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

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(Celtic Seas, Bay of Biscay)

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 (*Lophius piscatorius* and *L. budegassa*). 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 2021

For *L. budegassa*, ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 15 551 t.

For *L. piscatorius*, ICES advises that when the EU multiannual plan (MAP; EU, 2019) for Western waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 23 320 t and 45 996 t. According to the MAP, catches higher than those corresponding to F_{MSY} (34 579 t) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule.

3.1.3 Management applicable to 2021

Because the TAC for anglerfish in Subarea 7 is shared with the UK and because the UK can catch 10% of this TAC in area 8abde, there were considerable delays in setting the TAC for 2021. Initially, a roll-over TAC for Q1 2021 was agreed at 25% of the 2020 TAC; this was later replaced by a TAC of 50% of the 2021 advice for the first half of 2021 but at the time of writing this report, there was no agreed TAC for 2021.

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 tonnes (for both *Lophius* species combined). Since then, landings have fluctuated between 20 and 40 thousand tonnes 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. and Table 3.1.1).

Around 2/3 of the catches are taken by otter trawlers targeting demersal fish; gillnets take 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 Data revisions

No revised catch data prior to 2020 were submitted.

3.1.6.2 Landings and discards

Figure 3.1.1 shows the time-series of the official landings of the combined species. Table 3.1.1 gives the ICES estimates of landings and discards by species as well as the official landings.

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 by country. The proportions vary by country but the trends are similar between countries. The overall proportion of *L piscatorius* in the combined *Lophius* landings varied between 62% and 83% with a mean of 74%. The FR_IE_IBTS survey shows very similar trends in species proportion to the overall international landings proportion and the species proportion from the IE-IAMS (G3098) survey is very similar to the overall proportion.

3.1.6.3 Effort and LPUE

Figure 3.1.3 shows that the fishing effort of the main fleets catching anglerfish has declined substantially since the early 1990s. Figure 3.1.4 shows that the LPUE of *L. piscatorius* has increased considerably in many fleets since the 1990s. The LPUE of *L. budegassa*, however, (Figure 3.1.5) does not show a clear trend for most fleets except the IRE-OTB, which shows a strong increasing trend.

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

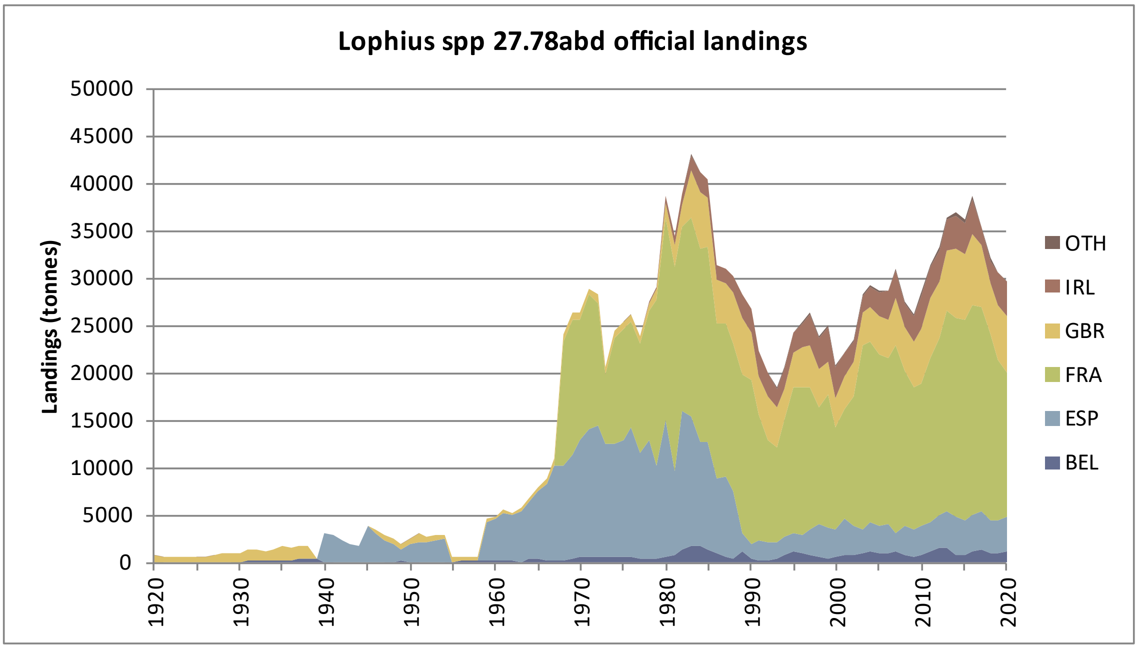

Figure 3.1.1. ***Lophius*** **spp in 27.78abd. Time-series of the official landings.**

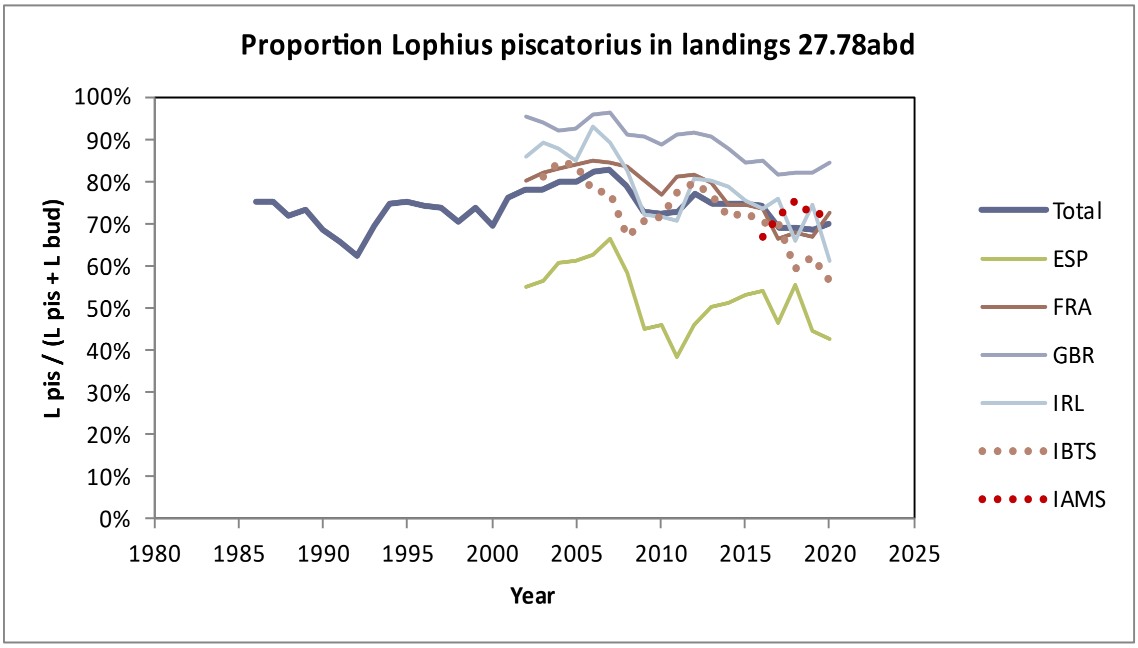

Figure 3.1.2. ***Lophius*** **spp in 27.78abd. Species composition by country. The species proportion in the combined FR_IE_IBTS survey is also shown but is not used to split the catches.**

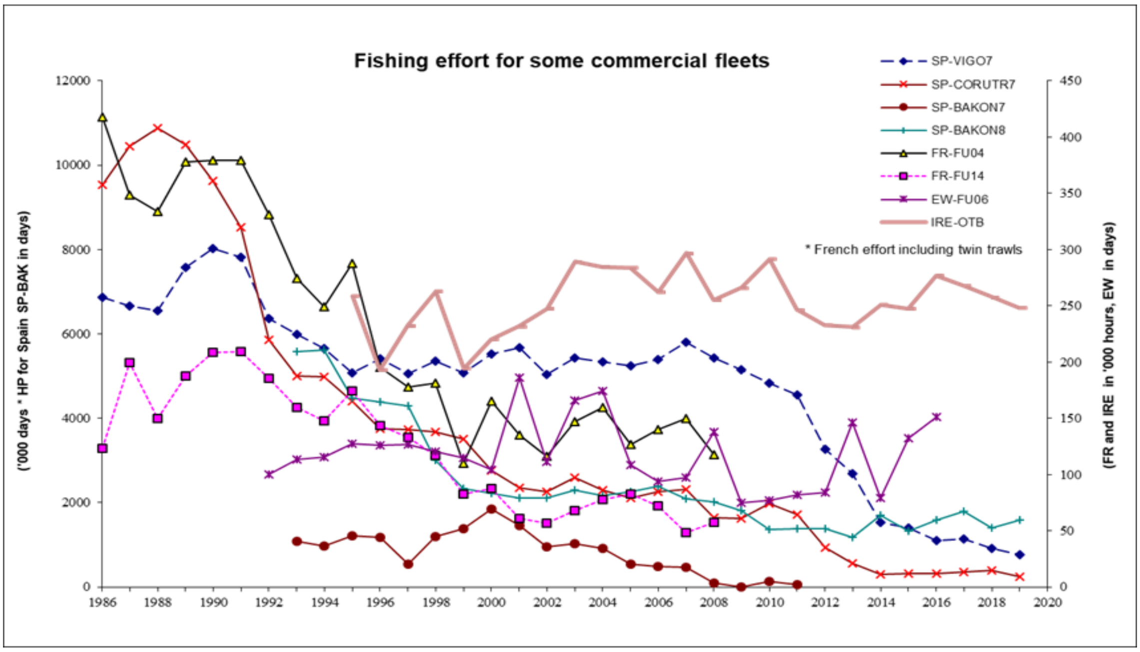

Figure 3.1.3. ***Lophius*** **spp in 27.78abd. Effort by main fleets.**

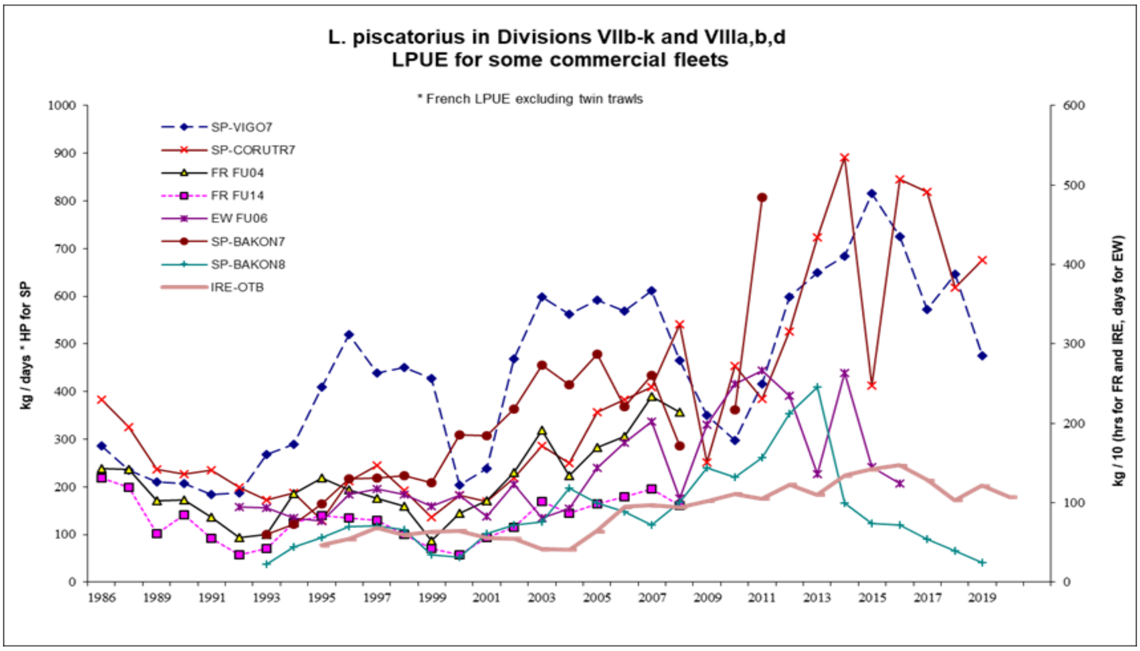

Figure 3.1.4. ***Lophius piscatorius*** **in 27.78abd. LPUE by the main fleets.**

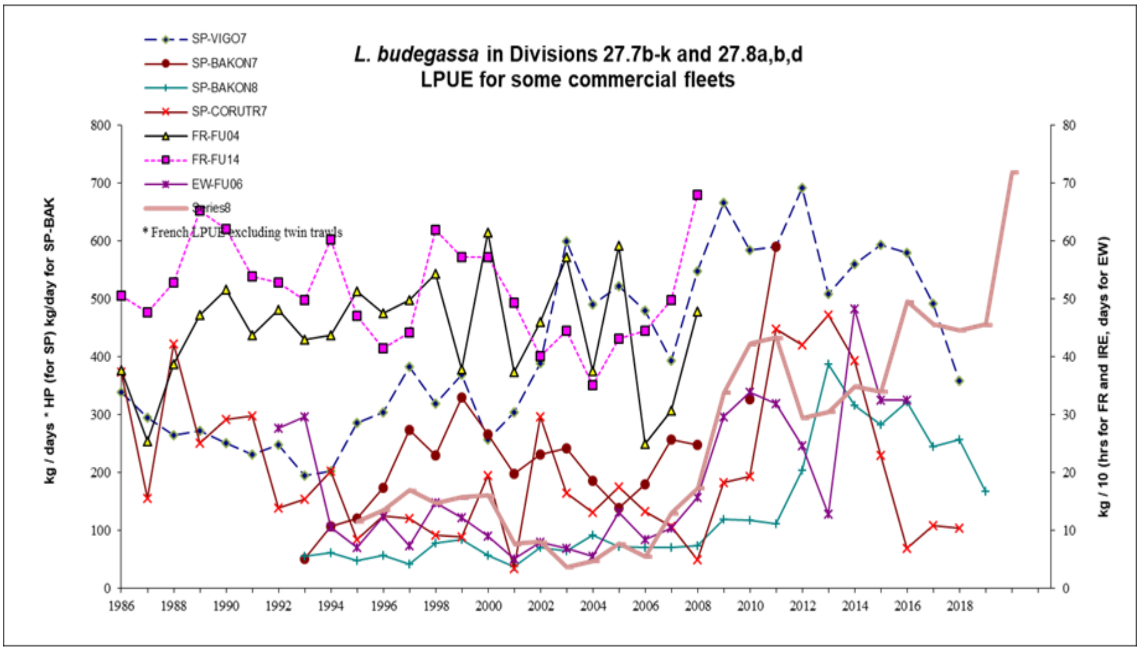

Figure 3.1.5. *Lophius budegassa* in 27.78abd. LPUE by the main fleets.

Table 3.1.1. *Lophius* spp in 27.78abd. Time-series of the ICES estimates of the landings, discards and official landings (in tonnes).

Year	*Lophius piscatorius*					*Lophius budegassa*				*L. piscatorius + L. budegassa*	
	Landings				Disc	Landings			Disc	ICES Land	Disc
	7a	7bk*	8abd	total	78abd	7bk	8abd	total	78abd	78abd	78abd
1986	1315	19545	4123	24983		6443	1774	8217		33200	
1987	1182	17181	4729	23092		5115	2503	7618		30710	
1988	1219	16148	3948	21315		6346	2035	8381		29696	
1989	2885	18240	2889	24014		6434	2387	8821		32835	
1990	1229	16374	3379	20982		7060	2571	9631		30613	
1991	603	14002	2159	16764		6254	2525	8779		25543	
1992	851	11404	1362	13617		6008	2168	8176		21793	
1993	1437	11870	1588	14895		4648	1919	6567		21462	
1994	1081	14075	2045	17201		3949	1796	5745		22946	
1995	1303	16618	3112	21033		5204	1750	6954		27987	
1996	1171	18174	3987	23332		5979	2114	8093		31425	
1997	1323	17742	3918	22983		6187	1929	8116		31099	
1998	902	16787	2787	20476		6509	2089	8598		29074	

Year	*Lophius piscatorius*					*Lophius budegassa*				*L. piscatorius + L. budegassa*	
	Landings				Disc	Landings			Disc	ICES Land	Disc
	7a	7bk*	8abd	total	78abd	7bk	8abd	total	78abd	78abd	78abd
1999	542	16776	1473	18791		5068	1670	6738		25529	
2000	505	12909	1031	14445		5219	1425	6644		21089	
2001	611	15056	1624	17291		4478	1250	5728		23019	
2002	672	17874	3537	22083		4734	1771	6505		28588	
2003	639	21980	5315	27933	2511	6256	1916	8171	179	36105	2690
2004	604	22479	5945	29028	2411	5358	2178	7537	676	36565	3087
2005	489	21882	5498	27869	2110	5214	1974	7187	727	35056	2837
2006	418	21947	5287	27652	892	4675	1456	6131	704	33783	1596
2007	428	25424	5361	31213	816	4857	1751	6608	413	37821	1229
2008	290	21097	5666	27053	993	6039	1360	7399	1585	34452	2579
2009	218	17145	4472	21835	2078	6478	1809	8287	2113	30122	4191
2010	177	17555	4483	22215	2672	6812	1815	8626	1436	30841	4107
2011	235	19309	5114	24657	1832	7416	1933	9348	971	34006	2802
2012	295	23007	4887	28188	2330	5959	2471	8429	1459	36618	3789
2013	269	25782	4560	30611	1684	7274	3200	10475	2285	41086	3970
2014	253	23276	4945	28474	1859	6114	3718	9832	2570	38306	4428
2015	234	23103	4521	27859	2324	6284	3365	9649	1460	37508	3784
2016	656	24836	3919	29411	3585	6127	4093	10220	2441	39630	6026
2017	312	22169	3154	25635	2175	7518	4172	11690	1770	37325	3945
2018	313	18865	3506	22685	1396	6341	3734	10076	1727	32420	3123
2019	110	18976	2181	21266	1444	6800	2880	9680	1084	30946	2528
2020	78	18226	1852	20156	1335	6502	2174	8676	855	28832	2190

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

Type of assessment

Update category 1 assessment. Age-based analytical assessment with a4a (Millar and Jardim, 2019).

Feedback from ADG

No issues identified.

Feedback from EG audit 2020

No issues identified.

3.2.1 Data

In 2018, WGBIE was made aware of an issue with the sampling level of Q1 and Q2 in 2017 from France (ICES, 2018b). Because of the lack of market sampling for length (biological and onboard sampling was unaffected), efforts were made to try to fill the deficiency in the sample number by using simulation techniques. However, both simulated data and actual data were uploaded to InterCatch combined making it impossible to distinguish true samples from simulated ones (Quemar *et al.*, 2018 in ICES, 2018b). Therefore, it is not possible to assess the impact of such simulated data on the assessment and the group recommended that sensitivities with and without the simulated data are carried out.

