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Scientific, Technical and Economic Committee for Fisheries (STECF) - Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-22-09)

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Joint Research Centre

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ABSTRACT

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines This report documents the outcomes of STECF Expert Working Group 22-09: 2022 stock assessments of demersal stocks in the western Mediterranean Sea from the meeting held remotely from 5th to 11th September 2022. A total of 20 fish stocks considered and 18 were fully evaluated. Two stocks had prior advice from 2021 with catch advice for 2022 and 2023, and this is reiterated here. The EWG reports age based assessments, target Fs, with short term forecasts for 15 of the remaining 18 stocks, of these 15, 12 were also analysed for biomass reference points. Catch advice for three stocks was based on ICES category three evaluations of biomass indices. The content of the report gives the STECF terms of reference; the basis of the evaluations; assessments, reference point calculations; summaries of state of stock and advised catch or F based on either the MSY approach for assessed stocks and category 3 based advice for those without assessments. The report contains the full stock assessment reports for the 15 assessments, the exploration of assessments and category 3 evaluations for the remaining three stocks. The report also contains the STECF observations and conclusions on the assessment report. These conclusions come from the STECF Plenary meeting November 2022.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - STOCK ASSESSMENTS: DEMERSAL STOCKS IN THE WESTERN MEDITERRANEAN SEA (EWG 22-09*)*

REQUEST TO THE STECF

STECF is requested to review the report of the STECF Expert Working Group meeting, evaluate the findings and make any appropriate comments and recommendations, especially in regard with the recently adopted EWG 22-11 on the management measures for demersal fisheries in the western Mediterranean Sea.

STECF OBSERVATIONS

EWG 22-09 met in hybrid format remotely, and in person in Arona, from 5th to 11th September 2022. The meeting was attended by 21 experts in total, including four STECF members and one JRC expert. One observer also attended the meeting. The objective of EWG 22-09 was to carry out demersal stock assessments and provide reference points and short-term forecast advice for stocks in the Western Mediterranean as defined in the EWG ToRs.

STECF COMMENTS

STECF acknowledges that the EWG has adequately addressed the ToRs. STECF notes that the EWG has carefully reviewed the quality of the assessments produced. From the overall stock list of 20 stocks, a total of 18 area/species combinations were evaluated this year (Table 1). For three of these assessments, models could not be found to provide acceptable forecasts and a biomass index-based advice is given for these stocks.

STECF notes that in 2021, two-year advice was given for two other stocks (i.e., striped red mullet in GSA 5 and Norway lobster in GSA 5). The rationale for this is explained in Section 5 of the EWG report.

STECF observes that the EWG carried out short term forecasts for the 15 accepted age-based assessments and calculated reference points for 12 of these. The remaining three assessed stocks are new assessments this year and they need further evaluation over time before reference points can be calculated.

Table 1 Summary of the work attempted and basis for advice in 2021 and 2022 assessments. a4a: an age-based assessment method; Index refers to the ICES Category 3 approach to advice for stocks without analytic assessment. * Indicates biomass reference points have been provided.

Area	Species	Method 2021	Basis 2022
1_5_6_7	Hake	a4a	a4a*
1	Deep-water rose shrimp	Index 2020	a4a
5_6_7	Deep-water rose shrimp	Index 2020	a4a
1	Red Mullet	a4a	a4a*
5	Striped Red Mullet	Index 2021	Index 2021
6	Red Mullet	a4a	a4a*
7	Red Mullet	a4a	a4a*
5	Norway lobster	Index 2021	Index 2021
6	Norway lobster	a4a	a4a*
8-9-10-11	Hake	a4a	a4a*
8_9_10_11	Deep-water rose shrimp	a4a	a4a*
9	Red Mullet	a4a	a4a*
10	Red Mullet	a4a	Index 2022
9	Norway lobster	a4a	a4a*
11	Norway lobster	Index 2020	Index 2022
1_2	Blue and red shrimp	a4a	a4a*
5	Blue and red shrimp	Index 2020	a4a
6_7	Blue and red shrimp	a4a	a4a*
8_9_10_11	Blue and red shrimp	a4a	Index 2022
8_9_10_11	Giant red shrimp	a4a	a4a*

The main results are summarized in the bullet point list below and in Table 2. Overall, the assessments indicate that 13 out of the 15 stocks with quantitative advice are being overfished, 4 are being fished close or at F_{MSY}, and 2 are under-exploited. In addition, in 2021, out of the 13 overfished stocks, 8 are behind transition to reach F_{MSY} by 2025 and 5 are ahead of transition (Table 3).

- Hake in GSA 1_5_6_7: the biomass is stable. Catches should be reduced by at least 57% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is ahead of transition. Reference points are available and SSB in 2021 is estimated to be below BMSY, below B_{pa} and below B_{lim}.

- Deep-water rose shrimp in GSA 1: the biomass is increasing. Catches may be increased by no more than 181% to reach F_{MSY} in 2023. F is already below F_{MSY}. Biomass reference points are not available.

- Deep-water rose shrimp in GSA 5_6_7: the biomass is increasing. Catches may be increased by no more than 197% to reach F_{MSY} in 2023. F is already below F_{MSY}. Biomass reference points are not available.

- Red Mullet in GSA 1: the biomass is increasing. Catches should be reduced by at least 59% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, below B_{pa} and above B_{lim}.

- Striped Red Mullet in GSA 5: the biomass is declining. Catches may be increased by no more than 7% to reach F_{MSY} in 2023. Biomass reference points are not available.

- Red Mullet in GSA 6: the biomass is fluctuating. Catches should be reduced by at least 70% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, below B_{pa} and above B_{lim}.

- Red Mullet in GSA 7: the biomass is increasing. Catches should be reduced by at least 12% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is ahead of transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, above B_{pa} and above B_{lim}.

- Norway lobster in GSA 5: the biomass is declining. Catches should be reduced by at least 30% to reach F_{MSY} in 2023. Reference points are not available.

- Norway lobster in GSA 6: the biomass is declining. Catches should be reduced by at least 83% to reach F_{MSY} in 2023. F_{2021} is < F_{MSY} Transition so progress to F_{MSY} in 2025 is ahead of transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, below B_{pa} and below B_{lim}.

- Hake in GSA 8-9-10-11: the biomass is increasing. Catches should be reduced by at least 78% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, below B_{pa} and below B_{lim}.

- Deep-water rose shrimp in GSA 8_9_10_11: the biomass is declining. Catches should be reduced by at least 18% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are available and SSB in 2021 is estimated to be above B_{MSY}, above B_{pa} and above B_{lim}.

- Red Mullet in GSA 9: the biomass is increasing. Catches may be increased by no more than 15% to reach F_{MSY} in 2023. F_{2021} is < F_{MSY} Transition so progress to F_{MSY} in 2025 is ahead of transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, above B_{pa} and above B_{lim}.

- Red Mullet in GSA 10: the biomass is increasing. Catches may be increased by no more than 8% to reach F_{MSY} in 2023. Reference points are not available.

- Norway lobster in GSA 9: the biomass is increasing. Catches should be reduced by at least 91% to reach F_{MSY} in 2023. F_{2021} is < F_{MSY} Transition so progress to F_{MSY} in 2025 is ahead of transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, below B_{pa} and above B_{lim}.

- Norway lobster in GSA 11: the biomass is low fluctuating. Catches should be reduced by at least 27% to reach F_{MSY} in 2023. Reference points are not available.

- Blue and red shrimp in GSA 1_2: the biomass is declining. Catches should be reduced by at least 56% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, below B_{pa} and below B_{lim}.

- Blue and red shrimp in GSA 5: the biomass is declining. Catches should be reduced by at least 53% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are not available.

- Blue and red shrimp in GSA 6_7: the biomass is increasing. Catches should be reduced by at least 50% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, below B_{pa} and above B_{lim}.

- Blue and red shrimp in GSA 8_9_10_11: the biomass is fluctuating. Catches should be reduced by at least 30% to reach F_{MSY} in 2023. Reference points are not available.

- Giant red shrimp in GSA 8_9_10_11: the biomass is declining. Catches should be reduced by at least 27% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2025 is behind transition. Reference points are available and SSB in 2021 is estimated to be below B_{MSY}, above B_{pa} and above B_{lim}.

Table 2 Summary of advice and stock status from EWG 22-09 by area and species based on FMSY target for F2023. Stock status is provided as change in Biomass and F from 2019 to 2021 and where reference points are available status above or below Bmsy, Bpa and Blim. (Reference point definitions and calculations are reported in Sections 4 and 6 of the EWG report respectively) Fishing mortality (F) 2021 is estimated F in the assessment. Where SSB at the start of 2023 is estimated to be below Bpa target F in 2023 is a reduced F (Section 4 of the EWG). Catch in 2023 is based on FMSY or reduced F whichever is lower. Change in F is the difference (%) between target F (FMSY) in 2023 and the estimated F for 2021. Change in catch is the difference (%) between catch 2021 and catch 2023. Biomass and catch 2019-2021 are given as an indication of trends over the last 3 years for stocks with time series analytical assessments or biomass indices. Shaded cells are index based.

Area	Species	Method / Basis	Age Fbar	Biomass 2019-2021	Catch 2019-2021	B rel B_{MSY}	B rel B_{pa}	B rel B_{lim}	F 2021	F MSY	Reduced F	Change in F**	Catch 2021*	Catch 2023	Change in catch**
1_5_6_7	Hake	a4a	1-3	stable	stable	below	below	below	1.34	0.41	0.19	-86%	2350	1004	-57%
1	Deep-water rose shrimp	a4a	1-2	increasing	increasing				0.87	0.99		14%	549	1543	181%
5_6_7	Deep-water rose shrimp	a4a	1-2	increasing	increasing	NA	NA	NA	0.64	1.45		127%	1501	4459	197%
1	Red Mullet	a4a	1-3	increasing	declining	below	below	above	1.42	0.61	0.34	-76%	148	61	-59%
5	Striped Red Mullet	Index 2021		declining	declining								79	85	7%
6	Red Mullet	a4a	1-3	fluctuating	declining	below	below	above	1.07	0.31		-71%	1306	397	-70%
7	Red Mullet	a4a	1-3	increasing	fluctuating	below	above	above	0.48	0.47		-2%	432	380	-12%
5	Norway lobster	Index 2021		declining	declining	NA	NA	NA					54	37	-30%
6	Norway lobster	a4a	3-6	declining	declining	below	below	below	0.49	0.17	0.05	-90%	159	27	-83%
8_9_10_11	Hake	a4a	1-3	increasing	stable	below	below	below	0.61	0.17	0.08	-87%	1964	441	-78%
8_9_10_11	Deep-water rose shrimp	a4a	1-2	declining	fluctuating	above	above	above	1.40	1.26		-10%	1784	1465	-18%
9	Red Mullet	a4a	1-3	Increasing	fluctuating	below	above	above	0.54	0.50		-8%	750	862	15%
10	Red Mullet	Index 2022		increasing	stable	NA	NA	NA					302	326	8%
9	Norway lobster	a4a	2-6	increasing	decreasing	below	below	above	0.17	0.11		-34%	927	79	-91%
11	Norway lobster	Index 2022		low fluctuating	declining	NA	NA	NA					42	31	-27%

1	Blue and Red shrimp	a4a	1-2	declining	fluctuation	below	below	below	1.17	0.29	0.15	-88%	118	52	-56%
5	Blue and Red shrimp	a4a	1-3	declining	declining	NA	NA	NA	1.64	0.34		-79%	99	46	-53%
6_7	Blue and Red shrimp	a4a	1-2	increasing	declining	below	below	above	0.85	0.26		-69%	510	257	-50%
8_9_10_11	Blue and Red shrimp	Index 2022		fluctuating	declining	NA	NA	NA					209	145	-30%
8_9_10_11	Giant red shrimp	a4a	1-3	declining	declining	below	above	above	0.77	0.43		-44%	370	270	-27%

* Estimated Catch from 2022 Assessments STECF EWG 22-09 or index based advice.

**Change in F is % change in F 2023 relative to 2021; change in catch % change catch 2023 relative to 2021.

Table 3 Summary of stock and fishery status by area and species, based on FMSY Transition target for F2023. Recent change gives general change in F and catch over the last three years. F2019 and F_{2021} are both estimated F in the 2022 assessment. F_{2025} is FMSY the target for the end of transition, F_{2019} is the starting point of the MAP. The estimate of progress so far is shown as the F change % 2019 to 2021 and the F status relative to transition with FMSY Transition 2021. Advice for 2023 is based on the FMSY Transition for the next advice year (2023) which is set at a level to reach FMSY in 2025, the change in F and implied by the MAP is the difference (as a fraction) between FMSY Transition in 2023 and the F in 2019 and the most recent year for which there are estimates, F in 2021. Change in catch is from catch 2021 to catch 2023. Shaded cells are index based.

Area	Species	F change	Catch Change	F	F	FMSY Transition	FMSY Transition	Target F 2025	F Change %	F Status 2021	F Change %	F Change %	Catch	Catch 2022	Catch Change
		2019-2021	2019-2021	2019	2021	2021	2023	F MSY	2019-2021	Rel to FMSY Transition 2021	2019-2022	2021-2023	2021	FMSY Transition	2021-2023
1_5_6_7	Hake	declining	stable	1.85	1.34	1.37	0.89	0.41	-28%	ahead transition	-52%	-33%	2350	3442	46%
1	Deep-water rose shrimp	declining	increasing	0.92	0.87	0.94	0.97	0.99	-5%	F below FMSY	5%	11%	549	1521	177%
5_6_7	Deep-water rose shrimp	declining	increasing	1.36	0.64	1.39	1.42	1.45	-53%	F below FMSY	4%	122%	1501	4410	194%
1	Red Mullet	declining	declining	1.62	1.42	1.28	0.95	0.61	-12%	behind transition	-42%	-33%	148	131	-12%
5	Striped Red Mullet		declining										79		
6	Red Mullet	declining	declining	1.14	1.07	0.86	0.59	0.31	-6%	behind transition	-48%	-45%	1306	658	-50%

7	Red Mullet	declining	fluctuating	0.50	0.48	0.49	0.48	0.47	-5%	ahead transition	-4%	0%	432	387	-11%
5	Norway lobster		declining										54		
6	Norway lobster	declining	declining	1.04	0.49	0.75	0.46	0.17	-53%	ahead of transition	-56%	-6%	155	203	30%
8-9-10-11	Hake	stable	stable	0.62	0.61	0.47	0.32	0.17	-2%	behind transition	-48%	-48%	1964	1514	-23%
8_9_10_11	Deep-water rose shrimp	increasing	fluctuating	1.23	1.40	1.24	1.25	1.26	14%	behind transition	2%	-11%	1784	1457	-18%
9	Red Mullet	declining	fluctuating	1.20	0.54	0.96	0.73	0.50	-55%	ahead of transition	-39%	35%	750	1155	54%
10	Red Mullet		stable										302		-100%
9	Norway lobster	decreasing	decreasing	0.30	0.17	0.24	0.17	0.11	-45%	ahead of transition	-43%	4%	927	232	-75%
11	Norway lobster		declining										42		
1_2	Blue and red shrimp	declining	fluctuation	1.41	1.17	1.04	0.66	0.29	-17%	behind transition	-53%	-43%	118	185	56%
5	Blue and red shrimp	declining	declining	2.11	1.64	1.52	0.93	0.34	-22%	behind transition	-56%	-43%	99	103	4%
6_7	Blue and red shrimp	declining	declining	1.09	0.85	0.81	0.54	0.26	-23%	behind transition	-51%	-36%	510	465	-9%
8_9_10_11	Blue and red shrimp		declining										209		-100%
8_9_10_11	Giant red shrimp	increasing	declining	0.71	0.77	0.62	0.52	0.43	8%	behind transition	-27%	-32%	370	318	-14%

STECF considers that for 15 age-based assessments presented in the report, the assessments can be used to provide advice on stock status in terms of F relative to F_{MSY}, and therefore provide catch advice for 2023. For Norway lobster in GSA 11, the assessment presented was not considered suitable for advice and category 3 advice is provided for 2023 and 2024. For blue and red shrimp in GSAs 8_9_10_11, the assessment was unable to reconcile the MEDITS survey and reported magnitude catch in 2018 and 2019 which more than doubled with respect to the years either side. For red mullet in GSA 10 the assessment could not be run due to poor catch sampling in GSA 10 coupled with late, out of sequence survey in recent years. For these two stocks, catch advice has been based on category 3 index advice.

STECF notes that the biomass conservation reference points calculated by EWG 22-03 were endorsed by STECF PLEN 22-02 for 12 stocks. Of the 12 stocks, four were found to be below B_{lim}, four were between B_{pa} and B_{lim} and four above B_{pa} in 2021. STECF considers that these reference points are suitably robust to be used for management purposes.

STECF notes that for stocks with analytical assessments, the EWG has updated the values for F0.1, which is used as a proxy for F_{MSY}. In addition, new biomass reference points have been calculated. STECF considers that, following the evaluation in July 2022 (PLEN 22-02), in order to maintain stability of advice, F and biomass reference points should be used for three years as long as the assessments remain stable (see table 4 below). Therefore, STECF proposes a practical approach based on a 3-year regime for revision of both biomass and F reference points. In order to spread the workload, four stocks should be evaluated every year starting in 2024.

STECF suggests reference points of the four stocks found to be below B_{lim} should be revised in 2024, since the reference points are more sensitive to new values of SSB and recruitment for these stocks (e.g., for these stocks, new values near to B_{lim} are more likely to be obtained in the near future).

STECF considers that the biomass reference points of the stocks between B_{pa} and B_{lim} should be revised in 2025, and those of the stocks above $B_{pa,}$ in 2026. In addition to this formal three yearly evaluation, the EWG should check biomass and F reference points each year and advise STECF if the assessments have changed significantly.

Table 4. Proposed schedule for revision of biological reference points

Year for review	Stock list
2024	Hake 1,5,6 and 7, hake 8,9,10 &11, Norway lobster 6, blue and red shrimp 1,2
2025	Red mullet 1, red mullet 7, blue and red shrimp 6 & 7, Norway lobster 9
2026	Red mullet 7, red mullet 9, deep-water rose shrimp 8,9,10 & 11, giant red shrimp 8,9,10 & 11

STECF notes that the primary catch advice is based on the target of F_{MSY} in 2023 (Table 2). Additional advice associated with the Western Med MAP transition to F_{MSY} in 2025 is also provided (Table 3). Of the 8 stocks estimated as below $B_{pa,}$ STECF observes that in 2021, five are forecast to be below B_{pa} at the start of 2023 and the catches for these stocks are therefore recommended to be reduced below catch at F_{MSY} in order to increase the likelihood of biomass being above B_{pa} in the short term. The values in Table 2 include these reductions (Reduced F).

STECF notes that all the assessments are based on short data series and some degree of uncertainty remains. However, STECF considers overall that the values presented in Table 2 provide robust guidance on the magnitude of changes in F and catches required to reach F_{MSY} by 2023 and those provided in Table 3 provide guidance for a linear transition to reach F_{MSY} in 2025.

STECF notes that the 15 age-based assessments form the basis of the detailed advice given in section 5 of the EWG 22-09 report. The estimates of F_{lower} and F_{MSY} are considered reasonable estimates that can be expected to be precautionary. STECF considers that they can be used directly in the advice. However, STECF notes that the values of F_{upper} are indicative only; they have not been evaluated as precautionary and should not be used to give catch advice without further evaluation.

STECF observes that the EWG 22-09 report also contains values of F and associated catch options for a linear transition in F to reach F_{MSY} in 2025 in Table 3. These F transition values do not consider uncertainty in the estimates. They should be considered as indicative to progressing towards F_{MSY} in 2025.

STECF notes that previously stable assessments have seriously deteriorated due to catch sampling data issues particularly in GSA 10, and to some extent, MEDITS survey timing in GSA 9, 10 and 11 (See below). In the case of red mullet in GSA 10, there has been a failure to provide adequate sampling of catch in 2020, 2021 and STECF understands that this is likely to have continued in 2022. The sampling of catch in GSA 10 has been poor across almost all species, and the current sampling is considered seriously inadequate. The failure of the assessment of red mullet in GSA 10 is due to this data disruption. For other species, catch samples from other GSAs have been used to partially offset the problem. Therefore, STECF observes there is an immediate need to ensure sampling of fisheries in GSA 10 is returned to the level foreseen by the Italian National Work Programme (NWP) in 2023.

STECF notes that the MEDITS survey in several GSAs including GSAs 9, 10 and 11 has been delayed from the time slot expected under the MEDITS protocol to much later in the year for the last two years. This is thought to be occurring in other areas as well. The timing of the survey is important for the consistency of the data used in the assessments, and in several cases, is particularly important for the detection of 0 group fish. If the survey is to deliver robust data for fisheries management, then, in cooperation with MEDITS scientists, the Italian administration needs to ensure that the timing of the survey is within the acceptable boundaries proposed in the MEDITS protocol.

STECF notes that the reported landings of blue and red shrimp in GSA 9, 10 and 11 have more than doubled in 2018 and 2019, relative to the years either side. There is no sign of increased abundance in the MEDITS survey. Such an increase seems unlikely without a change in fishing effort. The relevant Member State authorities need to carry out an evaluation at metier, fleet, port and GSA level to identify the reasons for this increase.

STECF notes that for red mullet in GSA 6 there are still some inconsistences between the two sources of official data from the Spanish authorities, landing data reported in FDI, and landings reported in the Med and Black Sea data calls. These inconsistencies need to be understood and resolved.

STECF CONCLUSIONS

STECF concludes that EWG 22-09 fully addressed all the ToRs. STECF endorses the assessments and evaluations of stock status produced by the EWG. STECF concludes that the results of the assessments provide reliable information on the status of the stocks and on the trends in stock biomass and fishing mortality. For three stocks where the assessment was rejected by the EWG and for two other stocks, advice was provided using ICES Category 3 index advice.

STECF acknowledges that for the first-time advice was provided based on MSY-biomass reference points for stocks where assessments supported the estimation of such reference points. STECF endorses this approach.

In PLEN 22-02, STECF endorsed the general approach for calculating biomass reference points and concluded that the framework developed and tested should be used by EWGs to estimate biomass reference points for the western Mediterranean stocks. STECF suggests that the F and biomass reference points of the stocks should follow a three yearly revision described above. STECF concludes that the calculated values should be checked each year and revised if the assessments change significantly.

STECF concludes that previously stable assessments have been disrupted due to failure in collecting sufficient length and biological data from landings and discards in GSA 10, and to some extent to the MEDITS survey timing. This needs to be resolved by the relevant Member State.

CONTACT DETAILS OF STECF MEMBERS

[1] - Information on STECF members' affiliations is displayed for information only. In any case, Members of the STECF shall act independently. In the context of the STECF work, the committee members do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

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REPORT TO THE STECF

EXPERT WORKING GROUP ON
Stock Assessments: demersal stocks in the western Mediterranean Sea (EWG 22-09)

Hybrid Meeting Arona, 05-11 September 2022

1 INTRODUCTION

1.1 EWG 22-09 ORGANISATION OF THE MEETING

The working group was held in hybrid form remotely and in person in Arona, Italy, from 5th to 11th Sept 2022. The meeting was attended by 21 experts in total, including four STECF members and one JRC expert along with one observer.

The objective of the EWG 22-09 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:15 on the first day. The ToRs were discussed and examined in detail. Stocks were allocated to participants based on expertise. An ad-hoc ftp repository was created to share documents, data and scripts and prepare the report. The stock assessments were evaluated by all participants. Following the exploratory assessment from last year's EWG, (EWG 21-11) deep-water rose shrimp in GSA 1,5,6,7 was split into two regions GSA 1 alone and GSA 5,6 & 7 combined, primarily due to different dynamics observed in the survey.

Over the week plenary sessions were held each day to monitor progress and share results. The overall conclusions for each stock were discussed and finalized in plenary on the Sunday. A review of the assessment quality was completed on Sunday and the meeting closed at 13:15.

1.1 ORGANISATION OF THE REPORT

Section 1 provides a meeting overview and ToRs, Section 2 gives a summary of the report containing all the main conclusions, stock status relative to MSY, MSY Transition and the newly defined biomass reference points and headline fishing mortality and catch values for MSY, reduced MSY and MSY Transition.

Section 3 summaries the areas of work that need additional attention in the future. Section 4 provides an overview of the methodology used to provide stock status, fishing mortality and catch options consistent with MSY and MSY Transition and the methods used to calculate biomass reference points.

Section 5 gives the summaries by stock relating to ToR 8 by stock, based on the template developed in EWG 18-12. Section 6 documents the data, assessments and short term forecasts from ToRs 1-5. Section 7 summarises data deficiencies for ToRs 6 and 7.

1.2 TERMS OF REFERENCE FOR EWG 22-09

STECF EXPERT WORKING GROUP EWG 22-09 concerning the stock assessments in the Western Mediterranean Sea *5 September – 11 September 2022,* ***(Arona, hybrid)***

Chair: John Simmonds

DG MARE focal points: Anne-Cécile Dragon and Giacomo Chato Osio.

TERMS OF REFERENCE

For the stocks given in Table 1.1, the group is requested:

ToR 1. To compile and provide the most updated information on stock identification and boundaries, length and age composition, growth, maturity, feeding, essential fish habitats including spawning grounds and seasonality as well as natural mortality.

ToR 2. To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2019, including length frequency distribution over time and, where possible, including estimates from recreational fisheries landings.

ToR 3. To assess trends in historic and recent stock parameters on fishing mortality, stock biomass, spawning stock biomass, and recruitment. Different assessment models should be applied as appropriate, including retrospective analyses. The selection of the most reliable assessment shall be explained. Assumptions and uncertainties shall be specified. To assist with development of management plans, give preference to models that allow estimation of uncertainty, in line with the recommendations of STECF EWG 17-07.

ToR 4. Using the work developed during EWG 22-03, estimate the F_{MSY} point value, range of F_{MSY} (i.e. MSY FLOWER and MSY FUPPER) and the conservation reference points (i.e. B_{pa} and BLIM), or proxy. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.

ToR 5. To provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, including: the status quo fishing mortality and target F_{MSY} range (i.e. F_{MSY} point value, MSY FLOWER and MSY FUPPER) or other appropriate proxy by 2023 and by 1 January 2025. If the stock is considered to be being fished above F_{MSY} provide a F and catch option (F_{MSY} Transition) consistent with the transition to MSY in January 2025. Also where the stock is considered likely to be below BLIM and/ or B_{pa} in 2023 provide catch options to restore SSB above B_{pa} in the short term, following the methodology adopted for other EU sea-basins (see Annex I below).

ToR 6. To summarize and concisely describe all data quality deficiencies, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched in May 2022. Identify further research studies and data collection which would be required for improved fish stock assessments.

ToR 7. To ensure that all unresolved data transmission issues encountered prior to and during the EWG meeting are reported online via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt. Guidance on precisely what should be inserted in the DTMT, log-on credentials and access rights will be provided separately by the STECF Secretariat focal point for the EWG.

ToR 8. Using the report structure developed in 2018 (EWG 18-12), provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stocks (spawning stock biomass, stock biomass, recruits and exploitation level relative to Fmsy and F Transition, and by fishing gear, if possible including relevant types of trawlers, longliners and netters); (iii) the source of data and methods and; (iv) the management advice taking into account stock biomass using e.g. the ICES control rule (see Annex I below), including F_{MSY} value, range of values, conservation reference points and effort levels. Provide a summary table showing the progress already made in the transition towards MSY and the F and catch advice for 2023 to reach F_{MSY} by 1 January 2025.

Table 1.1– List of suggested stocks to be assessed by the EWG 22-09.

Area	Common name	Scientific name
GSA 1-5-6-7	Hake	*Merluccius merluccius*
GSA 1-5-6-7	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 1	Red mullet	*Mullus barbatus*
GSA 5	Striped red mullet	*Mullus surmuletus*
GSA 6	Red mullet	*Mullus barbatus*
GSA 7	Red mullet	*Mullus barbatus*
GSA 5	Norway lobster	*Nephrops norvegicus*
GSA 6	Norway lobster	*Nephrops norvegicus*
GSA 8-9-10-11	Hake	*Merluccius merluccius*
GSA 8-9-10-11	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 9	Red mullet	*Mullus barbatus*
GSA 10	Red mullet	*Mullus barbatus*
GSA 9	Norway lobster	*Nephrops norvegicus*
GSA 11	Norway lobster	*Nephrops norvegicus*
GSA 1-2	Blue and red shrimp	*Aristeus antennatus*
GSA 5	Blue and red shrimp	*Aristeus antennatus*
GSA 6-7	Blue and red shrimp	*Aristeus antennatus*
GSA 8-9-10-11	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 8-9-10-11	Blue and red shrimp	*Aristeus antennatus*

2 SUMMARY OF MAIN OUTCOMES

2.1 STOCK-SPECIFIC FINDINGS & CONCLUSIONS

See the stock specific summary sheets (Section 5) for the main details by stock, and the assessments (Section 6) for full details. This section provides collated information on methods and stock status. The methods tested and chosen by stock are provided in Table 2.1. Where possible age-based assessments are used, where these do not provide stable enough models, if indices of abundance are available ICES category 3 stock advice is applied. Five stocks have advice based on biomass indices following these ICES category 3 procedures. The remaining 15 of the 20 assessments have been considered suitable for short term forecasts using the standard STF projection with assumptions of *status quo* F and historic recruitment. The results in terms of F and catch based on F_{MSY} targets and relative changes from 2019 to 2021 are provided in Table 2.2. along with biomass status relative to B_{MSY}, B_{pa} and B_{lim}. For several stocks in the Western Mediterranean a MAP has been adopted which aims to bring exploitation levels to F_{MSY} by 2025. In 2019 STECF suggested that as a guide to progress towards F_{MSY} in 2025 STECF would provide advice for F and catch based on a 6 year linear change in F from 2019 to 2025. The details of this approach are laid out in Section 4.4.1. Table 2.3 provides a summary by stock of progress to 2021, based on F_{2021} in the most recent assessment, which includes the effect of any changes implemented before and during 2021. The future F and catch options for 2023 based on the linear transition are also provided in Table 2.3.

Of the 15 assessed stocks 12 have had reference points calculated based on the methodology reported in EWG 22-03 and endorsed by STECF in their Summer Plenary held in July, the remaining three assessments are new assessments not yet suitable for reference points as the stability of the assessments is untested.

Table 2.1 Summary of the work attempted and basis for advice in 2020 and 2021 assessments. a4a: an age-based assessment method; Index refers to the ICES Category 3 approach to advice for stocks without analytic assessment[1]. Selected method in Bold

Area	Species	Method 2021	Basis 2022
1_5_6_7	Hake	a4a	**a4a,STF**
1	Deep-water rose shrimp	Index 2020	**a4a,STF**
5_6_7	Deep-water rose shrimp	Index 2020	**a4a,STF**
1	Red Mullet	a4a	**a4a,STF**
5	Striped Red Mullet	Index 2021	**Index 2021**
6	Red Mullet	a4a	**a4a,STF**
7	Red Mullet	a4a	**a4a,STF**
5	Norway lobster	Index 2021	**Index 2021**
6	Norway lobster	a4a	**a4a,STF**
8-9-10-11	Hake	a4a	**a4a,STF**
8_9_10_11	Deep-water rose shrimp	a4a	**a4a,STF**
9	Red Mullet	a4a	**a4a,STF**
10	Red Mullet	a4a	a4a, SPiCT, **Index 2022**
9	Norway lobster	a4a	a4a,**STF**
11	Norway lobster	Index 2020	**a4a, Index 2022**
1_2	Red and blue shrimp	a4a	**a4a,STF**
5	Red and blue shrimp	Index 2020	**a4a,STF**
6_7	Red and blue shrimp	a4a	**a4a,STF**
8_9_10_11	Red and blue shrimp	a4a	a4a, **Index 2022**
8_9_10_11	Giant red shrimp	a4a	**a4a,STF**

Table 2.2 Summary of advice and stock status from EWG 22-09 by area and species based on **F_{MSY} target for F2023**. Stock status is provided as change in Biomass and F from 2019 to 2021 and where reference points are available status above or below B_{msy}, B_{pa} and B_{lim}. (Reference point definitions and calculations are reported in Sections 4 and 6 respectively) Fishing mortality (F) 2020 is estimated F in the assessment. Where SSB at the start of 2023 is estimated to be below B_{pa} F is reduced (Section 4). Catch in 2023 is based on F_{MSY} or reduced F whichever is lower. Change in F is the difference (%) between target F (F_{MSY}) in 2022 and the estimated F for 2020. Change in catch is the difference (%) between catch 2020 and catch 2022. Biomass and catch 2018-2020 are given as an indication of trends over the last 3 years for stocks with time series analytical assessments or biomass indices. Shaded cells are index based.

Area	Species	Method / Basis	Age Fbar	Biomass 2019-2021	Catch 2019-2021	B rel B_{MSY}	B rel B_{pa}	B rel B_{lim}	F 2021	F MSY	Reduced F	Change in F**	Catch 2021*	Catch 2023	Change in catch**
1_5_6_7	Hake	a4a	1-3	stable	stable	below	below	below	1.34	0.41	0.19	-86%	2350	1004	-57%
1	Deep-water rose shrimp	a4a	1-2	increasing	increasing				0.87	0.99		14%	549	1543	181%
5_6_7	Deep-water rose shrimp	a4a	1-2	increasing	increasing				0.64	1.45		127%	1501	4459	197%
1	Red Mullet	a4a	1-3	increasing	declining	below	below	above	1.42	0.61	0.34	-76%	148	61	-59%
5	Striped Red Mullet	Index 2021		declining	declining								79	85	7%
6	Red Mullet	a4a	1-3	fluctuating	declining	below	below	above	1.07	0.31		-71%	1306	397	-70%
7	Red Mullet	a4a	1-3	increasing	fluctuating	above	above	above	0.48	0.47		-2%	432	380	-12%
5	Norway lobster	Index 2021		declining	declining								54	37	-30%
6	Norway lobster	a4a	3-6	declining	declining	below	below	below	0.49	0.17	0.05	-90%	159	27	-83%
8_9_10_11	Hake	a4a	1-3	increasing	stable	below	below	below	0.61	0.17	0.08	-87%	1964	441	-78%
8_9_10_11	Deep-water rose shrimp	a4a	1-2	declining	fluctuating	above	above	above	1.40	1.26		-10%	1784	1465	-18%
9	Red Mullet	a4a	1-3	Increasing	fluctuating	below	above	above	0.54	0.50		-8%	750	862	15%
10	Red Mullet	Index 2022		increasing	stable								302	326	8%
9	Norway lobster	a4a	2-6	increasing	decreasing	below	below	above	0.17	0.11		-34%	927	79	-91%
11	Norway lobster	Index 2022		low fluctuating	declining								42	31	-27%
1	Blue and Red shrimp	a4a	1-2	declining	fluctuation	below	below	below	1.17	0.29	0.15	-88%	118	52	-56%
5	Blue and Red shrimp	a4a	1-3	declining	declining				1.64	0.34		-79%	99	46	-53%
6_7	Blue and Red shrimp	a4a	1-2	increasing	declining	below	below	above	0.85	0.26		-69%	510	257	-50%
8_9_10_11	Blue and Red shrimp	Index 2022		fluctuating	declining								209	145	-30%
8_9_10_11	Giant red shrimp	a4a	1-3	declining	declining	below	above	above	0.77	0.43		-44%	370	270	-27%

* Estimated Catch from 2022 Assessments STECF EWG 22-09 or index based advice.

**Change in F is % change in F 2023 relative to 2021; change in catch % change catch 2023 relative to 2021.

Table 2.3 Summary of stock and fishery status by area and species, **based on $F_{MSY\ Transition}$ target for F_{2023}.** Recent change gives general change in F and catch over the last three years. F_{2019} and F_{2021} are both estimated F in the 2022 assessment. F $_{2025}$ is F_{MSY} the target for the end of transition, F_{2019} is the starting point of the MAP. The estimate of progress so far is shown as the F change % 2019 to 2021 and the F status relative to transition with $F_{MSY\ Transition}$ 2021. **Advice for 2023** is based on the $F_{MSY\ Transition}$ for the next advice year (2023) which is set at a level to reach F_{MSY} in 2025, the change in F and implied by the MAP is the difference (as a fraction) between $F_{MSY\ Transition}$ in 2023 and the F in 2019 and the most recent year for which we has estimates, F in 2021. Change in catch is from catch 2021 to catch 2023. Shaded cells are index based.

Area	Species	F change 2018-2020	Catch Change 2018-2020	F 2019	F 2021	F_{MSY} Transition 2021	F_{MSY} Transition 2023	Target F 2025 F MSY	F Change % 2019-2021	F Status 2021 Rel to F_{MSY} transition 2021	F Change % 2019-2022	F Change % 2021-2023	Catch 2021	Catch 2022 F_{MSY} Transition	Catch Change 2021-2023
1_5_6_7	Hake	declining	stable	1.85	1.34	1.37	0.89	0.41	-28%	ahead of transition	-52%	-33%	2350	3442	46%
1	Deep-water rose shrimp	declining	increasing	0.92	0.87	0.94	0.97	0.99	-5%	F below F_{MSY}	5%	11%	549	1521	177%
5_6_7	Deep-water rose shrimp	declining	increasing	1.36	0.64	1.39	1.42	1.45	-53%	F below F_{MSY}	4%	122%	1501	4410	194%
1	Red Mullet	declining	declining	1.62	1.42	1.28	0.95	0.61	-12%	behind transition	-42%	-33%	148	131	-12%
5	Striped Red Mullet		declining										79		
6	Red Mullet	declining	declining	1.14	1.07	0.86	0.59	0.31	-6%	behind transition	-48%	-45%	1306	658	-50%
7	Red Mullet	declining	fluctuating	0.50	0.48	0.49	0.48	0.47	-5%	ahead of transition	-4%	0%	432	387	-11%
5	Norway lobster		declining										54		
6	Norway lobster	declining	declining	1.04	0.49	0.75	0.46	0.17	-53%	ahead of transition	-56%	-6%	159	203	30%
8-9-10-11	Hake	stable	stable	0.62	0.61	0.47	0.32	0.17	-2%	behind transition	-48%	-48%	1964	1514	-23%
8_9_10_11	Deep-water rose shrimp	increasing	fluctuating	1.23	1.40	1.24	1.25	1.26	14%	behind transition	2%	-11%	1784	1457	-18%
9	Red Mullet	declining	fluctuating	1.20	0.54	0.96	0.73	0.50	-55%	ahead of transition	-39%	35%	750	1155	54%
10	Red Mullet		stable										302		
9	Norway lobster	decreasing	decreasing	0.30	0.17	0.24	0.17	0.11	-45%	ahead of transition	-43%	4%	927	232	-75%
11	Norway lobster		declining										42		
1_2	Red and blue shrimp	declining	fluctuation	1.41	1.17	1.04	0.66	0.29	-17%	behind transition	-53%	-43%	118	185	56%
5	Red and blue shrimp	declining	declining	2.11	1.64	1.52	0.93	0.34	-22%	behind transition	-56%	-43%	99	103	4%
6_7	Red and blue shrimp	declining	declining	1.09	0.85	0.81	0.54	0.26	-23%	behind transition	-51%	-36%	510	465	-9%
8_9_10_11	Red and blue shrimp		declining										209		
8_9_10_11	Giant red shrimp	increasing	declining	0.71	0.77	0.62	0.52	0.43	8%	behind transition	-27%	-32%	370	318	-14%

2.2 QUALITY OF THE ASSESSMENTS

There has been recent deterioration in the data collection in in Italian MEDITS surveys, timing has been late in 2020 and 2021 and is set to be late in 2022. In addition sampling of commercial catch and discards in GSA 10 has been unacceptably poor across almost all species in the same years (2020 and 2021). This has resulted in particular problems for the red mullet assessment in GSA 10, and because of these data collection failures it has not been possible to obtain an assessment for this species (see below and Section 6.12.). For other the stocks, that use data from GSA 10, and are assessed along with other GSAs it has been possible to cover the missing data from by borrowing catch sample information from GSAs 9 and 11, however, the deterioration in data does result in poorer assessments. It is a matter considerable urgency that sampling of catch from GSA 10 is improved immediately. In addition the MEDITS survey of 9 10 and 11 needs to be carried out at a specific time of year. It should be decided which time of year is best, for logistical and data reasons and then conducted at this time point henceforth. The survey is used for several short-lived summer spawning species and timing is critical for collecting consistent data for these species.

Hake

The assessment of hake in GSA 1567 is an update from last year and following the GFCM December 2019 benchmark. The results are very consistent with last year's results with biomass 2021 is similar to 2020. There is need to explore some of the historic survey data from 2010, 2011 in the hope that very low values could be explained and removed from the data. Currently MEDITS values at age 4 are probably slightly distorting the assessment in these years, though age 4 is outside the main age range used to compute Fbar. Recruitment in 2021 is observed to be high but information is sparse and may of course be revised in the light of more data, but currently SSB is expected to rise if F can be further reduced. Discards are observed to be increasing in recent years and are now included in this year's assessment. There is a small revision to reference points calculated in April (EWG 22-03) due to the higher 2021 recruitment.

The assessment for hake in GSA 8,9,10 & 11 is still following the benchmark settings from GFCM in December 2019 and is consistent with last year the model. The results are fully in line with previous years assessments. The assessment includes GSA 10 data sampling issues in recent years (noted above) and this has an impact but is not considered critical to the assessment, because the data from other GSAs can be used to mask some of the problems. For example in common with other species there was an issue with discard data in GSA 10, and data from other areas is better. Reference points are very similar to those calculated in April.

Red Mullet

Red mullet in GSA 1 results are consistent with last year, and the model is stable, and appears more stable than previous years. The lack of survey in 2020 is not causing significant problems because as a new survey point in line with 2018-2019 is available. There is evidence of discards, which is new and may need more attention in the future. Reference points are similar to those obtained in April (EWG 22-03).

The assessment of red mullet in GSA 6 is an update of last year's assessment, the model is unchanged and the results are similar to 2021 assessment. Discards are included. There still some inconsistences in the data between the FDI and Med and Black Sea calls, and the EWG used Med BS following information from Spanish authorities. But these inconsistencies need to be resolved. In addition there are some differences in reported catch in 2009 and 2010 between GFCM and Med and Black Sea data call. There is no obvious explanation for these differences and the again the differences should be resolved. These issues are reported in the DTMT and should be followed up. Using the new assessment the reference points are similar to those calculated in April.

For red mullet in GSA 7 the formulation of the model was consistent with previous years. The results are also consistent. It should be noted that the 2021 data in MEDITS survey indicated high abundance particularly for the older ages and looks anomalous, but could also signify reduced F. This revised assessment amends the estimated recruitment and the reference point fit was changed resulting in a big shift in the fitted breakpoint which was found to be very sensitive to the 2022 assessment, with resulting fitted B_{lim} found to be unstable. Given the reference point instability the methodology adopted in EWG 22-03 required a change to the use of geometric mean and default B_{lim} based on 25% of $B_{F0.1}$. The resulting B_{lim} was not significantly different from the previously proposed value, but is now much less sensitive to individual recruit values. The SSB is now estimated to be close to our estimate of B_{MSY}. The estimated recruitment reached a peak in 2020, the reason the long-term increase recruitment is not known. There is some long-term effort decline observed, but the effort data shows changes between fishing gears, with the fishery has moving partially to twin trawls. This shift in gear could influence both the management and the assessment. Because there is now a new important metier in GSA 7 this new fleet may need additional monitoring.

The red mullet in GSA 9 assessment is an update with same settings as 2021. The assessment this year is a little more unstable, due partly to sharp change in landings in recent years. There is a decline in retrospective performance. However, the model is still stable enough for advice. The MEDITS survey has been conducted later in the year over 2020, 2021 and is expected to be in late in 2022 as noted above. The reference point calculated with the new assessment are similar to those calculated in April (EWG 22-03).

For red mullet in GSA 10 the previous a4a assessment model could not be updated for use for advice, due to very poor sampling of catch in GSA 10 in 2020 and 2021. Last year the model was by used estimating catch at age in 2020. However now, with two years of very poor sampling in GSA 10 and with the MEDITS survey delayed in 2020 and 2021 the a4a model could not be used for providing advice. Without samples it is impossible to give estimates of incoming year classes Several other assessment methods were tested including the use of a MEDITS biomass index and a biomass surplus production model. However, it was not possible to complete this surplus production model satisfactorily. Advice is therefore based on an ICES category 3 method for short lived species. However, given the data issues this advice is only given for a single year. It is anticipated that this problem may be repeated next year as the MEDITS will be delayed again and there are no signs of improved sampling. (See also text at the head of this section above and Section 6.12 below)

Striped Red Mullet

For striped red mullet in GSA 5 advice was given for 2 years in 2021 and last year's advice is reiterated in Section 5.5. New data is documented in Section 6.5.

Norway lobster

For Norway lobster in GSA 5 advice was given for 2 years in 2021 and last year's advice is reiterated in Section 5.5. New data is documented in Section 6.5.

The Assessment of Norway lobster in GSA 6 has a number of revisions to the input information; a new maturity ogive calculated from new MS data in the MEDBS data call; there was a minor change to the use of the growth function used last year. Data from catch sampling in 2020 has been omitted as it now appears poorly sampled and incorrect in the light of 29021 sampling. The assessment model is unchanged, but selection in the new assessment results in a reduction in $F_{0.1}$, changing the perception of the fishery. The changes in stock dynamics and modified maturity ogive taken together have little influence on SSB and reference points thus the state of the stock in terms of biomass is largely unaltered.

The assessment for Norway lobster in GSA 9 is a slightly amended assessment with the extra data from 2021. The model has minor changes and the results are in line with last year. Small changes in the input data were made to correct errors in mean weight in 2019, these are reported in DTMT. The maturity ogive was changed to correct an error in age assignment found in last year's assessment. The model formulation was simplified but estimated F is similar, though

$F_{0.1}$ is slightly different with the new assessment. Reference points similar even though the $F_{0.1}$ has changed due to maturity correction.

For Norway lobster in GSA 11 a full exploration of the data was carried out but the EWG could not fit an acceptable age based assessment. Strong residual patterns in MEDITS survey (or catch) were observed and fitted models were very unstable. The conflict between catch and survey could not be resolved though the mismatch could be moved from one to the other. Overall, no satisfactory solution could be found. For the future a production model needs to be investigated, as the time series of age data are relatively short given number of ages. For this year advice is based on ICES cat 3 biomass survey index. This results in advice for decreasing catches, similar to previous years. The catches in the Med and Black Sea data call had been updated since the last advice so the new advice is based on the substantially revised catches.

Deep-water Rose Shrimp

Following the separate GSA evaluations carried out in 2021 (EWG 21-11) it was decided to assess GSA 1 separately because the survey suggested that stock dynamics was different from GSA 5, 6 & 7, with the recent recruitments occurring in different years, whereas GSA 5, 6 & 7 show more coherence. For both stocks in GSAs 1, and GSA 5, 6 and 7 there is strong evidence of increased recruitment in recent years this gives rise to uncertainty in model fit particularly for selection, though both areas show similar selection at age in the fishery. No reference points were calculated for these stocks as the new assessments need to be carried out for a few years to assess their stability before setting reference points.

For deepwater rose shrimp in GSA 1 there are catch length data issues for OTB_DWS in 2021. There is poor cohort consistency in the survey and the assessment suggests high values for F at age 2 particularly in the beginning of the time series. There is also uncertainty in the correct growth parameters with differences between published and DCF values. Overall the assessment diagnostics considered acceptable, but model uncertainty was particularly high in the last years, which is understandable because there is a steep increasing trend in catches in last years, recruitment is seen be changing and selectivity is hard to estimate. A few more years of data are needed to assess the stability of the assessment, nevertheless advice using this assessment is considered better than index based advice given last year.

This year the assessment of deep-water rose shrimp in GSAs 5, 6 and 7 is also a new assessment. Data preparations were carried out successfully even if some minor issues in the survey needed to be fixed. The first available year of Spanish landings data in GSA7 was 2008 the time series used has been constrained to 2008 to 2021. The survey data was standardized by removing Ibiza and Formentera hauls as the number of hauls in these areas is inconsistent over time. The stock is seen to be continuously evolving showing in all the 3 GSAs sharp increases both in catch and index values in the last years. Although these dynamics didn’t preclude the fitting of a sensible model it did give a residual pattern in age 0 in the catches. The chosen model is still considered to give an acceptable range of uncertainty but does result in some instability in the retrospective when more than two years have been removed. This is a short lived species in which almost 100% of the catches concentrated in age 1 and 2. Due to the retrospective instability, and because this is the first assessment, the group agreed in using the assessment results for providing stock advice (F/F_{MSY} =0.44). It is not yet considered stable enough for providing the biomass reference points.

For the assessment for deep-water rose shrimp in GSA 8 9 10 11 a new stock object and indices was calculated including GSA 8. Some changes in growth parameters were applied and a modified maturity vector used to better reflect midyear spawning and M changed slightly to conform to changes in growth parameters used. The resulting model was less complex and more stable than the one used previously. Overall, the results are coherent with last year’s results. Many of the quality issues for GSA 10 discussed above occur with this species too, with very poor catch sampling data in last three years and the delayed survey. The data sampling problem is masked to some extent by data in GSA 9 so an assessment is possible. Both landing and discards are poorly sampled. Calculation of reference points show only minor differences from those calculated in April (EWG 22-03).

Red and Blue Shrimp

For the assessment of blue and red shrimp in GSA 1 and 2 input data revised from the GSA 1 assessment of last year, to include data from GSA 2. Length data was available for GSA 2, though no biological parameters so those from GSA 1 were used. With the addition of GSA 2 some issues observed last year, low observations in GSA 1 in 2009, 2011 and 2013, were resolved. The a4a model was run with the similar sub-models to the previous year. Other submodels were tested to improve the residuals in ages 3 and 4 for the catch data but this increased model instability so were rejected. It seems there is some conflict between catch data and survey data at age, and there's a need to look at the raw data for the next EWG and to consider if growth parameters are suitable. This year the 2006 MEDITS survey allocation of stations to GSA 1 or 2 was resolved. The absence of a survey in 2020 means there is a gap in the time series. $F_{0.1}$ from the new assessment is the same as the GSA 1 assessment and F current is consistent with previous assessment. Biomass reference points have been revised since April (EWG 22-03) to account for account for the addition of GSA 2 catches.

For blue and red shrimp in GSA 5 a new assessment with similar model to the one used in GFCM was tested. Exploration of other selection options did not improve the model and the only difference is the treatment of age 0 which was omitted due to sparsity of data. The issues of selection at age 3 and 4 are similar to those observed in GSA 1 and again other submodels were tested to improve the residuals but again this increased model instability so was rejected. The assessment is accepted for advice but its stability is unknown and it is considered too soon to give reference points.

For blue and red shrimp in GSA 6 and 7 the data series was reassembled on the same basis at previously. Inconsistencies in sampling information and uncertainties on overall catch for 2003 and 2002 meant that data from these two years were not used and assessment was started from 2004. Models tested and found to be good are similar to last year but k was reduced from 8 to 7 based on both stability and statistical criteria. Overall, the new assessment is considered to be improved from last year. There are a few minor issues; there is a shortage of discard information; some small length in the catch in 2021 were assigned to age 0 but moved to age 1 because they came from 1st quarter catches and must have come from spawning in the previous year. The MEDITS index for 2020, where sampling was different, was evaluated spatially and found to be consistent so despite the partial area coverage no correction was applied and 2020 MEDITS index included. A very few samples with strange numbers could not be corrected so they were removed. Reference points calculated from the revised assessment were very similar to those calculated in April (EWG 22-03).

For blue and red shrimp in GSA 8, 9, 10 & 11 the data was updated with 2020 values. Data was extracted from clean start to ensure data came correctly by year, as there were some differences between 2021 data and those extracted this year. The assessment was unstable and evaluation suggests this is due to more than doubling of catch in 2018 and 2019 relative to years before and after. The assessment was rejected by because of very poor retrospective probably due to the two big values for catch. The MEDITS survey shows no evidence of increased abundance or increased mortality to account for these reported increases in catch in 2018 and 2019. Catch in GSA 10 was not sampled properly. Catch data from 2017 was corrected but has still not been supplied correctly, with different quarters missing in different data submissions, however, by examining both 2021 and 2022 data calls, the 2017 data could be estimated. The advice is based on an ICES category 3 biomass index method. It is very important that catch in 2018 and 2019 is verified by examining it by fleet, port, quarter and possibly by vessel to explain the differences from 2016 through to 2020.

Giant Red Shrimp.

For giant red shrimp in GSA 8, 9, 10 & 11 data from no data was available for GSA 8, and MEDITS in GSA 8 gives only scattered results. With no catches from GSA 8 and no real presence in the survey, it was considered preferable to deal with a coherent survey and catch area to provide a unit stock. So, this was an update assessment of GSAs 9, 10 & 11 with results very consistent with last year's assessment. This stock assessment suffers from the same GSA 10 data issues and delayed MEDITS survey discussed above. There were similar issues for 2017 catch data to those found for blue and red shrimp in the same area. Reference points were recalculated and were similar to those calculated in EWG 22-03.

2.3 REFERENCE POINTS

For 13 of the stocks evaluated here reference points were previously calculated in April 2022 (EWG 22-03) and endorsed by STECF Plenary July 2022. Three other stocks have assessments, but these are new this year and their stability is unchecked, reference points for these stocks have not been calculated. The remaining five stocks do not have analytical assessments. The reference points have been recalculated following the agreed procedures from EWG 22-03. The calculations are documented by stock in Section 6 and included in the summary sheets in Section 5. The reference points are tabulated in Table 2.4 along with the percentage change in value from the earlier evaluations. In most cases the revisions are small. Moderate revisions (~18%) have occurred in two stocks where HS fit has been altered by the assessment update and revised recruitment (hake 8-9-10-11, red mullet in GSA 1). In these cases the HS fit is still preferred to the use of geomean. For three stocks there have been revisions to the models which include: increased catches as blue and red shrimp in GSA 1 has been expanded to include GSA 2 catch as well; and Norway lobster in GSA 6 and GSA 9 where the assessments are slightly revised with changes to maturity ogives and some change in fishery selection to improve the models resulting in reducing F0.1. For the remainder the changes are negligible ranging from 1-9%

		Reference point value EWG 22-09 September 2022				Change from EWG 22-03 April 2022				Notes
Area	Species	$F_{0.1}$	$B_{F0.1}$	B_{lim}	B_{pa}	$F_{0.1}$	$B_{F0.1}$	B_{lim}	B_{pa}	
1_5_6_7	Hake	0.41	63696	3872	7743	-8%	7%	-6%	-6%	
1	Deep-water rose shrimp									
5_6_7	Deep-water rose shrimp									
1	Red Mullet	0.61	399	170	338	0%	-5%	-17%	-17%	Change in HS fit
5	Striped Red Mullet									
6	Red Mullet	0.31	3079	770	1540	-1%	-7%	-7%	-7%	
7	Red Mullet	0.47	491	123	246	3%	8%	-4%	-4%	Use of GM changes long term yield expectations
5	Norway lobster									
6	Norway lobster	0.17	1890	472	944	-28%	-6%	-6%	-6%	Includes change in Maturity ogive
8-9-10-11	Hake	0.17	49500	5132	10264	1%	14%	19%	19%	Shift in fitted level due big recruitment increased in last year
8-9-10-11	Deep-water rose shrimp	1.26	855	214	427	-2%	-5%	-5%	-5%	
9	Red Mullet	0.50	1846	462	923	-4%	2%	2%	2%	
10	Red Mullet	0.00	0	0	0					
9	Norway lobster	0.11	927	232	463	-63%	14%	14%	14%	Maturity change and simpler fishery selection model
11	Norway lobster									
1_2	Red and blue shrimp	0.29	622	154	309	-2%	18%	28%	28%	Catches now including GSA 2
5	Red and blue shrimp									
6_7	Red and blue shrimp	0.26	1520	261	521	-9%	-1%	-1%	-1%	
8-9-10-11	Red and blue shrimp									
8-9-10-11	Giant red shrimp	0.43	762	191	381	-8%	7%	7%	7%	

3 FUTURE DEVELOPMENTS

The EWG briefly addressed future development for data requirements and data issues currently affecting assessments. The following points were noted as important:

Improved data on differences by sex: A considerable number of species assessed by this EWG show quite strong sexual dependency on growth. This is particularly the case for hake, blue and red shrimp, giant red shrimp, Norway lobster and deep-water rose shrimp. For these species many have separate growth models by sex, but often the supporting sex based information is sparse, particularly fraction at length by sex by year. However, if recruitment varies fraction by sex at length will be expected to change by year as individual cohort abundances appear at different length at different times due to the different growth rates. There is a need for such data to be made available to the EWG if already available from the sampling, and if not it is important to amend the sampling programs to obtain sex at length data on an annual basis.

There has been a major failure to collect sufficient catch sample data for GSA 10 in 2020 and 2021 over almost all species dealt with in the EWG. It seems likely that this problem may also occur in 2022. It is affecting all the assessments, but has proved critical for red mullet in GSA 10 which has failed due to this poor sampling. The poor sampling in 2020 was thought to be due to COVID, but it now seems likely this was not the case, as the problem did not occur with the same severity elsewhere, and the fact that it is persisting through 2021 suggests there is some other reason for the failure. The issue is reported in the DTMT but it should be followed up with urgency with the Italian authorities as this is identified as a critical issue that has caused an assessment to fail. Without this data it will not be possible to obtain a length/age based assessment for red mullet in GSA 10, and all other assessments using catch from GSA 10 will be poorer and may fail.

It has been noted that MEDITS survey is being conducted by Italy in several GSAs very late in the year. This departs from the 'standard' period specified by the MEDITS survey coordination group. This delayed survey is influencing the ability of the EWG to do some assessment (e.g. MUT in 10) and is impacting on any of the assessments that use MEDITS from GSAs 9 10 and 11. We believe the problem also impacts on GSAs in the Adriatic where MEDITS is also being carried out late. This issue needs to be resolved and the survey should be carried out at a consistent time of the year. If there is a need for this period to be different from before, this should be considered by the MEDITS survey coordination group before the changes become permanent. Once agreed the survey should then be conducted as agreed and it should not be regarded as acceptable to conduct the survey outside the main survey period.

4 METHODS

The methods used in both data checking (Section 4.1) and in reference point calculation (Section 4.2) are provided below. In addition a further section exploring sensitivity of approach is provided in order to explore how the reference points are affected by the choices taken (Section 4.3)

4.1 DATA QUALITY

4.1.1 JRC SCRIPT ON QUALITY CHECKS

4.1.1.1 GENERAL INTRODUCTION

The quality checks on commercial data, provided through the Official Mediterranean and Black Sea Data Calls, were based on a suite of R scripts initially developed during the EWG2102 (https://stecf.jrc.ec.europa.eu/ewg2102) but reorganized and extended before and during EWG 2203 to provide a single pdf output structure.

Listed below the R scripts used during the EWG2102

1) Check_landings.R
2) Check_discards.R
3) Cumulative.R
4) Quality checks.R
5) Landings_LFgaps_metier.R
6) Discards_LFgaps_metier.R
7) Relative weights.R

For the EWG2202 all these R scripts have been just saved as an rmd file named "Checking_DCF.rmd" which when knitted produces a pdf output as Rmarkdown output. All the outputs produced in running the script chunks (plots and csv) are still saved in a dedicated folder as in the EWG2102 (see below) but adding as a main output a pdf document by stock which would be expected to be easier to check. The Checking_DCF.rmd file and all the pdf files produced for the ToR1 list of stocks have been attached as Annex 1 to this report (Annex 1 – Rscript, pdfs and main outputs on commercial quality checks"). The Rcode has been tested under R version 4.2.0 (64bit) and RStudio 2002.02.2 environments. The data sets are in the MEDBS DCF output formats which are shared with the STECF EWGs (by using output files it ensures that the data checked is the uploaded data, but *it means that columns headers and number of fields are not exactly the same of the ones used in the input templates*). The details for using these can be found in Section 4.1 of EWG 22-03 report

4.2 DATA PREPARATION

In addition to quality checks a series of fill-in procedures were developed in EWG 21-02 for replacing poor or missing commercial catch sampling, the basis of these is described below.

4.2.1 Fill-in procedures

All stratified sampling programs can result in fleets or metiers that are missed or severely under-sampled[2]. These strata are most often a very small part of the total catch however; they require the allocation of size/age as part of the stock assessment. This allocation of LFDs can be done within some assessment packages that operate by fleet/metier and handle patchy data on length frequency distributions (LFDs) and fit the missing data as part of the assessment model process. Other packages that operate by combining catch data to the total catch require a procedure that either leaves a year without an LFD, or alternatively fill-ins the small proportion of the catch with a suitable LFD. The modelling methods that work by fleet/metier and fit the missing observation often require more complex modelling but also the strong additional assumption that the catch is a true census (including discards) in order to estimate the missing LFDs. When a combined catch assessment is used with a minor fill-in the assumption that allows some error in catch estimation is then possible. For the purposes of estimating stock status (F and SSB) and giving catch advice the differences between the approaches are usually small, for example hake in GSA 17-18 (REF STECF 2020 report). The procedures used in this EWG for filling in landings and discard LFDs are documented below.

4.2.1.1 Fill in for length Frequency distributions for landings

If a metier is unsampled but another metier for the same gear is fully sampled, then the procedure is to use the samples at fleet level and apply these directly or through the use of an SoP correction.

For missing year(s) the procedure for filling-in LFDs for landings is first to identify combinations of years/fleets or metiers with catches but missing LFDs. If there is sufficient data on length from the same metier then the other years of data are used as fill-ins based on the mean or the median of the LFDs.

mean is used for normal distributions, which have no outliers.

median is generally used to return the central tendency for skewed distribution or when outliers are observed.

For the choice of year ranges for fill-ins, the two main options are to use the mean of the available data or to use two or more adjacent years either side of the gap.

Less than 5%. If fill-in is a small part of catch (less than 5%) then any solution is acceptable as the impact of the fill-in will be negligible.

Trend in mean length: If there is trend in the LFDs (seen as trends on mean or quartile values) then using adjacent data may be preferable.

High annual variability: If variability in the data (again seen as variability on mean and quartiles) is large then full data set is likely to be better the best source of the fill-in.

Similar to a sampled metier: If the missing LFDs are expected to be similar to another well sampled metier of fleet then data from that fleet is used to provide the LFDs. In some cases this is done by assuming the whole fishery is the best source of information for a year and the whole catch is raised with the available data.

Years with substantial gaps: If a fill-in is more than 50% of the catch users need to consider highlighting this for estimation in the model.

[2] The Regional Coordination Group Med & BS runs every year a ranking system of metiers at level 6 at regional level. According to this, a ranking of the métiers is performed three times: firstly according to their share in the total landings, secondly according to their share in the total value of the commercial landings and thirdly according to their share in the total effort (days at sea). For each ranking, the shares are cumulated starting with the largest, until a cut-off level of 90% is reached. At the end of the procedure, all métiers selected through each ranking are added.

4.2.1.2 FILL-IN FOR DISCARDS DATA

STECF has been requested to provide advice based on catch rather than landings, so inclusion of discard data is important in that context. In any case advice on landings based on a landings-only assessment is conditional on the assumption that discarding is constant both as a proportion of catch and in fraction at length discarded, so the use of landings data alone would not solve the problem of missing discard information. In a few cases discarding has been found to be negligible and consisting of individuals that are damaged and unmarketable, thus any discard amounts can be raised using landing LFDs. In other cases discarding is occurring but information is often much more sparse than that for landings and the total amount of discards is found to be non-negligible especially for species such as red mullet, and possibly hake. Also discarding can be confined to the trawl fleets only, both otter or beam trawls, with rarer occurrences of discarding by size in gillnet, trammel net or longline fisheries.

Quantities of discards by years:

Unlike landings data where the total amount is available, in some years there has been very poor or missing information on both the total amount of discards as well as the LFDs either because discard sampling failed or was not required or implemented in those years. In these cases, where the sampling has missed discarding that is found in all other years for a fleet or where fishing was from years before a discard program was started, as a first step the quantity of discards is inserted for years without discard records. This is computed based on the discard fraction from years with discard data and is suitable for situations where discard rates are variable due to natural variability of uncertainty due to low levels of sampling. If trends in discard rates are observed or regulations have changed subsets of years should be used. In either case the specific years/fleets used to obtain discard rates should be specified in the report.

Missing LFDs:

Fleets with known discarding: missing LFDs are filled in following the same procedure as for landings, using the LFDs from available years. In this case, the median is often used, as distributions tend to be skewed, and there are few observations.

Fleets with occasional discard reports: In some cases, the discards are not the result of undersized or small individuals, but are likely the result of damaged individuals with a similar size distribution as the catch. In this case, the LFD may be taken from the landed component, usually by raising the fleet level with a Sum of Products (SoP) correction applied at fleet of total catch level as appropriate.

4.2.2 LENGTH SLICING

Data for most stocks in this EWG are collected as length samples. In most cases ages are obtained by deterministic length slicing based on calendar year growth points derived from von Bertalanffy growth functions, by sex or sex combined. This aligns growth to the fishery management year, an assigns catch at length correctly through the calendar year. In the case of red mullet in GSA 7 slicing to age is by fixed ALK across years, but with the same age assignment with time discussed below for summer spawning. In the case of the deterministic length slicing from von Bertalanffy growth functions, stocks such as both hake stocks assume growth is calculated from time 0 at spawning at 1st of January thus the calendar aligns with the growth year and catches are correctly assigned by year. However, many stocks in the EWG have midyear spawning or spawning throughout the year assigned to midyear as the 'average' point. In this case average growth from spawning to the end of the calendar will occur for 6 months from 1st July to 31 December in the first year (age 0) and then for 12 months January to January in subsequent years. If the growth curves have been calculated on a time bases with the origin (time 0) at spawning time then growth in the first 6 months is at age 0 and 6 to 18 months to age 1 etc. For these species the T0 in the von Bertalanffy function is increased by 0.5 of a year, the time in the year that it is assumed spawning occurs. The size at each birthday is then checked to ensure the function is working as expected. For some species with midyear spewing the growth functions come from calendar year evaluations and already account for the 1st January annual birthday in the aging, in this case no correction is needed or applied. Again checking length at 1st January ensures the function is working as expected.

4.3 BASIS OF THE CATCH AND FISHING MORTALITY ADVICE

The summary sheets by stock, provided in Section 5 contain catch advice. The basis of this advice depends on the type and quality of information available from the analyses and is as follows:

- Full assessment and full MSY reference points or with surplus production model with F and biomass relative to F_{MSY} proxy and B_{MSY}: Catch advice at MSY based on short term forecast. F and catch advice reduced if SSB is forecast to be below B_{pa} at the start of the advice year. **Used for 13 stocks for this year**
- Full assessment without full evaluation MSY reference points due to short time historic series: Catch advice based on MSY proxy of $F_{0.1}$ based on short term forecast. **Used for 3 stocks for this year**
- Assessment providing SSB tend information historic F evaluation, not suitable for STF Catch / Effort advice under precautionary considerations (Patterson 1992) F= F_{MSY} with Harvest Rate (HR) based estimated SSB in most recent year. **Not used.**
- For sparse data with insufficient years for VPA type analysis, but with catch at length or age for most of the fishery: advice is based on pseudo cohort analysis at equilibrium, with estimate of current F relative to $F_{0.1}$. **Not used.**
- Trend based indicator with exploitation and stock status know to be OK: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend without precautionary buffer, giving 2 years advice. **Not used.**
- Trend based indictor: Catch / Effort advice under MSY considerations based on ICES smoothed index of trend **Used for 3 stocks this year and for 2 from last year**.
- Valid length analysis: statement of stock status, indication of direction of change required. **Not used**
- No valid analysis: no advice. **Not needed**

Section 6 contains the main input data and assessment results for this report.

4.4 MSY REFERENCE POINTS FOR STOCKS IN THIS REPORT

Following STECF decision in the absence of full MSY evaluations, and/or biomass reference points STECF considers that $F_{0.1}$ forms a good proxy for MSY. Thus for all stocks here with analytical assessments $F_{0.1}$ has been evaluated based on the stock conditions over the last three years. MSY advice in terms of F and catch for 2023 are based on this approach.

4.4.1 MSY RANGES

The EWG has been requested to provide MSY ranges for the stocks considered by the EWG. The usual procedure used by ICES would be to establish S-R functions and to evaluate the ranges using this method, constraining the upper interval to be precautionary. As discussed above it has not been possible to establish such relationships for these stocks, either because the data series are too short.

To evaluate MSY ranges for stocks in this report the EWG uses the values of F associated with $F=F_{0.1}$ which are given in Table 2.2. These are the F_{MSY} values from the most updated assessments carried out on Mediterranean stocks assessment. Those values were then used in the formulas provided by STECF EWG 15-06 (STECF, 2015) to derive F_{MSY} range (F_{low} and F_{upp}). The empirical relationships used to estimate F_{MSY} range are the following:

$F_{low} = 0.00296635 + 0.66021447 \times F_{0.1}$

$F_{upp} = 0.007801555 + 1.349401721 \times F_{0.1}$

where $F_{0.1}$ is a proxy of F_{MSY}.

None of these methods add information on the precautionary nature of the F_{MSY} ranges; the values of F_{upp} and F_{low}. In the case of stock based on $F_{0.1}$ the F_{MSY} is considered to be precautionary, and because F_{low} is a lower exploitation rate this is will also be precautionary. As the WG is unable to parameterise stock recruit models and does not currently have B_{lim} reference values, it has not been possible to evaluate F_{upp}, until further evaluations can be completed should not be used for exploitation, and should be replaced with F_{MSY}.

4.4.2 VALUES OF F_{MSY} FUPP AND FLOW

The values of $F_{0.1}$, Fupp and Flow are calculated in the assessment sections Section 6 by species. The values are given in the short term forecast table in the stock assessment sections. These are reproduced in the table in Section 5 but with the Fupp value replaced with $F_{0.1}$. This approach conforms to the one used by ICES (ICES 2014, ICES 2015)

4.5 BASIS OF SHORT TERM FORECASTS

The objective of the short term forecast is to provide the best estimate of catch in year Y+1 based on the assessment with final year y-1. This is then to predict 2 years forward for a range of catch options based on range of F options. The F option that corresponded to MSY approach or precautionary approach (see section 2.1) is then presented as advice. The basis of short term forecasts is as follows:-

Biological conditions are assumed to be recent biological conditions

This is mean Maturity, Natural Mortality (M), Fraction M and F before spawning from the last three years of the assessment. In many cases there are constant.

Recruitment **-** Most probable recruitment

If recruitment trend occurs ---- Recent recruitment is selected … Arithmetic Mean of recent years … at least 3 years

If no trend occurs expected value……………….Geometric mean of series

Fishery is assumed to be the same as the recent fishery

Fishery selection is assumed to be recent averages over the last three years

F in intermediate year ---- is assumed to be F status quo for all options

If F is fluctuating (F_{y-2} outside F_{y-1} and F_{y-3}, or $F_{y-2}=F_{y-3}$) – mean of 3 years

F trend - (F_{y-2} between F_{y-1} and F_{y-3} or $F_{y-2}=F_{y-1}$) – F last year of assessment

4.5.1 MSY TRANSITION

The EWG continues to provide the main catch option presented in section 5 based on the target of F_{MSY} in 2023 (modified if necessary if B at the beginning of the advice year is forecast to be below B_{pa}. This MSY option remains the primary advice. However, in Plenary November 2019 The STECF considered if it would be possible to give an additional advice option or options associated with the Western Med MAP. The MAPs have the objective of achieving F_{MSY} either by 2020 or at latest 2025. For a few stocks F_{2018} is close to F_{MSY}, but for many stocks such as hake F is substantially higher than F_{MSY} and it seems likely that these stocks will be considered under the objective for reaching F_{MSY} by 2025. For such stocks the plans do not specify how it is expected that F should change over the 6 years from 2020 to 2025. Currently STECF reports the F_{MSY} and expected catch in the advice year based on EWG assessment and short term forecasts. However, if the approach is to attempt a reduction in F to F_{MSY} by 2025 it may be helpful to give advice in relationship to such a transition, and the EWG has included an additional 'F_{MSY} Transition' option for the STF Table (Section 5 and 6). In 2010 and the following years ICES provided advice following an MSY transition approach with a linear change in F from 2010 to achieve F_{MSY} in 2015. This approach is updated below for transition from 2020 to 2025.

$F_{MSY\ Transition}$ (2020) = {•0.833 F (2019) + 0.167• F_{MSY}(2019)}

whereas for the following years:

$F_{MSY\text{-}Transition}$ (2021) = {0.667• F (2019) + 0.333• F_{MSY}(2020)}

$F_{MSY\text{-}Transition}$ (2022) = {0.5• F (2019) + 0.5• F_{MSY}(2021)}

$F_{MSY\text{-}Transition}$ (2023) = {0.333• F (2019) + 0.667• F_{MSY}(2022)}

$F_{MSY\text{-}Transition}$ (2024) = {0.166• F (2019) + 0.833• F_{MSY}(2023)}

$F_{MSY\text{-}Transition}$ (2025) = {0.0 • F (2019) + 1.0 • F_{MSY}(2024)}

Where for the first year F_{2019} =F_{2018}, but for subsequent years F_{2019} is the F in 2019 estimated/updated in the subsequent annual assessments and $F_{MSY(year)}$ is the estimate of F_{MSY} updated as F_{MSY}(2020, 2021 etc.) in each subsequent estimation of reference points following annual assessments.

In Section 5 Table 5.X.1 gives the exploitation status in terms of F_{MSY} and $F_{MSY\ Transition}$ the F status is defined as above or below the reference value for $F_{MSY\ Transition}$ this is calculated using the values of F_{2019} and F_{MSY} from the current assessment. Therefore the reference point $F_{MSY\ Transition\ 2020}$ is defined using the equation above with values of F_{2019} and F_{MSY} from the 2022 assessment. This value and subsequent values will be updated each year based the most up to date assessment.

4.6 REFERENCE POINTS METHODS

Following the methods developed in EWG 22-03 to provide biomass reference points, the STECF summer plenary in July 2022 endorsed the approach and the EWG 22-11 was requested to provide biomass reference point for stocks considered by the EWG. The results of these evaluations are reported in Section 6.X.4 and summarised by stock in Section 5.X. The methods used are described here.

4.6.1 STOCK ASSESSMENT DATA

The final stock assessment outputs used for reference point evaluation for the Western Mediterranean Sea 2022 are those documented below in section 6.X.3.

4.6.2 GLOSSARY

A summary of definitions of abbreviations of key biological quantities and reference points used in this section of the report are listed below.

Biological quantities:

N_a: Numbers at age

w_a: weight at age quantifying the somatic growth

mat_a: proportion of mature specimens at age

M_a: natural mortality at age

F_a: fishing mortality at age

F: here the average F_a over exploited age classes ($fbar$)

SSB: spawning stock biomass being a function of N_a, w_a and mat_a

SPR_0: un-fished spawning biomass per recruit at $F = 0$ at equilibrium being a function of w_a, mat_a and M_a

SPR_F: equilibrium spawning biomass per recruit at a specific F

SPR: spawning potential ratio of SPR_F/SPR_0

R_0: average recruitment of un-fished stock at $F = 0$

B_0: un-fished spawning stock biomass being a function of $B_0 = R_0 SPR_0$

Reference points:

B_{lim}: A deterministic biomass limit below which a stock is considered to have reduced reproductive capacity.

B_{pa}: A precautionary deterministic biomass reference point intended to represent a spawning stock size that is associated with low risk of impaired recruitment potential. B_{pa} is typically estimated as a function of B_{lim}.

F_{lim}: Fishing mortality corresponding to B_{lim}. Fishing at levels above

F_{pa}: Fishing mortality corresponding to B_{pa}. Fishing at levels above F_{pa} will result in a decline in the stock to levels below B_{pa}.

F_{MSY}: The fishing mortality rate that maximises the long-term catch (or surplus production) corresponding the Maximum Sustainable Yield (MSY)

B_{MSY}: Expected biomass of a stock that is exploited at F_{MSY}

$F_{0.1}$: The fishing mortality at which the slope of the yield-per-recruit curve is 10% of that at the origin. Accepted here as robust proxy for F_{MSY}

$B_{F0.1}$: Spawning Biomass reference point corresponding to $F_{0.1}$

4.6.3 BASIS OF REFERENCE POINTS

B_{lim} is the central biomass limit reference point used for North-East Atlantic stocks particularly by ICES, which is defined as the biomass below which recruitment is impaired so that reduces with SSB. The other reference points (B_{lim}, F_{lim}, and F_{pa}) used in the context of the precautionary approach are all estimated from B_{lim}. Principles for deriving reference for data-limited Mediterranean stocks

Considering international practice, biological principles and the characteristics of the fairly short S-R time series, the EWG 22-03 agreed on two guiding principles for estimating B_{lim}:

- Plausible B_{lim} estimates are assumed to within the range 0.1% - 20% of SSB_0 (equivalent to $0.01 - 0.2SPR_0$) if determined by way of fitting a segmented regression

- If no clear break point can be identified within this range, B_{lim} can be derived analytically as $B_{lim} = 0.25B_{F0.1}$, where $B_{F0.1}$ is the equilibrium SSB corresponding to $F_{0.1}$. In the absence of reliable stock recruitment function, the $B_{F0.1}$ can based on geometric mean of the available recruitment estimates.

It follows that a direct estimate of B_{lim} shall only be derived empirically in cases where there is sufficient contrast in the S-R data to estimate a well-defined break-point that falls within plausible biological limits. Alternatively, it is suggested that B_{lim} be specified as a ratio of B_{MSY} or its proxy, which is taken as $B_{F0.1}$. The EWG selected 0.25 $B_{F0.1}$ as a suitable default and STECF endorsed this.

4.6.4 FITTING STOCK RECRUITMENT RELATIONSHIPS

Where a break point is observed stock recruitment relationships (SSR) were fitted and evaluated with the **FLR** (Fisheries Library in R: Kell et al., 2007) package **FLSRTMB**(Winker and Mosqueira; https://github.com/flr/FLSRTMB), using maximum likelihood estimation in Template Model Builder (**TMB**; Kristensen 2015). The EWG concluded a conditioned Hockey-Stick (**segreg**) was the primary method for estimating such a break point. To estimate the break-point $b = B_{lim}$ within the expected range of 1% - 20% of SSB_0, a new conditional Hockey-Stick formulation was implemented in **FLSRTMB**. The Hockey-Stick function is based on a continuous, quadratic hockey-stick formulation (c.f. Barrowman and Myers, 2000), which is re-parameterized as a function of SPR_0 and a "re-purposed" steepness parameter *s**. In addition, the parameter P_{lim} is introduced, which then determines the lower of the ratio B_{lim}/B_0, where B_{lim} corresponds to break point *b* of the segmented regression and the un-fished B_0 being a function of $B_0 = R_0 SPR_0$.

$$R_y = \frac{s^*}{2P_{lim}SPR0}\left(SSB_{y-a_r} + P_{lim}R_0SPR_0/s^* - \sqrt{\left(SSB_{y-a_r} - P_{lim}R_0SPR_0/s^*\right)^2}\right)$$

where R_y is the number of recruits in year y, SSB_{y-a_r} is the spawning biomass in year y minus minimum age a_{min} defined for the stock (typically age-0 or age-1). The break point b (B_{lim}) and slope a are given by

$$b = P_{lim}R_0SPR_{0,y}/s^*$$

$$a = R_0/b$$

This formulation allows to bound the parameter s^* over an approximately uniform range defined for $0 > s^* \leq 1$ using a truncated logistic prior distribution (Thorson and Cope, 2014)

$$s \sim TrunkLogit(s_{logit}, \sigma_{logit})$$

where σ_{logit} is set by default to 20 and s* can be truncated by specifying the parameter c.

$$s^* = c + 1/\left(1 + exp(-s_{logit})\right)$$

where c is specified by ratio lower to upper fraction of SPR_0. For example, by considering a range bounded between 0.1% - 20% of SPR_0, c is taken a ratio of c = 0.001/0.2, resulting in an approximately uniform parameter space for which the ratio B_{lim}/B_0, but with soft penalties towards the bounds to facilitate robust convergence (Figure 4.6.3.1).

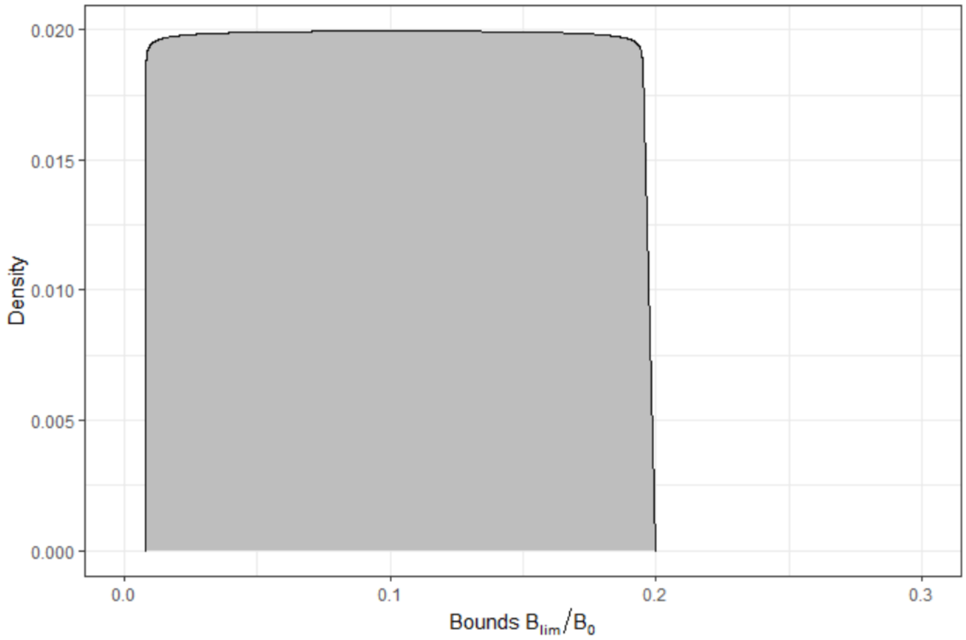


Figure 4.6.3.1: Representation of uninformative prior that constrains the defined range for the breakpoint to B_{LIM} / B_0 = 0.01-0.2.

A retrospective/ stability analysis was carried out at EWG 22-03 and the results are presented in the report. In addition a sensitivity analysis evaluated the implications of the choices in the procedure. Overall the procedure was judged to be useful.

4.6.5 SUMMARY OF REFERENCE POINT EVALUATION

The full basis of the reference points is described in detail in STECF EWG 22-03 report from April 2023.

- The Framework from EWG 22-03 consists of :-
  - F_{MSY} the fishing mortality which would provide a catch of MSY.
    - For Western Med MAP the EWG used $F_{0.1}$ as a proxy for F_{MSY}
  - A decision tree (Figure 4.6.3.2) developed in EWG 22-03 to obtain B_{lim} either from fit to data or 25% $B_{F0.1}$ ($_{BMSY}$)

STECF stated that it "considers this decision-tree is highly useful and would merit scientific dissemination beyond EU Mediterranean stock assessment EWGs".

  - B_{pa} is the biomass reference point '*which ensures that the spawning stock biomass has less than 5 % probability of being below B_{lim}'* B_{pa} is set to 2*B_{lim} (accounting for uncertainty in assessment and B_{lim}).

STECF stated that it "endorses this adjustment which is justified to account for the larger presumed uncertainties in the estimates of the SSB in the terminal year in the assessment of the Mediterranean stocks".

Overall STECF endorsed the proposed framework developed by the EWG 22-03 and stated it was "suitable/appropriate to estimate biological reference points in general as well as for short time series and stocks in poor conditions".

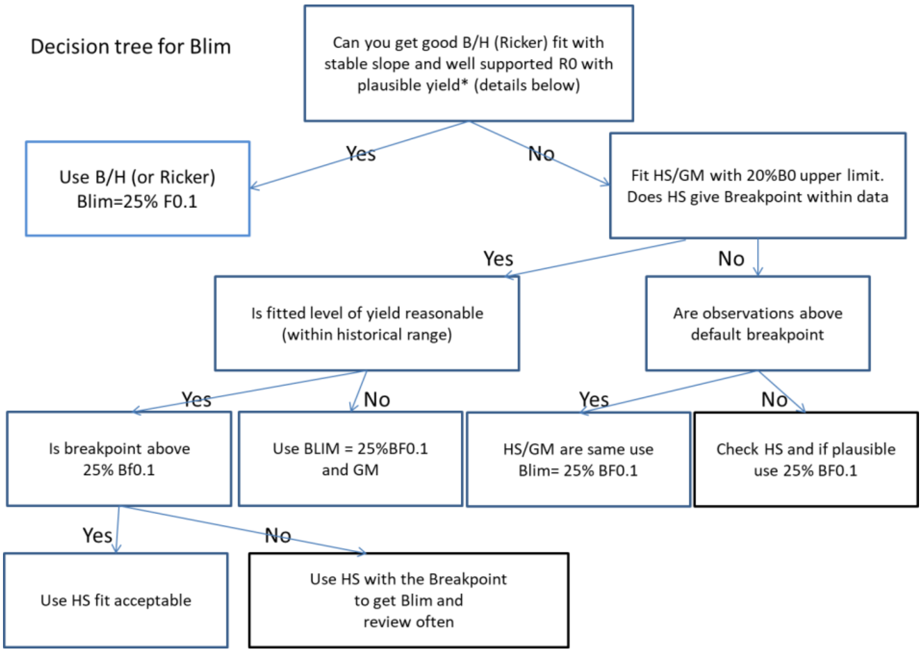


Figure 4.6.3.2 Approach to establishing B_{lim} and S-R relationship. Decision tree applied for 14 stocks with assessments in EWG 22-03.

4.6.6 PRACTICAL IMPLEMENTATION OF REFERENCE POINT ESTIMATION IN FLREF

For the estimation and evaluation reference points, the R package **FLRef** (Winker) was developed and is available on https://github.com/Henning-Winker/FLRef. This package is implemented with **FLR** and makes of the optimization routine for estimating fisheries reference points at equilibrium that is available in **FLBRP**. **FLRef** requires the stock data as **FLStock** objects and the stock recruitment functions in the form of **FLSR** objects, which were produced with the package **FLSRTMB** (Winker and Mosqueira). The EWG Expert Henning Winker (JRC) developed tested the package on the stock data prior to the meeting with the support of the FLR Core Team Members Iago Mosqueira (Wageningen University) and Laurence Kell (Imperial College).

Main features of **FLRef** include:

- Automation of estimating and visualizing a wide range of limit and target plots
- New plotting options for illustrating reference points both as relative or absolute quantities
- New plotting options for compare the impact of various stock recruit model assumptions on the estimated reference points
- Newly designed fisheries advice plots

FLRef user guidelines are provided in Annex 2 and reproducible R code and results based worked example for Mediterranean stocks are available in Annex 3.

4.7 INDEX BASED METHOD USED FOR STOCK WITHOUT ASSESSMENTS

ICES has updated the index approaches used for stock without analytical assessment using age based or surplus production methods. Accordingly, the EWG has updated the approach applied for stocks in this situation and has implemented two options so far. The full set of methods and their calculations are documented in Section 16.4.11 of the basis for ICES advice "ICES technical guidance for harvest control rules and stock assessments for stocks in categories 2 and 3".

Currently the STECF assessment EWG utilised two of the options:

4.7.1 CAT 3 OPTION WITH INDEX, LENGTH DATA ON CATCH, AND GROWTH (VB K) AVAILABLE:

ICES Method 2.1: rfb rule copied directly from ICES documentation:

This HCR provides MSY advice for category 3 stocks based on the stock trend from a biomass index (similar to the previous "2-over-3 rule"), the mean length in the catch relative to an MSY proxy length and a biomass safeguard to ensure compliance with ICES precautionary approach (ICES, 2017; Fischer *et al*., 2020, 2021a, 2021b). The three name-giving elements of the rfb rule are:

r : biomass ratio (survey trend)

f : fishing proxy (length data, target)

b : biomass safeguard

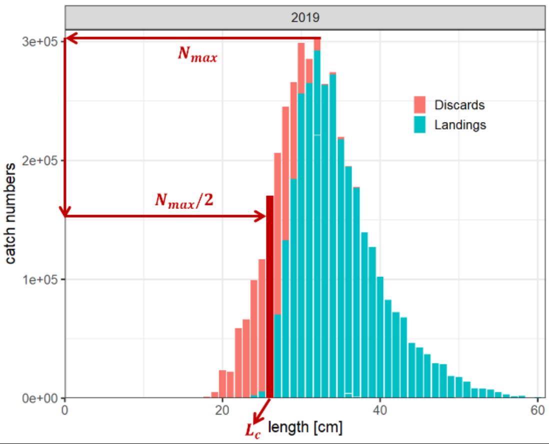
This HCR improves on the "2-over-3" rule (ICES, 2012a) with the addition of multipliers based on a stock's life history characteristics, its status in terms of relative biomass, and its status relative to a target reference length (ICES, 2018c, 2019a).

The rfb catch rule is defined as:

$$A_{y+1} = A_y \times r \times f \times b \times m \qquad (5)$$

where the advised catch (A) for next year y+1 (set on a biennial basis) is based on the most recent year's advised catch A_y adjusted by the components in Table 4.7.1.

Table 4.7.1 Data requirements of the rfb rule.

Component	Details
Previous catch advice	• If no previous catch advice (A_y) exists, use the most recent catch (C_{y-1}), or the average of the last three years of catch • If C_y is very different from A_y, consider replacing A_y as the **rfb** rule is meant to adjust realised catches influencing the stock
Biomass index	• At least five years of data needed • Without age structure • Should be representative of the stock • It is possible to combine indices for better coverage of the stock unit (e.g. VAST [Thorson *et al.*, 2019) was used for ple.27.7h-k in 2021 [ICES, 2021b]).
Length data	• At least one year of data needed • Should be representative of the fishery (ideally covering all fleets or gears; if not possible, ensure that mean length in the catch and length reference points are comparable) • Use total catch (if available) • Calculate mean length in the catch (consider lengths greater than length at first capture L_c) • If the distribution is noisy, consider increasing the bin width or applying a smoother • Length at first capture L_c should be determined following ICES (Section 3.4.1 in 2012b) 1. Find the mode of length distribution (length class with highest catch numbers N_{max}) 2. Find first length class where catch is at or above $N_{max}/2$. This is the length at first capture L_c 3. For estimating the mean catch length, consider only length classes above L_c 
Life history parameters	• von Bertalanffy growth parameters: k, L_∞

4.7.2 Cat 3 Option short lived species with index, no catch length data, and without MSE:

ICES Method 3.3: One-over-two rule for short-lived stocks copied directly from ICES documentation

When knowledge of catchability and observation errors of the abundance index are so poor as to preclude the selection of a robust constant harvest rate, a HCR that determines next year's advised catch based on the last advised catch can be used.

The HCR is defined as:

$$A_{y+1} = \left\{ \begin{Bmatrix} 0.2\,A_y & \dfrac{I_y}{\sum_{y-1}^{y-2} I_y/2} < 0.2 \\ A_y \dfrac{I_y}{\sum_{y-1}^{y-2} I_y/2} & 0.2 \le \dfrac{I_y}{\sum_{y-1}^{y-2} I_y/2} < 1.8 \\ 1.8\,A_y & \dfrac{I_y}{\sum_{y-1}^{y-2} I_y/2} \ge 1.8 \end{Bmatrix} \right. \cdot \left[min\left(1, \frac{I_{current}}{I_{trig}}\right)\right] \qquad (9)$$

where A_y and I_y represent the advised catch and the biomass indicator for year *y*, respectively.

The first and third cases of the formula correspond to the application of an 80% symmetrical uncertainty cap.

The last term in the equation refers to the biomass safeguard based on a trigger index value, below which the advice would be corrected downwards in proportion to the drop of the most recent abundance index over the $I_{trigger}$ value. This is a term which has been shown to further reduce the risks associated to this management system. A recommendation is made to take $I_{trigger}$ as I_{stat} = *geometric mean* (I_{hist}) exp(−1.645 *sd*(log (I_{hist})), where I_{hist} is the available historical series of the abundance index.

- The notation of these rules is for in-year advice where the advised catch for the current year is based on last year's advised catch adjusted by the trend in the most recent abundance index, I_y, relative to the average of the index value in the previous two years.
- An uncertainty cap is applied to limit the change in the index trend, the I_y component of the HCR, to ±80%, which allows the current years advised catch to increase or decrease up to 80% relative to the previous years advised catch.
- Note that $\frac{I_y}{\sum_{y-1}^{y-2} I_y/2}$ should be replaced by $\frac{I_{y+1}}{\sum_{y}^{y-1} I_y/2}$ in the formula above if the index is available at the beginning of the management year *y+1*, instead of being available at the end of the interim (management) year *y*.

The first time this rule is applied to a stock, the initial catch should be taken from the mean of the catch from the previous two years (ICES, 2019b).

Short-lived stocks with high interannual variability of biomass can show large biomass fluctuations from one year to the next. A symmetrical 80% uncertainty cap allows appropriate adjustment of the HCR accordingly from year to year. Large reductions in catch may be necessary between years to respond accordingly to reductions in the underlying stock biomass.

The precautionary buffer will certainly reduce the initial risks associated with a historic substantial exploitation of the stock (above F_{MSY}), though is probably unnecessary for lightly exploited stocks. The performance of the rule has been tested without any precautionary buffer. Therefore, the convenience of applying such a precautionary buffer would depend on an early assessment of the exploitation levels and depletion of the resource.

5 STOCK SUMMARIES

ToR 8. *Using the report structure developed in 2018 (EWG 18-12), provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stocks (spawning stock biomass, stock biomass, recruits and exploitation level relative to Fmsy and F Transition, and by fishing gear, if possible including relevant types of trawlers, longliners and netters); (iii) the source of data and methods and; (iv) the management advice taking into account stock biomass using e.g. the ICES control rule (see Annex I below), including* F_{MSY} *value, range of values, conservation reference points and effort levels. Provide a summary table showing the progress already made in the transition towards MSY and the F and catch advice for 2023 to reach Fmsy by 1 January 2025.*

Stock summaries provided in this section are based on the assessment, short term forecast and reference points reported in Section 6 below, except for striped red mullet in GSA 5 and Norway lobster in GSA 5 which have two years of advice provided in last year's report, EWG 21-11, these sections (5.5 and 5.7) are reproduced below for completeness.

5.1 SUMMARY SHEET FOR EUROPEAN HAKE IN GSA 1, 5, 6 & 7

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.19 and corresponding catches in 2023 should be no more than 1004 tons. The fishing mortality is reduced from F_{MSY} of 0.41 as SSB is projected to be below B_{pa} in 2023.

Stock development over time

Catches and SSB of European hake show a decreasing trend from 2009 to 2020, with some fluctuations in the time series and stability in 2020-2021. The assessment shows a general long term declining trend in the number of recruits but with an increase in the last year reaching in 2021 the same values as 2012, though the final year's value is the most uncertain. A similar recruitment peak was observed in last year assessment but has not been confirmed in this year estimation. Fbar (1-3) shows fluctuations across the trend with increasing values until 2019. F than decreased in 2020 and 2021 where it reached a value of F = 1.34.

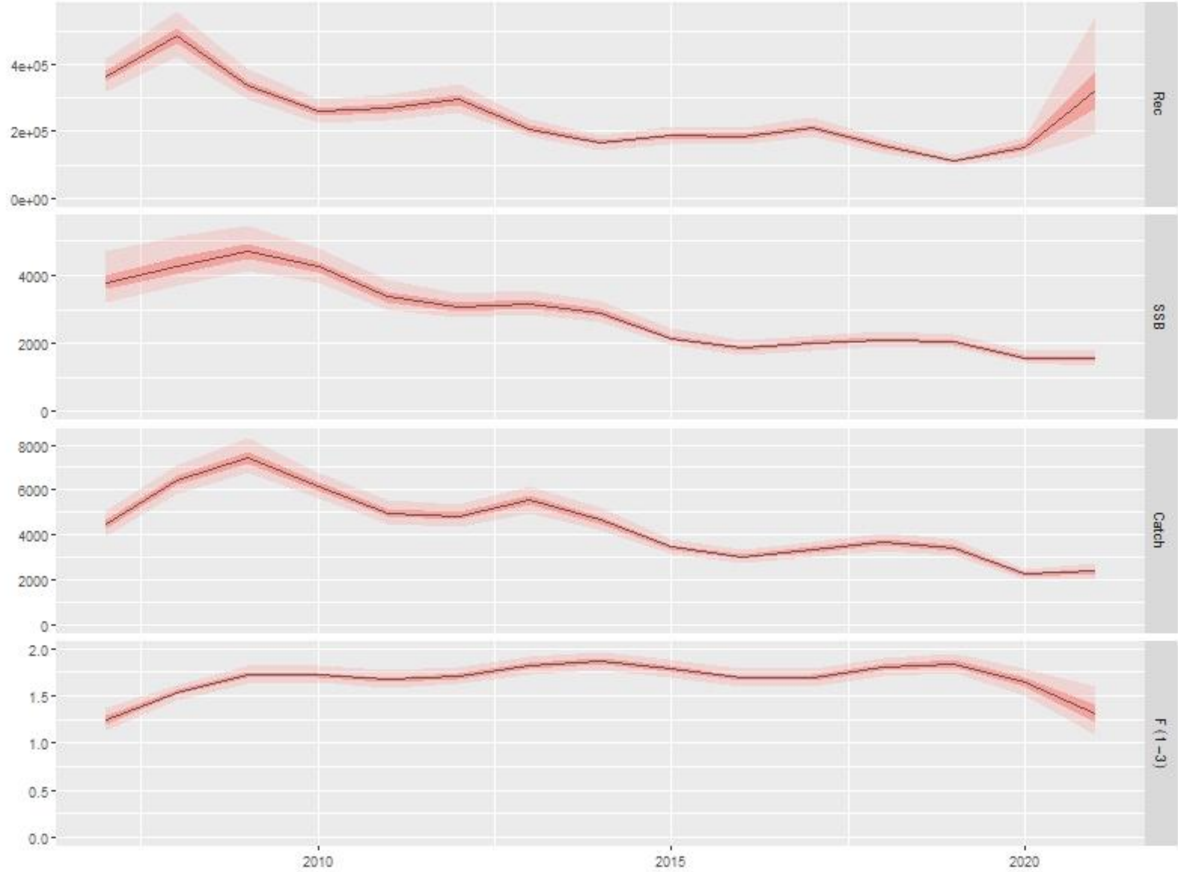


Figure 5.1.1 European hake in GSAs 1, 5, 6 & 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.34) is 3.28 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.41). F in 2021 is also higher than $F_{MSY\ Transition}$ (0.89) indicating progress to F_{MSY} in 2025 is behind transition. SSB in 2021 is estimated to be below B_{lim}.

Table 5.1.1 European hake in GSAs 1, 5, 6 & 7: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY} F / $F_{MSY\ Transition}$	$F > F_{MSY}$	$F > F_{MSY}$ $F > F_{MSY\ Transition}$	$F > F_{MSY}$ $F > F_{MSY\ Transition}$
B/B_{lim}	$B<B_{lim}$	$B<B_{lim}$	$B<B_{lim}$
B/B_{pa}	$B<B_{pa}$	$B<B_{pa}$	$B<B_{pa}$
B/B_{MSY}	$B<B_{MSY}$	$B<B_{MSY}$	$B<B_{MSY}$

Catch scenarios

Table 5.1.2 European hake in GSAs 1, 5, 6 & 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2021)	1.34	F 2021 used to give F status quo for 2022
SSB (2021)	1498	Stock assessment 1 January 2022
R_{age0} (2021,2022)	185367.4	Mean of the last 9 years
Total catch (2021)	2350	Assuming F status quo for 2021

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.1.3 European hake in GSAs 1, 5, 6 & 7: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	1930	0.41	7435	190.91	-17.90
$F_{MSY\ Transition}$ ^^	3442	0.89	4795	87.61	46.46
$F_{MSY\ Reduced}$ $B<B_{pa}$^^^	**1004**	**0.19**	**9126**	**257.04**	**-57.28**
$F_{MSY\ lower}$	1369	0.27	8455	230.78	-41.77
$F_{MSY\ upper}$**	2474	0.56	6464	152.91	5.27
Other scenarios					
Zero catch	0	0.00	11004	330.51	-100.00
Status quo	4378	1.34	3284	28.48	86.26
	717	0.13	9658	277.86	-69.48
	1349	0.27	8491	232.22	-42.62
	1905	0.40	7480	192.63	-18.94
	2397	0.54	6602	158.28	1.97
	2831	0.67	5839	128.45	20.47
	3217	0.80	5177	102.53	36.86
	3559	0.94	4601	80.00	51.42
	3863	1.07	4100	60.40	64.37
	4135	1.20	3664	43.34	75.93

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at $F> F_{MSY}$
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025
^^^$F_{MSY\ Reduced}$ $B<B_{pa}$ is based on ICES advice rule when B in TAC year is less than B_{pa}

The primary catch option selected is based on the ICES advice rule when B in TAC year is less than B_{pa} as is the case for hake in GSA 1, 5, 6 & 7 in 2023

Basis of the advice

Table 5.1.4 European hake in GSAs 1, 5, 6 & 7: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Commercial catches at age showed better internal consistency than MEDITS survey index. The historic assessment is stable, and the assessment model was not modified. The retrospective analysis showed consistency in the estimation of F estimated in the assessment of 2021. The estimation of recruitment is consistent compared to the ones obtained from last year assessment. All the diagnostics were considered acceptable. Biomass reference points given below updated with the new assessment and are consistent with those from the 2021 assessment.

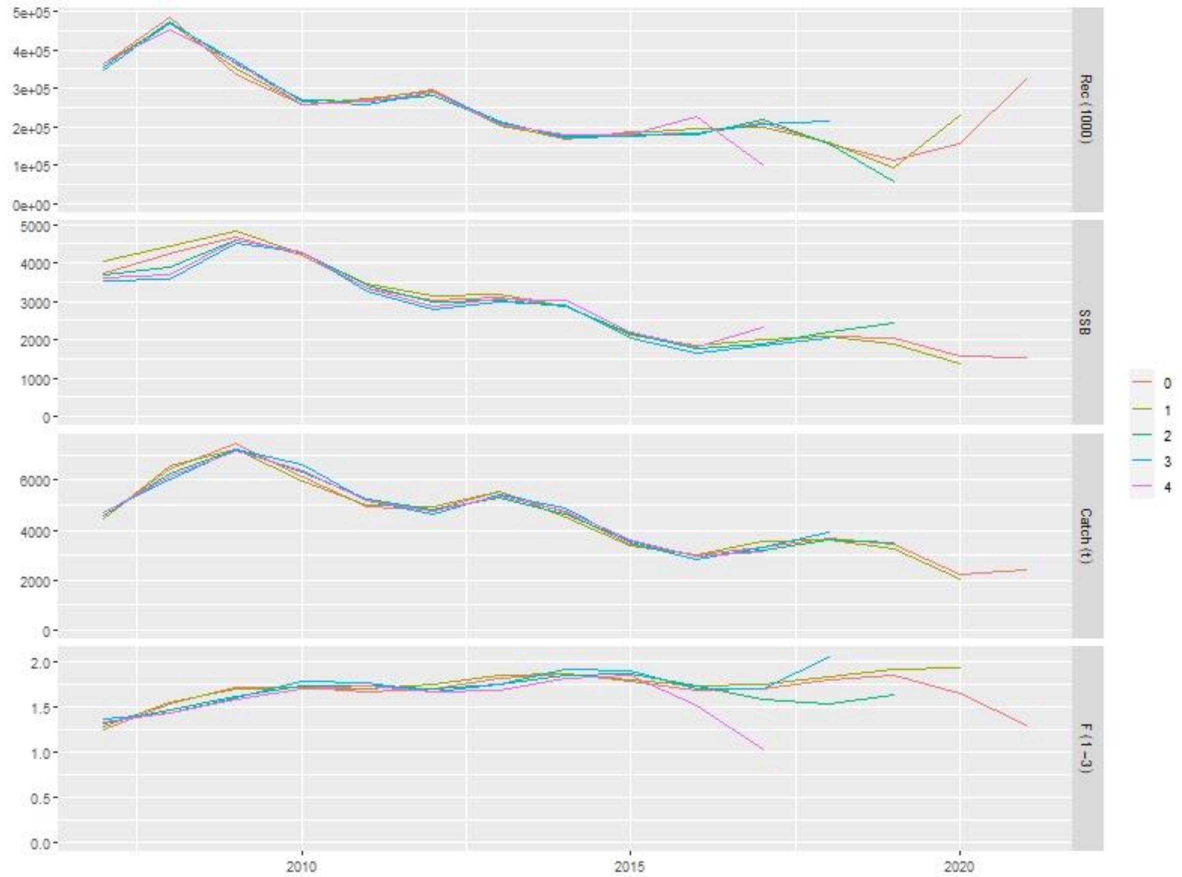


Figure 5.1.2 European hake in GSAs 1, 5, 6 & 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.1.5 European hake in GSAs 1, 5, 6 & 7: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.41	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	3872	HS fit to S-R data from 2022 assessment	STECF EWG 22-09
	B_{pa}	7743	B_{lim}*2	STECF EWG 22-09
	B_{MSY}	63696	B $F_{0.1}$ 2022 assessment	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.41	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.27	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.56	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.1.6 European hake in GSAs 1, 5, 6 & 7: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.1.7 European hake in GSAs 1, 5, 6 & 7: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		819	3148	
2020	F = F_{MSY}		1269	2011	
2021	F = F_{MSY}		721	2350	
2022	F = F_{MSY}		1220		
2023	F = $F_{MSY\ Reduced}$ B< B_{pa}		1004		

History of the catch and landings

Table 5.1.8 European hake in GSAs 1, 5, 6 & 7: Catch and effort (for the main gears) distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)	2813	Otter trawl 84.5%	Gillnets 4%	Trammel nets 3%	Other 8.5%	307t
Effort	--	79290 (37.8%)	99978 (47.67%)	30475 (14.53%)	NA	
		Fishing days				

Table 5.1.9 European hake in GSAs 1, 5, 6 & 7: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	SPAIN GSA1	SPAIN GSA5	SPAIN GSA6	SPAIN GSA7	FRANCE GSA7	Total landings	Total Effort * (Fishing Days)
2002	496	95	2835	369	2343	6138	37332
2003	398	48	4633	315	2273	7666	44311
2004	503	63	3151	182	1140	5039	236891
2005	359	98	3473	223	1002	5156	226951
2006	385	125	3627	261	1160	5558	222452
2007	340	185	2540	237	1394	4697	191584
2008	330	121	3341	280	2009	6082	202219
2009	619	67	3847	345	2485	7362	233372
2010	576	99	2822	195	2088	5780	309657
2011	683	85	3182	134	1415	5498	309470
2012	463	61	2641	180	1078	4423	298718
2013	375	109	2950	216	1580	5230	271354
2014	283	118	2489	224	1702	4816	271129
2015	183	102	1726	126	1003	3141	271158
2016	176	67	1810	120	895	3067	269161
2017	299	72	1728	95	768	2962	267246
2018	410	97	2443	87	794	3831	242487
2019	290	107	1630	73	1058	3159	242438
2020	182	68	1099	36	508	1893	225338
2021	281	73	1544	43	565	2506	209743

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.1.10 European hake in GSAs 1, 5, 6 & 7: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2007	373604			3550			4395	1.27		
2008	479766			4017			6449	1.56		
2009	341042			4522			7509	1.75		
2010	260468			4031			6196	1.76		
2011	267851			3173			4975	1.72		
2012	294742			2877			4775	1.74		
2013	207903			2996			5471	1.83		
2014	165332			2818			4671	1.86		
2015	187466			2100			3445	1.79		
2016	183712			1798			3028	1.71		
2017	213438			1945			3331	1.72		
2018	156536			2055			3656	1.82		
2019	111873			2008			3432	1.85		
2020	151181			1545			2244	1.66		
2021	290865			1498			2350	1.34		

Sources and references

STECF EWG 22-09

5.2 SUMMARY SHEETS FOR DEEP-WATER ROSE SHRIMP IN GSAS 1, 5, 6 & 7

Deep-water rose shrimp in GSAs 1, 5, 6, & 7 were assessed as two biological units in 2022

5.2.1 SUMMARY SHEET FOR DEEP-WATER ROSE SHRIMP IN GSA 1

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.99 and corresponding catches in 2022 should be no more than 1543 tons.

Stock development over time

The stock appears to have been quite stable from 2007 to 2014. From 2014 the stock has increased rapidly with a peak in 2018 and a maximum in 2021. SSB and recruitment show an increasing pattern in the last years, while F show an unusual opposite trend that can be justified by the huge increase in recruitment in the last year.

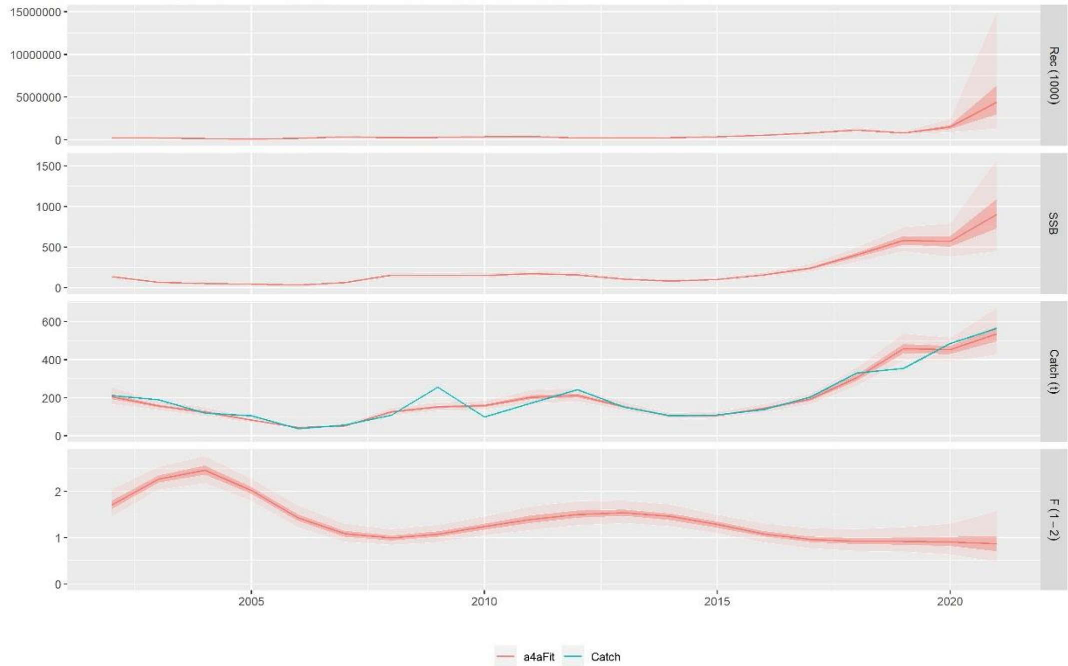


Figure 5.2.1.1Deep-water rose shrimp in GSA 1: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality is below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.99). No biomass reference points are calculated.

Table 5.2.2.1 Deep-water rose shrimp in GSA 1: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	F < F_{MSY}	F < F_{MSY}	F < F_{MSY}
F / $F_{MSY\ Transition}$		F < $F_{MSY\ Transition}$	F < $F_{MSY\ Transition}$

Catch scenarios

Table 5.2.1.2 Deep-water rose shrimp in GSA 1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-2}$ (2022)	0.87	F current in the last year used to give F status quo for 2022
SSB (2022; middle year)	2074.2 t	Stock assessment 1 January 2022
R_0 (2022-2023)	2193169 thousands	Mean of the last 3 years
Total catch (2022)	1441.1 t	Assuming F status quo for 2022

Table 5.2.1.3 Deep-water rose shrimp in GSA 1: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-2) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	1543.3	0.99	1430.4	-31.0	+181.2
F_{MSY} transition	1521.0	0.96	1453.2	-29.94	+177.1
$F_{MSY\ lower}$	1161.7	0.66	1841.5	-11.2	+111.7
$F_{MSY\ upper}$**	1852.4	1.34	1130.2	-45.5	+237.5
Other scenarios					
Zero catch	0.0	0.00	3328.6	+60.5	-100.0
Status quo	1414.1	0.86	1564.8	-24.6	+157.6

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.2.1.4 Deep-water rose shrimp in GSA 1: The basis of the advice.

Advice basis	F_{MSY}
Management plan	0.99

Quality of the assessment

Commercial catches showed better internal consistency than MEDITS survey index.
The assessment is new. As this is a new assessment no reference points are calculated.
All the diagnostics from the a4a assessment were considered acceptable although survey data residuals are high for age 2.From the retrospective analysis model results stable with the exception of recruitment.
The values of F at age show extremely high values for age 2 in the first 4 years of the assessment remaining high until 2016 but are below F_{MSY} in recent years.
MEDITS survey incomplete for 2020, a sensitivity analysis suggests the assessment results are not influenced by the incomplete survey.

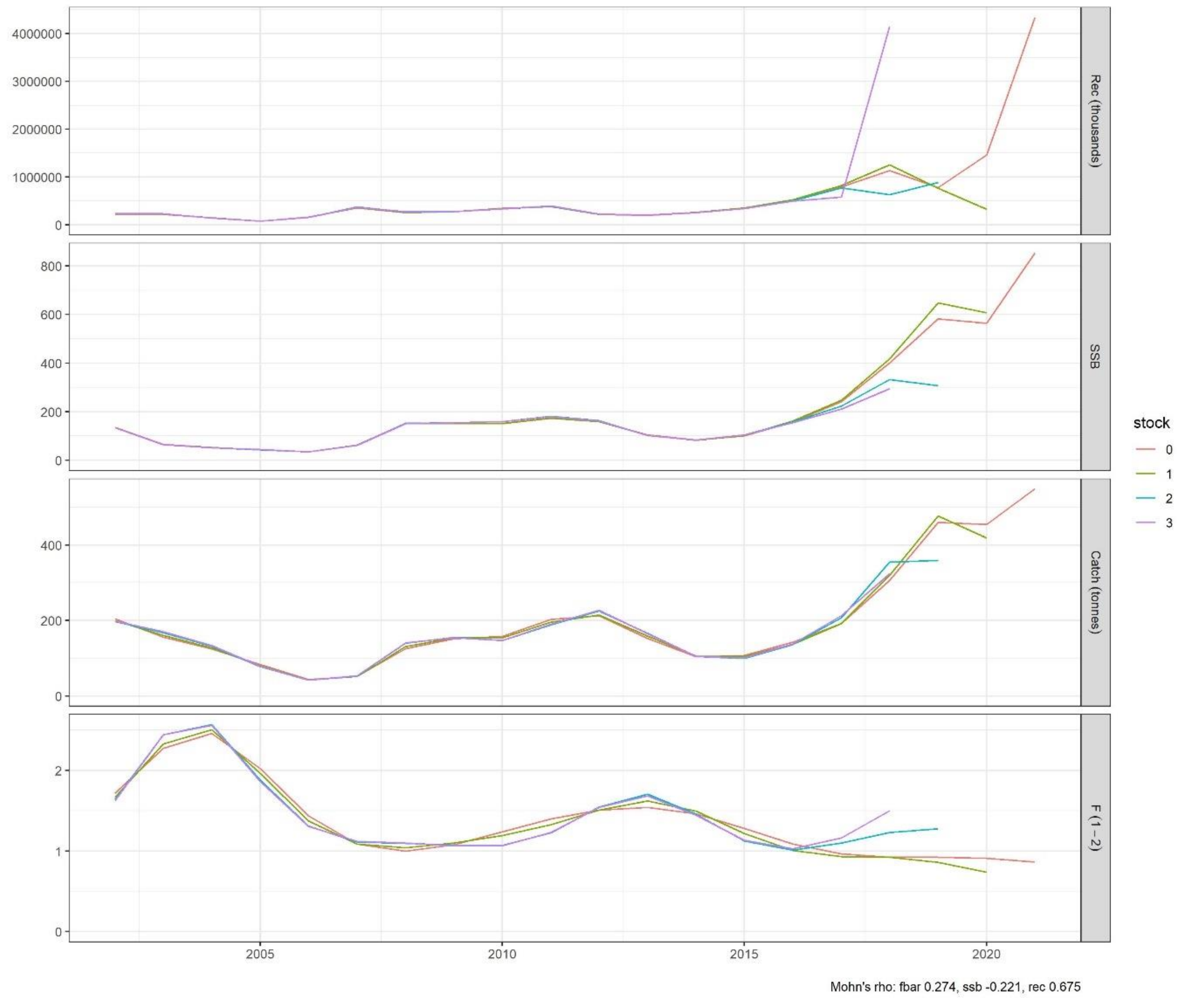


Figure 5.2.1.2 Deep-water rose shrimp in GSA 1: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.2.1.5 Deep-water rose shrimp in GSA 1: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.99	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.99	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.66	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	1.34	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.2.1.6 Deep-water rose shrimp in GSA 1: Basis of assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.2.1.7 Deep-water rose shrimp in GSA 1: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	Index GSA 1,5,6 & 7 combined			355.2	1.1
2020	Index GSA 1,5,6 & 7 combined			484.9	2
2021				564.2	0
2022	Index GSA 1,5,6 & 7 combined				
2023	$F = F_{MSY}$		1543.3		

History of the catch and landings

Table 5.2.6 Deep-water rose shrimp in GSA 1: Catch distribution by fleet in 2019 as estimated by STECF.

Catch (2021)		Landings		Discards
564.2 t	100 % trawl	% set nets t	% others	0 t

2021		Wanted catch				Discards
Catch (t)		Bottom Otter Trawl (OTB) 100%				0%
	564.2	564.2				
Effort (2021)		13984 (100%)				
		Fishing Days				

Table 5.2.7 Deep-water rose shrimp in GSA 1: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

Year	Landings	Discards	Total	Total Effort * (Fishing Days)
2002	209.75	2.27	212	28002
2003	187.17	2.026	189.2	32892
2004	118.14	1.279	119.4	34951
2005	103.03	1.71	104.7	32295
2006	37.59	0.407	38	31443
2007	56.16	0.608	56.8	29917
2008	108.87	0.55	109.4	26201
2009	253.93	1.74	255.7	27017
2010	97.6	1.81	99.4	28476
2011	171.57	0.38	171.9	28170
2012	241.52	1.65	243.2	25851
2013	149.12	0.87	150	22657
2014	100.42	4.25	104.7	21506
2015	108.55	1.17	109.7	20559
2016	136.75	0.88	137.6	20528
2017	201.79	1.71	203.5	22026
2018	329.62	0.66	330.3	20425
2019	354.15	1.071	355.2	22006
2020	482.93	2	484.9	18718
2021	564.23	0	564.2	13984

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.2.8 Deep-water rose shrimp in GSA 1: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2002	223099			135			205	1.72		
2003	216836			65			156	2.27		
2004	144529			53			125	2.46		

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2005	73851			44			83	2.02		
2006	157930			34			43	1.43		
2007	352195			63			52	1.09		
2008	255649			153			126	1		
2009	272873			152			152	1.08		
2010	345416			151			158	1.24		
2011	381951			173			203	1.4		
2012	214248			159			213	1.51		
2013	194252			105			153	1.54		
2014	255107			83			104	1.46		
2015	353749			101			108	1.28		
2016	523404			158			143	1.09		
2017	791935			241			192	0.96		
2018	1130145			401			307	0.92		
2019	780866			582			460	0.92		
2020	1461545			564			455	0.91		
2021	4337095			852			549	0.87		

Sources and references

For analysis and data supporting this summary sheet see STECF EWG 22-09 and STECF EWG 22-10.

5.2.2 SUMMARY SHEET FOR DEEP-WATER ROSE SHRIMP IN GSAS 5, 6 & 7

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 1.46 and corresponding catches in 2023 should be no more than 4459 tons.

Stock development over time

Catches, SSB and Recruitment show an increasing pattern from 2015. F shows a fluctuating pattern with a small bump in the beginning of the time series and another large increase between 2018 and 2019. In the last two years F values decrease likely due to the huge increasing in the estimated population biomass.

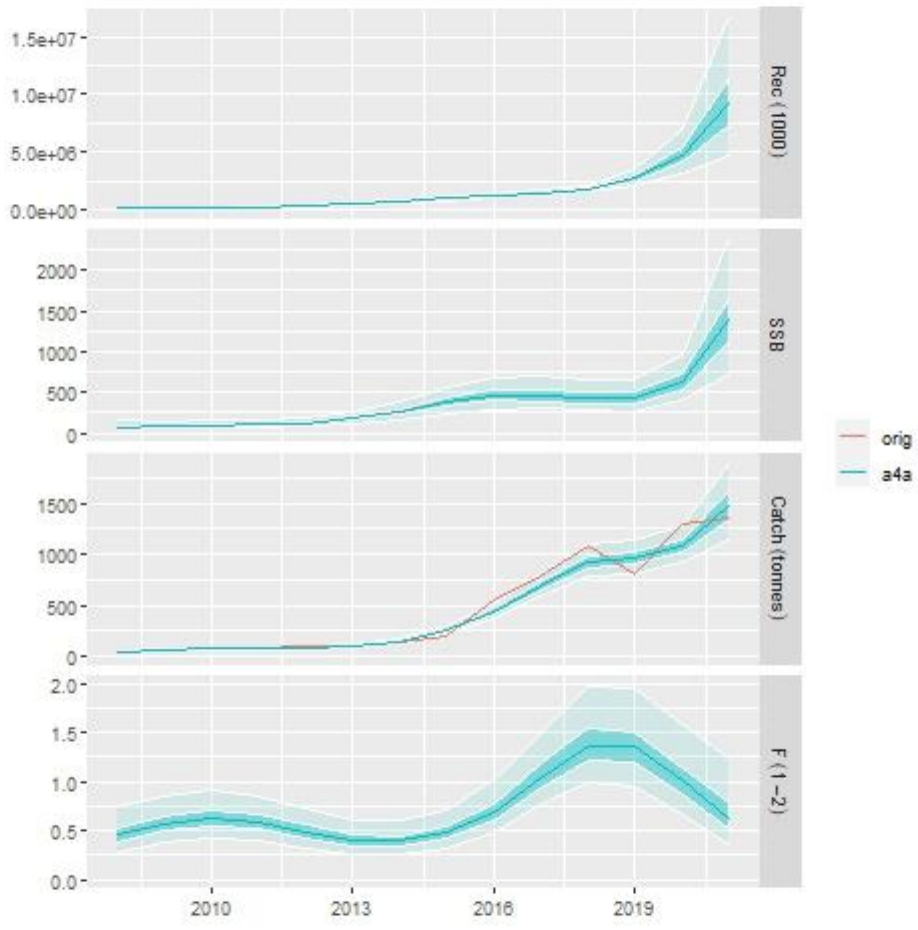


Figure 5.2.2.1 Deep-water rose shrimp in GSAs 5, 6, and 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality is well below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=1.46). No biomass reference points are calculated.

Table 5.2.2.1 Deep-water rose shrimp in GSAs 5, 6 & 7: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
$F / F_{MSY\ Transition}$		$F < F_{MSY\ Transition}$	$F < F_{MSY\ Transition}$

Catch scenarios

Table 5.2.2.2 Deep-water rose shrimp in GSAs 5, 6 & 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-2}$ (2022)	0.64	F current in the last year used to give F status quo for 2022
SSB (2022; middle year)	2756 t	Stock assessment 1 January 2022
R_0 (2022-2023)	4877619 thousands	Geometric mean of the period 2019-2021
Total catch (2022)	2932 t	Catch intermediate year from STF output

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of last three years.

Table 5.2.2.3 Red mullet in GSA 9: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-2) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	4459.4	1.46	1467.8	-46.74	197.11
F_{MSY} transition	4410.2	1.42	1498.6	-45.63	193.83
$F_{MSY\ lower}$	3469.3	0.96	2137.2	-22.45	131.14
$F_{MSY\ upper}$**	5190.3	1.96	1045.6	-62.06	245.80
Other scenarios					
Zero catch	0.0	0.00	5216.14	89.26	-100.00
Status quo	2597.2	0.64	2811.11	2.00	73.04

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.2.2.4 Deep-water rose shrimp in GSAs 5, 6 & 7: The basis of the advice.

Advice basis	F_{MSY}
Management plan	1.46

Quality of the assessment

The stock has been assessed for the first time in the STECF. Both catches and survey indices showed good internal consistency. All the main diagnostics were considered acceptable (just a pattern in age 0 still in an acceptable range of residuals values). The assessment passed all the model diagnostics tests. Only the retrospective analysis shows issues when more than two years have been removed likely due to the very short life of the species (basically 3 years) and the evolving dynamics of the stock with a continuous sharp increasing in the population in the last 5 years.

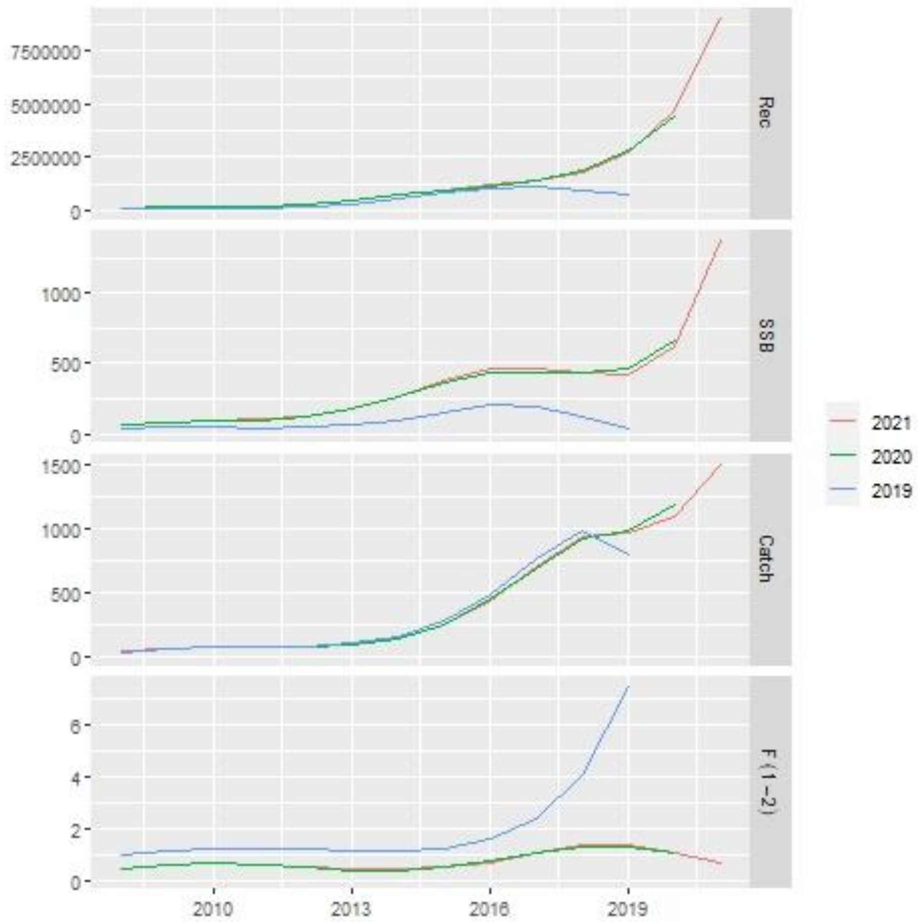


Figure 5.2.2.2 Deep-water rose shrimp in GSAs 5, 6 & 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.2.2.5 Deep-water rose shrimp in GSAs 5, 6 & 7: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	1.46	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	1.46	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.96	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	1.96	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Due to the instability on the retrospective the assessment has been considered only able in providing advice in term of fishing mortality level but not robust enough to compute biomass reference point.

Basis of the assessment

Table 5.2.2.6 Deep-water rose shrimp in GSAs 5, 6 & 7: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.2.2.7 Deep-water rose shrimp in GSAs 5, 6 & 7: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catches	STECF discards
2022	Index GSA 1,5,6 & 7 combined				
2023	F = F_{MSY}		4459		

History of the catch and landings

Table 5.2.2.8 Deep-water rose shrimp in GSAs 5, 6 & 7: Catch in 2021 and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)		Bottom Otter Trawl (OTB) 93.18%	Twins Otter Trawl (OTT) 6.73%	Others gears 0.08%		Bottom Otter Trawl (OTB) 100%
		1398.6	101.0	1.2		9
Effort (2021)		65306 (93.79%)	4325 (6.21%)	NA		
		Fishing Days				

Table 5.2.2.9 Deep-water rose shrimp in GSAs 5, 6 & 7: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days of OTB and OTT gear extracted from the Mediterranean and Black Sea database (2002-2012) and from the Fisheries Dependent Information (2013 onward).

Year	ESP GSA5	ESP GSA6	ESP GSA7	FRA GSA7	Total landings	Total Effort Fishing
2002	36.18	144.08	0.00	0.00	180.26	NA
2003	22.13	116.02	0.00	0.00	138.15	NA
2004	6.53	66.19	0.00	0.00	72.72	133802
2005	1.60	44.66	0.00	0.00	46.26	126080
2006	1.01	25.18	0.00	0.00	26.19	124065
2007	1.39	28.81	0.00	0.00	30.20	115098
2008	5.20	38.95	0.13	0.00	44.28	122787
2009	5.11	49.09	0.14	0.00	54.34	115947
2010	6.25	71.89	0.36	3.77	82.27	125640
2011	4.53	66.27	1.15	6.21	78.16	119418
2012	4.17	85.61	1.95	3.42	95.15	111134
2013	6.20	86.75	2.30	2.38	97.63	106518
2014	5.59	131.27	3.37	4.27	144.50	112031
2015	7.58	174.64	4.73	13.68	200.63	105936
2016	9.09	471.28	27.12	42.89	550.38	103712
2017	68.03	634.71	36.28	46.60	785.62	102037
2018	101.16	914.60	17.86	37.73	1071.35	97512
2019	59.76	703.99	7.29	24.53	795.56	96075
2020	67.94	1094.83	15.99	102.48	1281.25	88948
2021	79.18	1110.59	29.15	118.23	1337.14	69631

Summary of the assessment

Table 5.2.2.10 Deep-water rose shrimp in GSAs 5, 6 & 7: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 ('000)	High	Low	SSB (t)	High	Low	Catch (t)	F_{bar} ages 1-2	High	Low
2008	148645.5			65.26			40.39	0.453		
2009	156430.5			81.20			66.52	0.562		
2010	178213.1			93.26			74.51	0.625		
2011	231136.7			101.31			75.39	0.585		
2012	336806.5			123.27			80.56	0.484		
2013	513382.9			177.71			103.33	0.402		
2014	749165.1			258.92			145.54	0.388		
2015	989960.2			373.88			253.79	0.472		
2016	1195615			460.45			444.75	0.690		
2017	1417780			460.81			695.80	1.048		
2018	1819909			434.05			932.70	1.372		
2019	2715448			425.16			973.58	1.359		
2020	4730921			627.05			1094.48	1.013		
2021	9033092			1370.47			1500.94	0.639		

Sources and references

EWG 22-09: Stock assessments in the Western Mediterranean Sea 2022
https://stecf.jrc.ec.europa.eu/ewg2209

5.3 Summary sheet for red mullet in GSA 1

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.34 and corresponding catches in 2023 should be no more than 60.5 tons. The fishing mortality is reduced from F_{MSY} of 0.61 as SSB is projected to be below B_{pa} in 2023.

Stock development over time

The assessment shows fluctuation of all indicators along the available time series, while effective reduction of fbar has not occurred, keeping above 1.2. Catches, recruitment and SSB of red mullet show a decreasing trend since 2017, with a slight increase in these indicators in the last two years of the period assessed. Modelled catch follows properly the observed catch, excluding some years in the middle of the time series, where the model had greater problems to fit the catch data.

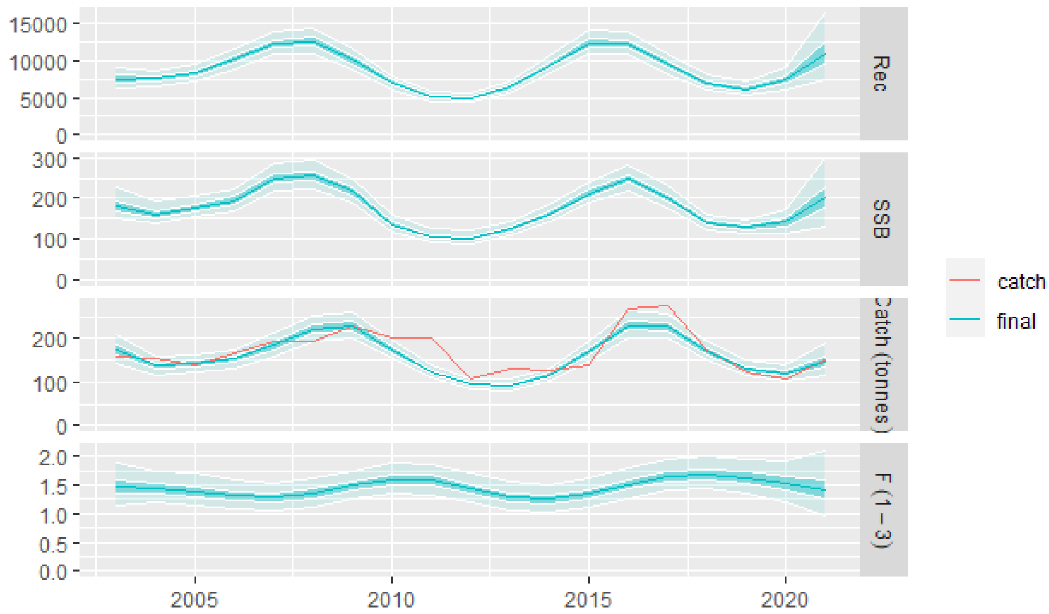


Figure 5.3.1 Red mullet in GSA 1: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality (1.42) is 2.32 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.61). F in 2021 is also higher than $F_{MSY\ Transition}$ (0.95) indicating progress to F_{MSY} in 2025 is behind transition. SSB in 2021 has increased a little since 2020 and is now estimated to be above B_{lim} but is still below B_{pa}.

Table 5.3.1 Red mullet in GSA 1: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}
F / $F_{MSY\ Transition}$		F > $F_{MSY\ Transition}$	F > $F_{MSY\ Transition}$
B / B_{lim}	B < B_{lim}	B < B_{lim}	B > B_{lim}
B / B_{pa}	B < B_{pa}	B < B_{pa}	B < B_{pa}
B / B_{MSY}	B < B_{MSY}	B < B_{MSY}	B < B_{MSY}

Catch scenarios

Table 5.3.2 Red mullet in GSA 1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2021)	1.42	F current in the last year used to give F status quo for 2022
SSB (2021)	199 t	Stock assessment 1 January 2022
R_0 (2021-2022)	8449 thousands	Geometric mean of the period 2003-2021
Total catch (2021)	180.8t	Assuming F status quo for 2021

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of last three years.

Table 5.3.3 Red mullet in GSA 1: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	96.13	0.61	276.56	+46.6	-35.2
F_{MSY} transition	131.04	0.95	224.65	+18.3	-11.7
$F_{MSY\ Reduced}$ B<B_{pa}^^^	**60.53**	**0.34**	**337.21**	**+77.6**	**-59.2**
$F_{MSY\ lower}$	69.75	0.40	320.77	+68.9	-52.9
$F_{MSY\ upper}$**	119.94	0.82	240.33	+26.6	-19.2
Other scenarios					
Zero catch	0.0	0.00	457.33	+140.8	-100.0
Status quo	167.23	1.42	178.77	-5.8	+12.7
		0.14	399.82	+110.5	-81.34
		0.28	353.28	+86.05	-65.10
		0.43	315.33	+66.07	-50.89
		0.57	284.16	+49.65	-38.39
		0.71	258.36	+36.06	-27.34
		0.85	236.83	+24.72	-17.52
		1	218.71	+15.18	-8.74
		1.14	203.32	+7.07	-0.86
		1.28	190.14	+0.14	+6.25

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025
^^^$F_{MSY\ Reduced}$ B<B_{pa} is based on ICES advice rule when B in TAC year is less than B_{pa}

The primary catch option selected is based on the ICES advice rule when SSB in TAC year is less than B_{pa} as is the case for red mullet in GSA 1 in 2023

Basis of the advice

Table 5.3.4 Red mullet in GSA 1: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Commercial catches showed worse internal consistency than MEDITS survey index. The historic assessment is stable, and the assessment model was not modified. The retrospective analysis showed consistency in the estimation of F estimated in the assessment of 2020. Also the estimation of recruitment is consistent with the ones obtained from last year assessment. All the diagnostics were considered acceptable.

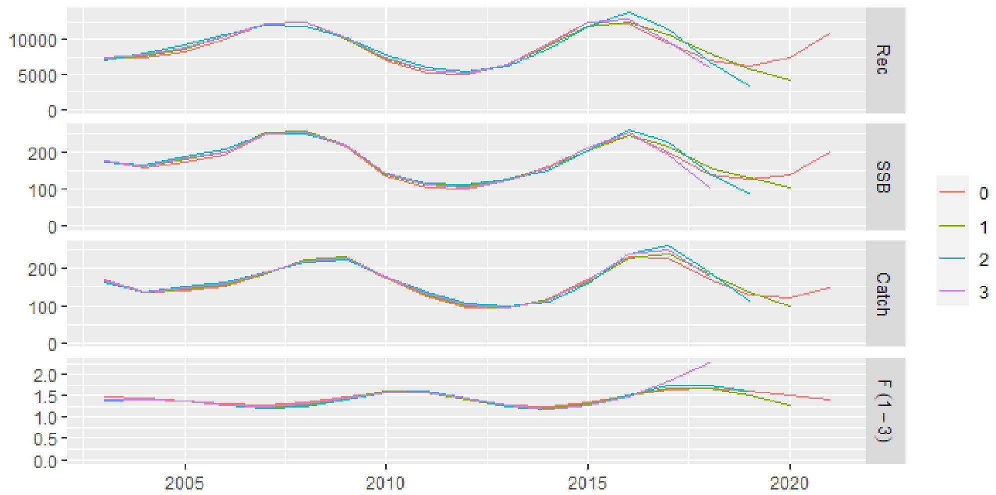


Figure 5.3.2 Red mullet in GSA 1: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.3.5 Red mullet in GSA 1: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.61	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	169.8	Estimated	STECF EWG 22-09
	B_{pa}	338.4	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	399	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.61	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.40	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.82	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.3.6 Red mullet in GSA 1: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.3.7 Red mullet in GSA 1: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catches	STECF discards
2019	$F = F_{MSY}$		99	125	
2020	$F = F_{MSY}$		97.7	107.6	
2021	$F = F_{MSY}$		103.2	151.1	
2022	$F = F_{MSY}$		180.7		
2023	$F = F_{MSY\ Reduced}$ $B< B_{pa}$		60.5		

History of the catch and landings

Table 5.3.8 Red mullet in GSA 1: Catch in 2021 and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)		Otter trawl 85.9%	Gillnets 0.01%	Trammel nets 9.6%		
		129.93	0.22	13.8		
Effort (2021)		13984 (59.41%)	NA	9553 (40.59%)		
		Fishing Days				

Table 5.3.9 Red mullet in GSA 1: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	ESP GSA1	Total landings	Total Effort Fishing
2003	159.68	159.68	38426
2004	154.07	154.07	40760
2005	140.21	140.21	37895
2006	164.54	164.54	37380
2007	194.01	194.01	35391
2008	193.65	193.65	32165
2009	228.37	228.37	36472
2010	201.65	201.65	37515
2011	201.18	201.18	38558
2012	107.31	107.31	36023
2013	131.63	131.63	33612
2014	123.87	123.87	33386
2015	135.9	135.9	28873
2016	260.49	260.49	29527
2017	274.67	274.67	30573
2018	170.23	170.23	30379
2019	124.62	124.63	32962
2020	107.321	107.32	28724
2021	151.102	151.102	23537

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.3.10 Red mullet in GSA 1: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 ('000)	High	Low	SSB (t)	High	Low	Catch (t)	F_{bar} ages 1-3	High	Low
2003	7454	8615	6293	181.4	207.7	155.1	159.7	1.5	1.8	1.2
2004	7522	8279	6765	162.2	184.0	140.4	154.1	1.4	1.7	1.2
2005	8310	9195	7425	177.4	197.6	157.2	140.2	1.4	1.6	1.2
2006	10156	11181	9131	194.9	216.3	173.5	164.6	1.3	1.5	1.1
2007	12308	13461	11155	249.9	274.5	225.3	194.1	1.3	1.5	1.1
2008	12613	13976	11250	255.8	282.6	229.0	193.8	1.3	1.5	1.2
2009	10142	11279	9005	217.8	241.9	193.7	229.5	1.5	1.7	1.3
2010	7027	7771	6283	136.2	152.7	119.7	201.7	1.6	1.8	1.4
2011	5205	5757	4653	106.3	118.9	93.7	201.3	1.6	1.8	1.4
2012	4971	5526	4416	101.9	114.8	89.0	109.0	1.4	1.6	1.2
2013	6381	7007	5755	125.5	138.7	112.3	131.9	1.3	1.5	1.1
2014	9416	10336	8496	161.5	177.5	145.5	127.2	1.2	1.4	1.1
2015	12379	13646	11112	212.8	233.0	192.6	137.7	1.3	1.5	1.2
2016	12267	13440	11094	248.2	271.5	224.9	268.1	1.5	1.7	1.3
2017	9498	10565	8431	201.9	221.5	182.3	278.2	1.7	1.9	1.5
2018	6933	7786	6080	141.5	156.7	126.3	173.0	1.7	1.9	1.5
2019	6175	6880	5470	128.7	142.2	115.2	125.0	1.6	1.8	1.4
2020	7434	8610	6258	140.9	163.5	118.3	107.6	1.5	1.8	1.2
2021	10950	14207	7693	201.2	262.9	139.5	151.1	1.4	1.8	1.0

Sources and references

EWG 22-09: Stock assessments in the Western Mediterranean Sea 2022, FDI EWG 22-10

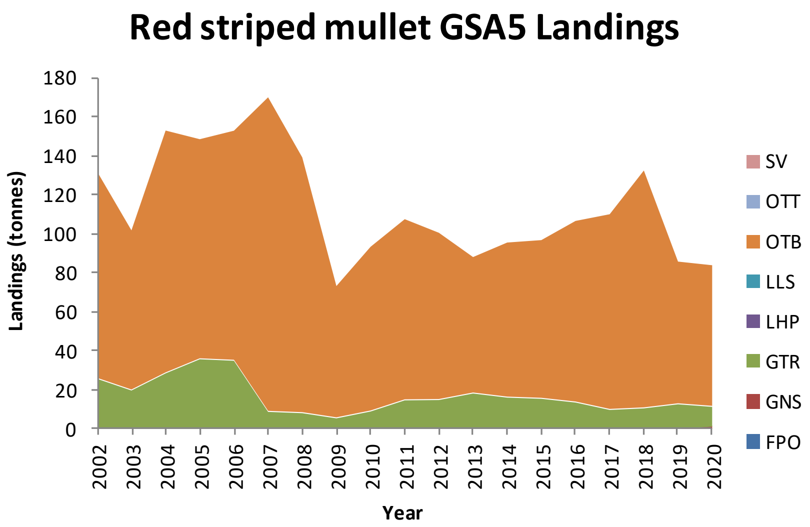
5.4 SUMMARY SHEET FOR STRIPED RED MULLET IN GSA 5

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 21-11 advises to decrease the catch by 16% from catch in 2020 equivalent to catches of no more than 84.6 tonnes in each of 2022 and 2023 implemented through either catch restrictions or effort reduction for the relevant fleets.

Stock development over time

Landings (Figure 5.4.1) have fluctuated over years, with an important decrease from 2007-2009, a constant increase from 2013-2018 and again a reduction from 2018-2020.
Only recent survey data since 2007 is considered useful due to the very small number of hauls prior to that year. The survey indicated that biomass has fluctuated along the data series, with high peak values in 2007 and 2017.



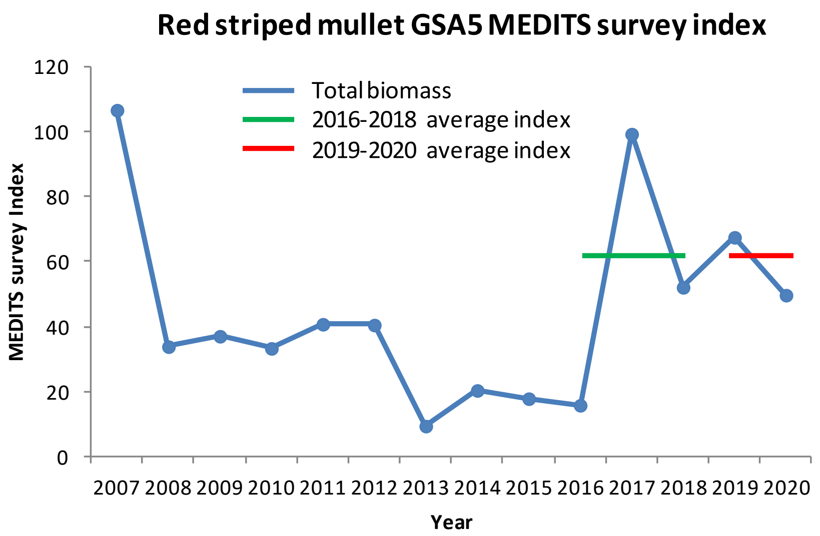


Figure 5.4.1 Red striped mullet in GSA 5: Landing (t) from 2002 to 2020. MEDITS estimated biomass in the last 2007-2020 and recent showing mean of last two years (2019-2020 in red) and previous three years (2016-2018 in green) used for calculating catch advice.

Stock and exploitation status

The status of the stock in terms of SSB and exploitation rate F is unknown.

Catch scenarios

The advice on fishing opportunities for 2022 and 2023 was based on the last catch advice adjusted to the change in the MEDITS survey biomass index between the periods 2016-2018 and 2019-2020, resulting in a ratio of 1.05 (Table 5.4.1). Accordingly, the previous catch (average of 2018-2020) 100.54 tonnes, × 1.05 index ratio, x 0.8 factor for the precautionary buffer was taken as the basis for a precautionary advice on fishing opportunities for 2022 and 2023, which corresponded to 84.6 tonnes. This implies a catch increase of 1% from reported 2020 catches of 83.7 tonnes, and a 30 reduction on the advice of 121 t given 2020.

Table 5.4.1 Striped red mullet in GSA 5: Assumptions made for the interim year and in the forecast. *

Index A (2019–2020)		58.70
Index B (2016–2018)		55.82
Index ratio (A/B)		1.05
-20% Uncertainty cap		Not applied
Average catch last 3 year (2018–2020)		100.54
Discard rate (2018–2020)		0 (negligible)
-20% Precautionary buffer		Not Applied (-0.8%)
Catch advice **		84.6
Landings advice ***		84.6
% advice change ^		-30%

* The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.
** (average catch 2018-2020 × index ratio x 0.8)
*** catch advice × (1 – discard rate), discards are negligible.
^ Advice value 2022 relative to advice value 2020.

Basis of the advice

Table 5.4.2 Striped red mullet in GSA 5: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

Due to the great fluctuations in data on the landings and survey, giving instability of retrospective analysis and patterns in the residuals, the assessment (a4a) was considered not acceptable and insufficient for the advice. EWG 21-11 decided to apply a survey-based assessment following the approach adopted by ICES for category 3 stocks.

Issues relevant for the advice

Precautionary advice provided as an age based assessment was not available to provide advice based on a MSY approach.

Reference points

Table 5.4.3 Striped red mullet in GSA 5: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach			Not defined	
Precautionary approach			Not defined	
Management plan			Not defined	

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}		Not defined	
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MSY $B_{trigger}$		Not defined	
	B_{lim}			
	F_{MSY}		Not defined	
	target range F_{lower}			
	target range F_{upper}			

Basis of the assessment

Table 5.4.4 Striped red mullet in GSA 5: Basis of assessment and advice.

Assessment type	Index based assessment
Input data	DCF commercial catches (2002 - 2020)
Discards and bycatch	Negligible
Indicators	MEDITS indices (2007-2020)
Other information	
Working group	EWG 21 – 11

History of the advice, catch, and management

Table 5.4.5 Striped red mullet in GSA 5: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted catch corresp. to advice	Official landings in (areas)	STECF landings	STECF discards	STECF catch
2019	$F = F_{MSY}$	113				85.55
2020	$F = F_{MSY}$	110				83.69
2021	$F = F_{MSY}$	121				
2022	precautionary advice reduce catch	84.6				
2023	precautionary advice reduce catch	84.6				

History of the catch and landings

Table 5.4.6 Striped red mullet in GSA 5: Catch distribution by fleet in YEAR as estimated by and reported to STECF.

Catch	Wanted catch				Discards
83.69	Otter trawl 86.41%	Gillnets 12.15%	0%	Other 1.42 %	0 t
	72.32	10.17		1.19	
Effort					
8431	Fishing days				

Table 5.4.7 Striped red mullet in GSA 5: History of commercial landings. All weights are in tonnes.

Year	Spain GSA5	STECF total landings	Total Effort* (Fishing days)
2002	131.68	131.68	
2003	101.62	101.62	
2004	152.95	152.95	13606
2005	148.51	148.51	13063
2006	152.88	152.88	12265
2007	170.06	170.06	12374
2008	139.16	139.16	12693
2009	72.97	72.97	15342
2010	93.15	93.15	15563
2011	107.36	107.36	14769
2012	100.36	100.36	15227
2013	87.88	87.88	15309
2014	95.35	95.35	16552
2015	96.60	96.60	16071
2016	106.46	106.46	13777
2017	109.93	109.93	12277
2018	132.40	132.40	9569
2019	85.55	85.55	9290
2020	83.69	83.69	8431

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.4.10 Striped red mullet in GSA 5: Assessment summary. Weights are in tonnes.

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2007	106.77	170.06	0	170.06
2008	33.93	139.16	0.57	139.73
2009	37.13	72.97	0.14	73.11
2010	33.39	93.15	9.32	102.47
2011	40.83	107.36	2	109.36
2012	40.59	100.36	9.52	109.88
2013	9.47	87.88	0.48	88.36
2014	20.44	95.35	2.86	98.21
2015	17.91	96.60	0.15	96.75
2016	15.87	106.46	2.26	108.72
2017	99.40	109.93	1.48	111.41
2018	52.20	132.40	0.24	132.64
2019	67.60	85.55	0	85.55
2020	49.79	83.69	0	83.69

Sources and references

Reproduced from STECF EWG 21-11 with 2 years advice, STECF EWG 22-10,

5.5 SUMMARY SHEET FOR RED MULLET IN GSA 6

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.314 and corresponding catches in 2023 should be no more than 396.5 tons.

Stock development over time

Catches of red mullet have fluctuated along the analysed period; in the most recent years catches have been higher than at the beginning of the period. Since 2013 both recruitment and SSB remained at similar values, although recruitment decreased in 2020 and 2021, though recruitment in the final years is particularly uncertain. F slightly decreased in the last three years 2019-2021.

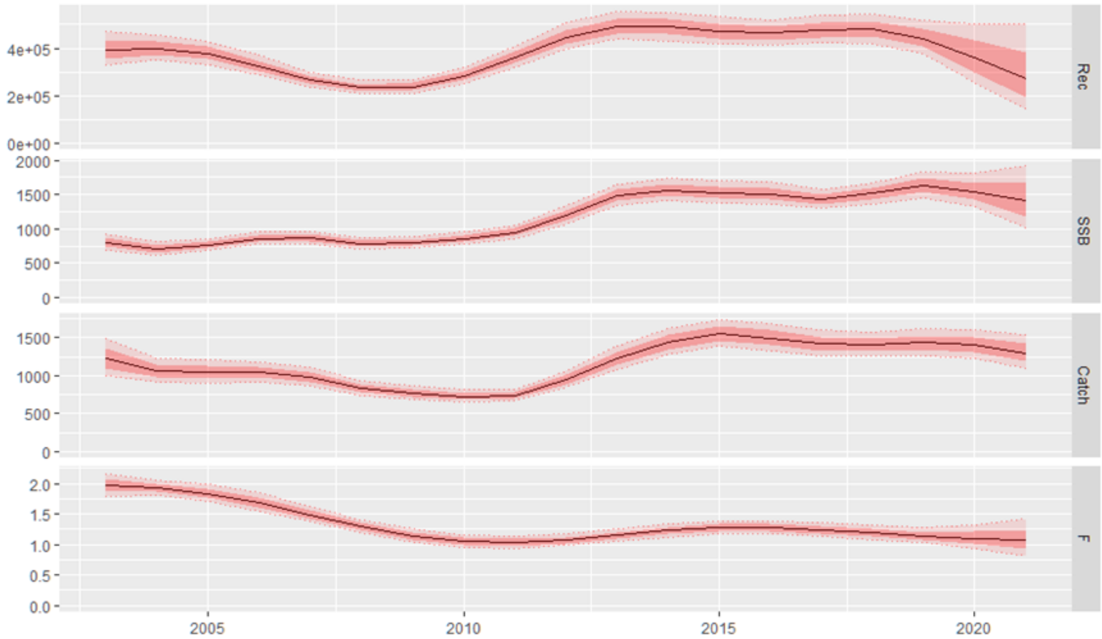


Figure 5.5.1 European hake in GSAs 6: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.07) is 3.6 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.314). F in 2021 (1.07) is also higher than $F_{MSY\ Transition}$ (0.589) indicating progress to F_{MSY} in 2025 is behind transition. SSB in 2021 has decreased a little since 2020 and is now estimated to be just below B_{pa} but remains well above B_{lim} but has remained below B_{MSY} since the start of the series.

Table 5.1.1 Red mullet in GSA 6: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
$F / F_{MSY\ Transition}$		$F > F_{MSY\ Transition}$	$F > F_{MSY\ Transition}$
B / B_{lim}	$B > B_{lim}$	$B > B_{lim}$	$B > B_{lim}$
B / B_{pa}	$B > B_{pa}$	$B = B_{pa}$	$B < B_{pa}$
B / B_{MSY}	$B < B_{MSY}$	$B < B_{MSY}$	$B < B_{MSY}$

Catch scenarios

Table 5.5.2 Red mullet in GSA 6: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	1.07	F 2021 used to give F status quo for 2022
SSB (2022)	1124.8	Stock assessment 1 January 2022
R_{age0} (2022,2023)	371343.4	Geometric mean of the series
Total catch (2022)	1102.4	Assuming F status quo for 2022

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.5.3 Red mullet in GSA 6: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	396.5	0.314	2214.6	96.9	-69.6
$F_{MSY\ Transition}$ ^^	657.5	0.589	1773.1	57.6	-49.7
$F_{MSY\ lower}$	279.0	0.210	2432.5	116.3	-78.6
$F_{MSY\ upper}$**	516.3	0.432	2004.8	78.2	-60.5
Other scenarios					
Zero catch	0	0	2995.3	166.3	-100.0
Status quo	986.1	1.07	1302.5	15.8	-24.5

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.1.4 Red mullet in GSA 6: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The historic assessment is stable, and the assessment model was not modified. The retrospective analysis showed consistency in the estimation of F estimated in the assessment of 2021. The estimation of recruitment is inverse compared to the ones obtained from last year assessment. All the diagnostics were considered acceptable.

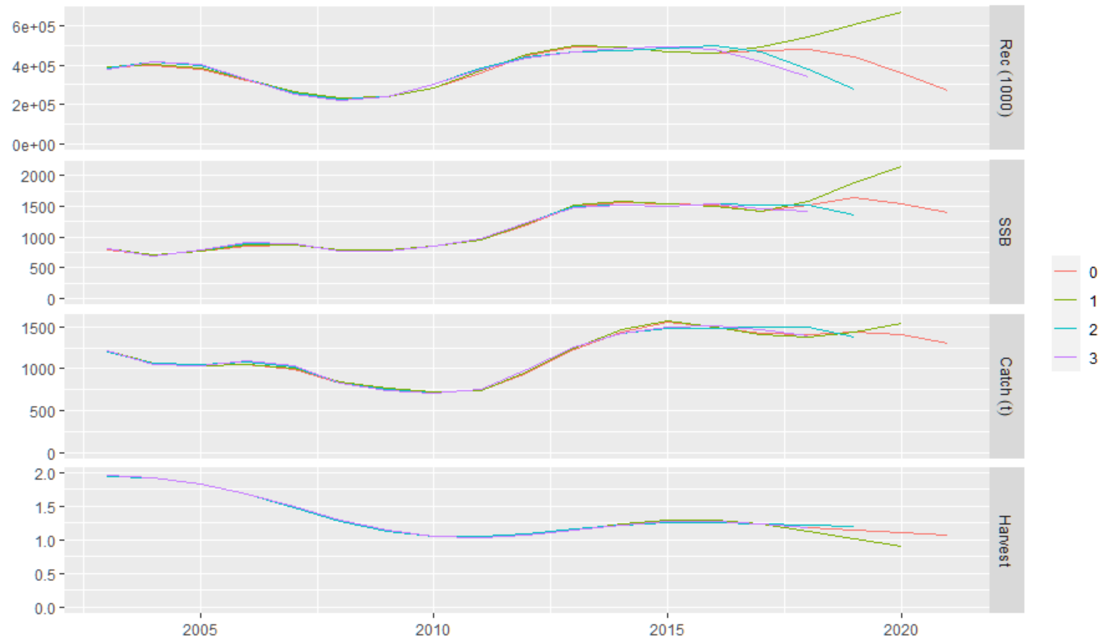


Figure Red mullet in GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.1.5 Red mullet in GSA 6: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.314	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	770	Default value based on 25% of $B_{F0.1}$ with geometric mean recruitment	STECF EWG 22-09
	B_{pa}	1540	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	3079	B $_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.314	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.210	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.432	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.1.6 Red mullet in GSA 6: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data. The LFDs of landings and discards reconstructed in the frame of EWG 21-02 (2003-2019) were used as input data for the assessment.
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.1.7 Red mullet in GSA 6: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	$F = F_{MSY}$		482	1445.8	
2020	$F = F_{MSY}$		448	1539.0	
2021	$F = F_{MSY}$		306	1306.4	
2022	$F = F_{MSY}$		842		
2023	$F = F_{MSY}$		397		

History of the catch and landings

Table 5.1.8 Red mullet in GSA 6: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)	1066.4	Otter trawl 93%	Trammel nets 6.7%		Other 0.3	9.7 t
Effort	91025	51514 (56.59%)	39511 (43.41%)		NA	
		Fishing days				

Table 5.1.9 Red mullet in GSA 6: History of commercial landings and total effort expressed in fishing days. All weights are in tonnes.

Year	GSA6 Landings (t)	Total Effort
2003	1400.0	NA
2004	919.5	150341
2005	995.0	144733
2006	1387.8	141557
2007	1183.6	125910
2008	872.1	138151
2009	520.9	141813
2010	514.1	132612
2011	1063.1	130739
2012	1069.9	125531
2013	1248.0	123746
2014	1309.2	129583
2015	1518.7	117692
2016	1673.9	120218
2017	1449.3	113423
2018	1280.7	110154
2019	1501.8	114654
2020	1446.3	107244
2021	1056.7	91025

Summary of the assessment

Table 5.1.10 Red mullet in GSA 6: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2003	391588			798.2			1211.2	1.97		
2004	400047			705.3			1058.2	1.92		
2005	379277			762.3			1040.6	1.84		
2006	325077			857.4			1045.1	1.69		
2007	266636			866.2			985.3	1.49		
2008	233388			783.3			829.9	1.29		
2009	237721			799.5			766.1	1.14		
2010	282874			858.5			722.0	1.05		
2011	362353			949.5			741.5	1.03		
2012	446336			1194.9			945.2	1.07		
2013	492046			1491.5			1224.1	1.15		
2014	489285			1568.1			1444.8	1.23		
2015	469322			1531.6			1552.4	1.27		
2016	463483			1510.2			1499.5	1.28		
2017	475258			1426.3			1420.8	1.24		
2018	478848			1518.1			1409.2	1.19		
2019	440612			1634.6			1435.3	1.14		
2020	359631			1543.2			1409.6	1.10		
2021	271200			1405.6			1306.4	1.07		

Sources and references

STECF EWG 22-09, EWG 22-10

5.6 SUMMARY SHEET FOR RED MULLET IN GSA 7

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.47 and corresponding catches in 2023 should be no more than 381 tons.

Stock development over time

Recruitment SSB and Catches of Red Mullet show a slow increasing trend initiated in 2007, then in 2021, recruitment seems to have decrease. Fbar (0-3) shows some fluctuations around a slowly decreasing trend and its value in 2021 is associated to quite high uncertainty.

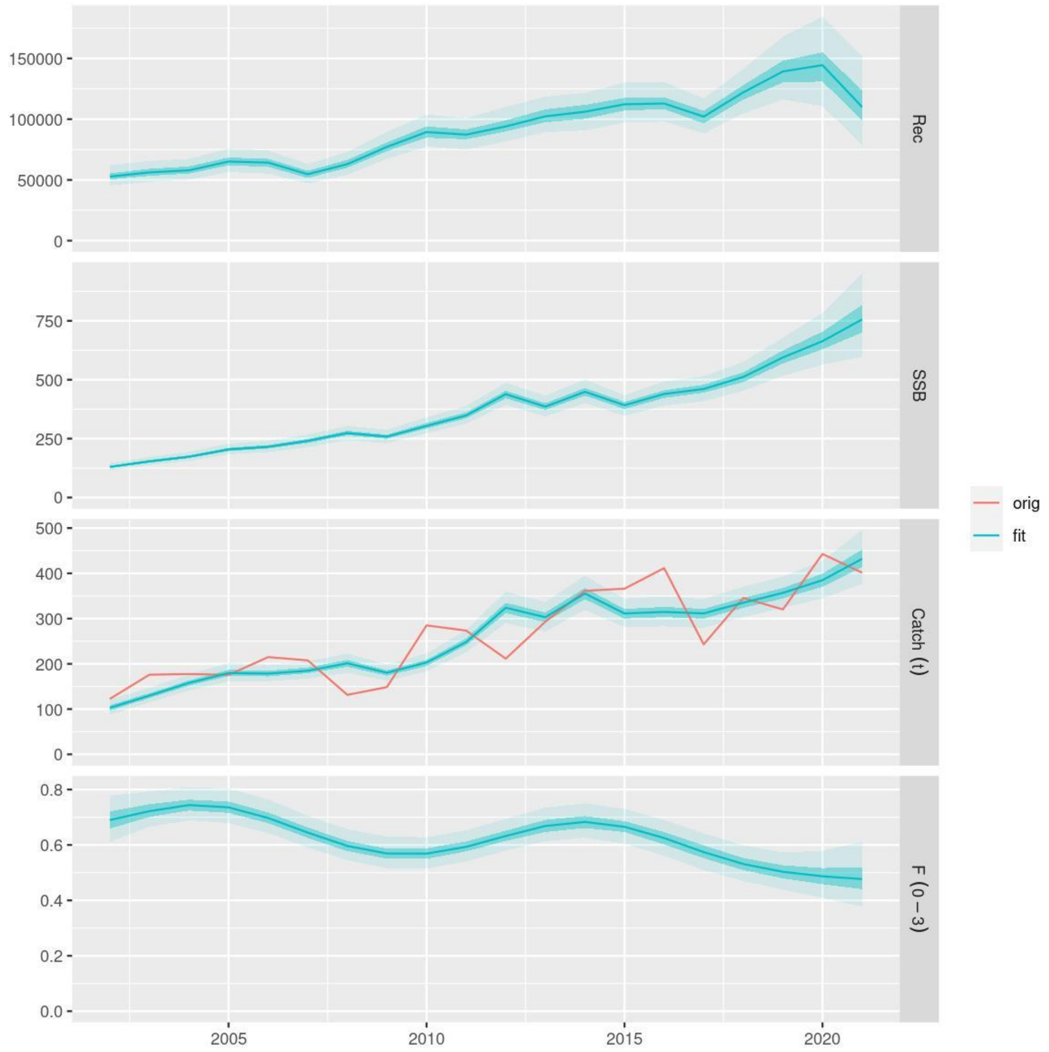


Figure 5.6.1 Red Mullet in GSA 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.479) is 1.016 times above the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.471). The stock is now very close to F_{MSY}. However, that situation may not hold, should the recruitment decrease observed in 2021 persist during the coming years.

Table 5.6.1 Red Mullet in GSA 7: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F = F_{MSY}$
$F / F_{MSY\ Transition}$		$F > F_{MSY\ Transition}$	$F = F_{MSY\ Transition}$
B / B_{lim}	$B > B_{lim}$	$B > B_{lim}$	$B > B_{lim}$
B / B_{pa}	$B > B_{pa}$	$B > B_{pa}$	$B > B_{pa}$
B / B_{MSY}	$B > B_{MSY}$	$B > B_{MSY}$	$B > B_{MSY}$

Catch scenarios

Table 5.6.2 Red Mullet in GSA 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 0\text{-}3}$ (2022)	0.479	F 2022 used to give F status quo for 2021
SSB (2022)	755	Stock assessment 1 January 2021
R_{age0} (2022,2023)	120650	Geometric mean of the last 6 years
Total catch (2022)	421	Assuming F status quo for 2021

Other biological parameters (maturity, natural mortality, mean weights) and fishery selection are taken as mean of the last three years

Table 5.6.3 Red Mullet in GSA 7: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 0-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	380	0.471	684	-0.19	-12.024

Basis	Total catch* (2023)	F_{total}# (ages 0-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
$F_{MSY\ Transition}$ ^^	386	0.481	677	-1.27	-10.62
$F_{MSY\ lower}$	276	0.314	817	19.34	-36.25
$F_{MSY\ upper}$**	477	0.644	571	-16.61	10.25
Other scenarios					
Zero catch	0	0	1223	78.45	-100
Status quo	385	0.479	678	-1.00	-10.97

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}

*** % change in SSB 2024 to 2022

^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.6.4 Red Mullet in GSA 7: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This assessment is an update of the previous year assessment, during which difficulties had been encountered due to reduced survey coverage because of COVID. Fortunately, MEDITS 2021 occurred as usual, leaving that issue behind. The same model has been implemented and the results are consistent with last year's assessment.

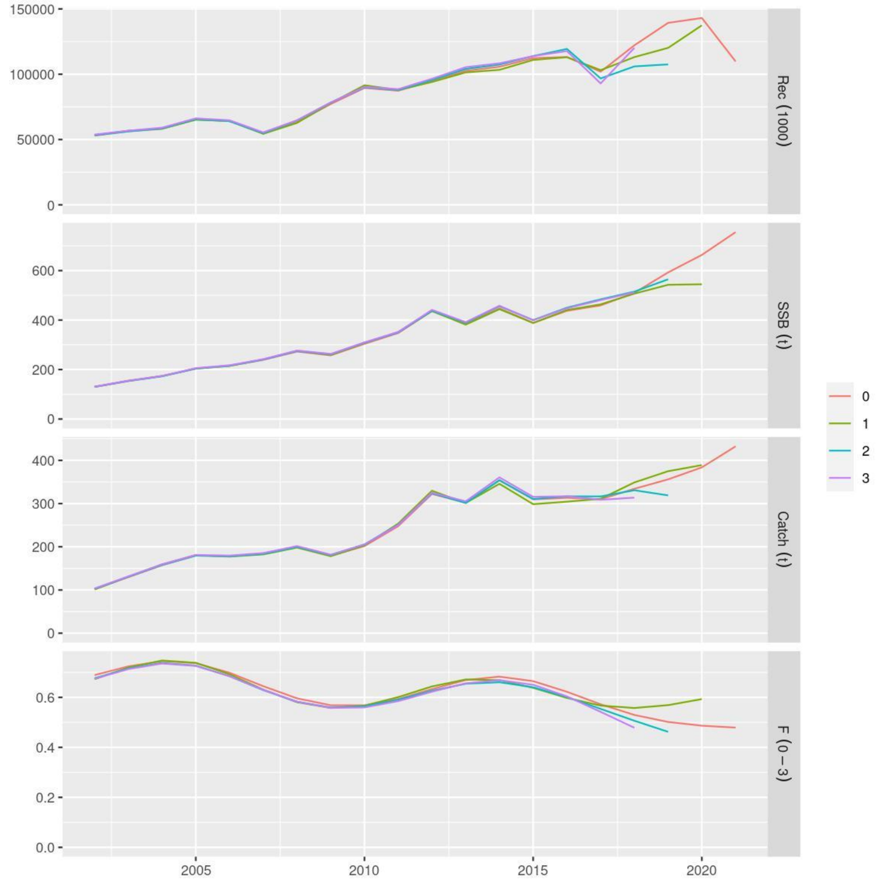


Figure 5.6.2 Red Mullet in GSA 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.6.5 Red Mullet in GSA 7: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.471	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	123	Based on default 25% of $B_{F0.1}$ with geometric mean recruitment.	
	B_{pa}	246	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	491	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		No Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.471	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.314	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.644	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.6.6 Red Mullet in GSA 7: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.6.7 Red Mullet in GSA 7: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2020	$F=F_{MSY}$		320	389	
2021	$F = F_{MSY}$		252	432	
2022	$F = F_{MSY}$		351		
2023	$F = F_{MSY}$		380.5		

History of the catch and landings

Table 5.6.8 Red Mullet in GSA 7: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

<table>
<tr><td>2021</td><td></td><td colspan="4">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Landings
(t)</td><td>395</td><td>Otter trawl
94.02%</td><td>Gillnets
3.09%</td><td>Trammel nets
2.79%</td><td>Other
0.10%</td><td>6.5t</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Effort</td><td>31485</td><td>7353
(23.35%)</td><td>24131 (76.65%)</td><td>NA</td><td>NA</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">Fishing Days</td></tr>
</table>

Table 5.6.9 Red Mullet in GSA 7: History of commercial landings, discards and catch; official reported values are presented by country and GSA. All weights are in tonnes.

YEAR	FRA_GSA7	ESP_GSA7	Total Landings	Discard	Catch	Effort (Fishing days)
2002	111.424	11.08	122.504	0	122.504	NA
2003	164.141	11.87	176.011	0	176.011	NA
2004	151.646	25.84	177.486	0	177.486	3906
2005	148.086	27.48	175.566	0	175.566	3788
2006	183.478	31.4	214.878	0	214.878	3717
2007	171.526	36.16	207.686	0	207.686	3747
2008	110.494	20.73	131.224	0.18	131.404	3922
2009	122.555	26.13	148.685	0	148.685	3019
2010	253.837	28.23	282.067	2.828	284.895	53465
2011	241.764	28.13	269.894	3.584	273.478	55300
2012	173.939	29.17	203.109	8.219	211.328	47055
2013	250.871	37.53	288.401	4.676	293.077	39310
2014	315.874	41.18	357.054	4.204	361.258	34736
2015	324.626	33.05	357.676	8.423	366.099	43290
2016	365.128	43.31	408.438	3.056	411.494	40673
2017	209.532	31.09	240.622	2.352	242.974	41018
2018	318.349	23.83	342.179	3.361	345.54	35388
2019	290.489	22.168	312.657	7.488	320.145	31083
2020	422.153	11.481	433.634	9.151	442.785	28230
2021	383.777	11.025	394.802	6.511	401.313	31485

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.6.10 Red Mullet in GSA 7: Assessment summary. Weights are in tonnes.

Year	Recruitment age 0	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2002	53017			129.67			102.24	0.689		
2003	56283			153.43			129.77	0.724		
2004	58142			173.3			157.38	0.745		
2005	65371			203.72			179.68	0.737		
2006	64075			215			178.24	0.698		
2007	54509			239.25			184.56	0.645		
2008	63308			272.56			200.21	0.596		
2009	77198			257.35			179.31	0.568		
2010	89482			304.09			201.74	0.568		
2011	87369			347.59			247.71	0.593		
2012	94683			436.37			322.4	0.633		
2013	102596			385.23			301.79	0.669		
2014	105743			446.99			354.08	0.683		
2015	112351			388.71			309.73	0.665		
2016	113188			437.42			313.37	0.622		
2017	101935			459.24			310.08	0.572		
2018	122148			510.14			334.26	0.53		
2019	139340			592.66			356.08	0.502		
2020	143072			663.41			383.83	0.487		
2021	109800			755.34			432.49	0.479		

Sources and references

STECF EWG 22-09, STECF EWG 22-10

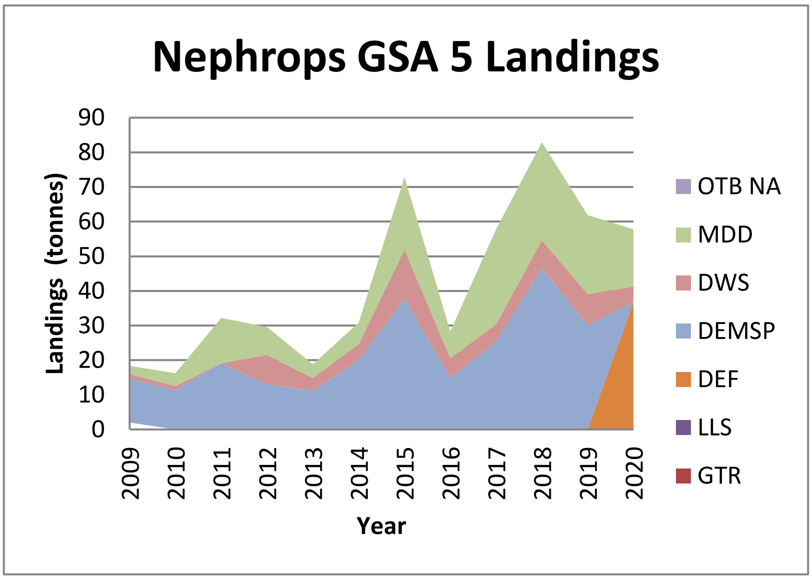
5.7 Summary sheet for Norway lobster in GSA 5

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 21-11 advises to decrease the catch by 35% from catch in 2020 equivalent to catches of no more than 37.4 tonnes in each of 2022 and 2023 implemented through either catch restrictions or effort reduction for the relevant fleets.

Stock development over time

Landings (Figure 5.7.1) have fluctuated over years but show recent rises, but without any evidence of increased effort. Only recent survey data since 2007 is considered useful due to the very small number of hauls prior to that year. The survey indicated that abundance has fluctuated in recent years unrelated to catch or catch per unit effort.



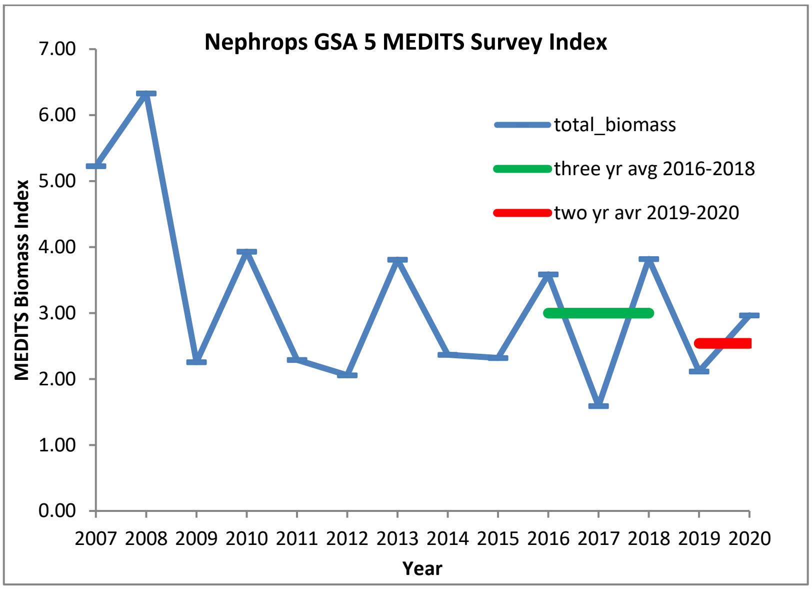


Figure 5.7.1 Norway lobster in GSA 5: Landing (t) from 2009 to 2020. MEDITS estimated biomass in the last 2007-2020 and recent showing mean of last two years (2017-2018 red) and previous three years (2014-2016 green) used for calculating catch advice.

Stock and exploitation status

The status of the stock in terms of SSB and exploitation rate F is unknown.

Catch scenarios

The advice on fishing opportunities for 2022 and 2023 was based on the last catch advice adjusted to the change in the MEDITS survey biomass index between the periods 2016-2018 and 2019-2020, resulting in a factor of 0.85 (Table 5.7.1). The precautionary buffer of -20% is not applied this year because it was applied in previously in 2019. Accordingly, the previous catch advice of 44.1 tonnes × 0.85 was taken as the basis for a precautionary advice on fishing opportunities for 2022 and 2023 giving a value of 37.4 tonnes. This implies a catch reduction of 35% from reported catches 57.8 tonnes and a reduction of 15% relative to STECF advice for 2020

Table 5.7.1 Norway lobster in GSA 5: Assumptions made for the interim year and in the forecast. *

Index A (2019–2020)		2.54
Index B (2015–2017)		3.00
Index ratio (A/B)		0.85
-20% Uncertainty cap		Not applied
Catch advice (2019–2020)		44.1
Discard rate (2016–2018)		0 (negligible)
-20% Precautionary buffer		No Applied
Catch advice **		37.4
Landings advice ***		37.4
% advice change ^		-15%

* The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.
** (catch advice 2020 × index ratio)
*** catch advice × (1 − discard rate)
^ Advice value 2022 relative to advice value 2020.

Basis of the advice

Table 5.7.4 Norway lobster in GSA 5: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

The time series of available data is short. Due to incoherence in the landings and survey cohorts, instability of retrospective analysis and patterns in the residuals the assessment (a4a) was considered not acceptable and insufficient for the advice. EWG 21-11 decided to apply a survey-based assessment following the approach adopted by ICES for category 3 stocks.

Issues relevant for the advice

Precautionary advice provided as an age based assessment was not available to provide advice based on a MSY approach.

Reference points

Table 5.7.2 Norway lobster in GSA 5: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach			Not defined	
Precautionary approach			Not defined	
Management plan			Not defined	

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}		Not defined	
Precautionary approach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MSY $B_{trigger}$		Not defined	
	B_{lim}			
	F_{MSY}		Not defined	
	target range F_{lower}			
	target range F_{upper}			

Basis of the assessment

Table 5.7.4 Norway lobster in GSA 5: Basis of assessment and advice.

Assessment type	Index based assessment
Input data	Catches (2009 - 2020)
Discards and bycatch	
Indicators	MEDITS indices (2007-2020)
Other information	
Working group	EWG 21 – 11

History of the advice, catch, and management

Table 5.7.5 Norway lobster in GSA 5: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted catch corresp. to advice	Official landings in (areas)	STECF landings	STECF discards	STECF catch
2020	precautionary advice	44.1		57.8	0	57.8
2021	precautionary advice	44.1				
2022	precautionary advice	37.4				
2023	precautionary advice	37.4				

History of the catch and landings

Table 5.7.8 Norway lobster in GSA 5: Catch distribution by fleet in YEAR as estimated by and reported to STECF.

Catch 2020	Wanted catch				Discards
57.8 tonnes	Otter trawl 100%	0%	0%	Other 0%	0 t
	t				
6439	6439 (100%)	0%	0%	Other 0%	0 t
Effort	Fishing days				

Table 5.7.9 Norway lobster in GSA 5: History of commercial landings. All weights are in tonnes.

Year	Spain	STECF total landings	Total Effort*
2002	12012	12012	NA
2003	11497	11497	NA
2004	10507	10507	12012
2005	11907	11907	11497
2006	12226	12226	10507
2007	10934	10934	11907
2008	11239	11239	12226
2009	10498	10498	10934
2010	10568	10568	11239
2011	9942	9942	10498
2012	11817	11817	10568
2013	11965	11965	9942
2014	10490	10490	11817
2015	10176	10176	11965
2016	8715	8715	10490
2017	8202	8202	10162
2018	7306	7306	8715
2019	6439	6439	8202
2020	12012	12012	7306
2021	11497	11497	6439

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.7.10 Norway lobster in GSA 5: Assessment summary. Weights are in tonnes.

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2009	5.23	16.34	0.05	16.39
2010	6.33	16.19	0	16.19
2011	2.26	32.26	0.07	32.33
2012	3.93	29.50	2.11	31.61
2013	2.29	18.82	0	18.82
2014	2.06	30.80	0.03	30.83
2015	3.81	72.87	0.74	73.61
2016	2.37	28.33	0.02	28.35
2017	2.32	57.82	0.02	57.84
2018	3.58	82.91	0	82.91
2019	1.59	61.85	0.1	61.95
2020	3.82	57.80	0	57.80

Sources and references

Reproduced from STECF EWG 21-11 with 2 years advice, STECF EWG 22-10

5.8 SUMMARY SHEET FOR NORWAY LOBSTER IN GSA 6

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.051 and corresponding catches in 2023 should be no more than 27.0 tons. The fishing mortality is reduced from F_{MSY} of 0.165 as SSB is projected to be below B_{pa} in 2023.

Stock development over time

Catches of Norway lobster show a decreasing trend from 2014 to 2021. SSB and Recruitment decreased from 2010 to 2021. Fbar (3-6) fluctuates around 0.85, with a sharp reduction in 2020. Fbar (3-6) reached the lowest value in the series (0.487) in 2021, at a level nearly three times F_{01}.

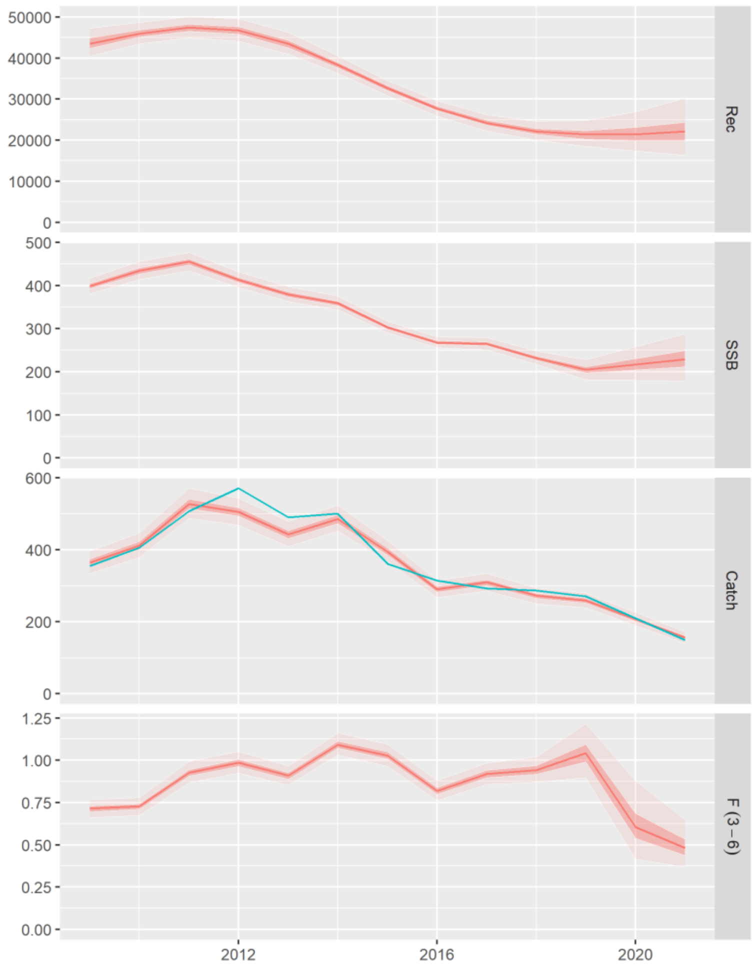


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Figure 5.8.1 Norway lobster in GSA 6: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and e--exploitation status

The current level of fishing mortality (0.487) is 2.95 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.165). F in 2021 (0.49) is lower than $F_{MSY\ Transition}$ (0.32) indicating progress to F_{MSY} in 2025 is ahead of transition. However, SSB in 2021 is estimated to be below B_{lim} and to have been below B_{lim} since 2012.

Table 5.8.1 Norway lobster in GSA 6: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
$F / F_{MSY\ Transition}$		$F < F_{MSY\ Transition}$	$F < F_{MSY\ Transition}$
B / B_{lim}	$B < B_{lim}$	$B < B_{lim}$	$B < B_{lim}$
B / B_{pa}	$B < B_{pa}$	$B < B_{pa}$	$B < B_{pa}$
B / B_{MSY}	$B < B_{MSY}$	$B < B_{MSY}$	$B < B_{MSY}$

Catch scenarios

Table 5.8.2 Norway lobster in GSA 6: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 3\text{-}6}$ (2022)	0.487	F 2021 used to give F status quo for 2022
SSB (2022)	290.04	Stock assessment 1 January 2022
R_{age2} (2022,2023)	21684.37	Geometric mean of the last 3 years
Total catch (2022)	192.06	Assuming F status quo for 2022

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.8.3 Norway lobster in GSA 6: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 3-6) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	83.2	0.165	503.6	73.6	-47.5
$F_{MSY\ Transition}$	202.7	0.457	376.8	29.9	27.8
$F_{MSY\ lower}$	57.9	0.112	531.7	83.3	-63.5
$F_{MSY\ upper}$**	112.8	0.230	471.4	62.5	-28.9
$F_{MSY\ Reduced}$ $B<B_{pa}$	**27.0**	**0.051**	**566.3**	**95.3**	**-83.0**
Other scenarios					
Zero catch	0	0	597.0	105.8	-100
Status quo	213.4	0.487	366.0	26.2	34.5
factor 0.8	178.1	0.390	402.2	38.7	12.2
factor 0.6	139.5	0.292	442.8	52.7	-12.1
factor 1.2	245.6	0.585	333.7	15.1	54.8
factor 1.4	275.1	0.682	304.9	5.1	73.5

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025
^^^$F_{MSY\ Reduced}$ $B<B_{pa}$ is based on ICES advice rule when B in TAC year is less than B_{pa}

The primary catch option selected is based on the ICES advice rule when B in TAC year is less than B_{pa} as is the case for Norway Lobster in GSA 6 in 2023.

Basis of the advice

Table 5.8.4 Norway lobster in GSA 6: The basis of the advice.

Advice basis	F_{MSY}
Management plan	Western Mediterranean Multi-Annual Plan

Quality of the assessment

Commercial catches showed better internal consistency than MEDITS survey index. The historic assessment is stable; Data has been reassembled since last year with some differences to treatment of discards. Although the assessment model was not modified from previous year assessment though there are some changes in selection, leading to a change in $F_{0.1}$. Better data on maturation at age has been included; the SSB has been revised a little. The retrospective analysis shows consistency in the estimation of F estimated in the assessment of 2020. Also the estimation of recruitment is consistent with the ones obtained from last year assessment. All the diagnostics were considered acceptable.

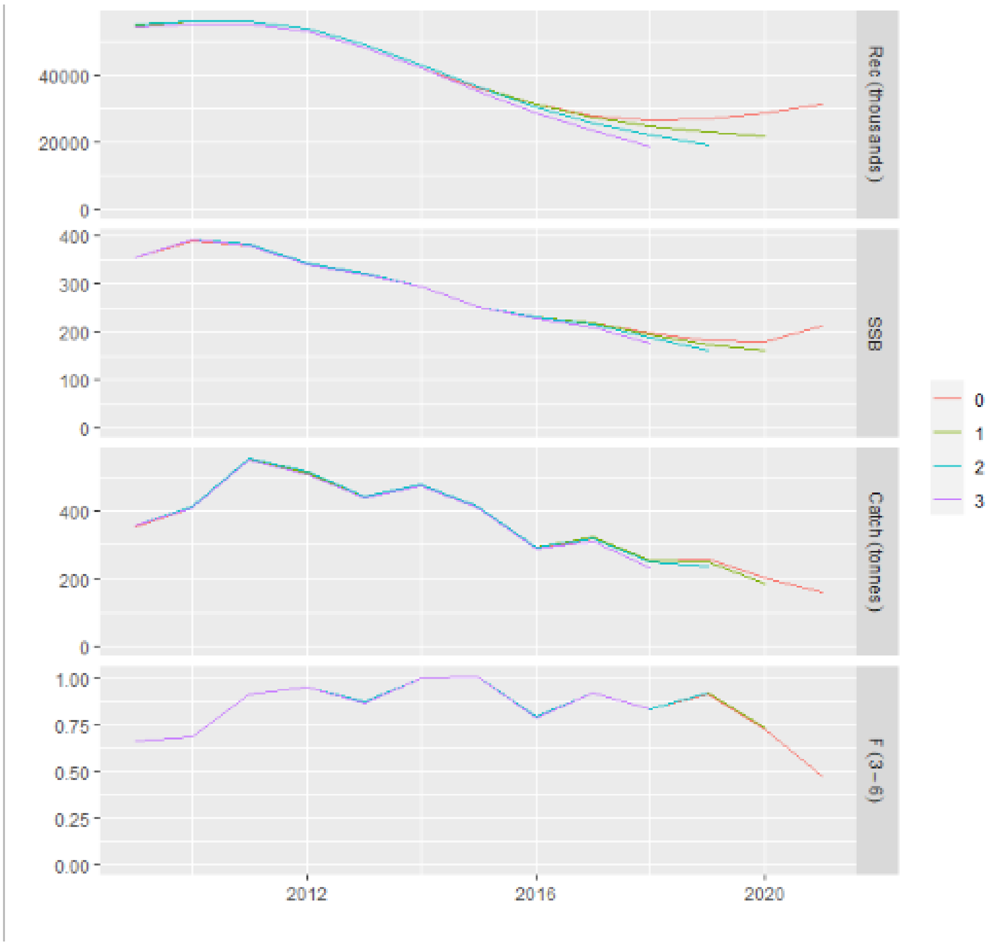


Figure 5.8.2 Norway lobster in GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.8.5 Norway lobster in GSA 6: Reference points, values, and their technical basis (HS stock / recruitment model).

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	944	B_{pa}	STECF EWG 22-09
	F_{MSY}	0.165	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	472	Default 25% of $B_{F0.1}$ at geomean recruitment	STECF EWG 22-09
	B_{pa}	944	2 x B_{lim}	STECF EWG 22-09
	B_{MSY}	1890	Based on B at $F_{0.1}$ with geometric mean recruitment	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.165	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.112	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.230	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.8.6 Norway lobster in GSA 6: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch; neither the landings nor the discards contain significant amount of catches BMS (<1%).
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.8.7 Norway lobster in GSA 6: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		125	269.1	1.2
2020	F = F_{MSY}		128	198.8	1.5
2021	F = F_{MSY}		169	149.4	0
2022	F = F_{MSY}		192.1		
2023	F = $F_{MSY\ Reduced}$ B < B_{pa}		27.0		

History of the catch and landings

Table 5.8.8 Norway lobster in GSA 6: Catch and effort distribution by fleet in 2021 as estimated by and reported to STECF.

<table>
<tr><td>2021</td><td></td><td colspan="4">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Catch
(t)</td><td>149.4</td><td>Otter trawl
100%</td><td>Gillnets
0%</td><td>Trammel nets
0%</td><td>Other
0%</td><td>0.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Effort</td><td>51514</td><td>51514
(100%)</td><td>NA</td><td>NA</td><td>NA</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">NA</td></tr>
</table>

Table 5.8.9 Norway lobster in GSA 6: History of commercial landings and discards and catch; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	Landings SPAIN GSA6	Discards	Total	Total Effort (Fishing Days)
2002	187.5		187.5	NA
2003	381.8		381.8	NA
2004	321.7		321.7	118076
2005	352.0		352.0	110957
2006	390.2		390.2	110008
2007	409.4		409.4	99638
2008	393.8		393.8	106867
2009	355.6	0.01	355.6	102005
2010	406.5	0.06	406.5	95438
2011	496.8	11.37	508.2	90470
2012	506.1	65.8	571.9	86589
2013	478.4	12.34	490.7	85133
2014	490.0	10.84	500.8	87515
2015	355.2	6.34	361.6	79416
2016	308.1	6.41	314.5	79063
2017	282.2	11.02	293.2	77802
2018	287.0	0	287.0	76467
2019	269.1	1.22	270.3	75860
2020	198.8	1.54	200.3	69201
2021	149.4	0	149.4	51514

Summary of the assessment

Table 5.9.10 Norway lobster in GSA 6: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 2 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 3-6	High	Low
2009	43708	49169	38247	398.7	425.1	372.3	365.1	0.71	0.80	0.63
2010	46099	50121	42077	434.1	465.3	403.0	412.8	0.73	0.81	0.64
2011	47483	51603	43363	454.6	486.4	422.9	527.4	0.93	1.02	0.83
2012	46742	50968	42516	413.3	440.3	386.3	503.6	0.99	1.08	0.89
2013	43445	47561	39329	379.6	406.6	352.6	443.5	0.91	1.00	0.82
2014	38276	41641	34911	358.9	384.1	333.6	485.5	1.09	1.20	0.99
2015	32674	35438	29910	303.8	323.8	283.8	395.5	1.03	1.13	0.93
2016	27757	30546	24968	267.6	287.0	248.3	289.9	0.82	0.91	0.73
2017	24239	27214	21264	265.1	285.7	244.4	309.7	0.92	1.02	0.82
2018	22173	25542	18804	232.2	254.4	210.1	271.7	0.94	1.06	0.83
2019	21360	26317	16403	204.8	240.4	169.3	259.0	1.04	1.29	0.79
2020	21563	29117	14009	188.9	242.7	135.1	155.7	0.60	0.95	0.26
2021	22164	32736	11592	229.2	313.7	144.7	155.8	0.49	0.69	0.28

Sources and references

STECF EWG 22-09 EWG STECF 22-10

5.9 SUMMARY SHEET FOR EUROPEAN HAKE IN GSA 8, 9, 10 & 11

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.08 and corresponding catches in 2023 should be no more than 441 tons. . The fishing mortality is reduced from F_{MSY} of 0.17 as SSB is projected to be below B_{pa} in 2023.

Stock development over time

Catches of European hake show a decline in the whole time series, with a very slight increase in the last year. SSB declines in the first part of the time series, reaching the lowest value in 2017, and slightly increases in the last four years. The assessment shows a decreasing trend in the number of recruits with the minimum value reached in 2019 (167681 thousands) and a rise in 2021. Fbar (1-3) shows a fluctuating pattern with a slightly declining trend, with the lowest value of 0.59 reached in 2020.

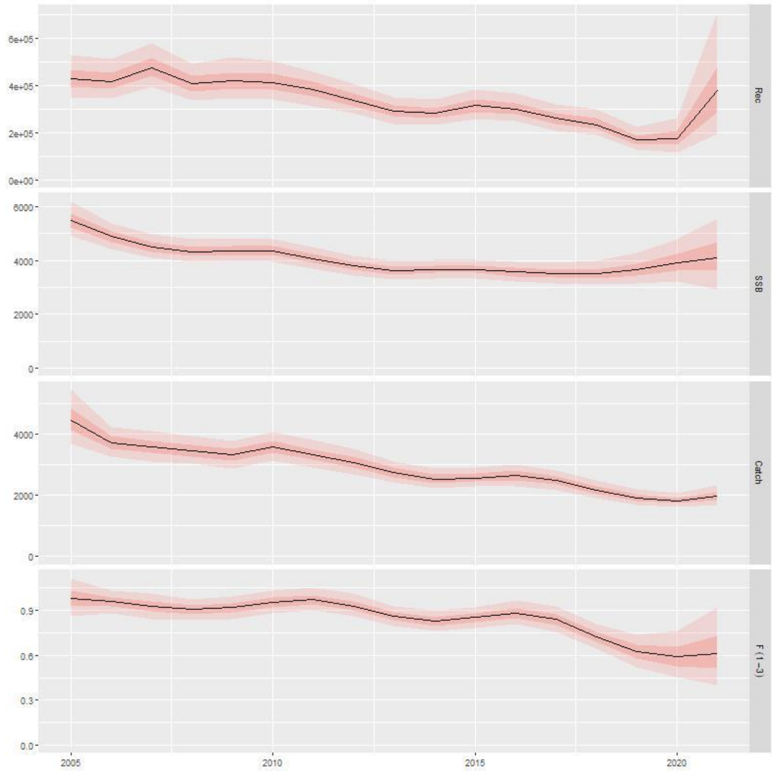


Figure 5.9.1. European hake in GSAs 8, 9, 10 & 11. Trends in catch, recruitment, fishing mortality resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.17). SSB in 2021 is estimated to be below $B_{lim.}$

Table 5.9.1. European hake in GSAs 8, 9, 10 & 11. State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
$F / F_{MSY\ transition}$		$F > F_{MSY\ transition}$	$F > F_{MSY\ transition}$
B / B_{lim}	$B < B_{lim}$	$B < B_{lim}$	$B < B_{lim}$
B / B_{pa}	$B < B_{pa}$	$B < B_{pa}$	$B < B_{pa}$
B / B_{MSY}	$B < B_{MSY}$	$B < B_{MSY}$	$B < B_{MSY}$

Catch scenarios

Table 5.9.2. European hake in GSAs 8, 9, 10 & 11. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Fages 1-3 (2022)	0.61	Fsq = average of the last 3 years
SSB (2022r)	4427.70 t	SSB intermediate year from STF output
R_0 (2022)	263478.73 thousands	Recruitment is set as mean of the last 8 years
R_0 (2023)	263478.73 thousands	Recruitment is set as mean of the last 8 years
Total catch (2022)	2403.13 t	Catch intermediate year from STF output at F status quo

Biological parameters and fishery selection taken as a mean of the last three years.

Table 5.9.3. European hake in GSAs 8, 9, 10 & 11. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	839.70	0.17	8095.13	82.83	-57.24
$F_{MSY\ Transition}$^^	1514.10	0.32	7080.44	59.91	-22.90
$F_{MSY\ Reduced}$ $B<B_{pa}$ ^^^	**440.7**	**0.08**	**8705**	**96.6**	**-77.6**
$F_{MSY\ lower}$	581.74	0.11	8488.89	91.72	-70.38
$F_{MSY\ upper}$**	1142.25	0.23	7637.18	72.49	-41.84
Other scenarios					
Zero catch	0	0	9387.23	112.01	-100
Status quo	2594.28	0.61	5507.12	24.38	32.10

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}

*** % change in SSB 2022 to 2024

^Total catch in 2023 relative to catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025
^^^$F_{MSY\ Reduced}$ B<B_{pa} is based on ICES advice rule when B in TAC year is less than B_{pa}

The primary catch option selected is based on the ICES advice rule when B in TAC year is less than B_{pa} as is the case for hake in GSA 8, 9, 10 & 11 in 2023

Basis of the advice

Table 5.9.4. European hake in GSAs 8, 9, 10 & 11. The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Both catches and survey indices showed good internal consistency. The assessment carried out during the benchmark meeting is stable and the assessment model was not modified. All the diagnostics were considered acceptable. The retrospective shows some instability, but overall the conclusion of F much greater than F_{MSY} over the time series is consistent.

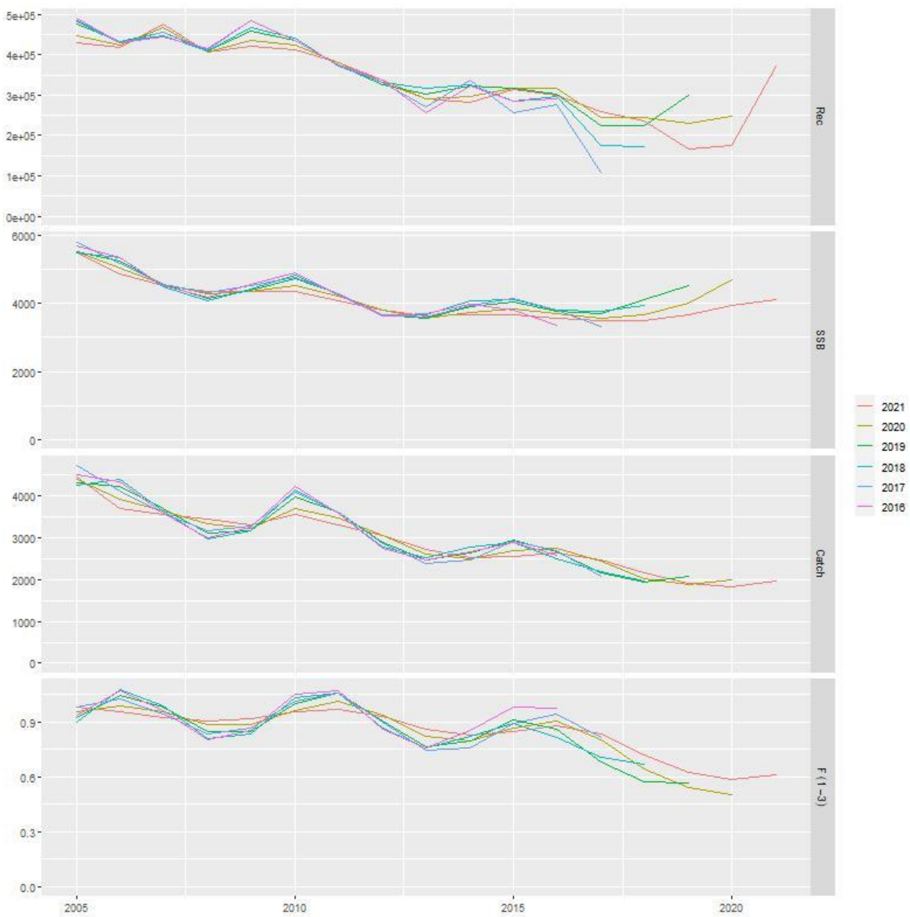


Figure 5.9.2. European hake in GSAs 8, 9, 10 & 11. Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.9.5. European hake in GSAs 8, 9, 10 & 11. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.17	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	5132	Estimated from HS fit to 2022 assessment	STECF EWG 22-09
	B_{pa}	10264	B_{lim} *2	STECF EWG 22-09
	B_{MSY}	49500	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not defined	
Management plan	MSY $B_{trigger}$		Not defined	
	B_{lim}		Not defined	
	F_{MSY}	0.17	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.11	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.23	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.9.6. European hake in GSAs 8, 9, 10 & 11. Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.9.7. European hake in GSAs 8, 9, 10 & 11. STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		494	2075	
2020	F = F_{MSY}		772	1983	
2021	F = F_{MSY}		953.6	1964	
2022	F = F_{MSY}		920.3		
2023	F = $F_{MSY\ reduced\ B<Bpa}$		441		

History of the catch and landings

Table 5.9.8. European hake in GSAs 8, 9, 10 & 11. Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

<table>
<tr><td>2020</td><td></td><td colspan="4">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Catch (t)</td><td></td><td>Otter trawl 58%</td><td>Gillnets 22%</td><td>Trammel nets 8%</td><td>Other 12%</td><td>t</td></tr>
<tr><td>1835</td><td>1067</td><td>406</td><td>154</td><td>208</td><td>272</td></tr>
<tr><td rowspan="2">Effort</td><td>398450</td><td>74028 (18.58%)</td><td>111003 (27.86%)</td><td>213418 (53.56%)</td><td>NA</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">Fishing days</td></tr>
</table>

Table 5.9.9. European hake in GSAs 8, 9, 10 & 11. History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	FRANCE GSA8	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total landings	Total Effort
2005		1859.98	1484.74	397.39	3757.11	612145
2006		2176.49	1544.07	341.06	4076.63	612859
2007		1733.03	1268.66	169.58	3186.28	569738
2008		1321.13	1122.85	138.77	2597.74	455120
2009	15.10	1308.47	1090.51	260.54	2674.61	506847
2010	11.97	1467.11	1329.45	175.88	2984.41	472726
2011	13.24	1351.74	1278.52	277.42	2920.92	523388
2012	13.01	1011.52	1107.24	176.05	2307.83	467470
2013	3.52	1341.63	1052.19	195.79	2593.13	480871
2014	12.61	1264.95	1271.11	44.96	2593.63	498817
2015	12.19	1047.70	1043.44	220.04	2323.36	492855
2016	39.85	782.25	1051.95	339.15	2213.19	489372
2017	14.60	572.37	870.43	356.52	1813.92	448992
2018	21.09	605.35	819.86	391.98	1838.28	462536
2019	18.00	722.26	765.17	445.53	1950.96	387838
2020	18.87	630.58	820.40	260.61	1730.46	280908

2021	18.58	641.17	693.81	210.07	1563.63	398445

Summary of the assessment

Table 5.9.10. European hake in GSAs 8, 9, 10 & 11. Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2005	429133			5479.4			4439.2	0.98		
2006	417621			4876.4			3703.6	0.96		
2007	477519			4513.3			3561.6	0.93		
2008	407210			4337.9			3432.4	0.90		
2009	421285			4341			3293.6	0.92		
2010	413012			4361.9			3563.3	0.96		
2011	382143			4083.9			3308.1	0.97		
2012	338223			3808.7			3064.4	0.93		
2013	291073			3631.1			2727.5	0.86		
2014	282718			3662.3			2522	0.83		
2015	314461			3675.5			2559.8	0.85		
2016	299873			3571.6			2632.7	0.88		
2017	258970			3509.5			2465.5	0.84		
2018	235940			3509.8			2159.1	0.72		
2019	167681			3650.4			1907.8	0.62		
2020	175716			3930.3			1821.5	0.59		
2021	372471			4125			1963.9	0.61		

Sources and references

STECF EWG 22-09, STECF 22-10

5.10 SUMMARY SHEET FOR DEEP-WATER ROSE SHRIMP IN GSAS 8, 9, 10 & 11

STECF advice on fishing opportunities

Based on the stock assessment outputs and reference points, STECF EWG 22-09 advises that the catches of Deep-water rose shrimp in 2023, consistent with $F_{0.1}$ (1.26), should not exceed 1465 tonnes.

Stock development over time

Recruitment
Recruitment (age 0) is characterised by an increasing trend until 2019 (4,054,450 thousands individuals). Then, a decrease in the last two years is observed.

Spawning stock biomass (SSB)
The spawning stock biomass shows a trend similar to the recruitment, with two peaks in 2017 (1094.5 tons) and 2020 (1113.1 tons). A decrease was observed in 2021.

Catch
After the minimum value in 2009 (638 tons), the catches have shown a constant increase over the years, until reaching the maximum value in 2020, corresponding to 2082 tons. A decrease was observed in 2021.

Fishing mortality (F)
The lowest value of fishing mortality (0.66) is observed at the beginning of the data series (2009). After that, a constant increase of F was showed, reaching the maximum value of 1.40 in 2021. The increasing is more evident in the last three years.

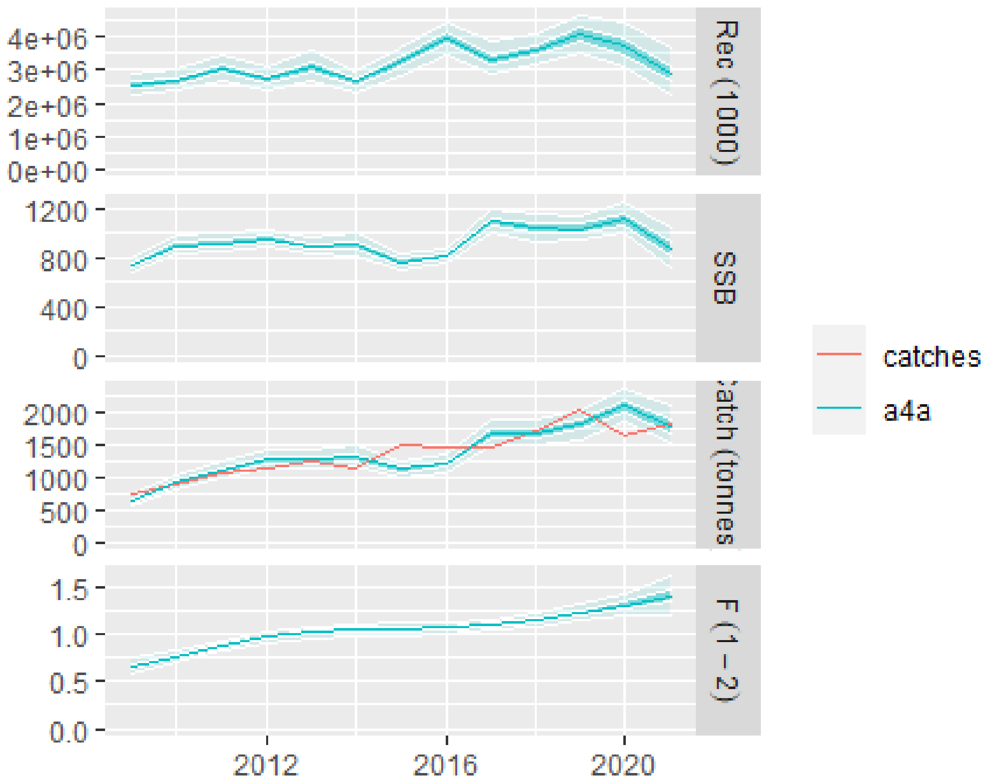


Figure 5.10.1 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Outputs of the a4a assessment.

Stock and exploitation status

Current F (1.40), estimated by the model as F_{bar1-2} in the last year of the time series (2021), is higher than $F_{0.1}$ (1.26), which is a proxy of F_{msy} and is used as the exploitation reference point consistent with high long term yields. This indicates that Deep-water rose shrimp stock in GSAs 8, 9, 10 and 11 is being over-exploited. SSB in 2021 is greater than B_{MSY}

Table 5.10.1 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F < F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
$F / F_{MSY\ Transition}$		$F > F_{MSY\ Transition}$	$F > F_{MSY\ Transition}$
B / B_{lim}	$B > B_{lim}$	$B > B_{lim}$	$B > B_{lim}$
B / B_{pa}	$B > B_{pa}$	$B > B_{pa}$	$B > B_{pa}$
B / BMSY	$B > B_{MSY}$	$B > B_{MSY}$	$B > B_{MSY}$

Catch scenarios

Table 5.10.2 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-2}$ (2021)	1.40	F current in the last year (2021) used to give F status quo for 2022
SSB (2022)	753 t	
R_0 (2022)	31,446,558 thousands	Geometric mean of the period 2009-2021
R_0 (2024)	31,446,558 thousands	Geometric mean of the period 2009-2021
Total catch (2022)	1545 t	Catch intermediate year from STF output

Table 5.10.3 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-2) (2023)	SSB (2024)	% SSB change***	% Catch change^^
STECF advice basis					
F_{MSY} / MAP	1465	1.26	851	13.1	-17.9
$F_{MSY\ lower}$	1102	0.83	1133	50.41	-38.2
$F_{MSY\ upper}$	1757	1.71	653	-13.3	-1.5
F_{MSY} transition	1457	1.25	857	13.8	-18.3
Other scenarios					
Zero catch	0.0	0.0	2251	199.0	-100.0
Status quo	1568	1.40	779	3.4	-12.1

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}

*** % change in SSB 2024 to 2022

^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025
^^^$F_{MSY\ Reduced}$ B<B_{pa} is based on ICES advice rule when B in TAC year is less than B_{pa}

Basis of the advice

Table 5.10.4 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. The basis of the advice.

Advice basis	F_{MSY}
Management plan	1.26

Quality of the assessment

The retrospective analysis run on the a4a model showed consistent results. All the diagnostics were considered acceptable.

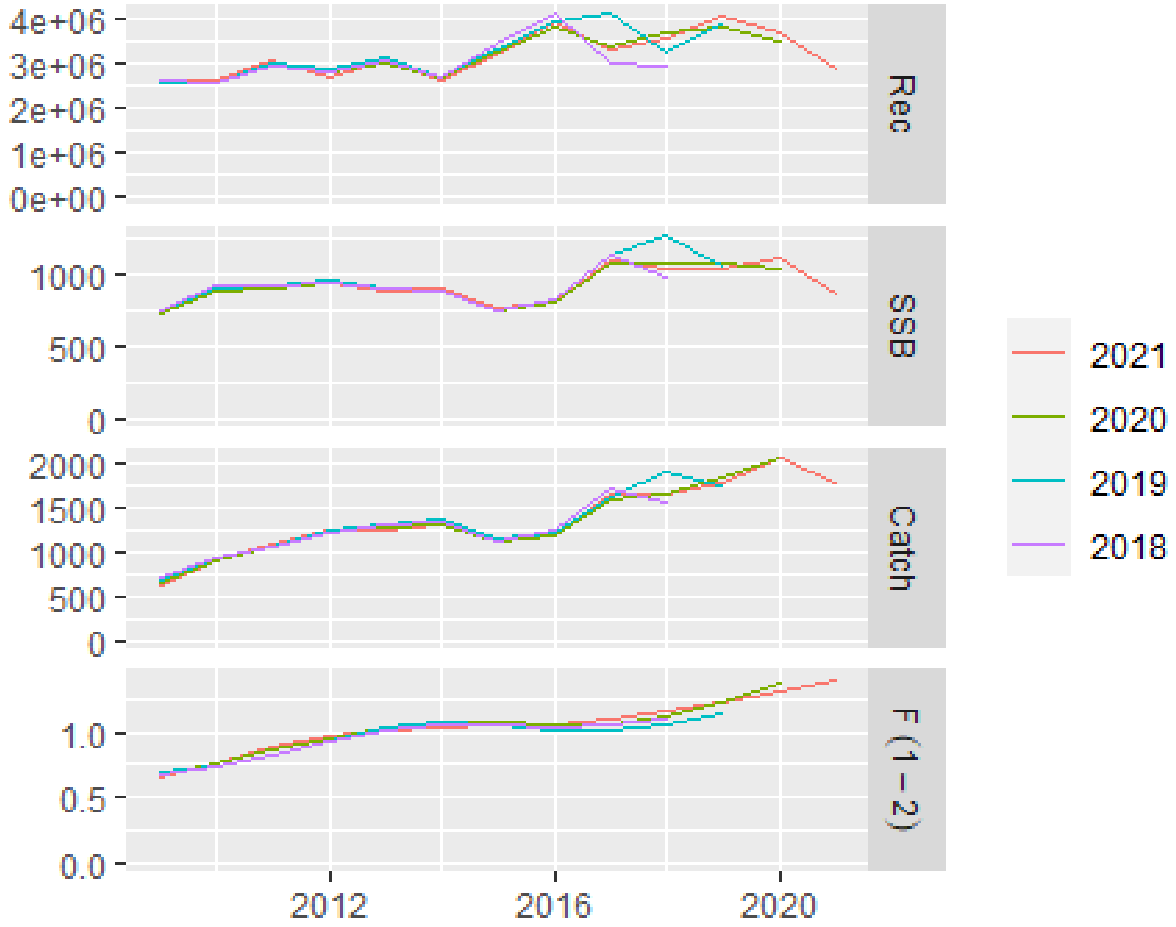


Figure 5.10.2 Deep-water rose shrimp in GSAs 8, 9, 10 & 11 Results of the retrospective analysis (a4a).

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.10.5 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	1.26	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	213.7	Default based on 25% $B_{F0.1}$ and GM recruitment	STECF EWG 22-09
	B_{pa}	427.5	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	855.0	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not defined	
Management plan	MSY $B_{trigger}$		Not defined	
	B_{lim}		Not defined	
	F_{MSY}	1.26	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	MAP target range F_{lower}	0.83		STECF EWG 22-09
	MAP target range F_{upper}	1.71		STECF EWG 22-09

Basis of the assessment

Table 5.10.6 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Basis of the assessment and advice.

Assessment type	Statistical catch-at-age (a4a)
Input data	Landings at length to landings at age (age slicing) from DCF data
Discards, BMS landings*, and bycatch	Discards included
Indicators	MEDITS in GSAs 8, 9, 10 & 11
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.10.7 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catches	STECF discards
2019	F = F_{MSY}		1800	2035	
2020	F = F_{MSY}		2082	1644	
2021	F = F_{MSY}		1784	1818	
2022	F = F_{MSY}		1545		
2023	F = F_{MSY}		1465		

History of the catch and landings

Table 5.10.8 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Catch and effort distribution by fleet in 2020 as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)		Bottom trawl 99.5%	Gillnets %	Trammel nets %	Other 0.5%	t
	1596	Tonnes				222
Effort	74028	74028 (100%)	NA	NA	NA	
		Nominal effort (‘000 kW*fishing days)				

Table 5.10.9 History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes.

Year	GSA8 FRA	GSA9 ITA	GSA10 ITA	GSA11 ITA	Total landings	Discards	STECF total catches	Total effort
2009		303	379	22	704	46	750	110207
2010	4	473	370	23	870	30	900	104445
2011	5	551	405	53	1015	66	1081	101849
2012	6	621	459	34	1120	12	1132	95200
2013	5	576	597	23	1200	39	1239	106497
2014	2	561	509	30	1103	48	1151	111965
2015	7	791	547	39	1385	103	1488	99835
2016	8	836	542	18	1403	41	1445	104768
2017	7	857	519	48	1431	46	1477	100731
2018	7	904	555	209	1675	50	1725	99566
2019	6	896	667	181	1750	285	2035	91095
2020	7	1028	366	172	1573	71	1644	71370
2021	8	1086	373	129	1596	222	1818	74023

Summary of the assessment

Table 5.10.10 Assessment summary. Weights are in tonnes.

Year	Recruitment age 0 thousands	SSB tonnes	Catch tonnes	F ages 1-2
2009	2561090	733.5	637.7	0.65662
2010	2658728	899.1	922.4	0.76754
2011	3039276	916.8	1094.4	0.87832
2012	2717567	953.8	1266.6	0.96705
2013	3098079	893.0	1264.1	1.02
2014	2644348	905.6	1306.1	1.04147
2015	3210664	764.6	1121.5	1.04947
2016	3944704	807.3	1201.7	1.06373
2017	3296743	1094.5	1667.5	1.09693
2018	3586505	1037.0	1680.9	1.15239
2019	4054450	1032.3	1799.5	1.22608
2020	3699621	1113.1	2081.6	1.31107
2021	2863840	871.5	1784.3	1.40278

Sources and references

STECF EWG 22-09, STECF 22-10

5.11 SUMMARY SHEET FOR RED MULLET IN GSA 9

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.50 and corresponding catches in 2023 should be no more than 861.9 tons.

Stock development over time

Catches show an increasing pattern up to 2016, and then they steady decrease. SSB fluctuates with an increasing trend. F follows the pattern of catches: it stays at high levels up to 2016, and then it decreases.

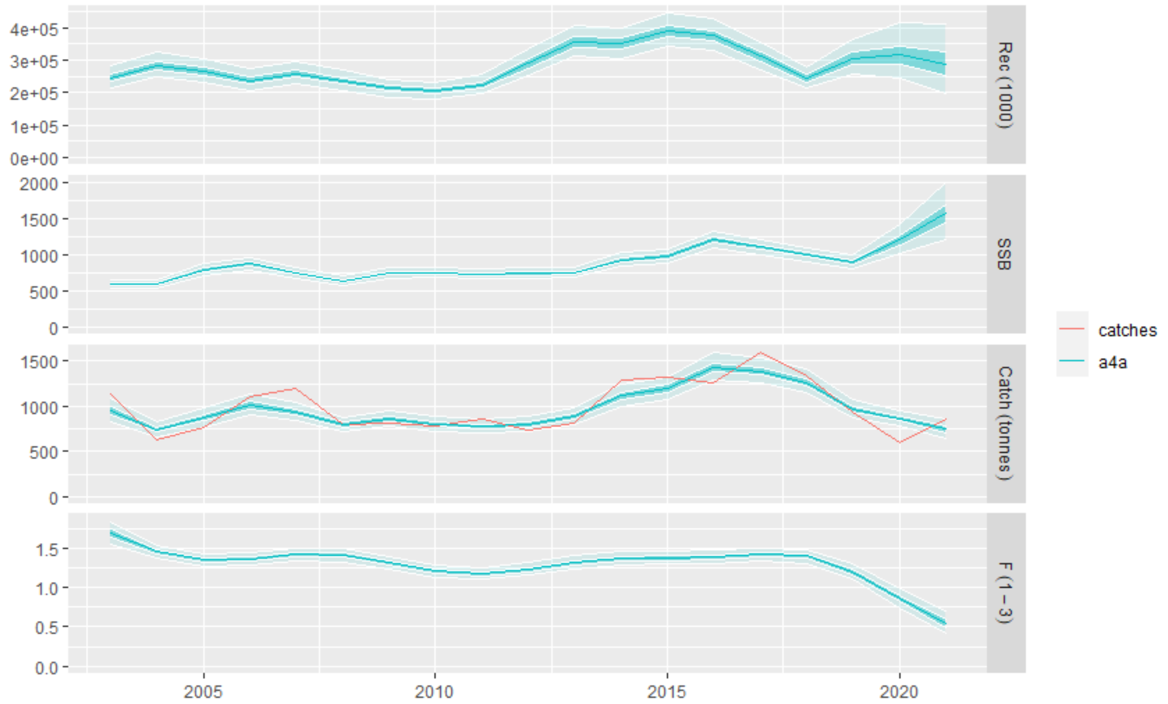


Figure 5.11.1 Red mullet in GSA 9: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality is below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.50). SSB in 2021 is above B_{pa} and below B_{MSY}

Table 5.11.1 Red mullet in GSA 9: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
$F / F_{MSY\ Transition}$		$F > F_{MSY\ Transition}$	$F < F_{MSY\ Transition}$
B / B_{lim}	$B > B_{lim}$	$B > B_{lim}$	$B > B_{lim}$
B / B_{pa}	$B < B_{pa}$	$B > B_{pa}$	$B > B_{pa}$
B / B_{MSY}	$B < B_{MSY}$	$B < B_{MSY}$	$B < B_{MSY}$

Catch scenarios

Table 5.11.2 Red mullet in GSA 9: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2022)	0.54	F current in the last year used to give F status quo for 2022
SSB (2022; middle year)	1732.8 t	Stock assessment 1 January 2022
R_0 (2022-2023)	279683 thousands	Geometric mean of the period 2003-2021
Total catch (2022)	891.9 t	Catch intermediate year from STF output

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of last three years.

Table 5.11.3 Red mullet in GSA 9: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	861.9	0.50	1833.4	+5.8	+14.9
F_{MSY} transition	1154.9	0.73	1503.5	-13.2	+53.9
$F_{MSY\ lower}$	614.6	0.33	2139.6	+23.5	-18.1
$F_{MSY\ upper}$**	1095.5	0.68	1567.5	-9.5	+46.0
Other scenarios					
Zero catch	0.0	0.00	3008.9	+73.6	-100.0
Status quo	922.0	0.54	1762.7	+1.7	+22.9

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.11.4 Red mullet in GSA 9: The basis of the advice.

Advice basis	F_{MSY}
Management plan	0.50

Quality of the assessment

Both catches and survey indices showed good internal consistency. The retrospective analysis run on the a4a model showed consistent results with exception of recruitment, which is poorly estimated in the last year (it must be noted that age0 was removed from the survey data to run the assessment). All the diagnostics were considered acceptable.

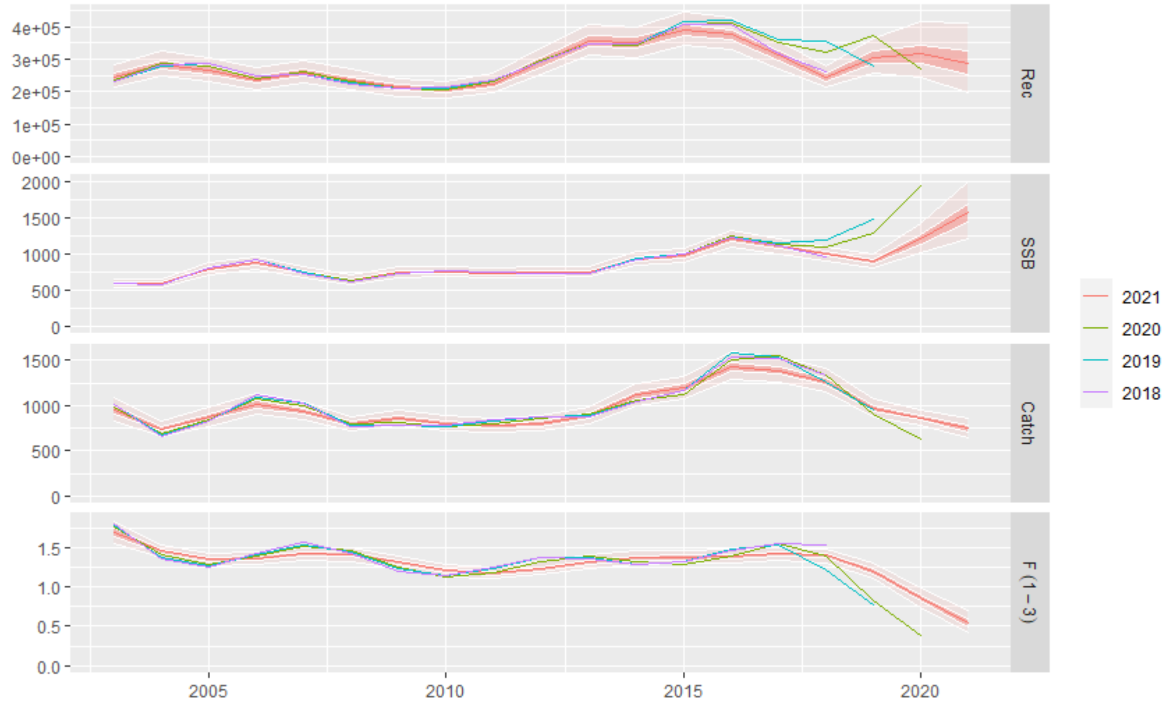


Figure 5.11.2 Red mullet in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.11.5 Red mullet in GSA 9: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.50	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	461.5	Default based on 25% $B_{F0.1}$ and GM recruitment	STECF EWG 22-09
	B_{pa}	923.05	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	1846.1	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.50	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.33	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.68	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.11.6 Red mullet in GSA 9: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.11.7 Red mullet in GSA 9: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catches	STECF discards
2019	F = F_{MSY}		821.0	942.1	
2020	F = F_{MSY}		521	599.0	
2021	F = F_{MSY}		667.6	853.4	
2022	F = F_{MSY}		1033		
2023	F = F_{MSY}		861.9		

History of the catch and landings

Table 5.11.8 Red mullet in GSA 9: Catch in 2021 and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)		Otter trawl 94.5%	Gillnets 1.7%	Trammel nets 3.5%	Others 0.3%	t
		736.6	13.1	27.4	2.2	74.1
Effort (2021)		36566 (44.48%)	NA	45644 (55.52%)	NA	
		Fishing Days				

Table 5.11.9 Red mullet in GSA 9: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	ITA	Total landings	Total Effort
2003	1056.7	1056.7	138810
2004	580.7	580.7	142063
2005	708.5	708.5	133531
2006	1049.6	1049.6	128455
2007	1096.0	1096.0	106906
2008	727.1	727.1	87667
2009	728.3	728.3	102059
2010	747.9	747.9	101693
2011	805.5	805.5	114647
2012	692.9	692.9	105271
2013	693.3	693.3	126601
2014	1181.4	1181.4	136954
2015	1183.4	1183.4	141720
2016	1221.6	1221.6	128278
2017	1460.7	1460.7	107396
2018	1204.8	1204.8	107971
2019	844.0	844.0	97096
2020	560.6	560.6	69228
2021	779.3	779.3	82210

Summary of the assessment

Table 5.11.10 Red mullet in GSA 9: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 ('000)	High	Low	SSB (t)	High	Low	Catch (t)	F_{bar} ages 1-3	High	Low
2003	246764	273523	220005	596.6	643.3	549.9	951.2	1.69	1.8	1.6
2004	284310	315021	253599	591.9	641.6	542.2	738.7	1.46	1.5	1.4
2005	266939	294534	239344	798.2	866.2	730.2	869.6	1.35	1.4	1.3
2006	237492	262357	212627	880.2	953.0	807.4	1011.8	1.36	1.4	1.3
2007	258455	285671	231239	751.8	810.7	692.9	935.9	1.42	1.5	1.4
2008	236718	260368	213068	643.6	692.5	594.7	794.0	1.41	1.5	1.3
2009	212170	234020	190320	748.6	802.9	694.3	860.5	1.31	1.4	1.2
2010	205588	227325	183851	751.7	806.8	696.6	801.3	1.21	1.3	1.1
2011	224424	246682	202166	739.1	793.7	684.5	778.3	1.17	1.2	1.1
2012	290647	321064	260230	742.1	796.8	687.4	800.7	1.23	1.3	1.2
2013	355368	390846	319890	753.3	810.8	695.8	888.5	1.32	1.4	1.3
2014	352008	387490	316526	936.6	1009.4	863.8	1112.5	1.37	1.4	1.3
2015	390905	431923	349887	984.2	1058.7	909.7	1190.0	1.37	1.4	1.3
2016	377440	416906	337974	1215.8	1310.3	1121.3	1433.9	1.39	1.5	1.3
2017	311552	342862	280242	1110.1	1193.0	1027.2	1386.9	1.42	1.5	1.4
2018	245416	270752	220080	1005.4	1078.3	932.5	1265.4	1.40	1.5	1.3
2019	307061	347646	266476	899.9	972.4	827.4	964.5	1.20	1.3	1.1
2020	317177	386072	248282	1212.1	1367.3	1056.9	863.8	0.86	0.9	0.8
2021	288186	370508	205864	1573.3	1885.8	1260.8	750.4	0.54	0.7	0.4

Sources and references

STECF EWG 22-09, STECF EWG 22-10

5.12 SUMMARY SHEET FOR RED MULLET IN GSA 10

STECF advice on fishing opportunities

Based on Precautionary considerations, STECF EWG 22-09 advises to increase the total catch by 8% relative to the catches in 2021 equivalent to catches of no more than 326 tons in 2023.

Stock development over time

A MEDITS biomass index was derived carrying out the age slicing of the LFDs from the MEDITS data, and multiplying the index by age and year by the mean weight at age. Then, the biomass at age was summed up by year excluding age 0, not every year detected by the survey. This biomass index was used to provide an index for change (Figure 5.12.1). The stock appears to have been fluctuating up to 2019. In 2020 a sharp increase was observed, followed by a slightly smaller value in 2021.
Based on the index value in the last year value relative to the previous two years the increase in biomass is estimated to be 1.2 times. Catches in 2020 decreased at about 60% relative to 2019. Catches in 2021 are around the 80% of the long term average.

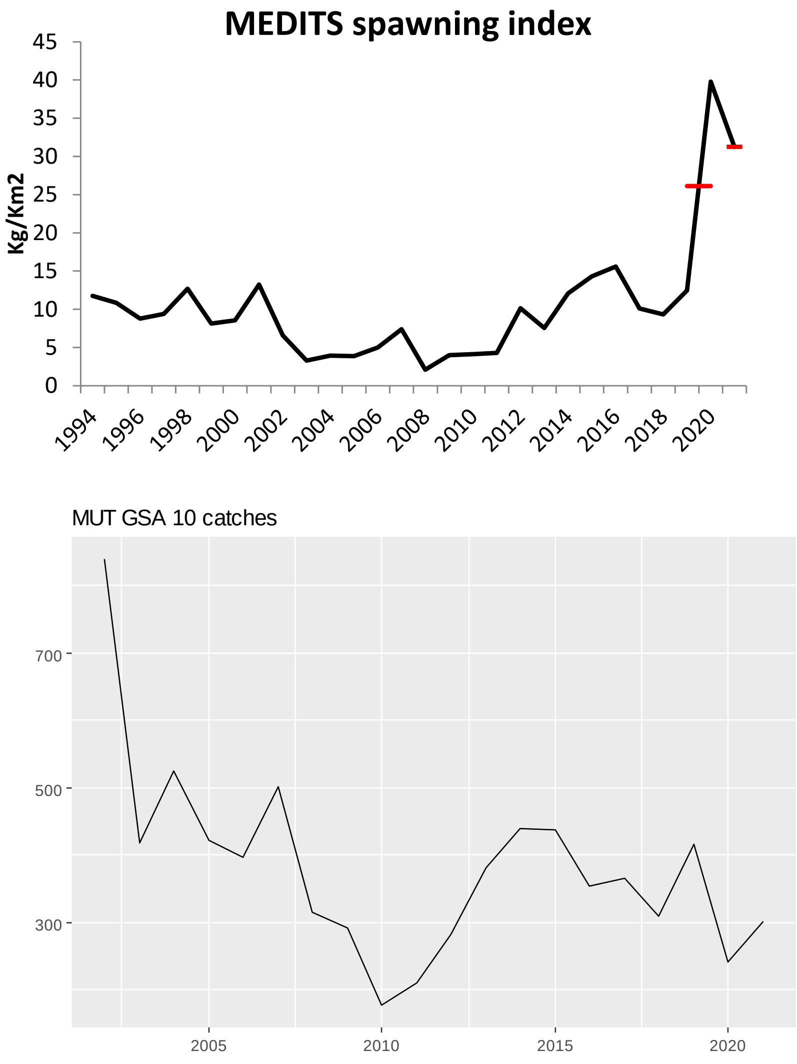


Figure 5.12.1 Red mullet in GSA 10: (top panel) MEDITS in GSA 10 biomass index. The two red segments represent the mean index of 2019-2020 and of 2021. (bottom panel) Catch by year.

Stock and exploitation status

It was not possible to evaluate the exploitation status in terms of fishing mortality respect to the reference point $F_{0.1}$, used as proxy of F_{MSY}.

Table 5.12.1 Red mullet in GSA 10: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	Unknown	Unknown	Unknown

Catch scenarios

ICES framework for category 2 stocks was applied (Method 3.3: One-over-two rule for short-lived stocks, ICES, 2022). A survey biomass index was used as an indicator of stock development. The advice is based on the recent catches, multiplied by the ratio of the last index values (index A) and the mean of the two preceding values (index B). No precautionary buffer id required as the biomass index shows the stock near historic high.

Table 5.12.2 Red mullet in GSA 10: Basis for the catch scenarios. The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the tables.

Last year catch C_{y-1} (catch in 2021)		302 tonnes
Stock biomass trend		
Index A (2021)		31.2 kg / km^2
Index B (2019,20)		26.1 kg / km^2
r: Index ratio (A/B)		1.2
Uncertainty cap (+-80%)	Not applied	
Discard rate		0%
Catch advice for 2023		326 tonnes
% advice change*		+8%

* Advice value for 2023 relative to the catch in 2021 (302 tonnes).

Basis of the advice

Table 5.12.4 Red mullet in GSA 10: The basis of the advice.

Advice basis	Precautionary approach (ICES category 3)
Management plan	

Quality of the assessment

Due to the unavailability of reliable catch at age information in the last two years and the consequent poor fitting of the last year model, the EWG 22-09 concluded that it is not possible to provide the basis of the current status of the stock.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

No reference point was estimated.

Table 5.12.5 Red mullet in GSA 10: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}		Not Defined	
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}		Not Defined	
	target range F_{lower}		Not Defined	
	target range F_{upper}		Not Defined	

Basis of the assessment

Table 5.12.6 Red mullet in GSA 10: Basis of the assessment and advice.

Assessment type	Survey biomass trend applying 1 over 2 rule for short-lived stocks for the advice (ICES,2022)
Input data	DCF commercial data (landings) and scientific survey (MEDITS) data
Discards and bycatch	Discards null
Indicators	Spawners biomass (kg) per km^2
Other information	
Working group	STECF EWG 22-09

History of the advice, catch, and management

Table 5.12.7 Red mullet in GSA 10: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF landings	STECF discards
2019	F = F_{MSY}		1056	392	
2020	F = F_{MSY}		309		

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF landings	STECF discards
2021	$F = F_{MSY}$		314		
2022	$F = F_{MSY}$		485		
2023	Precautionary approach (ICES category 3 short lived species)		326		

History of the catch and landings

Table 5.12.8 Red mullet in GSA 10: Catch and effort distribution by fleet in 2020 as reported to STECF.

2021		Wanted catch				Discards
Catch (t)		Otter trawl 82%	Gillnets 4%	Trammel nets 14%		T
		248	14	40		0
Effort (2019)	125701	22630 (18%)	NA	103071 (82%)		
		Fishing Days				

Table 5.12.9 Red mullet in GSA 10: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	ITA GSA10	Total landings	Total Effort
2002	847	847	395844
2003	424	424	349608
2004	522	522	146515
2005	389	389	117535
2006	396	396	172742
2007	511	511	178878
2008	321	321	145108
2009	291	291	143911
2010	177	177	116142
2011	207	207	136405
2012	281	281	111178
2013	381	381	120608
2014	422	422	128314
2015	417	417	140485
2016	353	353	141177
2017	364	364	141150
2018	576	576	165929
2019	416	416	134520
2020	242	242	81072
2021	301	301	125701

Summary of the assessment

Table 5.12.10 **Red mullet in GSA 10:** Assessment summary. Weights are in tonnes.

Year	Biomass Index			Total
	Low	Value	High	Catch
1994		11.74		1246
1995		10.83		939
1996		8.77		1040
1997		9.39		607
1998		12.68		421
1999		8.12		392
2000		8.54		213
2001		13.25		388
2002		6.57		839
2003		3.28		419
2004		3.92		524
2005		3.87		421
2006		5.00		393
2007		7.37		502
2008		2.10		315
2009		3.98		279
2010		4.14		177
2011		4.30		210
2012		10.15		264
2013		7.55		381
2014		12.06		438
2015		14.31		421
2016		15.60		353
2017		10.11		134
2018		9.31		265
2019		12.47		416
2020		39.78		242
2021		31.23		302

Sources and references

STECF EWG 22-09.

5.13 Summary sheet for Norway lobster in GSA 9

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.11 and corresponding catches in 2023 should be no more than 79tons.

Stock development over time

Catches of Norway lobster slow a decreasing pattern until 2015, then they increase to 2018 and then decrease again in the last years. SSB shows a slightly increasing pattern, in the last three years. Recruitment follows a general slightly decreasing pattern, with some oscillation. Fbar (2-6) shows fluctuations to 2018 and then decrease in the last three years until 2021 when the estimated F is 0.167.

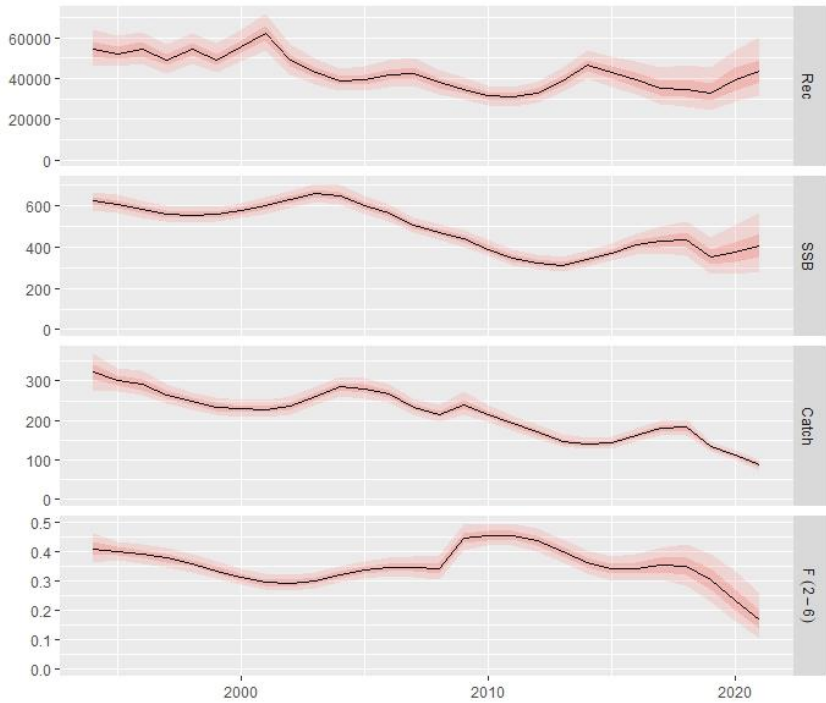


Figure 5.13.1 Norway lobster in GSA 9: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.167) is higher of the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.109). F in 2021 is higher than F_{MSY} but slightly lower than $F_{MSY\ Transition}$ .SSB in 2021 is estimated to be above B_{lim} and below B_{pa}

Table 5.13.1 Norway lobster in GSA 9 State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	F at F_{MSY}	F < F_{MSY}	F > F_{MSY}
F / $F_{MSY\ Transition}$		F < $F_{MSY\ Transition}$	F < $F_{MSY\ Transition}$
B / B_{lim}	B > B_{lim}	B > B_{lim}	B > B_{lim}
B / B_{pa}	B < B_{pa}	B < B_{pa}	B < B_{pa}
B / B_{MSY}	B < B_{MSY}	B < B_{MSY}	B < B_{MSY}

Catch scenarios

Table 5.13.2 Norway lobster in GSA 9: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 2\text{-}6}$ (2022)	0.167	F 2021 used to give F status quo for 2022
SSB (2022)	465.8 t	Stock assessment 1 January 2022
R_{age0} (2022,2023)	37684	Geometric mean of years 2004 to 2021
Total catch (2022)	102.3 t	Assuming F status quo for 2022

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.13.3 Norway lobster in GSA 9: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 2-6) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	79.4	0.11	617.9	32.7	-9
$F_{MSY\ Transition}$^^	120.9	0.18	551.6	18.4	30.6
$F_{MSY\ lower}$	55.8	0.08	656.5	40.9	-36.0
$F_{MSY\ upper}$**	109.3	0.16	570.3	22.4	25.3
Other scenarios					
Zero catch	0.00	0.00	751.8	61.4	-100
Status quo	116.5	0.17	559.2	20.1	33.5

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.13.4 Norway lobster in GSA 9: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Landings from 1994 to 2002 were gathered from the Italian official statistics as collected by the RECFISH project (Ligas, 2019) the addition of this information has improved the assessment.

Catches showed good internal consistency, while the MEDITS survey showed poor internal consistency. The retrospective analysis of three years run on the a4a model showed acceptable results. It must be noted that age0 was removed from the survey and catch data to run the assessment. All the diagnostics were considered acceptable.

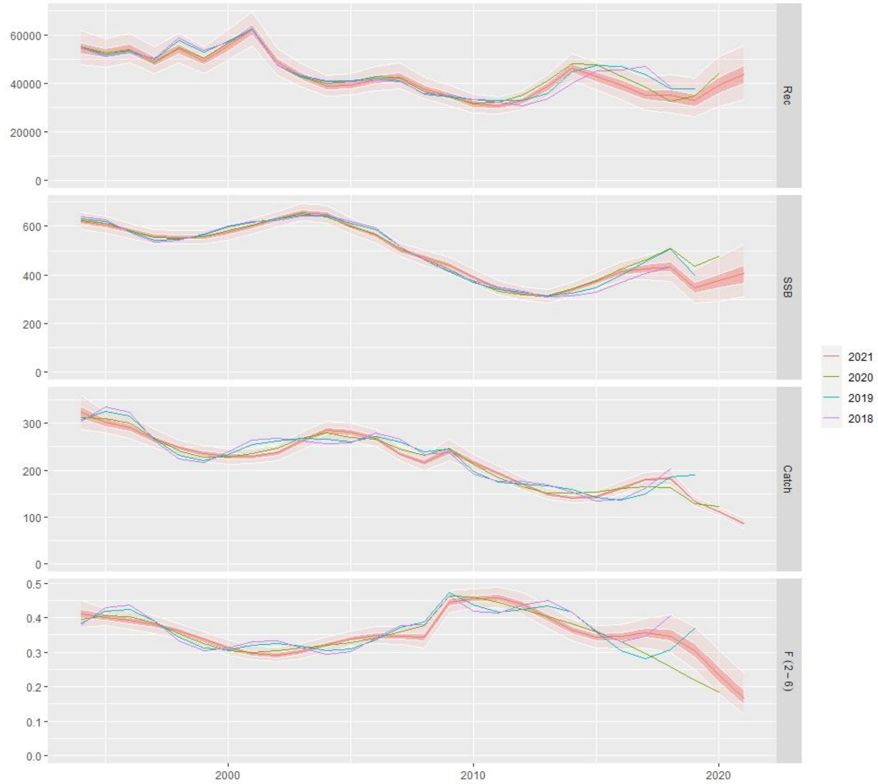


Figure 5.13.2 Norway lobster in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.13.5 Norway lobster in GSA 9: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.109	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	231	default value of 25% $B_{F0.1}$ with Geometric Mean recruitment	
	B_{pa}	463	2 * B_{lim}	
	B_{MSY}	926	$B_{F0.1}$	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.109	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.075	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.156	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.13.6 Norway lobster in GSA 9: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards), RECFISH project (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.13.7 Norway lobster in GSA 9: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	$F = F_{MSY}$		90	150	0.5
2020	$F = F_{MSY}$		142	103	1.0
2021	$F = F_{MSY}$		180	87.3	0
2022	$F = F_{MSY}$		220		
2023	$F = F_{MSY}$		79		

History of the catch and landings

Table 5.13.8 Norway lobster in GSA 9: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)	86.9	Otter trawl 99.999%	Gillnets 0.001%	Trammel nets 0%	Other 0%	0.02 t
Effort	36566	36566 (100%)	NA	NA	NA	
		Fishing days				

Table 5.13.9 Norway lobster in GSA 9: History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated.

Year	ITA GSA landings	Discards	STECF total catches	Total Effort* (Fishing days)
1994	376.4	0.00	376.4	
1995	345.4	0.00	345.4	
1996	359.4	0.00	359.4	
1997	727.6	0.00	727.6	
1998	225.5	0.00	225.5	
1999	178.6	0.00	178.6	
2000	335.0	0.00	335	
2001	269.5	0.00	269.5	
2002	276.9	0.00	276.9	62616
2003	320.9	0.0	320.9	63331
2004	268.7	0.0	268.7	67828
2005	288.5	0.0	288.5	67714
2006	247.5	0.0	247.5	62517
2007	260.5	0.0	260.6	64161
2008	227.7	0.0	227.7	49759
2009	250.3	9.2	259.5	53330
2010	161.6	1.0	162.6	52606
2011	184.0	1.0	185	50737
2012	178.2	0.8	179	47851
2013	147.6	1.3	149	51722
2014	111.6	0.4	112	51284
2015	113.6	0.1	113.7	52936
2016	130.9	0.4	131.3	51301
2017	173.6	8.2	181.8	47459
2018	223.2	0.7	223.9	44251
2019	177.0	0.7	177.7	42227
2020	90	0.9	90.9	33550
2021	86.9	0	89.9	36566

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.13.10 Norway lobster in GSA 9: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment	SSB	Catch	Fbar (2-6)	Total Biomass
1994	54317	620.4	322.175	0.410	1155
1995	52474	605.83	301.861	0.401	1142
1996	54290	582.03	291.121	0.391	1088
1997	49275	558.48	265.53	0.378	1048
1998	54377	554.14	247.757	0.360	1049
1999	49285	554.8	234.736	0.336	1017
2000	55542	574.17	229.103	0.312	1044
2001	62256	598.75	228.773	0.295	1088
2002	48720	629.1	236.358	0.292	1130
2003	42911	657.2	261.925	0.302	1155
2004	38854	648.29	284.607	0.321	1130
2005	39326	600.55	279.907	0.339	1053
2006	41777	561.79	267.574	0.347	1030
2007	42623	501.81	234.143	0.346	926
2008	37825	470.67	215.86	0.344	880
2009	34896	438.97	241.191	0.444	848
2010	31502	389.82	216.84	0.454	761
2011	30763	344.28	193.339	0.456	670
2012	32849	320.88	170.437	0.437	631
2013	38815	310.06	148.297	0.400	610
2014	46357	337.3	140.924	0.363	670
2015	42911	371.78	142.936	0.342	703
2016	39355	410.87	161.742	0.343	771
2017	35225	425.19	177.395	0.354	793
2018	34912	432.65	177.339	0.348	800
2019	33159	346.41	140.849	0.304	621
2020	39371	373.38	115.423	0.235	644
2021	43420	402.75	87.299	0.167	676

Sources and references

STECF EWG 22-09, STECF EWG 22-11

Ligas A., 2019. Recovery of fisheries historical time series for the Mediterranean and Black Sea stock assessment (RECFISH). EASME/EMFF/2016/032. Final Report, 95 pp.

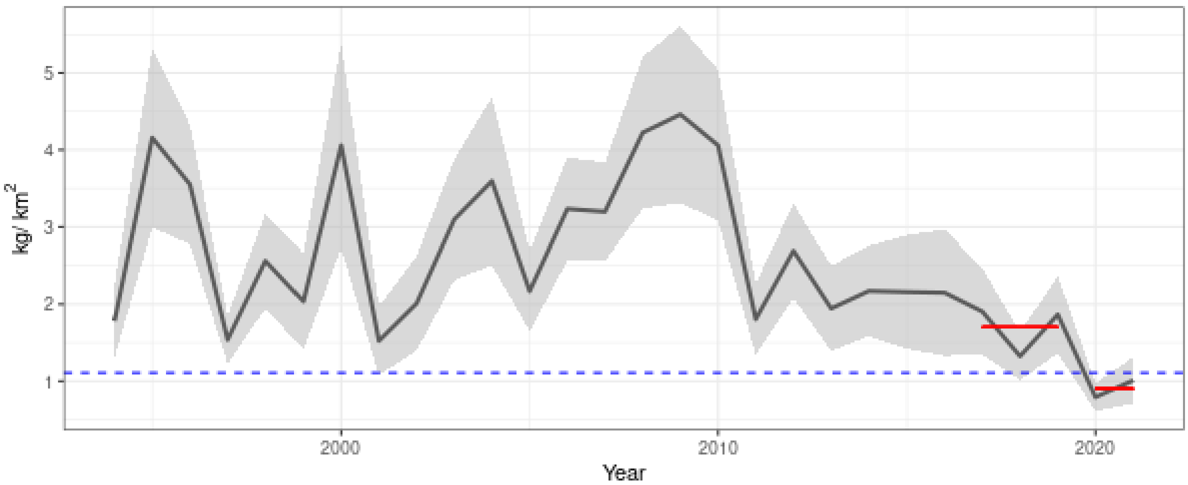
5.14 SUMMARY SHEET FOR NORWAY LOBSTER IN GSA 11

STECF advice on fishing opportunities

Based on MSY considerations, STECF EWG 22-09 advises to decrease the total catch by 26% relative to the catches in 2021 equivalent to catches of no more than 31 tons in 2023 implemented through either catch restrictions or effort reduction for the relevant fleets.

Stock development over time

The MEDITS biomass index was used to provide an index for change (Figure 5.18.1). The stock appears to have been fluctuating up to 2009, where it reached its maximum. From 2009 the stock has decreased and then fluctuating at lower values reaching its minimum in 2020. The biomass in 2020 and 2021 is below the reference point $I_{trigger}$. Catches have been fluctuating up to 2014. From 2014 the catches have been decreasing and reached a minimum value in 2016, where they rapidly increased reaching their maximum in 2018. Catches in 2021 are around 42 tonnes.



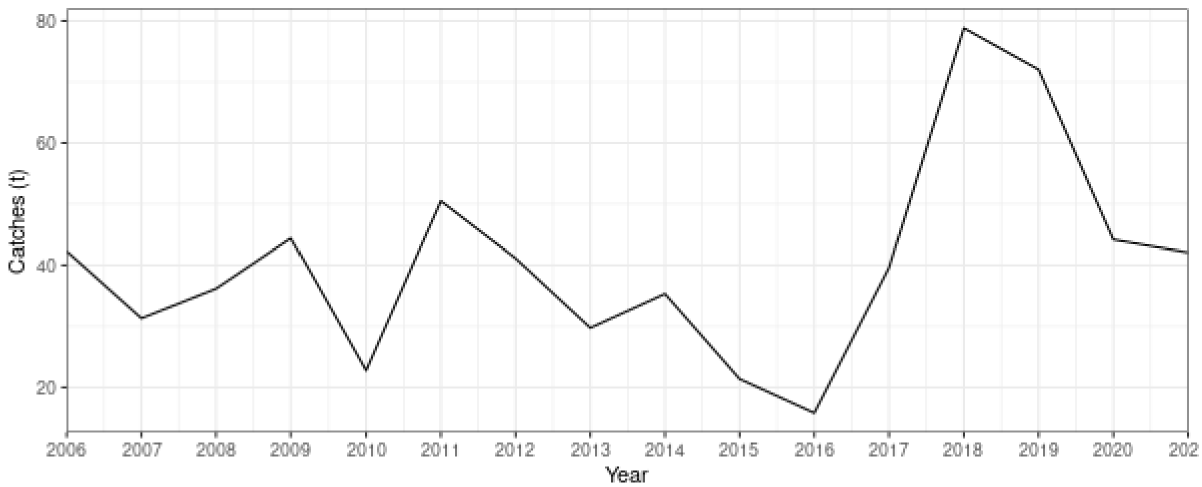


Figure 5.14.1 Norway lobster in GSA 11: (top panel) MEDITS in GSA 11 biomass index. The green dashed line represents $I_{trigger}$. The two red segments represent the mean index of 2020-2021 and of 2017-2019. (bottom panel) Catch by year.

Stock and exploitation status

The power of the fishing pressure proxy is considered to be poor. The fishing pressure proxy on the stock is below $F_{MSY\ proxy}$ (Figure 5.18.2), and the stock size index is below MSY $B_{trigger\ proxy}$ ($I_{trigger}$) (Figure 5.18.1).

Table 5.14.1 Norway lobster in GSA 11: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / $F_{MSY\ proxy}$	F > $F_{MSY\ proxy}$	F > $F_{MSY\ proxy}$	F > $F_{MSY\ proxy}$
B / MSY $B_{trigger\ proxy}$	B > MSY $B_{trigger\ proxy}$	B < MSY $B_{trigger\ proxy}$	B < MSY $B_{trigger\ proxy}$

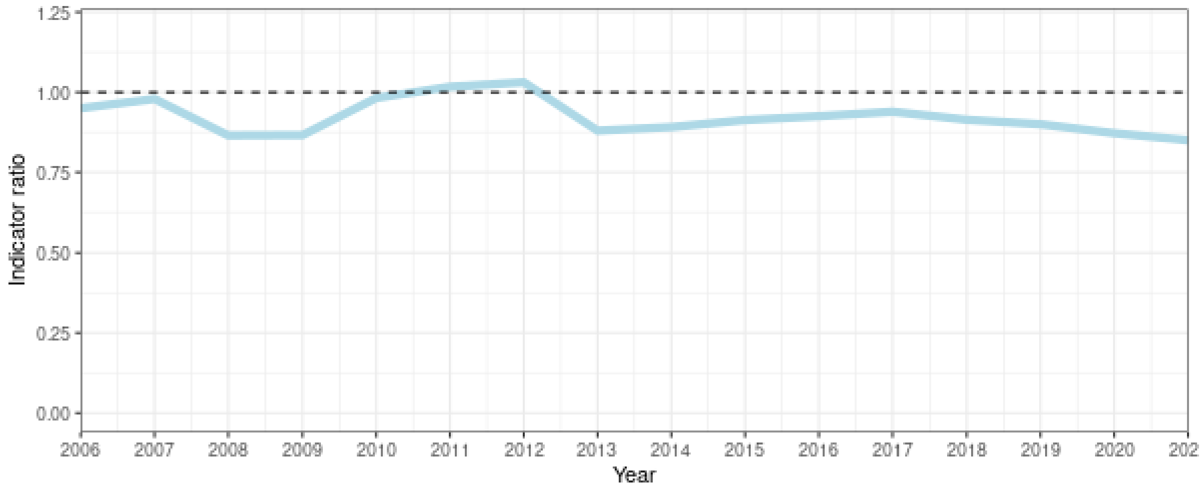


Figure 5.14.2 Norway lobster in GSA 11: Length indicator (mean length of fish in the catch divided by MSY proxy reference length). The exploitation status is below $F_{MSY\ proxy}$ when the indicator ratio value is higher than 1 (shown by the dashed line).

Catch scenarios

ICES framework for category 3 stocks was applied (rfb rule, method 2.1, ICES, 2022). A survey biomass index was used as an indicator of stock development. The advice is based on the recent catches, multiplied by the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), a ratio of observed mean length in the catch relative to the target mean length, a biomass safeguard, and a precautionary multiplier. The stability clause was considered but not applied since the stock is below $I_{trigger}$.

Table 5.14.2 Norway lobster in GSA 11: Basis for the catch scenarios. The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the tables.

Last year catch C_{y-1} (catch in 2021)		42 tonnes
Stock biomass trend		
Index A (2020, 2021)		0.901 kg / km^2
Index B (2017, 2018, 2019)		1.698 kg / km^2
r: Index ratio (A/B)		0.531
Fishing pressure proxy		
Mean catch length ($\overline{L}_{y-1}$=L_{2021})		34.37
MSY proxy length ($L_{F=M}$)		40.45
f: multiplier for relative mean length in catches ($\overline{L}_{y-1}$/ $L_{F=M\ 2021}$)		0.85
Biomass safeguard		
Last index value (I_{2021})		1.009 kg / km^2
Index trigger value ($I_{trigger}$=1.4*I_{loss})		1.109 kg / km^2
b: index relative to trigger value, min{I_{2021}/$I_{trigger}$, 1}		0.91
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability		
m: multiplier (generic multiplier based on life history)		0.95
rfb calculation*		
Uncertainty cap (+20%/-30% compared to C_{y-1}, only considered if b≥1)	Not applied	
Discard rate		0%
Catch advice for 2023		31 tonnes
% advice change**		-26%

* $A_{(y+1)} = A_y \times r \times f \times b \times m$ limited by stability clause if applicable.

** Advice value for 2023 relative to the catch in 2021 (209 tonnes).

Basis of the advice

Table 5.18.3 Norway lobster in GSA 11: The basis of the advice.

Advice basis	MSY approach (ICES category 3)
Management plan	

Quality of the assessment

Due to the model instability as shown by the residual plots as well as the retrospective analysis, the EWG 22-09 concluded that the output of this model was not suitable to provide the basis of the current status of the stock.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.14.4 Norway lobster in GSA 11: Reference points for use with ICE category 3 method 2.1, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$ proxy	1.109	Biomass index trigger value ($I_{trigger}$), defined as $I_{trigger} = I_{loss} \times 1.4$, where I_{loss} is the lowest observed historical biomass index value from 2020 MEDITS in GSA 11. In kg / km^2.	STECF EWG 22-09
	$F_{MSY\ proxy}$	1	$L_{mean}/L_{F=M}$; Mean catch length divided by MSY proxy reference length ($L_{F=M}$).	STECF EWG 22-09
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	SSB_{mgt}		Not Defined	
	F_{mgt}		Not Defined	

Basis of the assessment

Table 5.14.5 Norway lobster in GSA 11: Basis of the assessment and advice.

Assessment type	Survey biomass trend applying the rfb rule for advice (ICES, 2022)
Input data	DCF commercial data (landings) and scientific survey (MEDITS) data
Discards and bycatch	Discards were not reported
Indicators	Length-based indicator
Other information	
Working group	STECF EWG 22-09

History of the advice, catch, and management

Table 5.14.6 Norway lobster in GSA 11: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	$F = F_{MSY}$		17.1	40.1	
2020	$F = F_{MSY}$		17.1		
2021	$F = F_{MSY}$		13.2		
2022	$F = F_{MSY}$		13.2		
2023	MSY approach (ICES category 3)		31		

History of the catch and landings

Table 5.14.7 Norway lobster in GSA 11: Catch and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021		Wanted catch	Discards
Catch (t)	42	Otter trawl 100%	0 t
		42 t	
Effort	14228	14228 (100%)	
		Fishing days	

Table 5.14.8 Norway lobster in GSA 11: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	ITALY GSA11	Total landings	Total Effort^ (Fishing days)
2003	-	-	18957
2004	-	-	24827
2005	6.3	6.3	28645
2006	42.3	42.3	22836
2007	31.3	31.3	22321
2008	36.2	36.2	19435
2009	44.4	44.4	20128
2010	22.8	22.8	19321
2011	50.5	50.5	17018
2012	41.1	41.1	15472
2013	29.8	29.8	15872
2014	35.3	35.3	17582
2015	21.4	21.4	15277
2016	15.8	15.8	16925
2017	39.6	39.6	16286
2018	78.8	78.8	21240
2019	72.0	72.0	18878
2020	44.2	44.2	13677
2021	42.1	42.1	14228

^Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward.

Summary of the assessment

Table 5.14.9 Norway lobster in GSA 11: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Biomass Index			Length indicator	Landings tonnes	Discards tonnes	Total Catch
	Low	Value	High				
2006	2.56	3.23	3.90	0.950	42.3		42.3
2007	2.56	3.20	3.83	0.979	31.3		31.3
2008	3.24	4.22	5.21	0.865	36.2		36.2
2009	3.31	4.46	5.61	0.866	44.4		44.4
2010	3.08	4.06	5.04	0.982	22.8		22.8
2011	1.34	1.81	2.27	1.017	50.5		50.5
2012	2.08	2.69	3.30	1.031	41.1		41.1
2013	1.39	1.94	2.50	0.880	29.8		29.8
2014	1.59	2.17	2.76	0.891	35.3		35.3
2015	1.42	2.16	2.90	0.913	21.4		21.4
2016	1.33	2.15	2.97	0.925	15.8		15.8
2017	1.34	1.90	2.46	0.939	39.6		39.6
2018	1.01	1.32	1.64	0.914	78.8		78.8
2019	1.37	1.87	2.37	0.900	72.0		72.0
2020	0.61	0.79	0.97	0.872	44.2		44.2
2021	0.71	1.01	1.31	0.850	42.1		42.1

Sources and references

STECF EWG 22-09.

ICES 2022. ICES technical guidance for harvest control rules and stock assessments for stocks in category 2 and 3. In: Report of ICES Advisory Committee, 2022. ICES Advice 2022, Section 16.4.11. https://doi.org/10.17895/ices.advice.19801564

5.15 Summary sheet for blue and red shrimp in GSA 1 & 2

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.15 and corresponding catches in 2023 should be no more than 52 tons. The fishing mortality is reduced from F_{MSY} of 0.29 as SSB is projected to be below B_{pa} in 2023.

Stock development over time

Recruitment, SSB and catches of blue and red shrimp in GSA1&2 show a declining pattern with oscilations since 2006 (highest value in the time series). In particular, the assessment shows a general declining trend for the last three years, for SSB, recruitment, catches and Fbar. Fbar has fluctuated around 1.17-1.83, with a value of 1.17 in 2021, the lowest value in the time series.

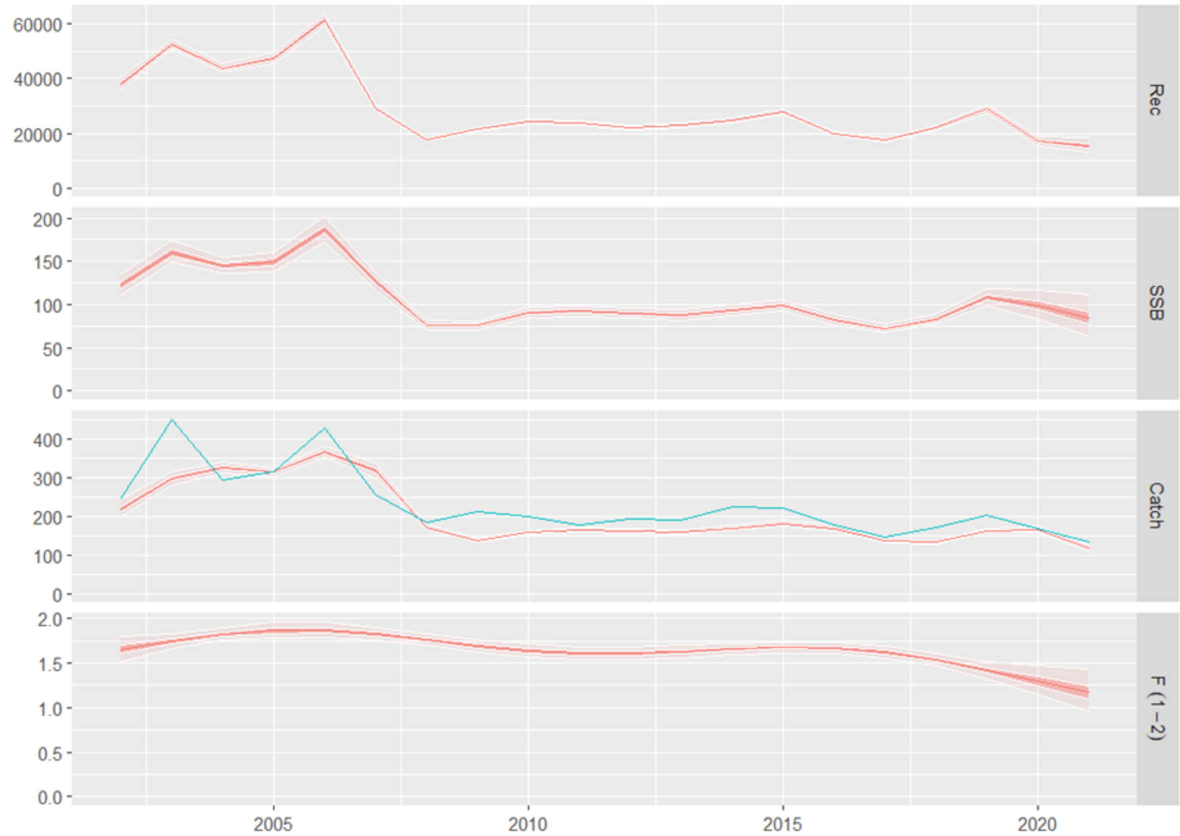


Figure 5.15.1 Blue and red shrimp in GSA 1 & 2: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.168) is 4 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.286). F in 2021 is also higher than $F_{MSY\ Transition}$ (0.145) indicating progress to F_{MSY} in 2025 is behind transition. F has been high throughout the available time series and SSB in 2021 is estimated to be below Blim.

Table 5.15.1 Blue and red shrimp in GSA 1 & 2: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
$F / F_{MSY\ Transition}$		$F > F_{MSY}$ transition	$F > F_{MSY}$ transition
B / B_{lim}	$B < B_{lim}$	$B < B_{lim}$	$B < B_{lim}$
B / B_{pa}	$B < B_{pa}$	$B < B_{pa}$	$B < B_{pa}$
B / B_{MSY}	$B < B_{MSY}$	$B < B_{MSY}$	$B < B_{MSY}$

Catch scenarios

Table 5.15.2 Blue and red shrimp in GSA 1 & 2: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}2}$ (2021)	1.17	F 2021 used to give F status quo for 2022
SSB (2021)	156.93	Stock assessment 1 January 2022
R_{age0} (2021,2022)	39334.69	Recruitment will be set on Hockey Stick relationship
Total catch (2021)	118.30	Assuming F status quo for 2022

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.15.3 Blue and red shrimp in GSA 1 & 2: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-2) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	95.21	0.29	443.20	182.42	-19.51
$F_{MSY\ Transition}$ ^^	184.51	0.66	303.53	93.42	55.98
$F_{MSY\ Reduced}$ B<B_{pa}^^^	**52.04**	**0.15**	**521.49**	**232.30**	**-56.01**
$F_{MSY\ lower}$	67.01	0.19	493.58	214.52	-43.36
$F_{MSY\ upper}$**	124.29	0.39	394.38	151.31	5.06
Other scenarios					
Zero catch	0	0.00	624.78	298.12	-100.00
Status quo	265.57	1.17	203.88	29.92	124.49
	42.46	0.12	539.78	243.96	-64.11
	79.88	0.23	470.22	199.64	-32.48
	112.98	0.35	412.98	163.16	-4.49
	142.40	0.47	365.58	132.96	20.37
	168.64	0.58	326.10	107.80	42.56
	192.16	0.70	293.02	86.72	62.43
	213.31	0.82	265.13	68.94	80.32
	232.43	0.93	241.46	53.86	96.47
	249.78	1.05	221.25	40.98	111.13

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025
^^^$F_{MSY\ Reduce}$ B<B_{pa} is based on ICES advice rule when B in TAC year is less than B_{pa}

Basis of the advice

Table 5.15.4 Blue and red shrimp in GSA 1 & 2: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

For the assessment of blue and red shrimp in GSA 1 and 2 input data revised from the GSA 1 assessment of last year, to include data from GSA 2. Length data was available for GSA 2, though no biological parameters so those from GSA 1 were used. With the addition of GSA 2 some issues observed last year, low observations in GSA 1 in 2009, 2011 and 2013, were resolved. It seems there is some conflict between catch data and survey data at age, and there's a need to look at the raw data for the next EWG and to consider if growth parameters are suitable. This year the 2006 MEDITS survey allocation of stations to GSA 1 or 2 was resolved. The absence of a survey in 2020 means there is a gap in the time series. $F_{0.1}$ from the new assessment is the similar to the GSA 1 assessment and F current is consistent with previous assessment. Biomass reference points have been revised since April (EW 22-03) to account for account for the addition of GSA 2 catches.

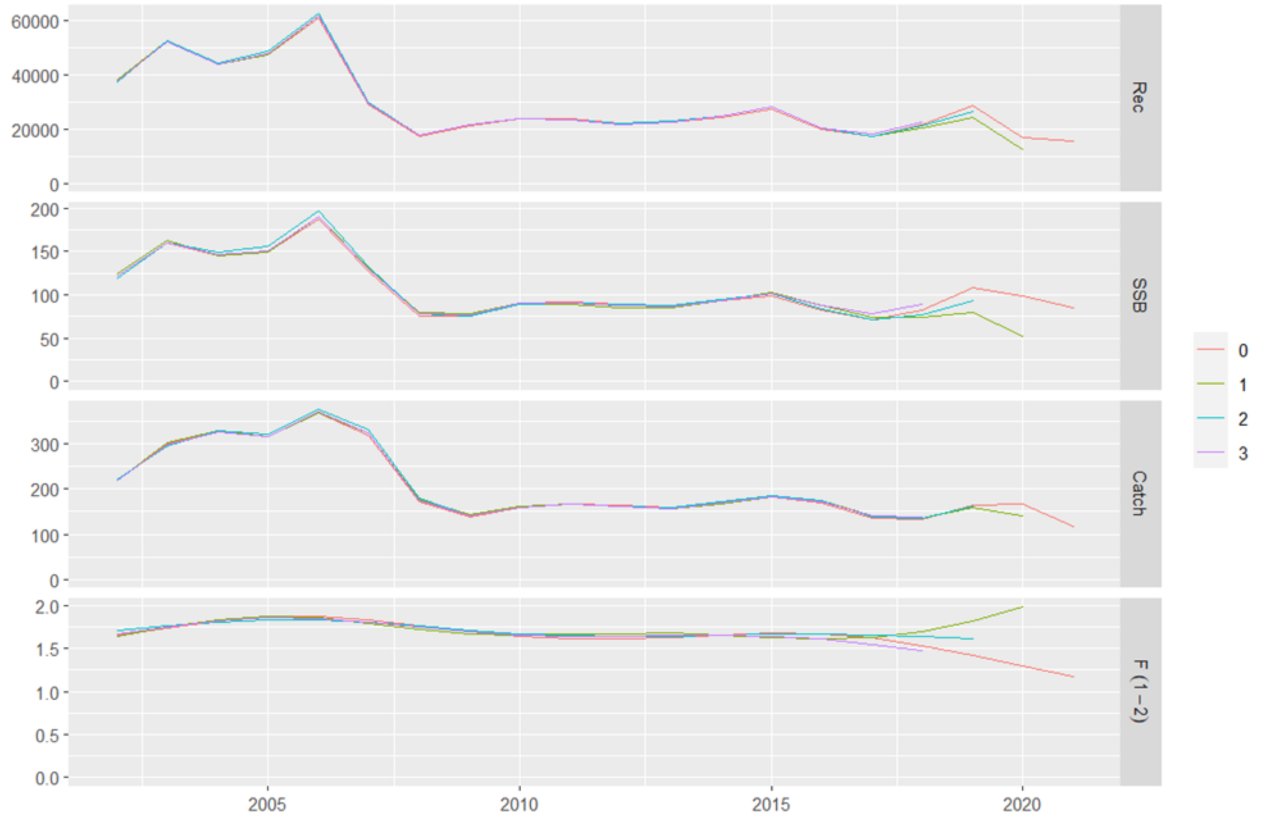


Figure 5.15.2 Blue and red shrimp in GSA 1 & 2: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.15.5 Blue and red shrimp in GSA 1 & 2: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.286	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	232	Estimated as fitted HS to 2022 assessment.	STECF EWG 22-09
	B_{pa}	463	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	927	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.286	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.19	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.39	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.15.6 Blue and red shrimp in GSA 1 & 2: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Not included, considered negligible (less than 0.3%).
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.15.7 Blue and red shrimp in GSA 1 & 2: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}	98	98	166	
2020	F = F_{MSY}	96	96	164	
2021	F = F_{MSY}	103.23	103.23	118	
2022	F = F_{MSY}	33.05	33.05		
2023	F = $F_{MSY\ Reduced}$ B< B_{pa}		52.0		

Advice in 2023 and STECF catch all years refers to full area of GSA 1 & 2, the earlier advice years refer only to GSA 1.

History of the catch and landings

Table 5.15.8 Blue and red shrimp in GSA 1 & 2: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)	134.6 (t)	Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	Negligible
Effort	14949	14949 (100%)	NA	NA	NA	
		Fishing days				

Table 5.15.9 Blue and red shrimp in GSA 1 & 2: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	SPAIN GSA1	SPAIN GSA2	Total landings	Total Effort * (Fishing Days)
2002	157.0	89.8	246.8	28903
2003	335.7	114.4	450.1	33931
2004	225.2	69.3	294.5	36062
2005	232.1	82.2	314.3	33576
2006	288.8	137.5	426.3	33636
2007	178.4	78.6	257	31399
2008	133.5	49.3	182.8	27417
2009	144.6	67.7	212.3	28868
2010	152.1	48.7	200.8	29731
2011	131.4	47.4	178.8	29521
2012	148.6	45.0	193.6	27053
2013	125.0	63.9	188.9	23487
2014	184.0	41.0	225	22168
2015	170.2	51.9	222.1	21438
2016	138.2	40.1	178.3	21315
2017	99.2	48.0	147.2	22829
2018	123.2	47.5	170.7	21036
2019	132.1	72.0	204.1	22657
2020	137.4	31.7	169.1	19211
2021	86.7	47.9	134.6	14949

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.15.10 Blue and red shrimp in GSA 1 & 2: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2002	38344			125			217	1.62		
2003	52951			164			301	1.71		
2004	44252			149			330	1.79		
2005	47864			153			318	1.83		
2006	61819			191			370	1.83		
2007	29498			130			323	1.80		
2008	17620			78			175	1.74		
2009	21518			77			140	1.68		
2010	23977			90			158	1.64		
2011	23536			91			166	1.62		
2012	21712			87			162	1.63		
2013	22352			85			157	1.66		
2014	24149			90			167	1.69		
2015	27277			96			179	1.70		
2016	19826			81			167	1.68		
2017	17339			71			134	1.62		
2018	21978			83			133	1.53		
2019	28972			109			164	1.41		
2020	17086			100			166	1.29		
2021	15468			85			118	1.17		

Sources and references

STECF EWG 22-09, EWG 22-10

5.16 SUMMARY SHEET FOR BLUE AND RED SHRIMP IN GSAS 5

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.34 and corresponding catches in 2023 should be no more than 46.3 tons.

Stock development over time

The results of the assessment show a fluctuation of all indicators along the available time series. After a fluctuating trend since the beginning of the time series until 2014, catches, recruitment and SSB showed a progressive increasing trend from 2014-2015 to 2018, but then a sharp decrease until 2021 (more attenuated for recruitment). Fbar (1-3) shows a fluctuating trend along all the time series (between 1.46 and 2.11), but with a noticeable decrease in the last three years (from 2019) reaching a values of 1.64 in 2021.

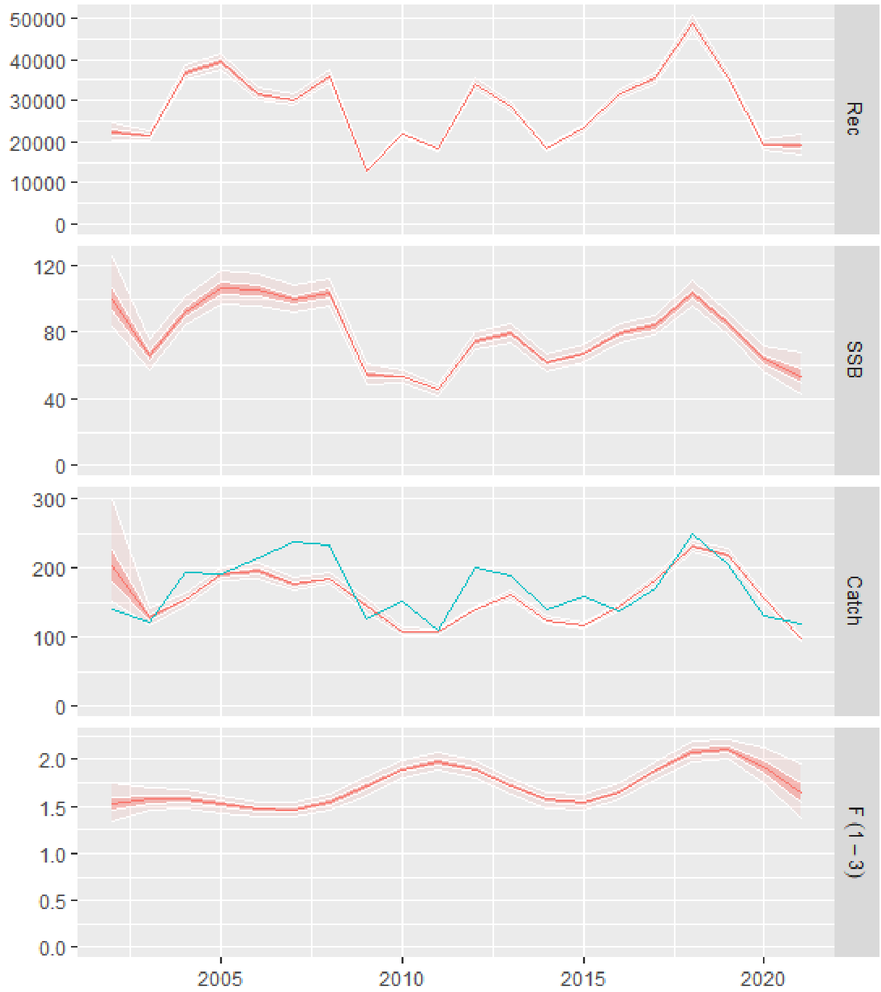


Figure 5.16.1 Blue and red shrimp in GSA 5: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.64) is 4.8 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.34). F in 2021 is also higher than $F_{MSY\ Transition}$ (0.93) indicating progress to F_{MSY} in 2025 is behind transition. No biomass reference points are calculated.

Table 5.16.1 Blue and red shrimp in GSA 5: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}
F / $F_{MSY\ Transition}$	NA	F > $F_{MSY\ Transition}$	F > $F_{MSY\ Transition}$

Catch scenarios

Table 5.16.2 Blue and red shrimp in GSA 5: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	1.64	F current in the last year used to give F status quo for 2022
SSB (2022)	73.3	SSB intermediate year from STF output
R_{age0} (2022,2023)	26808.8	Geometric mean of the last 20 years
Total catch (2022)	127.1	Catch intermediate year from STF output

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.16.3 Blue and red shrimp in GSA 5: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	46.3	0.34	188	156.6	-53.2
$F_{MSY\ Transition}$ ^^	102.9	0.93	118.3	61.4	4.1
$F_{MSY\ lower}$	32.4	0.23	208.7	184.8	-67.3
$F_{MSY\ upper}$**	60.5	0.46	168.3	129.7	-38.8
Other scenarios					
Zero catch	0	0	262.0	257.7	-100.00
Status quo	146.7	1.64	79.4	8.3	48.4
	24.0	0.16	221.8	202.7	-75.72
	45.0	0.33	189.9	159.2	-54.52
	63.3	0.49	164.6	124.6	-35.91
	79.6	0.65	144.2	96.8	-19.50
	94.0	0.82	127.7	74.3	-4.93
	106.8	0.98	114.2	55.9	8.07
	118.3	1.15	103.1	40.7	19.72
	128.7	1.31	93.8	28.0	30.22
	138.1	1.47	86.0	17.4	39.73

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.16.4 Blue and red shrimp in GSA 5: The basis of the advice.

Advice basis	F_{MSY}
Management plan	0.34

Quality of the assessment

The stock has been assessed with a4a and accepted for advice, after some years (since 2018) giving precautionary advice using the biomass index. Commercial catches showed better internal consistency than MEDITS survey index. However, the general results of the assessment are a bit unstable, especially in terms of the stability of residuals (both for commercial catches, especially in age class 3, as well as for MEDITS survey, in age classes 3 and 5) and for the high values of F along all the time series. Despite that, the model with the present parameterization showed a retrospective analysis quite stable for most of the variables, excepting for F where its trend changed with two years removed from the time series. Several other submodels were tested trying to improve the general results but all them increased model instability, so they were rejected. Finally, the stability in the present retrospective pattern caused that the model was considered acceptable as it is considered better than the biomass index advice used previously. However, the instability of the general model outputs and the lack of reference data for this stock from previous years determined that reference points had not been computed for this stock in the present year.

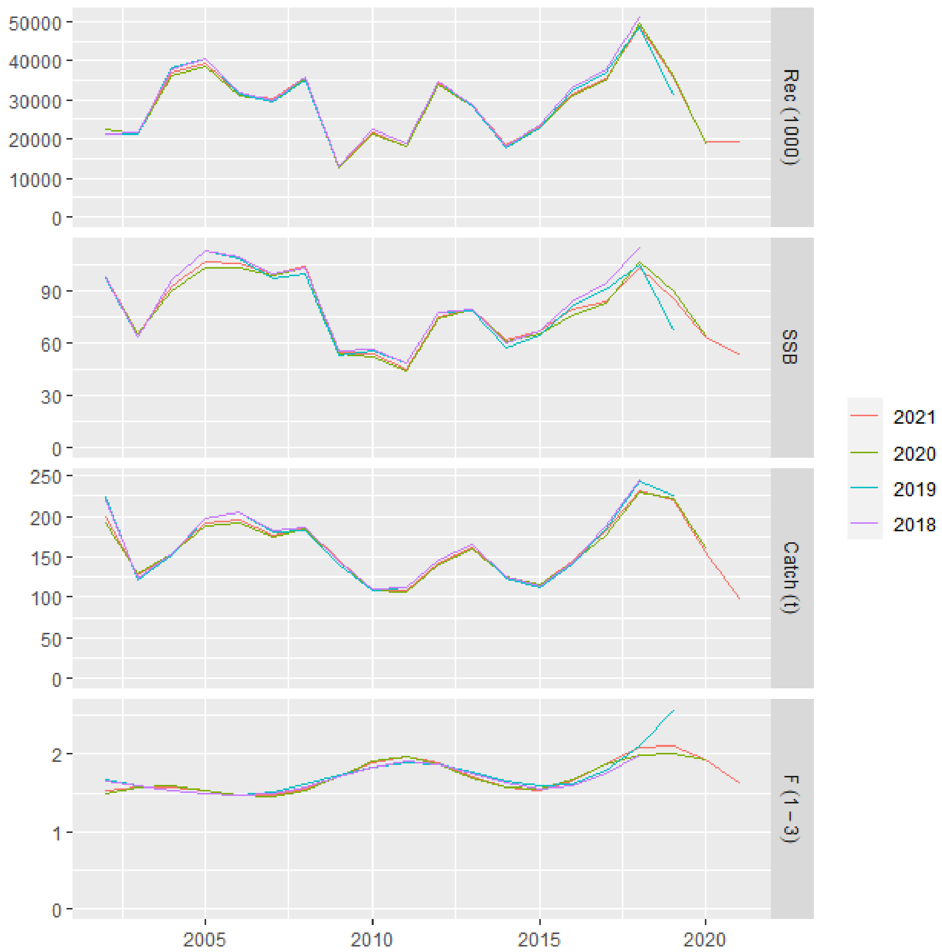


Figure 5.16.2 Blue and red shrimp in GSA: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.16.5 Blue and red shrimp in GSA 5: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.34	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.34	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.23	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.46	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.16.6 Blue and red shrimp in GSA 5: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Not included, considered negligible
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.16.7 Blue and red shrimp in GSA5: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	F = F_{MSY}		98.8	118.7	
2022	F = F_{MSY}		127.1		
2023	F = F_{MSY}		46.3		

History of the catch and landings

Table 5.16.8 Blue and red shrimp in GSA5: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

<table>
<tr><td>2021</td><td></td><td colspan="4">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Catch
(t)</td><td></td><td>Otter trawl 100%</td><td>Gillnets 0%</td><td>Trammel nets 0%</td><td>Other 0%</td><td>Negligible</td></tr>
<tr><td></td><td>118.7</td><td></td><td></td><td></td><td>Negligible</td></tr>
<tr><td rowspan="2">Effort</td><td>6439</td><td>6439 (100%)</td><td>NA</td><td>NA</td><td>NA</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">Fishing days</td></tr>
</table>

Table 5.16.9 Blue and red shrimp in GSA5: History of commercial landings; official reported values are presented by country and GSA,. All weights are in tonnes. Effort in Fishing Days.

Year	SPAIN GSA5	Total landings	Total Effort * (Fishing Days)
2002	141	141	
2003	122	122	
2004	194	194	12012
2005	191	191	11497
2006	214	214	10507
2007	239	239	11907
2008	233	233	12226
2009	126	126	10934
2010	153	153	11239
2011	111	111	10498
2012	201	201	10568
2013	189	189	9942
2014	141	141	11817
2015	160	160	11965
2016	138	138	10490
2017	171	171	10176
2018	250	250	8715
2019	206	206	8202
2020	131	131	7306
2021	119	119	6439

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.16.10 Blue and red shrimp in GSA5: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2002	22275			97.51			200.07	1.53		
2003	21384			65.28			127.97	1.57		
2004	36781			92.33			153.86	1.57		
2005	39403			106.46			191.44	1.53		
2006	31516			105.32			196.31	1.47		
2007	30154			99.47			177.39	1.46		
2008	35784			103.74			185.35	1.55		
2009	12969			54.57			145.97	1.72		
2010	21818			53.36			108.71	1.90		
2011	18253			45.23			108.51	1.98		
2012	34043			74.77			141.51	1.90		
2013	28671			79.24			160.75	1.72		
2014	18425			61.51			125.20	1.57		
2015	23356			67.18			116.85	1.54		
2016	31664			79.15			144.30	1.65		
2017	35318			83.85			182.16	1.88		
2018	48664			103.10			232.10	2.08		
2019	35620			84.91			219.46	2.11		
2020	19330			63.65			156.47	1.92		
2021	19270			53.92			98.85	1.64		

Sources and references

STECF EWG 22-09, STECF EWG 22-10

5.17 SUMMARY SHEET FOR BLUE AND RED SHRIMP IN GSAS 6 & 7

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.26 and corresponding catches in 2023 should be no more than 257 tons.

Stock development over time

Catches of Blue and red shrimp show a slight decrease after reaching a maximum in 2011, and are now fluctuating around 550 tonnes. SSB is increasing since 2019 reaching a maximum of 474 tonnes. The assessment shows a fairly stable recruitment since 2010, but from 2016 and onwards there are fluctuations, with the final year's value the most uncertain. Fbar (1-2) shows a decrease for the past three years, having been at higher levels since the beginning of the time series.

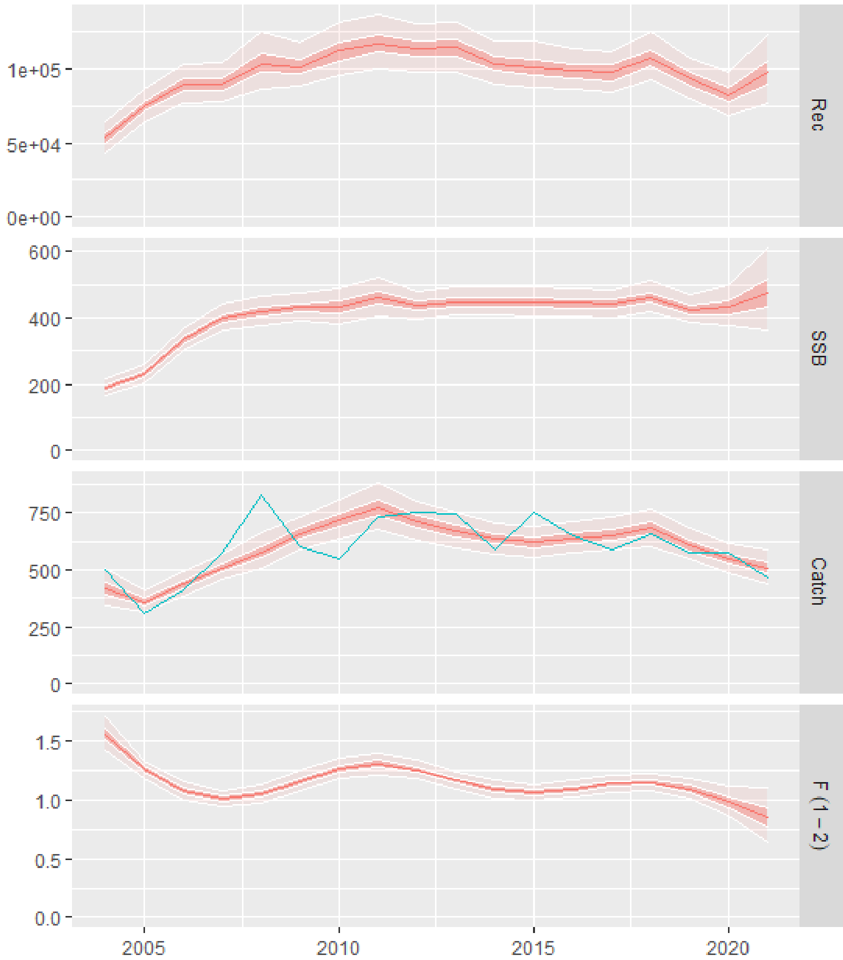


Figure 5.1.1 blue and red shrimp in GSAs 6 & 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.85) is more than 3 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.26). F in 2021 is also higher than $F_{MSY\ Transition}$ (=0.53) indicating progress to F_{MSY} in 2025 is behind transition. SSB in 2021 is above B_{lim} and below B_{pa}.

Table 5.1.1 blue and red shrimp in GSAs 6 & 7: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
F / $F_{MSY\ Transition}$		$F > F_{MSY\ Transition}$	$F > F_{MSY\ Transition}$
B / B_{lim}	$B > B_{lim}$	$B > B_{lim}$	$B > B_{lim}$
B / B_{pa}	$B < B_{pa}$	$B < B_{pa}$	$B < B_{pa}$
B / B_{MSY}	$B < B_{MSY}$	$B < B_{MSY}$	$B < B_{MSY}$

Catch scenarios

Table 5.1.2 blue and red shrimp in GSAs 6 & 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}2}$ (2022)	0.85	F 2021 used to give F status quo for 2022
SSB (2022)	554.45	Stock assessment 1 January 2022
R_{age0} (2022,2023)	102000	Recruitment will be set on Hockey Stick relationship
Total catch (2022)	603.38	Assuming F status quo for 2022

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.1.3 blue and red shrimp in GSAs 6 & 7: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	257.06	0.26	1123.43	+102.62	-49.56
$F_{MSY\ Transition}$ ^^	465.47	0.53	807.73	+45.68	-8.66
$F_{MSY\ lower}$	180.14	0.17	1253.82	+126.14	-64.65
$F_{MSY\ upper}$**	338.03	0.36	994.23	+79.32	-33.67
Other scenarios					
Zero catch	0	0	1588.00	+186.41	-100
Status quo	641.00	0.85	584.67	+5.45	+25.79
0.1 F_{sq}	91.19	0.08	1413.81	+154.99	-82.11
0.2 F_{sq}	174.67	0.17	1263.37	+127.86	-65.72
0.3 F_{sq}	251.20	0.25	1133.10	+104.36	-50.71
0.4 F_{sq}	321.46	0.34	1018.00	+83.96	-36.92
0.5 F_{sq}	386.05	0.42	921.53	+66.20	-24.24
0.6 F_{sq}	445.52	0.51	835.57	+50.70	-12.57
0.7 F_{sq}	500.33	0.59	760.31	+37.13	-1.82
0.8 F_{sq}	550.93	0.68	694.23	+25.21	+8.11
0.9 F_{sq}	597.71	0.76	636.05	+14.72	+17.29

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at $F > F_{MSY}$
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.1.4 blue and red shrimp in GSAs 6 & 7: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This is an update assessment of 2021 with rechecked data. Last year's assessment a4a submodels were used. The assessment was carried out with data from 2004 to 2021 only due to: incompatibility during the years 2002 and 2003 between landings reported in Catalonia (which produces around 70% of the total landings in GSAs 6 and 7) and those reported in the DCF (GSA 6); and also the mean weights out of trend reported for those same years. Discards were added to the catch data. For GSA 6, year 2021, length frequencies for metier OTB-DWS presented an unusual high increase in small individuals, these age 0 were removed and placed in age 1. The MEDITS survey 2020 was not included for the assessment due to incomplete hauls positions and density index out of trend. Lengths out of range were removed from the length frequencies (individual smaller than 10 mm and bigger than 80 mm). The retrospective analysis showed consistency in the estimation of F estimated in the assessment of 2021. The new assessment gives similar estimation of recruitment to the one obtained from the assessment of the previous year, but the scale changed a little. All the diagnostics were considered acceptable and are in accordance with EWG 21-09 report. Although there is still an issue with the estimated catch is not following annual fluctuations in the observed one.

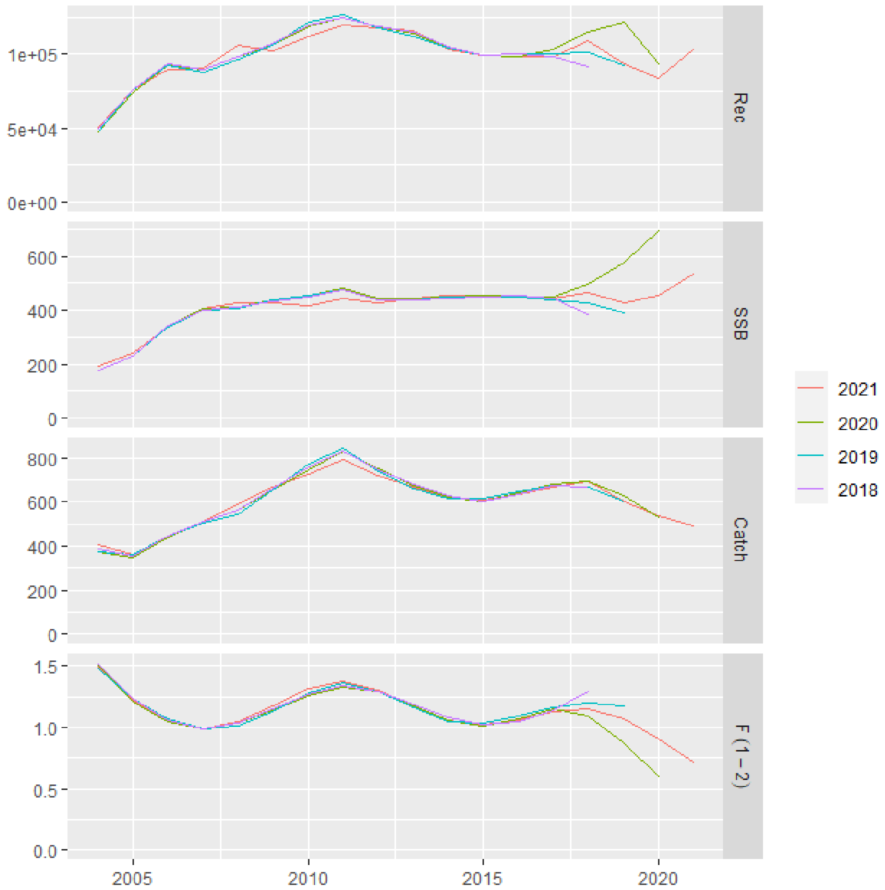


Figure 5.1.2 blue and red shrimp in GSAs 6 & 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.1.5 blue and red shrimp in GSAs 6 & 7: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.26	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	261	Estimated from HS fit to 2022 assessment.	STECF EWG 22-09
	B_{pa}	521	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	1520	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0-26	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.17	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.36	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.1.6 blue and red shrimp in GSAs 6 & 7: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 21-11

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.1.7 blue and red shrimp in GSAs 6 & 7: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		223	566	
2020	F = F_{MSY}		226	549	
2021	F = F_{MSY}		188	510	
2022	F = F_{MSY}		267		
2023	F = F_{MSY}		257		

History of the catch and landings

Table 5.1.8 blue and red shrimp in GSAs 6 & 7: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)	510	Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	Negligible
Effort	58868	58868 (100%)	NA	NA	NA	
		Fishing days				

Table 5.1.9 blue and red shrimp in GSAs 6 & 7: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	SPAIN GSA6	SPAIN GSA7	FRANCE GSA7	Total landings	Total Effort * (Fishing Days)
2004	448	50.8	0	498.8	121790
2005	294	11.9	0	305.9	114583
2006	396	15.7	0	411.7	113558
2007	527	47.5	0	574.5	103191
2008	737	90.5	0	827.5	110561
2009	515	84.5	0	599.5	105013
2010	509	38	0.105	547.1	114077
2011	663	62.8	0	725.8	108890
2012	703	32.9	0	735.9	100550
2013	679	51.7	0	730.7	95936
2014	546	45	0	591.0	99611
2015	689	61.1	0	750.1	93376
2016	570	76.5	0	646.5	91624
2017	523	58.4	0.0754	581.5	88754
2018	606	49.6	0	655.6	85481
2019	547	24	0	571.0	83956
2020	543	34.6	0	577.6	77180
2021	433	32.6	0.00044	465.6	58868

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.1.10 blue and red shrimp in GSAs 6 & 7: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2004	53255			188			416	1.55		
2005	74621			230			359	1.25		
2006	89812			332			434	1.07		
2007	90258			398			508	1.01		
2008	104044			419			575	1.05		
2009	102263			430			655	1.15		
2010	112085			431			714	1.26		
2011	117113			459			770	1.30		
2012	113800			436			706	1.25		
2013	114109			447			668	1.16		
2014	103694			448			632	1.08		
2015	101464			446			618	1.06		
2016	98837			444			636	1.09		
2017	97695			439			653	1.13		
2018	107771			462			680	1.15		
2019	93180			424			605	1.09		
2020	82316			432			548	0.98		
2021	97783			474			510	0.85		

Sources and references

STECF EWG 22-09, EWG 22-10

5.18 SUMMARY SHEET FOR BLUE AND RED SHRIMP IN GSAS 8, 9, 10 & 11

STECF advice on fishing opportunities

Based on MSY considerations, STECF EWG 22-09 advises to decrease the total catch by 30% relative to the catches in 2021 equivalent to catches of no more than 145 tons in 2023.

Stock development over time

The MEDITS biomass index was used to provide an index for change (Figure 5.18.1). The stock appears to have been fluctuating around an apparently sustainable level up to 2014. From 2014 the stock has decreased rapidly reaching a minimum in 2019. The biomass in 2021 is below the reference point $I_{trigger}$ and is the second lowest observed. Based on the index value in the last two years relative to the previous three years the decrease in biomass is estimated to be 0.87 times. Catches in 2018 and 2019 have increased considerably relative to earlier years in particular in GSAs 10 and 11. Catches in 2021 are around the long term average.

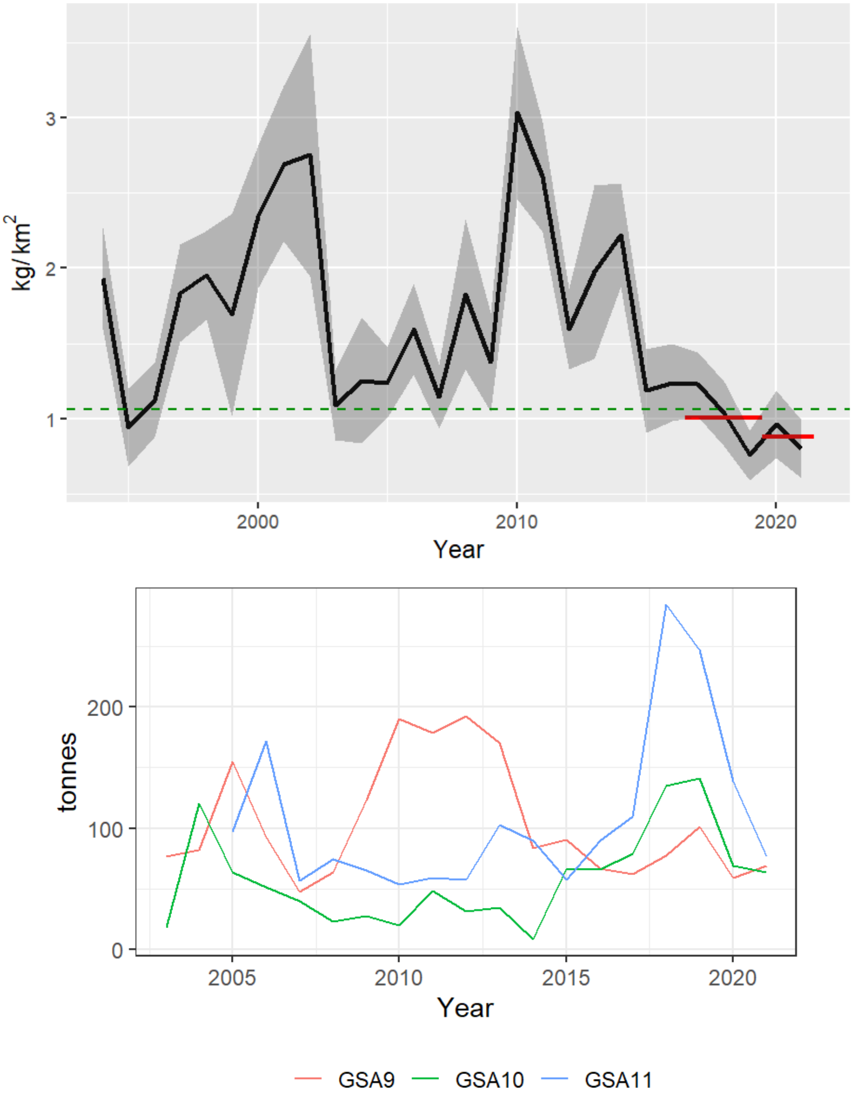


Figure 5.18.1 Blue and red shrimp in GSAs 8, 9, 10 & 11: (top panel) MEDITS in GSAs 8, 9, 10 and 11 biomass index. The green dashed line represents $I_{trigger}$. The two red segments represent the mean index of 2020-2021 and of 2017-2019. (bottom panel) Catch by year and GSA. Note that GSA 9 includes also GSA 8 in 2010 and 2011.

Stock and exploitation status

The fishing pressure proxy on the stock is below $F_{MSY\ proxy}$ (Figure 5.18.2), and the stock size index is below MSY $B_{trigger\ proxy}$ ($I_{trigger}$) (Figure 5.18.1).

Table 5.18.1 Blue and red shrimp in GSAs 8, 9, 10 & 11: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / $F_{MSY\ proxy}$	F > $F_{MSY\ proxy}$	F > $F_{MSY\ proxy}$	F < $F_{MSY\ proxy}$
B / MSY $B_{trigger\ proxy}$	B < MSY $B_{trigger\ proxy}$	B < MSY $B_{trigger\ proxy}$	B < MSY $B_{trigger\ proxy}$

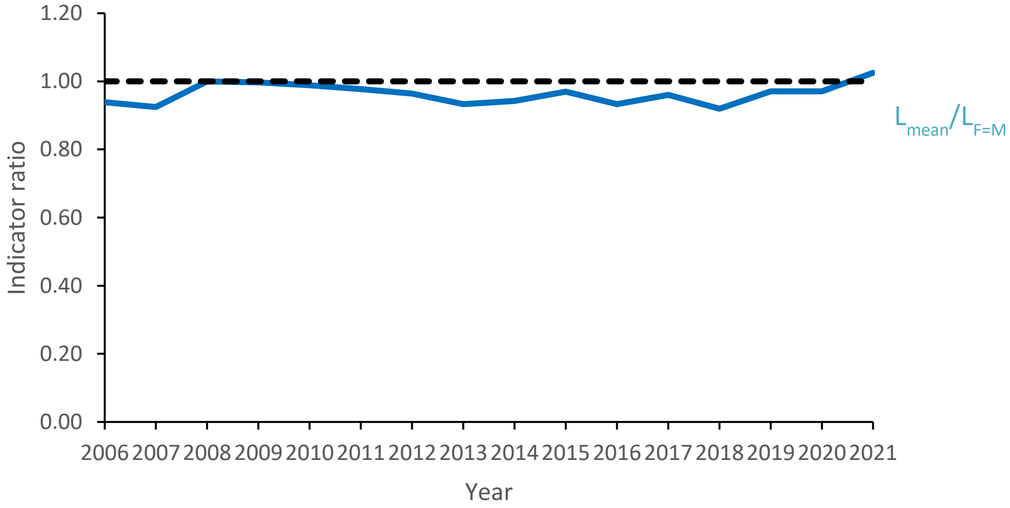


Figure 5.18.2 Blue and red shrimp in GSAs 8, 9, 10 & 11: Length indicator (mean length of fish in the catch divided by MSY proxy reference length). The exploitation status is below $F_{MSY\ proxy}$ when the indicator ratio value is higher than 1 (shown by the dashed line).

Catch scenarios

ICES framework for category 3 stocks was applied (rfb rule, method 2.1, ICES, 2022). A survey biomass index was used as an indicator of stock development. The advice is based on the recent catches, multiplied by the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), a ratio of observed mean length in the catch relative to the target mean length, a biomass safeguard, and a precautionary multiplier. The stability clause was considered but not applied since the stock is below $I_{trigger}$.

Table 5.18.2 Blue and red shrimp in GSAs 8, 9, 10 & 11: Basis for the catch scenarios. The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the tables.

Last year catch C_{y-1} (catch in 2021)		209 tonnes
Stock biomass trend		
Index A (2020, 2021)		0.88 kg / km^2
Index B (2017, 2018, 2019)		1.00 kg / km^2
r: Index ratio (A/B)		0.88
Fishing pressure proxy		
Mean catch length ($\bar{L}_{y-1}$=L_{2021})		35.9
MSY proxy length ($L_{F=M}$)		35.0
f: multiplier for relative mean length in catches ($\bar{L}_{y-1}$/ $L_{F=M\ 2021}$)		1.03
Biomass safeguard		
Last index value (I_{2021})		0.80 kg / km^2
Index trigger value ($I_{trigger}$=1.4*I_{loss})		1.06 kg / km^2
b: index relative to trigger value, min{I_{2021}/$I_{trigger}$, 1}		0.75
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability		
m: multiplier (generic multiplier based on life history)		0.9
rfb calculation*		
Uncertainty cap (+20%/-30% compared to C_{y-1}, only considered if b≥1)	Not applied	
Discard rate		0%
Catch advice for 2023		145 tonnes
% advice change**		-30%

* $A_{(y+1)} = A_y \times r \times f \times b \times m$ limited by stability clause if applicable.
** Advice value for 2023 relative to the catch in 2021 (209 tonnes).

Basis of the advice

Table 5.18.3 Blue and red shrimp in GSAs 8, 9, 10 & 11: The basis of the advice.

Advice basis	MSY approach (ICES category 3) Method 2.1
Management plan	

Quality of the assessment

Due to the model instability as shown by the retrospective analysis, the EWG 22-09 concluded that the output of this model was not suitable to provide the basis of the current status of the stock. The ICES category 3 Method 2.1 was applied. This involves two reference points, a biomass MSY $B_{trigger}$ proxy and F_{MSY} proxy. The biomass proxy available from the MEDITS series shown above is considered robust, with good indication of sustainable exploitation at higher biomass in the past. The F_{MSY} proxy defining optimal exploitation rate is not considered particularly good for this stock as length contrast is very limited (see Figure 5.18.2 above) and comparison of length and F indicators (EWG 16-13) suggest the Length indicators are poor at informing F levels, though they can sometimes be used to infer F change. For short lived stocks, length indicators tend to respond to recruitment more than exploitation rate.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.18.4 Blue and red shrimp in GSAs 8, 9, 10 & 11: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$ proxy	1.06	Biomass index trigger value ($I_{trigger}$), defined as $I_{trigger}$ = I_{loss}×1.4, where I_{loss} is the lowest observed historical biomass index value from 2019 MEDITS in GSAs 8, 9, 10 and 11. In kg / km^2.	STECF EWG 22-09
	$F_{MSY\ proxy}$	1	$L_{mean}/L_{F=M}$; Mean catch length divided by MSY proxy reference length ($L_{F=M}$).	STECF EWG 22-09
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	SSB_{mgt}		Not Defined	
	F_{mgt}		Not Defined	

Basis of the assessment

Table 5.18.5 Blue and red shrimp in GSAs 8, 9, 10 & 11: Basis of the assessment and advice.

Assessment type	Survey biomass trend applying the rfb rule for advice (ICES, 2022)
Input data	DCF commercial data (landings) and scientific survey (MEDITS) data
Discards and bycatch	Discards were negligible (<1%) but included.
Indicators	Length-based indicator
Other information	
Working group	STECF EWG 22-09

History of the advice, catch, and management

Table 5.18.6 Blue and red shrimp in GSAs 8, 9, 10 & 11: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		-	490	
2020	F = F_{MSY}		72	267	
2021	F = F_{MSY}		61	209	
2022	F = F_{MSY}		45		
2023	MSY approach (ICES category 3 method 2.1)		145		

History of the catch and landings

Table 5.18.7 Blue and red shrimp in GSAs 8, 9, 10 & 11: Catch and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021		Wanted catch	Discards
Catch (t)	209	Otter trawl 100%	0 t
		209 t	
Effort	74023	74023 (100%)	
		Fishing days	

Table 5.18.8 Blue and red shrimp in GSAs 8, 9, 10 & 11: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	FRANCE GSA8	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total landings	Total Effort^ (Fishing days)
2003	-	77	19	-	95**	120422
2004	-	82	120	-	203**	125209
2005	-	155	64	98	317	146415
2006	-	93	52	172	316	123716
2007	-	47	39	57	143	124633
2008	-	63	23	75	161	107303
2009	-	123	27	65	216	110207
2010	3.57	186	20	53	263***	104445
2011	4.30	175	48	59	287***	101849
2012	-	193	31	57	281	95200
2013	-	170	34	103	307	106497
2014	-	84	9	90	182	111965
2015	-	91	67	58	215	99835
2016	-	67	66	89	222	104768
2017	-	62	79*	110	219	100731
2018	-	77	135	285	497	99566
2019	-	101	141	247	490	91095
2020	-	59	69	139	267	71370
2021	-	69	64	77	209	74023

* Data from 2017 from FDI data.
** Incomplete
*** Includes GSA 8
^Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward.

Summary of the assessment

Table 5.18.9 Blue and red shrimp in GSAs 8, 9, 10 & 11: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Biomass Index			Length indicator	Landings tonnes	Discards tonnes	Total Catch
	Low	Value	High				
2006	1.29	1.59	1.90	0.94	316		316
2007	0.93	1.14	1.36	0.92	143		143
2008	1.33	1.83	2.33	1.00	161		161
2009	1.05	1.37	1.70	1.00	216		216
2010	2.46	3.03	3.61	0.99	263		264
2011	2.24	2.61	2.97	0.98	287	0.4	287
2012	1.32	1.59	1.86	0.96	281		281
2013	1.40	1.98	2.55	0.93	307		307
2014	1.88	2.22	2.57	0.94	182		182
2015	0.91	1.18	1.46	0.97	215		215
2016	0.98	1.24	1.50	0.93	222		222
2017	1.01	1.23	1.44	0.96	219		252
2018	0.81	1.03	1.25	0.92	497		497
2019	0.59	0.76	0.92	0.97	490		490
2020	0.74	0.96	1.19	0.97	267		267
2021	0.61	0.80	0.99	1.03	209	<0.1	209

Sources and references

STECF EWG 22-09.

ICES. 2022. ICES technical guidance for harvest control rules and stock assessments for stocks in category 2 and 3. In: Report of ICES Advisory Committee, 2022. ICES Advice 2022, Section 16.4.11. https://doi.org/10.17895/ices.advice.19801564

5.19 SUMMARY SHEET FOR GIANT RED SHRIMP IN GSA 9, 10 & 11

STECF advice on fishing opportunities

STECF EWG 22-09 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.43 and corresponding catches in 2023 should be no more than 270 tons.

Stock development over time

Catches of giant red shrimp in GSAs 9, 10, 11 show a fluctuating pattern, with peaks in 2005, 2014 and 2019. Recruitment, after a last peak in 2016, remains mostly constant in the last five years, while SSB shows a decrease since 2018. Fishing mortality is gradually increasing since 2010, reaching its maximum value (0.767) in the last year.

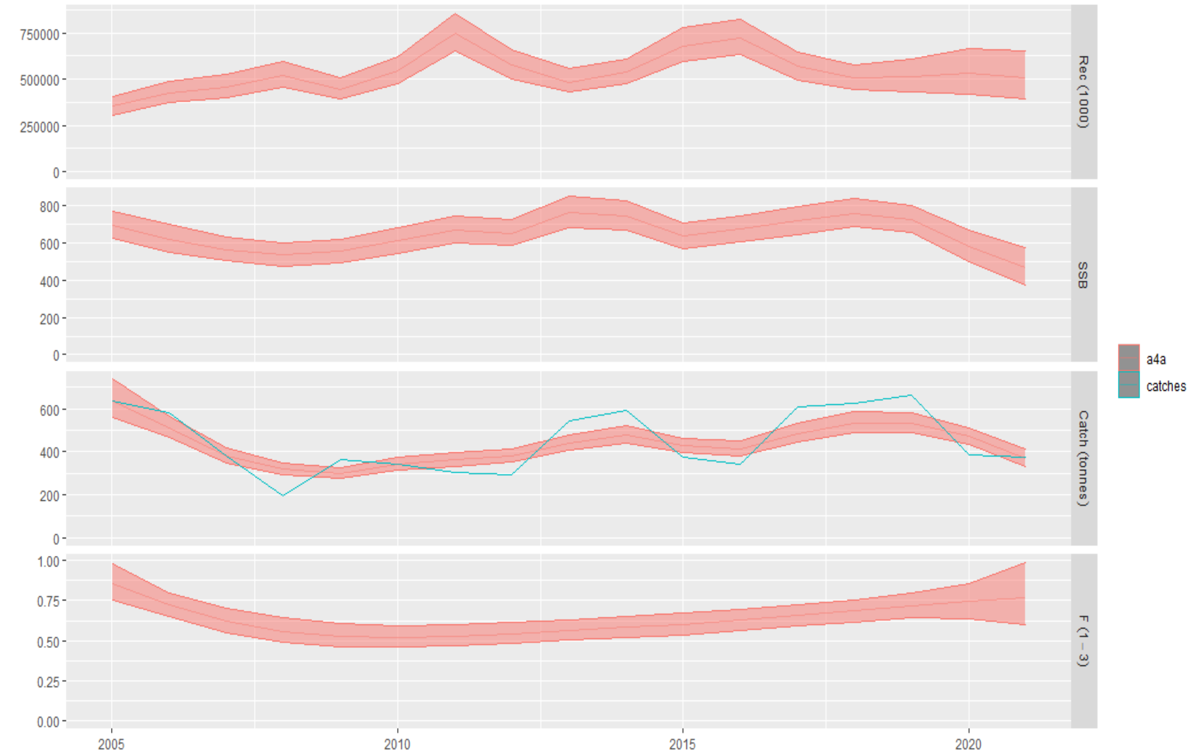


Figure 5.19.1 Giant red shrimp in GSAs 9, 10 & 11: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.767) is 1.8 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.426). F in 2021 is also higher than $F_{MSY\ Transition}$. SSB in 2021 is above B_{pa} and below B_{MSY}.

Table 5.19.1 Giant red shrimp in GSAs 9, 10 & 11: State of the stock and fishery relative to reference points.

Status	2019	2020	2021
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
$F / F_{MSY\ Transition}$		$F > F_{MSY\ transition}$	$F > F_{MSY\ transition}$
B / B_{lim}	$B > B_{lim}$	$B > B_{lim}$	$B > B_{lim}$
B / B_{pa}	$B > B_{pa}$	$B > B_{pa}$	$B > B_{pa}$
B / B_{MSY}	$B < B_{MSY}$	$B < B_{MSY}$	$B < B_{MSY}$

Catch scenarios

Table 5.19.2 Giant red shrimp in GSAs 9, 10 & 11: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	0.767	F 2021 used to give F status quo for 2022
SSB (2022)	552	Stock assessment 1 January 2022
R_{age0} (2022,2023)	528634	Geometric mean of the last 17 years
Total catch (2022)	427	Assuming F status quo for 2022

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three years

Table 5.19.3 Giant red shrimp in GSAs 9, 10 & 11: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	270	0.43	714	29.5	-26.9
$F_{MSY\ Transition}$ ^^	318	0.52	662	20.0	-14.0
$F_{MSY\ lower}$	192	0.28	808	46.4	-48.0
$F_{MSY\ upper}$**	346	0.58	632	14.6	-6.4
Other scenarios					
Zero catch	0	0	1077	95.3	-100.00
Status quo	424	0.77	555	0.7	14.5

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.19.4 Giant red shrimp in GSAs 9, 10 & 11: The basis of the advice.

