19 Striped red mullet in Subarea 4 (North Sea), divisions 7.d (Eastern English Channel) and 3.a (Skagerrak, Kattegat)

This stock is under a biennial advice. No TAC is set for this stock. The last advice issued in 2017 was based on the 4:1 rule applied to the SSB estimated by the age-based model. In 2021, fishing opportunities advice was again requested following the precautionary approach. Due to incomplete survey sampling in 2020, issues with calculation of survey indices, the lack of length and age samples from the main fleets, including other areas and nations, and problems with model formulation; ICES stock data category of striped red mullet in Subarea 4 and divisions 7.d and 3.a was downgraded from category 3 to category 5. ICES advice on fishing opportunities was based on the average ICES catches (considering discards negligible) over the period 2004–2020. Based on length-based indicators (LBI) analysis, fishing mortality is estimated above MSY reference points, the stock size relative to reference point is unknown. For that reasons, the precautionary buffer was applied.

The general perception is that the landings have gradually decreased since 2015, the highest observed in the recent years, up to 2018. In 2019, landings have increased near to the level of 2015, mainly due to the exploitation of the strong 2018 cohort. In 2020, landings decreased slightly, the structure of the population is still truncated and recent catches of this stock mainly consist of age 0 and age 1 fish. The fishery for striped red mullet would benefit from improved technical measures such as sorting grids, increased mesh size, and spatial and temporal closures. These measures could reduce the catches of small fish and contribute to more stable yields.

19.1 General

Striped red mullet has been benchmarked in 2015 (ICES, 2015).

The main issues addressed during the benchmark were the quantity and representativeness of the observational data. Analyses suggested the extrapolation of the assessment results from the eastern English Channel to the southern North Sea had merit. It was less clear whether the assessment was valid for the other areas within the stock region, because the fishery catches were small and data were sparse.

The conclusion of the benchmark were, that the agreed stock assessment seemed reasonable given the available information and that it could be used for providing fisheries advice under the ICES Stock Category 3 framework.

Ecosystem aspects

Striped red mullet (*Mullus surmuletus*) is a benthic species. Young fish are distributed in coastal areas, while adults have a more offshore distribution. Benzinou *et al.* (2013) conducted stock identification studies based on otolith and fish shape in European waters and showed that striped red mullet can be geographically divided into two units: Western Unit (subareas 6 and 8, and divisions 7.a–c, 7.e–k, and 9.a) and Northern Unit (Subarea 4 (North Sea) and divisions 7.d (Eastern English Channel) and 3.a (Skagerrak, Kattegat)).

A recent review of striped red mullet stock structure in the greater North Sea was realised by CEFAS and presented to WGNSSK 2020 (Ellis, 2020). This review does not support the current stock definition used by ICES. Indeed, survey data from IBTS might indicate that striped red

mullet in Division 3.a should be considered as a separate stock from the North Sea one. In addition, survey data and commercial data have highlighted migration pattern between the Western English Channel and the southern North Sea, with striped red mullet concentrating and mixing in the southern North Sea during summer. Thus, assessment of stripped red mullet in subarea 4 and division 7.d-e may need to be assessed as a single stock or a complex one with two subpopulation mixing during summer.

In the English Channel, the first sexual maturity was identified on fish of 16.2 cm for the male and 16.7 cm for the female (Mahé *et al.*, 2005). Juveniles are found in waters of low salinity, while adults are found at high salinity. Striped red mullet prefers sandy sediments (Carpentier *et al.*, 2009).

Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud.

19.2 Fisheries

Historically, France has taken most of the landings with a targeted fishery for striped red mullet (> 90% of landings in the beginning of the 2000s). This French fishery targeting striped red mullet is conducted by bottom trawlers using a mesh size of 70–99 mm in the eastern English Channel and in the southern North Sea.

The eastern English Channel and southern North Sea areas are also fished by trawlers of various types targeting a variety of species. Striped red mullet might be a bycatch in these fisheries.

From 2000, a Dutch targeted fishery, using fly shooters, and a UK fisheries has also developed. Landings are shared by these three fleets in the latter years. The Netherlands landed about or more than half of the total landings since the 2010s.

19.3 ICES advice

Advice for 2022 and 2023.

The ICES framework for category 5 stocks was applied (ICES 2012). For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented where there is no ancillary information clearly indicating that the current level of exploitation is appropriate for the stock. Discarding is considered negligible.

Fishing mortality is above proxies of the MSY reference points (as indicated by a length-based analysis). The stock size relative to reference points is unknown. For these reasons, the precautionary buffer, which was last applied in 2017, was applied again in this assessment.

ICES advises that when the precautionary approach is applied, catches should be no more than 1950 tonnes in each of the years 2022 and 2023. All catches are assumed to be landed.

Advice for 2020 and 2021.

ICES has not been requested to provide advice on fishing opportunities for this stock.

Advice for 2018 and 2019.

ICES advices that the fishery for striped red mullet should be managed through technical measures that would reduce the catches of small fish and would contribute to more stable yields.

Fishing mortality is above proxies of the MSY reference points (as indicated by a length-based analysis). The stock size relative to reference points is unknown. For these reasons, the precautionary buffer, which was last applied in 2013, was applied again in this assessment.

ICES advises that when the precautionary approach is applied, catches should be no more than 465 tonnes in each of the years 2018 and 2019. All catches are assumed to be landed.

19.4 Management

No specific management objectives are known to ICES. There is no TAC for this species.

There is no minimum landing size for this species.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

19.5 Data available

19.5.1 Catch

Official landings data are shown by country in Table 19.5.1.1 and by area in Table 19.5.1.2. There is no indication of discard of striped red mullet. All catches are assumed to be landed. Table 19.5.1.3 presents total official landings and ICES estimates over the period 2004–2020 as well as the predicted catch corresponding to advice. In 2020, 77% of the catches were made using demersal seines and 17% using demersal trawls.

Total landings were provided under the ICES InterCatch format for the period 2003–2013 during the benchmark. However, only France provided age composition for the period 2006–2013. 2014 to 2020 landings were provided under the ICES InterCatch format. Figure 19.5.1.1 shows that only landings from France in the Eastern Channel (representing around 11% of the total landings in 2020) were provided in 2014 to 2020 with an age structure. In 2020, some landings made in area 4 were also provided by France with an age structure but only representing around 3% of the total landings in area 4. Figure 19.5.1.2 shows that IC data and official landings are consistent over years and countries.

Prior to 2009, no landings of age 0 were observed (Figure 19.5.1.3, and Table 19.5.1.4). Most of the landings are made on age 1. There is no age reading problem reported. This change in the landings might reflect a change in the reporting or a change in the fishing behaviour.

Only France provides age structured information for the area 27.7.d and 4, all landings are then raised using French age structures. Age sampling has usually a low coverage for this stock, however in 2020, the COVID-19 pandemic significantly impacted the market sampling reducing the overall age sampling coverage of landings to 8%. To account for the lack of sampling in 2020, all quarters were raised with all samples available, except for quarter 4 that was raised using only samples from quarter 4.

19.5.2 Weight-at-age

Mean weights at age were computed as described in the Stock Annex and are presented in Figures 19.5.2.1 and 19.5.2.2 and Table 19.5.2.1.

Weights at age in the landings show a slight decrease for the oldest ages. However, sampling intensity for these ages is very low due to the low number of fishes in the catches. Stock weights

do not show this slight decrease of age 3 and 4+ as for landings weight, the sampling is very low due to the low number of fishes in the landings.

19.5.3 Maturity and natural mortality

Information about maturity per age class is given with the table included in this section. At an age of one year more than 50 percent of the striped red mullet are mature.

Age	0	1	2	3	4	5	6
Maturity	0	0.54	0.65	1	1	1	1

As defined during WKNSEA (ICES, 2015), natural mortality was derived from Gislason first estimator (Gislason *et al*., 2010) leading, as expected for this species, to high natural mortality for the youngest ages (see table below).

age	M_Gislason
0	1.426
1	0.6641
2	0.4888
3	0.4164
4	0.3616
5	0.3275
6	0.3421

19.5.4 Survey data

Survey index defined during the last benchmark.

During the las benchmark in 2015, the Channel Ground Fish Survey (CGFS) and the IBTS–Q3 surveys were estimated to be good indicators of the population trends as they cover the spatial distribution of this stock. However, none of them have an exhaustive coverage of the spatial distribution.

In 2015, a change in the research vessel used for the CGFS was realised. The consequences of these changes were assessed via an inter-calibration in 2014 and some analysis of the catch data (ICES, 2017, Section "CGFS: Change of vessel from 2015 onwards and consequences on survey design and stock indices"). It appeared that for red mullet indices seem to be used without correcting factor.

Only CGFS survey allowed deriving age structured indices. Internal consistencies of the survey (Figure 19.5.4.1) show reasonable consistencies between age 1 and 4.

The age composition of the catches made during CGFS is presented in Figure 19.5.4.2. The age composition is still truncated with catches hardly only composed by age 0 and 1 individual. The Abundance index shows an increase of the age 0 compared to 2015, 2016 and 2017 and is in 2018 the second highest observed.

