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Scientific, Technical and Economic Committee for Fisheries (STECF) - Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-21-11)

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TABLE OF CONTENTS

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 is from STECF Expert Working Group 21-11: 2021 stock assessments of demersal stocks in the western Mediterranean Sea from the meeting held remotely from 6th to 10th September 2021. A total of 22 fish stocks were evaluated. Two stocks had prior advice from 2020 for 2021 and 2022, and this is reiterated here. The EWG reports age based assessments and short term forecasts for 14 of the remaining 19 stocks. Catch advice for the other five stocks was based on ICES category 3 evaluations of biomass indices. The content of the report gives the STECF terms of reference, the basis of the evaluations and advice, summaries of state of stock and advised based on either the MSY approach for assessed stocks or the precautionary approach for category 3 based advice. The report contains the full stock assessment reports for the 14 assessments, the exploration of assessments and category 3 evaluations for the remaining five stocks. The report also contains the STECF observations and conclusions on the assessment report. These conclusions come from the STECF Plenary meeting November 2021.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-21-11)

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.

STECF comments

The working group was held remotely, from 6 to 10 September 2021. The meeting was attended by 21 experts in total, including two STECF members and two JRC experts. One observer also attended the meeting. The objective of the EWG 21-11 was to carry out demersal stock assessments in the western Mediterranean as defined in the EWG ToRs.

STECF acknowledges that the EWG has addressed adequately all ToRs. STECF notes that the EWG has carefully reviewed the quality of the assessments produced. Most of the assessments have been considered suitable for short term forecasts using the standard STF projection with assumptions of *status quo* F and historic recruitment.

A total of 23 area/species combinations were evaluated but for four of these (Deep-water rose shrimp in GSA 1, 5, 6 & 7) separate GSAs assessments were tested but did not provide suitable results and a single global index advice is given for the combined area (Table 1). The EWG carried out short term forecasts for 14 age-based assessments. Catch advice for five stocks is based on biomass index methods.

The main results are summarized in the bullet point list below and in Table 2. Overall, the assessments indicate that 11 out of the 19 stocks are being significantly overfished, five are being fished close or at F_{MSY} and three are under-exploited. In addition, in 2020, out of these 11 overfished stocks 8 are behind transition to F_{MSY} in 2025 and 3 are ahead of transition (Table 3).

- Hake in GSA 1_5_6_7: the biomass is declining. Catches should be reduced by at least 39% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is behind transition.
- Deep-water rose shrimp in GSA 1_5_6_7: the biomass is fluctuating. Catches should be reduced by at least 61% to conform to precautionary considerations in 2022.
- Red Mullet in GSA 1: the biomass is declining. Catches should be reduced by at least 16% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is ahead of transition.
- Striped Red Mullet in GSA 5: the biomass is fluctuating. Catches may be increased by no more than 1% to conform to precautionary considerations in 2022.
- Red Mullet in GSA 6: the biomass is declining. Catches should be reduced by at least 45% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is behind transition.

- Red Mullet in GSA 7: the biomass is increasing. Catches should be reduced by at least 10% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is behind transition.
- Norway lobster in GSA 5: the biomass is fluctuating. Catches should be reduced by at least 35% to conform to precautionary consideration in 2022.
- Norway lobster in GSA 6: the biomass is increasing. Catches may be increased by no more than 61% to reach F_{MSY} in 2022. F_{2020} is < $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is ahead of transition.
- Hake in GSA 8_9_10_11: the biomass is increasing. Catches should be reduced by at least 54% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ progress to F_{MSY} in 2025 is behind transition
- Deep-water rose shrimp in GSA 9_10_11: the biomass is fluctuating. Catches should be reduced by at least 26% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is behind transition.
- Red Mullet in GSA 9: the biomass is increasing. Catches may be increased by no more than 64% to reach F_{MSY} in 2022. F is already below F_{MSY}.
- Red Mullet in GSA 10: the biomass is increasing. Catches may be increased by no more than 14% to reach F_{MSY} in 2022. F is already below $F_{MSY.}$
- Norway lobster in GSA 9: the biomass is declining. Catches may be increased by no more than 113% to reach F_{MSY} in 2022. F is already below F_{MSY}.
- Norway lobster in GSA 11: the biomass is low fluctuating. Catches should be reduced by at least 70% to conform to precautionary consideration in 2022.
- Blue and red shrimp in GSA 1: the biomass is stable fluctuating. Catches should be reduced by at least 72% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is behind transition.
- Blue and red shrimp in GSA 5: the biomass is stable. Catches may be increased by no more than 5% to conform to precautionary considerations in 2022.
- Blue and red shrimp in GSA 6_7: the biomass is increasing. Catches should be reduced by at least 51% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is ahead transition.
- Blue and red shrimp in GSA 9_10_11: the biomass is declining. Catches should be reduced by at least 88% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is behind transition.
- Giant red shrimp in GSA 9_10_11: the biomass is declining. Catches should be reduced by at least 51% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2025 is behind transition.

Table 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].

Area	Species	Method 2020	Basis 2021
1_5_6_7	Hake	a4a	a4a
1_5_6_7	Deep-water rose shrimp	Index 2020	Index 2020
1	Red Mullet	a4a	a4a
5	Striped Red Mullet	a4a	Index 2021
6	Red Mullet	a4a	a4a
7	Red Mullet	a4a	a4a
5	Norway lobster	Index 2019	Index 2021
6	Norway lobster	a4a	a4a
8_9_10_11	Hake	a4a	a4a
9_10_11	Deep-water rose shrimp	a4a	a4a
9	Red Mullet	a4a	a4a
10	Red Mullet	a4a	a4a
9	Norway lobster	a4a	a4a
11	Norway lobster	Index 2020	Index 2020
1	Blue and red shrimp	a4a	a4a
5	Blue and red shrimp	Index 2020	Index 2020
6_7	Blue and red shrimp	a4a	a4a
9_10_11	Blue and red shrimp	a4a	a4a
9_10_11	Giant red shrimp	a4a	a4a

STECF notes that for hake in GSA 1_5_6_7, Norway lobster in GSA 9 and red mullet in GSA 1 and GSA 9 catches have decreased sharply in recent years. For these 4 stocks the lowest catches value of the available time series was recorded in 2020.

STECF notes that for some stocks, particularly red mullet in GSA 1 and GSA 10, recruitment has declined significantly in recent years. STECF notes that the short term forecast advice

[1] ICES. 2019. Advice basis. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, section 1.2. https://doi.org/10.17895/ices.advice. 5757

for catch accounts for trends (declines or increases) by using recent recruitment. STECF notes that if these changes are sustained they may also have implications for management. For example continued decline in recruitment will result in declining SSB and may require greater reduction in catch in order to maintain the stock biomass.

Table 2 Summary of advice from EWG 21-11 by area and species based on **F_{MSY} target for F2022**. F 2020 is estimated F in the assessment. 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. Biomass reference points are not available for any of these stocks.

Area	Species	Method / Basis	Age Fbar	Biomass 2018-2020	Catch 2018-2020	F 2020	F MSY	Change in F**	Catch 2020*	Catch 2022 at F_{MSY}	Change in catch**
1_5_6_7	Hake	a4a	1-3	declining	declining	1.94	0.44	-77%	2011	1220	-39%
1_5_6_7	Deep-water rose shrimp	Index 2020		fluctuating	increasing				1764	681	-61%
1	Red Mullet	a4a	1-3	declining	declining	1.29	0.61	-53%	98	82	-16%
5	Striped Red Mullet	Index 2021		fluctuating	declining				84	85	1%
6	Red Mullet	a4a	1-3	increasing	decreasing	0.90	0.32	-65%	1539	842	-45%
7	Red Mullet	a4a	1-3	Increasing	increasing	0.62	0.46	-27%	389	351	-10%
5	Norway lobster	Index 2021		fluctuating	declining				58	37	-35%
6	Norway lobster	a4a	3-6	increasing	decreasing	0.26	0.26	-1%	128	206	61%
8_9_10_11	Hake	a4a	1-3	increasing	stable	0.50	0.17	-67%	1983	920	-54%
9_10_11	Deep-water rose shrimp	a4a	1-2	fluctuating	increasing	1.58	1.29	-19%	1960	1455	-26%
9	Red Mullet	a4a	1-3	Increasing	declining	0.37	0.52	39%	629	1033	64%
10	Red Mullet	a4a	1-3	increasing	stable	0.31	0.40	27%	426	485	14%
9	Norway lobster	a4a	2-6	declining	declining	0.15	0.30	100%	103	220	113%
11	Norway lobster	Index 2020		low fluctuating	increasing				44	13	-70%
1	Blue and Red shrimp	a4a	1-2	stable fluctuation	fluctuation	1.68	0.29	-83%	117	33	-72%
5	Blue and Red shrimp	Index 2020	1-2	stable	declining				131	137	5%
6_7	Blue and Red shrimp	a4a	1-2	increasing	declining	0.85	0.29	-66%	549	267	-51%
9_10_11	Blue and Red shrimp	a4a	2-5	declining	increasing	1.68	0.29	-82%	366	45	-88%
9_10_11	Giant red shrimp	a4a	1-3	declining	stable	0.98	0.46	-35%	496	241	-51%

* Estimated catch from 2021 Assessments STECF EWG 21-11 or index based advice.

**Change in F is % change in F 2022 relative to 2020; change in catch % change catch 2022 relative to 2020.

Table 3 Summary of stock and fishery status by area and species, based on **F_{MSY} Transition target for F2022**. *Recent change* gives general change in F and catch over the last three years, being F2019 and F2020 estimated F in the 2021 assessment, F 2025 the F_{MSY} target for the end of transition and F2019 the starting point of the MultiAnnual Plan. The estimate of *progress so far* is shown as the F change % 2019 to 2020 and the F status relative to Transition. *Advice for 2022* is based on the F transition for the next advice year (2022) 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 transition in 2022 and the F in 2019 and the most recent year for which we has estimates, F in 2020. Change in catch is from required change catch 2020 to catch 2022. Shaded rows are stocks with a precautionary advice based on indices.

Area	Species	F change 2018-2020	Catch Change 2018-2020	F 2019	F 2020	F_{MSY} Transition 2020	F_{MSY} Transition 2022	TargetF 2025 F_{MSY}	F Change % 2019-2020	F Status 2020 Rel to FMSY transition 2020	F Change % 2019-2022	F Change % 2020-2022	Catch 2020 (t)	Catch 2022 Fmsy Transition (t)	Catch Change 2020-2022
1_5_6_7	Hake	stable	declining	1.91	1.94	1.67	1.18	0.44	1%	behind transition	-38%	-39%	2011	2435	21%
1_5_6_7	Deep-water rose shrimp		increasing										1764		
1	Red mullet	declining	declining	1.53	1.29	1.37	1.07	0.61	-15%	ahead of transition	-30%	-18%	98	123	26%
5	Striped red mullet		declining										84		
6	Red mullet	decreasing	stable	1.01	0.90	0.89	0.66	0.32	-11%	behind transition	-34%	-26%	1539	1487	-3%
7	Red mullet	stable	increasing	0.62	0.62	0.59	0.54	0.46	1%	behind transition	-13%	-14%	389	396	2%
5	Norway lobster		declining										58		
6	Norway lobster	decreasing	decreasing	0.58	0.26	0.52	0.42	0.26	-56%	ahead of transition	-28%	64%	128	311	143%
8_9_10_11	Hake	declining	stable	0.54	0.50	0.48	0.35	0.17	-7%	behind transition	-34%	-30%	1983	1807	-9%
9_10_11	Deep-water rose shrimp	increasing	increasing	1.11	1.58	1.14	1.20	1.29	42%	behind transition	8%	-24%	1960	1395	-29%
9	Red mullet	declining	declining	0.83	0.37	0.78	0.67	0.52	-55%	F below F_{MSY}	-19%	80%	629	1258	100%
10	Red mullet	decreasing	stable	0.41	0.31	0.41	0.41	0.40	-24%	F below F_{MSY}	-1%	29%	426	490	15%
9	Norway lobster	declining	declining	0.22	0.15	0.23	0.26	0.30	-32%	F below F_{MSY}	18%	73%	103	195	90%
11	Norway lobster		increasing										44		

1	Blue and Rec shrimp	declining	fluctuation	1.69	1.68	1.46	0.99	0.29	-1%	behind transition	-41%	-41%	117	92	-21%
5	Blue and Red shrimp		declining										131		
6_7	Blue and Red shrimp	declining	declining	1.12	0.85	0.98	0.70	0.29	-24%	ahead of transition	-37%	-18%	549	548	0%
9_10_11	Blue and Red shrimp	increasing	increasing	0.94	1.68	0.83	0.62	0.29	78%	behind transition	-34%	-63%	366	87	-76%
9_10_11	Giant red shrimp	increasing	stable	0.76	0.98	0.71	0.61	0.46	29%	behind transition	-20%	-38%	496	302	-39%

General comments

STECF considers that for the 14 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 to provide catch advice for 2022. In the case of striped red mullet in GSA 5, an age-based assessment was used previously to provide catch advice, but was not accepted by the EWG this year (due to the great fluctuations in data on the landings and survey, giving instability and poor fit in the assessment), and Category 3 approach is adopted for the first time for this stock.

STECF notes that the primary catch advice is based on the target of F_{MSY} in 2022 (Table 5.3.2) and an additional advice associated with the Western Med MAP transition to F_{MSY} in 2025 is also provided (Table 5.3.3).

STECF notes that the assessments are based on short data series and some degree of uncertainty therefore remains. This is possibly even more so this year due to a disrupted 2020 MEDITS survey program and, in some cases, the reduction in the sampling of commercial catches caused by the COVID-19. However, STECF considers overall that the values presented in Table 5.3.2 provide a robust guidance on the magnitude of changes in F and catches required to reach F_{MSY} by 2022 and those provided in Table 5.3.3 provide guidance to a linear transition from 2019 to F_{MSY} in 2025.

The 14 age-based assessments form the basis of the detailed advice given in section 5 of the EWG 21-11 report. The estimates of F_{low} and F_{MSY} are considered reasonable estimates that can be expected to be precautionary and STECF considers that they can be used directly in the advice. 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. The EWG 21-11 report also contains values of F and associated catch options for a linear transition in F from 2019 to reach F_{MSY} in 2025 in Table 5.3.3. Also they do not take into account uncertainty in estimates. They should be considered as guide for current progress towards F_{MSY} in 2025.

STECF notes that although hake in GSA 1_5_6_7 and red mullet in GSA 7 are behind $F_{MSY\ Transition}$ in 2020, Table 5.3.3 suggests an increase in catch advice for 2022 under the transition scenario. This is due to the increase in recruitment estimated for these two stocks in the most recent years, combined with the $F_{MSY\ Transition}$ estimated for 2022. Red mullet in GSA 7 has had increasing recruitment for a number of years, with the highest in the series in 2020 and hake in GSA 1 5 6 7 has a sharp increase in recruitment from the lowest observed in 2018 and 2019 to a high value in 2020, the highest recruitment since 2012. STECF notes though that there is always a higher uncertainty in the most recent recruitment estimates, and this increase in recruitment in 2020 will need to be confirmed by the results from next year's assessment.

STECF notes that for the stocks with analytical assessments the EWG has updated the values for both $F_{0.1}$, used as a proxy for F_{MSY}, and F_{2019}, which form the basis for Western Med MAP. STECF considers that this practice should continue, but as information on the stocks improves, where possible the proxy should be replaced by estimates of F_{MSY} to ensure that advice is based on the most up to date information.

For five stocks EWG 21-11 applied a survey-based assessment following the approach adopted by ICES for category 3 stocks. STECF notes though that an updated advice is only presented for two stocks (striped red mullet and lobster in GSA 5), since for the three others (Deep-water rose shrimp GSA 1_5_6_7, Norway lobster in GSA 11, and Blue and red shrimp in GSA 5) catch advice for 2021 is reiterated from 2020 (since assessments based on abundance index are only performed every two years by the STECF assessment EWGs). STECF notes also that according to the procedure used in the North East Atlantic, the advised change in catch for these stocks is based on the change in the stock Index of the last two years over the previous three years. A precautionary buffer of -20% shall apply if the stock status relative to MSY is unknown and if this buffer has not been applied in previous advice. STECF notes however that for the four stocks for which advice was previously based on ICES Category 3 abundance index approach, the precautionary buffer was already included in 2018 or 2019 and will not be applied again.

The COVID outbreak has impacted this year's input data for the assessments. They were affected by a number of factors, several of which relate to difficulties and reductions in sampling both of commercial and survey data. Dealing with reduced sampling of commercial data is challenging. In some cases reconstruction of usually well sampled fleets has been required and in one case the sampling was so scarce that the assessment was run without length/age data for 2020. The MEDITS surveys were affected in the following ways: in GSAs 1 and 8, it was cancelled, in GSA 9 and GSA 11, it was carried out late, in GSAs 6, 7 and 10, it was carried late and with a lower sampling coverage. STECF notes that a sensitivity analysis was performed to compare the impact of either using these partial 2020 MEDITS indices or removing the 2020 data points completely from the time series in the stock assessments. In all cases the differences were small but the assessment confidence intervals reduced with surveys, so the survey values were used in the final assessments. STECF suggests that an alternative method could be explored in the future by 'fill-in' the index for year where one of the surveys is missing through a model-based approach, such is the vector autoregressive spatio-temporal (VAST; Thorson 2019),[2] or using generalized linear models (GLMs) as a method of imputation for missing strata. However, STECF considers it little likely that this approach would result in significantly different assessment outcomes.

Inclusion of GSA 8 in crustacean assessment

STECF notes that the inclusion of crustacean assessment in GSA 8 is a complex issue mainly due to the unavailability of relevant information. The EWG was requested to include GSA 8 with GSA 9, 10 and 11 for assessments of deep-water rose shrimp, blue and red shrimp and giant red shrimp. There are two types of information used in the assessment, catch and survey. The EWG evaluated reported landings and discards of these species in GSA 8 relative to the catch in the three other GSAs. For giant red shrimp and blue and red shrimp there are no landings reported from GSA 8 in the last nine years. For deep-water rose shrimp reported landings from GSA 8 contribute less than 0.5% on average over the last 11 years with no reports prior to that. There are no discards reported for any of these species in GSA 8. Catches of less than 0.5% do not influence the assessment and can be ignored in the context of the fishery. For the survey, the area of GSA 8 contributes less than 10% of the total GSA 8, 9, 10 & 11 area, and would influence the long term trends by much less than this. Inclusion of GSA 8 survey is complicated because it was not carried out in 2020 due to COVID19 issues, so the addition of MEDITS data from this GSA is not straight forward, it would require assumptions of stability that would tend to ignore any differences anyway. Therefore, given the insignificant contribution of the landings from GSA 8 and the issues with survey data, STECF considers that the advice with GSA 8 included would not be different from advice excluding this GSA and the advice given for GSA 9, 10 & 11 can safely be applied for the whole region including GSA 8. Given the level of catch in GSA 8 it seems unlikely that this situation will change in the near future.

Biomass reference points

STECF notes that biomass reference points are not available for any stocks and, specifically B_{lim} and B_{pa} that are required for Management Plans. As many of the stocks have only very short time series, the stock dynamics is often poorly specified. In some cases (e.g. *Nephrops* in GSA 9) the information may be sufficient to give acceptable reference points based directly on the stock recruit data. However, for populations such as the two hake stocks, the dynamics of recruitment cannot be fully inferred from the limited stock assessment time series available and it may be necessary to incorporate some standardized population dynamics to evaluate these reference points. This approach needs some careful evaluation, which would be a good task for the methodological EWG suggested scheduled for spring 2022. During this EWG the guidelines for the

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[2] Thorson, J. T. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fisheries Research 210:143-161 DOI: 10.1016/j.fishres.2018.10.013

estimation of B_{lim} and B_{pa} will be defined and values for main stocks will be estimated. Besides, the potential impact of climate change on the robustness of biological reference points of Mediterranean stocks could be discussed.

EWG duration

STECF notes that the specific STECF EWG data processing workshop, EWG 21-02 resulted in more efficient and accurate data organisation and allowed for more analysis work being conducted during the 5 days assessment EWG for the Western Mediterranean 2021 assessments. However, STECF notes that workload remains high for this EWG, and it is suggested that for dealing with the data issues and carrying out better data checking during the meeting, the duration of the EWG for the Western Mediterranean assessments should be reinstated to 6.5 days as previously used.

STECF conclusions

STECF concludes that the EWG 21-11 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 accepted by EWG 21-11 provide reliable information on the status of the stocks and on the trends in stock biomass and fishing mortality. For one stock where assessment was rejected by the EWG and for four other stocks, advice was provided using survey index trends.

STECF concludes that the annual values of the advised catch based on $F_{MSY\ Transition\ 2022}$ and the status of F in 2020 relative to the $F_{MSY\ Transition\ 2020}$ provide important information for the follow up of the objectives of Multi-Annual Plans.

STECF concludes that given the minor contribution of the landings from GSA 8 to deep-water rose shrimp, blue and red shrimp and giant red shrimp stocks, the advice with GSA 8 included would not be different from the advice excluding this GSA and the advice given for GSA 9, 10 & 11.

STECF concludes that to best perform the tasks that EWG for the Western Mediterranean assessments has taken on, the duration of the EWG next meeting should be reinstated to 6.5 days.

Contact details of STECF members

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REPORT TO THE STECF

EXPERT WORKING GROUP ON Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-21-11)

Virtual meeting, 6-10 September 2021

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission’s future policy in this area

1 INTRODUCTION

1.1 Approach to the work

The working group was held in remotely, from 6th to 10th Sept 2021. The meeting was attended by 20 experts in total, including two STECF members and two JRC experts along with one observer.

The objective of the Mediterranean Methodology EWG 21-11 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:00 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 EWG 21-02 data preparation EWG data was available for assessments much earlier in the meeting, in all cases by Tuesday night. For stocks with assessment issues some sensitivity test were possible, but for DWRS in GSA 1,5,6,7 exploratory assessments were not fully concluded given time limitations.

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 Friday. After the main meeting it became apparent that the selected assessment for red and blue shrimp in GSA 1 had issues with the form of the model, the model was re-examined and details circulated to all EWG participants. A short 45minute plenary was held on Tuesday 21st and a revised assessment was agreed. This report contains this final assessment and advice based on it.

1.2 Terms of Reference for EWG-21-11

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

Chair: John Simmonds

TERMS OF REFERENCE

For the stocks given in Table 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 and 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. To 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 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 2021 and 2025.

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 on May 2019. 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.

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 stock (spawning stock biomass, stock biomass, recruits and exploitation level relative to F_{MSY} and F Transition, and by fishing gear); (iii) the source of data and methods and; (iv) the management advice, 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 2022 to reach Fmsy by 2025.

Table 1– List of suggested stocks to be assessed by the EWG 21-11.

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	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 FINDINGS AND CONCLUSIONS OF THE WORKING GROUP

A total of 20 area/species combinations were evaluated this year, advice for a further two area/species combinations were carried forward from last year. Of the 20 analysed one was given new index based advice this as an analysis last year had indicated an age based assessment was not possible. Of the remaining nineteen that the EWG has carried out and accepted 14 age based analytical assessments with short term forecasts, F target and catch advice for 2022. All of these were for the same stocks that were given advice based on analytical age based assessments as last year. The five remaining stocks index evaluations Nephrops in 5 and 11 and Red and blue shrimp in GSA 5 were index based as last year. For Deep water rose shrimp in GSAs 1,5,6 and 7 which had previously been evaluated as a combined area index the data was reanalysed and assessments by GSA were attempted some progress was made but more work is needed (See Section 3) and in the end index advice was used. The final stock striped red mullet in GSA 5 had been a marginal assessment for several years. Despite revised data the problems have persisted and in some ways the problems have become more persistent. The assessment with very poor residual patterns and instability in retrospectives has been rejected this year. Index based advice is provided.

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. The results in terms F and catch based on F_{MSY} targets and relative changes from 2019 to 2021 are provided in Table 2.2. 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 2020, based on F_{2020} in the most recent assessment, which includes the effect of any changes implemented before and during 2020. The future F and catch options for 2022 based on the linear transition are also provided in Table 2.3.

Table 2.1 Summary of work was attempted and basis for any advice. A4A is an age based assessment methods STF is a standard short term projection with assumptions of status quo F and historic recruitment. Index refers to the ICES Category 3 approach to advice for stocks without analytic assessments. Methods that are used for advice are in bold.

Area	Common Species name	2020 Assessment	2021Assessment
1_5_6_7	Hake	a4a STF	**a4a STF**
1_5_6_7	Deep-water rose shrimp	Index 2020	a4a assessments by GSA **Index 2020**
1	Red Mullet	a4a STF	**a4a STF**
5	Striped Red Mullet	a4a STF	A4a, **Index 2021**
6	Red Mullet	a4a STF	**a4a STF**
7	Red Mullet	a4a STF	**a4a STF**
5	Norway lobster	Index 2019	**Index 2021**
6	Norway lobster	a4a STF	**a4a STF**
8_9_10_11	Hake	a4a STF	**a4a STF**
9_10_11	Deep-water rose shrimp	a4a STF	**a4a STF**
9	Red Mullet	a4a STF	**a4a STF**
10	Red Mullet	a4a STF	**a4a STF**
9	Norway lobster	a4a STF	**a4a STF**

11	Norway lobster	a4a, Index 2020	**Index 2020**
1	Blue and red shrimp	a4a STF	**a4a STF**
5	Blue and red shrimp	a4a, XSA, Index 2020	**Index 2020**
6_7	Blue and red shrimp	a4a STF	**a4a STF**
9_10_11	Blue and red shrimp	a4a STF	**a4a STF**
9_10_11	Giant red shrimp	a4a STF	**a4a STF**

Table 2.2 Summary of advice from EWG 21-11 by area and species, **based on F_{MSY} target for 2022** except for grey shaded cells which are based on index advice and the precautionary approach. F_{2020} is the estimated F in the assessment. Change in F is the difference (as a fraction) between target F in 2022 and the estimated F for 2020. Change in catch is from catch 2020 to catch 2022. Biomass status is given as an indication of trend over the last 3 years for stocks with time series analytical assessments or biomass indices. Biomass reference points are not currently available for any of these stocks.

Area	Species	Method/ Basis	Age Fbar	Biomass 2018-2020	Catch 2018-2020	F 2020	F 2022	Change in F	Catch 2020*	Catch 2022	Change in catch
1_5_6_7	Hake	a4a	1-3	declining	declining	1.94	0.44	-77%	2011	1220	-39%
1_5_6_7	Deep-water rose shrimp	Index 2021		fluctuating	increasing				1764	681	-61%
1	Red Mullet	a4a	1-3	declining	declining	1.29	0.61	-53%	98	82	-16%
5	Striped Red Mullet	Index 2021		fluctuating	declining				84	85	-55%
6	Red Mullet	a4a	1-3	increasing	declining	0.90	0.32	-65%	1539	842	-45%
7	Red Mullet	a4a	1-3	increasing	increasing	0.62	0.46	-27%	389	351	-10%
5	Norway lobster	Index 2021		fluctuating	declining				58	37	-55%
6	Norway lobster	a4a	3-6	increasing	declining	0.26	0.26	-1%	128	206	61%
8_9_10_11	Hake	a4a	1-3	increasing	stable	0.50	0.17	-67%	1983	920	-54%
9_10_11	Deep-water rose shrimp	a4a	1-2	fluctuating	increasing	1.58	1.29	-19%	1960	1455	-26%
9	Red Mullet	a4a	1-3	increasing	declining	0.37	0.52	39%	629	1033	64%
10	Red Mullet	a4a	1-3	increasing	stable	0.31	0.40	27%	426	485	14%
9	Norway lobster	a4a	2-6	declining	declining	0.15	0.30	100%	103	220	113%
11	Norway lobster	Index 2020		low fluctuating	increasing				44	13	-70%
1	red and blue shrimp	a4a	1-2	stable fluctuation	fluctuation	1.68	0.29	-83%	117	33	-72%
5	R & B shrimp	Index 2020		stable	declining				131	137	5%
6_7	R & B shrimp	a4a	1-2	increasing	declining	0.85	0.29	-66%	549	267	-51%
9_10_11	R & B shrimp	a4a	2-5	declining	increasing	1.68	0.29	-82%	366	45	-88%
9_10_11	Giant red shrimp	a4a	1-3	declining	stable	0.98	0.46	-35%	496	241	-51%

*Estimated Catch from 2021 assessments.

Table 2.3 Summary of stock and fishery status by area and species, **based on $F_{MSY\ Transition}$ target for F_{2022}.** **Recent change** gives general change in F and catch over the last three years. F_{2019} and F_{2020} are both estimated F in the 2021 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 2020 and the F status relative to Transition. **Advice for 2022** is based on the $F_{Transition}$ for the next advice year (2022) 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 $F_{Transition}$ in 2022 and the F in 2019 and the most recent year for which we has estimates, F in 2020. Change in catch is from required change catch 2020 to catch 2022. Shaded cells are based on indices.

Area	Species	F change 2018-2020	Catch Change 2018-2020	F 2019	F 2020	Fmsy Transition 2022	Target F 2025 F MSY	F Change % 2019-2020	F Status 2020 Rel to F_{MSY} transition 2020	F Change % 2019-2022	F Change % 2020-2022	Catch 2020	Catch 2022 F_{MSY} Transition	Catch Change 2020-2022
1_5_6_7	Hake	stable	declining	1.91	1.94	1.18	0.44	1%	behind transition	-38%	-39%	2011	2435.31	21%
1_5_6_7	Deep-water rose shrimp		increasing									1764		
1	Red Mullet	declining	declining	1.53	1.29	1.07	0.61	-15%	ahead of transition	-30%	-18%	98	122.97	26%
5	Striped Red Mullet		declining									84		
6	Red Mullet	decreasing	stable	1.01	0.90	0.66	0.32	-11%	behind transition	-34%	-26%	1539	1487.41	-3%
7	Red Mullet	Stable	increasing	0.62	0.62	0.54	0.46	1%	behind transition	-13%	-14%	389	396.52	2%
5	Norway lobster		declining									58		
6	Norway lobster	decreasing	decreasing	0.58	0.26	0.42	0.26	-56%	ahead of transition	-28%	64%	128	311.00	142%
9_10_11	Hake	declining	stable	0.54	0.50	0.35	0.17	-7%	behind transition	-34%	-30%	1983	1807.74	-9%
9_10_11	Deep-water rose shrimp	increasing	increasing	1.11	1.58	1.20	1.29	42%	behind transition	8%	-24%	1960	1394.83	-29%
9	Red Mullet	declining	declining	0.83	0.37	0.67	0.52	-55%	F below F_{MSY}	-19%	80%	629	1258.36	100%
10	Red Mullet	decreasing	stable	0.41	0.31	0.41	0.40	-24%	F below F_{MSY}	-1%	29%	426	490.20	15%
9	Norway lobster	declining	declining	0.22	0.15	0.26	0.30	-32%	F below F_{MSY}	18%	73%	103	195.40	90%
11	Norway lobster		increasing									44		
1	Blue and red shrimp	declining	fluctuation	1.69	1.68	0.99	0.29	-1%	behind transition	-41%	-41%	117	91.80	-21%
5	Blue and red shrimp		declining									131		
6_7	Blue and red shrimp	declining	declining	1.12	0.85	0.70	0.29	-24%	ahead of transition	-37%	-18%	549	548.00	0%
9_10_11	Blue and red shrimp	increasing	increasing	0.94	1.68	0.62	0.29	78%	behind transition	-34%	-63%	366	87.00	-76%
9_10_11	Giant red shrimp	increasing	stable	0.76	0.98	0.61	0.46	29%	behind transition	-20%	-38%	496	302.05	-39%

2.2 Quality of the assessments

This year's input data for the assessments has been affected by a number of factors, several of which relate to difficulties and reductions in sampling both of commercial and survey data. Some reduced sampling of commercial data is difficult to quantify, in some cases reconstruction of usually well sampled fleets have been required and in one case the sampling was so scarce that the assessment was run without length/age data for 2020. The effects are noted below by stock. The MEDITS surveys have been affected in the following ways:

GSA 1	Cancelled
GSA 5	Carried out as normal in both timing and number of stations
GSA 6	Carried out on time with stations in only the northern part of the area
GSA 7	Carried late with partial stations omitting some deeper stations
GSA 8	Cancelled
GSA 9	Carried out late
GSA 10	Partial coverage carried out late
GSA 11	Carried out late

In the case of red mullet in GSA 7 the effect of the delayed non uniform coverage was corrected for with an ad hoc approach, for the other situations the sensitivity of the assessments were tested by running the assessments with and without the 2020 MEDITS survey data included in the model.

Hake

The assessment of hake in GSA 1567 is an update from last year and following the GFCM December 2019 benchmark. Survey and time series data have been resubmitted by Spain for GSAs 1, 5, 6. These changes of data do not appear to need a different approach and the assessment still used same structure of model. The overall assessment is very similar to last year and shows F has decreased in recent years. A sensitivity test with and without 2020 survey showed very similar results and the assessment using the survey corrected for the missing survey in GSA 1 was used. No corrections made to delayed surveys, and sensitivity analysis suggests for this species the effects are not big. Discards are increasing so it may be necessary to consider these more fully in the future.

The assessment for hake in GSA 8,9,10 & 11 following the benchmark settings from GFCM in December 2019 and consistent with last year the model results are fully in line with previous years. There was a minor issues with discard data in GSA 10. AS a sensitivity analysis several options were tested for different options for surveys specifically the missing GSA 8 survey. The assessment was not found to be sensitive to the different options tested.

Red Mullet

The assessment for red mullet in GSA 1 has a modification to input data with revisions to Spanish commercial data changing trends and absolute number. Data series extended back to 2003, though some data for 2002 is available reconstruction required was though too extensive. No significant survey revisions of historic data have occurred but no survey was carried out in 2020. Age range was set for the Survey to 1-3 and catch to 1-4 which overall improves the catch residuals in the model. As in 2019 the assessment is considered suitable for STF but it is noted that there are some concerns about the quality of the assessment and this is considered a marginal assessment.

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 2019 assessment with F estimated to be approximately 3 times $F_{0.1}$. The reconstructed catch series is now included in the assessment. There was concern with the 2020 survey due to partial area coverage. A sensitivity analysis showed overlap between the assessment with or without the survey, with the survey included lying inside the interval for the survey excluded assessment, so the survey was included in the assessment. The stock is overexploited but biomass is increasing.

Red mullet in GSA 7 was extensively reworked with growth based on otolith data with a new assessment throughout last year this approach used for 2020 data. The general perception of the stock is unchanged perception to last year, with increasing recruitment and SSB for around 10 years, with F declining in recent years. Recent recruitment is high poorly estimated in the first year but significantly higher than the mean, however, the reason for the change in recruitment is not known. The MEDITS survey was delayed and only partially executed and an ad hoc approach was used to correct the 2020 value for delayed survey and partial area coverage.

The assessment of red mullet in GSA 9 was carried out with small changes to discard data in the early part of the series. The assessment is an update assessment with same settings as 2019 except for a minor change in smoothing to account for the addition of the extra (2019) data year. $F/F_{0.1}$ is estimated to be declining to around 1.6. Sensitivity test with and without 2020 MEDITS showed no significant difference. Data from the April revision (EWG 21-02) were used, though there were not major differences, the reconstruction was mostly for discards. Concerns that F is now estimated as low but driven by reduced catch and also some increase from the survey. F is low with some uncertainty and F_{MSY} is within the interval of uncertainty.

The assessment of red mullet in GSA 10 is an updated assessment with the same input values for years to 2019 with 2020 data added. Some MEDITS data have been problems corrected. There were major issues with catch data Q 2 and 4 samples with very few individuals measured for length No data for Q 1 and 3 were available. The assessment could not be run with these sample based estimates of catch at age 2020, the assessment was run without 2020 size/age commercial data. Some trend was observed in the age 0 residuals and this was dealt with by allowing a separate component for age 0 this improved the fit. The trend in selection at age 0 is thought to be due to reduced reported discards in recent years. Assessment results in line with previous years. F current has slightly decreased from last year.

Striped Red Mullet

Data preparation were carried out successfully some minor issues in the survey that were fixed, The assessment could not be fitted, With extra year added the previously observed issues with residual patterns and retrospective bias have become worse, with large groups of positive and negative residuals. The decision was taken to reject the assessment this year and advice given based on Index.

Nephrops

For Nephrops in GSA 5 there is no analytical assessment the data was extensively reviewed in 2020 but the assessment was considered poor and not accepted. As in previous years the advice is based on a Category 3 index. Catches and index are declining

For Nephrops in GSA 6 the assessment is based on the same set of Linf, k, t0 for many years and these parameters are obtained from GSA05 but appear to be OK. There are still some outstanding errors in the DCF data - length frequency distribution of landings should be revised for 2020, métier OTB_DEF. The LFD of discards for 2019, métier OTB_DEMSP contains large values that are not plausible. The quality of the assessment is similar to 2020 despite incomplete MEDITS survey and is still considered borderline acceptable with the diagnostics of the selected model being quite good but the retrospective analysis being poor.

The assessment for Nephrops in GSA 9 is an updated assessment with the extra data from 2019. The model has a no changes results are in line with last year. F reduced slightly, partly driven by unusually low landing less than half previous 3 years and – lowest in the time series.

For Nephrops in GSA 11 index advice last year survey indices decreasing catches similar to previous years.

Deep-water Rose Shrimp

The basis for advice for DWRS in GSA 1567 is unchanged. Attempts were made to obtain assessments by GSA, some progress was made but more work is requires, see section 3 (Follow up)

For the assessment for DWRS in GSA 9 10 11 the model and biological parameterisation are the same as last year. Some catch data has been reconstructed, in particular OTB_DEF in GSA10 for 2019. In GSA11, the LFDs of the two main metiers (OTB_DWS and OTB-DEF) were reconstructed for the last two years. As all the MEDITS surveys were late a sensitivity analysis was carried out and showed that the results were similar but with narrower confidence intervals when the survey was included compared to without survey. As the confidence intervals overlap and with the survey more precise, the survey was included. Results show F_{2020} slightly above F.01, continuing a trend of increasing F observed in 2020 assessment.

Red and Blue Shrimp

For the assessment of blue and red shrimp in GSA 1 the input data and stock object were re-evaluated and it was observed that there were very low levels of sampling found in the survey in some years this year revise 2007 and 2008 data were included while 2009 and 2011 and 2013 are still excluded. This year the smoother function was modified this results in F and $F_{0.1}$ higher than last year but the ratio is similar (0.99 F 0.87 $F_{0.1}$) There was no MEDITS survey in GSA 1 in 2020 so the model was fitted without survey in final year.

For blue and red shrimp in GSA 5 advice in 2018/2019 based on biomass Index could not be resolved and advice was again given based on a biomass index method.

For Blue and Red in GSA 6 and 7 the assessment was updated with data added for 2020. The reported 2020 sampled catch is low, with high SoP. Reconstructed data from EWG21-02 was used for the assessment and the retrospective stability has improved. Overall the new assessment is improved from last year. F is the lowest observed over the whole time series. The assessment results are in line with estimates from last year. Results with MEDITS survey included and with MEDITS excluded were similar, so the assessment with MEDITS used.

For blue and red shrimp in GSA 9 10 & 11 the data was updated with 2020 values. Much improved historical data from the work done in EWG 21-02 resulted in some differences in the assessment when the new data was added. Catch for 2020 is reported as being high relative to other years. Overall the assessment model results are in line with previous years. Quality appears to have improved.

Giant Red Shrimp.

Some correction in GSA 10 2020 and 2019 – poor sampling data from GSA 11 and GSA 9. For Giant Red shrimp in GSA 9 10 & 11 the assessment is updated with new 2019 2020 data and the model remains unchanged from the formulation used in 2019 except for reducing k in the smoother for year for the F submodel to increase smoothing. The assessment model output is in line with last year's assessment. $F_{0.1}$ and $F_{current}$ are both estimated to be similar to the 2020 assessment value at 0.48 and 0.98 respectively.

GSA 8 in crustacean assessments:

For stocks of DWRS, Giant Red shrimp and Red and Blue shrimp in GSA 8, 9, 10 and 11: The inclusion of GSA 8 in assessment along with GSA 9, 10 and 11 was considered. For most of these species no catches are reported for GSA 8, so including the GSA will not change the catch data materially. As the area of GSA 8 is relatively small compared to the area of the other GSAs; it contributes less than 10% to a combined GSA 8,9,10&11 based index, thus the differences in the index with GSA 8 included will be slight. As the GSA 8 survey was not carried out this year (2020), due to Covid issues, inclusion of GSA 8 may increase complexity as we try to bridge gaps with little increased utility.

3 FOLLOW UP ITEMS

Further work on developing assessments for DWRS in 1,5,6,7 need to continue before full conclusions can be reached. Regarding quality and problems of DPS in 1, the commercial data assembly went more smoothly as in the previous years for GSA 1. Two quarters in 2020 were not sampled. MEDITS, 2020 is missing but most of the errors reported in previous years were corrected by Spain before the EWG. The main issue with this assessment is the choice of growth parameters to use in the assessments for continued evaluation using an annual age based assessment like a4a further exploration of growth needs to be considered. Given the short life history of DWRS it is possible that seasonal models might allow better fits to length/age information and a number of different approaches could be considered. Length based models which estimate growth and simpler two stage biomass/production models should be evaluated. The Methods EWG in spring 2022 might be an appropriate choice for this evaluation.

The ToRs requested biomass reference points; specifically Blim and Bpa were required for management plans. As many of the stocks have only very short time series, the stock dynamics is often poorly specified. In some cases (e.g. Nephrops in GSA 9) the information may be sufficient to give acceptable reference points based directly on the stock recruit data. However, for stocks such as the hake it is unclear if recruitment has been reduced throughout the assessed time series, and there may be a need to incorporate some standardised stock dynamics in order to evaluate reference points for these stocks. This approach needs some careful evaluation, which would be a good task for the method EWG in spring 2022.

4 BASIS OF THE REPORT

4.1 Data Preparation

A series of data checking procedures were developed by JRC for STECF EWG 21-02 and used to produce LFDs for all the stocks currently used in age based assessment by STECF. Part of this process fill in procedures for poor or missing commercial catch sampling were developed, the basis of these is described below.

4.1.1 Fill-in procedures

All stratified sampling programs can result in fleets or metiers that are missed or severely under-sampled[3]. 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.

4.1.1.1 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.

[3] 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.

4.1.1.2 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 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:

1) Full assessment and full MSY reference points or with surplus production model with F and biomass relative to F and B_{MSY}: Catch advice at MSY based on short term forecast. **Not used.**
2) 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 all a4a assessments**
3) 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.**
4) 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.**

5) 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.**
6) Trend based indictor: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend with precautionary buffer (20% reduction applied in earlier t=years) **Used for 3 stocks this year and for 2 from last year**.
7) Valid length analysis: statement of stock status, indication of direction of change required. **Not used**
8) No valid analysis: no advice. **Not needed**

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

4.3 MSY Reference points for stocks in this report

For all of the stocks evaluated in this assessment meeting, the number of years of S-R data is very limited and it is not possible to carry out full evaluations of MSY, because the stock - recruit relationships cannot be established.

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 2019 are based on this approach.

4.3.1 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}.

4.3.2 Values of F_{MSY} F_{upp} and F_{low}

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)

4.4 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

4.4.1 MSY Transition

The EWG continues to provide the main catch option presented in section 5 based on the target of F_{MSY} in 2021. This 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.

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

whereas for the following years:

$F_{MSY\text{-}Ttransition}$ (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.

This year F(2019) is the terminal F in the assessment and F_{MSY} is estimated this year (see section 6.X.4 by stock for the STF).

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 F2019 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 2021 assessment. This value and subsequent values will be updated each year based the most up to date assessment.

5 SUMMARY SHEETS BY STOCK

5.1 Summary sheet for European hake in GSA 1, 5, 6 & 7

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.444 and corresponding catches in 2022 should be no more than 1220 tons.

Stock development over time

Catches and SSB of European hake show a decreasing trend from 2009 to 2020, with some oscillations in time series. The assessment shows a general long term declining trend in the number of recruits but with an increase in the last year reaching in 2020 the same values as 2013, though the final year's value is the most uncertain. Fbar (1-3) shows an increase until 2010 and a slight upward trend until 2014, it has stabilized with a very slight increase until 2020 where it reached a value of F of 1.941.

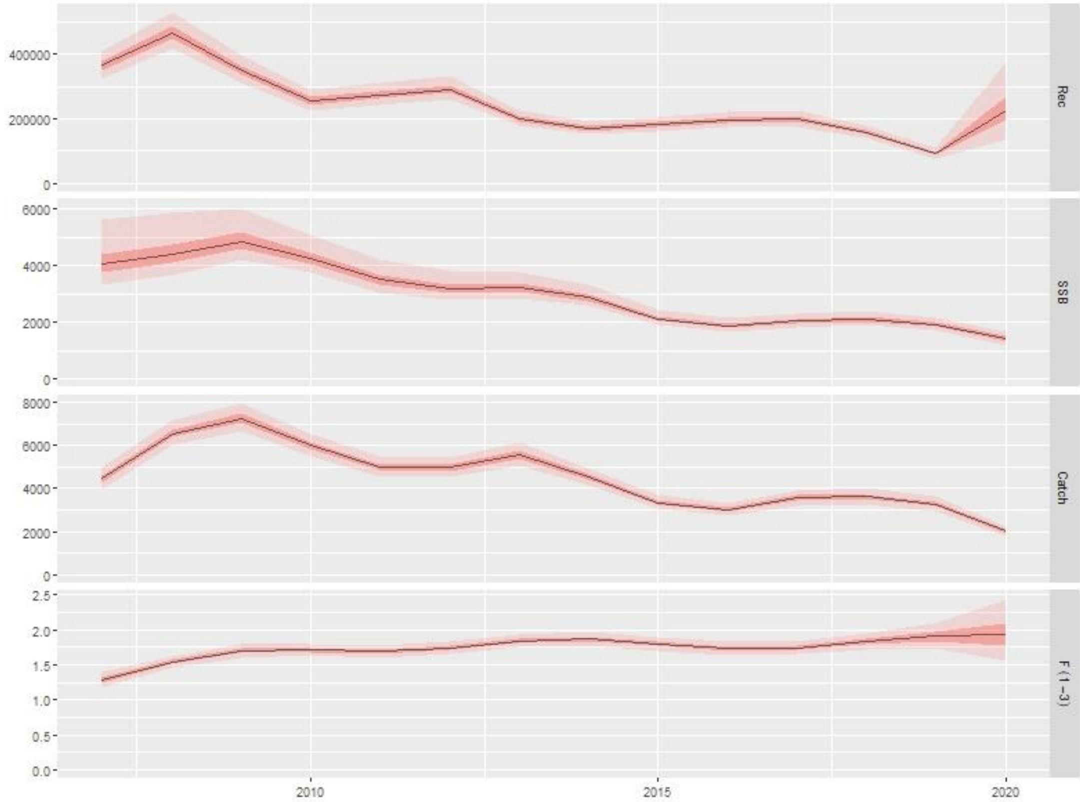


Figure 5.1.1 European hake in GSAs 1, 5, 6 and 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.941) is 4 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.444). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition

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

Status	2018	2019	2020
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
F / $F_{MSY\ Transition}$			$F > F_{MSY\ Transition}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2021)	1.941	F 2020 used to give F status quo for 2021
SSB (2021)	1482	Stock assessment 1 January 2021
R_{age0} (2021,2022)	149530	Mean of the last 3 years
Total catch (2021)	3674	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 and 7: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 1-3) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	1220	0.44	4601	210.48	-39.35
$F_{MSY\ Transition}$ ^^	2435	1.18	2507	69.19	21.08
$F_{MSY\ lower}$	867	0.30	5248	254.14	-56.91
$F_{MSY\ upper}$**	1559	0.61	3993	169.46	-22.49
Other scenarios					
Zero catch	0	0	6881	364.37	-100.00
Status quo	3127	1.94	1481	-0.07	55.47
	594	0.19	5756	288.41	-70.47
	1091	0.39	4835	226.25	-45.73
	1510	0.58	4080	175.32	-24.92
	1863	0.78	3461	133.55	-7.35
	2163	0.97	2953	99.26	7.54
	2418	1.17	2535	71.07	20.22
	2636	1.36	2191	47.87	31.07
	2824	1.55	1908	28.75	40.40
	2986	1.75	1674	12.97	48.46

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	

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 consistency in the estimation of F estimated in the assessment of 2020. The estimation of recruitment is inverse compared to the ones obtained from last year assessment. All the diagnostics were considered acceptable although survey data residuals got worse compared to last year. MEDITS survey incomplete for 2020, a sensitivity analysis suggests the assessment results are not influenced by the incomplete survey.

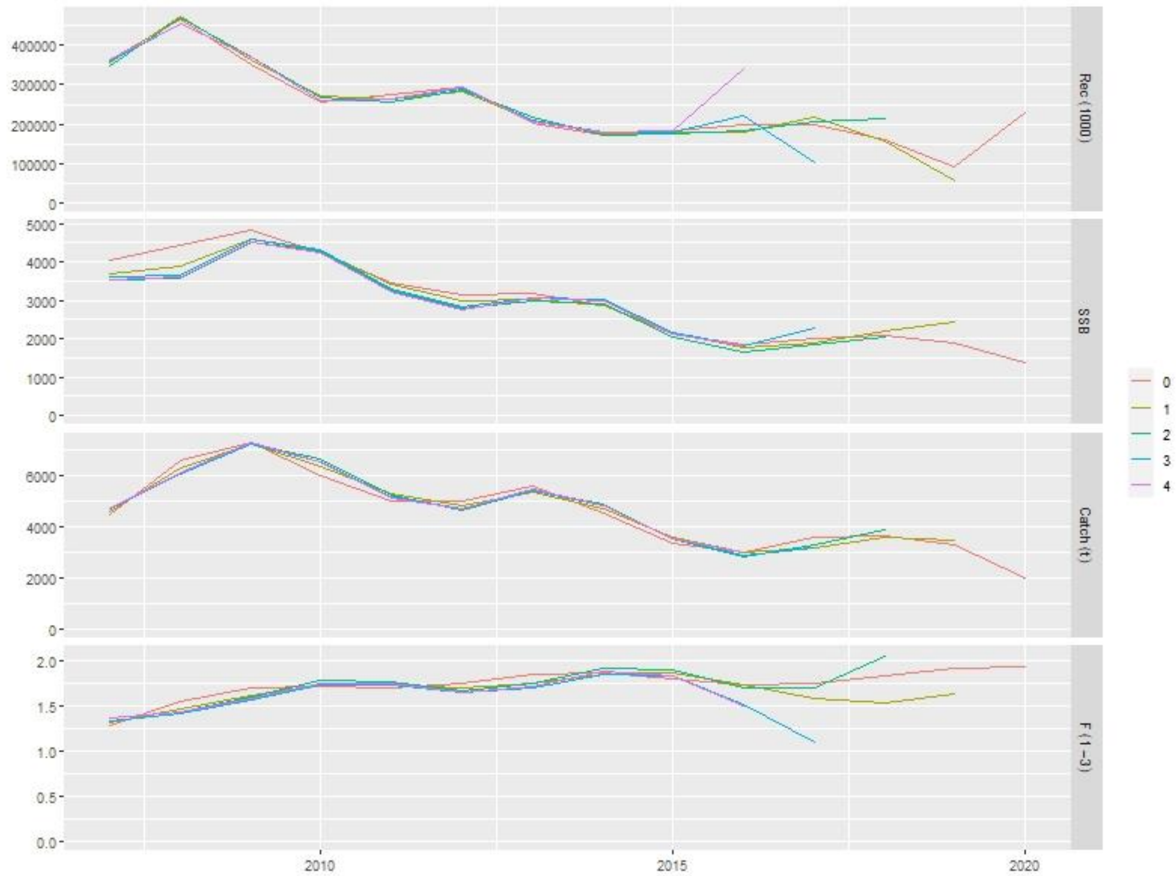


Figure 5.1.2 European hake in GSAs 1, 5, 6 and 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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 and 7: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.444	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.444	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.30	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.61	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

Basis of the assessment

Table 5.1.6 European hake in GSAs 1, 5, 6 and 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 European hake in GSAs 1, 5, 6 and 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		
2022	F = F_{MSY}		1220		

History of the catch and landings

Table 5.1.8 European hake in GSAs 1, 5, 6 and 7: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2020		Wanted catch				Discards
Catch (t)	1893	Otter trawl 78%	Gillnets 9%	Trammel nets 3%	Other 10%	81.31t
Effort	241834					
		Fishing days				

Table 5.1.9 European hake in GSAs 1, 5, 6 and 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	40688
2003	398	48	4633	315	2273	7666	47254
2004	503	63	3151	182	1140	5039	254061
2005	359	98	3473	223	1002	5156	240706
2006	385	125	3627	261	1160	5558	236842
2007	340	185	2540	237	1394	4697	200309
2008	330	121	3341	280	2009	6082	211574
2009	619	67	3847	345	2485	7362	253312
2010	576	99	2822	195	2088	5780	334986
2011	683	85	3182	134	1415	5498	332830
2012	463	61	2641	180	1078	4423	321059
2013	375	109	2950	216	1580	5230	315785
2014	283	118	2489	224	1702	4816	313268
2015	183	102	1726	126	1003	3141	284887

2016	176	67	1810	120	895	3067	286594
2017	299	72	1728	95	768	2962	272981
2018	410	97	2443	87	794	3831	260000
2019	290	107	1630	73	1058	3159	262069
2020	182	68	1099	36	508	1893	241834

*Effort data is taken from STECF EWG 21-13. 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 and 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	364462			4045			4438	1.286		
2008	468001			4429			6549	1.546		
2009	350570			4848			7253	1.706		
2010	255943			4236			5988	1.716		
2011	274518			3478			4989	1.695		
2012	292408			3150			4963	1.748		
2013	201456			3192			5564	1.846		
2014	170551			2855			4513	1.876		
2015	182022			2113			3348	1.805		
2016	196801			1857			3008	1.731		
2017	198969			2015			3547	1.745		
2018	158645			2100			3606	1.834		
2019	92203			1911			3273	1.914		
2020	228568			1401			2011	1.942		

Sources and references

STECF EWG 21-11, STECF EWG 21-13

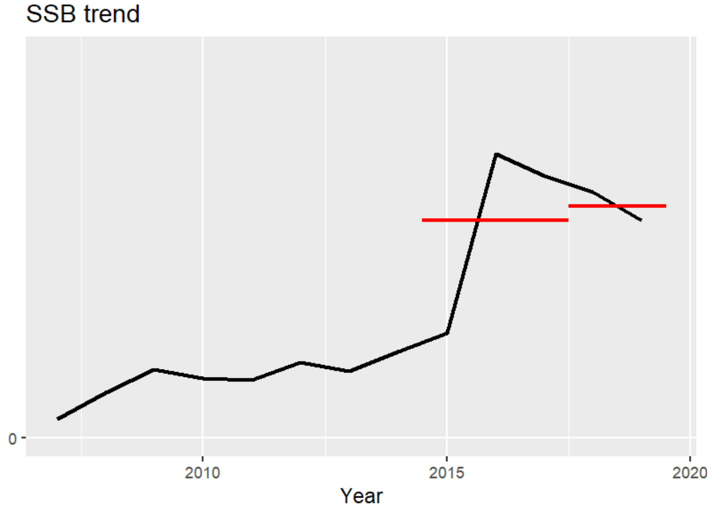
5.2 Summary Sheet for Deep-Water Rose Shrimp in GSAs 1, 5, 6 & 7

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 20-09 advises to decrease the total catch by 41% relative to the catches in 2019 equivalent to catches of no more than 681.2 tons in each of 2021 and 2022 implemented either through catch restrictions or effort reduction for the relevant fleets.

Stock development over time

The relative change in the estimated SSB was used to provide an index for change (Figure 5.2.1). The stock appears to have been quite stable from 2007 to 2014. From 2014 the stock has increased rapidly with a peak in 2016 and is now slightly decreasing. Based on the index value in the last two years relative to the previous three years the increase in SSB is estimated to be 1.07 times. Catches in 2018 and 2019 have already increased considerably relative to earlier years.



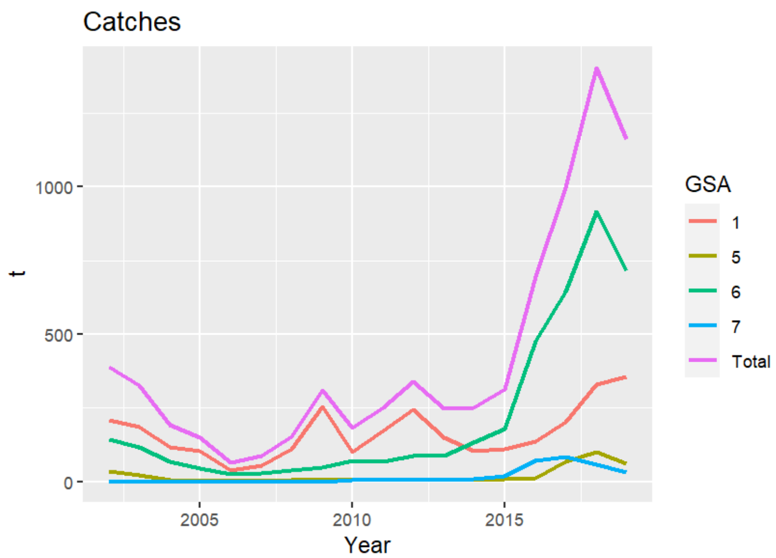


Figure 5.2.1 Deep water rose shrimp in GSA 1, 5, 6 & 7: Summary of the combined a4a and XSA assessments stock indicator and catch by year.

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown. However, the index of SSB shows a rapid increase in abundance from 2014 with a peak in 2016 and a slight decrease afterwards.

Catch scenarios

The advice on fishing opportunities for 2021 and 2022 is based on the last catch advice adjusted to the change in the stock size index. The SSB index used to provide the catch scenarios is the mean of the SSB values coming from the a4a and XSA assessments, which are accepted for trends. The change is estimated from the two most recent values relative to the three preceding values (see table 5.2.1). The precautionary buffer of -20% is not applied because it was applied in 2018.

Table 5.2.1 Deep water rose shrimp in GSA 1, 5, 6 & 7: Assumptions made for the interim year and in the forecast. *

Index A (2018–2019)		1.9
Index B (2015–2017)		1.8
Index ratio (A/B)		1.07
-20% Uncertainty cap	Applied/not applied	Not applied
Advised catch (2019–2020)		638.4
Discard rate		Negligible
-20% Precautionary buffer	Applied/not applied	Not applied
Catch advice **		681.2
Landings advice ***		681.2
% advice change ^		7%

* 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 advised catch × index ratio)
*** catch advice × (1 – discard rate)
^ Advice value 2021-2022 relative to advice value 2019-2020.

Although the advice for 2021/2022 is for a 7% increase relative to the 2018 advised catch, catch in 2018 and 2019 has risen considerably relative to the earlier catches that were used for the 2018 advice. Therefore to achieve the advised small increase catch for 2021/2022 a reduction of 41% relative to reported catch in 2019 is required.

Basis of the advice

Table 5.2.2 Deep water rose shrimp in GSA 1, 5, 6 & 7: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

The values of F at age from the a4a assessment show extremely high values for ages 1, 2 and 3. The catchability at age from the XSA assessment was not deemed acceptable. Therefore, the EWG 20-09 concluded that the output of these models was not suitable to provide the basis of the current status of the stock but could be used as indicative of a trend.

Issues relevant for the advice

Both estimated abundance and biomass indices from MEDITS show similar trends in GSAs 5-6-7, with a sharp increase in the last year. In GSA 1 the trend is more variable throughout the time series and does not show a sharp increase in the last years. Therefore, the advice should be more precautionary for GSA 1.

Reference points

Table 5.2.3 Deep water rose shrimp in GSA 1, 5, 6 & 7: Reference points, values, and their technical basis.

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

Basis of the assessment

Table 5.2.4 Deep water rose shrimp in GSA 1, 5, 6 & 7: Basis of assessment and advice.

Assessment type	Index based assessment
Input data	Landings at length sliced
Discards and bycatch	Discards included
Indicators	MEDITS in GSAs 1-5-6-7
Other information	
Working group	EWG 20-09

History of the advice, catch, and management

Table 5.2.5 Deep water rose shrimp in GSA 1, 5, 6 & 7: 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	Reduction of 4% of catch	638.4	638.4	1161	12
2020	Reduction of 4% of catch	638.4	638.4		
2021	Decrease catch by 39%	681.2	681.2		
2022	Decrease catch by 39%	681.2	681.2		

History of the catch and landings

Table 5.2.6 Deep water rose shrimp in GSA 1, 5, 6 & 7: Catch distribution by fleet in 2019 as estimated by STECF.

Catch (2019)	Landings			Discards
1160.8 t	100 % trawl	% set nets	% others	11.62 t
	t			

Table 5.2.7 Deep water rose shrimp in GSA 1, 5, 6 & 7: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

Year	SPAIN GSA1	SPAIN GSA5	SPAIN GSA6	FRANCE GSA6	SPAIN GSA7	FRANCE GSA7	Discards	Total	Total Effort * (Fishing Days)
2002	209.8	36.2	144.1		0.0		0.0	390.0	28002
2003	187.2	22.1	116.0		0.0		0.0	325.3	32892
2004	118.1	6.5	66.2		0.0		0.0	190.9	168753
2005	103.0	1.6	44.7		0.0		1.7	151.0	158375
2006	37.6	1.0	25.2		0.0		0.0	63.8	155508
2007	56.2	1.4	28.8		0.0		0.0	86.4	145015
2008	108.9	5.2	39.0		0.1		0.6	153.7	148988
2009	253.9	5.1	49.1		0.1		1.7	310.0	142964
2010	97.6	6.3	71.9		0.4	3.8	2.1	182.0	138250
2011	171.6	4.5	66.3		1.2	6.2	2.8	252.6	132624
2012	241.5	4.2	85.6		2.0	3.4	3.1	339.8	125972
2013	149.1	6.2	86.8		2.3	2.4	2.3	249.0	122776
2014	100.4	5.6	131.3		3.4	4.3	6.6	251.5	142994
2015	108.6	7.6	174.6		4.7	13.7	4.0	313.2	111135
2016	136.8	9.1	471.3		27.1	42.9	8.9	696.1	112679
2017	201.8	68.0	634.7		36.3	46.9	10.6	998.2	103456
2018	329.6	101.2	914.6		17.9	38.4	3.2	1404.7	106909
2019	354.2	59.8	704.0	0.03	7.3	24.0	11.6	1160.8	106653

*Effort data is taken from STECF EWG 21-13. 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, 5, 6 & 7: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2007	0.15	86.4	0.0	86.4
2008	0.37	153.2	0.6	153.7
2009	0.56	308.3	1.7	310.0
2010	0.48	179.9	2.1	182.0

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2011	0.47	249.7	2.8	252.6
2012	0.61	336.7	3.1	339.8
2013	0.54	246.7	2.3	249.0
2014	0.70	244.9	6.6	251.5
2015	0.86	309.2	4.0	313.2
2016	2.32	687.1	8.9	696.1
2017	2.14	987.7	10.6	998.2
2018	2.01	1401.6	3.2	1404.7
2019	1.77	1149.2	11.6	1160.8

Sources and references

Reproduced from STECF EWG 20-09 for use in this year’s WG. For original analysis and data supporting this summary sheet see STECF EWG 20-09. EWG 21-13.

5.3 Summary sheet for red mullet in GSA 1

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.61 and corresponding catches in 2022 should be no more than 82.3 tons.

Stock development over time

Catches, recruitment, SSB and fishery mortality of red mullet show a decreasing trend since 2017. The assessment shows fluctuation of all indicators along the available time series, while effective reduction of fbar has not occurred, keeping above 1.2. Modelled catch generally follows the observed catch, excluding some years in the middle of the time series, where de model had larger problems to fit the catch data.

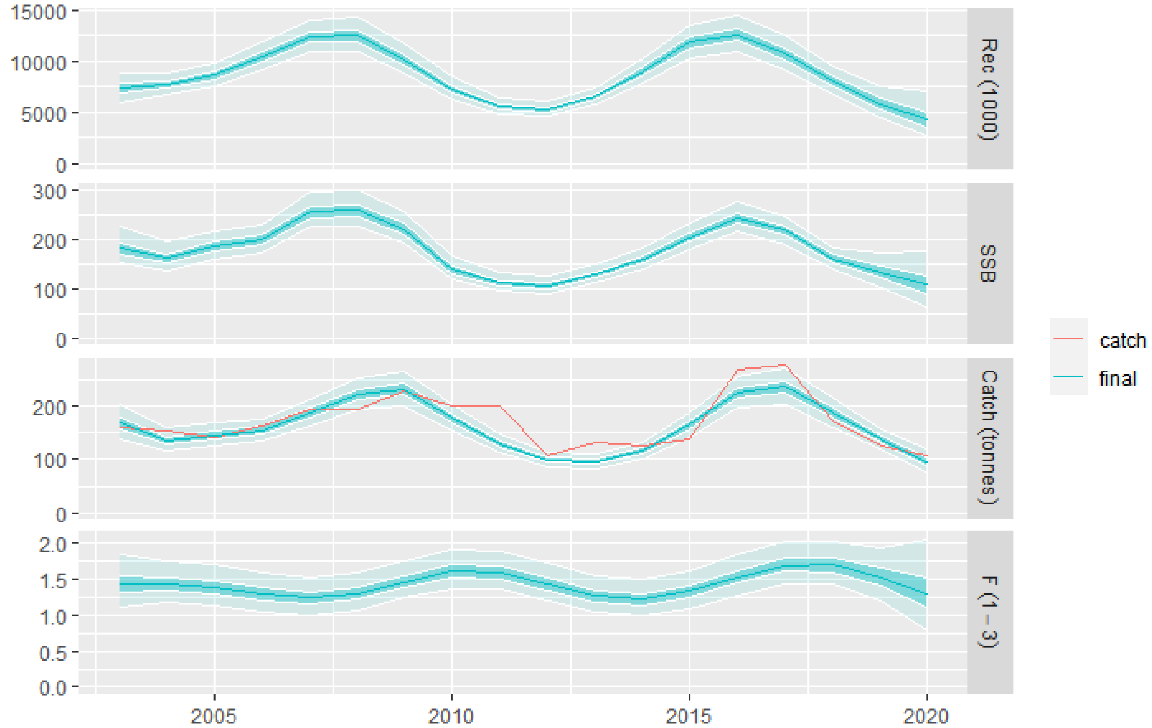


Figure 5.3.1 Red mullet in GSA 1: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.29) is twice times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.61). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

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

Status	2018	2019	2020
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

F / $F_{MSY\ Transition}$			F > $F_{MSY\ Transition}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2021)	1.29	F 2020 used to give F status quo for 2021
SSB (2021)	152.3321	Stock assessment 1 January 2021
R_{age1} (2021,2022)	8286.369	Mean of the full time series (18 years)
Total catch (2021)	103.2545	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 5.3.3 red mullet in GSA 1: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 1-3) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	82.30	0.60	3452	261.51	-1.1576
$F_{MSY\ Transition}$^^	122.97	1.06	1887	200.83	25.85
$F_{MSY\ lower}$	59.24	0.40	3831	301.69	-39.36
$F_{MSY\ upper}$**	103.47	0.82	3080	228.35	5.89
Other scenarios					
Zero catch	0.00	0.00	4747	424.58	-100
Status quo	138.71	1.29395	1441	180.65	41.967
0.1	21.28	0.1293865	1599	180.6510954	-78.21
0.2	40.27	0.258773	1992	377.1827274	-58.77
0.3	57.28	0.3881595	2517	337.957095	-41.36
0.4	72.57	0.517546	3219	305.3031709	-25.71

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

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 2019. Also the estimation of recruitment is consistent with the ones obtained from last year assessment. All the diagnostics were considered acceptable.

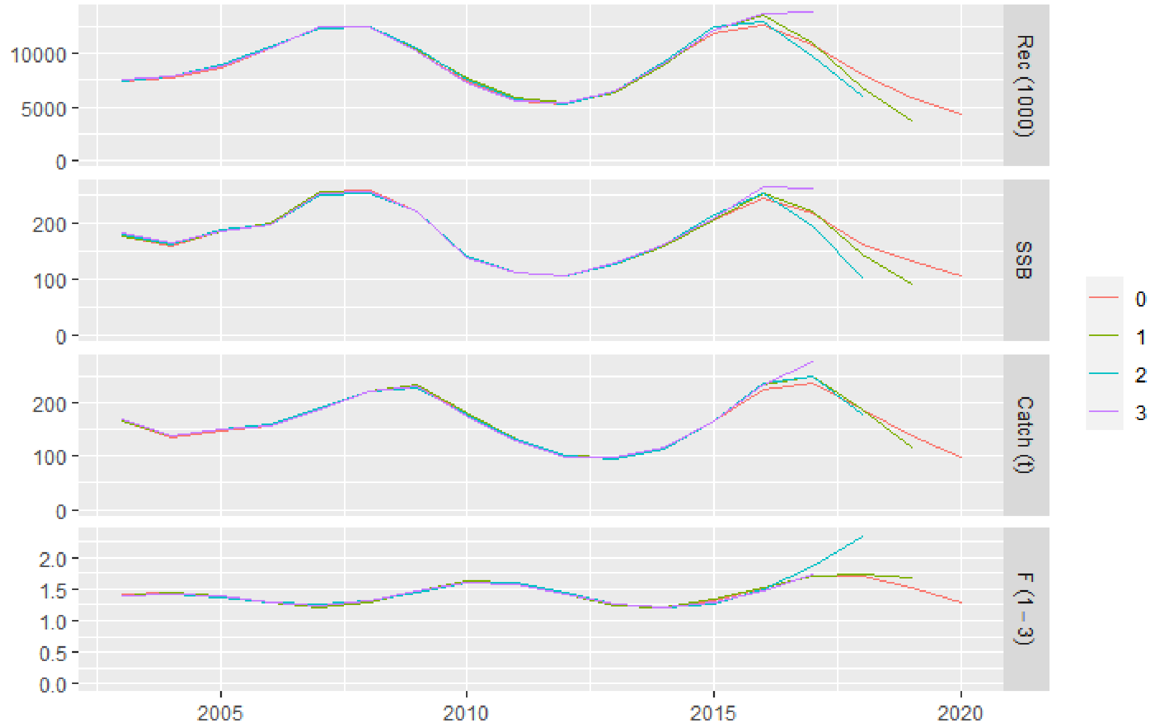


Figure 5.3.2 Red mullet in GSA 1: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.6074	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.6074	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.40	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.82	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

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 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 5.3.7 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 catch	STECF discards
2019	$F = F_{MSY}$		99	148	
2020	$F = F_{MSY}$		53.5	97.7	
2021	$F = F_{MSY}$		114		
2022	$F = F_{MSY}$		82.3		

History of the catch and landings

Table 5.3.8 Red mullet in GSA 1: 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>107.32</td><td>Otter trawl
100%</td><td>Gillnets
0%</td><td>Trammel nets
0%</td><td>Other
0%</td><td>0.26t</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Effort</td><td>21999</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">Fishing effort</td></tr>
</table>

Table 5.3.9 Red 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	Total Effort* (Fishing days)
2003	159.68	159.68	0.06313	159.74	28002
2004	154.07	154.07	0.062817	154.13	32892
2005	140.21	140.21	0	140.21	34951
2006	164.54	164.54	0.066926	164.61	32295
2007	194.01	194.01	0.080208	194.09	31443
2008	193.65	193.65	0.16	193.81	29917
2009	228.37	228.37	1.093332	229.46	26201
2010	201.65	201.65	0.012556	201.66	27017
2011	201.18	201.18	0.142143	201.32	28476
2012	107.31	107.31	1.656208	108.97	28170
2013	131.63	131.63	0.289404	131.92	25851
2014	123.87	123.87	3.287578	127.16	24334
2015	135.9	135.9	1.781318	137.68	23236
2016	260.49	260.49	7.624791	268.11	17651
2017	274.67	274.67	3.483104	278.15	15484
2018	170.23	170.23	2.798582	173.03	16970
2019	124.62741	124.63	0.409217	125.04	20397
2020	107.321	107.32	0.261602	107.58	21999

*Effort data is taken from STECF EWG 21-13. 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 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2003	7366.792			176.786			159.7431	1.421072		
2004	7693.231			158.8321			154.1328	1.43213		
2005	8657.274			183.3952			140.21	1.38091		
2006	10512.664			197.7888			164.6069	1.285882		
2007	12447.3			255.2826			194.0902	1.236465		
2008	12554.974			257.4253			193.81	1.300132		
2009	10213.864			220.1548			229.4633	1.46408		
2010	7319.251			138.0935			201.6626	1.610721		
2011	5569.389			110.2064			201.3221	1.594598		
2012	5300.091			105.2844			108.9662	1.42655		
2013	6495.8			128.3299			131.9194	1.261828		
2014	9055.9			160.2231			127.1576	1.219151		
2015	11832.789			203.706			137.6813	1.324532		
2016	12592.409			242.9866			268.1148	1.526006		
2017	10752.63			216.9644			278.1531	1.69404		
2018	8042.847			159.6508			173.0286	1.696177		
2019	5841.765			132.6478			125.0366	1.526744		
2020	4307.336			105.5267			107.5826	1.293865		

Sources and references

STECF EWG 21-11, STECF EWG 21-13

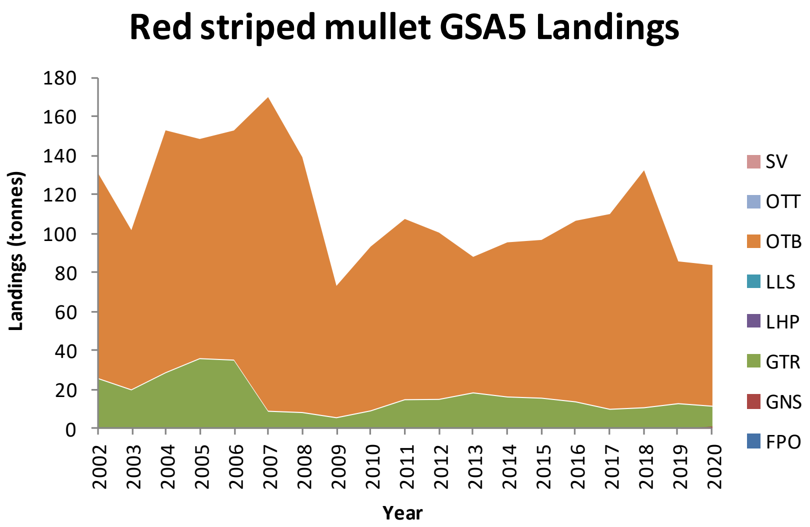
5.4 Summary sheet for striped red mullet in GSA 5

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 5.7.1) 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.



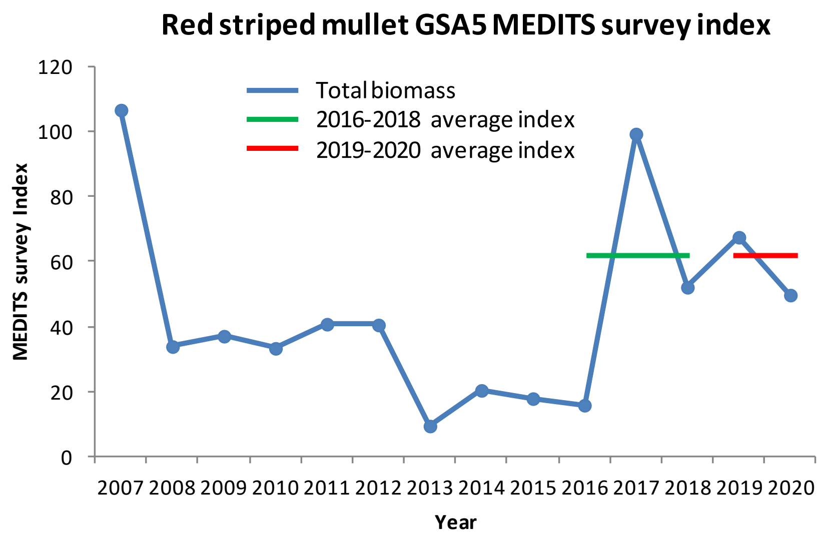


Figure 5.7.1 Red striped mullet in GSA 5: Landing (t) from 2002 to 2020. MEDITS estimated biomass in the last 2007-2020 and recent showing mean of last two years (2019-2020 in red) and previous three years (2016-2018 in green) used for calculating catch advice.

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 5.7.1). Accordingly, the previous catch (average of 2018-2020) 100.54 tonnes × 1.05 index ratio x 0.8 factor for 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 5.7.1 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		Applied
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 5.7.2 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 5.7.3 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 5.7.4 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 5.7.5 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 5.7.6 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 5.7.7 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 21-13. 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 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

STECF EWG 21-11, STECF EWG 21-13

5.5 Summary sheet for red mullet in GSA 6

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when the MSY considerations are applied, the fishing mortality in 2022 should not be more than 0.32 equivalent to catches of no more than 842 tonnes.

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. Both recruitment and SSB increased since 2017, though recruitment in the final year is particularly uncertain. F slightly decreased in the last three years 2018-2020.

Figure 5.5.1 Red mullet GSA 6: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.899) is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.317). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

Table 5.5.1 Red mullet GSA 6: State of the stock and fishery relative to reference points.