Advice basis	F_{MSY}
Management plan	0.43

Quality of the assessment

Commercial catches showed better internal consistency than MEDITS survey index. The historic assessment is stable, and the assessment model was not modified. The retrospective analysis showed consistent results. All the diagnostics were considered acceptable.

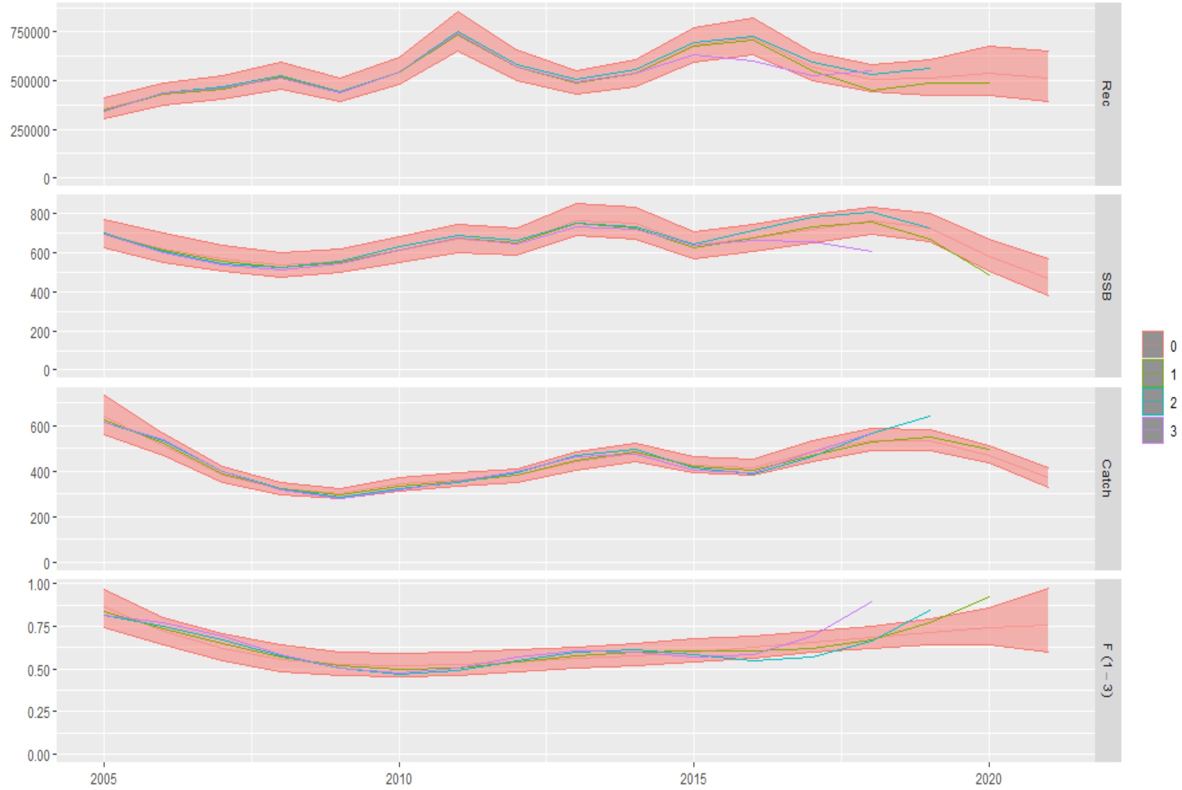


Figure 5.19.2 Giant red shrimp in GSAs 9, 10 & 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.19.5 Giant red shrimp in GSAs 9, 10 & 11: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.43	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
Precautionary approach	B_{lim}	190.6	Default based on 25% $B_{F0.1}$ and GM recruitment	STECF EWG 22-09
	B_{pa}	381.2	B_{lim} * 2	STECF EWG 22-09
	B_{MSY}	762.4	$B_{F0.1}$	STECF EWG 22-09
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.43	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-09
	target range F_{lower}	0.28	Based on regression calculation (see section 2)	STECF EWG 22-09
	target range F_{upper}	0.58	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-09

Basis of the assessment

Table 5.19.6 Giant red shrimp in GSAs 9, 10 & 11: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.1.7 Giant red shrimp in GSAs 9, 10 & 11: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		171	571	
2020	F = F_{MSY}		199	383	
2021	F = F_{MSY}		323	375	
2022	F = F_{MSY}		241		
2023	F = F_{MSY}		270		

History of the catch and landings

Table 5.19.8 Giant red shrimp in GSAs 9, 10 & 11: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)		Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	
	370	370				
Effort	73424	73424 (100%)	NA	NA	NA	
		Fishing days				

Table 5.19.9 Giant red shrimp in GSAs 9, 10 & 11: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total landings	Total Effort * (Fishing days)
2005	77.4	505.1	55.2	637.7	146415
2006	62.6	419.6	98.1	580.3	123716
2007	36.7	300.3	42.0	378.9	124633
2008	33.8	120.1	38.6	192.6	107303
2009	34.3	211.7	117.4	363.4	110207
2010	54.6	190.2	98.6	343.4	103668
2011	68.4	140.9	94.7	304.0	101011
2012	62.0	159.8	72.7	294.5	94547
2013	23.1	399.4	124.1	546.6	105867
2014	16.8	454.1	123.9	594.8	111284
2015	44.2	232.1	97.8	374.1	98969
2016	35.8	179.1	127.6	342.5	103845
2017	33.6	326.0	249.2	608.8	100037
2018	36.4	400.2	188.4	625.0	98977
2019	46.2	450.2	170.0	666.3	90631
2020	26.4	202.5	155.6	384.4	70892
2021	35.3	187.9	151.8	375.0	73424

*Effort data is taken from STECF EWG 22-10. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.19.10 Giant red shrimp in GSAs 9, 10 & 11: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2005	353362	398185	308539	692.3	748.4	636.2	637.1	0.85	0.94	0.77
2006	427798	470912	384684	617.3	677.3	557.3	513.1	0.72	0.78	0.66
2007	459434	504939	413929	564.2	615.7	512.7	381.7	0.62	0.68	0.56
2008	523442	575660	471224	532.3	579.9	484.7	319.5	0.56	0.62	0.50
2009	446457	494209	398705	551.9	600.1	503.7	299.0	0.53	0.58	0.47
2010	544850	601672	488028	610.6	666.2	555.0	341.9	0.52	0.57	0.47
2011	748036	824064	672008	665.7	721.7	609.7	361.0	0.53	0.58	0.48
2012	575298	632691	517905	650.6	705.9	595.3	378.5	0.54	0.60	0.49
2013	487240	536893	437587	761.7	826.9	696.5	440.6	0.56	0.61	0.51
2014	536655	590609	482701	744.9	805.7	684.1	478.9	0.58	0.63	0.53
2015	680909	747254	614564	634.4	686.8	582.0	426.5	0.60	0.65	0.55
2016	722911	793879	651943	671.1	725.7	616.5	413.6	0.63	0.67	0.58
2017	569266	629540	508992	718.7	777.2	660.2	483.4	0.65	0.70	0.61
2018	505957	561011	450903	757.2	814.5	699.9	532.7	0.68	0.74	0.63
2019	512470	580526	444414	723.5	779.5	667.5	533.2	0.71	0.77	0.65
2020	533744	628626	438862	579.5	641.2	517.8	471.0	0.74	0.82	0.66
2021	509526	605629	413423	466.3	537.2	395.4	369.9	0.77	0.91	0.62

Sources and references

STECF EWG 22-09, EWG 22-10

6 STOCK ASSESSMENTS

ToR 1. *To compile and provide the most updated information on stock identification and boundaries, length and age composition, growth, maturity, feeding, essential fish habitats including spawning grounds and seasonality as well as natural mortality.*

ToR 2. *To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2019, including length frequency distribution over time and, where possible, including estimates from recreational fisheries landings.*

ToR 3. *To assess trends in historic and recent stock parameters on fishing mortality, stock biomass, spawning stock biomass, and recruitment. Different assessment models should be applied as appropriate, including retrospective analyses. The selection of the most reliable assessment shall be explained. Assumptions and uncertainties shall be specified. To assist with development of management plans, give preference to models that allow estimation of uncertainty, in line with the recommendations of STECF EWG 17-07.*

ToR 4. *Using the work developed during EWG 22-03, estimate the* F_{MSY} *point value, range of* F_{MSY} *(i.e. MSY FLOWER and MSY FUPPER) and the conservation reference points (i.e. BPA and* B_{lim}*), or proxy. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.*

ToR 5. *To provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, including: the status quo fishing mortality and target* F_{MSY} *range (i.e.* F_{MSY} *point value, MSY FLOWER and MSY FUPPER) or other appropriate proxy by 2023 and by 1 January 2025. If the stock is considered to be being fished above* F_{MSY} *provide a F and catch option (*F_{MSY} *Transition) consistent with the transition to MSY in January 2025. Also where the stock is considered likely to be below* B_{lim} *and/ or BPA in 2023 provide catch options to restore SSB above* B_{pa} *in the short term, following the methodology adopted for other EU sea-basins (see Annex I below).*

The assembled data, stock assessments, reference point calculations and short term forecasts are given below by stock following the stock units of the ToRs with three exceptions. For deepwater rose shrimp in GSA 1, 5, 6 & 7 following separate GSA evaluations last year (EWG 21-11) it was decided to deal with this as two units GSA 1 and GSA 5, 6 & 7 based primarily on different dynamics observed in the surveys and two new assessments are provided. For Norway lobster in GSA 5 and striped red mullet in GSA 5 a full evaluation of data was carried out last year but could not find acceptable assessments. Advice based on ICES category 3 method was applied and given for two years 2022 and 2023. As advice is already supplied and it was considered that further analysis would be unlikely to find better solutions, the data including 2021 data is given below, but no assessment and no further advice is supplied. Please see Sections 5.4 and 5.7 for 2023 catch advice.

6.1 Hake in GSA 1, 5, 6 &7

6.1.1 Stock Identity and Biology

The assessment of European hake carried out during the STECF EWG 21-11 considered the stock shared by GSAs 1, 5, 6 and 7.

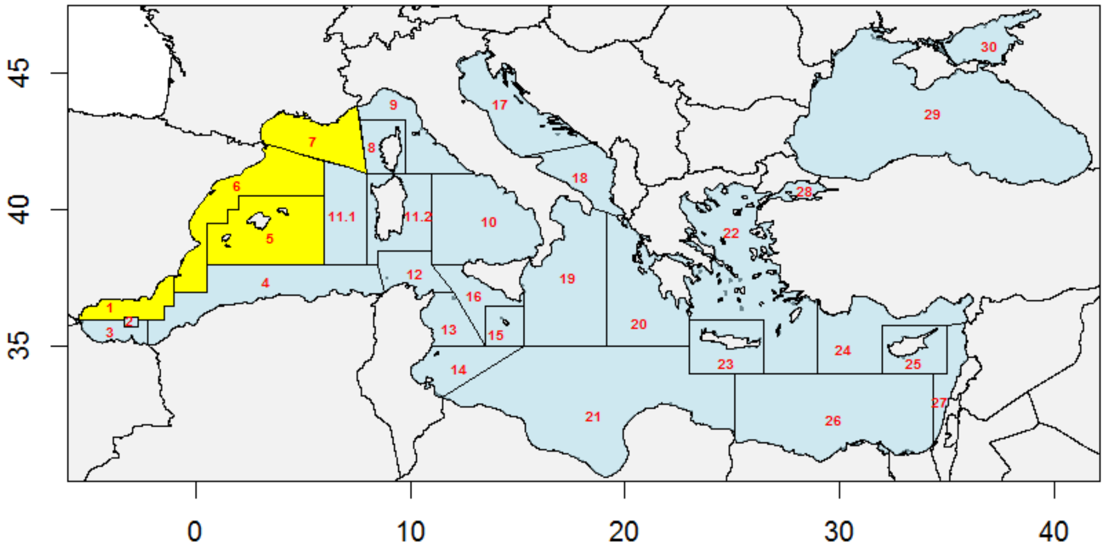


Figure 6.1.1.1 Geographical location of GSAs 1, 5, 6 & 7.

A sex combined model was applied to this stock, as information by sex was not available for the GSAs considered. All the parameters used were the same used during the GFCM hake benchmark carried out in December 2019 ("Working Group on Stock Assessment of Demersal Species (WGSAD) benchmark session for the assessment of European hake in GSAs 1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 22, 23", Rome, Italy, 2-7 December 2019).

The growth parameters used were those estimated by Mellon-Duval et al. (2010) from tagging experiments in the Gulf of Lions; length-weight relationship parameters were those estimated in the Spanish Data Collection Framework (Table 6.1.1.1 and Figure 6.1.1.2).

Table 6.1.1.1 European hake in GSAs 1, 5, 6 & 7. Growth parameters and length-weight relationship parameters.

L_{inf}	k	t0	a	b
110	0.178	-0.005	0.00677	3.0351

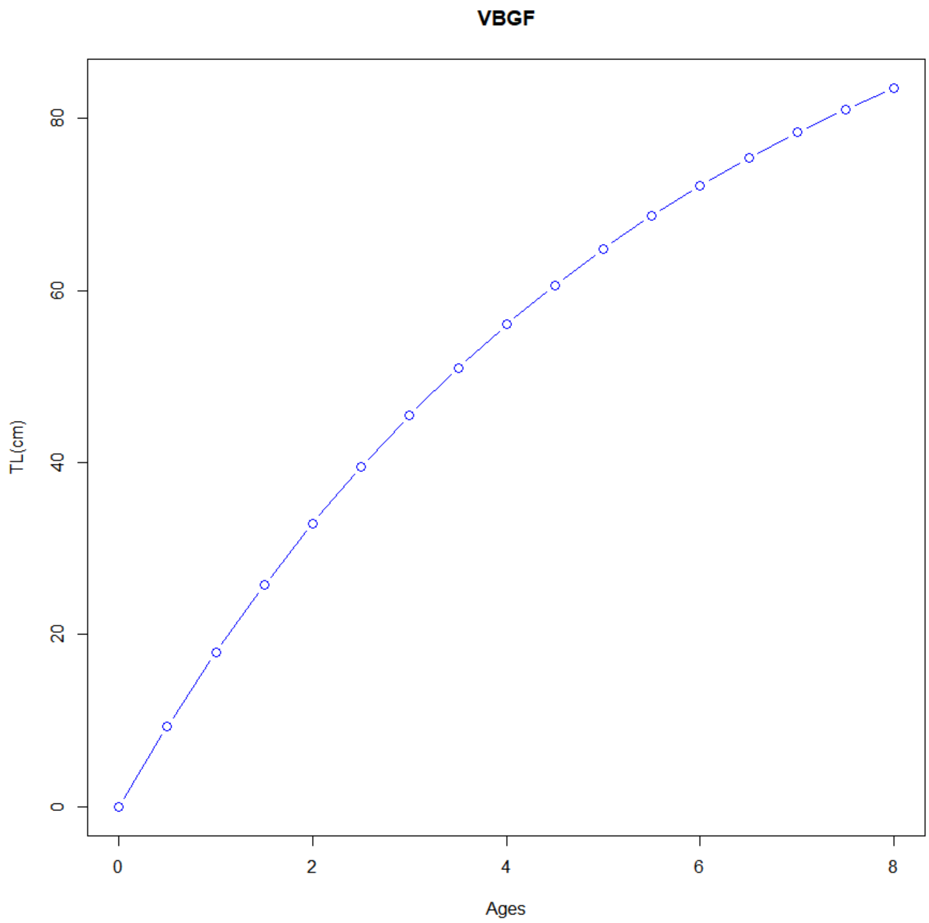


Figure 6.1.1.2. European hake in GSAs 1, 5, 6 & 7. Von Bertalanffy growth curve.

The maturity vector was taken from García-Rodríguez and Esteban (1995); the natural mortality vector was estimated as an average of different methods (Gislason, Prodbiom revised version with unique solution, Chen & Watanabe, Brodziak (2011 and 2012), Lorenz and Gulland), consistently with the approach used in the GFCM benchmark assessment of hake in Adriatic Sea in 2019 (Tab. 6.1.1.2).

Table 6.1.1.2. European hake in GSAs 1, 5, 6 & 7. Maturity and natural mortality vectors used in the assessment.

Age	Maturity	M
0	0	1.63
1	0.15	0.68
2	0.82	0.41
3	0.98	0.31
4	1	0.25
5+	1	0.22

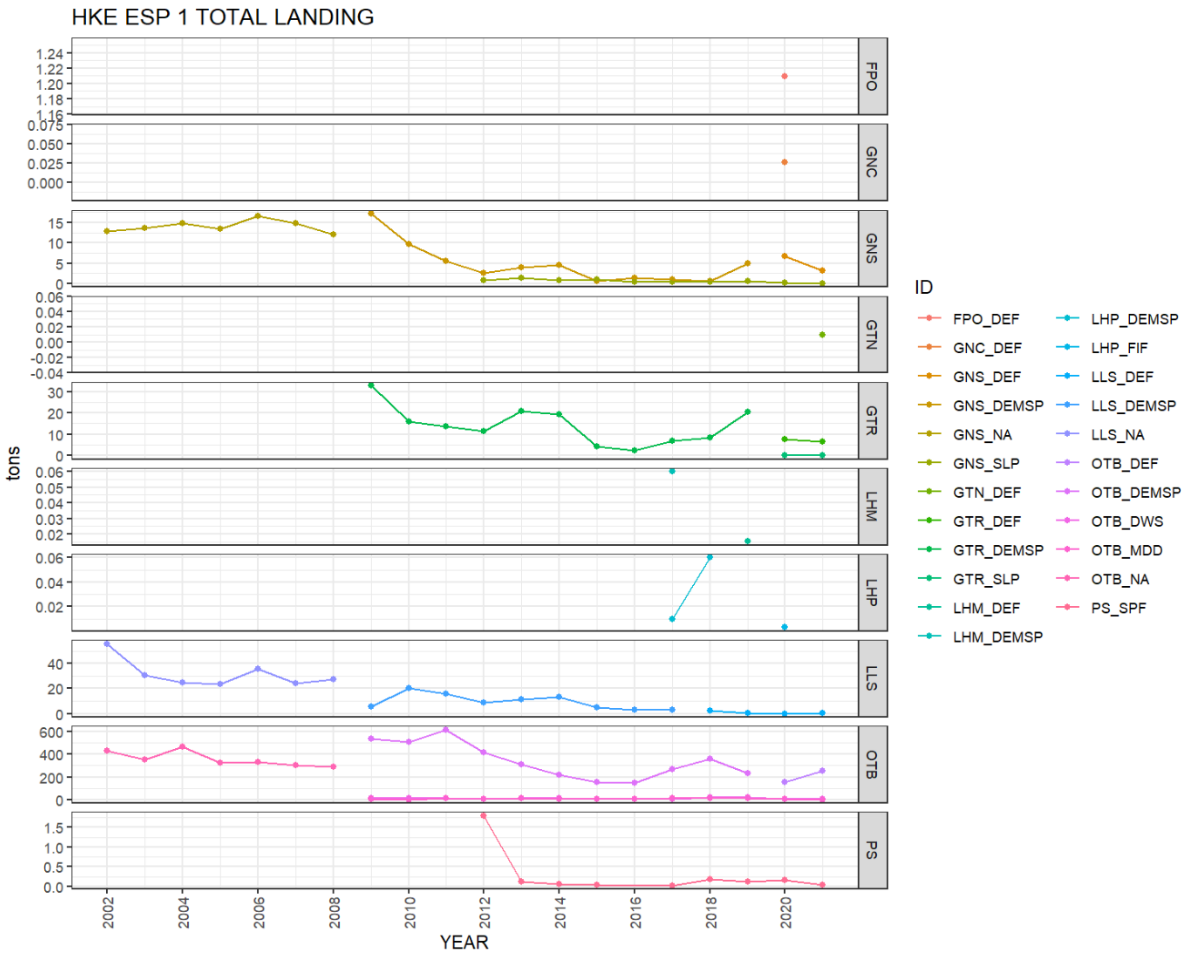
6.1.2 Data

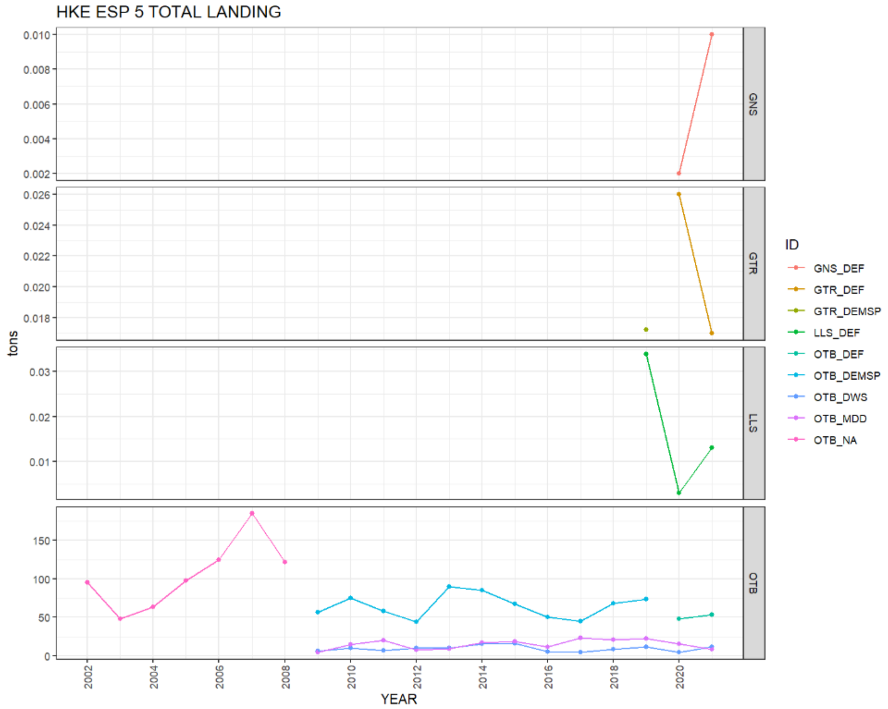
6.1.2.1 Catch (landings and discards)

European hake is largely exploited in GSAs 1 and 6, mainly by trawlers on the shelf and slope, but also by small-scale fisheries using long lines, gill nets and trammel nets. In GSA 5, hake catches come exclusively from bottom trawlers. They show important variation along the data series, between 50 and 200 tons. In the Gulf of Lions (GSA 7), hake is exploited by French trawlers, French gillnetters, Spanish trawlers and Spanish longliners.

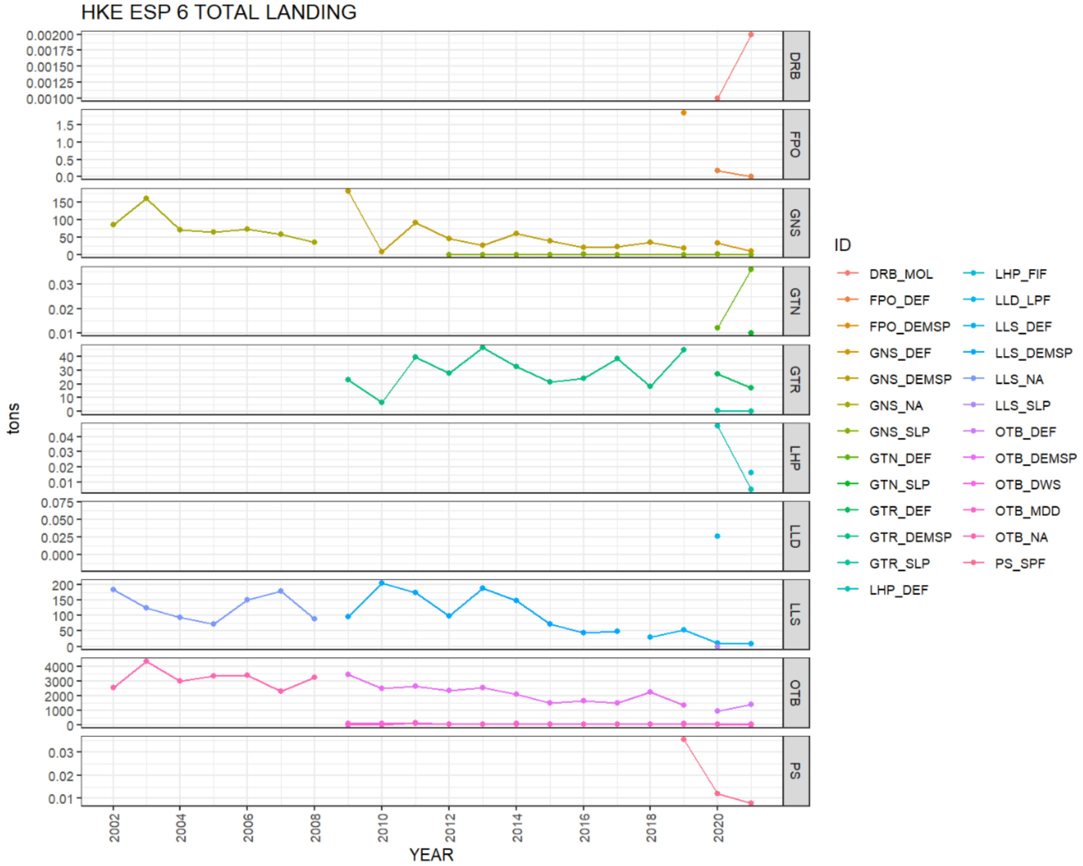
Landings

Landings data were reported to STECF EWG 22-09 through the DCF. In GSAs 1, 5, 6 and 7, most of the landings come from otter trawls. The contribution of set nets and longlines to the total landing is around the 4% each. Landings data by year, GSA, country and fleet are presented in Figure 6.1.2.1.1, total landings by year are presented in Table 6.1.2.1.1.





HKE ESP 5 TOTAL LANDING
tons
YEAR
GNS
GTR
LLS
OTB
ID
GNS_DEF
GTR_DEF
GTR_DEMSP
LLS_DEF
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA



HKE ESP 6 TOTAL LANDING
tons
YEAR
DRB
FPO
GNS
GTN
GTR
LHP
LLD
LLS
OTB
PS
ID
DRB_MOL
FPO_DEF
FPO_DEMSP
GNS_DEF
GNS_DEMSP
GNS_NA
GNS_SLP
GTN_DEF
GTN_SLP
GTR_DEF
GTR_DEMSP
GTR_SLP
LHP_DEF
LHP_FIF
LLD_LPF
LLS_DEF
LLS_DEMSP
LLS_NA
LLS_SLP
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
PS_SPF

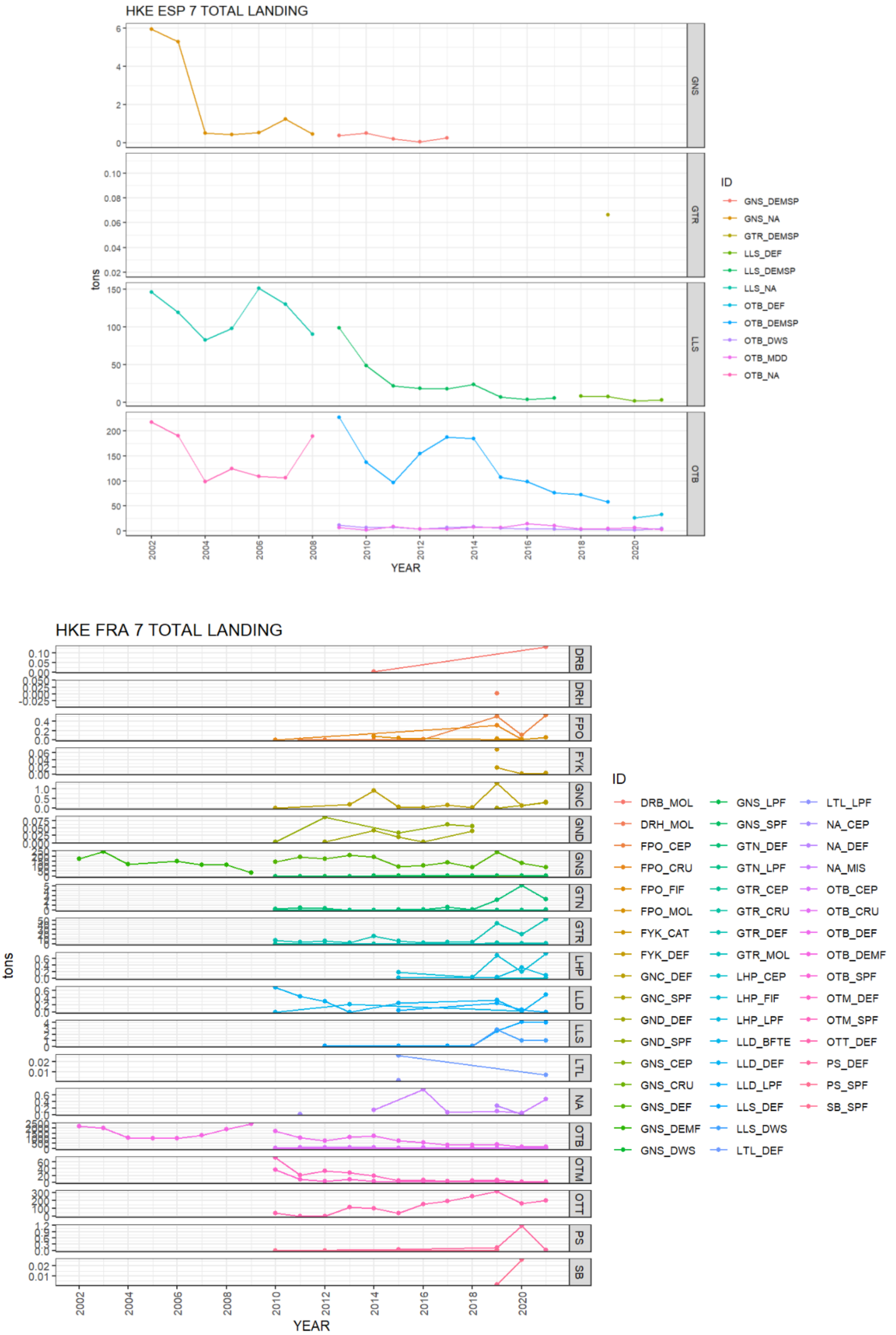
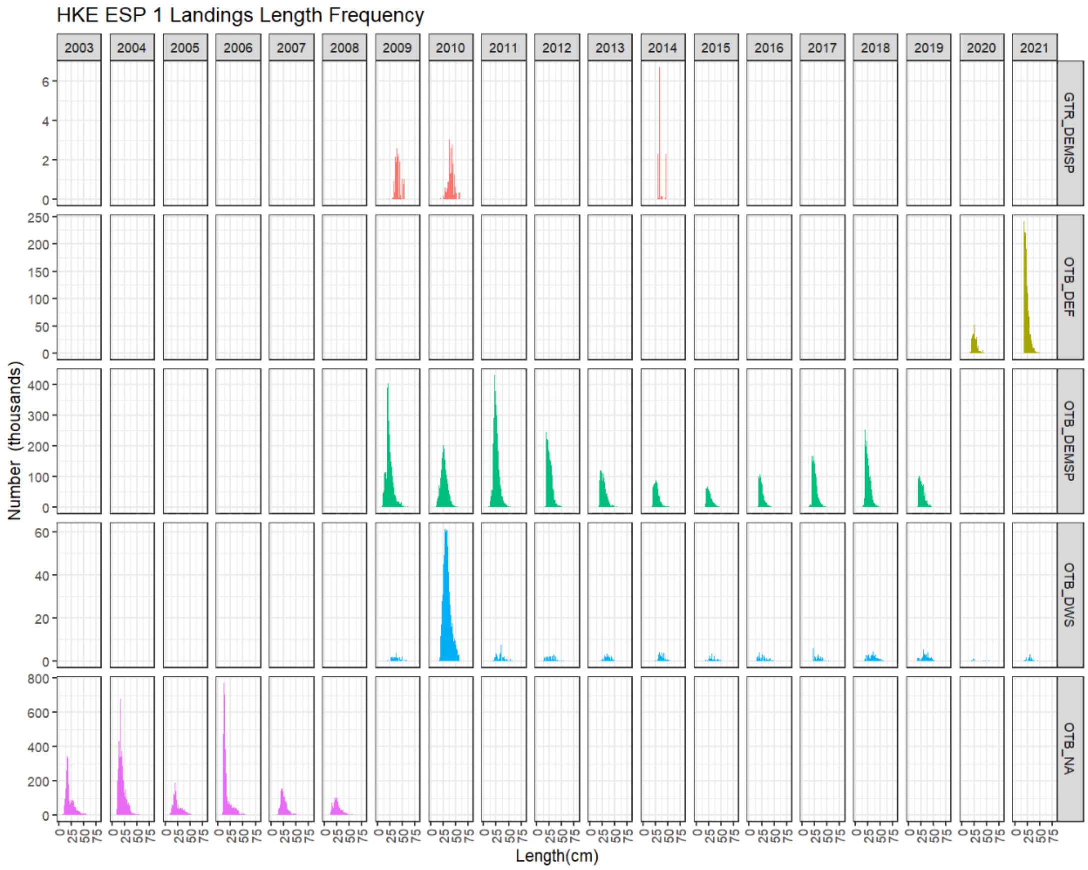


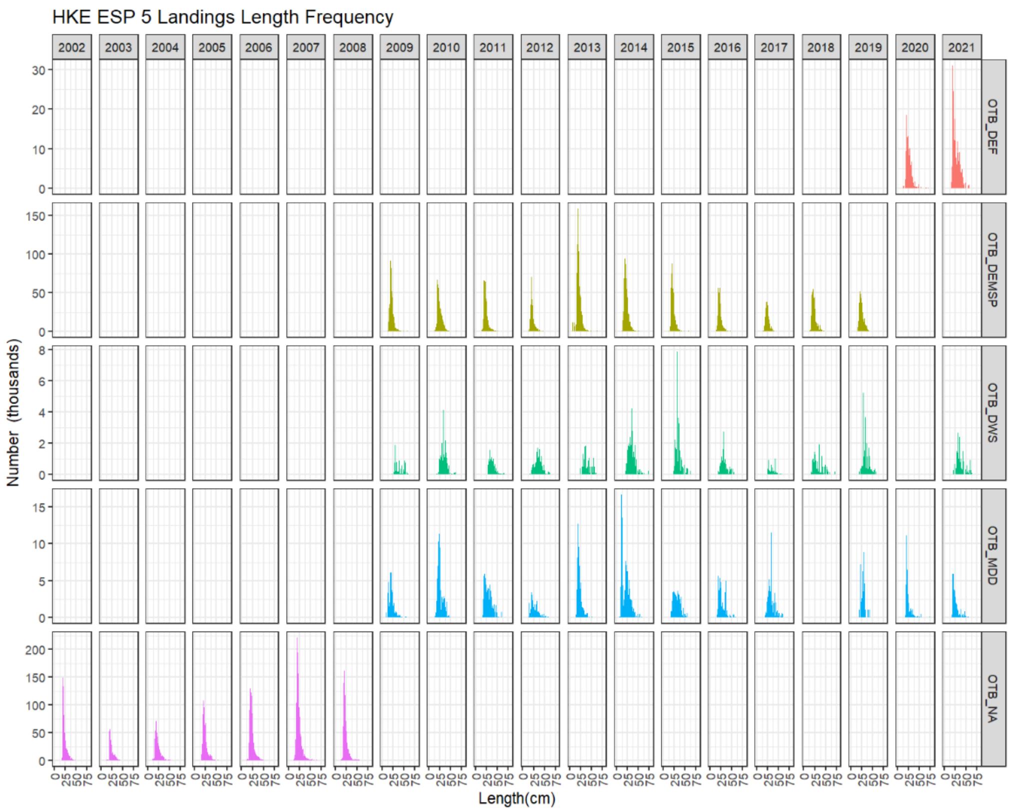
Figure 6.1.2.1.1. European hake in GSAs 1, 5, 6 & 7. Landings data in tons by year GSA country and fleet. From 2015 onwards there can be two points in the same year due to the increase in "fishery classes" for the same gear. Showing all the fishery classes and gears was overly complex, so the fishery classes for the same gear are both sown. As each fishery has different values it is possible to get double points or trends.

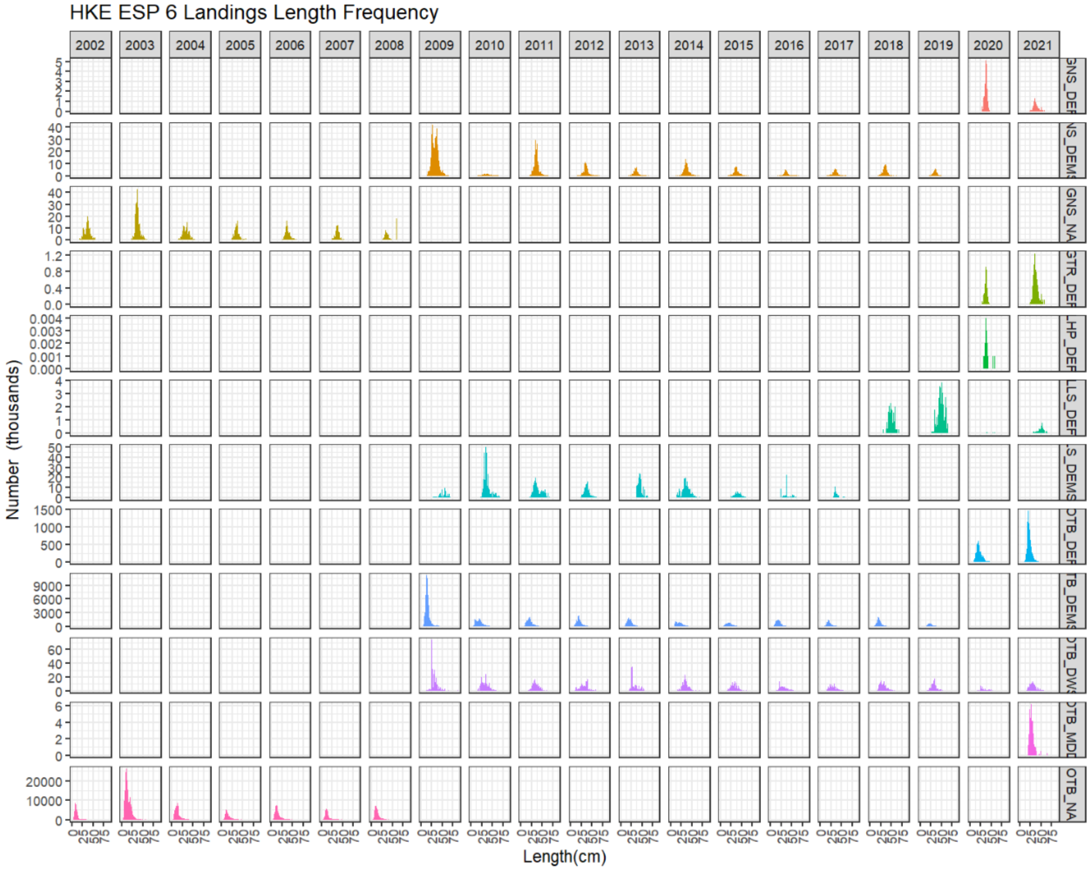
Table 6.1.2.1.1. European hake in GSAs 1, 5, 6 & 7. Total landings data in tons by year.

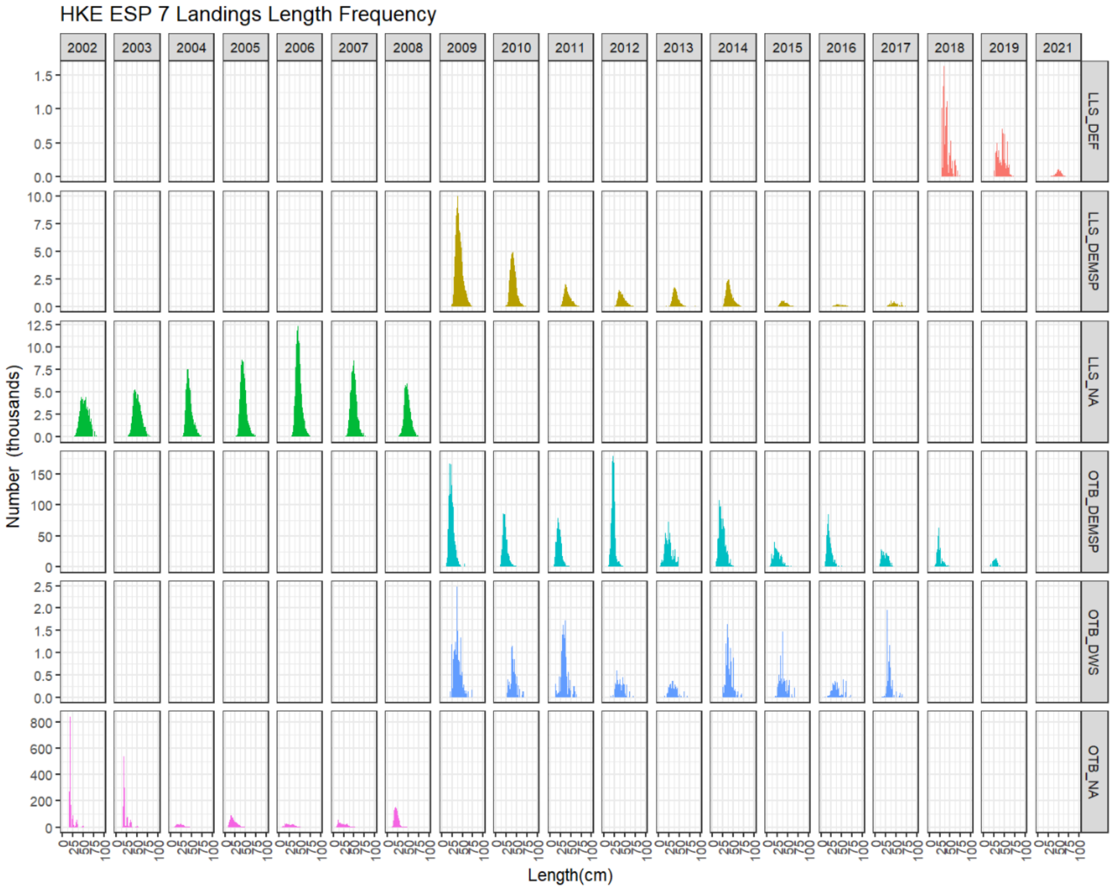
	Total Landing (tons)
2002	6138
2003	7666
2004	5039
2005	5156
2006	5558
2007	4697
2008	6082
2009	7362
2010	5466
2011	5279
2012	4278
2013	5131
2014	4786
2015	3129
2016	3083
2017	2946
2018	3831
2019	3159
2020	1893
2021	2506

Length frequency distribution of the landings by year and gear or fleet from the DCF database is presented in Figure 6.1.2.1.2. When data are reported by gear, different fisheries within gears are represented by different colours (to reduce the number of rows).


HKE ESP 1 Landings Length Frequency
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
GTR_DEMSP
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_NA
Number (thousands)
Length(cm)


HKE ESP 5 Landings Length Frequency
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
Number (thousands)
Length(cm)


HKE ESP 6 Landings Length Frequency
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Number (thousands)
Length(cm)


HKE ESP 7 Landings Length Frequency
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2021
LLS_DEF
LLS_DEMSP
LLS_NA
OTB_DEMSP
OTB_DWS
OTB_NA
Number (thousands)
Length(cm)

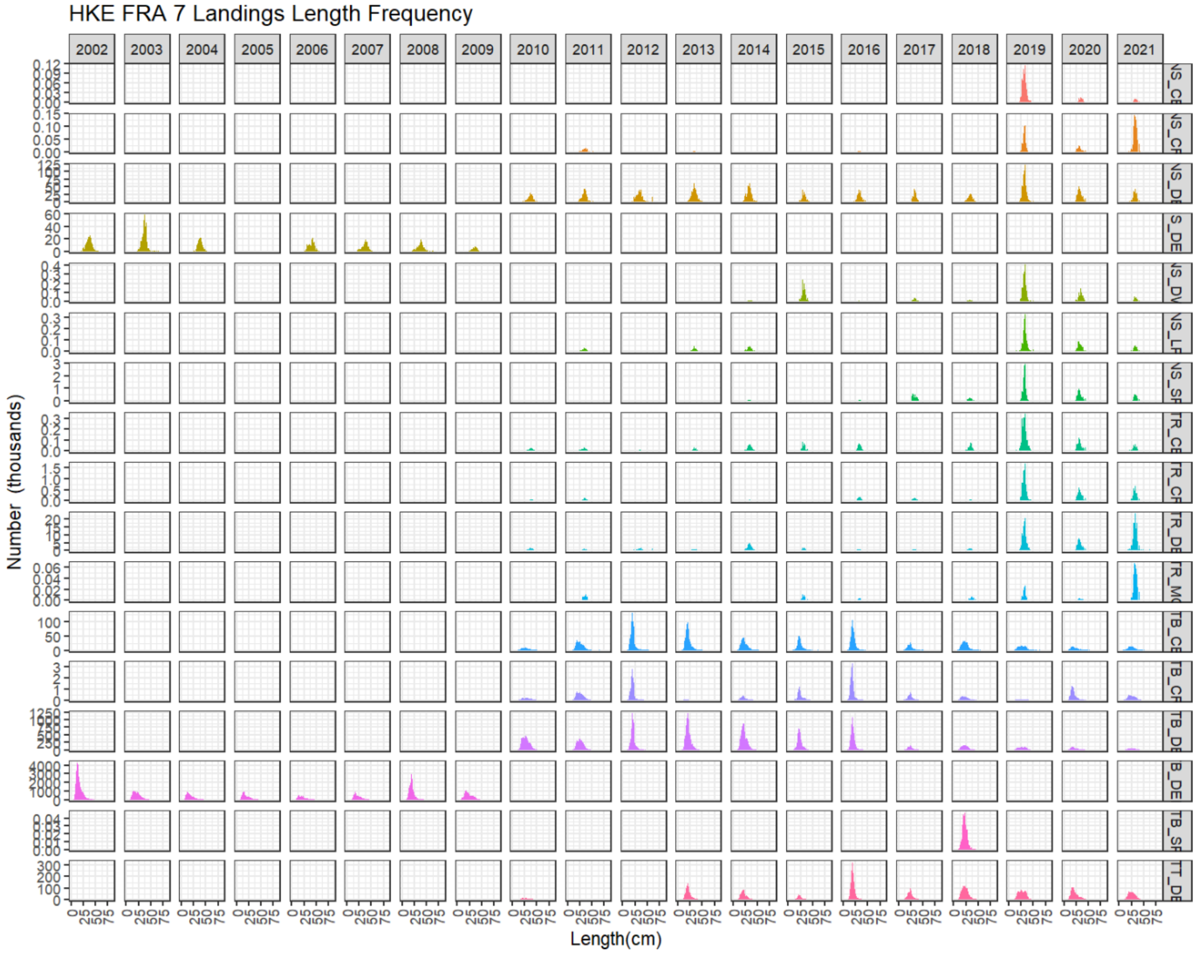


Figure 6.1.2.1.2. European hake in GSAs 1, 5, 6 & 7. Length frequency distribution of the landings by year and gear or fleet.

Discards

Discards data were reported to STECF EWG 22-09 through the DCF, and they were included in the stock assessment. For the years in which discards data were missing, they were estimated on the basis of the discard ratio (discard/landing) of the available years and the landing time series.

The highest discard rates were represented by the bottom trawl fishery for the most recent years; for the other gears the discards were negligible or absent. Total discard by year for the bottom trawl fishery is presented in Table 6.1.2.1.2 and shows a strong increase in discard for GSA 6 with a value of 253.19 t being the highest value in the time series.

Table 6.1.2.1.2. European hake in GSAs 1, 5, 6 & 7. OTB discards data in tons by GSA.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
GSA 1	19.3	24.2	19.1	13.2	20.8	14.9	5.8	20.8	10.4	30.5	23.5	24.9	21.4	27.6	9.9	4.33	24.77
GSA 5	12.2	11.9	9.4	7.1	16.2	19.2	6.5	6.5	13.1	5.6	0.6	9.8	4.1	46.3	17.1	21.58	5.83
GSA 6	0.1	98.4	77.8	0.5	0.3	0.8	141.6	194.3	156.6	151.8	50.3	70.8	69.0	139.2	28.1	34.22	253.19
GSA 7	1.4	14.4	11.4	186.4	9.6	1.5	3.6	10.4	46.2	46.8	20.4	20.8	9.6	32.7	14	21.18	22.27
Total discard (tons)	33.1	148.8	117.6	207.1	46.8	36.4	157.4	231.9	226.2	234.7	94.7	126.2	99.2	246.4	69.3	81.3	306.6

Length and age frequency distributions of discards were available from DCF data only for France in GSA 7 while for Spain only the last five years in GSAs 1 and 6 the last four years in GSA 5 were available.

Considering that this is a preliminary benchmarked stock, data were not reconstructed during STECF EWG 22-09 for years up to 2019. Nevertheless, the code from EWG 20-05 was used to show where sampling gaps are present in the data (Figure 6.1.2.1.3 - 7) and how these can affect the SOP correction values which are presented in Table 6.1.3.1 within the "Stock Assessment" section. AS in 2020 length measurements were completely lacking for 2021 from the Spanish commercial sampling of GSA 7, therefore only for these two years LFDs were reconstructed.

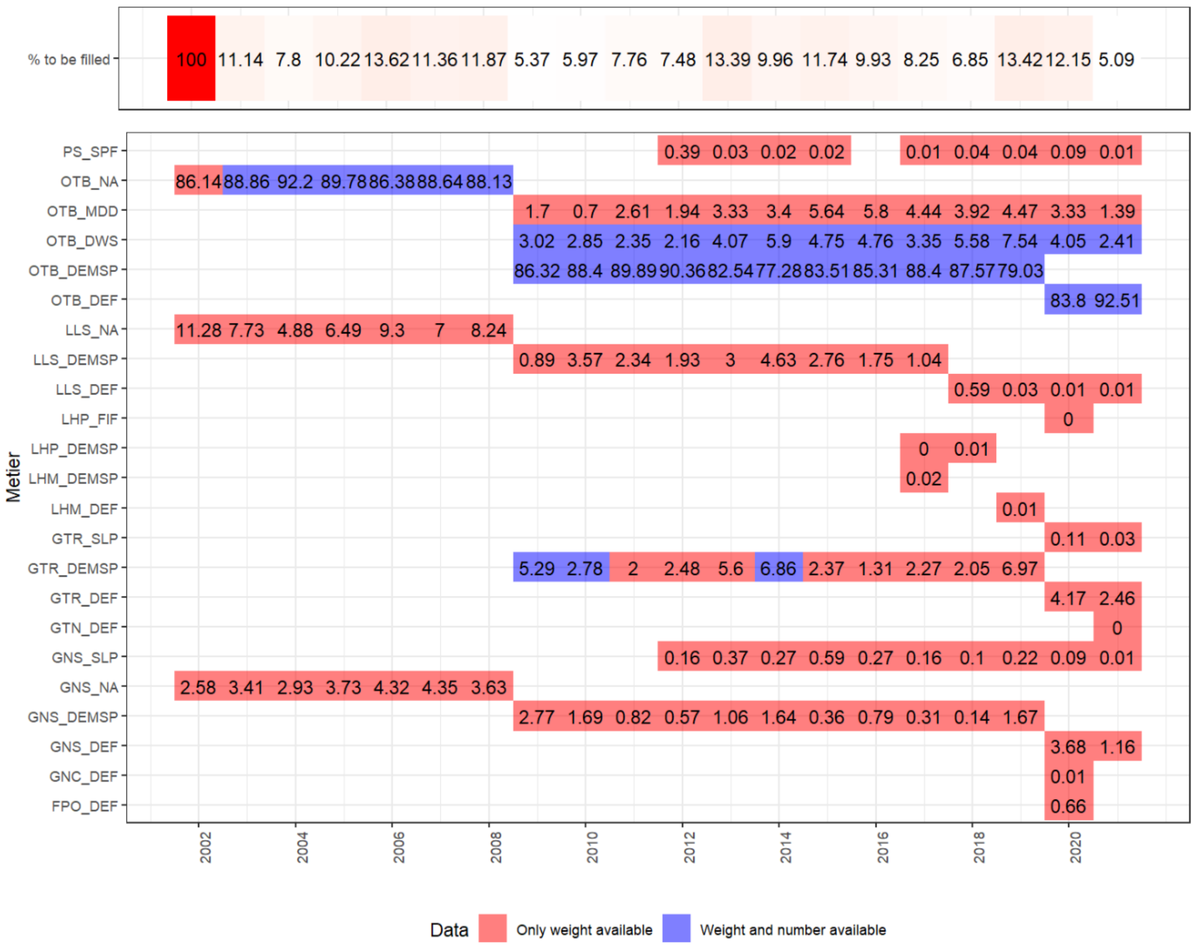


Figure 6.1.2.1.3 Time series of GSA 1 showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

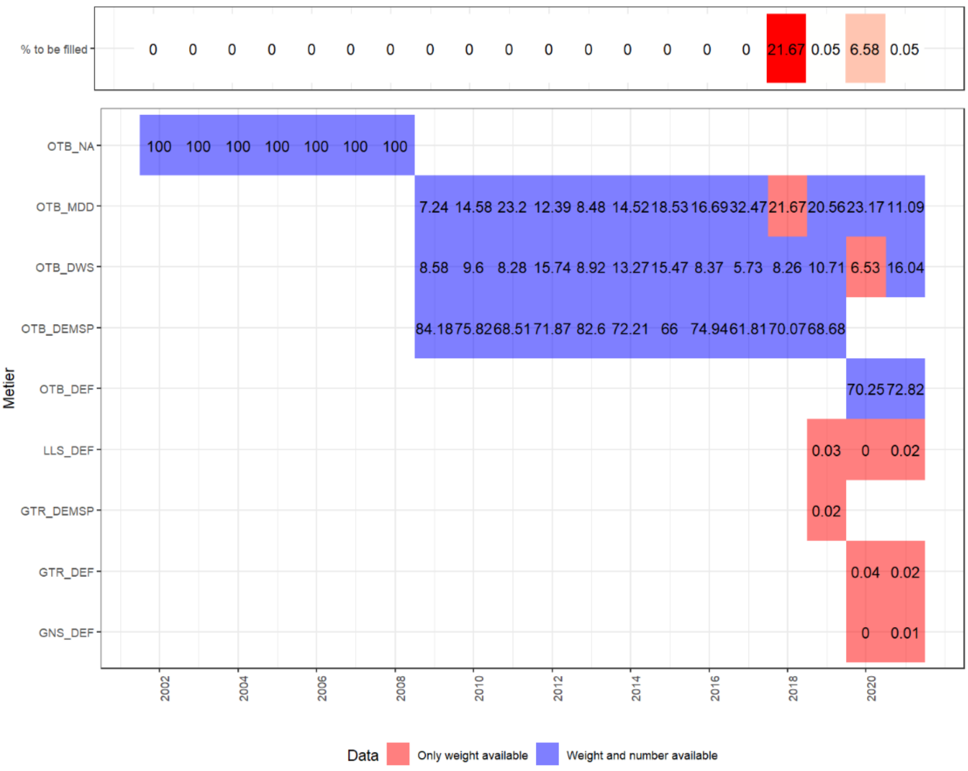


Figure 6.1.2.1.4 Time series of GSA 5 showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

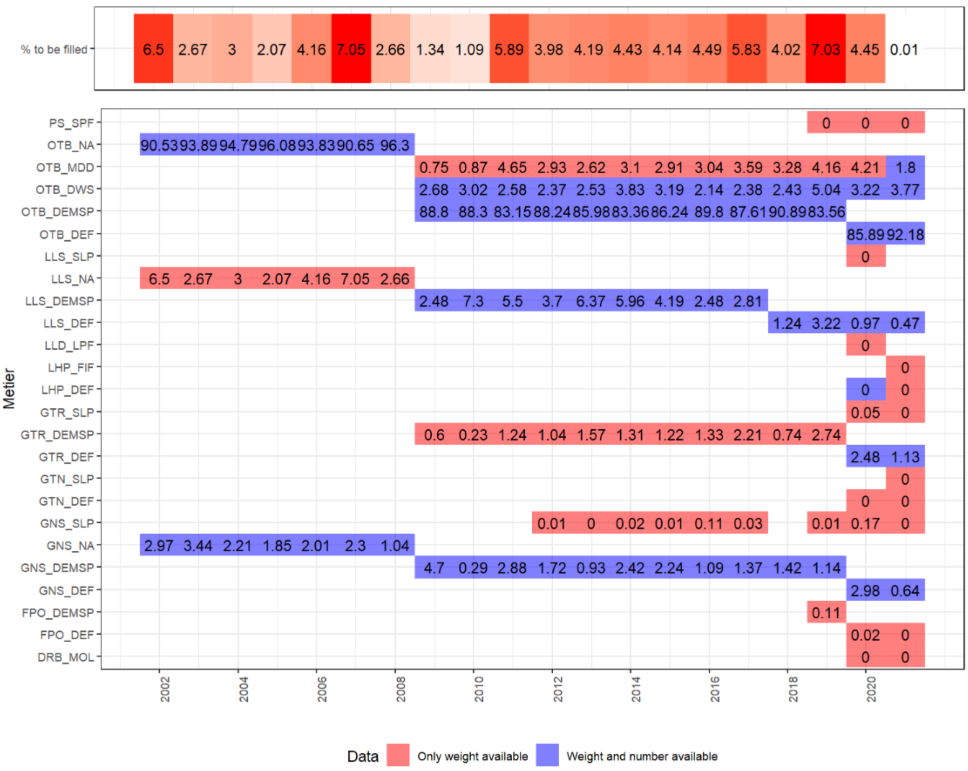


Figure 6.1.2.1.5 Time series of GSA 6 showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

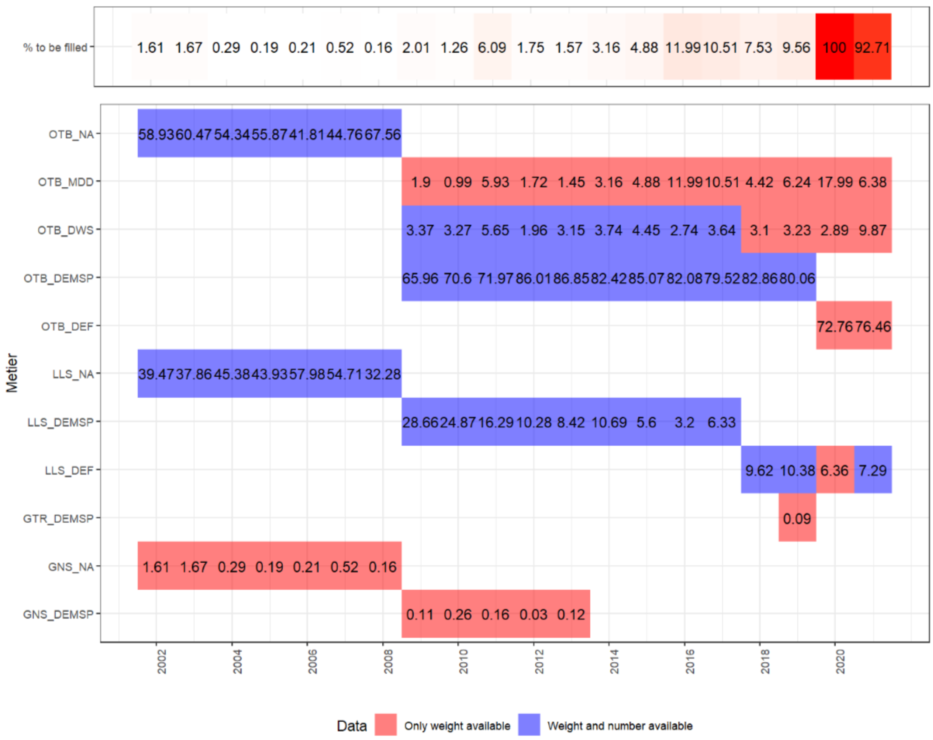


Figure 6.1.2.1.6 Time series of GSA 7 (Spanish data) showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

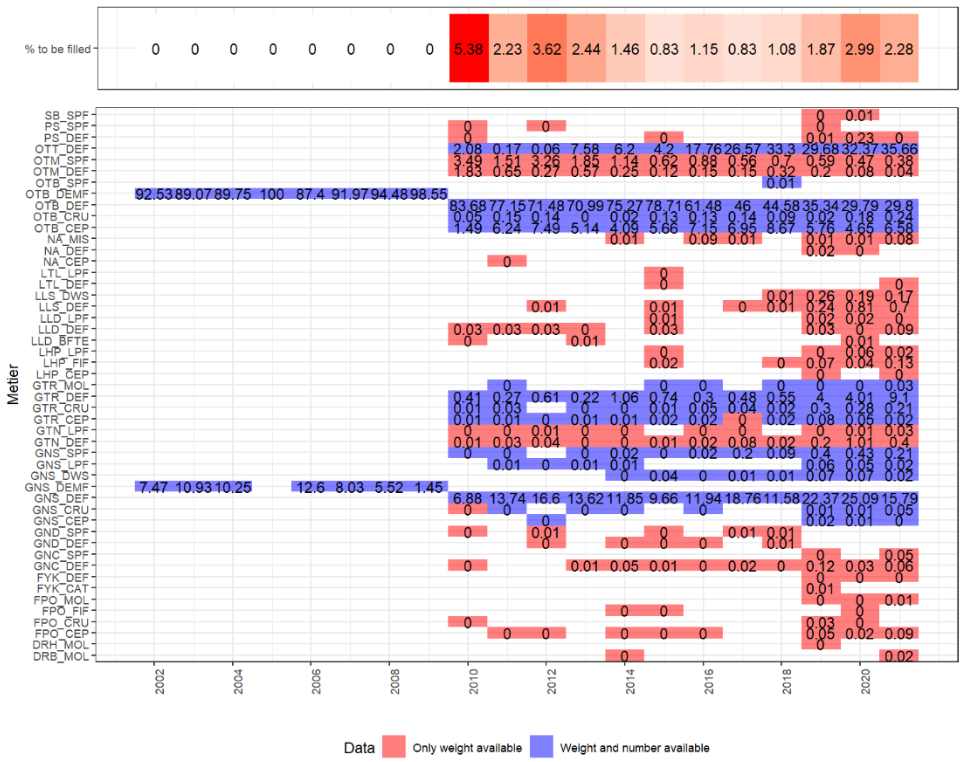


Figure 6.1.2.1.7 Time series of GSA 7 (French data) showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

6.1.2.2 Effort Data

Fishing effort data for 2021 will be reported to STECF EWG 22-11 through the FDI data call within the DCF framework.

6.1.2.3 Survey data

The MEDITS (Mediterranean International Trawl Survey) survey is an extensive trawl survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime, following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintained fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end, and is used throughout GSAs and years.

Since 1994, the MEDITS surveys have been regularly carried out each year during the spring season. In the current assessment combined MEDITS data for GSAs 1-5-6-7 from 2007 onwards were used, as in GSA 5 the survey has been carried out consistently only from that year. The Balearic Islands, in fact, were partially covered by the MEDITS survey during 1994-2006, with a very low number of hauls by year, covering only a small part of the area (Ibiza channel). Thus, only the information collected from 2007, when the sampling was extended, was considered reliable for the analysis.

The combined MEDITS indexes were calculated using the script provided by JRC (Figures 6.1.2.3.1 and 6.1.2.3.2).

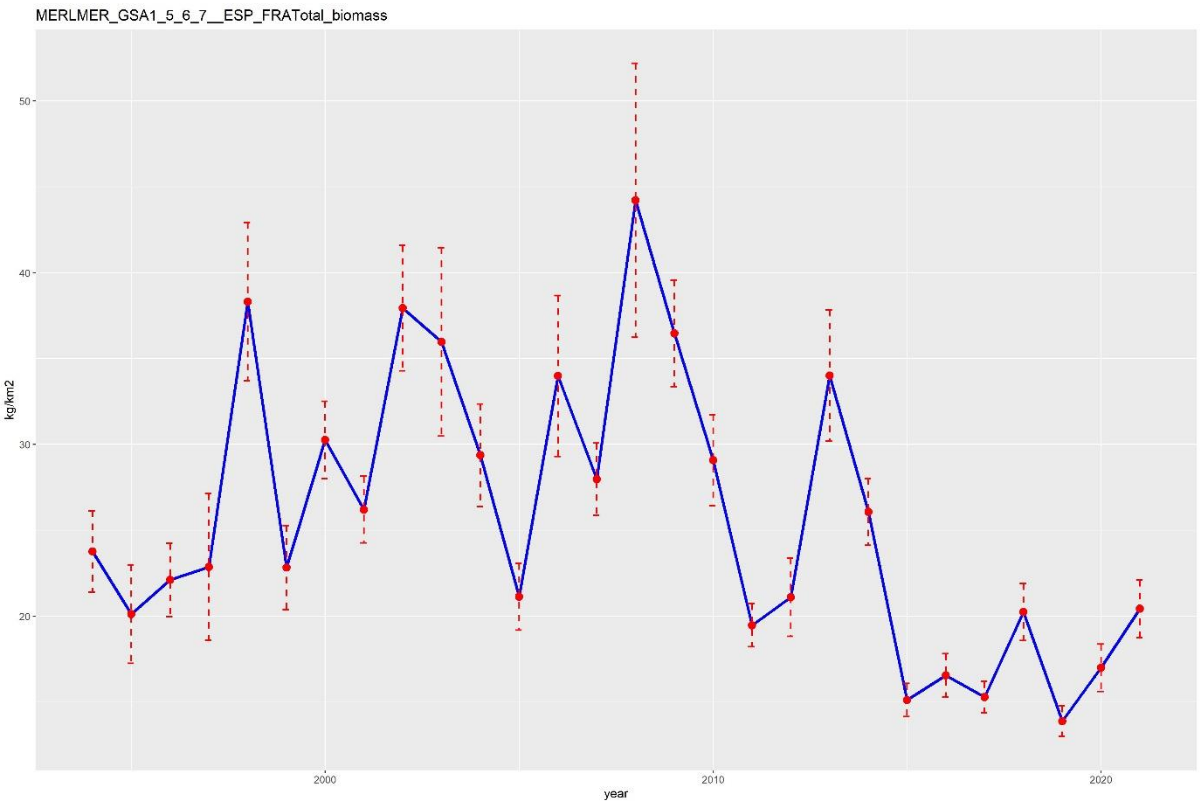


Figure 6.1.2.3.1. European hake in GSAs 1, 5, 6 & 7. Estimated biomass indices from the MEDITS survey (kg/km^2).

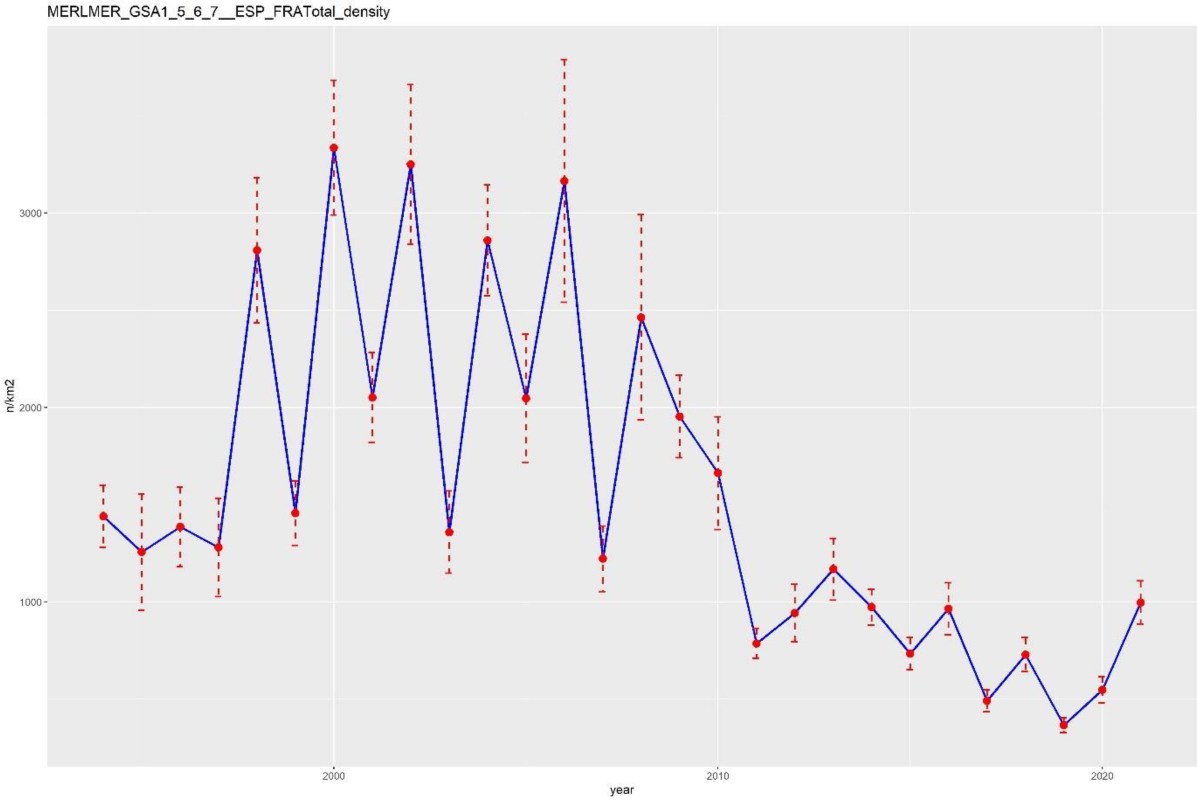


Figure 6.1.2.3.2. European hake in GSAs 1, 5, 6 & 7. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series and a decreasing trend since 2008, that than stabilized in a low range since 2011, decreasing between 2013 and 2020 but showing an increase in 2020.

Size structure indices are shown in Figure 6.1.2.3.3.

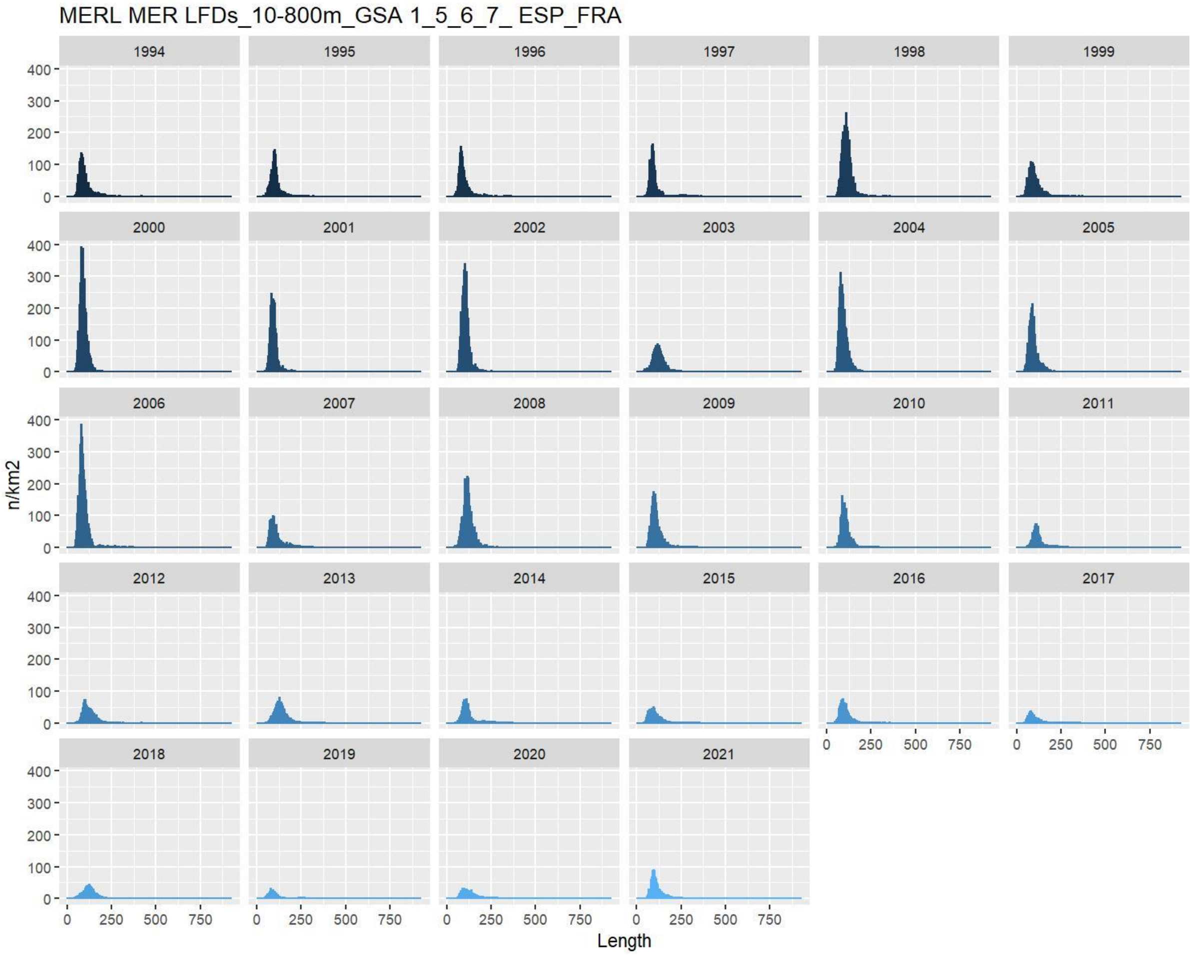


Figure 6.1.2.3.3. European hake in GSAs 1, 5, 6 & 7. Length frequency distribution by year of MEDITS survey.

Due to the COVID-19 outbreak the MEDITS survey was not carried out in 2020 in GSA 1, only half of GSA 6 was covered and the timing was delayed, and coverage was also reduced in GSA 7 with some offshore stations omitted, the survey was carried out normally in GSA 5. In order to account for the lack of data in GSA1, indices for this year were simulated as the average of the whole time series in GSA1 and a sensitivity analysis on the stock assessment analysis was run. The survey in 2021 was run in the correct time of the year and all hauls were carried out in all GSAs.

6.1.3 STOCK ASSESSMENT

A statistical catch-at-age assessment was carried out for this stock, using the Assessment for All Initiative (a4a) method (Jardim et al., 2015). The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike XSA, model parameters estimated using catch-at-age analysis are done so by propagation of population forward in time and analyses do not require the assumption that removals from the fishery are known without error.

The assessment was carried out using the period 2007-2021 for catch data and tuning file, as survey indices data were available only from 2007 for GSA 5. Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR. The analyses were carried out for the ages 0 to 5+. Concerning the Fbar, the age range used was 1-3 age classes.

Input data

The growth parameters used for VBGF were the one reported in table 6.1.1.1.

Total catches and catch numbers at age from the single GSAs were used as input data. SOP correction was applied to catch numbers at age by GSA (Table 6.1.3.1).

Table 6.1.3.1. European hake in GSAs 1, 5, 6 & 7. SOP correction vector.

year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GSA1	1.33	1.24	1.69	3.23	4.87	2.70	1.41	1.32	1.71	1.98	3.57	5.26	6.71	5.18	1.12
GSA5	0.72	0.46	0.22	0.65	0.64	0.38	0.44	0.52	0.85	0.69	0.81	1.73	2.78	2.48	1.06
GSA6	9.92	12.08	10.18	15.44	23.48	15.82	11.35	11.14	14.70	18.59	19.99	31.06	37.03	31.46	1.09
GSA7 ESP	0.93	1.06	0.91	1.07	0.97	1.01	0.79	0.95	1.06	1.19	1.06	1.07	1.62	1.00	1.03
GSA 7 FRA	5.45	7.89	6.60	11.53	10.05	6.06	5.87	7.41	8.50	9.12	8.64	9.93	23.94	14.67	1.04

Table 6.1.3.2 lists the input data for the a4a model, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age and the tuning series at age.

Table 6.1.3.2. European hake in GSAs 1, 5, 6 & 7. Input data for the a4a model.

Catches (t)

2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
4697	6289	7409	5836	5662	4654	5438	5061	3243	3195	3063	4077	3228	1974	2791

Catch numbers at age (thousands)

	0	**1**	**2**	**3**	**4**	**5+**
2007	41426	17907	3455	509	92	21
2008	74783	38015	2846	301	106	16
2009	69423	32247	5461	528	123	12
2010	15050	25481	5559	400	92	8
2011	9875	29764	4709	364	66	10
2012	11192	31142	2965	245	66	4
2013	11100	32903	3635	381	44	10
2014	16617	25095	4312	268	29	4
2015	8870	17994	2420	181	27	2
2016	14709	22347	1761	121	21	1
2017	10324	18455	2185	142	18	3
2018	16668	27571	2310	194	14	2
2019	4894	14101	3218	235	17	3
2020	6884	11536	1528	75	5	2
2021	12286	16949	1845	116	36	4

Weights at age (Kg)

	0	**1**	**2**	**3**	**4**	**5+**
2007	0.02	0.1	0.4	0.94	1.6	2.68
2008	0.02	0.09	0.4	0.96	1.61	2.6
2009	0.02	0.1	0.41	0.94	1.52	2.65
2010	0.02	0.11	0.41	0.93	1.61	2.34

2011	0.02	0.11	0.39	0.92	1.63	2.46
2012	0.02	0.09	0.39	0.9	1.67	2.47
2013	0.03	0.1	0.39	0.92	1.63	2.53
2014	0.02	0.11	0.39	0.92	1.56	2.55
2015	0.02	0.11	0.38	0.92	1.58	2.41
2016	0.02	0.09	0.38	0.93	1.57	2.53
2017	0.02	0.1	0.37	0.91	1.53	2.53
2018	0.02	0.1	0.39	0.92	1.58	2.48
2019	0.02	0.12	0.37	0.9	1.66	2.34
2020	0.02	0.1	0.38	0.86	1.59	2.63
2021	0.02	0.1	0.37	0.94	1.63	2.48

Maturity and Natural Mortality vectors

	0	**1**	**2**	**3**	**4**	**5+**
Maturity	0	0.15	0.82	0.98	1	1
Natural Mortality	1.63	0.68	0.41	0.31	0.25	0.22

MEDITS numbers at age (n/km^2) with simulated data for 2020 in GSA 1

	0	**1**	**2**	**3**	**4**
2007	1245.89	108.90	10.77	1.79	0.72
2008	2608.83	129.75	8.24	1.81	0.53
2009	1945.58	121.77	12.83	0.97	0.33
2010	1709.72	85.74	12.54	1.33	0.03
2011	779.54	103.22	6.98	0.65	0.00
2012	974.49	73.61	4.36	0.69	0.20
2013	1085.26	148.47	9.22	0.31	0.10
2014	870.92	114.63	12.59	1.52	0.52
2015	798.67	54.94	7.76	0.84	0.24
2016	1051.84	62.24	5.74	0.53	0.30
2017	551.38	81.38	10.38	0.57	0.21
2018	702.01	99.18	5.49	0.37	0.12
2019	364.60	63.49	11.59	0.61	0.37
2020	594.27	80.68	7.47	0.64	0.10
2020*	459.49	81.15	6.73	0.57	0.09
2021	863.17	77.09	3.74	0.58	0.20

*index values without simulating data for GSA 1

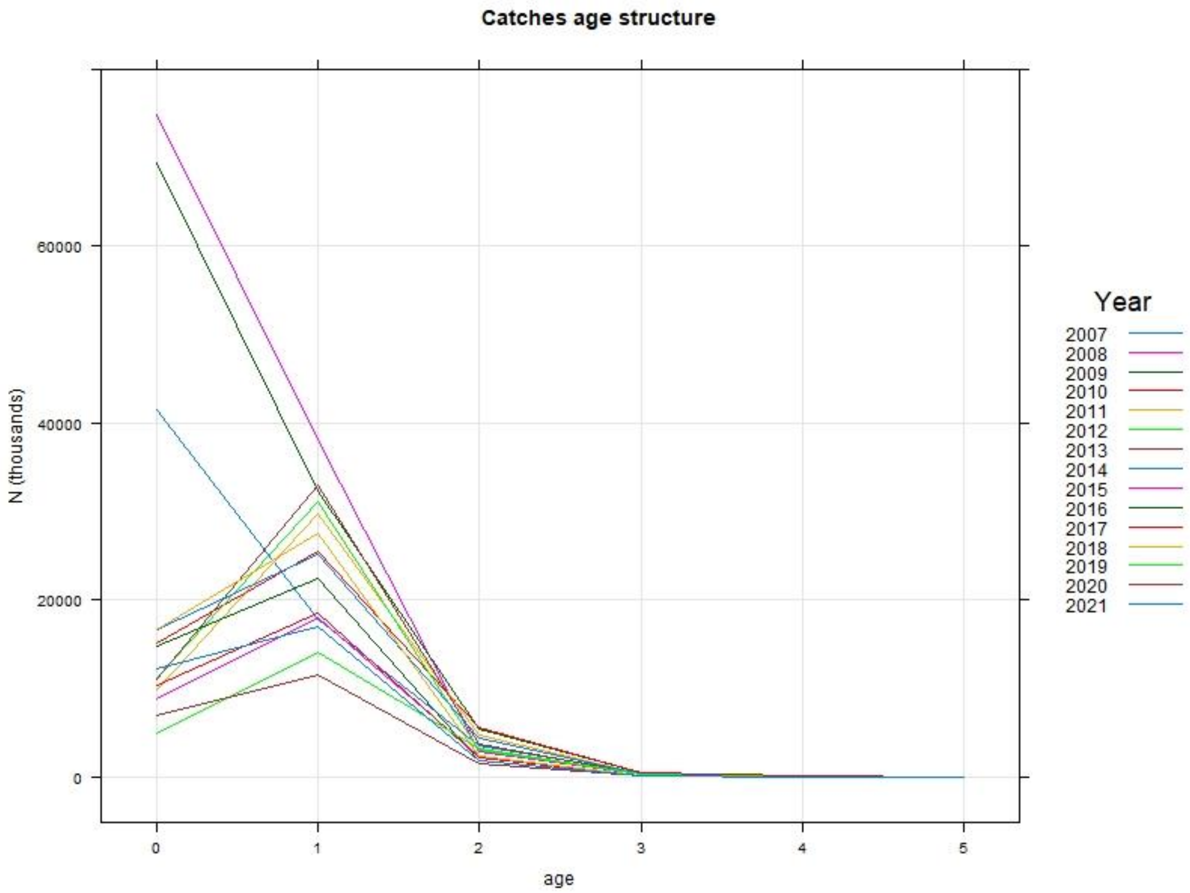


Figure 6.1.3.1. European hake in GSAs 1, 5, 6 & 7. Catch at age input data.

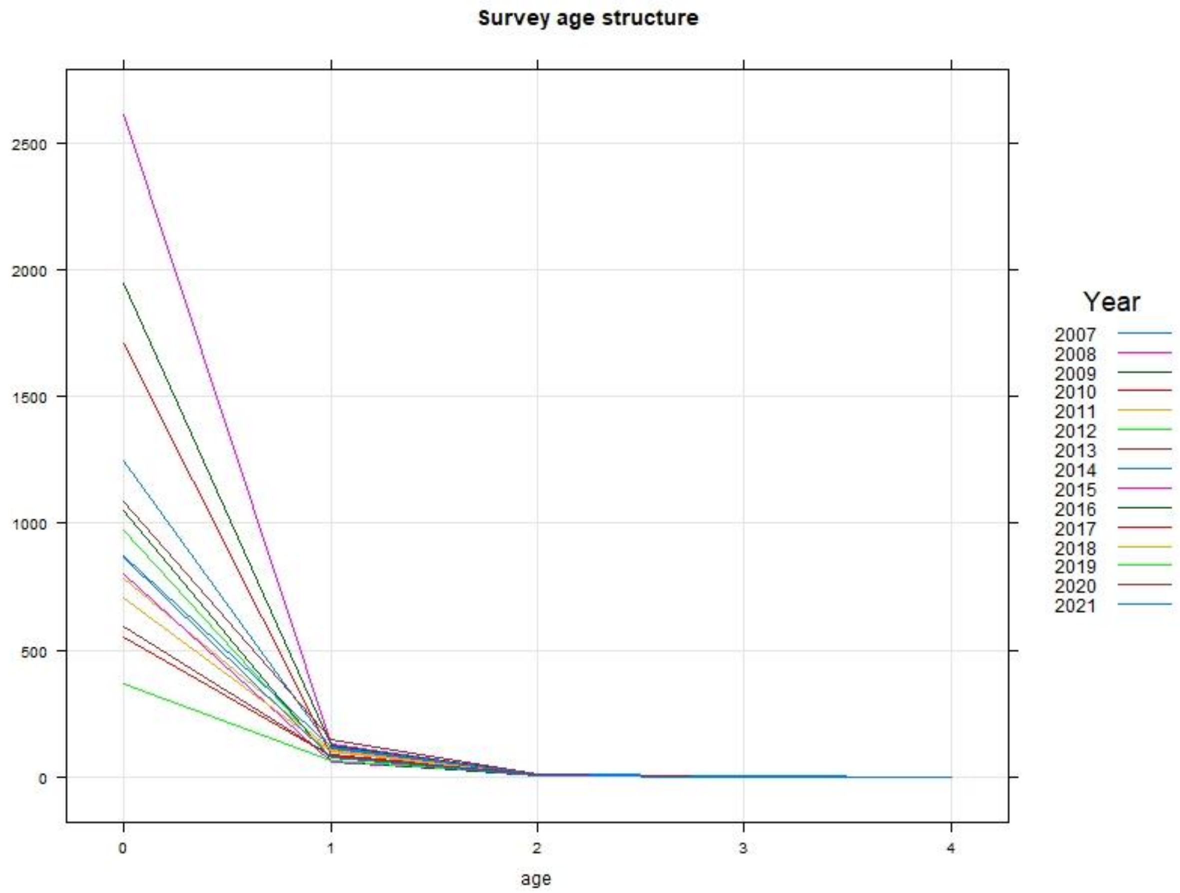


Figure 6.1.3.2. European hake in GSAs 1, 5, 6 & 7. Age structure of the index.

Assessment results

The same model as last year was fitted, the results were consistent with last year; the residuals and in the retrospective pattern were similar, giving an assessment consistent with last year:

fmodel: ~s(age, k = 4) + s(year, k = 6) +

+ s(year, k = 7, by = as.numeric(age == 0)) +

+ s(year, k = 7, by = as.numeric(age == 4))

srmodel: ~factor(year)

n1model: ~s(age, k = 3)

qmodel: ~I(1/(1 + exp(-age)))

vmodel:catch: ~s(age, k = 3) and Index:~1

The use of additional parameters on age 0 and age 4 in the fishery model were included to allow the model to fit better to the first few years of the data which show higher catches particularly at age 0. These extra terms also improved the retrospective performance, suggesting the early years are indeed different from the recent year's fishery.

Results are shown in Figures 6.1.3.3 – 6.1.3.9

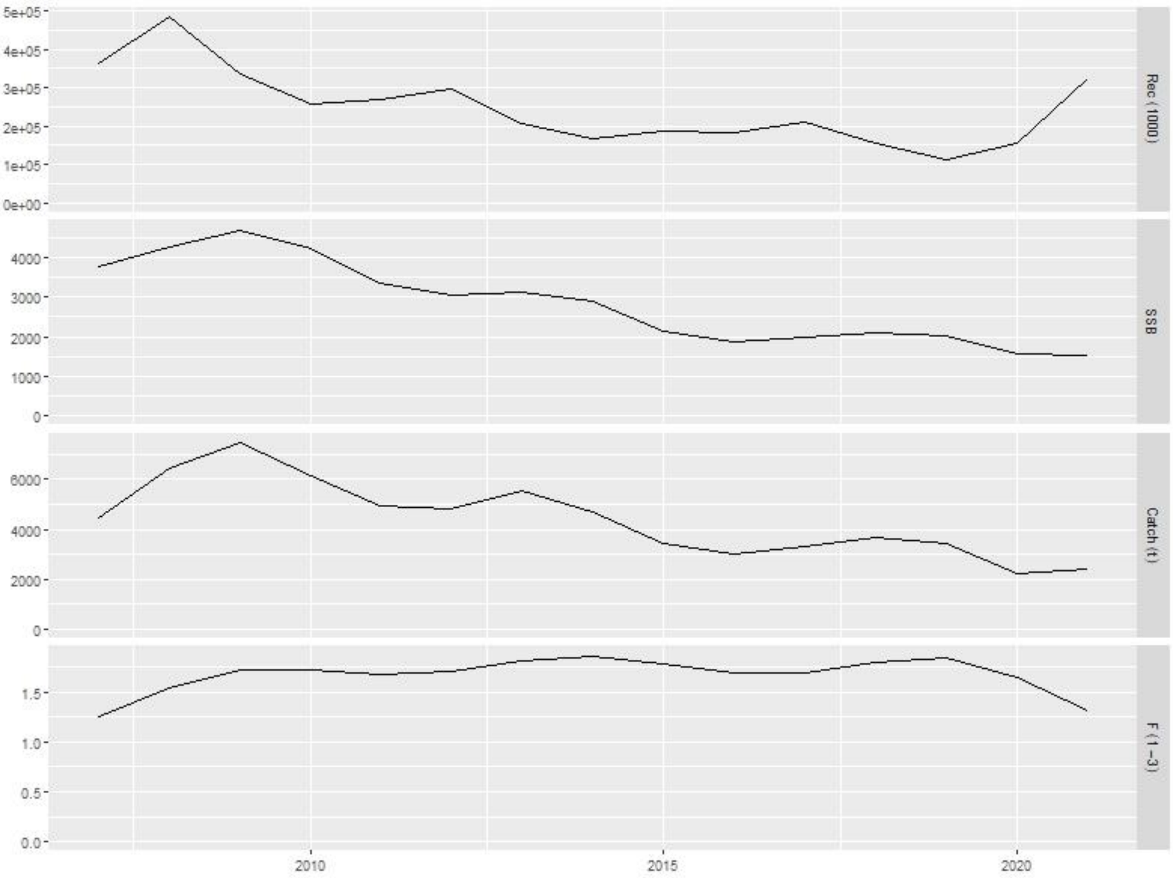
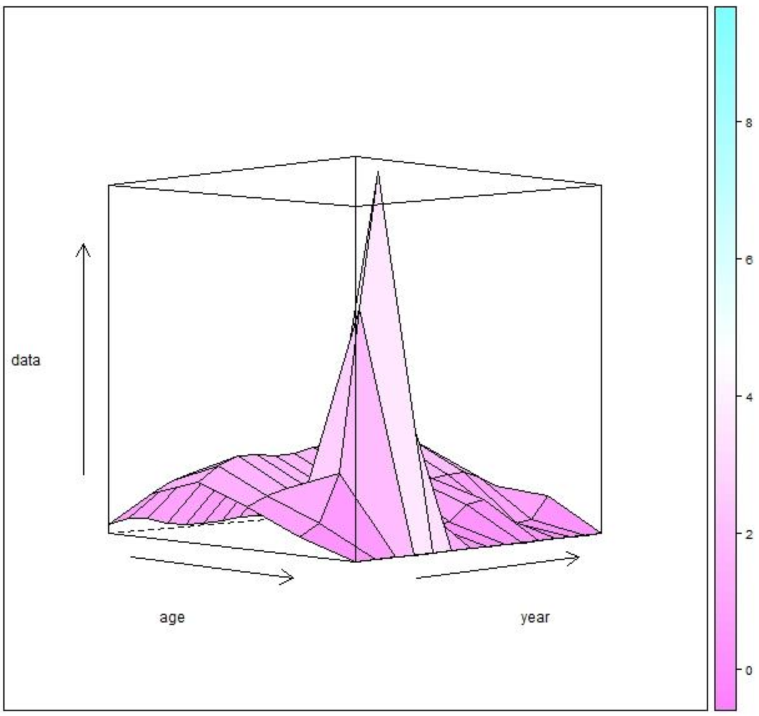


Figure 6.1.3.3. European hake in GSAs 1, 5, 6 & 7. Stock summary from the final a4a model.



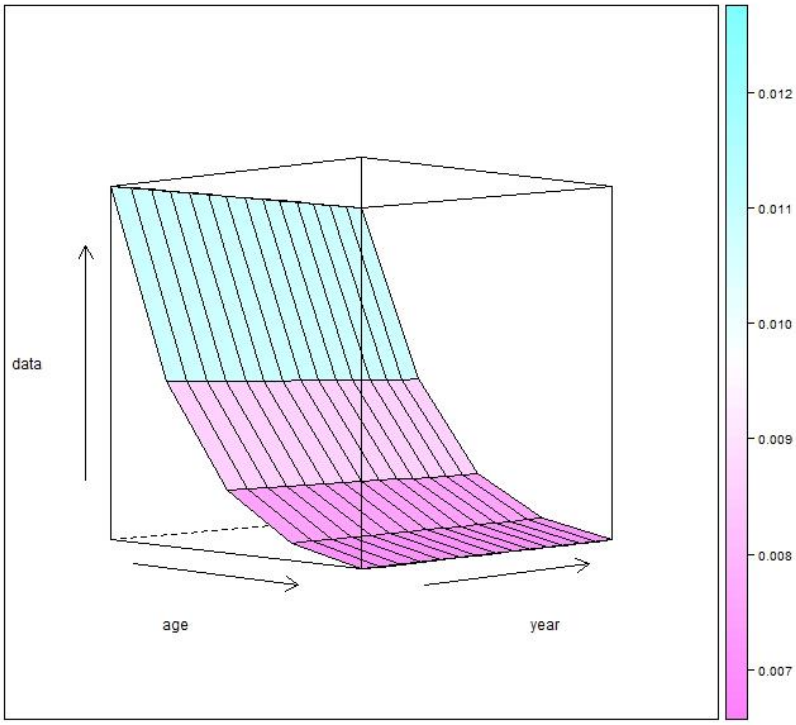
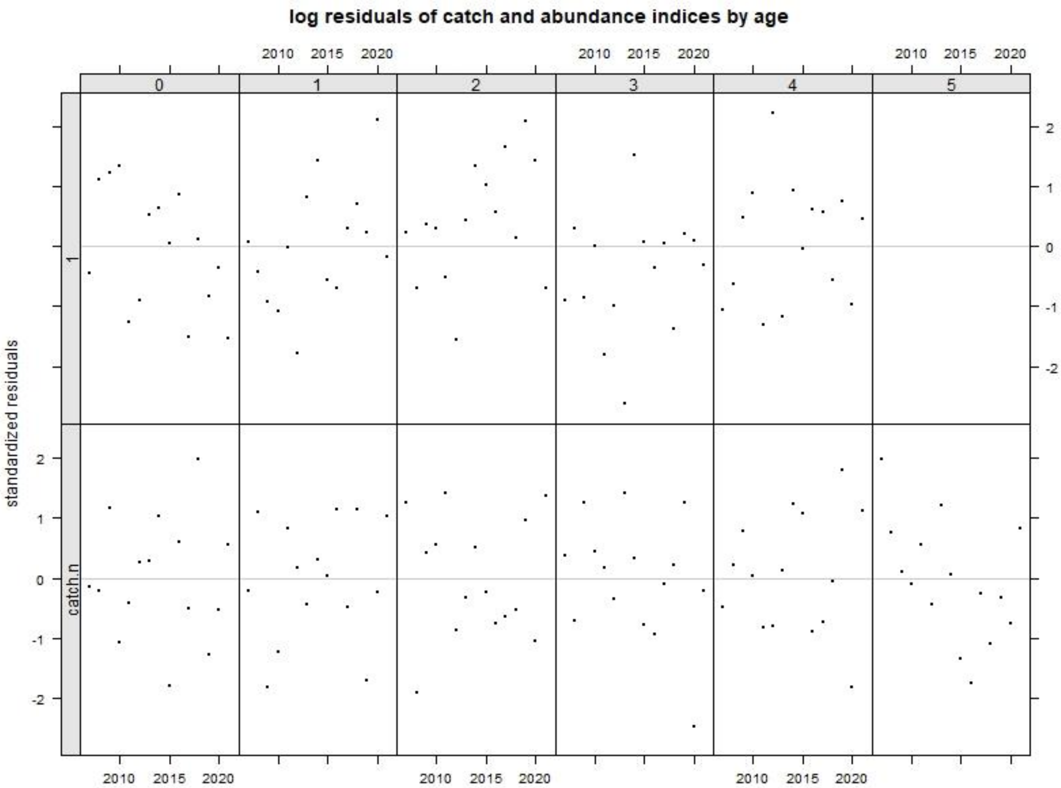


Figure 6.1.3.4. European hake in GSAs 1, 5, 6 & 7. 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.



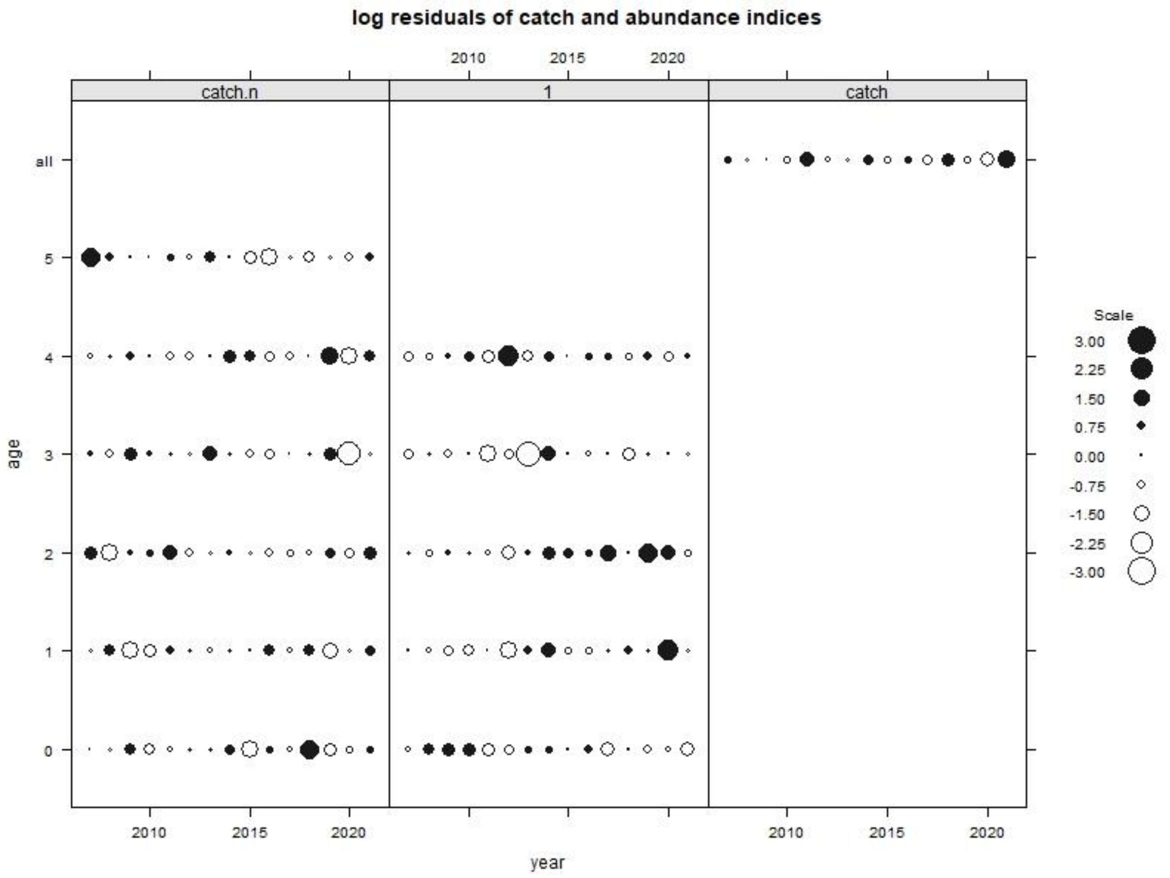


Figure 6.1.3.5. European hake in GSAs 1, 5, 6 & 7. Standardized residuals for abundance indices and for catch numbers.

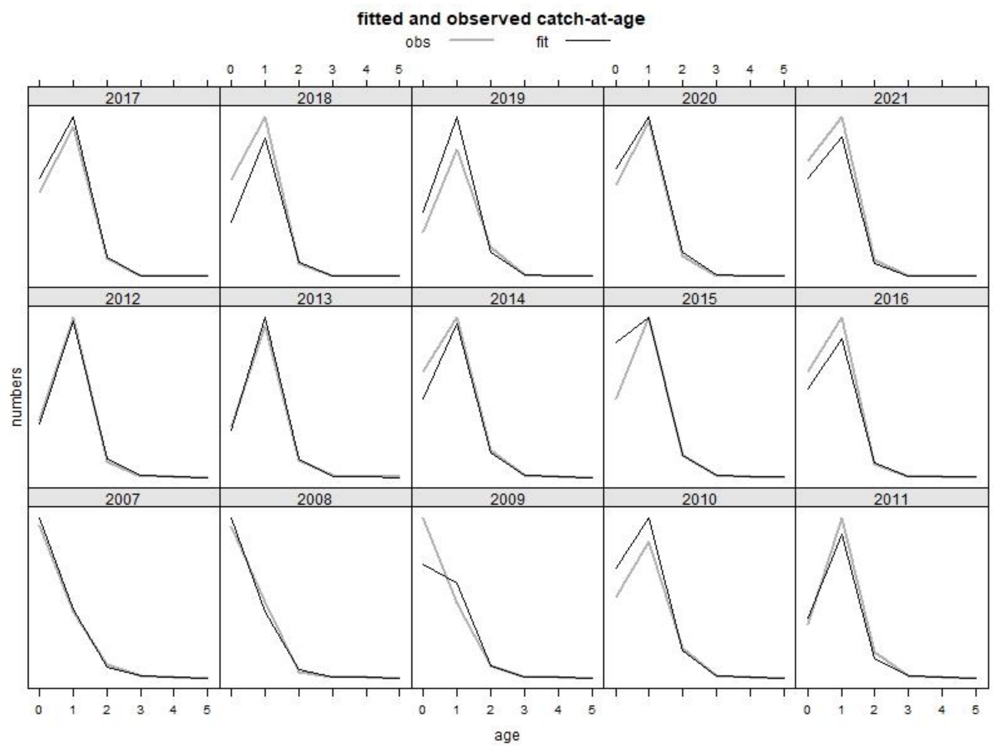


Figure 6.1.3.6. European hake in GSAs 1, 5, 6 & 7. Fitted and observed catch at age.

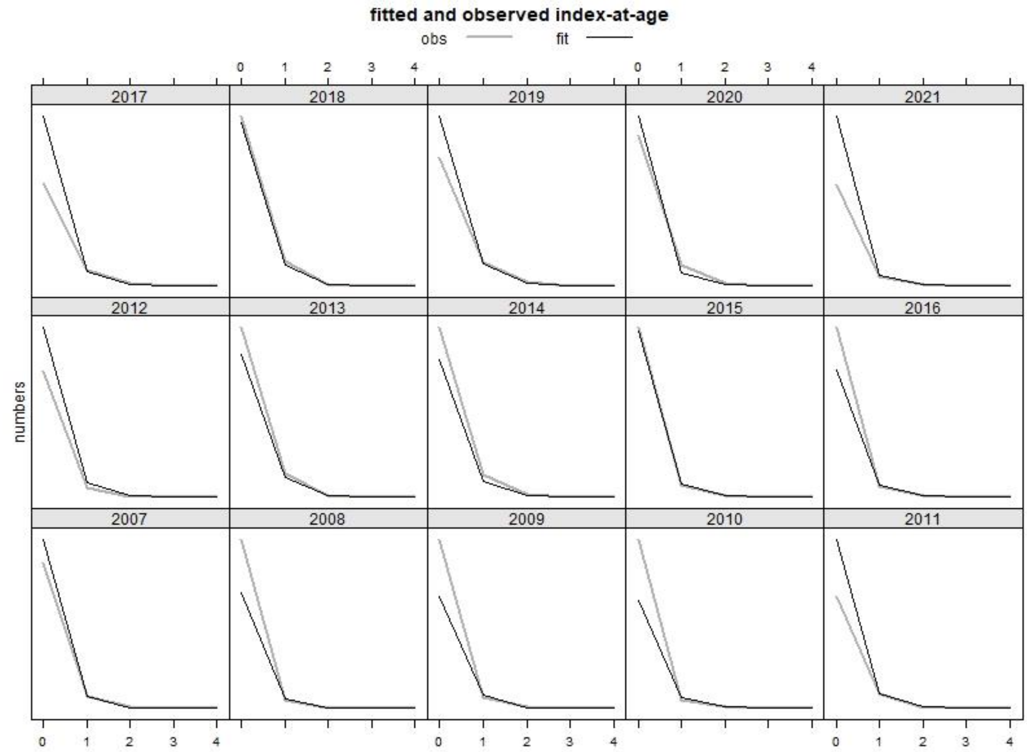


Figure 6.1.3.7. European hake in GSAs 1, 5, 6 & 7. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up only to 4 years back, due to the short time series. Model results were quite stable (Figure 6.1.3.8) except for recruitment which is estimated poorly in the terminal year of the assessment.

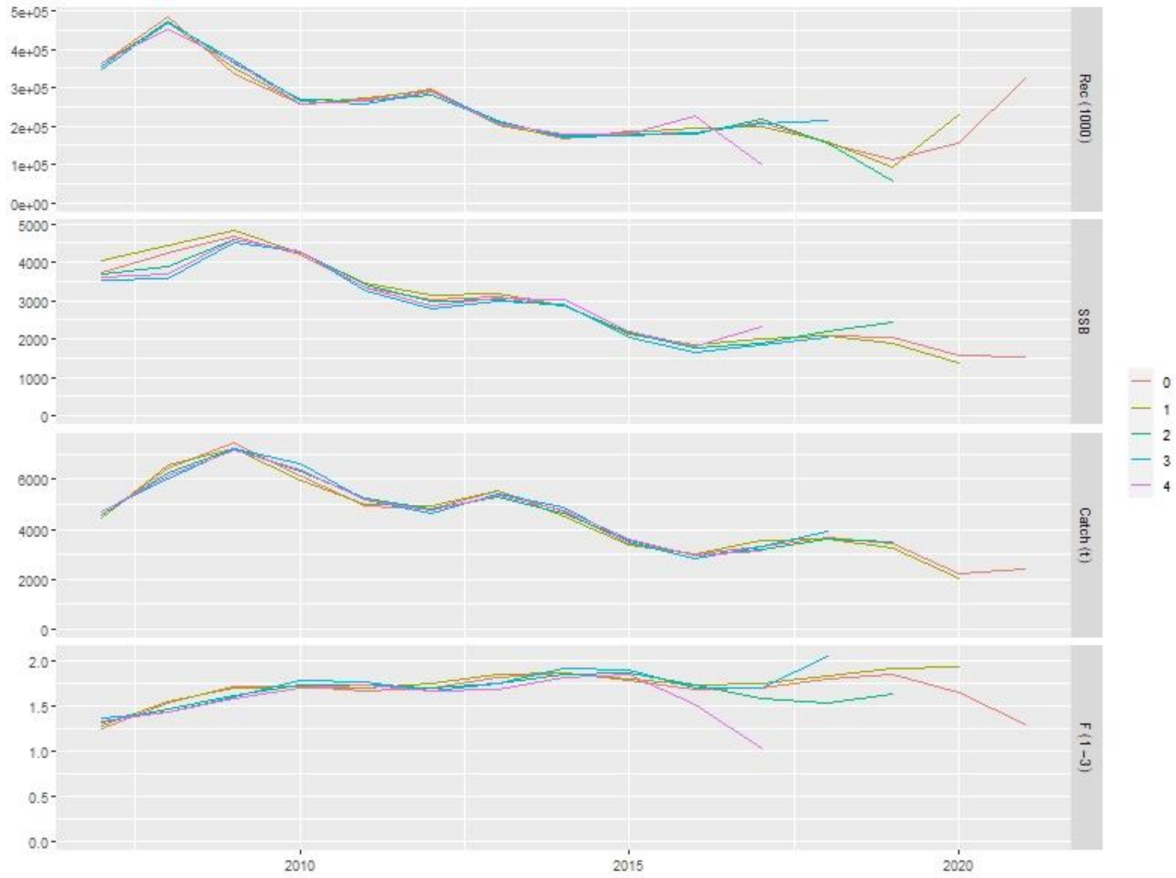


Figure 6.1.3.8. European hake in GSAs 1, 5, 6 & 7. Retrospective analysis.

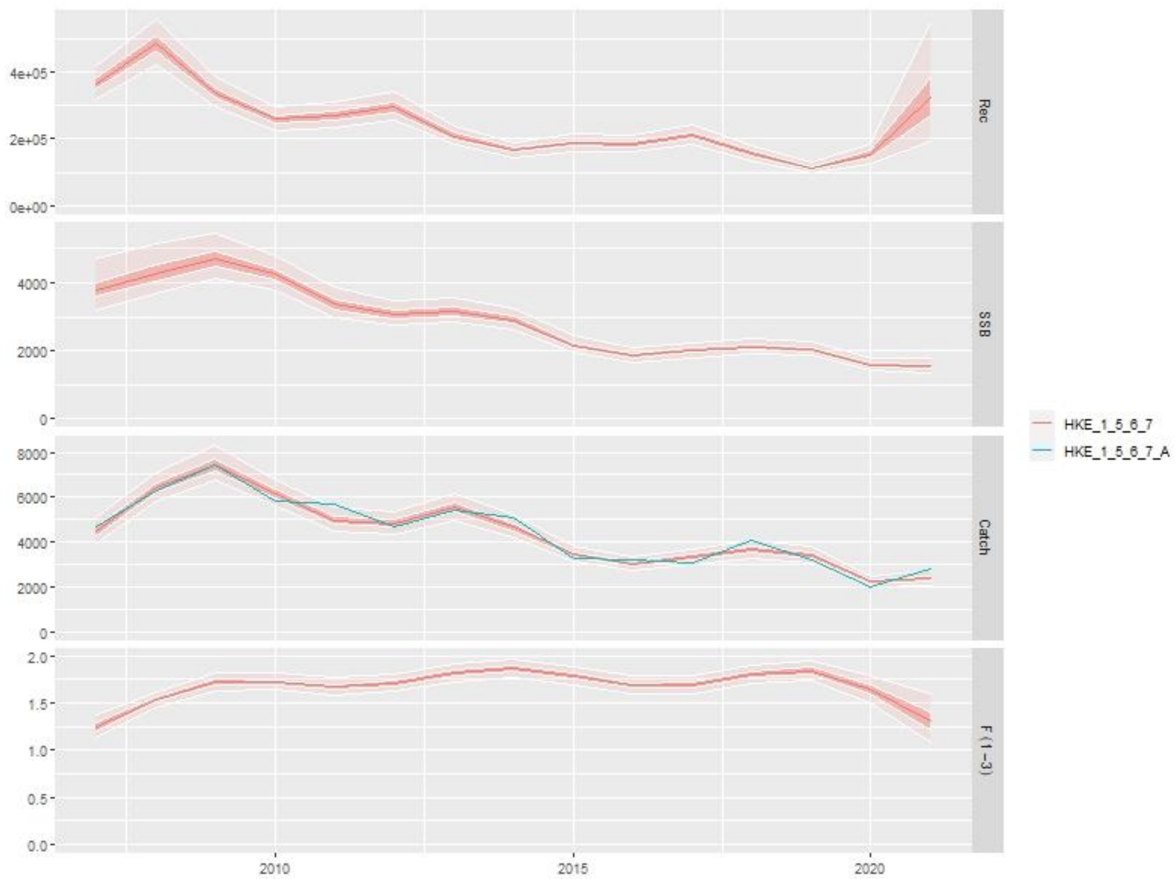


Figure 6.1.3.9. European hake in GSAs 1, 5, 6 & 7. Simulations over summary results. Blue line represents the observed catches.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.1.3.3. European hake in GSAs 1, 5, 6 & 7. Stock numbers at age (thousands) as estimated by a4a.

	0	**1**	**2**	**3**	**4**	**5+**
2007	373603,6	33430,54	4072,18	790,36	295,85	176,45
2008	479765,9	56412,44	5220,09	573,62	199,04	273,26
2009	341041,8	64326,84	6712,62	514,11	112,86	268,24
2010	260468,1	47831,16	6413,41	523,72	86,14	215,65
2011	267850,8	42939,78	4702,79	491,28	86,65	166,01
2012	294742,2	48104,57	4396,82	380,03	84,33	127,69
2013	207903,5	53694,57	4819,49	345,25	63,96	101,32
2014	165331,7	36736,61	4981,36	341,99	54,18	93,07
2015	187466,4	27633,12	3303,99	339,32	52,18	93,64
2016	183712,2	30808,04	2652,75	245,25	54,93	93,55
2017	213437,6	31193,57	3196,14	218,09	42,6	91,15
2018	156535,8	37104,51	3192,16	258,07	37,42	85,54
2019	111873,3	27082,94	3450,66	227,24	40,59	83,5
2020	151181,5	19144,51	2450,28	236,9	34,86	86,66
2021	290865,2	26409,31	2070,77	212,83	42,74	84,83

Table 6.1.3.4. European hake in GSAs 1, 5, 6 & 7. a4a summary results and F at age.

	Fbar(1-3)	Recruitment (thousands)	SSB (t)	TB (t)	Catch (t)
2007	1.27	373604	3550	13543	4395
2008	1.56	479766	4017	16902	6449
2009	1.75	341042	4522	17095	7509
2010	1.76	260468	4031	13673	6196
2011	1.72	267851	3173	13676	4975
2012	1.74	294742	2877	14088	4775
2013	1.83	207903	2996	13194	5471
2014	1.86	165332	2818	9887	4671
2015	1.79	187466	2100	8463	3445
2016	1.71	183712	1798	8552	3028
2017	1.72	213438	1945	8897	3331
2018	1.82	156536	2055	8387	3656
2019	1.85	111873	2008	6780	3432
2020	1.66	151181	1545	6206	2244
2021	1.34	290865	1498	9986	2350

	F at age					
	0	**1**	**2**	**3**	**4**	**5+**
2007	0.26	1.18	1.55	1.07	0.53	0.03
2008	0.38	1.45	1.91	1.32	0.99	0.04
2009	0.33	1.63	2.14	1.48	2.17	0.05
2010	0.17	1.64	2.16	1.49	4.45	0.05
2011	0.09	1.60	2.11	1.45	5.27	0.05
2012	0.07	1.62	2.13	1.47	2.95	0.05
2013	0.10	1.70	2.24	1.54	1.16	0.05
2014	0.16	1.73	2.28	1.57	0.63	0.05
2015	0.18	1.66	2.19	1.51	0.62	0.05
2016	0.14	1.59	2.09	1.44	0.79	0.04
2017	0.12	1.60	2.11	1.45	0.75	0.05
2018	0.12	1.70	2.23	1.54	0.48	0.05
2019	0.14	1.72	2.27	1.56	0.33	0.05
2020	0.11	1.54	2.03	1.40	0.40	0.04
2021	0.07	1.24	1.64	1.13	0.83	0.04

Based on the a4a results, the European hake SSB shows a decreasing trend from 2009 to 2016 (from 4522 to 1798 tons), which than stabilizes until 2019, to decrease again in the last two years reaching an historical minimum in 2021 (1498 t). The assessment shows a constant decreasing trend in the number of recruits in the time series from 2008 until 2020 that reached the minim of the time series (151181), but in 2020 and 2021 the model estimates an increase up to 290865 going back to values estimated in 2012 (294742). F_{bar} (1-3) shows an upward trend from 2007 (1.27) until 2014 (1.86) which than stabilizes until 2019 (1.85) to then decreases in 2020 and 2021 (1.34).

6.1.4 REFERENCE POINTS

The STECF EWG 18-02 recommended using $F_{0.1}$ as a proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

Current F (1.34, corresponding to the F of the last year of the time series) is 3.27 times higher than $F_{0.1}$ (0.41), chosen as a proxy for F_{MSY} and as the exploitation reference point consistent with high long-term yields. This indicates that European hake stock in GSAs 1, 5, 6 and 7 is highly over-exploited.

Estimation of biomass reference points

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4. An exploratory per-recruit analysis was performed using the stock object produced by EWG 22-09 containing the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.1.4.1 and Figure 6.1.4.1.

Table 6.1.4.1 European hake in GSAs 1, 5, 6 & 7. Per-recruit reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	B_0
0.41	0.18	0.05	0.92	0.64

Figure 6.1.4.1 shows the trajectories of the assessment outputs relative to the per-recruit reference points R_0, SPR_0, YPR at $F_{0.1}$ and B_{lim}.

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)
2. Hockey-Stick (model=segreg)
3. Beverton-Holt (model=bevholtSV)
4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ratio potential SRPlim = SPRlim/SPR_0. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP 0.1−20% by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y. When testing the different S-R models (Geometric mean, Hockey Stick, Beverton and Holt and Ricker models) the Hockey Stick model and the Geometric mean one coincided. Therefore, a jitter analysis was run to test if Hockey Stick models with a different slope would fit better the data.

Figure 6.1.4.2 shows the models fitted during the jitter analysis and Figure 6.1.4.3 compares the Hockey Stick curves obtained through the jitter analysis. Model number 2 was selected as it minimized the negative log-likelihood. Than the four SR models were refitted and the Hockey Stick model was selected as the observed SR data are sitting in the centre and to the right part of the R-SSB plot, and the breakpoint estimated by the HS model is within the observed values (Figure 6.1.4.3).

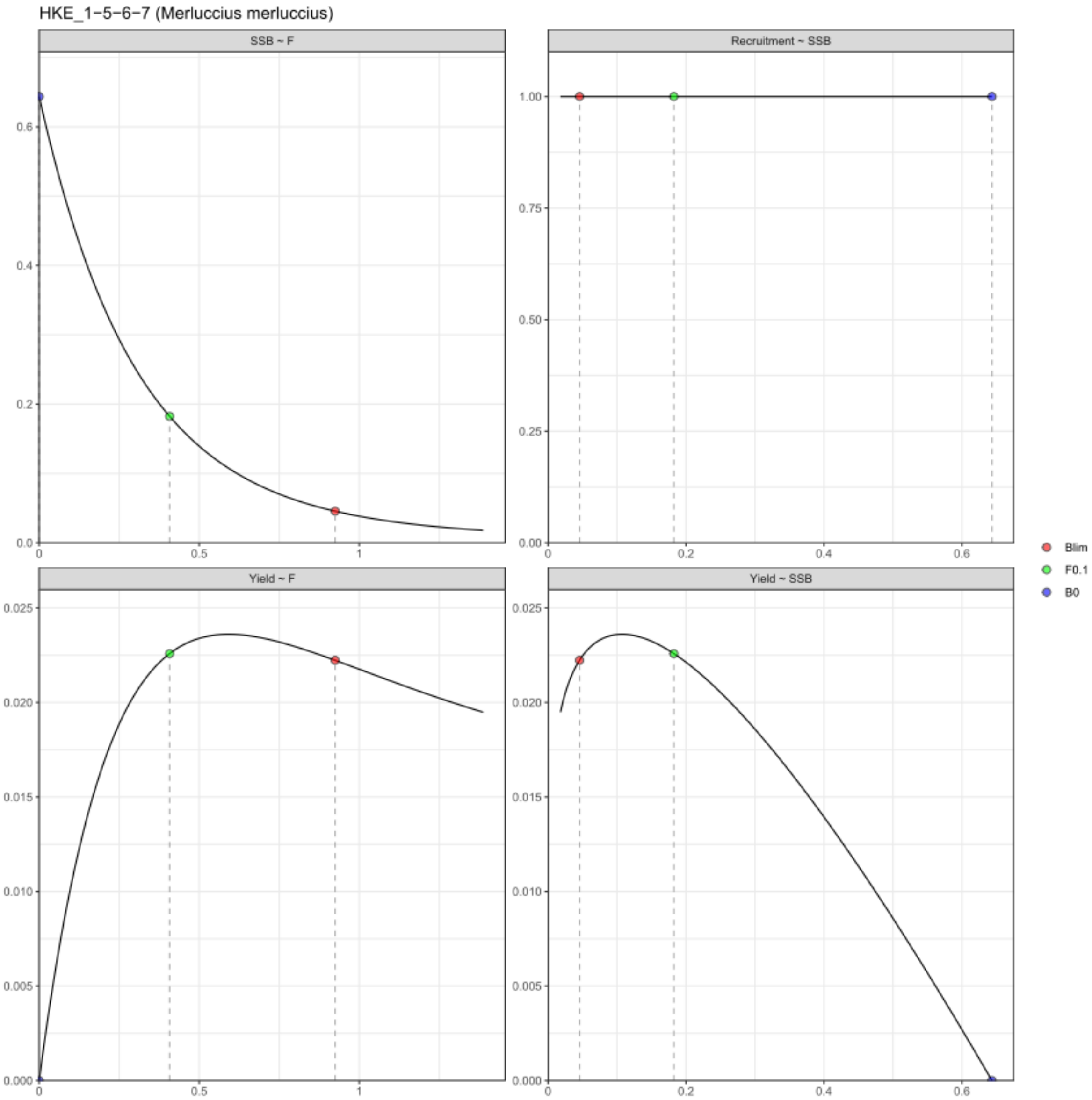


Figure 6.1.4.1. European hake in GSAs 1, 5, 6 & 7. Per-recruit reference points.

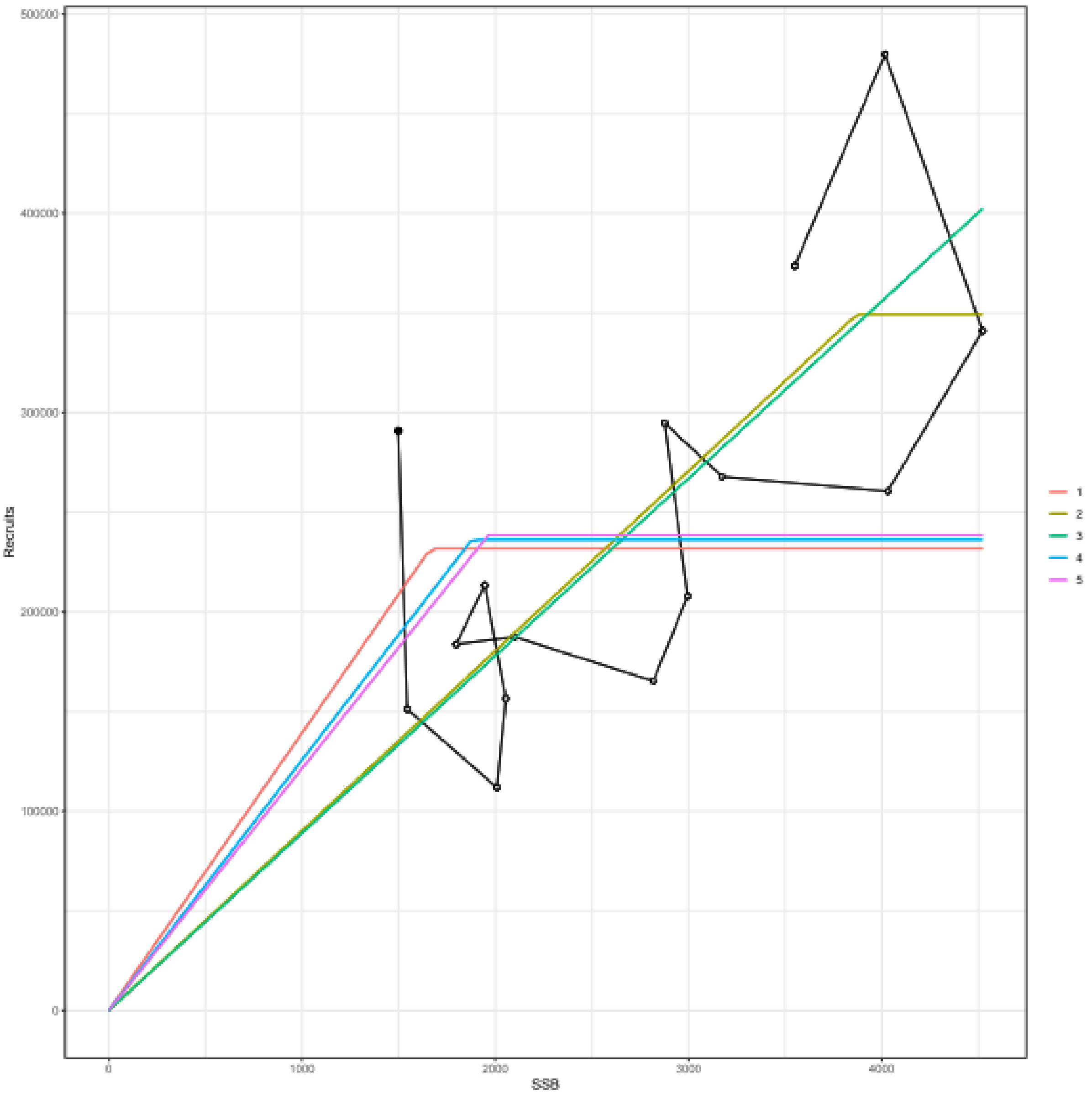


Figure 6.1.4.2. European hake in GSAs 1, 5, 6 & 7. Results of the jitter analysis.

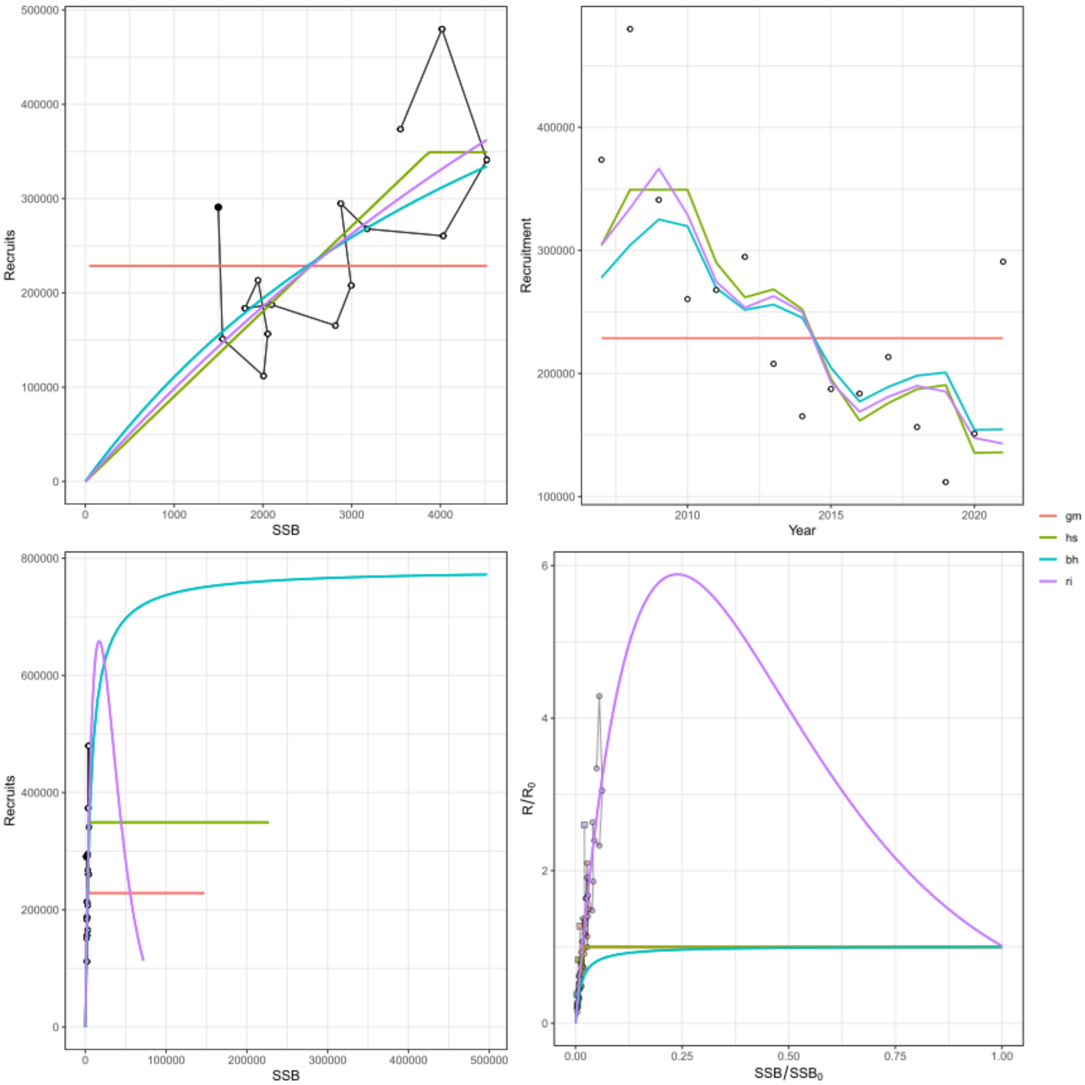


Figure 6.1.4.3. European hake in GSAs 1, 5, 6 & 7. Summary of the four SR models after the selection from the jitter analysis.

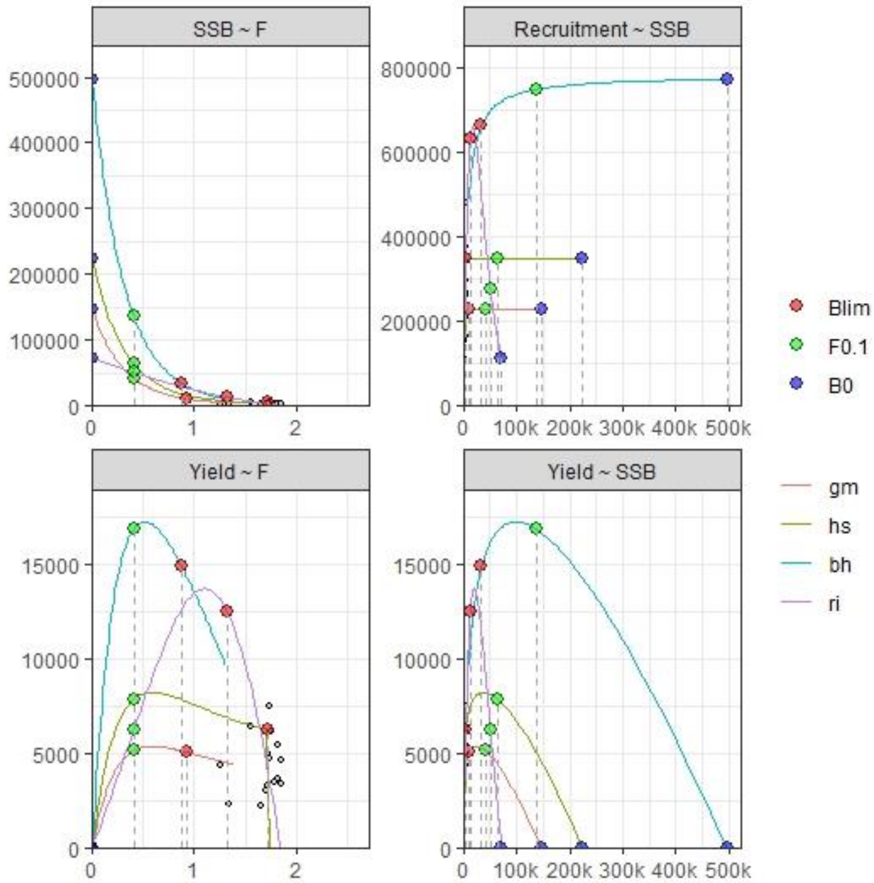


Figure 6.1.4.4. European hake in GSAs 1, 5, 6 & 7. Long term equilibrium evaluations for different S-R models.

In the light of the outcomes of the exploratory analysis, it was decided to consider the Hockey-stick approach the most appropriate to estimate the biomass reference points for the stock of European hake in GSAs 1, 5, 6 and 7. This is consistent with the approach used in EWG 22-03. Table 6.1.4.2 summaries the reference point values based on the Hockey-Stick model fitted to the data. B_{pa} is set to 2* B_{lim} as defined in STECF EWG 22-03. The reference point calculated with the updated assessment are very similar to those obtained from last year's assessment, differing by between 6-8%. The implied dynamics are illustrated in Figure 6.1.4.5, and the historic assessment information is shown in this context in Figures 6.1.4.6-.7. In conclusion the stock is considered to be below B_{lim} in 2021.

Table 6.1.4.2 European hake in GSAs 1, 5, 6 & 7. Per-recruit reference points.

$F_{0.1}$	B_{lim}	B_{pa}	$B_{F0.1}$	Fpa
0.41	3872	7743	63696	1.27

Figure 6.1.4.5 shows that SSB by year is below the equilibrium biomass at $F_{0.1}$ ($B_{F0.1}$) and the B_{lim} for the whole time series. At the same time, F is well above $F_{0.1}$ and F_{lim} across the whole time series, despite the decrease in 2020 and 2021.

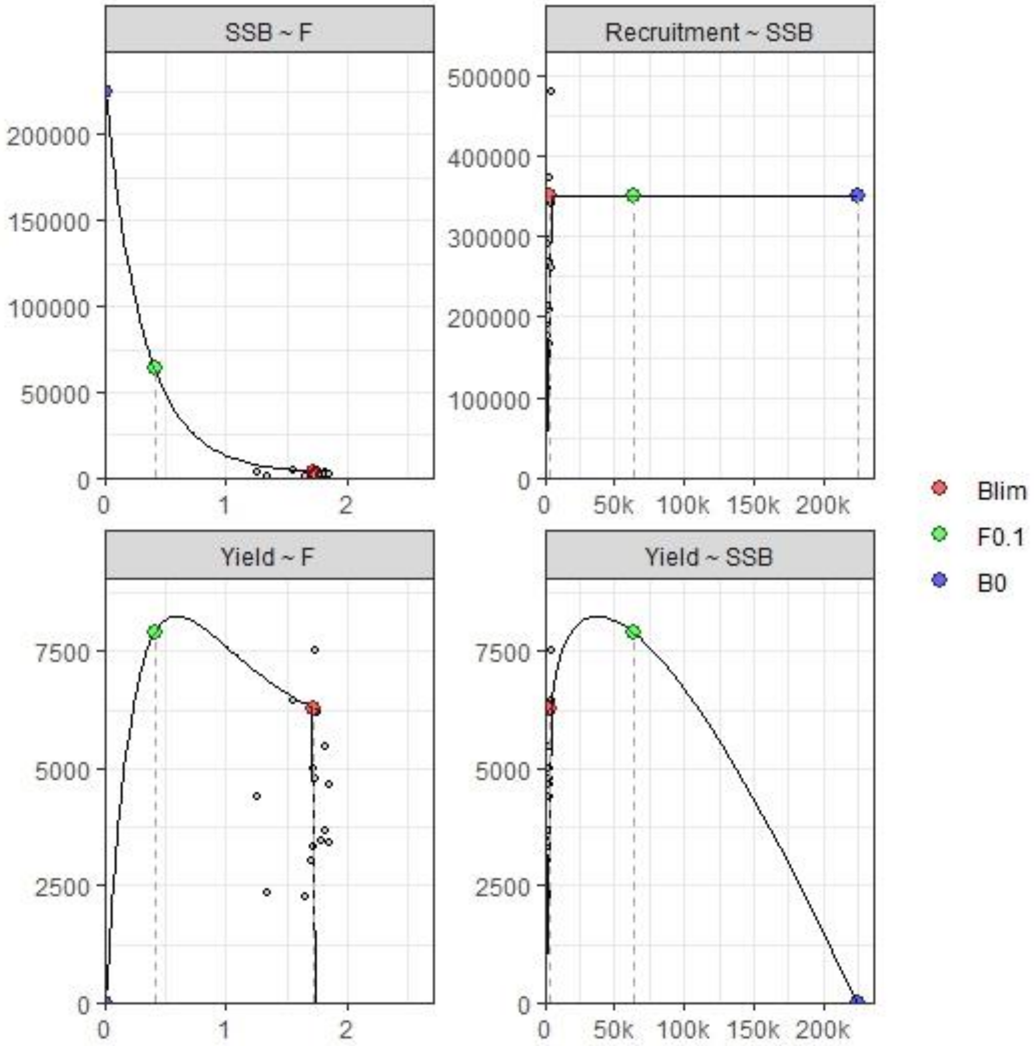


Figure 6.1.4.5. European hake in GSAs 1, 5, 6 & 7. Yield analysis with HS model.

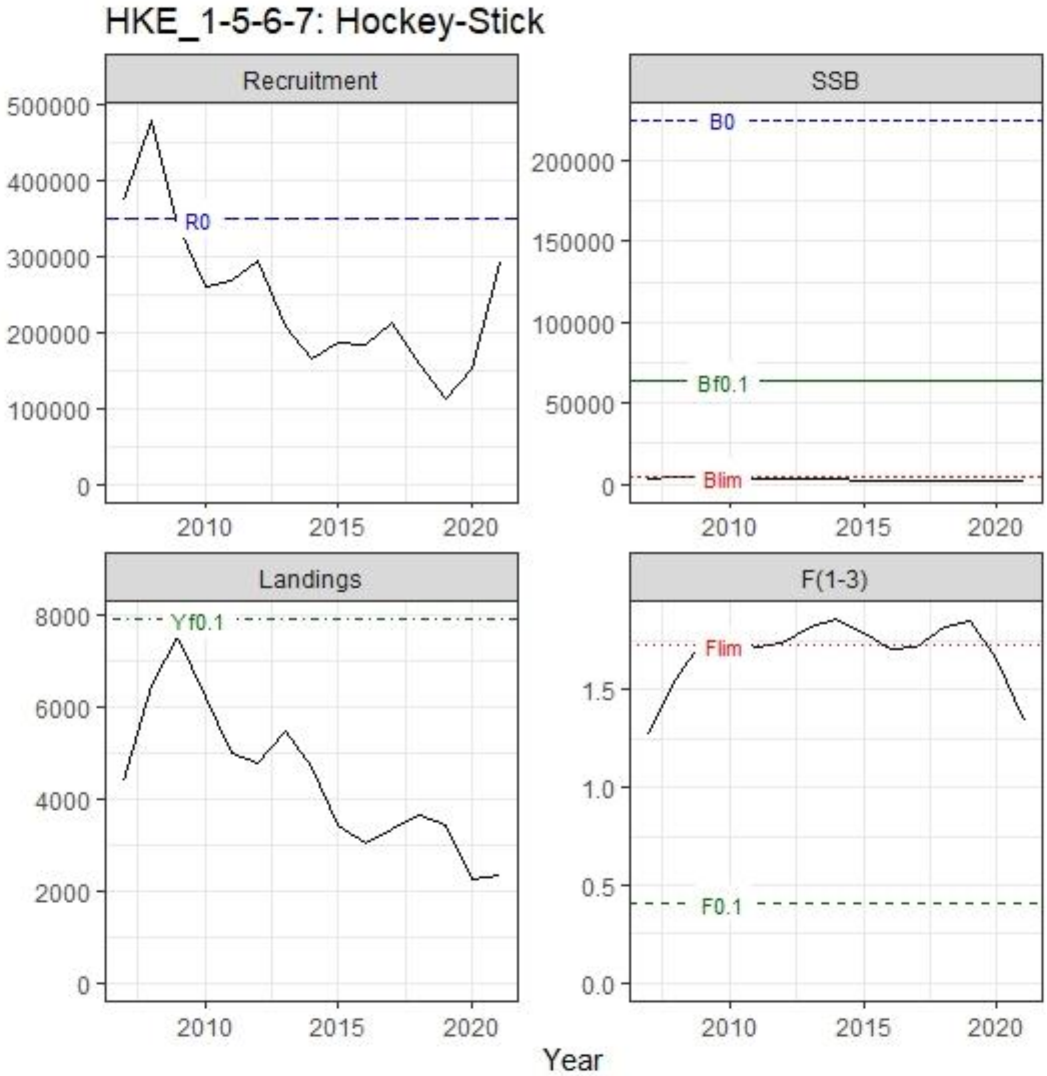


Figure 6.1.4.6. European hake in GSAs 1, 5, 6 & 7. Status Advice plot showing stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on a Hockey-Stick stock-recruitment relationship.

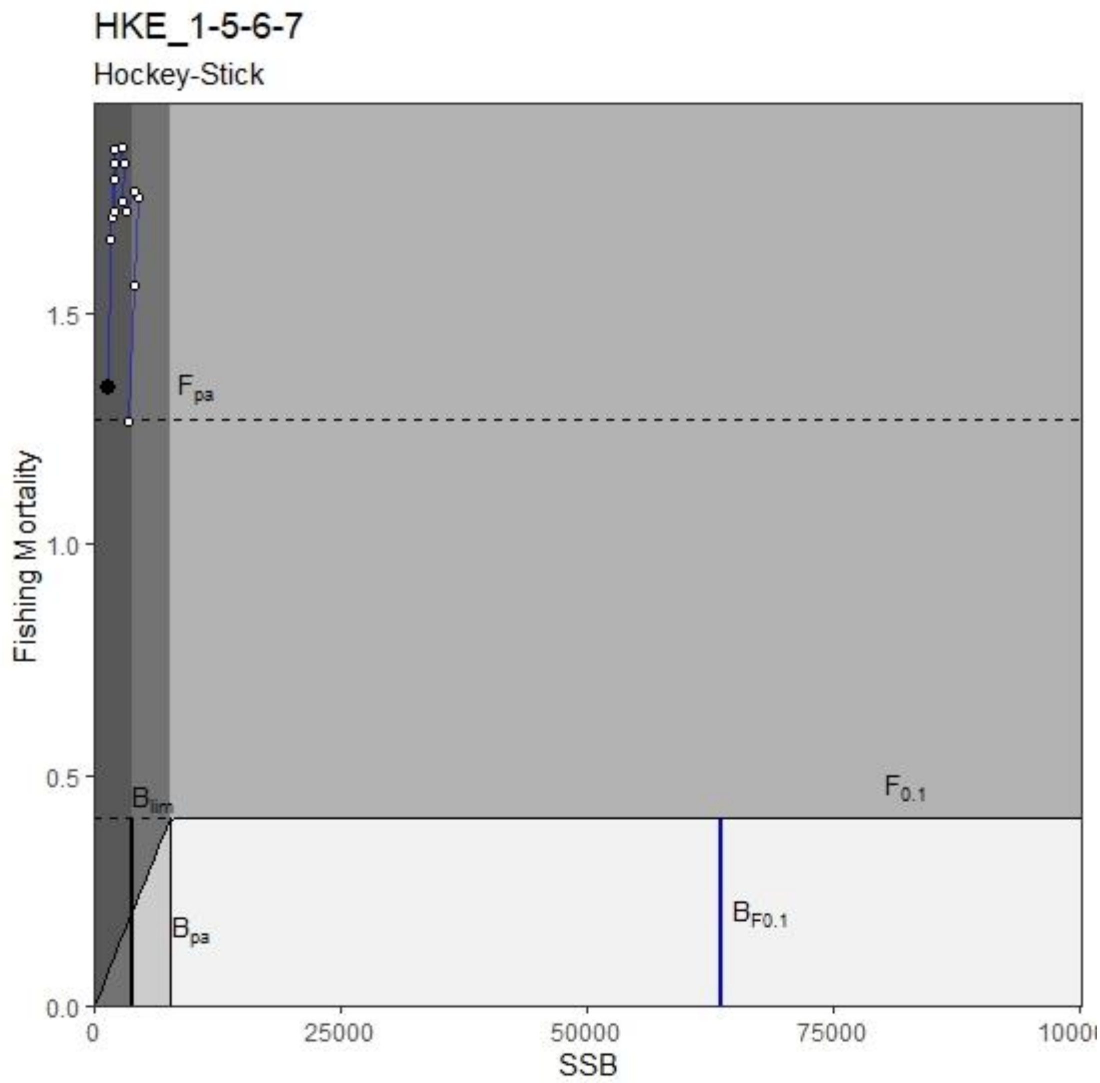


Figure 6.1.4.7. European hake in GSAs 1, 5, 6 & 7. Advice Rule plots, with B_{lim} fitted to the data and B_{pa} = 2 B_{lim}.

In conclusion The HS model defined above is considered as the best option for defining biomass reference points for this stock, but it may not be the most suitable for modelling. A Geometric mean model may be helpful too as a modelling option. The steepness options considered above are illustrated in Figure 6.1.4.8.

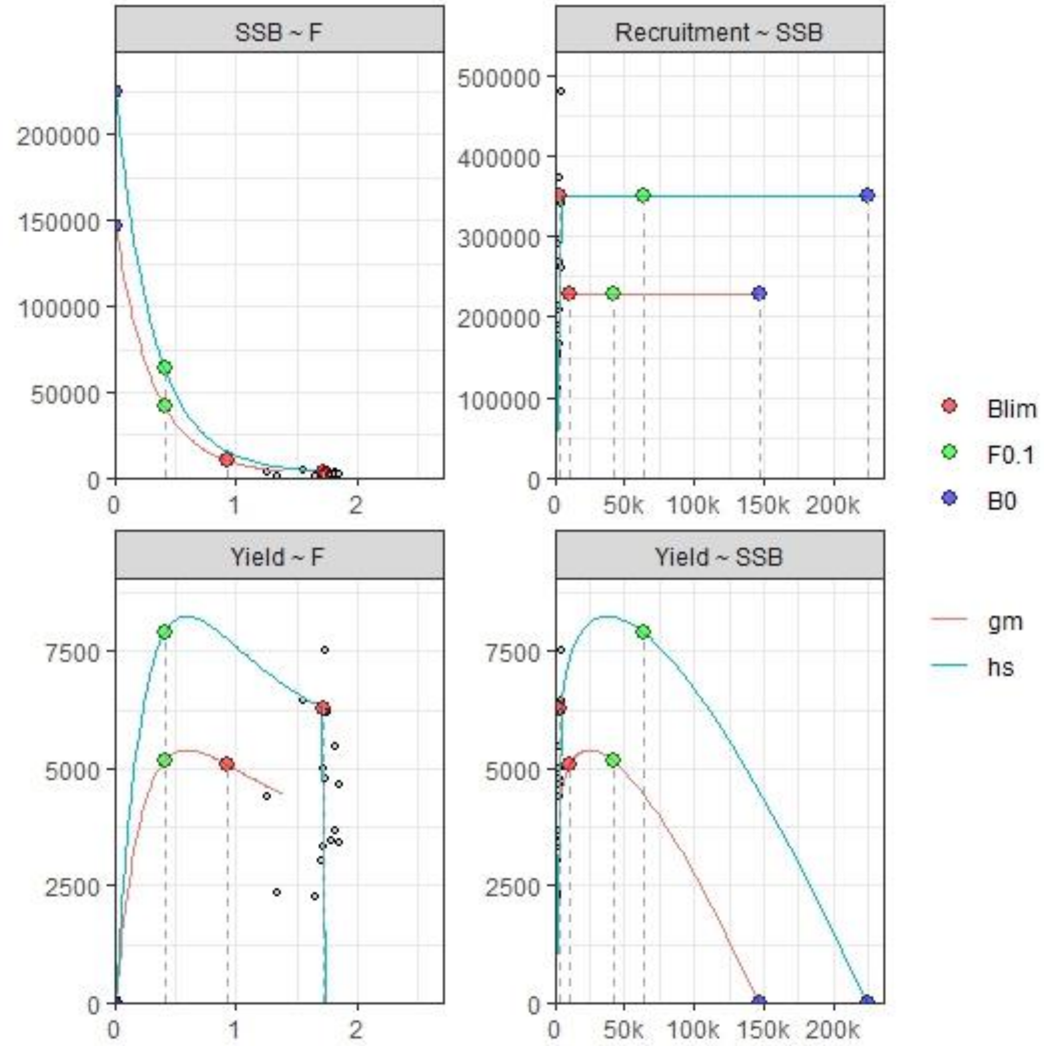


Figure 6.1.4.8. European hake in GSAs 1, 5, 6 & 7. Advice Rule plots, with B_{lim} fitted to the data and B_{pa} = 2 B_{lim}.

6.1.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age, while the F_{bar} =1.34 (the last year's F estimated by the assessment model) was used for F in 2022, as F shows a decreasing trend (See section 4.3). As for this stock the SSB is lower than B_{pa} across the time series, the recruitment estimated at the breakpoint with the HS model will not be used for the short term projections. Instead the Geometric mean of the estimated time series of recruitment will be used. Recruitment is observed to oscillate (Figure 6.1.3.9), so the last 9 years are used as an estimate of recruits in 2022 to 2023. Recruitment (age 0) was estimated from the population results as the geometric mean of the last 9 years (185367.4).

Table 6.1.5.1 European hake in GSAs 1, 5, 6 & 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3 years	mean weights at age, maturation at age, natural mortality at age and selection at age, are based average of years 2018-2020
Fages 1-3 (2021)	1.34	The F estimated in 2020 was used to give F status quo for 2021
SSB (2021)	1498	Stock assessment 1 January 2021
Rage0 (2021,2022)	185367	Geometric mean of the last 3 years
Total Catch (2021)	2350	Assuming F status quo for 2021

Table 6.1.5.2. European hake in GSAs 1, 5, 6 & 7. Short term forecast in different F scenarios.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	1930	0.41	7435	190.91	-17.90
$F_{MSY\ Transition}$	3442	0.89	4795	87.61	46.46
$F_{MSY\ Reduced}$ $B<B_{pa}$	1004	0.19	9126	257.04	-57.28
$F_{MSY\ lower}$	1369	0.27	8455	230.78	-41.77
$F_{MSY\ upper}$	2474	0.56	6464	152.91	5.27
Other scenarios					
Zero catch	0	0.00	11004	330.51	-100.00
Status quo	4378	1.34	3284	28.48	86.26
	717	0.13	9658	277.86	-69.48
	1349	0.27	8491	232.22	-42.62
	1905	0.40	7480	192.63	-18.94
	2397	0.54	6602	158.28	1.97
	2831	0.67	5839	128.45	20.47
	3217	0.80	5177	102.53	36.86
	3559	0.94	4601	80.00	51.42
	3863	1.07	4100	60.40	64.37
	4135	1.20	3664	43.34	75.93

6.1.6 Data Deficiencies

French data

For survey data in some years and for some hauls, hake MEDITS data seem biased due to have applied a very high raising factor. This fact could occur in TB data too.

The same issue is encountered within commercial data.

Spanish data

In some years and for some hauls, hake MEDITS data seem biased due to have applied a very high raising factor. This fact could occur in TB data too.

No length measurements were recorded for commercial data in GSA 7 this year.

6.2 DEEP-WATER ROSE SHRIMP IN GSAs 1, 5, 6 &7

An evaluation of Deep-water rose shrimp by GSA was carried out this year. The individual evaluations are presented below by GAS in section 6.2.1 and 6.2.2 respectively.

6.2.1 DEEP-WATER ROSE SHRIMP IN GSAs 1

6.2.1.1 STOCK IDENTITY AND BIOLOGY

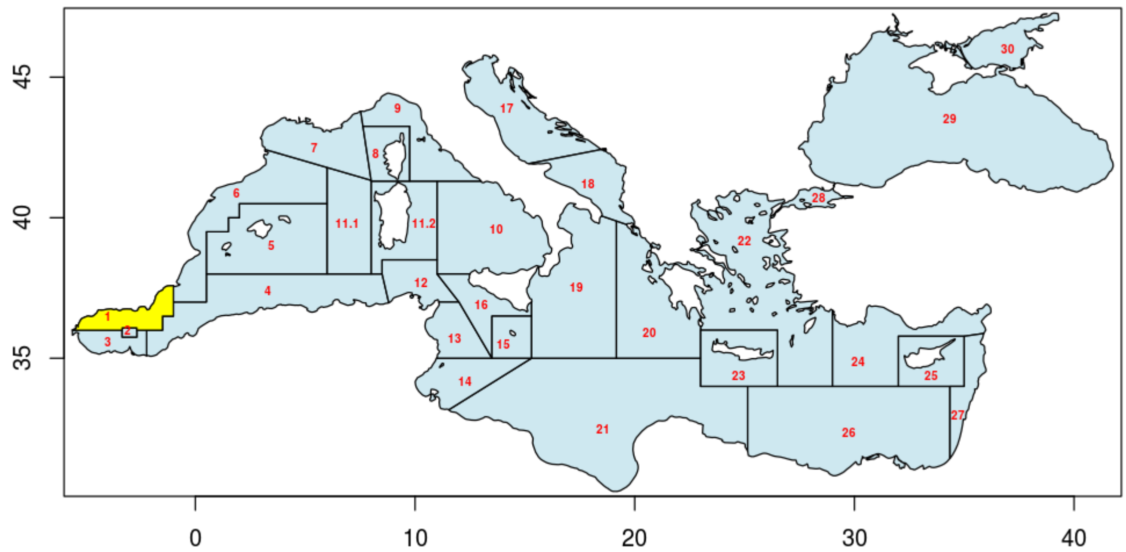


Figure 6.2.1.1.1. Geographical location of GSA 1.

STECF EWG 22-09 was asked to assess the state of Deep-water rose shrimp stocks in the GSA 1. Growth parameters and length-weight relationship parameters were available within the DCF 2021. However, the growth parameters used in the assessment for sexes combined and carapace length expressed in mm were taken from Guijarro et al,. (2009) in line with the last year assessment (EWG 21-11).

Table 6.2.1.1.1. Deep-water rose shrimp GSA 1. Growth parameters and length-weight relationship parameters.

Source	Area	L_∞	K	t_0	a	b
Guijarro et al., 2009	GSA 1	40	0.69	-0.230	0.0019	2.61

Maturity and Natural mortality have also been assumed to be equal to the values used in the last assessment from EWG 21-11.

Table 6.2.1.1.2. Deep-water rose shrimp GSA 1. Proportion of mature specimens at age and natural mortality at age.

Age	Area	0	1	2	3+
Maturity	GSA 1	0.022	1	1	1
M	GSA 1	2.05	1.06	0.57	0.4

6.2.1.2 DATA

6.2.1.2.1 CATCH (LANDINGS AND DISCARDS)

General description of Fisheries

Deep-water rose shrimp is targeted mainly by bottom trawlers in these areas.

Deep-water rose shrimp is a target species for trawling vessels operating on the upper slope and it is one of the most important crustacean species for the trawl fisheries of GSA 1. No artisanal boats target this species.

Landings

Landings data were reported to STECF EWG 22-09 through the DCF. In GSA 1 most of the landings come from otter trawls. DCF data coming from other gears were considered inaccurate or sampled inconsistently; nevertheless, their catches were included in the stock assessment to ensure consistency with reported catch. Accuracy of these is not considered a majopr issue due to the low amounts (Table 6.2.1.2.1.1). It is noted that catch is fitted in the assessment with error.

Table 6.2.1.2.1.1. Deep-water rose shrimp GSA 1. Landings data in tonnes by fleet.

Year	FPO	GTR	OTB
2002			209.75
2003			187.17
2004			118.14
2005			103.03
2006			37.59
2007			56.16
2008			108.87
2009			253.93
2010			97.6
2011			171.57
2012			241.52
2013			149.12
2014			100.42
2015			108.55
2016			136.75
2017		0.02	201.77
2018			329.62
2019			354.15
2020	0.008		482.92
2021	0.01	0.002	564.2

Landings data by year are presented in Table 6.2.1.2.1.2. Landings by year and fleet are presented in Figure 6.2.1.2.1.1.

Table 6.2.1.2.1.2. Deep-water rose shrimp GSA 1. Landings data in tonnes by year.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
212	189.2	119.4	104.7	38	56.8	109.4	255.7	99.4	171.9
2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
243.2	150	104.7	109.7	137.6	203.5	330.3	355.2	484.9	564.2

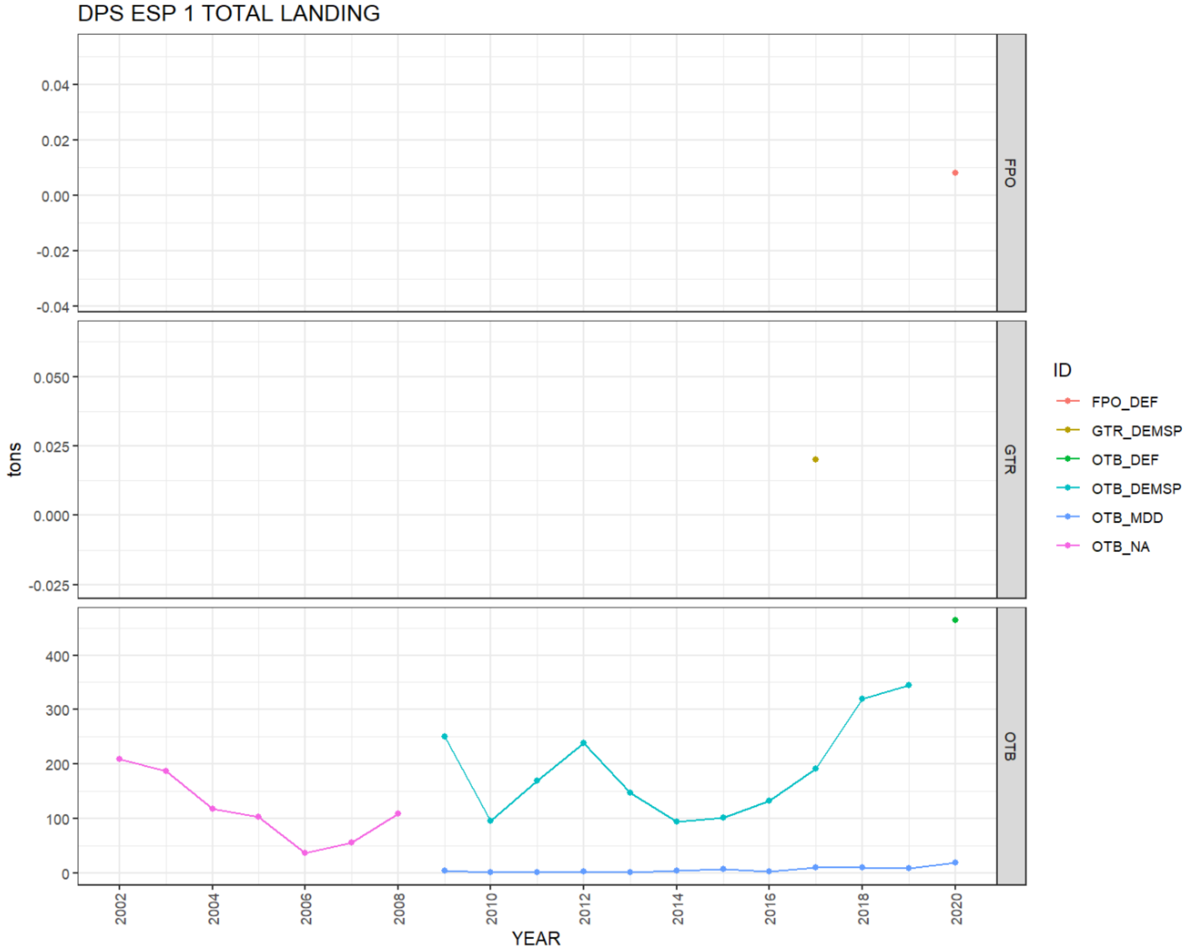


Figure 6.2.1.2.1.1. Deep-water rose shrimp GSA 1. Landings data in tonnes by year and fleet in GSA 1.

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.2.1.2.1.2.

In GSA 1, length frequency distributions were not available for 2002.

The group decided to use the scripts developed during EWG 2102 to fill the missing length frequency distributions for the metiers without any length information. However, raising of the landings from the metiers with partial length frequency distributions was performed together with the SOP correction. In addition a correction for OTB_DWS was done by removing unreliable information for lengths greater than 37 in 2021. The line of code to correct data was:

```
LFL<-LFL[-which(LFL$ID=="OTB_DWS" & LFL$year==2021 & LFL$start_length>37),]
```

Recontructed and revised length frequency distribution of the landings by year and fleet and the reconstruction procedure are presented in Figures 6.2.1.2.1.3-4.

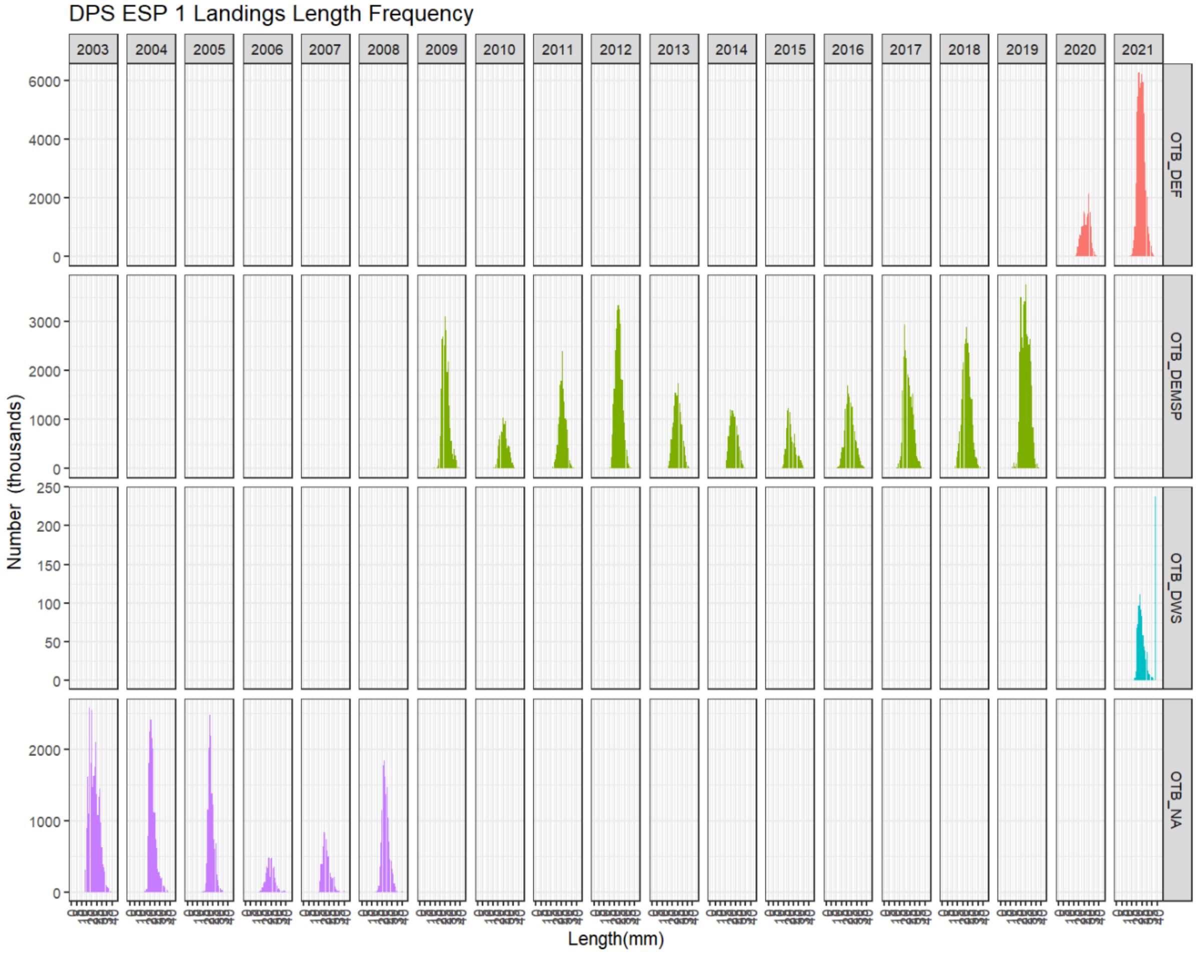


Figure 6.2.1.2.1.2. Deep-water rose shrimp GSA 1. Original length frequency distribution of the landings by year and fleet in GSA 1.

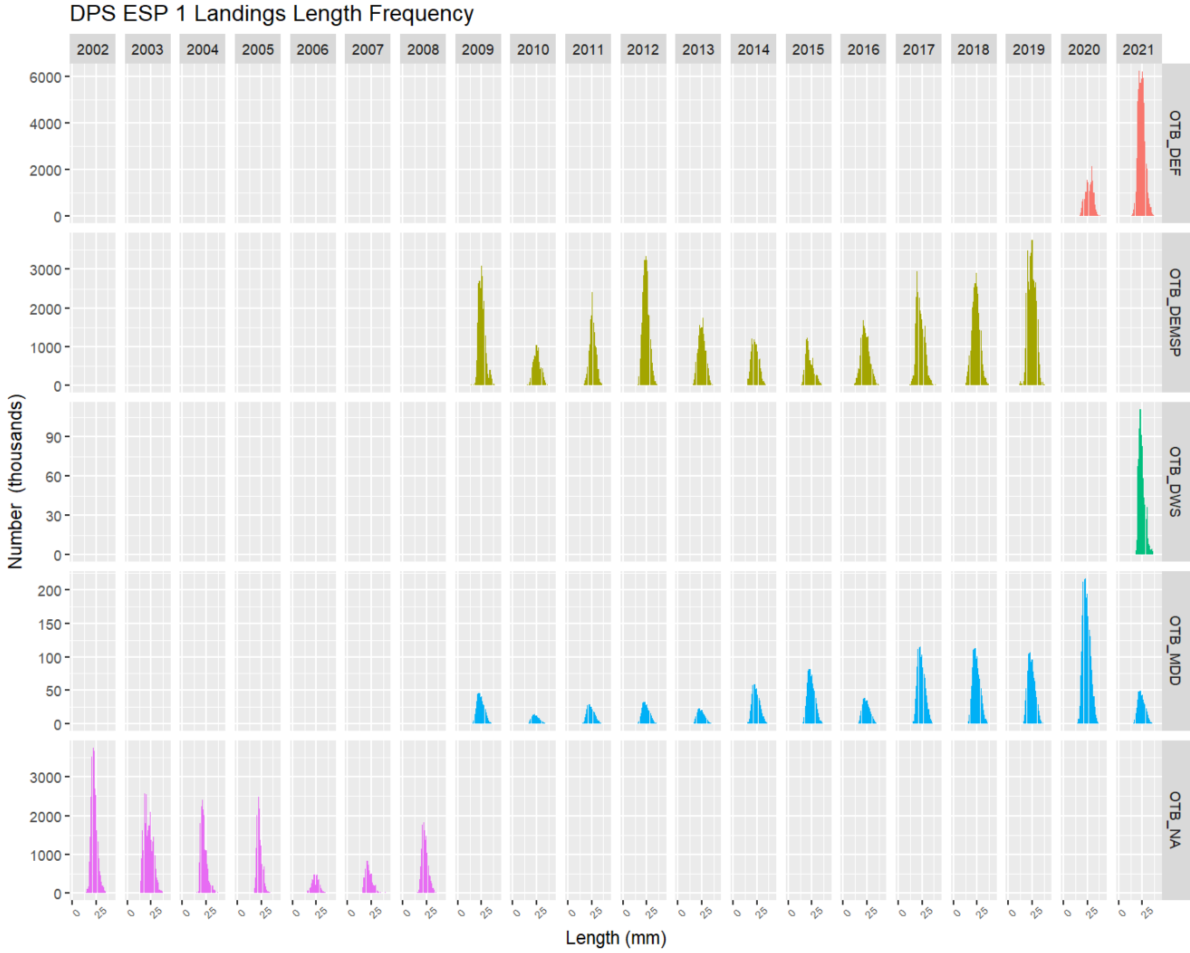


Figure 6.2.1.2.1.3. Deep-water rose shrimp GSA 1. Reconstructed length frequency distribution of the landings by year and fleet in GSA 1.

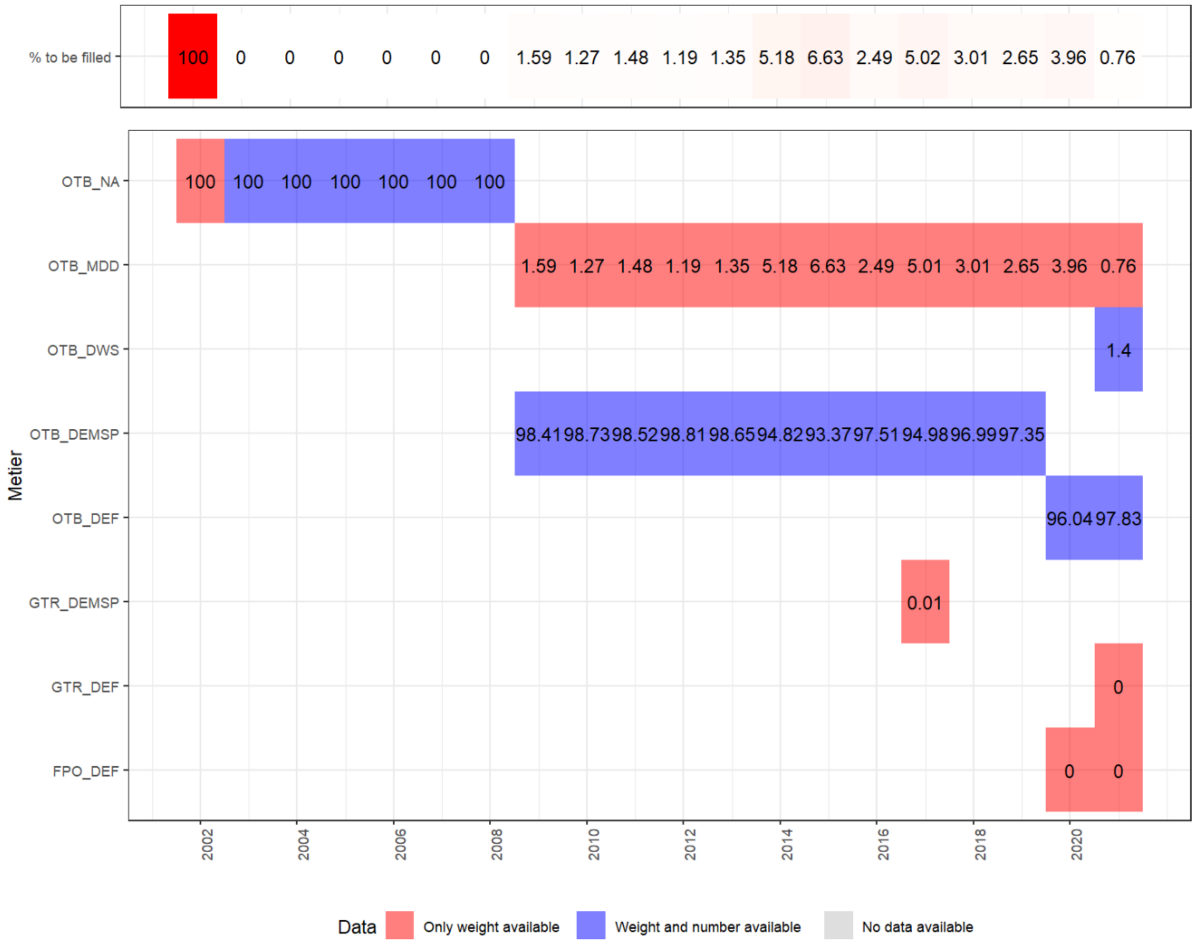


Figure 6.2.1.2.1.4. Deep-water rose shrimp GSA 1. Reconstruction of the length frequency distribution of the landings by year and fleet in GSA 1. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

Discards

Discards data were reported to STECF EWG 22-09 through the DCF. Discard weight was reconstructed using the procedure developed during EWG 21-02. Total discard by fleet and year and the reconstructed discards are presented in table 6.2.1.2.1.3.

Table 6.2.1.2.1.3. Deep-water rose shrimp GSA 1. Official and reconstructed discards data in tonnes by fleet.

Year	OTB	Reconstructed OTB
2002	0	2.27
2003	0	2.03
2004	0	1.28
2005	1.71	1.71
2006	0	0.41
2007	0	0.61
2008	0.55	0.55
2009	1.74	1.74
2010	1.81	1.81
2011	0.38	0.38
2012	1.65	1.65
2013	0.87	0.87
2014	4.25	4.25
2015	1.17	1.17
2016	0.88	0.88
2017	1.71	1.71
2018	0.66	0.66
2019	1.07	1.07
2020	2.00	2.00
2021		0.00

The percentages of the weight of the discards reconstructed are presented in Figure 6.2.1.2.1.5.

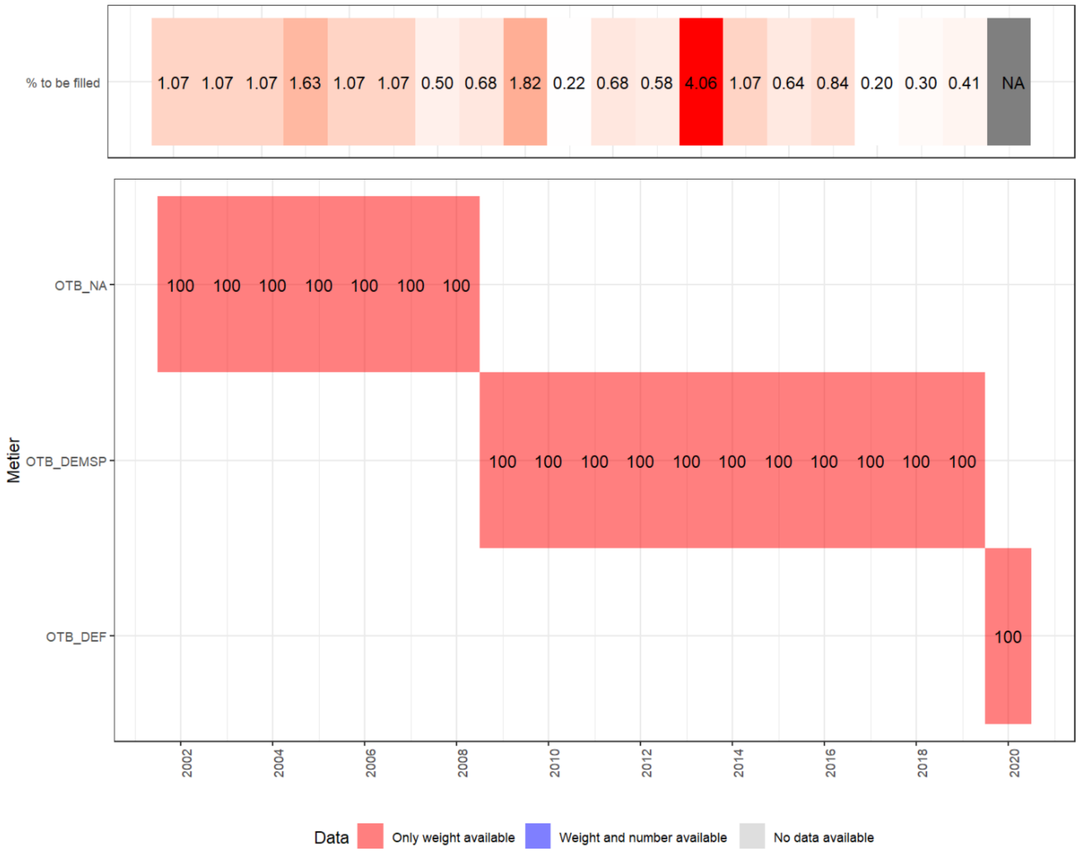


Figure 6.2.1.2.1.5. Deep-water rose shrimp GSA 1. Reconstruction of the the discards by year and fleet in GSA 1. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total catches per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total catches per year.

Discards were included in the stock assessment. Therefore, we will refer to catches as landings plus discards in the rest of the report.

Length frequency distributions of the discards were not in the DCF data.

6.2.1.2.2 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out each year during the spring season with the exception of 2020 when the survey was not carried out at all.

The sampling design of MEDITS is random stratified with number of haul by stratum proportional to stratum surface. Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Hauls noted as valid were used only, including stations with no catches (zero catches are included). Based on the DCF data call, abundance and biomass indices for GSA 1 were re-calculated.

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices for GSA 1 were calculated through stratified means. This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in GSA 1:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area   Ai=area of the i-th stratum

si=standard deviation of the i-th stratum   ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA   Yi=mean of the i-th stratum

Yst=stratified mean abundance   V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that this is a standard approach, and hence assumptions over the distribution of data affect estimates of precision. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial. Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance*100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

Observed abundance and biomass indices of Deep-water rose shrimp and the length frequency distributions are given in the figures below both for GSA 1 (Figures 6.2.1.2.2.1-10).

In GSA 1 the trends in both abundance and biomass have fluctuated throughout the time series; however, in this area a high value is observed in 2018.

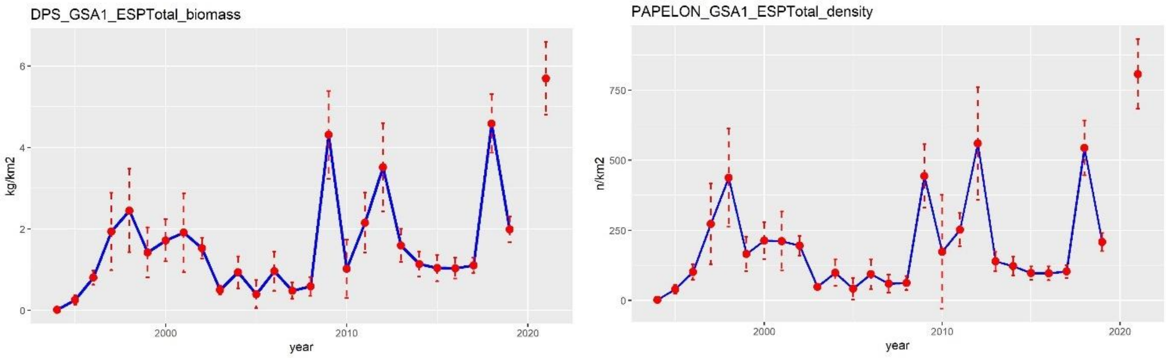


Figure 6.2.1.2.2.1. Deep-water rose shrimp GSA 1. Estimated density (N/km^2) and biomass (kg/km^2) indices in GSA 1.

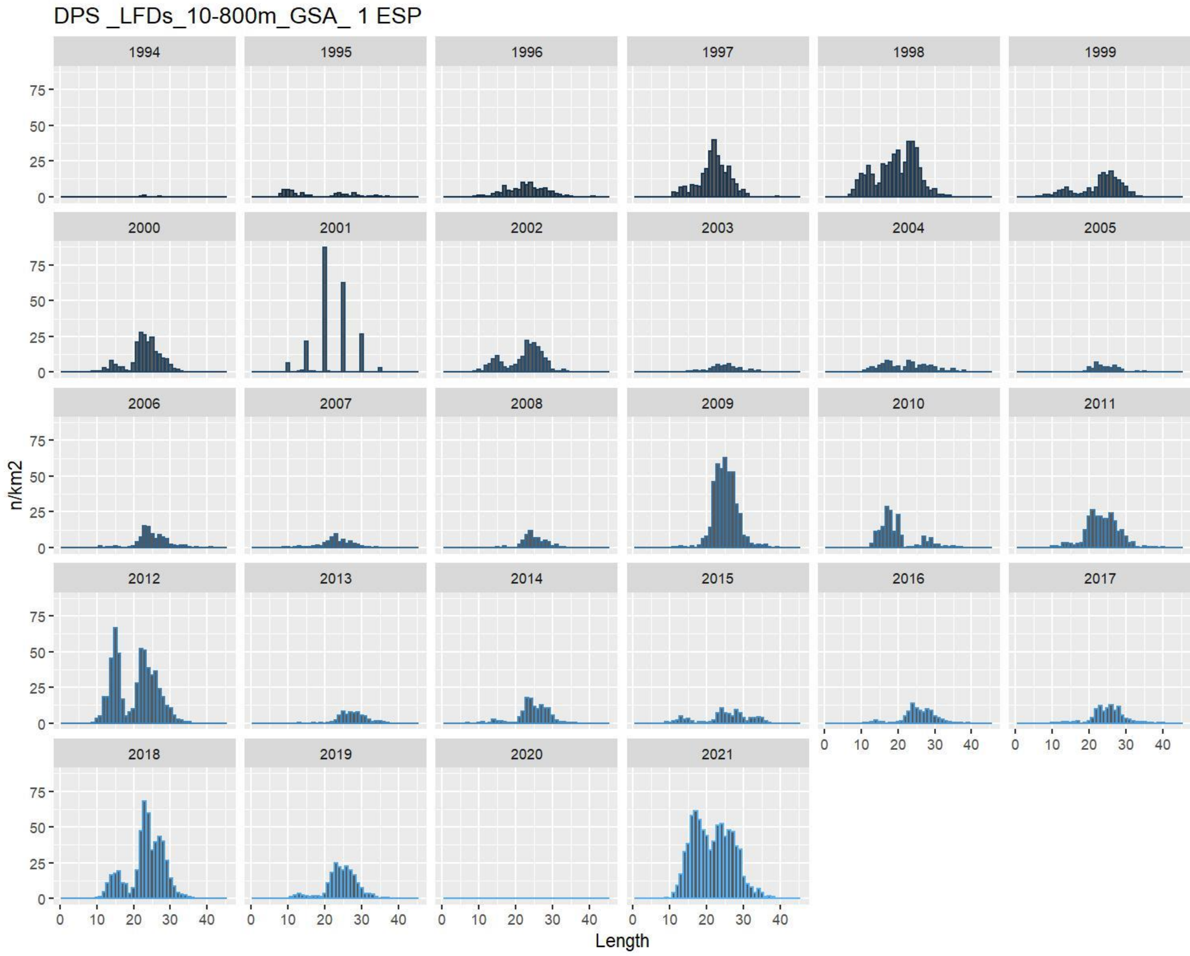


Figure 6.2.1.2.2.2. Deep-water rose shrimp GSA 1. Length frequency distribution by year of MEDITS GSA 1.

The length frequency distributions of the Spanish MEDITS in 2001 are wrong. This issue has been recurring and needs to be fixed.

6.2.1.2.3 STOCK ASSESSMENT

An age based method was used for this stock. a4a is a statistical catch-at-age method that utilize catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike XSA, model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. Data typically used are: catch, statistical sample of age composition of catch and abundance index. Specifically, for Deep-water rose shrimp GSA 1 we used the Assessment for All Initiative (a4a) (Jardim et al., 2015) in FLR environment. The model was fitted using as input data the period 2002-2021 for the catch data (landings + discards) and 2002-2021 for the tuning file where MEDITS in 2020 is missing. Both catch numbers at length and index number at length were sliced using the l2a routine in FLR using the GSA 1 growth parameters reported in table 6.2.1.1.1. Sensitivity analyses has been done for growth parameters derived from DCF. The t0 of the von Bertalanffy was always changed (adding 0.5) in order to account for the assumed spawning time in the middle of the year.

A single tuning fleet was used based on the biomass at age estimates from MEDITS GSA 1.

The analyses were carried out for the ages 0 to 3+. Concerning the Fbar, the age range used was 1-2 age groups.

Input data

The growth parameters used for VBGF were the one reported in table 6.2.1.1.1.

Total catches and catch numbers at age were used as input data. SOP correction was applied to catch numbers at age. Table 6.2.1.3.1 present the SOP correction vector applied. The SOP correction is quite high in 2007, 2015, 2018 and 2020 partly because of missing length frequency distributions in the catches of those years.

Table 6.2.1.3.1. Deep-water rose shrimp GSA 1. SOP correction vector by year.

2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
1.09	1.05	1.05	1.06	1.06	1.24	1.05	1.11	1.12	1.11
2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1.01	1.01	1.1	1.4	1.01	1.02	1.4	1.01	2.35	1.12

Table 6.2.1.3.2 lists the input data for the a4a model, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age, Proportion of M and F before spawning, and the tuning series at age. In the table also the values of 2020 are presented even if they are only used in the sensitivity analysis.

Table 6.2.1.3.2. Deep-water rose shrimp GSA 1. Input data for the a4a model.

Catches (t)

2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
212	189.2	119.4	104.7	38	56.8	109.4	255.7	99.4	171.9
2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
243.2	150	104.7	109.7	137.6	203.5	330.3	355.2	484.9	564.2

Catch numbers-at-age matrix (thousands)

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	25.33	1265.43	21.24	4.9	17.18	7.8	4.98	18.26	16.3	9.66
1	26272.23	21470.28	15825.88	13056.43	3500.75	7463.38	12719.14	20747.28	7378.5	11982.45
2	2762.39	4284.25	1344.88	1333.77	913.99	903.17	1759.05	6037.45	2817.77	5325.89
3	140.84	306.97	207.97	47.16	72.95	59.23	29.24	1005.38	252.41	246.93

age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	2.86	4.56	5.71	157.29	653.7	299.37	909.26	204.51	20.03	162.75
1	24175.15	12073.07	11861.03	13174.18	14075.22	21700.63	33020.61	29451.66	24508.07	56900.61
2	5237.78	4285.75	2141.4	2077.91	2919.51	4654.65	7178.81	10736.42	19686.03	11281.47
3	184.81	244.05	48.57	162.88	343.49	392	569.2	453.33	1550.85	758.97

Weights-at-age (kg)

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1	0.007	0.006	0.006	0.007	0.007	0.006	0.007	0.008	0.008	0.008
2	0.013	0.013	0.014	0.012	0.013	0.013	0.013	0.013	0.014	0.013
3	0.02	0.021	0.021	0.02	0.021	0.024	0.023	0.02	0.02	0.02

age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1	0.007	0.007	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007
2	0.013	0.013	0.013	0.014	0.014	0.013	0.013	0.013	0.014	0.013
3	0.02	0.02	0.02	0.02	0.021	0.02	0.021	0.021	0.02	0.02

Maturity, Natural mortality, proportion of M and F before spawning vectors.

Age	**0**	**1**	**2**	**3+**
Maturity	0.022	1	1	1
M	2.05	1.06	0.57	0.4
Prop M	0.5	0.5	0.5	0.5
Prop F	0.5	0.5	0.5	0.5

Deep-water rose shrimp GSA 1. MEDITS number (n/km^2) at age for GSA 1.

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	34.55	1.48	14.9	0.14	2.87	4.4	0.61	2.23	26.18	13.34
1	135.92	35.03	61.23	33.97	68.25	47.47	47.24	359.21	123.34	195.83
2	22.27	10.1	16.82	6.19	20.14	7.46	14	74.74	16.76	39.58
3	0.87	1.78	5.68	1.23	2.95	0.68	0.31	7.63	2.7	3.38

age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	157.31	0.28	5.77	15.47	4.56	2.99	51.8	11.94	NA	101.96
1	350.59	31.06	85.01	43.07	57.48	69.66	363.74	147.66	NA	581.46
2	50.77	29.07	30.45	29.24	31.95	25.31	96.65	45.61	NA	108.53
3	1.94	4.84	0.96	9.68	2.49	3.07	4.66	3.36	NA	15.68

Figures 6.2.1.3.1-6.2.1.3.2 show the structure of input data (index, catches, mean weight, maturity and natural mortality) by year and age perspective.

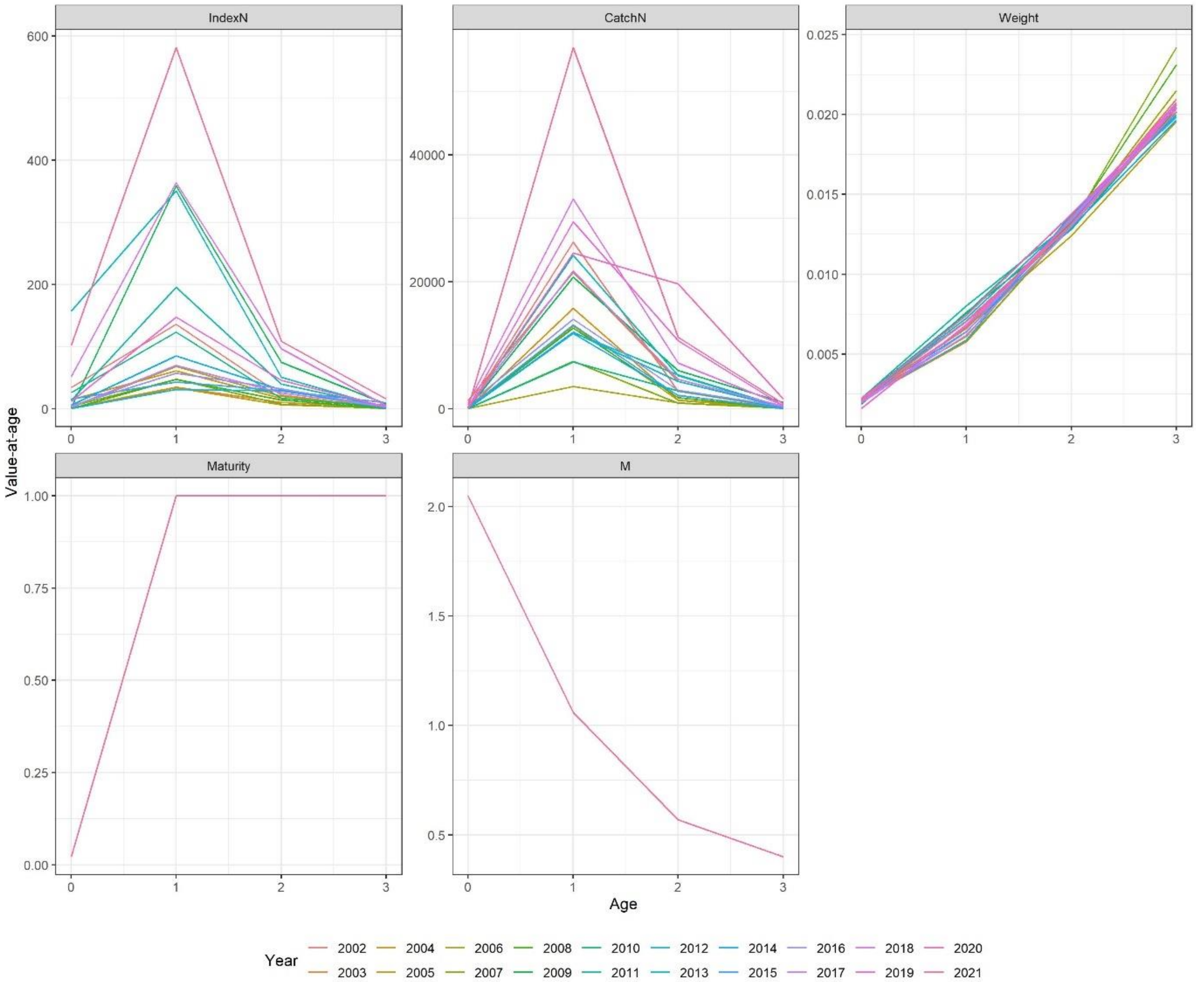


Figure 6.2.1.3.1. Deep-water rose shrimp GSA 1. Structure of input data by year.

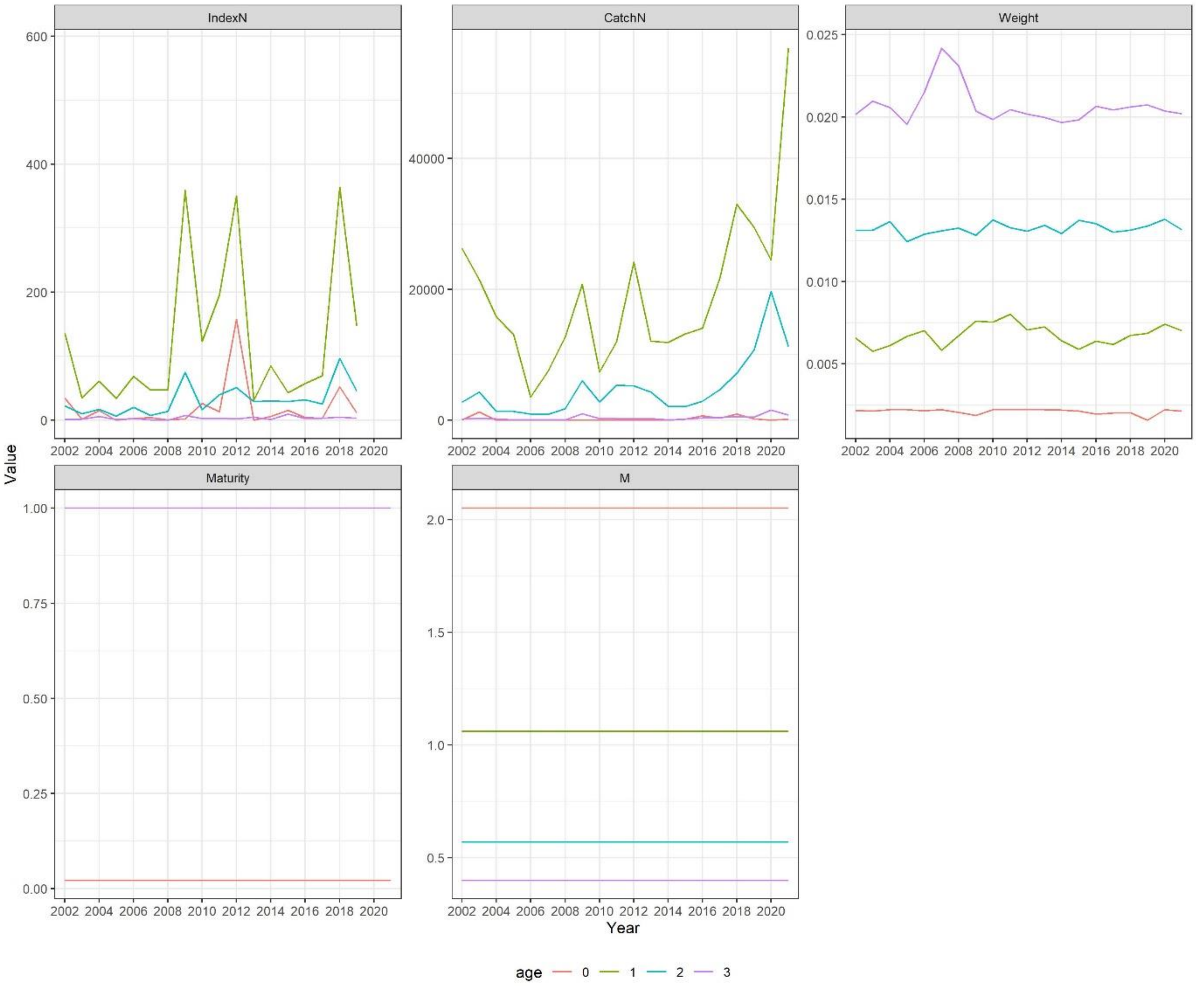


Figure 6.2.1.3.1. Deep-water rose shrimp GSA 1. Structure of input data by age.

Assessment results

Method a4a

Different a4a models were performed (combination of different f, q and sr). The best model (according to residuals and retrospective) included:

f ~ factor(age) + s(year, k = 9)

q ~ list(~ s(replace(age, age> 1, 1), k=3))

sr ~ factor(year)

Results are shown in Figures 6.2.1.3.4-6.2.1.3.10.

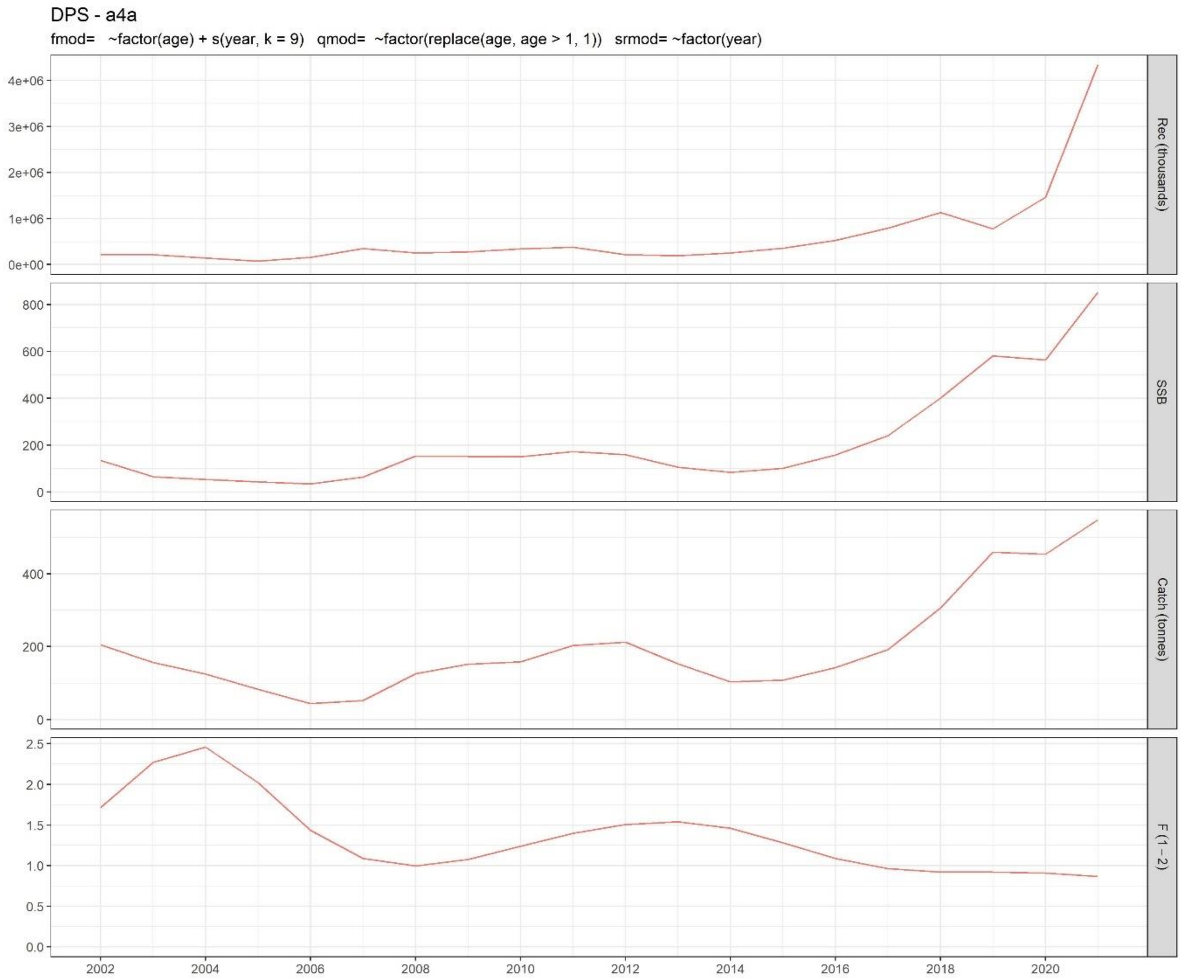


Figure 6.2.1.3.4. Deep-water rose shrimp GSA 1. Stock summary from the a4a model for Deep-water rose shrimp GSA 1 recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 2).

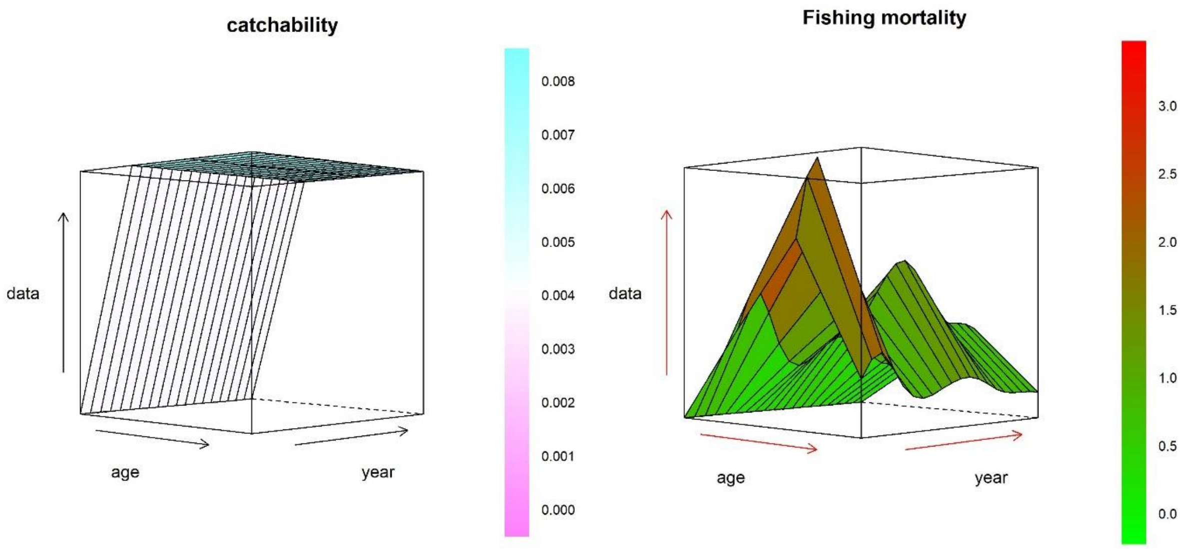


Figure 6.2.1.3.5. Deep-water rose shrimp GSA 1. 3D contour plot of catchability and estimated fishing mortality at age and year.

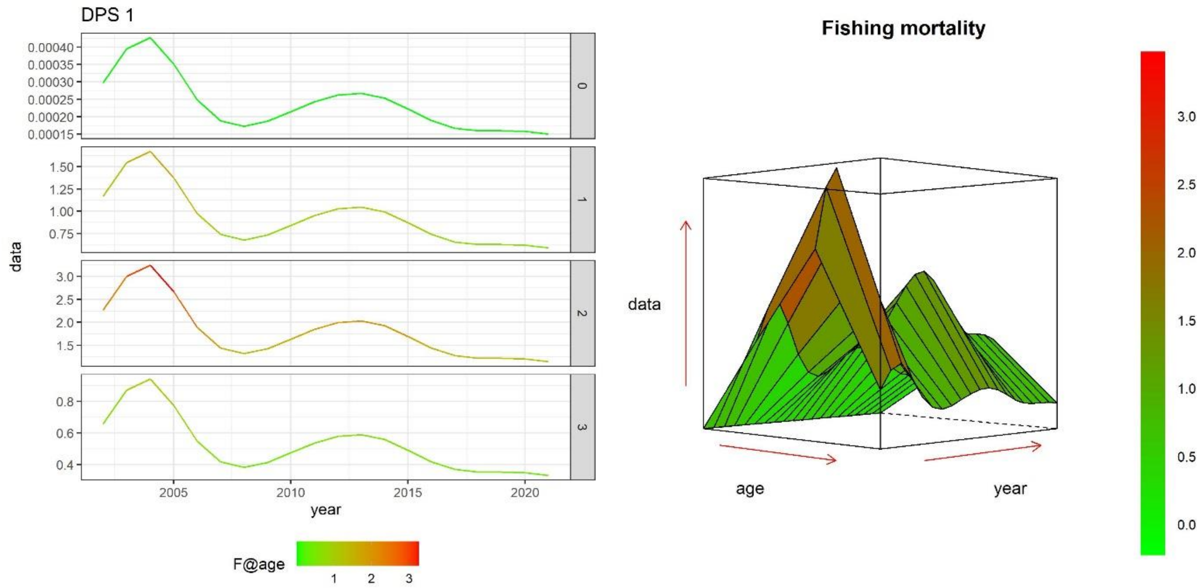


Figure 6.2.1.3.6. Deep-water rose shrimp GSA 1. 3D contour plot and estimated f at age and year.

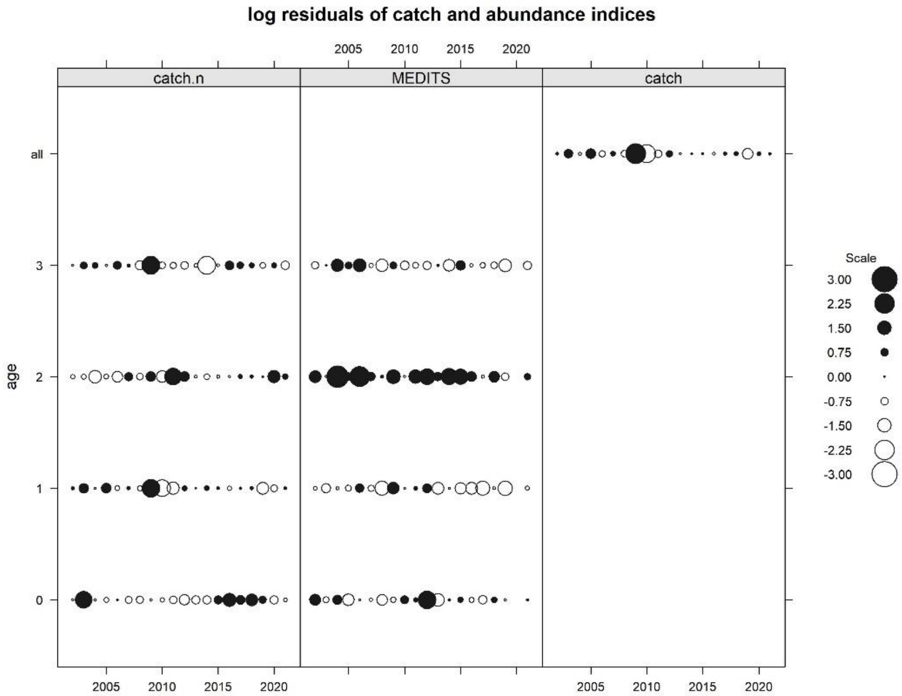


Figure 6.2.1.3.7. Deep-water rose shrimp GSA 1. Bubble plot of the log residuals of catch and abundance indices.

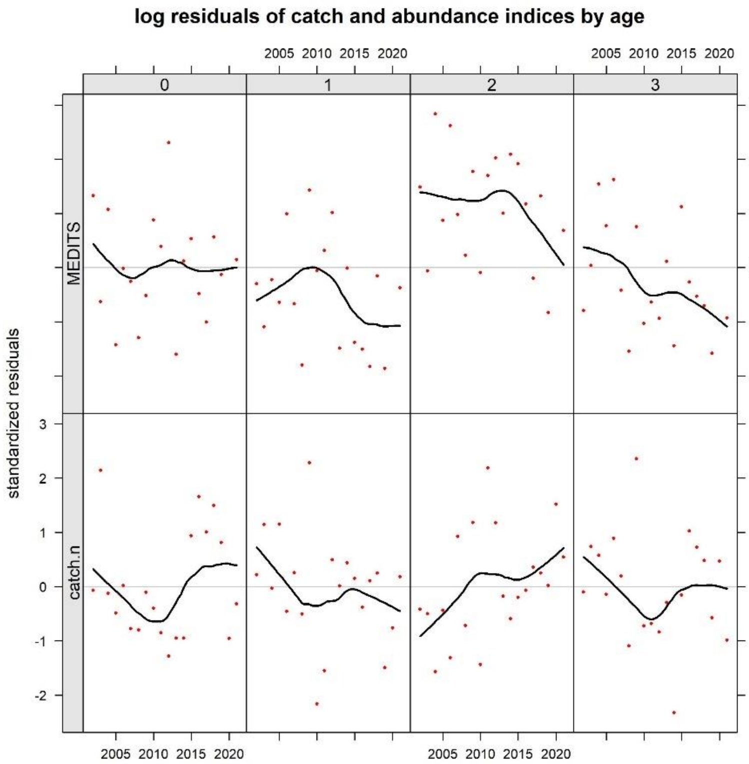


Figure 6.2.1.3.7. Deep-water rose shrimp GSA 1. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class; dots represent standardized residuals and lines simple smoothers.

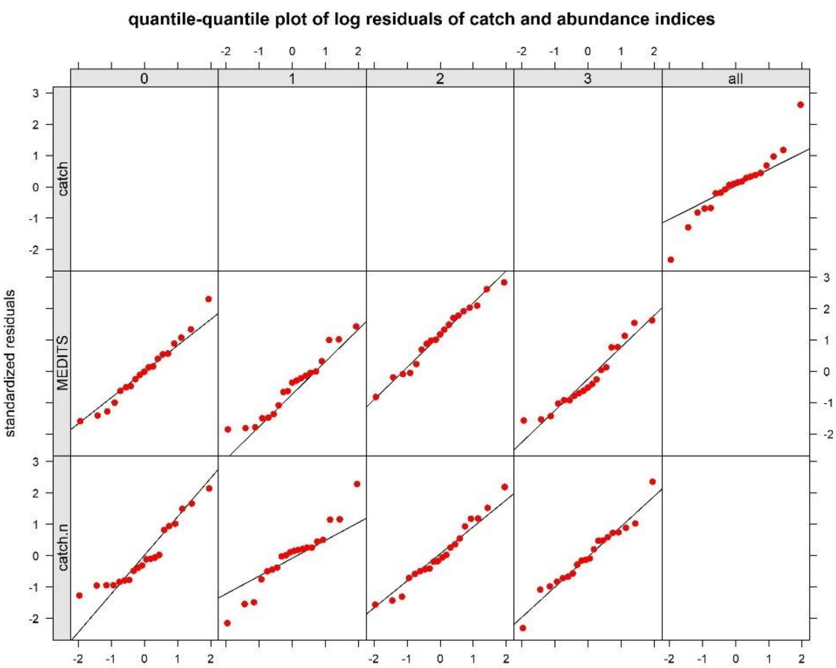


Figure 6.2.1.3.8. Deep-water rose shrimp GSA 1. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class; dots represent standardized residuals and lines the normal distribution quantiles.

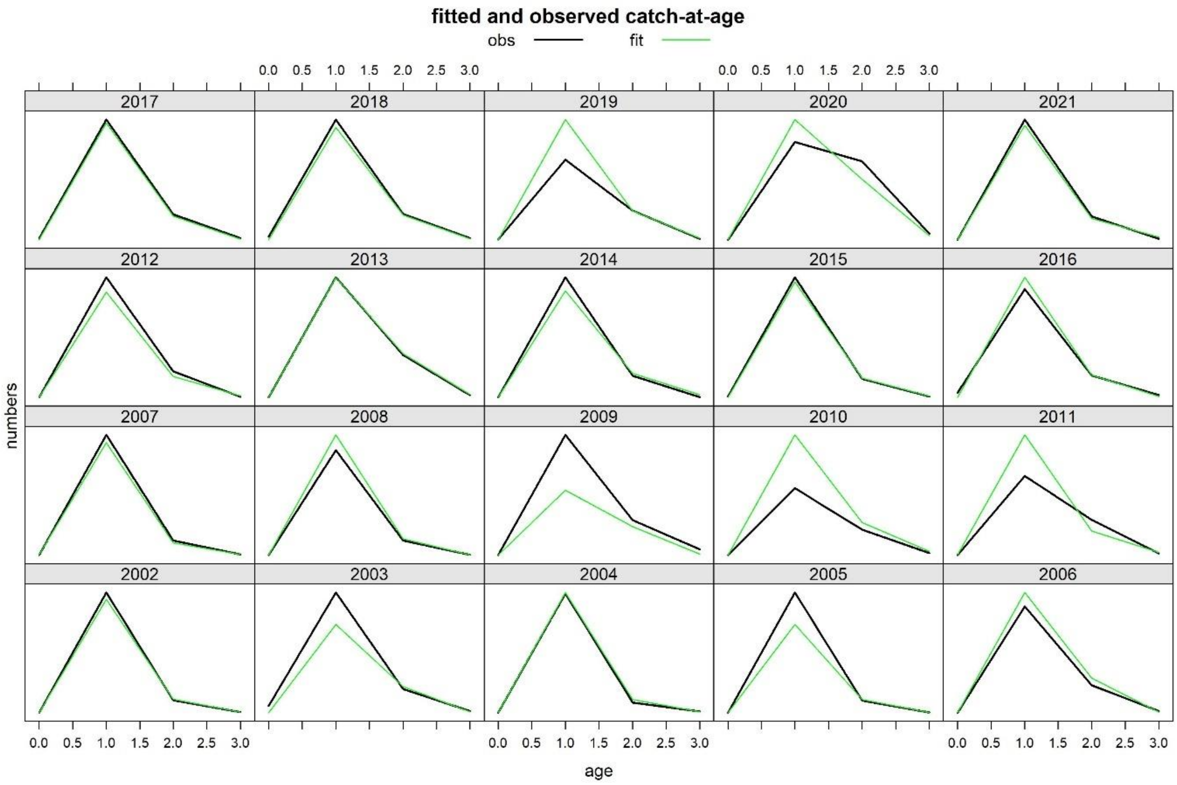


Figure 6.2.1.3.9. Deep-water rose shrimp GSA 1. Fitted and observed catch at age.

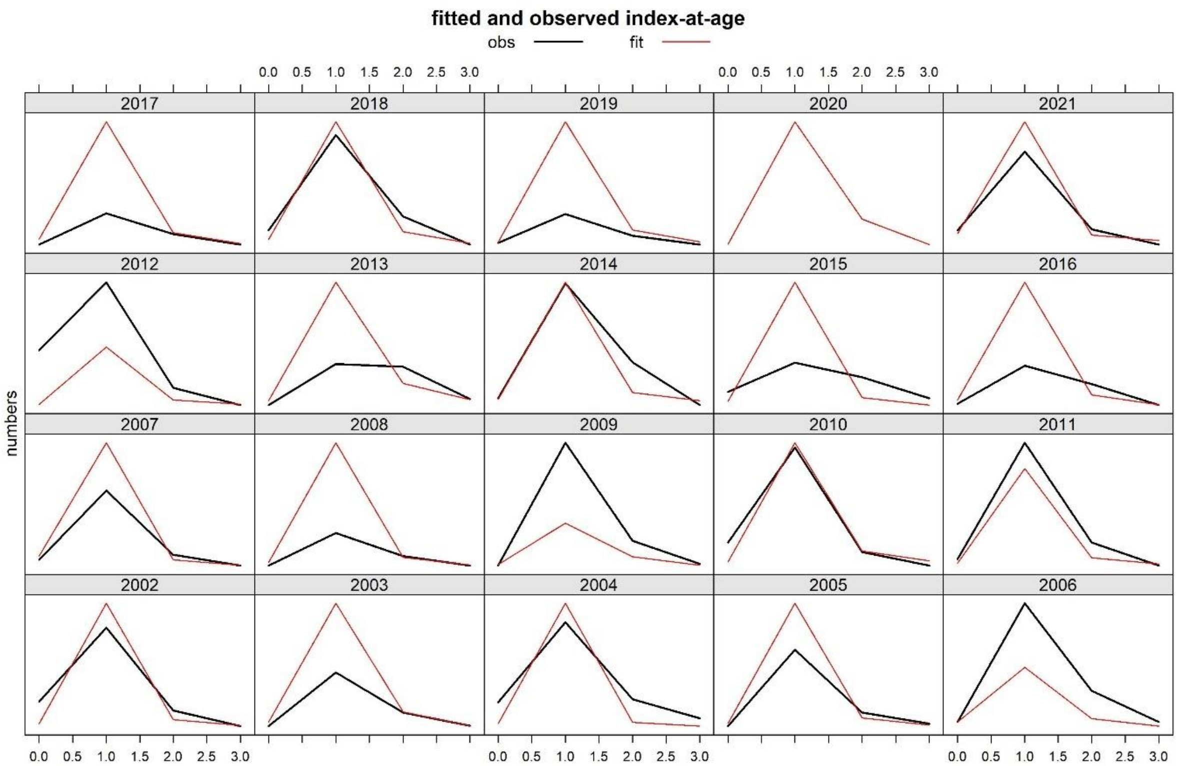


Figure 6.2.1.3.10. Deep-water rose shrimp GSA 1. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 3 years back. Model results stable with the exception of recruitment (Figure 6.2.1.3.12).

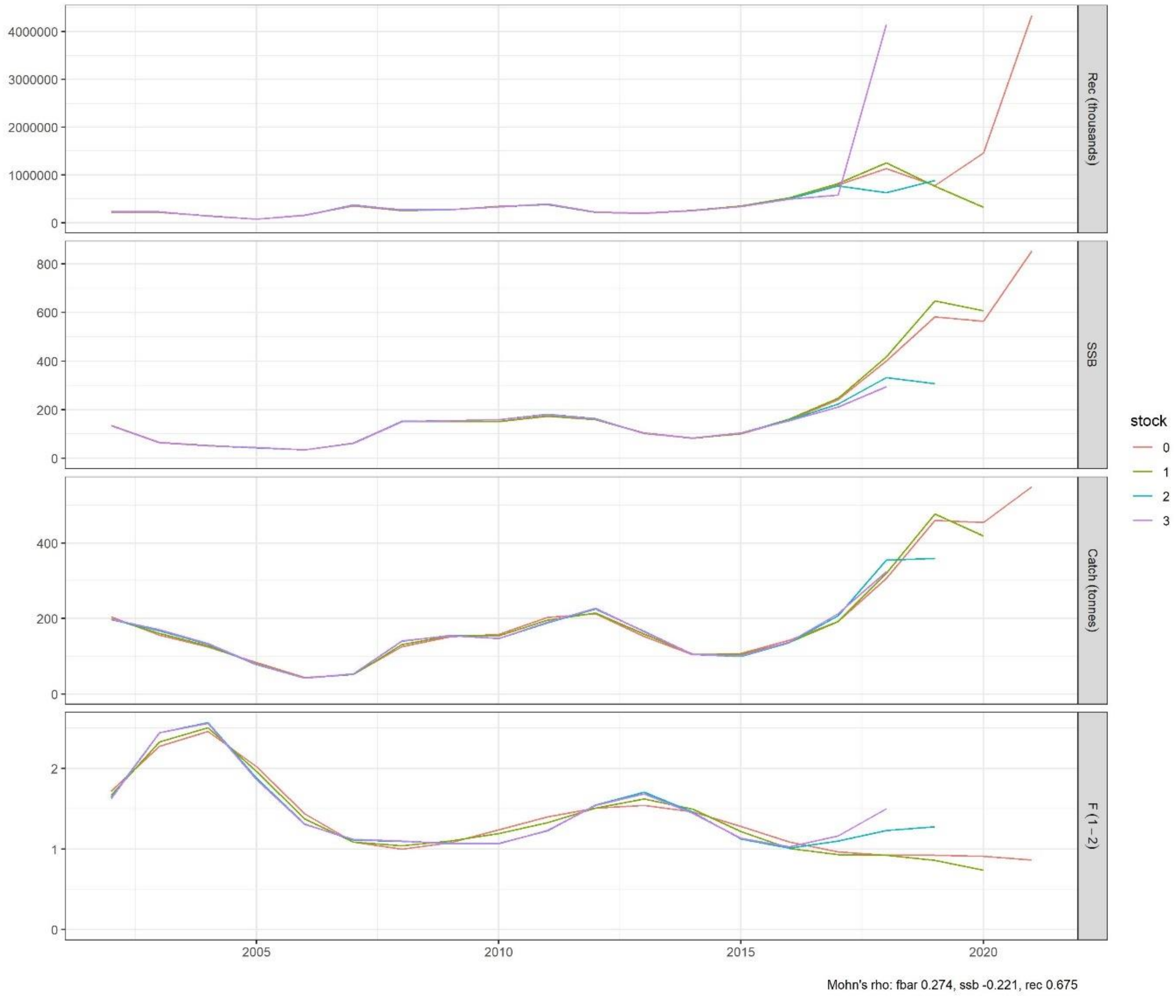


Figure 6.2.1.3.11. Deep-water rose shrimp GSA 1. Retrospective analysis output for the a4a model.

Simulations

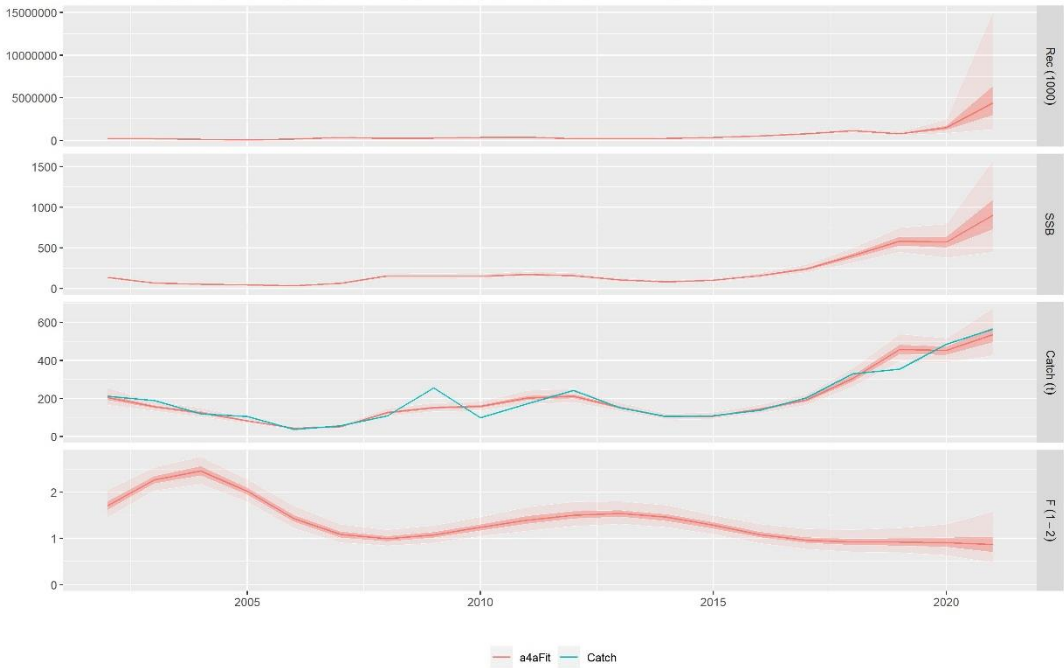


Figure 6.2.1.3.12. Deep-water rose shrimp GSA 1. Stock summary of the simulated and fitted data for the a4a model.

In the tables 6.2.1.3.3 and 4 the population estimates of Deep-water rose shrimp obtained by a4a are provided.

Table 6.2.1.3.3. Deep-water rose shrimp GSA 1. Stock numbers at age (thousands) as estimated by a4a.

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	223099	216836	144529	73851	157930	352195	255649	272873	345416	381951
1	52999	28712	27903	18598	9504	20326	45331	32905	35122	44458
2	3948	5719	2121	1818	1632	1242	3363	7974	5479	5244
3	373	361	262	115	107	180	247	623	1362	1172

age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	214248	194252	255107	353749	523404	791935	1130145	780866	1461545	4337095
1	49159	27574	25000	32833	45530	67368	101933	145466	100509	188122
2	5958	6108	3351	3211	4767	7533	12125	18869	26925	18780
3	928	808	752	564	566	892	1607	2785	4468	6703

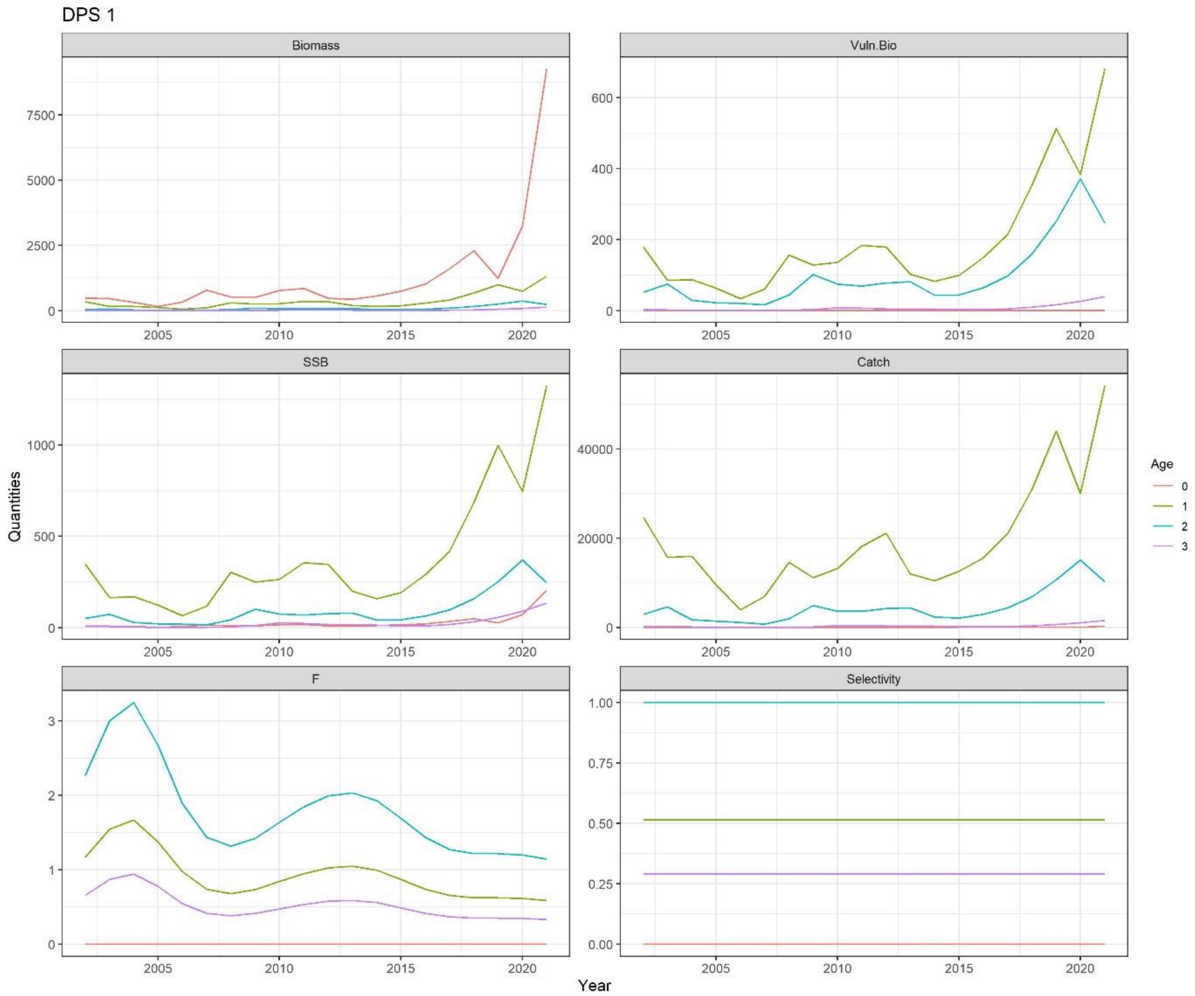


Figure 6.2.1.3.12. Deep-water rose shrimp GSA 1. Summary of trajectories at age for the a4a model.

Based on the a4a results, the Deep-water rose shrimp SSB fluctuated around 100 tons at the beginning of the time series and then increased from 2016 reaching steeply a peak of 852 tons in the last year. The assessment shows a steep increasing trend in the number of recruits in the last six years. The recruitment (age 0) reached a maximum of 4337095 thousand individuals in 2021. F_{bar} (1-2) shows a peak at the beginning of the time series in 2004, but in the last years shows a decreasing trend. However, the values of F at age show extremely high values particularly for age 2 for the first four years and remaining relatively high (between 1.3 and 2.0) until 2016.

Table 6.2.1.3.4. Deep-water rose shrimp GSA 1. a4a summary results and F at age.

	Fbar1-2	Recruitment (thousands)	SSB (t)	TB (t)	Catch (t)
2002	1.72	223099	135	897	205
2003	2.27	216836	65	711	156
2004	2.46	144529	53	527	125
2005	2.02	73851	44	314	83
2006	1.43	157930	34	430	43
2007	1.09	352195	63	925	52
2008	1	255649	153	878	126
2009	1.08	272873	152	875	152
2010	1.24	345416	151	1137	158
2011	1.4	381951	173	1302	203
2012	1.51	214248	159	921	213
2013	1.54	194252	105	731	153
2014	1.46	255107	83	781	104
2015	1.28	353749	101	1003	108
2016	1.09	523404	158	1385	143
2017	0.96	791935	241	2136	192
2018	0.92	1130145	401	3175	307
2019	0.92	780866	582	2545	460
2020	0.91	1461545	564	4457	455
2021	0.87	4337095	852	10967	549

F at age	0	1	2	3+
2002	0.0003	1.1665	2.2662	0.6579
2003	0.0004	1.5454	3.0022	0.8716
2004	0.0004	1.6712	3.2466	0.9426
2005	0.0004	1.3734	2.6681	0.7746
2006	0.0002	0.9748	1.8937	0.5498
2007	0.0002	0.7391	1.4358	0.4168
2008	0.0002	0.6779	1.3169	0.3823
2009	0.0002	0.7327	1.4234	0.4133
2010	0.0002	0.8418	1.6353	0.4748
2011	0.0002	0.9499	1.8453	0.5357
2012	0.0003	1.0255	1.9922	0.5784
2013	0.0003	1.0475	2.035	0.5908
2014	0.0003	0.9924	1.9278	0.5597
2015	0.0002	0.8698	1.6898	0.4906
2016	0.0002	0.7391	1.4359	0.4169
2017	0.0002	0.6549	1.2722	0.3694
2018	0.0002	0.6268	1.2177	0.3535
2019	0.0002	0.6269	1.2178	0.3536
2020	0.0002	0.6174	1.1995	0.3483
2021	0.0002	0.5882	1.1427	0.3318

All the diagnostics from the a4a assessment were considered acceptable although survey data residuals are high for age 2 showing a negative trend.
The model poor fit data in some years. Further, model uncertainty was particularly high in the last years. The values of F at age show extremely high values for age 2.
From the retrospective analysis model results relatively stable with the exception of recruitment. This is the first year that an assessment has been accepted for this stock, as it is similar to the assessment for this area last year it is considered that it is preferable to give advice based on this assessment rather than use a biomass index method used in 2021 (see Section 6.2.1.5).

6.2.1.3 Reference Points

The assessment is new. As this is a new assessment no biomass reference points are calculated though F_{MSY} is estimated. The STECF EWG 18-02 recommended using $F_{0.1}$ as a proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ = 0.99 from the stock object resulting from the outputs of the a4a assessment.

Current F (0.87, corresponding to the F of the last year of the time series) is 13% below $F_{0.1}$ (0.99), chosen as a proxy for F_{MSY} and as the exploitation reference point consistent with high long-term yields. This indicates that deepwater rose shrimp in GSA 1 is being exploited within MSY limits and below F_{MSY}.

6.2.1.4 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the stock assessment.

The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} = 0.87 terminal F (2021) from the a4a assessment was used for F in 2022. Recruitment is observed to be fluctutating at the beginning of the time series but peak in the last years, therefore a mean across last 3 years is used as an estimate of recruits from 2022 (recruitment 2193169 thousands).

Table 6.2.1.5.1 Deep-water rose shrimp GSA 1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2019-2021	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}2}$ (2022)	0.87	F 2021 used to give F status quo for 2022
$F_{ages\ 1\text{-}2}$ (2019)	0.92	MAP base year fishing mortality from current assessment
SSB (2022)	2074.2	Stock assessment 1 January 2022
R_{age0} (2022,2023)	2193169 (thousands)	mean of last 3 years
Total catch (2022)	1441.1	Assuming F status quo for 2022

The short term forecast was carried out estimating a catch for 2021-2023 on the basis of a recruitment hypothesis constant and equal to the mean of last 3 years and an F by age equal to that of the terminal year. These assumptions resulted in a catch and a SSB in 2021 equal to 549 and 852 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.99) would reduce biomass by 31% from 2022 to 2024, while increasing catches by 181% from 2021 to 2023.

Table 6.21.5.2 Deep-water rose shrimp GSA 1: Short term forecast table for red mullet in GSA 9.

Rationale	Ffactor	Fbar	Catch 2022	Catch 2023	SSB* 2022	SSB* 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield ($F_{0.1}$)	1.142189	0.988517	1441.09	1543.272	2074.191	1430.473	-31.0346	181.1825
F upper	1.550286	1.341708	1441.09	1852.401	2074.191	1130.239	-45.5094	237.5054
F lower	0.757517	0.6556	1441.09	1161.72	2074.191	1841.534	-11.2168	111.6642
F_{MSY} transition	1.116703	0.96646	1441.09	1521.037	2074.191	1453.228	-29.9376	177.1313
Zero catch	0	0	1441.09	0	2074.191	3328.579	60.47605	-100
Status quo	1	0.865459	1441.09	1414.093	2074.191	1564.786	-24.5592	157.6462
Different Scenarios	0.1	0.086546	1441.09	195.7792	2074.191	3056.179	47.34319	-64.3292
	0.2	0.173092	1441.09	376.3628	2074.191	2812.167	35.57899	-31.4271
	0.3	0.259638	1441.09	543.1279	2074.191	2593.329	25.0285	-1.04267
	0.4	0.346183	1441.09	697.3169	2074.191	2396.826	15.55476	27.05039
	0.5	0.432729	1441.09	840.0505	2074.191	2220.146	7.036725	53.05631
	0.6	0.519275	1441.09	972.341	2074.191	2061.069	-0.63262	77.1595
	0.7	0.605821	1441.09	1095.103	2074.191	1917.633	-7.54791	99.52656
	0.8	0.692367	1441.09	1209.162	2074.191	1788.101	-13.7928	120.3081
	0.9	0.778913	1441.09	1315.267	2074.191	1670.938	-19.4414	139.6402
	1.1	0.952004	1441.09	1506.253	2074.191	1468.441	-29.2042	174.4378
	1.2	1.03855	1441.09	1592.303	2074.191	1380.839	-33.4276	190.1159
	1.3	1.125096	1441.09	1672.745	2074.191	1301.038	-37.2749	204.7723
	1.4	1.211642	1441.09	1748.036	2074.191	1228.202	-40.7864	218.4903
	1.5	1.298188	1441.09	1818.591	2074.191	1161.592	-43.9978	231.3453
	1.6	1.384734	1441.09	1884.786	2074.191	1100.552	-46.9407	243.406
	1.7	1.471279	1441.09	1946.964	2074.191	1044.501	-49.643	254.7348
	1.8	1.557825	1441.09	2005.437	2074.191	992.9224	-52.1296	265.3885
	1.9	1.644371	1441.09	2060.488	2074.191	945.3595	-54.4227	275.4188
	2	1.730917	1441.09	2112.377	2074.191	901.4058	-56.5418	284.8729

*SSB at mid year

EWG advises that when the MSY approach is applied, catches in 2023 should be no more than 1543.2 tonnes.

6.2.1.5 Data Deficiencies

Data from DCF 2021 as submitted through the Official data call in 2021 were used.

MEDITS 2020 was not performed in GSA 1 in 2020. Further the length frequency distributions in the Spanish MEDITS for 2001 should be checked thoroughly because are considered to be wrong.

In GSA 1, length frequency distributions of the discards were not available.

Catch length data in 2021 showed an unreliable peak of abundance for the metier OTB_DWS.

Deep-water rose shrimp in GSAs 1, 5, 6, & 7 were assessed as two biological units in 2022

6.2.2 Deep-water rose shrimp in GSAs 5, 6 & 7

6.2.2.1 Stock Identity and Biology

The deep-water rose shrimp stock in Spanish and France waters (GSA1,5,6 and 7) has been already investigated in the previous years as stock jointed or split by GSAs. The main findings during those recent working groups suggested considering two main stock units: GSA1 alone and GSA5, 6 and 7 combined based mainly on similar dynamics in the combined areas. (https://stecf.jrc.ec.europa.eu/documents/43805/5780344/STECF+21-11++Stock+assess+west+MED.pdf/f22d3551-6e71-4b63-bb19-5afef7e07863)

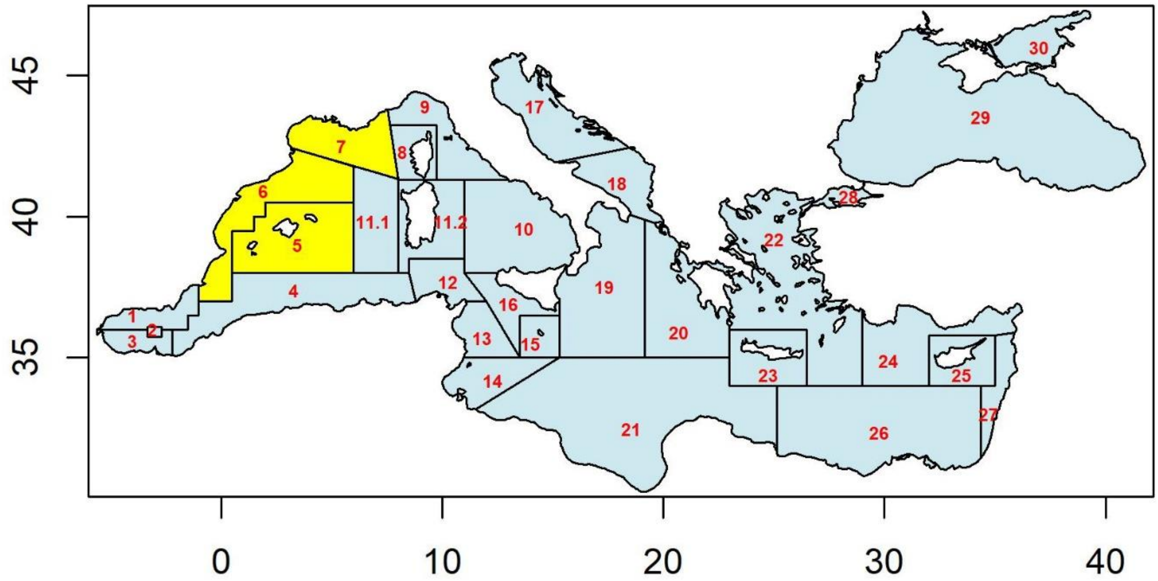


Figure 6.2.2.1 Deep-water rose shrimp in GSAs 5, 6 & 7: Location of the GSAs 5, 6 and 7 in the Mediterranean Sea.

Growth

Sex combined von Bertalanffy growth parameters and length weight relationships of deep-water rose shrimp were available both for GSA5 and GSA6 from 2002 to 2019 (Figure 6.2.2.2-6) from DCF data. No data by sex were available in both areas.

For the aim of the stock assessment a set of values by GSA given by the median along the years has been used (Table 6.2.1.1).

Table 6.2.2.1 Deep-water rose shrimp in GSAs 5, 6 & 7: Von Bertalnaffy growth and length weight relationships parameters used in the assessment.

Area	L∞	K	t0	a	b
GSA5	45	0.71	-0.14	0.002624	2.53
GSA6	45	0.71	-0.08	0.002624	2.53

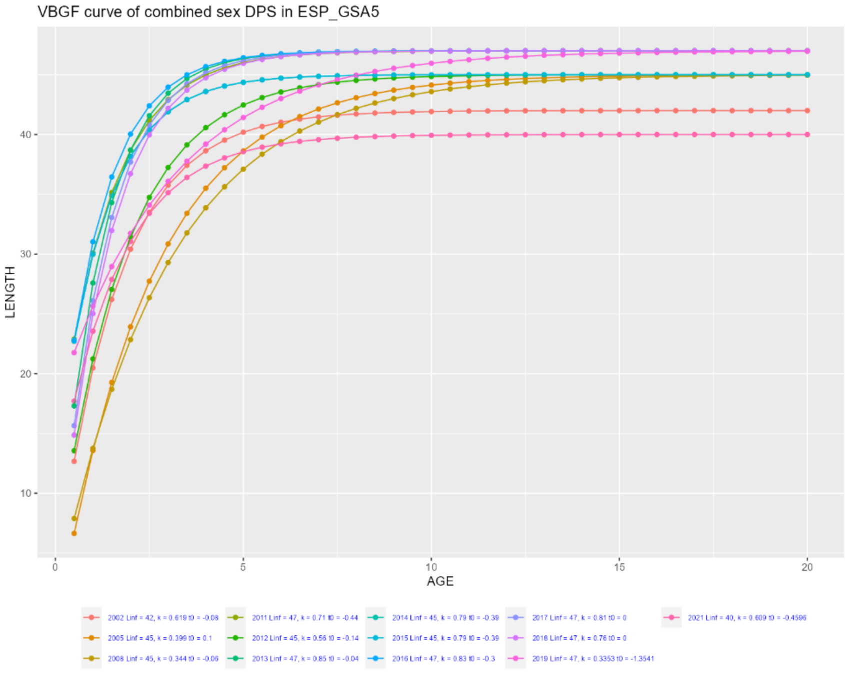


Figure 6.2.2.2 Deep-water rose shrimp in GSAs 5, 6 & 7: Estimated growth curves of sex combined deep-water rose shrimp in GSA 5.

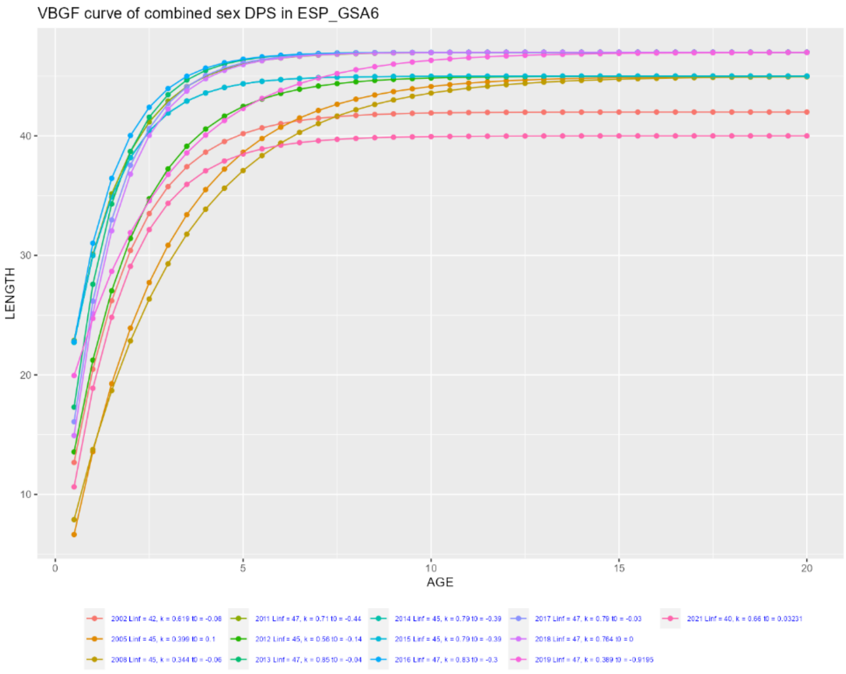


Figure 6.2.2.3 Deep-water rose shrimp in GSAs 5, 6 & 7: Estimated growth curves of sex combined deep-water rose shrimp in GSA 6.

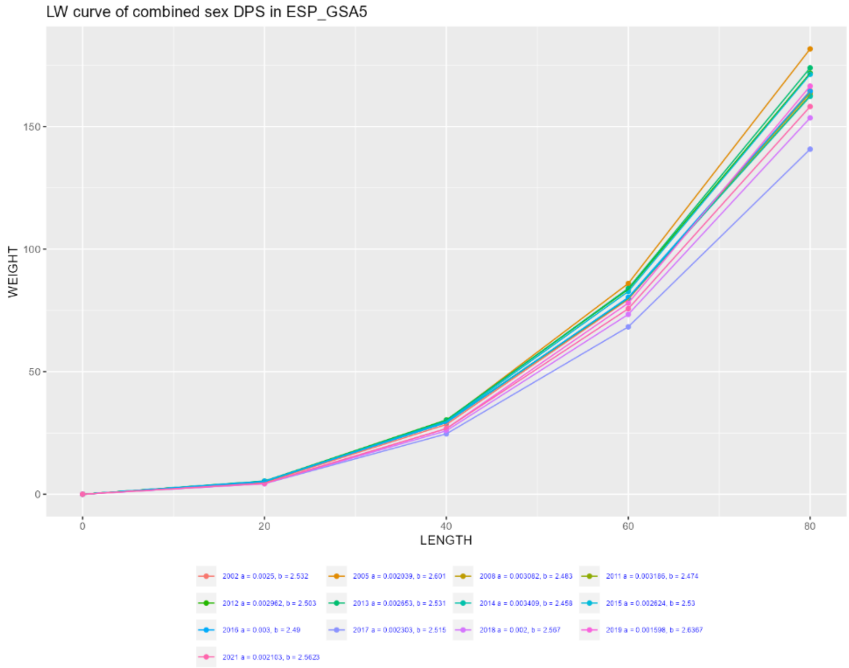


Figure 6.2.2.4 Deep-water rose shrimp in GSAs 5, 6 & 7: Length weight relationships of sex combined deep-water rose shrimp in GSA 5

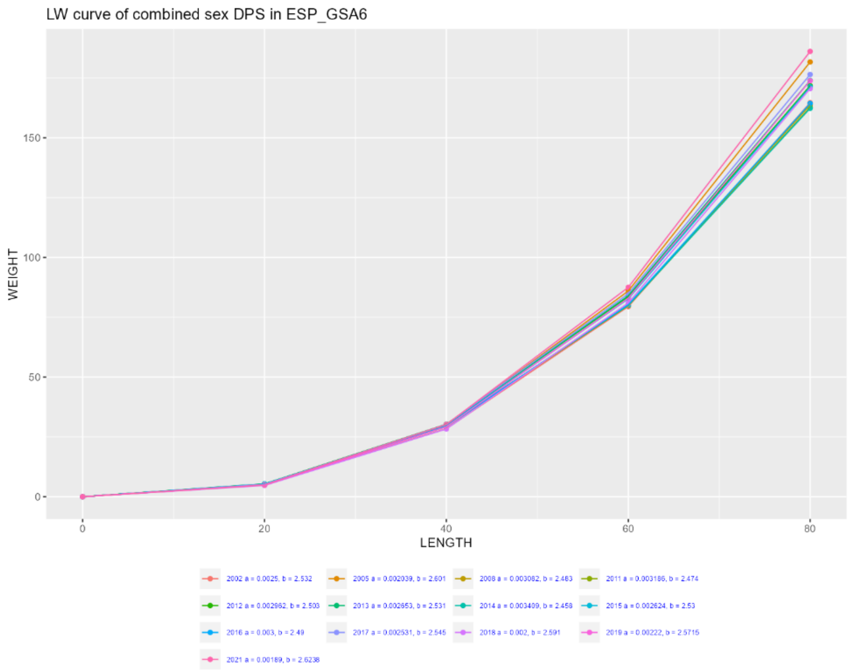


Figure 6.2.2.5 Deep-water rose shrimp in GSAs 5, 6 & 7: Length weight relationships of sex combined deep-water rose shrimp in GSA 6.

According to the maturity information available (see Maturity section below) this species seems able to spawn all along the year having the main peak in the Summer period (see Figure 6.2.2.9).

Based on this findings the values of fishing and natural mortality values before spawning have been set as 0.5.

Using the von Bertalanffy growth parameters in Table 6.2.2.1 the biological length at age0-age1 transition have been re-estimated being the DCF data provided with data on calendar year basis which are not in agreement with the assessment parametrization of the age0-age1 transtion on 31st December year n – 1st January year n+1 having set the spawning period in the middle of the year. On the basis of the discussions, the EWG 22-09 agreed to shift the length slicing by adding a value of 0.5 to the t0 value to assign the ages to calendar year correctly. In table 6.2.2.2 and in figure 6.2.2.6-8 the basis of this choice are illustrated.

Table 6.2.2.2 Deep-water rose shrimp in GSAs 5, 6 & 7: Length at transtion between age0-age1 on biological and calendar ("assessment") basis.

Area	Mean length at the end of the calendar year	Mean length at the end of the biological year
GSA5	16.43	24.56
GSA6	15.18	24.09

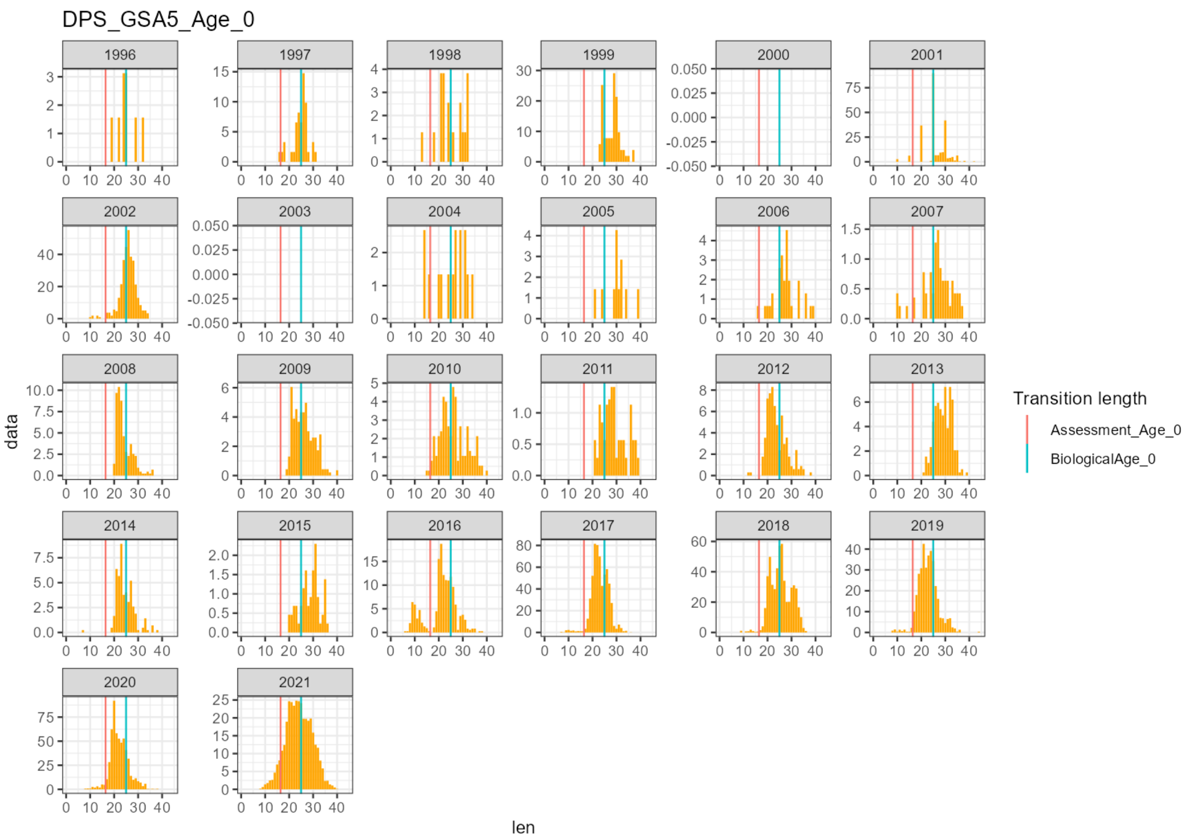


Figure 6.2.2.6 Deep-water rose shrimp in GSAs 5, 6 & 7: Commercial length frequency distributions from GSA5 overlapped with the length at Age0 at the end of the year (red line) and the one at the end of biological first year of life (blue line)

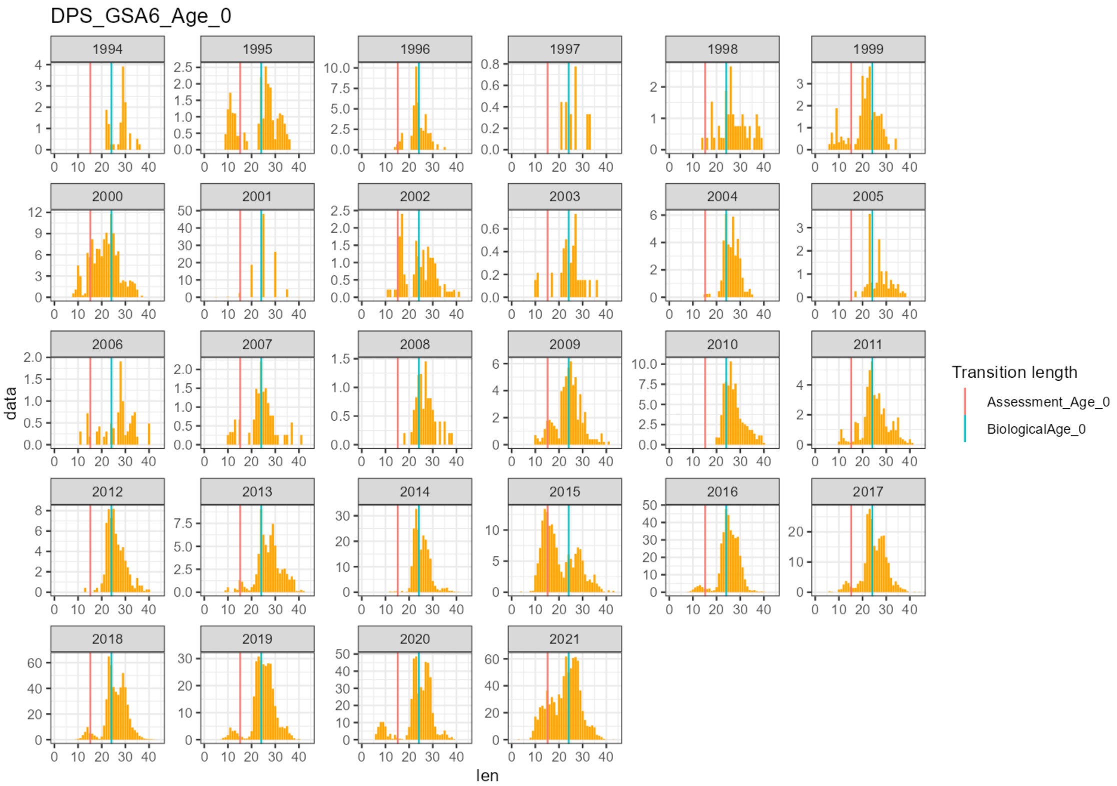


Figure 6.2.2.7 Deep-water rose shrimp in GSAs 5, 6 & 7: Commercial length frequency distributions from GSA6 overlapped with the length at Age0 at the end of the year (red line) and the one at the end of biological first year of life (blue line)

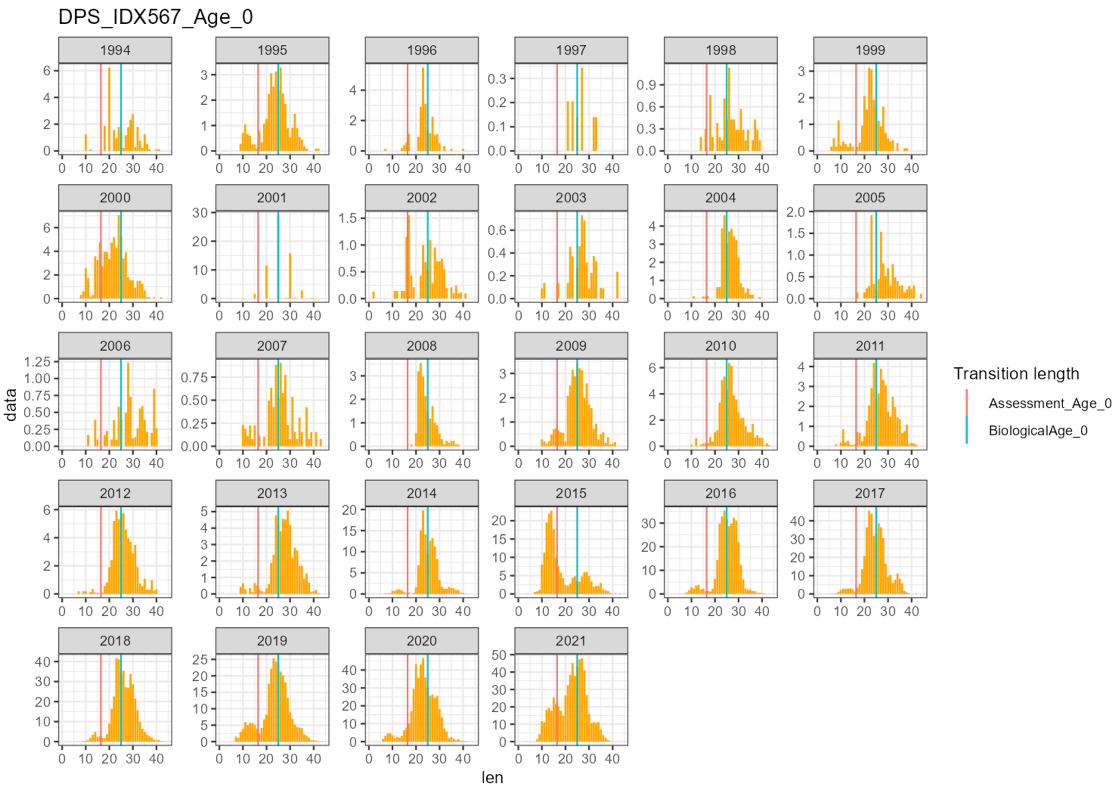


Figure 6.2.2.8 Deep-water rose shrimp in GSAs 5, 6 & 7: Standardized survey length frequency distributions from GSA5,6 and 7 overlapped with the length at Age0 at the end of the year (red line) and the one at the end of biological first year of life (blue line)

Natural mortality

Natural mortality (M) was estimated according to Chen and Watanabe model (1989) on the age vector at half year (0.5, 1.5, 2.5,…) using the orginal growth parameters, without the adjustement of the t0 (Table 6.2.2.3). The natural mortality vectors by GSAs have been weighted by catch number at age by GSA when the final combined stock object has been set (see section assessment).

Table 6.2.2.3 Deep-water rose shrimp in GSAs 5, 6 & 7: Natural mortality vector applied by GSAs

Age	GSA5	GSA6
0	1.94429	2.10343
1	1.03214	1.05293
2	0.83870	0.84536
3+	0.76793	0.77607

Maturity

In literature this species is reported as to be able in spawning all along the year (see Figure 6.2.2.9). However the main reproductive period seems to be in the middle Summer. Based on these considerations the EWG agreed in setting the natural and fishing before spawning values as 0.5.

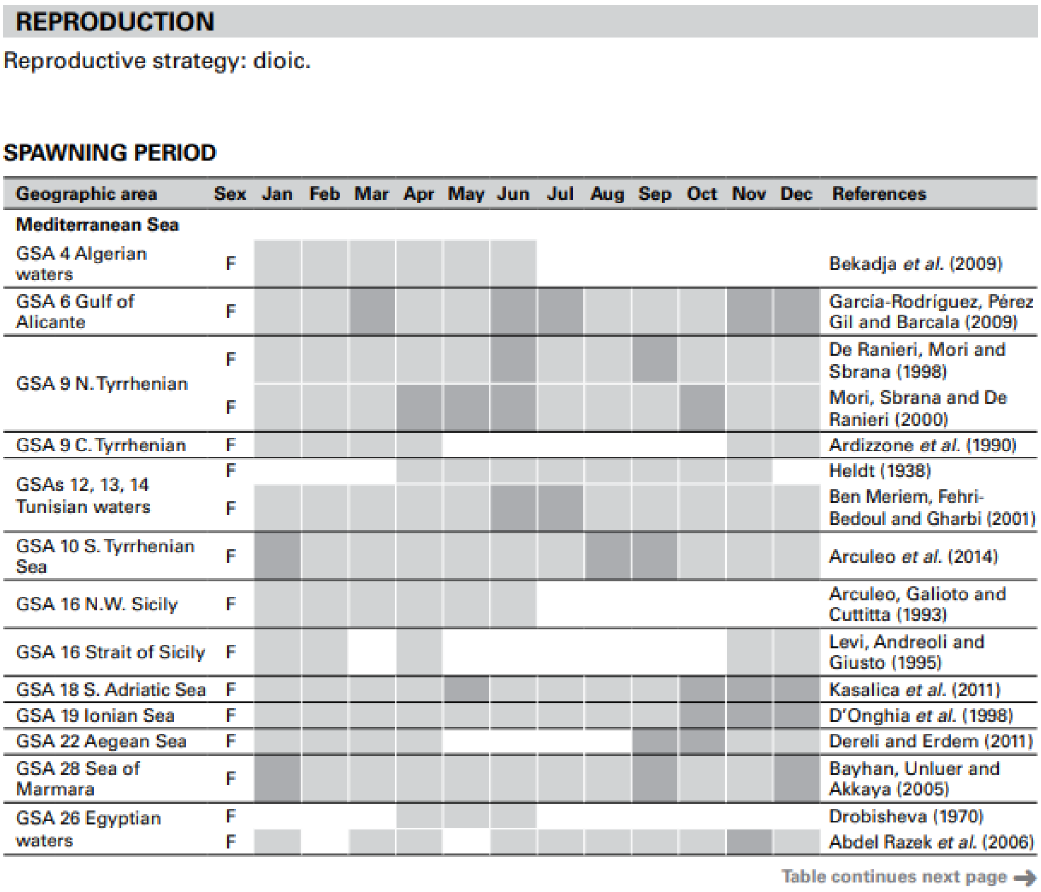


Figure 6.2.2.9 Deep-water rose shrimp in GSAs 5, 6 & 7: Spawning periods as reported in the Mediterranean areas.

Maturity ogives by age weren't available in the DCF data for any of the 3 GSAs. So, the vector of matures by year and age have been derived from the maturity length vectors available in GSA5 and 6 (Figures 6.2.2.9-10). The VBGF parameters (having included the t0+0.5 corrections) have been used to derive the corresponding age at length. The final vector has been derived by GSA as mean of the values obtained by age weighted for the number of samples by age. Table 6.2.2.4 shows the two final vectors by GSA and age. The proportion of fully mature in the GSA6 plus group didn't reach the maximum (due to the difference in the maturation stage in the length/samples available in the older ages / bigger sizes). However, the EWG agreed in setting the maturity level in the plus group as 1 matching the level observed in GSA 5 in the final input stock object used in fitting the final model.

Table 6.2.2.4 Deep-water rose shrimp in GSAs 5, 6 & 7: Maturity at age vector applied by GSAs

Age	GSA5	GSA6
0	0	0
1	0.5	0.5
2	0.8	0.8
3+	1	0.9

6.2.2.2 Data

6.2.2.2.1 Catch (landings and discards)

In GSA5, GSA6 and GSA7 the main spanish fleets targeting the deep-water rose shrimps are the bottom otter trawlers (OTB) while in GSA7 even if the OTB still target this species, the main french fleet fishing the deep-water rose shrimps are the twins otter trawlers (OTT). A minor proportion of landings derives from the set nets and others less mobile gear fleets. The discards values are basically on the OTB. However the discards amounts by weight were negligible (maximum proportion in the catch 3% in 2011 having a mean values in the whole series of 0.7%) nevertheless they have been added in the total catches used in the assessment.

The landings length structure of deep-water rose shrimps available in the DCF dataset in GSA5, 6 & 7 (Spain) are shown in Figures 6.2.2.10-12. There aren't any length frequencies distributions available for GSA7 French fleets. In Figures 6.2.2.13 the discards length frequencies distributions available for GSA6 are shown. There weren't any length frequencies distributions of discards both in GSA5 and GSA7 (Spain and France data as well). In Figures 6.2.2.14-17 the landings weight by GSAs is showed. Discards in weight by GSAs, gear and fisheries are showed in Figures 6.2.2.18-20. No discards reported for GSA7 (France).

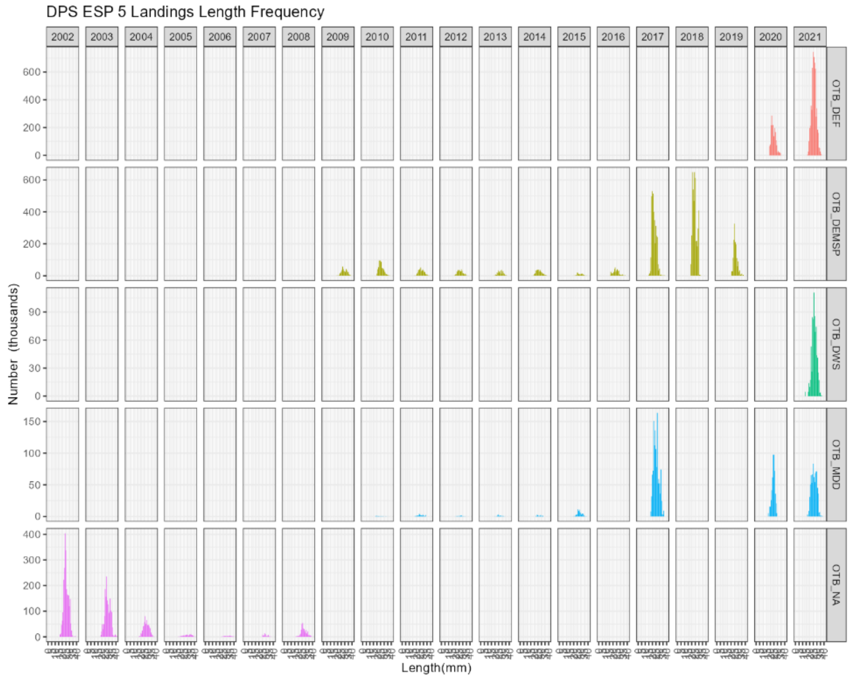


Figure 6.2.2.10 Deep-water rose shrimp in GSAs 5, 6 & 7: GSA5 landings length structures of the deep-water rose shrimps by fishing gear and fishery.

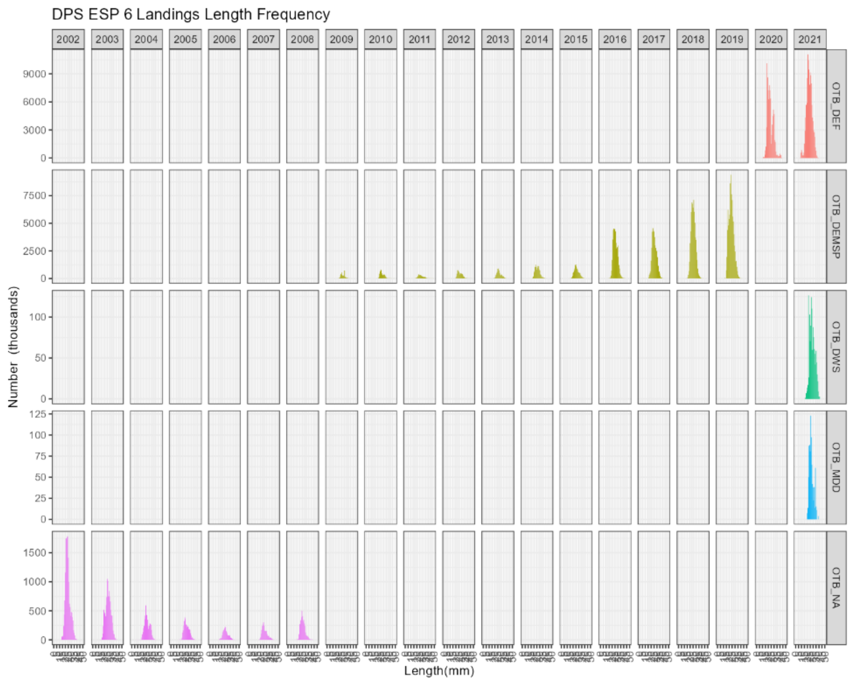


Figure 6.2.2.11 Deep-water rose shrimp in GSAs 5, 6 & 7: GSA6 landings length structures of the deep-water rose shrimps by fishing gear and fishery.

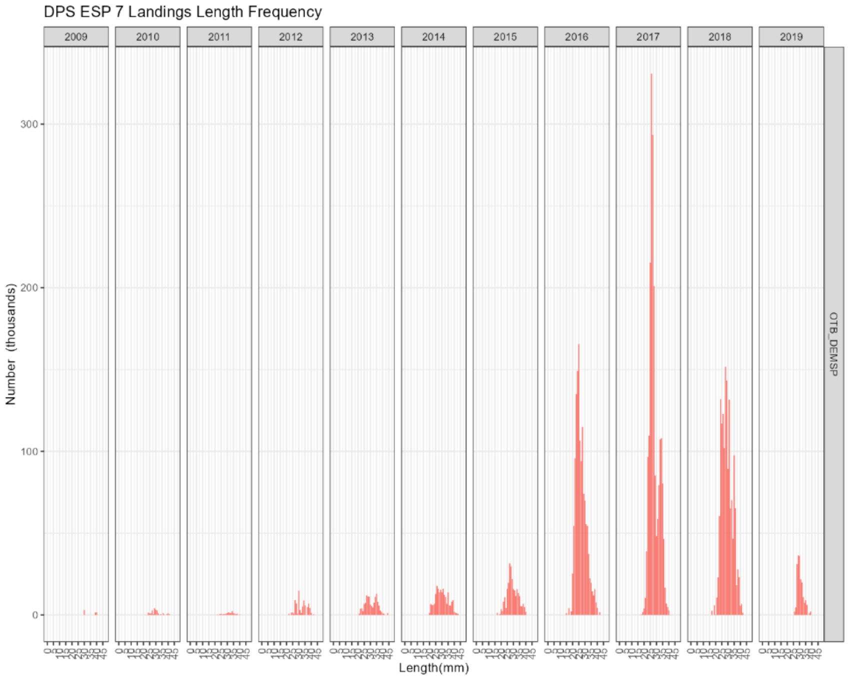


Figure 6.2.2.12 Deep-water rose shrimp in GSAs 5, 6 & 7: GSA7 (Spain) landings length structures of the deep-water rose shrimps by fishing gear and fishery.

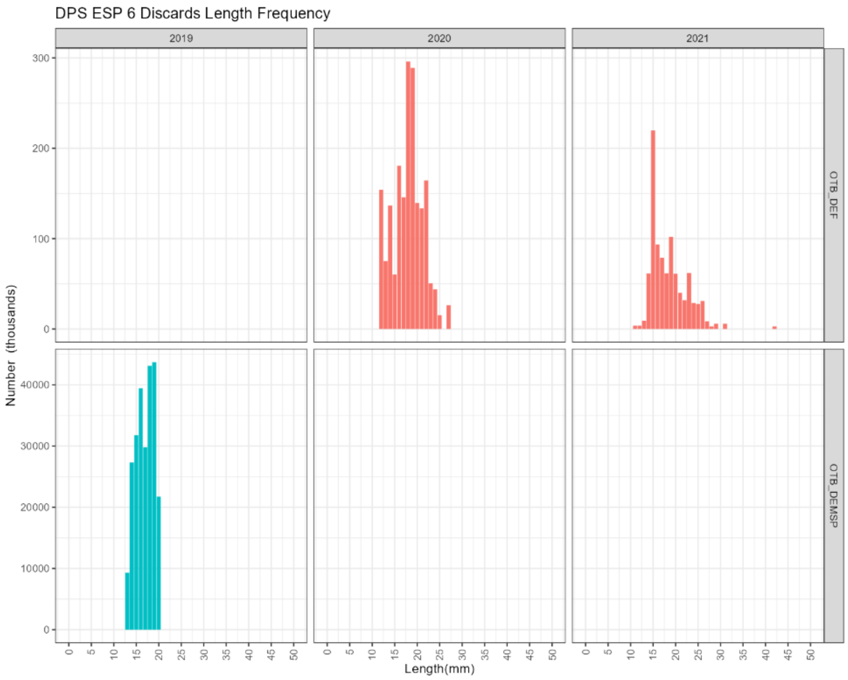


Figure 6.2.2.13 Deep-water rose shrimp in GSAs 5, 6 & 7: GSA6 discards length structures of the deep-water rose shrimps by fishing gear and fishery.

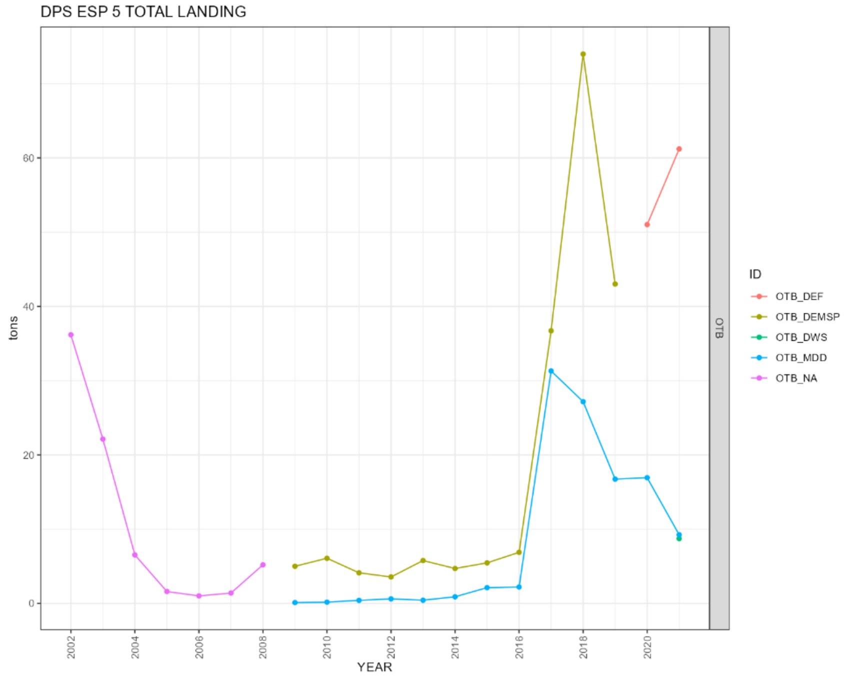


Figure 6.2.2.14 Deep-water rose shrimp in GSAs 5, 6 & 7: Landings (t) of deep-water rose shrimp in GSA 5 by fishing gear and fishery.

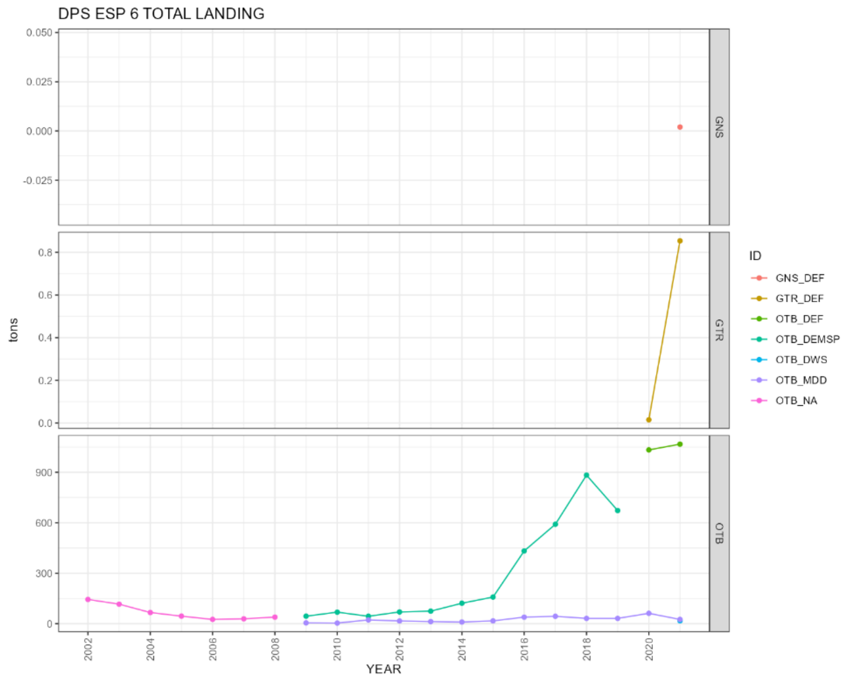


Figure 6.2.2.15 Deep-water rose shrimp in GSAs 5, 6 & 7: Landings (t) of deep-water rose shrimp in GSA 6 by fishing gear and fishery.

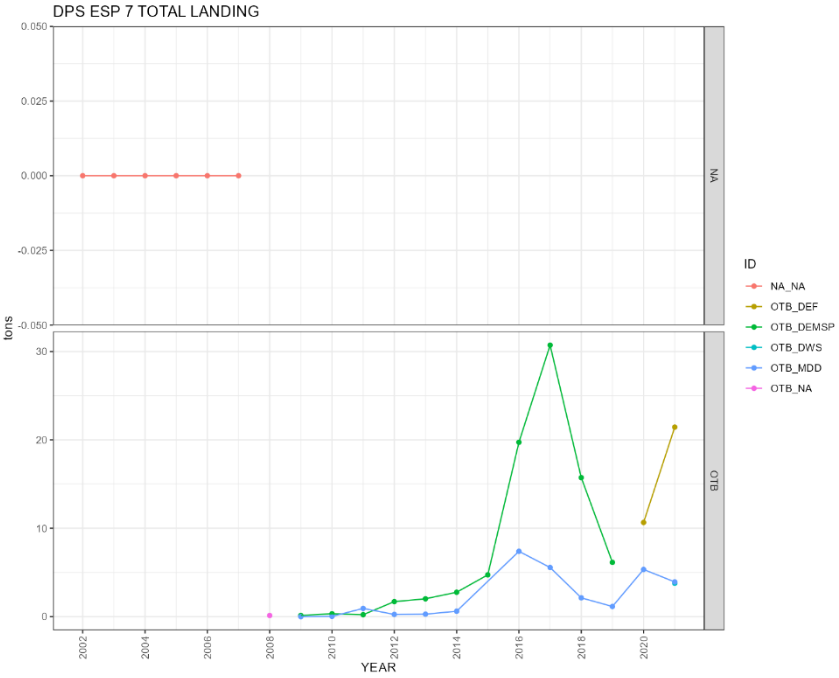


Figure 6.2.2.16 Deep-water rose shrimp in GSAs 5, 6 & 7: Landings (t) of deep-water rose shrimp in GSA 7 (Spain) by fishing gear and fishery.

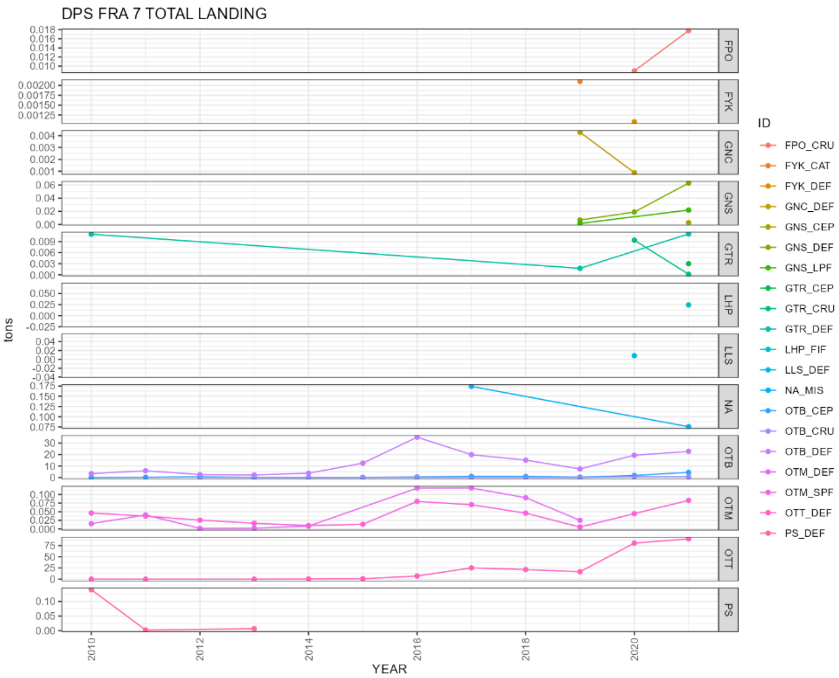


Figure 6.2.2.17 Deep-water rose shrimp in GSAs 5, 6 & 7: Landings (t) of deep-water rose shrimp in GSA 7 (France) by fishing gear and fishery.

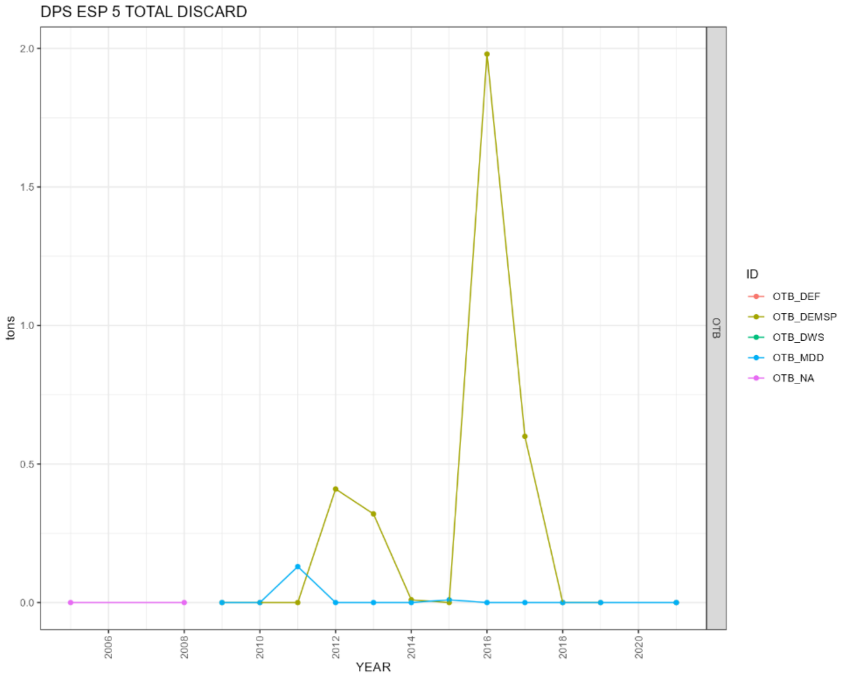


Figure 6.2.2.18 Deep-water rose shrimp in GSAs 5, 6 & 7: Discards (t) of deep-water rose shrimp in GSA 5 by fishing gear and fishery.

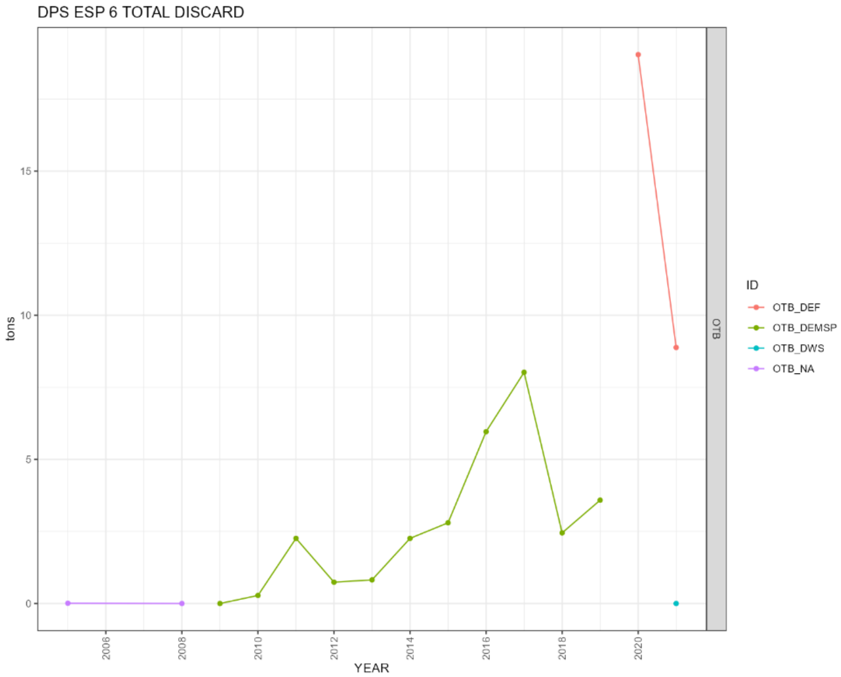


Figure 6.2.2.19 Deep-water rose shrimp in GSAs 5, 6 & 7: Discards (t) of deep-water rose shrimp in GSA 6 by fishing gear and fishery.

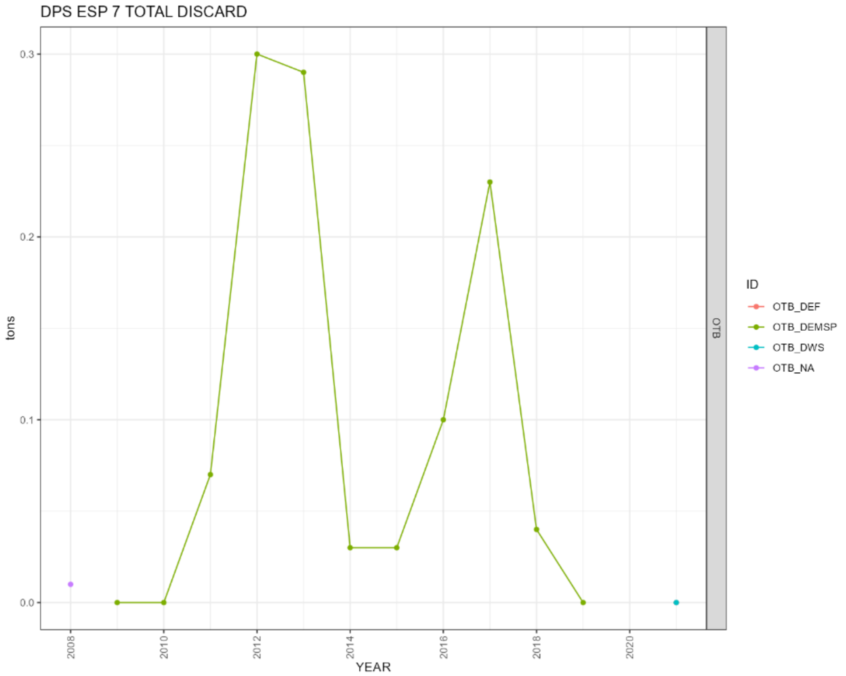


Figure 6.2.2.20 Deep-water rose shrimp in GSAs 5, 6 & 7: Discards (t) of deep-water rose shrimp in GSA 7 by fishing gear and fishery.

Table 6.2.2.5 Deep-water rose shrimp in GSAs 5, 6 & 7: Landings and discards (t) of deep-water rose shrimps in GSAs 5, 6 & 7 by gear.

	LANDINGS				DISCARDS
Year	OTB	OTT	Others	Total	OTB
2002	180.26	0.00	0.00	180.26	0.00
2003	138.15	0.00	0.00	138.15	0.00
2004	72.72	0.00	0.00	72.72	0.00
2005	46.26	0.00	0.00	46.26	0.01
2006	26.19	0.00	0.00	26.19	0.00
2007	30.20	0.00	0.00	30.20	0.00
2008	44.28	0.00	0.00	44.28	0.01
2009	54.34	0.00	0.00	54.34	0.00
2010	81.91	0.15	0.21	82.27	0.28
2011	78.07	0.01	0.08	78.16	2.46
2012	95.12	0.00	0.03	95.15	1.45
2013	97.60	0.00	0.03	97.63	1.43
2014	144.03	0.44	0.02	144.50	2.30
2015	199.62	1.00	0.01	200.63	2.84
2016	543.15	7.04	0.20	550.38	8.04
2017	760.06	25.20	0.36	785.62	8.85
2018	1049.85	21.36	0.14	1071.35	2.49
2019	778.89	16.62	0.05	795.56	3.58
2020	1200.73	80.42	0.11	1281.25	19.04
2021	1246.00	89.98	1.16	1337.14	8.88

6.2.2.2.2 EFFORT

Deep-water rose shrimp is almost exclusively caught by mixed fisheries, using bottom otter trawl (OTB) or twins otter trawl (OTT).

Effort data by Country/GSA/Gear levels are reported in Figure 6.2.2.21-22 and in Tables 6.2.2.6-7 in terms of total fishing days and days at sea respectively.

Data have been extracted fromk MEDBS database up to 2012 and from the FDI one from 2013 onward.

However, EWG 22-09 also highlights that gears indicated in the table are used in framework of different fisheries where multispecies catches are obtained. So, it is important to keep in mind that fishing effort data, that according to the ToR is analysed on fishing gear level, are related to multifisheries and multispecies aspects, and not just to one single species considered in the assessments. The main effort analysis for these areas is carried out by the EWG dealing with FDI data (EWG 22-10) the report for this group should be consulted for the STECF effort values.

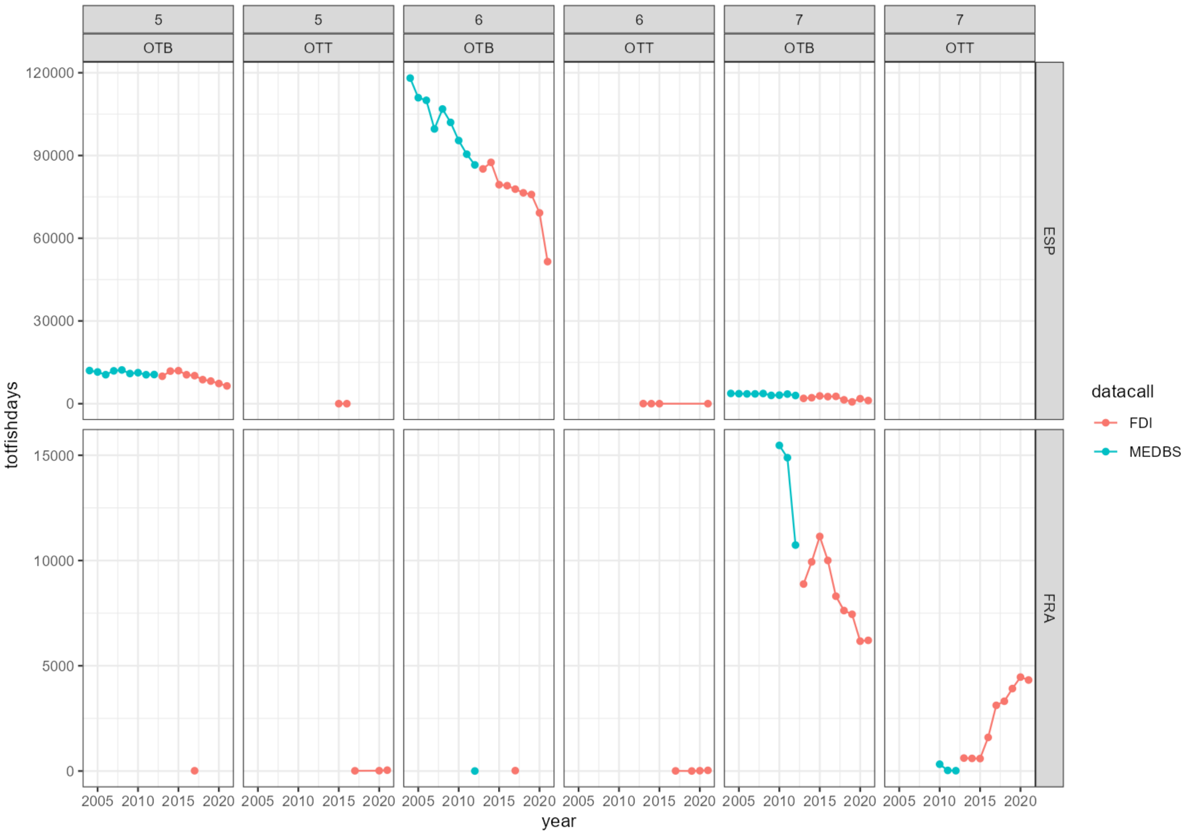


Figure 6.2.2.21 Deep-water rose shrimp in GSAs 5, 6 & 7: Effort in total fishing days associated to the main gears targeting deep-water rose shrimp. (In red FDI effort data and in blue MEDBS effort data).

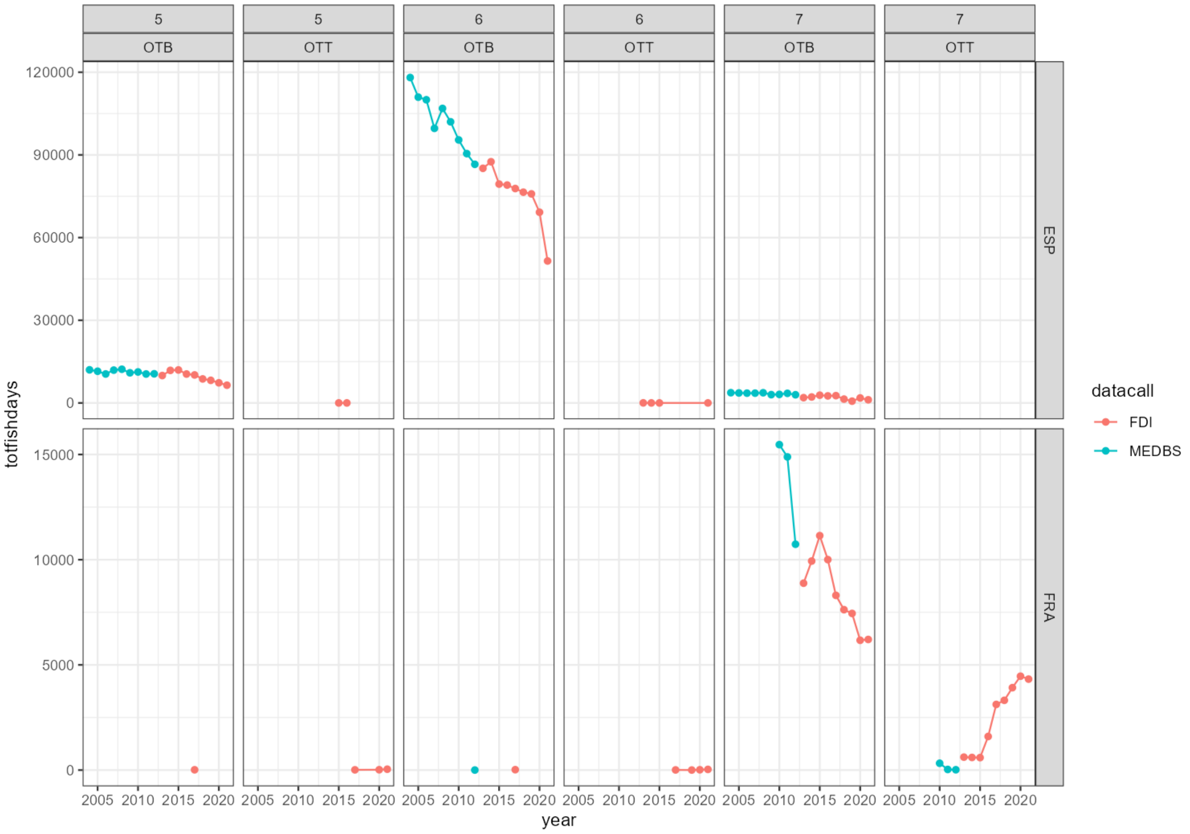


Figure 6.2.2.22 Deep-water rose shrimp in GSAs 5, 6 & 7: Effort in total days at sea associated to the main gears targeting deep-water rose shrimp (In red FDI effort data and in blue MEDBS effort data).

Table 6.2.2.6 Deep-water rose shrimp in GSAs 5, 6 & 7: Effort in total fishing days associated to the main gears targeting deep-water rose shrimp. Effort data up to 2012 from MEDBS data call and from 2013 onward from the FDI one.

ESP - OTB Total fishing days					ESP - OTT Total fishing days				ESP
Year	GSA5	GSA6	GSA7	Total	GSA5	GSA6	GSA7	Total	Grand total
2004	12012	118076	3714	133802					**133802**
2005	11497	110957	3626	126080					**126080**
2006	10507	110008	3550	124065					**124065**
2007	11907	99638	3553	115098					**115098**
2008	12226	106867	3694	122787					**122787**
2009	10934	102005	3008	115947					**115947**
2010	11239	95438	3097	109774					**109774**
2011	10498	90470	3486	104454					**104454**
2012	10568	86587	2966	100121					**100121**
2013	9942	85133	1920	96995		24		24	**97019**
2014	11817	87515	2161	101493		3		3	**101496**
2015	11965	79416	2816	94197	1	1		2	**94199**
2016	10490	79063	2557	92110	1			1	**92111**
2017	10162	77802	2648	90612					**90612**
2018	8715	76467	1391	86573					**86573**
2019	8202	75860	650	84712					**84712**
2020	7306	69201	1809	78316					**78316**
2021	6439	51514	1145	59098		1		1	**59099**
FRA - OTB Total fishing days					FRA - OTT Total fishing days				FRA
Year	GSA5	GSA6	GSA7	Total	GSA5	GSA6	GSA7	Total	Grand total
2010			15468	15468			324	324	**15792**
2011			14886	14886			30	30	**14916**
2012		2	10734	10736			16	16	**10752**
2013			8883	8883			615	615	**9499**
2014			9935	9935			600	600	**10535**
2015			11144	11144			593	593	**11737**
2016			10004	10004			1597	1597	**11601**
2017	14	19	8304	8337	11	8	3121	3140	**11477**
2018			7623	7623			3316	3316	**10940**
2019			7446	7446		2	3917	3919	**11365**
2020			6170	6170	17	15	4462	4494	**10664**
2021			6208	6208	41	33	4324	4398	**10606**

Table 6.2.2.7 Deep-water rose shrimp in GSAs 5, 6 & 7: Effort in total days at sea associated to the main gears targeting deep-water rose shrimp. Effort data up to 2012 from MEDBS data call and from 2013 onward from the FDI one.

ESP - OTB Total days at sea					ESP - OTT Total days at sea				ESP
Year	**GSA5**	**GSA6**	**GSA7**	**Total**	**GSA5**	**GSA6**	**GSA7**	**Total**	**Grand total**
2004	12012	118076	3714	133802					**133802**
2005	11497	110957	3626	126080					**126080**
2006	10507	110008	3550	124065					**124065**
2007	11907	99638	3553	115098					**115098**
2008	12226	106867	3694	122787					**122787**
2009	10934	102005	3008	115947					**115947**
2010	11239	95438	3097	109774					**109774**
2011	10498	90470	3486	104454					**104454**
2012	10568	86587	2966	100121					**100121**
2013	11045	99674	2013	112732		24		24	**112756**
2014	12972	105938	2428	121338		3		3	**121341**
2015	13310	95454	3716	112480	1	1		2	**112482**
2016	12225	102458	3539	118222	1			1	**118223**
2017	12761	103495	3881	120137					**120137**
2018	8623	76565	1391	86579					**86579**
2019	8222	75942	650	84813					**84813**
2020	7312	69257	1811	78380					**78380**
2021	6370	51476	1131	58977		1		1	**58978**
FRA - OTB Total days at sea					**FRA - OTT Total days at sea**				**FRA**
Year	**GSA5**	**GSA6**	**GSA7**	**Total**	**GSA5**	**GSA6**	**GSA7**	**Total**	**Grand total**
2010			15542	15542			324	324	**15866**
2011			14934	14934			30	30	**14964**
2012		2	10995	10997			16	16	**11013**
2013			9337	9337			627	627	**9964**
2014			10059	10059			608	608	**10667**
2015			11422	11422			600	600	**12022**
2016			10263	10263			1604	1604	**11867**
2017	16	22	8500	8538	11	8	3388	3407	**11945**
2018			7817	7817			3454	3454	**11271**
2019			7601	7601		3	4135	4138	**11739**
2020			6317	6317	18	16	4752	4786	**11102**
2021			6477	6477	54	49	4686	4789	**11266**

6.2.2.3 SURVEY DATA

The survey indices used as fisheries independent information to tune the commercial catch data originate from the MEDITS scientific bottom trawl survey. These surveys in the two countries and three GSAs usually took place between May and June. Only in 2020 the France MEDITS survey has been carried out in delay (Figures 6.2.2.23-25) while the Spain MEDITS in GSA6 had less number of hauls (no southern fishing ground explored).

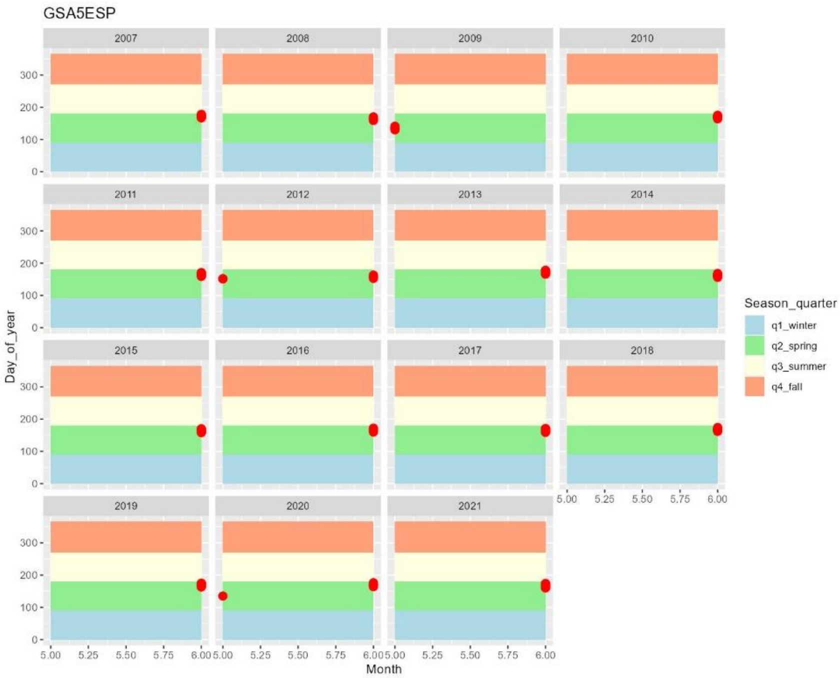


Figure 6.2.2.23 Deep-water rose shrimp in GSAs 5, 6 & 7: Survey periods of MEDITS in GSA 5.

Figure 6.2.2.24 Deep-water rose shrimp in GSAs 5, 6 & 7: Survey periods of MEDITS in GSA 6.

Figure 6.2.2.25 Deep-water rose shrimp in GSAs 5, 6 & 7: Survey periods of MEDITS in GSA 7.

Because in the GSA5 the areaa close to the Formentera and Ibiza islands have been not surveyed in all the years in the same way (only in 2021 was a comprehensive exploration of the GSA carried out). For consistency across years in the computation of the combined survey index the hauls around these two islands were excluded (Figure 6.2.2.26).

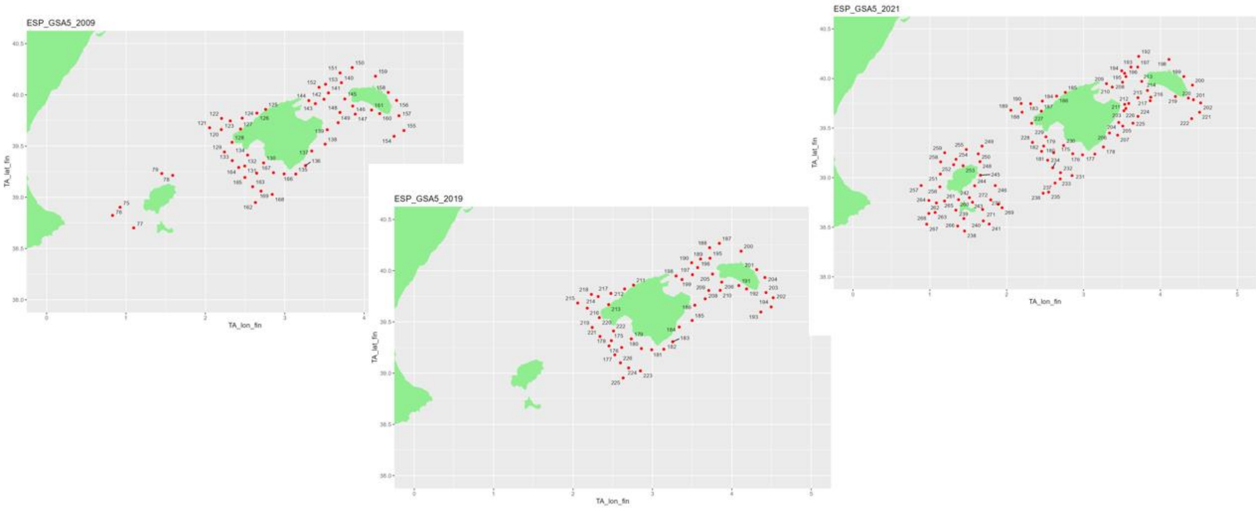


Figure 6.2.2.26 Deep-water rose shrimp in GSAs 5, 6 & 7: Mean positions of MEDITS hauls in GSA 5.

The biomass indexex in the three areas show a quite similar pattern having a sharp increase in the last 6-7 years (Figure 6.2.2.27). Values reported in GSA5 before 2007 are derived from experimental hauls not following the MEDITS protocol.

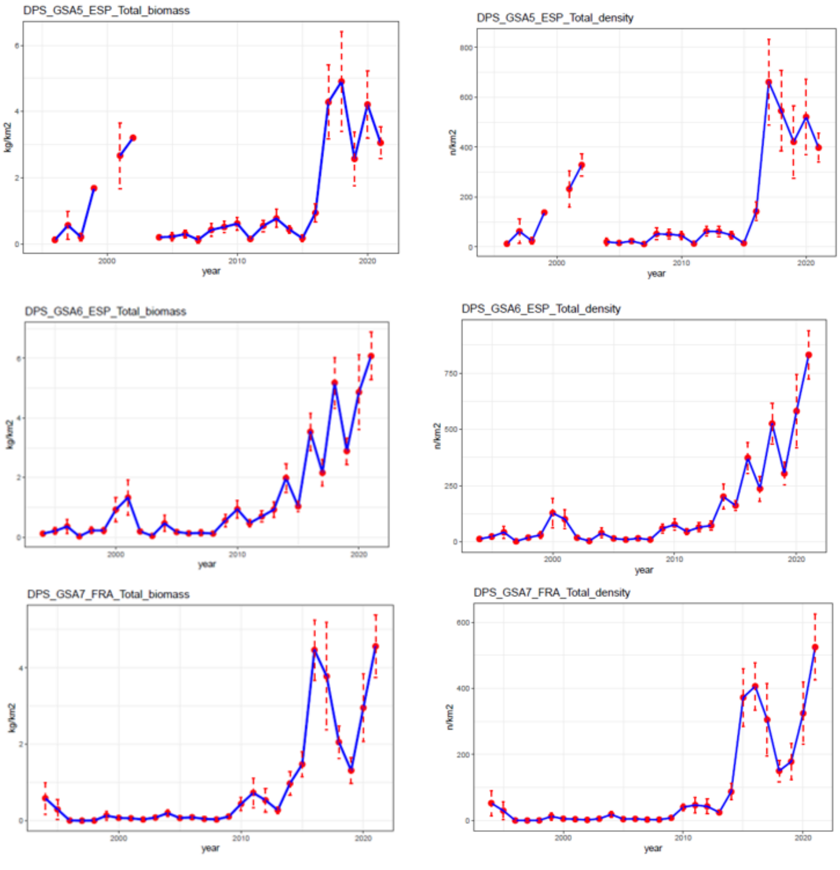


Figure 6.2.2.27 Deep-water rose shrimp in GSAs 5, 6 & 7: Biomass (kg/km2) and abundance (n/km2) indices of deep-water rose shrimp in GSas 5, 6 and 7 as derived from trawl surveys (MEDITS, 1994-2021).

In Figure 6.2.2.28-29 the biomass and abundance indexes from the combined survey and the standardized length frequencies distributions (n/km2) respectively are showed.

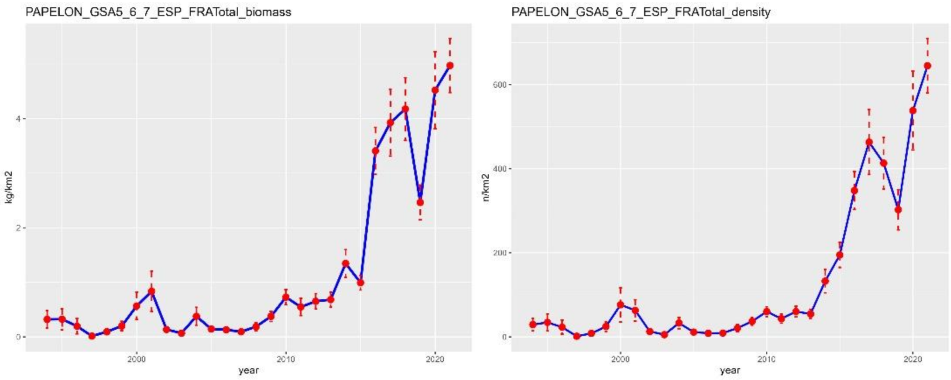


Figure 6.2.2.28 Deep-water rose shrimp in GSAs 5, 6 & 7: Biomass (kg/km2) and abundance (n/km2) indices of deep-water rose shrimp as GSAs combined index from trawl surveys (MEDITS, 1994-2021).

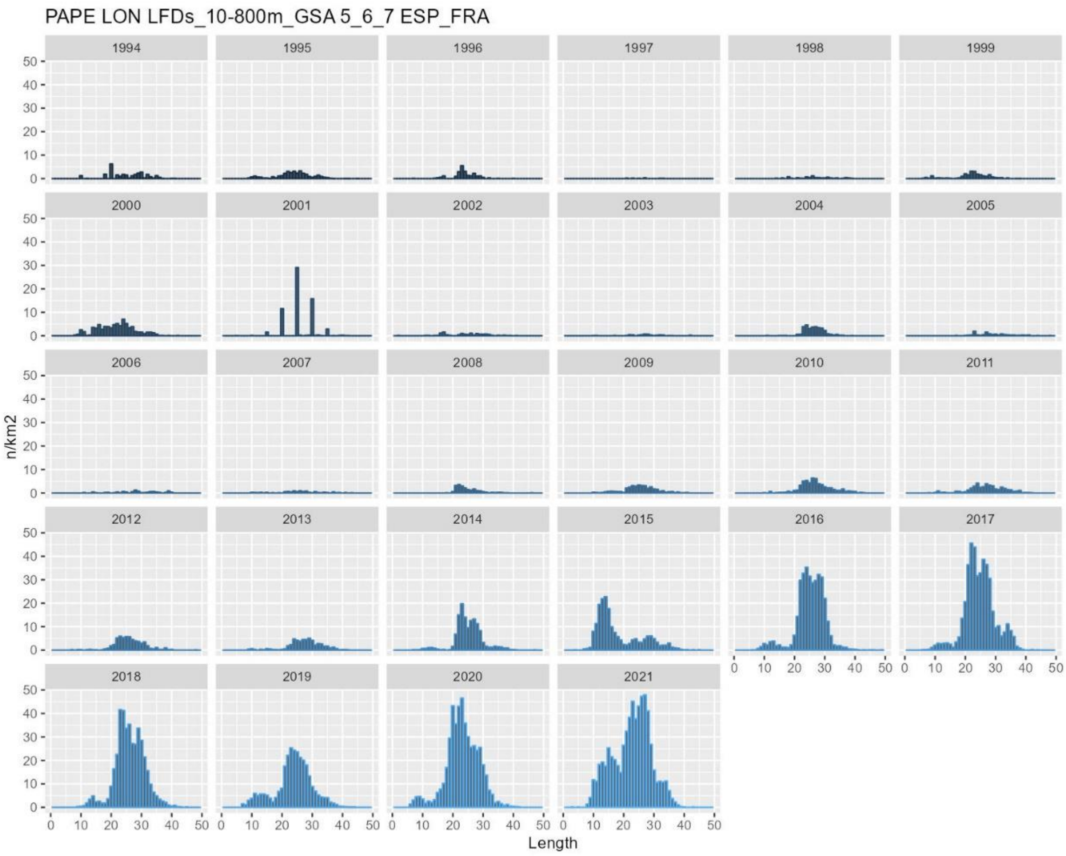


Figure 6.2.2.29 Deep-water rose shrimp in GSAs 5, 6 & 7: Combined sex size structure indices of deep-water rose shrimp in GSAs 5, 6 and 7 as derived from trawl surveys (MEDITS, 1994-2021).

6.2.2.4 STOCK ASSESSMENT

The present assessment of deep-water rose shrimp in GSAs 5, 6 and 7 has been based on a4a model. The a4a model is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by gear. The method was developed within FLR framework.

All the input data used were extracted and derived from the data collected through the official DCF Med&BS data call 2022.

The length data have been converted in age by a deterministic slicing method (l2a) available in the Fla4a package.

The set used in the slicing procedures are the ones showed in the section 6.2.2.1 having pplied the 0.5 correction of the t0 values (applied both on commercial and surveys data) to match with the calendar year basis of the assessment.

The slicing has been carried out by sex combined for each of the GSA length frequencies distributions available and on the combined (by sex and areas) survey length frequencies distributions.

Catch, landings and discards weight have been computed as sum of the corresponding values by year and GSAs. Because from GSA7 France data only total landings were avilable those values have been added to the corresponding slots throught a vector of values by year.

Catch, landings and discards at age have been computed as sum of the corresponding values by year and GSAs.

Catch, landings and discards mean weight at age, maturity at age and natural mortality at age have been obtained as weighted mean of the corresponding values by GSAs with the associated catch number at age by GSA.

Harvest and natural mortality values before spawning have been set euqal to 0.5 in all the GSAs

The formula applied are showed in Figure 6.2.2.30 as extracted directly from the script used.

```
## Merging stock object and adding France landings
FRA_land.flq <- FLQuant(c(0,0,3.77,6.21,3.42,2.38,4.26,13.68,42.89,46.60,37.22,24.53,102.48,118.22),
                        dimnames=list(age="all", year = (2008:2021)))

catch.totale <- catch(stk5)+ catch(stk6)+ catch(stk7)+FRA_land.flq
catch.n.totale <- catch.n(stk5)+catch.n(stk6)
catch.wt.totale <- (catch.wt(stk5)*catch.n(stk5) + catch.wt(stk6)*catch.n(stk6))/catch.n.totale

landings.totale <- landings(stk5)+ landings(stk6)+landings(stk7)+FRA_land.flq
landings.n.totale <- landings.n(stk5)+landings.n(stk6)
landings.wt.totale <- (landings.wt(stk5)*landings.n(stk5) + landings.wt(stk6)*landings.n(stk6))/landings.n.totale

discards.totale <- discards(stk5)+ discards(stk6)
discards.n.totale <- discards.n(stk6)

mat.totale <- (mat(stk5)*catch.n(stk5) + mat(stk6)*catch.n(stk6))/catch.n.totale
m.totale <- (m(stk5)*catch.n(stk5) + m(stk6)*catch.n(stk6))/catch.n.totale

stk <- FLStock(catch.n=catch.n.totale,catch.wt=catch.wt.totale,stock.wt=catch.wt.totale,
               landings.n=landings.n.totale,landings.wt=catch.wt.totale,
               discards.n=discards.n.totale,discards.wt=catch.wt.totale,
               mat=mat.totale,
                   harvest.spwn = harvest.spwn(stk5),m.spwn = m.spwn(stk5), m=m.totale,
                   catch=catch.totale,landings=landings.totale,discards=discards.totale)

units(catch(stk)) <- units(discards(stk)) <- units(landings(stk)) <- units(stock(stk)) <- 'tonnes'
units(catch.n(stk)) <- units(discards.n(stk)) <- units(landings.n(stk)) <- units(stock.n(stk)) <- '1000'
units(catch.wt(stk)) <- units(discards.wt(stk)) <- units(landings.wt(stk)) <- units(stock.wt(stk)) <- 'kg'
units(harvest(stk)) <- 'f'
units(m(stk)) <- 'm'
```

Figure 6.2.2.30 Deep-water rose shrimp in GSAs 5, 6 & 7: Combining the stock objects of different GSAs.

Finally, the whole stock object has been trimmed from 2008 onward just because the first landings/catch data available from GSA7 (Spain) start in that year.

A small sum of product correction (SoP) was needed in most years to raise the catch at age number to final production (Table 6.2.2.8).

Table 6.2.2.8 Deep-water rose shrimp in GSAs 5, 6 & 7: Sum of Product (SoP) applied by year to correct catch at age number in matching the correspondig total production.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average
SoP	1.00	1.00	1.05	1.10	1.06	1.05	1.06	1.10	1.14	1.12	1.05	1.04	1.10	1.12	1.07

In the following tables (Table 6.2.2.9-15) all the final input values are listed.

In Figures 6.2.2.31-32 the catch and index at age number respectively are showed. Finally in Figure 6.2.2.33 the complete input data are showed.

Table 6.2.2.9 Deep-water rose shrimp in GSAs 5, 6 & 7: Values of catch (t) per year used in the assessment.

Year	Catch (t)
2008	44.29
2009	54.34
2010	82.55
2011	80.62
2012	96.60
2013	99.06
2014	146.79
2015	203.47
2016	558.42
2017	794.47
2018	1073.33
2019	799.14
2020	1300.29
2021	1346.02

Table 6.2.2.10 Deep-water rose shrimp in GSAs 5, 6 & 7: Values of catch at age number (*1000) per year used in the assessment.

	Catch at age number (*1000)			
Year	Age0	Age1	Age2	Age3+
2008	37.2	3890.9	545.1	28.9
2009	42.8	3250.6	1383.4	16.6
2010	44.5	5270.6	1724.3	92.5
2011	67.1	5293.0	1551.3	162.2
2012	50.3	6389.6	2077.7	99.8
2013	45.4	6470.7	2036.7	47.4
2014	46.3	11811.6	2311.0	68.7
2015	63.4	14899.9	3945.8	136.4
2016	63.4	45678.4	9642.2	226.9
2017	121.1	67023.4	13382.3	251.6
2018	70.0	97097.1	13862.5	205.0
2019	11690.9	97834.4	2904.9	28.6
2020	1583.2	135744.5	16928.8	2507.5
2021	3894.4	134814.0	18620.2	139.0

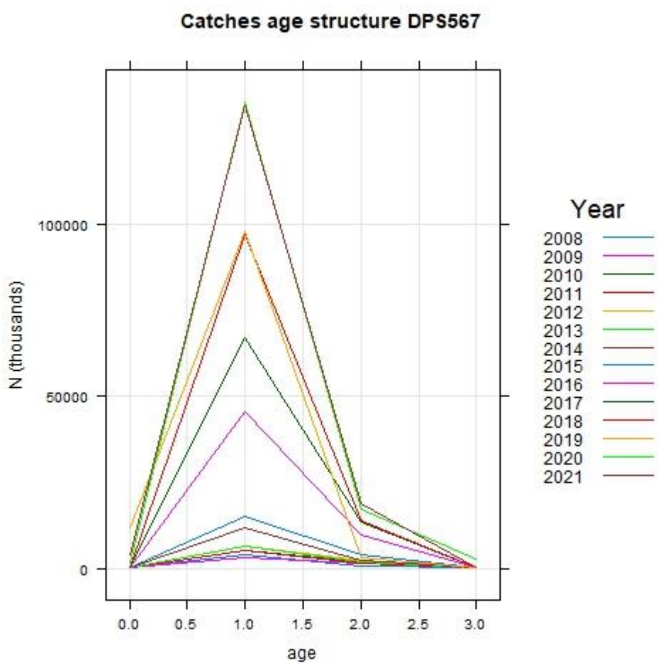


Figure 6.2.2.31 Deep-water rose shrimp in GSAs 5, 6 & 7: Catch at age numbers (*1000) used in the assessment.