The Stock Annex describes the methods for filling in unsampled landings and discards. Figure 3.2.1 shows that less than half of the landings had length data associated with them. More than half of the discards were unsampled and had to be estimated from the discard rate of the sampled catches. However, as discard rates are relatively low, this affects only a small proportion of the total catch weight.

In 2020, due to COVID-19, the numbers of landings and discards samples decreased compared with the previous year. There were no discard data from Spain during the first semester in Subarea 7. In the case of the French data, the discards of OTB_DEF and GNS_DEF were very high while the value for Ireland was too small. For the Spanish data, OTB_DEF discards are very similar to Subarea 8 and, therefore, Subarea 7 discards were filled with those data. For the French and Irish data, considering that discard values were similar for the last 3 years, the proportion of discards of this *métier* was assumed using the average of the last three years.

Figure 3.2.2 shows the quarterly length–frequency distribution (LFD) of the catch data.

The length data are converted to pseudo-ages by first estimating the mean lengths-at-age in each quarter from a von Bertalanffy growth function (VBGF) with the parameters $L_{inf} = 171$ cm, $K = 0.1075$ and $t_0 = 0$. Then, for each quarter and year, a mixed distribution is estimated for the length distribution of the catches with the mean values predicted by the VBGF and standard deviations that increase linearly from 3 cm at age-0 to 10 cm at age-9. This mixed distribution is then used as an age–length key (ALK) which is then applied to the catch, landings and discard numbers-at-length. Until now, when the total discards volume and the product of numbers-at-length discarded by the weight are different, the total discards are modified to fit the sum of products. However, in 2020 the code was modified in order to keep total discards as estimated and instead modify the number of individuals. In this way, the total discards in the assessment match the estimated total discards volume when the discards per country or area are summed. This affects the historical time-series of discards, with a difference of −1 to 3% when comparing with the last year's assessment values. The resulting numbers and weights-at-age are used as inputs for the assessment model.

Table 3.2.1 gives an overview of the model inputs.

Figures 3.2.3a and 3.2.3b show the age distribution of the catches in terms of abundance and biomass. Catch numbers are generally higher at ages 1 or 2. The highest biomass in the catches is at ages 3–5. Note that this stock is assumed to mature at age 5.

Figure 3.2.4 shows the cohort tracking of the catch numbers-at-age. Cohort tracking is reasonably consistent up to age 7.

Figure 3.2.5 shows the proportion of discards-at-age. Nearly all 0-group anglerfish are discarded; around 80% of 1-year-olds are discarded and in recent years an increasing proportion of 2-year-olds have been discarded.

3.2.1.1 Surveys

The surveys are described in detail in the Stock Annex and section 2 of the report.

The survey data are converted to pseudo-ages in the same way as the catch data (see above and Stock Annex for more details).

The combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey (FR_IE_IBTS combined survey) are very consistent in cohort tracking for the younger ages (Figure 3.2.6a). Note that no index was available in 2017 because the French survey did not take place due to mechanical issues.

The IE_Monksurvey (G3098) survey only consists of five recent years of data but appears to track the 2014 and 2010 cohorts (Figure 3.2.6b).

The SpGFS-WIBTS-Q4 (G5768, the previous acronym was SP-PGFS) survey tracks cohorts very consistently up to at least age 6 (Figure 3.2.6c).

Figures 3.2.7a and b show the internal and external consistency of the surveys. The FR_IE_IBTS is very consistent for young ages while the IE_Monksurvey (G3098) survey is too short to clearly show any internal consistency. The SpPGFS-WIBTS-Q4 (G5768) survey is somewhat noisy at ages 1 and 6 but otherwise quite consistent (Figure 3.2.7a). The FR_IE_IBTS and SpPGFS-WIBTS-Q4 (G5768) have very similar signals for the 1-year olds but contradicting for the 2 and 3-year-olds. Figure 3.2.7c shows the overall abundance indices of the surveys.

3.2.1.2 Biological

The Stock Annex describes the background of the biological parameter estimates.

- Maturity is assumed to be 0% for ages 0–4 and 100% for ages 5–7+
- Natural mortality (M) is assumed to be 0.25 for all ages and years

3.2.2 Historical stock development

Model used: a4a (+length-split based on VBGF to estimate age comp; Millar and Jardim, 2019)

Software used*:* Fla4a package version 1.6.4 (Millar and Jardim, 2019) in R version 3.5.2 (R Core Team, 2020)

An overview of the available input data by year and age is shown in Figure 3.2.8.

Model specification (see Stock Annex for details):

fmodel: ~factor(replace(age, age > 6, 6)) + factor(year)
srmodel: ~factor(year)

```
n1model: ~factor(age)
qmodel:
  FR_IE_IBTS:    ~1
  IE_MONKSURVEY: ~I(1/(1 + exp(-age)))
  SP-PGFS :      ~factor(replace(age, age > 5, 5))
vmodel:
  catch:         ~s(age, k = 3)
  FR_IE_IBTS:    ~1
  IE_MONKSURVEY: ~1
  SP-PGFS :      ~1
```

The F_{bar} range was set to ages 3–6.

3.2.2.1 Data screening and exploratory model runs

The data were thoroughly explored using the functionality of FLR and other packages. The sensitivity of the model to the inclusion of the tuning fleets was explored and the final WKANGLER assessment outputs (ICES, 2018a) were compared to the first retrospective run of the current model. The details of the data exploration can be found in the 2021 presentations folder on the WGBIE SharePoint.

3.2.2.2 Final update assessment

Figure 3.2.9 shows the patterns in F-at-age and catchability estimated by the model. F is estimated to be quite low for age 0, then gradually increases over ages 1 to 5 and decreases again for ages 6 and 7+ (F is forced to be the same for ages 6 and 7+). This may indicate reduced availability of older fish to the fishery as they move to deeper waters probably to feed (Stagioni *et al.*, 2013) or a response due to a transfer of fishing effort (Abad *et al.*, 2010). Alternatively, it could indicate higher natural mortality. The catchability (Q) of the FR_IE_IBTS combined survey is set to be the same for all ages. For the IE_Monksurvey (G3098), Q increases along a logistic function. This survey uses commercial fishing gear and the catchability follows a similar pattern to the estimated F-at-age. For the SpPGFS-WIBTS-Q4 (G5768, the previous acronym was SP-PGFS) survey, Q is freely estimated for ages 2, 3, and 4 while ages 5 and 6 are bound with reduced availability of older fish.

Figure 3.2.10 shows the residuals. These do not show any pattern except for the 2-year-olds from the FR_IE_IBTS combined survey for which most of the residuals are positive.

Figure 3.2.11 shows the summary plot as well as the retrospective analysis. The recruits are estimated with quite high precision. However, the retrospective estimates in some years are outside the confidence interval indicating a lower precision of the recruitment estimates. The 2017 recruitment estimate is highly uncertain because there was no recruitment index available for 2017.

Fishing mortality (F) shows a decreasing trend since 2004 (Figure 3.2.11) and is now below F_{MSY}.

SSB shows a steady increasing trend in SSB since 2005 and continues to rise. There is a retrospective adjustment of both SSB and F at the start of the time-series (in the period where no survey data are available). This is because in a separable assessment the F-pattern of the entire time-series is adjusted with each new year of data. Mohn's rho (Mohn, 1999) was calculated using the default 5 peels of the mohn() function in the R package 'icesAdvice 2.0.0'. The Mohn's rho values for SSB (0.33) and F (−0.16) are outside the accepted range for long-lived species (−0.15, 0.2) but not for recruitment (0.023). However, in all cases, the retrospective pattern is inside of the confidence interval. Nevertheless, a sensitivity analysis was done during the benchmark (WKANGLER; ICES, 2018a), introducing different Q-pattern to the IE_Monksurvey (G3098) due to the residual patterns observed at age 4 and 5. Assuming a Q-pattern with flexibility between ages, the model estimates a dome-shaped curve and the retrospective pattern of F and SSB are improved, with Mohn's rho values of −0.115 and 0.188, respectively, but not for the recruitment (0.259). The results suggest that this could improve the retrospective pattern, but further analysis is required. However, according to the decision tree from the Workshop on Catch Forecast from Biased Assessments (WKFORBIAS; ICES,2020b), if the retrospective pattern is found to be inside of the confidence interval, which is the case, advice shall be given.

Parameter	Mohn's Rho
Recruitment	0.023
F_{bar}	−0.160
SSB	0.330

3.2.2.3 Comparison with previous assessments

The code was modified in 2018 for filling the landings and discards but the historical data until 2017 were not modified (ICES, 2018b). In WGBIE 2021, these values were reviewed but did not have an impact on the catch-at-age numbers neither on the final results (Figure 3.2.13) compared with last year's assessment (ICES, 2020a).

3.2.2.4 State of the stock

Fishing mortality is now below F_{MSY} and has been below for the last 6 years. SSB has been above MSY $B_{trigger}$ and is now at the highest value in the time-series.

3.2.3 Biological reference points

Biological reference points were established by WKANGLER (ICES, 2018a).

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	22 278 t	B_{pa}
Approach	F_{MSY}	0.28	Median Eqsim estimate for landings (F_{MSY} catch = 0.30)
	F_{MSY} range	0.181–0.39	
	B_{lim}	16 032 t	B_{loss}
Precautionary	B_{pa}	22 278 t	B_{lim} + assessment error
Approach	F_{lim}	0.53	F with 5% probability of SSB <B_{lim}
	F_{pa}	0.39	$F_{p0.5}$ with AR; the F that leads to SSB ≥ B_{lim} with 95% probability

The definition of F_{pa} was modified to $F_{p0.5}$ in 2021 (ICES, 2021a) and the process of how $Fp_{0.5}$ was estimated can be found in the Stock Annex. The assessment presents some retrospective bias in 2019 and also in 2020 in the start as well as the end of the time-series. In 2019, WGBIE investigated if the biological reference points were still appropriate and the analysis showed that the F_{MSY} estimate was still sensitive to the addition of an extra year of data (ICES, 2019). It was estimated to be 0.23 in the 2019 assessment (ICES, 2019) and 0.36 in 2018 (ICES, 2018b). WGBIE in 2019 (ICES, 2019) considered that F_{MSY} = 0.28 (similar in WKANGLER; ICES, 2018a) is a conservative and pragmatic reference point as F has always been above F_{MSY} and yet the stock shows a sharp increase in SSB. Therefore, WGBIE did not propose to update the reference points in 2019 (ICES, 2019).

3.2.4 Short-term projections

Short-term projections were carried out as described in the Stock Annex:

- Although F shows a downward trend, F_{2021} was assumed as the average of the last 3 years ($F_{2018,}$ $F_{2019,}$ F_{2020}) due to the uncertainty observed in the retrospective pattern.
- No catch constraint was applied in the intermediate year as the TAC does not appear to be restrictive.

Table 3.2.3 gives the catch options. Figure 3.2.14 shows the contributions of the cohorts to the 2022 forecasted landings and 2023 SSB. The 2021 assumed geometric mean (GM) recruitment contributes about 9% to the forecasted landings.

3.2.5 Uncertainties in the assessment and forecast

In 2018 was the first time since 2006 that ICES has provided advice based on an analytical assessment for this stock. Previously, the advice was based on a category 3 assessment until 2018 and was raised to a category 1 stock after the WKANGLER (ICES, 2018a) meeting.

WKANGLER (ICES, 2018a) has shown that the estimated stock trends are robust to various assumptions on growth, natural mortality, the selection of tuning fleets and model specifications.

The estimate of the F_{MSY} reference point appears to be sensitive to the exact shape of the stock-recruit curve. The current F_{MSY} of 0.28 is considered to be conservative because the stock has increased considerably during the last 15 years although the fishing effort was well above 0.28 during that period.

3.2.6 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.

3.2.7 Recommendations for the next benchmark

WKANGLER (ICES, 2018a) accepted the current assessment model as an interim solution until a more appropriate model could be developed. One of the main concerns was that the allocation of length data into pseudo-ages was done outside the model. WKANGLER tested a number of growth parameters for use in the length-age conversion and the assessment was not overly sensitive to the growth parameters used. The conversion from length to age outside the model also has some advantages: although cohort strength is not explicitly taken into account in the length split, it is clear that cohorts can be tracked but until age 4 or 5 after which the tracking cohort is lost. However, the effect of this could be analysed in an integrated assessment model such as the Stock Synthesis (Methot and Wetzel, 2013) in the next benchmark. Other concerns include the retrospective pattern which is increasing for the last two years.

Roadmap of work in preparation for the next benchmark in 2021–2022

- During the WKTaDSA (ICES, 2021b), a preliminary base case in Stock Synthesis v3.30 was developed.
- The next steps include:
    1. Update of the 2020 data;
    2. Decide on an initial catch assumption;
    3. Analyse different spatial structures;

4. Analyse assumptions about growth and M and the option of implementing a sex-separated model;
5. Analyse the recruitment deviates;
6. Analyse the possibility of a spatially structured model;
7. Modify the se and cv of the surveys and number of samples of LFD data;
8. Try different options of weighting length–frequency data;
9. Compare SS (Merthot and Wetzel, 2013) assessment results with a4a (Millar and Jardim, 2019) results.

3.2.8 References

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3.2.9 Figures and tables

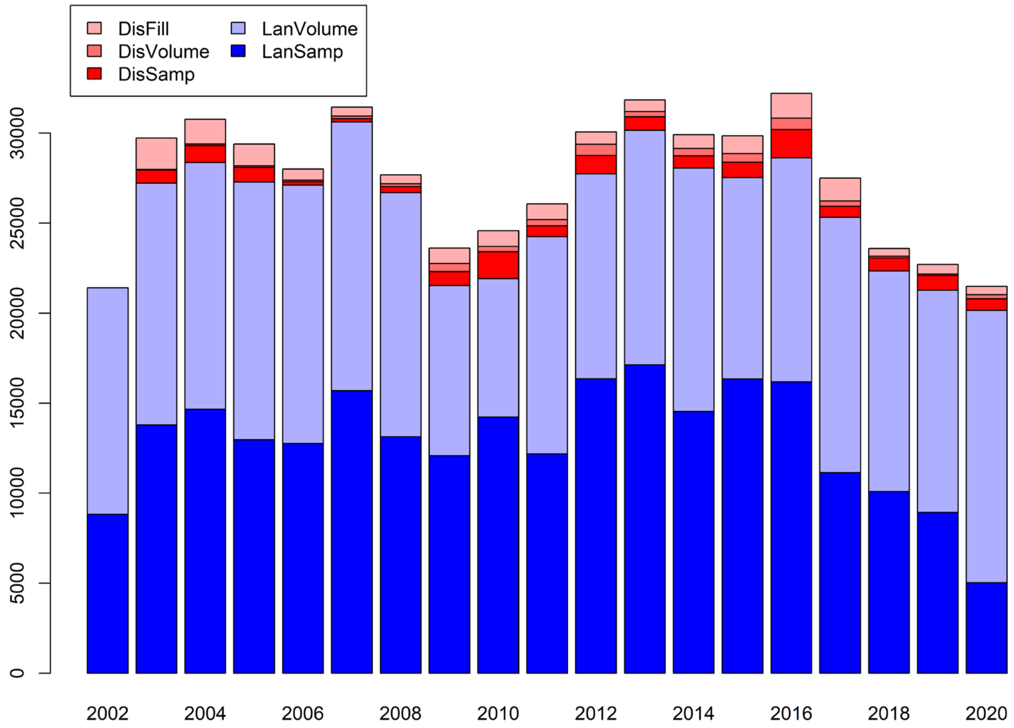

Figure 3.2.1. *Lophius piscatorius* in 27.78abd. Allocations of unsampled landings and discards by year. Dark blue represents the sampled landings while light blue represents landings for which only the total weight (in tonnes) was available but no length data and red represents the fully sampled discards (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) while the light pink represents the strata for which no discard tonnage or length data were available (discard rate and length data 'borrowed' from other strata).

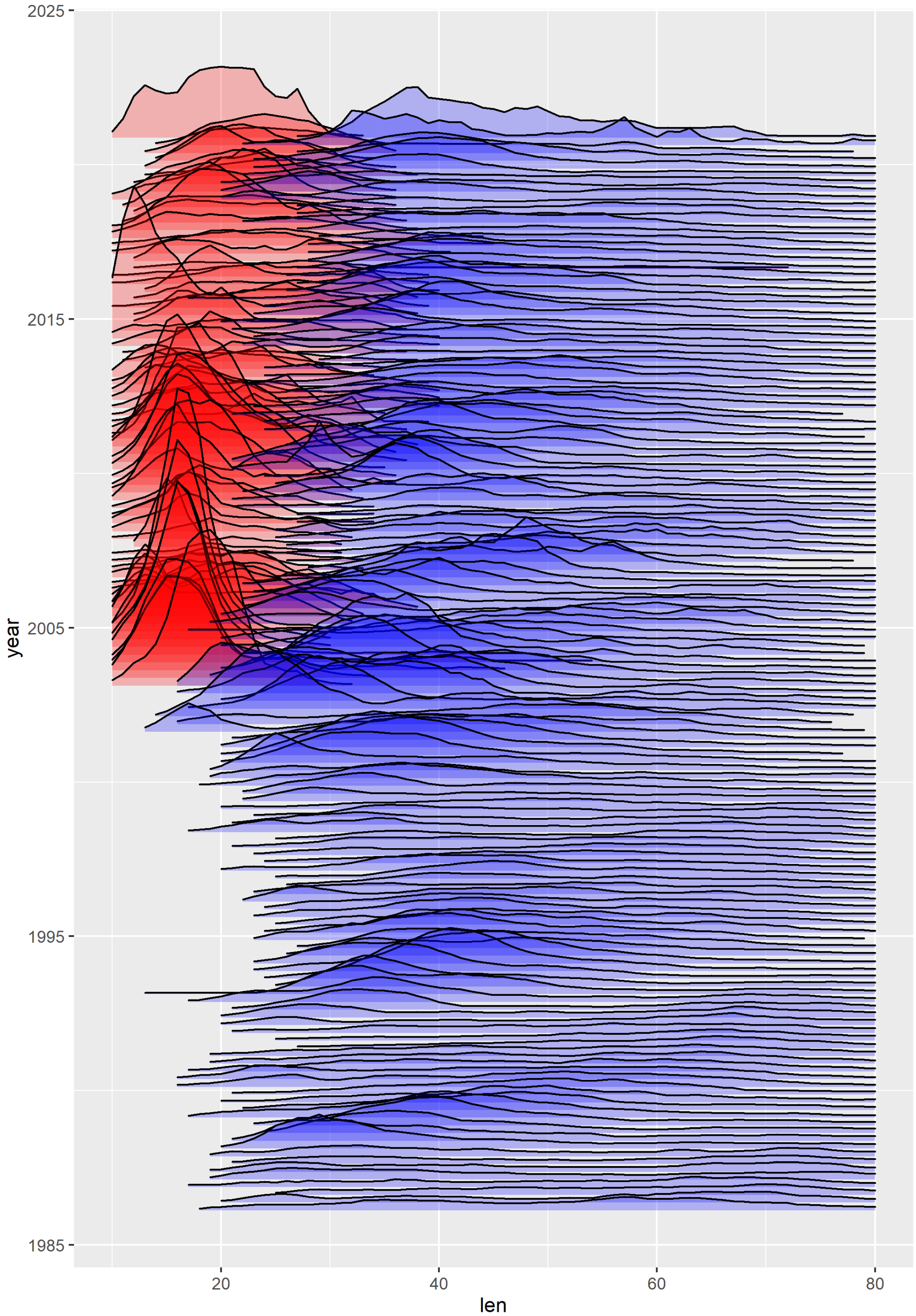

Figure 3.2.2. ***Lophius piscatorius*** **in 27.78abd. Quarterly length frequency distributions of the landings (blue) and discards (red). No discard data were available prior to 2003.**