Status	2018	2019	2020
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

F / $F_{MSY\ Transition}$			F > $F_{MSY\ Transition}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2021)	0.899	F current in the last year used to give F status quo for 2021
SSB (2021)	1809.7	Stock assessment 1 January 2021
R_{age0} (2021,2022)	403443.5	Geometric mean of the period 2003-2020 (thousands)
Total catch (2021)	1809.7	Assuming F status quo for 2021

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

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

Basis	Total catch* (2022)	F_{total}# (ages 1-3) (2022)	SSB (2023; middle year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	842.1	0.317	3060.8	24.5	-45.3
$F_{MSY\ Transition}$^^	1487.4	0.664	2146.3	-12.7	-3.3
$F_{MSY\ lower}$	595.6	0.212	3457.7	40.6	-61.3
$F_{MSY\ upper}$**	1089.6	0.435	2688.4	9.3	-29.2
Other scenarios					
Zero catch	0	0	4519.3	83.8	-100.0
Status quo	1812.7	0.899	1756.8	-28.6	17.8
Factor 0.5	1117.1	0.450	2648.6	7.7	-27.4
Factor 1.5	2264.2	1.349	1298.2	-47.2	47.1

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.5.4 Red mullet GSA 6: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This assessment is an update of the EWG 20-09 a4a assessment of red mullet in GSA 6. The growth curve was corrected for a calendar year assessment (t0 +0.5). All the diagnostics were considered acceptable.

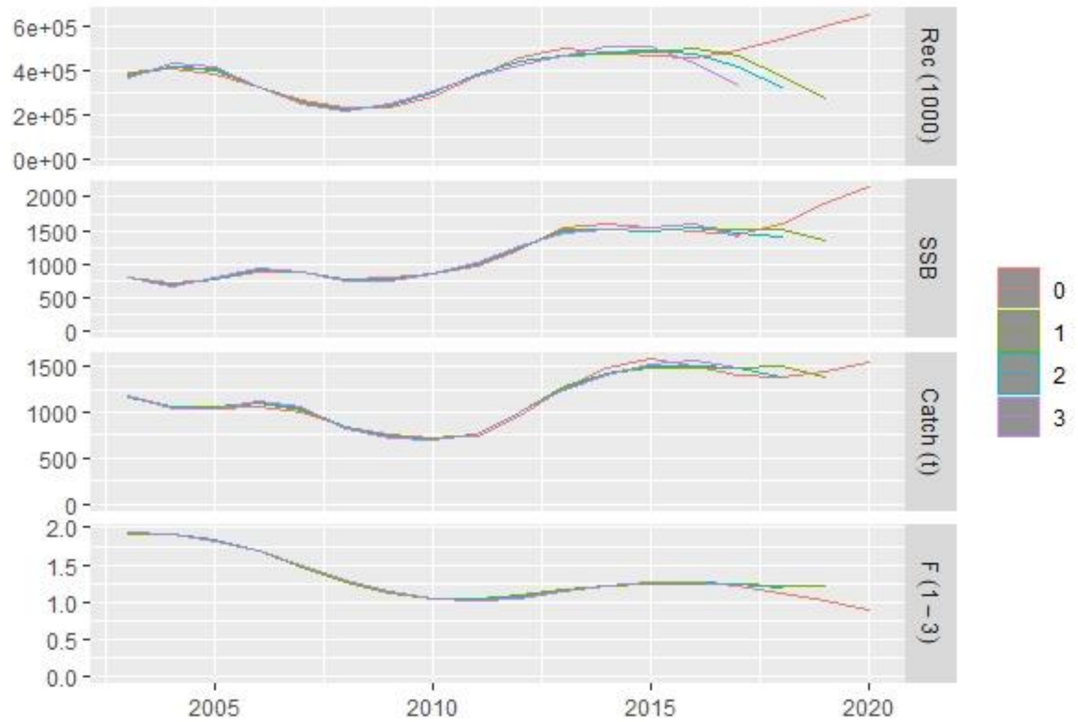


Figure 5.5.2 Red mullet GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for advice.

Reference points

Table 5.5.5 Red mullet 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}	0.317	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.317	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	MAP target range F_{lower}	0.212	Based on regression calculation (see section 2)	STECF EWG 21-11
	MAP target range F_{upper}	0.435	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

Basis of the assessment

Table 5.5.6 Red mullet 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. The main difference regarding DCF data is the reconstruction of discards.
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 21-11

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.5.7 Red mullet 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		
2022	$F = F_{MSY}$		842		

History of the catch and landings

Table 5.5.8 Red mullet GSA 6: Catch in 2019 and effort distribution by fleet in 2018 as estimated by and reported to STECF.

		Wanted catch				Discards
Catch (2020) (t)	1446	Otter trawl 93.1%	Trammel nets 6.2%	Gillnets, combined trammel and gillnet 0.4%	Other 0.3%	t
		1347	88.8	5.7	4.7	7.7 (OTB)
Effort	116801	NA	NA	NA	NA	
		Fishing days				

Table 5.5.9 Red mullet GSA 6: History of commercial landings and total effort expressed in fishing days. All weights are in tonnes.

Year	GSA6 Landings (t)	Total Effort* (Fishing days)
2003	1400.0	
2004	919.5	159374
2005	995.0	152538
2006	1387.8	149614
2007	1183.6	133082
2008	872.1	146015
2009	520.9	161275
2010	514.1	151984
2011	1063.1	150563
2012	1069.9	146946
2013	1248.0	146695
2014	1309.2	162731
2015	1518.7	132753
2016	1673.9	139757
2017	1449.3	126396
2018	1280.7	119643
2019	1501.8	124261
2020	1446.3	116801

*Effort data is taken from STECF EWG 21-13. 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 5.5.10 Red mullet 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	391427			801			1170.4	1.938		
2004	406613			711			1066.0	1.904		
2005	387767			774			1047.6	1.825		

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2006	329526			877			1063.0	1.678		
2007	266372			882			1003.0	1.480		
2008	231525			790			837.8	1.282		
2009	237537			800			765.2	1.127		
2010	287118			861			718.7	1.040		
2011	372012			963			743.2	1.022		
2012	457679			1225			960.0	1.062		
2013	498568			1532			1255.1	1.141		
2014	488918			1595			1480.0	1.225		
2015	465505			1535			1573.4	1.278		
2016	462765			1499			1496.6	1.278		
2017	491505			1429			1398.9	1.220		
2018	542984			1588			1383.8	1.123		
2019	600178			1891			1445.8	1.010		
2020	654577			2146			1539.0	0.899		

Sources and references

STECF EWG 21-11, STECF EWG 21-13

ICES. 2012. Report of the workshop on age reading of red mullet and striped red mullet, 2–6 July 2012, Boulogne-Sur-Mer, France. ICES CM 2012/ACOM:60. 52 pp.

5.6 Summary sheet for Red Mullet in GSA 7

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.46 and corresponding catches in 2022 should be no more than 351 tons.

Stock development over time

Catches and SSB of Red Mullet show an slow but increase initiated in 2007, with a slowing down in 2012, since which the number of recruits seems to have reached a plateau before resuming growth (with high uncertainty) in 2017 until 2020. Fbar (0-3) shows some fluctuations around 0.65, and its value in 2020 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 (0.624) is 1.4 times above the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.46). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

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

Status	2018	2019	2020
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}
F / F_{MSY} Transition			F > F_{MSY} Transition

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 0-3}$ (2021)	0.624	F 2020 used to give F status quo for 2021
SSB (2021)	575	Stock assessment 1 January 2021
R_{age0} (2020,2021)	113700	Geometric mean of the last 6 years
Total catch (2021)	462	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* (2022)	F_{total}# (ages 0-3) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	351	0.456	614	6.8	-9.70
$F_{MSY\ Transition}$^^	397	0.536	560	-2.72	1.93
$F_{MSY\ lower}$	253	0.304	741	28.86	-34.85
$F_{MSY\ upper}$**	442	0.623	506	-11.89	13.64
Other scenarios					
Zero catch	0	0	1120	94.73	-100
Status quo	442	0.624	506	-12.01	13.80

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ 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 a significant effort had been made to improve the data quality (notably the establishment of an Age-Length Key for Red Mullet in GSA 7). It is worth noting that due to the COVID crisis, the MEDITS survey has suffered a 4 month delay in 2020, resulting in the capture of a large amount of juveniles that would otherwise have been missed. In addition, the sampling scheme had to be reduced, resulting in a biased abundance estimate. Both issues have been accounted for in the assessment (see Section 6.6,), however, the quality of the assessment in 2020 has probably been impacted nonetheless. Fortunately, the survey has been carried out normally in 2021; hence this issue will have a reduced effect in the future.

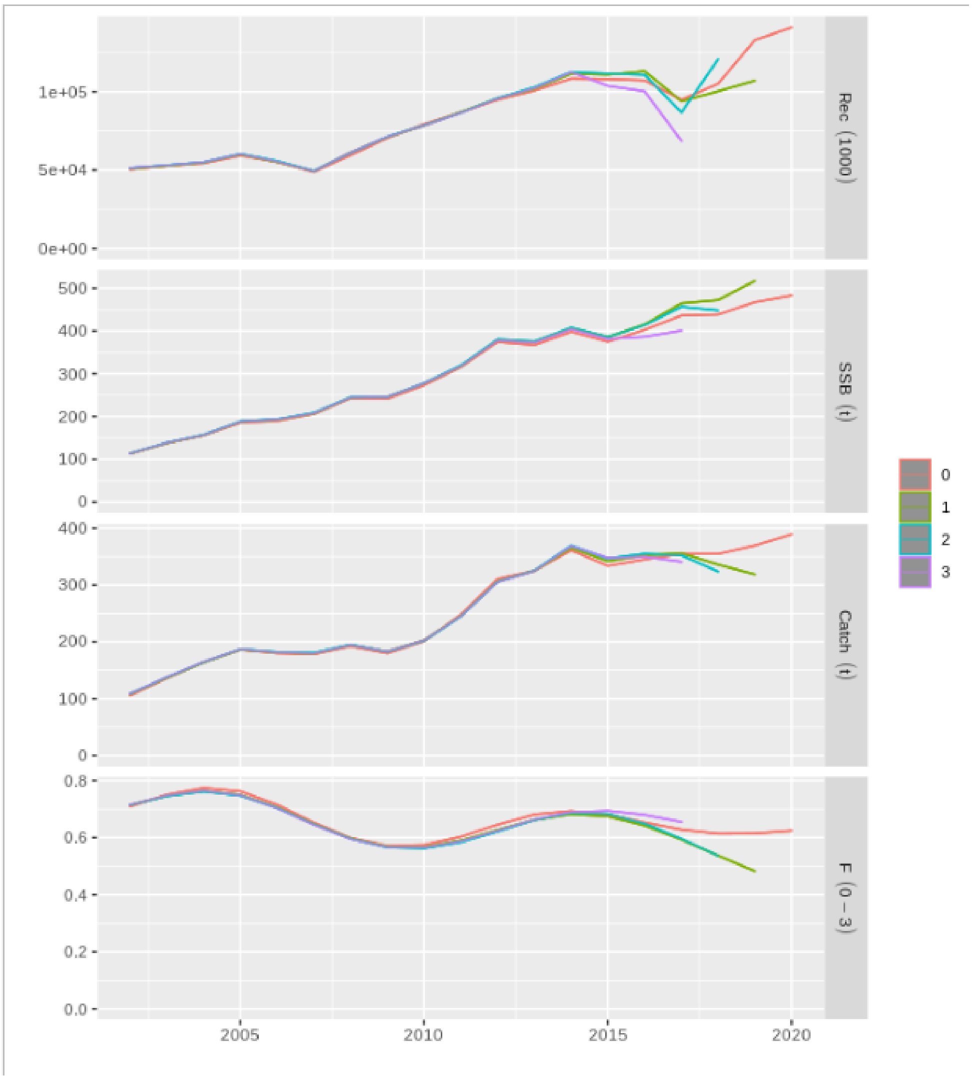


Figure 5.6.2 Red Mullet in GSA 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.456	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.456	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.28	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.58	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

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 21-11

*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		
2022	F = F_{MSY}		351		

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.

2020		Wanted catch				Discards
Landings (t)	420	Otter trawl 93.8%	Gillnets 3.0%	Trammel nets 3.1%	Other <0.1%	25t
Effort	57875					
		Fishing days				

Table 5.6.9 Red Mullet in GSA 7: History of commercial landings, discards and catches; 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	11.080	122.504	0.000	122.504	
2003	164.141	11.870	176.011	0.000	176.011	
2004	151.646	25.840	177.486	0.000	177.486	
2005	148.086	27.480	175.566	0.000	175.566	
2006	183.478	31.400	214.878	0.000	214.878	
2007	171.526	36.160	207.686	0.000	207.686	
2008	110.494	20.730	131.224	0.180	131.404	
2009	122.555	26.130	148.685	0.000	148.685	
2010	236.034	28.230	264.264	2.505	266.769	85585
2011	241.682	28.130	269.812	4.388	274.200	89327
2012	176.729	29.170	205.899	12.176	218.075	84912
2013	260.423	37.530	297.953	10.068	308.022	79112
2014	308.912	41.180	350.092	9.359	359.451	61582
2015	335.381	33.050	368.431	18.043	386.474	77838
2016	368.077	43.310	411.387	6.457	417.844	76958
2017	261.364	31.090	292.454	8.843	301.297	80595
2018	308.705	23.830	332.535	9.543	342.078	70089
2019	278.615	22.168	300.783	19.023	319.806	62836
2020	408.864	11.481	420.345	24.384	444.730	57875

*Effort data is taken from STECF EWG 21-13. 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	Rec0 (thousands)	SSB (t)	F03	Catch (t)
2002	50416.85	112.721	0.709	105.591
2003	52616.27	137.646	0.751	135.878
2004	54314.71	155.963	0.775	164.064
2005	59256.7	185.474	0.763	186.142
2006	55165.69	189.542	0.716	179.925
2007	48831.62	205.918	0.653	178.151
2008	59477.25	242.757	0.599	192.011
2009	70477.08	241.243	0.571	179.797
2010	79303.54	273.244	0.574	200.869
2011	86886.18	315.613	0.604	248.048
2012	94860.18	374.445	0.646	310.639
2013	100670.61	366.991	0.681	325.13
2014	108301.4	398.069	0.694	360.906
2015	107958.81	375.108	0.681	333.682
2016	107174.87	402.645	0.653	344.769
2017	94834.25	436.413	0.628	354.659
2018	105117.48	438.562	0.615	354.591
2019	132915.36	467.539	0.615	369.312
2020	140941.82	482.912	0.624	389.014

Sources and references

STECF EWG 21-11, STECF EWG 21-13

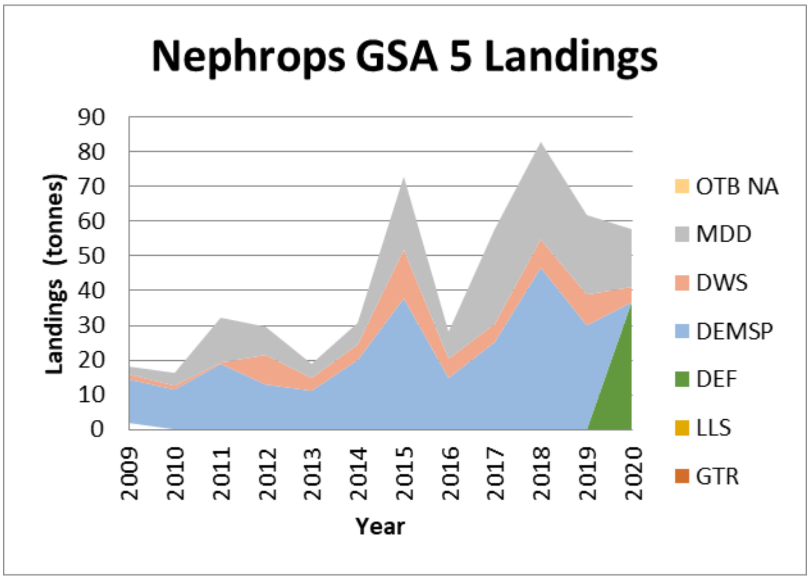
5.7 Summary sheet for Norway lobster in GSA 5

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.



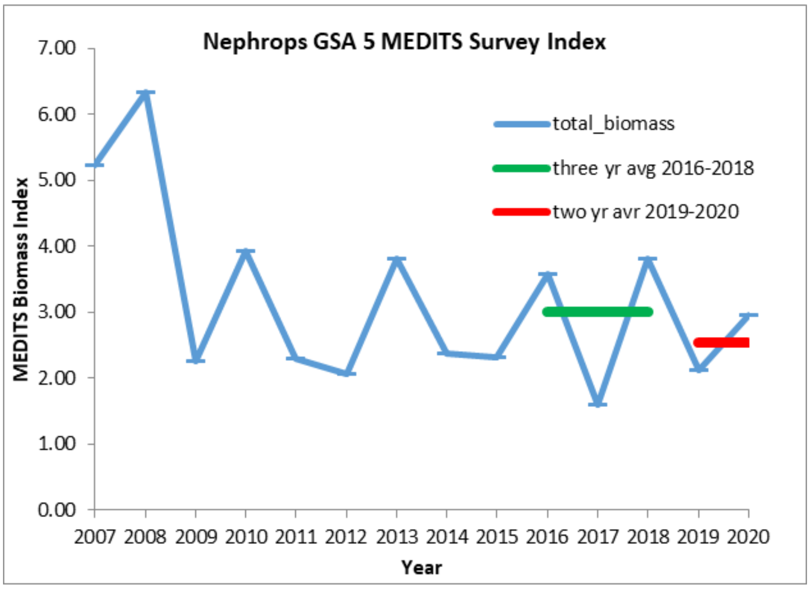


Figure 5.7.1 Norway lobster in GSA 5: Landing (t) from 2009 to 2020. MEDITS estimated biomass in the last 2007-2020 and recent showing mean of last two years (2017-

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				
Effort					
7306	Fishing days				

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

Year	Spain GSA5	STECF total landings	Total Effort* (Fishing days)
2002	17.32	17.32	
2003	17.77	17.77	
2004	25.09	25.09	12012
2005	20.17	20.17	11497
2006	21.27	21.27	10507
2007	57.78	57.78	11907
2008	89.63	89.63	12226
2009	16.34	16.34	10934
2010	16.19	16.19	11239
2011	32.26	32.26	10498
2012	29.50	29.50	10568
2013	18.82	18.82	10769
2014	30.80	30.80	13525
2015	72.87	72.87	12776
2016	28.33	28.33	10566
2017	57.82	57.82	9682
2018	82.91	82.91	8709
2019	61.85	61.85	8202
2020	57.80	57.80	7306

*Effort data is taken from STECF EWG 21-13. 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

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
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

STECF EWG 21-11, STECF EWG 21-13

5.8 Summary sheet for Norway lobster in GSA 6

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.257 and corresponding catches in 2022 should be no more than 206 tons.

Stock development over time

Catches of Norway lobster show a decreasing trend from 2011 to 2019, with a drastic reduction in 2020. SSB and Recruitment decreased from 2010 to 2018 and are increasing in the last two years. Fbar (3-6) shows a progressive decrease since 2014, with a sharp reduction in 2020, following a similar trend as the catches. Fbar (3-6) reached the lowest value in the series (0.258) in 2020, very close to F_{01} = 0.257.

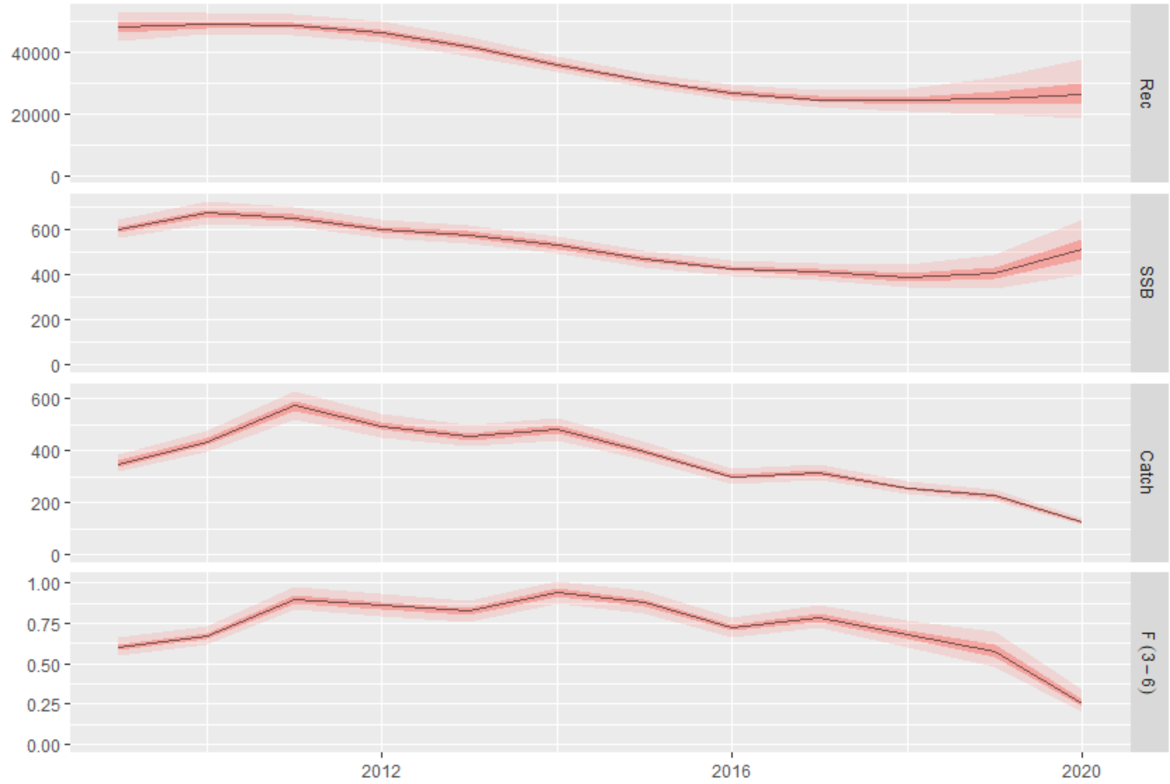


Figure 5.8.1 Norway lobster in GSA 6: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.26) is the same as the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.26). As F is currently estimated to be at F_{MSY} F is ahead of MSY transition.

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

Status	2018	2019	2020
F / F_{MSY} F / $F_{MSY\ Transition}$	F > F_{MSY}	F > F_{MSY}	F = F_{MSY} F < $F_{MSY\ Transition}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 3\text{-}6}$ (2021)	0.258	F 2020 used to give F status quo for 2021
SSB (2021)	612.73	Stock assessment 1 January 2021
R_{age2} (2021,2022)	25487.91	Geometric mean of the last 5 years
Total catch (2021)	167.45	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 5.8.3 Norway lobster in GSA 6: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 3-6) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	206	0.257	884	37.41	60.99
$F_{MSY\ Transition}$^^	311	0.418	716	11.37	142.63
$F_{MSY\ lower}$	144	0.173	990	53.87	12.67
$F_{MSY\ upper}$**	272	0.354	778	20.85	112.04
Other scenarios					
Zero catch	0.00	0.00	1255	95.05	-100
Status quo	207	0.258	883	37.29	61.37
factor 0.8	170	0.206	946	47.08	32.36
factor 0.6	130	0.155	1015	57.67	1.80
factor 1.2	242	0.309	825	28.24	88.93
factor 1.4	276	0.361	771	19.88	115.11
	206	0.257	884	37.41	60.99

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

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, and the assessment model was not modified. The retrospective analysis showed consistency in the estimation of F estimated in the assessment of 2019. Also the estimation of recruitment is consistent with the ones obtained from last year assessment. All the diagnostics were considered acceptable.

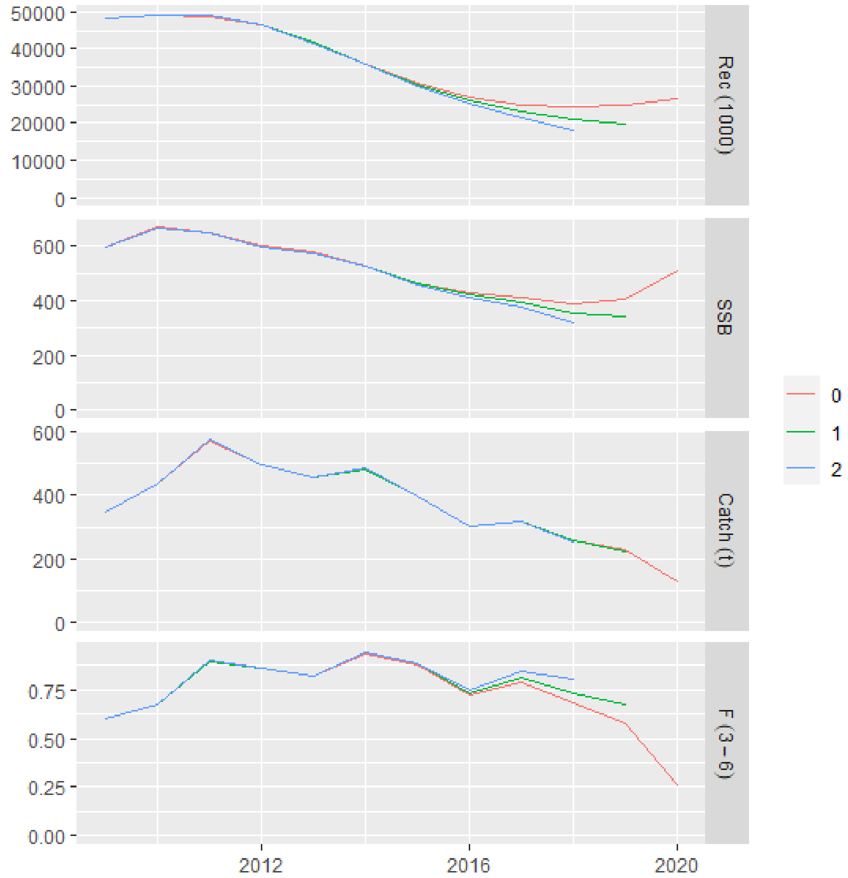


Figure 5.8.2 Norway lobster in GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.257	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.257	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.173	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.354	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

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 21-11

*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	227.	1.2
2020	$F = F_{MSY}$		77	128.	1.5
2021	$F = F_{MSY}$		68		
2022	$F = F_{MSY}$		206		

History of the catch and landings

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

2020		Wanted catch				Discards
Catch (t)	200	Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	1.5
Effort	69201	NA	NA	NA	NA	
		Fishing days				

Table 5.8.9 Norway lobster in GSA 6: 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	Total Effort* (Fishing days)
2002	187.5	
2003	381.8	
2004	321.7	118076
2005	352.0	110957
2006	390.2	110008
2007	409.4	99638
2008	393.8	106867
2009	355.6	102005
2010	406.5	95438
2011	496.8	90470
2012	506.1	86587
2013	478.4	84882
2014	490.0	103479
2015	355.2	76909
2016	308.1	83196
2017	282.2	73561
2018	287.0	76412
2019	269.1	75803
2020	198.8	69201

*Effort data is taken from STECF EWG 21-13. 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 5.9.10 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	48157	55253	41127	595.5	658.2	535.1	348.95	0.603	0.701	0.504
2010	49082	54059	43939	667.7	738.7	599.9	434.33	0.673	0.773	0.575

Year	Recruitment age 2 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 3-6	High	Low
2011	48825	53713	43685	649.3	715.9	583.8	572.47	0.897	1.021	0.772
2012	46377	51721	40976	599.1	663.5	535.3	495.22	0.860	0.984	0.740
2013	41736	46199	37080	575.4	641.7	508.4	455.90	0.821	0.942	0.703
2014	36037	39892	32121	527.4	590.3	464.5	483.52	0.936	1.069	0.803
2015	30750	34439	27123	465.6	520.3	410.9	397.82	0.877	1.007	0.748
2016	26874	30663	23182	427.5	480.4	374.2	301.02	0.722	0.834	0.611
2017	24749	28673	20686	409.1	467.1	350.6	317.49	0.785	0.907	0.662
2018	24267	29916	18637	387.3	463.1	312.6	256.98	0.681	0.818	0.547
2019	25063	34151	15597	406.3	522.3	293.8	227.24	0.579	0.752	0.404
2020	26591	40265	12292	510.0	704.8	317.1	128.14	0.258	0.370	0.144

Sources and references

STECF EWG 21-11, STECF EWG 21-13

5.9 Summary sheet for European hake in GSA 8, 9, 10 and 11

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.17 and corresponding catches in 2022 should be no more than 920 tons.

Stock development over time

Catches of European hake show a decreasing trend in the whole time series, even if fluctuating in the last three years. SSB declines in the first half of the time series and slightly increases in the last seven years. The assessment also shows a decreasing trend in the number of recruits with the minimum value reached in 2019. Fbar (1-3) shows a fluctuating pattern with a slightly decreasing trend until 2016 and a strong decrease in the last four years, with the lowest value of 0.50 reached in 2020.

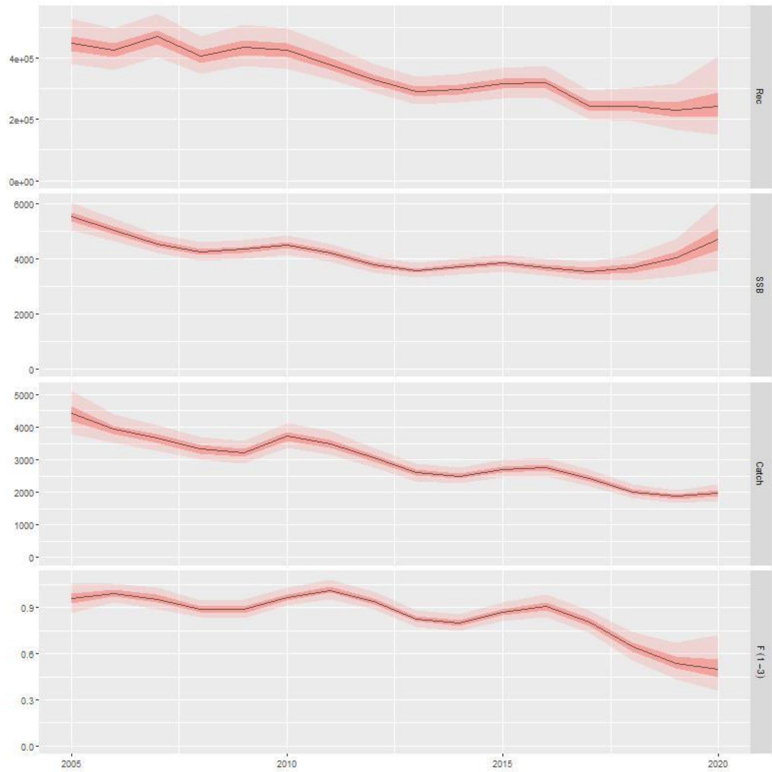


Figure 5.9.1. European hake in GSAs 8, 9, 10 & 11. Trends in catch, recruitment, fishing mortality resulting from the a4a model.

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). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

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

Status	2018	2019	2020
F / F_{MSY} $F / F_{MSY\ transition}$	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$ $F > F_{MSY\ transition}$

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
$F_{ages\ 1\text{-}3}$ (2021)	0.50	The F estimated in 2020 was used to give F status quo for 2021.
SSB (2021)	5422	Stock assessment 1 January 2020
R_{age0} (2021,2022)	273403	Mean of the last 8 years
Total catch (2021)	2200	Catch in 2020 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* (2022)	F_{total}# (ages 1-3) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	920.3	0.17	8981	65.65	-53.59
$F_{MSY\ Transition}$^^	1807.7	0.35	7674	41.55	-8.84
$F_{MSY\ lower}$	637	0.11	9405	73.47	-67.87
$F_{MSY\ upper}$**	1252.3	0.23	8489	56.56	-36.85
Other scenarios					
Zero catch	0	0	10369	91.26	-100
Status quo	2434.1	0.50	6775	24.96	22.75

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

*** % change in SSB 2021 to 2023

^Total catch in 2022 relative to catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

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 in 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.

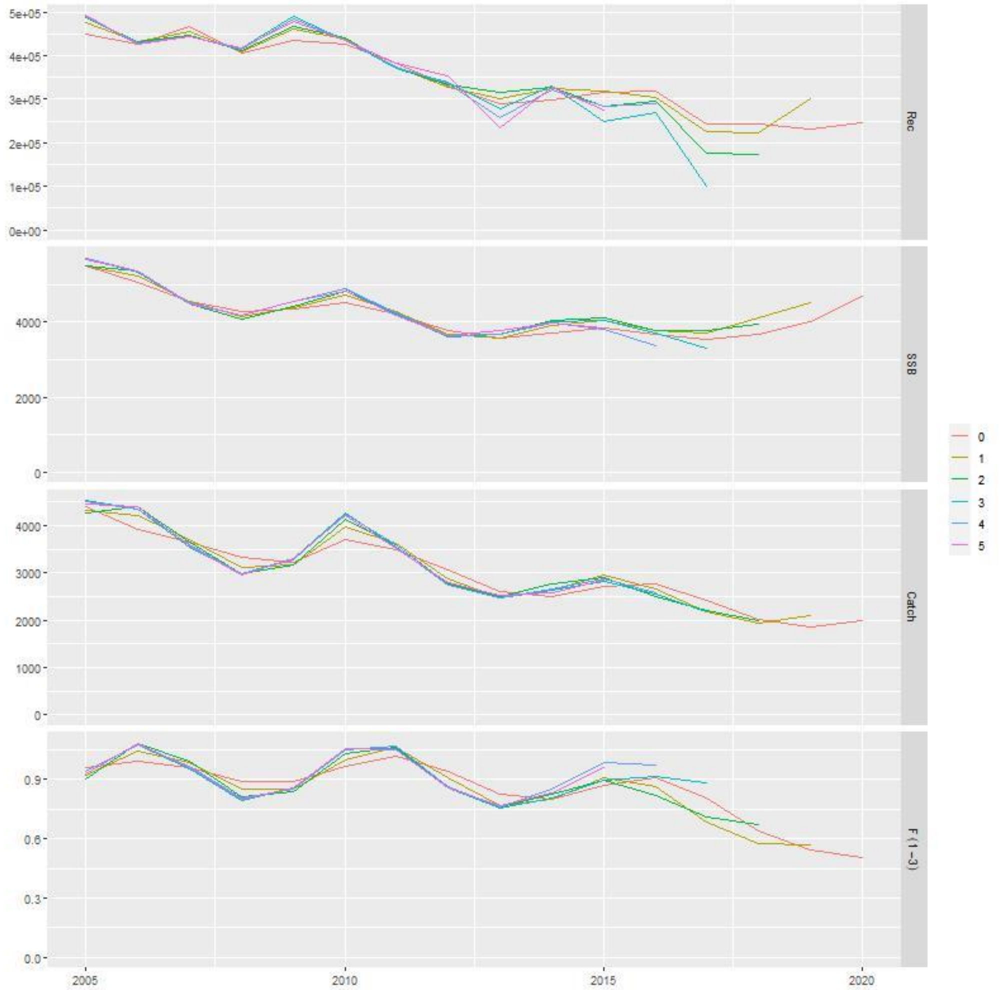


Figure 5.9.2. European hake in GSAs 8, 9, 10 & 11. Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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 21-11
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}	0.17	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.11	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.23	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

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 21-11

*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	1870	
2020	F = F_{MSY}		772	1983	
2021	F = F_{MSY}		954		
2022	F = F_{MSY}		920		

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.

2020		Wanted catch				Discards
Catch (t)		Otter trawl 52%	Gillnets 28%	Trammel nets 6%	Other 14%	t
	1933	998	534	122	277	200
Effort	432294	NA	NA	NA	NA	
		Fishing days				

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* (Fishing days)
2005		1859.98	1484.74	397.39	3757.11	884051
2006		2176.49	1544.07	341.06	4076.63	896282
2007		1733.03	1268.66	169.58	3186.28	828912
2008		1321.13	1122.85	138.77	2597.74	665886
2009	15.10	1308.47	1090.51	260.54	2674.61	757456
2010	11.97	1467.11	1329.45	175.88	2984.41	740242
2011	13.24	1351.74	1278.52	277.42	2920.92	803612
2012	13.01	1011.52	1107.24	176.05	2307.83	686532
2013	3.52	1341.63	1052.19	195.79	2593.13	664353
2014	12.61	1264.95	1271.11	44.96	2593.63	664373
2015	12.19	1047.70	1043.44	220.04	2323.36	691039
2016	39.85	782.25	1051.95	339.15	2213.19	712645
2017	14.60	572.37	870.43	356.52	1813.92	633208
2018	21.09	605.35	819.86	391.98	1838.28	648866
2019	18.00	722.26	765.17	445.53	1950.96	548508
2020	18.87	630.58	820.40	260.61	1730.46	432294

*Effort data is taken from STECF EWG 21-13. 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 5.9.10. 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	448561			5499.3			4389.7	0.96		
2006	425227			5042.6			3919.5	0.99		
2007	468246			4558.1			3654.3	0.96		
2008	405758			4269.8			3321.8	0.89		
2009	436120			4340.5			3220.4	0.89		
2010	425479			4508			3704.7	0.96		
2011	381144			4211.1			3485.5	1.01		
2012	330331			3786.6			3050.1	0.94		
2013	290917			3576.7			2599.6	0.838		
2014	297919			3719.7			2498.5	0.80		
2015	316100			3840.3			2702.9	0.87		
2016	318298			3685.8			2752.3	0.91		
2017	243616			3552.6			2428.2	0.80		
2018	243298			3664.9			2015.2	0.64		
2019	230467			4017.5			1869.7	0.54		
2020	246605			4689.9			1983	0.50		

Sources and references

STECF EWG 21-11

5.10 Summary sheet for Deep-water rose shrimp in GSAs 9, 10 & 11

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 1.29 and corresponding catches in 2022 should be no more than 1455 tons.

Stock development over time

Recruitment
Recruitment (age 0) is characterised by an increasing trend until 2016. Then, fluctuation is observed with a peak in 2018 (4,440,774 thousands individuals).

Spawning stock biomass (SSB)
The spawning stock biomass shows an increasing trend reaching the maximum value in 2018 (2686tons). A decrease was observed in 2019 and 2020.

Catch
After the minimum value in 2009 (712 tons), the catches have shown an increase over the years, until reaching the maximum value in 2020, corresponding to 1878 tons.

Fishing mortality (F)
The lowest value of fishing mortality (0.65) is observed at the beginning of the data series (2009-2010). After that, a constant increase of F is observed, reaching the maximum value of 1.06 in 2014. In the following three years the F decreased. In the period 2018-2020 a new increase in respect to the previous years was observed (maximum value of F=1.58 in 2020).

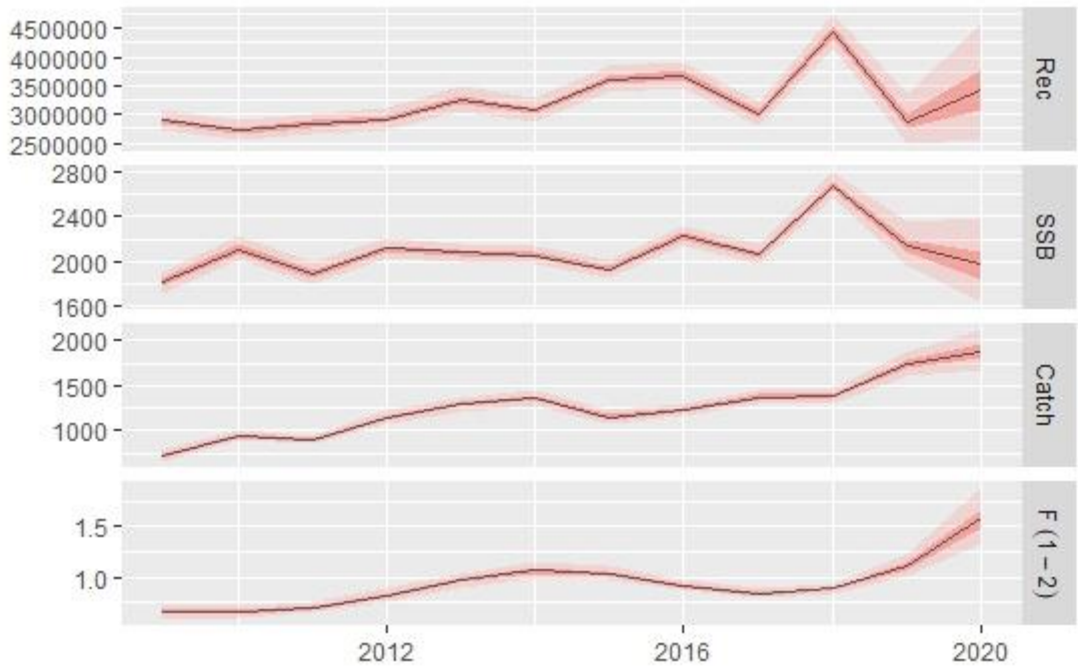


Figure 5.10.1 Deep-water rose shrimp in GSAs 9, 10 & 11. Outputs of the a4a assessment.

Stock and exploitation status

Current F (1.58), estimated by the model as $F_{bar1\text{-}2}$ in the last year of the time series (2020), is higher than $F_{0.1}$ (1.29), which is a proxy of F_{msy} and is used as the exploitation reference point consistent with high long term yields. This indicates that Deep-water rose shrimp stock in GSAs 9, 10 and 11 is being over-exploited. F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition, in this case this is because F has increased from below F_{MSY} in 2019 and is now above F_{MSY} in 2020

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

Status	2018	2019	2020
F/ F_{MSY}	F < F_{MSY}	F < F_{MSY}	F > F_{MSY}
F/$F_{MSY\ Transition}$			F > $F_{MSY\ Transition}$

Catch scenarios

Table 5.10.2 Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1–2}$ (2020)	1.58	F current in the last year (2020) used to give F status quo for 2021
SSB (2021)	1799 t	
R_0 (2021 & 2023)	3,197,123 thousands	Geometric mean of the period 2009-2020
Total catch (2021)	1741 t	Based on fishing at F status quo in 2021

Table 5.10.3 Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 1-2) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	1455	1.29	1902	5.7	-22.5
$F_{MSY\ lower}$	1113	0.85	2233	24.1	-40.7
$F_{MSY\ upper}$**	1718	1.74	1668	-7.3	-8.5
$F_{MSY\ Transition}$^^	1395	1.20	1958	8.8	-25.7
Other scenarios					
Zero catch	0.0	0.0	3538	96.7	-100.0
Status quo	1634	1.58	1741	-3.2	-13.0

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

*** % change in SSB 2021 to 2023

^Total catch in 2022 relative to catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

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

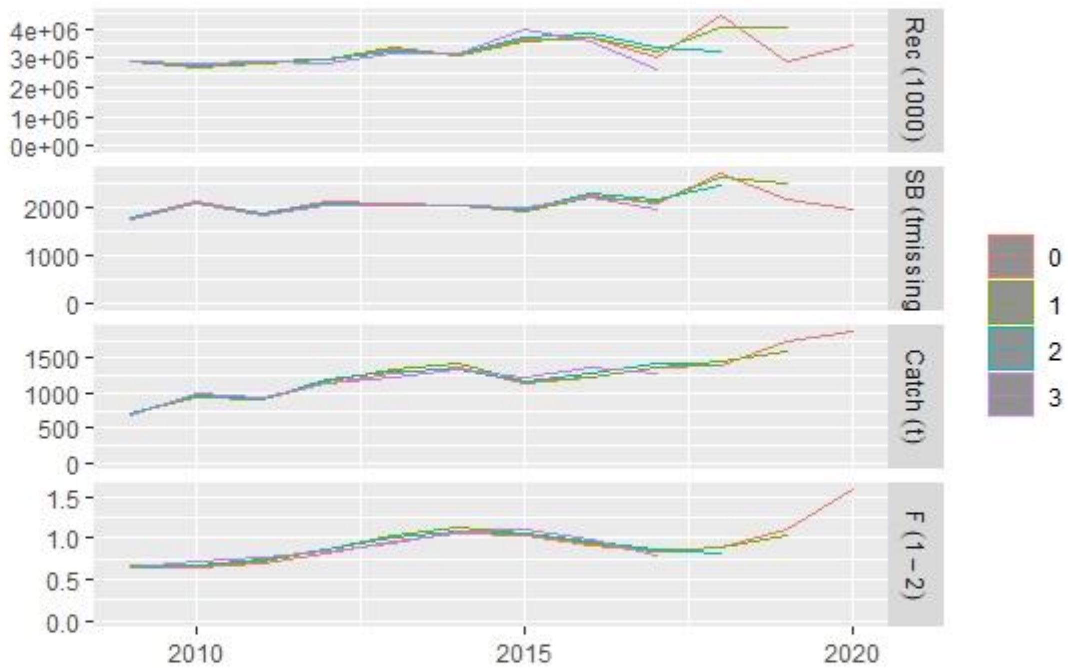


Figure 5.10.2 Deep-water rose shrimp in GSAs 9, 10 & 11 Results of the retrospective analysis (a4a).

The time series of landing data in biomass available in the database were different among the three GSAs: 2003-2018 for GSA09, 2002-2018 for GSA10 and 2009-2018 for GSA11. The assessment was carried out on the period 2009-2019.

For some métiers, the length frequency distributions of landing were not available and had to be reconstructed. In particular, the LFD of OTB_DEF for 2019 in GSA10 was not available; this métier represented a high percentage of the total landing (61.51%). In GSA11, the LFDs of OTB_DWS and OTB-DEF were not available for the years 2019 and 2020. These two métiers together contributed to 56.24% and 60.81% of the total landing in the two years respectively. In other cases, the reconstructions in the three GSAs involved métiers who contribute marginally to the total landing.

For some years, the LFDs of discard were not available and had to be reconstructed. However, the discarded quantities of this species were quite low, especially in GSA10. Demographic information on discard of DPS in GSA11 was not reported in the DCF database.

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

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.10.5 Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	1.29	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}			
	B_{pa}			
	F_{lim}			
	F_{pa}			
Management plan	MSY $B_{trigger}$			
	B_{lim}			
	F_{MSY}	1.29	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	MAP target range F_{lower}	0.85		STECF EWG 21-11
	MAP target range F_{upper}	1.74		STECF EWG 21-11

Basis of the assessment

Table 5.10.6 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 9, 10 & 11
Other information	
Working group	STECF EWG 21-11

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.10.7 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}	644	644	1740	
2020	F = F_{MSY}	1301	1301	1878	
2021	F = F_{MSY}	1741	1741		
2022	F = F_{MSY}		1455		

History of the catch and landings

Table 5.10.8 Catch and effort distribution by fleet in 2020 as estimated by and reported to STECF.

2020		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets %	Trammel nets %	Other %	t
	1878	tonnes				71
Effort	70922					
		Fishing days				

Table 5.10.9 History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	GSA9 ITA	GSA10 ITA	GSA11 ITA	Total landings	Discards	total catches	Total Effort* (Fishing days)
2009	303	379	22	704	46	750	110223
2010	473	370	23	866	30	896	103749
2011	551	405	53	1010	66	1076	101190
2012	621	459	34	1114	12	1126	94577
2013	576	597	21	1194	39	1233	105927
2014	561	509	30	1101	48	1149	111284
2015	791	547	26	1365	103	1467	98969
2016	836	542	18	1396	41	1437	103845
2017	857	265	29	1151	46	1197	100037
2018	904	555	68	1527	50	1577	98977
2019	896	667	181	1744	285	2029	90631
2020	1028	367	172	1567	71	1638	70922

*Effort data is taken from STECF EWG 21-13. 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 5.10.10 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
2009	2896475			1803			712	0.65		
2010	2724072			2112			945	0.65		
2011	2832808			1884			901	0.70		
2012	2919830			2112			1150	0.82		
2013	3261327			2074			1289	0.97		
2014	3064789			2050			1362	1.06		
2015	3615495			1926			1149	1.03		
2016	3682025			2228			1226	0.92		
2017	3000511			2065			1371	0.84		
2018	4440774			2686			1385	0.88		
2019	2880279			2141			1740	1.11		
2020	3422245			1960			1878	1.58		

Sources and references

STECF EWG 21-11, STECF EWG 21-13

5.11 Summary sheet for red mullet in GSA 9

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.52 and corresponding catches in 2022 should be no more than 1033 tons.

Stock development over time

Catches show an increasing pattern up to 2016, and then they decrease sharply in the last three years. SSB shows an almost continuous increasing trend. F follows the pattern of catches: it stays high up to 2016, and then it decreases sharply following the catch.

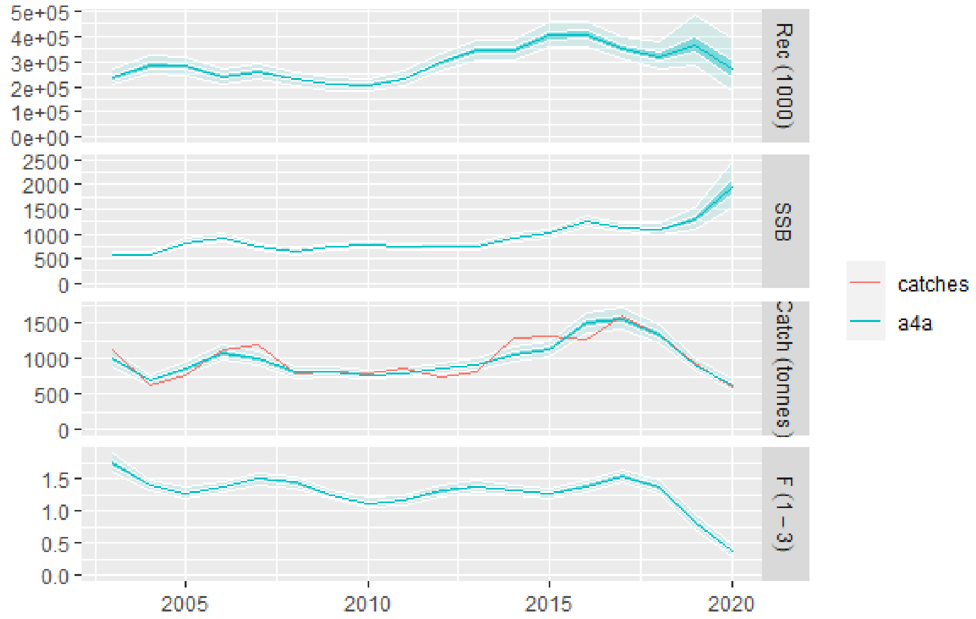


Figure 5.11.1 Red mullet in GSA 9: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality is below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.52). F in 2020 is also lower than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is ahead of transition, in addition 2020 F is now less than F_{MSY}

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

Status	2018	2019	2020
F / F_{MSY} F/ $F_{MSY\ Transition}$	F > F_{MSY}	F > F_{MSY}	F < F_{MSY} F < $F_{MSY\ Transition}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-3}$ (2021)	0.37	F current in the last year used to give F status quo for 2021
SSB (2021; middle year)	2054 t	Stock assessment 1 January 2021
R_0 (2021 2022)	287566 thousands	Geometric mean of the period 2003-2020
Total catch (2021)	765.9 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* (2022)	F_{total}# (ages 1-3) (2022)	SSB (2023; middle year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	1032.5	0.52	1891.6	-7.9	+64.1
$F_{MSY\ lower}$	739.2	0.35	2232.5	+8.7	+17.5
$F_{MSY\ upper}$**	1306.4	0.71	1600.3	-22.1	+107.6
$F_{MSY\ Transition}$ ^^	1258.4	0.67	1649.4	-19.7	+99.9
Other scenarios					
Zero catch	0.0	0.00	3221.2	+56.8	-100.0
Status quo	790.6	0.37	2170.7	+5.7	+25.6

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

*** % change in SSB 2023 to 2021

^Total catch in 2022 relative to Catch in 2020.

^^$F_{MSY\ Transition}$ 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	

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.

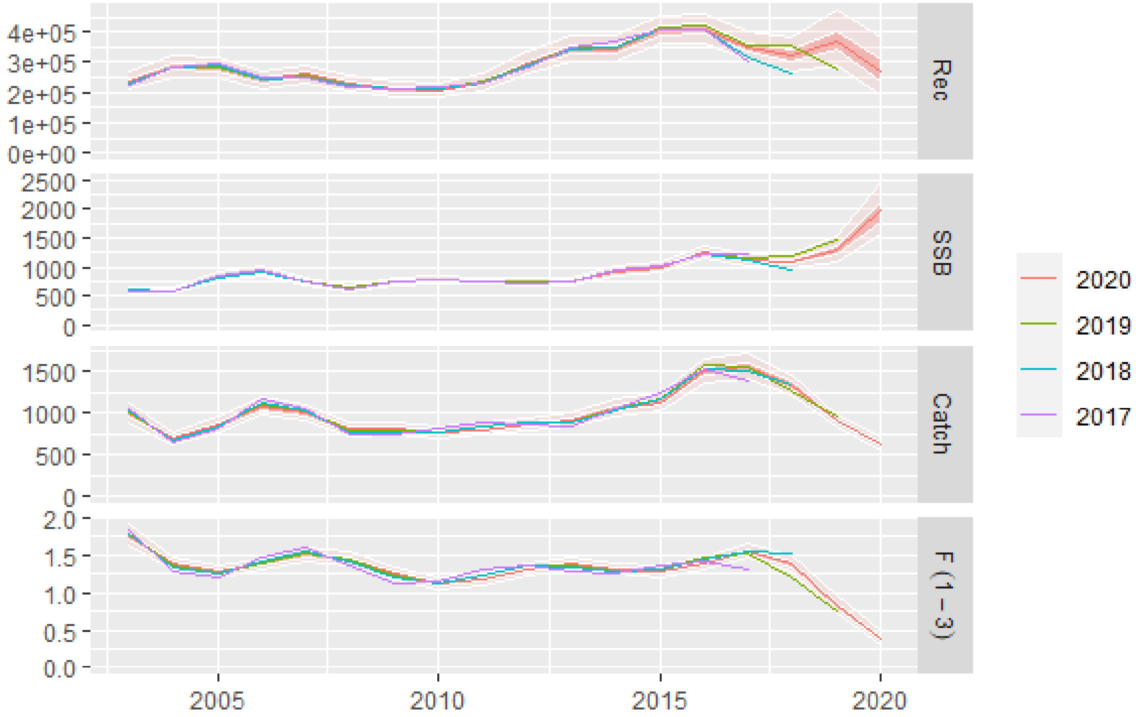


Figure 5.11.2 Red mullet in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.52	$F_{0.1}$ as proxy for F_{MSY}	
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}	0.52	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.35	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.71	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

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 21-11

*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 Catch	STECF discards
2019	$F = F_{MSY}$		821	911.4	
2020	$F = F_{MSY}$		521	629.3	
2021	$F = F_{MSY}$		667.6		
2022	$F = F_{MSY}$		1033		

History of the catch and landings

Table 5.11.8 Red mullet in GSA 9: Catch in 2020 and effort distribution by fleet in 2018 as estimated by and reported to STECF.

2020		Wanted catch				Discards
Catch (t)		Otter trawl 95.4%	Gillnets 0.9%	Trammel nets 3.2%	Others 0.5%	t
		534.8	4.9	18.0	2.8	38.5
Effort (2020)	87387	33550	18159	35678		
		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 GSA9	Total landings	Total Effort (Fishing
2003	1056.7	1056.7	
2004	580.7	580.7	230645
2005	708.5	708.5	217493
2006	1049.6	1049.6	209531
2007	1096.0	1096.0	204518
2008	727.1	727.1	153414
2009	728.3	728.3	179299
2010	747.9	747.9	162036
2011	805.5	805.5	193843
2012	692.9	692.9	159700
2013	693.3	693.3	168711
2014	1181.4	1181.4	169012
2015	1183.4	1183.4	186578
2016	1221.6	1221.6	166226
2017	1460.7	1460.7	148962
2018	1204.8	1204.8	143675
2019	844.0	844.0	120939
2020	560.6	560.6	87387

*Effort data is taken from STECF EWG 21-13. 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 5.11.10 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	237051	258548	215554	589.4	632.5	546.3	988.9	1.75	1.86	1.64
2004	285217	313904	256530	581.6	623.9	539.3	697.1	1.39	1.45	1.34
2005	280539	306796	254282	819.4	883.0	755.8	849.7	1.28	1.35	1.22
2006	241362	264201	218523	919.0	983.8	854.2	1074.4	1.38	1.44	1.32
2007	261020	285902	236138	743.5	797.0	690.0	997.6	1.50	1.57	1.43
2008	230203	251237	209169	631.9	676.2	587.6	799.7	1.45	1.52	1.38
2009	209277	227326	191228	744.3	794.5	694.1	816.6	1.25	1.31	1.19
2010	206704	225030	188378	768.5	816.5	720.5	769.0	1.13	1.19	1.07
2011	231460	253168	209752	752.6	801.0	704.2	799.1	1.17	1.23	1.11
2012	295159	322334	267984	737.9	790.4	685.4	857.0	1.31	1.37	1.25
2013	345488	377147	313829	738.2	788.7	687.7	913.0	1.38	1.44	1.32
2014	343120	375070	311170	925.0	992.0	858.0	1057.9	1.32	1.38	1.26
2015	404472	441503	367441	1001.3	1070.2	932.4	1129.3	1.28	1.34	1.22
2016	409037	446039	372035	1255.6	1339.8	1171.4	1500.3	1.39	1.46	1.32
2017	351809	386661	316957	1132.0	1210.4	1053.6	1553.8	1.55	1.62	1.48
2018	321557	363607	279507	1099.9	1183.5	1016.3	1335.8	1.38	1.46	1.29
2019	370311	447668	292954	1293.0	1458.2	1127.8	911.4	0.83	0.92	0.74
2020	270739	347030	194448	1950.1	2321.2	1579.0	629.3	0.37	0.45	0.30

Sources and references

STECF EWG 21-11, STECF EWG 21-13

5.12 Summary sheet for red mullet in GSA 10

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.4 and corresponding catches in 2022 should be no more than 485 tons.

Stock development over time

Catches and SSB of Red mullet show, after a gradual increase since 2011, an increase and decreasing F since 2016. However, reduced recruitment in 2020 although uncertain suggests that there is potential for stock to decline.

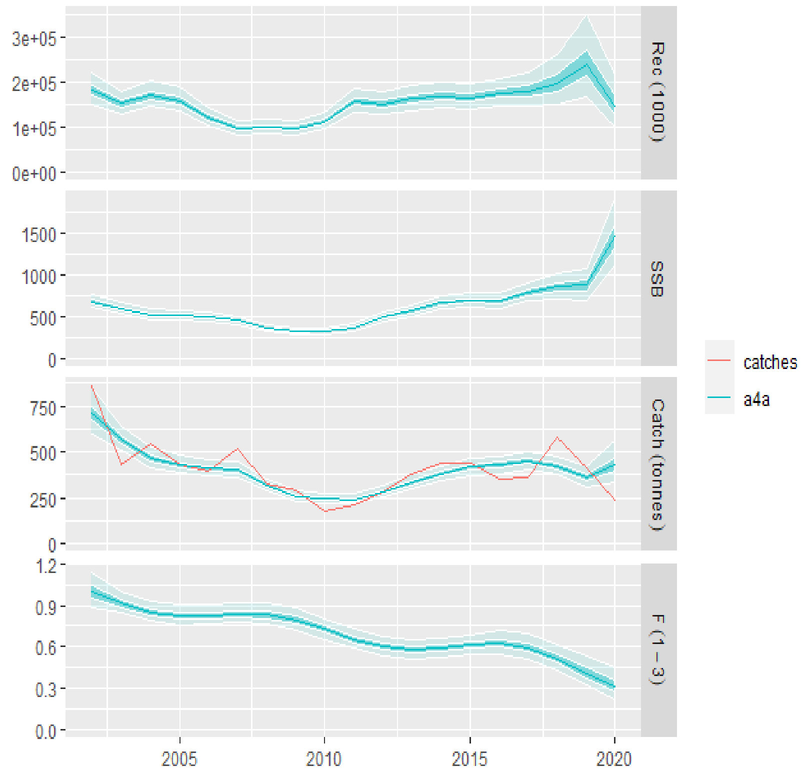


Figure 5.12.1 Red mullet in GSA 10: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.4). F in 2020 is also lower than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is ahead of transition, in addition 2020 F is now less than F_{MSY}

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

Status	2018	2019	2020
F / F_{MSY} F / $F_{MSY\ Transition}$	F > F_{MSY}	F > F_{MSY}	F < F_{MSY} F < $F_{MSY\ Transition}$

Catch scenarios

Table 5.12.2 Red mullet in GSA 10: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2018-2020	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}3}$ (2019)	0.315	F 2020 used to give F status quo for 2021
SSB (2020)	1449	Stock assessment at 1st July 2020
R_{age0} (2020,2022)	151186	Geometric mean of the time series 19 years 2002-2020
Total catch (2021)	423	Assuming F status quo for 2021

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

Table 5.12.3 Red mullet in GSA 10: Annual catch scenarios. All weights are in tonnes.

Basis	Total Catch* (2022)	F_{total} (ages 1-3) (2022)	SSB 2023	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	485	0.401	1089	-13.43	13.823
$F_{MSY\ Transition}$^^	490	0.407	1082	-14.0	15.1
$F_{MSY\ lower}$	344	0.268	1270	0.9434	-19.29
$F_{MSY\ upper}$**	622	0.549	926	-26.43	46.053
Other scenarios					
Zero catch	0	0	1763	40.119	-100
Status quo	395	0.315	1202	-4.438	-7.171

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.12.4 Red mullet in GSA 10: 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 retrospective analysis run on the a4a model showed consistent results with exception of recruitment which is poorly estimated in the last year. All the diagnostics were considered acceptable. There is uncertainty on the representativeness of available length structure of the MEDITS of 2020, due to one half of hauls not sampled and only bigger individuals sampled with an uncertain sex ratio. This uncertainty was partially reduced making the assumption of same sex ratio of 2016-2019. Catch at age data of 2020 was not used, because of several issues (see Section 6.12), thus the same selectivity of the previous years is assumed by the model to reconstruct the catch at age 2020. Overall the assessment of stock in 2020 is more uncertain that usual.

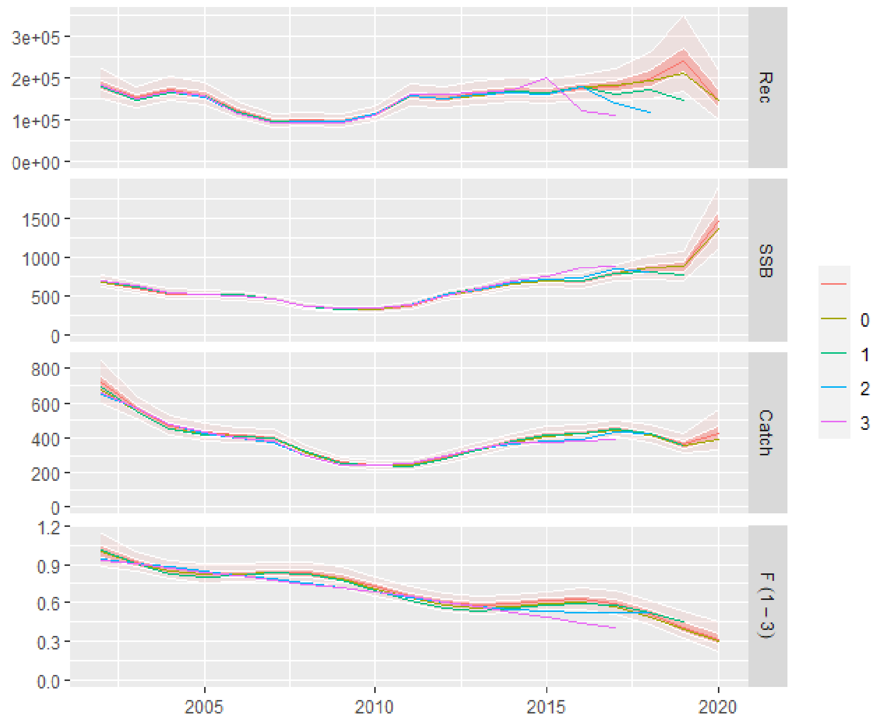


Figure 5.12.2 Red mullet in GSA 10: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.12.5 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}	0.4	$F_{0.1}$ as proxy for F_{MSY}	
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}	0.4	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.268	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.549	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

Basis of the assessment

Table 5.12.6 Red mullet in GSA 10: 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 21-11

*BMS (Below Minimum Size) landings?

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 catch	STECF discards
2019	F = F_{MSY}		1056	392	
2020	F = F_{MSY}		309	425	
2021	F = F_{MSY}		314		
2022	F = F_{MSY}		485		

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.

2020		Wanted catch				Discards
Catch (t)		Otter trawl 86%	Gillnets 4%	Trammel nets 10%		T
		207	8.8	24.1		0
Effort (2020)	109995	NA	NA	NA		
		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* (Fishing days)
2002	847	847	
2003	424	424	
2004	522	522	231917
2005	389	389	230851
2006	396	396	254722
2007	511	511	237675
2008	321	321	211065
2009	291	291	202518
2010	177	177	190116
2011	207	207	213353
2012	281	281	195291
2013	381	381	185585
2014	422	422	199397
2015	417	417	191748
2016	353	353	204448
2017	364	364	195720
2018	576	576	209578
2019	416	416	174879

2020	242	242	109995

*Effort data is taken from STECF EWG 21-13. 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 5.12.10 **Red mullet in GSA 10:** Assessment summary. Weights are in tonnes.

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2002	182940			673			701	1		
2003	152824			599			568	0.91		
2004	170823			524			466	0.85		
2005	159722			512			429	0.83		
2006	121420			498			411	0.83		
2007	98288			450			401	0.84		
2008	100869			354			320	0.83		
2009	97824			322			259	0.79		
2010	112382			331			246	0.73		
2011	156909			370			242	0.65		
2012	152051			495			284	0.6		
2013	163051			565			332	0.58		
2014	169779			658			382	0.59		
2015	166785			688			418	0.61		
2016	177221			682			427	0.63		
2017	181097			779			450	0.6		
2018	198183			850			420	0.52		
2019	243342			866			360	0.41		
2020	149593			1449			426	0.31		

Sources and references

STECF EWG 21-11, STECF 21-13

5.13 Summary sheet for Norway lobster in GSA 9

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.30 and corresponding catches in 2022 should be no more than 220 tons.

Stock development over time

Catches of Norway lobster slow a decreasing pattern until 2015, then they increase in 2018 and then decrease again in the last years. SSB shows a slightly increasing pattern, and then shows a sharp increase in 2018. Recruitment follows a general slightly decreasing pattern, with some oscillation. Fbar (2-6) shows a sharp increase in 2018 then decrease again in the last two years until 2020 when estimated F is 0.15.

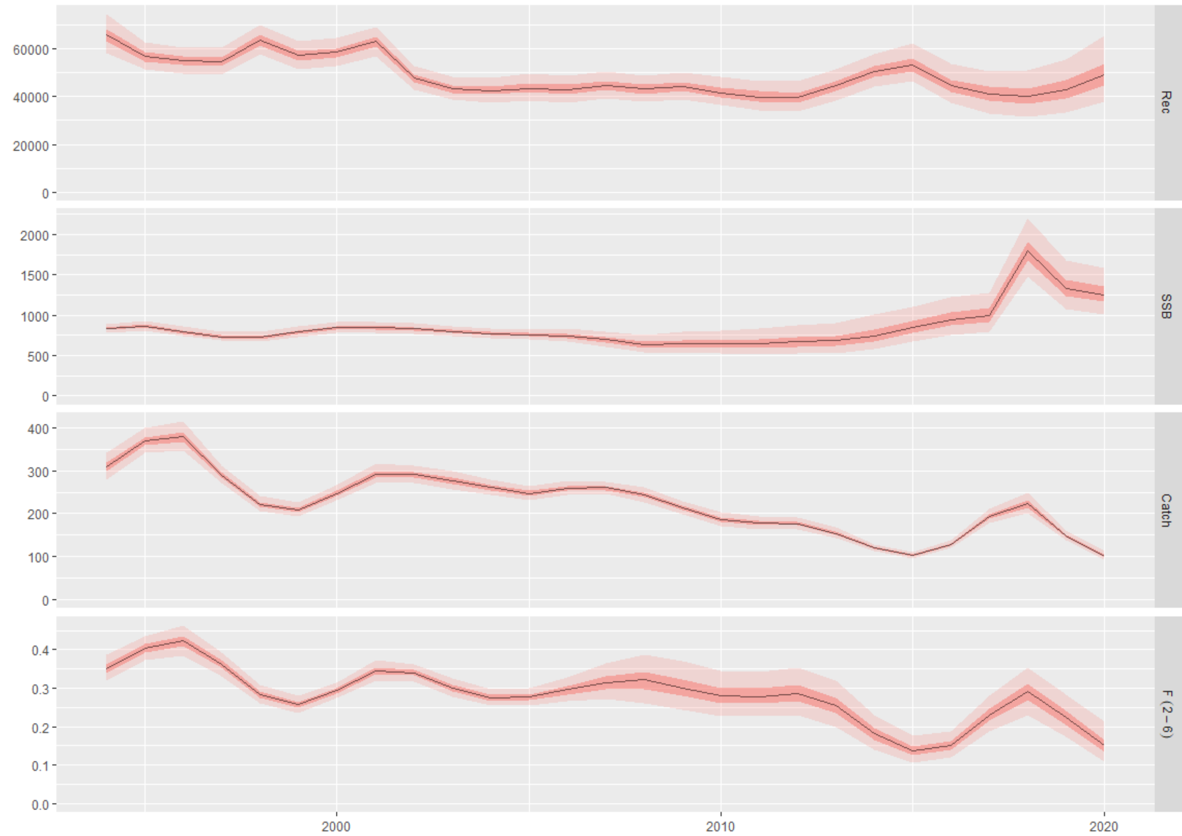


Figure 5.13.1 Norway lobster in GSA 9: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.15) is half of the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.30). F in 2020 is also lower than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is ahead of transition, in addition 2020 F is now less than F_{MSY}.

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

Status	2018	2019	2020
F / F_{MSY}	F < F_{MSY}	F at F_{MSY}	F < F_{MSY}
F / $F_{MSY\ Transition}$			F < $F_{MSY\ Transition}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 2\text{-}6}$ (2021)	0.30	F 2020 used to give F status quo for 2021
SSB (2021)	1620 t	Stock assessment 1 January 2021
R_{age0} (2021,2022)	43828	Geometric mean of years 2003 to 2020
Total catch (2021)	111.5 t	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 5.13.3 Norway lobster in GSA 9: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 2-6) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	219.7	0.30	1569	-3.1	114
$F_{MSY\ Transition}$^^	195.4	0.26	1604	-1.0	90.3
$F_{MSY\ lower}$	154.9	0.20	1662	2.6	50.9
$F_{MSY\ upper}$**	285.9	0.41	1479	-8.7	178.4
Other scenarios					
Zero catch	0.00	0.00	1896	17	-100
Status quo	119.6	0.15	1713	5.8	16.4

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ 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 five years run on the a4a model showed good 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.

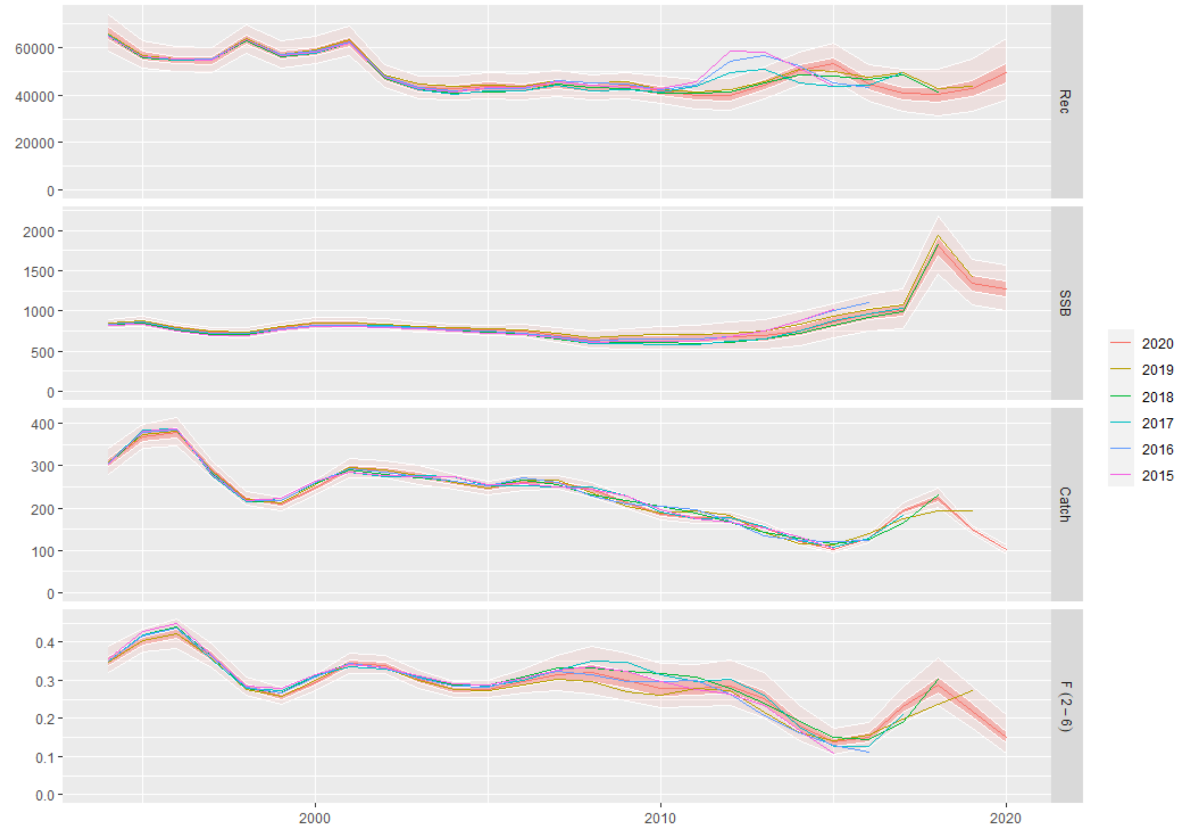


Figure 5.13.2 Norway lobster in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.30	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.30	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG

				21-11
	target range F_{lower}	0.20	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.41	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

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 21-11

*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		
2022	$F = F_{MSY}$		220		

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.

2020		Wanted catch				Discards
Catch (t)	89.1	Otter trawl 99.999%	Gillnets 0.001%	Trammel nets 0%	Other 0%	1.0t
Effort	33550	NA	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	
2003	320.9	0.0	320.9	
2004	268.7	0.0	268.7	68950
2005	288.5	0.0	288.5	65080
2006	247.5	0.0	247.5	58004
2007	260.5	0.0	260.6	61360
2008	227.7	0.0	227.7	49757
2009	250.3	9.2	259.5	53329
2010	161.6	1.0	162.6	52617
2011	184.0	1.0	185	50736
2012	178.2	0.8	179	47849
2013	147.6	1.3	149	51713
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	0.5	177.5	42227
2020	89.1	1.0	90.1	33550

*Effort data is taken from STECF EWG 21-13. 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	65851	837	308	0.35	1303
1995	56848	867	369	0.40	1379
1996	55013	795	379	0.42	1283
1997	54559	738	292	0.36	1155
1998	63541	728	223	0.28	1053
1999	57071	793	210	0.26	1172
2000	58564	846	248	0.29	1259
2001	62800	850	293	0.34	1299
2002	47587	831	292	0.34	1266
2003	43201	799	278	0.30	1159
2004	42487	774	261	0.27	1113
2005	43551	759	248	0.28	1126
2006	42964	747	260	0.30	1087
2007	44592	696	261	0.31	1077
2008	43038	636	245	0.32	946
2009	44000	645	216	0.30	992
2010	41753	651	188	0.28	977
2011	39904	654	179	0.28	961
2012	39699	674	179	0.29	984
2013	44502	689	156	0.25	986
2014	50649	753	122	0.18	992
2015	53264	856	103	0.14	1145
2016	44641	956	129	0.15	1287
2017	40878	1004	195	0.23	1380
2018	40090	1785	222	0.29	4301
2019	42864	1325	150	0.22	2568
2020	49315	1255	103	0.15	1346

Sources and references

STECF EWG 21-11, STECF EWG 21-13

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 precautionary considerations, STECF EWG 20-09 advises to decrease the total catch by 67% of the catch in 2019 equivalent to catches of no more than 13.2 tons in each of 2021 and 2022 implemented through either catch restrictions or effort reduction for the relevant fleets.

Stock development over time

The relative changes in the biomass estimated from the MEDITS survey were used to provide an index for change. In the first period, from 1994 to 2010, MEDITS indices (Figure 5.14.1) show highly fluctuating pattern, ranging between 1.5 and 4.5 in terms of biomass (kg/Km^2) and 31.1 and 129 in terms of density (n/Km^2). From 2011 onward the stock appears to have been more stable, but with a general decreasing behaviour. In these last 8 years biomass indices ranges from 1.3 to 2.7 (kg/Km^2) and densities from 31.5 to 58.7 (n/Km^2).
Based on the index value in the last two years relative to the previous three years the decrease in biomass index was estimated to be 0.77 times.