Based on the catch at age pattern a Fbar range between age1 and age2 has been set.

Table 6.2.2.11 Deep-water rose shrimp in GSAs 5, 6 & 7: Values of mean weight at age number (kg) per year used in the assessment.

	Mean weight at age (kg)			
Year	Age0	Age1	Age2	Age3+
2008	0.002	0.009	0.018	0.029
2009	0.002	0.010	0.016	0.028
2010	0.002	0.010	0.017	0.032
2011	0.002	0.009	0.018	0.033
2012	0.002	0.009	0.017	0.031
2013	0.002	0.010	0.018	0.027
2014	0.002	0.009	0.017	0.027
2015	0.002	0.009	0.017	0.027
2016	0.002	0.009	0.016	0.029
2017	0.001	0.008	0.017	0.027
2018	0.002	0.009	0.016	0.027
2019	0.002	0.007	0.017	0.027
2020	0.002	0.007	0.016	0.030
2021	0.001	0.008	0.017	0.027

Table 6.2.2.12 Deep-water rose shrimp in GSAs 5, 6 & 7: Values of maturity at age per year used in the assessment.

	Maturity at age			
Year	Age0	Age1	Age2	Age3+
2008	0	0.5	0.8	1
2009	0	0.5	0.8	1
2010	0	0.5	0.8	1
2011	0	0.5	0.8	1
2012	0	0.5	0.8	1
2013	0	0.5	0.8	1
2014	0	0.5	0.8	1
2015	0	0.5	0.8	1
2016	0	0.5	0.8	1
2017	0	0.5	0.8	1
2018	0	0.5	0.8	1
2019	0	0.5	0.8	1
2020	0	0.5	0.8	1
2021	0	0.5	0.8	1

Table 6.2.2.13 Deep-water rose shrimp in GSAs 5, 6 & 7: Values of natural mortality at age per year used in the assessment.

	Natural mortality at age			
Year	Age0	Age1	Age2	Age3+
2008	2.103	1.051	0.844	0.770
2009	2.103	1.051	0.845	0.770
2010	2.103	1.051	0.845	0.771
2011	2.103	1.051	0.845	0.771
2012	2.103	1.052	0.845	0.771
2013	2.103	1.052	0.845	0.771
2014	2.103	1.052	0.845	0.771
2015	2.103	1.052	0.845	0.771
2016	2.103	1.052	0.845	0.771
2017	2.086	1.050	0.845	0.771
2018	2.103	1.050	0.845	0.771
2019	2.103	1.052	0.844	0.771
2020	2.103	1.052	0.845	0.771
2021	2.103	1.052	0.845	0.771

Table 6.2.2.14 Deep-water rose shrimp in GSAs 5, 6 & 7: Values of harvest and natural mortality at age before spawning per year used in the assessment.

	Harvest and M before spawning at age			
Year	Age0	Age1	Age2	Age3+
2008	0.5	0.5	0.5	0.5
2009	0.5	0.5	0.5	0.5
2010	0.5	0.5	0.5	0.5
2011	0.5	0.5	0.5	0.5
2012	0.5	0.5	0.5	0.5
2013	0.5	0.5	0.5	0.5
2014	0.5	0.5	0.5	0.5
2015	0.5	0.5	0.5	0.5
2016	0.5	0.5	0.5	0.5
2017	0.5	0.5	0.5	0.5
2018	0.5	0.5	0.5	0.5
2019	0.5	0.5	0.5	0.5
2020	0.5	0.5	0.5	0.5
2021	0.5	0.5	0.5	0.5

Table 6.2.2.15 Deep-water rose shrimp in GSAs 5, 6 & 7: Values of index number at age (n/km2) per year used in the assessment.

	Index at age (n/km2)		
Year	Age0	Age1	Age2
2008	0.07	18.81	1.82
2009	1.26	28.37	6.43
2010	0.85	42.14	12.99
2011	1.70	28.02	11.91
2012	1.17	46.13	11.32
2013	1.83	33.86	17.45
2014	4.82	113.43	12.77
2015	86.05	85.71	19.87
2016	16.82	280.07	49.02
2017	15.63	359.99	60.68
2018	11.63	299.99	93.10
2019	31.75	216.47	37.67
2020	27.22	407.29	51.57
2021	84.07	486.75	72.84

The index has been trimmed at age 2 because it was considered as last true age to be used in tuning catches.

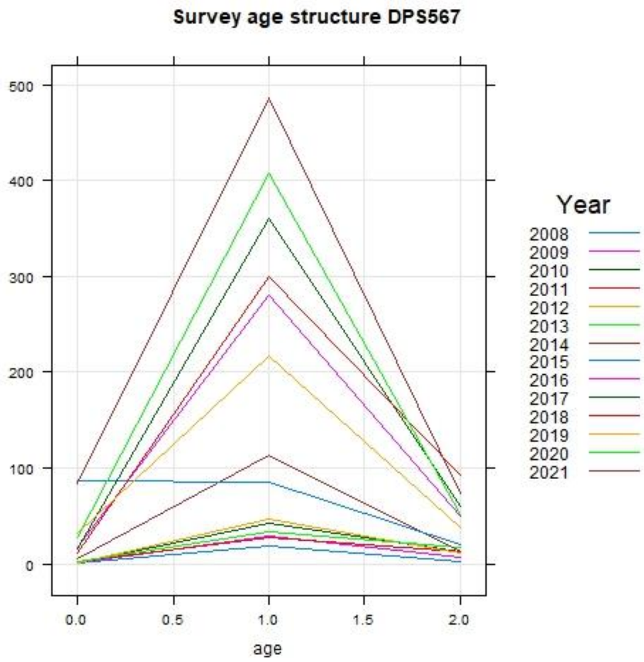


Figure 6.2.2.32 Deep-water rose shrimp in GSAs 5, 6 & 7: Index at age numbers (*1000) used in the assessment.

In 2015 the index at age number values are almost equal because it was the only year in which the amount of smaller individuals was higher than the following group (see Figures 6.2.2.8 and 6.2.2.29). Applying the t0 corrections split the first modal group almost in half ending up with same values by Age0 and Age1.

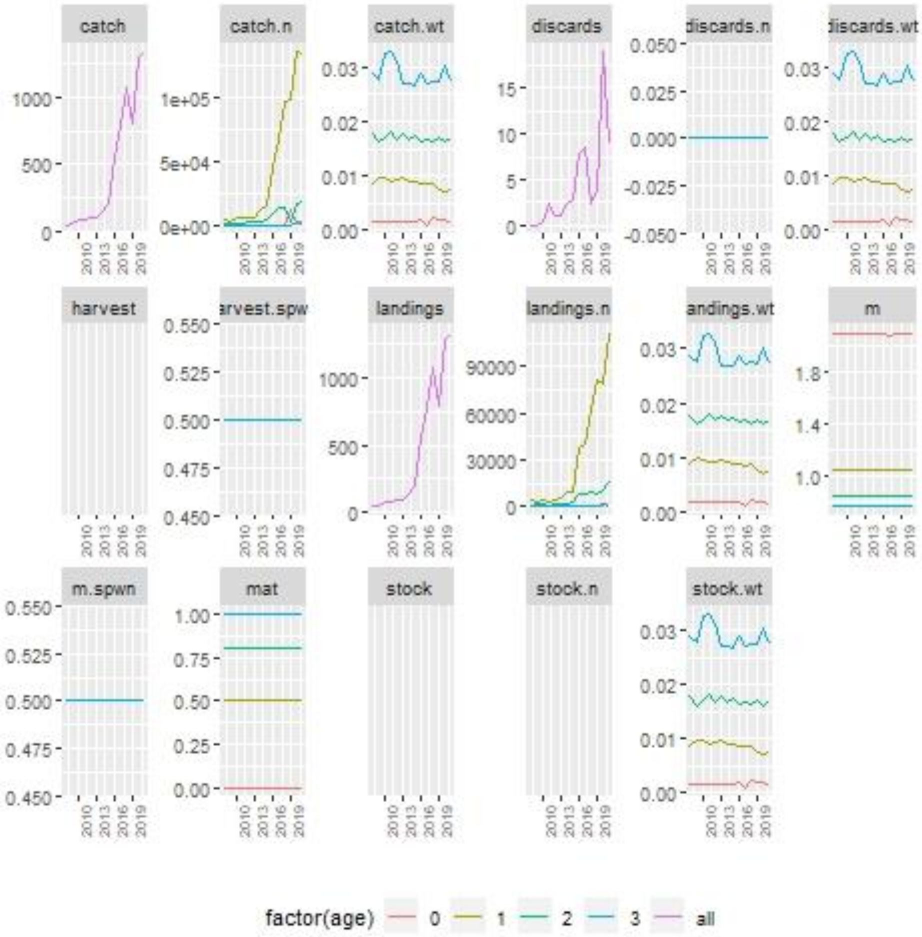


Figure 6.2.2.33 Deep-water rose shrimp in GSAs 5, 6 & 7: the whole stock object inputs.

All the input stock objects have been created using the R scripts developed in the JRC and made available in the EWG2209 ftp. Below the version of R, Rstudio and Rpackages used in running the assessment:

R: 4.2.1

RStudio: 2022.07.0

FLCore: 2.6.19

FLa4a: 1.8.3

Flash: 2.5.11

FLBRP: 2.5.8.9002

In Figures 6.2.2.34-39 the cohorts consistency, the number at age trend in time and the log number of the cohort decay derived from the catch and index at age numbers respectively are showed.

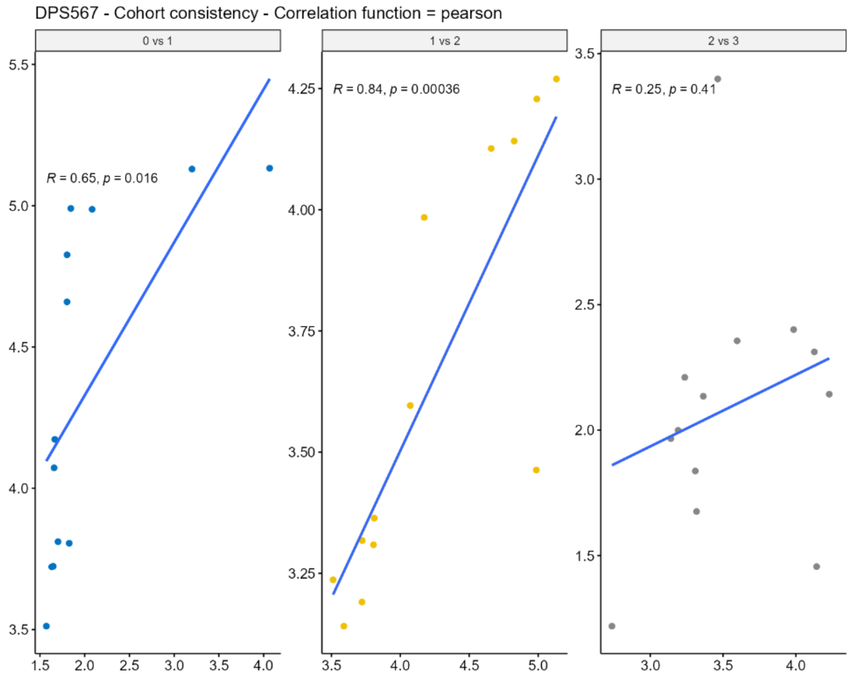


Figure 6.2.2.34 Deep-water rose shrimp in GSAs 5, 6 & 7: Catch at age numbers cohorts internal consistency.

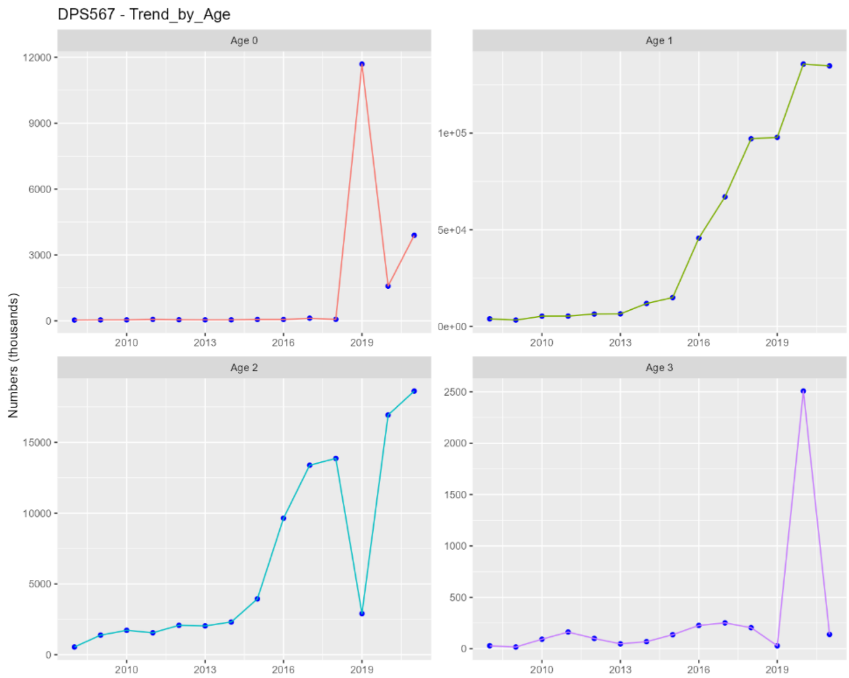


Figure 6.2.2.35 Deep-water rose shrimp in GSAs 5, 6 & 7: Trend in time of catch number at age.

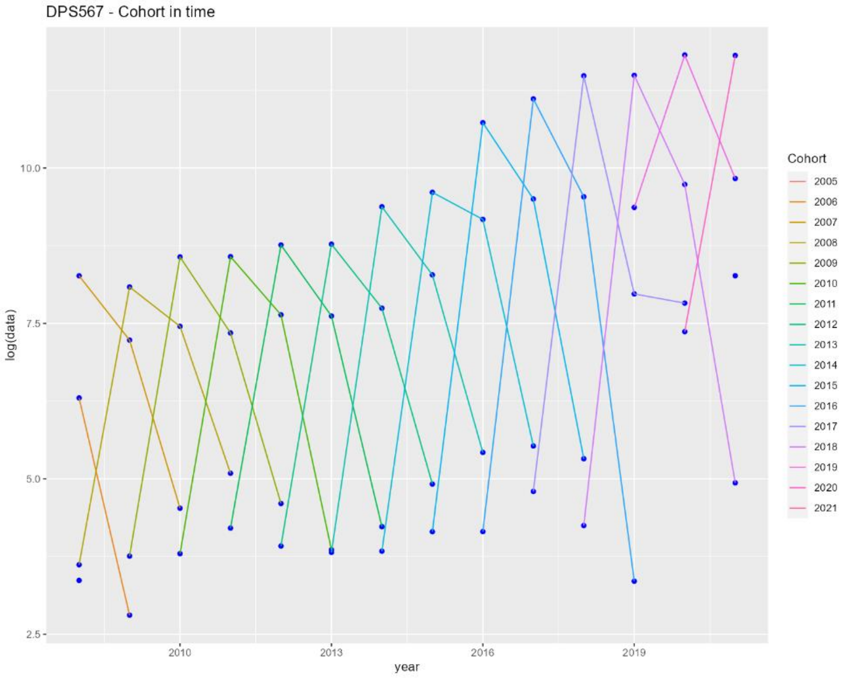


Figure 6.2.2.36 Deep-water rose shrimp in GSAs 5, 6 & 7: Log of the catch cohort number decay.

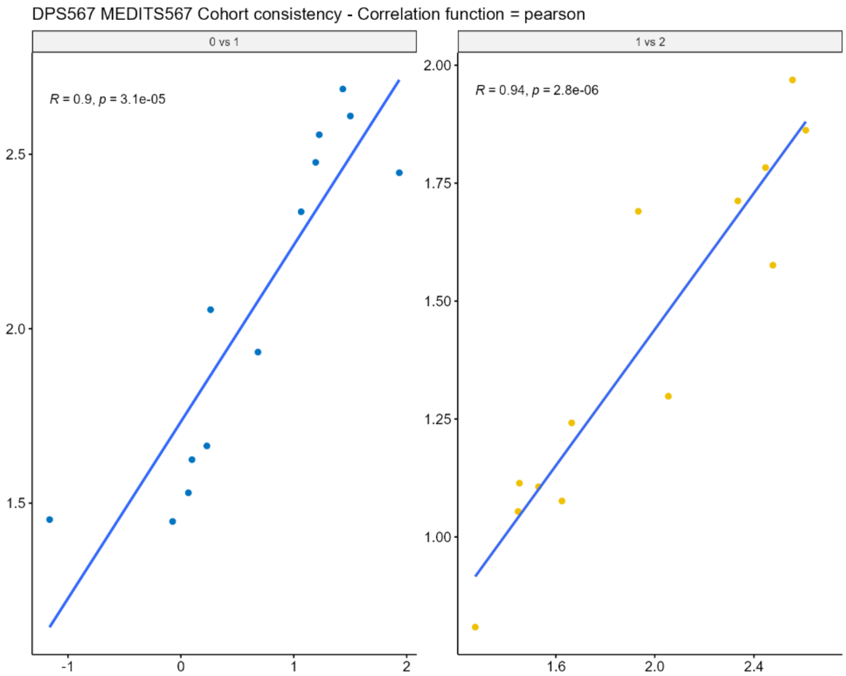


Figure 6.2.2.37 Deep-water rose shrimp in GSAs 5, 6 & 7: Index number at age cohorts internal consistency.

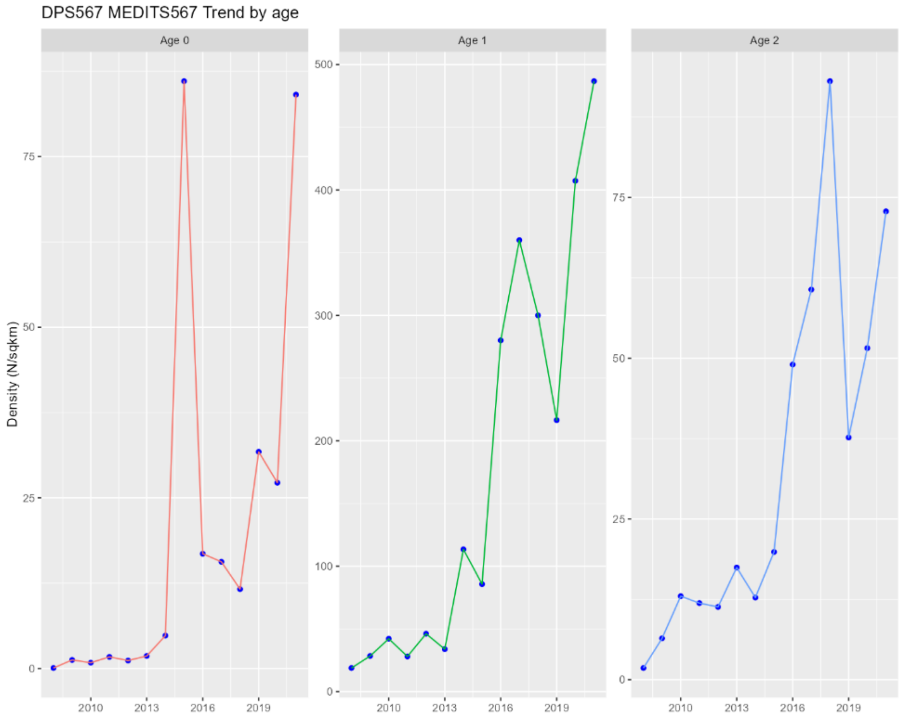


Figure 6.2.2.38 Deep-water rose shrimp in GSAs 5, 6 & 7: Trend in time of index number at age.

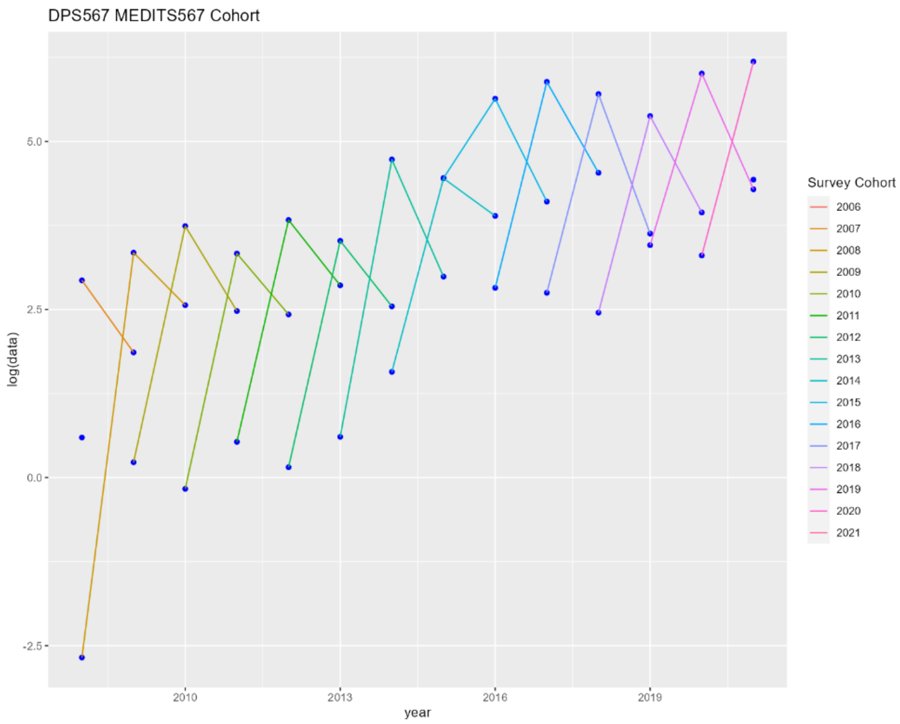


Figure 6.2.2.39 Deep-water rose shrimp in GSAs 5, 6 & 7: Log of the index cohort number decay.

Different models have been tried during the EWG (see list below)

```
# ## a4a DIFFERENT QMODEL, FMODEL and SRMODEL ####

# Testing models (list and selection from previous assessment)
# fmodel <- ~ factor(age)+s(year, k=6)
# fmodel <- ~ factor(replace(age,age>2,2))+s(year, k=7)
# fmodel <- ~ factor(year)+ s(year, k=5, by=as.numeric(age==0))
# fmodel <- ~ s(age,k=3)+s(year,k=5)
# fmodel <- ~factor(age)+s(year,k=4)
# fmodel <- ~s(age, k=3,by = breakpts(year, 2017))+s(year,k=4)
fmodel <- ~factor(age)+s(year,k=5)

# qmodel<- list(~ factor(age))
qmodel <- list(~ factor(replace(age,age>1,1)))

srmodel <- ~s(year, k=5)
#srmodel <- ~geomean(CV=0.5)
#srmodel <- ~factor(year)
```

selecting as the best one:

fmodel: ~factor(age) +s(year, k=5)

qmodel: list(~factor(replace(age, age > 1, 1)))

srmodel: ~s(year,k=5)

n1model: ~s(age, k = 3)

vmodel: catch: ~s(age, k = 3) index: ~1

Summary of the model fit using the fitSumm command:

```
> fitSumm(fit)
                  iters
                      1
nopar       2.200000e+01
nlogl       9.555878e+01
maxgrad     7.358590e-08
nobs        9.800000e+01
gcv         8.757111e-01
convergence 0.000000e+00
accrate               NA
nlogl_comp1 4.869820e+01
nlogl_comp2 4.686050e+01
```

The results and diagnostics of the assessment model are shown below.

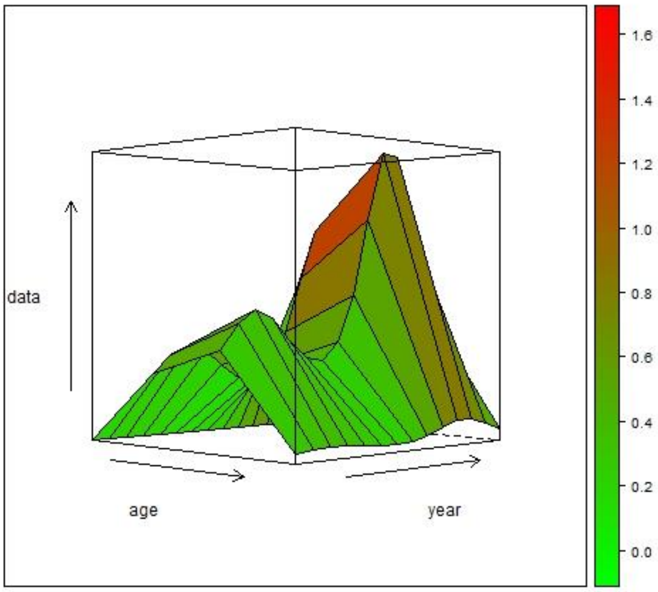


Figure 6.2.2.40 Deep-water rose shrimp in GSAs 5, 6 & 7: Harvest at age wireframe.

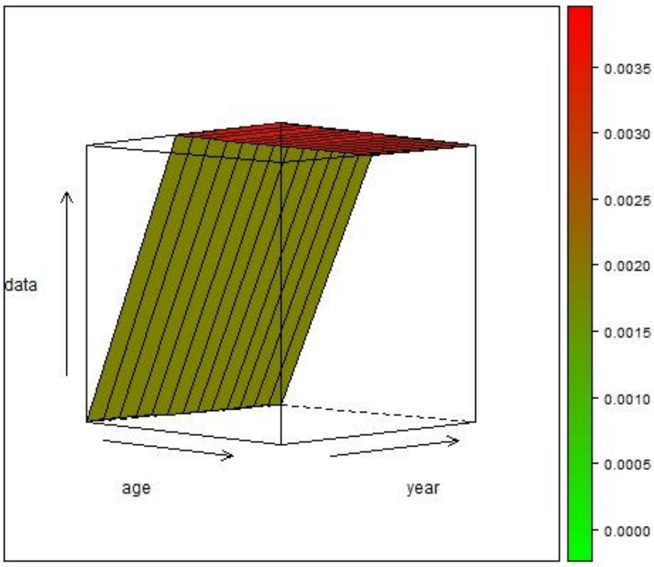


Figure 6.2.2.41 Deep-water rose shrimp in GSAs 5, 6 & 7: Survey Catchability at age wireframe

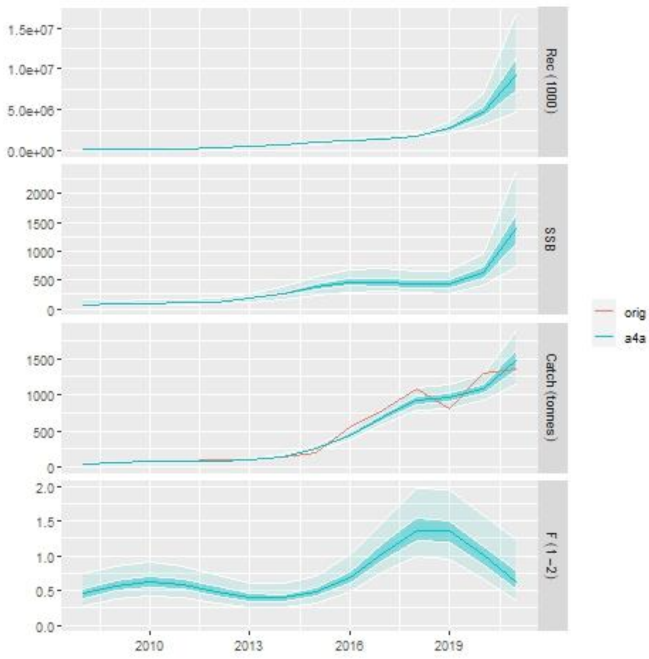


Figure 6.2.2.42 Deep-water rose shrimp in GSAs 5, 6 & 7: Results of the best a4a model. The observed catches are shown by the red line.

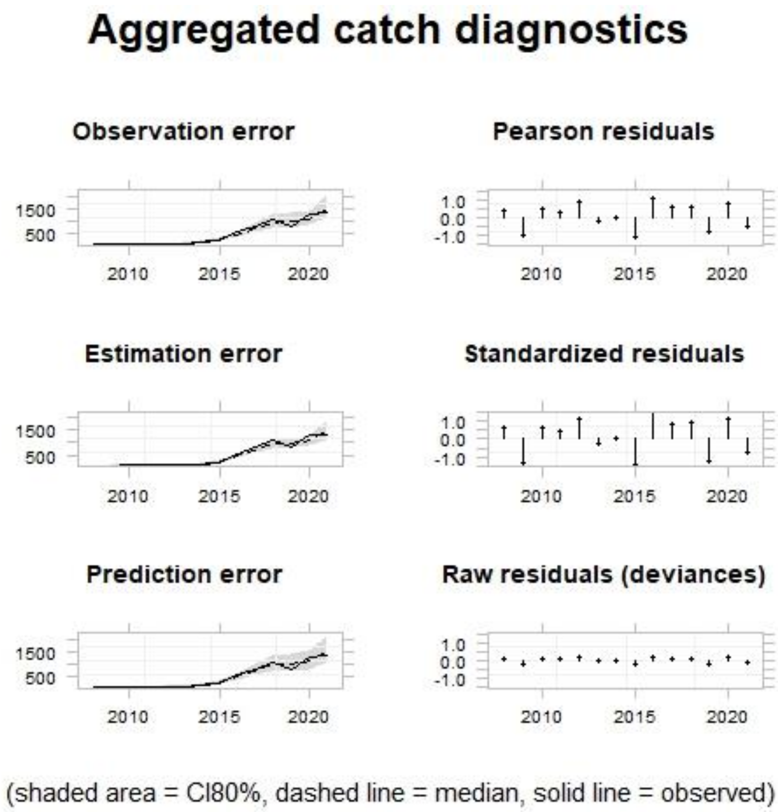


Figure 6.2.2.43 Deep-water rose shrimp in GSAs 5, 6 & 7: Catch diagnostics.

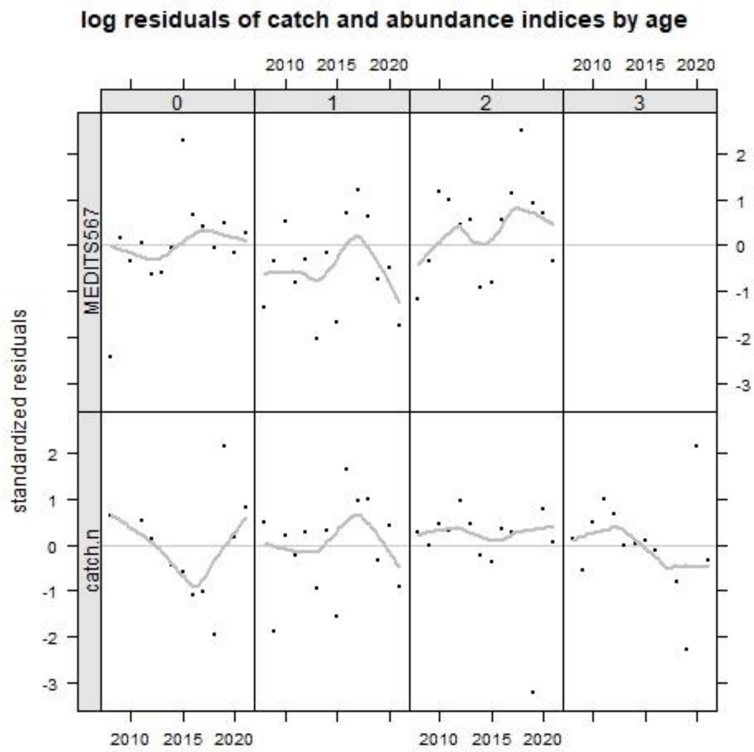


Figure 6.2.2.44 Deep-water rose shrimp in GSAs 5, 6 & 7: Log residuals of catch and abundance indices by age.

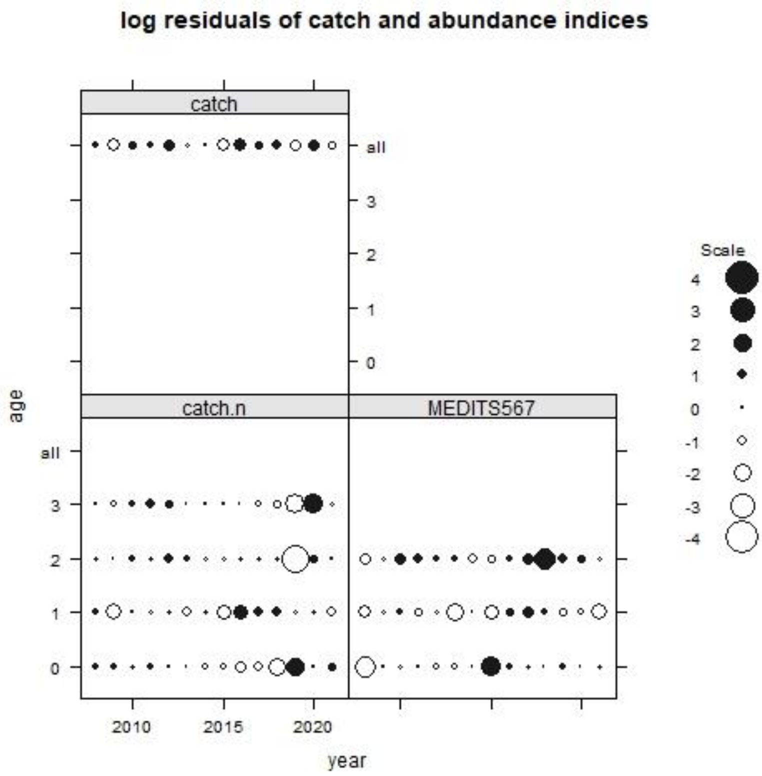


Figure 6.2.2.45 Deep-water rose shrimp in GSAs 5, 6 & 7: Bubble plot of the log residuals of catch and abundance indices by age.

Table 6.2.2.16 Deep-water rose shrimp in GSAs 5, 6 & 7: Range of variation of minimum and maximum residuals values estimated.

Variable	Minimum_residual_value	Maximum_residual_value
Catch	-1.434	1.477
Catch_at_age	-3.232	2.160
Index_at-age	-2.441	2.493

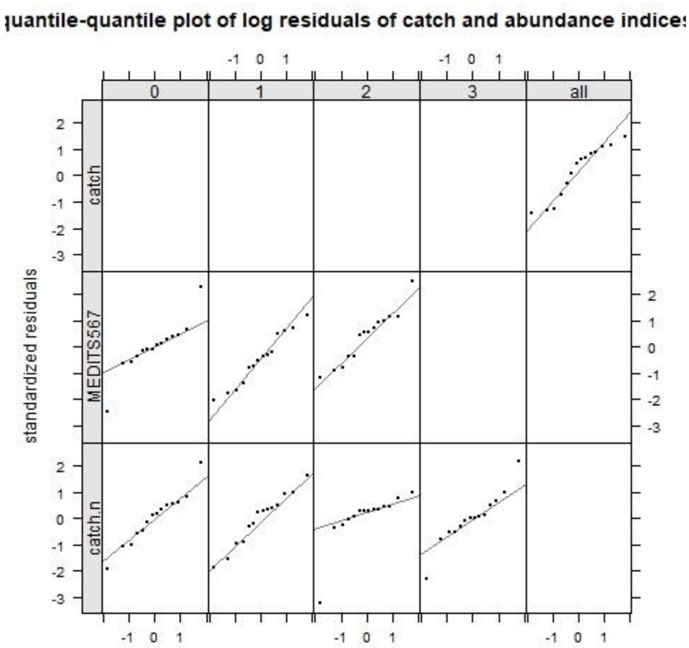


Figure 6.2.2.46 Deep-water rose shrimp in GSAs 5, 6 & 7: QQ-plot of the log residuals of catch and abundance indices by age.

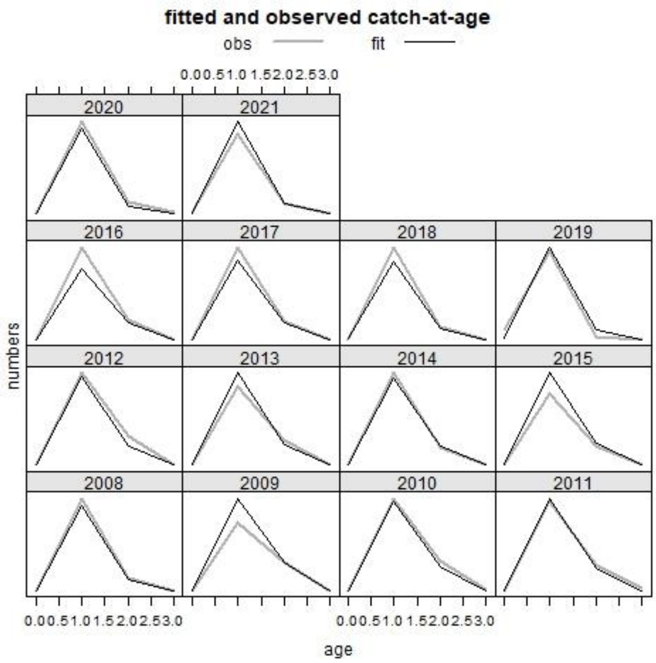


Figure 6.2.2.47 **Deep-water rose shrimp in GSAs 5, 6 & 7:** Fitting of the catch-at-age data.

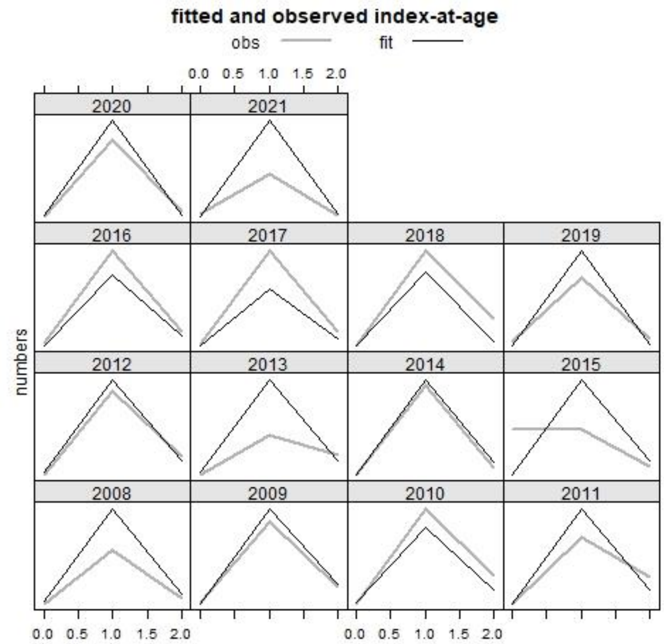


Figure 6.2.2.48 Deep-water rose shrimp in GSAs 5, 6 & 7: Fitting of the index-at-age data.

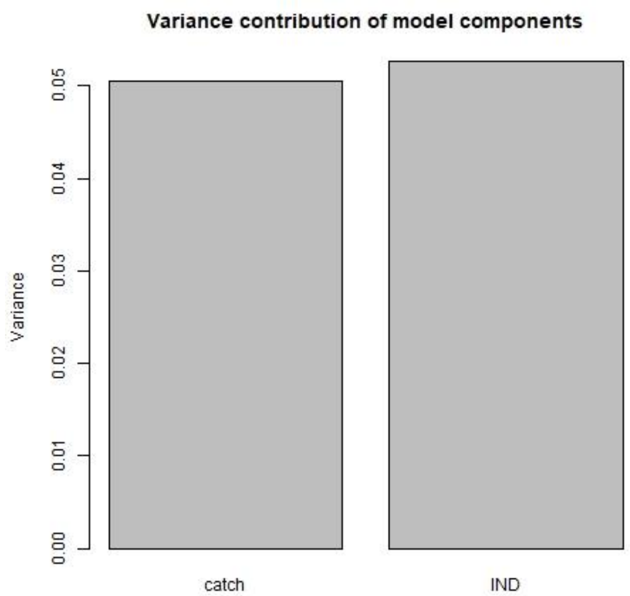


Figure 6.2.2.49 Deep-water rose shrimp in GSAs 5, 6 & 7: Variance contribution of model components: catches and survey for red mullet in GSA9.

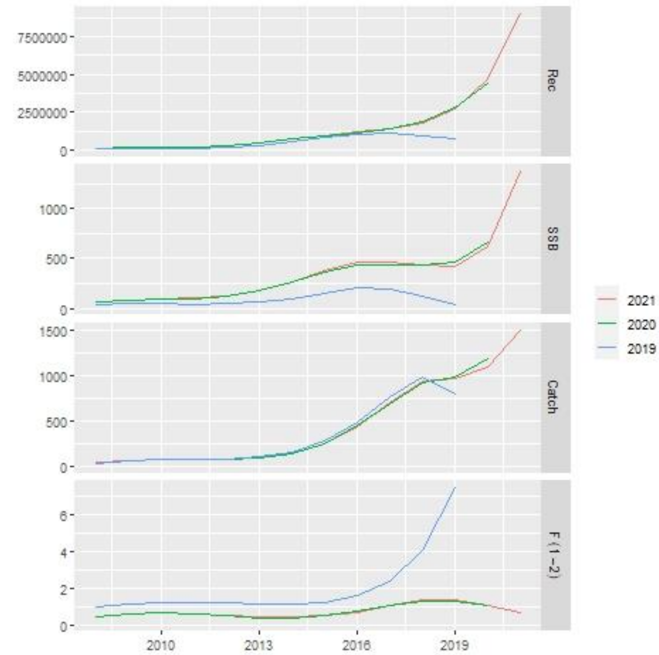


Figure 6.2.2.50 Deep-water rose shrimp in GSAs 5, 6 & 7: Retrospective analysis of the selected a4a model for red mullet in GSA9.

The residuals of the catch and abundance indices related to the outcomes of the best run do not show any particular trend aside a bit of pattern in Age0 though still in range of acceptable values. The most important issue observed was in the retrospective for which removing more the second year ended up in a quite unstable model. The explanation lais in the fact that the species is a very short live species (almost 100% of the catch belong to agea 1 and 2) and on the evolving dynamics observed in the last years with huge increase in the population. The instability on the retrospective led the EWG to accept the assessment only in providing advice on fishing mortality but not robust enough to be used in estimating biomass reference points.

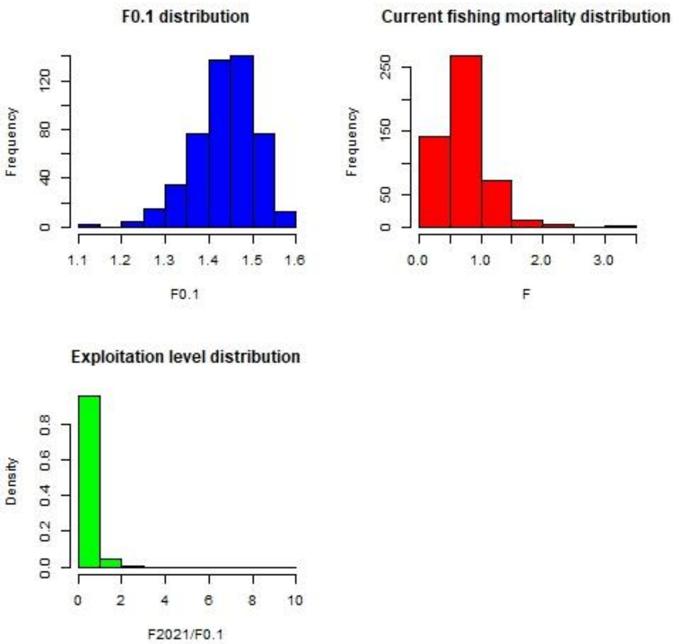


Figure 6.2.2.51 Deep-water rose shrimp in GSAs 5, 6 & 7: Histograms of probability for $F_{0.1}$, Fcurr and level of exploitation (Fcurr/F01 ratio) values for red mullet in GSA9.

A sensitivity analysis was performed on the number of knots applied to the smoother in year in the F sub-model.

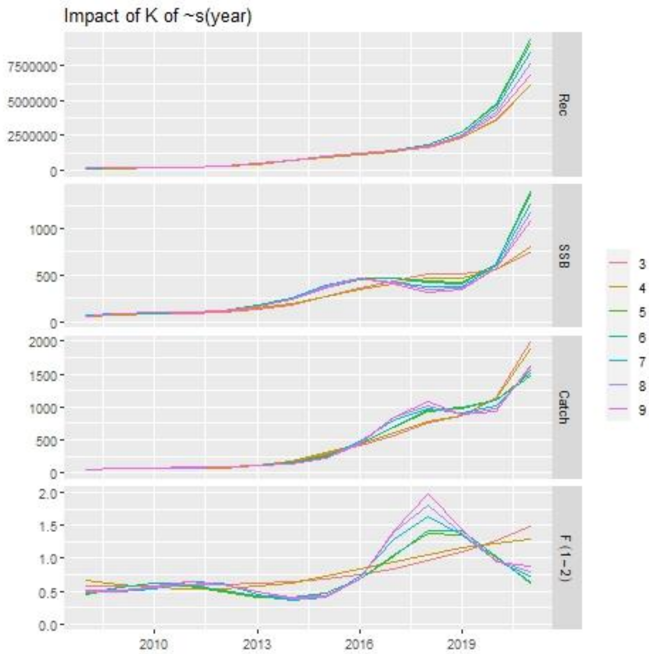


Figure 6.2.2.52 Deep-water rose shrimp in GSAs 5, 6 & 7: Outputs of model runs with different k values on the smoother on year in the fmodel.

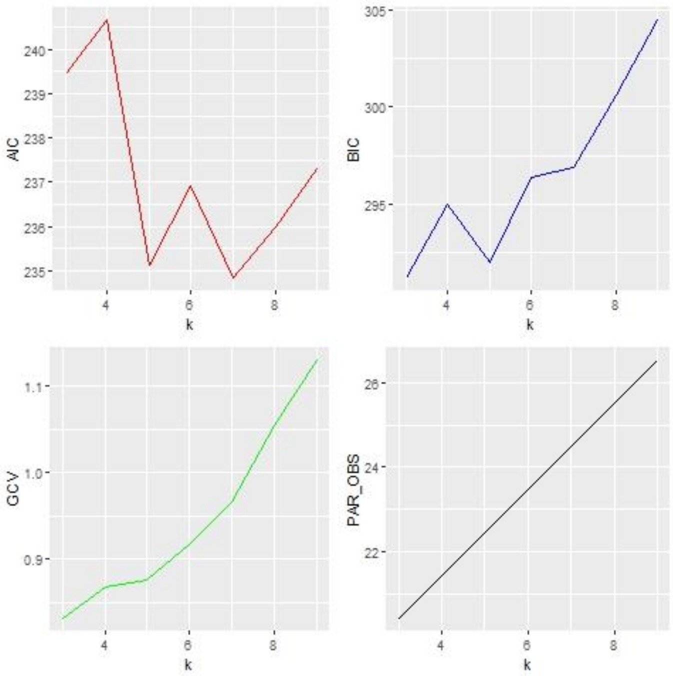


Figure 6.2.2.53 Deep-water rose shrimp in GSAs 5, 6 & 7: AIC, BIC and GCV values estimated on a range of k values of the smoother on year of the fmodel.

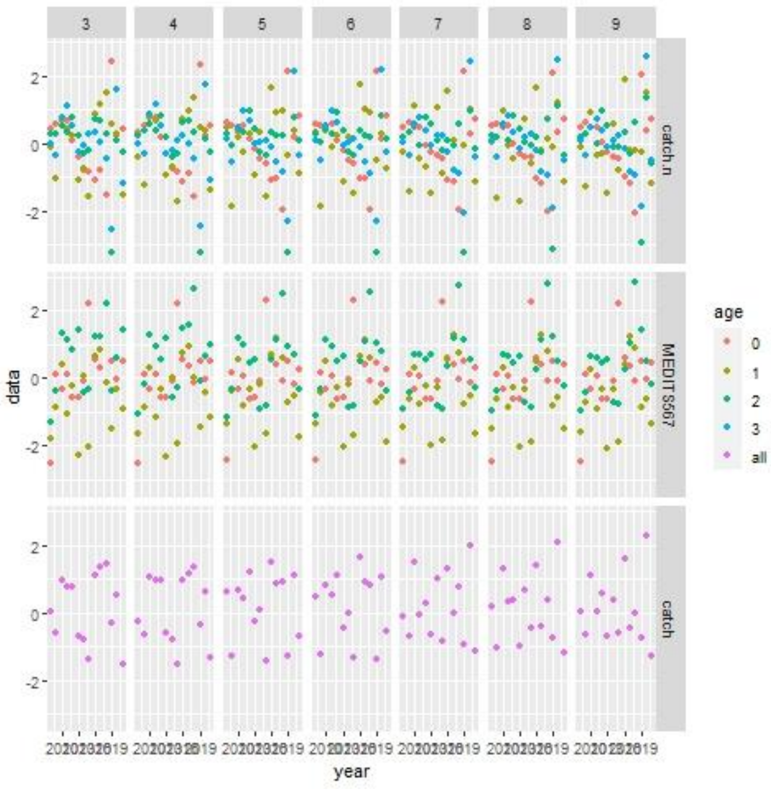


Figure 6.2.2.54 Deep-water rose shrimp in GSAs 5, 6 & 7: Log residuals of catch and abundance indices by age on a range of k values of the smoother on year of the fmodel.

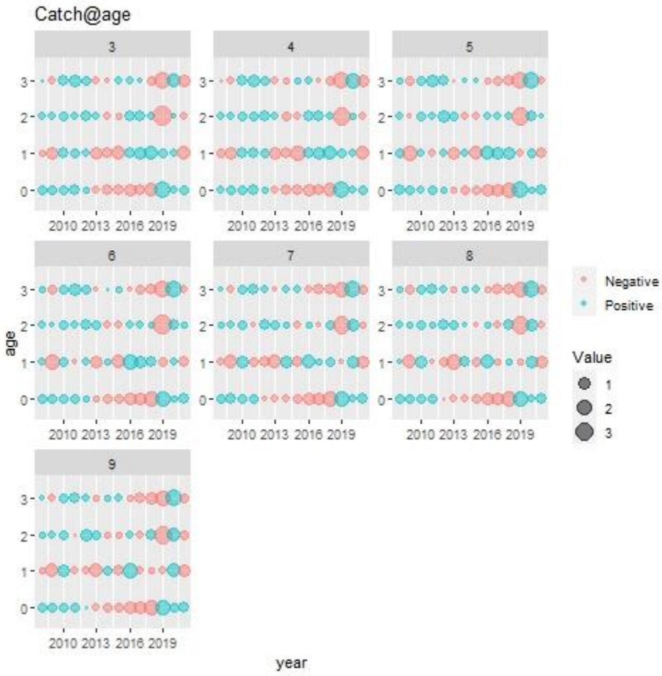


Figure 6.2.2.55 Deep-water rose shrimp in GSAs 5, 6 & 7: Bubble plots of the residuals of catch numbers by age on a range of k values of the smoother on year of the fmodel.

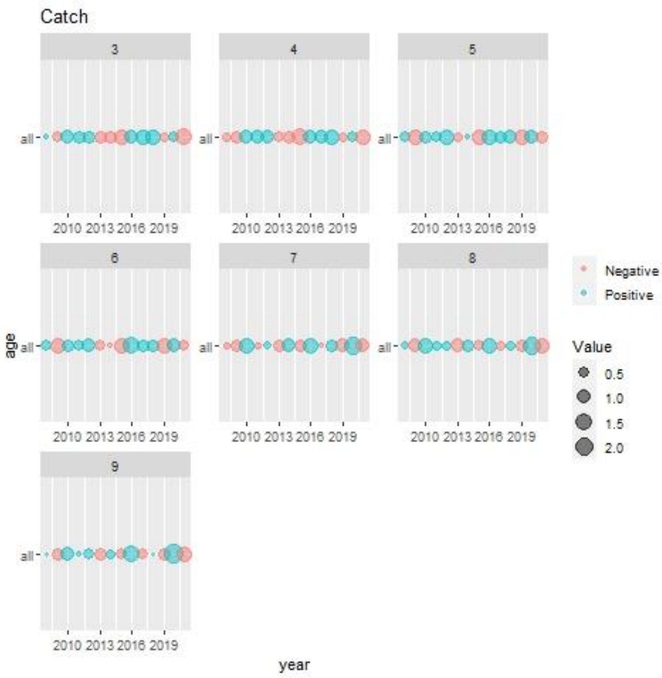


Figure 6.2.2.56 Deep-water rose shrimp in GSAs 5, 6 & 7: Bubble plots of the residuals of the catch on a range of k values of the smoother on year of the fmodel.

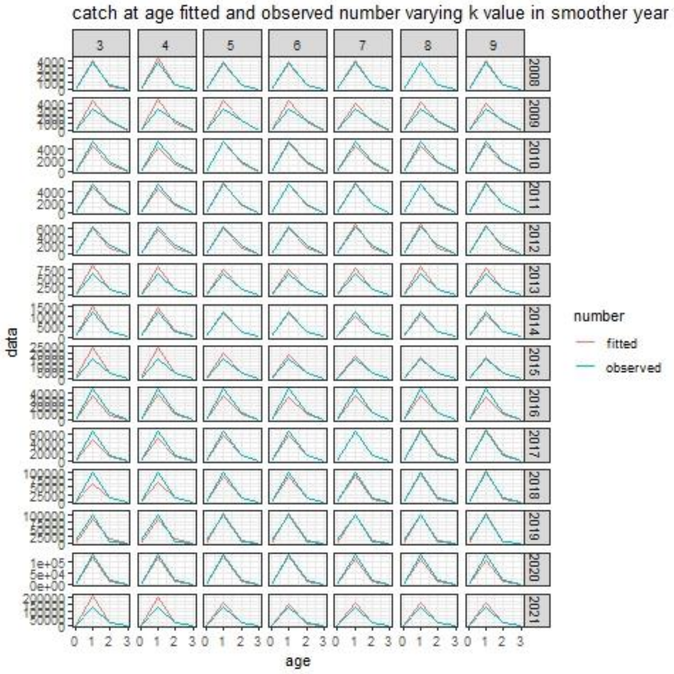


Figure 6.2.2.57 Deep-water rose shrimp in GSAs 5, 6 & 7: Fit of the catch at age numbers on a range of k values of the smoother on year of the fmodel.

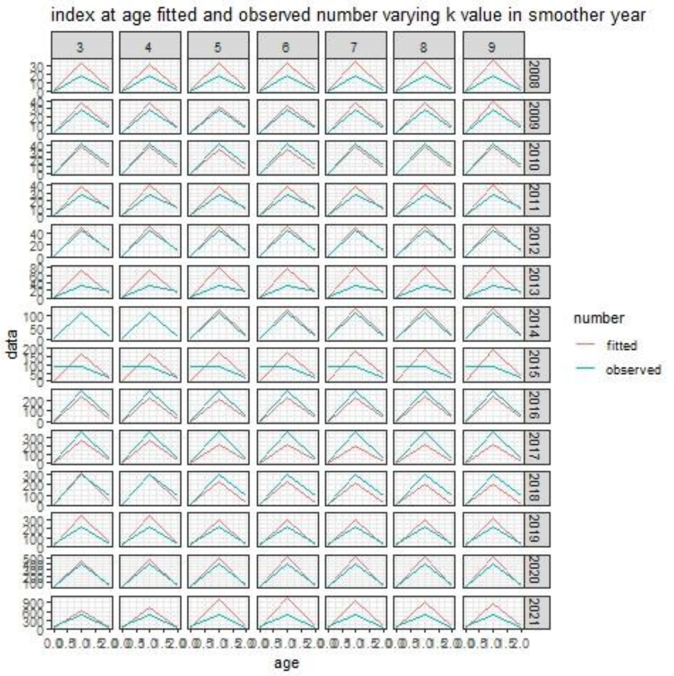


Figure 6.2.2.58 Deep-water rose shrimp in GSAs 5, 6 & 7: Fit of the index at age numbers on a range of k values of the smoother on year of the fmodel.

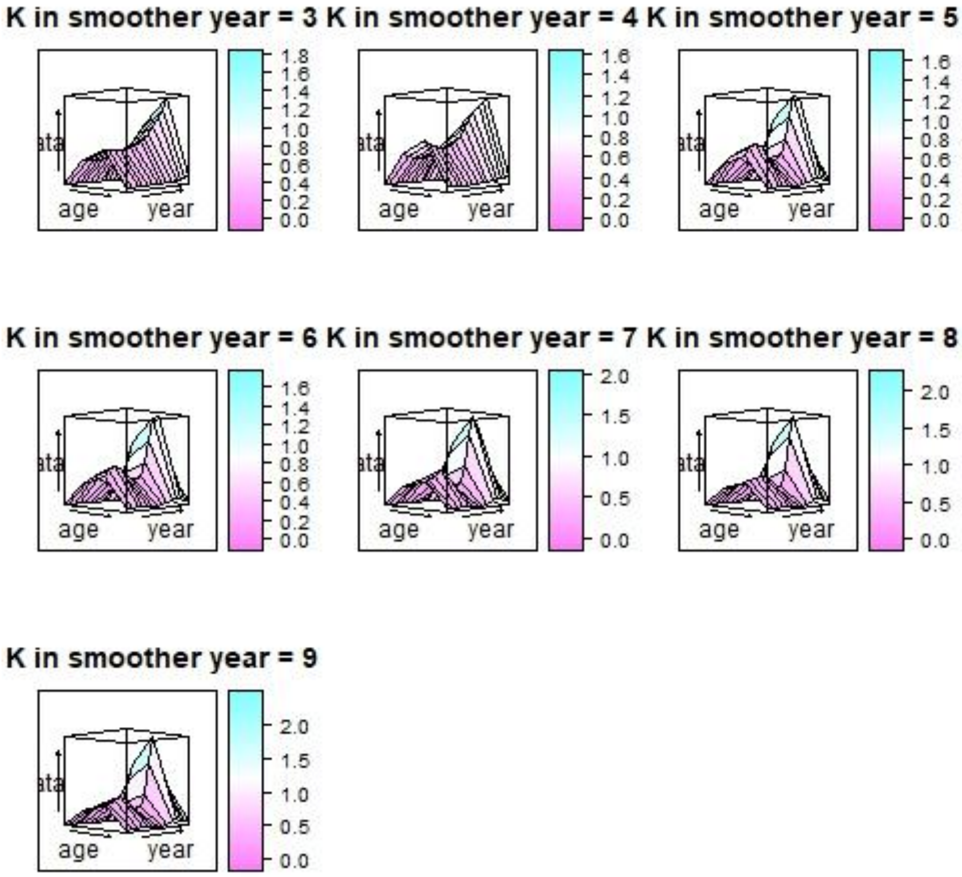


Figure 6.2.2.59 Deep-water rose shrimp in GSAs 5, 6 & 7: Harvest wireframe on a range of k values of the smoother on year of the fmodel.

The inputs and the final outputs have been tested also using the ad-hoc a4adiags package which run tests to evaluate the stability and good of fitness of the model (e.g. hindcasting, MASE value,etc). The model passed all the test resulting in a MASE value below the 1 threshold to be accepted.

In Figures 6.2.2.60-63 the main outputs

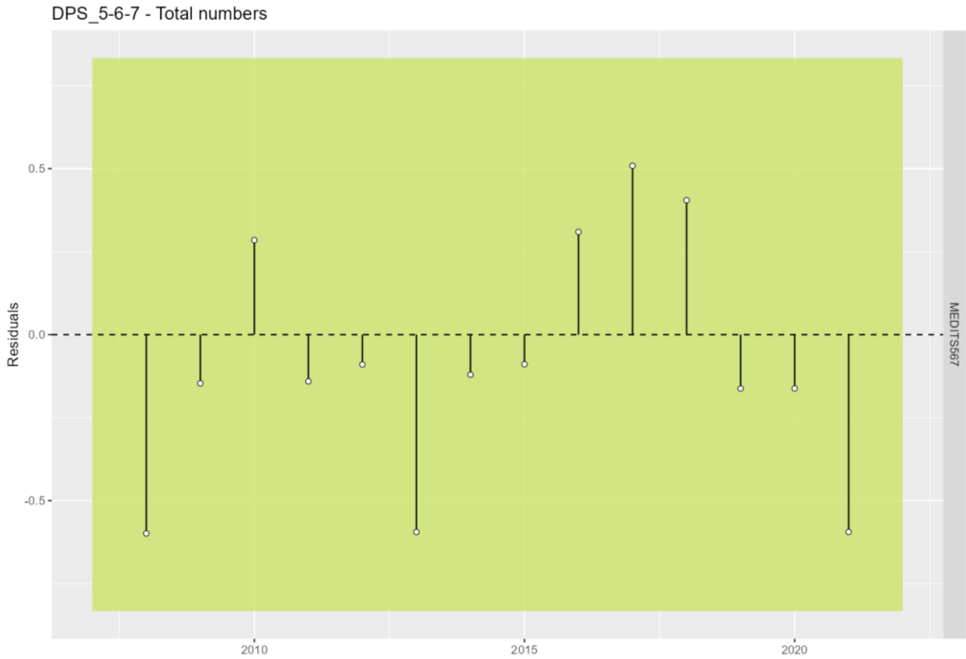


Figure 6.2.2.60 Deep-water rose shrimp in GSAs 5, 6 & 7: RuntestN results from the a4adigs package.

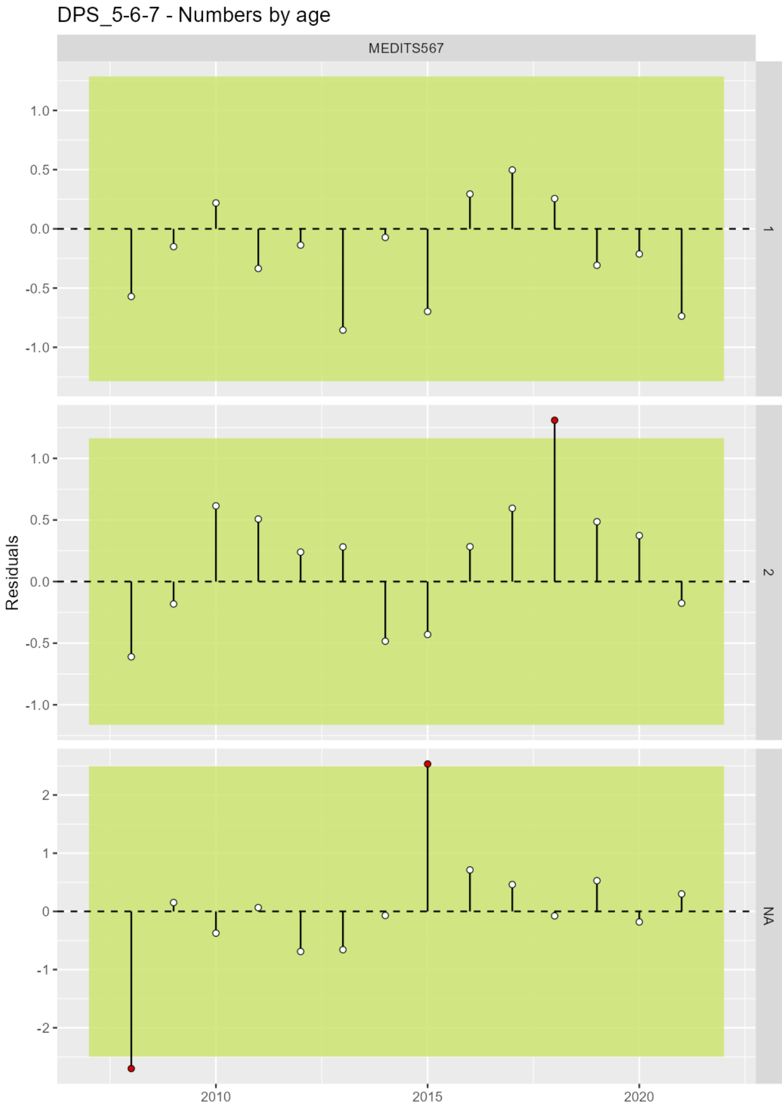


Figure 6.2.2.61 Deep-water rose shrimp in GSAs 5, 6 & 7: RuntestAge results from the a4adiags package.

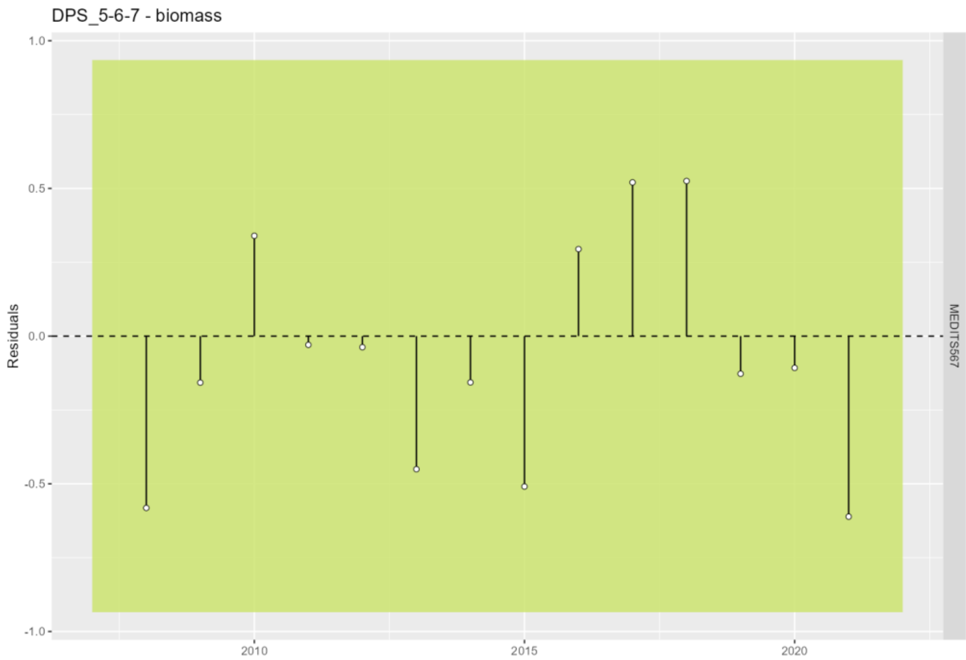


Figure 6.2.2.62 Deep-water rose shrimp in GSAs 5, 6 & 7: RuntestBio results from the a4adiags package.

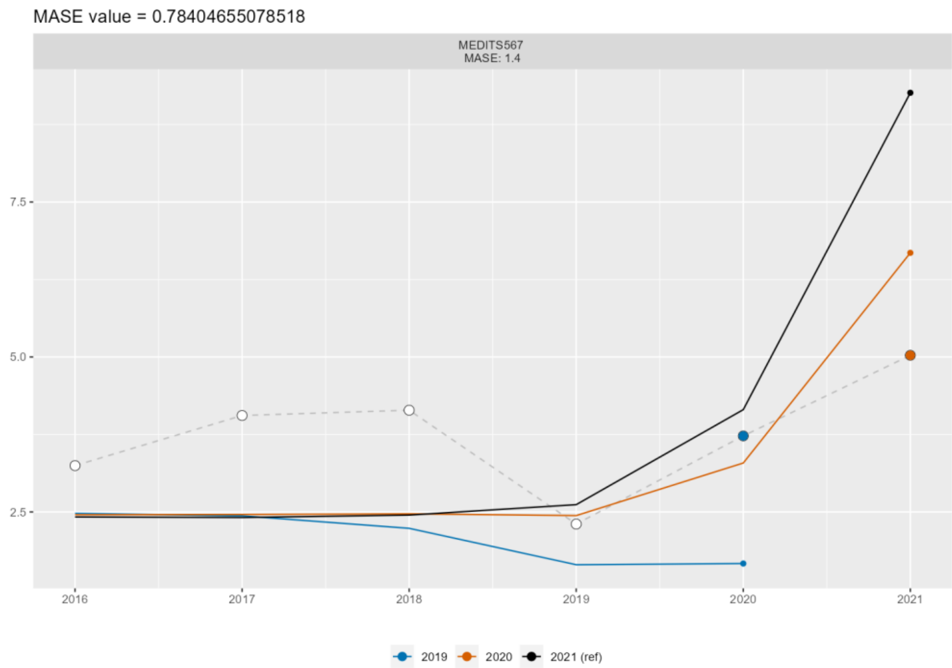


Figure 6.2.2.63 Deep-water rose shrimp in GSAs 5, 6 & 7: Hindcasting and MASE value results from the a4adiags package

Final assessment outcomes are given in Tables 6.11.3.4-6.11.3.6.

Table 6.2.2.17 Deep-water rose shrimp in GSAs 5, 6 & 7: Times series of the recruitment, SSB, catch and fishing mortality estimated by the model.

Year	Recruitment age 0 ('000)	SSB (t)	Catch (t)	F_{bar} ages 1-2	Total biomass
2008	148645.5	65.26072	40.39294	0.452855	442.7718
2009	156430.5	81.20266	66.51792	0.56242	514.1461
2010	178213.1	93.25722	74.50973	0.624751	573.8165
2011	231136.7	101.3051	75.38801	0.585296	678.7894
2012	336806.5	123.2687	80.5553	0.483543	917.3875
2013	513382.9	177.712	103.3304	0.401786	1371.552
2014	749165.1	258.9176	145.5421	0.388431	1994.503
2015	989960.2	373.8829	253.7919	0.471639	2759.167
2016	1195615	460.4525	444.751	0.689822	3672.843
2017	1417780	460.8129	695.8036	1.047724	3020.201
2018	1819909	434.0534	932.7025	1.37179	5826.152
2019	2715448	425.1624	973.577	1.35899	6793.778
2020	4730921	627.0488	1094.481	1.013083	11442.19
2021	9033092	1370.468	1500.936	0.639139	16417.62

Table 6.2.2.18 Deep-water rose shrimp in GSAs 5, 6 & 7: Stock numbers at age.

	Stock numbers at age			
Year	Age0	Age1	Age2	Age3+
2008	148645.5	17536.9	1703.4	832.6
2009	156430.5	18138.1	4171.3	803.8
2010	178213.1	19085.4	3929.6	1290.8
2011	231136.7	21742.1	3925.1	1384.5
2012	336806.5	28218.4	4619.7	1465.0
2013	513382.9	41100.7	6536.3	1784.2
2014	749165.1	62649.6	10206.5	2562.6
2015	989960.2	91416.9	15725.8	3945.8
2016	1195615.4	120807.0	21376.5	5670.3
2017	1417779.8	145888.9	23467.7	6604.3
2018	1819909.2	175894.5	20956.5	5778.2
2019	2715448.0	221944.4	19177.6	4195.2
2020	4730921.3	331096.2	24428.4	3426.0
2021	9033092.0	576977.8	48899.6	4707.2

Table 6.2.2.19 Deep-water rose shrimp in GSAs 5, 6 & 7: Fishing mortality at age.

	Fishing mortality at age			
Year	Age0	Age1	Age2	Age3+
2008	0.000	0.385	0.521	0.044
2009	0.000	0.478	0.647	0.055
2010	0.000	0.531	0.719	0.061
2011	0.000	0.497	0.673	0.057
2012	0.000	0.411	0.556	0.047
2013	0.000	0.341	0.462	0.039
2014	0.000	0.330	0.447	0.038
2015	0.000	0.401	0.542	0.046
2016	0.000	0.586	0.793	0.068
2017	0.001	0.890	1.205	0.103
2018	0.001	1.166	1.578	0.134
2019	0.001	1.155	1.563	0.133
2020	0.001	0.861	1.165	0.099
2021	0.000	0.543	0.735	0.063

6.2.2.5 Reference Points

The STECF EWG recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the assessment.

Values of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 1.445. Current F values (2021), as calculated by model a4a, is 0.639 indicating that the stock is in underfishing conditions (Fcurr/ $F_{0.1}$=0.442). Because of the instability in the retrospective and considering that it was the first year in which for this stock a sensible assessment has been obtained the EWG agreed not to run any procedures to estimate biomass reference points.

6.2.2.6 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the stock assessment.

An average of the last three years has been used for weight at age, maturity at age, natural mortality at age and selectivity at age while the F_{bar} = 0.639 terminal F (2021) from the a4a assessment was used for F in 2022. Recruitment is in a clear increasing phase over the period of the assessment (Figure 6.11.3.5) so the geometric mean across the last three years has been used as an estimate of recruits from 2022.

Table 6.2.2.20 Deep-water rose shrimp in GSAs 5, 6 & 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 1-2 (2022)	0.639139	Fsq = F in the last year
SSB (2022)	2756.005467	SSB intermediate year from STF output
Rage0 (2022,2023)	4877619.101	Recruitment will be set as geometric mean of the last 3 years
Total Catch (2022)	2932.282696	Catch intermediate year from STF output
Fbar (2019)	1.35899	MAP base year fishing mortality from current assessment
a and b values	a=0.33 and b=0.66	Regression parameters from Transition regression line

The analysis, carried out with the ad-hoc script developed by JRC and made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=1.445) would reduce biomass by 46.7% from 2022 to 2024, while increasing catches by 197.1% from 2021 to 2023.

Table 6.2.2.20 Deep-water rose shrimp in GSAs 5, 6 & 7: Short term forecast table.

Rationale	Ffactor	Fbar	Catch 2022	Catch 2023	SSB* 2022	SSB* 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield ($F_{0.1}$)	2.26	1.445	2932.3	4459.4	2756.0	1467.8	-46.7	197.1
F upper	3.06	1.958	2932.3	5190.3	2756.0	1045.6	-62.1	245.8
F lower	1.50	0.957	2932.3	3469.3	2756.0	2137.2	-22.5	131.1
F_{MSY} transition (intermediate year)	2.22	1.417	2932.3	4410.2	2756.0	1498.6	-45.6	193.8
Zero catch	0	0.000	2932.3	0.0	2756.0	5216.1	89.3	-100.0
Status quo	1	0.639	2932.3	2597.2	2756.0	2811.1	2.0	73.0
Different Scenarios	0.1	0.064	2932.3	326.3	2756.0	4884.7	77.2	-78.3
	0.2	0.128	2932.3	635.3	2756.0	4578.1	66.1	-57.7
	0.3	0.192	2932.3	928.1	2756.0	4294.3	55.8	-38.2
	0.4	0.256	2932.3	1205.7	2756.0	4031.4	46.3	-19.7
	0.5	0.320	2932.3	1468.9	2756.0	3787.9	37.4	-2.1
	0.6	0.383	2932.3	1718.6	2756.0	3562.2	29.3	14.5
	0.7	0.447	2932.3	1955.6	2756.0	3352.9	21.7	30.3
	0.8	0.511	2932.3	2180.6	2756.0	3158.7	14.6	45.3
	0.9	0.575	2932.3	2394.2	2756.0	2978.5	8.1	59.5
	1.1	0.703	2932.3	2790.2	2756.0	2655.6	-3.6	85.9
	1.2	0.767	2932.3	2973.7	2756.0	2511.0	-8.9	98.1
	1.3	0.831	2932.3	3148.3	2756.0	2376.5	-13.8	109.8
	1.4	0.895	2932.3	3314.5	2756.0	2251.3	-18.3	120.8
	1.5	0.959	2932.3	3472.7	2756.0	2134.7	-22.5	131.4
	1.6	1.023	2932.3	3623.4	2756.0	2026.0	-26.5	141.4
	1.7	1.087	2932.3	3767.0	2756.0	1924.7	-30.2	151.0
	1.8	1.150	2932.3	3903.9	2756.0	1830.2	-33.6	160.1
	1.9	1.214	2932.3	4034.6	2756.0	1741.9	-36.8	168.8
	2	1.278	2932.3	4159.2	2756.0	1659.4	-39.8	177.1

*SSB at mid year

EWG advises that when the MSY approach is applied, catches in 2023 should be no more than 4459.4 tonnes.

6.2.2.7 DATA DEFICIENCIES

Below the main issues and/or data gaps spotted during the meeting.

Country	Data Requested	Issue
Spain	Catch	GSA_05_DPS. There are at least 55 records (in particular in 2020 and 2021) for which the landings in weight obtained by run a sum of product between catch number at age and corrisponding mean at weight at age ended up with a need of a huge SoP corrections. Please check.
Spain	Maturity ogive at length Maturity ogive at age Growth parameters Sex ratio at length Sex ratio at age	GSA_05_DPS. Biological data available only at sex combined level. No data by sex separated.
Spain	MEDITS survey TA	GSA_05_DPS. The total number of hauls changes in time ending up with almost number of hauls carried out. In particular in close the Ibiza and Formentera islands the hauls varying a lot.
Spain	MEDITS survey TB_TC	GSA_05_DPS. There are some hauls showing inconsistencies between total weight and/or number reported in TB and TC files. In particular haul 192 in 2017, haul 188 in 2019 and haul 246 in 2021. A general check should be run.
Spain	MEDITS survey TA	GSA_06_DPS. The total number of hauls changes in time. The number of hauls carried out are not in agreement with the total number of hauls stated in the MEDITS handbook for this area.
Spain	MEDITS survey TB_TC	GSA_06_DPS. There are some hauls showing inconsistencies between total weight and/or number reported in TB and TC files. In particular haul 33 in 2020 and haul 50 in 2020. A general check should be run.
Spain	MEDITS survey TC	GSA_06_DPS. Unrealistic length measures (more than 50mm CL) reported for the species in 2013 and 2021
Spain	MEDITS survey TC	GSA_05_DPS. Unrealistic length measures (more than 50mm CL) reported for the species in 2009 and 2021
France	MEDITS survey TA	GSA_07_DPS. The total number of hauls changes in time. The number of hauls carried out are not in agreement with the total number of hauls stated in the MEDITS handbook for this area.
France	MEDITS survey TC	GSA_07_DPS. Unrealistic length measures (more than 50mm CL) reported for the species in 2010, 2015 and 2016. In particular check haul 65 in 2010.
Spain	Maturity ogive at length Maturity ogive at age Growth parameters Sex ratio at length Sex ratio at age	GSA_06_DPS. Biological data available only at sex combined level. No data by sex separated.
Spain	Landings length	GSA_05_DPS. In some years total landings in weight differ with the ones made available from the FDI dataset at the time of the EWG
Spain	Landings length	GSA_06_DPS. In some years total landings in weight differ with the ones made available from the FDI dataset at the time of the EWG
Spain	Landings length	GSA_07_DPS. In some years total landings in weight differ with the ones made available from the FDI dataset at the time of the EWG
Spain	Discards length	GSA_05_DPS. In some years total discards in weight differ with the ones made available from the FDI dataset at the time of the EWG
Spain	Discards length	GSA_06_DPS. In some years total discards in weight differ with the ones made available from the FDI dataset at the time of the EWG
Spain	Discards length	GSA_07_DPS. In some years total discards in weight differ with the ones made available from the FDI dataset at the time of the EWG
Spain	Catch	GSA_06_DPS. There are at least 77 records (in particular in 2020 and 2021) for which the landings in weight obtained by run a sum of product between catch number at age and corrisponding mean at weight at age ended up with a need of a huge SoP corrections. Please check.
France	Landings length	GSA_07_DPS. There aren't any length frequencies distributions available for this species.
France	Maturity ogive at length Maturity ogive at age Growth parameters Sex ratio at length Sex ratio at age	GSA_07_DPS. Biological data are not available.
Spain	Discards length	GSA_06_DPS.Discards number reported for 2019 third quarter in metier OTB-DEMSP are reported in total number rather than in thousands.

6.3 Red mullet in GSA 1

6.3.1 Stock Identity and Biology

Red mullet (*Mullus barbatus*) is among the most important target species for the trawl fisheries but is also caught with set gears, in particular trammel nets (about the 10% of the catches). From official data, the total trawl fleet of the geographical sub area GSA 1 (Northern Alboran Sea region) is composed by about 170 boats (data compiled in EWG 22-09). Smaller vessels operate almost exclusively on the continental shelf (targeting red mullets, octopus, hake and sea breams), bigger vessels operate almost exclusively on the continental slope (targeting decapod crustaceans) and the remaining can operate indistinctly on the contine ntal shelf and slope fishing grounds. Red mullet is intensively exploited during its recruitment from August to November.

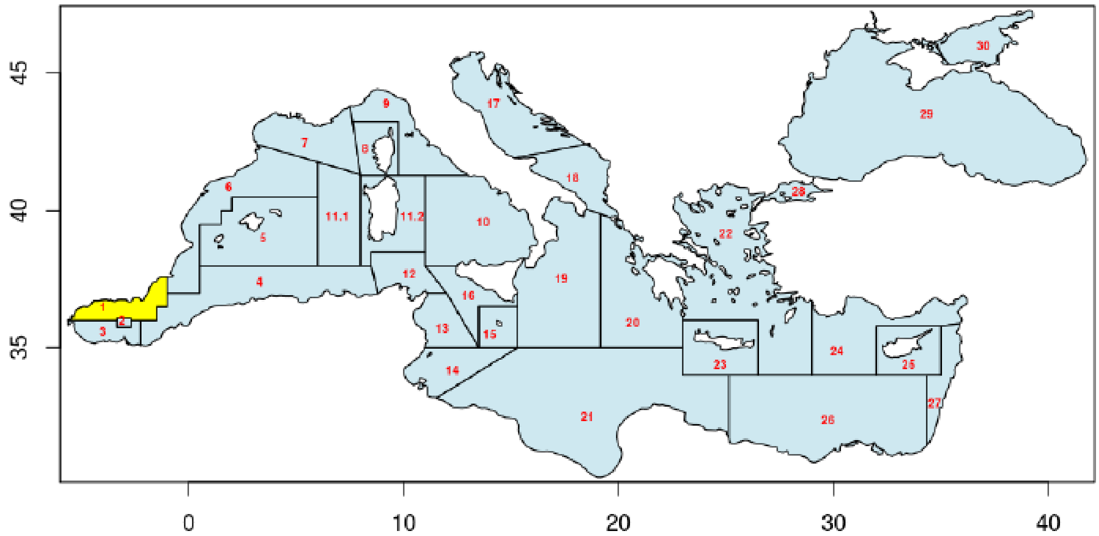


Figure 6.3.1.1 Red mullet in GSA 1: Location of GSA 1 in the Mediterranean Sea.

Trawl fisheries in GSA 1 are regulated by "Oren AAA/2808/2012" published in the Spanish Official Bulletin (BOE nº 313 29 December 2012) containing an Integral Management Plan for Mediterranean fishery resources. Fisheries are subject to the traditional fisheries regulations already in place (e.g. the daily and weekly fishing effort limited to 12 hours per day five days a week; trawl cod end 40 mm square mesh or 50 mm diamond stretched mesh; engine power of maximum 373 kW; license system; minimum landing size of 11 cm TL). Minimum landing size for red mullet is established at 11 cm TL from the CE Regulation 1967/2006. Currently this species is included in the regulatory EU MAP body (EU No 508/2014 and Orden APA, 423/2020).

Growth

The Von Bertallanfy growth parameters estimated within the Spanish DCF considered to have a very low t 0 , (STECF EWG 12 02) and thus, the STECF EWG 19 10 decided to use the ones selected during EWG 15 06 meeting with a 0.5 added in the t0 according to the suggestions of the EWG in order to align the growth at length correctly with the age based on the calendar year.

Table 6.3.1.1 Red mullet in GSA 1: Von Bertallanfy growth parameters

Age	Value
Linf	34.5
k	0.34
t0	-0.1431
4+	1

Length-weight reationship

Length weight parameters (a=0.0102, b=3.03) were derived from Spanish DCF for the year 2007 for sexes combined and total length expressed in cm. used in EWG 2111.

Natural mortality

A vector of natural mortality was estimated by Chen Watanaby method (Chen S. & Watanabe S., 1989) using growth and length-weight relationship parameters for sex combined.

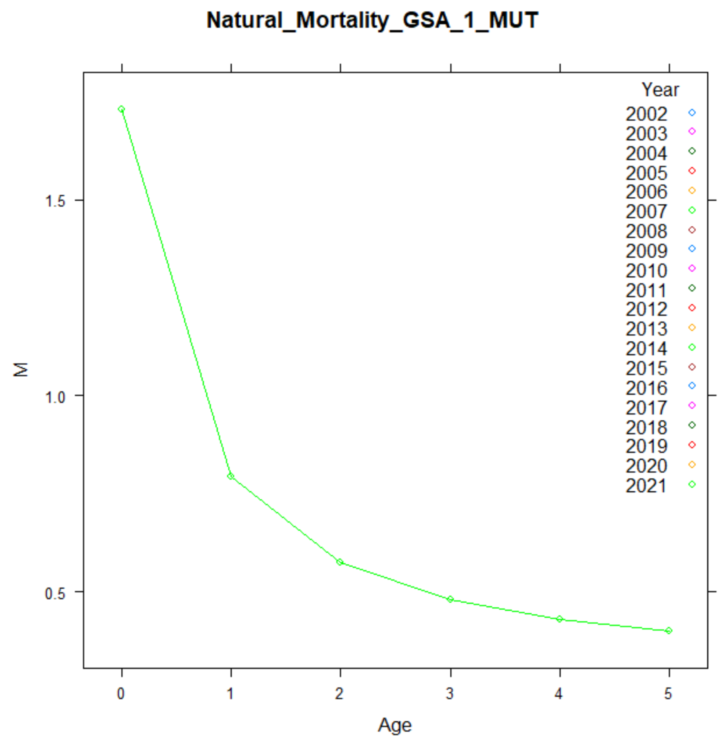


Figure 6.3.1.2 Red mullet in GSA 1: Natural mortality estimated from the parameters presented in the **Table 6.3.1.2**

Maturity

The species reaches sexual maturity at one year old. The vector of maturity at age was provided by the experts of the EWG 20–09, in line with the previous assessments.

Table 6.3.1.2 Red mullet in GSA 1: natural mortality and maturity vector at age.

Age	Maturity	M
1	1	0.79
2	1	0.57
3	1	0.47
4+	1	0.42

6.3.2 Data

6.3.2.1 Catch (landings and discards)

Principal fishing gears used to catch red mullet in GSA 1 together with other species (mixed catches) are gillnets (GNS), trammel nets (GTR) and bottom trawls (OTB).

Landings: Missing LFDs were reconstructed for the two main fleets (GTR and OTB) with catches of MUT in GSA1. Discards: LFDs were available for 2003-2020 for OTB_DEMSP. The median was used to reconstruct discards LFD for the two metiers OTB_NA and OTB_MDD. No discards are reported for GTR and they can be considered negligible.

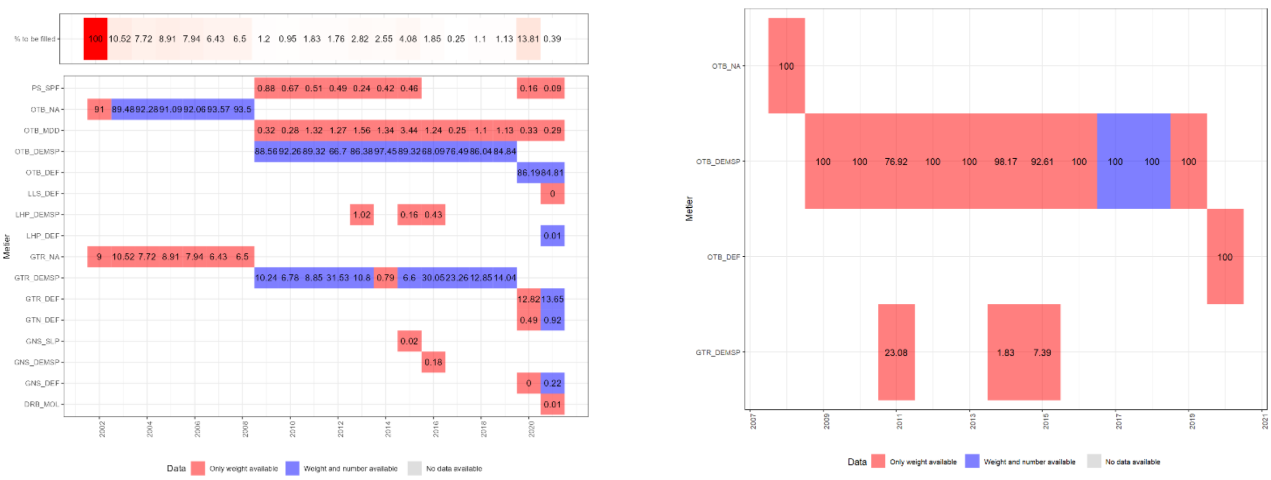


Figure 6.3.2.1.1 Red mullet in GSA 1: Summary of the reconstruction of landings and discards data carried by EWG-21-02.

Table 6.3.2.1.1Red mullet in GSA 1: History of commercial landings; official reported values are presented. Catches are used in the stock assessment. All weights are in tonnes.

Year	Total landings	STECF landings	STECF discards	STECF catch
2003	159.68	159.68	0.063	159.74
2004	154.07	154.07	0.062	154.13
2005	140.21	140.21	0	140.21
2006	164.54	164.54	0.06	164.61
2007	194.01	194.01	0.080	194.09
2008	193.65	193.65	0.16	193.81
2009	228.37	228.37	1.093	229.46
2010	201.65	201.65	0.012	201.66
2011	201.18	201.18	0.142	201.32
2012	107.31	107.31	1.656	108.97
2013	131.63	131.63	0.289	131.92
2014	123.87	123.87	3.287	127.16
2015	135.9	135.9	1.781	137.68
2016	260.49	260.49	7.624	268.11
2017	274.67	274.67	3.483	278.15
2018	170.23	170.23	2.798	173.03
2019	124.62	124.63	0.409	125.04
2020	107.321	107.32	0.261	107.58
2021	151.102	151.102	0	151.102

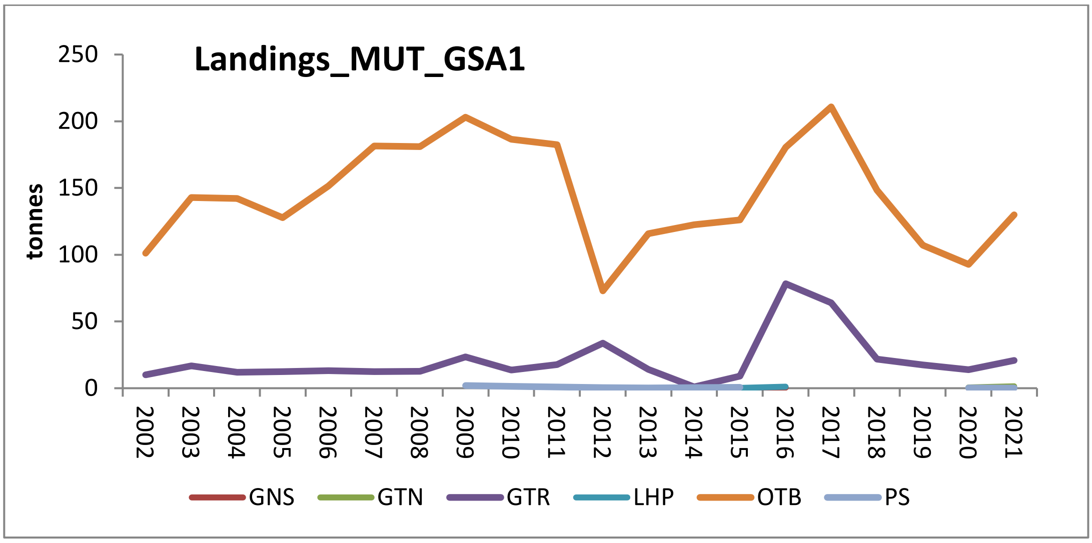


Figure 6.3.2.1.2 Red mullet in GSA 1: Landings (t) of red mullet in GSA 1 in the period from 2003 to 2021 by fishing gear and fishery.

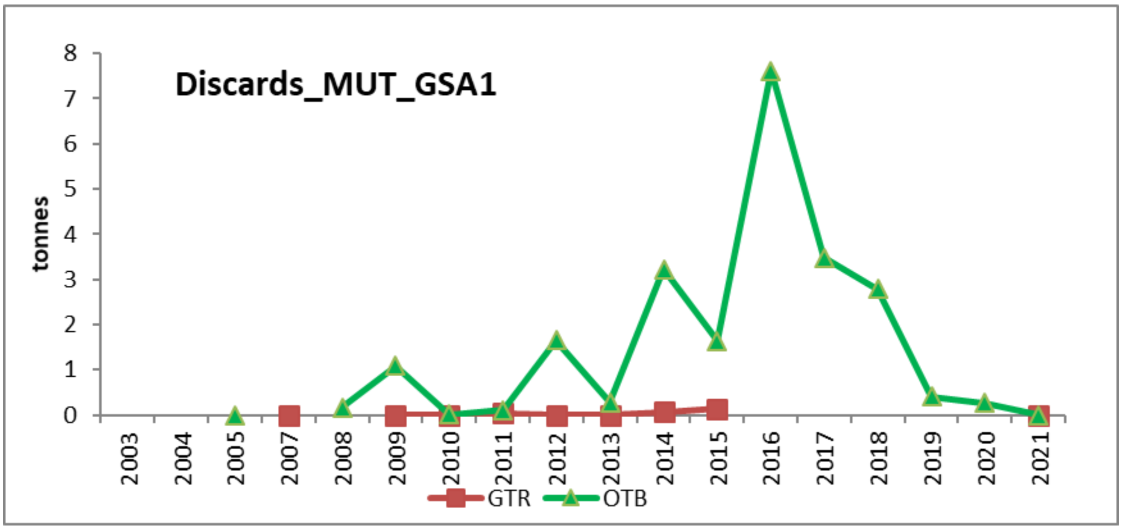


Figure 6.3.2.1.3 Red mullet in GSA 1: Discards (t) of red mullet in GSA 1 in the period from 2003 to 2021 by fishing gear and fishery.

Length structure of red mullet catches (landings and discards) for all gears in the period from 2003 to 2021 are shown in Figures 6.3.2.1.4 - 6.3.2.1.5 for landings and discards respectively. Reconstructed Length structure of red mullet catches (landings and discards) for all gears in the period from 2003 to 2021 are shown in Figures 6.3.2.1.6 - 6.3.2.1.7 for landings and discards respectively. Final length catches structure of red mullet are shown in Figure 6.3.2.1.8.

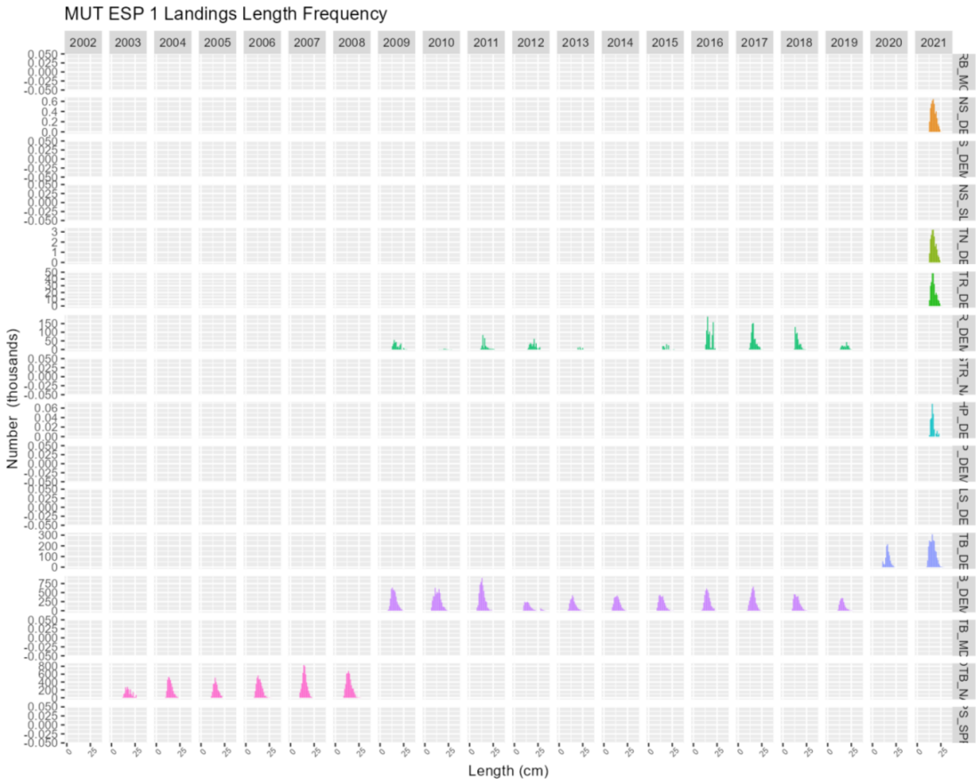


Figure 6.3.2.1.4 Red mullet in GSA 1: Length structure of red mullet landed in GSA 1 in the period from 2003 to 2021 by fishing gear and fishery.

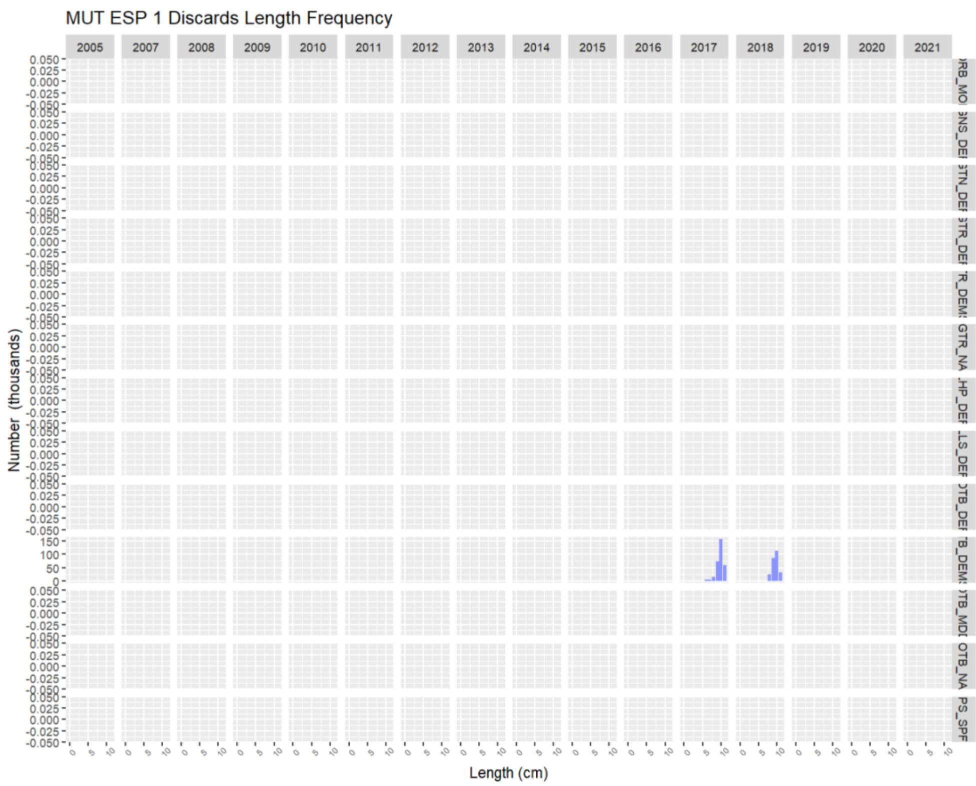


Figure 6.3.2.1.5 Red mullet in GSA 1: Length structure of red mullet discards in GSA 1 in the period from 2003 to 2021 by fishing gear and fishery.

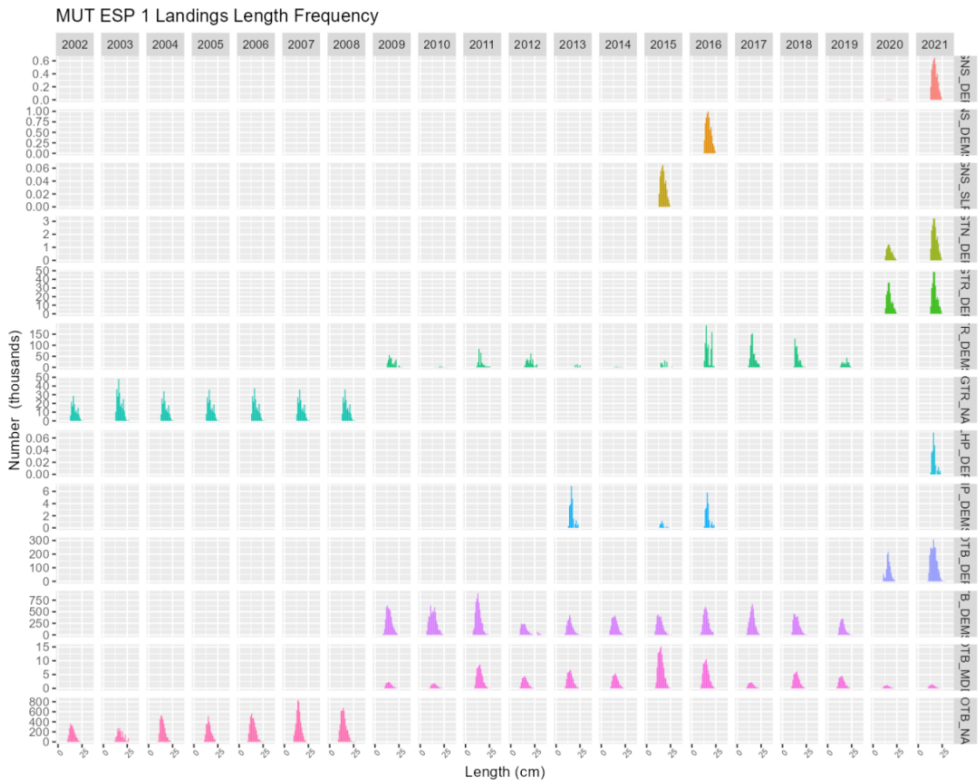


Figure 6.3.2.1.6 Red mullet in GSA 1: Length structure of red mullet landed in GSA 1 in the period from 2003 to 2021 by fishing gear and fishery as reconstructed by EWG 21-02.

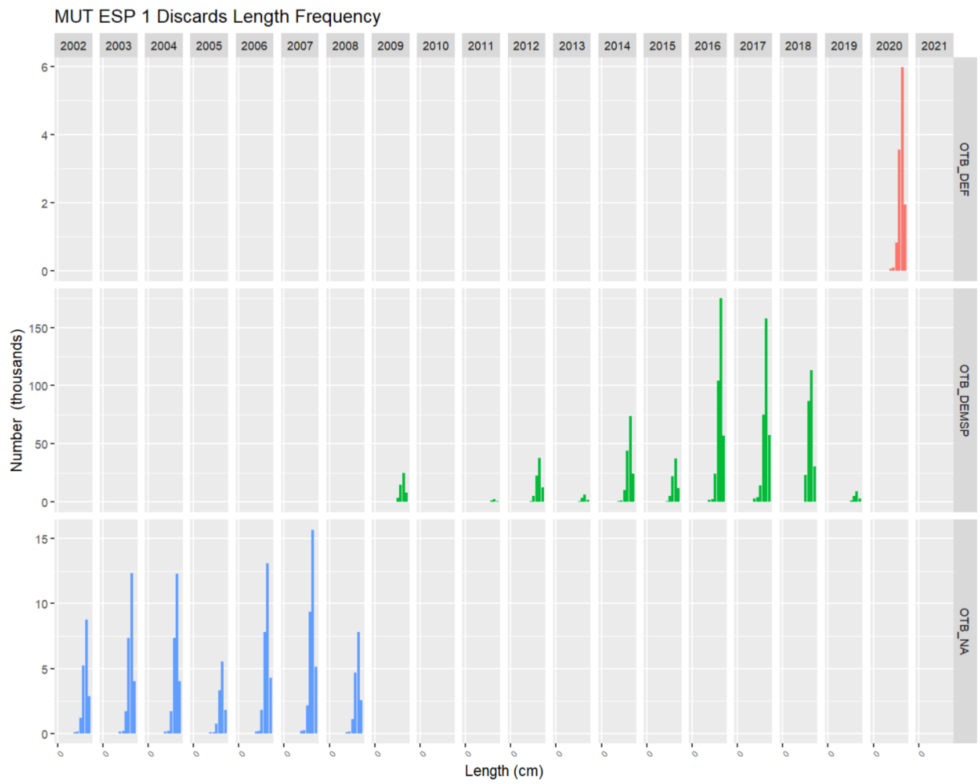


Figure 6.3.2.1.7 Red mullet in GSA 1: Length structure of red mullet catch discarded in GSA 1 in the period from 2006 to 2021 by fishing gear and fishery as reconstructed by EWG 21-02.

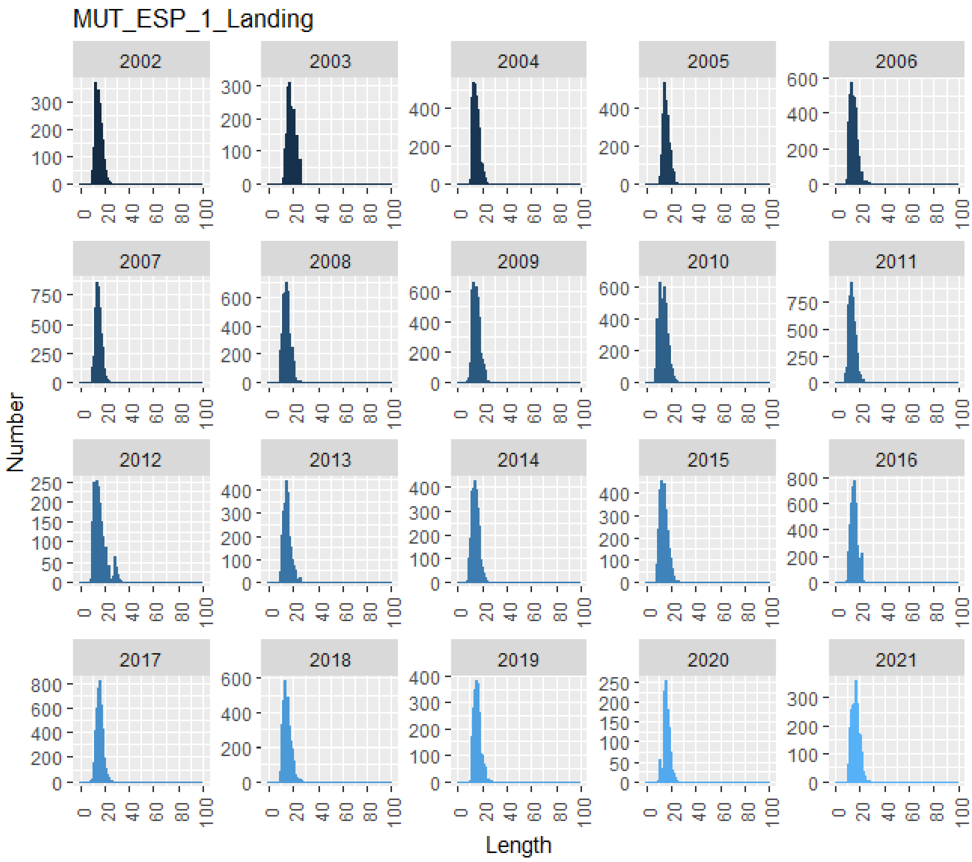


Figure 6.3.2.1.8 Red mullet in GSA 1. Landings length frequency distribution, by year (TL cm). LFDs until 2021 as reconstructed by EWG21-02.

6.3.2.2 Effort

Red mullet is caught by mixed fisheries, using a variety of fishing gears (trammel nets and trawls), by fishing boats of different sizes and métiers. Although the main bulk of the catch comes from the trawlers. In such situation, red mullet is only one component of entire catch, fishing effort specifically related to red mullet only cannot be obtained independent of other fisheries. Fishing effort is dealt with by the FD EWG and STECF values for effort can be found in the their report (EWG 22-10).

Table 6.3.2.2.1 Red mullet in GSA 1: Nominal effort (fishing days) for trammel nets associated to *Mullus barbatus* in GSA 1 in the period 2002-2021.

Years	GT * days at sea	days at sea	fishing days
2002	16851	4747	4747
2003	20530	5534	5534
2004	18075	5809	5809
2005	19536	5600	5600
2006	20914	5937	5937
2007	18456	5474	5474
2008	19906	5964	5964
2009	33983	9455	9455
2010	29579	9039	9039
2011	31878	10388	10388
2012	31833	10172	10172
2013	37276	12423	12423
2014	38856	13663	13663
2015	28649	9810	9810
2016	28699	10189	10189
2017	31995	10586	10586
2018	23408	8424	8424
2019	28079	10105	10105
2020	28818	10371	10371
2021	28065	10100	10100

Table 6.3.2.2.2 Red mullet in GSA 1: Nominal effort (fishing days) for trawlers associated to *Mullus barbatus* in GSA 1 in the period 2002-2021.

Years	GT * days at sea	days at sea	fishing days
2002	1333918	28002	28002
2003	1684655	32892	32892
2004	1894693	34951	34951
2005	1761339	32295	32295
2006	1685266	31443	31443
2007	1631930	29917	29917
2008	1495816	26201	26201
2009	1520713	27017	27017
2010	1568334	28476	28476
2011	1507685	28170	28170
2012	1395133	25851	25851
2013	1295309	24334	24334
2014	1159530	22395	22395
2015	1102193	21587	21587
2016	1083165	21345	21345
2017	1131873	22537	22537
2018	1079838	21633	21633
2019	918010	18391	18391
2020	795216	15931	15931
2021	736464	14754	14754

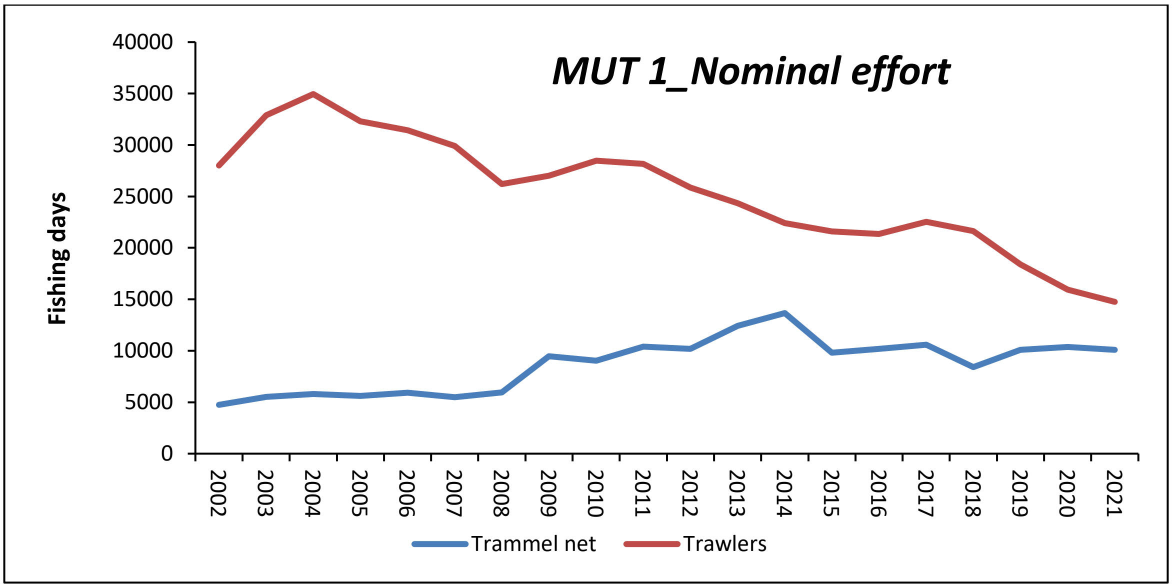


Figure 6.3.2.2.1 Red mullet in GSA 1: Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 1 in the period 2002-2021.

6.3.2.3 Survey data

Since 1994, MEDITS trawl surveys have been carried out during the end of spring –beginning of the summer season, as part of the DCF National Program (Figure 6.3.2.3.1). In the current assessment, for the a4a method, MEDITS data from 2004 onwards were used. MEDITS survey was not reported for the year 2011 and there were some inconsistencies with the data for the year 2006, due to some incorrect raising factor reported in the MEDITS TB file, these have been corrected.

The sampling design of MEDITS is random stratified sampling with number of hauls by stratum proportional to stratum surface. Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Only hauls noted as valid were used, including stations with no catches (zero catches are included). Based on the DCF data call, abundance and biomass indices were calculated.

Observed abundance and biomass indices of Red mullet are given on the figures below (Figures 6.3.2.3.2/3). Both estimated abundance and biomass indices show similar stable trends throughout the years with a peak through years 2006 -2009. Length frequency distributions are given on the figures below 6.3.2.3/4/5/6).

MEDITS survey in GSA 1 in 2020 was not carried out due to the COVID pandemic, therefore abundance and biomass indices for this year are not included in the a4a analysis. A significant increase in the MEDITS indices in GSA1 for Red mullet has been observed in the year 2021.

Figure 6.3.2.3.1 Red mullet in GSA 1: Survey periods of MEDITS in GSA 1.

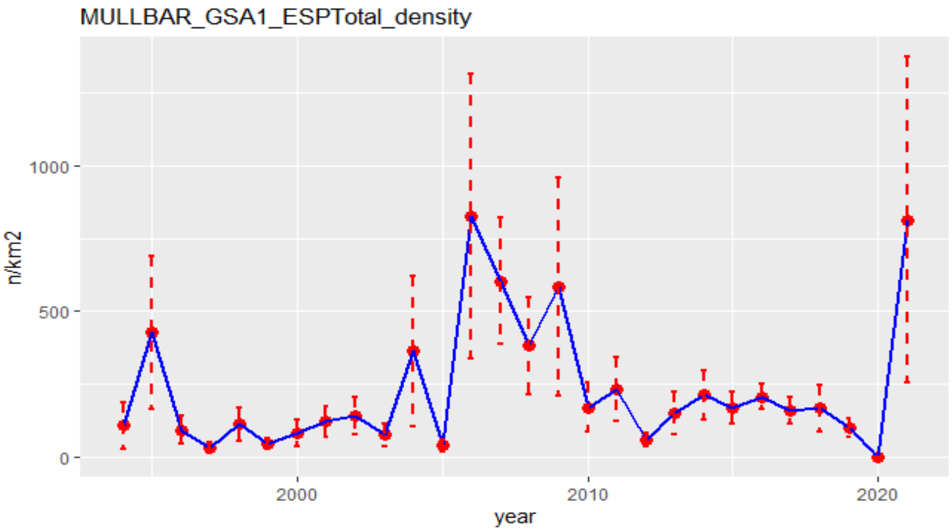


Figure 6.3.2.3.2 Red mullet in GSA 1: Abundance indices of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2021).

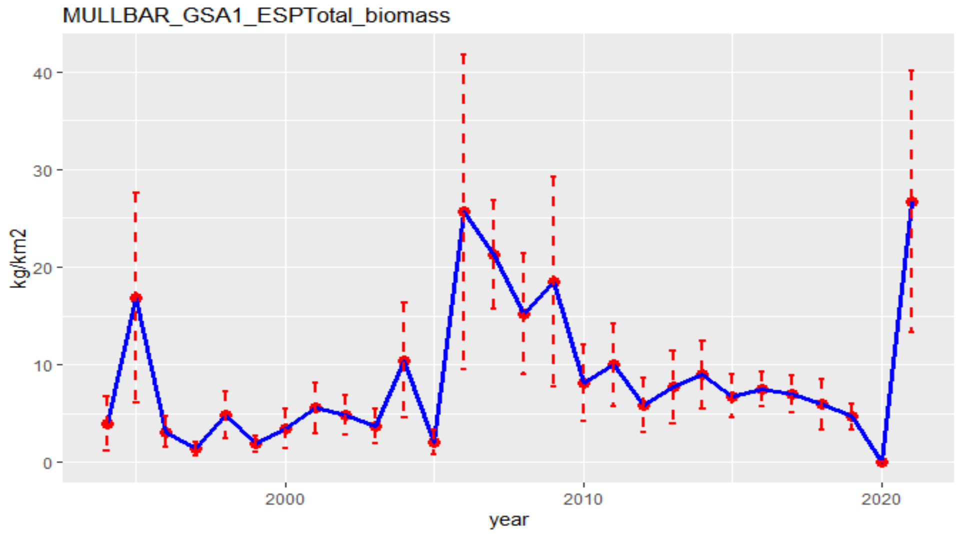


Figure 6.3.2.3.3 Red mullet in GSA 1: Biomass indices of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2021).

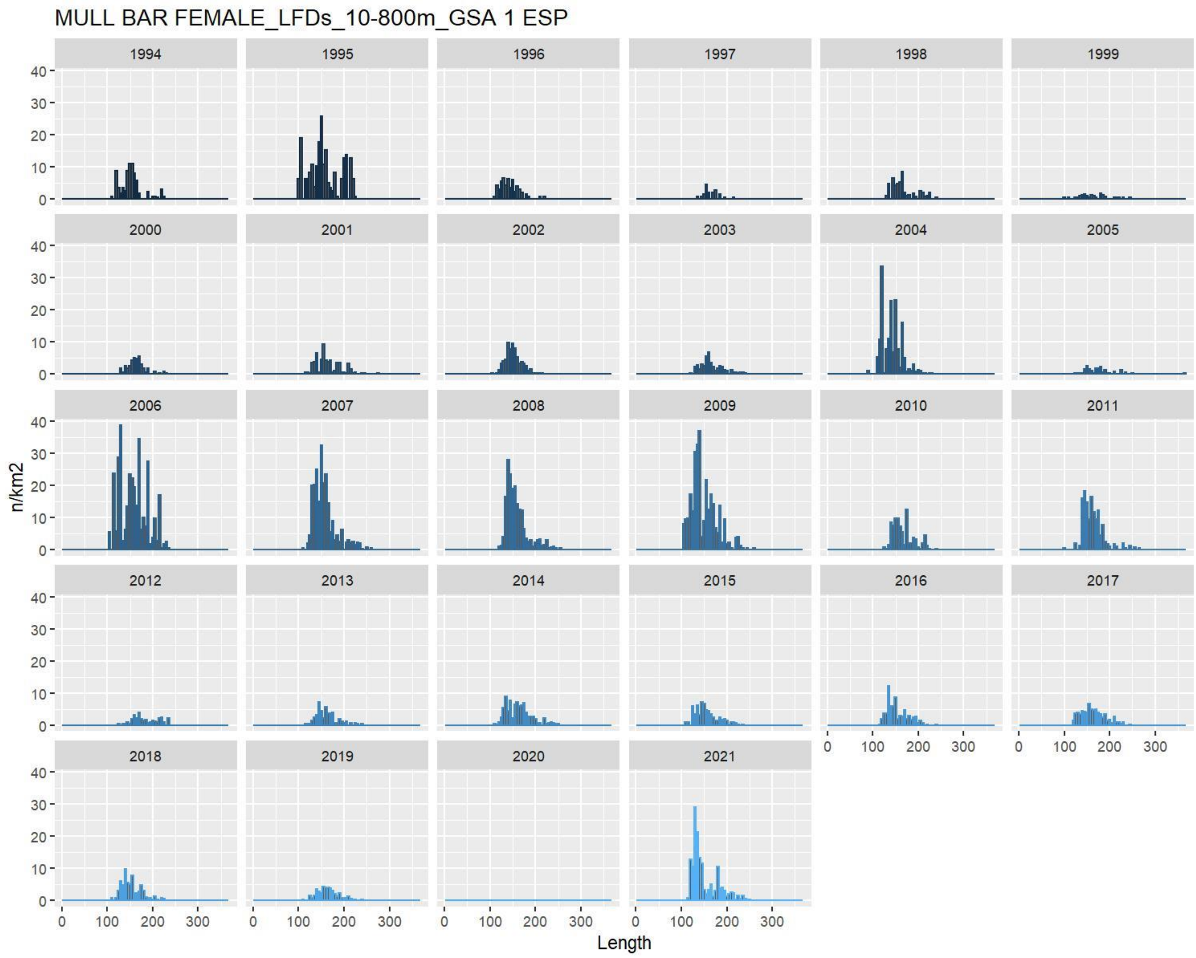


Figure 6.3.2.3.4 Red mullet in GSA 1: Size structure indices (females) of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2021).

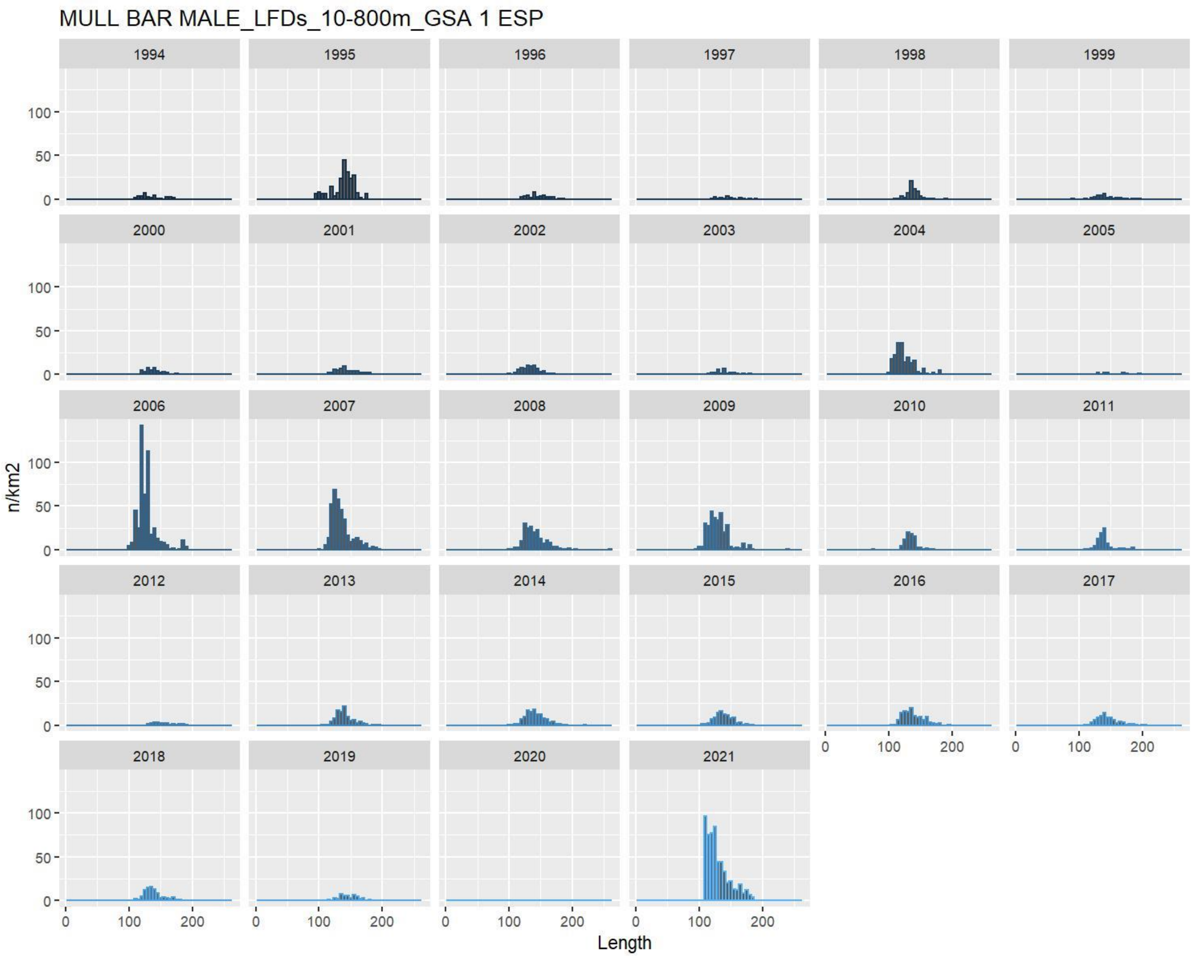


Figure 6.3.2.3.5 Red mullet in GSA 1: Size structure indices (males) of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2021).

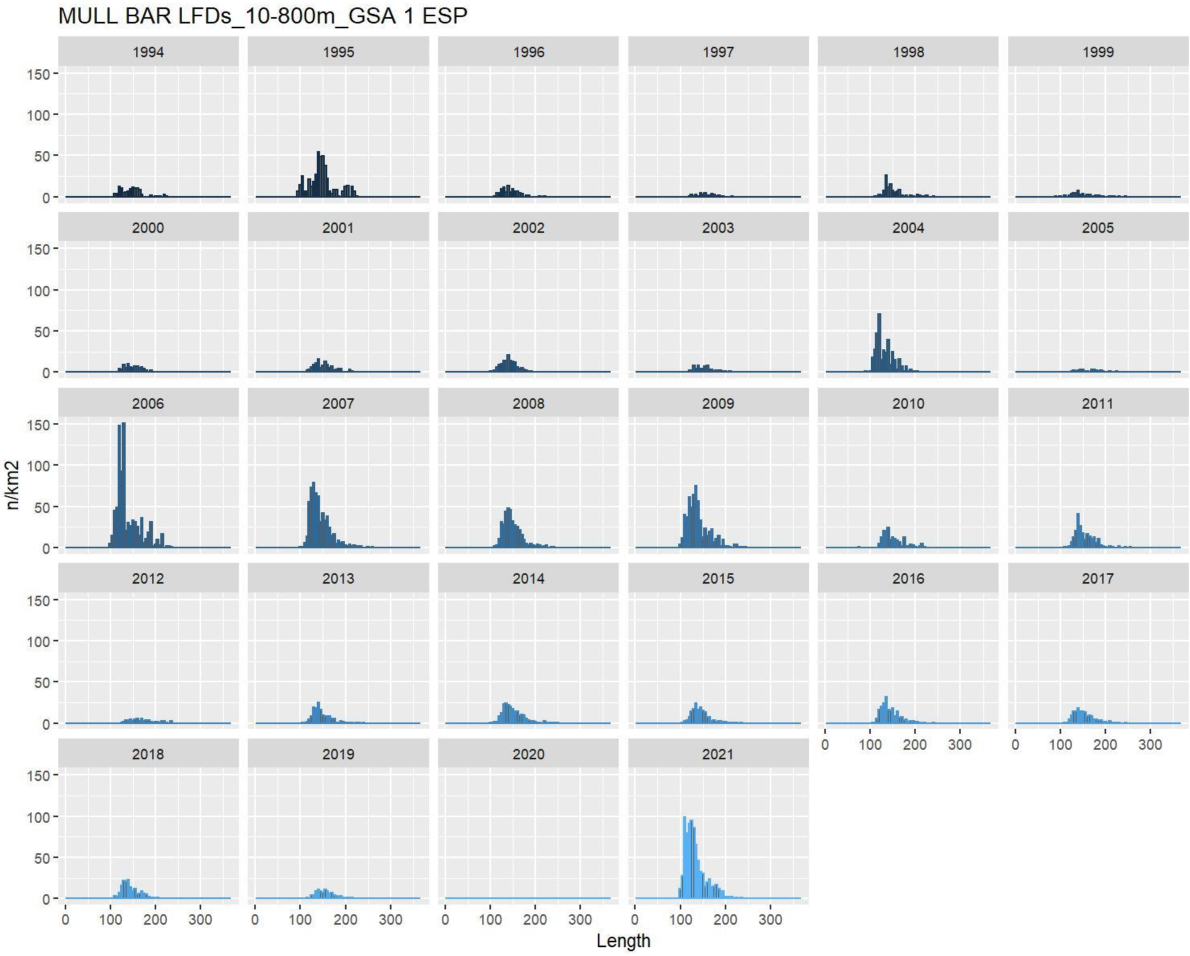


Figure 6.3.2.3.6 Red mullet in GSA 1: Size structure indices (total) of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2021).

6.3.3 STOCK ASSESSMENT

Assessment for all Initiative (a4a) (Jardim et al., 2015) is a statistical catch at age method that utilize catch at age data to derive estimated of historical population size and fishing mortality. Model parameters are estimated by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. A4a is implemented as a package (Fla4a) of the FLR library.The present assessment of red mullet in GSA 1 has been based on an a4a model.

Catch numbers at age and index numbers at age were derived by slicing the catch numbers at length and index numbers at length respectively. For the slicing procedure the R routine of FLR was used. The growth parameters for the slicing are reported in Table 6.3.1.1 and were chosen as the most suitable for this species and this area. Sum of Products (SoP) correction was applied in catch numbers at age to match the total catch by year reported in the DCF. Most of the years the SoP is very close to 1.

Table 6.3.3.1 Red mullet in GSA 1. Sum of Products correction array.

Year	SOP
2003	1.00
2004	0.99
2005	1.01
2006	0.99
2007	1.00
2008	1.00
2009	1.00
2010	1.00
2011	1.00
2012	0.99
2013	1.00
2014	1.00
2015	1.00
2016	0.99
2017	1.00
2018	1.01
2019	1.00
2020	1.00
2021	0.99

Table 6.3.3.1 Red mullet in GSA 1: Values of catch at age per year used in the assessment.

	1	2	3	4
2003	292.70	1274.88	606.72	95.09
2004	1959.47	1665.52	246.03	1.18
2005	947.52	1744.70	276.50	1.10
2006	2322.50	1802.64	196.89	13.84
2007	2235.96	2389.23	226.74	1.09
2008	2598.49	1997.40	319.64	17.00
2009	2768.62	2343.34	444.36	19.98
2010	3868.14	2067.18	323.71	8.46
2011	4499.61	1865.24	169.53	8.70
2012	957.97	597.39	188.63	138.41
2013	1644.16	1307.70	222.20	28.90
2014	2293.45	1313.33	145.14	0.77
2015	2352.38	1393.95	188.87	14.59
2016	3194.71	2702.33	592.10	2.34
2017	2458.19	3349.88	463.13	4.28
2018	2283.93	1778.50	265.57	19.17
2019	923.54	1385.15	275.66	16.31
2020	450.63	1461.79	210.38	2.05
2021	1902.83	877.89	72.00	3.07

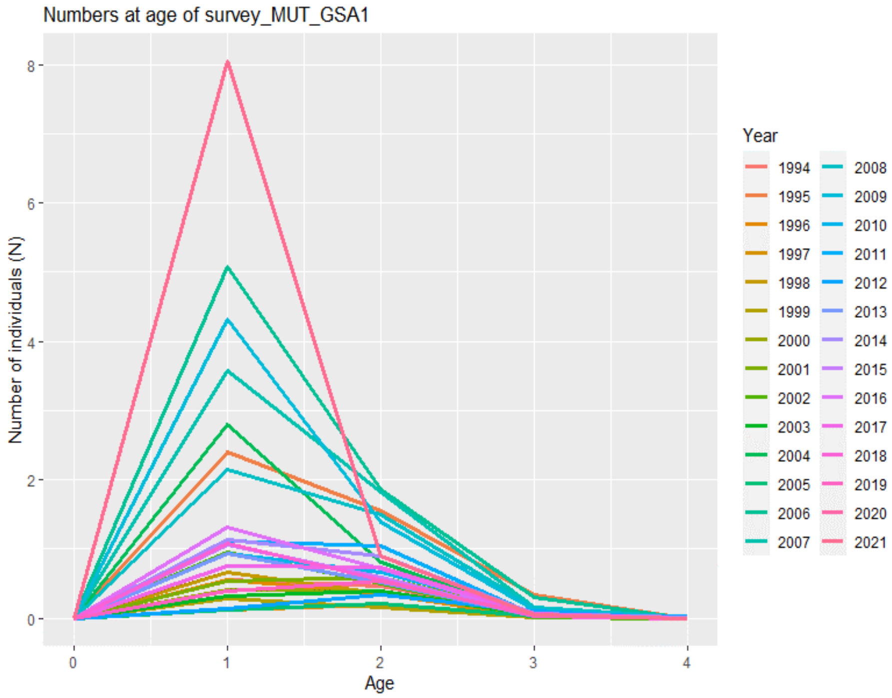


Figure 6.3.3.1 Red mullet in GSA 1: Catch-at-age data of red mullet in GSA1 used in assessment.

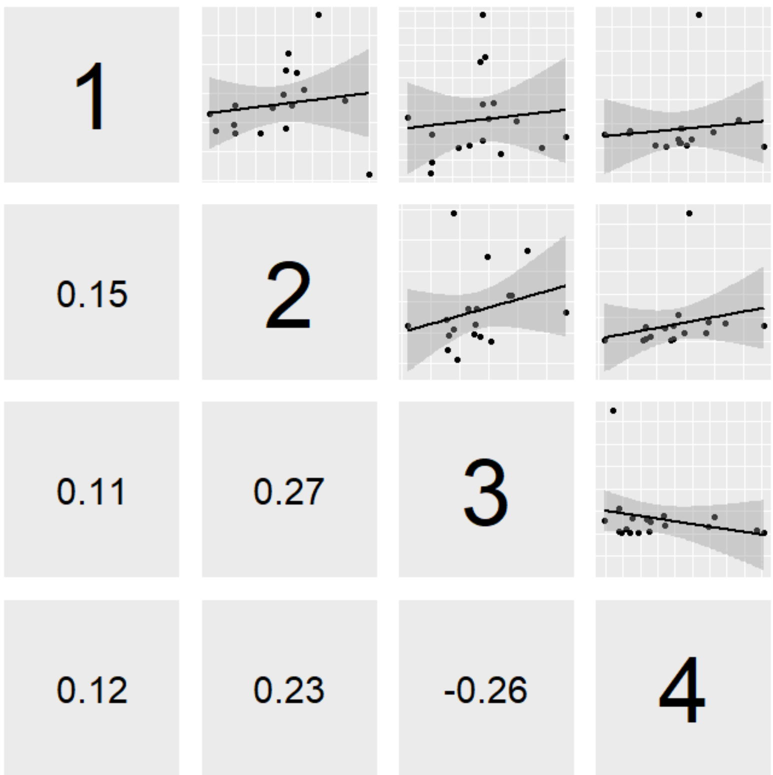


Figure 6.3.3.2 Red mullet in GSA 1: Cohort concistency of catches used in the assessment.

Table 6.3.3.2 Red mullet in GSA 1: Values of catch in the assessment.

Year	Catch
2003	159.74
2004	154.13
2005	140.21
2006	164.61
2007	194.09
2008	193.81
2009	229.46
2010	201.66
2011	201.32
2012	108.97
2013	131.92
2014	127.16
2015	137.68
2016	268.11
2017	278.15
2018	173.03
2019	125.04
2020	107.58
2021	151.10

Table 6.3.3.3 Red mullet in GSA 1: Values of mean weight at age per year used in the assessment.

	1	2	3	4
2003	0.027	0.053	0.109	0.193
2004	0.024	0.050	0.102	0.191
2005	0.025	0.050	0.101	0.191
2006	0.022	0.051	0.105	0.182
2007	0.024	0.049	0.100	0.191
2008	0.022	0.051	0.101	0.189
2009	0.022	0.050	0.105	0.186
2010	0.017	0.049	0.104	0.225
2011	0.020	0.049	0.106	0.183
2012	0.021	0.051	0.110	0.276
2013	0.023	0.050	0.107	0.189
2014	0.020	0.050	0.103	0.185
2015	0.020	0.049	0.102	0.192
2016	0.024	0.049	0.102	0.200
2017	0.024	0.051	0.102	0.201
2018	0.022	0.051	0.103	0.200
2019	0.025	0.050	0.106	0.190
2020	0.024	0.051	0.104	0.191
2021	0.024	0.050	0.104	0.193

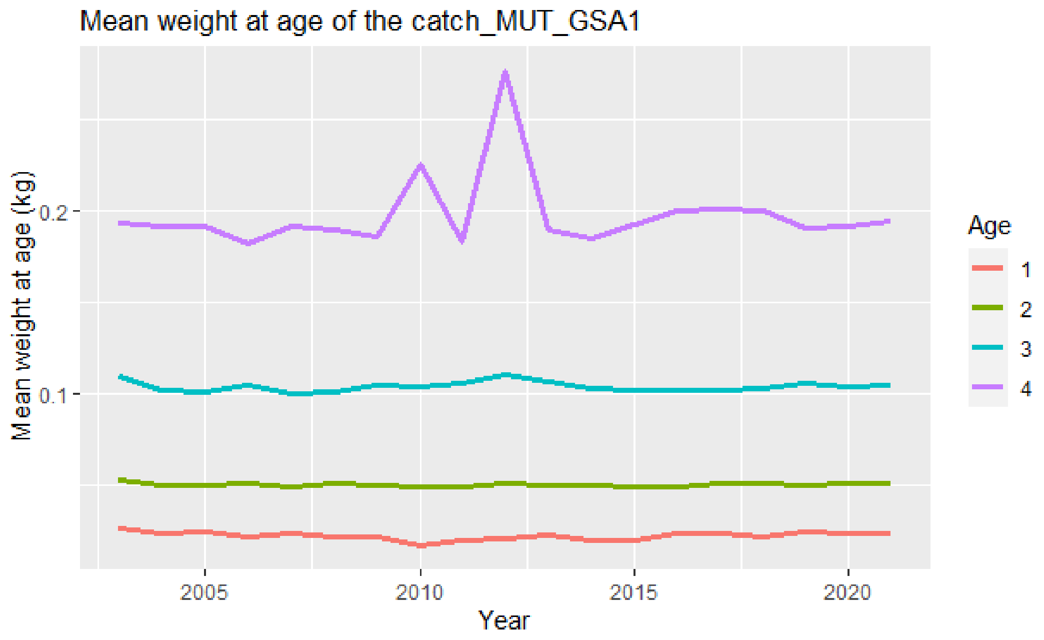


Figure 6.3.3.3 Red mullet in GSA 1: Values of mean weight at age per year used in the assessment.

Table 6.3.3.4 Red mullet in GSA 1: Survey index (MEDITS) values at age per year used in the assessment.

	1	2	3
2003	31.4743	39.4886	4.3295
2004	280.1343	81.3984	2.581
2005	12.5943	22.0857	3.2457
2006	508.0889	185.8544	30.1658
2007	357.4417	181.4307	16.3195
2008	215.779	149.2909	15.1962
2009	432.9404	139.2379	12.9186
2010	94.4677	66.0315	9.0899
2011	111.5451	104.687	5.3598
2012	13.8405	34.6748	9.9426
2013	93.7863	52.0226	3.9663
2014	114.4301	90.453	6.4633
2015	105.977	60.048	3.5266
2016	132.2457	71.7248	2.4408
2017	76.2341	74.2201	7.0482
2018	108.0575	56.2829	2.8531
2019	40.2134	53.5584	4.8403
2020	NA	NA	NA
2021	804.331	89.4215	5.1113

Survey indices (density by age) from MEDITS were used assuming that spring surveys are not designed to detect recruitment of red mullet. Recruitment (age class 0) was detected just in some years when surveys were carried out in late summer or autumn. Due to the variability of survey timing, age 0 class was not included in the tuning indices used for the assessment. MEDITS indices (density by age) are shown in figure 6.3.3.4.

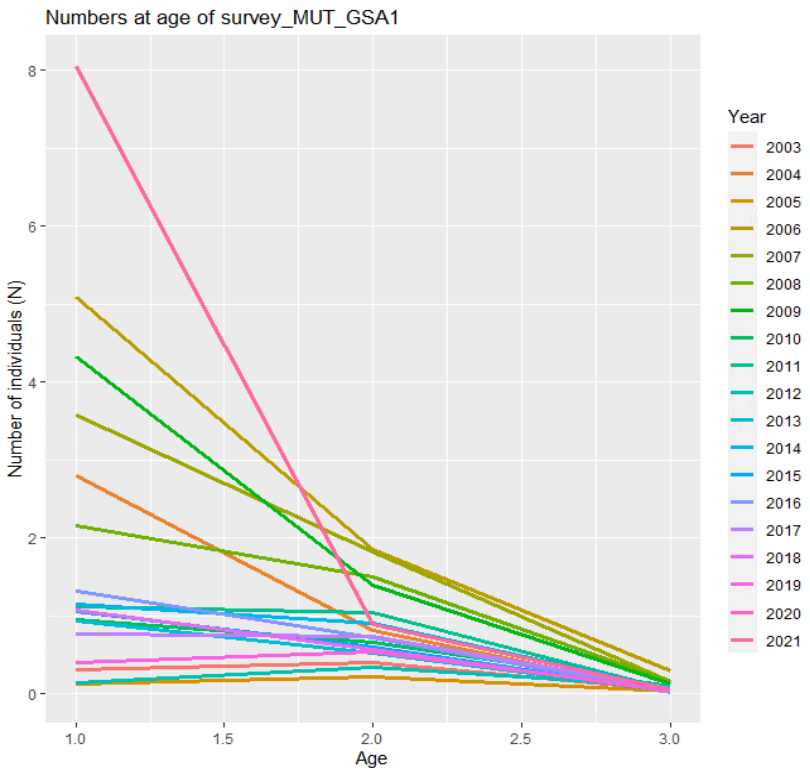


Figure 6.3.3.4 Red mullet in GSA 1: MEDITS indices describing density by age of red mullet in GSA1 by year

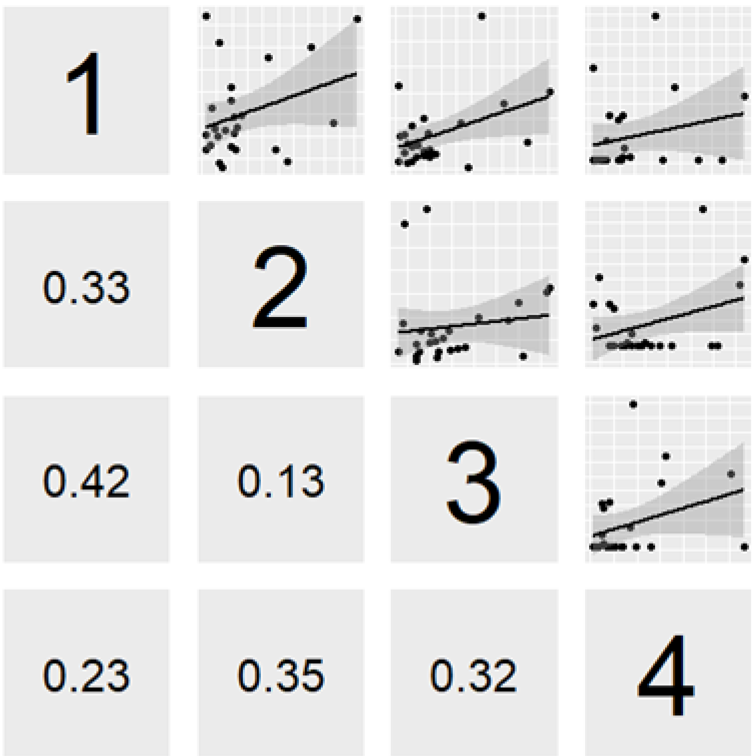


Figure 6.3.3.5 Red mullet in GSA 1: Cohort concistency of survey data used in the assessment.

Different a4a models were investigated in terms of fishing mortality, catchability of the survey index and stock –recruitment relationship models (fmodel, qmodel, and srmodel). Smoothing splines were essential in fitting a model, both in the recruitment and the fishing mortality model.

The model selected is the same as used last year in the EWG 21-09. A factor was selected to model years in the fmodel and a k = 7 was applied for the smoothing splines of the recruitment model.

The following model was selected on the basis of best fit, both for residuals as well as fitted vs observed data and retrospective; this model also coincides with the general perception of the STECF EWG on fishing mortality allocation throughout age groups, as well as on the catchability of the index.

```
fmod<- ~factor(age) + s(year, k =8)
qmod<-  list(~ factor(replace(age, age>2, 2)))
srmod<- ~ s(year, k=7)
```

Summary of the model fit using the fitSumm command:

nopar	27
nlogl	111.41
maxgrad	0.00
nobs	130
gcv	0.88
convergence	0.00
accrate	NA
nlogl_comp1	51.67
nlogl_comp2	59.74

The following figure presents the summary of the stock object after the fit of the model. The recruitment, spawning stock biomass catch and fishing mortality.

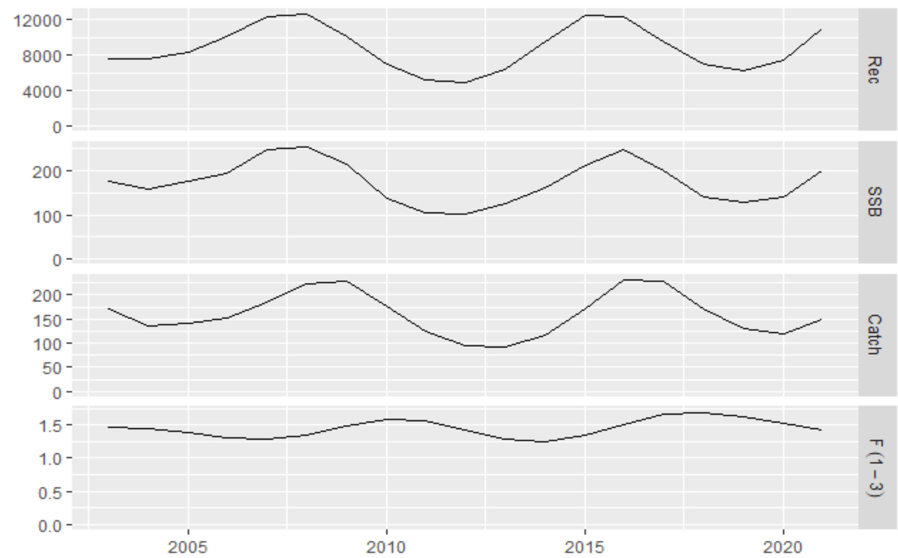


Figure 6.3.3.6 Red mullet in GSA 1: Stock indicators derived from the stock assessment.

The results and diagnostics of the assessment model are shown below.

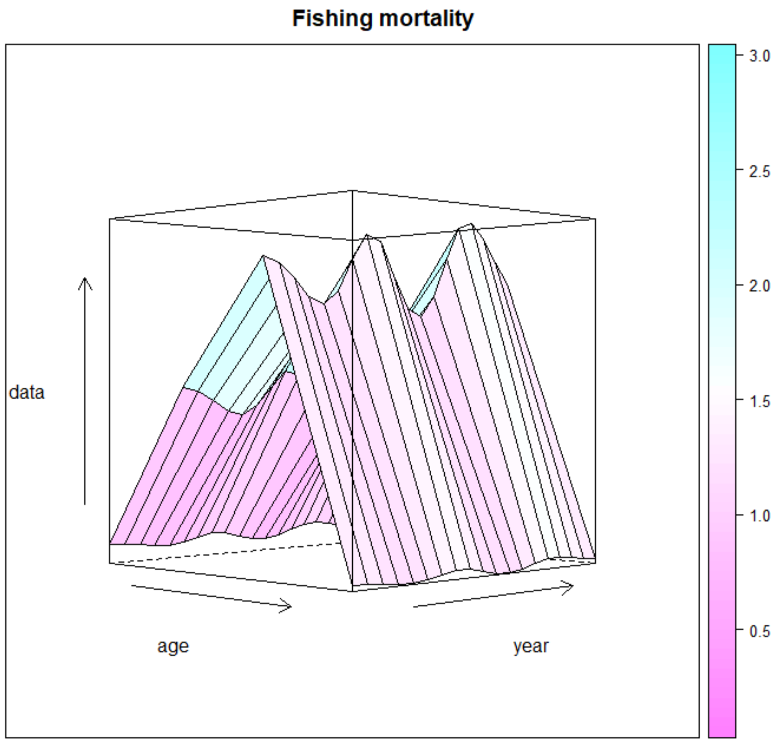


Figure 6.3.3.7 Red mullet in GSA 1: 3D-plot of the F-at-age for red mullet in GSA1.

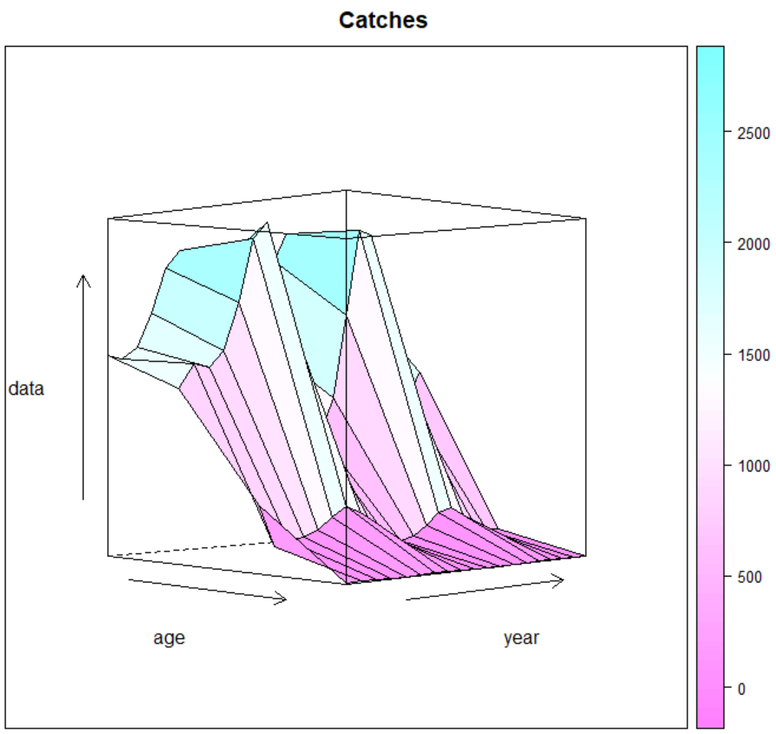


Figure 6.3.3.8 Red mullet in GSA 1: 3D-plot of the catches for red mullet in GSA1.

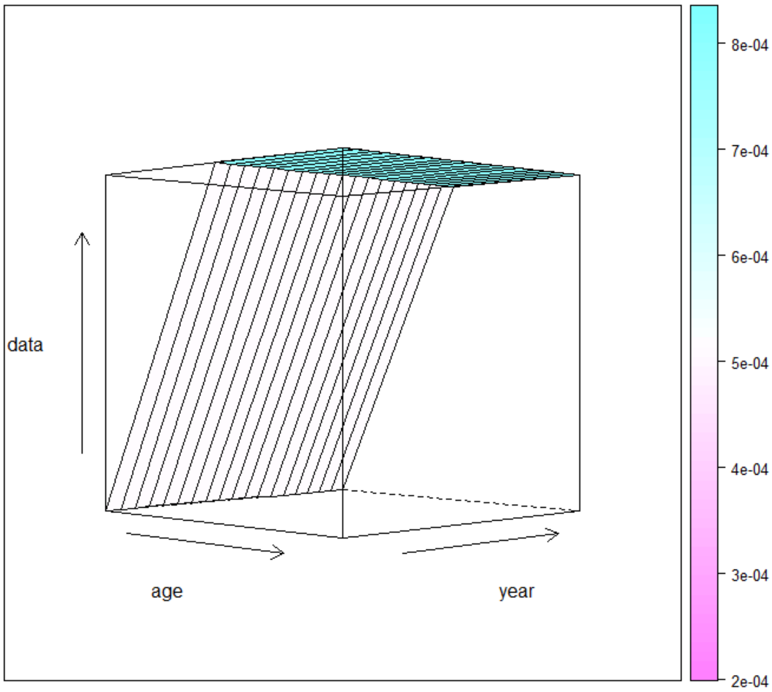


Figure 6.3.3.9 Red mullet in GSA 1: 3D-plot of the catchability of the MEDITS survey for red mullet in GSA1.

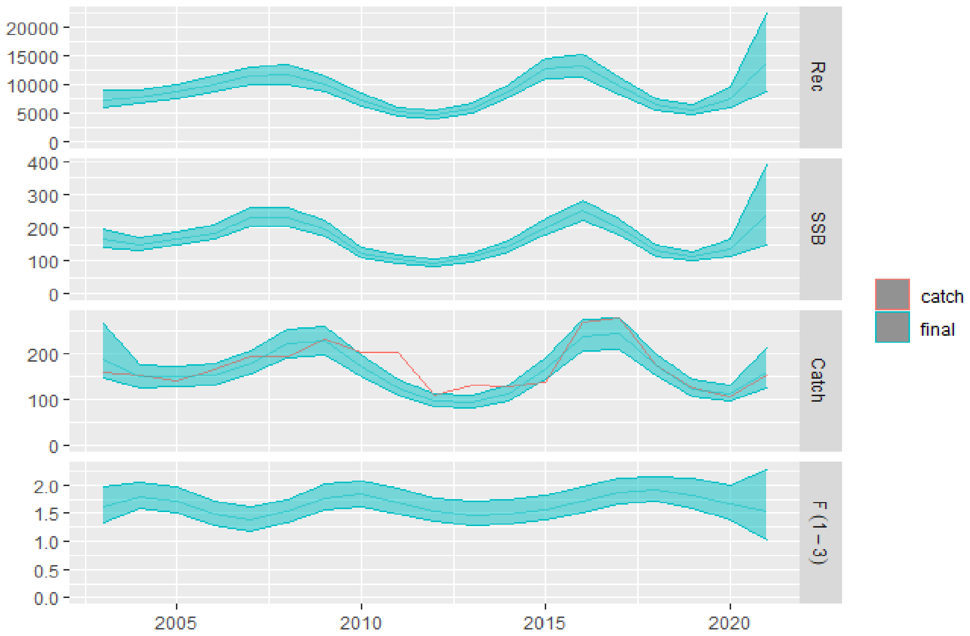


Figure 6.3.3.10 Red mullet in GSA 1: Results of the best a4a model for red mullet in GSA1. The observed catches are shown by the red line.

The Mohn' rho for $F_{bar1\text{-}3}$, SSB and recruitment are shown below:

fbar	ssb	rec
0.06045265	-0.27269812	-0.33547961

The results of the retrospective analysis are shown in Figure 6.3.3.11.

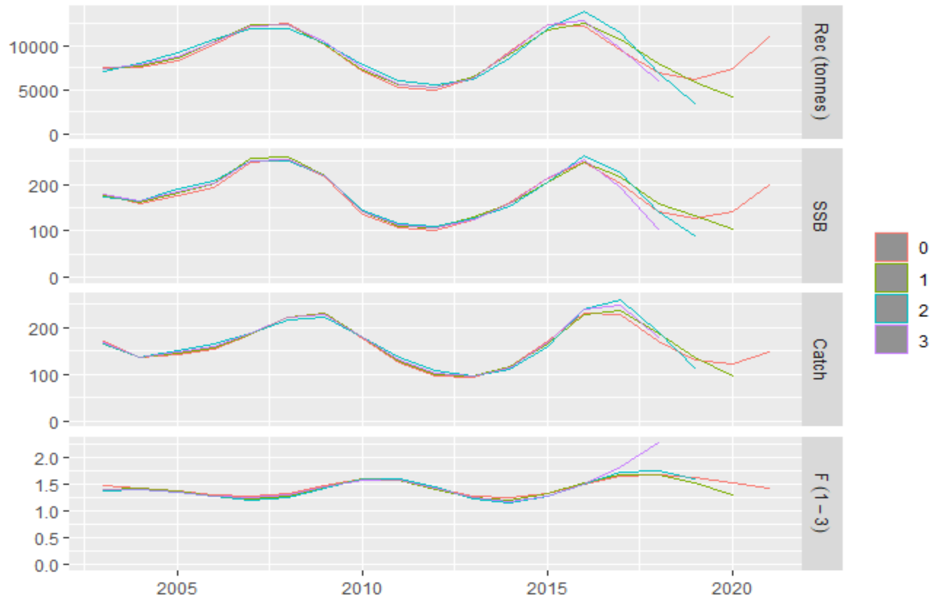


Figure 6.3.3.11 Red mullet in GSA 1: Retrospective analysis of the selected a4a model for red mullet in GSA1.

Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of Red mullet stock. Residuals of index showed a slight descending trend especially for the ages 2 and 3, due to the constraint of index catchability model. EWG 20 09 considered the fact that there is a trade of between a better fit and the best representative model of the catchability of the survey, and used a flat catchability ages 2 and 3 for the index.

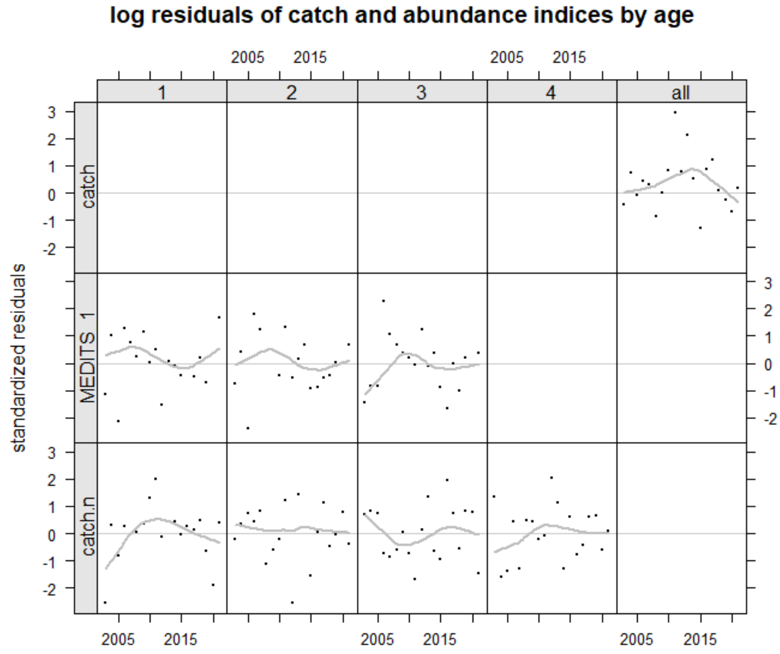


Figure 6.3.3.12 Red mullet in GSA 1: Log residuals of catch and abundance indices for red mullet in GSA1.

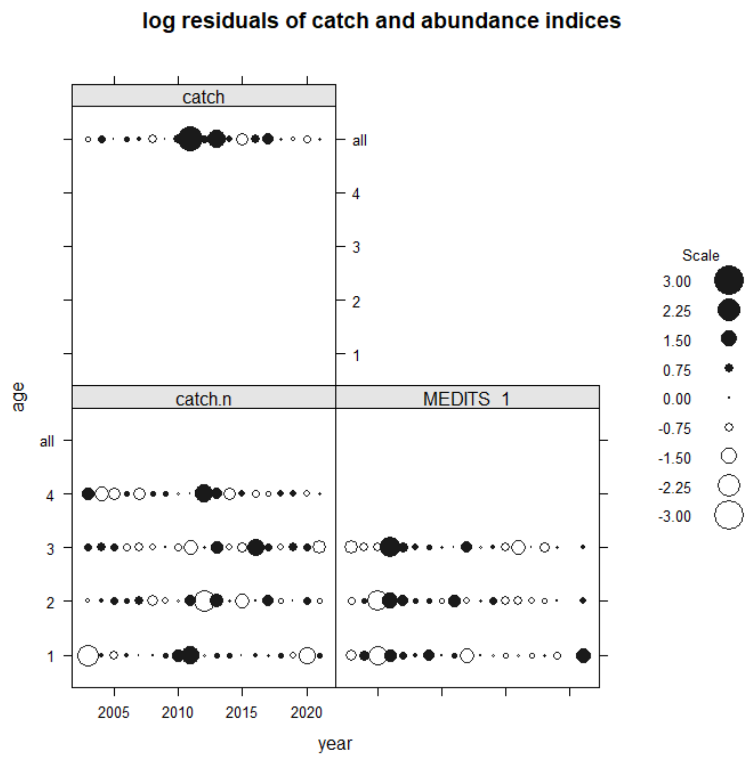


Figure 6.3.3.13 Red mullet in GSA 1: Bubble plot of the log residuals of catch and abundance indices for red mullet in GSA1.

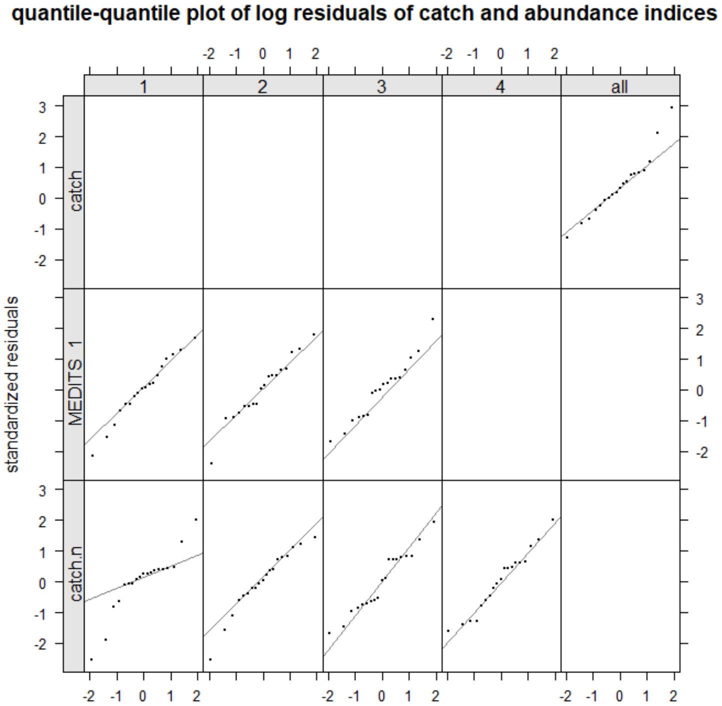


Figure 6.3.3.14 Red mullet in GSA 1: QQ-plot of the log residuals of catch and abundance indices for red mullet in GSA1.

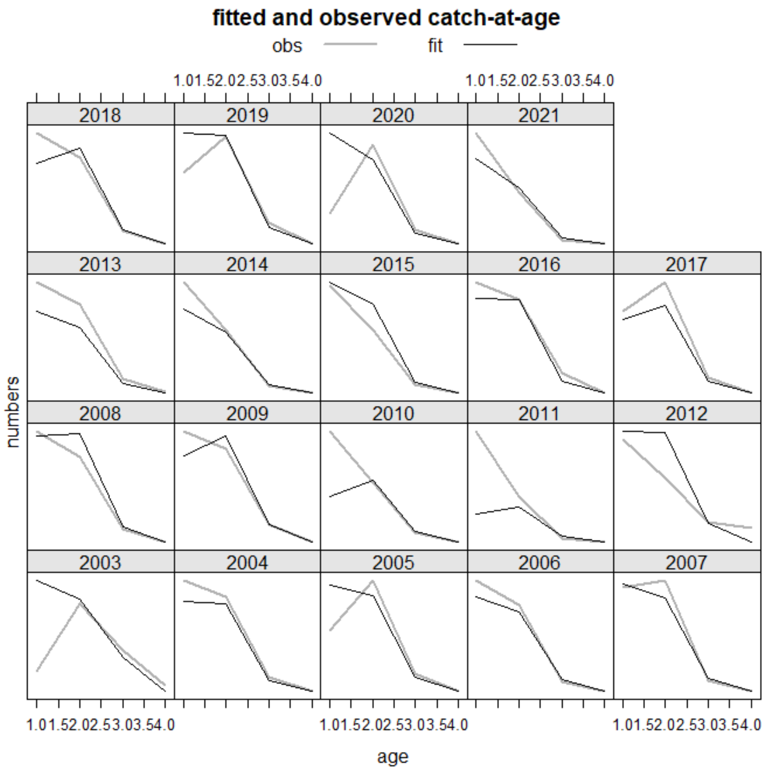


Figure 6.3.3.15 Red mullet in GSA 1: Fitting of the catch-at-age data for red mullet in GSA1.

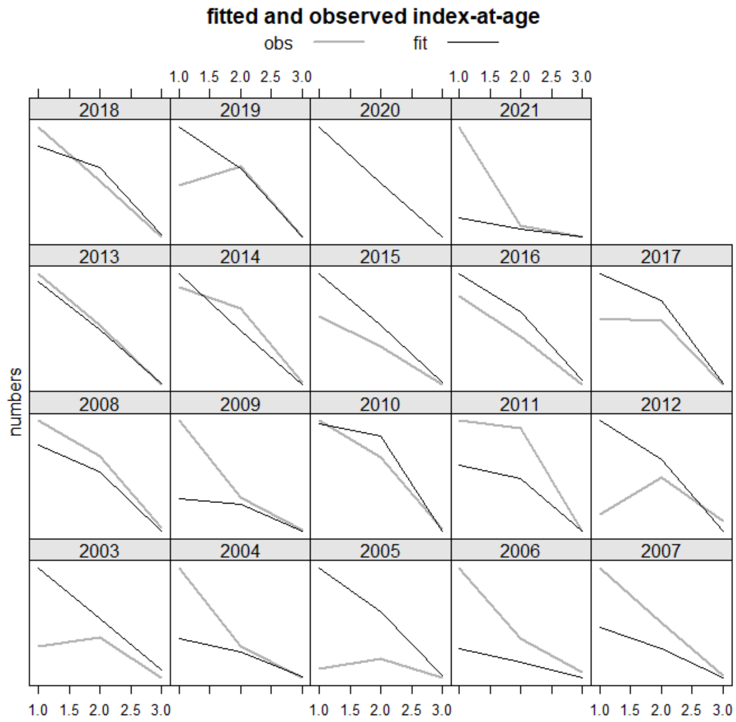


Figure 6.3.3.16 Red mullet in GSA 1: Fitting of the numbers-at-age data of the MEDITS survey for red mullet in GSA1.

Table 6.3.3.5 Red mullet in GSA 1: Final results of the red mullet assessment in GSA1.

Year	Recruitment age 1 ('000)	High	Low	SSB (t)	High	Low	Catch (t)	F_{bar} ages 1-3	High	Low
2003	7454	8615	6293	181.39	207.69	155.09	170.9	1.47	1.75	1.19
2004	7522	8279	6765	162.22	184.02	140.42	136.4	1.44	1.65	1.23
2005	8310	9195	7425	177.42	197.62	157.22	141.8	1.38	1.6	1.16
2006	10156	11181	9131	194.94	216.34	173.54	152.8	1.3	1.5	1.1
2007	12308	13461	11155	249.92	274.52	225.32	184.5	1.28	1.47	1.09
2008	12613	13976	11250	255.78	282.58	228.98	222.6	1.34	1.52	1.16
2009	10142	11279	9005	217.83	241.93	193.73	229.5	1.47	1.65	1.29
2010	7027	7771	6283	136.24	152.74	119.74	176.0	1.59	1.78	1.4
2011	5205	5757	4653	106.29	118.89	93.69	124.3	1.57	1.76	1.38
2012	4971	5526	4416	101.91	114.81	89.01	95.6	1.42	1.62	1.22
2013	6381	7007	5755	125.49	138.69	112.29	93.1	1.28	1.47	1.09
2014	9416	10336	8496	161.53	177.53	145.53	116.7	1.24	1.42	1.06
2015	12379	13646	11112	212.8	233	192.6	170.6	1.33	1.51	1.15
2016	12267	13440	11094	248.19	271.49	224.89	231.8	1.51	1.71	1.31
2017	9498	10565	8431	201.93	221.53	182.33	228.5	1.66	1.85	1.47
2018	6933	7786	6080	141.46	156.66	126.26	170.6	1.68	1.88	1.48
2019	6175	6880	5470	128.66	142.16	115.16	130.6	1.62	1.84	1.4
2020	7434	8610	6258	140.87	163.47	118.27	120.7	1.52	1.8	1.24
2021	10950	14207	7693	201.19	262.89	139.49	148.4	1.41	1.83	0.99

Table 6.3.3.6 Red mullet in GSA 1: Stock number at age for red mullet in GSA 1.

	Age			
Year	1	2	3	4+
2003	7521.3	2068.2	625.7	69.5
2004	7522.6	2385.4	245.2	68.1
2005	8280.5	2401.4	291.0	48.2
2006	10126.1	2682.0	312.0	42.5
2007	12277.5	3340.0	377.3	43.6
2008	12580.6	4078.0	484.4	50.1
2009	10126.5	4114.9	553.0	57.4
2010	7018.3	3202.8	482.0	57.5
2011	5186.2	2159.1	332.5	49.0
2012	4965.3	1604.4	229.7	39.1
2013	6385.8	1591.9	199.4	33.0
2014	9423.1	2119.7	230.2	31.6
2015	12421.6	3155.3	318.4	34.2
2016	12320.9	4065.3	429.0	38.5
2017	9456.6	3865.3	459.6	40.2
2018	6926.0	2862.8	374.1	37.2
2019	6172.4	2080.4	267.8	31.6
2020	7428.4	1885.7	209.5	26.5
2021	10963.2	2327.2	211.9	23.4

Table 6.3.3.7 Red mullet in GSA 1: Fishing mortality at age for red mullet in GSA 1.

	Age			
Year	1	2	3	4+
2003	0.36	1.56	2.48	0.25
2004	0.35	1.53	2.44	0.25
2005	0.34	1.47	2.34	0.24
2006	0.32	1.39	2.21	0.23
2007	0.31	1.36	2.16	0.22
2008	0.33	1.43	2.27	0.23
2009	0.36	1.57	2.50	0.26
2010	0.39	1.70	2.69	0.28
2011	0.38	1.67	2.66	0.27
2012	0.35	1.52	2.41	0.25
2013	0.31	1.36	2.17	0.22
2014	0.30	1.33	2.11	0.22
2015	0.33	1.43	2.27	0.23
2016	0.37	1.61	2.56	0.26
2017	0.40	1.77	2.81	0.29
2018	0.41	1.80	2.86	0.29
2019	0.40	1.73	2.74	0.28
2020	0.37	1.62	2.57	0.26
2021	0.35	1.51	2.40	0.25

6.3.4 REFERENCE POINTS

, The STECF EWG 18-02 recommended using $F_{0.1}$ as a proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

Values of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 0.61. Current F values (2021), as calculated by model a4a, is 1.42 indicating that the stock is overexploited.

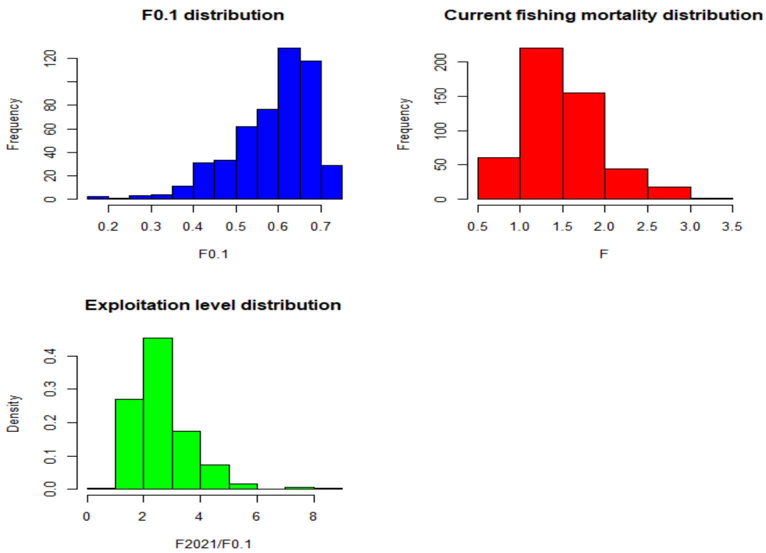


Figure 6.3.4.1 Red mullet in GSA 1: Histograms of probability for $F_{0.1}$, Fcurr and level of exploitation (Fcurr/F01 ratio) values for red mullet in GSA1.

Estimation of biomass reference points

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4. An exploratory per-recruit analysis was performed using the stock object produced by EWG 22-09 containing the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.3.4.1 and Figure 6.3.4.2.

Table 6.3.4.1 Red mullet in GSA 1. Per-recruit reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	B_0
0.61	0.041	0.013	3.037	0.127

Figure 6.3.4.1 shows the trajectories of the assessment outputs relative to the per-recruit reference points R_0, SPR_0, YPR at $F_{0.1}$ and B_0.

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)

2. Hockey-Stick (model=segreg)

3. Beverton-Holt (model=bevholtSV)

4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ratio potential SRPlim = SPRlim/SPR_0. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP 0.1−20% by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y.When testing the different S-R models (Geometric mean, Hockey Stick, Beverton and Holt and Ricker models) the Hockey Stick model and the Geometric mean one coincided. Therefore, a jitter analysis was run to test if Hockey Stick models with a different slope would fit better the data.

Figure 6.3.4.2 shows the models fitted during the jitter analysis and Figure 6.3.4.3 compares the Hockey Stick curves obtained through the jitter analysis. Model number 2 was selected as it minimized the negative log-likelihood other models were at local minima. Four SR models were refitted and the Hockey Stick model was selected, following the approach adopted from EWG 22-03, as the observed SR data are sitting in the centre and to the right part of the R-SSB plot, and the breakpoint estimated by the HS model is within the observed values (Figure 6.3.4.3).

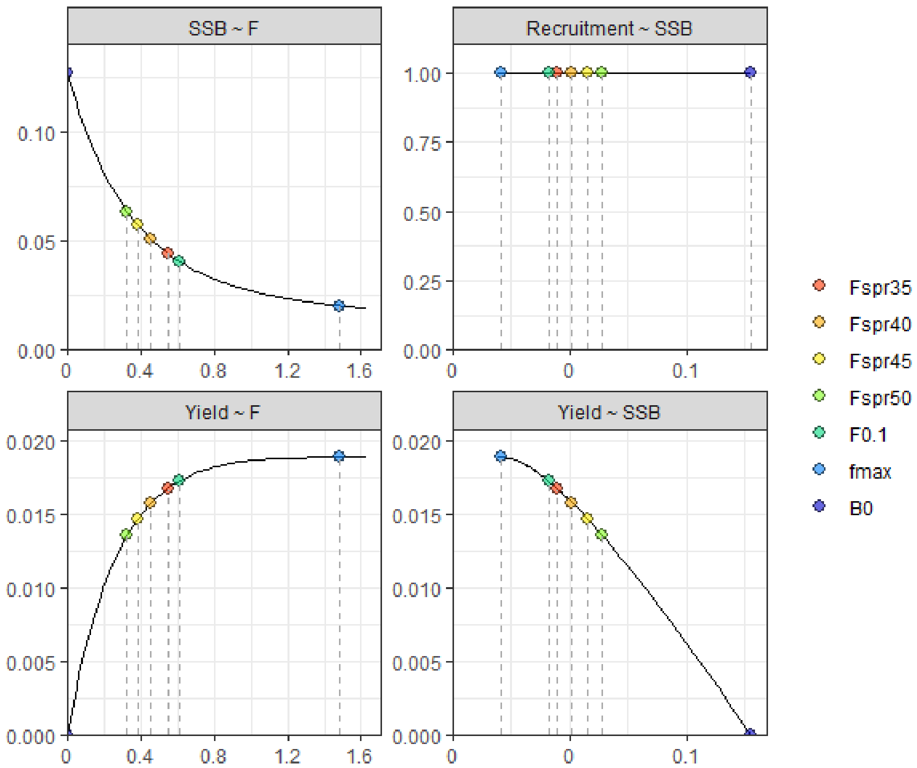


Figure 6.3.4.1. Red mullet in GSA 1. Per-recruit reference points.

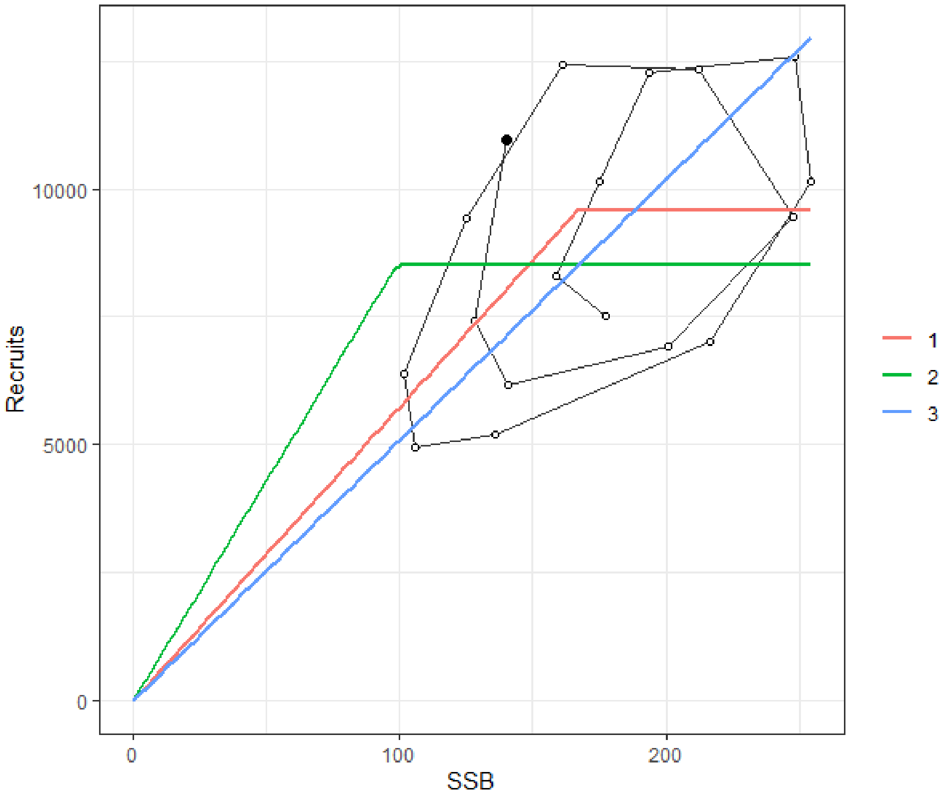


Figure 6.3.4.2. Red mullet in GSA 1. Results of the jitter analysis.

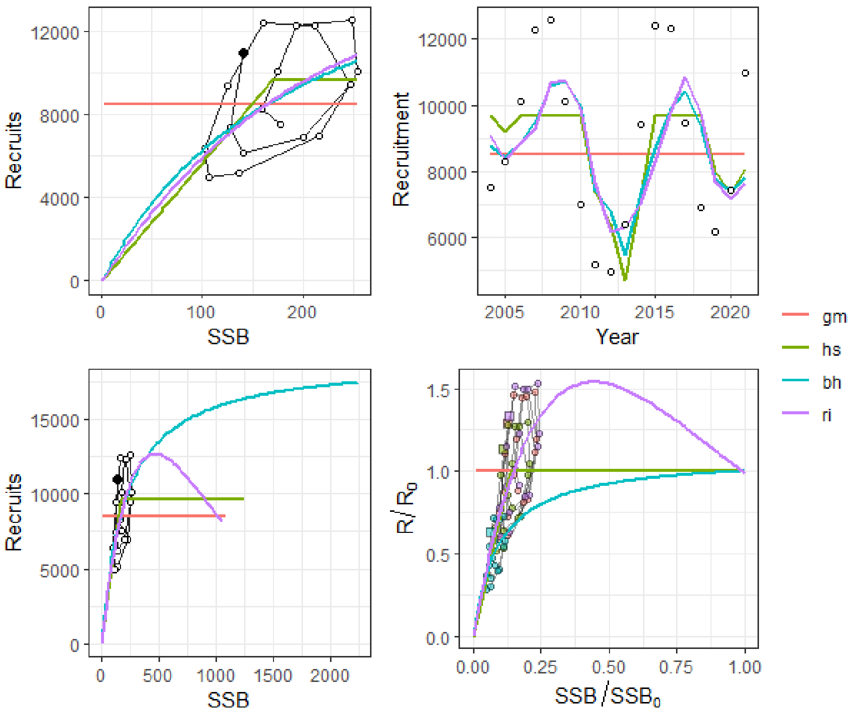


Figure 6.3.4.3. Red mullet in GSA 1. Summary of the four SR models after the selection from the jitter analysis.

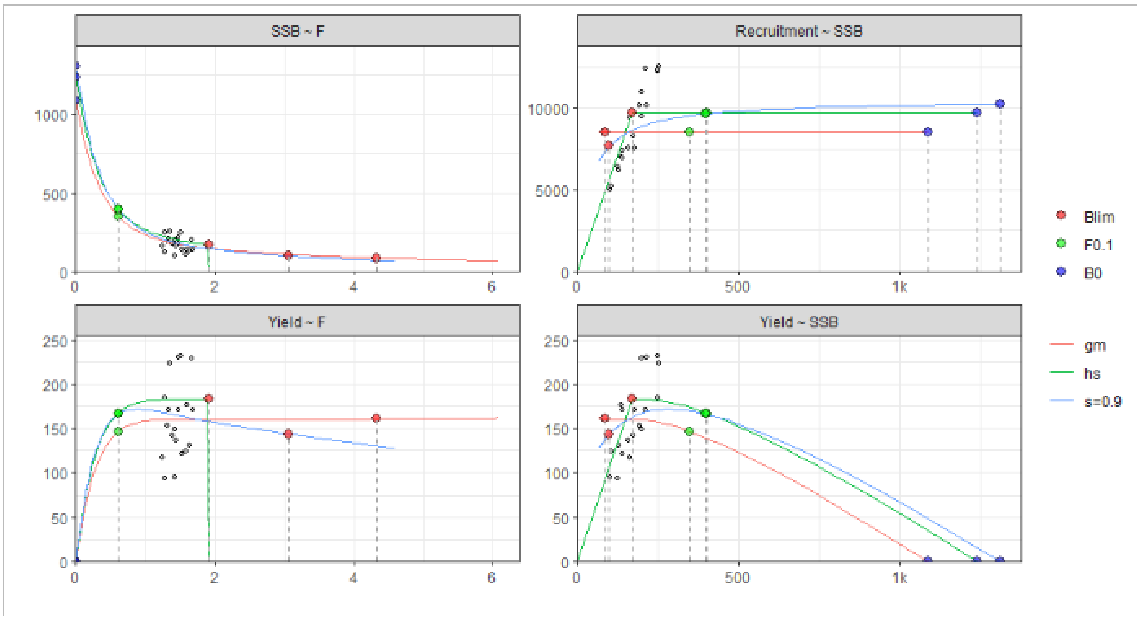


Figure 6.3.4.4. Red mullet in GSA 1. Long term equilibrium evaluations for different S-R models.

In the light of the outcomes of the exploratory analysis, it was decided to consider the Hockey-stick approach the most appropriate to estimate the biomass reference points for the stock of Red mullet in GSA 1. This is in line with the method chosen in EWG 22-03. Table 6.3.4.2 summaries the reference point values based on the Hockey-Stick model fitted to the data. B_{pa} is set to 2* B_{lim} as defined in STECF EWG 22-03. The implied dynamics are illustrated in Figure 6.3.4.5, and the historic assessment information is shown in this context in Figures 6.3.4.6-7, In conclusion the stock is considered to be slightly above to B_{lim} in 2021.

Table 6.3.4.2 Red Mullet in GSA 1. Per-recruit reference points.

$F_{0.1}$	B_{lim}	B_{pa}	$B_{F0.1}$	Fpa	B2021
0.61	169.8	338.4	399	0.74	199

Figure 6.3.4.6 shows that SSB by year fluctuates close to the B_{lim} and below the equilibrium biomass at $F_{0.1}$ ($B_{F0.1}$) for the whole time series. At the same time, F is well above $F_{0.1}$ and F_{lim} across the whole assessed period, despite the decrease in 2020 and 2021.

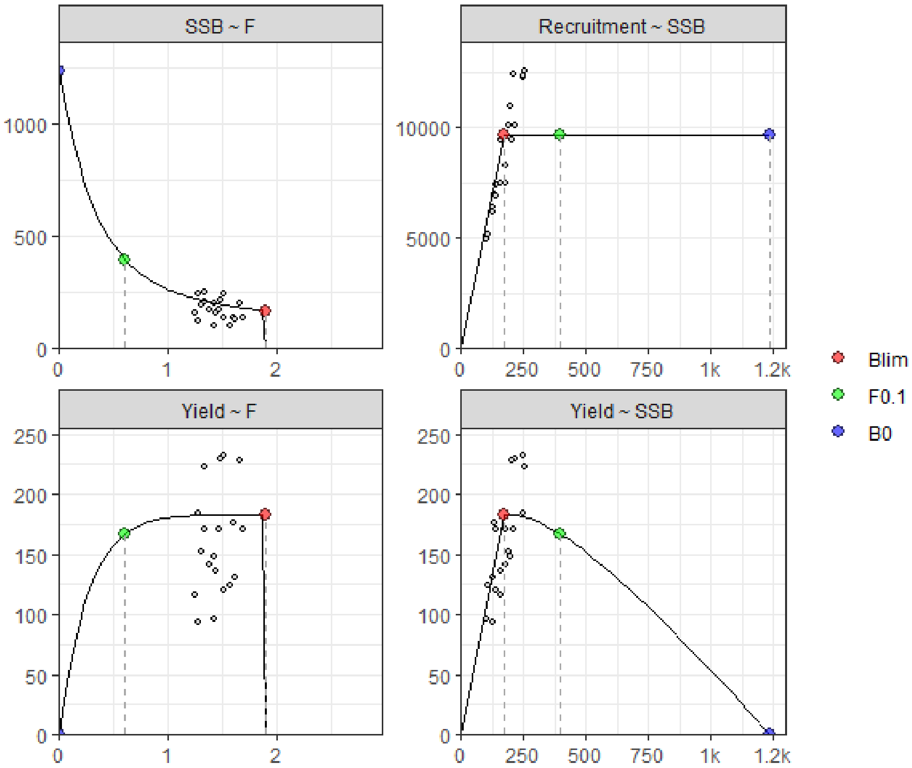


Figure 6.3.4.5. Red Mullet in GSA 1. Yield analysis with HS model.

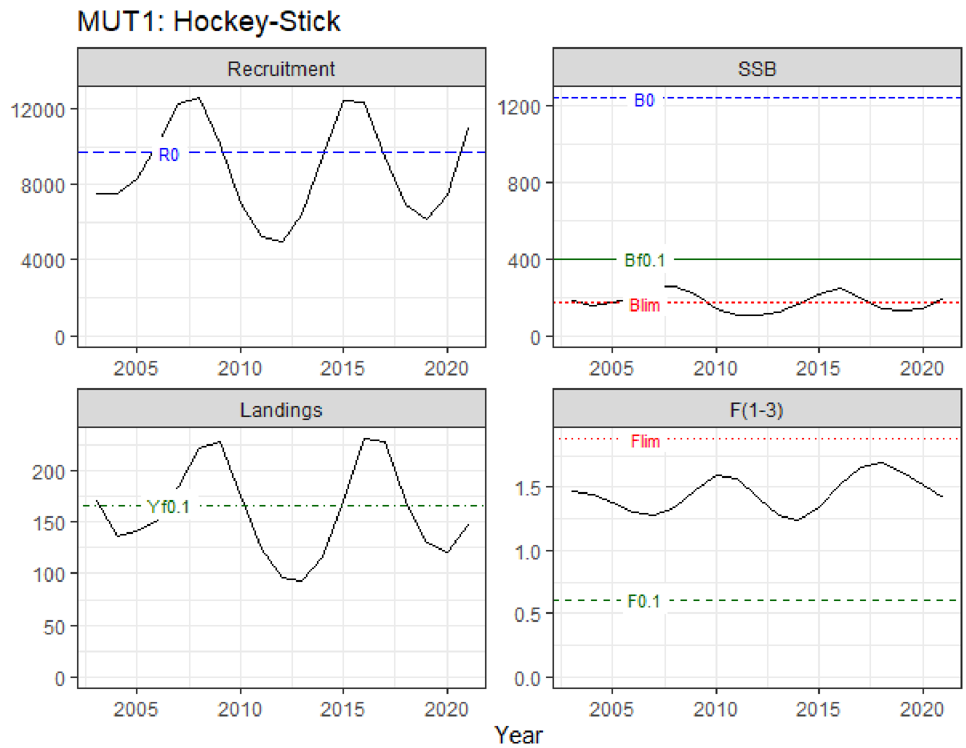


Figure 6.3.4.6. Red Mullet in GSA 1. Status Advice plot showing stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on a Hockey-Stick stock-recruitment relationship.

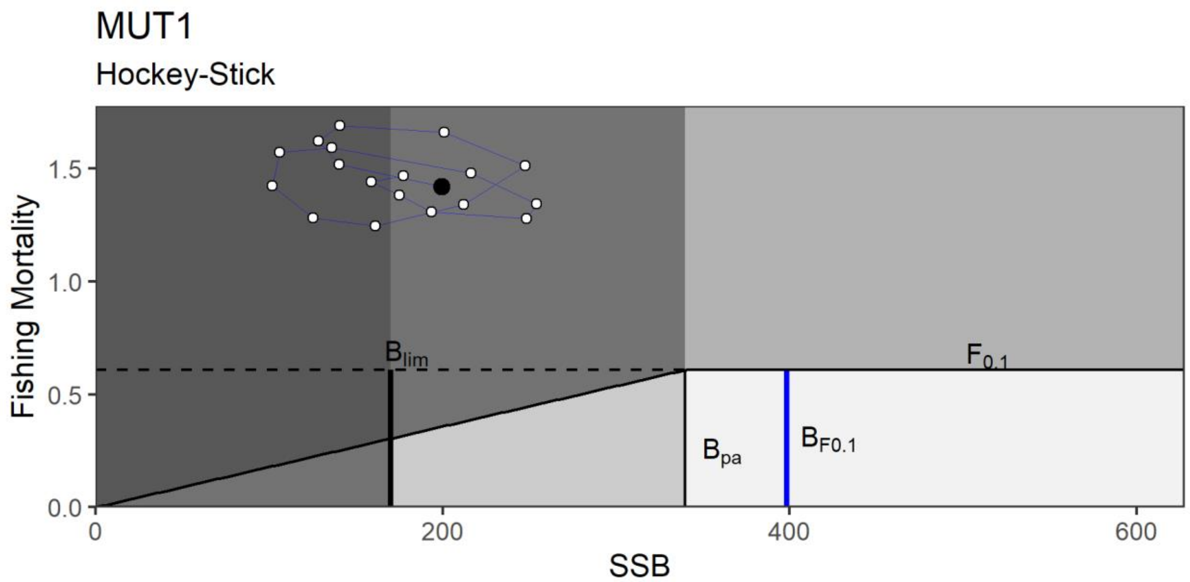


Figure 6.3.4.7. Red Mullet in GSA 1. Advice Rule plots, with B_{lim} fitted to the data and B_{pa} = 2 B_{lim}.

The HS model defined above is considered as the best option for defining reference points for this stock, but it may not be the most suitable for modelling. A Geometric mean model may be helpful too as a modelling option. The steepness options considered above are illustrated in Figure 6.3.4.8.

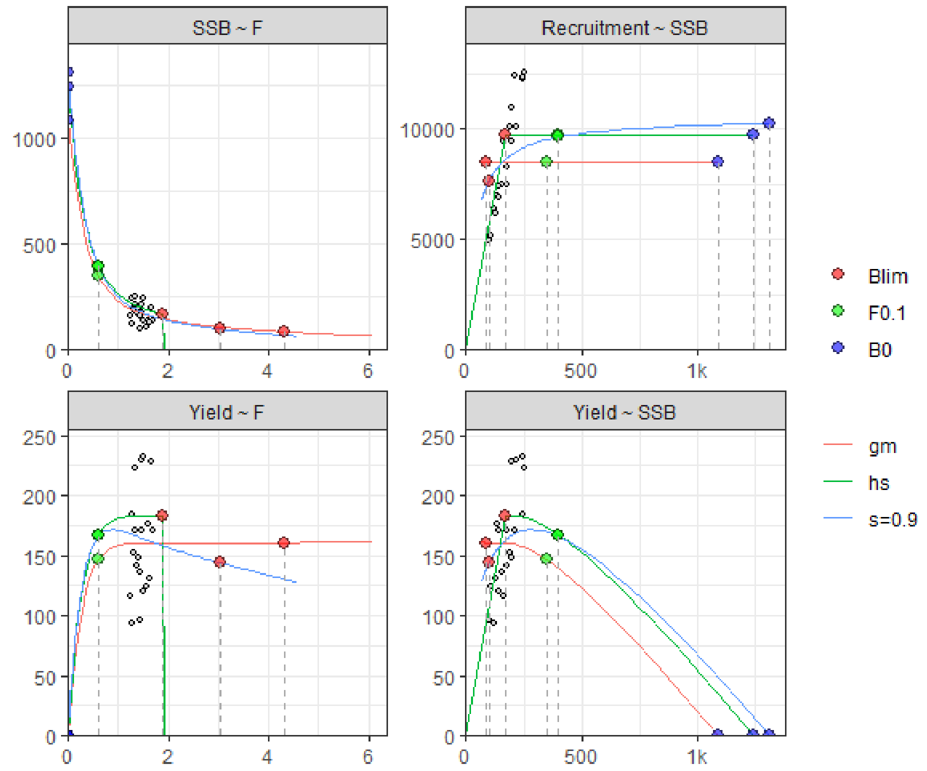


Figure 6.3.4.8. Red Mullet in GSA 1. Long term equilibrium evaluation for different S-R models.

6.3.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age, while the F_{bar} =1.42 (the last year's F estimated by the assessment model) was used for F in 2022, as F shows a decreasing trend (See section 6.3.3). The Geometric mean of the estimated time series of recruitment is be used. Recruitment (age 0) was estimated from the population results as the geometric mean of the years available (8448.9).

Table 6.3.5.1 Red mullet in GSA 1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2019-2021	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}3}$ (2022)	1.42	F 2021 used to give F status quo for 2022
SSB (2022)	189.88	Stock assessment 1 January 2021
R_{age1}(2022,2023)	8448.894(thousands)	Geometric mean of the time series (19 years)
Total catch (2022)	180.763	Catch intermediate year from STF output
Fbar 2019	1.62	MAP base year fishing mortality from current assessment
a and b values	a=0.333 and b=0.666	Regression parameters from Transition regression line

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.61) would increase biomass by 45.6% from 2022 to 2024, while reducing catches by35% from 2021 to 2023.

Table 6.3.5.2 Red mullet in GSA 1: Short term forecast table for red mullet in GSA 1.

Rationale	Ffactor	Fbar	Recruitment2022	Fsq2022	Catch2021	Catch2022	Catch2023	SSB2022	SSB2024	SSB_change_2022-2024(%	Catch_change_2021-2023(%
High long term yield (F0.1)	0.43	0.61	8448.89	1.42	148.37	180.76	96.13	189.88	276.56	45.65	-35.21
F upper	0.58	0.83	8448.89	1.42	148.37	180.76	119.94	189.88	240.33	26.57	-19.16
F lower	0.28	0.40	8448.89	1.42	148.37	180.76	69.75	189.88	320.77	68.93	-52.99
FMSY transition	0.67	0.95	8448.89	1.42	148.37	180.76	131.04	189.88	224.65	18.31	-11.68
F/Catch_option	0.24	0.34	8448.89	1.42	148.37	180.76	60.53	189.88	337.21	77.59	-59.20
Zero catch	0.00	0.00	8448.89	1.42	148.37	180.76	0.00	189.88	457.33	140.85	-100.00
Status quo	1.00	1.42	8448.89	1.42	148.37	180.76	167.23	189.88	178.77	-5.85	12.71
Different Scenarios	0.10	0.14	8448.89	1.42	148.37	180.76	27.68	189.88	399.83	110.57	-81.34
	0.20	0.28	8448.89	1.42	148.37	180.76	51.78	189.88	353.28	86.06	-65.10
	0.30	0.43	8448.89	1.42	148.37	180.76	72.86	189.88	315.33	66.07	-50.89
	0.40	0.57	8448.89	1.42	148.37	180.76	91.40	189.88	284.17	49.66	-38.40
	0.50	0.71	8448.89	1.42	148.37	180.76	107.80	189.88	258.37	36.07	-27.34
	0.60	0.85	8448.89	1.42	148.37	180.76	122.37	189.88	236.83	24.73	-17.52
	0.70	0.99	8448.89	1.42	148.37	180.76	135.40	189.88	218.71	15.18	-8.74
	0.80	1.14	8448.89	1.42	148.37	180.76	147.09	189.88	203.32	7.08	-0.86
	0.90	1.28	8448.89	1.42	148.37	180.76	157.65	189.88	190.15	0.14	6.25
	1.10	1.56	8448.89	1.42	148.37	180.76	175.96	189.88	168.87	-11.06	18.59
	1.20	1.71	8448.89	1.42	148.37	180.76	183.95	189.88	160.18	-15.64	23.98
	1.30	1.85	8448.89	1.42	148.37	180.76	191.30	189.88	152.50	-19.69	28.94
	1.40	1.99	8448.89	1.42	148.37	180.76	198.09	189.88	145.65	-23.29	33.51
	1.50	2.13	8448.89	1.42	148.37	180.76	204.39	189.88	139.51	-26.53	37.75
	1.60	2.27	8448.89	1.42	148.37	180.76	210.24	189.88	133.96	-29.45	41.70
	1.70	2.42	8448.89	1.42	148.37	180.76	215.72	189.88	128.93	-32.10	45.39
	1.80	2.56	8448.89	1.42	148.37	180.76	220.84	189.88	124.33	-34.52	48.84
	1.90	2.70	8448.89	1.42	148.37	180.76	225.66	189.88	120.11	-36.75	52.09
	2.00	2.84	8448.89	1.42	148.37	180.76	230.20	189.88	116.21	-38.80	55.15

*SSB at mid year

The catch at F_{MSY} is 96.12 tonnes. AS the stock is below B_{pa} at the start of the catch year (1st Jan 2023) following the ICES advice rule with B below B_{pa} F is reduced to 0.34 and catch should be no more than 60.5 tonnes.

6.3.6 DATA DEFICIENCIES

Commercial data

Although catches are available from 2002, the year 2003 is considered the first assessment year because year 2002 suffered a large reconstruction.

Discard data

The discards reported in the STECF 21-09 for 2022 were = 0. In the previous years, except in 2005, discards are reported, although these are very low in the whole series.

Survey data

The survey data was supposed to be subjected to revision between the last and current assessments. However, the general trend and standard deviation kept equal to those presented in the STECF 21-09. This is coherent with the quality checks including TB to TC, which did not show any particular problem. Index for 2020 was not available.

Stock assessment.

Time series of catches included 2003 and class group kept age 4. Age 4 was removed of the Index survey because artificial cohort consistency was observed. Changes in the catch at age number did not modify the stock either harvest trends but promoted higher estimation of the overall time series of fishing mortality, meaning higher overexploitation.

6.4 STRIPED RED MULLET IN GSA 5

6.4.1 STOCK IDENTITY AND BIOLOGY

GSA 5 (Figure 6.4.1.1) has been selected as an individualized area for assessment and management purposes in the western Mediterranean (Quetglas *et al.*, 2012) due to its main specificities. These include: 1) Geomorphological, the Balearic Islands (GSA 5) are clearly separated from the Iberian Peninsula (GSA 6) by depths between 800 and 2000 m, which would constitute a natural barrier to the interchange of adult stages of demersal resources; 2) Physical geographically-related characteristics, such as the lack of terrigenous inputs from rivers and submarine canyons in GSA 5 compared to GSA 6, give rise to differences in the structure and composition of the trawling grounds and hence in the benthic assemblages; 3) Owing to these physical differences, the faunistic assemblages exploited by trawl fisheries differ between GSA 5 and GSA 6, resulting in large differences in the relative importance of the main commercial species; 4) There are no important or general interactions between the demersal fishing fleets in the two areas, with only local cases of vessels targeting red shrimp in GSA 5 but landing their catches in GSA 6; 5) Trawl fishing exploitation in GSA 5 is much lower than in GSA 6; the density of trawlers around the Balearic Islands is one order of magnitude lower than in adjacent waters; and 6) Due to this lower fishing exploitation, the demersal resources and ecosystems in GSA 5 are in a healthier state than in GSA 6, which is reflected in the population structure of the main commercial species (populations from the Balearic Islands have larger modal sizes and lower percentages of small-sized individuals), and in the higher abundance and diversity of elasmobranch assemblages.

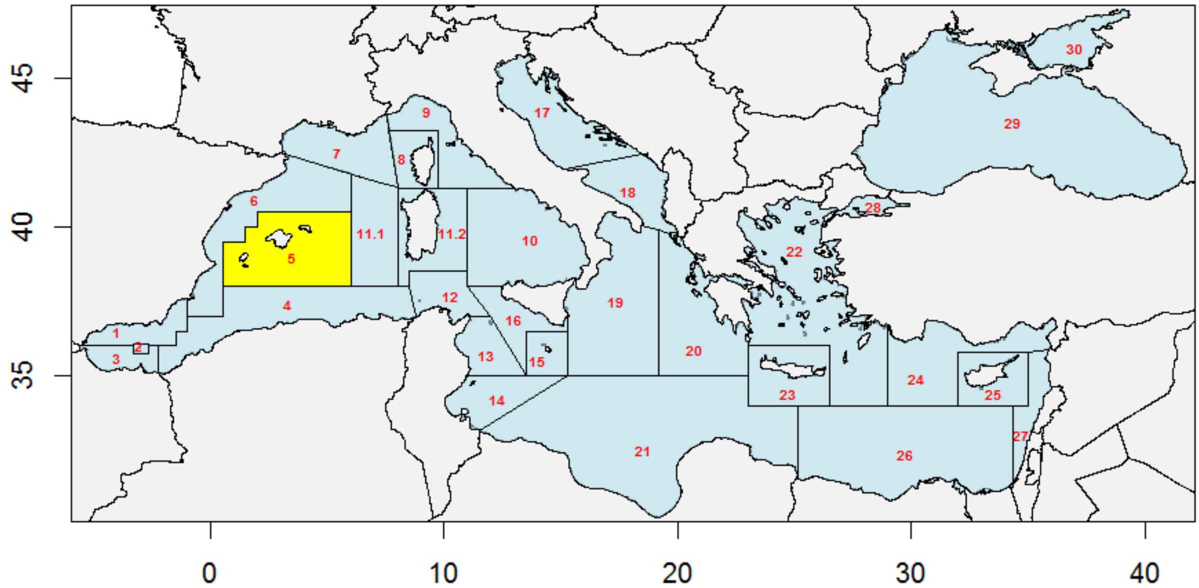


Figure 6.4.1.1. Geographical localization of GSA 5.

The biological parameters, natural mortality vector and maturity ogive used for the assessment of the striped red mullet (*Mullus surmuletus* designated by the ASFIS 3-letters code "MUR") were those shown in the following tables. Growth parameters (Table 6.4.1.1) and natural mortality vector (Table 6.4.1.2) were those used in the 2020 assessment of this stock carried out by the Working Group of Stock Assessment of Demersal Stocks in the Western Mediterranean Sea of the STECF (EWG-20-09), from Campillo (1992). Length-weight relationship (Table 6.4.1.1.) was obtained from the STECF Med&BS data call, using the median value of the parameters, excluding 2021 (see 6.4.6 Data issues). Proportion of matures (Table 6.4.1.3) has been set considering all the individuals become mature in age 1.

Table 6.4.1.1. Striped red mullet in GSA 5. Growth and length-weight parameters.

Growth	
L_{inf} (cm)	33.4
k	0.43
t_0	-0.1
Length-Weight	
a	0.0085
b	3.115

Table 6.4.1.2. Striped red mullet in GSA 5. Natural Mortality vector.

Age	0	1	2	3	4	5+
M	1.14	0.86	0.64	0.55	0.50	0.47

Table 6.4.1.3. Striped red mullet in GSA 5. Maturity ogive.

Age	0	1	2	3	4	5+
Prop. Mature	0.00	1.00	1.00	1.00	1.00	1.00

6.4.2 DATA

General description of the fisheries

In the Balearic Islands (western Mediterranean), commercial trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope (Guijarro and Massutí 2006; Ordines et al. 2006), mainly targeted to: (i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50-80 m); (ii) *Merluccius merluccius*, *Mullus spp.*, *Zeus faber* and a mixed fish category on the deep shelf (80-250 m); (iii) *Nephrops norvegicus*, but with an important by-catch of big *M. merluccius*, *Lepidorhombus spp*., *Lophius spp.* And *Micromesistius poutassou* on the upper slope (350-600 m) and (iv) *Aristeus antennatus* on the middle slope (600-750 m). The striped red mullet, *Mullus surmuletus*, is one of the target species in the shallow shelf.

Management regulations

- Fishing license: number of licenses observed
- Engine power limited to 316 KW or 500 HP: not fully observed.
- Mesh size in the cod-end (before June 1st 2010: 40 mm, diamond: after June 1st 2010: 40 mm square or 50 mm diamond –by derogation-): fully observed.
- Time at sea (12 hours per day and 5 days per week): fully observed.
- Minimum landing size (EC regulation 1967/2006, 11 cm TL): mostly fully observed catch.

6.4.2.1 CATCH (LANDINGS AND DISCARDS)

Landings for striped red mullet in GSA 5 come both from bottom trawlers and trammel nets, with bottom trawlers representing around 80-90% of total landings. Following a reduction in 2007-2009, from 2013 to 2018 an increase in bottom trawl catches is observed. Since then, again a slight reduction was noted from 2018-2021 (Figure 6.4.2.1 and Table 6.4.2.1.).

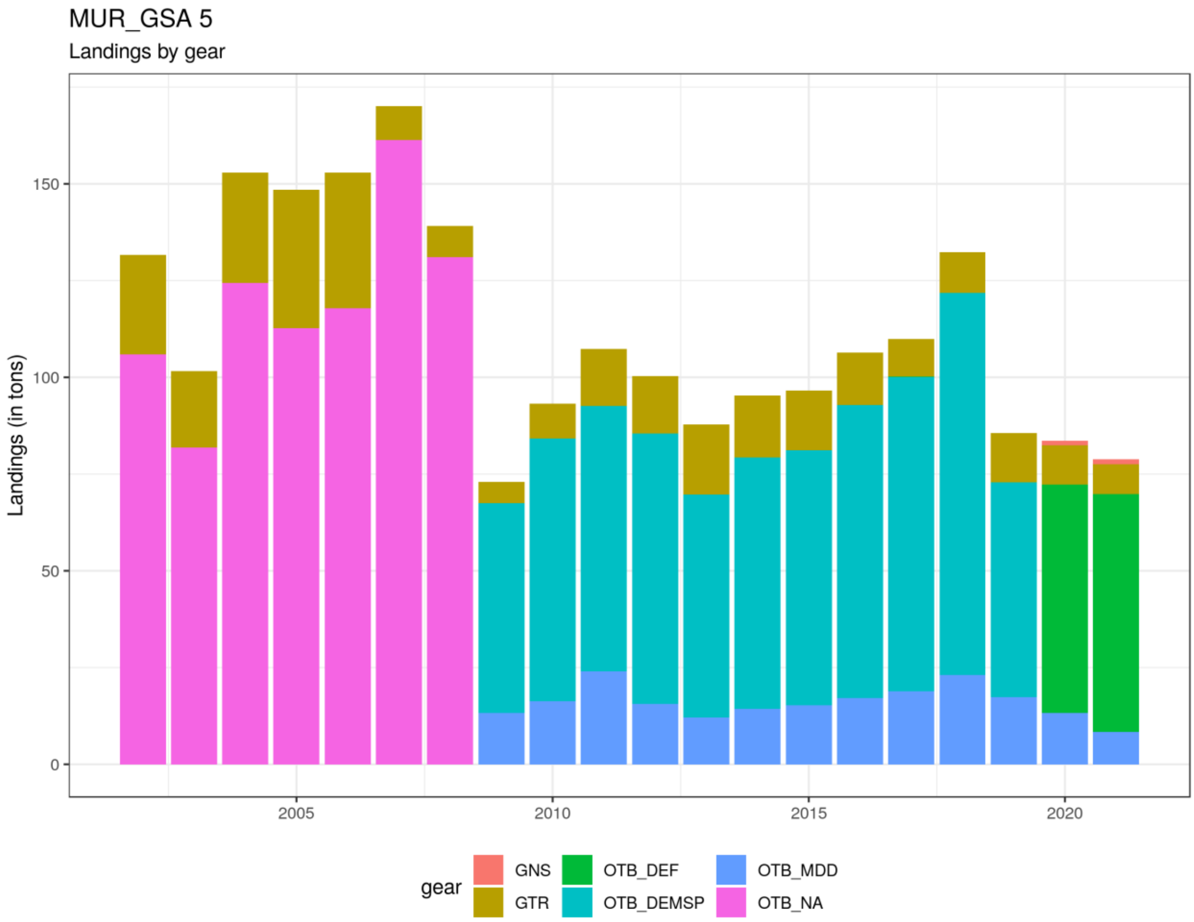


Figure 6.4.2.1. Striped red mullet in GSA 5. Reported landings from the STECF Med&BS data call by gear.

Table 6.4.2.1. Striped red mullet in GSA 5. Reported landings by gear from the STECF Med&BS data call.

year	GNS	GTR	OTB_DEF	OTB_DEMSP	OTB_MDD	OTB_NA	total
2002	0	25.72	0	0	0	105.96	131.68
2003	0	19.75	0	0	0	81.87	101.62
2004	0	28.55	0	0	0	124.4	152.95
2005	0	35.8	0	0	0	112.71	148.51
2006	0	35.04	0	0	0	117.84	152.88
2007	0	8.76	0	0	0	161.3	170.06
2008	0	8.09	0	0	0	131.07	139.16
2009	0	5.43	0	54.28	13.26	0	72.97
2010	0	8.95	0	67.94	16.26	0	93.15
2011	0	14.69	0	68.69	23.98	0	107.36
2012	0	14.85	0	69.93	15.58	0	100.36
2013	0	18.2	0	57.55	12.13	0	87.88
2014	0	16.09	0	64.97	14.29	0	95.35
2015	0	15.48	0	65.85	15.27	0	96.6
2016	0	13.57	0	75.77	17.12	0	106.46
2017	0	9.76	0.04	81.25	18.9	0	109.97
2018	0	10.56	0	98.78	23.06	0	132.4
2019	0	12.65	0	55.48	17.41	0	85.54
2020	1.17	10.17	59.09	0	13.23	0	83.67
2021	1.32	7.67	61.52	0	8.31	0	78.92

Discards for this stock was considered as negligible and catches are assumed to be equal to landings. Nevertheless, it is recognized that some years as 2010 and 2012 presented discards over 5 tonnes for GTR and OTB, respectively (Figure 6.4.2.2 & Table 6.4.2.2). Such small amounts are not expected to change the assessment in any important way.

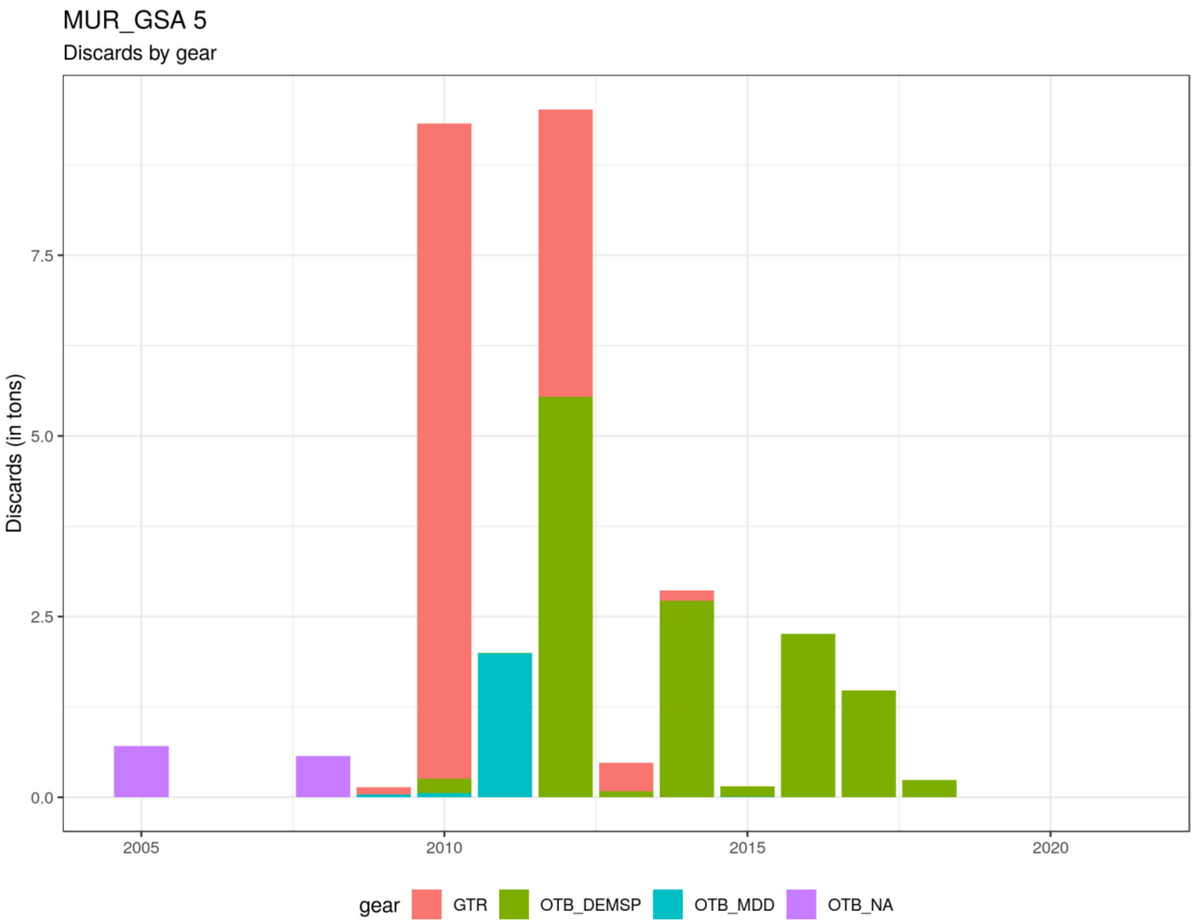


Figure 6.4.2.2. Striped red mullet in GSA 5. Reported discards (in tons) by gear from the STECF Med&BS data call.

Table 6.4.2.2. Striped red mullet in GSA 5. Reported discards (in tons) by gear from the STECF Med&BS data call.

year	GTR	OTB_DEMSP	OTB_MDD	OTB_NA	total
2005	0	0	0	0.71	0.71
2007	0	0	0	0	0
2008	0	0	0	0.57	0.57
2009	0.1	0	0.04	0	0.14
2010	9.06	0.2	0.06	0	9.32
2011	0	0.01	1.99	0	2
2012	3.98	5.54	0	0	9.52
2013	0.4	0.08	0	0	0.48
2014	0.14	2.72	0	0	2.86
2015	0	0.14	0.01	0	0.15
2016	0	2.26	0	0	2.26
2017	0	1.48	0	0	1.48
2018	0	0.24	0	0	0.24
2019	0	0	0	0	0
2021	0	0	0	0	0

Evaluation of length frequency distribution data from STECF Med&BS shows that most of the information comes from OTB_DEMSP up to 2019 and OTB_DEF since 2020 (Figure 6.4.2.3). The change in gear type results not from a change in the fishery, just a redefinition of the gear designations.

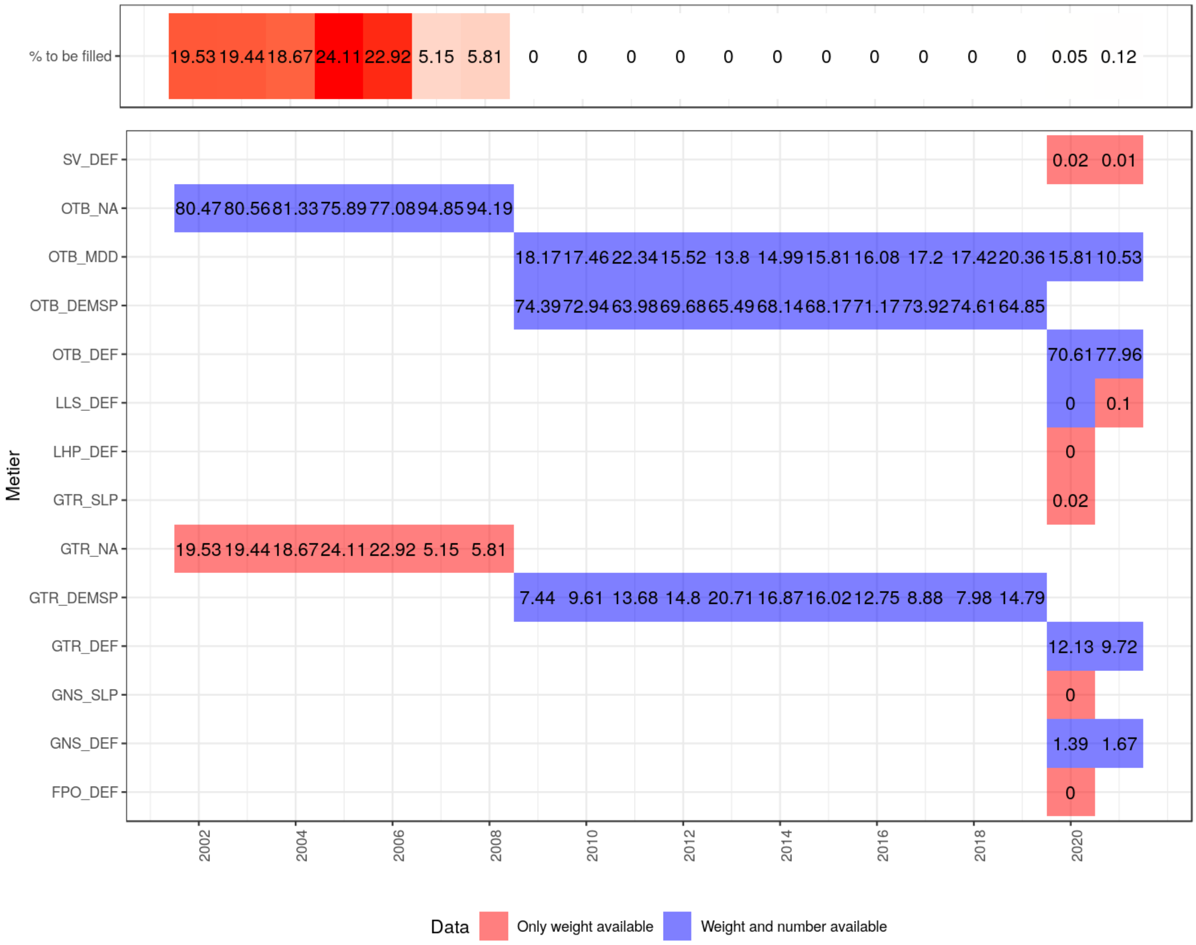


Figure 6.4.2.3. Striped red mullet in GSA5. Sampling of landings by gear from the STECF Med&BS data call.

Length frequency distribution for the striped red mullet in GSA 5 shows differences between métiers, with trammel-nets targeting larger individuals than bottom trawlers (Figure 6.4.2.4).

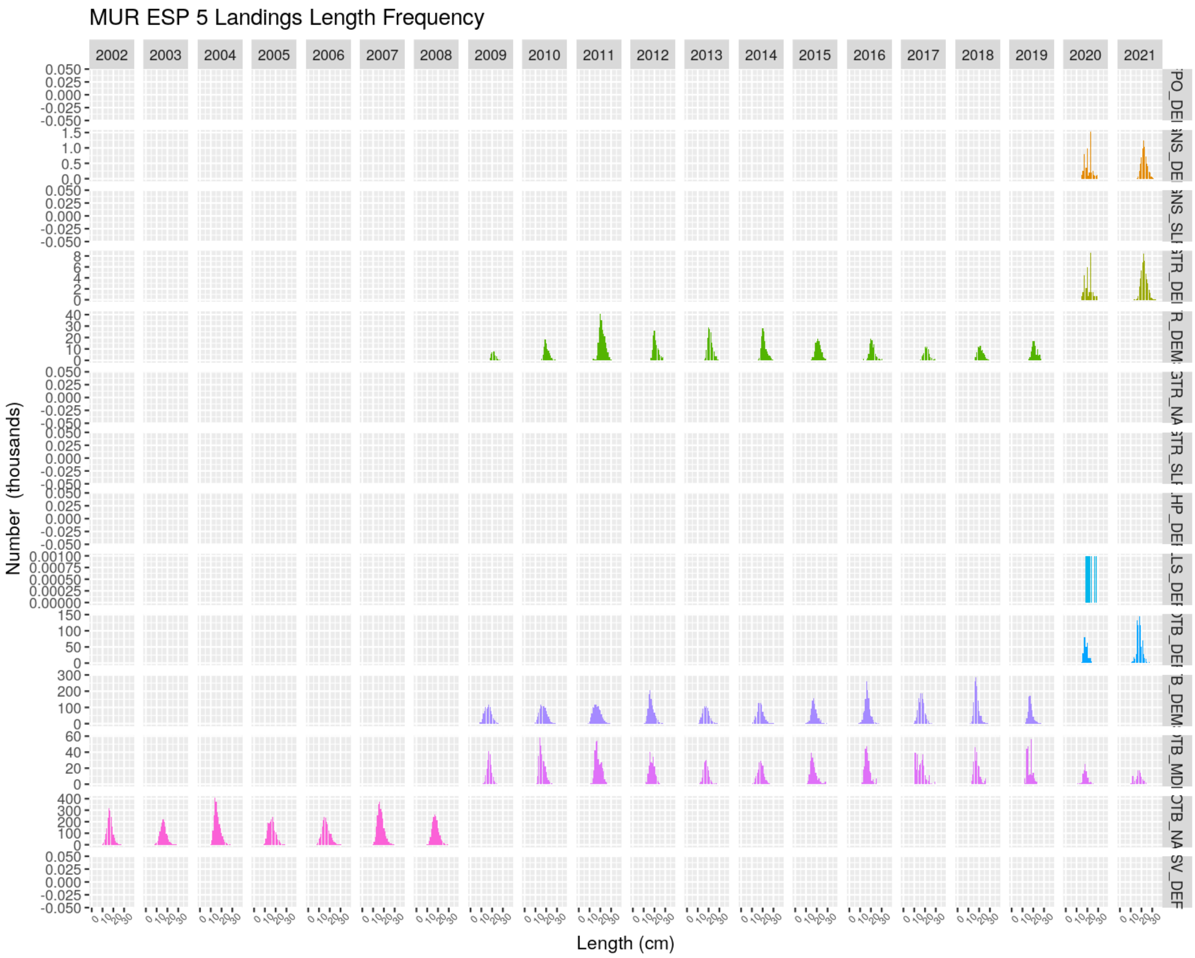


Figure 6.4.2.4. Striped red mullet in GSA5. Catch length frequency distribution, by year and métier (TL cm, numbers in thousands) from the STECF Med&BS data call.

Table 6.4.2.3. Striped red mullet in GSA 5. Catch length structure (TL in cm, numbers in thousands) reported in STECF Med&BS data call (2009-2021).

Length (cm)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
8	0.46	0.74	0	0	0	0	0	0	0	0	0	0	0
9	7.17	0.76	2.21	0	0	0.5	1.02	1.79	0	0	0	0	0
10	9.64	7.18	12.4	1.17	0.44	1.08	3.22	9.71	3.35	0	0	0.39	1.37
11	29.05	23.8	37.21	2.79	3.67	9.21	9.06	10.22	56.21	0.52	0	0.97	5.05
12	65.52	55.83	63.77	14.7	23.99	26	15.09	25.5	56.64	5.08	8.52	0.39	16.34
13	80	102.49	112.64	49.11	41.69	56.44	29.51	87.49	118.56	17.11	10.15	1.57	19.13
14	112.02	149.49	116.4	105.74	72.52	50.94	83.75	99.54	174.63	59.56	77.17	2.47	17.25
15	113.06	163.83	158.26	202.64	109.52	85.64	132.4	198.18	155.56	161.67	121.79	6.19	34.09
16	131.54	145.01	170.48	245.89	133.45	143.78	179.87	311.39	211.61	307.24	178.52	46.18	143.17
17	156.51	142.71	158.24	183.16	126.55	158.67	185.74	245.44	217.63	320.26	187.79	103.65	135.57
18	139.69	148.5	151.66	148.13	144.96	165.12	153.46	193.11	191.57	277.46	185.51	104.53	164.39
19	107.44	138.55	139.38	143.62	142.13	163.88	117.84	118.48	154.98	177.58	105.93	68.86	135.14
20	77.73	105.79	148.2	115.76	121.49	124.7	89.59	83.27	87.55	110.88	75.44	78.85	65.81
21	48.4	77.94	121.3	77.84	84.72	88.63	58.83	65.44	70.97	68.01	46.62	25.45	84.13
22	36.23	57.91	87.04	55.48	61.69	67.14	55.9	38.95	43.05	61.91	35.42	19.46	41.81
23	23.34	38.37	68.55	37.57	37.9	36.39	30.88	23.86	33.44	30.14	21.26	28.54	27.36
24	15.18	17.53	45.5	20.93	28.21	27.16	34.17	13.14	21.48	16.13	16.68	8.67	21.71
25	7.82	12.89	28.67	14.93	17.32	21.16	10.51	14.04	9.61	16.54	6.97	5.19	6.99
26	3.89	6.92	20.3	6.71	8.44	11.12	7.52	4.32	5.3	14.42	6.11	1.34	3.47
27	1.63	3.46	13.08	5.4	8.26	8	6.36	3.83	1.61	3.46	3.67	3.11	4.18
28	0.39	2.08	7.37	4.92	3.52	5.27	4.78	1.92	1.3	5.65	0.51	0.88	2.05
29	1.4	0.9	4.62	0.59	1.53	2.26	3.44	0.81	5.26	0.82	0.39	0.87	0.8
30	0.12	0.36	0.6	0.12	0.8	1.72	0.25	1.34	0.37	0.31	0.49	0	0.33
31	0.48	1.1	0.34	0.16	0.25	0.39	0.08	0.03	0	0	0.54	0	0.11
32	0.12	0	0.16	0.04	0	0.12	0.42	0	0	0	0.08	0	0.03
34	0.18	0.2	0.09	0	0	0	0.02	0	0	0	0	0	0
33	0	0.03	0.15	0	0	0	0.23	0	0	0	0	0	0.03
38	0	0.04	0.05	0	0	0	0	0	0	0	0	0	0

Age composition is mainly formed by age 1 individuals, although age 0 and age 2 are also frequent in the catches (Figure 6.4.2.5, Table 6.4.2.4). Cohorts showed low consistency, only good for the youngest classes (figure 6.4.2.6). An "age plus" group was defined at age 5.

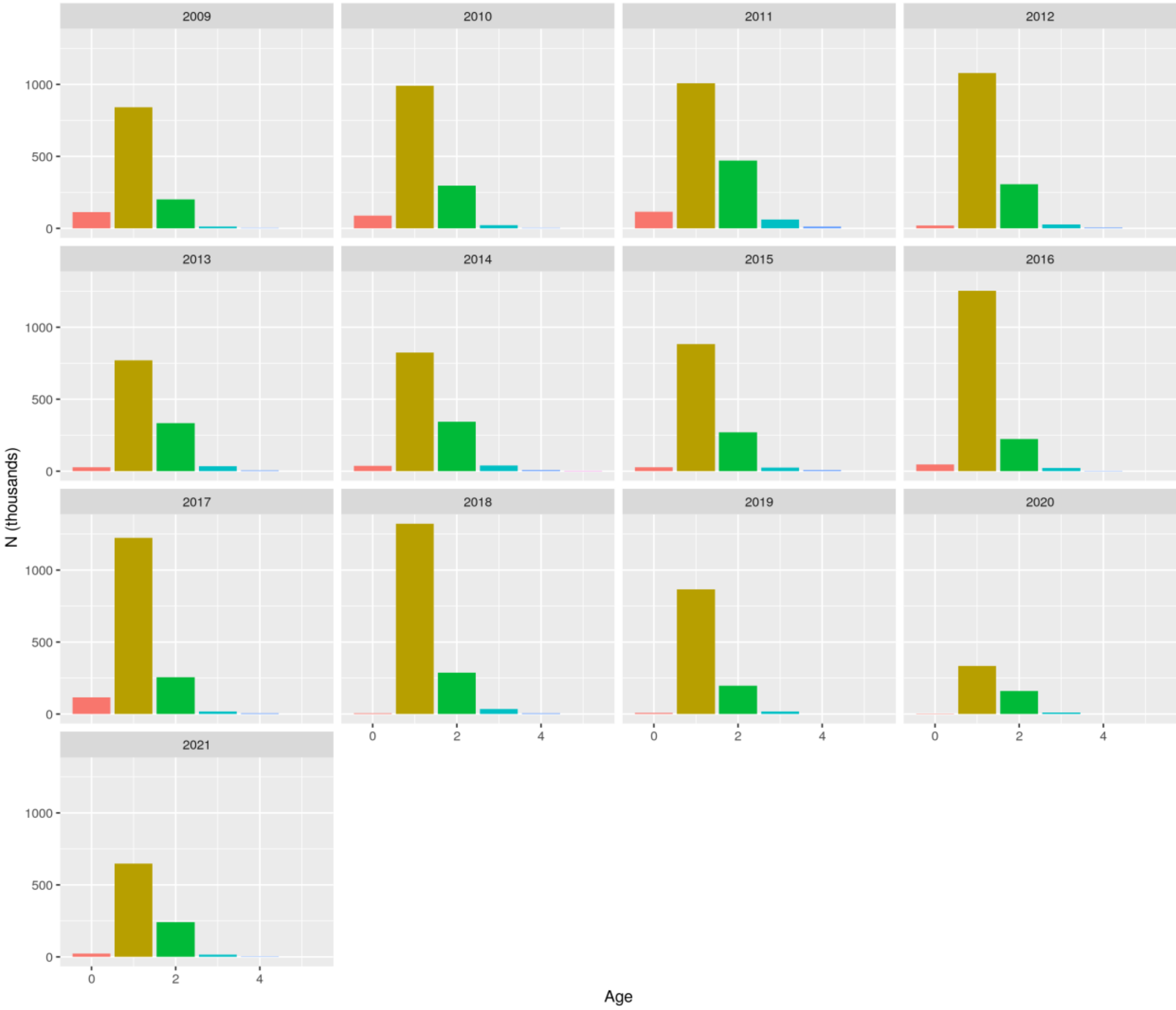


Figure 6.4.2.5. Striped red mullet in GSA 5. Landings at age, numbers in thousands.

Table 6.4.2.4. Striped red mullet in GSA 5. Landings at age, numbers in thousands.

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	111.83	88.31	115.59	18.66	28.1	36.78	28.39	47.23	116.2	5.6	8.52	1.75	22.76
1	840.25	990.59	1007.06	1078.29	770.82	824.47	882.55	1253.63	1224.55	1320.87	866.86	333.44	648.74
2	200.88	297.53	470.59	307.58	334.01	344.02	269.37	224.67	256.49	287.08	195.42	160.98	240.83
3	13.34	23.27	62.05	27.05	34.02	40.27	24.38	22.19	16.52	34.41	16.75	9.64	14.63
4	1.8	2.99	11.99	5.5	5.05	7.53	8.22	2.73	6.56	6.47	0.91	1.75	2.85
5	0.72	1.46	1.09	0.32	1.05	2.23	0.76	1.37	0.37	0.31	1.1	0	0.47

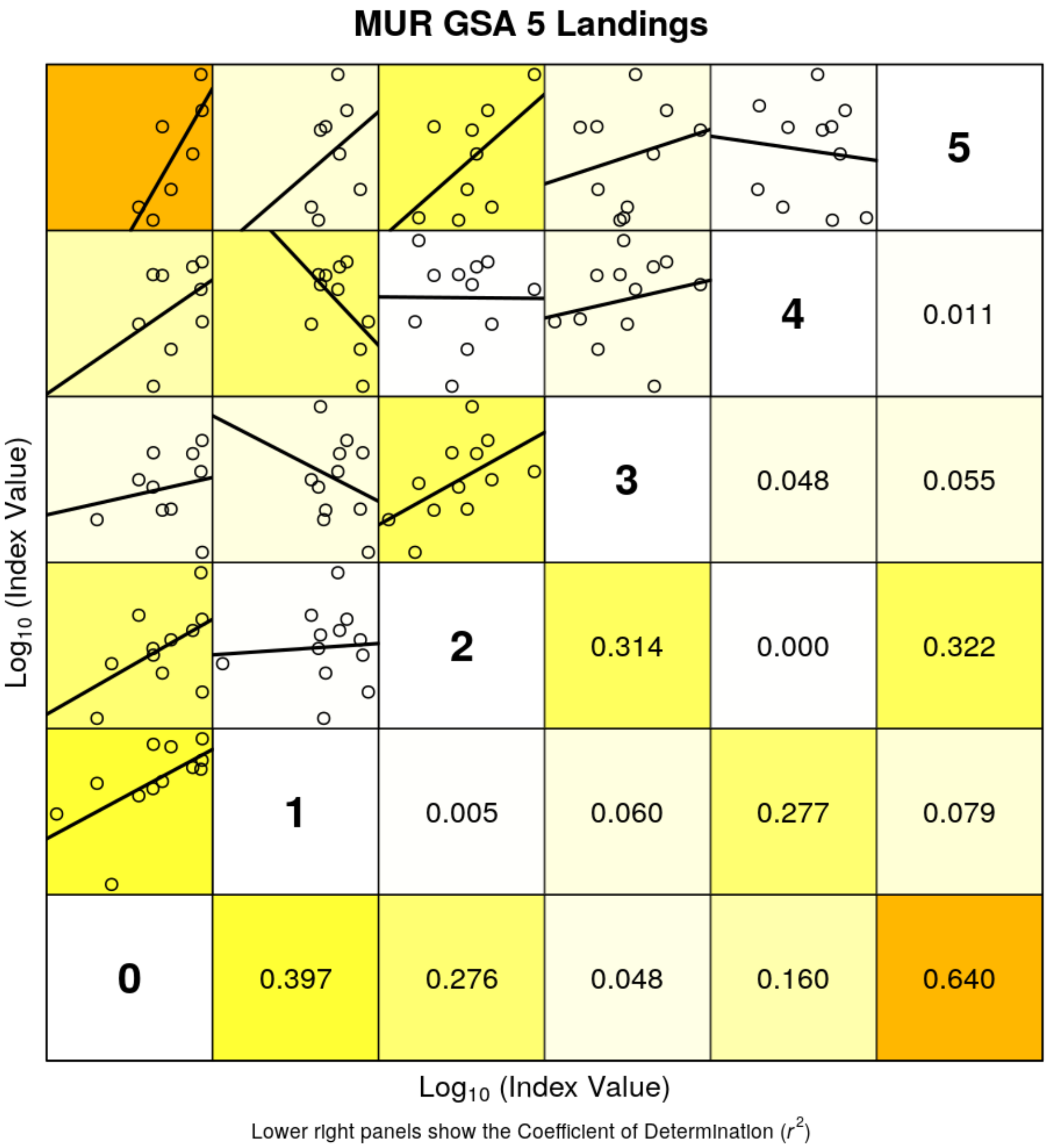


Figure 6.4.2.6. Striped red mullet in GSA 5. Cohort consistency for the commercial landings.

6.4.2.2 Effort data

Fishing effort data for 2021 will be reported to STECF EWG 22-10 through the FDI data call within the DCF framework.

6.4.2.3 SURVEY DATA

The MEDITS (MEDiterranean International Trawl Survey) survey is an extensive trawl survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintain fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end is used throughout GSAs and years.

MEDITS survey started in GSA 5 in 2007. Before 2007, data were collected for only a few stations, so these years were considered non representative and not included. Mean stratified abundances and biomass by km^2 have been computed using the methodology described by Grosslein and Laurec (1982). In 2021 an unusual number of stations were sampled around the Ibiza Island (Figure 6.4.2.7.). To harmonize the MEDITS dataset from the STECF Med&BS data call, only stations with a longitude > 2°E were conserved for computations (Figure 6.4.2.8.). Also three stations were removed due to suspicious individual mean weight (<= 1g) in MEDITS Table B: haul #134 in 2009, #130 and 131 in 2012. The haul #149 in 2009 was also removed due to a suspicious high catch (240 kg), as it was in the last assessment.

Density and biomass indices showed variations along the data series, with high values for 2007 and 2017 (Figure 6.4.2.9). Length frequency distributions are shown in Figure 6.4.2.10 and Table 6.4.2.5.

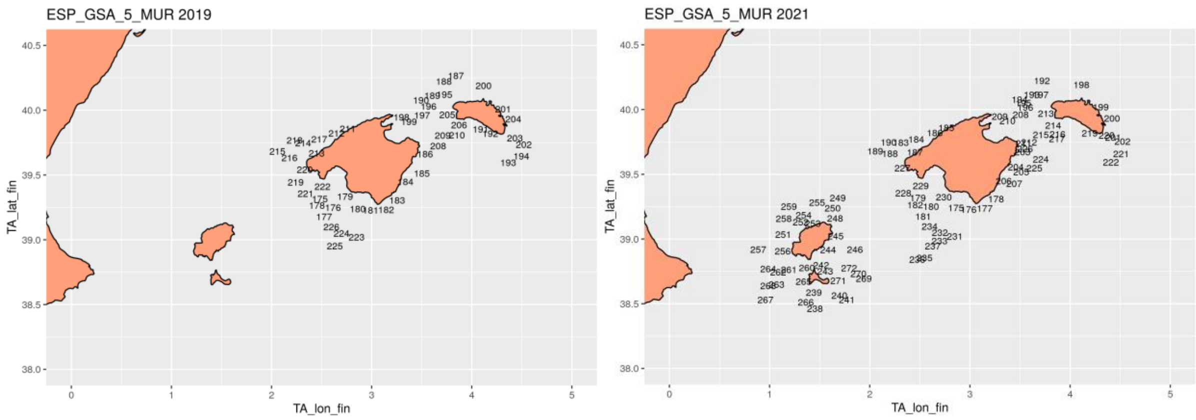


Figure 6.4.2.7. Striped red mullet in GSA 5. MEDITS stations in 2019 and 2021 to illustrate the large number of samplings done around Ibiza in 2021.

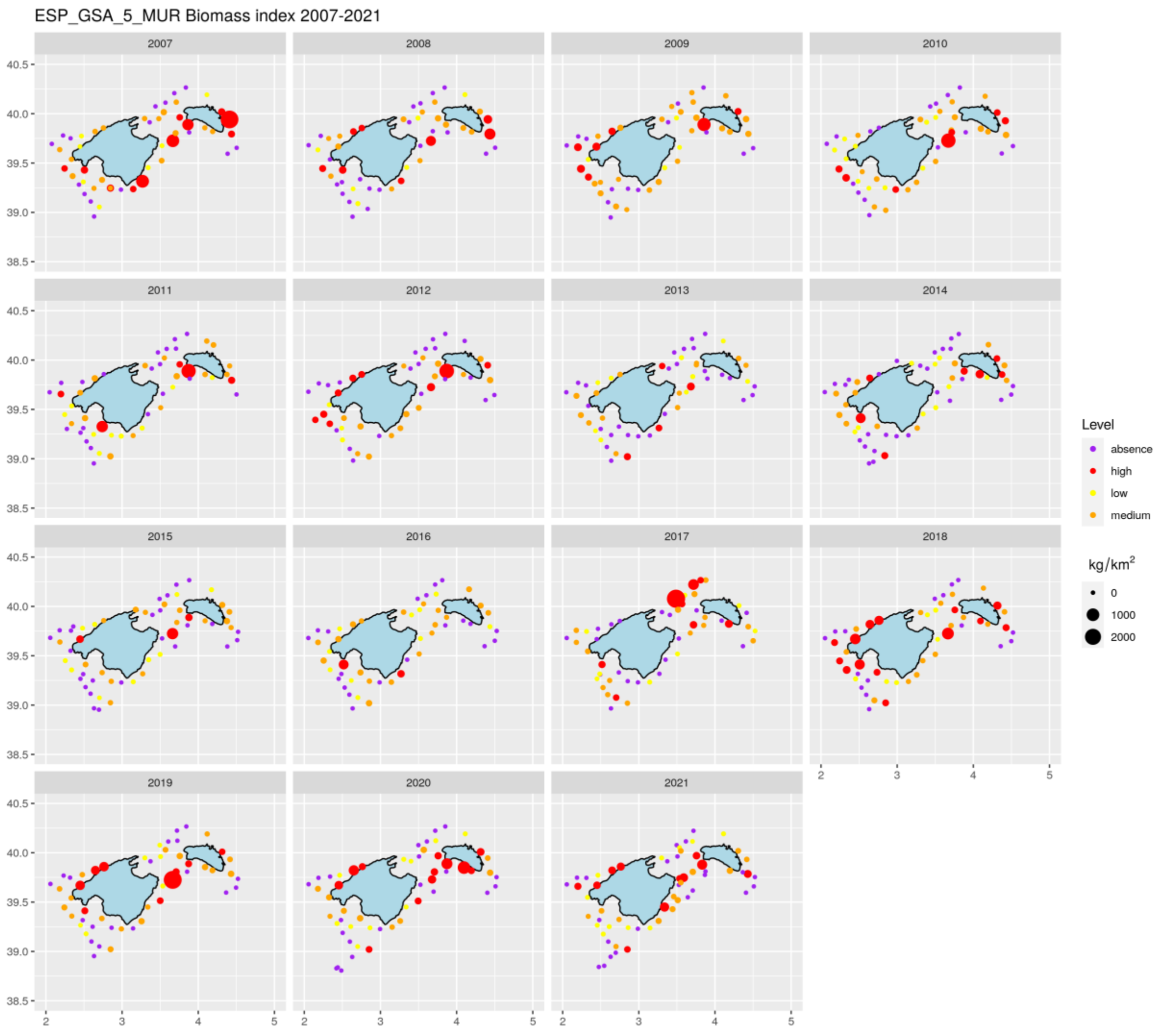


Figure 6.4.2.8. Striped red mullet in GSA 5. MEDITS Biomass index by stations.

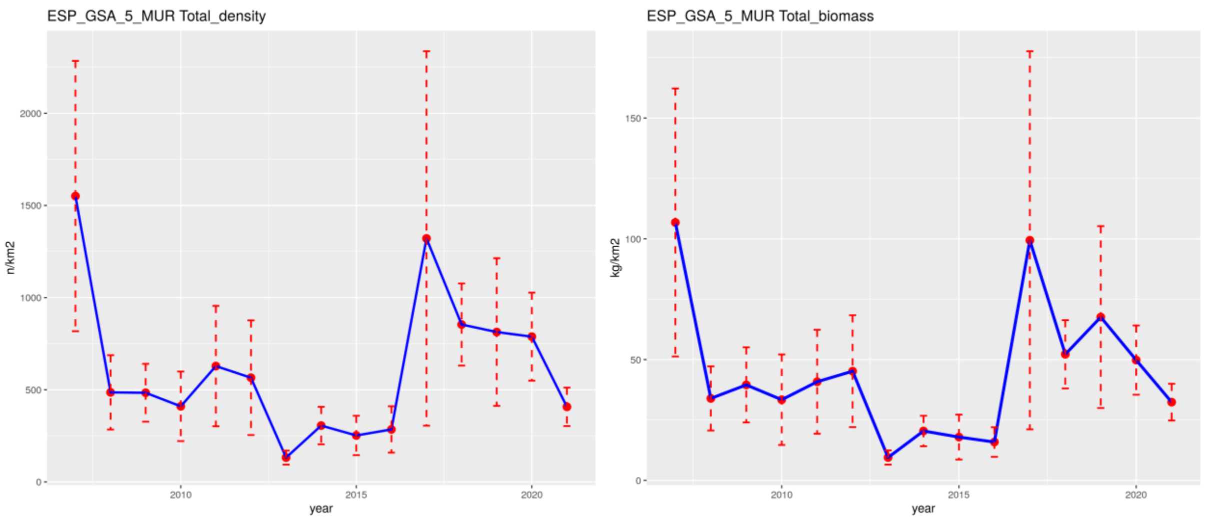


Figure 6.4.2.9. Striped red mullet in GSA 5. MEDITS abundance (n/km^2) and biomass (kg/km^2) indices over 2007-2021.

Figure 6.4.2.10. Striped red mullet in GSA 5. Length frequency distribution (TL in mm, numbers in n/km^2) reported in MEDITS (2007-2021) survey data.

Table 6.4.2.5. Striped red mullet in GSA 5. Length frequency distribution (TL in mm, numbers in n/km^2) reported in MEDITS (2007-2021) survey data.

Length	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
35	0	0.38	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0.87	0
55	0	0	0	0	0.47	0	0	0	0	0	0	0	0.45	0.44	0
60	0	0	0	0	0	0	0	0	0	0	0.31	0	0	0.44	0
70	0	0	0	0	0	0	0	0	0	0	0	1.19	0	0	0
110	0	0	0.7	3.52	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	1.76	0	0	0	0	0	0	0.76	0	0	0	0
120	0	0	0	0	0	0.9	0	0	0	0	0.76	0.44	0	0	0
125	0.75	0	0	3.52	0	1.79	0	0	0	0.37	1.14	0.87	0.81	1.3	0
130	2.02	0	2.05	0	0.47	3.03	0	0	1.26	2.96	3.34	1.23	0.45	0	2.17
135	9.74	1.39	5.92	1.7	1.74	1.91	0.42	2.87	1.26	4.57	4.62	9.34	0	0.81	1.96
140	28.9	5.1	8.41	4.43	3.62	11.71	1.13	4.41	4.78	9.54	9.46	17.9	2.34	11.69	7.58
145	43.7	12.86	10.62	10.65	10.82	18.9	1.96	7.94	11.77	19.98	36.96	37.04	0.81	17.42	20.84
150	108.87	13.77	22.39	14.25	26.41	25.06	6.92	18.29	21.47	19.11	59.03	66.77	21.27	56.87	22.45
155	108.78	20.55	32.17	19.98	51.29	31.77	10.3	32.83	26.1	33.38	65.41	94.17	22.72	59.54	25.95
160	130.73	28.65	31.99	24.32	72.54	47.86	10.08	45.39	20.43	35.56	97.33	111.24	42.26	118.58	34.05
165	113.61	42.62	28.74	25.78	72.08	46.19	9.25	33.72	17.3	29.59	91.63	83.77	47.79	108.57	32.89
170	118.31	44.52	29.06	28.53	85.14	68.53	13.24	32.38	15.24	27.1	126.2	89.71	61.67	107.03	42.67
175	96.86	52.93	27.47	32.75	50.24	42.98	16.05	19.2	14.35	22.43	87.37	65.23	49.02	70.59	31.42
180	174	45.91	32.7	27.32	51.92	39.74	10.85	22.27	14.5	17.26	143.71	55.65	72.01	51.66	32.91
185	86.64	35.03	30.43	42.32	49	39.17	10.99	16.96	14.11	16.29	88	42.68	49.85	39.74	22.74
190	109.95	22.34	28.84	23.21	36.51	33.03	5.83	12.64	9.99	10.35	93.38	39.36	94.05	24.19	28.94
195	122.97	31.17	24.03	32.97	21.56	34.23	5.5	11.59	12	10.07	70.63	26.57	69.62	33.65	19.2
200	103.64	20.84	28.53	22.03	22.38	20.71	9.41	11.61	12.56	9.5	71.66	17.3	59.16	18.08	17.14
205	29.69	28.19	20.06	18.77	16.89	15.86	5	7.1	9.19	4.09	53.59	14.66	51.67	12.48	13.76
210	42.41	26.3	20.21	8.15	16.33	7.23	3.34	5.91	10.59	4.2	49.31	15.52	39.88	11.97	10.69
215	31.37	6.01	12.98	15.81	10.67	13.14	2.67	6.11	5.04	4.1	36.87	13.48	31.83	13.28	11.78
220	29.4	11.97	10.97	7.43	18.6	12.1	3.12	4.57	7.6	1.68	42.97	11.02	20.25	8.1	6.45
225	32.62	8.93	13.83	7.07	3.95	12.86	1.13	1.24	5.42	0.64	17.97	8.43	11.62	8.54	4.31
230	3.9	5.54	12.01	4.19	2.61	5.9	1.09	1.69	5.04	1.11	22.6	9.7	18.51	6.08	6.28
235	8.86	3.33	7.51	6.39	5.18	6.46	0.67	2.13	2.92	0	15.22	3.33	13.58	4.24	3.05
240	9.19	3.78	9.39	1.5	2.83	9.97	1.17	1.69	3.06	0.47	4.13	7.14	11.41	0	2.71
245	1.39	2.61	7.13	2.41	0.32	3.61	1.58	1.24	1.68	0.37	9.82	2.33	5.07	1.19	2.16
250	0.38	3.52	2.61	7.68	0	1.66	0.42	0.89	1.75	0	4.62	1.75	2.14	0.89	0
255	1.75	5.29	5.63	0	0.79	1.12	0	0.84	0	0	5.68	2.19	2.14	0.44	1.46
260	0	0.88	7.59	0.38	0	0	0	0	0.44	0	0.76	1.45	4.29	0	0.89
265	0	0.28	3.2	0.47	0	0.56	0	0.24	0.37	0	4.15	0.44	3.38	0	0.73
270	0	0.35	4.39	0	0.47	1.66	0	0	1.68	0	0.31	0.87	0	0.44	0.36
275	0	0.88	0.26	1.76	0	0	0	0	0	0	0	0.44	1.69	0.44	0
280	0	0	0.64	0	0	0	0	0	0	0	0.76	0.44	1.69	0	0
285	0.38	0	0.26	1.76	0	0.56	0	0	0	0	0	0	0	0	0
290	0.38	0	0.44	0	0	0	0	0	0	0	0	0	0	0	0
305	0	0	0	1.76	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	0	0	0	0	0	0.22	0	0
320	0	0	0.44	0	0	0	0	0	0	0	0	0	0	0	0
365	0	0	0	0	0	0.56	0	0	0	0	0	0	0	0	0
560	0	0	0.36	0	0	0	0	0	0	0	0	0	0	0	0

Age composition of the catches from the survey showed that most of the individuals correspond to age 1, although age 2 is also important (Figure 6.4.2.10). Cohorts showed no consistency (Figure 6.4.2.11).

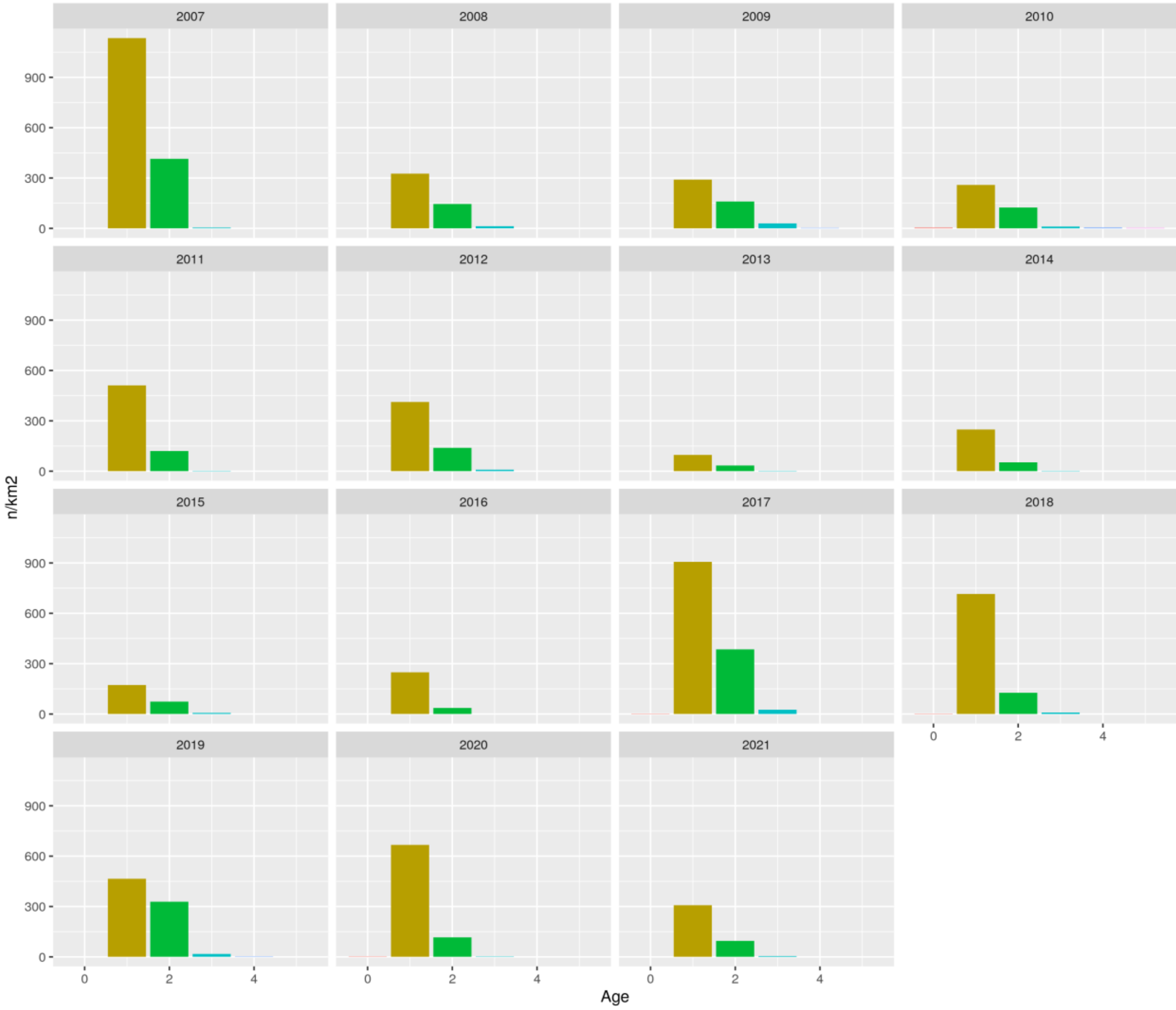


Figure 6.4.2.11. Striped red mullet in GSA 5. Age structure (numbers in n/km^2) estimated from length frequency distribution reported in MEDITS (2007-2021) survey data, with plus group set at age 5.

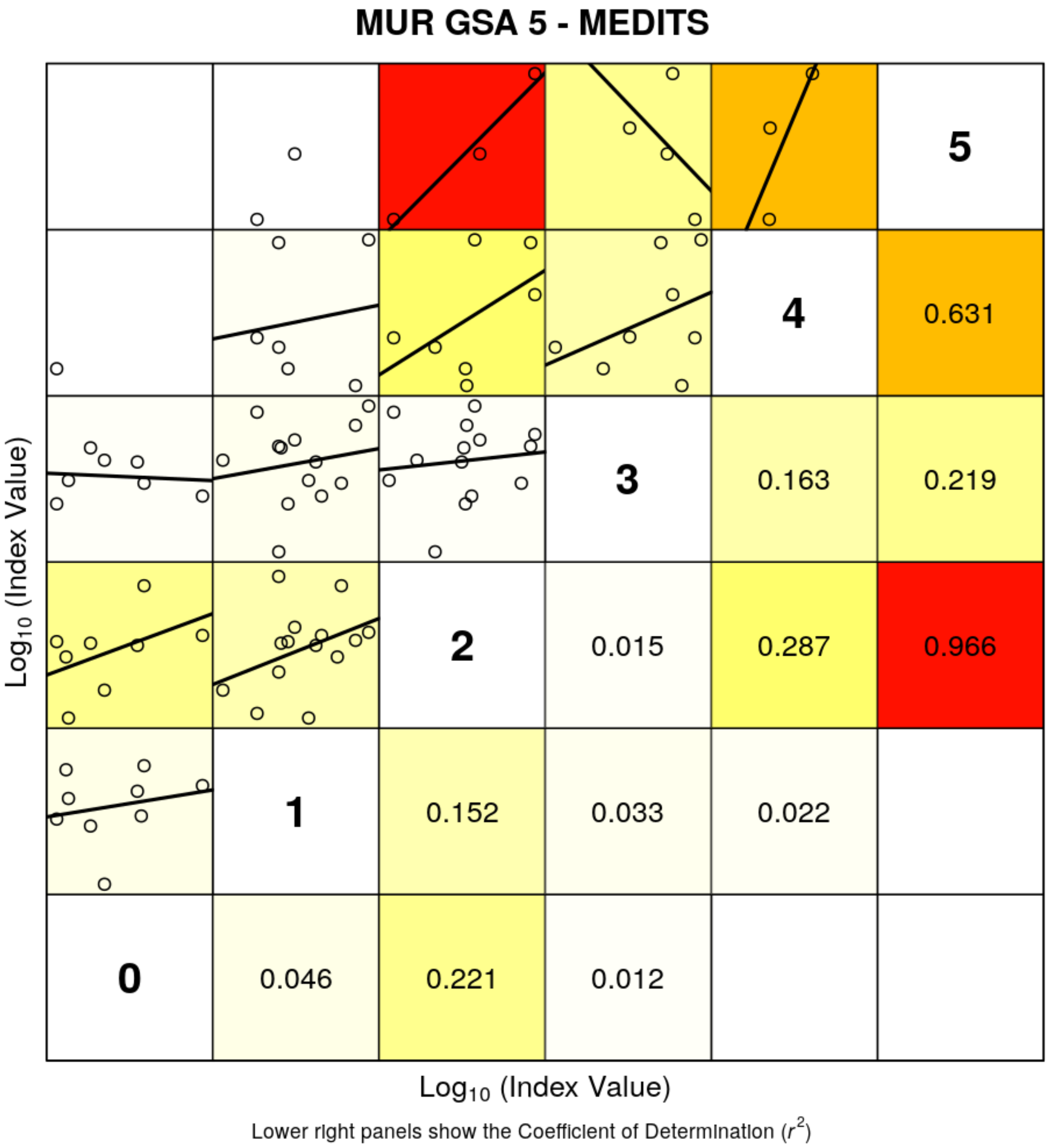


Figure 6.4.2.12. Striped red mullet in GSA 5. Cohort consistency for the MEDITS data with age estimated from length frequency distribution reported in MEDITS (2007-2021) survey data, with plus group set at age 5.

6.4.3 Data issues

- The Length-Weight parameters for 2021 from the STECF Med&BS data call should be checked.

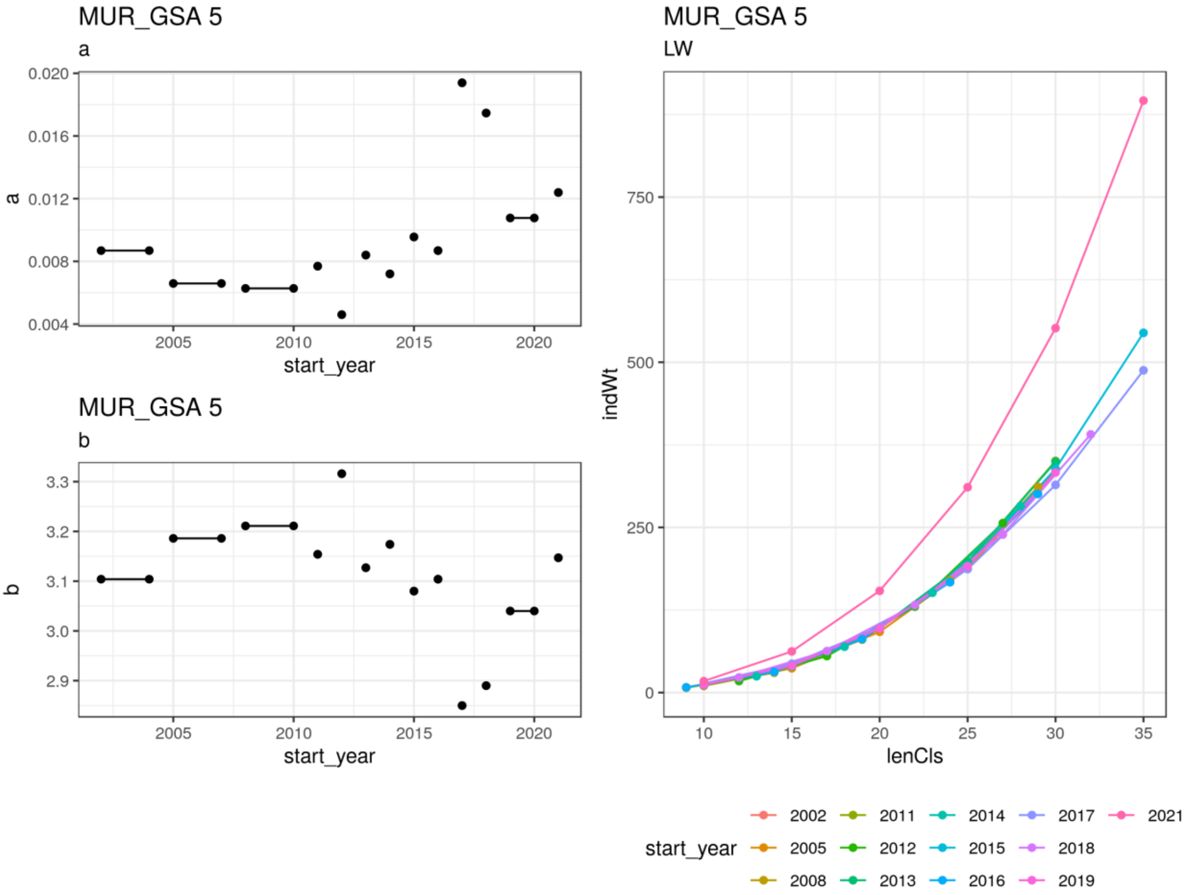


Figure 6.4.6.1 Striped red mullet GSA 5. Length-Weight parameters from the STECF Med&BS data call.

- MEDITS Stations: suspicious individual mean weight (<= 1g) in MEDITS Table B: station #134 in 2009, #130 and 131 in 2012 for Mullus surmuletus in GSA 5.
- The MEDITS station #149 in 2009 has a suspicious high catch of for Mullus surmuletus in GSA 5 (240 kg).

6.5 Red mullet in GSA 6

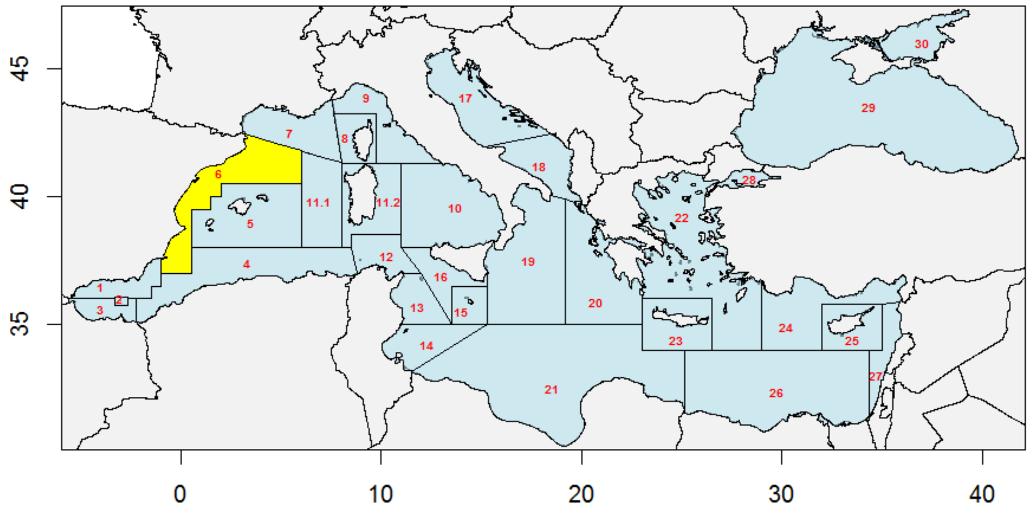


Figure 6.5.1 Red mullet in GSA 6: Location of GSA 6 in the Mediterranean Sea.

Red mullet, benthic species that inhabits coastal waters, is among the main demersal fishing target species in the Mediterranean fisheries. Its fishing displays characteristics which typically define the Mediterranean fisheries, that is, marked seasonality, strong dependence on recruitment, and exploitation based on a very small number of age classes, basically age classes 1 and 2.

6.5.1 Stock Identity and Biology

The red mullet's genetic distribution was found to be highly structured, resembling that of a meta-population composed by independent, self-recruiting sub-populations with some connections between them. This species showed significant genetic differentiation across Cabo de Gata (GSA 1) - Blanes (northern GSA 6) - Italy (GSA 9) comparisons (Galarza *et al.* 2009).

Gonadal maturation and spawning take place in late spring (May-June in the western Mediterranean). Larvae are found in the plankton during June-July in the upper levels of the water column, above thermocline. Horizontal and vertical distribution of larvae showed good correspondence with that of cladocera, their preferential prey from 8 mm standard length. Prey items consumed by the smallest size classes of larvae <8 mm SL were dominated by copepod nauplii, and then diet and prey selectivity shifted towards the cladoceran *Evadne* spp. (Sabatés and Palomera 1987; Sabatés *et al*. 2015).

M. barbatus is a batch spawner with an income breeding strategy (continues feeding throughout the spawning period), an asynchronous development of oocytes and indeterminate fecundity (Ferrer-Maza *et al.* 2015). Recruitment to the benthic life on coastal bottoms takes place during a well-defined season, in summer and early autumn (Lloret and Lleonart, 2002), in relation to the short spawning period. The maximum abundance and frequency of pre-adults and adults occurs on muddy bottoms in waters between 50 and 200 m deep (Lombarte *et al.* 2000). Red mullet feeds on small benthic crustaceans, worms and molluscs (Hureau 1986). Size groups (that correspond to different cohorts) are concentrated in specific areas. The massive presence of the O+ year class, very close to the coast immediately after recruitment to the bottom (in late summer) is followed by a dispersal towards deeper waters (Suau and Vives 1957; Voliani et al 1998).

Maturity
Red mullet has a short spawning period of around two months (May-June). The EWG assumed that age0 corresponds to juveniles and at age1 all individuals will spawn, that is, are mature the spawning season following the spawning season when they were born.

Age	0	1	2	3	4
Proportion mature	0	1	1	1	1

Growth
The growth parameters submitted by the MS did not fit the observed length-at-first maturity and spawning timing because of the very negative t_0 values. EWG-20-02 used DCF supplied vBGF estimates as the median values across the DCF dataset: Linf = 35.0, k= 0.17, t0= -2.81 (sexes combined), but concentrated on producing LFDs with the responsibility for selecting growth being allocated to the assessment EWG. According to these parameters, by the end of the first year (12 months) the fish length would be much larger than that at first maturity (around 11-12 cm TL; ICES 2012). Thus, the growth parameters proposed by Demestre *et al.* 1997 were selected to be used in the assessment of the stock (Linf=34.5, k=34, t_0=-0.14), as in previous EWG assessments. In addition, since the red mullet spawning takes place in the middle of the year, the growth curve was corrected for a calendar year assessment (t_0+0.5). The parameters of the length-weight relationship were a=0.0096 and b=3.04 (DCF (2017), the same as used in the previous EWG20-09 assessment).

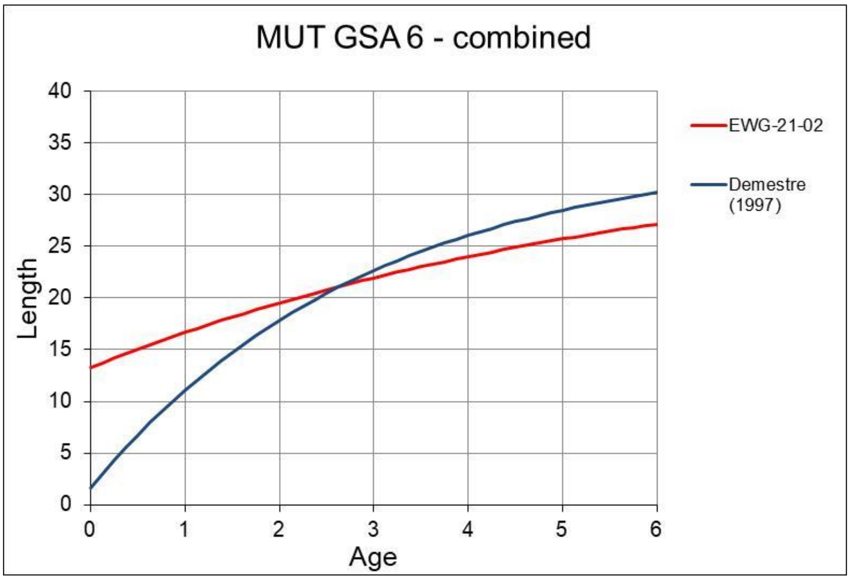


Figure 6.5.1.1 Red mullet in GSA 6: Growth curves according to the parameters used by EWG-21-02 and Demestre *et al.* (1997).

Natural mortality vector
M vector was estimated with the method proposed by Chen and Watanabe (1989).

Age	0	1	2	3	4
M	1.74	0.8	0.57	0.48	0.43

6.5.2 Data

6.5.2.1 Catch (landings and discards)

Figure 6.5.2.1 summarises the reconstruction carried out by EWG-21-02.

Landings: Missing LFDs were reconstructed for the two main fleets with catches of MUT in GSA06. For GTR_NA 2002-2008 the median LFDs of GTR_DEMSP 2009-2019 were used. LFDs for the metier OTB_MDD (2009-2019) were reconstructed from the median OTB_DEMSP LFDs, applying SOP correction.

Discards: LFDs were available for 2017-2019 for OTB_DEMSP. The median was used to reconstruct discards LFD for the two metiers OTB_NA and OTB_MDD. No discards are reported for GTR but they can be considered negligible.

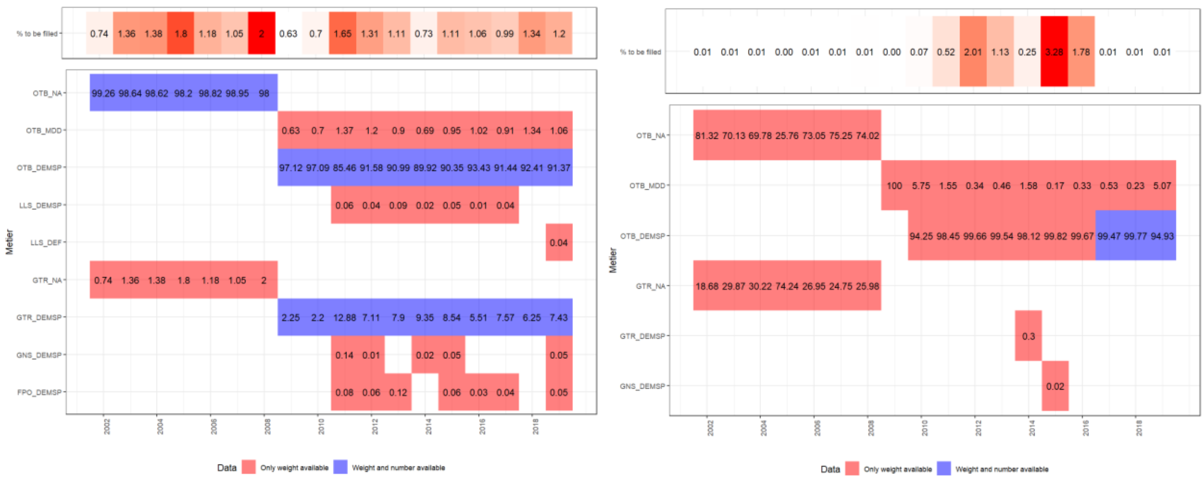


Figure 6.5.2.1.1 Red mullet in GSA 6: Summary of the reconstruction of landings and discards data carried by EWG-21-02.

Red mullet landings in GSA 6 come predominantly from OTB; a small amount is reported for small-scale fishing gears (trammel-net). Red mullet discards come from OTB. Landings from small-scale gears other than entangling nets may be a mistake when coding the fishing gear.

Table 6.5.2.1.1 Red mullet in GSA 6. Landings (t) by fishing gear over 2002-2021(tonnes; FPO=pots and traps; GNS=gillnet; GTN= combined gillnets-trammel nets; GTR=trammel net; LHP= pole lines; LLS=longlines; OTB=otter bottom trawl).

	FPO	GNS	GTN	GTR	LHP	LLS	OTB	LANDINGS
2002				2.3			303.1	305.4
2003				19.0			1381.0	1400.0
2004				12.7			906.8	919.5
2005				17.9			977.1	995.0
2006				16.4			1371.4	1387.8
2007				12.5			1171.1	1183.6
2008				17.5			854.6	872.1
2009				11.7			509.2	520.9
2010				11.3			502.8	514.1
2011	0.9	1.5		137.0		0.6	923.1	1063.1
2012	0.6	0.1		76.1		0.4	992.7	1069.9
2013	1.5			98.6		1.2	1146.7	1248.0
2014		0.3		122.4		0.3	1186.2	1309.2
2015	0.9	0.8		129.7		0.8	1386.5	1518.7
2016	0.6			92.2		0.2	1580.9	1673.9
2017	0.6			109.8		0.5	1338.4	1449.3
2018				80.0			1200.7	1280.7
2019	0.7	0.8		111.6		0.5	1388.2	1501.8
2020	1.6	5.1	0.6	88.8	0.1	3.0	1347.0	1446.3
2021	0.5	1.9	0.1	71.3		1.2	981.7	1056.7

Table 6.5.2.1.2 Red mullet in GSA 6. Discards (t) by fishing gear (left) and total catch (right) over 2002-2021 (tonnes; GNS=gillnet; GTR=trammel net; OTB=otter bottom trawl).

	GNS	GTR	OTB	DISCARDS
2002			0	0.0
2003			0	0.0
2004			0	0.0
2005			0.01	0.0
2006			0	0.0
2007		0.0	0	0.0
2008			0.08	0.1
2009		0.0	0	0.0
2010		0.0	0.4	0.4
2011	0.0	0.0	5.4	5.4
2012	0.0	0.0	21.9	21.9
2013		0.0	14.2	14.2
2014	0.0	0.0	3.3	3.3
2015	0.0	0.0	51.5	51.5
2016		0.0	30.2	30.2
2017		0	14.7	14.7
2018		0	43.9	43.9
2019	0.0	0	1.8	1.8
2020	0.0	0	7.7	7.7
2021	0.0	0	9.7	9.7

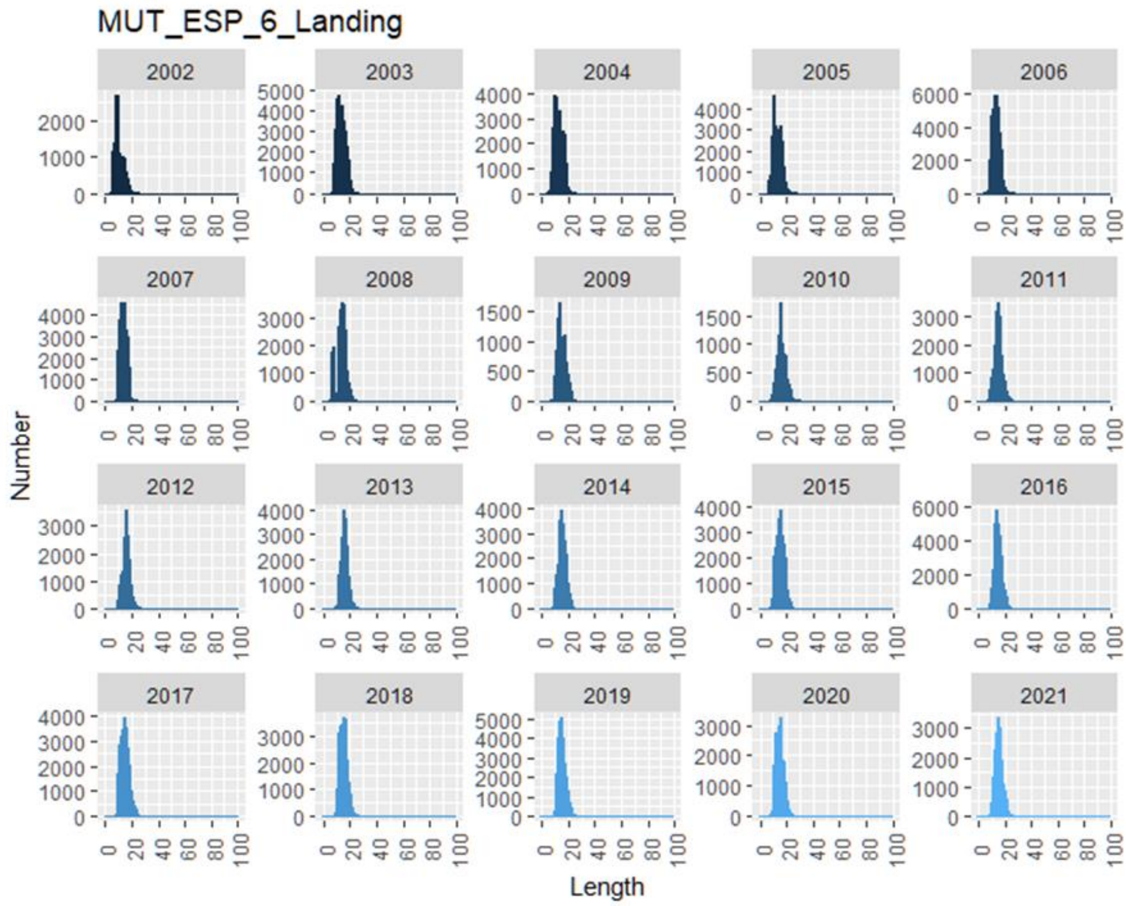


Figure 6.5.2.1.2 Red mullet in GSA 6. Landings length frequency distribution, by year (TL cm). LFDs until 2019 as reconstructed by EWG21-02

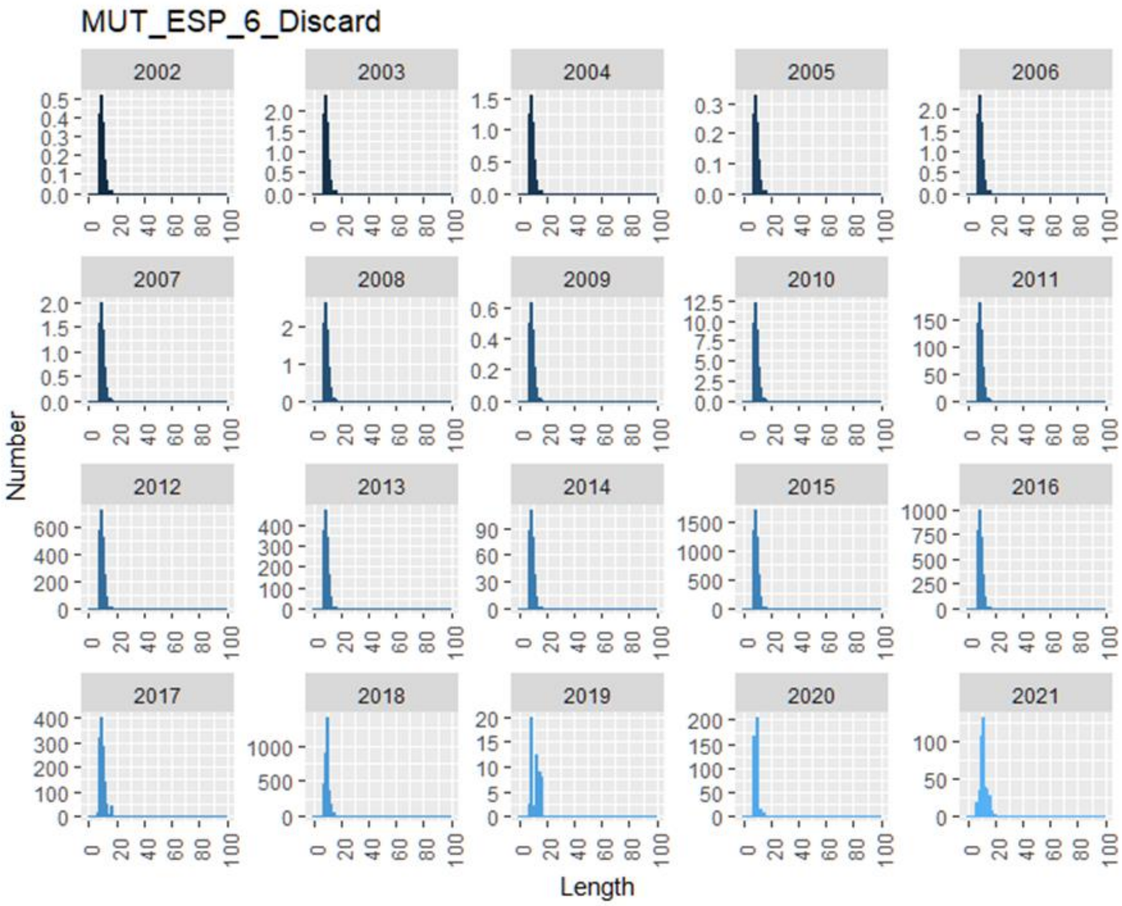


Figure 6.5.2.1.3 Red mullet in GSA 6. Discards length frequency distribution, by year (TL cm). LFDs until 2019 as reconstructed by EWG21-02.

For the assessment, LFDs of landings and discards in 2020 and 2021 were added to the reconstructed data series.

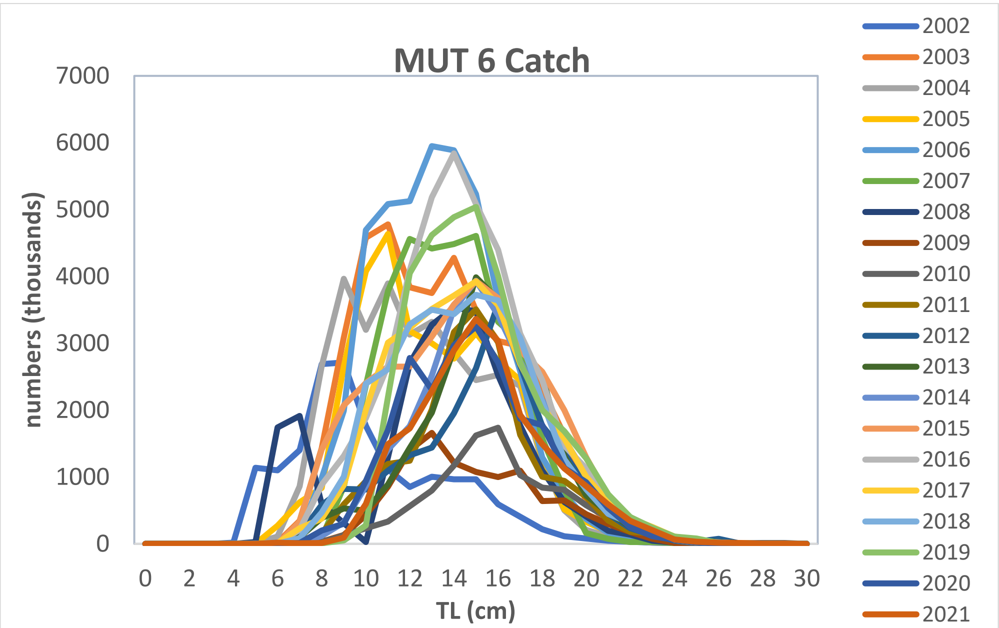


Figure 6.5.2.1.4 Red mullet in GSA 6. Catch length frequency distribution (TL cm).

SOP correction was applied in the preparation of the input data for the a4a assessment. The 2020 value was high because no measurements were available for the second quarter and in the fourth quarter, and the landings were not raised, numbers provided were around half of those the previous year 2019, with similar annual landings in these two years.

Table 6.5.2.1.3 Red mullet in GSA 6. SoP correction.

	SoP correction
2003	1.13
2004	1.11
2005	1.11
2006	1.12
2007	1.11
2008	1.10
2009	1.16
2010	0.96
2011	1.27
2012	1.12
2013	1.13
2014	1.15
2015	1.10
2016	1.12
2017	1.14
2018	1.07
2019	1.07
2020	1.52
2021	1.11

Table 6.5.2.1.4 Red mullet in GSA 6. Catch at age, input to a4a (SoP corrected).

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	
0	29.4	29.4	26.6	21.0	15.2	11.5	10.3	11.4	14.3	
1	23006.7	21818.7	21525.1	19087.1	14796.2	10781.0	8469.2	8048.2	9429.0	
2	14002.7	13882.2	13388.3	13651.2	12945.5	11109.1	9126.6	8044.4	8338.6	
3	1080.4	568.7	593.9	633.6	777.4	950.2	1066.6	1100.3	1126.1	
4	92.6	51.9	28.9	32.1	41.3	65.4	106.0	153.7	190.9	
age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	18.3	21.6	22.9	22.9	22.6	22.6	21.8	19.2	15.1	11.1
1	12480.8	16302.9	19018.4	19547.5	18782.3	18107.8	17900.7	17393.9	15537.2	12373.9
2	10173.6	13315.5	16536.2	18114.9	17763.7	16809.7	16452.8	16799.2	16894.3	15506.8
3	1231.2	1443.4	1701.0	1873.8	1890.0	1822.4	1797.8	1888.4	2068.1	2197.3
4	211.5	222.7	231.6	238.3	239.8	237.8	239.8	254.5	287.0	333.2

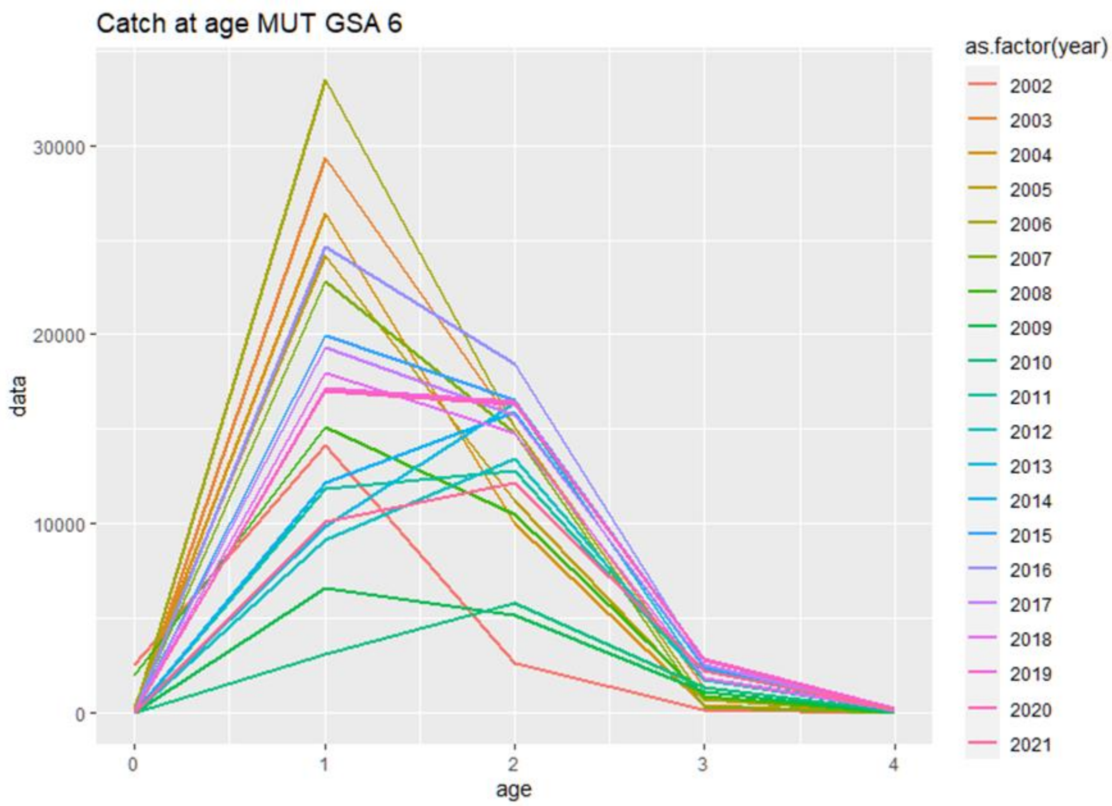


Figure 6.5.2.1.5 Red mullet in GSA 6. Catch at age, input to a4a.

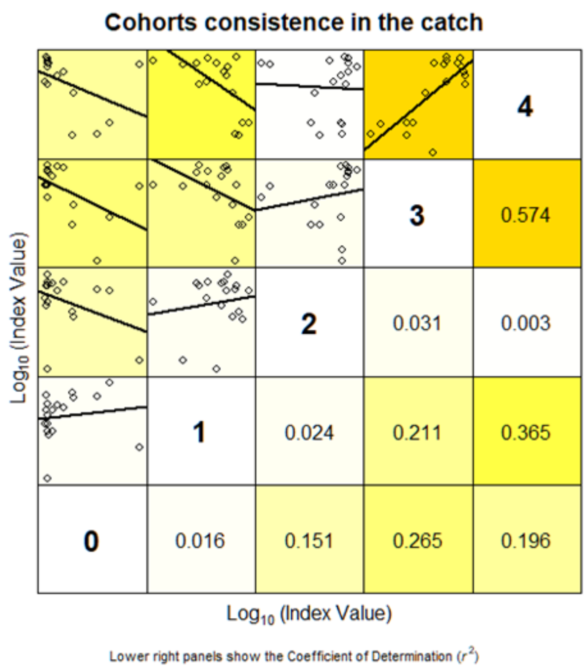


Figure 6.5.2.1.6 Red mullet in GSA 6. Cohort's internal consistency in the catch.

6.5.2.2 Effort data

Fishing effort data for 2021 will be reported to STECF EWG 22-10 through the FDI data call within the DCF framework.

6.5.2.3 Survey data

Survey indices used in this assessment originate from the MEDITS bottom trawl survey. This survey was carried out regularly in late spring, in May-June, over the period 1994-2021 (Figure 6.5.2.3.1). In 2021 the survey coverage was similar as that previous to 2020, when because of covid-19 half of the usual survey area was covered (Figure6.5.2.3.2).

Figure 6.5.2.3.1 Red mullet in GSA 6. MEDITS survey period in GSA 6.

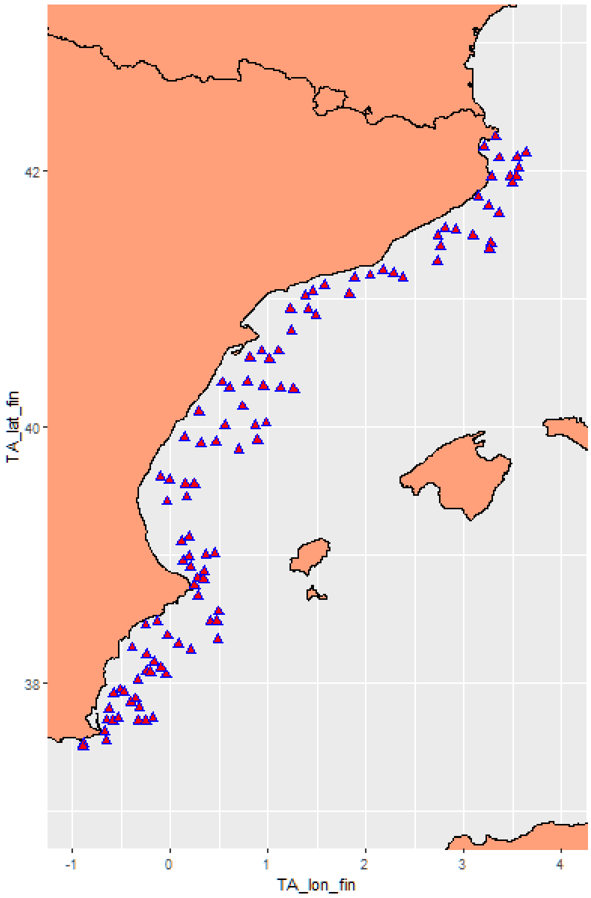


Figure 6.5.2.3.2 Red mullet in GSA 6. MEDITS survey in GSA 6 in 2021, hauls position.

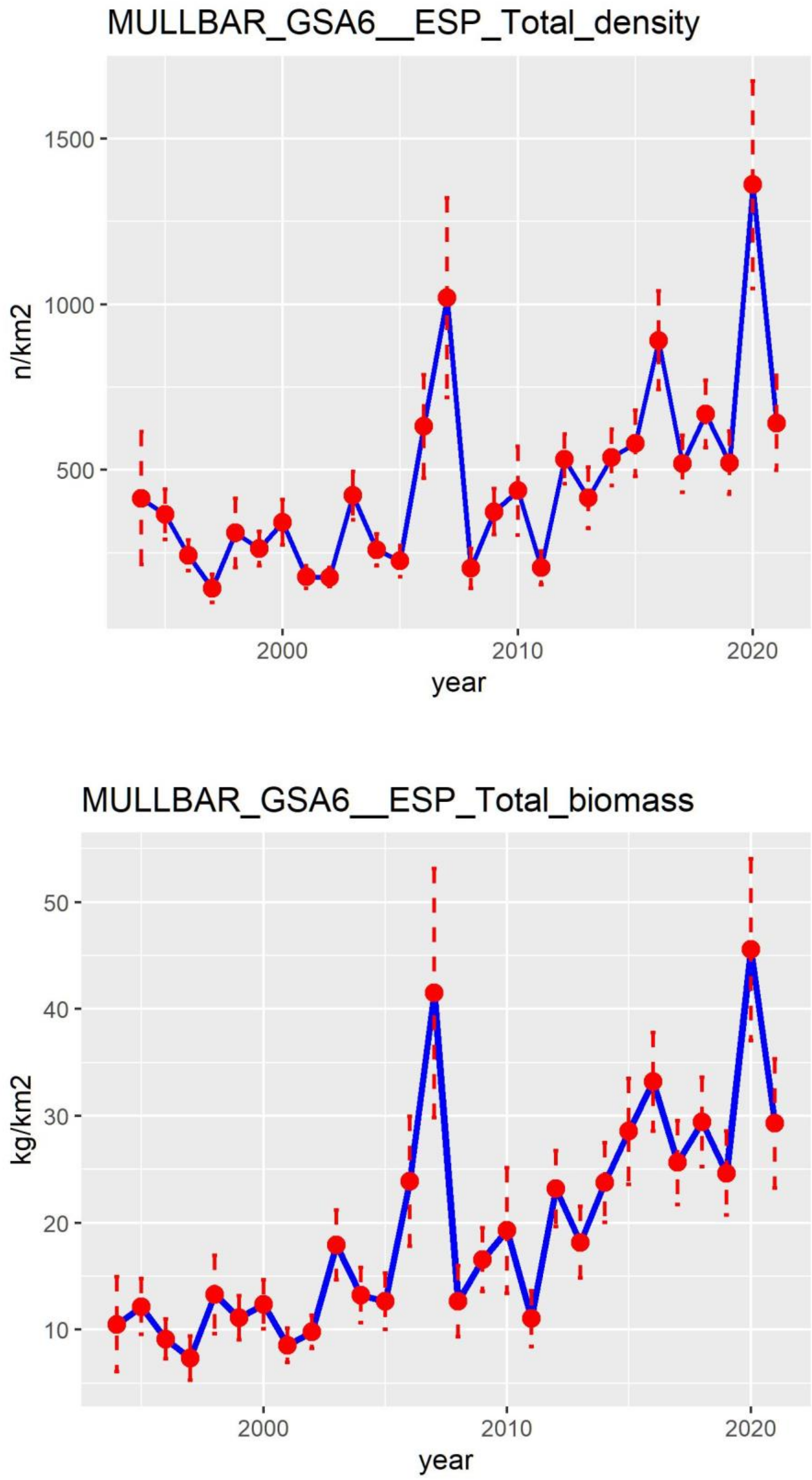


Figure 6.5.2.3.3 Red mullet in GSA 6. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2019.

Figure 6.5.2.3.4 Red mullet in GSA 6. MEDITS length frequency distribution n/km^2).

Table 6.5.2.3.1 Red mullet in GSA 6. MEDITS age structure as resulting from slicing.

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	
0	0.0	0.0	0.0	11.2	0.0	0.0	1.0	0.0	0.2	
1	290.3	159.7	120.6	414.6	722.6	68.7	257.2	287.7	96.3	
2	123.8	91.5	94.4	184.6	272.2	117.5	98.7	129.2	93.7	
3	7.9	5.9	9.0	20.2	24.0	14.4	14.3	20.1	13.9	
4	0.8	0.9	1.0	1.1	0.6	2.3	2.5	1.7	1.4	
Age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0.0	0.0	0.2	0.2	0.0	0.2	0.1	0.0	0.0	0.2
1	385.7	262.5	341.2	341.4	684.3	287.2	427.7	317.3	1020.5	395.9
2	136.9	139.9	176.6	214.3	187.2	208.4	209.6	181.7	285.7	217.2
3	9.1	12.1	18.5	22.5	18.3	21.3	29.1	21.0	44.5	26.0
4	2.1	1.6	0.9	1.6	1.2	1.0	2.1	1.8	10.1	2.3

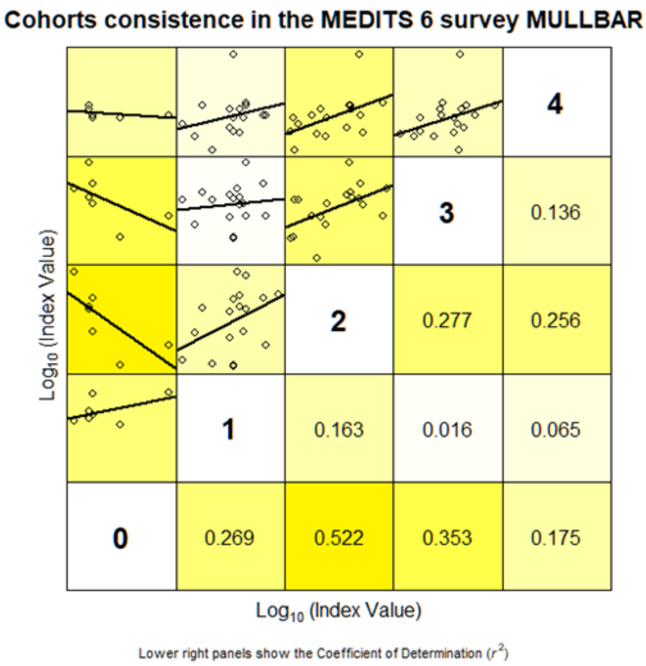


Figure 6.5.2.3.5 Red mullet in GSA 6. Cohort's internal consistency in MEDITS survey.

6.5.3 STOCK ASSESSMENT

Method a4a

Assessment for All Initiative (a4a) (Jardim et al., 2015) is a statistical catch–at– age method that utilizes catch at age data to derive estimates of historical population size and fishing mortality. Model parameters are estimated by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. A4a is implemented as a package (Fla4a) of the FLR library.

Input data growth parameters, total catch, numbers at age, natural mortality M, maturity at age and survey index are given in previous sections. Fbar was set to F(1-3).

Table 6.5.3.1 Red mullet in GSA 6. Input data. Catch and stock weight at age (kg)

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	
0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
1	0.017	0.015	0.016	0.018	0.020	0.019	0.021	0.022	0.022	
2	0.051	0.048	0.048	0.046	0.047	0.047	0.051	0.050	0.047	
3	0.098	0.096	0.099	0.096	0.097	0.098	0.099	0.102	0.099	
4	0.159	0.157	0.170	0.166	0.170	0.159	0.167	0.189	0.163	
age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1	0.022	0.023	0.022	0.021	0.022	0.020	0.021	0.022	0.021	0.022
2	0.050	0.050	0.050	0.051	0.049	0.050	0.050	0.049	0.049	0.049
3	0.098	0.100	0.098	0.099	0.098	0.100	0.100	0.099	0.098	0.100
4	0.176	0.169	0.160	0.165	0.161	0.164	0.166	0.163	0.159	0.171

Assessment Results

This assessment is an update of the EWG-21-11 assessment. In previous assessments different a4a models were performed (combination of different f, q and sr) and k values for the fmodel were explored. The following model, the same as in EWG-21-11, was selected, according to residuals and retrospective:

fmodel: ~s(replace(age, age > 2, 2), k = 3) + s(year, k = 6)

srmodel: ~s(year, k = 7)

qmod <- list(~ factor(replace(age, age>2, 2)))

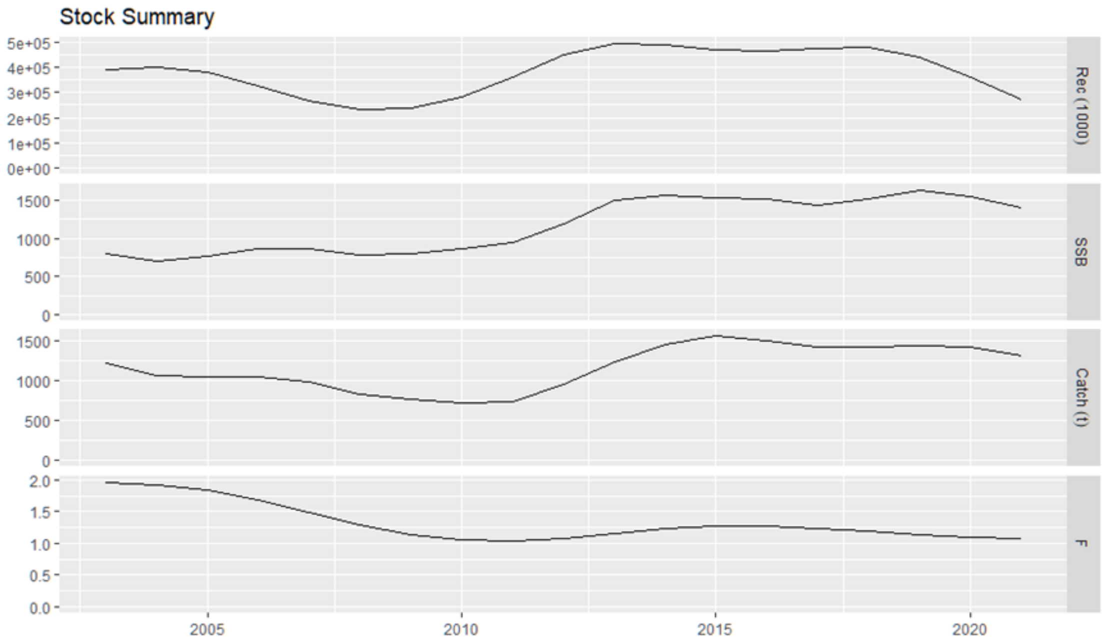


Figure 6.5.3.1 Red mullet in GSA 6. Stock summary from the a4a model for Red mullet in GSA 6, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

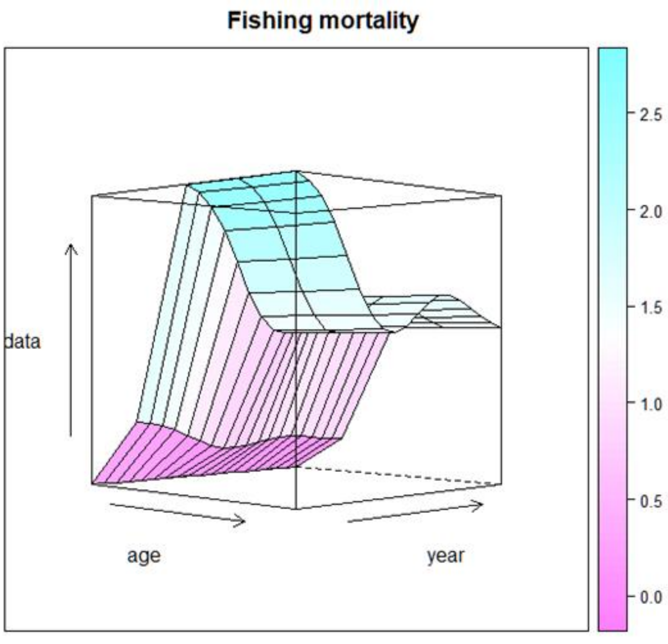


Figure 6.5.3.2 Red mullet in GSA 6. 3D contour plot of estimated fishing mortality by age and year.

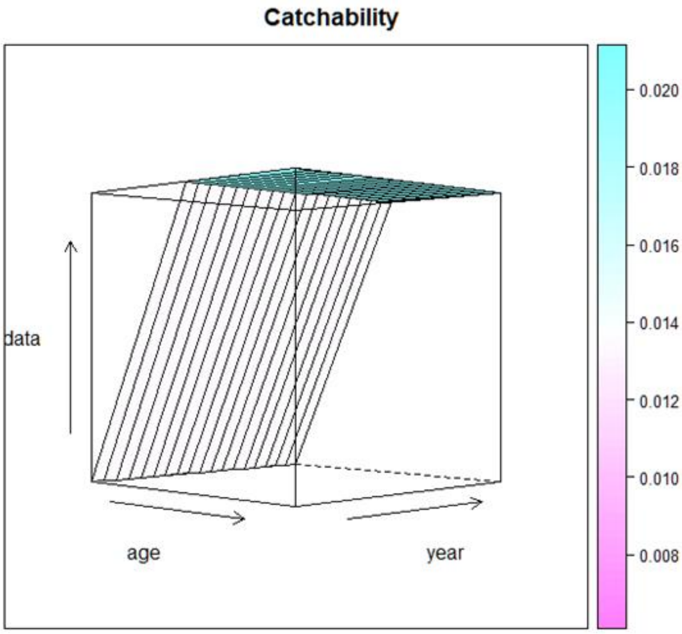


Figure 6.5.3.3 Red mullet in GSA 6. 3D contour plot of estimated catchability by age and year.

Diagnostics

Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of red mullet stock.

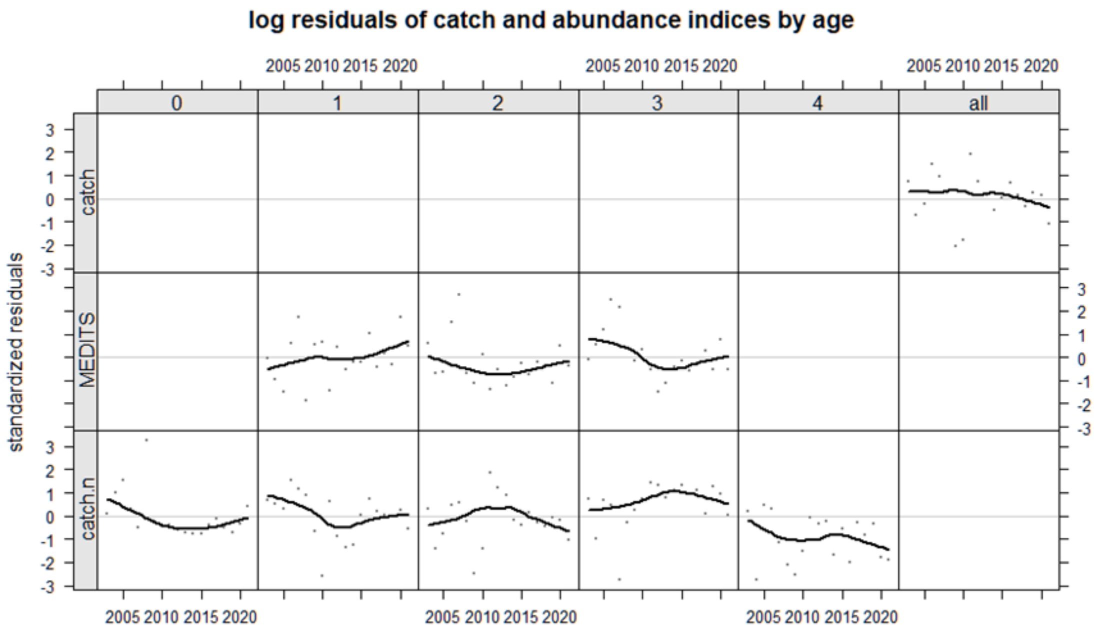


Figure 6.5.3.4 Red mullet in GSA 6. Standardized residuals for catch, abundance indices and for catch numbers.

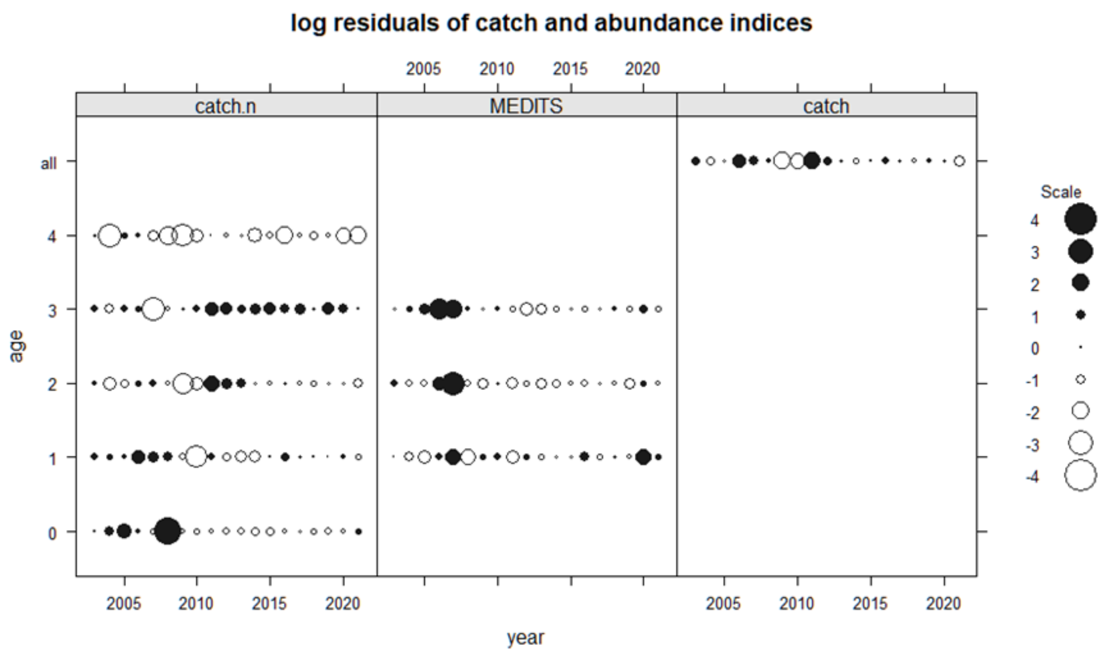


Figure 6.5.3.5 Red mullet in GSA 6. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

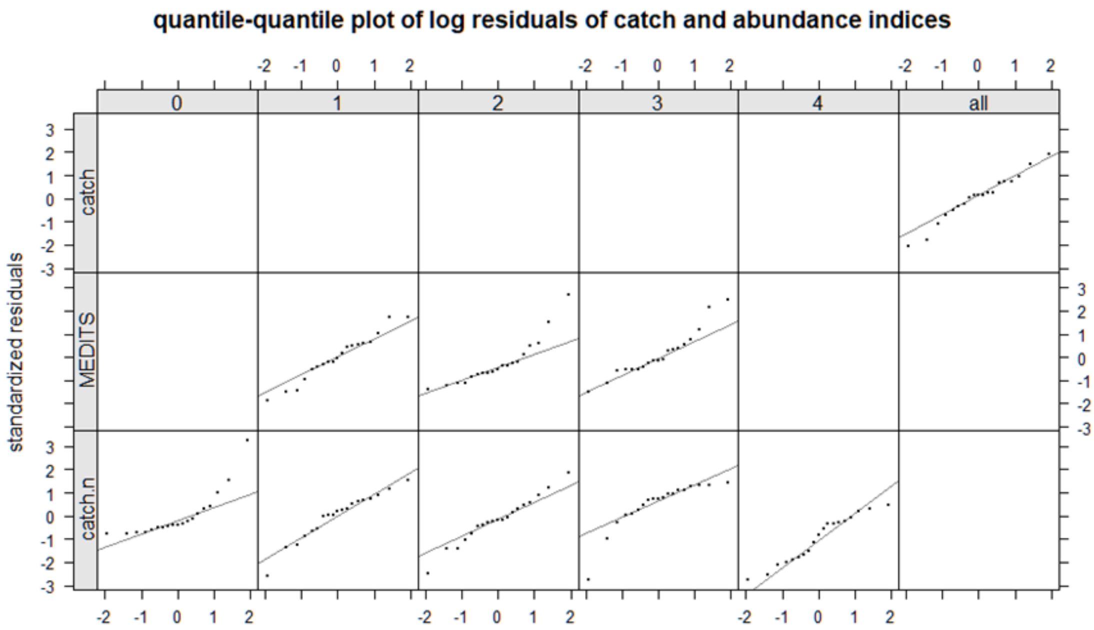


Figure 6.5.3.6 Red mullet in GSA 6. QQ-plot of the log residuals of catch and abundance indices in GSA 6.

Table 6.5.3.2 Red mullet in GSA 6. Catches log residuals.

	Catches log residuals									
age	2003	2004	2005	2006	2007	2008	2009	2010	2011	
0	0.065	0.994	1.544	0.298	-0.522	3.248	-0.253	-0.430	-0.397	
1	0.664	0.521	0.314	1.533	1.183	0.915	-0.669	-2.588	0.627	
2	0.324	-1.404	-0.763	0.446	0.576	-0.251	-2.464	-1.418	1.855	
3	0.724	-0.993	0.702	0.486	-2.753	-0.292	0.238	0.708	1.415	
4	0.221	-2.750	0.441	0.288	-1.159	-2.090	-2.531	-1.497	-0.076	
age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	-0.633	-0.729	-0.758	-0.786	-0.385	-0.134	-0.514	-0.693	-0.323	0.408
1	-0.858	-1.370	-1.228	0.057	0.743	0.177	0.013	-0.035	0.245	-0.545
2	1.195	0.895	-0.173	-0.395	0.170	-0.280	-0.450	-0.082	-0.159	-1.041
3	1.308	0.765	1.107	1.352	0.932	1.099	0.107	1.290	0.923	0.045
4	-0.350	-0.238	-1.688	-0.578	-1.979	-0.289	-0.833	-0.322	-1.791	-1.907

Table 6.5.3.3 Red mullet in GSA 6. MEDITS survey log residuals.

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	
1	-0.034	-0.971	-1.487	0.615	1.752	-1.849	0.525	0.663	-1.438	
2	0.575	-0.702	-0.658	1.514	2.687	-0.662	-1.115	0.116	-1.372	
3	-0.098	0.529	1.193	2.506	2.147	0.388	-0.146	0.312	-0.524	
age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	0.454	-0.512	-0.225	-0.206	1.014	-0.408	0.169	-0.317	1.746	0.510
2	-0.503	-1.199	-0.852	-0.281	-0.730	-0.209	-0.346	-1.110	0.515	-0.349
3	-1.490	-1.089	-0.410	-0.124	-0.560	-0.235	0.300	-0.516	0.749	-0.528

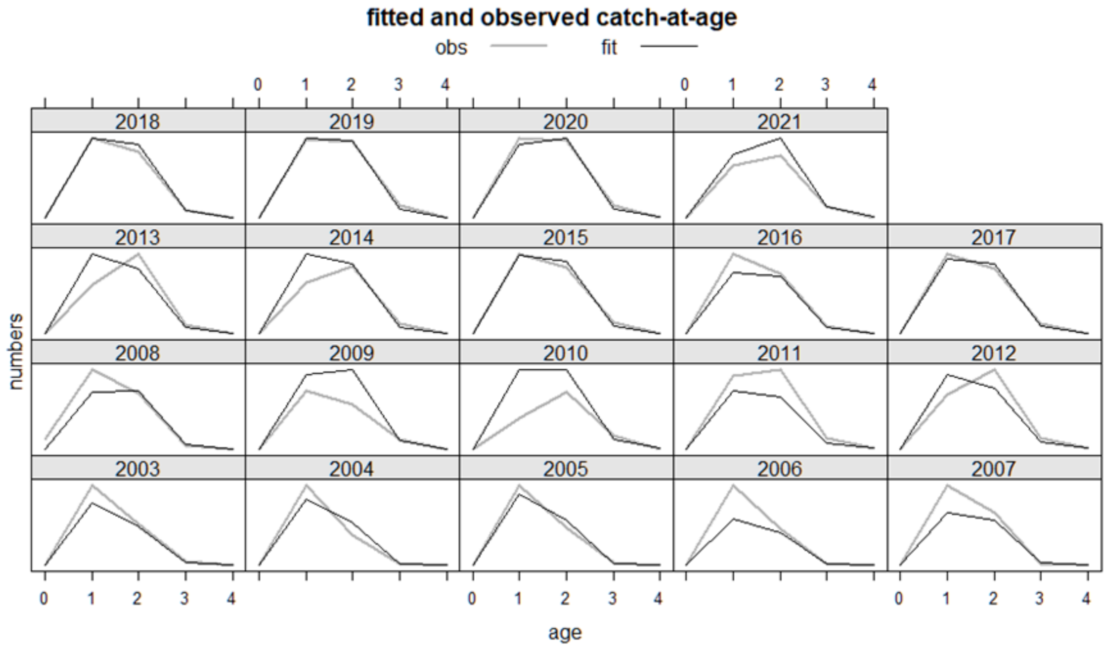


Figure 6.5.3.7 Red mullet in GSA 6. Fitted and observed catch at age.