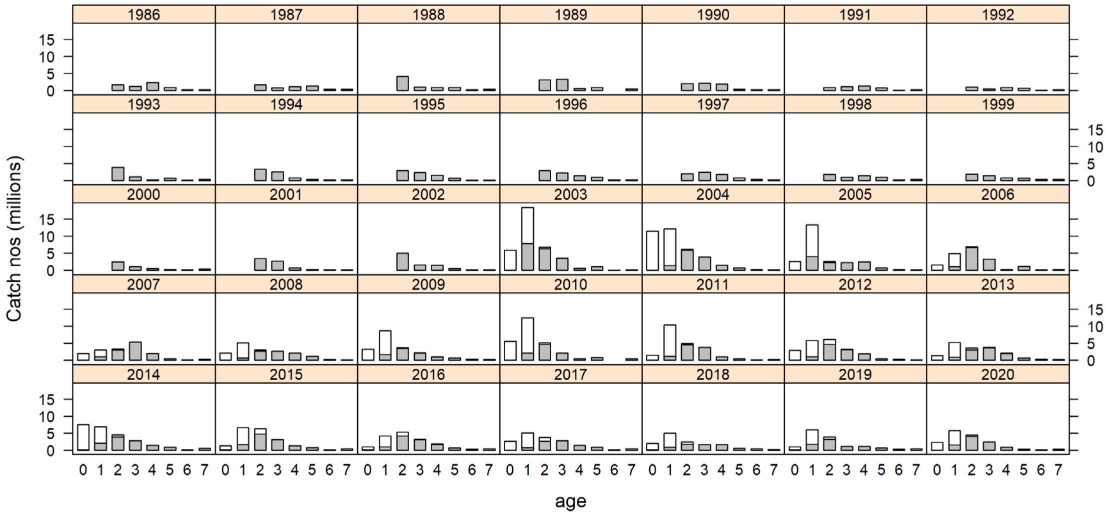

Figure 3.2.3a. ***Lophius piscatorius*** **in 27.78abd. Age distributions of the catches by year in terms of abundance**

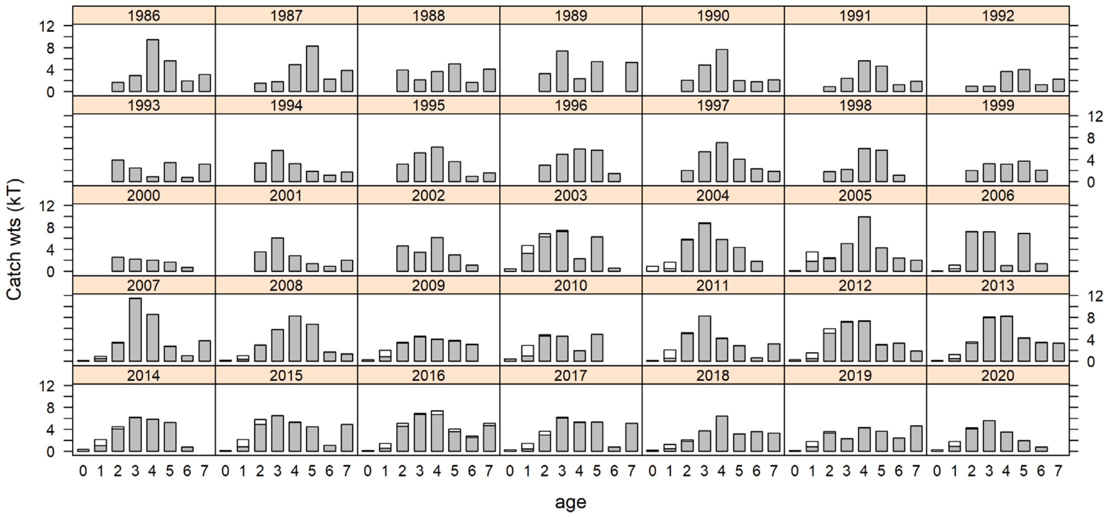

Figure 3.2.3b. ***Lophius piscatorius*** **in 27.78abd. Age distribution of the catches by year in terms of biomass.**

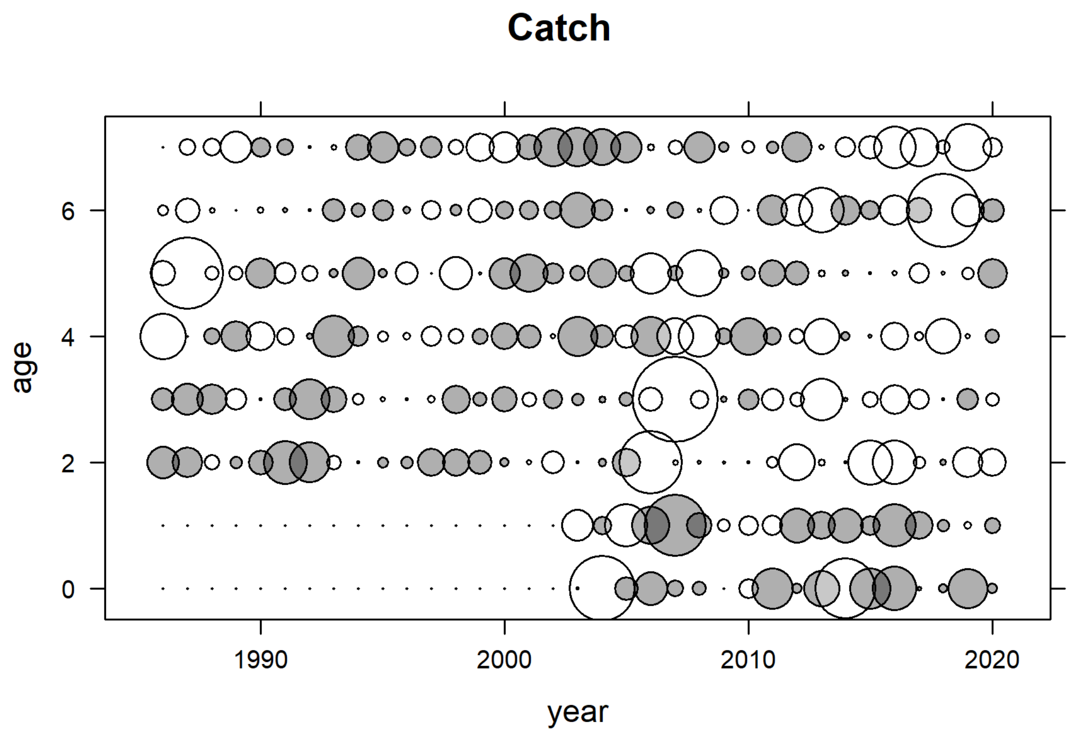

Figure 3.2.4 ***Lophius piscatorius*** **in 27.78abd. Standardized proportion at age-per-year of the catch numbers. Cohorts can be tracked consistently up to age 7.**

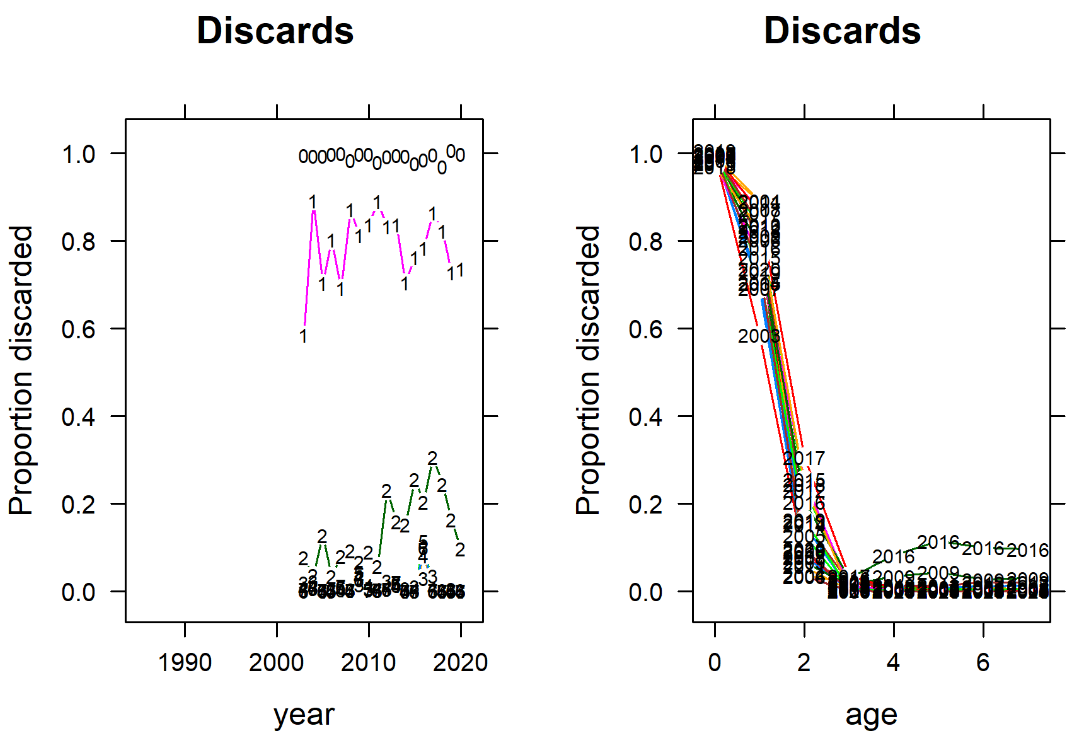

Figure 3.2.5. ***Lophius piscatorius*** **in 27.78abd. Proportions of discards-at-age over time (left) and by age (right).**

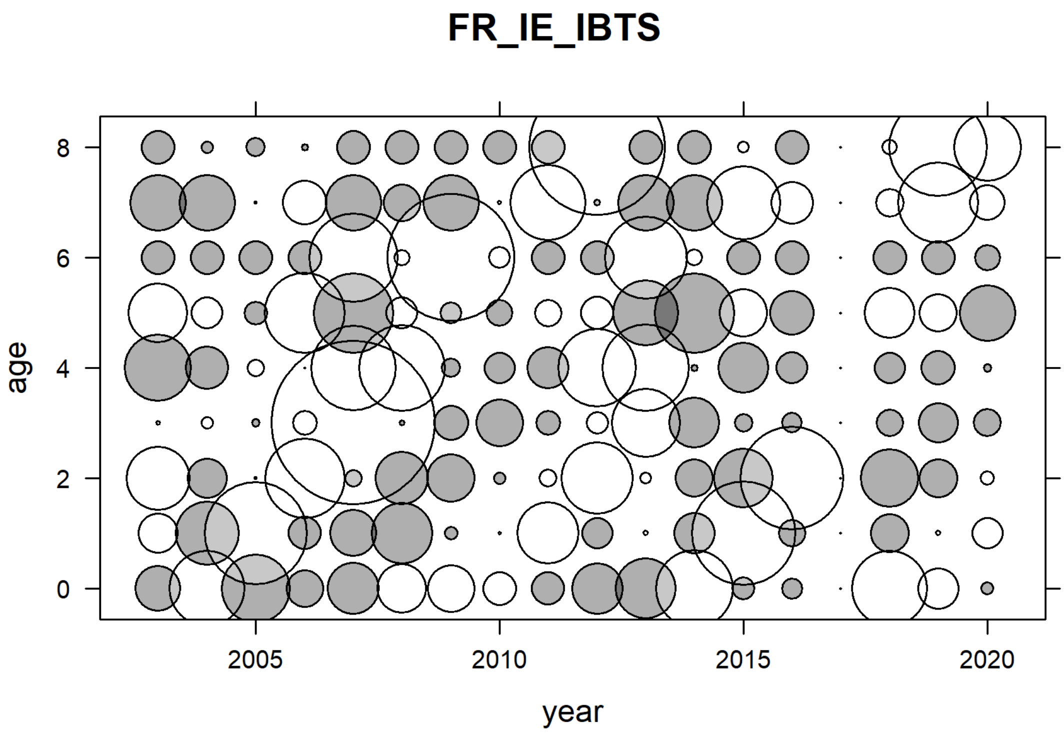

Figure 3.2.6a. ***Lophius piscatorius*** **in 27.78abd. Standardized proportion-at-age per year of the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey) index.**

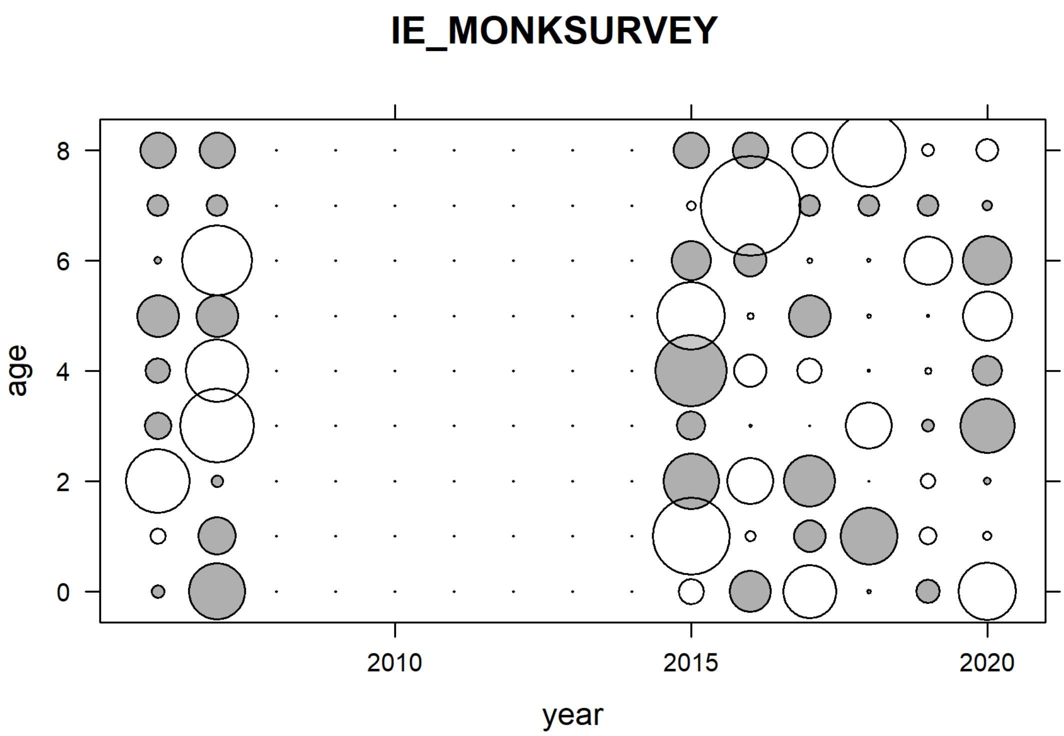

Figure 3.2.6b. ***Lophius piscatorius*** **in 27.78abd. Standardized proportion-at-age per year of the IE_Monksurvey (G3098) index.**

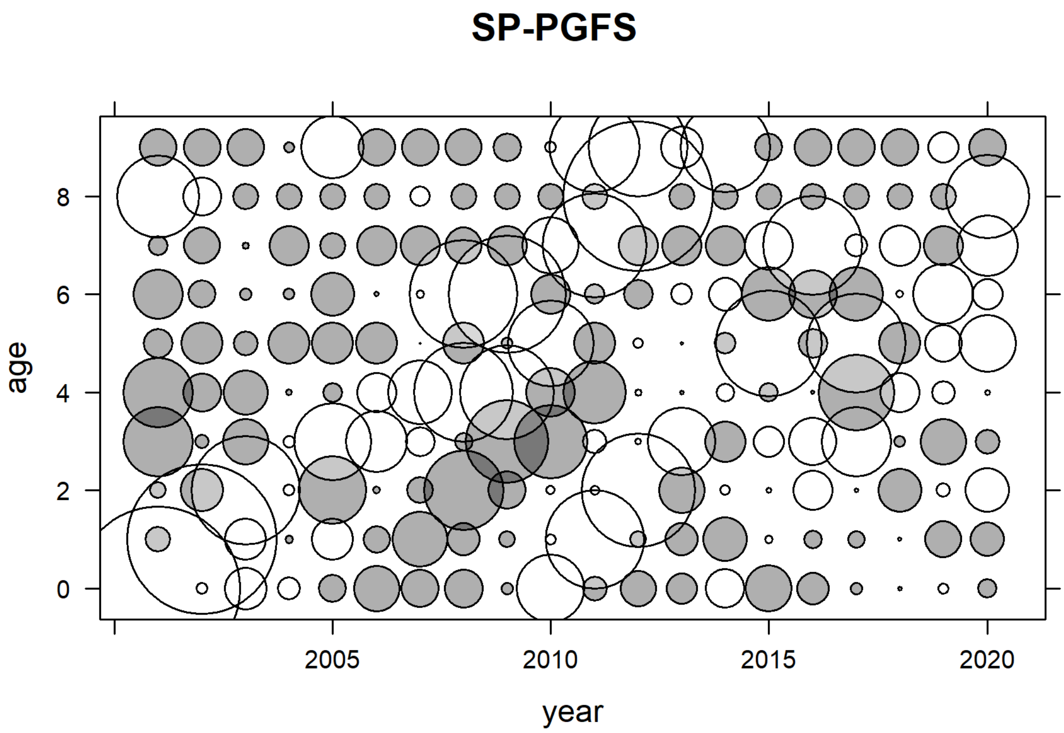

Figure 3.2.6c. ***Lophius piscatorius*** **in 27.78abd. Standardized proportion at age per year of the SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) survey index. Cohorts can be tracked consistently up to age 6.**