Issues regarding CGFS survey index in 2020.

In 2020, CGFS survey design was impacted by COVID-19 pandemic and issues regarding historical index calculation were uncovered. In this section, we describe the two different issues that impact 2021 stock assessment. In the next section, the impact of the different issues on the assessment were evaluated using data up to 2019.

- Issue with sampling coverage in 2020

In 2020, due to the COVID-19 pandemic and the lockdown in France, CGFS JNC Cruise application form was unfortunately not processed in a timely manner by the French Foreign Ministry. By consequence, the formal authorisation to operate in UK waters was not received before the starting of the 2020 CGFS survey. Therefore, only the French waters of the English Channel were sampled covering 70% of the sampling design (Figure 19.5.4.3) (ICES IBTSWG, 2021 (*in prep*)).

- Issue with historical index calculation

In order to improve data quality and storage, and consequently to the deployment of a new software used on board during sea surveys, the format of survey data collected by IFREMER has evolved from 2017 onwards. This evolution is associated with data quality check at several steps of the process from data collection to storage. To handle this change but also to be prepared for the coming integration of indices' calculation within DATRAS for some species sampled by IBTS North-Eastern Atlantic surveys, new scripts have been produced to compute abundance indices using this new data format.

Whilst writing the R scripts, discrepancies were found between the resulting indices and the ones calculated historically (Figure 19.5.4.4). An error was found in the historical scripts as some hauls with absence of a species were not included in the average abundance per stratum. A new preliminary index was produced to correct the error; however, some work is still required to compute properly the survey age-length key used for the new index calculation. At the moment, some age at length are still missing in the preliminary new index calculations.

19.6 Trend based assessment

19.6.1 Assessment model agreed on during the last benchmark

As agreed during WKNSEA (ICES, 2015), the assessment model was used for trend as the SSB estimated by the model was considered to be a more reliable indicator of stock status than the direct use of survey indices.

Sensitivity runs were explored in 2020 and different numbers of knots (from 6 to 9) were tested for the spline used to estimate fishing mortality (ICES, 2020). F_{bar} (age 1–2) estimates for 2019 remain in absolute value above 3 in all the scenarios. Scenario with 6 knots was disregarded as F for age 3 was unrealistic. It was agreed to add one more knot to the spline as compared to 2019 assessment, however other configuration of a4a needs to be investigated if we want to keep using this model as an indicator of the stock status in the future.

The settings used are described on the following table.

Setting/Data	Values/source
Catch at age	Landings (since 2004, ages 0–4+) InterCatch Discards are assumed negligible.
Tuning indices	FR CGFS (since 2004 ages 0–4+)
Plus group	4
First tuning year	2004
Fishing mortality	~ s(year, k=8) + factor(age)
Survey catchability	~ factor(age)
Recruitment	~ factor(year)

Results from the assessment are presented in Figure 19.6.1.3. Log residuals of the model are presented in Figure 19.6.1.4 and observed and predicted catches in Figure 19.6.1.5 and indices in Figure 19.6.1.6.

As observed during WKNSEA, there is still a relatively high uncertainty in this assessment. SSB is at a low level and the recruitment seems poorly estimated. Trends show a lot of variation in spawning stock biomass and a very high fishing mortality. Most of the catches rely only on the recruitment (age 0) and age 1 fishes.

19.6.2 Exploratory runs with a4a

Several formulations of a4a were tested to constrain the model. Splines were added to characterize the selectivity of catches and survey. In addition, fishing mortality at age 0 was modelled separately as the catch at age 0 remains lower than age 1 or 2. Finally, splines were added to estimates the variance at age of F and the survey indices.

The final settings tested are described on the following table.

Setting/Data	Values/source
Catch at age	Landings (since 2004, ages 0–4+) InterCatch Discards are assumed negligible.
Tuning indices	FR CGFS (since 2004 ages 0–4+)
Plus group	4
First tuning year	2004
Fishing mortality	~ s(year, k=10) + s(age, k=3) + s(year, k=5, Age 0)
Survey catchability	~ s(age, k=3)
Recruitment	~ factor(year)
Variance	F ~ s(age, k=3) & Survey ~ s(age, k=3)

Results from the alternative assessment model are presented in Figure 19.6.2.1. Log residuals of the model are presented in Figure 19.6.2.2 and observed and predicted catches in Figure 19.6.2.3 and indices in Figure 19.6.2.4.

With this new model formulation, residual patterns at age 0 for the catches have improved as compared to the model formulation decided during the benchmark. Adding a spline to characterise selectivity seems to allow a more realistic representation of the fishing pressure. However,

F_{bar} estimated by the alternative model remains high and the uncertainty around F_{bar} and SSB is still relatively important.

More exploratory runs are required to fix the different issues of the current model used as indicative of the stock status (to test different a4a formulation, and more models).

19.6.3 Impact of survey index issues

To assess the impact of survey index issues on the age-based assessment, three separate analyses were performed using commercial and survey age structured data from 2004 to 2019. The a4a settings were the same as the one used in section 19.6.1. All the runs describe below were compared with the baseline assessment produced in 2020 (ICES, 2020).

Issues with CGFS survey index	Runs	Description	Hypothesis tested
Missing UK hauls in 2020	woUK	Run the assessment with a survey index calculated without all the UK stations in the historical CGFS survey time series. The methods used is the one agreed upon during the last benchmark and include error in the index calculation.	Model is influenced by CGFS survey station in the UK EEZ.
	wo2019	Run the assessment with survey index agreed upon during the last benchmark without the last data year (2004-2018 period).	Last survey data year has a strong influenced on the assessment outcome.
Missing some hauls with no stripped red mullet	newindex	Run the assessment with the preliminary new index including all the hauls in the index calculation.	Omitting some hauls without stripped red mullet during the index calculation as a strong influence on assessment outcome and the model cannot account for the changes through a change in survey catchability estimation.

Estimates of recruitment, SSB and F_{bar} (1–2) from the different runs are presented in Figure 19.6.3.1. Removing CGFS survey hauls within UK EEZ during the age structure index calculation has little effect on the assessment outcomes and the model is able to capture the change in index through the survey catchability estimation. However, removing the last survey data year or using the preliminary new CGFS index have a strong impact on the fishing mortality estimates as well as the estimates of the final year recruitment and SSB in 2019.

19.6.4 Striped red mullet trend-based assessment conclusion

Due to incomplete survey sampling in 2020, issues with calculation of survey indices, the lack of length and age samples from the main fleets, including other areas and nations, and problems with model formulation, the stripped red mullet trend-based assessment was rejected. Therefore, the ICES stock data category of striped red mullet in Subarea 4 and divisions 7.d and 3.a was downgraded from category 3 to category 5.

19.7 Length-based indicators screening

The ICES LBI were computed for five years of data (2014–2016 and 2018–2020), using the length distributions from InterCatch (Tables 19.7.1).

Most of the indicators appear outside the established references in 2020:

- Length at first catch Lc and Length of 25% of catches are above Lmat (16 cm) in 2015, 2016, 2019 and 2020. These indicators are below Lmat in 2014 and 2018 (for Lc). This is directly linked with the good recruitment observed in 2014 and 2018. The good recruitment observed in 2014 and 2018 decreased Lc and L25, but the next years (2015–2016 and 2019–2020) no good recruitment was observed and Lc and L25 increased to be above Lmat.
- ratio of the Lmax5, mean length of 5% largest catches, to Linf (40 cm) around 0.6/0.7 over the two periods 2014–2016 and 2018–2020 clearly show the lack of big/old fish in the population
- Lmean/Lopt around 0.8 give the same picture as Lmax5, exploitation is not optimal.
- Lmean/$L_{F=M}$ below 1 tend to show that this stock is not exploited sustainably except for 2018 where the ratio is just above 1.

This indicates that the stock may be considered not to be exploited sustainably. The main concerns are for the big/old fish that are missing from the population. Length-based indicators based on samples from commercial catches (2014–2016 and 2019–2020) show that in relation to conservation criteria there is strong evidence of growth overfishing, meaning the fish is caught before it has realized its growth potential (Table 19.7.2).

Conclusions drawn from analyses:

The very good recruitment observed in 2014 and 2018 was confirmed by the catches in 2015 and 2019 respectively and the remaining age 1 seen in 2015 and 2019 during CGFS. There is no TAC on this species so the advice was not followed and the catches overshot the advice for 2015-2019 (5328, 3438, 2856, 1651 and 4044 tonnes against 460, 552, 552, 465 and 465 tonnes respectively in the advice). In 2018, the recruitment as seen by CGFS appears to be the second highest since 2004 and was confirmed by the catches in 2019 and the age 1 in CGFS survey. The stock age distribution appears to be still truncated.

Basis for the advice:

Length-based indicators based on samples from commercial catches (2014–2016 and 2018–2020) show in 2021 that in relation to conservation criteria there is strong evidence of growth overfishing, meaning the fish is caught before it has realized its growth potential. The SSB is dependent on recruitment.