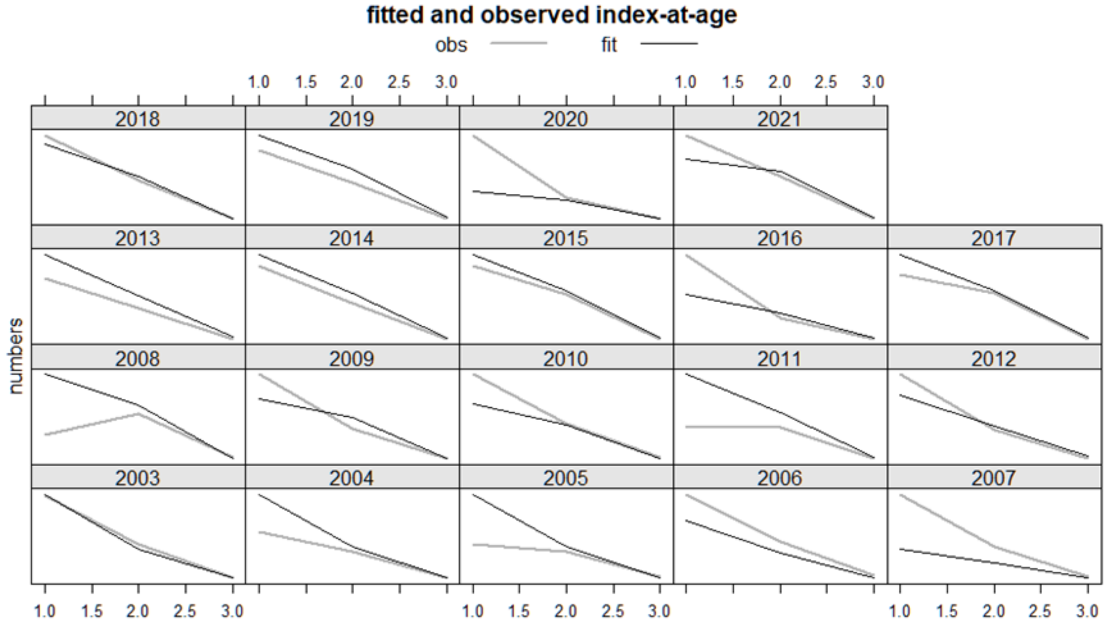


Figure 6.5.3.8 Red mullet in GSA 6. Fitted and observed index at age

RETROSPECTIVE

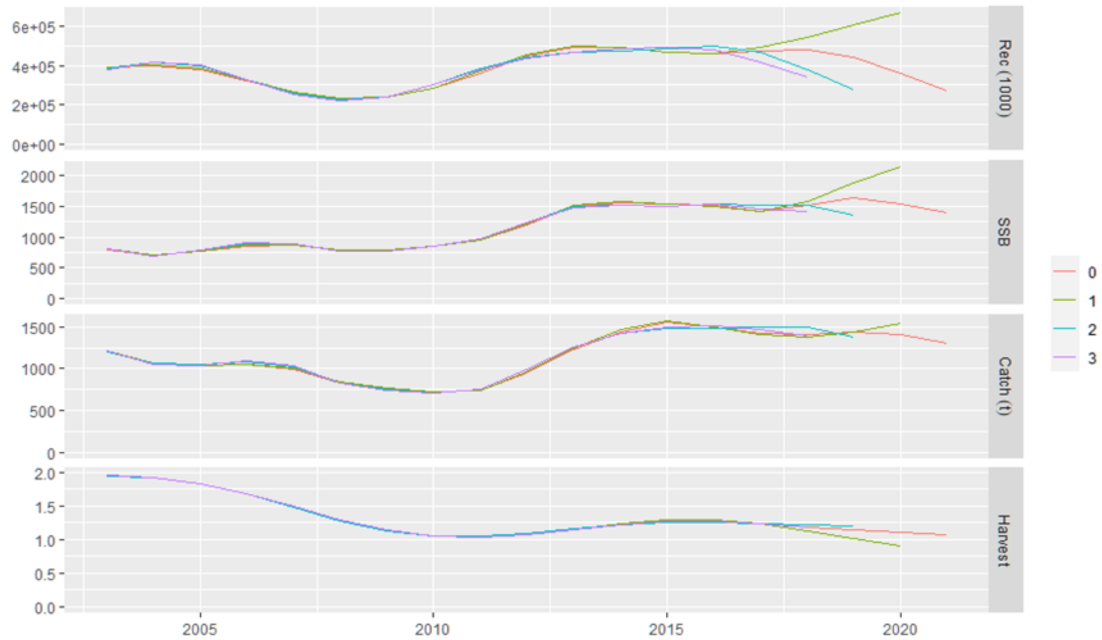


Figure 6.5.3.9 Red mullet in GSA 6. Retrospective analysis for the a4a model.

SIMULATIONS

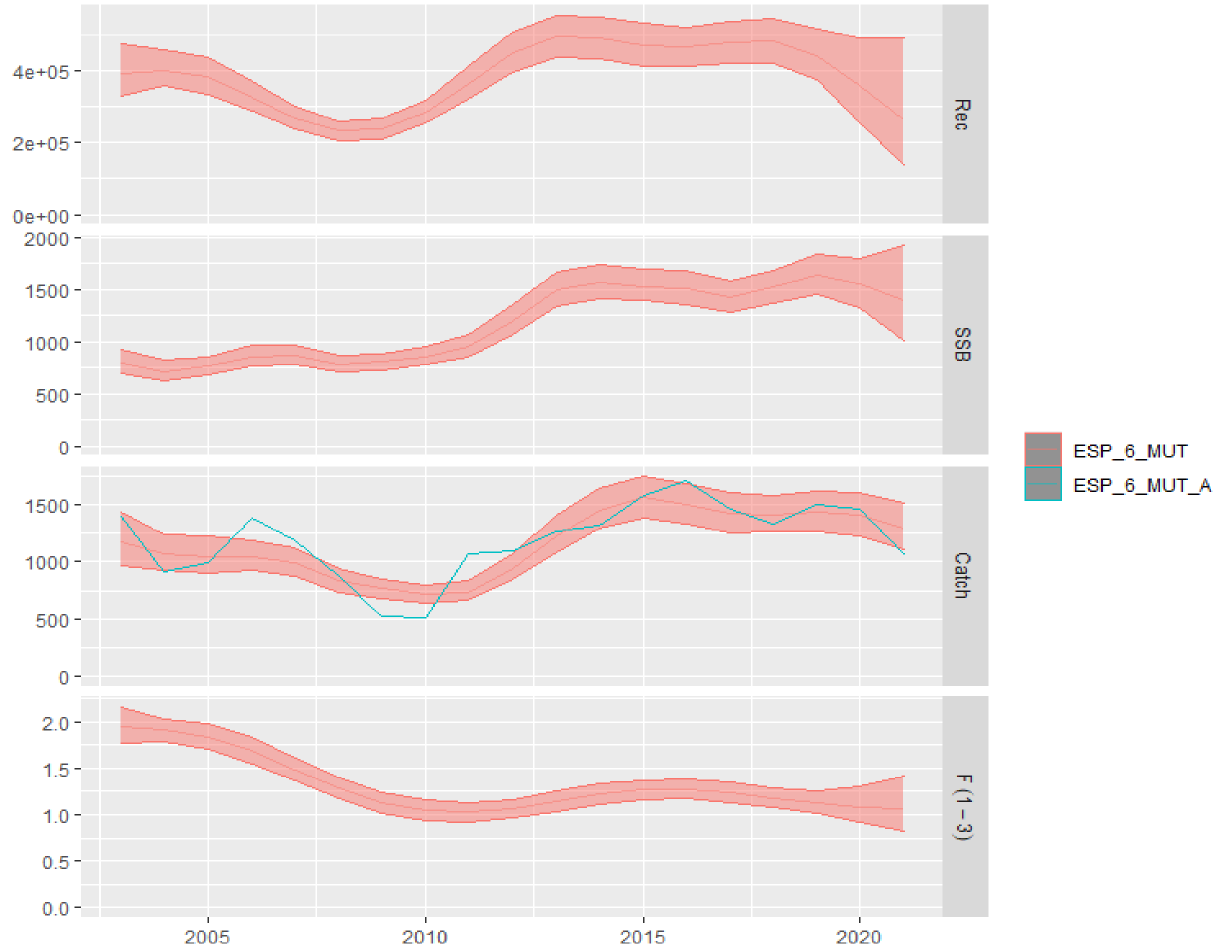


Figure 6.5.3.10 Red mullet in GSA 6. Stock summary of the simulated and fitted data for the a4a model.

The model fits the data well, particularly in recent years. The assessment uses the same model at 2021 and the results are consistent.

Table 6.5.3.4 Red mullet in GSA 6. F at age from a4a assessment.

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1	0.598	0.585	0.559	0.514	0.454	0.393	0.346	0.320	0.314	
2	2.649	2.591	2.477	2.276	2.010	1.743	1.535	1.416	1.391	
3	2.649	2.591	2.477	2.276	2.010	1.743	1.535	1.416	1.391	
4	2.649	2.591	2.477	2.276	2.010	1.743	1.535	1.416	1.391	
age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.326	0.349	0.373	0.388	0.389	0.378	0.362	0.347	0.335	0.326
2	1.445	1.546	1.652	1.718	1.722	1.673	1.603	1.537	1.485	1.443
3	1.445	1.546	1.652	1.718	1.722	1.673	1.603	1.537	1.485	1.443
4	1.445	1.546	1.652	1.718	1.722	1.673	1.603	1.537	1.485	1.443

Table 6.5.3.5 Red mullet in GSA 6. N at age from a4a assessment.

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	
0	391588	400047	379277	325077	266636	233388	237721	282874	362353	
1	71321	68813	70300	66650	57126	46857	41015	41777	49713	
2	17742	17705	17309	18143	18000	16382	14272	13094	13698	
3	1334	707	748	819	1050	1359	1615	1733	1790	
4	113	64	36	41	55	92	158	238	298	
age	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	446336	492046	489285	469322	463483	475258	478848	440612	359631	271200
1	63680	78439	86472	85986	82478	81451	83521	84152	77433	63202
2	16393	20747	24975	26882	26337	25242	25201	26256	26854	25002
3	1920	2178	2490	2696	2717	2652	2668	2858	3182	3428
4	324	330	333	337	339	340	350	379	434	511

Table 6.5.3.6 Red mullet in GSA 6. Summary results of Recruitment, Spawning stock biomass, Catch and F at ages 1-3.

	Recruitment	SSB(t)	Catch (t)	Fages(1-3)
2003	391588	798.2	1211.2	1.97
2004	400047	705.3	1058.2	1.92
2005	379277	762.3	1040.6	1.84
2006	325077	857.4	1045.1	1.69
2007	266636	866.2	985.3	1.49
2008	233388	783.3	829.9	1.29
2009	237721	799.5	766.1	1.14
2010	282874	858.5	722.0	1.05
2011	362353	949.5	741.5	1.03
2012	446336	1194.9	945.2	1.07
2013	492046	1491.5	1224.1	1.15
2014	489285	1568.1	1444.8	1.23
2015	469322	1531.6	1552.4	1.27
2016	463483	1510.2	1499.5	1.28
2017	475258	1426.3	1420.8	1.24
2018	478848	1518.1	1409.2	1.19
2019	440612	1634.6	1435.3	1.14
2020	359631	1543.2	1409.6	1.10
2021	271200	1405.6	1306.4	1.07

6.5.4 Reference Points

The STECF EWG 18-02 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.
Values of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 0.314. Current F values (2021), as calculated by model a4a, is 1.07 indicating that the stock is being overfished.

Estimation of biomass reference points

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4.

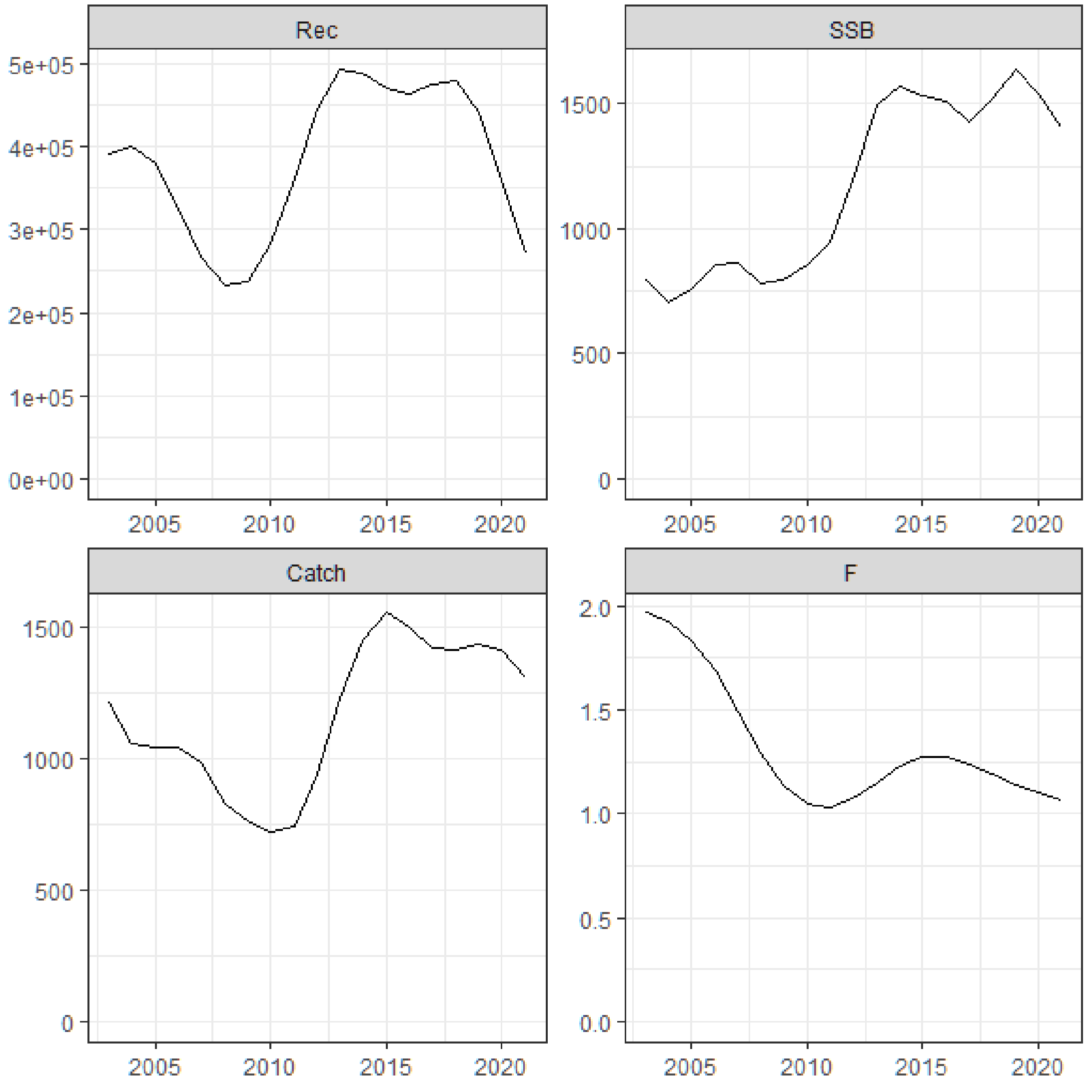


Figure 6.5.4.1 Red mullet in GSA 6. Stock summary from the a4a assessment.

An exploratory per-recruit analysis was performed using the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.5.4.1 and Figure 6.5.4.2.

Table 6.5.4.1. Red mullet in GSA 6. Per-recruit reference points.

$F_{0.1}$	B_{msy}	B_{lim}	F_{lim}	Yeq	B_0
0.31418	0.00829	0.00276	1.5685	0.00279	0.0195

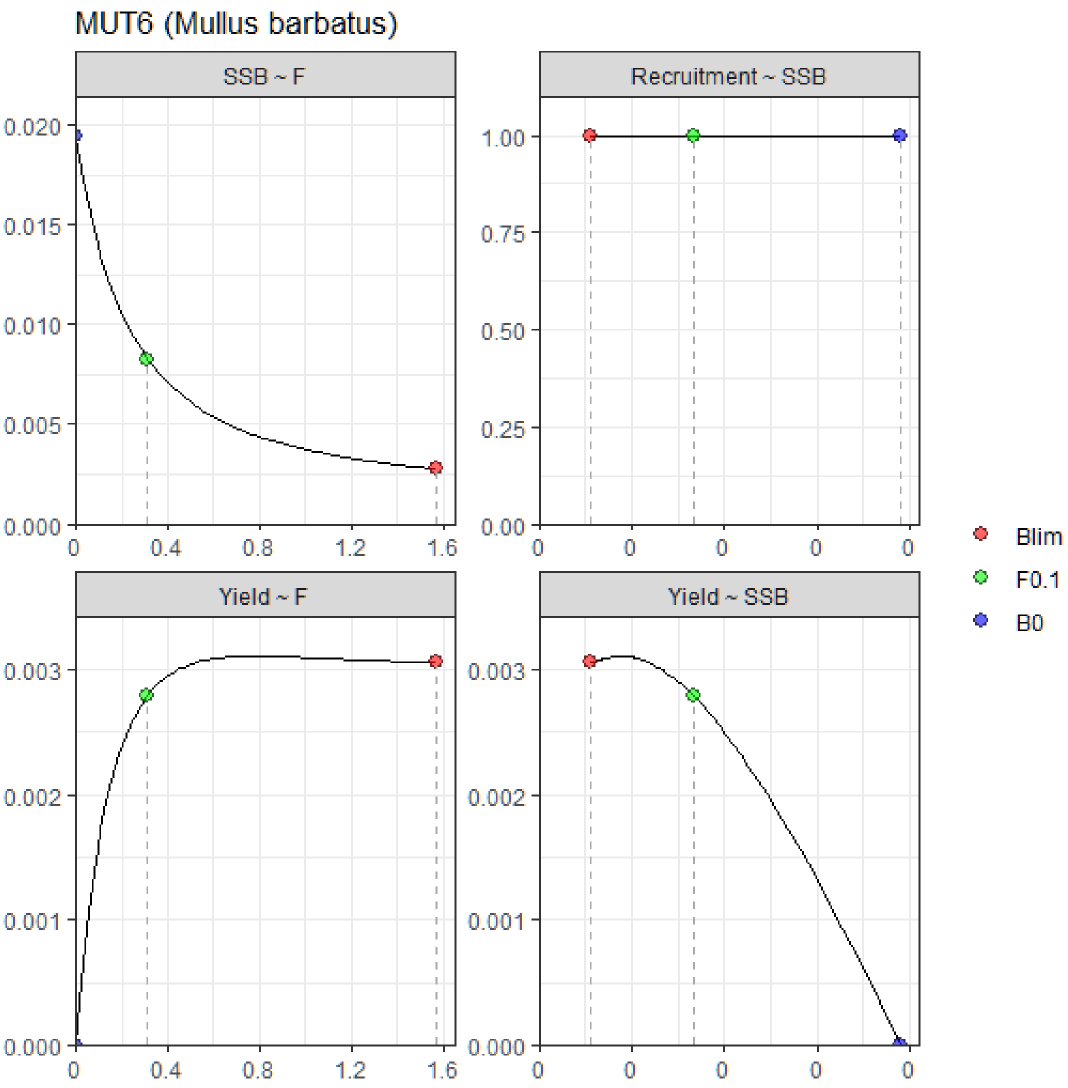


Figure 6.5.4.2 Red mullet in GSA 6. Per-recruit analysis.

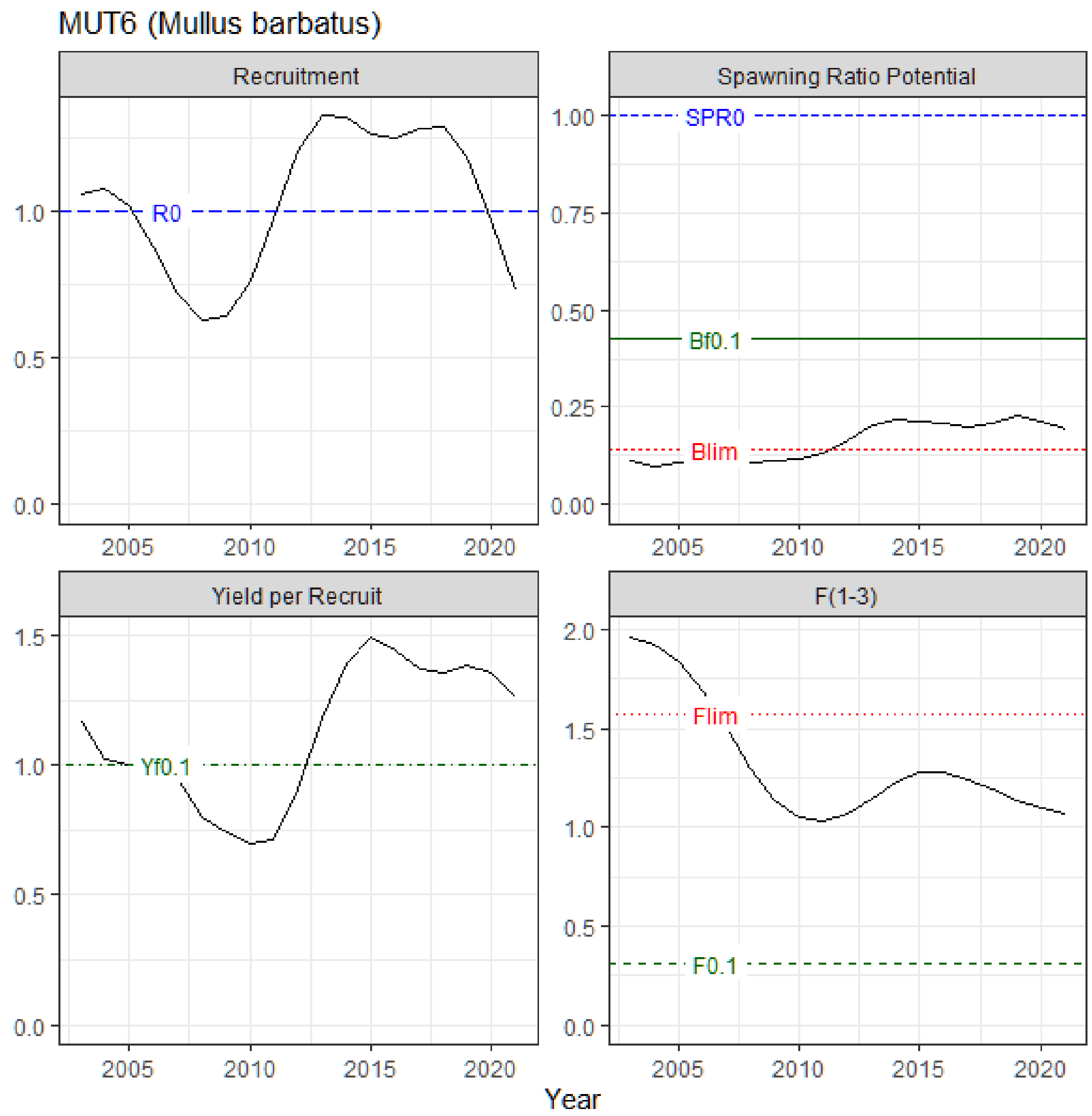


Figure 6.5.4.3 Red mullet in GSA 6. Per recruit analysis: outcomes of the a4a assessment compared against the per-recruit reference points.

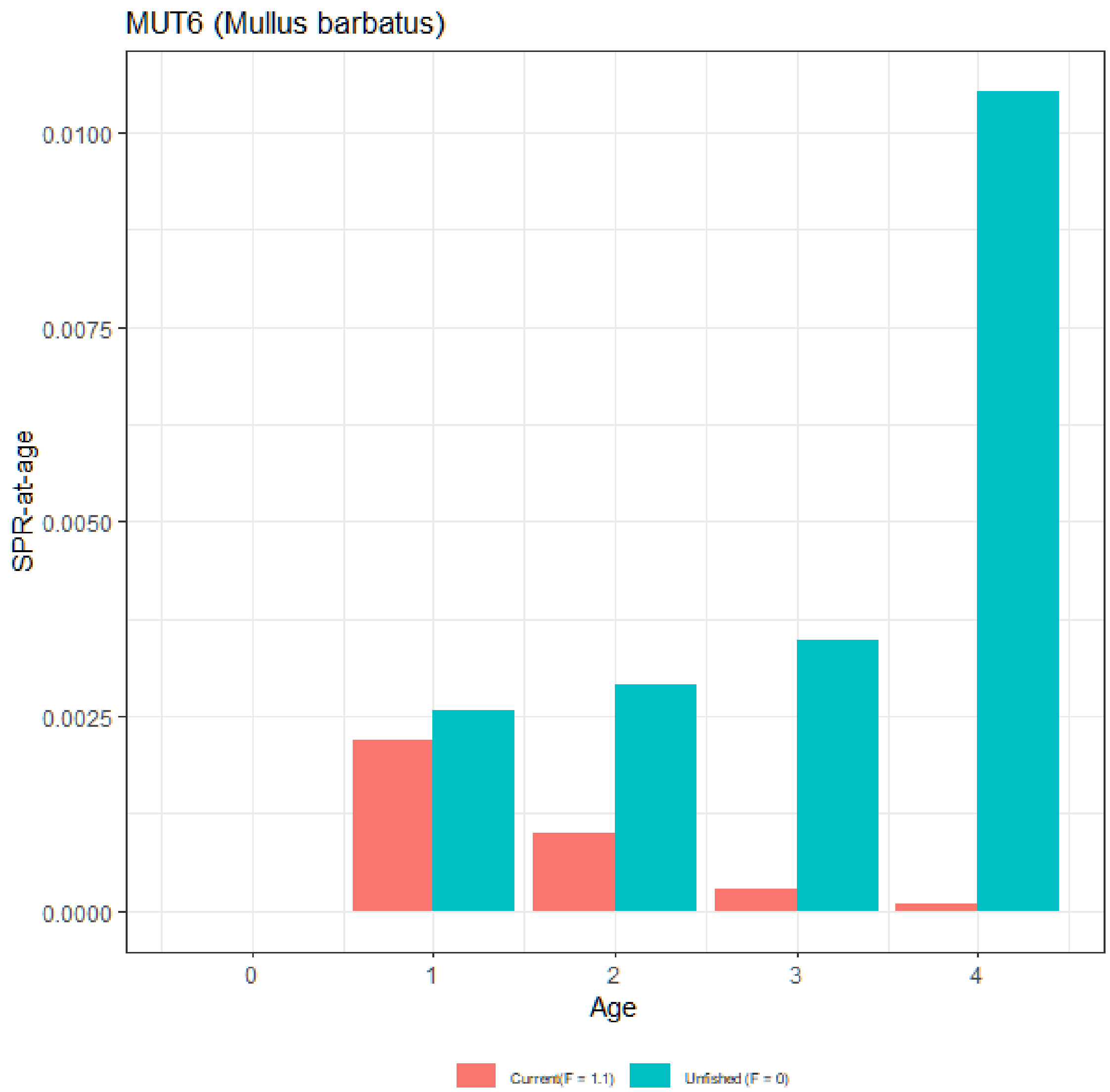


Figure 6.5.4.4 Red mullet in GSA 6. Spawning potential ratio by age class for the current (red bars) and a virgin population (blue bars).

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)
2. Hockey-Stick (model=segreg)
3. Beverton-Holt (model=bevholtSV)
4. Ricker (model=ricker)

Results are presented for the reference points based on the Geometric Mean approach.

Table 6.5.4.1. Red mullet in GSA 6. Reference points based on Geometric mean and a default value of B_{lim} =25% $B_{F0.1}$

$F_{0.1}$	Fpa	$B_{F0.1}$	B_{lim}	B_{pa}
0.314	0.871	3079	770	1540

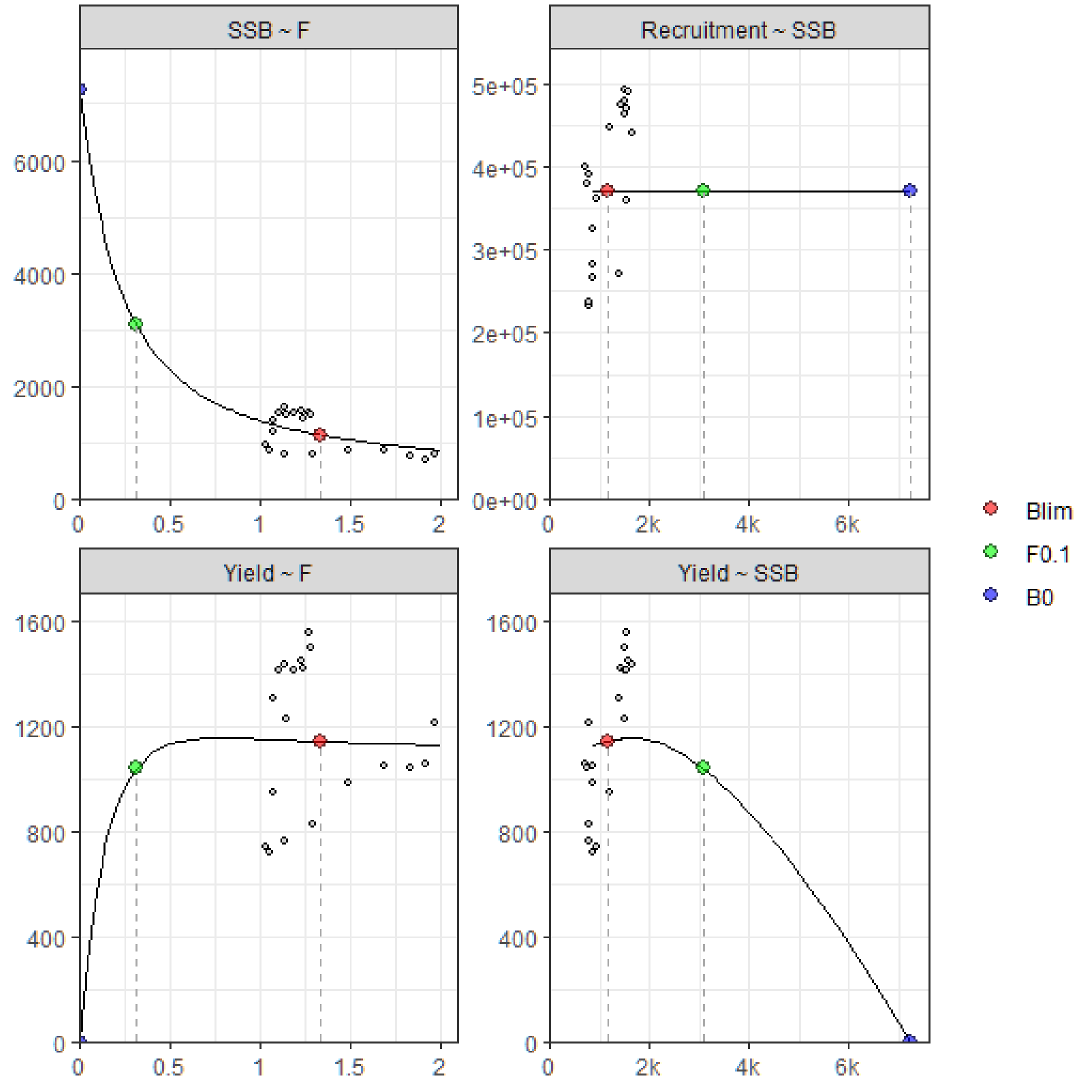


Figure 6.5.4.5 Red mullet in GSA 6 Reference points estimates. Grey dots show the corresponding observations.

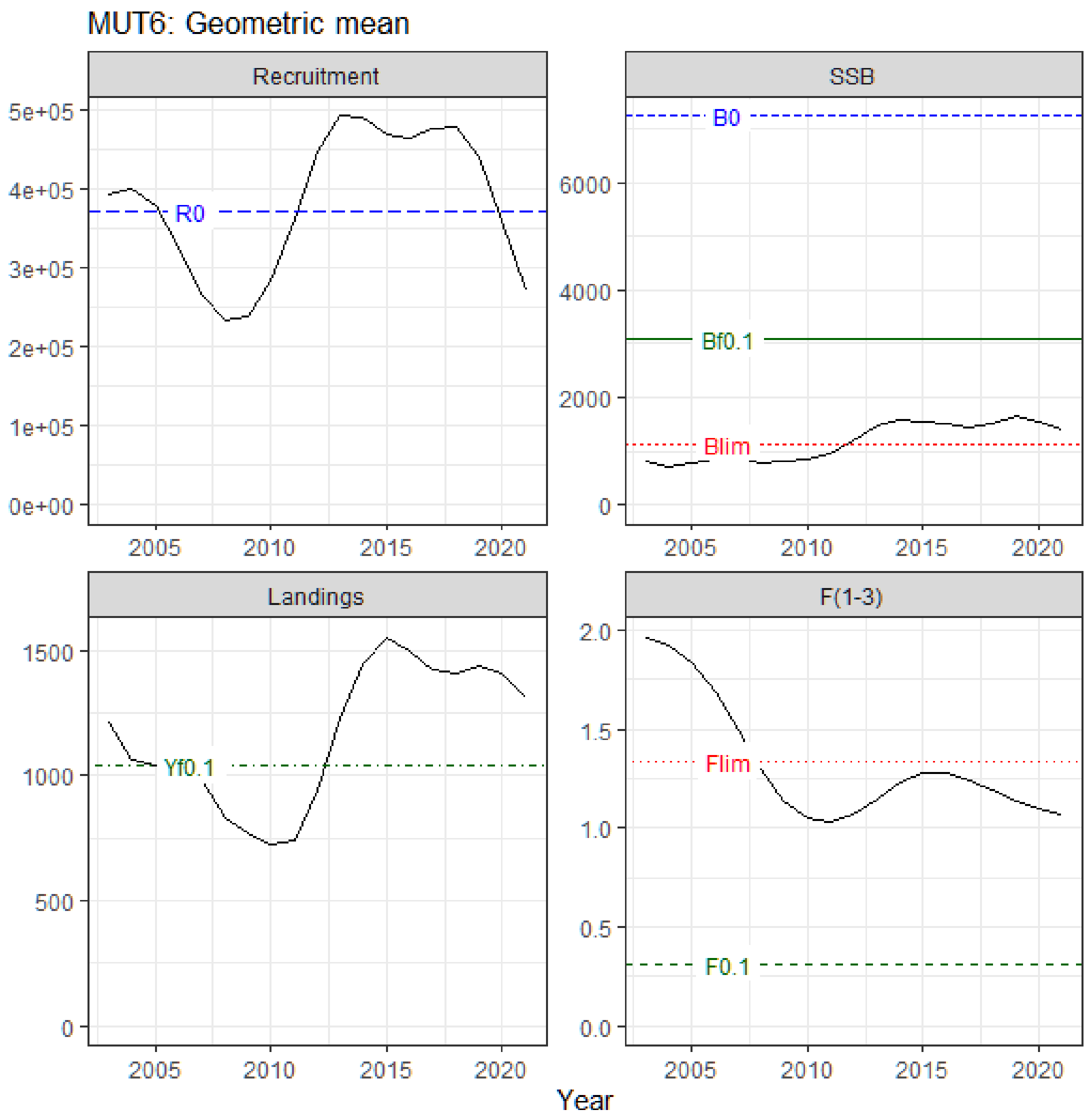


Figure 6.5.4.6 Red mullet in GSA 6 Reference points estimated for the Geometric mean model.

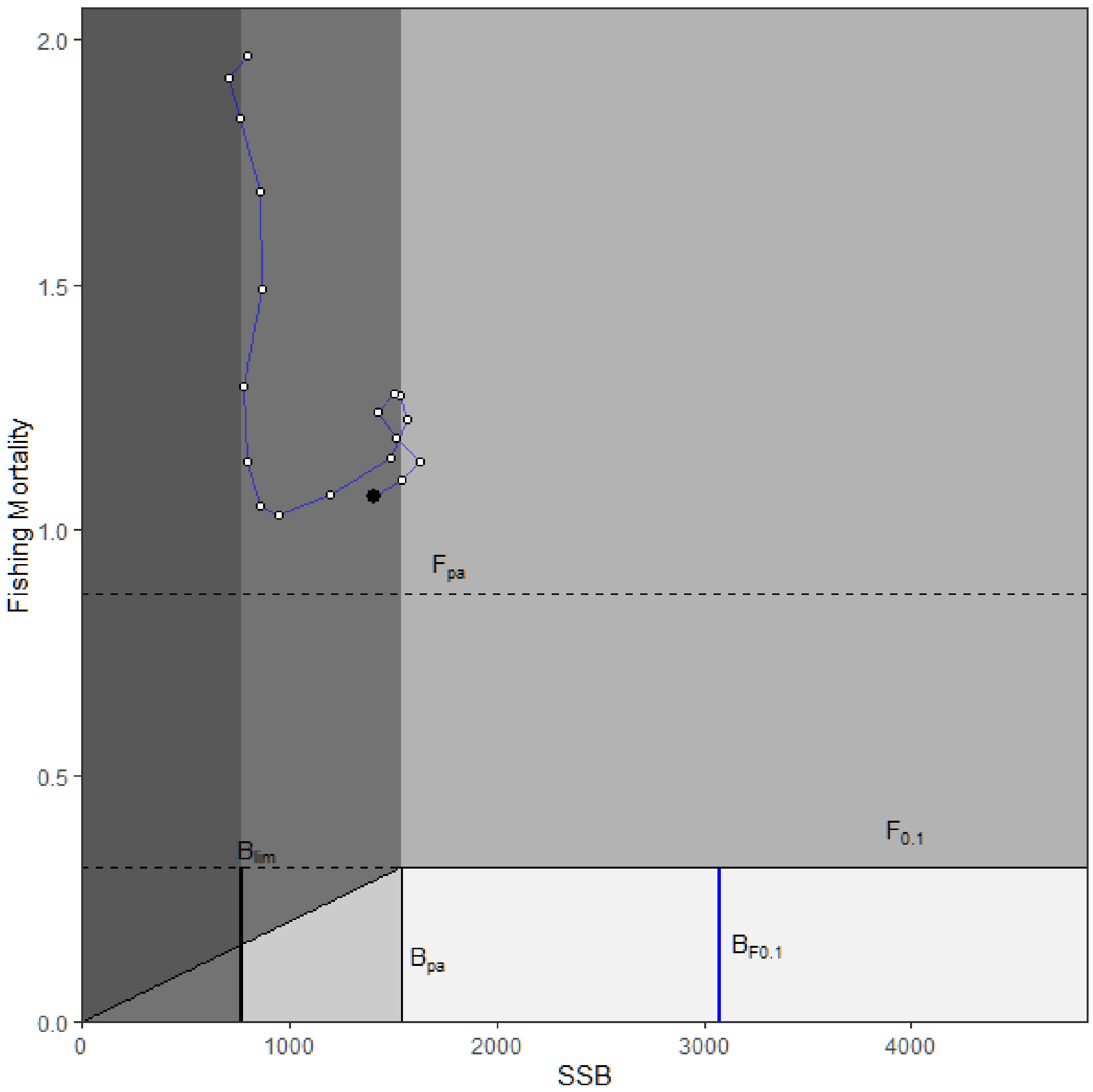


Figure 6.5.4.7 Red mullet in GSA 6 Advice rule plot for the Geometric mean model, with an empirical B_{lim} =0.25 $B_{F0.1}$ and B_{pa} =2xB_{lim}.

6.5.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for the biological parameters, while the F_{bar} =1.07 terminal F (2021) from the a4a assessment was used for F in 2022 because F slightly decreased in the last three years. Recruitment is observed to fluctuate over the period of the assessment (Figure 6.5.3.1). Recruitment for 2022 to 2023 has been estimated from the population results as the geometric mean of the whole series (371343.4).

EWG advises that when the MSY approach is applied, catches in 2023 should be no more than 396.5 tonnes.

Table 6.5.5.1 Red mullet GSA 6: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc were averaged
Fages 1-3 (2022)	1.070	Fsq = F in the last year
SSB (2022)	1124.838	SSB intermediate year from STF output
Rage0 (2022,2023)	371343.4	Recruitment will be set as geometric mean of the last 19 years
Total Catch (2022)	1102.4	Catch intermediate year from STF output
Fbar (2019)	1.140	MAP base year fishing mortality from current assessment
a and b values	a=0.333333333333333 and b=0.666666666666667	Regression parameters from Ftransition regression line

The short term forecast was carried out estimating a catch for 2022-2023 on the basis of a recruitment hypothesis constant and equal to the mean on the whole time series and an F by age equal to that of the terminal year. These assumptions resulted in a catch and a SSB in 2022 equal to 1102.4 and 1124.8 tons, respectively.

Table 6.5.5.2 Red mullet GSA 6. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Recruitment 2022	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB_change _2022-2024(%)	Catch_change _2021-2023(%)
High long term yield (F0.1)	0.3	0.314	371343.4	1.070	1306.4	1102.4	396.5	1124.8	2214.6	96.9	-69.6
F upper	0.4	0.432	371343.4	1.070	1306.4	1102.4	516.3	1124.8	2004.8	78.2	-60.5
F lower	0.2	0.210	371343.4	1.070	1306.4	1102.4	279.0	1124.8	2432.5	116.3	-78.6
FMSY transition	0.6	0.589	371343.4	1.070	1306.4	1102.4	657.5	1124.8	1773.1	57.6	-49.7
F/Catch_option	0.2	0.229	371343.4	1.070	1306.4	1102.4	301.5	1124.8	2389.8	112.5	-76.9
Zero catch	0.0	0.000	371343.4	1.070	1306.4	1102.4	0.0	1124.8	2995.3	166.3	-100.0
Status quo	1.0	1.070	371343.4	1.070	1306.4	1102.4	986.1	1124.8	1302.5	15.8	-24.5
Different Scenarios	0.1	0.107	371343.4	1.070	1306.4	1102.4	149.3	1124.8	2686.1	138.8	-88.6
	0.2	0.214	371343.4	1.070	1306.4	1102.4	283.4	1124.8	2424.1	115.5	-78.3
	0.3	0.321	371343.4	1.070	1306.4	1102.4	404.0	1124.8	2201.2	95.7	-69.1
	0.4	0.428	371343.4	1.070	1306.4	1102.4	512.8	1124.8	2010.6	78.7	-60.7
	0.5	0.535	371343.4	1.070	1306.4	1102.4	611.3	1124.8	1847.1	64.2	-53.2
	0.6	0.642	371343.4	1.070	1306.4	1102.4	700.6	1124.8	1706.0	51.7	-46.4
	0.7	0.749	371343.4	1.070	1306.4	1102.4	781.8	1124.8	1583.8	40.8	-40.2
	0.8	0.856	371343.4	1.070	1306.4	1102.4	856.0	1124.8	1477.4	31.3	-34.5
	0.9	0.963	371343.4	1.070	1306.4	1102.4	923.8	1124.8	1384.3	23.1	-29.3
	1.1	1.178	371343.4	1.070	1306.4	1102.4	1043.4	1124.8	1230.2	9.4	-20.1
	1.2	1.285	371343.4	1.070	1306.4	1102.4	1096.4	1124.8	1166.1	3.7	-16.1
	1.3	1.392	371343.4	1.070	1306.4	1102.4	1145.4	1124.8	1108.9	-1.4	-12.3
	1.4	1.499	371343.4	1.070	1306.4	1102.4	1190.9	1124.8	1057.6	-6.0	-8.8
	1.5	1.606	371343.4	1.070	1306.4	1102.4	1233.3	1124.8	1011.5	-10.1	-5.6
	1.6	1.713	371343.4	1.070	1306.4	1102.4	1272.9	1124.8	969.7	-13.8	-2.6
	1.7	1.820	371343.4	1.070	1306.4	1102.4	1310.0	1124.8	931.8	-17.2	0.3
	1.8	1.927	371343.4	1.070	1306.4	1102.4	1344.9	1124.8	897.3	-20.2	2.9
	1.9	2.034	371343.4	1.070	1306.4	1102.4	1377.6	1124.8	865.6	-23.0	5.5
	2.0	2.141	371343.4	1.070	1306.4	1102.4	1408.6	1124.8	836.5	-25.6	7.8

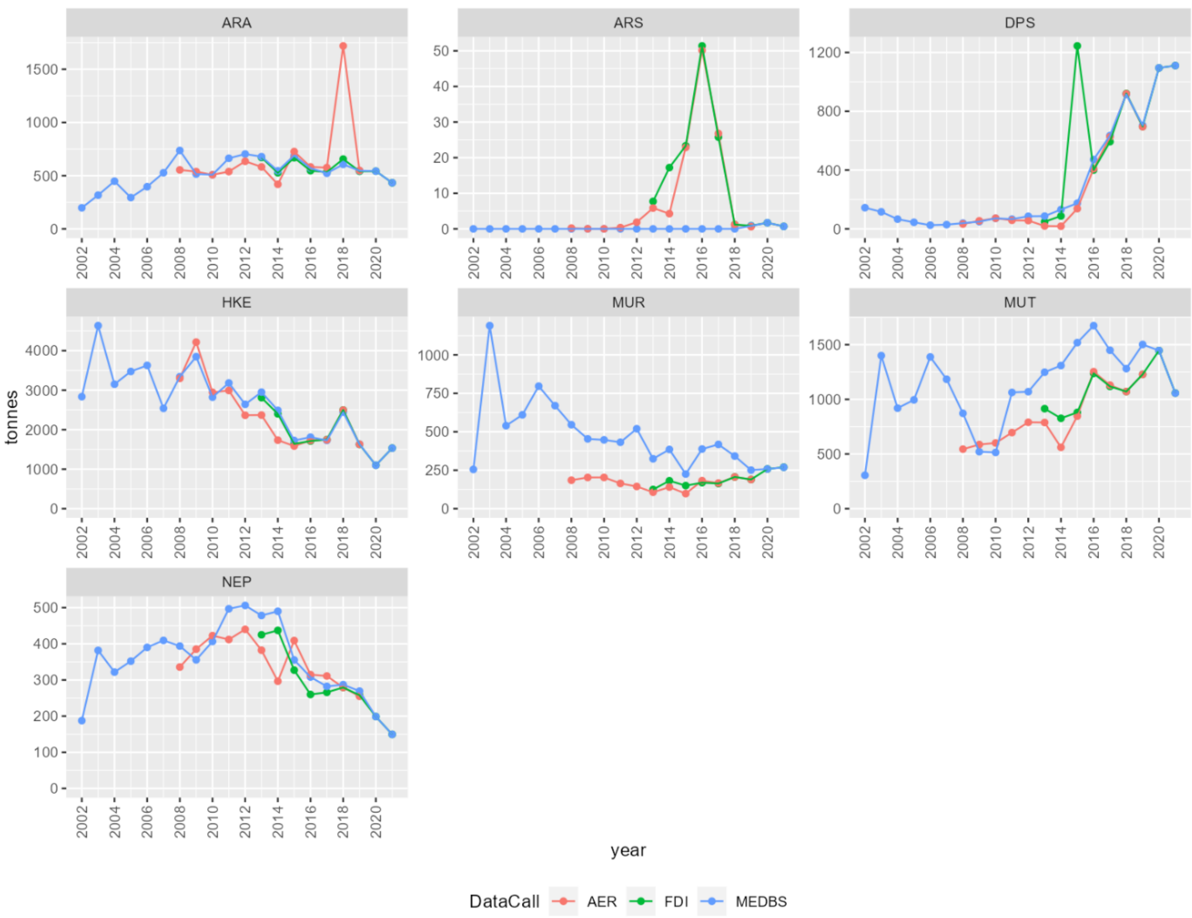
6.5.6 DATA ISSUES

MUT 6- gear coding

Red mullet landings from small-scale gears other than entangling nets may be a mistake when coding the fishing gear and should be checked (FPO=pots and traps; LHP= pole lines; LLS=longlines). This issue was reported in EWG-21-11.

MUT landings in GSA - differences in red mullet (MUT) landings in GSA 6 were observed among the MEDBS, FDI and AER data calls.

ESP GSA6 Total landings by species



country	year	GSA	species	landings	DataCall
ESP	2002	6	MUT	305.4	MEDBS
ESP	2003	6	MUT	1400.0	MEDBS
ESP	2004	6	MUT	919.5	MEDBS
ESP	2005	6	MUT	995.0	MEDBS
ESP	2006	6	MUT	1387.8	MEDBS
ESP	2007	6	MUT	1183.6	MEDBS
ESP	2008	6	MUT	872.1	MEDBS
ESP	2009	6	MUT	520.9	MEDBS
ESP	2010	6	MUT	514.1	MEDBS
ESP	2011	6	MUT	1063.1	MEDBS
ESP	2012	6	MUT	1069.9	MEDBS
ESP	2013	6	MUT	1248.0	MEDBS
ESP	2014	6	MUT	1309.2	MEDBS
ESP	2015	6	MUT	1518.7	MEDBS
ESP	2016	6	MUT	1673.9	MEDBS
ESP	2017	6	MUT	1449.3	MEDBS
ESP	2018	6	MUT	1280.7	MEDBS
ESP	2019	6	MUT	1501.8	MEDBS
ESP	2020	6	MUT	1446.3	MEDBS
ESP	2021	6	MUT	1056.7	MEDBS
FRA	2020	6	MUT	0.00361	MEDBS

FRA	2021	6	MUT	0.01059	MEDBS
country	year	GSA	species	landings	DataCall
ESP	2013	6	MUT	914.7	FDI
ESP	2014	6	MUT	826.6	FDI
ESP	2015	6	MUT	880.4	FDI
ESP	2016	6	MUT	1237.5	FDI
ESP	2017	6	MUT	1118.5	FDI
ESP	2018	6	MUT	1071.0	FDI
ESP	2019	6	MUT	1228.4	FDI
ESP	2020	6	MUT	1446.3	FDI
ESP	2021	6	MUT	1057.7	FDI
FRA	2020	6	MUT	0.004	FDI
FRA	2021	6	MUT	0.011	FDI
country	year	GSA	species	landings	DataCall
ESP	2008	6	MUT	544.5	AER
ESP	2009	6	MUT	586.3	AER
ESP	2010	6	MUT	600.9	AER
ESP	2011	6	MUT	695.9	AER
ESP	2012	6	MUT	790.3	AER
ESP	2013	6	MUT	788.2	AER
ESP	2014	6	MUT	560.9	AER
ESP	2015	6	MUT	846.9	AER
ESP	2016	6	MUT	1253.0	AER
ESP	2017	6	MUT	1129.8	AER
ESP	2018	6	MUT	1070.9	AER
ESP	2019	6	MUT	1228.4	AER

EWG-22-09 used the data of the MEDBS data call, since FDI and AER data approach MEDBS along the time series and are similar in the most recent years. In addition, MEDBS data in 2009 and 2010 appear to be rather low when compared with the previous and the following years. MUT landings in GSA 6 in 2009 and 2010 should be checked.

6.6 Red mullet in GSA 7

6.6.1 Stock Identity and Biology

Red mullet (*Mullus barbatus*) in the Gulf of Lions (GSA 7) is a shared stock exploited by both Spanish and French trawlers and since 2011 also by French artisanal gears.

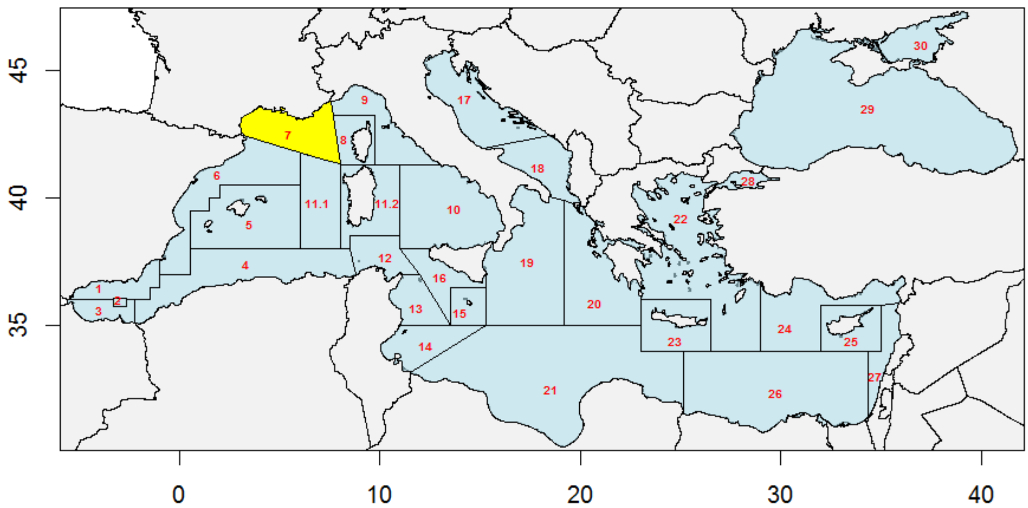


Figure 6.6.1.1. Localisation of GSA 7 (in Yellow) in the Mediterranean Sea.

Age-slicing and growth

The process of age slicing has been performed using a global Age-Length-Key obtained from age reading data. This year, we reviewed yearly-based ALKs since 2010 and noticed a lack of consistency in 2010-2013 readings, as well as 2020. 2010-2013 corresponds to years prior harmonization age-reading ICES workshops for red mullet in the Mediterranean Sea, while 2020 corresponds to the year during which MEDITS occurred in October due to Covid. Hence, red-mullet this year were larger, for the same age, resulting in potentially biased ALK if a global key was used. We therefore removed 2010-2013 and 2020 readings and computed ALK on the basis of 2014-2019 and 2021 data.

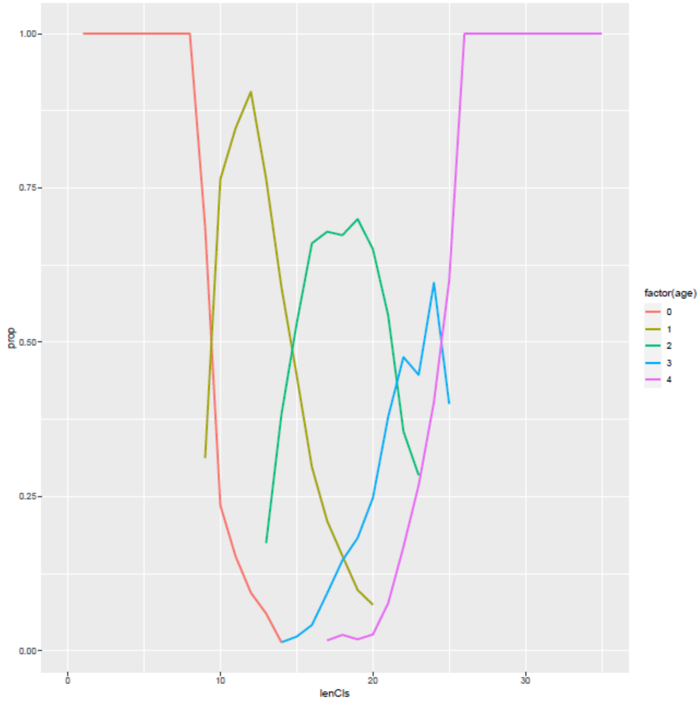


Figure 6.6.1.2. Red mullet GSA 7. Age-length Key derived from age-reading data. The purple line corresponds to age 4 or more.

Length-Weight relationships

For the purpose of computing biomass and average weights at age from numbers at length, we used a length weight relationships fitted on individual DCF sample data – the same that were used to produce the ALK. The resulting relationships has parameters ln(a)=-4.50, and b=3.015.

Maturity and natural mortality

Regarding maturity, spawning red mullet season is quite short (April-July). We decided to assume that individuals reaching age 1 (~12cm) should be considered as mature (Figure 6.6.1.3).

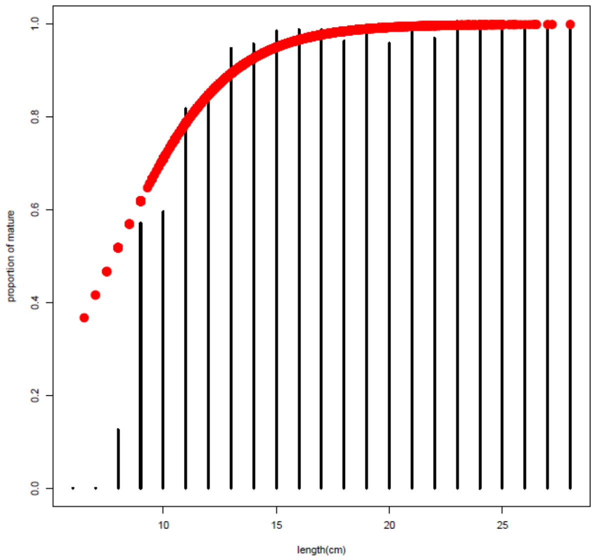


Figure 6.6.1.3. Red mullet GSA 7. Proportion of mature Red Mullet per length in GSA 7. The red line corresponds to the predicted proportion following a logistic regression model.

Natural mortality was obtained from Rscript provided during the meeting and is based on Chen Watanabe formula, with M=1.74, 0.8, 0.57, 0.48 and 0.43 at ages 0, 1, 2, 3 and 4+, respectively.

6.6.2 DATA

Available catch, landing and discards data are from DCF. EWG 22-09 received French and Spanish data for GSA 7 by fishing gears. French and Spanish data are provided since 2002 to 2021 (Fig 6.6.1.1 & 6.5.2.2).

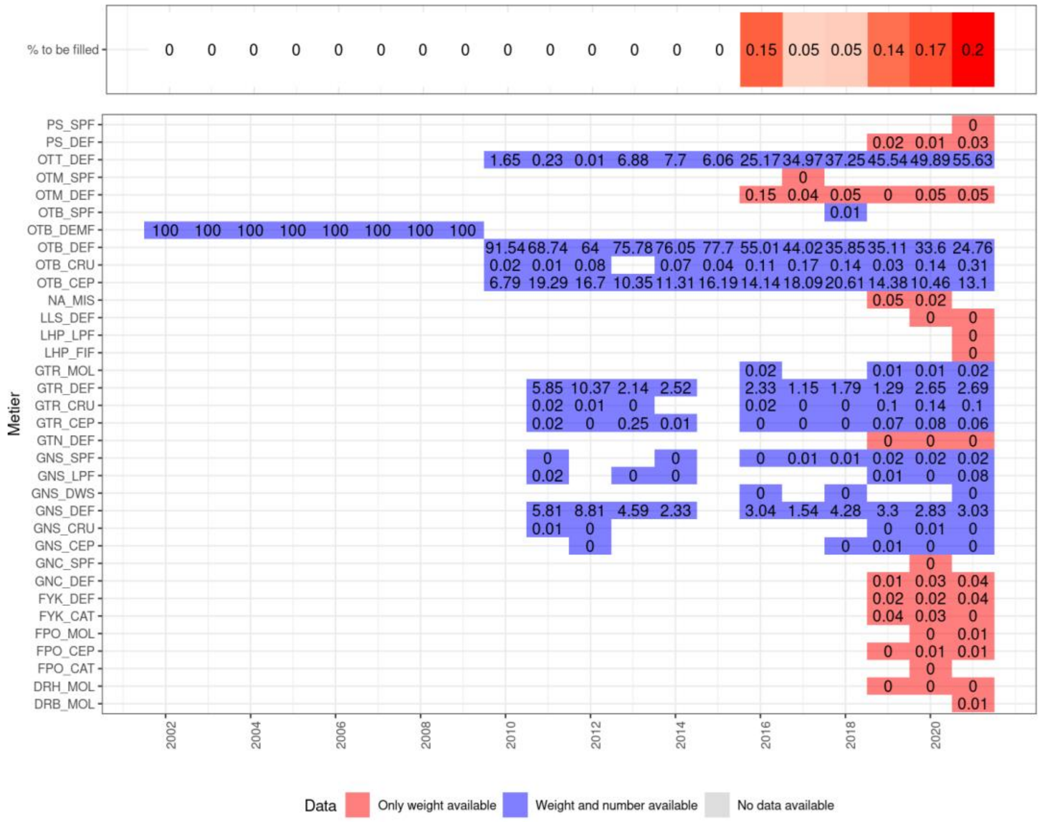


Figure 6.6.2.1. Red mullet GSA 7. Summary of data provided by France on GSA 7

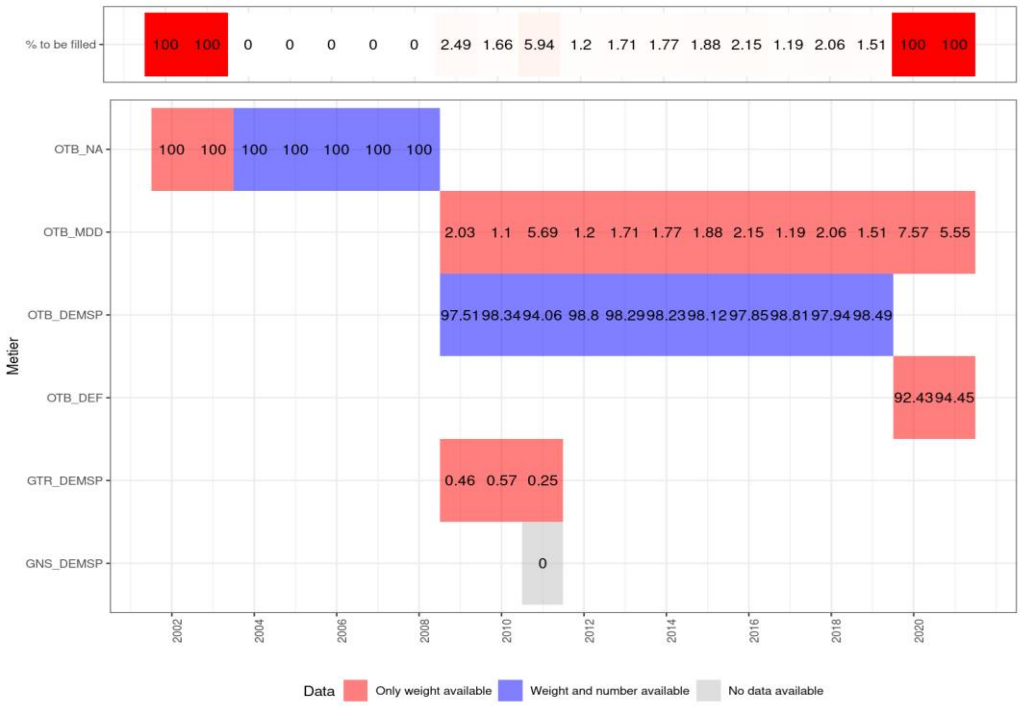


Figure 6.6.2.2. Red mullet GSA 7. Summary of data provided by Spain on GSA 7

6.6.2.1 CATCH, LANDINGS AND DISCARDS

Landings and discards at length.

Total catch by year is reported in Table 6.6.2.1 (in terms of landings and discards). The French fleet is usually responsible for ~90% of the catch, most of which results from trawlers (>95%, Figure 6.6.2.3 & Table 6.6.2.). The 2021 length distribution of landings is in line with previous years, but with one noticeable exception: smaller individuals (mostly <12cm) are notably less abundant from the landings

Year	Fra_GSA7	Spa_GSA7	Total landings	Discards	Catch
2002	111.424	11.08	122.504	0	122.504
2003	164.141	11.87	176.011	0	176.011
2004	151.646	25.84	177.486	0	177.486
2005	148.086	27.48	175.566	0	175.566
2006	183.478	31.4	214.878	0	214.878
2007	171.526	36.16	207.686	0	207.686
2008	110.494	20.73	131.224	0.18	131.404
2009	122.555	26.13	148.685	0	148.685
2010	253.837	28.23	282.067	2.828	284.895
2011	241.764	28.13	269.894	3.584	273.478
2012	173.939	29.17	203.109	8.219	211.328
2013	250.871	37.53	288.401	4.676	293.077
2014	315.874	41.18	357.054	4.204	361.258
2015	324.626	33.05	357.676	8.423	366.099
2016	365.128	43.31	408.438	3.056	411.494
2017	209.532	31.09	240.622	2.352	242.974
2018	318.349	23.83	342.179	3.361	345.54
2019	290.489	22.168	312.657	7.488	320.145
2020	422.153	11.481	433.634	9.151	442.785
2021	383.777	11.025	394.802	6.511	401.313

Table 6.6.2.1. Red mullet GSA 7. Landings per country, discards and catch per year, in tons.

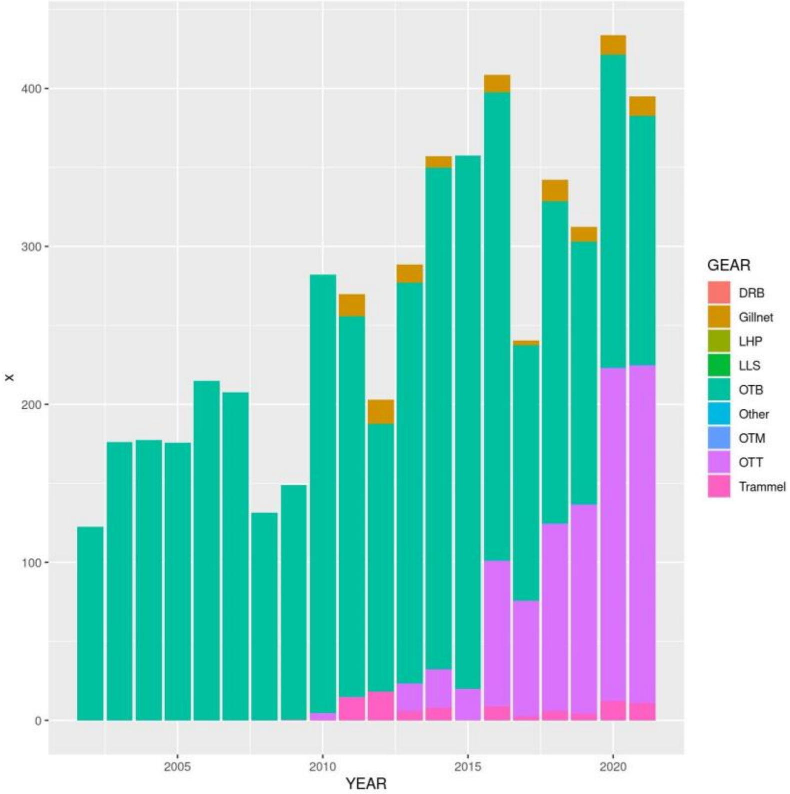


Fig 6.6.2.3. Red mullet GSA 7. Landings per year and gear in GSA 7 (French and Spanish fleet combined).

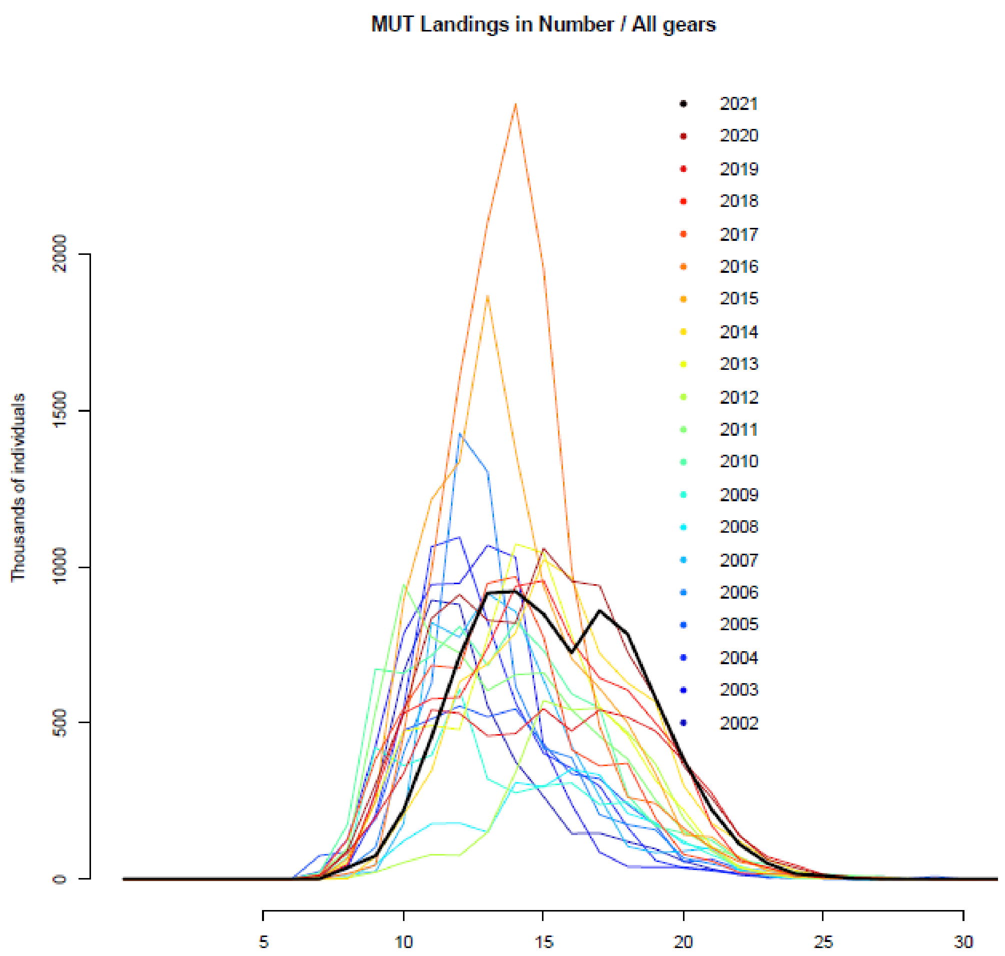


Fig 6.6.2.4. Red mullet GSA 7. Size-Class distribution of Red Mullet landings per year, for gillnetts & trammel nets (left) and trawlers (right). The thick black line corresponds to the most recent year (2021).

Year	ESP Gillnet	ESP Trammel	ESP Trawl	FRA DRB	FRA Gillnet	FRA LHP	FRA LLS	FRA Other	FRA Trammel	FRA Trawl
2002	0	0	11.08	0	0	0	0	0	0	111.424
2003	0	0	11.87	0	0	0	0	0	0	164.141
2004	0	0	25.84	0	0	0	0	0	0	151.646
2005	0	0	27.48	0	0	0	0	0	0	148.086
2006	0	0	31.4	0	0	0	0	0	0	183.478
2007	0	0	36.16	0	0	0	0	0	0	171.526
2008	0	0	20.73	0	0	0	0	0	0	110.494
2009	0	0.12	26.01	0	0	0	0	0	0	122.555
2010	0	0.16	28.07	0	0	0	0	0	0	253.837
2011	0	0.07	28.06	0	14.101	0	0	0	14.236	213.428
2012	0	0	29.17	0	15.325	0	0	0	18.071	140.543
2013	0	0	37.53	0	11.511	0	0	0	6.011	233.348
2014	0	0	41.18	0	7.376	0	0	0	7.986	300.512
2015	0	0	33.05	0	0	0	0	0	0	324.626
2016	0	0	43.31	0	11.122	0	0	0	8.665	345.341
2017	0	0	31.09	0	3.251	0	0	0	2.419	203.862
2018	0	0	23.83	0	13.672	0	0	0	5.713	298.964
2019	0	0	22.168	0	9.723	0	0	0.359	4.268	276.139
2020	0	0	11.481	0	12.206	0	0.004	0.37	12.203	397.37
2021	0	0	11.025	0.025	12.192	0.016	0.002	0.356	11.022	360.165

Table 6.6.2.2. Red mullet GSA 7. Landings per Year, Gear and country

Landings in recent years have peaked around 400 tons, with a minimum in 2002 (Table 2). The majority of the landings of red mullet come from trawlers, and the other part is mainly nets. Landings of gears other than OTB, OTT, GNS and GTR are on average less than 1%. Since 2014, the French Trawl fleet are dominated by OTB, OTM and OTT trawlers. The majority of landings were initially due to OTB, but OTT has displayed an increasing importance over the last years and has become on par with OTB since 2020 (Table 6.6.2.2).

Discards (Figure 6.6.2.4) were regularly reported since 2010 (Table 6.6.2.3). They are mostly composed of small individuals and account for [1-3]% of the landed biomass, depending on year. In 2019 and 2020, discards of small individuals have been particularly important.

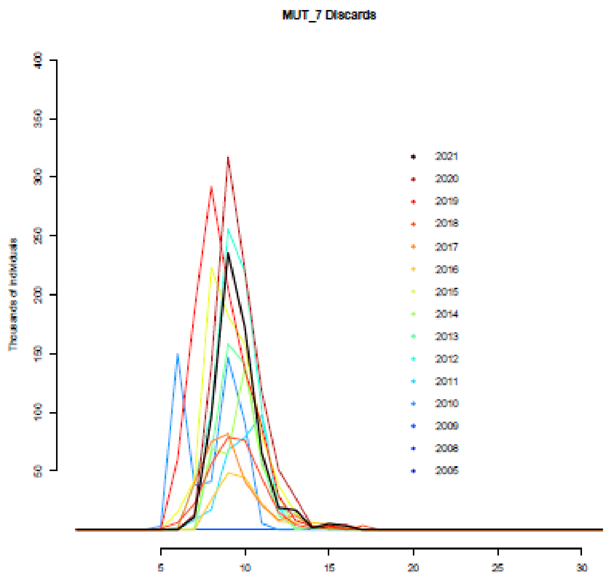


Figure 6.6.2.4. Red mullet GSA 7. Size-Class distribution of Red Mullet discards per year

Landings and discards at age.

Landings and discards at age have been recovered by combining landings and discards at length data, the Age-Length-Key (Figure 6.6.1.2) and the length-weight relationship. The resulting numbers and average weight at age are summarized below (Tables 3 – 6), and the resulting catch at age is displayed in Figure 6.6.2.5.

Year	0	1	2	3	4+
2002	657.873	3074.156	801.894	105.492	17.096
2003	1067.189	4651.865	1274.636	102.249	15.493
2004	712.19	4089.733	1328.814	144.265	26.432
2005	622.514	2698.29	1439.347	211.146	60.423
2006	603.563	4526.453	1611.11	194.931	37.405
2007	392.081	3682.961	1759.266	220.801	40.687
2008	131.167	1154.558	1243.436	217.318	36.006
2009	617.451	2150.435	1171.89	214.62	39.384
2010	1167.386	4160.303	2312.614	362.91	95.285
2011	1011.225	3999.897	2163.22	359.596	95.655
2012	67.045	1189.366	2018.214	351.373	66.08
2013	530.666	3494.728	2779.391	378.876	60.087
2014	264.669	3125.161	3281.693	589.78	122.386
2015	893.435	6130.956	3005.83	406.112	76.924
2016	612.953	6990.695	3829.935	375.391	62.868
2017	830.657	3929.43	2095.587	258.913	55.938
2018	566.649	3621.837	3102.111	530.876	92.577
2019	494.412	2627.915	2456.906	599.956	143.686
2020	724.324	4442.848	3747.706	708.837	150.456
2021	361.675	3607.111	3536.785	662.152	126.444

Table 6.6.2.3. Red mullet GSA 7. Landings at age (Thousands of individuals)

Year	0	1	2	3	4+
2002	0.013	0.021	0.05	0.078	0.099
2003	0.012	0.022	0.041	0.075	0.114
2004	0.014	0.022	0.047	0.074	0.107
2005	0.011	0.025	0.052	0.081	0.156
2006	0.016	0.024	0.048	0.08	0.118
2007	0.017	0.025	0.048	0.083	0.111
2008	0.014	0.031	0.058	0.081	0.097
2009	0.011	0.024	0.058	0.084	0.104
2010	0.011	0.025	0.053	0.087	0.132
2011	0.011	0.024	0.055	0.085	0.14
2012	0.015	0.039	0.059	0.079	0.129
2013	0.013	0.029	0.053	0.076	0.102
2014	0.017	0.032	0.058	0.085	0.115
2015	0.015	0.025	0.051	0.08	0.111
2016	0.018	0.027	0.045	0.075	0.128
2017	0.012	0.025	0.049	0.076	0.129
2018	0.013	0.029	0.057	0.082	0.104
2019	0.012	0.028	0.064	0.094	0.122
2020	0.013	0.028	0.059	0.086	0.115
2021	0.016	0.031	0.059	0.084	0.106

Table 6.6.2.4. Red mullet GSA 7. Average weight of landings at age (Kg)

Year	0	1	2	3	4+
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	394.252	133.104	0	0	0
2011	117.062	198.156	1.117	0.034	0
2012	399.659	372.736	3.753	0.069	0
2013	220.569	223.75	2.037	0.09	0
2014	159.044	201.864	0.803	0.029	0
2015	460.813	295.15	6.025	0.168	0
2016	73.089	83.654	6.034	0.207	0
2017	201.096	101.842	5.404	0.128	0
2018	167.183	140.915	5.175	0.419	0.061
2019	754.376	288.579	6.864	0.283	0
2020	461.903	451.586	7.373	0.116	0
2021	337.385	308.443	8.923	0.296	0

Table 6.6.2.5. Red mullet GSA 7. Discards at age (Thousands of individuals)

Year	0	1	2	3	4+
2002	0.013	0.021	0.05	0.078	0.099
2003	0.012	0.022	0.041	0.075	0.114
2004	0.014	0.022	0.047	0.074	0.107
2005	0.011	0.025	0.052	0.081	0.156
2006	0.016	0.024	0.048	0.08	0.118
2007	0.017	0.025	0.048	0.083	0.111
2008	0.014	0.031	0.058	0.081	0.097
2009	0.011	0.024	0.058	0.084	0.104
2010	0.005	0.01	0.053	0.087	0.132
2011	0.009	0.014	0.031	0.032	0.14
2012	0.008	0.013	0.031	0.042	0.129
2013	0.008	0.012	0.039	0.043	0.102
2014	0.008	0.013	0.032	0.032	0.115
2015	0.007	0.014	0.033	0.041	0.111
2016	0.008	0.015	0.034	0.037	0.128
2017	0.007	0.014	0.032	0.037	0.129
2018	0.007	0.014	0.045	0.053	0.057
2019	0.006	0.013	0.038	0.043	0.122
2020	0.008	0.013	0.03	0.04	0.115
2021	0.008	0.013	0.036	0.042	0.106

Table 6.6.2.6. Red mullet GSA 7. Average weight of discards at age (Kg)

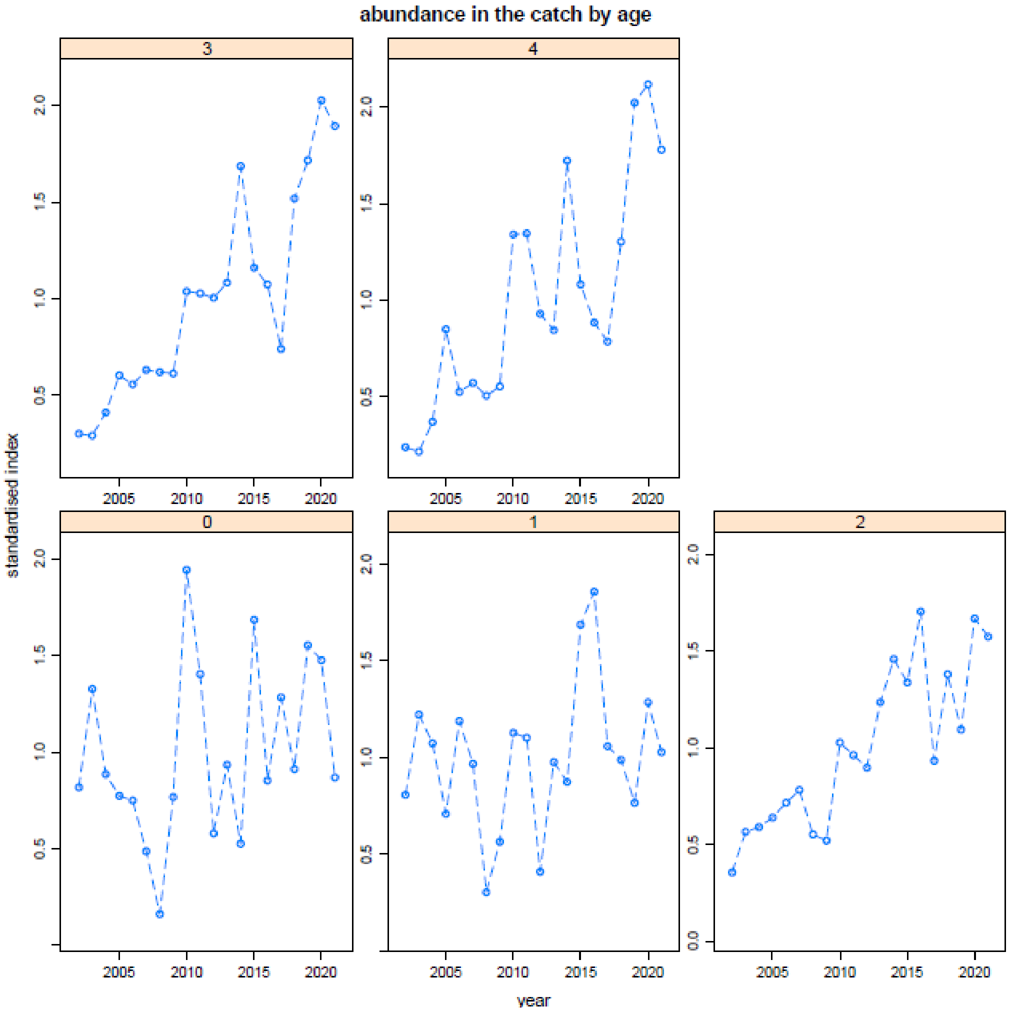


Figure 6.6.2.5. Red mullet GSA 7. Catch at age of Red Mulled in GSA 7. Y-axis is standardised.

6.6.2.2 EFFORT

Effort information regarding GSA 7 has been compiled by C. Bensebaini in terms of number of days at sea by fleet segment (Figure 6.6.2.6). It shows that the number of fishing days has been reduced notably after 2010.

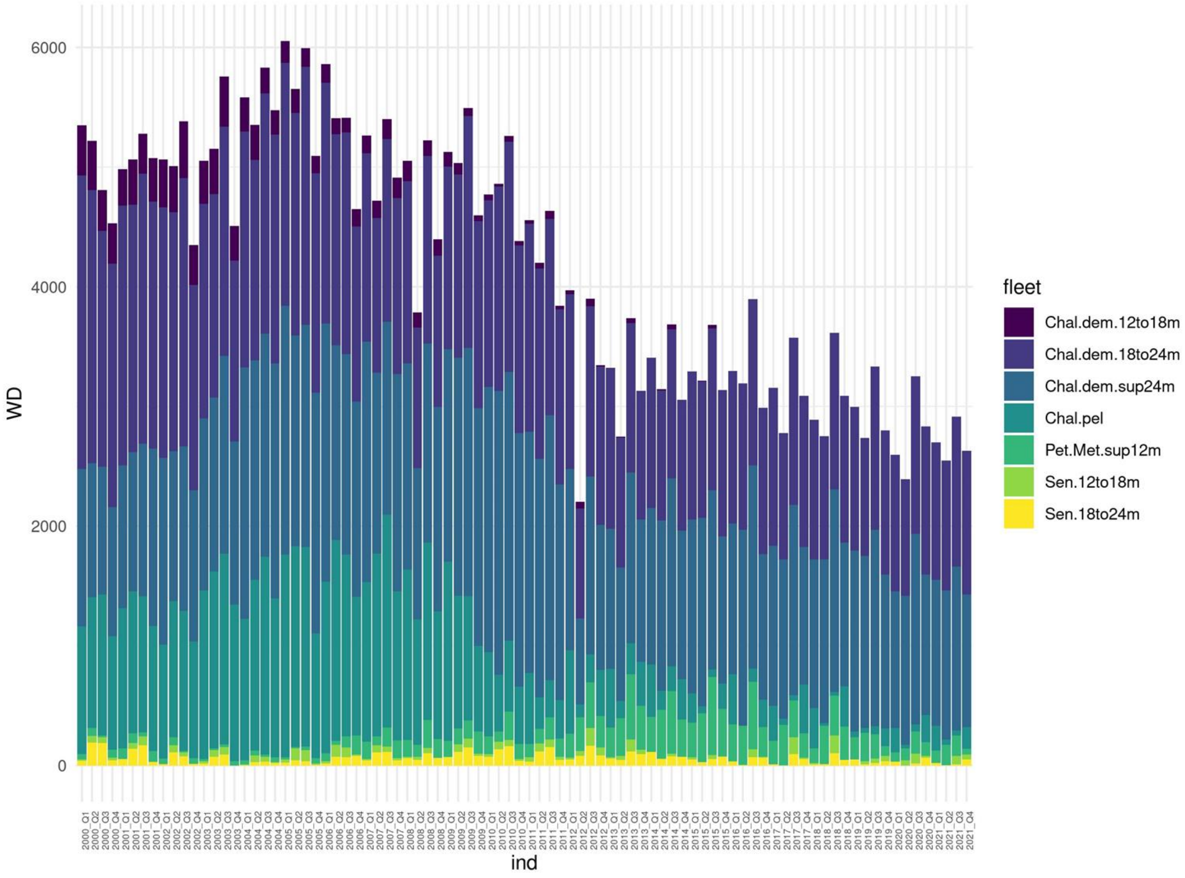


Figure 6.6.2.6. Red mullet GSA 7. Effort of the French fishing fleet in the GSA 7 in terms of number of fishing days (y-axis) per trimester (x-axis) from 2000 to 2021. Colour corresponds to fleet segments, darker colours point towards demersal trawlers.

6.6.2.3 SURVEY DATA

Distribution and abundances

According to the MEDITS protocol (Bertrand et al. 2002), trawl surveys were yearly carried out from end of May until end of June, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed for red mullet. Abundances at trawl were standardized to square kilometer, using the swept area method, then MEDITS abundances (numbers of fish at length over the GSA 7 area) were computed.

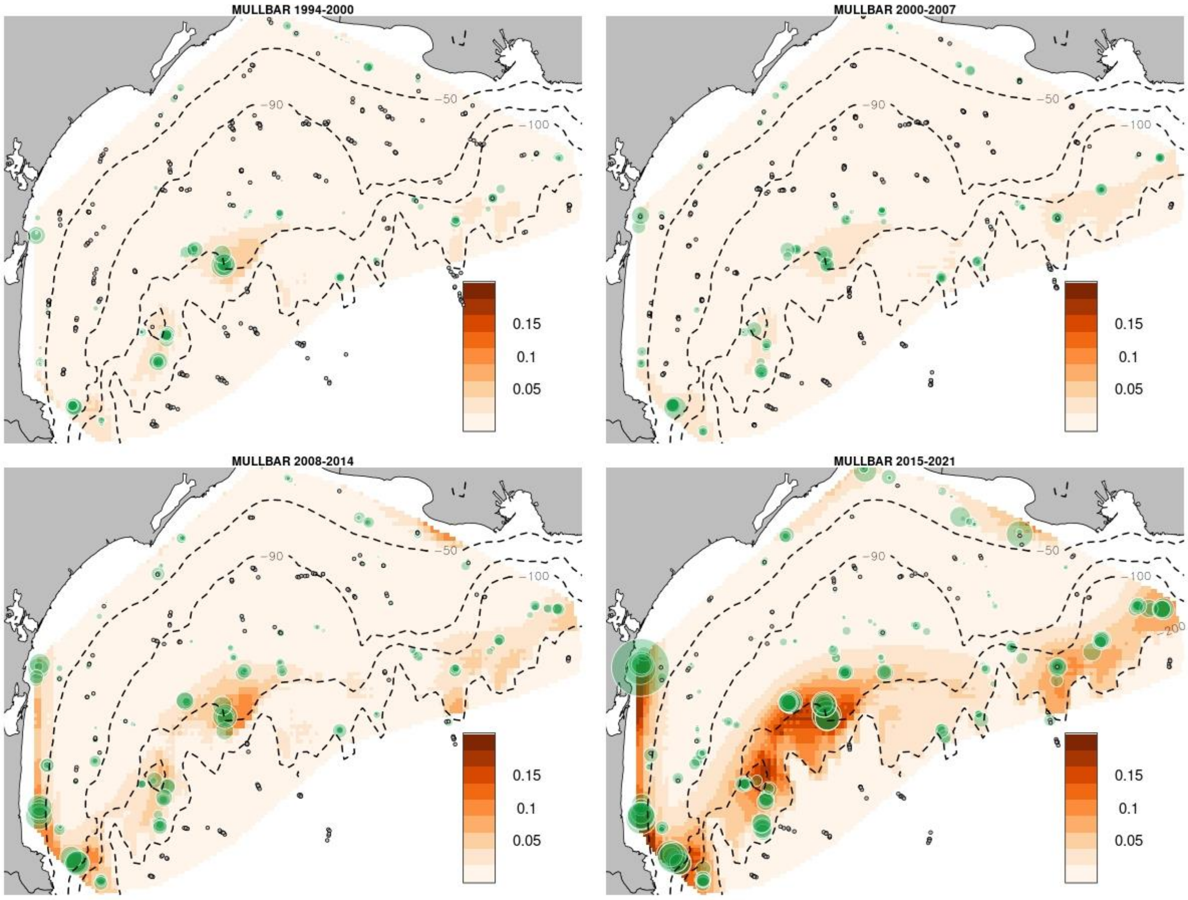


Figure 6.6.2.7. Red mullet GSA 7. Colours: Biomasses of Red Mullet from MEDITS survey in t/km2. Green circles corresponds to trawls with red mullet, their size is proportional to densities. Grey dots locate trawls without red mullet.

Figure 6.6.2.7 shows MEDITS sampling and estimates of red mullet spatial distribution for 4 time periods, exemplifying quite well their core area of distribution in the Gulf of Lion in June in the South-Western upper slope, and their increasing numbers since 1994.

MEDITS index at length and age

The size range caught by the survey (Figure 6.6.2.8) is quite constant [8 – 27cm] over the years, with a strong increase in the abundances of young individuals in some of the most recent years, illustrating increased recruitment over the last decade. Regarding 2021, MEDITS abundances at length are strikingly important for older [14 – 22cm] individuals compared to other years, while abundances for smaller individuals are on par with previous years, and below years with highest recruitment.

MEDITS at-age data preparation

Numbers and average weight at age issued from the MEDITS survey are summarized below in tables 6.6.2.7 and 6.6.2.8. The evolution of the MEDITS index at age is shown in Figure 6.6.2.9.

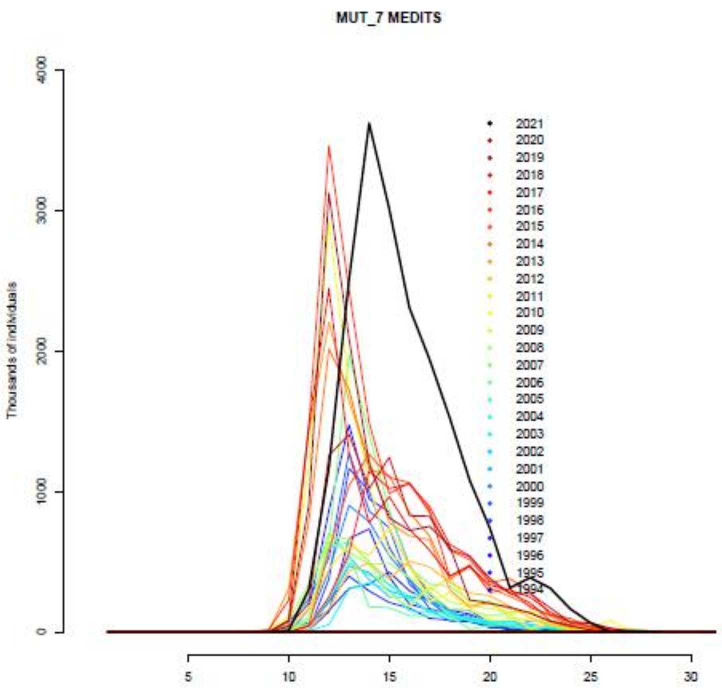


Fig 6.6.2.8. Red mullet GSA 7. Length distribution of MEDITS abundance index over the years. The black thick line corresponds to 2021.

Year	0	1	2	3	4
2002	61.555	1108.434	890.146	180.612	71.42
2003	29.524	731.04	772.91	144.554	42.04
2004	124.55	1716.309	983.146	171.129	63.327
2005	68.825	1209.418	1023.381	167.419	48.466
2006	147.283	1569.048	572.256	110.515	53.592
2007	214.71	3680.219	2491.958	360.272	120.13
2008	173.594	2094.616	1417.081	309.059	102.924
2009	125.776	1794.802	1330.274	388.814	178.157
2010	613.906	6185.251	1915.508	294.348	180.384
2011	117.684	1985.177	1845.782	315.948	63.317
2012	53.132	1312.088	1862.36	413.43	130.464
2013	619.832	6191.066	2693.502	449.15	131.569
2014	442.871	5552.947	3380.925	631.1	166.795
2015	142.66	3263.296	3852.522	840.083	234.372
2016	780.455	8347.703	3855.467	695.818	190.231
2017	80.018	2501.827	3662.802	735.92	192.342
2018	561.389	5851.83	3013.435	707.031	240.469
2019	259.067	4169.103	3720.06	813.876	262.444
2020	595.058	6827.257	3112.196	515.974	122.578
2021	361.745	8216.576	8923.867	1571.207	405.091

Table 6.6.2.7. Red mullet GSA 7. MEDITS index at age (Numbers in thousands for the 13800 km^2 of the Gulf of Lion)

Year	0	1	2	3	4
2002	0.02	0.026	0.048	0.093	0.14
2003	0.02	0.027	0.046	0.081	0.131
2004	0.017	0.022	0.044	0.087	0.135
2005	0.018	0.026	0.045	0.083	0.128
2006	0.016	0.02	0.045	0.094	0.15
2007	0.019	0.024	0.041	0.077	0.133
2008	0.015	0.023	0.049	0.09	0.133
2009	0.019	0.025	0.056	0.1	0.15
2010	0.015	0.018	0.041	0.083	0.159
2011	0.017	0.026	0.046	0.075	0.098
2012	0.02	0.031	0.054	0.083	0.134
2013	0.014	0.02	0.045	0.085	0.121
2014	0.016	0.022	0.048	0.084	0.12
2015	0.019	0.028	0.049	0.084	0.114
2016	0.016	0.021	0.047	0.086	0.122
2017	0.019	0.031	0.05	0.08	0.114
2018	0.016	0.021	0.051	0.091	0.131
2019	0.016	0.024	0.047	0.082	0.118
2020	0.02	0.025	0.053	0.089	0.117
2021	0.017	0.026	0.043	0.074	0.105

Table 6.6.2.8. Red mullet GSA 7.MEDITS average weight at age.

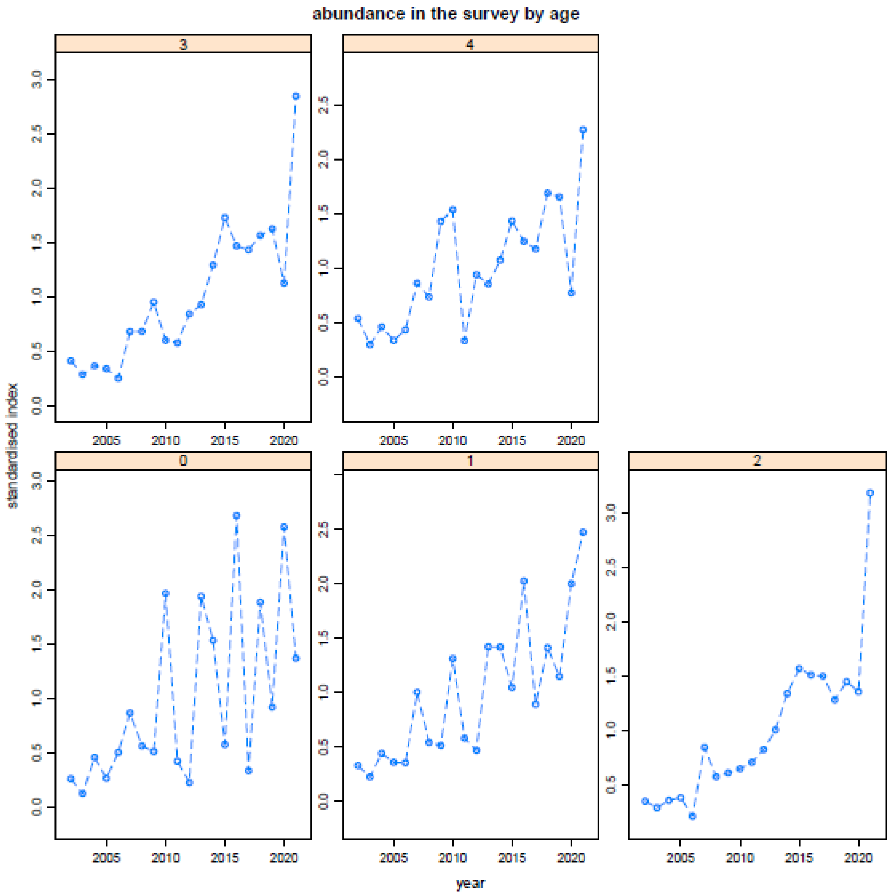


Figure 6.6.2.9. Red mullet GSA 7. MEDITS index at age of Red Mulled in GSA 7. Y-axis is standardised.

6.6.3 STOCK ASSESSMENT: A4A.

Input data & model specification

Input data for the stock assessment are those summarised in tables 3 – 8 above, together with assumed maturity and natural mortality (see section 6.6.4). The model used for this year is the exact same specification than the one selected last year during STECF 21_11:

fmodel = ~ factor(age) + s(year, k = 6)

qmodel = ~factor(replace(age,age>3,3))

srmodel = ~geomean(CV=0.35)

Final run

Recruitment, SSB, catch and Fbar (ages 0-3) estimates from the final model are provided in table 6.6.3.1, the resulting fishing mortality at age in Table 6.6.3.2 and the estimated stock abundance in Table 6.6.3.3.

Table 6.6.3.1. Red mullet GSA 7. Recruitment (rec, in thousands), spawning stock biomass (ssb, in tons), catch (in tons) and fbar estimated by the stock assessment model.

year	rec	ssb	catch	fbar
2002	53016.62	129.669	102.241	0.689
2003	56283.26	153.431	129.773	0.724
2004	58141.64	173.296	157.38	0.745
2005	65370.85	203.724	179.68	0.737
2006	64075.41	215.001	178.238	0.698
2007	54508.6	239.252	184.561	0.645
2008	63308.46	272.561	200.207	0.596
2009	77198.02	257.345	179.313	0.568
2010	89482.26	304.085	201.736	0.568
2011	87368.96	347.585	247.707	0.593
2012	94682.62	436.374	322.399	0.633
2013	102595.56	385.225	301.786	0.669
2014	105742.85	446.992	354.083	0.683
2015	112351.04	388.71	309.734	0.665
2016	113187.54	437.422	313.371	0.622
2017	101934.8	459.237	310.076	0.572
2018	122147.5	510.138	334.258	0.53
2019	139340.23	592.663	356.076	0.502
2020	143071.89	663.413	383.832	0.487
2021	109799.92	755.34	432.491	0.479

Table 6.6.3.2. Red mullet GSA 7. Fishing mortality at age resulting from the stock assessment model.

Year	0	1	2	3	4+
2002	0.02	0.485	1.255	0.996	0.42
2003	0.021	0.509	1.319	1.047	0.441
2004	0.021	0.524	1.357	1.077	0.454
2005	0.021	0.518	1.342	1.065	0.449
2006	0.02	0.491	1.272	1.01	0.425
2007	0.018	0.454	1.174	0.932	0.393
2008	0.017	0.419	1.086	0.862	0.363
2009	0.016	0.4	1.035	0.822	0.346
2010	0.016	0.4	1.035	0.821	0.346
2011	0.017	0.417	1.081	0.858	0.361
2012	0.018	0.445	1.153	0.915	0.386
2013	0.019	0.471	1.219	0.968	0.408
2014	0.019	0.48	1.244	0.987	0.416
2015	0.019	0.468	1.211	0.961	0.405
2016	0.018	0.438	1.134	0.9	0.379
2017	0.016	0.403	1.043	0.827	0.349
2018	0.015	0.373	0.965	0.766	0.323
2019	0.014	0.353	0.914	0.725	0.306
2020	0.014	0.342	0.887	0.704	0.296
2021	0.014	0.337	0.873	0.693	0.292

Table 6.6.3.3. Red mullet GSA 7. Stock abundance (in thousands) at age estimated by the model

Year	0	1	2	3	4
2002	53016.62	8300.262	1272.243	251.265	63.941
2003	56283.26	9124.532	2296.876	205.055	84.752
2004	58141.64	9677.108	2463.506	347.313	80.012
2005	65370.85	9990.719	2574.822	358.689	106.278
2006	64075.41	11235.538	2673.42	380.458	120.636
2007	54508.6	11024.891	3088.592	423.556	137.041
2008	63308.46	9393.182	3147.594	539.724	163.393
2009	77198.02	10924.784	2774.999	600.944	214.998
2010	89482.26	13332.138	3290.961	557.221	262.419
2011	87368.96	15453.639	4016.725	661.074	272.405
2012	94682.62	15077.927	4574.32	770.757	296.939
2013	102595.56	16321.628	4339.906	816.376	322.312
2014	105742.85	17667.299	4579.542	725.025	331.393
2015	112351.04	18202.301	4910.051	746.388	309.355
2016	113187.54	19349.745	5123.4	827.014	310.843
2017	101934.8	19517.419	5611.683	932.431	346.508
2018	122147.5	17602.217	5863.336	1118.878	411.316
2019	139340.23	21118.14	5448.755	1263.331	515.682
2020	143071.89	24109.866	6667.683	1235.709	625.688
2021	109799.92	24766.089	7692.291	1553.642	680.903

Through the years, the fishing mortality has decreased by roughly 30% on Red Mullet, starting from 0.69 to reach 0.48 in 2021 (Table 6.6.3.1 & Figure 6.6.3.1). The model estimates that recruitment has increased steadily since 2008, reached a maximum in 2020, and now seems to decrease again – a tendency that must be confirmed by future data. As a result, spawning stock biomass has increased since 2010, and is estimated in 2021 to be almost 6 times higher than at the beginning of the series in 2002.

The reasons behind this increase are unclear. First, an environmental regime shift occurred in the Gulf of Lions between 2005 and 2010. Small pelagics and especially sardines responded to it with increased mortality at higher ages, leaving only smaller individuals in the population with sizes unsuitable for commercial purpose. As a result, the fishery strongly reconfigured in GSA 7, with the former pelagic trawlers subsequently reporting their effort on demersal species. Then, effort on demersal stocks have been exceptionably strong and economically unsustainable between 2008 and 2012, ultimately leading to the reduction of the number of active demersal trawlers in 2012 (Figure 6.6.3.2). Furthermore, red mullet is known to be a relatively fast growing, productive species. All these factors have probably all contributed to the positive trend of the stock. New environmental conditions in the Gulf of Lion after the regime shift may have been more suitable for red mullet recruitment, while fishing effort reduction after 2012 also possibly contributed to the increased survival of adults.

A last element of caution regarding this assessment is the increase in the use of OTT in the French fleet, the fishing efficiency of which is globally superior to OTB (see EWG 21_01 on conversion factors), with possibly a differing selectivity when compared to OTB. The assessment now assumes the same selectivity for all trawlers, but gear-specific selectivity patterns could be investigated to explicitly distinguish between OTB and OTT in the assessment.

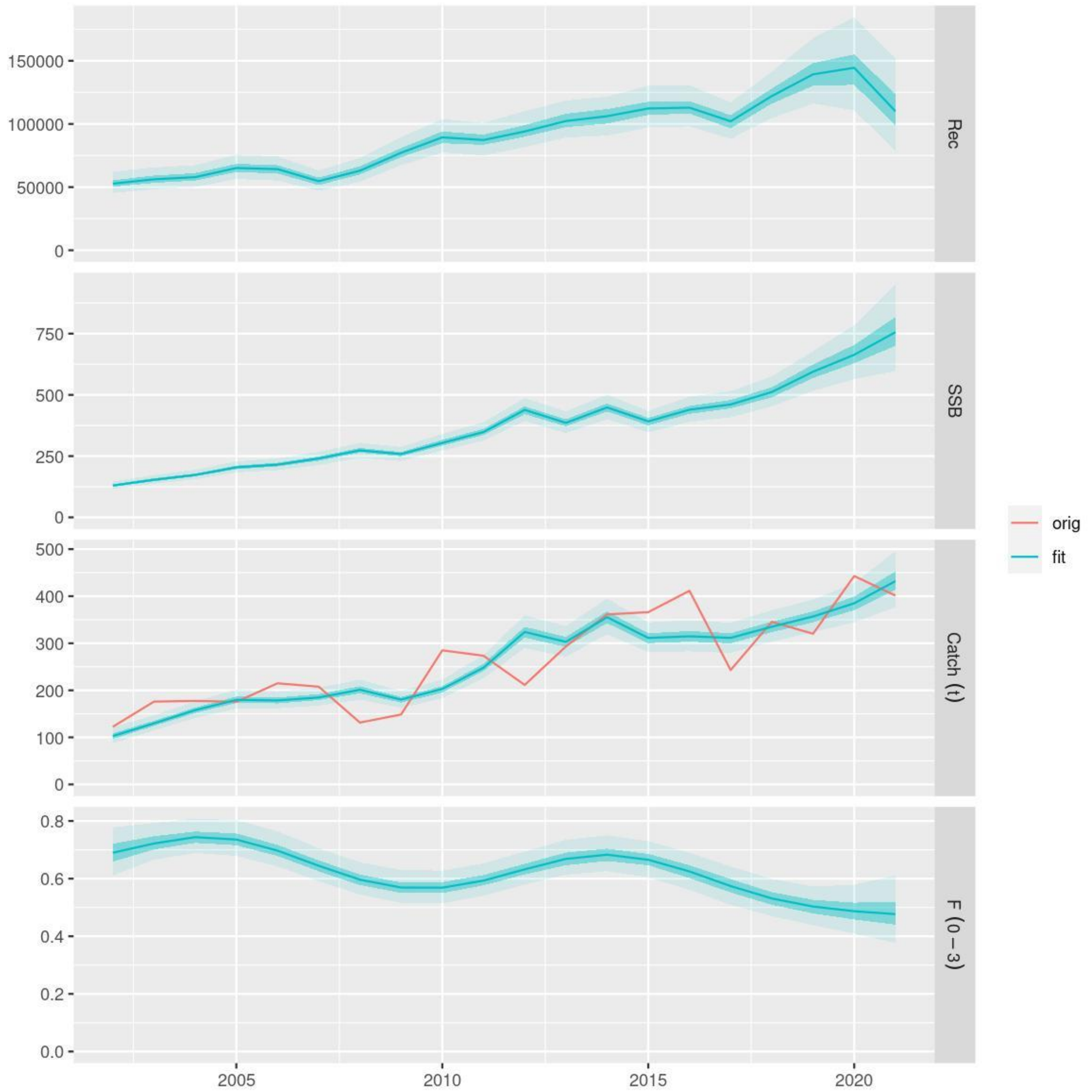


Fig 6.6.3.1. Red mullet GSA 7. Time series and confidence intervals of Recruitment, SSB, Catch and Fbar estimated by the model, together with confidence intervals. The red line corresponds to the observed catch.

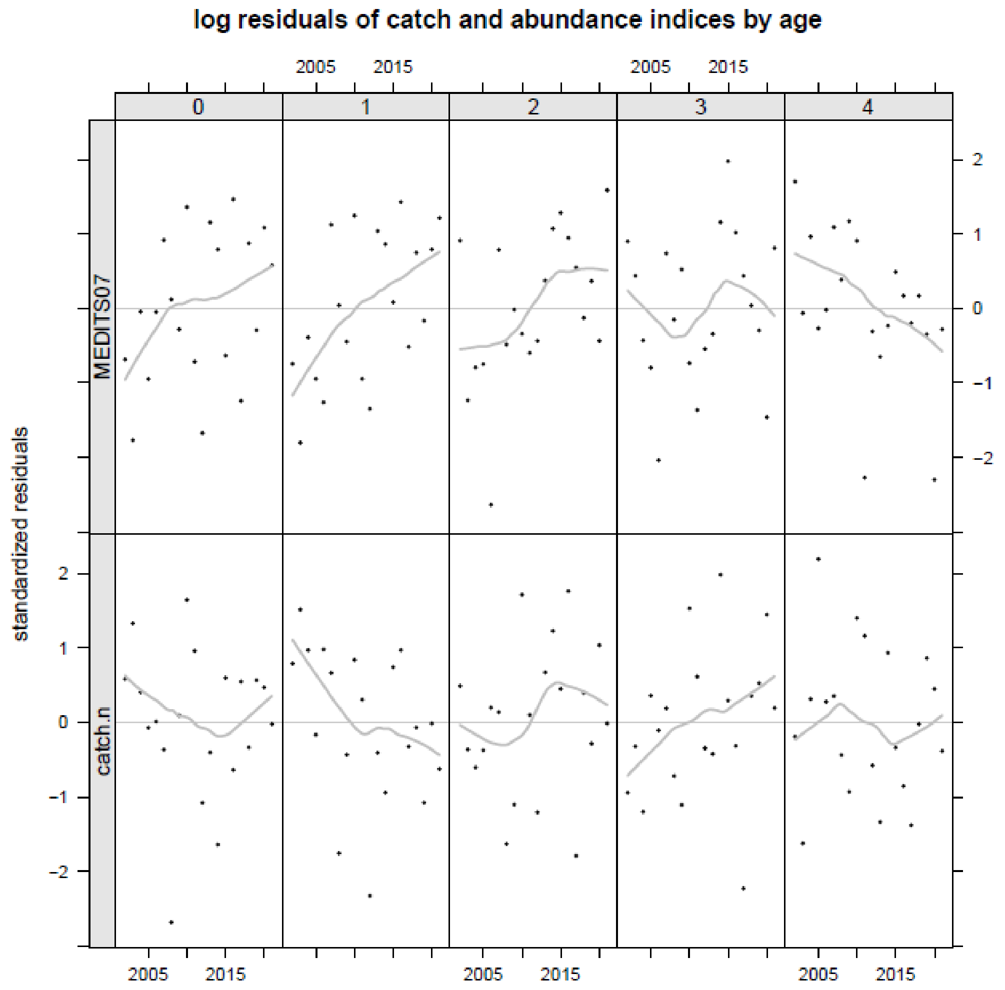


Fig 6.6.3.2. Red mullet GSA 7. Log residuals from the stock assessment model.

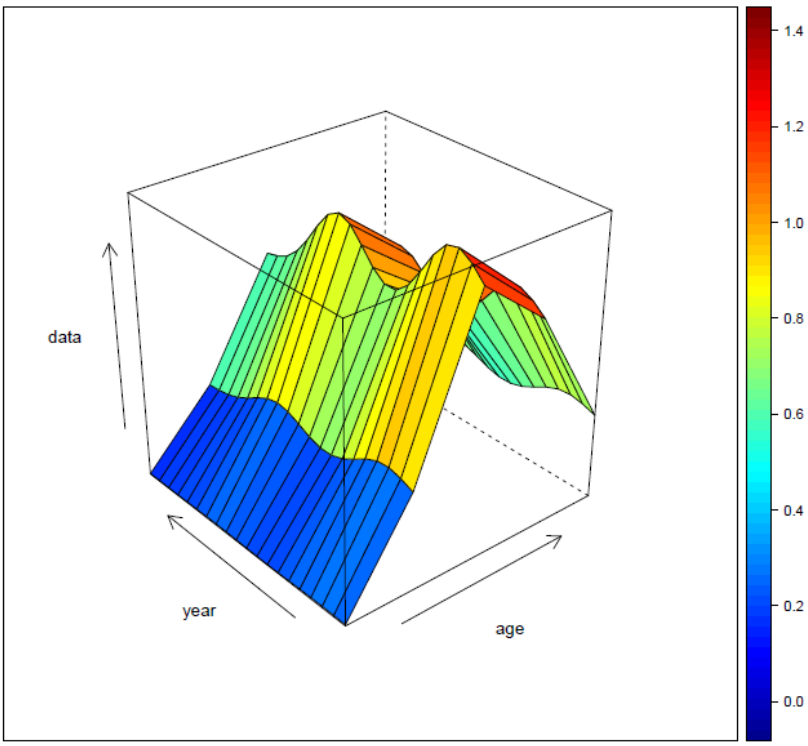
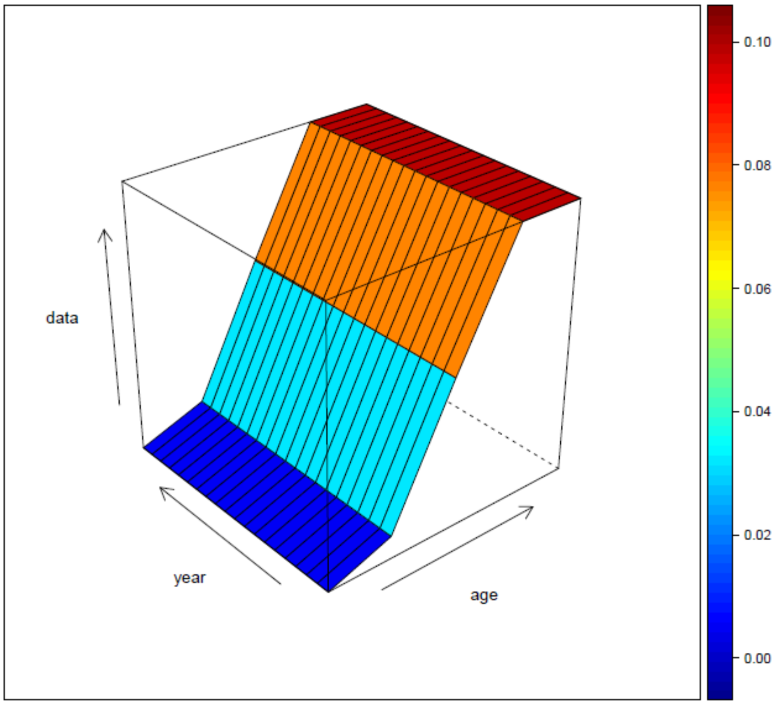


Figure 6.6.3.3. Red mullet GSA 7. Fishing mortality at age through the years

As in previous years, Log-residuals (Figure 6.6.3.3) exhibited few patterns, except for positive residuals at age 1 for the catch at the first half of the series (up to 2010).

Tri-dimensional representation of fishing mortality at age through the years (Fig 6.6.3.4) suggests that fishing mortality is quite low at age 0 compared to other ages, and is also somewhat reduced at older ages. Survey catchability (Figure 6.6.3.5) is assumed constant through the years, but increases with age up to age 3, in accordance with the catchability



submodel specification.

Figure 6.6.3.4. Red mullet GSA 7. Survey catchability at age through the years

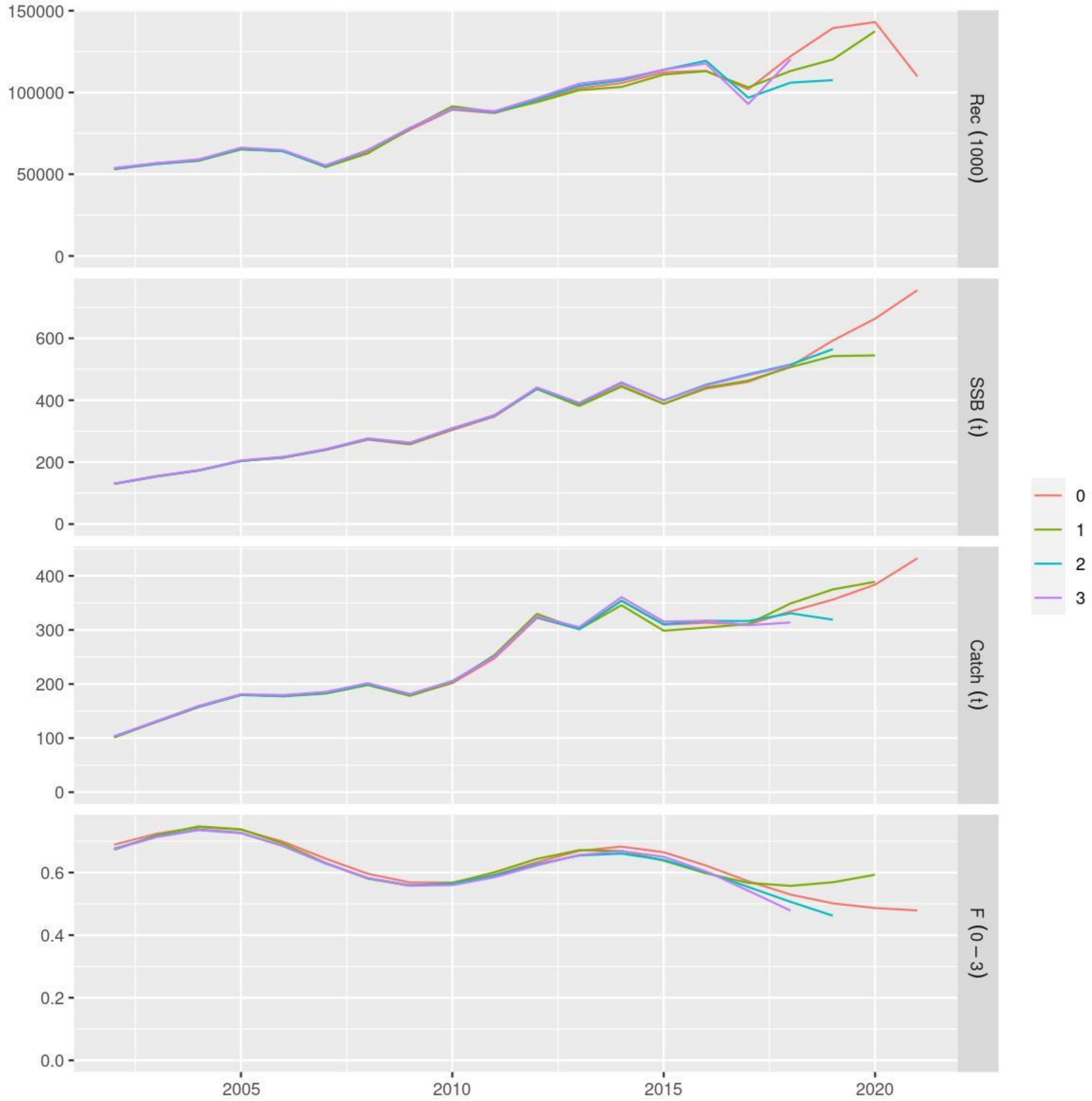


Figure 6.6.3.5. Retrospective analysis carried out for the selected model.

6.6.4 Reference points.

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4. An exploratory per-recruit analysis was performed on the new assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.6.4.1 and Figure 6.6.4.1.

Table 6.6.4.1. Red mullet GSA 7. Per-recruit reference points.

$F_{0.1}$	B_{msy}	B_{lim}	F_{lim}	Yeq	B_0
0.471	491.49	122.87	1.5685	273.26	1486.56

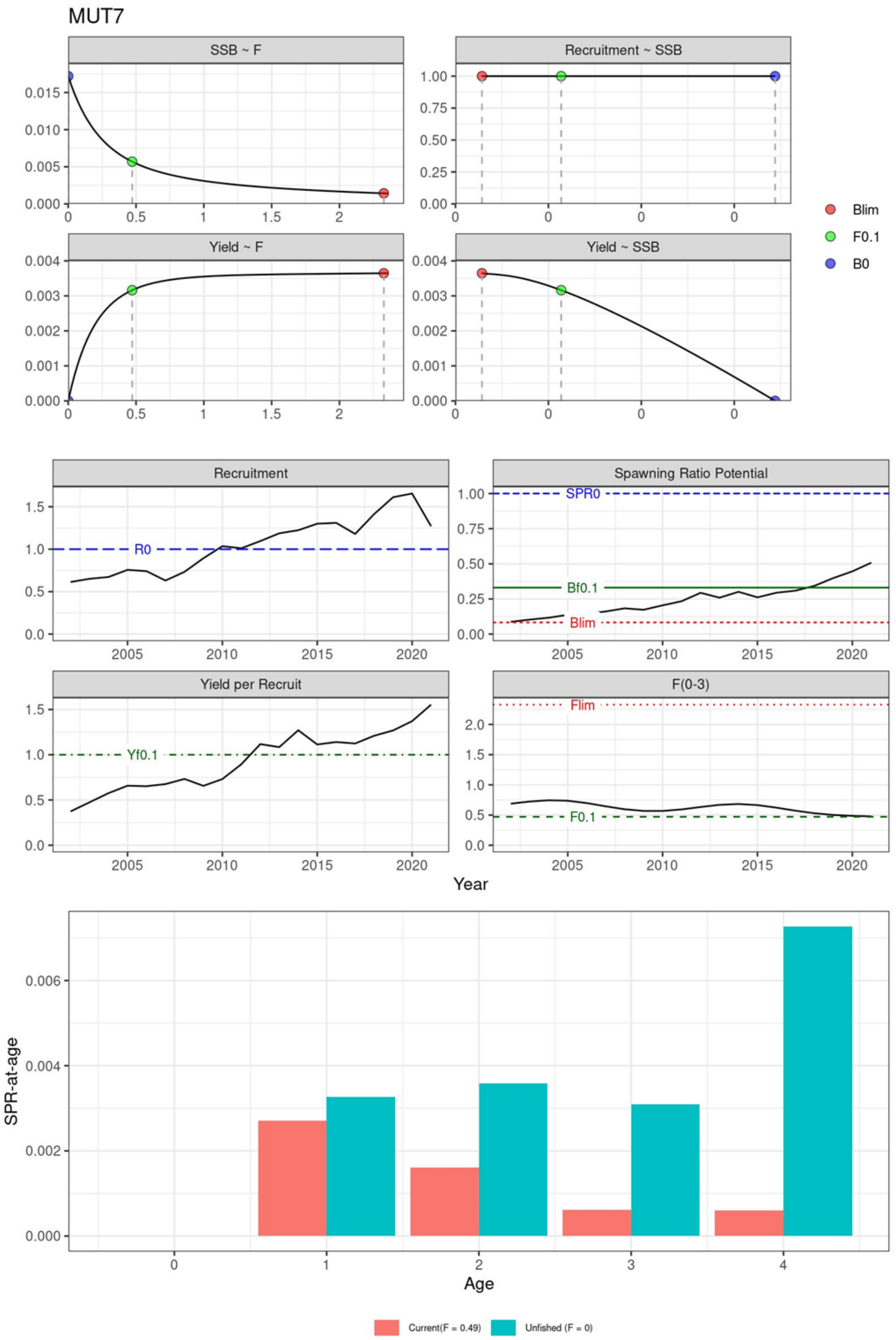


Figure 6.6.4.1. Red mullet GSA 7. Per-recruit analysis.

Spawning ratio potential has been increasing from B_{lim} and is now above $B_{f0.1}$, traducing a progressive evolution from strong overfishing towards a more sustainable situation. Observed fishing mortality now lies very close to $F_{0.1}$. In unfished scenarios, biomasses are supposed to increase at all ages, but especially for older ages.

Stock-recruitment models

Four recruitment functions were explored: Geometric Mean "GM"; Hockey-stick "HS", Beverton-Holt "BH", Ricker "Ri" (Figure 6.6.4.2).

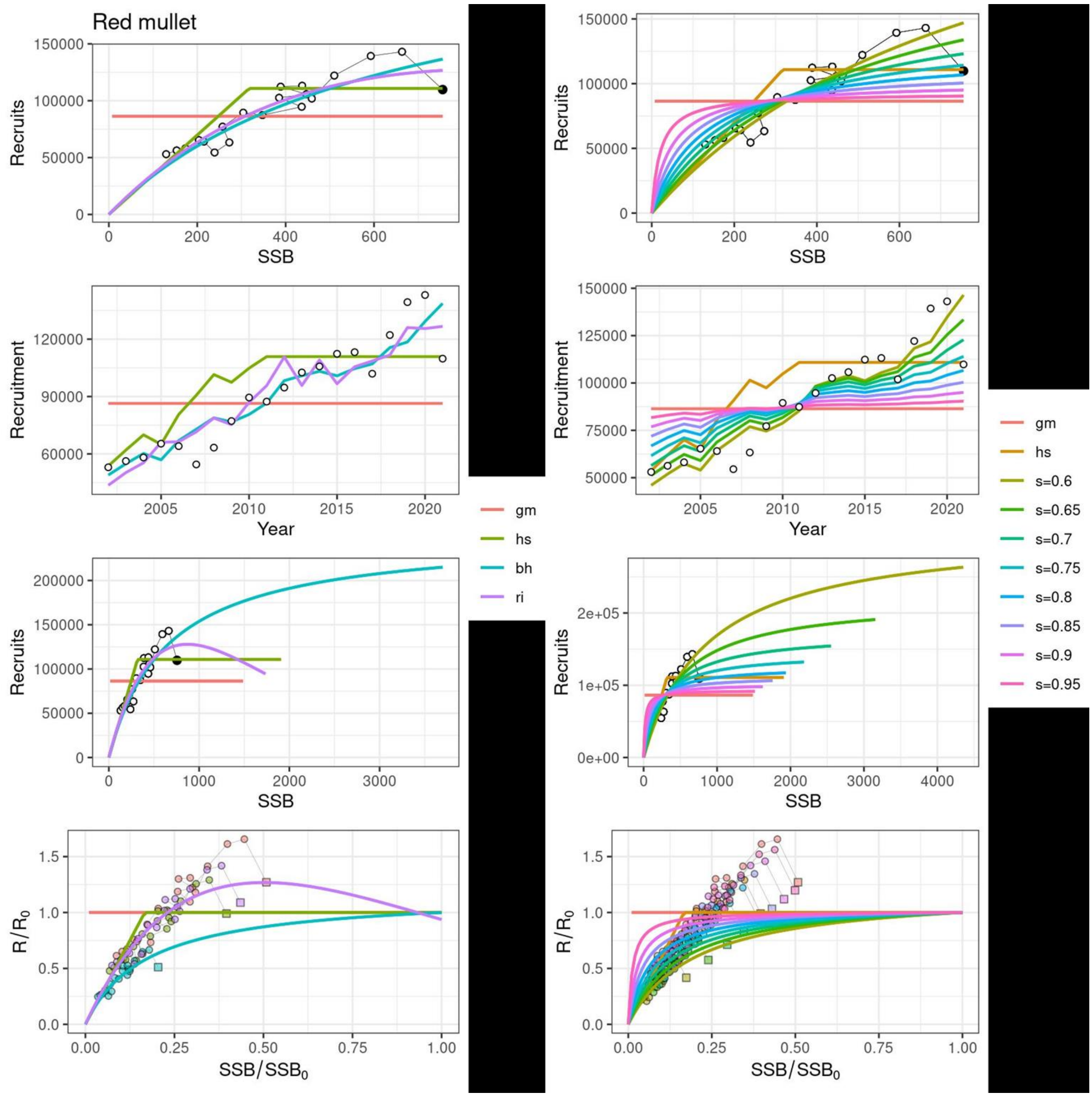


Fig 6.6.4.2. Red mullet GSA 7. Stock-recruitment models.

With the new 2021 data point, the fit of the HS model was quite different from the one obtained during EWG 22_09. Hence, the HS model was deemed unstable and unsuitable, and following the procedure from EWG 22-03 it was decided to consider the Geometric-mean approach as the most adequate to estimate the biomass reference points for the stocks of red mullet in GSA 7 (Fig 6.6.4.3 & 6.6.4.4., Table 6.6.4.2). The resulting value for B_{lim} and B_{pa} are different by 4%, but the $B_{F0.1}$ has increased substantially due to the different treatment.

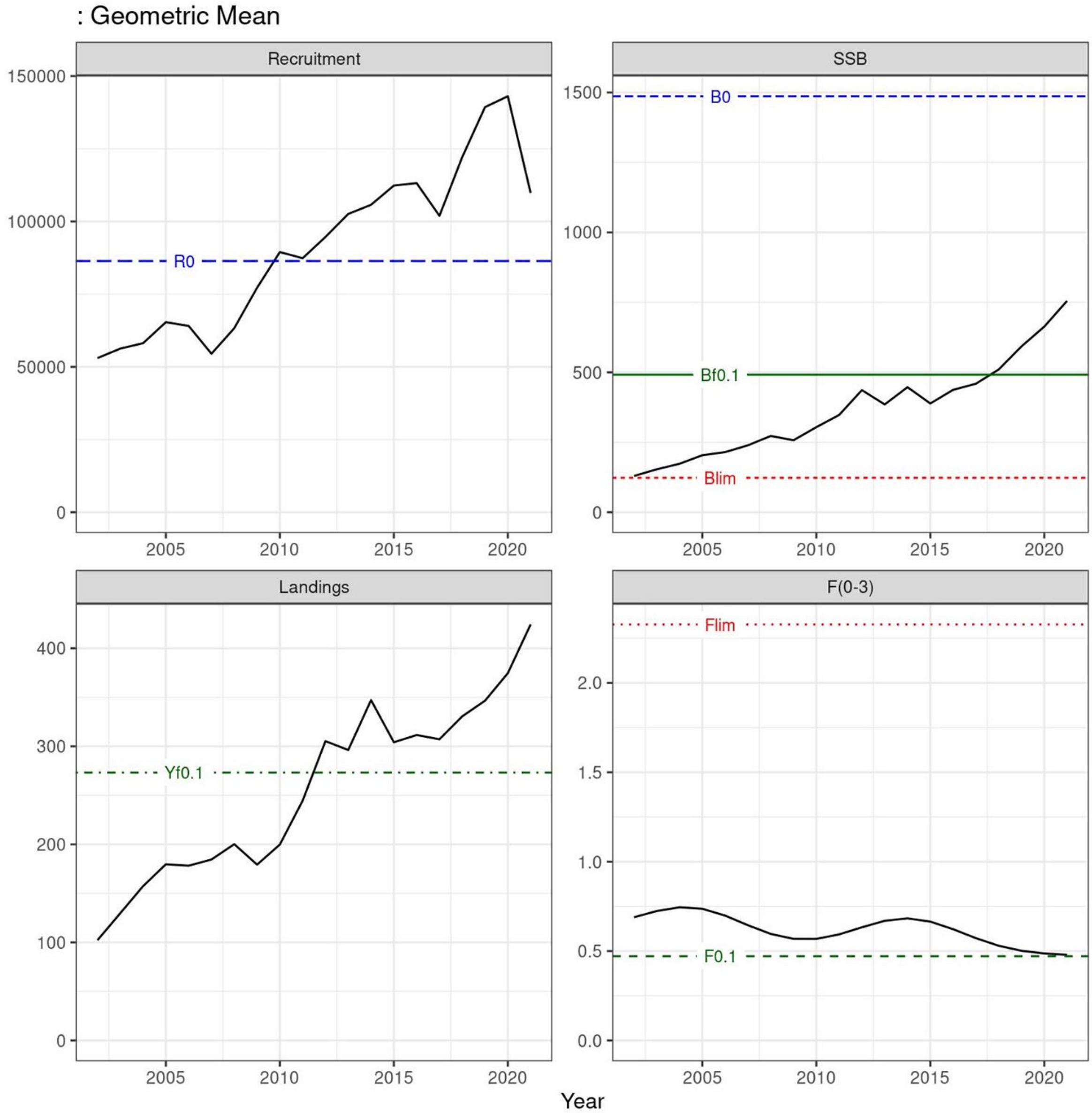


Figure 6.6.4.3. Red mullet GSA 7. Status advice plot.

Table 6.6.4.2. Red mullet GSA 7. Final reference points for MUT 7 based on the geometric mean model.

$F_{0.1}$	B_{trg}	B_{lim}	F_{lim}	Yeq	B_0
0.471	491	123	2.332	273	1487

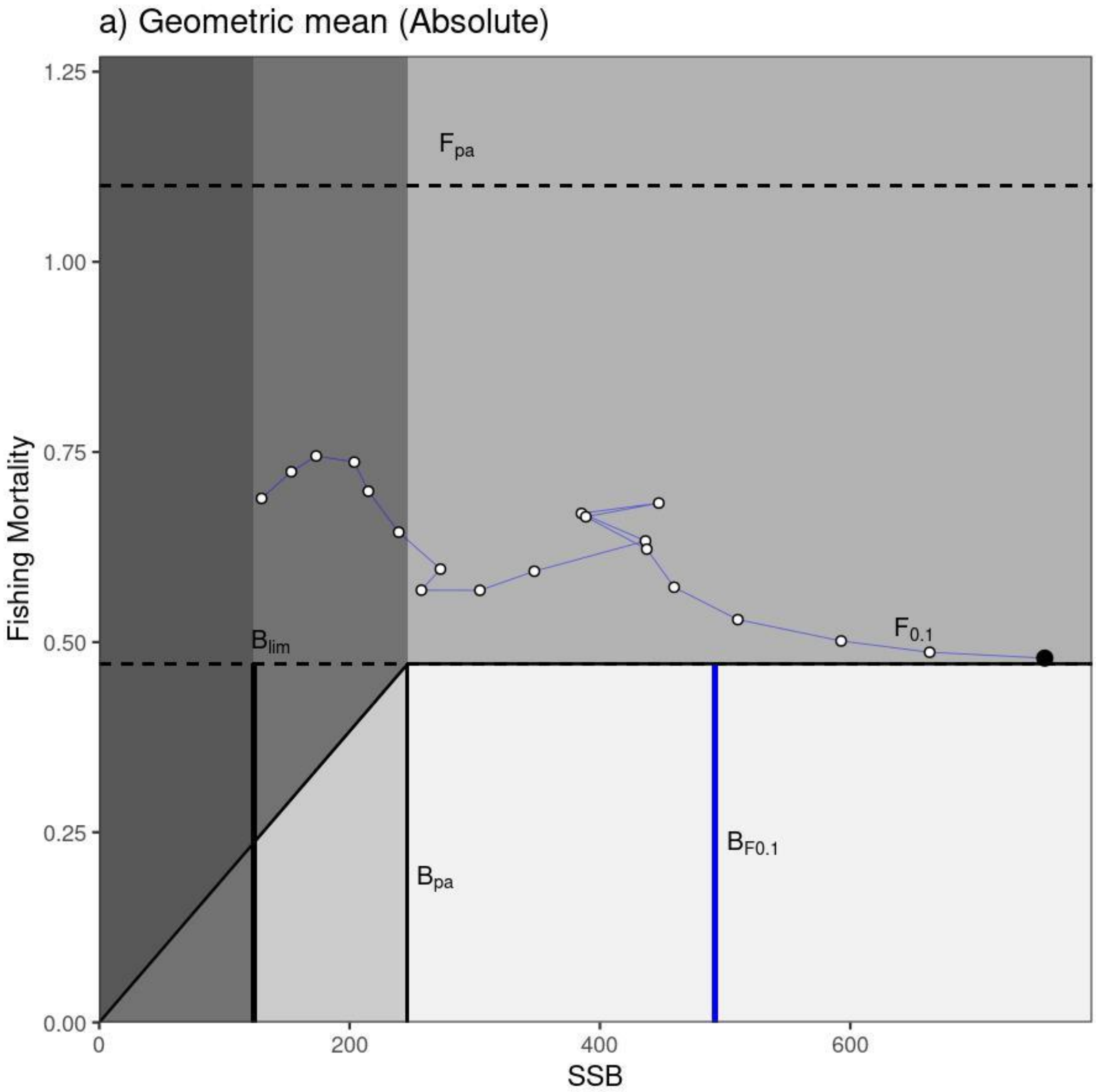


Fig 6.6.4.4. Red mullet GSA 7. Advice Rule plots, with B_{pa} = 2* B_{lim}, showing the results of the Geometric mean model with an empirical B_{lim} set as 0.25* $B_{F0.1}$.

6.6.5 SHORT-TERM FORECAST

Input parameters used in the stock assessment were used for the STF (Figure 14). Different scenarios of constant harvest strategy with F_{bar} calculated as the average of ages 0 to 3 and F status quo (F_{stq} = 0.479 based on F in 2021) were performed. Recruitment (class 0) has been estimated as the geometric mean of the stock assessment output since 2015 as it corresponds to the high-recruitment time period. $F_{MSY\ Transition}$ has been estimated as a linear transition from F_{2019} to reach F_{MSY} in 2025.

Table 6.6.5.1 Red Mullet in GSA 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological parameters	3 year average	Default assumptions for M, Mat, mean weight at age fishery selection etc.
$F_{ages\ 0\text{-}3}$ (2022)	0.479	F 2022 used to give F status quo for 2021
SSB (2022)	755	Stock assessment 1 January 2021
R_{age0} (2022,2023)	120650	Geometric mean of the last 6 years
Total catch (2022)	421	Assuming F status quo for 2021

Table 6.6.5.2. Red Mullet in GSA 7: Short-term forecast

Rationale	F factor	Fbar	Recruitment 2022	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB change 2022-2024 (%)	Catch change 2021-2023 (%)
High long term yield (F0.1)	0.984	0.471	120653.5	0.479	432.491	420.542	380.49	685.358	684.087	-0.186	-12.024
F upper	1.345	0.644	120653.5	0.479	432.491	420.542	476.821	685.358	571.546	-16.606	10.25
F lower	0.656	0.314	120653.5	0.479	432.491	420.542	275.695	685.358	817.928	19.343	-36.254
FMSY transition	1.005	0.481	120653.5	0.479	432.491	420.542	386.576	685.358	676.675	-1.267	-10.616
Zero catch	0	0	120653.5	0.479	432.491	420.542	0	685.358	1223	78.446	-100
Status quo	1	0.479	120653.5	0.479	432.491	420.542	385.053	685.358	678.525	-0.997	-10.968
Different Scenarios	0.1	0.048	120653.5	0.479	432.491	420.542	48.989	685.358	1145.69	67.167	-88.673
	0.2	0.096	120653.5	0.479	432.491	420.542	95.202	685.358	1074.82	56.826	-77.987
	0.3	0.144	120653.5	0.479	432.491	420.542	138.829	685.358	1009.78	47.336	-67.9
	0.4	0.192	120653.5	0.479	432.491	420.542	180.045	685.358	950.036	38.619	-58.37
	0.5	0.239	120653.5	0.479	432.491	420.542	219.014	685.358	895.095	30.603	-49.36
	0.6	0.287	120653.5	0.479	432.491	420.542	255.886	685.358	844.522	23.223	-40.834
	0.7	0.335	120653.5	0.479	432.491	420.542	290.802	685.358	797.919	16.424	-32.761
	0.8	0.383	120653.5	0.479	432.491	420.542	323.889	685.358	754.929	10.151	-25.111
	0.9	0.431	120653.5	0.479	432.491	420.542	355.27	685.358	715.229	4.358	-17.855
	1.1	0.527	120653.5	0.479	432.491	420.542	413.344	685.358	644.554	-5.954	-4.427
	1.2	0.575	120653.5	0.479	432.491	420.542	440.237	685.358	613.076	-10.547	1.791
	1.3	0.623	120653.5	0.479	432.491	420.542	465.821	685.358	583.875	-14.807	7.707
	1.4	0.671	120653.5	0.479	432.491	420.542	490.179	685.358	556.755	-18.764	13.339
	1.5	0.718	120653.5	0.479	432.491	420.542	513.388	685.358	531.537	-22.444	18.705
	1.6	0.766	120653.5	0.479	432.491	420.542	535.517	685.358	508.06	-25.869	23.822
	1.7	0.814	120653.5	0.479	432.491	420.542	556.634	685.358	486.178	-29.062	28.704
	1.8	0.862	120653.5	0.479	432.491	420.542	576.8	685.358	465.757	-32.042	33.367
	1.9	0.91	120653.5	0.479	432.491	420.542	596.072	685.358	446.677	-34.826	37.823
	2	0.958	120653.5	0.479	432.491	420.542	614.504	685.358	428.828	-37.43	42.085

Fishing at $F_{0.1}$ (0.471) generates a decrease of the catch of 12% from 2021 to 2023 and has almost no effect on the SSB (-0.186% from 2022 to 2024).

6.7 Norway Lobster in GSA 5

6.7.1 Stock Identity and Biology

GSA 5 (Figure 6.7.1.1) has been pointed as an individualized area for assessment and management purposes in the western Mediterranean (Quetglas *et al.*, 2012) due to its main specificities. These include: 1) Geomorphological, the Balearic Islands (GSA 5) are clearly separated from the Iberian Peninsula (GSA 6) by depths between 800 and 2000 m, which would constitute a natural barrier to the interchange of adult stages of demersal resources; 2) Physical geographically-related characteristics, such as the lack of terrigenous inputs from rivers and submarine canyons in GSA 5 compared to GSA 6, give rise to differences in the structure and composition of the trawling grounds and hence in the benthic assemblages; 3) Owing to these physical differences, the faunistic assemblages exploited by trawl fisheries differ between GSA 5 and GSA 6, resulting in large differences in the relative importance of the main commercial species; 4) There are no important or general interactions between the demersal fishing fleets in the two areas, with only local cases of vessels targeting red shrimp in GSA 5 but landing their catches in GSA 6; 5) Trawl fishing exploitation in GSA 5 is much lower than in GSA 6; the density of trawlers around the Balearic Islands is one order of magnitude lower than in adjacent waters; and 6) Due to this lower fishing exploitation, the demersal resources and ecosystems in GSA 5 are in a healthier state than in GSA 6, which is reflected in the population structure of the main commercial species (populations from the Balearic Islands have larger modal sizes and lower percentages of small-sized individuals), and in the higher abundance and diversity of elasmobranch assemblages.

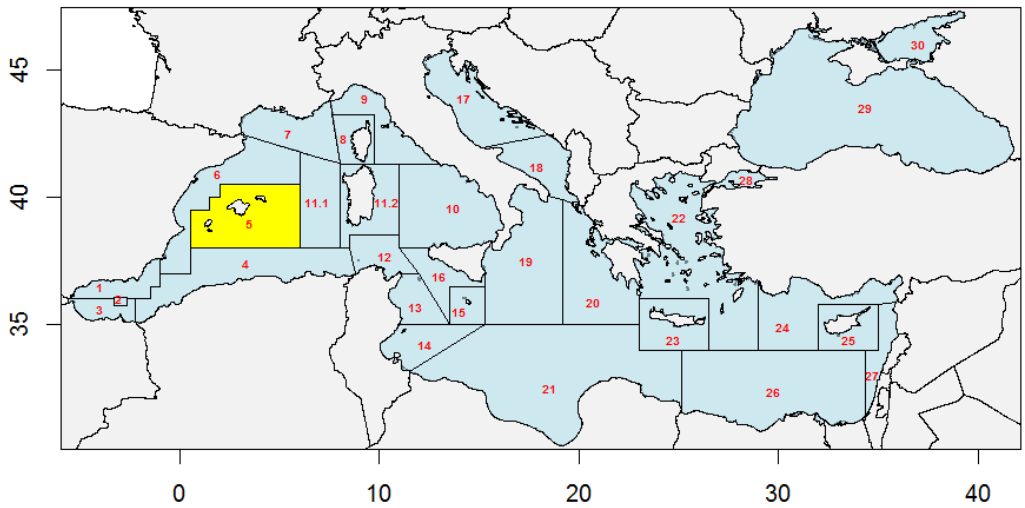


Figure 6.7.1.1. Geographical localization of GSA 5.

For Norway lobster (*Nephrops norvegicus* designated by the ASFIS 3-letters code "NEP") aas the stock had been evaluated in 2020 and it had not been possible to obtain an assessment, one year on it is considered that attempting an assessment would be unproductive. For completeness the biological parameters, natural mortality vector and maturity ogive used for the assessment of *N. norvegicus* were those shown in the following tables. Growth and length-weight parameters (Table 6.7.1.1) were those from the last Med&BS data call. Length-weight parameters for 2016 give a very different relation (Figure 6.7.6.1). Natural mortality vector (Table 6.7.1.2) and the proportion of mature (Table 6.7.1.3) were the same presented in 2020.

Table 6.7.1.1. Norway Lobster in GSA 5. Growth and length-weight parameters.

Growth	
L_{inf} (cm)	86.1
k	0.126
t_0	0
Length-Weight	
a	0.000493
b	3.08

Table 6.7.1.2. Norway Lobster in GSA 5. Natural Mortality vector.

Age	1	2	3	4	5	6	7	8	9+
M	0.732	0.466	0.353	0.291	0.252	0.226	0.206	0.191	0.18

Table 6.7.1.3. Norway Lobster in GSA 5. Maturity ogive.

Age	1	2	3	4	5	6	7	8	9+
Mat.	0.10	0.25	0.80	1.00	1.00	1.00	1.00	1.00	1.00

6.7.2 DATA

General description of the fisheries

In the Balearic Islands (western Mediterranean), commercial trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope (Guijarro and Massutí 2006; Ordines et al. 2006), mainly targeted to: (i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50-80 m); (ii) *Merluccius merluccius*, *M. surmuletus*, *Zeus faber* and a mixed fish category on the deep shelf (80-250 m); (iii) *Nephrops norvegicus*, but with an important by-catch of big *M. merluccius*, *Lepidorhombus spp*., *Lophius spp.* And *Micromesistius poutassou* on the upper slope (350-600 m) and (iv) *Aristeus antennatus* on the middle slope (600-750 m). The Norway lobster, *N. norvegicus*, is the main target species in the upper slope.

Management regulations

- Fishing license: number of licenses observed
- Engine power limited to 316 KW or 500 HP: not fully observed.
- Mesh size in the cod-end (before Jun 1st 2010: 40 mm, diamond: after Jun 1st 2010: 40 mm square or 50 mm diamond –by derogation-): fully observed.
- Time at sea (12 hours per day and 5 days per week): fully observed.
- Minimum landing size (EC regulation 1967/2006, 2 cm carapace length): mostly fully observed.

6.7.2.1 CATCH (LANDINGS AND DISCARDS)

Landings for Norway lobster in GSA 5 come exclusively from bottom trawlers. During last years, catches has shown an increasing trend, but this has not continued in the last three years (Figure 6.7.2.1, Table 6.7.2.1) Discards are reported at very low levels in some years (Figure 6.7.2.2, Table 6.7.2.2). In 2021 < 1 tons of discards were reported. Overall discards can be considered negligible.

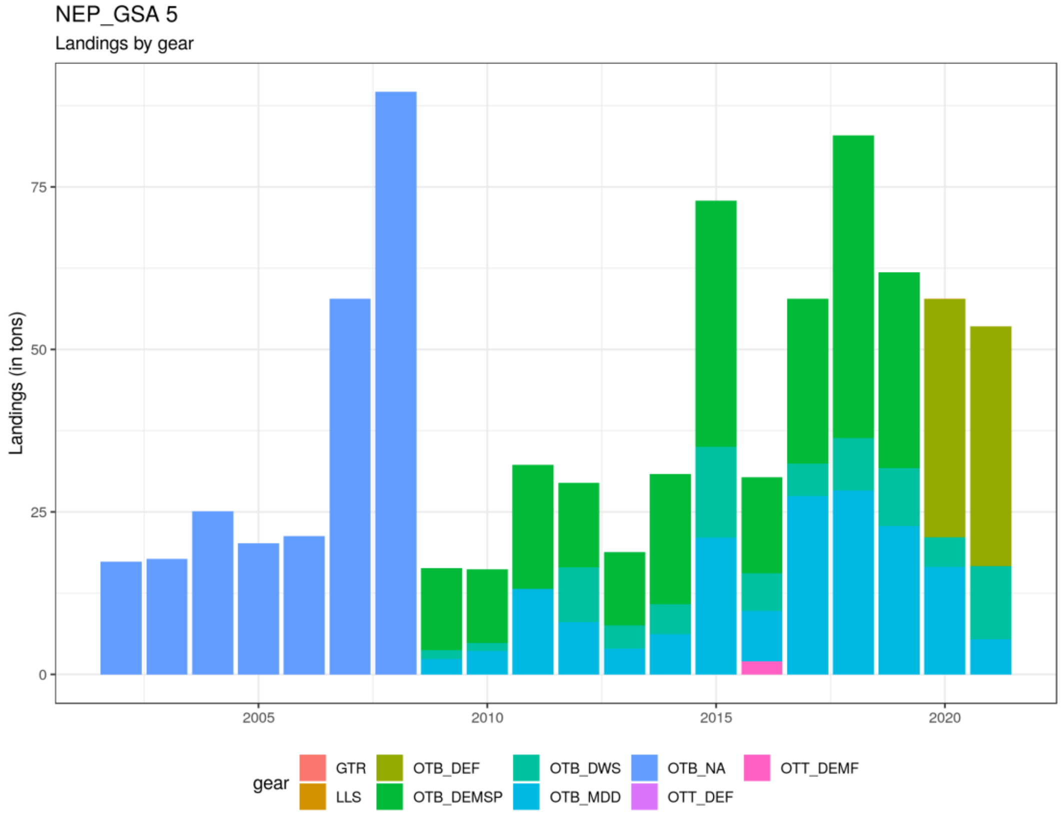


Figure 6.7.2.1. Norway Lobster in GSA 5. Reported landings (in tons) by gear from the STECF Med&BS Data call.

Table 6.7.2.1. Norway Lobster in GSA5. Reported landings (in tons) by gear from the STECF Med&BS Data call.

year	GTR	LLS	OTB_DEF	OTB_DEMSP	OTB_DWS	OTB_MDD	OTB_NA	OTT_DEF	OTT_DEMF	total
2002	0	0	0	0	0	0	17.32	0	0	17.32
2003	0	0	0	0	0	0	17.77	0	0	17.77
2004	0	0	0	0	0	0	25.09	0	0	25.09
2005	0	0	0	0	0	0	20.17	0	0	20.17
2006	0	0	0	0	0	0	21.27	0	0	21.27
2007	0	0	0	0	0	0	57.78	0	0	57.78
2008	0	0	0	0	0	0	89.63	0	0	89.63
2009	0	0	0	12.63	1.34	2.37	0	0	0	16.34
2010	0	0	0	11.35	1.22	3.62	0	0	0	16.19
2011	0	0	0	19.08	0.04	13.14	0	0	0	32.26
2012	0	0	0	13.04	8.42	8.04	0	0	0	29.5
2013	0	0	0	11.26	3.58	3.98	0	0	0	18.82
2014	0	0	0	19.96	4.65	6.19	0	0	0	30.8
2015	0	0	0	37.83	14.03	21.01	0	0	0	72.87
2016	0	0	0	14.76	5.77	7.8	0	0	1.98	30.31
2017	0	0	0	25.37	4.98	27.47	0	0	0	57.82
2018	0	0	0	46.51	8.08	28.32	0	0	0	82.91
2019	0	0	0	30.12	8.91	22.81	0	0	0	61.84
2020	0.02	0.01	36.69	0	4.55	16.53	0	0	0	57.8
2021	0.01	0	36.9	0	11.28	5.37	0	0	0	53.56

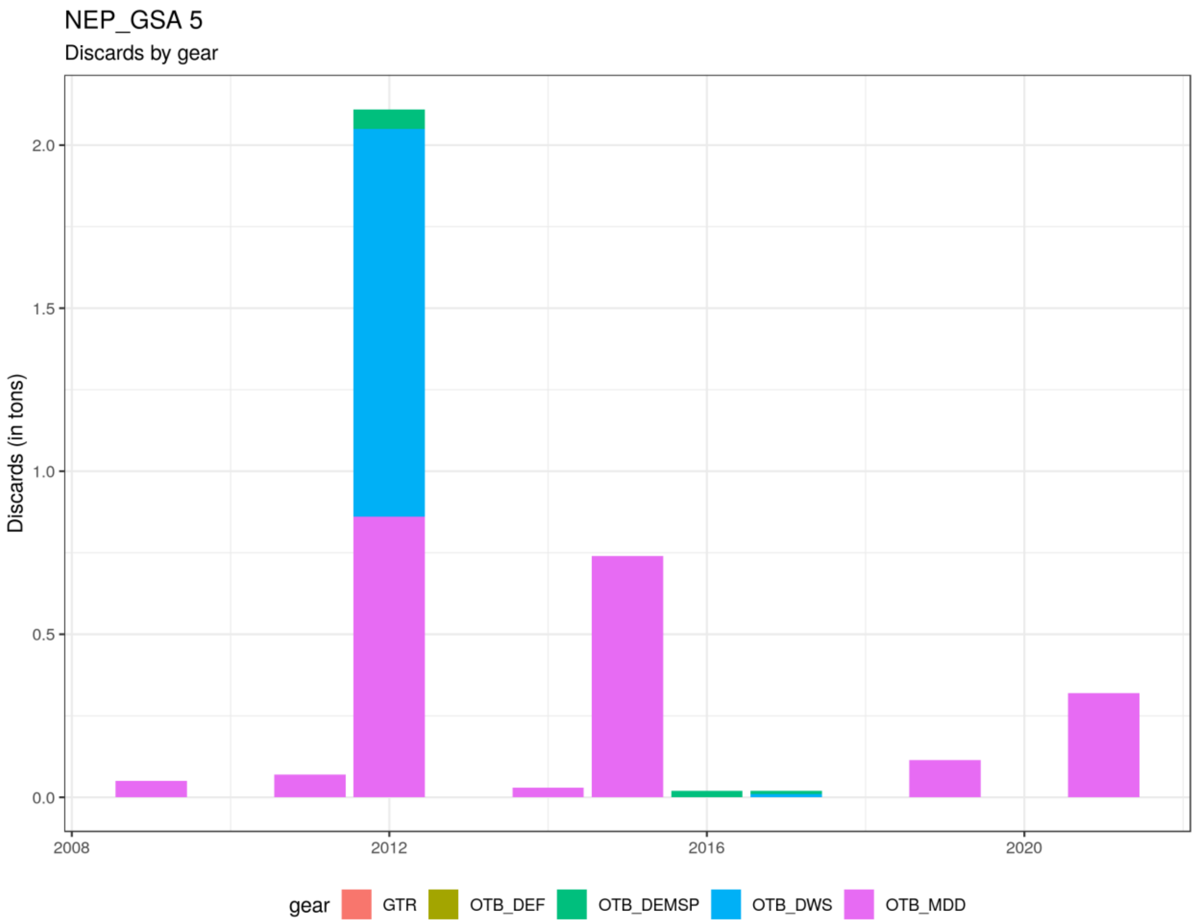


Figure 6.7.2.2. Norway Lobster in GSA 5. Reported discards (in tons) by gear from the STECF Med&BS data call.

Table 6.7.2.2. Norway Lobster in GSA5. Reported discards (in tons) by gear from the STECF Med&BS data call.

year	GTR	OTB_DEF	OTB_DEMSP	OTB_DWS	OTB_MDD	total
2009	0	0	0	0	0.05	0.05
2010	0	0	0	0	0	0
2011	0	0	0	0	0.07	0.07
2012	0	0	0.06	1.19	0.86	2.11
2013	0	0	0	0	0	0
2014	0	0	0	0	0.03	0.03
2015	0	0	0	0	0.74	0.74
2016	0	0	0.02	0	0	0.02
2017	0	0	0.01	0.01	0	0.02
2018	0	0	0	0	0	0
2019	0	0	0	0	0.11	0.11
2021	0	0	0	0	0.32	0.32

Evaluation of length frequency distribution data from STECF Med&BS for the Norway lobster in GSA 5 shows that most of the information comes from OTB_DEMSP up to 2019 and OTB_DEF since 2020 (Figure 6.7.2.3); there is no sample data before 2009. The change in gear type results not from a change in the fishery, just a redefinition of the gear designations.

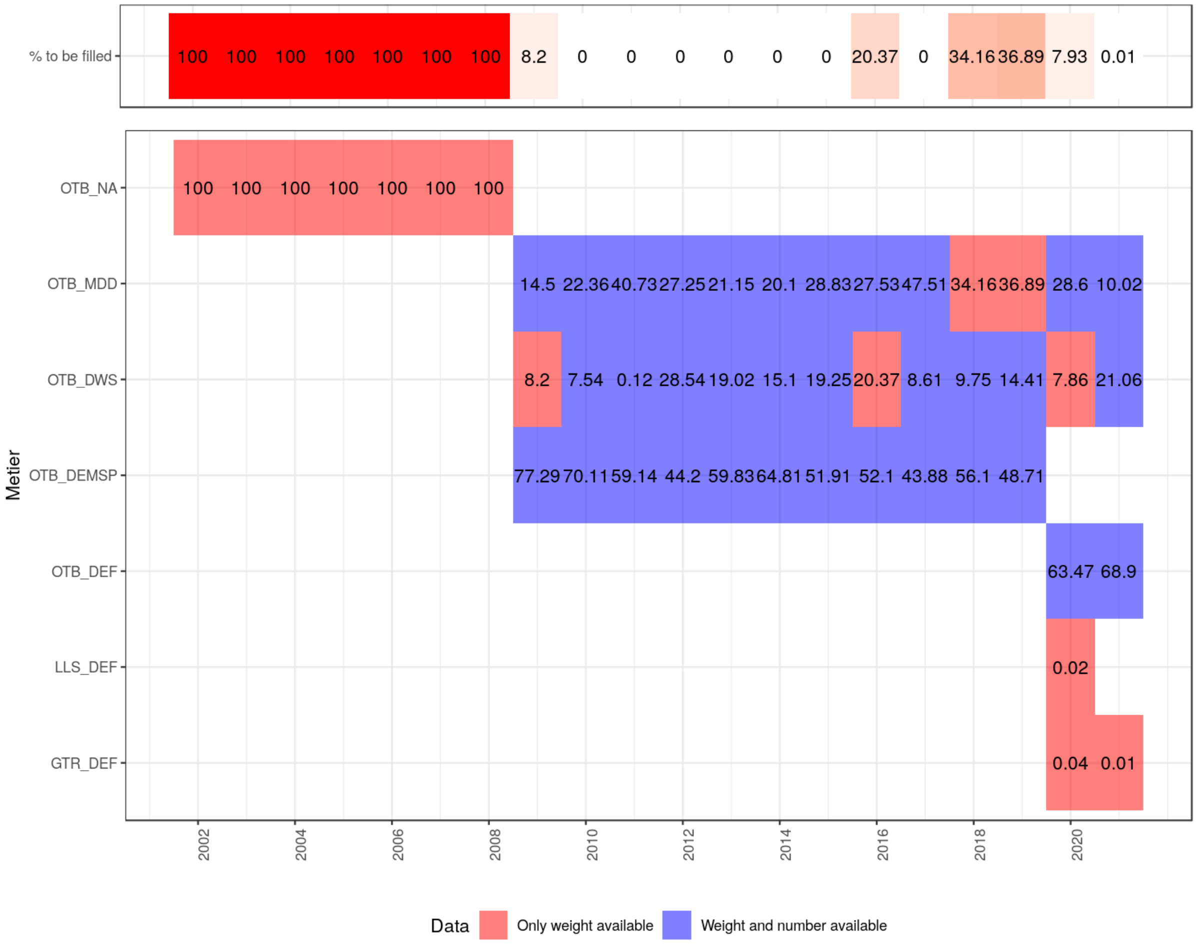


Figure 6.7.2.3. Norway Lobster in GSA 5. Sampling of landings by gear from the STECF Med&BS data call.

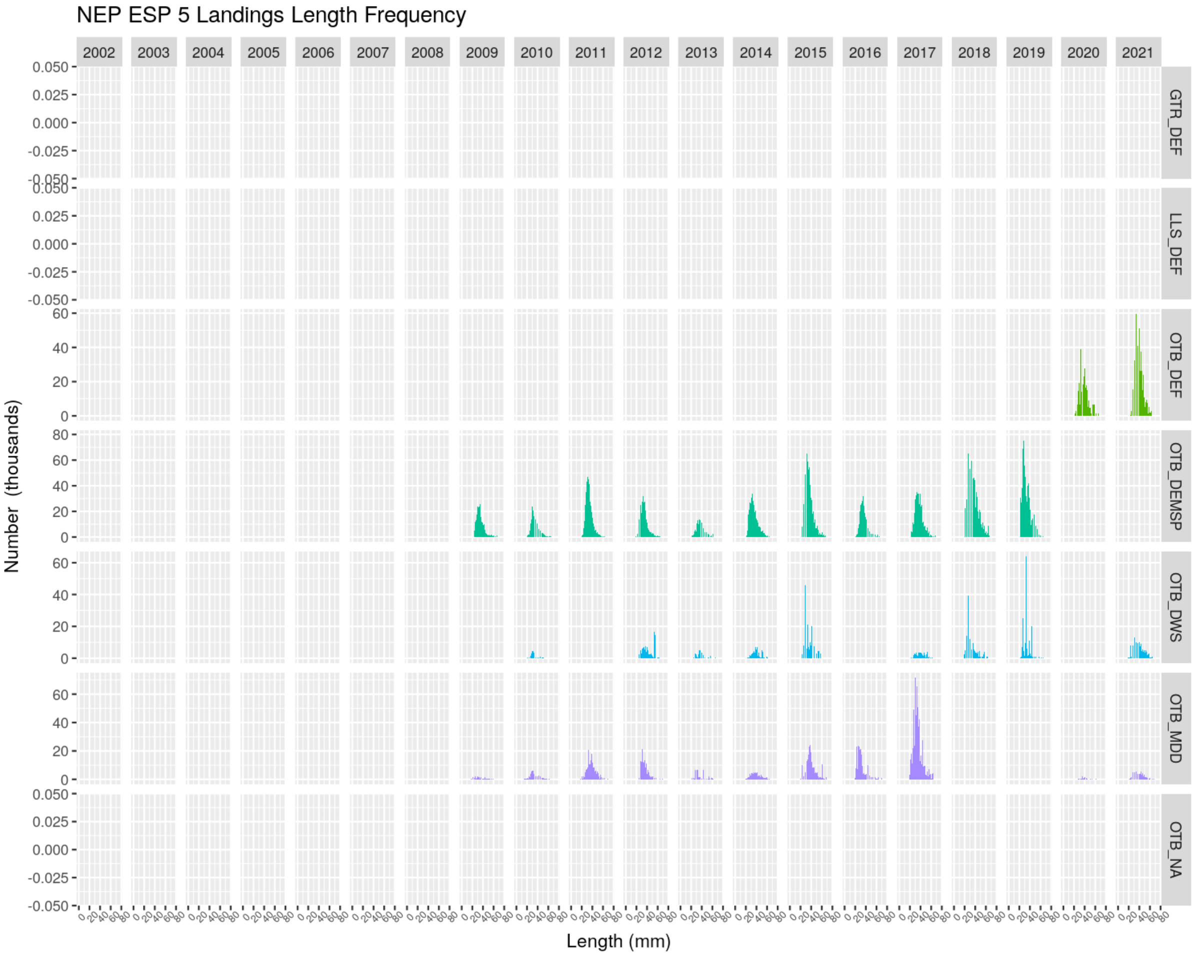


Figure 6.7.2.4. Norway Lobster in GSA5. Landing length frequency distribution, by year and métier (CL in mm, numbers in thousands) from the STECF Med&BS data call.

Table 6.7.2.3. Norway Lobster in GSA 5. Length structure (CL in mm, numbers in thousands) for total landings reported in the STECF Med&BS data call...

length	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
12	0	0	0	0	0	0	0	0	0	0	0	0	0.87
13	0.23	0.06	0	0	0	0	0	0	0	0	0	0	0
14	0	0.25	0.24	0	0	0	0	0	0	0	0	0	0
15	0	0.38	0	0	0	0	0	0	0	0	0	0	0.19
16	0	0.44	0	0.28	0	0	0	0.12	0	0	0	0	0
17	0.11	0.38	0.25	0	0	0.06	0	0	0	0	0	0	0
18	0.23	0.38	0.25	0.11	0	0.1	0	0	0	0	0	0	0
19	0.74	0.55	0.23	0.72	0	0.05	0	0	0	2.49	0	0	0.31
20	0.45	1.36	1.71	1.6	0.24	0.29	0.61	1.24	3.53	8.33	2.35	0	0.68
21	1.49	2.26	3.14	2.71	0.63	1.05	7.01	8.58	14.12	32.69	4.24	0.06	0.69
22	0.69	2.19	2.12	2.71	1.99	1.53	14.13	5.11	6.7	27.19	33.7	1.39	1.15
23	0.46	2.07	3.93	6.48	1.05	6.33	20.83	25.5	22.68	49.96	25.64	0.45	9.56
24	5.72	4.18	9.15	12.53	0.63	10.15	25.44	10.45	15.03	55.73	38.35	3.18	5.18
25	5.68	6.96	14.05	17.13	3.25	19.18	50.91	17.83	24.76	93.93	53.75	1.9	5.75
26	14.18	14.26	17.56	24.24	4.62	23.14	35.89	31.79	33.59	111.74	65.24	2.19	12.37
27	14.54	15.85	29.7	19.1	5.21	23.2	58.52	36.29	60.86	126.01	111.54	9.35	20.34
28	17.51	22.45	41.67	43.09	15.29	33.02	45.81	39.07	37.63	120.21	113.01	20.23	29.03
29	19.75	26.64	47.2	46.49	7.08	30.59	99.24	45.6	45.15	89.03	116.18	19.03	32.51

30	27.03	33.89	50.63	34.31	17.67	30.35	87.13	53.19	103.73	110.7	94	25.18	36.97
31	26.89	30.94	55.33	55.23	18.5	37.27	91.68	59.36	96.93	108.79	91.55	14.2	50.15
32	25.97	22.98	59.69	46.87	20.59	41.2	84.22	49.45	81.04	133.78	108.62	12.59	66.58
33	28.03	23.49	65.72	51	28.45	34.62	100.09	47.21	102.55	109.66	131.6	46.85	70.6
34	26.92	20.22	52.4	45.51	14.05	35.85	94.18	50.12	72	86.8	61.34	21.4	74.75
35	28.28	19.2	49.99	48.61	20.16	34.02	76.57	43.62	86.29	113.73	80.67	37.58	69.9
36	19.13	16.6	38.59	46.3	22.93	30.35	68.69	37.13	74.08	82.17	63.45	8.35	58.16
37	23.33	19.54	38.16	36.02	19.66	27.51	83.07	33.8	49.36	96.85	67.62	24.84	54.18
38	13.53	12.97	35.68	29.05	20.21	32.1	74.57	30.19	71.4	83.32	69.66	42.54	74.2
39	13.47	13.88	36.98	29.27	15.95	24.45	115.9	26.94	49.73	71.29	59.35	29.93	72.94
40	18.64	12.53	26.64	21.93	15.21	24.16	58.02	29.9	49.18	73.18	44.99	36.6	64.88
41	11.2	12.54	26.41	11.29	14.7	25.02	61.2	23.12	43.84	49.86	31.13	19.44	51.4
42	11.56	9.18	19.09	18.35	14.99	17.8	35.1	20.76	39.11	61.87	29.57	20.73	37.78
43	8.46	8.33	16.06	13.38	15.26	14.94	26.57	17.18	40.31	55.07	60.38	21.85	52.05
44	8.11	7.25	14.38	9.79	6.72	14.7	28.7	20.72	41.23	52.66	30.3	25.76	29.57
45	4.35	7.75	10.76	9.69	12.93	15.87	28.57	11.96	22.16	40.06	28.59	18.22	33.97
46	3.01	6.79	11.7	8.06	4.57	11.83	26.86	10.57	30.25	29.47	14.56	7.27	25.1
47	3.14	6.27	10.17	6.59	6.86	9.74	17.95	9.18	20.53	26.05	41.4	12.33	17.57
48	2.94	4.82	6.98	9.28	6.84	8.64	54.87	8.5	19.98	34.86	25.91	10.87	29.96
49	2.75	5.16	8.97	6.17	4.26	7.99	11.34	7.39	18.11	16.87	34.63	5.44	19.3
50	2.11	4.99	8.06	5.37	4.85	11.54	14.3	5.94	9.17	30.78	14.77	8.93	21.63
51	2.31	3.86	6.7	6.53	6.97	6.7	21.9	5.92	10.46	19.69	17.53	6.62	10.31
52	2.8	2.47	3.99	3.14	3.41	10.54	13.68	3.37	11.65	19.97	10.71	2.52	14.48
53	1.66	2.23	2.76	4.84	3.19	4.84	12.41	4.62	16.57	13.89	7.5	2.19	9.17
54	1.34	2.17	2.22	19.21	4.3	5.43	17.62	2.1	5.16	19.98	12.94	1.14	15.02
55	0.94	1.52	4.04	15.46	0.35	4.37	7.32	3.05	7.31	13.82	13.55	8.08	10.42
56	2.22	1.35	3.53	2.12	1.17	2.57	4.45	0.98	12.6	12.59	4.66	9.49	2.82
57	1.02	0.9	2.08	1.61	2	2.39	12.95	1.29	3.88	15.74	5.75	7.15	4.27
58	0.44	1.1	1.3	1.03	2.54	2.86	6.41	3.58	6.04	10.29	5.18	7.03	8.3
59	0.98	0.56	1.15	2.04	1.67	3.13	2.82	0.54	6.11	4.92	2.13	0.05	2.8
60	1.19	0.33	1.38	1.54	0.97	3.27	9.7	2.28	1.72	6.34	2.3	0	3.39
61	0.36	0.85	0.88	0.76	2.51	1.78	14.11	0.99	2.06	2.78	1.5	1.99	2.08
62	0.39	0.63	0.12	3.2	0.13	2.84	2.38	3.15	5.2	4.05	1.4	3.33	1.85
63	0.43	0.48	1.28	1.21	0.16	1.25	1.66	0.87	4.54	4.12	0.1	0.12	3.26
64	0.25	0.51	1.74	0.98	0.11	0.86	2.03	1.75	0.95	2.29	1.84	0	1.16
65	0.2	0.5	0.11	0.97	0.64	0.63	0.69	0.37	0.47	8.78	0.89	0.02	0
66	0.92	0.08	0.24	0.07	0.3	0.72	13.69	0	0.5	1	0	1.39	0
67	0	0.37	0.08	0.06	0.08	0.12	0.94	0.05	1.01	1.37	0	0	0.31
68	0	0	0.43	0.09	0	0.05	1.7	0	1.24	0	0	0	0.31
69	0.2	0	0.5	0.36	0	0.05	0	0	0	0	0	0	0
70	0	0	0	0.02	0.02	0	0	1.09	0	0	0	0	0
72	0	0	0	0	0.02	0.05	0	0	0	0	0	0	0
78	0	0.03	0	0	0	0	0	0	0	0	0	0	0

Age composition is mainly formed by age 3 to 5 individuals, although age 0 and age 2 are also frequent in the catches (Figure 6.7.2.5 and Table 6.7.2.4). Cohorts showed weak consistency (figure 6.7.2.6). An "age plus" group was defined at age 10.

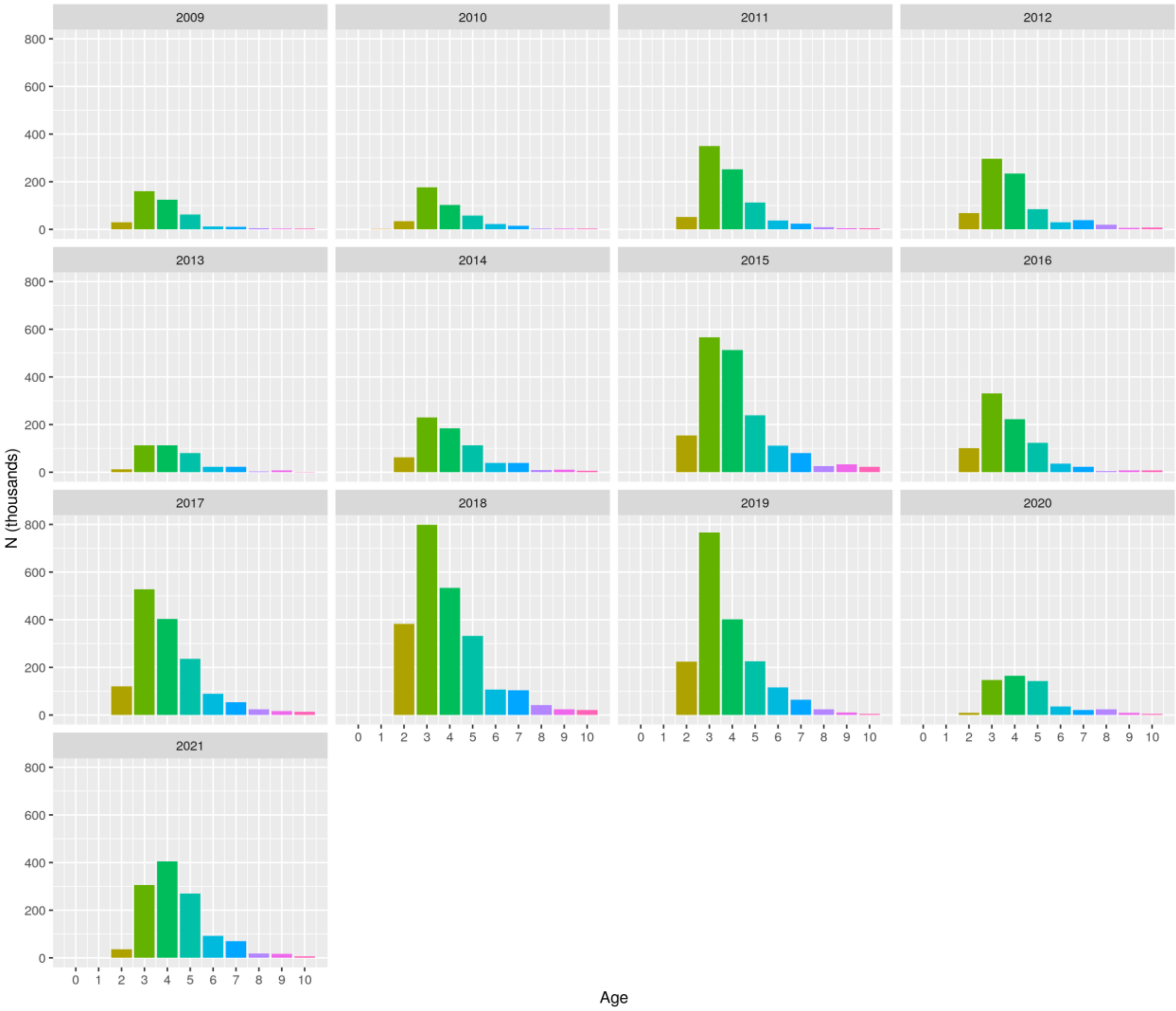


Figure 6.7.2.5. Norway Lobster in GSA 5. Landings at age, numbers in thousands.

Table 6.7.2.4. Norway Lobster in GSA 5. Landings at age, numbers in thousands.

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.57	1.88	0.74	0.39	0	0.16	0	0.12	0	0	0	0	1.06
2	29.41	33.82	51.89	68.12	12.42	61.72	154.82	100.5	120.4	382.07	223.27	9.17	35.67
3	159.73	176.23	349.94	296.09	112.78	230.24	566.69	330.17	527.89	798.19	766.5	147.44	306.18
4	124.65	102.41	251.81	234.78	112.97	184.26	512.98	221.8	402.85	534.15	402.09	164.63	404.13
5	62.33	57.57	113.33	84.45	79.81	112.5	238.15	123.63	235.83	332.7	224.98	142.6	269.65
6	11.84	23.04	37.82	30.1	22.54	38.21	111.02	35.64	88.88	107.25	116.5	35.9	91.92
7	10.22	15.71	23.73	39.09	22.73	39.05	79.91	21.96	53	104.3	63.45	21.4	70.6
8	4.18	3.77	9.65	19.19	3.52	9.34	24.71	5.32	23.79	42.16	23.96	24.73	17.52
9	2.98	2.84	4.7	5.37	7.69	11.04	33.04	7.4	15.94	24.32	11.12	9.07	16.57
10	2.38	2.61	4.51	6.96	1.46	6.55	23.08	7.27	13.9	21.61	4.23	4.86	6.9

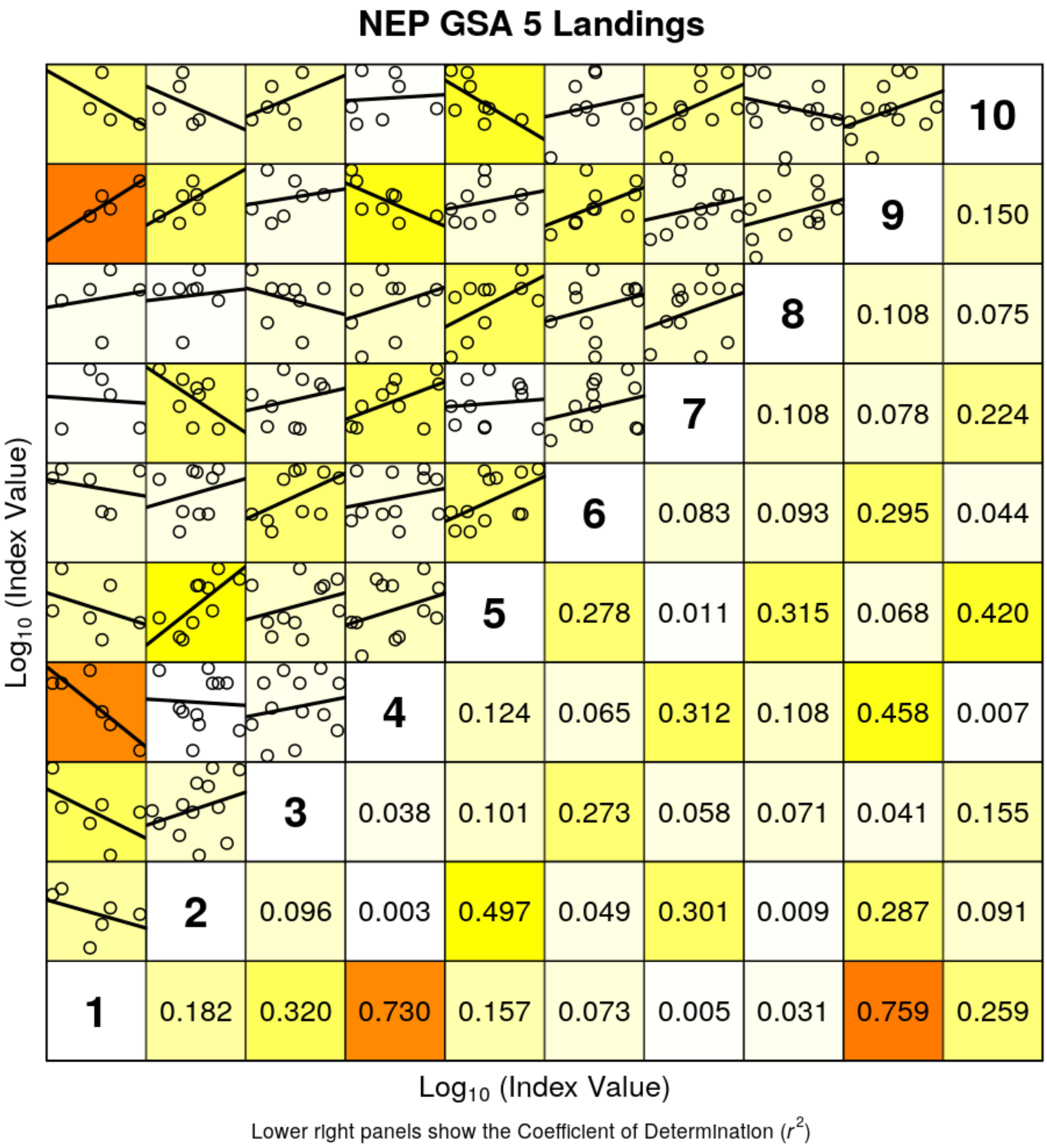


Figure 6.7.2.6. Norway Lobster in GSA 5. Cohort consistency for the commercial landings.

6.7.2.2 Effort data

Fishing effort data for 2021 will be reported to STECF EWG 22-11 through the FDI data call within the DCF framework.

6.7.2.3 Survey data

The MEDITS (MEDiterranean International Trawl Survey) survey is an extensive trawl survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintain fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end is used throughout GSAs and years.

MEDITS survey started in GSA 5 in 2007. Before 2007, data were collected for only a few stations, so these years are considered non representative. A few stations have been carried out near Formentera, however, the Nephrops stock is fished mostly around Menorca and Mallorca, and so only these stations are used for the MEDITs biomass index used for this stock. In 2021 an unusual number of stations were sampled around the Ibiza Island (Figure 6.7.2.7.). To harmonize the MEDITS dataset, only stations with a longitude > 2°E were conserved for computations

(Figure 6.7.2.8.). Then mean stratified abundances and biomass by km^2 have been computed using the methodology described by Grosslein and Laurec (1982).

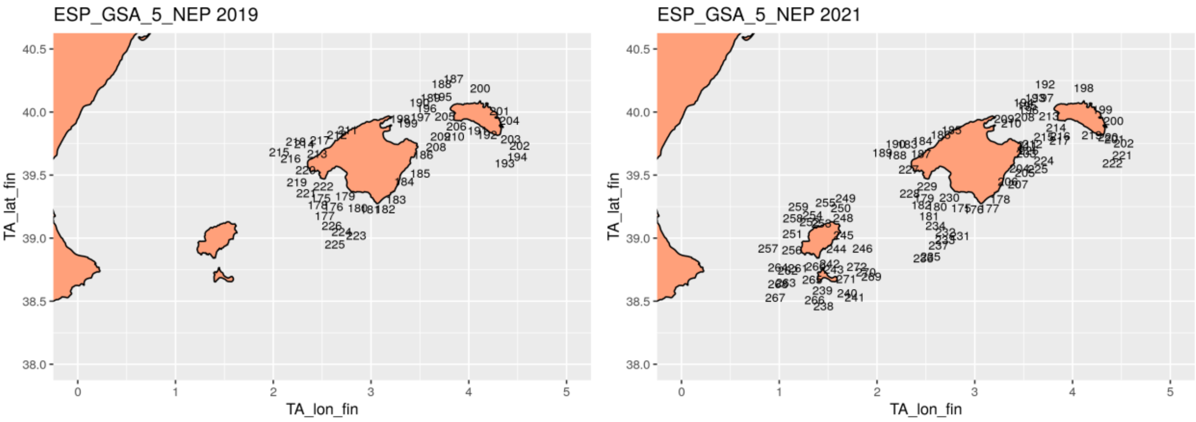


Figure 6.7.2.7. Norway Lobster in GSA 5. MEDITS stations in 2019 and 2021 to illustrate the large number of samplings done around Ibiza in 2021.

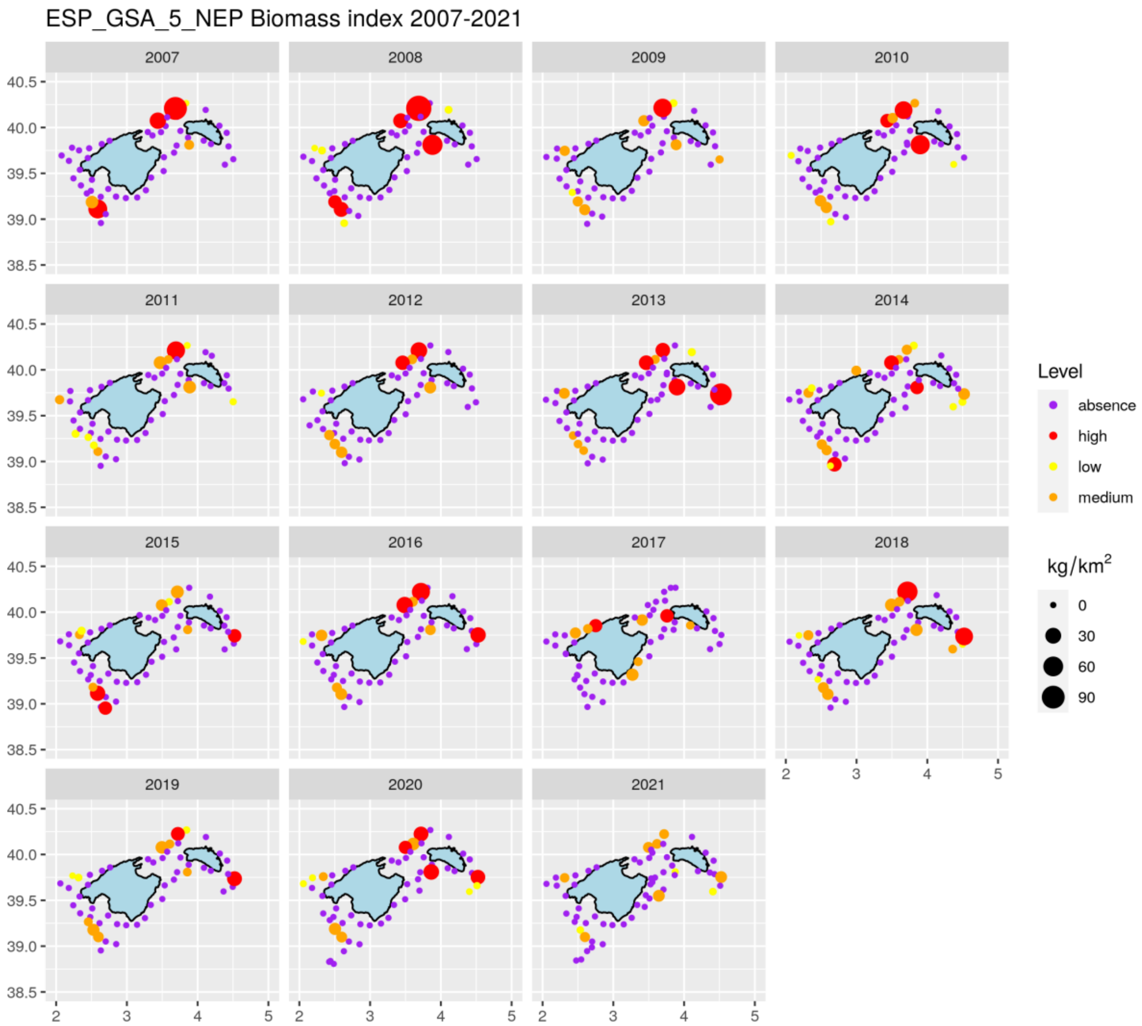


Figure 6.7.2.8. Norway Lobster in GSA 5. MEDITS Biomass index by stations.

Density and biomass indices showed variations along the data series, with the highest recent values of abundance in 2013 and 2018 (Figure 6.7.2.9). Density and abundance show their lowest values in the 2021 survey. Length frequency distributions are shown in Figure 6.7.2.10 and Table 6.7.2.5. Age composition of the catches from the survey showed that most of the individuals correspond to ages 3-5; age 3 showed a peak in 2018 (Figure 6.7.2.11).

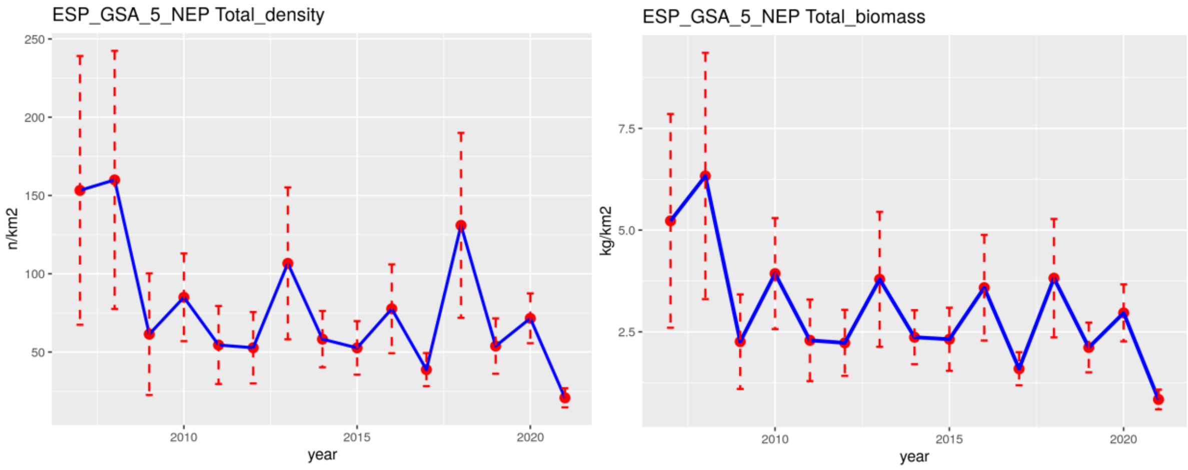


Figure 6.7.2.9. Norway Lobster in GSA 5. MEDITS abundance (n/km^2) and biomass (kg/km^2) indices over 2007-2021.

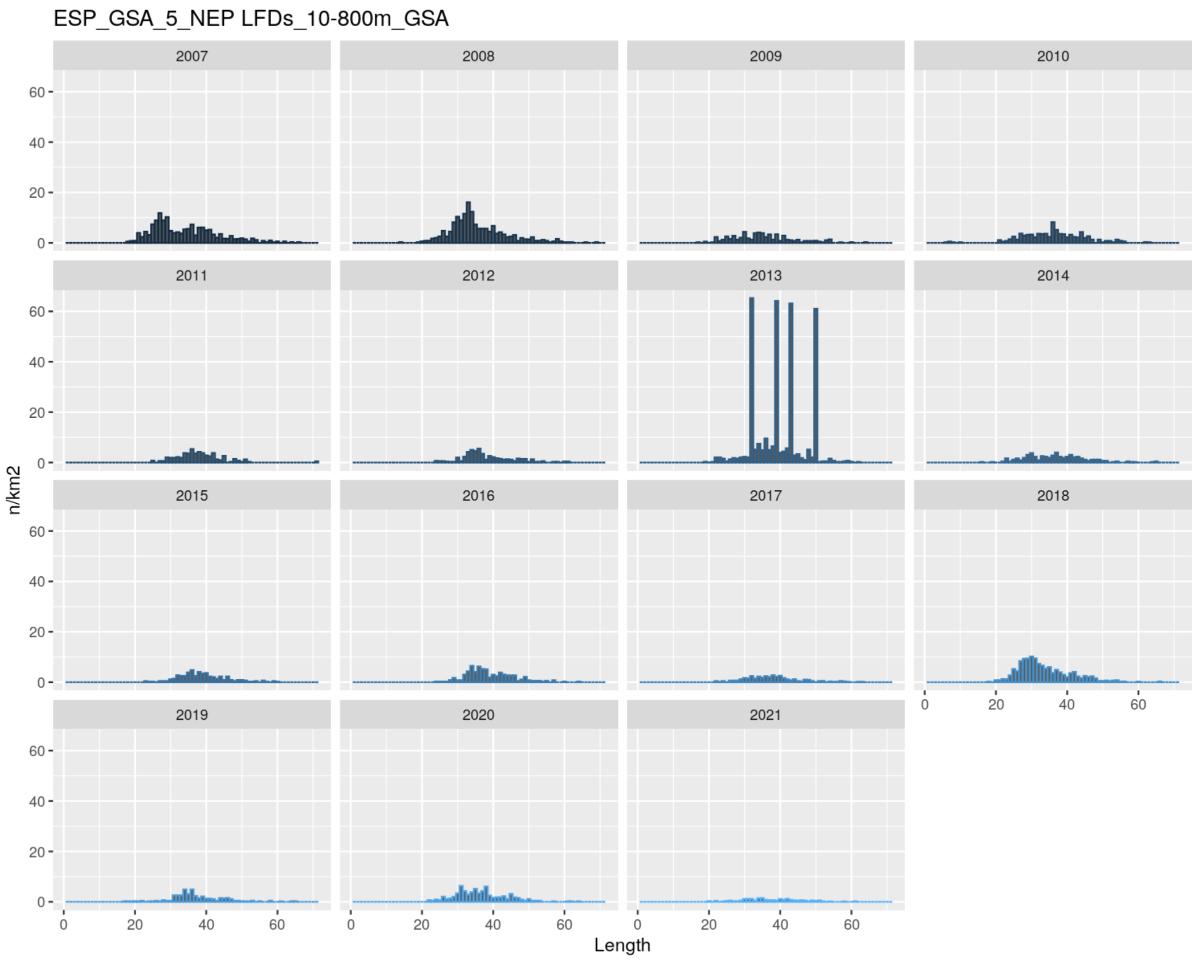


Figure 6.7.2.10 Norway Lobster in GSA 5. MEDITS Length Frequency distribution (TL in mm, numbers in n/km^2) reported in MEDITS survey data.

Table 6.7.2.5. Norway Lobster in GSA5. Length structure (CL in mm) reported in MEDITS (2007-2021) for survey data.

Length	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
6	0	0	0	0.27	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0.53	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0.27	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0.27	0	0	0	0	0	0	0	0	0	0	0
14	0	0.32	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0.24	0	0	0	0	0	0	0
17	0	0	0.26	0	0	0	0	0	0	0	0	0	0.22	0	0
18	0.53	0	0	0	0	0	0	0	0	0	0	0.23	0.22	0	0
19	0.79	0.28	0.52	0	0	0	0.34	0.24	0	0	0	0	0.22	0	0
20	0.85	0.6	0	0	0	0	0	0	0	0	0	0.8	0.27	0	0.33
21	3.95	0.84	0.26	1.13	0	0	0.26	0	0	0	0	0.8	0.22	0	0
22	2.37	0.88	2.33	0.53	0	0	2.07	0.47	0	0	0.48	1.25	0.43	0.68	0.39
23	4.47	1.73	0.78	0.8	0	0	2.07	1.65	0.46	0	0.17	1.19	0	0.45	0
24	3.16	2.01	1.29	1.45	0	0.71	1.55	0.47	0.23	0.27	0.48	2.7	0.22	0.91	0.17
25	7.37	2.57	2.59	2.52	0.8	0.59	0.52	1.18	0.23	0.27	0	5.24	0.22	0.68	0.33
26	8.95	4.78	1.55	1.33	0	0.59	1.29	1.65	0	0.27	0.65	4.34	0.43	2.05	0.5
27	11.84	2.57	2.85	3.71	0.63	0.41	1.81	0.94	0.46	0.27	0.65	8.4	0.22	1.14	0.23
28	8.95	4.5	1.29	2.93	0.63	0.3	1.55	1.89	0.46	0.87	0.69	9.3	0.7	1.37	0.23
29	10.26	8.2	2.07	3.26	2.06	0.3	2.07	3.07	0.46	1.7	1.17	9.42	0.43	2.05	0.5
30	4.8	10.41	4.4	3.32	1.89	2	2.32	3.78	1.14	0.8	1.69	10.2	0.43	3.39	1.12
31	3.95	9	1.81	2.25	1.89	0.59	2.07	2.36	1.38	0.8	1.55	9.46	2.58	6.33	1.16
32	4.27	11.57	1.29	3.65	2.21	2.36	65.28	0.94	2.75	3.01	2.48	7.33	2.58	4.29	1.16
33	3.75	16.11	3.88	3.52	1.89	4.25	5.16	2.59	2.52	4.31	1.48	6.59	2.58	2.94	0.5
34	5.39	12.38	4.14	3.65	3.79	5.02	7.49	2.36	2.52	6.48	2.27	5.41	4.95	3.84	1.45
35	5.59	7.31	3.88	2.4	3.63	4.54	4.91	1.89	3.9	4.08	1.83	5.98	3.07	5.2	1.49
36	7.29	5.67	2.33	8.24	5.38	5.55	9.55	2.83	4.81	6.22	2.44	3.67	4.95	3.4	0.79
37	3.02	5.67	3.36	5.18	3.63	3.48	4.99	4.01	2.52	5.25	2.06	4.91	2.37	4.29	0.66
38	6.1	5.67	1.29	3.59	4.27	1.18	6.46	2.35	4.12	5.11	2.75	3.95	1.51	6.12	0.66
39	6.12	4.5	3.42	3.46	3.79	2.66	64.16	1.89	3.43	1.9	2.21	2.93	2.15	2.49	0.5
40	4.99	6.75	0.83	2.25	2.84	2.18	3.96	2.36	3.66	2.97	2.58	2.03	1.29	1.58	1.12
41	5.25	3.7	2.9	3.26	2.52	1.71	4.39	3.07	2.29	2.41	1.69	3.6	1.29	1.81	0.83
42	3.35	4.26	1.29	2.4	3.79	1.48	5.68	2.12	2.06	3.84	1.14	4.12	1.08	1.81	1.18
43	2.11	3.38	1.09	2.19	1.26	1.18	63.13	2.36	1.38	3.04	0.79	2.31	0.43	2.27	0.79
44	3.53	2.29	0.78	4.32	0.95	1.3	2.84	1.65	2.29	2.71	1.17	1.58	1.51	1.13	0.56
45	1.7	2.57	1.29	1.99	2.69	1.18	3.36	1.18	0.91	2.71	0.48	2.54	1.4	3.17	0.5
46	1.64	3.13	0.26	2.66	0	0.59	1.81	0.7	2.29	2.71	0.35	2.09	1.56	1.81	0.66
47	2.81	0.84	0.78	1.33	0.32	1.59	1.03	1.18	0.92	0.53	1.04	2.38	1.08	1.58	0.5
48	1.5	1.97	0.78	0	1.43	1.41	5.16	1.18	0.46	1.07	0.96	1.54	0.43	0.9	0.17
49	1.57	1.45	0.78	1.33	0.8	1.41	2.07	1.18	0.92	2.14	0.48	0.51	0.43	0.46	0.56
50	1.83	1.41	0.88	0.27	0.32	0.3	61.07	0.71	0.92	0.8	0	0.51	0.27	1.13	0.39
51	1.44	2.29	0.52	0.8	1.26	1.3	0.26	0.71	0.68	0.57	0.48	0.68	0.22	0.46	0.56
52	0.59	0.88	0.26	0.8	0.32	0.3	0.52	0	0.23	0.57	0.52	0.45	0.22	0.46	0.23
53	1.77	0.84	1.09	0.27	0	0.3	0.52	0.23	0.23	0.57	0	0.68	0.48	0.46	0
54	1.18	1.24	1.4	1.33	0	0.59	1.55	0.47	0.46	0.27	0.31	0.8	0	0	0.17
55	0	0.84	0	0.86	0	0	0.77	0	0	0.57	0.17	0.23	0.27	0	0
56	0.85	0.28	0	0.59	0	0	0.26	0	0.69	0	0.17	0.29	0	0	0
57	0.33	0.6	0.26	0	0	0.3	0.26	0.47	0.23	0.8	0.52	0	0	0.23	0
58	0.98	1.56	0	0	0	0.3	0.52	0.23	0	0	0.35	0	0.48	0	0.17
59	0.26	0.64	0	0	0	0	0.77	0.23	0.46	0	0.17	0	0	0	0
60	0.59	0.28	0.31	0	0	0.41	0.34	0	0.23	0.27	0	0.23	0	0	0
61	0	0.28	0	0	0	0.41	0	0	0	0	0	0	0.22	0.23	0.23

62	0.59	0.28	0	0.33	0	0	0.26	0	0	0	0.17	0	0	0.23	0
63	0	0	0	0.27	0	0	0	0	0	0	0.17	0	0	0	0
64	0.33	0	0.31	0	0	0	0	0.23	0	0.27	0	0	0.27	0.23	0
65	0	0	0	0	0	0	0	0.47	0	0	0	0	0.27	0	0
66	0.33	0.28	0	0	0	0	0	0	0	0	0	0.29	0	0	0
69	0	0.32	0	0	0	0	0	0	0	0	0	0	0	0	0
71	0	0	0	0	0.48	0	0	0	0	0	0	0	0	0	0

The LFD data (Figure 6.7.2.10) shows possible errors in 2013 that may influence the abundance index, but do not affect the biomass index used for advice. These potential errors are reported in Section 7. Those errors are also visible in the age structure (Figure 6.7.2.11). Cohorts showed no consistency (Figure 6.7.2.12).

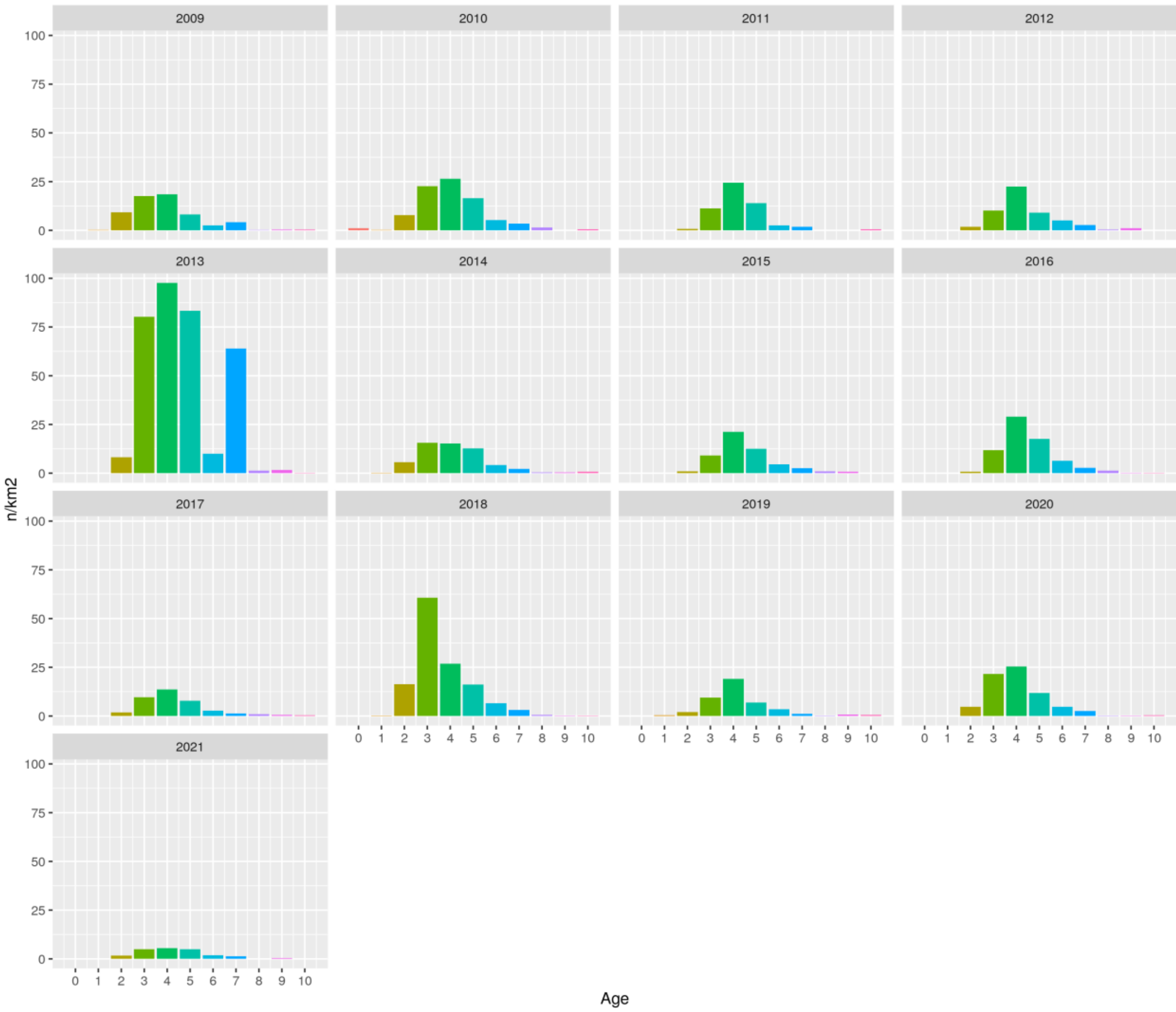


Figure 6.7.2.11 Norway Lobster in GSA 5. Age structure (numbers in n/km^2) estimated from length frequency distribution reported in MEDITS (2007-2021) survey data, with plus group set at age 10.

Table 6.7.2.6. Norway Lobster in GSA 5. Age structure (numbers in n/km^2) estimated from length frequency distribution reported in MEDITS (2007-2021) survey data, with plus group set at age 10.

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0	1.07	0	0	0	0	0	0	0	0	0	0	0
1	0.26	0.27	0	0	0	0.24	0	0	0	0.23	0.43	0	0
2	9.32	7.76	0.8	1.89	8.09	5.67	0.92	0.8	1.79	16.32	1.99	4.77	1.72
3	17.6	22.64	11.21	10.21	80.26	15.57	9.16	11.76	9.72	60.7	9.53	21.5	4.89
4	18.43	26.51	24.48	22.42	97.56	15.32	21.29	29.04	13.56	26.85	19	25.33	5.55
5	8.18	16.41	14.04	9.03	83.36	12.73	12.59	17.68	7.85	16.18	7	11.78	4.98
6	2.59	5.33	2.54	5.01	10.07	4.24	4.58	6.45	2.83	6.51	3.5	4.75	1.88
7	4.15	3.46	1.89	2.77	63.91	2.12	2.51	2.77	1.31	3.11	1.18	2.5	1.35
8	0.26	1.45	0	0.3	1.29	0.47	0.91	1.37	0.86	0.51	0.27	0.23	0
9	0.31	0	0	1.12	1.64	0.47	0.69	0.27	0.52	0.23	0.7	0.23	0.39
10	0.31	0.59	0.48	0	0.26	0.71	0	0.27	0.35	0.29	0.54	0.46	0

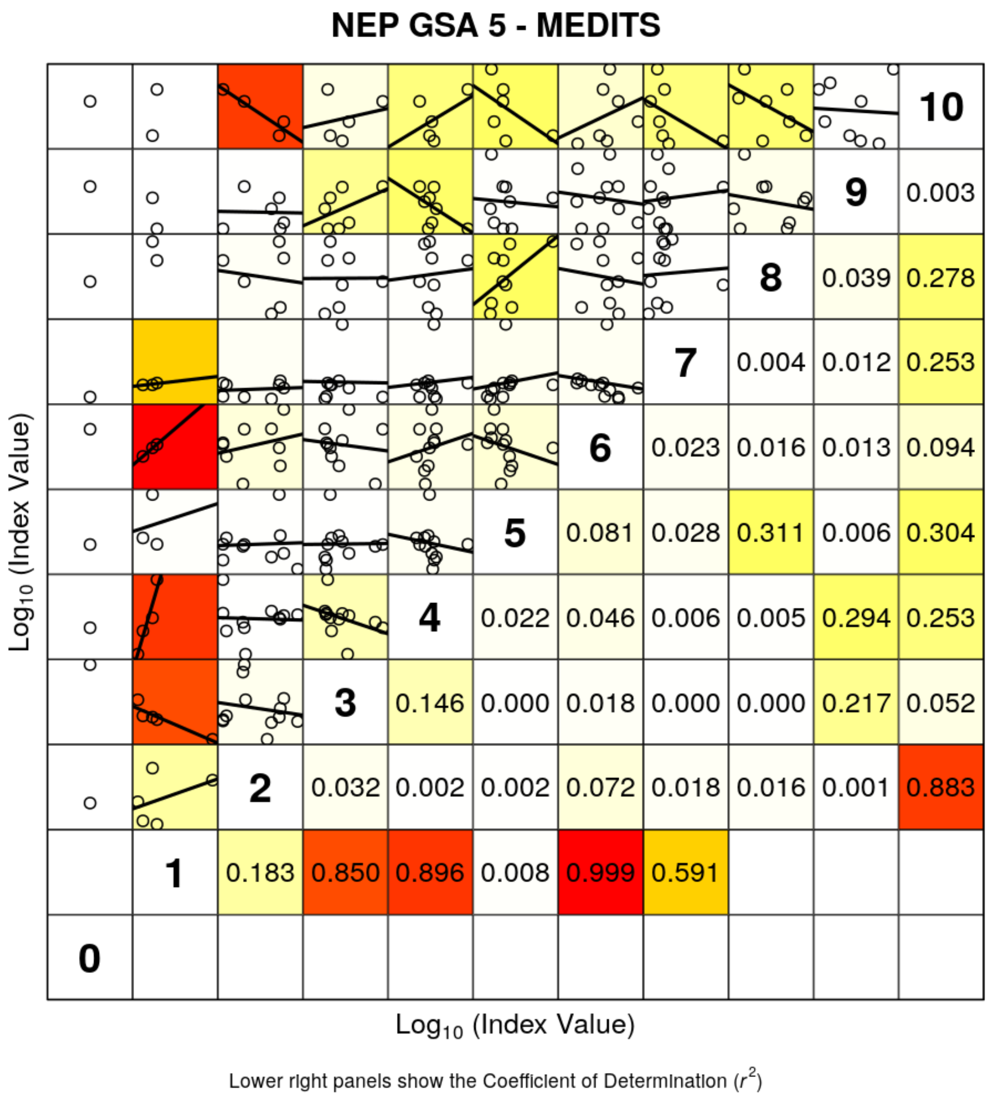


Figure 6.7.2.12. Norway Lobster in GSA 5. Cohort consistency for the MEDITS data with age estimated from length frequency distribution reported in MEDITS (2007-2021) survey data, with plus group set at age 10.

6.7.3 Data Issues

- MEDITS data show odd length frequency values for two years :

In 2013 four abundances are very high in haul 150 2013 and may be the result of incorrect raising, but could be correct if sampling of that haul was low. The data id values are:- 46328062, 46328063, 46506353 and 46506354

In 2019 max length is 580mm with a number of lengths at about 10x the normal size.

- Length-weight parameters for 2016 give very lightweight individuals (Figure 6.7.6.1).

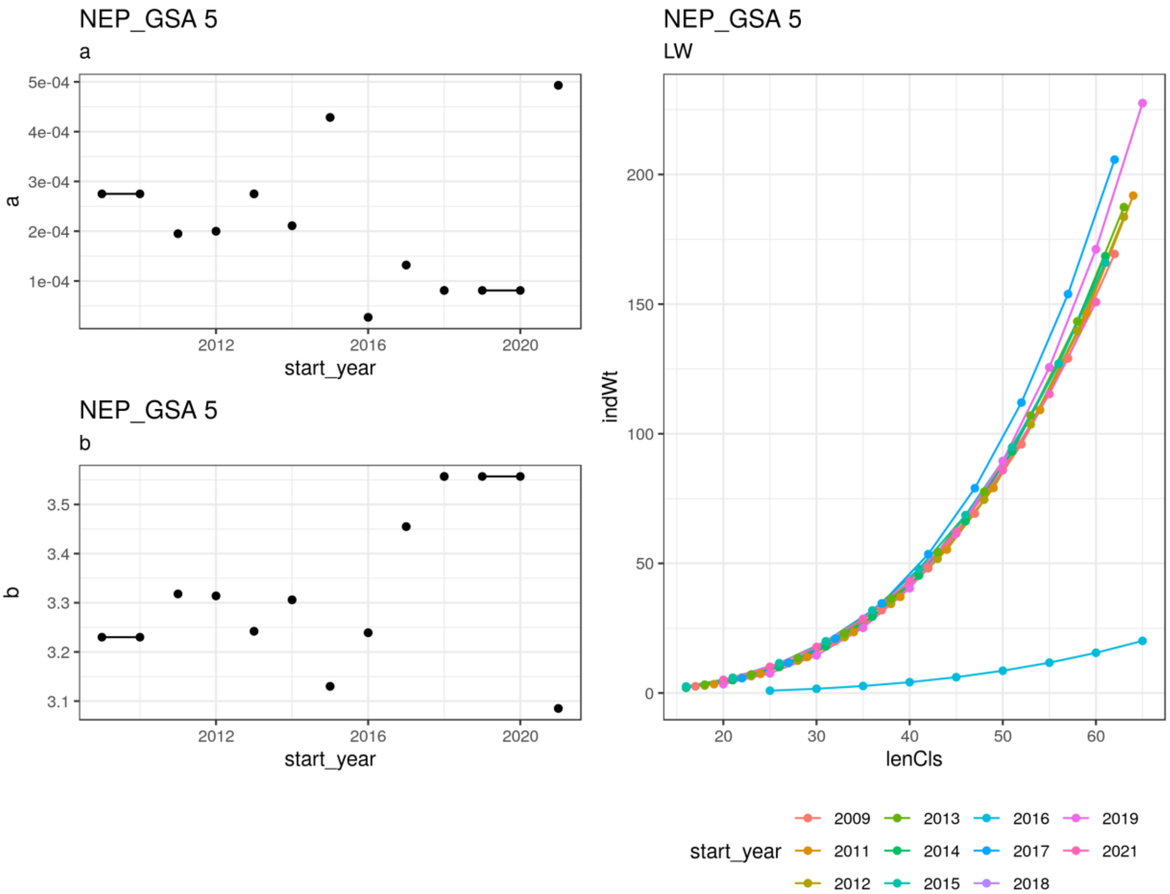


Figure 6.7.6.1 Norway Lobster GSA 5. Length-weight parameters from the 2022 STECF Med&BS data call.

6.8 NORWAY LOBSTER IN GSA 6

6.8.1 STOCK IDENTITY AND BIOLOGY

The spatial extent of the stock is assumed to coincide with the boundaries of GSA 6 (Figure 6.8.1.1) due to lack of information on stock structure for the Norway lobster *Nephrops norvegicus* in the Mediterranean Sea. Norway lobster is distributed in deep waters in GSA 6, from 300 to 600 m approximately. It is a benthic species of fossorial habits, with higher abundance in areas with muddy sediments.

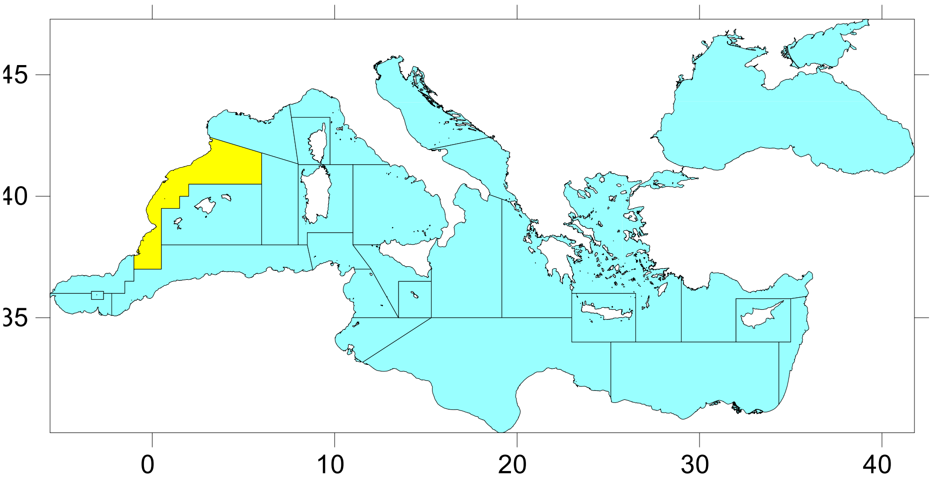


Figure 6.8.1.1. Geographical location of GSA 6.

Age and growth

The Norway lobster is known to have a dimorphic growth pattern, with males growing slower and reaching larger sizes than females. However, sex-specific growth parameters are not available in the DCF MED_BS data set. As in previous assessments, the parameters of the von Bertalanffy growth function were taken from those estimated for GSA 5 and reported in the DCF as applicable to GSA 6, and which correspond to both sexes combined (reproduced in Table 6.8.1.1). The parameters of the weight-at-length equation were available in the DCF for the 2021 sampling, again not separated by sex.

Table 6.8.1.1. Norway lobster in GSA 6: Parameters used for growth and weight at length.

Growth model	**L∞**	**k**	**t_0**
$L_t = L_\infty\left(1 - e^{-k(t-t_0)}\right)$	86.1 mm CL	0.126 yr^{-1}	0.
Weight at length	**a**	**b**	
$W = a\,L^b$	0.000481 g mm^{-1}	3.075	

Gonad maturity for females of this stock peaks during the months May to August. Eggs are not immediately spawned after mating, but females brood the eggs in their pleopods for several months ("brooding"). Eggs hatch in January and February of the following year, approximately half a year later than female gonad maturity (Figure 6.8.2.2) (Orsi Relini et al. 1998[3]; Aguzzi et al. 2004[4]).

year t												year t+1			
J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	....
				GONAD MAT.											
								BROODING							
												HATCHING			

Figure 6.8.1.2. Norway lobster in GSA 6: Schematic reproductive cycle of female Norway lobster in GSA 6. Hatching corresponds to the release of eggs to the sea, equivalent to spawning in fishes.

Maturity and natural mortality

The maturity vector at age was calculated from the maturity at length data reported in the DCF MED_BS data set (sampling years 2009, 2011, 2012, 2013, 2014 and 2018 Figure 6.8.1.3) and converted to maturity at age with the von Bertalanffy parameters given above (Table 6.8.1.1). The difference in maturity from last year to this year is substantial 0.8 to 0.36 at age 3 and 1.0 at ages 4+ reduced to 0.6 at age 4 rising to 1.0 at age 10 (Figure 6.8.1.2). While not affecting the fit of the assessment this also results in only a minor shift in $F_{0.1}$ but a more substantial reduction in SSB. This latter change acts just a scaling factor for SSB and reference points together, having no influence on management.

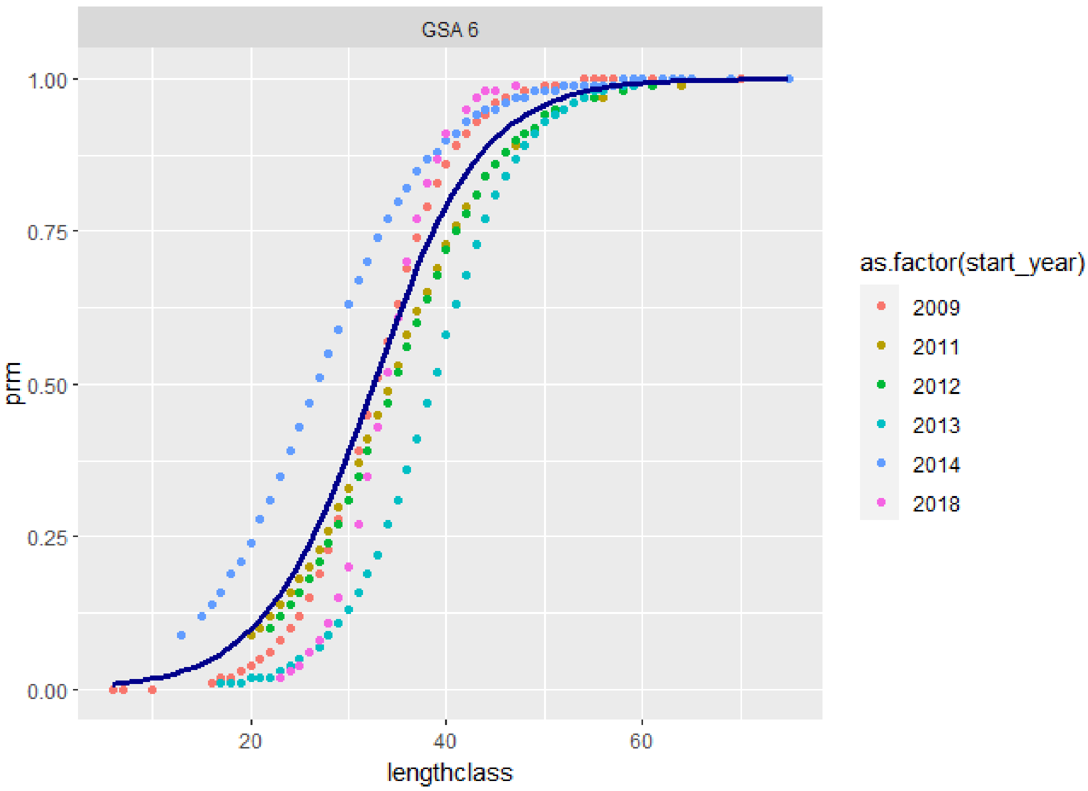


Figure 6.8.1.3. Maturity at length for Norway lobster in GSA06. Black thick line corresponds to the logistic model fitted, with parameters s1=5.808866, s2= -0.1785838, corresponding L50: 32.53 mm CL.

Natural mortality was obtained by application of the Chen-Watanabe formula (Table 6.8.1.2).

[3] Orsi Relini et al. 1998, Scientia Marina, vol 62(Suppl. 1), 25-41.
[4] Aguzzi et al. 2004, Biogeographia, vol 25, pp. 81-92.

Table 6.8.1.2. Norway lobster in GSA 6: Maturity and natural mortality at age.

	1	2	3	4	5	6	7	8	9	10
maturity	0.09	0.20	0.36	0.60	0.80	0.89	0.94	0.97.	0.99	1.00
M: Chen-Watanabe	0.732	0.466	0.353	0.291	0.252	0.225	0.206	0.192	0.181	0.172

6.8.2 DATA

All data were obtained from the 2022 DCF data call.

6.8.2.1 CATCH (LANDINGS AND DISCARDS)

Data on catches are available from 2002 to 2021 for GSA 6 (Figs. 6.8.2.1.1 and 6.8.2.1.2; Table 6.8.2.1.1). The catches of Norway lobster are produced exclusively by otter bottom trawl (OTB) at depths generally between 300 and 600 m. The main métier is coastal demersal (coded DEMSP and DEF since 2020), with important contributions from métier DWS and MDD. The landings were highest in the first half of the 2010s and have declined importantly since 2016, from ~500 t/yr in 2011-2014 to less than 200 t in 2021. The landings for 2021, for an amount of 149.4 t, have been the lowest in the data series. Discards, reported since 2009, are negligible, especially in recent years but included, normally below 5% of the catches, but for one anomalously high value in 2012.

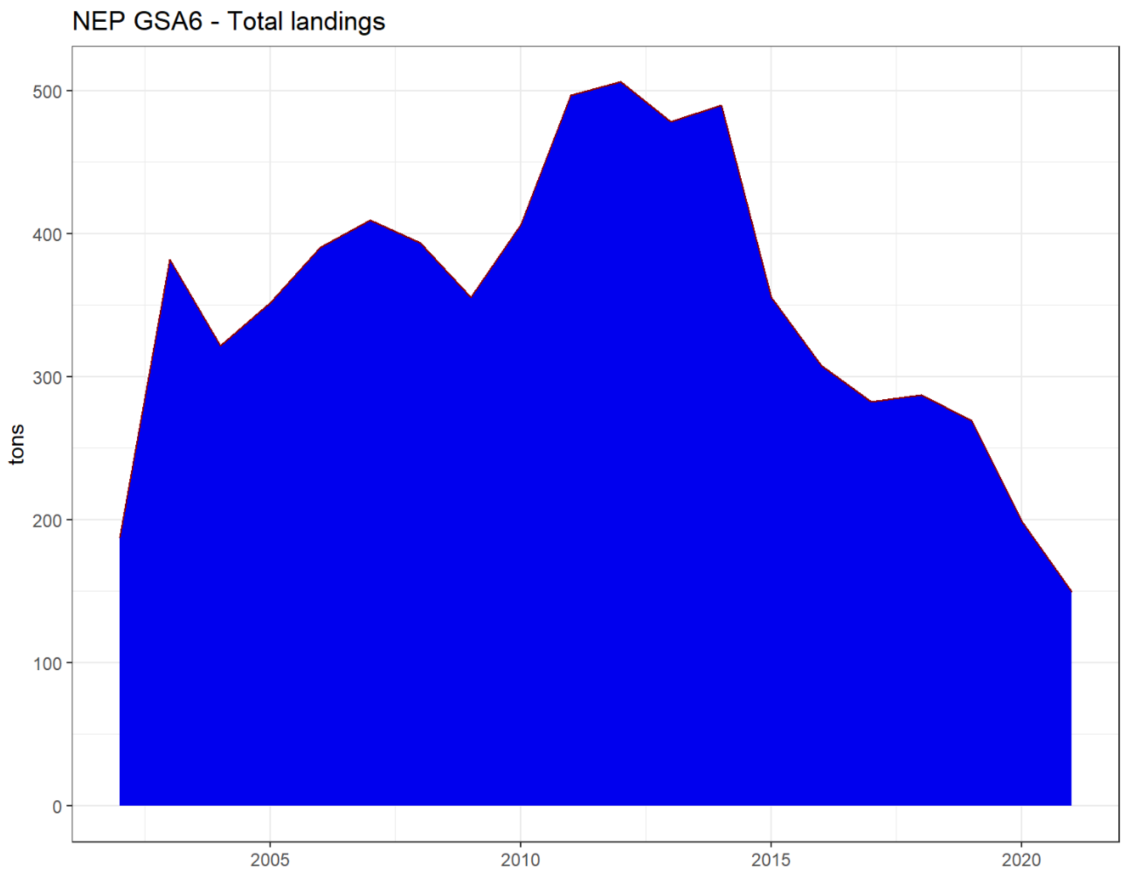


Figure 6.8.2.1.1. Norway lobster in GSA6: Total landings per year (t).

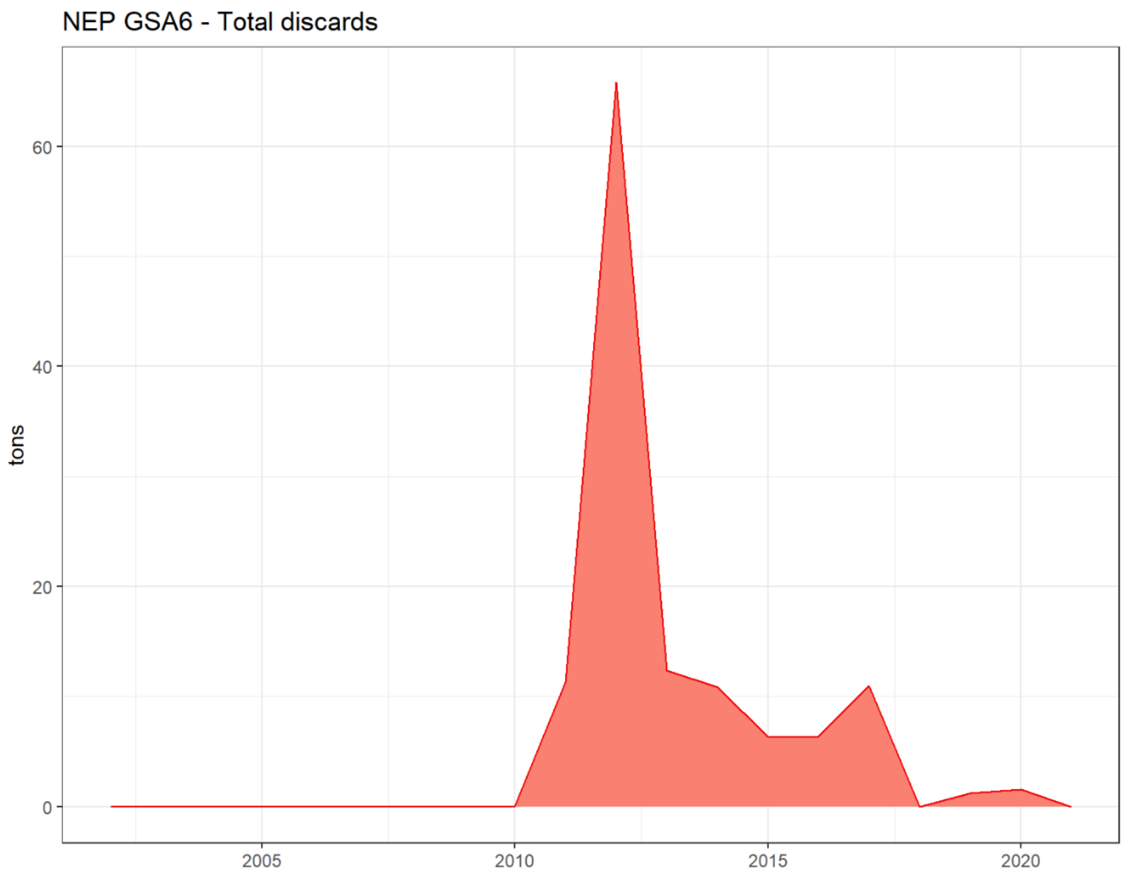


Figure 6.8.2.1.2. Norway lobster in GSA 6: Total discards per year.

Table 6.8.2.1.1. Norway lobster in GSA 6: Reported landings, discards, catches and calculated proportion of discards.

year	Landings (t)	Discards (t)	Catches (t)	% discards
2002	187.50		187.5	
2003	381.81		381.81	
2004	321.72		321.72	
2005	351.99		351.99	
2006	390.18		390.18	
2007	409.40		409.4	
2008	393.77		393.77	
2009	355.60	0.01	355.61	0.0%
2010	406.45	0.06	406.51	0.0%
2011	496.84	11.37	508.21	2.2%
2012	506.09	65.80	571.89	11.5%
2013	478.36	12.34	490.7	2.5%
2014	489.95	10.84	500.79	2.2%
2015	355.24	6.34	361.58	1.8%
2016	308.06	6.41	314.47	2.0%
2017	282.22	11.02	293.24	3.8%
2018	287.03	0	287.03	0.0%
2019	269.12	1.22	270.34	0.5%
2020	198.79	1.54	200.33	0.8%
2021	149.43	0	149.432	0.0%

Information on the demographic structure of the exploited population is available as quarterly length frequencies from 2009 to 2021. Length frequency distributions for those years or métiers where no length frequencies were available in DCF MEDBS were filled-in (Figure 6.8.2.1.3 and Figure 6.8.2.1.4). The length frequency of Norway lobster is reasonably well sampled for métiers OTB_DEMSP (defined as OTB_DEF in 2020) and OTB_DWS since 2009. For métier OTB_MDD length frequencies start to be available in 2021. Discards were generally not sampled, but length frequencies are available for 2019 and 2020 for the principal métier landing *Nephrops*, viz. OTB_DEMSP, recoded OTB_DEF.

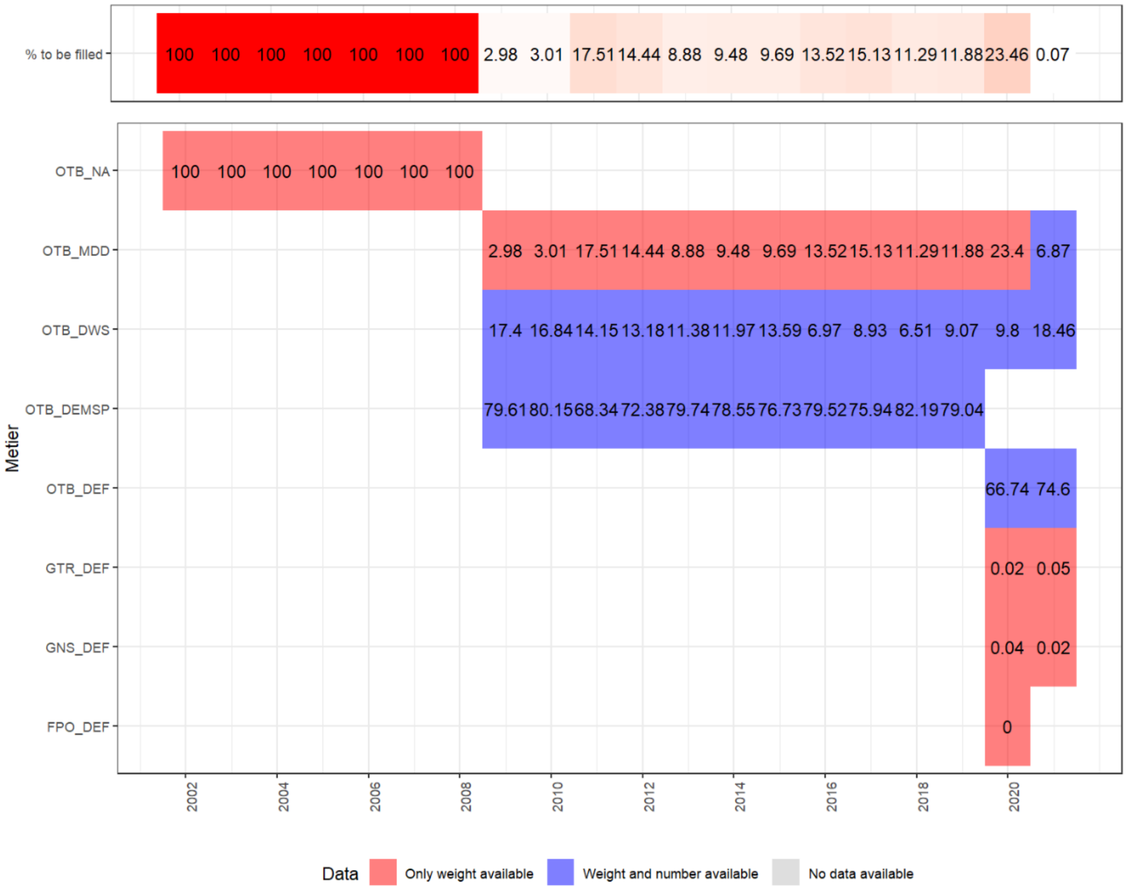


Figure 6.8.2.1.3. Norway lobster in GSA 6: Available and reconstructed length frequencies for landings. Series of data with weight and length frequencies available in the DCF in blue; series with weight only for which length frequencies were reconstructed using median values in red.

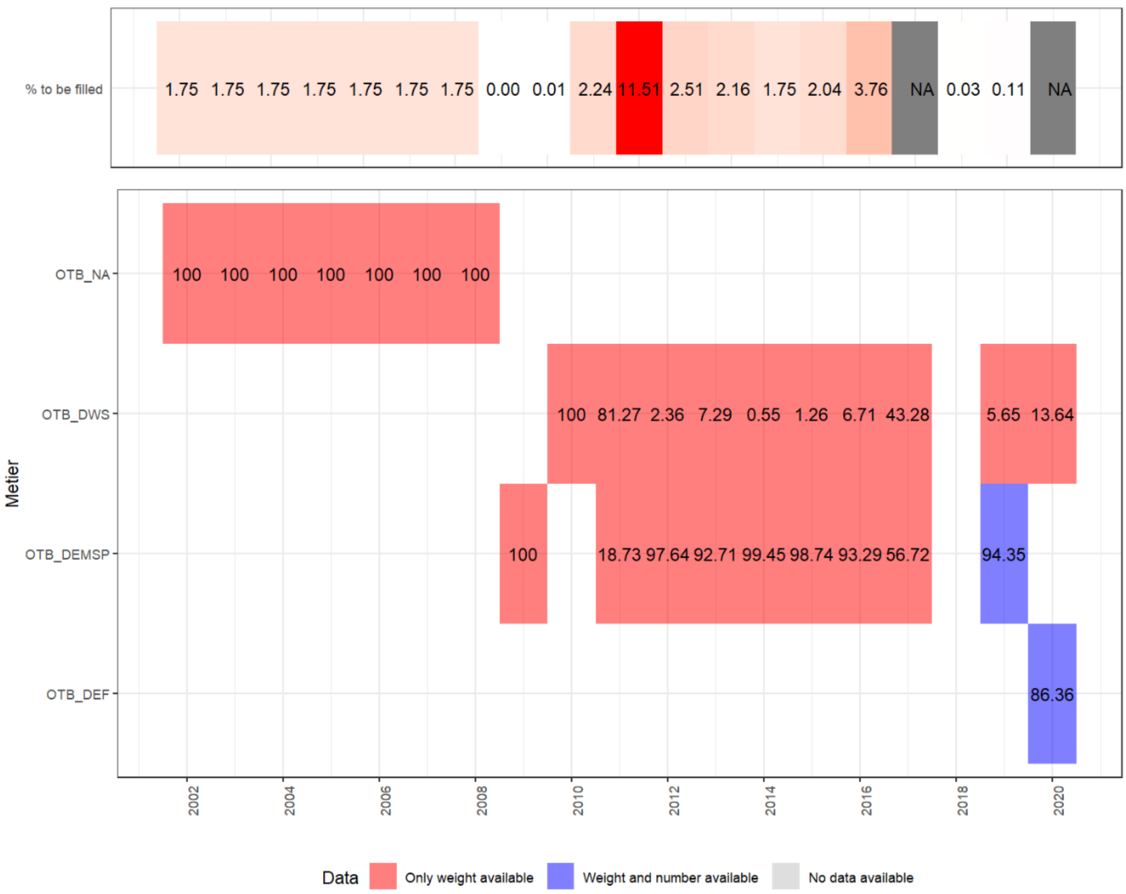


Figure 6.8.2.1.4. Norway lobster in GSA 6: Available and reconstructed length frequencies for discards. Series of data with weight and length frequencies available in the DCF in blue; series with weight only for which length frequencies were reconstructed using median values in red.

The annual length frequencies by métier for the period 2002-2021 are shown in Figure 6.8.2.1.5. Note the low number of individuals sampled in 2020 for métier DWS and the irregular size structure for métier DEF in 2020. In typical years (e.g. before 2020 and in 2021) 5000 individuals or more were sampled from the catches in ~150 samplings, while in 2020 only ~1000 individuals were measured in ~100 samples.

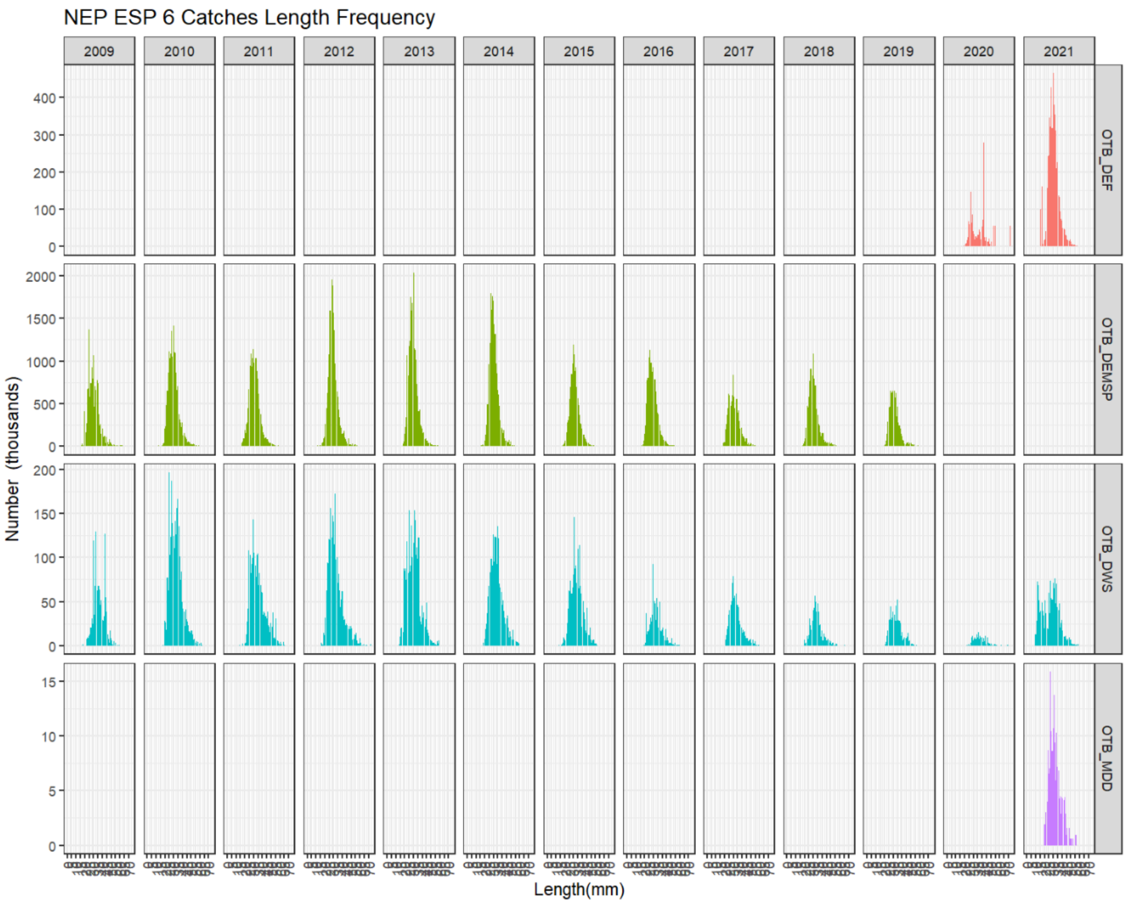


Figure 6.8.2.1.5. Norway lobster in GSA 6: Length frequency distribution of catches.

Discards were included in the total catches for stock assessment purposes. The catches at length were raised to the total catches with sum-of-products (SOP) correction. The SOP corrections were similar on all years, except in 2020 which was considerably higher than 1 and 2021, which was lower (Table 6.8.2.1.2).

Table 6.8.2.1.2. Norway lobster in GSA 6: values of SOP correction used to raise the annual catches in number in the length frequency data to total catches in weight.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SOP	1.101	1.000	1.248	1.308	1.152	1.159	1.112	1.116	1.180	1.113	1.226	2.284	0.874

6.8.2.2 Effort

See EWG 22-10 report of FDI data.

6.8.2.3 Survey data

The MEDITS trawl surveys carried out annually in GSA 6 in late spring since 1994 were used to derive a fisheries independent abundance index (Figure 6.8.2.3.1). Note that in 2020 only the northern half of GSA 6 could be covered by the survey (approximately northwards from 40 º latitude), but in 2021 experimental survey covered again the entire area.

Figure 6.8.2.3.1. Time of MEDITS surveys in GSA 6.

The length frequency distribution obtained during the MEDITS survey samplings is shown in Figure 6.8.2.3.2.

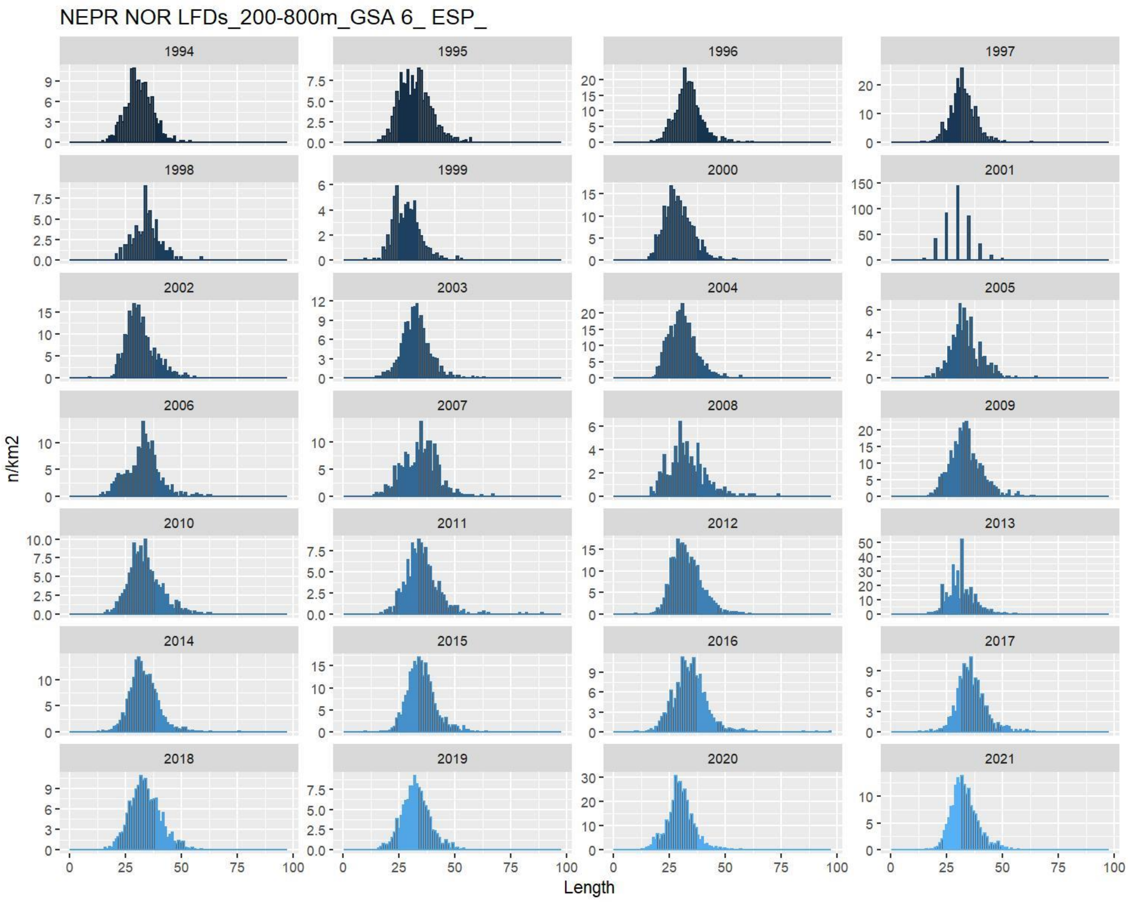


Figure 6.8.2.3.2. **Norway lobster in GSA 6:** Length frequency distribution by year in the MEDITS sampling. (Note that length frequencies in 2001 were reported in 5-mm bins, while 1-mm bins are used normally in all years for crustaceans).

The abundance indices derived from the MEDITS survey, in number of individuals / km^2 and kg / km^2, are shown in Figs. 6.8.2.3.3 and 6.8.2.3.4. The abundance of Norway lobster fluctuated without a trend over the 28-year period. The indicator n km^{-2} in 2020 was the highest in the series (534 ind km^{-2}), but it decreased to 170 ind km^{-2} in 2021, close to the series average (200 ind km^{-2}). The indicator kg/km^2 in recent years is well within the average of the entire series (5 kg/km^2).

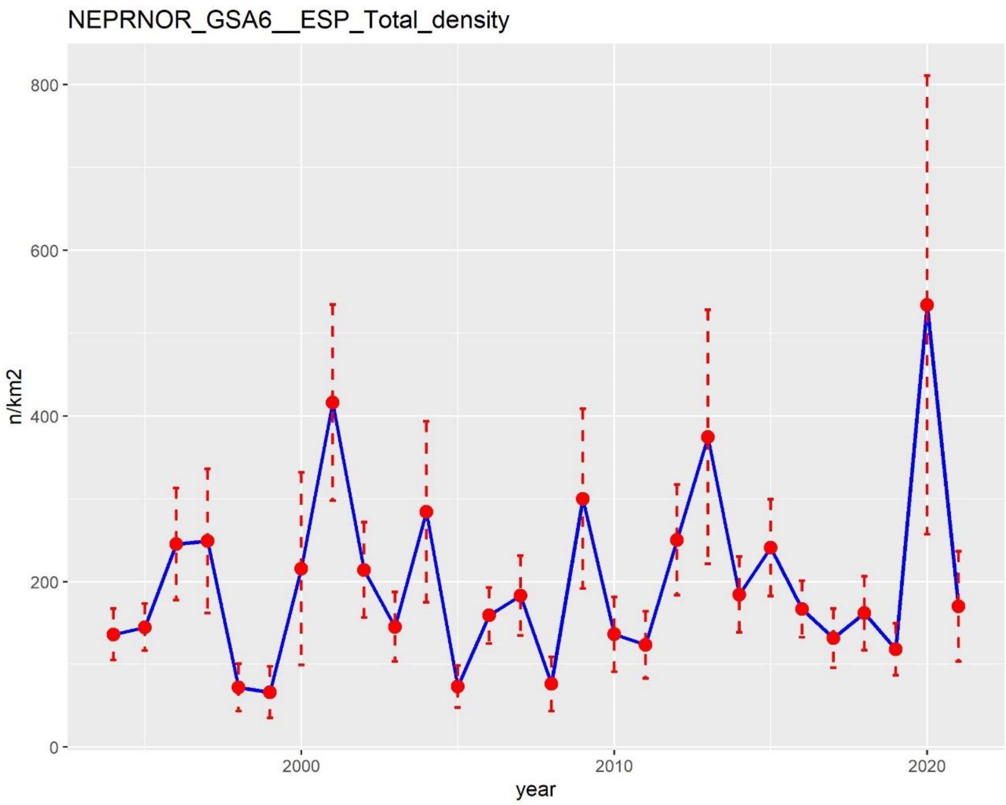


Figure 6.8.2.3.3. **Norway lobster in GSA 6:** Abundance index (n/km^2) estimated from MEDITS survey over the period 1994-2021.

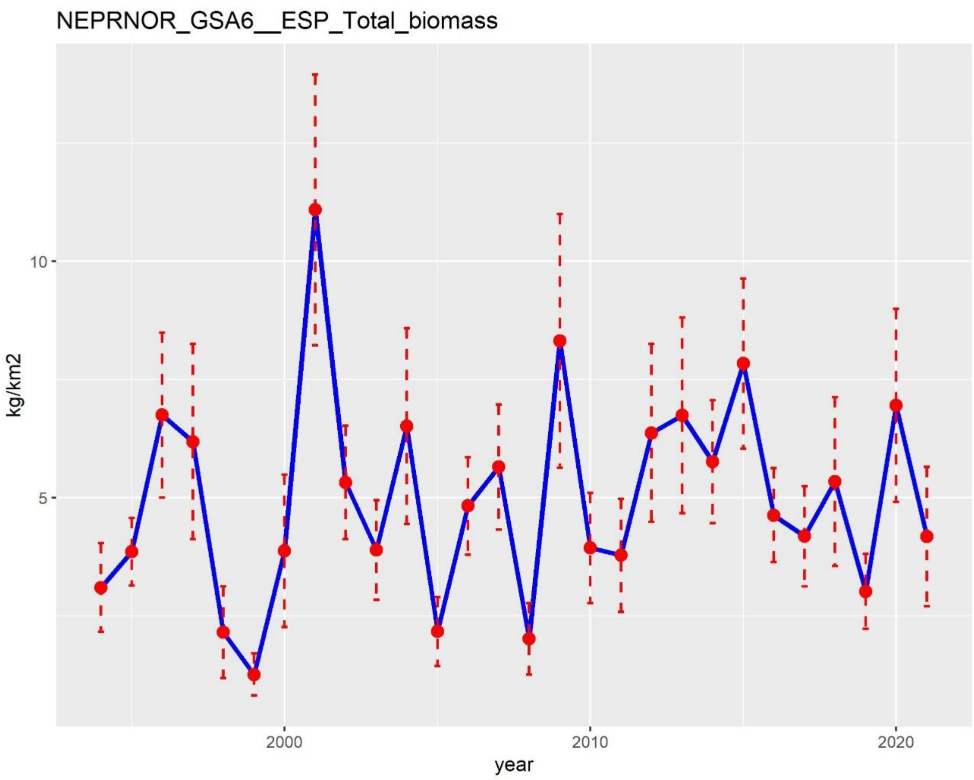


Figure 6.8.2.3.4. **Norway lobster in GSA 6:** Abundance index (kg/km^2) estimated from MEDITS survey over the period 1994-2021.

The length frequencies from the MEDITS series were converted to age frequencies with the standard **l2a** routine in FLa4a. The resulting catch at age matrix is shown in Figure 6.8.2.3.5.

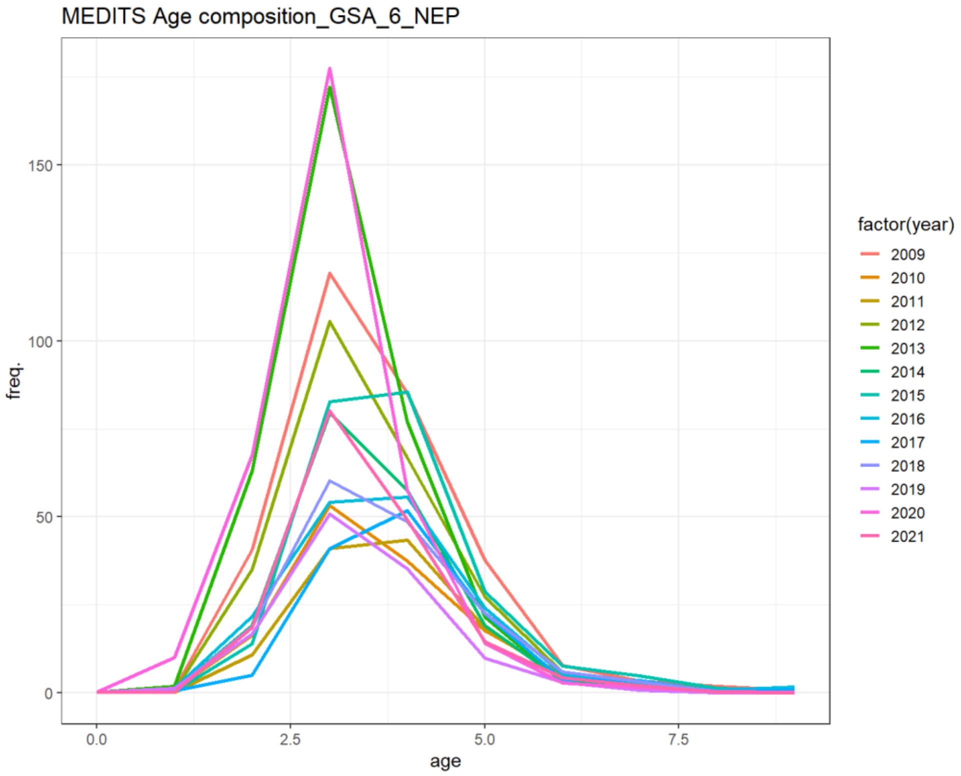


Figure 6.8.2.3.5. Norway lobster in GSA 6: Catch at age distribution in the MEDITS survey samples (data for years before 2009 have been omitted for clarity).

6.8.3 Stock Assessment

6.8.3.1 Assessment Input Data

The basic input data for the stock assessment of Norway lobster in GSA 6 using the a4a method are provided in tables 6.8.3.1 to 6.8.3.5. The assessment period covers the years 2009-2021 for which data on length frequencies are available and of reasonably good quality. Nevertheless, initial trial stock assessments with the entire data set led to unreasonably large residuals for 2020, which can be attributed to insufficient quality of the length frequency of commercial catches in 2020, as discussed at the end of Section 6.8.1. It was decided to remove the data from the discards.n, landings.n and catch.n slots for year 2020. Excluding the data for 2020 the diagnostics of the stock assessment were observed to be more robust.

Table 6.8.3.1. **Norway lobster in GSA 6:** Total Catch by year in tonnes (SOP corrected).

year	2009	2010	2011	2012	2013	2014	2015	2016
Catches (t)	355.61	406.51	508.21	571.89	490.7	500.79	361.58	314.47
year	2017	2018	2019	2020	2021			
Catches (t)	293.24	287.03	270.34	200.33	149.432			

Table 6.8.3.2. **Norway lobster in GSA 6:** Catch in numbers by age and by year. Note that data for 2020 was excluded from the final accepted assessment.

age	2009	2010	2011	2012	2013	2014	2015	2016
2	4967.55	5491.56	6124.78	8972.26	8671.07	6201.28	3301.33	6946.82
3	6841.91	9549.44	10563.32	15750.93	13472.15	13665.67	8691.29	7950.80
4	3431.52	3497.85	4994.43	4033.73	3621.07	4339.97	3705.11	2509.08
5	1196.26	1150.18	1343.40	1284.76	1144.79	1155.32	1042.16	678.90
6	277.10	270.35	394.50	336.55	264.60	314.48	250.68	126.20
7	135.12	185.61	272.17	220.98	115.88	158.89	71.80	81.89
8	27.25	34.56	76.88	92.28	34.17	18.04	9.03	15.92
9+	61.05	31.65	48.79	46.60	30.71	11.51	1.81	4.75

age	2017	2018	2019	2020	2021
2	5050.33	3361.38	2411.19	1190.06	1584.77
3	5749.70	7612.19	6558.71	1695.89	3559.15
4	2870.75	2172.16	2609.26	908.03	1332.53
5	852.90	713.79	557.13	1823.53	440.26
6	147.15	221.82	250.56	263.48	120.40
7	151.86	171.48	158.25	265.99	57.31
8	19.46	24.52	9.91	55.33	14.09
9+	11.55	4.20	14.75	6.15	4.71

The catch at age in numbers is also shown in Figure 6.8.3.1. Note that the years 2019, 2020 and 2021 had the lowest age classes in the time series 2009-2021. Catch.n at age differed from last year. In 2021 a stating time of T0=+.5 was applied, but this was removed in the light of further examination of biology (See Section 6.8.1). The changes shifted the numbers at age to younger ages at 2 with increases at ages 3 to 8 which is consistent with the T0 shift. The plus group last year was lower as the other ages had increased numbers at age. The change in length slicing from 2021 to 2022 was tested this year and found to give negligible differences in F and $F_{0.1}$, reinforcing the robustness of the assessment.

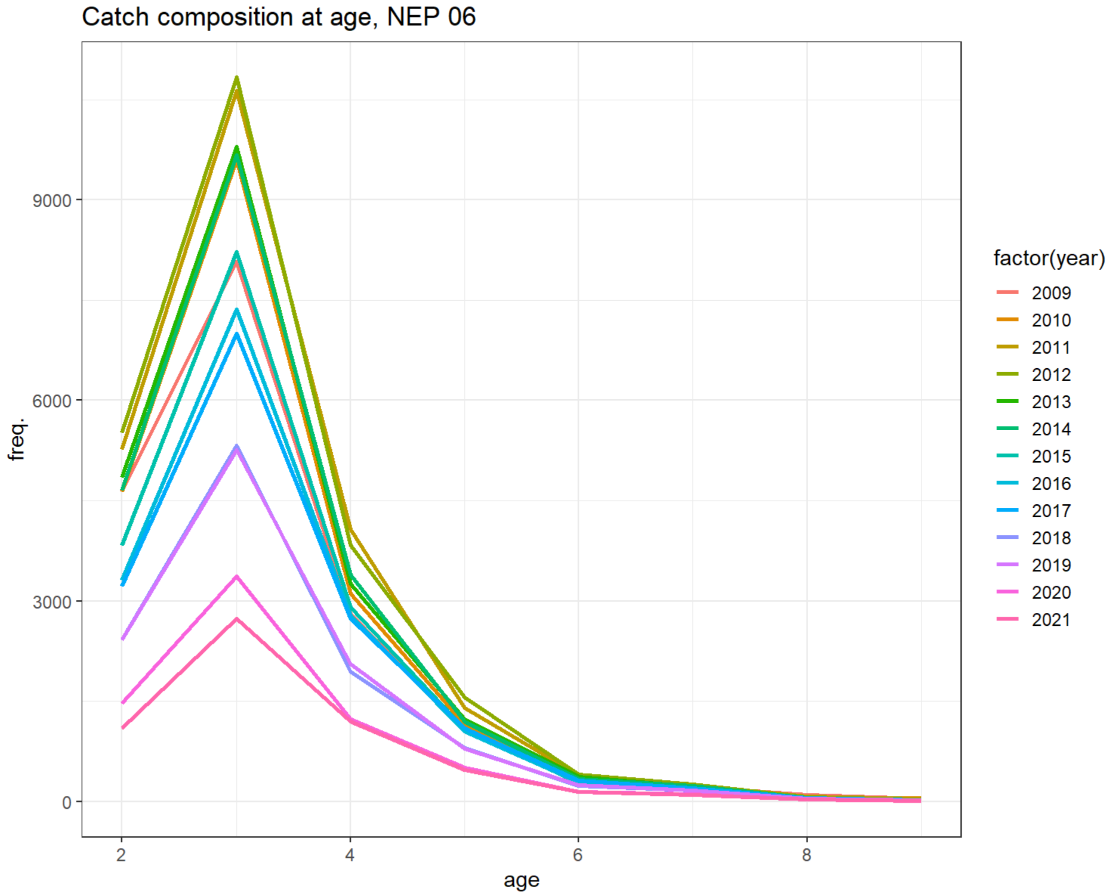


Figure 6.8.3.1. **Norway lobster in GSA 6:** Catch in numbers by age and by year (data for 2020 not included in the assessment).

Table 6.8.3.3. Norway lobster in GSA 6: Stock and catch weights at age.

age	2009	2010	2011	2012	2013	2014	2015	2016
2	0.0084	0.0086	0.0087	0.0088	0.0085	0.0090	0.0088	0.0085
3	0.0168	0.0167	0.0170	0.0162	0.0164	0.0165	0.0172	0.0166
4	0.0287	0.0292	0.0292	0.0292	0.0291	0.0291	0.0295	0.0291
5	0.0483	0.0472	0.0472	0.0473	0.0473	0.0470	0.0470	0.0471
6	0.0698	0.0678	0.0674	0.0678	0.0678	0.0680	0.0674	0.0673
7	0.0878	0.0896	0.0883	0.0898	0.0895	0.0860	0.0893	0.0890
8	0.1129	0.1131	0.1136	0.1121	0.1150	0.1136	0.1120	0.1117
9	0.1376	0.1348	0.1349	0.1384	0.1310	0.1299	0.1273	0.1365

age	2017	2018	2019	2020	2021
2	0.0086	0.0088	0.0093	0.0092	0.0088
3	0.0170	0.0167	0.0169	0.0152	0.0169
4	0.0294	0.0290	0.0294	0.0308	0.0293
5	0.0478	0.0463	0.0463	0.0470	0.0473
6	0.0681	0.0684	0.0683	0.0680	0.0690
7	0.0871	0.0895	0.0888	0.0942	0.0881
8	0.1098	0.1143	0.1139	0.1084	0.1145
9	0.1331	0.1362	0.1273	0.1273	0.1337

Table 6.8.3.4. Norway lobster in GSA 6: Maturity and Natural mortality at age.

age	2	3	4	5	6	7	8	9+
maturity	0.20	0.36	0.60	0.80	0.89	0.94	0.97	1.00
M: Chen-Watanabe	0.466	0.353	0.291	0.252	0.225	0.206	0.192	0.181

Other conditions:

Average spawning time set at 1/6 because *Nephrops* in GSA 6 spawns (=eggs hatch) in January – February.

Catch numbers for 2009 to 2021 (excl. 2020); age range 2 to 9+

Fbar set to ages 3 to 6.

Table 6.8.3.5. **Norway lobster in GSA 6:** MEDITS tuning index of abundance by age and by year.

age	2009	2010	2011	2012	2013	2014	2015	2016
2	40.57	16.33	10.78	35.12	62.99	19.15	14.00	21.72
3	119.17	53.20	41.00	105.53	172.01	79.54	82.66	54.14
4	85.18	37.54	43.44	66.73	76.91	57.46	85.53	55.58
5	37.69	17.70	18.30	27.22	21.50	19.10	28.80	24.07
6	7.85	5.22	4.07	5.83	2.93	3.36	7.56	5.22
7	3.31	2.69	2.98	2.74	1.82	2.50	4.77	2.22
8	1.86	0.62	0.12	1.09	0.66	0.53	1.23	0.69
9	0.81	0.88	1.09	0.43	0.12	0.55	0.57	1.62

age	2017	2018	2019	2020	2021
2	5.01	18.78	16.66	67.50	18.64
3	41.05	60.27	50.91	177.38	80.07
4	51.69	48.53	35.20	57.27	49.24
5	22.42	22.61	9.82	14.06	14.56
6	3.79	6.03	3.04	2.80	4.33
7	3.49	3.10	0.83	1.56	2.05
8	0.44	0.47	0.06	0.39	0.23
9	0.95	0.14	0.06	0.17	0.06

The internal consistency of the catch at age data is good (Figure 6.8.3.2) but the index at age data is not (Figure 6.8.3.3)

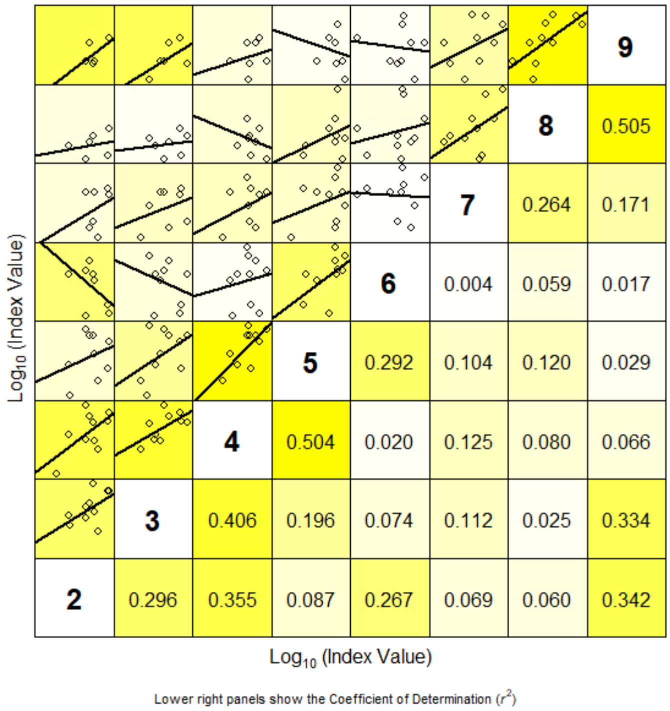


Figure 6.8.3.2. Norway lobster in GSA6: Consistency of cohorts of the catch-at-age data.

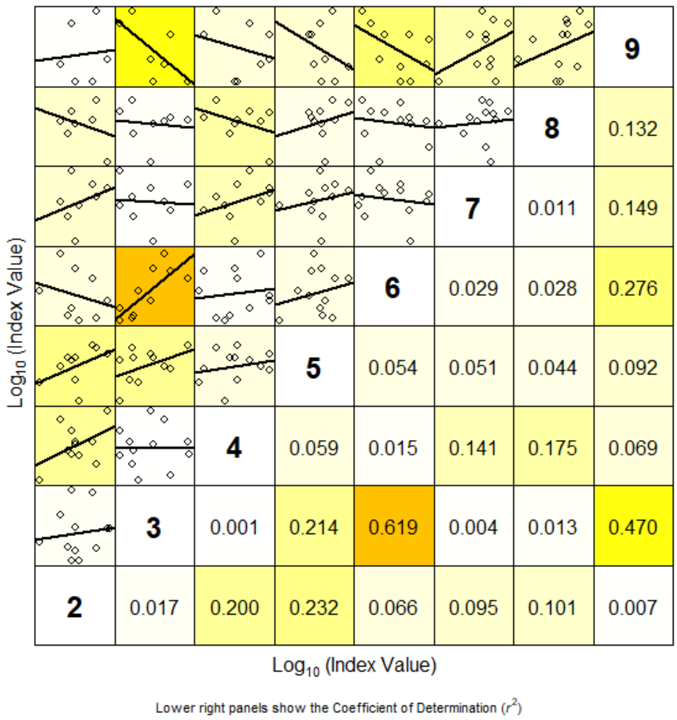


Figure 6.8.3.3. Norway lobster in GSA6: Consistency of cohorts of the index-at-age data.

6.8.3.2 ASSESSMENT RESULTS (METHOD A4A)

The stock assessment was based on the following sub-models:

fmodel: ~factor(age) + factor(year)

srmodel: ~s(year, k = 4)

qmodel: list(~factor(replace(age, age > 5, 5)))

A number of model options were checked, including reducing asymptotic age for qmodel to 4+, applying a smoother on age in Fmodel. The latter was tested because a ripple was observed in the selection pattern through ages 5 and 6. Smoothing resulted in amplifying the ripple and making F at the oldest age unstable. It's uncertain why the F at age has a ripple at these ages; it might be due to the use of sex combined parameterisation. The smoothing was not productive and was rejected. Reducing the asymptotic age for qmodel to 4+ gave results that were almost indistinguishable from 5+. GCV was better but DIC and AIC criteria worse, retrospective performance was very similar for SSB and very slightly worse for F. Based on this the EWG decided to keep the same model as last year with qmodel asymptotic at 5+.

The assessment results for Norway lobster in GSA 6 are shown in Figure 6.8.3.4 and in Tables 6.8.3.6 to 6.8.3.8.

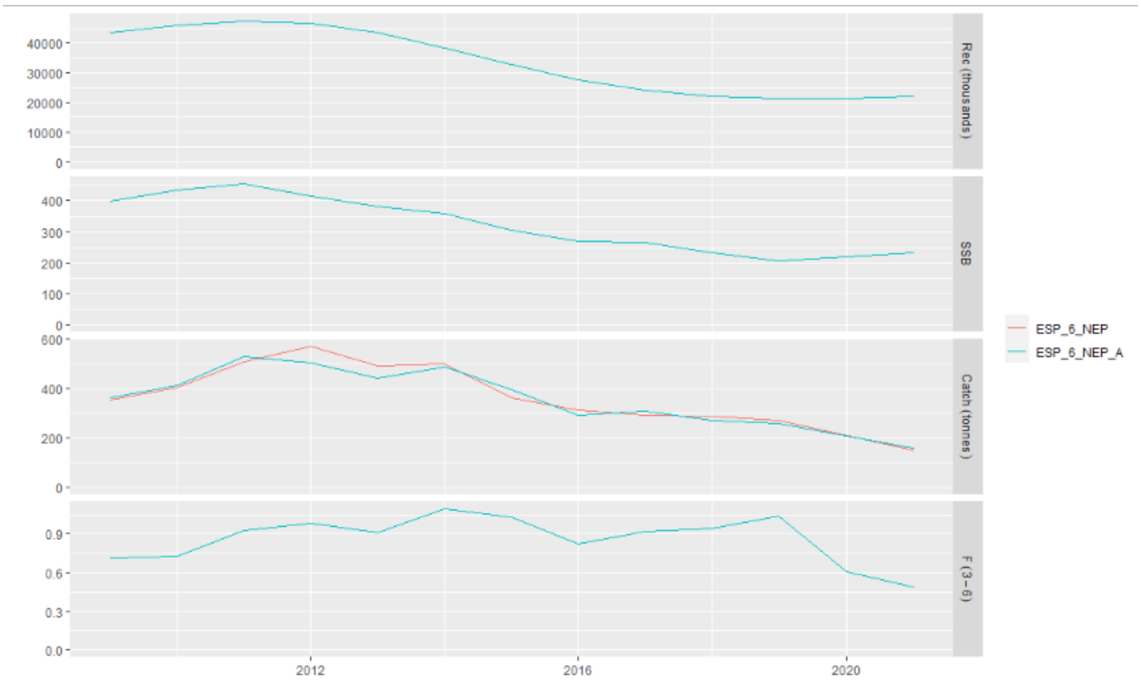


Figure 6.8.3.4. **Norway lobster in GSA 6:** Stock summary from the final a4a model.

Table 6.8.3.6. **Norway lobster in GSA 6:** Stock summary from the a4a assessment (base year 2019 for Western Med. MAP).

	Fbar	Rec. (000)	SSB (t)	Catch (t)
2009	363.9	0.712	398.30	43688
2010	411.7	0.727	434.28	46049
2011	528.3	0.926	455.43	47460

2012	505.5	0.985	414.21	46763
2013	443.6	0.908	380.46	43491
2014	486.6	1.094	359.81	38327
2015	395.5	1.028	304.01	32659
2016	290.5	0.820	268.41	27733
2017	310.0	0.919	265.46	24196
2018	272.1	0.943	232.50	22149
2019	259.8	1.042	205.10	21384
2020	156.8	0.608	188.76	21532
2021	158.7	0.487	232.40	22145

Table 6.8.3.7. **Norway lobster in GSA 6:** Stock number by age and by year (thousands).

age	2009	2010	2011	2012	2013	2014	2015	2016
2	43687.8	46048.9	47459.9	46762.6	43490.6	38327.1	32658.6	27732.7
3	19325.1	23347.4	24530.4	24171.8	23503.7	22243.3	18798.5	16258.0
4	6429.1	6888.7	8210.3	7133.6	6646.9	6957.4	5515.1	4963.5
5	2165.3	2177.1	2296.1	2192.3	1784.3	1811.9	1542.2	1315.6
6	745.7	764.4	756.6	639.6	572.2	507.4	419.3	384.0
7	263.5	329.6	334.0	280.1	225.6	215.2	163.5	142.7
8	95.2	71.5	87.5	65.2	49.9	45.3	32.4	27.3
9+	34.8	53.9	53.2	49.0	38.2	31.7	23.2	17.9

age	2017	2018	2019	2020	2021
2	24195.6	22149.0	21383.8	21532.0	22144.7
3	14467.0	12343.8	11238.9	10612.4	11781.4
4	5232.4	4237.3	3533.8	2929.0	4179.5
5	1491.8	1408.8	1110.9	830.2	1114.3
6	412.4	419.1	385.4	272.4	329.2
7	155.3	153.6	153.0	129.7	131.4
8	32.8	30.7	29.2	25.0	41.4
9+	17.4	17.5	16.4	14.2	18.3

Table 6.8.3.8. **Norway lobster in GSA 6:** Fishing Mortality by age and by year

age	2009	2010	2011	2012	2013	2014	2015	2016
2	0.160	0.163	0.208	0.222	0.204	0.246	0.231	0.184
3	0.678	0.692	0.882	0.938	0.864	1.041	0.978	0.780
4	0.792	0.808	1.029	1.095	1.009	1.215	1.142	0.911
5	0.789	0.805	1.026	1.091	1.005	1.212	1.138	0.908
6	0.591	0.603	0.768	0.817	0.753	0.907	0.852	0.680
7	1.098	1.120	1.428	1.518	1.399	1.686	1.584	1.263
8	0.754	0.769	0.980	1.042	0.960	1.157	1.087	0.867
9+	0.545	0.556	0.708	0.753	0.694	0.836	0.786	0.627

age	2017	2018	2019	2020	2021
2	0.207	0.212	0.234	0.137	0.110
3	0.875	0.897	0.991	0.578	0.464
4	1.021	1.048	1.157	0.675	0.541
5	1.018	1.044	1.154	0.673	0.540
6	0.762	0.782	0.864	0.504	0.404
7	1.416	1.453	1.605	0.937	0.751
8	0.972	0.997	1.102	0.643	0.515
9+	0.703	0.721	0.796	0.465	0.372

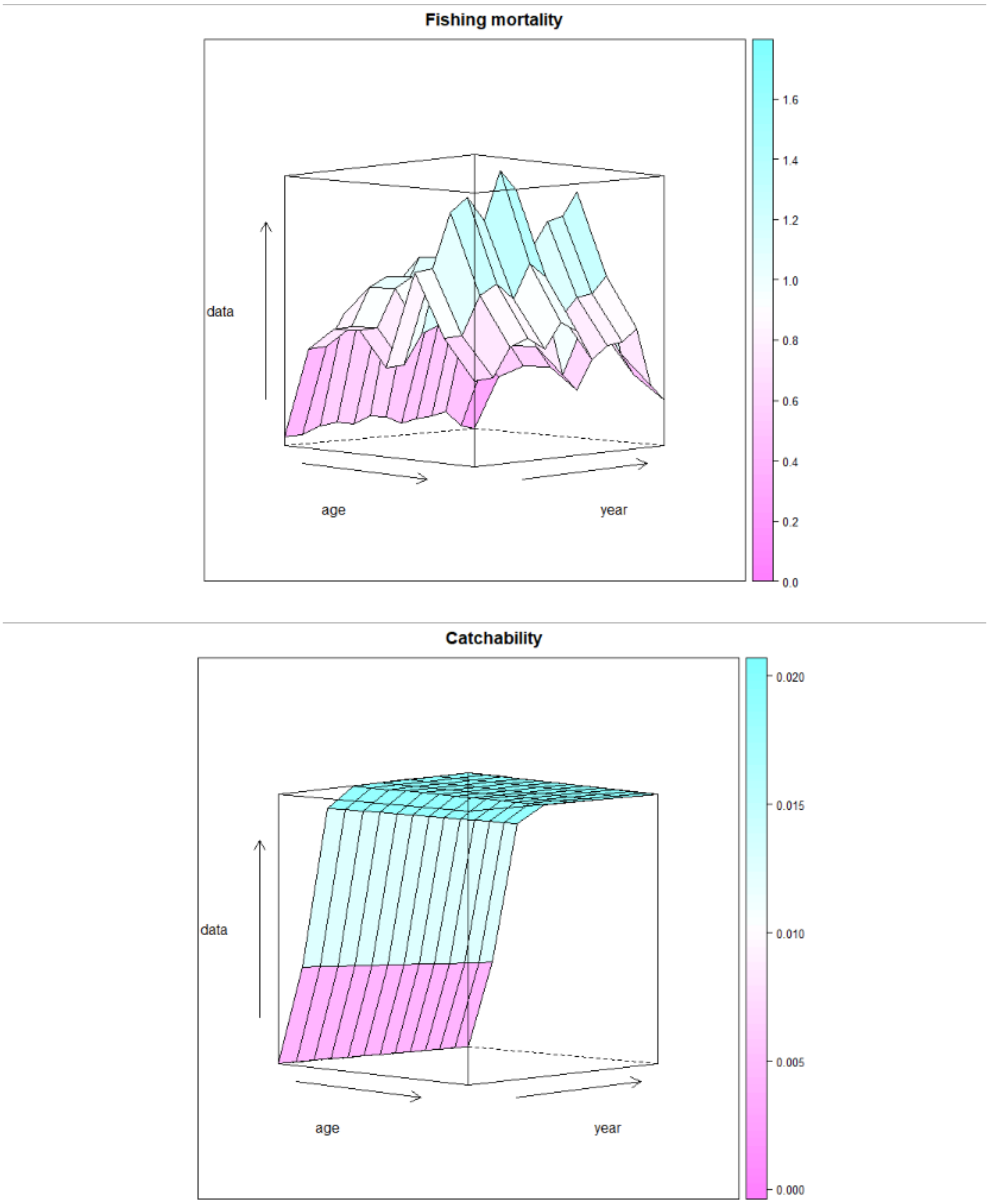


Figure 6.8.3.5. Norway lobster in GSA6: 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.

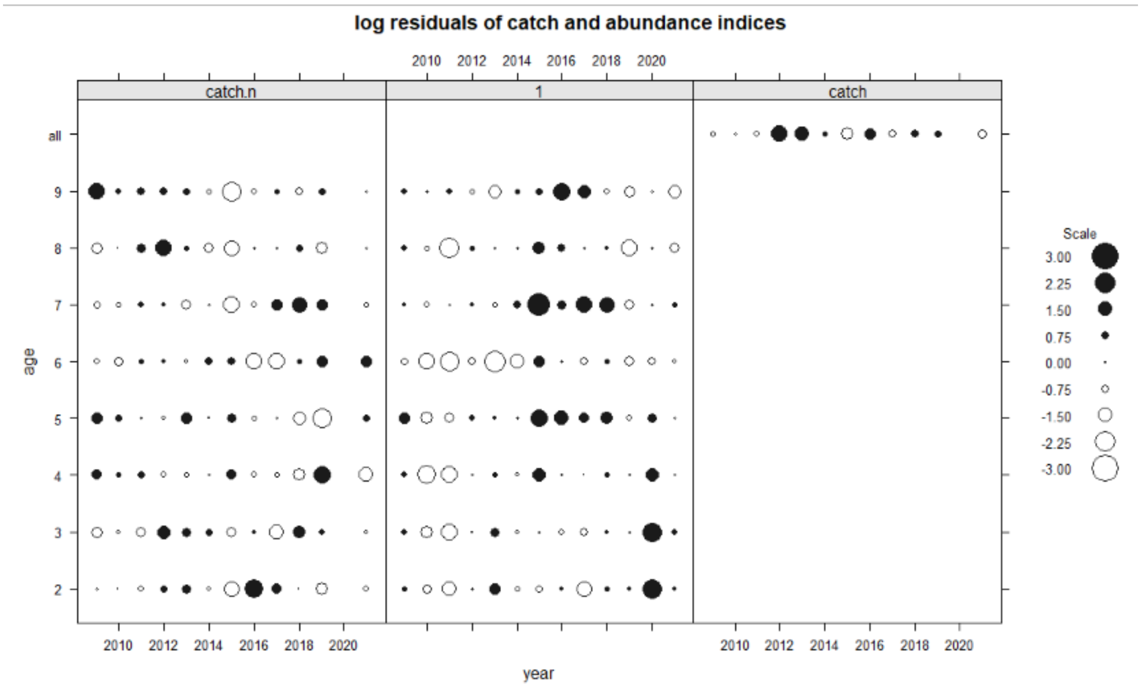


Figure 6.8.3.6. Norway lobster in GSA6: Standardized residuals for abundance indices and for catch numbers.

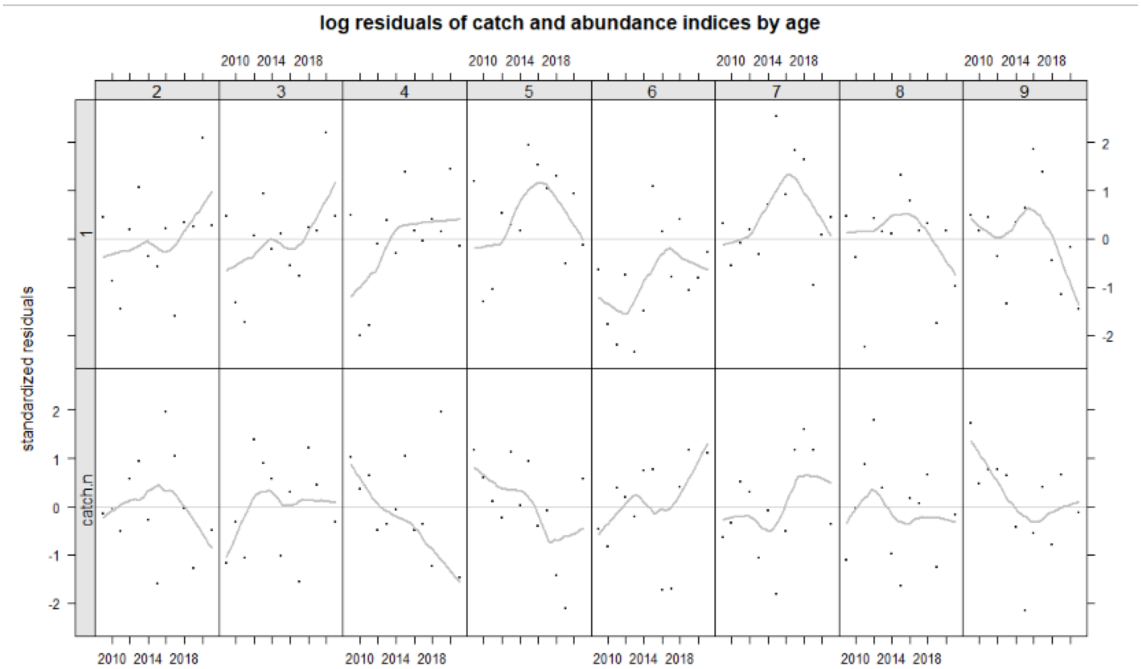


Figure 6.8.3.7. Norway lobster in GSA6: Standardized residuals for abundance indices and for catch numbers.

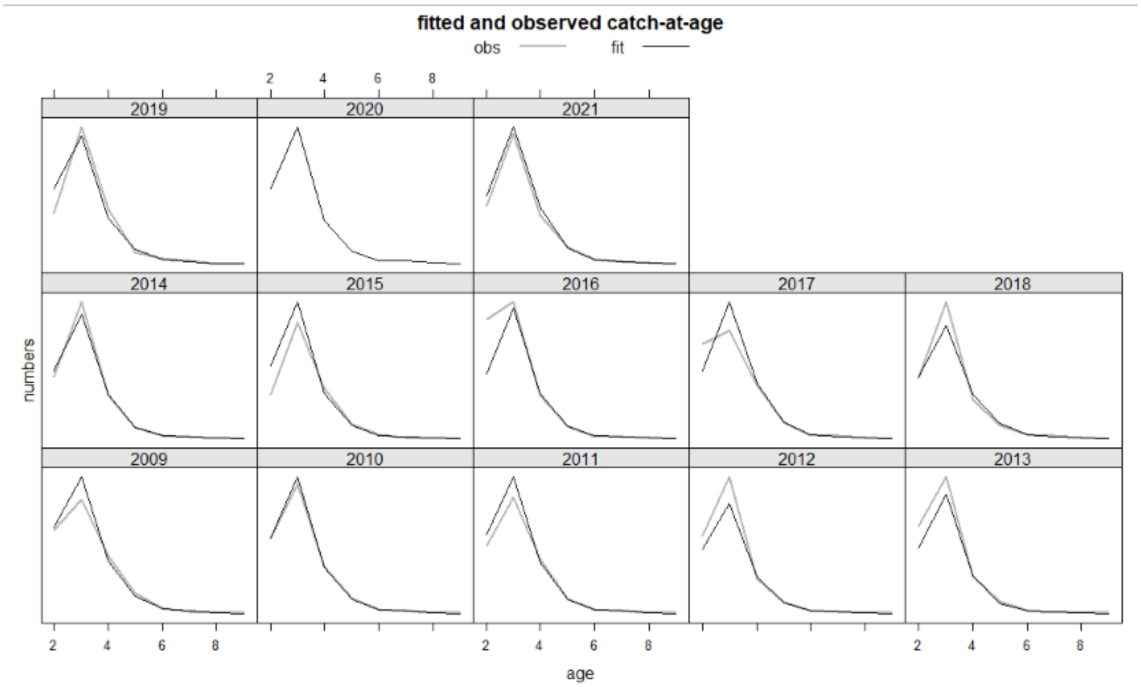


Figure 6.8.3.8. Norway lobster in GSA6: Fitted and observed catch-at-age.

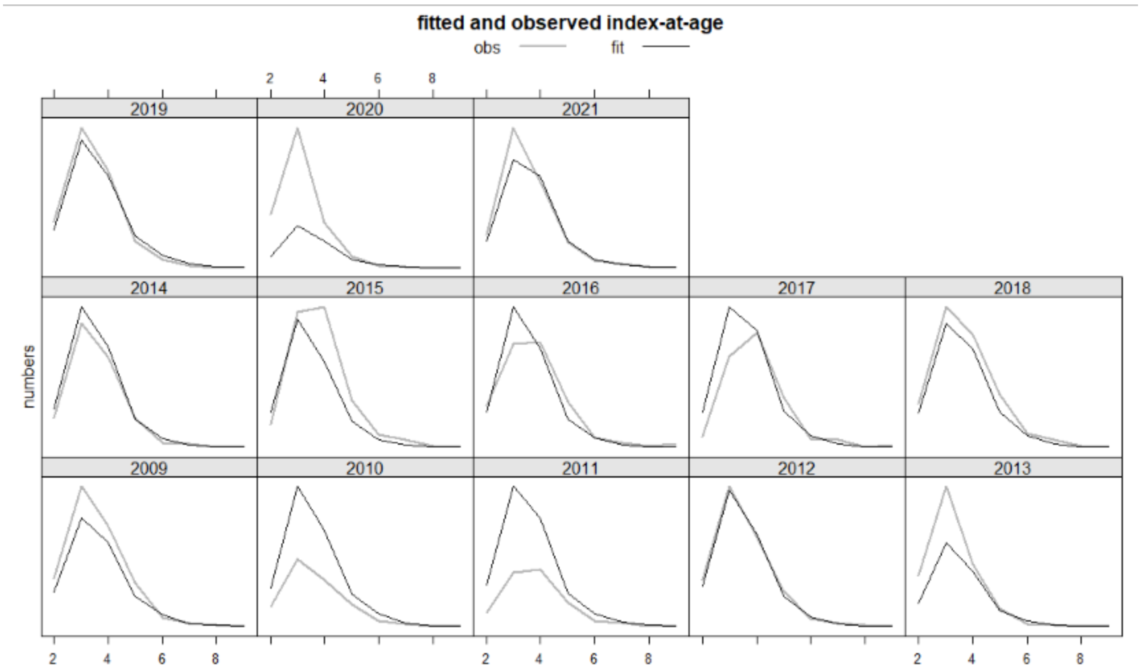


Figure 6.8.3.9. Norway lobster in GSA6: Fitted and observed index-at-age.

Retrospective

The retrospective analysis was applied up to 3 years back. Models results can be considered acceptable (Figure 6.8.3.10).

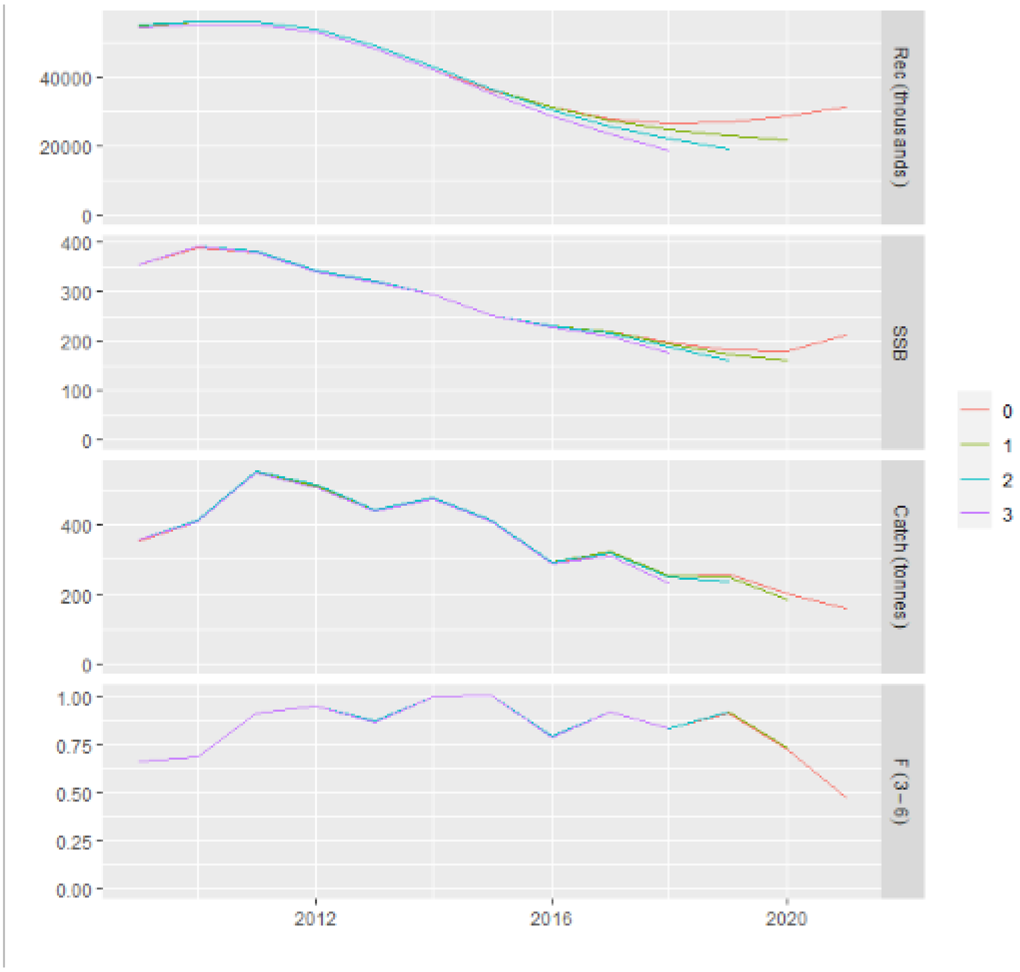


Figure 6.8.3.10. Norway lobster in GSA 6: Retrospective analysis.

Other fit statistics show that the model is not over parameterized (number of parameters / number of observations < 0.25):

fitSumm(fit.ll)

nopar	3.50E+01
nlogl	9.00E+01
maxgrad	4.36E-06
nobs	2.00E+02
gcv	1.56E-01
convergence	0.00E+00
accrate	NA
nlogl_comp1	- 9.97E+00
nlogl_comp2	9.99E+01
AIC	249.9413
BIC	365.3824

Conclusions to the assessment

The stock assessment results (Figure 6.8.3.10) show that fishing mortality Fbar (3-6) has been fluctuating between 2014 and 2019 and started to decrease in 2020. Fishing mortality was above F_{MSY} (using the F_{01} proxy, see section 6.8.4) for all years. In the last assessment year Fbar(3:6) [2021] = 0.460 while $F_{0.1}$ = 0.165. Recruitment and SSB appear to be decreasing since 2012, along with catches.

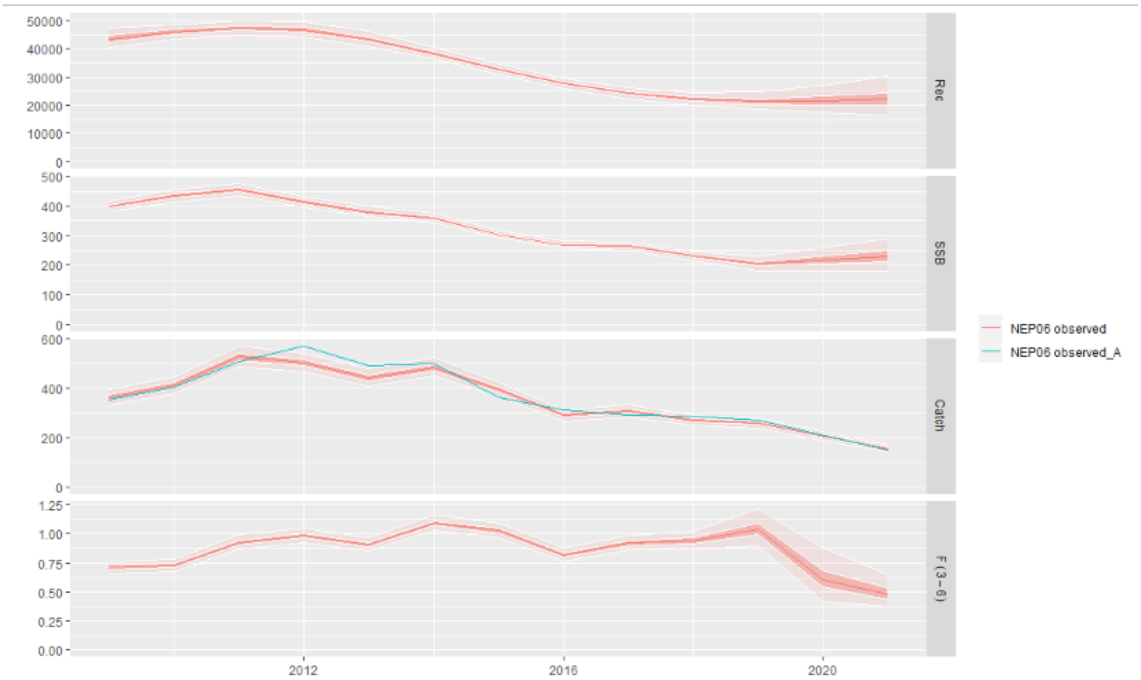


Figure 6.8.3.10. **Norway lobster in GSA 6:** Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals for the period 2009 to 2020.

6.8.4 Reference Points

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4 above. The input data is taken from the assessment above summarized in Figure 6.8.4.1.

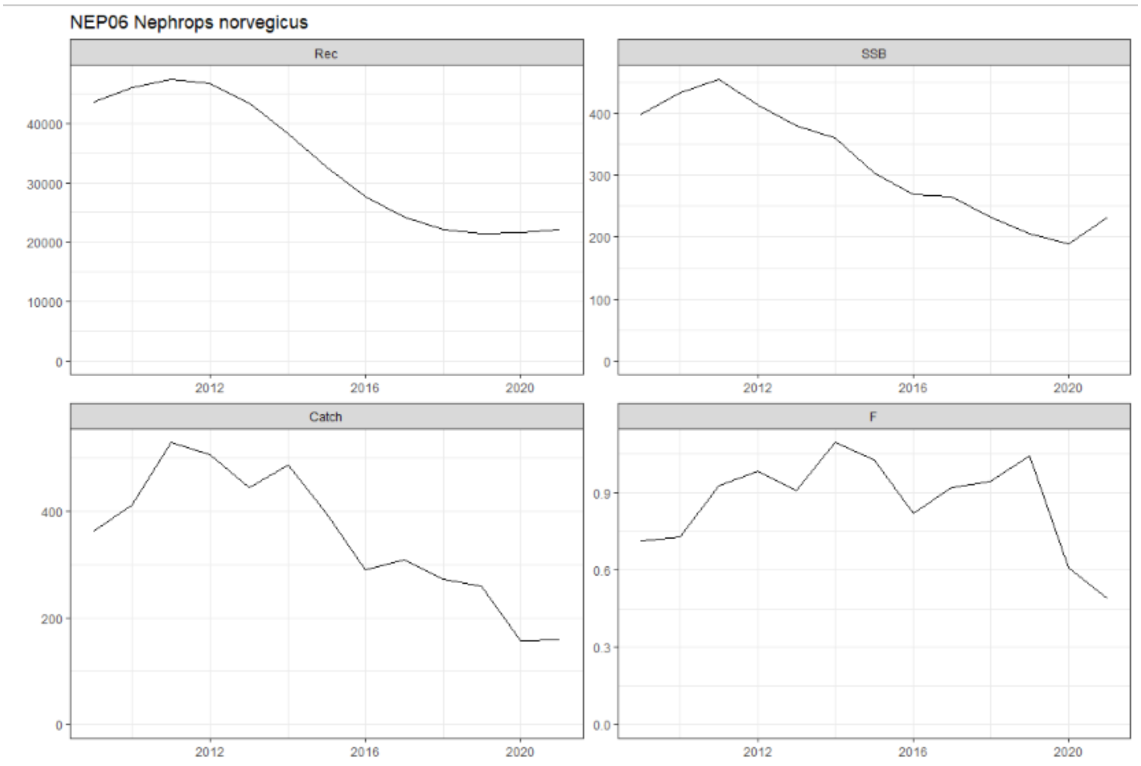


Figure 6.8.4.1. Nephrops in GSA06. Stock summary from the final a4a model.

A detailed overview of the input data used in the assessment and outcomes is provided in Figs. 6.8.4.2 to 6.8.4.4.

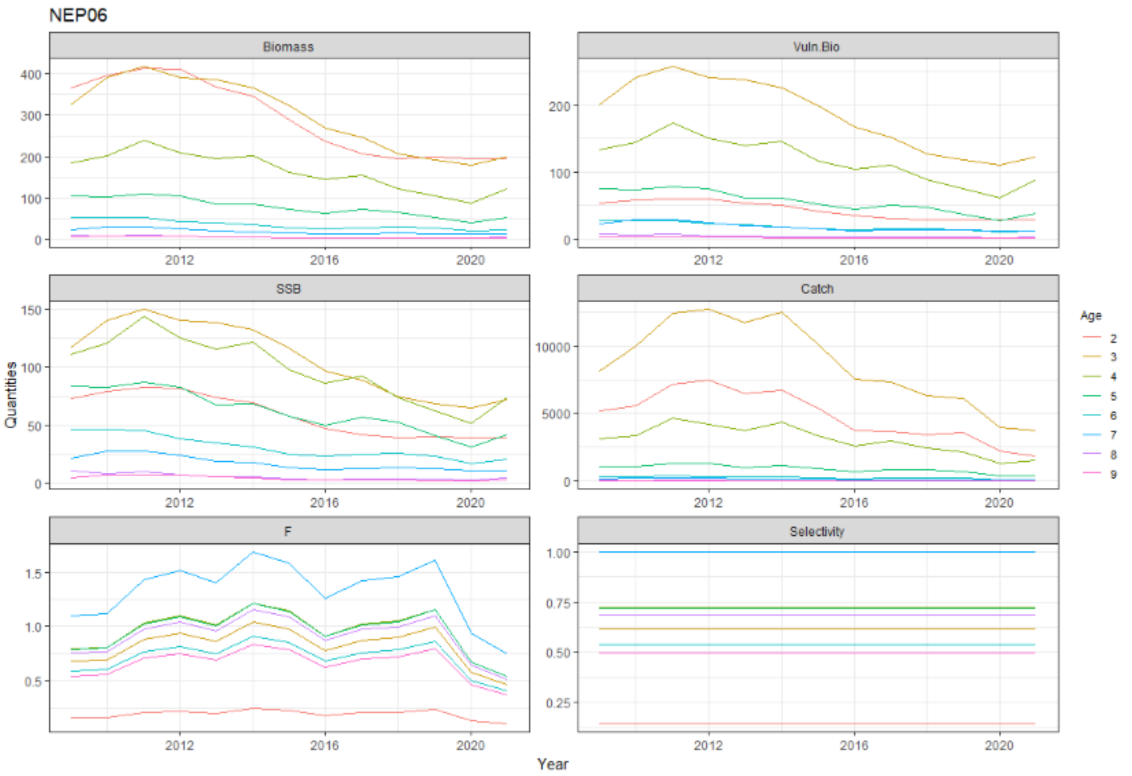


Figure 6.8.4.2. Norway lobster in GSA 6. Stock assessment trajectories at age.

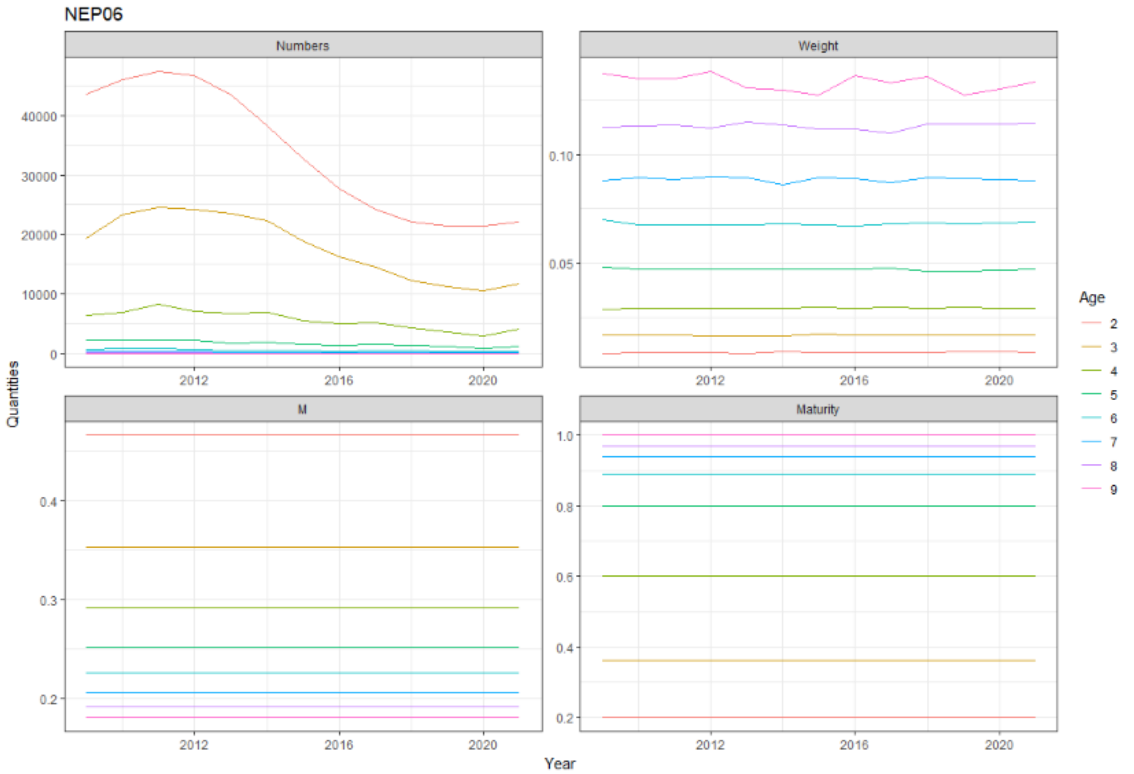


Figure 6.8.4.3. Norway lobster in GSA 6. Stock biology trajectories at age.

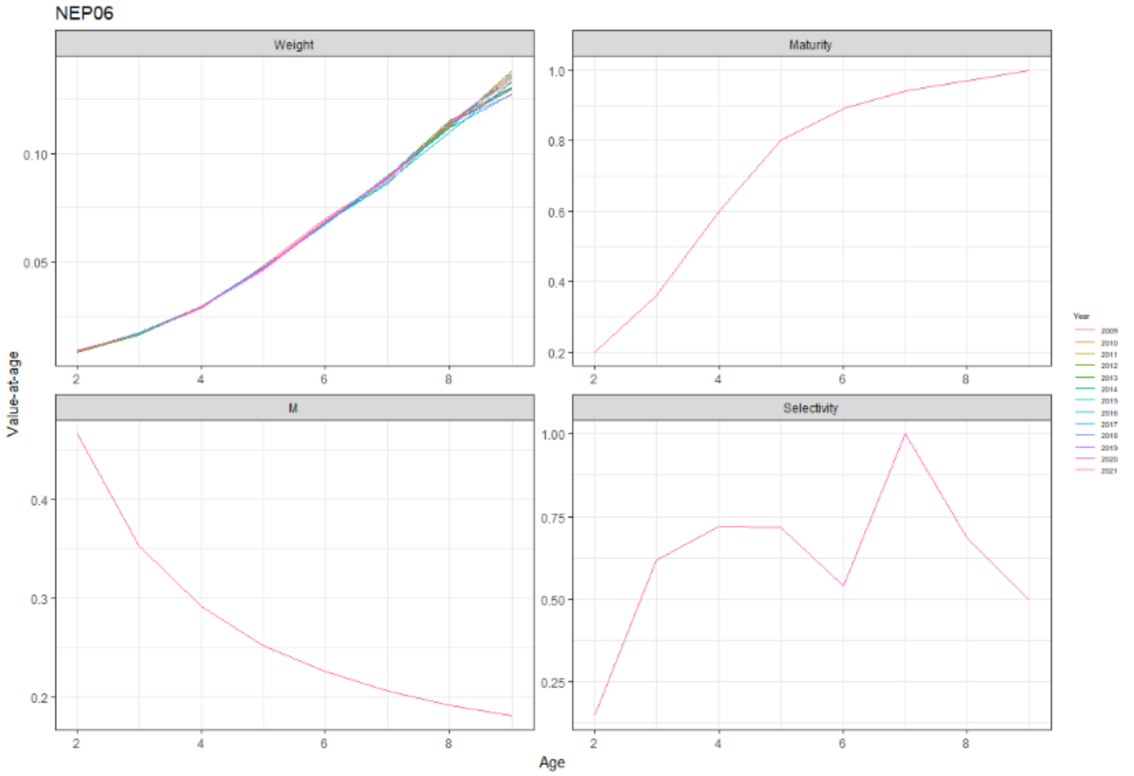


Figure 6.8.4.4. Norway lobster in GSA 6. Annual stock quantities at age: individual weights at age, fraction mature at age, natural mortality at age and selectivity at age in the fishery.

Exploratory analysis

An exploratory per-recruit analysis was performed using the stock object produced by EWG 22-09 with the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.8.4.1 and Figure 6.8.4.5.

Table 6.8.4.1. Norway lobster in GSA 6. Per-recruit reference points.

$F_{0.1}$	B_{trg}	B_{lim}	F_{lim}	Yeq	B_0
0.1646	0.0628	0.0157	0.5623	0.0111	0.179

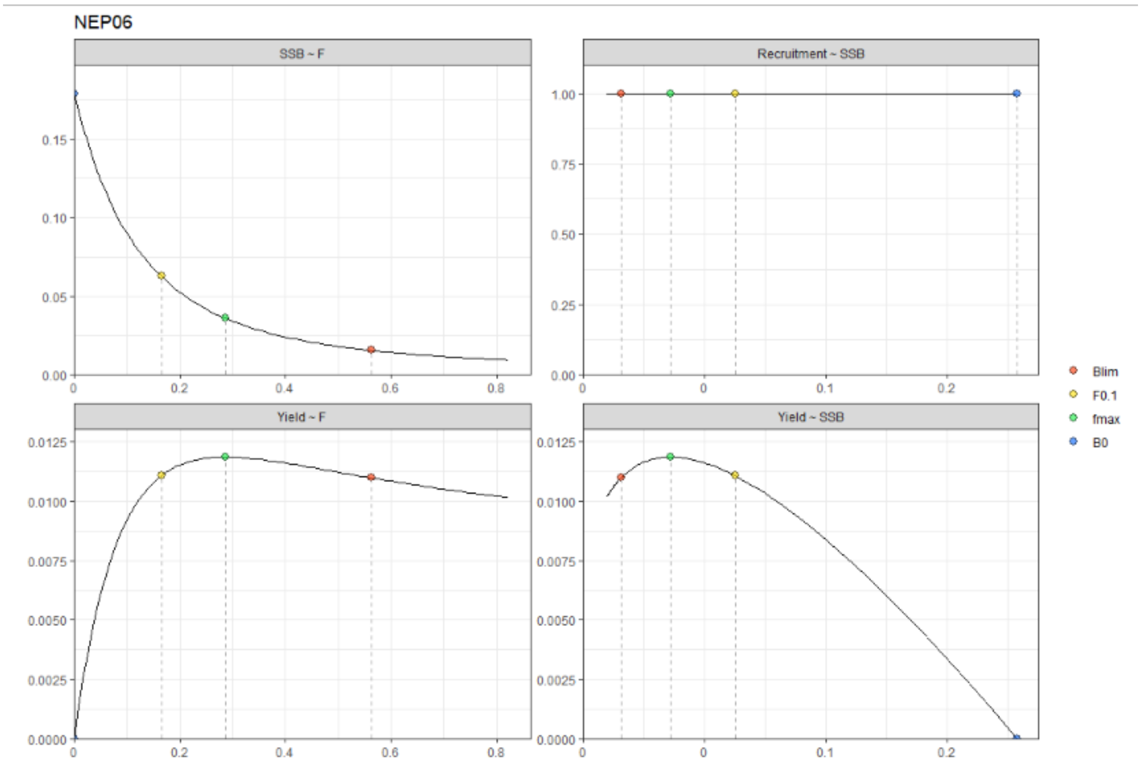


Figure 6.8.4.5. **Norway lobster in GSA 6**. Per-recruit analysis.

Figure 6.8.4.6 shows the trajectories of the assessment outputs relative to the per-recruit reference points R_0, SPR_0, YPR at $F_{0.1}$ and B_{Lim}. SSB by year is below the equilibrium biomass at $F_{0.1}$ ($B_{F0.1}$) for the whole time series and below B_{Lim} except in the years 2010-2011. At the same time, F is well above $F_{0.1}$ and F_{lim}, except for the last year 2021 when a strong decrease is apparent, moving the fishing mortality towards $F_{0.1}$.

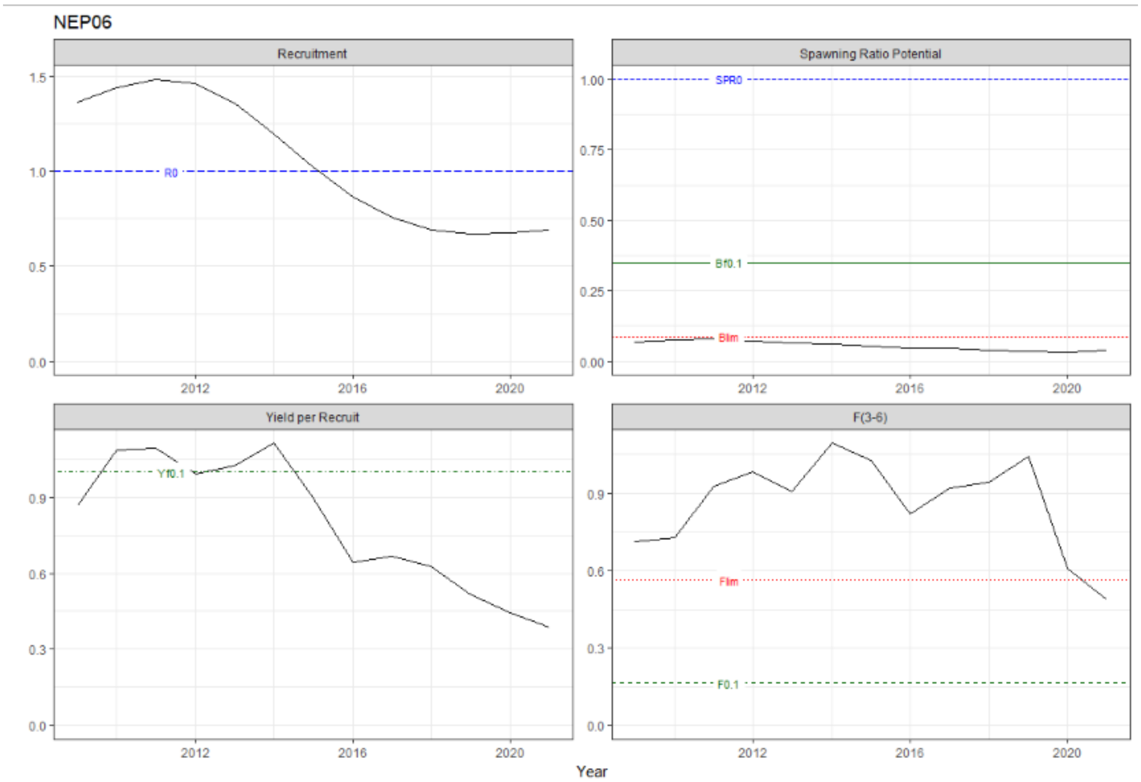


Figure 6.8.4.6 Norway lobster in GSA 6. Per-recruit analysis: outcomes of the a4a assessment relative to the per-recruit reference points.

Figure 6.8.4.7 shows the contribution in terms of spawning biomass per recruit (SPR) by age class in the current situation (red bars) compared to an un-fished scenario. This illustrates how overfished the population is from a yield per recruit perspective.

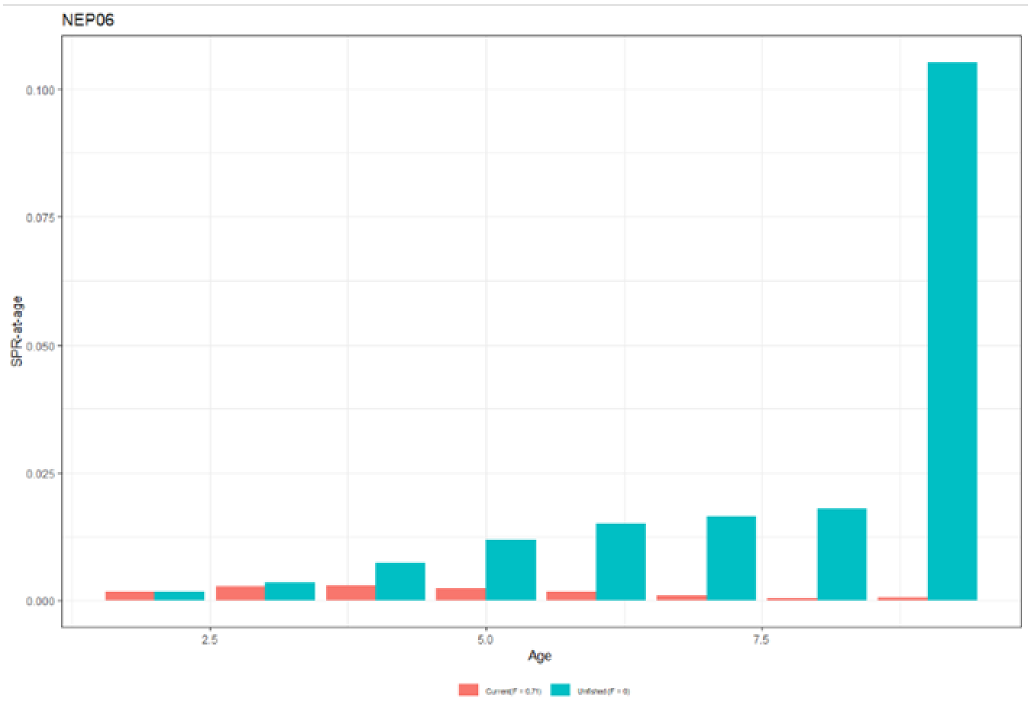


Figure 6.8.6.7 Norway lobster in GSA 6. Comparison of the spawning biomass per recruit SPRF at current F (average of last 3 years, red bars) and SPR_0 with F = 0 (blue bars).

Four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. GM: Geometric Mean (model=geomean)

2. HS: Hockey-Stick or segmented regression (model=segreg), estimated using lplim = 0.001 and uplim = 0.070, after several trials with uplim varying from 0.001 to 0.15 to test for sensitivity of the results to the specification of uplim (where *uplim* is the upper bound to the ratio SPR / SPR_0).

3. BH: Beverton-Holt (model=bevholtSV), with unconstrained estimation of steepness (s).

4. RI: Ricker (model=ricker), with unconstrained estimation of steepness (s).

Table 6.8.4.2. Norway lobster in GSA 6. Summary of four S/R candidate models.

	S	sigmaR	R_0	rho	B_0
gm@SV		0.327675	30090.01	0.977982	5417.075
hs@SV		0.312426	30090.01	0.977982	5417.075
bh@SV	0.810948	0.145879	949198.4	0.759105	170883.3
ri@SV	1.896827	0.136912	949198.4	0.726707	170883.3

The estimates of the four candidate models differ widely for R_0 and B_0. The estimate of R_0 produced by the BH or RI models was 30x the values obtained with the GM or HS models. The steepness of the BH model was 0.81, leading to very high estimates of R_0 and B_0. Hence, BH models with higher ***s*** values were explored (next section). The RI model was not further considered because the series of SSB and R available allowed examination of only the initial part of the SSB/R relationship for this stock.

The value of R_0 for the HS model depends on the priors; one option was to force it to be in line with the geometric mean recruitment by exploring HS models with lower limit 0.1% to upper limit 7.0% of SPR. The break-point of the HS in this cases is estimated at b = 185 tons, corresponding to a SRPlim = 0.0332. The breakpoint for the HS model (Figure 6.8.6.8) appears to the left of the all data points and at the geometric mean of the observed recruitment. With HS priors set to the standard values of 0.1 to 20% B_0, the HS follows the line of the BH model again with the breakpoint outside the data points, but this time to the right of the points, B_{lim} is thus not known, but probably higher than 455 t, the highest estimated biomass. If the GM model is used and the default value of 25% $B_{F0.1}$ applied this gives B_{lim} =472. Thus the Geometric mean and 25% $B_{F0.1}$ seems a good option, lying only a little above the highest biomass.

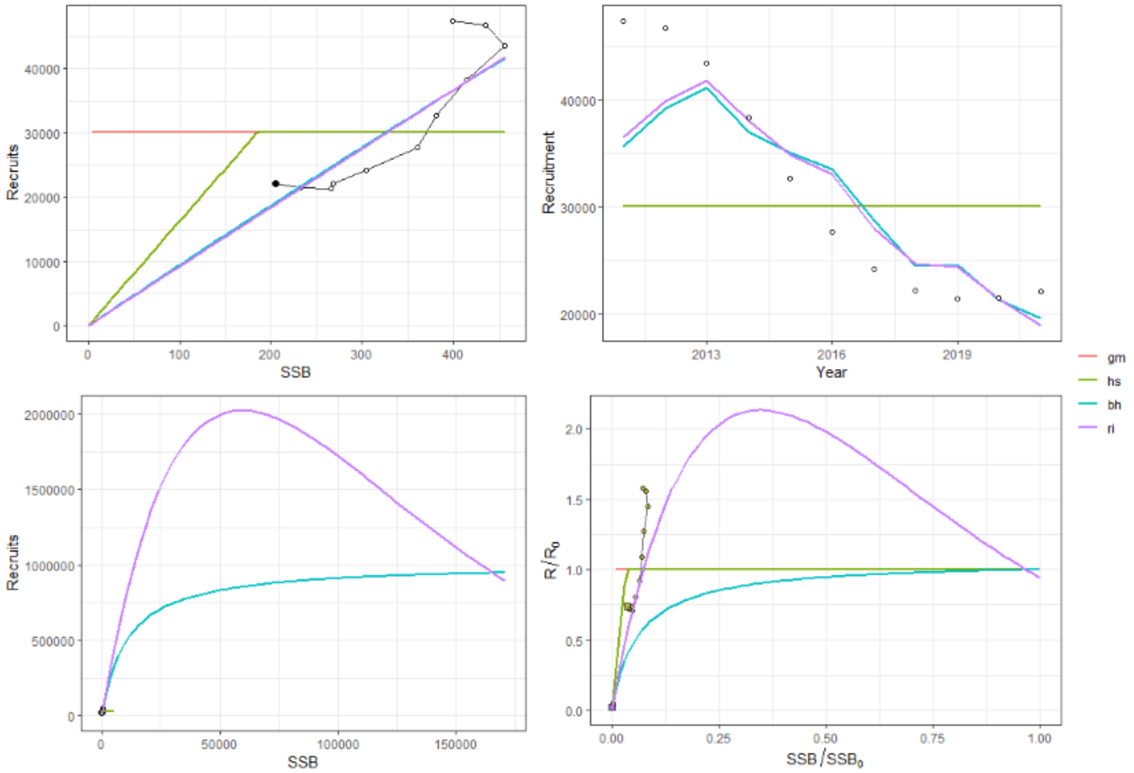


Figure 6.8.6.8. Norway lobster in GSA 6. Summary of four candidate S/R models, gm: geometric mean; hs: hockey-stick; bh: Beverton and Holt; ri: Ricker.