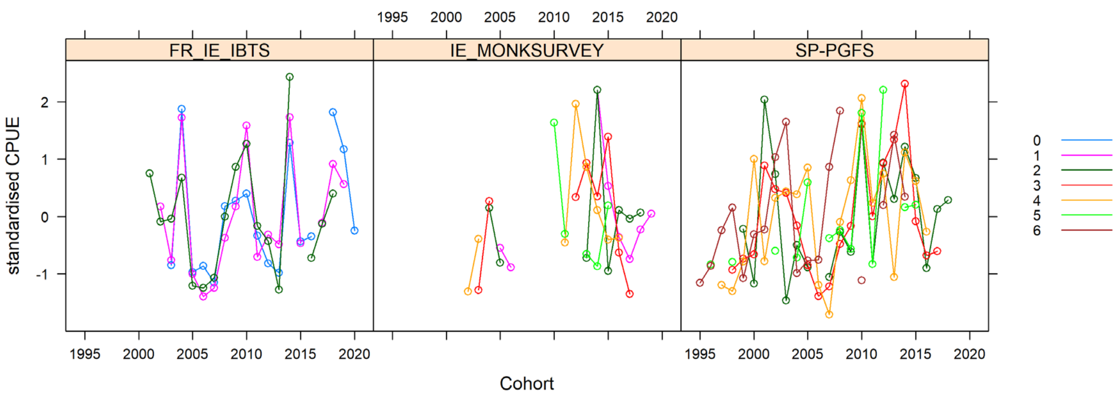

Figure 3.2.7a. ***Lophius piscatorius*** **in 27.78abd. Internal consistency of the standardized cpue indices from the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.**

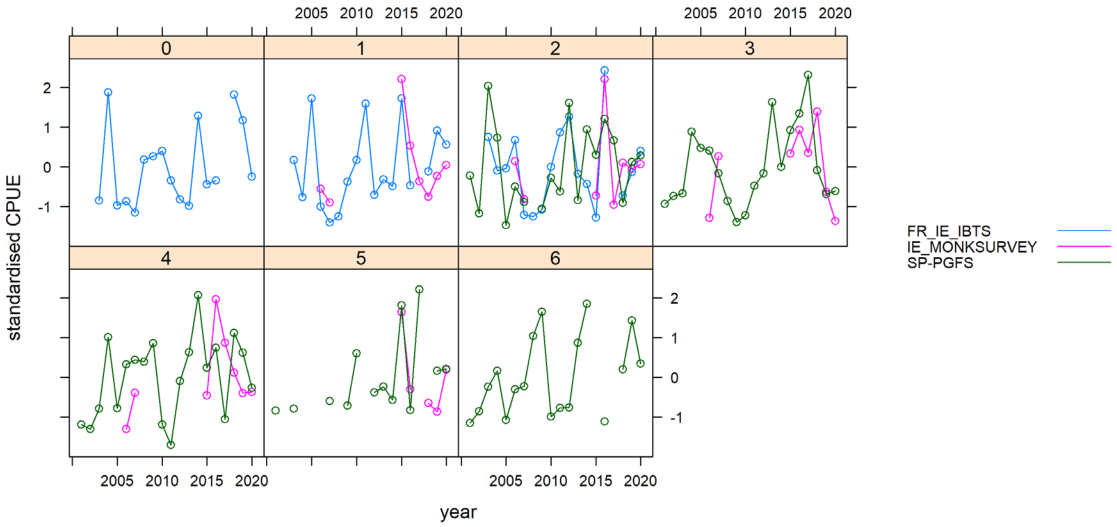

Figure 3.2.7b. ***Lophius piscatorius*** **in 27.78abd. External consistency of the standardized cpue indices from the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.**

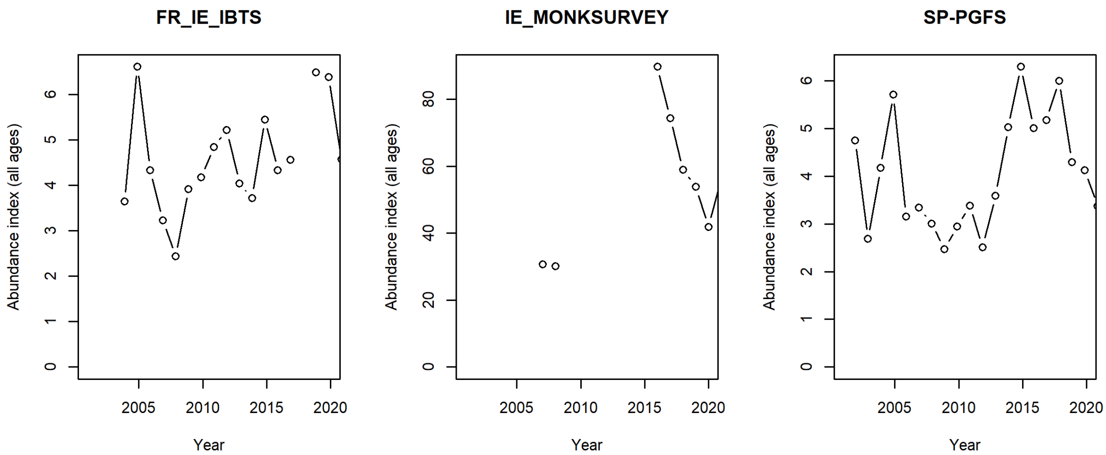

Figure 3.2.7c. ***Lophius piscatorius*** **in 27.78abd. Overall abundance trends (all ages combined) from the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.**

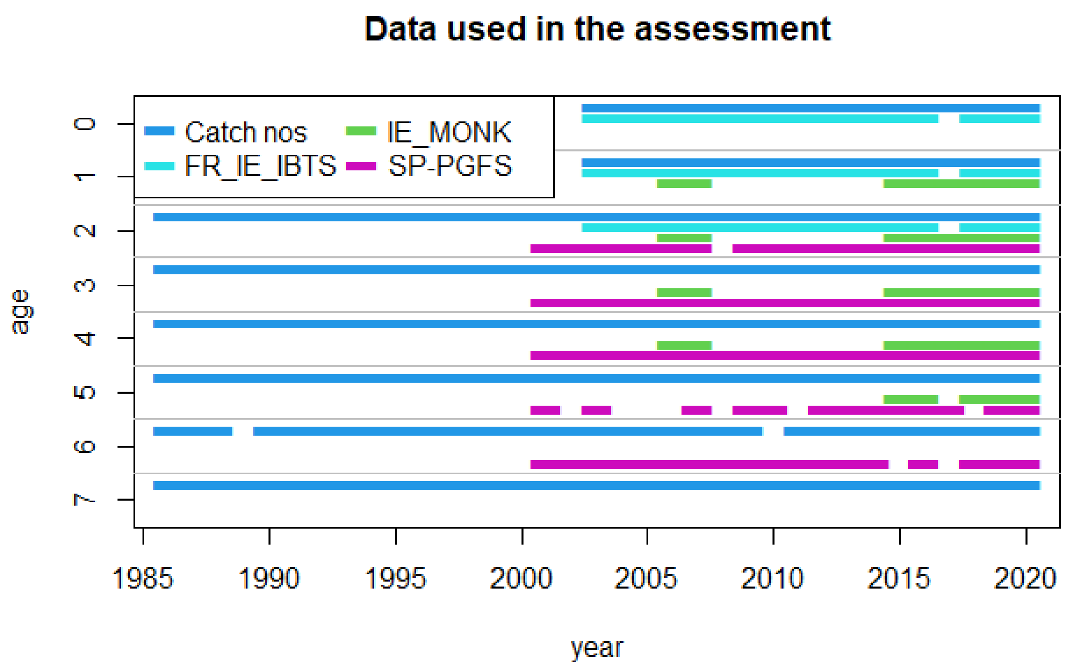

Figure 3.2.8. ***Lophius piscatorius*** **in 27.78abd. Overview of the available catch and survey data. Age 7 is a plus group. FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4 (G5768, previous acronym SP-PGFS) surveys.**

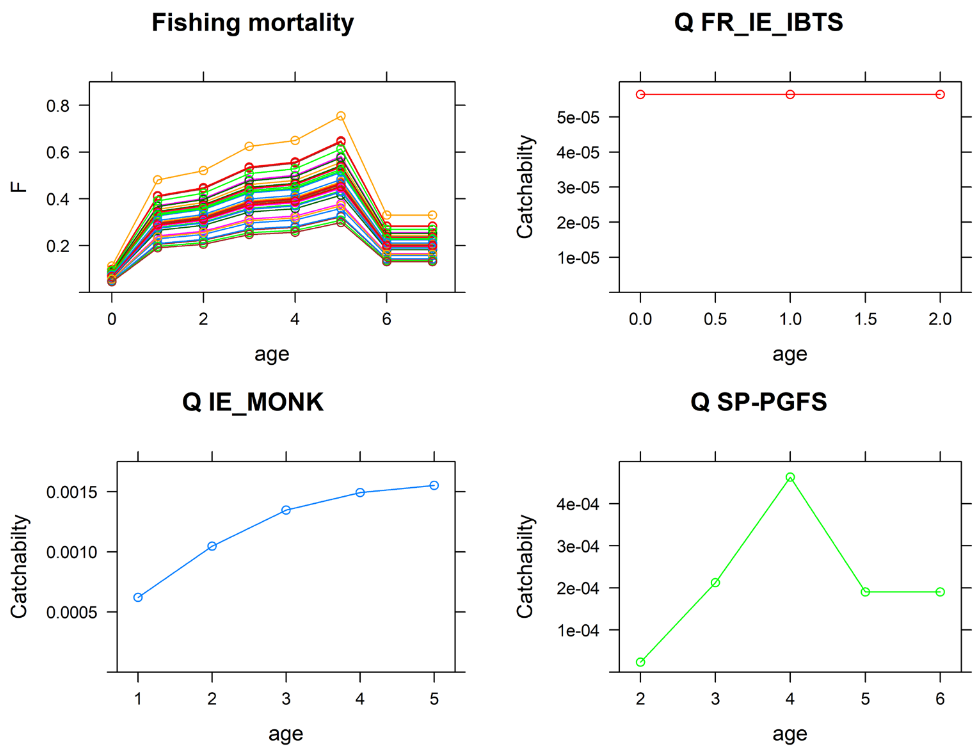

Figure 3.2.9. ***Lophius piscatorius*** **in 27.78abd. F-at-age (colours indicate years) and catchability-at-age patterns of the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4(G5768, previous acronym SP-PGFS) surveys.**

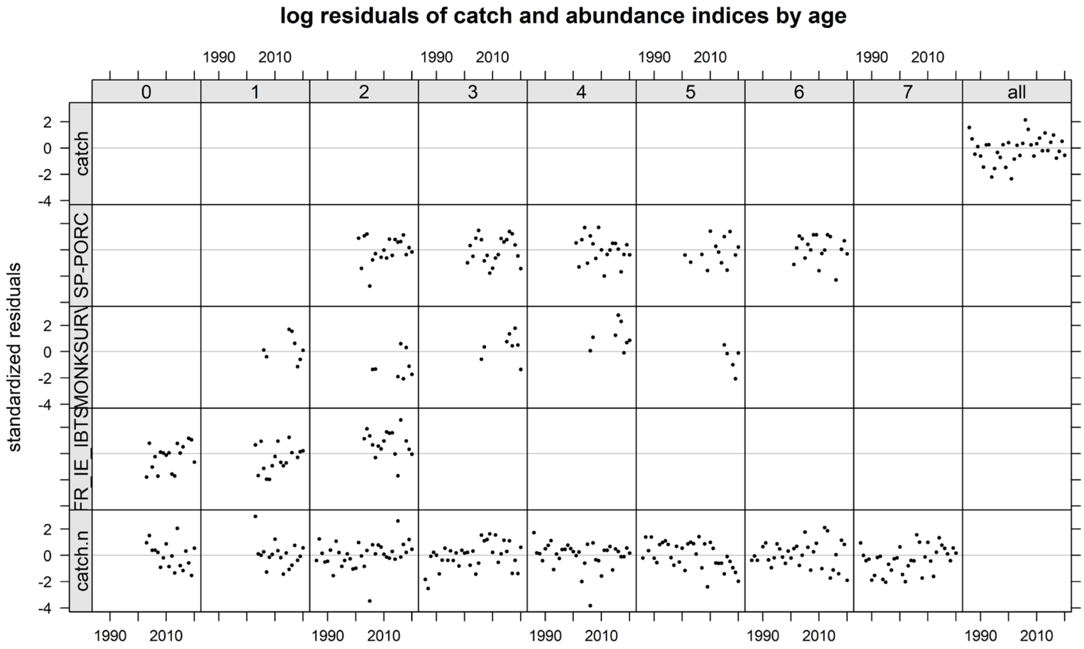

Figure 3.2.10. ***Lophius piscatorius*** **in 27.78abd. Standardized residuals of the catch and the FR_IE_IBTS (combined IGFS-WIBTS-Q4 (G7212) and EVHOE-WIBTS-Q4 (G9527) survey), IE_Monksurvey (G3098) and SpPGFS-WIBTS-Q4(G5768, previous acronym SP-PGFS) surveys.**

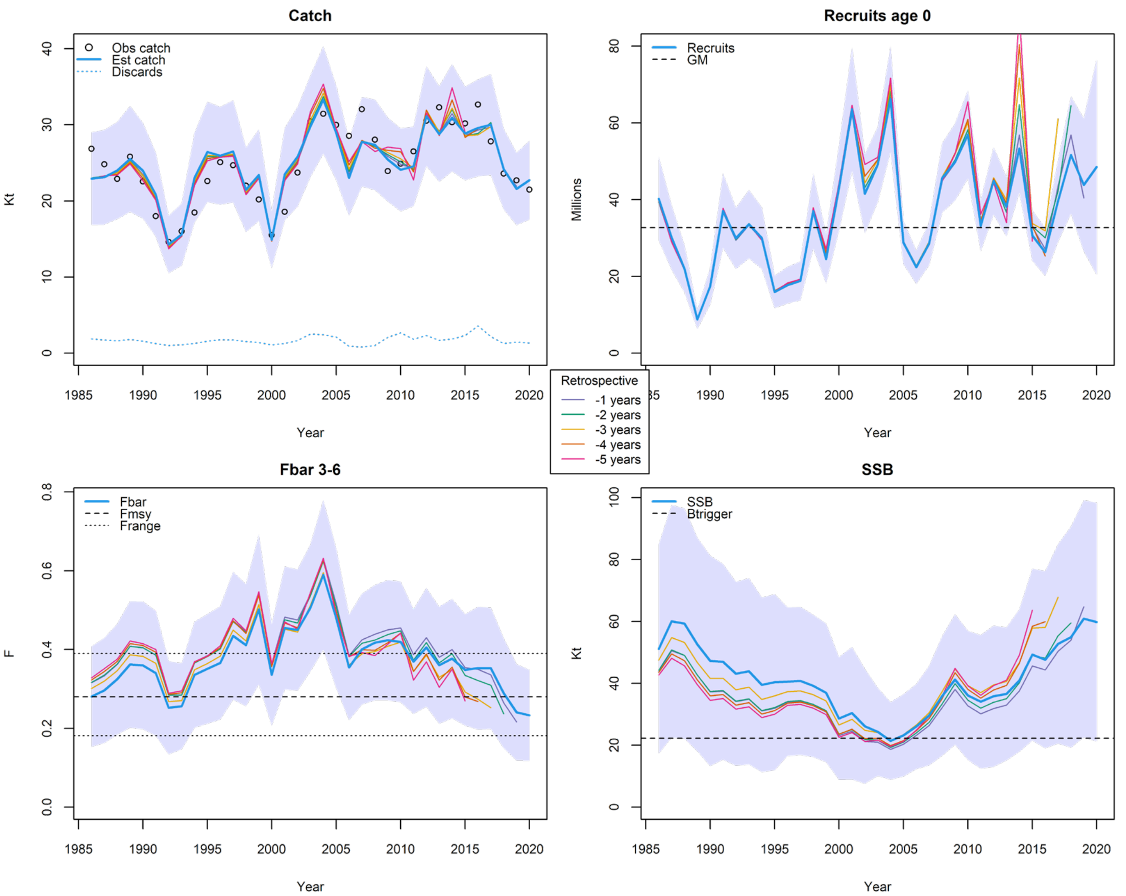

Figure 3.2.11. ***Lophius piscatorius*** **in 27.78abd. Summary plot of the assessment outputs. Light blue areas are the 95% confidence intervals. The coloured lines are the retrospective runs.**

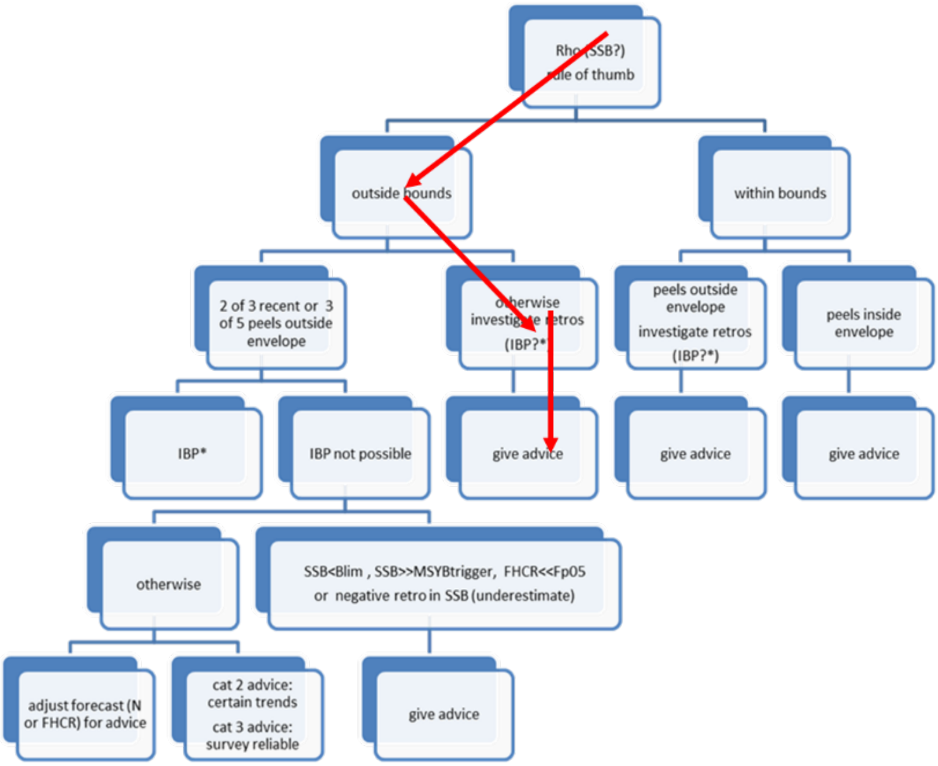

Figure 3.2.12. Decision tree from WKFORBIAS (ICES, 2020b) for handling assessments with retrospective patterns. The arrows show the path followed for the *Lophius piscatorius* in area 27.78abd 2021 assessment.

Figure 3.2.13. Comparison of the outputs from the previous assessment in WGBIE 2020 (ICES, 2020a) and this year assessment excluding the last year data (2020) Final-1y. FinalRun is the result of this year assessment and WKAngler18 is the result from the 2018 WKANGLER benchmark (ICES, 2018a).