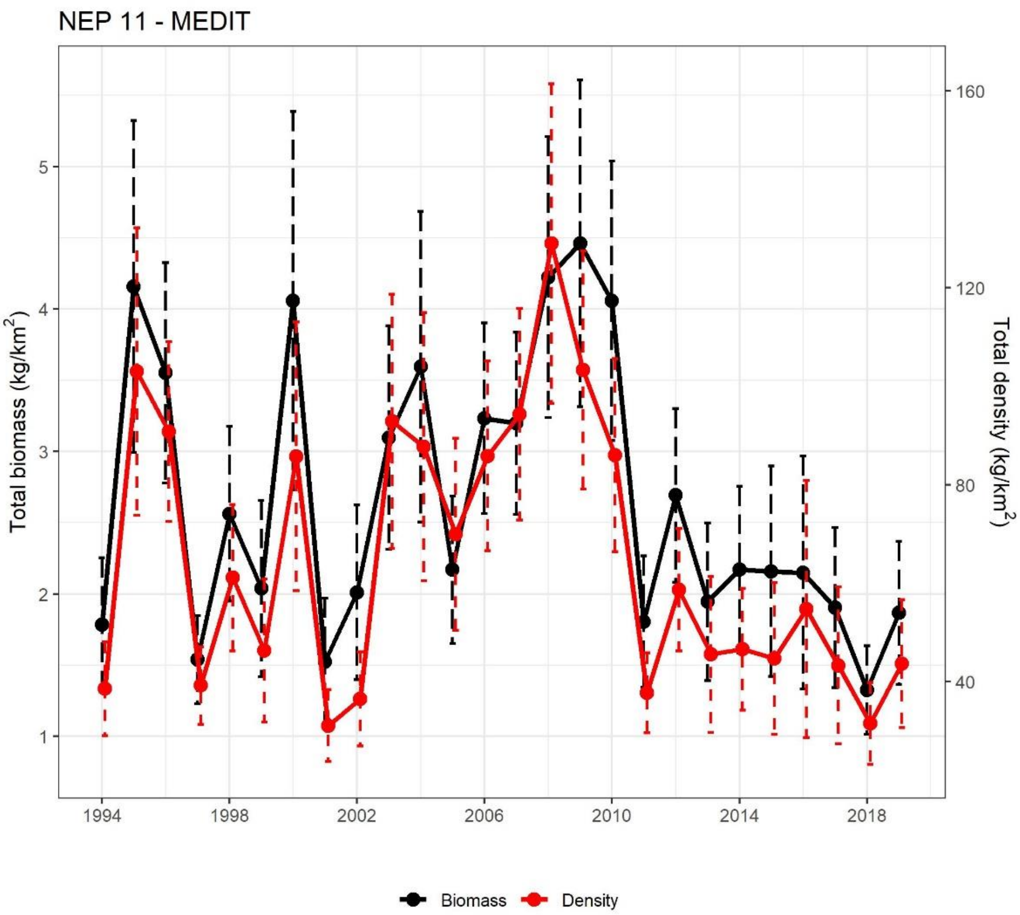


Figure 5.14.1 Norway lobster in GSA 11: MEDITS indices

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown. However, the biomass index shows a fluctuating but general decreasing trend from 2011 to 2019.

Catch scenarios

The advice on fishing opportunities for 2021 and 2022 was based on the last catch advice adjusted to the change in the stock size index (MEDITS). The change was estimated from the two most recent values relative to the three preceding values (see table 5.14.1). The precautionary buffer of -20% is not applied because it was applied in 2019. The previous catch advice (17.1 tons) was then used to derive a precautionary advice on fishing opportunities for 2021 and 2022 (13.2 tons).

Table 5.14.1 Norway lobster in GSA 11: Assumptions made for the interim year and in the forecast. *

Index A (2018–2019)		1.61
Index B (2015–2017)		2.07
Index ratio (A/B)		0.77
-20% Uncertainty cap	Applied/not applied	Not applied
Advised catch (2019–2020)		17.1
Discard rate		Negligible
-20% Precautionary buffer	Applied/not applied	Not applied
Catch advice **		13.2
Landings advice ***		13.2
% advice change ^		-22.8%

* 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 advised catch × index ratio)
*** catch advice × (1 – discard rate)
^ Advice value 2021-2022 relative to advice value 2019-2020.

Although the advice for 2021/2022 is for a 22.8% decrease relative to the 2018 advised catch, catch in 2018 and 2019 has risen considerably relative to the earlier catches that were used for the 2018 advice. Therefore to achieve the advised small decrease in catch for 2021/2022 a reduction of -67% relative to reported catch in 2019 is required.

Basis of the advice

Table 5.14.2 Norway lobster in GSA 11: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

The a4a assessment was considered unacceptable due to incoherence in the landings cohorts, patterns in the residuals. EWG 20-09 decided to apply a survey-based assessment following the approach adopted by ICES for category 3 stocks.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.14.3 Norway lobster in GSA 11: 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	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}		Not Defined	
	MAP target range F_{lower}		Not Defined	
	MAP target range F_{upper}		Not Defined	

Basis of the assessment

Table 5.14.4 Norway lobster in GSA 11: Basis of the assessment and advice.

Assessment type	Index based assessment
Input data	Landings at length sliced by sex
Discards, BMS landings*, and bycatch	Discards negligible.
Indicators	MEDITS indices
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.14.5 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 landings	STECF discards
2019	precautionary advice reduce catch	17.1		40.1	
2020	precautionary advice reduce catch	17.1			
2021	precautionary advice reduce catch of 23% of previous catch advice	13.2			
2022	precautionary advice reduce catch of 23% of previous catch advice	13.2			

History of the catch and landings

Table 5.14.6 Norway lobster in GSA 11: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

	Landings			Discards
28.3 t	100 % trawl	% set nets	% others	0 t
	t			

Table 5.14.7 Norway lobster in GSA 11: 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. Effort in days at sea.

Year	ITALY GSA11	Total landings	Total BMS landings	STECF total landings	Total Effort* (Fishing days)
2005	6.3	6.3			27654
2006	42.3	42.3			23503
2007	31.3	31.3			22924
2008	36.2	36.2			19434
2009	44.4	44.4			20127
2010	22.8	22.8			19322
2011	50.5	50.5			17105
2012	41.1	41.1			15495
2013	20.6	20.6			15872
2014	17.2	17.2			17582
2015	18.2	18.2			15277
2016	15.8	15.8			16925
2017	28.3	28.3			16286
2018	37.8	37.8			21240
2019	40.1	40.1			18878
2020					13677

*Effort data is taken from STECF EWG 21-13. 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 5.14.8 Norway lobster in GSA 11: Assessment summary. Weights are in tonnes.

Year	Biomass Index (MEDITS tons/Km^2)	Landings tonnes	Discards tonnes	Total catch
2005	0.00217	6.3	0	6.3
2006	0.00323	42.3	0	42.3
2007	0.00320	31.3	0	31.3
2008	0.00422	36.2	0	36.2
2009	0.00446	44.4	0	44.4
2010	0.00406	22.8	0	22.8
2011	0.00181	50.5	0	50.5
2012	0.00269	41.1	0	41.1
2013	0.00194	20.6	0	20.6
2014	0.00217	17.2	0	17.2
2015	0.00216	18.2	0	18.2
2016	0.00215	15.8	0	15.8
2017	0.00190	28.3	0	28.3
2018	0.00132	37.8	0	37.8
2019	0.00187	40.1	0	40.1

Sources and references

Reproduced from STECF EWG 20-09 for use in this year's WG. For original analysis and data supporting this summary sheet see STECF EWG 20-09. STECF EWG 21-13.

5.15 Summary sheet for blue and red shrimp in GSA 1

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.29 and corresponding catches in 2022 should be no more than 33 tons.

Stock development over time

The Spawning stock biomass (SSB) shows high values at the beginning of the time series and a stable stock since 2008. The average SSB in the last 5 years of the dataset (2015-2020) is 221.8 t. The recruitment shows similar pattern The recruitment in 2020 was 12300 individuals, lower compared to the mean of the time series, 24134 individuals. Catches have declined from around 250 t in 2003-2007 to around 116 t in 2020. F has fluctuated around 1.6-1.8, with a value of 1.68 in 2020.

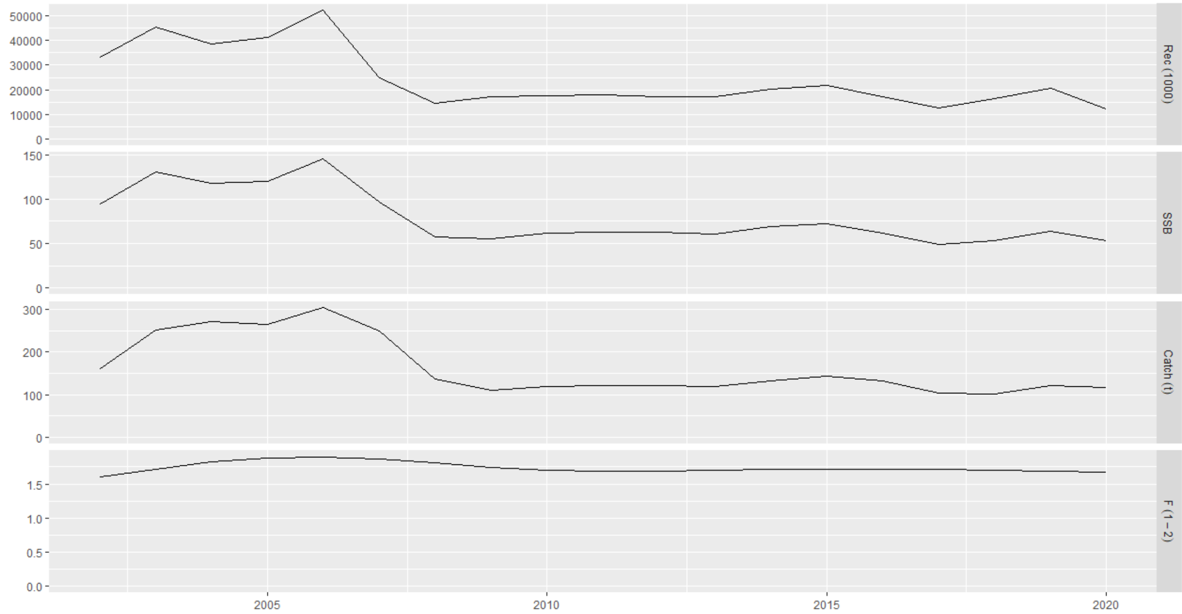


Figure 5.15.1. Blue and red shrimp in GSA1: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current F (=1.68) equal to that of the terminal year (2020) 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 is over exploited. F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

Table 5.15.1. Blue and red shrimp in GSA1: State of the stock and fishery relative to reference points.

Status	2018	2019	2020
F / F_{MSY} $F / F_{MSY\ Transition}$	$F > F_{MSY}$	F > FMSY	$F > F_{MSY}$ $F > F_{MSY\ Transition}$

Catch scenarios

Table 5.15.2. Blue and red shrimp in GSA1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Fages 1-2 (2021)	1.679	The F estimated in 2020 was used to give F status quo for 2021
SSB (2021)	55.77	Stock assessment 1 January 2021
Rage1 (2021-2022)	16924	Geometric mean of years 2007 to 2020
Total catch (2021)	103.23	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 5.15.3. Blue and red shrimp in GSA1: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 1-2) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	33.05	0.29	171.15	206.89	-71.65
$F_{MSY\ Transition}$^^	91.80	1.12	83.23	49.24	-21.26
$F_{MSY\ lower}$	23.15	0.20	189.86	240.44	-80.14
$F_{MSY\ upper}$**	43.34	0.40	152.88	174.13	-62.82
Other scenarios					
Zero catch	0.00	0.00	237.83	326.45	-100.00
Status quo	115.05	1.68	59.30	6.34	-1.31
0.1	20.10	0.34	195.84	251.16	-82.76
0.2	37.26	0.50	163.54	193.24	-68.04
0.3	52.00	0.67	138.44	148.23	-55.40
0.4	64.77	0.84	118.73	112.89	-44.45

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.15.4. Blue and red shrimp in GSA1: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The input data and stock object were re-evaluated. For the commercial data, after catch reconstruction, the LFD for age 0 has 0 values for all years, and ages from 1 to 5 plus were used. For the survey, data was revised from 2006 to 2010 before EWG21-11. MEDITS index for 2020 was not available. It was observed that there were very low levels of sampling found in the survey in 2009 and 2011 and 2013. For the initial runs all these were excluded from survey index due to high uncertainty. The model without the poor years gave more reliable estimates of catch. Based on this these data were not included in the assessment. The model from last year fits the data much as it did last year with similar issues sensitivity to k etc. Was explored and a smoother of k=6 gives the best retrospective and was selected.

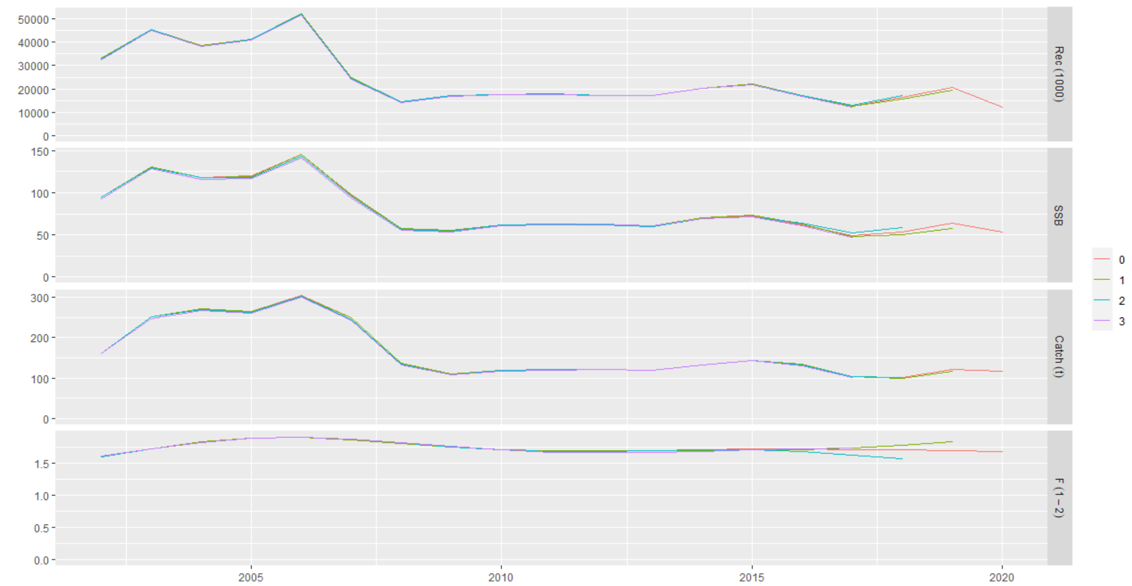


Figure 5.15.2. Blue and red shrimp in GSA1: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.15.5. Blue and red shrimp in GSA1: Reference points, Values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.29	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.29	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.20	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.40	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

Basis of the assessment

Table 5.15.6. Blue and red shrimp in GSA1: Basis of the assessment and advice.

Assessment type	Statistical catch-at-age method (a4a)
Input data	Commercial catches (2002-2020) from one fleet (OTB) and one tuning index, MEDITS bottom trawl survey (CPUE, kg/km2, 2002-2019). Percentage maturity from previous assessment, natural mortality estimated as a vector.
Discards. BMS landings*. and bycatch	Not included, considered negligible (less than 0.3%).
Indicators	None.
Other information	Previously assessed in 2020
Working group	STECF EWG 21-11

*BMS (Below Minimum Size) landings?

History of the advice, Catch, and management

Table 5.15.7. Blue and red shrimp in GSA1: STECF advice and STECF estimates of landings and 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	120	
2020	$F = F_{MSY}$	96	96	117	
2021	$F = F_{MSY}$	32	32		
2022	$F = F_{MSY}$	33	33		

History of the catch and landings

Table 5.15.8. Blue and red shrimp in GSA1: Catch and effort distribution by fleet in 2020 as estimated by and reported to STECF.

2020		Wanted catch				Discards
Catch (t)	126 (t)	OTB 100%	Gillnets 0%	Trammel nets 0%	Other 0%	Negligible
Effort	18718	NA	NA	NA	NA	
		Fishing days				

Table 5.15.9. Blue and red shrimp in GSA1: History of commercial landings; official reported values are presented by country and GSA 1. All weights are in tonnes. Effort in Fishing Days.

Year	SPAIN GSA1	Total landings	Total Effort (Fishing days)
2002	156.96	156.96	28002
2003	335.74	335.74	32892
2004	225.2	225.2	34951
2005	232.1	232.1	32295
2006	288.82	288.82	31443
2007	178.43	178.43	29917
2008	133.48	133.48	26201
2009	144.59	144.59	27017
2010	152.09	152.09	28476
2011	131.42	131.42	28170
2012	148.57	148.57	25851
2013	124.96	124.96	24334
2014	184.03	184.03	23236
2015	170.23	170.23	17651
2016	138.22	138.22	15484
2017	99.19	99.19	16970
2018	123.21	123.21	20397
2019	132.09	132.09	21999
2020	137.36	137.36	18718

*Effort data is taken from STECF EWG 21-13. 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 GSA1: Assessment summary. Weights are in tonnes.

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2002	33083			332.03			160.63	1.604		
2003	45615			485.46			251.70	1.718		
2004	38509			474.51			271.63	1.820		
2005	41347			477.22			265.04	1.884		
2006	52431			568.43			303.87	1.897		
2007	24641			408.70			248.37	1.864		
2008	14590			232.44			135.65	1.806		
2009	17142			207.30			109.23	1.746		
2010	17690			230.38			119.74	1.703		
2011	17845			232.45			121.86	1.683		
2012	17157			231.37			121.44	1.683		
2013	17371			225.44			118.67	1.695		
2014	20296			256.96			133.14	1.709		
2015	21813			269.96			143.35	1.717		
2016	17023			238.43			132.10	1.716		
2017	12680			186.55			103.33	1.710		
2018	16334			195.74			100.22	1.700		
2019	20686			235.09			120.16	1.689		
2020	12300			204.96			116.58	1.679		

Sources and references

STECF EWG 21-11, STECF EWG 21-13

5.16 Summary sheet for blue and red shrimp in GSA 5

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 20-09 advises to decrease the catch by 33% from catch in 2019 equivalent to catches of no more than 137 tonnes in each of 2021 and 2022 implemented through either catch restrictions or effort reduction for the relevant fleets.

Stock development over time

Relative changes in stock biomass were estimated based on MEDITS survey biomass index (kg/km^2) in GSA 5 (Figure 5.16.1). Stock biomass show larger fluctuation over the available period 2007-2019 but with no clearly discernible trend. Based on the ratio in mean index values in the last two years (2018-2019) to the preceding three years (2015-2017) a small decrease by 9% is estimated. Current catches of blue and red shrimp in the past two years show an increase by more than 60% compared to 2016 level, and the advised reduction is 33% relative to 2019 catch.

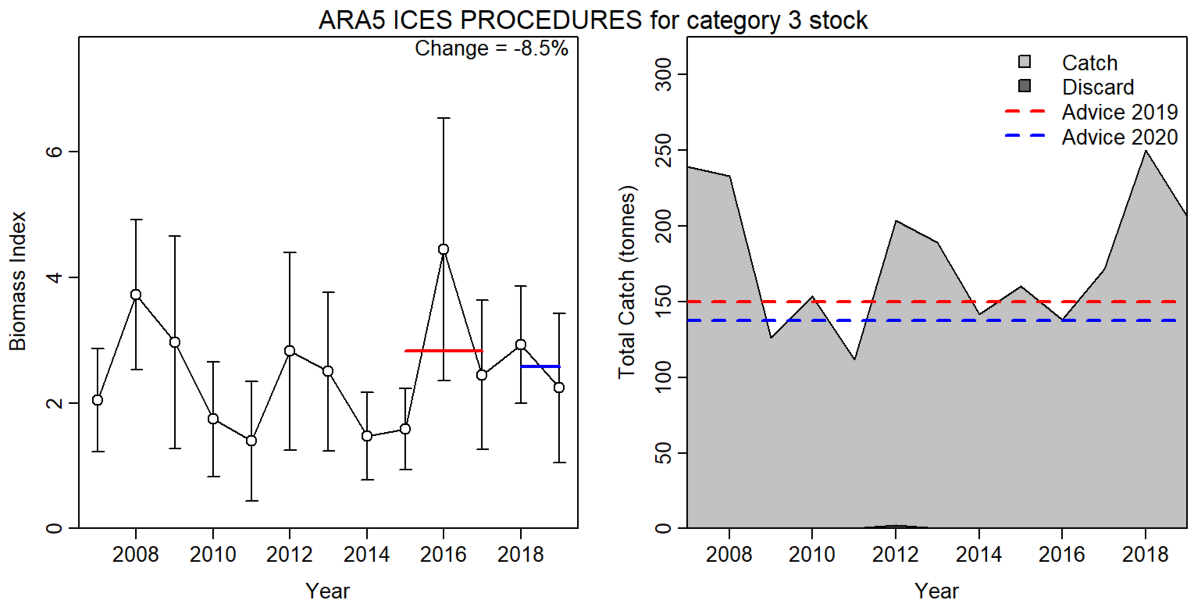


Figure 5.16.1 Blue and red shrimp in GSA 5: Trends in the MEDITS survey biomass index (kg/km2) with 95% Confidence Intervals (left) and time series of reported total catches (tonnes) for the period 2007-2019, denoting the 2019 and 2020 precautionary catch advice.

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown. The biomass index shows a slightly decreasing trend since 2016 while total catch has been increased by more 60% over the same period.

Catch scenarios

The advice on fishing opportunities for 2021 and 2022 was based on the last catch advice adjusted to the change in the MEDITS survey biomass index between the periods 2015-2017 and 2018-2019, resulting in a of 0.914 (Table 5.16.1). The precautionary buffer of -20% is not applied because it was applied in 2018. Accordingly, the previous catch advice of 150 tonnes × 0.914 was taken as the basis for a precautionary advice on fishing opportunities for 2021 and 2022 of 137 tonnes.

Table 5.16.1 Red and blue shrimp in GSA 5: Assumptions made for the interim year and in the forecast. *

Index A (2018–2019)		2.59
Index B (2015–2017)		2.83
Index ratio (A/B)		0.915
-20% Uncertainty cap	Applied/not applied	Not applied
Advised catch (2019–2020)		150
Discard rate		Negligible
-20% Precautionary buffer	Applied/not applied	Not applied
Catch advice **		137
Landings advice ***		137
% advice change ^		-8.5%

* 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 advised catch × index ratio)
*** catch advice × (1 − discard rate)
^ Advice value 2021-2022 relative to advice value 2019-2020.

Although the advice for 2021/2022 is for an 8.5% decrease relative to the 2018 advised catch, catch in 2018 and 2019 has risen considerably relative to the earlier catches that were used for the 2018 advice. Therefore to achieve the advised small reduction in catch for 2021/2022 a reduction of 33% relative to reported catch in 2019 is required.

Basis of the advice

Table 5.16.2 Blue and red shrimp in GSA 5: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

Although some advances were made in developing a statistical catch at age assessment models using a4a, the assessment was considered as not acceptable due to unresolvable conflict between catch composition and survey composition data. Commercial catches showed overall better internal consistency than MEDITS survey index, but the incoherence in the information of cohort strength for the dominant age classes 1 and 2 resulted in inadequate residual diagnostics. EWG 20-09 therefore decided to apply a survey-based assessment following the approach adopted by ICES for category 3 stocks.

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}		Not Defined	
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}		Not Defined	
	MAP target range F_{lower}		Not Defined	
	MAP target range F_{upper}		Not Defined	

Basis of the assessment

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

Assessment type	Index based assessment
Input data	Landings at length for aggregated sexes
Discards, BMS landings*, and bycatch	Discards negligible.
Indicators	MEDITS biomass index
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.16.7 Blue and red shrimp in GSA 5: 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	precautionary advice reduce catch	150		206	
2020	precautionary advice reduce catch	150			
2021	precautionary advice reduce catch by 8.5% of previous catch advice	137			
2022	precautionary advice reduce catch by 8.5% of previous catch advice	137			

History of the catch and landings

Table 5.16.8 Blue and red shrimp in GSA 5: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2020		Wanted catch		Discards
Catch (t)		Otter trawl 100%		0 t
		206 t		
Effort	8202			
		Fishing Days		

Table 5.16.9 Blue and red shrimp in GSA 5: 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	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	10769
2014	141	141	13525
2015	160	160	12776
2016	138	138	10566
2017	171	171	9682
2018	250	250	8709
2019	206	206	8202

Summary of the assessment

Table 5.16.10 Blue and red shrimp in GSA 5: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Biomass Index (MEDITS tonnes/km^2)	Landings tonnes	Discards tonnes	Total catch
2007	0.00204	239	0	239
2008	0.00372	233	0	233
2009	0.00297	126	0.03	126
2010	0.00174	153	0	153
2011	0.00139	111	0.41	112
2012	0.00283	201	2.5	204
2013	0.00251	189	0.17	189
2014	0.00147	141	0.23	142
2015	0.00159	160	0.1	160
2016	0.00445	138	0.04	138
2017	0.00245	171	0.14	171
2018	0.00293	250	0.23	250
2019	0.00224	206	0	206

Sources and references

Reproduced from STECF EWG 20-09 for use in this year's WG. For original analysis and data supporting this summary sheet see STECF EWG 20-09. STECF EWG 21-13

5.17 Summary sheet for blue and red shrimp in GSA 6 and 7

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.29 and corresponding catches in 2022 should be no more than 267 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 600 tonnes. SSB is increasing since 2017 reaching a maximum of 540 tonnes. The assessment shows a fairly stable recruitment since 2010 around 750000 thousands. Fbar (1-2) shows a decrease for the past three years, having been at higher levels since the beginning of the time series.

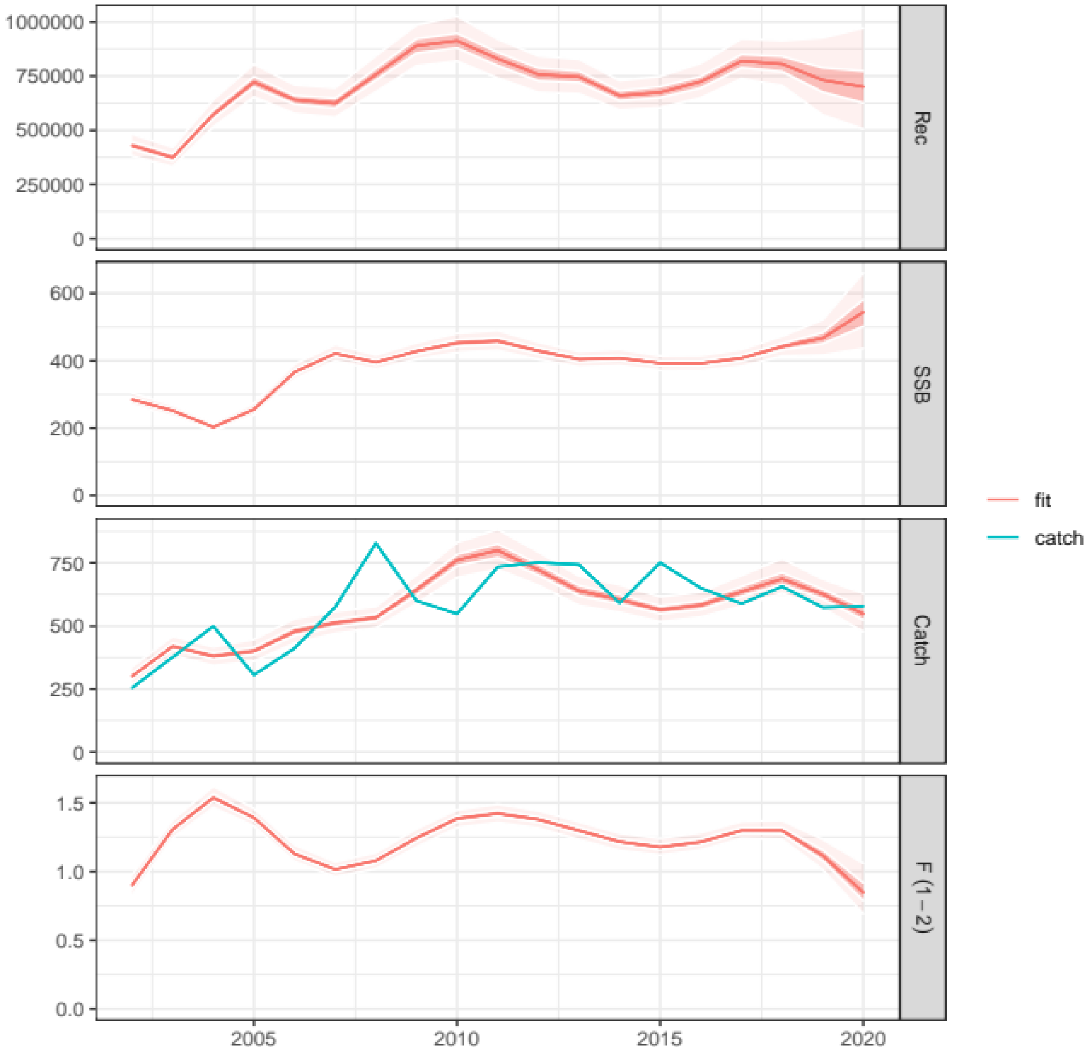


Figure 5.17.1 Blue and red shrimp in GSAs 6 and 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.853) is 3 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.286). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

Table 5.17.1 Blue and red shrimp in GSAs 6 and 7: State of the stock and fishery relative to reference points.

Status	2018	2019	2020
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}
F / $F_{MSY\ Transition}$			F > $F_{MSY\ Transition}$

Catch scenarios

Table 5.17.2 Blue and red shrimp in GSAs 6 and 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}2}$ (2021)	0.853	F 2020 used to give F status quo for 2021 or
SSB (2021)	577	Stock assessment 1 January 2021
R_{age0} (2021,2022)	740193	Geometric mean of the last 6 years
Total catch (2021)	600	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 5.17.3 Blue and red shrimp in GSAs 6 and 7: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 1-2) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	267	0.286	1112	92	-51
$F_{MSY\ Transition}$^^	548	0.702	702	22	0
$F_{MSY\ lower}$	187	0.192	1246	116	-66
$F_{MSY\ upper}$**	351	0.393	982	70	-36
Other scenarios					
Zero catch	0.00	0.00	1587	175	-100
Status quo	626	0.853	610	6	14
0.2 F_{sq}	168	0.171	1278	122	-69
0.4 F_{sq}	311	0.341	1042	81	-43
0.6 F_{sq}	433	0.512	861	49	-21
0.8 F_{sq}	537	0.683	720	25	-2

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.17.4 Blue and red shrimp in GSAs 6 and 7: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This is an update assessment of 2020 with reconstructed data according to the output of EWG 21-02. 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. Although there is still an issue with the estimated catch now following precisely the observed one.

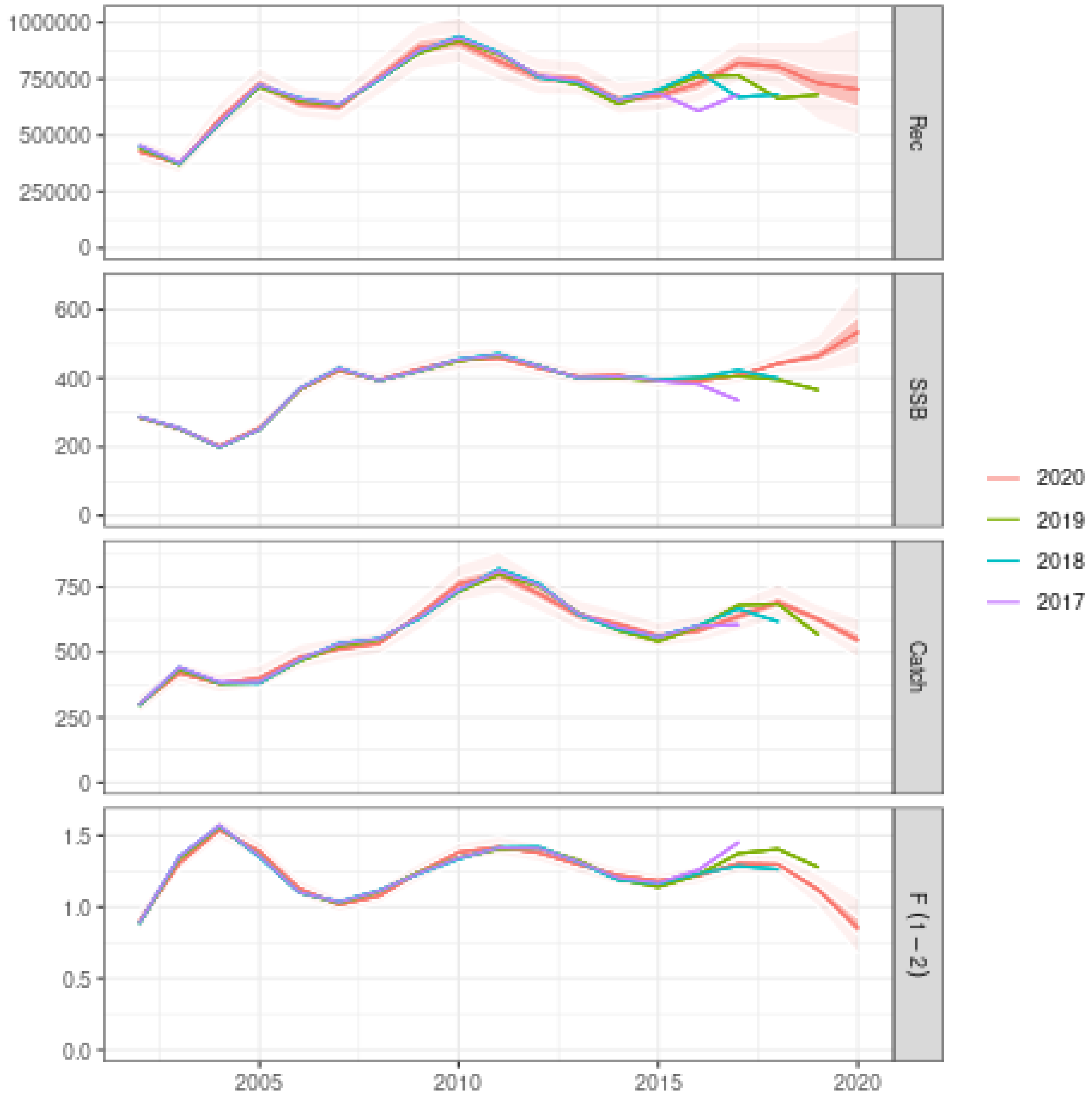


Figure 5.1.2 Blue and red shrimp in GSAs 6 and 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.17.5 Blue and red shrimp in GSAs 6 and 7: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.286	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.286	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.192	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.393	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

Basis of the assessment

Table 5.17.6 Blue and red shrimp in GSAs 6 and 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 5.17.7 Blue and red shrimp in GSAs 6 and 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		
2022	F = F_{MSY}		267		

History of the catch and landings

Table 5.17.8 Blue and red shrimp in GSAs 6 and 7: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2020		Wanted catch				Discards
Catch (t)	549	Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	t
						Negligible
Effort	71010	NA	NA	NA	NA	
		Fishing days				

Table 5.17.9 Blue and red shrimp in GSAs 6 and 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 GSAs 6 & 7	Total landings	Total Effort* (Fishing days)
2002	255	255	
2003	377	377	
2004	499	499	121790
2005	306	306	114583
2006	412	412	113558
2007	575	575	103191
2008	828	828	110561
2009	600	600	105013
2010	548	548	98535
2011	734	734	93956
2012	751	751	89553

2013	743	743	87673
2014	591	591	106233
2015	751	751	80708
2016	650	650	86629
2017	588	588	76804
2018	656	656	77803
2019	574	574	76452
2020	578	578	71010

*Effort data is taken from STECF EWG 21-13. 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 5.17.10 Blue and red shrimp in GSAs 6 and 7: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment	SSB	Fbar(1-2)	Catch
2002	429176	285	0.90	301
2003	374376	251	1.31	419
2004	573899	203	1.54	380
2005	723769	255	1.39	401
2006	639962	366	1.13	478
2007	624931	422	1.01	512
2008	757433	395	1.08	533
2009	887532	428	1.24	642
2010	914297	452	1.38	760
2011	828081	459	1.42	799
2012	756117	429	1.38	722
2013	746420	404	1.30	638
2014	659242	408	1.22	605
2015	674513	393	1.18	564
2016	723276	392	1.22	582
2017	820914	407	1.30	636
2018	804422	442	1.30	690
2019	729079	466	1.12	625
2020	700194	540	0.85	549

Sources and references

STECF EWG 21-11, STECF 21-13

5.18 Summary sheet for Blue and red shrimp in GSA 9, 10 & 11

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.29 and corresponding catches in 2022 should be no more than 45 tons.

Stock development over time

The number of recruits of blue and red shrimp fluctuates until 2016 and shows a decreasing trend from then to 2020, SSB follows the same pattern with a time lag of one year. Catch (=landings as discards are negligible) peaked in 2008, then in 2014 and after a minimum in 2017 increased thereafter. Fbar (2-5) follows the catch pattern and sharply increased after 2017 until 2020 when estimated F is 1.683.

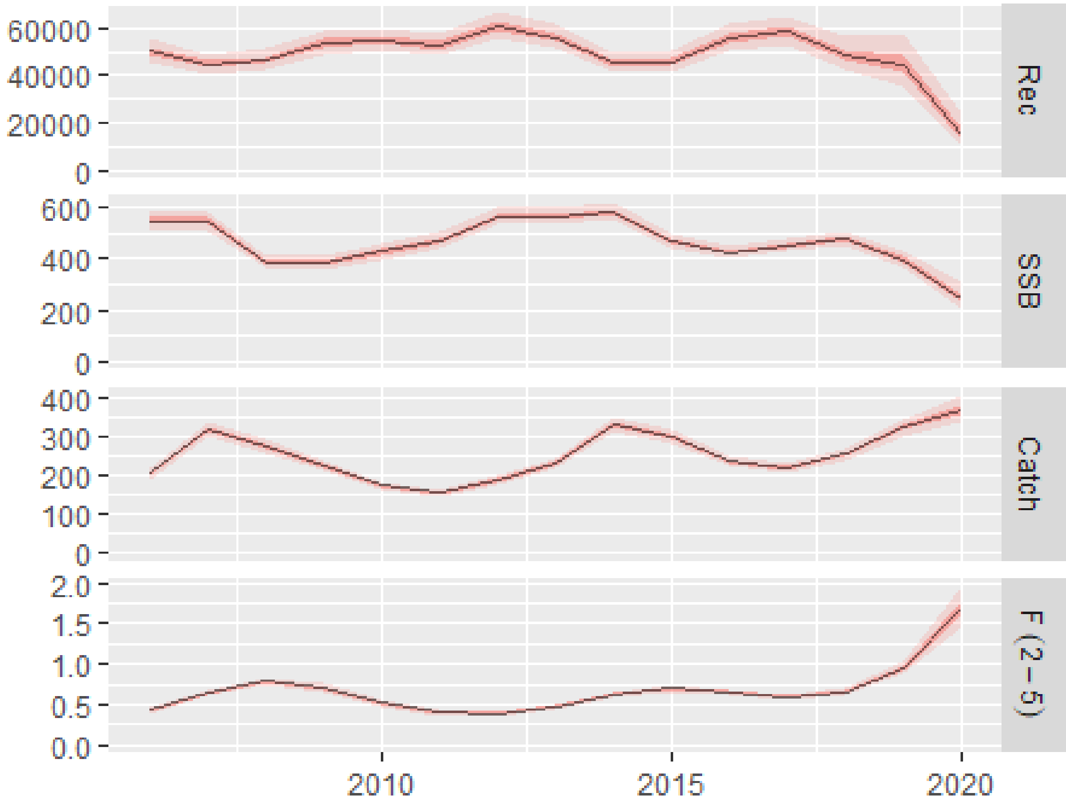


Figure 5.18.1 Blue and red shrimp in GSAs 9, 10 and 11: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.683) is 5.7 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.294). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

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

Status	2018	2019	2020
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

F / $F_{MSY\ Transition}$			F > $F_{MSY\ Transition}$

Catch scenarios

Table 5.18.2 Blue and red shrimp in GSAs 9, 10 and 11: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 2-5}$ (2021)	1.683	F 2020 used to give F status quo for 2021.
SSB (2021)	146	Stock assessment 1 January 2021
R_{age1} (2021,2022)	47259	Geometric mean of the last 14 years.
Total catch (2021)	184	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 5.18.3 Blue and red shrimp in GSAs 9, 10 and 11: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 2-5) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	45	0.294	404	177	-88
$F_{MSY\ Transition}$^^	87	0.619	337	131	-76
$F_{MSY\ lower}$	31	0.197	428	194	-91
$F_{MSY\ upper}$**	60	0.405	379	160	-84
Other scenarios					
Zero catch	0.00	0.00	486	233	-100
Status quo	183	1.683	210	44	-49
F=0.84	112	0.84	301	106	-70
F=1.34	159	1.34	240	64	-57
F=2.52	238	2.52	159	9	-35
F=3.35	278	3.35	128	-12	-24

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2025

Basis of the advice

Table 5.18.4 Blue and red shrimp in GSAs 9, 10 and 11: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Reconstructed 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 consistency in the estimation of F estimated in the assessment of 2020. Also the estimation of SSB is consistent with the ones obtained from last year assessment. All the diagnostics were considered acceptable.

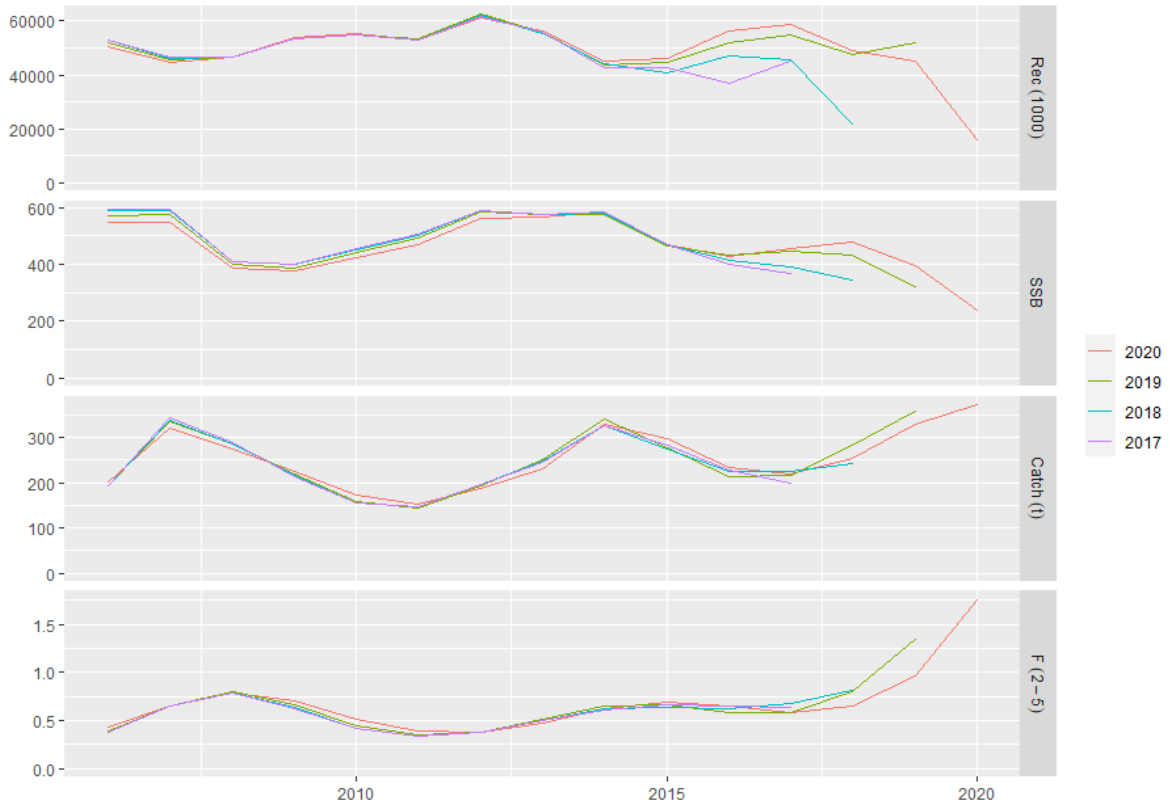


Figure 5.18.2 Blue and red shrimp in GSAs 9, 10 and 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.18.5 Blue and red shrimp in GSAs 9, 10 and 11: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.294	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.294	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.197	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.405	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

Basis of the assessment

Table 5.18.6 Blue and red shrimp in GSAs 9, 10 and 11: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards were negligible (<1%) and considered as zero discards.
Indicators	
Other information	
Working group	STECF EWG 21-11

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.18.7 Blue and red shrimp in GSAs 9, 10 and 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	365	
2021	$F = F_{MSY}$		61		
2022	$F = F_{MSY}$		45		

History of the catch and landings

Table 5.18.8 Blue and red shrimp in GSAs 9, 10 and 11: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2020		Wanted catch				Discards
Catch (t)	267	Otter trawl 100%				0t
Effort	70922	NA	NA	NA	NA	
		Fishing days				

Table 5.18.9 Blue and red shrimp in GSAs 9, 10 and 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	0	77	19	0	95	
2004	0	82	120	0	203	126752
2005	0	155	64	98	317	139217
2006	0	93	52	172	316	119749
2007	0	47	39	57	143	122654
2008	0	63	23	75	161	107345
2009	0	123	27	65	216	110223
2010	0	186	20	53	260	103749
2011	0	175	48	59	283	101190
2012	0	193	31	57	281	94577
2013	0	170	34	41	245	105927
2014	0	84	9	90	182	111284
2015	0	91	67	57	215	98969
2016	0	67	66	89	222	103845
2017	0	62	33	110	205	100037
2018	0	77	135	284	497	98977
2019	0	101	141	247	490	90631
2020	0	59	69	139	267	70922

*Effort data is taken from STECF EWG 21-13. 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 5.18.10 Blue and red shrimp in GSAs 9, 10 and 11: 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 2-5	High	Low
2006	50459			549			202	0.424		
2007	44757			548			317	0.638		
2008	46745			390			273	0.776		
2009	53834			381			225	0.691		
2010	55031			428			173	0.505		
2011	52737			473			153	0.388		
2012	61148			564			187	0.380		
2013	56335			567			230	0.471		
2014	45538			584			330	0.614		
2015	46076			472			297	0.691		
2016	56141			430			235	0.646		
2017	58827			453			218	0.586		
2018	48803			477			253	0.643		
2019	44533			397			323	0.943		
2020	16345			244			366	1.683		

Sources and references

STECF EWG 21-11, STECF EWG 21-13.

5.19 Summary sheet for Giant red shrimps in GSA 9, 10 & 11

STECF advice on fishing opportunities

STECF EWG 21-11 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.46 and corresponding catches in 2022 should be no more than 241 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, catches are a little above the long term mean in the last year. Recruitment peaked in 2011 and 2016, and remained constant in the last three years, while SSB, after a generally increasing trend, showed a decrease starting from 2018. Fishing mortality showed a gradual increase since 2017, reaching its maximum value (0.983) in the last year.

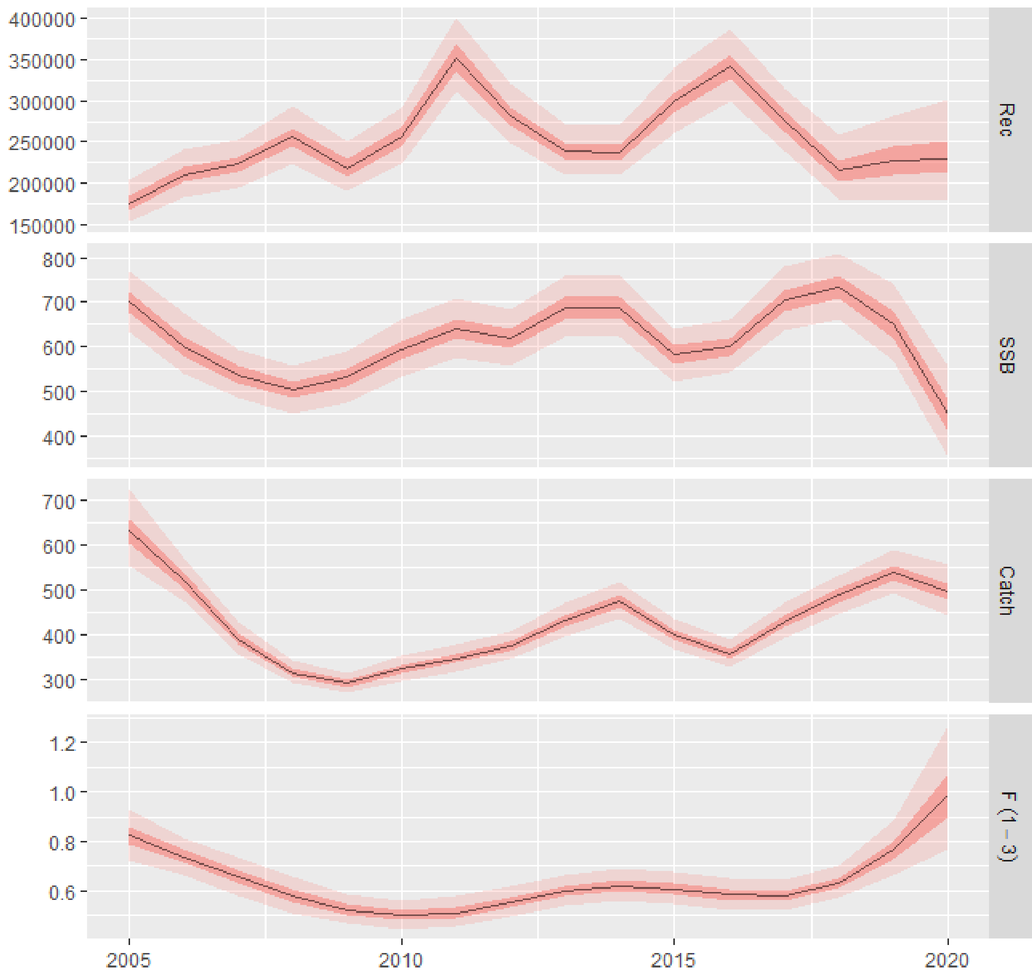


Figure 5.1.1 Giant red shrimp in GSAs 9, 10 and 11: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.983) is 2 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.462). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2025 is behind transition.

Table 5.1.1 Giant red shrimp in GSAs 9, 10 and 11: State of the stock and fishery relative to reference points.

Status	2018	2019	2020
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}
F / $F_{MSY\ Transition}$			F > $F_{MSY\ Transition}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2021)	0.983	F 2020 used to give F status quo for 2021
SSB (2021)	437	Stock assessment 1 January 2021
R_{age0} (2021,2022)	248799	Geometric mean of the whole time series (2005-2020)
Total catch (2021)	424	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 5.19.3 Giant red shrimp in GSAs 9, 10 and 11: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}# (ages 1-3) (2022)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	241	0.462	654	49.8	-51
$F_{MSY\ Transition}$^^	302	0.613	586	34.3	-39
$F_{MSY\ lower}$	171	0.308	739	69.2	-66
$F_{MSY\ upper}$**	309	0.631	579	32.6	-38
Other scenarios					
Zero catch	0	0.000	979	124.3	-100
Status quo	427	0.983	465	6.5	-14
0.2 F_{sq}	114	0.197	813	86.1	-77
0.4 F_{sq}	211	0.393	690	57.9	-58
0.6 F_{sq}	293	0.590	596	36.5	-41
0.8 F_{sq}	364	0.787	523	19.8	-27

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ 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 and 11: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Commercial catches showed better internal consistency than MEDITS survey index. The assessment model was not modified from last year. The retrospective analysis run on the a4a model showed consistency in the estimation of F estimated in the assessment of 2019. All the diagnostics were considered acceptable.

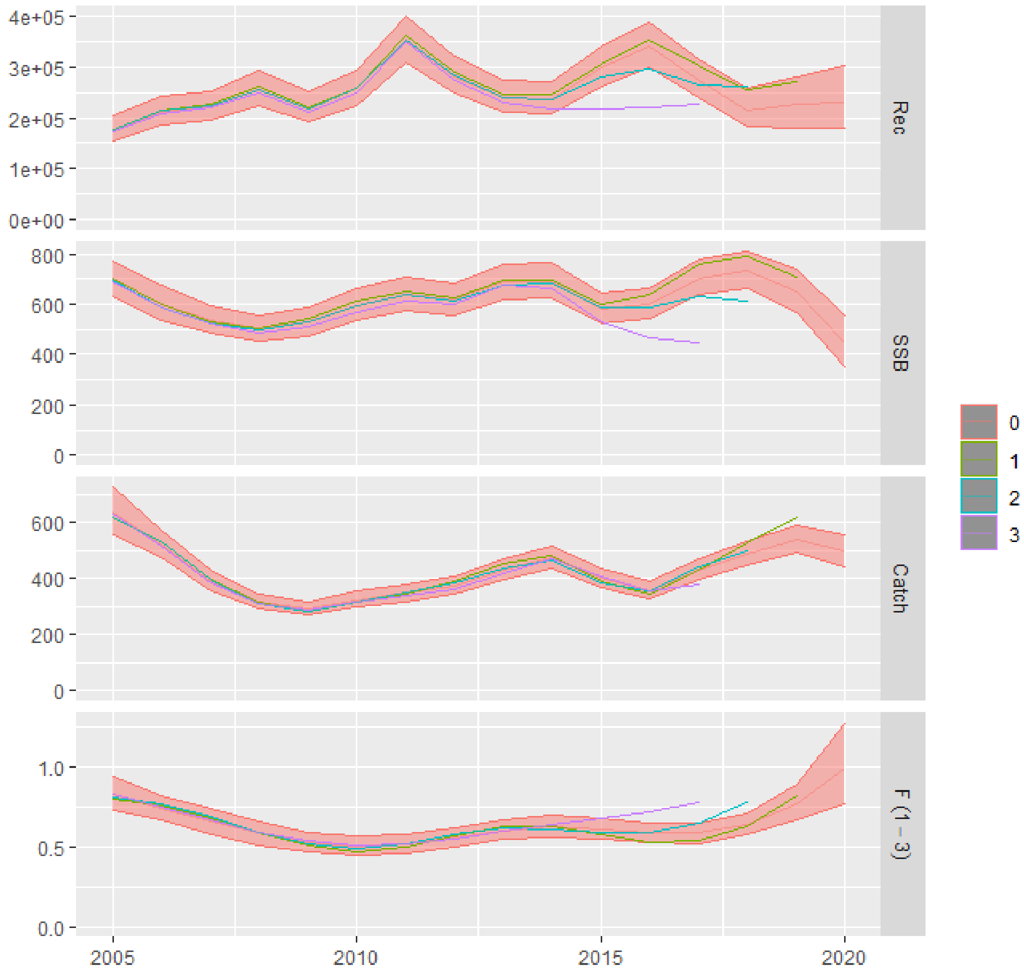


Figure 5.19.2 Giant red shrimp in GSAs 9, 10 and 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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 and 11: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.462	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
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}	0.462	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-11
	target range F_{lower}	0.308	Based on regression calculation (see section 2)	STECF EWG 21-11
	target range F_{upper}	0.631	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-11

Basis of the assessment

Table 5.19.6 Giant red shrimp in GSAs 9, 10 and 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 21-11

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.19.7 Giant red shrimp in GSAs 9, 10 and 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	536	
2020	F = F_{MSY}		199	496	
2021	F = F_{MSY}		323		
2022	F = F_{MSY}		241		

History of the catch and landings

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

2020		Wanted catch				Discards
Catch (t)	383	Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	0t
Effort	70922	NA	NA	NA	NA	
		Fishing days				

Table 5.19.9 Giant red shrimp in GSAs 9, 10 and 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	139217
2006	62.6	419.6	98.1	580.3	119749
2007	36.7	300.3	42.0	379	122654
2008	33.8	120.1	38.6	192.5	107345
2009	34.3	211.7	117.4	363.4	110223
2010	54.6	190.2	98.6	343.4	103749
2011	68.4	140.9	94.7	304.0	101190
2012	62.0	159.8	72.7	294.5	94577
2013	23.1	399.4	63.3	485.8	105927
2014	16.8	454.1	123.9	594.8	111284
2015	44.2	232.1	97.6	373.9	98969
2016	35.8	179.1	127.6	342.5	103845
2017	33.6	139.4	249.2	422.2	100037
2018	36.4	400.2	188.3	624.9	98977
2019	46.2	450.2	170.0	666.4	90631

2020	26.4	201.5	155.6	383.5	70922

*Effort data is taken from STECF EWG 21-13. 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 and 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	177364			697			628	0.822		
2006	211314			600			520	0.738		
2007	223150			536			389	0.656		
2008	256130			500			315	0.580		
2009	219335			529			289	0.524		
2010	256459			593			323	0.500		
2011	351364			638			346	0.512		
2012	281626			617			374	0.552		
2013	238766			686			430	0.599		
2014	238090			686			474	0.622		
2015	297634			578			398	0.609		
2016	339906			598			357	0.583		
2017	274881			704			429	0.579		
2018	216632			732			486	0.632		
2019	227033			648			536	0.764		
2020	232523			445			496	0.983		

Sources and references

STECF EWG 21-11, STECF EWG 21-13

6 ASSESSMENTS BY STOCK

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.

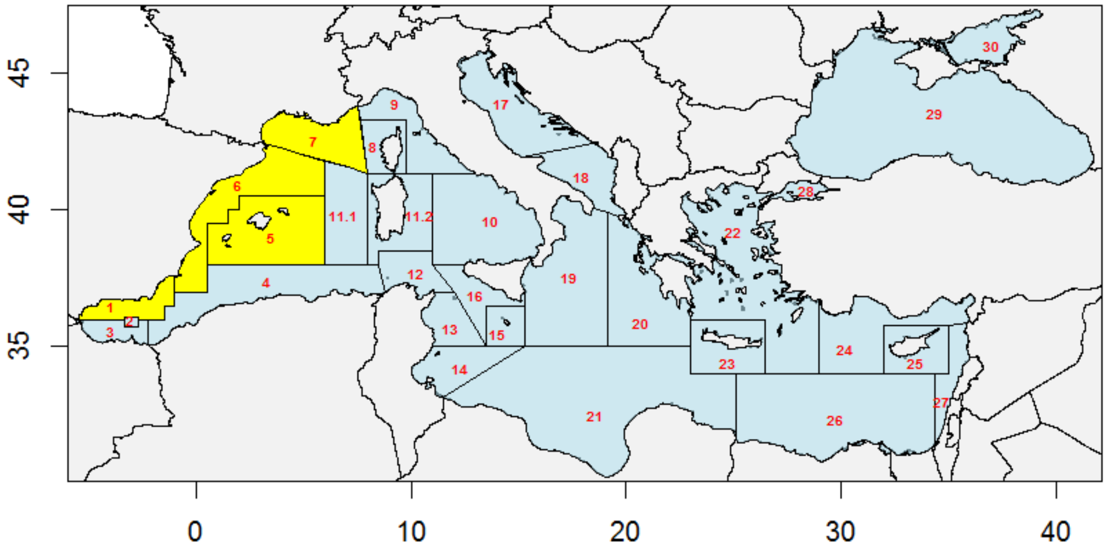


Figure 6.1.1.1 Geographical location of GSAs 1, 5, 6 and 7.

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 (Tab. 6.1.1.1 and Fig. 6.1.1.2).

Table 6.1.1.1 European hake in GSAs 1, 5, 6 and 7. Growth parameters and length-weight relationship parameters.

L_{inf}	k	t0	a	b
110	0.178	-0.005	0.00677	3.0351

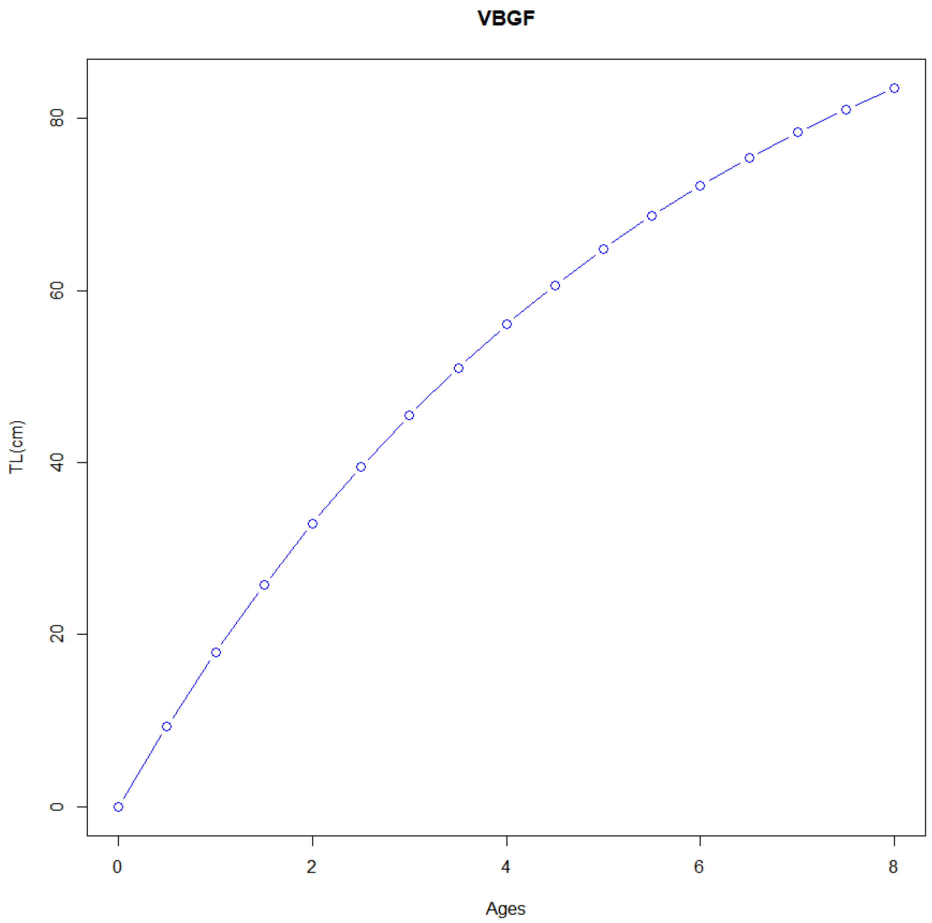


Figure 6.1.1.2. European hake in GSAs 1, 5, 6 and 7. Von Bertalanffy growth curve.

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 and 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

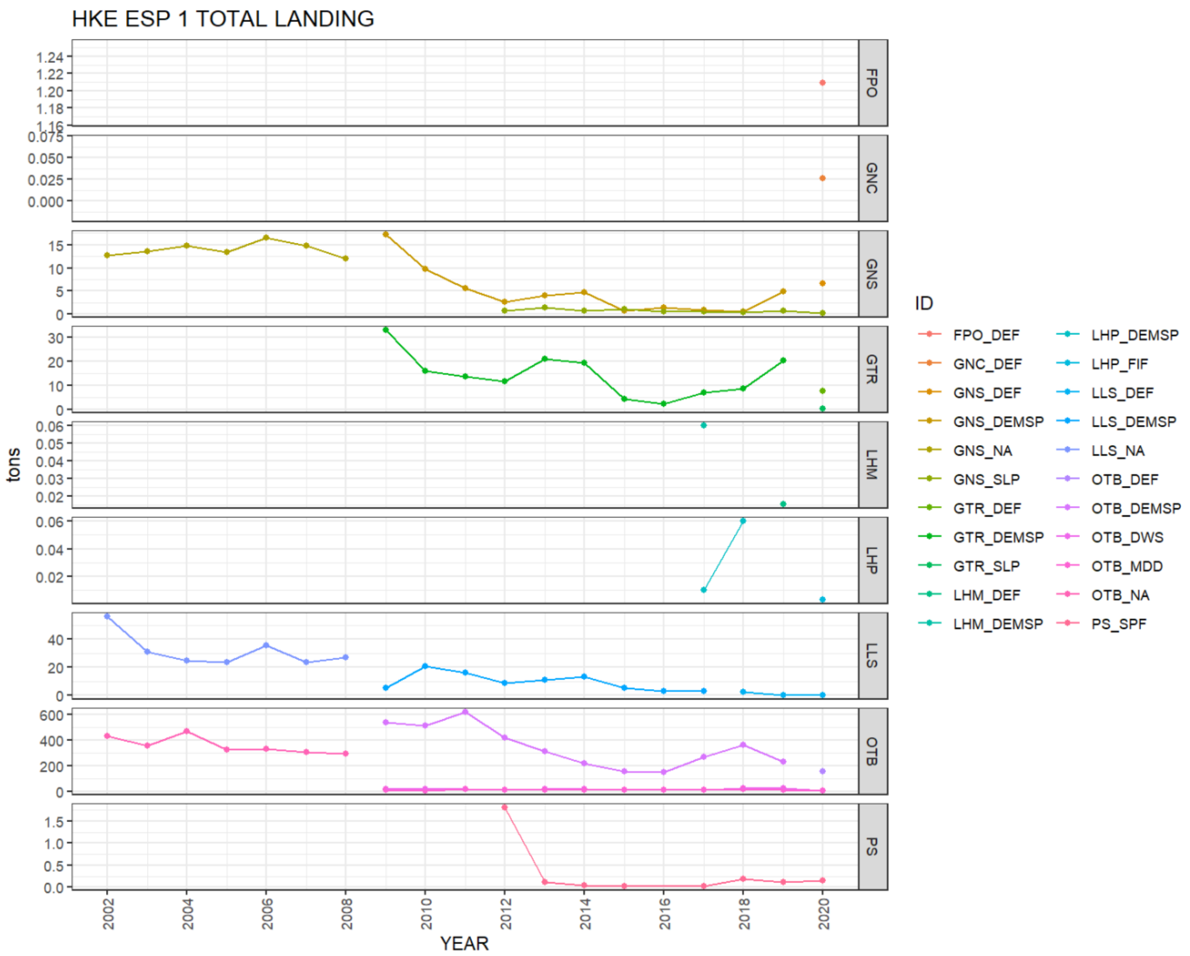
6.1.2 Data

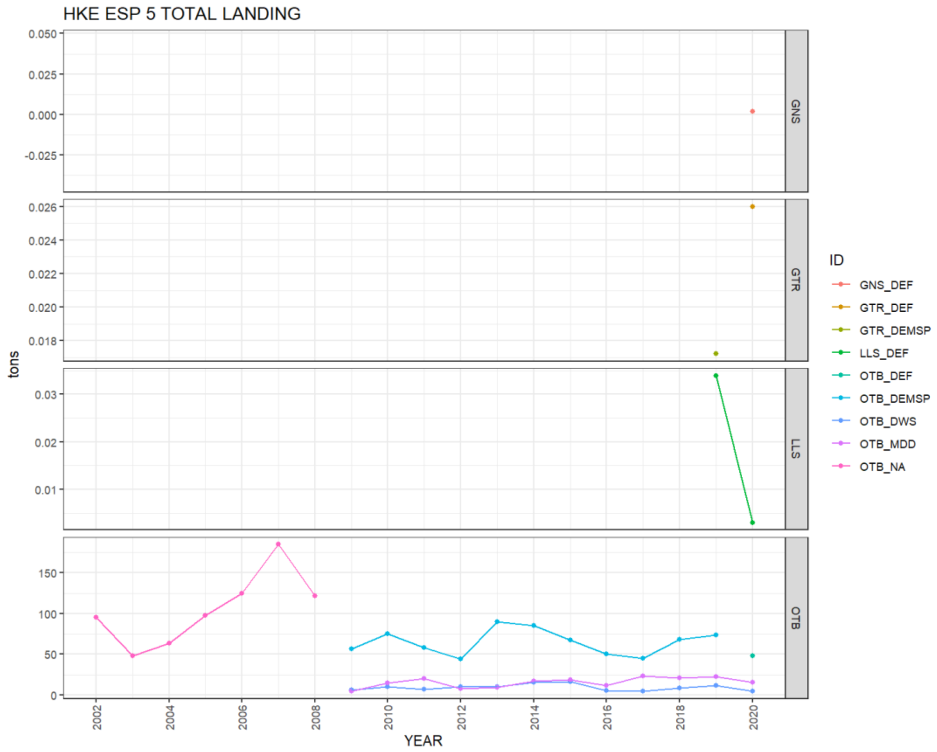
6.1.2.1 Catch (landings and discards)

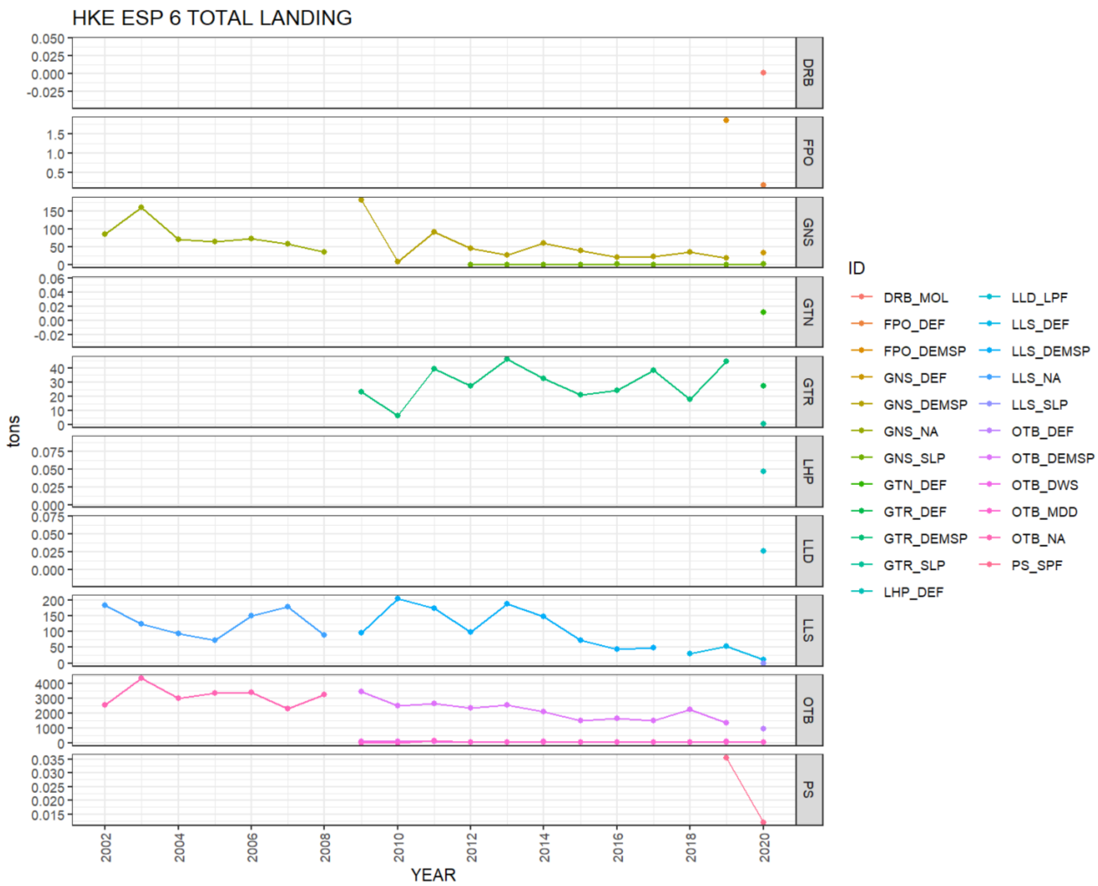
European hake is largely exploited in GSAs 1 and 6, mainly by trawlers on the shelf and slope, but also by small-scale fisheries using long lines, gill nets and trammel nets. In GSA 5, hake catches come exclusively from bottom trawlers. They show important variation along the data series, between 50 and 200 tons. In the Gulf of Lions (GSA 7), hake is exploited by French trawlers, French gillnetters, Spanish trawlers and Spanish longliners.

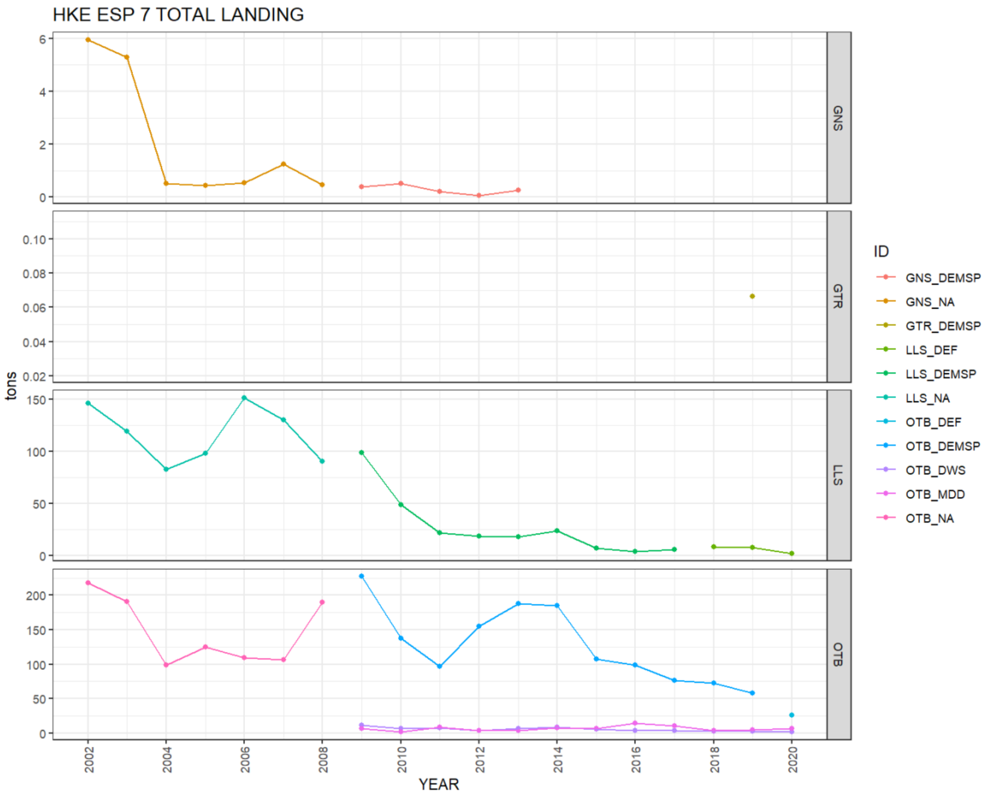
Landings

Landings data were reported to STECF EWG 21-11 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
GTR_DEF
GTR_DEMSP
GTR_SLP
LHP_DEF
LLD_LPF
LLS_DEF
LLS_DEMSP
LLS_NA
LLS_SLP
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
PS_SPF



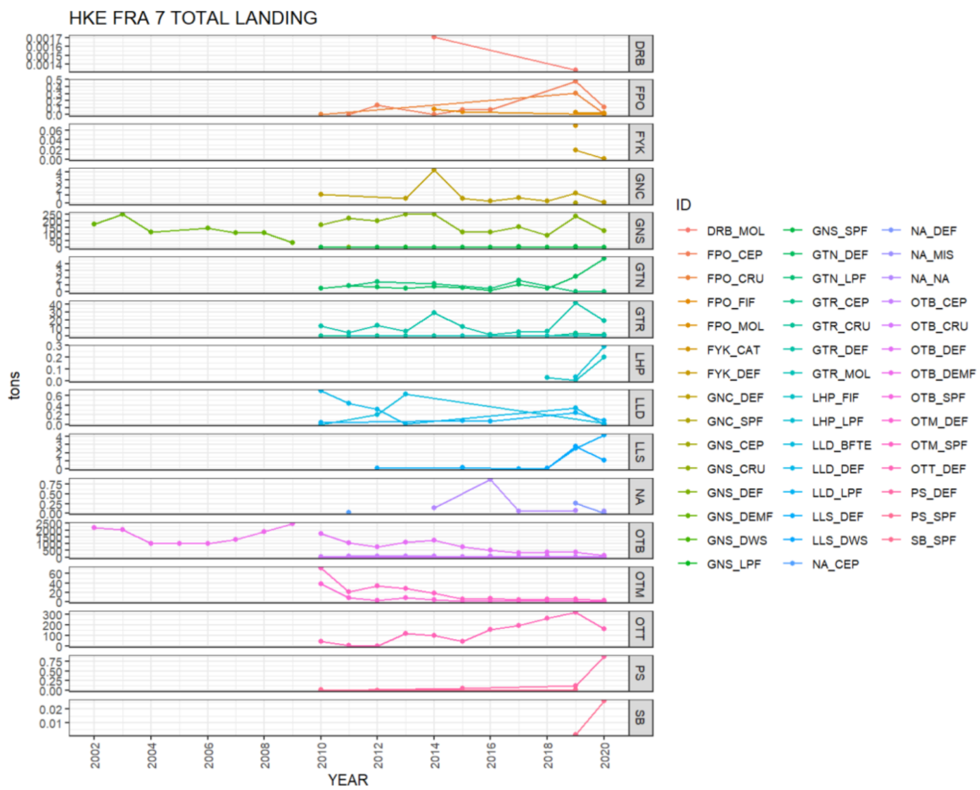
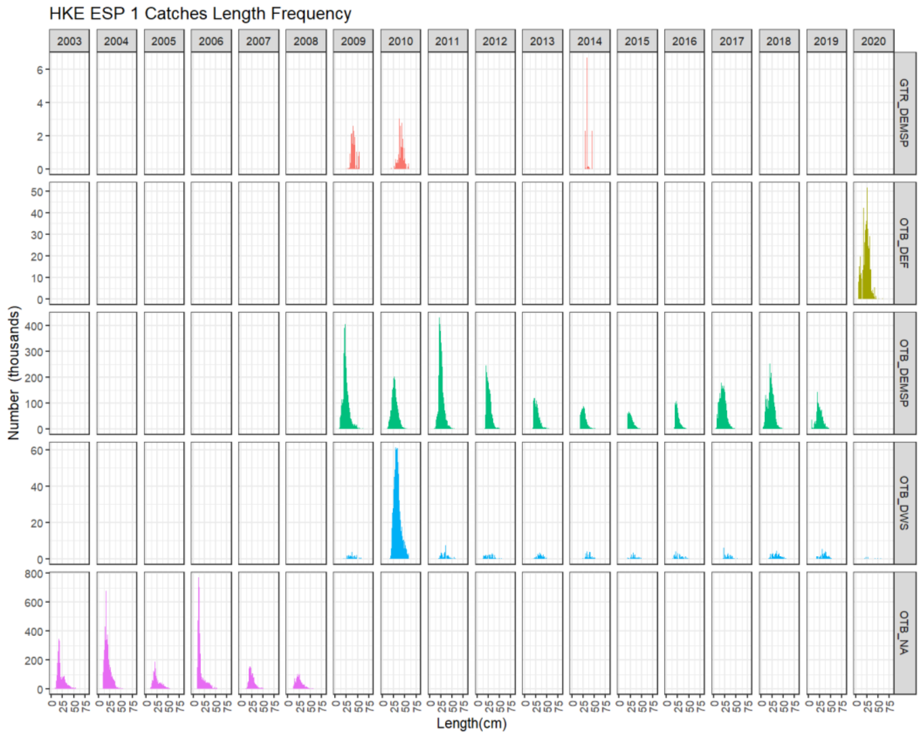


Figure 6.1.2.1.1. European hake in GSAs 1, 5, 6 and 7. Landings data in tons by year GSA country and fleet. From 2015 onwards there can be two points in the same year due to the increase in "fishery classes" for the same gear. Showing all the fishery classes and gears was overly complex, so the fishery classes for the same gear are both sown. As each fishery has different values it is possible to get double points or trends.