Figure 6.8.6.9- shows the results of the sensitivity analysis of the BH model to a range of steepness values from s=0.85 to s=0.95. These results show that increasing ***s*** helps bring down R_0 and SSB0 to levels compatible with the GM or HS model estimates. Considering the highest values of R ever observed in the study period (ca. 40 000 thousand recruits) a BH model with s= 0.90 would be a good alternative to the HS model. However, it is not possible to obtain consistent values of steepness from the available data.

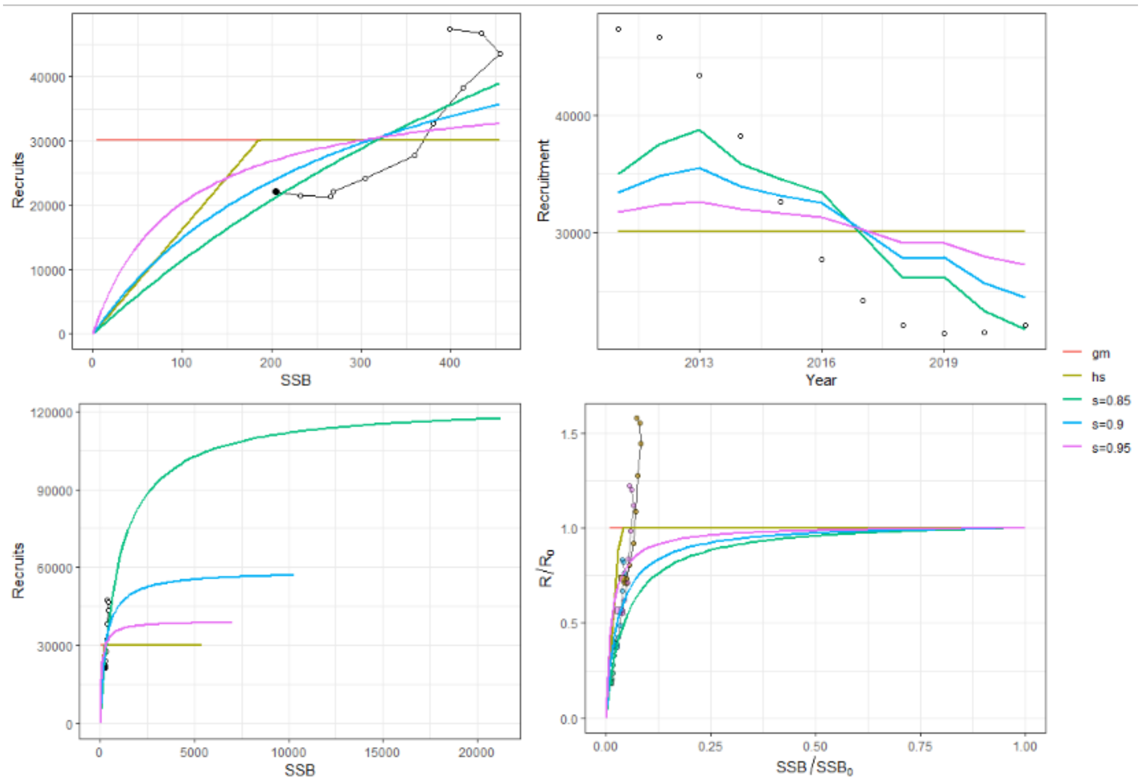


Figure 6.8.6.9. Norway lobster in GSA 6. Summary of candidate models based on BH model at four levels of steepness, with the GM and HS models of Figure 6.8.6.9 for comparison.

Historical catches (yield) for Norway lobster in GSA 6 for the period 2002-2021 have oscillated between 200 and 500 t approximately (Table 6.8.2.10). The maximum amount was observed in 2012 corresponding to 506 t and has been decreasing ever since to the lowest observed yield of 149 t in 2021. Given the strong territorial character of the species (Norway lobster lives in burrows excavated in soft sediments), and the relatively stable character of the fishery, carried out by a subset of the GSA 6 trawlers, it is unlikely that past (20th century) recruitment and catches were much higher than the values observed in the first two decades of the 21st century. The BH curves show that long-term equilibrium recruitment when fishing at $F_{0.1}$ would be ca. the highest recruitment values observed in the 2009-2021 series and towards the upper values of yield reported, which is not implausible. The long term equilibrium predicted by the GM and HS models is around the average recruitment and yield observed in the series. In all cases, GM, HS and BH models, the long term equilibrium SSB when fishing at $F_{0.1}$ range between 2000 and 3000 t. Both GM and BH would be appropriate models to describe the dynamics of the Norway lobster stock in GSA 6, but the GM model is more conservative by implying that long term equilibrium are within the mean values observed of SSB and Yield. The fitted HS models give breakpoints either at a rather low biomass outside the observed data range, or at a value above the data just below the default value of 25% $B_{F0.1}$. Following the procedures from EWG 22-03 and agreed by STECF under these circumstances the GM model is preferred. It should be noted that in the next few years as the assessment is updated annually new values of recruitment will be obtained and in these circumstances a fitted HS relationship may also be possible. For now results suggest that a value of 472 provides an acceptable option.

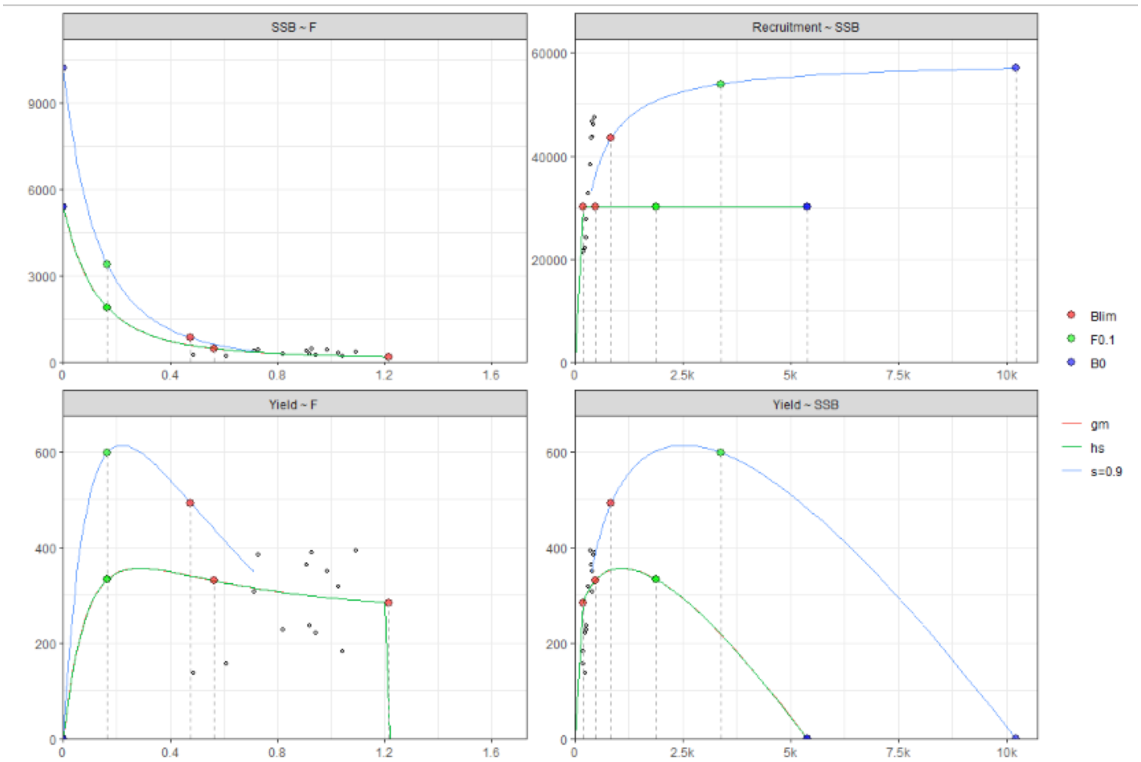


Figure 6.8.4.10. Norway lobster in GSA 6. Comparison of per-recruit analysis results produced with different models (gm: geometric mean, hs: hockey-stick, s=0.9: Beverton-Holt with steepness 0.90).

Reference points results

From the considerations made in the previous section, the GM model was selected to provide reference points for Norway lobster in GSA 6. Figure 6.8.4.12 shows the advice plot from the per-recruit analysis of Norway lobster in GSA 6 (Figure 6.8.4.11); with the equivalent Kobe plot in Figure 6.8.4.13. The figures show that according to the GM model the stock has been fished above F_{lim} and F_{01} for the entire assessment period, except for the last year (2021), while biomass was severely depleted (below B_{lim}), except in 2010-2011. Table 6.8.4.3 summaries the reference point values based on the Geometric Mean model fitted to the data. B_{pa} is set to 2* B_{Lim}.

Table 6.8.4.3: Norway lobster in GSA 6. **Final reference points based on Geometric Mean stock recruit model fitted to the data.**

$F_{0.1}$	B_{Lim}	B_{pa}	$B_{F0.1}$	B_0	Fpa
0.165	472.22	944.44	1890	5390	0.324

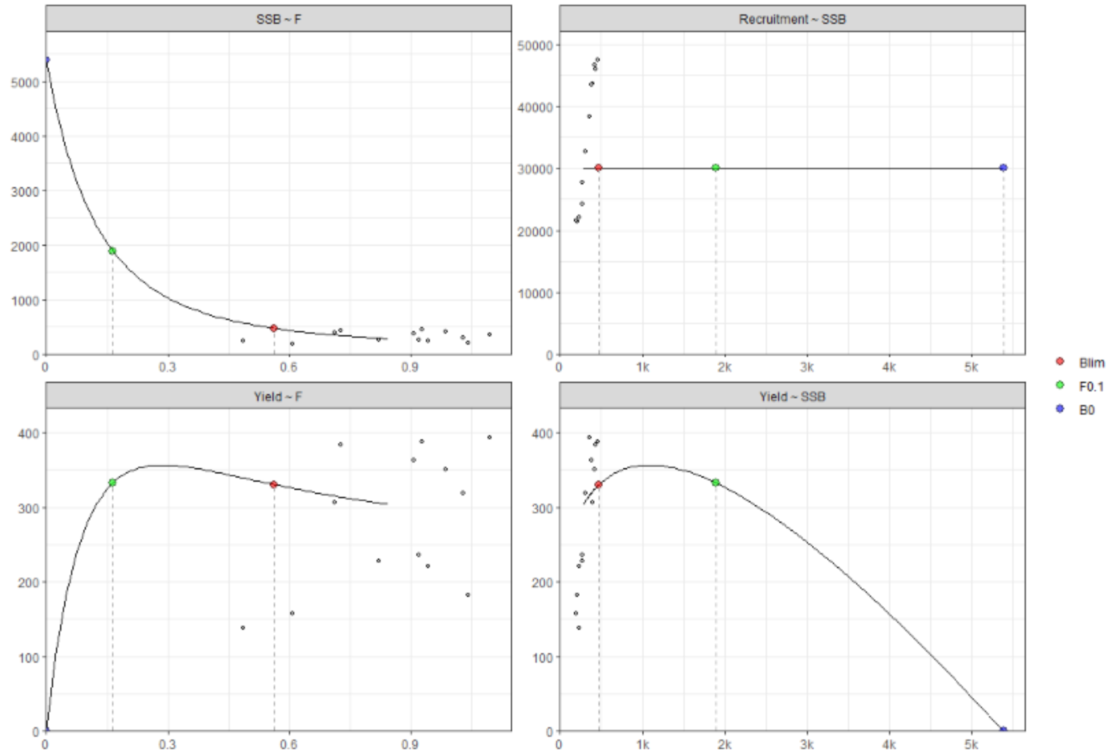


Figure 6.8.4.11.: Norway lobster in GSA 6. Yield analysis with GM model.

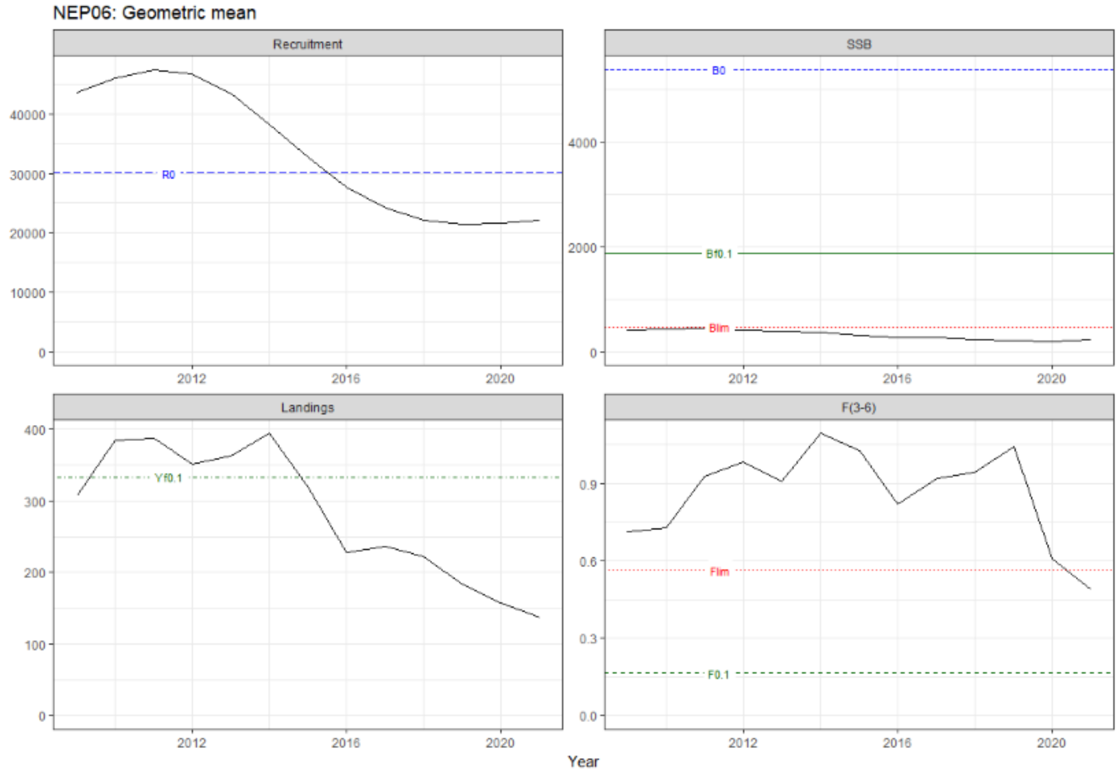


Figure 6.8.4.13. Norway lobster in GSA 6. Advice plot showing the trajectory of four stock assessment indicators (Recruitment, SSB, F, Landings = Yield) along with the reference points estimated from a GM stock-recruitment relationship.

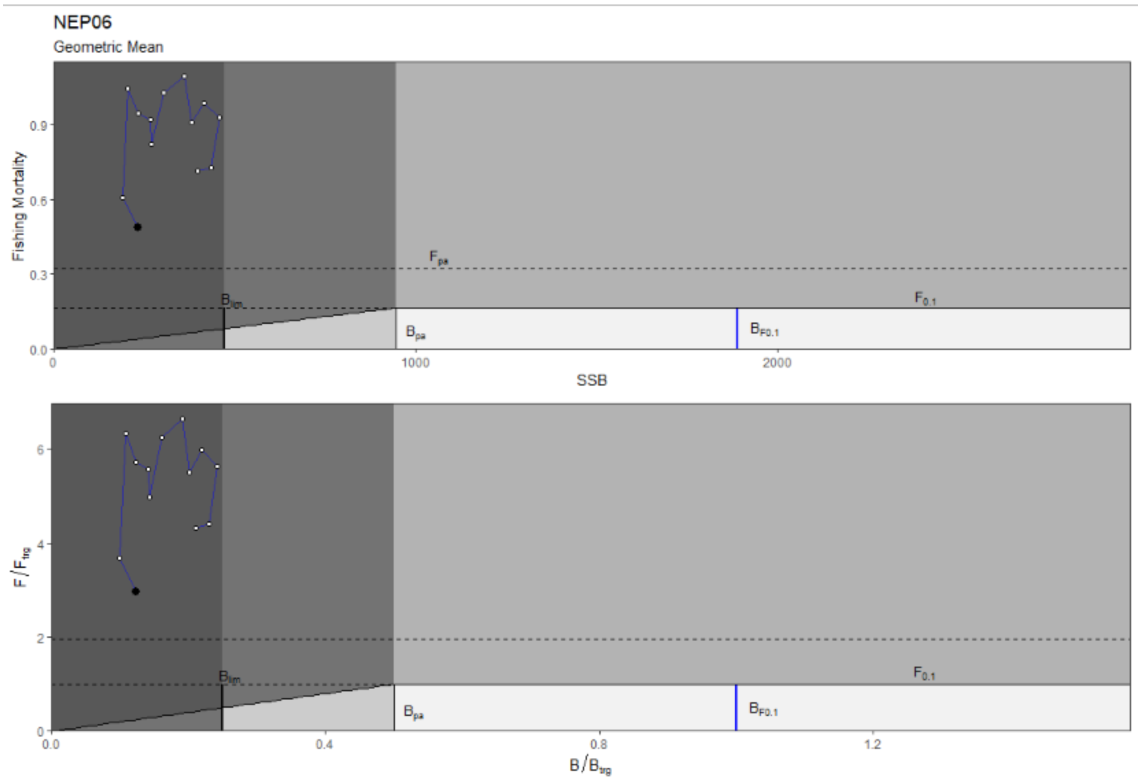


Figure 6.8.4.13. Norway lobster in GSA 6. Kobe plots: GM model in absolute (top) and relative (bottom) terms.

Modelling options

The GM model defined above is considered as the best option for defining reference points for this stock, but it may not be the most suitable for modelling. A Beverton-Holt model may be helpful to as a modelling option. The steepness options considered above are illustrated in Figure 6.8.4.10. The steepness option that most closely mimics in terms of deviation from slope and asymptote the GM chosen is thought to be steepness = 0.90, leading to the yield per recruit plot in Figure 6.8.4.14.

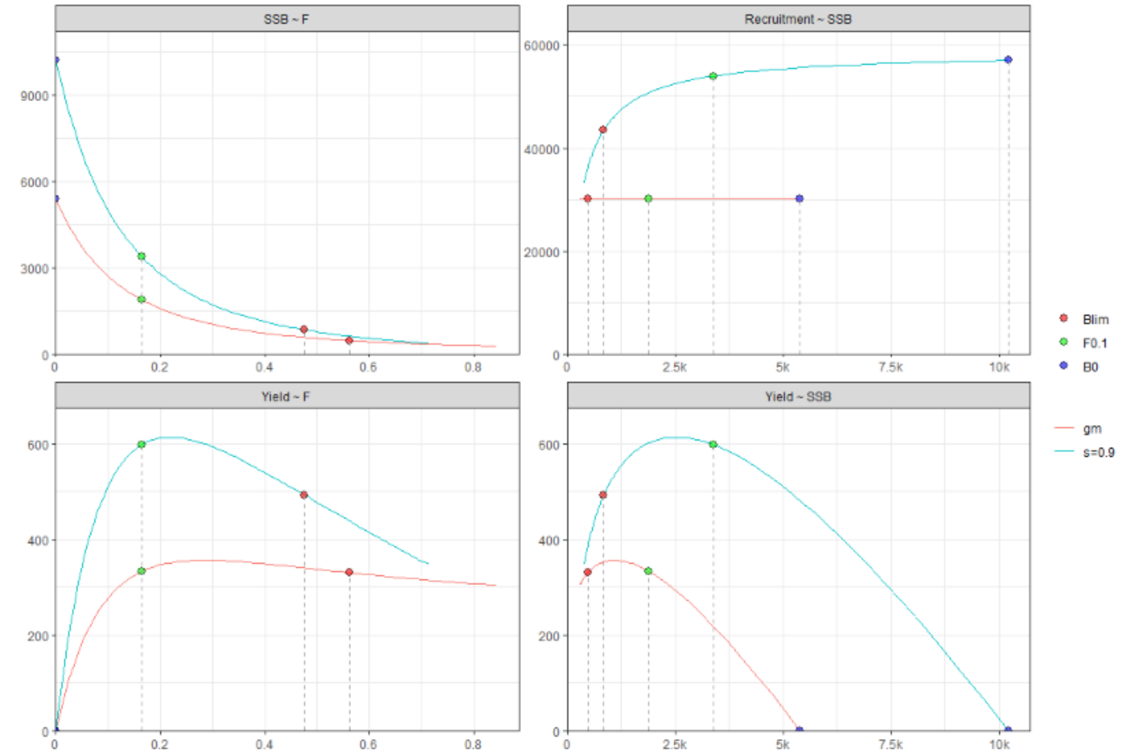


Figure 6.8.4.14. Norway lobster in GSA 6. **Per-recruit analysis: relative reference points for GM and BH (steepness 0.90) models.**

6.8.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts provided to the EWG, and based on the results of the NEP GSA 6 stock assessment results in section 6.8.3.

For stock mean weight, maturity, natural mortality and selection pattern an average of the last three years was used. Recruitment was observed to be decreasing over the entire period but it was stable in the last three years. Hence, a geometric mean of the estimated recruitment for the last three years was used (2019 to 2021), corresponding to a value of 21 684.34 x 10^3 individuals. The F_{sq} was taken as the F_{bar}(3-6) for 2021, given the decreasing pattern observed in F, Fsq = 0.487.

Table 6.8.5.1. Norway lobster in GSA 6: Assumptions made for the interim year in the forecast.

Default assumptions on biology	3	Number of years over which M, Mat, Mean weight, etc. were averaged
F ages 3-6 (2022)	0.487	Fsq = F in the last year (2021)
SSB (2022)	290.04	SSB intermediate year from STF output
R age2 (2022, 2023)	21684.37	Recruitment will be set as geometric mean of the last 3 years
Total Catch (2022)	192.06	Catch intermediate year from STF output
Fbar (2019, base year)	1.042	MAP base year fishing mortality from current assessment
a and b values	a = 1/3 b= 2/3	Regression parameters from F-transition regression line

Table 6.8.5.2. Norway lobster in GSA 6: Results and catch options from short term forecast.

Rationale	F factor	Fbar	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield (F0.1)	0.338	0.165	0.487	158.7	192.1	83.2	290.0	503.6	73.6	-47.5
F upper	0.472	0.230	0.487	158.7	192.1	112.8	290.0	471.4	62.5	-28.9
F lower	0.229	0.112	0.487	158.7	192.1	57.9	290.0	531.7	83.3	-63.5
$F_{MSY\ transition}$	0.938	0.457	0.487	158.7	192.1	202.7	290.0	376.8	29.9	27.8
$\mathbf{F_{MSY\ Reduced}}$	0.104	0.051	0.487	158.7	192.1	27.0	290.0	566.3	95.3	-83.0
Zero catch	0	0	0.487	158.7	192.1	0.0	290.0	597.0	105.8	-100
Status quo	1	0.487	0.487	158.7	192.1	213.4	290.0	366.0	26.2	34.5
Different Scenarios	0.1	0.049	0.487	158.7	192.1	26.0	290.0	567.4	95.6	-83.6
	0.2	0.097	0.487	158.7	192.1	50.8	290.0	539.5	86.0	-68.0
	0.3	0.146	0.487	158.7	192.1	74.5	290.0	513.2	76.9	-53.0
	0.4	0.195	0.487	158.7	192.1	97.2	290.0	488.4	68.4	-38.8
	0.5	0.244	0.487	158.7	192.1	118.8	290.0	464.9	60.3	-25.1
	0.6	0.292	0.487	158.7	192.1	139.5	290.0	442.8	52.7	-12.1
	0.7	0.341	0.487	158.7	192.1	159.2	290.0	421.9	45.5	0.3
	0.8	0.390	0.487	158.7	192.1	178.1	290.0	402.2	38.7	12.2
	0.9	0.438	0.487	158.7	192.1	196.1	290.0	383.6	32.3	23.6
	1.1	0.536	0.487	158.7	192.1	229.9	290.0	349.4	20.5	44.9
	1.2	0.585	0.487	158.7	192.1	245.6	290.0	333.7	15.1	54.8
	1.3	0.633	0.487	158.7	192.1	260.7	290.0	318.9	10.0	64.3
	1.4	0.682	0.487	158.7	192.1	275.2	290.0	304.9	5.1	73.5
	1.5	0.731	0.487	158.7	192.1	289.1	290.0	291.7	0.6	82.2
	1.6	0.779	0.487	158.7	192.1	302.3	290.0	279.1	-3.8	90.5
	1.7	0.828	0.487	158.7	192.1	315.0	290.0	267.3	-7.8	98.6
	1.8	0.877	0.487	158.7	192.1	327.2	290.0	256.1	-11.7	106.2
	1.9	0.926	0.487	158.7	192.1	338.8	290.0	245.5	-15.4	113.6
	2	0.974	0.487	158.7	192.1	350.0	290.0	235.5	-18.8	120.6

6.8.6. Data deficiencies

The quality of the stock assessment is acceptable, despite some data deficiencies that were identified during the exercise.

- The available landings and discards size frequencies for the year 2020 lead to inconsistent catch at age data for the year 2020, due to the limitations of commercial data sampling for that year (COVID pandemic). The issue is unlikely to be resolved. Removing the catch at age data for 2020 provided a better stock assessment.

- The biological growth parameters have been taken as the set of Linf, k, t0 from GSA 5, as done in previous assessments of Norway lobster in GSA 6, but this set was estimated in 2009-2010 and has been reused ever since. The member state might consider studying growth of Norway lobster in GSA 6.

- The Norway lobster is a crustacean species showing dimorphic growth, where females reach lower ultimate sizes than males, despite very similar growth rates. Providing biological data separated by sex should allow better stock assessment results.

6.9 HAKE IN GSAS 8, 9, 10 &11

6.9.1 STOCK IDENTITY AND BIOLOGY

The assessment of European hake carried out during the STECF EWG 21-11 considered the stock shared by the GSAs 8, 9, 10 and 11, as agreed during the GFCM Benchmark Session on Hake in the Mediterranean, held in dicember 2019.

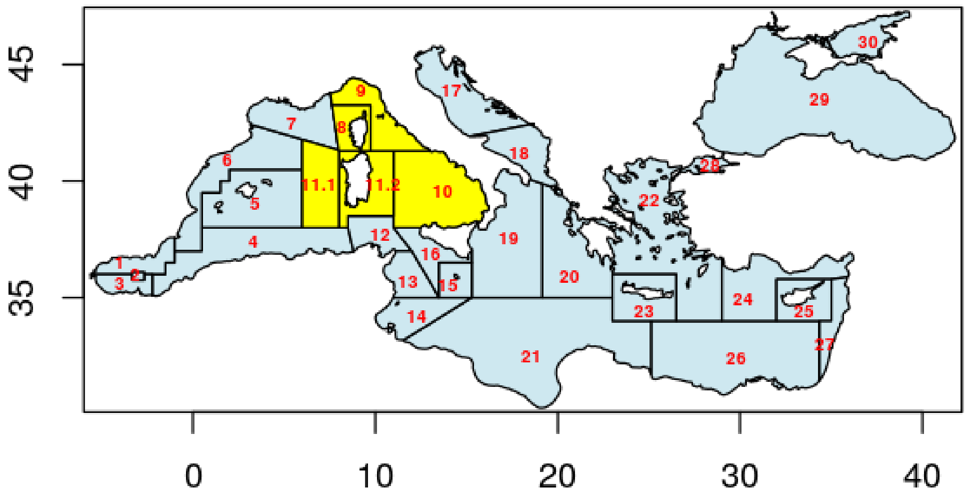


Figure 6.9.1.1. **European hake in GSAs 8, 9, 10 & 11.** Map of the stock unit.

Hake is distributed in the whole area between 10 and 800 m depth (Biagi et al., 2002; Colloca et al., 2003). Recruits peak in abundance between 150 and 250 m depth over the continental shelf-break and appear to move slightly deeper when they reach 10 cm total length. Crinoid (Leptometra phalangium) beds over the shelf-break are the main settlement habitat for hake in the area (Colloca et al., 2004, 2009). Migration from nurseries takes place when juveniles attained a critical size between 13 and 15.5 cm TL (Bartolino et al., 2008a, 2008b). Maturing hakes (15-35 cm TL) persist on the continental shelf with a preference for water of 70-100 m depth, while larger hakes can be found in a larger depth range from the shelf to the upper slope. Juveniles show a patchy distribution with some main density hot spots (i.e. nurseries areas) showing a high spatio-temporal persistence (Abella et al., 2005; Colloca et al., 2009) as also highlighted by the MEDISEH project in areas with frontal systems and other oceanographic structures that can enhance larval transport and retention (Abella et al., 2008).

Although hake are demersal fish feeding typically upon fast-moving pelagic preys while ambushed in the water column (Alheit and Pitcher, 1995), there is evidence that hake feed in mid-water or at the surface during night-time, undertaking daily vertical migrations (Orsi-Relini et al., 1989, Carpentieri et al., 2008) which are more intense for juveniles. In GSA 9, many different studies are available on hake diet. Results from stomach data collected in the 1996-2001 period can be found in Sartor et al. (2003) and Carpentieri et al. (2005). Hake diet shifts from euphausids and mysiids consumed by smaller hake (<16 cm TL), to fishes consumed by larger hake.

Before the transition to the complete ichthyophagous phase (TL> 36 cm), hake show more generalized feeding habits where decapods, benthic (Gobiidae, Callionymus spp.,) and necktonic fish (S. pilchardus, E. encrasicolus) dominated the diet, whereas cephalopods had a lower incidence.

Estimation of cannibalism rate has been provided for the southern part of the GSA (Latium, EU Because project). Cannibalism increased with size and can be considered significant for hakes between 30 and 40 cm TL (up to 20% by weight in diet) and seems to relate closely to hake recruitment density and level of spatial overlapping.

Consumption rate has been estimated for juveniles and piscivorous hakes. Daily consumption of juveniles, calculated in proportion of body weight (%BW), varied between 5 (July) and 5.9 % BW (Carpentieri et al., 2008). The estimated relative daily consumption for hake between 14 and 40 cm TL, using a bioenergetic approach (EU Because project), was between 2.9 and 2.3 BW%.

In GSA 10, European hake ranks among the species with highest abundance indices in the trawl surveys (e.g. Spedicato and Lembo, 2011). It is a long lived fish mainly exploited by trawlers, especially on the continental shelves of the Gulfs (e.g. Gaeta, Salerno, Palermo) but also by artisanal fishers using fixed gears (gillnets, bottom long-line).
Trawl-survey data have evidenced highest biomass indices on the continental shelf of the GSA 10 (100-200 m; Spedicato and Lembo, 2011), where juveniles (less than 12 cm total length) are mainly concentrated. During autumn trawl surveys, one of the main recruitment pulses of this species is observed. Two main recruitment events (in spring and autumn; Spedicato and Lembo, 2011) are reported in GSA 10 as for other Mediterranean areas. European hake is considered fully recruited to the bottom at 10 cm TL (from SAMED, 2002). The length structures from trawl surveys are generally dominated by juveniles, while large size individuals are rare. This pattern might be also due to the different vulnerability of older fish beside the effect of high exploitation rates. The few large European hake caught during trawl surveys are generally females and inhabit deeper waters. The overall sex ratio (~0.41-0.47) estimated from trawl survey data is slightly skewed towards males. The size at first maturity for females was recently estimated by Carbonara et. al. (2019) at 33 cm, with a maturity range of 2.55 cm, and is in line with previous studies in the area (Recasens et al., 2008).
In GSA 11, hake is distributed in the whole area between 10 and 800 m depth. Recruits peak in abundance over the continental shelf-break (between 150 and 250 m depth). The stock is mainly exploited by the local fishing fleet, although seasonally and occasionally some other Italian fleet use to fish in some areas of the GSA 11. Spawning is taking place almost all year round, with a peak during winter–spring.
Juveniles showed a patchy distribution with some main density hot spots (nurseries) showing a high spatio-temporal persistence (Murenu et al., 2010) in western areas.
In GSA 8, hake is distributed along the narrow shelf and slope at depths up to 1000 m, but is mainly concentrated in the depth range 0-400 m. There is not any evidence that inside GSA8 boundaries inhabits a single, homogeneous hake stock that behaves as a single well-mixed and self-perpetuating population. The GSA boundaries are, as for other areas, arbitrary and do not consider neither the existence of local biological features nor differences in the spatial allocation in fishing pressure within it. It is likely some connectivity exists as larval drifts, movements of individuals and sharing of spawning areas in particular with GSA9, 10 and 11.

Growth parameters and length-weight parameters were those used for the assessment carried out during the benchmark meeting in 2019 and the followings EWGs in 2020 and 2021 (Table 6.9.1.1).

Table 6.9.1.1. **European hake in GSAs 8, 9, 10 & 11.** VBGF parameters used in the assessment.

GSAs	Sex	L_∞	k	t_0	Source	Notes
9, 10, 11	M	60.00	0.265	-0.06	Otolith reading	Benchmark data preparation
	F	95.00	0.16	-0.06	Otolith reading	Benchmark data preparation

Length-weight relationship parameters were estimated by sex as the average of those available in GSAs 9, 10, 11 under EU DCR/DCF (Table 6.9.1.2). No biological data are available for hake in GSA 8.

Table 6.9.1.2. European hake in GSAs 8, 9, 10 & 11. Length-weight relationship parameters used in the assessment.

GSAs	Sex	a	b
8, 9, 10, 11	M	0.004645	3.133
	F	0.005009	3.107705

Using the selected VBGF parameters, a combined vector of proportion of matures-at-age was estimated starting from the vectors of maturity-at-length available under the EU DCR/DCF. The maturity vector used for the assessment carried out during the benchmark session is shown in Table 6.9.1.3.

Table 6.9.1.3. European hake in GSAs 8, 9, 10 & 11. Maturity vector used in the assessment.

Age	0	1	2	3	4	5	6	7+
Mat-at-age	0.00	0.25	0.80	1.00	1.00	1.00	1.00	1.00

During the benchmark meeting, the selected VBGF and LW relationship parameters were used to estimate a range of natural mortality (M) vectors using different models and empirical formulas, and their mean was used as final M vector. The combined M vector used for the assessment is shown in Table 6.9.1.4.

Table 6.9.1.4. European hake in GSAs 8, 9, 10 & 11. Natural mortality vector combined by sex used in the assessment.

Age	0	1	2	3	4	5	6	7+
M	1.85	0.80	0.48	0.37	0.30	0.27	0.24	0.22

6.9.2 DATA

6.9.2.1 CATCH (LANDINGS AND DISCARDS)

European hake is one of the main target species in terms of landings, incomes and vessel involved in the area. In GSAs 9 and 10, it is mainly exploited by trawlers on the shelf and slope, but also by small-scale fisheries using set nets (gillnets and trammel nets) and bottom long-lines. In GSA 11, although hake is not target of a specific fishery, it is one of the most important species in terms of biomass landed. It is caught exclusively by a mixed bottom trawl fishery that operates at depth between 50 and 800 m. No gillnet or longline fleets target this species, but it can be find as by catch of gillnet fleets targeting other species. In Corsica (GSA 8), six trawlers are active and their average length is 15 m, these ships operate with bottom trawls with panels (OTB) and are targeting demersal species (Norway lobster, striped red mullet, deep-water rose shrimp, etc.) including some very few catches of hake (average 8.2 t per year on the period 2015-2017). Even though small-scale fisheries are quite important along the coasts, fishers target other resources such as lobster, finfish living on hard bottoms. There are no available data for the size structure of the landings of hake, since it is not a target species of trawlers and it is mainly absent from other gears catches (very few catches from gillnetters). Moreover, it is important to notice that trawlers can only work on the eastern part of Corsica since the western part is characterized by a very narrow continental shelf and steep slopes.

Landings and discards

Landings data were reported to STECF EWG 22-09 through the DCF. In GSAs 9, 10 and 11, most of the landings come from otter trawls. The contribution of set nets to the total landings is around the 30% in GSAs 9 and 10; longlines in GSA 10 contribute for around the 13% to the total landings. In GSA 11 landings data come exclusively from the bottom trawl fishery. In GSA8, landings are very low in all the years where data are available (2009-2021) and the discards are not reported. Reconstructed data were estimated from 2005 to 2008, considering an average of the available information (Table 6.9.2.1.1 red values).
In addition, discards were not available in GSA 9, 10 and 11 for some years, therefore they were estimated using an average proportion between landings and discards computed on the available years.

Landings and discards by GSA, total landings and discards and total catches used in the assessment are shown in Table 6.9.2.1.1; the estimated values are highlihted in red.

Table 6.9.2.1.1. **European hake in GSAs 8, 9, 10, 11.** Landings and discards data in the four GSAs. Values highlighted in red were missing, and re-estimated from adjacent years.

	GSA8	GSA9		GSA10		GSA11		Total		
Year	Landings	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Total catches
2005	**15.00**	1859.98	**348.30**	1484.74	**66.70**	397.39	158.59	3757.11	573.59	4330.70
2006	**15.00**	2176.49	105.20	1544.07	26.57	341.06	595.48	4076.62	727.25	4803.87
2007	**15.00**	1733.03	**338.74**	1268.66	**69.84**	169.58	**106.57**	3186.27	515.15	3701.42
2008	**15.00**	1321.13	**302.32**	1122.85	**54.57**	138.77	**87.20**	2597.75	444.09	3041.84
2009	15.10	1308.47	697.27	1090.51	99.78	260.54	106.87	2674.62	903.92	3578.54
2010	11.97	1467.11	116.41	1329.45	68.06	175.88	164.79	2984.41	349.26	3333.67
2011	13.24	1351.74	527.79	1278.52	54.93	277.42	268.67	2920.92	851.39	3772.31
2012	13.01	1011.52	174.23	1107.24	117.90	176.05	16.72	2307.82	308.85	2616.67
2013	3.52	1341.63	242.43	1052.19	35.63	195.79	32.27	2593.13	310.33	2903.46
2014	12.61	1264.95	285.84	1271.11	17.00	44.96	24.51	2593.63	327.35	2920.98
2015	12.19	1047.70	231.04	1043.44	29.71	220.04	102.85	2323.37	363.60	2686.97
2016	39.85	782.25	305.13	1051.95	28.38	339.15	102.29	2213.20	435.80	2649.00
2017	14.60	572.37	75.68	870.43	3.18	356.52	212.34	1813.92	291.20	2105.12
2018	21.09	605.35	114.35	819.86	0.18	391.98	166.70	1838.28	281.23	2119.51
2019	18.00	722.26	199.60	765.17	0.37	445.53	45.99	1950.96	245.96	2196.92
2020	18.87	630.58	132.68	820.40	6.00	260.61	63.61	1730.46	202.29	1932.75
2021	18.58	641.17	256.08	693.81	0.00	210.07	15.59	1563.63	271.68	1835.31

Landing and discard data by year and fishing gear are presented in Figures 6.9.2.1.1-6.9.2.1.7, while length-frequency distributions of landings and discards by GSA, year and fishing gear are shown in Figures 6.9.2.1.8-6.9.2.1.14.

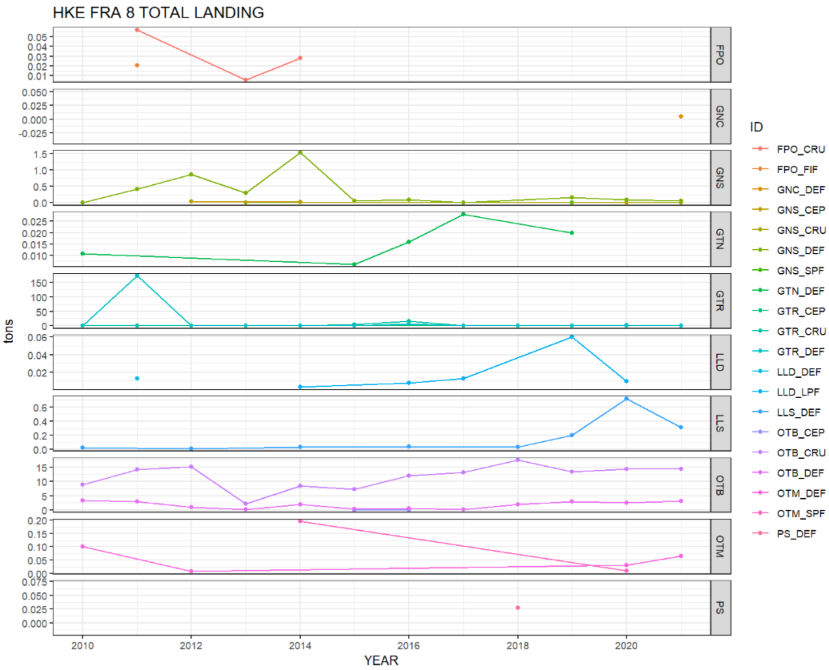


Figure 6.9.2.1.1. **European hake in GSAs 8, 9, 10 & 11.** Landings data in tons by year and fleet in GSA 8.

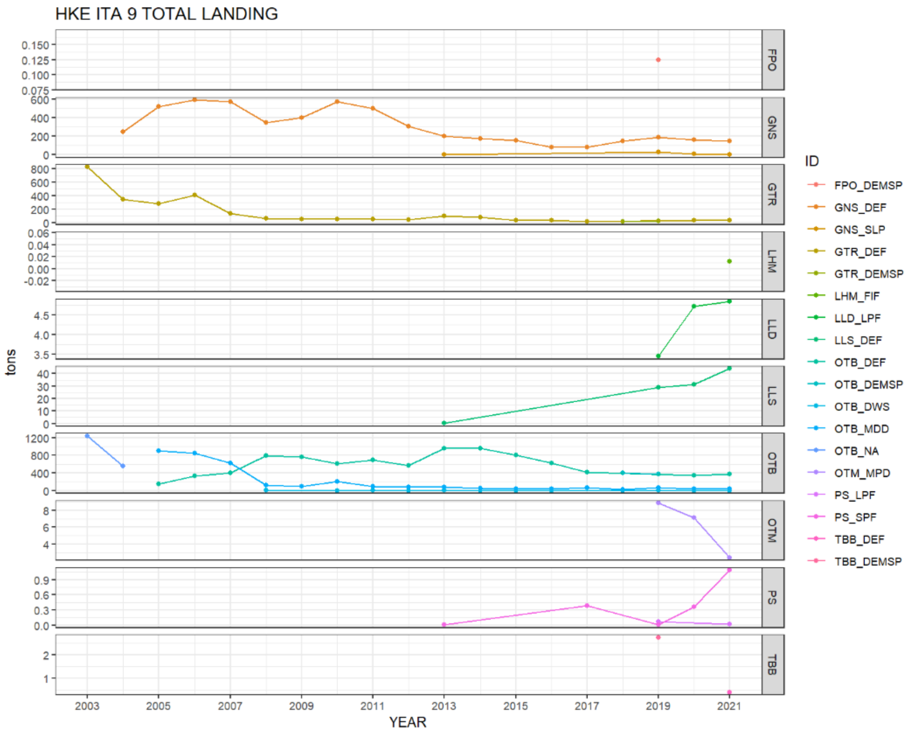


Figure 6.9.2.1.2. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 9.

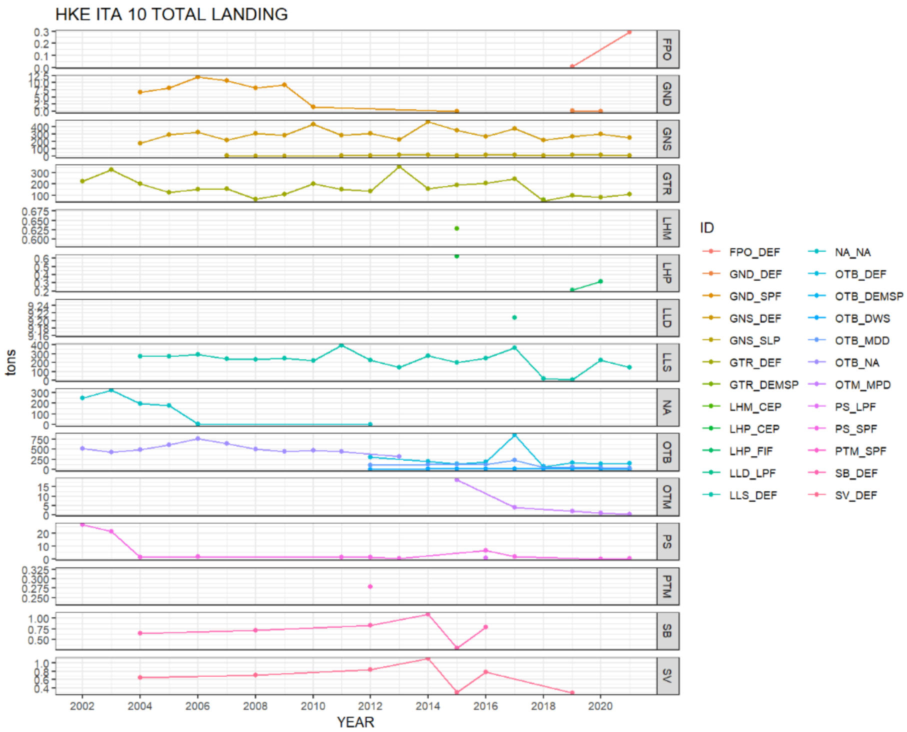


Figure 6.9.2.1.3. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 10.

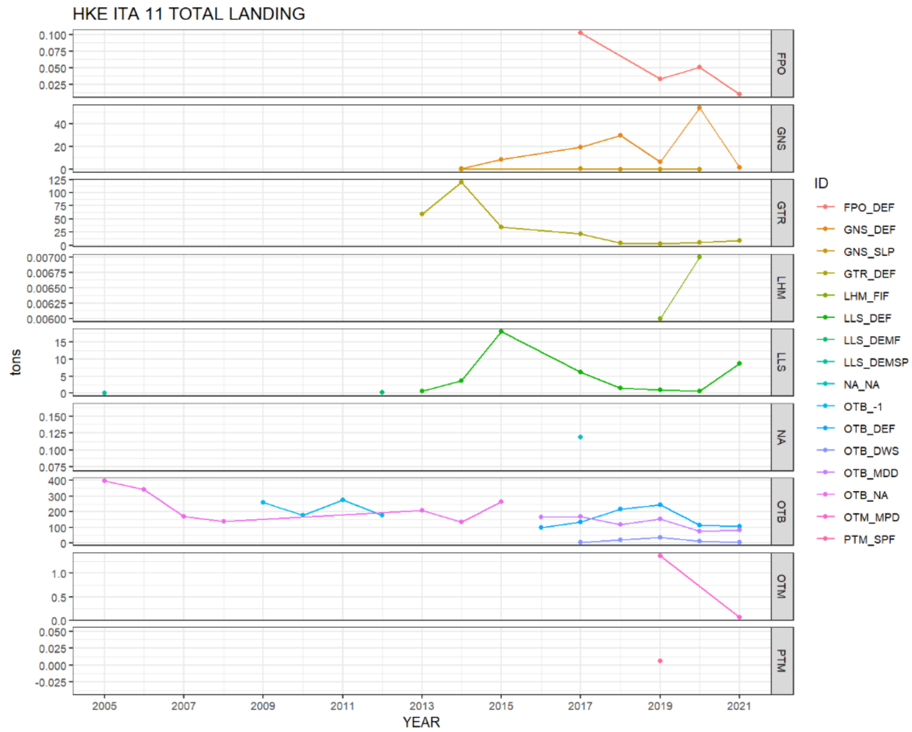


Figure 6.9.2.1.4. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 11.

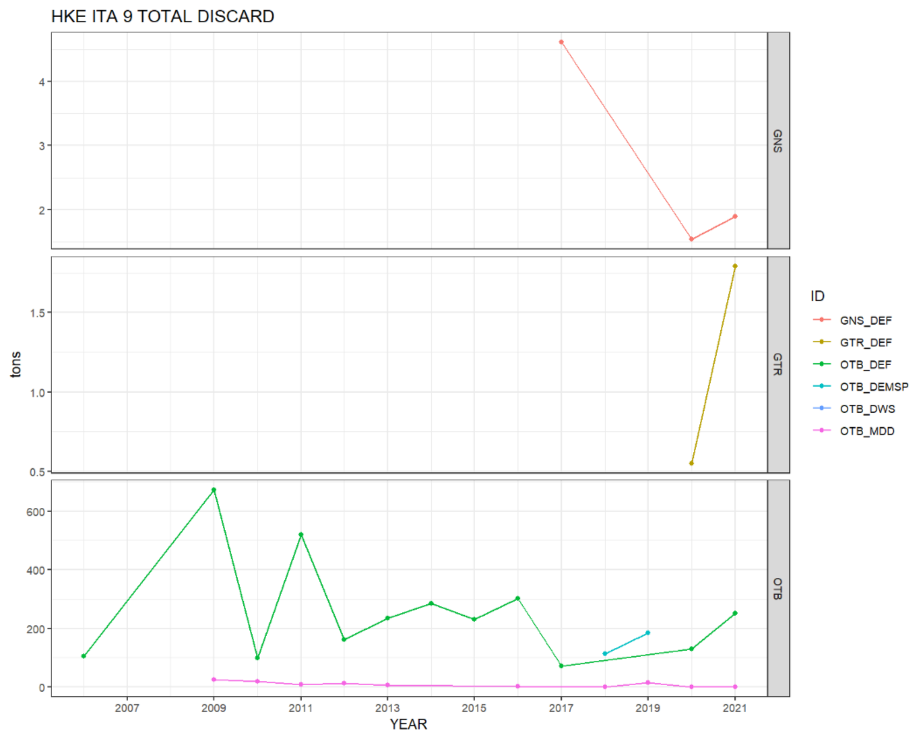


Figure 6.9.2.1.5. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 9.

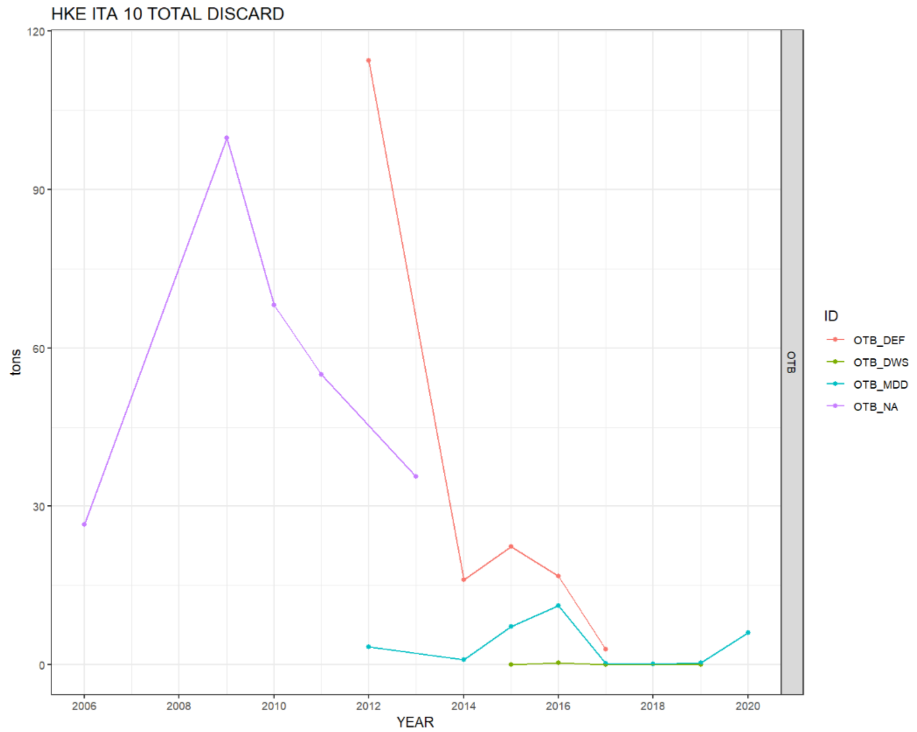


Figure 6.9.2.1.6. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 10.

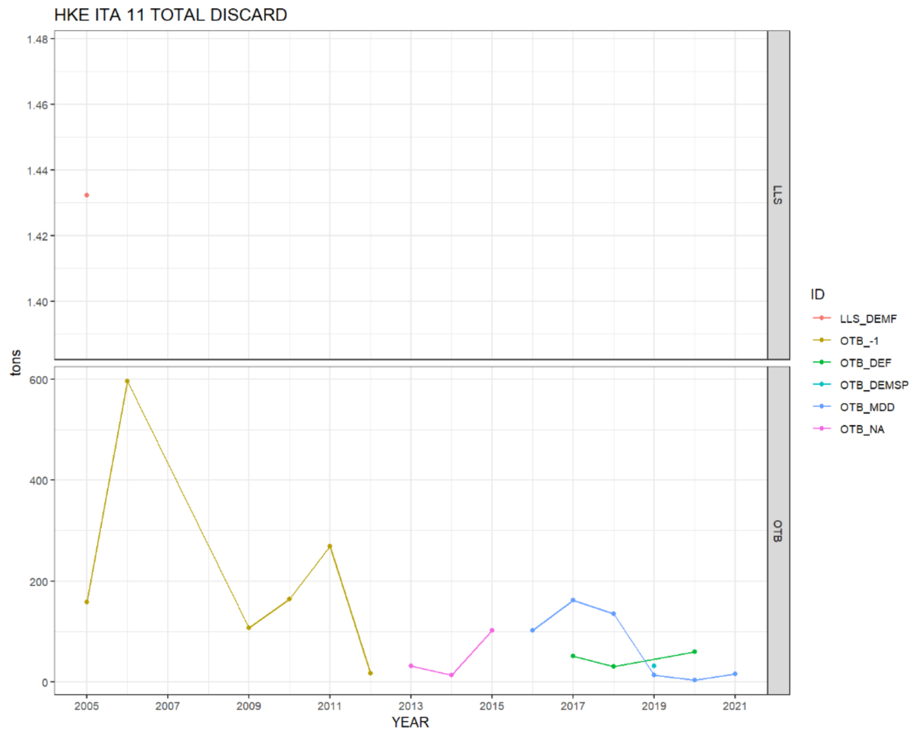


Figure 6.9.2.1.7. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 11.

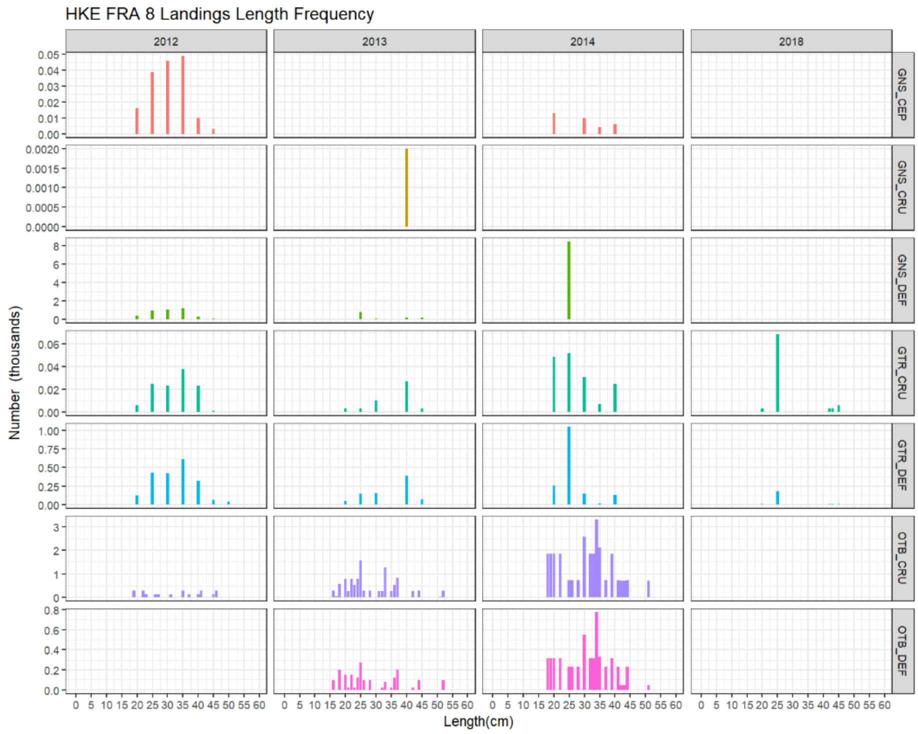


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Figure 6.9.2.1.8. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 8.

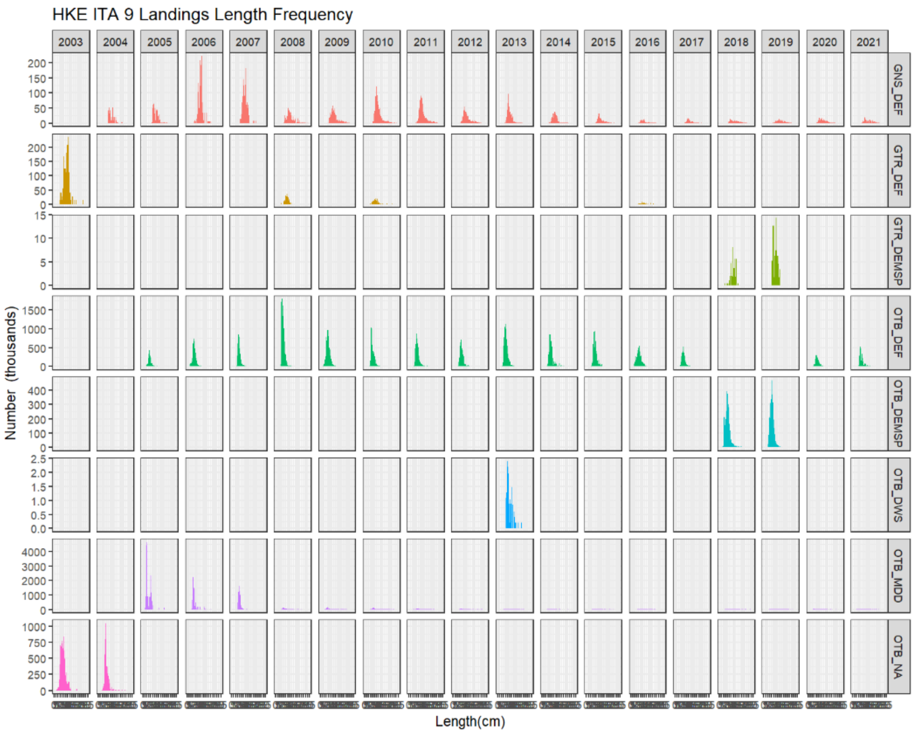


Figure 6.9.2.1.9. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 9.

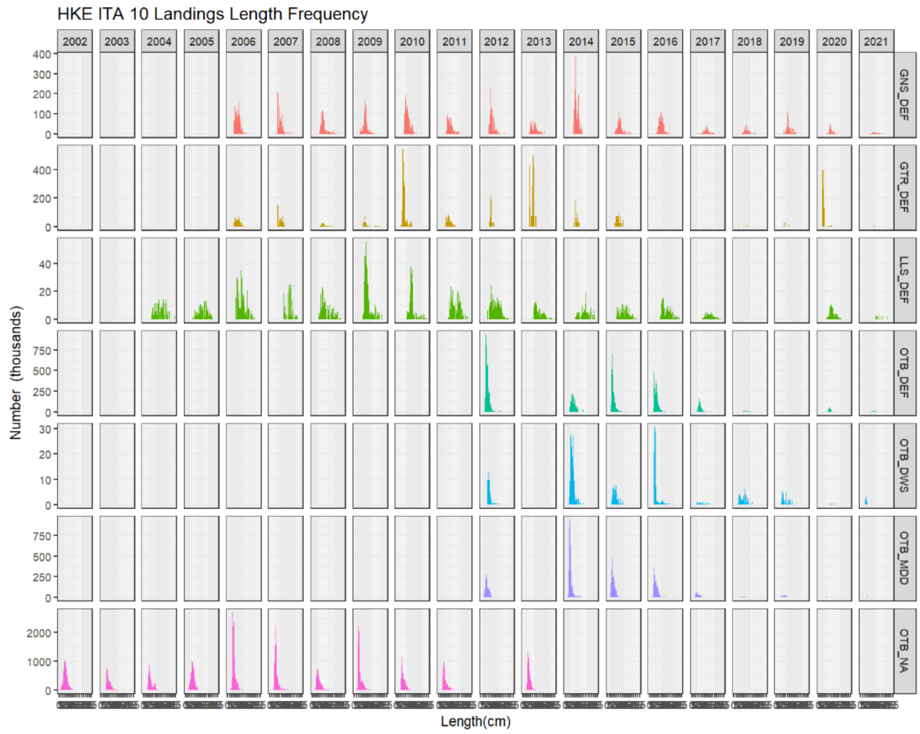


Figure 6.9.2.1.10. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 10.

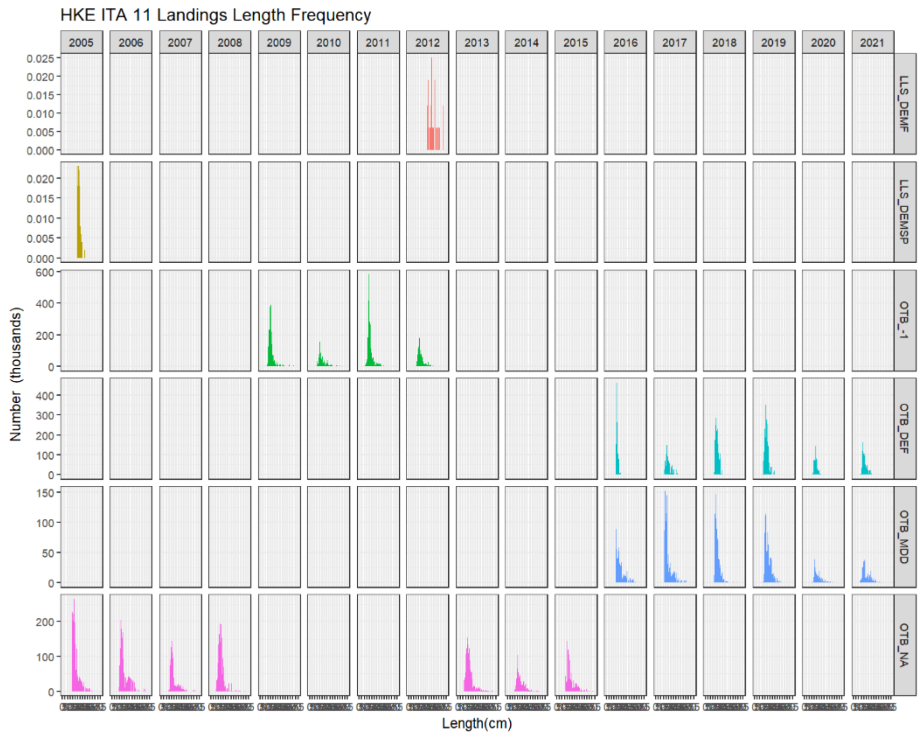


Figure 6.9.2.1.11. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 11.

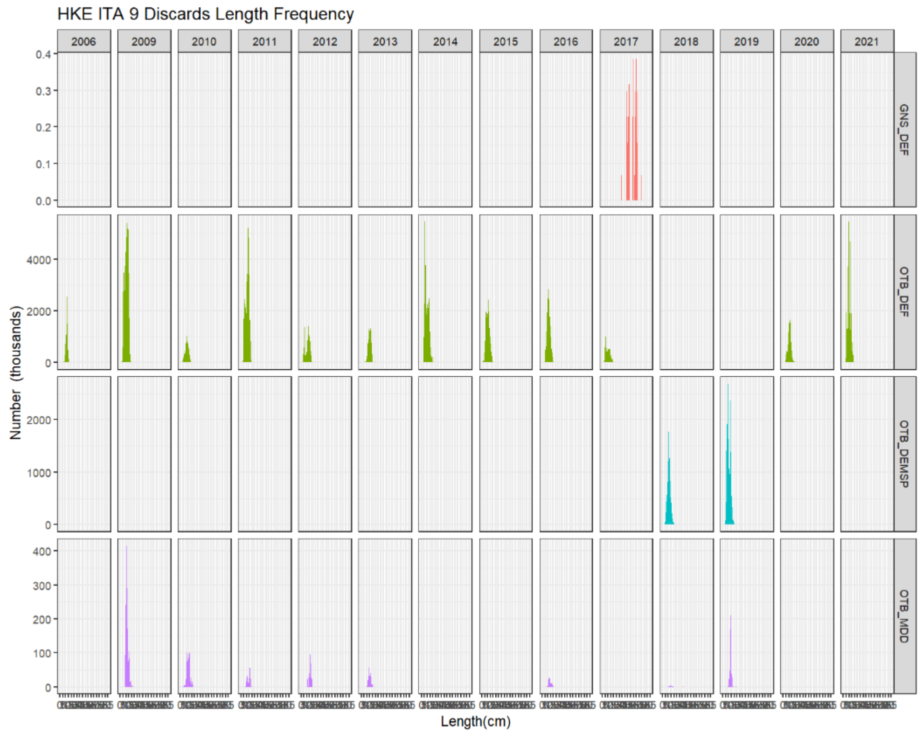


Figure 6.9.2.1.12. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 9.

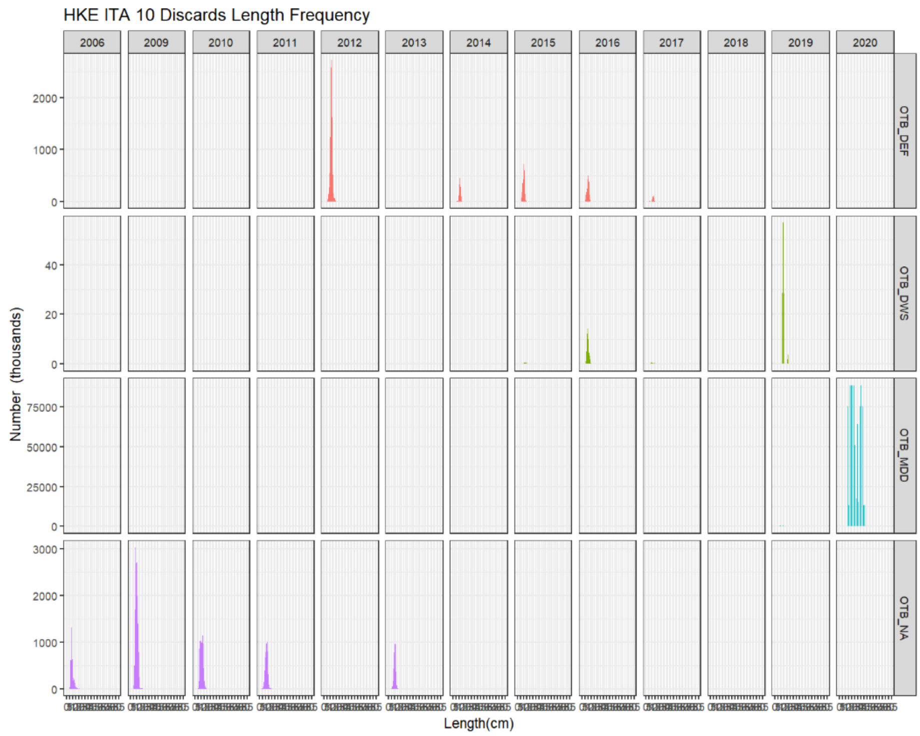


Figure 6.9.2.1.13. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 10.

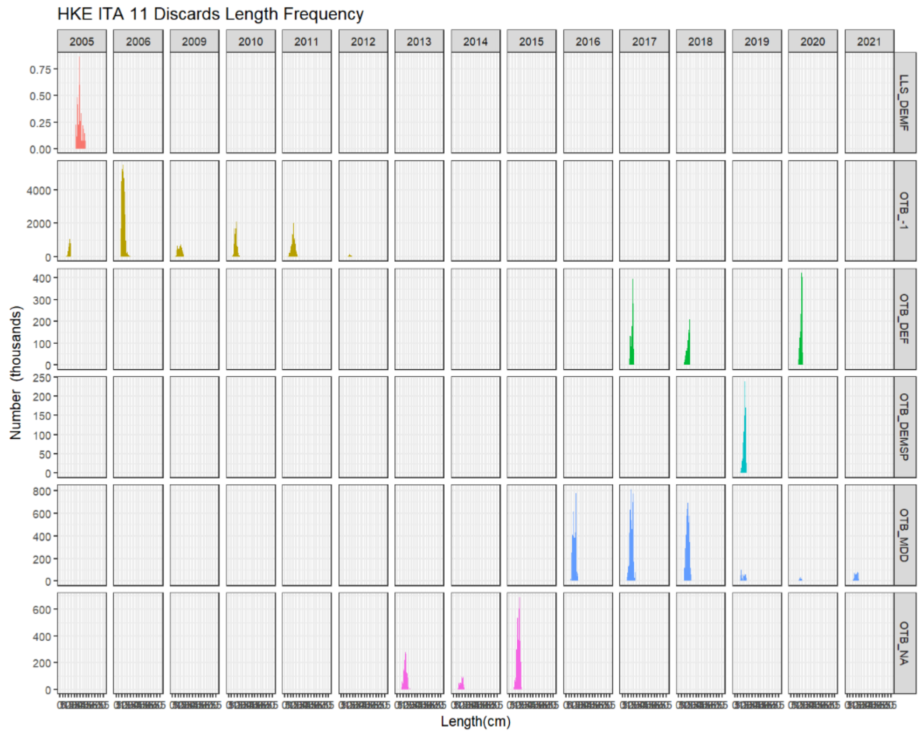


Figure 6.9.2.1.14. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 11.

6.9.2.2 Survey data

The MEDITS (MEDiterranean International Trawl Survey) survey is an extensive trawl survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime, following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintained fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end, is used throughout GSAs and years.

In the current assessment, combined MEDITS data for GSAs 8, 9, 10 and 11 from 2005 onwards were used, as commercial data were available for the GSAs starting from that year. For 2020, MEDITS indexes and LFDs were not available in GSA8, as the survey was not carried out in that area. During EWG 21-11, after a sensitivity analysis, the group decided to not include GSA8 area in the computation of 2020 survey index, and this approach was not changed during EWG 22-09.

The combined MEDITS indexes were calculated using the script provided by JRC (Figures 6.9.2.2.1 and 6.9.2.2.2).

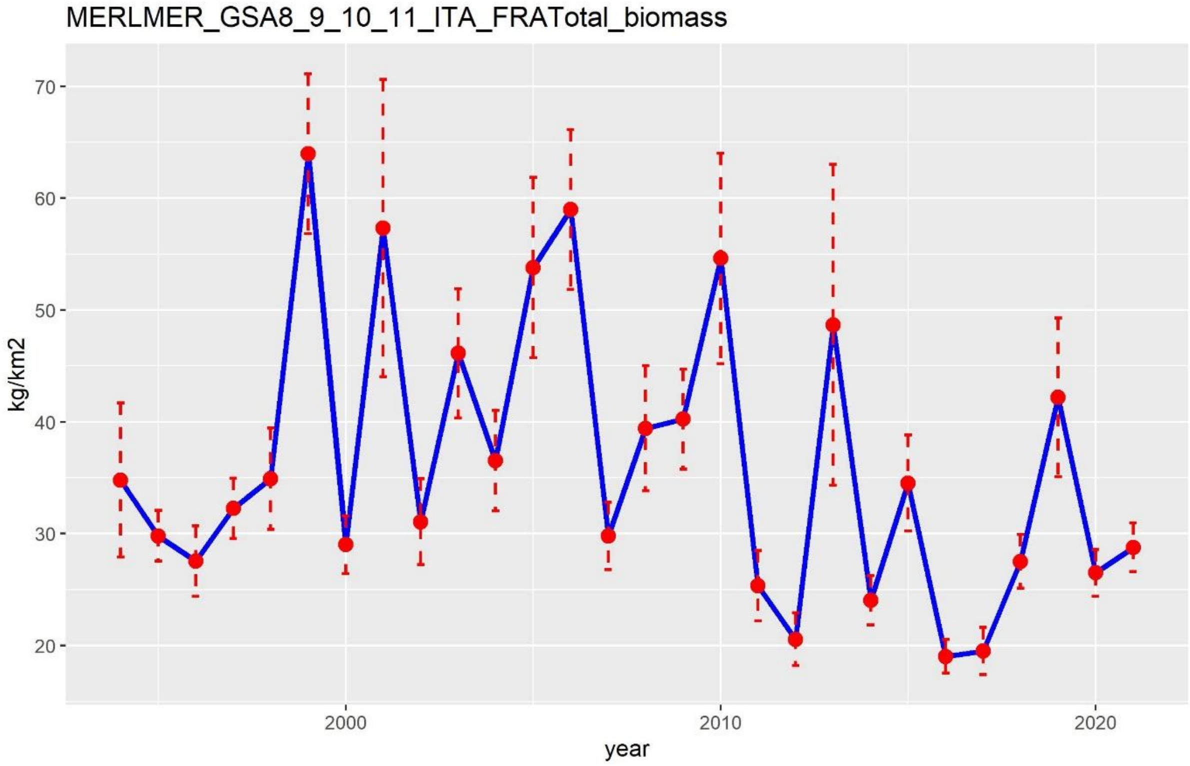


Figure 6.9.2.2.1. European hake in GSAs 8, 9, 10 & 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

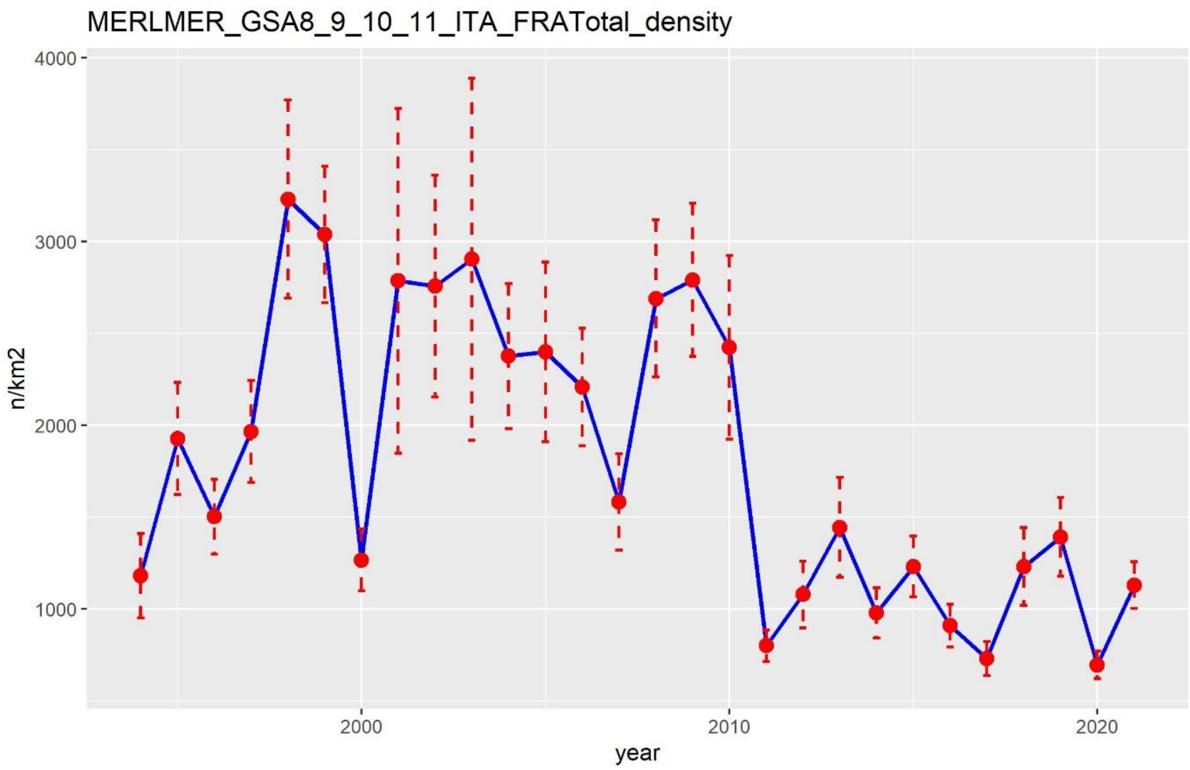


Figure 6.9.2.2.2. European hake in GSAs 8, 9, 10 & 11. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series, with a general decreasing trend from the beginning of the time series. Size structure indices are shown in Figure 6.9.2.2.3.

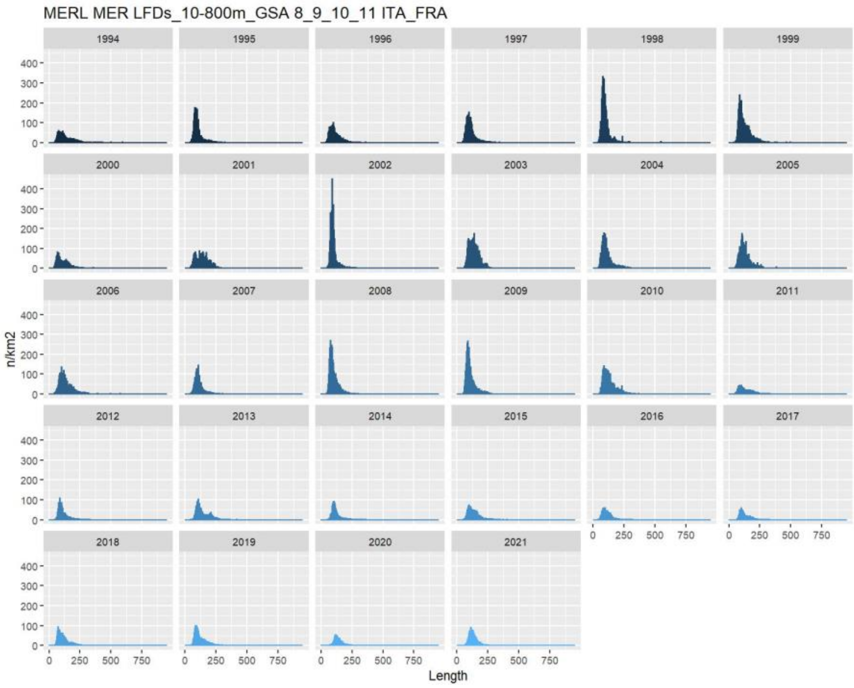


Figure 6.9.2.2.3. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution by year of MEDITS survey.

6.9.3 STOCK ASSESSMENT

A statistical catch-at-age assessment was carried out for this stock, using the Assessment for All Initiative (a4a) method (Jardim et al., 2015). The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike XSA, model parameters estimated using catch-at-age analysis are done by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. The assessment was carried out using the period 2005-2021 for catch data and tuning file. Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR, using for each GSA the corresponding growth parameters by sex. The analyses were carried out for the ages 0 to 7+. Concerning the Fbar, the age range used was age groups 1-3.

Input data

The growth parameters used for VBGF were the one reported in table 6.9.1.1.
Total catches and catch numbers at age from the single GSAs were used as input data. Catch numbers at age were corrected for SoP differences by year (see below).

Table 6.9.3.1 European hake in GSAs 9, 10 and 11. SoP factors for landings and discards

Landings	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GSA9	1.55	1.34	1.19	1.1	1.14	1.08	1.13	1.15	1.19	1.16	1.08	1.04	1.2	1.01	1.17	1.20	1.17
GSA10	1.77	1.07	1.07	1.07	1.08	1.03	1.05	1.02	1.05	0.99	1.07	1.33	2.06	4.45	2.71	3.29	7.30
GSA11	1.07	1.07	1.07	1.07	1.05	1.06	1.06	1.05	1.07	2.06	1.09	1.36	1.24	1.24	1.14	2.04	1.36

Discards	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GSA9	1.19	1.19	1.19	1.19	1.19	1.18	1.19	1.17	1.16	1.2	1.18	1.18	1.17	1.08	1.13	1.15	1.11
GSA10	1.05	1.05	1.05	1.08	1.08	1.04	1.11	1.08	1.07	1.08	1.09	1.07	0.84	5.95	0.02	0.02	
GSA11	0.11	1.09	0.07	1.62	1.09	1.09	1.08	1.08	1.08	1.08	1.08	1.08	1.07	1.08	1.07	1.07	0.95

Table 6.9.3.2 lists the input data for the a4a model, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age and the tuning series at age.

Table 6.9.3.2. European hake in GSAs 9, 10 and 11. Input data for the a4a model.

Catches (t)

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
4330.7	4803.9	3701.4	3041.8	3578.5	3333.7	3772.3	2616.7	2903.5	2921.0	2687.0	2649.0	2105.1	2119.5	2196.9	1932.7	1835.3

Catch numbers at age (thousands)

	0	1	2	3	4	5	6	7+
2005	64080	36024	3574	1002	222	323	71	45
2006	48934	41481	5471	1699	457	134	99	39
2007	45329	31929	3628	1324	191	96	50	29
2008	38497	24398	3422	677	239	118	70	60
2009	77199	28800	4542	719	159	117	46	61
2010	26391	20644	4460	1177	263	134	53	79
2011	46825	28922	4123	1011	343	153	64	81
2012	22391	17497	4031	722	222	114	46	31
2013	12759	24955	5025	643	178	70	31	26
2014	38826	13903	4987	971	298	105	31	49
2015	28335	16012	3606	894	247	139	46	35
2016	30244	18558	3291	758	202	106	46	50
2017	9059	14491	1897	826	270	114	50	39
2018	11208	11521	3151	939	172	128	25	14
2019	17342	10937	3372	892	295	69	29	16
2020	14604	7685	3231	870	232	69	21	11
2021	26965	6821	1573	915	310	82	65	29

Weights at age (Kg)

	0	1	2	3	4	5	6	7+
2005	0.009	0.052	0.178	0.453	0.768	1.269	1.742	2.329
2006	0.011	0.039	0.202	0.437	0.781	1.228	1.738	2.419
2007	0.010	0.048	0.198	0.437	0.765	1.278	1.702	2.582
2008	0.010	0.046	0.181	0.438	0.842	1.270	1.717	2.626
2009	0.009	0.044	0.185	0.410	0.821	1.325	1.753	2.634
2010	0.010	0.050	0.187	0.449	0.764	1.273	1.735	2.801
2011	0.010	0.044	0.193	0.424	0.850	1.280	1.743	2.569
2012	0.010	0.051	0.179	0.431	0.815	1.243	1.755	2.560
2013	0.013	0.049	0.178	0.414	0.828	1.305	1.742	2.664
2014	0.007	0.056	0.191	0.388	0.794	1.245	1.619	2.913
2015	0.009	0.050	0.195	0.427	0.801	1.336	1.687	2.662
2016	0.010	0.050	0.193	0.403	0.834	1.264	1.721	2.927
2017	0.008	0.053	0.186	0.456	0.794	1.250	1.736	2.604
2018	0.010	0.053	0.200	0.437	0.771	1.345	1.735	2.414
2019	0.009	0.057	0.193	0.432	0.823	1.225	1.669	2.291
2020	0.011	0.056	0.201	0.421	0.804	1.248	1.621	2.347
2021	0.008	0.053	0.212	0.438	0.783	1.193	1.753	2.588

Maturity vector

	0	1	2	3	4	5	6	7+
All years	0	0.25	0.8	1	1	1	1	1

Natural Mortality vector

	0	1	2	3	4	5	6	7+
All years	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22

MEDITS numbers at age (n/km^2)

	0	1	2	3	4	5	6	7+
2005	1821.3	580.8	60.9	11.4	0.5	0.3	0.0	0.2
2006	1491.1	627.5	84.5	6.6	2.8	2.6	0.1	0.1
2007	1381.4	197.9	24.8	5.9	2.6	0.6	0.4	0.1
2008	2404.2	599.7	116.6	27.5	0.9	0.4	1.5	0.4
2009	2485.5	394.6	26.5	1.4	0.6	0.5	0.1	0.1
2010	1772.4	635.3	84.8	9.2	1.8	0.2	0.1	0.2
2011	526.0	256.5	34.2	4.9	2.3	0.3	0.0	0.1
2012	935.9	163.4	19.0	2.4	0.5	0.3	0.0	0.2
2013	968.0	480.8	52.0	6.5	0.8	0.2	0.1	0.2
2014	823.1	161.2	27.8	3.4	1.0	0.5	0.1	0.3
2015	812.2	397.8	47.3	4.6	1.0	0.1	0.2	0.1
2016	766.3	144.7	18.7	2.8	0.9	0.3	0.1	0.2
2017	527.8	201.0	15.5	2.1	0.6	0.6	0.2	0.5
2018	1004.1	227.3	28.4	3.9	1.1	0.4	0.2	0.2
2019	1027.3	317.7	36.6	7.6	1.5	0.4	0.1	0.2
2020	440.8	223.4	26.6	6.5	1.8	0.3	0.1	0.5
2021	799.1	304.4	20.2	3.2	1.1	0.4	0.3	0.2

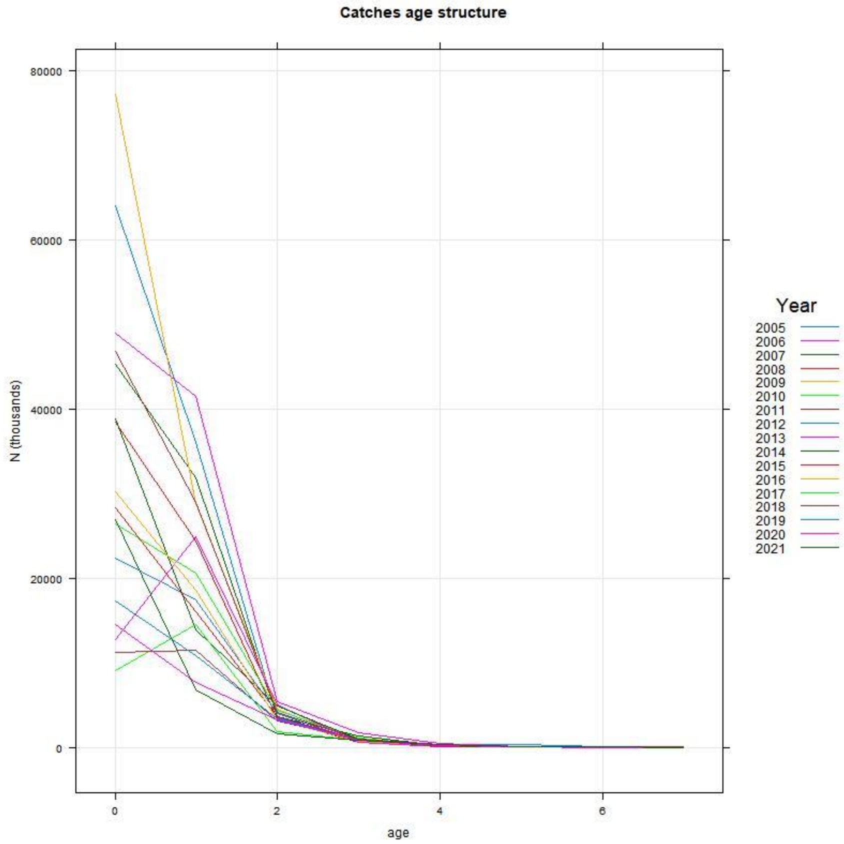


Figure 6.9.3.1. European hake in GSAs 8, 9, 10 & 11. Catch at age input data.

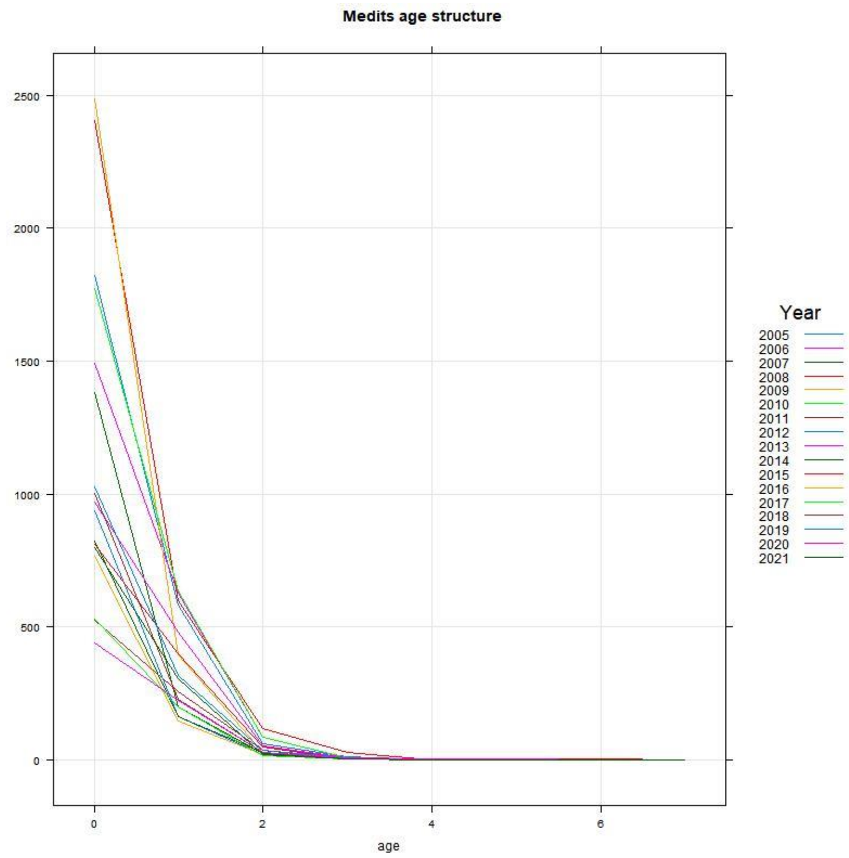


Figure 6.9.3.2. European hake in GSAs 8, 9, 10 & 11. Age structure of the index.

Assessment results

After a sensitivity analysis on the number of knots to be used for the F model, the group decided to apply the same model adopted during the benchmark meeting and the following EWGs. The model specifications are the following:

Submodels:

fmodel: ~factor(replace(age, age > 4, 4)) + s(year, k = 8)

srmodel: ~factor(year)

n1model: ~s(age, k = 3)

qmodel:

MEDITS_SA08091011: ~factor(replace(age, age > 4, 4))

vmodel:

catch: ~s(age, k = 3)

MEDITS_SA08091011: ~1

Results of the final model are shown in Figures 6.9.3.5 – 6.9.3.11.

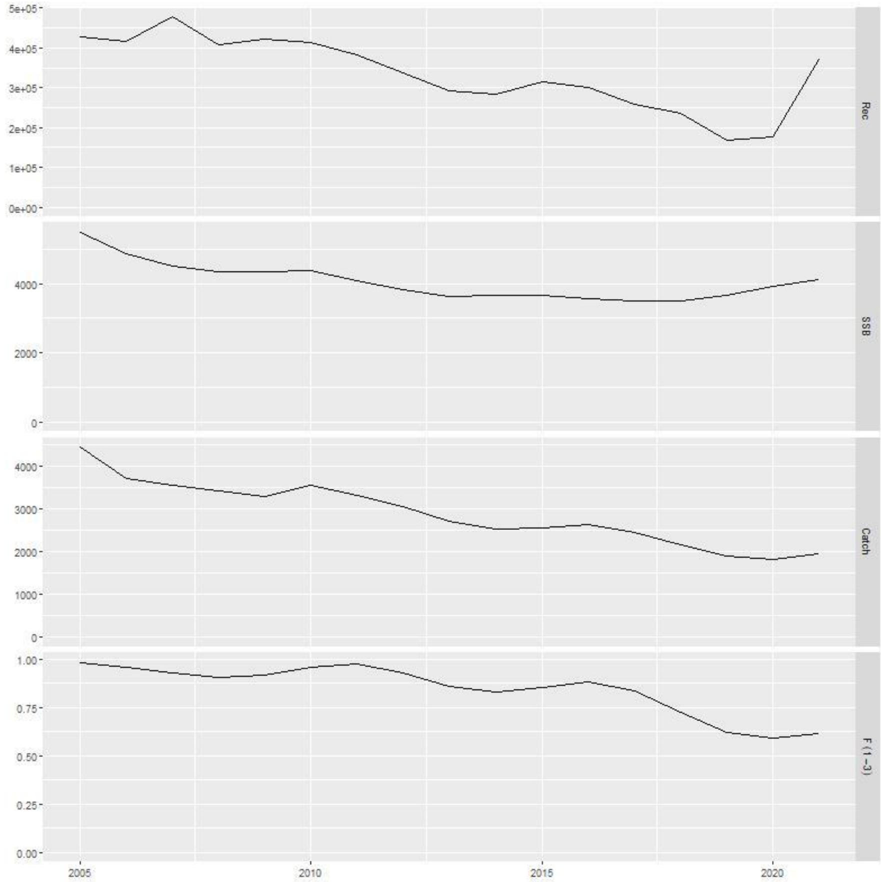


Figure 6.9.3.5. European hake in GSAs 8, 9, 10 & 11. Stock summary from the final a4a model.

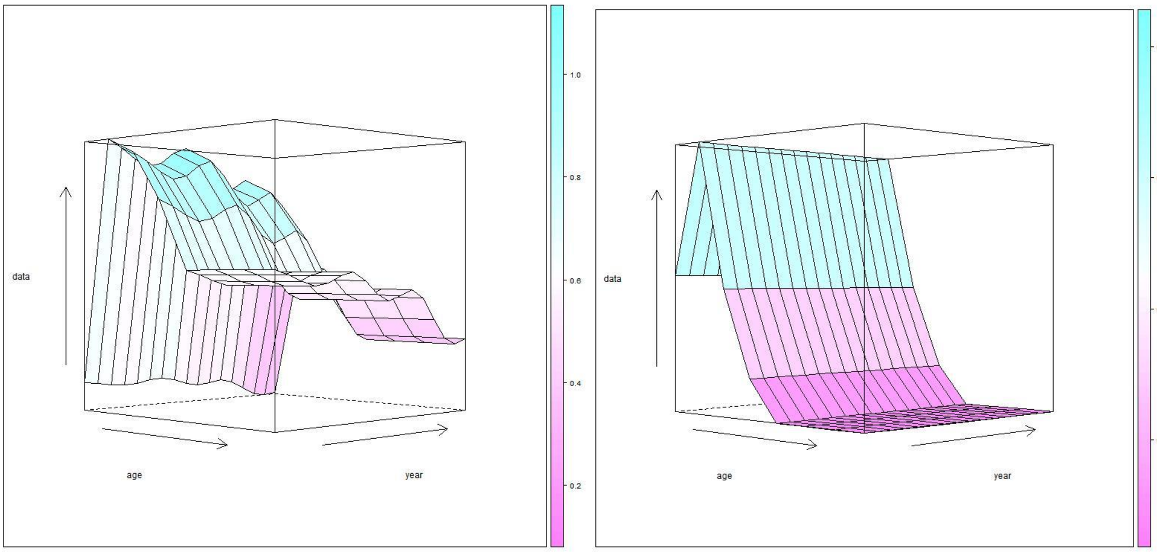


Figure 6.9.3.6. European hake in GSAs 8, 9, 10 & 11. 3D contour plot of estimated fishing mortality (left) and 3D contour plot of estimated catchability (right) at age and year.

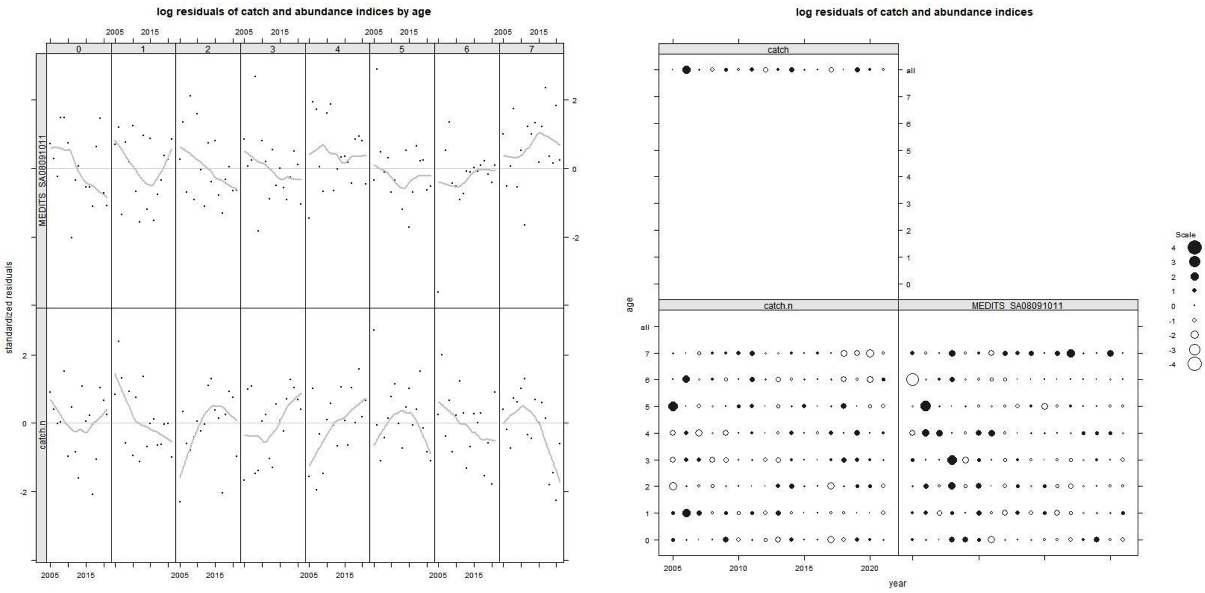


Figure 6.9.3.7. European hake in GSAs 8, 9, 10 & 11. Standardized residuals for abundance indices and for catch numbers.

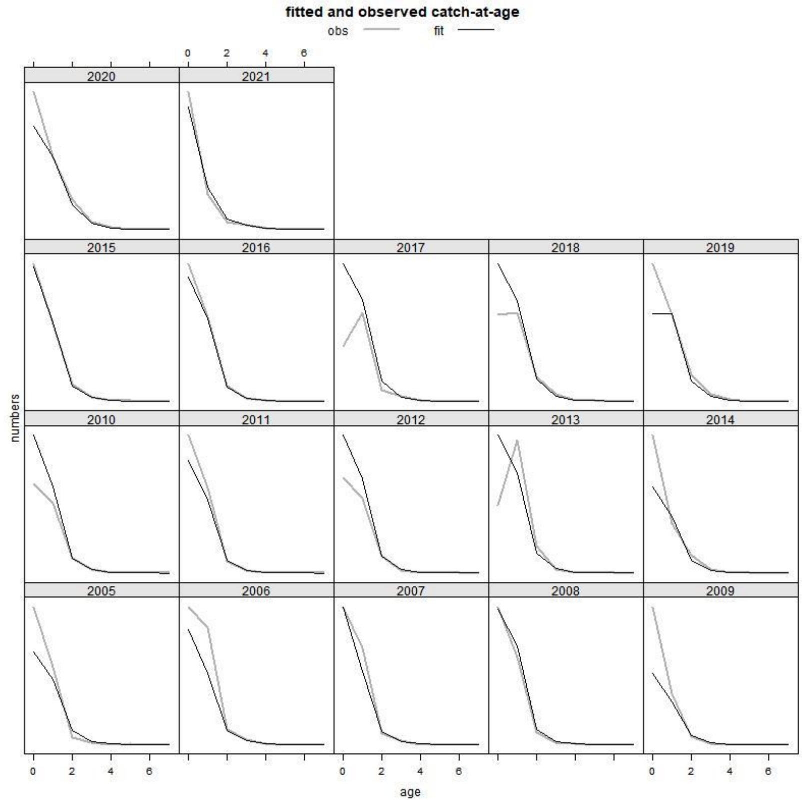


Figure 6.9.3.8. European hake in GSAs 8, 9, 10 & 11. Fitted and observed catch at age.

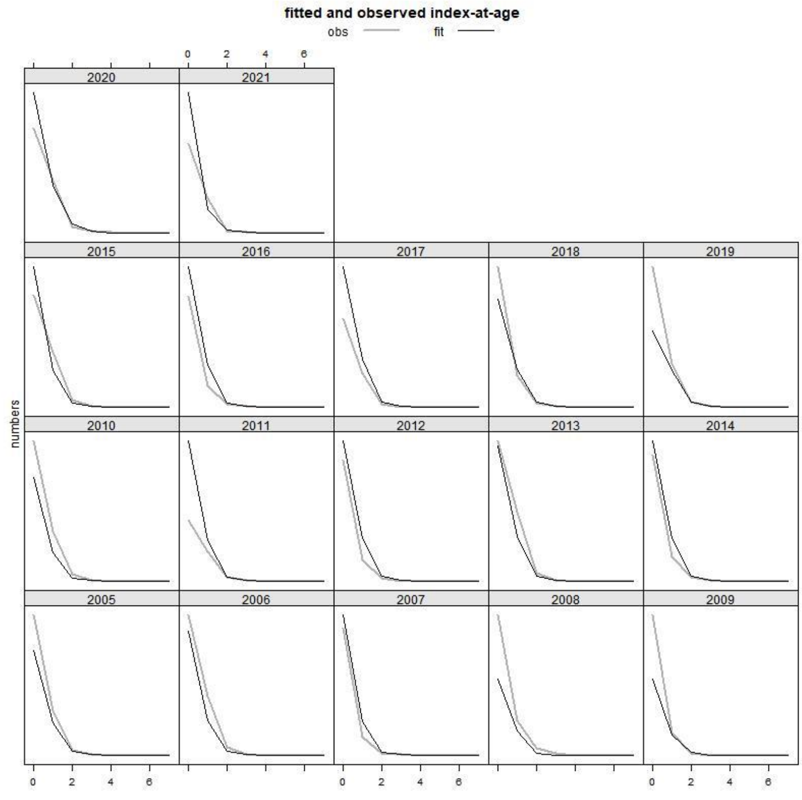


Figure 6.9.3.9. European hake in GSAs 8, 9, 10 & 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 5 years back. Models results were quite stable (Figure 6.9.3.10).

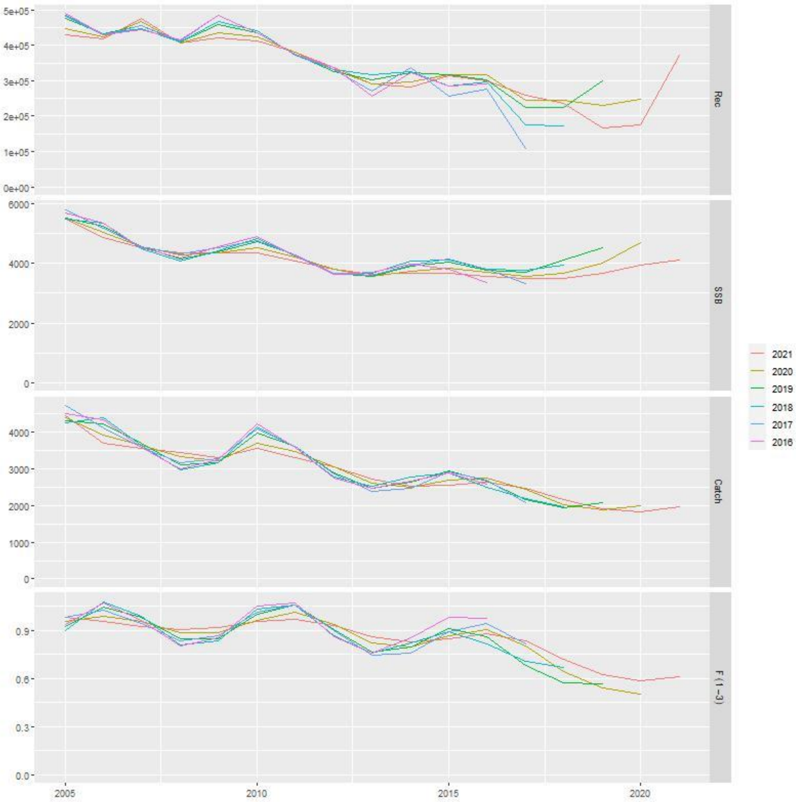


Figure 6.9.3.10. European hake in GSAs 8, 9, 10 & 11. Retrospective analysis.

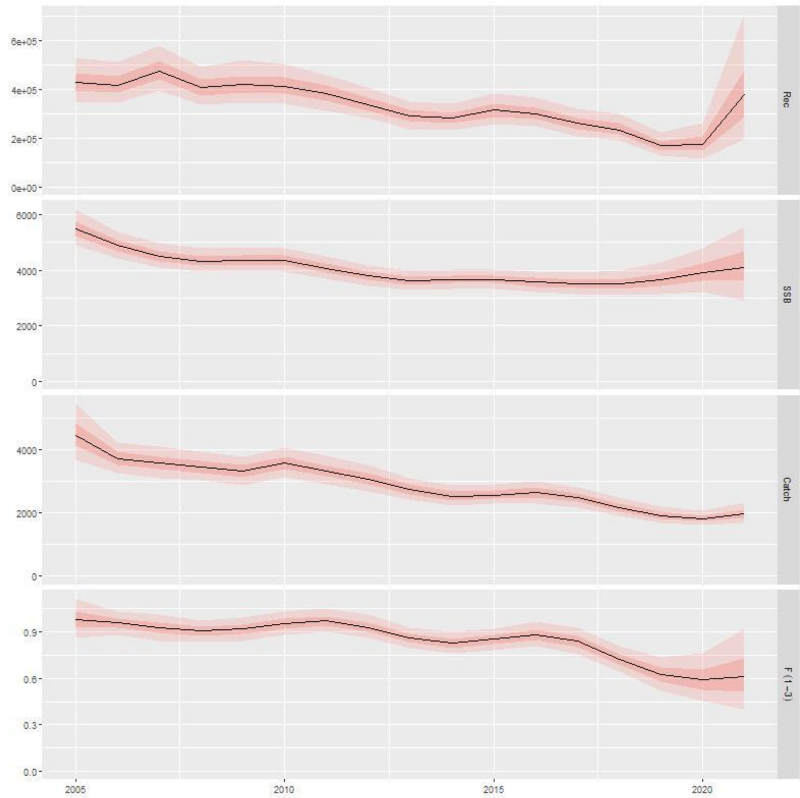


Figure 6.9.3.11. European hake in GSAs 8, 9, 10 & 11. Stock summary of the simulated and fitted data for the a4a model.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.9.3.3. European hake in GSAs 8, 9, 10 & 11. Stock numbers at age (thousands) as estimated by a4a.

	0	1	2	3	4	5	6	7+
2005	429133	62578	12656	2916	849	325	158	87
2006	417621	53083	9641	2835	855	336	133	104
2007	477519	51972	8401	2215	850	344	140	102
2008	407210	59875	8506	1993	682	349	146	106
2009	421285	51325	10030	2063	625	284	149	112
2010	413012	52943	8486	2402	640	258	121	116
2011	382143	51414	8391	1952	721	258	107	102
2012	338223	47372	7997	1897	577	287	106	89
2013	291073	42369	7721	1890	582	236	121	86
2014	282718	37096	7457	1962	617	249	104	95
2015	314461	36320	6766	1960	659	270	112	93
2016	299873	40153	6447	1734	644	284	120	95
2017	258970	38009	6897	1601	555	272	123	97
2018	235940	33180	6850	1793	532	241	122	102
2019	167681	31090	6777	2005	659	249	116	112
2020	175716	22646	7087	2202	805	328	128	122
2021	372471	23921	5350	2382	909	409	172	136

Table 6.9.3.4. European hake in GSAs 8, 9, 10 & 11. a4a summary results Fbar age 1-3, recritment (thousands SSB and total biomass (tonnes) and F at age.

	Fbar(1-3)	Recruitment	SSB (t)	TB (t)	Catch (t)
2005	0.98	429133	5479.4	12236.8	4439.2
2006	0.96	417621	4876.4	11582.2	3703.6
2007	0.93	477519	4513.3	11575.8	3561.6
2008	0.90	407210	4337.9	10838.5	3432.4
2009	0.92	421285	4341	10054.1	3293.6
2010	0.96	413012	4361.9	10816.2	3563.3
2011	0.97	382143	4083.9	10019.9	3308.1
2012	0.93	338223	3808.7	9284.2	3064.4
2013	0.86	291073	3631.1	9105.9	2727.5
2014	0.83	282718	3662.3	7451.4	2522
2015	0.85	314461	3675.5	8123.2	2559.8
2016	0.88	299873	3571.6	8265.6	2632.7
2017	0.84	258970	3509.5	7463.1	2465.5
2018	0.72	235940	3509.8	7414.6	2159.1
2019	0.62	167681	3650.4	6658.4	1907.8
2020	0.59	175716	3930.3	7036.3	1821.5
2021	0.61	372471	4125	8160	1963.9

Table 6.9.3.5. European hake in GSAs 8, 9, 10 & 11. Fishing mortality at age as estimated by a4a.

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2005	0.24	1.07	1.02	0.86	0.63	0.63	0.63	0.63
2006	0.23	1.04	0.99	0.83	0.61	0.61	0.61	0.61
2007	0.23	1.01	0.96	0.81	0.59	0.59	0.59	0.59
2008	0.22	0.99	0.94	0.79	0.58	0.58	0.58	0.58
2009	0.22	1.00	0.95	0.80	0.58	0.58	0.58	0.58
2010	0.23	1.04	0.99	0.83	0.61	0.61	0.61	0.61
2011	0.24	1.06	1.01	0.85	0.62	0.62	0.62	0.62
2012	0.23	1.01	0.96	0.81	0.59	0.59	0.59	0.59
2013	0.21	0.94	0.89	0.75	0.55	0.55	0.55	0.55
2014	0.20	0.90	0.86	0.72	0.53	0.53	0.53	0.53
2015	0.21	0.93	0.88	0.74	0.54	0.54	0.54	0.54
2016	0.22	0.96	0.91	0.77	0.56	0.56	0.56	0.56
2017	0.20	0.91	0.87	0.73	0.53	0.53	0.53	0.53
2018	0.18	0.79	0.75	0.63	0.46	0.46	0.46	0.46
2019	0.15	0.68	0.64	0.54	0.40	0.40	0.40	0.40
2020	0.14	0.64	0.61	0.51	0.38	0.38	0.38	0.38
2021	0.15	0.67	0.63	0.53	0.39	0.39	0.39	0.39

Based on the a4a results, the European hake SSB declines in the first part of the time series, reaching the lowest value in 2017, and slightly increases in the last four years. The assessment shows a decreasing trend in the number of recruits with the minimum value reached in 2019 (167681 thousands) and a peak in 2021. Fbar (1-3) shows a fluctuating pattern with a slightly declining trend, with the lowest value of 0.59 reached in 2020. The retrospecive performance is moderate, but shows that the F is high, well above F_{MSY} over the whole time series.

6.9.4 REFERENCE POINTS

The time series is too short to fit a stock recruitment relationship, therefore reference points are based on equilibrium methods. The STECF EWG 18-02 recommended using $F_{0.1}$ as a proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.
Current F (0.61, estimated as the average of F_{bar1-3} in the last three years of the time series) is higher than $F_{0.1}$ (0.17), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that European hake stock in GSAs 8, 9, 10 and 11 is over-exploited.

Estimation of biomass reference points

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4. An exploratory per-recruit analysis was performed using the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in table 6.9.4.1 and figure 6.9.4.1.

Table 6.9.4.1. European hake in GSAs 8, 9, 10 & 11. Per-recruit reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	B_0
0.1661	0.1153	0.0288	0.5236	0.2765

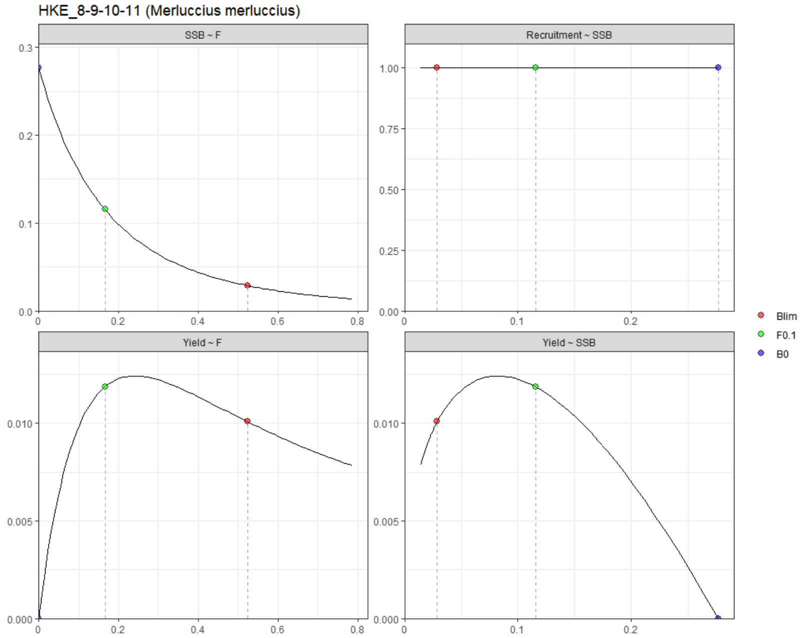


Figure 6.9.4.1. European hake in GSAs 8, 9, 10 & 11. Per-recruit analysis.

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)
2. Hockey-Stick (model=segreg)
3. Beverton-Holt (model=bevholtSV)
4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ration potential SRPlim = SPRlim/SPR_0. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP0.1−20% by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y. The results of the fits are given in Table 6.9.4.2 and Figure 6.9.4.2.

Table 6.9.4.2. European hake in GSAs 8, 9, 10 & 11. Summary of the four SR models.

	s	sigmaR	R_0	rho	B_0
Geometric mean		0.31	320994	0.72	88768.63
Hockey-stick		0.26	429133.1	0.59	118673.7
Beverton-Holt	0.86	0.26	9550387	0.59	2641092
Ricker	2.38	0.23	9550387	0.58	2641092

The observed SR data are sitting on the left side of the R-SSB plot, and the breakpoint estimated by the HS model is within the observed values.

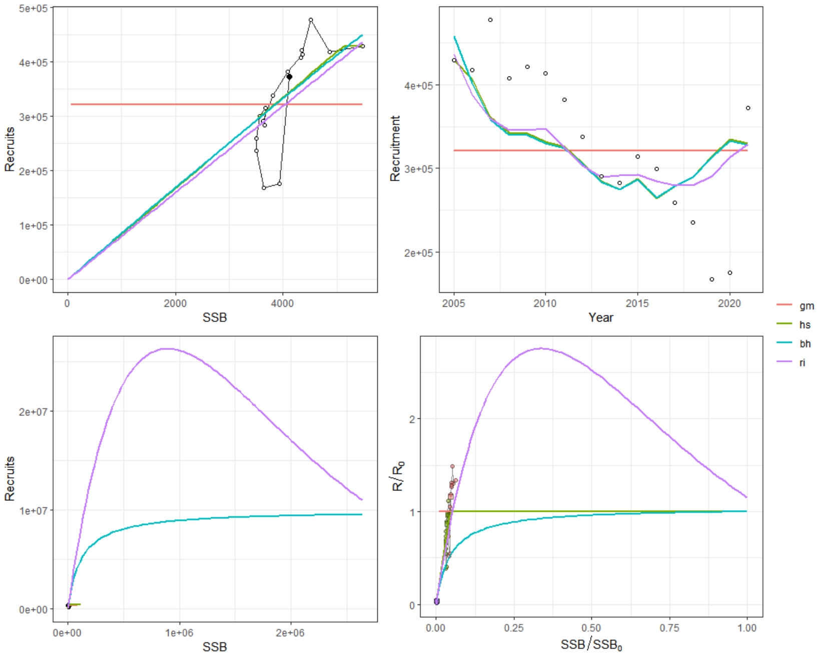


Figure 6.9.4.2. European hake in GSAs 8, 9, 10 & 11. Summary of the four SR models.

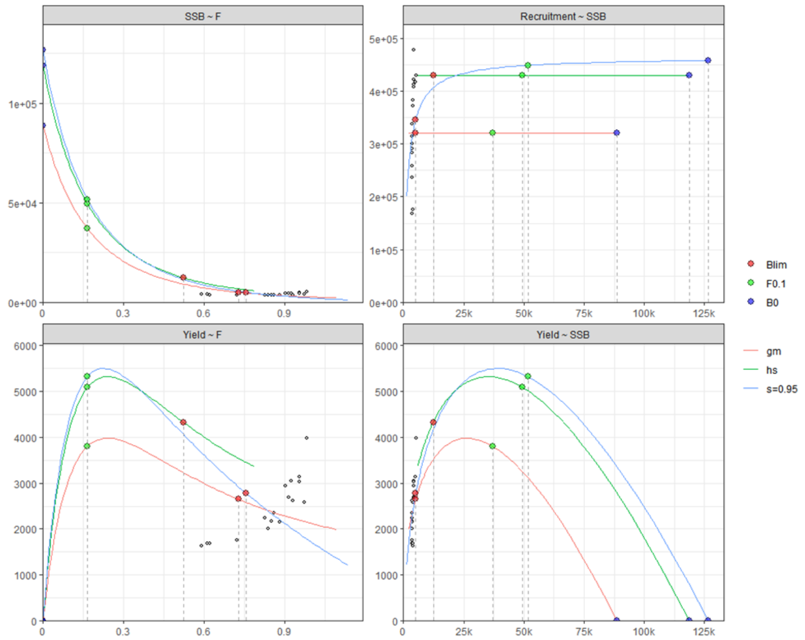


Figure 6.9.4.3. European hake in GSAs 8, 9, 10 & 11. Long-term equilibrium evaluations for different S-R models.

In the light of the outcomes of the exploratory analysis, it was decided to consider the Hockey-stick approach the most appropriate to estimate the biomass reference points for the stock of European hake in GSAs 8, 9, 10 and 11. Table 6.9.4.3 summaries the reference point values based on the Hockey-Stick model fitted to the data. B_{pa} is set to 2* B_{lim}, and the implied dynamics are illustrated in Figure 6.9.4.4. The results of this analysis give slightly higher reference point than those given in EWG 22-03, due mostly to the high value of recent recruitment.

Table 6.9.4.3. European hake in GSAs 8, 9, 10 & 11. Final reference points based on Hockey-Stick stock recruit model fitted to the data.

$F_{0.1}$	B_{lim}	B_{pa}	$B_{F0.1}$	B_0	F_{lim}
0.166	5132	10264	49500	118700	0.827

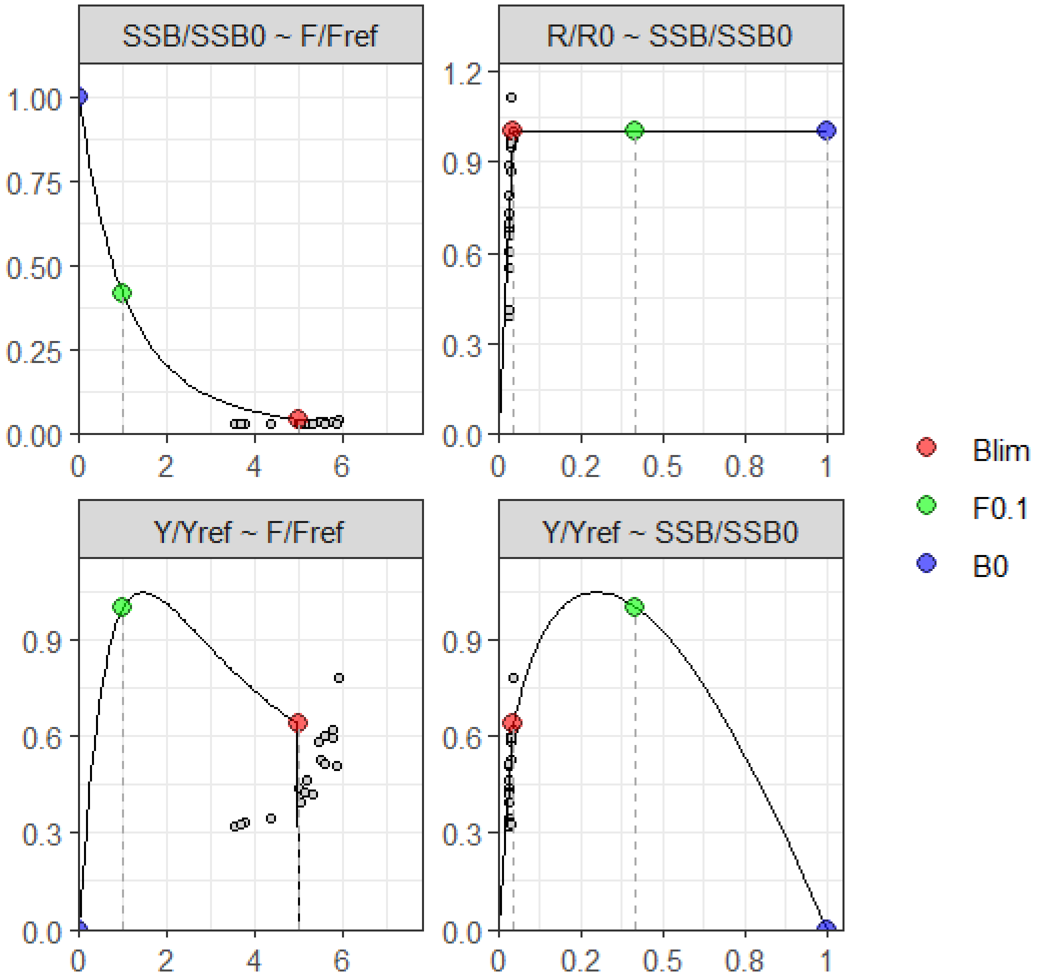


Figure 6.9.4.4. European hake in GSAs 8, 9, 10 & 11. Yield analysis with HS model.

In conclusion, the stock is considered to be below B_{lim} in 2021, as shown in Figure 6.9.4.5.

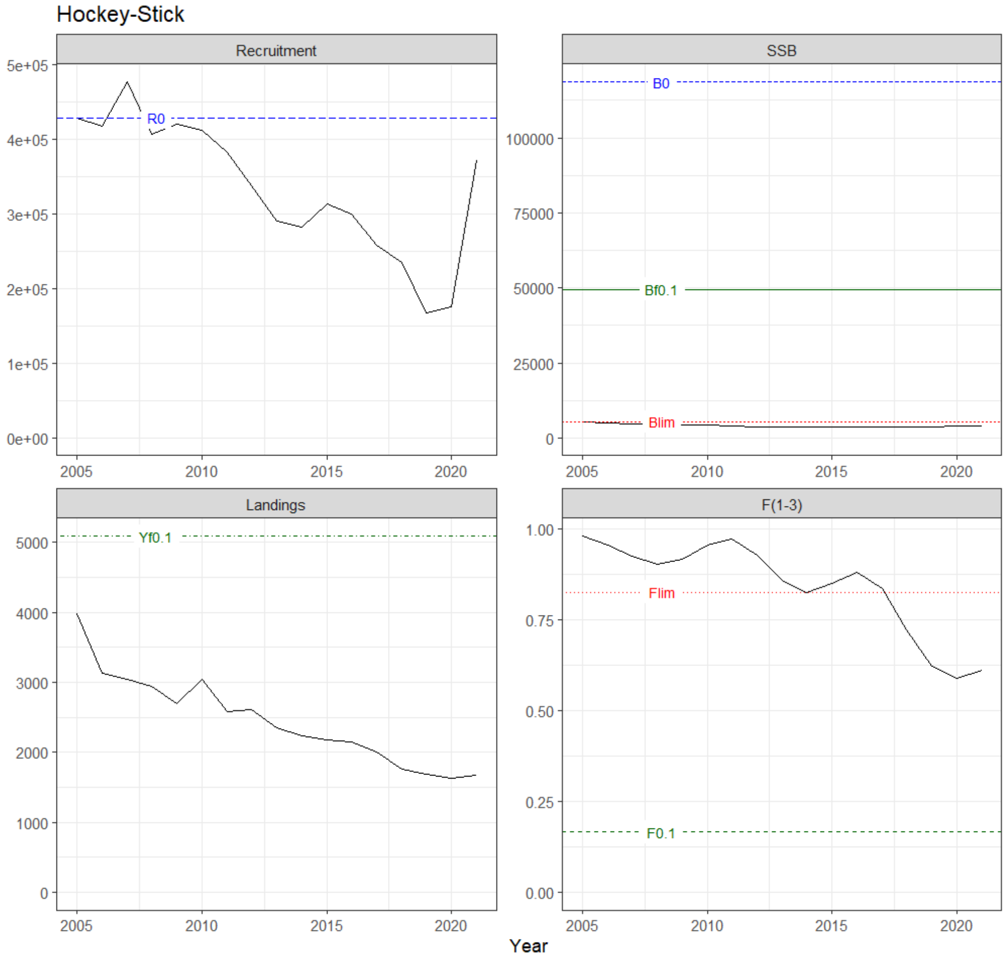


Figure 6.9.4.5. European hake in GSAs 8, 9, 10 & 11. Stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on a Hockey-Stick stock-recruitment relationship.

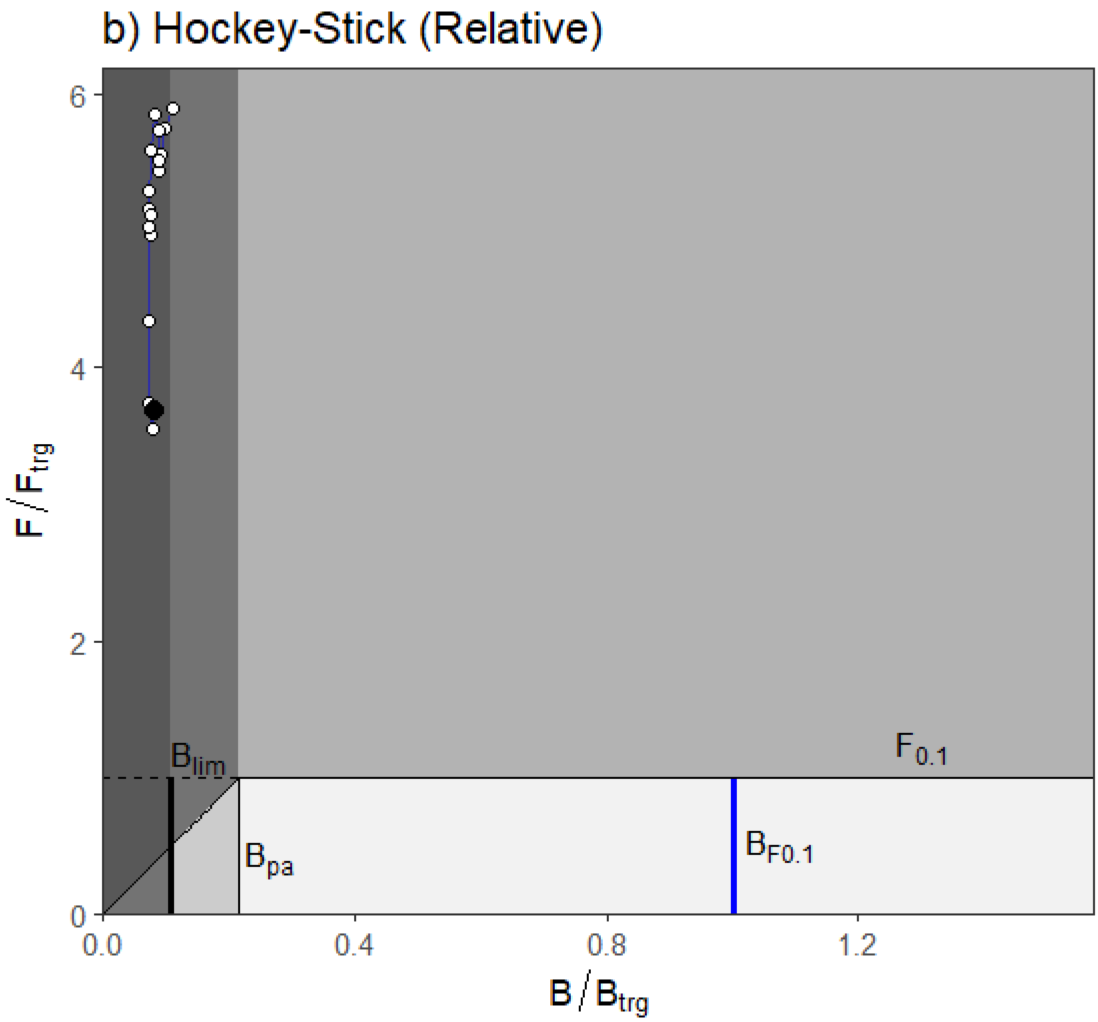


Figure 6.9.4.6. European hake in GSAs 8, 9, 10 & 11. Advice Rule plots, with B_{lim} based on HS model fitted to the data and B_{pa} = 2 B_{lim}.

The HS model defined above is considered as the best option for defining reference points for this stock, but it may not be the most suitable for modelling. A Beverton-Holt model may be helpful too as a modelling option. The steepness option that most closely mimics in terms of deviation from slope and asymptote the HS chosen is thought to be steepness = 0.95 (Figure 6.9.4.7).

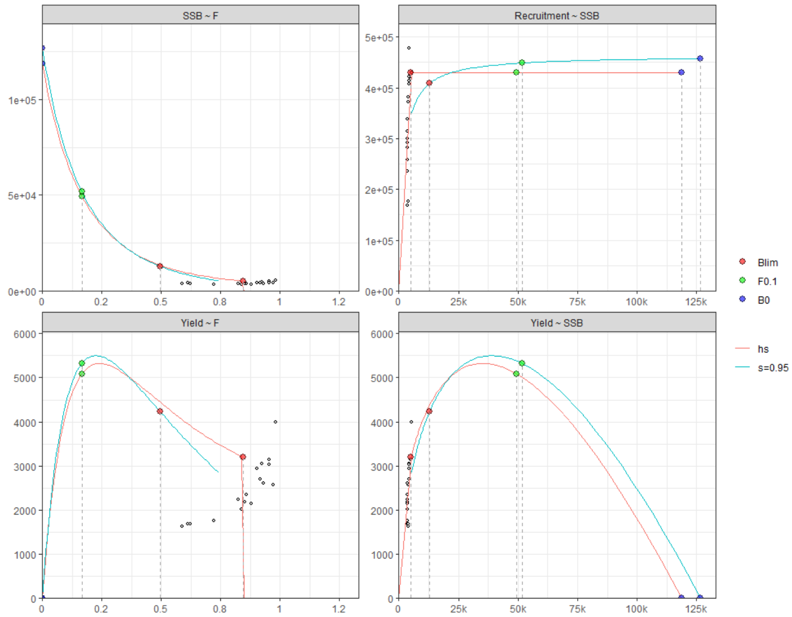


Figure 6.9.4.7. European hake in GSAs 8, 9, 10 & 11. Relative reference points for HS and BH (steepness 0.95) models.

6.9.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.
An average of the last three years has been used for weight at age and maturity at age, while F_{bar}=0.61 (average of the last 3 years) was used for F in 2021, as F shows a fluctuating trend (see section 4.3). Recruitment shows a declining pattern over the period of the assessment, with a peak in the last year, so it has been estimated from the population results as the mean of the last 8 years (263479 thousands).

Table 6.9.5.1: European hake in GSAs 8, 9, 10 & 11. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 1-3 (2022)	0.61	Fsq = average of the last 3 years
SSB (2022)	4427.70	SSB intermediate year from STF output
Rage0 (2022,2023)	263478.73	Recruitment will be set as mean of the last 8 years
Total Catch (2022)	2403.13	Catch intermediate year from STF output
Fbar (2019)	0.62	MAP base year fishing mortality from current assessment
a and b values	a=0.333333 and b=0.666667	Parameters from FTransition line

Table 6.9.5.2: European hake in GSAs 8, 9, 10 & 11. Short term forecast in different F scenarios.

Rationale	F factor	Fbar	Recruitment 2022	Fsq 2022	Catch 2021	Catch 2023	SSB 2022	SSB 2024	SSB 2021-2023(%)	Catch 2021-2023(%)
$F_{0.1}$	0.27	0.17	263478.73	0.61	1963.86	839.70	4427.70	8095.13	82.83	-57.24
F upper	0.38	0.23	263478.73	0.61	1963.86	1142.25	4427.70	7637.18	72.49	-41.84
F lower	0.19	0.11	263478.73	0.61	1963.86	581.74	4427.70	8488.89	91.72	-70.38
F_{MSY} Transition	0.52	0.32	263478.73	0.61	1963.86	1514.10	4427.70	7080.44	59.91	-22.90
Reduced Foption	0.14	0.08	263478.73	0.61	1963.86	440.69	4427.70	8705.43	96.61	-77.56
Zero catch	0.00	0.00	263478.73	0.61	1963.86	0.00	4427.70	9387.23	112.01	-100.00
Status quo	1.00	0.61	263478.73	0.61	1963.86	2594.28	4427.70	5507.12	24.38	32.10
Different Scenarios	0.10	0.06	263478.73	0.61	1963.86	320.52	4427.70	8890.57	100.79	-83.68
	0.20	0.12	263478.73	0.61	1963.86	625.42	4427.70	8422.01	90.21	-68.15
	0.30	0.18	263478.73	0.61	1963.86	915.54	4427.70	7979.92	80.23	-53.38
	0.40	0.24	263478.73	0.61	1963.86	1191.69	4427.70	7562.75	70.81	-39.32
	0.50	0.30	263478.73	0.61	1963.86	1454.61	4427.70	7169.03	61.91	-25.93
	0.60	0.36	263478.73	0.61	1963.86	1705.02	4427.70	6797.40	53.52	-13.18
	0.70	0.43	263478.73	0.61	1963.86	1943.57	4427.70	6446.57	45.60	-1.03
	0.80	0.49	263478.73	0.61	1963.86	2170.91	4427.70	6115.32	38.12	10.54
	0.90	0.55	263478.73	0.61	1963.86	2387.62	4427.70	5802.53	31.05	21.58
	1.10	0.67	263478.73	0.61	1963.86	2791.40	4427.70	5228.08	18.08	42.14
	1.20	0.73	263478.73	0.61	1963.86	2979.50	4427.70	4964.47	12.12	51.72
	1.30	0.79	263478.73	0.61	1963.86	3159.05	4427.70	4715.38	6.50	60.86
	1.40	0.85	263478.73	0.61	1963.86	3330.48	4427.70	4480.00	1.18	69.59
	1.50	0.91	263478.73	0.61	1963.86	3494.23	4427.70	4257.51	-3.84	77.93
	1.60	0.97	263478.73	0.61	1963.86	3650.70	4427.70	4047.20	-8.59	85.89
	1.70	1.03	263478.73	0.61	1963.86	3800.25	4427.70	3848.35	-13.08	93.51
	1.80	1.09	263478.73	0.61	1963.86	3943.25	4427.70	3660.30	-17.33	100.79
	1.90	1.15	263478.73	0.61	1963.86	4080.03	4427.70	3482.45	-21.35	107.76
	2.00	1.22	263478.73	0.61	1963.86	4210.91	4427.70	3314.21	-25.15	114.42

6.10 Deep-water rose shrimp in GSAs 8, 9, 10 & 11

6.10.1 Stock Identity and Biology

According to the results of Stockmed project (Fiorentino *et al*., 2014), Deep-water rose shrimp of GSA09 is part of the stock that includes many GSAs of western Mediterranean (GSA01, GSAs 05-08, GSA11). However, the analyses underlined that the southern part of GSA09 presents characteristics more similar to those of GSA10. In the present assessment, the stock was assumed to be confined within the GSAs 08, 09, 10 and 11 boundaries.

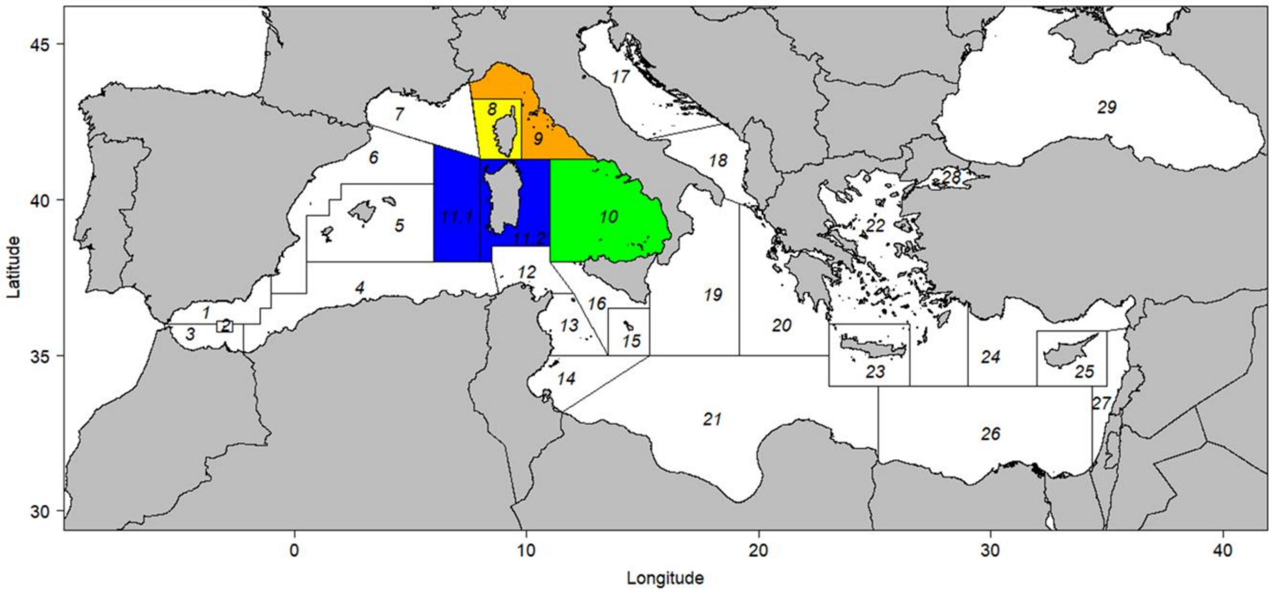


Figure 6.10.1.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Geographical location of the GSAs.

The Deep-water rose shrimp is an epibenthic species and inhabits the muddy or sandy-muddy bottoms of the continental shelf. A gradient of size increasing with depth has been observed in the area, being the smallest specimens fished more frequently in the upper part of the continental shelf (100-200 m), while the largest ones are mainly distributed along the slope at depths greater than 200 m (, Ardizzone *et al*., 1990; Spedicato *et al*., 1996).

In GSA09, the species shows a wide bathymetric distribution, being present from 50 to 650 m depth with greatest abundance between 150 and 400 m depth over muddy or sandy-muddy bottoms (Ardizzone and Corsi, 1997; Biagi *et al*., 2002). The highest abundances have been found in the Tyrrhenian part of the GSA (south Tuscany and Latium). In GSA10, aggregations with higher abundance were localised between 100 and 200 m depth, with some intrusions in the deeper waters in three sub-areas. Two most important patches were located in the Gulf of Naples and along the Calabrian coasts in correspondence with Cape Bonifati, while a third one in the Gulf of Salerno (Lembo *et al*., 1999). These are the areas where also the main nurseries are localised.

The Deep-water rose shrimp with hake and red mullet is a key species of fishing assemblages in the area. In the last decade it was generally also ranked among the species with higher abundance indices (number of individuals) in the trawl surveys as observed for different Mediterranean areas (Abelló *et al*., 2002). The species is caught on the same fishing grounds as European hake and the production of this shrimp is steadily growing in the last decade in the southern basin and it reached in 2006 about 10% of the demersal landings. The core of nursery areas in GSA09 overlap with crinoid beds (*Leptometra phalangium*) areas over the shelf-break (Colloca *et al*., 2004, 2006a; Reale *et al*., 2005). This is a peculiar habitat in the GSA09, which is also an essential fish habitat for other commercially important species as the European hake, *Merluccius merluccius*.

Growth

The structure of the sizes of *P. longirostris* is characterised by differences in growth between the sexes, the larger individuals being females. The Deep-water rose shrimp is a short-living crustacean with a life span of about 4 years (Carbonara *et al*., 1998).

The growth of *P. longirostris* has been studied in the southern part of the GSA09 (central Tyrrhenian Sea) using modal progression analysis (Ardizzone *et al*., 1990). The following sets of Von Bertalanffy growth parameters were estimated: Females: L∞ = 43.5, K=0.74, t0=-0.13; Males: L∞ = 33.1, K=0.93, t0=-0.05. Females grow faster than males attaining larger size-at-age.

In GSA10, past estimates of the growth pattern of the Deep-water rose shrimp females were obtained using different methods based on the LFD analysis (modal progression analysis-MPA, Elefan, Multifan) applied to GRUND data from 1990 to 1995. Parameters of VBGF were as follows: L∞=45.9; K=0.673 t0=-0.251 (Carbonara *et al*., 1998). VBGF parameters were also re-estimated during the Samed project (SAMED, 2002) using the MEDITS time series from 1994 to 1999, that gave the following values: females: CL∞=45.0 mm, K=0.7, t0= -0.15; males: CL∞=40.0 mm; K=0.78; t0= -0.2.

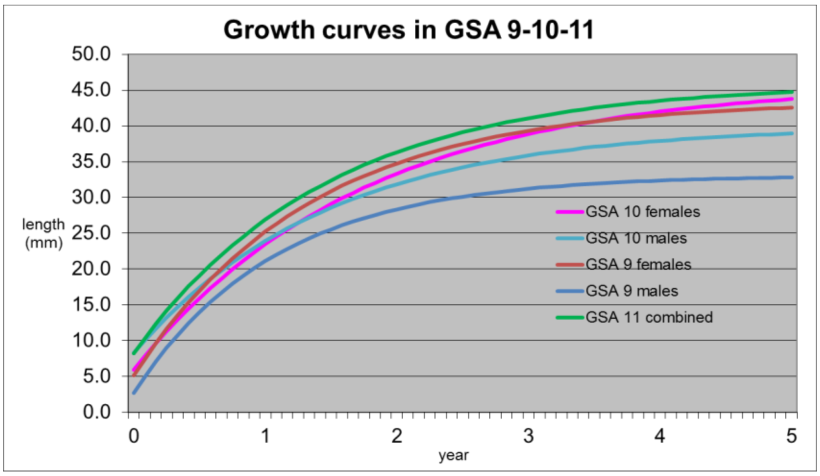


Figure 6.10.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Von Bertalanffy curves.

For the present assessment the growth parameters reported in Table 6.10.1.1 has been used. Weight length relationships for the different years and GSAs have been obtained from DCF database.

Table 6.10.1.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Growth parameters used in the present assessment.

Sex	VB_LINF	VB_K	VB_T0
Females	43.5	0.74	-0.13
Males	33.1	0.93	-0.05

Maturity

In the northern Tyrrhenian Sea (GSA09), the reproduction area of *P. longirostris* is located from 150 to 350 m; mature females are present all year round, even though the species shows two peaks in reproductive activity, one in spring and another at the beginning of autumn (Mori *et al*., 2000a). In the central Tyrrhenian Sea, the southern part of GSA09, a main winter spawning was hypothesized (Ardizzone *et al*., 1990). The size at onset of sexual maturity estimated for different years in northern Tyrrhenian Sea is about 24 mm CL (Mori *et al*., 2000a). The number of oocytes in the ovary was related to the size of the females and ranged from 23,000 oocytes at 26 mm CL to 204,000 at 43 mm CL. An exponential relationship was observed between fecundity and carapace length: Fecundity = 0.0569*CL4.0177 (r = 0.829) (Mori *et al*., 2000).

In the Central-Southern Tyrrhenian Sea (GSA10) the occurrence of mature females was observed in spring (May), summer (July-August) and autumn (October), with a higher relative frequency in spring-summer seasons (Spedicato *et al*., 1996). Thus, a continuous recruitment pattern is shown which, however, exhibits a main pulse in the autumn season. At 16 mm carapace length the pink shrimp is considered recruited to the grounds (SAMED, 2002). In GSA09, the main nurseries revealed a high spatio-temporal persistency between 60 and 220 m depth. Recruits (CL 15 mm) occur all year round, with a main peak from July to October (De Ranieri *et al*., 1997).

The overall sex ratio is about 0.5.

The maturity proportion at age adopted in the present assessment is reported In Table 6.10.1.2. This maturity at age differes from the one assumed previously and is considered to better respresent the average growth with an age increment on the calendar year.

Table 6.10.1.2 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Maturity proportion at age adopted in the present assessment.

Age	0	1	2	3+
	0.0	0.7	1.0	1.0

Ecology

P. longirostris diet is composed of a great variety of organisms; the prey items consisted mostly of external skeletons of bottom organisms, always crushed and often in an advanced state of deterioration. Crustaceans dominated the diet both qualitatively and quantitatively; they were characterized by a high abundance of peracarids, mainly represented by mysids (*Lophogaster typicus*) and amphipods (Lysianassidae). Molluscs (juvenile bivalves and gastropods), cephalopods (Sepiolids), small echinoderms, annelids, small fishes, foraminiferans, (Globigerinidae) and organic detritus are other important food item in the diet of the species (Mori *et al*., 2000b).

Natural mortality

Natural mortality was estimated applying Chen & Watanabe model. A single M vector was produced combining the vectors obtained by sex. The input growth parameters (k and t_0) used are reported in Table 6.10.1.1. The natural mortality vector by age is reported in Table 6.10.1.3.

Table 6.10.1.3 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Vector of natural mortality used in the present assessment.

Age	**0**	**1**	**2**	**3+**
M	2.01	1.13	0.94	0.91

6.10.2 DATA

Deep-water rose shrimp is one of the most important target species of the bottom trawl fisheries carried out on the continental shelf and upper slope. Some catches coming from gillnet and trammel net are sporadically observed in GSAs 09 and 10.

6.10.2.1 CATCH (LANDINGS AND DISCARDS)

The annual total landing of Deep-water rose shrimp observed from 2002 to 2021 is reported in Figure 6.10.2.1.1 and Table 6.10.2.1.1. The time series available in the DCF database are different for the four GSAs: 2010-2021 for GSA08, 2003-2021 for GSA09, 2002-2021 for GSA10 and 2004-2021 for GSA11.

In the first years, the landing was higher in GSA10, and then, since 2010, GSA09 has become the most important in terms of biomass landed. The landings coming from GSA11 resulted low in comparison with the GSAs 09 and 10. The landings coming from GSA08 are negligible. The trend of the landing for the combined GSAs shows fluctuations at the beginning of the series with an evident peak in 2005 and 2006 followed by a sharp decrease. Starting from 2010, a constant increase is observed until the maximum value registered in 2019.

Discard data (Figure 6.10.2.1.2 and Table 6.10.2.1.1) are available in GSA09 since 2009. In this area this fraction of the catches ranged from 5 to 24% of the total biomass caught. In GSA10, where discard represents a lower percentage of the total catch (around 1-2%), data are available since 2006. Data on discard are not available in 2018, 2020 and 2021 in GSA10 and for all the data series in GSAs 08 and 11. Missing discard data were not reconstructed.

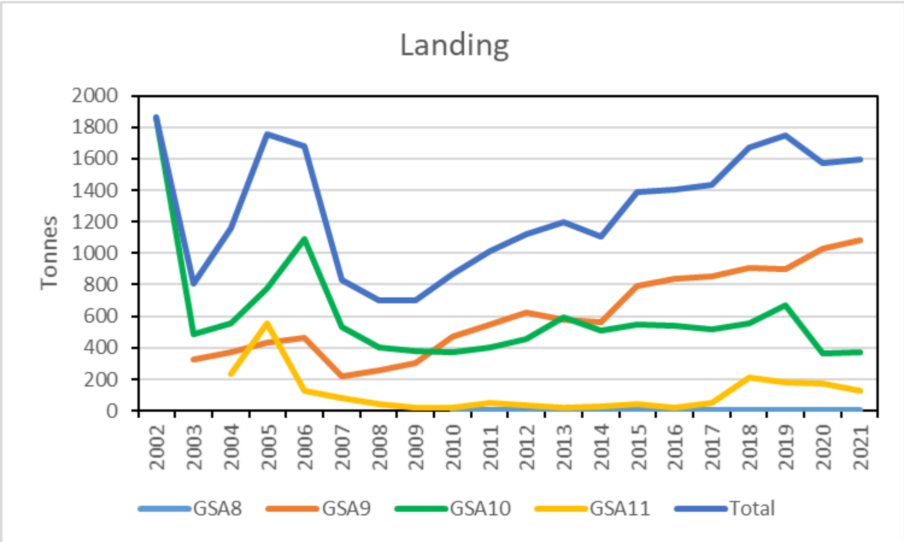


Figure 6.10.2.1.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings from 2002 to 2020 by single and combined GSAs.

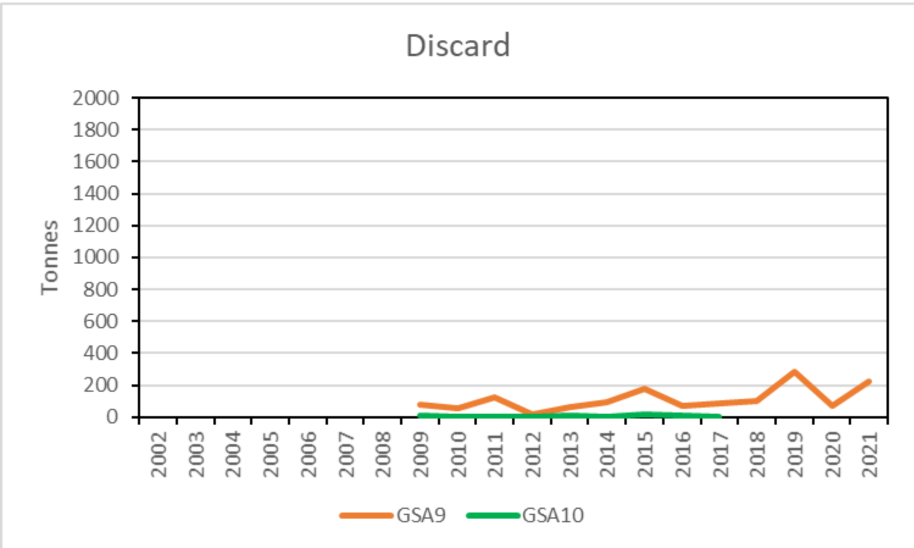


Figure 6.10.2.1.2 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual discards from 2002 to 2021 by single GSAs.

Table 6.10.2.1.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual catches (t) by GSA and fishing technique as provided through the official DCR-DCF database.

LANDING	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GSA08_FPO_CRU										
GSA08_OTB_CRU									3.5	4.9
GSA08_OTB_DEF										0.1
GSA09_GNS_DEF			3.6			2.3	0.5			
GSA09_GTR_DEF		5.9	4.2	0.5						
GSA09_OTB_DEF				42.0	55.3	89.8	187.3	238.5	309.6	404.5
GSA09_OTB_DEMSP										
GSA09_OTB_DWS							0.2		9.7	9.7
GSA09_OTB_MDD				388.5	407.1	125.3	66.1	64.6	154.0	136.9
GSA09_OTB_NA		316.6	367.4							
GSA09_OTM_MPD										
GSA09_TBB_DEMSP										
GSA10_GND_SPF				0.0						
GSA10_GNS_DEF			2.9	5.9			0.1	0.2		3.0
GSA10_GTR_DEF		71.2	2.5	0.4						
GSA10_LLD_LPF				0.6						
GSA10_LLS_DEF			0.6	26.1						
GSA10_NA	373.4		0.2	0.0						
GSA10_OTB_DEF									242.0	282.5
GSA10_OTB_DEMSP										
GSA10_OTB_DWS									3.1	6.6
GSA10_OTB_MDD									124.6	113.1
GSA10_OTB_NA	1451.6	416.0	544.2	742.7	1087.7	534.3	400.2	378.9		
GSA10_OTM_MPD										
GSA10_PS_SPF	33.7		1.3		1.0					
GSA10_SB_DEF			0.1							
GSA10_SV_DEF			0.1							
GSA11_GTR_DEMSP				4.0	2.7					
GSA11_OTB_NA								21.7	23.3	53.3
GSA11_OTB_DEF										
GSA11_OTB_DEMSP			45.2	46.3	23.0	1.1	5.1			
GSA11_OTB_DWS							0.5			
GSA11_OTB_MDD			187.2	501.8	104.5	78.4	40.2			
Total	1858.7	809.7	1159.6	1758.8	1681.4	831.2	700.1	703.9	869.8	1014.6

LANDING	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GSA08_FPO_CRU		0.0		0.3						
GSA08_OTB_CRU	6.4	3.7	2.3	6.7	7.8	7.2	6.4	6.1	6.5	7.9
GSA08_OTB_DEF	0.0	0.8	0.1	0.1	0.1	0.1	0.4	0.1	0.0	0.3
GSA09_GNS_DEF			0.0			0.0			0.1	0.0
GSA09_GTR_DEF	0.2								0.6	
GSA09_OTB_DEF	483.4	426.4	466.7	663.6	648.6	730.1			905.7	913.6
GSA09_OTB_DEMSP							827.8	725.3		
GSA09_OTB_DWS	5.5	3.8	2.1	8.5	10.5		7.7	15.4	7.7	5.7
GSA09_OTB_MDD	132.1	145.5	92.6	119.3	176.6	126.7	68.3	150.1	114.0	166.4
GSA09_OTB_NA										
GSA09_OTM_MPD								3.7	0.0	0.1
GSA09_TBB_DEMSP								1.3		
GSA10_GND_SPF										
GSA10_GNS_DEF	3.7		0.3			0.6			-1.0	
GSA10_GTR_DEF										
GSA10_LLD_LPF										
GSA10_LLS_DEF										
GSA10_NA										
GSA10_OTB_DEF	262.0		211.0	224.2	311.8	302.1	265.0	410.6	224.0	264.2
GSA10_OTB_DEMSP							120.1			
GSA10_OTB_DWS	15.3		52.3	18.0	9.3	33.3	34.4	89.1	25.5	6.1
GSA10_OTB_MDD	177.7		245.6	282.7	221.3	182.9	135.9	166.2	117.7	103.1
GSA10_OTB_NA		596.7								
GSA10_OTM_MPD				21.8				1.6		
GSA10_PS_SPF										
GSA10_SB_DEF										
GSA10_SV_DEF										
GSA11_GTR_DEMSP		23.3	30.2	39.5						
GSA11_OTB_NA	33.8									
GSA11_OTB_DEF						18.3	130.9	78.3	94.6	44.9
GSA11_OTB_DEMSP										
GSA11_OTB_DWS						0.6	9.9	23.4	9.7	2.4
GSA11_OTB_MDD					17.6	29.1	67.9	79.2	67.3	81.7
Total	1120.0	1200.1	1103.2	1384.7	1403.5	1431.0	1674.6	1750.4	1572.6	1596.4

DISCARD	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GSA09_OTB_DEF								38.4	24.4	60.5
GSA09_OTB_DEMSP										
GSA09_OTB_DWS										
GSA09_OTB_MDD									2.7	2.7
GSA10_OTB_DEF									1.9	1.6
GSA10_OTB_DWS										
GSA10_OTB_MDD									0.7	1.3
GSA10_OTB_NA					3.9			7.3		
Total					3.9			45.7	29.7	66.2

DISCARD	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
	6.6	26.8	45.0	89.3	29.7	41.3			68.9	221.4
							50.2	277.8		
										0.0
	1.0	3.3			5.2	0.2		6.8	1.7	0.3
GSA10_OTB_DEF	3.1		1.9	9.2	3.6	3.7				
GSA10_OTB_DWS			0.1	0.1	0.0					
GSA10_OTB_MDD	1.4		1.4	4.0	2.8	0.4		0.3		
GSA10_OTB_NA		9.4								
Total	12.1	39.5	48.3	102.6	41.4	45.6	50.2	284.9	70.6	221.7

Annual landings in tonnes by year and fleet for GSAs 09, 10 and 11 are reported in Figs. 6.10.2.1.3-6. Annual discards in tonnes by year and fleet for GSA09 and GSA10 are displayed in Figs. 6.10.2.1.7-8.

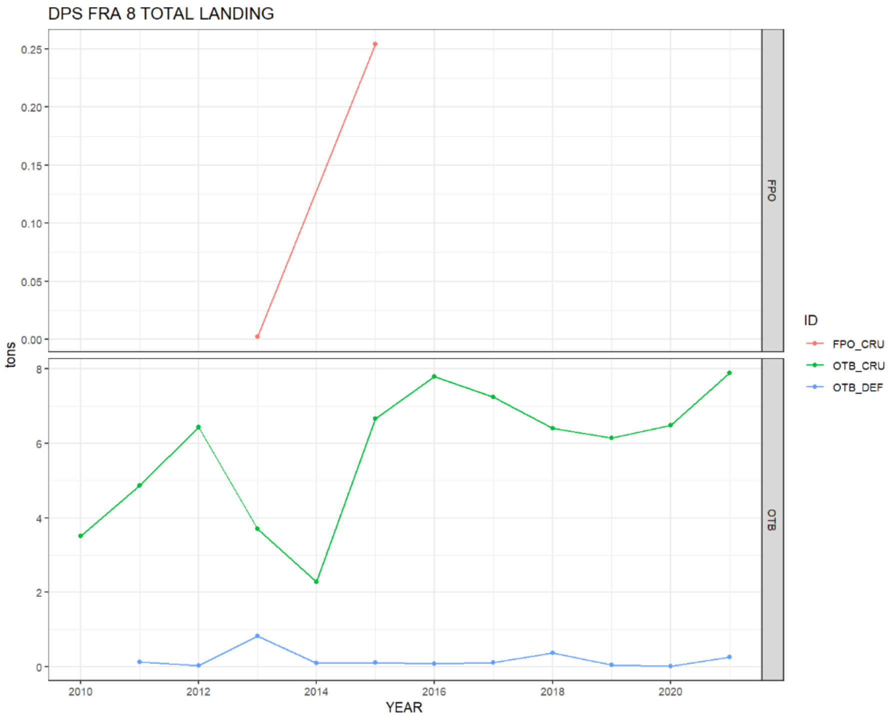


Figure 6.10.2.1.3 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA08.

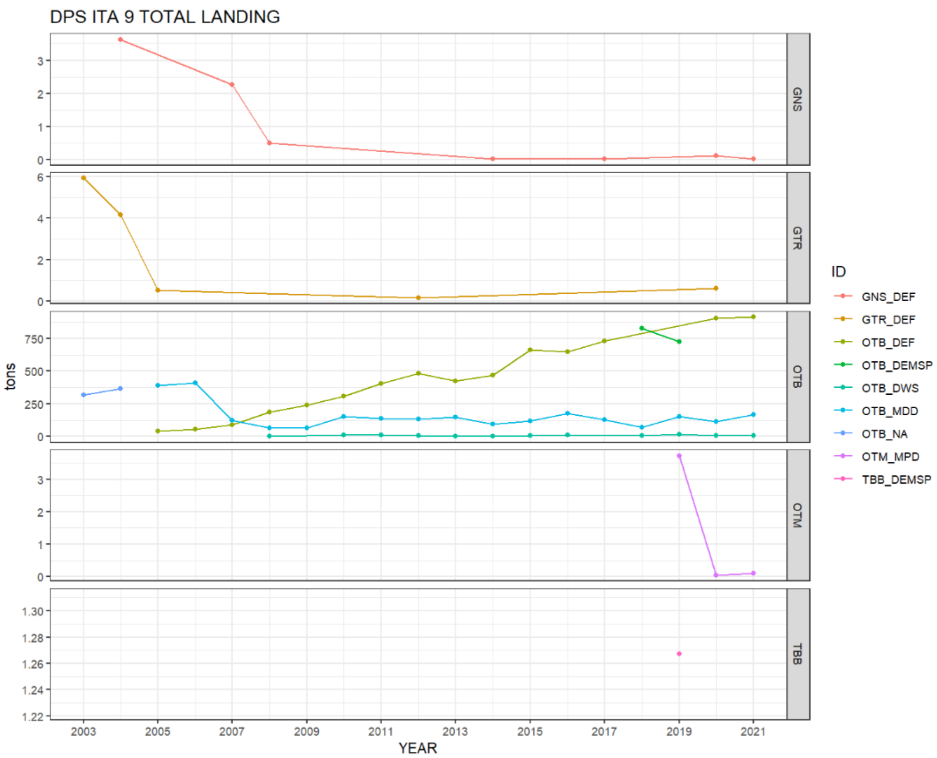


Figure 6.10.2.1.4 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA09.

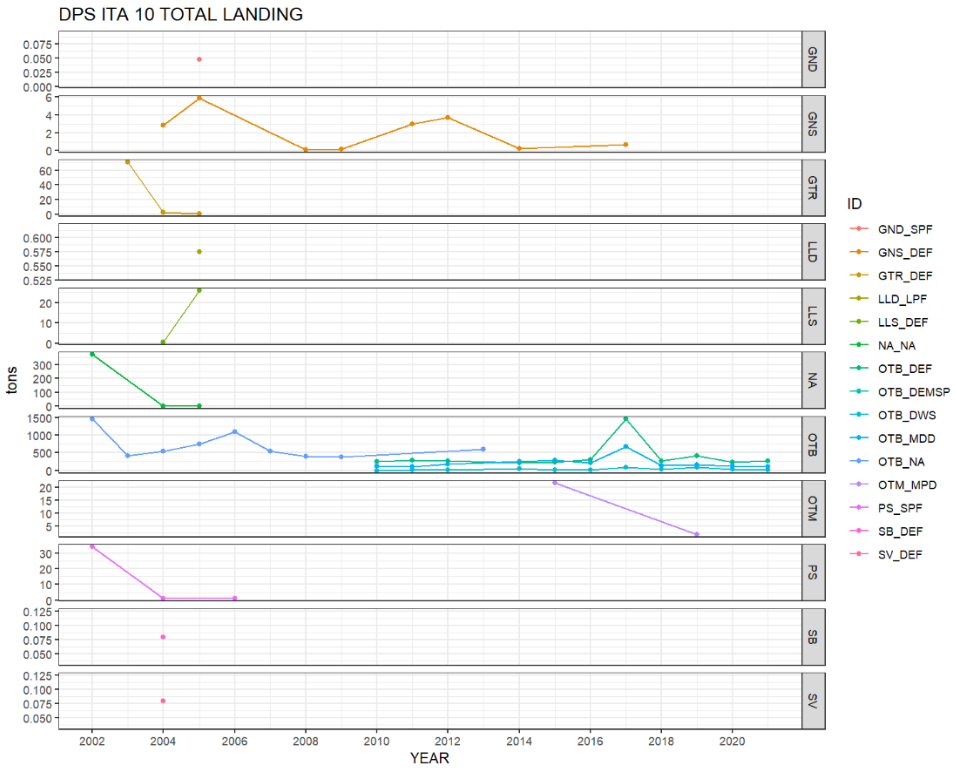


Figure 6.10.2.1.5 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA10.

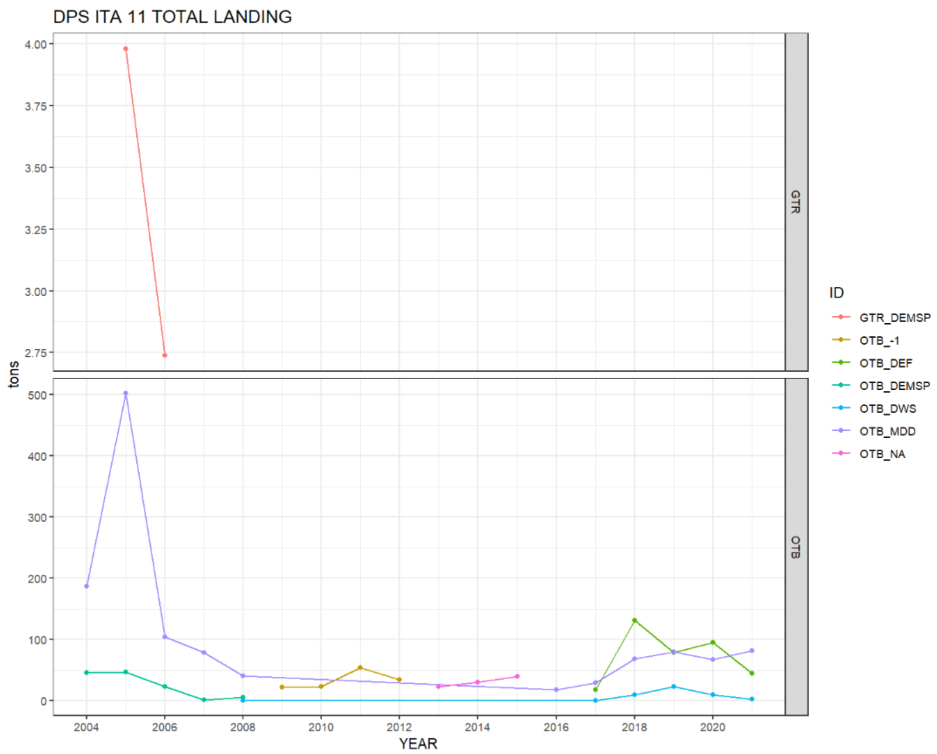


Figure 6.10.2.1.6 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA11.

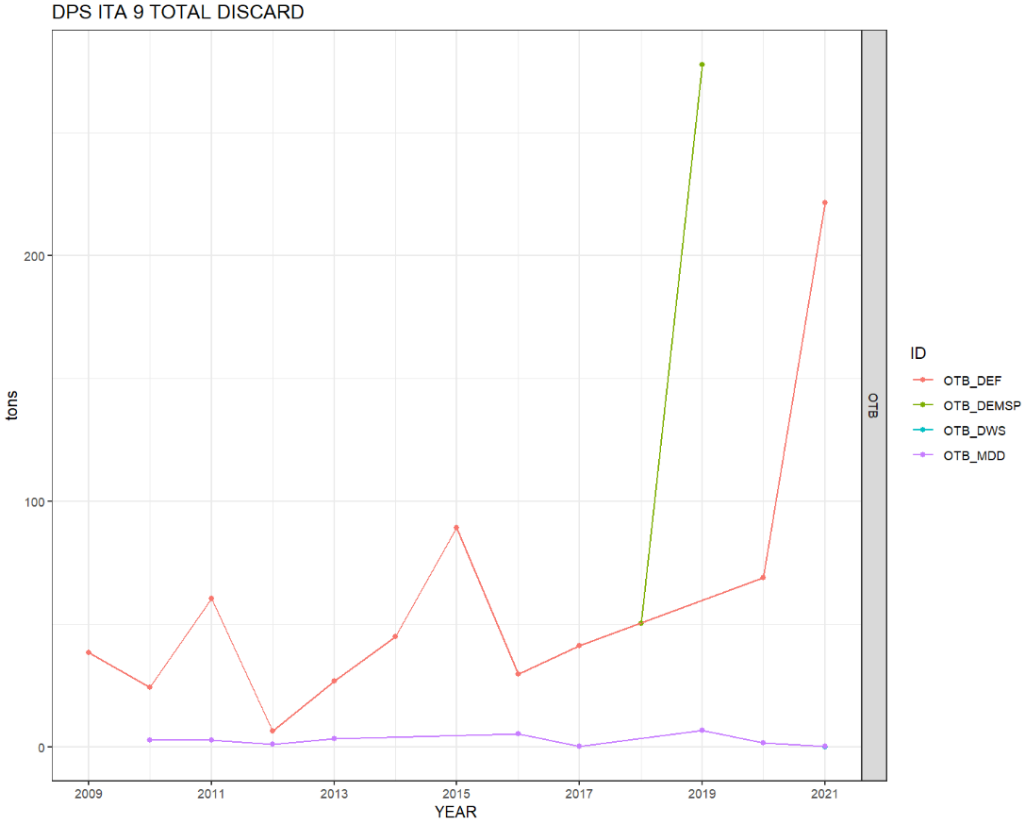


Figure 6.10.2.1.7 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA09.

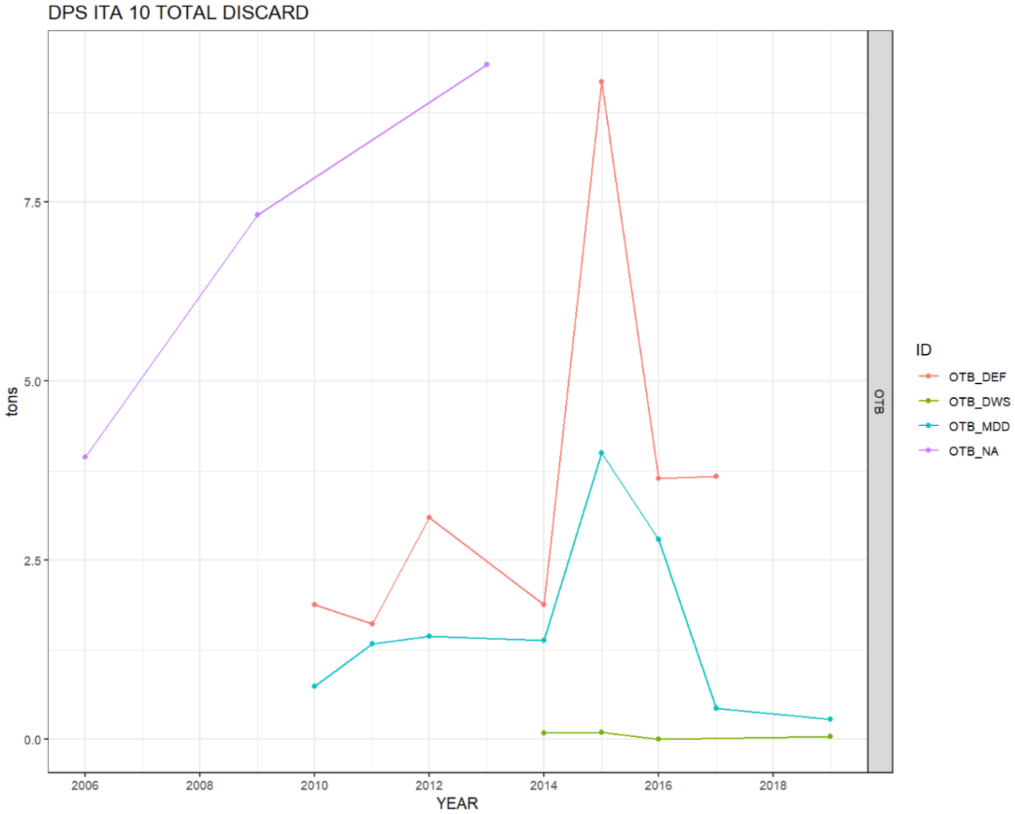


Figure 6.10.2.1.8 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA10.

Length frequency distributions (LFDs) and the relative impact of the metiers on the year total landings and discards are displayed in Figs. 6.10.2.1.9-18.

LFDs of landing and discard for GSA08 are not available.

In GSA09, demographic structure of the landing is available for OTB in 2003 and 2004 and by metier from 2005 to 2021 (OTB_DEF, OTB_DEMSP, OTB_DWS and OTB_MDD). For TBB_DEMSP, OTM_MPD, GTR_DEF and GNS_DEF, the LFDs were not available but the contribution of those metiers to the total landing of DPS in the area is negligible. LFDs not available were not reconstructed and a SOP correction to the total landing was performed.

In GSA10, the demographic structure of the landing is available for 2002 and for the period 2004-2019. Data by metier are available for the periods 2010-2012 and 2014-2021. Length frequency distributions for the other metiers are available for 2012 (GNS_DEF). LFDs not available were not reconstructed and a SOP correction to the total landing was performed.

In GSA11, length frequency distributions of landing are present in the DCR-DCF database for the period 2009-2020. LFDs have been reconstructed for OTB_DWS (years 2007 and 2019-2020), OTB_MDD (2004-2008), OTB_DEMSP (2004-2008) and OTB_DEF (2019-2020). For GTR_DEF, the LFDs were not reconstructed but the contribution of that metier to the total landing of DPS in the area is negligible.

Length frequency distributions of discard by metier in GSA09 are available from 2009.

Size structure of the discard in GSA10 is available for 2006 and for the period 2009-2019. LFDs not available were not reconstructed.

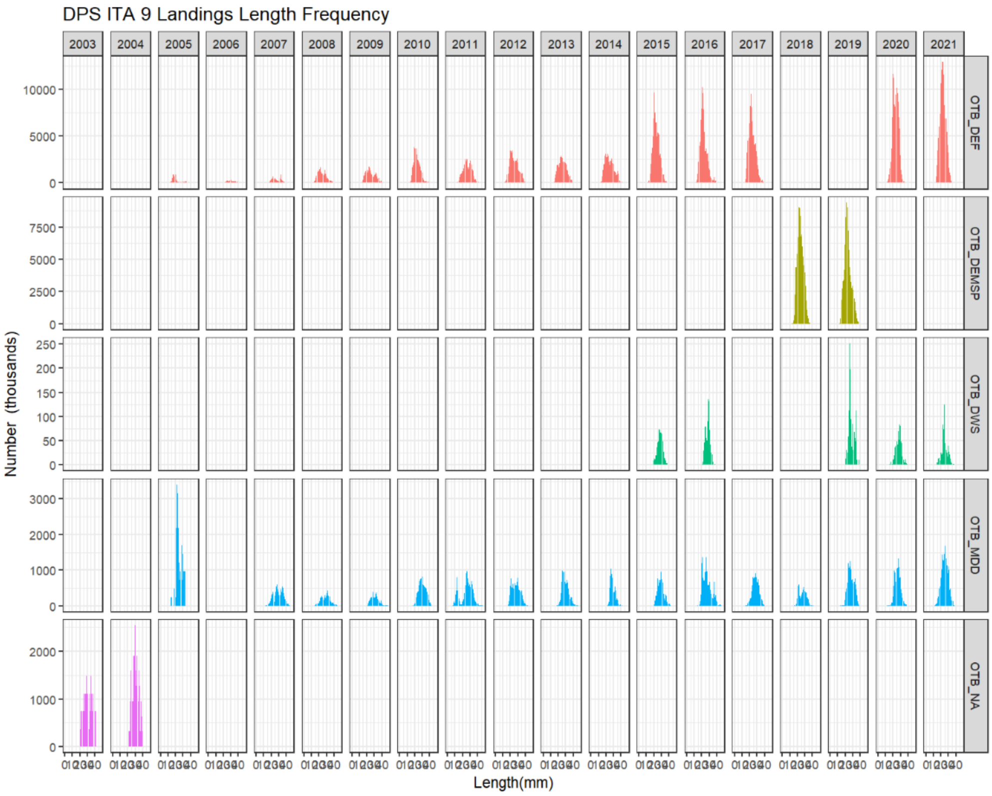


Figure 6.10.2.1.9 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Size frequency distributions of landing in GSA09.

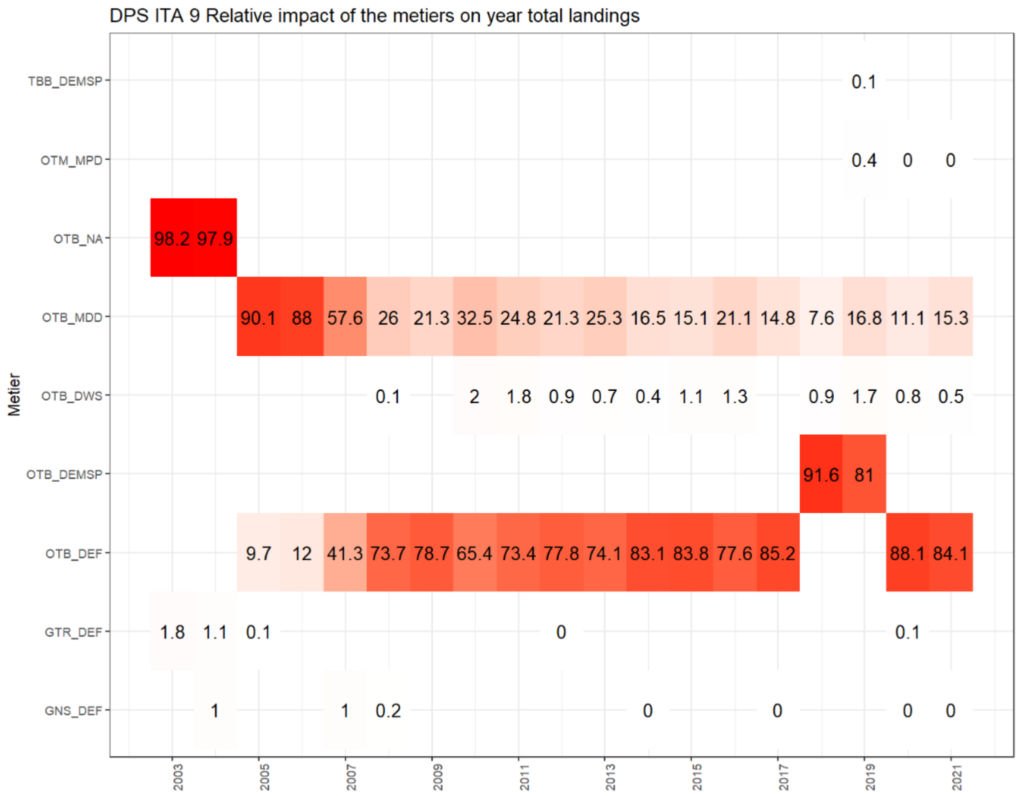


Figure 6.10.2.1.10 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Table summarising the relative impact of the metiers on the year total landings in GSA09.

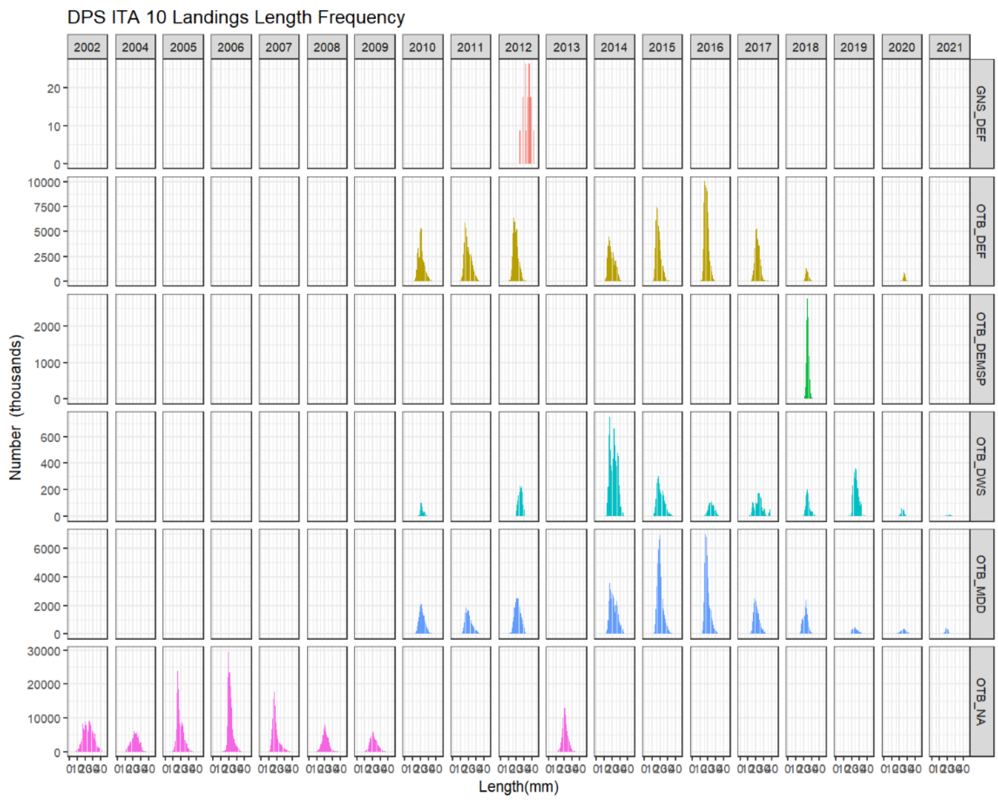


Figure 6.10.2.1.11 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Size frequency distributions of landing in GSA10.

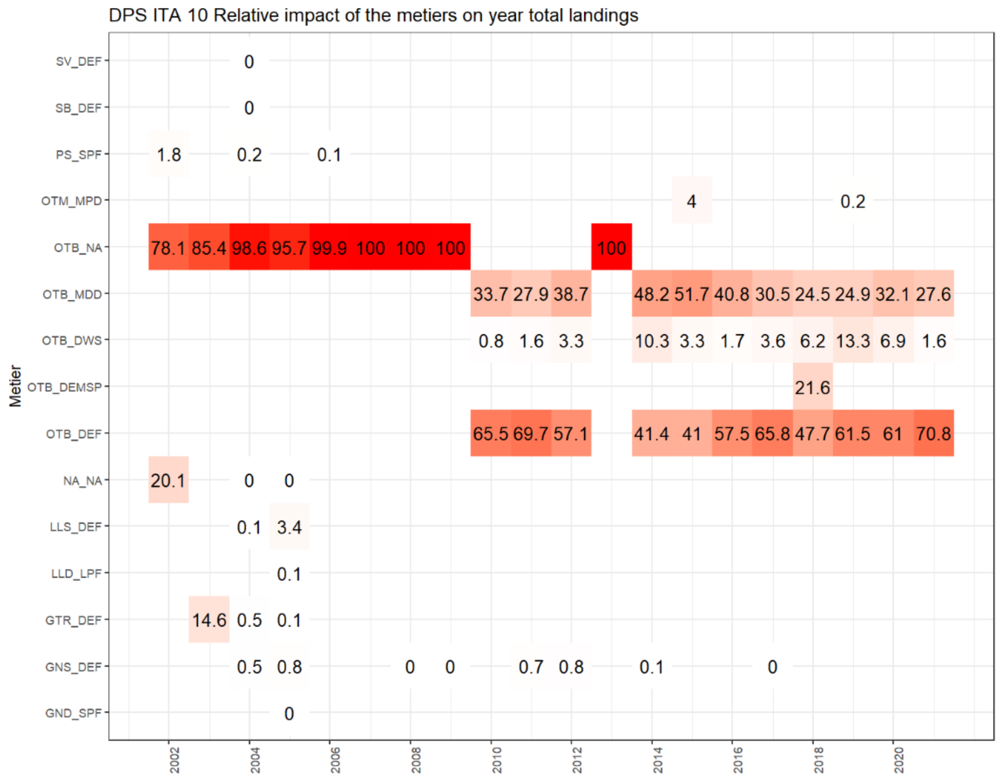


Figure 6.10.2.1.12 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Table summarising the relative impact of the metiers on the year total landings in GSA10.

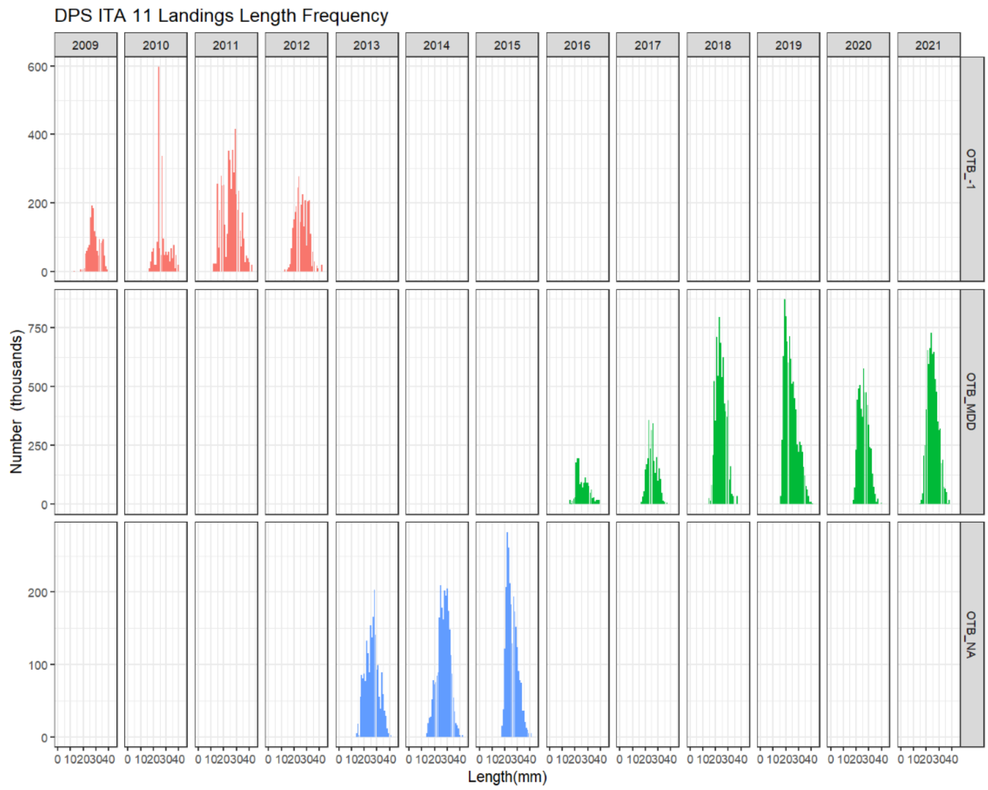


Figure 6.10.2.1.13 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Size frequency distributions of landing in GSA11.

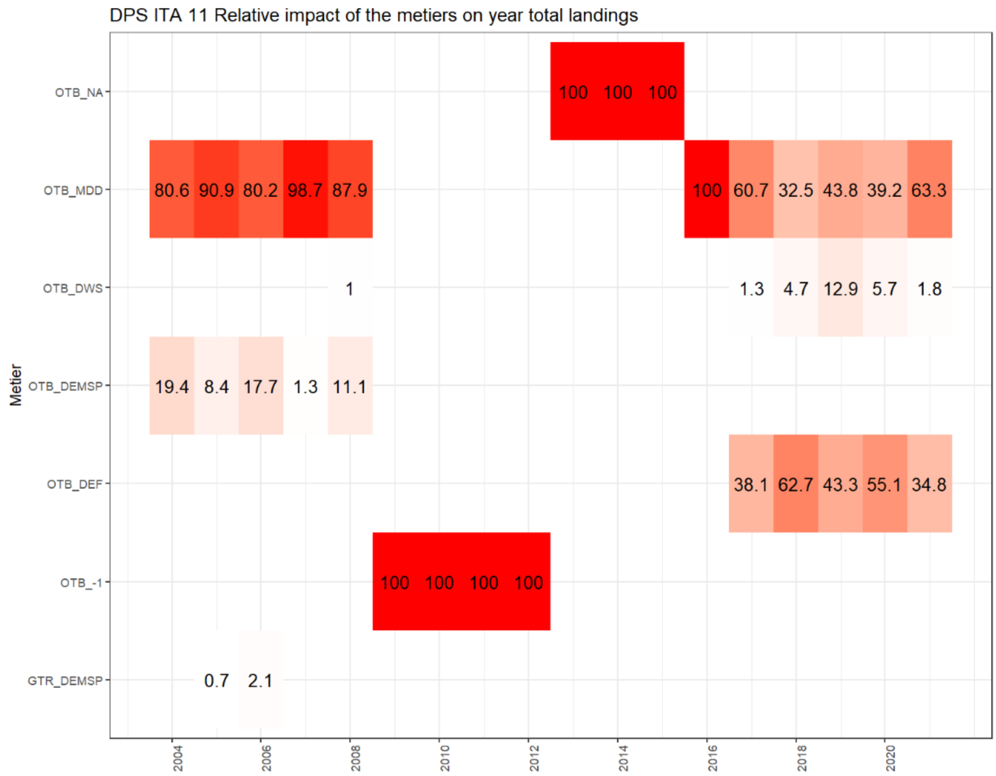


Figure 6.10.2.1.14 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Table summarising the relative impact of the metiers on the year total landings in GSA11.

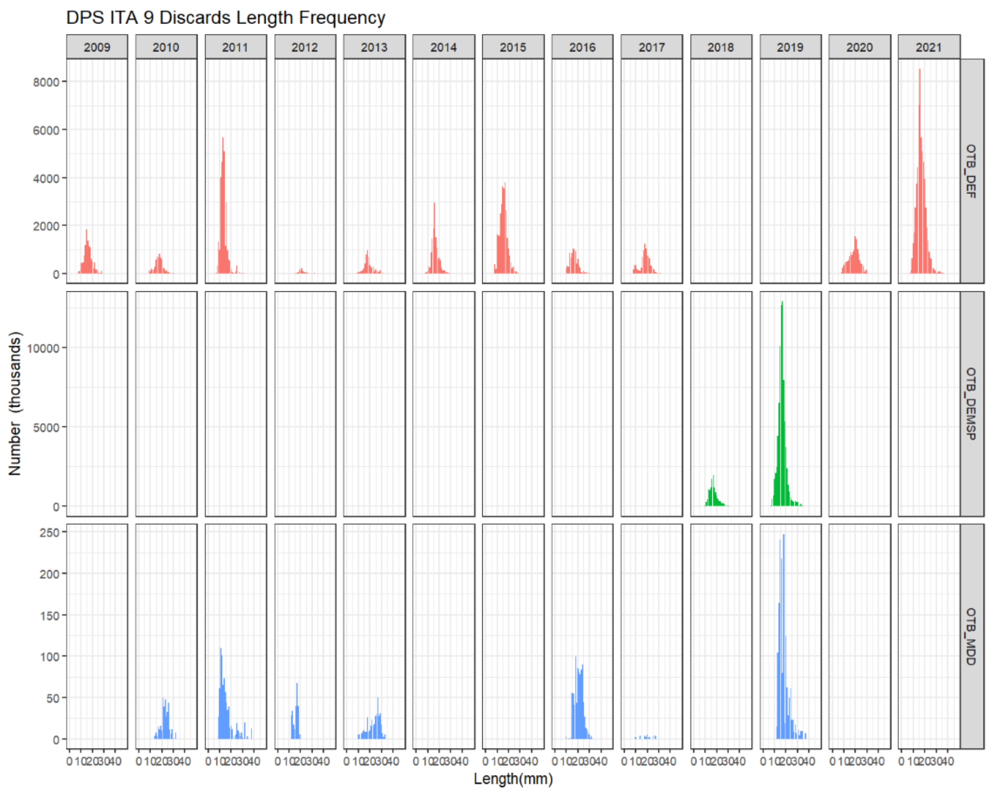


Figure 6.10.2.1.15 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Size frequency distributions of discard in GSA09.

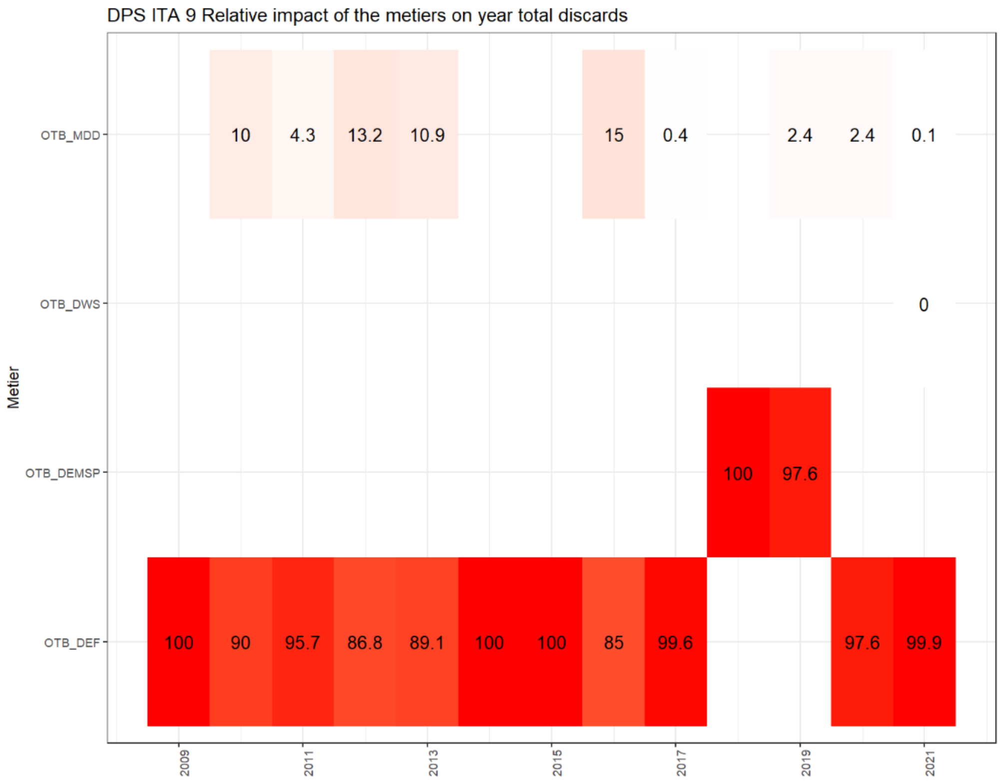


Figure 6.10.2.1.16 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Table summarising the relative impact of the metiers on the year total discards in GSA09.

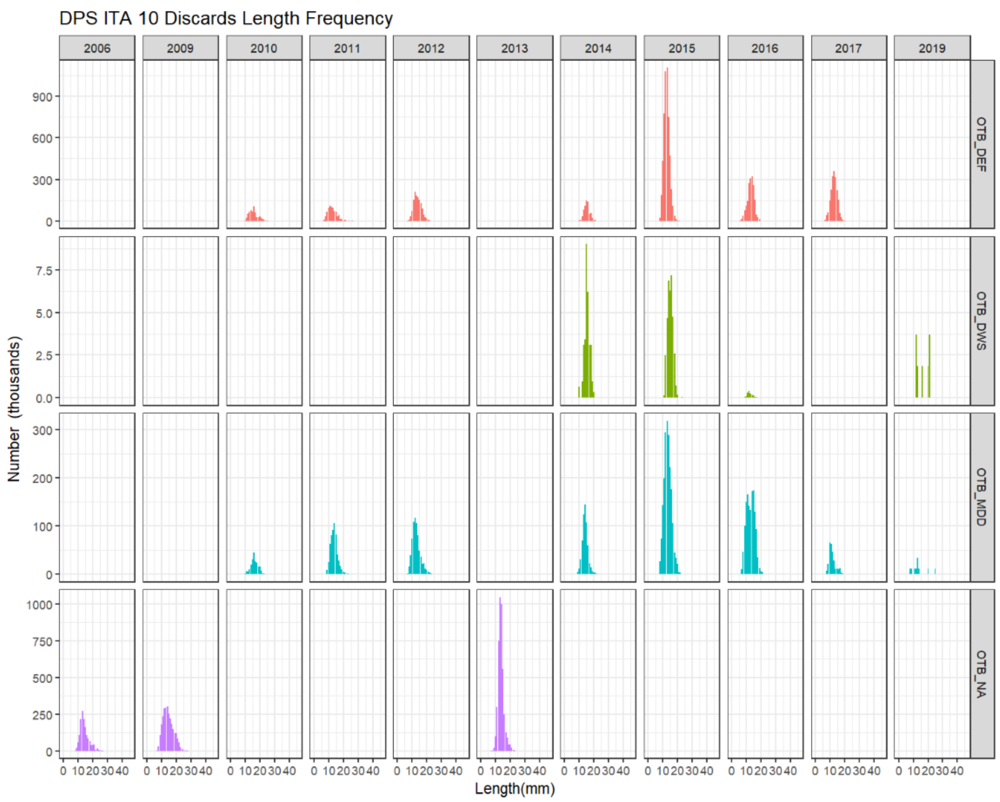


Figure 6.10.2.1.17 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Size frequency distributions of discard in GSA10.

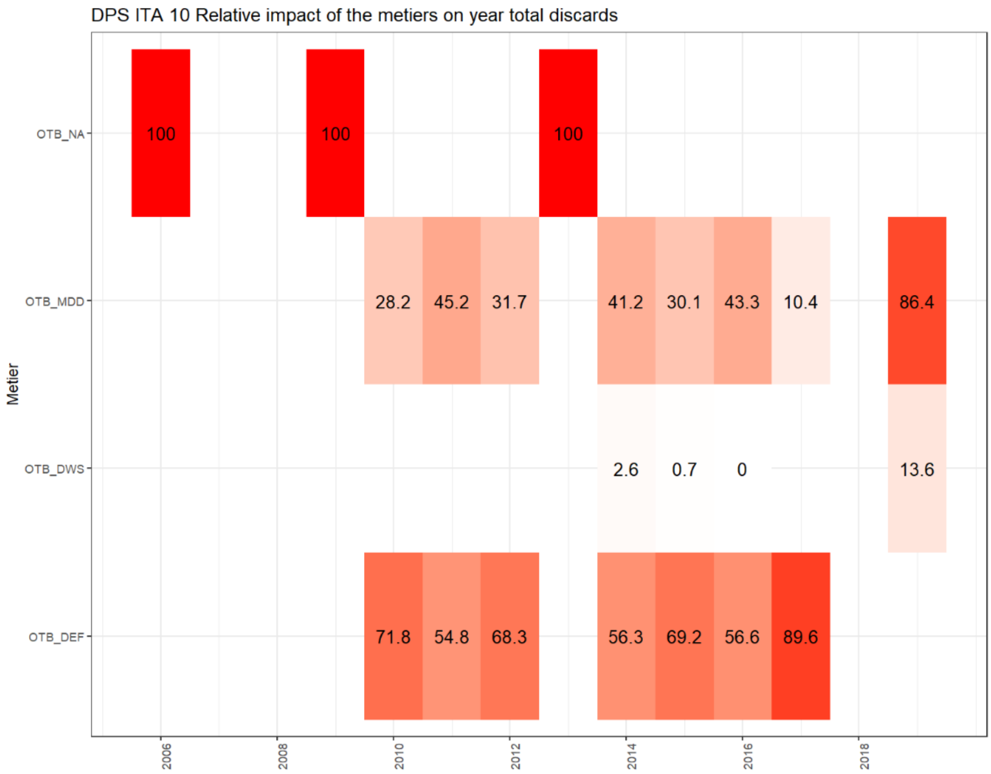


Figure 6.10.2.1.18 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Table summarising the relative impact of the metiers on the year total discards in GSA10.

6.10.2.2 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out each year, generally during the spring-summer season (Figure 6.10.2.2.1).

Figure 6.10.2.2.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Table summarising the period in which the surveys have been carried out.

In 2017, 2020 and 2021, the survey was carried out very late (autumn) in GSAs 9, 10 and 11 and about half hauls were performed in GSA10 in 2020. In 2020, the survey in GSA08 was not carried out.

Methods

Based on the DCF data, abundance and biomass indices for GSAs 08, 09, 10 and 11 combined were calculated. In Tabs. 6.10.2.2.1.1-4 the number of hauls was reported per depth stratum in each GSA.

Table 6.10.2.2.1.1 Number of hauls per year and depth stratum in GSA08, period 1994-2021.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
10-50	0	0	0	0	0	0	0	0		0	0	0	0
50-100	5	5	6	2	6	6	5	5		6	6	6	6
100-200	4	4	3	0	4	4	4	4		4	4	4	4
200-500	8	8	9	6	9	8	10	8		9	7	8	9
500-800	5	5	4	4	4	5	4	5		4	5	5	4
Total	22	22	22	12	23	23	23	22		23	22	23	23

STRATUM	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
10-50	0	0	0	0	0	0	0	0	0	0	0	0	0
50-100	5	7	5	6	6	6	6	6	7	6	6	6	6
100-200	3	4	4	3	4	4	4	4	3	4	4	4	4
200-500	7	10	10	10	9	10	10	10	11	9	11	11	11
500-800	5	4	3	3	4	3	3	3	2	3	2	2	2
Total	20	25	22	22	23	23	23	23	23	22	23	23	23

STRATUM	2020	2021
10-50		0
50-100		8
100-200		3
200-500		8
500-800		4
Total		23

Table 6.10.2.2.1.2 Number of hauls per year and depth stratum in GSA09, period 1994-2021.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
10-50	21	20	20	20	21	20	20	20	15	15	15	16	15
50-100	21	21	20	22	20	21	22	22	17	17	17	16	18
100-200	38	39	40	38	39	39	38	38	30	30	30	31	29
200-500	40	40	40	41	40	41	42	42	33	31	34	34	35
500-800	33	33	33	32	33	32	31	31	25	27	24	23	23
Total	153	153	153	153	153	153	153	153	120	120	120	120	120

STRATUM	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
10-50	15	16	16	15	15	15	16	15	14	14	14	15	15
50-100	18	16	16	19	18	17	17	19	19	18	20	18	18
100-200	29	31	31	29	30	31	30	29	30	31	29	30	30
200-500	35	34	34	34	33	35	35	36	35	36	36	36	38
500-800	23	23	23	23	24	22	22	21	22	21	21	21	19
Total	120	120	120	120	120	120	120	120	120	120	120	120	120

STRATUM	2020	2021
10-50	14	15
50-100	19	19
100-200	30	29
200-500	37	37
500-800	20	20
Total	120	120

Table 6.10.2.2.1.3 Number of hauls per year and depth stratum in GSA10, period 1994-2020.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
10-50	7	8	8	8	8	8	8	8	7	7	7	7	7
50-100	10	10	10	10	10	10	10	10	8	8	8	8	8
100-200	17	17	17	17	17	17	17	17	14	14	14	14	14
200-500	22	23	22	22	22	22	22	24	18	18	18	18	18
500-800	28	27	28	28	28	27	28	26	23	23	23	23	23
Total	84	85	85	85	85	84	85	85	70	70	70	70	70

STRATUM	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
10-50	7	7	7	7	7	7	7	7	7	7	7	7	6
50-100	8	8	8	8	8	8	7	8	8	8	8	8	8
100-200	14	14	14	14	14	14	14	14	14	14	14	14	15
200-500	18	19	18	18	18	18	18	18	18	18	18	18	20
500-800	23	22	23	23	23	23	23	23	23	23	23	23	21
Total	70	70	70	70	70	70	69	70	70	70	70	70	70

STRATUM	2020	2021
10-50	3	7
50-100	4	9
100-200	9	14
200-500	10	18
500-800	11	23
Total	37	71

Table 6.10.2.2.1.4 Number of hauls per year and depth stratum in GSA11, period 1994-2020.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
10-50	16	19	22	21	21	20	19	17	20	18	18	17	19
50-100	25	20	22	23	22	22	22	24	19	19	17	22	19
100-200	20	23	30	31	30	30	31	30	24	24	24	24	24
200-500	32	28	29	26	25	27	24	25	20	24	21	20	20
500-800	23	17	22	25	25	24	27	26	16	14	15	14	16
Total	116	107	125	126	123	123	123	122	99	99	95	97	98

STRATUM	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
10-50	20	19	18	20	20	20	20	21	18	18	21	19	21
50-100	19	18	20	18	19	19	19	19	19	19	19	18	18
100-200	24	21	24	24	24	24	24	24	24	24	24	24	24
200-500	20	21	19	20	21	21	21	21	21	21	21	21	21
500-800	17	16	16	17	17	17	17	17	17	17	17	17	17
Total	100	95	97	99	101	101	101	102	99	99	102	99	101

STRATUM	2020	2021
10-50	20	20
50-100	19	19
100-200	24	24
200-500	21	21
500-800	17	17
Total	101	101

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means. This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the assumptions over the distribution of data may give incorrect estimates of precision. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-Poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial. Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance*100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

6.10.2.2.3 Trends in abundance and biomass

The trends of the MEDITS indices (density and biomass) for the three GSAs combined are displayed in Figure 6.10.2.2.3.1. Both indices showed an evident increasing trend with very high values in the periods 2010-2013 and 2015-2020. In 2021, a decreasing was observed both for density and biomass.

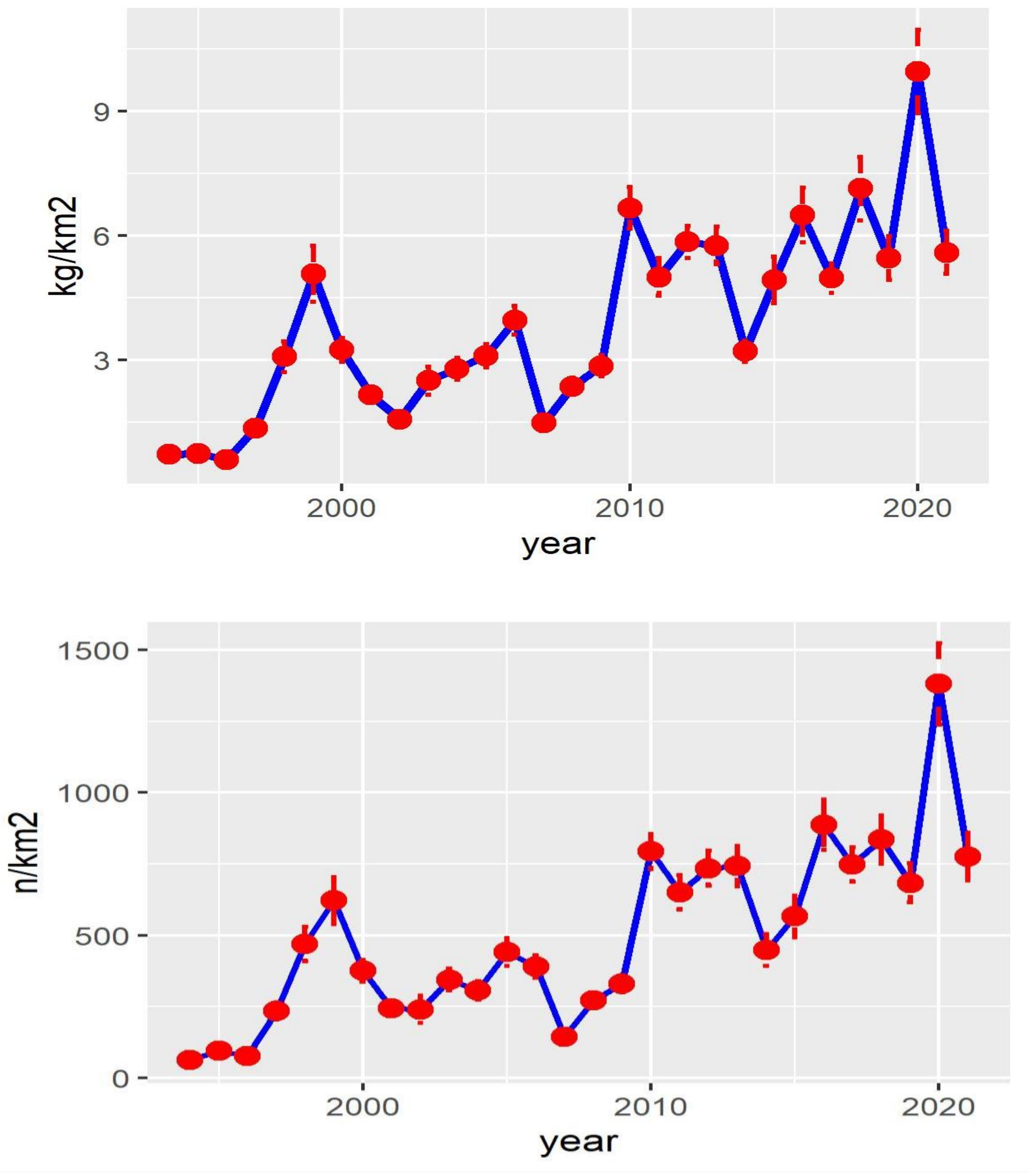


Figure 6.10.2.2.3.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. MEDITS standardized abundance and biomass indices (10-800 m).

Trends in abundance and biomass by length

Figs. 6.10.2.2.4.1-3 display the stratified abundance indices by length for the three GSAs combined during the MEDITS surveys from 1994 to 2021.

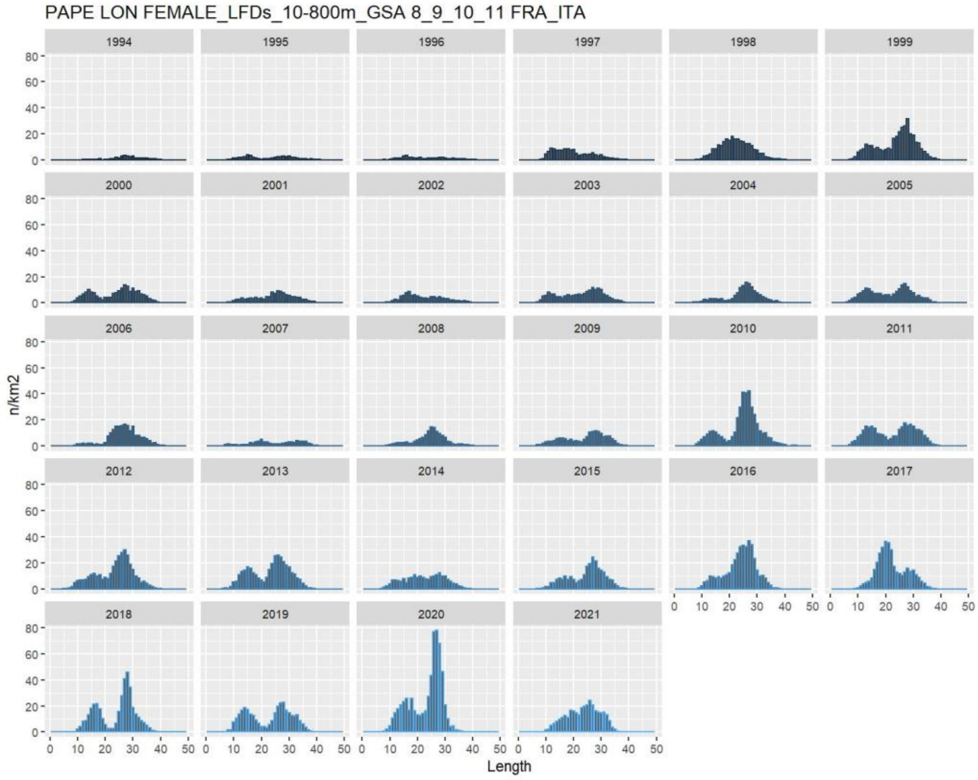


Figure 6.10.2.2.4.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Stratified abundance indices by size for females, period 1994-2021.

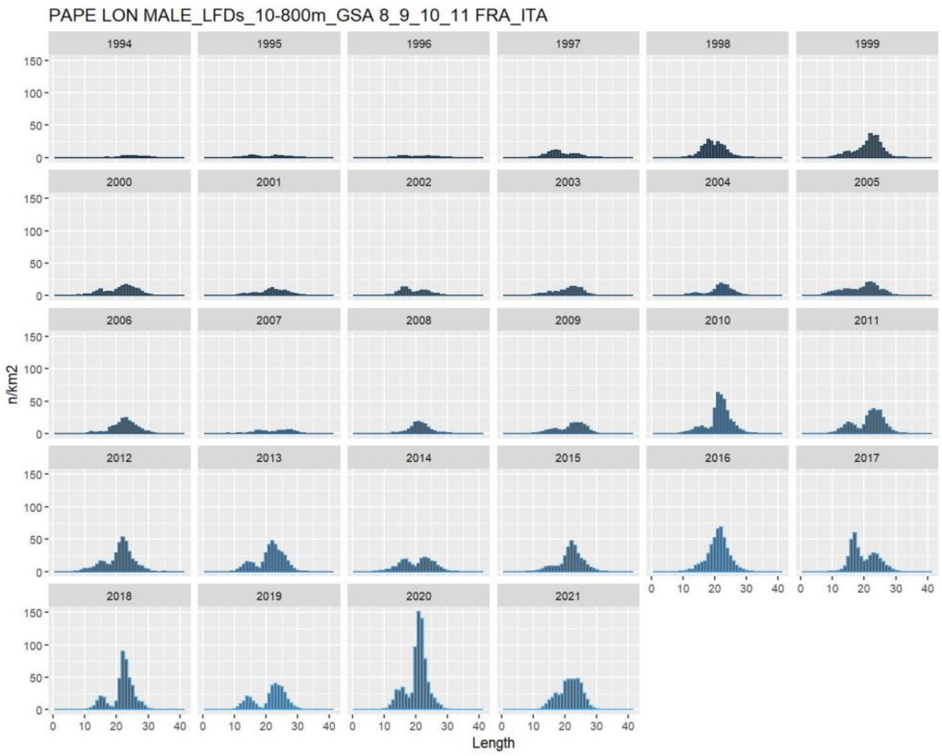


Figure 6.10.2.2.4.2 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Stratified abundance indices by size for males, period 1994-2021.

Figure 6.10.2.2.4.3 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Stratified abundance indices by size for the total population, period 1994-2021.

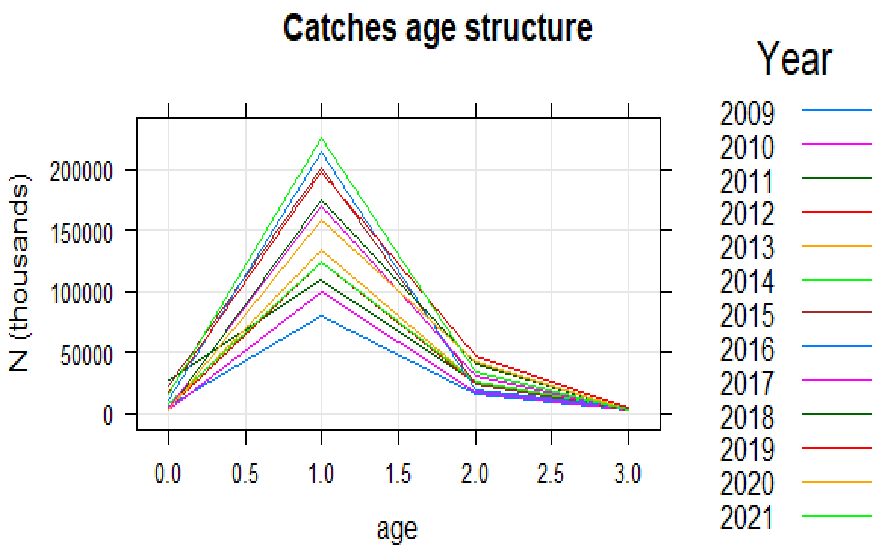
6.10.3 STOCK ASSESSMENT

A Statistical Catch-at-age (a4a) assessment was carried out during STECF EWG 22-09 using catch data collected under DCR-DCF from 2009 to 2021 and calibrated with survey data (MEDITS 2009-2021). FLR libraries were employed in order to perform the analyses.

A natural mortality vector computed using Chen and Watanabe model was used in the assessment. Length-frequency distributions of commercial catches (landing + discard) and surveys were split by sex (vectors from DCR-DCF database) and then transformed in age classes using length-to-age slicing with different growth parameters by sex. For the transformation of the frequency distributions into age classes, t_0 growth parameter has been added 0.5 because the peak of reproduction for this species mainly occurs in summer. Plus group was set at age 3 for commercial data. The number of individuals by age was SOP corrected [SOP = Landings / Σa (total catch numbers at age a x catch weight-at-age a)]. The correction factor resulted low except in very few cases. MEDITS data from the three GSAs for the period 2009-2021 were used for tuning.

Discards were included in the analysis with the exception of GSAs 08 and 11 for which data is not available. This information was not available in some years also for GSA 10 but LFDs were not reconstructed as discard of DPS is quite low in the area.

Given that the catches were composed mainly of individuals between 1 and 2 years, these ages were selected as the F_{bar}.



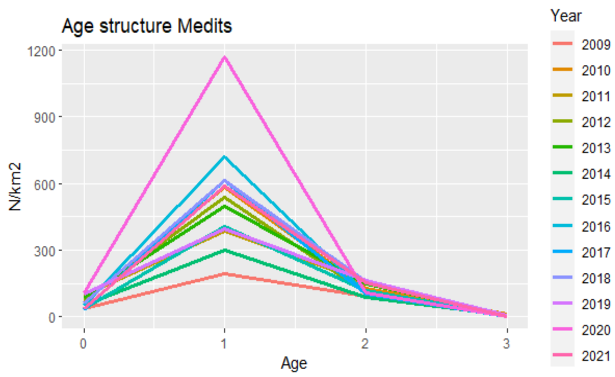


Figure 6.10.3.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Age frequency distributions of the total commercial catches (above) and of the Medits catches (below) by year.

Table 6.10.3.1 Deep-water rose shrimp in GSAs 08, 09, 10 and 11. Input parameters for a4a.

Catch at age (thousands)	Age 0	Age 1	Age 2	Age 3+
2009	6842.9	79425.6	16321.4	2696.2
2010	2531.2	100574.4	17967.9	3440.1
2011	27388	109166.6	25373.6	4442.4
2012	4272.5	124022.3	24588.0	4618.2
2013	4532.8	134143.8	26430.6	4399.7
2014	7742.0	124762.7	25846.9	3980.8
2015	22229.8	202014.2	25055.6	2962.8
2016	11689.0	214345.3	19659.1	4759.7
2017	4442.5	169793.8	30366.8	3465.6
2018	2951.0	175235.6	41495.2	3396.5
2019	17852.4	198523.3	46752.6	4612.1
2020	3654.8	158424.5	43007.6	2724.6
2021	16052.7	226562.3	34587.0	2959.3

	Catches (in tons)
2009	749.6
2010	899.5
2011	1080.8
2012	1132.2
2013	1239.6
2014	1151.5
2015	1487.2
2016	1444.9
2017	1476.6
2018	1724.8
2019	2035.3
2020	1644.2
2021	1818.0

Mean weight at age (Catches)	Age 0	Age 1	Age 2	Age 3+
2009	0.002	0.006	0.013	0.019
2010	0.002	0.006	0.012	0.020
2011	0.002	0.006	0.013	0.018
2012	0.002	0.006	0.013	0.019
2013	0.002	0.006	0.013	0.018
2014	0.002	0.006	0.013	0.018
2015	0.002	0.005	0.012	0.016
2016	0.002	0.005	0.012	0.020
2017	0.002	0.006	0.012	0.016
2018	0.002	0.007	0.011	0.014
2019	0.002	0.007	0.013	0.016
2020	0.002	0.007	0.011	0.014
2021	0.002	0.006	0.012	0.013

Mean weight at age (Stock)	Age 0	Age 1	Age 2	Age 3+
2009	0.002	0.006	0.013	0.019
2010	0.002	0.006	0.012	0.020
2011	0.002	0.006	0.013	0.018
2012	0.002	0.006	0.013	0.019
2013	0.002	0.006	0.013	0.018
2014	0.002	0.006	0.013	0.018
2015	0.002	0.005	0.012	0.016
2016	0.002	0.005	0.012	0.020
2017	0.002	0.006	0.012	0.016
2018	0.002	0.007	0.011	0.014
2019	0.002	0.007	0.013	0.016
2020	0.002	0.007	0.011	0.014
2021	0.002	0.006	0.012	0.013

Natural mortality	Age 0	Age 1	Age 2	Age 3+
2009	2.01	1.13	0.94	0.91
2010	2.01	1.13	0.94	0.91
2011	2.01	1.13	0.94	0.91
2012	2.01	1.13	0.94	0.91
2013	2.01	1.13	0.94	0.91
2014	2.01	1.13	0.94	0.91
2015	2.01	1.13	0.94	0.91
2016	2.01	1.13	0.94	0.91
2017	2.01	1.13	0.94	0.91
2018	2.01	1.13	0.94	0.91
2019	2.01	1.13	0.94	0.91
2020	2.01	1.13	0.94	0.91
2021	2.01	1.13	0.94	0.91

Proportion of mature	Age 0	Age 1	Age 2	Age 3+
2009	0.0	0.7	1	1
2010	0.0	0.7	1	1
2011	0.0	0.7	1	1
2012	0.0	0.7	1	1
2013	0.0	0.7	1	1
2014	0.0	0.7	1	1
2015	0.0	0.7	1	1
2016	0.0	0.7	1	1
2017	0.0	0.7	1	1
2018	0.0	0.7	1	1
2019	0.0	0.7	1	1
2020	0.0	0.7	1	1
2021	0.0	0.7	1	1

Tuning MEDITS index	Age 0	Age 1	Age 2	Age 3+
2009	38.6	192.8	92.2	4.4
2010	69.9	583.9	126.1	13.6
2011	98.0	383.7	158.6	8.8
2012	78.5	537.3	109.3	8.9
2013	89.7	498.6	148.0	6.0
2014	53.0	301.1	87.6	6.0
2015	36.9	404.5	116.1	6.5
2016	51.9	720.2	110.0	4.2
2017	29.4	612.6	102.9	3.0
2018	60.3	612.4	155.7	6.9
2019	104.6	394.4	163.8	7.4
2020	106.1	1166.9	106.0	2.4
2021	36.4	586.5	150.5	2.8

The assessment was performed by sex combined. The model settings that minimized the residuals and showed the best diagnostics outputs were used for the final assessment, and are the following:

Fishing mortality sub-model:

fmodel <- ~ factor(replace(age, age>2,2))+s(year, k=5)

Catchability sub-model:

qmodel <- list(~ factor(age))

Recruitment sub-model:

srmodel <- ~ geomean (CV=0.25)

Model <- a4aSCA(stock = stk, indices = idx, fmodel, qmodel, srmodel)

The results are shown in Figs. 6.10.3.2-12 and Tabs. 6.10.3.2-4.

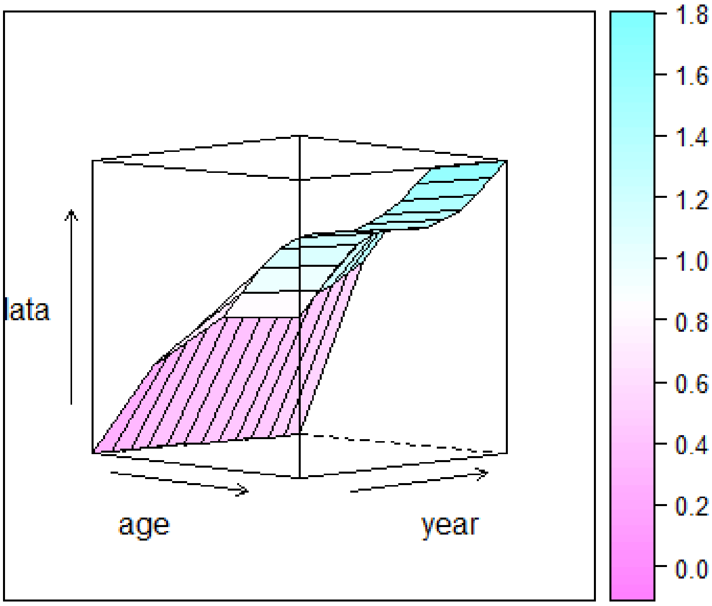


Figure 6.10.3.2 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Fishing mortality by age and year obtained from the a4a model (2009-2021).

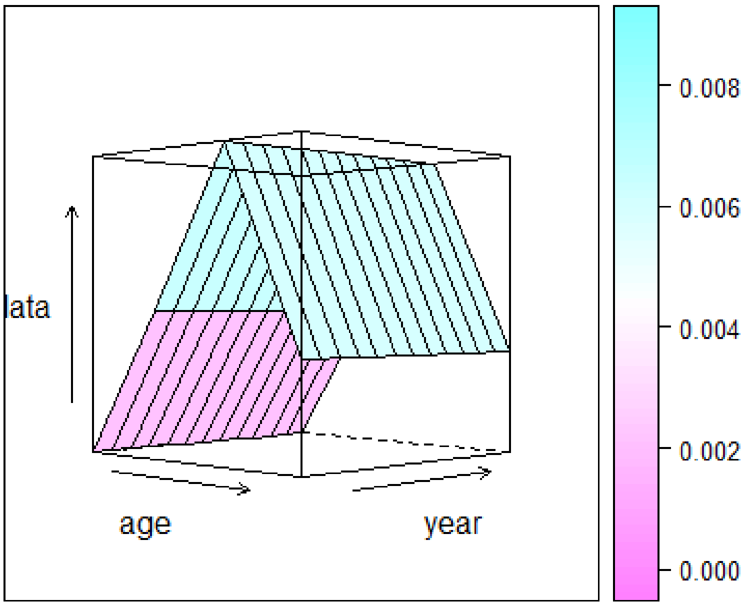


Figure 6.10.3.3 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Catchability by age and year obtained from the a4a model (2009-2021).

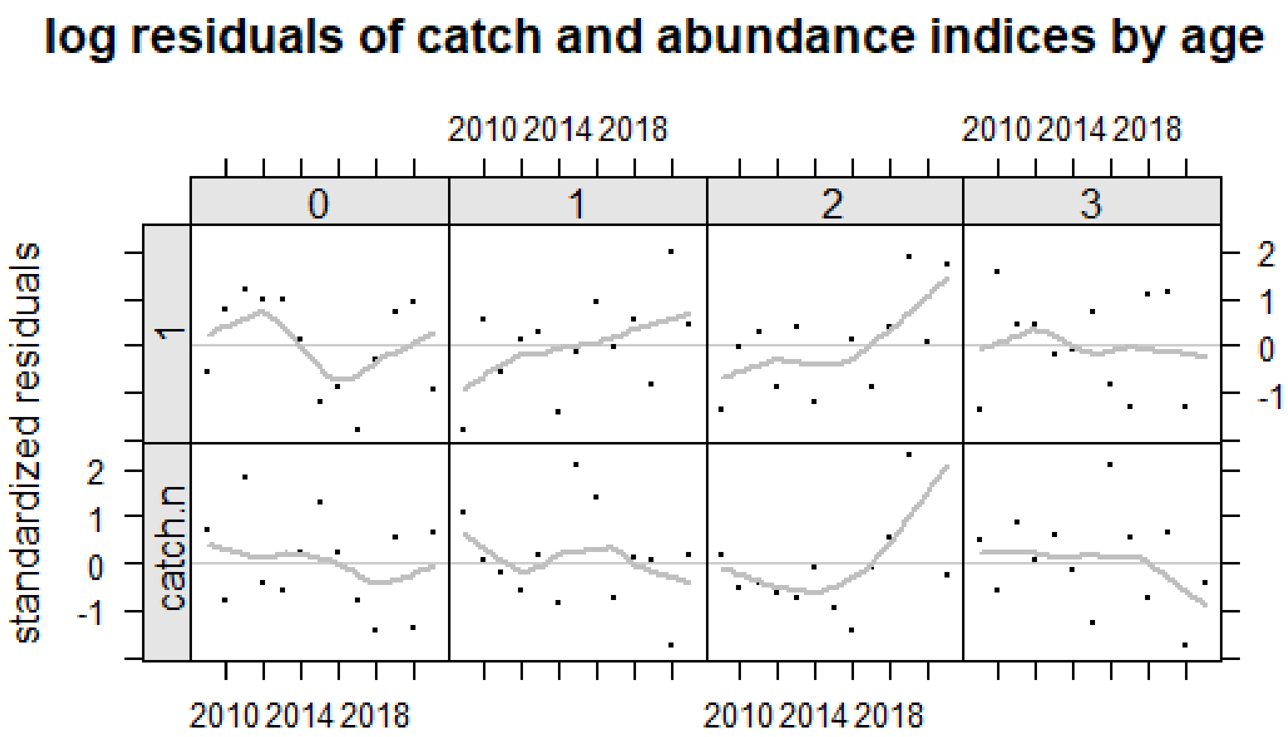


Figure 6.10.3.4 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Log residuals of the fishery and the survey data by age, and of the total catches.

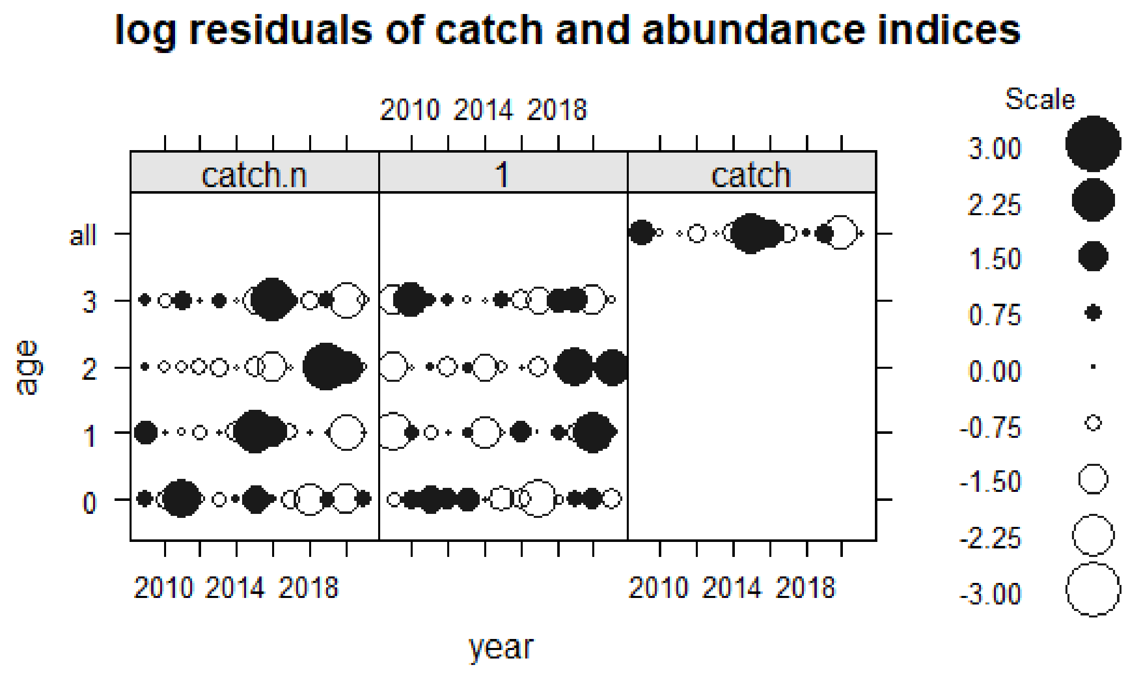


Figure 6.10.3.5 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Bubble plot of the log residuals of the fishery and the survey data by age, and of the total catches.

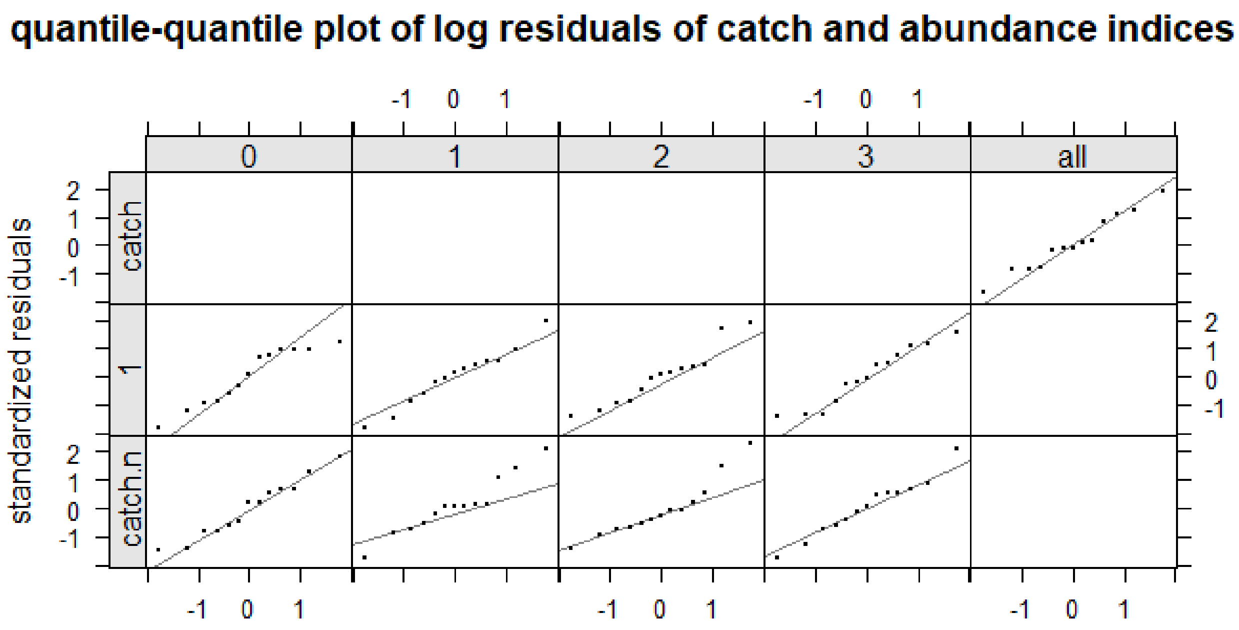


Figure 6.10.3.6 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. QQ-plot of the log residuals of the fishery and the survey data by age, and of the total catches.

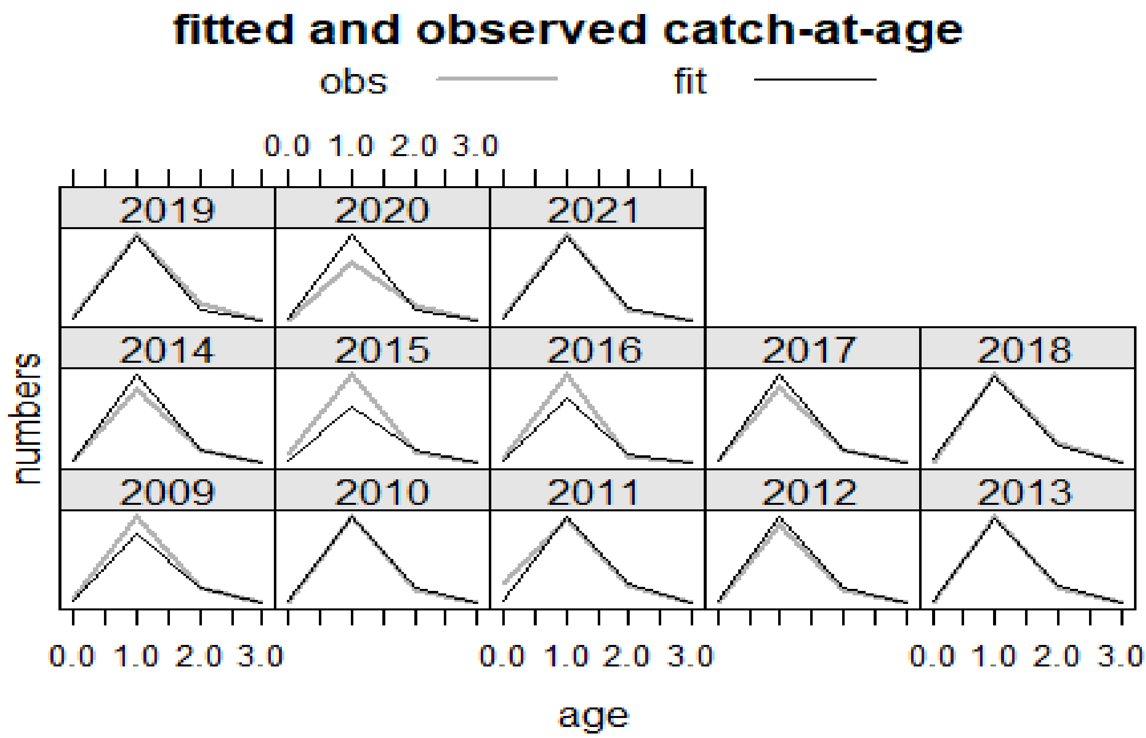


Figure 6.10.3.7 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Fitted and observed catches at age by year.

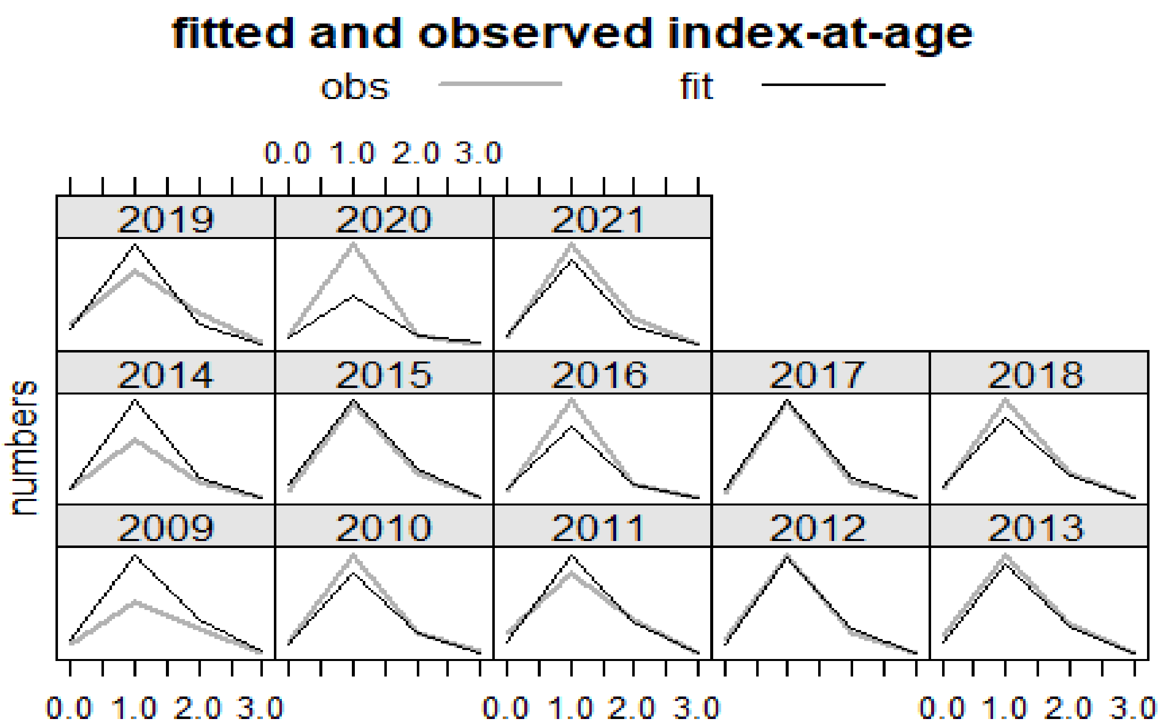


Figure 6.10.3.8 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Fitted and observed MEDITS index at age by year.

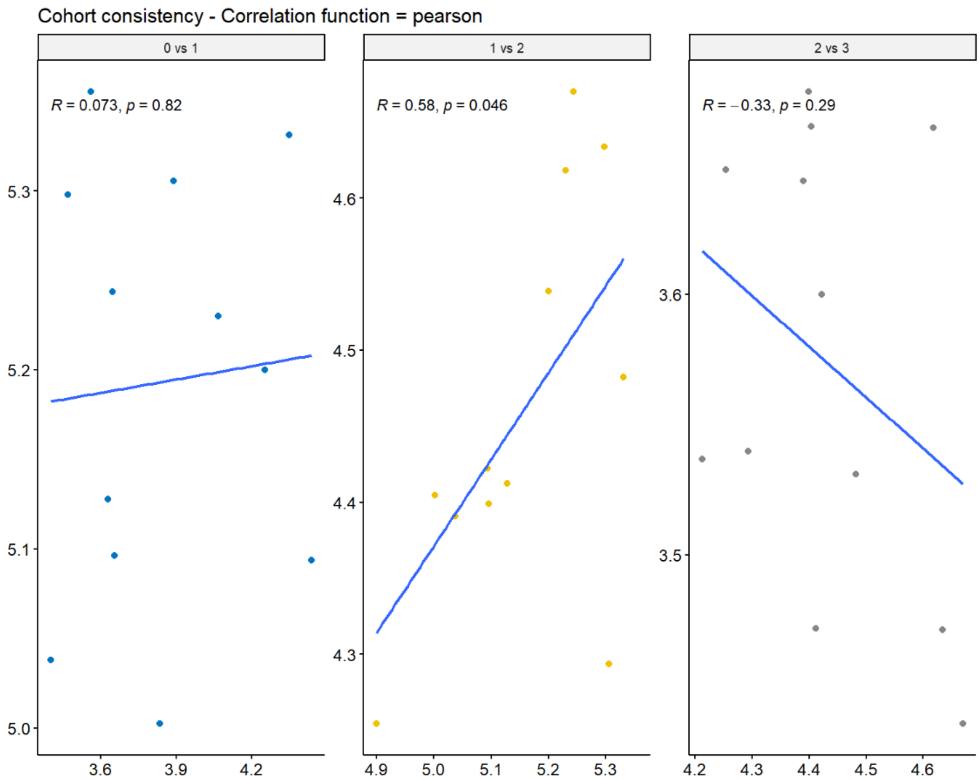


Figure 6.10.3.9 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Internal consistency of the catch at age data.

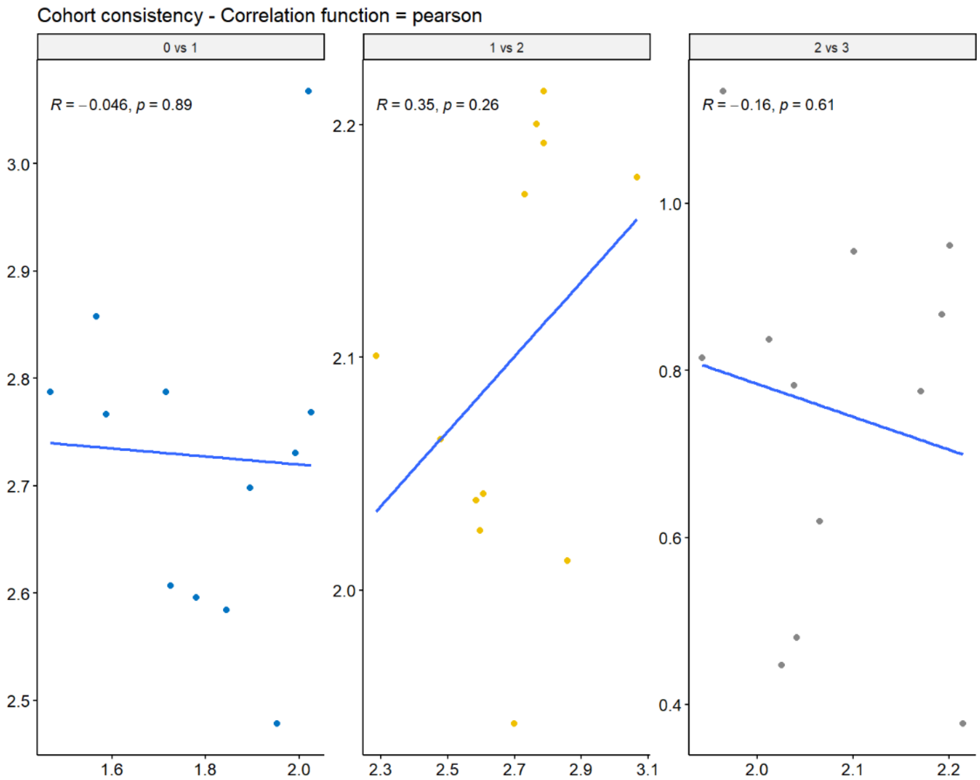


Figure 6.10.3.10 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Internal consistency of the MEDITS index at age data.

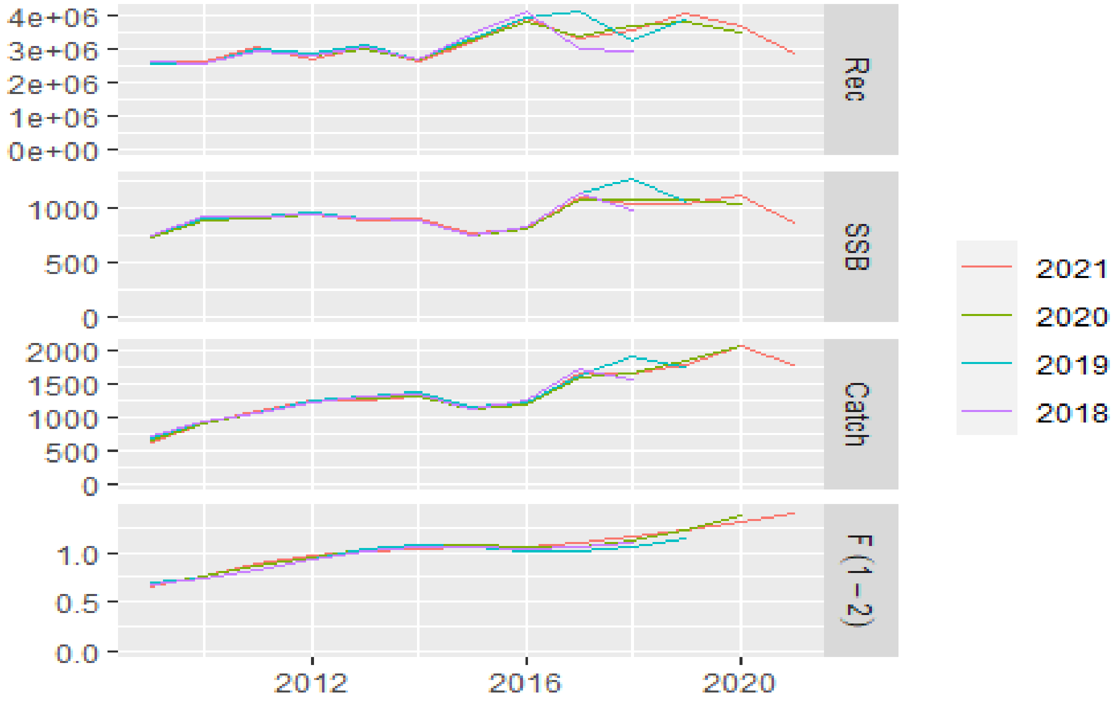


Figure 6.10.3.11 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Retrospective analysis.

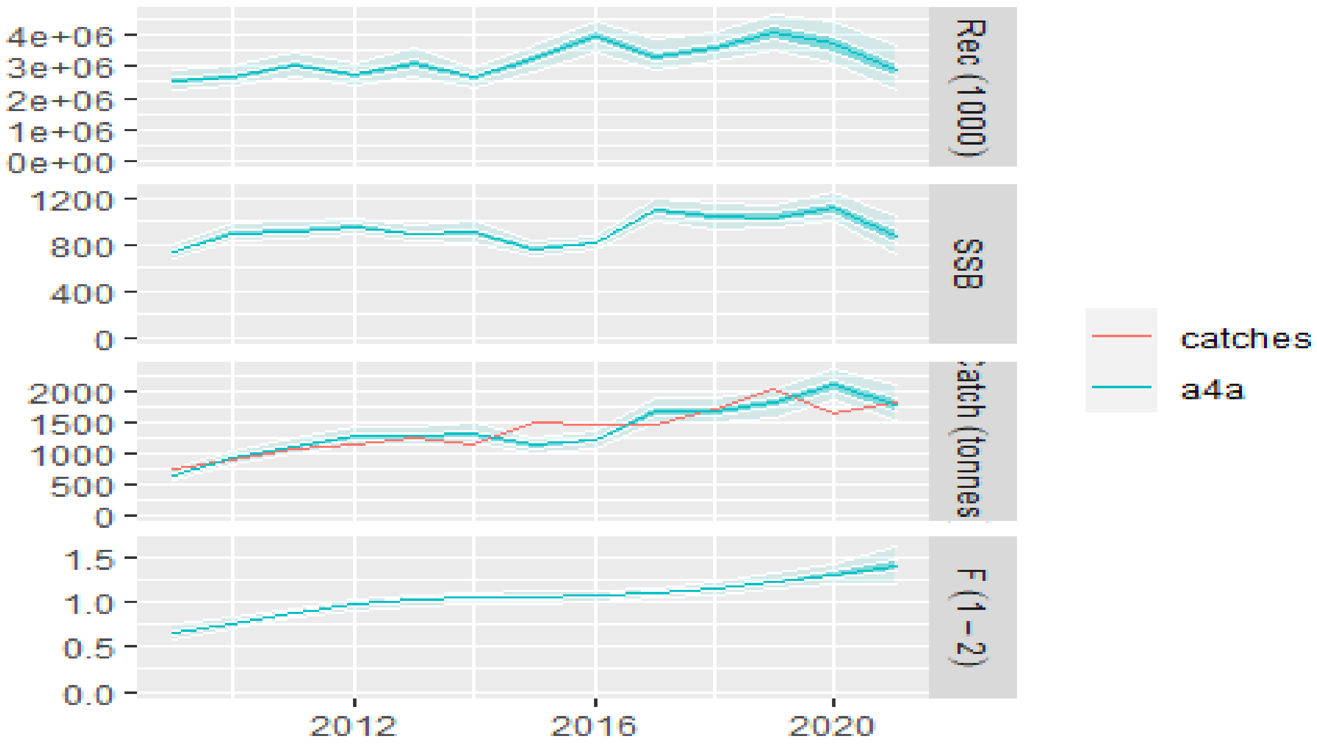


Figure 6.10.3.12 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Outputs of the a4a stock assessment model with uncertainty. Green line represents the catches observed.

Table 6.10.3.2 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Outputs of the a4a stock assessment model - Stock number at age (thousands).

Stock number at age (thousands)	Age 0	Age 1	Age 2	Age 3+
2009	2561090.2	246037.5	42135.5	6705.8
2010	2658727.8	341940.3	47004.7	8712.4
2011	3039276.1	354763.3	59779.8	8705.2
2012	2717566.8	405296.7	56762.2	9359.8
2013	3098078.5	362224.4	60404.5	8127.5
2014	2644347.8	412821.9	51746.1	7899.6
2015	3210664.0	352321.4	57970.2	6703.2
2016	3944704.3	427757.0	49159.0	7192.6
2017	3296742.6	525513.6	59007.3	6165.2
2018	3586504.5	439112.6	70592.5	6844.9
2019	4054450.4	477563.1	56426.6	7607.9
2020	3699621.2	539659.1	57854.9	5764.0
2021	2863839.9	492203.3	61080.3	5166.8

Table 6.10.3.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment – Fishing mortality at age.

Fishing mortality at age	Age 0	Age 1	Age 2	Age 3+
2009	0.004	0.525	0.788	0.788
2010	0.004	0.614	0.921	0.921
2011	0.005	0.703	1.054	1.054
2012	0.005	0.774	1.161	1.161
2013	0.006	0.816	1.224	1.224
2014	0.006	0.833	1.250	1.250
2015	0.006	0.839	1.259	1.259
2016	0.006	0.851	1.277	1.277
2017	0.006	0.877	1.316	1.316
2018	0.006	0.922	1.383	1.383
2019	0.007	0.981	1.471	1.471
2020	0.007	1.049	1.573	1.573
2021	0.008	1.122	1.683	1.683

Table 6.10.3.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment.

	$F_{bar\ 1\text{-}2}$	Recruitment (thousands	SSB (t)	Total Biomass (t)
2009	0.657	2561090.2	733.5	7315.6
2010	0.768	2658727.8	899.1	8455.5
2011	0.878	3039276.1	916.8	7735.2
2012	0.967	2717566.8	953.8	8640.0
2013	1.020	3098078.5	893.0	9213.5
2014	1.041	2644347.8	905.6	8689.2
2015	1.049	3210664.0	764.6	9270.7
2016	1.064	3944704.3	807.3	11301.4
2017	1.097	3296742.6	1094.5	11097.1
2018	1.152	3586504.5	1037.0	11594.9
2019	1.226	4054450.4	1032.3	12970.3
2020	1.311	3699621.2	1113.1	12021.7
2021	1.403	2863839.9	871.5	9976.1

Based on a4a results, the Deep-water rose shrimp SSB showed an increasing trend, reaching the maximum value in 2020 (1113 tons) and a decreasing in the last year (871 tons). The recruitment (age 0) showed a similar trend of SSB, with a maximum value of 4,054,450 thousands individuals in 2019 and a decreasing in the last two years. The lowest value of fishing mortality (Fbar = 0.66) is observed at the beginning of the time series. After that, a constant increase of F was showed, reaching a peak of 1.40 in 2021.

6.10.4 Reference Points

The STECF EWG 22-09 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

The yield per recruit (YpR) analysis was performed to estimate $F_{0.1}$, chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields. YpR output curve is illustrated in Figure 6.10.4.1.

Current F (1.40), estimated as the $F_{bar1\text{-}2}$ in the last year of the time series (2021), is higher than $F_{0.1}$ (1.26), which indicates that Deep-water rose shrimp stock in GSAs 08, 09, 10 and 11 is in overexploitation.

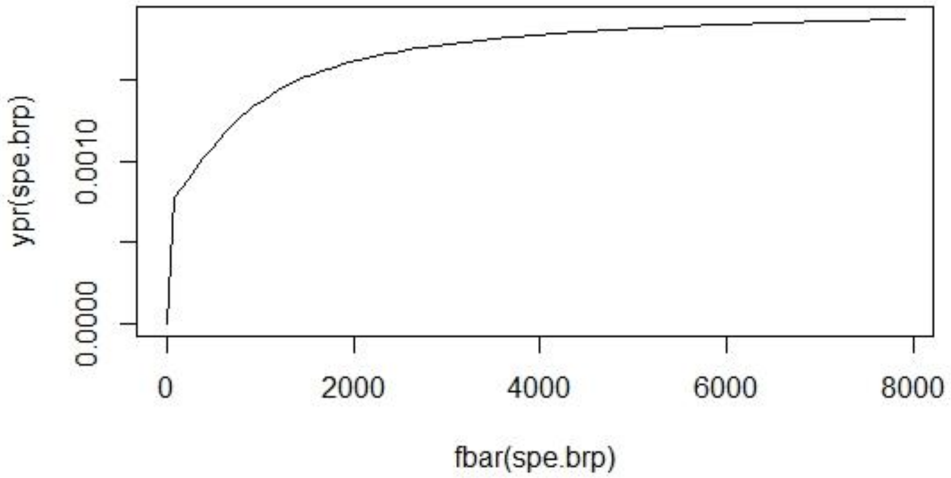


Figure 6.10.4.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Yield per Recruit curve.

Estimation of biomass reference points

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4.

An exploratory per-recruit analysis was performed using the stock object containing the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.10.4.1 and Figure 6.10.4.1.

Table 6.10.4.1 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Per-recruit reference points.

$F_{0.1}$	B_{trg}	B_{lim}	F_{lim}	Yeq	B_0
1.26	0.000272	0.0000709	3.99	0.00131	0.000922

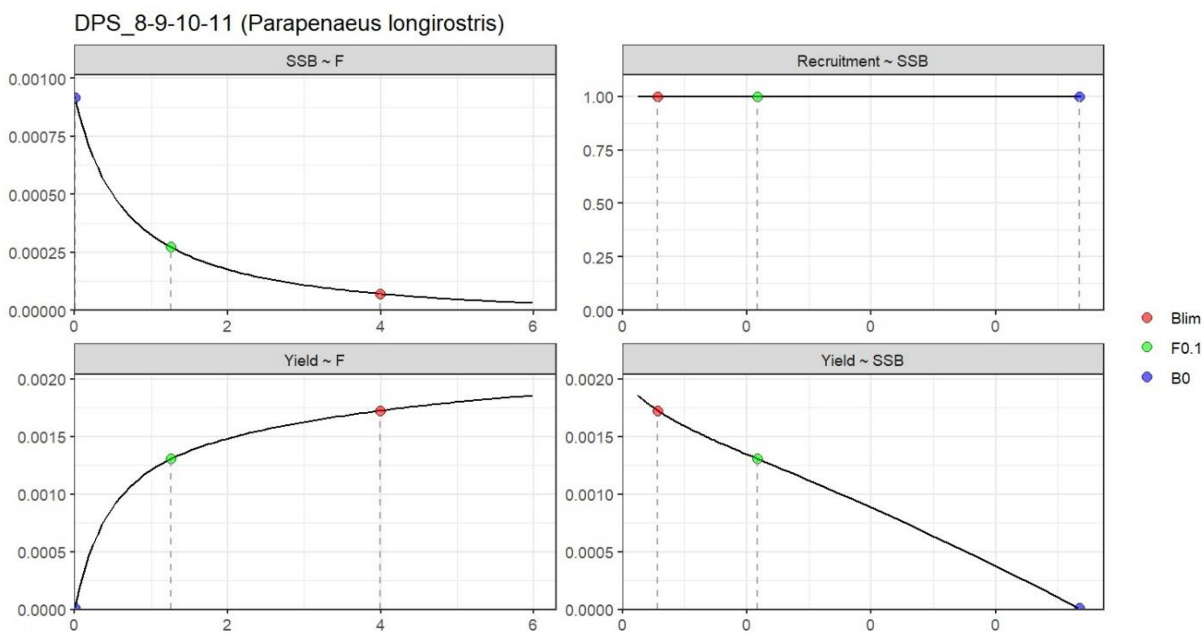


Figure 6.10.4.1 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Per-recruit analysis.

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)

2. Hockey-Stick (model=segreg)

3. Beverton-Holt (model=bevholtSV)

4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ration potential SRPlim = SPRlim/SPR_0. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP0.1−20 by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y.

The observed SR data are sitting on the right part of the R-SSB plot, and the breakpoint estimated by the HS model is lower that the observed values.

The results show that the recruitment variation is fairly low, e.g. σr = 0.13 for the Beverton-Holt model, associated with a steepness of s = 0.60. The predicted recruitment by Hockey-Stick, Beverton-Holt and Ricker models follow the observed recruitment pattern over time, however, the three models differ largely in scale of their R_0 and B_0 estimates. Information on the slope to the origin is not found within the observed SSB Recruitment results from the assessment.

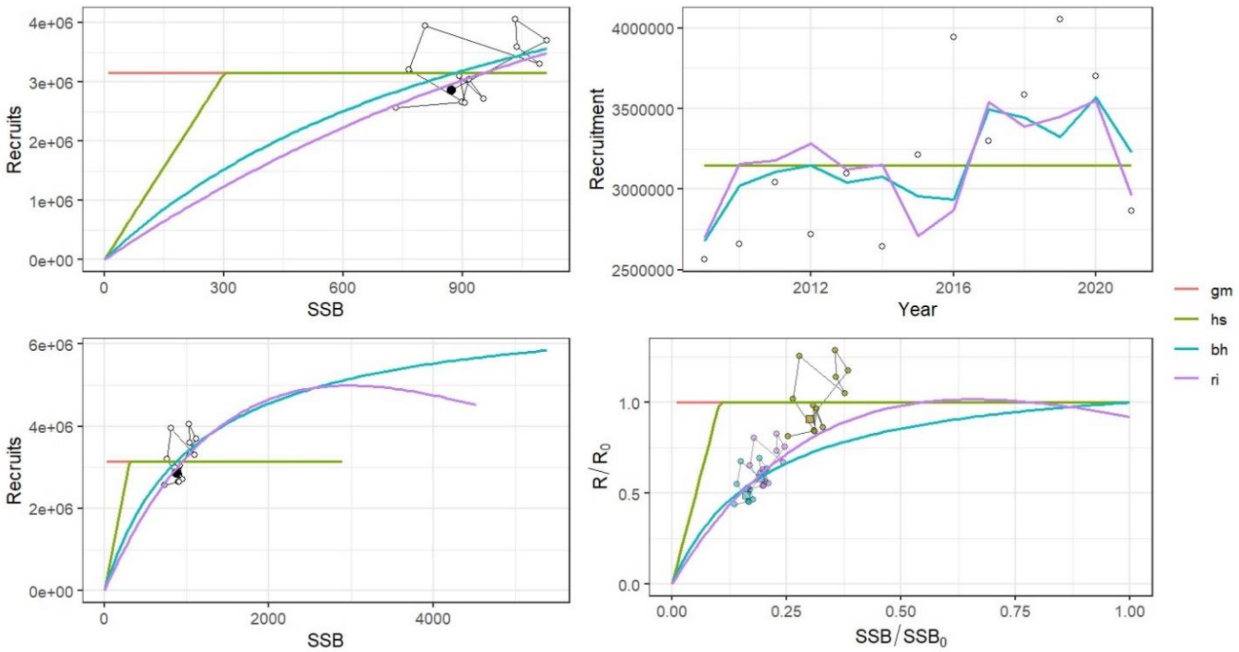


Figure 6.10.4.2 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Summary of the four SR models.

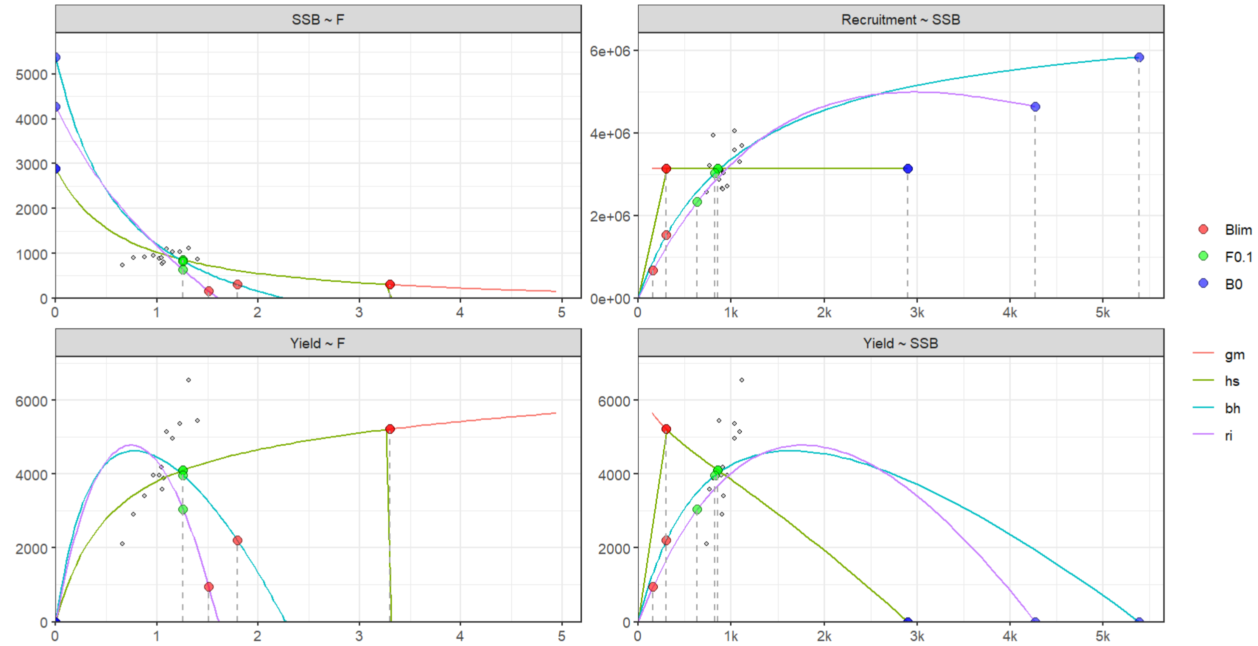


Figure 6.10.4.3 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Long-term equilibrium evaluations for different S-R models.

In the light of the outcomes of the exploratory analysis, because the point of inflection on the HS was outside the data, it was decided to consider the Geometric Mean approach as the most suitable to estimate the biomass reference points for the stock of deep-water rose shrimp in GSAs 8, 9, 10 and 11 this being also equivalent to the asymptote of the HS. Table 6.10.4.2 summaries the reference point values based on the default value of 25% of $B_{F0.1}$ for BLim and Geometric Mean fitted to the data for R_0.

B_{pa} is set to 2* BLim. The implied dynamics, based on a Hockey-stick model with R_0 from GM recruitment and the HS breakpoint at 25% $B_{F0.1}$ are illustrated in Figure 6.10.4.4.

Table 4.10.1.2 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Final reference points based on Geometric mean and a default value of BLim =25% $B_{F0.1}$.

$F_{0.1}$	B_{lim}	B_{pa}	$B_{F0.1}$	B_0	Fpa
1.26	213.7	427.5	855.0	2899.6	2.53

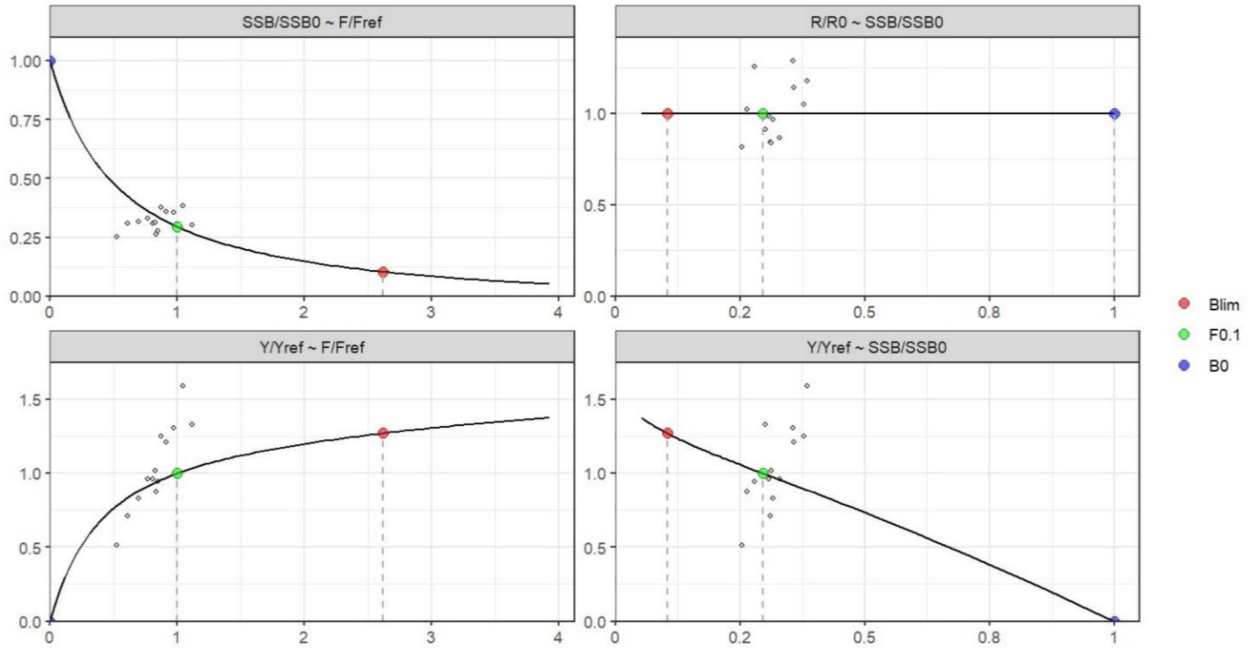


Figure 6.10.4.4 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Reference point estimates. Grey dots show the corresponding observations.

Figures 6.10.4.5-6.10.4.6 show the historic stock relative to the reference points, in time (Figure 6.10.4.5) and as Kobe plot in SSB and F (Figure 6.10.4.6) based on the reference points estimated for the Geometric mean model for deep-water rose shrimp in GSAs 8, 9, 10 and 11.

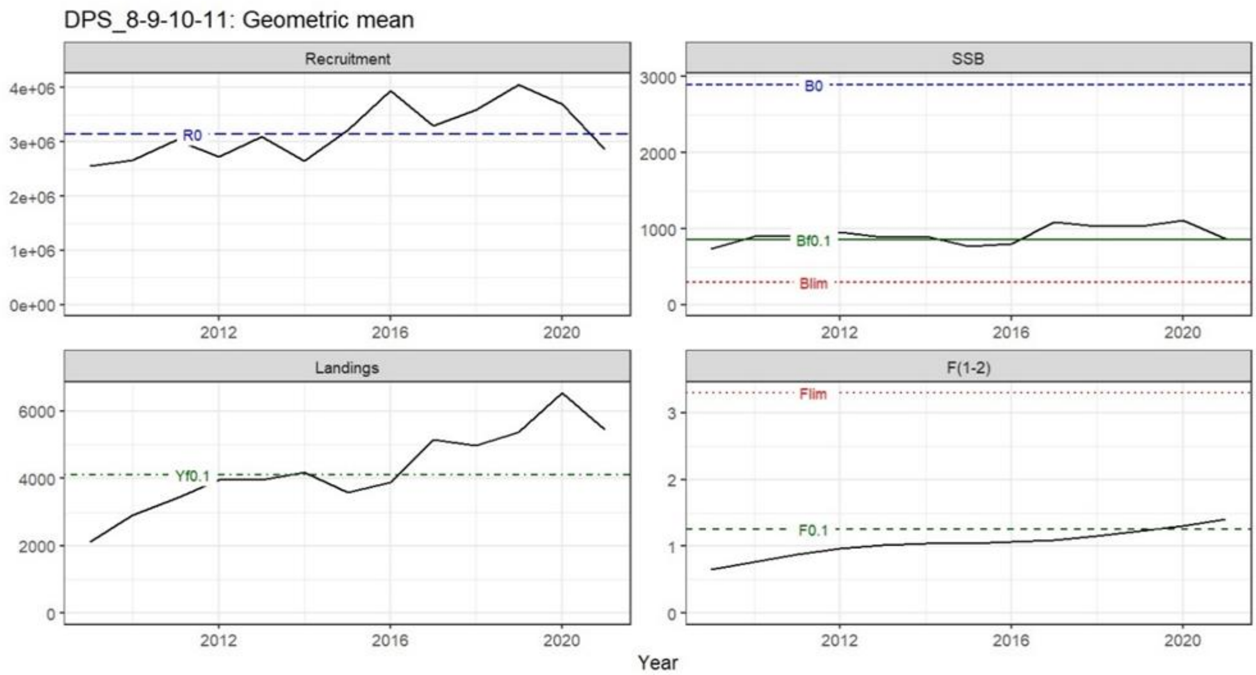


Figure 6.10.4.5 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Status Advice plot showing stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on a Geometric mean stock-recruitment relationship.

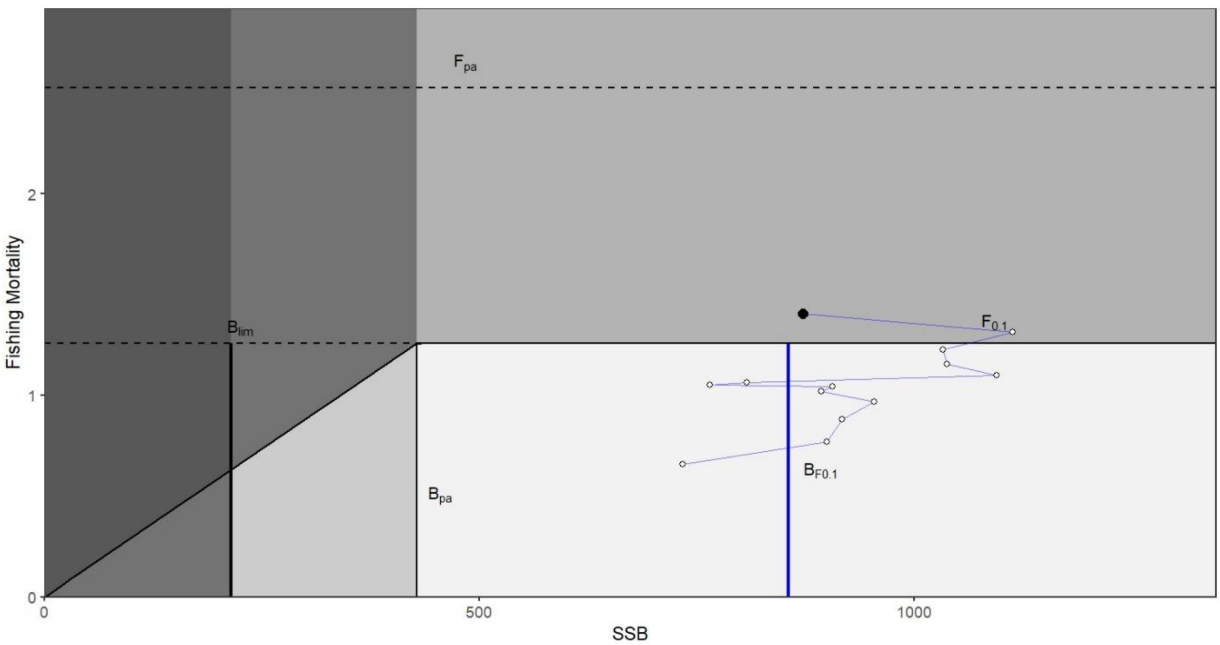


Figure 6.10.4.6 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Advice Rule plots for the Geometric mean model, with an empirical B_{lim} = 0.25 $B_{F0.1}$ and B_{pa} = 2x B_{lim}.

The Geometric mean model defined above is considered as the best option for defining reference points for this stock, but it may not be the most suitable for modelling. A Beverton-Holt model may be helpful to as a modelling option. The steepness option that most closely mimics in terms of deviation from slope and asymptote the HS chosen is thought to be steepness = 0.95 (Figure 6.10.4.7).

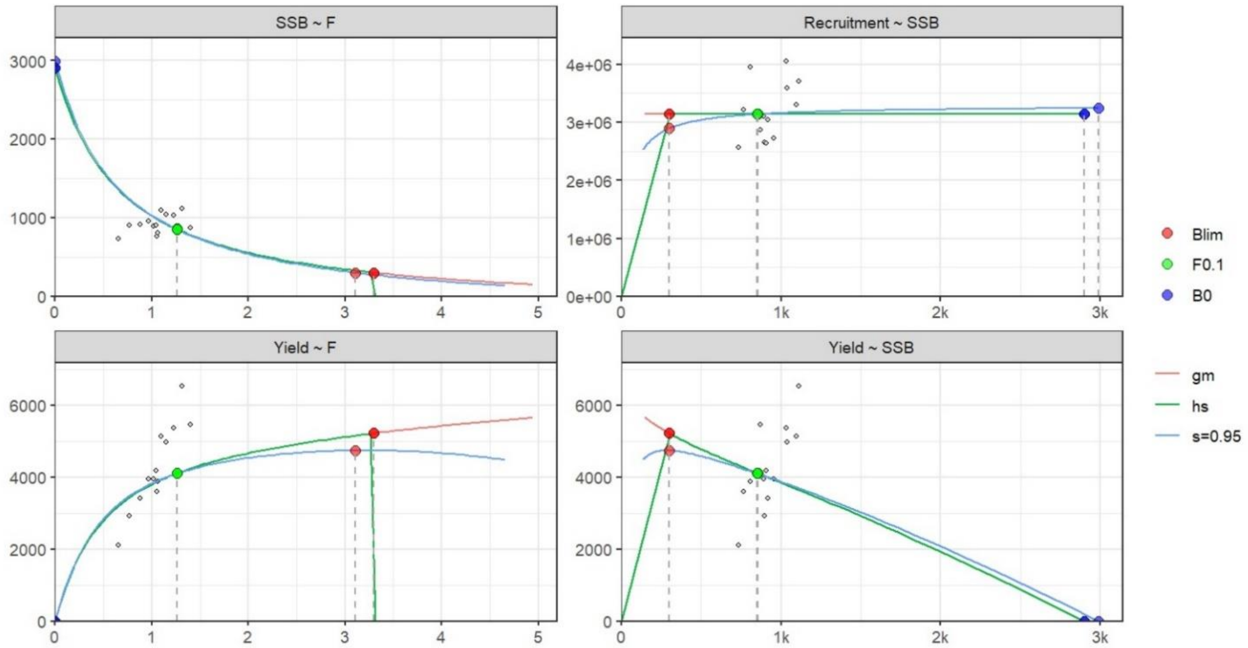


Figure 6.10.4.7 Deep-water rose shrimp in GSAs 8, 9, 10 & 11. Per-recruit analysis: relative reference points for GM, HS and BH (steepness 0.95) models.

6.10.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

The input parameters for the deterministic short-term predictions for the period 2019 to 2021 were from the a4a stock assessment and its results (Table 6.10.1). An average of the last three years has been used for weight at age and maturity at age, while the F_{bar} = 1.40 terminal F (2021) from the a4a assessment was used for status quo F in 2022.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the whole data series (3,146,557 thousand individuals).

The short term forecast (Table 6.10.5.2) was carried out estimating a catch for 2022-2024 on the basis of a recruitment constant and equal to the mean on the whole time series and an F by age equal to that of the terminal year. These assumptions resulted in a catch and a SSB in 2022 equal to 1545.0 and 753.0 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (= 1.26) would increase SSB of 13.05% from 2022 to 2024, while decreasing the catch of 17.87% from 2021 to 2023.

Table 6.10.1 Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-2}$ (2021)	1.40	F current in the last year (2021) used to give F status quo for 2022
SSB (2022)	753 t	
R_0 (2022)	31,446,558 thousands	Geometric mean of the period 2009-2021
R_0 (2024)	31,446,558 thousands	Geometric mean of the period 2009-2021
Total catch (2022)	1545 t	Catch intermediate year from STF output

Table6.10.5.2 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Short term forecast in different F scenarios. SSB refers to the middle of the year.

Rationale	Ffactor	Fbar	Recr. 2022	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield ($F_{0.1}$)	0.90	1.26	3146558	1.40	1784	1545.0	1465.4	753.0	851.2	13.05	-17.87
F upper	1.22	1.71	3146558	1.40	1784	1545.0	1757.3	753.0	652.9	-13.28	-1.51
F lower	0.59	0.83	3146558	1.40	1784	1545.0	1101.9	753.0	1132.5	50.40	-38.24
F_{MSY} transition	0.89	1.25	3146558	1.40	1784	1545.0	1457.3	753.0	857.0	13.82	-18.32
Zero catch	0	0	3146558	1.40	1784	1545.0	0.0	753.0	2251.3	198.99	-100.00
Status quo	1	1.40	3146558	1.40	1784	1545.0	1568.3	753.0	778.7	3.42	-12.11
Different Scenarios	0.1	0.14	3146558	1.40	1784	1545.0	233.5	753.0	1979.3	162.87	-86.91
	0.2	0.28	3146558	1.40	1784	1545.0	444.5	753.0	1749.8	132.39	-75.09
	0.3	0.42	3146558	1.40	1784	1545.0	635.6	753.0	1555.3	106.56	-64.38
	0.4	0.56	3146558	1.40	1784	1545.0	808.9	753.0	1389.7	84.57	-54.67
	0.5	0.70	3146558	1.40	1784	1545.0	966.3	753.0	1248.0	65.75	-45.84
	0.6	0.84	3146558	1.40	1784	1545.0	1109.6	753.0	1126.1	49.56	-37.81
	0.7	0.98	3146558	1.40	1784	1545.0	1240.1	753.0	1020.8	35.57	-30.50
	0.8	1.12	3146558	1.40	1784	1545.0	1359.3	753.0	929.2	23.40	-23.82
	0.9	1.26	3146558	1.40	1784	1545.0	1468.4	753.0	849.1	12.77	-17.71
	1.1	1.54	3146558	1.40	1784	1545.0	1660.0	753.0	716.5	-4.84	-6.97
	1.2	1.68	3146558	1.40	1784	1545.0	1744.3	753.0	661.3	-12.17	-2.24
	1.3	1.82	3146558	1.40	1784	1545.0	1821.9	753.0	612.0	-18.72	2.11
	1.4	1.96	3146558	1.40	1784	1545.0	1893.6	753.0	567.7	-24.60	6.13
	1.5	2.10	3146558	1.40	1784	1545.0	1959.8	753.0	527.8	-29.91	9.84
	1.6	2.24	3146558	1.40	1784	1545.0	2021.1	753.0	491.6	-34.71	13.27
	1.7	2.38	3146558	1.40	1784	1545.0	2078.0	753.0	458.7	-39.07	16.46
	1.8	2.52	3146558	1.40	1784	1545.0	2130.9	753.0	428.7	-43.06	19.43
	1.9	2.67	3146558	1.40	1784	1545.0	2180.1	753.0	401.2	-46.72	22.18
	2	2.81	3146558	1.40	1784	1545.0	2226.0	753.0	375.9	-50.08	24.76

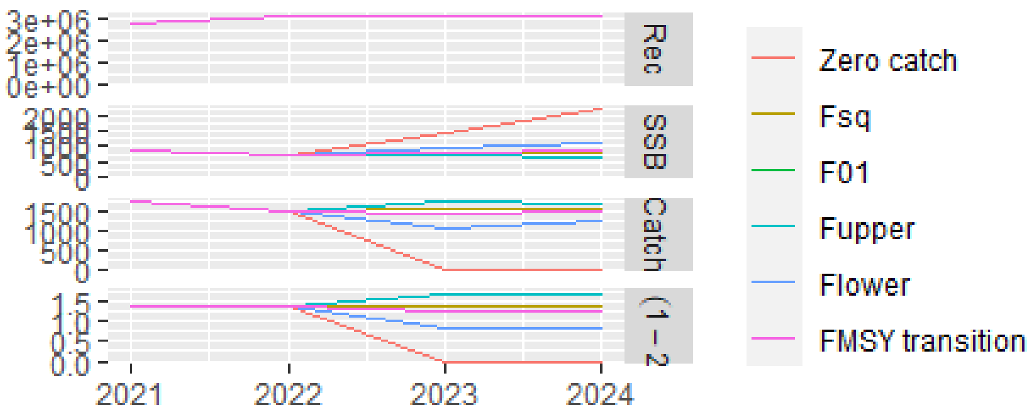


Figure 6.10.5.1 Deep-water rose shrimp in GSAs 08, 09, 10 & 11. Short-term forecast in different F scenarios.

6.10.6 DATA DEFICIENCIES

Data from DCR-DCF database as submitted through the Official data call in 2022 were used for the stock assessment.

Landing data. The time series of landing data in biomass available in the database were different among the three GSAs: 2010-2021 for GSA08, 2003-2021 for GSA09, 2002-2021 for GSA10 and 2004-2021 for GSA11.

Length frequency distributions of the landing are not available for GSA08. However, the landing of this GSA is negligible, representing on average 0.5% of the total landings of the four GSAs.

The length frequency distributions for GSA09 are available for the period 2003-2021 (year 2002 is missing).

For GSA10, data are not available for 2003. The length frequency distributions of the main metiers targeting DPS in 2019 and 2021 (OTB_DEF and OTB_DEMSP) are missing. In 2019-2021, a high SOP correction was needed to arise the size structures of the three OTB metiers (OTB_DEF, OTB_MDD and OTB_DWS) to the total landing as data is available only for some quarter and fleet segment.

The historical data series for GSA11 includes the period 2009-2019 (the years 2002-2008 are missing).

Discard data. The biomass discarded and the related length frequency distributions in GSA08 are not available. However, this fraction of the total catch is negligible.

In GSA09, length frequency distributions are available for the period 2009-2021.

In GSA10, the data on discard are available for 2006 and for the years 2009-2017. The lack of data in 2020 and 2021 for GSA10 had a low impact on the assessment as, on average, discard in GSA10 represents about 2% of the total catch.

With regard to GSA11, there are no data on this fraction of the catch. Due to the low catches of DPS in GSA11 the discard of this species could be considered negligible in the area.

It should be emphasized that the Italian national data collection program did not provide for the collection of discard before 2006 and in the years 2007-2008.

6.11 RED MULLET IN GSA 9

6.11.1 STOCK IDENTITY AND BIOLOGY

Red mullet (*Mullus barbatus*) is distributed in GSA 9 (Figure 6.11.1.1) along the shelf at depths up to 200m, but mainly concentrated in the depth range 0-100 m. EU project STOCKMED outcomes suggest a single stock unit in the GSA 9 and the rest of Western Mediterranean (see: https://ec.europa.eu/fisheries/documentation/studies/stockmed_en). Available spatial information from MEDITS show continuous distribution of the red mullets along western Italian coast (i.e. connectivity of GSA9 with GSA 10) (Figure 6.11.1.2).

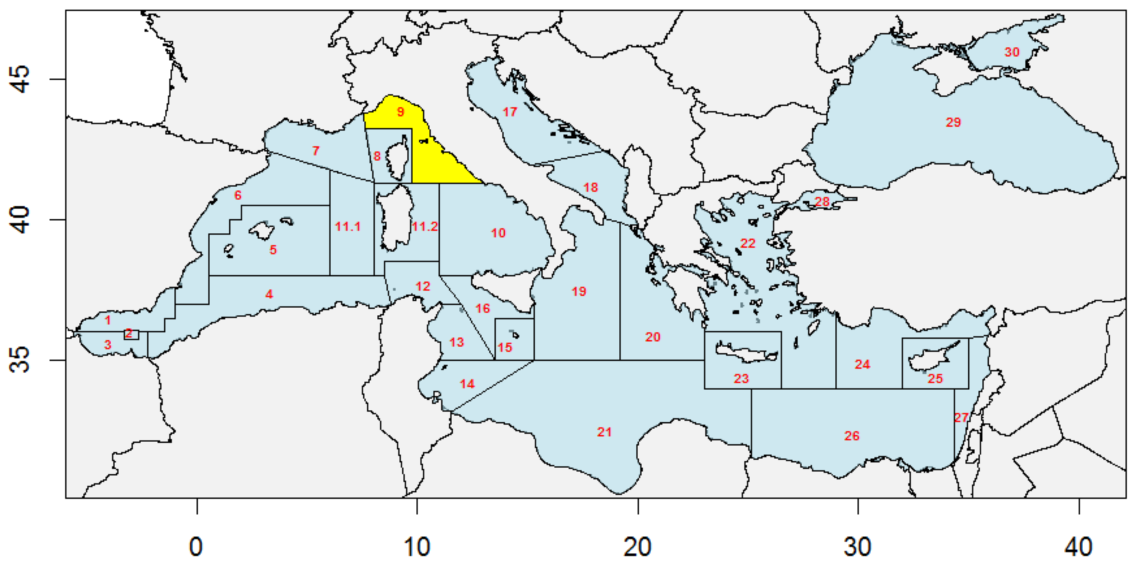


Figure 6.11.1.1 Red mullet in GSA 9: Location of GSA 9 in the Mediterranean Sea.

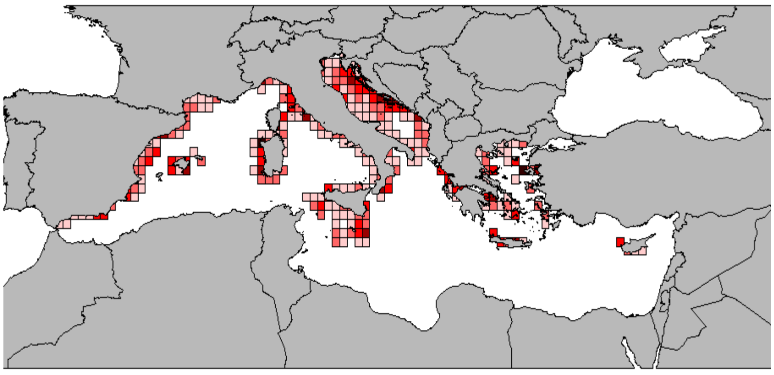


Figure 6.11.1.2 Red mullet in GSA 9: Geographical distribution of red mullet in the Mediterranean basin (kg/km^2, average 2004-2014 by GFCM rectangle), STOCKMED Project.

However, in line with ToR given, EWG 222-09 assumed here that inside the GSA 9 boundaries inhabits a single, homogeneous red mullet stock that behaves as a single well-mixed and self-perpetuating population. The hypothesis of a single stock of red mullet in GSA 9, which includes waters belonging to 2 different seas (Ligurian and Tyrrhenian) separated by the Elba Island as well as fleets that do not show any spatial overlapping is unlikely. The inability to account for spatial structure reduces flexibility and can lead to uncertainty in the definition of the status of the stocks, due to the possibility of local depletions and to a worse utilization of the potential productivity of the resources (STECF, 2014).

Growth

Growth parameters of red mullet in GSA 9 are available from 2006 to 2021 (Figure 6.11.1.3) from DCF data. For the aim of the stock assessment a set of von Bertalanffy parameters given by the average along the years was used. It should be noticed that these growth parameters are quite different from the ones used for the neighbouring area (GSA 10; Section 6.12.1), that were consistent with the parameters estimated and validated by means of a set of different methods in Carbonara *et al.* (2018).

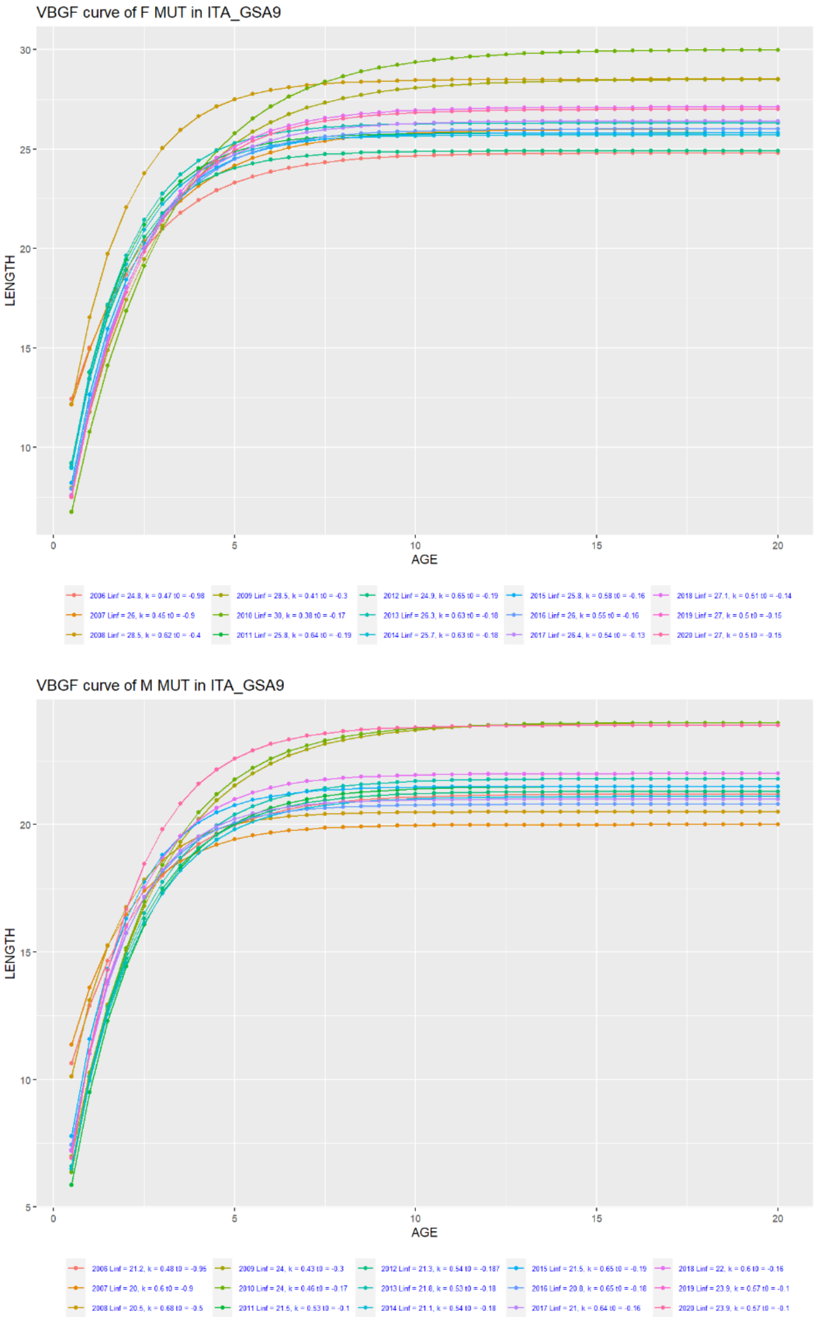


Figure 6.11.1.3 Red mullet in GSA 9: Estimated growth curves of red mullet in GSA9.

Similarly to the previous assessment, the mean length at age 0 were associated to the age classes to the mean length at the end of the year, being the a4a model parameterized with calendar year. On as in the EWG 21-11 it was agreed to shift length slicing by adding a value of 0.5 to the t0 value used in earlier assessments (set at -0.33 for both females and males) for internal consistency in the stock assessment model. The adjusted parameters, used in L2a length slicing for the assessment, are:

Linf=26.56, k=0.545, t0=0.17 for females; Linf=21.55, k=0.56, t0=0.17 for males.

Original growth curves are used to estimate natural mortality see below.

Length-weight relationships for females and males were the ones used for the assessment performed by EWG 19-10: females: a = 0.012, b = 3; males: a = 0.017, b = 2.84 (average of DCF data along the years 2002-2017).

Natural mortality

Natural mortality (M) was estimated according to Chen and Watanabe model (1989) on the age vector at half year (0.5, 1.5, 2.5,…) using the orginal growth parameters, without the adjustement of the t0.

Linf=26.56, k=0.545, t0=-0.33 for females; Linf=21.55, k=0.56, t0=-0.33 for males.

Maturity

Maturity ogives by age were available from 2006 to 2019 in the DCF data. The vector of matures by year and age showed a wide uncertainty especially on maturity at age 0 and 1, that seems inconsistent with the growth curve and the spawning season of the species. For this reason the EWG 22-09 preferred to use the vector of maturity agreed and used for all the red mullet stocks assessed in the working group. Mortality and maturity parameters used in assessment are shown in Table 6.11.1.1.

Table 6.11.1.1 Red mullet in GSA 9: natural mortality and maturity vector at age.

Age	0	1	2	3	4+
M *	1.52	0.87	0.7	0.63	0.59
Proportion mature	0	1	1	1	1

6.11.2 DATA

6.11.2.1 CATCH (LANDINGS AND DISCARDS)

Principal fishing gears used to catch red mullet in GSA 9 together with other species (mixed catches) are gillnets (GNS), trammel nets (GTR) and bottom trawls (OTB). Length structure of red mullet catches (landings and discards) for all gears in the period from 2003 to 2019 are shown in Figures 6.11.2.1.1 - 6.11.2.1.3 for landings, discards and catches respectively.

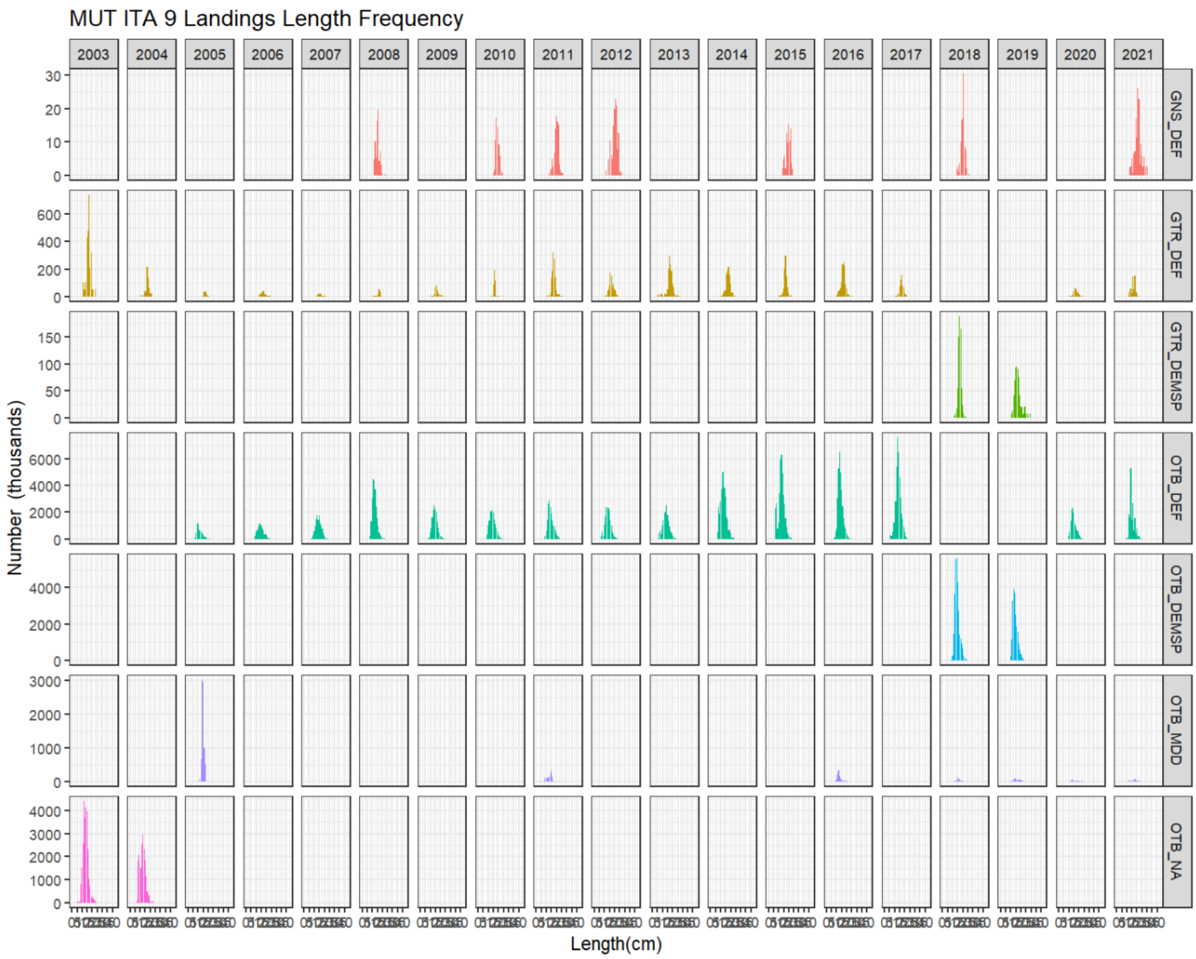


Figure 6.11.2.1.1 Red mullet in GSA 9: Length structure of red mullet landed in GSA 9 in the period from 2003 to 2021 by fishing gear and fishery.

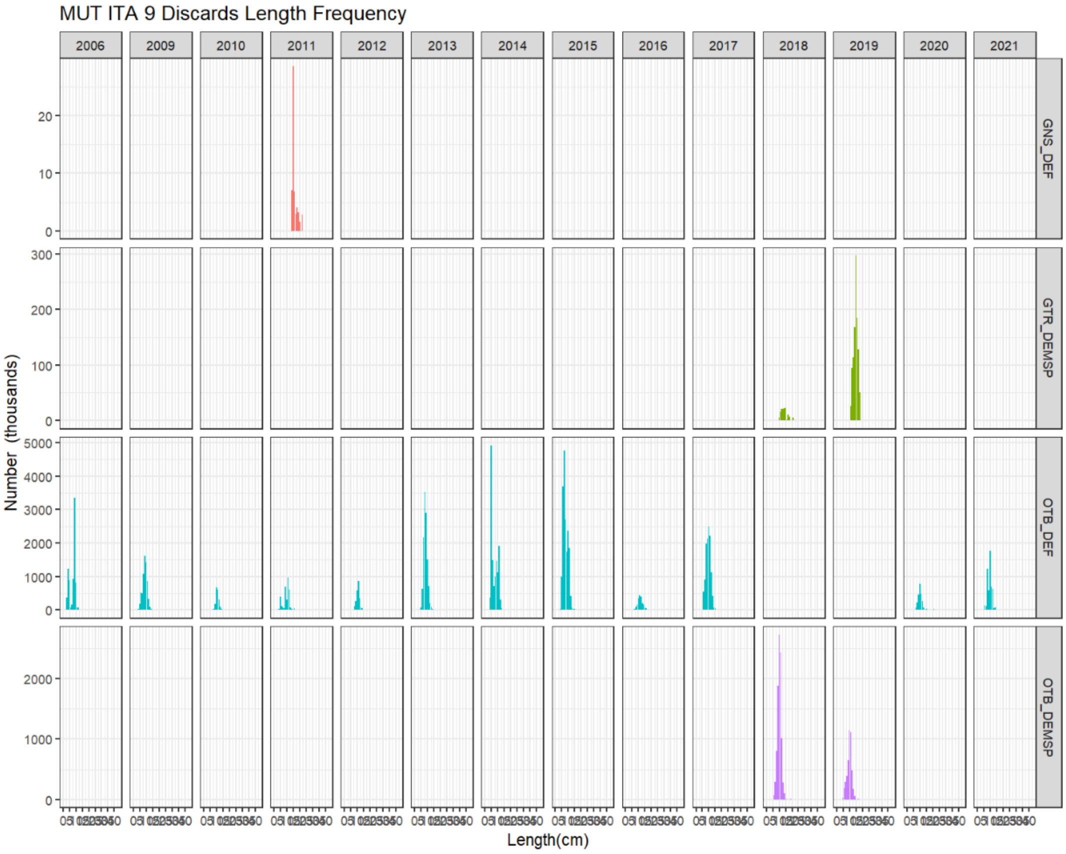


Figure 6.11.2.1.2 Red mullet in GSA 9: Length structure of red mullet catch discarded in GSA 9 in the period from 2006 to 2021 by fishing gear and fishery.

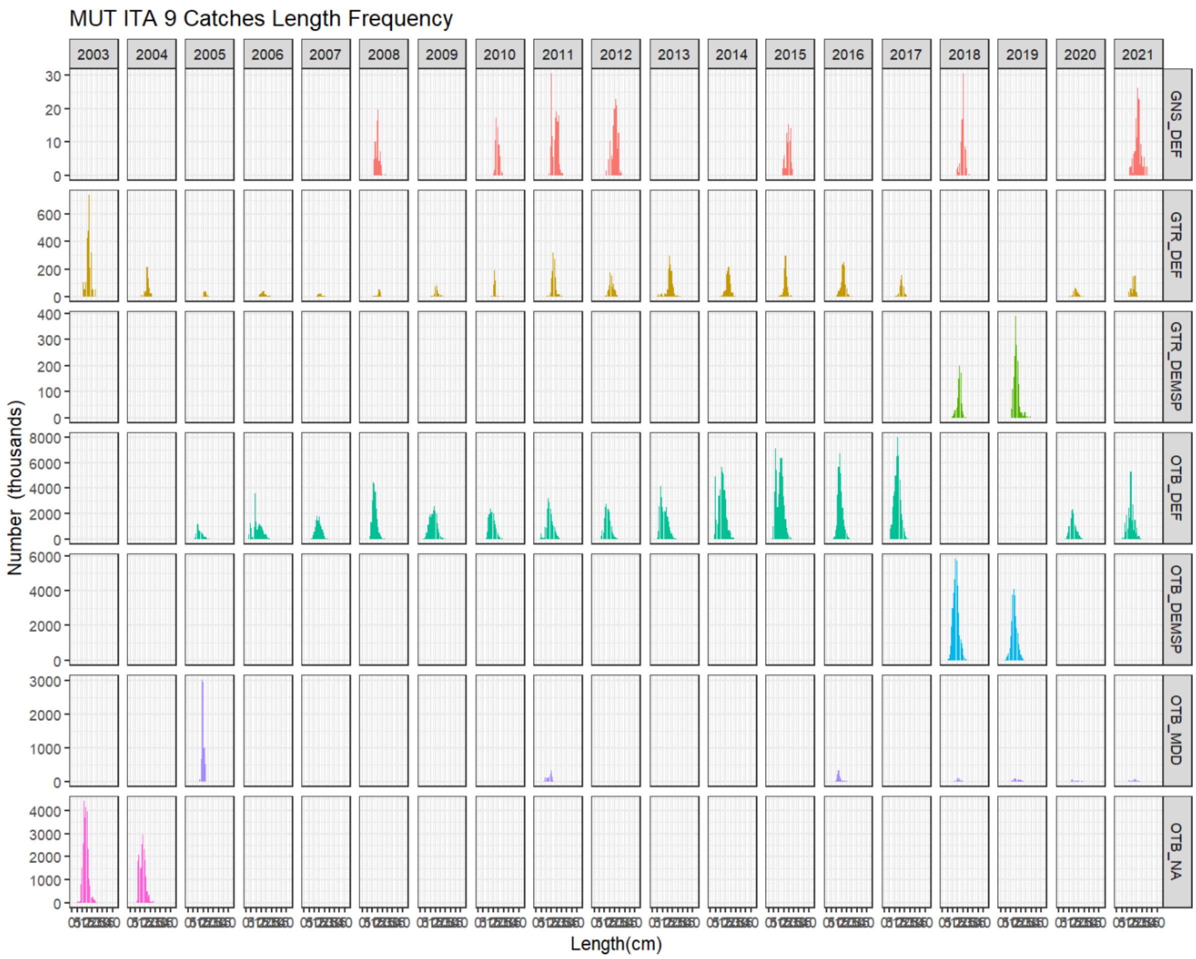


Figure 6.11.2.1.3 Red mullet in GSA 9: Length structure of red mullet total catch (landing plus discard) in GSA 9 in the period from 2003 to 2021 by fishing gear and fishery.

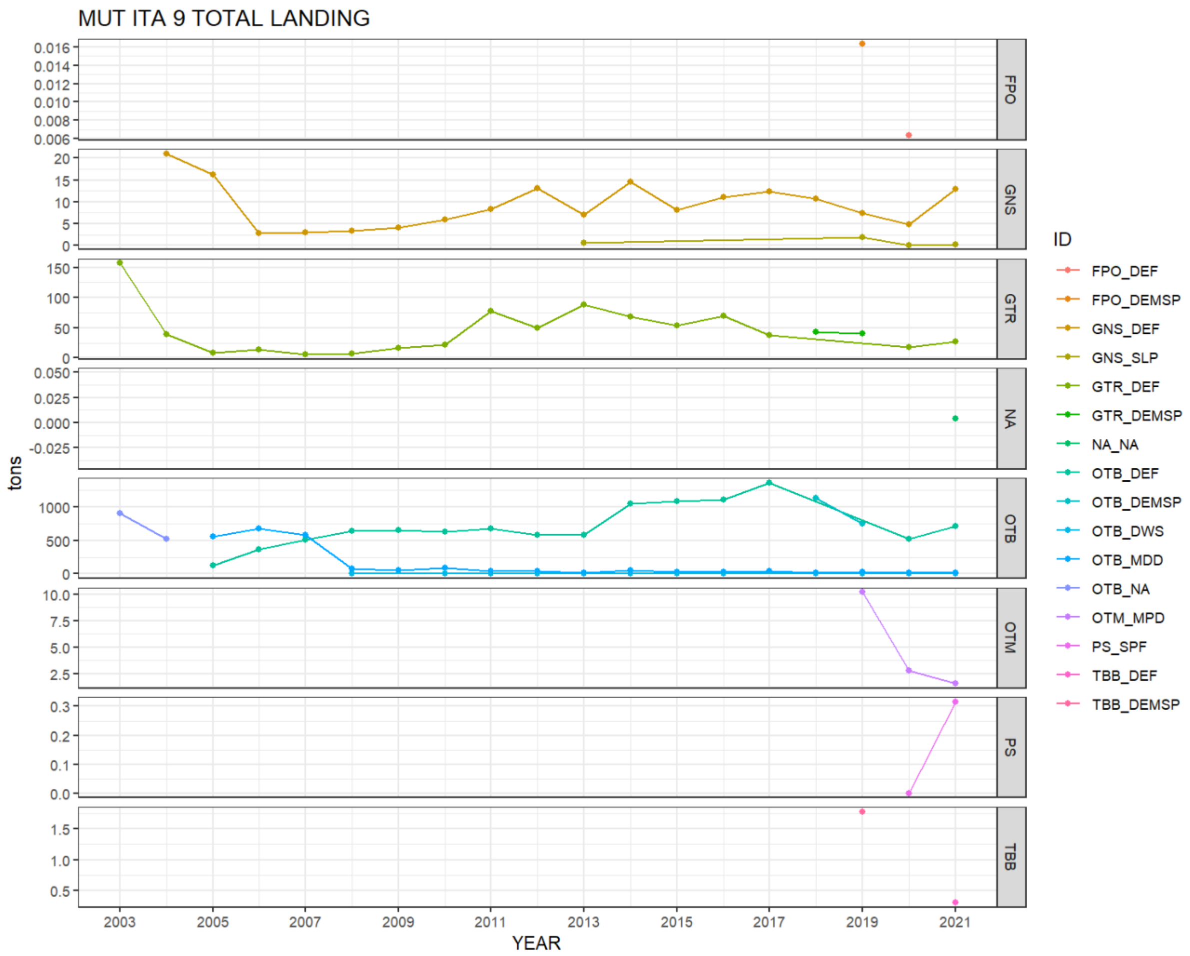


Figure 6.11.2.1.4 Red mullet in GSA 9: Landings (t) of red mullet in GSA 9 in the period from 2003 to 2021 by fishing gear and fishery.

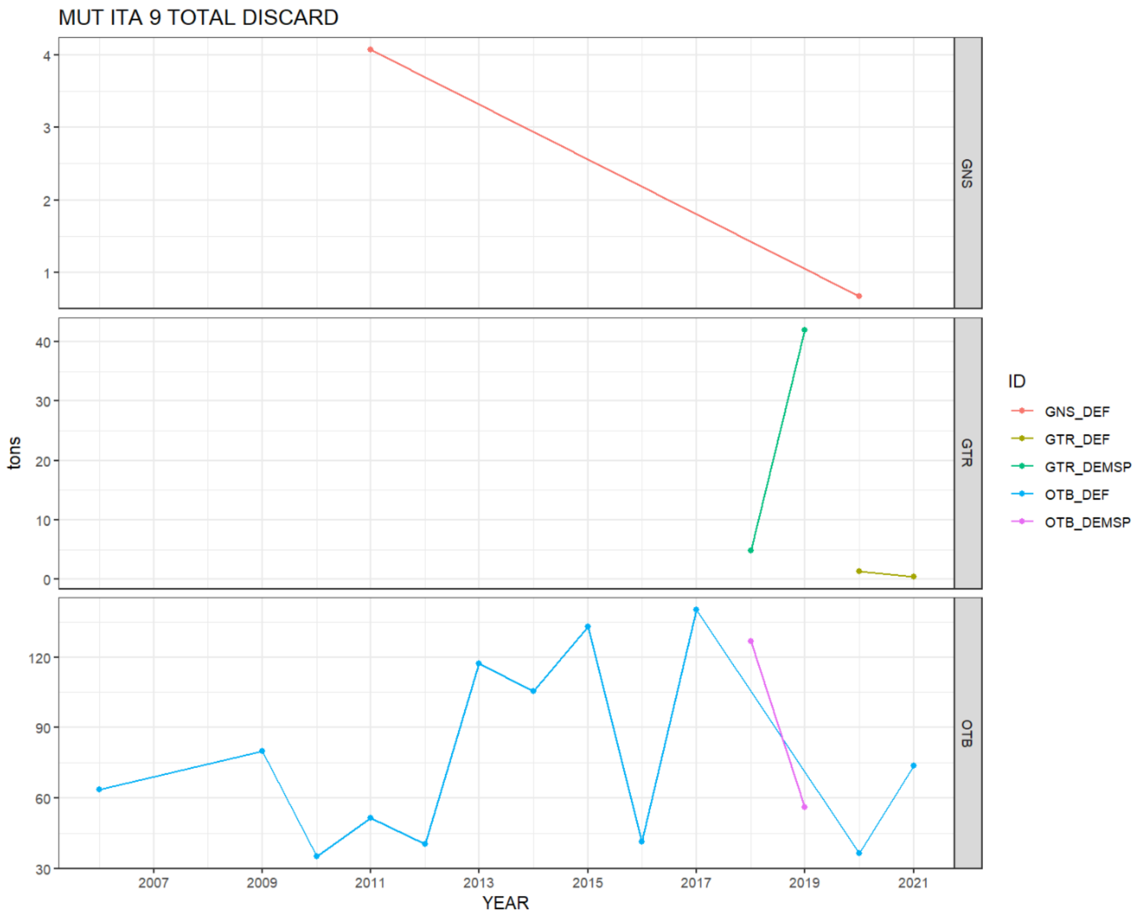


Figure 6.11.2.1.5 Red mullet in GSA 9: Discards (t) of red mullet in GSA 9 in the period from 2006 to 2021 by fishing gear and fishery.

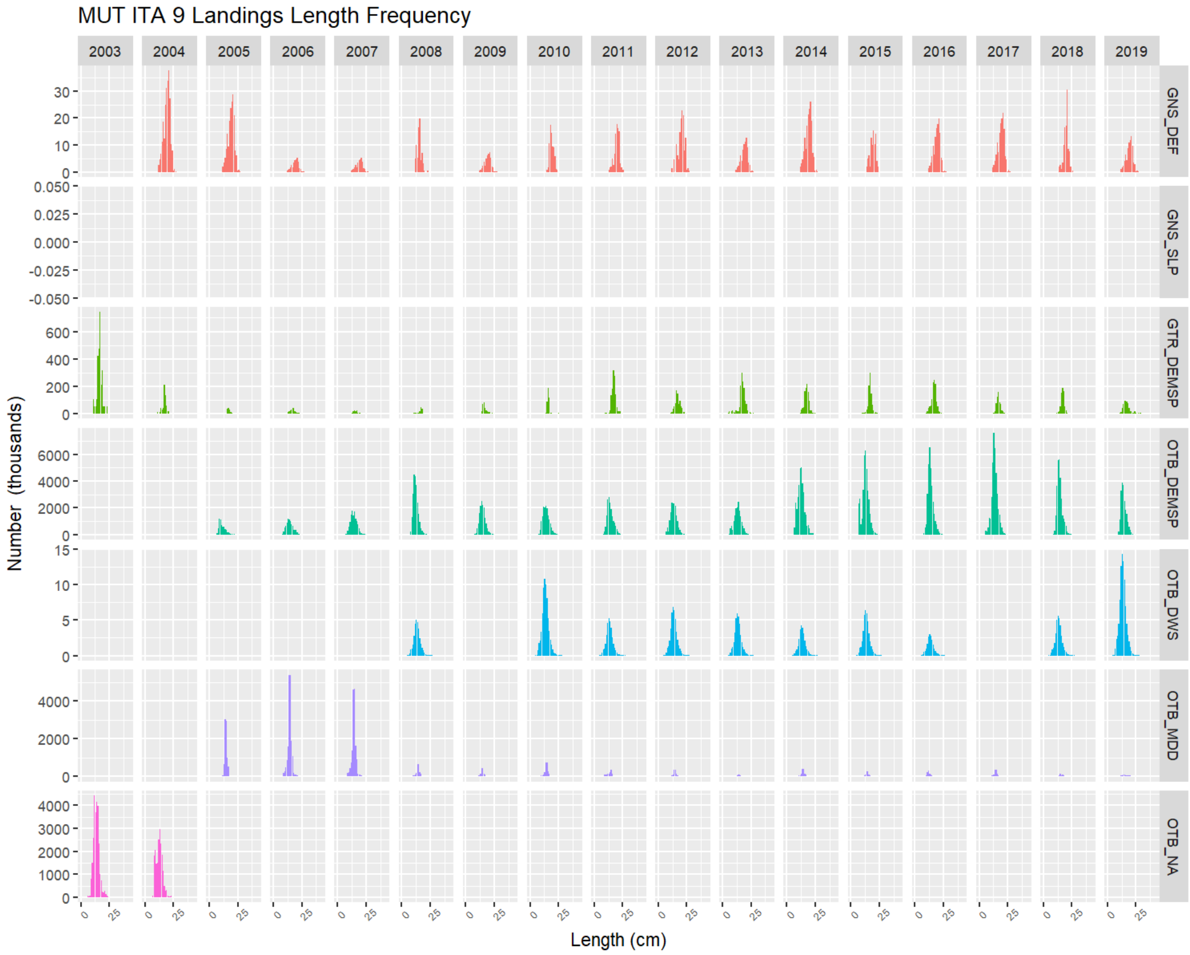


Figure 6.11.2.1.6 Red mullet in GSA 9: Length structure of red mullet landed in GSA 9 in the period from 2003 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02.

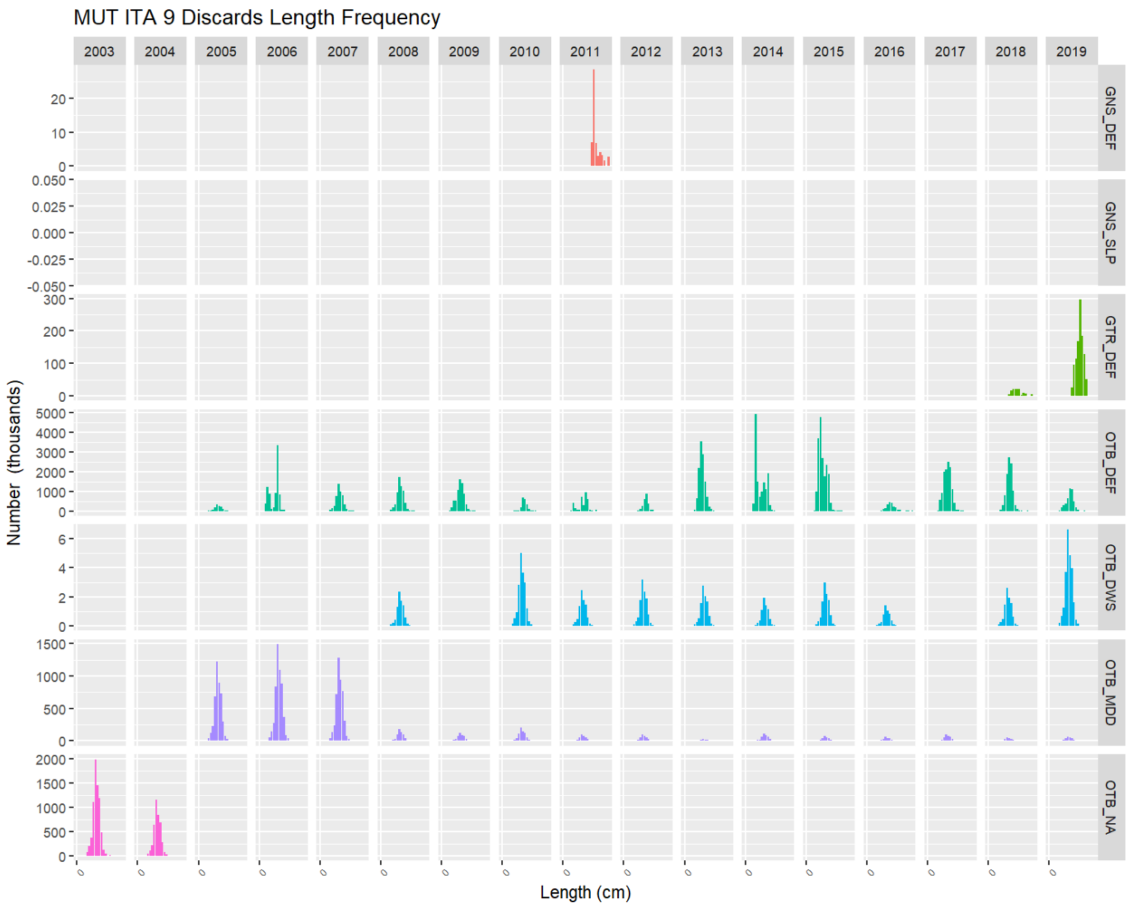


Figure 6.11.2.1.7 Red mullet in GSA 9: Length structure of red mullet catch discarded in GSA 9 in the period from 2006 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02.