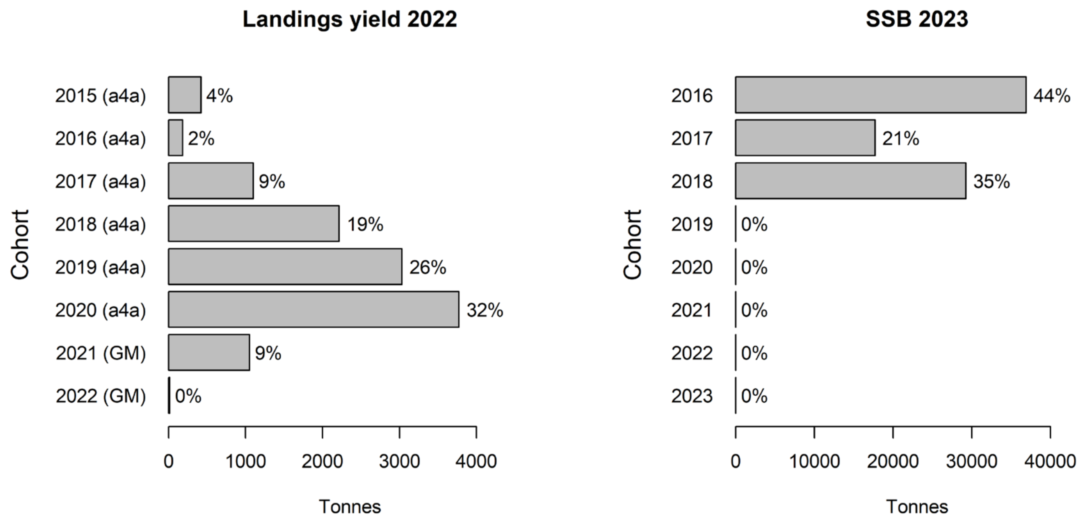

Figure 3.2.14. *Lophius piscatorius* in 27.78abd. Cohort contributions to the forecast landings in 2022 and SSB in 2023.

Table 3.2.1. ***Lophius piscatorius*** **in 27.78abd. Stock assessment model input data. catch.n is the catch numbers-at-age (thousands), p.dis is the proportion of the catch numbers that are discarded, catch.wt and stock wt are the catch and stock weights-at-age (kg), respectively. FR_IE_IBTS (n/hr), IE_Monksurvey (G3098, n/km2) and SpPGFS-WIBTS-Q4 (G5768, previous acronym was SP-PGFS, n/30mis) are the tuning indices used.**

catch.n	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986			1649	1239	2365	935	219	244
1987			1661	828	1168	1386	266	295
1988			4159	971	883	840	205	331
1989			2920	3152	539	862		410
1990			2069	2120	1941	338	203	161
1991			927	1094	1423	789	146	154
1992			976	417	897	669	141	192
1993			3827	1089	196	564	82	253
1994			3350	2649	788	325	130	135
1995			2966	2401	1546	617	101	114
1996			2915	2243	1492	978	163	183
1997			1954	2460	1762	694	266	157
1998			1812	965	1489	965	129	290
1999			1957	1508	808	642	263	346
2000			2594	1034	527	295	97	344
2001			3676	2844	720	262	111	140
2002			4882	1574	1460	492	121	80
2003	5936	18336	6683	3488	516	1054	59	137
2004	11484	12171	5975	3886	1423	719	188	164
2005	2625	13344	2583	2255	2465	693	254	146
2006	1528	4887	6812	3172	273	1166	159	281
2007	2046	2986	3247	5246	1984	472	106	282
2008	2156	5111	2940	2616	2081	1100	178	97
2009	3196	8690	3602	2168	952	637	337	231
2010	5543	12473	5084	2045	483	798		452
2011	1429	10329	4787	3759	1035	475	66	245
2012	2922	5806	6058	3137	1869	482	369	127
2013	1313	5202	3475	3706	2049	704	363	254
2014	7516	6835	4480	2783	1441	846	76	460
2015	1280	6595	6302	3052	1327	740	116	389
2016	958	4143	5265	3111	1792	670	290	413
2017	2617	5115	3661	2777	1355	843	73	400
2018	1960	4938	2353	1629	1629	537	389	234
2019	950	5924	3850	1041	1060	631	253	367
2020	2333	5761	4411	2448	867	324	79	307
prop.dis	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								

1999								
2000								
2001								
2002								
2003	0.996	0.585	0.077	0.019	0.007	0.001	0	0.005
2004	0.994	0.892	0.036	0.021	0.009	0.006	0.007	0.006
2005	0.994	0.703	0.128	0.001	0.001	0.002	0	0.002
2006	0.998	0.802	0.033	0	0.002	0.002	0.004	0
2007	1	0.691	0.08	0.004	0.003	0.008	0.011	0.012
2008	0.984	0.872	0.092	0.001	0.001	0.001	0.004	0.001
2009	0.998	0.812	0.066	0.014	0.033	0.043	0.026	0.029
2010	0.999	0.837	0.09	0.003	0.013	0.006		0.001
2011	0.979	0.89	0.056	0.002	0.005	0.002	0.002	0.003
2012	0.992	0.832	0.23	0.024	0.007	0.005	0.004	0.004
2013	0.995	0.838	0.159	0.019	0.013	0.013	0.02	0.02
2014	0.995	0.704	0.151	0.006	0	0	0	0
2015	0.977	0.763	0.255	0.011	0.003	0.001	0	0
2016	0.985	0.783	0.204	0.029	0.082	0.114	0.099	0.095
2017	0.996	0.865	0.306	0.034	0.007	0.001	0	0.001
2018	0.97	0.823	0.244	0.002	0	0	0	0
2019	1.007	0.728	0.164	0.004	0.002	0.001	0	0
2020	0.998	0.736	0.096	0.002	0	0	0	0
catch.wt	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986	0.124	0.385	1.015	2.367	4.114	6.131	9.078	13.062
1987	0.141	0.385	0.941	2.226	4.263	6.115	8.63	13.242
1988	0.125	0.466	0.964	2.276	4.225	6.175	8.395	12.717
1989	0.12	0.384	1.067	2.239	4.196	6.069	9.085	12.415
1990	0.118	0.352	1.027	2.331	4.077	6.109	8.907	13.784
1991	0.134	0.39	1.016	2.302	4.092	6.11	8.895	12.663
1992	0.12	0.451	1.003	2.252	4.133	6.016	9.008	11.944
1993	0.08	0.5	1.017	2.217	4.375	6.006	9.138	12.345
1994	0.097	0.549	1.027	2.208	4.202	5.802	9.366	12.772
1995	0.097	0.496	1.093	2.231	4.173	6.039	9.379	14.085
1996	0.097	0.414	1.04	2.278	4.12	6.073	9.125	12.455
1997	0.126	0.455	1.034	2.266	4.144	5.968	9.009	11.903
1998	0.127	0.412	1.019	2.371	4.138	6.117	9.071	11.617
1999	0.123	0.462	1.071	2.26	4.094	6.038	8.272	12.158
2000	0.11	0.452	1.034	2.298	4.077	5.979	7.907	12.623
2001	0.098	0.363	1.021	2.293	4.207	5.763	9.044	15.462
2002	0.117	0.362	0.921	2.132	4.094	5.832	8.957	18.11
2003	0.071	0.252	0.999	2.088	4.389	5.812	9.719	13.378
2004	0.077	0.135	0.965	2.23	4.016	5.977	9.604	12.586
2005	0.062	0.265	0.953	2.206	3.96	6.053	9.38	13.831
2006	0.07	0.231	1.053	2.243	3.706	5.872	8.693	11.945
2007	0.071	0.295	1.046	2.161	4.251	5.73	9.502	13.116
2008	0.087	0.195	1.002	2.194	3.951	6.063	9.374	13.683
2009	0.085	0.231	0.943	2.064	4.202	5.92	9.134	11.685
2010	0.078	0.233	0.942	2.201	3.973	6.101	9.085	11.715
2011	0.086	0.201	1.079	2.179	3.999	5.966	8.702	12.862
2012	0.084	0.259	0.972	2.289	3.914	6.187	8.813	14.625
2013	0.091	0.243	1.007	2.164	3.993	6.013	9.41	12.981
2014	0.04	0.31	0.983	2.193	4.015	6.095	9.58	11.917
2015	0.096	0.319	0.906	2.109	3.936	6.006	9.257	12.422

2016	0.083	0.337	0.962	2.189	4.06	5.945	9.281	12.218
2017	0.086	0.278	0.981	2.201	3.838	6.199	9.555	12.573
2018	0.091	0.247	0.879	2.287	3.945	5.822	9.159	14.035
2019	0.1	0.3	0.928	2.194	4.052	5.802	9.476	12.538
2020	0.095	0.309	0.964	2.278	4.043	5.795	8.975	11.623
stock.wt	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1986	0.012	0.197	0.702	1.784	3.394	5.45	7.845	12.463
1987	0.012	0.222	0.643	1.788	3.397	5.459	7.78	12.249
1988	0.012	0.248	0.589	1.789	3.412	5.452	7.853	11.642
1989	0.012	0.186	0.748	1.719	3.436	5.36	7.877	11.417
1990	0.012	0.203	0.661	1.801	3.4	5.452	7.836	13.013
1991	0.012	0.189	0.701	1.736	3.428	5.447	7.845	11.922
1992	0.012	0.227	0.647	1.751	3.444	5.441	7.845	11.092
1993	0.012	0.122	0.679	1.736	3.448	5.385	7.862	11.437
1994	0.012	0.253	0.711	1.736	3.424	5.385	7.877	12.131
1995	0.012	0.221	0.769	1.725	3.455	5.362	7.877	13.992
1996	0.012	0.26	0.618	1.777	3.43	5.449	7.813	11.35
1997	0.012	0.199	0.752	1.732	3.424	5.443	7.852	11.288
1998	0.012	0.187	0.73	1.739	3.433	5.449	7.849	10.743
1999	0.012	0.199	0.694	1.8	3.364	5.48	7.848	11.181
2000	0.012	0.217	0.691	1.736	3.423	5.455	7.831	11.564
2001	0.012	0.219	0.708	1.733	3.438	5.366	7.877	14.726
2002	0.012	0.2	0.609	1.718	3.438	5.264	7.877	15.446
2003	0.012	0.132	0.738	1.648	3.497	5.181	7.877	12.225
2004	0.012	0.094	0.721	1.727	3.411	5.411	7.877	11.618
2005	0.014	0.129	0.608	1.769	3.41	5.441	7.877	12.648
2006	0.007	0.135	0.712	1.646	3.494	5.289	7.877	10.757
2007	0.013	0.145	0.689	1.745	3.442	5.337	7.877	11.986
2008	0.012	0.128	0.676	1.692	3.387	5.405	7.877	13.212
2009	0.012	0.117	0.695	1.668	3.444	5.378	7.997	10.993
2010	0.01	0.134	0.699	1.65	3.476	5.288	7.877	10.657
2011	0.012	0.114	0.786	1.694	3.431	5.338	7.877	11.844
2012	0.012	0.137	0.662	1.797	3.37	5.504	7.96	13.785
2013	0.015	0.136	0.649	1.731	3.392	5.456	7.877	12.278
2014	0.012	0.134	0.716	1.695	3.404	5.483	7.877	11.094
2015	0.012	0.162	0.654	1.68	3.418	5.447	7.877	11.61
2016	0.012	0.159	0.683	1.713	3.416	5.459	7.993	11.286
2017	0.012	0.149	0.69	1.708	3.419	5.494	7.877	11.88
2018	0.012	0.148	0.605	1.733	3.389	5.461	8.032	13.278
2019	0.012	0.182	0.563	1.74	3.424	5.416	7.877	11.841
2020	0.012	0.161	0.68	1.712	3.412	5.402	7.877	10.946
FR_IE_IBTS	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2003	0.871	1.126	1.03	0.507		0.1		
2004	3.944	0.647	0.745	0.981	0.129	0.145		
2005	0.739	1.922	0.762	0.554	0.284	0.05		0.023
2006	0.853	0.526	1.005	0.532	0.171	0.103		0.031
2007	0.533	0.322	0.365	0.818	0.291		0.073	
2008	2.035	0.402	0.353	0.514	0.478	0.086	0.046	0.007
2009	2.136	0.849	0.412	0.393	0.163	0.05	0.168	
2010	2.279	1.129	0.775	0.38	0.142	0.052	0.064	0.027
2011	1.45	1.853	1.069	0.559	0.107	0.11		0.066
2012	0.903	0.678	1.204	0.655	0.466	0.09		0.02
2013	0.724	0.877	0.719	0.817	0.454	0.011	0.107	

2014	3.281	0.788	0.629	0.402	0.265		0.065	
2015	1.335	1.925	0.342	0.496	0.059	0.11		0.054
2016	1.44	0.801	1.601	0.513	0.132	0.033		0.043
2017								
2018	3.883	0.983	0.53	0.674	0.192	0.168		0.052
2019	3.15	1.508	0.732	0.559	0.17	0.149		0.084
2020	1.55	1.329	0.91	0.472	0.219	0.022	0.009	0.04
IE_MONKSURVEY	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2006	6.63	7.951	8.249	4.318	2.669		0.811	
2007	2.714	4.614	3.948	11.913	4.631		2.252	
2008								
2009								
2010								
2011								
2012								
2013								
2014								
2015	28.72	34.967	4.313	12.264	4.496	4.072	0.525	0.367
2016	9.883	18.559	17.502	15.179	9.693	1.464	0.783	1.306
2017	23.624	9.784	3.306	12.334	7.334		1.957	
2018	12.965	6.036	8.065	17.438	5.717	0.996	1.724	
2019	7.772	11.085	7.385	7.53	4.614	0.707	2.538	
2020	23.322	13.801	7.876	3.967	4.675	2.128		0.094
SP-PGFS	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2001	2.933	0.228	0.254	0.567	0.608	0.064	0.016	0.049
2002	0.45	0.82	0.085	0.705	0.557		0.058	0.004
2003	1.077	0.597	0.655	0.754	0.8	0.077	0.145	0.069
2004	1.153	0.42	0.424	1.831	1.648		0.201	
2005	0.198	0.452	0.032	1.543	0.803		0.028	0.022
2006	0.027	0.15	0.205	1.5	1.326		0.136	
2007	0.099	0.008	0.135	1.104	1.38	0.13	0.147	
2008	0.076	0.09		0.624	1.355		0.324	0.004
2009	0.323	0.181	0.105	0.251	1.578	0.098	0.411	
2010	1.135	0.329	0.244	0.369	0.607	0.462	0.04	0.16
2011	0.179	0.576	0.183	0.883	0.365		0.071	0.18
2012	0.14	0.221	0.578	1.101	1.128	0.19	0.072	
2013	0.266	0.183	0.145	2.34	1.471	0.229	0.301	
2014	1.57	0.124	0.46	1.219	2.151	0.138	0.439	
2015	0.036	0.466	0.347	1.855	1.286	0.798		0.217
2016	0.254	0.303	0.509	2.144	1.525	0.067	0.023	0.358
2017	0.655	0.361	0.412	2.816	0.671	0.909		0.182
2018	0.559	0.371	0.132	1.158	1.701		0.207	0.169
2019	0.686	0.13	0.316	0.743	1.465	0.34	0.38	
2020	0.299	0.116	0.344	0.794	1.047	0.353	0.227	0.167

Table 3.2.2. *Lophius piscatorius* in 27.78abd. Summary of the assessment. Landings, discards, catch and estimated catch in tonnes. Total-stock biomass in kilotonnes, recruitment in millions. CV is the relative standard error.

Year	Lan	Dis	Cat	CatEst	Tsb	Ssb	SsbCv	Recr	RecrCv	Fbar	FbarCv
1986	24981	1861.375598	26842.3756	22932.38269	92.91198067	51.09325925	0.331933905	40.23587264	0.138344877	0.2804485	0.228060785
1987	23091	1720.548574	24811.54857	23115.87421	96.02187846	60.05490221	0.317287294	30.12545047	0.141697266	0.2962845	0.227370571
1988	21314	1588.141367	22902.14137	23988.64415	93.30874108	59.307149	0.321735473	22.00484233	0.141859465	0.3248335	0.215636925
1989	24015	1789.397341	25804.39734	25510.95794	91.04427828	52.59364089	0.338586955	8.786219187	0.141474902	0.36209225	0.228687509
1990	20982	1563.403498	22545.4035	23973.82732	87.59528043	47.28489551	0.371226027	17.40164989	0.139579577	0.35970225	0.225044962
1991	16763	1249.038835	18012.03884	20811.24896	75.21446905	46.95026213	0.34699849	37.08659584	0.133878778	0.33990575	0.23677936
1992	13617	1014.625176	14631.62518	14276.68492	68.0699918	43.09650577	0.353655541	29.91536277	0.13476185	0.25213675	0.234206922
1993	14895	1109.851068	16004.85107	15596.25553	71.13028345	43.91816829	0.352618012	33.59791672	0.134128846	0.25609625	0.212967142
1994	17201	1281.674939	18482.67494	23055.90512	84.08553902	39.50772728	0.366612731	29.95972972	0.134789971	0.33593125	0.203463956
1995	21033	1567.203592	22600.20359	26434.24302	90.82805543	40.37015246	0.362972255	15.95210298	0.137126654	0.3509665	0.200040961
1996	23333	1738.580394	25071.58039	25920.24041	81.62413032	40.55905104	0.303383074	17.69493776	0.137647712	0.3661135	0.197823322
1997	22983	1712.501315	24695.50132	26512.01895	76.35063532	40.79035896	0.300400894	18.837411	0.13598092	0.43484825	0.189164466
1998	20474	1525.551579	21999.55158	21453.63698	65.60415825	39.17338841	0.30170461	37.00892941	0.135978588	0.41126375	0.189979984
1999	18792	1400.222979	20192.22298	23388.2119	60.61528229	36.94482562	0.311586416	24.49618736	0.131141802	0.5016745	0.192764612
2000	14451	1076.767894	15527.76789	14901.23573	54.90597205	28.63853883	0.355628862	42.95332407	0.131405575	0.33562325	0.196414361
2001	17294	1288.604523	18582.60452	23501.67898	66.11857556	30.37137934	0.361849256	63.54657897	0.129670382	0.45464575	0.175363585
2002	22083.00977	1645.441556	23728.45133	25807.26501	68.32231723	26.12283756	0.364152408	41.51241756	0.128120331	0.44947625	0.172605226
2003	27933.46309	2510.817171	30444.28026	29817.63698	70.49641709	24.33665269	0.299681324	49.09411774	0.101206766	0.506068	0.16274016
2004	29028.00126	2410.556223	31438.55748	33276.28362	71.24656482	21.42969914	0.297572016	66.1884998	0.106851385	0.58944025	0.16148755
2005	27869.35939	2110.338056	29979.69745	28939.09192	69.51687347	23.1827284	0.294498088	28.80987817	0.098117944	0.4796245	0.186368856
2006	27652.49326	892.2528058	28544.74607	23033.3898	71.85244824	26.04280759	0.269842612	22.37880621	0.098502532	0.35449125	0.191778272
2007	31213.04686	816.3189681	32029.36583	27767.92387	80.29959928	29.58225919	0.277874494	28.53882231	0.099546813	0.400837	0.1786927
2008	27052.92671	993.0674397	28045.99415	27373.53472	80.109602	35.90409659	0.275546586	45.646796	0.101023505	0.41759	0.180077999
2009	21835.08873	2077.856726	23912.94546	25431.54875	73.02813856	41.24468048	0.260583509	49.7944748	0.10301779	0.423781	0.183409132
2010	22214.8459	2671.610317	24886.45622	24085.11104	72.6900707	36.11241472	0.294393845	56.94415544	0.103441335	0.41952125	0.187320091
2011	24657.2995	1831.627297	26488.9268	24536.95375	81.57656452	34.05049014	0.323667132	33.19657542	0.101081376	0.36936375	0.182382271
2012	28188.30083	2330.437647	30518.73848	31131.27928	92.51961589	35.83898336	0.324335034	44.8887716	0.099608765	0.40564225	0.189669966

Year	Lan	Dis	Cat	CatEst	Tsb	Ssb	SsbCv	Recr	RecrCv	Fbar	FbarCv
2013	30610.84745	1684.481731	32295.32918	28785.46007	91.61443067	36.5688335	0.299277014	38.1315977	0.102562815	0.36019425	0.211867005
2014	28474.47624	1858.624016	30333.10026	30929.33242	94.87847133	40.92842415	0.285977224	53.35373329	0.109293835	0.377076	0.201153086
2015	27858.77952	2324.197026	30182.97655	28853.43887	97.52928101	49.27661751	0.286483468	30.61038027	0.108640917	0.34837175	0.205932017
2016	29082.58175	3585.107215	32667.68897	29591.44361	101.7897246	47.62363197	0.305905434	26.30610651	0.118878912	0.3529085	0.225129975
2017	25633.57728	2174.834674	27808.41195	30014.90288	103.8070334	52.78169262	0.311511736	39.68414971	0.135705569	0.352439	0.224286241
2018	22344.81308	1249.805086	23594.61817	24171.97922	102.9236713	54.93541689	0.331511732	51.60750062	0.151217913	0.28936325	0.24364582
2019	21266.21357	1443.739683	22709.95325	21574.07403	104.639306	60.87096918	0.322087703	43.83299352	0.198421074	0.24074825	0.258813556
2020	20155.77051	1334.996028	21490.76654	22722.87941	115.2108823	59.80658679	0.330450181	48.51938613	0.294110797	0.23311875	0.256224286

*** Discards before 2003 were estimated from the proportion of the catch that was discarded over the period 2003–2020.**

Table 3.2.3. *Lophius piscatorius* in 27.78abd. Catch options: Catch, landings and discards in 2021 (tonnes). F of the catch, landings and discards (tonnes) in 2021, SSB in 2023 (kilotonnes). dSSB, dLand and dCatch are the change in SSB, landings and catch with the previous year (%).