19.8 Issues List

Data and stock ID:

- Age (length) data from other countries than France need to be provided as everything is actually raised using the French catches in the Eastern Channel and part of North Sea.
- No survey is available in the North Sea; IBTS/UK BTS should be investigated again. So work was done to assess the representativeness of the Eastern Channel data compared to the stock, but these should be investigated further
- CGFS survey data issues in index calculation needs to be fixed. GAM or GLMM methods such as the method developed by Berg et al. (2014) or Thorson et al. (2015) should be explored to account for missing data UK haul in 2020 and also better account for the change in vessel in 2014.
- Even if discards are expected to be very low (no minimum landing size, high price), discards data should be re-investigated

- Based on Ellis, J. R. (2020) stock ID should be reinvestigated.

Assessment:

- Assessment model was rejected in 2021 and a category 5 advice is given for this stock, new methods should be investigated.

- Explore methods applied to "short lived species" (two stages model)?
- New model formulations need to be explored to solve the issue relative to the recent high F estimate for 2019
- SPiCT should be explore again either as basis for advice or to estimate the stock status.
- Other models should be also explored (SAM, SURBAR, length-based models…)

Forecast and reference points:

- This stock is not category 1, so no forecast is done currently. This should be investigated if the assessment method is improved. However, there is no TAC for that stock so a forecast is not a priority, although reference points are still important.

19.9 References

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Table 19.5.1.1. Striped red mullet in Subarea 4 and divisions 7.d and 3.a: Official landings by country (tonnes).

Year	Belgium	Denmark	France	Netherlands	UK	total
1975	0	0	140	0	0	140
1976	0	0	156	3	1	160
1977	0	0	279	12	1	292
1978	0	0	207	25	3	235
1979	0	0	212	32	11	255
1980	0	0	86	25	4	115
1981	0	0	44	19	1	64
1982	0	0	32	18	2	54
1983	0	0	232	15	1	248
1984	0	0	204	0	3	207
1985	0	0	135	0	4	140
1986	0	0	84	0	3	88
1987	0	1	40	0	3	46
1988	0	1	35	0	4	41
1989	0	0	37	0	5	42
1990	0	0	524	0	13	537
1991	0	0	208	0	11	219
1992	0	0	458	0	17	475
1993	0	0	576	0	21	597
1994	0	0	362	0	18	380
1995	0	0	2537	0	69	2606
1996	0	2	2039	2	44	2087
1997	0	2	856	0	61	919
1998	0	2	2966	0	117	3085
1999[1)]	0	4	NA	0	103	107
2000	0	4	3201	464	133	3802
2001	0	10	1789	915	183	2897
2002	0	24	1658	560	141	2383
2003	28	0	3256	626	177	4087
2004	31	0	4137	1148	129	5445
2005	29	0	1918	914	136	2997
2006	16	0	1145	466	97	1724
2007	17	0	3982	1147	182	5328
2008	20	0	3723	1270	353	5366
2009	17	0	827	889	293	2026
2010	80	0	947	802	338	2167
2011	97	0	704	771	243	1815
2012	51	0	170	525	146	892
2013	40	0	122	260	40	462

Year	Belgium	Denmark	France	Netherlands	UK	total
2014	79	0	765	912	246	2002
2015	250	0	1741	2657	679	5327
2016	184	0	690	2024	540	3438
2017	120	0	887	1443	406	2856
2018	92	0.044	665	1112	167	2036
2019	232	0.037	1401	1821	589	4043
2020	220	0.124	723	1752	787	3482

[1] No data reported by France in 1999.

Table 19.5.1.2. Striped red mullet in Subarea 4 and divisions 7.d and 3.a: Official landings by area (tonnes). Note: Most of the Subarea 4 catches are made in Division 4.c.

Year	4	3.a	7.d	Total [2]
1975	0	0	140	140
1976	4	0	156	160
1977	19	0	273	292
1978	30	0	205	235
1979	49	0	206	255
1980	29	0	86	115
1981	20	0	44	64
1982	21	0	33	54
1983	41	0	207	248
1984	22	0	185	207
1985	10	0	130	140
1986	6	0	82	88
1987	7	0	38	46
1988	7	0	33	41
1989	5	0	37	42
1990	33	0	504	537
1991	26	0	193	219
1992	60	0	415	475
1993	126	0	471	597
1994	116	0	264	380
1995	1054	0	1552	2606
1996	528	0	1559	2087
1997	278	0	641	919
1998	778	0	2307	3085
1999[1]	70	0	37	107
2000	1764	0	2038	3802
2001	1600	0	1297	2897
2002	1234	0	1149	2383

Year	4	3.a	7.d	Total [2]
2003	1618	0	2469	4087
2004	1820	0	3625	5445
2005	1404	0	1593	2997
2006	642	0	1083	1725
2007	1546	0	3782	5328
2008	1830	0	3536	5366
2009	910	0	1115	2025
2010	699	0	1468	2167
2011	609	0	1206	1815
2012	387	0	505	892
2013	196	0	266	462
2014	526	0	1476	2002
2015	1601	0	3727	5328
2016	1649	0.03	1789	3438
2017	1304	0	1552	2856
2018	769	0.002	1267	2036
2019	1282	0.022	2761	4043
2020	1379	0.157	2103	3482

[1] No data reported by France in 1999.

[2] Differ from Table 19.5.1.1 and Table 19.5.1.3 due to rounding.

Table 19.5.1.3. Striped red mullet in Subarea 4 and divisions 7.d and 3.a: History of ICES advice, the agreed TAC, and ICES estimates of landings.

Year	ICES Advice	Predicted catch corresp. to advice	Official landings [1]	ICES Estimates
2004			5445	4674
2005			2997	2350
2006		-	1725	1476
2007		-	5328	4604
2008		-	5366	2064
2009		-	2025	1513
2010		-	2167	1919
2011		-	1815	1511
2012	No increase in catch	-	892	726
2013	No increase in catches (average 2009–2010)	< 1700	462	408
2014	Reduce catches by 36% compared to 2012	< 460	2002	1718
2015	No new advice, same as for 2014	< 460	5328	4487
2016	Precautionary approach	<552	3438	2579
2017	Precautionary approach	<552	2856	2195
2018	Precautionary approach	<465	2036	1640
2019	Precautionary approach	<465	4044	4048

Year	ICES Advice	Predicted catch corresp. to advice	Official landings [1)]	ICES Estimates
2020	No Advice	-	3483	3503
2021	No Advice	-		
2022	Precautionary approach	<1950		
2023	Precautionary approach	<1950		

Weights in tonnes.

[1)] Differ from Table 19.5.1.1 and Table 19.5.1.2 due to rounding.

Table 19.5.1.4. Striped red mullet landing numbers at age (thousands).

	0	1	2	3	4	5	6	4+
2004	0	43076	1826	940	75	111	0	186
2005	0	16557	2448	262	56	199	0	255
2006	0	3900	2325	1674	109	78	0	187
2007	0	36872	1120	551	94	33	0	127
2008	0	1316	10459	1248	313	221	0	534
2009	45	13256	1075	540	83	0	0	83
2010	12971	13384	593	125	70	19	1	90
2011	0	9310	1453	639	76	4	0	80
2012	6	1337	1246	1479	181	2	0	183
2013	1170	2342	395	244	0	0	0	0
2014	9904	10556	1300	14	14	14	0	28
2015	1728	35360	5952	18	2	32	0	34
2016	38	3498	9680	2129	148	51	0	199
2017	872	10314	2974	1105	223	130	100	453
2018	511	6630	3017	234	140	0	0	140
2019	1582	31105	1511	466	119	0	0	119
2020	590	27386	512	31	0	0	0	0

Table 19.5.2.1. Striped red mullet stock weights (kg).

	0	1	2	3	4	5	6	4+
2004	0	0.09	0.222	0.27	0.434	0.66	0	0.569
2005	0	0.105	0.172	0.3	0.383	0.419	0	0.411
2006	0	0.146	0.188	0.241	0.379	0.35	0	0.367
2007	0	0.107	0.313	0.422	0.446	0.677	0	0.506
2008	0	0.096	0.139	0.226	0.326	0.41	0	0.361
2009	0.046	0.07	0.16	0.177	0.423	0	0	0.423
2010	0.042	0.077	0.112	0.24	0.225	0.149	0.215	0.209
2011	0	0.052	0.15	0	0	0.323	0	0.016
2012	0.023	0.091	0.169	0.255	0.229	0.772	0	0.235
2013	0.025	0.063	0.118	0.115	0	0	0	0
2014	0.029	0.093	0.144	0.259	0.294	0.323	0	0.309

	0	1	2	3	4	5	6	4+
2015	0.038	0.1	0.114	0.37	0.42	0.187	0	0.2
2016	0.038	0.114	0.138	0.319	0.42	0.187	0	0.360
2017	0.038	0.114	0.138	0.319	0.42	0.187	0	0.260
2018	0.046	0.143	0.166	0.273	0.315	0	0	0.315
2019	0.033	0.111	0.144	0.158	0.156	0	0	0.156
2020	0.038	0.114	0.110	0.320	0	0	0	0

Table 19.7.1. Striped red mullet 27.3a47d length-based indicators.