Table 6.11.2.1.1 Red mullet in GSA 9: Landings and discards (t) of red mullet in GSA 9 by gear in the period from 2003 to 2021. Values in red were reconstructed by EWG 21-02.

	Landings (t)					Discards (t)			
Year	GNS	GTR	OTB	Others	Total landings	GNS	GTR	OTB	Total discards
2003	0.0	157.0	899.7	0.0	1056.7	-	-	**77.1**	**77.1**
2004	21.0	38.6	521.1	0.0	580.7	-	-	**44.7**	**44.7**
2005	16.1	8.4	684.0	0.0	708.5	-	-	**61.0**	**61.0**
2006	2.9	13.5	1033.2	0.0	1049.6	0.0	0.0	63.6	63.6
2007	2.9	5.6	1087.4	0.0	1096.0	-	-	**102.5**	**102.5**
2008	3.4	7.4	716.3	0.0	727.1	-	-	**73.0**	**73.0**
2009	4.1	16.8	707.4	0.0	728.3	0.0	0.0	80.1	80.1
2010	6.0	22.3	719.6	0.0	747.9	0.0	0.0	35.1	35.1
2011	8.4	77.4	719.6	0.0	805.5	4.1	0.0	51.6	55.7
2012	13.1	49.3	630.5	0.0	692.9	0.0	0.0	40.3	40.3
2013	7.0	88.4	597.9	0.0	693.3	0.0	0.0	117.2	117.2
2014	14.5	69.0	1097.9	0.0	1181.4	0.0	0.0	105.6	105.6
2015	8.1	54.1	1121.3	0.0	1183.4	0.0	0.0	132.9	132.9
2016	11.1	70.3	1140.2	0.0	1221.6	0.0	0.0	41.2	41.2
2017	12.3	38.1	1410.3	0.0	1460.7	0.0	0.0	140.1	140.1
2018	10.7	43.0	1151.0	0.0	1204.8	0.0	4.8	126.7	131.5
2019	9.3	39.9	782.8	12.0	844.0	0.0	42.0	56.1	98.1
2020	4.9	18.0	534.8	2.8	560.5	0.7	1.3	36.5	38.5
2021	13.1	27.4	736.6	2.2	779.3	0.0	0.5	73.6	74.1

Discard of red mullet in GSA 9 occurs mainly from the catches of bottom trawls (OTB). Discard data were available in 2006, and for all years since 2009. For the assessment purposes, in the years where discard data were missing, reconstructions were made by EWG 21-02 using the mean of the available LFDs for discards. This was done for OTB discards only.

6.11.2.2 Effort

Red mullet is caught by mixed fisheries, using more than a fishing gear (gillnets, trammel nets, trawls), by fishing boats of different sizes (different metiers, VL0006 - VL1824). With the aim to associate effort data with particular stock assessments, based on local expert knowledge, EWG 22-09 made a selection of gear types in different GSAs. Effort data for *Mullus barbatus* for GSA 9 are reported in Figure 6.11.2.2.1 and in Tables 6.11.2.2.1. and 6.11.2.2.2 for fishing days and days at sea respectively.

However, EWG 22-09 also highlights that gears indicated in the table are used in framework of different fisheries where multispecies catches are obtained. So, it is important to keep in mind that fishing effort data, that according to the ToR is analysed on fishing gear level, are related to multifisheries and multispecies aspects, and not just to one single species considered in the assessments.

These are provided for illustrative purposes, STECF provides definitive effort data from the FDI data base from the EWG 22-10

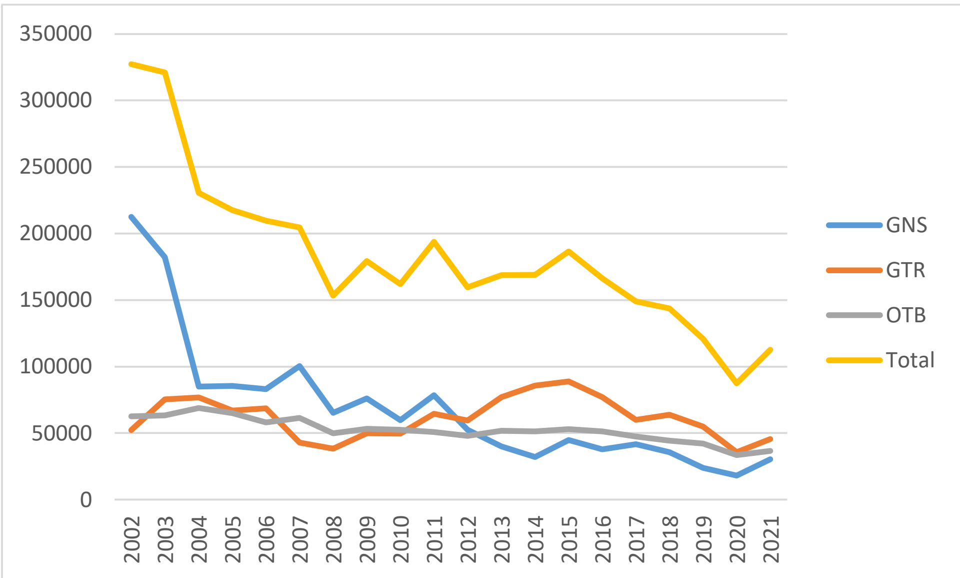


Figure 6.11.2.2.1 Red mullet in GSA 9: Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 9 in the period 2002-2021.

Table 6.11.2.2.1 Red mullet in GSA 9: Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 9 in the period 2002-2021.

	GNS	GTR	OTB	Total
2002	212455	52193	62616	327264
2003	182159	75479	63331	320969
2004	84893	76802	68950	230645
2005	85487	66927	65080	217494
2006	82971	68556	58004	209531
2007	100280	42878	61360	204518
2008	65286	38371	49757	153414
2009	76140	49830	53329	179299
2010	59708	49711	52617	162036
2011	78452	64654	50736	193842
2012	52450	59401	47849	159700
2013	40024	76974	51713	168711
2014	32058	85701	51284	169043
2015	44857	88784	52936	186577
2016	37949	76977	51301	166227
2017	41566	59937	47459	148962
2018	35705	63723	44321	143749
2019	23843	54869	42227	120939
2020	18159	35678	33550	87387
2021	30427	45644	36566	112637

Table 6.11.2.2.2 Red mullet in GSA 9: Effort (days at sea) associated to *Mullus barbatus* in GSA 9 in the period 2002-2021.

	GNS	GTR	OTB	Total
2002	212455.4	52193.11	62616.5	327265
2003	182158.7	75479.02	63331.27	320969
2004	82163.11	74235.07	67827.51	224225.7
2005	83554.54	65817.63	67713.57	217085.7
2006	81688.8	65937.85	62516.75	210143.4
2007	99988.2	42745	64161.07	206894.3
2008	64754.85	37908.23	49758.79	152421.9
2009	74733.06	48728.33	53330.45	176791.8
2010	58778.3	49086.67	52606.12	160471.1
2011	77406.5	63909.87	50736.79	192053.2
2012	50560.92	57420.22	47851.04	155832.2
2013	35473.43	74997.49	51715.36	162186.3
2014	30015.32	80963.25	51285.86	162264.4
2015	43630.29	86417.56	52900.08	182947.9
2016	37026.27	74173.6	51256.7	162456.6
2017	41019.37	59023.62	47456.85	147499.8
2018	34218.53	62727.54	44296.1	141242.2
2019	24793.84	58467.34	43475.6	126736.8
2020	17085	33696	33552	84333
2021	30272	44707	36566	111545

6.11.2.3 SURVEY DATA

Survey indices used in this assessment originate from MEDITS scientific bottom trawl survey. These surveys in GSA9 took place in different seasons of the year (Figure 6.11.2.3.1). EWG 20-11 considered this fact during interpretation of available survey indices in the assessment excluding age 0 in the tuning index, because not intercepted every year. This procedure was followed by EWG 22-09 too.

Figure 6.11.2.3.1 Red mullet in GSA 9: Survey periods of MEDITS in GSA 9.

Analyses of available MEDITS data show large variations between years (Figs. 6.11.2.3.2 and 6.11.2.3.3). An increase in red mullet density and biomass indices can be noticed from 2014 onward.

However, in relation to MEDITS data available, EWG 22-09 also noted very different survey periods in these two years, concluding that autumn survey in 2017 and 2020 probably recorded red mullet recruits that were not recorded by 2016 spring survey. This is reflected in the size structure indices of red mullet in GSA 9, as derived from trawl surveys (MEDITS, 1994-2021), shown in Figure 6.11.2.3.6. Large inter-annual variations in length structure can be noticed due to the survey time, that in some years allowed to detect the recruitment of the species.

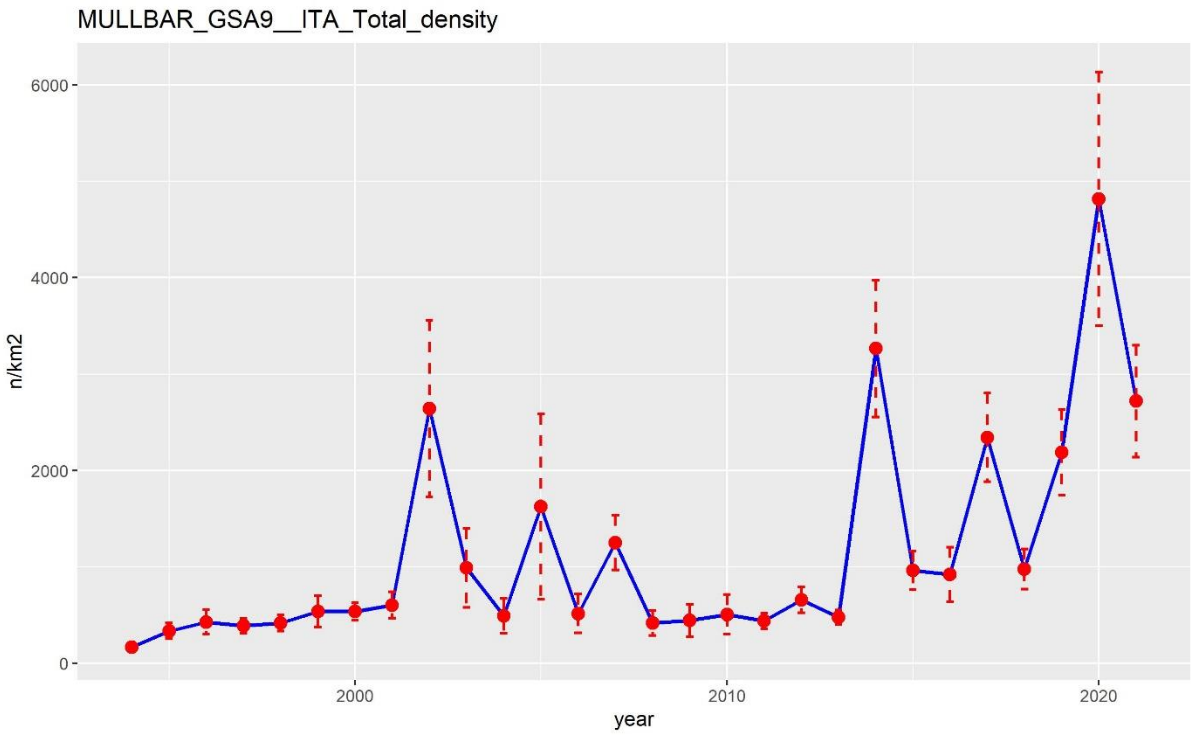


Figure 6.11.2.3.2 Red mullet in GSA 9: Abundance indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2021).

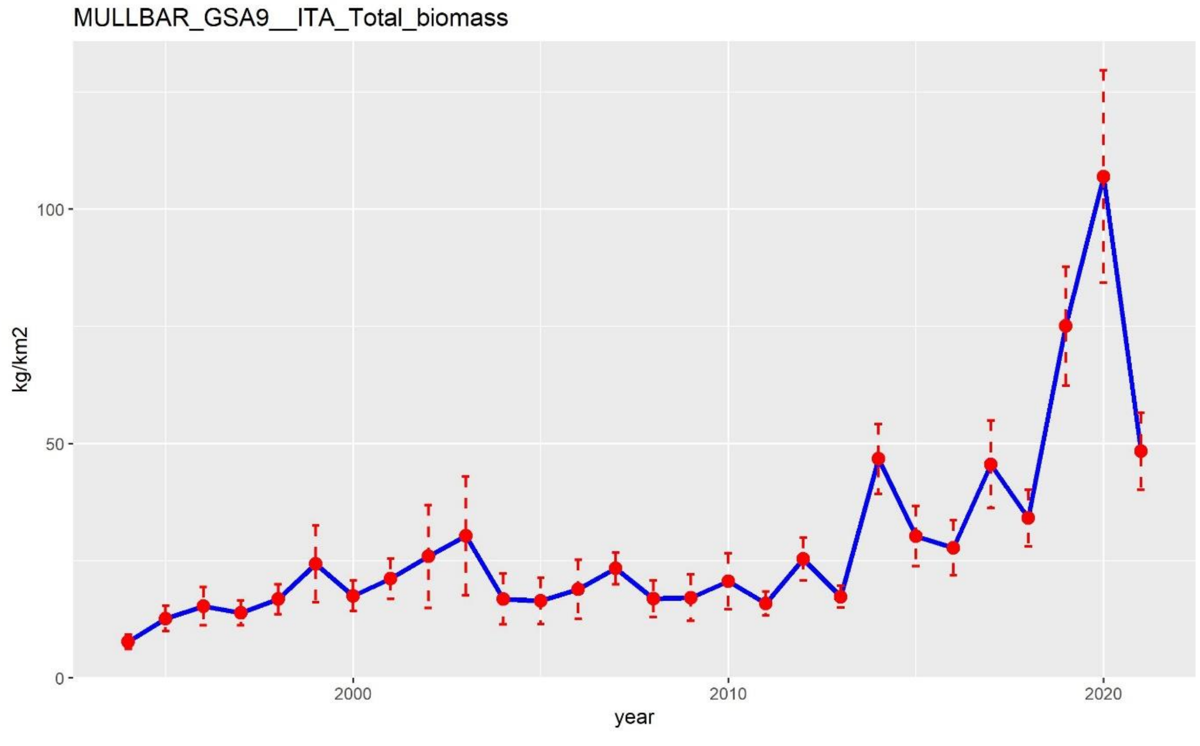


Figure 6.11.2.3.3 Red mullet in GSA 9: Biomass indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2021).

Figure 6.11.2.3.6 Red mullet in GSA 9: Size structure indices (females) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2021).

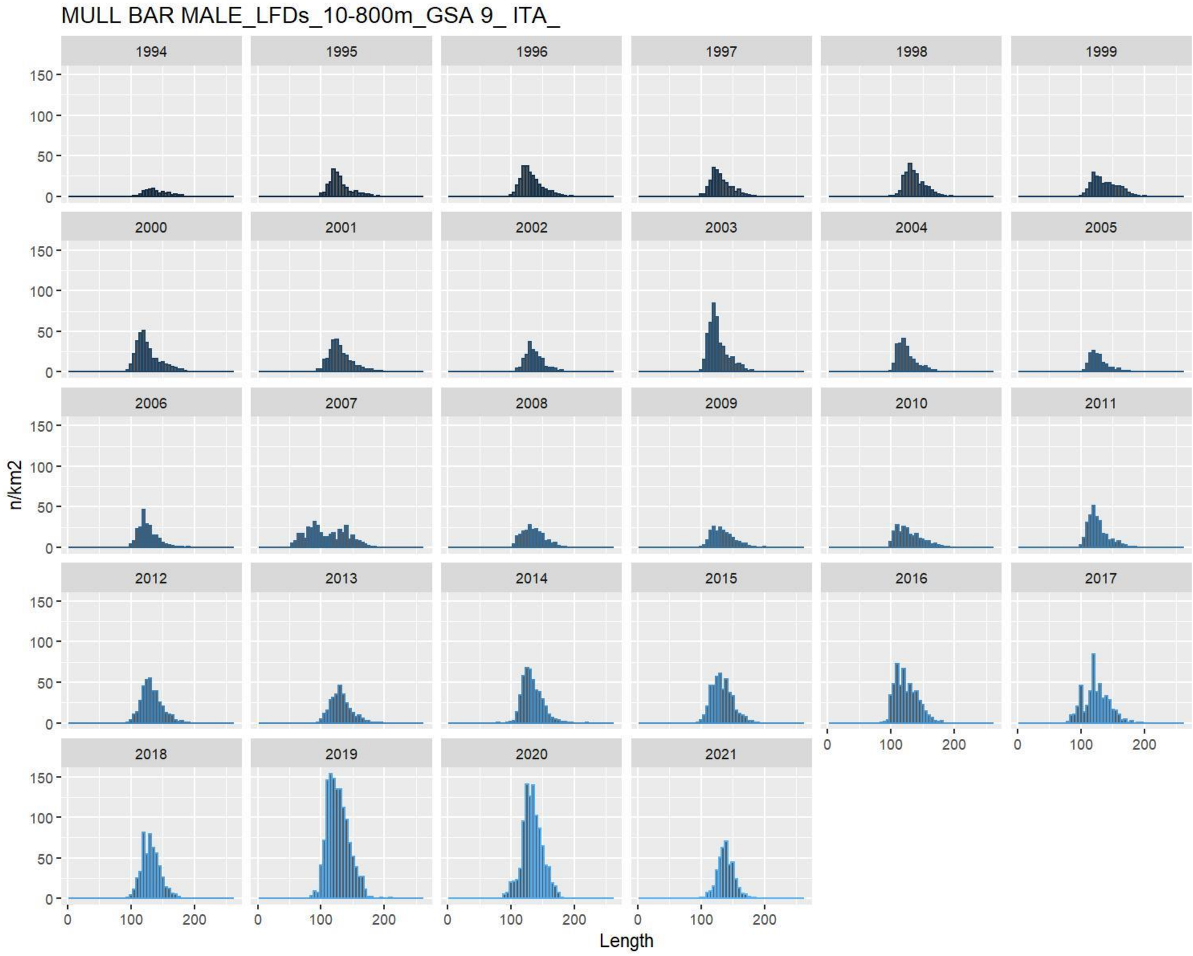


Figure 6.11.2.3.7 Red mullet in GSA 9: Size structure indices (males) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2021).

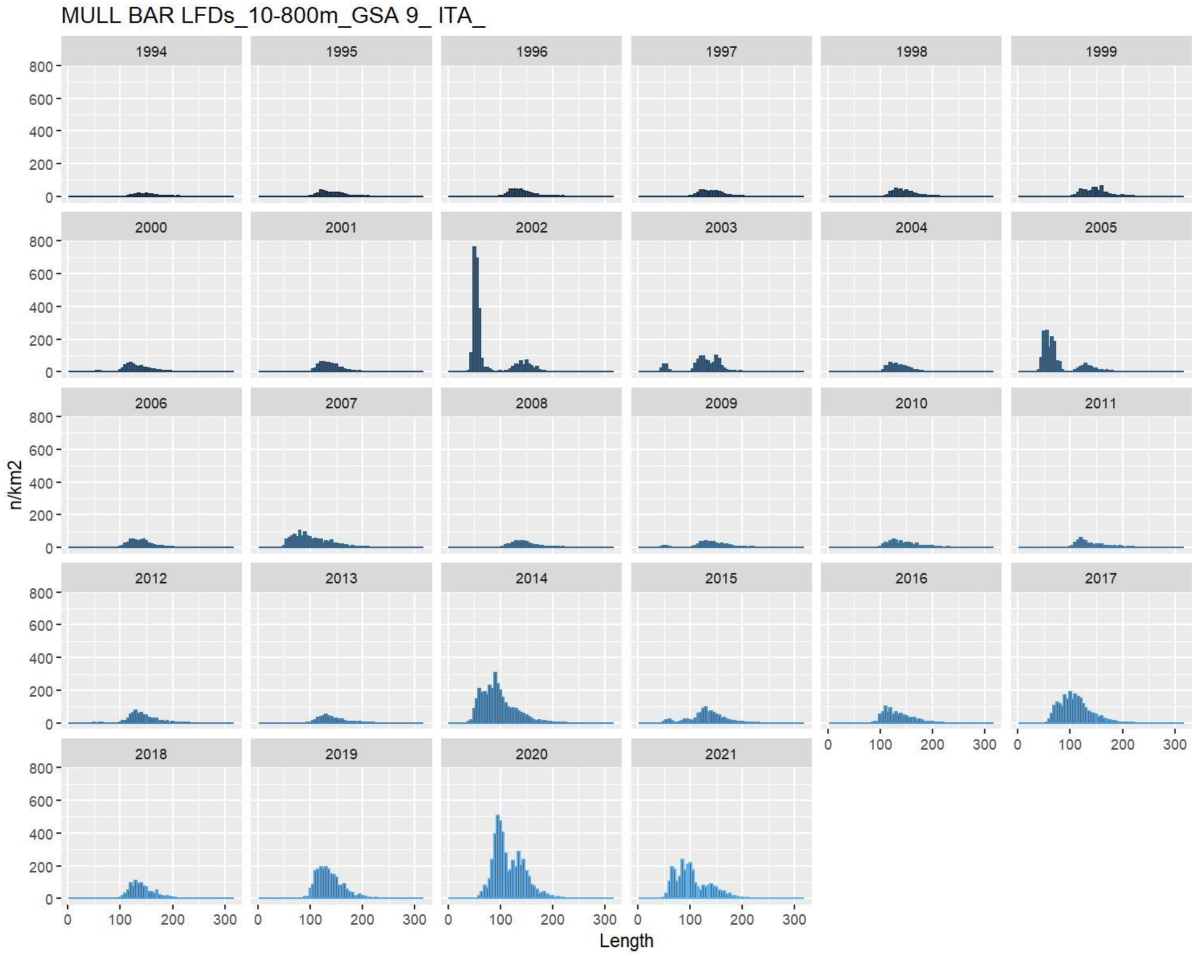


Figure 6.11.2.3.8 Red mullet in GSA 9: Size structure indices (total) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2021).

6.11.3 STOCK ASSESSMENT

The present assessment of red mullet in GSA 9 has been based on a4a model. The a4a model is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by gear. The method was developed within FLR framework.

Input data considered (landing, discard, age, maturity, MEDITS) originate from DCF Med&BS data call and cover the years 2003-2021.

Age slicing using a4aGr of the length frequency distributions of landing, discard and survey has been carried out by sex (in combination with sex ratio at length) using a4aGr model and then data were combined. The final catch at age data are shown in the figure 6.11.3.1. Age 4 in the survey index is a true age class, and not a plus group, while catches have a plus group at age 4.

Table 6.11.3.1 Red mullet in GSA 9: Values of catch at age per year used in the assessment.

	Age				
Year	0	1	2	3	4+
2003	2243.5	26164.3	7813.0	922.4	192.1
2004	2656.1	17894.3	3798.5	348.7	127.8
2005	2557.0	18915.2	6233.9	371.3	34.2
2006	3488.8	21489.7	9501.0	697.5	105.0
2007	2647.8	25080.5	9766.6	738.1	131.7
2008	2361.2	28134.1	4117.4	292.4	35.2
2009	2773.5	16550.7	6074.0	662.7	147.8
2010	432.5	14901.4	6063.9	657.1	152.6
2011	1252.4	16229.5	6477.4	801.9	119.5
2012	858.8	16089.3	5339.0	557.7	103.0
2013	7468.2	19987.5	5573.1	689.4	111.3
2014	12408.4	34057.9	8258.8	777.7	181.6
2015	14777.9	34932.4	8273.4	765.7	94.3
2016	419.6	26874.8	8939.3	909.2	175.0
2017	4267.2	37827.7	11214.7	1039.0	165.6
2018	1419.4	28304.9	9976.0	928.8	136.9
2019	935.7	18489.6	7216.9	759.0	119.8
2020	347.5	10057.8	4699.7	667.7	85.0
2021	1083.5	14265.4	7006.1	765.9	153.4

Total catches used in the assessment:

Year	Catches (t)
2003	1133.9
2004	625.4
2005	769.5
2006	1113.2
2007	1198.4
2008	800.1
2009	808.5
2010	783.1
2011	861.1
2012	733.2
2013	810.5
2014	1287.0
2015	1316.3
2016	1262.8
2017	1600.8
2018	1336.3
2019	942.1
2020	599.1
2021	853.4

Table 6.11.3.2 Red mullet in GSA 9: Values of mean weight at age per year used in the assessment.

	Age				
Year	0	1	2	3	4+
2003	0.006	0.024	0.049	0.087	0.139
2004	0.007	0.021	0.050	0.085	0.136
2005	0.007	0.024	0.041	0.078	0.149
2006	0.005	0.027	0.046	0.081	0.142
2007	0.006	0.026	0.047	0.078	0.141
2008	0.007	0.020	0.045	0.081	0.138
2009	0.005	0.024	0.052	0.084	0.148
2010	0.007	0.026	0.053	0.082	0.158
2011	0.005	0.025	0.057	0.086	0.128
2012	0.006	0.025	0.051	0.082	0.143
2013	0.005	0.020	0.055	0.086	0.139
2014	0.003	0.021	0.053	0.082	0.131
2015	0.004	0.022	0.050	0.079	0.131
2016	0.008	0.026	0.052	0.085	0.133
2017	0.006	0.024	0.051	0.083	0.129
2018	0.007	0.025	0.053	0.085	0.125
2019	0.005	0.026	0.053	0.080	0.149
2020	0.007	0.026	0.055	0.092	0.123
2021	0.006	0.026	0.055	0.096	0.154

Table 6.11.3.3 Red mullet in GSA 9: Survey index (MEDITS) values at age per year used in the assessment.

	Age			
Year	1	2	3	4
2003	679.5	166.7	14.8	1.3
2004	407.7	71.7	9.1	1.2
2005	308.5	60.4	7.3	1.1
2006	410.7	89.1	9.4	2.4
2007	668.6	124.0	17.8	1.6
2008	261.1	132.3	19.6	0.7
2009	266.7	127.1	21.1	1.6
2010	347.7	128.0	23.7	2.9
2011	311.7	106.1	16.5	1.0
2012	429.0	199.0	18.0	1.9
2013	318.8	127.0	15.8	1.0
2014	1632.8	213.5	18.8	0.7
2015	602.7	240.4	22.9	1.0
2016	687.7	209.5	16.2	1.2
2017	1620.6	188.0	13.3	1.9
2018	666.1	287.8	18.5	0.4
2019	1626.7	513.8	41.2	2.9
2020	3630.3	558.8	50.8	2.4
2021	1489.5	314.3	22.0	2.7

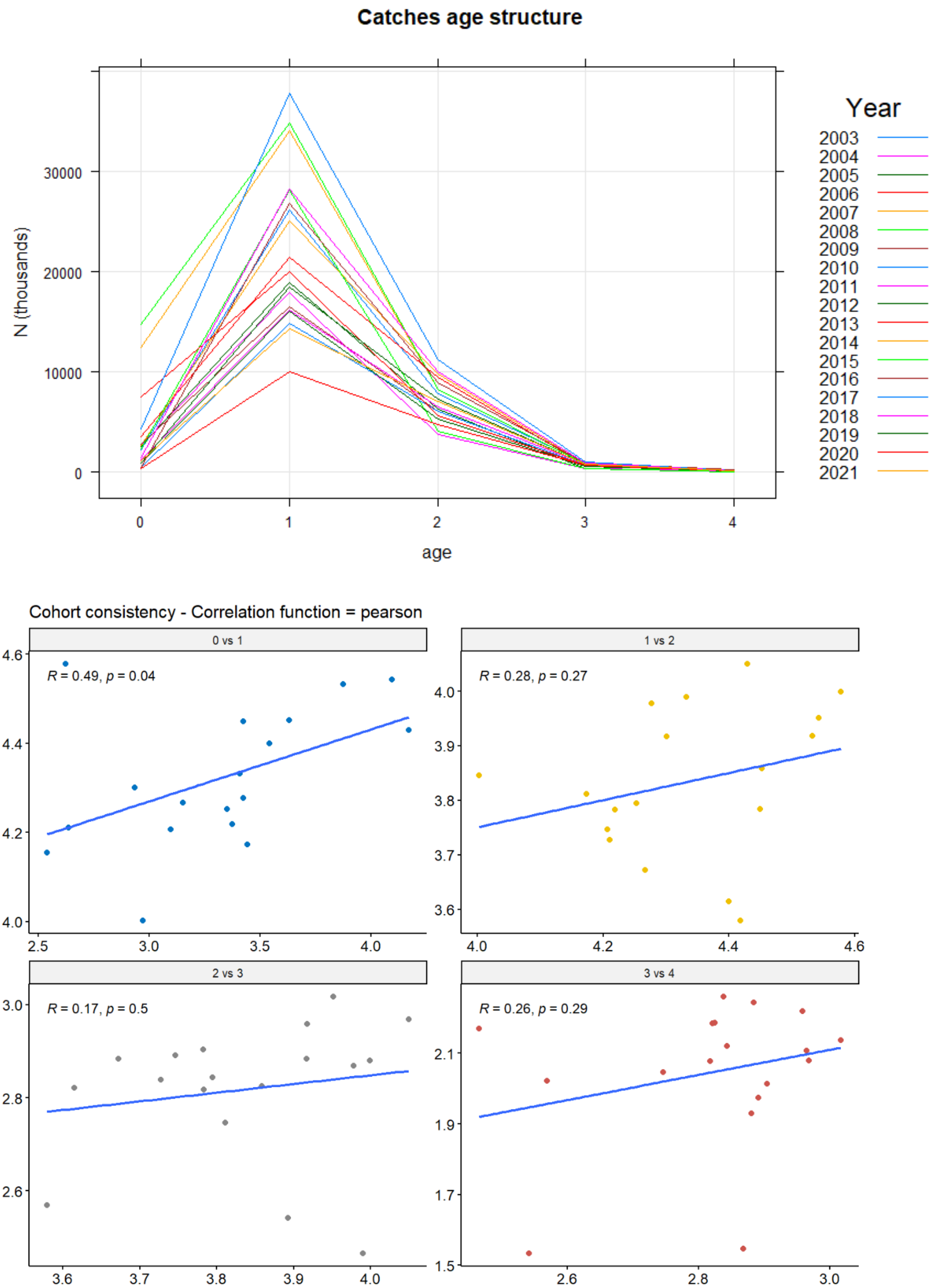
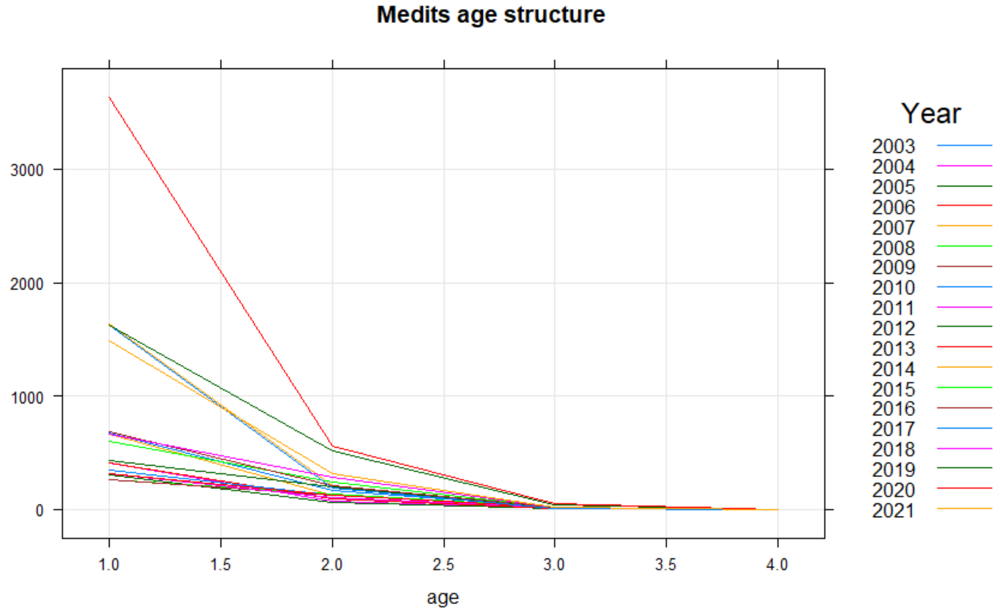


Figure 6.11.3.1 Red mullet in GSA 9: Catch-at-age data of red mullet in GSA9 used in assessment, and cohorts internal consistency.

Survey indices (density by age) from MEDITS were used considering that spring surveys are not designed to detect recruitment of red mullet. Recruitment (age class 0) was detected just in some years when surveys were carried out in late summer or autumn. Due to the variability of survey timing, age 0 class was not included in the tuning indices used for the assessment. MEDITS indices (density by age) are shown in figure 6.11.3.2.



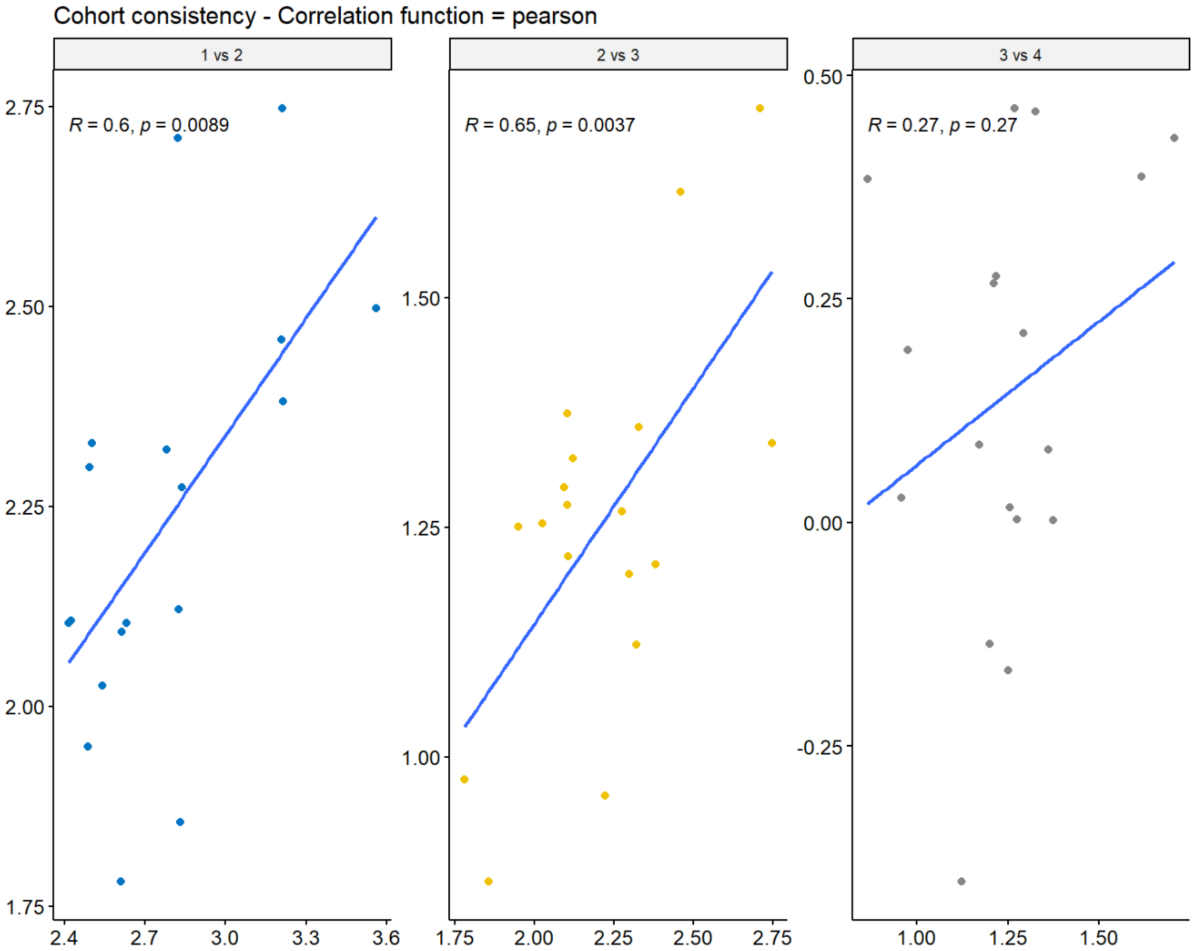


Figure 6.11.3.2 Red mullet in GSA 9: MEDITS indices describing density by age of red mullet in GSA9 by year, and cohorts internal consistency.

For the assessment purposes, the model selected by EWG 21-11 (and previous EWGs) was used also by EWG 22-09. The age0 was removed from the tuning index, as done in previous EWGs. An Fbar range between age1 and age3 was used, as in previous assessments.

Sub-models of the a4a assessment used for MUT9 at EWG 21-11:

fmodel: ~s(replace(age, age > 2, 2), k = 3) + s(year, k = 8)

srmodel: ~geomean(CV = 0.3)

n1model: ~s(age, k = 3)

qmodel: ~factor(replace(age, age > 2, 2))

vmodel:

catch: ~s(age, k = 3)

MEDITS_SA09: ~1

Summary of the model fit using the fitSumm command:

nopar 39

nlogl 8.798772e+01

maxgrad 1.850879e-06
nobs 171
gcv 3.104785e-01
convergence 0.000000e+00
accrate NA
nlogl_comp1 2.842970e+01
nlogl_comp2 6.130950e+01
nlogl_comp3 -1.751520e+00

The results and diagnostics of the assessment model are shown below.

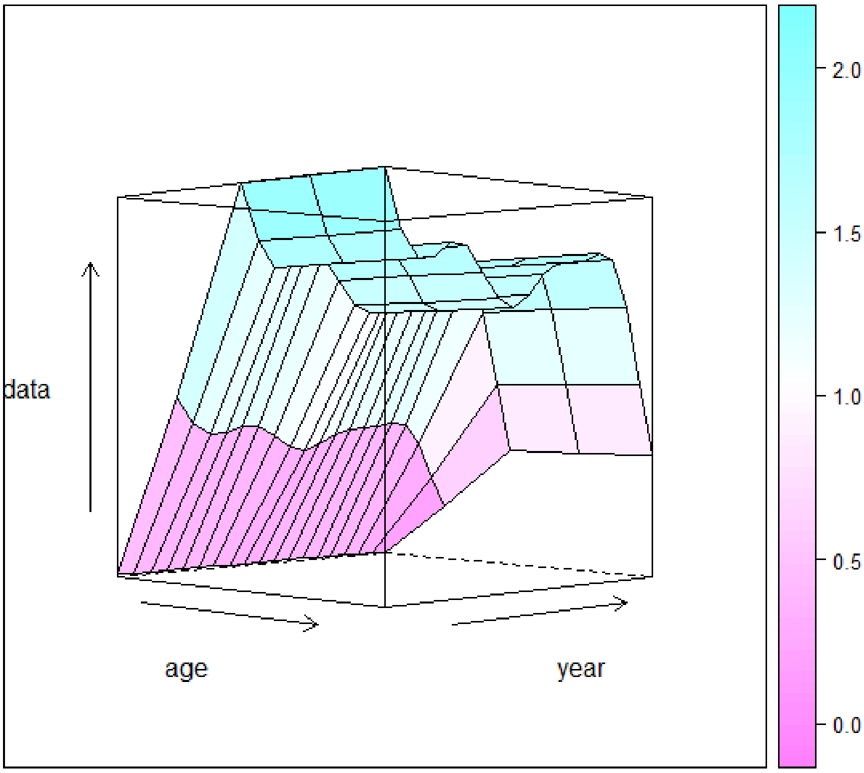


Figure 6.11.3.3 Red mullet in GSA 9: 3D-plot of the F-at-age for red mullet in GSA9.

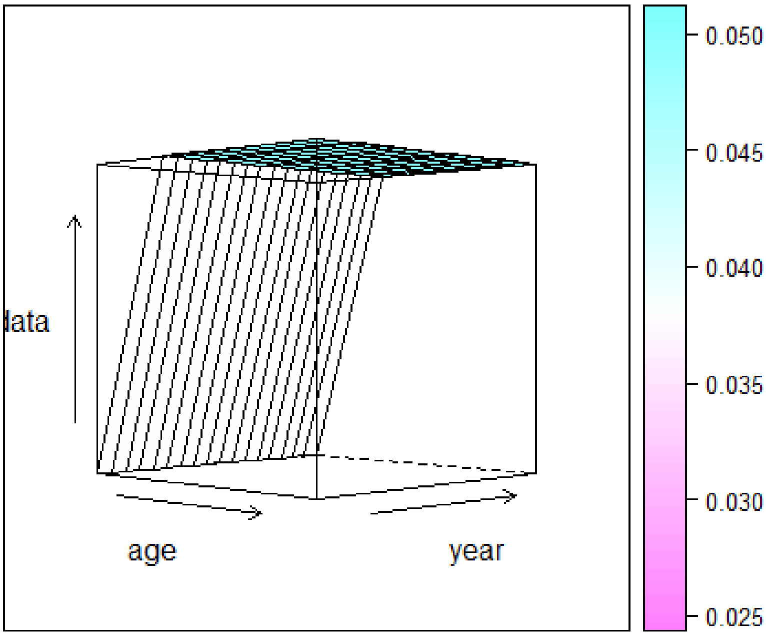


Figure 6.11.3.4 Red mullet in GSA 9: 3D-plot of the catchability of the MEDITS survey for red mullet in GSA9.

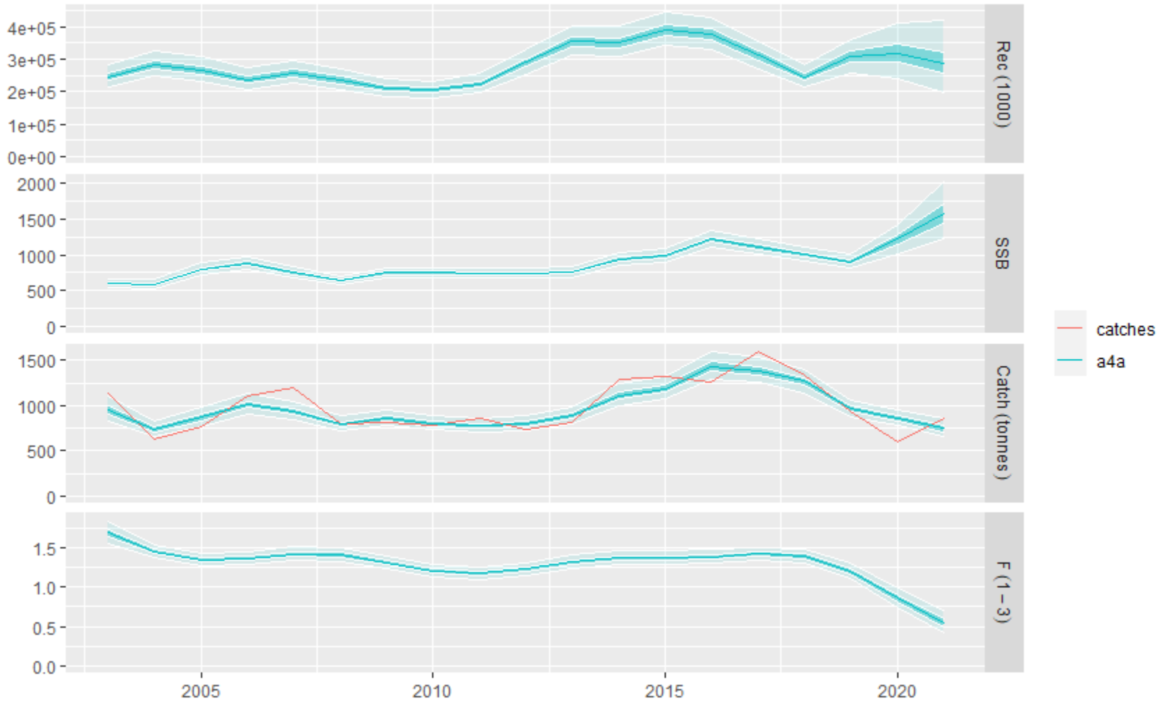


Figure 6.11.3.5 Red mullet in GSA 9: Results of the best a4a model for red mullet in GSA9. The observed catches are shown by the red line.

The results of the retrospective analysis are shown in Figure 6.11.3.6.

The Mohn' rho for F_{bar1-3}, SSB and recruitment are shown below:

fbar	ssb	rec
-0.20	0.25	-0.12

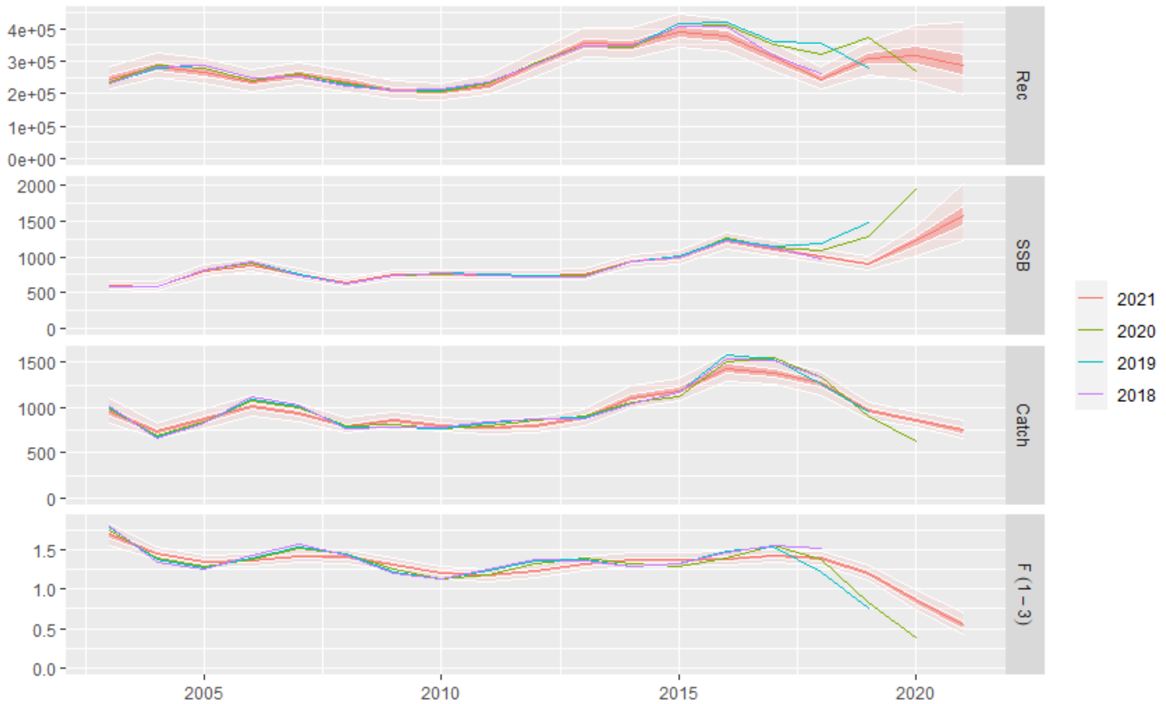


Figure 6.11.3.6 Red mullet in GSA 9: Retrospective analysis of the selected a4a model for red mullet in GSA9. Confidence intervals are also shown.

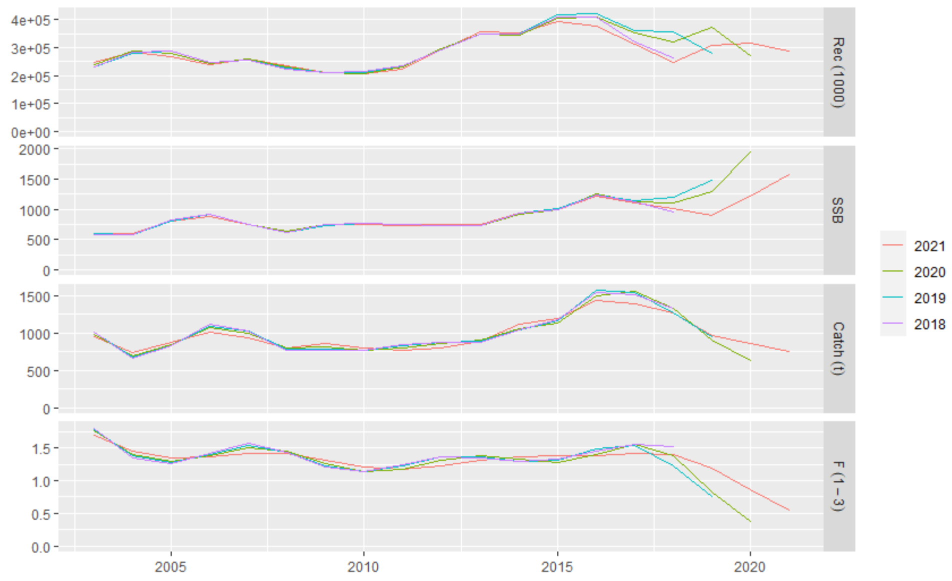


Figure 6.11.3.6bis Red mullet in GSA 9: Retrospective analysis of the selected a4a model for red mullet in GSA9.

The residuals of the catch and abundance indices related to the outcomes of the best run do not show any particular trend, and they are shown in Figures 6.11.3.7-6.11.3.13. The cryptic biomass (% of SSB in the plus group) was also investigated, and resulted to be always lower than 5% of the total SSB.

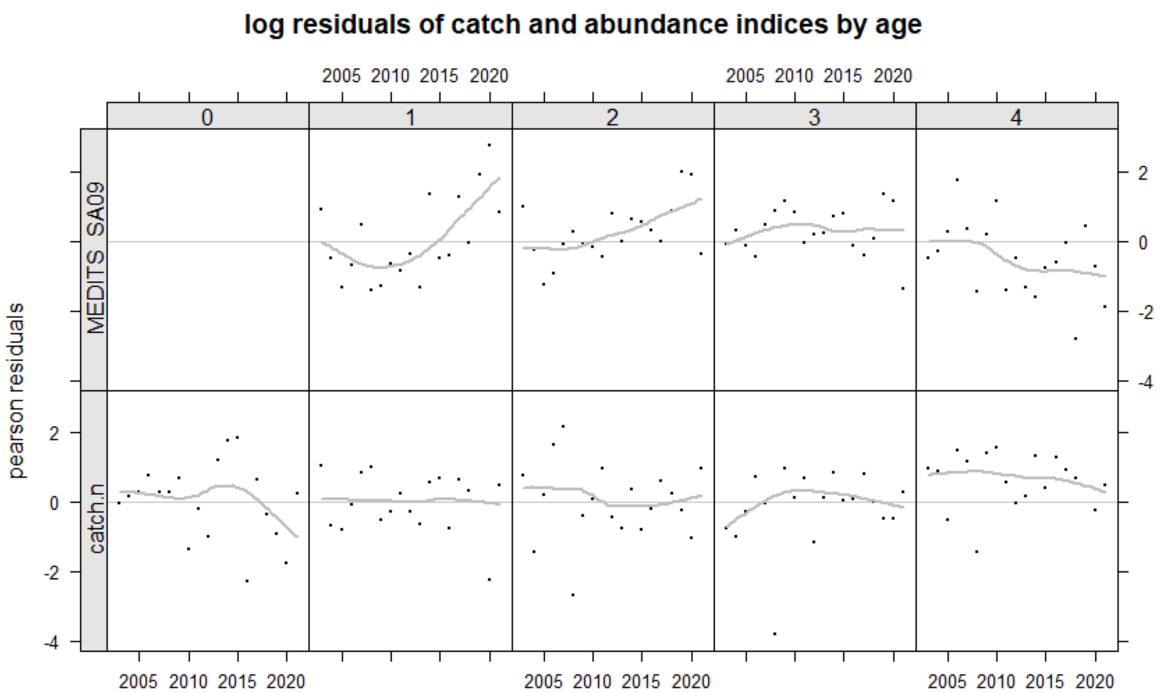


Figure 6.11.3.8 Red mullet in GSA 9: Pearson residuals of catch and abundance indices for red mullet in GSA9.

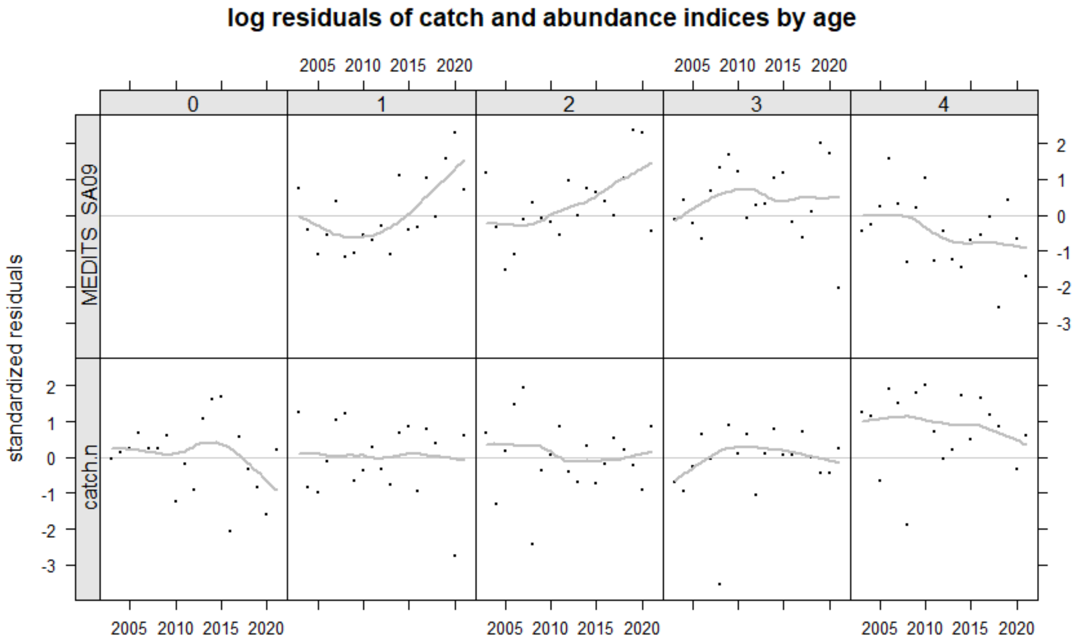


Figure 6.11.3.9 Red mullet in GSA 9: Log residuals of catch and abundance indices for red mullet in GSA9.

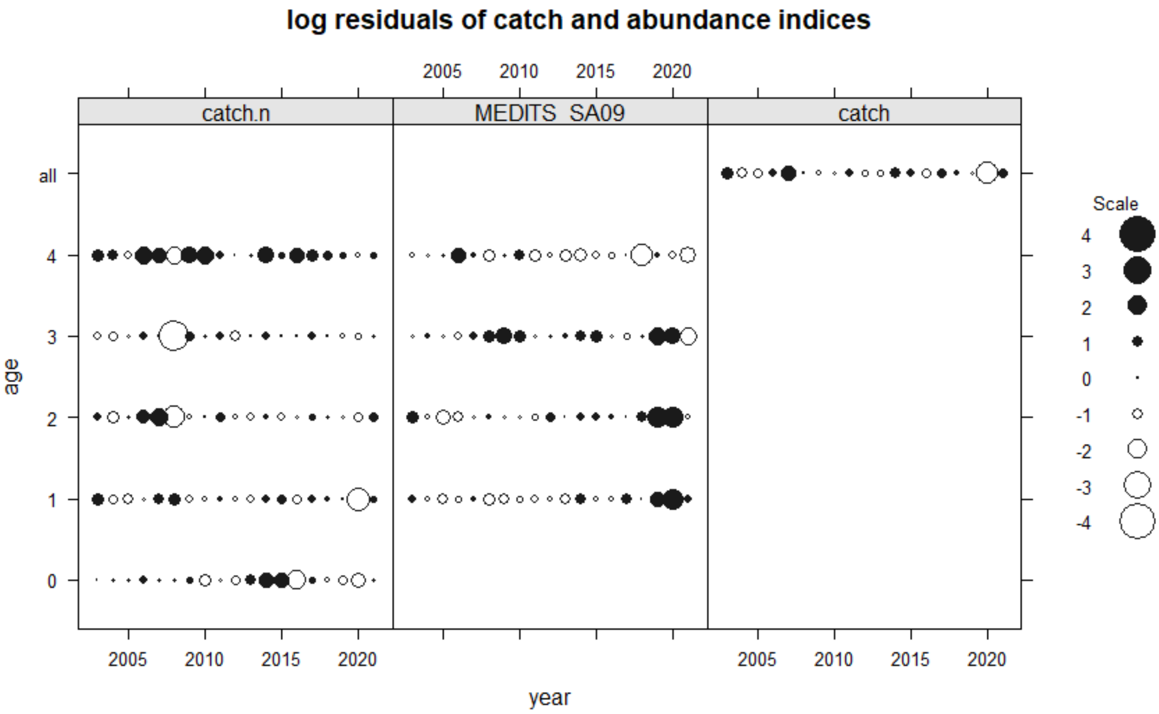


Figure 6.11.3.10 Red mullet in GSA 9: Bubble plot of the log residuals of catch and abundance indices for red mullet in GSA9.

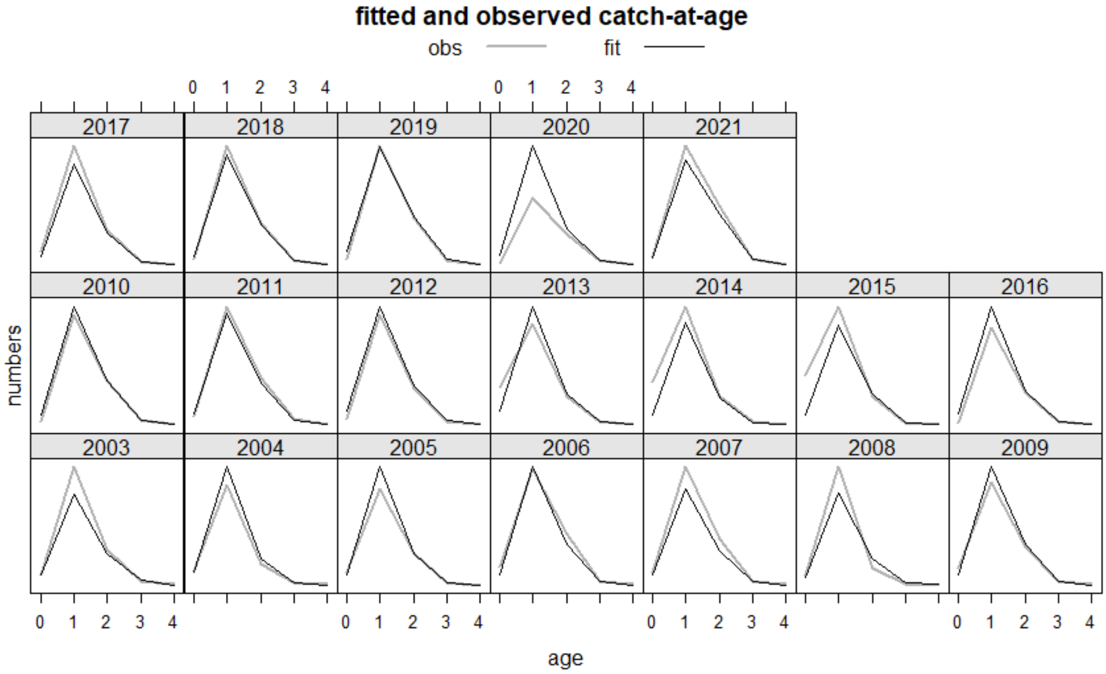


Figure 6.11.3.12 Red mullet in GSA 9: Fitting of the catch-at-age data for red mullet in GSA9.

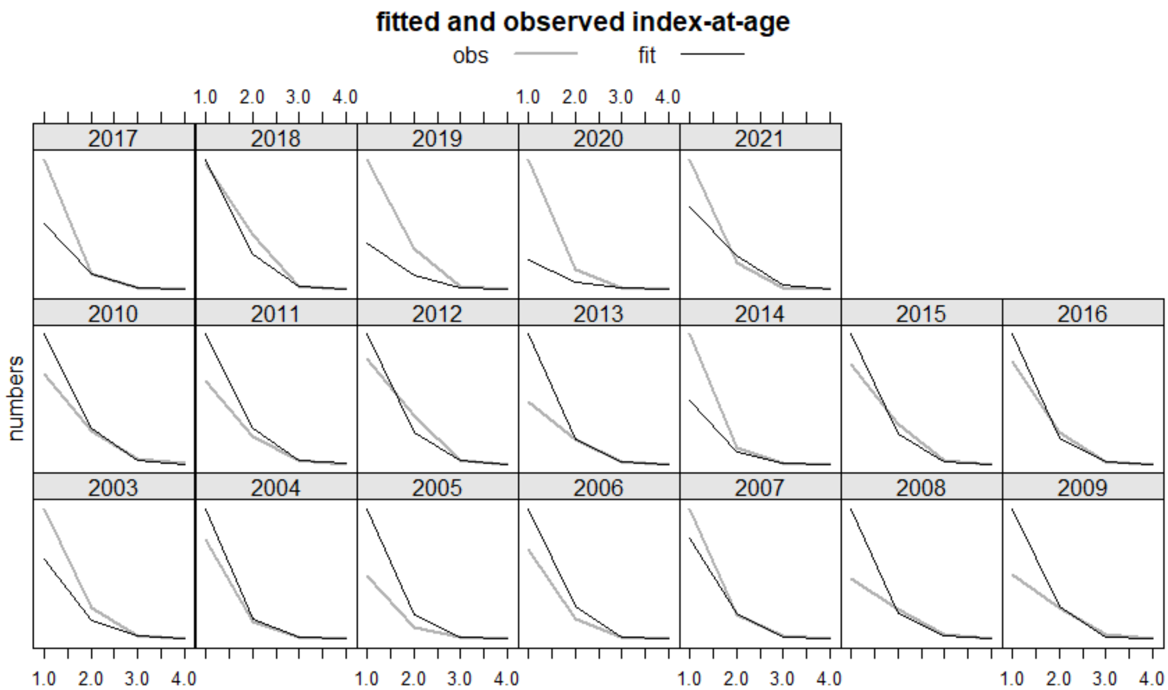


Figure 6.11.3.13 Red mullet in GSA 9: Fitting of the numbers-at-age data of the MEDITS survey for red mullet in GSA9.

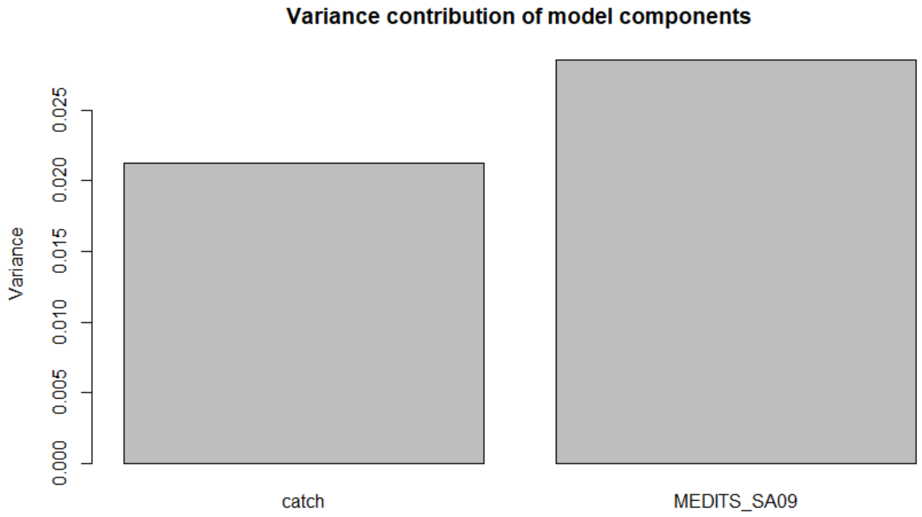


Figure 6.11.3.14 Red mullet in GSA 9: Variance contribution of model components: catches and survey for red mullet in GSA9.

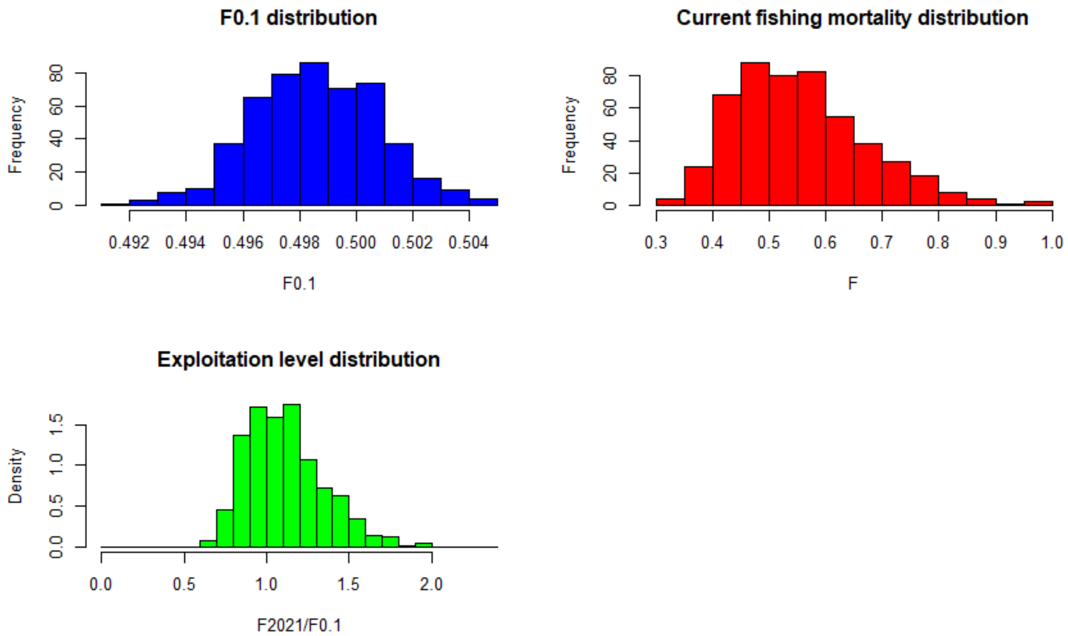


Figure 6.11.3.15 Red mullet in GSA 9: Histograms of probability for $F_{0.1}$, Fcurr and level of exploitation (Fcurr/F01 ratio) values for red mullet in GSA9.

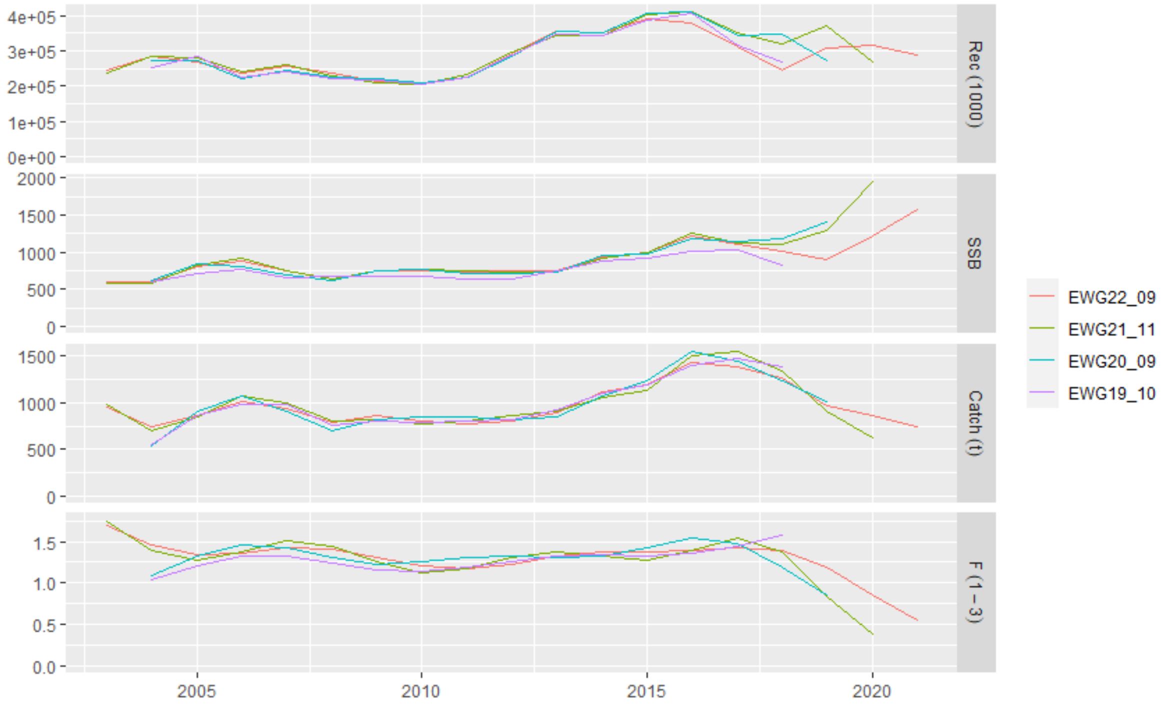


Figure 6.11.3.16 Red mullet in GSA 9: comparison among the assessment results obtained at EWG 19-10, EWG 20-09, EWG 21-11 and EWG 22-09.

A sensitivity analysis was performed on the number of knots (k, ranging from 6 to 12) in the smoother of the variable year in the F sub-model.

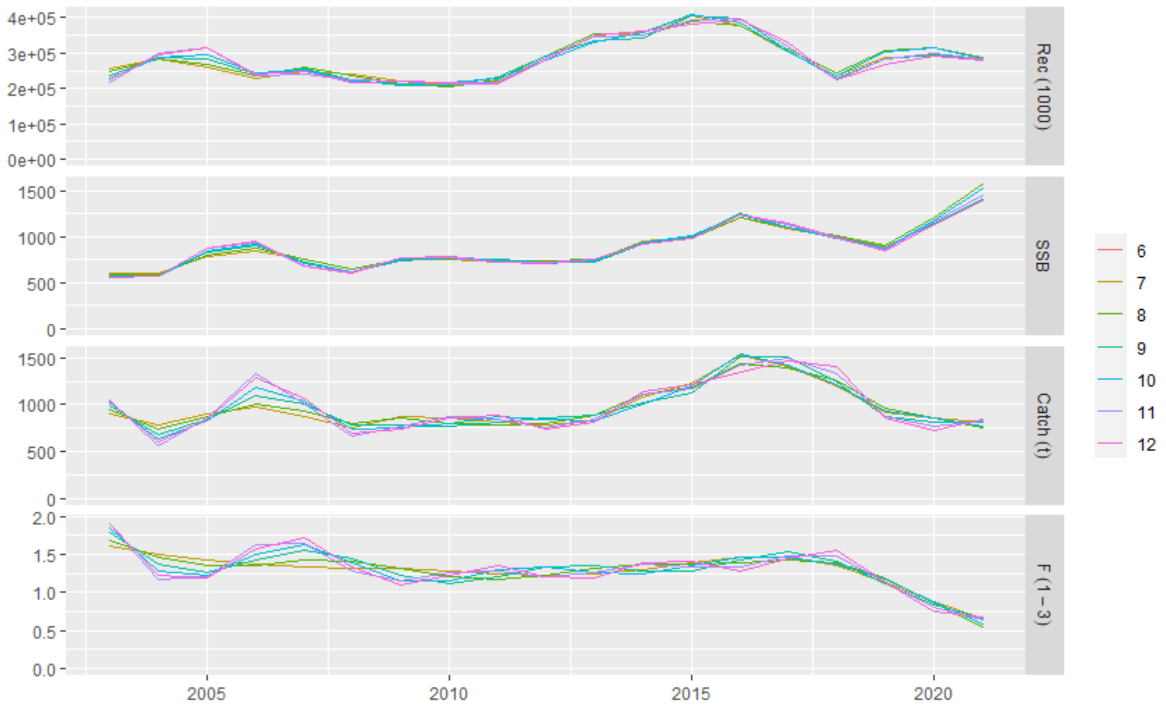


Figure 6.11.3.17 Red mullet in GSA 9: Outputs of model runs with different k values on the smoother on year in the fmodel.

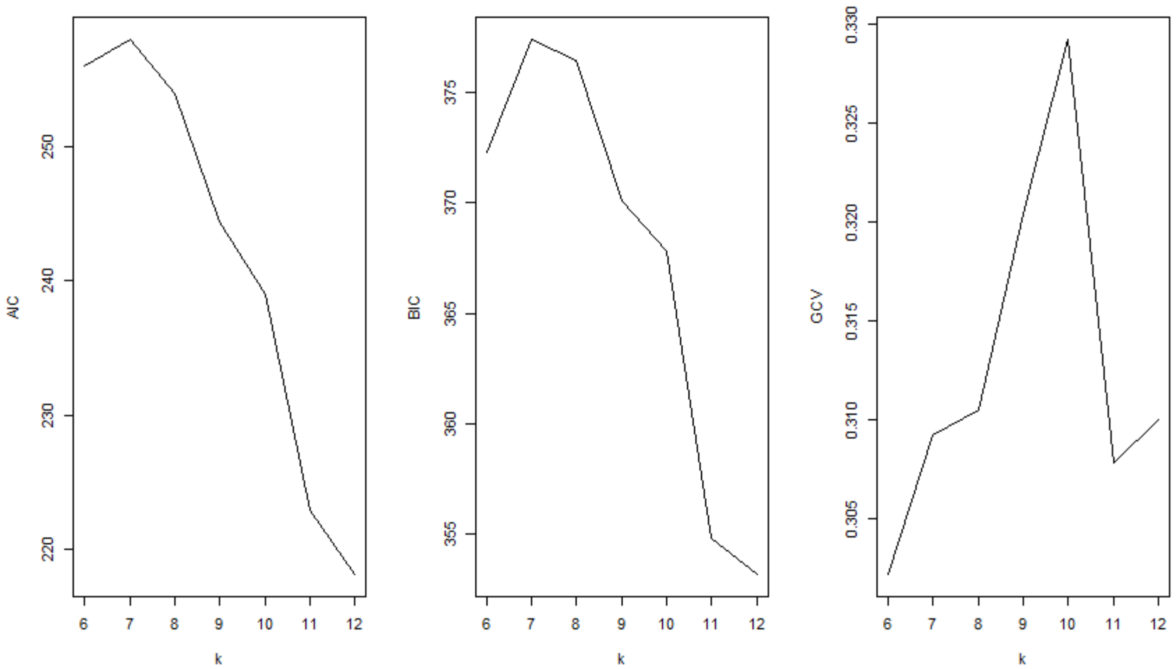


Figure 6.11.3.18 Red mullet in GSA 9: AIC, BIC and GCV values estimated on a range of k values of the smoother on year of the fmodel.

Final assessment outcomes are given in Tables 6.11.3.4-6.11.3.6.

Table 6.11.3.4 Red mullet in GSA 9: Final results of the red mullet assessment in GSA9.

Year	Recruitment age 0 ('000)	High	Low	SSB (t)	High	Low	Catch (t)	F_{bar} ages 1-3	High	Low
2003	246764	273523	220005	596.6	643.3	549.9	951.2	1.69	1.8	1.6
2004	284310	315021	253599	591.9	641.6	542.2	738.7	1.46	1.5	1.4
2005	266939	294534	239344	798.2	866.2	730.2	869.6	1.35	1.4	1.3
2006	237492	262357	212627	880.2	953.0	807.4	1011.8	1.36	1.4	1.3
2007	258455	285671	231239	751.8	810.7	692.9	935.9	1.42	1.5	1.4
2008	236718	260368	213068	643.6	692.5	594.7	794.0	1.41	1.5	1.3
2009	212170	234020	190320	748.6	802.9	694.3	860.5	1.31	1.4	1.2
2010	205588	227325	183851	751.7	806.8	696.6	801.3	1.21	1.3	1.1
2011	224424	246682	202166	739.1	793.7	684.5	778.3	1.17	1.2	1.1
2012	290647	321064	260230	742.1	796.8	687.4	800.7	1.23	1.3	1.2
2013	355368	390846	319890	753.3	810.8	695.8	888.5	1.32	1.4	1.3
2014	352008	387490	316526	936.6	1009.4	863.8	1112.5	1.37	1.4	1.3
2015	390905	431923	349887	984.2	1058.7	909.7	1190.0	1.37	1.4	1.3
2016	377440	416906	337974	1215.8	1310.3	1121.3	1433.9	1.39	1.5	1.3
2017	311552	342862	280242	1110.1	1193.0	1027.2	1386.9	1.42	1.5	1.4
2018	245416	270752	220080	1005.4	1078.3	932.5	1265.4	1.40	1.5	1.3
2019	307061	347646	266476	899.9	972.4	827.4	964.5	1.20	1.3	1.1
2020	317177	386072	248282	1212.1	1367.3	1056.9	863.8	0.86	0.9	0.8
2021	288186	370508	205864	1573.3	1885.8	1260.8	750.4	0.54	0.7	0.4

Table 6.11.3.5 Red mullet in GSA 9: Stock numbers at age for red mullet in GSA 9.

	Age				
Year	0	1	2	3	4+
2003	246764.2	45227.42	10020.37	1513.21	155.757
2004	284309.8	52965.53	7159.326	642.203	115.156
2005	266939	61181.76	9582.825	607.764	69.383
2006	237492.4	57513.59	11787.47	928.503	70.662
2007	258454.6	51161.61	10993.16	1123.208	102.407
2008	236717.8	55641.72	9463.854	977.759	117.312
2009	212169.7	50967.05	10341.97	850.254	105.979
2010	205588.2	45731.79	10027.41	1047.224	104.318
2011	224424.2	44365.58	9565.51	1154.949	142.777
2012	290647.4	48447.26	9448.922	1144.429	167.267
2013	355368.1	62704.36	9993.115	1056.84	158.167
2014	352007.5	76591.7	12291.33	1004.095	131.63
2015	390904.8	75824.44	14578.69	1160.97	115.597
2016	377440.1	84198.37	14391.95	1368.863	129.029
2017	311552	81288.52	15881.84	1333.682	149.396
2018	245416.3	67071.82	15022.83	1409.827	141.779
2019	307061.3	52847.49	12561.2	1371.365	152.475
2020	317176.5	66269.01	11105.26	1460.977	190.863
2021	288186.1	68712.84	16951.33	1953.295	313.077

Table 6.11.3.6 Red mullet in GSA 9: Fishing mortality at age for red mullet in GSA 9.

	Age				
Year	0	1	2	3	4+
2003	0.019	0.973	2.047	2.047	2.047
2004	0.016	0.840	1.766	1.766	1.766
2005	0.015	0.777	1.634	1.634	1.634
2006	0.015	0.785	1.651	1.651	1.651
2007	0.016	0.818	1.720	1.720	1.720
2008	0.016	0.813	1.710	1.710	1.710
2009	0.015	0.756	1.590	1.590	1.590
2010	0.013	0.695	1.461	1.461	1.461
2011	0.013	0.677	1.423	1.423	1.423
2012	0.014	0.709	1.491	1.491	1.491
2013	0.015	0.760	1.598	1.598	1.598
2014	0.015	0.789	1.660	1.660	1.660
2015	0.015	0.792	1.666	1.666	1.666
2016	0.015	0.798	1.679	1.679	1.679
2017	0.016	0.818	1.722	1.722	1.722
2018	0.016	0.805	1.694	1.694	1.694
2019	0.013	0.690	1.452	1.452	1.452
2020	0.010	0.493	1.038	1.038	1.038
2021	0.006	0.313	0.658	0.658	0.658

6.11.4 Reference Points

The STECF EWG recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the assessment.

Values of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 0.50. Current F values (2021), as calculated by model a4a, is 0.54 indicating that the stock is in overexploitation.

The STECF EWG 19-10 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4.

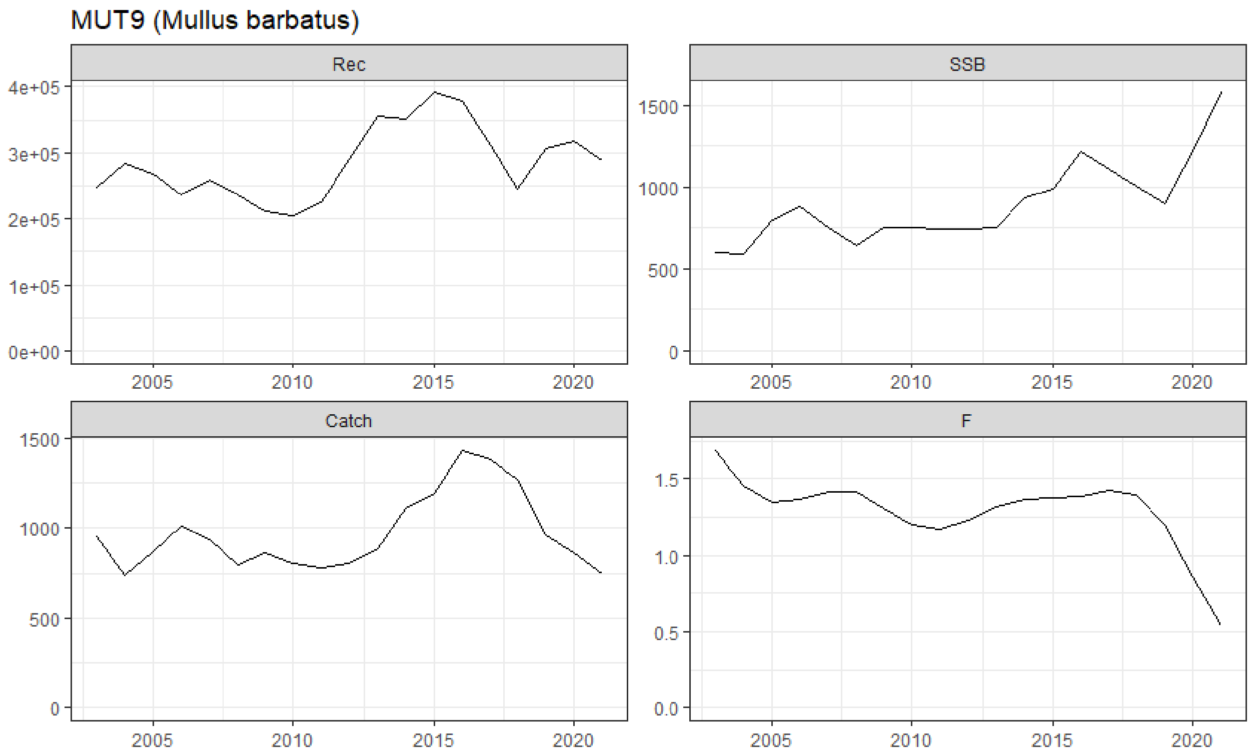


Figure 6.11.4.1. Red mullet in GSA 9. Stock summary from the final a4a model.

An overview of the input data used in the assessment and outcomes is provided in Figures 6.11.4.2-6.11.4.3

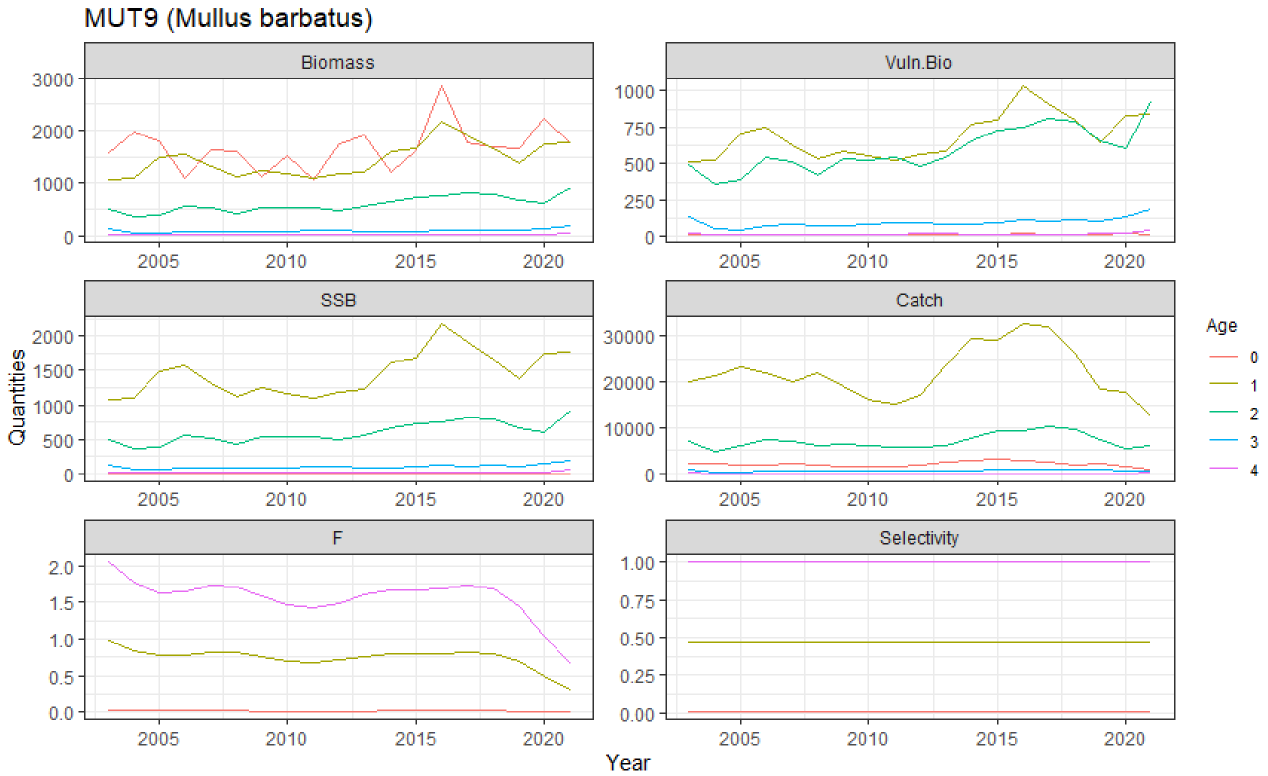


Figure 6.11.4.2. Red mullet in GSA 9. Stock assessment trajectories at age.

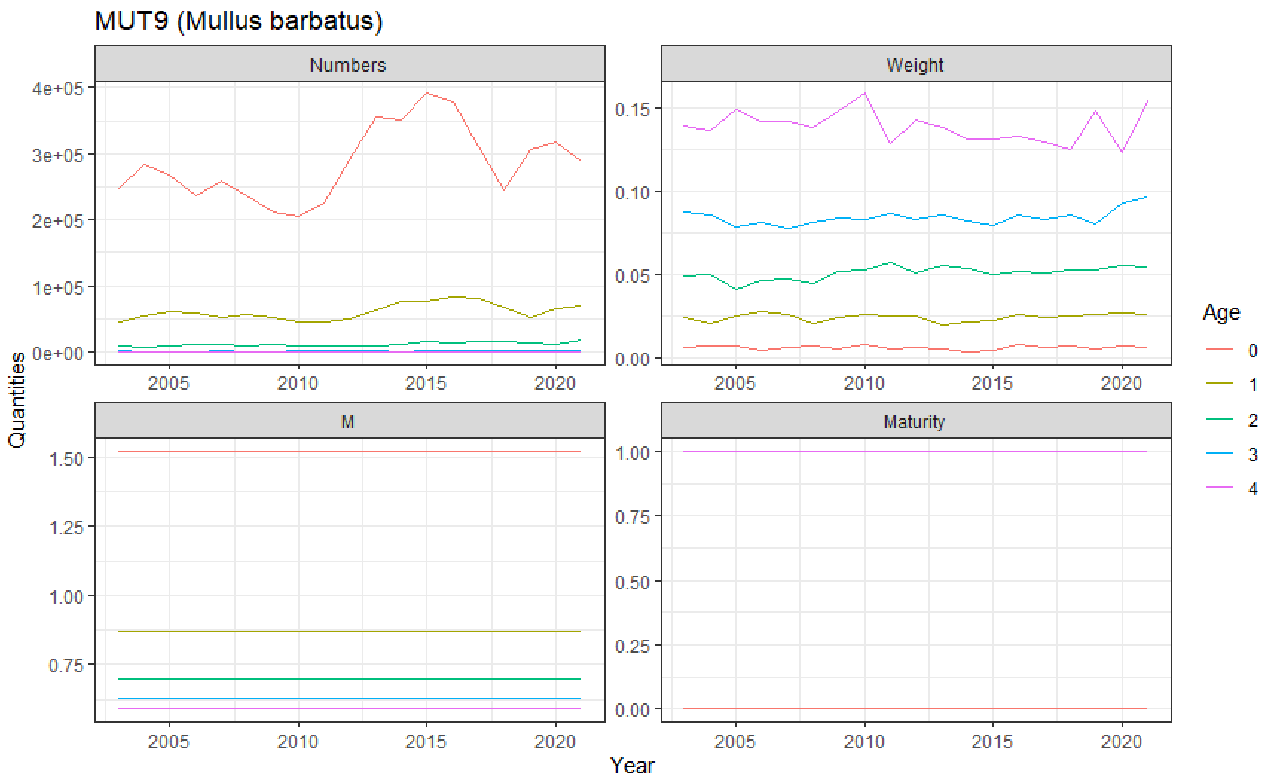


Figure 6.11.4.4. Red mullet in GSA 9. Stock biology trajectories at age.

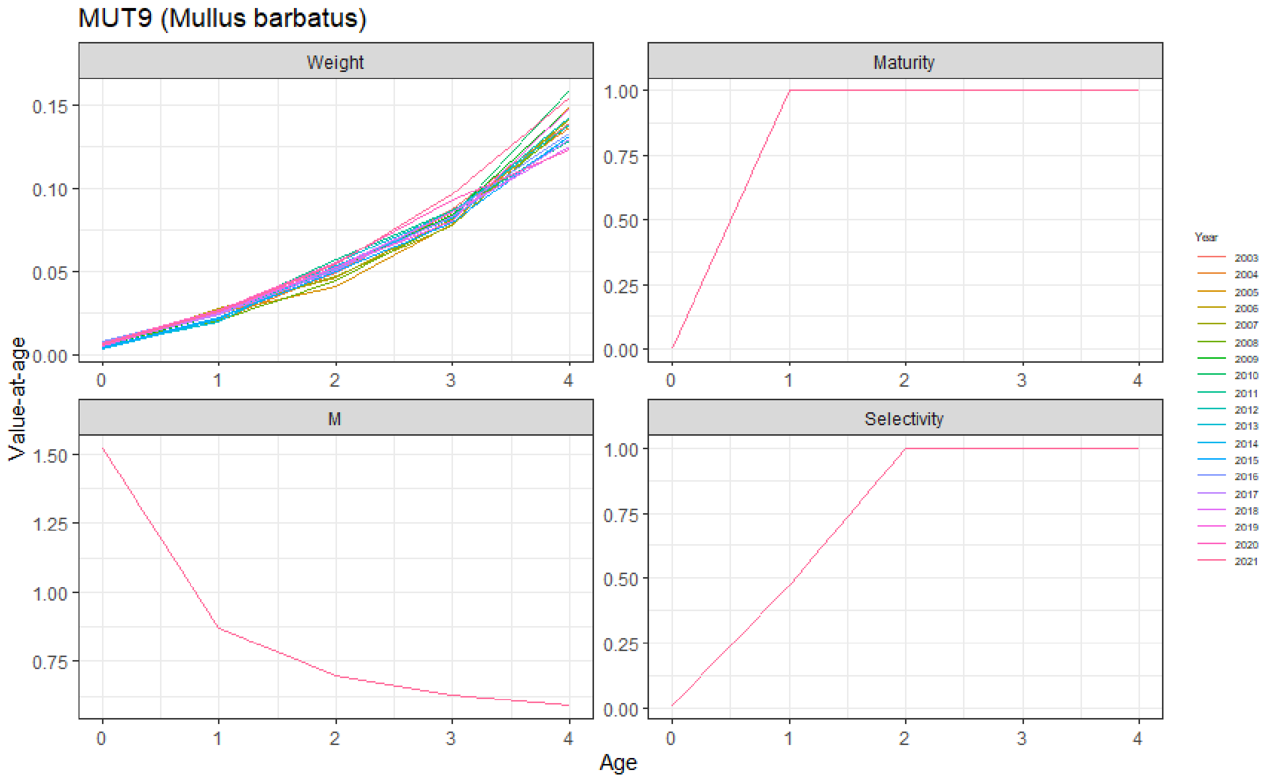


Figure 6.11.4.3. Red mullet in GSA 9. Annual stock quantities at age.

4.11.2 Exploration analysis

An exploratory per-recruit analysis was performed using the stock object containing the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.11.4.1 and Figure 6.11.4.4.

Table 6.11.4.1. Red mullet in GSA 9. Per-recruit reference points.

$F_{0.1}$	B_{trg}	B_{lim}	F_{lim}	Yeq	B_0
0.50	0.0066	0.00194	2.49	0.00299	0.01589

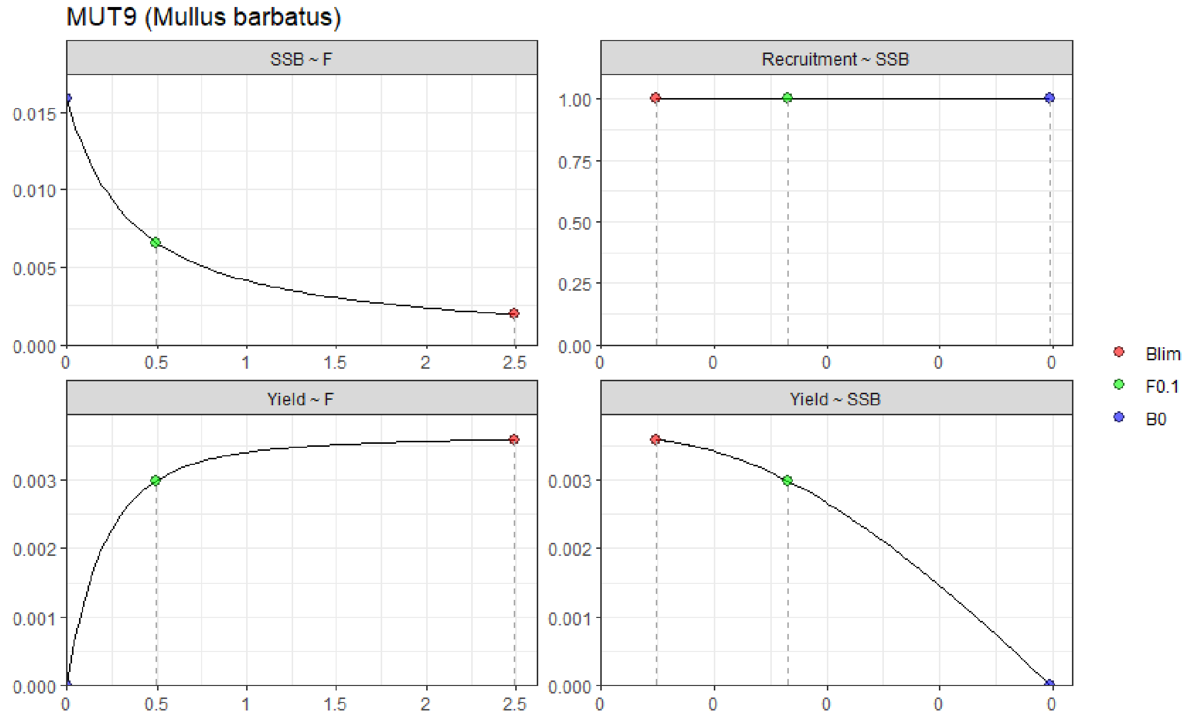


Figure 6.11.4.4. Red mullet in GSA 9. Per-recruit analysis.

Figure 6.11.4.7 is showing the trajectories of the assessment outputs against the per-recruit reference points. SSB has been fluctuation and rising towards the biomass at $F_{0.1}$ ($B_{F0.1}$) and is quite above B_{lim} in recent years, with a sharper increase in the last year. At the same time, F has been well above $F_{0.1}$, though decreasing towards $F_{0.1}$in the last years.

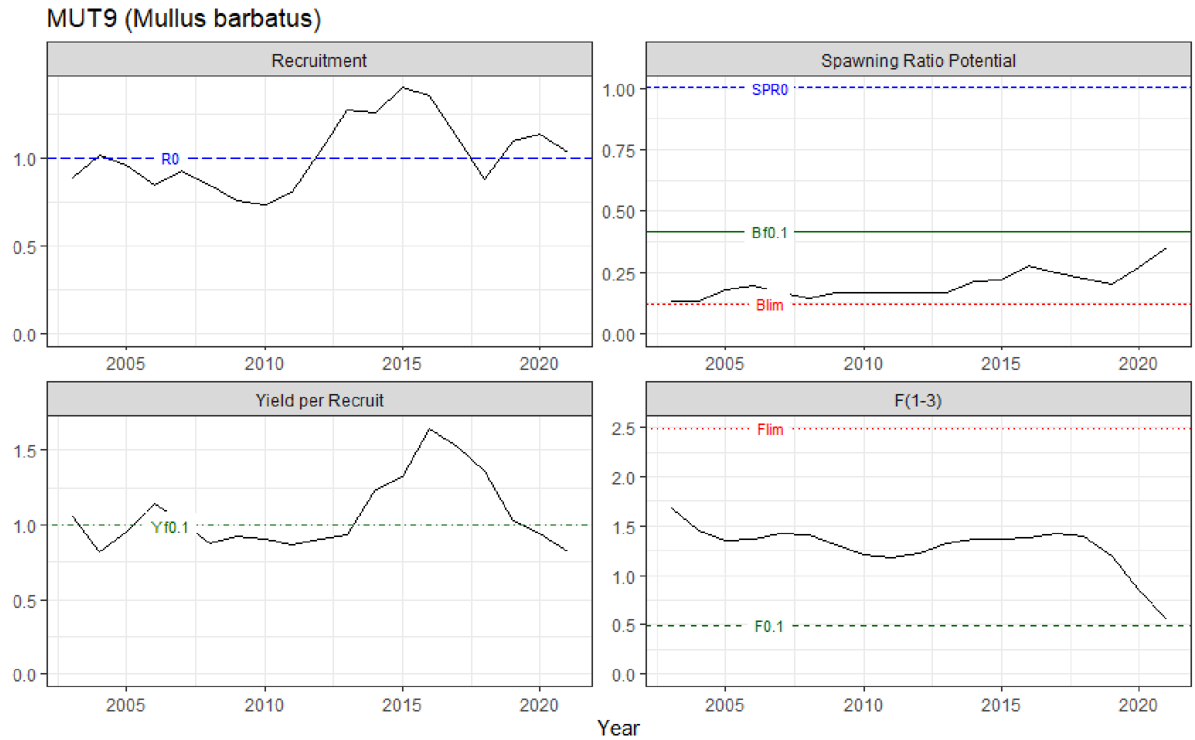


Figure 6.11.4.5. Red mullet in GSA 9. Per-recruit analysis: outcomes of the a4a assessment compared against the per-recruit reference points.

Figure 6.11.4.6 shows the contribution in terms of spawning biomass per recruit (SPR) by age class in the current situation (red bars) compared to an unfished scenario.

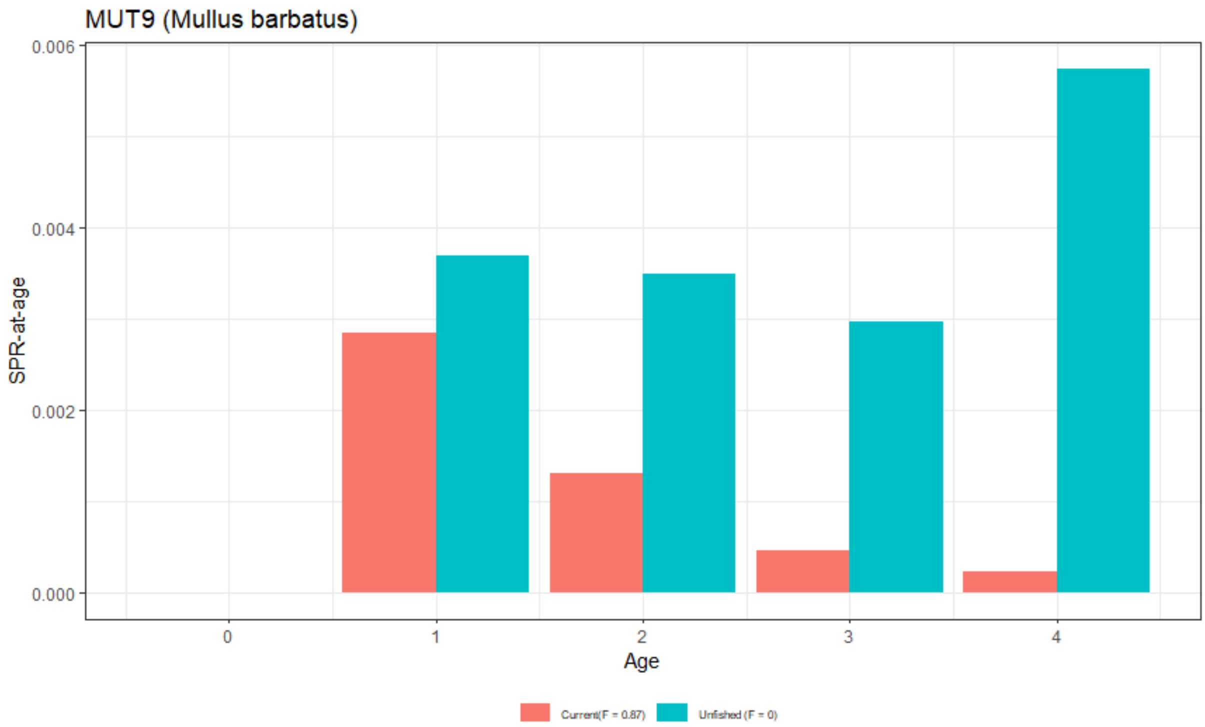


Figure 6.11.4.6. Red mullet in GSA 9. Comparison of the spawning biomass per recruit SPR_F at current F (average of last 3 years) and SPR_0 with F = 0.

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)

2. Hockey-Stick (model=segreg)

3. Beverton-Holt (model=bevholtSV)

4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ration potential SRPlim = $SPRlim/SPR_0$. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP0.1−20 by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y. The Beverton-Holt model was run on the stock object with the full time series (2003-2021), and with reduced time series (BH1 up to 2020, and BH2 up to 2019) to check for consistency in the steepness.

Table 6.11.4.2. Red mullet in GSA 9. Summary of the four SR models.

	S	sigmaR	R_0	rho	B_0
Geometric mean	NA	0.1923939	279682.9	0.7371945	4444.177
Hockey stick	NA	0.1872625	279682.9	0.7371945	4444.177
Beverton-Holt	0.7389156	0.1571048	454455.2	0.5207759	7221.321
BH1 (data up to 2019)	0.6966122	0.1546488	555803.4	0.4729503	8503.58
BH2 (data up to 2018)	0.6855947	0.1584046	595819.5	0.473474	8973.413
Ricker	1.200136	0.1783381	219885	0.5572907	3493.986

The observed SR data are sitting on the right part of the R-SSB plot, and the breakpoint estimated by the HS model is lower that the observed values.

The results show that the recruitment variation is fairly low, e.g. σr = 0.16 for the Beverton-Holt model, associated with a steepness of s = 0.73. The predicted recruitment by Hockey-Stick, Beverton-Holt and Ricker models follow the observed recruitment pattern over time, however, the three models differ largely in scale of their R_0 and B_0 estimates. Information on the slope to the origin is not found within the observed SSB Recruitment results from the assessment.

The break-point of the Hockey-Stick is estimated at b = 461.5 t, and the corresponding R_0 is equal to the one estimated by the geometric mean recruitment. The breakpoint from the Hockey-Stick comes from the control setting and is not informed by the data.

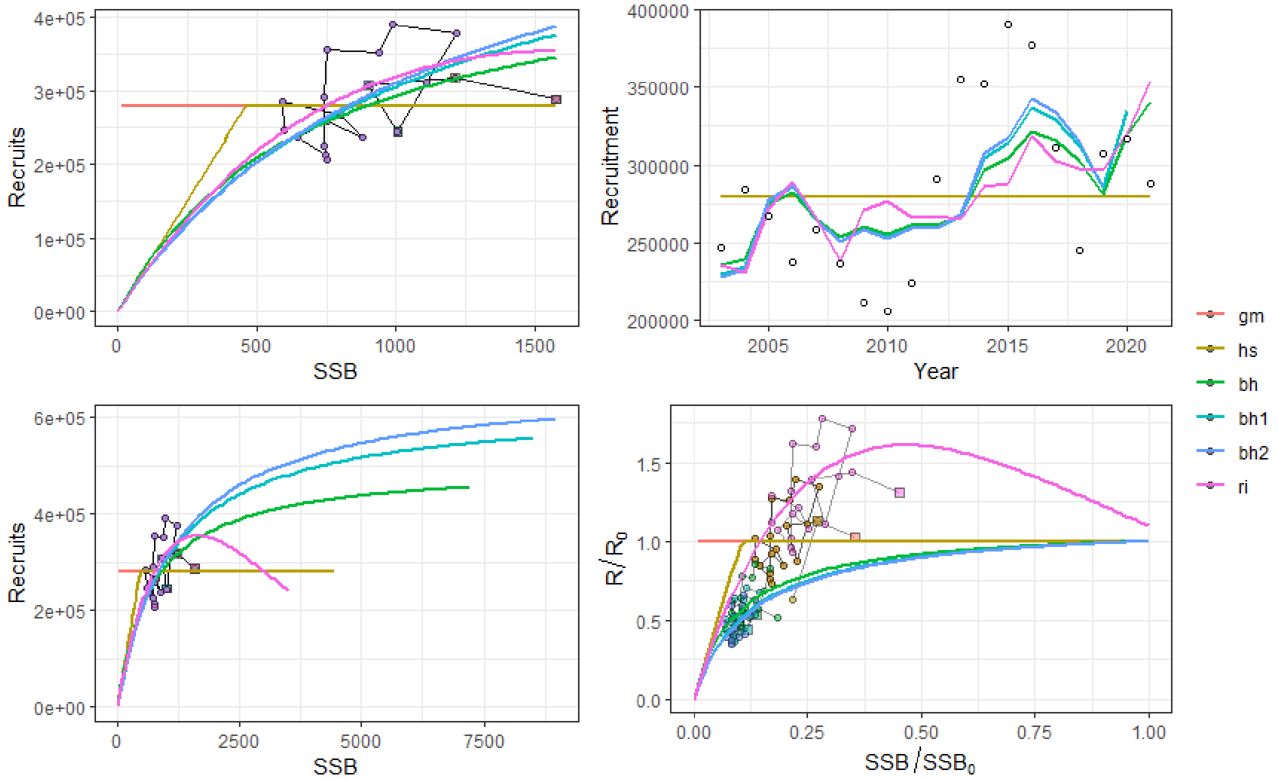


Figure 6.11.4.9. Red mullet in GSA 9. Summary of the four SR models. Two additional tests were made with Beverton-Holt model using reduced time series (BH1 up to 2020, BH2 up to 2019).

Figure 6.11.4.10 shows the results of the sensitivity analysis to alternative fixed steepness values of s = 0.55 – 0.95 for the Beverton-Holt model explored. The results show that increasing steepness to 0.9-0.95 substantially decreases the R_0 and B_0 estimates to a scale that is comparable to the Hockey-Stick estimates. It is not possible to obtain consistent values of steepness from the given available data.

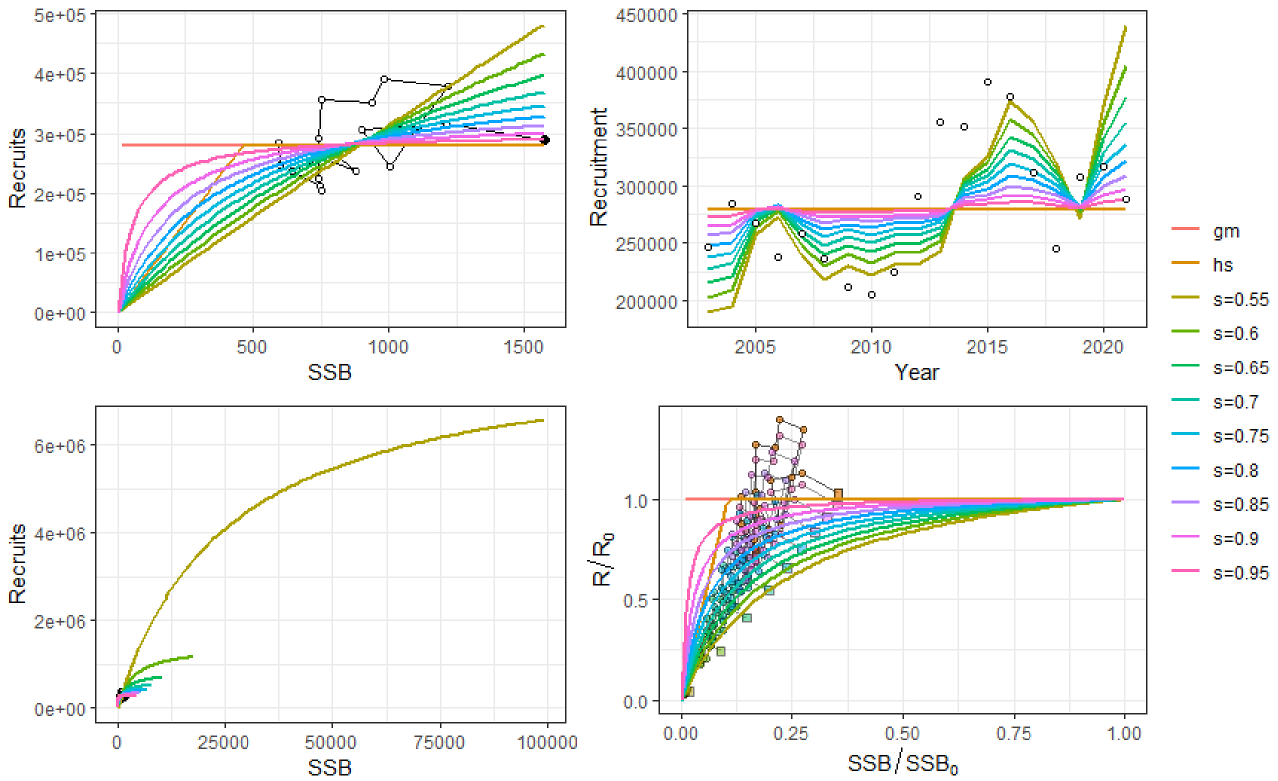


Figure 6.11.4.10. Red mullet in GSA 9. Per-recruit analysis with GM, HS and BH models with different slope (s, steepness) scenarios for the BH model.

6.11.4.3 Results

In the light of the outcomes of the exploratory analysis, because the point of inflection on the HS was outside the data it was decided to consider the Geometric Mean approach as the most suitable to estimate the biomass reference points for the stock of red mullet in GSA 9, this being also equivalent to the asymptote of the HS. Table 6.11.4.2 summaries the reference point values based on the default value of 25% of $B_{F0.1}$ for B_{lim} and Geometric Mean fitted to the data for R_0.

B_{pa} is set to 2* B_{lim}. The implied dynamics, based on a Hockey-stick model with R_0 from GM recruitment and the HS breakpoint at 25% $B_{F0.1}$ are illustrated in Figure 6.11.4.11.

Table 6.11.4.2. Red mullet in GSA 9. Final reference points based on Geometric mean and a default value of B_{lim} =25% $B_{F0.1}$.

$F_{0.1}$	B_{lim}	B_{pa}	$B_{F0.1}$	B_0	Fpa
0.50	461.5	923.0	1846.1	4440.0	1.34

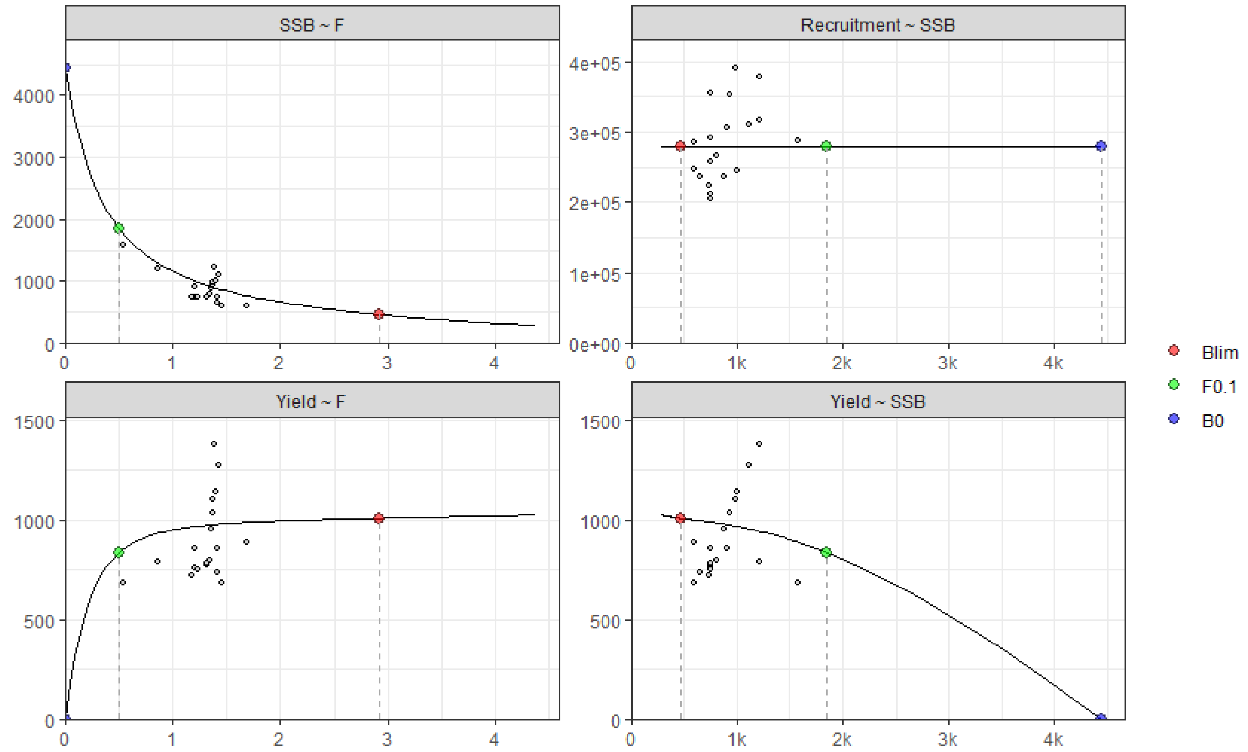


Figure 6.11.4.9. Red mullet in GSA 9. Red mullet in GSA 9. Reference point estimates. Grey dots show the corresponding observations.

Figures 6.11.4.10-6.11.4.11 show the reference points estimated for the Geometric mean model for red mullet in GSA 9.

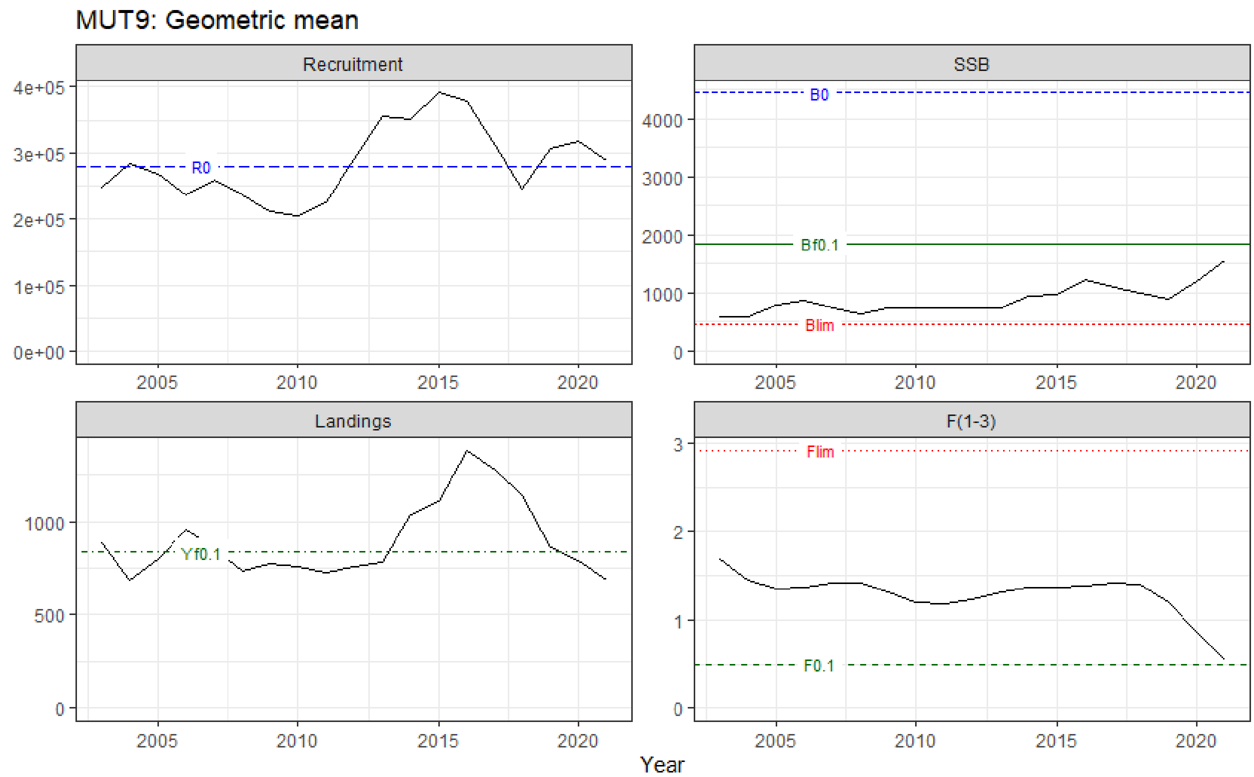


Figure 6.11.4.10. Red mullet in GSA 9. Status Advice plot showing stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on a Geometric mean stock-recruitment relationship.

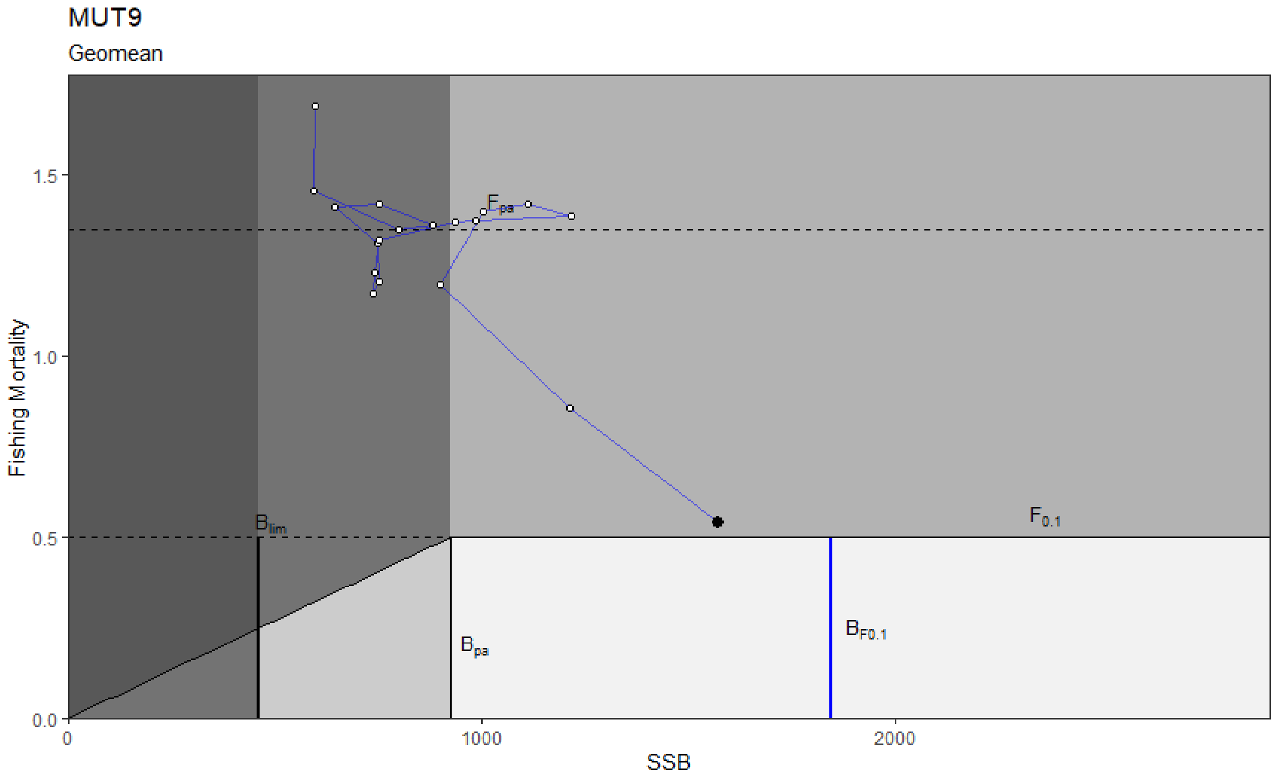


Figure 6.11.4.11. Red mullet in GSA 9. Advice Rule plots for the Geometric mean model, with an empirical B_{lim} = 0.25 $B_{F0.1}$ and B_{pa} = 2x B_{lim}.

6.11.4.4 Modelling options

The Geometric mean model defined above is considered as the best option for defining reference points for this stock, but it may not be the most suitable for modelling. A Beverton-Holt model may be helpful to as a modelling option. The steepness option that most closely mimics in terms of deviation from slope and asymptote the HS chosen is thought to be steepness = 0.95 (Figure 6.11.4.12).

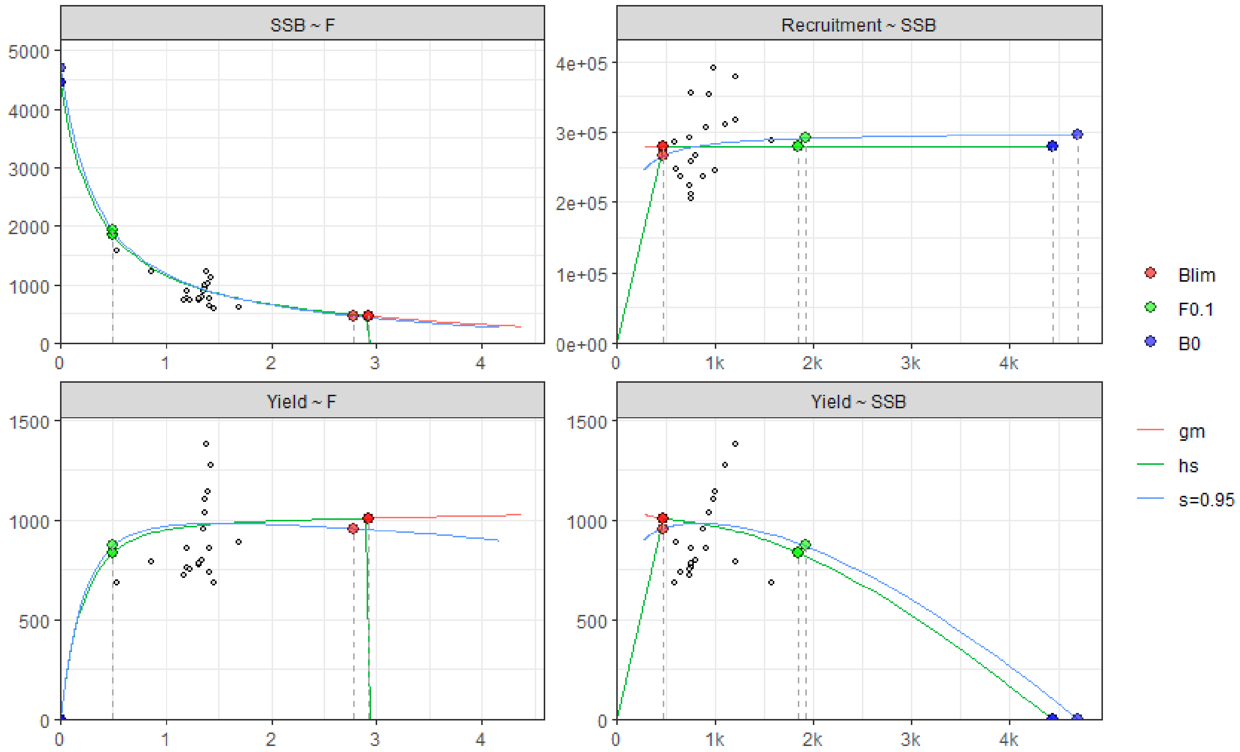


Figure 6.11.4.12. Red mullet in GSA 9. Per-recruit analysis: relative reference points for GM, HS and BH (steepness 0.95) models.

6.11.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the stock assessment.

The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} = 0.54 terminal F (2021) from the a4a assessment was used for F in 2022. Recruitment is observed to be fluctutating over the period of the assessment (Figure 6.11.3.5) so the geometric mean across the whole time series is used as an estimate of recruits from 2022 (whole time series of 19 years; recruitment 279683 thousands).

Table 6.11.5.1 Red mullet in GSA 9: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2019-2021	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}3}$ (2022)	0.54	F 2021 used to give F status quo for 2022
$F_{ages\ 1\text{-}3}$ (2019)	1.20	MAP base year fishing mortality from current assessment
SSB (2022)	1732.8	Stock assessment 1 January 2022
R_{age0} (2022,2023)	279683 (thousands)	Geometric mean of the time series (19 years)
Total catch (2022)	891.9	Catch intermediate year from STF output

The short term forecast was carried out estimating a catch for 2021-2023 on the basis of a recruitment hypothesis constant and equal to the mean on the whole time series and an F by age equal to that of the terminal year. These assumptions resulted in a catch and a SSB in 2021 equal to 891.9 and 1732.8 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.50) would reduce biomass by 6% from 2022 to 2024, while increasing catches by 14% from 2021 to 2023.

Table 6.11.5.2 Red mullet in GSA 9: Short term forecast table for red mullet in GSA 9.

Rationale	Ffactor	Fbar	Catch 2022	Catch 2023	SSB* 2022	SSB* 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield ($F_{0.1}$)	0.92	0.50	891.9	861.9	1732.8	1833.4	5.8	14.9
F upper	1.25	0.68	891.9	1095.5	1732.8	1567.5	-9.5	46.0
F lower	0.61	0.33	891.9	614.6	1732.8	2139.6	23.5	-18.1
F_{MSY} transition (intermediate year)	1.35	0.73	891.9	1154.9	1732.8	1503.5	-13.2	53.9
Zero catch	0.00	0.00	891.9	0.0	1732.8	3008.9	73.6	-100.0
Status quo	1.00	0.54	891.9	922.0	1732.8	1762.7	1.7	22.9
Different Scenarios	0.10	0.05	891.9	113.3	1732.8	2837.3	63.7	-84.9
	0.20	0.11	891.9	221.2	1732.8	2678.6	54.6	-70.5
	0.30	0.16	891.9	324.0	1732.8	2531.7	46.1	-56.8
	0.40	0.22	891.9	421.9	1732.8	2395.7	38.3	-43.8
	0.50	0.27	891.9	515.3	1732.8	2269.7	31.0	-31.3
	0.60	0.33	891.9	604.4	1732.8	2152.8	24.2	-19.5
	0.70	0.38	891.9	689.4	1732.8	2044.3	18.0	-8.1
	0.80	0.43	891.9	770.5	1732.8	1943.6	12.2	2.7
	0.90	0.49	891.9	848.0	1732.8	1849.9	6.8	13.0
	1.10	0.60	891.9	992.8	1732.8	1681.6	-3.0	32.3
	1.20	0.65	891.9	1060.4	1732.8	1606.0	-7.3	41.3
	1.30	0.71	891.9	1125.1	1732.8	1535.4	-11.4	49.9
	1.40	0.76	891.9	1187.0	1732.8	1469.5	-15.2	58.2
	1.50	0.81	891.9	1246.3	1732.8	1407.9	-18.7	66.1
	1.60	0.87	891.9	1303.1	1732.8	1350.4	-22.1	73.6
	1.70	0.92	891.9	1357.5	1732.8	1296.4	-25.2	80.9
	1.80	0.98	891.9	1409.6	1732.8	1245.9	-28.1	87.8
	1.90	1.03	891.9	1459.6	1732.8	1198.5	-30.8	94.5
	2.00	1.09	891.9	1507.5	1732.8	1153.9	-33.4	100.9

*SSB at mid year

EWG advises that when the MSY approach is applied, catches in 2023 should be no more than 861.9 tonnes.

6.11.6 DATA DEFICIENCIES

The EWG 22-09 did not find any particular data deficiency for this stock in terms of data quality.

6.12 Red mullet in GSA 10

6.12.1 Stock Identity and Biology

Red mullet (*Mullus barbatus*) is distributed in GSA 10 along the shelf at depths up to 200m, but mainly concentrated in the depth range 0-100 m. The area of GSA 10 extends in the South and Central Tyrrhenian Sea, that features one of the most complex structures in the seas around the Italian peninsula, due to its morphological and geophysical characteristics and water mass dynamics (Cataudella and Spagnolo, 2011). In line with the given ToR, it is assumed in the present assessment that inside the GSA 10 boundaries inhabits a single, homogeneous red mullet stock that behaves as a single well-mixed and self-perpetuating population.

However, the EWG19-10 noticed that EU project STOCKMED outcomes suggest a single stock unit in Western Mediterranean (see: https://ec.europa.eu/fisheries/documentation/studies/stockmed_en).

In addition, available spatial information from MEDITS shows continuous distribution of the red mullet along western Italian coast (i.e. continuity in spatial distribution in GSA10 and GSA9).

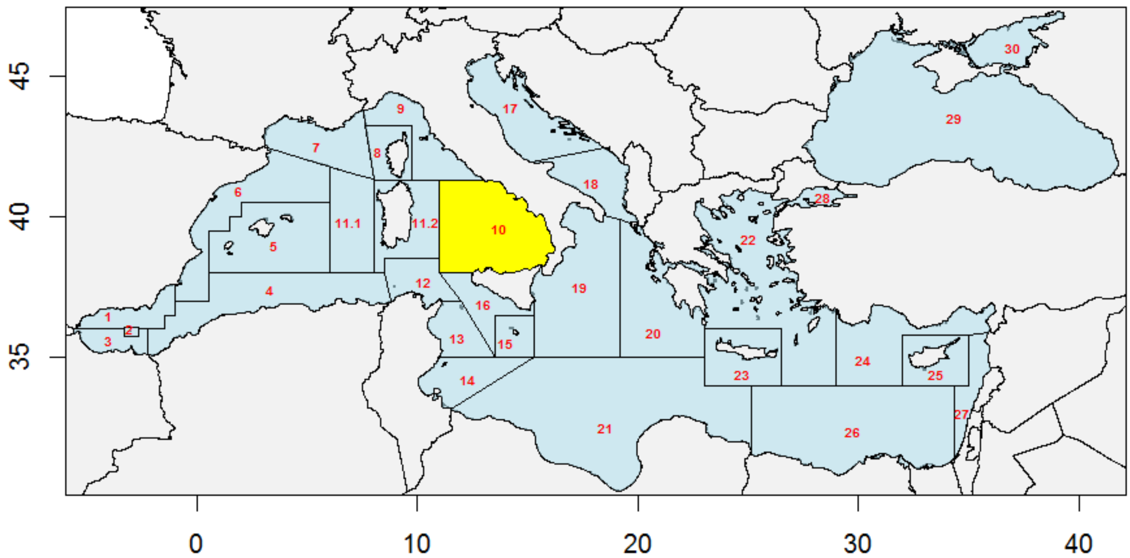


Figure 6.12.1.1. Map of GSA 10.

Growth

The information on the age-length key (ALK) and on the growth von Bertalanffy parameters was available from 2002 to 2020.

The previous STECF EWG agreed to use the same growth parameters used during EWG 20-09 without correction on t_0 for consistency: females: Linf=30, k=0.243, t0=-0.62; males: Linf=26, k=0.237, t0=-0.9. This parameters are consistent with the recent study of Carbonara et al. (2018) on age validation of red mullet in Adriatic Sea.

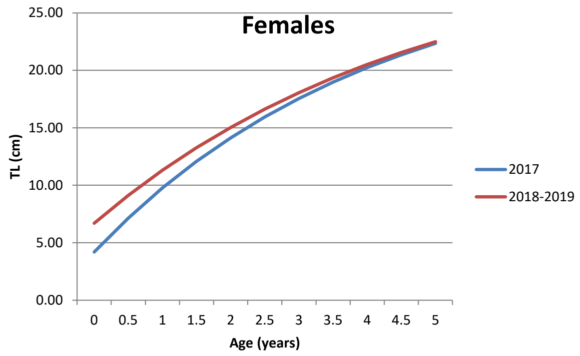


Figure 6.12.1.2. Red mullet in GSA 10: Growth curves for red mullet in GSA 10 (DCF).

Natural mortality

Natural mortality is the same used during EWG 21-11 and 20-09, that was estimated according to Chen and Watanabe model (1989) on the age vector at half year (0.5, 1.5, 2.5,…) using the same growth parameters used in the slicing.

Maturity

Maturity ogives by length and age were available from 2002 to 2021. The group agreed to use the maturity vector used in EWGs 21-11 and 20-09. Mortality and maturity parameters used in assessment are shown in Table 6.12.1.1.

Table 6.12.1.1 Red mullet in GSA 10 natural mortality and maturity vector by age used in the stock assessment.

Age	0	1	2	3	4+
M *	1.44	0.75	0.57	0.48	0.43
Proportion mature	0	1	1	1	1

*Chen & Watanabe method.

6.12.2 DATA

6.12.2.1 CATCH (LANDINGS AND DISCARDS)

Principal fishing gears used to catch red mullet, together with other species (mixed catches) are gillnets (GNS), trammel nets (GTR) and bottom trawls (OTB). Length structure of red mullet landings and discards for all gears in the period from 2002 to 2021 are shown in Figures 6.12.2.1.1 and 6.12.2.1.2 for landing and discards, respectively, and in 6.12.2.1.3 for combined landing plus discards.

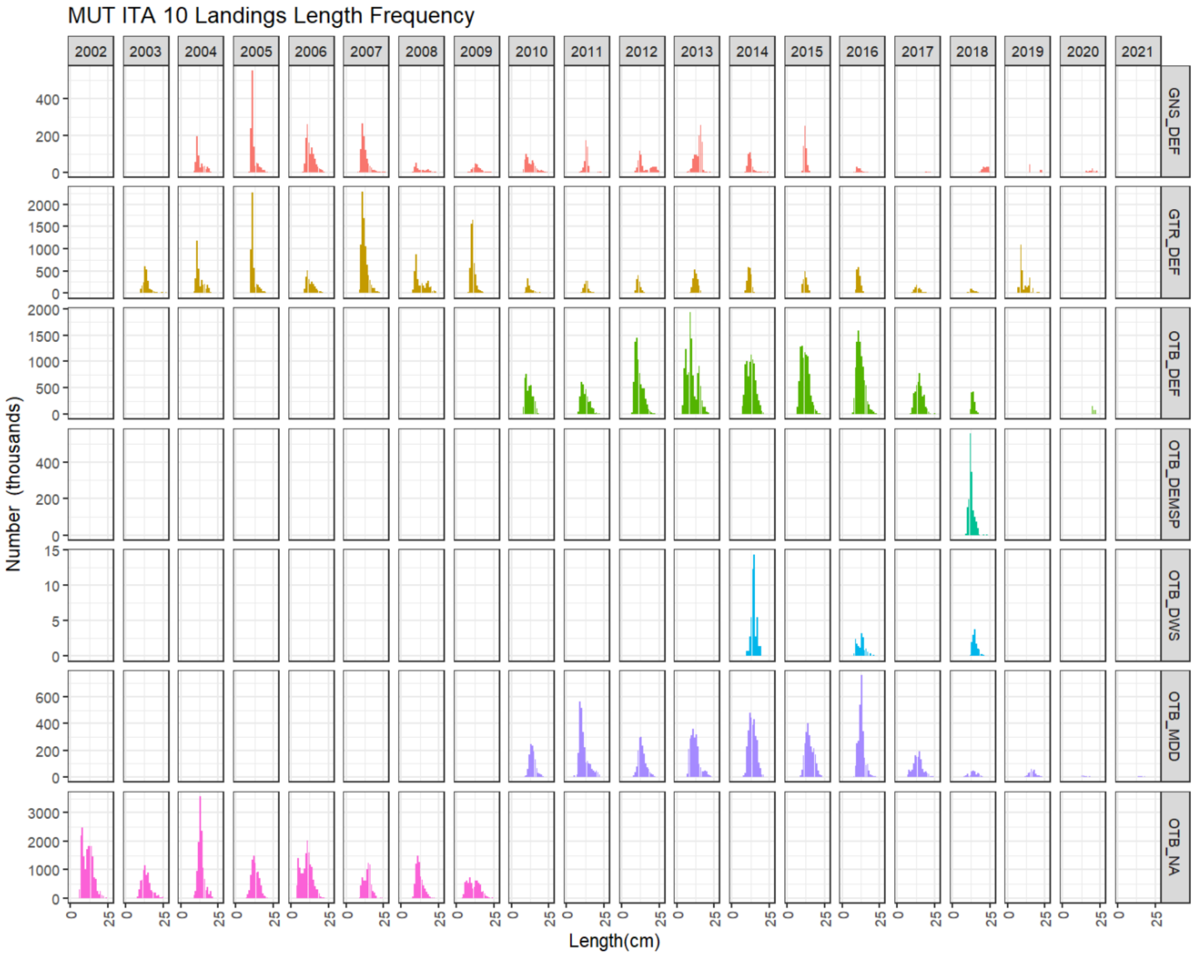


Figure 6.12.2.1.1. Red mullet in GSA 10 Length structure of red mullet landed in GSA 10 in the period from 2002 to 2021 by fishing gear and fishery.

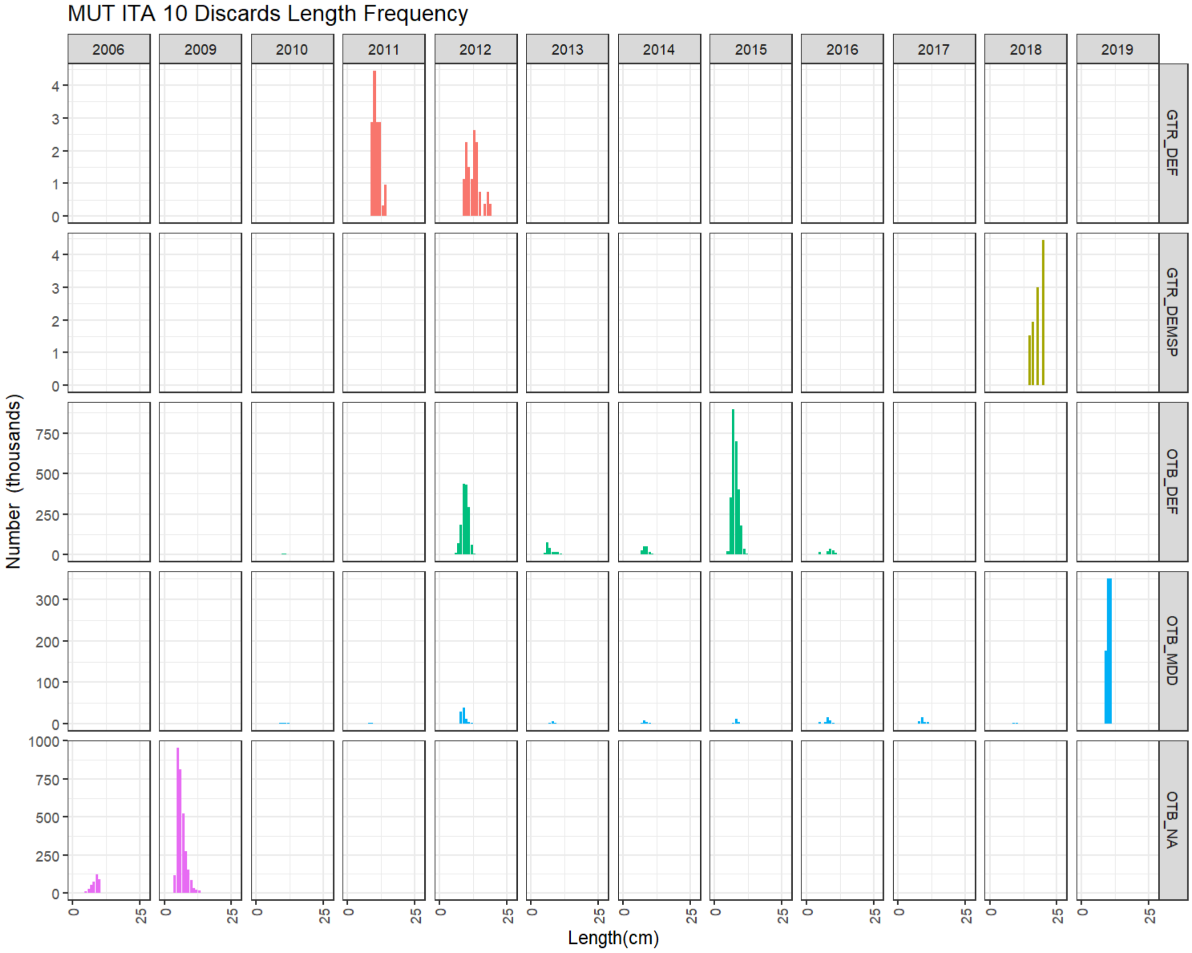


Figure 6.12.2.1.2. Red mullet in GSA 10 Length structure of discarded catch of red mullet in GSA 10 in the period from 2006 to 2019 by fishing gear and fishery. Discards in 2020 and 2021 are null.

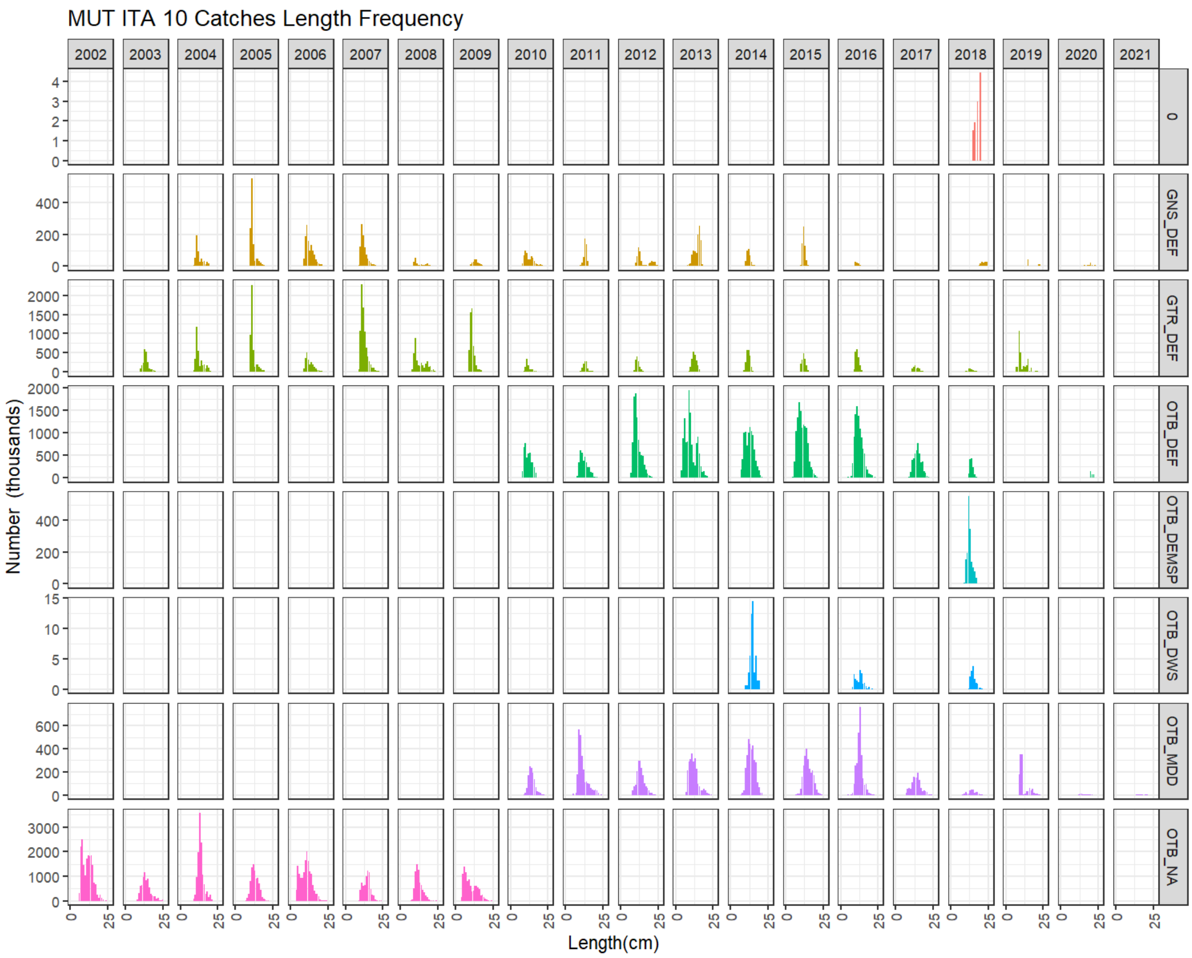
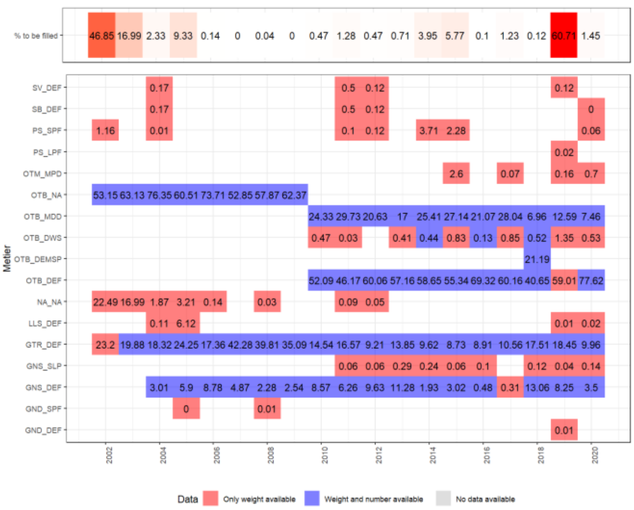
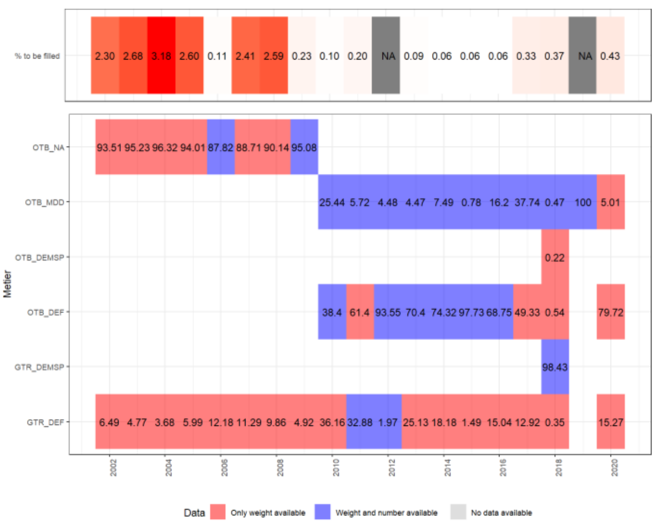


Figure 6.12.2.1.3. Red mullet in GSA 10 Length structure of catches (landing+discarded catch) of red mullet in GSA 10 in the period from 2002 to 2021 by fishing gear and fishery.

The final LFDs derived from EWG 21-02 until 2019 were used. During EWG 21-02 the landing LFDs of 2002 GTR, 2019 OTB_DEF and 2010-2019 OTB_DWS were reconstructed according to the preocedure agreed during the same meeting. The LFDs of discards 2002-2009 and 2017-2019 of OTB were reconstructed analogously during EWG 21-11 and used in the stock assessment.





6.12.2.2 SURVEY DATA

Survey indices used in this assessment originate from demersal trawl surveys, DCF-MEDITS. These surveys in GSA10 took place in different seasons of the year (Figure 6.12.2.2.1) and, in particular, in 2020 at the end of the year (only 38 hauls out of 71).

Size structure indices of red mullet in GSA 10, as derived from trawl surveys (MEDITS, 1994-2020), are shown in Figure 6.12.2.2.6. Large inter-annual variations in length structure can be noticed due to the survey time, that in some years allowed to detect the recruitment of the species.

Analyses of available MEDITS data show large variations between years (Figures 6.12.2.2.2-6.12.2.2.3).

In 2020 about one half of the hauls annually planned for the area was not carried out leaving out of the sample most part of Calabria and North of Sicily; these areas, excluded by the sampling, include also relevant spawning areas (Figure 6.12.2.7).

EWG 21-11 considered the survey period shift during interpretation of available survey indices in the assessment not including age 0 in the tuning index, because not intercepted every year, as done also in EWG 20-09. During EWG 22-09 an attempt to create an spawners biomass index for all the years was carried out, in combination with another index of density by age (including age 0) only for the years 2004, 2005, 2006, 2009, 2010, 2011, 2012, 2013, 2015 and 2019, when the survey was connducted during the months indicated by the survey protocol.

Figure 6.12.2.2.1. Red mullet in GSA 10 Survey periods (MEDITS, 1994-2021) in GSA 10.

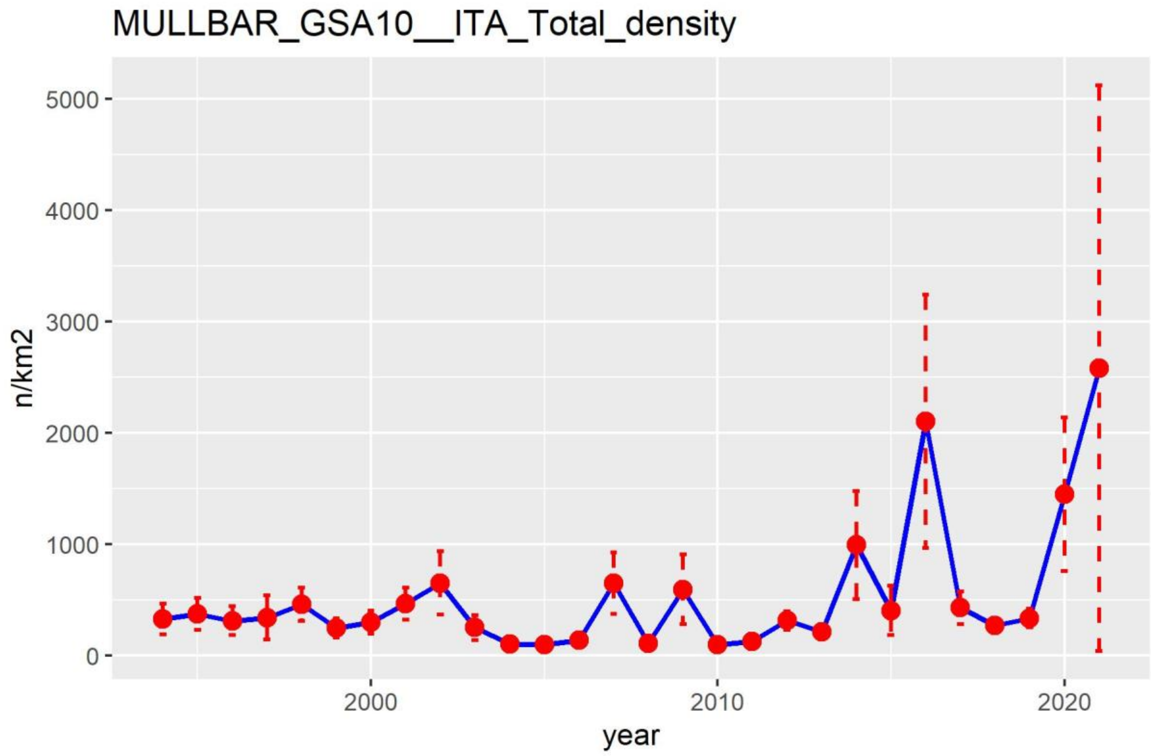


Figure 6.12.2.2.2. Red mullet in GSA 10. Abundance indices (N/km^2) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2021).

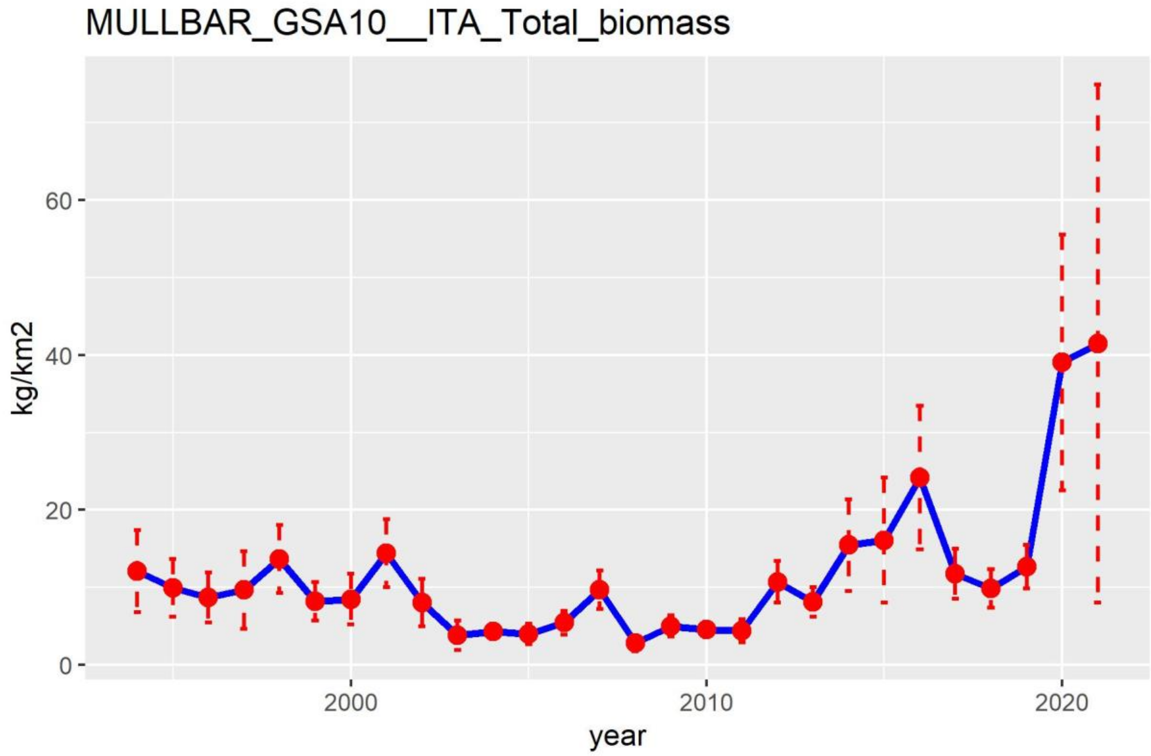


Figure 6.12.2.2.3. Red mullet in GSA 10. Biomass indices (kg/km^2)) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2021).

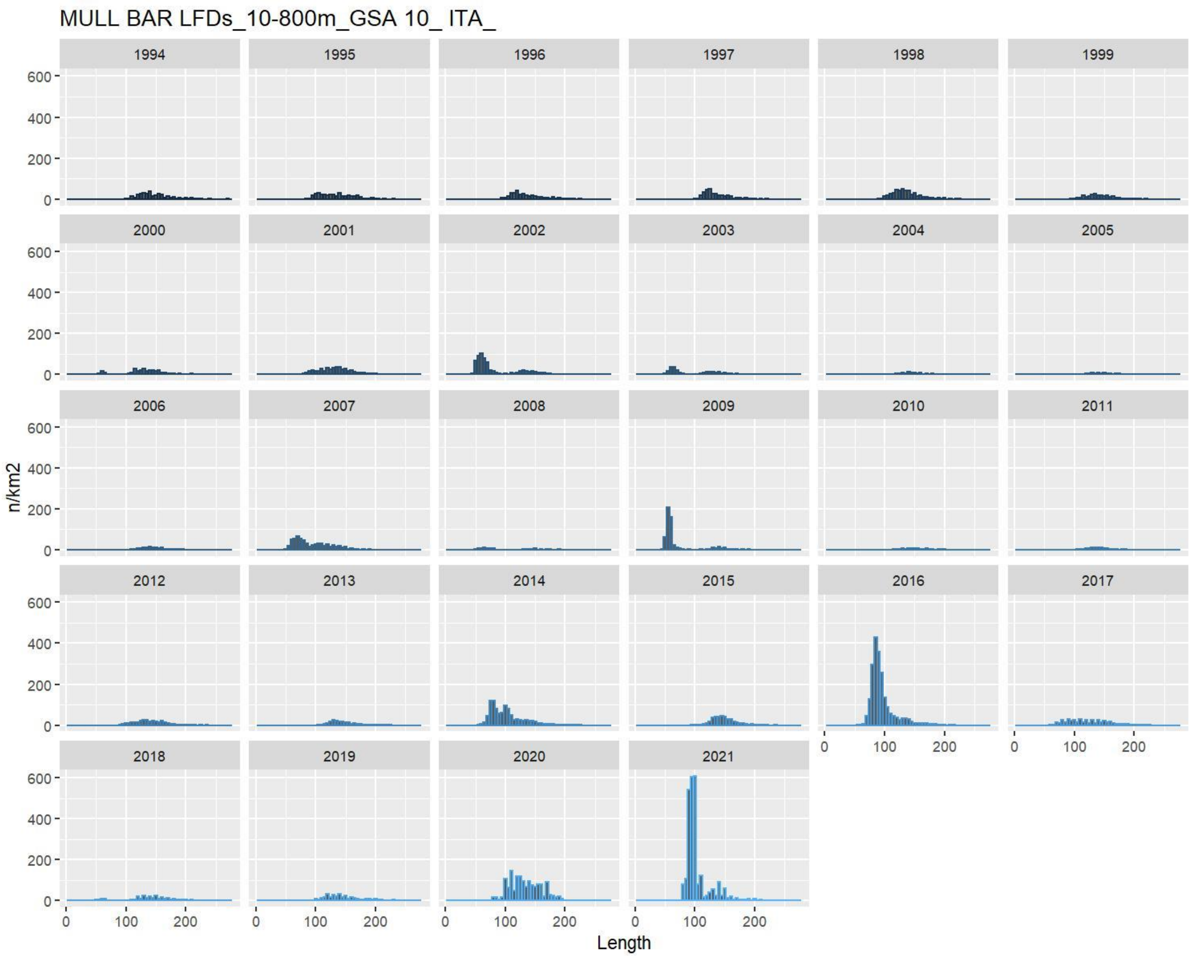


Figure 6.12.2.2.6. Red mullet in GSA 10. Size structure indices of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2021).

A anomalous sex ratio was observed in 2020 respect to the previous years (Figure 6.12.2.7); for this reason the sex ratio of 2016-2019 was modelled and used to split the 2020 total LFDs in females and males, as in EWG 21-11.

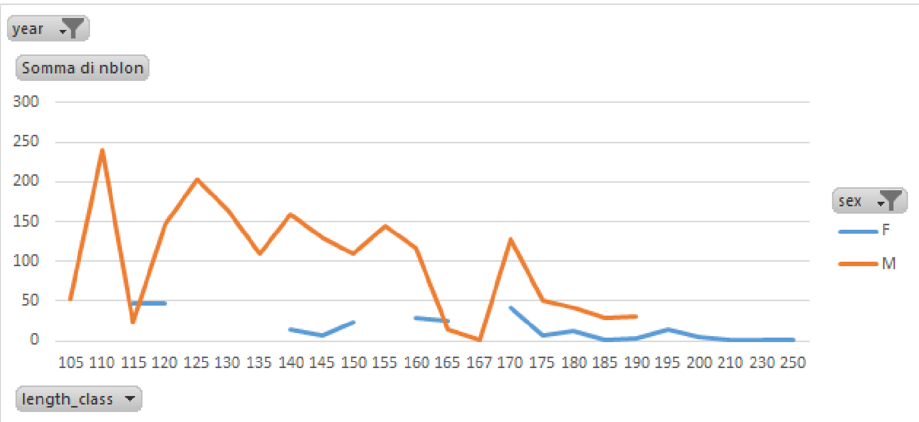


Figure 6.12.2.7 Red mullet in GSA 10. Sex ratio of MEDITS 2020 for MUT 10.

In Table 6.12.2.1 are reported the SOP correction applied by year. For 2020 a small number of inidividuals have been sampled, in few length classes, producing a SOP correction of 6.54. For 2021 only one trip was sampled in the 4th quarter, with 53 length measurements in total, between 14 and 21 cm of TL. This produced a SOP of 200.

Table 6.12.2.1 Red mullet in GSA 10: SOP correction applied by year

year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
data	2.2	1.36	1.15	1.27	1.19	1.15	1.15	1.17	1.15	1.21
year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
data	1.14	1.22	1.23	1.21	1.16	1.61	2.9	5.4	6.54	200

6.12.3 STOCK ASSESSMENT

During the EWG an attempt to update the a4a model of the EWG 21-11 was made. The a4a model is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by gear. The method was developed within FLR framework.

Input data considered (landing, discard, age, maturity, MEDITS) originate from DCF Med&BS data call. Commercial fishery data are available since 2002. EWG 21-11 used all the input used in the last assessment except for the LFDs and discards, for which the available DCF information was integrated by EWG 21-02.

Age slicing of the length frequency distributions of landing, discard and survey has been done by sex (in combination with sex ratio at length) using a4aGr model and then data were combined. The final catch at age data are shown in the Figure 6.12.3.1 and Table 6.12.3.1. The corresponding mean weights at age ate shown in Table 6.12.3.2.

The catch at age data of 2020 and 2021 were considered not reliable and were not used in the assessment.

Table 6.12.3.1. Red mullet in GSA 10: Values of catch at age per year used in the assessment (SOP applied).

	Age				
	0	1	2	3	4+
2002	14616.1	18184.4	10894.2	1726.8	1028.1
2003	3666.2	5340.9	5761.2	1046.6	846.4
2004	4478.8	8775.8	8262.5	1372.8	537.9
2005	3421.7	11999.2	5200.7	995.8	199.9
2006	6255.9	10115.3	4792.7	1048.3	325.5
2007	2963.7	9753.5	6755.3	1578.6	443.5
2008	2577.3	7687.2	3123.7	970.6	528.3
2009	5935.9	7823.0	3109.7	761.3	278.8
2010	492.5	4287.5	2702.9	390.7	100.9
2011	716.0	4947.9	2846.4	489.7	272.6
2012	1818.5	8620.3	3028.8	536.9	323.1
2013	6039.6	8059.8	5371.5	1021.6	296.5
2014	1200.7	8518.0	6612.8	1322.4	289.2
2015	4036.7	9116.2	5859.0	1101.7	460.1
2016	889.9	9875.1	4663.7	744.9	275.3
2017	284.1	3123.8	5319.0	1517.5	611.3
2018	416.7	8434.0	9998.6	828.5	795.1
2019	2883.6	9796.6	5700.2	1035.0	398.3
2020*	46.0	91.3	326.6	264.7	2367.4
2021*	1364	895	2769	1370	1356

*Data not considered reliable and not used in the assessment.

Table 6.12.3.2. Red mullet in GSA 10: Values of mean weight at age per year used in the assessment.

	Age				
	0	1	2	3	4+
2002	0.005	0.014	0.032	0.054	0.088
2003	0.007	0.016	0.031	0.056	0.099
2004	0.007	0.017	0.030	0.055	0.077
2005	0.006	0.015	0.033	0.052	0.077
2006	0.003	0.014	0.032	0.056	0.080
2007	0.007	0.015	0.033	0.053	0.090
2008	0.007	0.014	0.033	0.056	0.086
2009	0.004	0.013	0.032	0.055	0.084
2010	0.007	0.014	0.032	0.051	0.087
2011	0.006	0.014	0.031	0.054	0.087
2012	0.006	0.013	0.032	0.055	0.094
2013	0.004	0.013	0.033	0.053	0.085
2014	0.006	0.015	0.032	0.054	0.078
2015	0.006	0.015	0.031	0.056	0.081
2016	0.006	0.014	0.031	0.053	0.085
2017	0.006	0.016	0.033	0.055	0.084
2018	0.006	0.017	0.030	0.051	0.107
2019	0.005	0.013	0.033	0.054	0.086
2020	0.006	0.021	0.037	0.057	0.090
2021	0.006	0.016	0.035	0.052	0.082

Table 6.12.3.3. Red mullet in GSA 10: Survey index (MEDITS) values at age per year used in the assessment.

	Age				
	0	1	2	3	4+
2002	455.994	59.294	94.481	28.426	12.991
2003	137.383	46.567	52.242	12.728	2.564
2004	0.221	15.955	53.571	24.242	7.485
2005	0.181	18.741	43.712	25.843	9.142
2006	0.181	28.356	78.946	27.208	6.590
2007	354.758	173.814	90.829	23.037	7.578
2008	58.292	8.096	25.747	16.034	3.313
2009	487.894	15.863	62.389	18.721	8.437
2010	0.181	14.459	44.866	26.518	12.114
2011	0.363	35.112	62.477	21.018	7.298
2012	4.540	101.924	143.927	47.300	16.814
2013	0.181	42.797	122.524	33.149	13.715
2014	467.631	362.087	111.077	41.450	10.676
2015	1.979	62.896	253.153	68.821	17.554
2016	1326.018	594.902	137.258	37.254	6.556
2017	103.212	142.510	115.358	47.764	19.991
2018	32.168	49.829	111.433	48.032	27.672
2019	0.708	99.918	133.013	62.570	38.575
2020	46.814	653.103	499.064	229.419	19.290
2021	992.72	1285	231	43.34	28.72

Even after the derivation of the LFDs by sex using a sex ratio based of the years 2016-2019, the index by age in 2020 seems not in line with the prevoius years, showing a higher number of older individuals. MEDITS indices (density by age) are shown in Figure 6.12.3.2 and Table 6.12.3.3.

Catch at age 2021 shows a sharp increase in ages 2-4+ individuals respect to the past. Several runs were carried out during EWG 22-09 using the 2021 landing at age data, but the results were considered unreliable, showing an unrealistically low F respect to the 2019 and 2020. For this reason, as it happened during EWG 21-11 for the 2020, the 2021 landing at age data were not used, allowing the model to estimate them according to the other available data.

A mismatch of 2018 landing of FDI was again observed. In the assessment the values of FDI were used, as in the previous assessment.

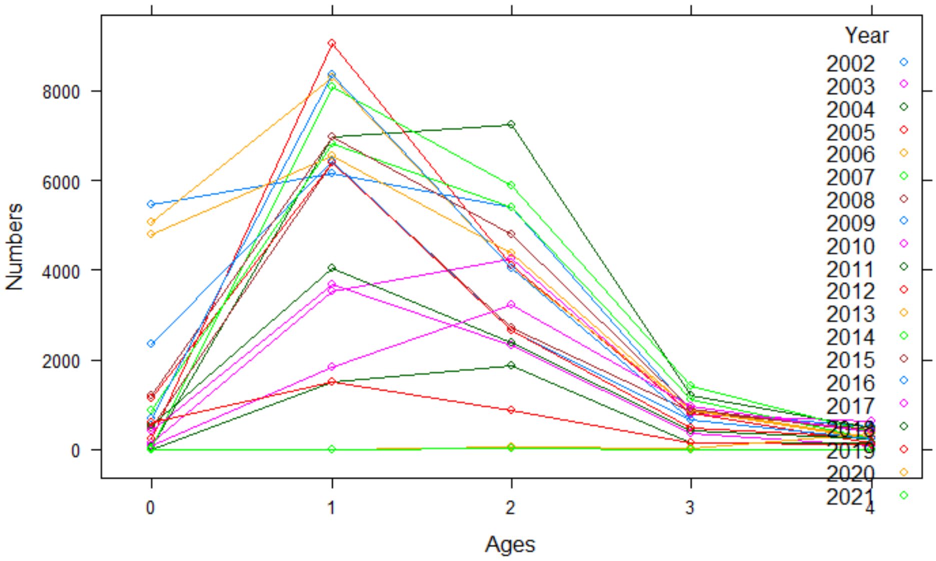


Figure 6.12.3.1. Red mullet in GSA 10: Catch-at-age data of red mullet in GSA10.

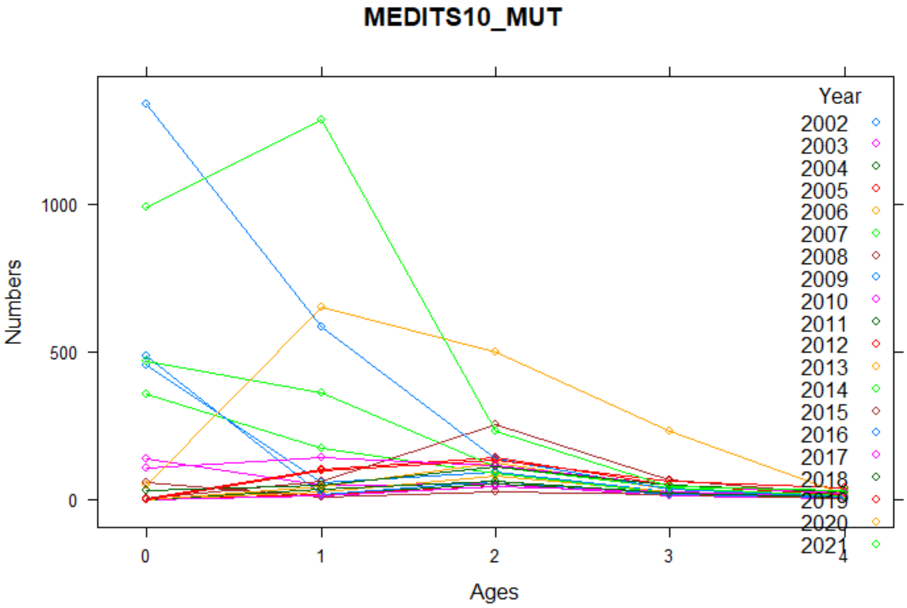


Figure 6.12.3.2. Red mullet in GSA 10:MEDITS indices describing density by age of red mullet in GSA10 by years.

The same sub-models have been used for F and S-R. A new index was explored during EWG 22-09, in order to inform the model about the age structure of the survey only in the years with correct period, while informing about the SSB in all the eyars. This SSB index excluded the age 0, because immature. The models used are:

- `fmodel: ~s(replace(age, age > 3, 3), k = 3) + s(year, k = 6) + s(year, k = 4, by = as.numeric(age == 0))`
- `srmodel: ~geomean(CV = 0.3)`
- `qmodel ~list(~1,factor(replace(age, age > 2, 2)))`

Results are shown below (Figure 6.12.3.4).

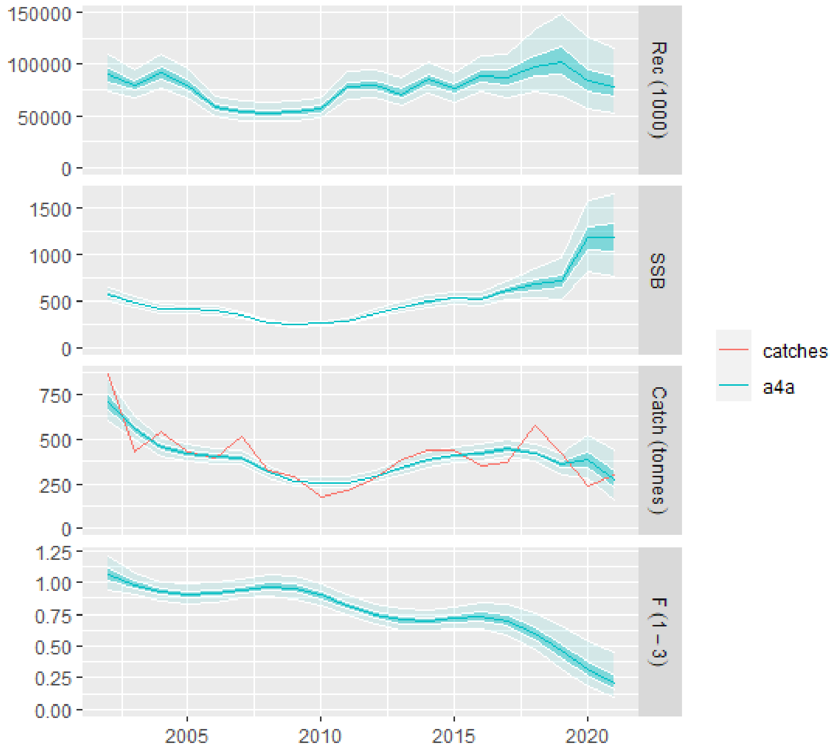


Figure 6.12.3.4. Red mullet in GSA 10: Results of the best a4a model outcomes for red mullet in GSA10.

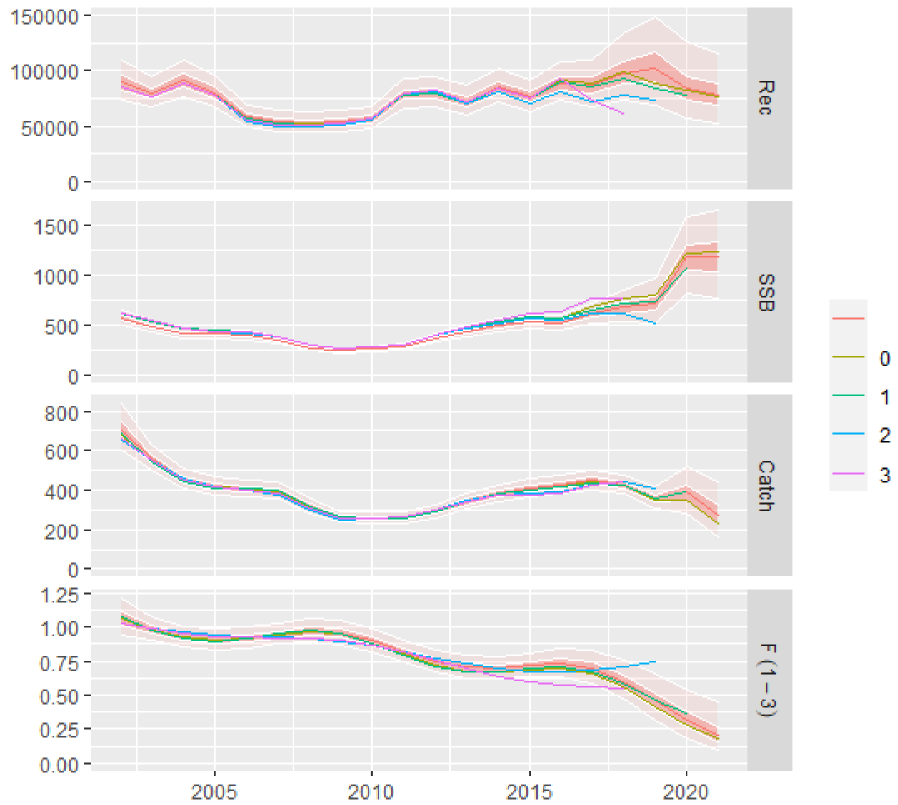


Figure 6.12.3.5. Red mullet in GSA 10: Retrospectve analysis of the best a4a model outcomes for red mullet in GSA10.

Log residuals of the catch and MEDITS abundance indices related to the run showed trend in the biomass index along all the years (Figure 6.12.3.6), highlighting the unreliability of the model to estimate a reasonible percption of the population.

The comparison with the assessment of last year was made, indicates a very different level of recruitment estimated in the assessment of this year (Figure 6.12.3.). This is probably due to the missing information on recruitment from the commercial data in 2020 and 2021, that does not allow the model to fit the current level of recruitment.

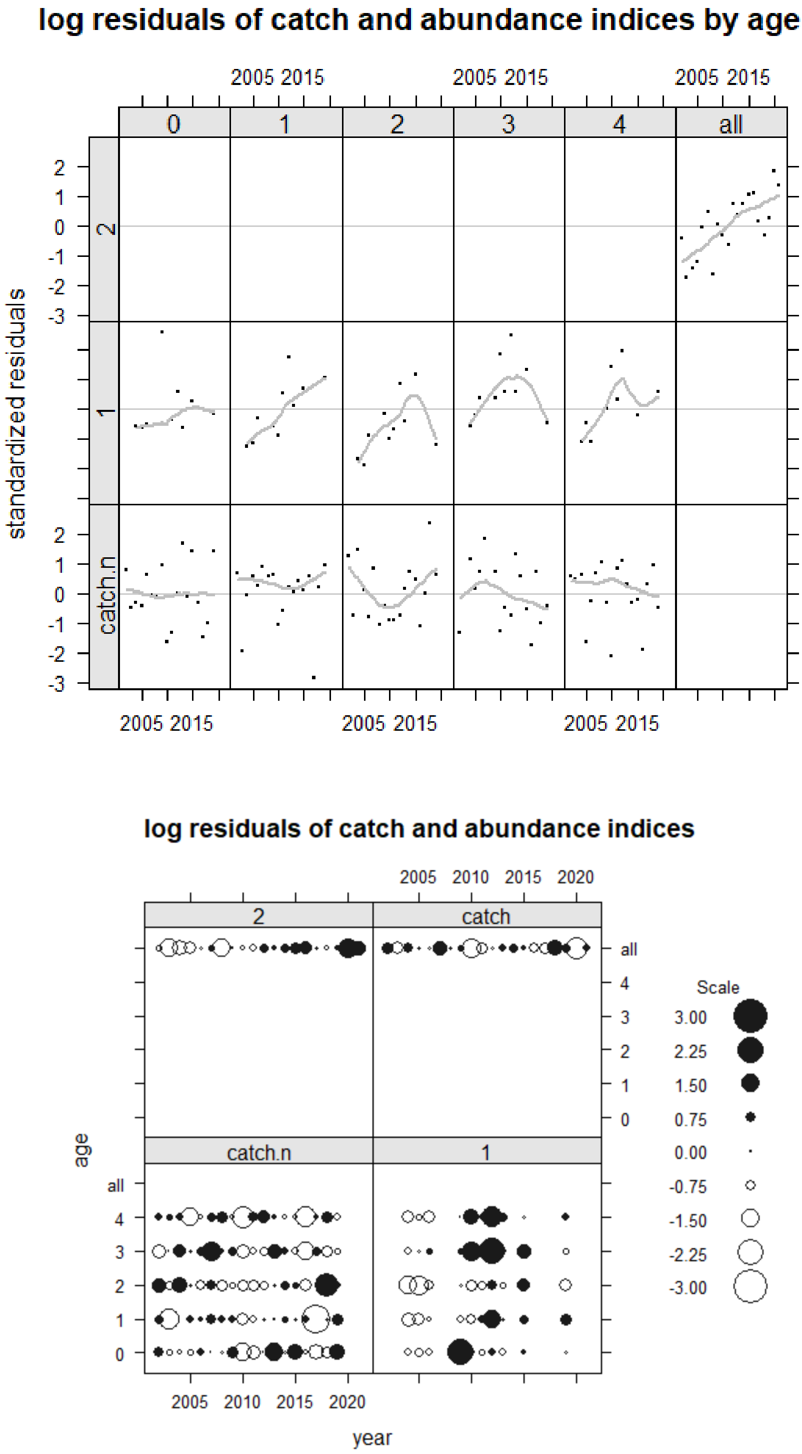


Figure 6.12.3.6 Red mullet in GSA 10: Log residuals of catch and MEDITS abundance indices.

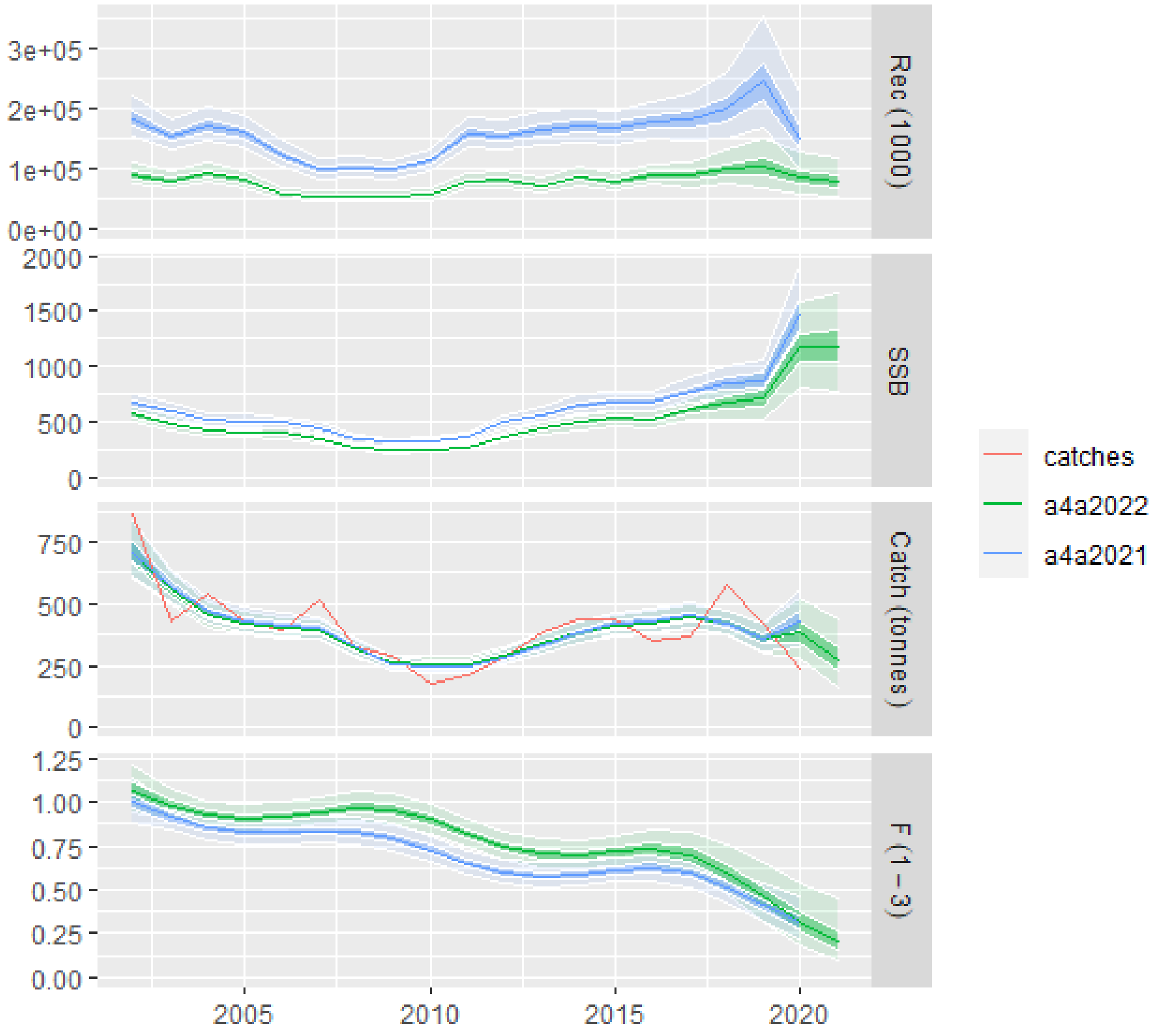


Figure 6.12.3.7 Red mullet in GSA 10: Comparison between the assessment carried out in EWG 21-11 and the assessment attempted in EWG 22-09.

Table 6.12.3.4. Red mullet in GSA 10 Final results of the red mullet assessment in GSA10.

Year	Recruitmen age 0 (thousands)	SSB tonnes	Catch tonnes (observed)	F ages 1-3
2002	89027	615	860	1.07
2003	79420	534	431	0.98
2004	91227	462	542	0.92
2005	80134	449	433	0.90
2006	57959	434	397	0.92
2007	53593	383	515	0.95
2008	52876	301	324	0.97
2009	53503	268	292	0.95
2010	56394	283	178	0.90
2011	78246	304	210	0.82
2012	79603	402	283	0.75
2013	71521	479	382	0.70
2014	84911	536	440	0.70
2015	76193	578	438	0.72
2016	88942	565	354	0.73
2017	86629	658	366	0.70
2018	97965	729	577	0.60
2019	102018	773	417	0.46
2020	84094	1235	242	0.31
2021	78131	1243	302	0.21

Table 6.12.3.5. Red mullet in GSA 10: Stock number at age for red mullet in GSA10.

	Age				
	0	1	2	3	4+
2002	89027	37690	12389	4135	1401
2003	79420	31040	11202	1917	1245
2004	91227	26559	9667	1942	780
2005	80134	29712	8561	1816	712
2006	57959	27868	9760	1650	679
2007	53593	20671	9090	1851	615
2008	52876	17971	6601	1650	630
2009	53503	18070	5679	1164	569
2010	56394	19399	5761	1022	440
2011	78246	19985	6395	1119	395
2012	79603	28293	6915	1382	443
2013	71521	29525	10239	1644	576
2014	84911	27199	10975	2570	734
2015	76193	31906	10107	2780	1096
2016	88942	28822	11732	2501	1262
2017	86629	33185	10510	2853	1212
2018	97965	33320	12281	2656	1351
2019	102018	36813	13063	3553	1482
2020	84094	37960	15988	4561	2161
2021	78131	31846	17407	6716	3346

Table 6.12.3.6. Red mullet in GSA 10: Fishing mortality at age for red mullet in GSA10.

	Age				
	0	1	2	3	4+
2002	0.13	0.65	1.43	1.13	1.13
2003	0.12	0.60	1.31	1.04	1.04
2004	0.11	0.56	1.23	0.98	0.98
2005	0.10	0.55	1.20	0.95	0.95
2006	0.10	0.56	1.22	0.97	0.97
2007	0.10	0.58	1.26	1.00	1.00
2008	0.09	0.59	1.29	1.02	1.02
2009	0.08	0.58	1.27	1.01	1.01
2010	0.06	0.55	1.20	0.95	0.95
2011	0.05	0.50	1.09	0.86	0.86
2012	0.04	0.45	1.00	0.79	0.79
2013	0.03	0.43	0.94	0.74	0.74
2014	0.03	0.42	0.93	0.74	0.74
2015	0.02	0.44	0.96	0.76	0.76
2016	0.02	0.44	0.97	0.77	0.77
2017	0.02	0.42	0.93	0.74	0.74
2018	0.02	0.36	0.80	0.63	0.63
2019	0.01	0.28	0.61	0.48	0.48
2020	0.01	0.19	0.42	0.33	0.33
2021	0.01	0.13	0.27	0.22	0.22

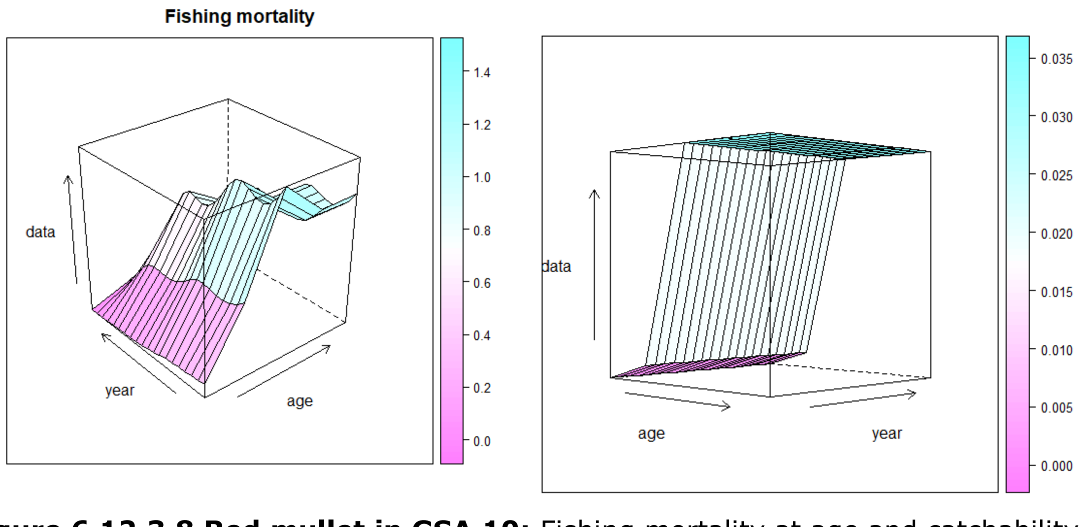
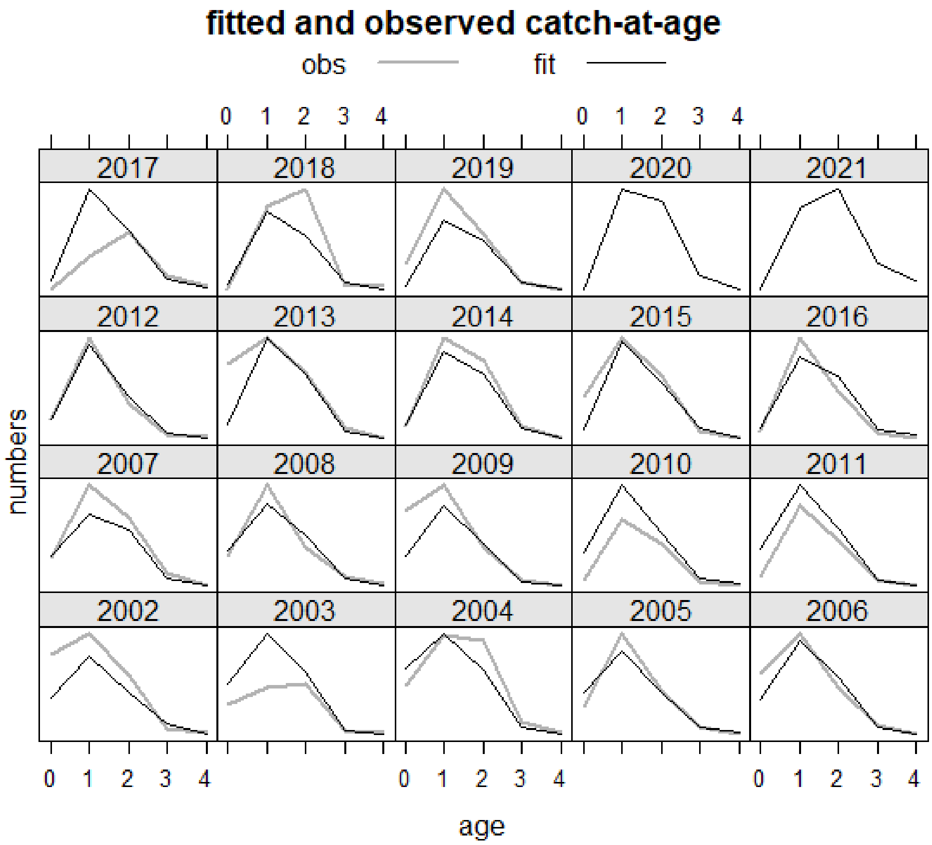


Figure 6.12.3.8 Red mullet in GSA 10: Fishing mortality at age and catchability at age.



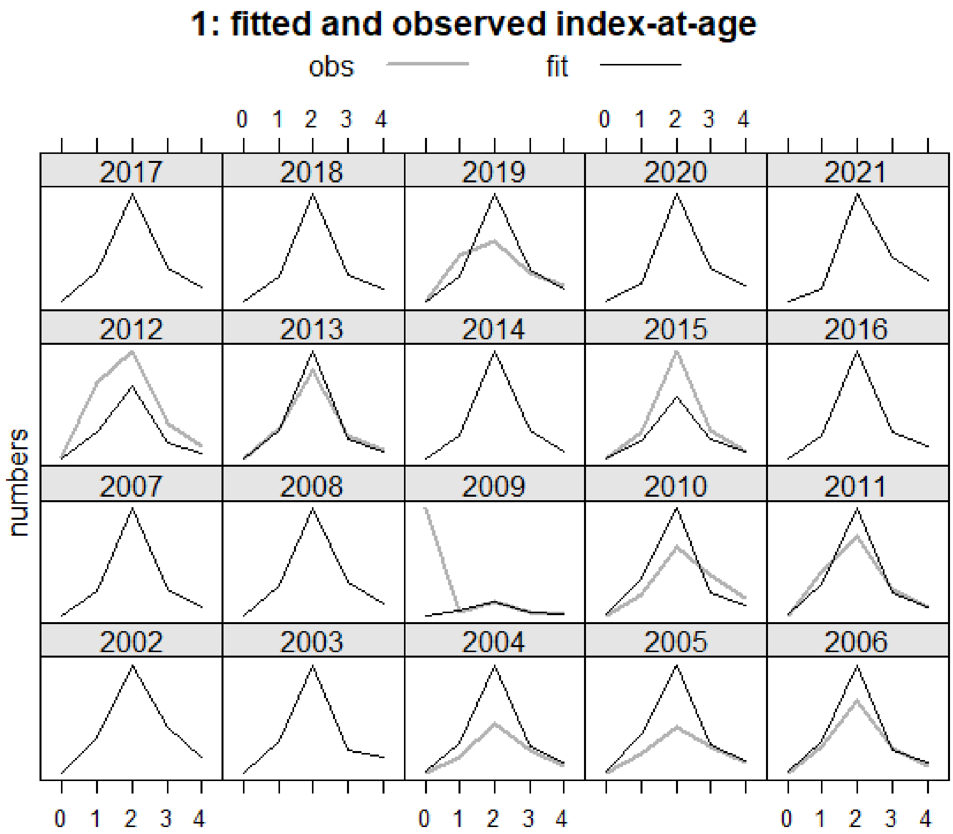


Figure 6.12.3.9 Red mullet in GSA 10: Comparison between catch at age estimated by the model and observed for the catch (top) and MEDITS (bottom).

During the EWG an attempt to carry out an assessment, using the MEDITS spawner biomass index and the catch amount, with Spict was also made. Spict fits surplus production models in continuous-time to fisheries catch data and biomass indices (either scientific or commercial). Spict is routinely used by ICES stock assessment working groups in the cases of unreliable catch at age information and/or missing length distributions.

The landing before 2002 was collected by RECFISH project. No information o the discard were available before 2002, thus the landing was used as proxy of the catch (discard <10%).The data are reported in Table 6.12.3.7.

Table 6.12.3.7. Red mullet in GSA 10: Landing and spawner biomass index for red mullet in GSA10 used for Spict runs.

year	landings	Spawner biomas index	year	landings	Spawner biomas index
1972	457	NA	2001	388	0.013
1973	702	NA	2002	839	0.007
1974	888	NA	2003	419	0.003
1975	675	NA	2004	524	0.004
1976	1585	NA	2005	421	0.004
1977	863	NA	2006	393	0.005
1978	762	NA	2007	502	0.007
1979	935	NA	2008	315	0.002
1980	823	NA	2009	279	0.004
1981	1002	NA	2010	177	0.004
1982	1091	NA	2011	210	0.004
1983	976	NA	2012	264	0.010
1984	1390	NA	2013	381	0.008
1985	1268	NA	2014	438	0.012
1986	1178	NA	2015	421	0.014
1987	825	NA	2016	353	0.016
1988	620	NA	2017	134	0.010
1989	1125	NA	2018	265	0.009
1990	785	NA	2019	416	0.012
1991	1267	NA	2020	242	0.040
1992	1361	NA	2021	302	0.031
1993	1374	NA			
1994	1246	0.012			
1995	939	0.011			
1996	1040	0.009			
1997	607	0.009			
1998	421	0.013			
1999	392	0.008			
2000	213	0.009			

The catch data before 2002 were considered more uncertain respect to the one collected under DCF (weight = 5 before 2002).

Different runs were carried out, testing the long time series (from 1972) and the short time series (from 1985). The best runs were the ones starting from 1985, being the runs with better diagnostics plot.

Sensitivity runs were also performed on the prior of B(initial biomass)/K, arying the ration among 0.3, 0.5 and 0.7.

Several attempts were made to rescale the biomass of the a4aassessment of last year to the biomass estimated by Spict, setting the ratio B/ B_{msy} in 2002 equal to 0.7, as in the a4a assessment. This setting was imposed into 2 ways:

- run1: Starting from 2002 and setting b/K = 0.7 `np$priors$logbkfrac <- c(log(0.7),0.3,1);`
- run2: Starting from 1985 and set B B_{msy} =0.7 in 2002 `inp$priors$logB` B_{msy} `<- c(log(0.7),0.3,1,2002).`

Both runs showed a general improved perception of the stock in last years (Figure 6.12.3.10 and Figure 6.12.3.13); the retrospective and the disagnostic plots do not show any particulare trend and/or autocorrelation in the residuals (Figure 6.12.3.11-12 and Figure 6.12.3.14-15).

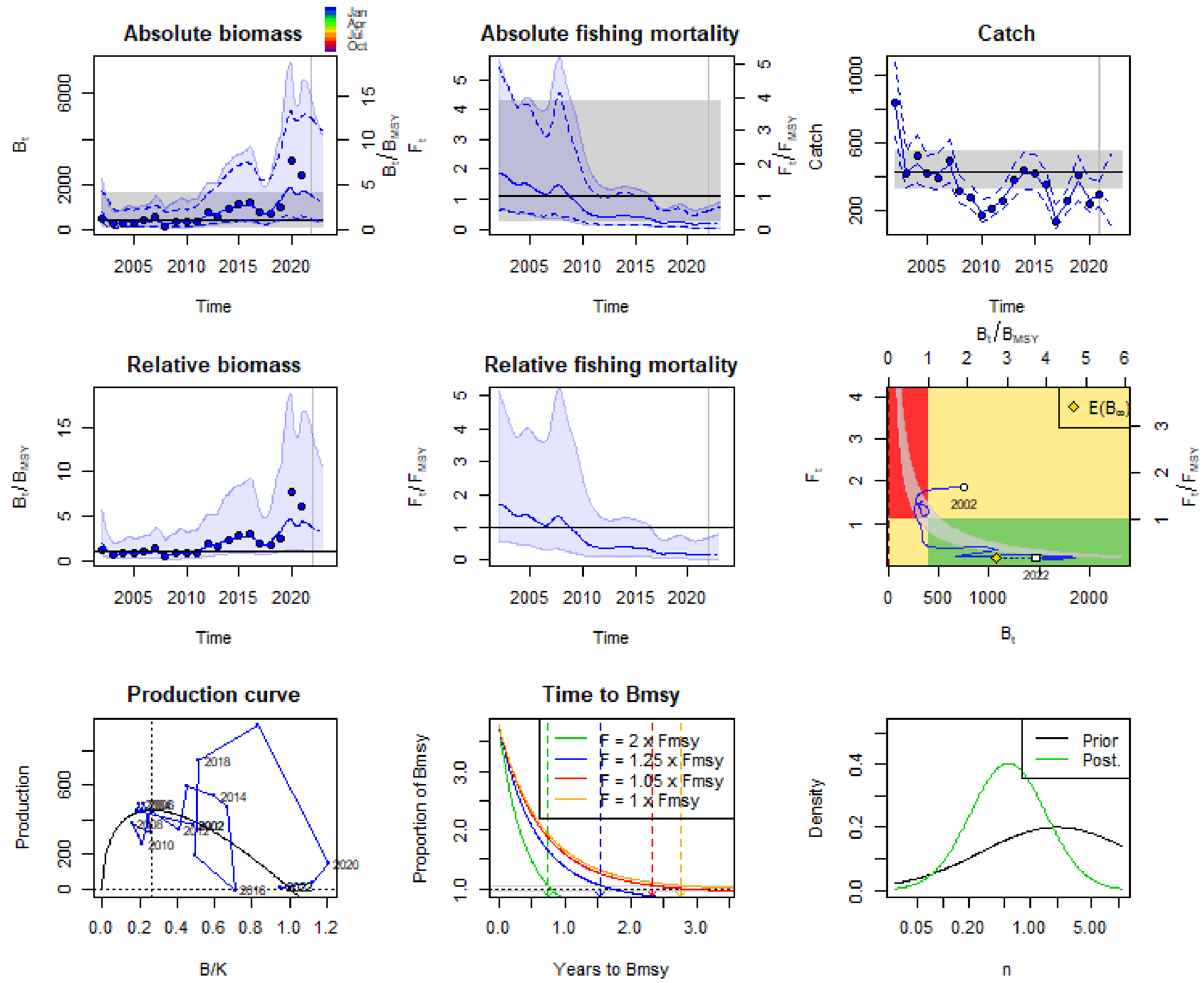


Figure 6.12.3.10 Red mullet in GSA 10: Summary of Spict run 1.

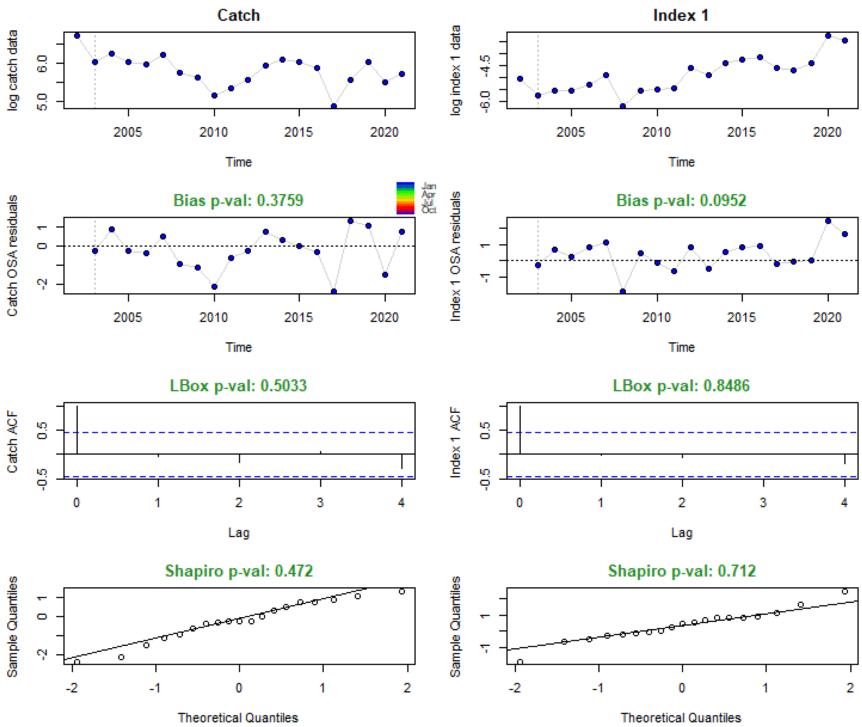


Figure 6.12.3.11 Red mullet in GSA 10: Diagnostic plots of Spict run 1.

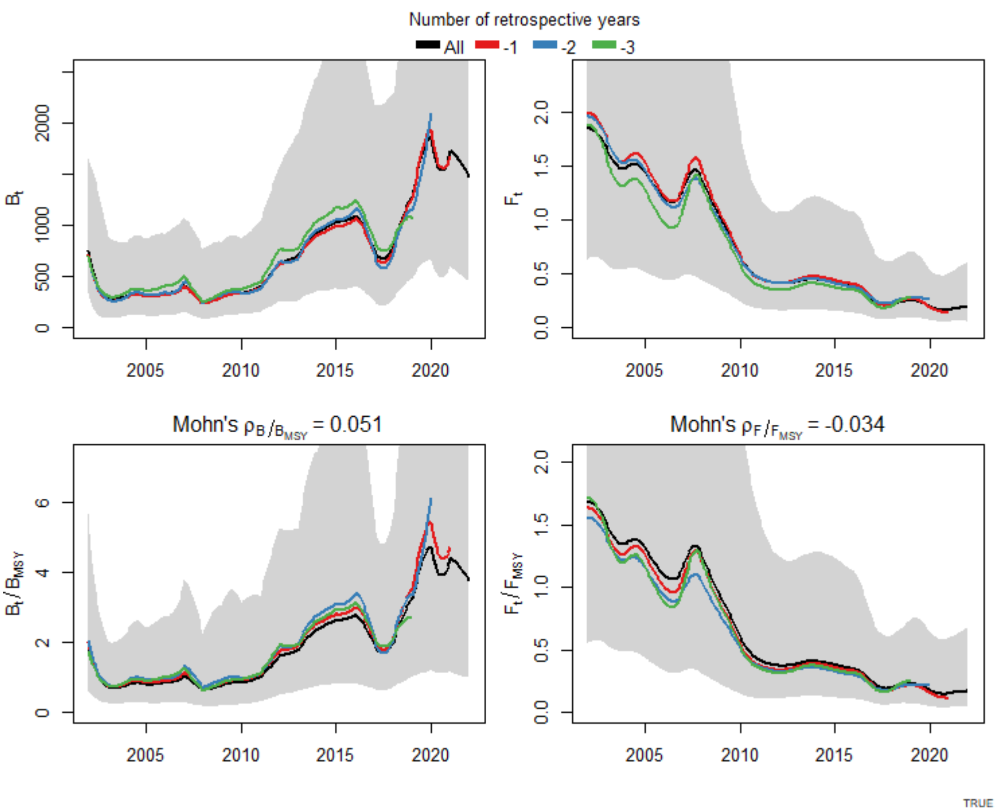


Figure 6.12.3.12 Red mullet in GSA 10: Retrospective analysis of Spict run 1.

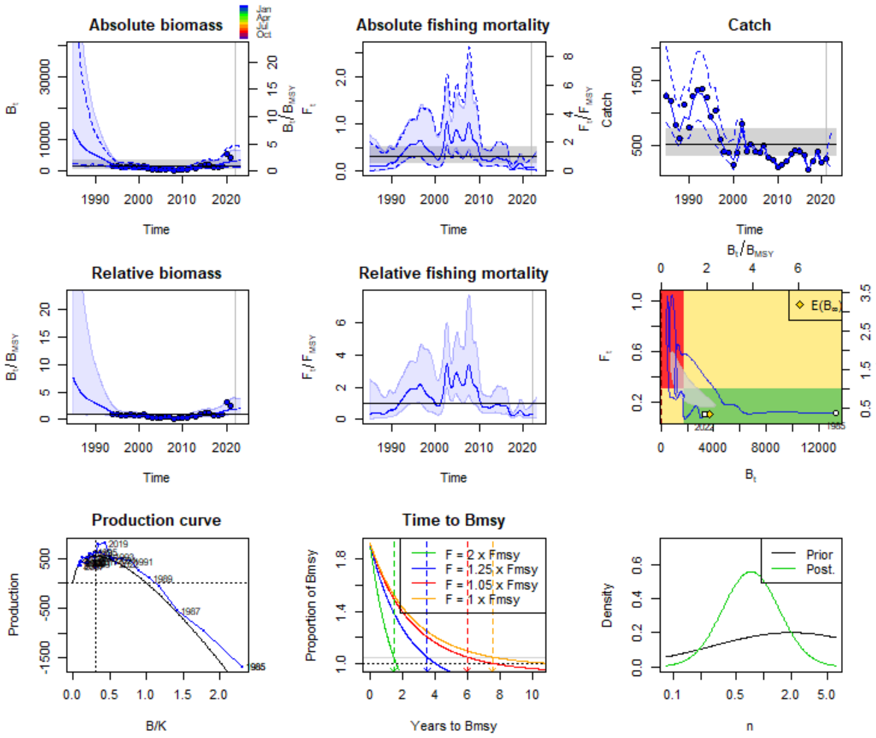


Figure 6.12.3.13 Red mullet in GSA 10: Summary of Spict run 2.

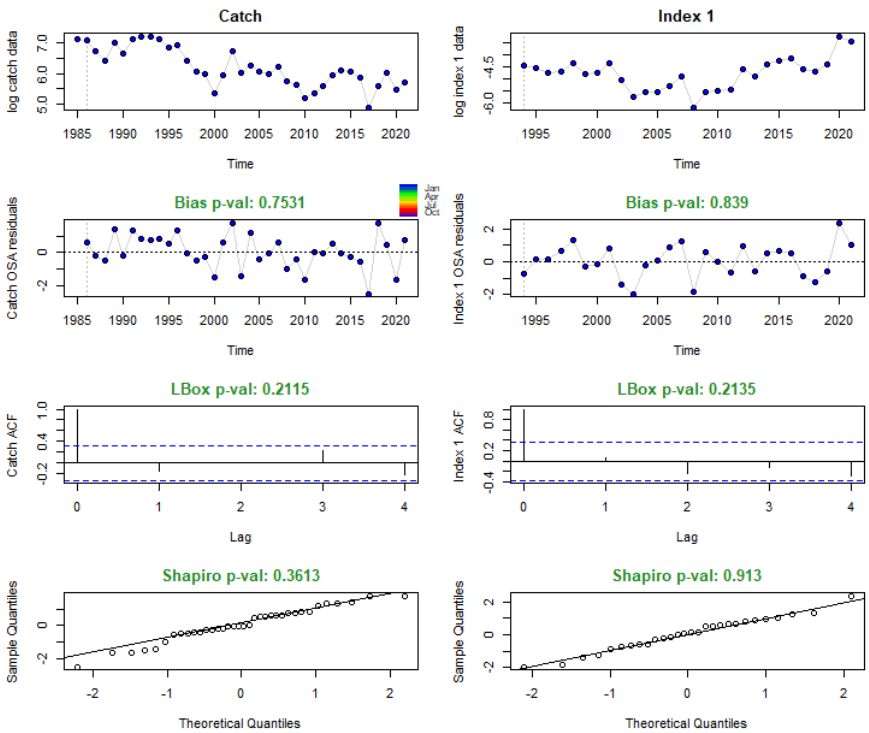


Figure 6.12.3.14 Red mullet in GSA 10: Diagnostic plots of Spict run 2.

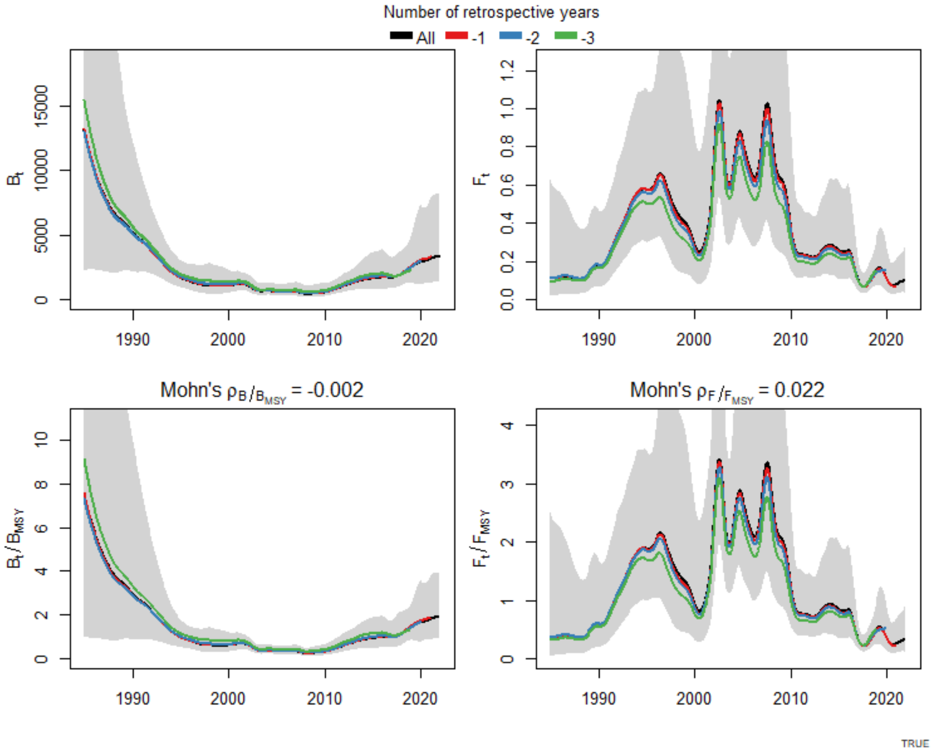


Figure 6.12.3.15 Red mullet in GSA 10: Retrospective analysis of Spict run 2.

The checklist defined during the last ICES WKMSYSPiCT 2021 was applied to decide if retain or not the best runs. The results of the checks highlighted that the short time series is more stable respect to the initial values, while the long time series allows to have a production curve that is more plausible. The group agreed that a foundation has been made with these Spict runs for a future validated assessment; more time and more exploration on the priors would be needed in order to identify a run on which to base the estimation of the reference points.

Table 6.12.3.8. Red mullet in GSA 10: Checklist ICES WKMSYSPiCT 2021 applied to the runs 1 and 2.

Check list	Check	long	short
1	Convergence	√	√
2	All variance parameters of the model parameters are finite	√	√
3	No violation of model assumptions	√	√
4	Consistent patterns in the retrospective analysis	√	√
5	Realistic production curve	B/K=0.47	B/K=0.19
6	High assessment uncertainty	logsdb=0.21; logsdc=0.047; logsdi=0.31; logsdf=0.476; B/ Bmsy and F/Fmsy om = 0	logsdb=0.3; logsdc=0.142; logsdi=0.275; logsdf=0.38; B/ Bmsy =0 and F/Fmsy om = 1
7	Initial values do not influence the parameter estimates	unstable	stable

6.12.4 Reference Points

Considering that neither the a4a assessment nor the spict were accepted to provide quantitative advice, no reference point was estimated.

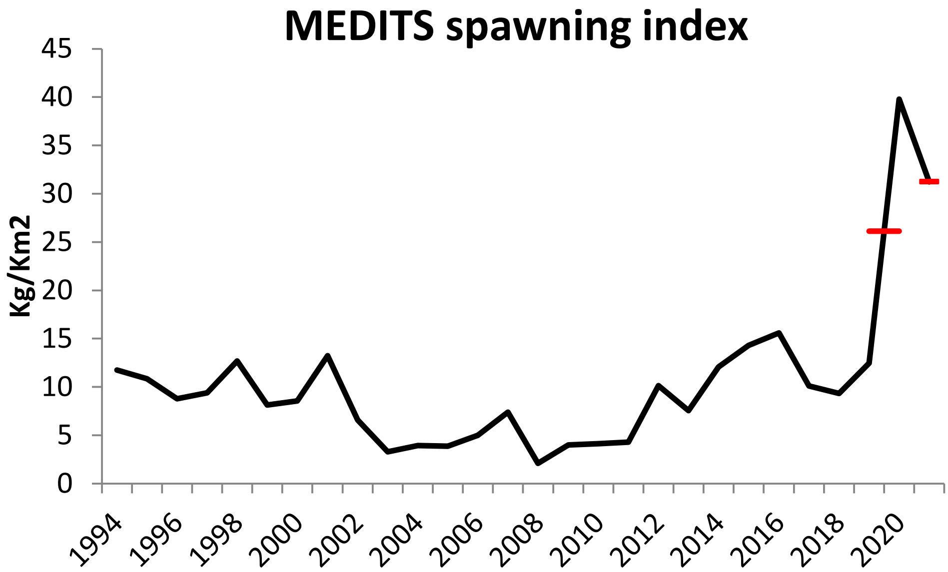
6.12.5 SHORT TERM FORECAST AND CATCH OPTIONS

Since the a4a and the Spict models were not accepted, advice is based on the biomass index of the MEDITS survey in GSA 10. Following the ICES procedures the advice for 2023 was provided using the ICES framework for category 3 stocks was applied (ICES, 2022 and documented in Section 4.7 above). Following the decision tree provided in the ICES technical guidance, given the availability of an index of abundance and the catch of the last three years, Method 3.3 (One-over-two rule for short-lived stocks) was used to provide the catch advice:

$A_{y+1} = A_y * (I_y / \text{mean } I_{y-1}:I_{y-2}) \pm 80\%$ cap

where A_{y+1} is the catch in 2023 that is derived as the average catch in 2019 and 2020 (= 272 tons) multiplied by the ratio between the spaners biomass index in 2021 and the average between 2019 and 2020 (1.2).

The cap was not required.



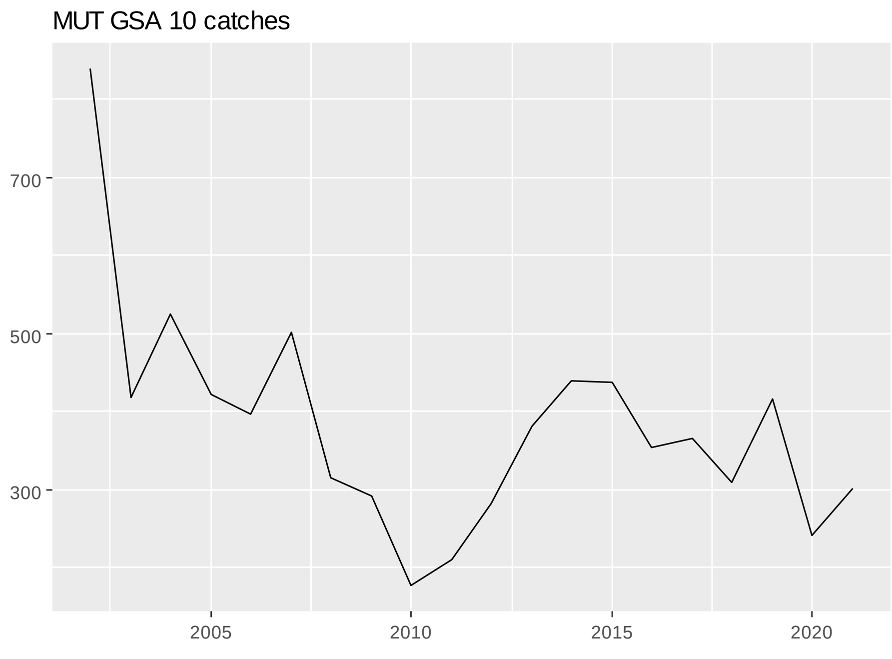


Figure 6.12.1 Red mullet in GSA 10: (top panel) MEDITS in GSA 10 biomass index. The two red segments represent the mean index of 2019-2020 and of 2021. (Bottom panel) Catch by year.

Based on MSY considerations, STECF EWG 22-09 advises to increase the total catch by 8% relative to the catches in 2021 equivalent to catches of no more than 326 tons in 2023.

6.12.6 DATA DEFICIENCIES

The uncommon length structure (between 15 and 20 cm) associated to the discard of the GTR with vessel length VL0006 in 2018 was still present in quarter 4 of 2018. Even the ratio between discard and landing for this stratum seems considerably high (D/L around 400%) for the type of fishery. This anomaly seems due to the only 4 individuals sampled in the discard in only 1 sample collected in the stratum.

In 2019 discard is reported only in the first quarter, while it was expected especially in the third, when the species recruits. The 2019 discard length frequency distribution was distributed into three length classes: 9, 10 and 11 cm.

A mismatch of 2018 landing of FDI was still observed.

In MEDITS data of 2020 less than one half of the hauls were performed.

In 2020 and 2021 no discard sample are present.

A SOP correction of 6.54 was found in the 2020 catch data and a SOP of 200 in the 2021 data. This was found to be due to the small number of trips (in 2021 only 1 trip in quarter 4)monitored and of length measurements collected (in 2021 only 53 in the whole year).

6.13 Norway lobster in GSA 9

6.13.1 Stock Identity and Biology

Due to a lack of information about the structure of *N. norvegicus* population in the western Mediterranean, this stock was assumed to be confined within the GSA 9 boundaries (Figure 6.11.1.1).

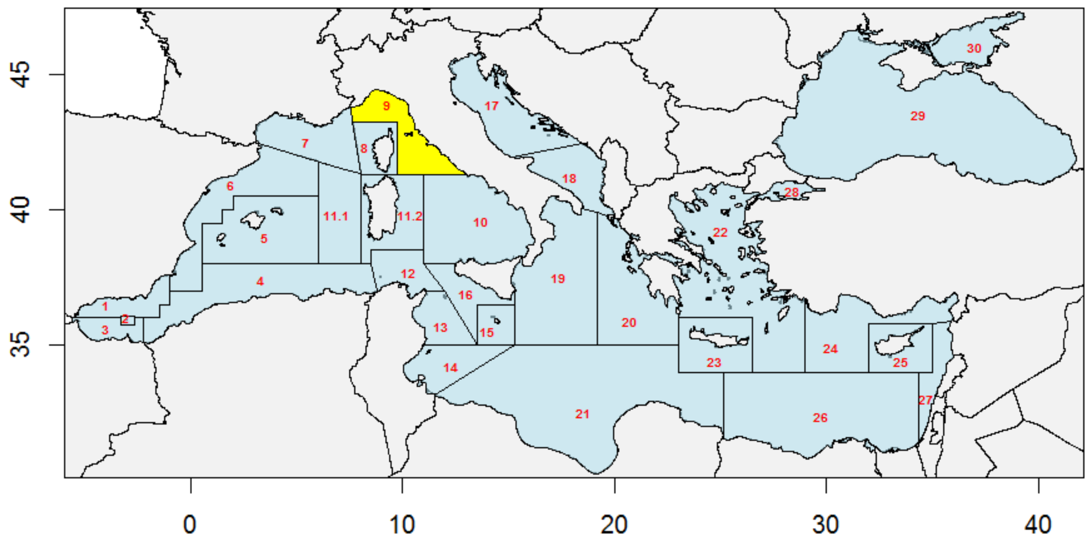


Figure 6.13.1.1 Limit of Geographical Sub-Area (GSA) 9.

Growth Maturity and Natural Mortality

For *N. norvegicus*, there is a difference in growth between males and females. Males attaining greater lengths at ages and maximum sizes compared to females. Growth parameters for *N. norvegicus* in GSA 9 are provided in Table 6.13.1.1

Several sets of VBGF parameters have been reported in the DCF database. Also for the Length-Weight relationship, several sets of paramentes by sex are provided for GSA 9. The VBGF and LW relationship parameters used for the assessment are summarized in the following table (Table 6.13.1.1).

Table 6.13.1.1 Norway lobster in GSA 9: VBGF and LW relationship parameters. A correction of 0.5 was applied to t_0 to account for spawning at middle year.

		Units	Females	Males
VBGF parameters	**L_∞**	Mm	56.0	72.1
	k	years^{-1}	0.21	0.17
	t_0	Years	0.0 + 0.5	0.0 + 0.5
LW relationship	**a**	mm/g	0.00032	0.00038
	b	mm/g	3.24848	3.18164

A vector of proportion of mature by age was computed as a weighed average of the vectors available from the DCF database in GSA 9. A natural mortality vector was estimated by sex using the Chen and Watanabe equation and the growth parameters described above. A combined natural mortality vector was then computed as a weighed average of the vectors by sex. The vector of proportion of mature and the natural mortality vector used in the assessment of Norway lobster in GSA 9 are shown in Table 6.13.1.2. The Maturity vector used this year is shifted by one age from the one applied for the lat two years, which was set in error. Maturity acts primarily as a scalling factor on SSB and reference points and has little influece on management parameters, though $F_{0.1}$ does depend in a small way on maturity at age.

Table 6.13.1.2 Norway lobster in GSA 9: natural mortality and proportion of mature vectors by age.

Age	Natural mortality	Proportion mature
1	**0.75**	**0.10**
2	**0.50**	**0.40**
3	**0.39**	**0.75**
4	**0.33**	**1.00**
5	**0.29**	**1.00**
6	**0.26**	**1.00**
7	**0.24**	**1.00**
8	**0.23**	**1.00**
9+	**0.23**	**1.00**

6.13.2 DATA

6.13.2.1 CATCH (LANDINGS AND DISCARDS)

The annual total landings of Norway lobster available in the DCF database are reported in Table 6.13.2.1.1 and Figure 6.13.2.1.1. In general, landings are showing a decreasing pattern along the time series. The time series of landings by gear are shown in Figure 6.13.2.1.2.

Landings of Norway lobster in GSA 9 in the period 1994-2002 were gathered from the Italian official statistics (prior to DCR/DCF) which were collected and stored under the RECFISH project (Ligas, 2019).

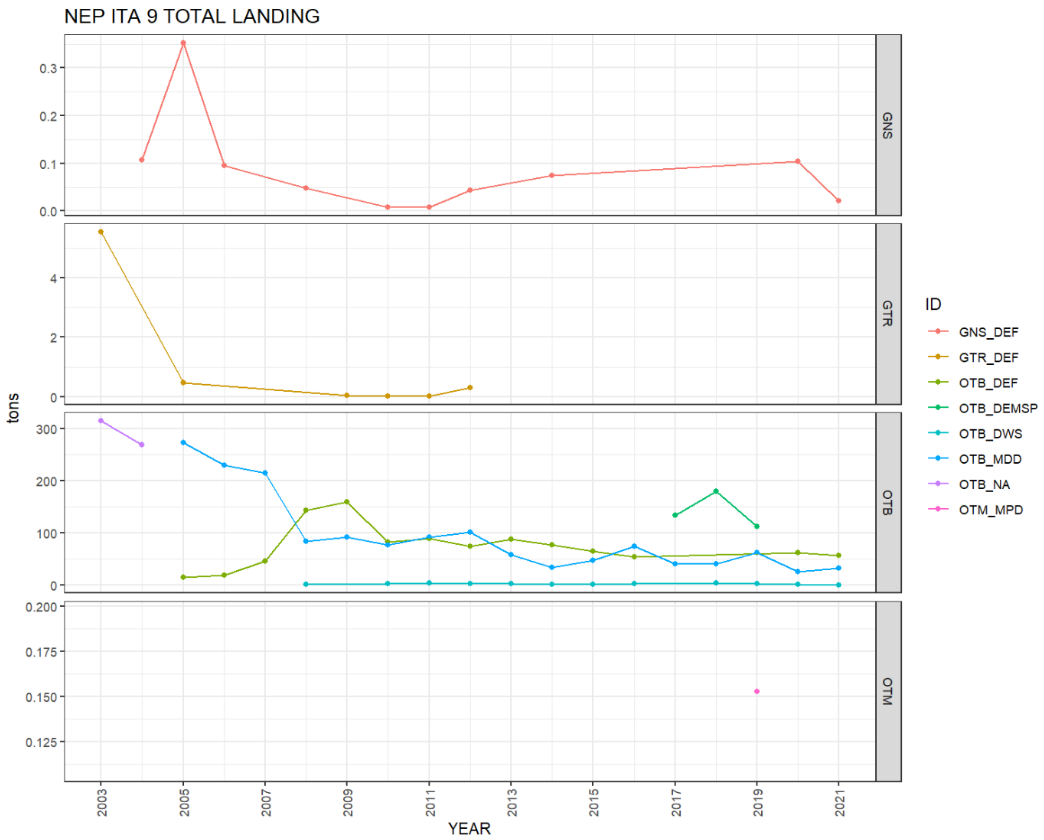


Figure 6.13.2.1.1. Norway lobster in GSA 9: landings trend by gear in GSA 9.

Although the bulk of the production in GSA 9 is coming from the trawl fisheries (mostly demersal species and mixed demersal and deep-water species trawling), other fisheries (mostly gill nets) provide small contribution to the total production.

Table 6.13.2.1.1. Norway lobster in GSA 9: landings by gear.

	GSA 9	
year	**OTB**	**Other gears**
2003	320.9	5.54
2004	268.7	0.11
2005	288.5	0.83
2006	247.5	0.09
2007	260.5	0.00
2008	227.7	0.04
2009	250.3	0.04
2010	161.6	0.04
2011	184.0	0.04
2012	178.2	0.34
2013	147.6	0.00
2014	111.6	0.07
2015	113.6	0.00
2016	130.9	0.00
2017	173.6	0.00
2018	223.2	0.00
2019	177.0	0.00
2020	88.9	0.10
2021	86.9	0.02

Table 6.13.2.1.2. Norway lobster in GSA 9: landings from Italian official statistics as collected by the RECFISH project.

Year	OTB
1994	376.4
1995	345.4
1996	359.5
1997	727.6
1998	225.5
1999	178.6
2000	334.9
2001	269.5
2002	276.8

Landings in 1997 were considered misreported. Checking the data it was pointed out that the landings reported in two ports were unreliably high compared to the other ports and the time series. Therefore the value was re-estimated for being used in the assessment.

The size structures by year and gear are shown in Figures 6.13.2.1.2-6.13.2.1.4.

LFDs for the period 1994-2002 were provided by the results of the RECFISH project (Ligas, 2019), who collected historical fishery information from previous projects and studies performed in the Mediterranean and Black Sea.

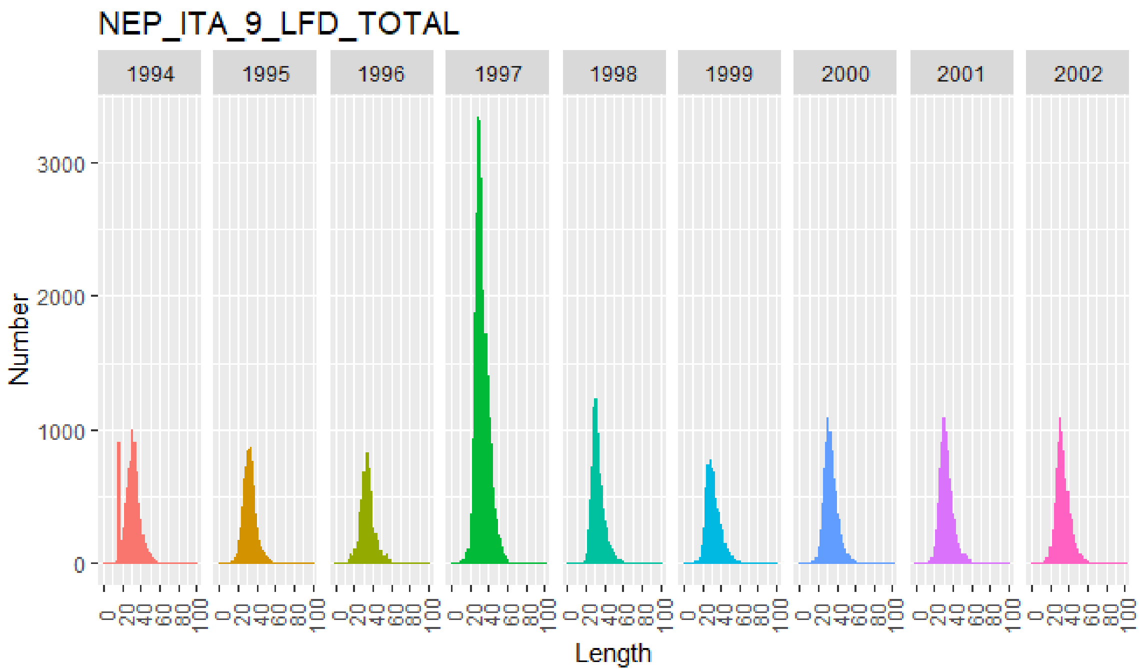


Figure 6.13.2.1.2. Norway lobster in GSA 9: LFDs of landings by year provided by the RECFISH project.

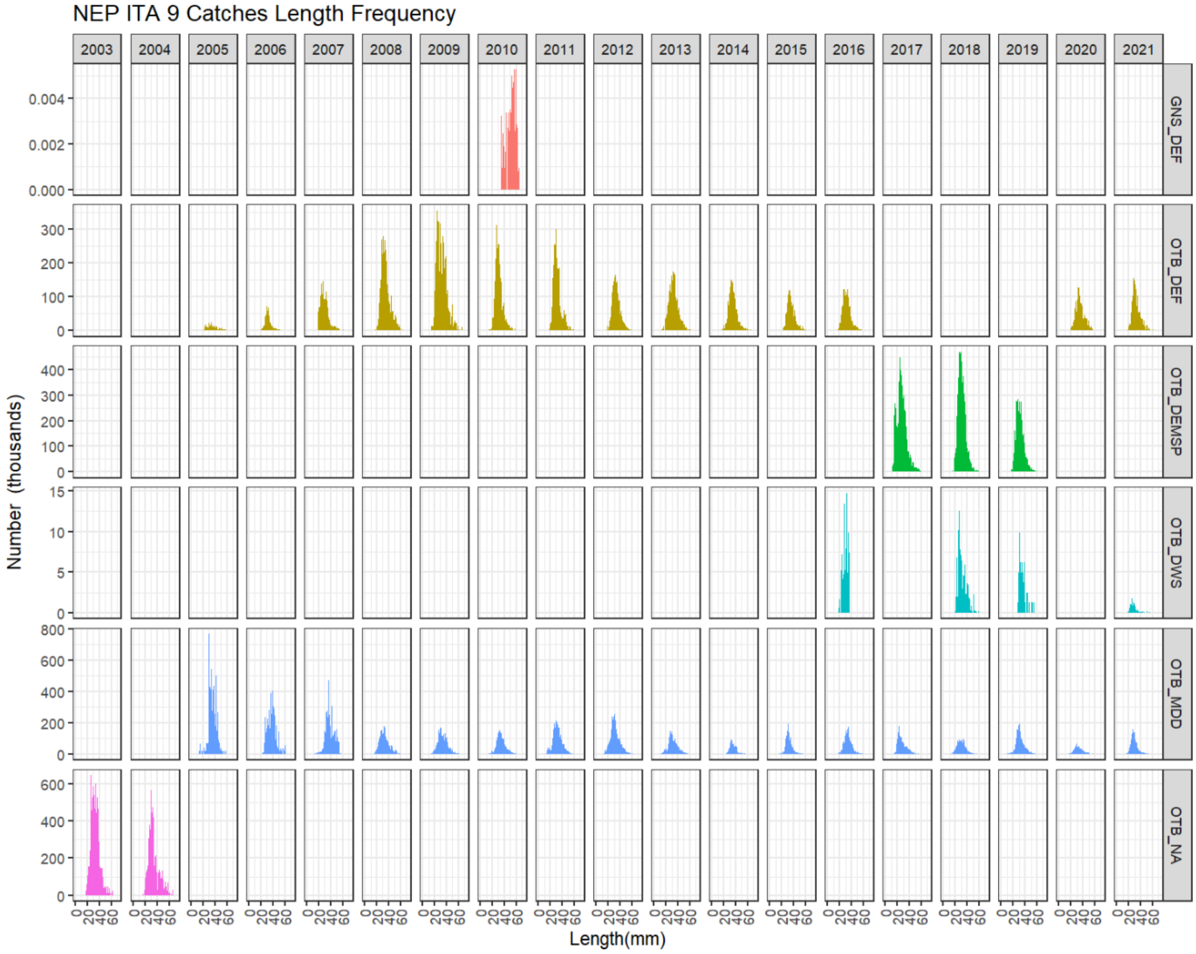


Figure 6.13.2.1.3. Norway lobster in GSA 9: LFDs of landings by year and gear of Norway lobster in GSA 9.

Discards of Norway lobster are low. Low values of discards (from OTB) are reported in GSA 9 from 2009 onwards. The discards are summarized in Table 6.13.2.1.3. Despite the low values of discards, LFDs are available, and the data were included into the stock assessment. LFDs of discards of Norway lobster are shown in Figure 6.13.2.1.4

Table 6.13.2.1.3. Norway lobster in GSA 9: Discards by GSA.

year	GSA9 discards (t)	year	GSA9 discards (t)
2003	0.0	2013	1.3
2004	0.0	2014	0.4
2005	0.0	2015	0.1
2006	0.0	2016	0.4
2007	0.0	2017	8.2
2008	0.0	2018	0.7
2009	9.2	2019	0.7
2010	0.9	2020	0.9
2011	1.0	2021	0
2012	0.8		

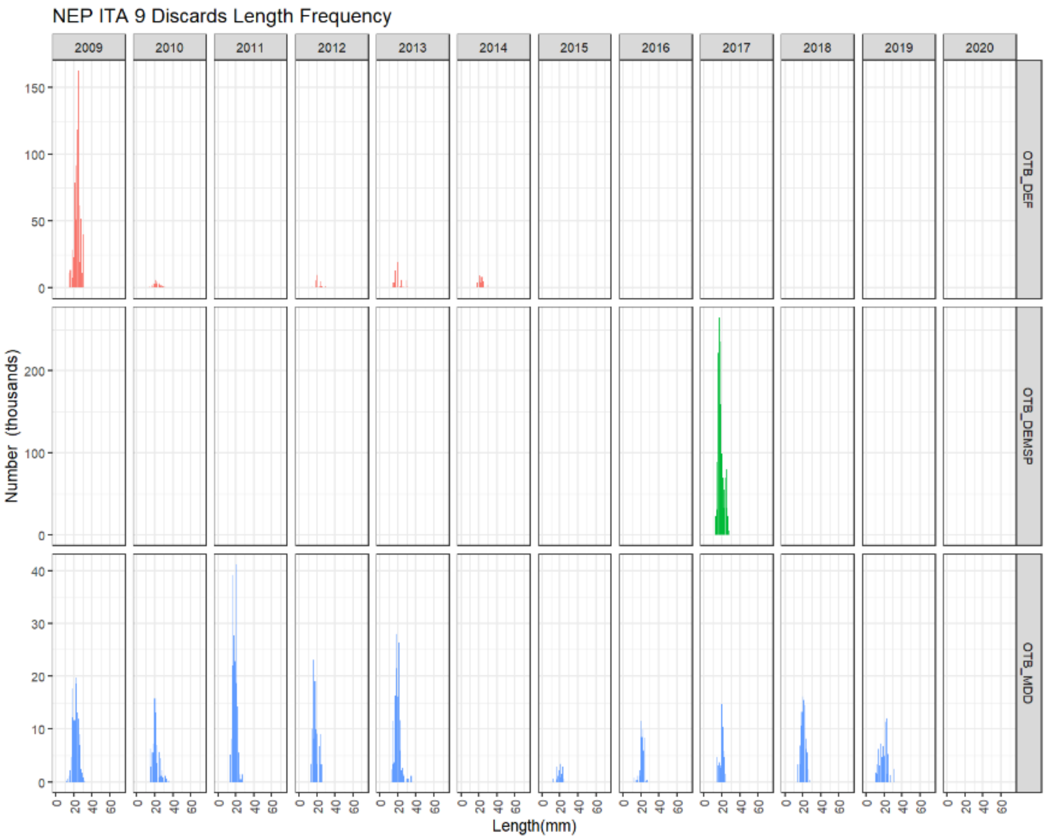


Figure 6.13.2.1.4 Norway lobster in GSA 9: LFDs of discards of Norway lobster in GSA 9.

6.13.2.2 Effort

Fishing effort data for 2021 will be reported to STECF through the FDI data call within the DCF framework and is reported by STECF EWG 22-10.

6.13.2.3 Survey data

Since 1994, MEDITS trawl surveys have been regularly carried out each year (centred in the early summer). A random stratified sampling by depth (five strata with depth limits at 50, 100, 200, 500 and 800 m) is applied. Haul allocation was proportional to the stratum area. All the abundance data (number and total weight of fish per surface unit) are standardized to the km^2 using the swept area method.

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance*100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the three GSAs.

Geographical distribution

The following maps Figure 6.13.2.3.1. show the biomass indices (kg/km^2) by haul of the MEDITS survey.

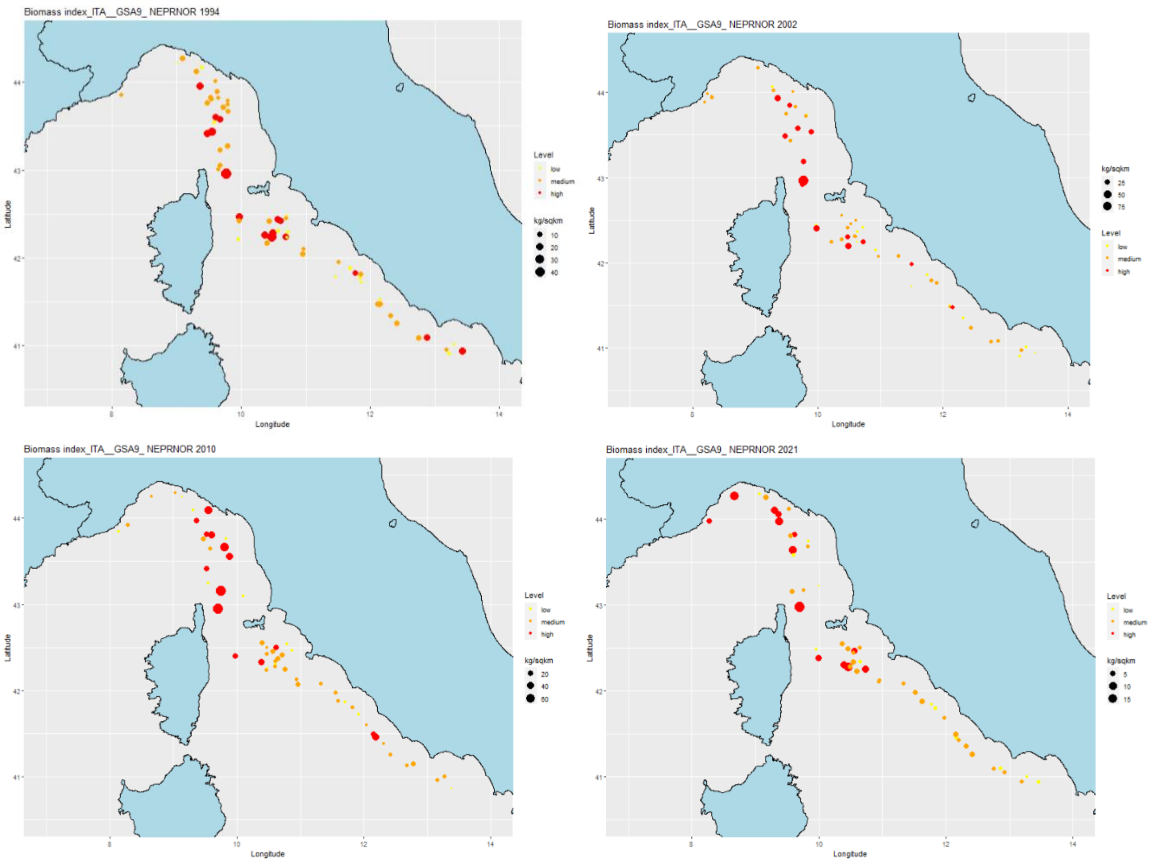
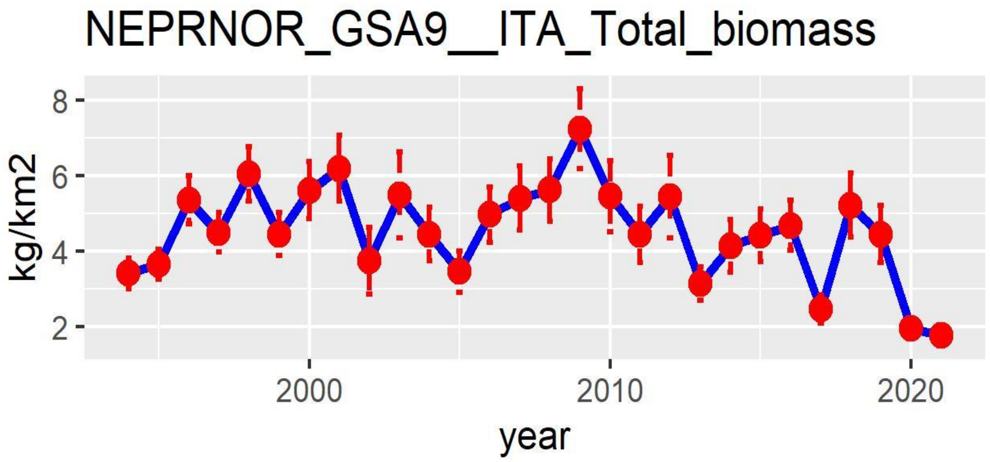


Figure 6.13.2.3.1. Norway lobster in GSA 9: distribution pattern in the period 1994-2019 (MEDITS survey). Maps for the years 1994, 2002, 2010 and 2021 are shown.

Trends in abundance and biomass

The trends of the MEDITS indices (biomass and density) computed on the three GSAs combined are shown in Figure 6.13.2.3.2.

The time series are characterized by wide fluctuations. A first evident peak is observed in 2001, then the highest was in 2009. Despite a further peak in 2012 and 2019, the trend from 2009 onward follows a decreasing pattern until 2021. The biomass index obtained in 2021 is among the lowest observed in the whole time series of the MEDITS data in GSAs 9. The densitiy index in 2021 although shows a small increase trend remain one of the lowest of all time series. This survey was carried out on time in 2021. A sensitivity check on inclusion or exclusion of the survey was conducted and is discussed in Section 6.13.3.



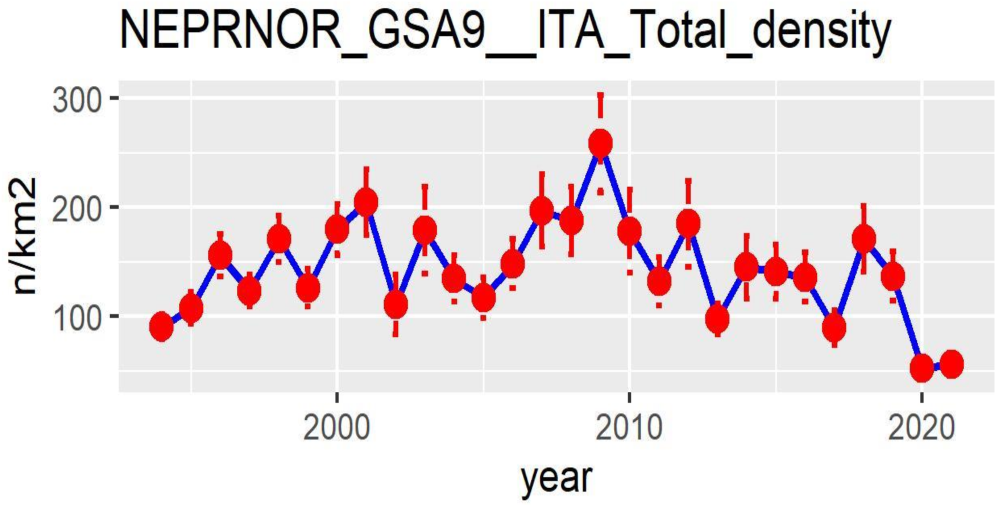


Figure Figure 6.13.2.3.2. Norway lobster in GSA 9: MEDITS standardized biomass and density indices (10-800 m).

Trends in abundance and biomass by length

The stratified abundance indices by length (by sex and total) computed on the GSA 9 during the MEDITS surveys from 1994 to 2021 are shown in Figures 6.13.2.3.3-6.13.2.3.5. Also these plots show that the densities observed in 2013, 2017, 2020 and 2021 are among the lowest observed in the whole time series of the MEDITS survey in the GSAs 9.

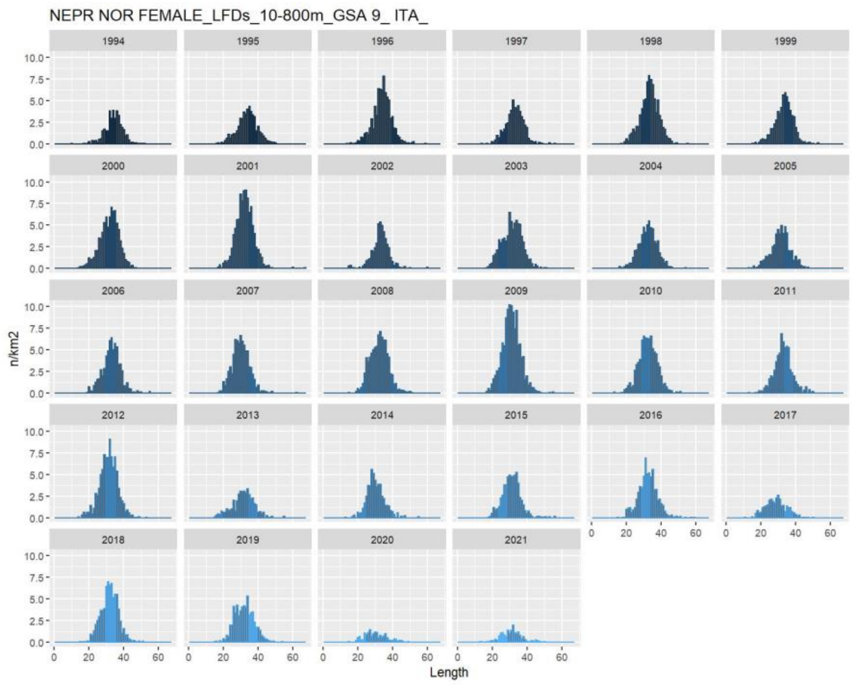


Figure 6.13.2.3.3. Norway lobster in GSA 9: stratified abundance indices by size for females, 1994-2021.

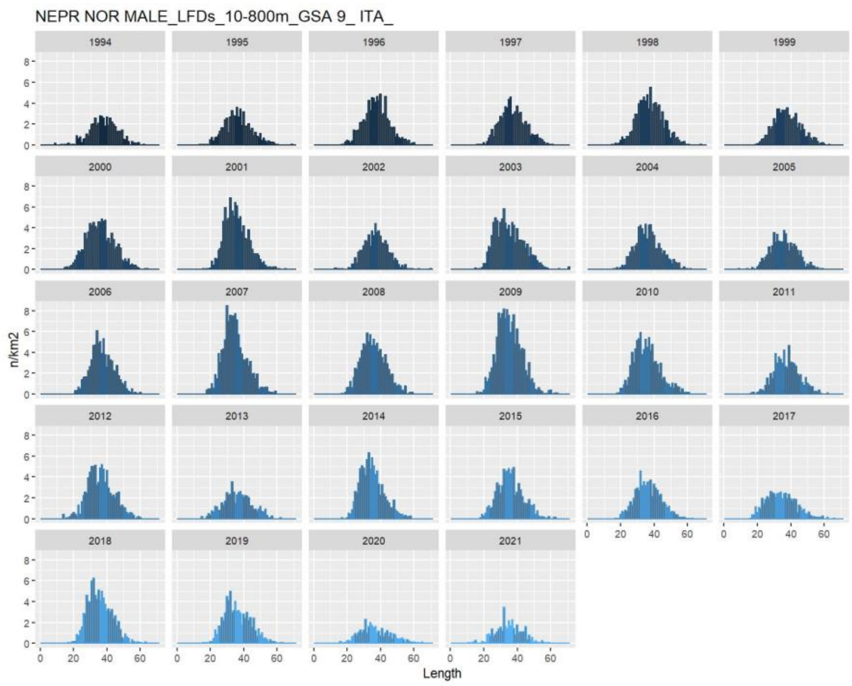


Figure 6.13.2.3.4. Norway lobster in GSA 9: stratified abundance indices by size for males, 1994-2021.

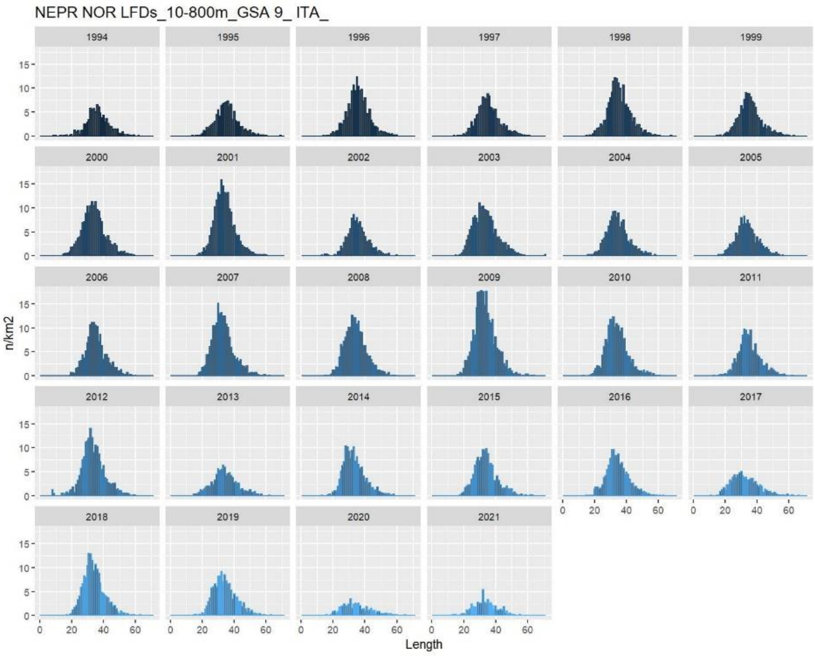


Figure 6.13.2.3.5 Norway lobster in GSA 9: total stratified abundance indices by size, 1994-2021.

6.13.3 STOCK ASSESSMENT

FLR libraries were employed in order to carry out a Statistical Catch-at-age (a4a) assessment.

An a4a stock assessments was carried out adopting as input data the period 1994-2021 for the catch and the index data (MEDITS).On the base results and test carried out during the EWG 21-11 any LFD reconstructed was carried out. The missing LFDs were replaced by raising to catch with LFDs available through the use of SoP. The full period 1994-2021 for the tuning file (MEDITS indices) was used for tuning.

A natural mortality vector computed using Chen and Watanabe model was estimated and used in the assessment. Natural mortality vector and proportion of mature are described in section 6.13.1.2. Length-frequency distributions of commercial catches and surveys were split by sex and then transformed in age classes using length-to-age slicing with different growth parameters by sex. A correction of 0.5 was applied to t_0 to account for spawning at middle year.

The number of individuals by age was SOP corrected [SOP = catches / Σa (total catch numbers at age a x catch weight-at-age a)] the correction was only required in one year 2021 with a value of 0.99. The stock assessment was carried out updating the stock object used in the previous assessment (EWG 21-11).

Minor corrections on mean weight of age 1 in year 2018 and 2019 were applied as suggested by the EWG 22-03. The maturity ogive used in EWG 21-11 was also updated (Table 6.13.1.2).

In catches, a plus group at age 9 was set, while the age structure in the MEDITS survey was from age 1 to age 8.

F_{bar} range was fixed at 2-6.

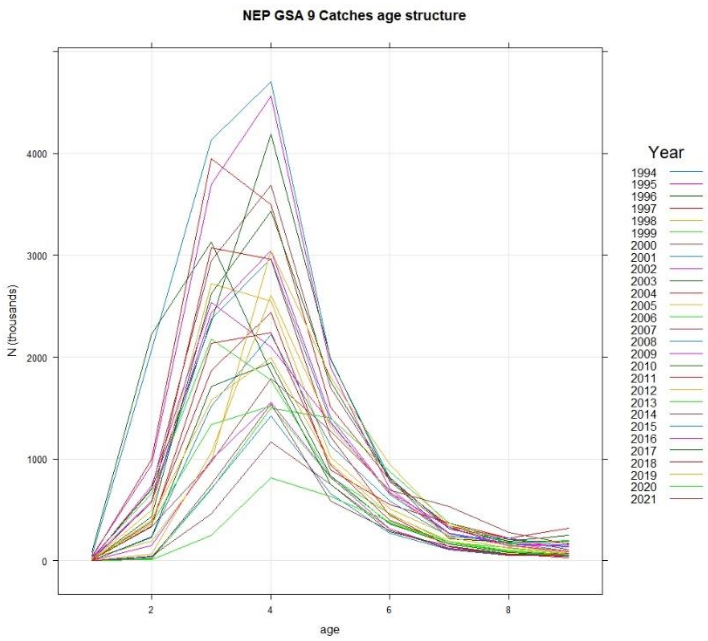


Figure 6.13.3.1. Norway lobster in GSA 9: catch-at-age distribution by year of the catches (1994-2021).

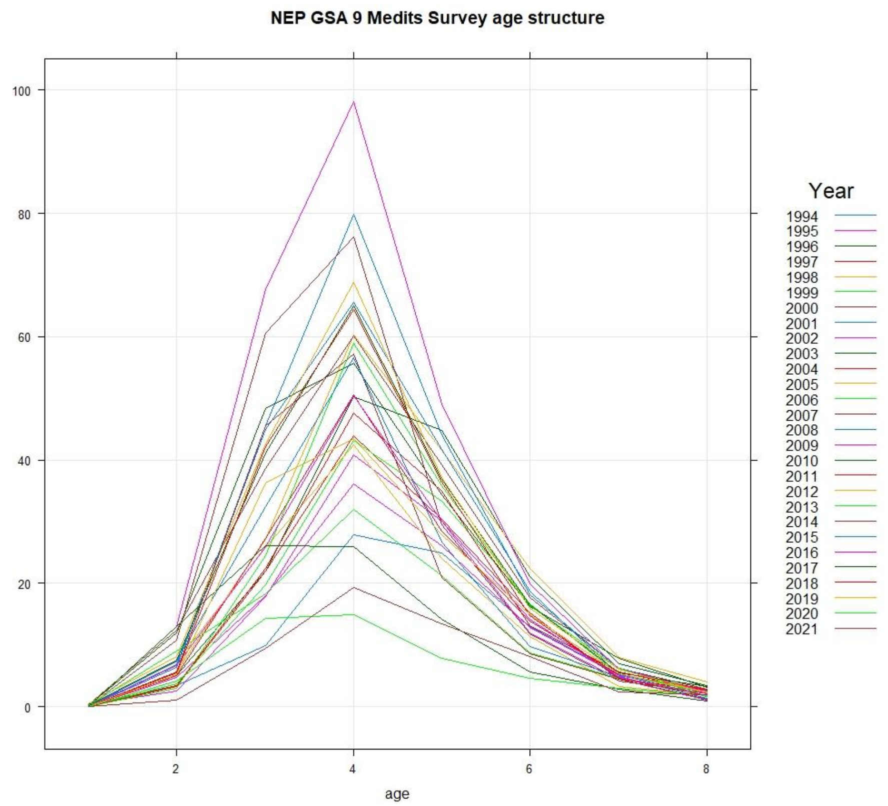


Figure 6.13.3.2. Norway lobster in GSA 9: catch-at-age distribution by year of the MEDITS survey (1994-2021).

Table 6.13.3.1. Norway lobster in GSA 9: catch-at-age (thousands).

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	52.95	44.04	15.87	28.96	0.60	28.52	22.56	18.15	18.64	0.02	0.02
2	2068.15	940.40	697.83	997.69	496.42	657.78	710.43	571.64	587.18	434.60	382.37
3	4130.57	3693.43	2349.24	3947.95	2722.83	2174.58	2947.57	2371.72	2436.22	2620.62	1864.63
4	4706.35	4563.82	4187.22	3494.08	2553.18	1771.00	3687.89	2967.40	3048.10	3433.13	2437.39
5	1973.47	1902.95	1986.65	1505.99	1020.68	820.93	1698.78	1366.89	1404.07	1760.81	890.20
6	818.65	707.86	780.78	791.73	510.77	462.32	807.52	649.75	667.42	811.33	553.90
7	315.25	266.57	312.32	340.16	250.85	179.66	328.55	264.36	271.55	214.78	368.55
8	175.67	147.23	194.77	223.05	147.60	130.76	204.54	164.58	169.05	188.10	220.04
9	95.38	85.85	245.60	110.10	73.73	62.79	170.19	136.94	140.67	193.16	316.53

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	29.66	0.02	6.07	0.02	4.94	2.89	7.88	7.34	13.37	0.02	0.70
2	192.73	16.69	335.97	229.16	737.92	236.77	337.78	394.08	360.66	43.89	36.95
3	967.75	702.52	968.53	1519.77	2539.82	1709.13	2134.85	1578.94	1338.82	458.35	708.16
4	3043.55	1496.65	1786.35	2219.04	2097.09	1942.86	2237.00	1992.22	1523.26	1168.84	1420.51
5	1804.23	1402.44	1270.58	1131.09	1350.61	836.48	940.49	951.33	810.06	753.40	656.60
6	946.61	876.36	696.87	590.84	672.54	363.55	398.46	451.81	368.85	311.06	269.80
7	340.41	371.26	532.22	233.97	324.62	162.19	177.71	189.65	177.05	108.16	109.92
8	158.83	168.06	276.72	218.80	141.91	77.72	94.87	91.35	88.92	48.21	54.87
9	92.35	197.08	161.23	133.98	155.83	56.99	50.45	66.81	53.59	58.25	50.90

age	2016	2017	2018	2019	2020	2021
1	0.94	88.95	3.64	0.01	0.01	0.01
2	149.96	2225.09	574.65	64.18	5.25	21.59
3	990.63	3127.00	3075.68	1063.27	247.90	750.28
4	1555.56	1853.21	2963.39	2606.78	813.30	1538.78
5	817.10	748.57	1215.84	1313.54	629.58	586.63
6	311.86	286.39	445.00	678.30	382.09	295.21
7	119.04	142.22	134.76	227.81	176.21	112.91
8	61.68	62.07	59.89	122.74	100.68	65.55
9	44.25	73.84	46.89	67.82	57.98	30.48

Table 6.13.3.2. Norway lobster in GSA 9: tuning data (MEDITS survey, n/km^2).

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.338	0.067	0.064	0.064	0.065	0.001	0.323	0.001	0.315	0.154	0.001
2	3.359	4.768	5.102	3.279	5.610	3.736	12.384	6.411	2.463	11.915	5.038
3	9.959	18.055	21.953	21.984	27.120	19.713	38.673	45.479	17.882	48.320	27.302
4	27.894	36.119	50.213	43.950	60.245	43.146	60.076	79.863	40.812	55.665	50.602
5	24.898	26.055	44.789	30.299	41.635	33.301	39.263	44.113	30.080	34.328	28.499
6	13.005	12.913	21.050	15.236	22.391	16.690	17.669	18.123	11.988	16.201	13.931
7	5.169	5.100	6.911	4.403	7.925	5.158	6.205	6.195	4.395	7.767	5.247
8	1.584	2.559	3.358	2.645	3.962	2.262	2.814	2.377	1.066	3.073	2.781

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.243	0.001	0.001	0.001	0.001	0.156	0.100	0.525	0.177	0.074	0.001
2	7.237	2.990	10.739	6.874	13.039	7.534	3.435	8.122	9.060	5.655	7.418
3	25.777	24.449	60.542	44.890	67.584	41.081	22.403	42.608	18.352	45.580	32.492
4	42.383	58.893	76.251	65.505	98.156	64.962	47.581	68.760	32.000	57.123	56.616
5	24.092	35.850	29.501	41.775	49.126	36.821	34.918	37.211	21.239	20.952	26.687
6	11.420	16.369	11.756	18.663	19.968	16.552	13.211	15.915	8.784	8.583	9.822
7	3.229	6.240	4.139	5.203	6.127	5.432	5.676	6.125	4.604	4.450	4.926
8	1.786	1.612	2.206	2.554	2.400	3.229	2.738	2.248	2.138	1.243	1.324

age	2016	2017	2018	2019	2020	2021
1	0.001	0.062	0.001	0.001	0.064	0.074
2	6.696	13.059	5.500	5.200	4.218	1.123
3	25.881	26.054	42.110	36.225	14.366	9.498
4	50.470	26.008	64.386	43.482	14.936	19.283
5	30.091	14.118	36.402	27.815	7.868	13.376
6	14.145	5.657	14.758	14.832	4.548	8.193
7	4.746	2.786	4.541	5.290	2.988	2.339
8	2.126	0.842	1.847	2.358	1.820	1.998

Table 6.13.3.3. **Norway lobster in GSA 9:** Catch (tons; discards are included).

1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
376.4	345.4	359.4	327.0	225.5	178.6	335.0	269.5	276.9	320.9	268.7	288.5	247.5
2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
260.6	227.7	259.5	162.6	185.0	179.0	149.0	112.0	113.7	131.3	181.8	223.9	177.5
2020	**2021**											
90.1	89.9											

Table 6.13.3.4. Norway lobster in GSA 9: Weight-at-age matrix (kg).

age	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1	0.001	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001
2	0.005	0.006	0.005	0.007	0.008	0.007	0.007	0.007	0.007	0.007
3	0.014	0.015	0.015	0.014	0.015	0.014	0.015	0.015	0.015	0.015
4	0.026	0.027	0.027	0.027	0.026	0.027	0.027	0.027	0.027	0.028
5	0.041	0.040	0.040	0.041	0.040	0.041	0.041	0.041	0.041	0.041
6	0.059	0.058	0.060	0.056	0.057	0.056	0.059	0.059	0.059	0.058
7	0.082	0.083	0.081	0.079	0.081	0.077	0.081	0.081	0.081	0.082
8	0.097	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.099
9	0.125	0.127	0.143	0.137	0.132	0.141	0.143	0.143	0.143	0.154

age	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
1	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	0.007	0.005	0.008	0.007	0.007	0.007	0.007	0.006	0.006	0.006
3	0.015	0.018	0.016	0.014	0.015	0.014	0.015	0.015	0.015	0.015
4	0.026	0.028	0.028	0.029	0.027	0.027	0.026	0.026	0.026	0.027
5	0.041	0.043	0.045	0.043	0.041	0.043	0.041	0.041	0.042	0.042
6	0.063	0.060	0.061	0.062	0.061	0.058	0.059	0.061	0.059	0.059
7	0.087	0.076	0.085	0.087	0.084	0.085	0.085	0.082	0.083	0.084
8	0.104	0.088	0.091	0.103	0.103	0.101	0.099	0.098	0.097	0.099
9	0.151	0.128	0.150	0.121	0.137	0.145	0.130	0.127	0.129	0.127

age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.002
2	0.006	0.007	0.007	0.007	0.007	0.004	0.004	0.004
3	0.016	0.016	0.015	0.013	0.014	0.011	0.011	0.011
4	0.028	0.027	0.027	0.026	0.026	0.020	0.021	0.020
5	0.042	0.042	0.041	0.041	0.040	0.033	0.035	0.033
6	0.057	0.058	0.058	0.059	0.057	0.050	0.051	0.050
7	0.081	0.082	0.083	0.082	0.081	0.070	0.071	0.069
8	0.095	0.096	0.097	0.100	0.090	0.090	0.092	0.090
9	0.147	0.134	0.131	0.139	0.132	0.128	0.119	0.118

The assessment was performed by sex combined. Given that the catches were composed mainly of individuals between 2 and 6 years, these ages were selected as F_{bar} range.

The model settings that minimized the residuals and showed the best diagnostics outputs were used for the final assessment, and are the following:

Fishing mortality sub-model: fmodel = ~ s(age, k = 6, by = breakpts(year, 2008))+ s(year, k=10)

Catchability sub-model: qmodel = list(~ factor(replace(age, age>5,5)))

SR sub-model: srmod = geomean(CV=0.2)

Model <- sca(stock = stk, indices = idx, fmodel, qmodel, srmod)

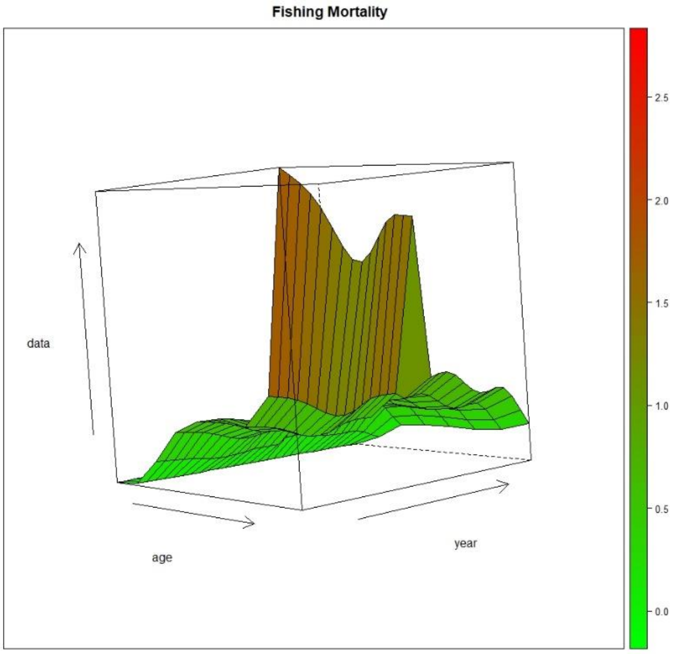


Figure 6.13.3.3. Norway lobster in GSA 9: fishing mortality by age and year obtained from the a4a model (1994-2021).

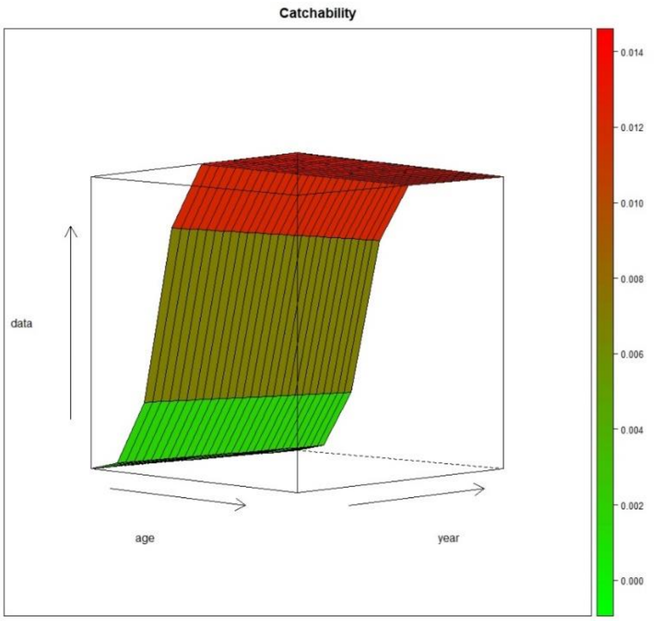


Figure 6.13.3.4. Norway lobster in GSA 9: catchability of the survey by age and year obtained from the a4a model.

The log residuals for the survey show some sign of correlation, that could be linked to the poor internal consistency of the survey data. The residuals and the fitting of the catch data are good, and are probably driving the main outcomes of the assessment. The retrospective analysis is quite stable and the mohn values are low (fbar=0.07024668; ssb=0.15283234; rec=0.14326650). In general, for the assessment above the diagnostics are considered acceptable and the a4a model is acceptable as a basis for advice.

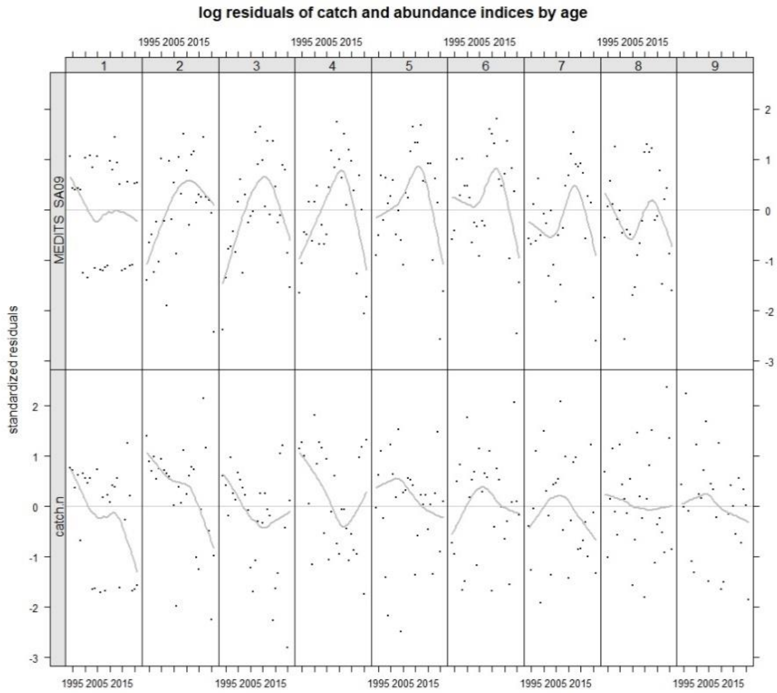


Figure 6.13.3.5. Norway lobster in GSA 9: log residuals for the catch-at-age data of the fishery and the survey, and the catches.

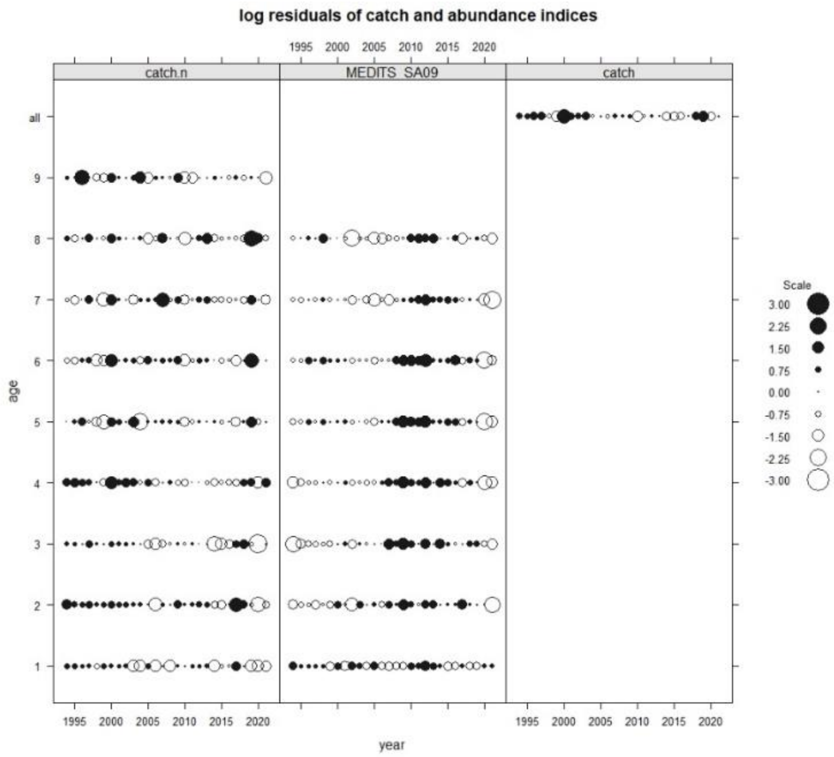


Figure 6.13.3.6. Norway lobster in GSA 9: bubble plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

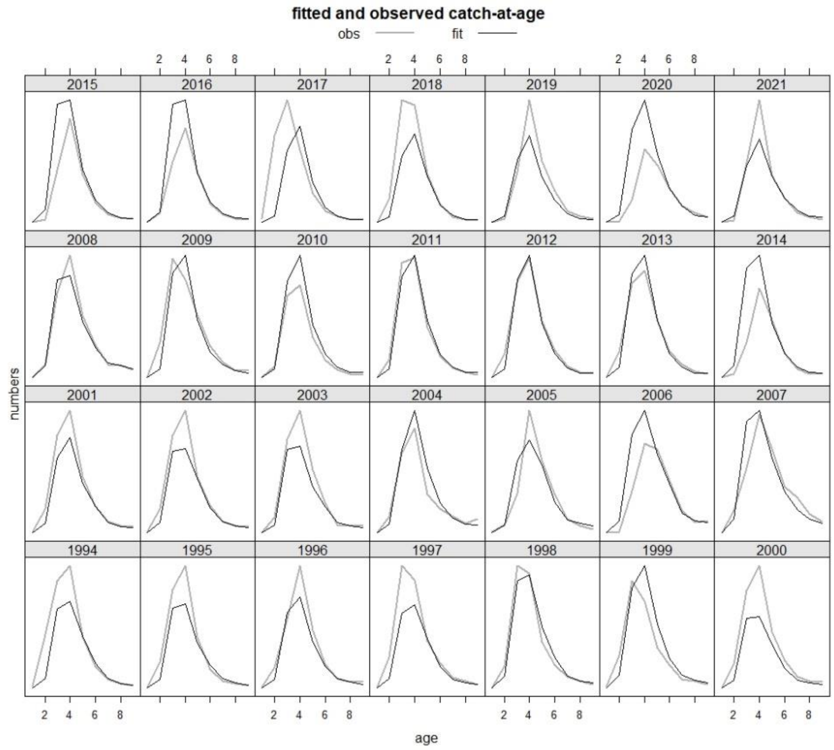


Figure 6.13.3.7. Norway lobster in GSA 9: fitted vs observed values by age and year for the catches.

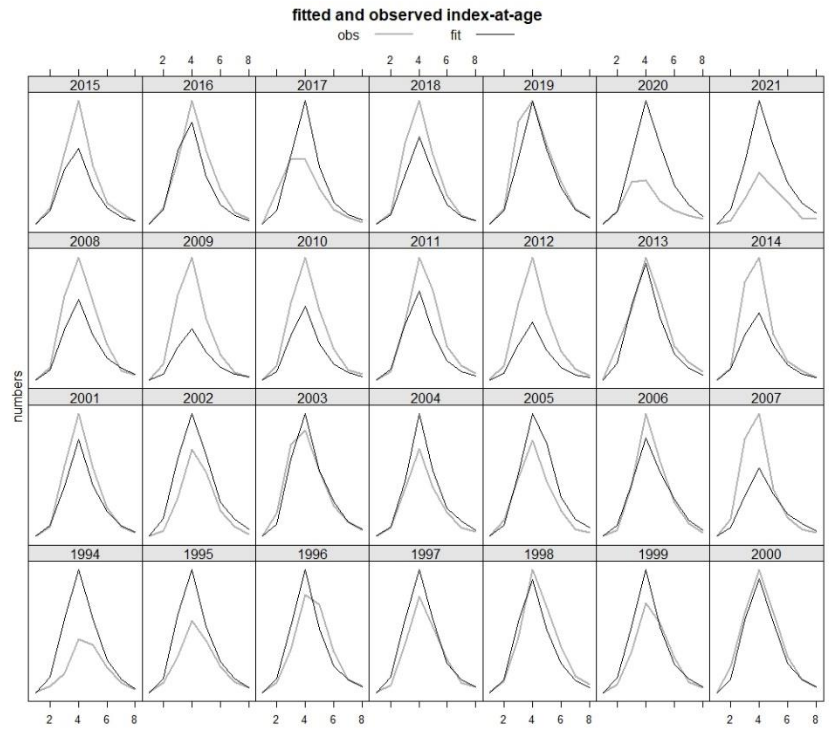


Figure 6.13.3.8. Norway lobster in GSA 9: fitted vs observed values by age and year for the survey.

The internal consistency of the catches is good, while some issues are present in the survey internal consistency. The assessment is relying on the signals from the catch with only minor imput from the survey which shows small blocks of residuals across ages and years suggesting poor reslution of cohorts and correlated errors.

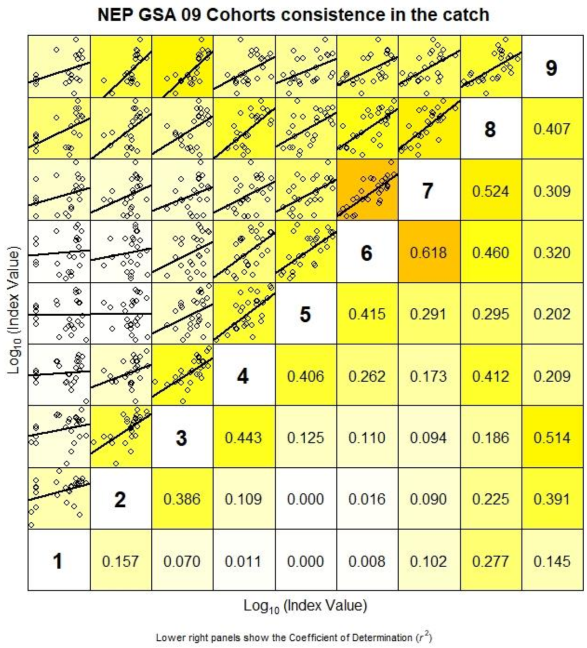


Figure 6.13.3.9. Norway lobster in GSA 9: internal consistency of the catch-at-age data.

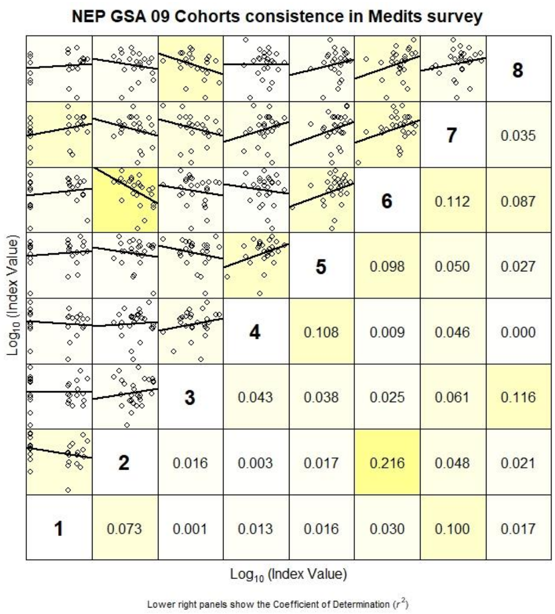


Figure 6.13.3.10. Norway lobster in GSA 9: internal consistency of the catch-at-age data of the MEDITS survey.

The retrospective analysis shows that the assessment model is quite stable with respect to catch REC and SSB. The assessment is considered acceptable for advice.

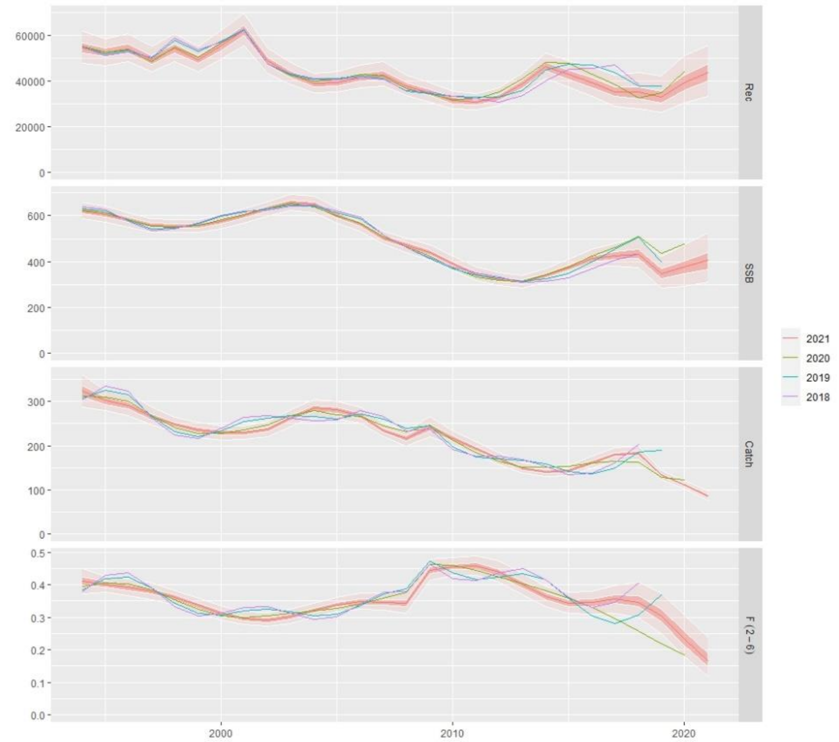


Figure 6.13.3.11. Norway lobster in GSA 9: retrospective analysis.

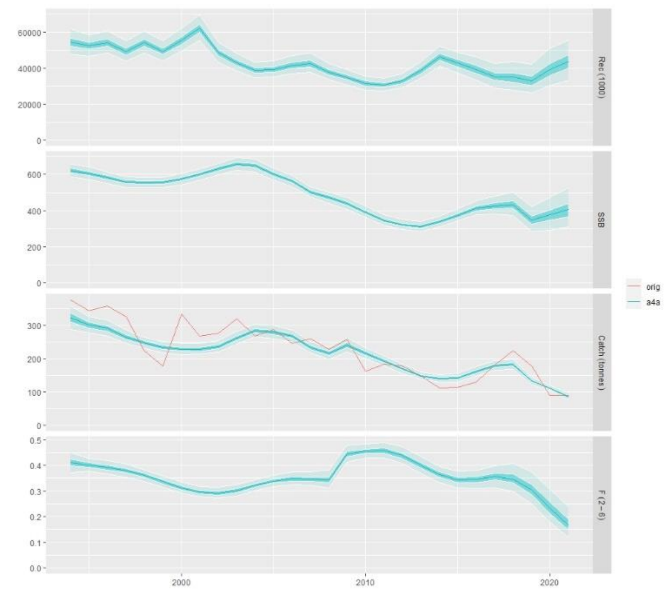


Figure 6.13.3.12. Norway lobster in GSA 9: outputs of the a4a stock assessment model, with uncertainty; input catch data (red) are plotted against the estimated catches (blue line).

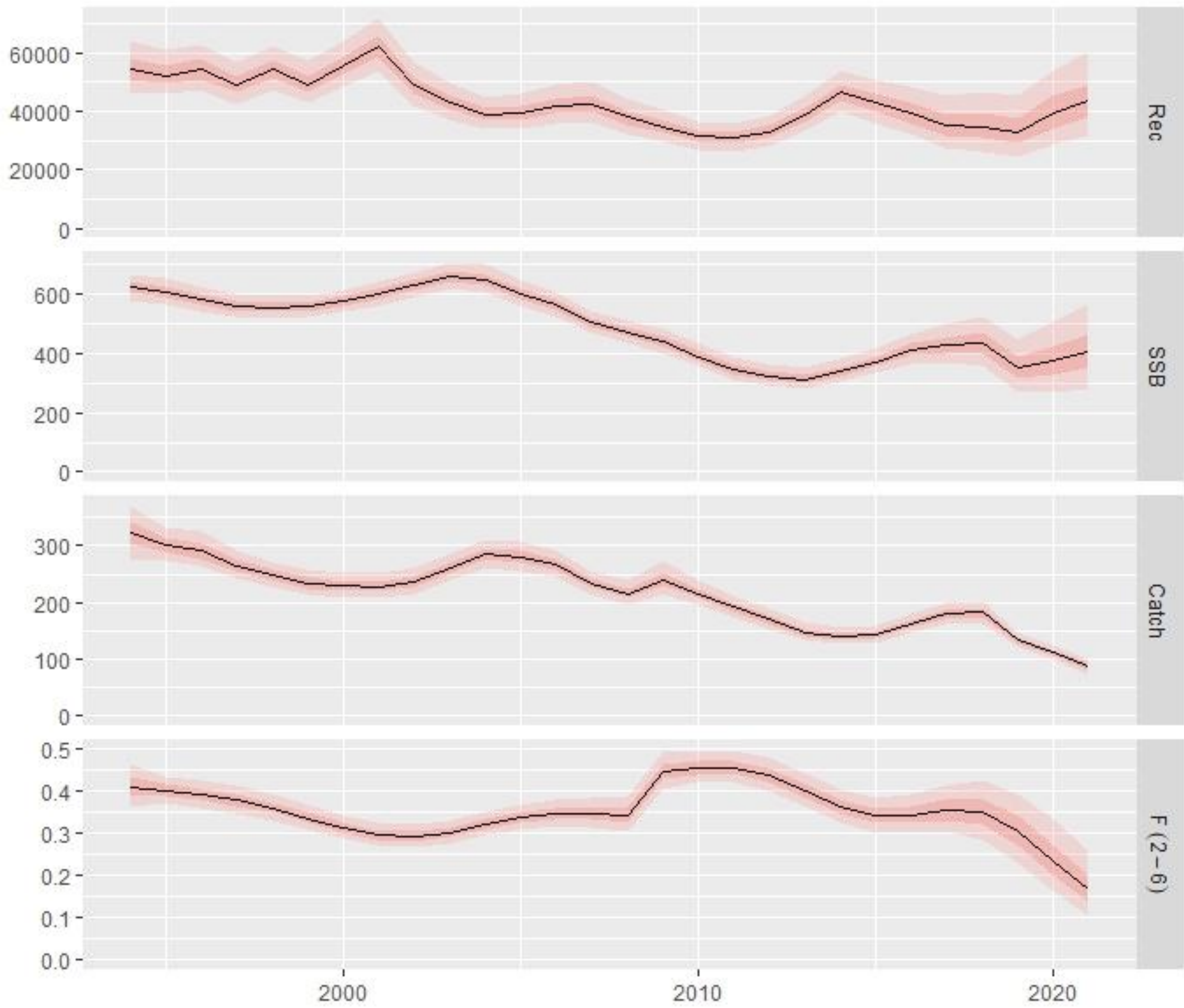


Figure 6.13.3.13. Norway lobster in GSA 9: outputs of the a4a stock assessment model (with uncertainty).

Table 6.13.3.5. Norway lobster in GSA 9: Stock numbers-at-age (thousands).

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	54317	52474	54290	49275	54377	49285	55542	62256	48720	42911
2	29157	25654	24784	25641	23273	25683	23278	26234	29405	23011
3	17269	17406	15320	14806	15326	13920	15376	13949	15731	17635
4	9679	9232	9354	8280	8061	8433	7765	8697	7967	9003
5	4879	4169	4022	4126	3711	3697	3984	3780	4324	3979
6	2148	1964	1701	1666	1743	1612	1664	1860	1810	2082
7	826	851	790	695	695	749	720	773	888	869
8	286	351	367	345	310	319	356	354	390	451
9	94	100	124	134	132	124	135	159	169	187

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	38854	39326	41777	42623	37825	34896	31502	30763	32849	38815
2	20267	18351	18574	19732	20131	17865	16482	14879	14530	15515
3	13795	12141	10986	11116	11809	12049	10693	9862	8902	8698
4	10033	7763	6763	6090	6165	6557	6343	5597	5156	4704
5	4439	4831	3656	3152	2842	2884	2545	2428	2136	2020
6	1886	2045	2166	1619	1398	1264	1107	962	915	828
7	983	864	910	951	712	616	498	430	372	364
8	435	478	409	425	445	334	253	202	173	154
9	209	195	201	172	176	185	196	164	133	115

age	2014	2015	2016	2017	2018	2019	2020	2021
1	46357	42911	39355	35225	34912	33159	39371	43420
2	18333	21896	20268	18588	16638	16490	15662	18597
3	9298	10999	13145	12168	11156	9987	9911	9433
4	4694	5126	6134	7326	6742	6203	5691	5875
5	1941	2040	2291	2738	3223	2992	2923	2954
6	828	842	912	1023	1204	1430	1417	1537
7	349	369	387	418	462	549	696	766
8	160	161	176	184	196	219	277	389
9	108	115	122	132	137	147	173	240

Table 6.13.3.6. Norway lobster in GSA 9: Fishing mortality-at-age.

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.016	0.016	0.015	0.015	0.014	0.013	0.012	0.011	0.011	0.012	0.012	0.013	0.013	0.013
3	0.236	0.231	0.225	0.218	0.207	0.194	0.180	0.170	0.168	0.174	0.185	0.195	0.200	0.199
4	0.512	0.501	0.489	0.472	0.450	0.420	0.390	0.369	0.364	0.377	0.401	0.423	0.433	0.432
5	0.620	0.606	0.591	0.572	0.544	0.508	0.472	0.446	0.441	0.456	0.485	0.512	0.524	0.523
6	0.666	0.651	0.635	0.614	0.584	0.546	0.507	0.479	0.473	0.490	0.521	0.550	0.563	0.562
7	0.616	0.602	0.587	0.568	0.540	0.505	0.469	0.443	0.438	0.453	0.482	0.508	0.521	0.519
8	0.877	0.857	0.836	0.809	0.770	0.719	0.667	0.632	0.624	0.646	0.686	0.724	0.742	0.740
9	2.646	2.588	2.524	2.441	2.323	2.170	2.014	1.906	1.882	1.948	2.071	2.186	2.239	2.233
age	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.013	0.013	0.014	0.014	0.013	0.012	0.011	0.010	0.010	0.011	0.010	0.009	0.007	0.005
3	0.198	0.252	0.257	0.259	0.248	0.227	0.206	0.194	0.195	0.200	0.197	0.172	0.133	0.095
4	0.430	0.616	0.630	0.633	0.607	0.555	0.504	0.475	0.477	0.491	0.482	0.422	0.326	0.232
5	0.520	0.668	0.683	0.686	0.658	0.602	0.546	0.515	0.516	0.532	0.523	0.458	0.353	0.252
6	0.559	0.671	0.687	0.690	0.661	0.605	0.549	0.518	0.519	0.535	0.526	0.460	0.355	0.253
7	0.517	0.649	0.664	0.667	0.640	0.585	0.531	0.501	0.502	0.517	0.508	0.445	0.343	0.245
8	0.736	0.681	0.696	0.700	0.671	0.614	0.556	0.525	0.527	0.542	0.533	0.467	0.360	0.257
9	2.221	0.874	0.894	0.898	0.861	0.788	0.714	0.674	0.676	0.697	0.684	0.599	0.462	0.330

Table 6.13.3.7. Norway lobster in GSA 9: summary results of the a4a assessment.

Year	Recruitment	SSB	Catch	Fbar (2-6)	Total Biomass
1994	54317	620.4	322.175	0.410	1155
1995	52474	605.83	301.861	0.401	1142
1996	54290	582.03	291.121	0.391	1088
1997	49275	558.48	265.53	0.378	1048
1998	54377	554.14	247.757	0.360	1049
1999	49285	554.8	234.736	0.336	1017
2000	55542	574.17	229.103	0.312	1044
2001	62256	598.75	228.773	0.295	1088
2002	48720	629.1	236.358	0.292	1130
2003	42911	657.2	261.925	0.302	1155
2004	38854	648.29	284.607	0.321	1130
2005	39326	600.55	279.907	0.339	1053
2006	41777	561.79	267.574	0.347	1030
2007	42623	501.81	234.143	0.346	926
2008	37825	470.67	215.86	0.344	880
2009	34896	438.97	241.191	0.444	848
2010	31502	389.82	216.84	0.454	761
2011	30763	344.28	193.339	0.456	670
2012	32849	320.88	170.437	0.437	631
2013	38815	310.06	148.297	0.400	610
2014	46357	337.3	140.924	0.363	670
2015	42911	371.78	142.936	0.342	703
2016	39355	410.87	161.742	0.343	771
2017	35225	425.19	177.395	0.354	793
2018	34912	432.65	177.339	0.348	800
2019	33159	346.41	140.849	0.304	621
2020	39371	373.38	115.423	0.235	644
2021	43420	402.75	87.299	0.167	676

6.13.4 REFERENCE POINTS

The STECF EWG 19-10 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

Current F (0.167), estimated as the F_{bar2-6} in the last year of the time series, 2021 is above the level of $F_{0.1}$(0. 0.109), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that Norway lobster in GSA 9 is exploited at unsustainable level.

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4.

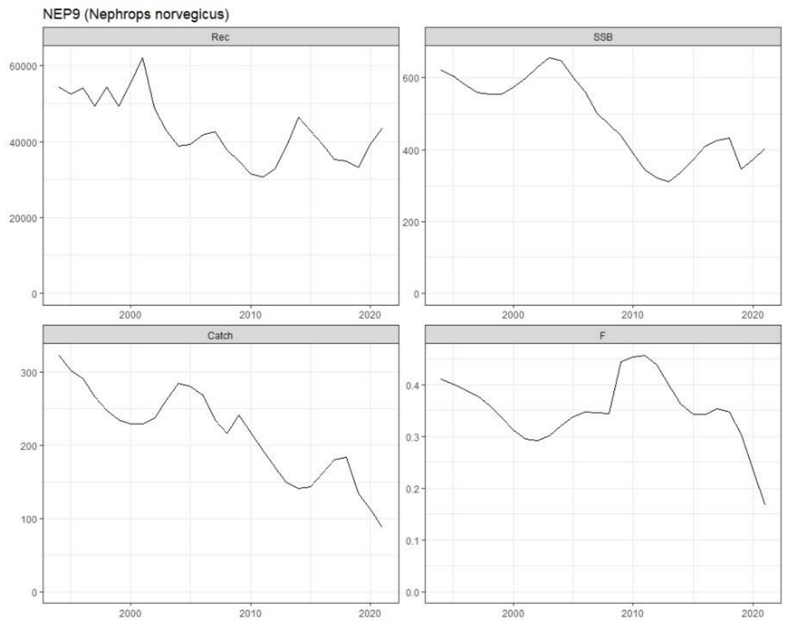


Figure 6.13.4 Norway lobster in GSA 9: Stock summary from the final a4a model

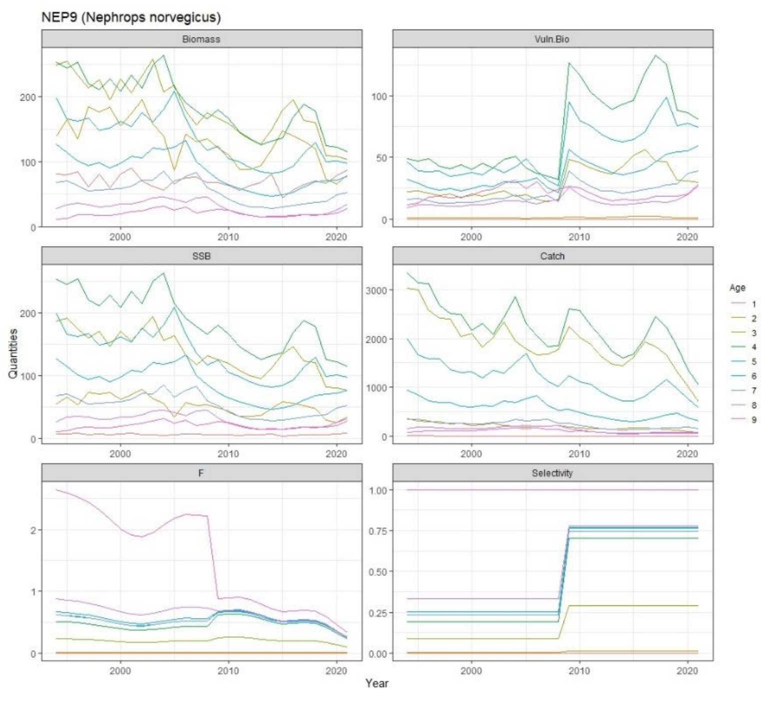


Figure 6.13.4Norway lobster in GSA 9: Stock assessment trajectories at age.

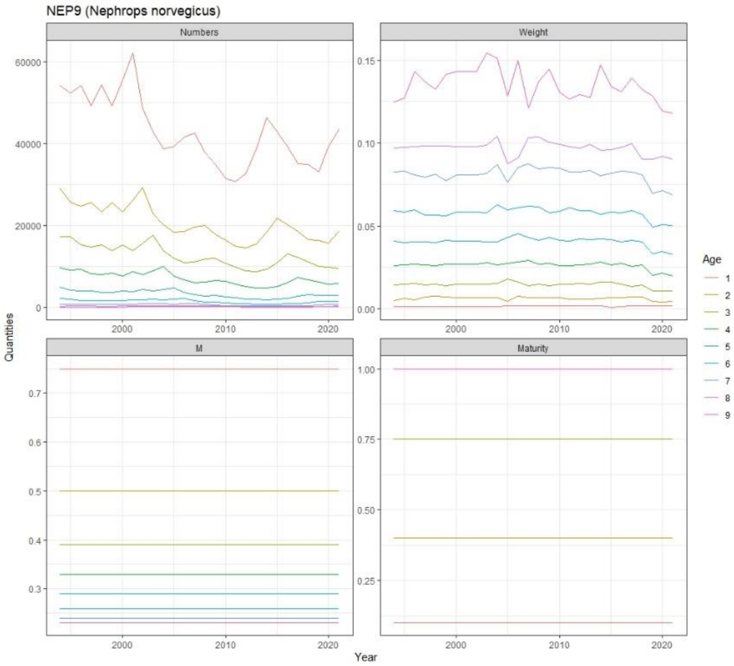


Figure 6.13.4Norway lobster in GSA 9: Stock biology trajectories at age.

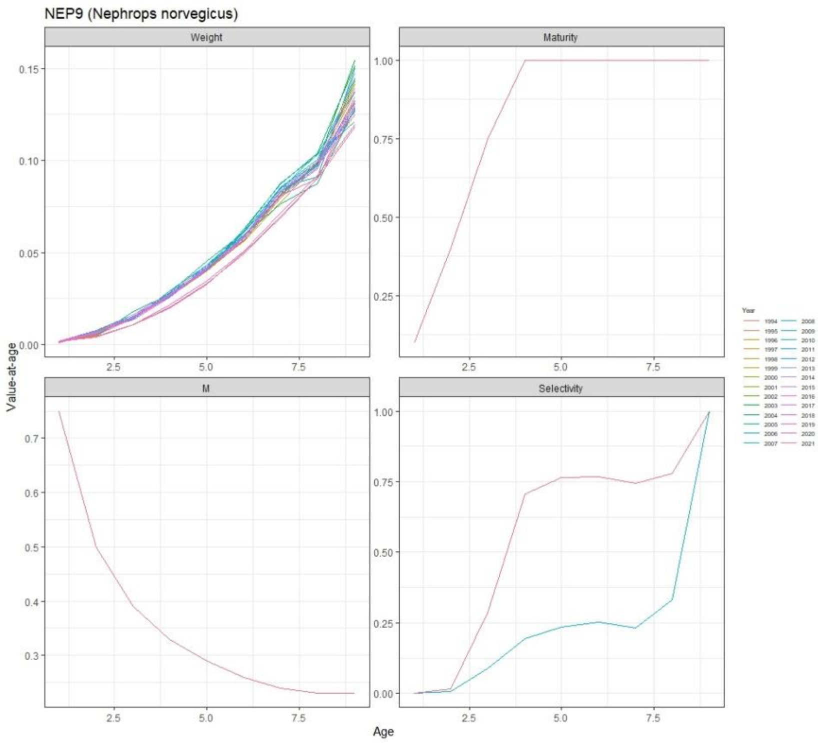


Figure 6.13.4Norway lobster in GSA 9: Annual stock quantities at age: individual weights at age, fraction mature at age, natural mortality at age and selectivity at age in the fishery.

Estimation of biomass reference points

An exploratory per-recruit analysis was performed using the stock object produced by EWG 22-09 (see above) containing the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.13.4.1 and Figure 6.13.4.5.

Table 6.13.4.1 Norway lobster in GSA 9. Per-recruit reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	B_0
0.109	0.022	0.006	0.548	0.051

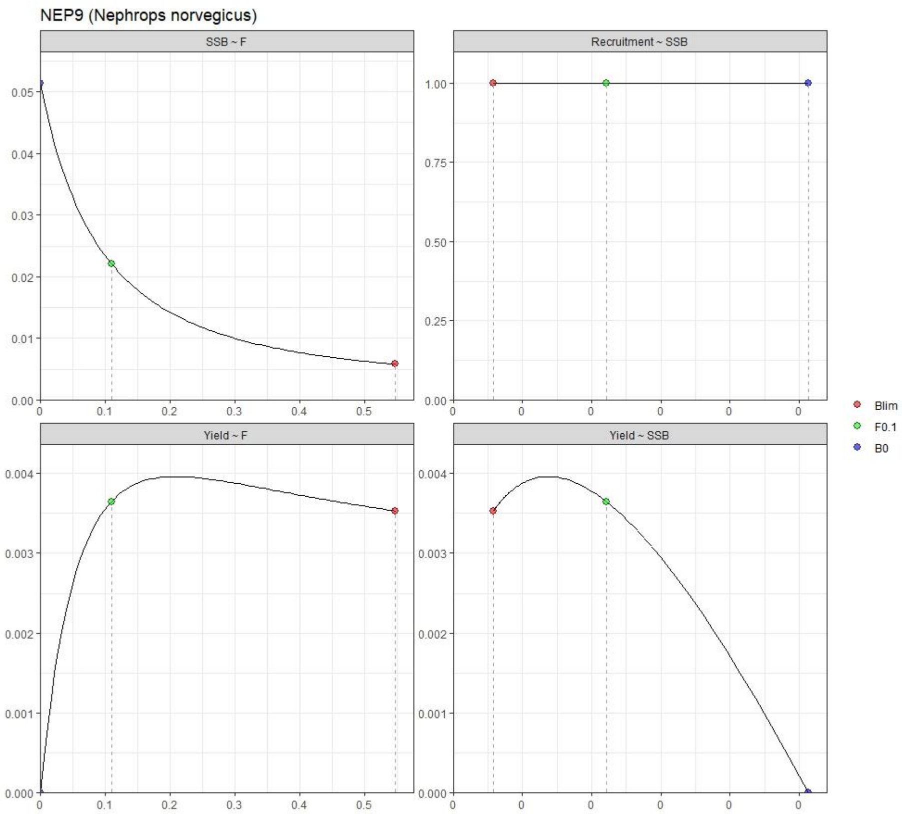


Figure 6.13.4Norway lobster in GSA 9:Per-recruit analysis

Figure 6.13.4.5 shows the trajectories of the assessment outputs relative to the per-recruit reference points R_0, SPR_0, YPR at $F_{0.1}$ and B_{lim}. SSB by year is below the equilibrium biomass at $F_{0.1}$ ($B_{F0.1}$) and the B_{lim} for the whole time series. At the same time, F is below $F_{0.1}$ and the trend is decreasing until 2020.

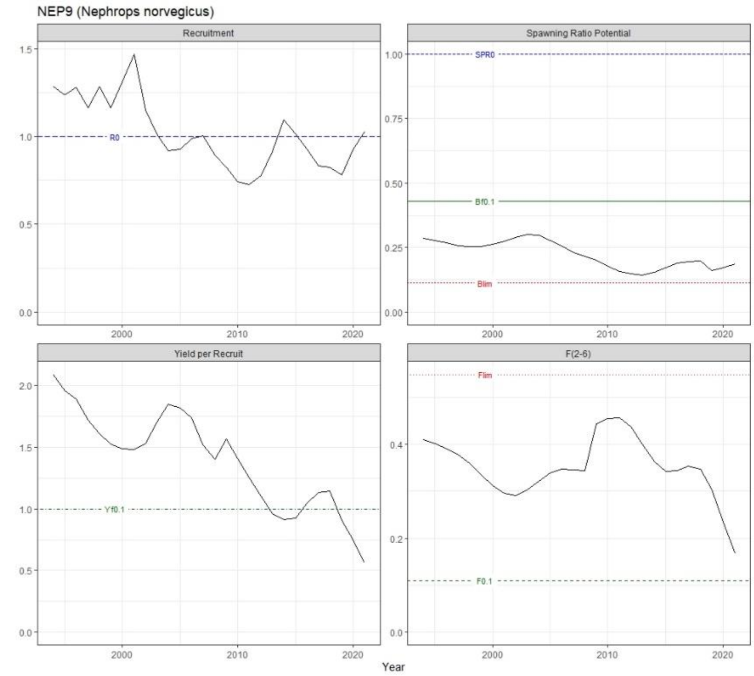


Figure 6.13.4Norway lobster in GSA 9:Per-recruit analysis: outcomes of the a4a assessment relative to the per-recruit reference points.

Figure 6.13.4.7 shows the contribution in terms of spawning biomass per recruit (SPR) by age class in the current situation (red bars) compared to an un-fished scenario. This illustrates how overfished the population is from a yield per recruit perspective.

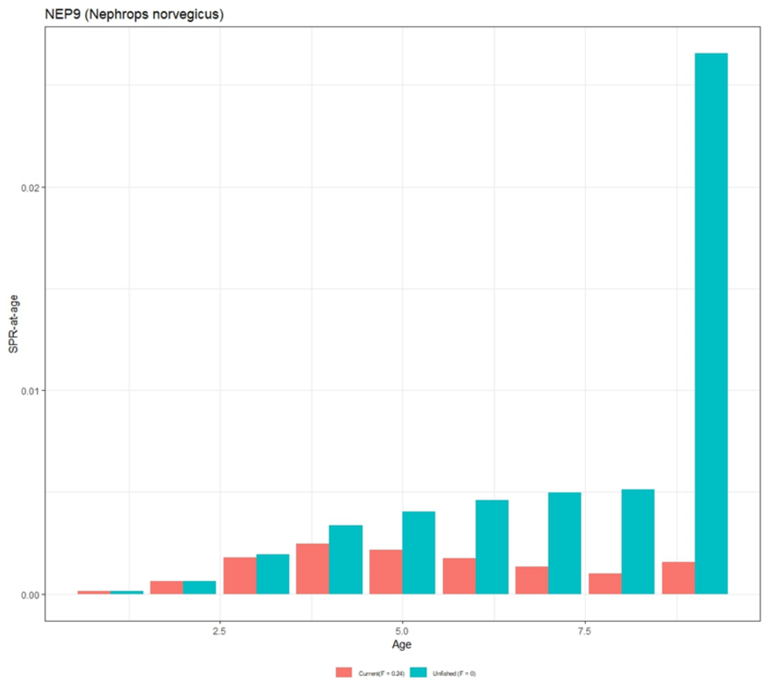


Figure 6.13.4Norway lobster in GSA 9 Comparison of the spawning biomass per recruit SPRF at current F (average of last 3 years) and SPR_0 with F = 0.

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)
2. Hockey-Stick (model=segreg)
3. Beverton-Holt (model=bevholtSV)
4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ratio potential SRPlim = SPRlim/SPR_0. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP 0.1−20% by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y.

Table 6.13.4.1: Norway lobster in GSA 9 Summary of the four SR models.

	s	sigmaR	R_0	rho	B_0
Geometric mean	NA	0.1892966	41967.3	0.8295362	2264.17
Hockey-stick	NA	0.1857581	41967.3	0.8295362	2264.17
Beverton-Holt	0.7614658	0.1618474	66020.33	0.7183367	3561.85
Ricker	1.101321	0.1787042	30762.73	0.6998739	1659.674

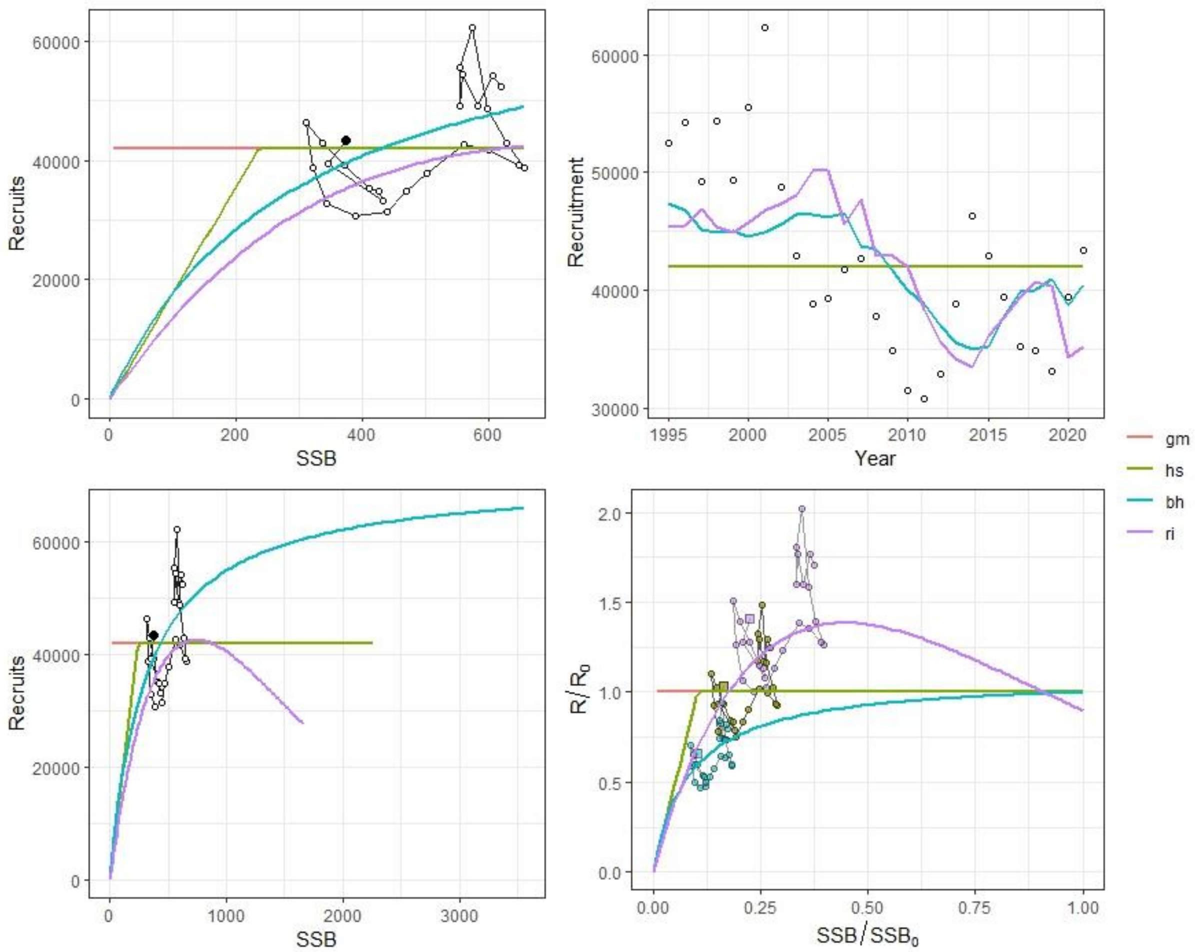
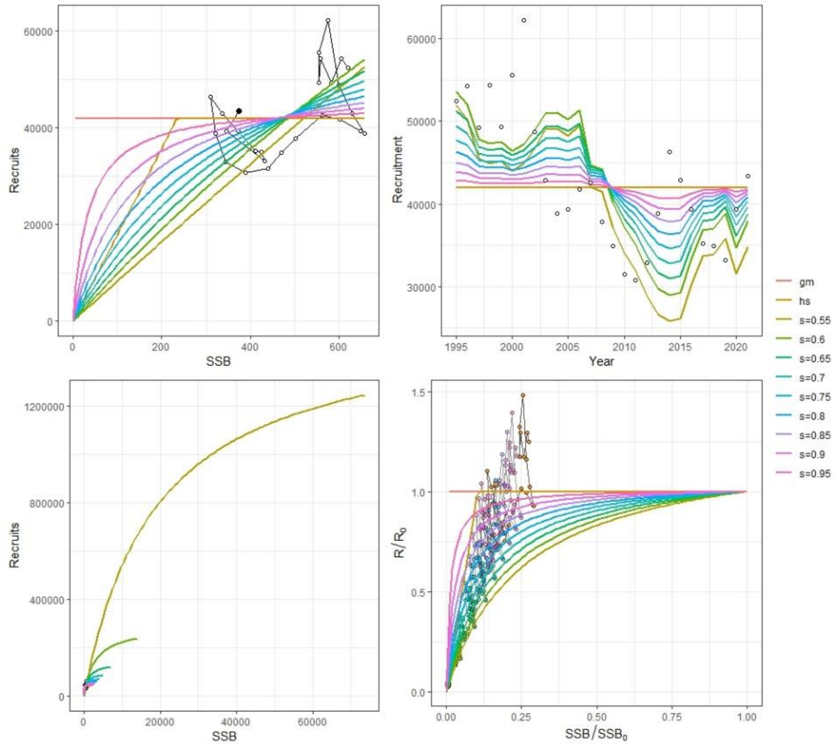


Figure 6.13.4Norway lobster in GSA 9 Summary of the four SR models.

Figure 6.13.4.9 shows the results of the sensitivity analysis to alternative fixed steepness values of s = 0.55 – 0.95 for the Beverton-Holt model explored. The results show that increasing steepness to 0.95 substantially decreases the R_0 and B_0 estimates to a scale that is comparable to the Hockey-Stick estimates.



. **Figure 6.13.4Norway lobster in GSA 9** Per-recruit analysis with different slope (s, steepness) scenarios for the Beverton-Holt model.

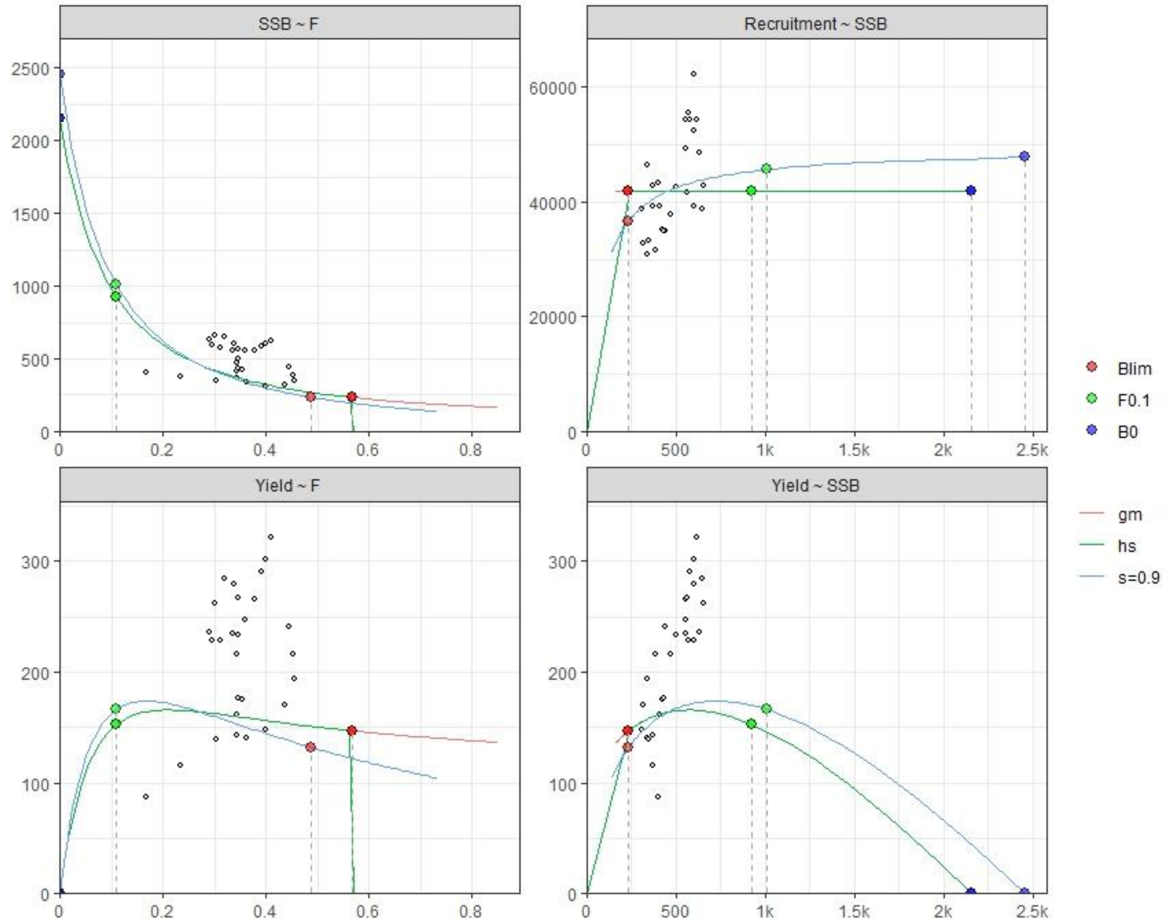


Figure 6.13.4Norway lobster in GSA 9 Long Term equilibrium evaluations for different S-R models

In the light of the outcomes of the exploratory analysis with HS breakpoint lying outside the data, it was decided to consider the Geometric Mean approach the most appropriate to estimate the biomass reference points for the stock of Norway lobster in GSA 9. Table 6.13.4.3 summaries the reference point values based on the Geometric Mean model fitted to the data. B_{pa} is set to 2* B_{lim}.