Basis21	Catch21	Land21	Dis	FCatch21	FLand21	FDis21	SSB22	dSSB	dLand	dCatch	dadv21
FMSY	34275	32953	1322	0.28000	0.27972	0.00028	82203	15.82	52.79	50.40	-0.88
FMSYlower	23162	22277	885	0.18100	0.18082	0.00018	89903	26.67	3.29	1.64	-33.02
FMSYupper	45491	43720	1771	0.39000	0.38961	0.00039	74500	4.97	102.72	99.62	31.56
F = Fsq	31499	30287	1212	0.25441	0.25416	0.00026	84120	18.53	40.43	38.23	-8.91
F = 0	0	0	0	0.00000	NaN	NaN	106148	49.56	-100.00	-100.00	-100.00
F = 0.181	23162	22277	885	0.18100	0.18082	0.00018	89903	26.67	3.29	1.64	-33.02
F = 0.18	23045	22164	881	0.18000	0.17982	0.00018	89985	26.79	2.77	1.13	-33.36
F = 0.19	24215	23289	926	0.19000	0.18981	0.00019	89171	25.64	7.98	6.26	-29.97
F = 0.2	25375	24403	971	0.20000	0.19980	0.00020	88365	24.51	13.15	11.35	-26.62
F = 0.21	26524	25507	1016	0.21000	0.20979	0.00021	87567	23.38	18.27	16.39	-23.29
F = 0.22	27662	26601	1061	0.22000	0.21978	0.00022	86778	22.27	23.34	21.39	-20.00
F = 0.23	28790	27684	1105	0.23000	0.22977	0.00023	85996	21.17	28.36	26.33	-16.74
F = 0.24	29907	28758	1149	0.24000	0.23976	0.00024	85222	20.08	33.34	31.24	-13.51
F = 0.25	31014	29821	1193	0.25000	0.24975	0.00025	84456	19.00	38.27	36.10	-10.31
F = 0.26	32111	30875	1236	0.26000	0.25974	0.00026	83697	17.93	43.16	40.91	-7.14
F = 0.27	33198	31919	1279	0.27000	0.26973	0.00027	82947	16.87	48.00	45.68	-3.99
F = 0.28	34275	32953	1322	0.28000	0.27972	0.00028	82203	15.82	52.79	50.40	-0.88
F = 0.29	35342	33978	1364	0.29000	0.28971	0.00029	81467	14.79	57.55	55.09	2.21
F = 0.3	36399	34993	1406	0.30000	0.29970	0.00030	80739	13.76	62.25	59.72	5.26
F = 0.31	37447	35999	1448	0.31000	0.30969	0.00031	80018	12.75	66.92	64.32	8.29
F = 0.32	38485	36996	1489	0.32000	0.31968	0.00032	79304	11.74	71.54	68.88	11.30
F = 0.33	39513	37983	1530	0.33000	0.32967	0.00033	78597	10.74	76.12	73.39	14.27
F = 0.34	40532	38961	1571	0.34000	0.33966	0.00034	77897	9.76	80.65	77.86	17.22
F = 0.35	41542	39931	1611	0.35000	0.34965	0.00035	77204	8.78	85.15	82.29	20.14
F = 0.36	42543	40891	1652	0.36000	0.35964	0.00036	76518	7.81	89.60	86.68	23.03
F = 0.37	43535	41843	1692	0.37000	0.36963	0.00037	75839	6.86	94.01	91.03	25.90
F = 0.38	44517	42786	1731	0.38000	0.37962	0.00038	75166	5.91	98.39	95.34	28.74
F = 0.39	45491	43720	1771	0.39000	0.38961	0.00039	74500	4.97	102.72	99.62	31.56

3.3 Black-bellied anglerfish (*L. budegassa*) in Subarea 7 and divisions 8.a–b and 8.d

Type of assessment

Category 3 assessment using survey trends (ICES, 2012; ICES, 2021a).

Feedback from ADG, WC and audit

ADG: No specific issues raised that require further response.
WC: For mixed-species TAC the proportion of each species in the catches should be indicated in Table 3. Response WGBIE21: This proportion can be calculated from Table 3 but a sentence has been added to the "Issues relevant to the advice" section specifying the proportion of *L. budegassa* in the landings. No other issues were raised that require a further response.
EG Audit 2020: No specific issues raised.

3.3.1 Data

3.3.1.1 Catch numbers at length

No updated catch data were submitted for 2019.

The number of samples taken in 2020 was reduced for a number of strata due to the effects of COVID-19. WGBIE decided to retain data resulting from low sample numbers as none of the poorly sampled strata contributed more than 3% of the catch. The Stock Annex describes the methods for filling in unsampled landings and discards. Figure 3.3.1 shows that about 1/2 of the landings had length data associated with them while in most other years this figure is closer to 2/3. About half of the discards were unsampled and had to be estimated from the discard rate of the sampled catches. The discard rates of some of the fleets were very different from recently observed values (Figure 3.3.1a). WGBIE concluded that this was due to reduced sampling levels under COVID-19 conditions. Normally discard rates (proportion of the catchweight that was discarded) are used to fill in strata with missing discard data. This year, the discard rates of the French OTB_DEF fleet, the Irish OTB_DEF and OTB_CRU fleets and the UK TBB_DEF fleet were replaced with the average discard rates of those fleets from 2015–2019 (for the purpose of filling in unsampled discards only). Overall, discard rates are relatively low so this affects only a small proportion of the total catch weight.

Figures 3.3.2a shows the annual length–frequency distribution of the catch data both before and after allocating length data to unsampled catches. Figure 3.3.2b shows the quarterly length–frequency distributions and shows that there is limited cohort tracking in the length data.

Figure 3.3.3 shows the length distribution of the catches in terms of abundance and biomass. Catch numbers are generally highest at size classes 10–20 cm. The highest biomass in the catches is around 50–60 cm. Note that the females mature around 65 cm.

3.3.1.2 Discards

Discarding occurs nearly exclusively in the smaller length classes (Figure 3.3.2a). In the last three years, the average discard rate was 9% (in weight).

3.3.1.3 Surveys

The surveys are described in detail in the Stock Annex and section 2 of the report.

The combined IE-IGFS (IGFS-WIBTS-Q4, G7212) and FR-EVHOE (EVHOE-WIBTS-Q4, G9527) survey biomass index is used as the basis of the advice.

Figure 3.3.4a shows the spatial distribution of the catches of recruits on the FR_IE_IBTS surveys, combined Irish IBTS Q4 groundfish survey (IGFS-WIBTS-Q4, G7212) and French EVHOE-WIBTS-Q4 (G9527) survey. Recruitment generally occurs in the western Celtic Sea and in some years in Biscay. In 2020 there were widespread large numbers of recruits in the Biscay area. 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 3.3.5a shows the biomass and recruitment indices of the two surveys as well as the combined index. The combined survey biomass index is more stable than the single survey indices but the uncertainty around the index is still considerable. Both surveys recorded high biomass in the last 3 years. Both surveys agree on a very strong 2013 recruitment. However, this cohort was not obvious in the length distributions of the following years in the surveys or catches. In 2020, recruitment in the EVHOE-WIBTS-Q4 (G9527) survey area was the highest on record; the IGFS-WIBTS-Q4 (G7212) survey also saw reasonably high recruitment but on a much smaller scale than the EVHOE-WIBTS-Q4 (G9527) survey.

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. 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 are provided in Working Document (WD) 01 (Gerritsen and Minto, 2019) to WGBIE 2019 (ICES, 2019).

3.3.1.4 Advice rule

Table 3.3.1 provides the index values. The 3-over-2 ratio (mean biomass index in the most recent 2 years and the preceding 3 years) is 1.36. This will result in a 20% increase in advice after applying the uncertainty cap. The precautionary buffer was applied in 2018 and therefore does not have to be considered again this year.

3.3.2 Deviations from the Stock Annex

There were two deviations from the Stock Annex:

- The 2017 survey SSB index value was modelled using a spatio-temporal model to account for a large gap in survey coverage. This approach was accepted by WGBIE (ICES, 2019) and ACOM in 2019.
- The discard rates of some of the fleets were very different from recently observed values and these were replaced with the average values from 2015–2019.

3.3.3 Biological reference points

3.3.3.1 Length-based indicators

Length-based indicators were explored for this stock. Most of the indicators were well below the reference level set out by WKLIFE V (ICES, 2015). However, recent work Kell *et al.* (in prep) testing these indicators using Management Strategy Evaluations, has indicated that the reference levels need to be tuned to the life-history characteristics of the stock in order to be robust.

However, Kell *et al*. (in prep) found that trends in many length-based indicators can accurately describe trends in exploitation and stock development. Therefore, the length-based indicators are presented as trends in Figure 3.3.6. Most of the indicators show increasing trends in recent years. The exceptions are the indicators relating to immature fish; it is likely that these are driven by variation in recruitment, rather than describing actual changes in the stock structure. The overall conclusion is that there are relatively more large fish in the recent catches, which suggest that fishing mortality is decreasing.

3.3.3.2 F/F_{MSY} proxy

The mean-length Z method was applied to the catch data for the period 2003–2020 with the following life-history parameters:

Parameter	Value
L_{inf}	175
K	0.078
T_0	0
M	0.3
a	0.0195
b	2.93
maxage	10
L_c	36

F_{01} = 0.23 was estimated in an equilibrium yield-per-recruit analysis, using the parameters listed above (Figure 3.3.7).

The Mean Length Z analysis was then performed using the mlen_effort() function in the code from https://github.com/ices-tools-dev/ICES_MSY. A proxy of fishing effort was obtained by dividing the commercial catches of *L. budegassa* by the biomass index of the survey. WGBIE considered this to be an appropriate proxy for fishing effort. Figure 3.3.8 shows the outputs of the mean-length Z analysis. The trend in F is declining and F < F_{MSY} proxy in recent years. A number of sensitivity runs were performed with high and slow growth, estimated (rather than fixed) M and L_c = 16 and L_c = 25. Each of these runs resulted in F<$F_{0.1}$ in the last few years.

3.3.4 Quality of the assessment

Due to reductions in sampling levels, the precision of the catch length data are assumed to be reduced somewhat. Catch data are not used directly in providing the catch advice (this is based on survey data). However, the catch length data are used in the Mean Length Z method to estimate the stock status relative to the F_{MSY} proxy reference point. The 2020 estimate of F/F_{MSY} proxy is very close to the estimates of the previous two years so there is no particular concern regarding the quality of the 2020 catch length data.

The combined IE-IGFS (IGFS-WIBTS-Q4, G7212) and FR-EVHOE (EVHOE-WIBTS-Q4, G9527) surveys cover a large part of the stock distribution and most of the depth range of the stock (< 500 m). However, the catch rates are low, leading to some uncertainty around the index. These two surveys sometimes display conflicting signals and the combined index is expected to provide a more robust basis for the advice than the individual indices.

3.3.4.1 Other indicators

There are a number of other indicators of stock size:

- The Irish Anglerfish and Megrim Survey (IE-IAMS, G3098) covers the majority of the stock area in Subarea 27.7. Figure 3.3.9 indicates a large increase in biomass between 2006–2007 and 2016 but since then the biomass in the survey area appears to have decreased somewhat or possibly stabilized but there does not appear to be an increase in recent years. It should be noted that the IE-IGFS (IGFS-WIBTS-Q4, G7212) survey (which has similar spatial coverage) shows a similar pattern, so this may indicate that the biomass of the stock in the Biscay area is increasing while the biomass in the Celtic Sea is stagnating or decreasing.
- The two species of anglerfish largely overlap in distribution and are often caught together. The assessment for white anglerfish in 27.78abd indicates a reduction in effort and increase in SSB in the last 15 years. The proportion of the two species in the catches has remained relatively constant (Figure 3.1.2) this suggests that the black anglerfish stock in 27.78abd has followed a similar development over time.

Overall, nearly all indicators suggest that the stock size is at a high level. However, there are some indications that the stock size is no longer increasing in Subarea 27.7.

3.3.5 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.

3.3.6 Recommendations for the next benchmark

The last benchmark, WKANGLER (ICES, 2018) could not agree on an analytical assessment for this stock. The stock was included in the Workshop on Tools and Development of Stock Assessment Models using a4a and Stock Synthesis (WKTaDSA; ICES, 2021b) with the purpose of developing a base case Stock Synthesis (SS; Methot and Wetzel, 2013) model to bring to the next benchmark which is planned for 2021–2022. The progress that was made during and after WKTaDSA (ICES, 2021b) was presented to WGBIE. The working group agreed that the current SS model has been developed to a stage where it is close to a base case to present to the benchmark workshop.

Roadmap of work in preparation for the next benchmark

- April 2021: ACOM agreed to include this stock in the benchmark process for 2021–2022.
- 2021: Further model development: Further model settings will be explored over the coming months (e.g. split the model into two areas (27.7 and 27.8abd); try to apply sex-specific growth (based on survey data).
- Late 2021: Data compilation: WKANGLER (2018a) compiled and formatted available data; it is unlikely that any new catch data will be available. Some progress may be made in developing improved estimation methods for the survey data (e.g. applying spatial-temporal models; sex separated indices)
- Early 2022: Benchmark workshop

Benchmark scoring

1. The assessment is judged to have high potential to be upgraded to cat1 (SS model in development; see roadmap below) (score: 4)

2. New methods will be available: SS model developed at WKTaDSA (score: 4)
3. Catch advice is requested by EC
    a) The stock managed under the multi-annual plan for Western Waters (WWMAP; EU, 2019)
    b) Most catches of anglerfish originate in directed fisheries
    c) The stock is not included in the mixed fisheries analysis for the Celtic Sea (score: 5)
4. The biomass is perceived to be near the highest on record (score: 1)
5. The stock was last benchmarked in 2018 in WKANGLER (ICES, 2018) (score: 2)

3.3.7 References

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

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3.3.8 Figures and tables

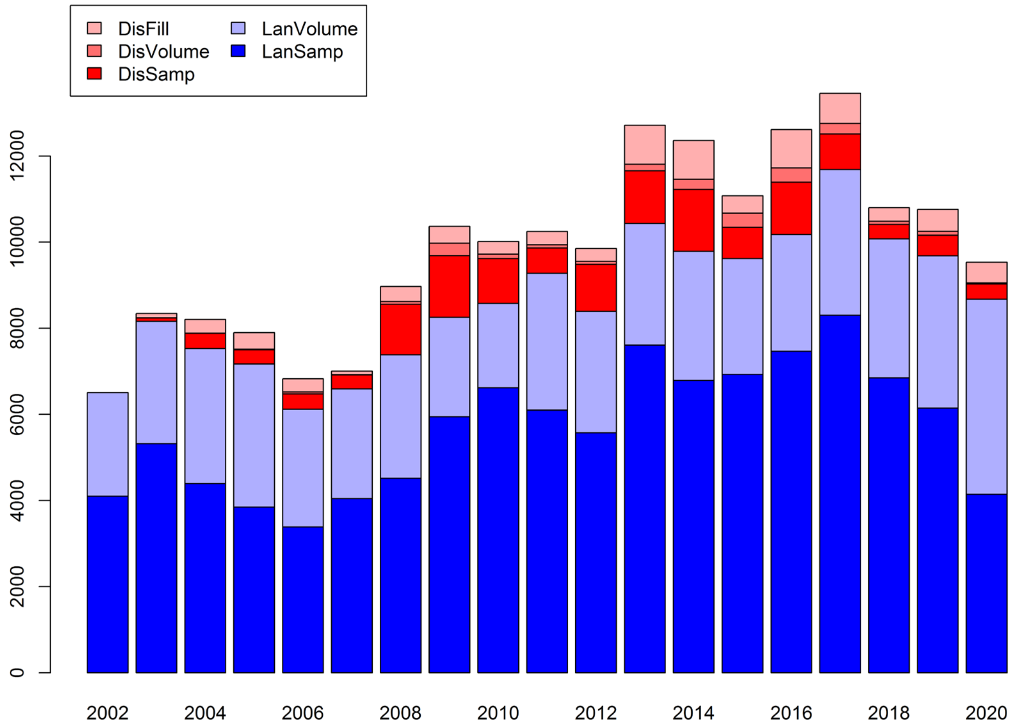

Figure 3.3.1. *Lophius budegassa* in 27.78abd. Allocations of unsampled landings and discards by year. Dark blue represents the sampled landings; light blue represents landings for which only the tonnage was available but no length data; Red represents the fully sampled discards (tonnage and length data); 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.