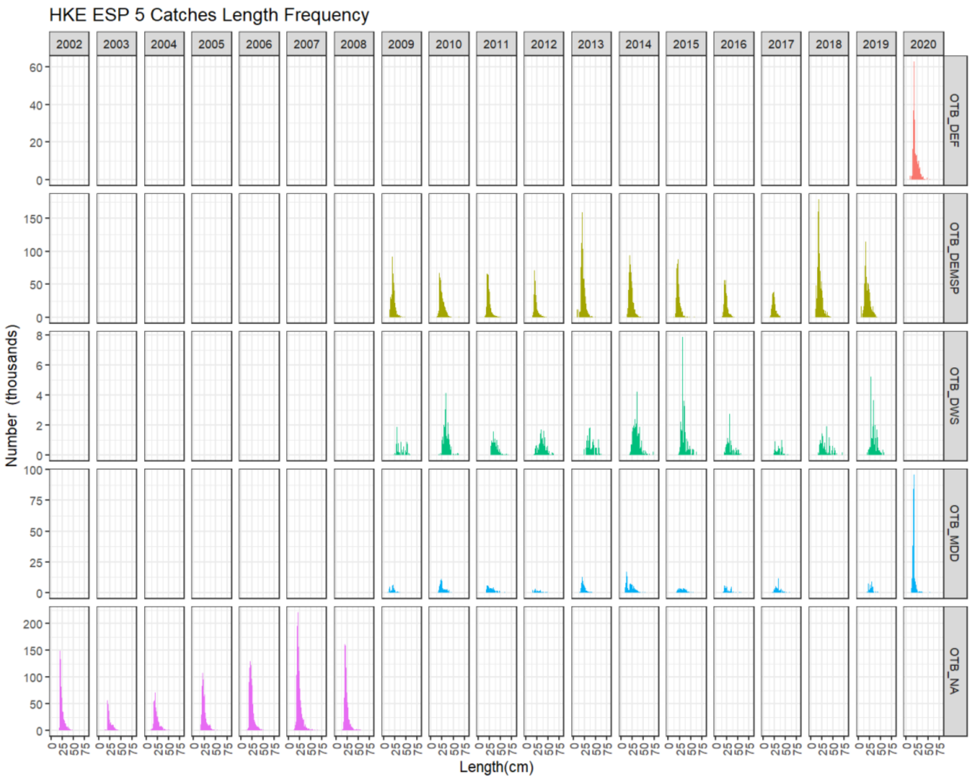
Table 6.1.2.1.1. European hake in GSAs 1, 5, 6 and 7. Total landings data in tons by year.

	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

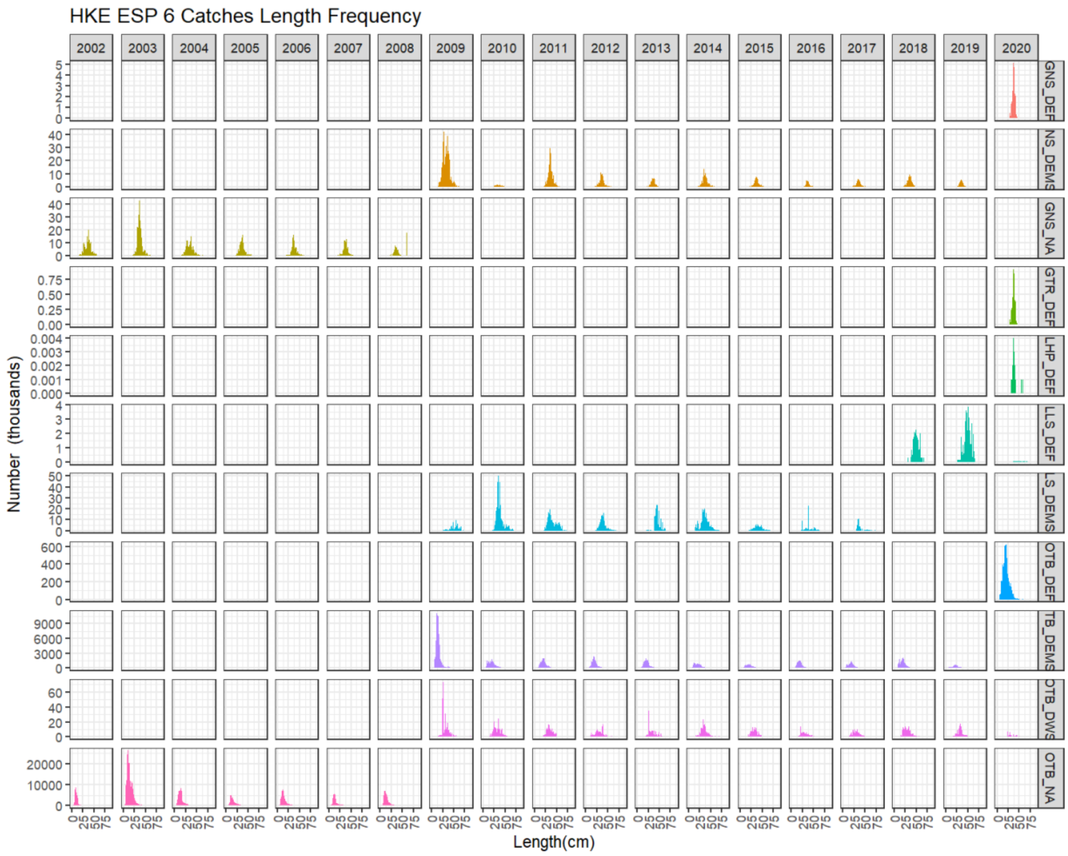
Length frequency distribution of the landings by year and gear or fleet from the DCF database is presented in Figure 6.1.2.1.2. When data are reported by gear different fisheries within gears are represented by different colours (to reduce number of rows).

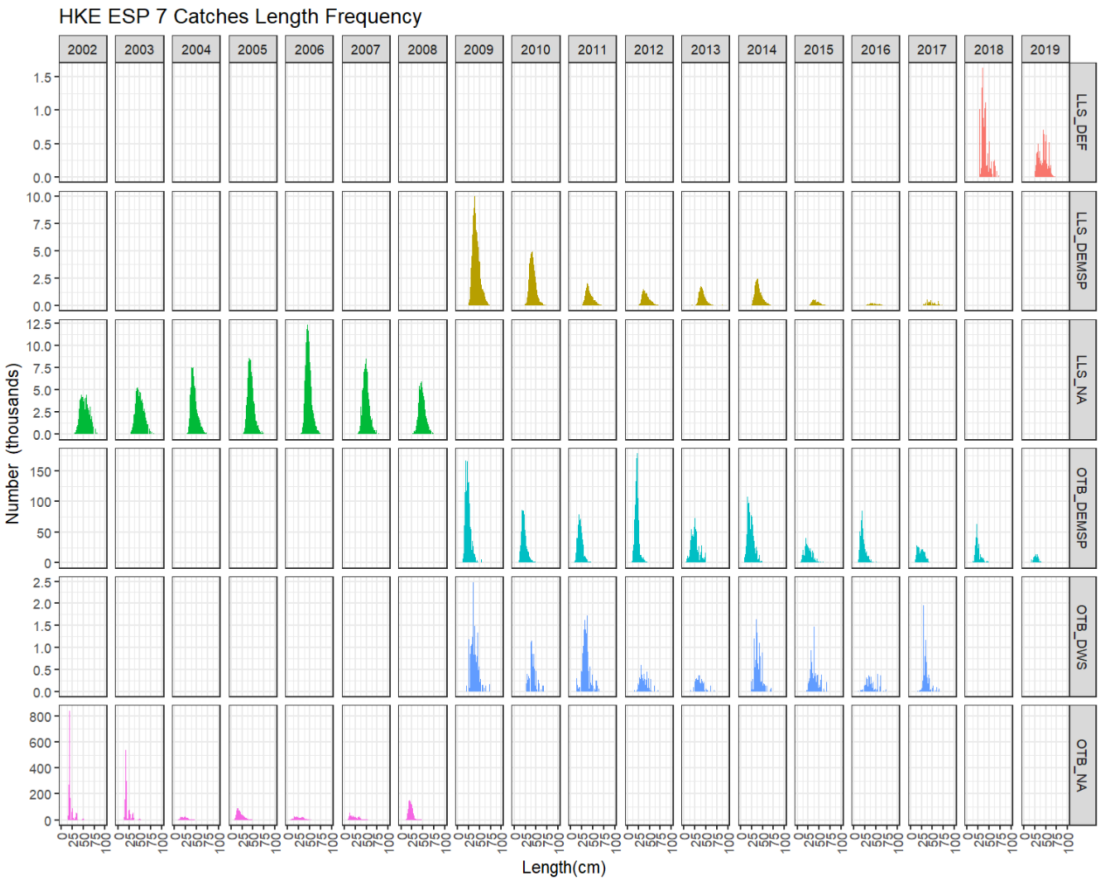


HKE ESP 1 Catches Length Frequency
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
GTR_DEMSP
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_NA
Number (thousands)
Length(cm)



HKE ESP 5 Catches Length Frequency
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
Number (thousands)
Length(cm)


HKE ESP 6 Catches Length Frequency
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
GNS_DEF
GNS_NA
GTR_DEF
LHP_DEF
LLS_DEF
OTB_DEF
OTB_NA
Number (thousands)
Length(cm)


HKE ESP 7 Catches Length Frequency
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
LLS_DEF
LLS_DEMSP
LLS_NA
OTB_DEMSP
OTB_DWS
OTB_NA
Number (thousands)
Length(cm)

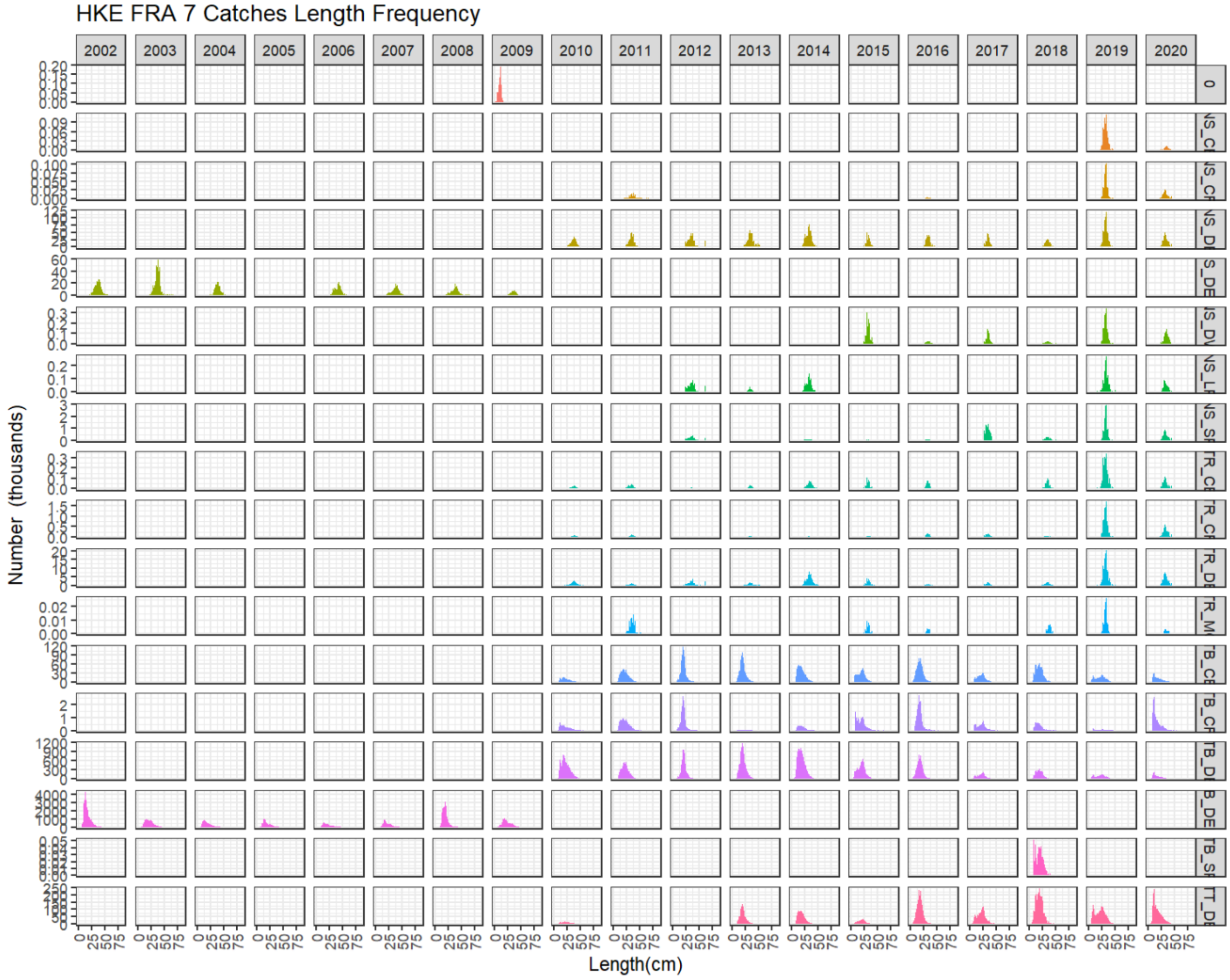


Figure 6.1.2.1.2. European hake in GSAs 1, 5, 6 and 7. Length frequency distribution of the landings by year and gear or fleet.

Discards

Discards data were reported to STECF EWG 21-11 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.

Table 6.1.2.1.2. European hake in GSAs 1, 5, 6 and 7. OTB discards data in tons by GSA.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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
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
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
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
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**

Length and age frequency distributions of discards were available from DCF data only for France in GSA 7 while for Spain only the last three years in GSAs 1 and 6 the last two years in GSA 5 were available.

Considering that this is a benchmarked stock, data were not reconstructed during STECF EWG 21-02. Nevertheless the code from that working group 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. This year length measurements were completely lacking from the Spanish commercial sampling of GSA 7, therefore only for this year LFDs were reconstructed.

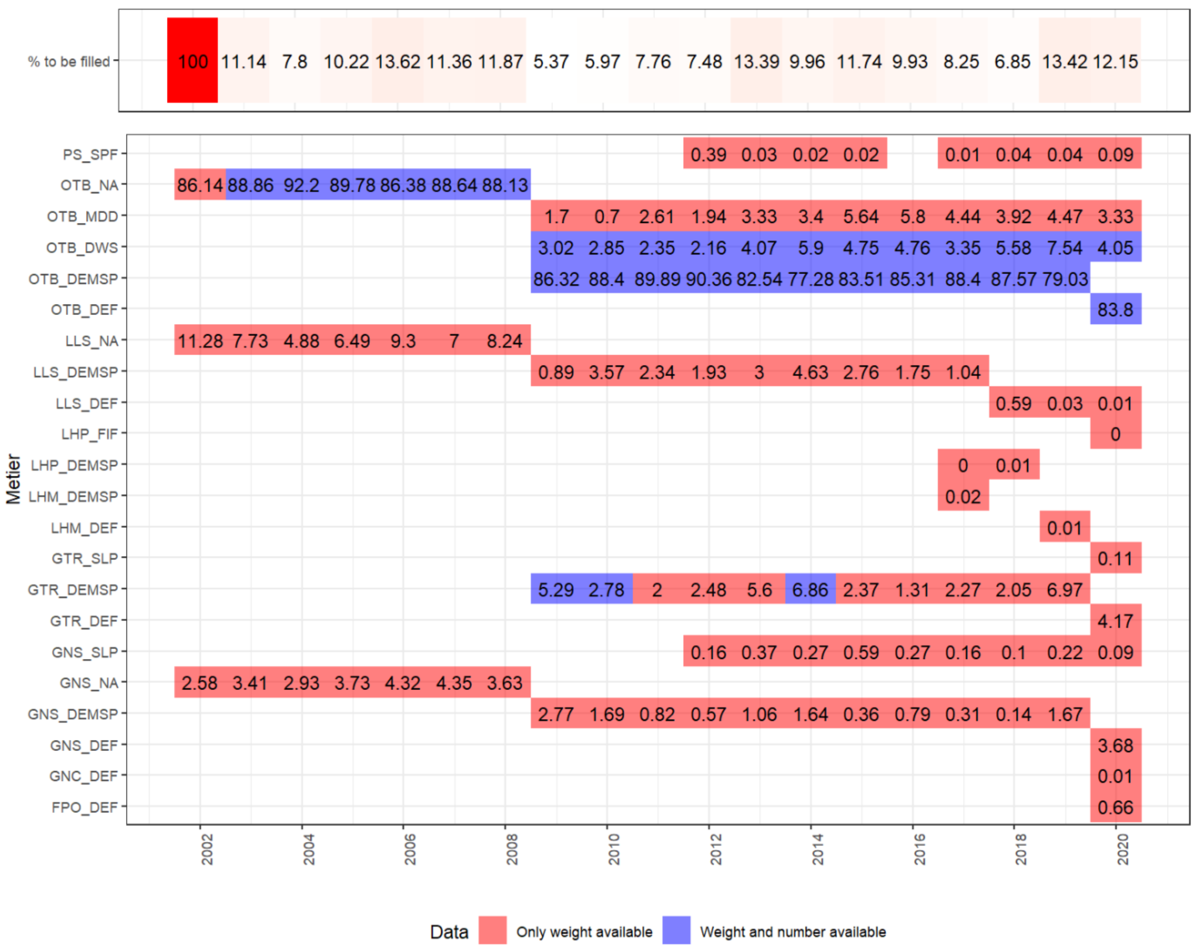


Figure 6.1.2.1.3 Time series of GSA 1 showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

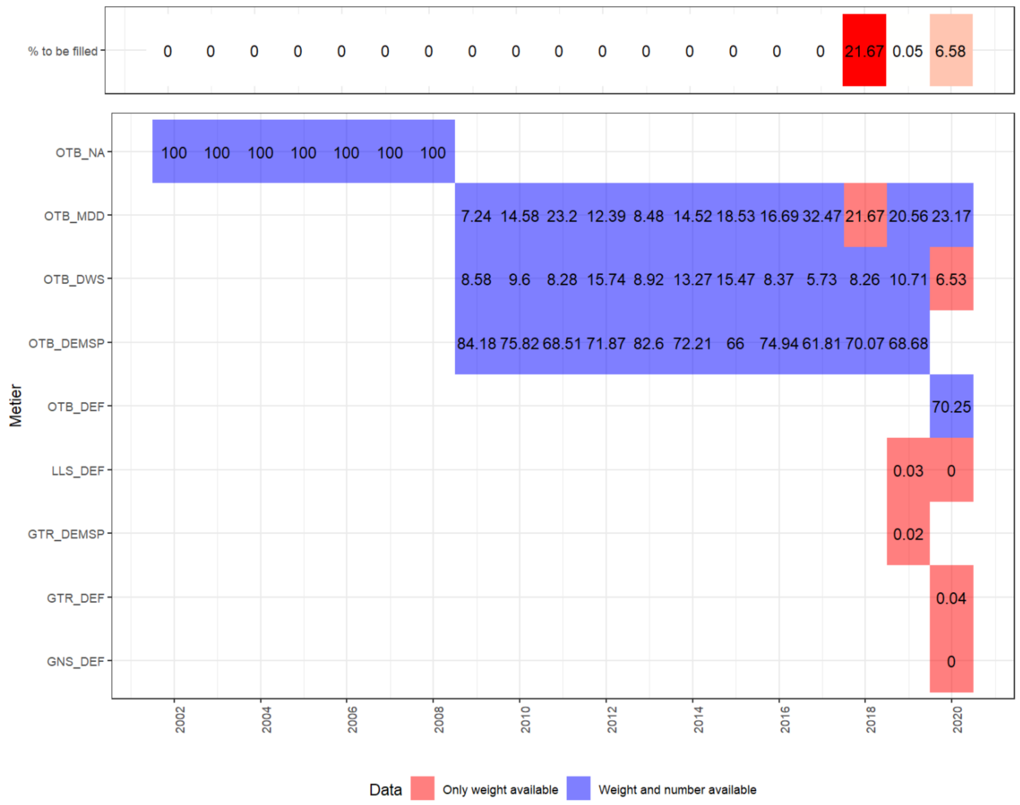


Figure 6.1.2.1.4 Time series of GSA 5 showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

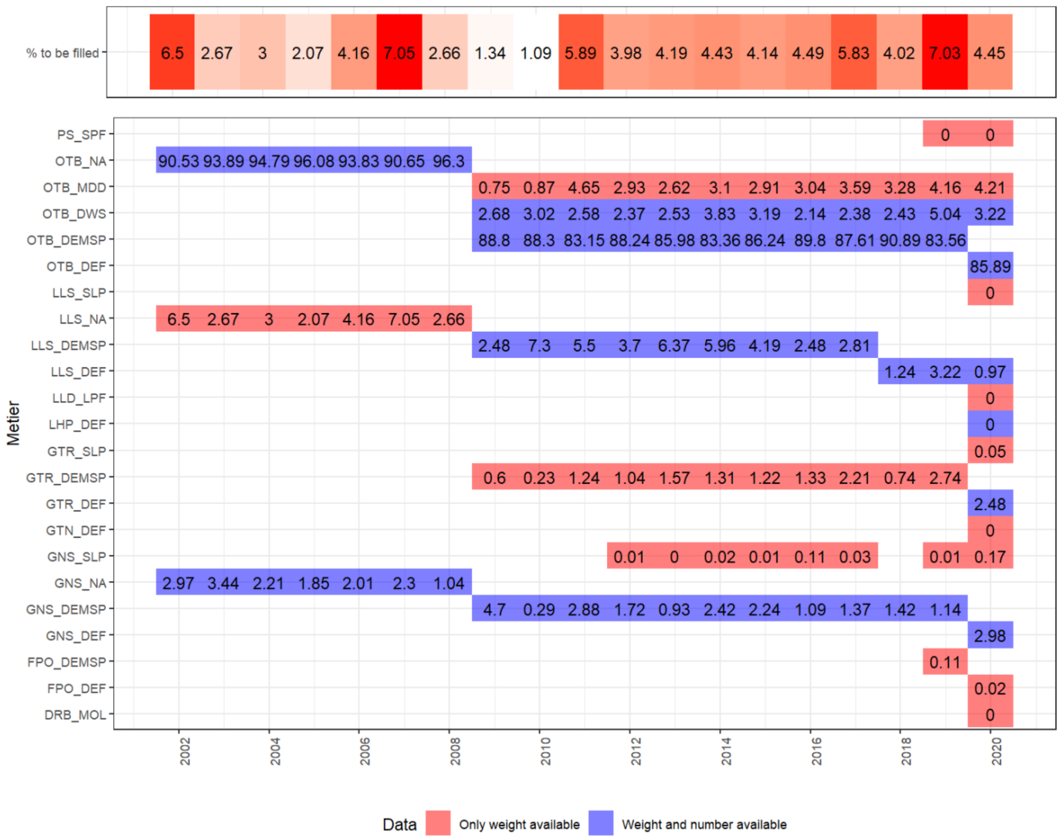


Figure 6.1.2.1.5 Time series of GSA 6 showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

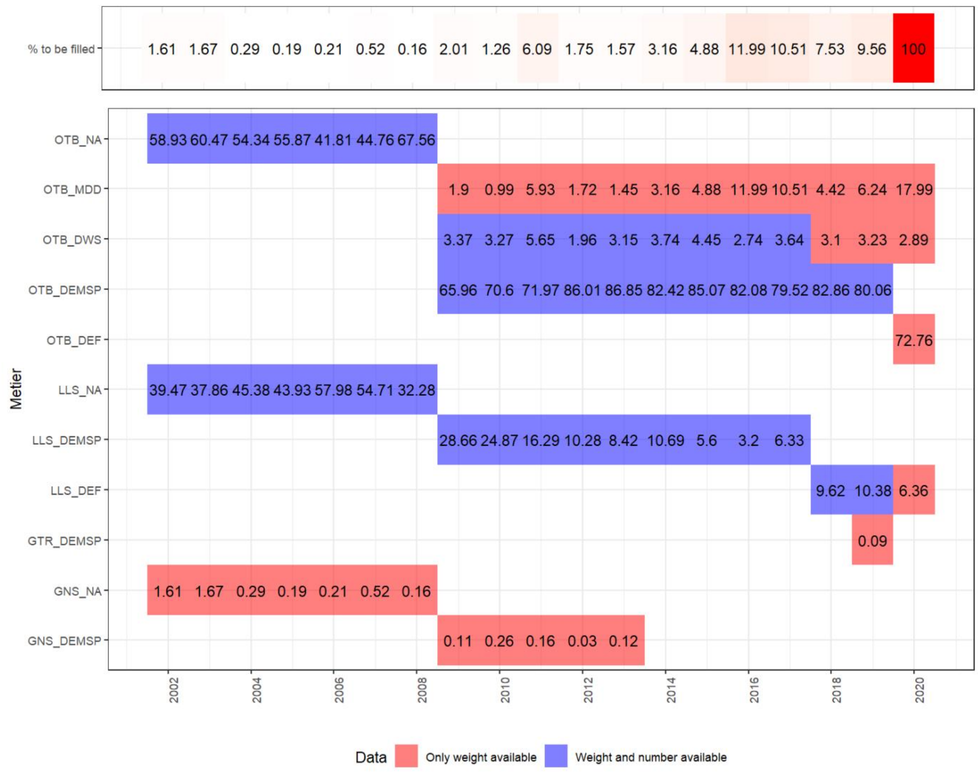


Figure 6.1.2.1.6 Time series of GSA 7 (Spanish data) showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

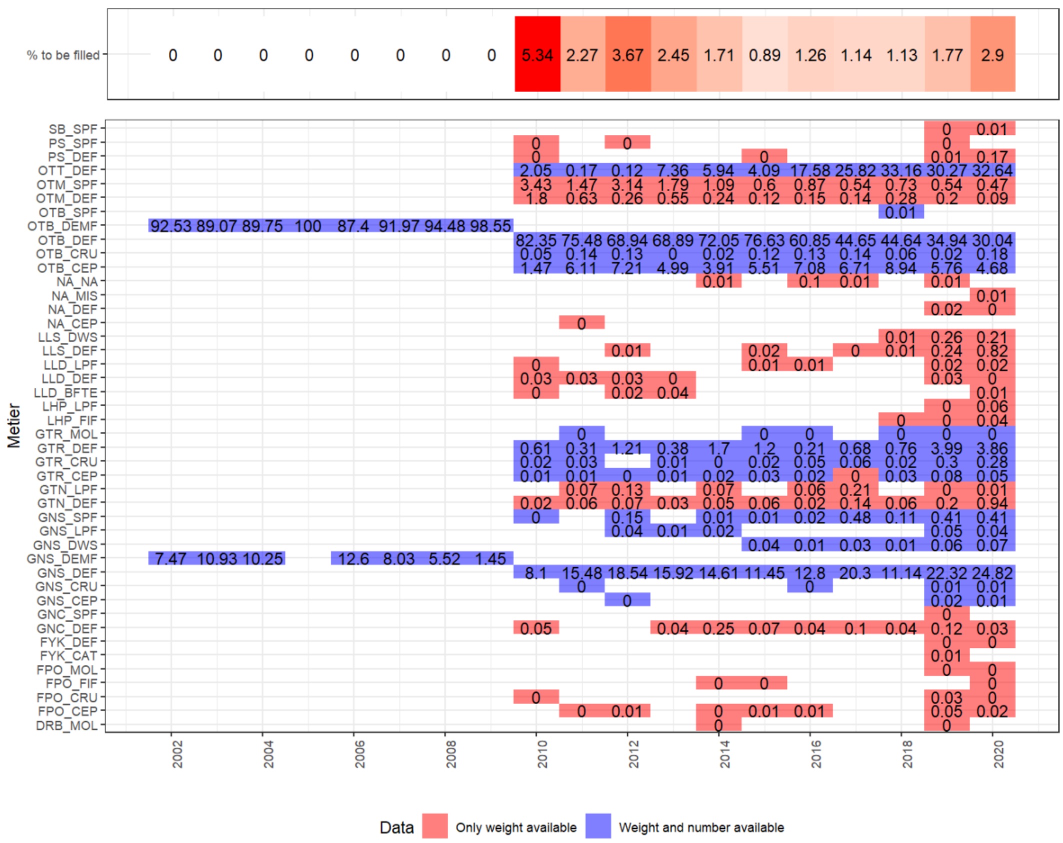


Figure 6.1.2.1.7 Time series of GSA 7 (French data) showing were landings were sampled by length (blue) or only total weight was reported (red). On the top row is reported the proportion of data that would need reconstruction for that year.

6.1.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 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).

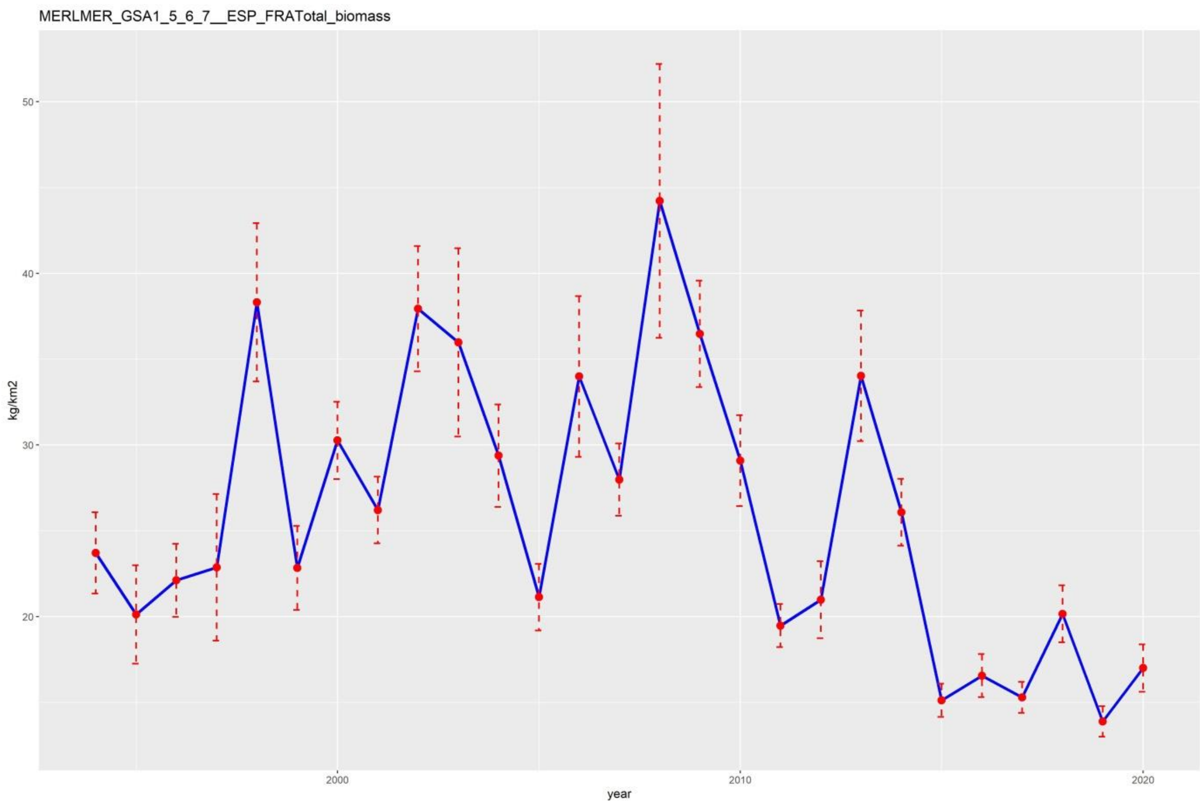


Figure 6.1.2.3.1. European hake in GSAs 1, 5, 6 and 7. Estimated biomass indices from the MEDITS survey (kg/km^2).

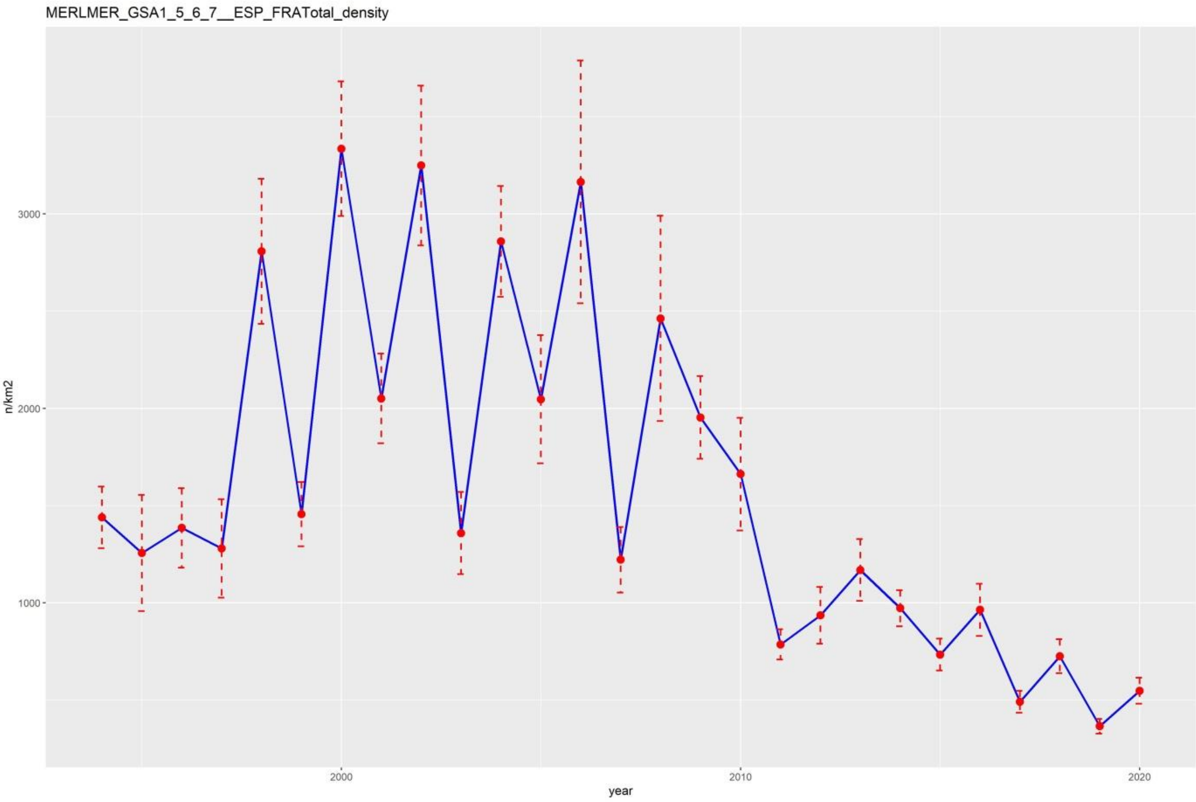


Figure 6.1.2.3.2. European hake in GSAs 1, 5, 6 and 7. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series and a decreasing trend in the last years.

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 and 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.

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 2007-2020 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.

As a sensitivity analysis to account for the lack of survey data in GSA 1, two runs were tested. In the first run the time series of abundance index was taken as it is, without data for GSA1 in 2020 effectively assuming GSA 1 follows the same trend in density as in GSAs 5, 6&7 for 2020. The second run had a reconstructed abundance index for GSA 1 in 2020. In order to reconstruct the data the new LFDs for 2020 in GSA 1 were obtained as the average of the time series from 2007 to 2019, as the time series for this GSA is a stable trend. The new LFDs of GSA 1, 5, 6, and 7 were each multiplied by the total are of the respective GSA in order to obtain the absolute numbers at length and sum these all together. The total LFDs were than divided by the total area of the combined GSAs1-5-6-7 to standardize them by the area. All strata areas were used in the process as European hake is caught in all strata in this area.

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 and 7. SOP correction vector.

year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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
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
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
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
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

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 and 7. Input data for the a4a model.

Catches (t)

2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4697	6289	7409	5836	5662	4654	5438	5061	3243	3195	3063	4077	3228	1974

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

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

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

*index values without simulating data for GSA 1

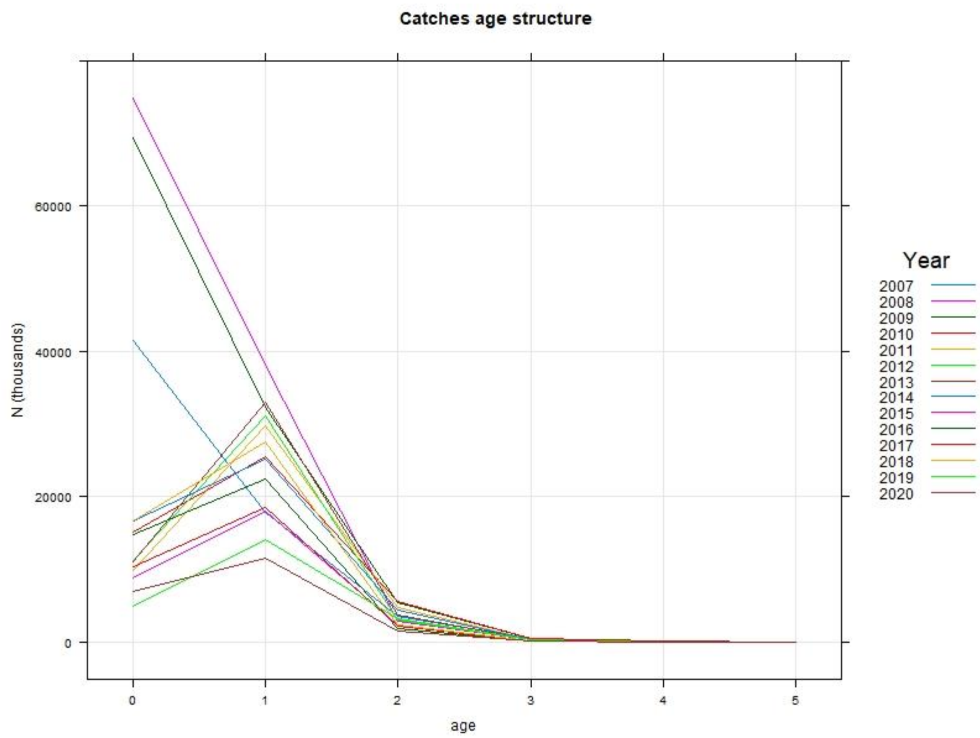


Figure 6.1.3.1. European hake in GSAs 1, 5, 6 and 7. Catch at age input data.

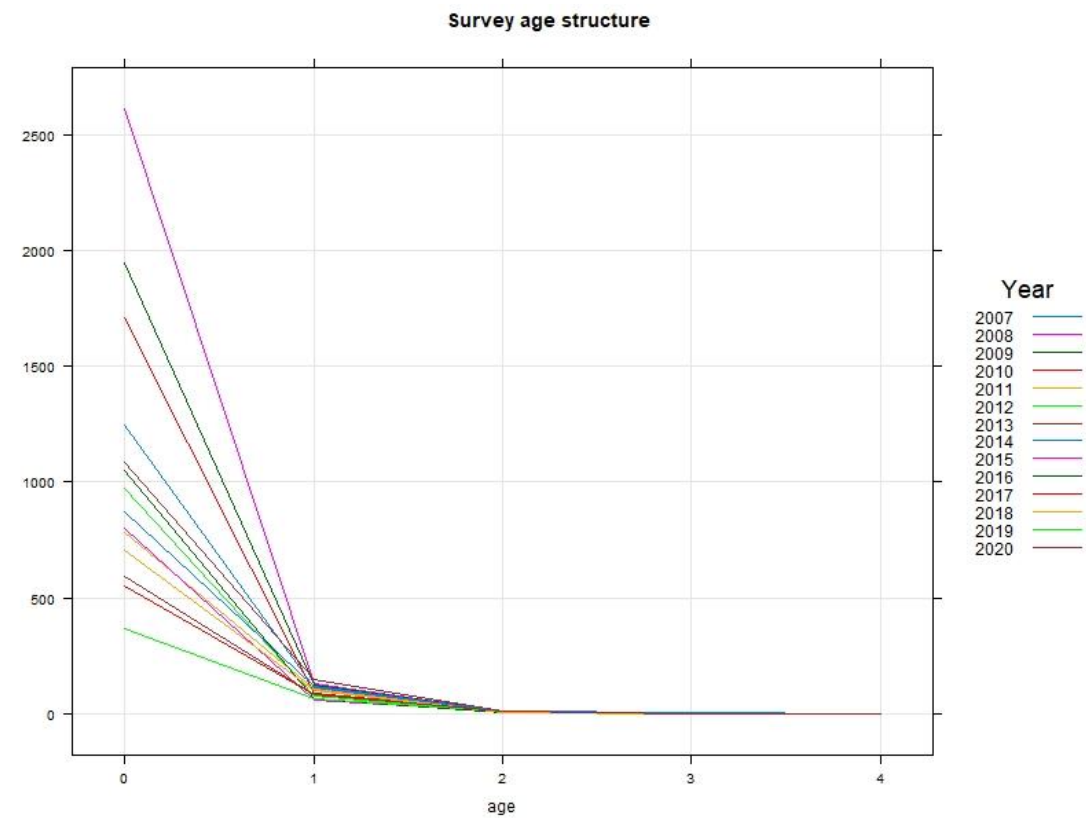


Figure 6.1.3.2. European hake in GSAs 1, 5, 6 and 7. Age structure of the index.

Assessment results

Considering that results obtained from the sensitivity analysis did not differ, the group decided to consider as final results from the model in which 2020 abundance index data were reconstructed. Only results from this model are shown in the following section.

Different a4a models were performed (combination of different f, q and sr). The best model (according to residuals and retrospective) included:

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

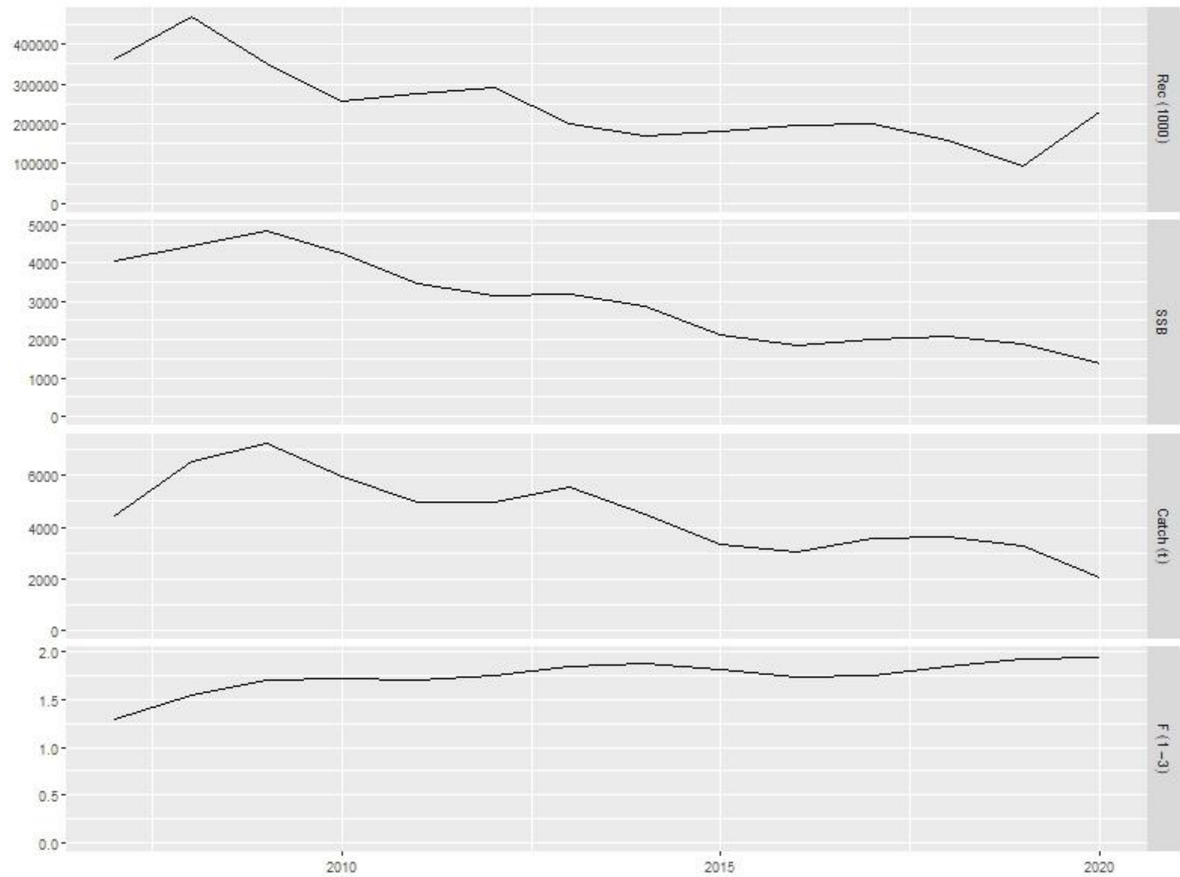
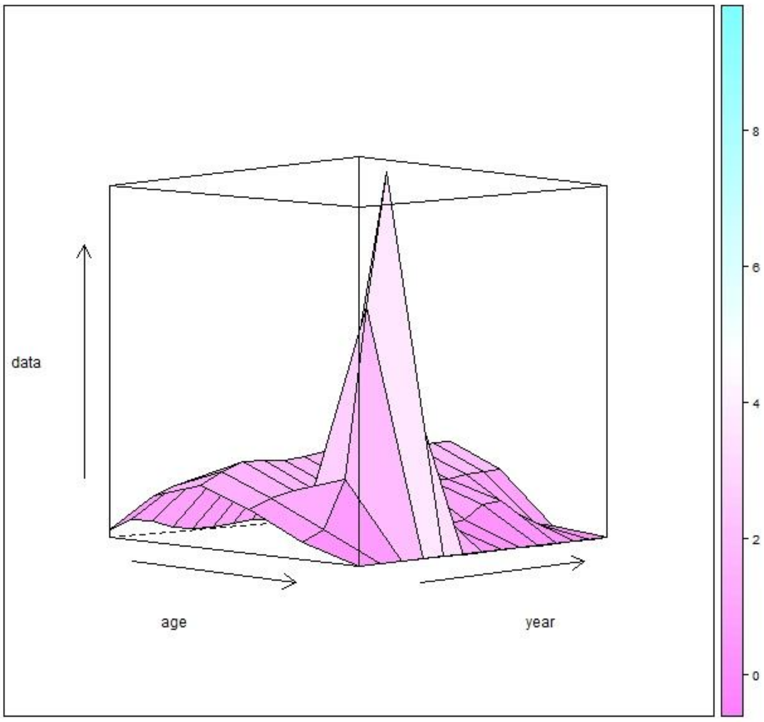


Figure 6.1.3.3. European hake in GSAs 1, 5, 6 and 7. Stock summary from the final a4a model.



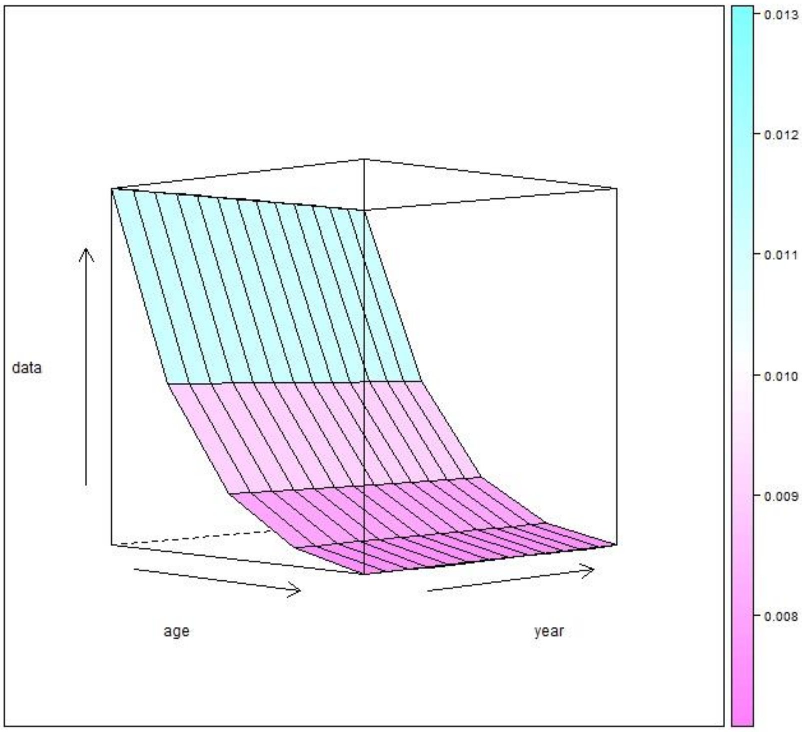
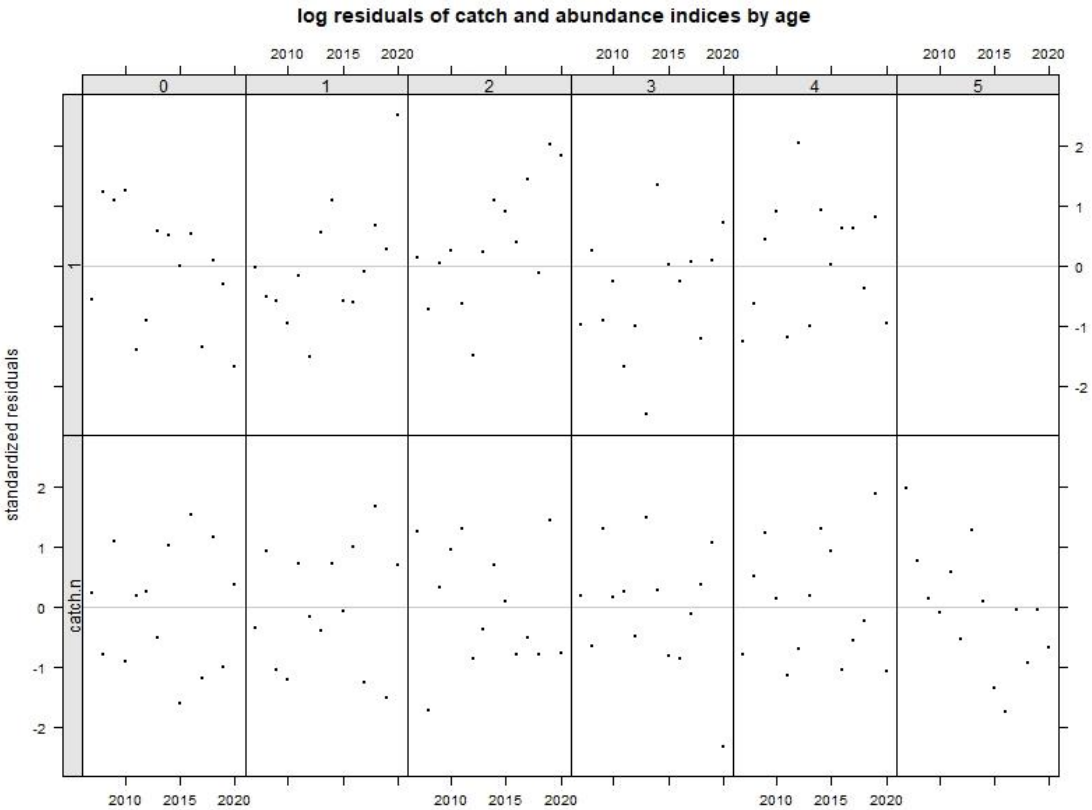


Figure 6.1.3.4. European hake in GSAs 1, 5, 6 and 7. 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.



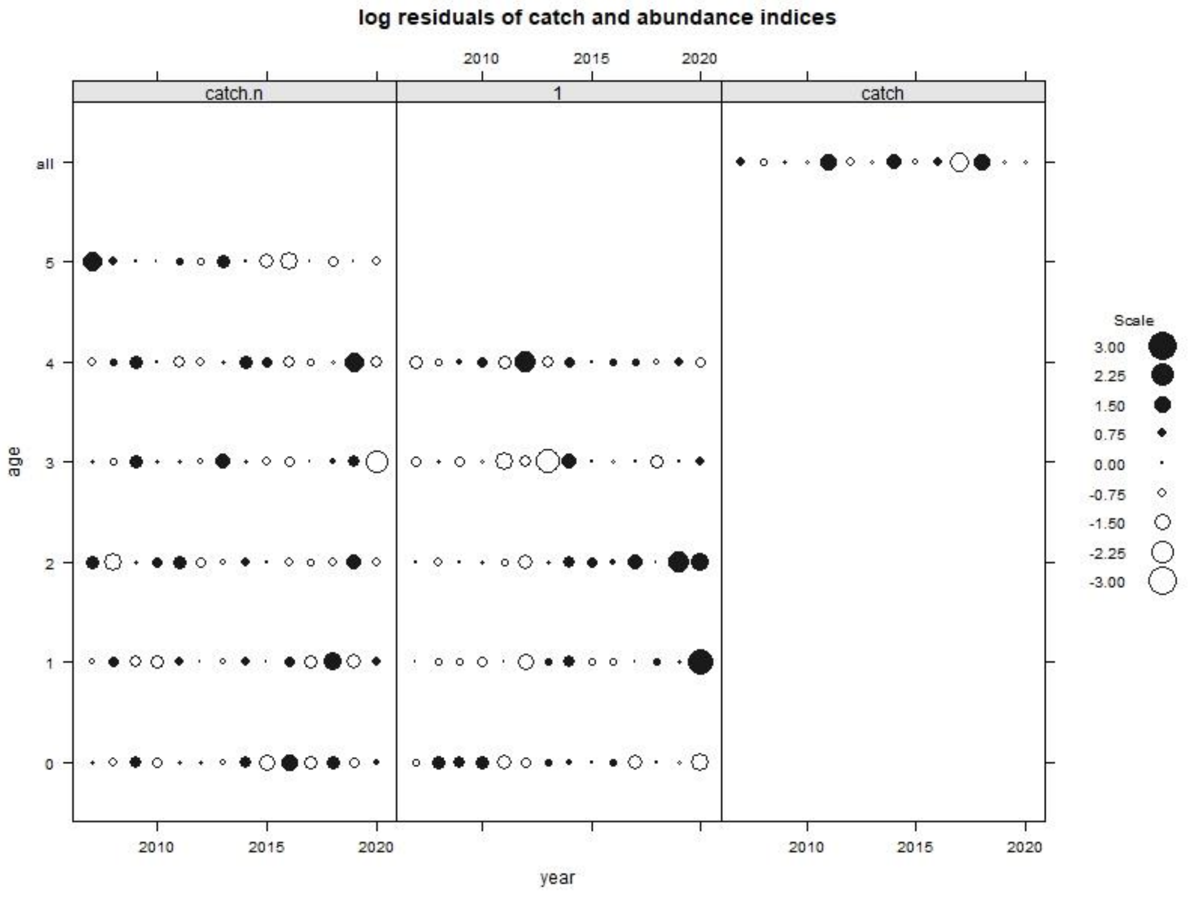


Figure 6.1.3.5. European hake in GSAs 1, 5, 6 and 7. Standardized residuals for abundance indices and for catch numbers.

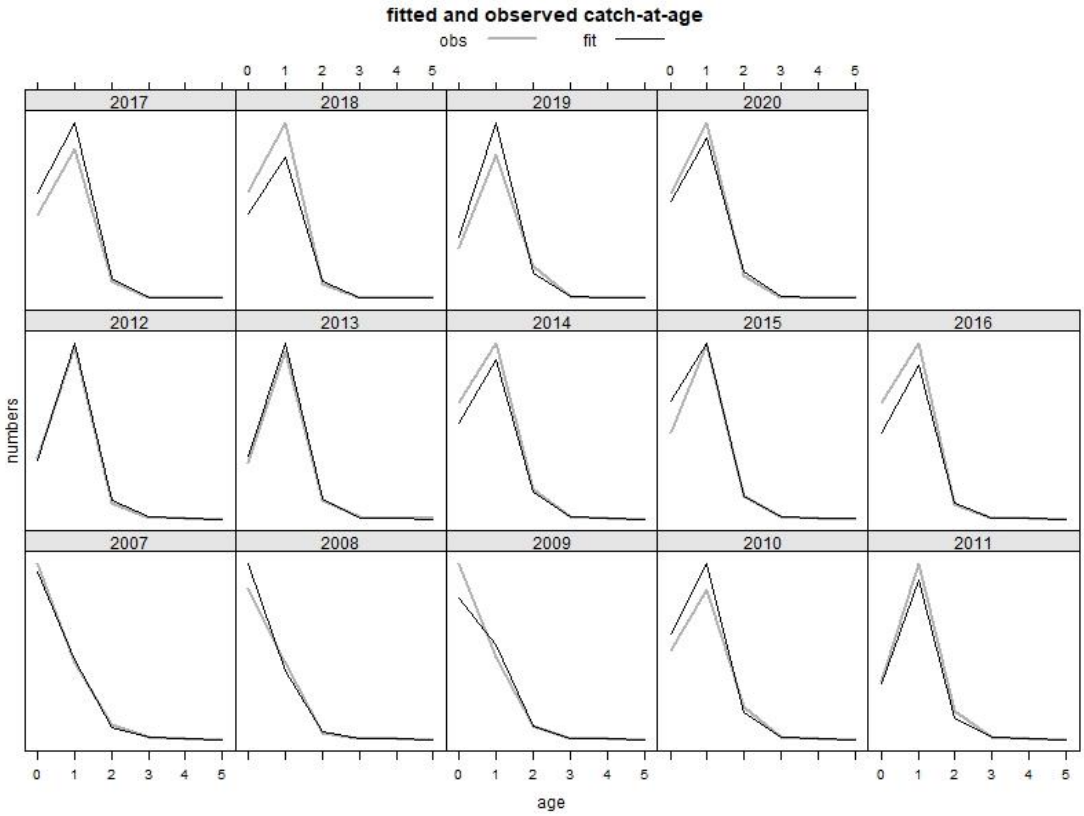


Figure 6.1.3.6. European hake in GSAs 1, 5, 6 and 7. Fitted and observed catch at age.

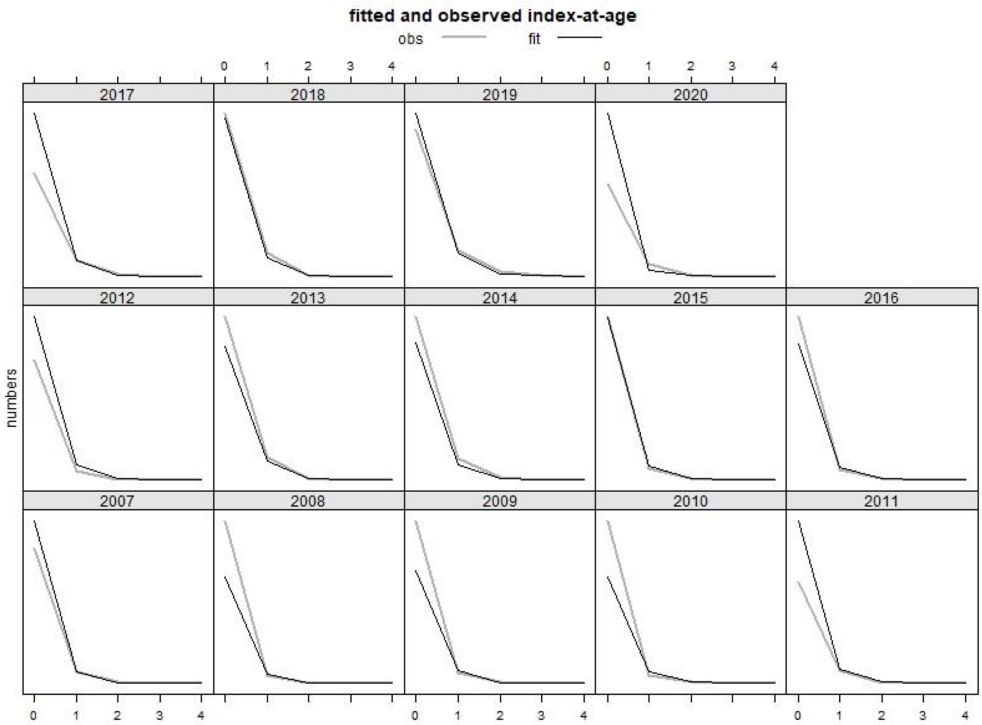


Figure 6.1.3.7. European hake in GSAs 1, 5, 6 and 7. Fitted and observed index at age.

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.

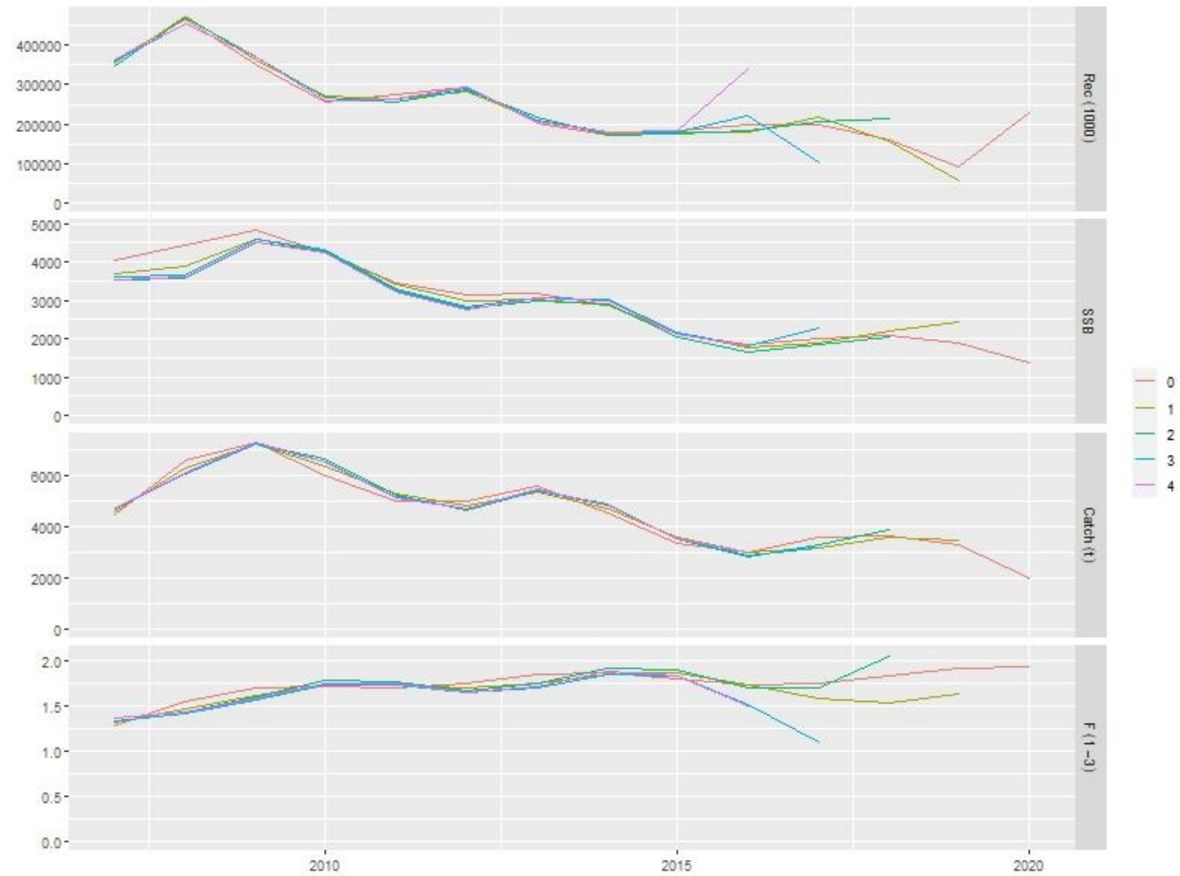


Figure 6.1.3.8. European hake in GSAs 1, 5, 6 and 7. Retrospective analysis.

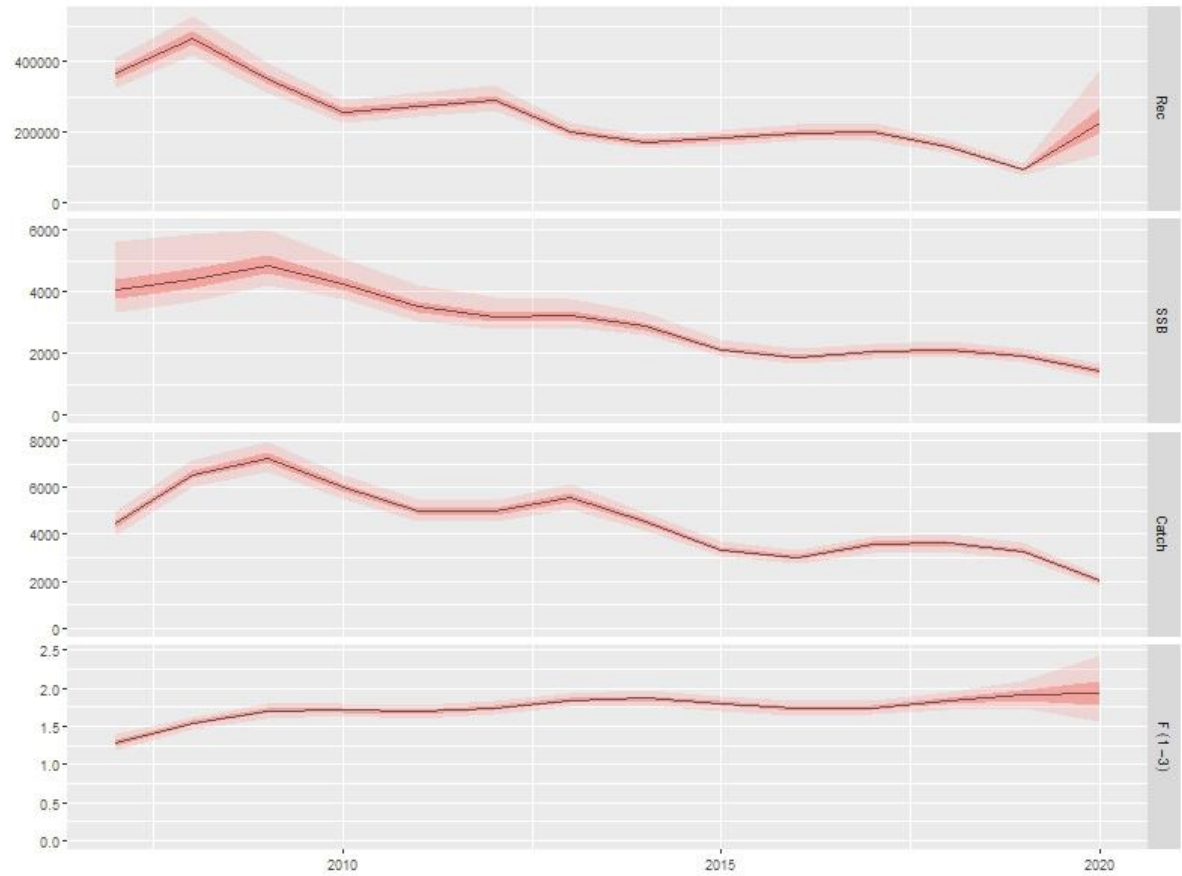


Figure 6.1.3.9. European hake in GSAs 1, 5, 6 and 7. Simulations over summary results.

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 and 7. Stock numbers at age (thousands) as estimated by a4a.

	0	**1**	**2**	**3**	**4**	**5+**
2007	364462	34676	4010	821	375	304
2008	468001	56197	5290	556	202	428
2009	350570	58971	6722	534	110	414
2010	255943	47483	6076	559	92	336
2011	274518	43126	4846	499	96	262
2012	292408	50041	4488	408	87	204
2013	201456	53111	4956	354	68	160
2014	170551	34689	4804	348	54	141
2015	182022	28144	3051	325	52	135
2016	196801	30927	2643	225	51	127
2017	198969	34306	3111	213	38	115
2018	158645	33905	3407	247	36	100
2019	92203	25950	3098	242	38	93
2020	228568	15739	2201	200	35	93

Table 6.1.3.4. European hake in GSAs 1, 5, 6 and 7. a4a summary results and F at age.

	Fbar(1-3)	Recruitment (thousands)	SSB (t)	TB (t)	Catch (t)
2007	1.286	364462	4045	13982	4438
2008	1.546	468001	4429	17100	6549
2009	1.706	350570	4848	17181	7253
2010	1.716	255943	4236	13739	5988
2011	1.695	274518	3478	14166	4989
2012	1.748	292408	3150	14464	4963
2013	1.846	201456	3192	13186	5564
2014	1.876	170551	2855	9824	4513
2015	1.805	182022	2113	8401	3348
2016	1.731	196801	1857	8918	3008
2017	1.745	198969	2015	8960	3547
2018	1.834	158645	2100	8227	3606
2019	1.914	92203	1911	6235	3273
2020	1.942	228568	1401	7188	2011

	F at age					
	0	**1**	**2**	**3**	**4**	**5+**
2007	0.24	1.20	1.57	1.09	0.43	0.02
2008	0.44	1.44	1.88	1.31	0.69	0.03
2009	0.37	1.59	2.08	1.45	1.84	0.03
2010	0.15	1.60	2.09	1.46	5.93	0.03
2011	0.07	1.58	2.06	1.44	9.19	0.03
2012	0.08	1.63	2.13	1.48	4.31	0.03
2013	0.13	1.72	2.25	1.57	1.15	0.03
2014	0.17	1.75	2.28	1.59	0.52	0.03
2015	0.14	1.69	2.20	1.53	0.59	0.03
2016	0.12	1.62	2.11	1.47	0.95	0.03
2017	0.14	1.63	2.13	1.48	1.00	0.03
2018	0.18	1.71	2.23	1.56	0.61	0.03
2019	0.14	1.79	2.33	1.62	0.34	0.03
2020	0.06	1.81	2.36	1.65	0.22	0.03

Based on the a4a results, the European hake SSB shows a decreasing trend from 2009 to 2016 (from 4848 to 1857 tons), with a slight increase in 2017 and 2018 to than decrease again up to 2020 reaching the minimum historical value (1401 tons). The assessment shows a constant decreasing trend in the number of recruits in the time series from 2007 until 2019 that reached the minim of the time series (92203), but in 2020 the model estimated a recruitment peak (228568) that went back to values estimated in 2013 (201456). F_{bar} (1-3) shows an upward trend from 2008 (1.29) until 2014 (1.88) which than declines until 2017 (1.75) and then goes back up until a value of 1.94 in 2020.

6.1.4 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 (1.94, corresponding to the F of the last year of the time series) is 4 times higher than $F_{0.1}$ (0.44), 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.

6.1.5 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 was used for weight at age and maturity at age, while the F_{bar} =1.94 (the last year's F estimated by the assessment model) was used for F in 2021, as F shows a stable trend (See section 4.3). Recruitment is observed to oscillate over the end of the time series (Figure 6.1.3.9), so the last 3 years are used as an estimate of recruits in 2021 to 2022. Recruitment (age 0) was estimated from the population results as the geometric mean of the last 3 years (149530).

Table 6.1.5.1 European hake in GSAs 1, 5, 6 and 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3	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)	1.94	The F estimated in 2020 was used to give F status quo for 2021
SSB (2021)	1482	Stock assessment 1 January 2021
Rage0 (2021,2022)	149530	Geometric mean of the last 3 years
Total Catch (2021)	3674	Assuming F status quo for 2021

Table 6.1.5.2. European hake in GSAs 1, 5, 6 and 7. Short term forecast in different F scenarios.

Scenario	Fbar	Catch 2022	SSB 2021	SSB 2023	SSB_2021-2023(%)	Catch_2020-2022(%)
F0.1	0.444	1220	1482	4601	210.48	-39.35
F upper	0.608	1559	1482	3993	169.46	-22.49
F lower	0.296	867	1482	5248	254.14	-56.91
F_{MSY} transition	1.179	2435	1482	2507	69.19	21.08
Zero catch	0.000	0	1482	6881	364.37	-100.00
Status quo	1.942	3127	1482	1481	-0.07	55.47
Different Scenarios	0.194	594	1482	5756	288.41	-70.47
	0.388	1091	1482	4835	226.25	-45.73
	0.583	1510	1482	4080	175.32	-24.92
	0.777	1863	1482	3461	133.55	-7.35
	0.971	2163	1482	2953	99.26	7.54
	1.165	2418	1482	2535	71.07	20.22
	1.359	2636	1482	2191	47.87	31.07
	1.553	2824	1482	1908	28.75	40.40
	1.748	2986	1482	1674	12.97	48.46
	2.136	3250	1482	1321	-10.87	61.59
	2.330	3358	1482	1188	-19.83	66.98
	2.524	3454	1482	1078	-27.28	71.74
	2.718	3539	1482	986	-33.49	75.97
	2.913	3616	1482	909	-38.67	79.77
	3.107	3684	1482	844	-43.02	83.18
	3.301	3746	1482	790	-46.67	86.27
	3.495	3803	1482	745	-49.75	89.09
	3.689	3855	1482	706	-52.36	91.68
	3.883	3903	1482	673	-54.58	94.06

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. Due to the Covid-19 outbreak MEDITS survey was delayed and only half of the hauls were carried out.

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. Due to the Covid-19 outbreak the MEDITS survey was not carried out in GSA 1 and in the first part of GSA 6.

No length measurements were recorded for commercial data in GSA 7 this year.

6.2 Deep-water rose shrimp in GSA 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, 6.2.2, 6.2.3 and 6.2.4 respectively.

6.2.1 Deep-water rose shrimp in GSA 1

6.2.1.1 Stock Identity and Biology

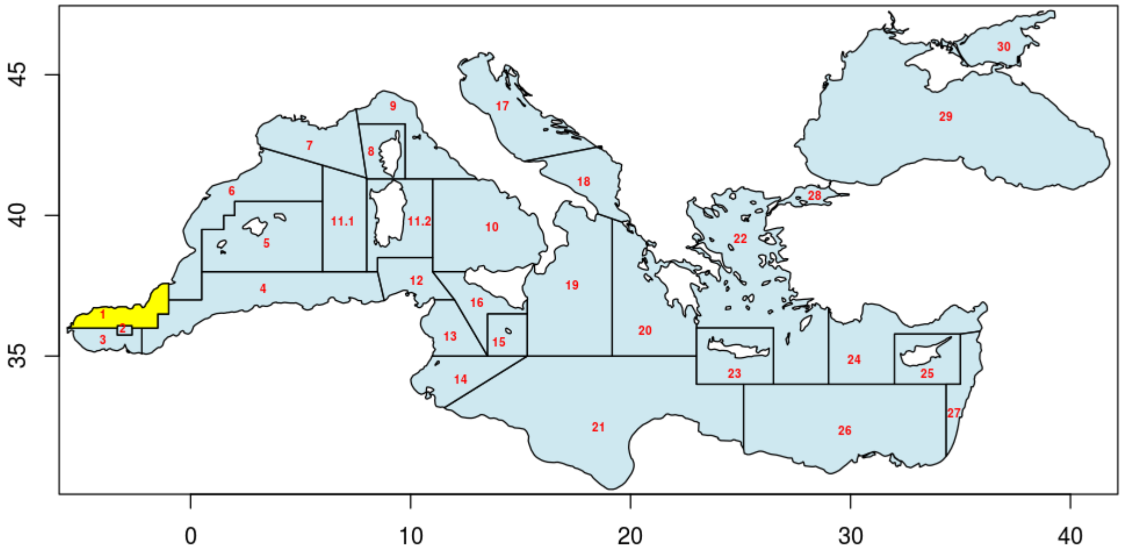


Figure 6.2.1.1.1. Geographical location of GSA 1.