Data Type	Value/Year	Source
Length at maturity	162 162 162	Mahé *et al.*, 2013
von Bertalanffy growth parameter (Linf)	400 400 400	Mahé *et al.*, 2013
Catch at length by year	2014–2016 2018–2020	Length data from IC
Length-weight relationship parameters for landings	2014–2016 2018–2020	Mean weight at length from IC

Table 19.7.2. Striped red mullet in Subarea 4 and divisions 7.d and 3.a: Traffic light table for length-based indicators. Conservation criteria for small fish: L_c (length at first catch) and 25% percentile relative to L_{mat} (length at 50% maturity); and for large fish: mean length of the largest 5% in the catch ($L_{max5\%}$) relative to asymptotic length L_{inf} and the proportion of mega spawners (P_{mega}). Optimising yield criterion: the mean length L_{mean} is compared to the theoretical length of optimal biomass (L_{opt}). MSY criterion: L_{mean} is compared to $L_{F=M}$, the MSY proxy. "Ref" indicates the reference criterion: green colour for meeting the criterion, and red flagging issues (e.g. dome-shaped vs. overexploitation). "Ref" indicates the criterion required for a green light. Each year is evaluated separately.

	Conservation				Optimizing Yield	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{inf}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
Ref	**>1**	**>1**	**>0.8**	**>30%**	**~1 (>0.9)**	**≥1**
2014	0.87	0.93	0.66	0.01	0.72	0.96
2015	1.2	1.17	0.64	0	0.82	0.89
2016	1.2	1.23	0.68	0.01	0.84	0.91
2018	0.83	1.17	0.73	0.01	0.8	1.06
2019	1.2	1.11	0.64	0	0.81	0.87
2020	1.2	1.17	0.62	0	0.8	0.87

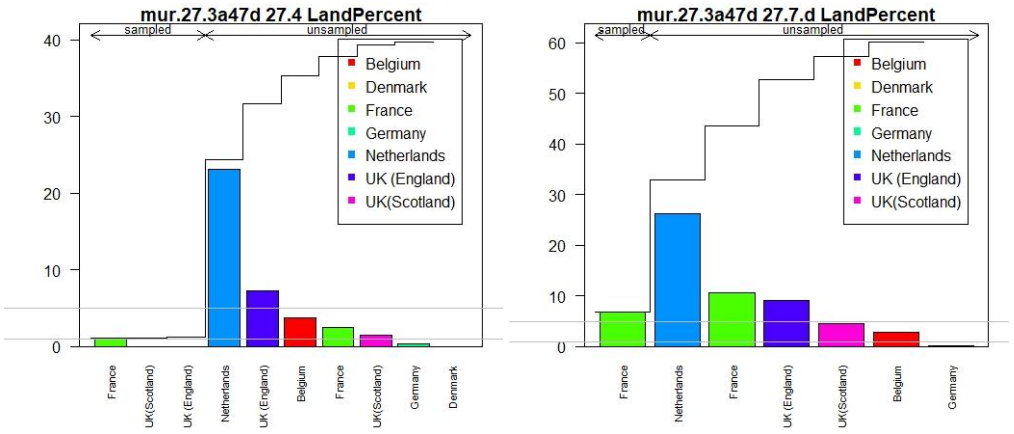

Figure 19.5.1.1. Striped red mullet in Subarea 4 and Division 7.d ICES landings by country (percentage over the total area).

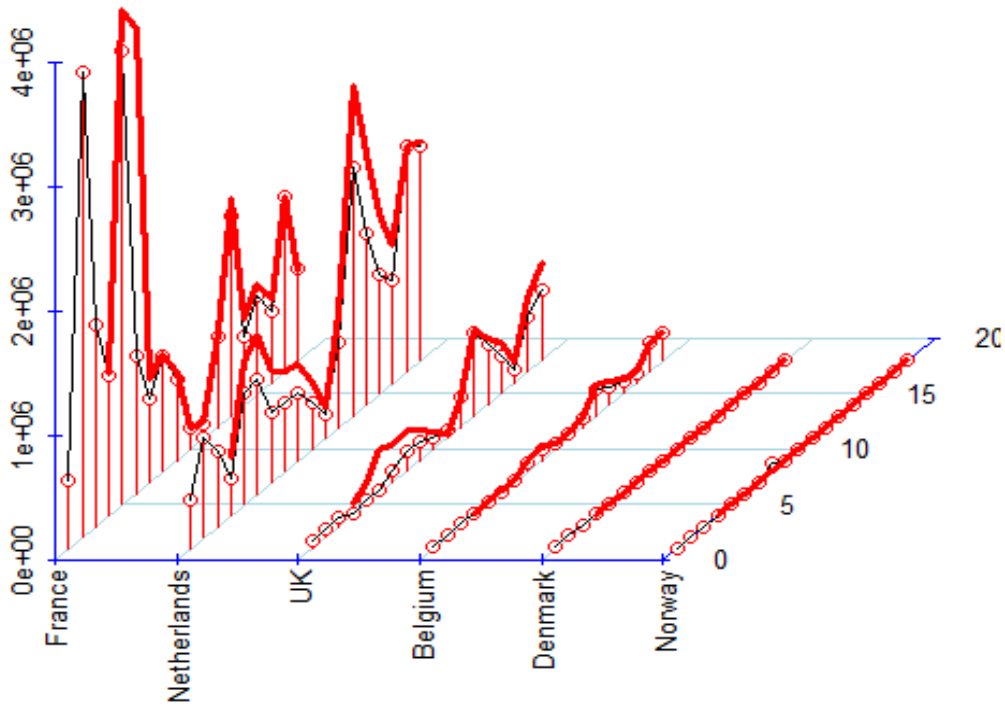

Figure 19.5.1.2. Striped red mullet in Subarea 7d and 4 landings (comparison between IC data, red line) and official catch statistics (black and blue for provisional).

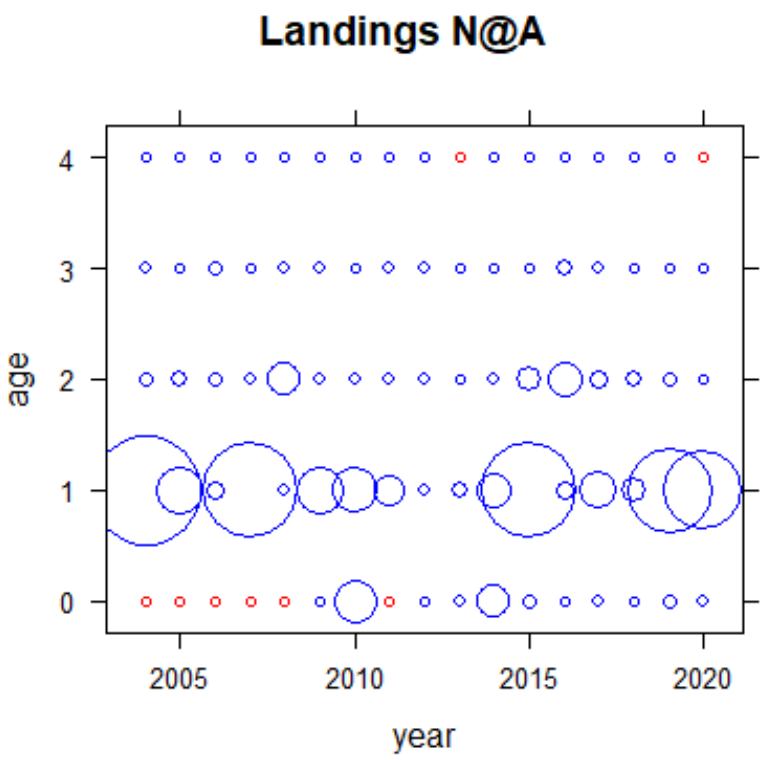

Figure 19.5.1.3. Striped red mullet age structure (in numbers) as provided in the landings.

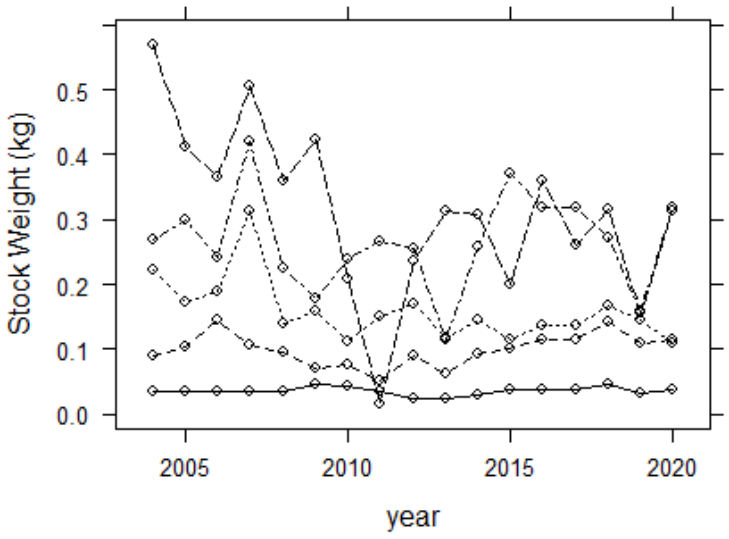

Figure 19.5.2.1. Weight at age in the stock.