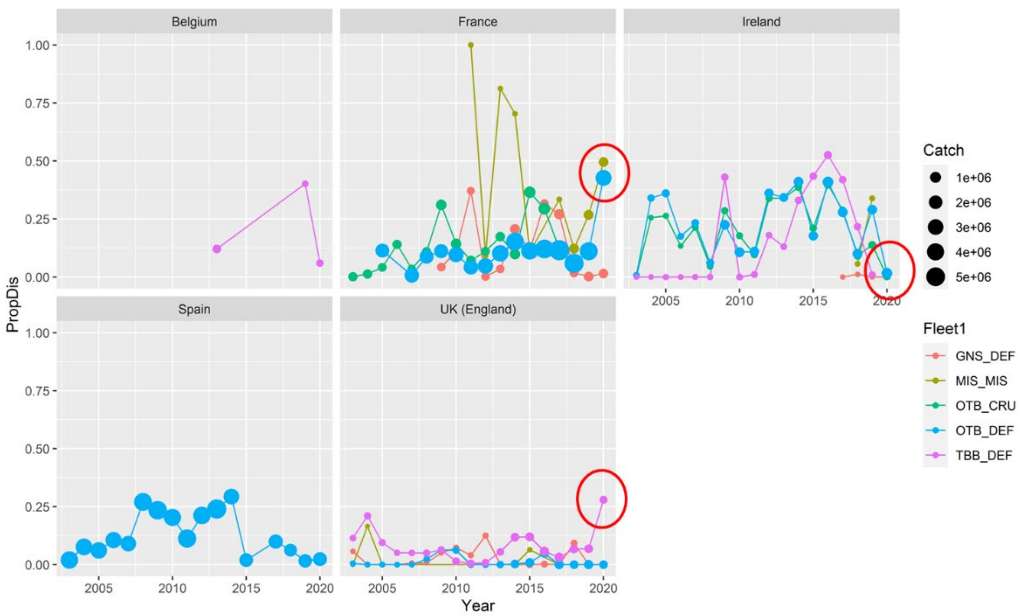

Figure 3.3.1a. *Lophius budegassa* in 27.78abd. Unsampled discards (i.e. métiers with landings without discard data) were filled in using available discard rates following the procedure described in the Stock Annex. However, the French OTB_DEF, UK TBB_DEF and Irish OTB_DEF and OTB_CRU proportions were very different from recently observed values and were replaced with the average values from 2015–2019.

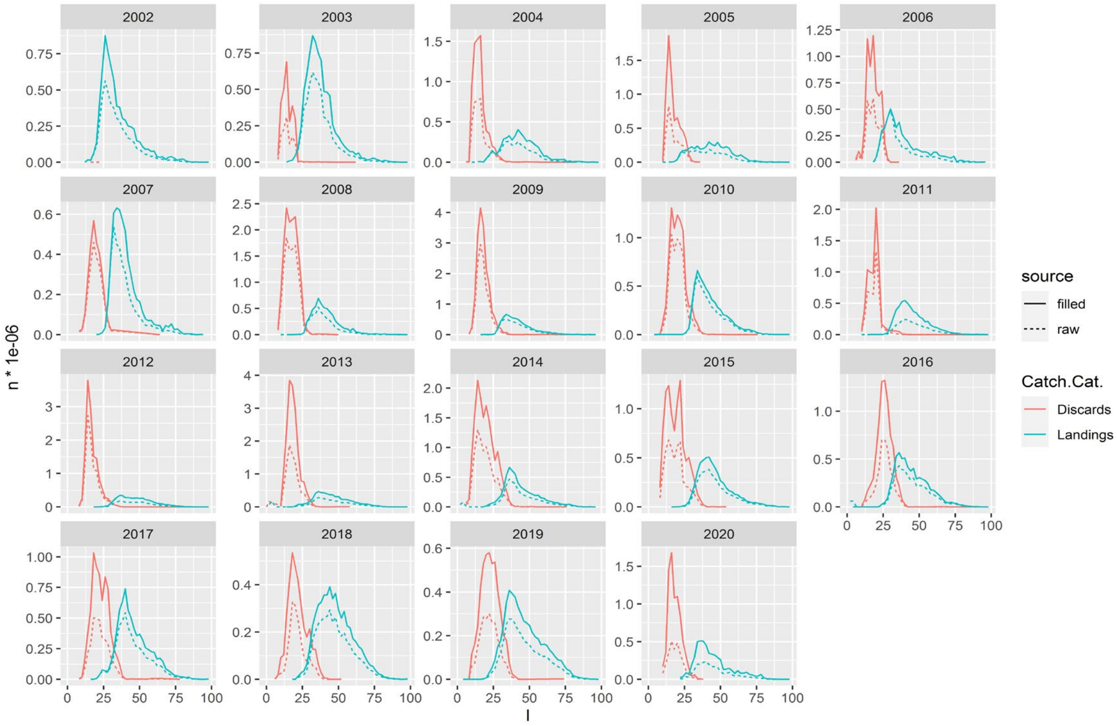

Figure 3.3.2a. ***Lophius budegassa*** **in 27.78abd. Annual length–frequency distributions of the landings (blue) and discards (red). The dotted lines show the sampled strata submitted to InterCatch; the solid lines are the estimates after allocations of unsampled catches. No discard data were available prior to 2003.**

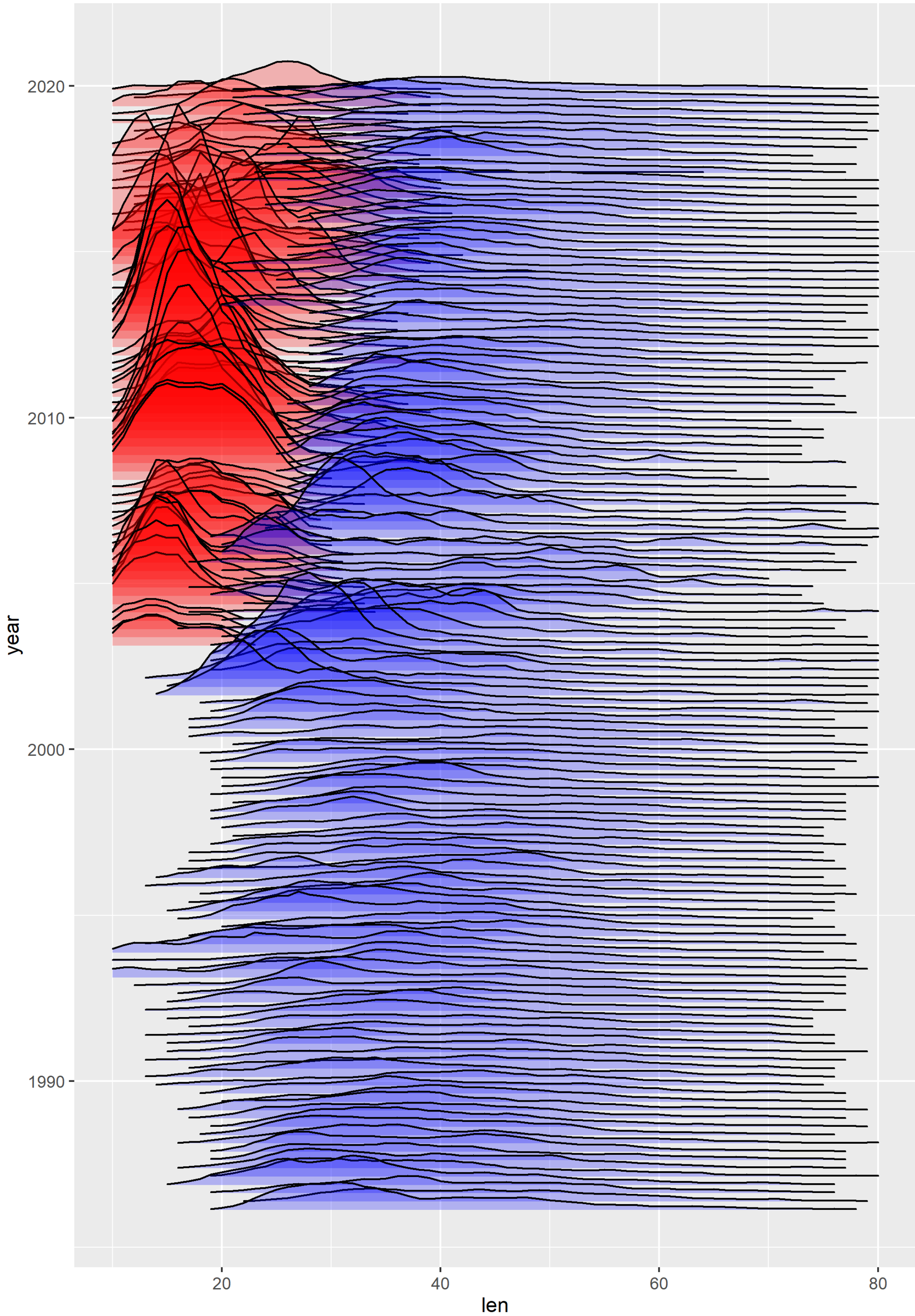

Figure 3.3.2b. ***Lophius budegassa*** **in 27.78abd. Quarterly raised length–frequency distributions of the landings (blue) and discards (red). No discard data were available prior to 2003.**

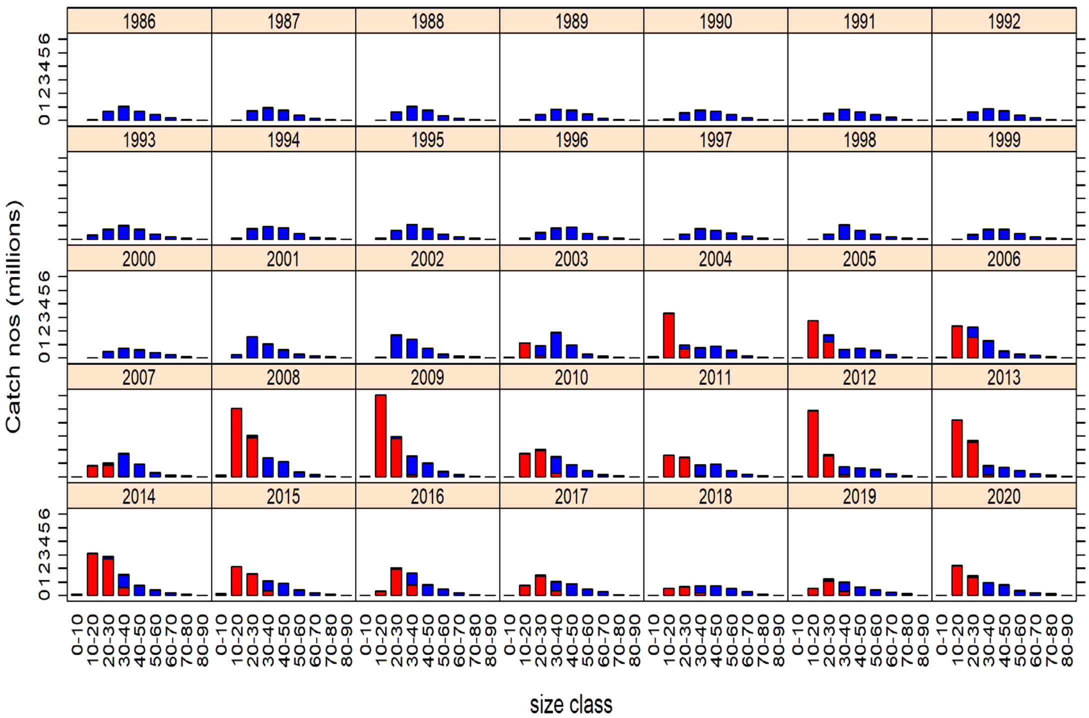

Figure 3.3.3a. ***Lophius budegassa*** **in 27.78abd. Length distributions of the catches (landings – blue, discards – red) by year in terms of abundance.**

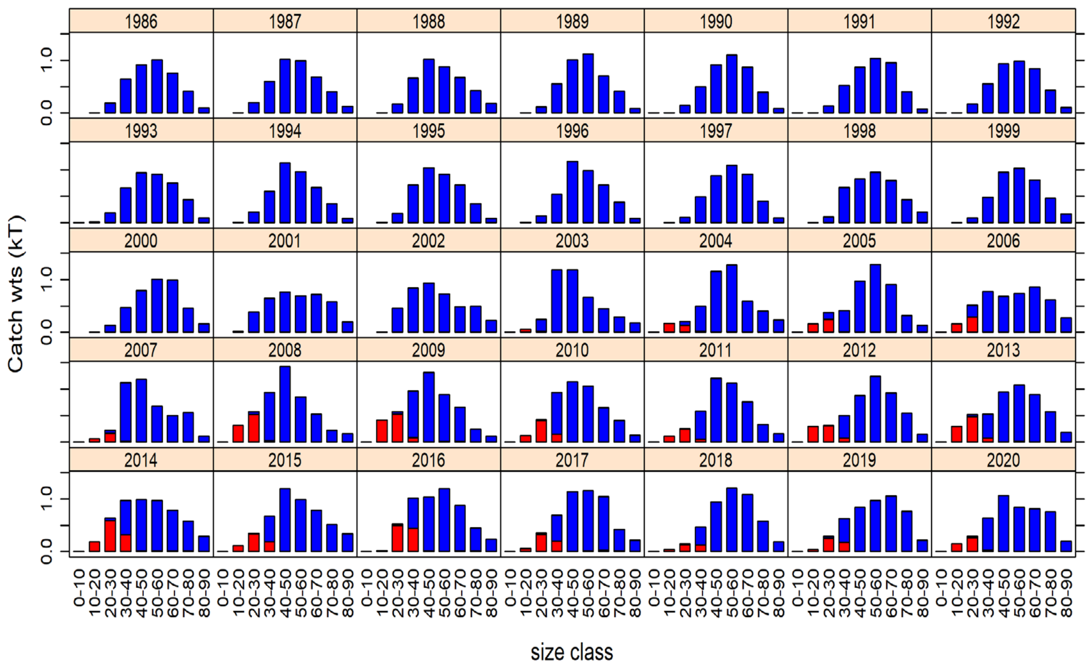

Figure 3.3.3b. ***Lophius budegassa*** **in 27.78abd. Length distributions of the catches (landings – blue, discards – red) by year in terms of biomass.**

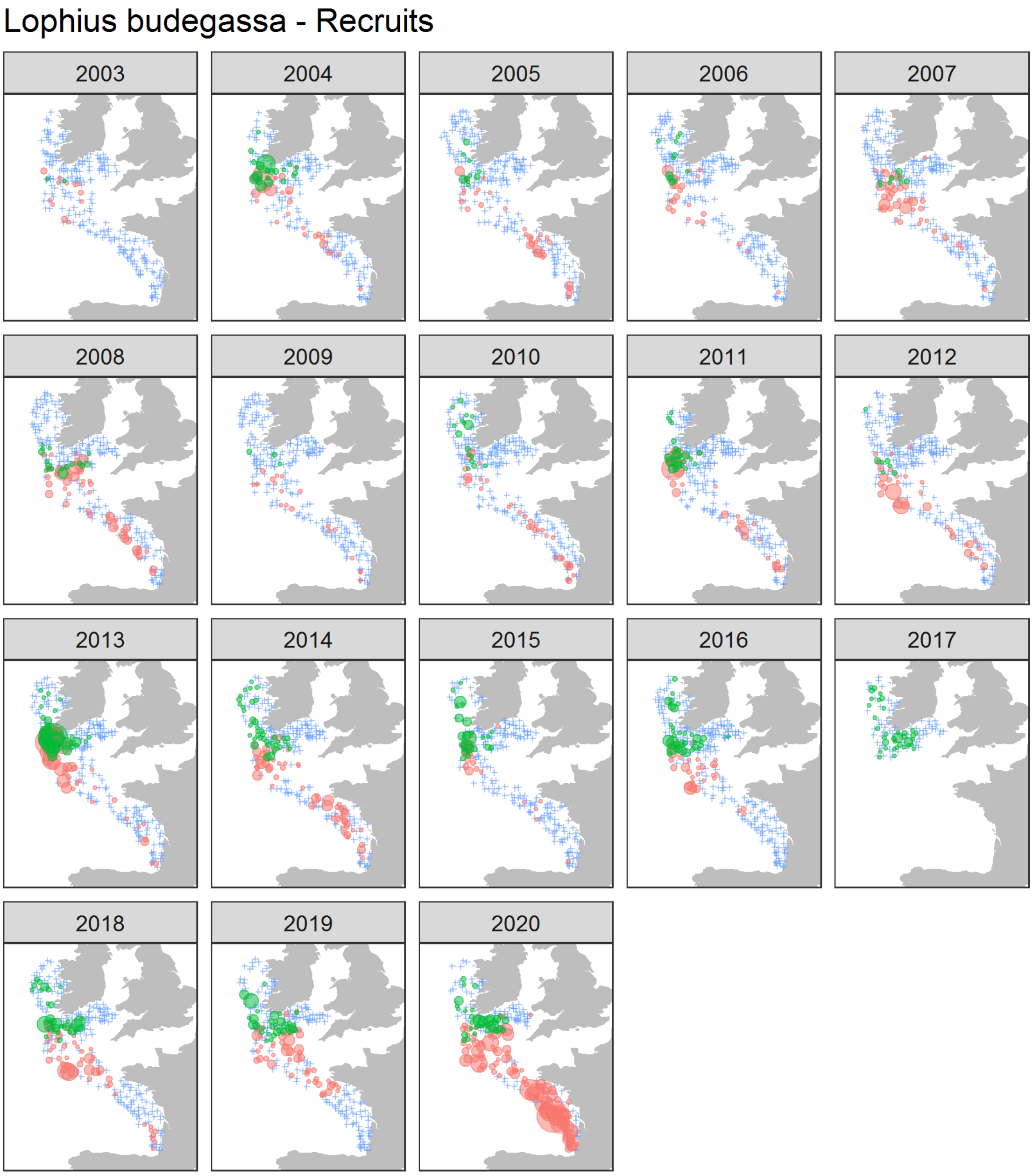

Figure 3.3.4a. *Lophius budegassa* in 27.78abd. Abundance of recruits on the IGFS-WIBTS-Q4 (G7212 in green) and EVHOE-WIBTS-Q4 (G9527 in red) surveys.