STECF EWG 21-11 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 GFCM assessment.

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 latest GFCM assessment.

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 21-11 through the DCF. In GSA 1most 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 (Table 6.2.1.2.1.1).

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

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
209.8	187.2	118.1	103.0	37.6	56.2	108.9	253.9	97.6	171.6
2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
241.5	149.1	100.4	108.6	136.8	201.8	329.6	354.2	482.9	

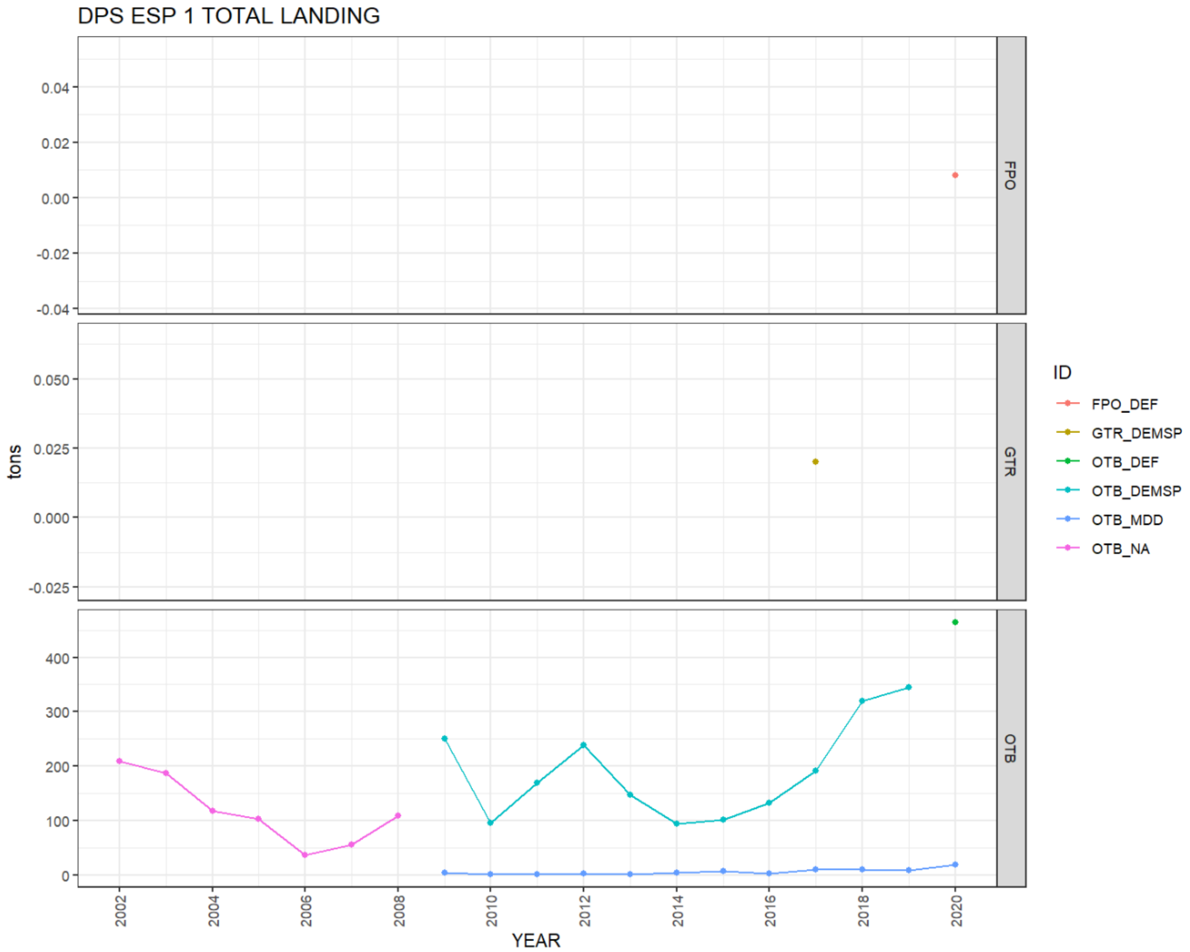


Figure 6.2.1.2.1.1. Deep-water rose shrimp GSA 1. Landings data in tonnes by year and fleet in GSA 1.

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. Recontructed 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.

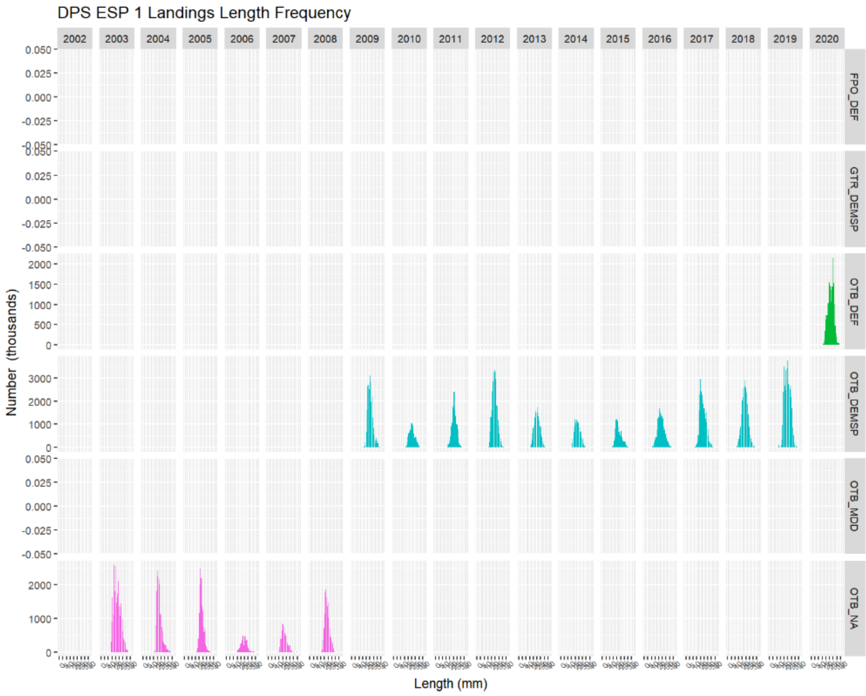


Figure 6.2.1.2.1.2. Deep-water rose shrimp GSA 1. Original length frequency distribution of the landings by year and fleet in GSA 1.

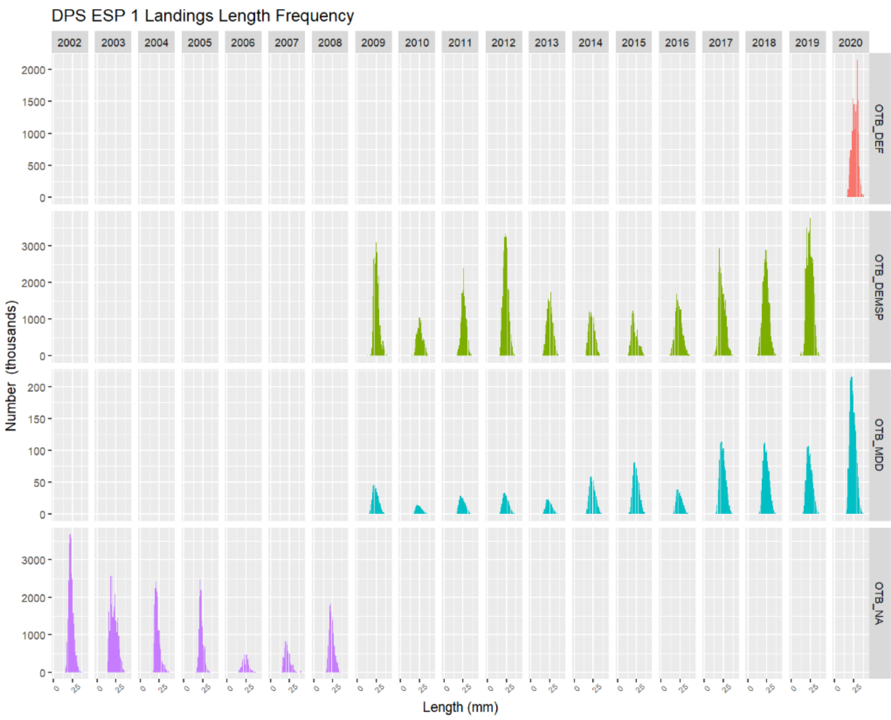


Figure 6.2.1.2.1.3. Deep-water rose shrimp GSA 1. Reconstructed length frequency distribution of the landings by year and fleet in GSA 1.

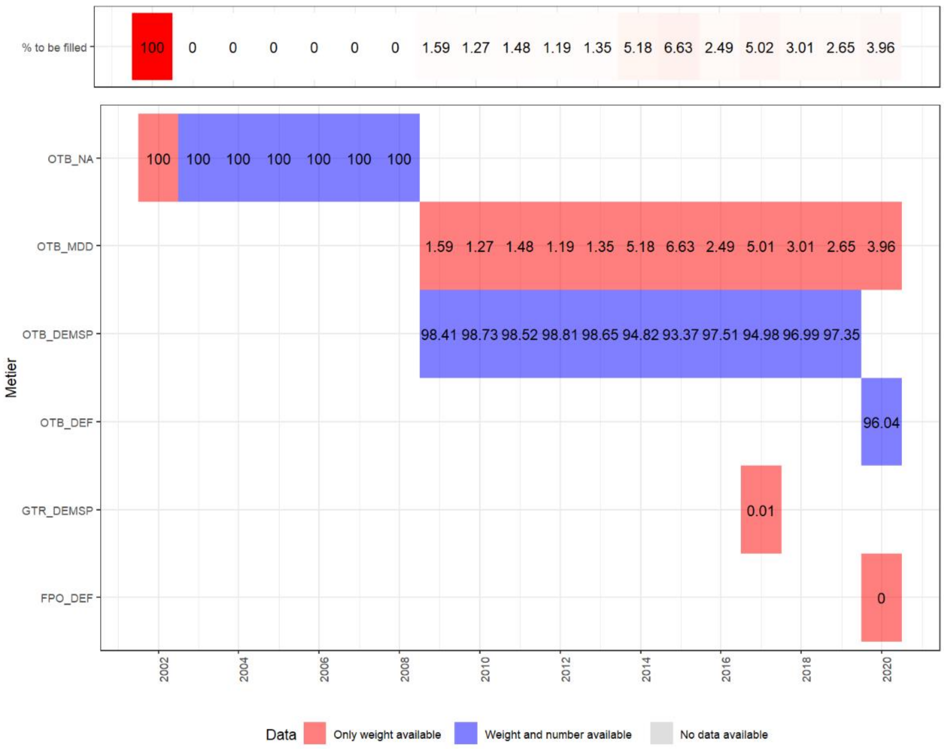


Figure 6.2.1.2.1.4. Deep-water rose shrimp GSA 1. Reconstruction of the length frequency distribution of the landings by year and fleet in GSA 1. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

Discards

Discards data were reported to STECF EWG 21-11 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	1.77
2010	1.81	1.82
2011	0.38	0.40
2012	1.65	1.67
2013	0.87	0.88
2014	4.25	4.28
2015	1.17	1.22
2016	0.88	0.90
2017	1.71	1.78
2018	0.66	0.73
2019	1.07	1.13
2020	2.00	2.13

The percentages of the weight of the discards reconstructed are presented in Figure 6.2.1.2.1.5.

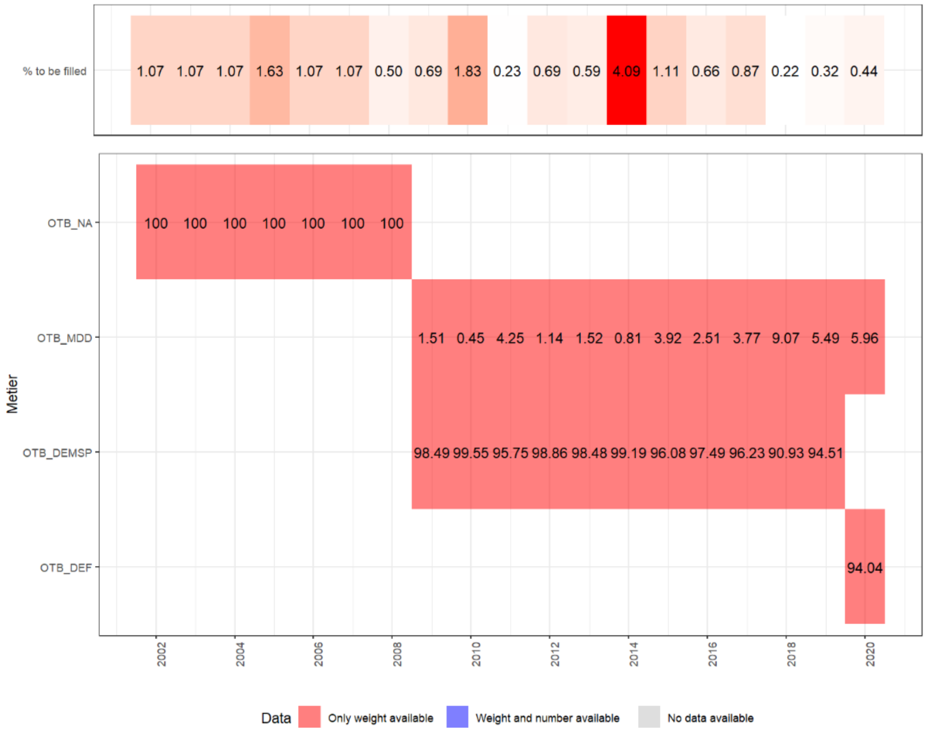


Figure 6.2.1.2.1.5. Deep-water rose shrimp GSA 1. Reconstruction of the the discards by year and fleet in GSA 1. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total catches per year. The lower panel shows the percentage of the weight of each metier to 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.

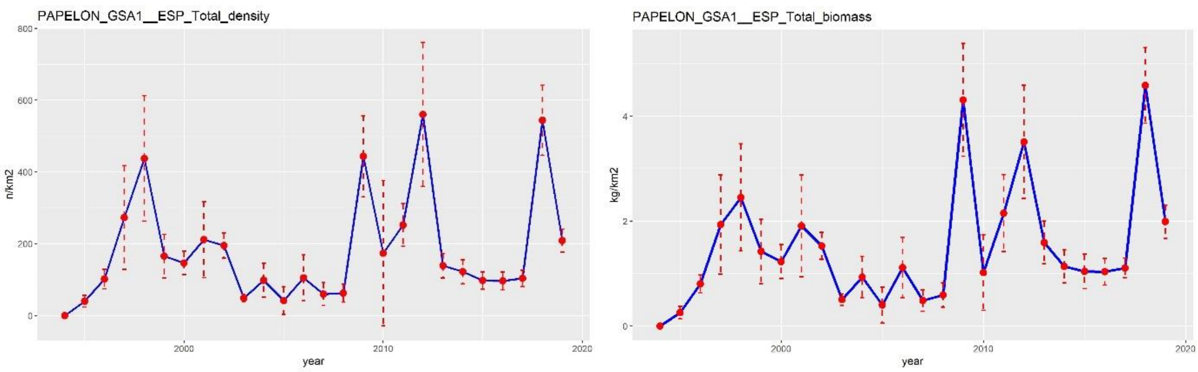


Figure 6.2.1.2.2.1. Deep-water rose shrimp GSA 1. Estimated density (N/km^2) and biomass (kg/km^2) indices in GSA 1.

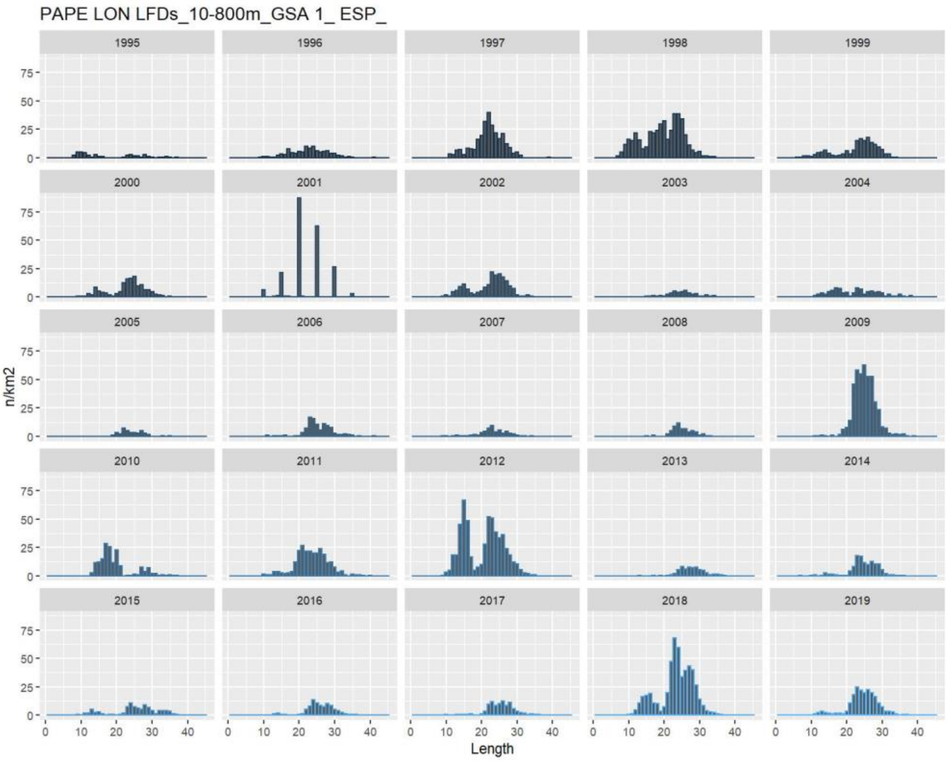


Figure 6.2.1.2.2.2. Deep-water rose shrimp GSA 1. Length frequency distribution by year of MEDITS GSA 1.

The length frequency distributions of the Spanish MEDITS in 2001 are wrong. This issue has been recurring and needs to be fixed.

6.2.1.3 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 2003-2019 for the catch data (landings + discards) and 2003-2019 for the tuning file due to the missing MEDITS in 2020. Sensitivity analyses has been done for the inclusion of the 2020 catch data in the assessment. Both catch numbers at length and index number at length were sliced using the l2a routine in FLR using the GSA 1 growth parameters. The t0 of the von Bertalanffy was 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.

Year	SOP	Year	SOP
2003	1.05	**2012**	1.01
2004	1.05	**2013**	1.01
2005	1.06	**2014**	1.10
2006	1.06	**2015**	1.40
2007	1.24	**2016**	1.01
2008	1.05	**2017**	1.02
2009	1.11	**2018**	1.40
2010	1.12	**2019**	1.01
2011	1.11	**2020**	2.35

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)

2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
189.2	119.4	104.7	38.0	56.8	109.4	255.7	99.4	172.0
2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
243.2	150.0	104.7	109.8	137.7	203.6	330.3	355.3	485.1

Catch numbers-at-age matrix (thousands)

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	1265.429	21.2399	4.9009	17.1765	7.7974	4.9846	18.2617	16.3061	9.661
1	21470.28	15825.88	13056.43	3500.749	7463.38	12719.14	20749.24	7379.014	11983.38
2	4284.248	1344.88	1333.77	913.9936	903.1745	1759.053	6038.068	2818.028	5326.475
3+	306.965	207.9677	47.1606	72.9519	59.229	29.2414	1005.515	252.4357	246.9549
Age	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
0	2.8597	4.5638	5.7127	157.4058	653.8664	299.5192	909.5688	204.5605	20.0292
1	24177.09	12074.05	11865.32	13180.82	14077.63	21708.21	33027.45	29456.43	24507.59
2	5238.166	4286.164	2142.031	2078.626	2919.955	4656.132	7180.116	10738.5	19693.74
3+	184.8103	244.0674	48.5544	162.9426	343.5594	392.1342	569.3049	453.3911	1551.474

Weights-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	0.006	0.006	0.007	0.007	0.006	0.007	0.008	0.008	0.008
2	0.013	0.014	0.012	0.013	0.013	0.013	0.013	0.014	0.013
3+	0.021	0.021	0.020	0.021	0.024	0.023	0.020	0.020	0.020
Age	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
0	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
2	0.013	0.013	0.013	0.014	0.014	0.013	0.013	0.013	0.014
3+	0.020	0.020	0.020	0.020	0.021	0.020	0.021	0.021	0.020

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	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	1.48	14.90	0.14	2.55	4.40	0.61	2.23	26.18	13.34
1	35.03	61.23	33.97	73.28	47.47	47.24	359.21	123.34	195.83
2	10.10	16.82	6.19	26.01	7.46	14.00	74.74	16.76	39.58
3	1.78	5.68	1.23	3.82	0.68	0.31	7.63	2.70	3.38
age	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
0	157.31	0.29	5.77	15.47	4.56	2.99	51.80	11.94	
1	350.59	31.06	85.01	43.07	57.48	69.66	363.74	147.66	
2	50.77	29.07	30.45	29.24	31.95	25.31	96.65	45.61	

3	1.94	4.84	0.96	9.68	2.49	3.07	4.66	3.36

Figures 6.2.1.3.1-6.2.1.3.2-6.2.1.3.3 show the age structure of the catches, of the index and the weight at age matrix.

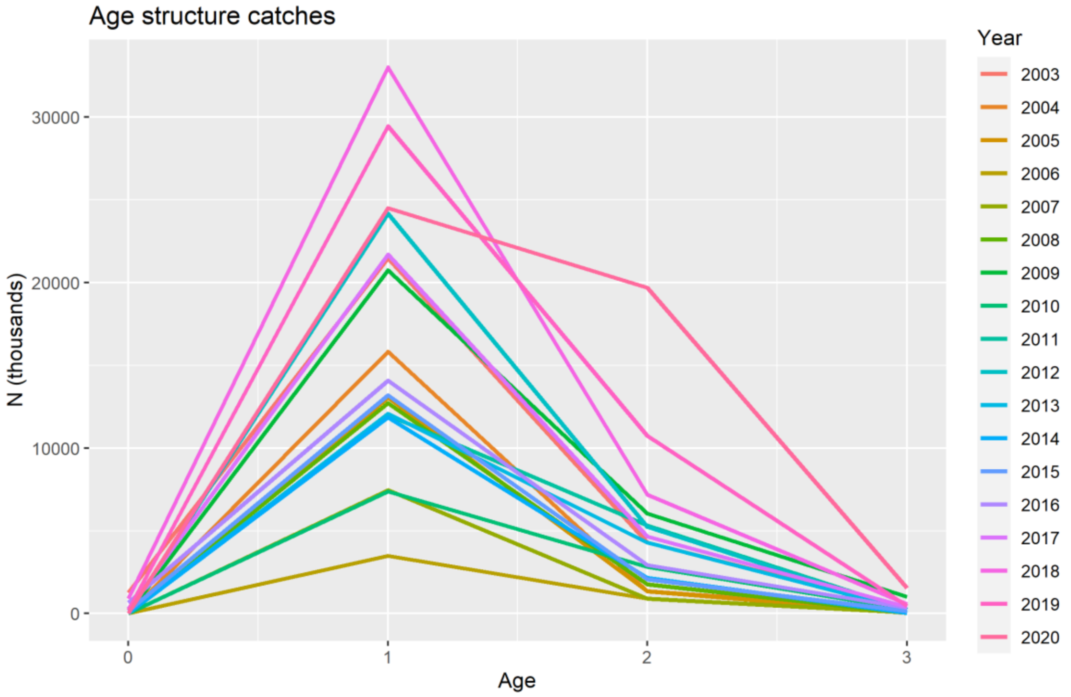


Figure 6.2.1.3.1. Deep-water rose shrimp GSA 1. Age structure of the catches.

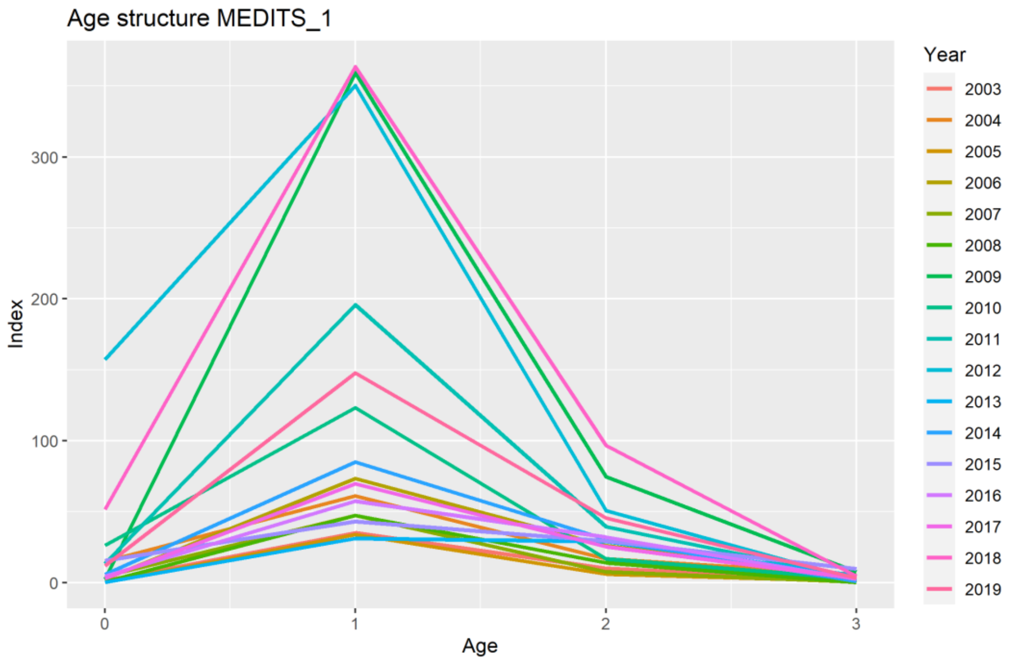


Figure 6.2.1.3.2. Deep-water rose shrimp GSA 1. Age structure of the index.

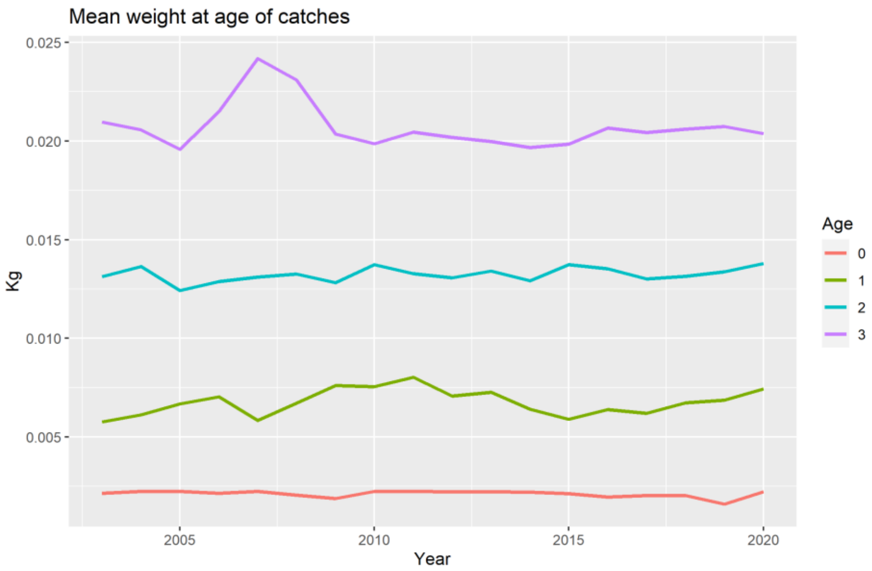


Figure 6.2.1.3.3. Deep-water rose shrimp GSA 1. Weight at age matrix.

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 = 6)

q ~ list(~ s(replace(age, age> 2, 2), k=3))

sr ~ factor(year)

Results are shown in Figures 6.2.1.3.4-6.2.1.3.10.

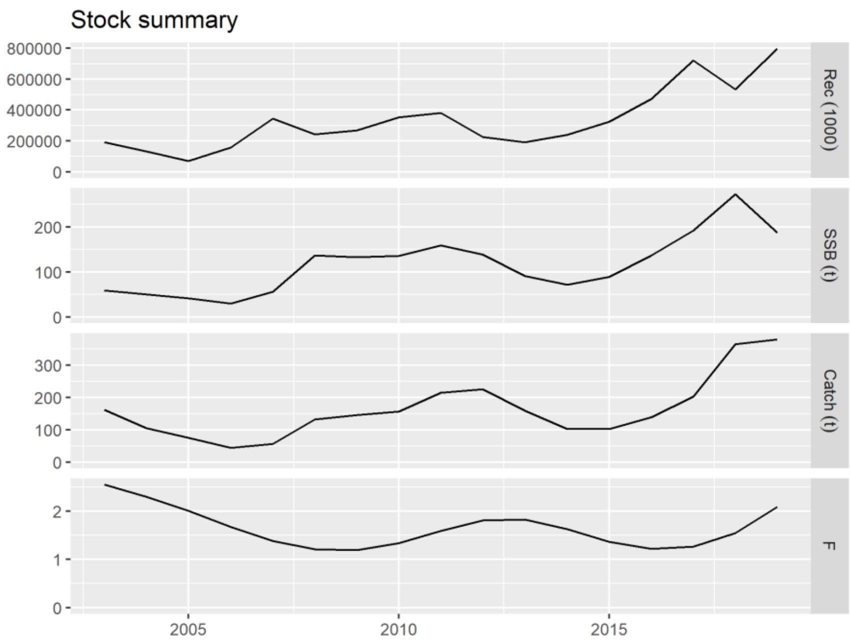


Figure 6.2.1.3.4. Deep-water rose shrimp GSA 1. Stock summary from the a4a model for Deep-water rose shrimp GSA 1 recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 2).

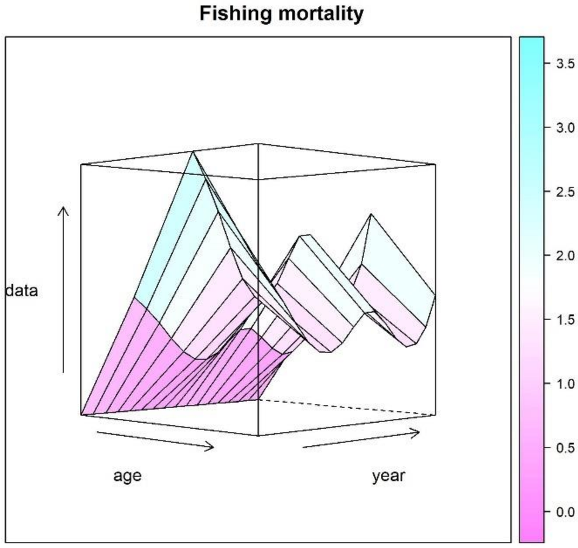


Figure 6.2.1.3.5. Deep-water rose shrimp GSA 1. 3D contour plot of estimated fishing mortality at age and year.

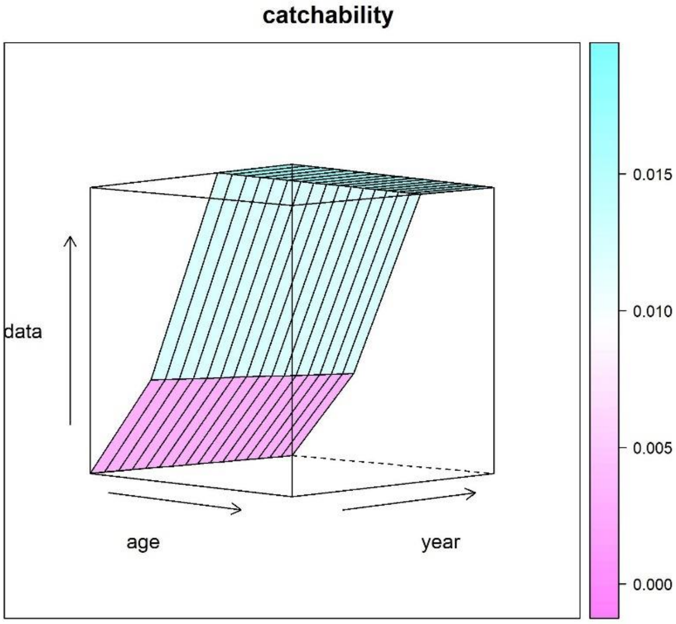


Figure 6.2.1.3.6. Deep-water rose shrimp GSA 1. 3D contour plot of estimated catchability at age and year.

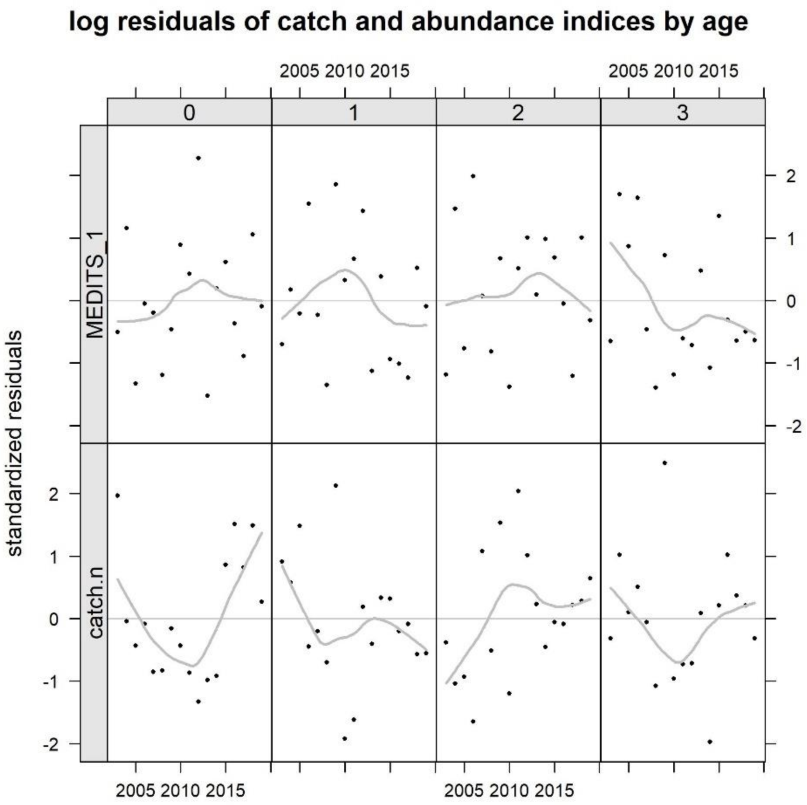


Figure 6.2.1.3.7. Deep-water rose shrimp GSA 1. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines simple smoothers.

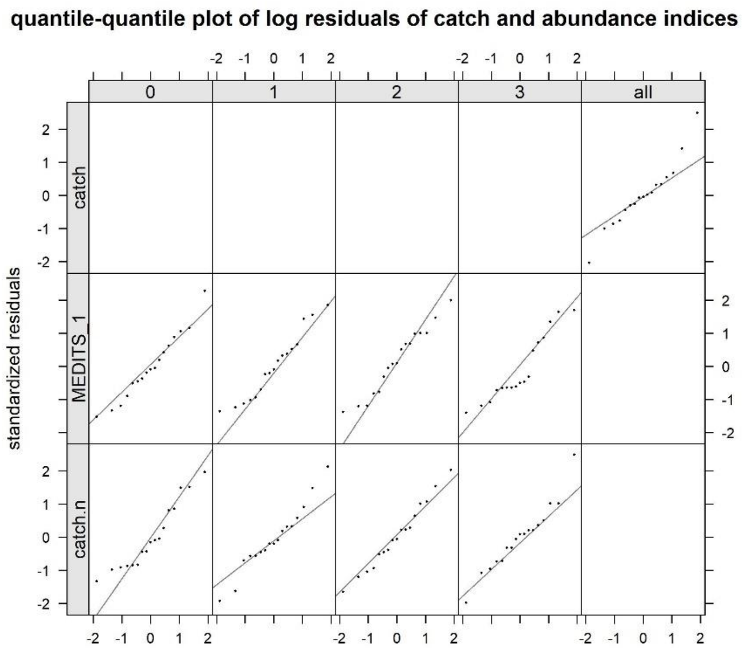


Figure 6.2.1.3.8. Deep-water rose shrimp GSA 1. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

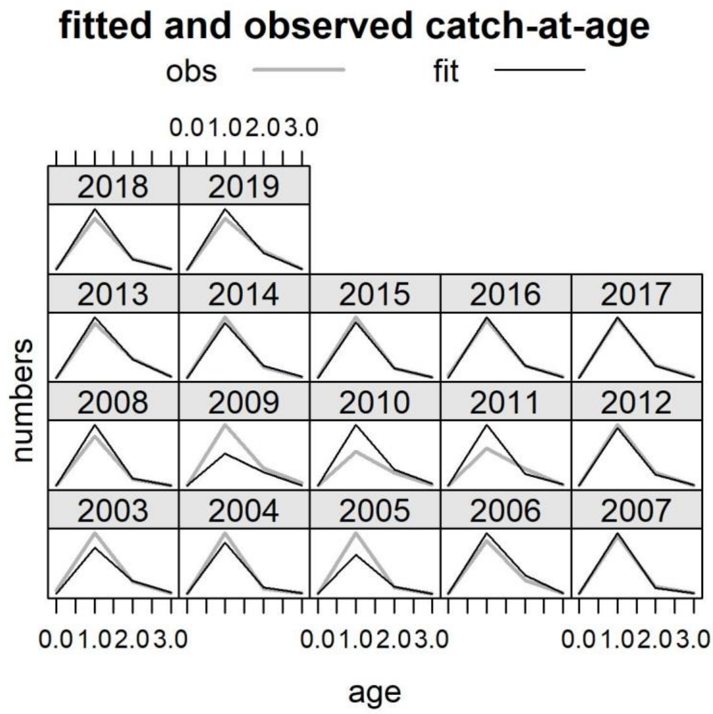


Figure 6.2.1.3.9. Deep-water rose shrimp GSA 1. Fitted and observed catch at age.

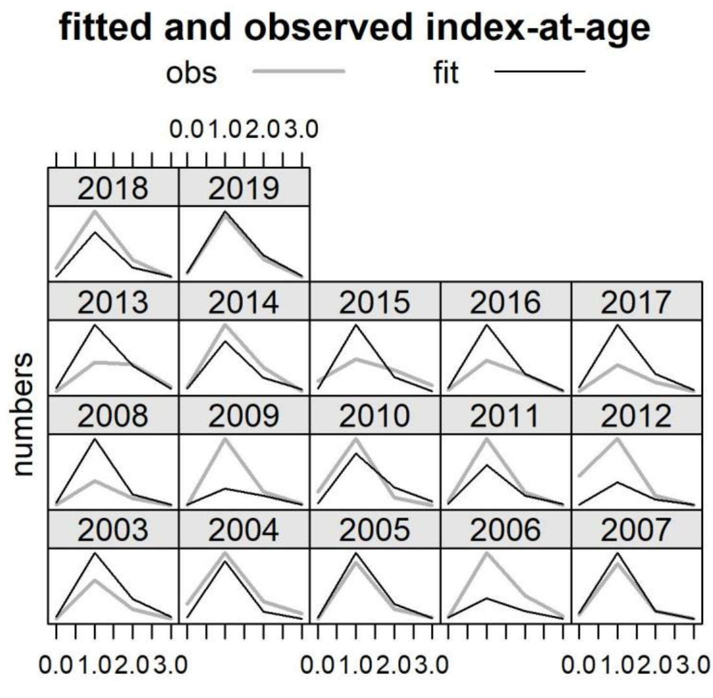


Figure 6.2.1.3.10. Deep-water rose shrimp GSA 1. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 2 years back. Model results were quite stable with the exception of recruitment (Figure 6.2.1.3.11).

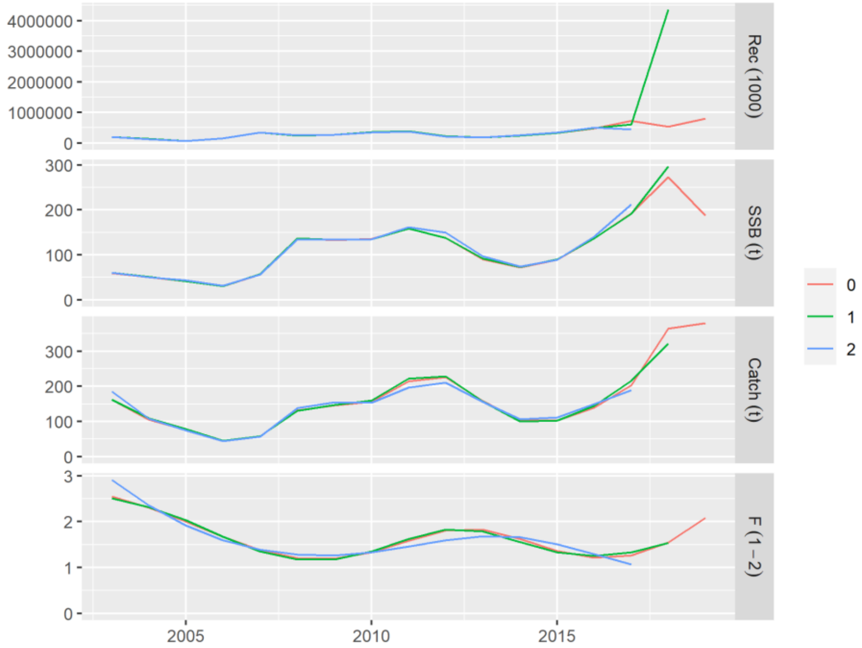


Figure 6.2.1.3.11. Deep-water rose shrimp GSA 1. Retrospective analysis output for the a4a model.

Simulations

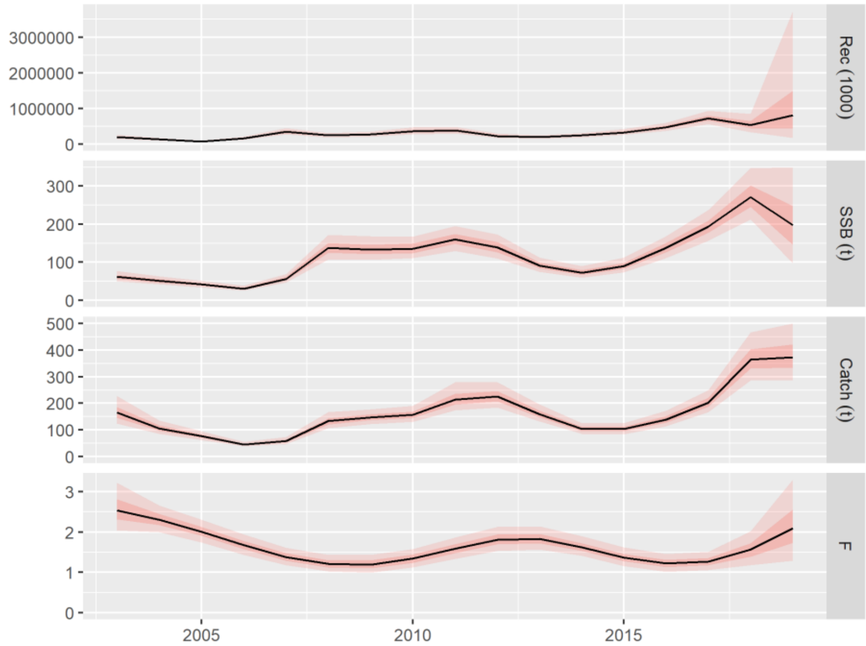


Figure 6.2.1.3.12. Deep-water rose shrimp GSA 1. Stock summary of the simulated and fitted data for the a4a model.

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	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	192939	131002	70246	158008	343609	241800	268067	353607	380805
1	28884	24827	16858	9040	20335	44224	31121	34502	45511
2	5425	1951	1965	1611	1071	2906	7054	5013	5076
3+	503	141	64	81	108	117	348	879	668

age	2012	2013	2014	2015	2016	2017	2018	2019
0	225532	191578	240426	325660	471495	722242	533675	797395
1	49009	29024	24655	30942	41914	60685	92957	68684
2	5697	5315	3109	3012	4467	6648	9341	11938
3+	460	349	305	250	324	566	814	807

Based on the a4a results, the Deep-water rose shrimp SSB fluctuated around 90 tons at the beginning of the time series and then increased from 2014 reaching a maximum of 273tons in 2018. In 2019 the SSB is 187 tons. The assessment shows an increasing trend in the number of recruits in the last years. The recruitment (age 0) reached a maximum of 797395 thousand individuals in 2019. F_{bar} (1-2) shows an increasing trend from around 1.22 in 2016 up to a value of 2.09 in 2019. The values of F at age show extremely high values particularly for age 2.

The sensitivity analysis including the year 2020 in the assessment shows a different perception of the stock with fishing mortality decreasing in the last years. Moreover, it shows important signs of instability as can be seen in the retrospective plot in Figure 6.2.1.3.13

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)
2003	2.55	192939	59.18	660.47	162.38
2004	2.30	131002	50.15	473.46	105.48
2005	2.01	70246	41.22	294.96	76.20
2006	1.67	158008	30.32	426.12	44.97
2007	1.38	343609	56.22	901.47	57.61
2008	1.21	241800	136.65	833.07	132.40
2009	1.19	268067	132.79	835.26	146.44
2010	1.34	353607	135.38	1135.05	156.53
2011	1.59	380805	159.14	1295.15	214.80
2012	1.81	225532	138.19	932.54	225.27
2013	1.83	191578	90.55	715.87	158.76
2014	1.62	240426	72.04	734.82	102.51
2015	1.36	325660	89.44	923.04	102.25
2016	1.22	471495	136.98	1251.60	139.12
2017	1.26	722242	192.22	1935.35	202.51

2018	1.55	533675	272.62	1849.57	363.97
2019	2.09	797395	187.10	1911.31	379.22

F at age	**0**	**1**	**2**	**3+**
2003	0.0005	1.63	3.46	2.01
2004	0.0004	1.48	3.13	1.82
2005	0.0004	1.29	2.73	1.59
2006	0.0003	1.07	2.27	1.32
2007	0.0002	0.89	1.87	1.09
2008	0.0002	0.78	1.64	0.96
2009	0.0002	0.77	1.62	0.94
2010	0.0002	0.86	1.81	1.05
2011	0.0003	1.02	2.16	1.25
2012	0.0003	1.16	2.46	1.43
2013	0.0003	1.17	2.49	1.45
2014	0.0003	1.04	2.21	1.28
2015	0.0002	0.88	1.85	1.08
2016	0.0002	0.78	1.65	0.96
2017	0.0002	0.81	1.72	1.00
2018	0.0003	0.99	2.10	1.22
2019	0.0004	1.34	2.83	1.65

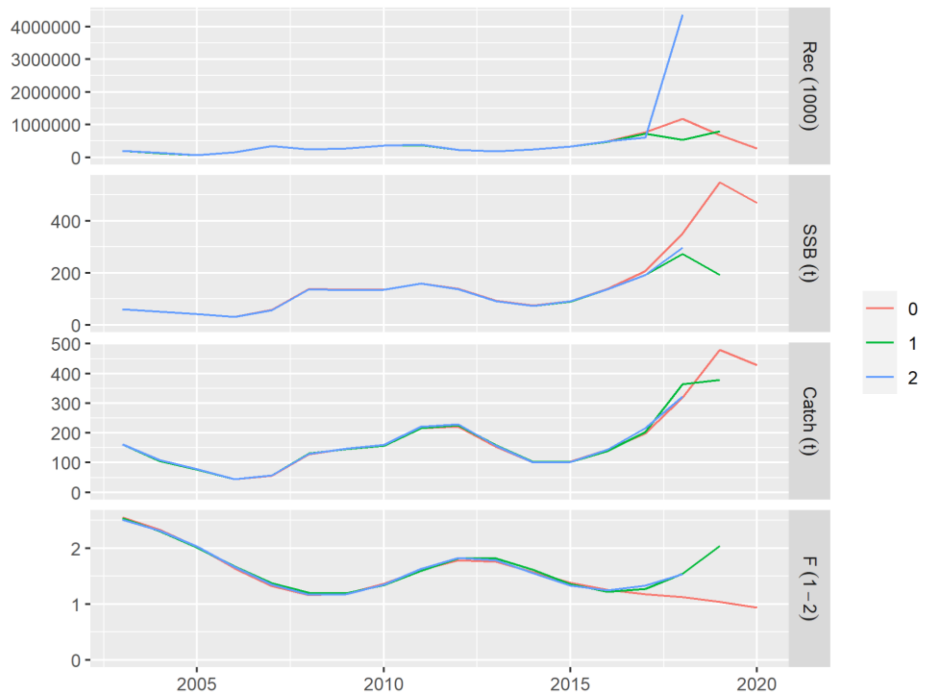


Figure 6.2.1.3.13. Deep-water rose shrimp GSA 1. Retrospective analysis output for the a4a model including catch data for 2020.

Due to the high fishing mortality and to the instability of the model including the catch data of 2020 (but with missing MEDITS), the EWG 21-1 concluded that the output of this model was not suitable to provide the basis of the current status of the stock.

6.2.1.4 Reference Points

As the assessment carried out during EWG 21-11 was not accepted for advice, reference points were not calculated.

6.2.1.5 Short term Forecast and Catch Options

As the assessment carried out during EWG 21-11 was not accepted for advice no short term forecast has been performed. Combined catch advice given in 2020 for both 2021 and 2022 (EWG 20-09) is provided again for 2022, see section 5.2.

6.2.1.6 Data Deficiencies

Data from DCF 2020 as submitted through the Official data call in 2021 were used.

In GSA 1, length frequency distributions were not available for 2002.

Length frequency distributions of the discards were not available in the DCF data.

MEDITS 2020 was not performed in GSA 1 in 2020.

The length frequency distributions in the Spanish MEDITS for 2001 should be checked thoroughly because are considered to be wrong.

6.2.2 DEEP-WATER ROSE SHRIMP IN GSA 5

6.2.2.1 STOCK IDENTITY AND BIOLOGY

GSA 5 (Figure 6.2.2.1.1) 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) 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; 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.

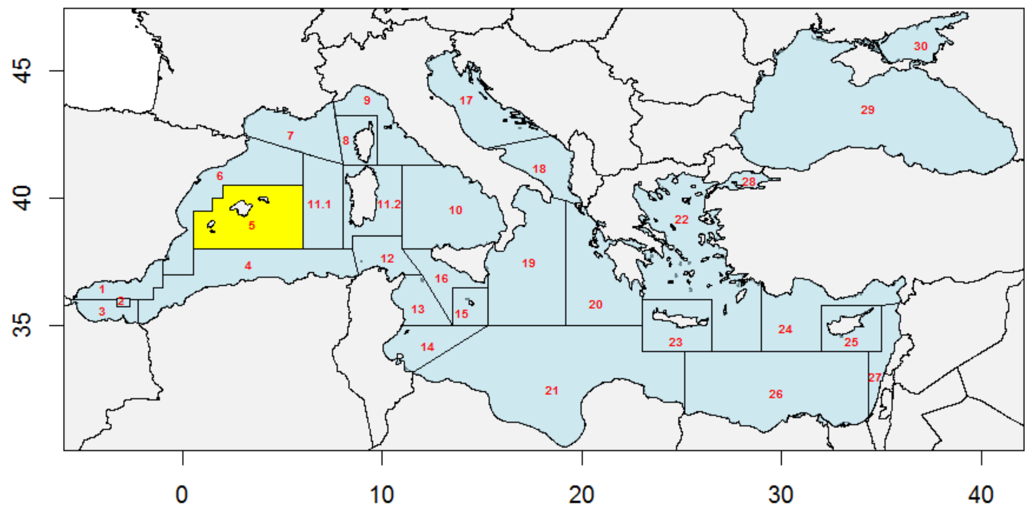


Figure 6.2.2.1.1. Geographical location of GSA 5.

STECF EWG 21-11 was asked to assess the state of Deep-water rose shrimp stocks in the GSA 5. 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 GFCM assessment (Table 6.2.2.1.1).

Table 6.2.2.1.1. Deep-water rose shrimp GSA 5. Growth parameters and length-weight relationship parameters.

Source	Area	L_∞	K	t_0	a	b

Guijarro et al., 2009	GSA 5	44	0.67	-0.21	0.0022	2.5626

Maturity and Natural mortality have also been assumed to be equal to the values used in the latest GFCM assessment (Table 6.2.2.1.2).

Table 6.2.2.1.2. Deep-water rose shrimp GSA 5. Proportion of mature specimens at age and natural mortality at age.

Age	Area	0	1	2	3+
Maturity	GSA 5	0.11	0.62	0.96	1.00
M	GSA 5	1.42	0.83	0.71	0.64

6.2.2.2 DATA

6.2.2.2.1 CATCH (LANDINGS AND DISCARDS)

General description of 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 deep water rose shrimp *P. longirostris* is mainly caught 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.

Landings

Landings data were reported to STECF EWG 21-11 through the DCF. In GSA 5, the speces is exclusively caught by bottom trawls (Table 6.2.2.2.1, Figure 6.2.2.2.1).

Table 6.2.2.2.1. Deep-water rose shrimp GSA 5. Landings data in tonnes by fleet.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
OTB	36.18	22.13	6.53	1.6	1.01	1.39	5.2	5.11	6.25	4.53

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	
OTB	4.17	6.2	5.59	7.58	9.09	68.03	101.16	59.76	67.9	

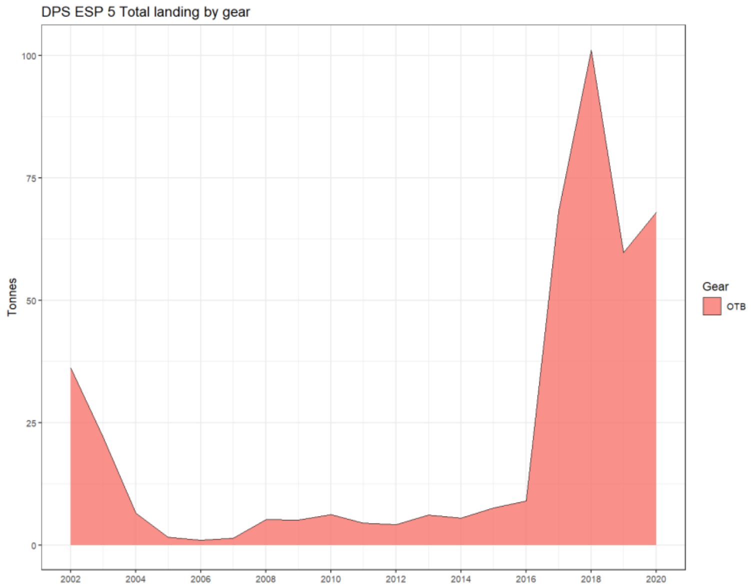


Figure 6.2.2.2.1. Deep-water rose shrimp GSA 5. Landings data in tonnes by year and fleet in GSA 5.

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.2.2.2.2.

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. Recontructed length frequency distribution of the landings by year and fleet and the reconstruction procedure are presented in Figure 6.2.2.2.3 and Figure 6.2.2.2.4.

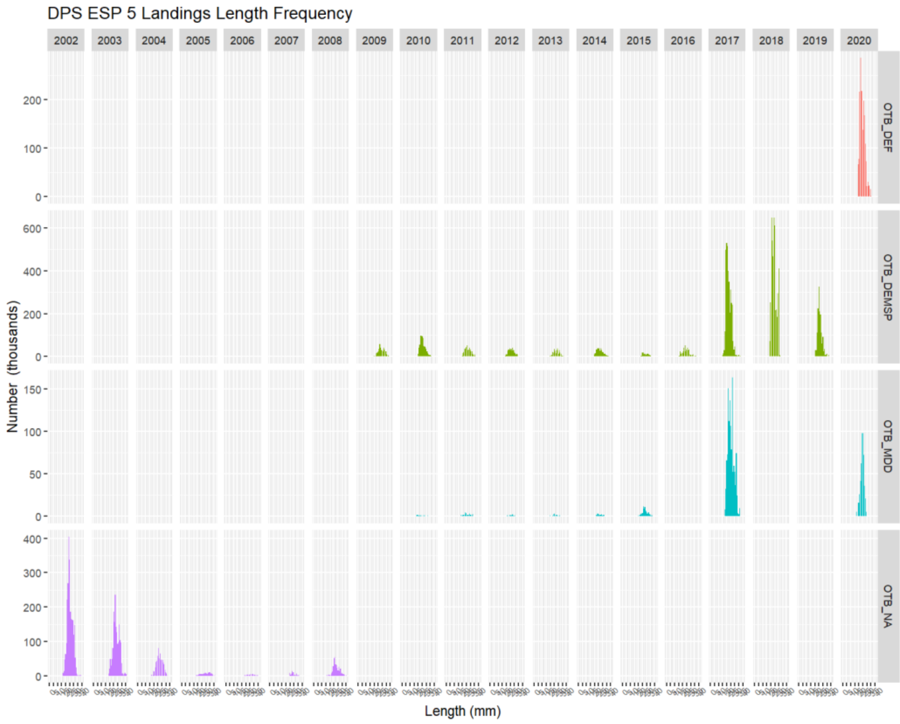


Figure 6.2.2.2.2. Deep-water rose shrimp GSA 5. Original length frequency distribution of the landings by year and fleet in GSA 5.

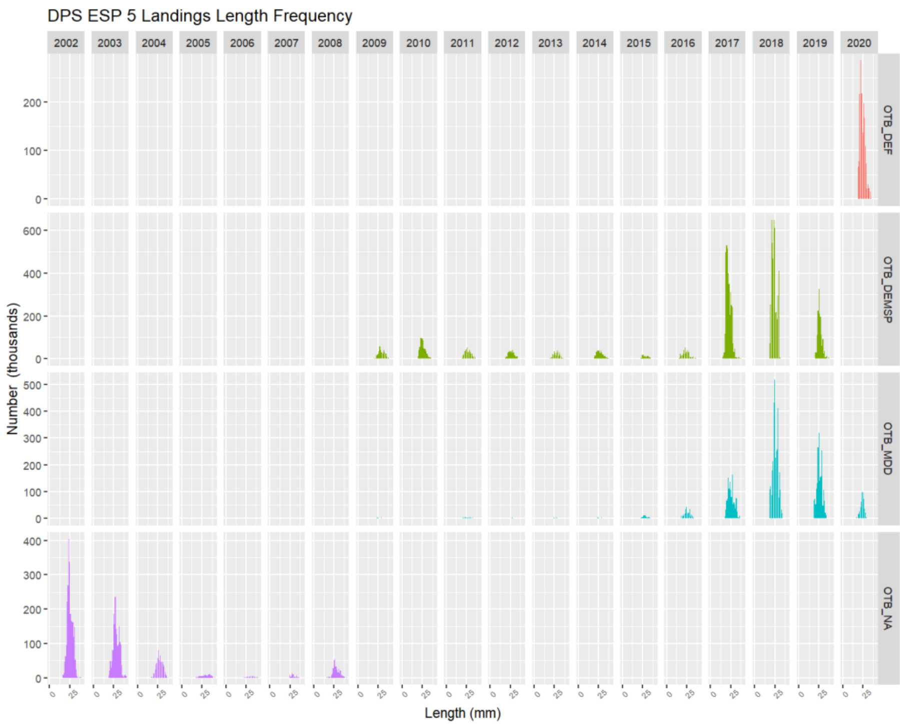


Figure 6.2.2.2.3. Deep-water rose shrimp GSA 5. Reconstructed length frequency distribution of the landings by year and fleet in GSA 5.

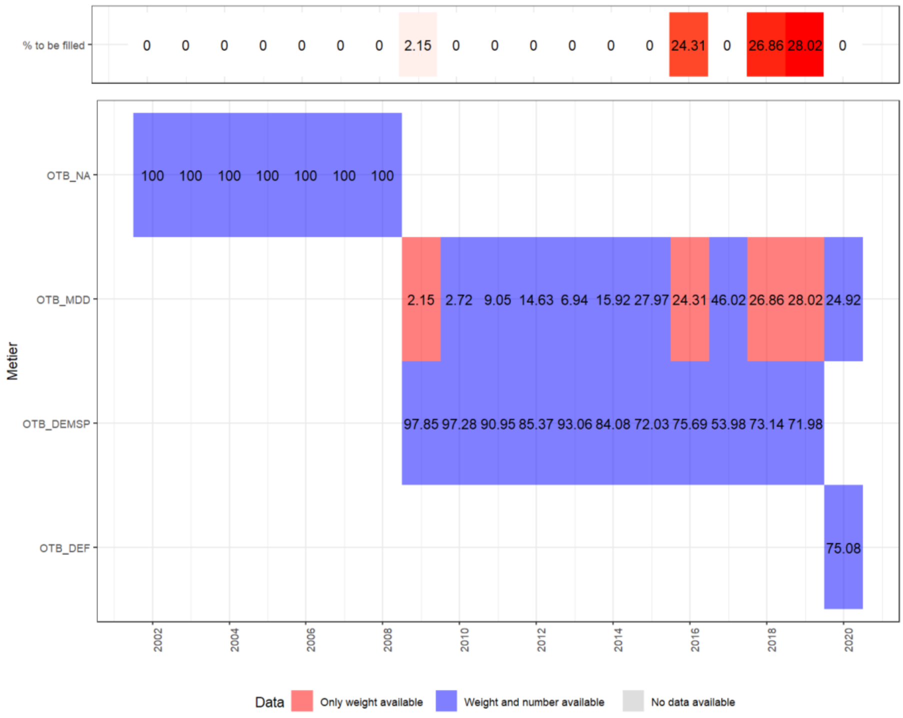


Figure 6.2.2.2.4. Deep-water rose shrimp GSA 5. Reconstruction of the length frequency distribution of the landings by year and fleet in GSA 5. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

Discards

Discards data were reported to STECF EWG 21-11 through the DCF. Discard weight was very low in all cases, so it was considered negilible and not included in the assessment.

6.2.2.2.2 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 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. Mean stratified abundances and biomasses by km^2 have been computed using the methodology described by Grosslein and Laurec (1982). The MEDITS survey for 2020 was carried out as usual.

Density and biomass indices showed the highest values for the last four years of the time series (Figure 6.2.2.2.5). Length frequency distributions are shown in Figure 6.2.2.2.6.

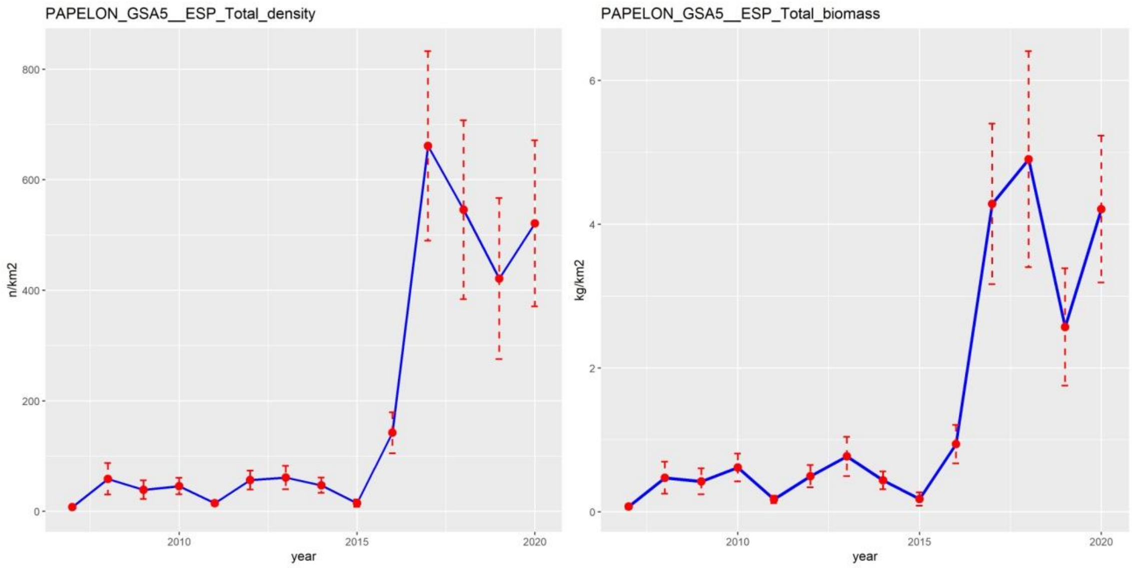


Figure 6.2.2.2.5. Deep-water rose shrimp GSA 5. Total density (N/km^2) and biomass (kg/km^2) indices in GSA 5.

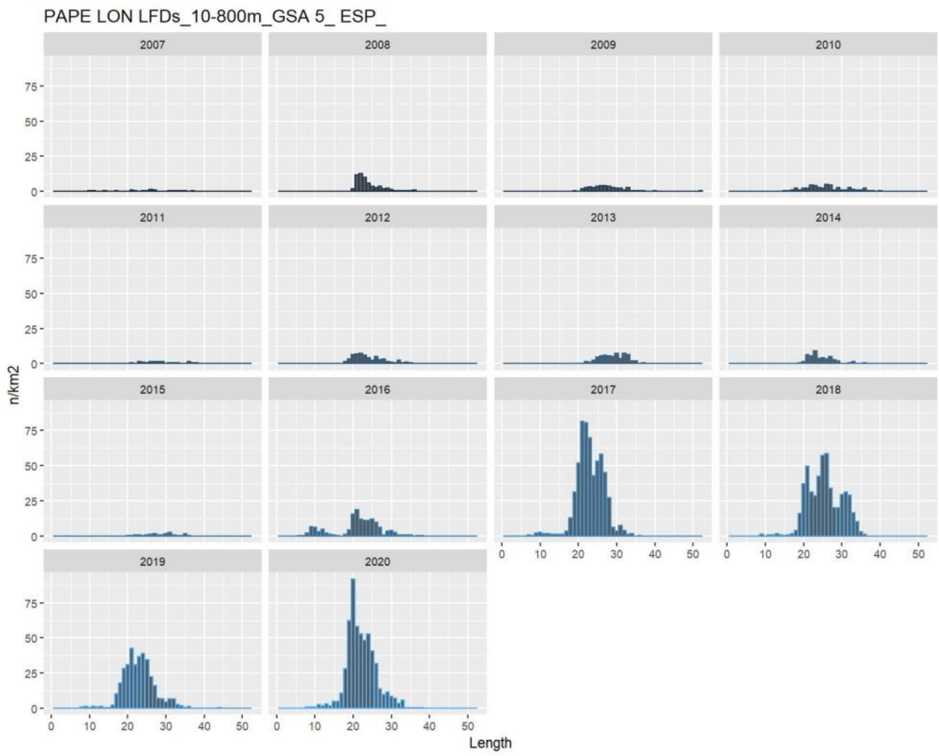


Figure 6.2.2.2.6. Deep-water rose shrimp GSA 5. Length frequency distribution by year of MEDITS GSA 5.

6.2.2.3 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 5 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 2002-2020 for the catch data (landings) and 2007-2020 for the tuning fleet. Both catch numbers at length and index number at length were sliced using the l2a routine in FLR using the GSA 5 growth parameters. The t0 of the von Bertalanffy was 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 5.

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

Total catches and catch numbers at age were used as input data. SOP correction was applied to catch numbers at age. Table 6.2.2.3.1 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 6.2.2.3.1. Deep-water rose shrimp GSA 5. Input data for the a4a model.

Catches (t)

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
OTB	36.18	22.13	6.53	1.6	1.01	1.39	5.2	5.11	6.25	4.53
Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
OTB	4.17	6.2	5.59	7.58	9.09	68.03	101.16	59.76	67.9	

Catch numbers-at-age matrix (thousands)

age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
0	0	0	0.1	0	0	0	0.5	0	0	0.3
1	2136.5	1084.9	438.8	52.6	16.2	42.2	250.7	239.4	623.6	332.5
2	351.7	581.5	197.8	53.1	24.7	18.5	93.6	181.1	100.3	114.1
3+	4.6	26.2	3.8	14.8	6.5	0.3	11.3	11.3	2.6	3.5
age	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
0	0.4	0	0.1	0.2	1.5	15.7	0	0	0	
1	292.3	208.2	308.5	125.3	581	4587.5	6963	3023	2258.3	
2	66.8	82.8	83.5	74.6	64.4	265.4	823.6	425.2	114.9	
3+	0.8	0.7	3.7	3.2	2.2	4.1	0.1	6.2	0.1	

Weights-at-age (kg)

age	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
0	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1	0.009	0.01	0.01	0.009	0.011	0.011	0.01	0.01	0.009	0.009
2	0.016	0.017	0.017	0.018	0.018	0.018	0.017	0.018	0.016	0.017
3+	0.026	0.028	0.025	0.025	0.026	0.024	0.025	0.025	0.025	0.025
age	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
0	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1	0.009	0.01	0.009	0.01	0.008	0.007	0.009	0.009	0.008	0.009
2	0.017	0.017	0.017	0.017	0.016	0.016	0.015	0.016	0.017	0.017
3+	0.024	0.023	0.024	0.025	0.024	0.024	0.024	0.024	0.024	0.024

Maturity, Natural mortality, proportion of M and F before spawning vectors.

Age	0	1	2	3+
Maturity	0.11	0.62	0.96	1.00
M	1.42	0.83	0.71	0.64
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 5. MEDITS number (n/km^2) at age for GSA 5.

age	2007	2008	2009	2010	2011	2012	2013
0	1.1	0	0	0.4	0	0.5	0
1	4.9	54.9	28.5	34.2	9.5	50.6	31.6
2	1.6	3.8	9.5	10	3.6	5.4	28.8
3+	0.3	0.1	1.1	1.7	1.8	0.3	0.8
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
0	0.2	0	26.9	12.4	6	8.2	19.8
1	43.6	7.6	105.3	563.7	401.1	324	515.1
2	2.9	7.1	9.3	17.4	119.8	23.6	25.6
3+	0.4	0	0.5	0	0.2	0.6	0.8

Figures 6.2.2.2.7 and 6.2.2.2.8 show the age structure of the catches and their cohort consistency.

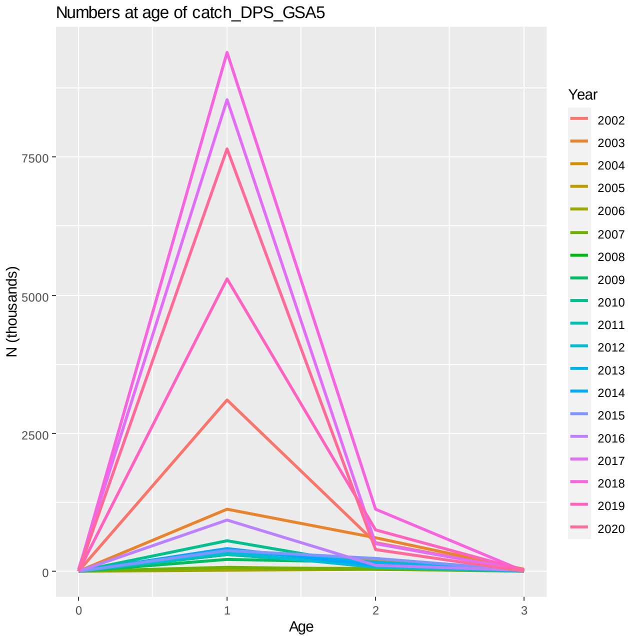


Figure 6.2.2.2.7. Deep-water rose shrimp GSA 5. Age structure of the catches.

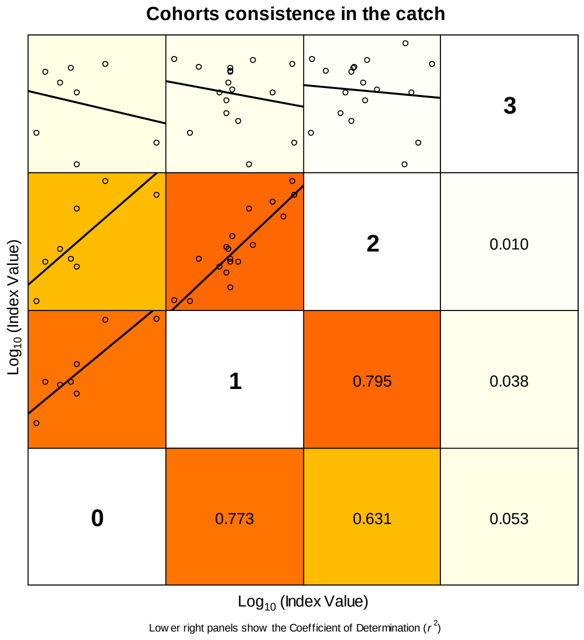


Figure 6.2.2.2.8. Deep-water rose shrimp GSA 5. Cohort consistency of the catches.

Figures 6.2.2.2.9 and 6.2.2.2.10 show the age structure of the index and their cohort consistency. Figure 6.2.2.2.11 shows the weight at age matrix.

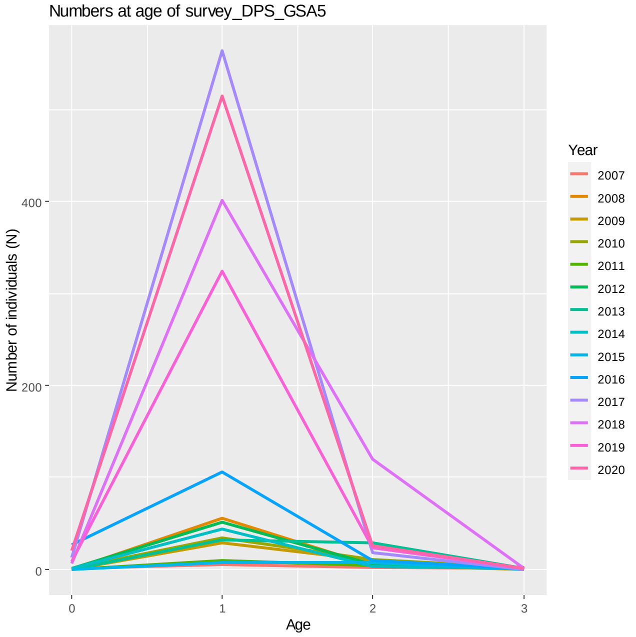


Figure 6.2.2.2.9. Deep-water rose shrimp GSA 5. Age structure of the index.

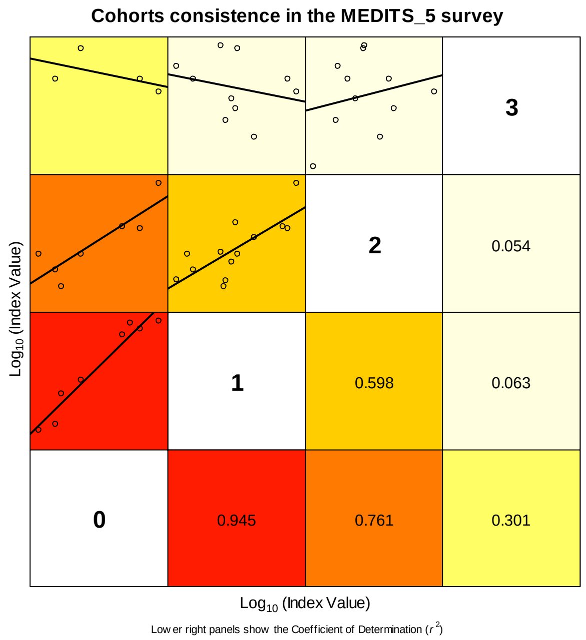


Figure 6.2.2.2.10. Deep-water rose shrimp GSA 5. Cohort consistence of the index.

Figure 6.2.2.2.11. Deep-water rose shrimp GSA 5. Weight at age matrix.

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(replace(age, age>2,2)) + s(year, k=6)
q ~ list(~factor(replace(age, age>1,1)))
sr ~ factor(year)

The results of the assessment are shown in Figure 6.2.2.2.10. All the values showed and increasing trend for the last years. Figure 6.2.2.2.11 shows the fishing mortality at age and year and Figure 6.2.2.2.12 shows the survey catchability. Figures 6.2.2.2.13 and 6.2.2.2.14 show the residuals of the final model. Figures 6.2.2.2.15 and 6.2.2.2.16 show the fitted and observed values for the commercial fleet and the index, respectively.

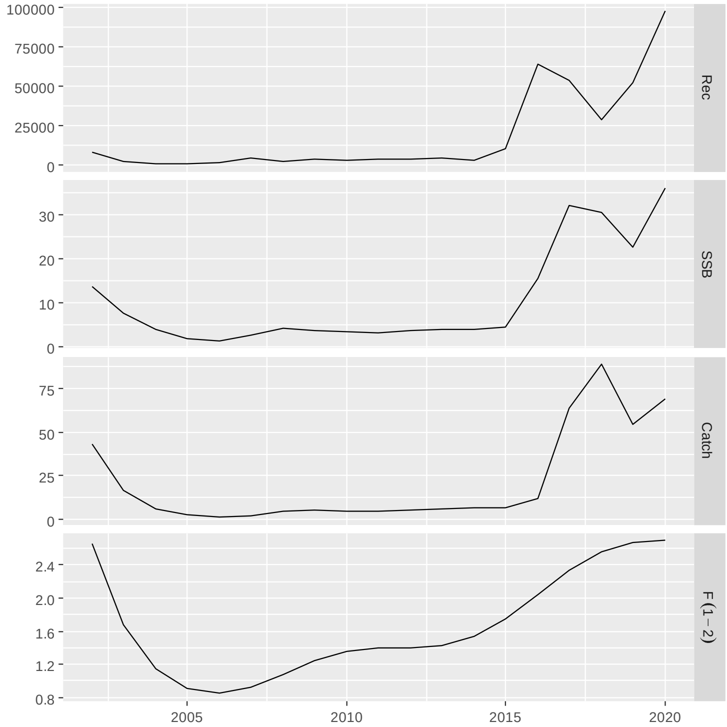


Figure 6.2.2.2.10. Deep-water rose shrimp GSA 5. Stock summary from the a4a model for Deep-water rose shrimp GSA 5 recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 2).