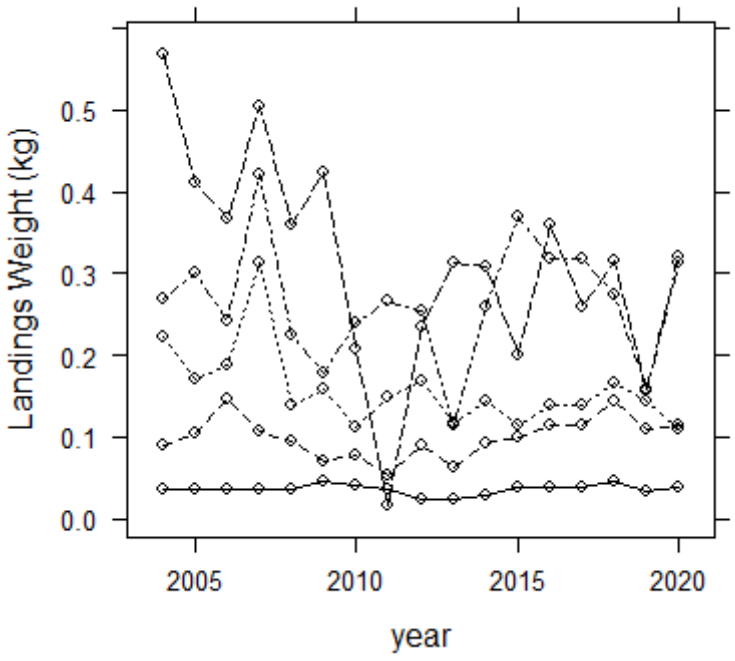

Figure 19.5.2.2. Weight at age in the landings.

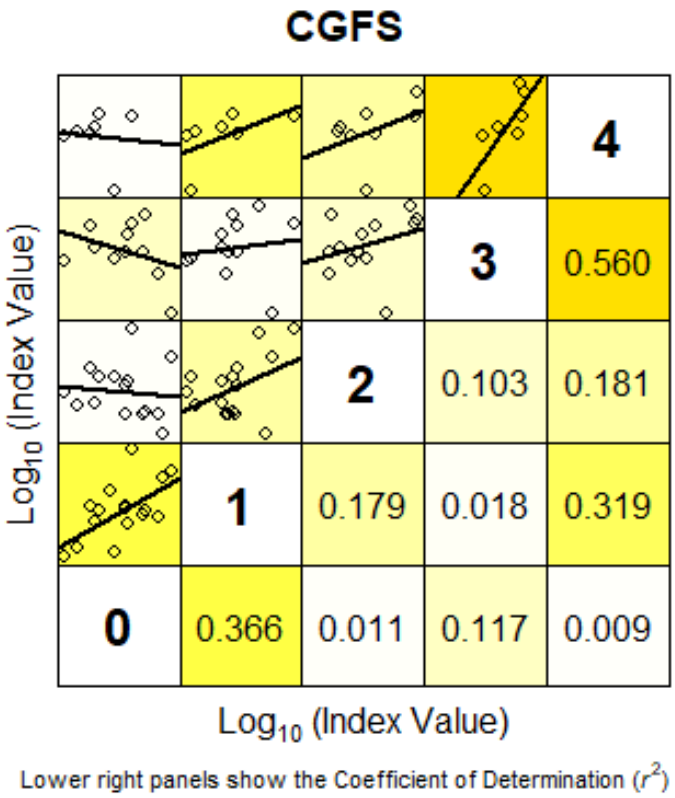

Figure 19.5.4.1. CGFS internal consistencies.

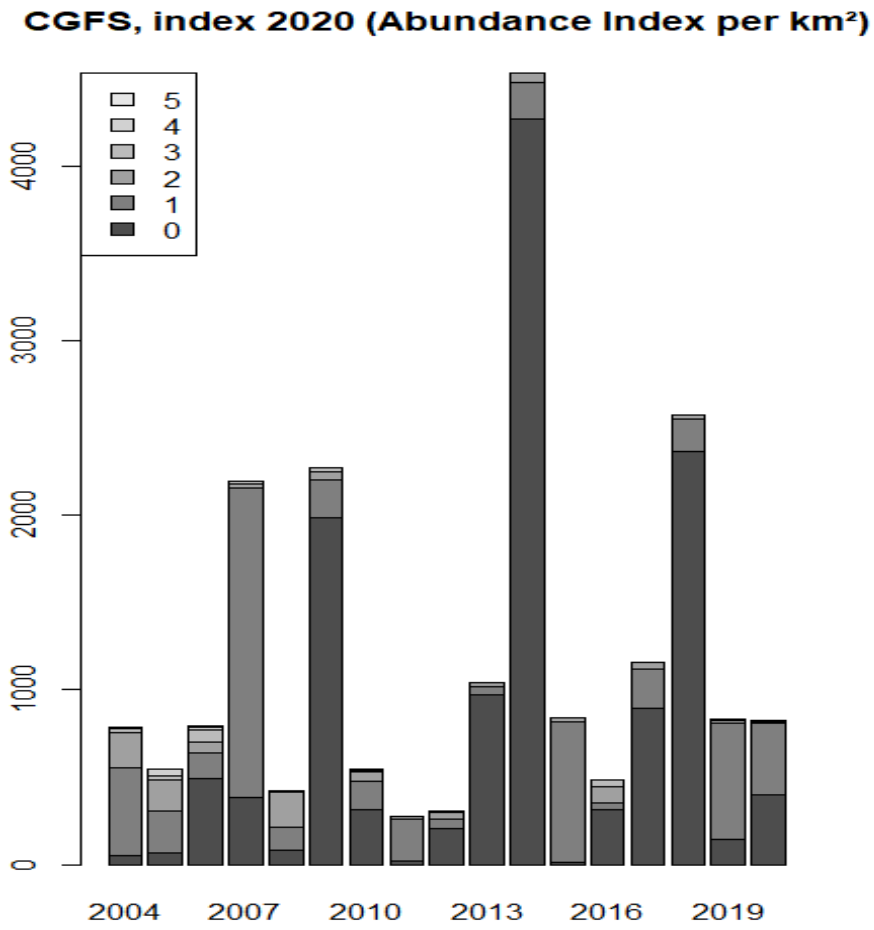

Figure 19.5.4.2. CGFS catch age composition.

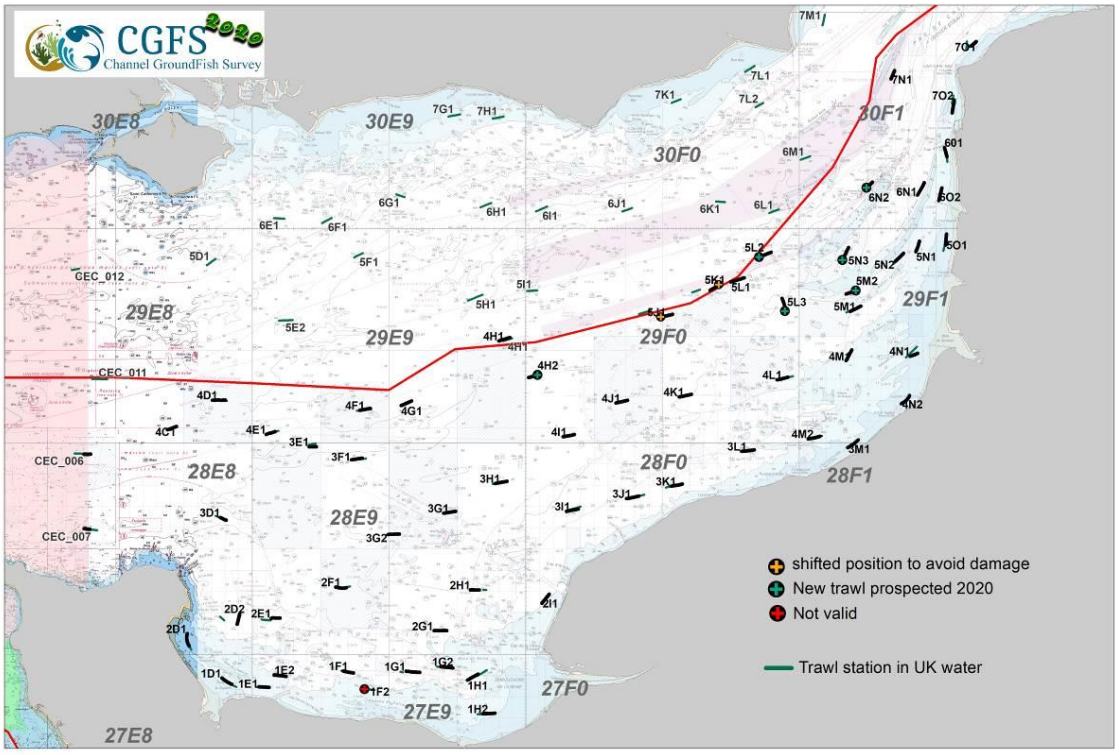

Figure 19.5.4.3. CGFS hauls positions in 2020, north of the redline is the UK EEZ with stations not sampled in 2020 (ICES IBTSWG, 2021 (*in prep*).