Table 6.13.4.3:Norway lobster in GSA 9. Final reference points based on Geometric Mean stock recruit model fitted to the data.

$F_{0.1}$	B_{lim}	B_{pa}	$B_{F0.1}$	B_0	Fpa
0.109	232	463	927	2275.59	0.27

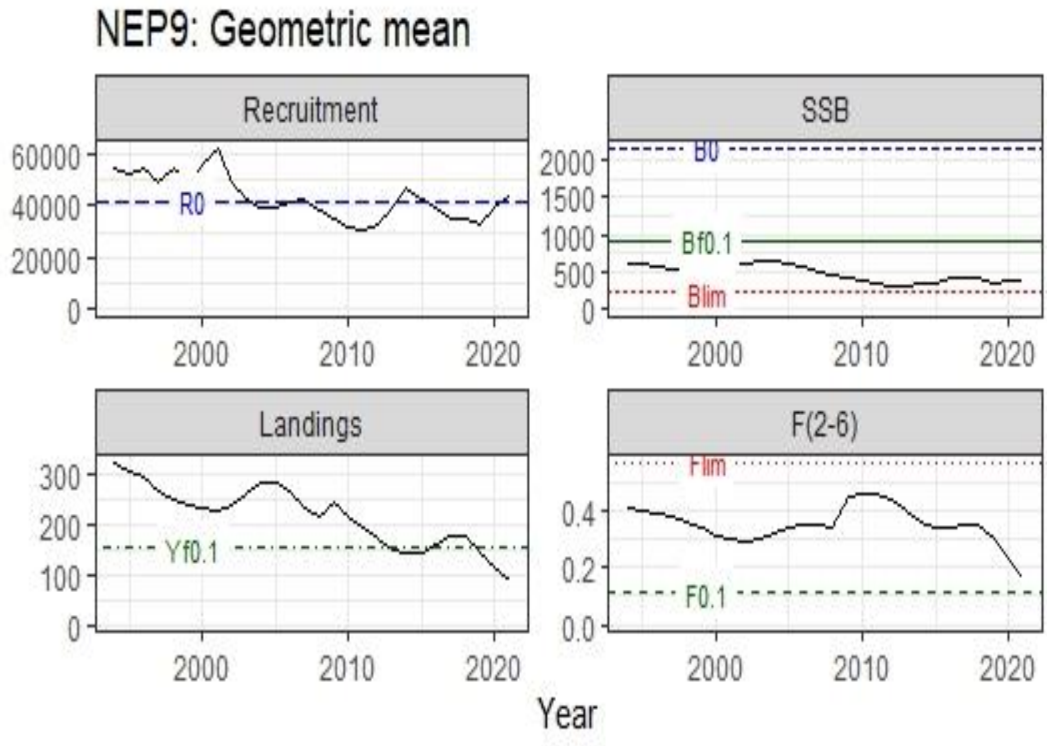


Figure 6.13.4Norway lobster in GSA 9 Status Advice plot showing stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on Geometric Mean stock-recruitment relationship.

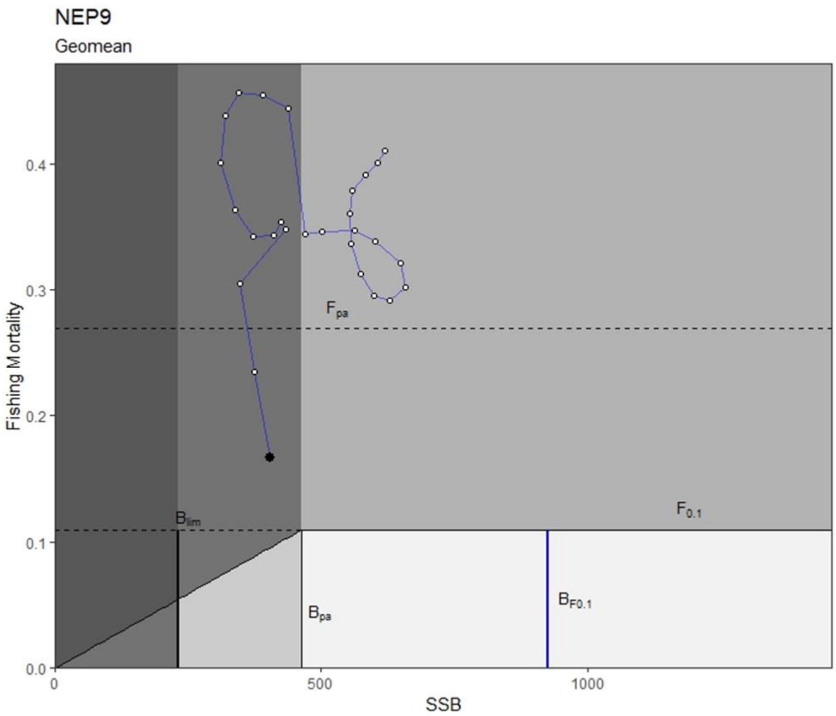


Figure 6.13.4Norway lobster in GSA 9 Advice Rule plots, with B_{lim} fitted to the data and B_{pa} = 2 B_{lim}

The GM model defined above is considered as the best option for defining reference points for this stock. Figures 6.13.4.11 & 12 illustrate the history and current state of the stock relative to reference pioints, B is currently estimated to be between B_{lim} and B_{pa} in 2021. The steepness options considered above are illustrated in Figure 6.13.4.9.

The steepness option that most closely mimics in terms of deviation from slope and asymptote the GM model chosen to define the breakpoint is thought to be steepness = 0.9 (Figure 6.13.4.9) This model may be more suitable for stock simulation than the HS while retaining much of the dynamicsshown in Figure 6.13.4.13.

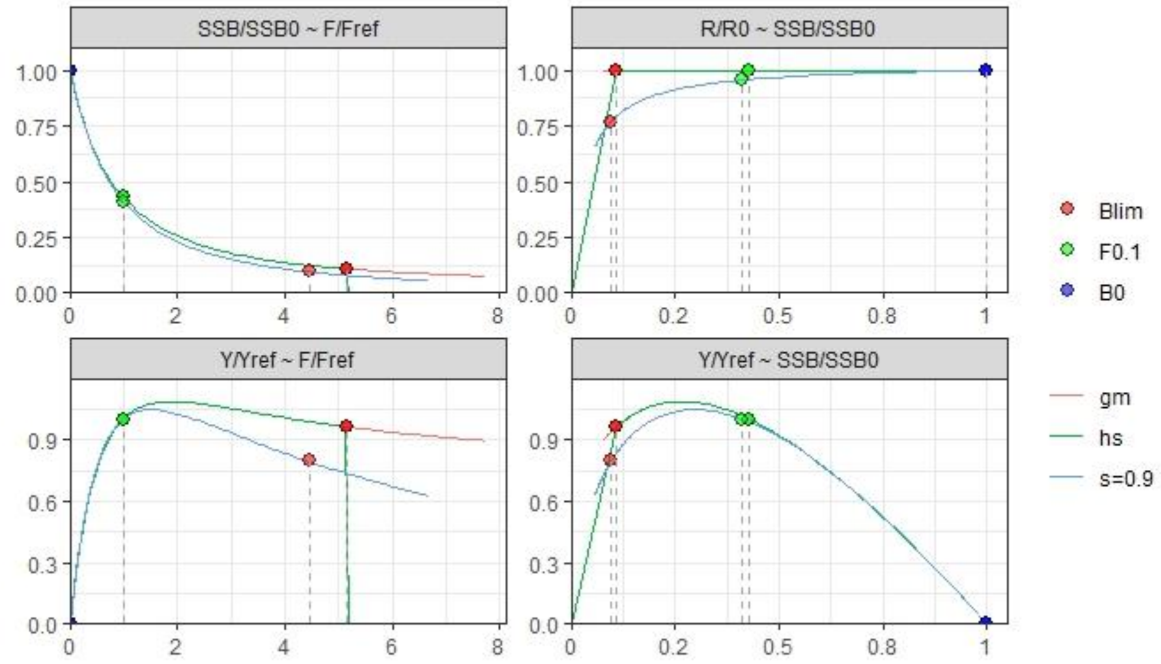


Figure 6.13.4Norway lobster in GSA 9 Per-recruit analysis: relative reference points for GM and HS (steepness 0.90) models.

6.13.5Short term Forecast and Catch Options

A deterministic short term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

The input parameters for the deterministic short-term predictions (Table 6.13.5.1) were the same used for the a4a stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} terminal (2021) from the a4a assessment was used.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the 2004-2021, recruitment estimated for earlier years is higher and considered unsuitable to provide values for next few years .

Results of the STF are given in Table 6.13.5.2

Table 6.13.1 Norway lobster in GSA 9: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 2\text{-}6}$ (2022)	0.167	F 2021 used to give F status quo for 2022
SSB (2022)	465.8 t	Stock assessment 1 January 2022
R_{age0} (2022,2023)	37684	Geometric mean of years 2004 to 2021
Total catch (2022)	102.3 t	Assuming F status quo for 2022

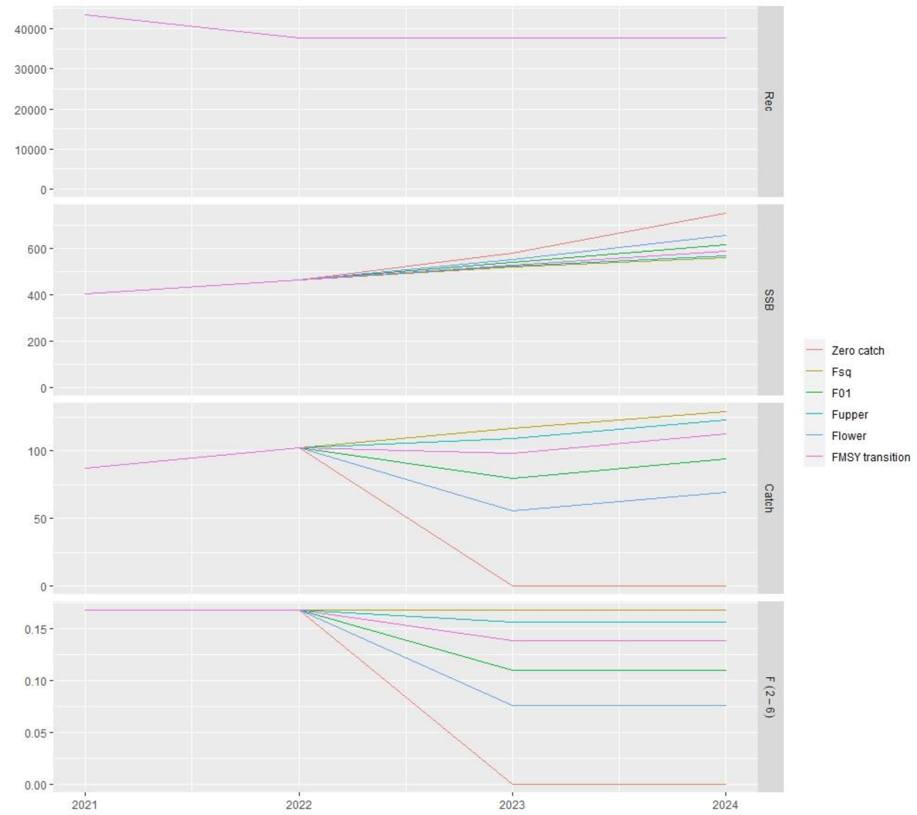


Figure 6.13.5.2 Norway lobster in GSA 9: short term forecast in different F scenarios. SSB estimates refer to middle year.

Table 6.13.5.2 Norway lobster in GSA 9: short term forecast in different F scenarios. SSB estimates refer to middle year.

Rationale	Ffactor	Fbar	Recruitment 2022	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB_change 2022-2024 (%)	Catch_change 2021-2023 (%)
High long term yield (F0.1)	0.656	0.110	37415.188	0.167	87.230	102.342	79.374	465.72	617.201	32.527	-9.006
F upper	0.932	0.156	37415.188	0.167	87.230	102.342	109.315	465.72	569.606	22.307	25.318
F lower	0.451	0.075	37415.188	0.167	87.230	102.342	55.835	465.72	655.750	40.804	-35.991
FMSY transition	1.043	0.175	37415.188	0.167	87.230	102.342	120.919	465.72	551.601	18.441	38.620
Zero catch	0.000	0.000	37415.188	0.167	87.230	102.342	0.000	465.72	751.061	61.269	-100.000
Status quo	1.000	0.167	37415.188	0.167	87.230	102.342	116.458	465.72	558.493	19.921	33.506
Different Scenarios	0.100	0.017	37415.188	0.167	87.230	102.342	12.900	465.72	728.565	56.439	-85.212
	0.200	0.033	37415.188	0.167	87.230	102.342	25.502	465.72	706.862	51.779	-70.765
	0.300	0.050	37415.188	0.167	87.230	102.342	37.814	465.72	685.923	47.283	-56.651
	0.400	0.067	37415.188	0.167	87.230	102.342	49.843	465.72	665.720	42.945	-42.861
	0.500	0.084	37415.188	0.167	87.230	102.342	61.596	465.72	646.225	38.759	-29.387
	0.600	0.100	37415.188	0.167	87.230	102.342	73.081	465.72	627.412	34.719	-16.221
	0.700	0.117	37415.188	0.167	87.230	102.342	84.302	465.72	609.256	30.821	-3.356
	0.800	0.134	37415.188	0.167	87.230	102.342	95.269	465.72	591.733	27.058	9.215
	0.900	0.151	37415.188	0.167	87.230	102.342	105.985	465.72	574.819	23.426	21.500
	1.100	0.184	37415.188	0.167	87.230	102.342	126.694	465.72	542.732	16.536	45.240
	1.200	0.201	37415.188	0.167	87.230	102.342	136.697	465.72	527.516	13.269	56.709
	1.300	0.218	37415.188	0.167	87.230	102.342	146.475	465.72	512.825	10.115	67.918
	1.400	0.234	37415.188	0.167	87.230	102.342	156.033	465.72	498.640	7.069	78.875
	1.500	0.251	37415.188	0.167	87.230	102.342	165.376	465.72	484.942	4.128	89.585
	1.600	0.268	37415.188	0.167	87.230	102.342	174.509	465.72	471.714	1.287	100.055
	1.700	0.285	37415.188	0.167	87.230	102.342	183.437	465.72	458.938	-1.456	110.290
	1.800	0.301	37415.188	0.167	87.230	102.342	192.166	465.72	446.597	-4.106	120.297
	1.900	0.318	37415.188	0.167	87.230	102.342	200.700	465.72	434.677	-6.665	130.080
	2.000	0.335	37415.188	0.167	87.230	102.342	209.044	465.72	423.162	-9.138	139.646

6.13.6 DATA DEFICIENCIES

MEDITS index haul n 67 has been removed due to an error, total weight was wrong.

6.14 NORWAY LOBSTER IN GSA 11

An advice on Norway lobster (NEP) in GSA 11 based on MEDITS indices trends was given for 2020 and 2021 (STECF EWG 20-09 and STECF 21-11 reports). STECF EWG 22 – 09 was asked to perform new analysis based on new and revised data for the species; various trials using the a4a model were tested, but none of them deemed appropriate for advice. Therefore, advice is given based on ICES category 3 rules.

6.14.1 STOCK IDENTITY AND BIOLOGY

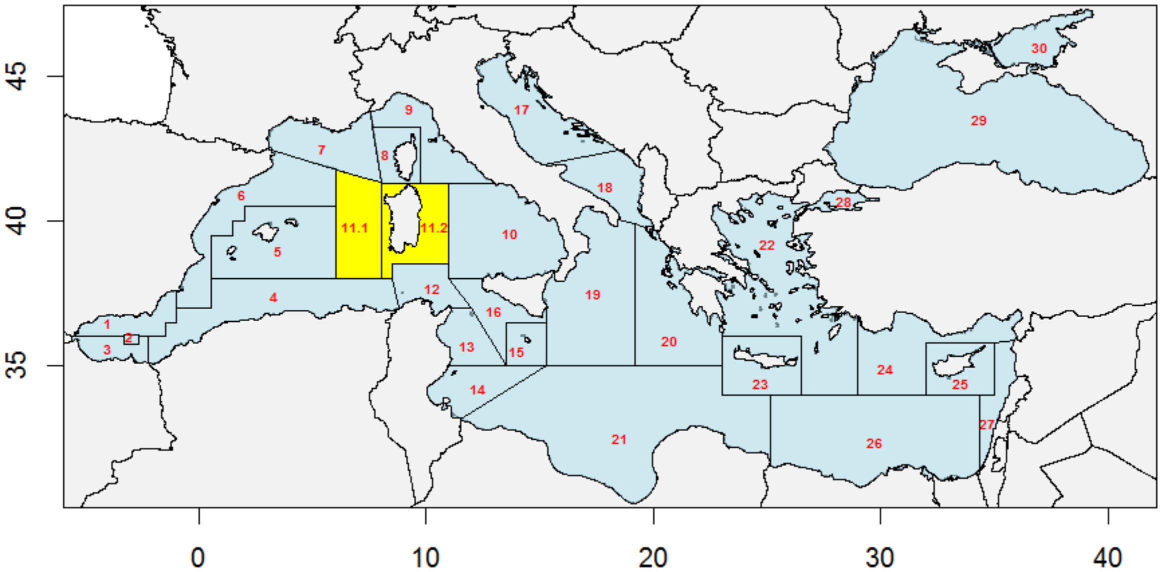


Figure 6.14.1.1. Norway lobster in GSA 11. Geographical location of GSA 11

The stock is assumed to be confined within GSA 11 (6.14.1.1) boundaries due to the lack of information about the stock structure in the western Mediterranean Sea.

Growth pattern in *Nephrops norvegicus* is known to differ between males and females. Males are characterized by slower growth and higher maximum size than females. Sex ratio in relation to the available landings time series (2005 - 2019) is available from DCF for GSA11 with some years missing. Growth parameters reported by DCF are available by sex and from 2016 onward do not change along years. The “a” and “b” coefficients slightly differ along the reported years.

The assessment runs were carried out by sex. The growth parameters reported for GSA11 for 2016 - 2021 and mean values along years for the “a” and “b” coefficients were used.

Table 6.14.1.1. Norway lobster in GSA 11. Growth parameters (Linf, K, t0) and parameters of the Length-Weight relationship (a, b) used for the assessment

Country	Area	Sex	L_∞	K	t_0	a	b
IT	GSA 11	F	69.4	0.12	-0.64	0.0006	3.05
IT	GSA 11	M	80.8	0.13	0.07	0.0005	3.09

For the assessment a vector of maturity and of natural mortality were also used. The natural mortality was computed using Chen and Watanabe model (Table 6.14.1.2).

Table 6.14.1.2. Norway lobster in GSA 11. Proportion of mature specimens and natural mortality at age.

age	1	2	3	4	5	6	7	8	9	10	11	12
maturity	0.00	0.16	0.40	0.71	0.93	0.96	0.96	1.00	1.00	1.00	1.00	1.00
mortality	0.56	0.42	0.34	0.28	0.24	0.22	0.20	0.19	0.18	0.17	0.16	0.16

6.14.2 DATA

6.14.2.1 CATCH (LANDINGS AND DISCARDS)

For GSA 11 landings were available through the DCF from 2005 onwards and were related exclusively to OTB (Table 6.14.2.1.1, Figure 6.14.2.1.1). No discards were reported.

Table 6.14.2.1.1. Norway lobster in GSA 11. Landings data (in tons) in GSA 11

year	landings
2005	6.3
2006	42.3
2007	31.3
2008	36.2
2009	44.4
2010	22.8
2011	50.5
2012	41.1
2013	29.8
2014	35.3
2015	21.4
2016	15.8
2017	39.6
2018	78.8
2019	72.0
2020	44.2
2021	42.1

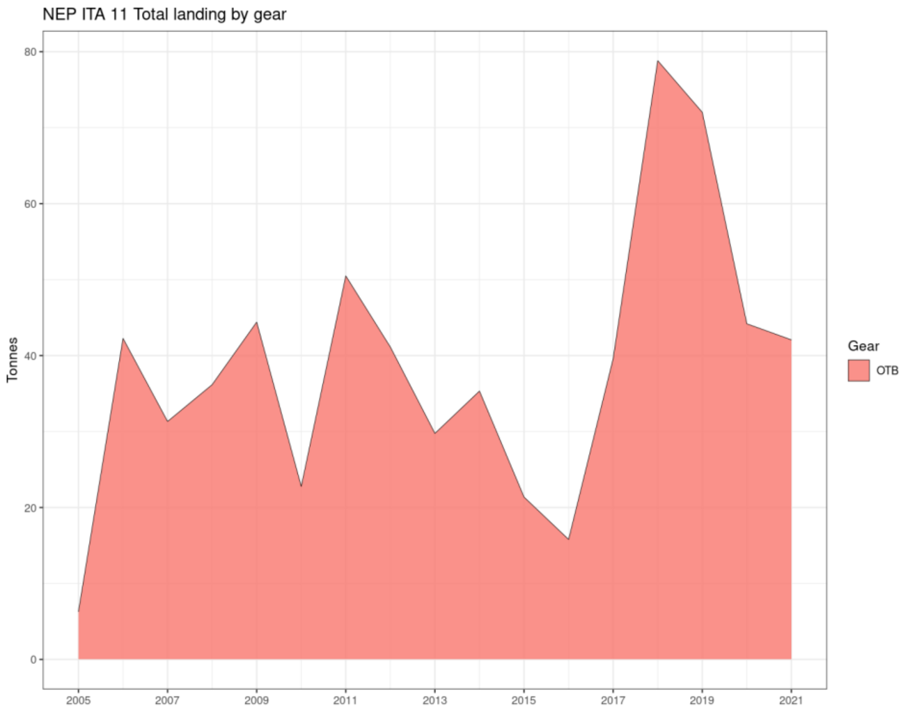


Figure 6.14.2.1.1. Norway lobster in GSA 11. Landings data (in tons) in GSA 11

Length frequency distributions by year gear and metier were available through DCF from the year 2005 onwards. Due to missing LFDs for some metiers in various years, a reconstruction of these LFDs was performed using JRC's script following the methodology proposed in EWG21-02/EWG 22-03. In figure 6.14.2.1.2 the original LFDs are presented while in figure 6.14.2.1.3 the reconstructed ones.

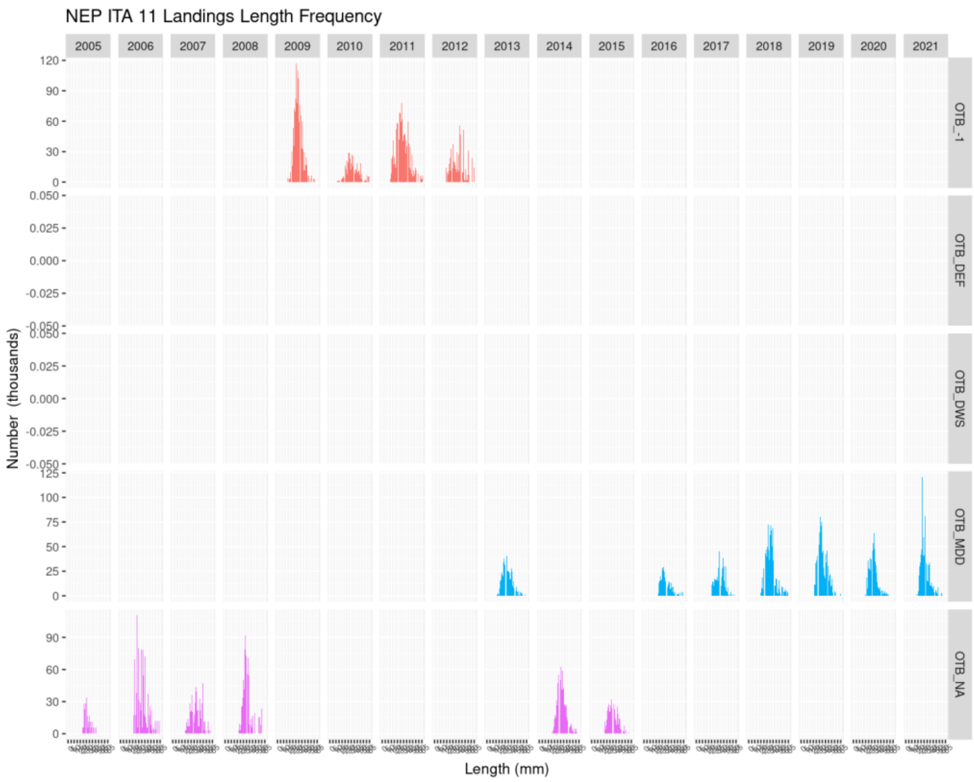


Figure 6.14.2.1.2. Norway lobster in GSA 11. Length frequency distribution of the landings by year and gear in GSA 11.

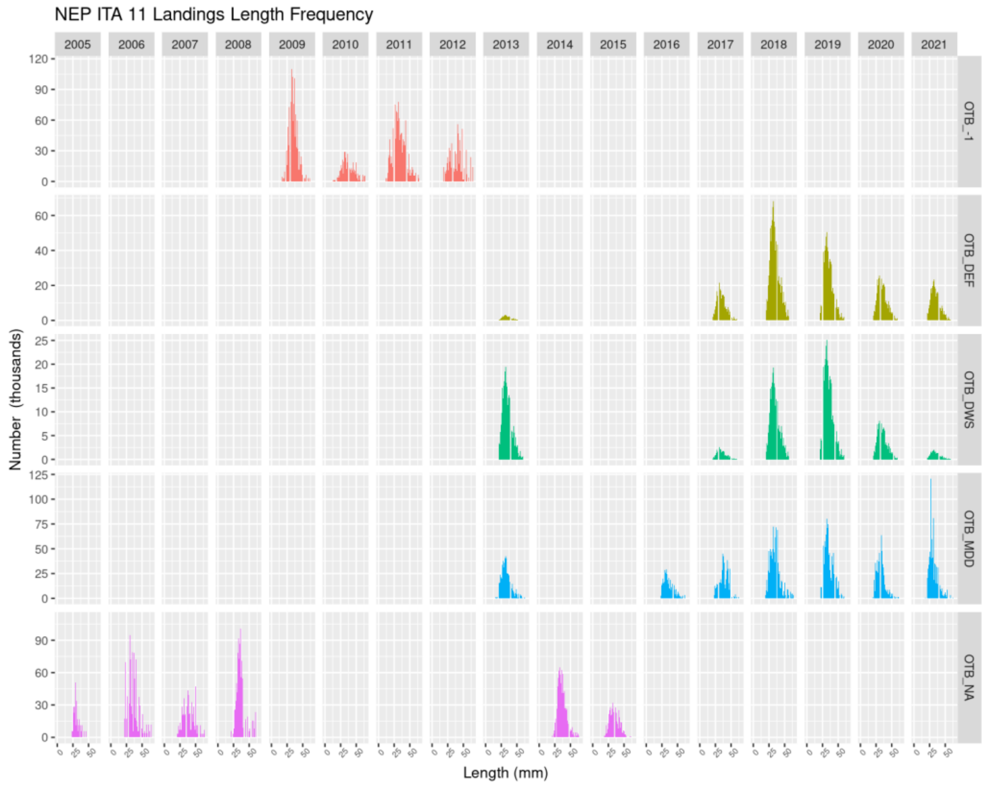


Figure 6.14.2.1.3. Norway lobster in GSA 11. Length frequency distribution of the landings by year and fleet after the reconstruction process.

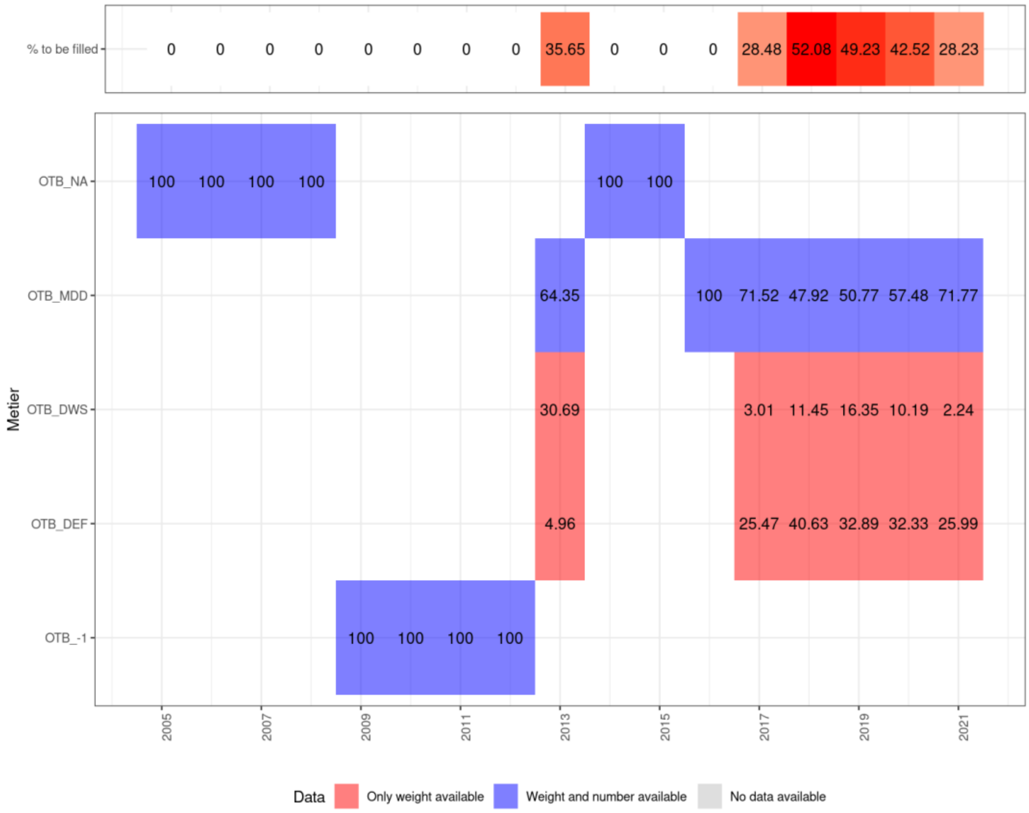


Figure 6.14.2.1.5. Norway lobster in GSA 11. Percentages of reconstructed landings LFD in total and by metier for GSA 11.

6.14.2.2 EFFORT DATA

Fishing effort data for 2021 will be reported to STECF EWG 22-10 through the FDI data call within the DCF framework.

6.14.2.3 SURVEY DATA

The MEDITS surveys are carried mainly from May to July (Figure 16.14.2.3.1). Tables TA, TB, TC were provided according to the MEDITS protocol. Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). In recent years the survey has been carried out later in the year.

The abundance and biomass indices for GSA 11 were calculated through stratified means. This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas.

MEDITS data are available in GSA 11 since 1994. In the period 1994 – 2010 MEDITS indices (Figure 6.14.2.3.2-3) show highly fluctuating pattern, ranging between 1.52 (2001) and 4.46 (2009) in terms of biomass (kg/Km^2) and 31.1 (2001) and 129 (2008) in terms of density (n/Km^2), with an average value for this period of 3.01 kg/km^2 and 75.37 n/Km^2. From 2011 onward the stock appears to have been more stable, but with a general decreasing trend both for biomass and densities than decline to the minimum values of the time series in 2020.

Observed length frequency distribution for MEDITS data are reported in Figure 6.14.2.3.4 and 6.14.2.3.5 by sex and in Figure 6.14.2.3.6 as total.

Figure 6.14.2.3.1. Norway lobster in GSA 11. Month of the year when the MEDITS survey is conducted.

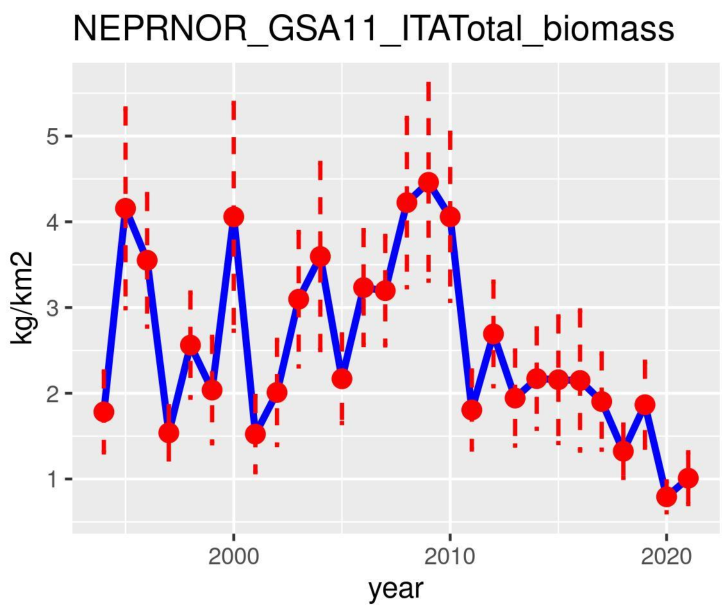


Figure 6.14.2.3.2 Norway lobster in GSA 11. MEDITS indices for the period 1994-2021: relative biomass (kg km^2) and density (n km^2).

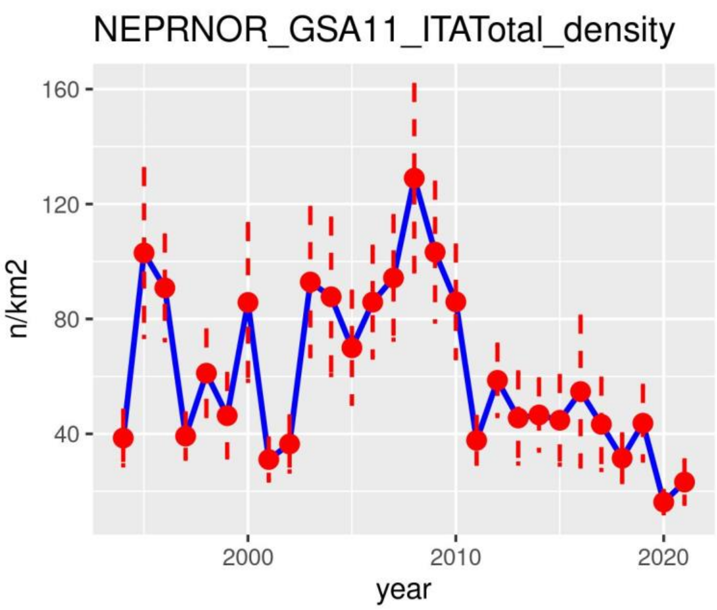


Figure 6.14.2.3.3 Norway lobster in GSA 11. MEDITS indices for the period 1994-2021: density (n km^2).

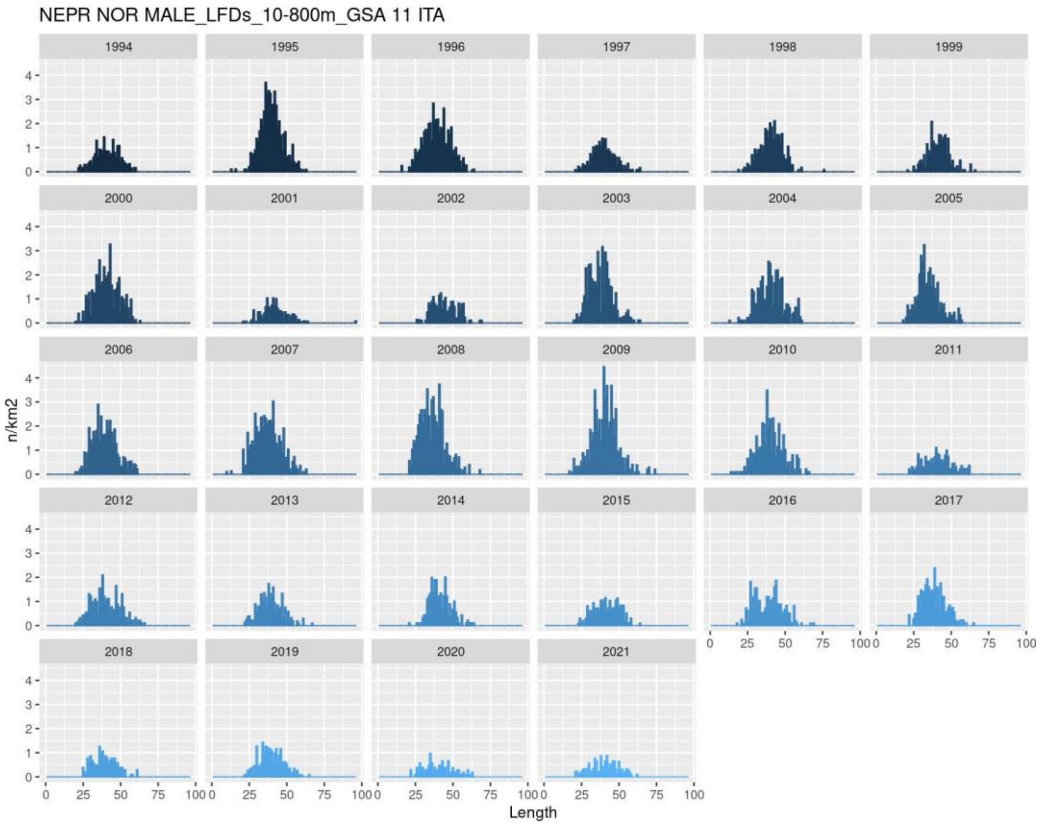


Figure 6.14.2.3.4. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for males.

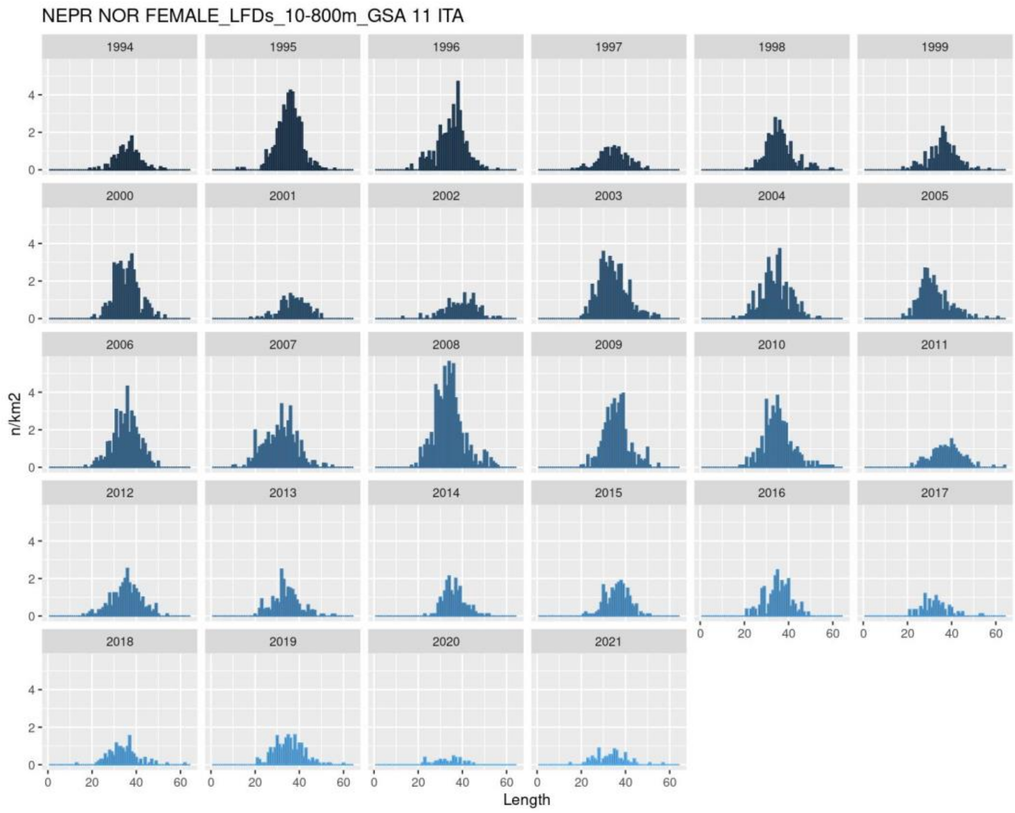


Figure 6.14.2.3.5. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for females.

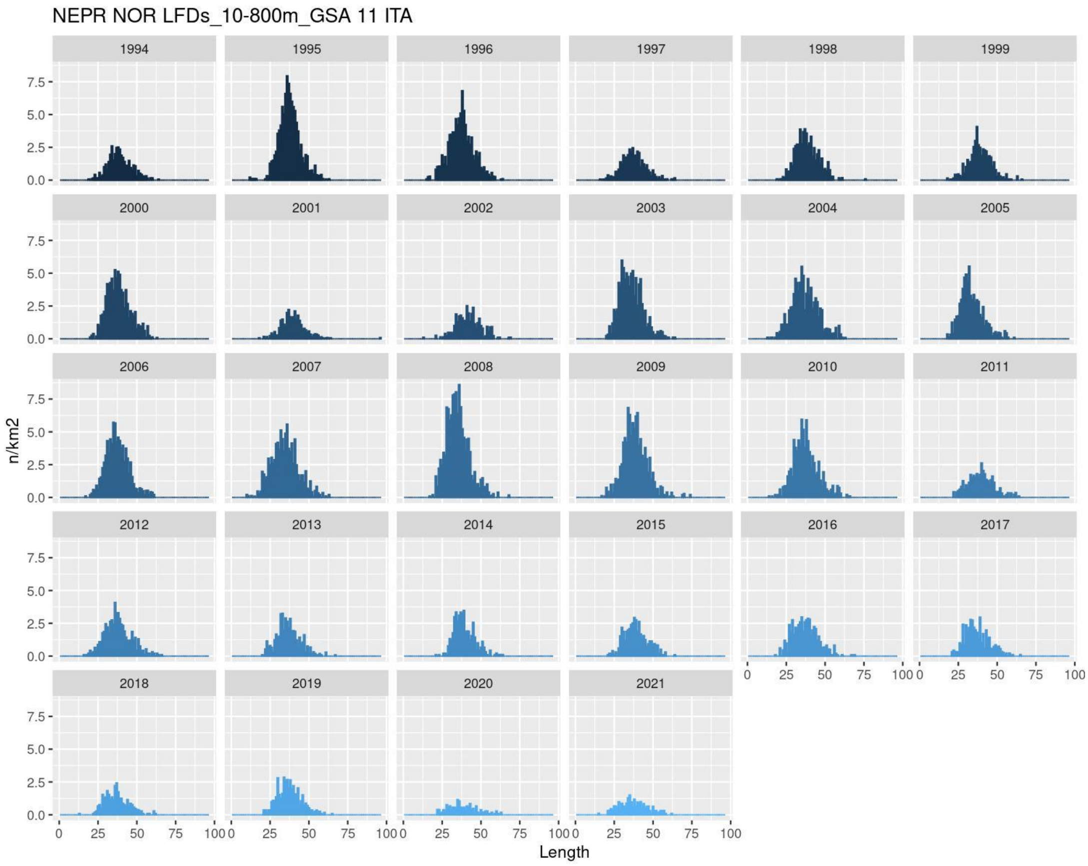


Figure 6.14.2.3.6. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data).

6.14.3 Stock Assessment

An assessment was attempted for this stock, using a statistical catch at age method, assessment for all initiative (a4a) (Jardim et al. 2015). The assessment was deemed inapropriate to provide catch advice and was not endorsed by the EWG.

Input data for the assessment and selected results from the best model are presented in the following section.

Input data

Time series from 2006 – 2021 was used to fit the model for catch, catch numbers at age and index numbers per km^2. Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR, using sex specific growth parameters in catch and survey data. When processing length frequency data here, 0.5 years was added to t_0, in order to account for the mid-season spawning of the Norway lobster. Catch at age by sex were obtained by splitting commercial total length distribution according to a sex-ratio vector model obtained from DCF available sex ratio vectors in the respective areas.

The analyses were carried out for the ages 1 to 12 for catches and the tuning index. Concerning the Fbar, the age range used was 2-7.

VBGF parameters are reported in table 6.14.1.1. SoP corrections were applied to catch numbers at age yearly (Table 6.14.3.1). Natural mortality (M) at age was estimated using the Chen-Watanabe (1989) model.

Table 6.14.3.1 Norway lobster in GSA 11. SoP correction for years 2005 – 2021.

Year	SoP
2005	0.72
2006	0.97
2007	0.95
2008	0.96
2009	0.98
2010	0.93
2011	0.98
2012	1.00
2013	0.94
2014	0.96
2015	1.08
2016	0.91
2017	1.07
2018	0.97
2019	0.97
2020	1.10
2021	1.21

Tables 6.14.3.2 - 4 present the input data for the stock assessment model for catches, catch number at age, weight age and the tuning index at age. Maturity and natural mortality at age are presented in table 6.14.1.2.

Table 6.14.3.2 Norway lobster in GSA 11. Catches (tonnes) for the years 2006 – 2021.

2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
42.3	31.3	36.2	44.4	22.8	50.5	41.1	29.8
2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
35.3	21.4	15.8	39.6	78.8	72.0	44.2	42.1

Table 6.14.3.3 Norway lobster in GSA 11. Catches numbers at age for the years 2006 – 2021.

age	2006	2007	2008	2009	2010	2011	2012	2013
1	1.3	1.3	1.3	1.4	2.6	10.1	1.4	1.3
2	0.7	3.3	5.3	20.5	10.9	150.5	23.4	15.6
3	187.6	54.1	44.2	144.9	58.3	263.0	94.0	165.9
4	316.4	125.0	255.7	453.1	97.4	335.7	135.9	283.4
5	258.5	123.9	354.0	375.4	101.9	242.4	89.5	209.2
6	121.8	116.3	161.5	226.9	81.2	196.7	161.8	125.3
7	100.2	64.5	21.3	99.1	40.7	106.4	101.9	62.7
8	42.4	77.9	22.1	24.4	37.2	62.2	47.7	30.2
9	20.6	14.3	17.4	21.6	18.1	41.5	51.4	14.6
10	19.7	20.5	22.3	4.2	8.0	23.8	4.2	7.8
11	19.1	4.7	22.6	3.9	7.9	2.4	24.1	2.0
12	20.9	19.2	10.9	9.4	18.8	28.9	32.5	9.5
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	1.3	1.5	1.3	1.5	1.3	1.4	1.5	1.7
2	1.5	7.1	5.2	2.2	18.0	6.2	5.4	12.0
3	59.0	87.1	49.9	108.3	344.2	323.3	253.1	360.5
4	231.3	148.6	112.8	206.8	638.1	653.1	454.6	519.1
5	269.2	132.3	82.0	230.8	590.5	503.2	369.3	263.1
6	171.7	97.8	58.1	228.8	373.8	317.0	180.0	176.2
7	72.1	43.5	31.2	96.1	145.4	176.8	74.9	59.8
8	45.5	26.1	21.9	60.3	79.5	91.0	42.8	49.9
9	16.9	17.1	8.3	23.4	50.2	42.1	23.5	11.4
10	7.1	2.7	4.0	10.1	23.1	14.8	7.7	11.0
11	10.1	2.2	4.3	3.2	14.2	4.7	5.2	2.0
12	11.1	10.2	11.4	10.0	18.9	11.1	10.7	12.5

Table 6.14.3.4 Norway lobster in GSA 11. Catches mean weight at age for the years 2006 – 2021.

age	2006	2007	2008	2009	2010	2011	2012	2013
1	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	0.006	0.006	0.006	0.005	0.005	0.004	0.005	0.005
3	0.010	0.011	0.012	0.012	0.011	0.010	0.011	0.011
4	0.018	0.019	0.020	0.020	0.019	0.019	0.018	0.019
5	0.032	0.033	0.030	0.030	0.032	0.030	0.032	0.031
6	0.045	0.046	0.039	0.042	0.046	0.047	0.050	0.044
7	0.063	0.065	0.068	0.060	0.066	0.063	0.064	0.060
8	0.082	0.085	0.075	0.072	0.081	0.074	0.075	0.076
9	0.089	0.080	0.110	0.091	0.100	0.102	0.106	0.101
10	0.120	0.121	0.133	0.130	0.116	0.128	0.138	0.117
11	0.150	0.139	0.152	0.148	0.152	0.106	0.166	0.129
12	0.193	0.191	0.193	0.203	0.192	0.190	0.197	0.202
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	0.006	0.005	0.006	0.006	0.006	0.006	0.006	0.006
3	0.012	0.011	0.011	0.011	0.011	0.011	0.011	0.011
4	0.020	0.019	0.019	0.019	0.019	0.019	0.019	0.018
5	0.031	0.030	0.030	0.032	0.031	0.030	0.030	0.031
6	0.044	0.046	0.046	0.047	0.043	0.046	0.043	0.044
7	0.059	0.062	0.061	0.066	0.061	0.062	0.063	0.061
8	0.079	0.074	0.083	0.070	0.077	0.078	0.079	0.082
9	0.094	0.100	0.093	0.086	0.100	0.092	0.095	0.090
10	0.128	0.099	0.127	0.123	0.123	0.118	0.117	0.125
11	0.151	0.139	0.144	0.125	0.147	0.099	0.133	0.113
12	0.194	0.203	0.199	0.206	0.185	0.197	0.201	0.199

Figures (6.14.3.3.1 – 6.14.3.3.5) present catch-at-age, mean weight at age and index-at-age input data for the stock assessment along with the cohort consistency plots for both catch numbers and tuning index.

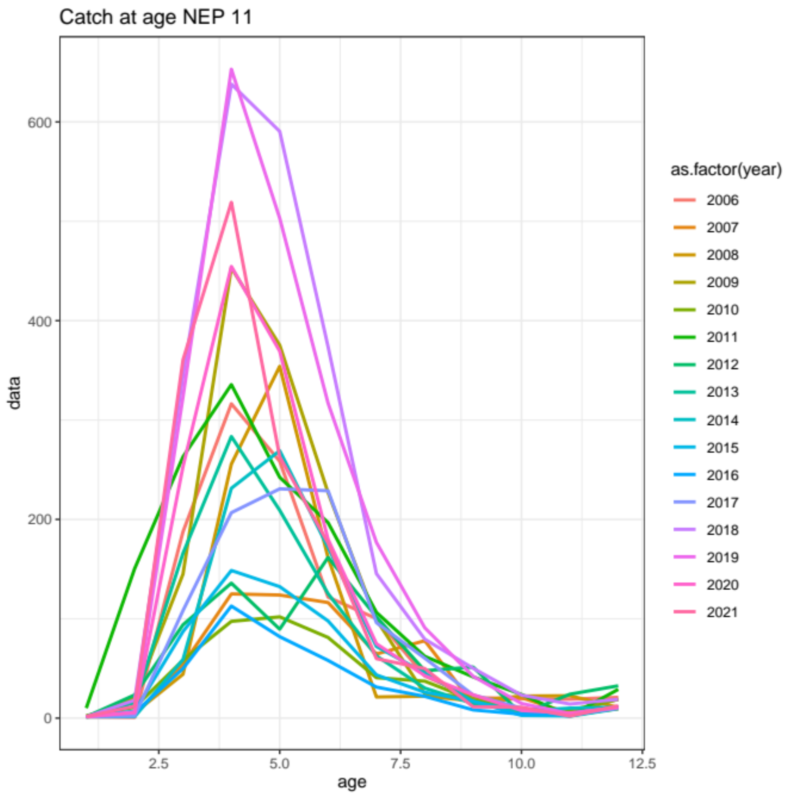


Figure 6.14.3.1 Norway lobster in GSA 11. Catch numbers by age for years 2006 – 2021.

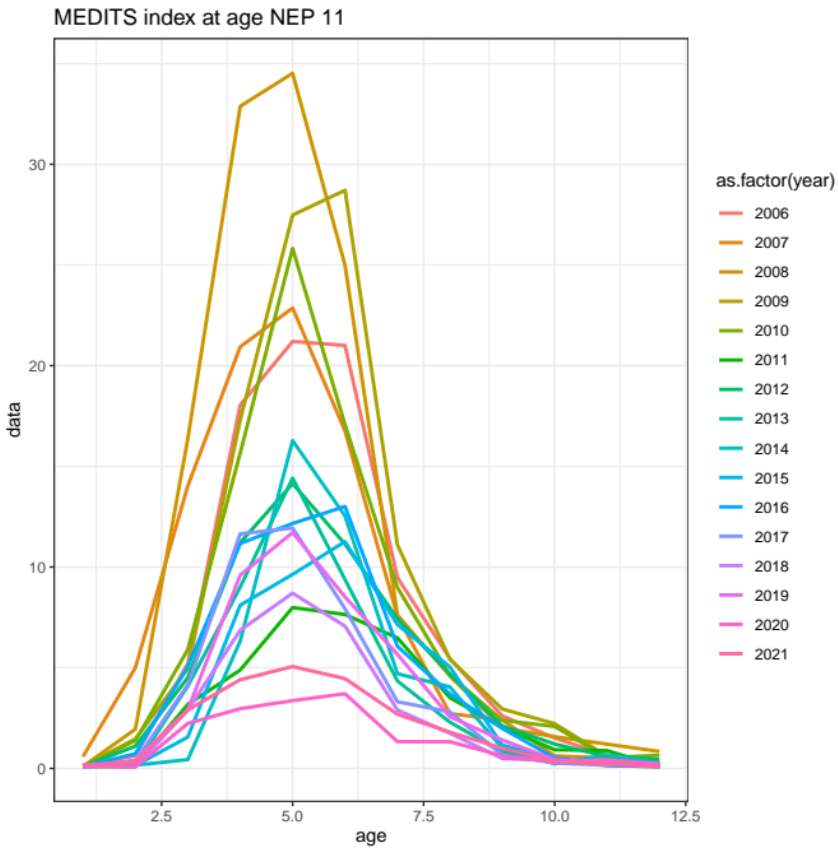


Figure 6.14.3.2 Norway lobster in GSA 11. Catch MEDITS index by age for years 2006 – 2021.

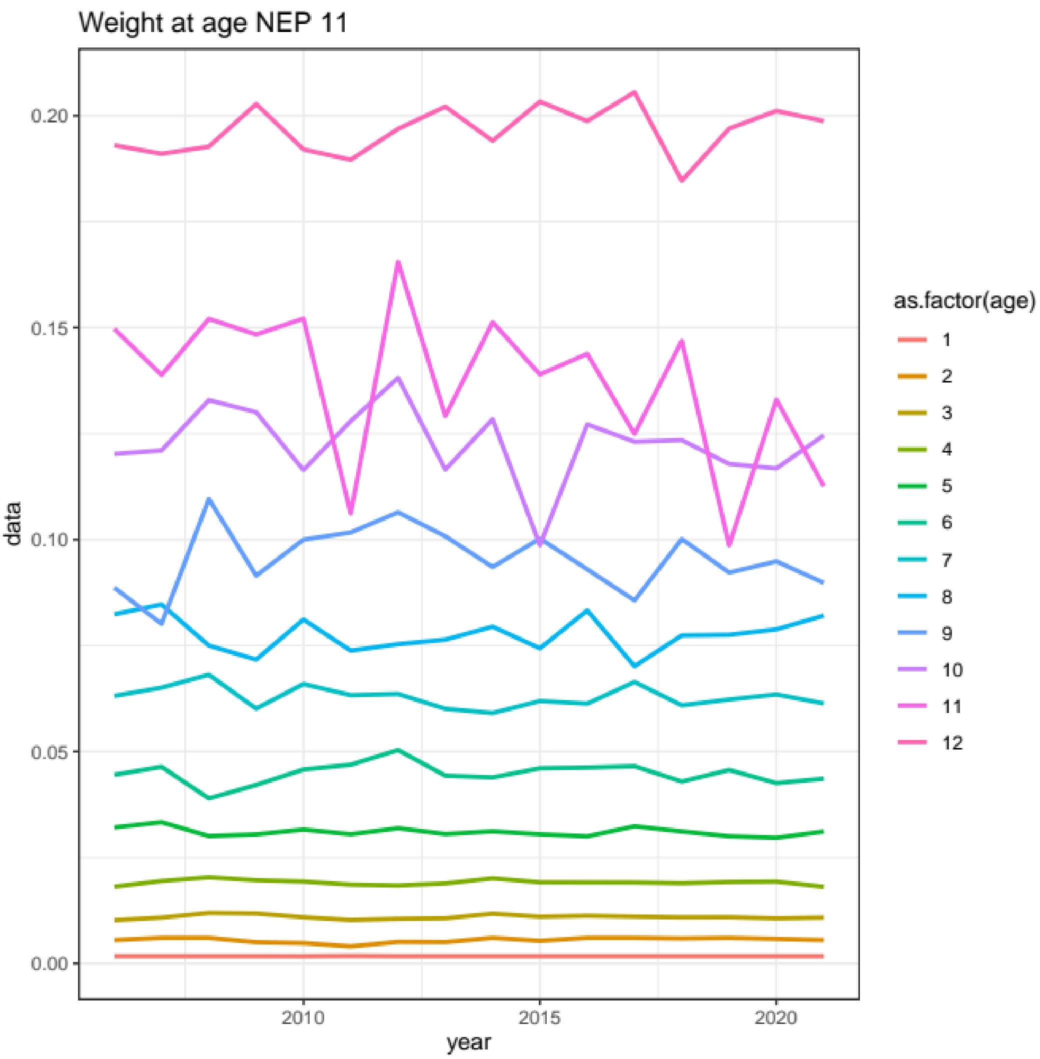


Figure 6.14.3.3 Norway lobster in GSA 11. Mean weight by age of the catch for years 2006 – 2021.

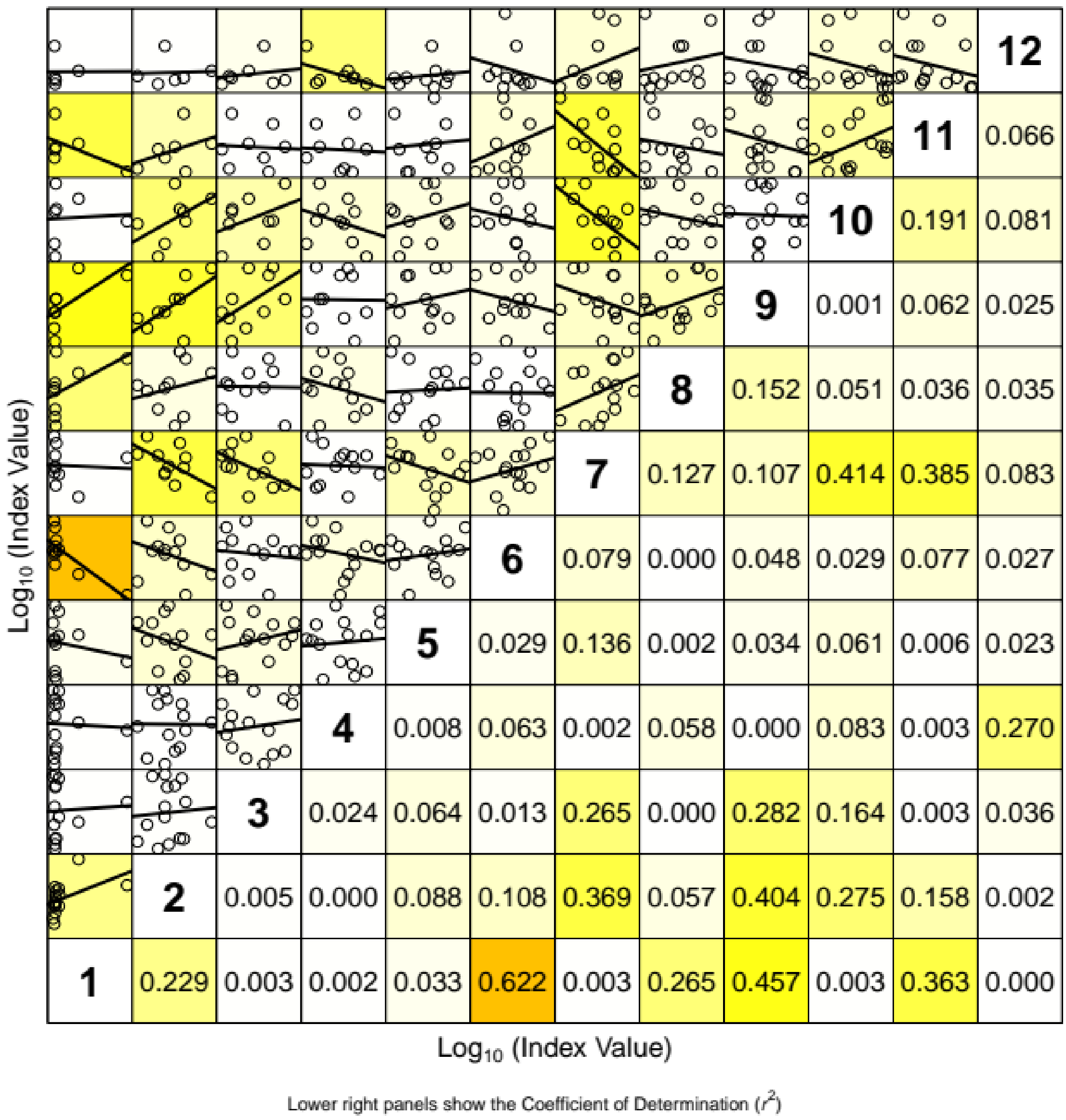


Figure 6.14.3.4 Norway lobster in GSA 11. Cohort consistency of the catch for the years 2006-2021.

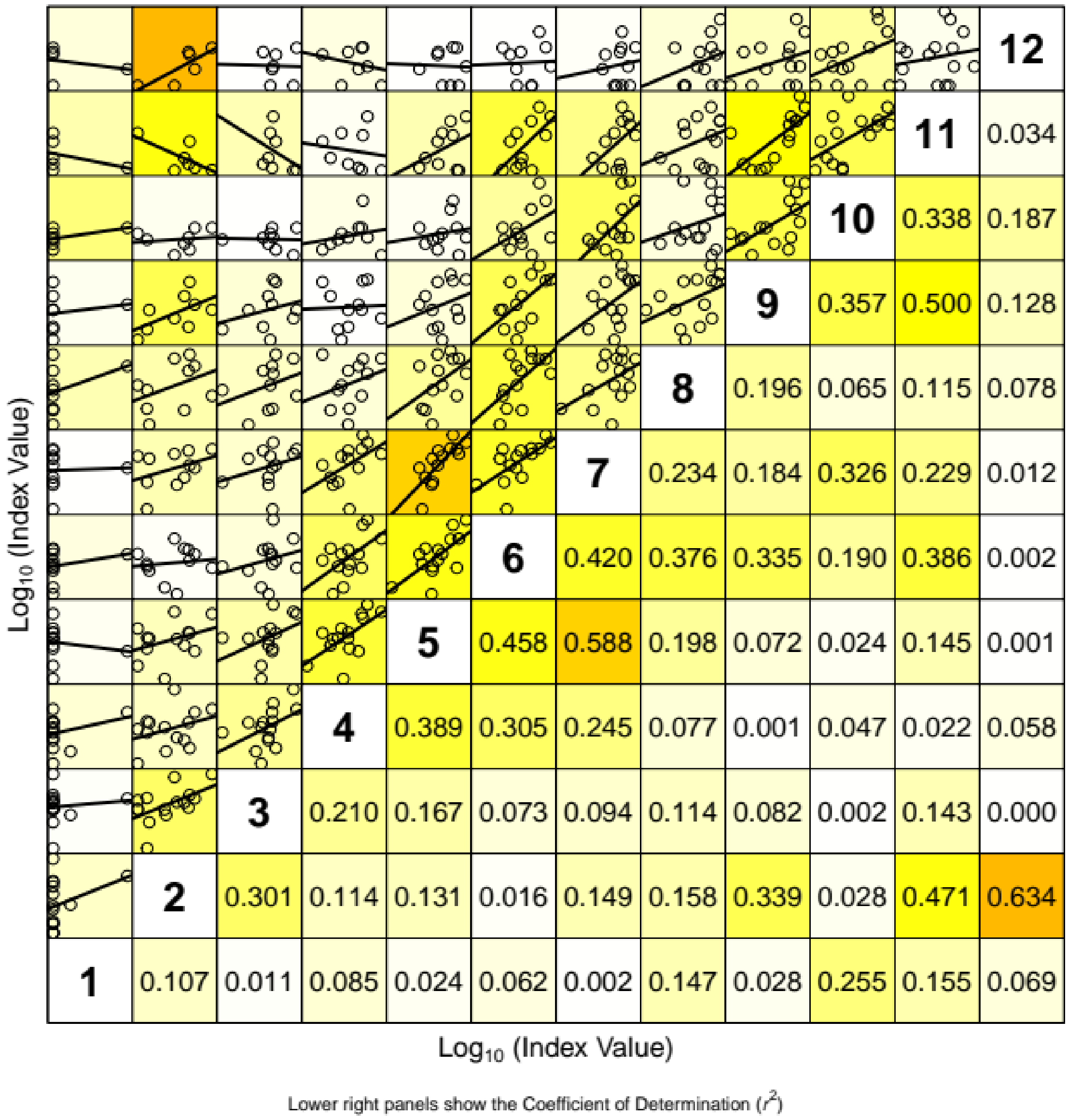


Figure 6.14.3.5 Norway lobster in GSA 11. Cohort consistency of the MEDITS tuning index for the years 2006-2021.

Stock Assessment Results

Various a4a models were examined trying to find the best both in terms of residuals and retrospective patterns. The models were unstable with strong patterns in the MEDITS residuals and biased retrospective results. The model, that was considered the best among the models performed, is presented in the following section.

Model setup:

```
Submodels:
fmodel: ~s(year, k = 8) + factor(replace(age, age > 10, 10))
srmodel: ~s(year, k = 6)
n1model: ~s(age, k = 3)
       qmodel:
         MEDITS_11: ~s(age, k = 5)
       vmodel:
         catch:      ~s(age, k = 3)
         MEDITS_11: ~1
```

Figures (6.17.3.3.6 – 6.17.3.3.8) present stock assessment results, 3D plot of fishing mortality by age and year and 3D plot of catchability by age and year.

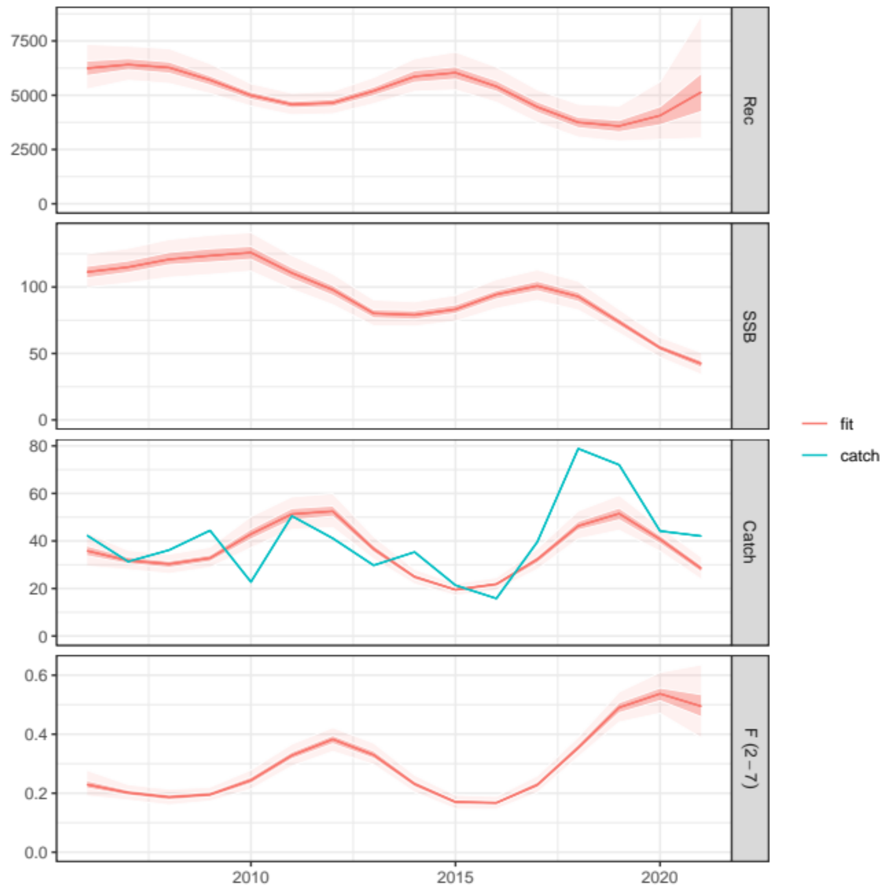


Figure 6.14.3.6 Norway lobster in GSA 11. Results of the stock assessment with 95% confidence limits and the observed catch.

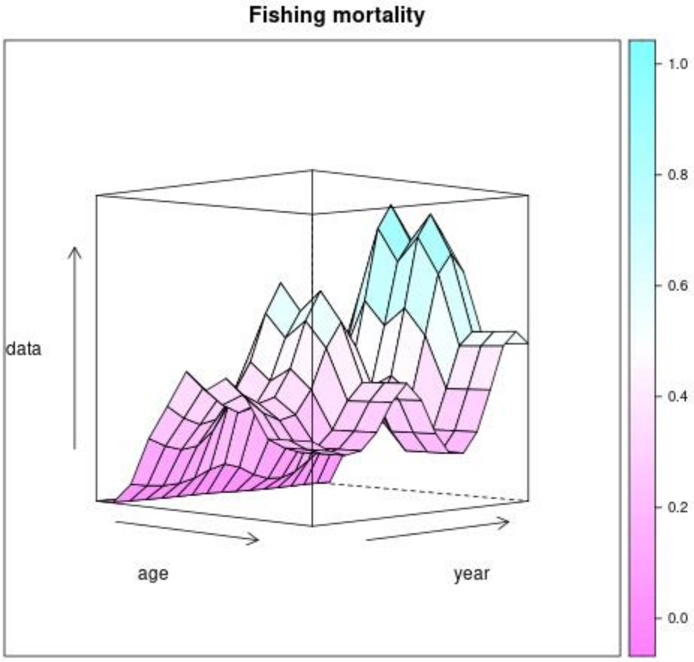


Figure 6.14.3.7 Norway lobster in GSA 11. 3D plot of fishing mortality by age and year.

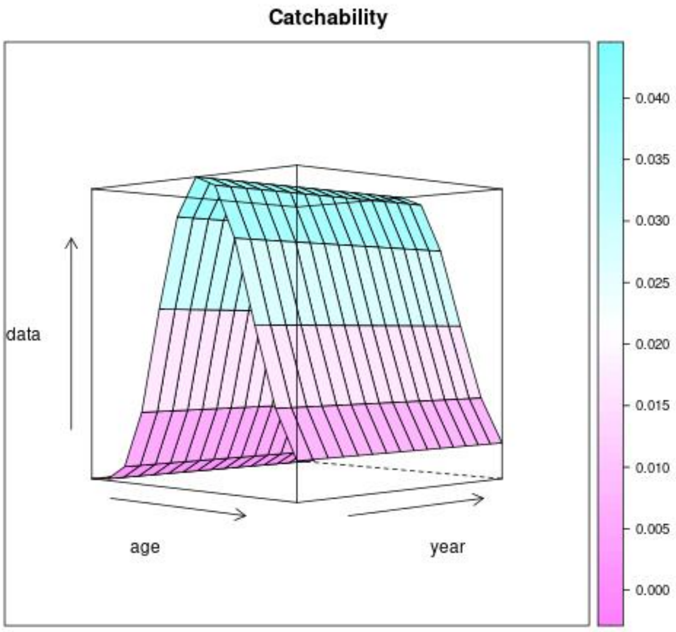


Figure 6.14.3.8 Norway lobster in GSA 11. 3D plot of catchability by age and year.

The Figures (6.17.3.3.9 – 6.17.3.3.12) present the diagnostics of the assessment. Besides the strong positive pattern in the total catch residuals through the last years, the model was also not able to explain both catch numbers and the tuning index which resulted in strong patterns in the residuals of the MEDITS. Retrospective results are unstable for all cases (recruits, SSB and F).

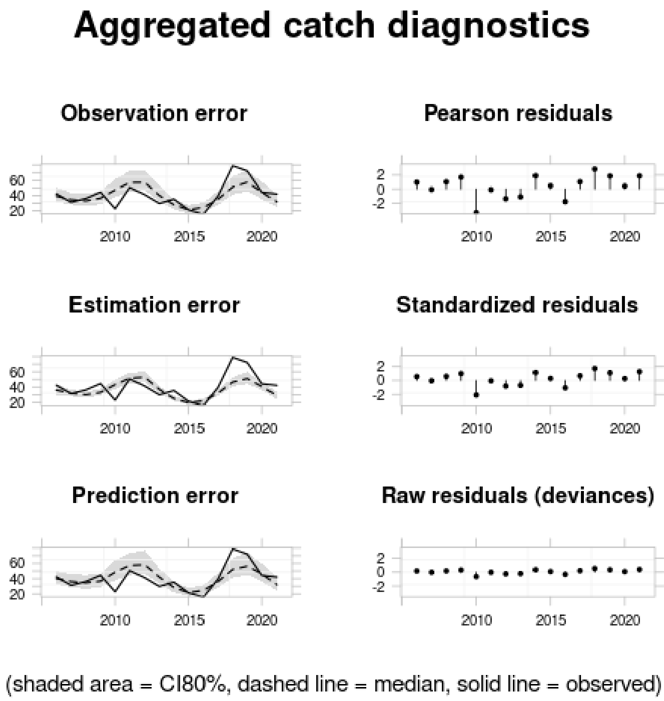


Figure 6.14.3.9 Norway lobster in GSA 11. Catch diagnostics for the a4a assessment.

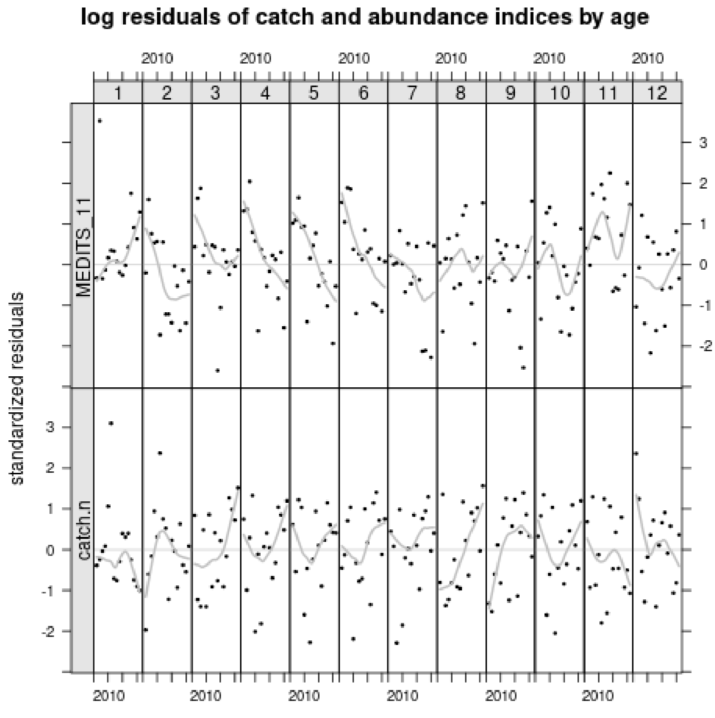


Figure 6.14.3.10 Norway lobster in GSA 11. Catch at age and Index by age residuals.

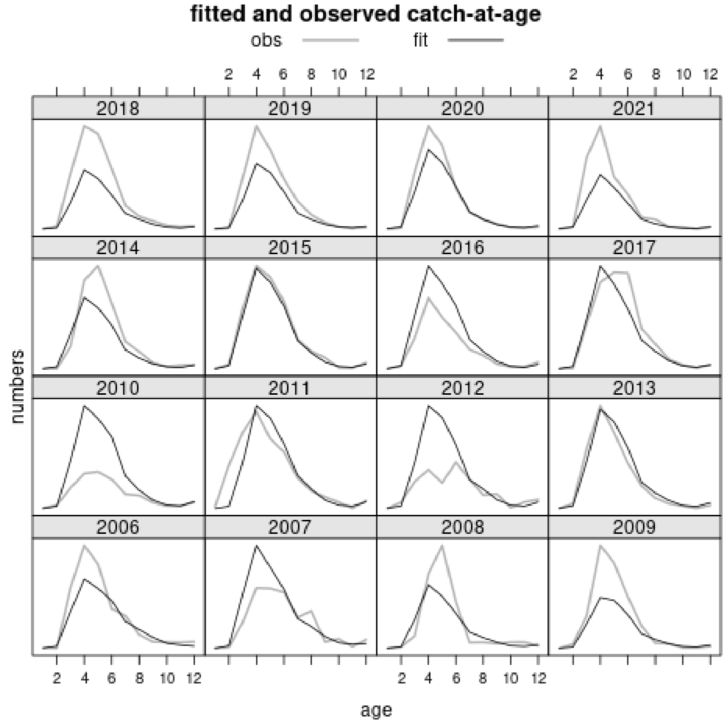


Figure 6.14.3.11 Norway lobster in GSA 11. Fitted versus observed catch by age and year.

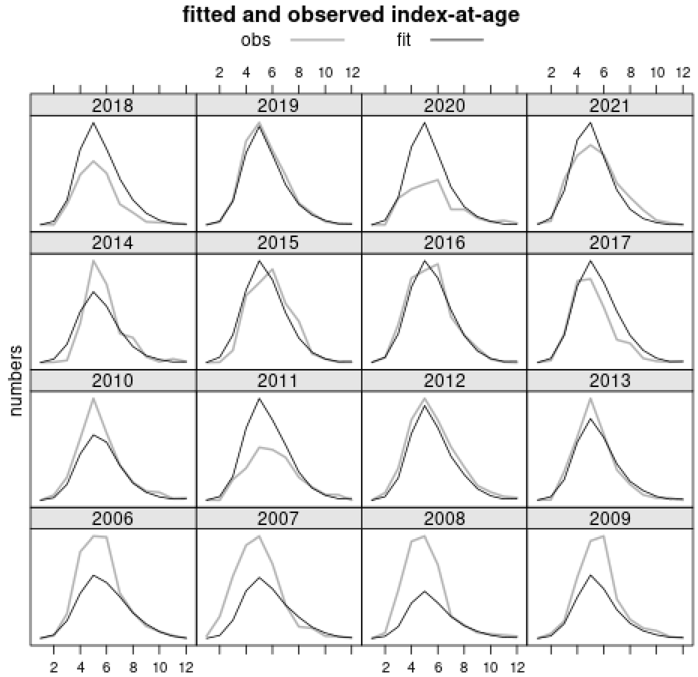


Figure 6.14.3.12 Norway lobster in GSA 11. Fitted versus observed index by age and year.

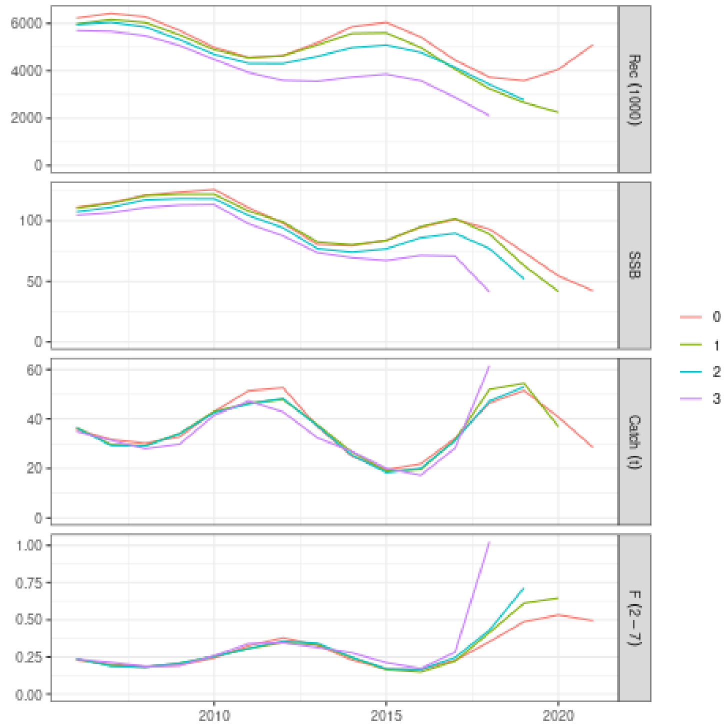


Figure 6.14.3.12 Norway lobster in GSA 11. Retrospective for three years back.

In the following tables the results of the a4a stock assessment are presented. F-at-age, Stock numbers by age, Recruitment, SSB estimated catch and Fbar.

Table 6.14.3.5 Norway lobster in GSA 11. Fishing mortality by age as estimated through the a4a stock assessment

age	2006	2007	2008	2009	2010	2011	2012	2013
1	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
2	0.003	0.002	0.002	0.002	0.003	0.004	0.004	0.004
3	0.065	0.057	0.052	0.055	0.069	0.092	0.107	0.093
4	0.210	0.185	0.170	0.179	0.224	0.301	0.349	0.303
5	0.312	0.274	0.252	0.266	0.332	0.445	0.518	0.449
6	0.418	0.367	0.338	0.356	0.445	0.596	0.694	0.602
7	0.363	0.319	0.294	0.309	0.387	0.518	0.603	0.523
8	0.400	0.351	0.324	0.341	0.426	0.571	0.664	0.576
9	0.341	0.300	0.276	0.291	0.363	0.487	0.567	0.492
10	0.232	0.203	0.188	0.197	0.247	0.331	0.385	0.334
11	0.232	0.203	0.188	0.197	0.247	0.331	0.385	0.334
12	0.232	0.203	0.188	0.197	0.247	0.331	0.385	0.334
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
2	0.003	0.002	0.002	0.003	0.004	0.006	0.006	0.006
3	0.065	0.048	0.047	0.064	0.100	0.138	0.151	0.140
4	0.212	0.156	0.154	0.210	0.326	0.449	0.491	0.456
5	0.314	0.230	0.227	0.311	0.482	0.665	0.727	0.676
6	0.420	0.309	0.305	0.416	0.646	0.891	0.975	0.905
7	0.365	0.268	0.265	0.362	0.562	0.775	0.847	0.787
8	0.402	0.295	0.292	0.398	0.618	0.853	0.933	0.866
9	0.343	0.252	0.249	0.340	0.528	0.728	0.796	0.739
10	0.233	0.171	0.169	0.231	0.358	0.494	0.540	0.502
11	0.233	0.171	0.169	0.231	0.358	0.494	0.540	0.502
12	0.233	0.171	0.169	0.231	0.358	0.494	0.540	0.502

Table 6.14.3.6 Norway lobster in GSA 11. Stock numbers by age as estimated through the a4a stock assessment

age	2006	2007	2008	2009	2010	2011	2012	2013
1	6233	6432	6289	5703	4991	4568	4644	5189
2	3630	3545	3658	3577	3243	2838	2631	2641
3	2147	2375	2320	2394	2343	2114	1856	1720
4	1278	1435	1599	1558	1612	1561	1378	1189
5	770	784	902	1016	984	974	875	736
6	474	441	466	549	610	552	489	408
7	298	251	246	269	310	314	244	195
8	193	169	149	149	161	171	153	109
9	127	107	98	89	88	87	80	65
10	86	76	67	62	56	51	45	38
11	59	57	52	46	43	37	31	26
12	40	67	86	97	101	95	81	65
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	5861	6045	5428	4448	3735	3585	4060	5099
2	2951	3333	3438	3087	2530	2123	2038	2308
3	1727	1930	2184	2251	2020	1653	1385	1329
4	1117	1151	1311	1484	1504	1303	1027	850
5	664	682	745	850	910	821	628	475
6	368	380	424	466	487	440	331	238
7	179	195	224	251	247	205	145	101
8	95	102	122	140	142	115	77	51
9	51	52	63	75	78	64	41	25
10	33	30	34	41	45	39	26	15
11	23	22	22	24	27	26	20	13
12	55	53	54	54	53	48	39	29

Table 6.14.3.6 Norway lobster in GSA 11. Stock summary: number of recruits, SSB, Total Biomass, Fbar 1-2, estimated catch

year	Recruitment	SSB (t)	TB (t)	Fbar (2-7)	Catch (t)
2006	6233	111	195	0.228	36
2007	6432	115	202	0.201	32
2008	6289	121	210	0.185	30
2009	5703	124	210	0.195	33
2010	4991	126	214	0.243	43
2011	4568	111	196	0.326	51
2012	4644	98	182	0.379	53
2013	5189	81	151	0.329	37
2014	5861	80	149	0.230	25
2015	6045	84	151	0.169	20
2016	5428	95	170	0.167	22
2017	4448	101	181	0.227	32
2018	3735	93	174	0.353	46
2019	3585	74	151	0.487	51
2020	4060	54	119	0.533	41
2021	5099	42	98	0.495	29

6.14.4 REFERENCE POINTS

The table below summarises reference points defined for Norway lobster in GSAs 11 for the purposes of providing index based category 3 advice and their technical basis.

Table 6.14.4.6 Norway lobster in GSA 11. Summary of reference points

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$ proxy	1.11	Biomass index trigger value ($I_{trigger}$), defined as $I_{trigger} = I_{loss} \times 1.4$, where I_{loss} is the lowest observed historical biomass index value from 2020 MEDITS in GSA 11. In kg / km^2.	STECF EWG 22-09
	$F_{MSY\ proxy}$	1	$L_{mean}/L_{F=M}$; Mean catch length divided by MSY proxy reference length ($L_{F=M}$).	STECF EWG 22-09
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	SSB_{mgt}		Not Defined	
	F_{mgt}		Not Defined	

6.14.5 SHORT TERM FORECAST AND CATCH OPTIONS

Following the ICES procedures advice is based on the biomass index of the MEDITS survey in GSA 11 (ICES, 2022). ICES framework for category 3 stocks was applied, based on the decision tree provided in the ICES technical guidance and given the data available the rfb rule was chosen to provide advice.

The *rfb* formula contains different factors to determine the catch in the advice year:

$$A_{y+1} = A_y \times r \times f \times b \times m$$

where the advised catch (A) for next year y+1 is based on the most recent year's advised catch A_y adjusted by the components in table 6.18.5.1. According to the guidelines if the most recent realized catch (catch in 2021 = 42 tonnes) is very different from the latest advice (advice for 2022 = 13 tonnes) it is suggested to consider replacing A_y as the rfb rule is meant to adjust realised catches influencing the stock. The two options for substituting A_y are the most recent catch value (catch in 2021) or the average of the last three years (2019-2021). It was decided to use as A_y the catches in 2021.

Table 6.14.5.1 Norway lobster in GSA 11. Components of the rfb rule

Component	Definition	Description and use
A_{y+1}	$A_y \times r \times f \times b \times m$	The advised catch for next year *y*+1.
A_y		The most recent catch (catch in 2021).
r	$\frac{\sum_{i=y-2}^{y-1}(I_i/2)}{\sum_{i=y-5}^{y-3}(I_i/3)}$	The rate of change in the biomass index (I), based on the average of the two most recent years of data (*y*−2 to *y*−1) relative to the average of the three years prior to the most recent two (*y*−3 to *y*−5), and termed the "2-over-3" rule; *y* = 2022.
f	$\frac{\bar{L}_{y-1}}{L_{F=M}}$	The fishing proxy is the mean length in the observed catch ($\bar{L}_{y-1}$) relative to an MSY proxy length ($L_{F=M}$) and is meant to move the stock towards MSY. Only lengths above the length of first capture (L_c) are considered for $\bar{L}_{y-1}$. The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where L_c is defined as length at 50% of modal abundance (ICES, 2012, 2018). The reference length follows Beverton and Holt (1957), derived by Jardim et al. (2015), and assumes *M*/*k* = 1.5.
b	$min\left\{1, \frac{I_{y-1}}{I_{trigger}}\right\}$	Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger} = 1.4I_{loss}$ such that b is set equal to $I_{y-1}/I_{trigger}$. When the most recent index data I_{y-1} is greater than $I_{trigger}$, b is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock. $I_{trigger}$ may need to be adapted if the stock has been exploited only heavily or lightly in the past.
m	$[0,1]$	A tuning parameter to ensure that the rfb rule is precautionary (that risk does not exceed 5%). It does not decrease advice continuously but can be considered as adjusting the target in component *f*. ***m*** is linked to von Bertalanffy ***k*** and based on generic MSE simulations. May range from 0 to 1.0. Since ***k*** is 0.13 ***m*** is 0.95
Stability clause	$min\{max(0.7A_y, A_{y+1}), 1.2A_y\}$	Asymmetric conditional uncertainty cap. Limits the amount the advised catch (A_{y+1}) can change upwards or downwards relative to the previous catch advice (A_y). The recommended values are +20% and −30%; i.e. the catch would be limited to a maximum 20% increase or a maximum 30% decrease relative to the previous year's advised catch. The stability clause does not apply when **b** < 1.

To obtain the *f* component of the *rfb* rule:

For the first parameter, we calculate the length at first capture (L_c) by year, which is defined as the first length class where abundance is more than or equal to half of the maximum abundance. Length data without reconstruction from 2006 onwards was used. L_c per year is shown in the table below.

year	L_c (mm)
2006	23
2007	28
2008	32
2009	28
2010	26
2011	18
2012	27
2013	27
2014	30
2015	26
2016	26
2017	27
2018	25
2019	26
2020	27
2021	27

Second parameter the target reference length $L_{F=M} = 0.75L_c + 0.25L_{inf}$ is calculated per year and shown in the table below. We used as L_{inf} the female L_{inf} as reported in table 6.14.1.1.

year	$L_{F=M}$ (mm)
2006	37.45
2007	41.2
2008	44.2
2009	41.2
2010	39.7
2011	33.7
2012	40.45
2013	40.45
2014	42.7
2015	39.7
2016	39.7
2017	40.45
2018	38.95
2019	39.7
2020	40.45
2021	40.45

Third parameter, the mean length above L_c is calculated.

year	$L_{mean} > L_c$
2006	35.5774793102308
2007	40.3147983280771
2008	38.2252045158146
2009	35.6790454536657
2010	39.0031227438768
2011	34.272615016118
2012	41.7142457876318
2013	35.6069984392413
2014	38.0518194714913
2015	36.2314577872631
2016	36.7105066242985
2017	37.9960090307947
2018	35.598324123489
2019	35.7464776225227
2020	35.2523346448473
2021	34.3738581219673

Fourth parameter, the quantity *f* is calculated as the ratio of the mean length above L_c and $L_{F=M}$. Calculations were done with unrounded values. For all years except in 2011 and 2012 the fishing pressure proxy relative to the MSY proxy indicator ratio L_{mean} / $L_{F = M}$ (*f*) was smaller than 1. In 2021, the ratio is 0.85 (figure 6.14.5.1). The exploitation status is considered sustainable when the indicator ratio value is higher than 1 ($F_{MSY\ proxy}$ = 1).

year	$L_{mean}/L_{F=M}$
2006	0.950
2007	0.979
2008	0.865
2009	0.866
2010	0.982
2011	1.017
2012	1.031
2013	0.880
2014	0.891
2015	0.913
2016	0.925
2017	0.939
2018	0.914
2019	0.900
2020	0.872
2021	0.850

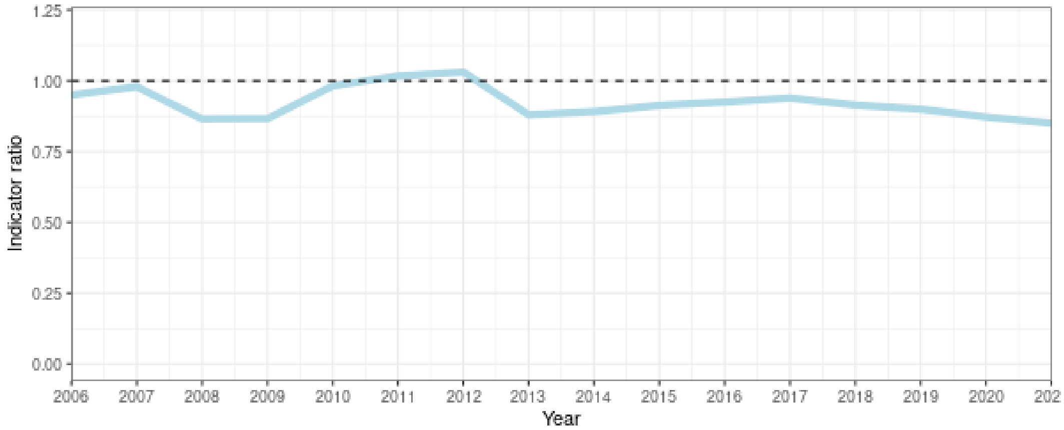


Figure 6.14.5.1 Norway lobster in GSA 11. Length indicator (mean length of fish in the catch divided by MSY proxy reference length). Value of 1 is indicated by the dashed line.

To obtain the *b* component of the *rfb* rule we defined the biomass index trigger value ($I_{trigger}$), defined as $I_{trigger} = I_{loss} \times 1.4$, where I_{loss} is the lowest observed historical biomass index value from 2020 MEDITS in GSA 11 (figure 6.14.5.2).

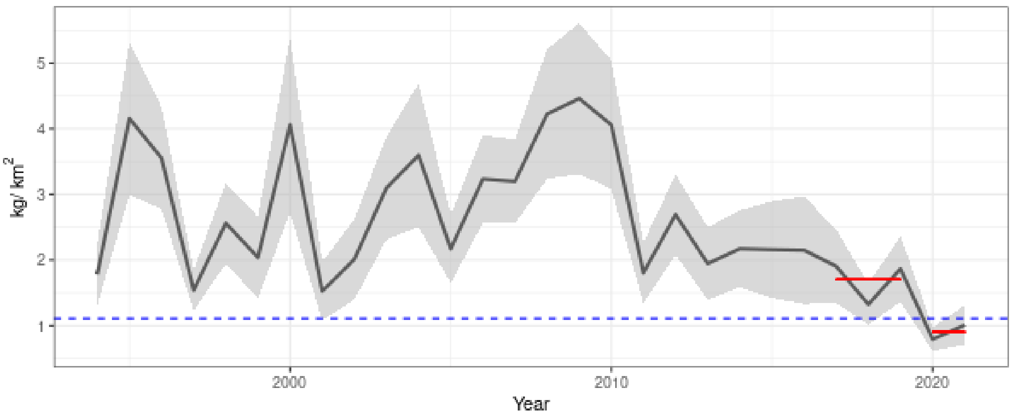


Figure 6.14.5.2 Norway lobster in GSA 11. MEDITS in GSA 11 biomass index. Blue line represents the $I_{trigger}$ while the two red segments the mean index of 2017 – 2019 and 2020-2021.

Table 6.14.5.1 Norway lobster in GSA 11. Basis for the catch scenarios. The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the table.

Last year catch C_{y-1} (catch in 2021)	42 tonnes	
Stock biomass trend		
Index A (2020, 2021)	0.901 kg / km^2	
Index B (2017, 2018, 2019)	1.698 kg / km^2	
r: Index ratio (A/B)	0.531	
Fishing pressure proxy		
Mean catch length ($\overline{L}_{y-1}$=L_{2021})	34.37	
MSY proxy length ($L_{F=M}$)	40.45	
f: multiplier for relative mean length in catches ($\overline{L}_{y-1}$/ $L_{F=M\ 2021}$)	0.85	
Biomass safeguard		
Last index value (I_{2021})	1.009 kg / km^2	
Index trigger value ($I_{trigger}$=1.4*I_{loss})	1.109 kg / km^2	
b: index relative to trigger value, min{I_{2021}/$I_{trigger}$, 1}	0.91	
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability		
m: multiplier (generic multiplier based on life history)	0.95	
rfb calculation*		
Uncertainty cap (+20%/-30% compared to C_{y-1}, only considered if b≥1)	Not applied	
Discard rate	0%	
Catch advice for 2023	31 tonnes	
% advice change**	-26%	

$A_{y+1} = A_y \times r \times f \times b \times m$ limited by stability clause if applicable.

** Advice value for 2023 relative to the catch in 2021 (209 tonnes).

Based on MSY considerations STECF EWG 22-09 advises to decrease the total catch by 26% relative to the catches in 2021 equivalent to catches of no more than 31 tons in 2023.

6.14.6 Data Deficiencies

Total catches in 2005 were considered ureliable and were excluded from the stock assessment attempts,

No other major issues were detected in the quality check of both DCF commercial data and MEDITS tuning index.

6.15 Blue and Red Shrimp in GSA 1 & 2

6.15.1 Stock Identity and Biology

The assessment of blue and red shrimp carried out during the STECF EWG 21-11 considered the stock shared by GSA 1 & 2 (Figure 6.15.1.1). No information was documented regarding stock delimitation of blue and red shrimp, *Aristeus antennatus* (Risso, 1816).

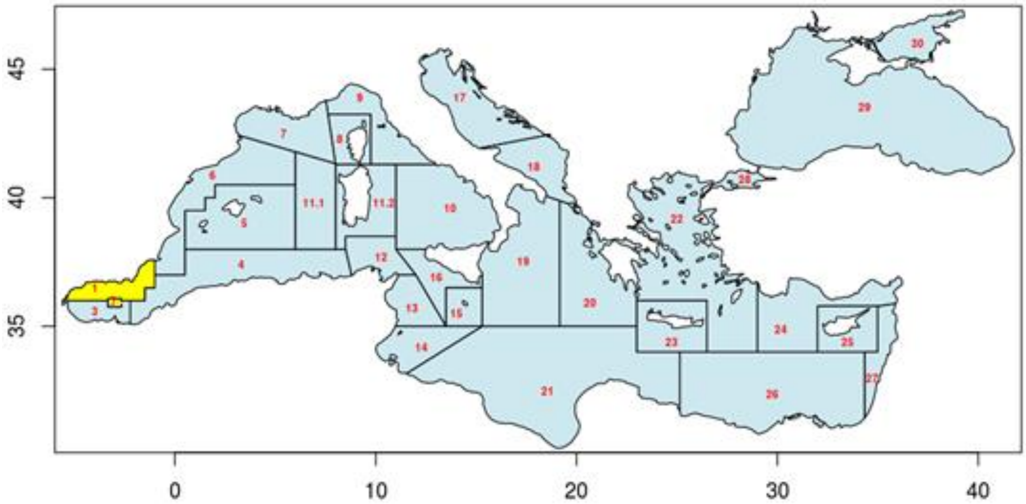


Figure 6.15.1.1. Blue and red shrimp in GSA 1 & 2. Geographical location of GSAs 1 & 2.

For the assessment of blue and red shrimp in GSA 1 and 2 input data revised from the GSA 1 assessment of last year, to include data from GSA 2. Length data was available for GSA 2, though no other biological parameters were provided in the data call so those from GSA 1 were used.

The same basic growth parameters (L_{inf} = 80 mm (carapace length), K = 0.37 $year^{-1}$, t_0 = 0.032 year) with the previous assessment for this stock in GSA 1 (STECF 21-11) were used because growth parameters were not available in the DCF dataset for blue and red shrimp in GSA 2. In 2019 the starting point for the growth curve is assumed to be mid-year (1st July) for length slicing of length to age. In 2019 the t_0 was intended to be as given in this way but was in fact used as -0.032 which gave slightly different values of n at age resulting in very small differences in the assessment, from 2020 the length slicing has included the seasonal correction. In 2019, 2020, and 2021 and the present assessment, the length slicing for assessment was run with 0.532 value of t_0 to provide correct length transitions for 1st of January to coincide with Jan-Dec assessment year. It should be noted that the natural mortality was calculated with t_0 set +0.032 the intended value last year.

These length equations above were calculated with modal progression analysis (Battacharya/NORMSEP), based on monthly length-frequency distribution obtained from Data Collection Framework (DCF, 2014). Although females reach larger sizes compared to males, a combined set of growth parameters was used to comply with previous assessments and with the available length data, which is also combined. Length frequency distributions from the Spanish OTB fleet as well as from survey data (MEDITS) were sliced to catch-at-age, using those growth parameters with t0 set to 0.532 and age boundaries set to 1,2,3, etc. This indicates that it is rare to catch blue and red shrimp at age zero in the commercial catch and they are never observed in the survey which is consistent with 3rd quarter survey timing (see Section 6.15.2.3).

The parameters of the length-weight relationship (a = 0.002 and b = 2.515) were also used as in the previous assessment for GSA 1 and had been calculated based on DCF data (DCF, 2014). The length of the sample from which growth parameters and length-weight relationship were estimated ranged between 15 and 64 mm CL.

The proportion of mature individuals at age was not available from the DCF data for blue and red shrimp in GSA 1 & 2 and in 2021 was taken from the 2015 assessment of GSA 1 that was based on the DCF data this was applied in the present assessment (Table 6.15.1.1). A fixed maturity ogive is used for all years.

Table 6.15.1.1. Blue and red shrimp in GSA 1 & 2. Proportion of mature specimens (Pmat) at age.

Age	0	1	2	3	4	5
Pmat	0.0	0.7	1.00	1.00	1.00	1.00

The natural mortality of blue and red shrimp in the present assessment was calculated as a vector using the Chen Watanabe (1989) model (Table 6.15.1.2). These are calculated using the t0 =+0.032. It noted that age zero natural mortality is for a full 12 months while the actual mortality is lower, only occurring in the last 6 months of the year after spawning.

Table 6.15.1.2. Blue and red shrimp in GSA 1 & 2. Natural mortality (M) at age.

Age	0	1	2	3	4	5
M	2.327	0.883	0.618	0.512	0.458	0.426

6.15.2 DATA

6.15.2.1 CATCH (LANDINGS AND DISCARDS)

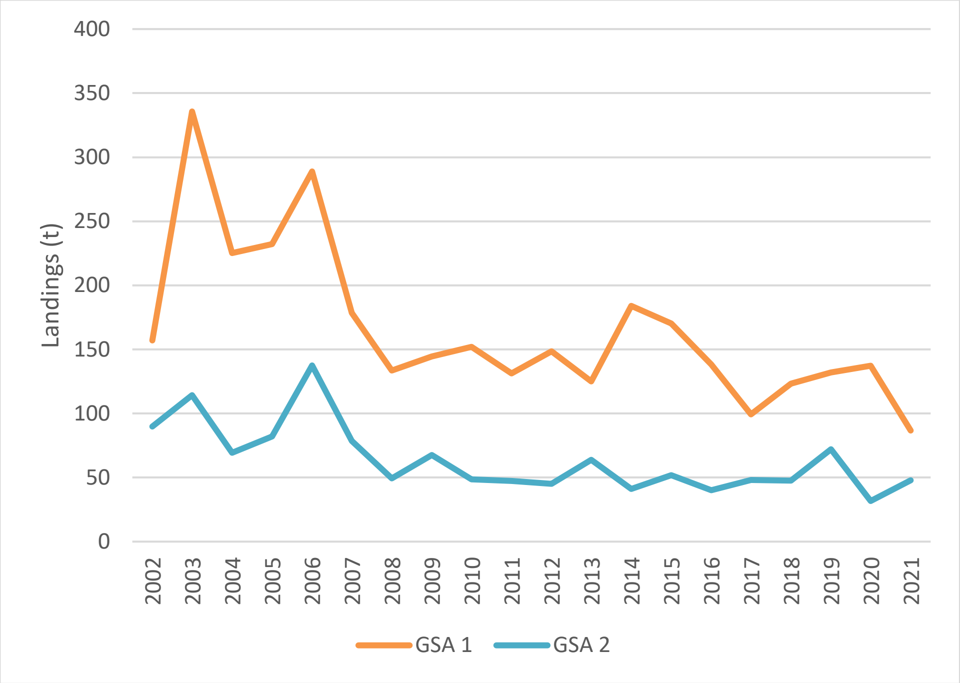
General description of Fisheries

The blue and red shrimp (*Aristeus antennatus*) is present in GSA 1 & 2 at depths ranging from 400 to 800 m. The stock is exploited only by deep bottom otter trawl and particularly by the fleet segment composed of the largest trawlers. The blue and red shrimp fishery can be considered as monospecific with no significant discards (less than 0.01 tonnes per year), due to the very high price of the species. Catch is landings taken as landings with negligible discards (typically 0.02% with a max 0.3%) reported in few years that can be safely taken as zero in all years (Table 6.15.2.1.1). The SoP correction is applied and catch is used throughout this report. The total OTB landings per year, as reported by DCF, are shown in Figure 6.15.2.1.1

Table 6.15.2.1.1. Blue and red shrimp in GSA 1 & 2. Blue and red shrimp DCF landings (t) and discards (t) by OTB (all metiers) in GSA 1 & 2.

Year	OTB Landings (t) for GSA1	OTB Landings (t) for GSA 2	OTB Discards (t) for GSA1	OTB Discards (t) for GSA 2
2002	157.0	89.8		
2003	335.7	114.4		
2004	225.2	69.3		
2005	232.1	82.2	0.65	
2006	288.8	137.5		
2007	178.4	78.6		
2008	133.5	49.3		
2009	144.6	67.7		2.58
2010	152.1	48.7	0.01	0.57
2011	131.4	47.4	0.14	0.03
2012	148.6	45.0	0.06	0.06
2013	125.0	63.9	0.05	0.03
2014	184.0	41.0	0.01	0.01
2015	170.2	51.9	0.03	0.22
2016	138.2	40.1	0.01	0.29
2017	99.2	48.0	0.01	0.21
2018	123.2	47.5	0.01	0.04
2019	132.1	72.0	0.07	0.07
2020	137.4	31.7	0	0
2021	86.7	47.9	0.03	0.15

Figure 6.15.2.1.1. Blue and red shrimp in GSA 1 & 2. Blue and red shrimp DCF landings (t), in GSA 1 & 2 (2002-2021).



For both GSA 1 & 2, the LFD per gear and metier before reconstruction in Figure 6.15.2.1.2. Length structure of blue and red shrimp landed in GSA 1 & 2 in the period from 2002 to 2021 by fishing gear and fishery as reconstructed is shown in Figure 6.15.2.1.3.

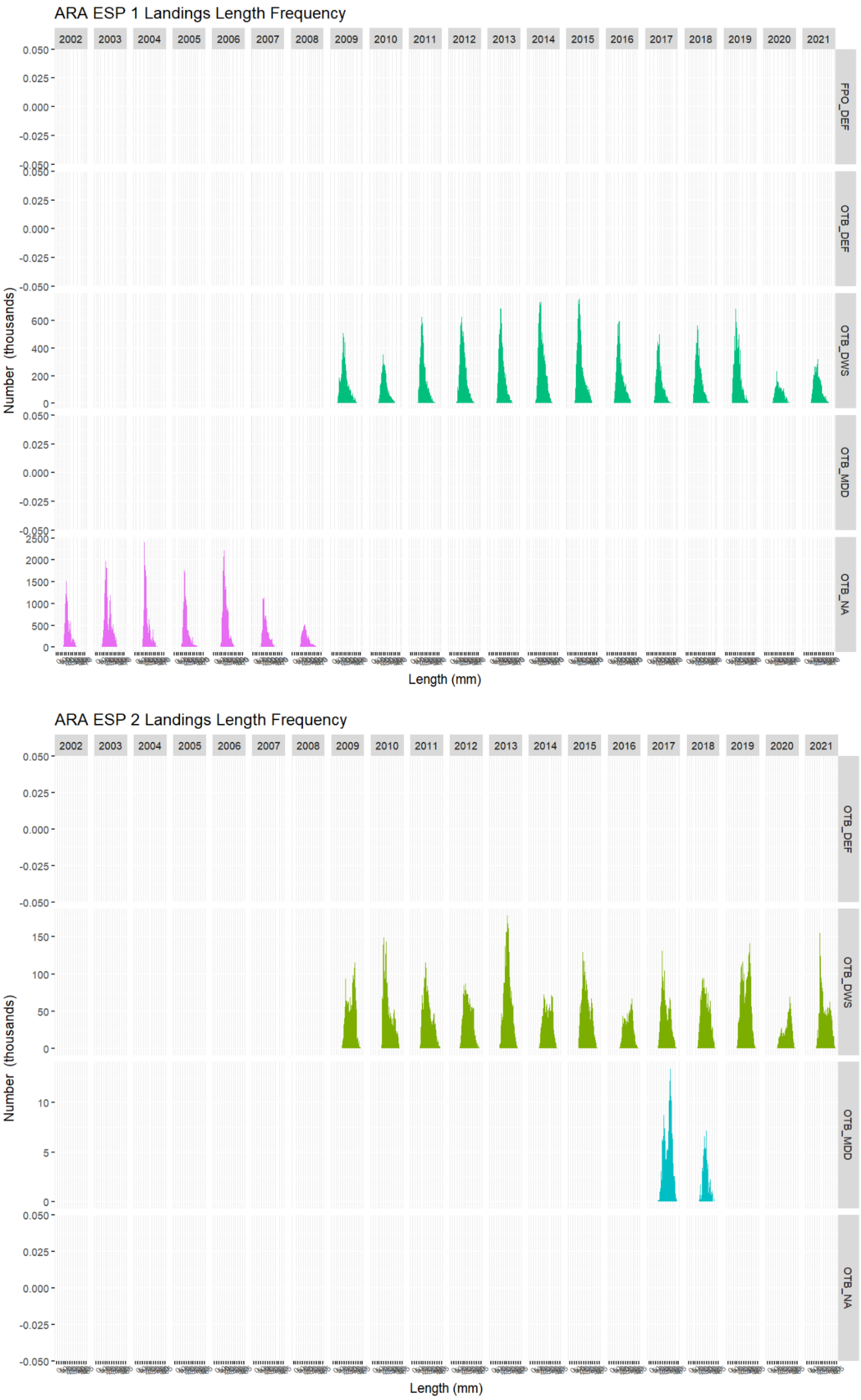


Figure 6.15.2.1.2. Blue and red shrimp in GSA 1 & 2: Length structure of Blue and red shrimp landed in GSA 1 & 2 in the period from 2002 to 2021 by fishing gear and fishery.

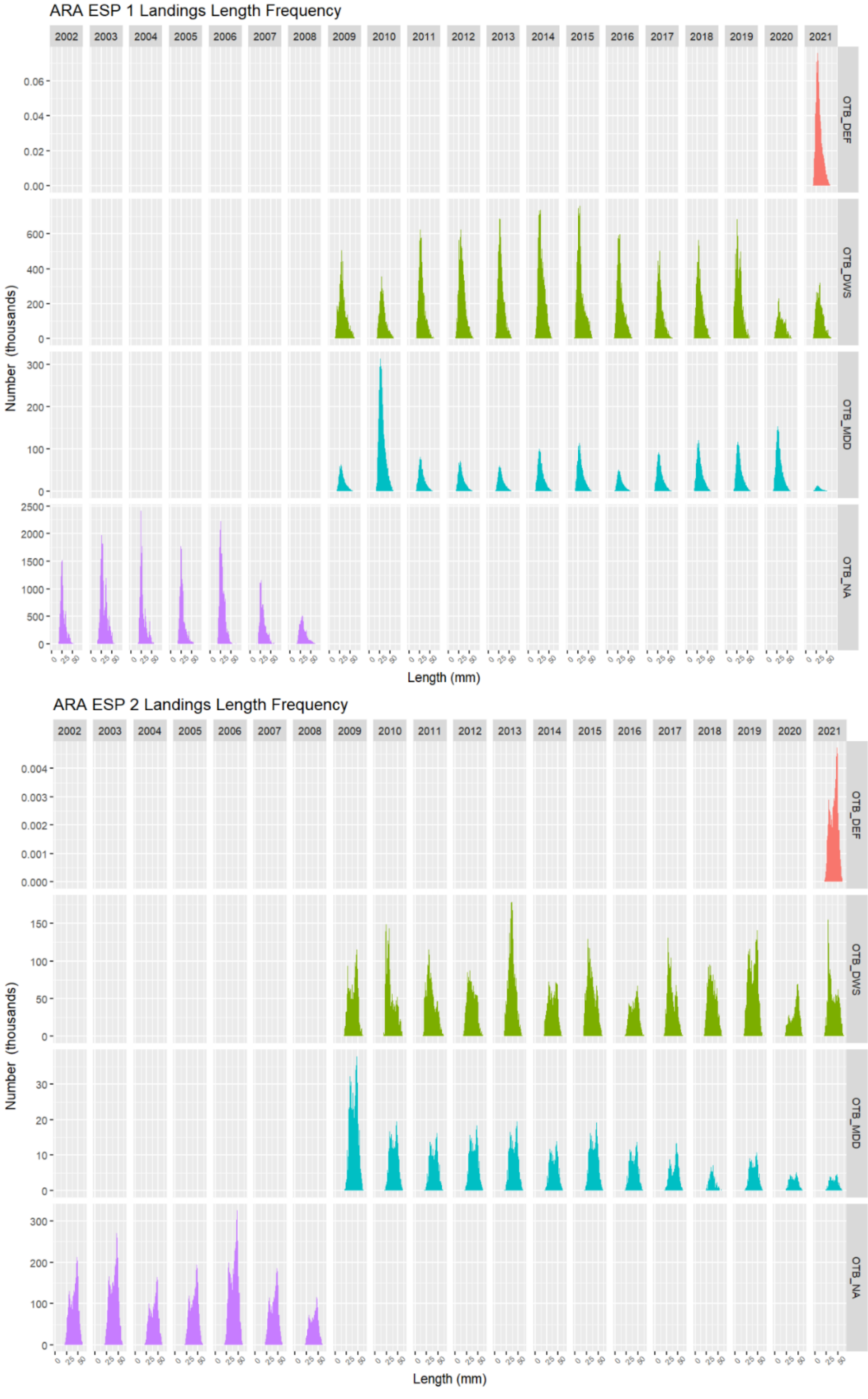


Figure 6.15.2.1.3. Blue and red shrimp in GSA 1 & 2: Length structure of blue and red shrimp landed in GSA 1 & 2 in the period from 2002 to 2021 by fishing gear and fishery as reconstructed.

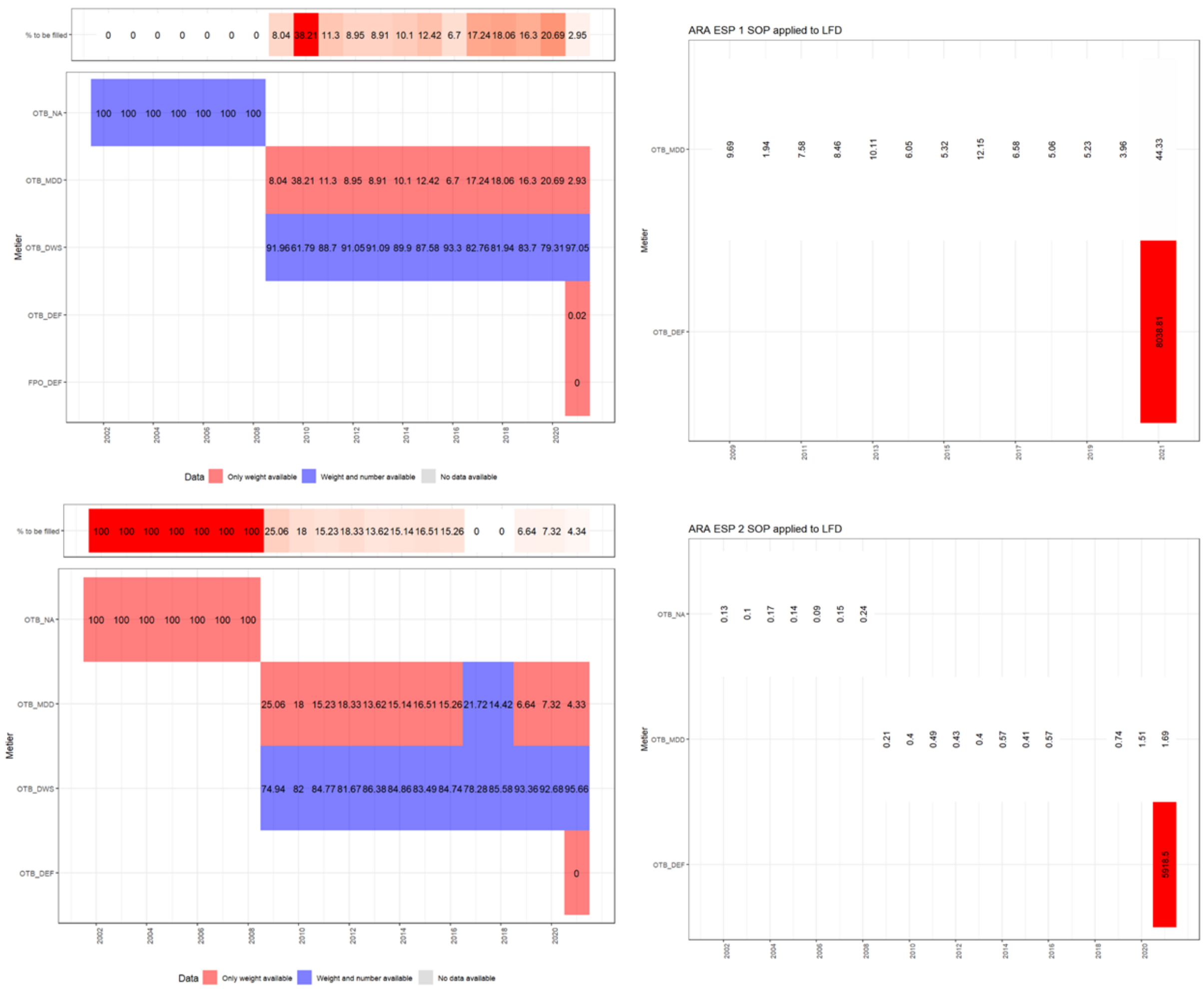


Figure 6.15.2.1.4. Blue and red shrimp in GSA 1 & 2. Percentages of total landings LFDs that were reconstructed by year and gear and SoP applied to LFD for Spain in GSA 1 & 2.

6.15.2.2 EFFORT

Fishing effort data for 2021 will be reported to STECF EWG 22-11 through the FDI data call within the DCF framework.

6.15.2.3 SURVEY DATA

The MEDITS survey is carried out annually from April to June (Figure 16.15.2.3.1) by the Spanish Institute of Oceanography (IEO) since 1994 at fixed haul positions. Tables TA, TB, TC were provided according to the MEDITS protocol. Data were assigned to strata based upon the shooting position and average depth between shooting and hauling depth.
The abundance and biomass indices by GSA were calculated through stratified means. This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA.

Figure 6.15.2.3.1 Month of the year when the hauls of MEDITS survey are being conducted in GSA 1 & 2.

The time series of abundance and biomass indices of blue and red shrimp from MEDITS bottom trawl survey in GSA 1 & 2 are shown in the following figures (Figure 6.15.2.3.2 and 6.15.2.3.3). Both estimated abundance and biomass indices show similar trends, both maximized in 2000 and fluctuated around a mean for the last five years. The total biomass time series had been fluctuating with lower mean from 2007-2019. In GSA 2 in 2019 the value is similar to the mean of the later period.

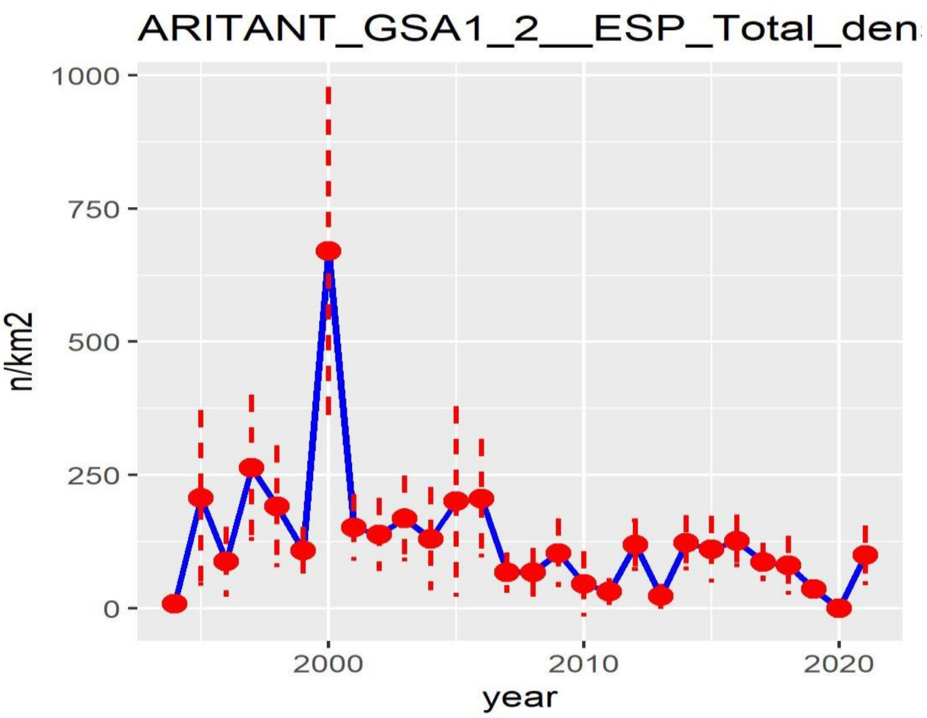


Figure 6.15.2.3.2. Blue and red shrimp in GSA 1 & 2. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 & 2 as reported by DCF. The survey is carried out from April to June. The zero value shown for 2020 is a missing value, and is not included in the assessment.

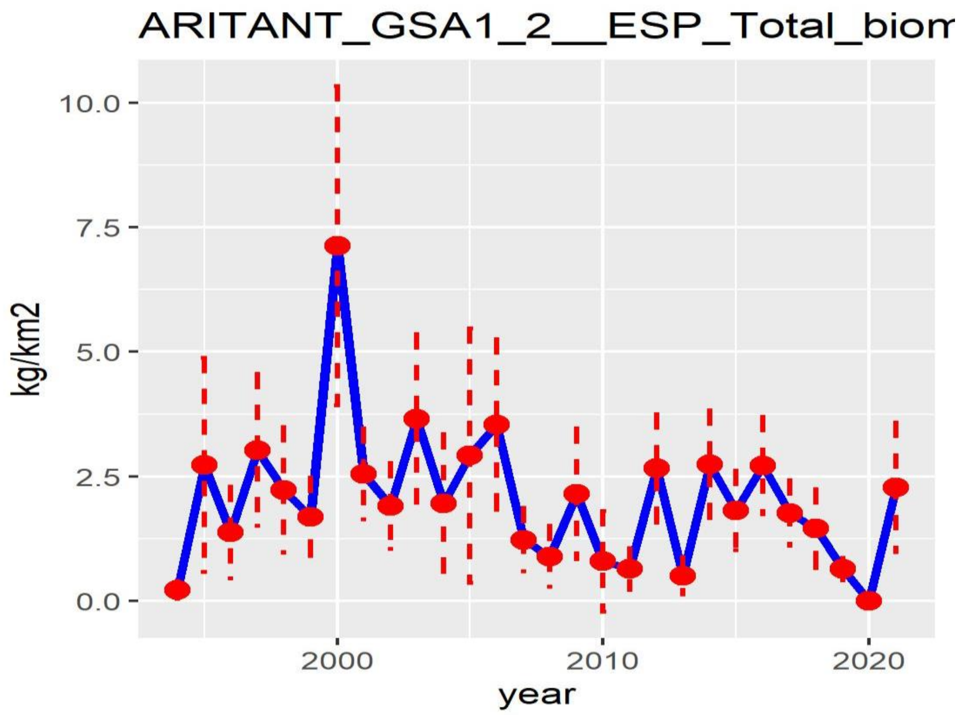


Figure 6.15.2.3.3. Blue and red shrimp in GSA 1 & 2. MEDITS survey biomass index (kg/km^2) of blue and red shrimp in GSA 1 & 2 as reported by DCF. The survey is carried out from April to June. The zero value shown for 2020 is a missing value and used in the analysis

Trends in abundance by length (Figure 6.15.2.3.4) are shown below.

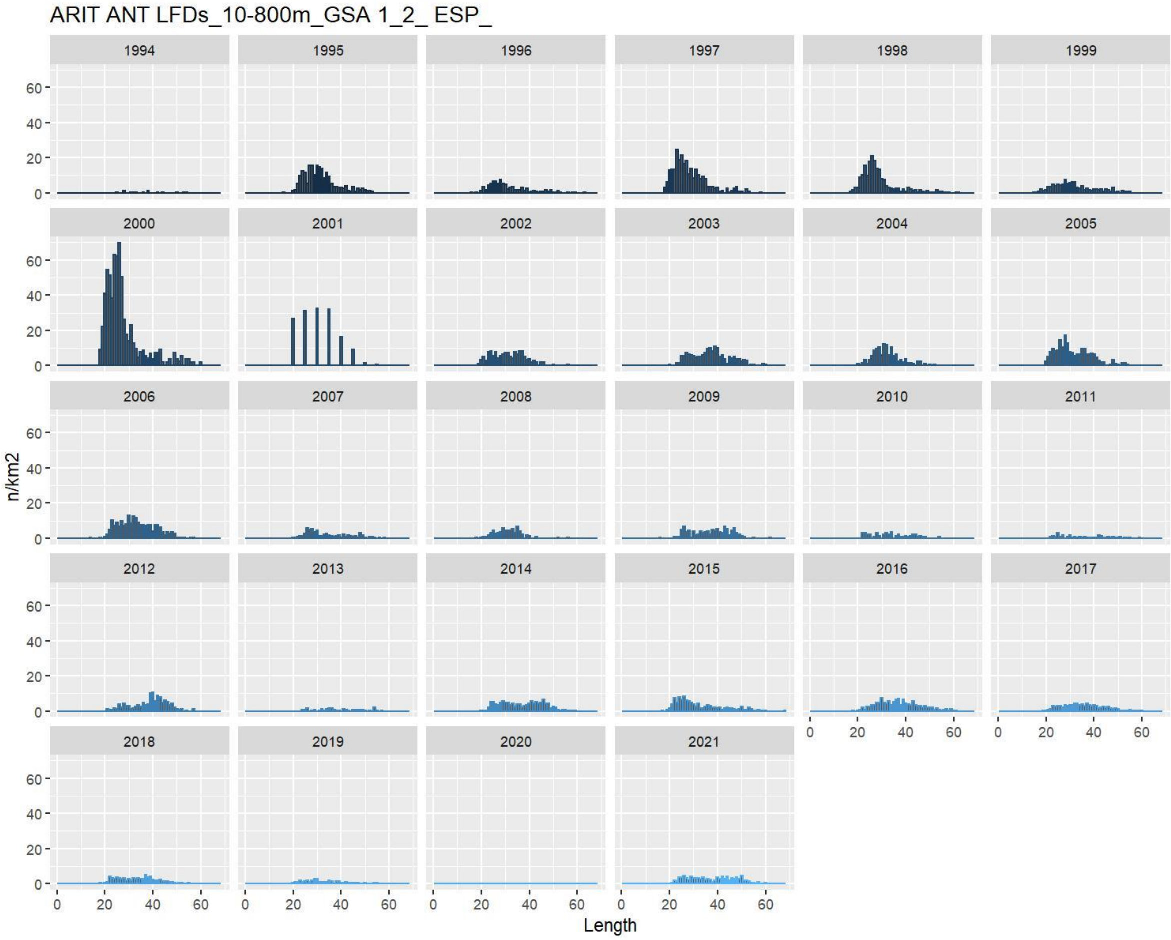


Figure 6.15.2.3.4. Blue and red shrimp in GSA 1 & 2. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 & 2 as reported by DCF. The survey is carried out from April to June.

6.15.3 Stock assessment

The present assessment was carried out using a statistical catch-at-age analysis (a4a). The same input data but re-evaluated was used this year for GSA1 and added data for GSA 2. There's no survey data for 2020. Treatment of length to age that better aligns the the birthday to 1st of January for stocks with summer spawing resultys in different age structure which is considered to better reflect the observed growth.

Input data

As decribed above the input growth parameters used were Linf = 80 mm, k = 0.37 y^{-1}, t0 =-0.032 and were kept identical as in the previous assessment with 0.5 was added to t_0 for purpose of aligning sizes appropriately with 1st of January for length slicing.

The spawning of blue and red shrimp peaks during the summer, although continuous spawning throughout the year has been reported from some areas of the Mediterranean.

The proportion of mature individuals at age was not available for blue and red shrimp in GSA 1 & 2 and was taken from the previous assessment that was based on the DCF data for GSA 1(Table 6.15.1.1). The maturity at age ogive was used for blue and red shrimp assessment in GSA 1 & 2 as estimated from biological sampling based on length at first maturity and growth, giving 0.7 at age 1 (spawning in the first summer).
Natural mortality (M) was estimated using Chen-Watanabe (1989) model and is shown in Table 6.15.1.2. using the original growth parameters (without adding 0.5 to t_0)

Sum of Products (SoP) correction was applied in catch numbers at age to match the total catch by year reported in the DCF (Table 6.15.3.1)

Table 6.15.3.1. Blue and red shrimp in GSA 1 & 2. Sum of Products (SoP) correction array.

Year	SoP
2002	1.08
2003	1.06
2004	1.10
2005	1.07
2006	1.07
2007	1.03
2008	1.03
2009	1.03
2010	1.03
2011	1.04
2012	1.03
2013	1.03
2014	1.03
2015	1.04
2016	1.04
2017	1.03
2018	1.04
2019	1.05
2020	1.02
2021	1.03

Table 6.15.3.2. Blue and red shrimp in GSA 1 & 2: Values of catch at age per year used in the assessment.

	1	2	3	4	5+
2002	14018.00	4561.00	111.06	4.16	0.24
2003	20117.00	6154.30	210.16	5.58	0.23
2004	17342.00	8268.90	246.07	9.17	0.27
2005	19088.00	6722.90	291.94	9.49	0.38
2006	24677.00	7128.80	219.95	10.44	0.37
2007	11612.00	9147.20	231.05	7.79	0.40
2008	6777.50	4395.50	312.49	8.63	0.32
2009	8077.30	2668.00	164.21	12.76	0.38
2010	8840.00	3319.50	109.40	7.35	0.62
2011	8617.70	3757.30	145.82	5.25	0.40
2012	7984.60	3720.90	169.87	7.20	0.29
2013	8314.50	3434.10	166.16	8.28	0.38
2014	9089.20	3511.10	147.25	7.78	0.43
2015	10314.00	3754.50	143.89	6.59	0.38
2016	7432.00	4205.30	150.51	6.30	0.32
2017	6336.70	3051.50	172.79	6.75	0.31
2018	7693.20	2688.10	136.15	8.42	0.36
2019	9561.80	3456.30	137.37	7.60	0.51
2020	5254.70	4635.60	209.88	9.10	0.56
2021	4403.50	2776.40	339.62	16.77	0.81

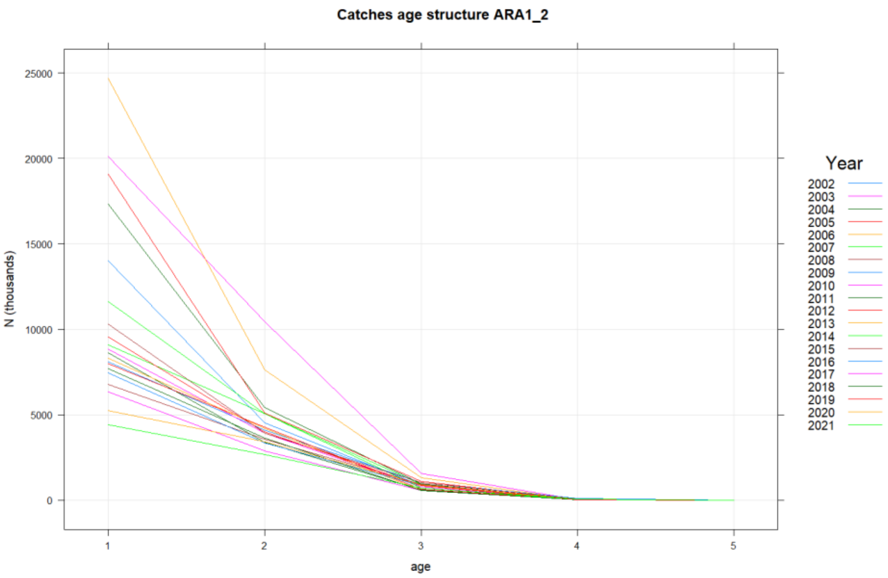


Figure 6.15.3.1. Blue and red shrimp in GSA 1 & 2: Catch-at-age data of blue and red shrimp in GSA 1 & 2 used in assessment.

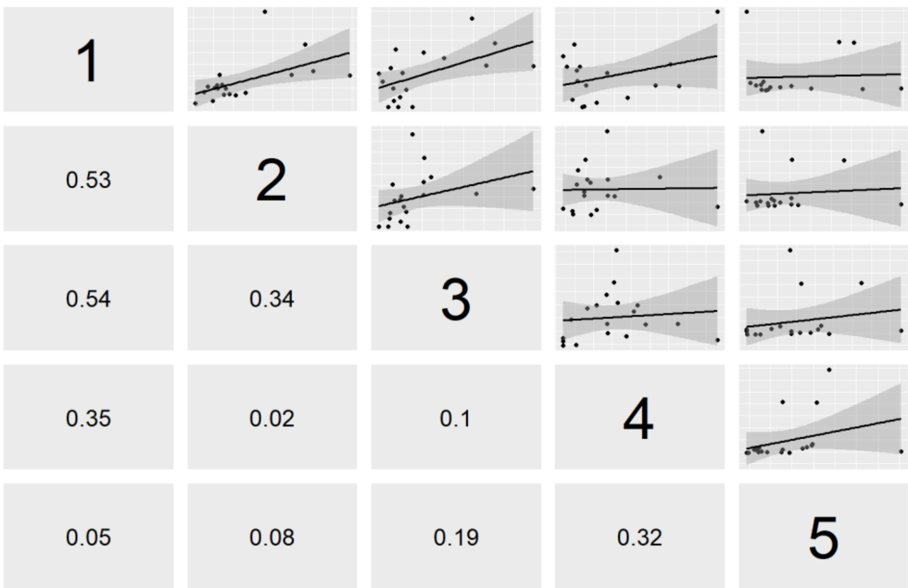


Figure 6.15.3.2. Blue and red shrimp in GSA 1 & 2. Cohort consistency of catches used in the assessment.

Table 6.15.3.2. Blue and red shrimp in GSA 1 & 2: Values of catch in the assessment.

Year	Catch
2002	217.41
2003	300.94
2004	330.07
2005	318.11
2006	370.04
2007	322.57
2008	175.21
2009	139.54
2010	158.22
2011	165.61
2012	161.52
2013	156.53
2014	167.39
2015	179.23
2016	166.6
2017	134.04
2018	133.09
2019	163.64
2020	166.19
2021	118.3

Table 6.15.3.3. Blue and red shrimp in GSA 1 & 2: Values of mean weight at age per year used in the assessment.

	1	2	3	4	5+
2002	0.008	0.023	0.040	0.056	0.075
2003	0.008	0.022	0.040	0.056	0.075
2004	0.008	0.023	0.040	0.056	0.075
2005	0.008	0.023	0.041	0.056	0.075
2006	0.008	0.022	0.040	0.057	0.075
2007	0.009	0.023	0.040	0.055	0.075
2008	0.009	0.023	0.041	0.057	0.073
2009	0.009	0.023	0.041	0.057	0.075
2010	0.009	0.022	0.041	0.056	0.075
2011	0.009	0.022	0.041	0.057	0.074
2012	0.009	0.022	0.041	0.057	0.074
2013	0.009	0.021	0.040	0.056	0.075
2014	0.009	0.022	0.040	0.055	0.075
2015	0.009	0.023	0.041	0.056	0.075
2016	0.009	0.023	0.041	0.059	0.075
2017	0.009	0.022	0.041	0.058	0.073
2018	0.009	0.022	0.040	0.056	0.075
2019	0.008	0.022	0.040	0.057	0.074
2020	0.009	0.023	0.041	0.057	0.075
2021	0.009	0.022	0.042	0.057	0.080

Table 6.15.3.3. Blue and red shrimp in GSA 1 & 2: Survey index (MEDITS) values at age per year used in the assessment.

	1	2	3
2002	81.98	53.51	2.60
2003	54.83	93.24	20.03
2004	82.70	43.58	3.70
2005	124.25	65.40	10.63
2006	113.29	83.61	8.99
2007	37.12	19.99	9.20
2008	46.48	19.78	0.86
2009	35.93	58.56	8.86
2010	23.43	20.41	1.51
2011	14.16	11.47	5.06
2012	27.00	80.99	11.20
2013	5.73	10.31	4.87
2014	48.27	59.40	14.45
2015	71.24	27.24	12.18
2016	48.00	61.05	16.93
2017	38.71	40.04	7.28
2018	40.31	36.32	4.14
2019	20.05	13.16	2.86
2020	-	-	-
2021	38.55	39.96	20.39

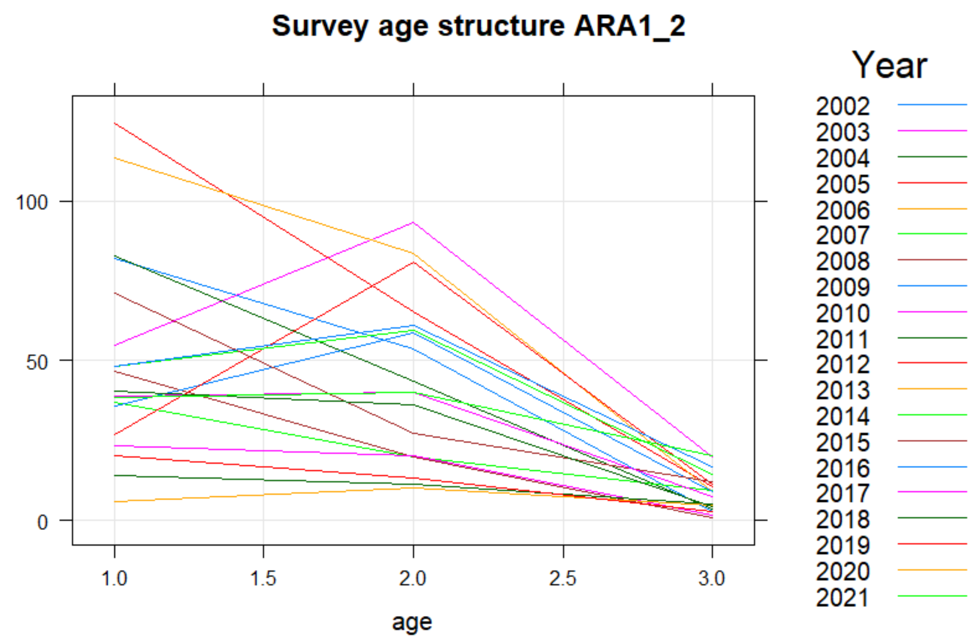


Figure 6.15.3.4. Blue and red shrimp in GSA 1 & 2: MEDITS indices describing density by age of blue and red shrimp in GSA 1 & 2 by year.

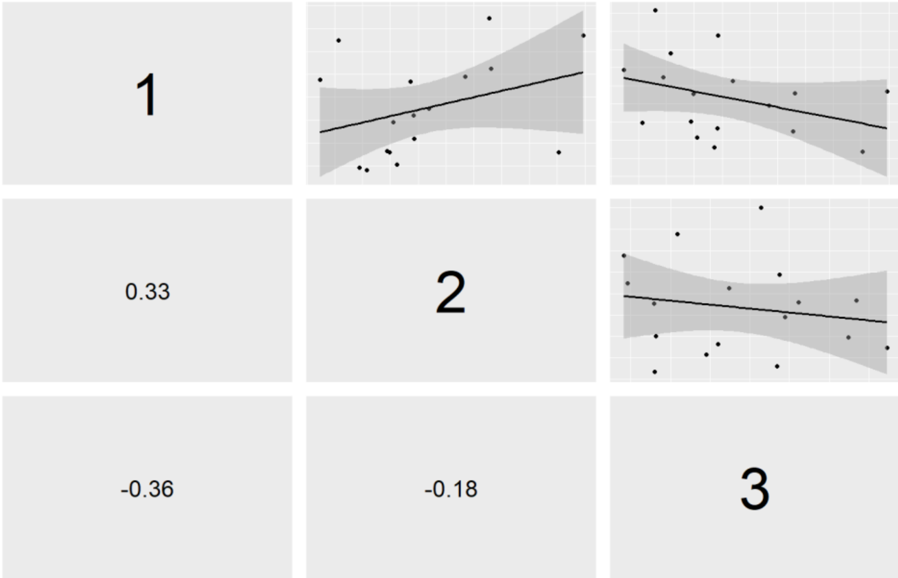


Figure 6.15.3.5. Blue and red shrimp in GSA 1 & 2: Cohort consistency of survey data used in the assessment.

Assessment results

Different a4a models were investigated in terms of fishing mortality, catchability of the survey index and stock –recruitment relationship models (fmodel, qmodel, and srmodel).

The model selected is the same as the one used by the EWG 21-11 for blue and red shrimp in GSA1.

The following model was selected on the basis of best fit, both for residuals as well as fitted vs observed data and retrospective; this model also coincides with the general perception of the STECF EWG on fishing mortality allocation throughout age groups, as well as on the catchability of the index. Also in line with results for other stocks in adjacent GSAs.

Models applied and selected

fmodel <- ~ factor(replace(age,age>2,2)) + s(year,k=6)

qmodel <- list(~ factor(replace(age,age>2,2)))

srmodel <- ~factor(year)

Summary of the model fit using the fitSumm command:

nopar	3.600000e+01
nlogl	7.745169e+01
maxgrad	7.636624e-04
nobs	1.570000e+02
gcv	1.178005e+00
convergence	0.000000e+00
accrate	NA
nlogl_comp1	1.048870e+00
nlogl_comp2	7.640280e+01

The following figure presents the summary of the stock object after the fit of the model. The recruitment, spawning stock biomass catch and fishing mortality.

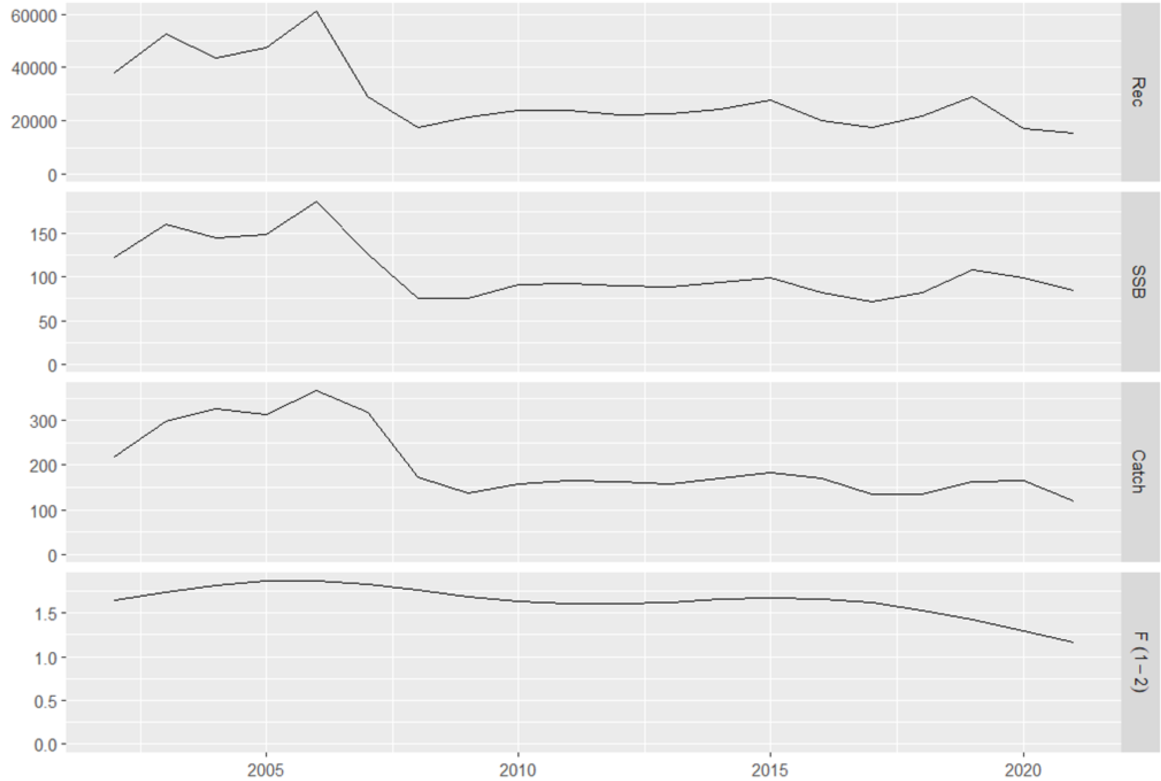


Figure 6.15.3.6. Blue and red shrimp in GSA 1 & 2: Stock summary from the final a4a model.

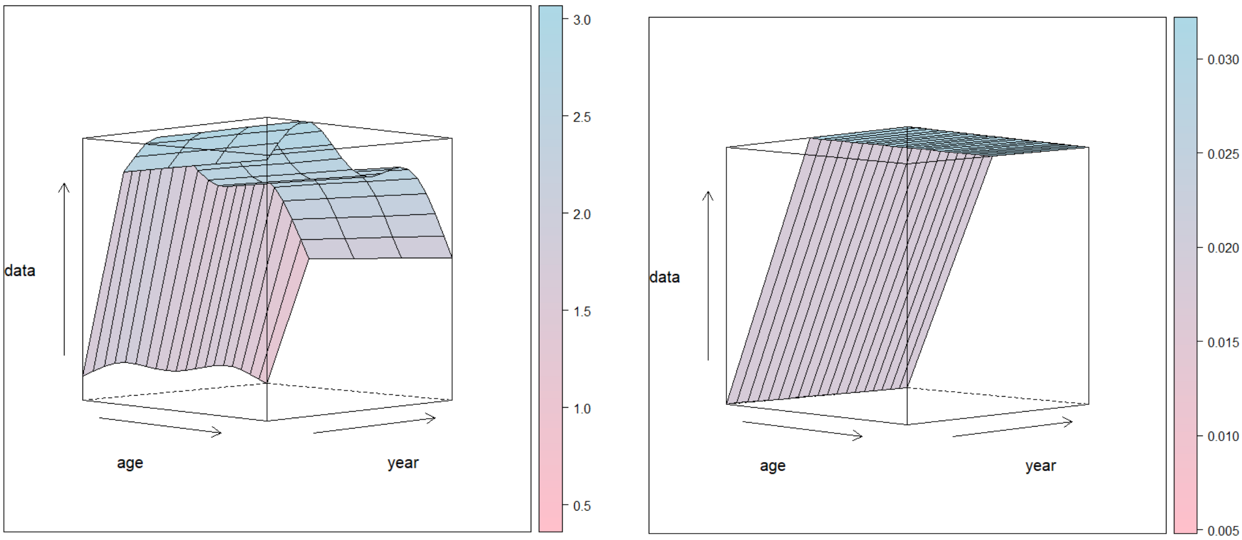
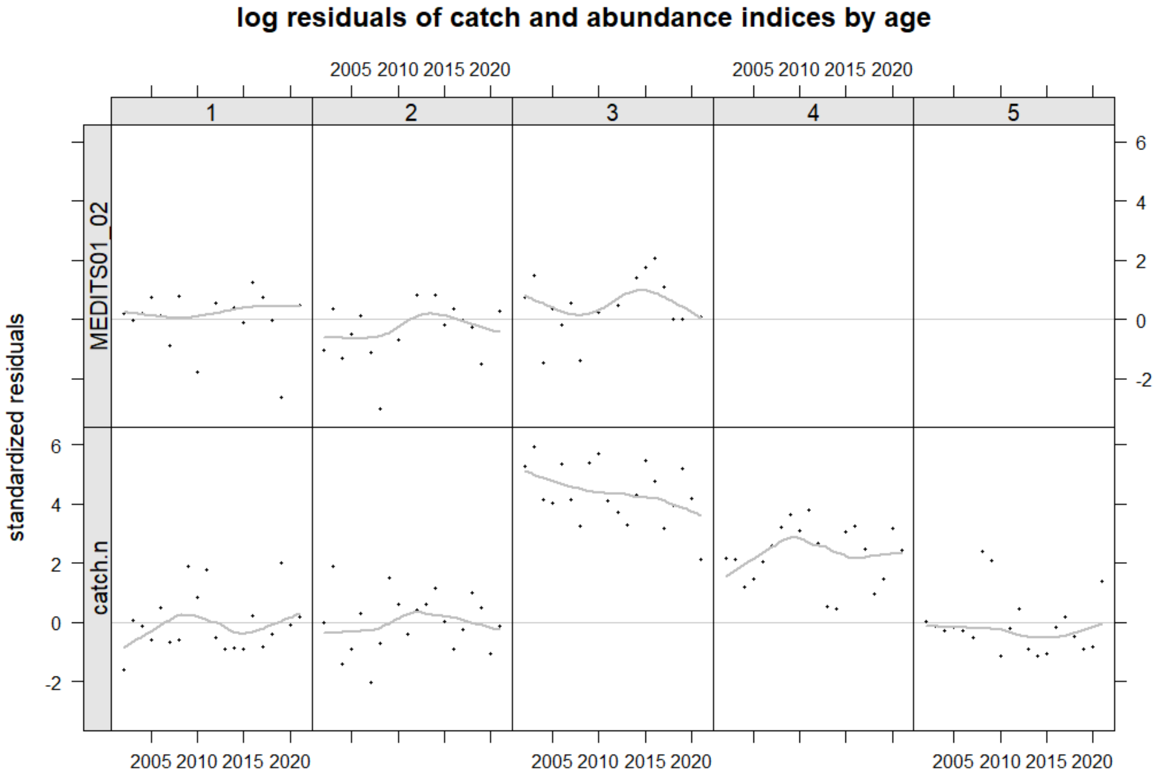


Figure 6.15.3.7. Blue and red shrimp in GSA 1 & 2: 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.



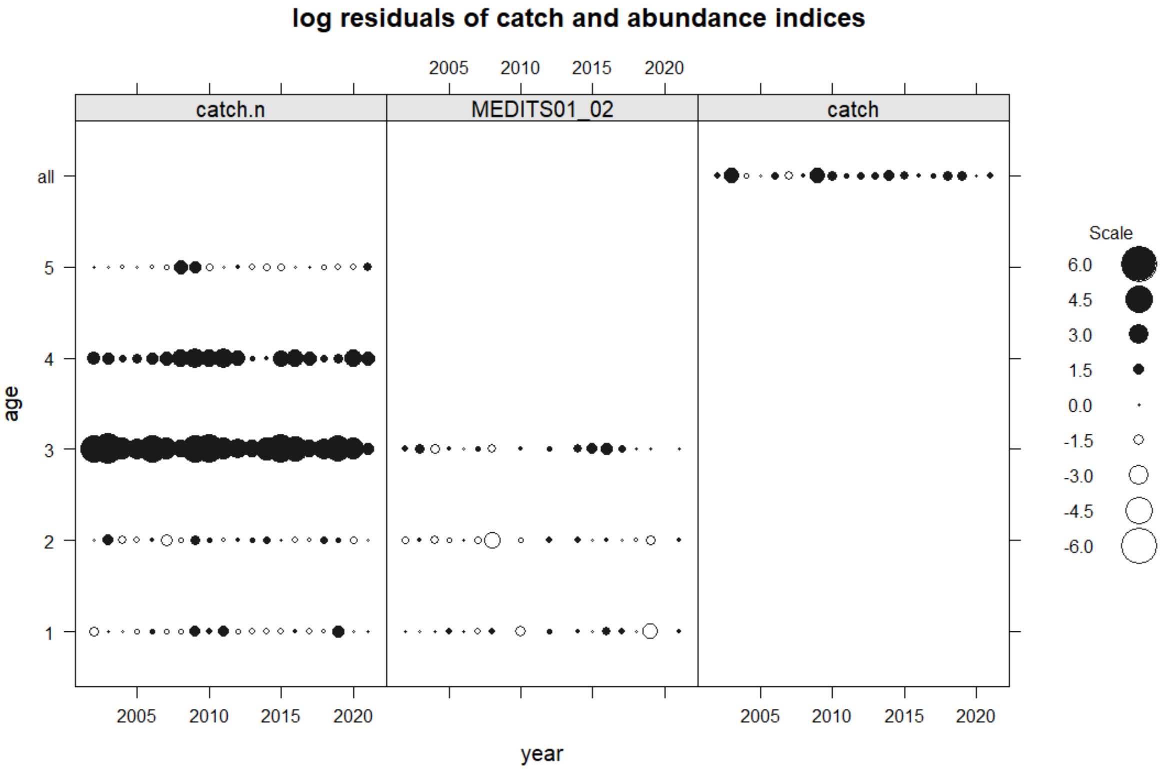


Figure 6.15.3.8. Blue and red shrimp in GSA 1 & 2: Standardized residuals for abundance indices and for catch numbers.

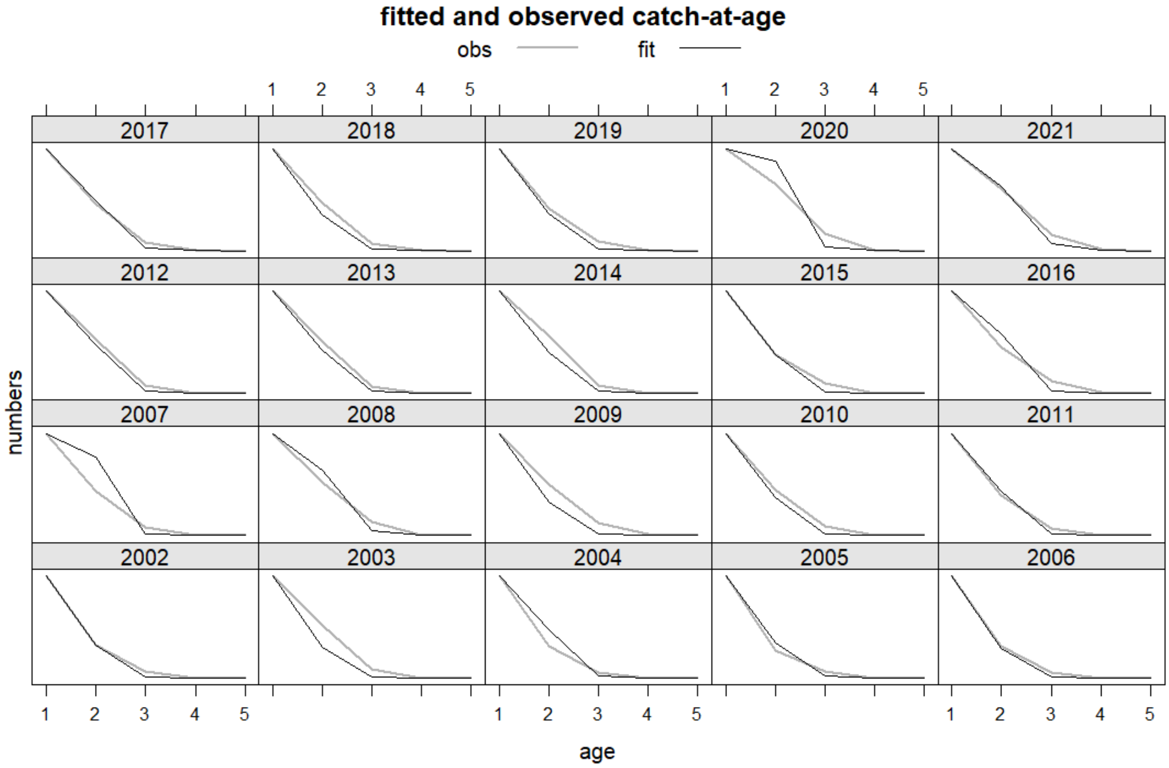


Figure 6.15.3.9. Blue and red shrimp in GSA 1 & 2: Fitted and observed catch at age.

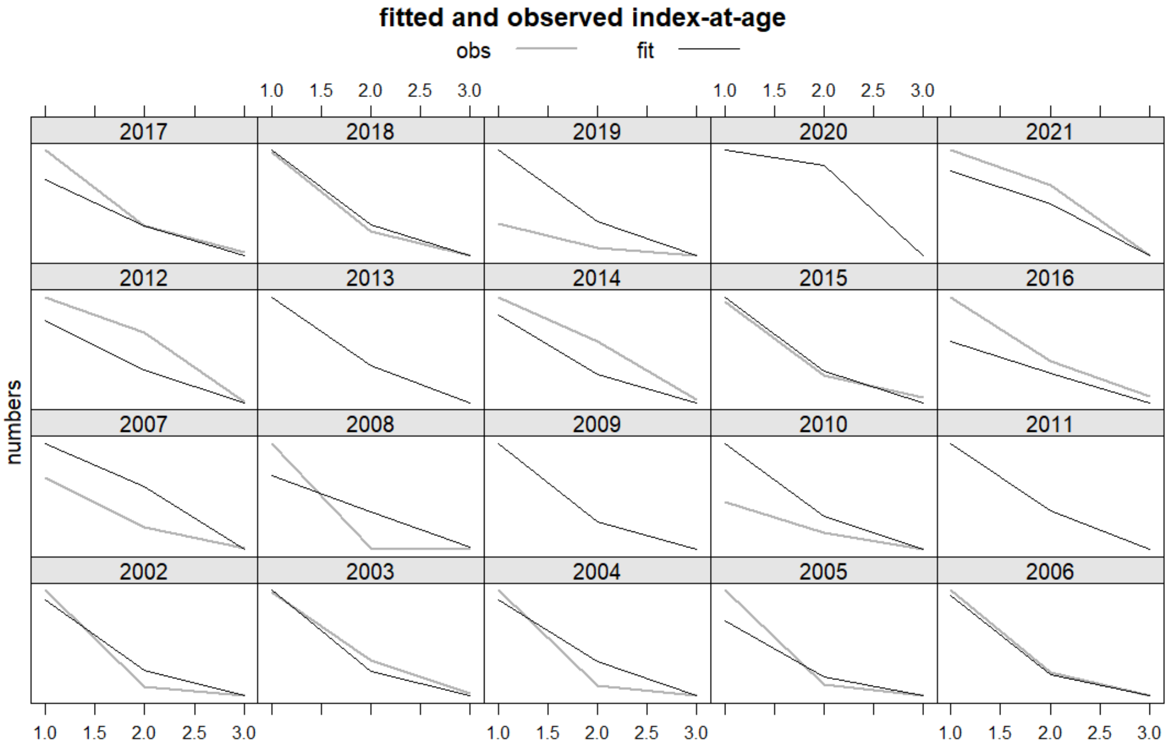


Figure 6.15.3.10. Blue and red shrimp in GSA 1 & 2: Fitted and observed index at age.

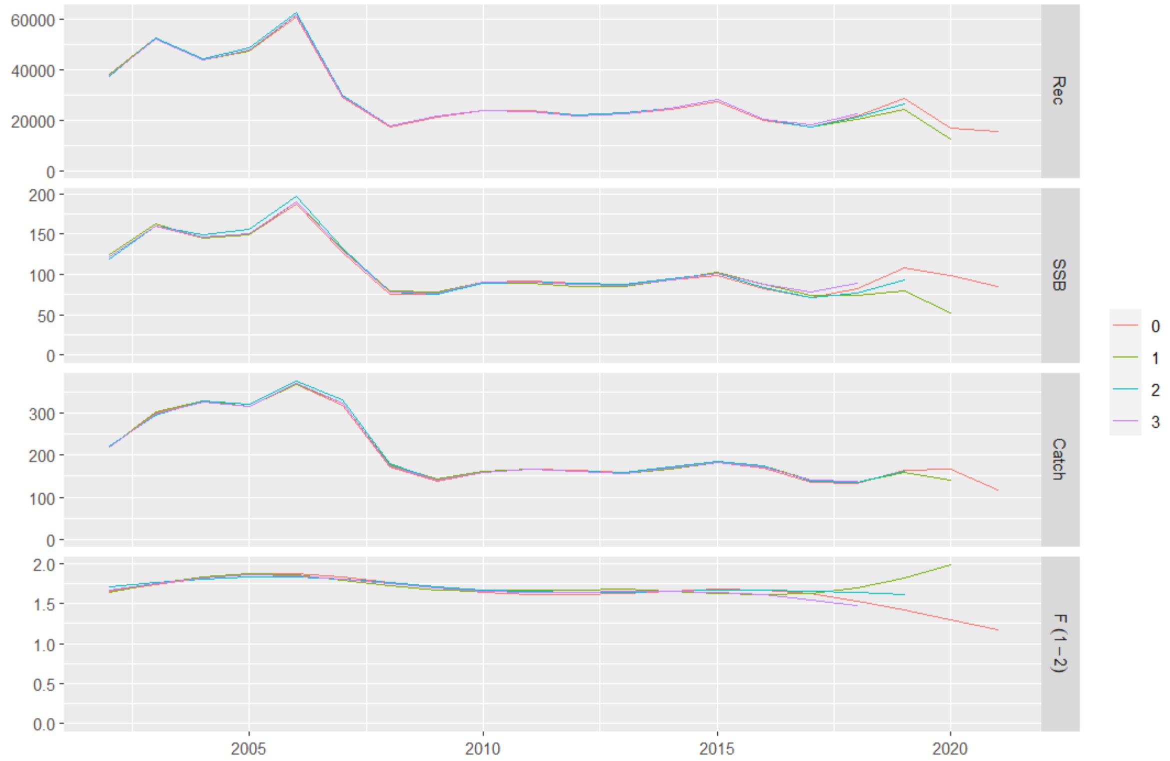


Figure 6.15.3.11. Blue and red shrimp in GSA 1 & 2: Retrospective analysis.

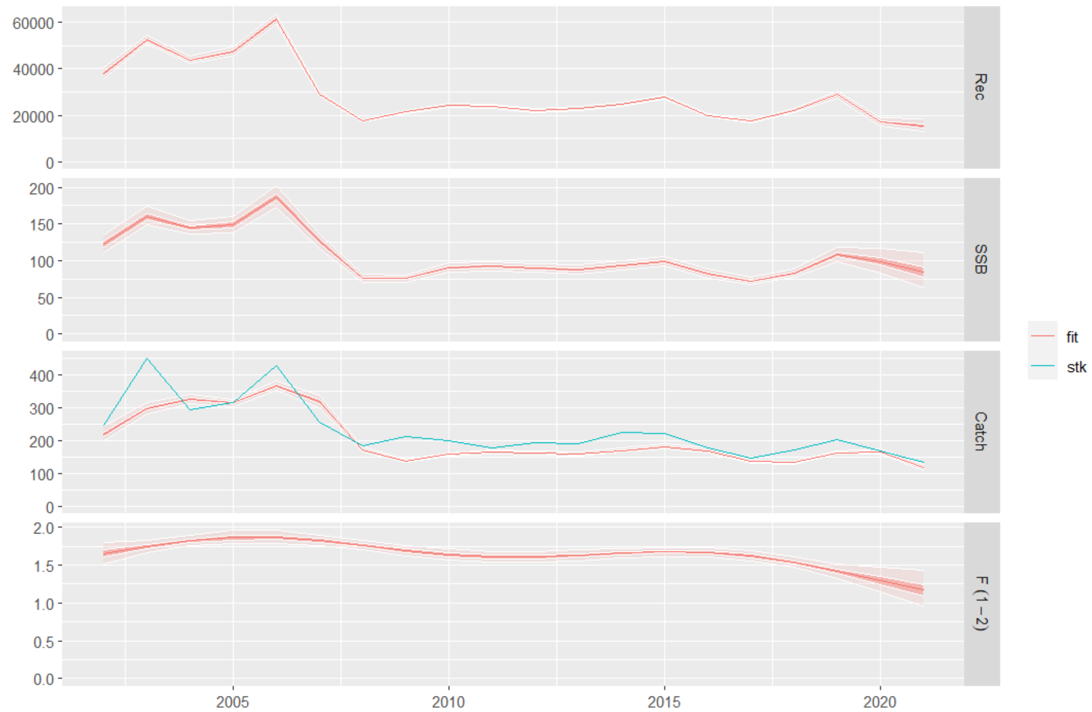


Figure 6.15.3.12. Blue and red shrimp in GSA 1 & 2: Simulations over summary results.

The Mohn' rho for F_{bar1-3}, SSB and recruitment are shown below:

fbar	ssb	rec
0.201	-0.169	-0.097

In the following tables. the population estimates obtained by the a4a model are provided.

Table 6.15.3.4. Blue and red shrimp in GSA 1 & 2: Stock numbers at age (thousands) as estimated by a4a.

	1	2	3	4	5+
2002	38344.0	5927.0	140.3	5.2	0.3
2003	52951.0	7869.9	261.5	6.9	0.3
2004	44252.0	10443.0	302.6	11.1	0.3
2005	47864.0	8432.8	356.7	11.4	0.5
2006	61819.0	8938.6	268.6	12.6	0.4
2007	29498.0	11532.0	283.7	9.4	0.5
2008	17620.0	5592.6	387.0	10.5	0.4
2009	21518.0	3428.6	205.3	15.7	0.5
2010	23977.0	4298.3	137.8	9.1	0.8
2011	23536.0	4879.4	184.2	6.5	0.5
2012	21712.0	4823.2	214.1	8.9	0.4
2013	22352.0	4430.0	208.5	10.2	0.5
2014	24149.0	4507.3	183.9	9.6	0.5
2015	27277.0	4810.6	179.4	8.1	0.5
2016	19826.0	5407.3	188.3	7.8	0.4
2017	17339.0	3966.0	218.4	8.4	0.4
2018	21978.0	3560.1	175.2	10.7	0.5
2019	28972.0	4703.3	181.4	9.9	0.7
2020	17086.0	6530.0	286.6	12.2	0.8
2021	15468.0	4071.8	482.3	23.4	1.1

Table 6.15.3.5. Blue and red shrimp in GSA 1 & 2: a4a summary results and F at age.

	Fbar(1-2)	Recruitment (thousands)	SSB (t)	Catch (t)
2002	1.62	38344	125	217
2003	1.71	52951	164	301
2004	1.79	44252	149	330
2005	1.83	47864	153	318
2006	1.83	61819	191	370
2007	1.80	29498	130	323
2008	1.74	17620	78	175
2009	1.68	21518	77	140
2010	1.64	23977	90	158
2011	1.62	23536	91	166
2012	1.63	21712	87	162
2013	1.66	22352	85	157
2014	1.69	24149	90	167
2015	1.70	27277	96	179
2016	1.68	19826	81	167
2017	1.62	17339	71	134
2018	1.53	21978	83	133
2019	1.41	28972	109	164
2020	1.29	17086	100	166
2021	1.17	15468	85	118

Table 6.15.3.13. Blue and red shrimp in GSA 1 & 2: Fishing mortality at age for red mullet in GSA 9.

	1	2	3	4	5+
2002	0.728	2.512	2.512	2.512	2.512
2003	0.768	2.650	2.650	2.650	2.650
2004	0.803	2.768	2.768	2.768	2.768
2005	0.823	2.838	2.838	2.838	2.838
2006	0.824	2.842	2.842	2.842	2.842
2007	0.808	2.786	2.786	2.786	2.786
2008	0.782	2.696	2.696	2.696	2.696
2009	0.756	2.606	2.606	2.606	2.606
2010	0.737	2.542	2.542	2.542	2.542
2011	0.730	2.518	2.518	2.518	2.518
2012	0.734	2.533	2.533	2.533	2.533
2013	0.746	2.573	2.573	2.573	2.573
2014	0.758	2.615	2.615	2.615	2.615
2015	0.763	2.632	2.632	2.632	2.632
2016	0.754	2.601	2.601	2.601	2.601
2017	0.728	2.511	2.511	2.511	2.511
2018	0.687	2.368	2.368	2.368	2.368
2019	0.635	2.190	2.190	2.190	2.190
2020	0.579	1.997	1.997	1.997	1.997
2021	0.525	1.811	1.811	1.811	1.811

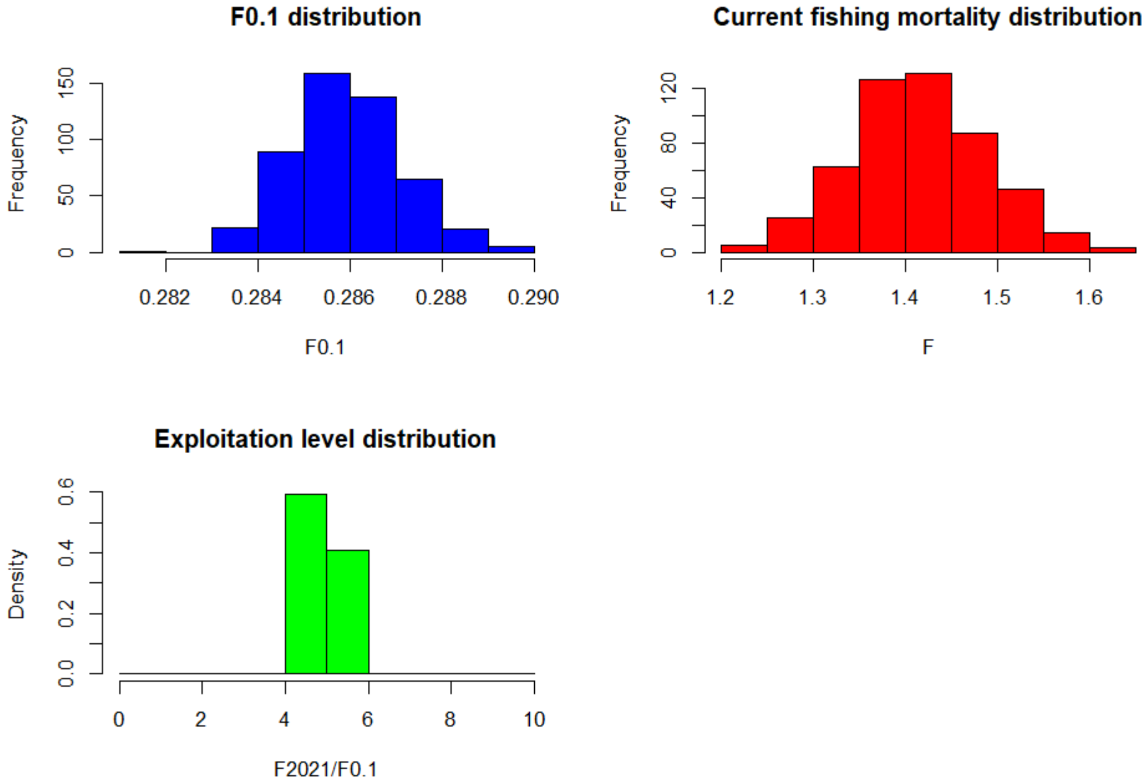


Figure 6.15.3.10. Blue and red shrimp in GSA 1 & 2. Histograms of probability for $F_{0.1}$, Fcurr and level of exploitation (Fcurr/F01 ratio) values for Blue and red shrimp in GSA 1 & 2.

6.15.4 REFERENCE POINTS

The STECF EWG recommended using $F_{0.1}$ as a proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

The current F (=1.17) equal to that of the terminal year (2021) was larger than $F_{0.1}$ (0.29), which is a proxy of F_{MSY} and is used as the exploitation reference point consistent with high long term yields. This indicates that blue and red shrimp in GSA 1 & 2 is over exploited.

Estimation of biomass reference points

The procedure used follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4. An exploratory per-recruit analysis was performed using the stock object produced by EWG 22-09 containing the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.15.4.1.

Table 6.15.4.1 Blue and red shrimp in GSA 1 & 2. Per-recruit reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	B_0
0.286	0.01581	0.00439	1.42843	0.04073

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)
2. Hockey-Stick (model=segreg)
3. Beverton-Holt (model=bevholtSV)
4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ratio potential SRPlim = SPRlim/SPR_0. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP 0.1−20% by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y. When testing the different S-R models (Geometric mean, Hockey Stick, Beverton and Holt and Ricker models) the Hockey Stick model and the Geometric mean one coincided. Therefore, a jitter analysis was run to test if Hockey Stick models with a different slope would fit better the data.

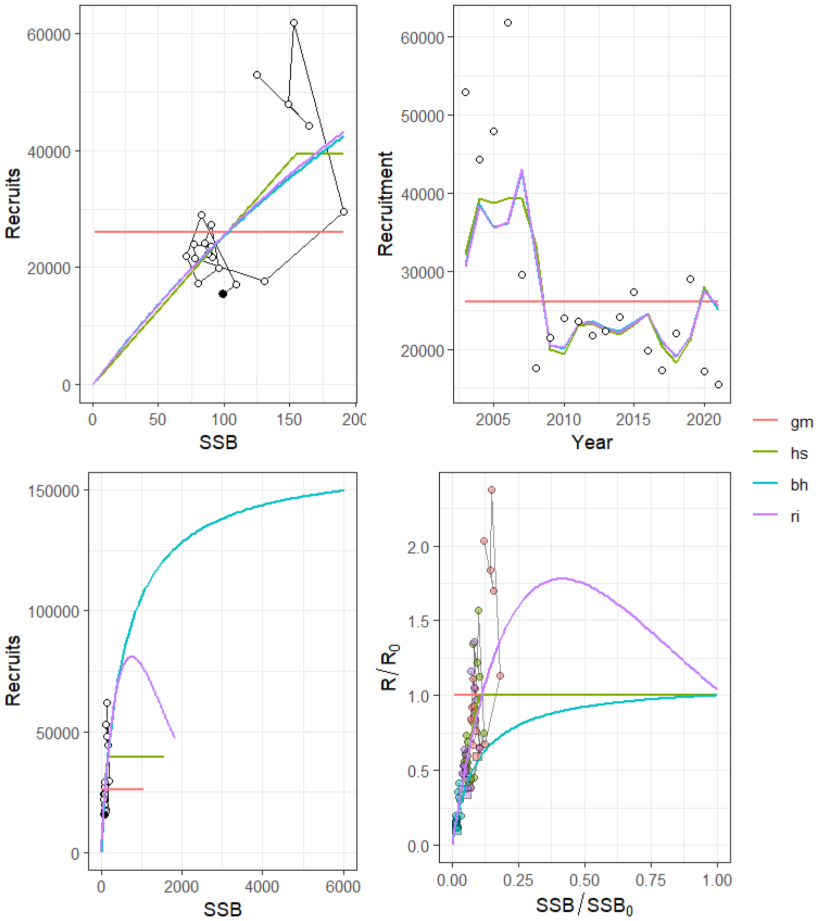


Figure 6.15.4.1. Blue and red shrimp in GSA 1 & 2. Summary of the four SR models.

In light of the outcomes of the exploratory analysis and following the procedures from EWG 22-03, it was decided to consider the Hockey-stick approach as the most appropriate to estimate the biomass reference points for the stock of Blue and red shrimp in GSA 1 & 2. Table 6.15.4.2 summarizes the reference point values based on the Hockey-Stick model fitted to the data. B_{pa} is set to 2* B_{lim} as defined in STECF EWG 22-03. The historic assessment information is shown in this context in Figures 6.1.4.2-.3. In conclusion the stock is considered to be below B_{lim} in 2021.

Table 6.15.4.2 Blue and red shrimp in GSA 1 & 2. Final reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	B_{pa}	F_{lim}	B_0
0.29	622	154	308.8	0.15	1670

These biomass reference points are revised from those presented in EWG 22-03, April 2022, which were based on an assessment of blue and red shrimp in GSA 1 only. The use of the fitted HS model is retained and changes are mostly due to the increased biomass with increased stock and area.

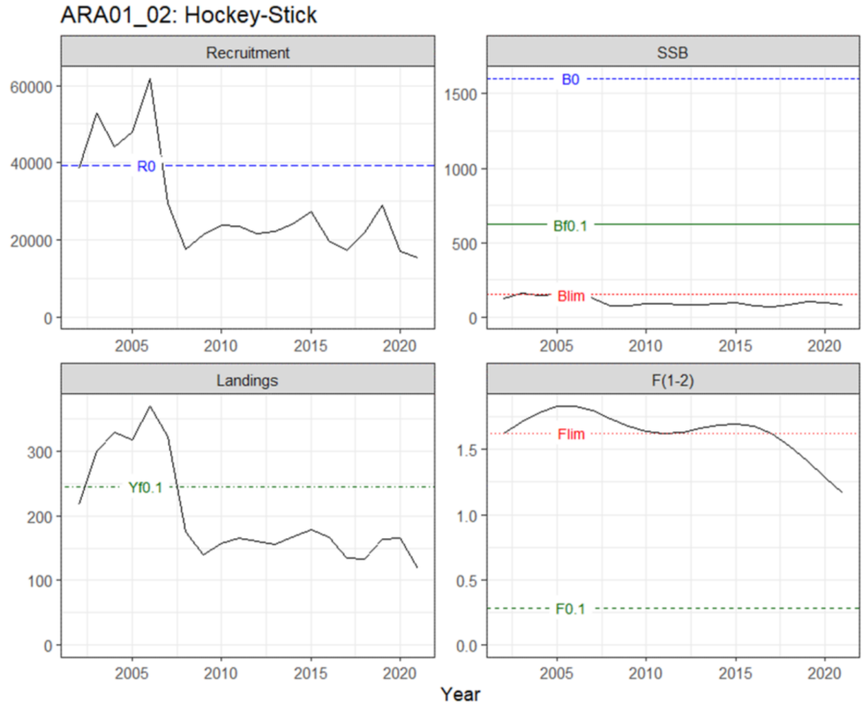


Figure 6.15.4.2. Blue and red shrimp in GSA 1 & 2. Status Advice plot showing stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on a Hockey-Stick stock-recruitment relationship.

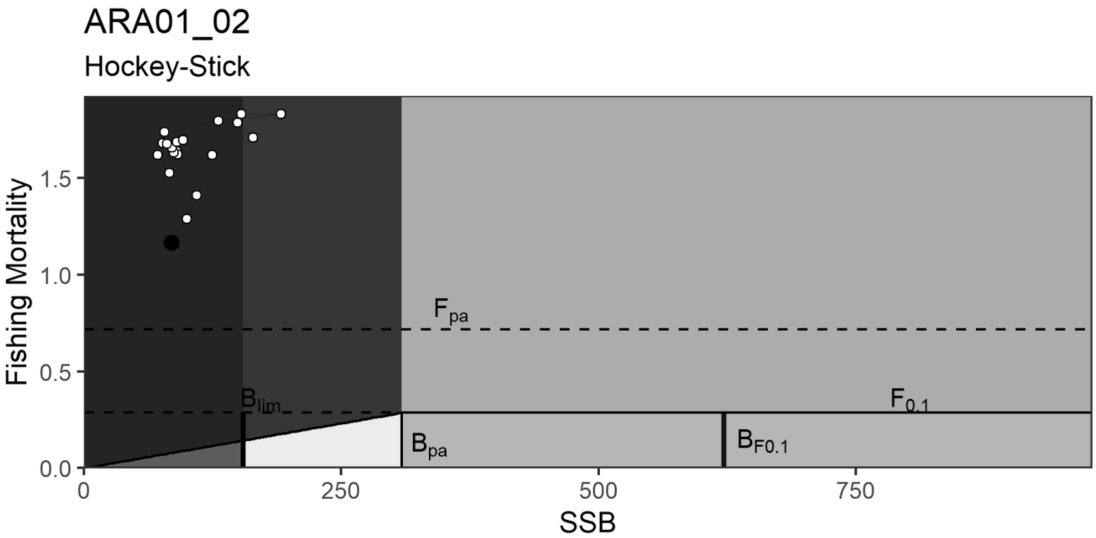


Figure 6.15.4.3. Blue and red shrimp in GSA 1 & 2. Advice Rule plots, with B_{lim} fitted to the data and B_{pa} = 2 B_{lim}.

6.15.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age. While the F_{bar1-2} =1.17 (the last year's F estimated by the assessment model) was used for F in 2022 as F shows a declining trend.

Table 6.15.3.7. Blue and red shrimp in GSA 1 & 2: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}2}$ (2021)	1.17	F 2021 used to give F status quo for 2022
SSB (2021)	156.93	Stock assessment 1 January 2022
R_{age0} (2021,2022)	39334.69	Recruitment will be set on Hockey Stick relationship
Total catch (2022)	118.30	Assuming F status quo for 2022

Table 6.15.3.8. Blue and red shrimp in GSA 1 & 2: Short term forecast in different F scenarios.

Basis	Total catch* (2023)	F_{total}# (ages 1-2) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	95.21	0.29	443.20	182.42	-19.51
$F_{MSY\ Transition}$ ^^	184.51	0.66	303.53	93.42	55.98
$F_{MSY\ Reduced}$ $B<B_{pa}$^^^	52.04	0.15	521.49	232.30	-56.01
$F_{MSY\ lower}$	67.01	0.19	493.58	214.52	-43.36
$F_{MSY\ upper}$**	124.29	0.39	394.38	151.31	5.06
Other scenarios					
Zero catch	0	0.00	624.78	298.12	-100.00
Status quo	265.57	1.17	203.88	29.92	124.49
	42.46	0.12	539.78	243.96	-64.11
	79.88	0.23	470.22	199.64	-32.48
	112.98	0.35	412.98	163.16	-4.49
	142.40	0.47	365.58	132.96	20.37
	168.64	0.58	326.10	107.80	42.56
	192.16	0.70	293.02	86.72	62.43
	213.31	0.82	265.13	68.94	80.32
	232.43	0.93	241.46	53.86	96.47
	249.78	1.05	221.25	40.98	111.13

6.15.6 Data Deficiencies

For the assessment of blue and red shrimp in GSA 1 and 2 input data revised from the GSA 1 assessment of last year, to include data from GSA 2. Length data was available for GSA 2, though no biological parameters so those from GSA 1 were used. With the addition of GSA 2 some issues observed last year, low observations in GSA 1 in 2009, 2011 and 2013, were resolved.

Other submodels were tested to improve the residuals in ages 3 and 4 for the catch data but this increased model instability so were rejected. It seems there is some conflict between catch data and survey data at age, and there's a need to look at the raw data for the next EWG and to consider if growth parameters are suitable.

This year the 2006 MEDITS survey allocation of stations to GSA 1 or 2 was resolved. The absence of a survey in 2020 means there is a gap in the time series.

$F_{0.1}$ from the new assessment is the same as the GSA 1 assessment and F current is consistent with previous assessment.

Biomass reference points have been revised since April (EW 22-03) to account for account for the addition of GSA 2 catches.

6.16 Blue and red shrimp in GSA 5

6.16.1 Stock Identity and Biology

GSA 5 (Figure 6.16.1.1) has been selected as an separate area for assessment and management purposes in the western Mediterranean (Quetglas et al., 2012) due to its main specificities. These include: 1) Geomorphologically, the Balearic Islands (GSA 5) are clearly separated from the Iberian Peninsula (GSA 6) by depths between 800 and 2000 m, which would constitute a natural barrier to the interchange of adult stages of demersal resources; 2) Physical geographically-related characteristics, such as the lack of terrigenous inputs from rivers and submarine canyons in GSA 5 compared to GSA 6, give rise to differences in the structure and composition of the trawling grounds and hence in the benthic assemblages; 3) Owing to these physical differences, the faunistic assemblages exploited by trawl fisheries differ between GSA 5 and GSA 6, resulting in large differences in the relative importance of the main commercial species; 4) There are no important or general interactions between the demersal fishing fleets in the two areas, with only local cases of vessels targeting red shrimp in GSA 5 but landing their catches in GSA 6) Trawl fishing exploitation in GSA 5 is much lower than in GSA 6; the density of trawlers around the Balearic Islands is one order of magnitude lower than in adjacent waters; and GSA 6. Due to this lower fishing exploitation, the demersal resources and ecosystems in GSA 5 are in a healthier state than in GSA 6, which is reflected in the population structure of the main commercial species (populations from the Balearic Islands have larger modal sizes and lower percentages of small-sized individuals), and in the higher abundance and diversity of elasmobranch assemblages.

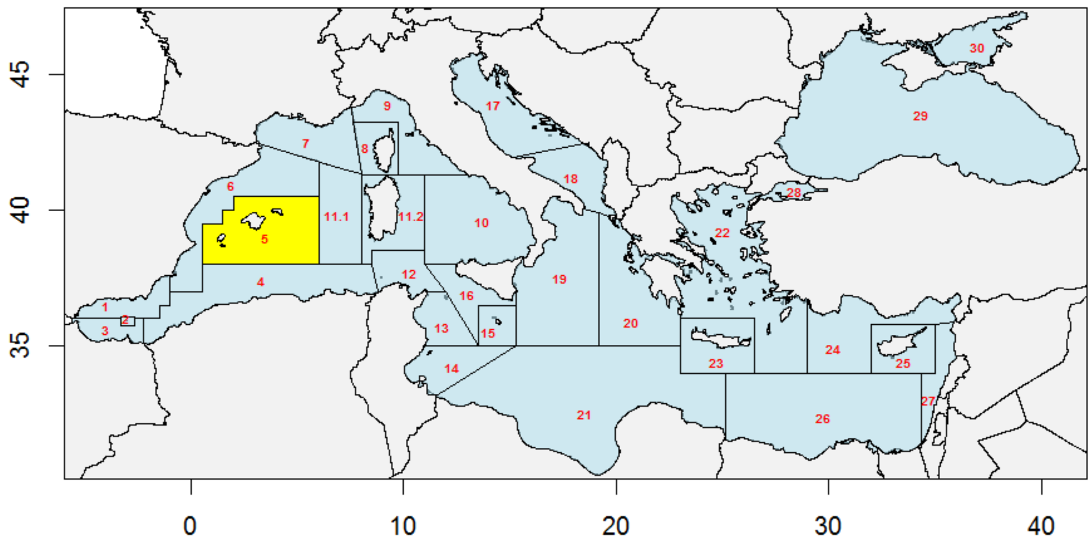


Figure 6.16.1.1. Geographical localization of GSA 5.

The reproductive period for the blue and red shrimp in GSA 5 began in May and ended in September. Two main peaks were detected as an entry of juveniles (recruits) to the fishery: one in February-March and the other in September-October, for both females and males (Carbonell et al., 1999). For females, condition index, hepatosomatic index and the content of lipids in the hepatopancreas showed the minimum values at the end of the spawning period (Guijarro et al., 2008).

In the absence on new information on somatic growth, the same growth function and length-weight relationship parameters presented in the 2018 assessment for GSA 5 (STECF 15-18) were used (Table 6.16.1.1). Although females reach notable larger maximum sizes than males, it was decided to combine sexes for consistency with both previous assessments and the approaches used for the adjacent areas GSA 1 and GSA 6 and 7. Similarly, sex-aggregated estimates for maturity-at-age and mortality-age vectors presented in the 2018 (STECF 15-18) were considered as input for the stock assessment model (Table 6.16.1.2), where age-dependent M estimates were computed based on the Chen Watanabe (1989) model.

Table 6.16.1.1. Blue and red shrimp in GSA 5. Growth parameters (L_{inf}, K, t_0) and parameters of the Length-Weight relationship (a, b) used for the assessment.

	Growth parameters			**Length-weigth**	
Parameter	**L_{inf}**	**k**	**t_0**	**a**	**b**
Value	75	0.38	005	0.002	2.515

Table 6.16.1.2. Blue and red shrimp in GSA 5. Proportion of mature specimens and natural mortality at age.

Age	**0**	**1**	**2**	**3**	**4**	**5**
Maturity	0.477	0.611	0.747	0.974	1	1
Mortality	2.063	0.835	0.585	0.482	0.428	0.428

6.16.2 Data

General description of the fisheries

In the Balearic Islands, commercial trawlers develop up to four different fishing tactics, which are associated with the shallow shelf (SS), deep shelf (DS), upper slope (US) and middle slope (MS) (Guijarro and Massutí 2006; Ordines et al. 2006), mainly targeted to: (i) Spicara smaris, Mullus surmuletus, Octopus vulgaris and a mixed fish category on the SS (50-80 m); (ii) Merluccius merluccius, Mullus spp., Zeus faber and a mixed fish category on the DS (80-250 m); (iii) Nephrops norvegicus, but with an important by-catch of big M. merluccius, Lepidorhombus spp., Lophius spp. and Micromesistius poutassou on the US (350-600 m) and (iv) Aristeus antennatus on the MS (600-750 m). The MS fishing tactics coincides with the metier OTB_DWSP; OTB_DEMSP corresponds to those days in one of the other fishing tactics is present (SS, DS and/or US) and OTB_MDDWSP corresponds to those days in which one haul is MS and at least one of the other fishing tactics is performed.

6.16.2.1 Catch (landings and discards)

Landings for GSA 5 were reported to STECF EWG 22-09 through the Data Call. Data are available for the period 2002-2021 and were exclusively reported by OTB fishing operations (Table 6.16.2.2.1 and Figure 6.16.2.2.1). Reported discards were considered negligible since they make up for <0.2% of the total catch.

Table 6.16.2.2.1. Blue and red shrimp in GSA 5. Reported landings (t) and discards (t) from the DCF Data by all OTB metiers (2002-2021).

Year	Landings	Discards
2002	141.5	
2003	122.0	
2004	193.6	
2005	191.5	
2006	213.9	
2007	239.1	
2008	232.9	
2009	126.2	0.03
2010	153.2	
2011	111.2	0.4
2012	201.1	2.5
2013	188.6	0.2
2014	141.3	0.2
2015	160.2	0.1
2016	138.1	0.04
2017	171.4	0.1
2018	249.7	0.2
2019	205.9	
2020	130.7	0.02
2021	118.7	

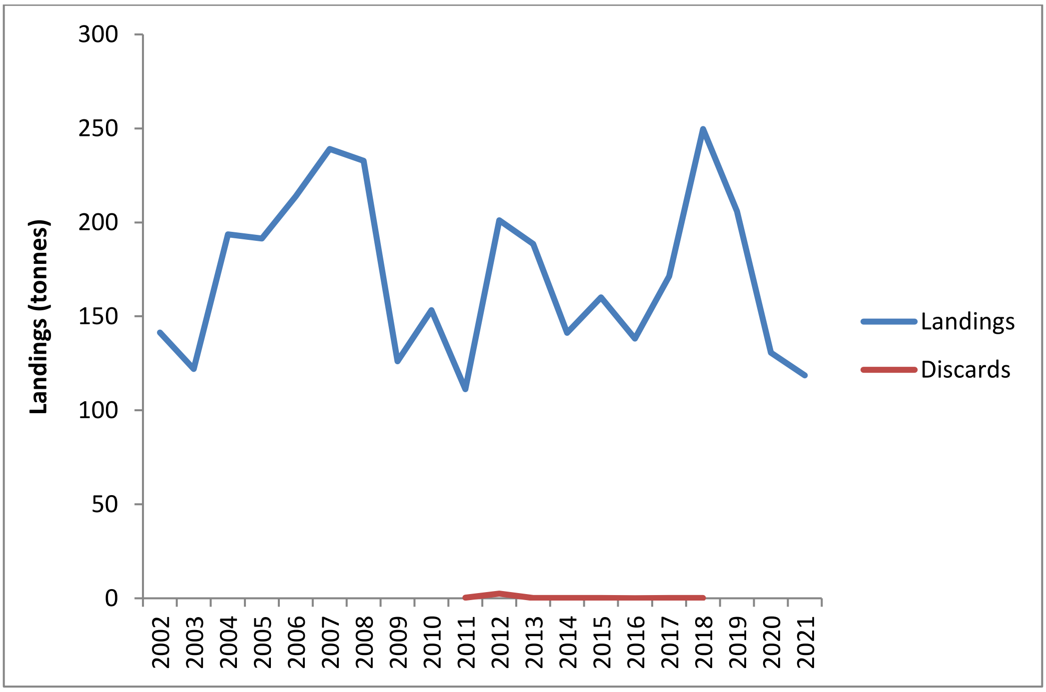


Figure 6.16.2.2.1. Blue and red shrimp in GSA 5. Reported landings (t) and discards (t) from the DCF Data by all OTB metiers (2002-2021).

Length frequency distributions per gear, metier and year of landings from the DCF database (2002-2021) before reconstructions are presented in Figure 6.16.2.2.2. Length structure by gear, fishery and year (2002-2021) after reconstruction is shown in Figure 6.16.2.2.3. The percentage of total landings that were reconstructed applying the SoP correction to LFDs (only in OTB_DEF for this stock) is shown in Figure 6.16.2.2.4.

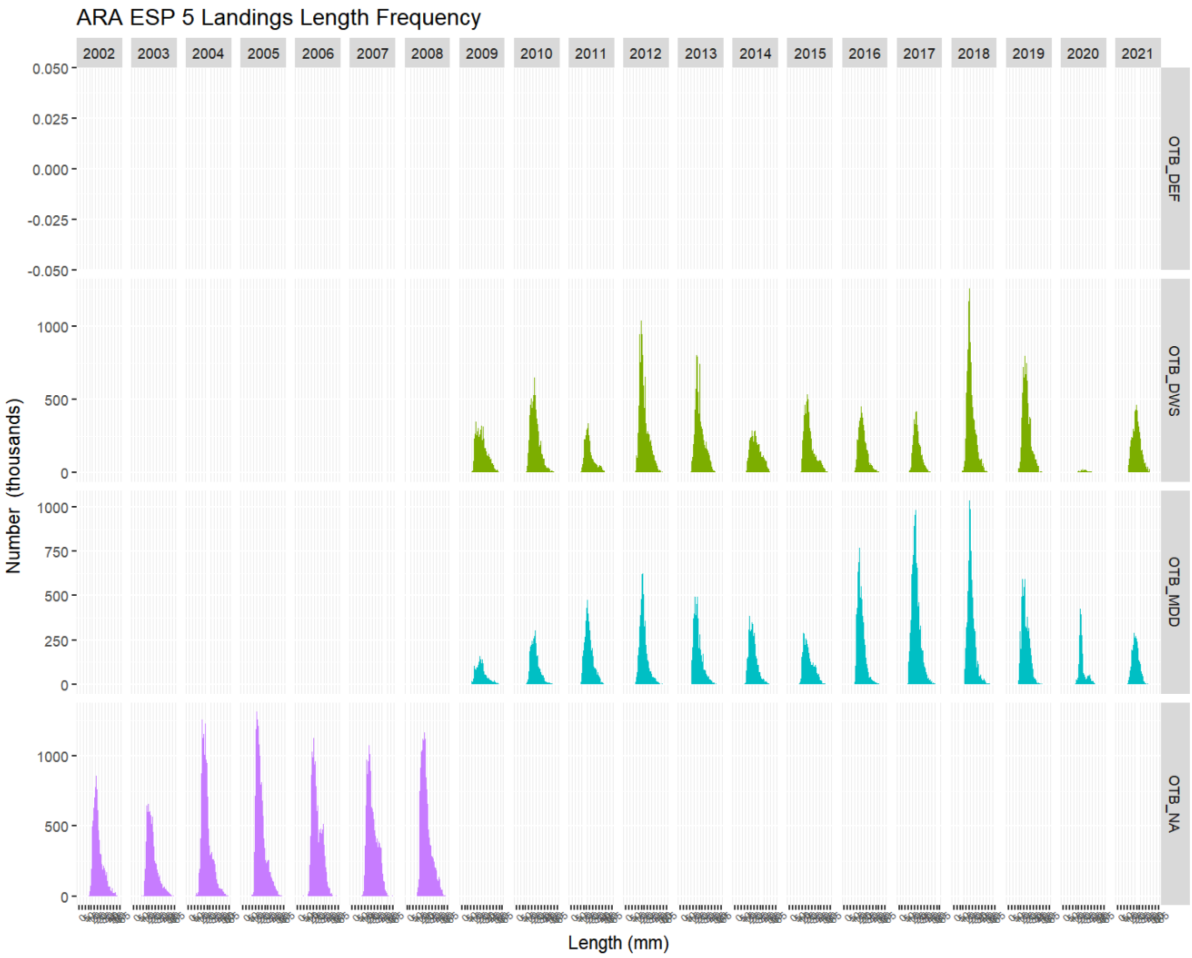


Figure 6.16.2.2.2. Blue and red shrimp in GSA 5. Original length frequency distribution before reconstruction by fishing gear and fishery (2002-2021).

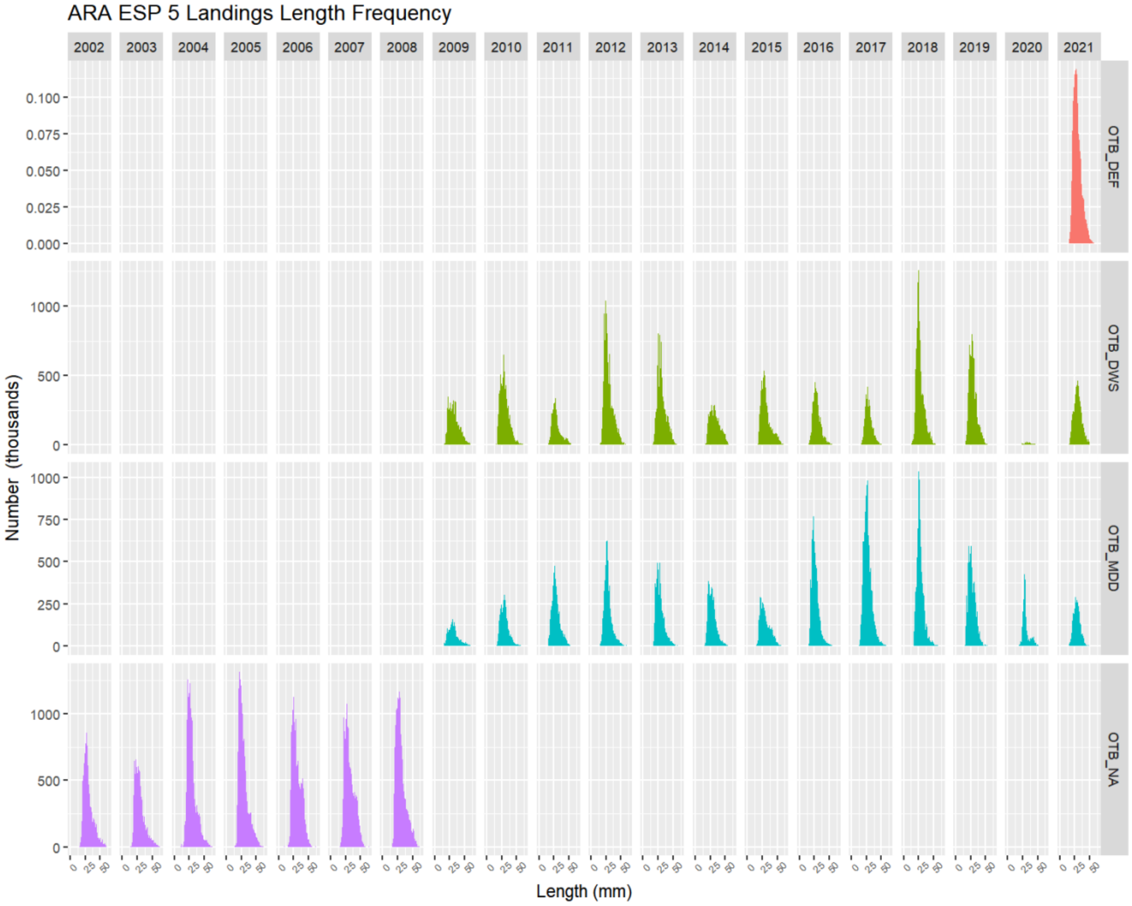


Figure 6.16.2.2.3. Blue and red shrimp in GSA 5. Length frequency distribution after reconstruction by fishing gear and fishery (2002-2021).

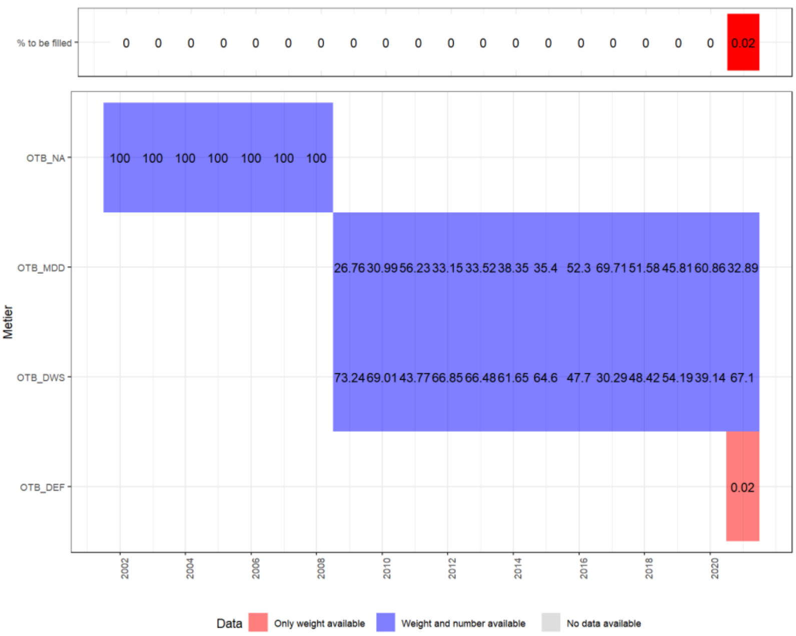


Figure 6.16.2.2.4. Blue and red shrimp in GSA 5. Percentages of total landings LFDs that were reconstructed by year and gear and SoP applied to LFD.

6.16.2.2 SURVEY DATA

The MEDITS (MEDiterranean International Trawl Survey) survey is an extensive trawls survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintain fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end, is used throughout GSAs and years.

The survey area around the Balearic Islands (GSA5) was only very partially covered by the MEDITS survey during 1994-2006, with a very low number of surveys by year, covering only a small part of the area (Ibiza channel). Thus, survey data prior to 2007 was excluded from the stock assessment analysis. Since 2007, the survey has taken place between May and June (Figure 6.16.2.3.1).

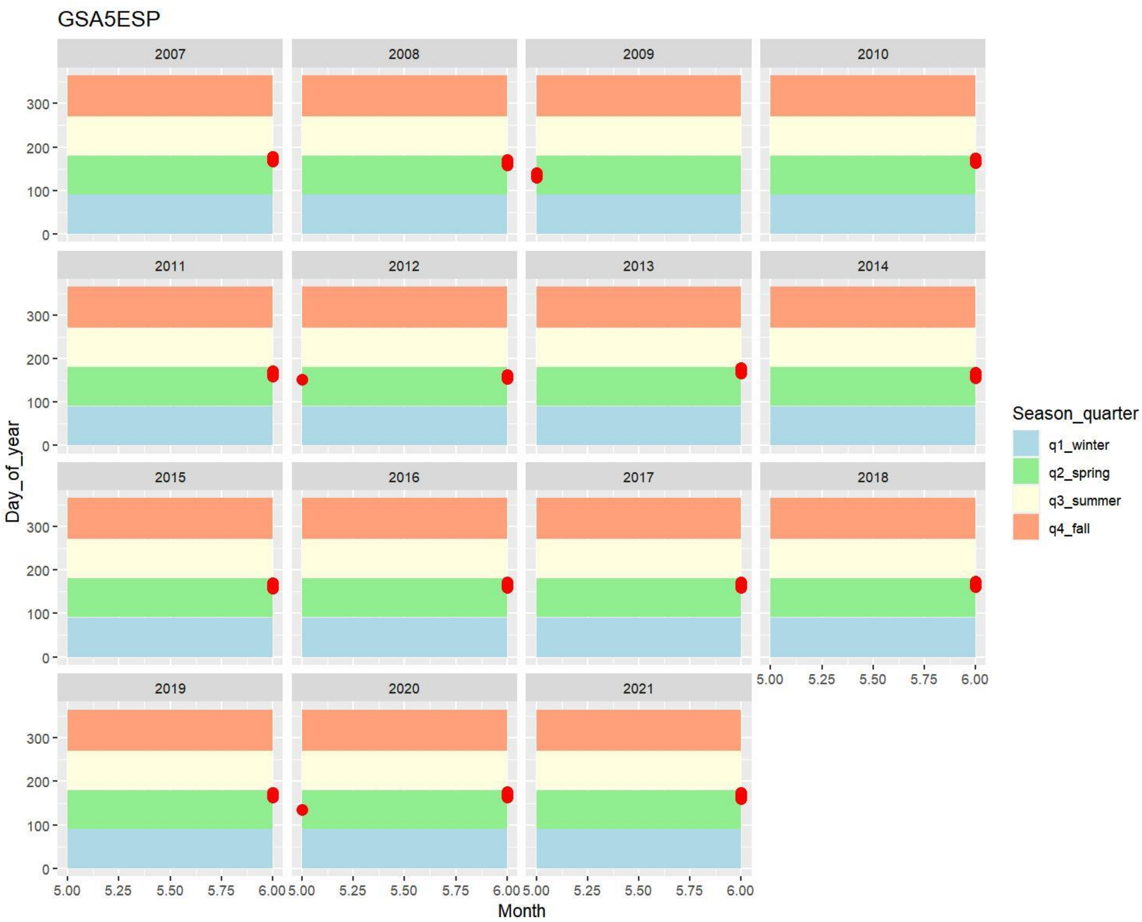


Figure 6.16.2.3.1 Year period when the hauls of MEDITS survey are being conducted in GSA 5.

The time series of abundance and biomass indices of blue and red shrimp from MEDITS bottom trawl survey in GSA5 are shown in Figure 6.16.2.3.2 and 6.16.2.3.3. Large variations and no clearly discernible trends over the available period can be observed. Both estimated abundance and biomass indices show similar variation along the time series, excepting for 2020 and 2021 where the pattern between both variables were oposite, suggesting a shift in size.

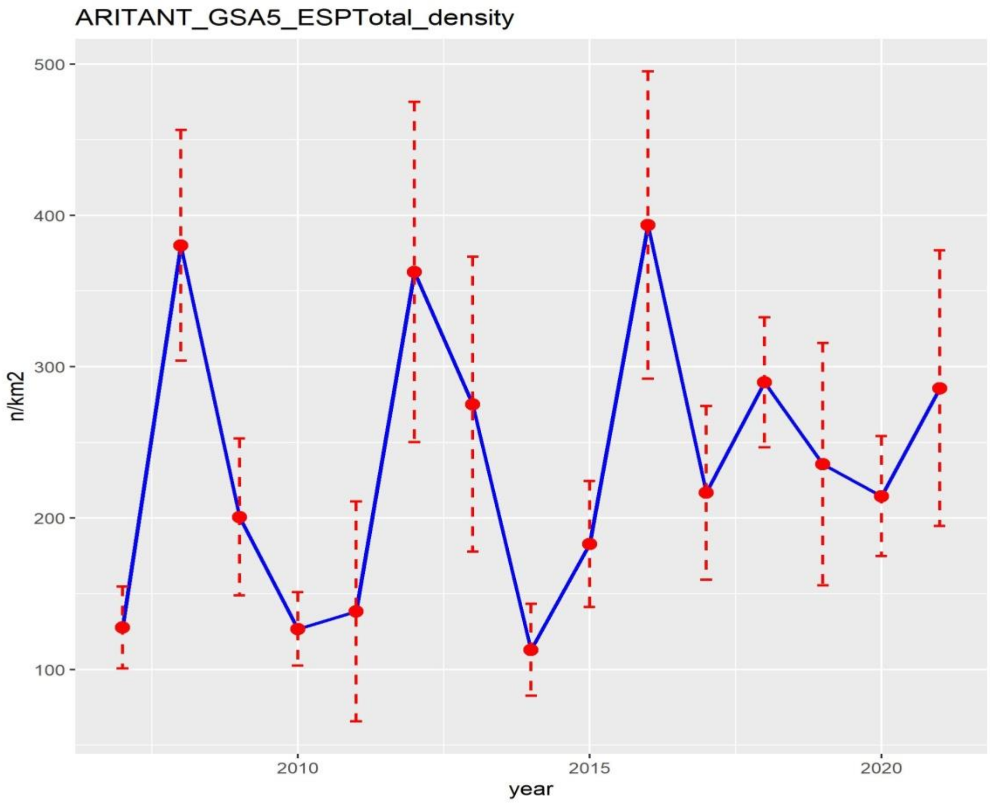


Figure 6.16.2.3.2 Blue and red shrimp in GSA 5. MEDITS survey abundance index (n/km2) as reported by DCF (2007-2021).

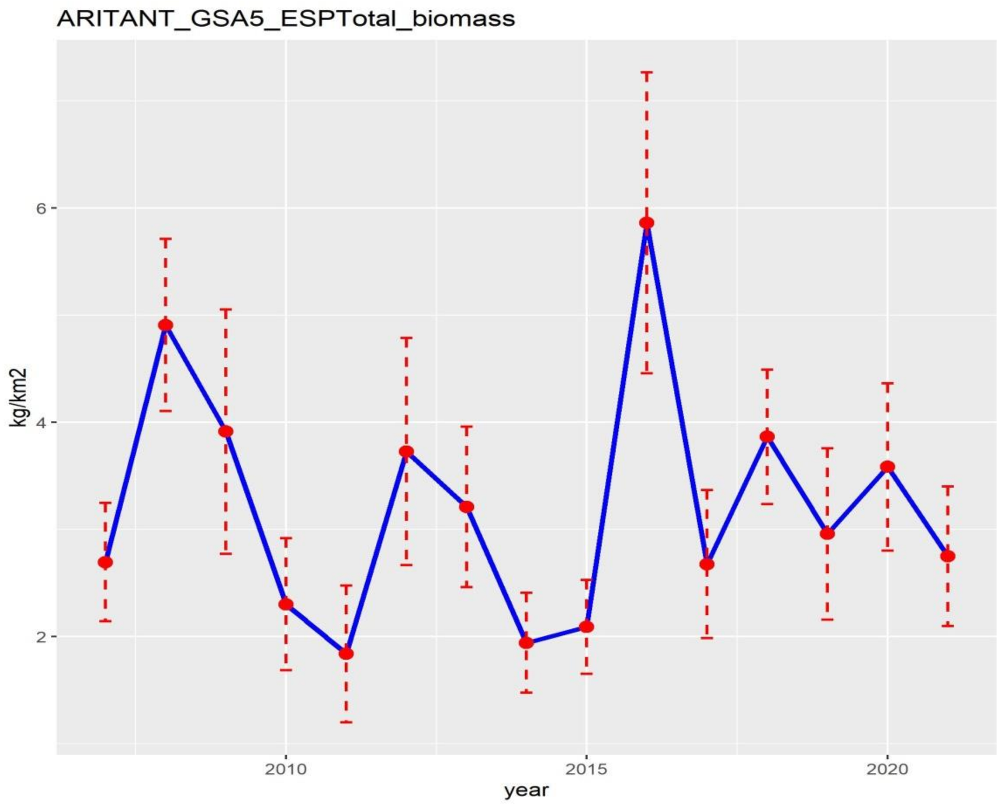


Figure 6.16.2.3.3 Blue and red shrimp in GSA 5. MEDITS survey biomass index (kg/km^2) as reported by DCF (2007-2021).

The observed length frequency distributions from MEDITS survey in GSA 5 are illustrated in Figure 6.16.2.3.4.

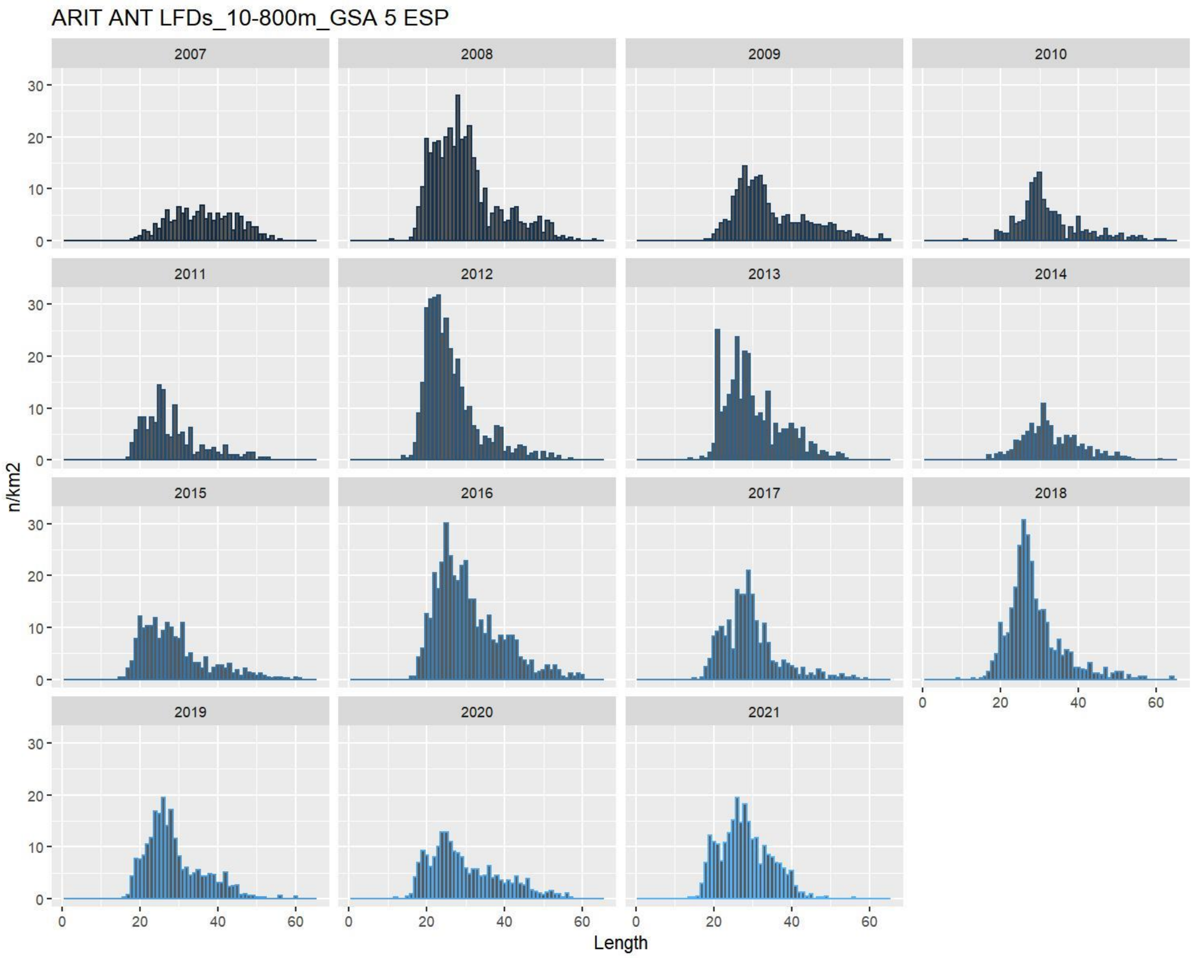


Figure 6.16.2.3.4. Blue and red shrimp in GSA 5. Length frequency distribution of the MEDITS survey data (n/km^2).

6.16.3 Stock assessment

The present assessment was carried out using a statistical catch-at-age analysis (a4a). A4a is a statistical catch-at-age method that utilizes catch-at-age data to derive estimates of historical population size and fishing mortality (Jardim et al., 2015). Model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. Data typically used are: catch, statistical sample of age composition of catch and abundance index.

Input data

Data used were landings (Table and Figure 6.16.2.2.1) and length frequency distribution of the commercial landings (Figure 6.16.2.2.3), as well as the index and length frequency distributions of the MEDITS survey (Figures 6.16.2.3.2, 6.16.2.3.3 and 6.16.2.3.4). The used biological parameters were those included in section 6.16.1. The catch at age structure for the commercial data and of the MEDITS survey and their internal consistency was checked. Age composition is mainly composed by age 1 individuals both for commercial and MEDITS survey data, although age 2 are also frequent in the catches (Figures 6.16.3.1 and 6.16.3.3). The internal consistency was quite good for the commercial data (Figure 6.16.3.2), but for the MEDITS it was in general poorer, especially for ages 1-2, 2-3 and 4-5 (Figure 6.16.3.4).

Table 6.16.3.1. Blue and red shrimp in GSA 5: Values of landings at age per year used in the assessment.

	1	2	3	4	5+
2002	7283.50	3295.00	645.85	111.74	2.58
2003	7135.00	2623.30	562.29	127.27	12.13
2004	12279.00	4113.70	719.88	158.21	17.96
2005	12844.00	3933.60	907.97	76.17	5.47
2006	9977.10	6070.50	831.83	17.81	2.72
2007	9518.30	6006.70	1686.20	27.37	2.36
2008	11791.00	5246.00	1358.00	138.69	4.83
2009	4613.40	3417.90	785.34	100.40	9.08
2010	8342.40	4196.40	468.24	68.13	5.59
2011	7187.10	2528.70	471.29	16.55	0.36
2012	13019.00	4494.30	784.97	49.55	0.17
2013	10214.00	4735.60	848.94	27.61	0.18
2014	6135.40	3717.30	874.59	24.29	0.97
2015	7662.60	3590.90	970.16	108.87	0.18
2016	10967.00	3035.70	314.04	25.18	2.38
2017	13410.00	4015.20	335.81	31.81	0.54
2018	19872.00	5530.50	574.28	15.30	1.90
2019	14682.00	5346.30	374.84	7.87	0.20
2020	7463.00	2775.70	444.83	8.59	0.64
2021	6620.10	3788.40	197.77	4.13	0.18

Table 6.16.3.2. Blue and red shrimp in GSA 5: Values of mean weigth at age per year used in the assessment.

	1	2	3	4	5+
2002	0.007	0.018	0.035	0.052	0.062
2003	0.007	0.017	0.036	0.052	0.065
2004	0.007	0.018	0.035	0.051	0.065
2005	0.007	0.018	0.035	0.051	0.063
2006	0.007	0.019	0.033	0.050	0.064
2007	0.007	0.018	0.033	0.049	0.070
2008	0.007	0.017	0.035	0.051	0.063
2009	0.007	0.017	0.035	0.052	0.066
2010	0.007	0.017	0.035	0.053	0.064
2011	0.007	0.017	0.034	0.051	0.064
2012	0.007	0.017	0.034	0.051	0.064
2013	0.007	0.017	0.034	0.051	0.064
2014	0.007	0.017	0.034	0.049	0.065
2015	0.007	0.018	0.035	0.051	0.064
2016	0.007	0.016	0.034	0.051	0.066
2017	0.007	0.017	0.034	0.051	0.062
2018	0.007	0.017	0.033	0.050	0.062
2019	0.007	0.016	0.032	0.052	0.064
2020	0.009	0.018	0.032	0.049	0.064
2021	0.008	0.016	0.033	0.049	0.064

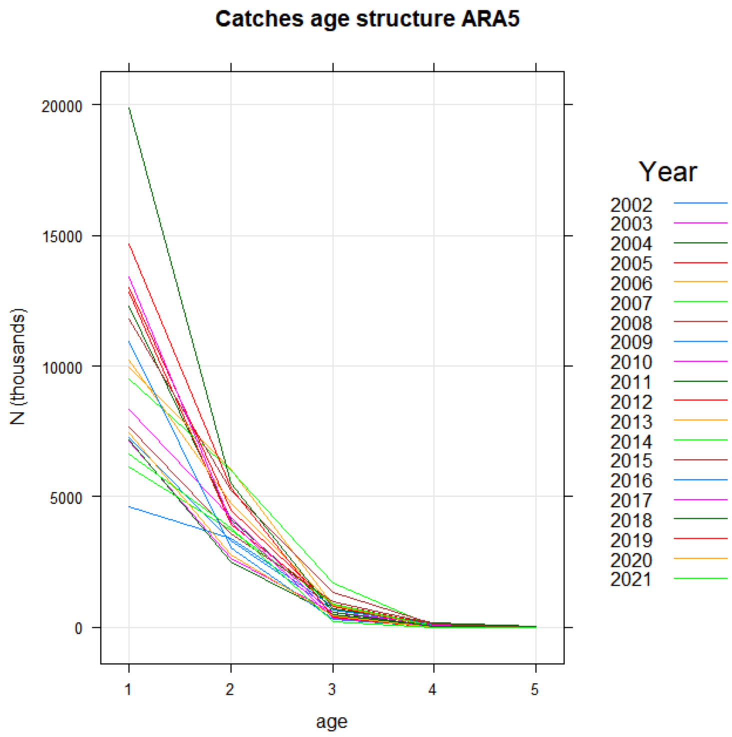


Figure 6.16.3.1. Blue and red shrimp in GSA 5. Catch at age data by year from the commercial fleet used in this assessment.

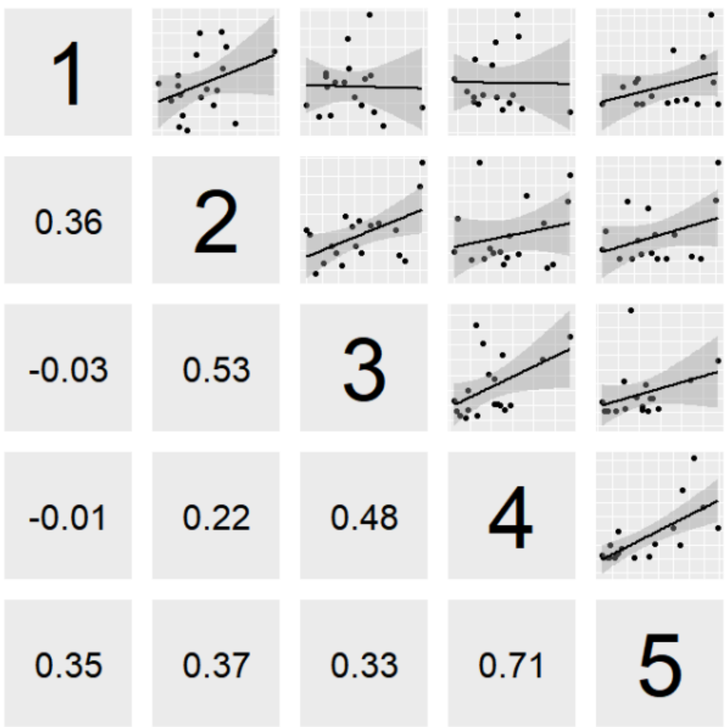


Figure 6.16.3.2 Blue and red shrimp in GSA 5. Internal consistency of the catch at age data from used in this assessment.

Table 6.16.3.3. Blue and red shrimp in GSA 5: Values of catches at age from MEDITS survey per year used in the assessment.

	1	2	3	4	5+
2007	41.4	61.6	24.4	0.3	0.0
2008	259.5	90.5	27.4	2.2	0.3
2009	93.6	71.8	27.2	5.6	2.5
2010	73.4	40.6	9.5	2.3	0.7
2011	104.7	27.9	6.7	0.0	0.0
2012	295.1	50.3	10.7	0.4	0.0
2013	175.9	81.1	14.8	0.0	0.0
2014	54.7	48.4	9.6	0.0	0.2
2015	133.4	37.2	10.3	1.8	0.2
2016	248.8	116.6	23.4	4.8	0.0
2017	158.5	48.7	8.0	1.5	0.0
2018	219.4	58.2	9.7	1.4	0.6
2019	160.1	54.8	6.3	1.0	0.0
2020	127.4	55.2	15.7	1.5	0.0
2021	180.8	68.0	1.8	0.2	0.0

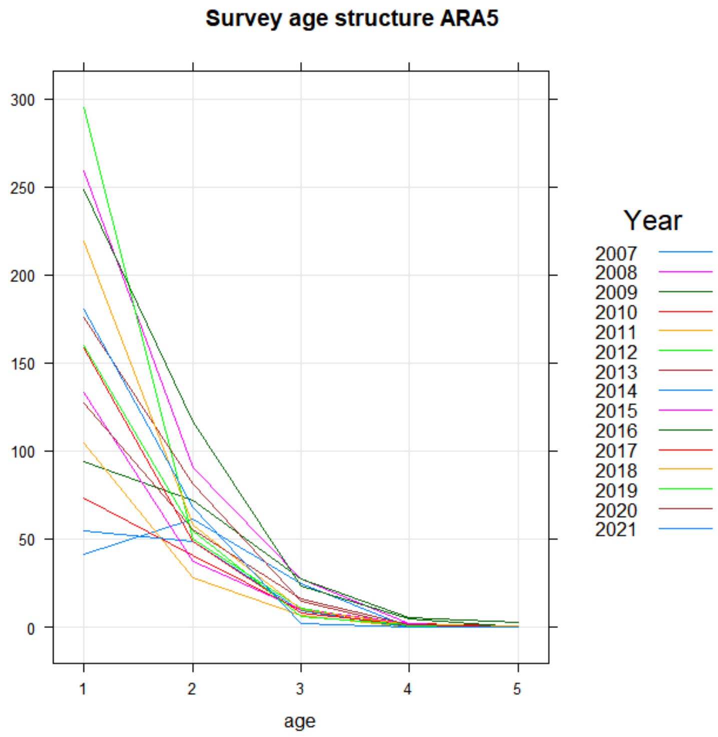


Figure 6.16.3.3. Blue and red shrimp in GSA 5. Catch at age data by year from the MEDITS survey used in this assessment.

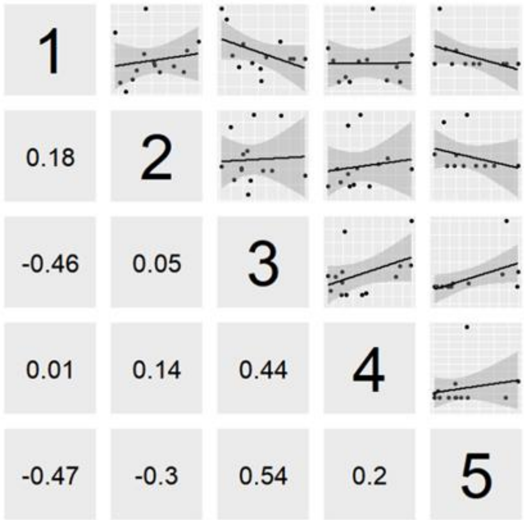


Figure 6.16.3.4. Blue and red shrimp in GSA 5. Internal consistency of the catch at age data from the MEDITS survey used in this assessment.

Assessment results

Different a4a models were investigated in terms of fishing mortality, catchability of the survey index and stock–recruitment relationship models (fmodel, qmodel, srmodel).

Although the results of most of the assessment trials were in general a bit unstable, especially related to the stability of residuals as well as for the high values of F along all the time series, finally the following model with this specific parameterization was selected for assessment and advice since it provided the best results in terms of residuals and retrospective analysis:

- fmodel <- ~ factor(replace(age,age>2,2)) + s(year,k=7)
- qmodel <- list(~ s(replace(age,age>3,3), k=3))
- srmodel <- ~geomean(CV=0.35)

The general results of the a4a assessment, including the summary of the fitting of the model for all the parameters (recruitment, spawning stock biomass SSB, catches and Fishing mortality F), the estimated fishing mortality and catchability for the survey, the residuals patterns, the fit vs. observed catch at ages, the retrospective analysis and the performed simulations, are shown in Figures 6.16.3.5 to 6.16.3.11.

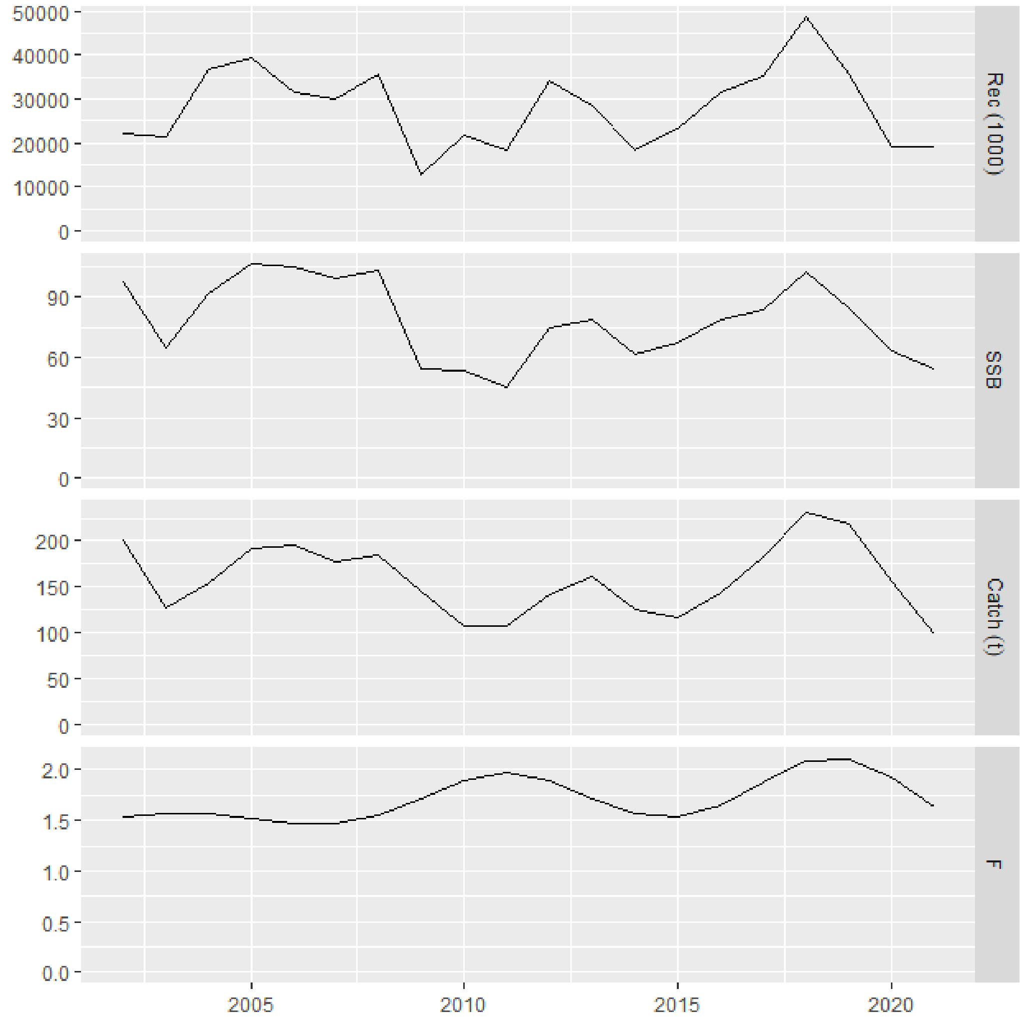
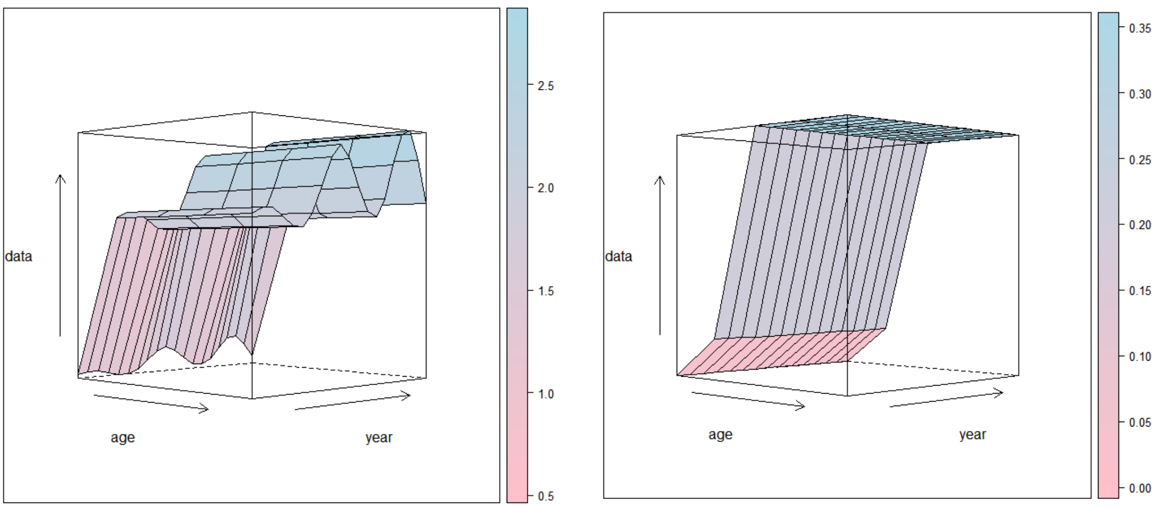
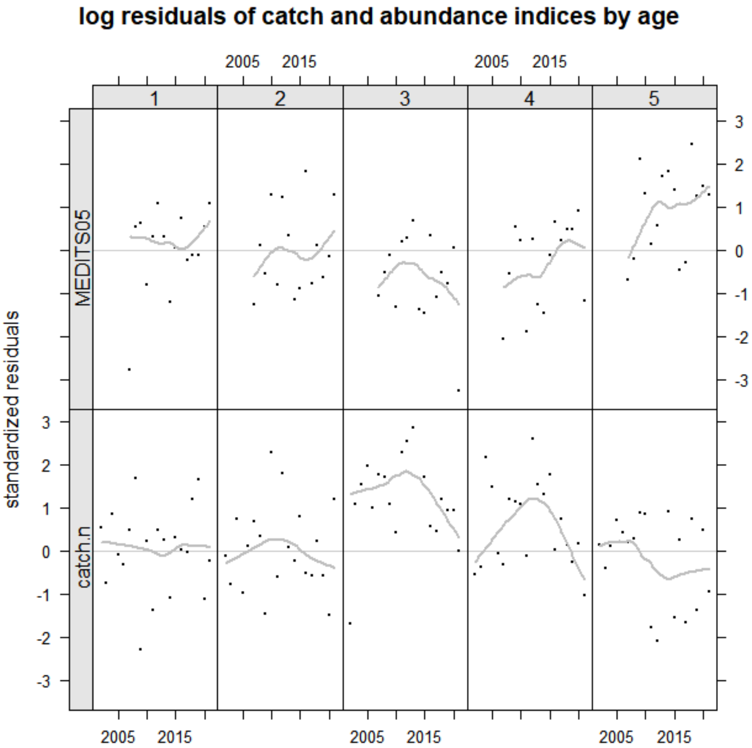


Figure 6.16.3.5. Blue and red shrimp in GSA 5. Stock summary of the final a4a model for recruitment, SSB, catch and fishing mortality.

Figure



6.16.3.6. Blue and red shrimp in GSA5. 3D contour plot of estimated fishing mortality (left) and 3D contour plot of estimated survey catchability (right) at age and year.



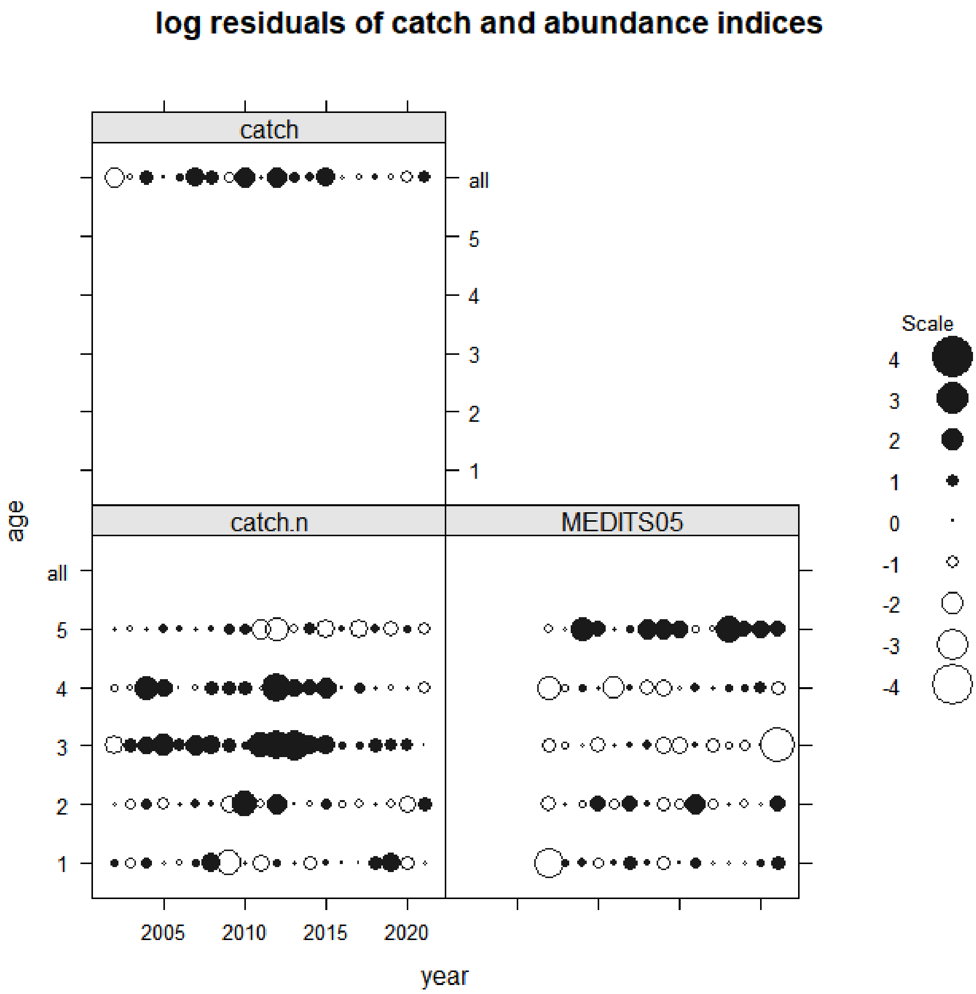


Figure 6.16.3.7. Blue and red shrimp in GSA 5. Standardized residuals for abundance indices and for catch numbers.

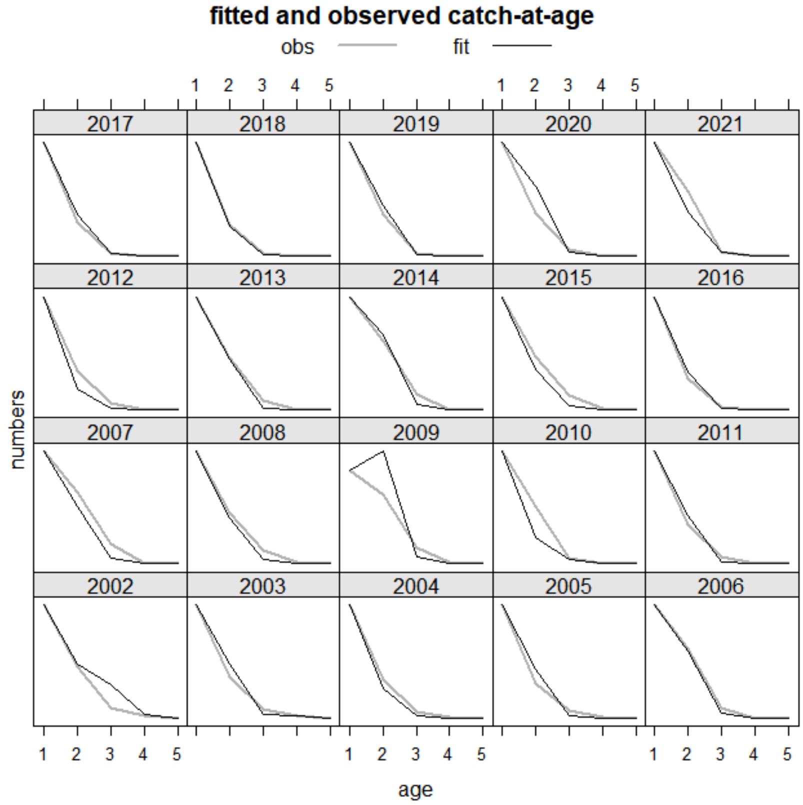


Figure 6.16.3.8. Blue and red shrimp in GSA 5. Fitted and observed catch at age.

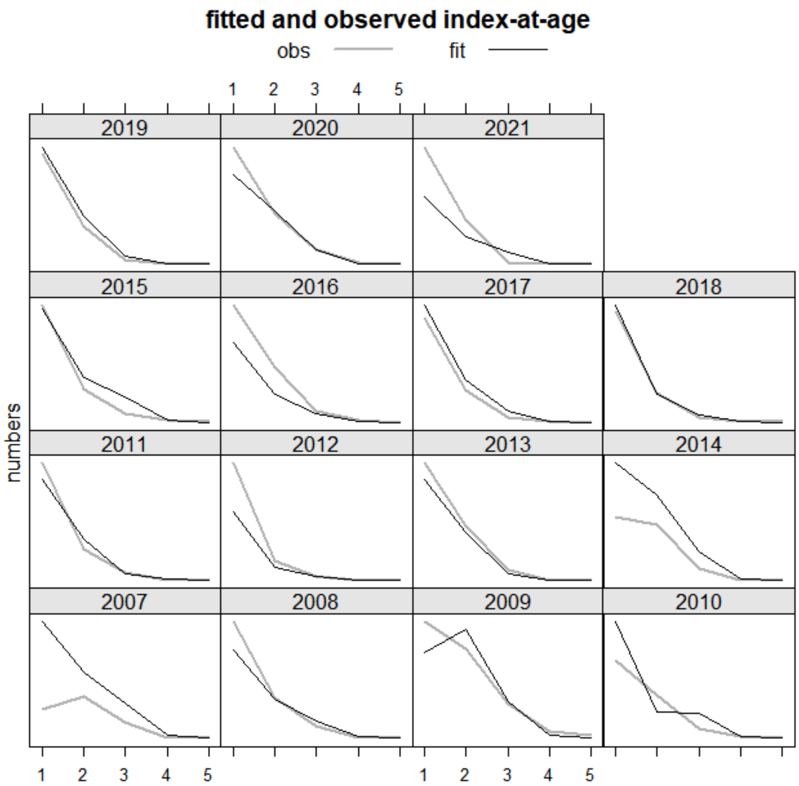


Figure 6.16.3.9. Blue and red shrimp in GSA 5. Fitted and observed index at age (MEDITS survey data).

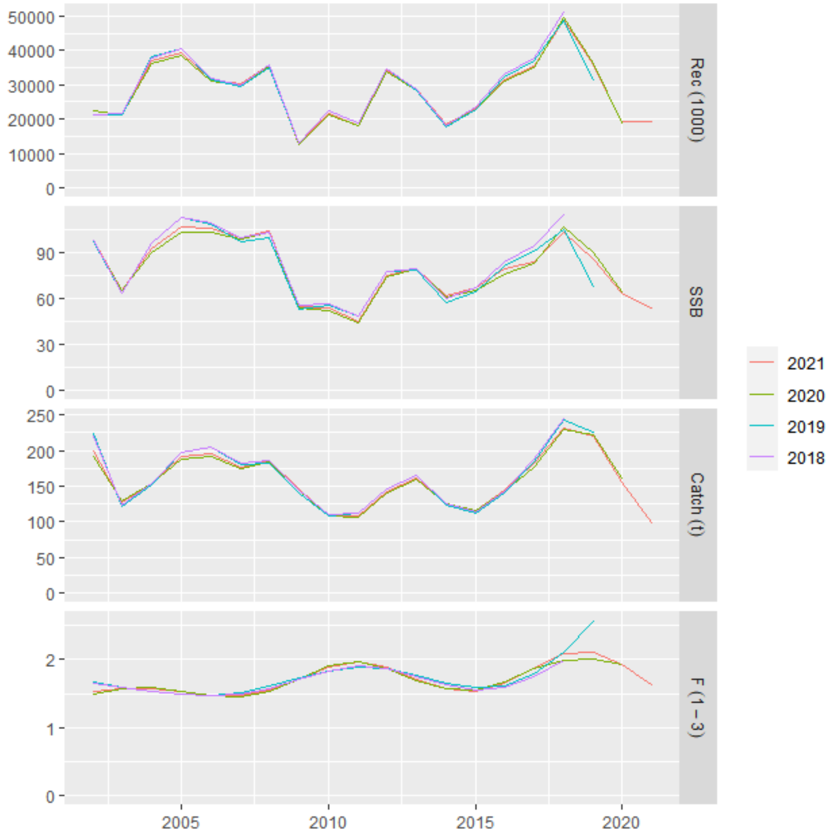


Figure 6.16.3.10. Blue and red shrimp in GSA 5. Results of the retrospective analysis from the a4a analysis.

Figure 6.16.3.11. Blue and red shrimp in GSA 5. Simulations over the summary results.

The Mohn' rho test for $Fbar_{1-3}$, SSB and recruitment are also shown below:

fbar	ssb	rec
0.0559758	-0.03224849	-0.02756459

In the following tables, the population estimates obtained by the a4a model are provided:

Table 6.16.3.4. Blue and red shrimp in GSA 5. Stock numbers at age (thousands) as estimated by a4a.

	1	2	3	4	5+
2002	22275.0	4870.4	2938.8	253.2	3.1
2003	21384.0	4788.1	359.9	241.7	22.3
2004	36781.0	4517.2	335.3	28.1	21.8
2005	39403.0	7766.7	315.9	26.1	4.2
2006	31516.0	8492.1	578.6	26.2	2.7
2007	30154.0	6957.1	681.2	51.7	2.7
2008	35784.0	6671.6	562.1	61.3	5.2
2009	12969.0	7642.1	483.2	45.3	5.7
2010	21818.0	2582.5	445.9	31.4	3.5
2011	18253.0	4028.9	119.4	22.9	1.9
2012	34043.0	3259.1	167.9	5.5	1.2
2013	28671.0	6285.5	150.6	8.6	0.4
2014	18425.0	5701.1	365.1	9.7	0.6
2015	23356.0	3899.0	401.4	28.6	0.9
2016	31664.0	5006.3	285.6	32.7	2.5
2017	35318.0	6467.7	316.0	20.1	2.6
2018	48664.0	6573.1	306.3	16.7	1.3
2019	35620.0	8311.4	238.7	12.4	0.8
2020	19330.0	6011.5	290.9	9.3	0.5
2021	19270.0	3530.9	268.7	14.5	0.5

Table 6.16.3.5. Blue and red shrimp in GSA 5. a4a summary results and F at age.

	Fbar (1-3)	Recruitment (thousands)	SSB (t)	Catch (t)
2002	1.532	22275	97.51	200.07
2003	1.5736	21384	65.28	127.97
2004	1.5746	36781	92.33	153.86
2005	1.5257	39403	106.46	191.44
2006	1.4684	31516	105.32	196.31
2007	1.4629	30154	99.47	177.39
2008	1.5476	35784	103.74	185.35
2009	1.7151	12969	54.57	145.97
2010	1.8954	21818	53.36	108.71
2011	1.9759	18253	45.23	108.51
2012	1.8958	34043	74.77	141.51
2013	1.7184	28671	79.24	160.75
2014	1.5694	18425	61.51	125.20
2015	1.5388	23356	67.18	116.85
2016	1.6541	31664	79.15	144.30
2017	1.8767	35318	83.85	182.16
2018	2.0823	48664	103.09	232.10
2019	2.1108	35620	84.91	219.46
2020	1.9215	19330	63.65	156.47
2021	1.6361	19270	53.92	98.85

Table 6.16.3.6. Blue and red shrimp in GSA 5. Fishing mortality at age.

	1	2	3	4	5+
2002	0.640	1.978	1.978	1.978	1.978
2003	0.658	2.032	2.032	2.032	2.032
2004	0.658	2.033	2.033	2.033	2.033
2005	0.638	1.970	1.970	1.970	1.970
2006	0.614	1.896	1.896	1.896	1.896
2007	0.611	1.889	1.889	1.889	1.889
2008	0.647	1.998	1.998	1.998	1.998
2009	0.717	2.214	2.214	2.214	2.214
2010	0.792	2.447	2.447	2.447	2.447
2011	0.826	2.551	2.551	2.551	2.551
2012	0.792	2.448	2.448	2.448	2.448
2013	0.718	2.219	2.219	2.219	2.219
2014	0.656	2.026	2.026	2.026	2.026
2015	0.643	1.987	1.987	1.987	1.987
2016	0.691	2.136	2.136	2.136	2.136
2017	0.784	2.423	2.423	2.423	2.423
2018	0.870	2.688	2.688	2.688	2.688
2019	0.882	2.725	2.725	2.725	2.725
2020	0.803	2.481	2.481	2.481	2.481
2021	0.684	2.112	2.112	2.112	2.112

The model is fitted with assumptions of flat selection at age 2 and above in the catch and flat q age 3 and above in the survey. This results in some systematic residuals at age 3 in the catch suggesting a more flexible selection might fit better, this was tested, but found to result in an unstable assessment, giving much worse retrospective performance. It was decided to accept smoothing at age by fixing selection to obtain better model stability at the expense of minor systematic differences between the model estimates and catch at age observations.
Based on the a4a results, the main conclusions are that the stock of Blue and Red Shrimp in GSA5 shows a very variable pattern for all the variables, with no clear trends, along the entire time series. After a fluctuating trend since the beginning of the time series until 2014, catches, recruitment and SSB showed a progressive increasing trend from 2014-2015 to 2018, where they reached a maximum peak. However, since then, a sharp decrease until 2021 was observed for all of them, more attenuated in the case of recruitment in the last year 2021. Fbar (1-3) shows a fluctuating trend along all the time series (between 1.46-2.11), but with a noticeable decrease in the last three years (from 2019) acquiring a value of 1.64 in 2021.

6.16.4 Reference Points

The STECF EWG recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the assessment.

Values of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 0.34. Current F values (2021), as calculated by model a4a, is 1.6361 indicating that the stock is in highly overfishing conditions (Fcurr/ $F_{0.1}$=4.8364).

However, because of the instability in the retrospective and residuals analysis of the model, and considering the lack of continuity in references of the previous years (this stock was not accepted for advice last three years, so it was proposed precautionaty advice based on biomass index), the STEFC EWG agreed in not running any procedures to estimate biomass reference points. Therefore, reference points were not computed for this stock.

6.16.5Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age, while the F_{bar1-3} =1.6361 (the last year's F estimated by the assessment model) was used for F in 2022, as F shows a declining trend. Recruitment is observed to decline over the period of the assessment, so the geometric mean across the entire time series (20 years) was used as an estimate of recruits in 2022.

Table 6.16.5.1. Blue and red shrimp in GSA 5. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 1-3 (2022)	1.6361	Fsq = F in the last year
SSB (2022)	73.27	SSB intermediate year from STF output
Rage1 (2022, 2023)	26808.78	Recruitment will be set as geometric mean of the last 20 years
Total Catch (2022)	127.08	Catch intermediate year from STF output
Fbar (2019)	2.1108	MAP base year fishing mortality from current assessment
a and b values	a=0.333 and b=0.667	Regression parameters from FTransition regression line

Table 6.16.5.2. Blue and red shrimp in GSA 5. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield ($F_{0.1}$)	0.21	0.34	127.08	46.27	73.27	188.02	156.62	-53.19
F upper	0.28	0.46	127.08	60.52	73.27	168.31	129.72	-38.78
F lower	0.14	0.23	127.08	32.36	73.27	208.68	184.82	-67.26
F_{MSY} Transition	0.57	0.93	127.08	102.85	73.27	118.28	61.43	4.05
Zero catch	0	0.00	127.08	0.00	73.27	262.09	257.72	-100.00
Status quo	1	1.64	127.08	146.66	73.27	79.35	8.30	48.37
Different Scenarios	0.1	0.16	127.08	24.00	73.27	221.76	202.68	-75.72
	0.2	0.33	127.08	44.95	73.27	189.92	159.22	-54.52
	0.3	0.49	127.08	63.35	73.27	164.57	124.61	-35.92
	0.4	0.65	127.08	79.58	73.27	144.21	96.83	-19.50
	0.5	0.82	127.08	93.98	73.27	127.72	74.32	-4.93
	0.6	0.98	127.08	106.82	73.27	114.23	55.91	8.07
	0.7	1.15	127.08	118.34	73.27	103.09	40.71	19.72
	0.8	1.31	127.08	128.72	73.27	93.81	28.03	30.22
	0.9	1.47	127.08	138.12	73.27	85.99	17.37	39.73
	1.1	1.80	127.08	154.47	73.27	73.65	0.53	56.27
	1.2	1.96	127.08	161.62	73.27	68.72	-6.21	63.51
	1.3	2.13	127.08	168.21	73.27	64.41	-12.09	70.17
	1.4	2.29	127.08	174.29	73.27	60.61	-17.28	76.32
	1.5	2.45	127.08	179.92	73.27	57.23	-21.89	82.02
	1.6	2.62	127.08	185.15	73.27	54.21	-26.01	87.31
	1.7	2.78	127.08	190.03	73.27	51.48	-29.74	92.25
	1.8	2.95	127.08	194.58	73.27	49.00	-33.12	96.85
	1.9	3.11	127.08	198.84	73.27	46.73	-36.22	101.16
	2	3.27	127.08	202.84	73.27	44.65	-39.06	105.21

6.16.6 DATA DEFICIENCIES

During the stock assessment procedure, some hauls of MEDITS series (2007-2020) had to be removed, concretely some hauls of the westernmost part of the GSA5 (west of Ibiza and Formentera), since they were present inconsistently along the time series appearing only for some years along the temporal series. In order to remove their potential noise in the overall model procedure, these hauls were removed from the stock assessment analysis.

6.17 BLUE AND RED SHRIMP IN GSAS 6 & 7

6.17.1 STOCK IDENTITY AND BIOLOGY

This stock was assessed for the last time in 2021 (STECF EWG 21-09) using a4a. No information was documented regarding stock delimitation of blue and red shrimp, *Aristeus antennatus* (Risso, 1816). It is assumed that the stock geographical distribution corresponds to GSA 6 & 7 (Figure 6.17.1.1).

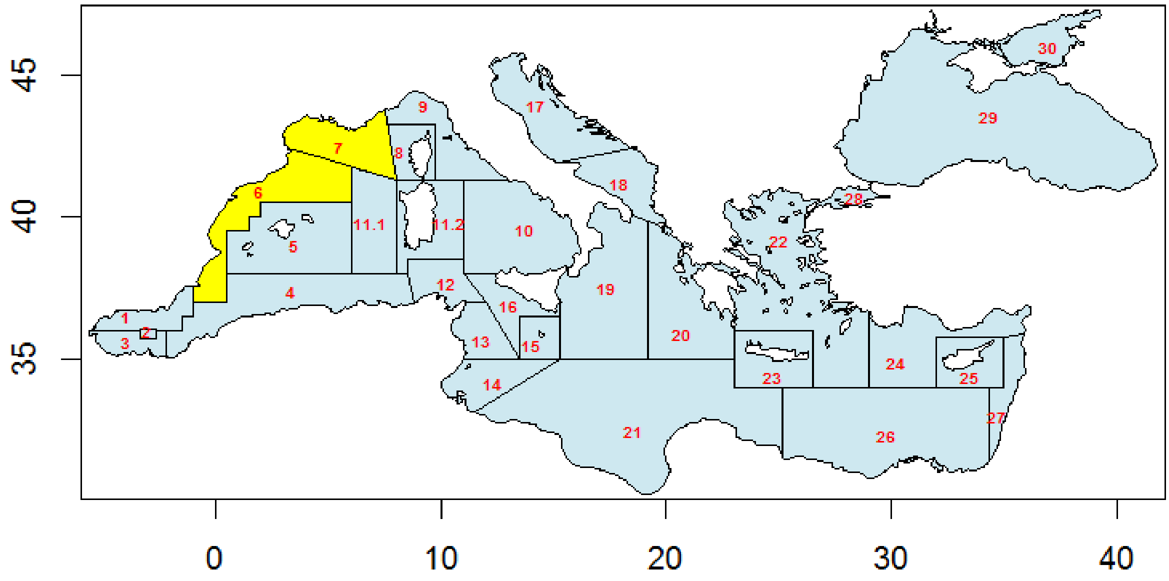


Figure 6.17.1.1. Blue and red shrimp in GSA 6 & 7. Geographical location of the stock.

The growth parameters used were taken from Garcia-Rodriguez (2003), just as in the previous assessment (STECF EWG 21-09); these are estimated from length frequency distributions analysis (Linf = 77.0 mm (carapace length); K = 0.38 year $^{-1}$; t0= -0.065 year).

This species shows sexual dimorphism, as females reach larger sizes compared to males, but only a combined set of growth parameters was available, and catch length data available were combined as well. Therefore, length frequency distributions from the Spanish OTB fleet as well as from survey data (MEDITS) were sliced to catch-at-age, using combined growth parameters.

The parameters of the length-weight relationship were taken from DCF data call 2017 (a= 0.0020; b= 2.5120) and corresponded to the ones used in the previous assessment (STECF EWG 21-09).

The proportion of mature individuals at age was available from the previous assessment report (STECF EWG 21-11, Table 6.17.1.1).

Table 6.17.1.1 Blue and red shrimp in GSA 6 & 7. Proportion of mature specimens (Pmat) at age.

Age	0	1	2	3	4	5+
Pmat	0.07863	0.7669	0.998	1	1	1

The natural mortality of blue and red shrimp in the present assessment was calculated as a vector using the Chen and Watanabe (1989) equation (Table 6.17.1.2).

Table 6.17.1.2 Blue and red shrimp in GSA 6 & 7. Natural mortality (M) at age Chen and Watanabe (1989).

Age	0	1	2	3	4	5+
M	1.967	0.848	0.610	0.512	0.461	0.432

6.17.2 Data

6.17.2.1 Catch (landings and discards)

General description of Fisheries

Blue and red shrimp is one of the most important crustacean species in catches and value of GSAs 6 & 7. It is a deepwater species caught exclusively by bottom trawl. The blue and red shrimp has a wide bathymetric distribution, between 80 and 3300 m depth (Sardà et al., 2004), although commercial fishing grounds are located between 450 and 900 m depth. Deeper areas may act as a refuge for the stock, especially for the juvenile fraction, as they are located far from the main fishing ports and below 1000 m of depth where the trawl fishing is banned (GFCM resolution 2005/1). Females predominate in the landings, representing nearly 80% of the total landings. Discards of the blue and red shrimp are practically zero because of the high commercial value of the species and no minimum catch size. Other accompanying species of commercial value in the catches are large individuals of hake, greater forkbeard, Nephrops and blue whiting. Exploitation is based on young age classes, mainly 1 and 2 year old individuals. Figure 6.17.2.1 shows the landings by year, where a comparison is also presented with the landings reported by Catalonia (which produces around 70% of the total landings in GSAs 06 and 07) and the STECF 2015-11. As reported in EWG 22-03, there is a large discrepancy between landings in the first two years, which is why they were excluded from the assessment. The discarded component of the catch is small (Table 6.17.2.1), therefore catch and landings are considered as equal and the term catch will be used throughout this report. The total landings by metier (=catch as discards were negligible) is shown in Figure 6.17.2.2.

For both GSA 6 & 7, the LFD per year and metier before reconstruction are shown in Figure 6.17.2.3 Length structure of blue and red shrimp landed in GSA 6 & 7 by year and metier as reconstructed is shown in Figure 6.17.2.4

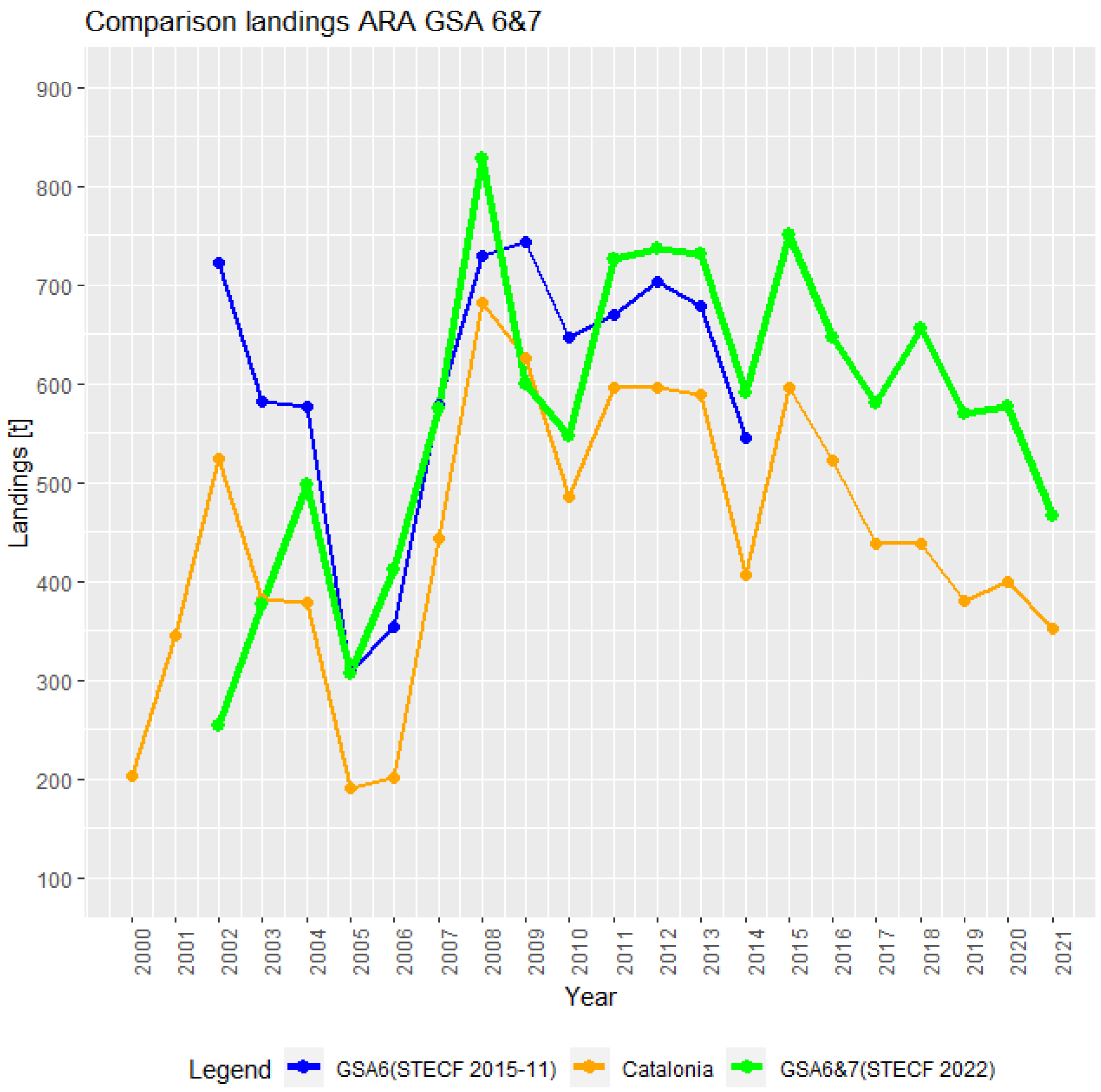
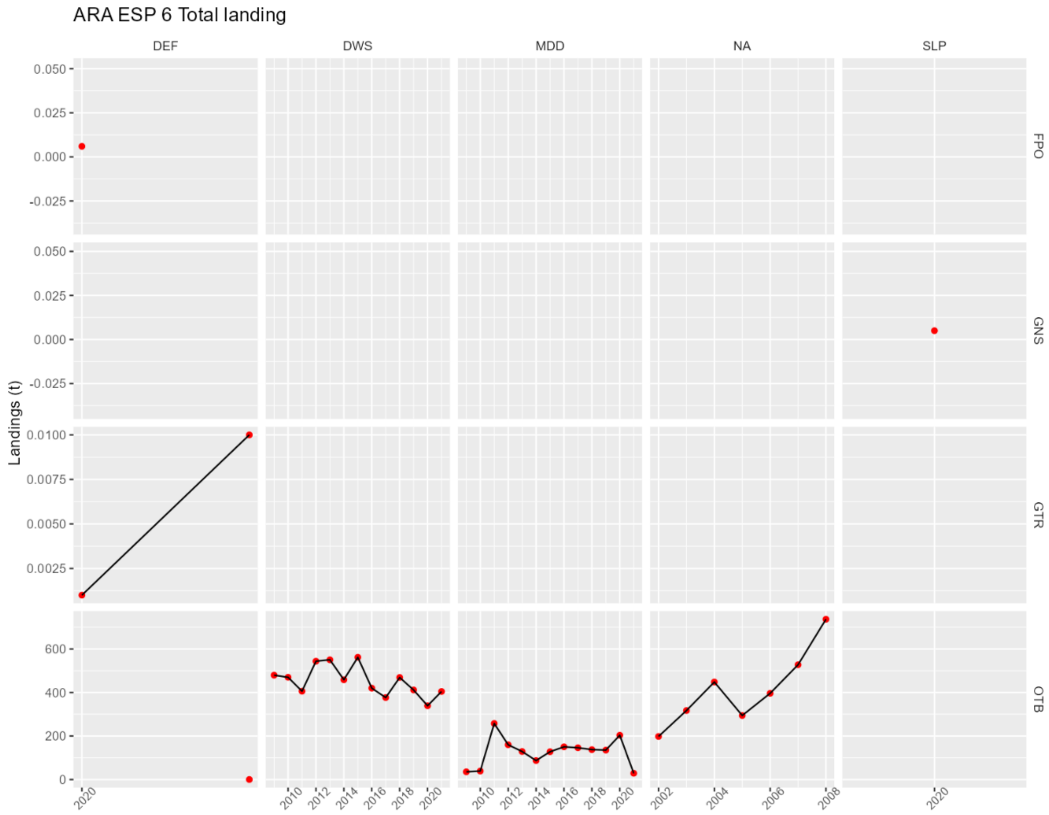


Figure 6.17.2.1 Blue and red shrimp in GSA 6 & 7. Comparison of total landings reported in STECF 2015-11 (blue), Catalonia (orange) and EWG 22-09 (green).

Table 6.17.2.1 Blue and red shrimp in GSA 6 & 7. DCF landings (t) and discards (t) by OTB (all metiers).

Year	Landings(t)	Discards (t)
2004	498.80	0.00
2005	305.90	0.00
2006	411.70	0.00
2007	574.50	0.00
2008	827.50	1.14
2009	599.50	0.52
2010	547.11	1.31
2011	725.80	7.97
2012	735.90	15.10
2013	730.70	12.11
2014	591.00	0.60
2015	750.10	0.33
2016	646.50	3.38
2017	581.48	6.88
2018	655.60	0.04
2019	571.00	2.84
2020	577.60	0.49
2021	465.60	0.00



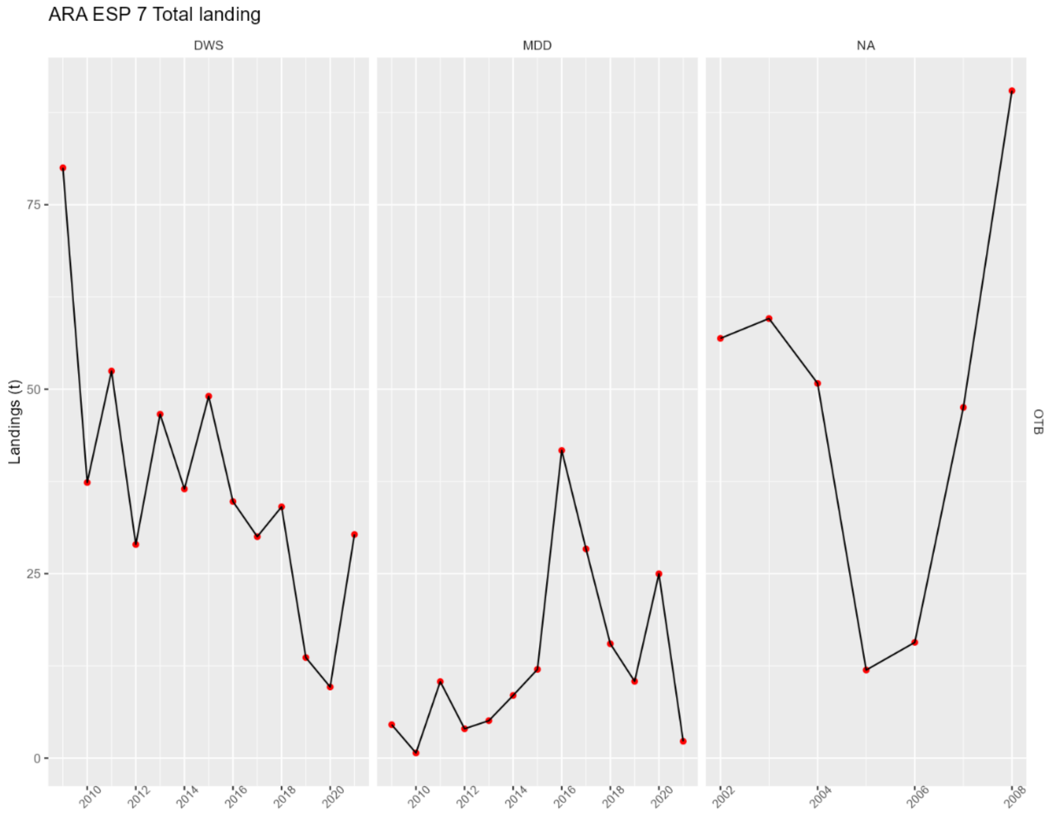


Figure 6.17.2.2 Blue and red shrimp in GSA 6 & 7. Total landing by gear and metier in GSA 6 and 7.

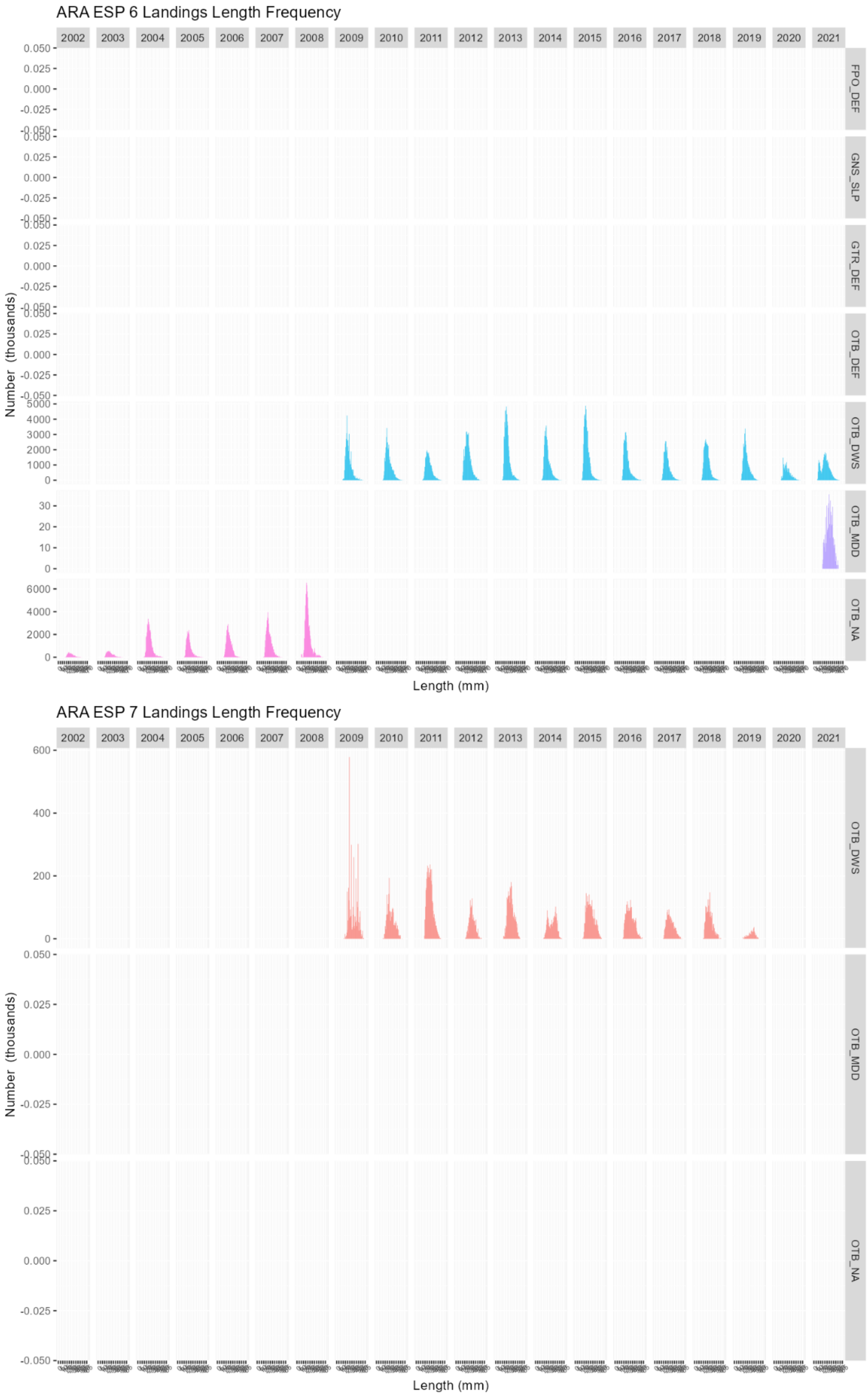


Figure 6.17.2.3 Blue and red shrimp in GSA 6 & 7. Length frequency distribution of catch by year and metier in GSA 6 and 7.

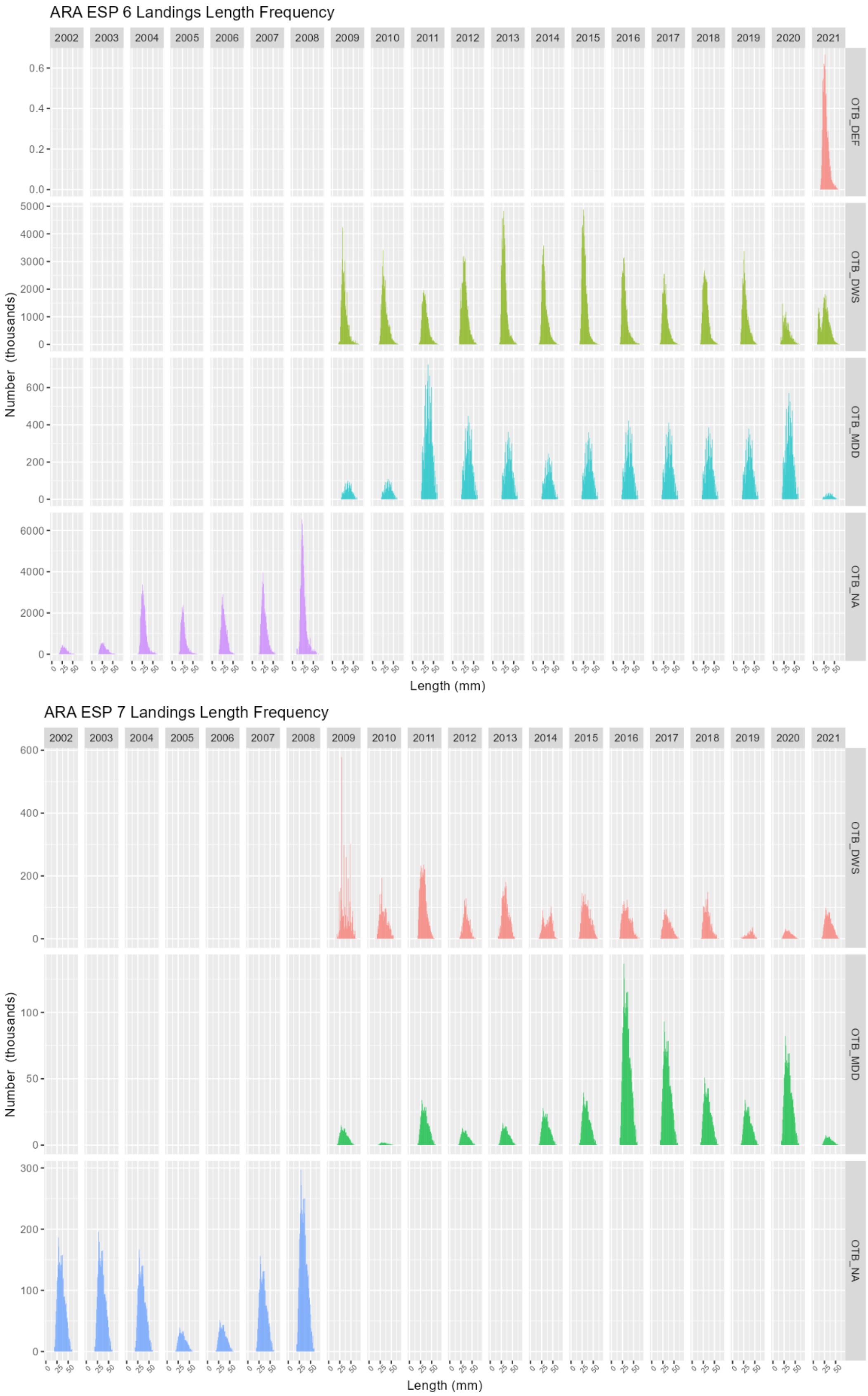


Figure 6.17.2.4 Blue and red shrimp in GSA 6 & 7. Reconstructed length frequency distribution of catch by year and metier in GSA 6 and 7.

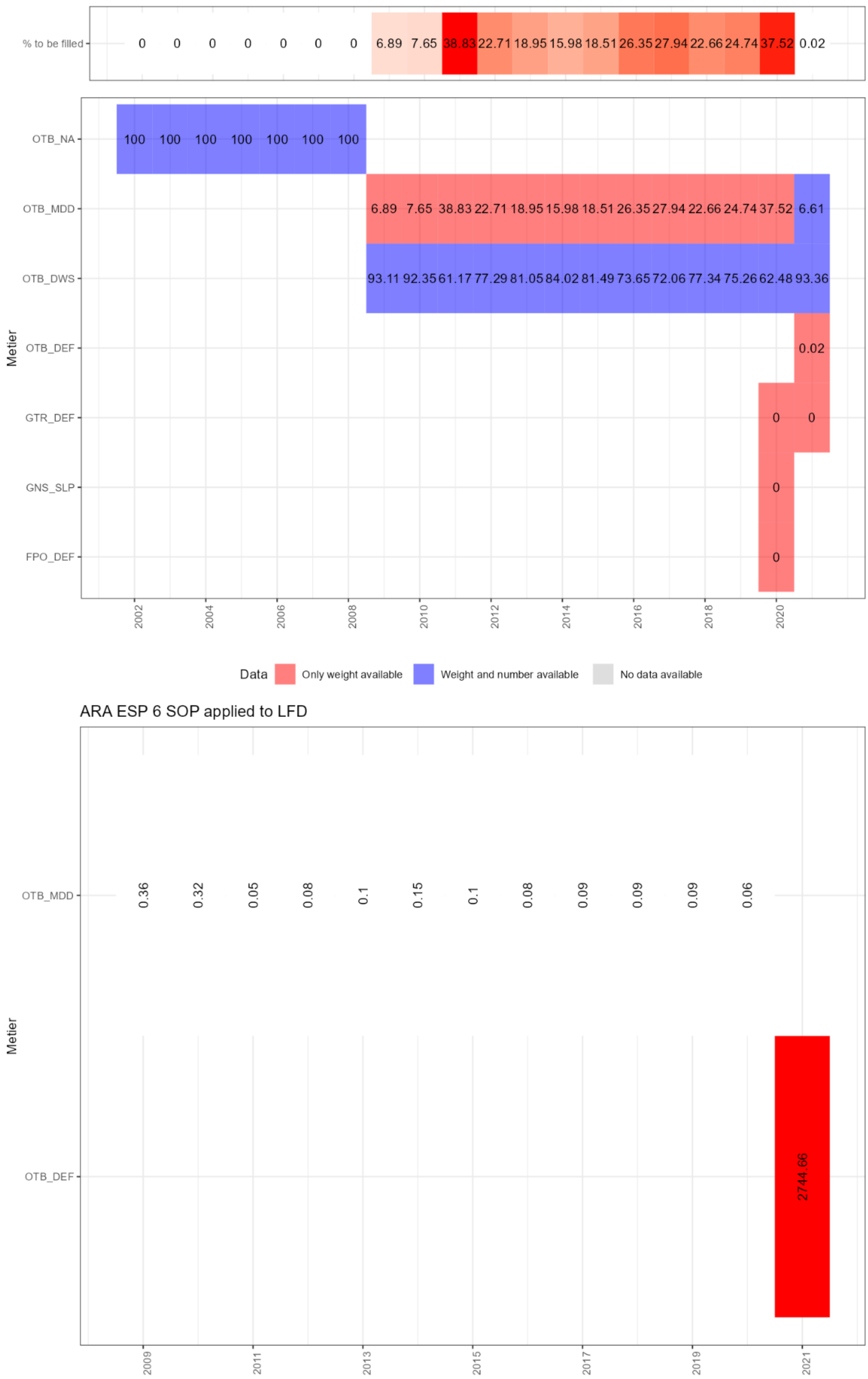


Figure 6.17.2.5 Blue and red shrimp in GSA 6 & 7. Percentages of reconstructed landings LFD in total and by metier for GSA 6 and SoP applied to LFD in GSA 6.

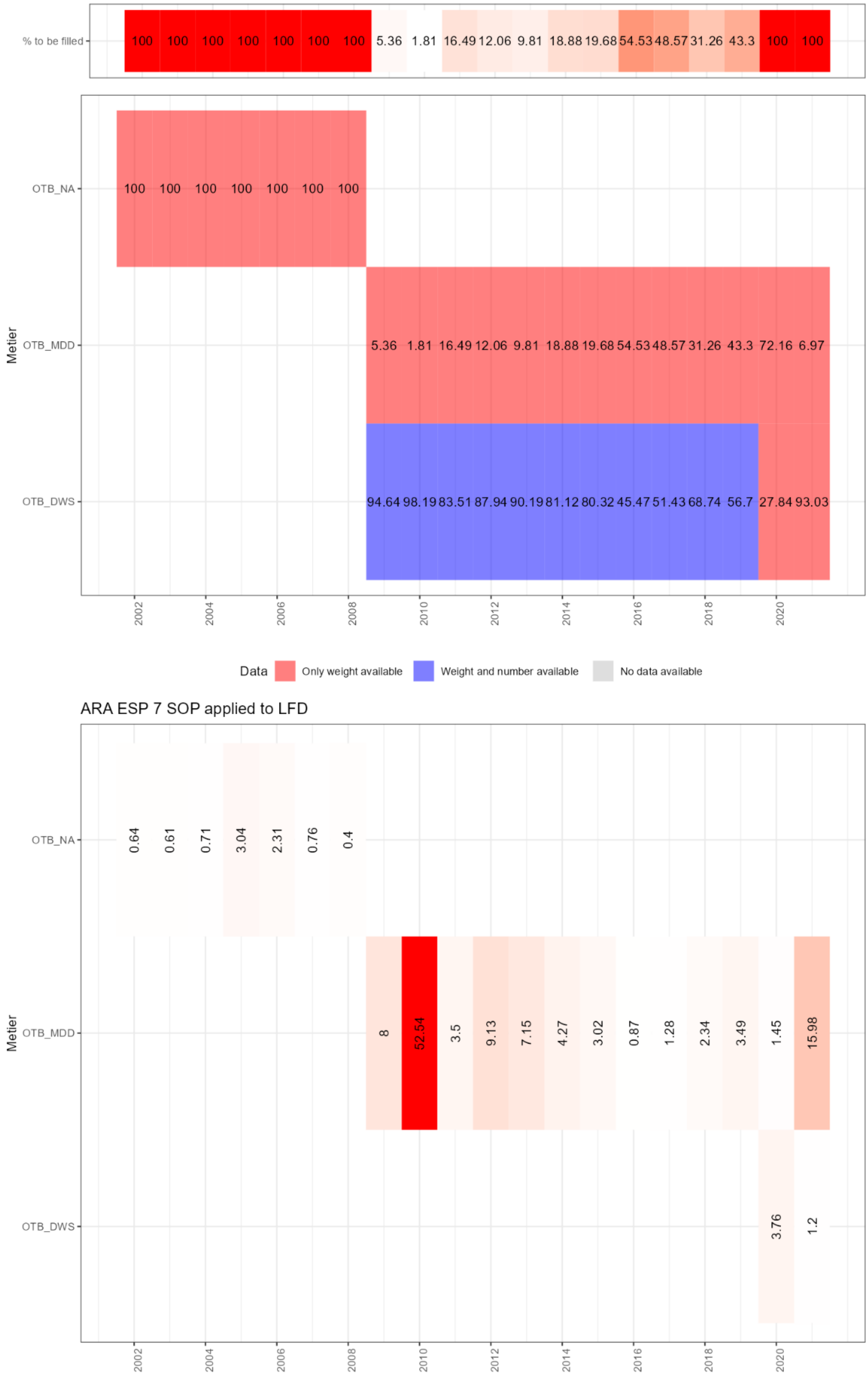


FIGURE 6.17.2.6 Blue and red shrimp in GSA 6 & 7. Percentages of reconstructed landings LFD in total and by metier for GSA 7 and SoP applied to LFD in GSA 7.

6.17.2.2 **EFFORT DATA**

Fishing effort data for 2021 will be reported to STECF EWG 22-11 through the FDI data call within the DCF framework.

6.17.2.3 **SURVEY DATA**

6.17.2.2.1 Description and timing

The MEDITS surveys are carried mainly from May to July (Figure 6.17.2.7). Tables TA, TB, TC were provided according to the MEDITS protocol. Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Data errors (e.g. length ranges) had been noted and were corrected prior to the analysis.

The abundance and biomass indices for GSA 6 & 7 were calculated through stratified means. This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas.

Figure 6.17.2.7 Blue and red shrimp in GSA 6 & 7. Month of the year when the MEDITS survey is conducted.

The MEDITS survey data for the year 2020 was not included in the assessment, due to reduced coverage with only the Northern half of the area surveyed for the GSA 6 and 7, but also an inaccurate value for the density index in the GSA 6 (Figures 6.17.2.9).

6.17.2.2.2 Geographical distribution

The blue and red shrimp are mainly concentrated in the northern and southern parts of the region, while it is rare in the centre of the Spanish area where waters are shallower. The distribution did not show substantial variation across time (Figure 6.17.2.8).

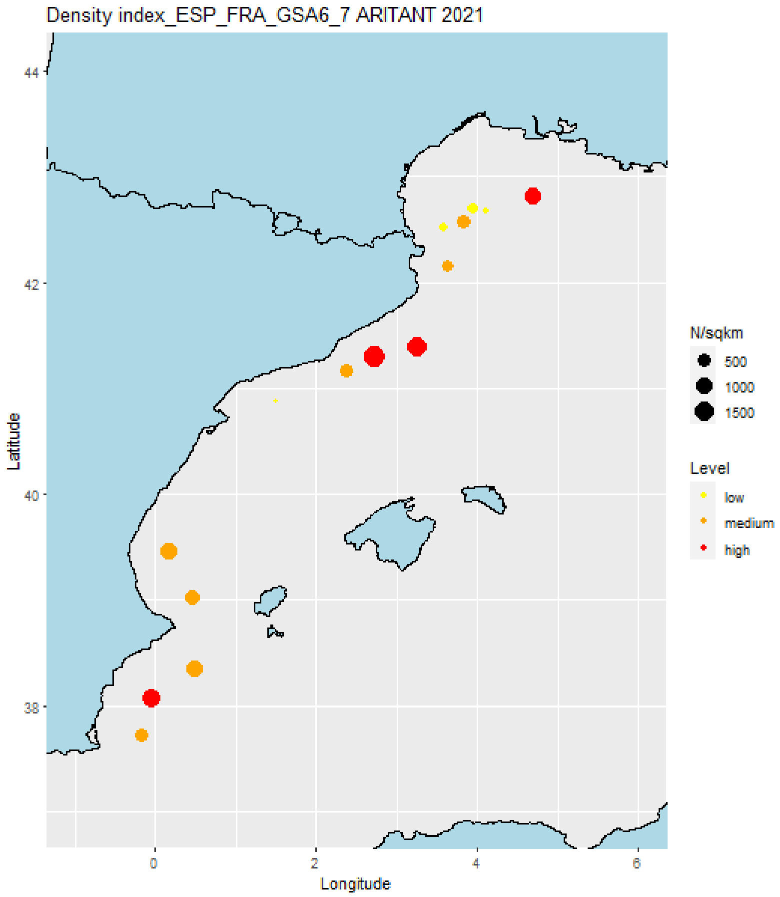


Figure 6.17.2.8 Blue and red shrimp in GSA 6 & 7. Geographical distribution based on the density index of MEDITS survey in 2021.

6.17.2.2.3 Trends in abundance and biomass

The time series of abundance and biomass indices of blue and red shrimp from MEDITS bottom trawl survey in GSAs 6 & 7 combined are available since 1994 as shown in the Figures 6.17.2.9 and 6.17.2.10, and Table 6.17.2.2.3. The density index shows an almost stable trend across the years while the biomass index shows a slight declining trend. The trends in abundance by length are shown on Figure 6.17.2.10.

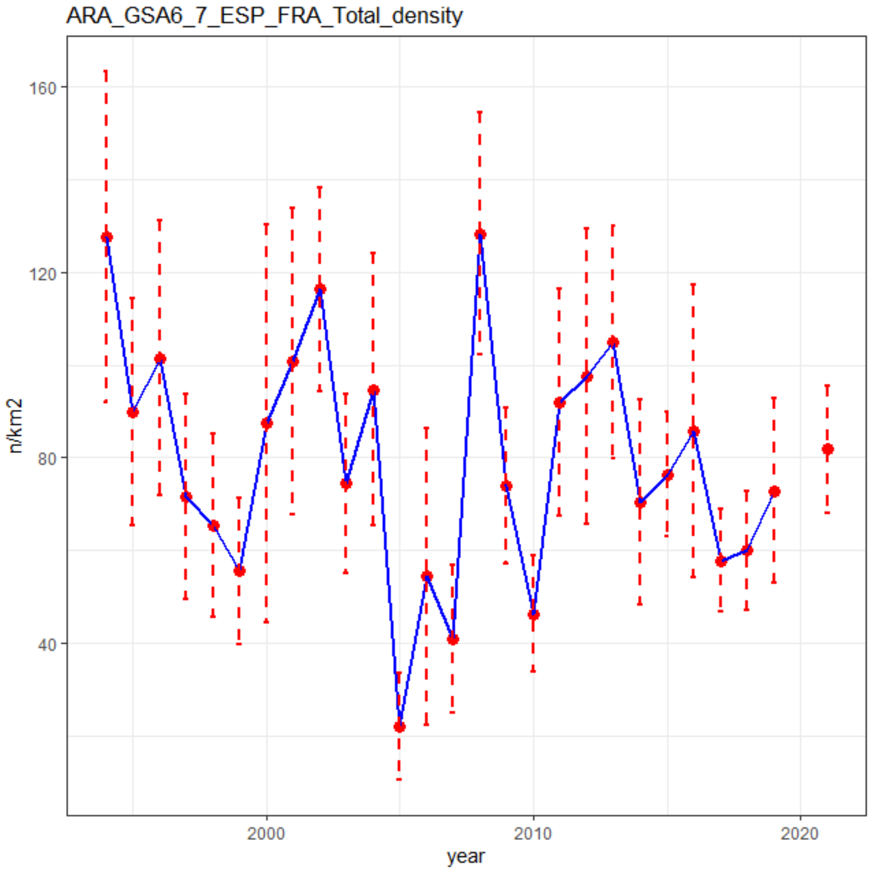


Figure 6.17.2.9 Blue and red shrimp in GSA 6 & 7. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 6 & 7 as reported by DCF. 2020 data omitted due to uncertainty with N at age data for that year (see value for 2020 in **Table 6.17.2.2)**.

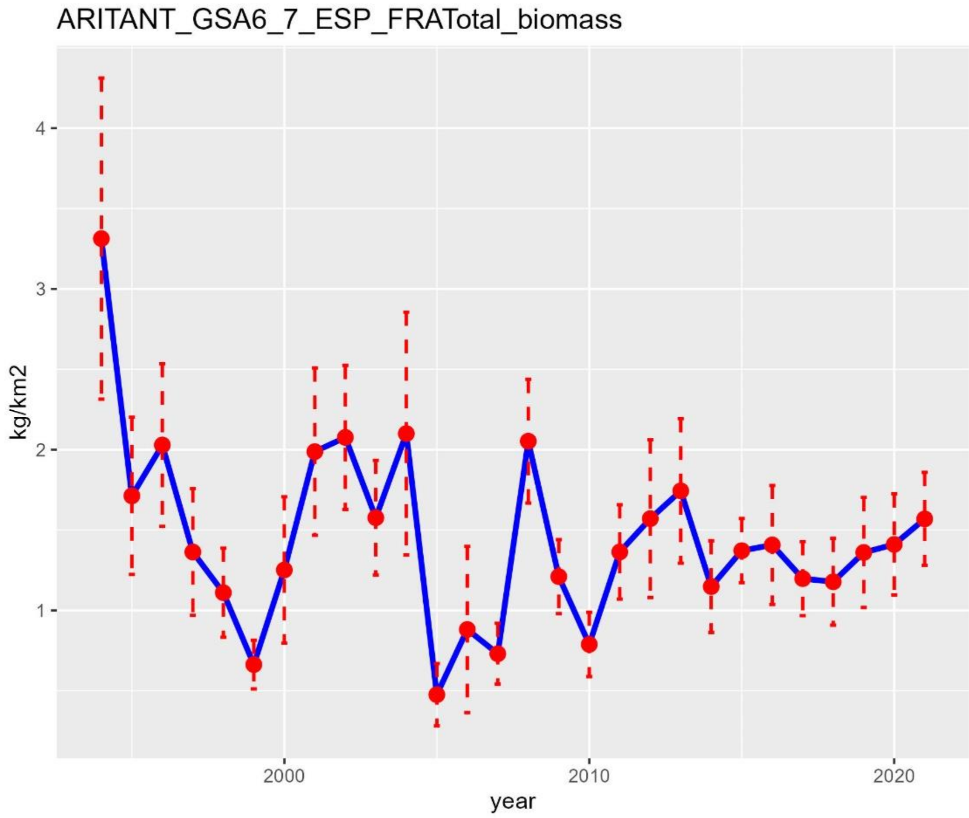


Figure 6.17.2.10 Blue and red shrimp in GSA 6 & 7. MEDITS survey biomass index (kg/km^2) as reported by DCF.

Table 6.17.2.2 Blue and red shrimp in GSA 6 & 7. MEDITS survey biomass index (kg/km^2) as reported by DCF. The survey is carried out from June to July.

Year	total_density	total_biomass
1994	127.71	3.31
1995	89.94	1.71
1996	101.43	2.03
1997	71.64	1.36
1998	65.35	1.11
1999	55.48	0.66
2000	87.39	1.25
2001	100.67	1.99
2002	116.31	2.08
2003	74.39	1.58
2004	94.62	2.10
2005	21.90	0.48
2006	54.33	0.88
2007	40.88	0.73
2008	128.38	2.05
2009	73.84	1.21
2010	46.28	0.79
2011	91.81	1.36
2012	97.51	1.57
2013	104.93	1.74
2014	70.43	1.15
2015	76.36	1.37
2016	85.76	1.41
2017	57.78	1.20
2018	59.93	1.18
2019	72.86	1.36
2020	1837.93	1.41
2021	81.82	1.57

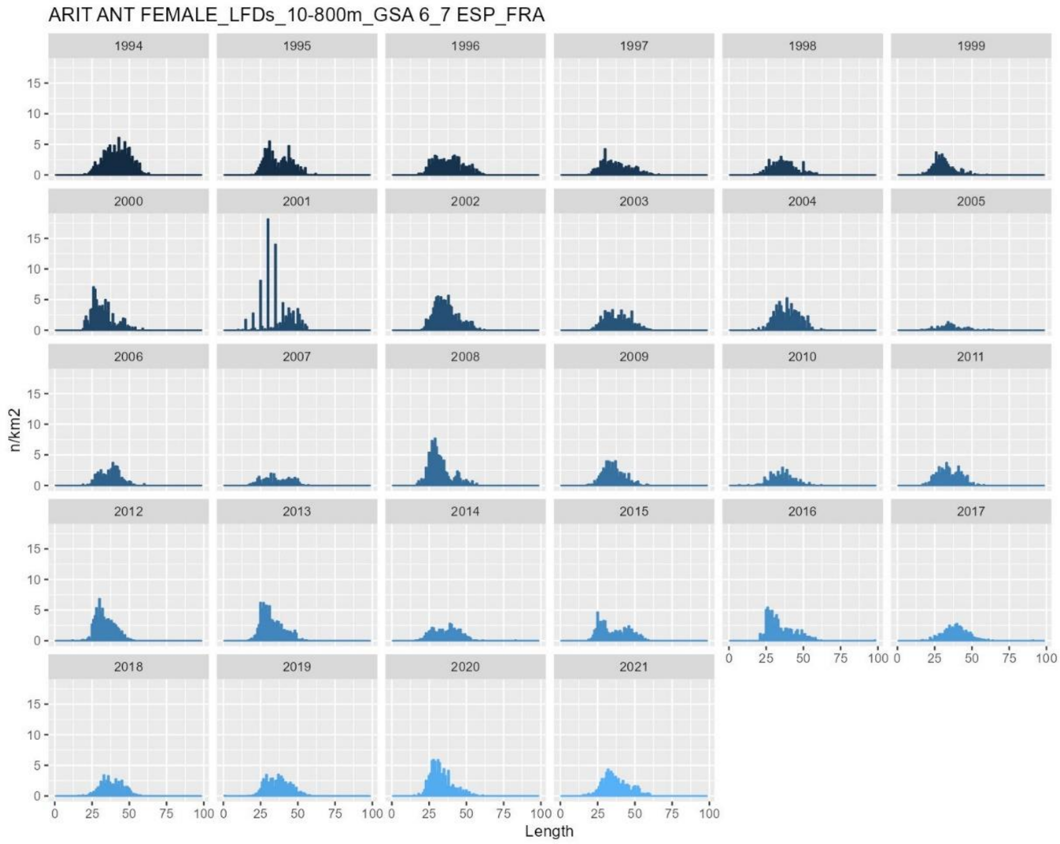


Figure 6.17.2.11 Blue and red shrimp in GSA 6 & 7. Length frequency distribution of the MEDITS survey abundance index (n/km^2) as reported by DCF.

6.17.3 STOCK ASSESSMENT

This is an update assessment of 2021 with re-evaluated/checked data following same data preparation procedures as 2021. Historical assessment a4a submodels were used for blue and red shrimp in GSA 6 and 7. The present assessment was carried out using also the statistical catch-at-age modelling framework – Assessment for all (a4a, Jardim et al., 2014) in FLR (http://www.flr-project.org/).

When slicing length to age for stocks with mid-year spawning and January to December assessment year it is necessary to ensure that growth to January (calendar year boundary) and growth to July (12 months of growth) are coherent with the slicing process (see Section 3). The slicing routine assigns age 0 to ages from 0 to 0.99 and age 1 to 1 to 1.99. If growth is defined on a birth date mid-year and the assessment is from January to December then slicing needs to occur at age 0 from 0 to 0.49 and age 1 from 0.5 to 1.5, this is arranged by adding 0.5 to t_0. When processing length frequency data here, 0.5 years was added to t_o in catch and survey data. This was necessary because without adding 0.5, there were large numbers of age 0 in both catch and particularly survey adjusted to the start of assessment year (January), which are not expected.

6.17.3.1. Input data

The growth parameters used to slice length frequency data from both, commercial and survey data, were Linf = 77 mm, k = 0.38 y^{-1}, t0 =-0.065 y, the same as in the previous assessment. SoP corrections were applied to catch numbers at age yearly (Table 6.15.3.1). The spawning of blue and red shrimp peaks during the summer, although continuous spawning throughout the year has been reported from some areas of the Mediterranean. Natural mortality (M) at age was estimated using the Chen-Watanabe (1989) model. Proportion of mature and M at age are shown in Tables 6.17.1.1 and 6.17.1.2. The MEDITS bottom trawl survey data (Table 6.17.2.9) were used for tuning of the a4a models.

Sum of Products (SoP) correction was applied in catch numbers at age to match the total catch by year reported in the DCF (Table 6.17.3.1)

Input data in terms of catch numbers and mean weight at age, and tuning data in terms of catch numbers from the MEDITS survey are shown in Figure 6.17.3.3.1 to Figure 6.17.3.3.4. Due to an unusual increase in small length frequencies for year 2021, an increase in catch numbers was observed for age 0. This was solved removing age 0 catch numbers and place them at age 1. MEDITS catch at age for 2020 was omitted from the stock assessment.

The plus group in the catch data was set to age 5, and ages 1-4 in MEDITS survey data were used to tune the assessment model. The age range of Fbar was set to age 1-2 as the majority of the catches were represented within these age classes.

Table 6.17.3.1. Blue and red shrimp in GSA 6 & 7. Sum of Products (SoP) correction array.

Year	SoP
2004	1.01
2005	1.00
2006	1.00
2007	1.01
2008	1.01
2009	1.01
2010	1.00
2011	1.01
2012	1.02
2013	1.02
2014	1.01
2015	1.01
2016	1.01
2017	1.02
2018	1.00
2019	1.01
2020	1.00
2021	1.00

6.17.3.3 Stock assessment models and results

The same model settings were applied as the EWG 21-09, but minor changes were made in the fishing mortality submodel values. The k value was changed from 9 to 8, since the time series for the assessment was lowered due to the removal of years 2002 and 2003.

A4a submodels:

Fishing mortality:	fmodel	<- ~ s(year, k=8) + factor(replace(age,age>2,3))
Survey catchability:	qmodel	<- list(~factor(replace(age,age>3,3)))
Variance model:	vmodel	<- list(~s(age,k=3),~s(age, k=3))
Stock-recruit:	srmodel	<- ~ geomean(CV=0.25)

Figures (6.17.3.3.1 – 6.17.3.3.4) present catch-at-age and index-at-age input data for the stock assessment along with their cohort consistency plots. Consistency for the catch is poor between age 1 and 2 and moderate through the rest of the ages. Cohort consistency of the index is poor between age 1 and 2 and moderate through the rest of the ages.

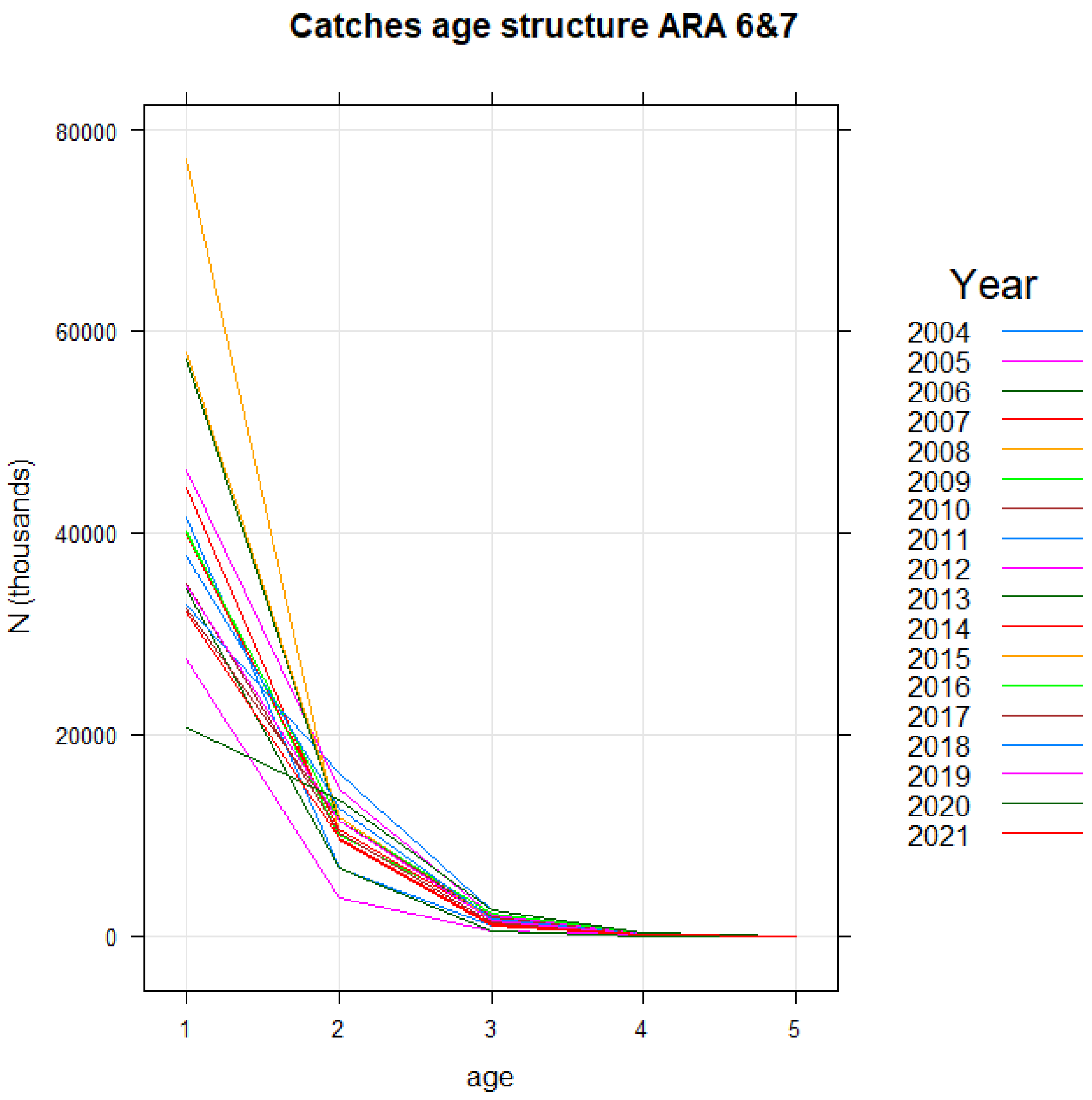


Figure 6.17.3.3.1 Blue and red shrimp in GSA 6 & 7. Blue and red shrimp number of individuals (thousands) at age of the catch in GSA 6 & 7 (2004-2021). Data from DCF.

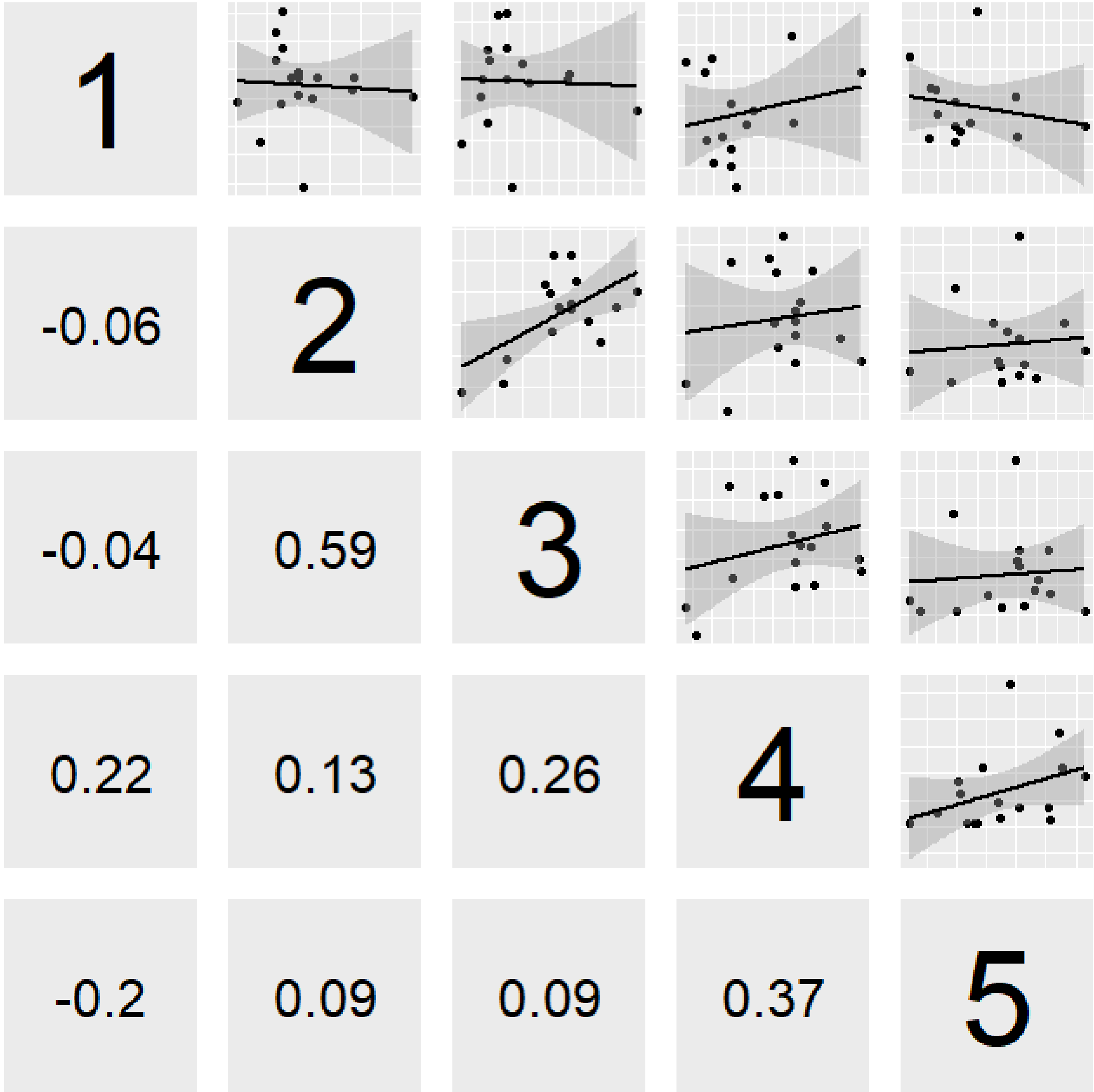


Figure 6.17.3.3.2 Blue and red shrimp in GSA 6 & 7. Cohort consistency in the catch.

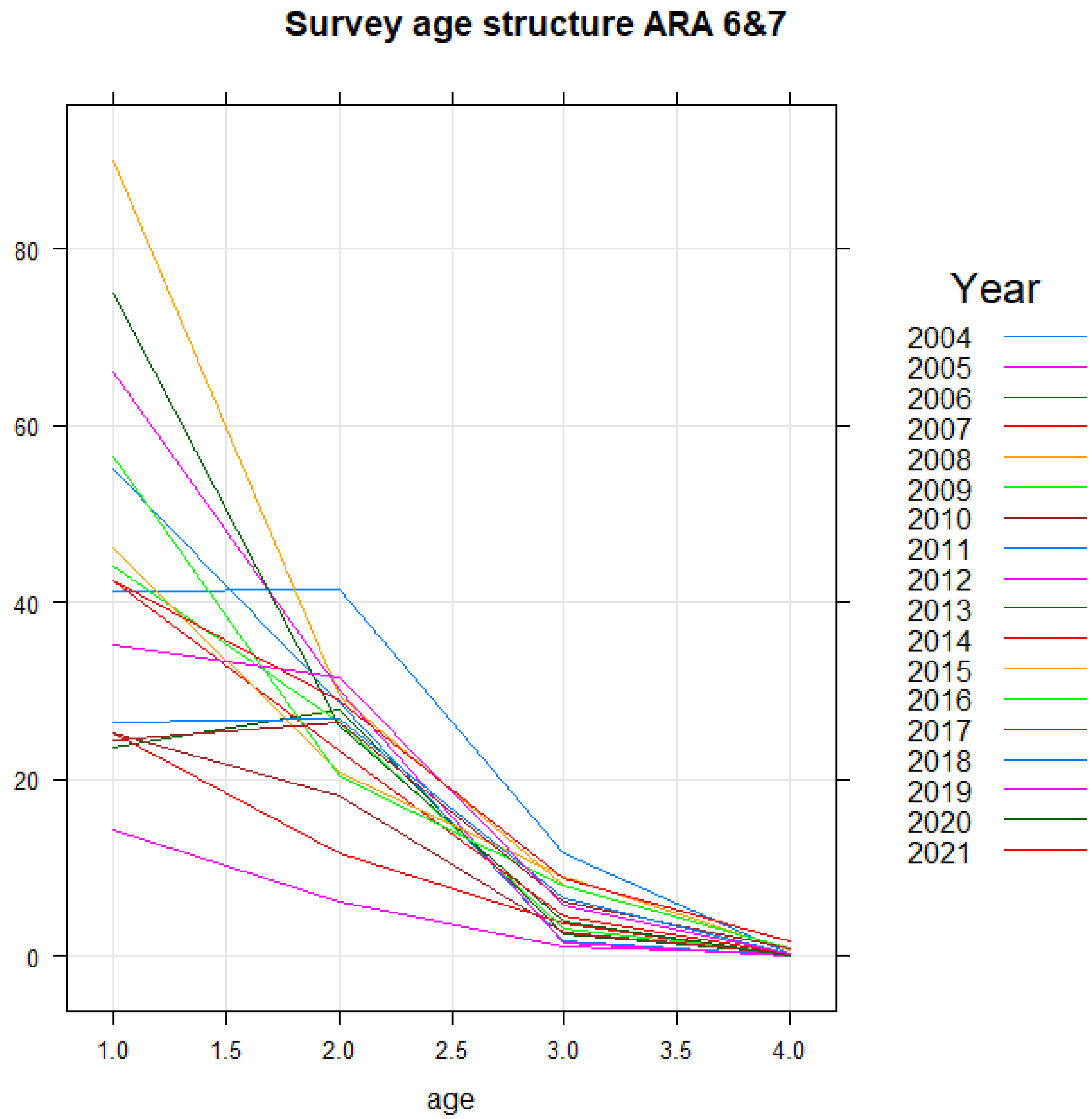


Figure 6.17.3.3.3 Blue and red shrimp in GSA 6 & 7. Age composition of the MEDITS survey as reported by DCF.

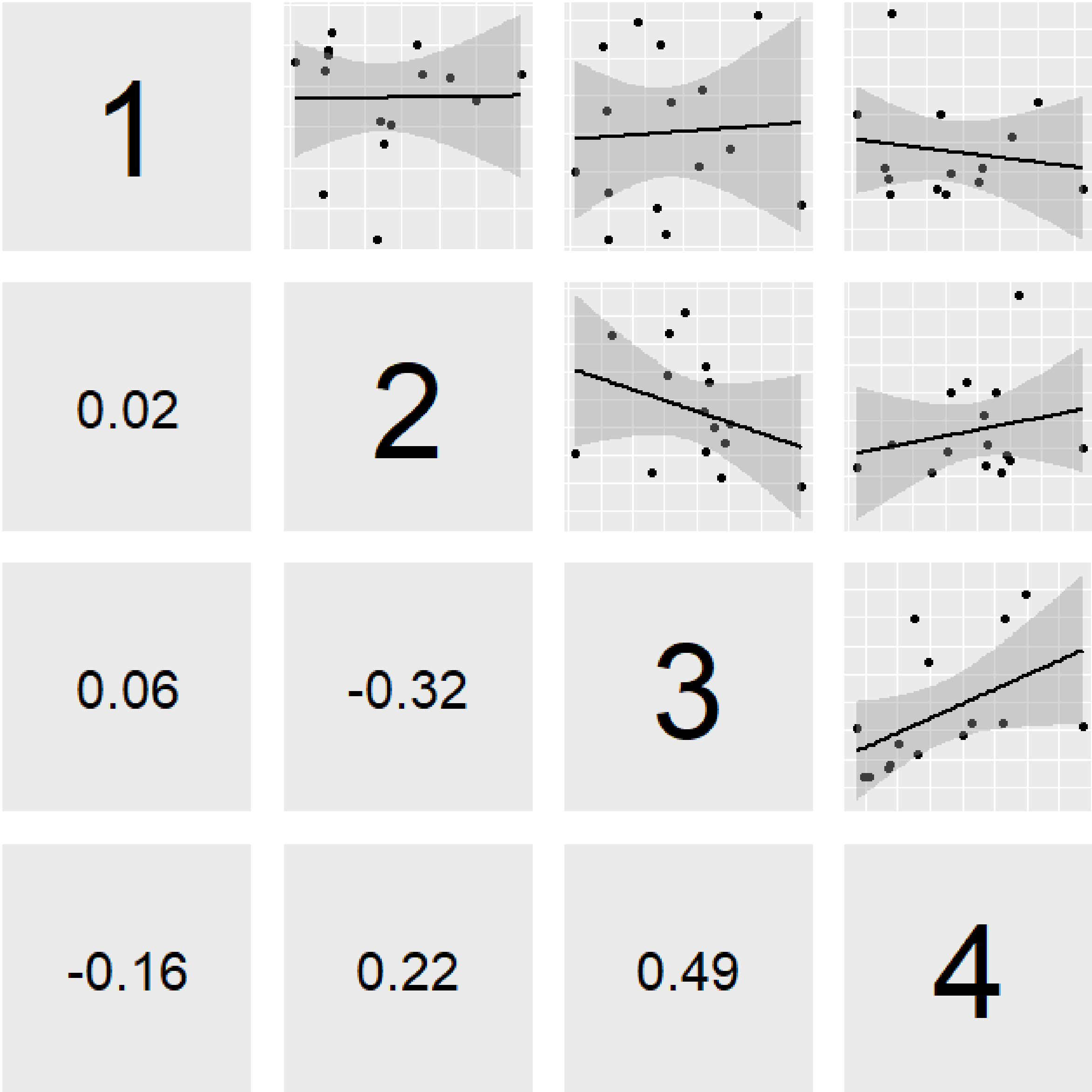


Figure 6.17.3.3.4 Blue and red shrimp in GSA 6 & 7. Cohort consistency of the index.