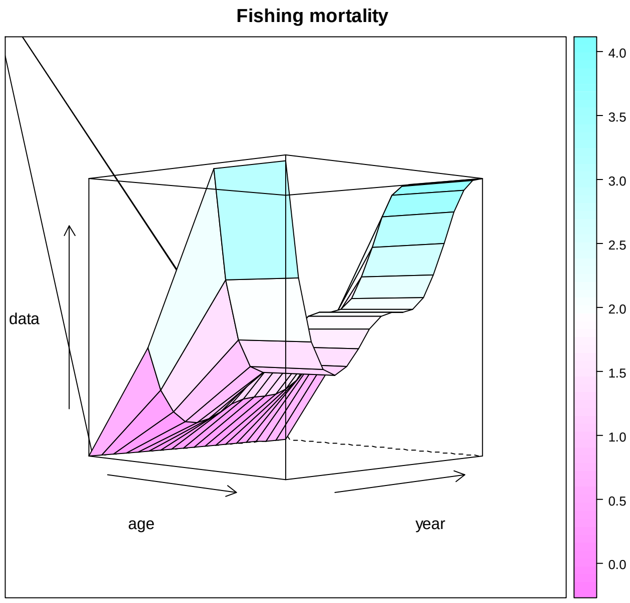


Figure 6.2.2.2.11. Deep-water rose shrimp GSA 5. 3D contour plot of estimated fishing mortality at age and year.

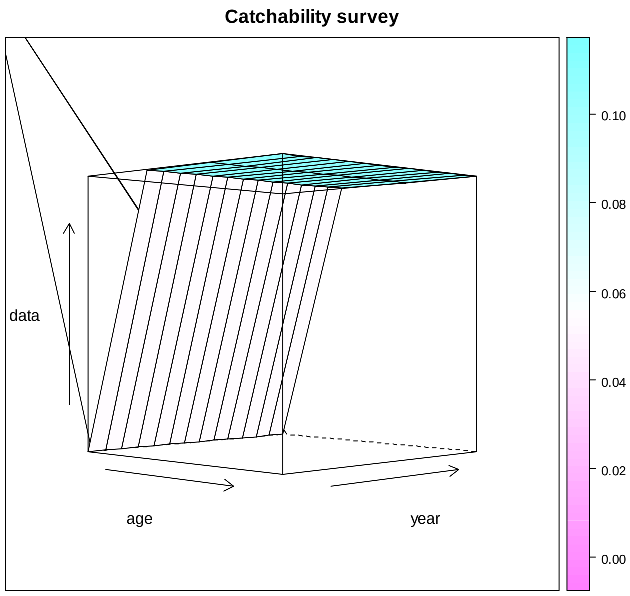


Figure 6.2.2.2.12. Deep-water rose shrimp GSA 5. 3D contour plot of estimated catchability at age and year.

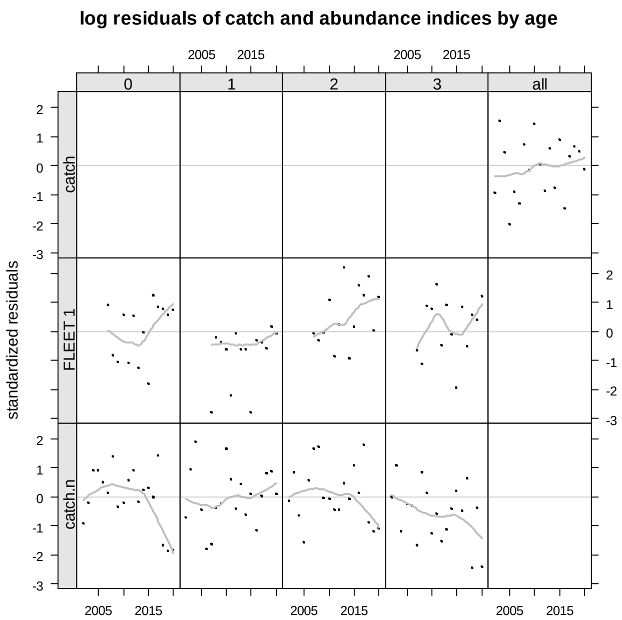


Figure 6.2.2.2.13. Deep-water rose shrimp GSA 5. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines simple smoothers.

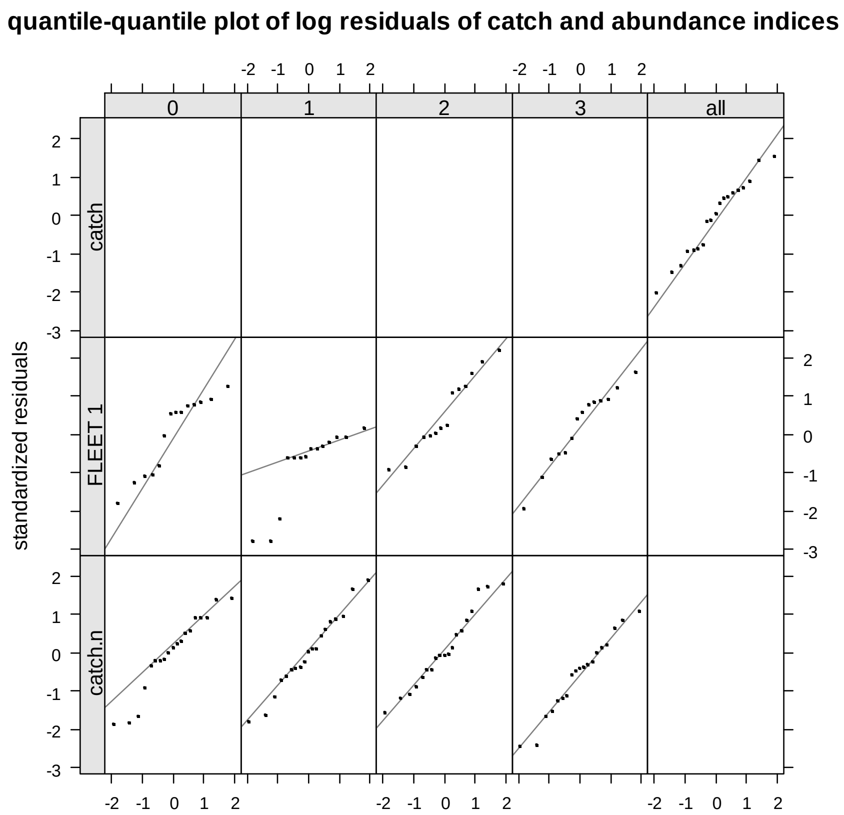


Figure 6.2.2.2.14. Deep-water rose shrimp GSA 5. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

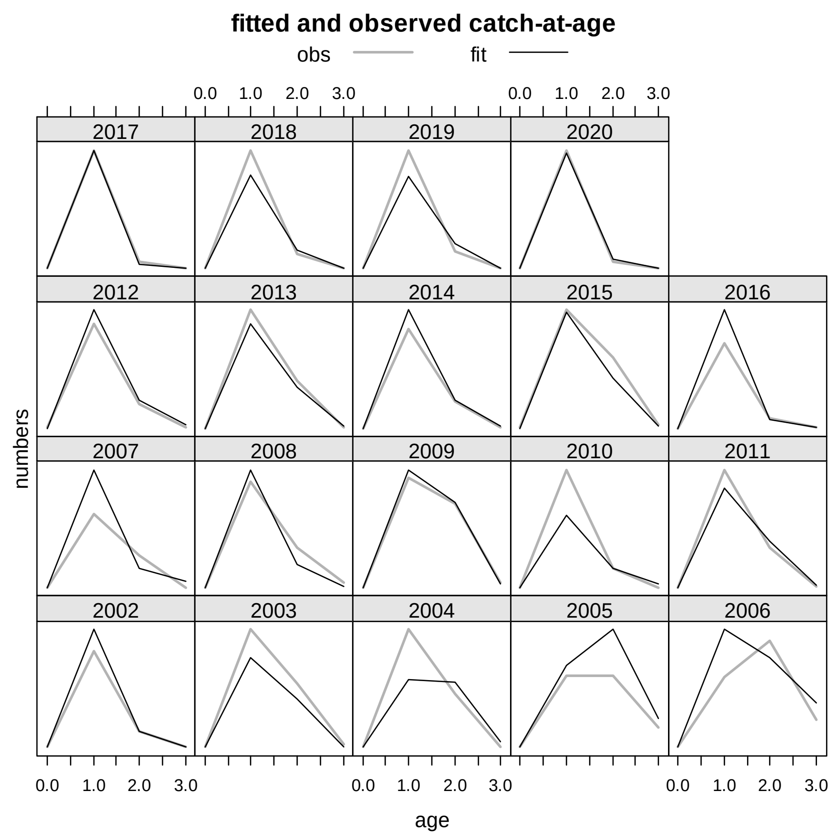


Figure 6.2.2.2.15. Deep-water rose shrimp GSA 5. Fitted and observed catch at age.

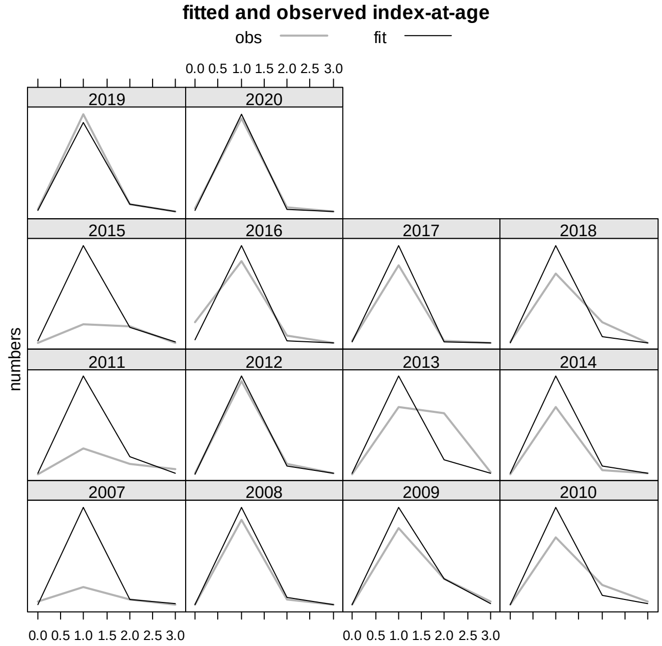


Figure 6.2.2.2.16. Deep-water rose shrimp GSA 5. Fitted and observed index at age.

Simulations

Figure 6.2.2.2.17 shows the results of the simulations.

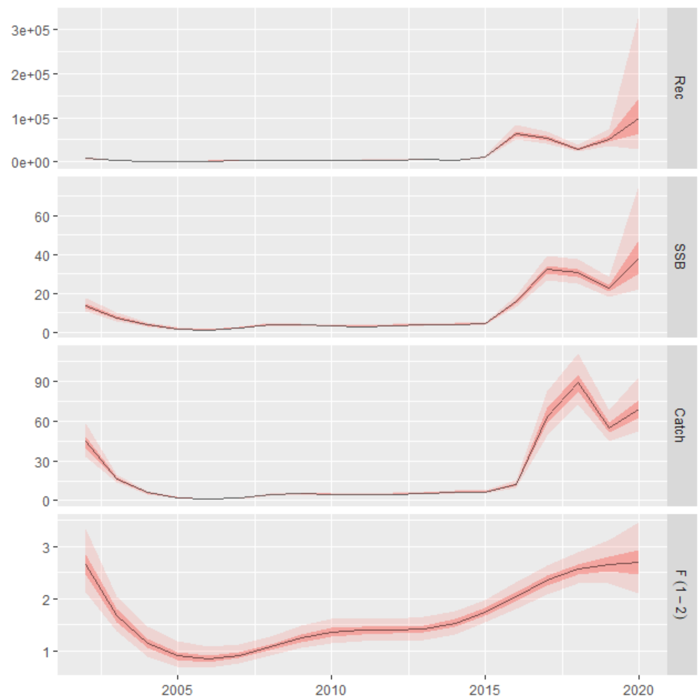


Figure 6.2.2.2.17. Deep-water rose shrimp GSA 5. Stock summary of the simulated and fitted data for the a4a model.

Tables 6.2.2.3.2 shows the summary results for the assessment of the deep-water rose shrimp obtained by a4a in GSA 5.

Table 6.2.2.3.2. Deep-water rose shrimp GSA 5. a4a summary results and F at age.

	Fbar1-2	Recruitment (thousands)	SSB (t)	TB (t)	Catch (t)
2002	2.652	7884.39	13.62	93.01	36.18
2003	1.674	2532.73	7.45	37.47	22.13
2004	1.141	776.39	3.78	14.57	6.53
2005	0.901	528.2	1.82	6.61	1.60
2006	0.847	1697.71	1.29	7.99	1.01
2007	0.919	4242.2	2.42	18.12	1.39
2008	1.072	2514.4	4.11	19.75	5.20
2009	1.241	3551.33	3.62	21.39	5.11
2010	1.358	2631.67	3.25	18.24	6.25
2011	1.395	3842.58	2.99	20.45	4.53
2012	1.395	3354.08	3.45	20.84	4.17
2013	1.423	4757.53	3.79	25.69	6.20
2014	1.532	3225.74	3.93	22.98	5.59
2015	1.744	10608.1	4.39	43.40	7.58
2016	2.038	64128.94	15.44	215.11	9.09
2017	2.340	53593.78	32.13	274.93	68.03
2018	2.562	28827.78	30.47	229.73	101.16
2019	2.666	52273.05	22.59	240.88	59.76
2020	2.694	97348.87	36.06	404.67	67.90

F at age	0	1	2	3+
2002	0.00009	1.52000	3.78460	3.78460
2003	0.00006	0.95945	2.38890	2.38890
2004	0.00004	0.65414	1.62870	1.62870
2005	0.00003	0.51653	1.28610	1.28610
2006	0.00003	0.48544	1.20870	1.20870
2007	0.00003	0.52670	1.31140	1.31140
2008	0.00004	0.61406	1.52890	1.52890
2009	0.00004	0.71122	1.77090	1.77090
2010	0.00005	0.77801	1.93720	1.93720
2011	0.00005	0.79971	1.99120	1.99120
2012	0.00005	0.79922	1.99000	1.99000
2013	0.00005	0.81522	2.02980	2.02980
2014	0.00005	0.87802	2.18620	2.18620
2015	0.00006	0.99974	2.48920	2.48920
2016	0.00007	1.16780	2.90770	2.90770
2017	0.00008	1.34110	3.33910	3.33910
2018	0.00009	1.46830	3.65580	3.65580
2019	0.00009	1.52780	3.80420	3.80420
2020	0.00009	1.54390	3.84410	3.84410

Based on the a4a results, the deep-water rose shrimp SSB showed the minimum values of less than 2 tons around 2005-2006 and the maximum values (36 t) in the last year, 2020. Recruitment also its minimum in 2004-2005 (<800 thousand individuals) and the highest values since 206. F_{bar} (1-2) shows the values in 2018-2010 around 2.6, similarly as at the beginning of the data series (2002). F at age showed very high values, larger than 3, for age 2.

A retrospective analysis showed strong variability, especially for recruitment (Figure 6.2.2.2.17). Several aspects from this assessment were robust, like cohort consistency which was considered good both for the commercial catches and the survey. However, the best fit resulted in very high values of F, especially for the oldest ages. This, together with certain trends in the residuals, a poor fit between observed and predicted values in the survey and the trends in the retrospective analysis lead to conclude that the assessment should not be considered for providing advice.

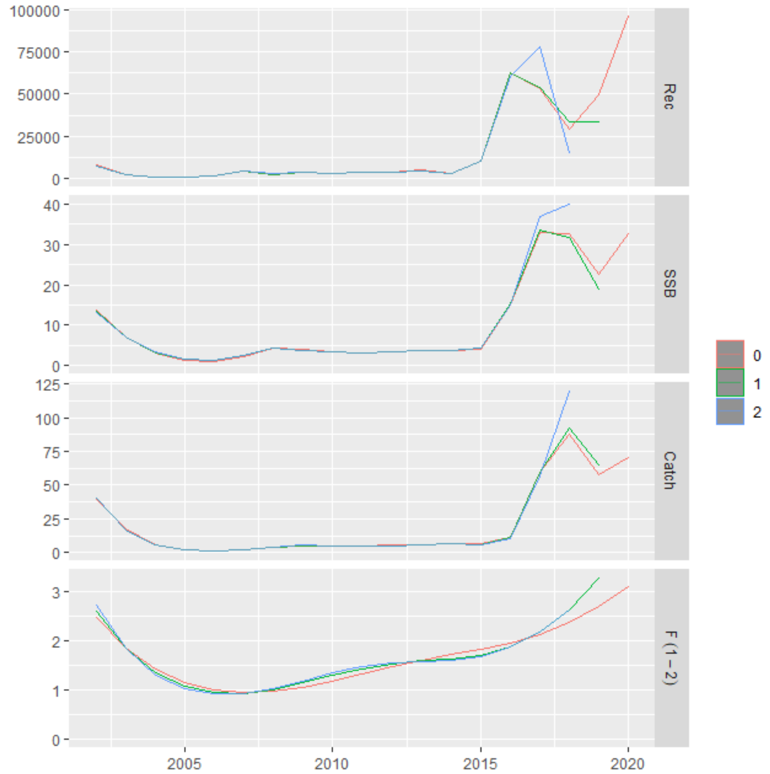


Figure 6.2.2.2.17. Deep-water rose shrimp GSA 5. Retrospective analysis.

6.2.2.4 Short term Forecast and Catch Options

As the assessment carried out during EWG 21-11 was not accepted for advice no short term forecast has been performed. Combined catch advice given in 2020 is used for 2022, see section 5.2.

6.2.2.5 Data Deficiencies

Data from DCF 2020 as submitted through the Official data call in 2021 were used.

Length frequency distributions of the discards were not available in the DCF data.

6.2.3 Deep-water rose shrimp in GSA 6

6.2.3.1 Stock Identity and Biology

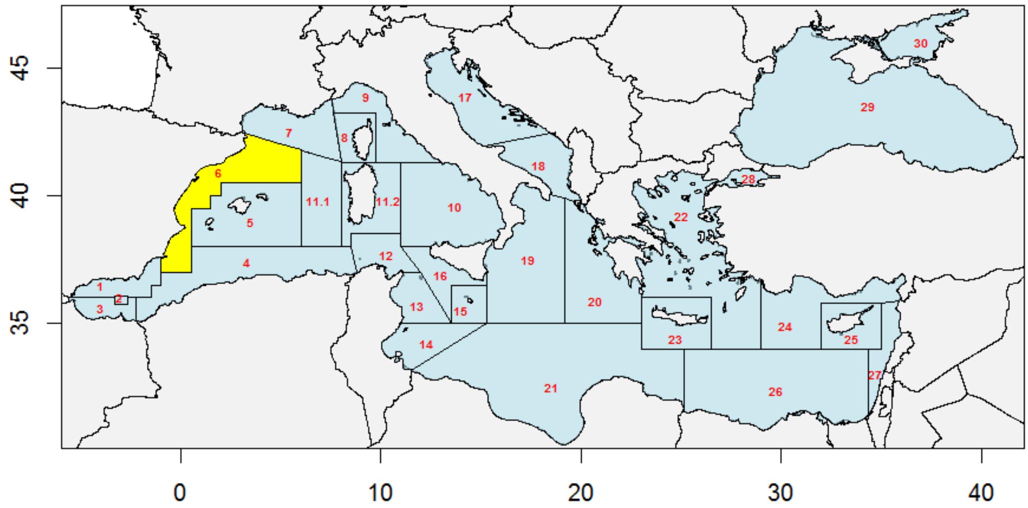


Figure 6.2.3.1.1. Geographical location of GSAs 6.

STECF EWG 21-11 was asked to assess the state of Deep-water rose shrimp stocks in the combined GSAs 6.
Growth parameters and length-weight relationship parameters were not available within the DCF 2020 so the growth parameters for sexes combined and carapace length expressed in mm were taken from the previous assessment. These parameters were used in the current assessment.

Table 6.2.3.1.1. Deep-water rose shrimp GSAs 6. Growth parameters and length-weight relationship parameters.

Country	Area	Year	L_∞	K	t_0	a	b
ESP	GSA 6	2017	47	0.79	-0.03	0.0025	2.545

The vector of proportion of mature individuals by age has been derived by slicing the maturity ogive by length with the von Bertalanffy coefficients.

A vector of natural mortality was estimated by PRODBIOM method (Abella et al., 1997) using growth and length-weight relationship parameters for sex combined for each GSA.

Table 6.2.3.1.2. Deep-water rose shrimp GSAs 6. Proportion of mature specimens at age and natural mortality at age by GSA.

Age	Area	0	1	2	3+
Maturity	GSA 6	0	1	1	1
M	GSA 6-7	1.62	0.88	0.73	0.67

6.2.3.2 DATA

6.2.3.2.1 CATCH (LANDINGS AND DISCARDS)

General description of Fisheries

Deep-water rose shrimp is targeted mainly by bottom trawlers.

In GSA 6 it is estimated that half of the trawl fleet operates on deep-water rose shrimp fishing grounds and other deep-water fishing grounds, targeting other valuable crustaceans (Norway lobster; red shrimp).

Landings

Landings data were reported to STECF EWG 21-11 through the DCF. In GSAs 6 most of the landings come from otter trawls and main métier is DEMSP, with a low proportion of landings (<10%) allocated to MDD. 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 (Table 6.2.3.1.1).

Landings data by year are presented in Table 6.2.3.1.1. Landings by year and fleet are presented in Figures 6.2.2.1.1.

Table 6.2.3.1.1. Deep-water rose shrimp GSAs 6. Landings data in tonnes by year.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
144.1	116.0	66.2	44.7	25.2	28.8	39.0	49.1	71.9	66.3	85.6	86.7	131.3	174.6	471.3	634.7	914.6	704	1094.8

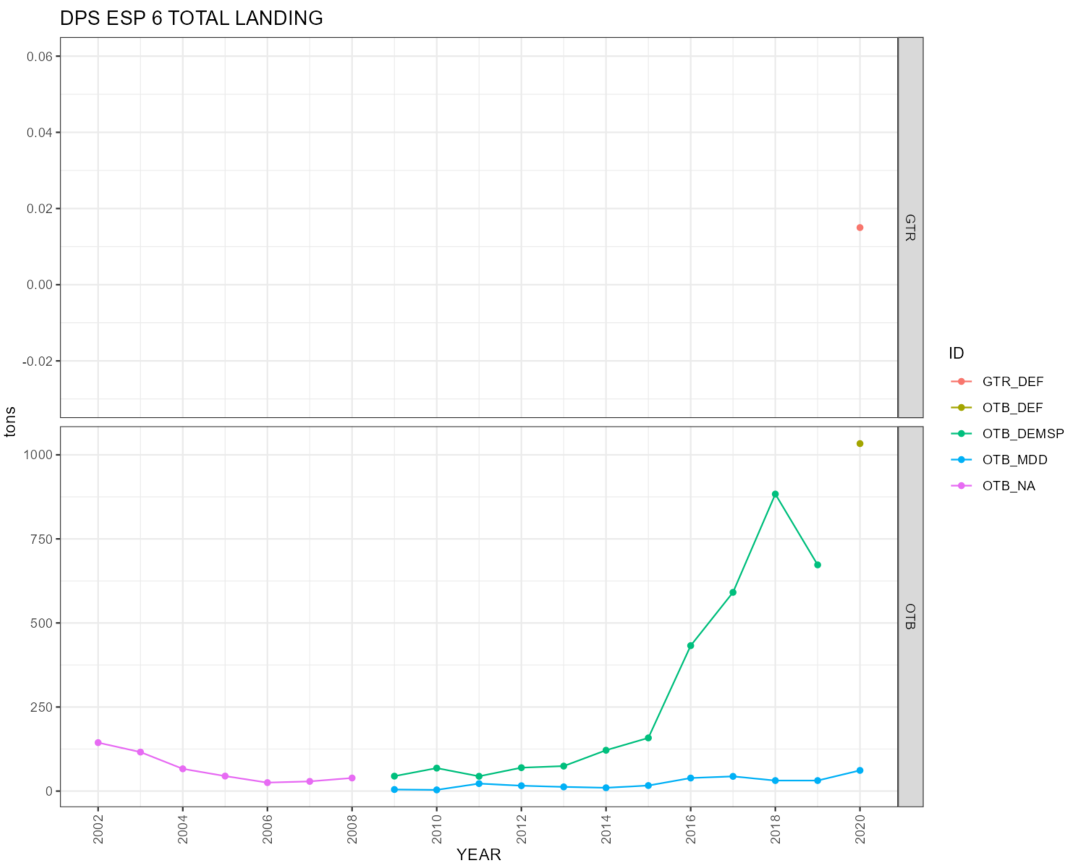


Figure 6.2.3.1.1. Deep-water rose shrimp GSAs 6. Landings data in tonnes by year and fleet.

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figures 6.2.3.1.2.

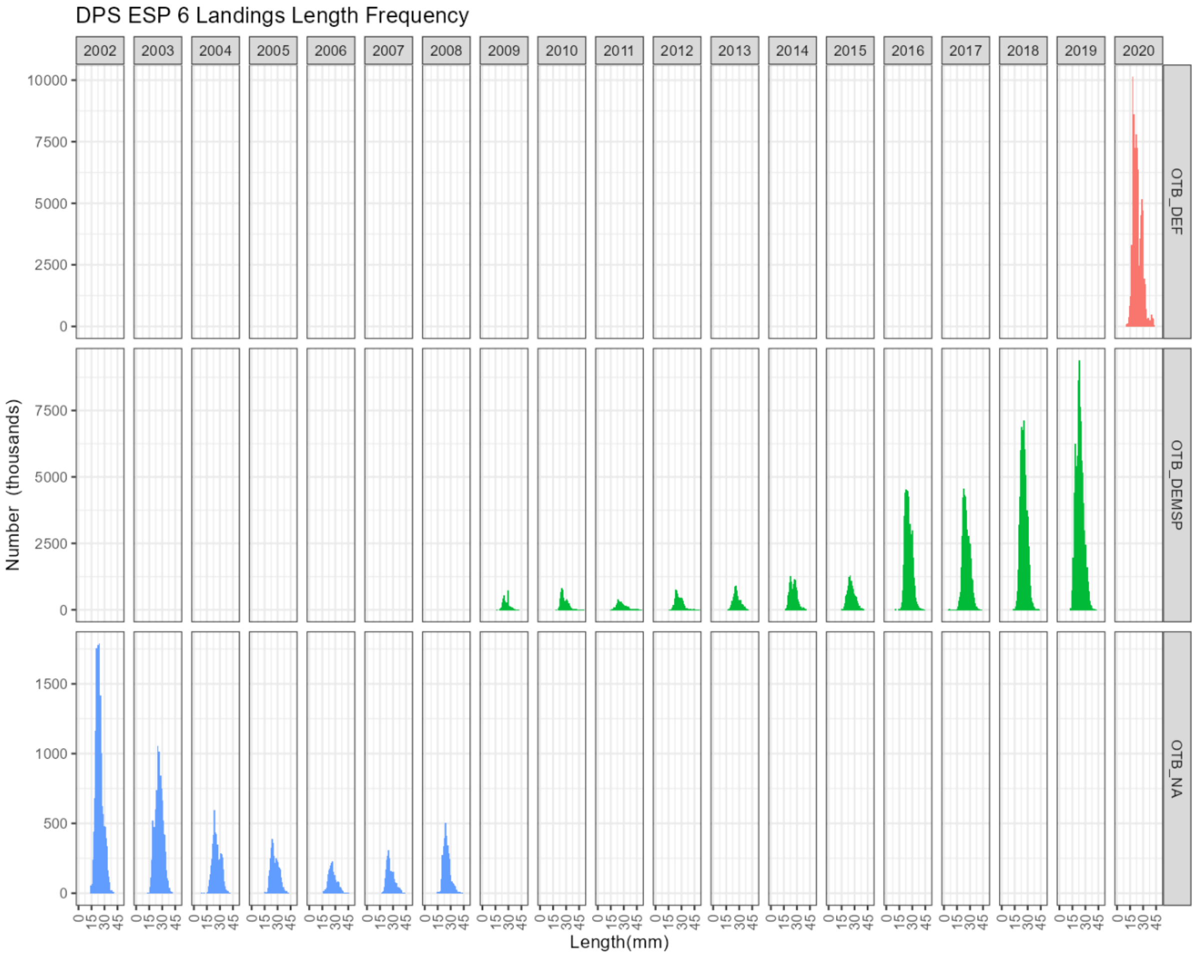


Figure 6.2.3.1.2. Deep-water rose shrimp GSAs 6. Landings data in tonnes by year and fleet.

As shown, in GSA 6 length frequency distributions were not available for all years of OTB-MDD as it is not a selected metier for sampling in this GSA. As reported by EWG 21-02 length frequency distribution for missing year-gear were reconstructed. The median of the available data in the reconstruction process was used and final outcomes are shown in Figure 6.2.3.1.3-4.

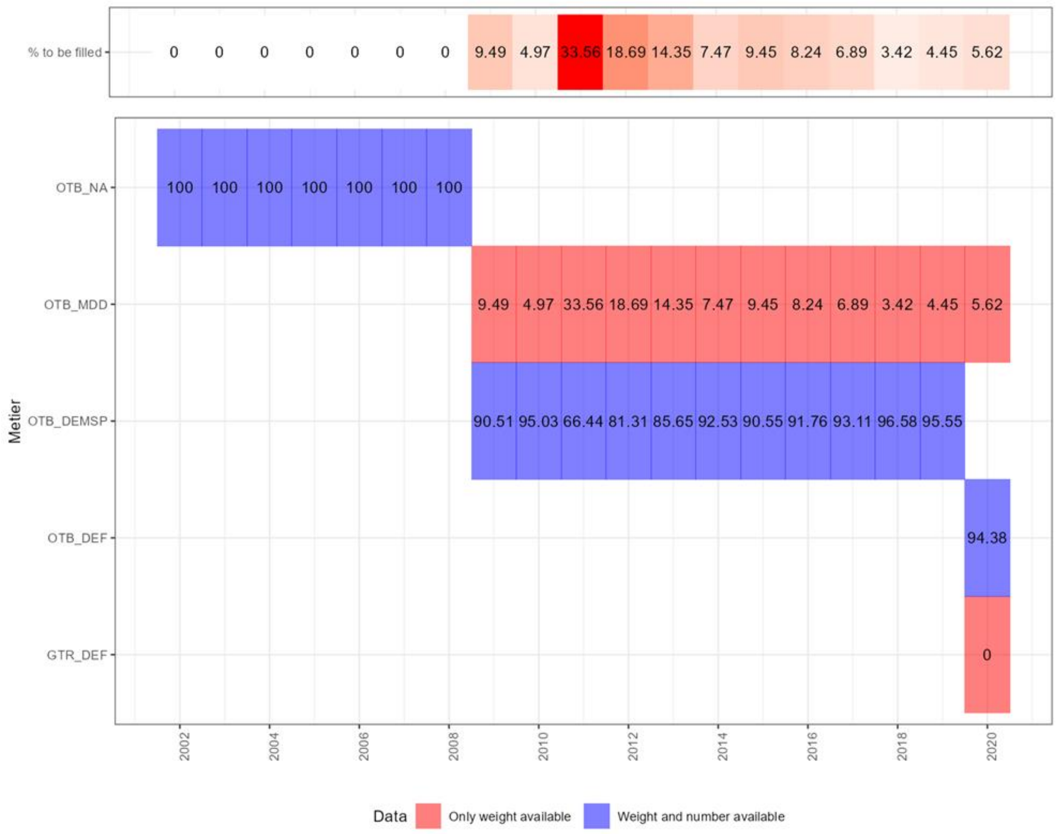


Figure 6.2.3.1.3. Deep-water rose shrimp GSAs 6. Summary of landings without length data and % filled in the reconstructions process.

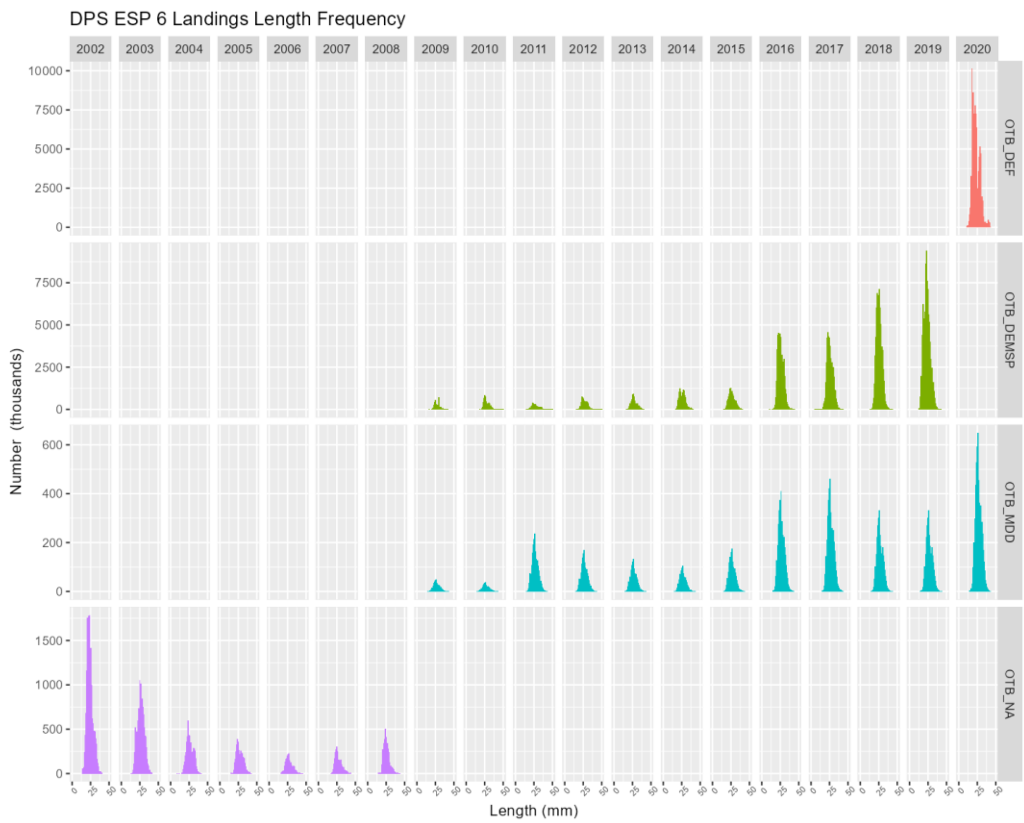


Figure 6.2.3.1.5. Deep-water rose shrimp GSAs 6. Length frequency distribution of the landings by year and fleet after the reconstruction process.

Discards

Discards data were reported to STECF EWG 21-11 through the DCF. Total discard by year are presented in table 6.2.2.1.2 and by year and fleet in Figure 6.2.2.1.6

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Table 6.2.3.1.2. Deep-water rose shrimp GSAs 6. Discards data in tonnes by year.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.01	0.01	0.010	0.01	0.001	0.010	0	0.04	0.3	2.5	0.9	0.9	2.3	2.9	6.3	8.4	2.7	1.8	19.6

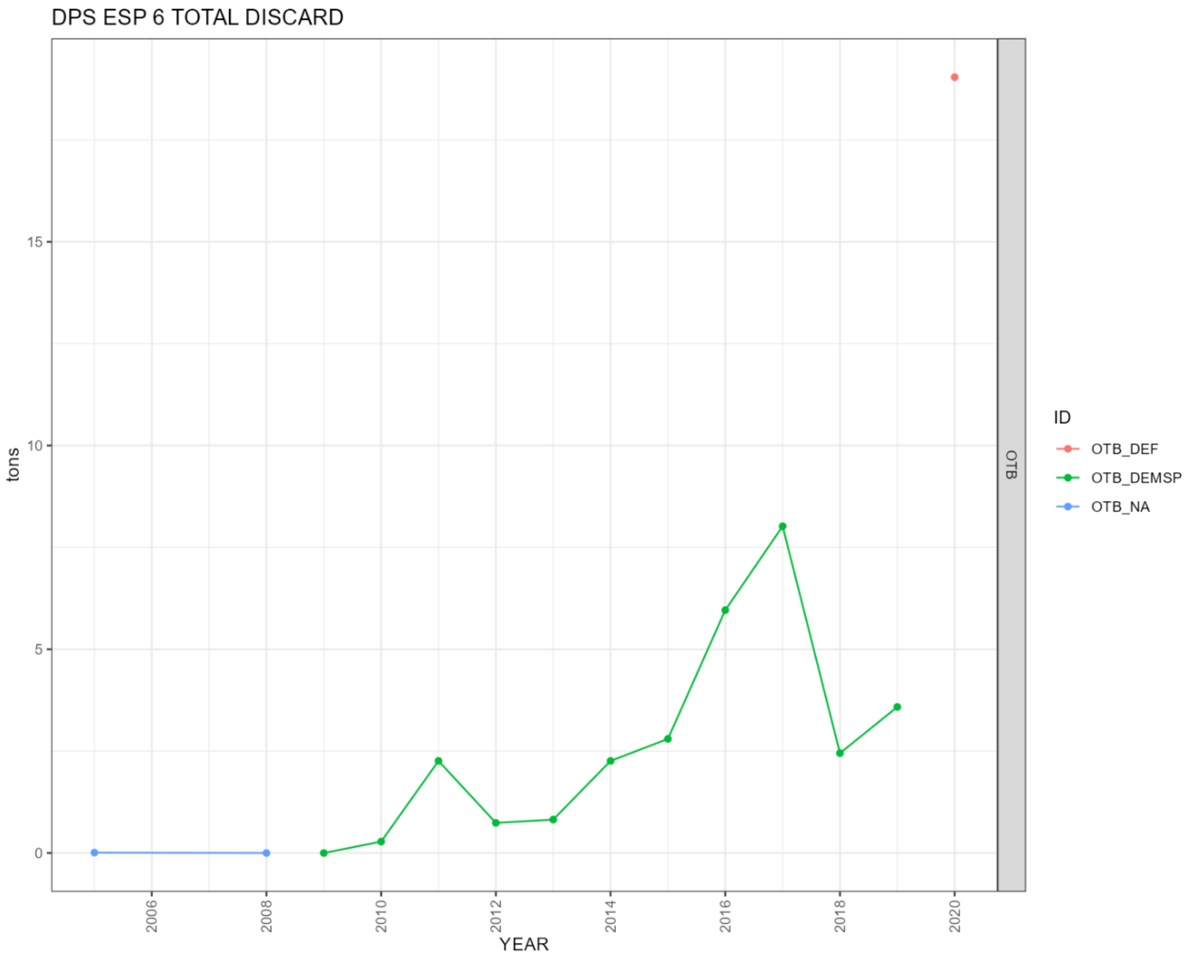


Figure 6.2.3.1.6. Deep-water rose shrimp GSAs 6. Discards data in tonnes by year and fleet.

Length frequency distribution of the discards by year and fleet from the DCF database are presented in Figure 6.2.3.1.7.

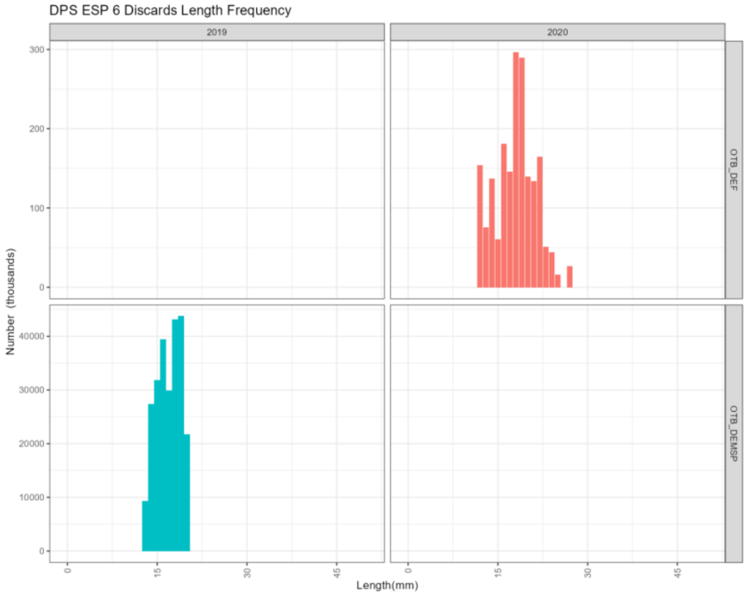


Figure 6.2.3.1.7. Deep-water rose shrimp GSAs 6. Discards data in tonnes by year and fleet.

In 2019 an error was detected in the record ID= 500814 and was then removed before reconstruct the discards for the years with only weigth availables. Final outputs of the reconstruction process are shown in Figures 6.2.3.1.8-9.

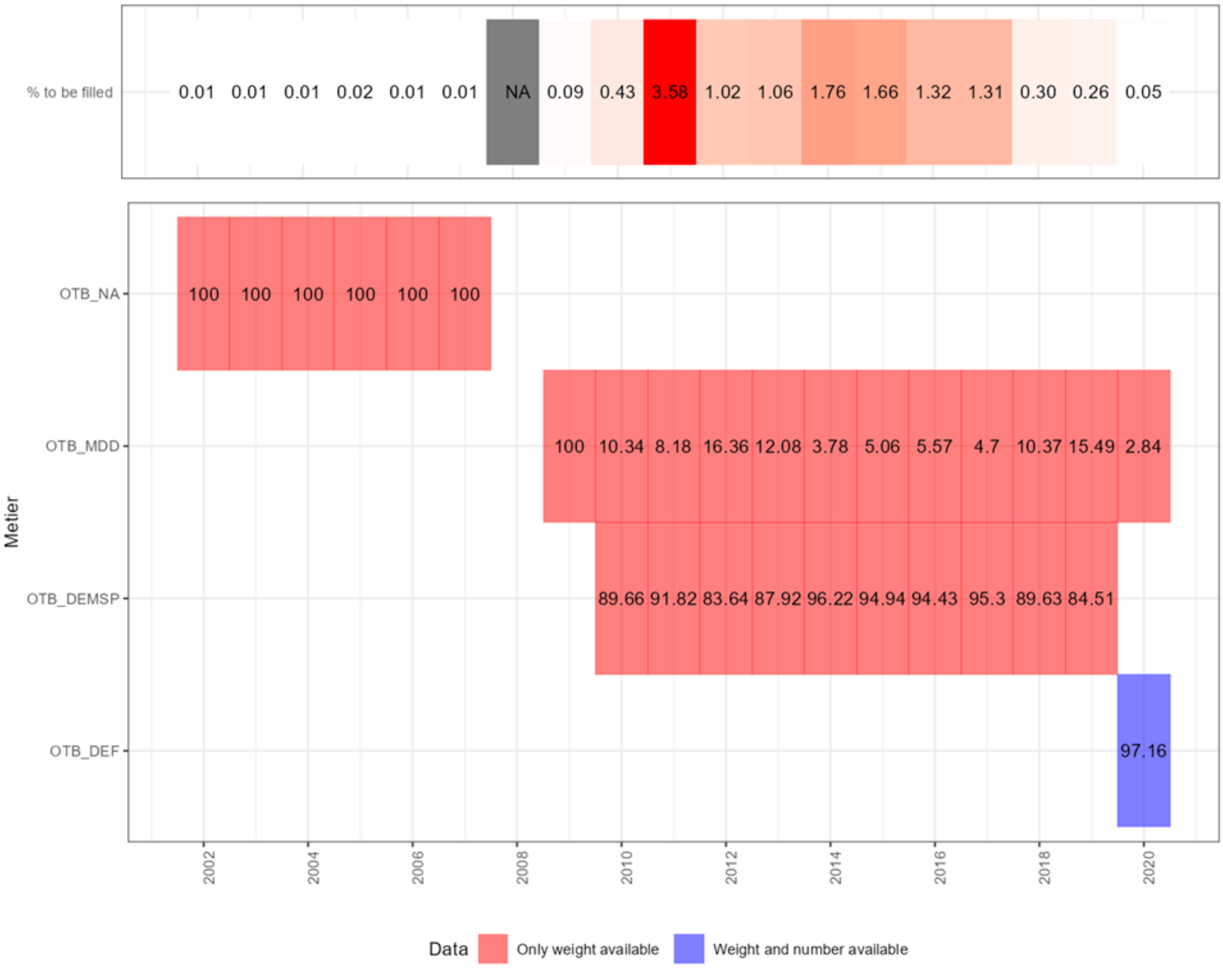


Figure 6.2.3.1.8. Deep-water rose shrimp GSAs 6. Summary of discards without length data and % filled in the reconstructions process.

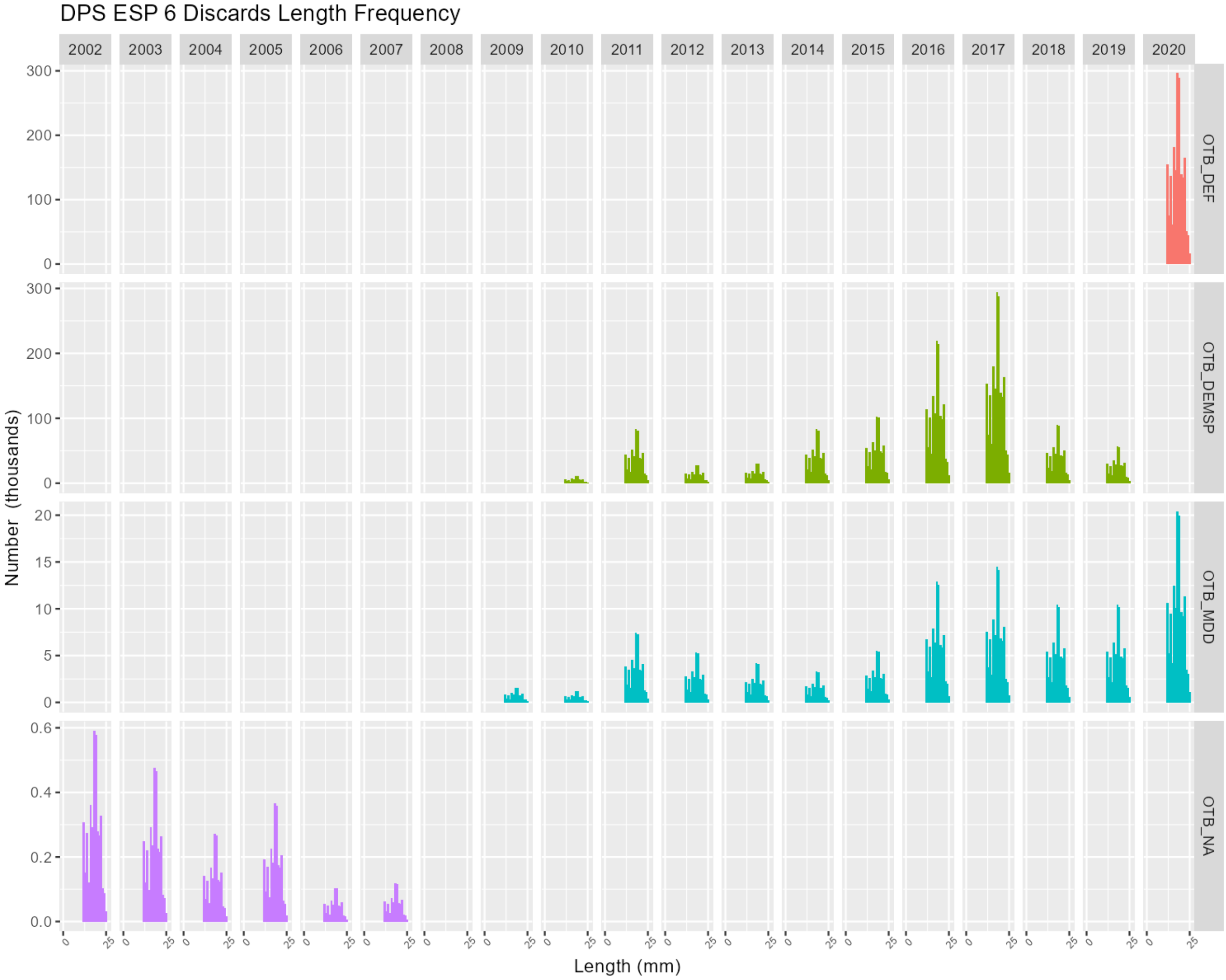


Figure 6.2.3.1.5. Deep-water rose shrimp GSAs 6. Length frequency distribution of the discards by year and fleet after the reconstruction process.

Discards were included in the stock assessment. Therefore, we will refer to catches as landings plus discards in the rest of the report.

6.2.3.2.2 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out each year during the spring season. The MEDITS in GSA 5 has been carried out consistently only from 2007. Hauls performed around the island of Ibiza after were removed from the index due to lack of consistent coverage. Therefore, in the current assessment combined MEDITS data for GSAs 6 from 2007 onwards were used. The different GSAs MEDITS indexes were merged using an average weighted by the GSA area.

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 combined GSAs 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 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 calculation of precision may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. 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 (Figures 6.2.3.3.1-10).

In GSAs 6 both density and biomass indices showed a steep increase in the last 6 years (2015-2020).

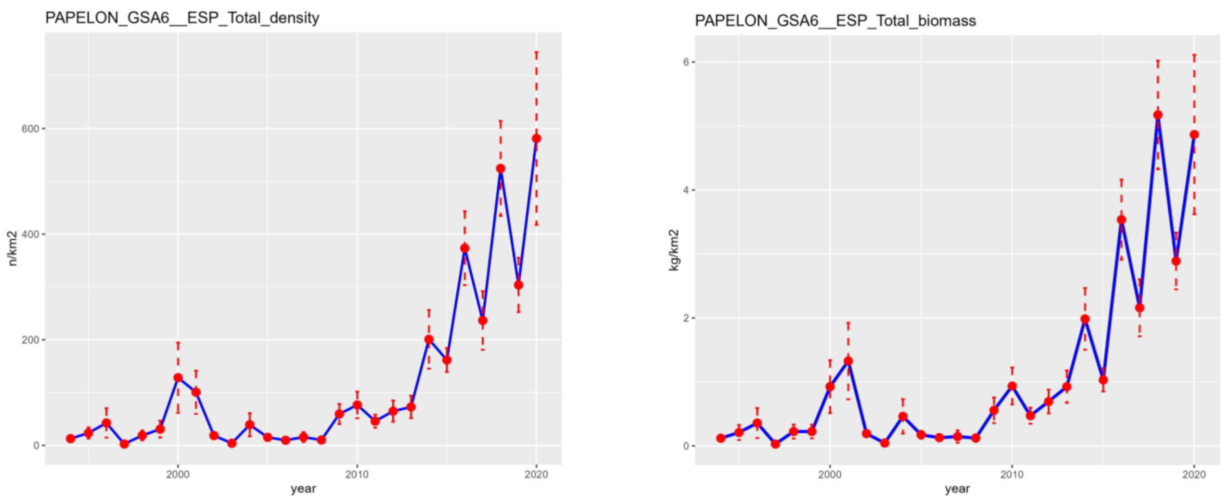


Figure 6.2.3.3.3. Deep-water rose shrimp GSAs 6. Estimated density (N/km^2) and biomass (kg/km^2) indices.

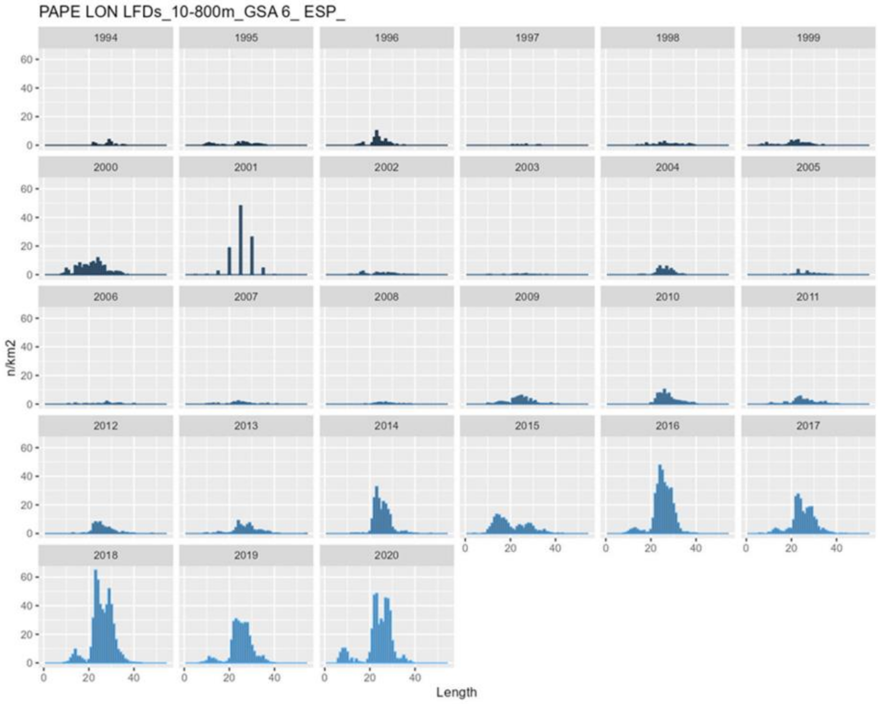


Figure 6.2.3.3.8. Deep-water rose shrimp GSAs 6. Length frequency distribution by year of MEDITS.

The length frequency distributions of the Spanish MEDITS in 2001 as reported in previous meeting are wrong. This issues have been recurring and needs to be fixed.

6.2.3.3 STOCK ASSESSMENT

The Assessment for All Initiative (a4a) approach (Jardim et al., 2015) was used for Deep water rose shrimp in GSA 6.

The EWG 21-11 concluded that a4a results were considered unacceptable due to the low stability of the model. The advice done in EWG 20-15 for al the spanish GSAs combined was then used instead and confirmed.

A single tuning fleet was used and is based on the biomass at age estimates from MEDITS.

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

A4A modelling was carried out using as input data the catch data (landings + discards) from 2002 to 2020. Both catch numbers at length and index number at length were sliced by using the growth parameters reported in table 6.2.3.1.1 to apply the l2a FLR’s routine. However, the von Bertalanffy t0 parameter was changed (adding 0.5) in order to account for the assumed spawning time in the middle of the year.

SOP correction was applied to catch numbers at age. Table 6.2.3.3.2 lists the input data for the a4a, 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 6.2.3.3.2. Deep-water rose shrimp GSAs 6. Input data for the a4a and XSA models.

Catches (t)

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
144.1	116	66.2	44.7	25.2	28.8	39	49.1	72.2	68.7	86.5	87.7	133.6	177.6	477.6	643.1	917.3	705.8	1114.4

Catch numbers-at-age matrix (thousands)

Year/Age	0	1	2	3
2002	114.3	15592.3	771	0.3
2003	7.9	9462.4	1103.2	4.7
2004	10	5338	720.3	3.1
2005	6.8	3364.6	499.6	6.2
2006	0.2	1872.9	298.2	6.9
2007	0.2	2168.5	311.1	9
2008	9.2	3757.5	222.6	7.7
2009	2.5	3961.6	272.1	1.2
2010	17.3	5439	590.2	38.1
2011	132	5273.2	675.2	52.2
2012	46.6	6960.3	635.9	28.7
2013	47	6748.7	837.6	0.7
2014	123.9	12172.2	687	0.6
2015	205.8	15207.8	1355.1	1.3
2016	343.1	44771.2	2236.5	44.7
2017	621.7	59187.6	3880	10.1
2018	215.6	90419.6	3095.7	19.2
2019	827.2	82373.9	2530.7	11.9
2020	2574.2	124557.4	4314.1	908.9

Weights-at-age (kg)

Year/Age	0	1	2	3
2002	0.002	0.008	0.02	0.034
2003	0.002	0.01	0.02	0.032
2004	0.002	0.01	0.02	0.032
2005	0.002	0.01	0.021	0.033
2006	0.002	0.01	0.021	0.033
2007	0.002	0.01	0.022	0.034
2008	0.002	0.009	0.021	0.033
2009	0.002	0.011	0.021	0.033
2010	0.002	0.011	0.02	0.038
2011	0.002	0.01	0.021	0.038
2012	0.002	0.01	0.021	0.038
2013	0.002	0.01	0.021	0.032
2014	0.002	0.01	0.021	0.032
2015	0.002	0.01	0.021	0.032
2016	0.002	0.01	0.021	0.033
2017	0.001	0.01	0.02	0.032
2018	0.002	0.009	0.02	0.033
2019	0.002	0.008	0.02	0.032
2020	0.002	0.008	0.023	0.033

Maturity, proportion of M and F before spawning vectors.

Age	0	1	2	3+
Maturity	0	1	1	1
Prop M	0.5	0.5	0.5	0.5
Prop F	0.5	0.5	0.5	0.5

Natural mortality and maturity

Age	Area	0	1	2	3+
Maturity	GSA 6	0	1	1	1
M	GSA 6	1.62	0.88	0.73	0.67

Deep-water rose shrimp GSAs 6. MEDITS number (n/km^2) at age.

Year/Age	0	1	2	3
2002	0.9	16.6	1.4	0.2
2003	0.4	3.5	0.3	0.1
2004	0.2	37.7	1.2	0.1
2005	0.1	13.2	2.1	0.1
2006	1.2	6.7	2.1	0.1
2007	2.3	12.1	1.1	0.3
2008	0.1	9	1.2	0.1
2009	4.8	51.5	2.9	0.2
2010	0.1	66.1	10.6	0.1
2011	2.2	37.6	6	0.1
2012	0.4	59.8	4.4	0.1
2013	2.7	58.1	11.8	0.5
2014	1.2	192.4	7	0.3
2015	52.8	98.5	9.4	0.5
2016	17.4	347.6	8.3	0.1
2017	13.5	210.6	12.2	0.2
2018	26.2	468.3	29.3	0.6
2019	18	266.9	18.8	0.1
2020	49	370.4	17.1	0.1

Figures 6.2.3.3.1-2 show the age structure of the catches, of the index and the weight at age matrix.

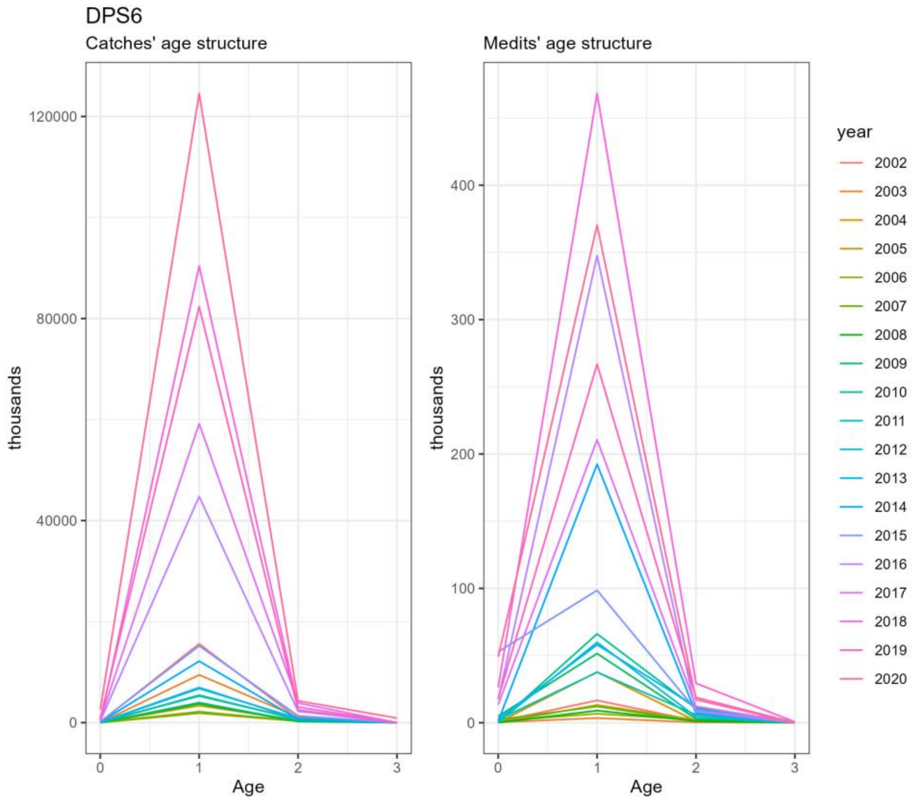


Figure 6.2.3.3.1. Deep-water rose shrimp GSAs 6. Age structure of the catches and of the survey.

Figure 6.2.3.3.2. Deep-water rose shrimp GSAs 6. Weight at age matrix.

Assessment results

Method a4a

Different a4a models were performed and a sensitivity of different combination of models' parameters was carried out. The best model was chosen according to the best outcomes in terms of residuals, retrospective, information criteria (AIC,BIC,GCV) and number of parameters used:

f ~ factor(replace(age, age > 2, 2)) + s(year, k = 9)

q ~ factor (replace(age, age> 1, 1))

sr ~ factor(year)

Results and diagnostic are below shown in Figures 6.2.3.3.3-6.2.3.3.12.

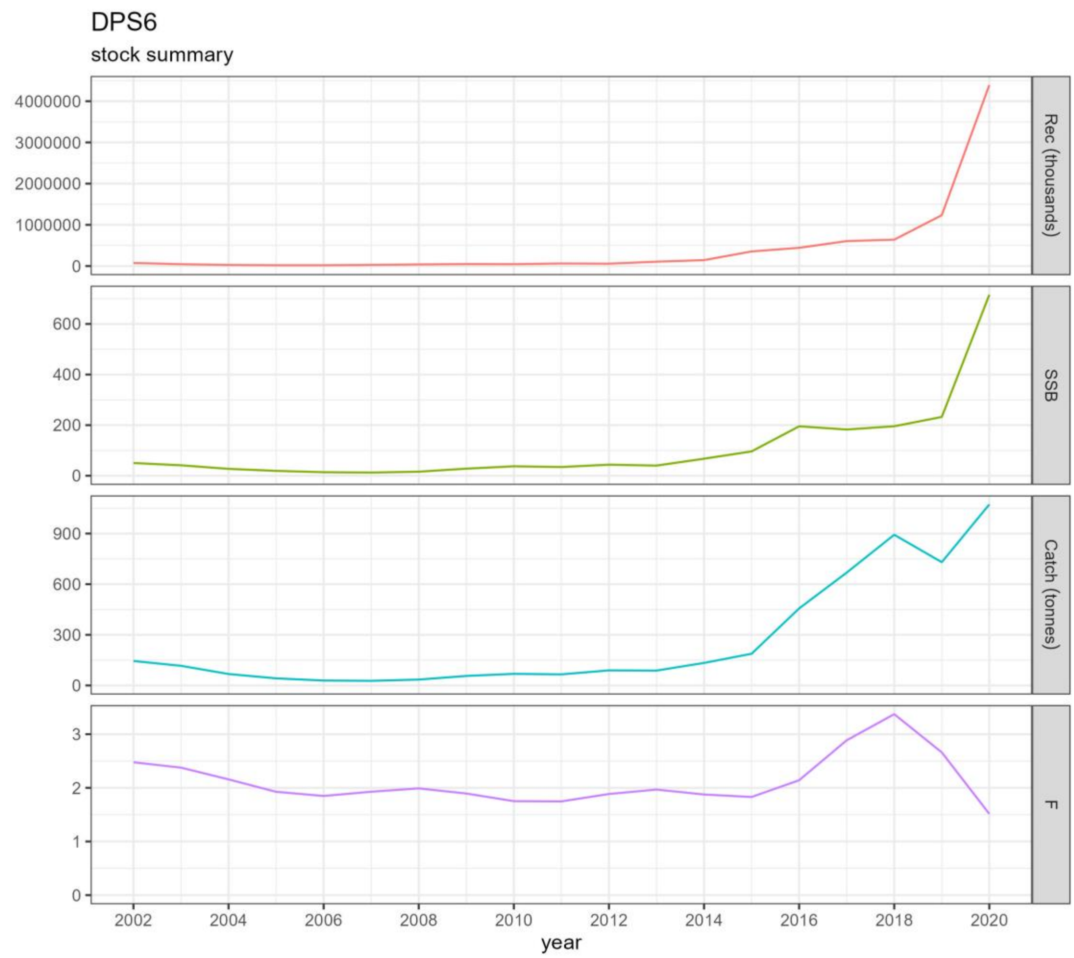


Figure 6.2.3.3.3. Deep-water rose shrimp GSAs 6. Stock summary from the a4a model for recruits (Rec), SSB (Stock Spawning Biomass), catch and harvest (F, for ages 1 to 2).

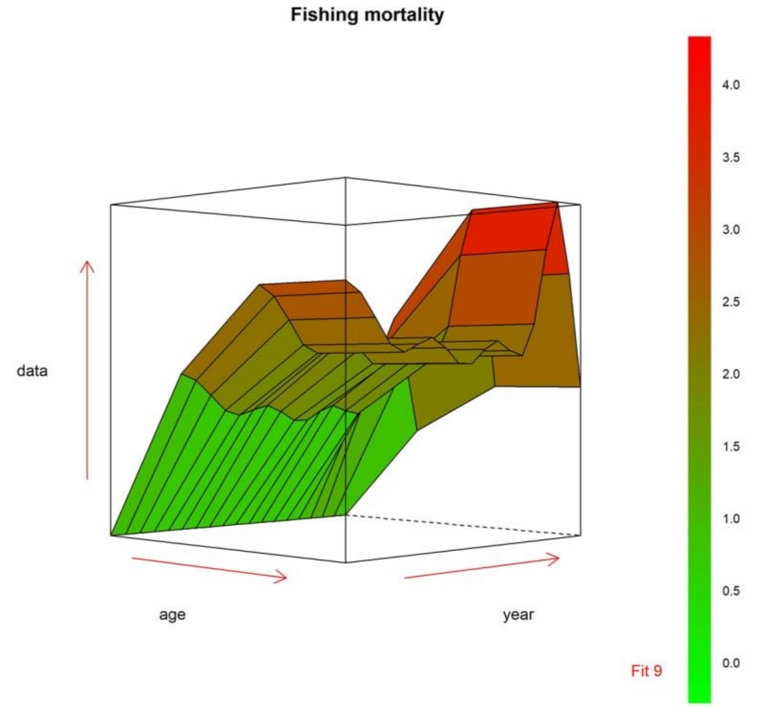


Figure 6.2.3.3.4. Deep-water rose shrimp GSAs 6. 3D contour plot of estimated fishing mortality at age and year.

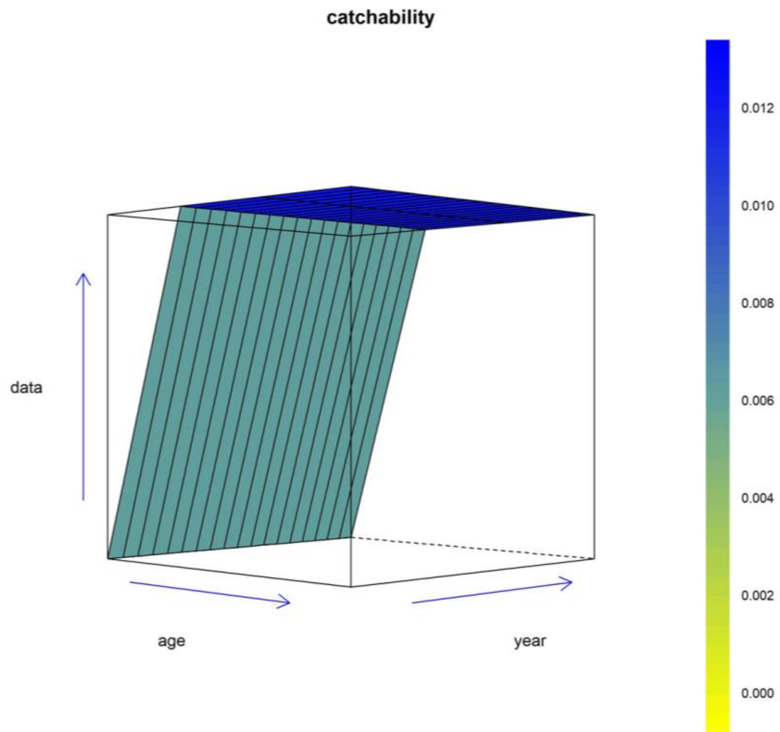


Figure 6.2.3.3.5. Deep-water rose shrimp GSAs 6. 3D contour plot of estimated catchability at age and year.

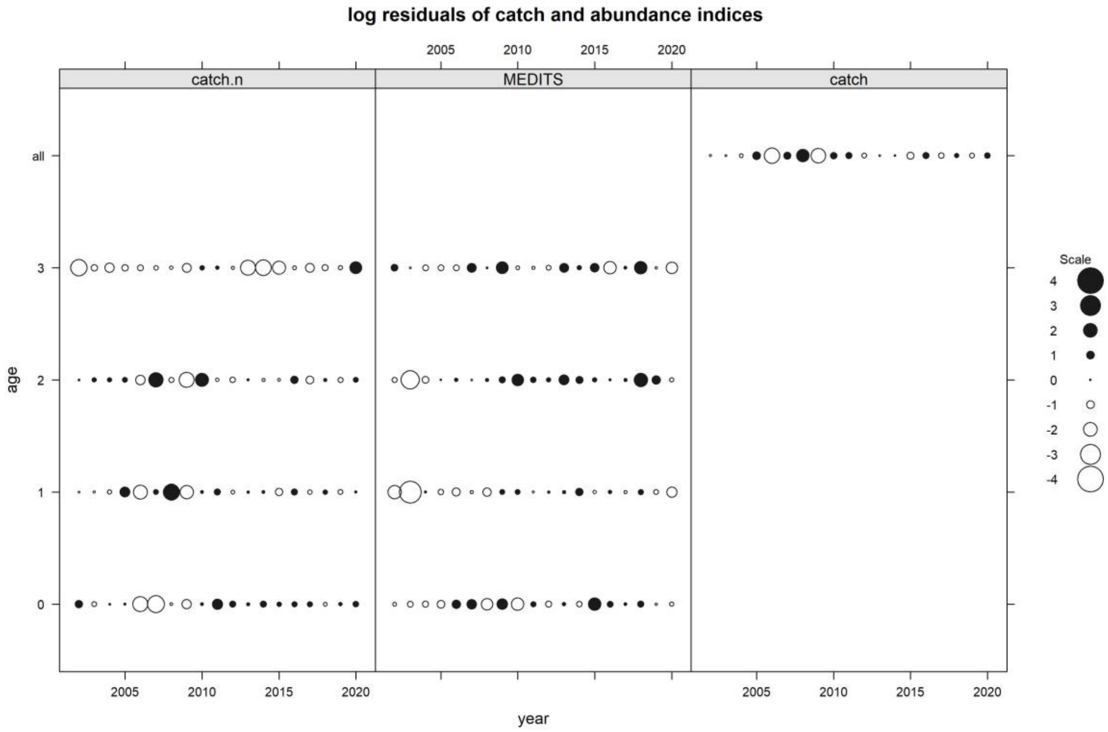


Figure 6.2.3.3.6. Deep-water rose shrimp GSAs 6. Standardized residuals for abundance indices and for catch numbers. Each panel is coded by age class.

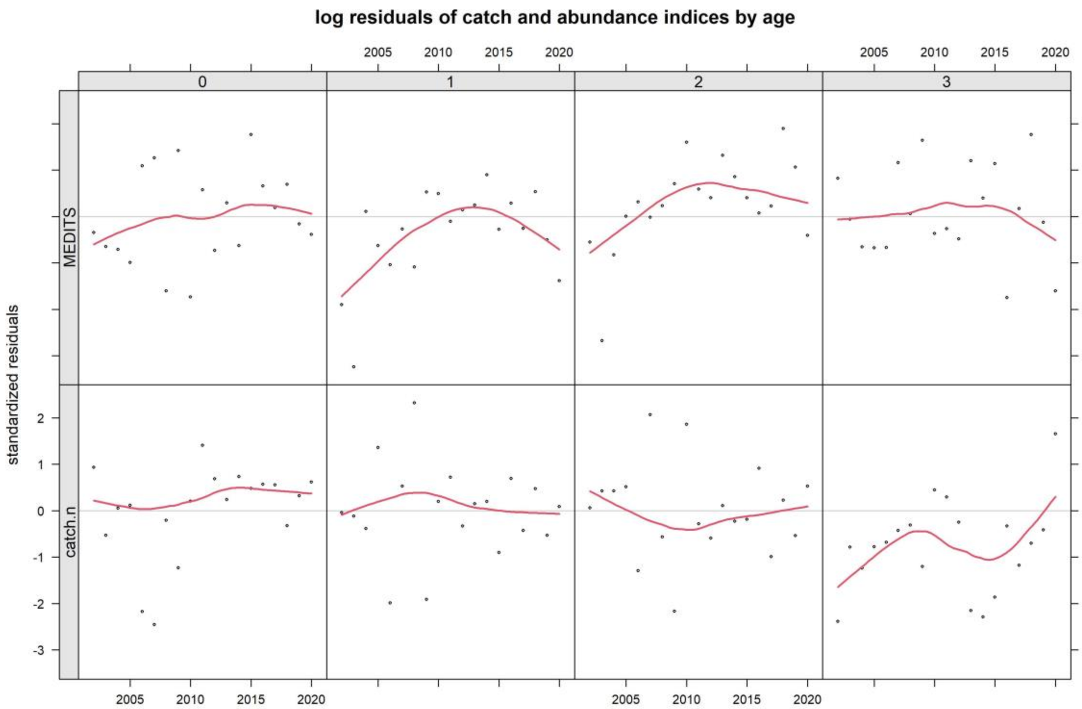


Figure 6.2.3.3.7. Deep-water rose shrimp GSAs 6. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines simple smoothers.

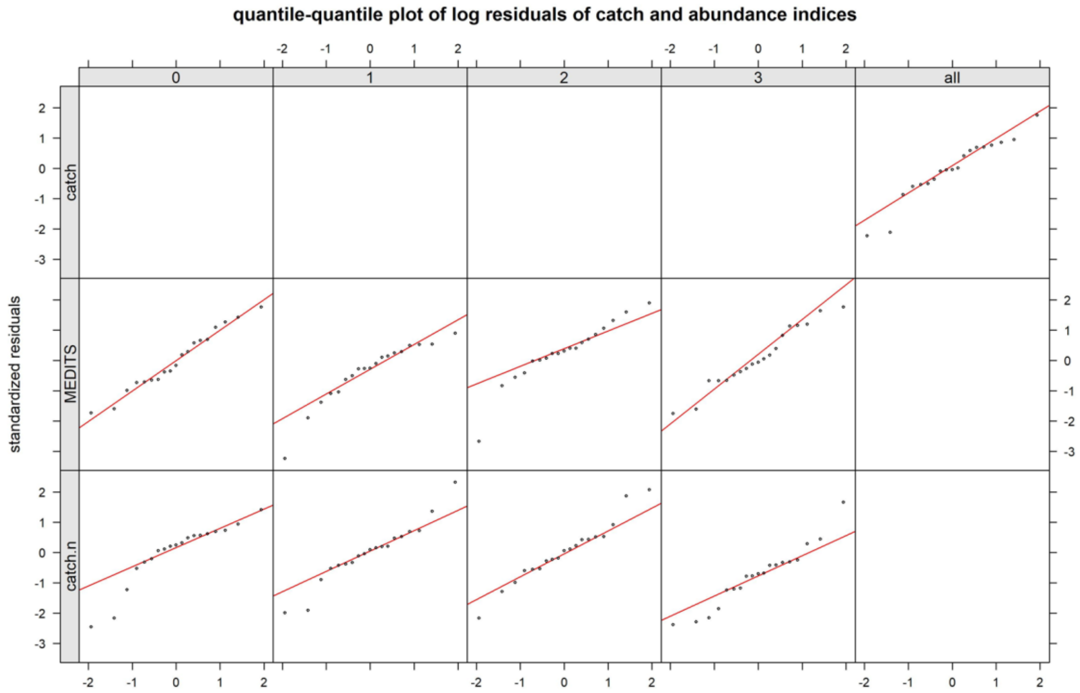


Figure 6.2.3.3.8. Deep-water rose shrimp GSAs 6. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

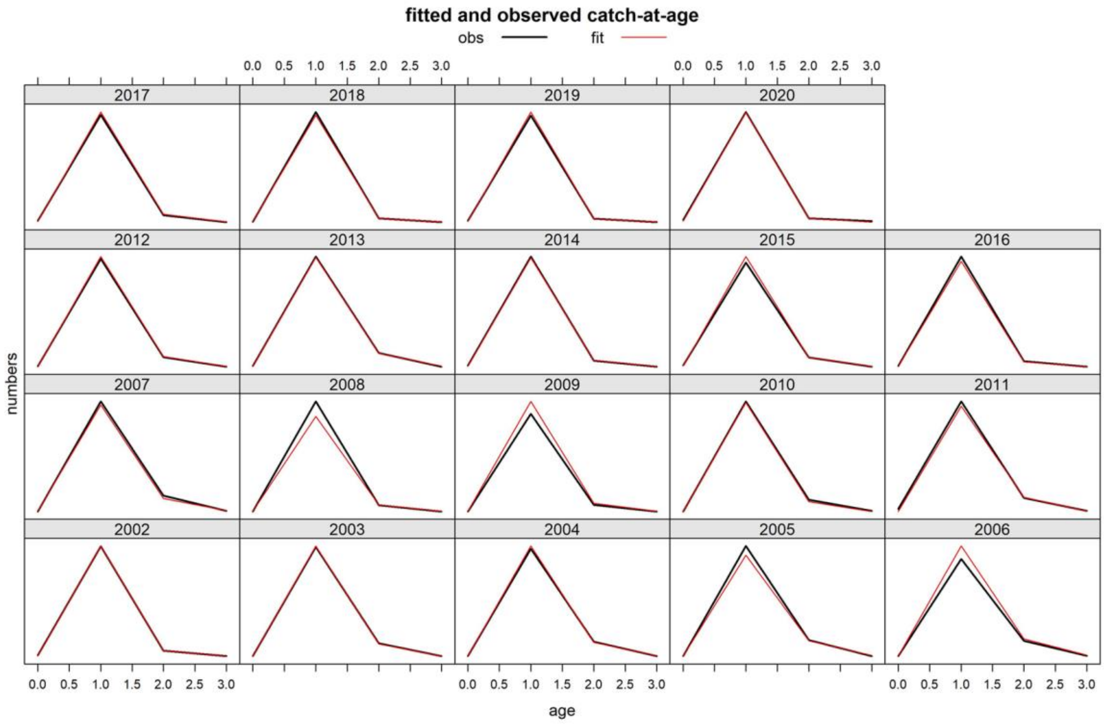


Figure 6.2.3.3.9. Deep-water rose shrimp GSAs 6. Fitted and observed catch at age.