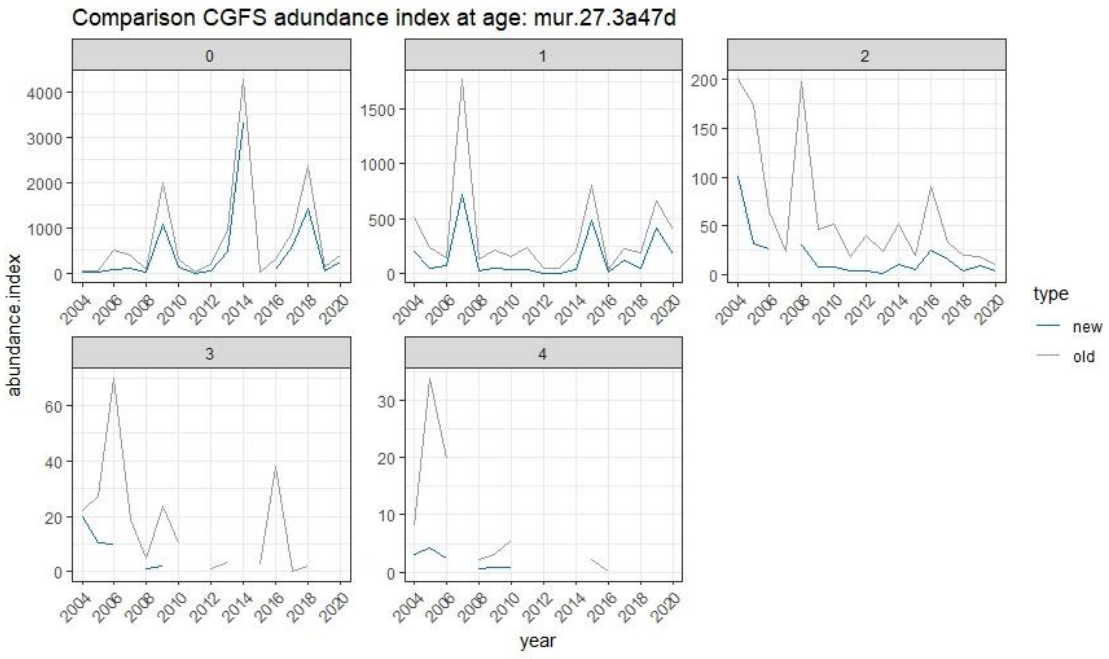

Figure 19.5.4.3. CGFS stripped red mullet index at age. Comparison between the methodology approved during the last benchmark in grey excluding in the index calculation some sampled hauls without stripped red mullet and the preliminary new index including all the hauls in blue. Age-length key calculation in the preliminary new index needs to be improved as some age at length are still missing in the calculation.

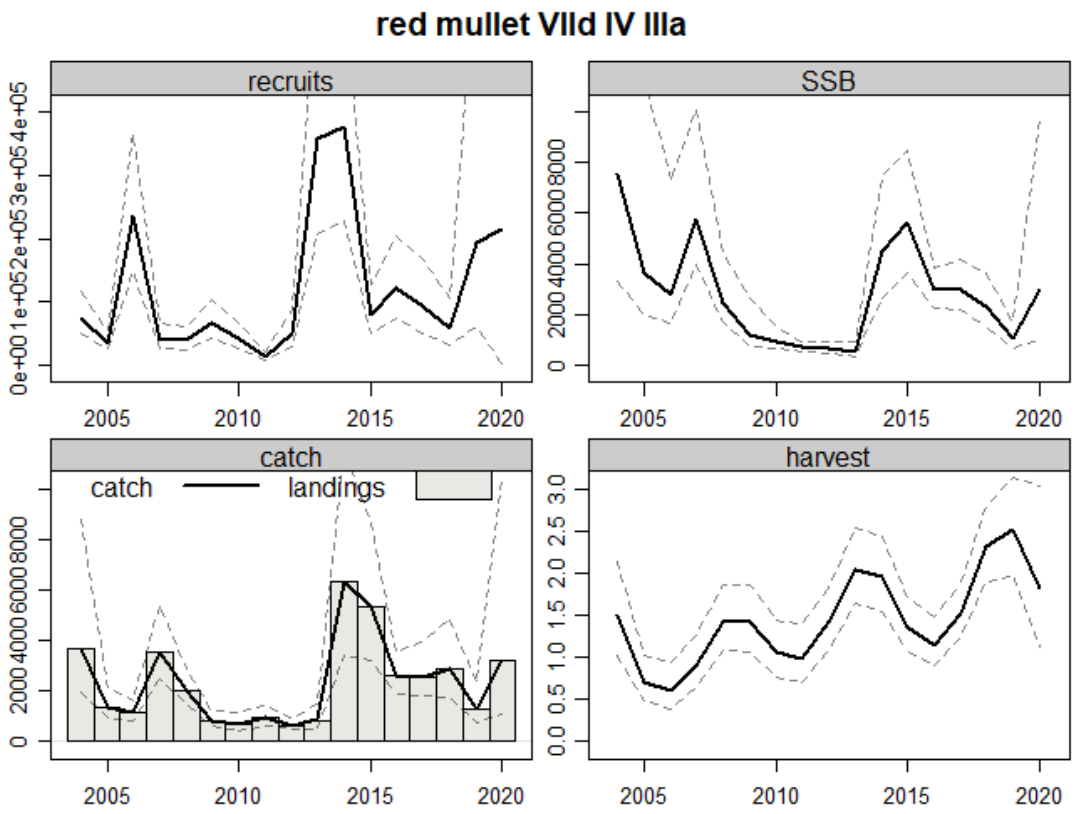

Figure 19.6.1.3. Absolute value of recruitment, SSB, catch and $F_{bar(1-2)}$ estimate using a4a model formulation approved during the last benchmark.

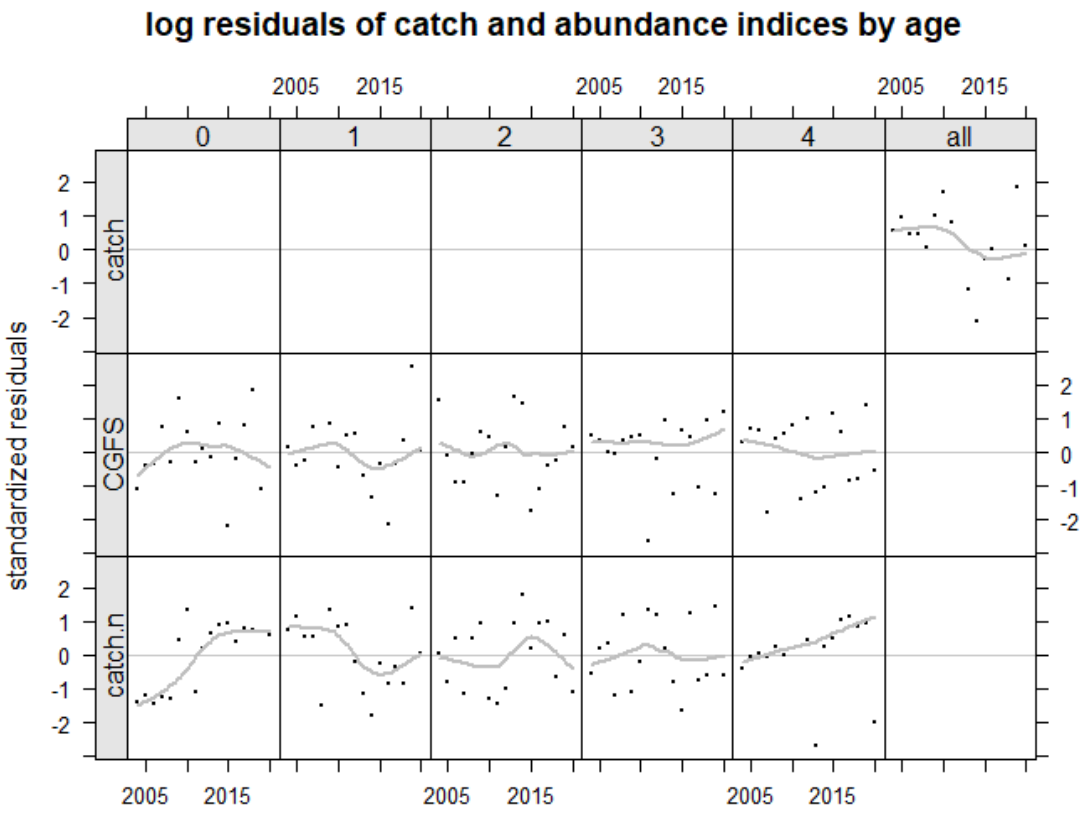

Figure 19.6.1.4. Log residuals of the assessment.