Figures (6.17.3.3.5 – 6.17.3.3.7) present stock assessment results, 3D plot of fishing mortality by age and year and 3D plot of catchability by age and year. The 3D plots of harvest and catchability reflect the assumption of constant F and q after age 3. The results were in line with the last year's assessment, but in both cases the assessments did not appear to follow the annual variability in observed catches, and discrepancies were noted in some years.

Figure 6.17.3.3.5 Blue and red shrimp in GSA 6 & 7. Results of the stock assessment with 95% confidence limits and the observed catch.

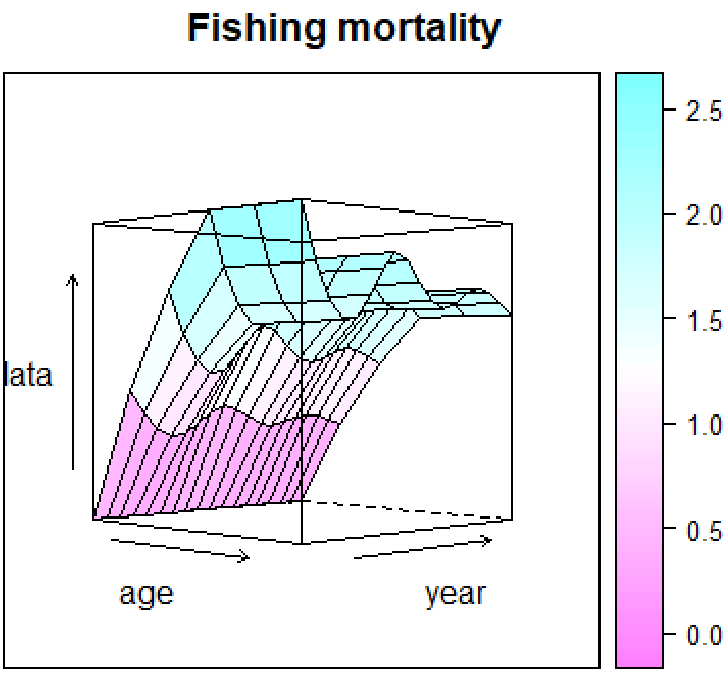


Figure 6.17.3.3.6 Blue and red shrimp in GSA 6 & 7. 3D plot of fishing mortality by age and year.

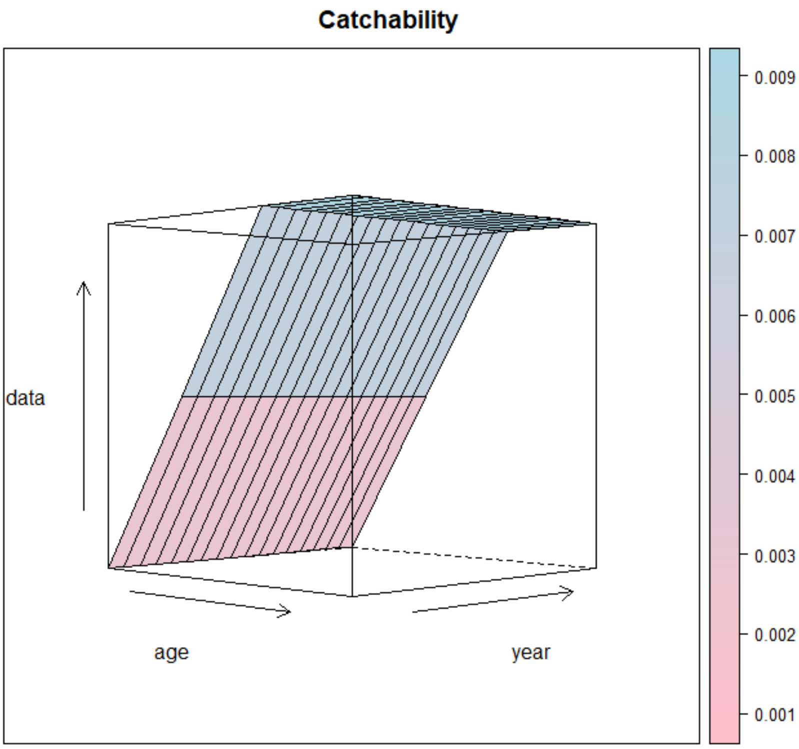


Figure 6.17.3.3.6 Blue and red shrimp in GSA 6 & 7. 3D plot of catchability by age and year.

The Figures (6.17.3.3.7 – 6.17.3.3.11) present the diagnostics of the assessment. The total catch residuals did not show any particular pattern and the range of the standardized residuals values considered acceptable. The fitted versus observed catch at age was good, with some discrepancies for age 1 in years 2004, 2008, 2010, 2011 and 2020. The fitted versus observed index by age was poor in some cases especially in age 1 and the beginning of the time series. Retrospective plots were quite stable and the values of Mohn's rho for fbar, ssb and recruitment were inside of the suggested limits (-0.2 – 0.2).

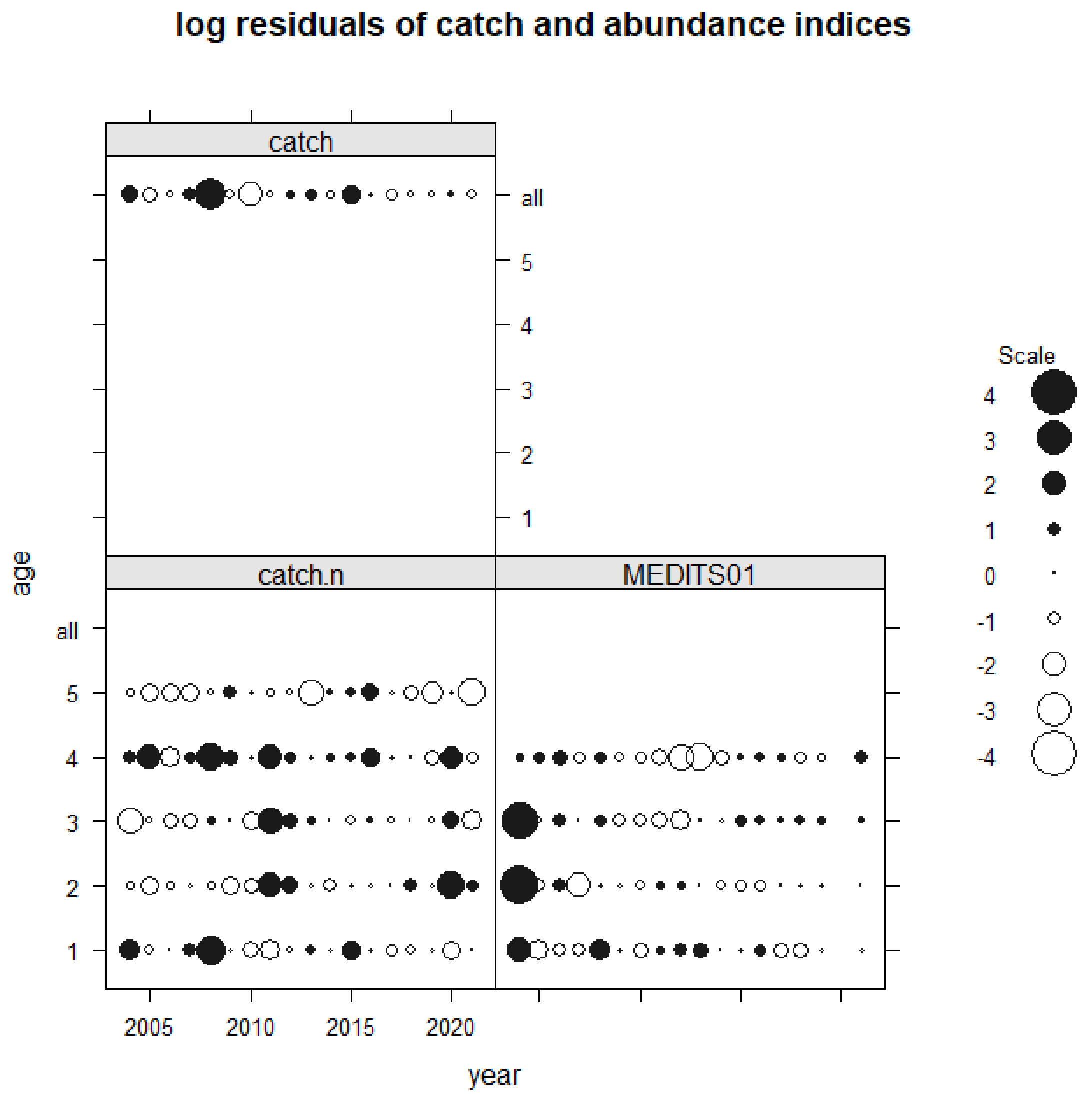


Figure 6.15.3.7 Blue and red shrimp in GSA 6 & 7: Standardized residuals for abundance indices and for catch numbers.

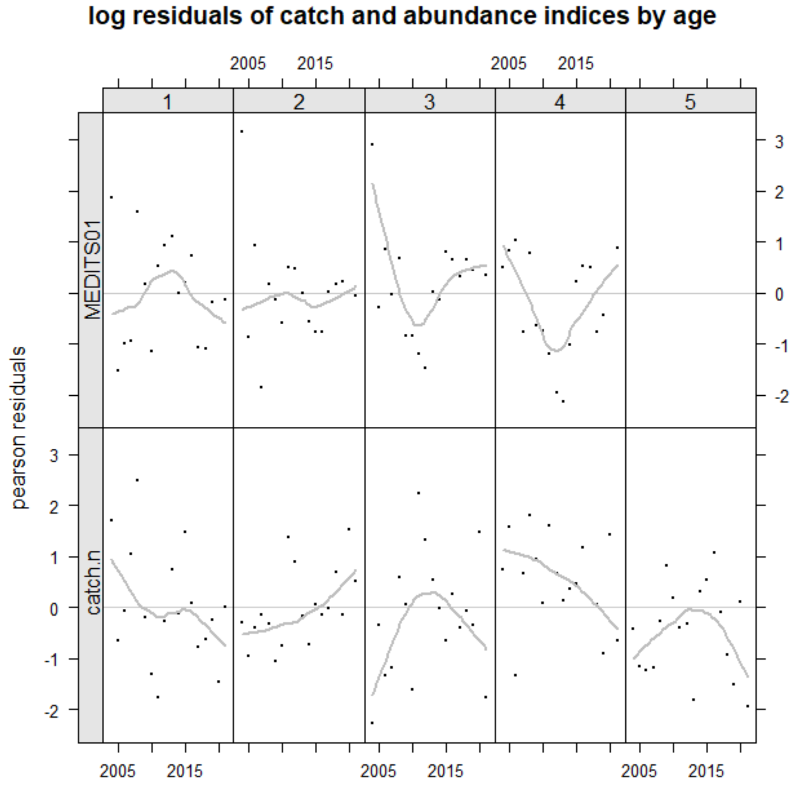


Figure 6.17.3.3.8 Blue and red shrimp in GSA 6 & 7. Catch at age and Index by age residuals.

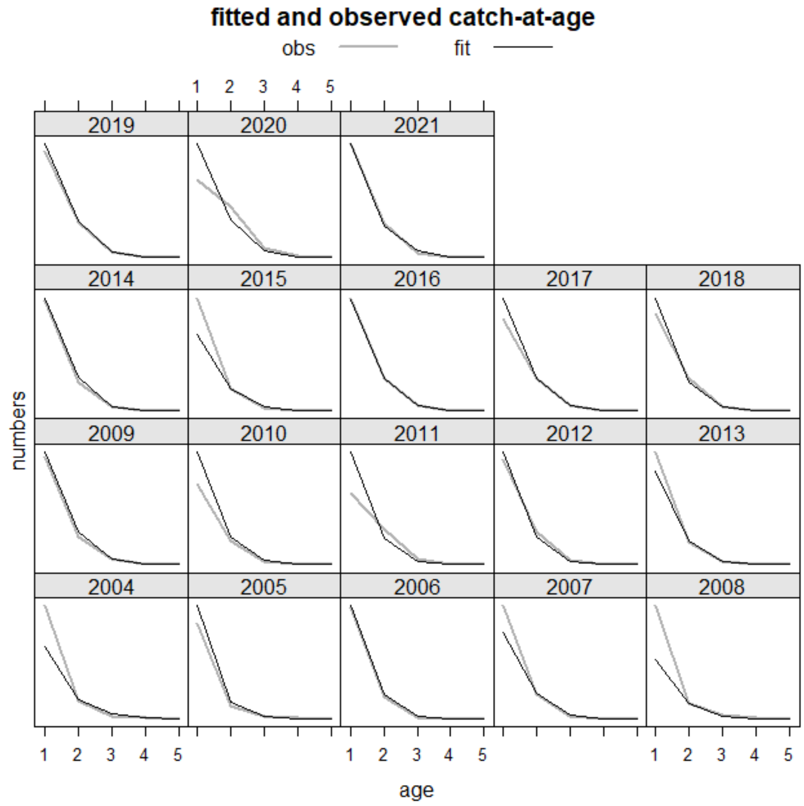


Figure 6.17.3.3.9 Blue and red shrimp in GSA 6 & 7. Fitted versus observed catch by age and year.

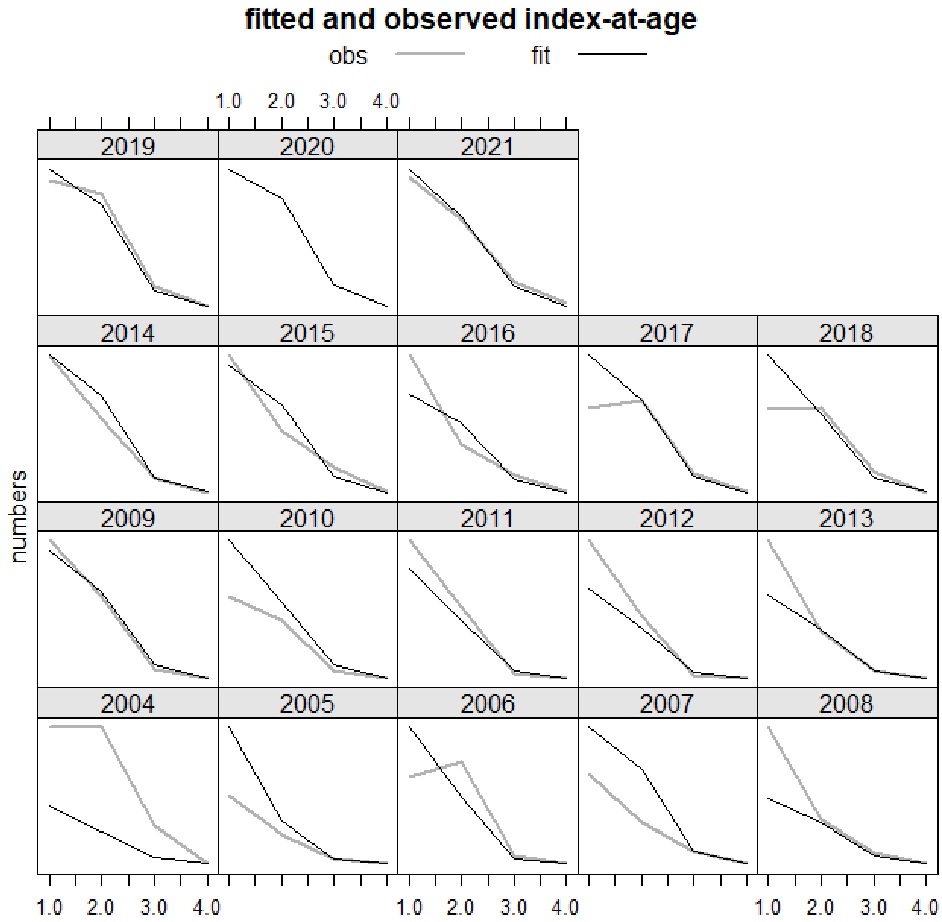


Figure 6.17.3.3.10 Blue and red shrimp in GSA 6 & 7. Fitted versus observed index by age and year.

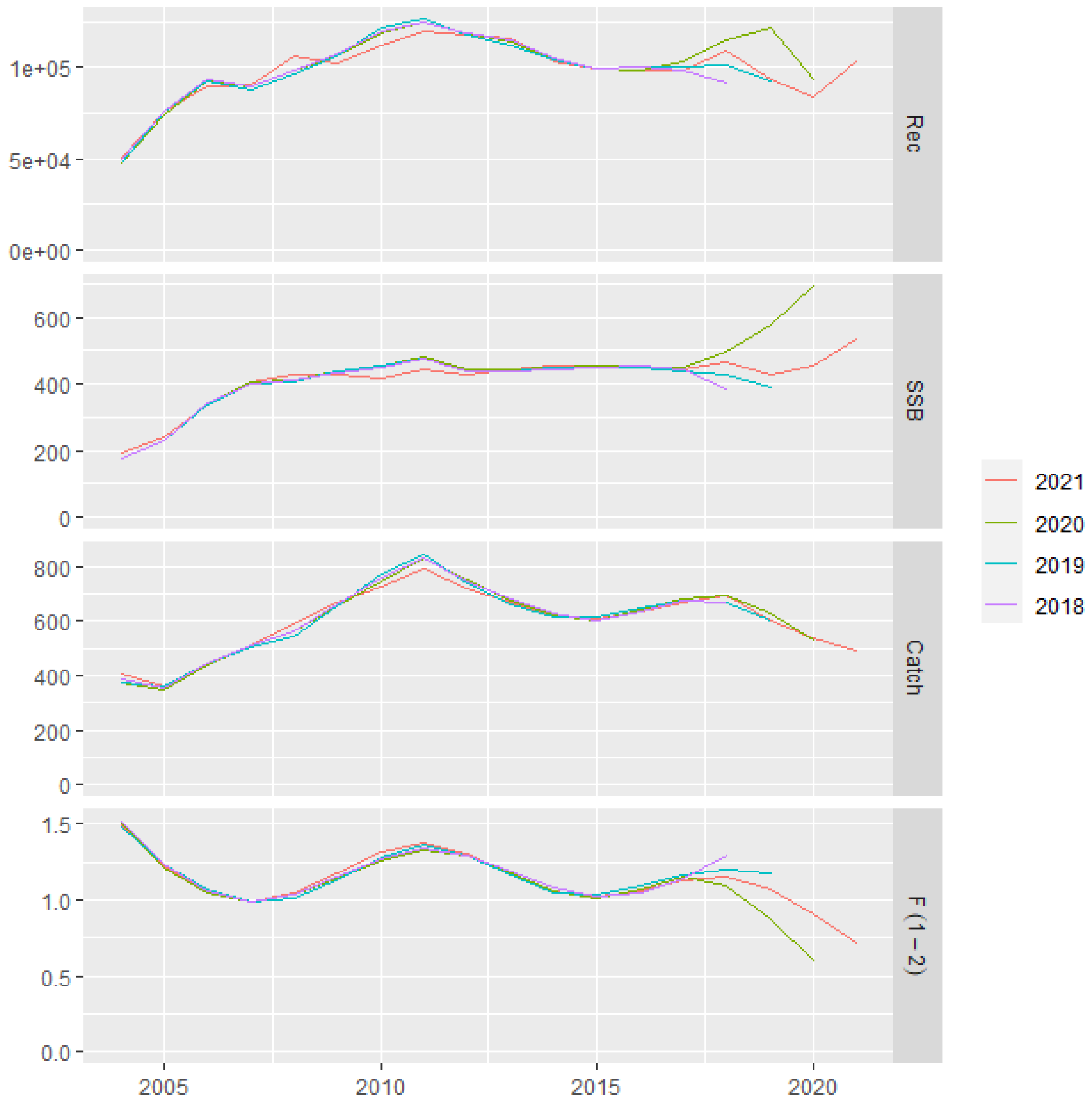


Figure 6.17.3.3.11 Blue and red shrimp in GSA 6 & 7. Retrospective plot for 3 years back.

Table 6.17.3.3.1 Blue and red shrimp in GSA 6 & 7. Mohn's rho values for fbar, ssb and recruitment.

	Fbar	**SSB**	**Recruitment**
Mohn's rho	-0.043	0.085	-0.017

In the following tables the results of the a4a stock assessment are presented. F-at-age, Stock numbers by age, Recruitment, SSB estimated catch and Fbar.

Table 6.17.3.3.2 Blue and red shrimp in GSA 6 & 7. Fishing mortality by age as estimated through the a4a stock assessment

year	1	2	3	4	5+
2004	1.16	1.95	2.71	2.71	2.71
2005	0.94	1.57	2.19	2.19	2.19
2006	0.80	1.34	1.87	1.87	1.87
2007	0.75	1.26	1.76	1.76	1.76
2008	0.78	1.31	1.83	1.83	1.83
2009	0.86	1.45	2.01	2.01	2.01
2010	0.94	1.58	2.20	2.20	2.20
2011	0.97	1.63	2.27	2.27	2.27
2012	0.93	1.57	2.18	2.18	2.18
2013	0.86	1.45	2.02	2.02	2.02
2014	0.81	1.36	1.89	1.89	1.89
2015	0.79	1.33	1.85	1.85	1.85
2016	0.81	1.36	1.89	1.89	1.89
2017	0.84	1.42	1.97	1.97	1.97
2018	0.85	1.44	2.00	2.00	2.00
2019	0.81	1.37	1.90	1.90	1.90
2020	0.73	1.23	1.70	1.70	1.70
2021	0.63	1.06	1.47	1.47	1.47

Table 6.17.3.3.2 Blue and red shrimp in GSA 6 & 7. Stock numbers by age as estimated through the a4a stock assessment

year	1	2	3	4	5+
2002	53255	10116	2026	123	2
2003	74621	7152	782	81	5
2004	89812	12541	806	53	6
2005	90258	17317	1781	75	6
2006	104040	18233	2660	184	9
2007	102260	20386	2660	256	20
2008	112080	18515	2605	213	23
2009	117110	18745	2070	173	17
2010	113800	19026	1996	129	12
2011	114110	19167	2153	135	10
2012	103690	20587	2434	171	12
2013	101460	19789	2874	221	17
2014	98837	19712	2846	271	24
2015	97695	18823	2742	257	28
2016	107770	17989	2474	228	25
2017	93180	19645	2325	201	22
2018	82316	17688	2718	208	21
2019	97783	17009	2822	296	26
2020	53255	10116	2026	123	2
2021	74621	7152	782	81	5

Table 6.17.3.3.3 Blue and red shrimp in GSA 6 & 7. Stock summary: number of recruits, SSB, Fbar 1-2**,** estimated catch

Year	Recruitment (thousands)	SSB (t)	Fbar (1-2)	Catch (t)
2004	53255	188	1.55	416
2005	74621	230	1.25	359
2006	89812	332	1.07	434
2007	90258	398	1.01	508
2008	104044	419	1.05	575
2009	102263	430	1.15	655
2010	112085	431	1.26	714
2011	117113	459	1.30	770
2012	113800	436	1.25	706
2013	114109	447	1.16	668
2014	103694	448	1.08	632
2015	101464	446	1.06	618
2016	98837	444	1.09	636
2017	97695	439	1.13	653
2018	107771	462	1.15	680
2019	93180	424	1.09	605
2020	82316	432	0.98	548
2021	97783	474	0.85	510

6.17.4 Reference Points

The STECF EWG recommended using $F_{0.1}$ as a proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

The current level of fishing mortality (0.85) is more than 3 times the reference point F0.1, used as a proxy of F_{MSY} (=0.26).

The procedure used for biomass reference points follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4.

6.17.4.1 Exploratory analysis

An exploratory per-recruit analysis was performed using the stock object produced by EWG 22-09 containing the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in Table 6.17.4.1 and Figure 6.17.4.5.

Table 6.17.4.1 Blue and red shrimp in GSA 6 & 7. Per-recruit reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	Yeq	B_0
0.2604	0.0149	0.0037	1.3003	0.0057	0.0373

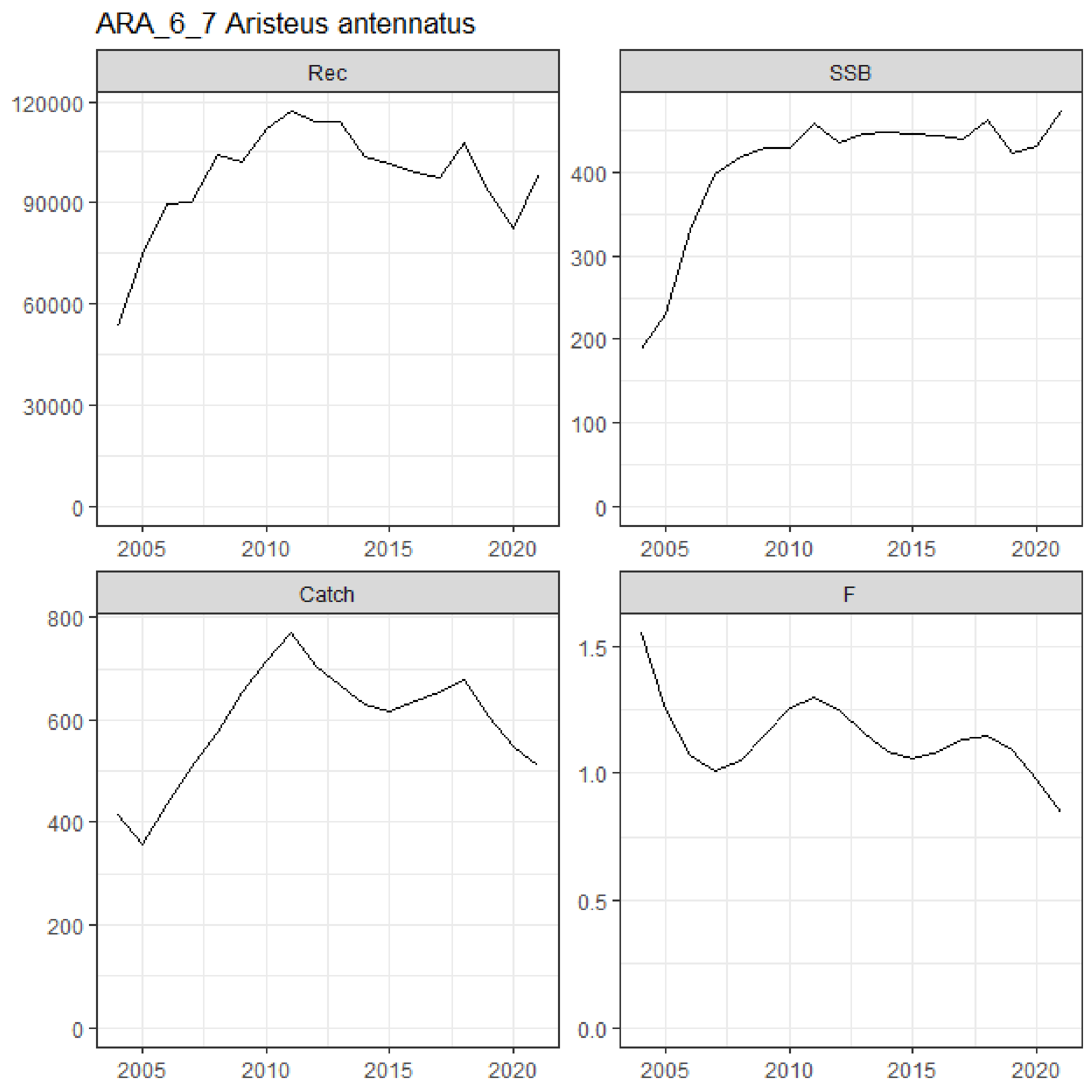


Figure 6.17.4.1 Blue and red shrimp in GSA 6 & 7. Stock summary from the final a4a model.

An overview of the input data used in the assessment and outcomes is provided in Figure 6.17.4.2 - 6.17.4.4.

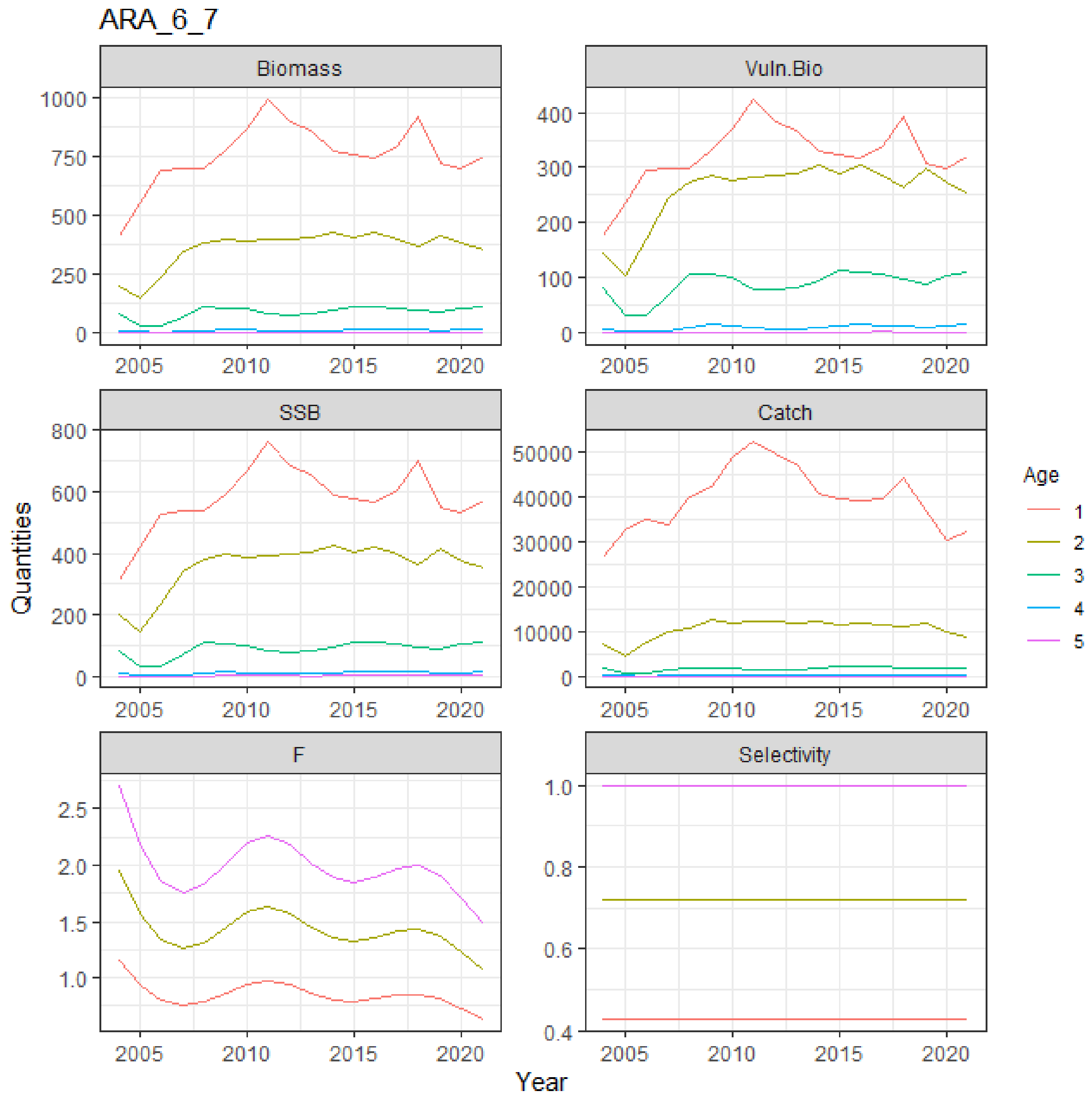


Figure 6.17.4.2 Blue and red shrimp in GSA 6 & 7. Stock assessment trajectories at age.

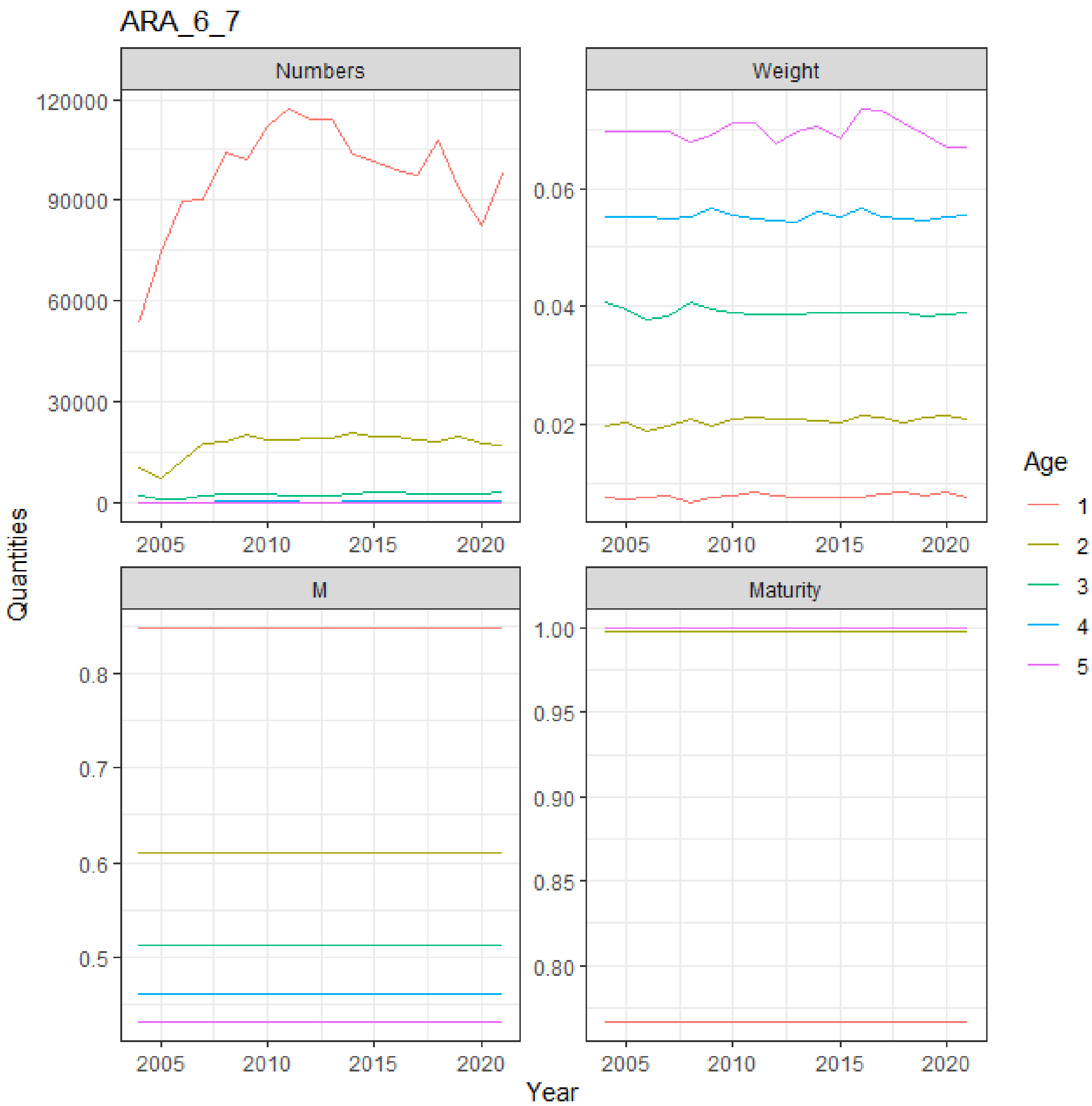


Figure 6.17.4.3 Blue and red shrimp in GSA 6 & 7. Stock biology trajectories at age.

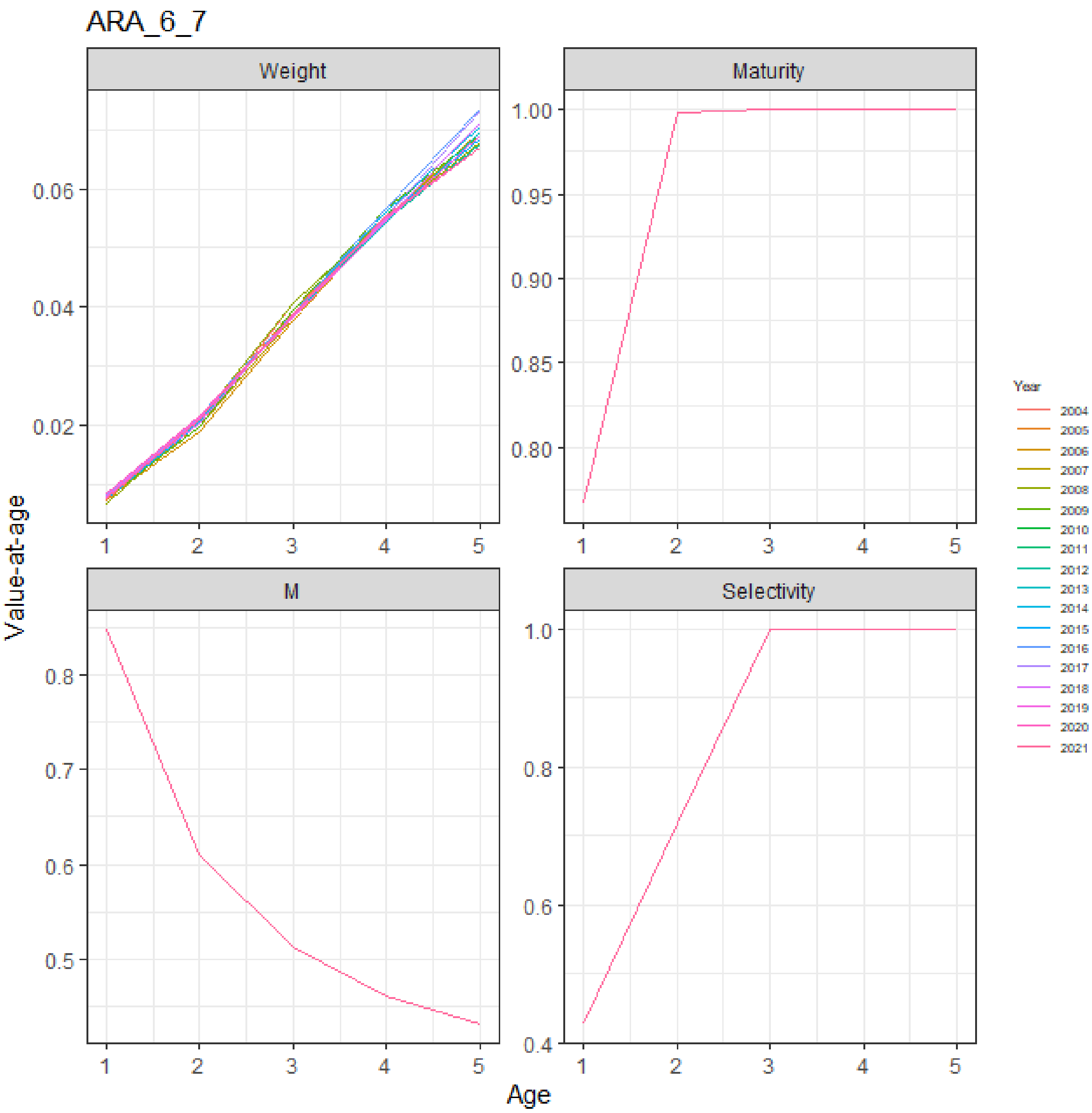


Figure 6.17.4.4 Blue and red shrimp in GSA 6 & 7. Annual stock quantities at age: individual weights at age, fraction mature at age, natural mortality at age and selectivity at age in the fishery

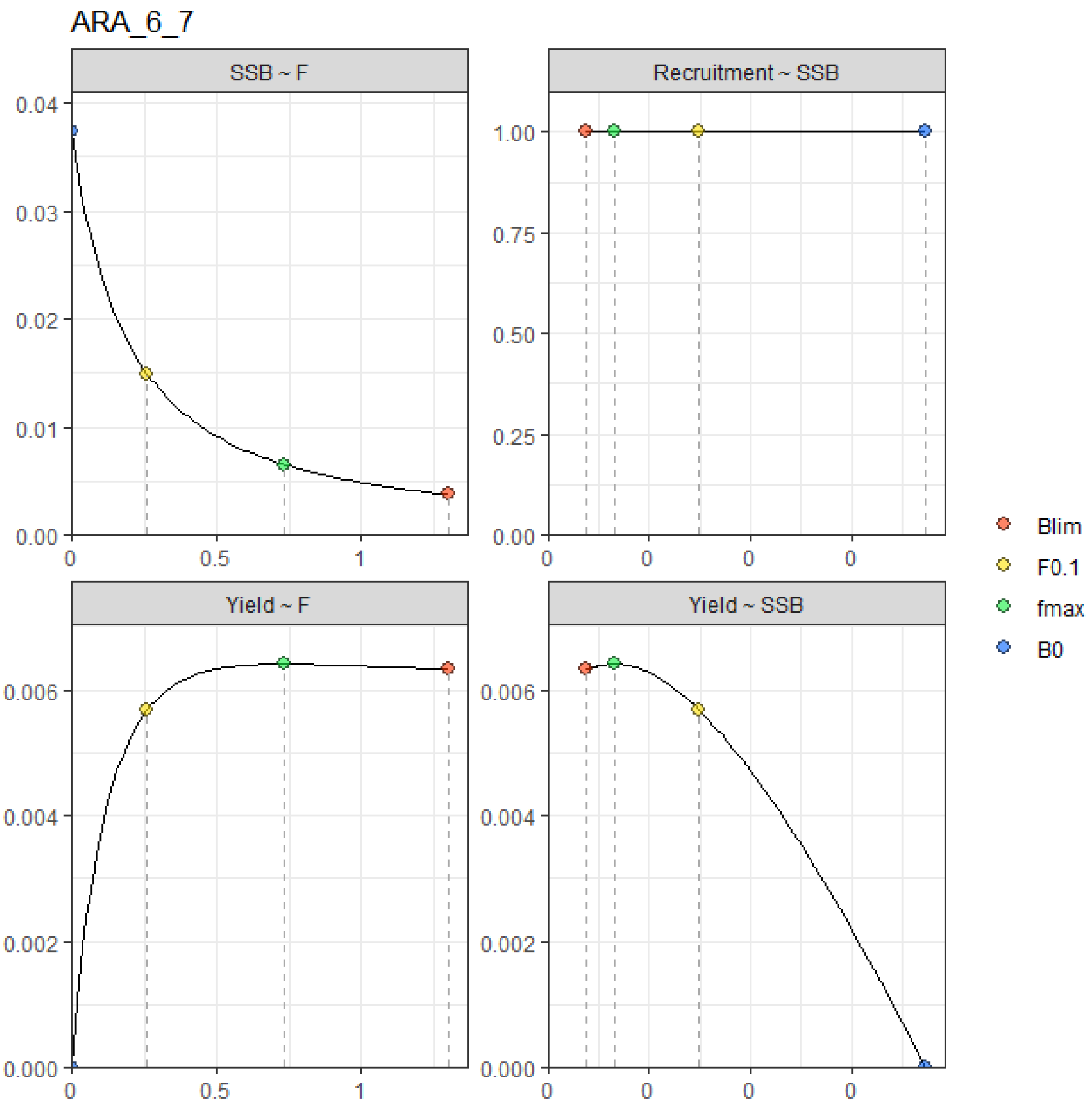


Figure 6.17.4.5 Blue and red shrimp in GSA 6 & 7. Per-recruit analysis.

Figure 6.17.4.6 Blue and red shrimp in GSA 6 & 7. Per-recruit analysis: outcomes of the a4a assessment relative to the per-recruit reference points.

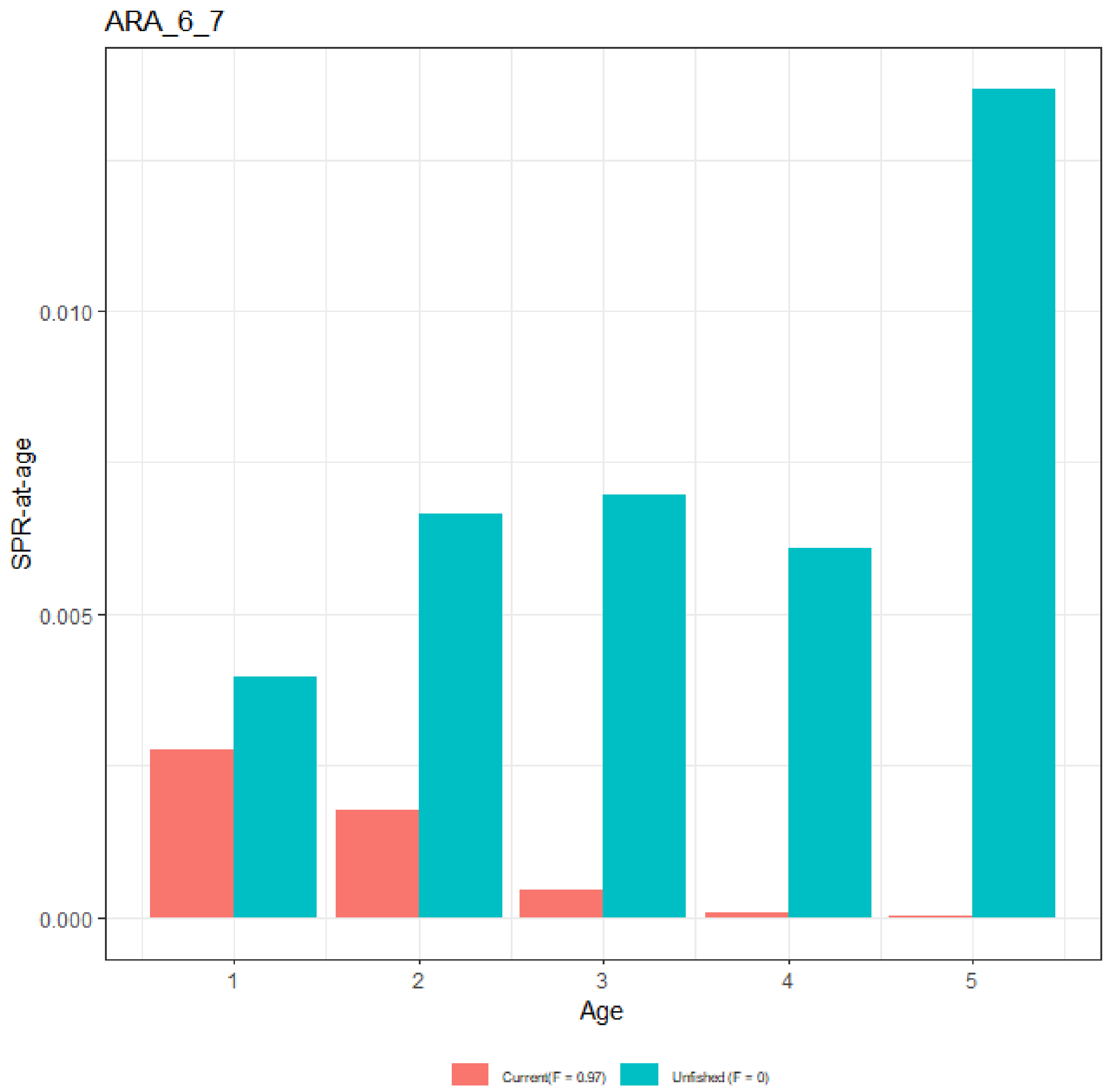


Figure 6.17.4.7 Blue and red shrimp in GSA 6 & 7. Comparison of the spawning biomass per recruit SPRF at current F (average of last 3 years) and SPR_0 with F = 0.

6.17.4.2 Stock – Recruit relationships

Initially four recruitment functions were explored, using the function ssrTBM in the package FLSRTMB:

1. Geometric Mean (model=geomean)

2. Hockey-Stick (model=segreg)

3. Beverton-Holt (model=bevholtSV)

4. Ricker (model=ricker)

The Hockey-Stick was constrained to search for solutions of the break-point so that it falls within a lower bound (lplim) and upper bound (uplim) of spawning ratio potential SRPlim = $SPRlim/SPR_0$. The initial bounds were chosen to be fairly on constrained for a range of SRPlim = SRP 0.1−20% by setting lplim=0.001 and uplim=0.2. In the initial fits of the Beverton-Holt and Ricker models steepness s and R_0 were estimated given the input SPR_0y.

Table 6.17.4.2 Blue and red shrimp in GSA 6 & 7. Stock summary from the final a4a model produced in STECF EWG 22-09.

	s	sigmaR	R_0	rho	B_0
Geometric mean	NA	0.12	99387.79	0.63	3744.79
Hockey-stick	NA	0.09	101991.60	0.50	3842.90
Beverton-Holt	0.90	0.09	132898.20	0.45	5007.41
Ricker	1.65	0.13	74620.87	0.67	2811.61

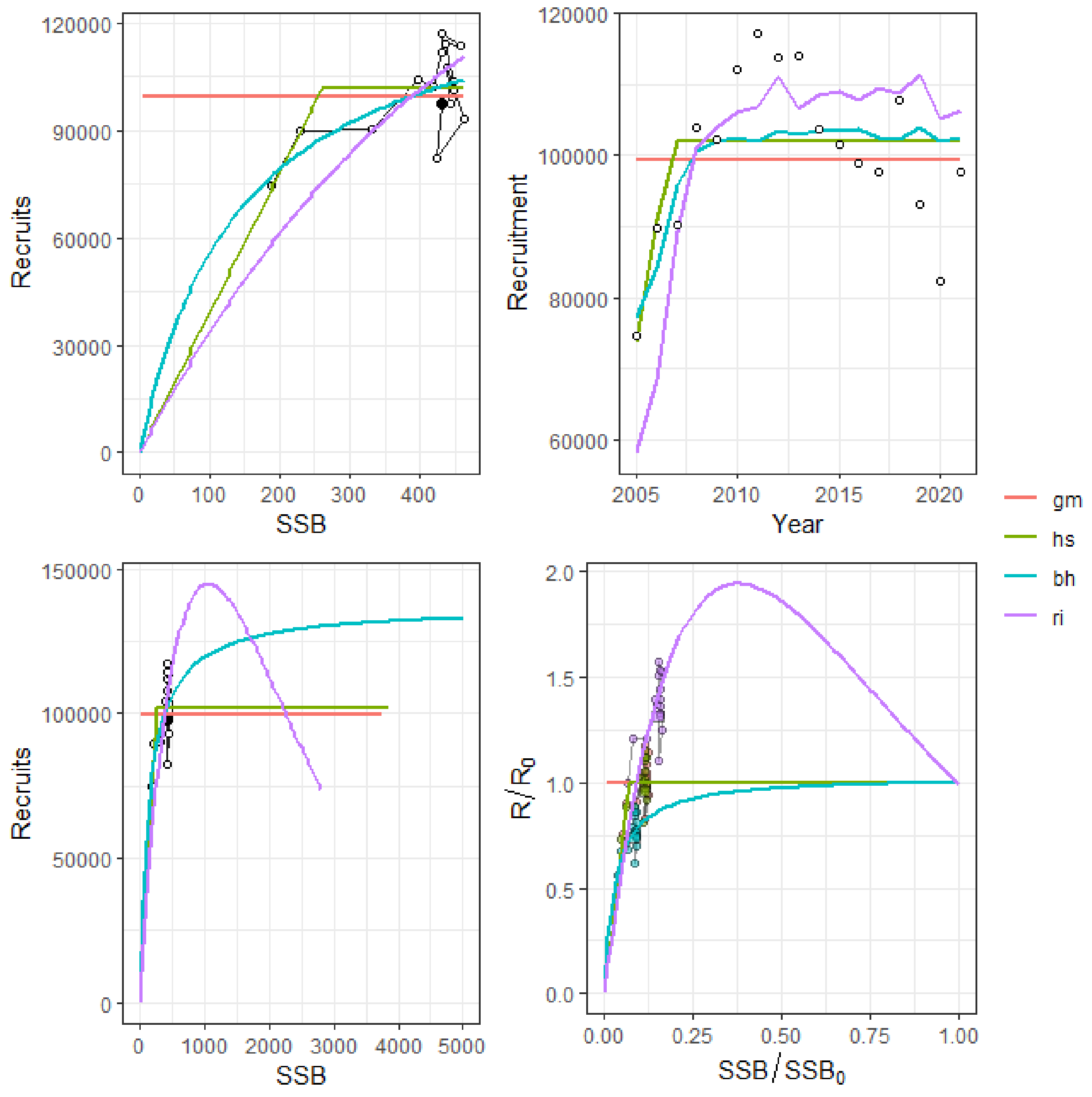


Figure 6.17.4.8 Blue and red shrimp in GSA 6 & 7. Summary of the four SR models.

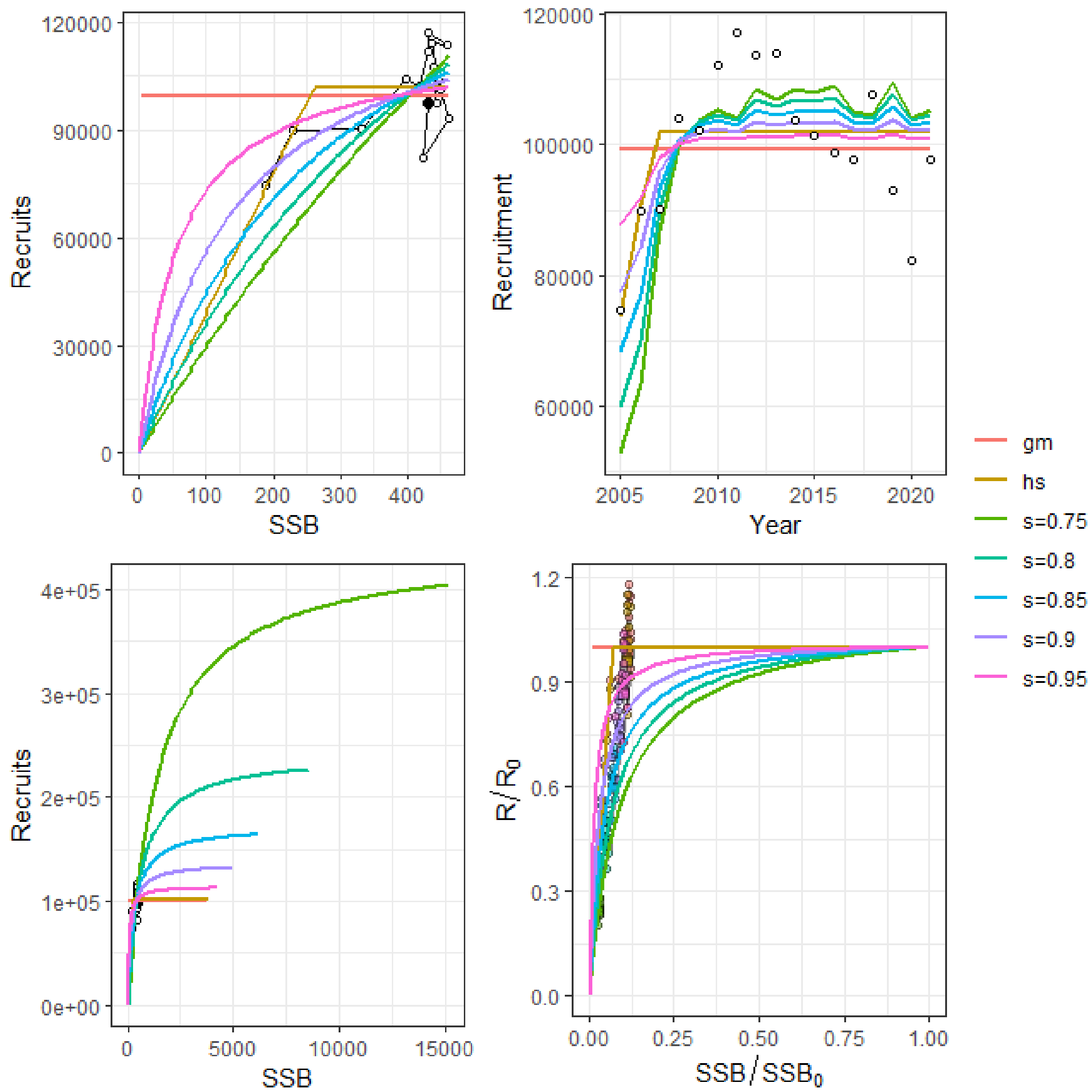


Figure 6.17.4.9 Blue and red shrimp in GSA 6 & 7. Per-recruit analysis with different slope (s, steepness) scenarios for the Beverton-Holt model.

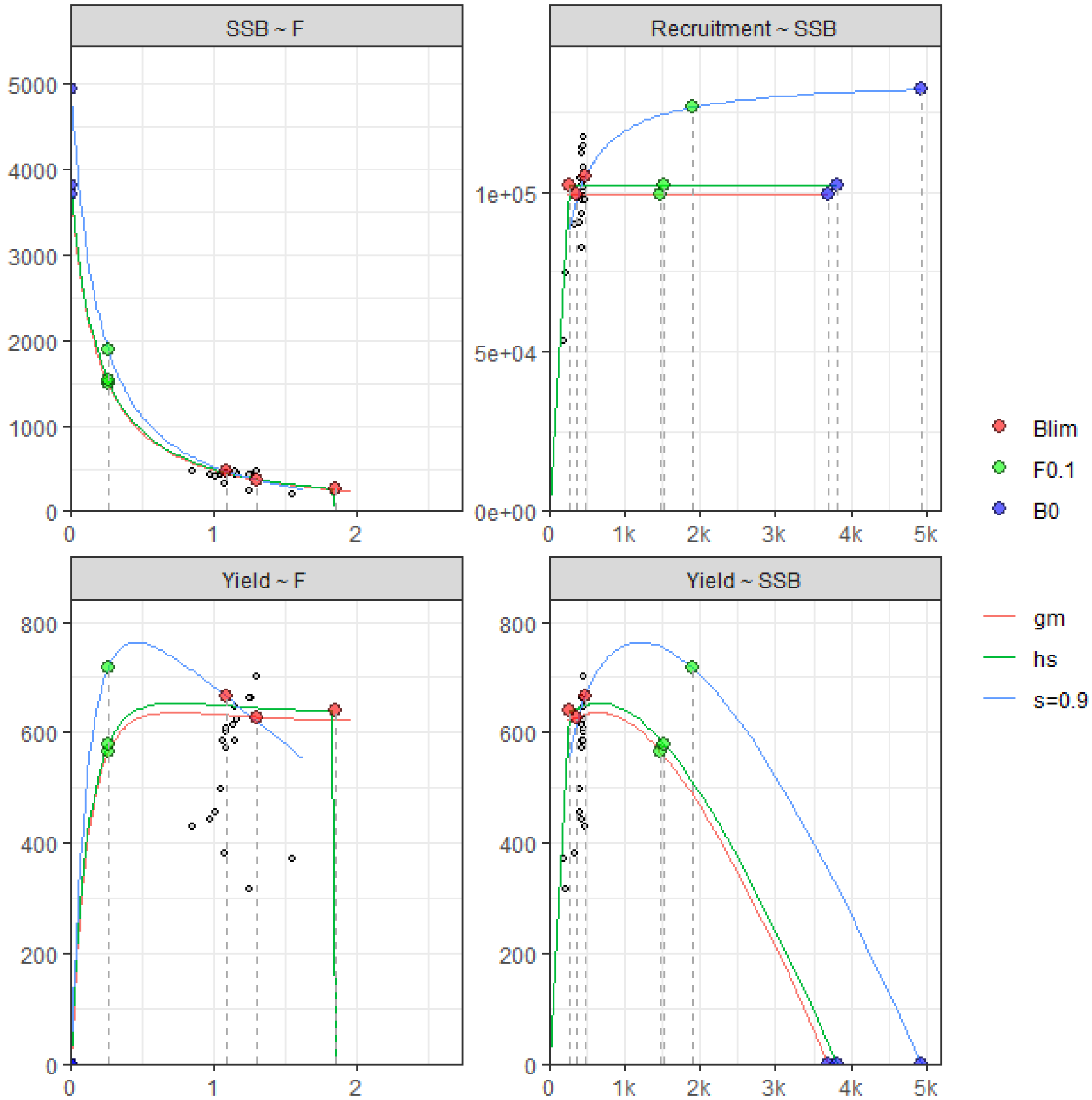


Figure 6.17.4.10 Blue and red shrimp in GSA 6 & 7. Long Term equilibrium evaluations for different S-R models.

6.17.4.3 Results

In the light of the outcomes of the exploratory analysis, it was decided to consider the HS model to provide reference points for the blue and red shrimp in GSA 6 & 7. Table 6.17.4.3 summaries the reference point values based on the Hockey-Stick model fitted to the data. B_{pa} is set to 2* B_{lim}. Historic assessment information is shown in Figures 6.17.4.11 and 6.17.4.12.

Table 6.17.4.3 Blue and red shrimp in GSA 6 & 7. Final reference points based on Hockey-Stick stock recruit model fitted to the data.

$F_{0.1}$	B_{lim}	B_{pa}	$B_{F0.1}$	B_0	Fpa
0.26	261	521	1520	3810	0.954

Figure 6.17.4.11 Blue and red shrimp in GSA 6 & 7. Status Advice plot showing stock trajectories of Recruitment, SSB, F, Landings and Yield compared to the estimated reference points, based on a Hockey-Stick stock-recruitment relationship.

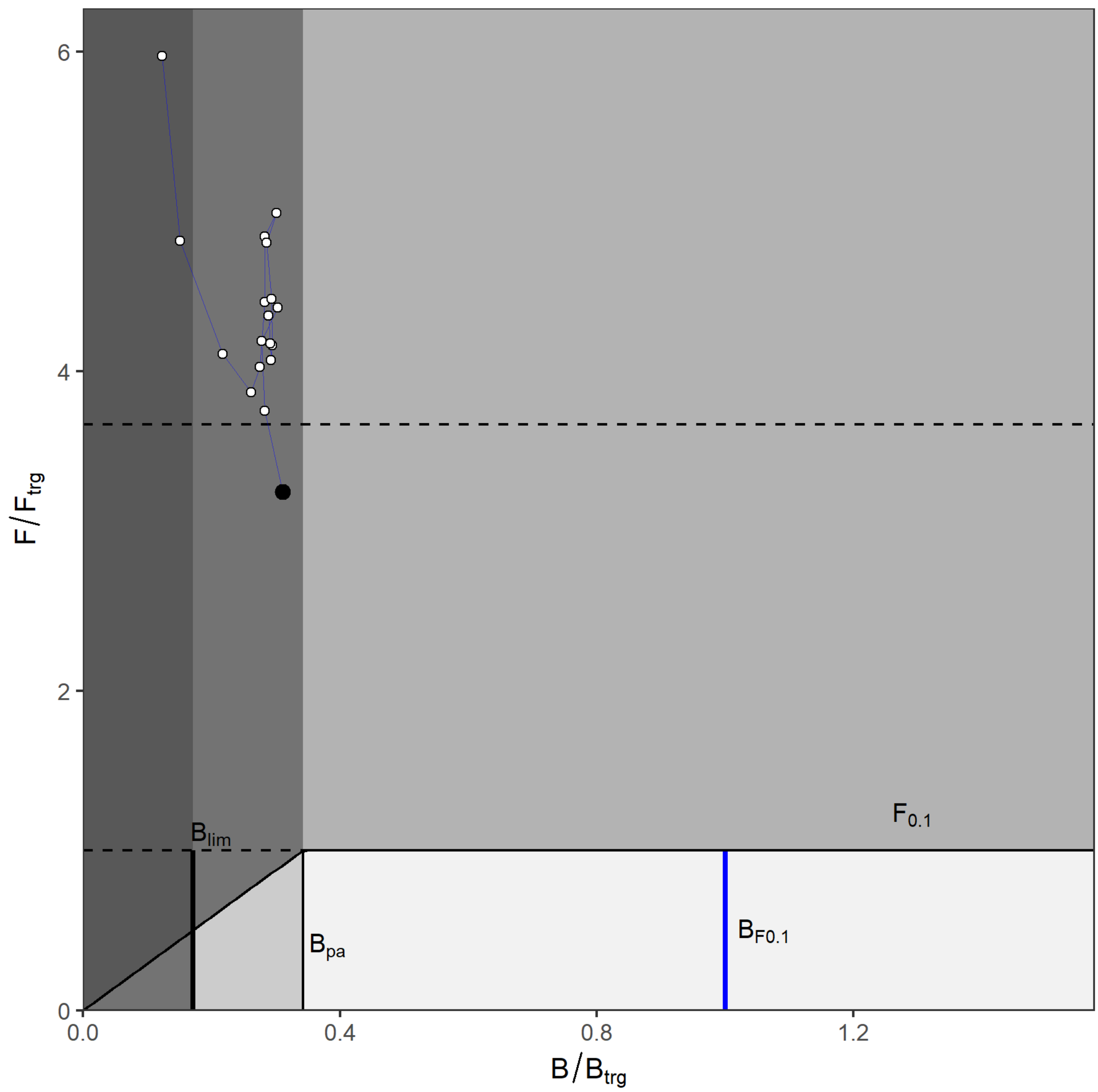


Figure 6.17.4.12 Blue and red shrimp in GSA 6 & 7. Advice Rule plots, with B_{lim} fitted to the data and B_{pa} = 2 B_{lim}

6.17.5 SHORT TERM FORECAST AND CATCH OPTIONS

6.17.5.1 Method

A deterministic short-term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age. While the F_{bar1-2} =0.85 (the last year's F estimated by the assessment model) was used for F in 2022 as F shows a declining trend.

Recruitment was taken from the fitted HS with SSB well above the break point, This is similar to the value obtained by excluding the three low recruitments observed at the beginning of the timeseries.

Table 6.17.5.1 Blue and red shrimp in GSAs 6 & 7: Assumptions made for the interim year and in the STF forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 1-2 (2022)	0.85	Fsq = F in the last year (2021)
SSB (2022)	554.45	SSB intermediate year from STF output
Rage1 (2022,2023)	102000	Recruitment is set on Hockey Stick relationship
Total Catch (2022)	603.38	Catch intermediate year from STF output

6.17.5.2 Results

The results of the short term forecasts for blue and red shrimp (GSA 6 & 7) are shown in Figure 6.17.5.1. and Table 6.17.5.2.

The current level of fishing mortality (0.85) is more than 3 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.26). This indicates that blue and red shrimp in GSA 6 & 7 is over fished.

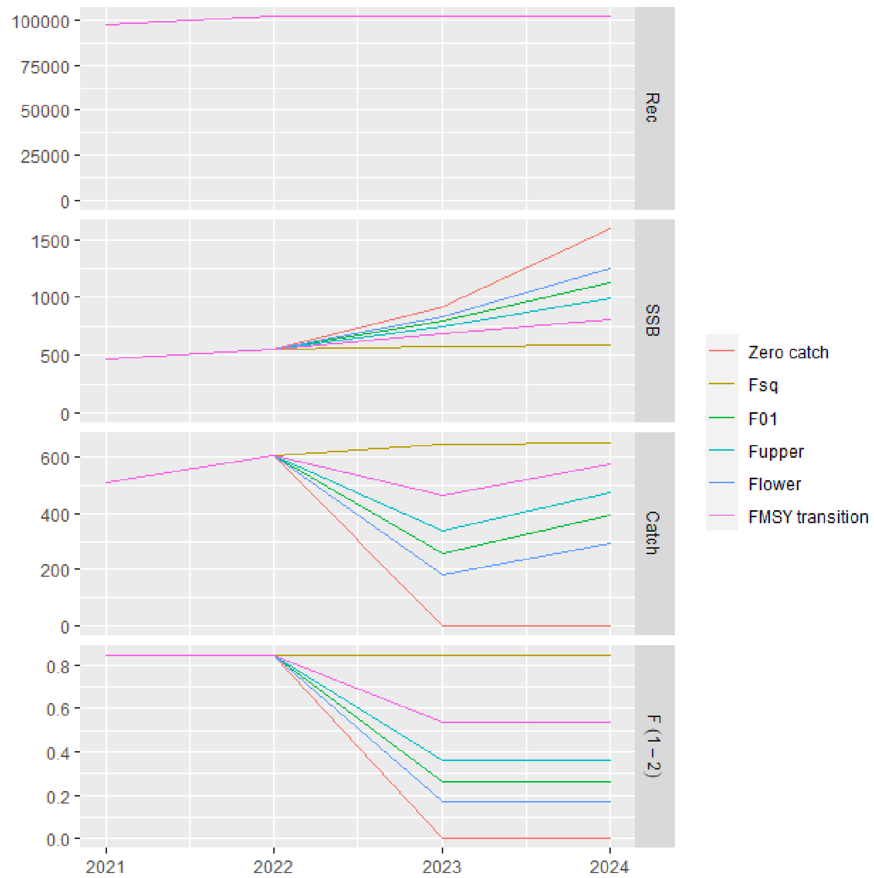


Figure 6.17.5.1 Blue and red shrimp in GSA 6 & 7. Annual catch scenarios and predictions of catch and SSB for blue and red shrimp (GSA 6 & 7).

Table 6.17.5.2 Blue and red shrimp (ARA) in GSA 6 & 7. Short term forecast. Annual catch scenarios and predictions of catch and SSB. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-2) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	257	0.26	1123	102.6	-49.6
$F_{MSY\ Transition}$ ^^	465	0.54	808	45.7	-8.7
$F_{MSY\ lower}$	180	0.17	1254	126.1	-64.7
$F_{MSY\ upper}$**	338	0.36	994	79.3	-33.7
Other scenarios					
Zero catch	0	0.00	1588	186.4	-100.0
Status quo	641	0.85	585	5.4	25.8
0.1	91	0.08	1414	155.0	-82.1
0.2	175	0.17	1263	127.9	-65.7
0.3	251	0.25	1133	104.4	-50.7
0.4	321	0.34	1020	84.0	-36.9
0.5	386	0.42	922	66.2	-24.2
0.6	446	0.51	836	50.7	-12.6
0.7	500	0.59	760	37.1	-1.8
0.8	551	0.68	694	25.2	8.1
0.9	598	0.76	636	14.7	17.3
1.1	681	0.93	539	-2.8	33.7
1.2	718	1.01	499	-10.1	41.0
1.3	753	1.10	463	-16.6	47.8
1.4	785	1.18	430	-22.4	54.1
1.5	815	1.27	402	-27.6	60.0

*SSB at mid-year

6.18 Blue and red shrimp in GSAs 8, 9, 10 and 11

6.18.1 Stock Identity and Biology

STECF EWG 22-09 was asked to assess the state of Blue and red shrimp in the GSAs 8, 9, 10 and 11.

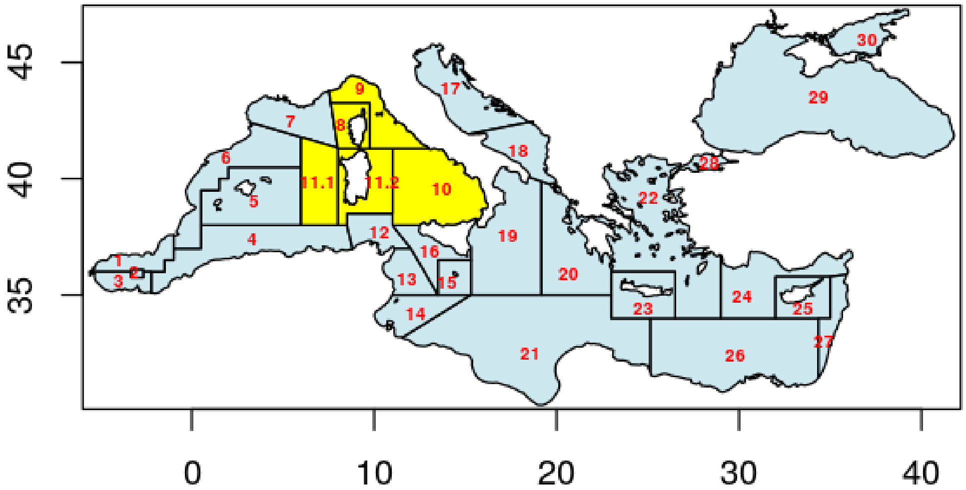


Figure 6.18.1.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Geographical location of GSAs 8, 9, 10 & 11.

The growth of blue and red shrimp (*Aristeus antennatus*) has been studied in GSA9 using model progression analysis (Colloca et al. 1998; Orsi Relini and Relini 1998). Data on recruitment from the Ligurian Sea (Orsi Relini and Relini, 1998) and results of tagging studies (Relini et al. 2000, 2004) provided the basis for an interpretation of growth in which the possible life span of blue and red shrimp is 8-10 years.

The following sets of Von Bertalanffy growth parameters (VBGP) are available in the literature (Orsi Relini and Relini 1998) and have been used in the present assessment to comply with the previous ones (STECF EWG 19-10, STECF EWG 20-09, STECF EWG 21-11):

Females : L_∞= 76.9, K=0.21, t_0=-0.02 and

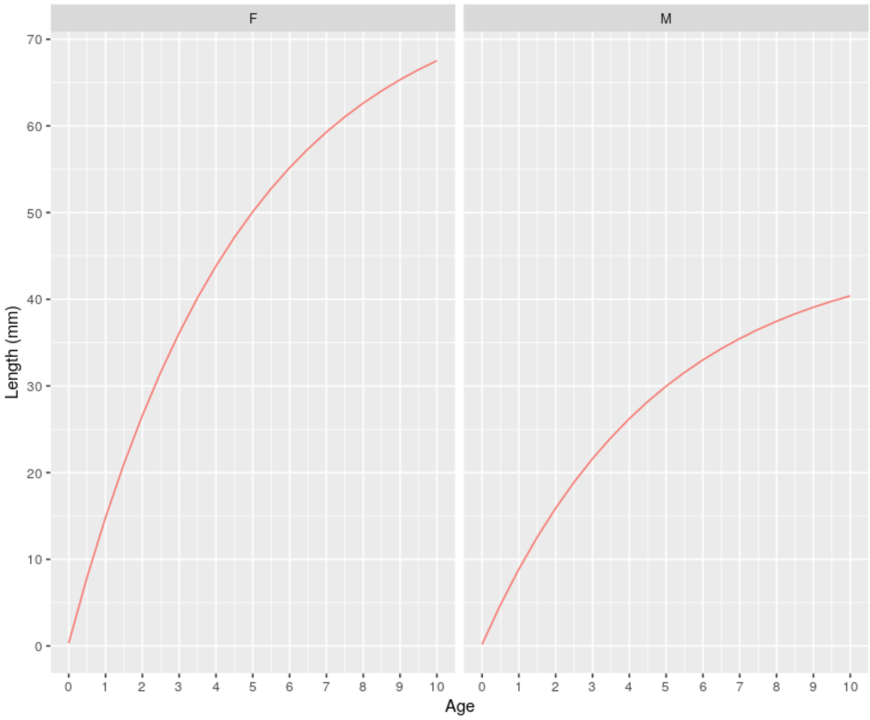
Males : L_∞= 46, K=0.21, t_0=-0.02.

These growth parameters were confirmed recently (Orsi Relini and Mannini, 2011; Orsi Relini et al., 2013) and are very close to the ones available in DCF biological dataset. STECF EWG 22-09 used the above set of growth parameters to convert catch in length into age (Figure 6.18.1.2).

As in previous years as input for the assessment the median values of *a* and *b* from GSA9 (Figure 6.18.1.3) were used (STECF EWG 19-10, STECF EWG 20-09, STECF EWG 21-11).

The VBGF and LW relationship parameters used are summarized in the following Table (Table 6.18.1.1).

The spawning season, although with some regional differences in the Mediterranean Sea, is somewhat extended, starting in spring (April), peaking in summer (July-August), when most of the females reach sexual maturity, and ending in autumn (October-November) (Orsi Relini and Relini, 1979; Orsi Relini and Pestarino, 1981; Colloca et al., 1998). Based on this, the proportions



of F and M before spawning were set to 0.5 in the assessment model.

Figure 6.18.1.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. Von Bertalanffy growth curves by sex used in the assessment (Orsi Relini and Relini, 1998).

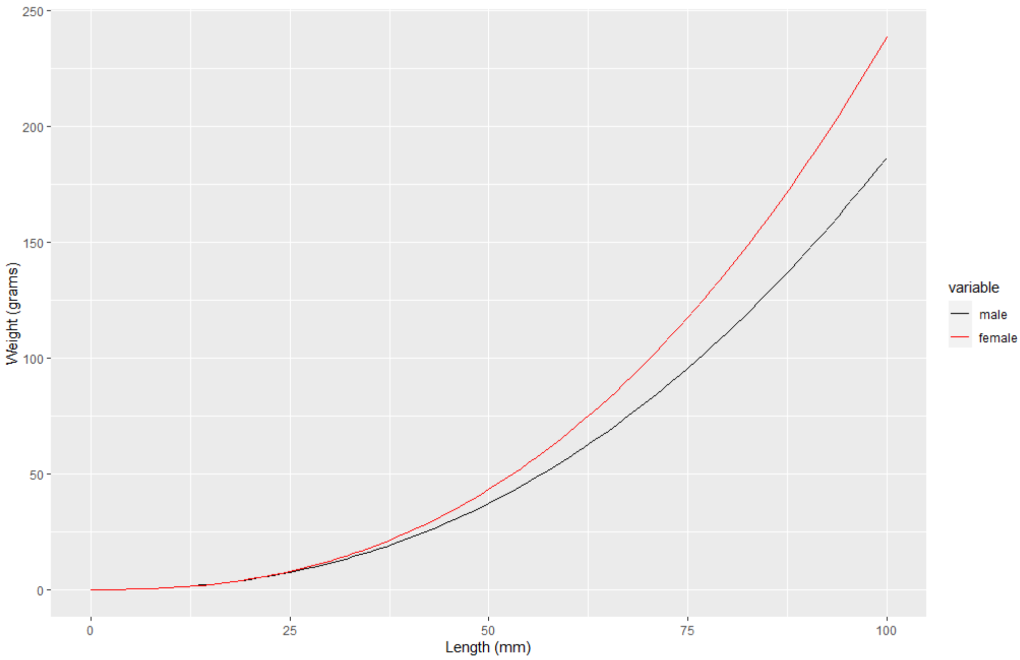


Figure 6.18.1.3. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length weight relationship by sex used in the assessment.

Table 6.18.1.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Growth parameters and length-weight relationship parameters used in the assessment.

GSA	Sex	L_{inf}	k	t_0	a	b
8_9_10_11	M	46.0	0.21	-0.02	0.0042	2.3237
	F	76.9	0.21	-0.02	0.0028	2.4652

The maturity vector was taken from previous year assessments (STECF EWG 19-10, STECF EWG 20-09, STECF EWG 21-11) (Table 6.18.1.2) and natural mortality vector was computed using Chen & Watanabe formula (Table 6.18.1.3) based on the same VBGF parameters reported above.

Table 6.18.1.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. Maturity vector used in the assessment.

Maturity	0	1	2	3	4	5	6+
GSAs 8_9_10_11	0	0.204	0.786	0.983	0.999	1.000	1.000

Table 6.18.1.3. Blue and red shrimp in GSAs 8, 9, 10 & 11. Natural mortality vectors used in the assessment.

M	0	1	2	3	4	5	6+
GSAs 8_9_10_11	2.023	0.768	0.511	0.402	0.342	0.301	0.281

6.18.2 DATA

6.18.2.1 CATCH (LANDINGS AND DISCARDS)

The blue and red shrimp is one of the most important target species of the fishery carried out on the muddy bottoms of the upper and middle slope. The species is almost exclusively exploited by bottom trawlers. In the past, in particular in GSA 10 there was a Gillnet fleet (GNS) targeting ARA associated with very low landings (less than 1.5 t). Sporadic landings are reported for FPO, GTR and OTM.

Landings

Landings data were reported to STECF EWG 22-09 through the DCF. Landings data by year, GSA and fleet are presented in Figures 6.18.2.1.1-3, total landings by year and GSA are presented in Table 6.18.2.1.1. In all GSAs most of the landings come from otter trawls. DCF data coming from other gear were considered inaccurate or sampled inconsistently; anyway, their catches were included in the stock assessment due to the low amounts. GSA 8 reported catches only in 2010 and 2011.

Data from GSA 10 in 2017 was reported only for Q3 and Q4. Therefore, the landings for Q1 and Q2 were recovered from the FDI data.

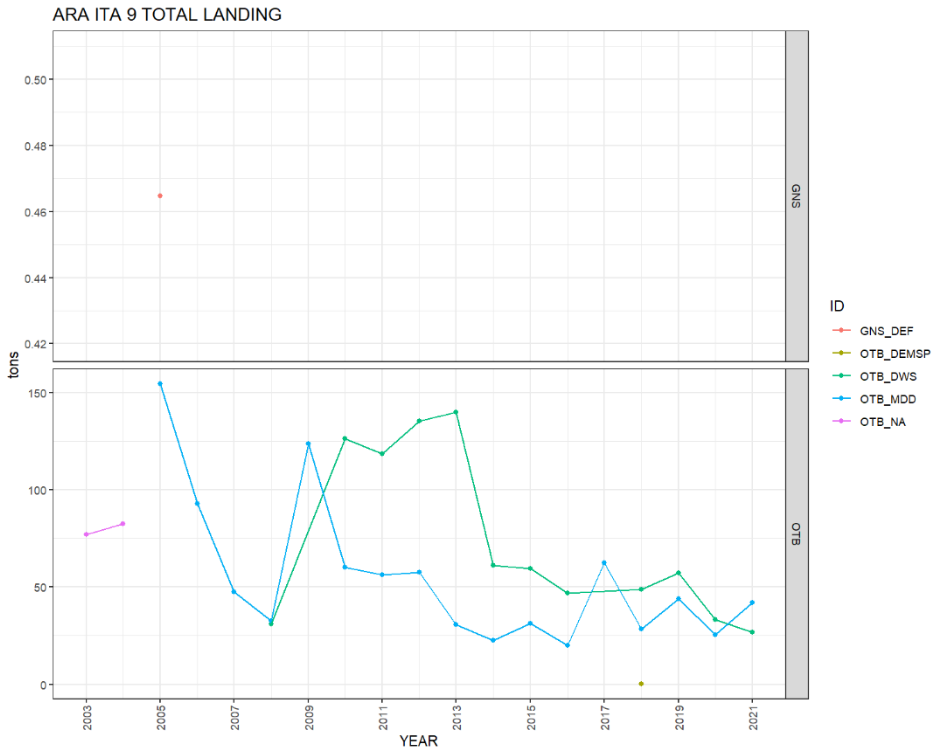


Figure 6.18.2.1.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Landings data in tonnes by year, area and fleet in GSA 9.

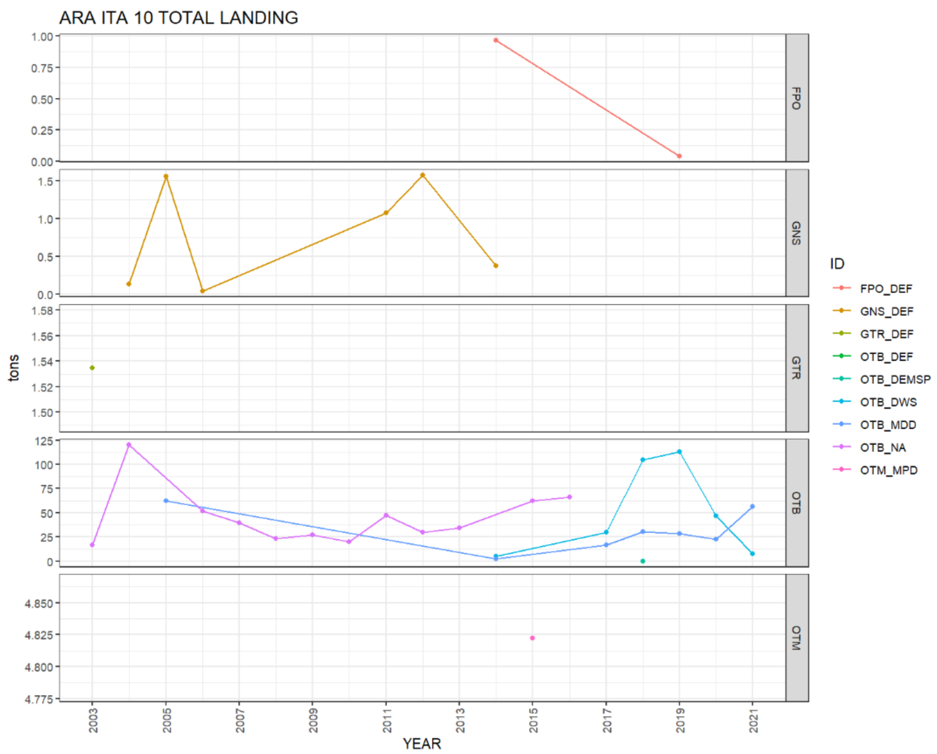


Figure 6.18.2.1.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. Landings data in tonnes by year, area and fleet in GSA 10. Data from 2017 is incomplete.

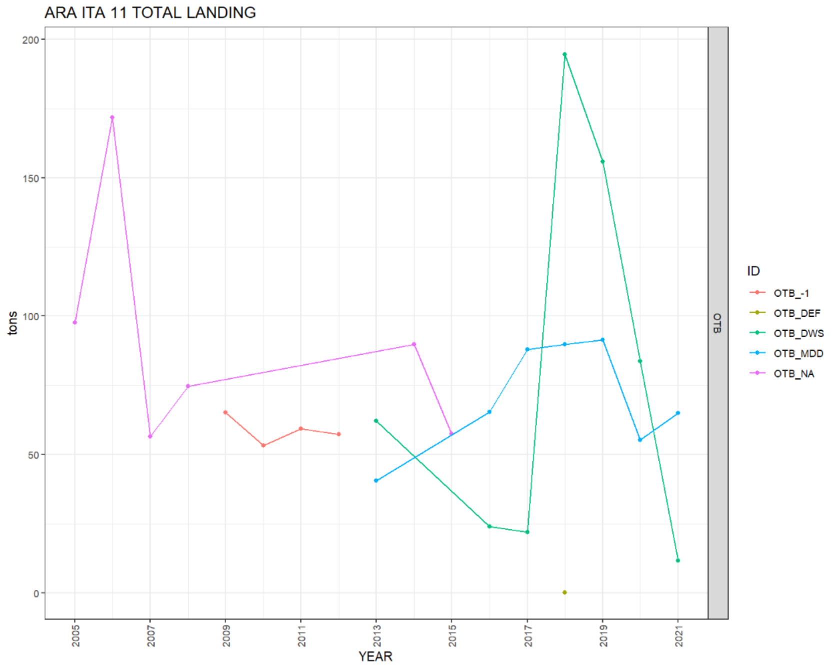


Figure 6.18.2.1.3. Blue and red shrimp in GSAs 8, 9, 10 & 11. Landings data in tonnes by year, area and fleet in GSA 11.

Table 6.18.2.1.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Landings data in tonnes by year and GSA.

Year	GSA 8	GSA 9	GSA 10	GSA 11	Total landings
2003	-	77	19	-	95**
2004	-	82	120	-	203**
2005	-	155	64	98	317
2006	-	93	52	172	316
2007	-	47	39	57	143
2008	-	63	23	75	161
2009	-	123	27	65	216
2010	3.57	186	20	53	263***
2011	4.30	175	48	59	287***
2012	-	193	31	57	281
2013	-	170	34	103	307
2014	-	84	9	90	182
2015	-	91	67	58	215
2016	-	67	66	89	222
2017	-	62	79*	110	219
2018	-	77	135	285	497
2019	-	101	141	247	490
2020	-	59	69	139	267
2021	-	69	64	77	209

* Data from 2017 from FDI data.

** Incomplete

*** Includes GSA 8

Length frequency distribution of the landings by year, GSA and fleet from the DCF database are presented in Figures 6.2.1.2.1.4-6.

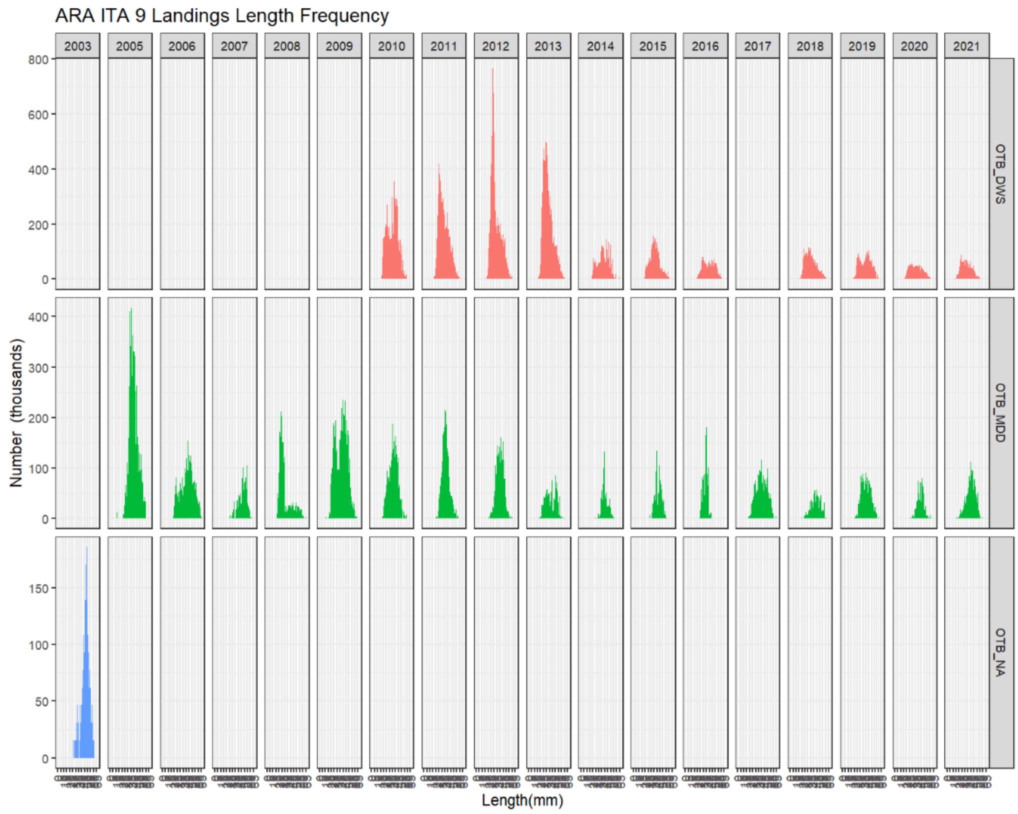


Figure 6.18.2.1.4. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 9.

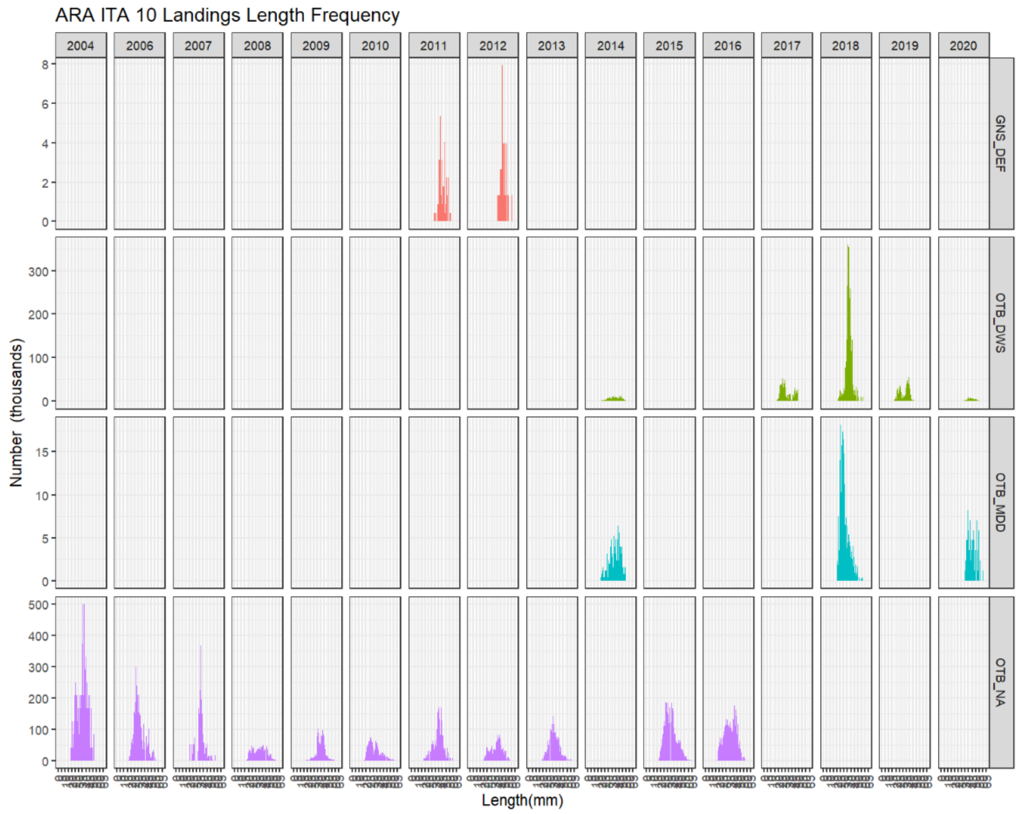


Figure 6.18.2.1.5. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 10.

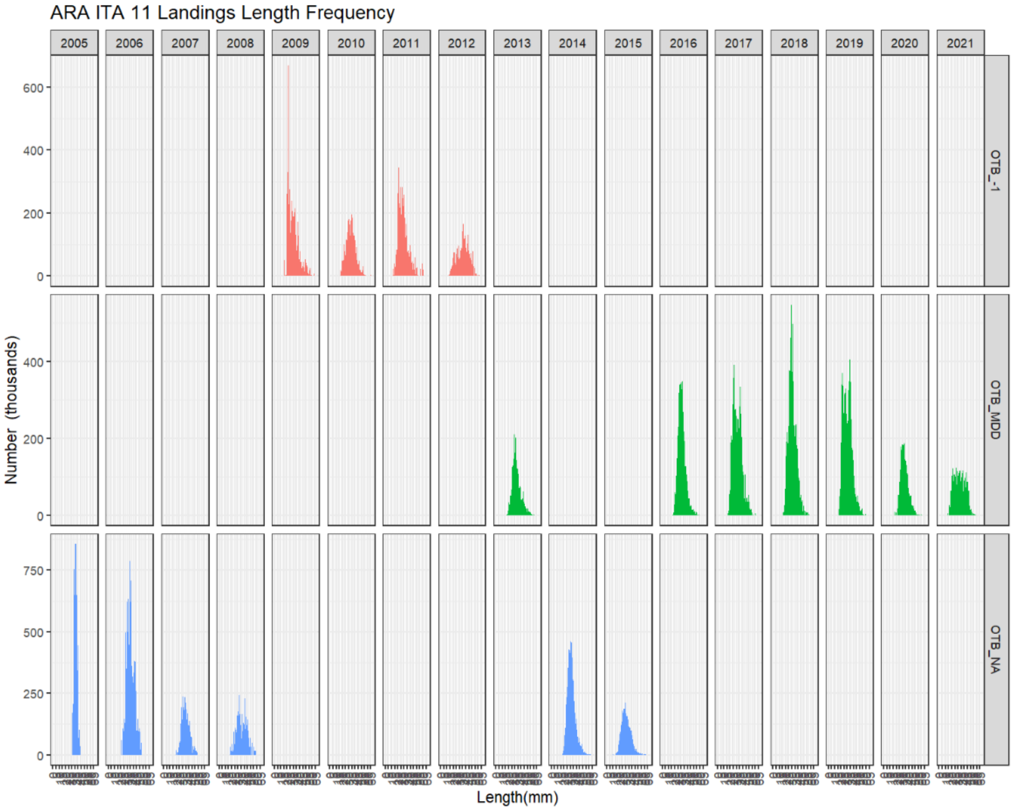


Figure 6.18.2.1.6. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 11.

In GSA 9, length frequency distributions were not available for 2004.

In GSA 10, length frequency distributions were not available for 2003, 2005 and 2021. For the period 2018-2020 the length frequency distribution is provided for a very low percentage of the landings.

In GSA 11, length frequency distributions for OTB_DWS were not available for any year with landings associated.

The group decided to use the scripts developed during STECF EWG 21-02 to fill the missing length frequency distributions for the metiers without any length information with the exception of GSA 8. However, raising of the landings for the metiers with partial length frequency distributions was performed together with the SOP correction. Reconstructed length frequency distribution of the landings by year and fleet and the reconstruction procedure are presented in Figures 6.2.1.2.1.7-12.

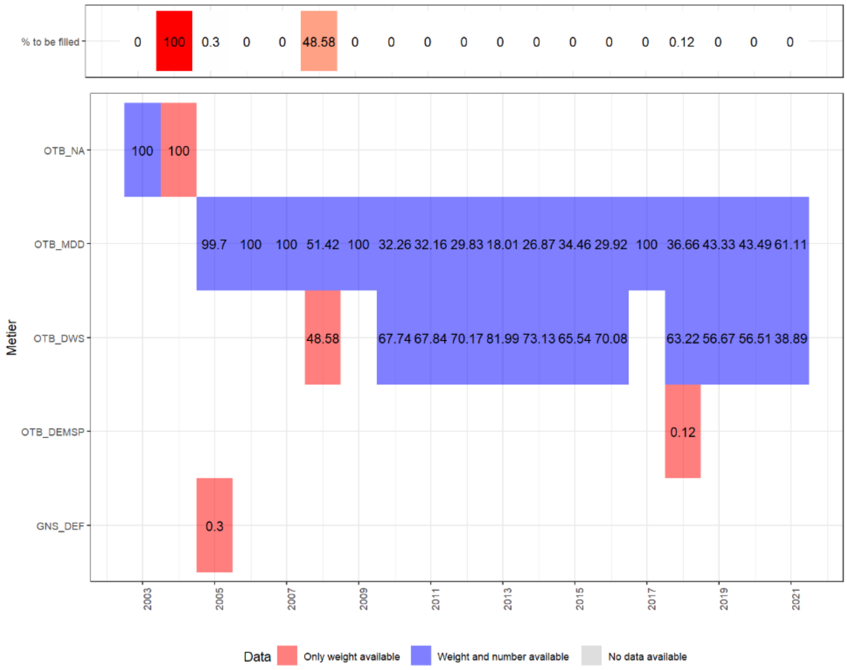


Figure 6.18.2.1.7. Blue and red shrimp in GSAs 8, 9, 10 & 11. Reconstruction of the length frequency distribution of the landings by year and fleet for GSA 9. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

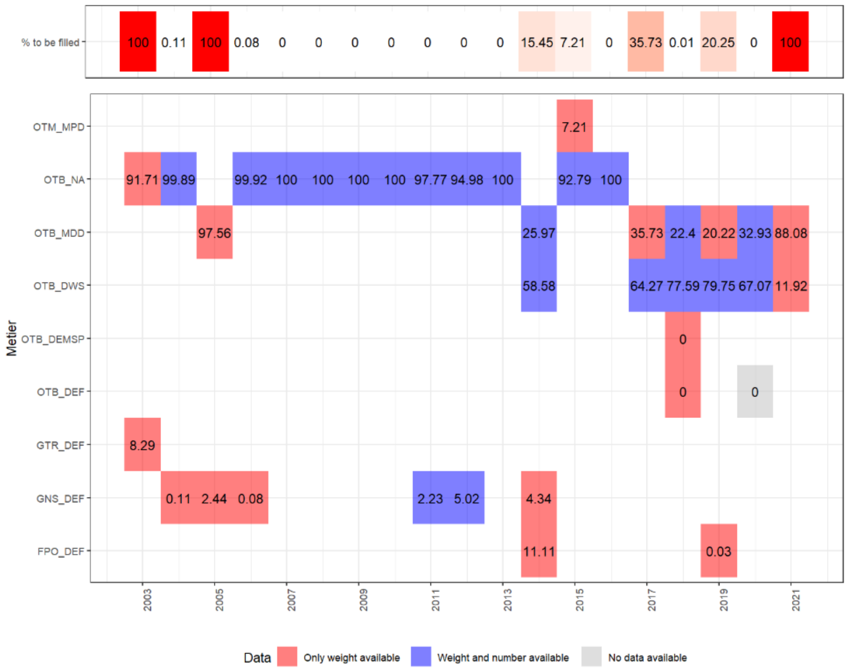


Figure 6.18.2.1.8. Blue and red shrimp in GSAs 8, 9, 10 & 11. Reconstruction of the length frequency distribution of the landings by year and fleet for GSA 10. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

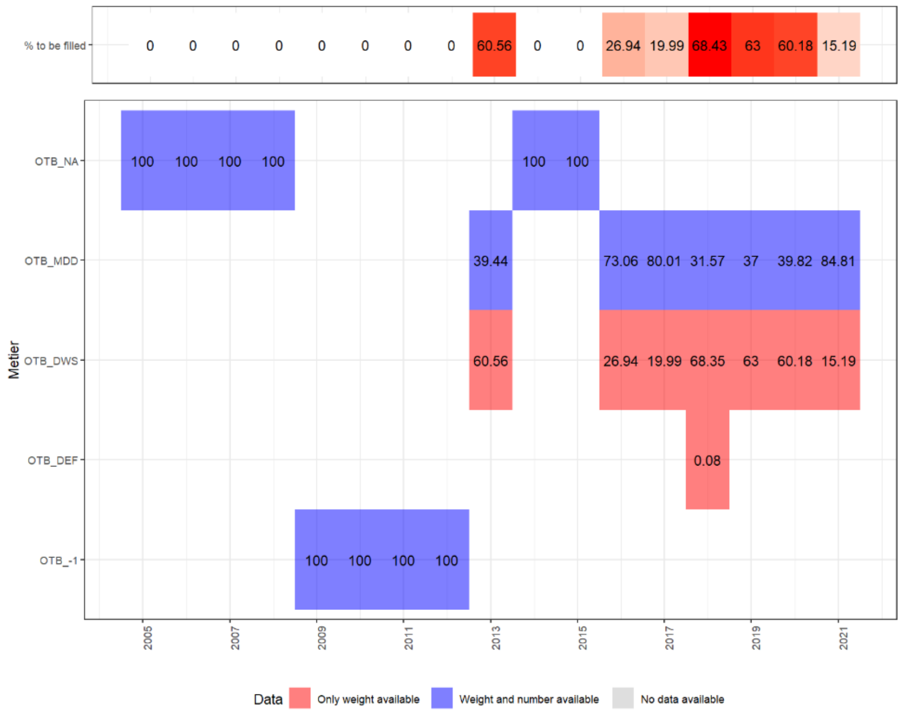


Figure 6.18.2.1.9. Blue and red shrimp in GSAs 8, 9, 10 & 11. Reconstruction of the length frequency distribution of the landings by year and fleet for GSA 11. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

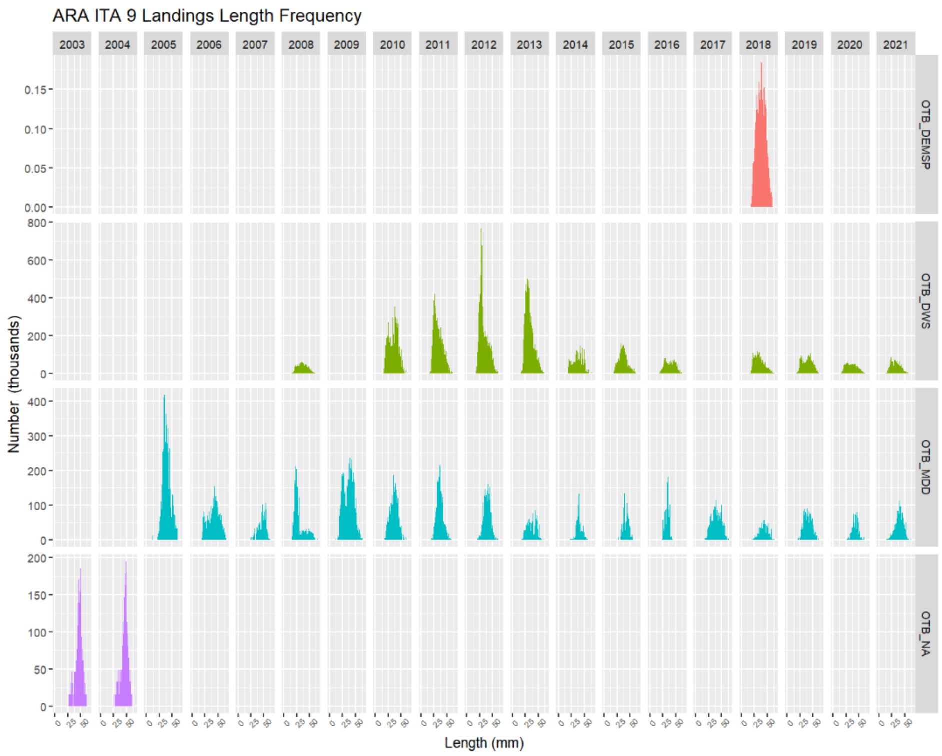


Figure 6.18.2.1.10. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution of the reconstructed landings by year and fleet for GSA 9.

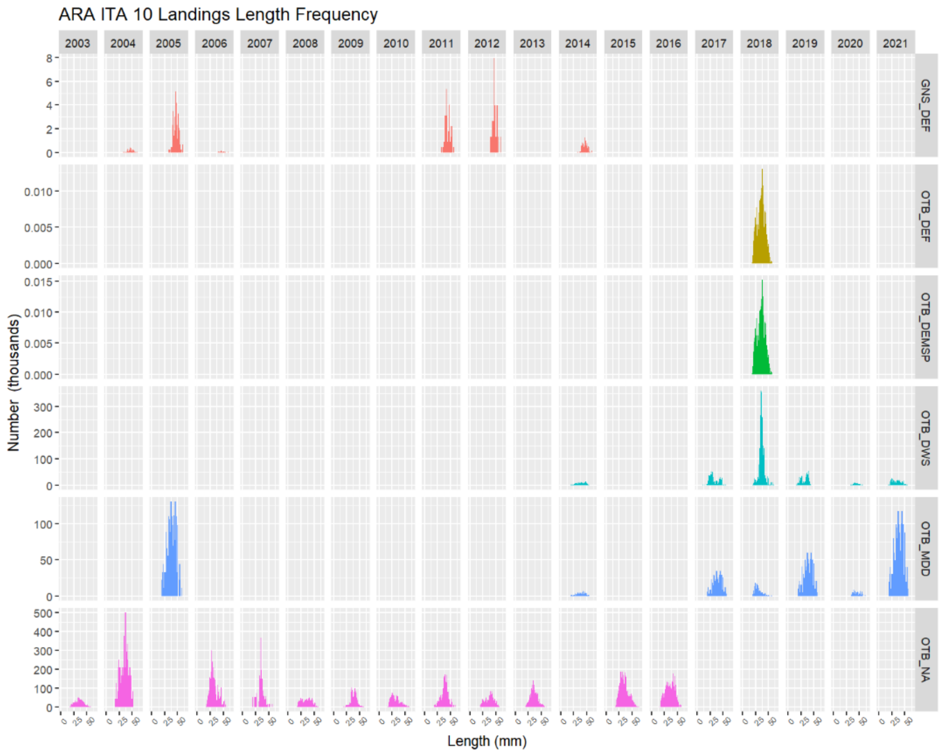


Figure 6.18.2.1.11. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution of the reconstructed landings by year and fleet for GSA 10.

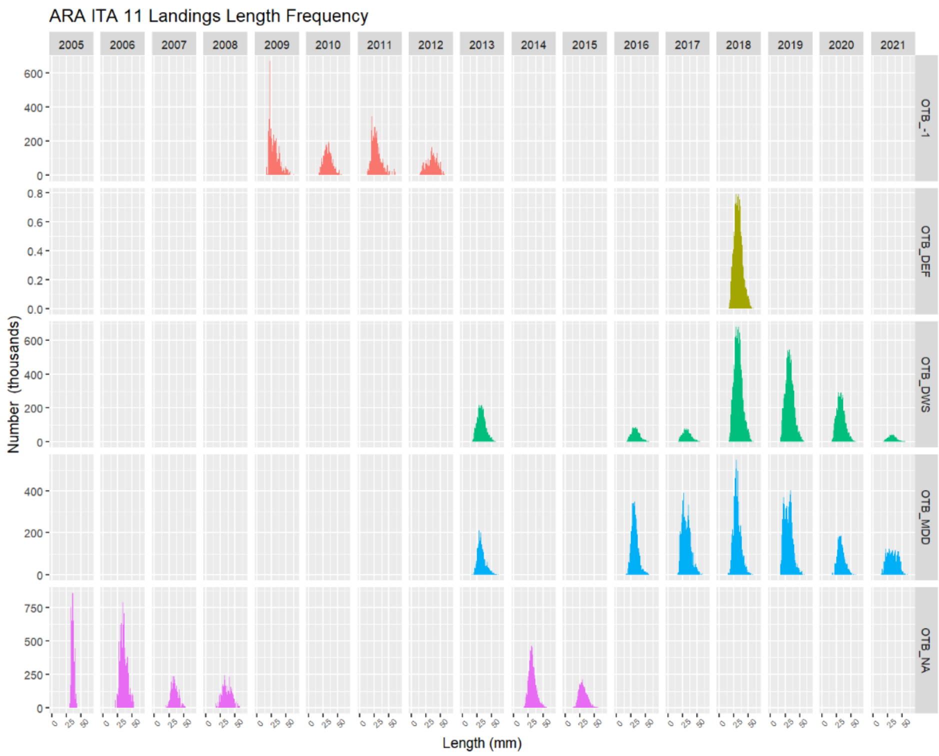


Figure 6.18.2.1.12. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution of the reconstructed landings by year and fleet for GSA 11.

Discards

Discards data were reported to STECF EWG 22-09 through the DCF. In general, blue and red shrimp is very rarely discarded. In the study area, very small quantities of blue and red shrimp were only discarded in 2011 and in 2021 in GSA 9; no discard data are reported for GSAs 8, 10 and 11. Total discard by year and GSA for the bottom trawl fishery is presented in Table 6.18.2.1.2. Due to the negligible amount of discards, no discard reconstruction was performed.

Table 6.18.2.1.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. OTB discards data in tonnes by GSA.

	Total Discard (tonnes)				
	GSA 8	**GSA 9**	**GSA 10**	**GSA 11**	**Total**
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	-	-	-	-
2006	-	-	-	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	0.403	-	-	0.403
2012	-	-	-	-	-
2013	-	-	-	-	-
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	-	-	-	-
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	0.0004	-	-	0.0004

Discards were included in the stock assessment. Therefore, we will refer to catches as landings plus discards in the rest of the report.

6.18.2.2 EFFORT DATA

Effort data is not available to this EWG, the effort analysis is now carried out by STECF EWG 22-10, and effort results are available from that meeting.

6.18.2.3 SURVEY DATA

The MEDITS (Mediterranean International Trawl Survey) survey is an extensive trawl survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime, following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintained fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end, is used throughout GSAs and years. The timing of the survey is shown in Figure 6.18.2.3.1.

In the current assessment, combined MEDITS data for GSAs 8, 9, 10 and 11 from 2006 onwards were used, as commercial data were fully available for the four GSAs starting from that year. The combined MEDITS biomass and density indexes as well as the corresponding length frequency distributions were calculated using the script provided by JRC (Figures 6.18.2.3.2 and 6.18.2.3.3). MEDITS surveys in all four GSAs were delayed in 2020 and not performed in GSA 8.

Sensitivity analyses of the effects on the index of the inclusion or exclusion of GSA 8 showed negligible differences. Therefore, the index in 2020 was not modified to take into account the missing hauls in GSA 8.

Figure 6.18.2.3.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Timing of the survey.

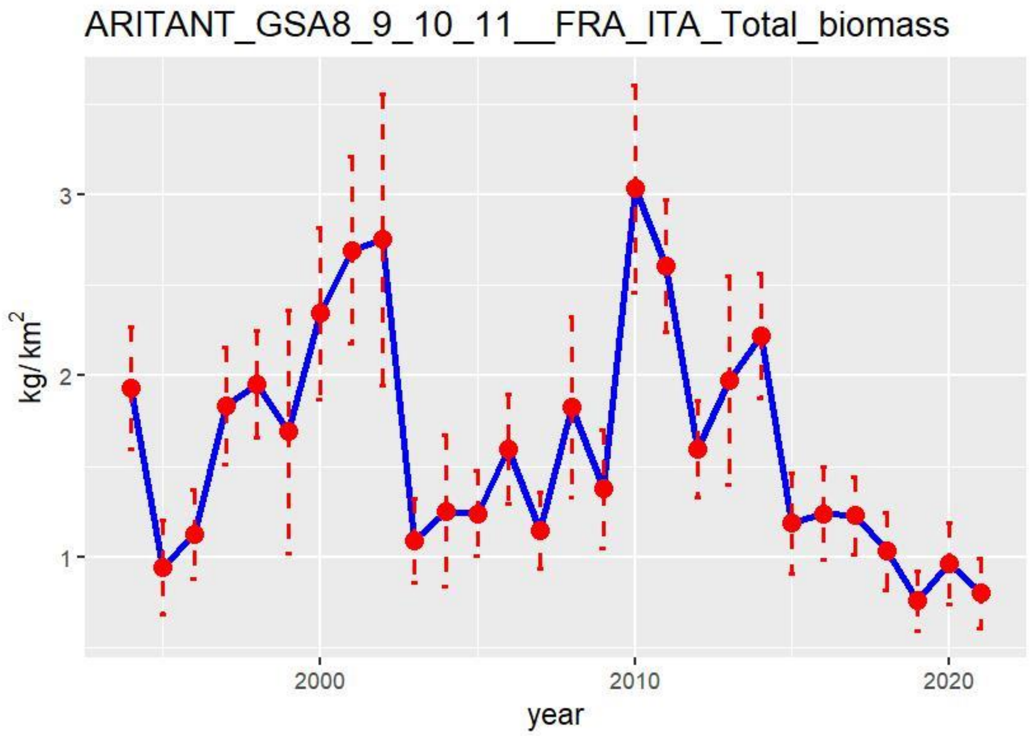


Figure 6.18.2.3.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

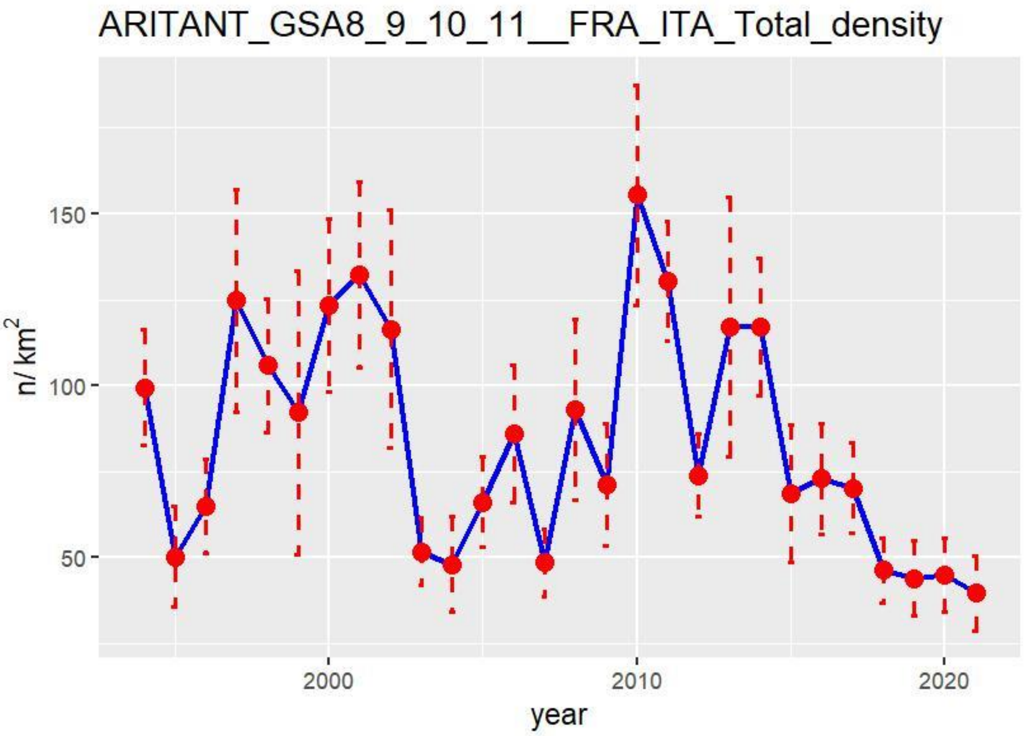


Figure 6.18.2.3.3. Blue and red shrimp in GSAs 8, 9, 10 & 11. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series and a clear declining trend since 2014.

Length frequency distributions for male, female and sex combined are shown in Figures 6.18.2.3.4-6.

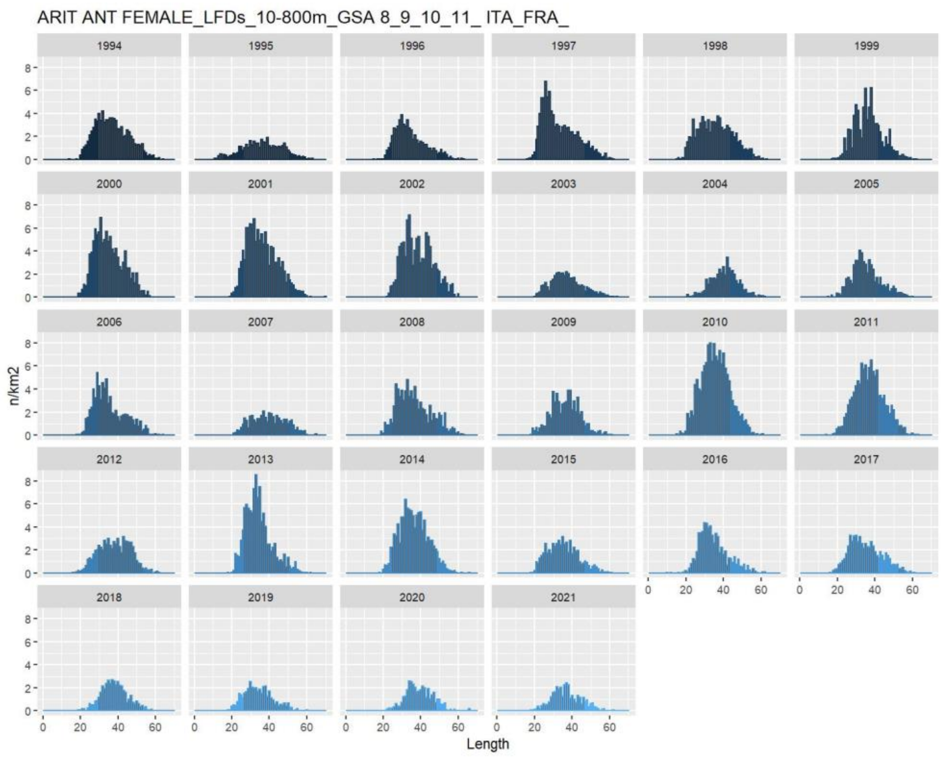


Figure 6.18.2.3.4. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution by year for females of MEDITS survey.

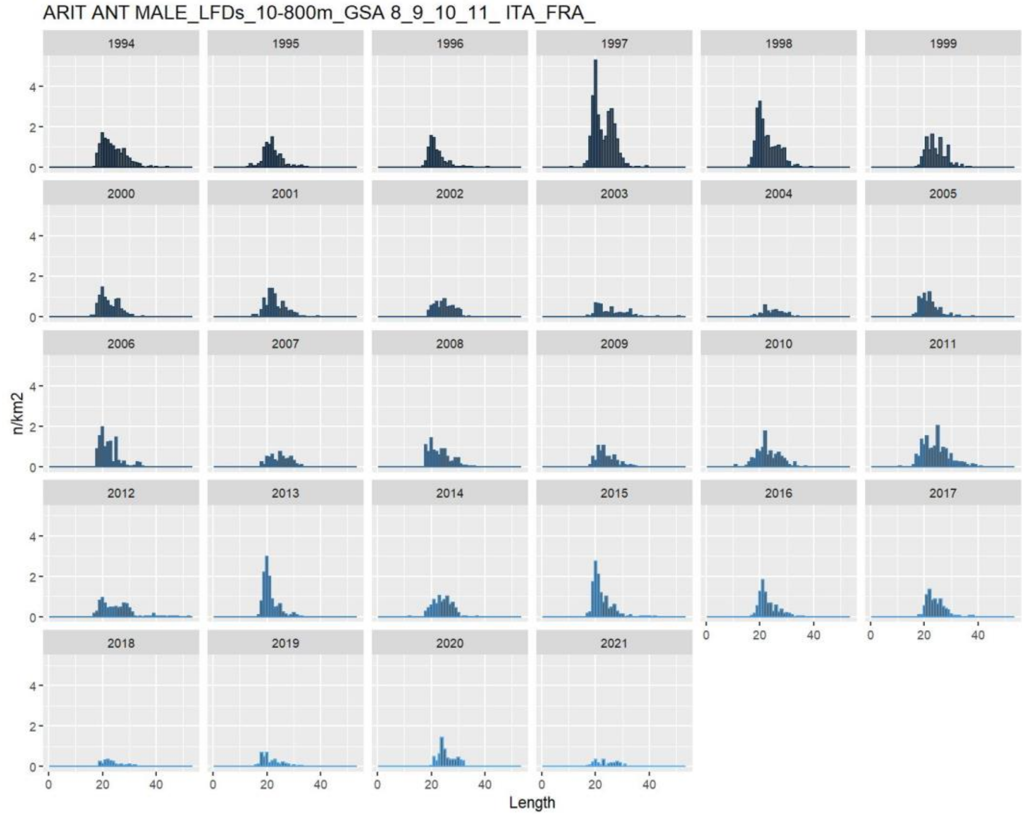


Figure 6.18.2.3.5. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution by year for males of MEDITS survey.

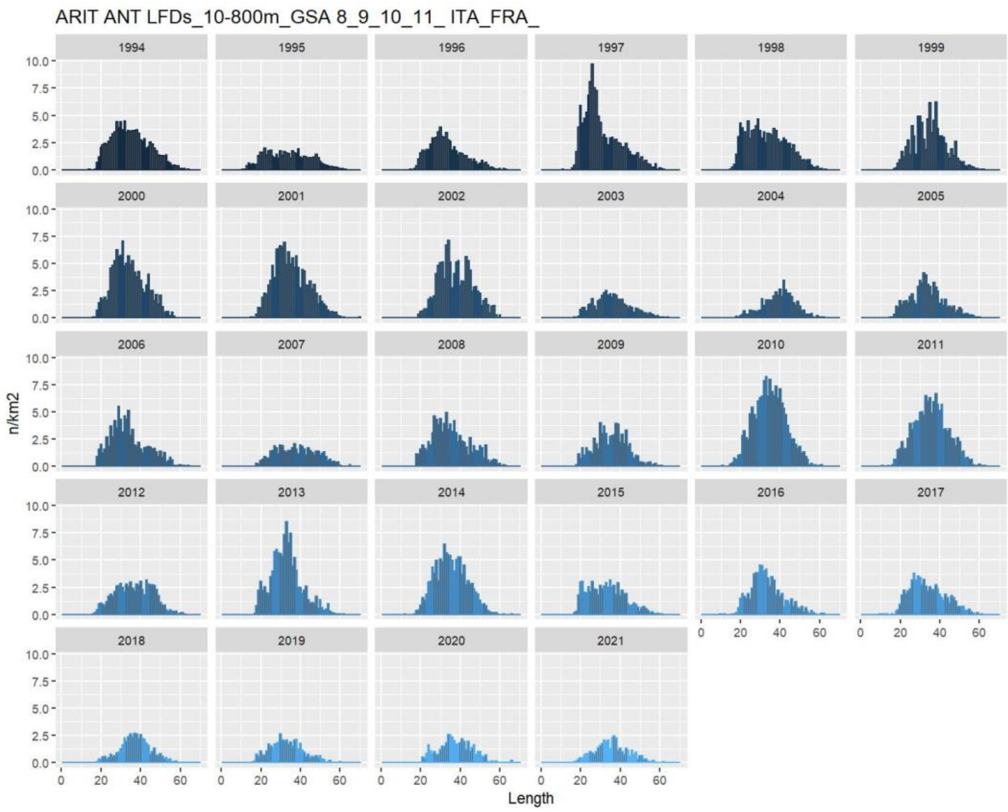


Figure 6.18.2.3.6. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length frequency distribution by year for sexes combined of MEDITS survey.

6.18.3 STOCK ASSESSMENT

A statistical catch-at-age assessment was carried out for this stock, using the Assessment for All Initiative (a4a) method (Jardim et al. 2015). The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike XSA, model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error.

The model was fitted using as input data the period 2006-2021 for the catch data (landings + discards) and for the tuning index.

Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR, using for each GSA the same sex specific growth parameters. Catch at age by sex were obtained by splitting commercial total length distribution according to a sex-ratio vector model obtained from DCF available sex ratio vectors in the respective areas. The analyses were carried out for the ages 1 to 6+. Concerning the Fbar, the age range used was 2-5.

Input data

The growth parameters used for VBGF were the one reported in table 6.18.1.1.

Total catches and catch numbers at age were used as input data. SOP correction was applied to catch numbers at age. Table 6.18.3.1 present the SOP correction vector applied. The SOP correction is quite high in 2017-2020 partly because of missing length frequency distributions in the catches of those years.

Table 6.18.3.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. SOP correction vector.

Year	SOP
2006	0.95
2007	0.95
2008	0.96
2009	0.97
2010	0.99
2011	0.98
2012	0.97
2013	0.98
2014	0.97
2015	1.04
2016	0.97
2017	1.23
2018	1.18
2019	1.25
2020	1.38
2021	1.04

Table 6.18.3.2 lists the input data for the a4a model, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age, Proportion of M and F before spawning, and the tuning series at age.

Table 6.18.3.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. Input data for the a4a model.

Catches (t)

2006	2007	2008	2009	2010	2011	2012	2013
316.1	143.4	161.1	216.2	263.8	286.9	281.4	307.5
2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
182.1	215.1	222.1	251.5	496.9	489.6	266.8	209.0

Catch numbers-at-age matrix (thousands)

age	2006	2007	2008	2009	2010	2011	2012	2013
1	766.1	229.6	997.7	1753.6	1355.5	2157.3	1243.9	1767.4
2	5946.7	2116.1	2420.3	2923.1	3803.6	4972.2	3922.8	6610.1
3	4616.3	2268.5	2433.6	3543.7	4864.5	4941.4	4292.2	4744.9
4	2067.5	811.0	1414.5	1819.1	2205.8	2388.3	3080.1	2580.7
5	944.1	517.4	538.0	689.9	749.0	896.3	1049.2	1093.4
6+	485.6	225.6	274.5	356.9	426.2	551.0	410.3	462.1
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	883.7	1074.0	1071.9	1745.3	3202.0	3510.0	1329.2	1003.8
2	3832.5	3709.2	5128.4	4566.3	11929.6	10426.1	5575.1	2763.7
3	2725.7	3528.8	3156.8	3983.4	8973.2	8074.6	4193.4	3342.0
4	1322.8	1636.1	1685.5	1907.7	2890.3	3394.5	1986.6	1991.5
5	567.1	619.8	673.7	761.6	1095.9	1254.4	656.3	605.7
6+	214.8	348.4	285.8	325.1	431.3	457.6	262.8	213.0

Weights-at-age (kg)

age	2006	2007	2008	2009	2010	2011	2012	2013
1	0.007	0.007	0.007	0.006	0.007	0.007	0.007	0.007
2	0.014	0.014	0.013	0.012	0.013	0.013	0.013	0.013
3	0.023	0.022	0.021	0.020	0.022	0.021	0.022	0.020
4	0.029	0.032	0.028	0.030	0.028	0.026	0.027	0.025
5	0.038	0.044	0.038	0.040	0.034	0.031	0.033	0.030
6+	0.056	0.052	0.048	0.044	0.028	0.032	0.031	0.029
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
2	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
3	0.021	0.021	0.022	0.021	0.021	0.021	0.022	0.022
4	0.028	0.029	0.027	0.028	0.025	0.028	0.029	0.031
5	0.037	0.037	0.034	0.039	0.033	0.037	0.036	0.038
6+	0.033	0.037	0.035	0.045	0.042	0.040	0.043	0.034

Maturity, Natural mortality, proportion of M and F before spawning vectors.

Age	1	2	3	4	5	6+
Maturity	0.20	0.79	0.98	1	1	1
M	0.77	0.51	0.40	0.34	0.31	0.28
Prop M	0.5	0.5	0.5	0.5	0.5	0.5
Prop F	0.5	0.5	0.5	0.5	0.5	0.5

Deep-water rose shrimp GSA 8, 9, 10 & 11. MEDITS number (n/km^2) at age for GSA 1.

age	2006	2007	2008	2009	2010	2011	2012	2013
1	8.26	2.83	8.32	4.97	17.62	9.13	5.56	11.47
2	41.63	13.26	38.63	24.89	59.50	46.80	23.25	65.73
3	19.56	14.80	24.84	26.81	53.27	45.11	21.77	27.85
4	9.76	9.95	11.05	9.10	17.70	19.02	17.02	7.15
5	4.35	5.31	7.50	1.96	6.25	7.63	4.20	4.11
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	10.43	9.19	5.92	8.96	2.06	6.38	1.24	3.31
2	44.85	28.31	36.96	27.43	14.93	19.56	12.13	14.13
3	38.73	20.77	18.98	19.74	19.70	12.41	18.11	13.55
4	17.72	6.66	7.39	9.85	6.32	3.89	9.25	5.93
5	4.50	2.76	2.78	3.13	2.72	1.51	3.94	2.23

Figures 6.18.3.1-5 show the age structure of the catches, of the index, the weight at age matrix and the catch at age and MEDITS cohort consistency

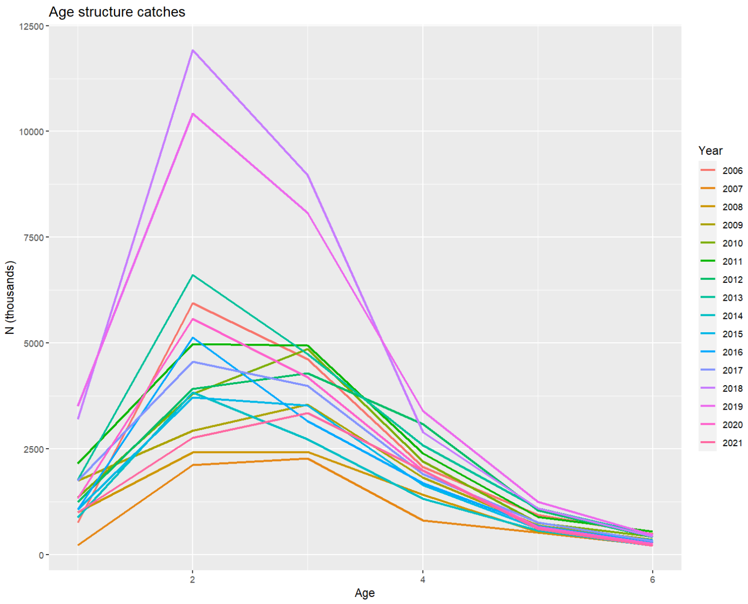


Figure 6.18.3.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Age structure of the catches.

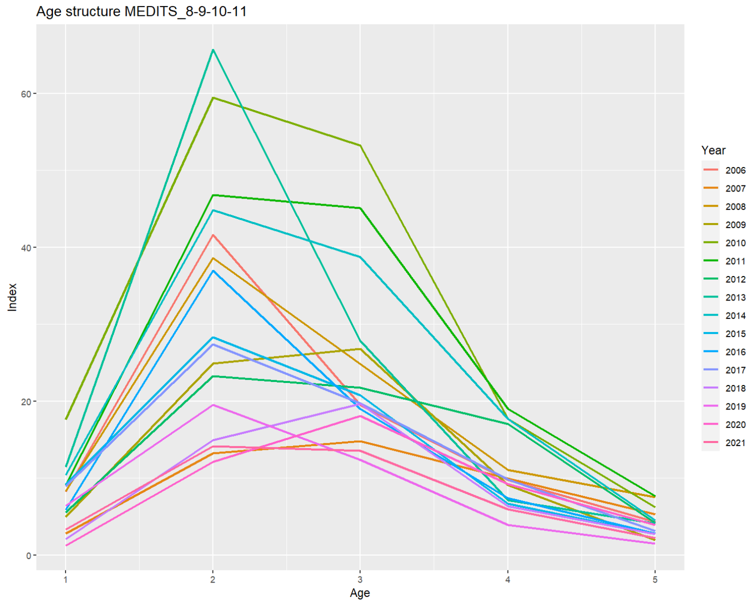


Figure 6.18.3.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. Age structure of the index.

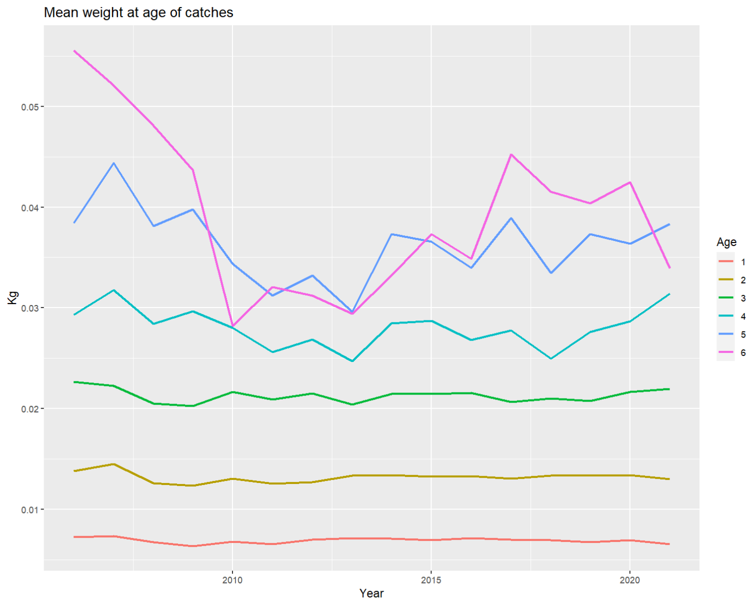


Figure 6.18.3.3. Blue and red shrimp in GSAs 8, 9, 10 & 11. Weight at age matrix.

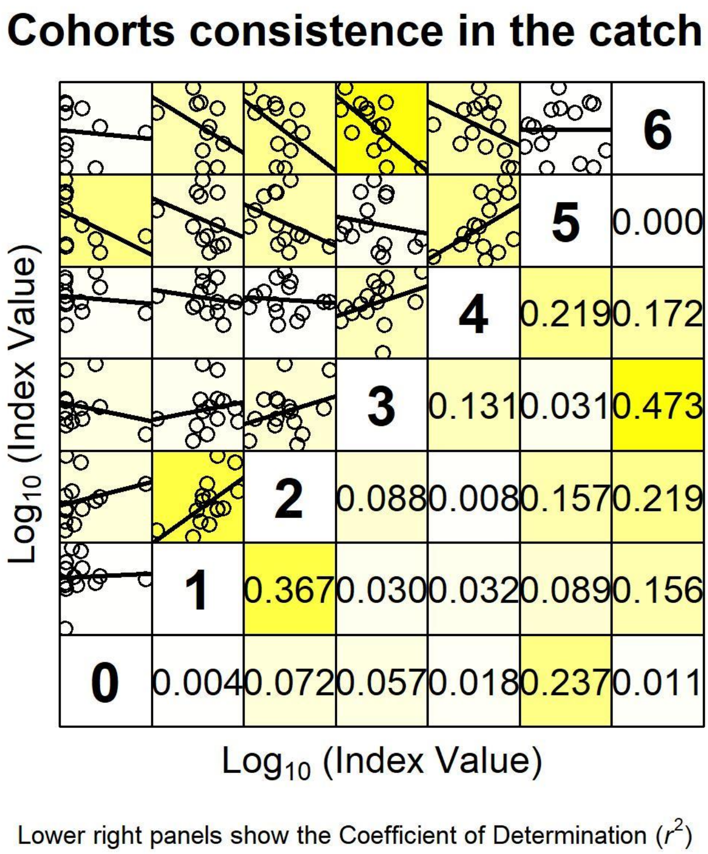


Figure 6.18.3.4. Blue and red shrimp in GSAs 8, 9, 10 & 11. Catch at age cohort consistency. Note age 0 is included in the plot but not in the assessment.

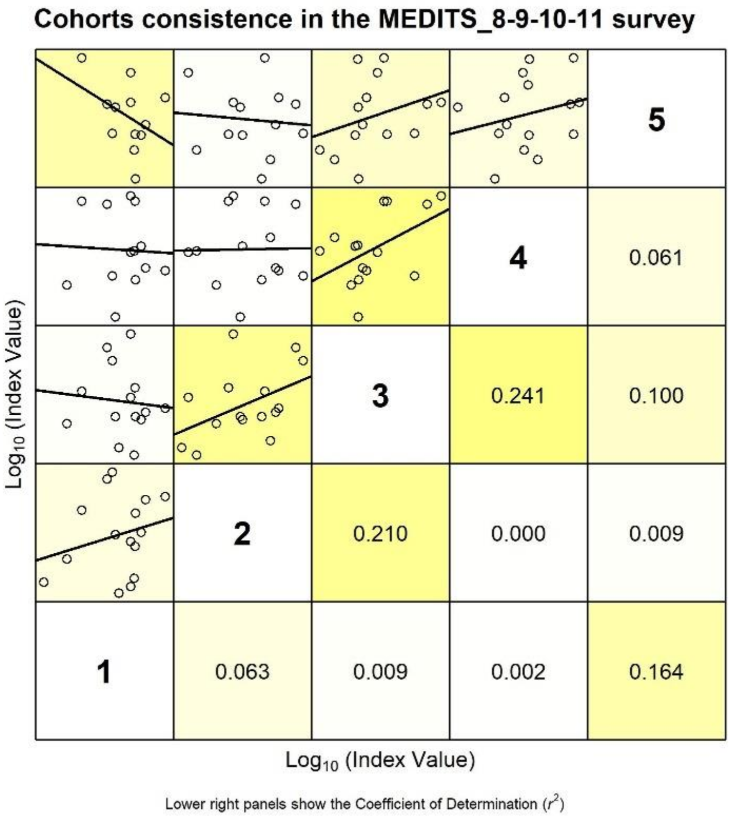


Figure 6.18.3.5. Blue and red shrimp in GSAs 8, 9, 10 & 11. Index at age cohort consistency.

Assessment results

Different a4a models were examined (combination of different f and q models). The best model (according to residuals and retrospective) included:

Submodels:

fmodel: ~ factor(age) + s(year, k=8)

srmodel: ~factor(year)

qmodel: MEDITS: ~factor(replace(age, age > 4, 4))

Assessment results are shown in Figures 6.18.3.3-6.18.3.9 and Tables 6.18.3.3- 6.18.3.6,

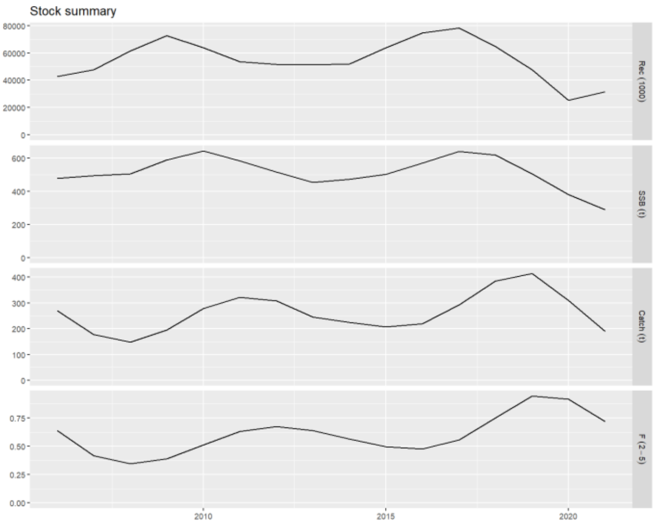


Figure 6.18.3.6. Blue and red shrimp in GSAs 8, 9, 10 & 11. Stock summary from the final a4a model. Recruits (Age 1), SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 2 to 5).

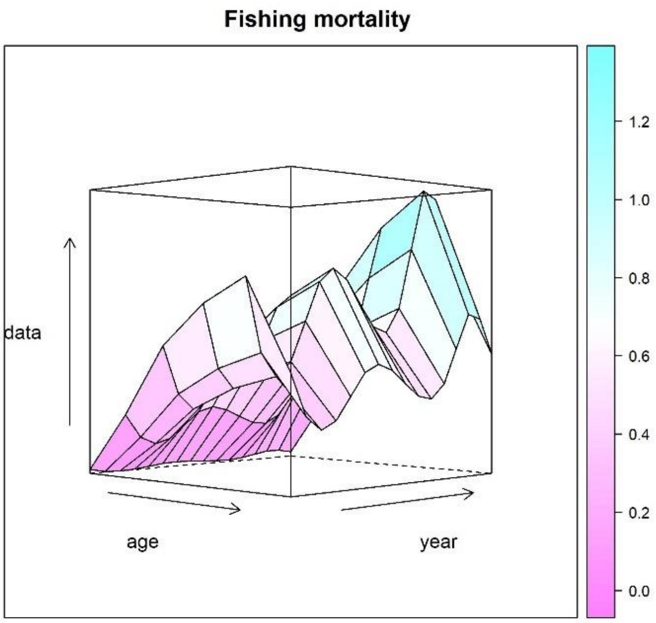


Figure 6.18.3.7. Blue and red shrimp in GSAs 8, 9, 10 & 11. 3D contour plot of estimated fishing mortality at age and year.

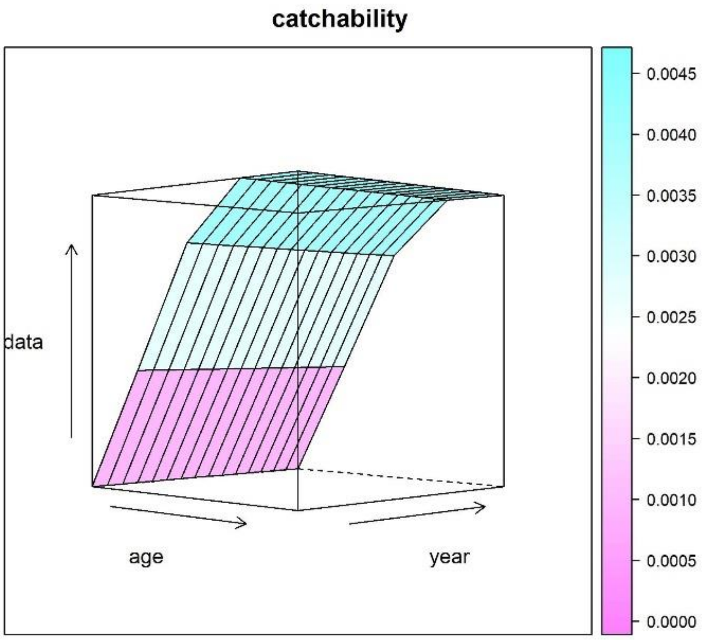


Figure 6.18.3.8. Blue and red shrimp in GSAs 8, 9, 10 & 11. 3D contour plot of estimated catchability at age and year.

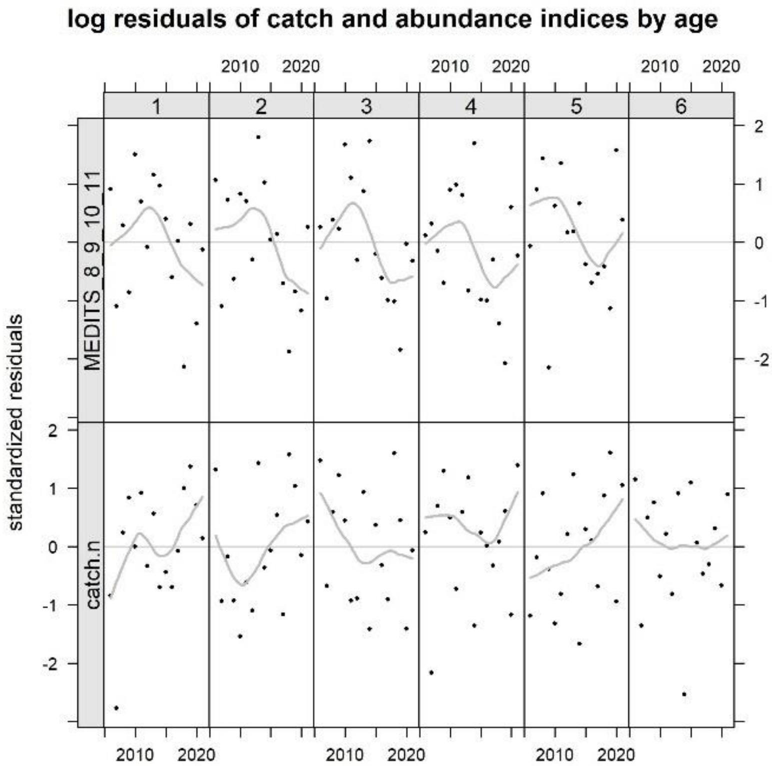


Figure 6.18.3.9. Blue and red shrimp in GSAs 8, 9, 10 & 11. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class; dots represent standardized residuals and lines simple smoothers.

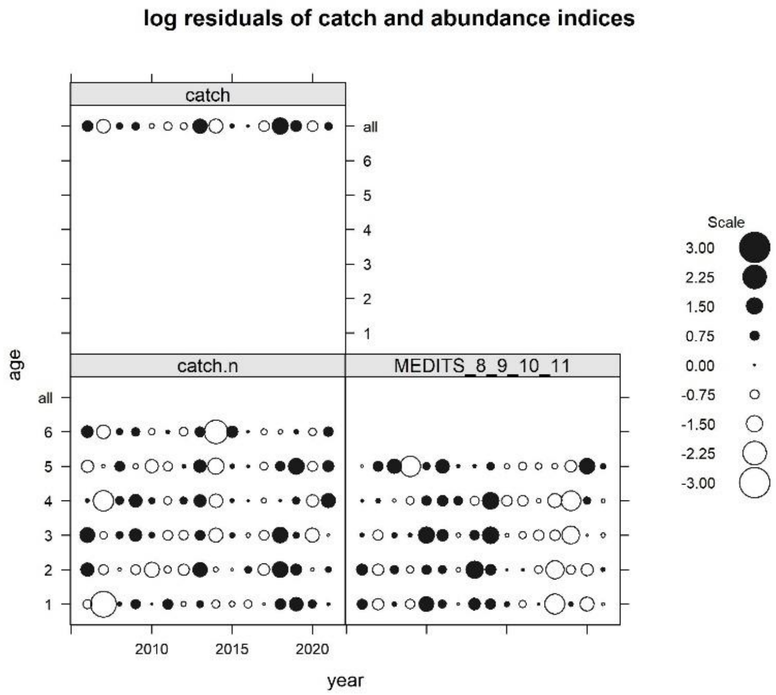


Figure 6.18.3.10. Blue and red shrimp in GSAs 8, 9, 10 & 11. Standardized residuals for abundance indices and for catch numbers.

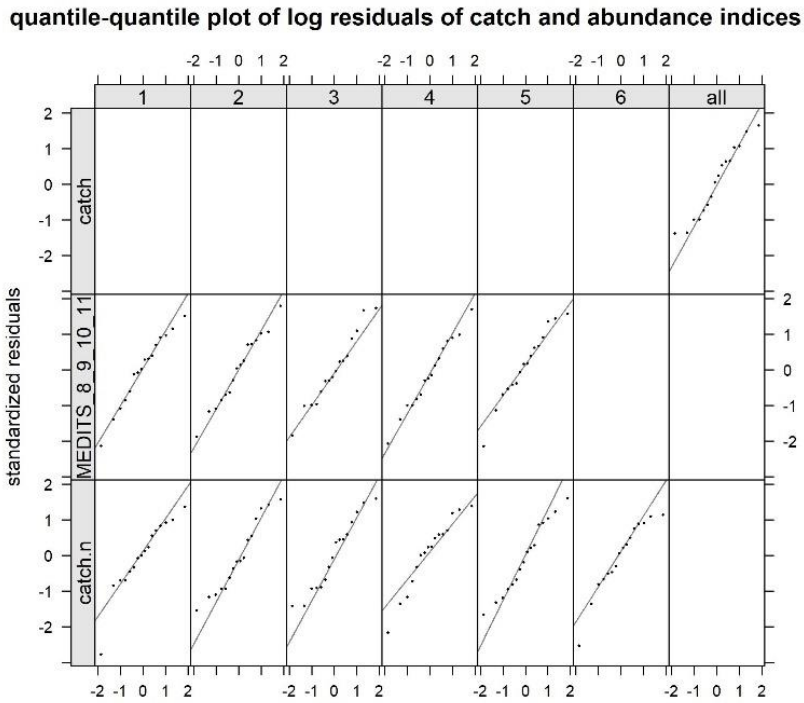


Figure 6.18.3.11. Blue and red shrimp in GSAs 8, 9, 10 & 11. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class; dots represent standardized residuals and lines the normal distribution quantiles.

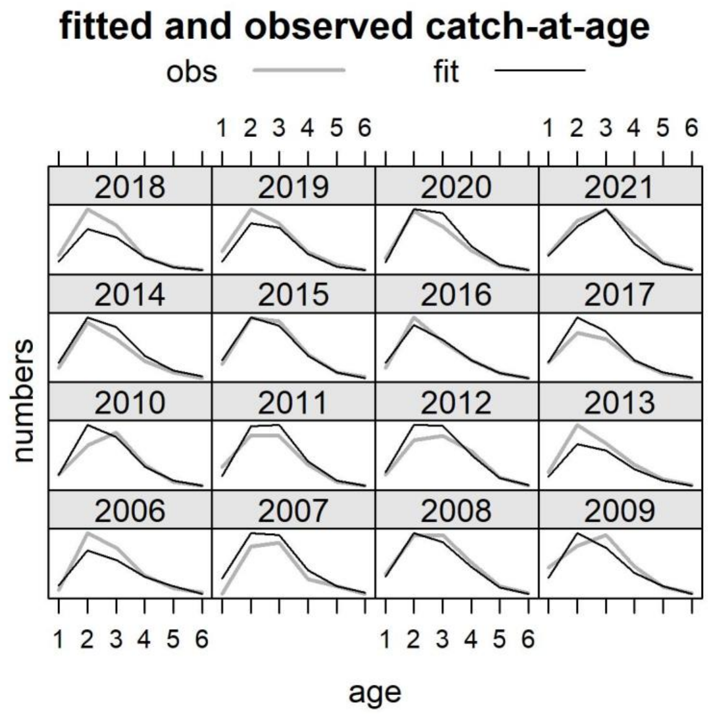


Figure 6.18.3.12. Blue and red shrimp in GSAs 8, 9, 10 & 11. Fitted and observed catch at age.

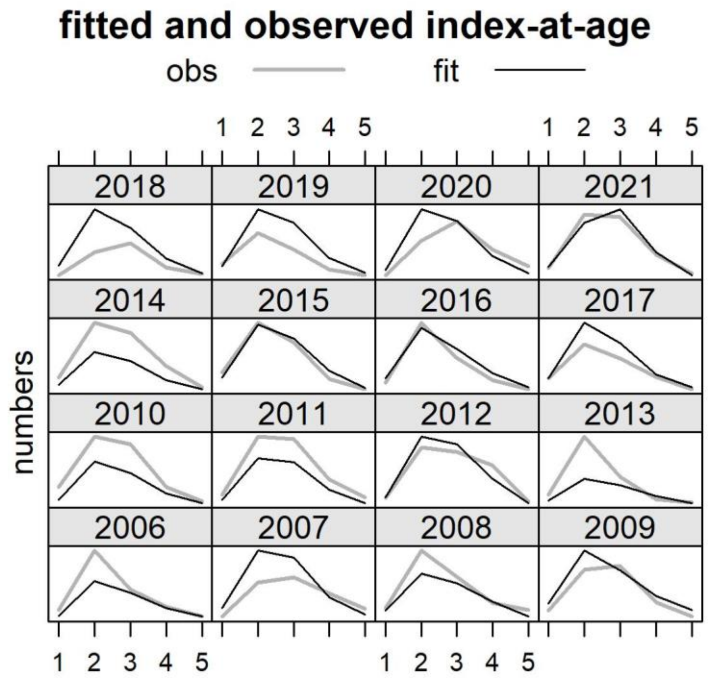


Figure 6.18.3.13. Blue and red shrimp in GSAs 8, 9, 10 & 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up only to 3 years back, due to the short time series. Model results were extremely unstable (Figure 6.18.3.14) and show a tendency to overestimate F and underestimate SSB.

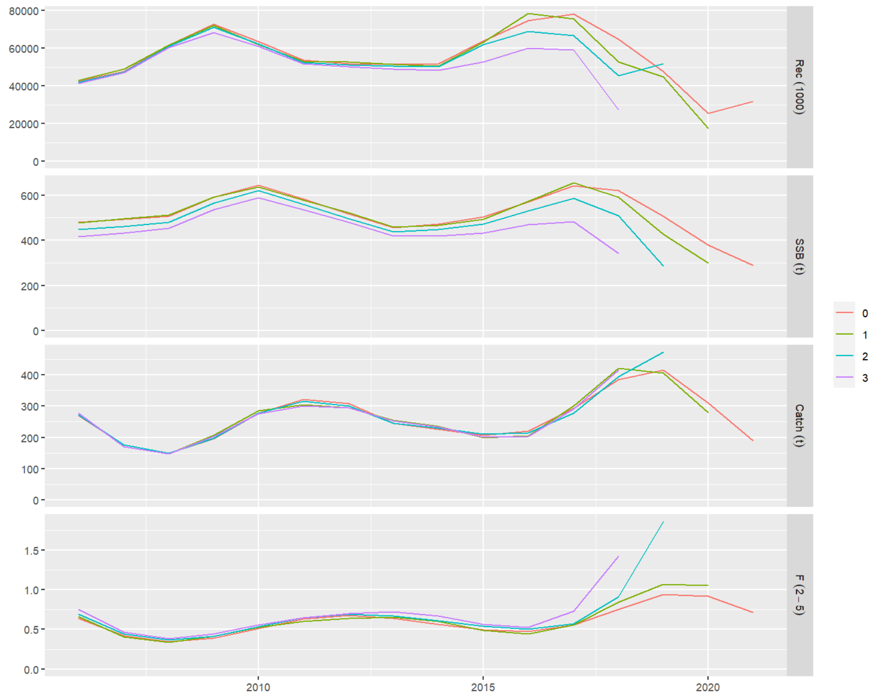


Figure 6.18.3.14. Blue and red shrimp in GSAs 8, 9, 10 & 11. Retrospective analysis.

Simulations

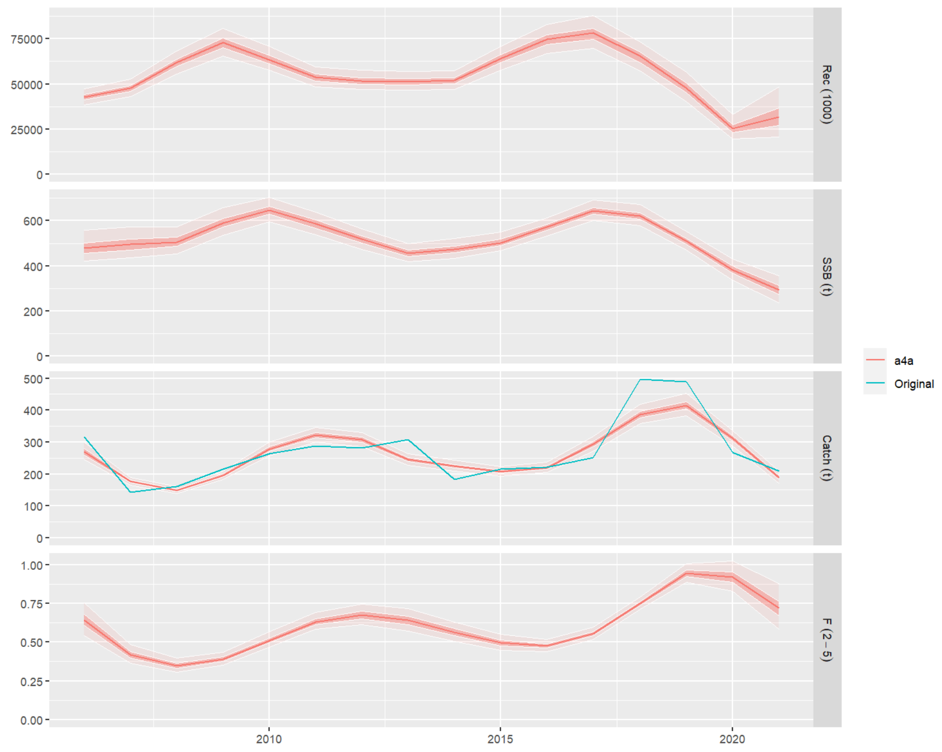


Figure 6.18.3.9. Blue and red shrimp in GSAs 8, 9, 10 & 11. Simulations over summary results.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.18.3.3. Blue and red shrimp in GSAs 8, 9, 10 & 11. Stock numbers at age (thousands) as estimated by a4a.

	1	2	3	4	5	6+
2006	42633	21268	9205	4240	2132	1141
2007	47624	19019	9483	3372	1382	1170
2008	61582	21533	9399	4281	1440	1208
2009	72794	27965	11001	4539	1994	1352
2010	63662	32970	14001	5099	2005	1609
2011	53590	28623	15607	5791	1944	1543
2012	51800	23920	12811	5761	1906	1308
2013	51345	23060	10494	4541	1800	1135
2014	51922	22908	10287	3848	1482	1068
2015	63899	23270	10577	4045	1375	1018
2016	74592	28759	11101	4445	1575	1033
2017	78173	33609	13837	4746	1769	1138
2018	64860	35054	15586	5490	1715	1161
2019	47742	28746	14861	5153	1567	937
2020	25324	20912	11137	4093	1162	652
2021	31743	11110	8198	3142	952	481

Table 6.18.3.4. Blue and red shrimp in GSAs 8, 9, 10 & 11. a4a summary results.

	Fbar(2-5)	Recruitment (thousands)	SSB (t)	TB (t)	Catch (t)
2006	0.64	42633	479	1080	316
2007	0.42	47624	494	1066	143
2008	0.35	61582	505	1116	161
2009	0.39	72794	590	1305	216
2010	0.51	63662	645	1423	264
2011	0.63	53590	584	1297	287
2012	0.68	51800	517	1201	281
2013	0.64	51345	455	1088	307
2014	0.56	51922	472	1096	182
2015	0.49	63899	503	1184	215
2016	0.48	74592	570	1364	222
2017	0.56	78173	642	1524	252
2018	0.75	64860	620	1489	497
2019	0.94	47742	507	1254	490
2020	0.92	25324	380	885	267
2021	0.72	31743	290	683	209

Table 6.18.3.5. Blue and red shrimp in GSAs 8, 9, 10 & 11. a4a results F at age.

	F at age					
	1	**2**	**3**	**4**	**5**	**6+**
2006	0.04	0.30	0.60	0.78	0.88	0.50
2007	0.03	0.19	0.39	0.51	0.58	0.33
2008	0.02	0.16	0.33	0.42	0.48	0.27
2009	0.02	0.18	0.37	0.47	0.54	0.30
2010	0.03	0.24	0.48	0.62	0.71	0.40
2011	0.04	0.29	0.59	0.77	0.87	0.49
2012	0.04	0.31	0.64	0.82	0.93	0.53
2013	0.04	0.30	0.60	0.78	0.88	0.50
2014	0.03	0.26	0.53	0.69	0.78	0.44
2015	0.03	0.23	0.47	0.60	0.68	0.39
2016	0.03	0.22	0.45	0.58	0.66	0.37
2017	0.03	0.26	0.52	0.68	0.77	0.43
2018	0.05	0.35	0.70	0.91	1.03	0.59
2019	0.06	0.44	0.89	1.15	1.30	0.74
2020	0.06	0.43	0.86	1.12	1.27	0.72
2021	0.04	0.33	0.67	0.87	0.99	0.56

Based on the a4a results, the blue and red shrimp recruitment shows a decreasing trend from 2014 to 2020 with a slight increase in 2021. SSB follows the same pattern but is declining also in 2021. F has been fluctuating throughout the time series, reached a maximum in 2019 and has been slightly decreasing after.

Due to the model instability as shown by the retrospective analysis, the EWG 22-09 concluded that the output of this model was not suitable to provide the basis of the current status of the stock.

One of the main causes of the retrospective is the massive increase in catches in 2018 and 2019. This increase is evident both for GSA 10 and GSA 11. It would be important for future work to receive more information from these GSAs about the quality of these two data points.

6.18.4 Reference Points

The table below summarises reference points for use with ICES category 3 advice for Blue and red shrimp in GSAs 8, 9, 10 and 11 and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$ proxy	1.06	Biomass index trigger value ($I_{trigger}$), defined as $I_{trigger} = I_{loss} \times 1.4$, where I_{loss} is the lowest observed historical biomass index value from 2019 MEDITS in GSAs 8, 9, 10 and 11. In kg / km^2.	STECF EWG 22-09
	$F_{MSY\ proxy}$	1	$L_{mean}/L_{F=M}$; Mean catch length divided by MSY proxy reference length ($L_{F=M}$).	STECF EWG 22-09
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	SSB_{mgt}		Not Defined	
	F_{mgt}		Not Defined	

6.18.5 SHORT TERM FORECAST AND CATCH OPTIONS

Since the a4a models was not accepted, advice is based on the biomass index of the MEDITS survey in GSAs 8, 9, 10 and 11. Following the ICES procedures the advice for 2023 was provided using the ICES framework for category 3 stocks was applied (ICES, 2022) method 2.1 (see Section 4.7 above). Following the decision tree provided in the ICES technical guidance, given the availability of an index of abundance, of length data and a von Bertalanffy *k* of 0.21, the *rfb* rule is chosen to provide advice.

The *rfb* formula contains different factors to determine the catch in the advice year:

$$A_{y+1} = A_y \times r \times f \times b \times m$$

where the advised catch (*A*) for next year *y*+1 is based on the most recent year's advised catch A_y adjusted by the components in table 6.18.5.1. According to the guidelines if the most recent realized catch (catch in 2021 = 209 tonnes) is very different from the latest advice (advice for 2022 = 45 tonnes) it is suggested to consider replacing A_y as the *rfb* rule is meant to adjust realised catches influencing the stock. The two options for substituting A_y are the most recent catch value (catch in 2021) or the average of the last three years (2019-2021). Due to the massive increase in catches in 2018 and 2019, it was decided to use as A_y the catches in 2021.

Table 6.18.5.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Components of the *rfb* rule.

Component	Definition	Description and use
A_{y+1}	$A_y \times r \times f \times b \times m$	The advised catch for next year *y*+1.
A_y		The most recent catch (catch in 2021).
r	$\frac{\sum_{i=y-2}^{y-1}(I_i/2)}{\sum_{i=y-5}^{y-3}(I_i/3)}$	The rate of change in the biomass index (I), based on the average of the two most recent years of data (*y*−2 to *y*−1) relative to the average of the three years prior to the most recent two (*y*−3 to *y*−5), and termed the "2-over-3" rule; *y* = 2022.
f	$\frac{\bar{L}_{y-1}}{L_{F=M}}$	The fishing proxy is the mean length in the observed catch ($\bar{L}_{y-1}$) relative to an MSY proxy length ($L_{F=M}$) and is meant to move the stock towards MSY. Only lengths above the length of first capture (L_c) are considered for $\bar{L}_{y-1}$. The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where L_c is defined as length at 50% of modal abundance (ICES, 2012, 2018). The reference length follows Beverton and Holt (1957), derived by Jardim et al. (2015), and assumes *M*/*k* = 1.5.
b	$\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$	Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{\text{trigger}} = 1.4I_{\text{loss}}$ such that b is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger}, ***b*** is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock. I_{trigger} may need to be adapted if the stock has been exploited only heavily or lightly in the past.
m	[0,1]	A tuning parameter to ensure that the rfb rule is precautionary (that risk does not exceed 5%). It does not decrease advice continuously but can be considered as adjusting the target in component *f*. ***m*** is linked to von Bertalanffy ***k*** and based on generic MSE simulations. May range from 0 to 1.0. Since ***k*** is 0.21 ***m*** is 0.9

Component	Definition	Description and use
Stability clause	$min\{max(0.7A_y, A_{y+1}), 1.2A_y\}$	Asymmetric conditional uncertainty cap. Limits the amount the advised catch (A_{y+1}) can change upwards or downwards relative to the previous catch advice (A_y). The recommended values are +20% and −30%; i.e. the catch would be limited to a maximum 20% increase or a maximum 30% decrease relative to the previous year's advised catch. The stability clause does not apply when **b** < 1.

To obtain the *f* component of the *rfb* rule:

- First parameter, calculation of the length at first capture (L_c) by year, which is defined as the first length class where abundance is more than or equal to half of the maximum abundance. Length data without reconstrucions from 2006 onwards was used. L_c per year is shown in the table below.

Year	L_c (mm)
2006	28
2007	33
2008	21
2009	21
2010	23
2011	21
2012	25
2013	24
2014	25
2015	24
2016	25
2017	23
2018	26
2019	22
2020	26
2021	21

Second parameter, the target reference length $L_{F=M}$ = $0.75L_c + 0.25L_{inf}$ is calculated per year and shown in the table below. We used as L_{inf} the female L_{inf} as reported in table 6.18.1.1.

Year	$L_{F=M}$ (mm)
2006	40.23
2007	43.98
2008	34.98
2009	34.98
2010	36.48
2011	34.98
2012	37.98
2013	37.23
2014	37.98
2015	37.23
2016	37.98
2017	36.48
2018	38.73
2019	35.73
2020	38.73
2021	34.98

- Third parameter, the mean length above L_c is calculated.

Year	$L_{mean} > L_c$ (mm)
2006	37.8
2007	40.7
2008	35.0
2009	34.9
2010	36.1
2011	34.2
2012	36.6
2013	34.7
2014	35.8
2015	36.1
2016	35.4
2017	35.0
2018	35.6
2019	34.7
2020	37.6
2021	35.9

- Fourth parameter, the quantity *f* is calculated as the ratio of the mean length above L_c and $L_{F=M}$. Calculations were done with unrounded values. For all years except in 2008 and 2021 the fishing pressure proxy relative to the MSY proxy indicator ratio L_{mean} / $L_{F = M}$ (*f*) was smaller than 1. *f* in 2021 is 1.03 (figure 6.18.5.1).

Year	L_{mean} / $L_{F = M}$
2006	0.94
2007	0.92
2008	1.00
2009	1.00
2010	0.99
2011	0.98
2012	0.96
2013	0.93
2014	0.94
2015	0.97
2016	0.93
2017	0.96
2018	0.92
2019	0.97
2020	0.97
2021	1.03

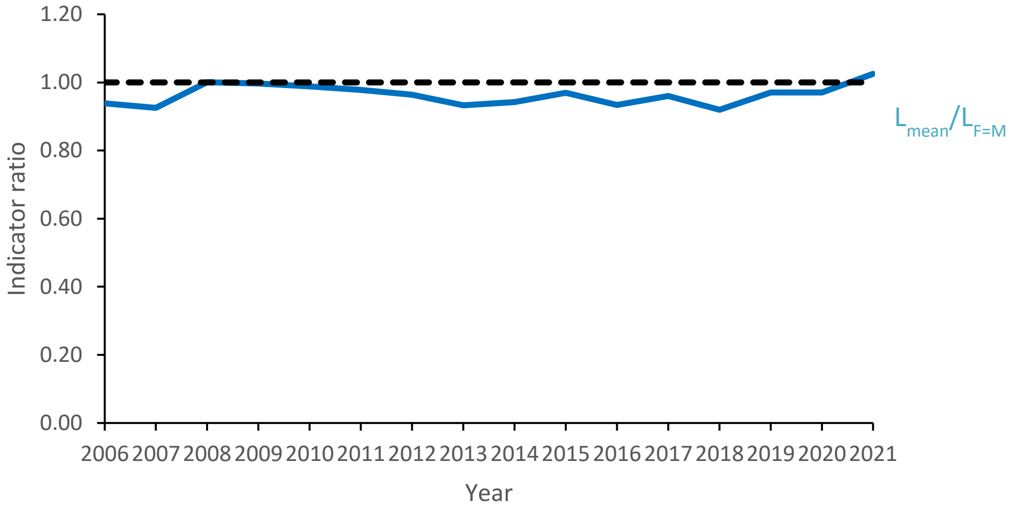


Figure 6.18.5.1. Blue and red shrimp in GSAs 8, 9, 10 & 11. Length indicator (mean length of fish in the catch divided by MSY proxy reference length). The exploitation status is above $F_{MSY\ proxy}$ when the indicator ratio value is lower than 1 (shown by the dashed line).

To obtain the *b* component of the *rfb* rule we defined the biomass index trigger value ($I_{trigger}$), defined as $I_{trigger} = I_{loss} \times 1.4$, where I_{loss} is the lowest observed historical biomass index value from 2019 MEDITS in GSAs 8, 9, 10 and 11 (figure 6.18.5.2).

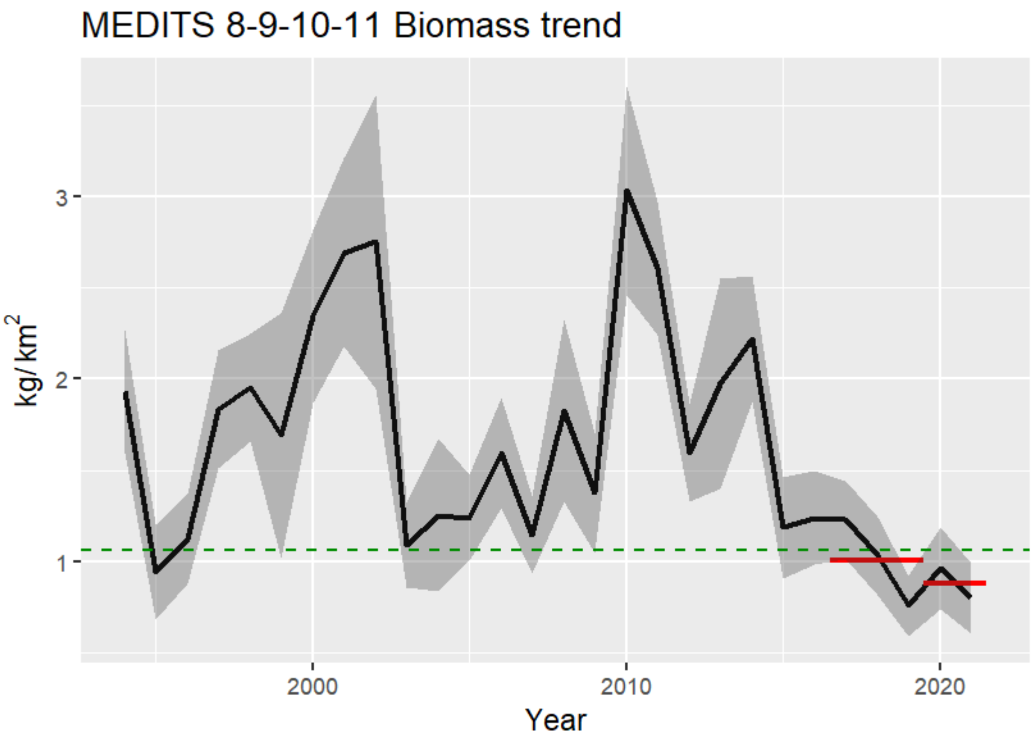


Figure 6.18.5.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. MEDITS in GSAs 8, 9, 10 and 11 biomass index. The green dashed line represents $I_{trigger}$. The two red segments represent the mean index of 2020-2021 and of 2017-2019.

The advice for 2023 was set using the *rfb* as outlined in the table below.

Table 6.18.5.2. Blue and red shrimp in GSAs 8, 9, 10 & 11. Basis for the catch scenarios. The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the table.

Last year catch C_{y-1} (catch in 2021)		209 tonnes
Stock biomass trend		
Index A (2020, 2021)		0.88 kg / km^2
Index B (2017, 2018, 2019)		1.00 kg / km^2
r: Index ratio (A/B)		0.88
Fishing pressure proxy		
Mean catch length ($\bar{L}_{y-1}$=L_{2021})		35.9
MSY proxy length ($L_{F=M}$)		35.0
f: multiplier for relative mean length in catches ($\bar{L}_{y-1}$/ $L_{F=M\ 2021}$)		1.03
Biomass safeguard		
Last index value (I_{2021})		0.80 kg / km^2
Index trigger value ($I_{trigger}$=1.4*I_{loss})		1.06 kg / km^2
b: index relative to trigger value, min{I_{2021}/$I_{trigger}$, 1}		0.75
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability		
m: multiplier (generic multiplier based on life history)		0.9
rfb calculation*		
Uncertainty cap (+20%/-30% compared to C_{y-1}, only considered if b≥1)	Not applied	
Discard rate		0%
Catch advice for 2023		145 tonnes
% advice change**		-30%

* $A_{y+1} = A_y \times r \times f \times b \times m$ limited by stability clause if applicable.

** Advice value for 2023 relative to the catch in 2021 (209 tonnes).

Based on MSY considerations STECF EWG 22-09 advises to decrease the total catch by 30% relative to the catches in 2021 equivalent to catches of no more than 145 tons in 2023.

6.18.6 Data Deficiencies

Data from DCF 2021 as submitted through the Official data call in 2022 were used.

In GSA 9, length frequency distributions were not available for 2004.

In GSA 10, length frequency distributions were not available for 2003, 2005 and 2021. For the period 2018-2020 the length frequency distribution is provided for a very low percentage of the landings.

Data from GSA 10 in 2017 was reported only for Q3 and Q4 though Q1 and Q2 are present in the FDI database.

In GSA 11, length frequency distributions for OTB_DWS were not available for any year with landings associated.

One of the main causes of the retrospective is the massive increase in catches in 2018 and 2019. This increase is evident both for GSA 10 and GSA 11. It would be important for future work to receive more information from these GSAs about the quality of these two data points.

6.19 GIANT RED SHRIMP IN GSAS 9, 10 & 11

6.19.1 STOCK IDENTITY AND BIOLOGY

In the Mediterranean, *Aristaeomorpha foliacea* (Risso, 1827) is a dominant species of bathyal megafaunal assemblages, and it is sympatric with *Aristeus antennatus*. Both species have considerable interest for fisheries.

The giant red shrimp is mainly found in the epibathyal and mesobathyal waters of the Mediterranean. Due to a lack of enough information about the structure of giant red shrimp (*Aristaeomorpha foliacea*) in the western Mediterranean, this stock was assumed to be confined within the GSAs 9, 10 and 11 boundaries (Figure 6.19.1.1).

In the GSA 9, *A. foliacea* is more abundant in the Tyrrhenian Sea, while lower concentrations are present in the Ligurian Sea, where the blue and red shrimp, *Aristeus antennatus*, is more abundant, and the giant red shrimp considerably decreased over time (Masnadi et al., 2018).

In GSA10, this species and the blue and red shrimp are characterised by seasonal variability and annual fluctuations of abundance (Spedicato et al., 1994), as reported for different geographical areas (e.g. Relini, 2007). The giant red shrimp is distributed beyond 350 m depth, but mainly in water deeper than 500 m.

The giant red shrimp shows high densities and well-structured populations with a clear multimodal size pattern in the GSA 11. Seasonal changes have been reported from southern Sardinia in both the vertical distribution and size-related spatial abundance of *A. foliacea*, with large females (preferentially) tending to move gradually deeper (to 650-740 m) from spring to summer (Mura et al., 1997).

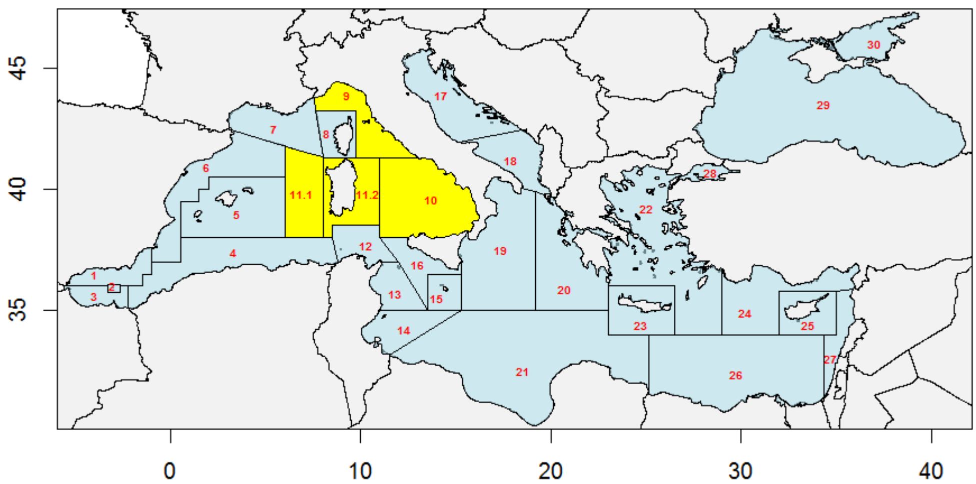


Figure 6.19.1.1 Limit of Geographical Sub-Areas (GSAs) 9, 10, 11.

Growth, maturity and natural mortality

Several sets of VBGF parameters have been reported in the DCF database for *A. foliacea*. VBGF curves by sex are available for the three GSAs. However, being the VBGF parameters computed in GSA10 a good proxy of the average of the VBGF parameters provided for the three areas, it was decided to use those parameters, as in the previous assessments, to slice the size frequency distributions by sex. As done in the last assessments, the parameters were adjusted to shift length slicing by adding a value of 0.5 to the t_0 value.
Also for the Length-Weight relationship, several sets of parameters by sex are provided for the three GSAs. The LW parameters used in the assessment to estimate mean weight at length and mean weight at age by sex are those from GSA 9 in 2019, chosen as good average values among all parameters.
The VBGF and LW relationship parameters used are summarized in the following table (Table 6.19.1.1).

Table 6.19.1.1 Giant red shrimp in GSAs 9, 10, 11: VBGF and LW relationship parameters.

		Units	Females	Males
VBGF parameters	**L_∞**	mm	73.0	50
	k	years^{-1}	0.438	0.40
	t_0	years	-0.10	-0.10
LW relationship	**a**	mm/g	0.00164	0.00127
	b	mm/g	2.58855	2.67574

A vector of proportion of mature by age was provided by the three GSAs. The same weighed average of the vectors used in the previous assessment was used.
The natural mortality vector used was the one previously estimated last year by sex using the Chen and Watanabe equation and the growth parameters described above. A combined natural mortality vector was then computed as a weighted average of the vectors by sex.
The vector of proportion of mature and the natural mortality vector used in the assessment of giant red shrimp in GSAs 9, 10, 11 are shown in Table 6.19.1.2.

Table 6.19.1.2 Giant red shrimp in GSAs 9, 10, 11: natural mortality and proportion of mature vectors by age.

Age	Natural mortality	Proportion of matures
0	**1.89**	**0.00**
1	**0.86**	**0.40**
2	**0.62**	**1.00**
3	**0.53**	**1.00**
4+	**0.48**	**1.00**

6.19.2 Data

6.19.2.1 Catch (landings and discards)

The annual total landings of giant red shrimp available in the DCF database are reported in Table 6.19.2.1.1 and Figure 6.19.2.1.1. The landings coming from GSA 9 and 11 are lower along almost all the time series in comparison to those in GSA 10. Landings data are available in GSA 11 since 2005, while they are available from 2003 in GSAs 9 and 10. In general, landings are showing a fluctuating pattern along the time series, with peaks in 2005, 2014 and 2019. The time series of landings by GSA and gear are shown in Figures 6.19.2.1.2-6.19.2.1.4.

No commercial data at all was present in the DCR-DCF database for GSA 8. Given this lack of landings, demographic and biological data, GSA08 was not included in the stock assessment.

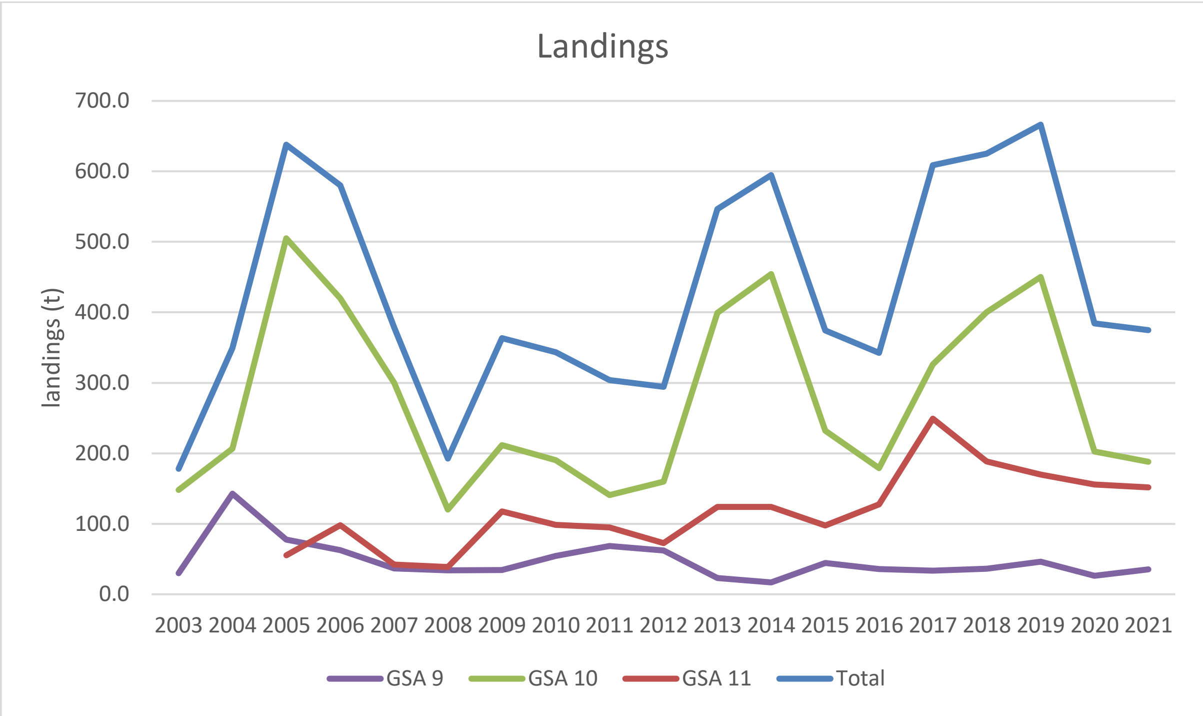


Figure 6.19.2.1.1 Giant red shrimp in GSAs 9, 10, 11: landings by GSA and total landings.

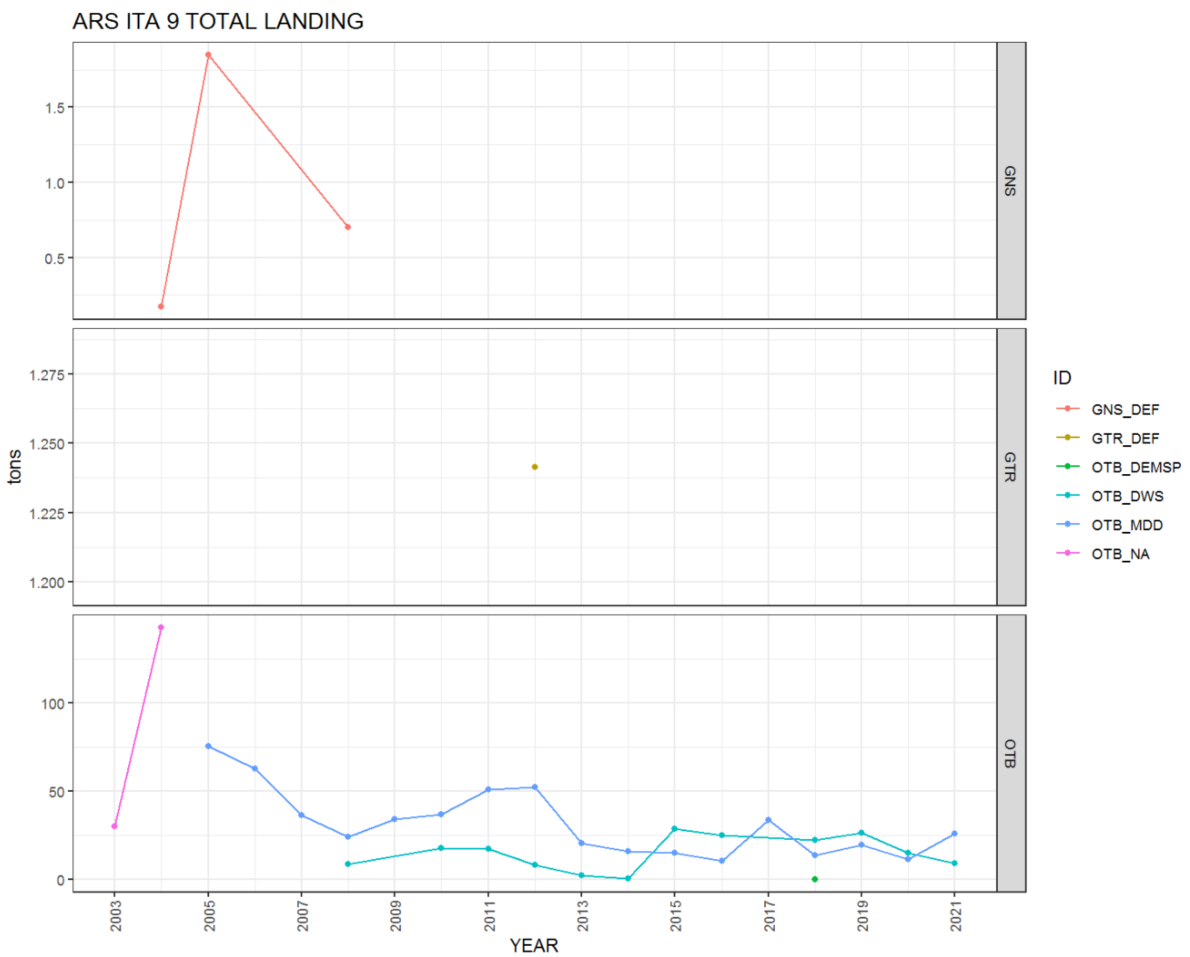


Figure 6.19.2.1.2. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 9.

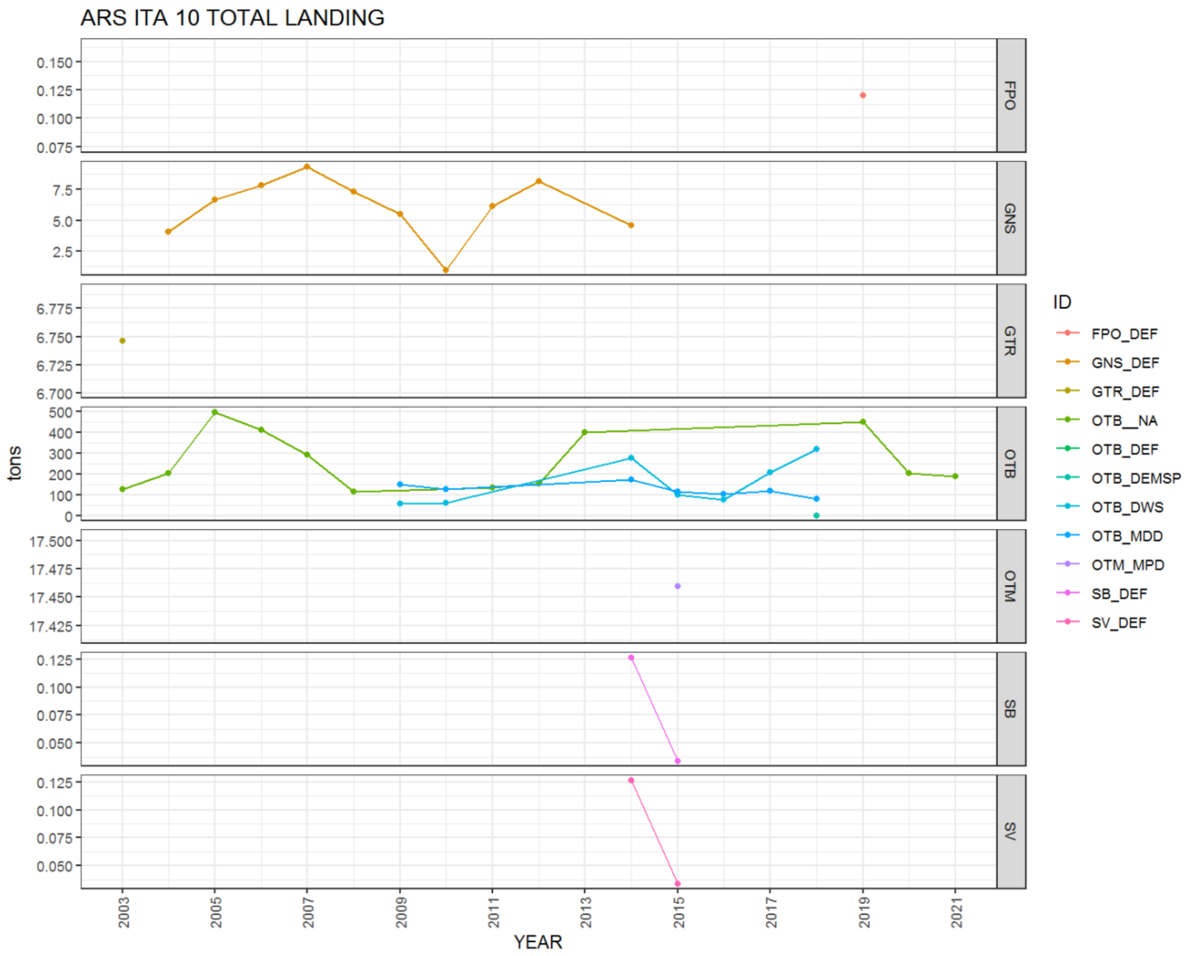


Figure 6.19.2.1.3. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 10.

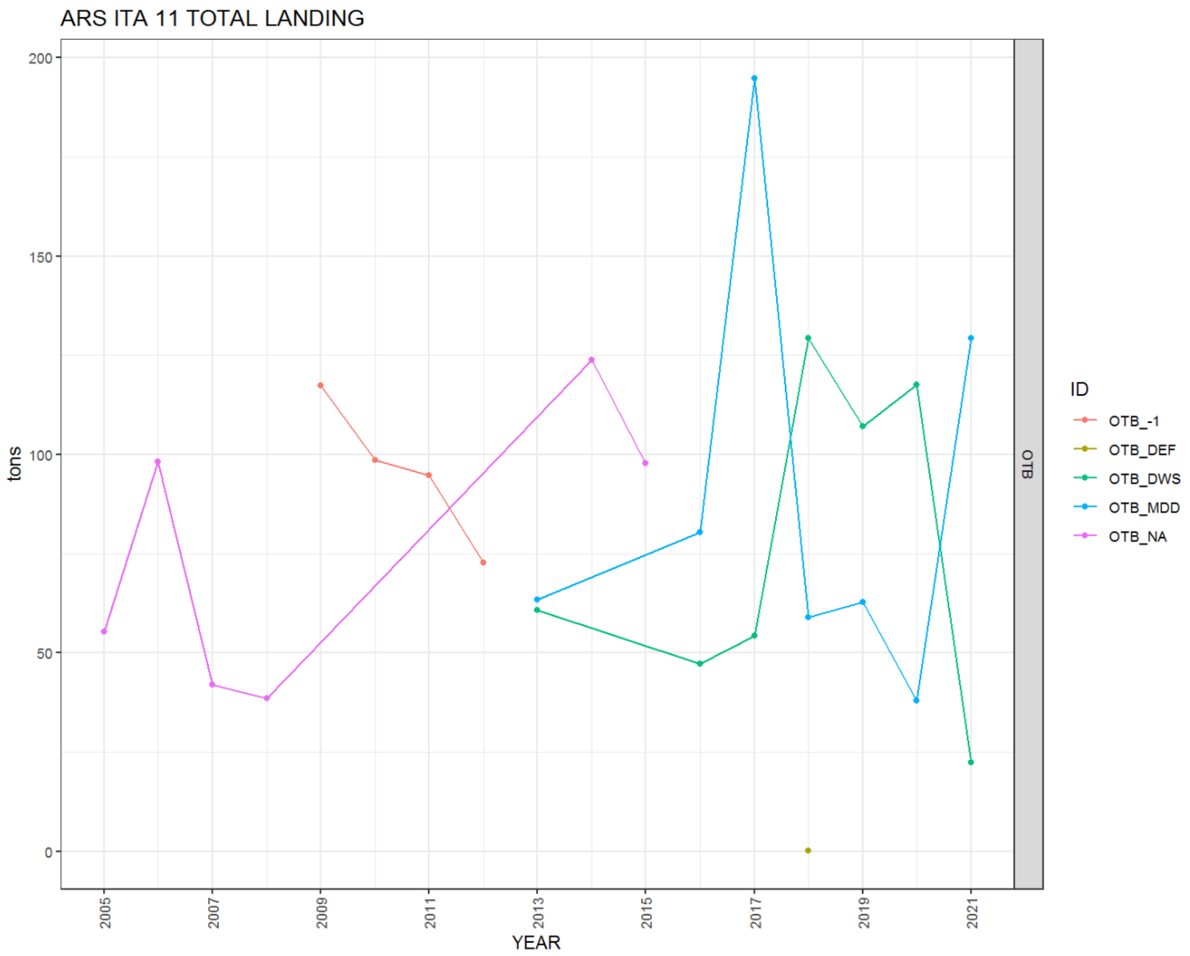


Figure 6.19.2.1.4. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 11.

Although the bulk of the production in GSA 10 is coming from the trawl fisheries (mainly deep-water species and mixed demersal and deep-water species trawling), other fisheries (mostly gill nets) provided some contribution to the total production. In GSA 9, the contribution of GNS fisheries is negligible, while in GSA 11 giant red shrimp is exploited exclusively by OTB.

Table 6.19.2.1.1. Giant red shrimp in GSAs 9, 10, 11: landings by GSA and gear.

	GSA11	GSA 10		GSA 9	
year	OTB	OTB	Other gears	OTB	Other gears
2003		125.2	22.8	30.0	
2004		202.6	4.0	142.5	0.2
2005	55.2	498.4	6.7	75.5	1.8
2006	98.1	411.8	7.9	62.6	
2007	42.0	290.9	9.3	36.7	
2008	38.6	112.8	7.3	33.1	0.7
2009	117.4	206.2	5.5	34.3	
2010	98.6	189.3	1.0	54.6	
2011	94.7	134.7	6.2	68.4	
2012	72.7	151.6	8.2	60.7	1.2
2013	124.1	399.4		23.1	
2014	123.9	449.3	4.8	16.8	
2015	97.8	214.6	17.5	44.2	
2016	127.6	179.1		35.8	
2017	249.2	326.0		33.6	
2018	188.4	400.2		36.4	
2019	170.0	450.1	0.1	46.2	
2020	155.6	202.5		26.4	
2021	151.8	187.9		35.3	

Discards of giant red shrimp are negligible. Low values of discards (from OTB) are reported in GSA 9 and 10 only for some years. The discards are summarized in Table 6.19.2.1.2.

Table 6.19.2.1.2. Giant red shrimp in GSAs 9, 10, 11: Discards by GSA.

year	GSA9 discards (t)	GSA10 discards (t)	GSA11 discards (t)
2003			
2004			
2005			
2006			
2007			
2008			
2009			
2010	0.453		
2011		0.051	
2012		0.351	
2013			
2014			
2015			
2016			
2017		0.964	
2018			
2019			
2020	0.009		
2021			

Table 6.19.2.1.3. Giant red shrimp in GSAs 9, 10, 11: Annual catches (t) by GSA and fishing technique as provided through the official DCR-DCF database.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
GSA 10_FPO_DEF										
GSA 10_GNS_DEF		4.0	6.7	7.9	9.3	7.3	5.5	1.0	6.2	8.2
GSA 10_GTR_DEF	6.7									
GSA 10_NA_NA	16.0									
GSA 10_OTB_DEF										
GSA 10_OTB_DEMSP										
GSA 10_OTB_DWS							57.9	62.1		
GSA 10_OTB_MDD							148.3	127.2		
GSA 10_OTB_NA	125.2	202.6	498.4	411.8	290.9	112.8			134.7	152.0
GSA 10_OTM_MPD										
GSA 10_SB_DEF										
GSA 10_SV_DEF										
GSA 11_OTB_-1							117.4	98.6	94.7	72.7
GSA 11_OTB_DEF										
GSA 11_OTB_DWS										
GSA 11_OTB_MDD										
GSA 11_OTB_NA			55.2	98.1	42.0	38.6				
GSA 9_GNS_DEF		0.2	1.8			0.7				
GSA 9_GTR_DEF										1.2
GSA 9_OTB_DEMSP										
GSA 9_OTB_DWS						8.7		17.7	17.6	8.3
GSA 9_OTB_MDD			75.5	62.6	36.7	24.4	34.3	37.3	50.8	52.4
GSA 9_OTB_NA	30.0	142.5								

	2013	2014	2015	2016	2017	2018	2019	2020	2021
GSA 10_FPO_DEF							0.1		
GSA 10_GNS_DEF		4.6							
GSA 10_GTR_DEF									
GSA 10_NA_NA									
GSA 10_OTB_DEF						0.0			
GSA 10_OTB_DEMSP						0.0			
GSA 10_OTB_DWS		278.5	101.0	76.8	209.1	319.2	360.6	141.0	36.6
GSA 10_OTB_MDD		170.7	113.6	102.3	117.9	81.0	89.6	61.4	151.3
GSA 10_OTB_NA	399.4								
GSA 10_OTM_MPD			17.5						
GSA 10_SB_DEF		0.1	0.0						
GSA 10_SV_DEF		0.1	0.0						
GSA 11_OTB_-1									
GSA 11_OTB_DEF						0.2			
GSA 11_OTB_DWS	60.8			47.2	54.3	129.3	107.1	117.6	22.4
GSA 11_OTB_MDD	63.3			80.3	194.9	59.0	62.9	37.9	129.4
GSA 11_OTB_NA		123.9	97.8						
GSA 9_GNS_DEF									
GSA 9_GTR_DEF									
GSA 9_OTB_DEMSP						0.0			
GSA 9_OTB_DWS	2.6	0.6	29.0	25.1		22.4	26.3	15.0	9.1
GSA 9_OTB_MDD	20.5	16.2	15.2	10.7	33.6	13.9	19.8	11.4	26.1
GSA 9_OTB_NA									

Since data from GSA 10 in 2019, 2020 AND 2021 is derived from few quarters only, the group decided to substitute this LFD data with the ones derived from the average of the LFD of the same years from GSA 9 and 11, expanding it to the production of GSA 10. The used landings size structure by year, area and gear is shown in Figures 6.19.2.1.5-6.18.2.1.7.

Despite the low values of discards, LFDs are available and data were included into the stock assessment. LFDs of discards of giant red shrimp are shown in Figures 6.19.2.1.8 - 6.19.2.1.9.

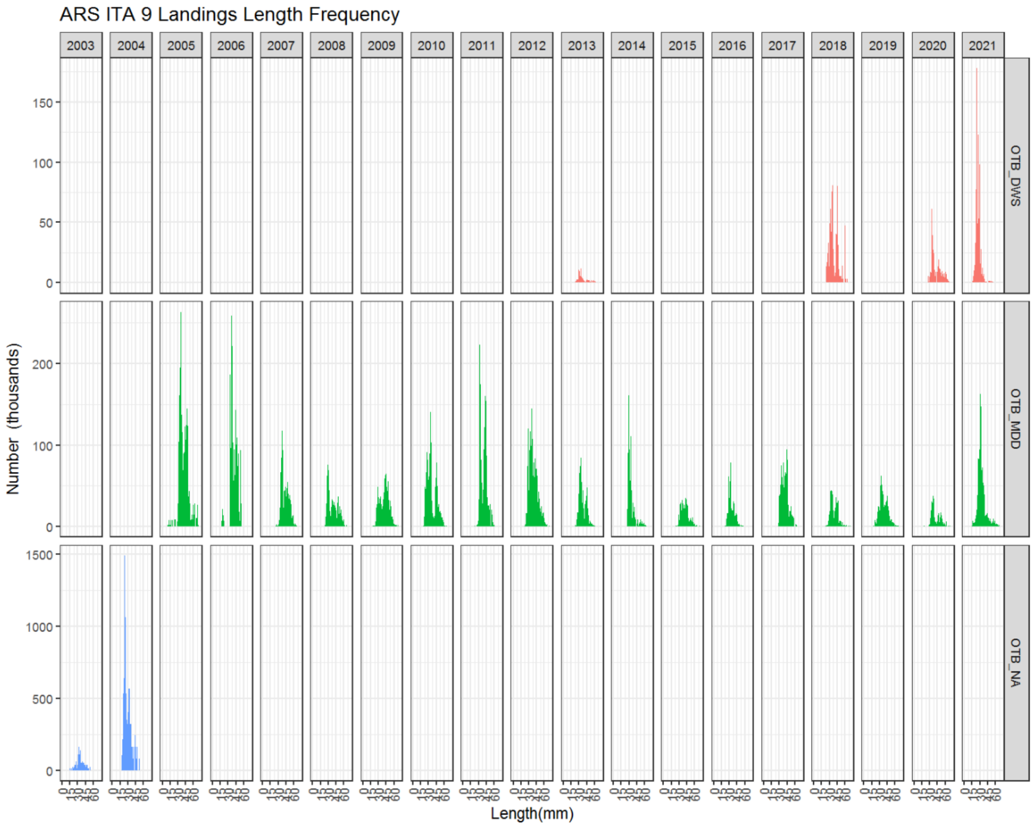


Figure 6.19.2.1.5. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 9.

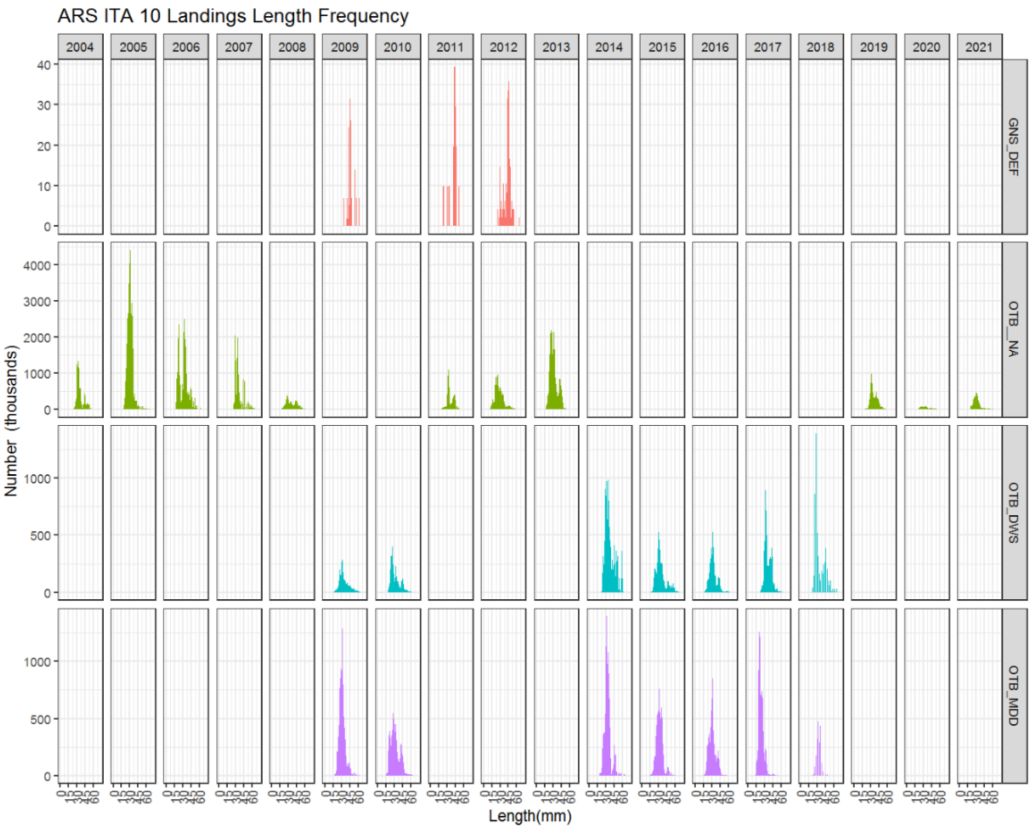


Figure 6.19.2.1.6. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 10.

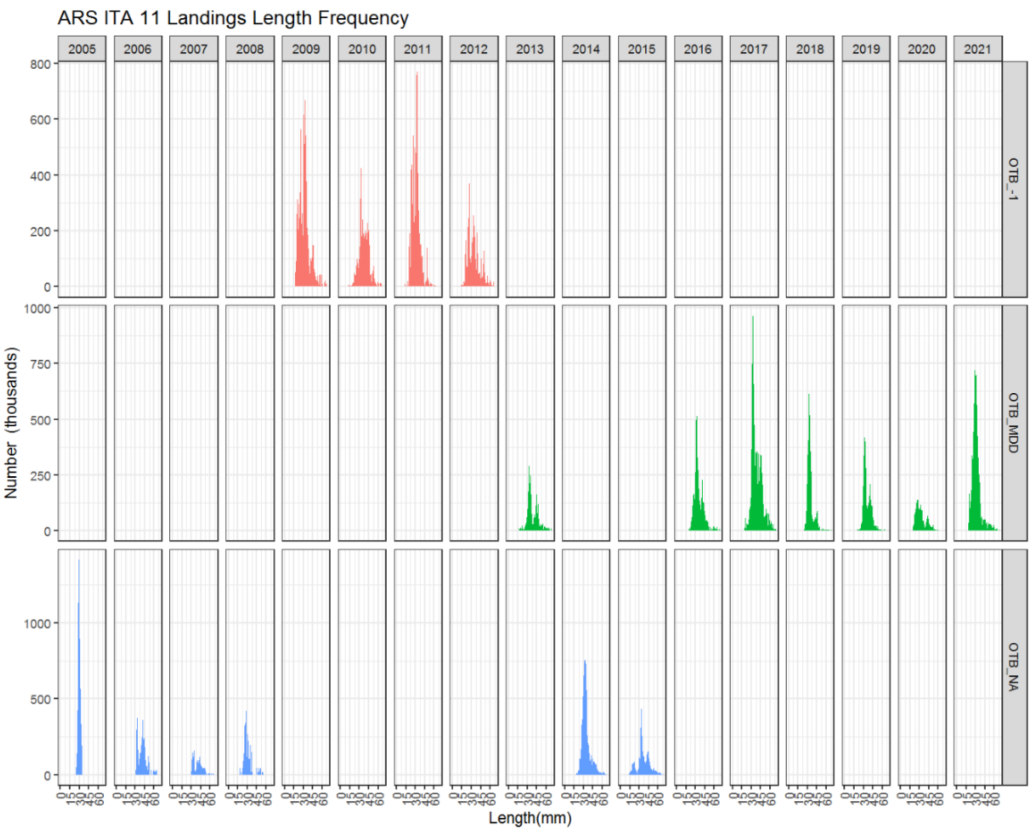


Figure 6.19.2.1.7. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 11.

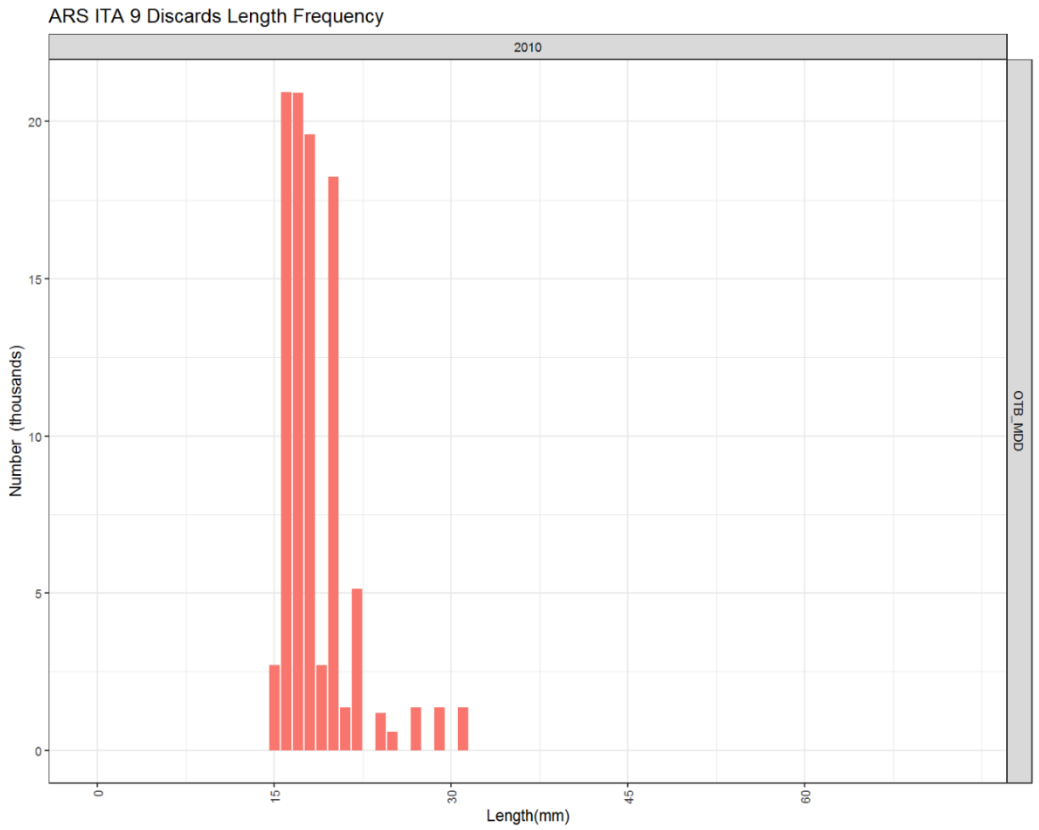


Figure 6.19.2.1.8. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 9

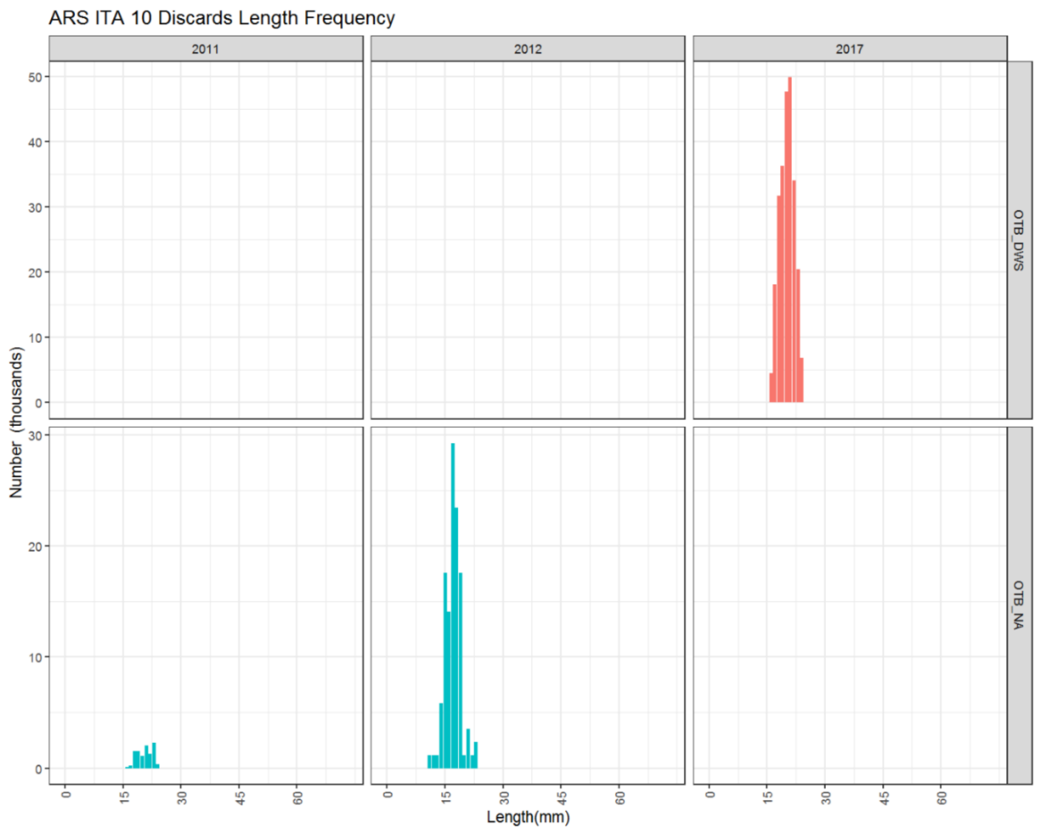


Figure 6.19.2.1.9. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 10.

6.19.2.2 SURVEY DATA

Since 1994, MEDITS trawl surveys have been regularly carried out each year (centred in the early summer). A random stratified sampling by depth (five strata with depth limits at 50, 100, 200, 500 and 800 m) is applied. Haul allocation was proportional to the stratum area. All the abundance data (number and total weight of fish per surface unit) are standardized to the km2 using the swept area method.

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance*100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the three GSAs.

In some years (2017, 2020 and 2021) surveys in all three GSAs were delayed (Figure 6.19.2.3.1), however, length frequency distributions observed are not noticeably different from the other years (Figure 6.19.2.3.6)

Figure 6.19.2.3.1 Giant red shrimp in GSAs 9, 10, 11: Suvery periods (MEDITS, 1994-2021) in GSAs 9, 10 and 11.

Geographical distribution

The following maps show the biomass indices (kg/km^2) by haul of the MEDITS survey. It is evident as the giant red shrimp is more abundant in GSAs 10 and 11 than in GSA 9. Furthermore, the species is mostly present in the southern part of the GSA 9 (Masnadi et al., 2018).

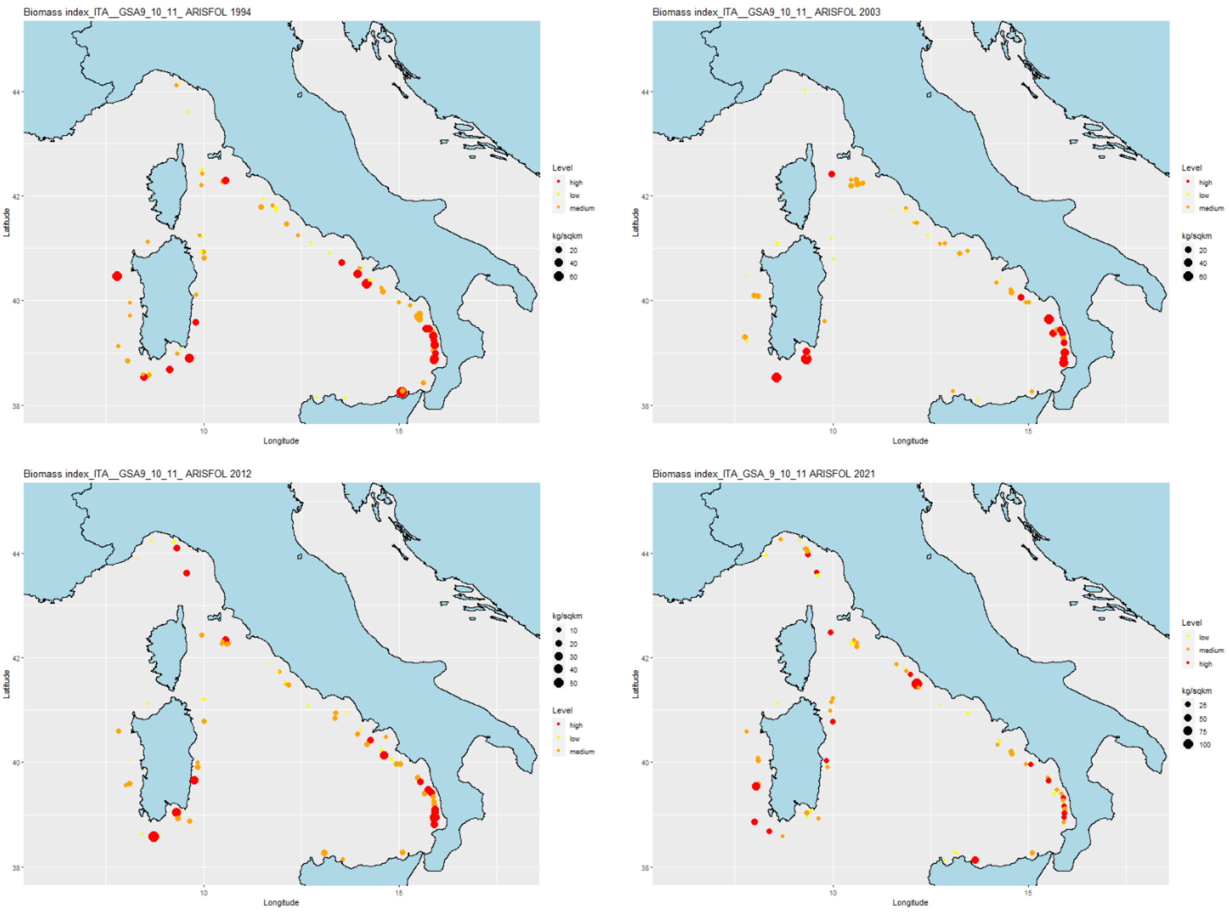
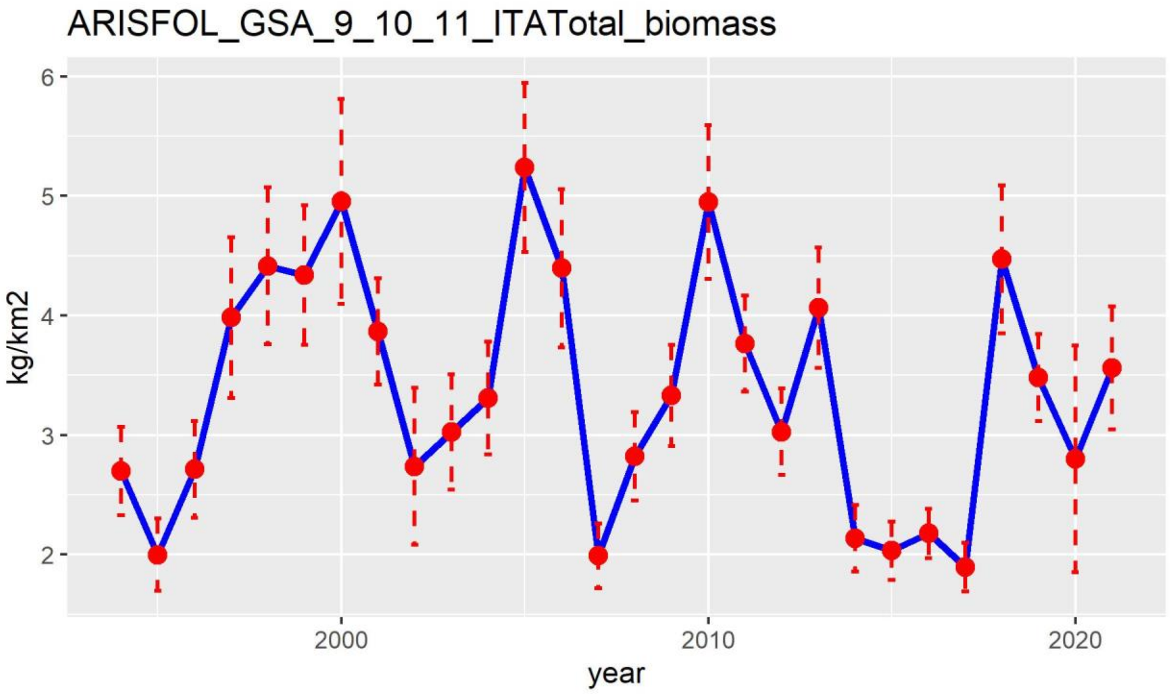


Figure 6.19.2.3.2 Giant red shrimp in GSAs 9, 10, 11: distribution pattern in the period 1994-2021 (MEDITS survey). Maps for the years 1994, 2003, 2012 and 2021 are shown.

Trends in abundance and biomass

The trends of the MEDITS indices (biomass and density) computed on the three GSAs combined are shown in Figure 6.19.2.3.3.

The time series of both indices are characterized by wide fluctuations with two main peaks in 2005 and 2010. An absence of a statistical trend can be observed for the two indices, with mean values along the time series of 3.4 kg/km^2 and 207 individuals/km^2.



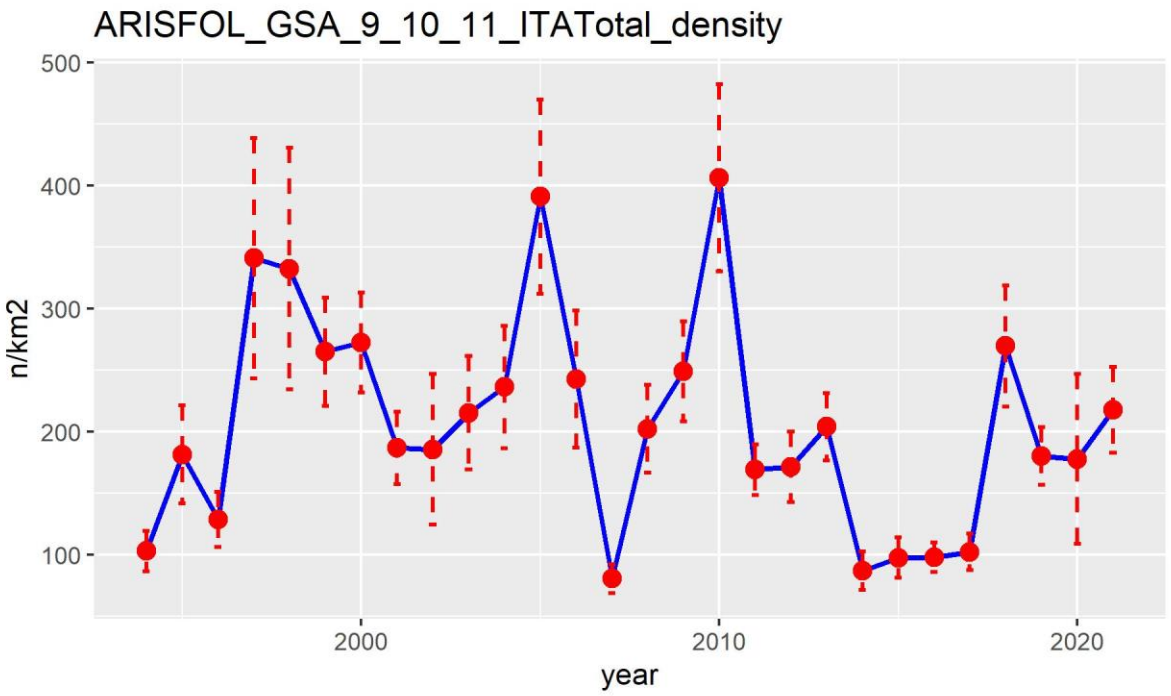


Figure 6.19.2.3.3. Giant red shrimp in GSAs 9, 10 & 11: MEDITS 1994-2021 standardized biomass and density indices (10-800 m).

Trends in abundance and biomass by length

The stratified abundance indices by length (by sex and total) computed on the three GSAs combined during the MEDITS surveys from 1994 to 2021 are shown in Figures 6.19.2.3.4-6.19.2.3.6.

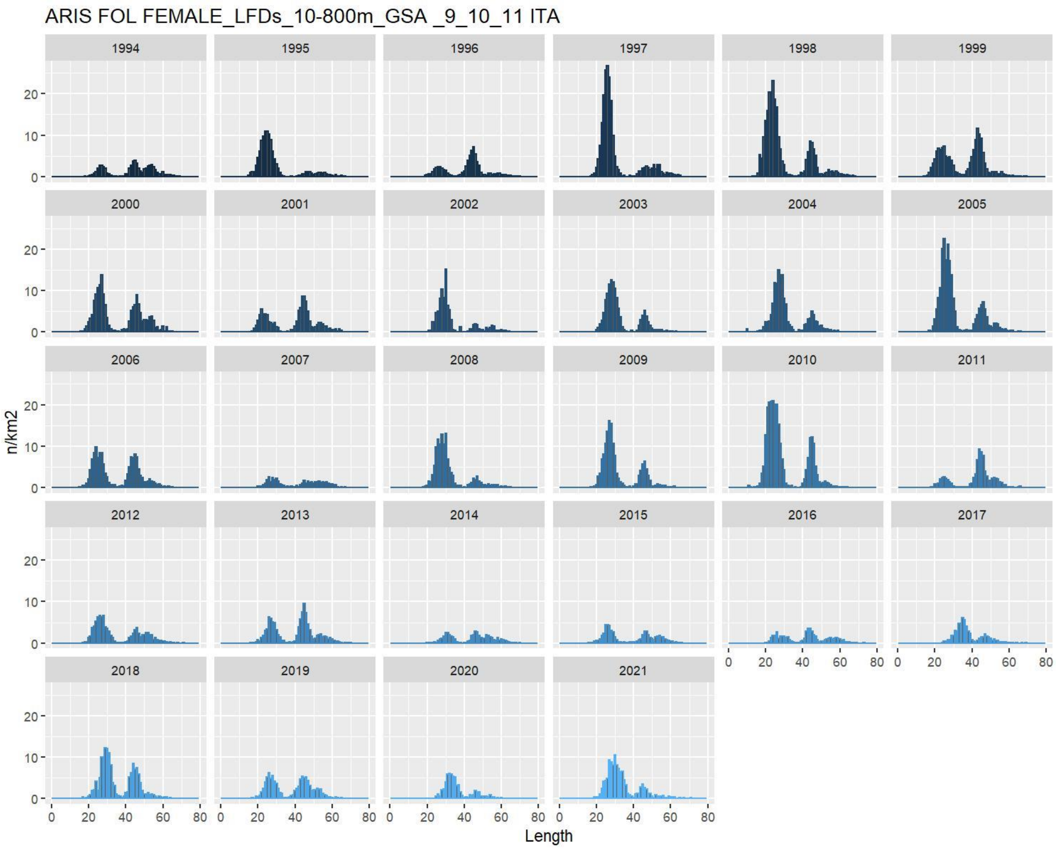


Figure 6.19.2.3.4. Giant red shrimp in GSAs 9, 10 & 11: stratified abundance indices by size for females, 1994-2021.

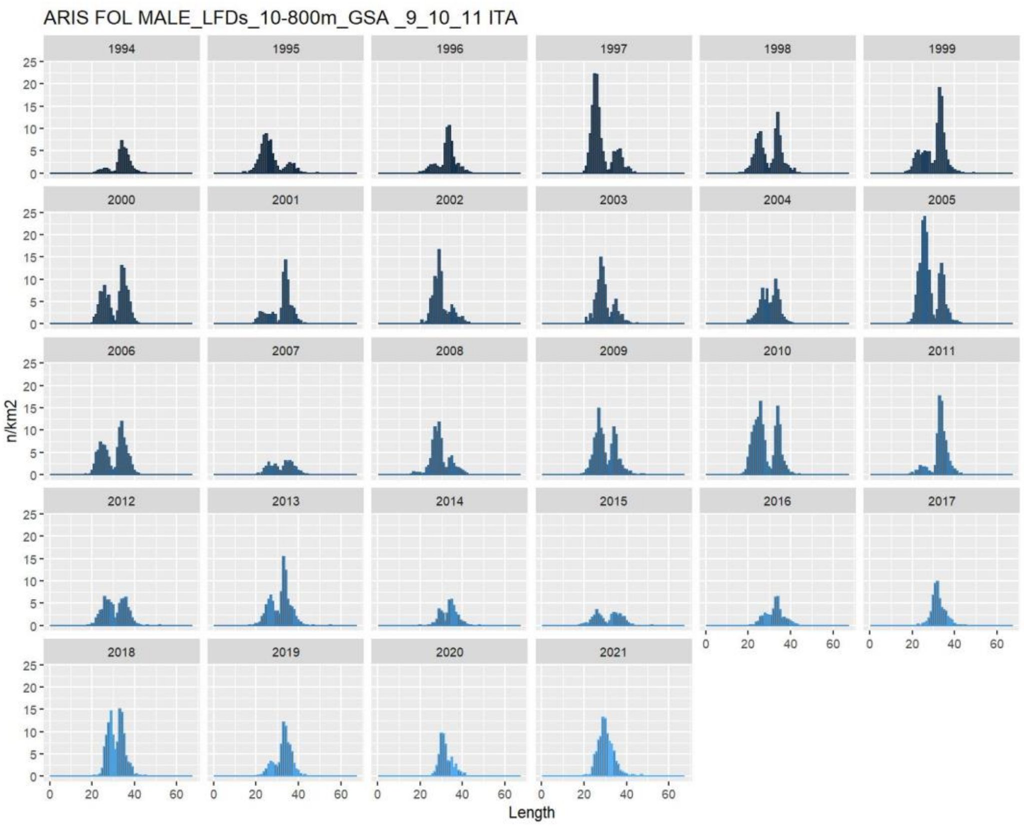


Figure 6.19.2.3.5. Giant red shrimp in GSAs 9, 10 & 11: stratified abundance indices by size for males, 1994-2021.

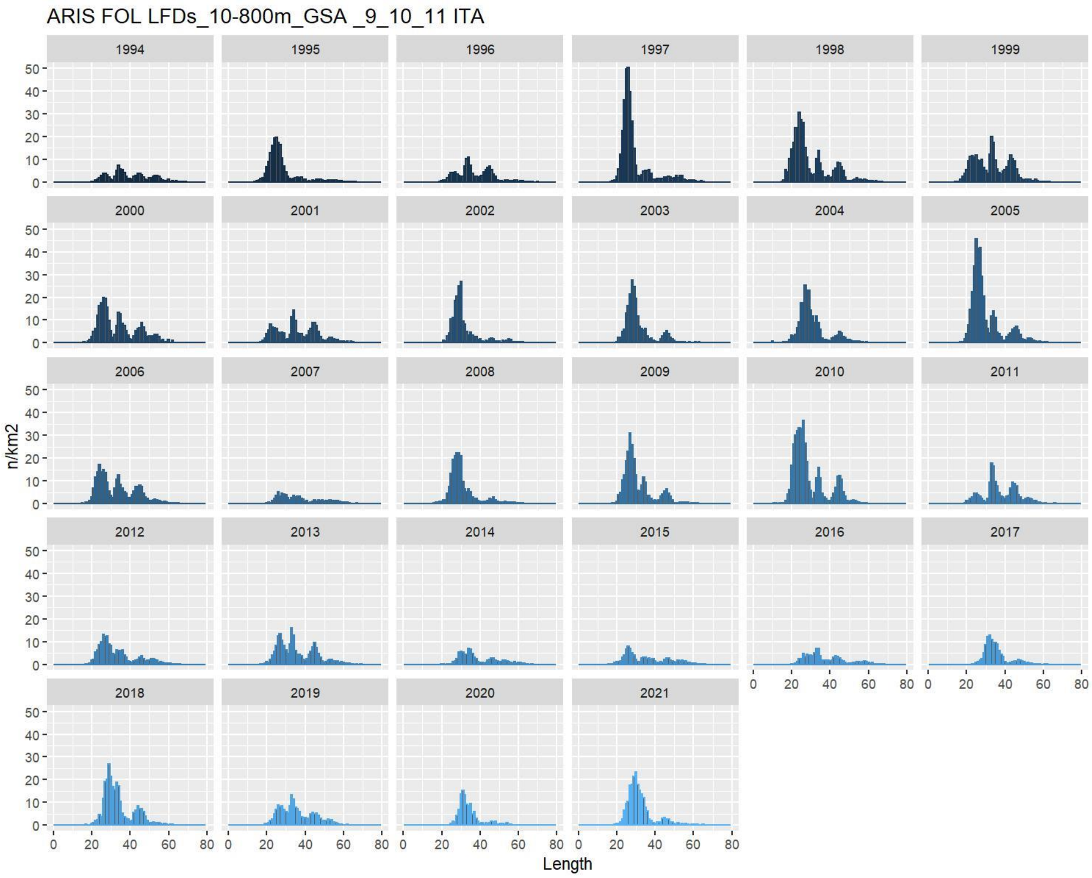


Figure 6.19.2.3.6 Giant red shrimp in GSAs 9, 10 & 11: total stratified abundance indices by size, 1994-2021.

6.19.3 STOCK ASSESSMENT

Input data

FLR libraries were employed in order to carry out a Statistical Catch-at-age (a4a) assessment.

The assessment by means of a4a was carried out using as input data the period 2005-2021 for the catch data and 2005-2021 for the tuning file (MEDITS indices).

A natural mortality vector computed using Chen and Watanabe model was used in the assessment. Natural mortality vector and proportion of mature are described in section 6.19.1.1. Length-frequency distributions of commercial catches and surveys were split by sex and then transformed in age classes (plus group was set at age 4) using length-to-age slicing with different growth parameters by sex. A correction of 0.5 was applied to t_0 to align length slicing to assessment year January to December to account for spawning at the middle of the year. The number of individuals by age relative to the catches was SOP corrected:

[SOP = catch / Σa (total catch numbers at age a x catch weight-at-age a)].

In both catches and survey, a plus group at age 4 was set. F_{bar} range was fixed at 1-3.

The final data input are shown in the tables and figures below (Figures 6.19.3.1-2, Tables 6.19.3.1-4).

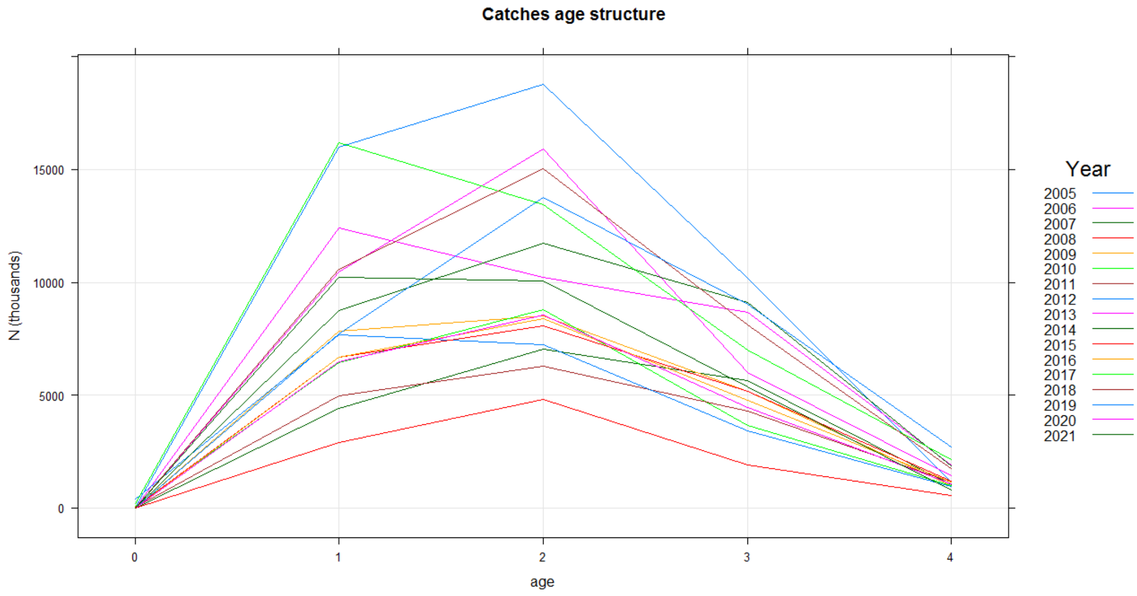


Figure 6.19.3.1 Giant red shrimp in GSAs 9, 10 & 11: catch-at-age distribution by year of the catches (2005-2021).

Table 6.19.3.1. SOP correction vectors for the Giant red shrimp in GSAs 9, 10 & 11.

	GSA 9	GSA 10	GSA 11
2003	1.0	11.3	
2004	1.1	1.0	
2005	1.0	1.0	0.8
2006	1.1	1.0	0.9
2007	1.1	1.0	0.9
2008	1.5	1.0	0.9
2009	1.1	1.0	0.9
2010	1.6	1.0	0.9
2011	1.5	1.0	0.9
2012	1.3	1.0	0.9
2013	1.1	1.0	1.9
2014	1.2	1.0	0.9
2015	2.9	1.0	1.2
2016	3.5	1.0	1.5
2017	1.0	1.7	1.2
2018	1.0	3.2	2.9
2019	2.4	2.5	2.5
2020	1.1	6.5	4.9
2021	1.1	2.7	1.4

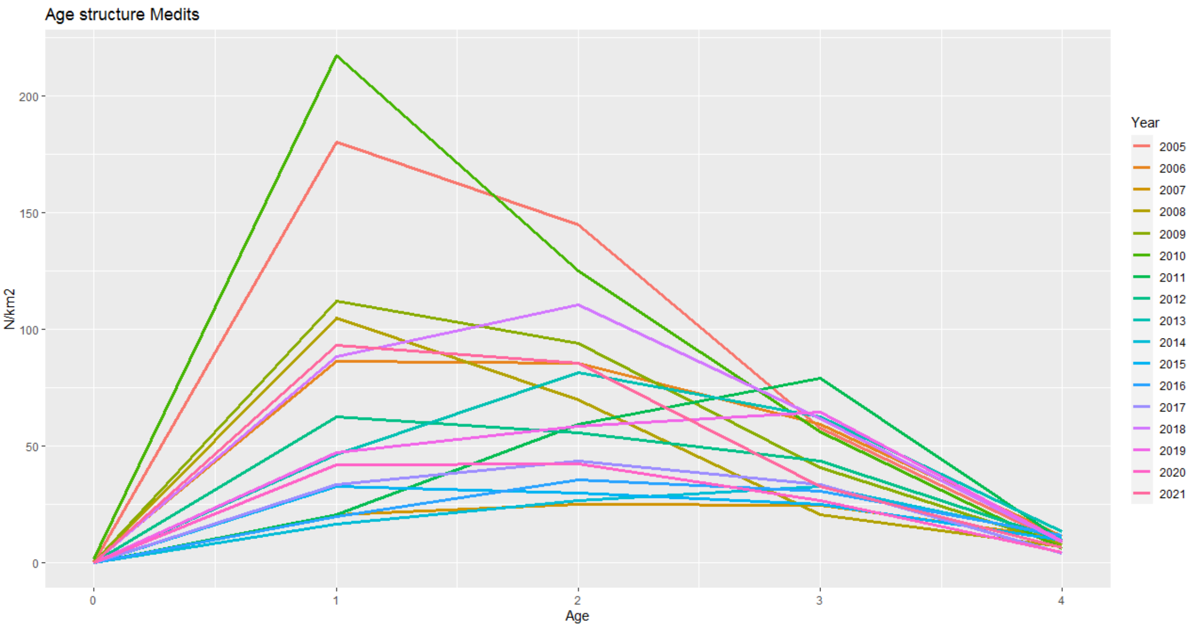


Figure 6.19.3.2 Giant red shrimp in GSAs 9, 10 & 11: MEDITS index-at-age distribution by year (2005-2021).

Table 6.19.3.2. Giant red shrimp in GSAs 9, 10 & 11: Values of catch numbers at age per year used in the assessment (SOP applied).

Age	2005	2006	2007	2008	2009
0	14.82	1.06	1.06	1.36	1.30
1	16010.74	12414.09	4403.57	2879.92	7847.13
2	18770.46	10210.43	7054.93	4802.42	8525.26
3	10198.42	8680.60	5649.58	1886.63	5154.41
4+	1164.79	1895.84	1033.08	544.96	985.19
Age	2010	2011	2012	2013	2014
0	53.63	14.11	393.26	8.59	1.12
1	6442.58	4961.68	7677.99	10450.40	8747.55
2	8793.63	6286.28	7243.32	15931.76	11726.97
3	3637.22	4271.76	3423.66	5997.92	9090.38
4+	994.85	1147.46	929.26	1418.13	1882.53
Age	2015	2016	2017	2018	2019
0	35.28	4.66	189.52	1.96	2.47
1	6686.81	6669.75	16190.83	10579.40	7725.29
2	8070.63	8385.14	13446.42	15028.78	13749.51
3	5173.34	4755.97	6979.44	8105.79	9035.01
4+	1183.06	1148.00	2151.53	1734.65	2702.65
Age	2020	2021			
0	11.23	3.25			
1	6496.58	10233.86			
2	8557.11	10045.48			
3	4464.22	5358.35			
4+	1077.90	780.09			

Table 6.19.3.3. Giant red shrimp in GSAs 9, 10 & 11: Values of mean weight at age per year used in the assessment.

Age	2005	2006	2007	2008	2009
0	0.000	0.000	0.000	0.000	0.000
1	0.011	0.009	0.014	0.010	0.010
2	0.013	0.022	0.021	0.019	0.017
3	0.017	0.022	0.023	0.029	0.020
4+	0.038	0.030	0.041	0.035	0.037
Age	2010	2011	2012	2013	2014
0	0.000	0.000	0.000	0.000	0.000
1	0.009	0.011	0.008	0.010	0.013
2	0.019	0.022	0.016	0.018	0.019
3	0.022	0.018	0.024	0.018	0.021
4+	0.033	0.028	0.035	0.034	0.040
Age	2015	2016	2017	2018	2019
0	0.000	0.000	0.000	0.000	0.000
1	0.011	0.011	0.008	0.012	0.013
2	0.018	0.018	0.020	0.018	0.022
3	0.022	0.017	0.021	0.020	0.019
4+	0.037	0.032	0.035	0.037	0.030
Age	2020	2021			
0	0.000	0.000			
1	0.010	0.010			
2	0.019	0.013			
3	0.025	0.020			
4+	0.040	0.041			

Table 6.19.3.4. Giant red shrimp in GSAs 9, 10 & 11: Survey index (MEDITS) values of numbers at age per year used in the assessment.

Age	2005	2006	2007	2008	2009
0	0.178	0.377	0.030	0.048	0.094
1	180.141	86.310	20.440	105.050	112.061
2	144.642	85.376	24.921	69.670	94.008
3	57.538	59.137	24.574	20.658	40.582
4+	8.392	11.390	10.620	6.859	7.754
Age	2010	2011	2012	2013	2014
0	1.518	0.129	0.049	0.054	0.030
1	217.376	20.788	62.401	46.374	16.618
2	125.252	59.448	55.508	81.645	26.744
3	56.139	79.142	43.593	62.426	32.862
4+	6.074	9.631	9.743	13.418	10.748
Age	2015	2016	2017	2018	2019
0	0.095	0.030	0.030	0.160	0.127
1	32.857	19.765	33.581	88.490	47.175
2	29.711	35.661	43.685	110.535	58.547
3	24.856	30.732	33.689	61.574	64.757
4+	9.584	11.706	4.231	8.844	9.133
Age	2020	2021			
0	0.030	0.045			
1	42.167	93.183			
2	42.455	85.467			
3	26.746	32.690			
4+	4.388	6.439			

Assessment results

The assessment was performed by sex combined. Given that the catches were composed mainly of individuals between 1 and 3 years, these ages were selected as F_{bar} range.

The model settings that minimized the residuals and showed the best diagnostics outputs were used for the final assessment, and are the following:

Fishing mortality sub-model: fmodel = factor(replace(age, age>3,3))+s(year, k=6)

Catchability sub-model: qmodel = list(~ factor(age))

SR sub-model: srmod = geomean(CV=0.2)

Model <- sca(stock = stk, indices = idx, fmodel, qmodel, srmod)

The n1model and vmodel used in the final fit are the default ones:

n1model <- ~s(age, k = 3)

vmodel <- list(~s(age, k=3), ~1)

The log residuals for both the catches and the survey do not show any particular trend or issue, and are similar to the assessment from last year. The fitting of the survey shows some problems (Figures 6.19.3.9), probably due to the poor internal consistency of the survey. Despite this, the diagnostics are considered acceptable and the a4a model is acceptable as a basis for advice.

The effect of cryptic biomass was investigated, and did not show any relevant issue, as the biomass of the plus group (age 4+) is never higher than the 7% of the total SSB.

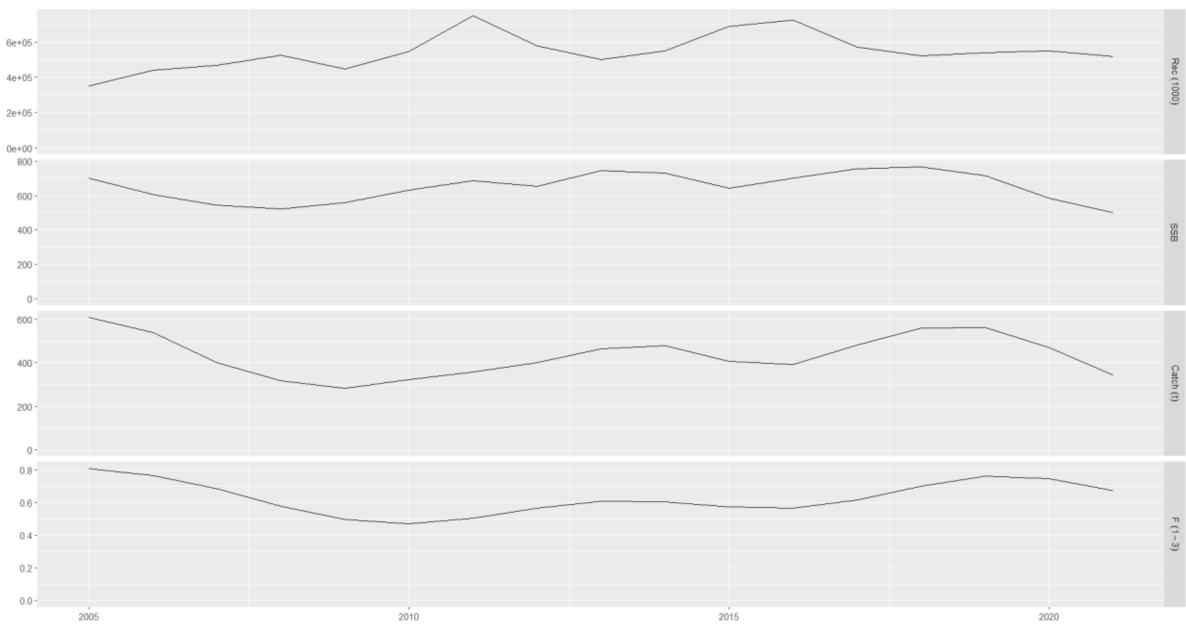
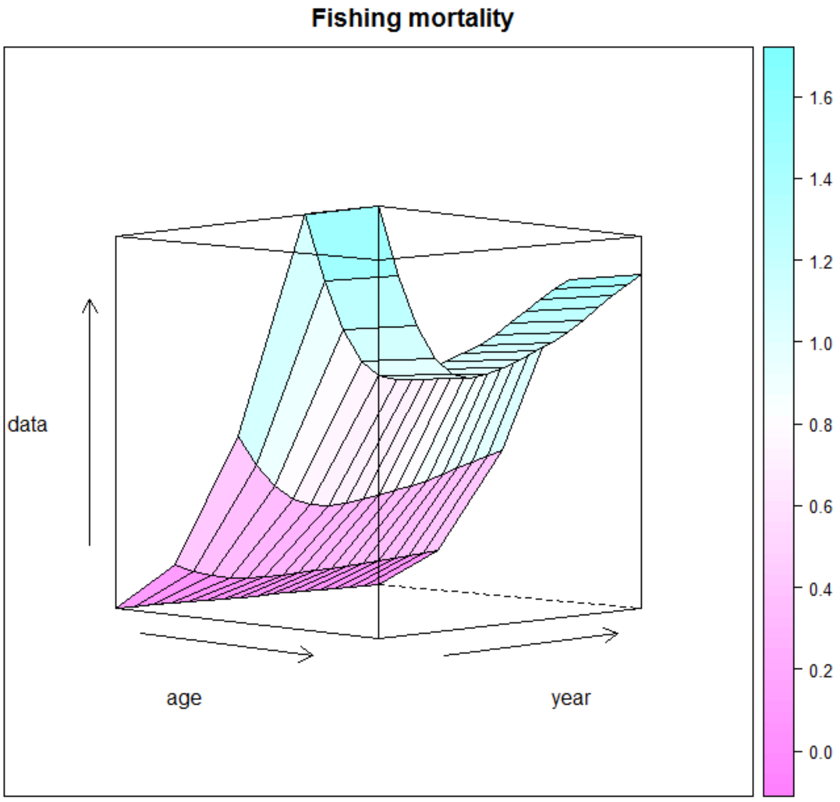


Figure 6.19.3.3. Giant red shrimp in GSAs 9, 10 & 11. Stock summary from the final a4a model.



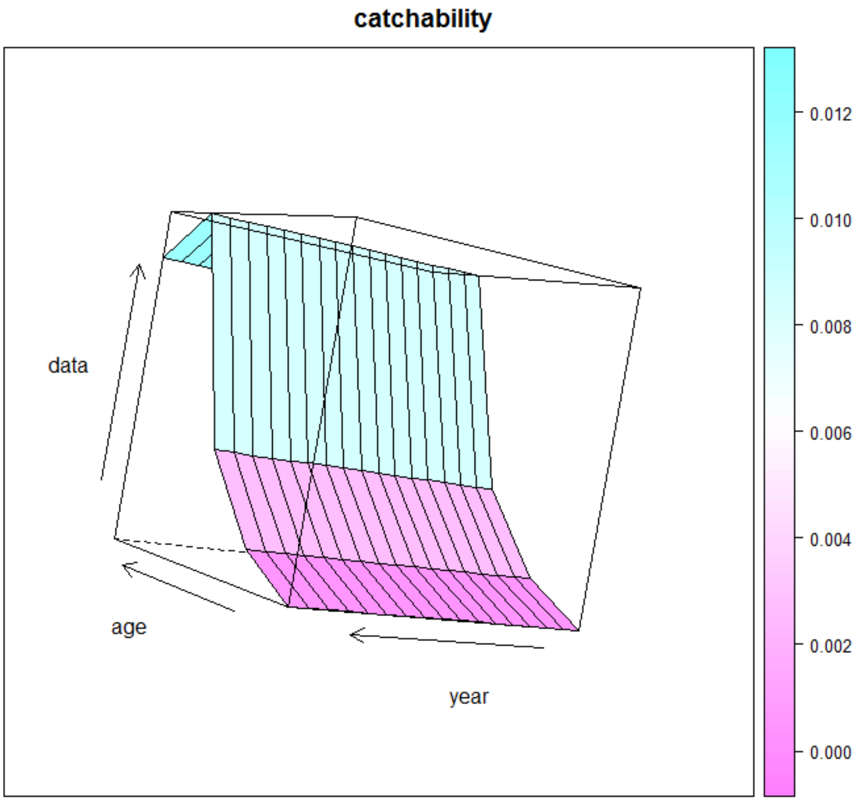


Figure 6.19.3.4. Giant red shrimp in GSAs 9, 10 & 11. 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.

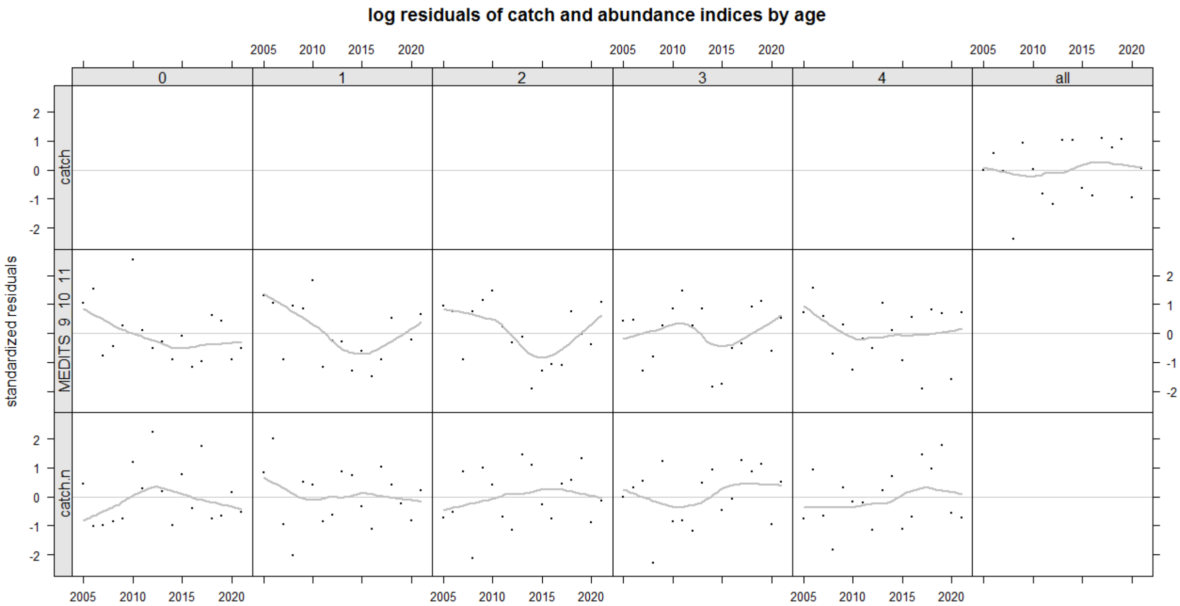


Figure 6.19.3.5. Giant red shrimp in GSAs 9, 10 & 11. log residuals for the catch-at-age data of the fishery and the survey.

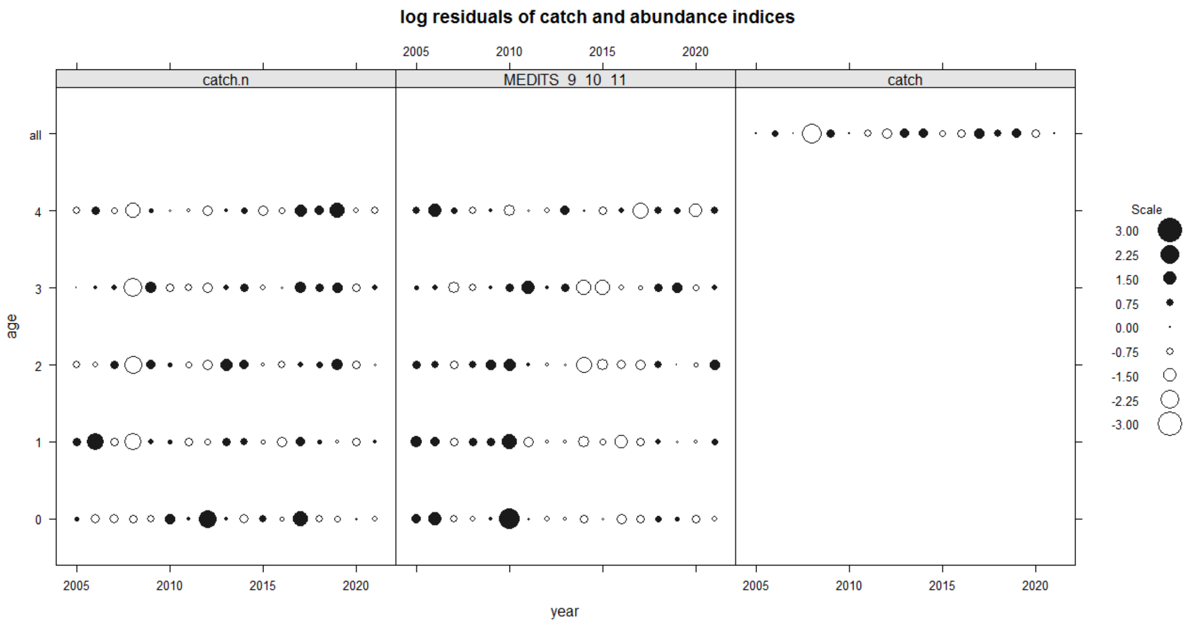


Figure 6.19.3.6. Giant red shrimp in GSAs 9, 10 & 11. Bubble plot of the log residuals for the catch-at-age data of the fishery and the survey.

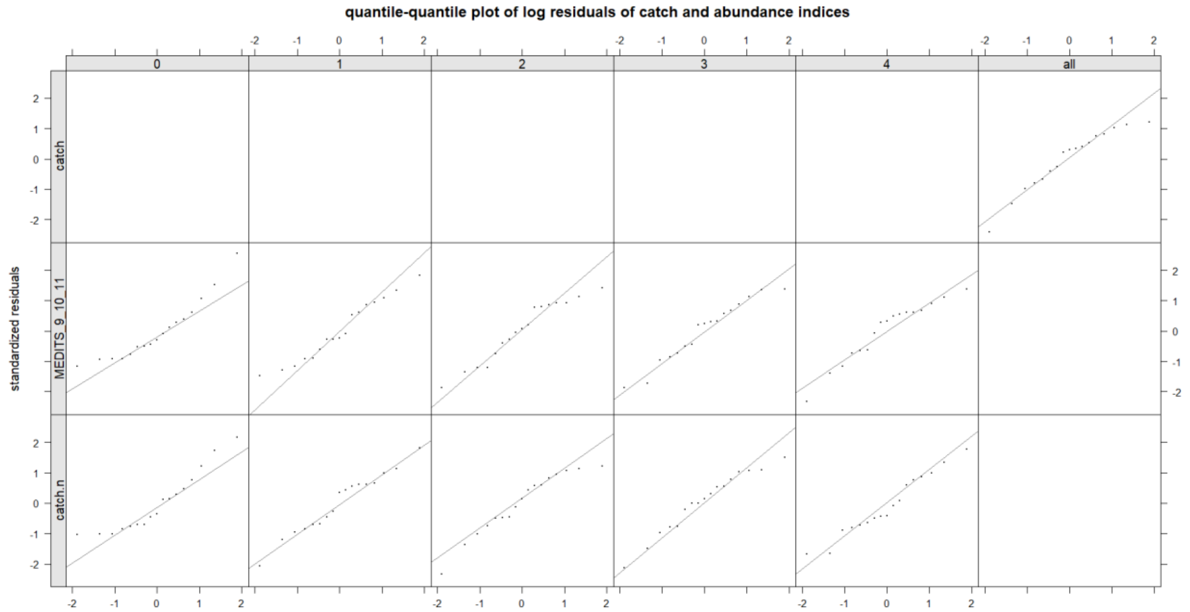


Figure 6.19.3.7. Giant red shrimp in GSAs 9, 10 & 11: QQ-plot of the log residuals for the catch-at-age data of the fishery and the survey.

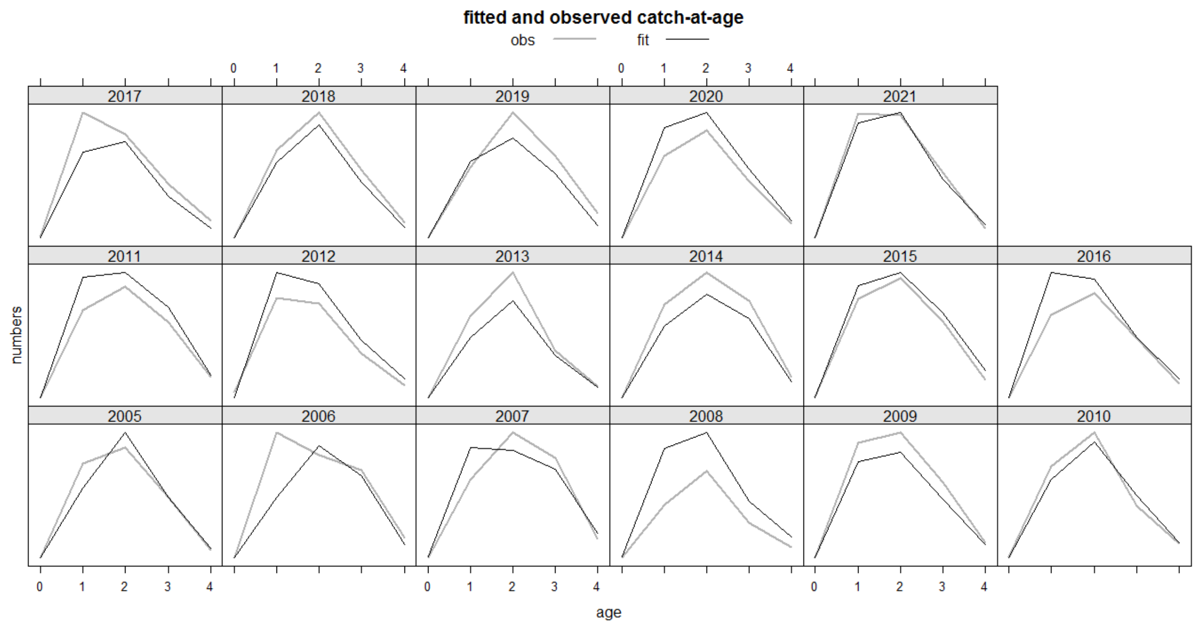


Figure 6.19.3.8. Giant red shrimp in GSAs 9, 10 & 11: fitted vs observed values by age and year for the catches.

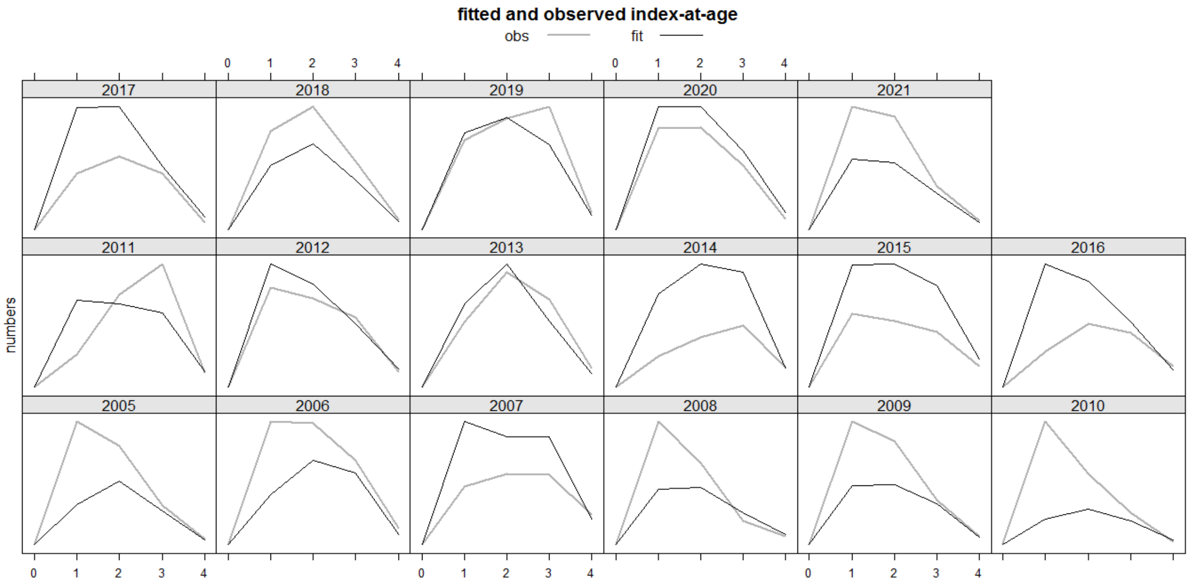


Figure 6.19.3.9. Giant red shrimp in GSAs 9, 10 & 11: fitted vs observed values by age and year for the survey.

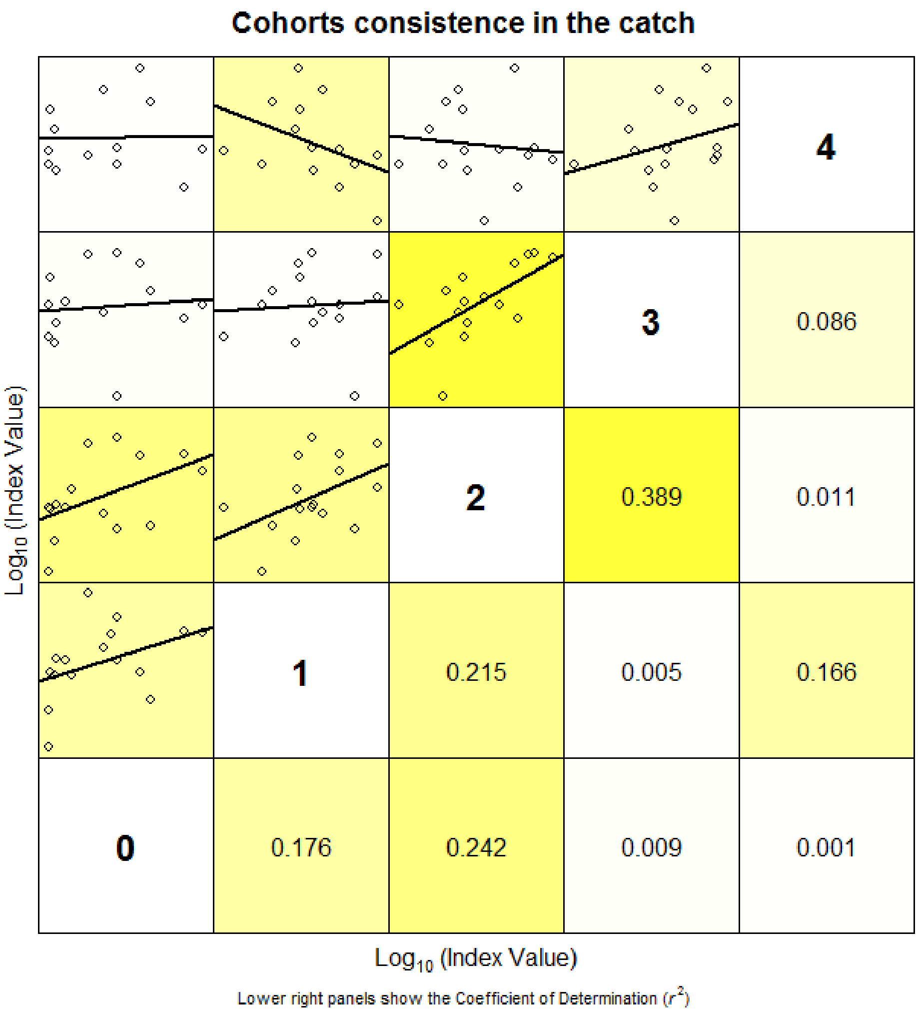


Figure 6.19.3.10. Giant red shrimp in GSAs 9, 10 & 11: internal consistency of the catch-at-age data.

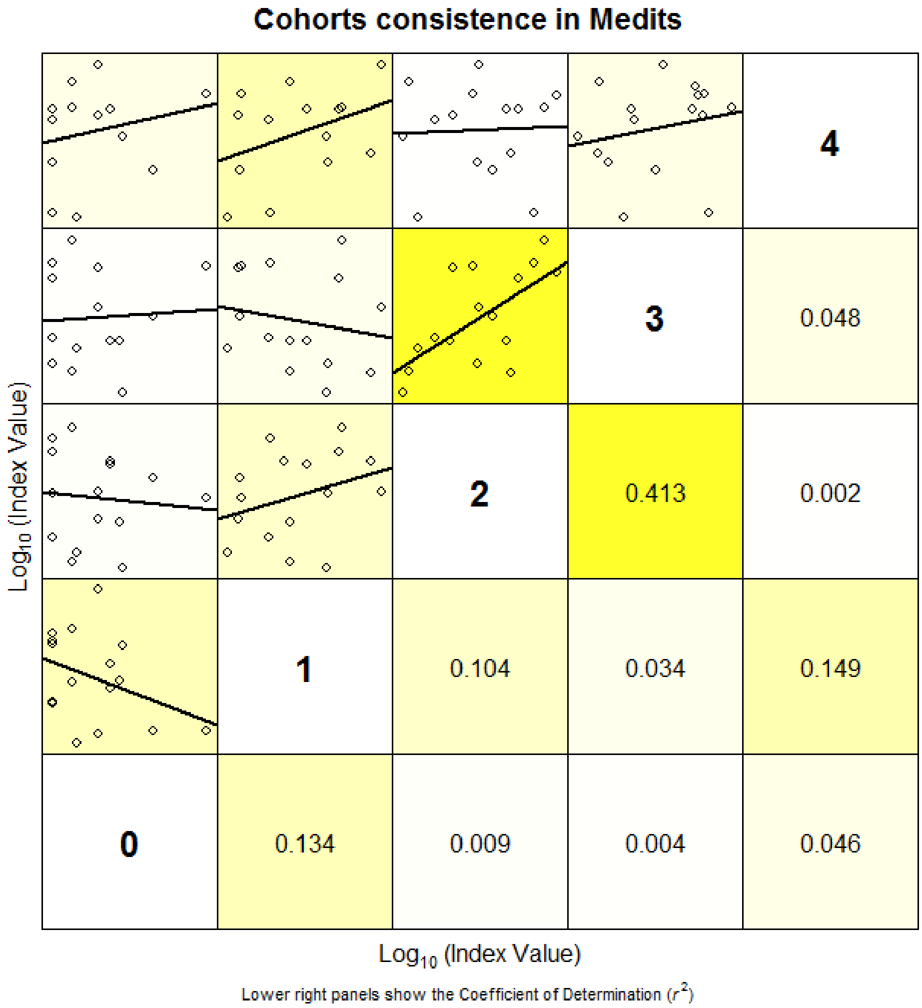


Figure 6.19.3.11. Giant red shrimp in GSAs 9, 10 & 11: internal consistency of the catch-at-age data of the MEDITS survey.

Retrospective

The retrospective analysis was applied up to 3 years back, due to the short time series. It shows that the assessment model is moderately stable, and the catch estimates obtained by the a4a assessment are fitting well the observed catches. There is some evidence of retrospective bias, underestimation of F, probably linked to large negative and then positive residuals in survey data. The instability does not affect the conclusion F>F_{MSY} in all years with F_{MSY} = 0. 43, F in 2021 is estimated as $F_{current}$=0.77.

Based on the a4a results, the Giant red shrimp showed a slight decrease in the SSB since 2018 (from 757 to 466 tons) and an increase in F_{bar} (1-3) that reached the maximum values since 2006 in the last year (0.77).

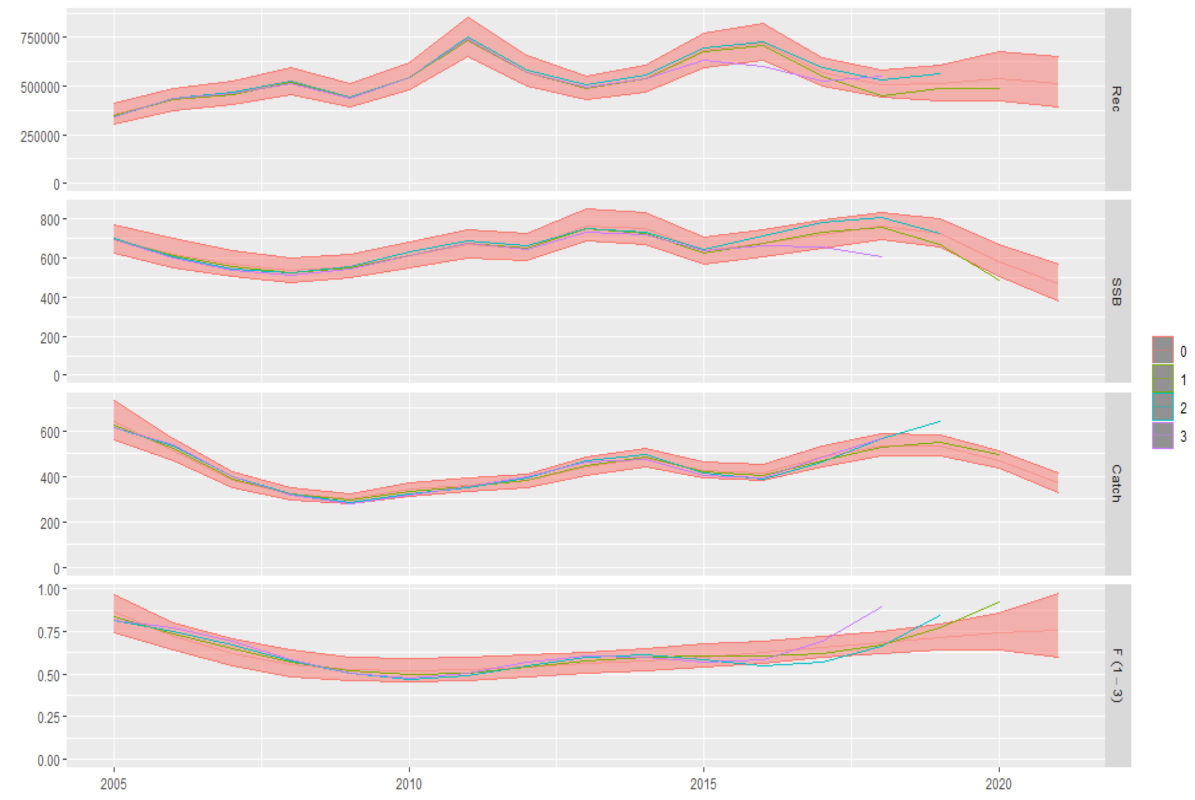


Figure 6.19.3.12. Giant red shrimp in GSAs 9, 10 & 11. Retrospective analysis

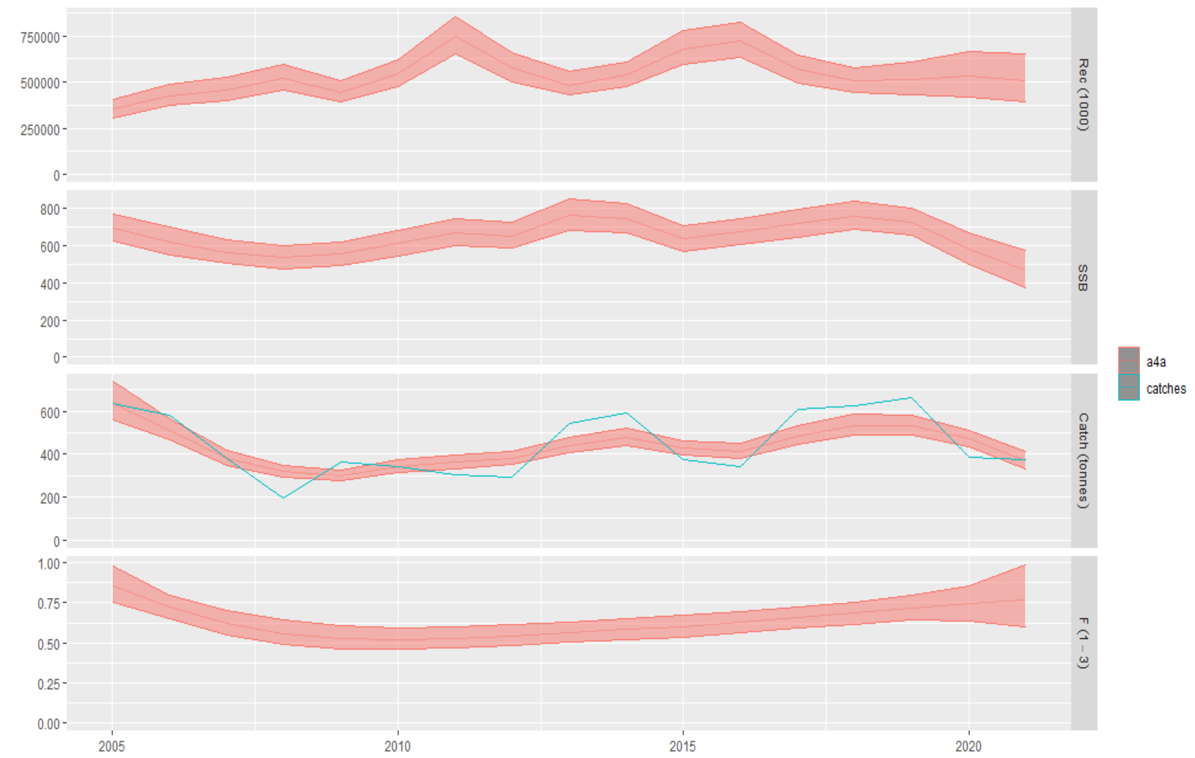


Figure 6.19.3.13. Giant red shrimp in GSAs 9, 10 & 11. Simulations over summary results.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.19.3.5. Giant red shrimp in GSAs 9, 10 & 11. Stock numbers at age (thousands) as estimated by a4a.

	0	1	2	3	4+
2005	353362	90755	52109	15388	2337
2006	427798	53381	31083	13287	2107
2007	459434	64626	18898	8909	2354
2008	523442	69405	23451	5909	2084
2009	446457	79075	25583	7750	1671
2010	544850	67445	29373	8688	2079
2011	748036	82309	25096	10036	2410
2012	575298	113004	30563	8512	2742
2013	487240	86909	41797	10223	2412
2014	536655	73606	32003	13763	2612
2015	680909	81071	26979	10368	3263
2016	722911	102863	29563	8584	2623
2017	569266	109208	37283	9207	2059
2018	505957	85997	39307	11327	1957
2019	512470	76433	30722	11631	2177
2020	533744	77417	27108	8861	2142
2021	509526	80631	27272	7634	1624

Table 6.19.3.6. Giant red shrimp in GSAs 9, 10 & 11. Fishing mortality-at-age.

	0	1	2	3	4+
2005	0.00	0.21	0.75	1.61	1.61
2006	0.00	0.18	0.63	1.36	1.36
2007	0.00	0.15	0.54	1.17	1.17
2008	0.00	0.14	0.49	1.05	1.05
2009	0.00	0.13	0.46	0.99	0.99
2010	0.00	0.13	0.45	0.98	0.98
2011	0.00	0.13	0.46	0.99	0.99
2012	0.00	0.13	0.48	1.02	1.02
2013	0.00	0.14	0.49	1.06	1.06
2014	0.00	0.14	0.51	1.09	1.09
2015	0.00	0.15	0.53	1.13	1.13
2016	0.00	0.15	0.55	1.18	1.18
2017	0.00	0.16	0.57	1.23	1.23
2018	0.00	0.17	0.60	1.29	1.29
2019	0.00	0.18	0.62	1.34	1.34
2020	0.00	0.18	0.65	1.39	1.39
2021	0.00	0.19	0.67	1.44	1.44

Table 6.19.3.7. Giant red shrimp in GSAs 9, 10 & 11. a4a summary results and F at age.

	Fbar(1-3)	Recruitment (thousands)	SSB (t)	Catch (t)
2005	0.85	353362	692.3	637.1
2006	0.72	427798	617.3	513.1
2007	0.62	459434	564.2	381.7
2008	0.56	523442	532.3	319.5
2009	0.53	446457	551.9	299.0
2010	0.52	544850	610.6	341.9
2011	0.53	748036	665.7	361.0
2012	0.54	575298	650.6	378.5
2013	0.56	487240	761.7	440.6
2014	0.58	536655	744.9	478.9
2015	0.60	680909	634.4	426.5
2016	0.63	722911	671.1	413.6
2017	0.65	569266	718.7	483.4
2018	0.68	505957	757.2	532.7
2019	0.71	512470	723.5	533.2
2020	0.74	533744	579.5	471.0
2021	0.77	509526	466.3	369.9

6.19.4 REFERENCE POINTS

The time series is too short to produce meaningful stock recruitment relationship, so reference points are based on equilibrium methods. The STECF EWG recommended using $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the assessment.

The value of $F_{0.1}$, chosen as proxy of F_{MSY}, is equal to 0.43. The current F, estimated as the $F_{bar1\text{-}3}$ in the last year of the time series, 2021, is 0.77, well above the $F_{0.1}$. This indicates that the giant red shrimps in GSAs 9, 10 & 11 is over – exploited.

Estimation of biomass reference points

The procedure used for biomass reference points follows the methods set out in EWG 22-03 endorsed by STECF in July 2022, and described briefly above in Section 4. An exploratory per-recruit analysis was performed using the results of the a4a assessment. The per-recruit reference points of interest were computed from the stock object and are summarized in table 6.19.4.1 and figure 6.19.4.1.

Table 6.19.4.1. Giant red shrimp in GSAs 9, 10 & 11. Per-recruit reference points.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	B_0
0.4262	0.001442	0.000548	2.110876	0.000695

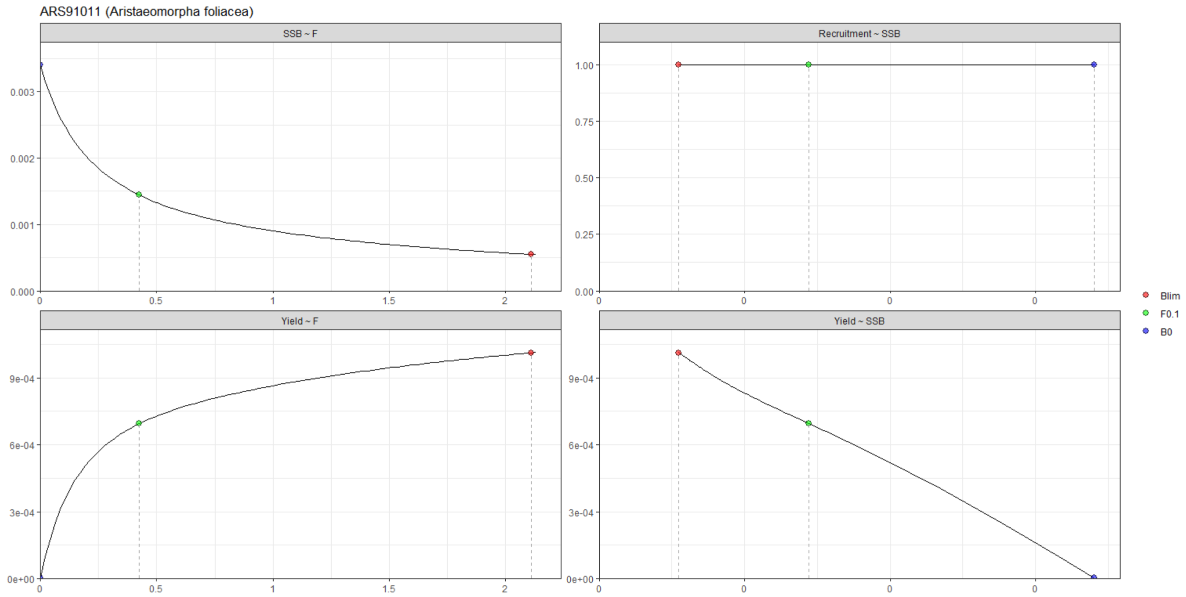


Figure 6.19.4.2: Giant red shrimp in GSAs 9, 10 & 11. Per recruit analysis.

Figure 6.19.4.2 is showing the trajectories of the assessment outputs against the per-recruit reference points. SSB has been fluctuating slightly below the biomass at $F_{0.1}$ ($B_{F0.1}$) and well above B_{lim}, with a sharper decrease in the last years. At the same time, F has been slightly above $F_{0.1}$, though increasing in the last years.

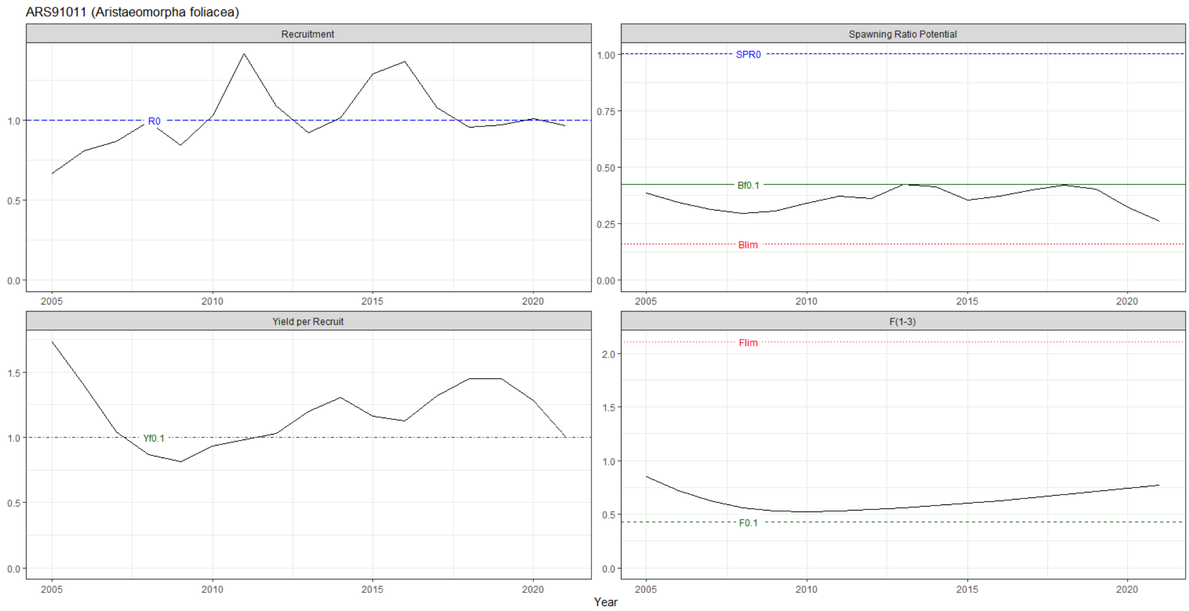


Figure 6.19.4.3. Giant red shrimp in GSAs 9, 10 & 11. Per recruit analysis: outcomes of the a4a assessment compared against the per recruit reference points.

Following the procedure laid out in EWG 22-03 the Geometric Mean approach has been considered the most suitable to estimate the biomass reference points for the stock of giant red shrimp in GSAs 9, 10 & 11, because the hockey Stick model fits the break point outside the data (Figure 6.19.4.3). The Beverton-Holt and Ricker models give higher biomasses but these also lie outside the range of observations, making the GM a conservative option. Table 6.19.4.2 summaries the reference point values based on the default value of 25% of $B_{F0.1}$ for B_{lim} and

Geometric Mean fitted to the data for R_0. B_{pa} is set to 2* B_{lim}. The stock is considered to be between B_{pa} and $B_{F0.1}$ in 2021.

The stock history relative to the reference points is illustrated over time (Figure 6.19.4.4) and as a Kobe plot in SSB and F (Figure 6.19.4.6).

Modelling using a HS construction (fixed slope to origin, breakpoint and constant mean recruitment) can often give simplistic results for stock management. A BH model which most closely represents the chosen model has a steepness of 0.9 and is shown in Figure 6.19.4.7.

Table 6.19.4.1. Giant red shrimp in GSAs 9, 10 & 11. Final reference points based on Geometric mean stock recruit model fitted to the data and the default B_{lim}.

$F_{0.1}$	$B_{F0.1}$	B_{lim}	F_{lim}	B_{pa}	B_0
0.4262	762.4255	190.6064	3.547685	381.2128	1802.188

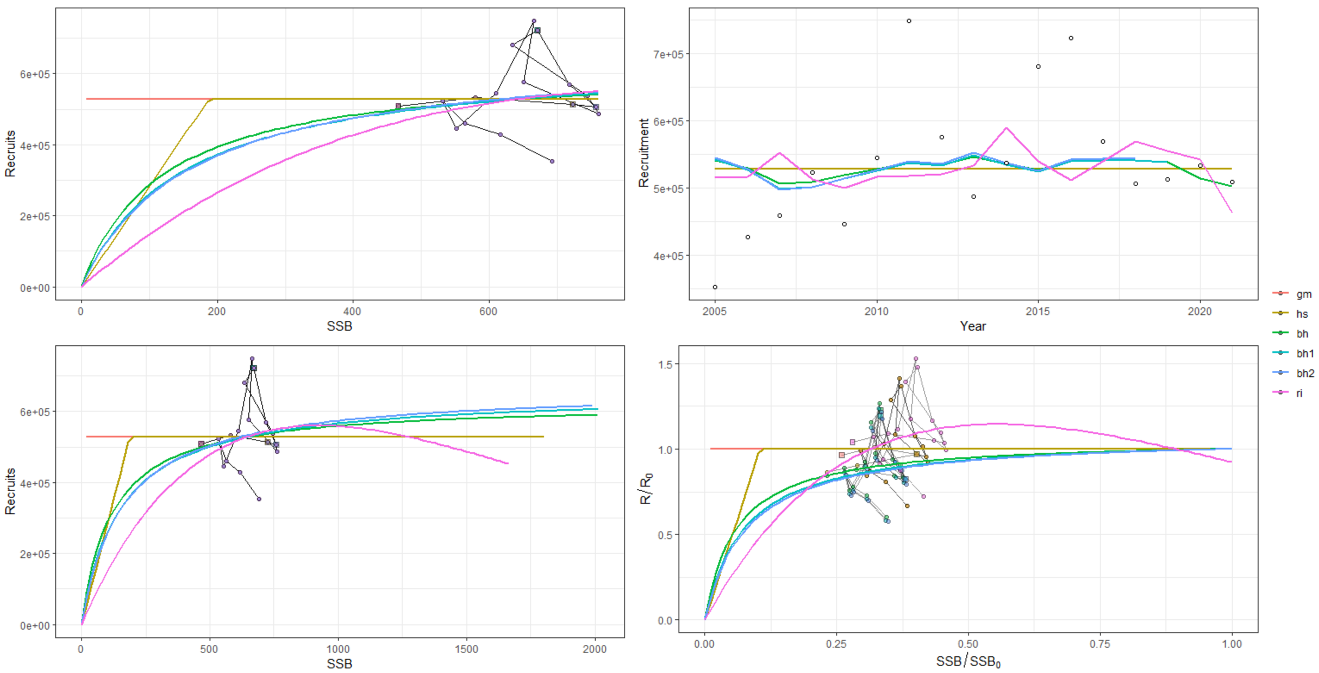


Figure 6.19.4.4: Giant red shrimp in GSAs 9, 10 & 11. Fit of S-R relationships to data from 2022 assessment. HS breakploint lies outside the data.

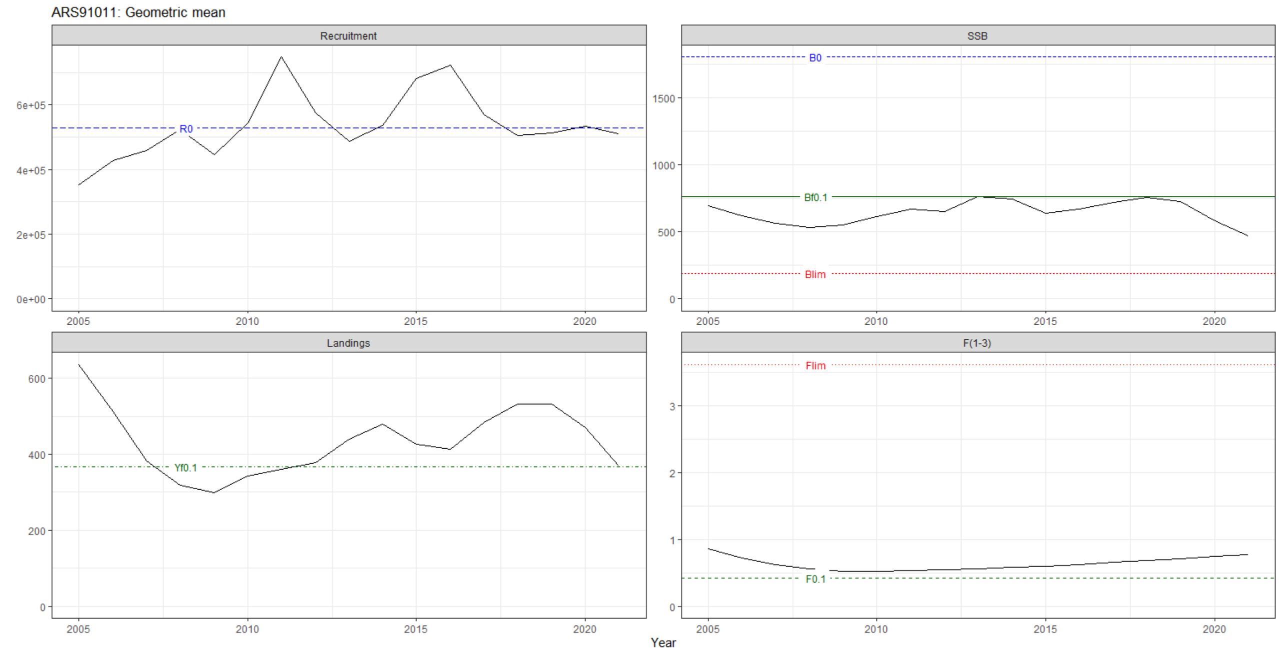


Figure 6.19.4.5: Giant red shrimp in GSAs 9, 10 & 11. History of the giant red shrimp stock relative to biomass points based on GM and 25% of $B_{F0.1}$.

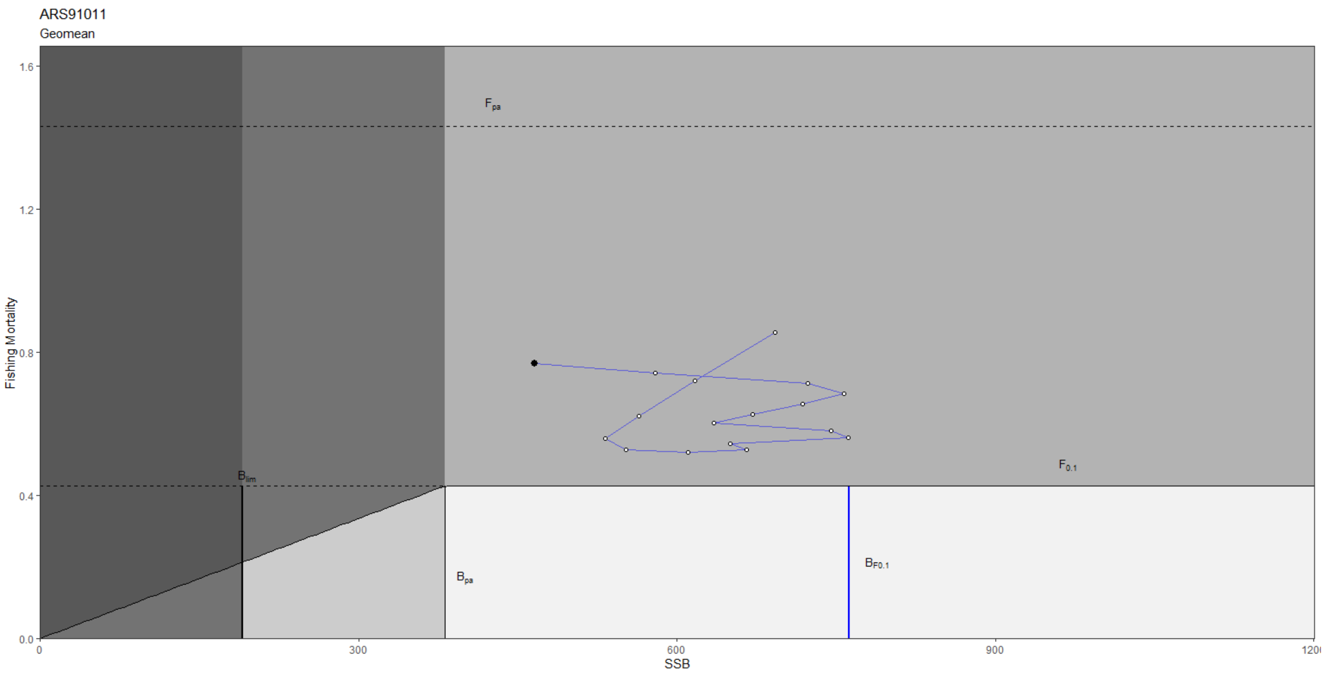


Figure 6.19.4.6: Giant red shrimp in GSAs 9, 10 & 11. Kobe plot SSB and R with fitted reference points based on GM mean recruitment and breakpoint at 25% $B_{F0.1}$

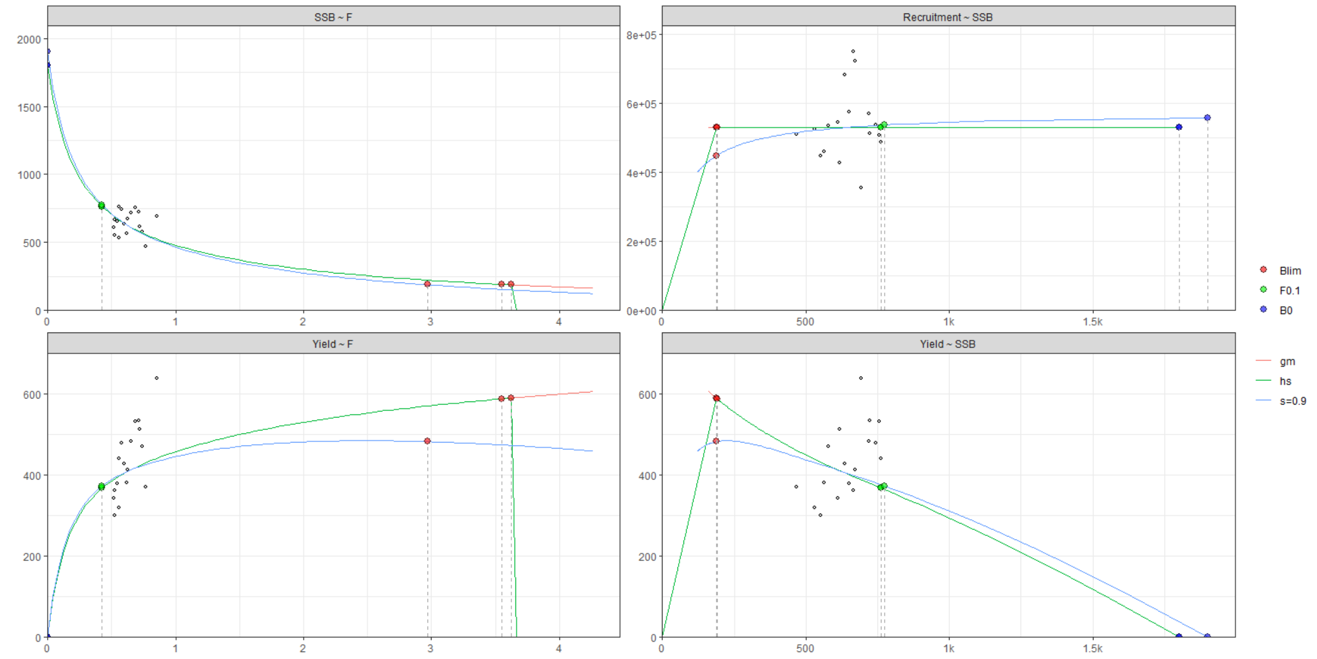


Figure 6.19.4.7: Giant red shrimp in GSAs 9, 10 & 11. Comparison of HS based on GM recruitment and breakpoint 25% $B_{F0.1}$ and BH with steepness 0.90 which best represents the same dynmics with a continuous model.

6.19.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age, natural mortality and maturity at age, while the $F_{bar1\text{-}3}$ =0.77 (the last year's F estimated by the assessment model) was used for F in 2022, as F shows an increasing trend
Recruitment (age 0) is observed to have no clear trend, for this reason the geometric mean of the whole time series (528634 thousand individuals, 17 years) has been used as an estimate of recruits in 2022-2023.

Table 6.19.5.1 Giant red shrimp in GSAs 9, 10 & 11: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2019-2021	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-3}$ (2022)	0.767	F 2021 used to give F status quo for
SSB (2022)	552	Stock assessment 1 January 2021
R_{age0} (2022,2023)	528634	Mean of the last 3 years
Total catch (2022)	427	Catch intermediate year from STF output

Table 6.19.5.2 Giant red shrimp in GSAs 9, 10 & 11. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB change 2021-2023(%)	Catch change 2020-2022(%)
High long term yield ($F_{0.1}$)	0.56	0.426	426.7	270.5	551.6	714.3	29.5	-26.9
F upper	0.76	0.583	426.7	346.2	551.6	632.0	14.6	-6.4
F lower	0.37	0.284	426.7	192.4	551.6	807.8	46.4	-48.0
F_{MSY} transition (intermedia te year)	0.68	0.522	426.7	318.0	551.6	661.7	20.0	-14.0
Zero catch	0.00	0.000	426.7	0.0	551.6	1077.4	95.3	-100.0
Status quo	1.00	0.767	426.7	423.7	551.6	555.5	0.7	14.5
Different Scenarios	0.10	0.077	426.7	57.4	551.6	990.9	79.6	-84.5
	0.20	0.153	426.7	110.5	551.6	915.5	66.0	-70.1
	0.30	0.230	426.7	159.8	551.6	849.5	54.0	-56.8
	0.40	0.307	426.7	205.5	551.6	791.4	43.5	-44.4
	0.50	0.384	426.7	248.2	551.6	740.1	34.2	-32.9
	0.60	0.460	426.7	288.0	551.6	694.6	25.9	-22.2
	0.70	0.537	426.7	325.2	551.6	654.0	18.6	-12.1
	0.80	0.614	426.7	360.1	551.6	617.7	12.0	-2.7
	0.90	0.691	426.7	392.9	551.6	585.0	6.1	6.2
	1.10	0.844	426.7	452.8	551.6	528.7	-4.2	22.4
	1.20	0.921	426.7	480.4	551.6	504.3	-8.6	29.8
	1.30	0.998	426.7	506.4	551.6	482.0	-12.6	36.9
	1.40	1.074	426.7	531.1	551.6	461.5	-16.3	43.6
	1.50	1.151	426.7	554.6	551.6	442.7	-19.7	49.9
	1.60	1.228	426.7	576.9	551.6	425.3	-22.9	55.9
	1.70	1.305	426.7	598.2	551.6	409.2	-24.2	19.8
	1.80	1.381	424.1	614.3	436.7	317.6	-27.3	23.7
	1.90	1.458	424.1	632.7	436.7	305.1	-30.1	27.4
	2.00	1.967	424.1	650.3	436.7	293.4	-32.8	31.0

6.19.6 Data Deficiencies

In terms of coverage, information on LFD in GSA 10 for 2021 are available only for OTBDWS/quarter 4/VL1824. No LFDs for OTBMDD is present. This required, as also for the years 2019 and 2020, the reconstruction on the LFD by using data from the other two GSAs and a SOP correction. The impact on the assessment was low.

7 Data Deficiencies

ToR 6. *To summarize and concisely describe all data quality deficiencies, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched in May 2022. Identify further research studies and data collection which would be required for improved fish stock assessments.*

ToR 7. *To ensure that all unresolved data transmission issues encountered prior to and during the EWG meeting are reported on line via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt. Guidance on precisely what should be inserted in the DTMT, log-on credentials and access rights will be provided separately by the STECF Secretariat focal point for the EWG.*

<u>There are two general issues, both are noted above in Section 2:-</u>

<u>Poor sampling in GSA 10 has resulted in failure of red mullet in GAS 10 and issues with other assessments this needs to be improved.</u>

Late timing for MEDITS in GSAd 9 10 11, and possibly other areas outside this EWG. The timing of these surveys need to be evaluated scientifically and dministratively and a solution that maintains a regular times slot agreed.

7.1 Hake in GSA 1, 5, 6 and 7

<u>French data</u>

For survey data in some years and for some hauls, hake MEDITS data seem biased due to have applied a very high raising factor. This fact could occur in TB data too.

The same issue is encountered within commercial data.

<u>Spanish data</u>

In some years and for some hauls, hake MEDITS data seem biased due to have applied a very high raising factor. This fact could occur in TB data too.

No length measurements were recorded for commercial data in GSA 7 this year.

7.2 Deepwater rose shrimp in GSA 1, 5, 6 and 7

Data from DCF 2021 as submitted through the Official data call in 2021 were used.

Further the length frequency distributions in the Spanish MEDITS for 2001 should be checked thoroughly because are considered to be wrong.

In GSA 1, length frequency distributions of the discards were not available.

Catch length data in 2021 showed an unreliable peak of abundance for the metier OTB_DWS.

Deep-water rose shrimp in GSAs 1, 5, 6, & 7 were assessed as two biological units in 2022

7.3 Red mullet in GSA 1

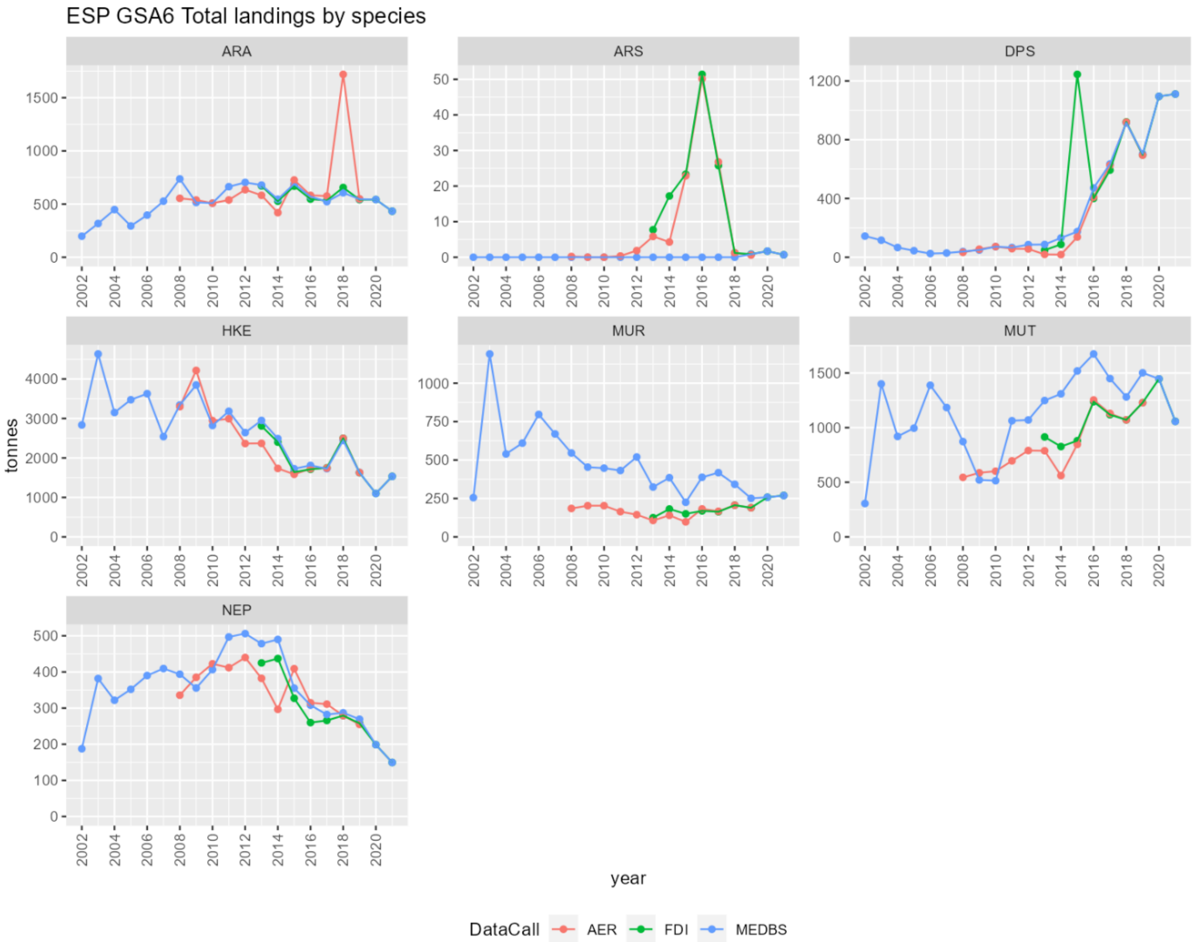
No DTMT related issues are reported for red mullet in GSA 1.

7.4 Red Mullet in GSA 6

MUT 6- gear coding

Red mullet landings from small-scale gears other than entangling nets may be a mistake when coding the fishing gear and should be checked (FPO=pots and traps; LHP= pole lines; LLS=longlines). This issue was reported in EWG-21-11.

MUT landings in GSA - differences in red mullet (MUT) landings in GSA 6 were observed among the MEDBS, FDI and AER data calls.



country	year	GSA	species	landings	DataCall
ESP	2002	6	MUT	305.4	MEDBS
ESP	2003	6	MUT	1400.0	MEDBS
ESP	2004	6	MUT	919.5	MEDBS
ESP	2005	6	MUT	995.0	MEDBS
ESP	2006	6	MUT	1387.8	MEDBS
ESP	2007	6	MUT	1183.6	MEDBS
ESP	2008	6	MUT	872.1	MEDBS
ESP	2009	6	MUT	520.9	MEDBS
ESP	2010	6	MUT	514.1	MEDBS
ESP	2011	6	MUT	1063.1	MEDBS
ESP	2012	6	MUT	1069.9	MEDBS
ESP	2013	6	MUT	1248.0	MEDBS
ESP	2014	6	MUT	1309.2	MEDBS
ESP	2015	6	MUT	1518.7	MEDBS
ESP	2016	6	MUT	1673.9	MEDBS
ESP	2017	6	MUT	1449.3	MEDBS
ESP	2018	6	MUT	1280.7	MEDBS
ESP	2019	6	MUT	1501.8	MEDBS
ESP	2020	6	MUT	1446.3	MEDBS
ESP	2021	6	MUT	1056.7	MEDBS
FRA	2020	6	MUT	0.00361	MEDBS
FRA	2021	6	MUT	0.01059	MEDBS
country	year	GSA	species	landings	DataCall
ESP	2013	6	MUT	914.7	FDI
ESP	2014	6	MUT	826.6	FDI
ESP	2015	6	MUT	880.4	FDI
ESP	2016	6	MUT	1237.5	FDI
ESP	2017	6	MUT	1118.5	FDI
ESP	2018	6	MUT	1071.0	FDI
ESP	2019	6	MUT	1228.4	FDI
ESP	2020	6	MUT	1446.3	FDI
ESP	2021	6	MUT	1057.7	FDI
FRA	2020	6	MUT	0.004	FDI
FRA	2021	6	MUT	0.011	FDI
country	year	GSA	species	landings	DataCall
ESP	2008	6	MUT	544.5	AER
ESP	2009	6	MUT	586.3	AER
ESP	2010	6	MUT	600.9	AER
ESP	2011	6	MUT	695.9	AER
ESP	2012	6	MUT	790.3	AER
ESP	2013	6	MUT	788.2	AER
ESP	2014	6	MUT	560.9	AER
ESP	2015	6	MUT	846.9	AER
ESP	2016	6	MUT	1253.0	AER
ESP	2017	6	MUT	1129.8	AER
ESP	2018	6	MUT	1070.9	AER
ESP	2019	6	MUT	1228.4	AER

EWG 22-09 used the data of the MEDBS data call, since FDI and AER data approach MEDBS along the time series and are similar in the most recent years. In addition, MEDBS data in 2009 and

2010 appear to be rather low when compared with the previous and the following years. MUT landings in GSA 6 in 2009 and 2010 should be checked.

7.5 RED MULLET IN GSA 7

No data issues identified

7.6 NEPHROPS IN GSA 5

No data issues identified

7.7 NEPHROPS IN GSA 6

- The biological growth parameters have been taken as the set of Linf, k, t0 from GSA 5, as done in previous assessments of Norway lobster in GSA 6, but this set was estimated in 2009-2010 and has been reused ever since. The member state might consider studying growth of Norway lobster in GSA 6.

- The Norway lobster is a crustacean species showing dimorphic growth, where females reach lower ultimate sizes than males, despite very similar growth rates. Providing biological data separated by sex should allow better stock assessment results.

7.8 HAKE IN GSA 8 9 10 & 11

No data issues identified

7.9 DPS IN GSA 8 9 10 & 11

Data from DCR-DCF database as submitted through the Official data call in 2022 were used for the stock assessment.

<u>Landing data.</u> The time series of landing data in biomass available in the database were different among the three GSAs: 2010-2021 for GSA08, 2003-2021 for GSA09, 2002-2021 for GSA10 and 2004-2021 for GSA11.

Length frequency distributions of the landing are not available for GSA08. However, the landing of this GSA is negligible, representing on average 0.5% of the total landings of the four GSAs.

The length frequency distributions for GSA09 are available for the period 2003-2021 (year 2002 is missing).

For GSA10, data are not available for 2003. The length frequency distributions of the main metiers targeting DPS in 2019 and 2021 (OTB_DEF and OTB_DEMSP) are missing. In 2019-2021, a high SOP correction was needed to raise the size structures of the three OTB metiers (OTB_DEF, OTB_MDD and OTB_DWS) to the total landing as data is available only for some quarter and fleet segment.

The historical data series for GSA11 includes the period 2009-2019 (the years 2002-2008 are missing).

<u>Discard data.</u> The biomass discarded and the related length frequency distributions in GSA08 are not available. However, this fraction of the total catch is negligible.

In GSA09, length frequency distributions are available for the period 2009-2021.

In GSA10, the data on discard are available for 2006 and for the years 2009-2017. The lack of data in 2020 and 2021 for GSA10 had a low impact on the assessment as, on average, discard in GSA10 represents about 2% of the total catch.

With regard to GSA11, there are no data on this fraction of the catch. Due to the low catches of DPS in GSA11 the discard of this species could be considered negligible in the area.

It should be emphasized that the Italian national data collection program did not provide for the collection of discard before 2006 and in the years 2007-2008.

7.10 Red Mullet in GSA 9

The EWG 22-09 did not find any particular data deficiency for this stock in terms of data quality.

7.11 Red Mullet in GSA 10

The uncommon length structure (between 15 and 20 cm) associated to the discard of the GTR with vessel length VL0006 in 2018 was still present in quarter 4 of 2018. Even the ratio between discard and landing for this stratum seems considerably high (D/L around 400%) for the type of fishery. This anomaly seems due to the only 4 individuals sampled in the discard in only 1 sample collected in the stratum.

In 2019 discard is reported only in the first quarter, while it was expected especially in the third, when the species recruits. The 2019 discard length frequency distribution was distributed into three length classes: 9, 10 and 11 cm.

A mismatch of 2018 landing of FDI was still observed.

In MEDITS data of 2020 less than one half of the hauls were performed.

In 2020 and 2021 no discard sample are present.

A SOP correction of 6.54 was found in the 2020 catch data and a SOP of 200 in the 2021 data. This was found to be due to the small number of trips (in 2021 only 1 trip in quarter 4)monitored and of length measurements collected (in 2021 only 53 in the whole year).

Failure to sample catch fully in GSA 10 in 2020 and 2021 combined with a misplaced MEDITS survey has resulted in a critical failure, the failed assessment this year.

7.12 Nephrops in GSA 9

MEDITS index haul n 67 has been removed due to an error, total weight was wrong this should be corrected.

7.13 Nephrops in GSA 11

Total catches in 2005 were considered ureliable and were excluded from the stock assessment attempts, this could be checked.

No other major issues were detected in the quality check of both DCF commercial data and MEDITS tuning index.

7.14 Blue and red shrimp in GSA 1

No data issues identified

7.15 Blue and red shrimp in GSA 5

No data issues identified

7.16 Blue and red shrimp in GSA 6 & 7

Data problem in TB: id 12844664; haul 42; ptot 1700; nbtot 13356: - nbtot has an extremely high value that strongly decreases the mean weight of the species, consequently, resulting in a high value in the density index for 2020.

7.17 Blue and red shrimp in GSA 9, 10 & 11

Data from DCF 2021 as submitted through the Official data call in 2022 were used.

In GSA 9, length frequency distributions were not available for 2004.

In GSA 10, length frequency distributions were not available for 2003, 2005 and 2021. For the period 2018-2020 the length frequency distribution is provided for a very low percentage of the landings.

Data from GSA 10 in 2017 was reported only for Q3 and Q4 though Q1 and Q2 are present in the FDI database.

In GSA 11, length frequency distributions for OTB_DWS were not available for any year with landings associated.

One of the main causes of the retrospective is the massive increase in catches in 2018 and 2019. This increase is evident both for GSA 10 and GSA 11. It would be important for future work to receive more information from these GSAs about the quality of these two data points.

7.18 Giant red shrimp in GSA 9, 10 & 11

In terms of coverage, information on LFD in GSA 10 for 2021 are available only for OTBDWS/quarter 4/VL1824. No LFDs for OTBMDD is present. This required, as also for the years 2019 and 2020, the reconstruction on the LFD by using data from the other two GSAs and a SOP correction. The impact on the assessment was low.

Reporting of sampling data for catch in 2017 by quarter is still incorrect in the MED and BS data call for sevveral species. One call gave Q1 and Q2 the other call Q3 and Q4 but so far the MED and BS calls have not given all four quarters.

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9 CONTACT DETAILS OF EWG 22-09 PARTICIPANTS

[1] - Information on EWG participant's affiliations is displayed for information only. In any case, Members of the STECF, invited experts, and JRC experts shall act independently. In the context of the STECF work, the committee members and other experts do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members and experts also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

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10 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg2209

List of electronic annexes documents:

EWG-22-09 – Annex 1 – Final stock objects

EWG-22-09 – Annex 2 – R-scripts

EWG-22-09 – Annex 3 – .Reference points reproducible R code and results based worked example for Mediterranean stocks

11 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg2209

List of background documents:

EWG-22-09 – Doc 1 - Declarations of invited and JRC experts (see also section 9 of this report – List of participants)

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