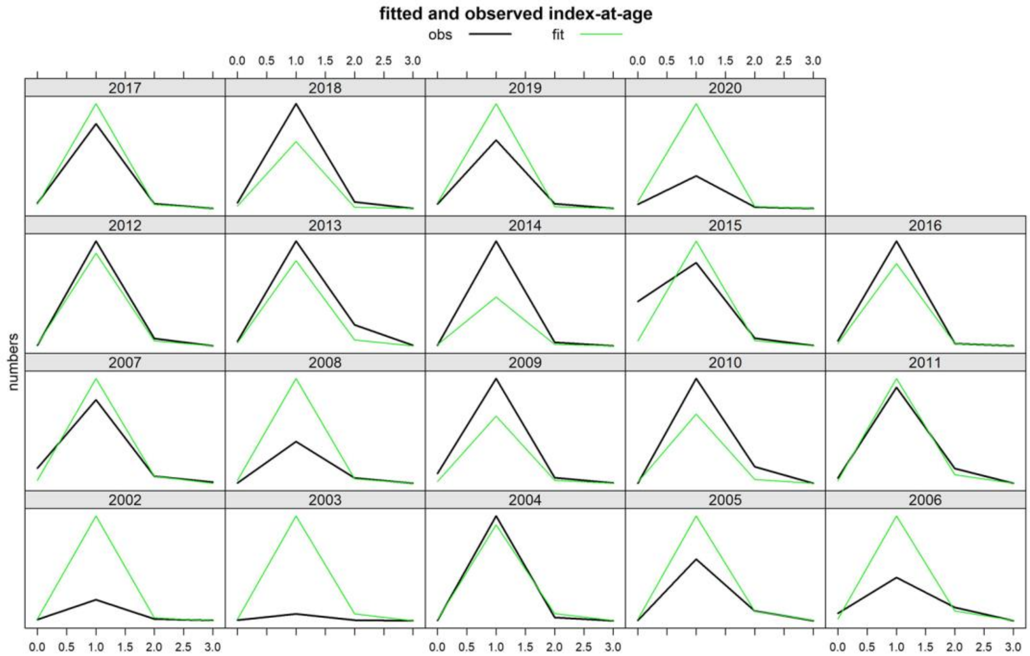


Figure 6.2.3.3.10. Deep-water rose shrimp GSAs 6. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 4 years back. Models results were consistent for the early part of the series but show considerable year on year revision in recent years (Figure 6.2.3.3.11). Because of this instability in recent years and rather high and fluctuating F the assessment was not accepted.

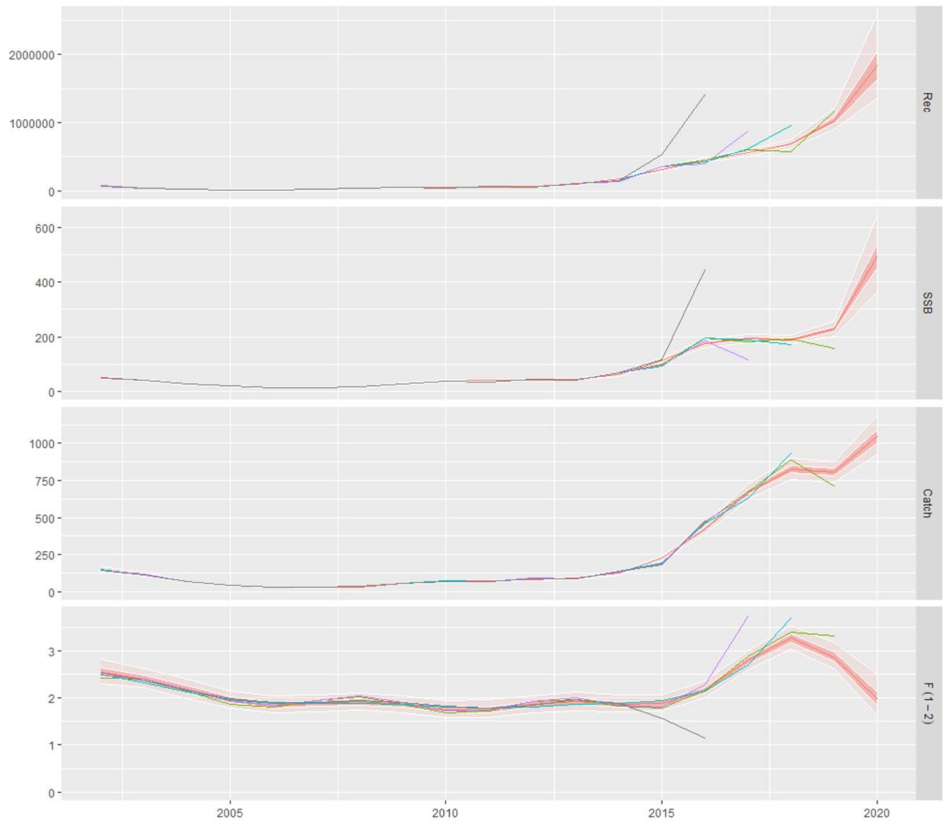


Figure 6.2.3.3.11. Deep-water rose shrimp GSAs 6. Retrospective analysis output for the a4a model.

Simulations

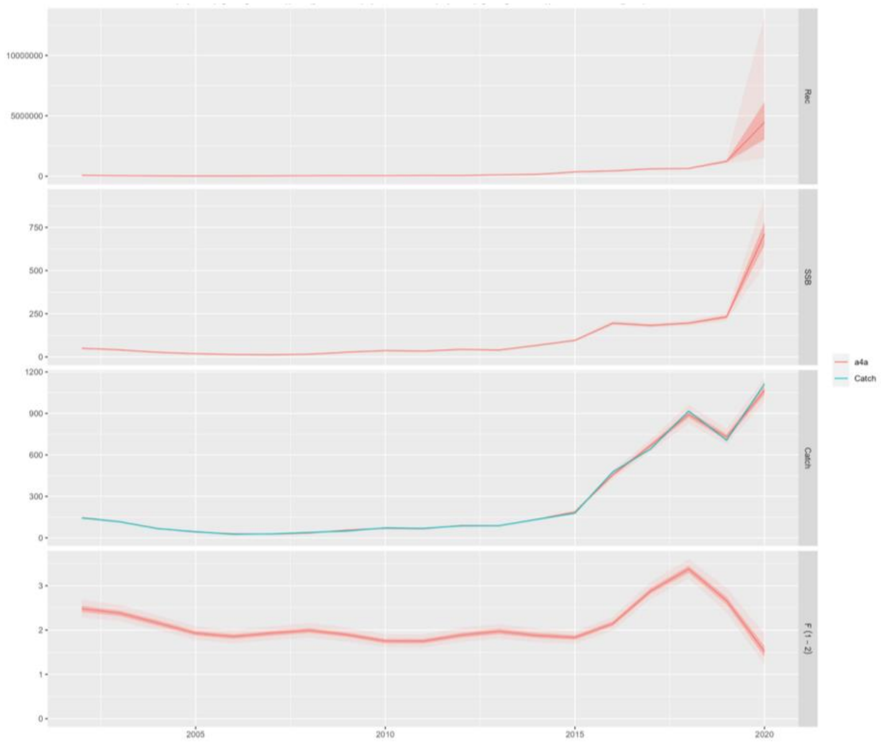


Figure 6.2.3.3.12. Deep-water rose shrimp GSAs 6. Stock summary of the simulated and fitted data for the a4a model.

In the tables 6.2.3.3.3-4 the population estimates of Deep-water rose shrimp obtained by a4a are finally provided.

Table 6.2.3.3.3. Deep-water rose shrimp GSAs 6. Stock numbers at age (thousands) as estimated by a4a.

Year/Age	0	1	2	3
2002	76590	23834	965	30
2003	42999	15144	1281	22
2004	26245	8503	909	35
2005	19547	5190	612	33
2006	19512	3866	449	30
2007	25601	3859	364	25
2008	37488	5063	354	20
2009	49535	7414	451	18
2010	53740	9797	694	24
2011	53570	10629	992	42
2012	61680	10595	1078	60
2013	94326	12199	993	59
2014	176221	18655	1085	51
2015	316986	34852	1723	58
2016	459115	62692	3212	90
2017	555936	90792	4575	118
2018	690327	109916	3998	78
2019	1036973	136465	3309	39
2020	1837963	205018	5625	51

Table 6.2.3.3.4. Deep-water rose shrimp GSAs 6. a4a summary results and F at age.

year	Fbar	Recruitment	SSB	TB	Catch
2002	2.55	76590	49	390	146
2003	2.42	42999	41	271	117
2004	2.19	26245	26	143	65
2005	1.96	19547	18	114	41
2006	1.85	19512	14	93	29
2007	1.88	25601	14	105	28
2008	1.92	37488	15	146	32
2009	1.86	49535	27	213	53
2010	1.76	53740	37	253	69
2011	1.76	53570	39	260	74
2012	1.86	61680	39	286	80
2013	1.92	94326	43	381	90
2014	1.88	176221	61	640	122
2015	1.88	316986	112	1159	223
2016	2.17	459115	175	1650	422
2017	2.8	555936	194	1603	672
2018	3.28	690327	188	2691	824
2019	2.89	1036973	228	3650	807
2020	2	1837963	494	5753	1051

Based on the a4a results, the Deep-water rose shrimp SSB in GSA 6 fluctuated over 2002-2014 comes down from 50 tons and up to 60 tons. In the following years it shown a continuous increase up to 494 tons. The assessment shows an increasing trend in the number of recruits in the last years also. The recruitment (age 0) reached a maximum of 1837963 thousands individuals in 2020. F_{bar} (1-2) shows an increasing trend from around 2 in 2015 up to a value of 3.28 in 2018, and then drop again to 2. The values of F at age show extremely high values for ages 1, 2 and 3. Therefore, the EWG 21-11 concluded that the output of this model was not suitable to provide the basis of the current status of the stock.

6.2.3.4 REFERENCE POINTS

As the assessment carried out during EWG 21-11 was not accepted for advice, reference points were not calculated.

6.2.3.5 SHORT TERM FORECAST AND CATCH OPTIONS

No short term forecast was performed. Combined catch advice given in 2020 is used for 2022, see section 5.2.

6.2.3.6 DATA DEFICIENCIES

Data from DCF 2020 as submitted through the Official data call in 2021 were used.

In GSA 6, length frequency distributions of discard in 2019 were not reliable. A check on the submitted data highlight a possible error for the record ID = 500814.

6.2.4 DEEP-WATER ROSE SHRIMP IN GSA 7

6.2.4.1 STOCK IDENTITY AND BIOLOGY

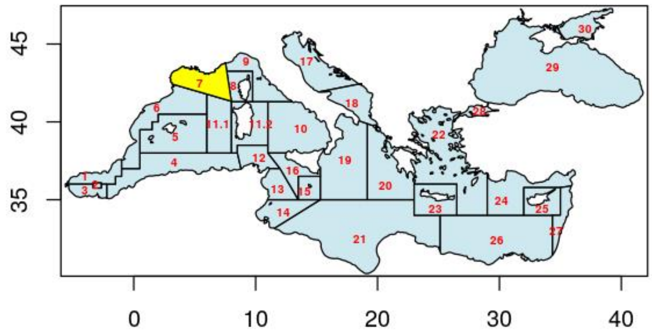


Figure 6.2.4.1.1. Geographical location of GSA 7.

STECF EWG 21-11 was requested to assess the Deep-water rose shrimp stock in GSA 7 (Figure 6.2.4.1.1). Growth parameters and length-weight relationship parameters were available within the DCF 2021. However, for the purpose of the assessment of DPS 7, the same parameters as 2020 in EWG 20-09 were used (STECF-20-09)

Table 6.2.4.1.1. Deep-water rose shrimp GSA 7. Growth parameters and length-weight relationship parameters.

Source	Area	L_∞	K	t_0	a	b
STECF-20-09	GSA 7	47	0.79	-0.03	0.025	2.545

Maturity and Natural mortality have also been assumed to be equal to the values used in the latest GFCM assessment (Table 6.2.4.1.2).

Table 6.2.4.1.2. Deep-water rose shrimp GSA 7. Proportion of mature specimens-at-age and natural mortality-at-age. taken from 20-09

Age	Area	0	1	2	3+
Maturity	GSA 7	0	1	1	1
M	GSA 7	1.62	0.88	0.73	0.67

6.2.4.2 DATA

6.2.4.2.1 CATCH (LANDINGS AND DISCARDS)

General description of Fisheries

Deep-water rose shrimp is not a target species in GSA 7, most likely due to the low biomass observed by the MEDITS survey (see estimated abundance derived from survey data in Figure 6.2.4.2.2.1). It is primarily caught by bottom trawlers in this area.

In other areas, where deep-water rose shrimp is a target species, bottom trawlers operate on the upper slope of the continental shelf. In areas where it is abundant, the deep-water rose shrimp is a valuable species. Boats that target this species are not part of the artisanal fleet.

Landings

Landings data were reported to STECF EWG 21-11 through the Data Collection Framework. In GSA 7 most of the landings came from otter trawls (Table 6.2.4.2.1.1 and Figure 6.2.4.2.1.1). Landings data increased from 2008 to 2020 when they reached their maximum (Table 6.2.4.2.1.2). Spain collected length frequency data that were used to raise the landings and the discards and derive catch-at-age data. However, France did not report any length frequency data. The Spanish data were used to reconstruct French data for the purpose of running an age structured stock assessment model.

Table 6.2.4.2.1.1. Deep-water rose shrimp GSA 7. Landings data in tonnes by fleet.

Year	FPO	GTR	OTB	OTM	OTT
2008			0.13		
2009			0.14		
2010		0.01	3.77	0.06	0.14
2011			7.27	0.08	0.01
2012			5.34	0.03	
2013			4.64	0.02	0.002
2014			7.17	0.02	0.44
2015			17.4	0.01	1.00
2016			62.8	0.20	7
2017			57.5	0.19	25.3
2018			34.4	0.14	21.7
2019			14.3	0.04	16.9
2020	0.01		54.0	0.04	80.3

Table 6.2.4.2.1.2. Deep-water rose shrimp GSA 7. Landings data in tonnes by year.

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.13	0.14	4.13	7.36	5.37	4.68	7.64	18.41	70.01	83.15	56.22	31.25	134.33

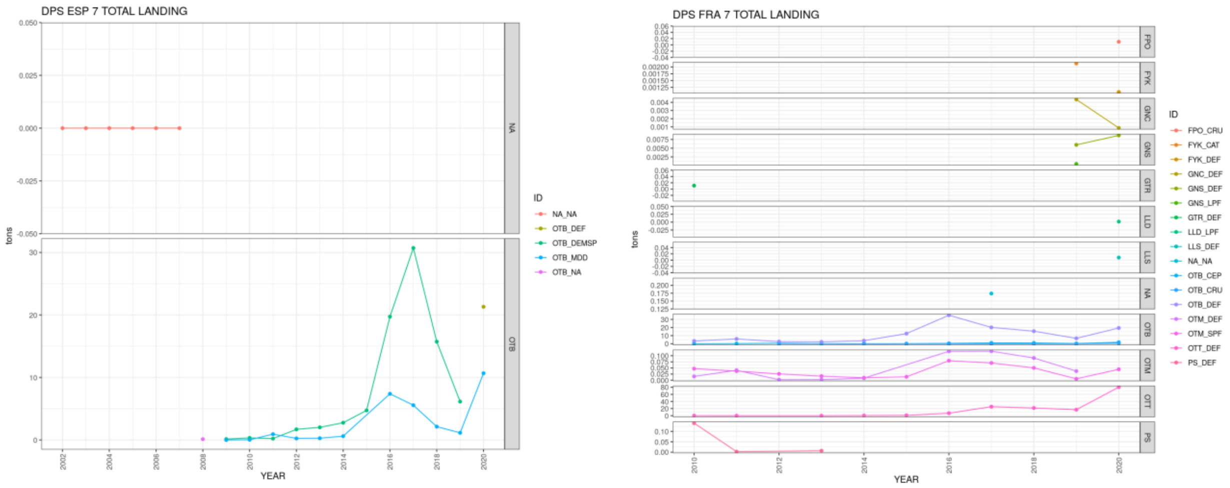


Figure 6.2.4.2.1.1. Deep-water rose shrimp GSA 7. Landings data in tonnes by year and fleet in GSA 7 for the Spanish fleet (left) and the French fleet.

In GSA 7, length frequency distributions were only available from 2009. The group decided to use the scripts developed during EWG 21-02 to fill the missing length frequency distributions for the metiers without any length information. Reconstructed length frequency distribution of the landings by year and fleet and the reconstruction procedure are presented in Figures 6.2.4.2.1.3-4.

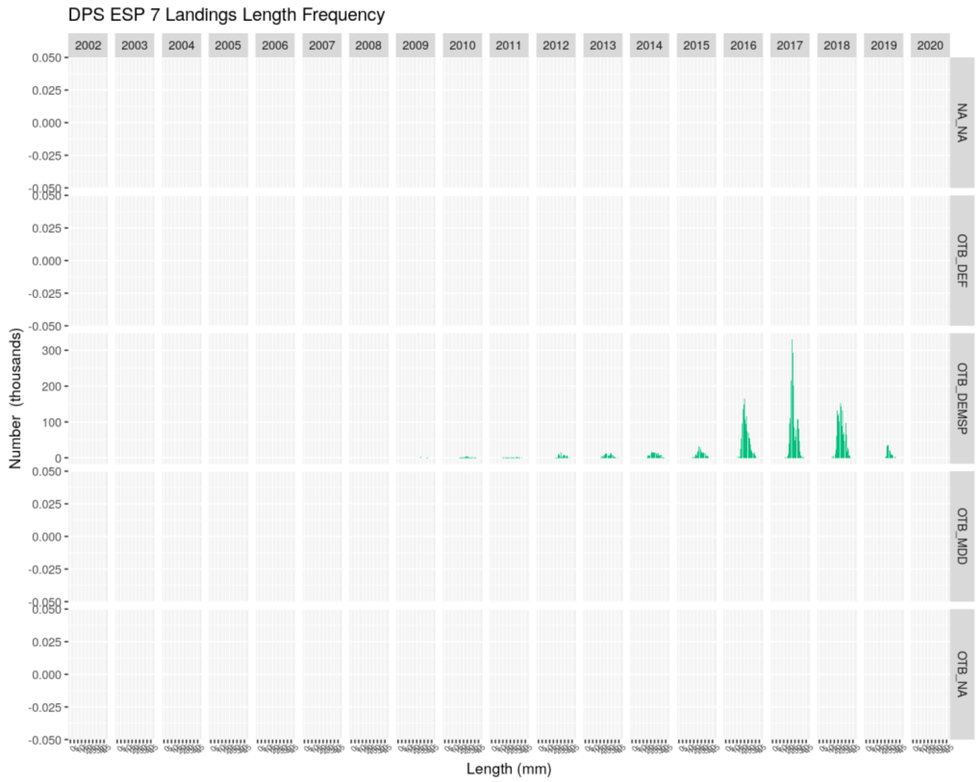


Figure 6.2.4.2.1.2. Deep-water rose shrimp GSA 7. Original length frequency distribution of the landings by year and fleet in GSA 7 for the Spanish fleet. No length frequency were provided for the French fleet.

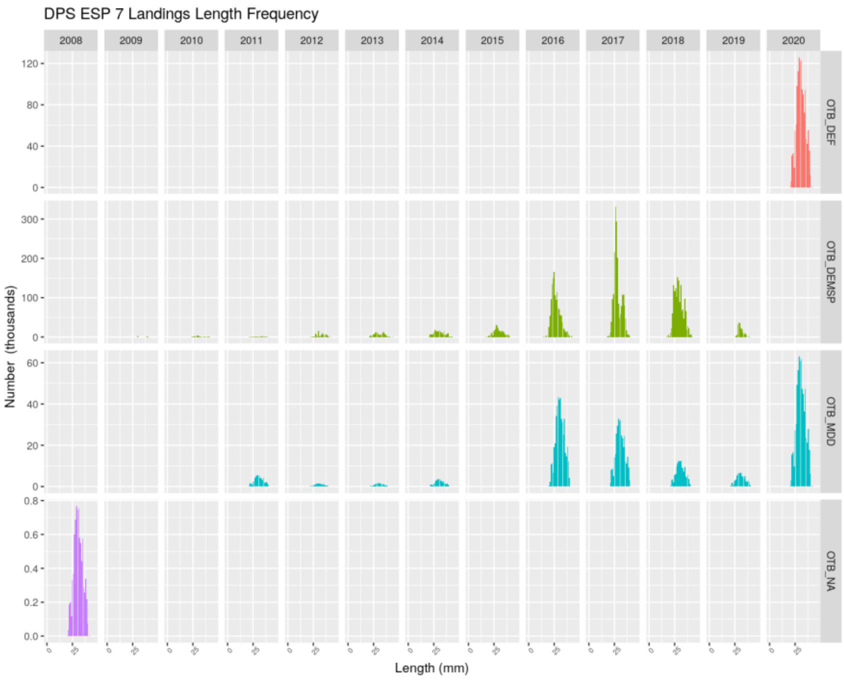


Figure 6.2.4.2.1.3. Deep-water rose shrimp GSA 7. Reconstructed length frequency distribution of the landings by year and fleet in GSA 7. As shown in Figure 6.2.4.2.1.2, no length frequency data were collected for the French fleet.

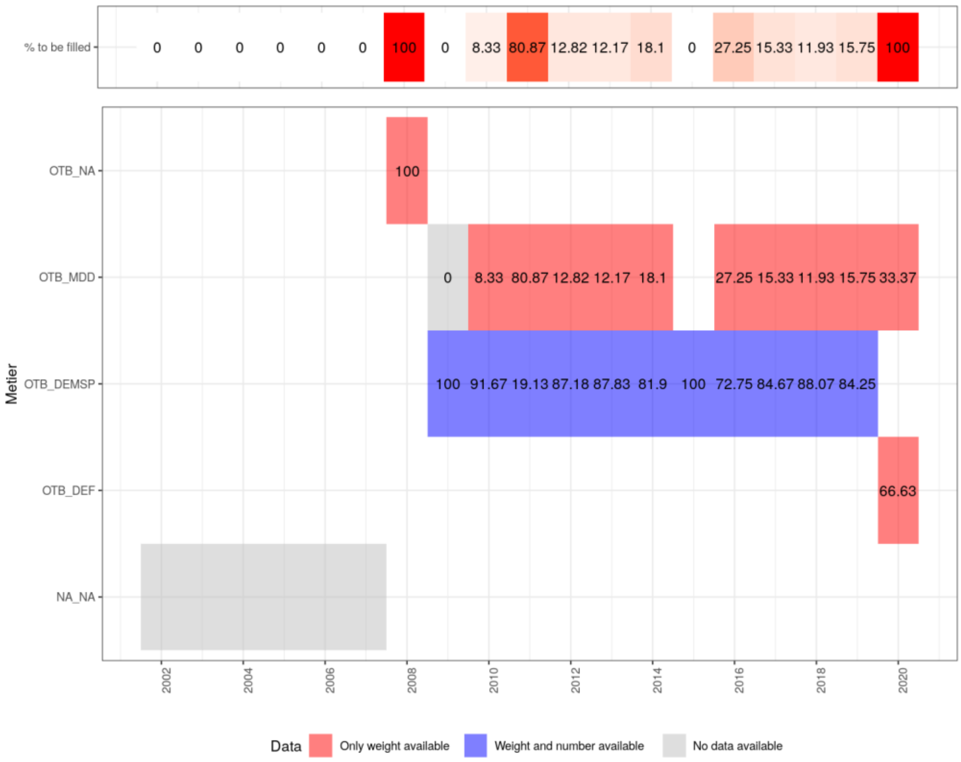


Figure 6.2.4.2.1.4. Deep-water rose shrimp GSA 7. Reconstruction of the length frequency distribution of the landings by year and fleet in GSA 7. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

Discards

Discards data were reported to STECF EWG 21-11 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 6.2.4.2.1.3.

Table 6.2.4.2.1.3. Deep-water rose shrimp GSA 7. Official discards data in tonnes by fleet.

Year	OTB
2008	0.01
2009	0.00
2010	0.00
2011	0.07
2012	0.30
2013	0.29
2014	0.03
2015	0.03
2016	0.10
2017	0.23
2018	0.04
2019	0.00
2020	

The percentages of the weight of the discards reconstructed are presented in Figure 6.2.4.2.1.5.

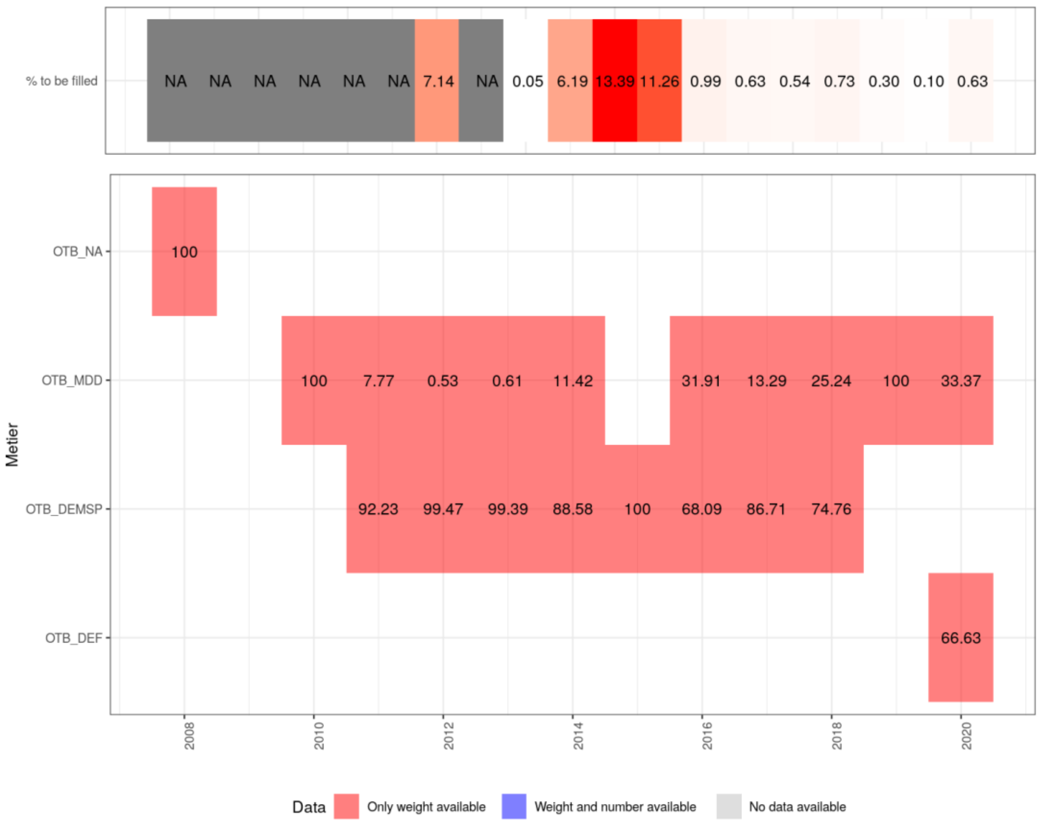


Figure 6.2.4.2.1.5. Deep-water rose shrimp GSA 7. Reconstruction of the discards by year and fleet in GSA 7. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total catches per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total catches per year.

Discards were included in the stock assessment. Therefore, we will refer to catches as the sum of landings and discards as catch in the rest of the report.

Length frequency distributions of the discards were not in the DCF data.

6.2.4.2.2 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out each year in spring season with the exception of 2020. Due to the COVID-19 pandemic that broke out in 2020, the MEDITS survey was delayed and conducted in autumn instead of spring.

The sampling design of MEDITS is randomly 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). 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 for GSA 7 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 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 in GSA 7:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

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, and there are assumptions over the distribution of data. 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.

In GSA 7, the abundance and the biomass ranged 0-50 individuals/km² and 0-0.5 kg/km² from the start of the time series to 2013 (Figures 6.2.4.2.2.1-2). A steep increase in both variables was then observed until 2016. Following that period, both the abundance and the biomass were highly variable.

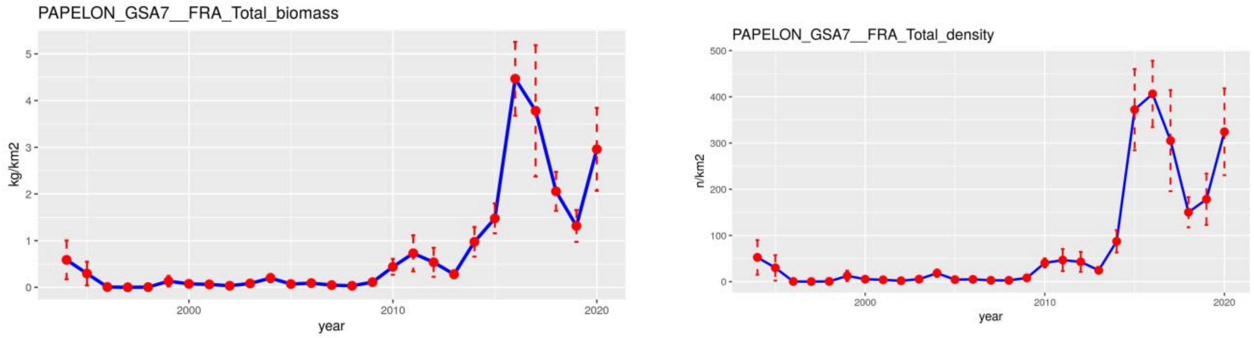


Figure 6.2.4.2.2.1. Deep-water rose shrimp GSA 7. Estimated density (N/km^2) and biomass (kg/km^2) indices in GSA 7.

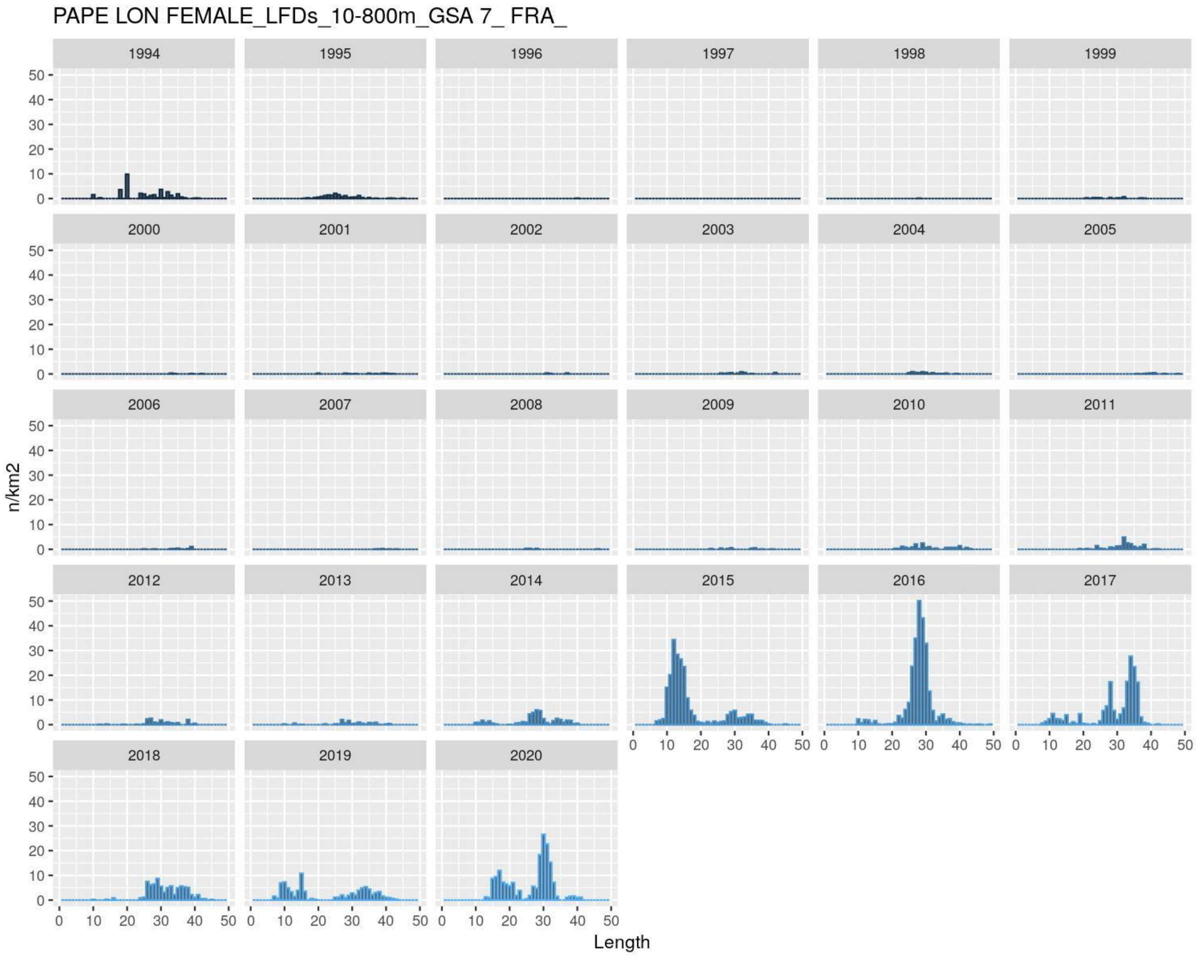


Figure 6.2.4.2.2.2. Deep-water rose shrimp GSA 7. Length frequency distribution by year of MEDITS GSA 7.

6.2.4.3 Stock assessment

The stock DPS 7 has not been benchmarked yet. However, experts decided to use in trial the statistical catch-at-age (SCA) model a4a (Jardim et al., 2015). This age-structured model uses as input data catch-at-age and an index of abundance to derive abundance-at-age and fishing mortality-at-age. As opposed to VPA like models (such as XSA), in a SCA, 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. For the DPS 7 stock, data are scarce and only data from 2010 were used as input to the a4a model. The model was tuned using an index derived from the MEDITS survey data from 2010. Both catch numbers-at-length and index numbers-at-length were sliced using the l2a routine in FLR and the GSA 7 growth parameters. The t0 of the von Bertalanffy was changed (adding 0.5) in order to account for the assumed spawning time in the middle of the year. The analyses were carried out for the ages 0 to 3+ and age groups 0-2 were considered to compute Fbar

Input data

The growth parameters used for VBGF were the one reported in table 6.2.4.1.1.

Total catches and catch numbers at age were used as input data. No SOP correction was required (Table 6.2.4.3.1).

Table 6.2.4.3.1. Deep-water rose shrimp GSA 7. SOP correction vector.

Year	SOP
2010	1
2011	1
2012	1
2013	1
2014	1
2015	1
2016	1
2017	1
2018	1
2019	1
2020	2

Table 6.2.4.3.2 lists the input data for the a4a model, namely catches, catch numbers-at-age, weights-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 6.2.4.3.2. Deep-water rose shrimp GSA 7. Input data for the a4a model.

Deep-water rose shrimp GSA 7 Catches (t)

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
3.8	6.2	3.4	2.4	4.4	13.8	43.3	48.1	40.6	26.6	105.7

Deep-water rose shrimp GSA 7 Catch numbers-at-age matrix (thousands)

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.11	0.11	0.02	0.01	0.01	0.04	2.12	0.02	0.02	0.07	0.07
1	197	246	107	87	197	736	2917	2882	2157	1314	4414
2	45	141	89	56	87	247	560	784	691	403	2248
3+	5	0.11	0.89	3.08	3.65	0.01	3.48	0.63	14.0	0.16	2.33

Deep-water rose shrimp GSA 7 Weights-at-age (kg)

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
1	0.013	0.013	0.013	0.012	0.012	0.011	0.011	0.011	0.011	0.014	0.013
2	0.024	0.022	0.023	0.022	0.023	0.022	0.022	0.021	0.022	0.021	0.022
3+	0.032	0.034	0.034	0.040	0.033	0.034	0.034	0.033	0.032	0.034	0.034

Deep-water rose shrimp GSA 7 Maturity, Natural mortality, proportion of M and F before spawning vectors.

Age	0	1	2	3+
Maturity	0	1	1	1
M	1.62	0.88	0.73	0.67
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 7. MEDITS number (n/km^2) at age for GSA 7.

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	2.35	2.28	2.67	3.97	15.3	255.5	16.6	26.7	1.66	90.0	23.4
1	26.5	34.6	35.3	16.4	60.1	93.3	371	187.5	113	59.0	283
2	5.4	9.7	4.93	3.64	11.7	18.3	16.1	90.5	32.2	26.5	16.1
3	1.12	0.3	0.07	0.42	0.07	0.27	1.03	0.26	3.53	1.88	1.45

Figures 6.2.4.3.1-6.2.1.3.2-6.2.1.3.3 show the age structure of the catches, of the index and the weight at age matrix.

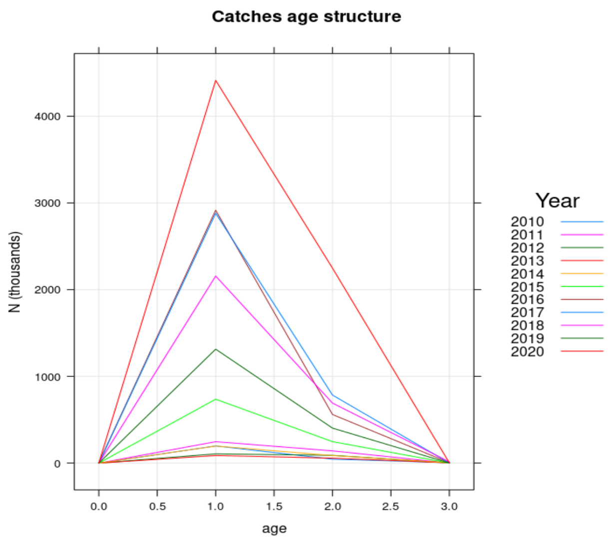


Figure 6.2.4.3.1. Deep-water rose shrimp GSA 7. Age structure of the catches.

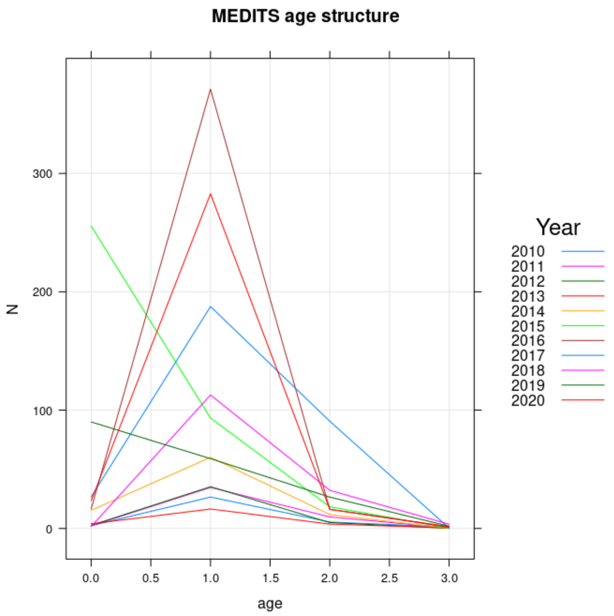


Figure 6.2.4.3.2. Deep-water rose shrimp GSA 7. Age structure of the index.

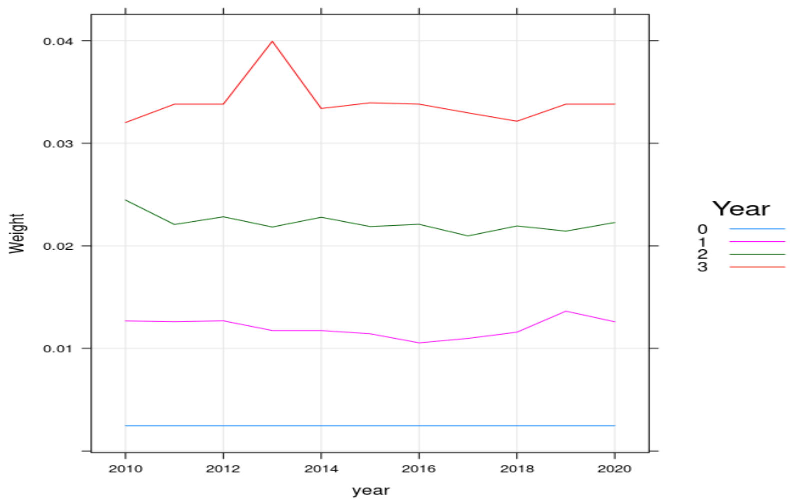


Figure 6.2.4.3.3. Deep-water rose shrimp GSA 7. Weight at age matrix.

Assessment results

Method a4a

A series of submodels for the fishing mortality, catchability and stock-recruitment were tested in a4a. The best model set (according to residuals and retrospective) was:

f ~ s(year, k = 4) + s(age, k=3)

q ~ list(~factor(age))

sr ~ factor(year)

Results are shown in Figures 6.2.4.3.4-6.2.4.3.10.

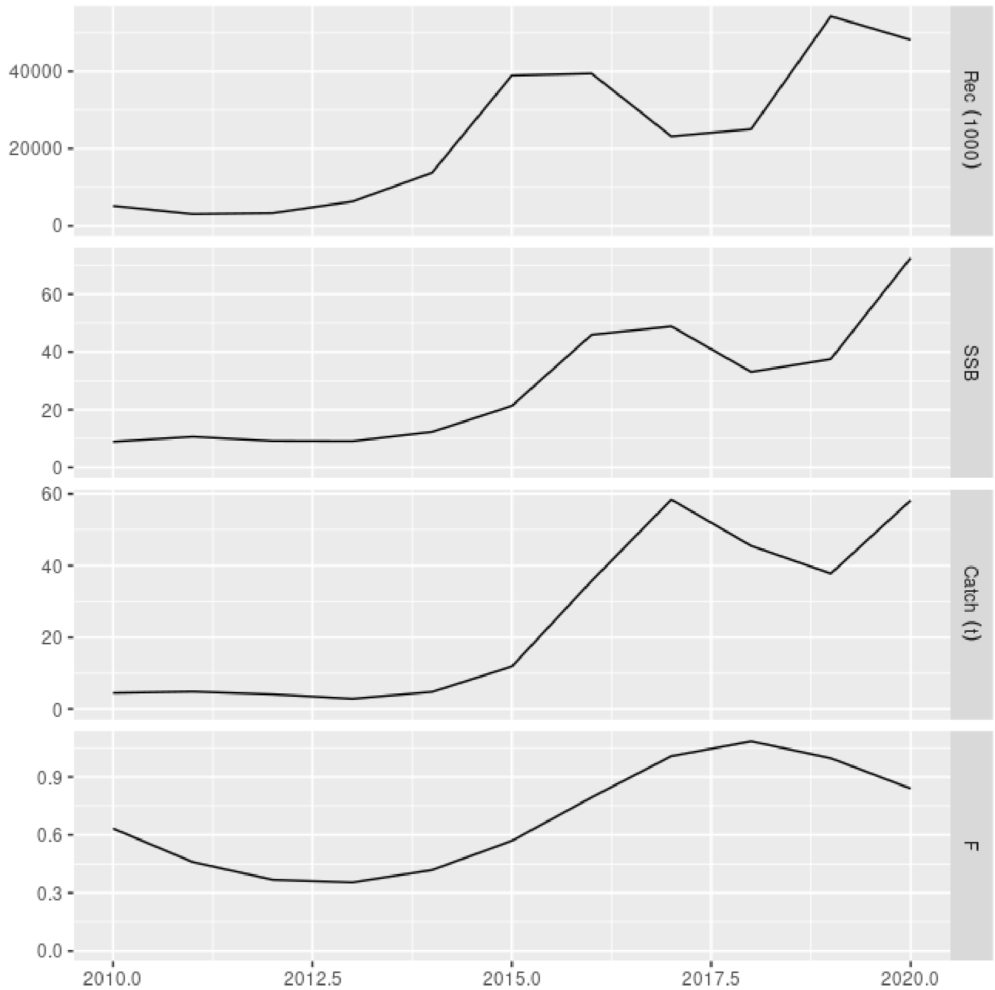


Figure 6.2.4.3.4. Deep-water rose shrimp GSA 7. Stock summary from the a4a model for Deep-water rose shrimp GSA 7 recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 0 to 2).

Figure 6.2.4.3.5. Deep-water rose shrimp GSA 7. 3D contour plot of estimated fishing mortality at age and year.

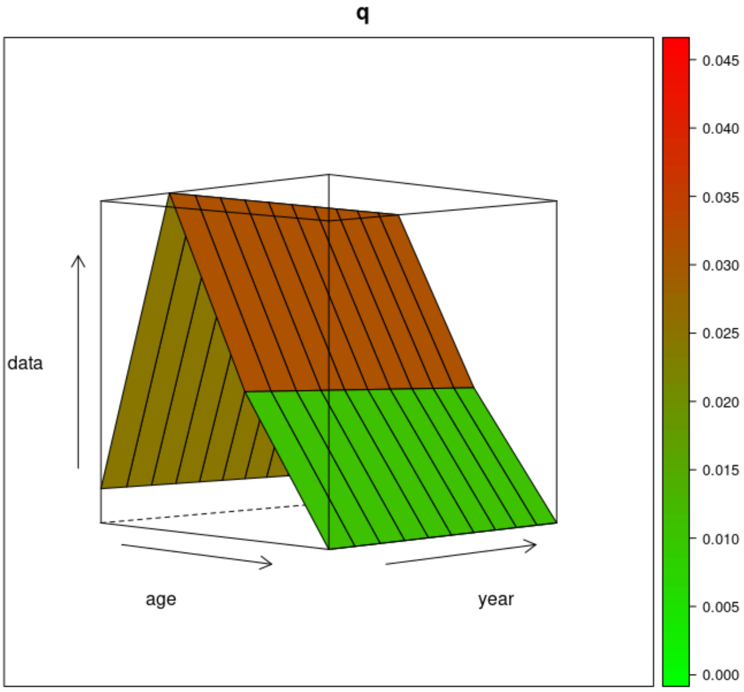


Figure 6.2.4.3.6. Deep-water rose shrimp GSA 7. 3D contour plot of estimated catchability at age and year.

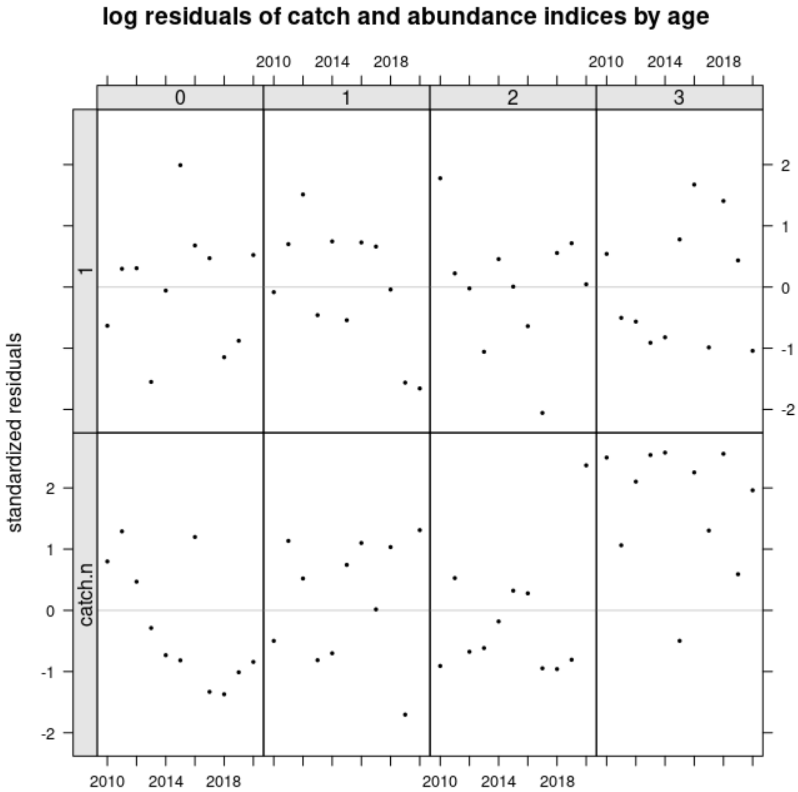


Figure 6.2.4.3.7. Deep-water rose shrimp GSA 7. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines simple smoothers.

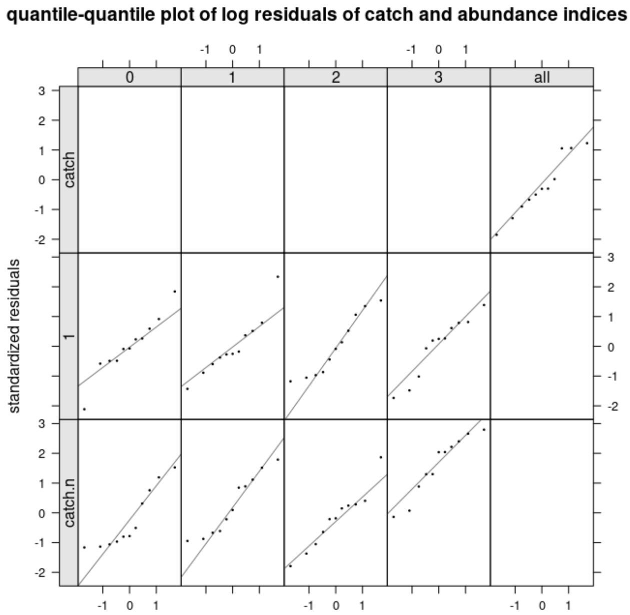


Figure 6.2.4.3.8. Deep-water rose shrimp GSA 7. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

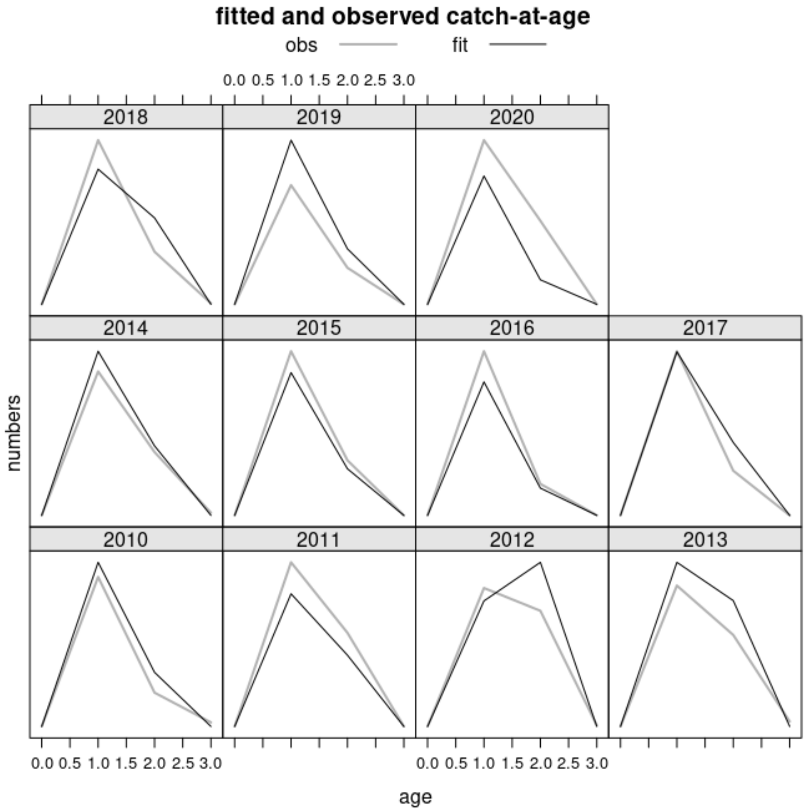


Figure 6.2.4.3.9. Deep-water rose shrimp GSA 7. Fitted and observed catch at age.

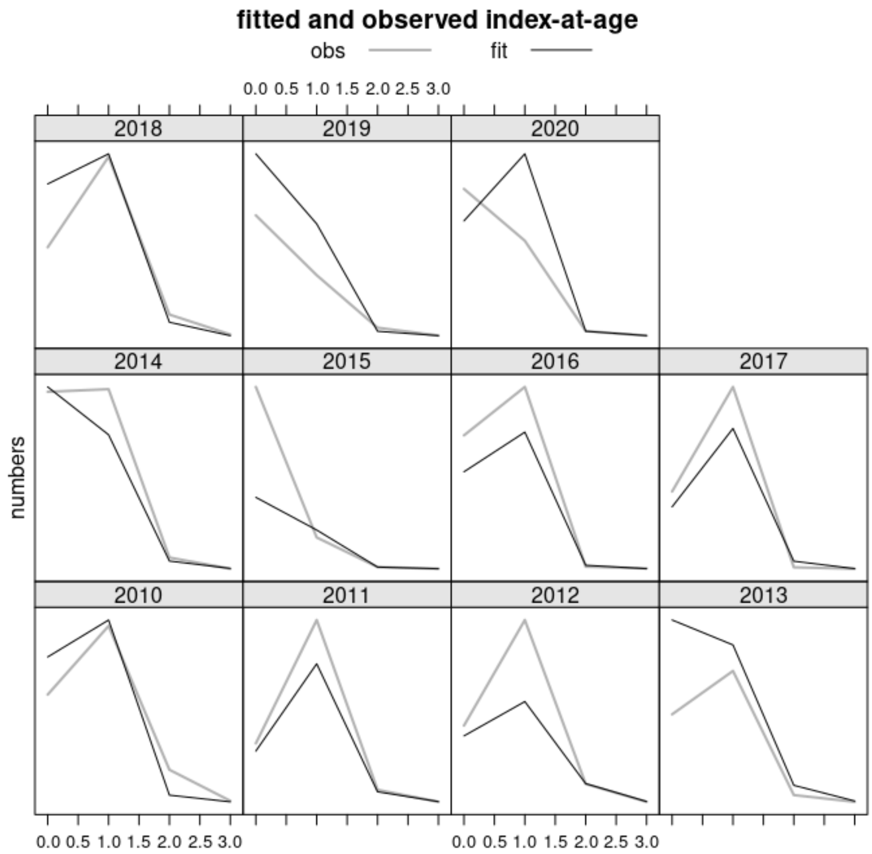


Figure 6.2.4.3.10. Deep-water rose shrimp GSA 7. Fitted and observed index at age.

Retrospective

Considering that the time series was short, only one peel was considered in the retrospective analysis (Figure 6.2.4.3.13.) The single year of data removal does not show excessive instability, but a single year is too short to make a full judgement of retrospective performance.

Simulations

In the tables 6.2.4.3.3 and 4 the population estimates of Deep-water rose shrimp obtained by a4a are provided.

Table 6.2.4.3.3. Deep-water rose shrimp GSA 7. Stock numbers at age (thousands) as estimated by a4a.

age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	11222	7651	9091	20463	38819	170790	79193	51248	31146	131152	60778
1	1939	2221	1514	1799	4050	7682	33799	15672	10142	6164	25955
2	313	660	800	564	679	1525	2843	12117	5375	3307	1909
3+	1532	890	701	675	574	568	888	1506	4905	4183	3078

Table 6.2.4.3.4. Deep-water rose shrimp GSA 7. a4a summary results and F at age.

	Fbar 0-2	Recruitment (thousands)	SSB (t)	TB (t)	Catch (t)
2010	0.19	11222	53.9	109	4.64
2011	0.13	7651	47.2	91.5	4.86
2012	0.10	9091	40.2	83.6	3.66
2013	0.09	20463	40.1	111	2.67
2014	0.09	38819	52.7	178	4.73
2015	0.11	170790	88	561	10.8
2016	0.14	79193	273	644	43.0
2017	0.18	51248	285	602	73.8
2018	0.23	31146	246	470	47.4
2019	0.27	131152	187	619	35.8
2020	0.32	60778	273	623	79.6

F at age	0	1	2	3+
2010	5.2e-6	0.20	0.36	3.1e-5
2011	3.7e-6	0.14	0.26	2.2
2012	2.8e-6	0.11	0.20	1.7
2013	2.5e-6	0.09	0.17	1.5
2014	2.5e-6	0.10	0.18	1.5
2015	3.0e-6	0.11	0.21	1.8
2016	3.8e-6	0.15	0.26	2.3
2017	5.0e-6	0.19	0.35	3.0
2018	6.3e-6	0.24	0.44	3.8
2019	7.7e-6	0.29	0.53	4.6
2020	9.1e-6	0.34	0.63	5.4

The results of the a4a run showed that the SSB of deep-water rose shrimp ranged 40-88 t from 2010 to 2015 (Table 6.2.4.3.4). Following that period an increase was observed and the SSB varied from 187 to 285 t over the following 5 years. Recruitment remained below 40e+6 from 2010 to 2014 and then increased and fluctuated around 100e+6. Fbar decreased from 0.19 to 0.09 over the years 2010-2014 and then increased to reach 0.32 in 2020. Residuals did not show any pattern apart from the catch-at-age for year class 0 and 3+. However, a high instability for the model was observed when the submodels were slightly modified. Fbar was found to be especially unstable with sometimes an increase by 10 folds. The exploration of the retrospective pattern also showed a high instability of the model (Figure 6.2.1.3.13). This might be due to the short time series.

In conclusion, the a4a model is not suitable to provide a reliable perception of the stock and the experts decided not to use it. The experts suggest to explore other methods such as surplus production models (implemented in SPiCT or JABBA) and the 2-stage biomass model that might be more suitable. Finally, the low abundance and biomass observed in the survey questions on the stock id of this stock.

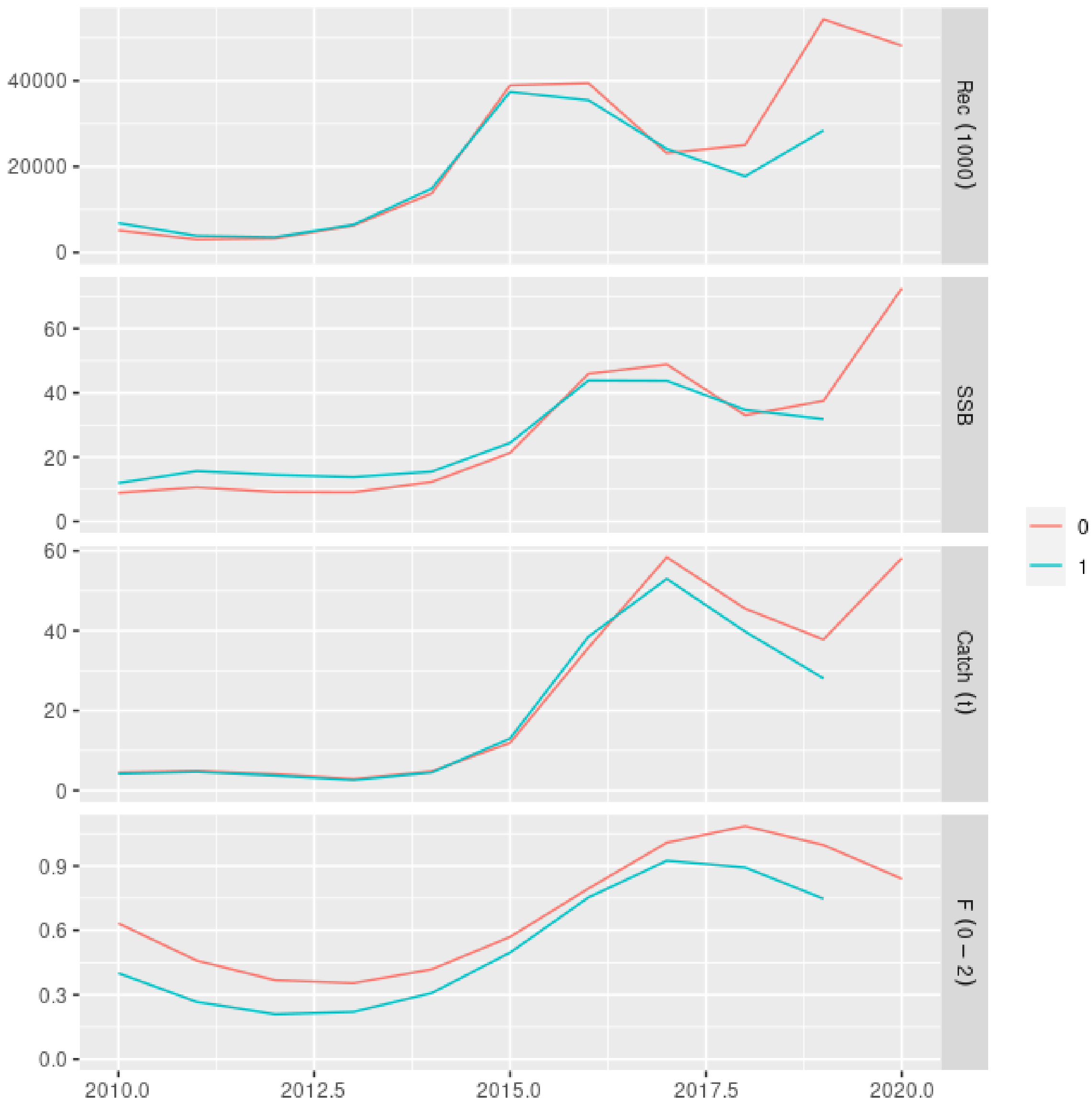


Figure 6.2.4.3.13. Deep-water rose shrimp GSA 7. Retrospective analysis output for the a4a model including catch data for 2020.

6.2.4.4 Reference Points

As the assessment carried out during EWG 21-11 was not accepted for advice, reference points were not calculated.

6.2.4.5 Short term Forecast and Catch Options

As the assessment carried out during EWG 21-11 was not accepted for advice no short term forecast was performed. Combined catch advice given in 2020 is used for 2022, see section 5.2.

6.2.4.6 Data Deficiencies

Data from DCF 2020 as submitted through the Official data call in 2021 were used. Length frequencies were provided only by Spain. France reported some catches but did not provide the associated length frequencies. The catch data series is very short which does not help to run an age structured model. The MEDITS survey in GSA 7 was conducted in autumn instead of spring which brings additional uncertainty in the modelling.

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 12% of the catches). From official data, the total trawl fleet of the geographical sub area GSA 1 (Northern Alboran Sea region) is composedby about 170 boats (data compiled in EWG 11 12). 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.

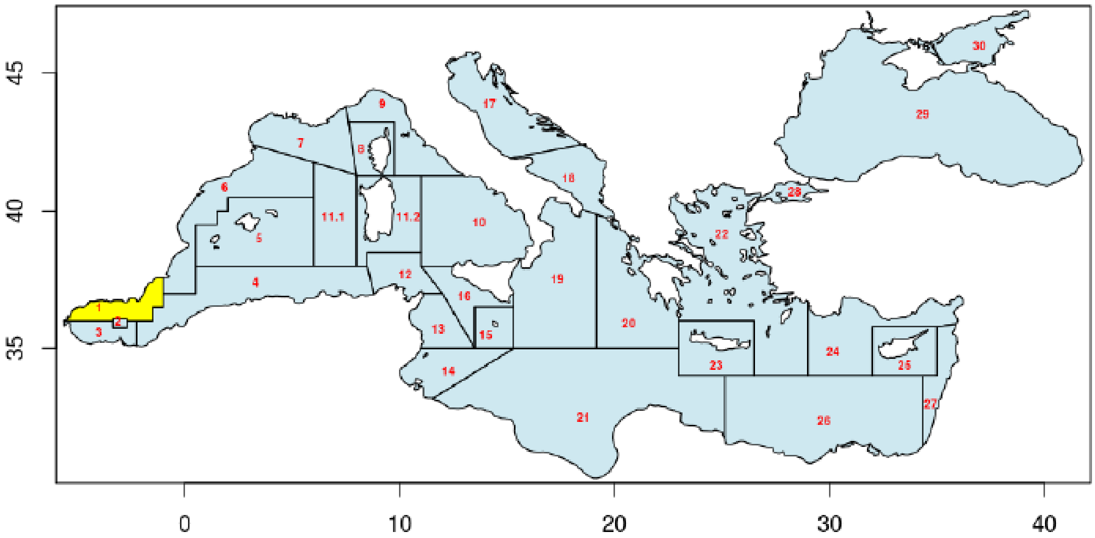


Figure 6.3.1.1 Red mullet in GSA 1: Location of GSA 1 in the Mediterranean Sea.

Trawl fisheries in GSA 1 are regulated by "Orden AAA/2808/2012" published in the Spanish Official Bulletin (BOE nº 313 29 December 2012) containing an Integral Management Plan for Mediterranean fishery resources. 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.

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 correctly with the length.

Table 6.3.1.1 Red mullet in GSA 1: natural mortality and maturity vector at age.

Age	Value
Linf	34.5
k	0.34
t0	-0.1431

Age	Value
4+	1

Length-weight reationship

Dec. 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.

Natural mortality

A vector of natural mortality was estimated by Chen Watanabe 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 6.3.1.1.** .

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). Length structure of red mullet catches (landings and discards) for all gears in the period from 2003 to 2019 are shown in Figures 6.3.2.1.1 - 6.3.2.1.3 for landings, discards and catches respectively.

In 2020 quarters 1 and 2 were not sampled, in contrast to previous years where samles came frpm all quarters. This lack of the length-structure information is important since a larger number of individuals, for instance from 2017 to 2019 (last three years), has been observed in the first semester, and particularly first quarter than third and fourth quarters. Absent length-structure information in Q1 and Q2 is thought to be due to the COVID-19 pandemic.

Table 6.3.2.1.1 Red 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	0.06313	159.74
2004	154.07	154.07	0.062817	154.13
2005	140.21	140.21	0	140.21
2006	164.54	164.54	0.066926	164.61
2007	194.01	194.01	0.080208	194.09
2008	193.65	193.65	0.16	193.81
2009	228.37	228.37	1.093332	229.46
2010	201.65	201.65	0.012556	201.66
2011	201.18	201.18	0.142143	201.32
2012	107.31	107.31	1.656208	108.97
2013	131.63	131.63	0.289404	131.92
2014	123.87	123.87	3.287578	127.16
2015	135.9	135.9	1.781318	137.68
2016	260.49	260.49	7.624791	268.11
2017	274.67	274.67	3.483104	278.15
2018	170.23	170.23	2.798582	173.03
2019	124.62741	124.63	0.409217	125.04
2020	107.321	107.32	0.261602	107.58

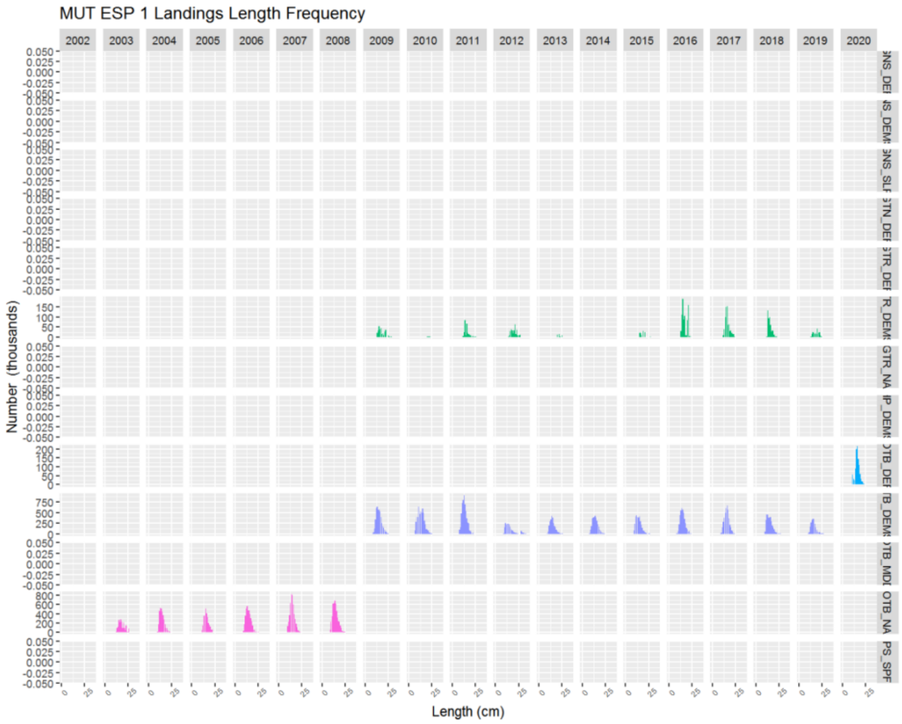


Figure 6.3.2.1.1 Red mullet in GSA 1: Length structure of red mullet landed in GSA 1 in the period from 2003 to 2020 by fishing gear and fishery.

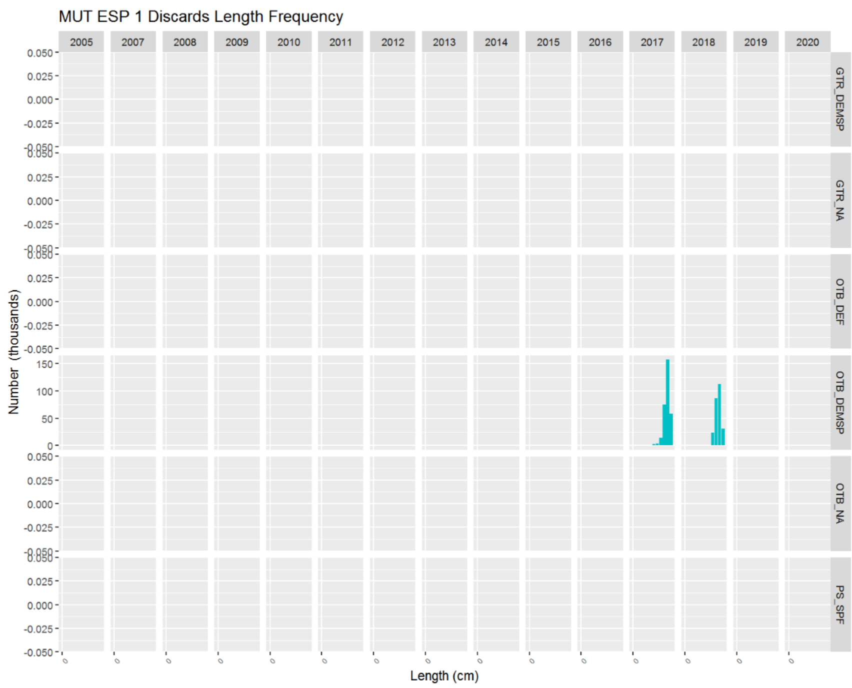


Figure 6.3.2.1.2 Red mullet in GSA 1: Length structure of red mullet discards in GSA 1 in the period from 2003 to 2020 by fishing gear and fishery.

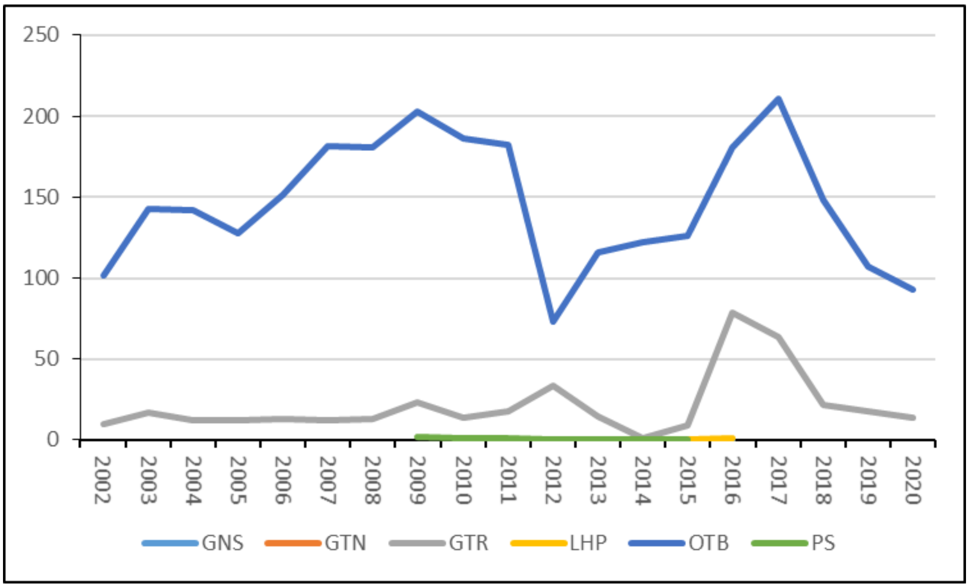


Figure 6.3.2.1.3 Red mullet in GSA 1: Landings (t) of red mullet in GSA 1 in the period from 2003 to 2020 by fishing gear and fishery.

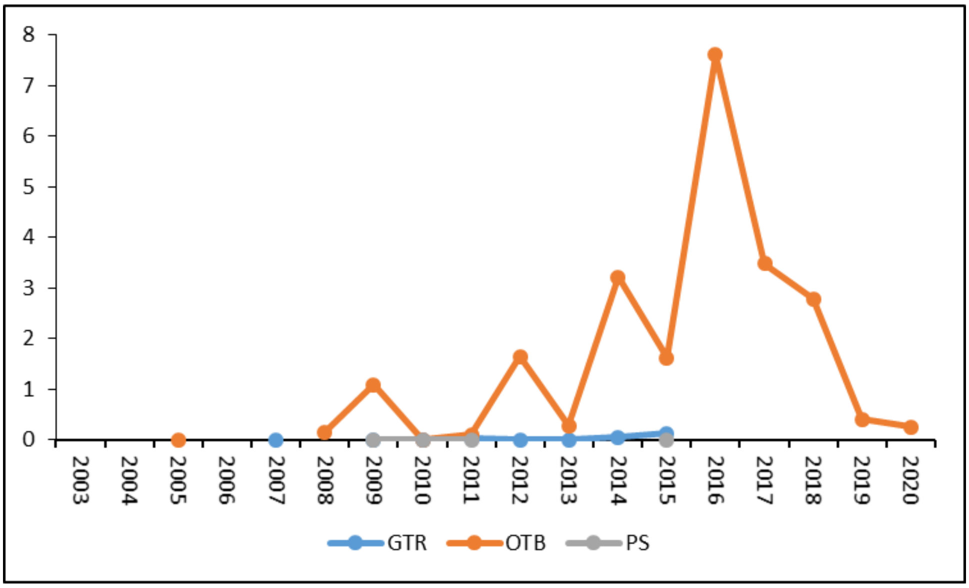


Figure 6.3.2.1.4 Red mullet in GSA 1: Discards (t) of red mullet in GSA 1 in the period from 2003 to 2020 by fishing gear and fishery.

Figure 6.3.2.1.5 Red mullet in GSA 1: Length structure of red mullet landed in GSA 1 in the period from 2003 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02.

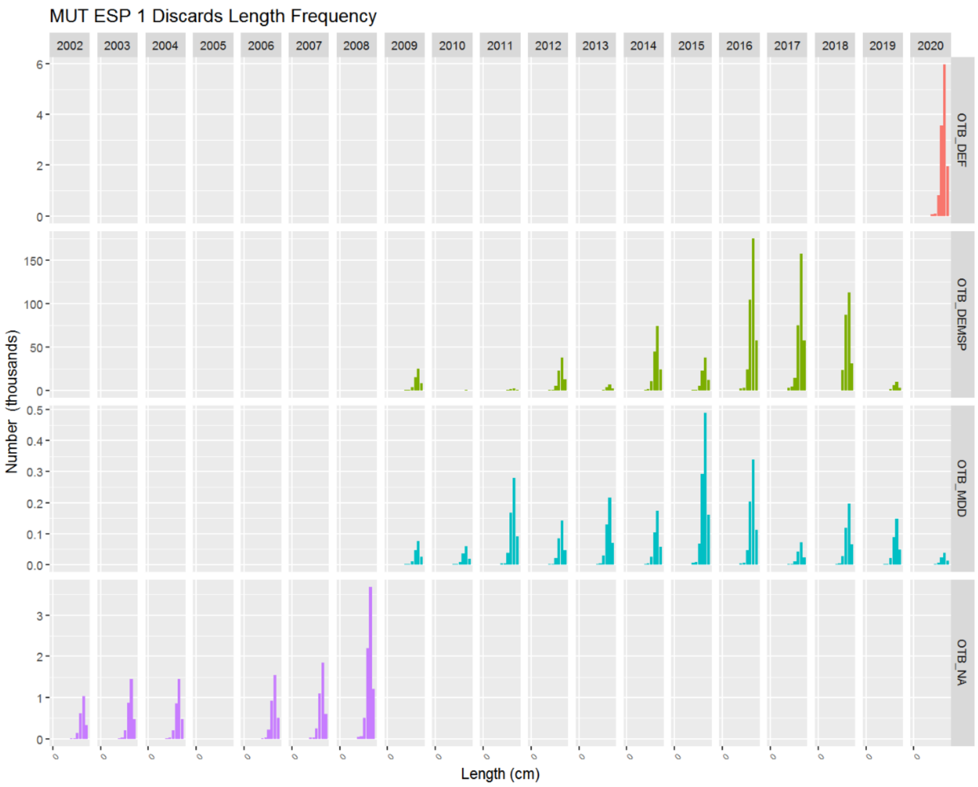


Figure 6.3.2.1.6 Red mullet in GSA 1: Length structure of red mullet catch discarded in GSA 1 in the period from 2006 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02.