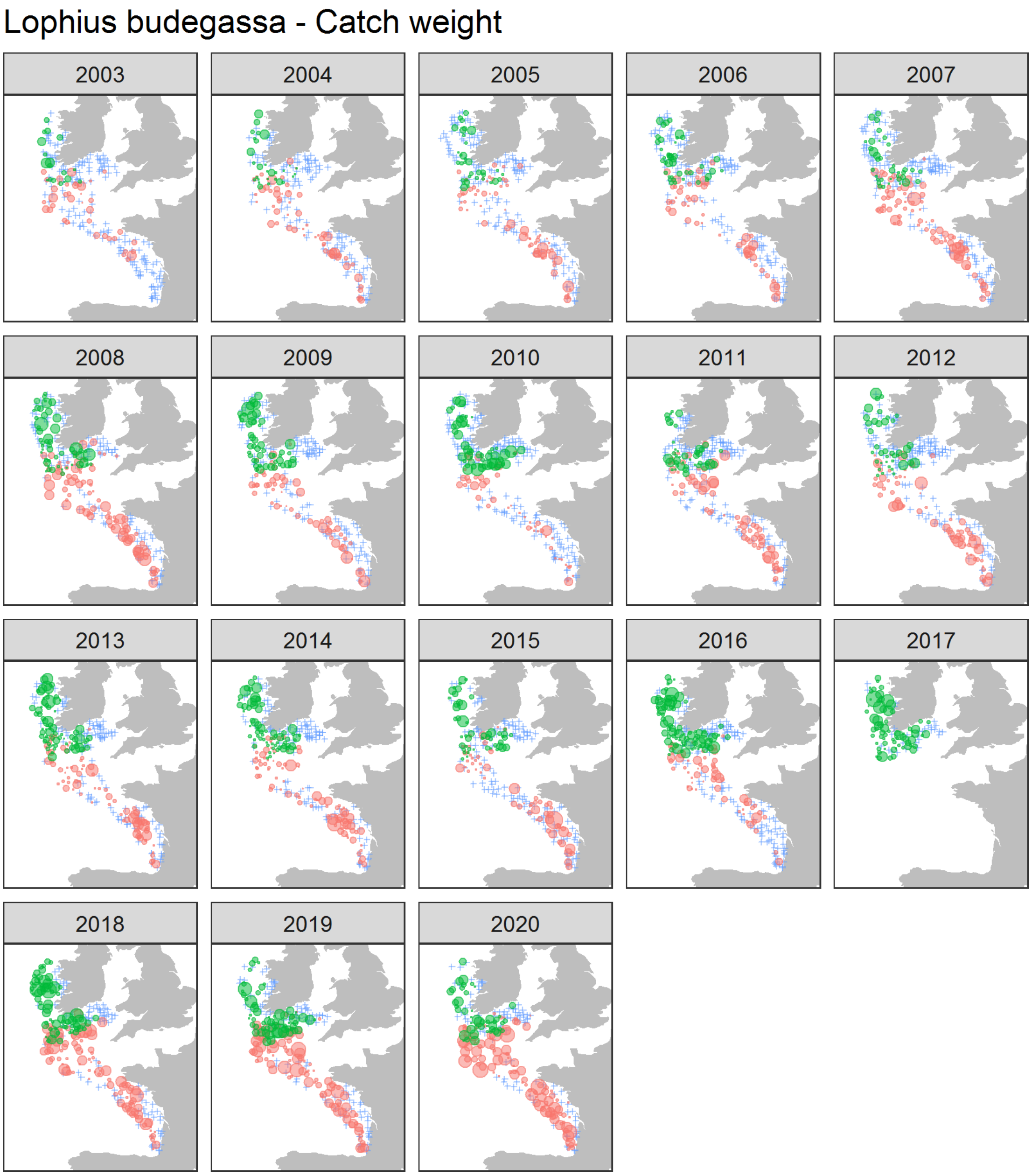

Figure 3.3.4b. ***Lophius budegassa*** **in 27.78abd. Catch weights on the IGFS-WIBTS-Q4 (G7212 in green) and EVHOE-WIBTS-Q4 (G9527 in red) surveys.**

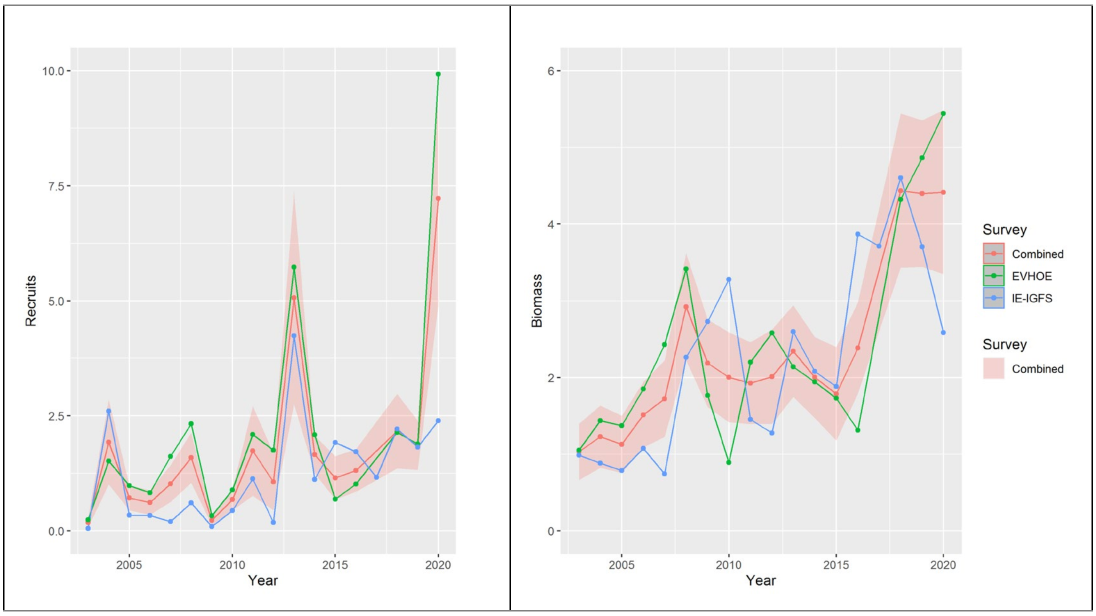

Figure 3.3.5a. ***Lophius budegassa*** **in 27.78abd. Survey trends in terms of biomass (left) and recruits (< 16 cm; right). The EVHOE-WIBTS-Q4 (G9527) index is shown in green, IGFS-WIBTS-Q4 (G7212) in blue and the combined FR_IE_IBTS survey index in red, all with 95% confidence intervals.**

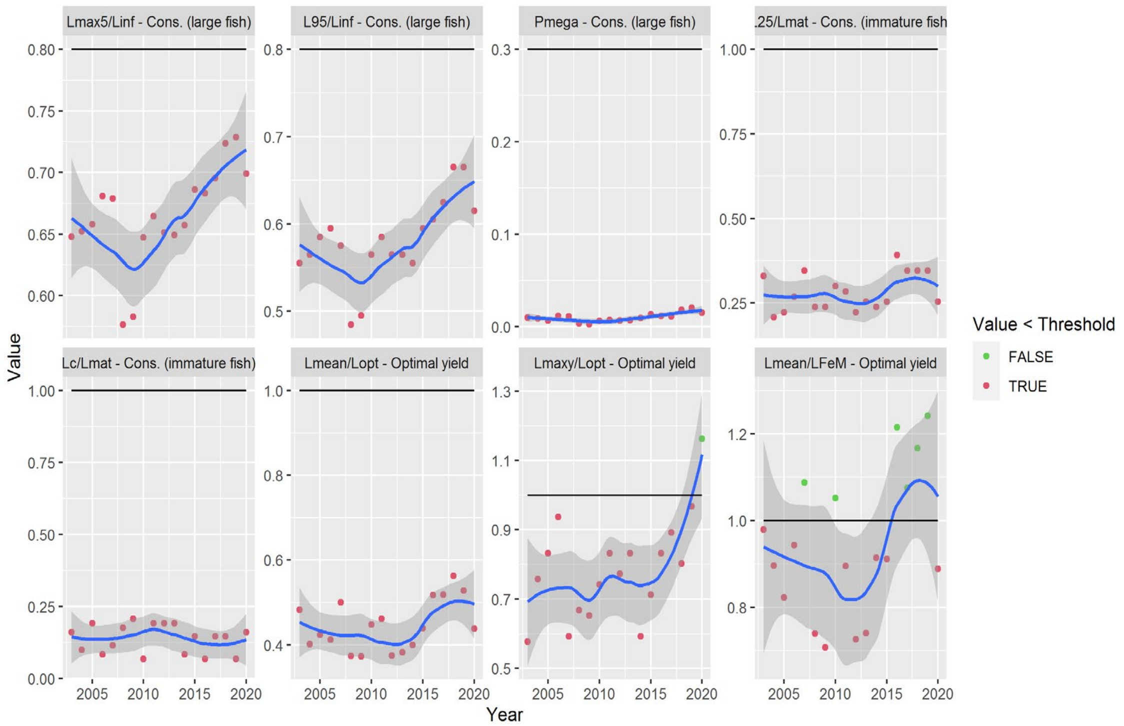

Figure 3.3.6. ***Lophius budegassa*** **in 27.78abd. Length-based indicators. Length-based indicators are presented for information only as WGBIE does not consider them appropriate to determining reference points. The horizontal black line indicates the reference value or threshold. Although most indicators are below the threshold, they are all showing positive trends.**

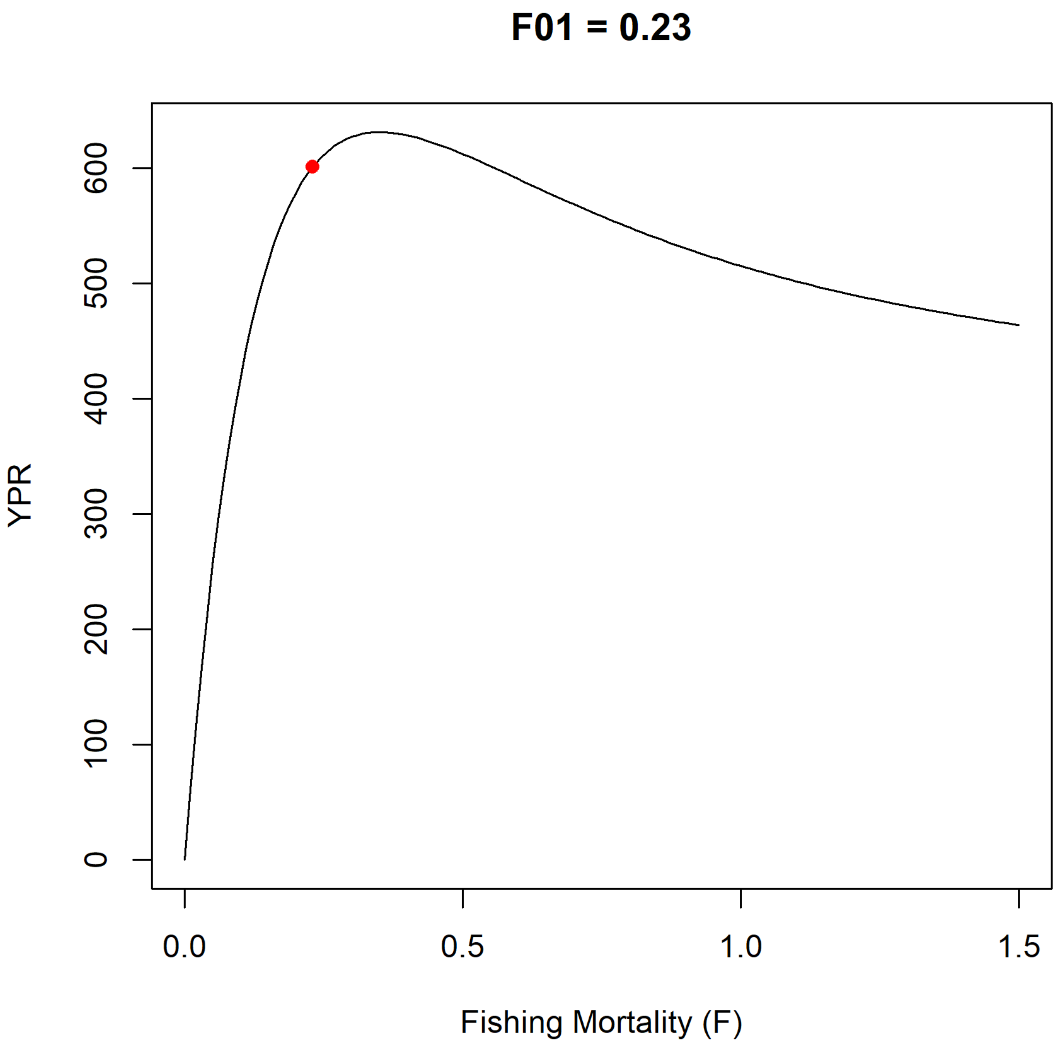

Figure 3.3.7. ***Lophius budegassa*** **in 27.78abd. YPR curve.** $\mathbf{F_{01}}$**.**

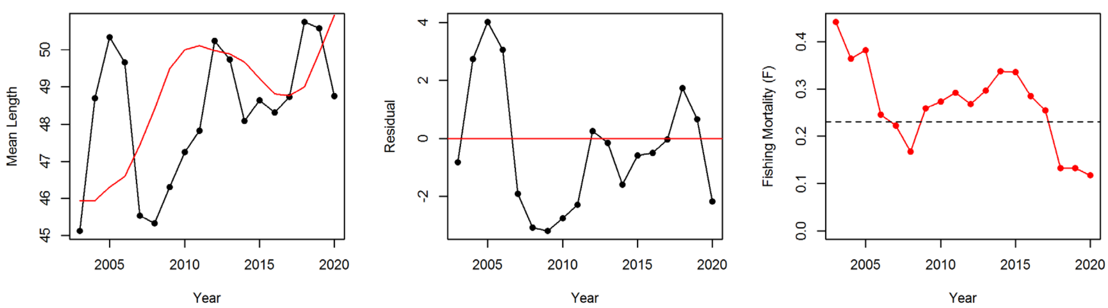

Figure 3.3.8. ***Lophius budegassa*** **in 27.78abd. Length-based Z (with effort) estimate of F (right), the dashed line is** $\mathbf{F_{01}}$**. The trend in fishing effort is based on the commercial catch of** ***L. budegassa*****, divided by the survey index of biomass.**

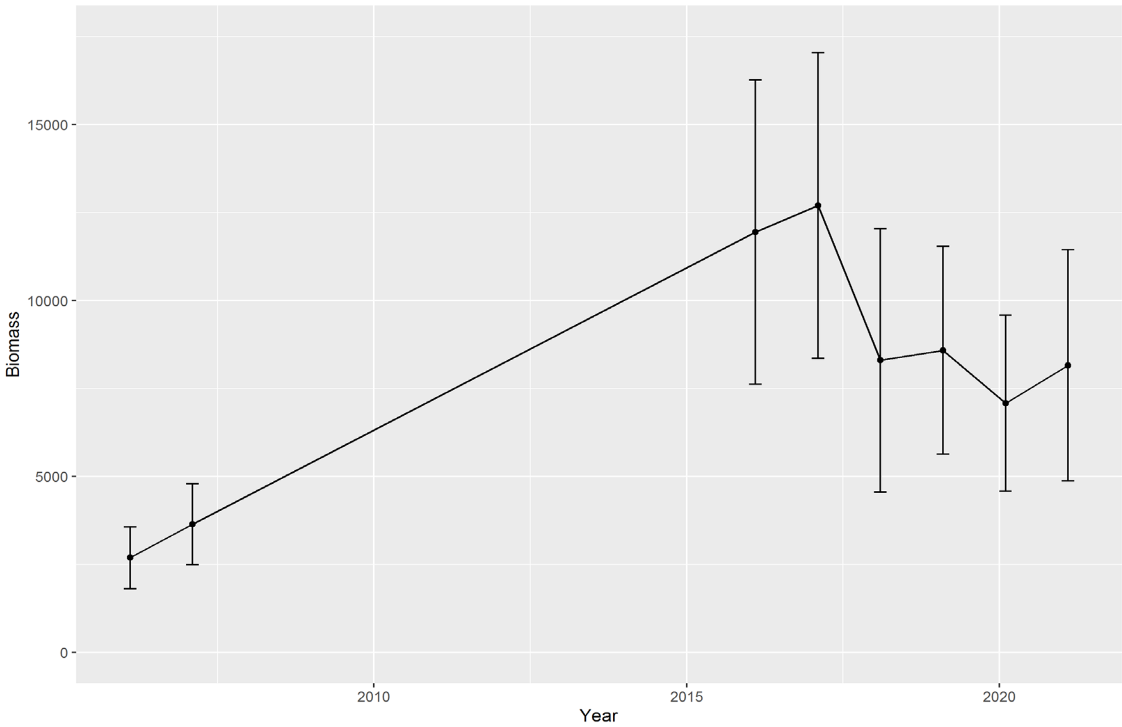

Figure 3.3.9. ***Lophius budegassa*** **in 27.78abd. IE-IAMS (G3098) survey biomass index (not used for the advice).**

Table 3.3.1. ***Lophius budegassa*** **in 27.78abd. Biomass and recruitment index for the individual surveys (EVHOE-WIBTS-Q4, G9527 and IGFS-WIBTS-Q4, G7212) and combined FR_IE_IBTS survey. Estimated values (Est) and 95% confidence limits (CiLo and CiHi). The average of the last 2 years and the preceding 3 years and its ratio are given at the bottom of the table. This is the basis for the catch advice.**

Year	Recruitment (nos < 16 cm / hr)			Biomass (kg / hr)			F/F_{MSY}
	Est	CiLo	CiHi	Est	CiLo	CiHi	
2003	0.18	0.07	0.29	1.03	0.66	1.40	1.92
2004	1.93	1.01	2.85	1.23	0.82	1.63	1.58
2005	0.72	0.44	0.99	1.13	0.76	1.50	1.66
2006	0.62	0.35	0.89	1.51	1.09	1.94	1.07
2007	1.02	0.63	1.42	1.72	1.22	2.22	0.97
2008	1.59	1.04	2.13	2.92	2.22	3.62	0.73
2009	0.22	0.13	0.32	2.19	1.62	2.76	1.13
2010	0.68	0.45	0.92	2.00	1.42	2.59	1.19
2011	1.74	0.76	2.72	1.93	1.39	2.46	1.27
2012	1.07	0.45	1.68	2.01	1.39	2.63	1.17
2013	5.06	2.75	7.37	2.34	1.75	2.94	1.29
2014	1.66	1.25	2.07	2.00	1.47	2.53	1.47
2015	1.16	0.69	1.64	1.80	1.19	2.42	1.46
2016	1.33	0.86	1.80	2.42	1.82	3.02	1.24
2017	0.84	0.60	1.17	2.88	2.19	3.78	1.11
2018	2.17	1.36	2.98	4.44	3.43	5.44	0.58
2019	1.87	1.33	2.41	4.43	3.47	5.40	0.57
2020	7.22	4.91	9.53	4.42	3.35	5.49	0.51
2019–2020			**Average A**	4.43			
2016–2018			**Average B**	3.24			
			Ratio A/B	1.36			