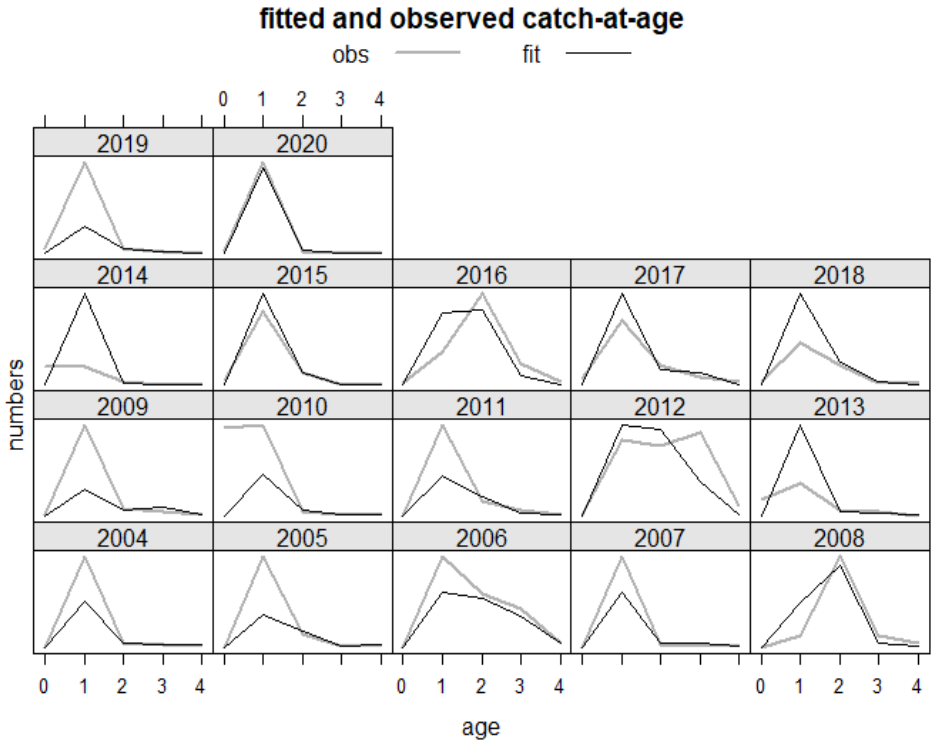

Figure 19.6.1.5. Observed (grey) and estimated (black) catch number-at-age.

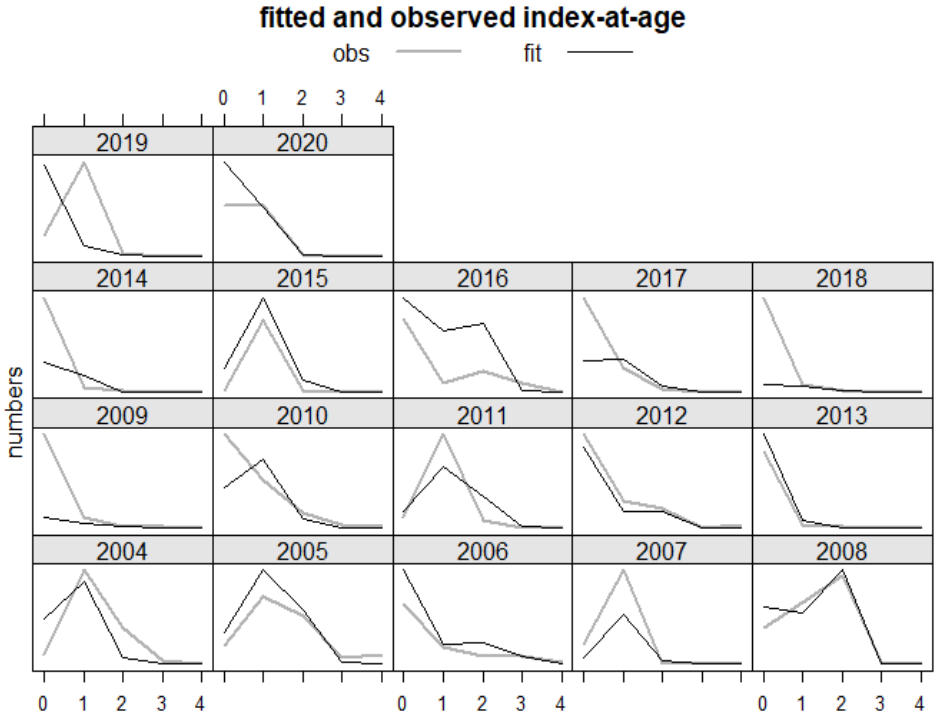

Figure 19.6.1.6. Observed (grey) and estimated (black) indices at age.

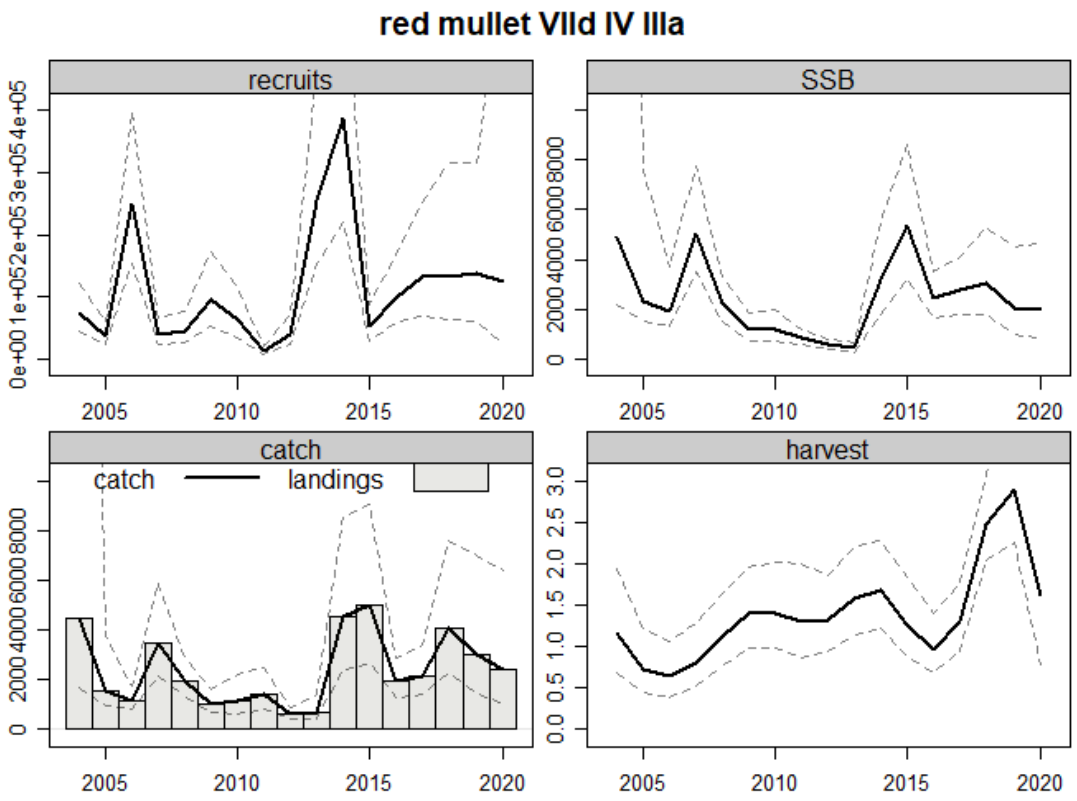

Figure 19.6.2.1. Absolute value of recruitment, SSB, catch and $F_{bar(1-2)}$ estimate using alternative formulation of a4a to constrain selectivity at age and consider variance at age.

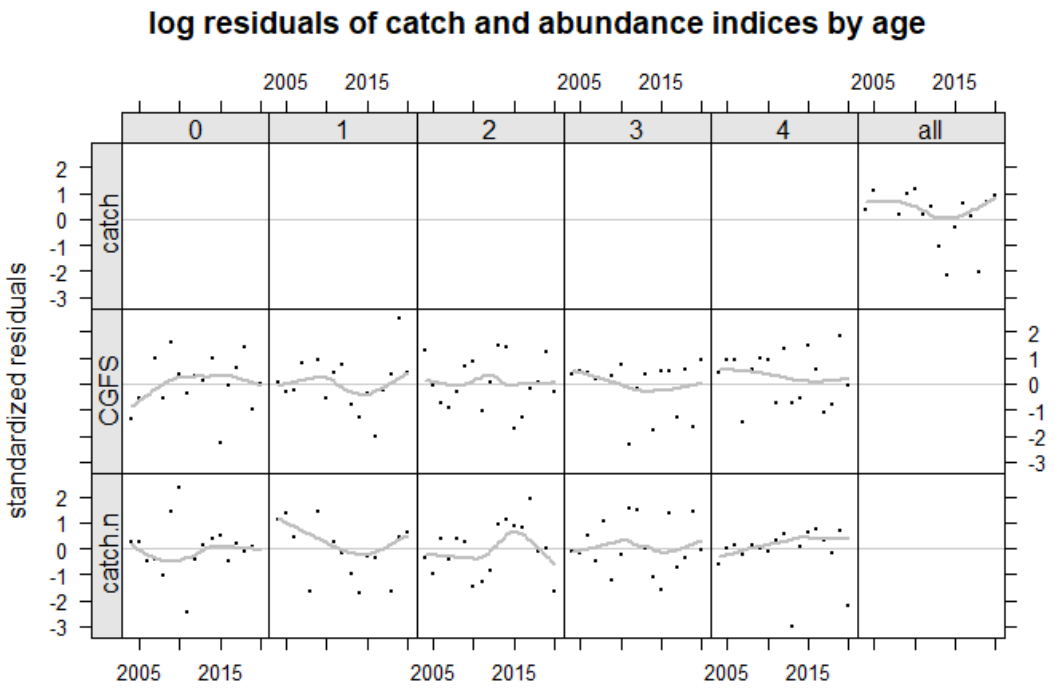

Figure 19.6.2.2. Log residuals of the alternative a4a model.

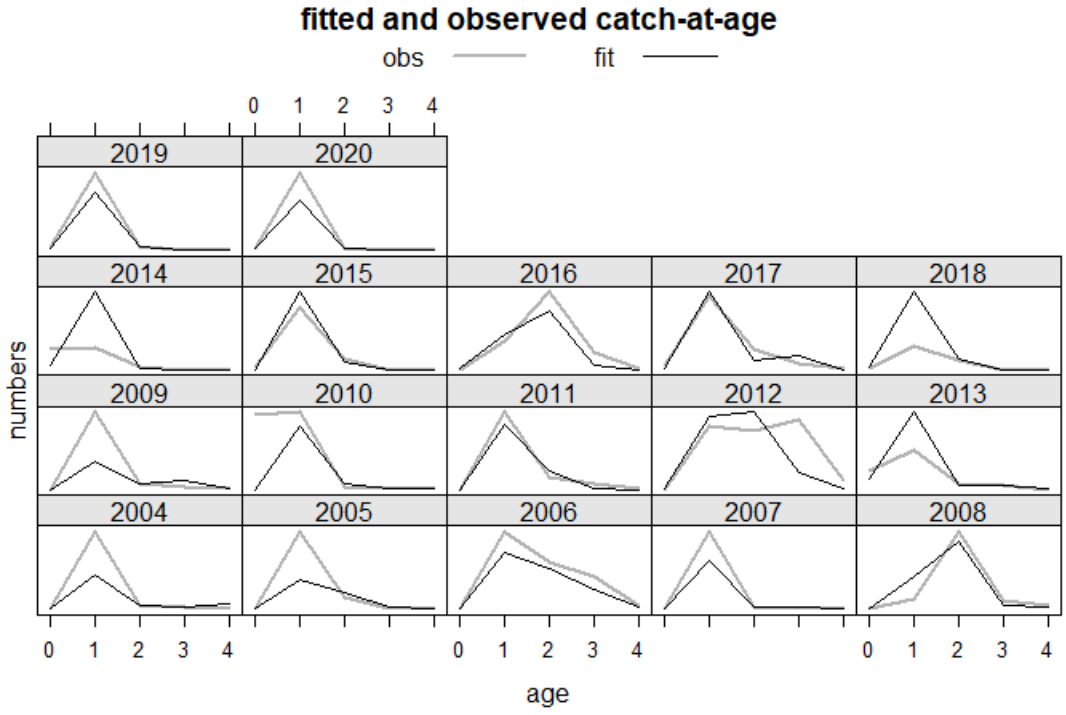

Figure 19.6.2.3. Observed (grey) and estimated by the alternative a4a model (black) catch number-at-age.

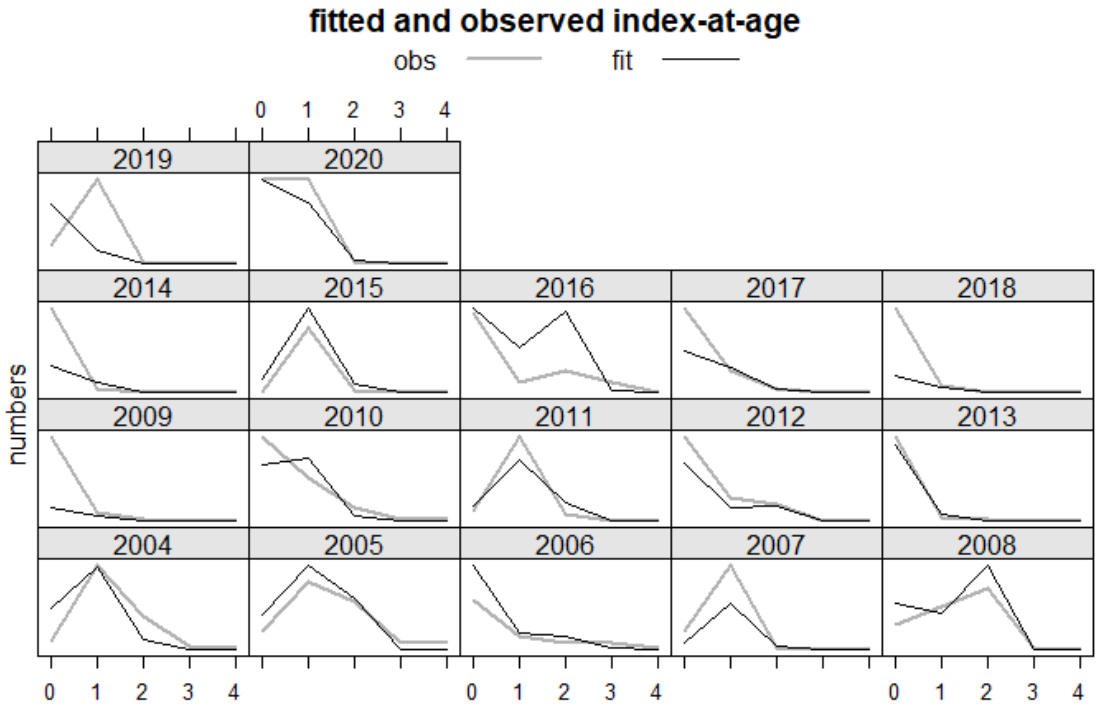

Figure 19.6.2.4. Observed (grey) and by the alternative a4a model (black) indices at age.

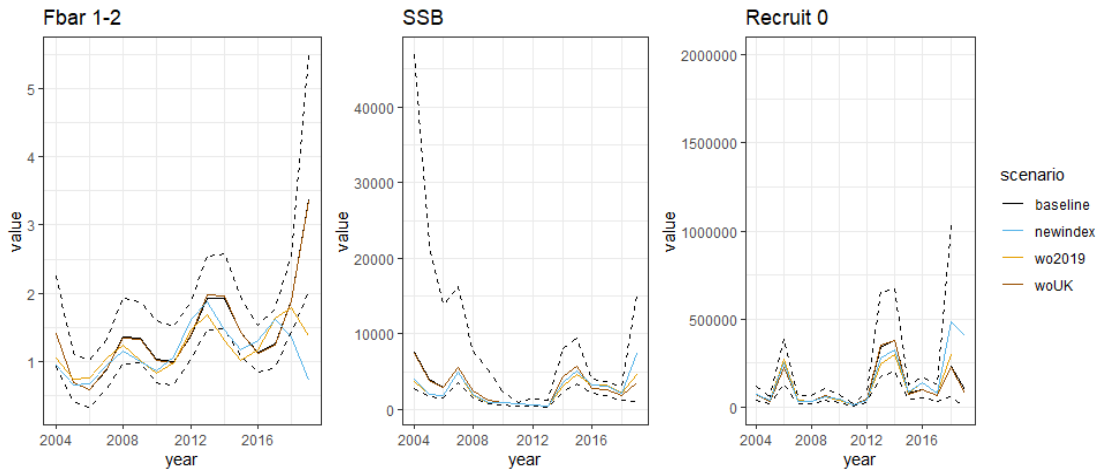

Figure 19.6.3.1. Evaluation of the impact of CGFS survey index issues on stripped red mullet assessment estimation of recruitment, SSB, catch and $F_{bar\ (1–2)}$. All the assessment used the settings from WGNSSK 2020 assessment (ICES, 2020) and data from 2004–2019. The baseline (in black), the run wo2019 (in yellow) and the run woUK (in brown) used the methodology agreed upon during the last benchmark and omits some survey hauls without stripped red mullet in the calculation of the index. The baseline is the assessment from WGNSSK 2020 (ICES, 2020). The run wo2019 is the assessment without CGFS survey data year 2019. woUK is the assessment run that used an index calculated on CGFS survey hauls within the French EEZ. The blue line are the outputs from the assessment using the new preliminary CGFS survey index that still requires age-length key calculation improvement.