6.3.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

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. 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.

The 2020 MEDITS survey was not carried out in GSA 1; the assessment is fitted without survey data for that year. Observed abundance and biomass indices of Red mullet and the length frequency distributions are given on the figures below (Figures 6.2.2.3.1 -6.2.2.3.2-6.2.2.3.3). Both estimated abundance and biomass indices show similar stable trends throughout the years with a peak through years 2006 -2009.

Figure 6.3.2.3.1 Red mullet in GSA 1: Survey periods of MEDITS in GSA 1.

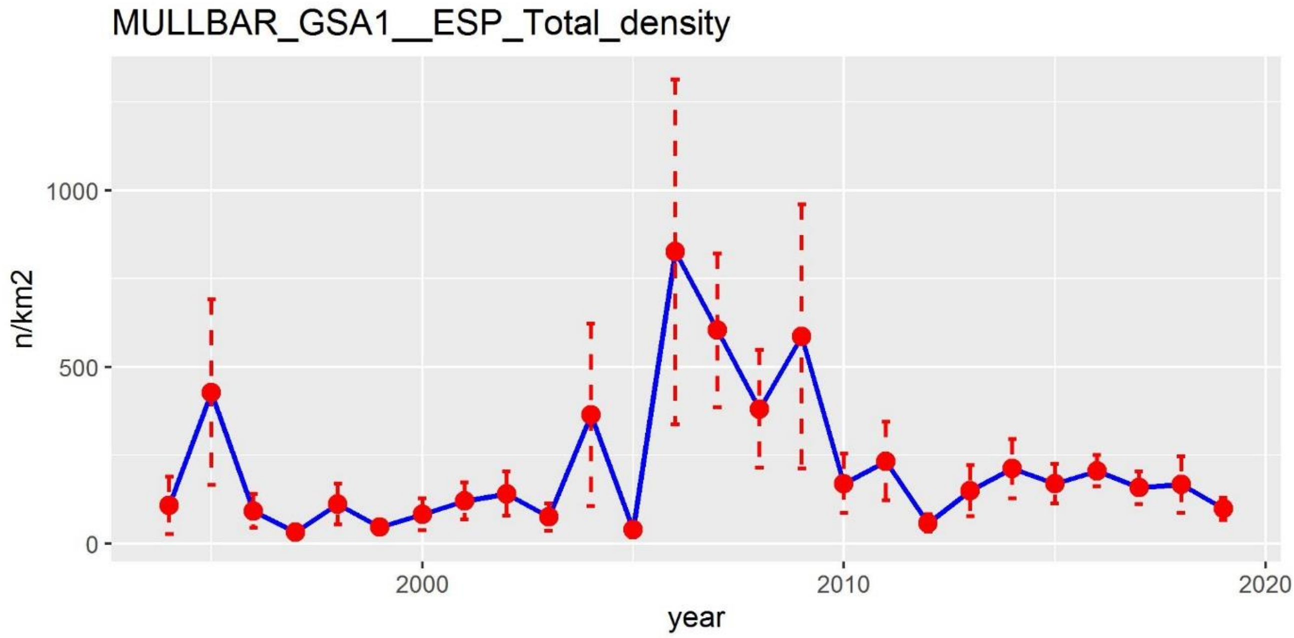


Figure 6.3.2.3.2 Red mullet in GSA 1: Abundance indices of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2020).

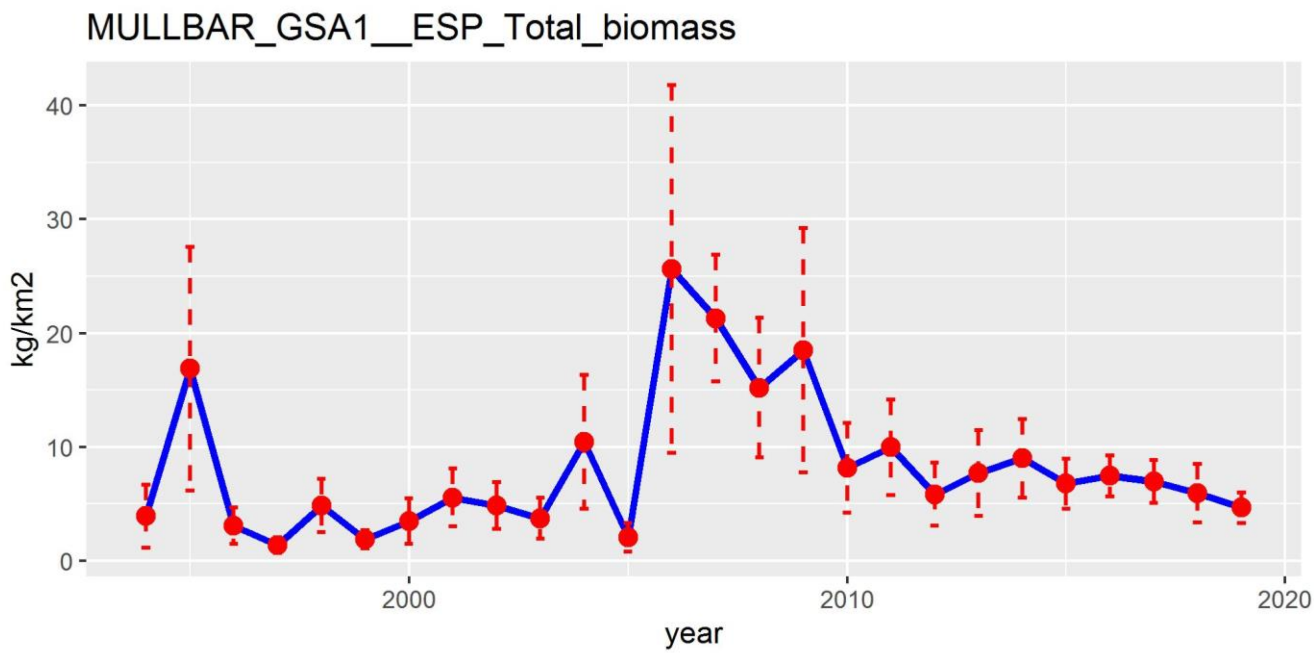


Figure 6.3.2.3.3 Red mullet in GSA 1: Biomass indices of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2020).

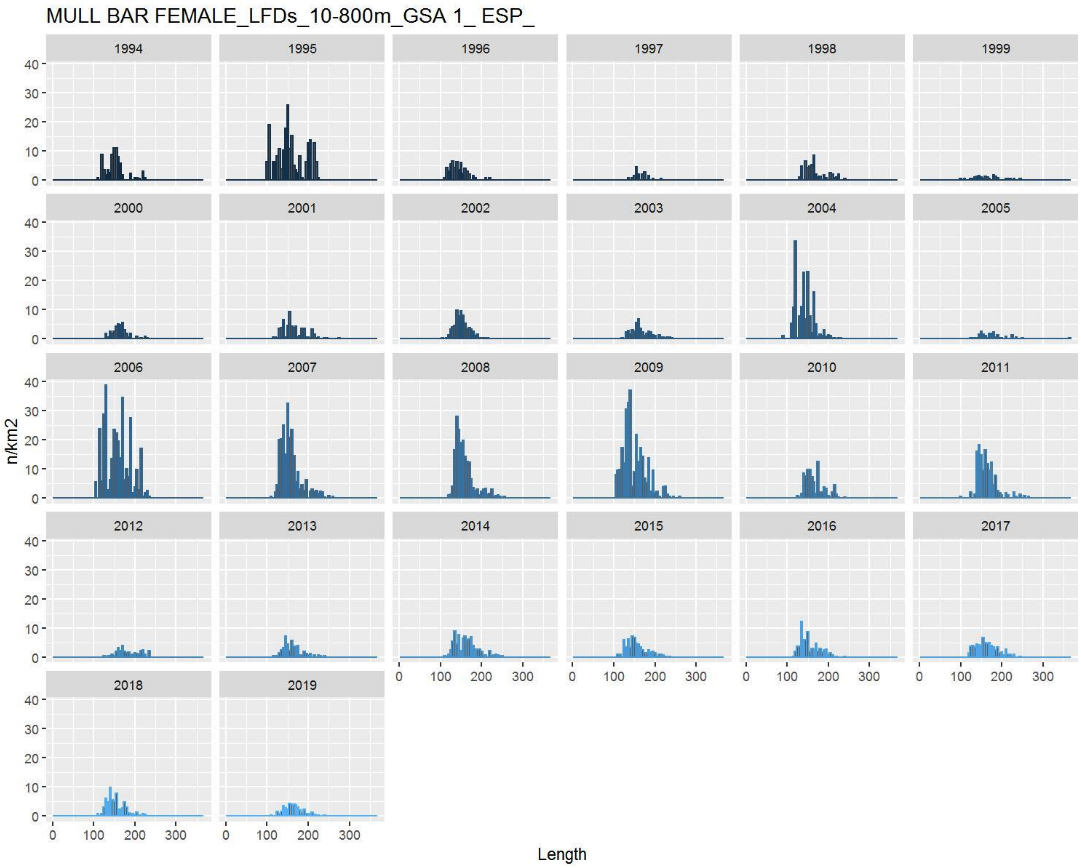


Figure 6.3.2.3.4 Red mullet in GSA 1: Size structure indices (females) of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2020).

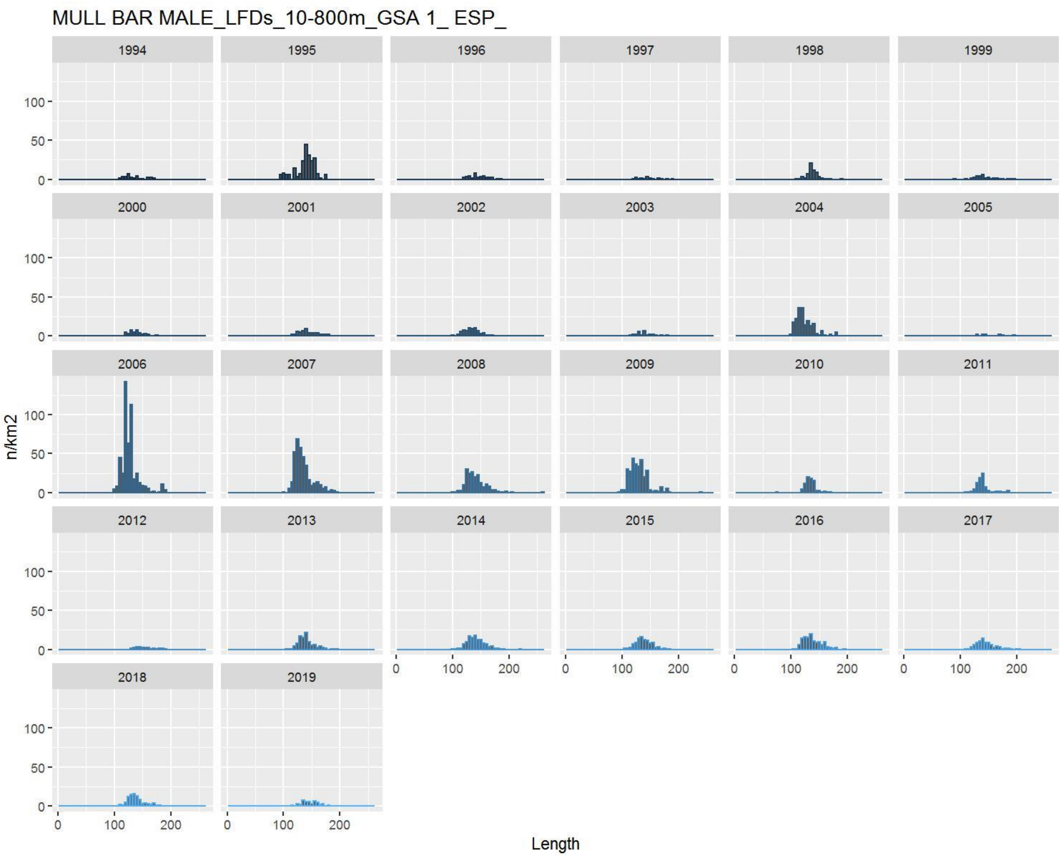


Figure 6.3.2.3.5 Red mullet in GSA 1: Size structure indices (males) of red mullet in GSA 1 as derived from trawl surveys (MEDITS, 1994-2020).

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, 1994-2020).

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 er ror. A4a is implemented as a package (Fla4a) of the FLR library.The present assessment of red mullet in GSA 1 has been based on 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 l2a routine of FLR was used. The growth parameters for the slicing are reported in table **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 lower than 20% but in the year 2020 the value seem very high probably due to the misreported length frequency that year (see Section 6.3.2.1).

Table 6.3.3.1 Red mullet in GSA 1. Sum of Products correction array.

Year	SOP
2003	1.05
2004	1.14
2005	1.01
2006	1.09
2007	1.00
2008	1.01
2009	1.12
2010	1.18
2011	1.13
2012	0.77
2013	1.21
2014	1.09
2015	1.11
2016	1.20
2017	1.16
2018	1.05
2019	1.07
2020	1.70

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

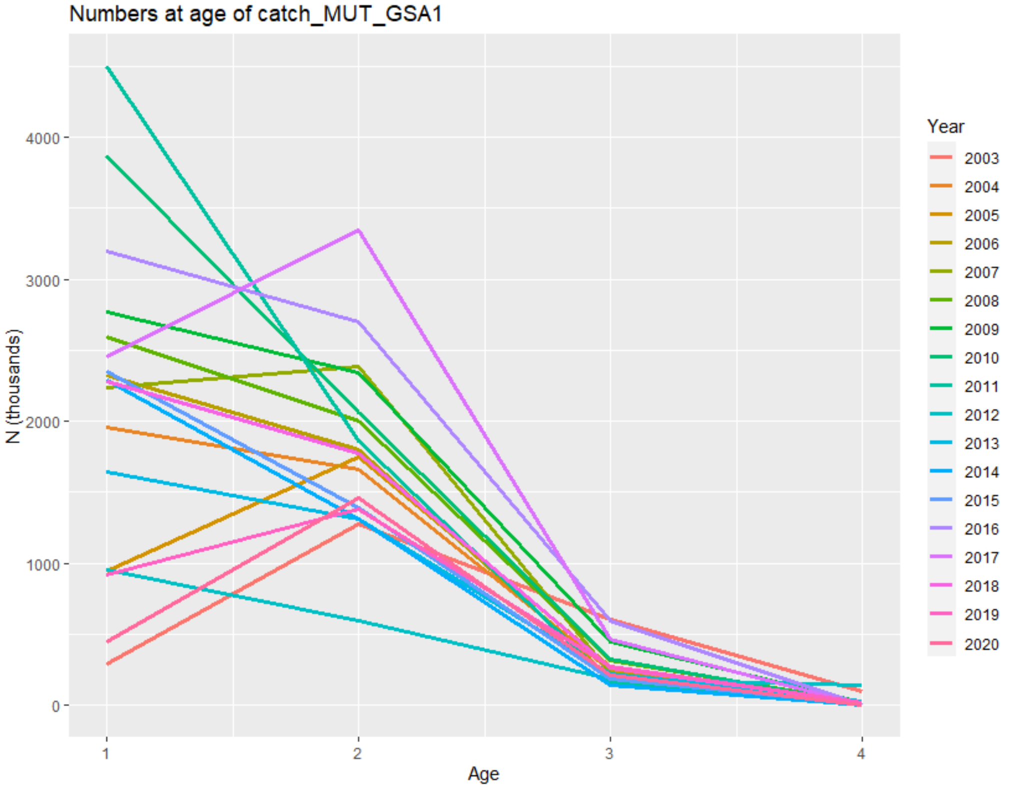


Figure 6.3.3.1 Red mullet in GSA 1: Catch-at-age data of red mullet in GSA1 used in assessment.

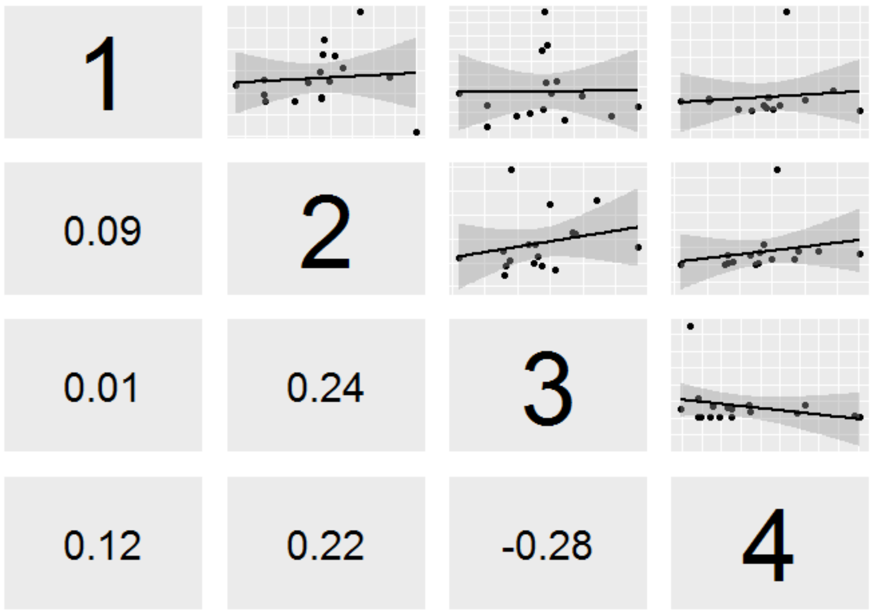


Figure 6.3.3.2 Red mullet in GSA 1: Cohort concistency of catches used in the assessment.

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

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

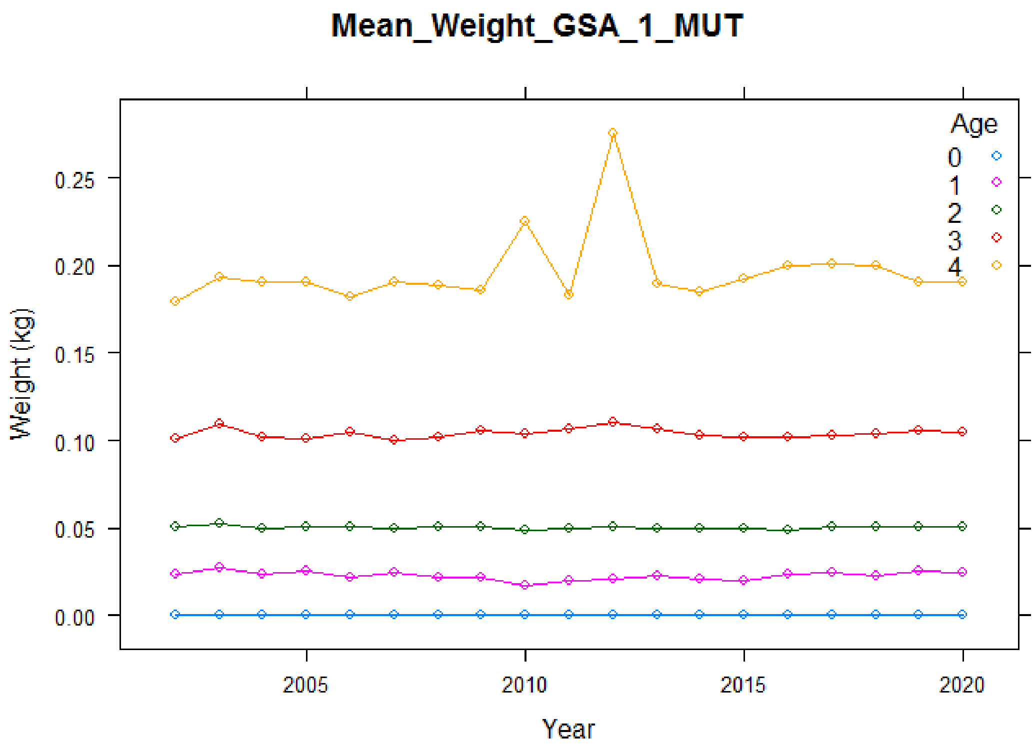


Figure 6.3.3.3 Red mullet in GSA 1: Values of mean weight at age per year used in the assessment.

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

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 6.3.3.2. No MEDITS survey was carried out in 2020.

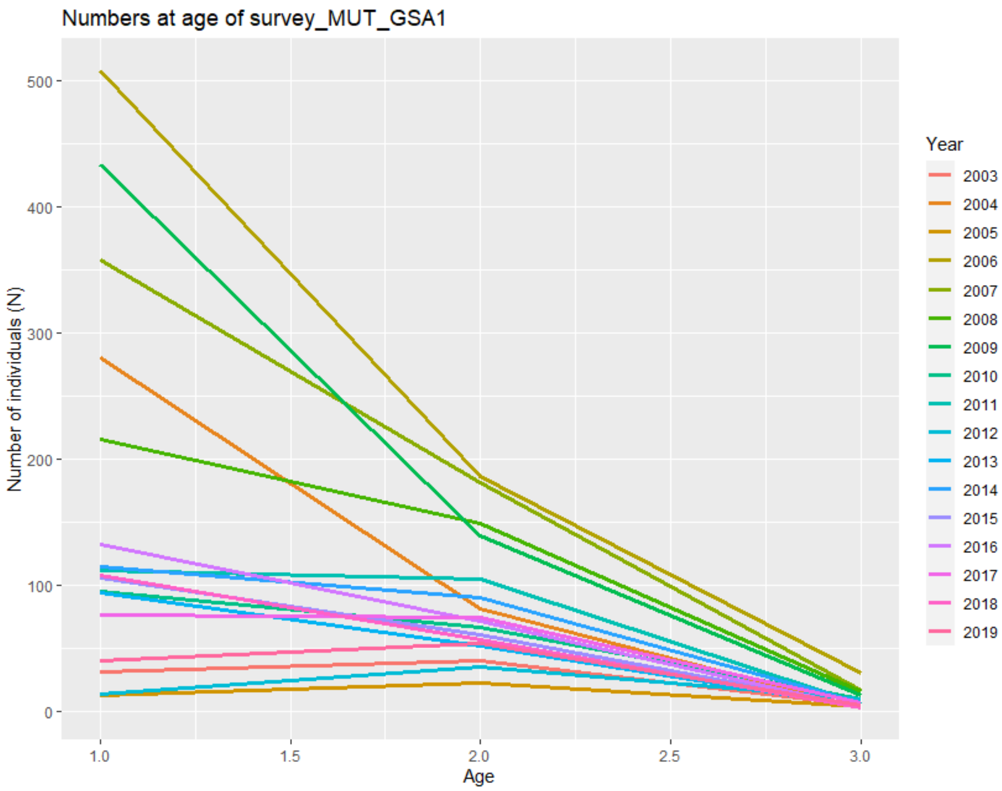


Figure 6.3.3.4 Red mullet in GSA 1: MEDITS indices describing density by age of red mullet in GSA1 by year

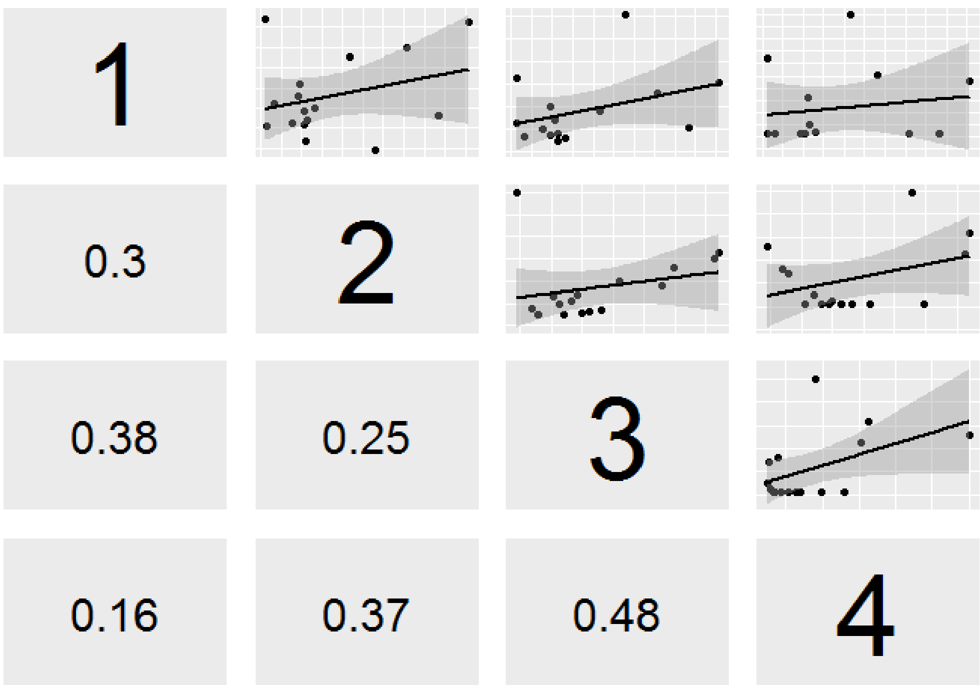


Figure 6.3.3.5 Red mullet in GSA 1: Cohort concistency of survey data used in the assessment.

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 a slight modification of the one used by the EWG 20-09. A factor was selected to model years in the fmodel and 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	27.000
nlogl	103.170
maxgrad	0.000
nobs	123.000
gcv	0.928
convergence	0.000
accrate	NA
nlogl_comp1	48.686
nlogl_comp2	54.485

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.

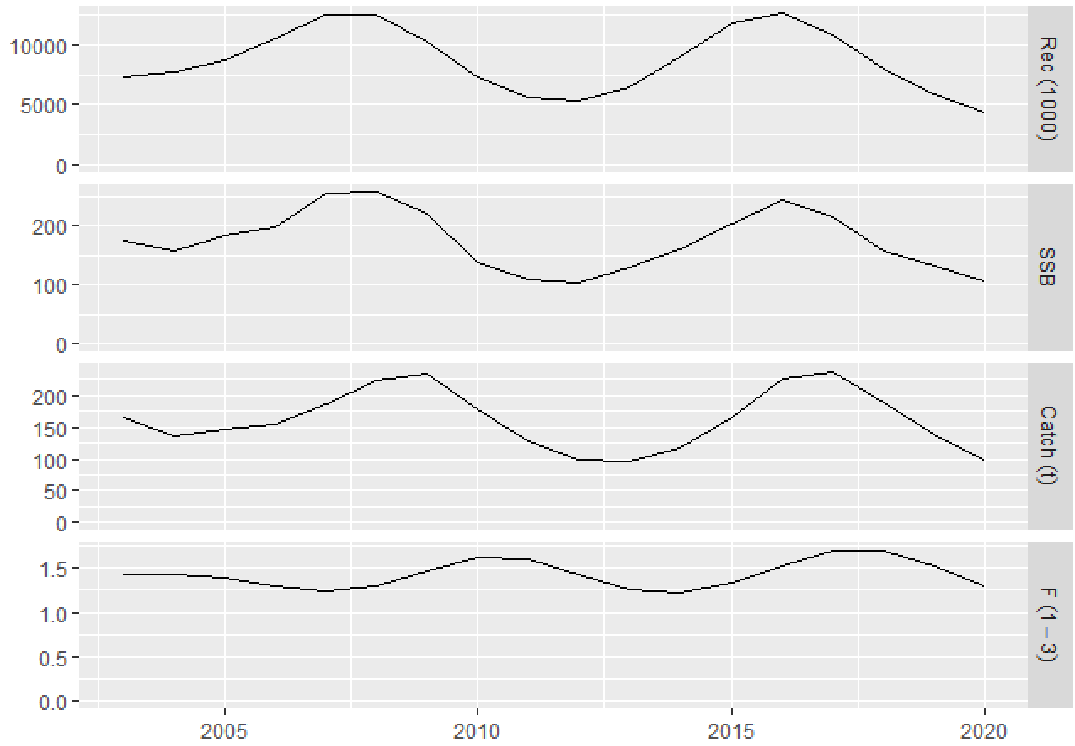


Figure 6.3.3.6 Red mullet in GSA 1: Stock indicators derived from the stock assessment.

The results and diagnostics of the assessment model are shown below.

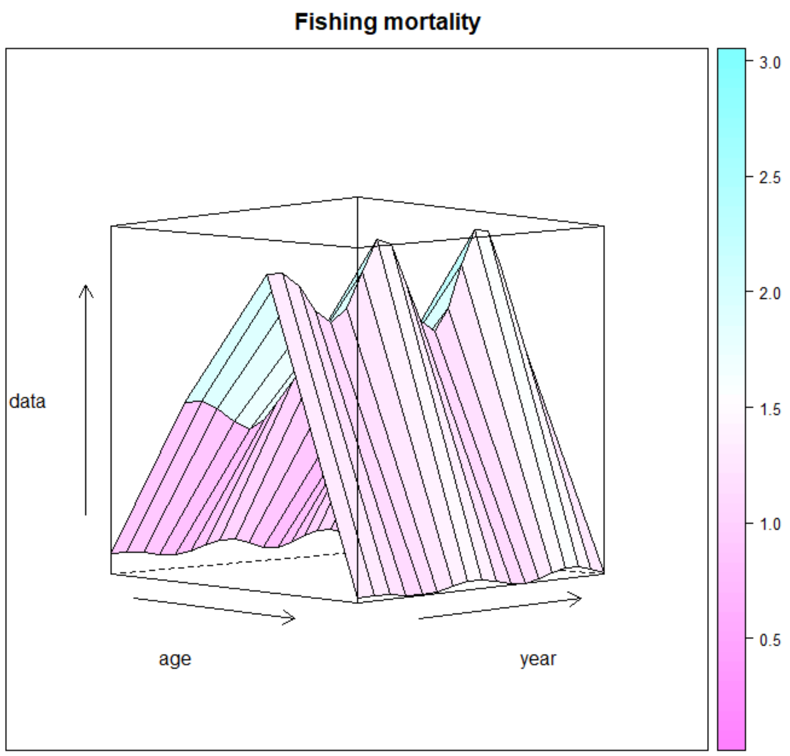


Figure 6.3.3.7 Red mullet in GSA 1: 3D-plot of the F-at-age for red mullet in GSA1.

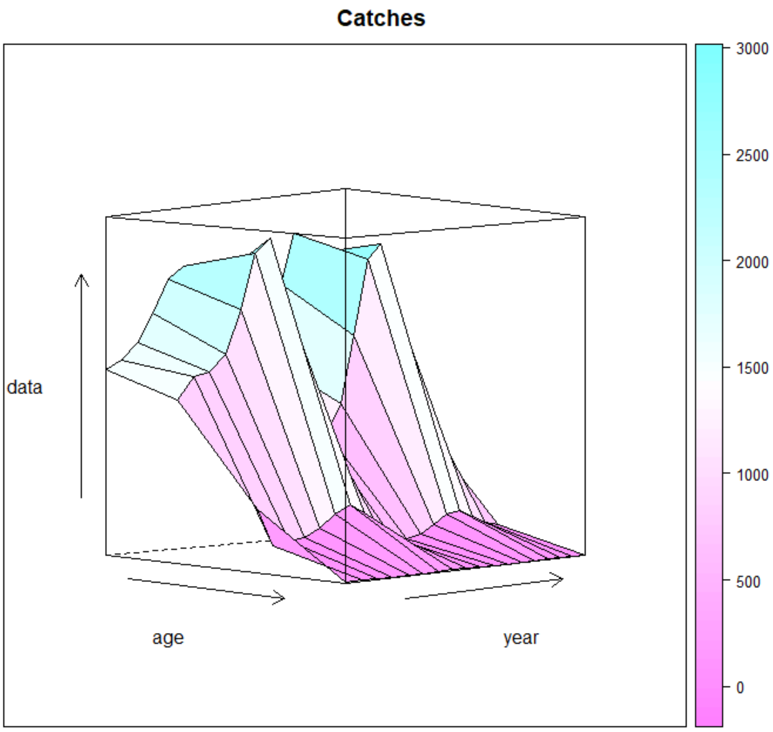


Figure 6.3.3.8 Red mullet in GSA 1: 3D-plot of the catches for red mullet in GSA1.

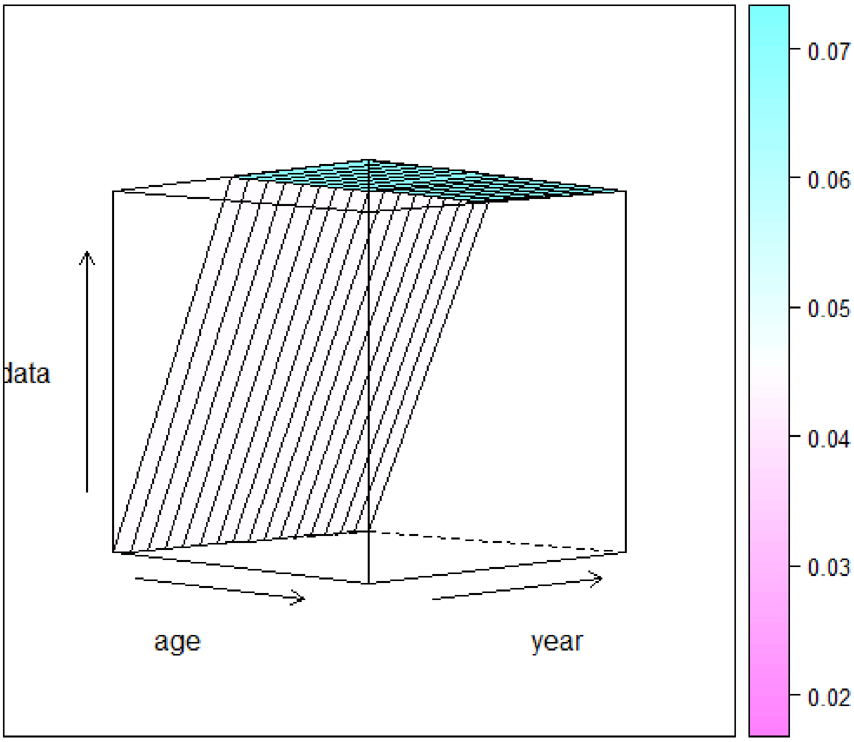


Figure 6.3.3.9 Red mullet in GSA 1: 3D-plot of the catchability of the MEDITS survey for red mullet in GSA1.

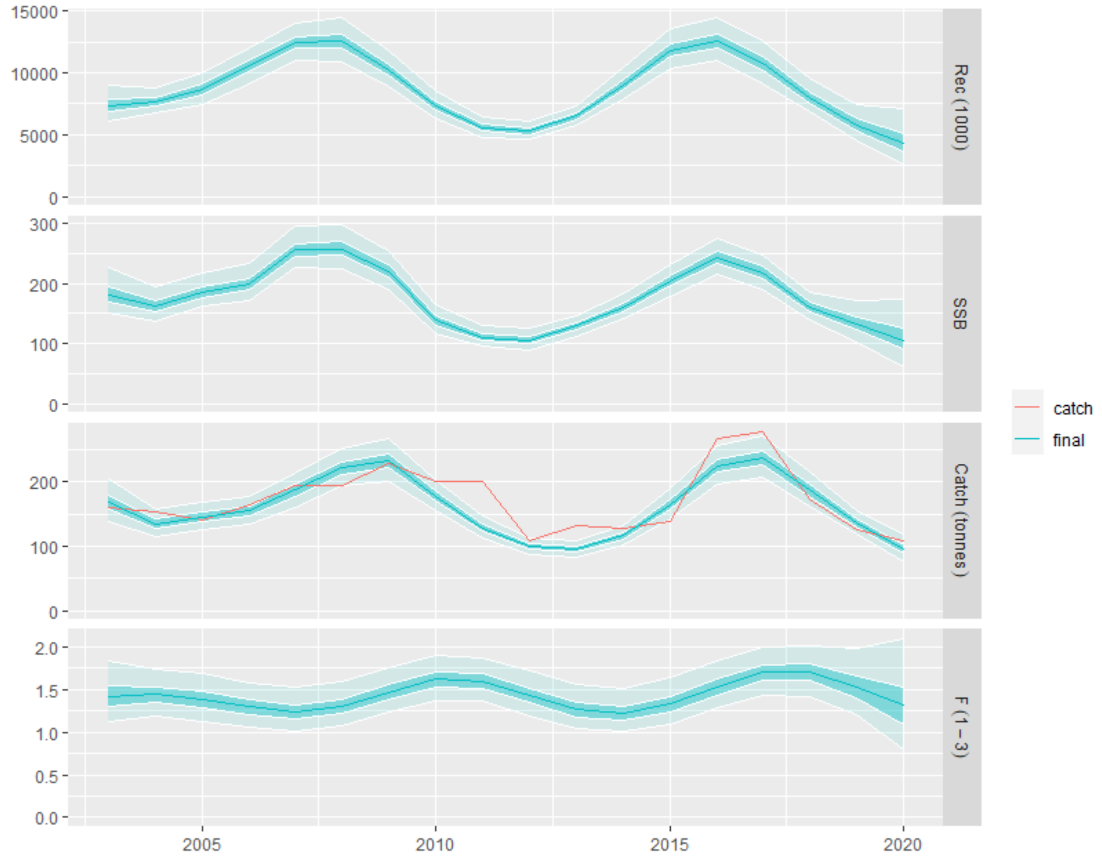


Figure 6.3.3.10 Red mullet in GSA 1: Results of the best a4a model for red mullet in GSA1. The observed catches are shown by the red line.

The Mohn' rho for F_{bar1-3}, SSB and recruitment are shown below:

fbar	ssb	rec
0.1632227	-0.1566187	-0.115753

The results of the retrospective analysis are shown in Figure 6.3.3.11.

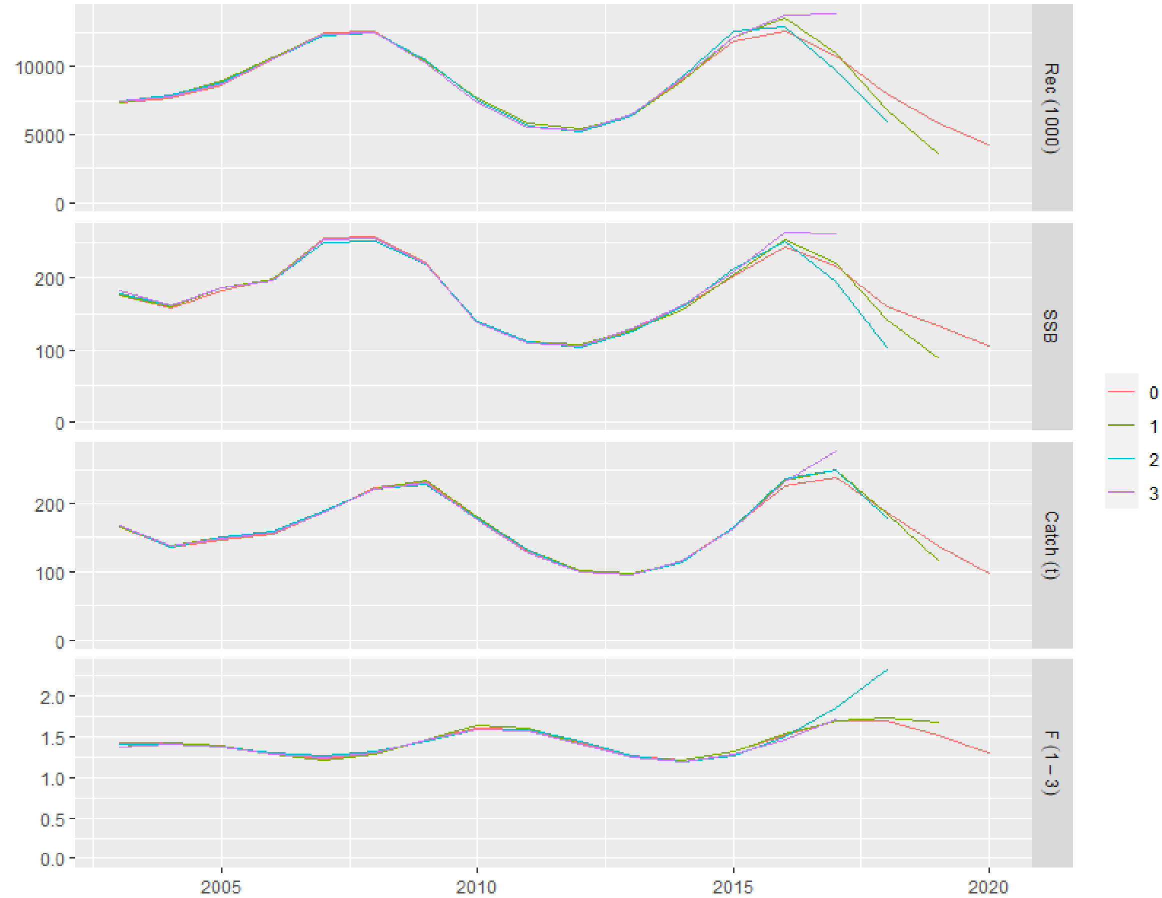


Figure 6.3.3.11 Red mullet in GSA 1: Retrospective analysis of the selected a4a model for red mullet in GSA1.

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. Generally it is expected that surveys provide stable catchability over time due to standardisation of proceedures, so allwing trends in the survey may hide other issues in the assessment.

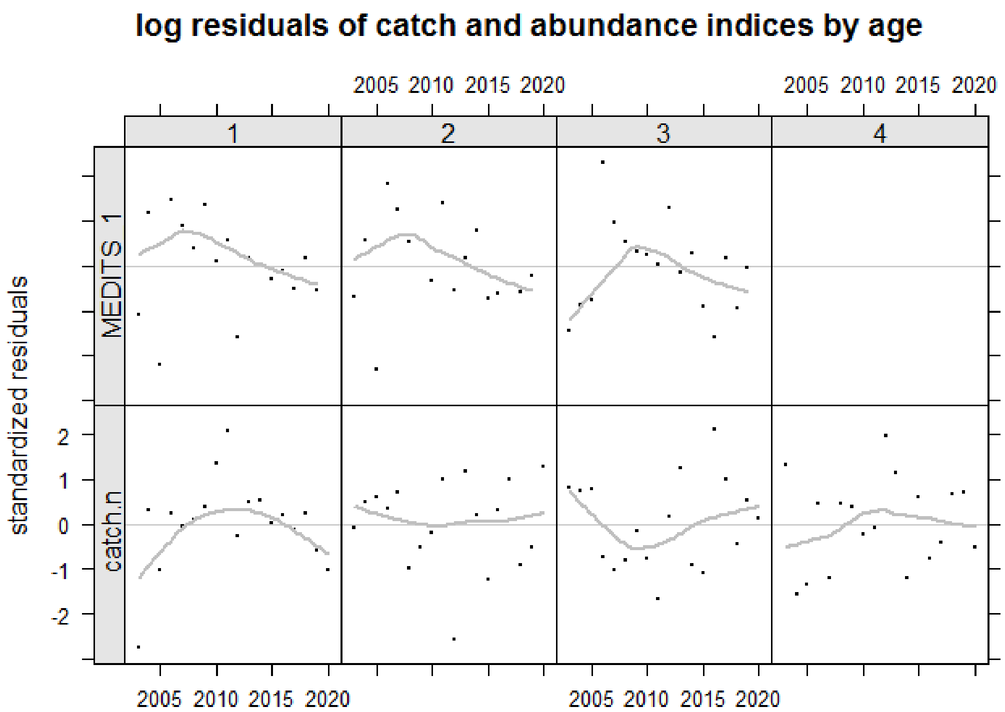


Figure 6.3.3.12 Red mullet in GSA 1: Log residuals of catch and abundance indices for red mullet in GSA1.

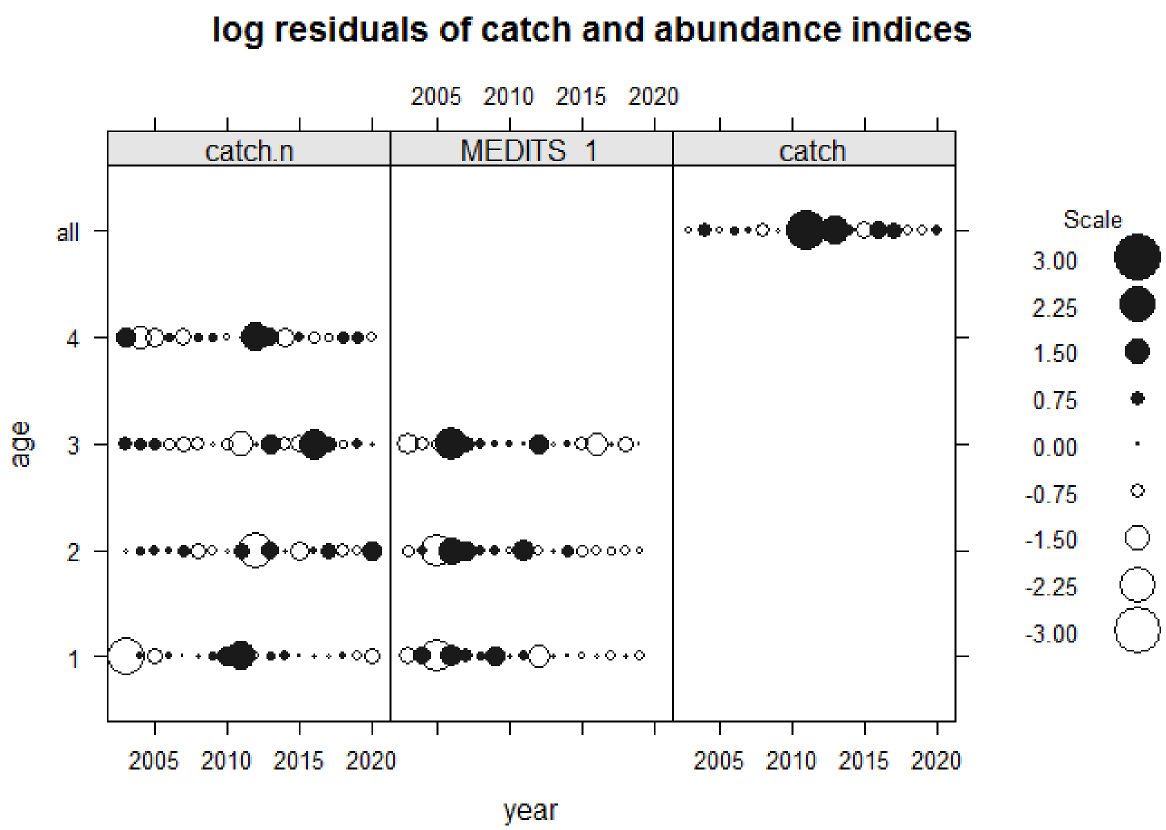


Figure 6.3.3.13 Red mullet in GSA 1: Bubble plot of the log residuals of catch and abundance indices for red mullet in GSA1.

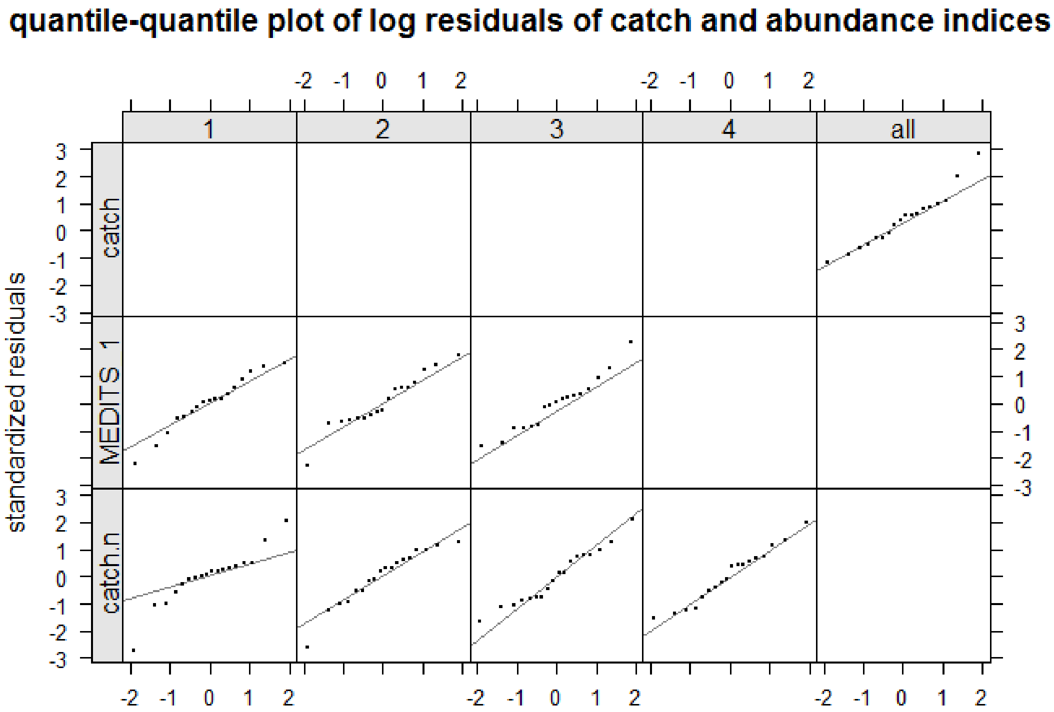


Figure 6.3.3.14 Red mullet in GSA 1: QQ-plot of the log residuals of catch and abundance indices for red mullet in GSA1.

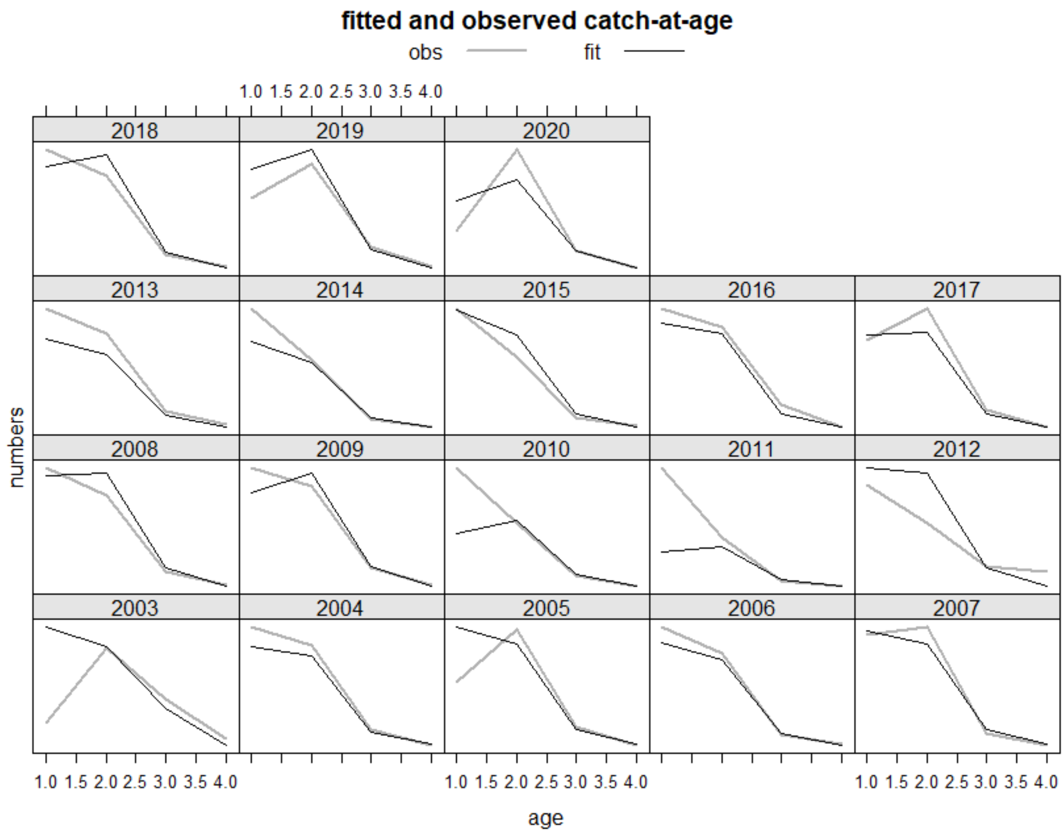


Figure 6.3.3.15 Red mullet in GSA 1: Fitting of the catch-at-age data for red mullet in GSA1.

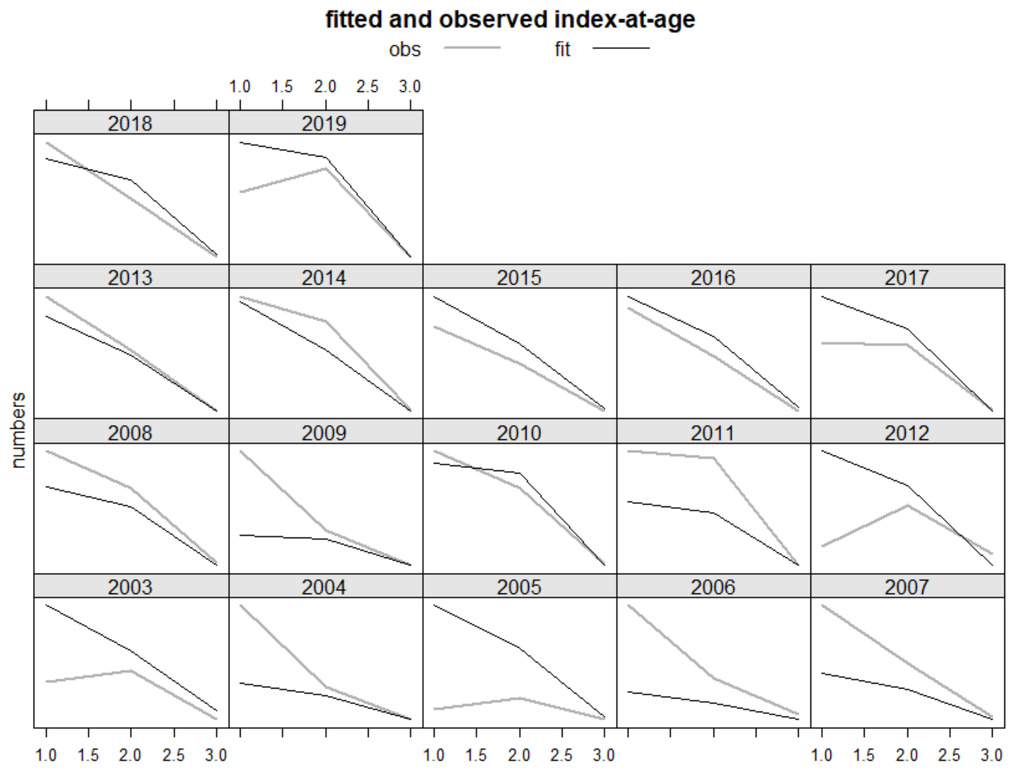


Figure 6.3.3.16 Red mullet in GSA 1: Fitting of the numbers-at-age data of the MEDITS survey for red mullet in GSA1.

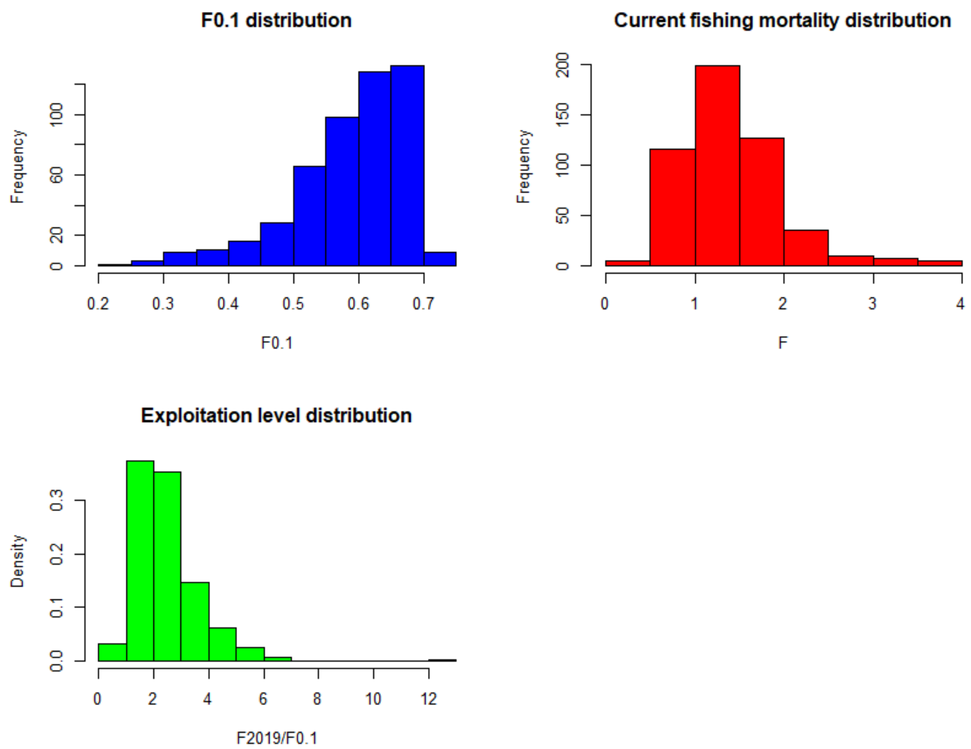


Figure 6.3.3.17 Red mullet in GSA 1: Histograms of probability for $F_{0.1}$, Fcurr and level of exploitation (Fcurr/F01 ratio) values for red mullet in GSA1.Final assessment outcomes are given in Tables 6.3.3.4-6.3.3.6.

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	7367			176.8			166.1	1.42		
2004	7693			158.8			135.2	1.43		
2005	8657			183.4			146.3	1.38		
2006	10513			197.8			155.1	1.29		
2007	12447			255.3			187.2	1.24		
2008	12555			257.4			222.9	1.30		
2009	10214			220.2			232.6	1.46		
2010	7319			138.1			178.4	1.61		
2011	5569			110.2			128.8	1.59		
2012	5300			105.3			99.4	1.43		
2013	6496			128.3			96.0	1.26		
2014	9056			160.2			116.4	1.22		
2015	11833			203.7			165.0	1.32		
2016	12592			243.0			225.3	1.53		
2017	10753			217.0			237.6	1.69		
2018	8043			159.7			188.0	1.70		
2019	5842			132.7			137.6	1.53		
2020	4307			105.5			97.7	1.29		

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	7367	2050	619	74
2004	7693	2336	255	73
2005	8657	2433	287	52
2006	10513	2773	316	44
2007	12447	3448	399	46
2008	12555	4133	522	55
2009	10214	4103	585	65
2010	7319	3205	488	64
2011	5569	2214	326	52
2012	5300	1692	229	40
2013	6496	1679	209	33
2014	9056	2143	248	33
2015	11833	3020	331	37
2016	12592	3844	417	41
2017	10753	3891	428	41
2018	8043	3186	362	35
2019	5842	2382	296	30
2020	4307	1805	265	29

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	0.35	1.51	2.40	0.23
2004	0.36	1.52	2.42	0.23
2005	0.34	1.47	2.33	0.23
2006	0.32	1.37	2.17	0.21
2007	0.31	1.31	2.09	0.20
2008	0.32	1.38	2.20	0.21
2009	0.36	1.56	2.47	0.24
2010	0.40	1.71	2.72	0.26
2011	0.40	1.69	2.69	0.26
2012	0.36	1.52	2.41	0.23
2013	0.31	1.34	2.13	0.21
2014	0.30	1.30	2.06	0.20
2015	0.33	1.41	2.24	0.22
2016	0.38	1.62	2.58	0.25
2017	0.42	1.80	2.86	0.28
2018	0.42	1.80	2.86	0.28
2019	0.38	1.62	2.58	0.25
2020	0.32	1.37	2.18	0.21

6.3.4 REFERENCE POINTS

The time series is too short to produce meaningful stock recruitment rationship, so reference points are based on equilibrium methods. 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 0.607. Current F values (2020), as calculated by model a4a, is 1.29 indicating that the stock is overexploited.

6.3.5 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 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} = 1.29 terminal F (2020) from the a4a assessment was used for F in 2021. Recruitment is observed to be fluctutating over the period of the assessment (Figure 6.3.3.5) so the geometric mean across the whole time series is used as an estimate of recruits from 2021 (whole time series of 18 years; recruitment 287566 thousands).

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 2018-2020	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}3}$ (2021)	1.29	F 2020 used to give F status quo for 2021
SSB (2021)	152.3321	Stock assessment 1 January 2020
R_{age1} (2021,2022)	8286.369 (thousands)	Geometric mean of the time series (18 years)
Total catch (2021)	103.2545	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 103.25 and 152.33 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. 607) would increase biomass by 71.67% from 2021 to 2023, while reducing catches by 15% from 2020 to 2022.

Table 6.3.5.2 Red mullet in GSA 1: Short term forecast table for red mullet in GSA 1.

Rationale	Ffactor	Fbar	Recruitment 2021	Fsq 2021	Catch 2020	Catch 2021	Catch 2022	SSB 2021	SSB 2023	SSB_change 2021-2023(%)	Catch_change 2020-2022(%)
High long term yield (F0.1)	0.47	0.61	8286.37	1.29	97.71	103.25	82.31	152.33	261.52	71.68	-15.76
F upper	0.64	0.83	8286.37	1.29	97.71	103.25	103.47	152.33	228.35	49.90	5.90
F lower	0.31	0.40	8286.37	1.29	97.71	103.25	59.25	152.33	301.69	98.05	-39.36
FMSY transition	0.82	1.07	8286.37	1.29	97.71	103.25	122.97	152.33	200.84	31.84	25.86
Zero catch	0	0.00	8286.37	1.29	97.71	103.25	0.00	152.33	424.59	178.73	-100.00
Status quo	1	1.29	8286.37	1.29	97.71	103.25	138.71	152.33	180.65	18.59	41.97
Different Scenarios	0.1	0.13	8286.37	1.29	97.71	103.25	21.28	152.33	377.18	147.61	-78.22
	0.2	0.26	8286.37	1.29	97.71	103.25	40.28	152.33	337.96	121.86	-58.78
	0.3	0.39	8286.37	1.29	97.71	103.25	57.29	152.33	305.30	100.42	-41.37
	0.4	0.52	8286.37	1.29	97.71	103.25	72.58	152.33	277.95	82.46	-25.72
	0.5	0.65	8286.37	1.29	97.71	103.25	86.37	152.33	254.87	67.31	-11.60
	0.6	0.78	8286.37	1.29	97.71	103.25	98.86	152.33	235.28	54.45	1.18
	0.7	0.91	8286.37	1.29	97.71	103.25	110.21	152.33	218.53	43.45	12.79
	0.8	1.04	8286.37	1.29	97.71	103.25	120.55	152.33	204.10	33.98	23.38
	0.9	1.16	8286.37	1.29	97.71	103.25	130.02	152.33	191.58	25.77	33.07
	1.1	1.42	8286.37	1.29	97.71	103.25	146.72	152.33	171.04	12.28	50.16
	1.2	1.55	8286.37	1.29	97.71	103.25	154.13	152.33	162.53	6.69	57.74
	1.3	1.68	8286.37	1.29	97.71	103.25	160.99	152.33	154.94	1.71	64.77
	1.4	1.81	8286.37	1.29	97.71	103.25	167.38	152.33	148.15	-2.75	71.30
	1.5	1.94	8286.37	1.29	97.71	103.25	173.33	152.33	142.02	-6.77	77.40
	1.6	2.07	8286.37	1.29	97.71	103.25	178.91	152.33	136.46	-10.42	83.10
	1.7	2.20	8286.37	1.29	97.71	103.25	184.14	152.33	131.39	-13.75	88.45
	1.8	2.33	8286.37	1.29	97.71	103.25	189.05	152.33	126.75	-16.79	93.49
	1.9	2.46	8286.37	1.29	97.71	103.25	193.69	152.33	122.49	-19.59	98.23
	2	2.59	8286.37	1.29	97.71	103.25	198.08	152.33	118.54	-22.18	102.72

*SSB at mid year

EWG advises that when the MSY approach is applied, catches in 2022 should be no more than 82.31 tonnes.

6.3.6 Data Deficiencies

Commercial data

Compared to data reported in the STECF 20-09, the catch-at-age number was importantly modified, changing both general Trend among years and absolute numbers by age. Although catches are available from 2002, the year 2003 is considered the first assessment year because year 2002 suffered a large reconstruction.

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 20-09. This is coherent with the quality checks including TbtoTC, 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 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) 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; 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.

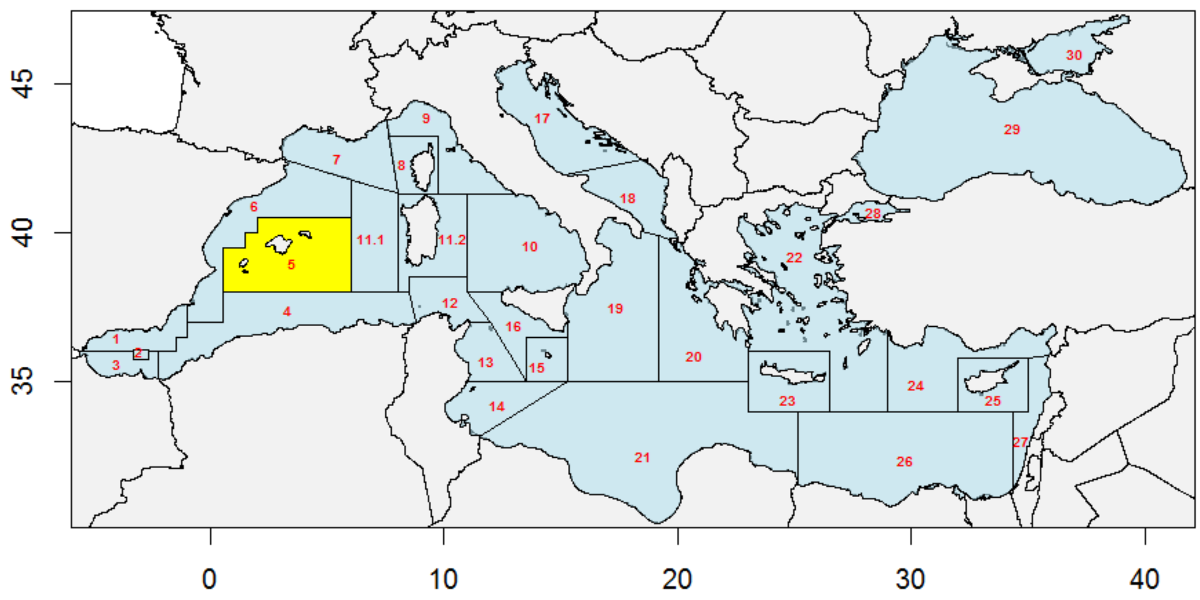


Figure 6.4.1.1. Geographical localization of GSA 5.

The biological parameters, natural mortality vector and maturity ogive used for the assessment of *M. surmuletus* were those shown in the following tables. Growth parameters (Table 6.4.1.1) and natural mortality vectror (Table 6.4.1.2) were those used in the last 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 was obtained from the Data Collection. 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. *Mullus surmuletus* in GSA 5. Growth and length-weight parameters.

Growth	
L_{inf} (cm)	33.4
k	0.43
t_0	-0.1
Length-Weight	
a	0.0084
b	3.118

Table 6.4.1.2. *Mullus surmuletus* 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. *Mullus surmuletus* 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, *M. 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 reduction was noted from 2018-2020 (Figure 6.4.2.1).

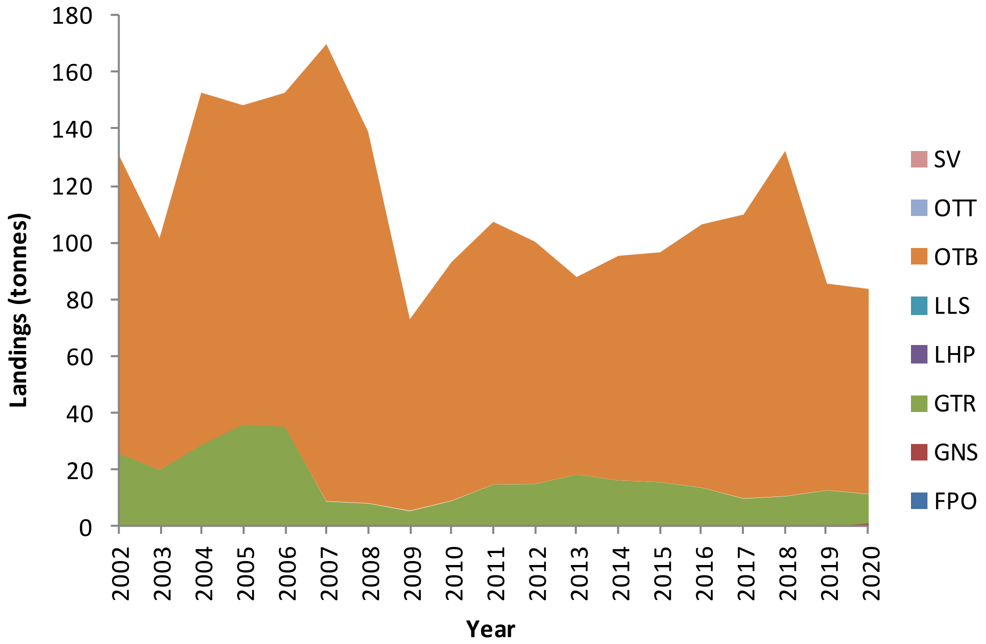


Figure 6.4.2.1. *Mullus surmuletus* in GSA 5. Reported landings from the DCF Data call by gear.

Table 6.4.2.1. *Mullus surmuletus* in GSA 5. Reported landings from the DCF Data call by gear.

Year	GTR	OTB	Total
2002	25.72	105.96	131.68
2003	19.75	81.87	101.62
2004	28.55	124.4	152.95
2005	35.8	112.71	148.51
2006	35.04	117.84	152.88
2007	8.76	161.3	170.06
2008	8.09	131.07	139.16
2009	5.43	67.54	72.97
2010	8.95	84.2	93.15
2011	14.69	92.67	107.36
2012	14.85	85.51	100.36
2013	18.2	69.68	87.88
2014	16.09	79.26	95.35
2015	15.48	81.12	96.6
2016	13.57	92.89	106.46
2017	9.76	100.15	109.91
2018	10.56	121.84	132.4
2019	12.65	72.89	85.55
2020	10.17	72.32	83.69

Discards for this stock was considered as neligible 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). Such small amounts are not expected to change the assessment in any important way.

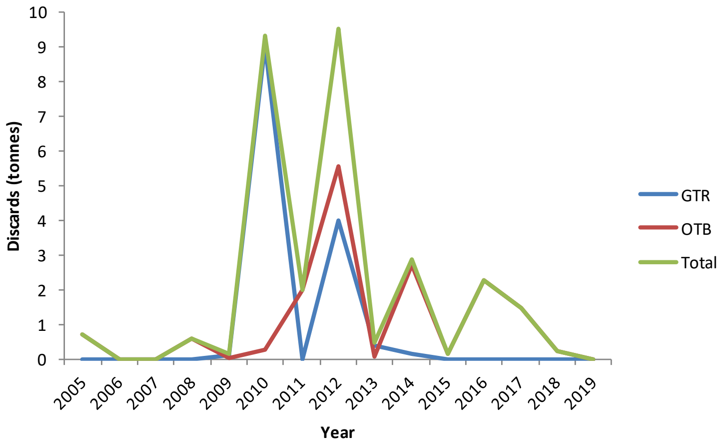


Figure 6.4.2.2. *Mullus surmuletus* in GSA 5. Reported discards from the DCF Data call by gear.

Length frequency distribution for the striped red mullet in GSA 5 shows differences between métiers, with trammelnets targetting larger individuals than bottom trawlers (Figure 6.4.2.3).

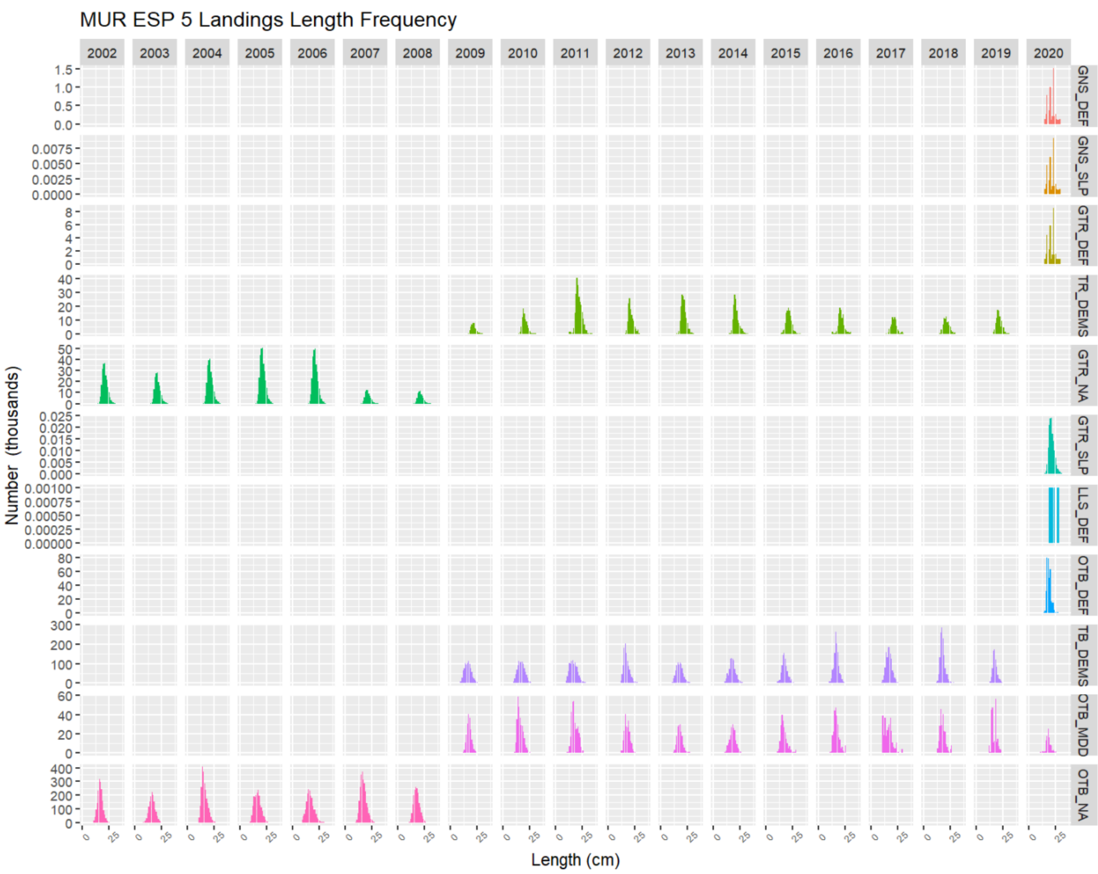


Figure 6.4.2.3. Striped red mullet in GSA5. Catch length frequency distribution, by year and métier (TL cm).

Table 6.4.2.2. *Mullus surmuletus* in GSA 5. Length structure (TL cm) reported in DCF (2002-2010) for total landings.

Length (cm)	2002	2003	2004	2005	2006	2007	2008	2009	2010
8	0.00	5.56	0.00	0.08	2.13	0.00	0.39	0.46	0.74
9	0.06	12.05	0.47	4.44	21.33	0.00	0.00	7.17	0.76
10	2.27	15.82	2.87	12.28	51.70	7.18	2.13	9.64	7.18
11	17.44	35.86	37.47	56.14	64.03	24.39	6.58	29.06	23.81
12	43.33	71.76	124.05	122.52	97.61	67.86	29.48	65.52	55.83
13	97.02	115.23	258.80	190.43	154.91	159.28	69.96	80.00	102.49
14	145.90	157.01	405.73	188.33	210.20	258.66	135.26	112.02	149.49
15	233.61	189.62	372.09	201.27	244.40	350.31	200.72	113.06	163.83
16	319.24	223.26	287.38	222.25	236.73	374.23	239.07	131.54	145.01
17	304.17	204.98	247.76	246.60	206.88	312.83	264.13	156.51	142.71
18	261.48	167.94	195.29	219.86	202.60	292.00	254.66	139.69	148.50
19	189.88	122.39	180.23	170.09	164.07	238.53	225.57	107.44	138.55
20	125.12	108.79	145.07	161.01	144.55	156.09	153.22	77.73	105.79
21	93.85	76.84	117.27	136.68	145.09	127.09	121.47	48.40	77.94
22	57.97	48.67	75.07	84.30	97.62	81.04	85.95	36.23	57.91
23	38.16	33.97	47.14	70.98	67.40	62.18	56.08	23.34	38.37
24	25.86	22.61	32.85	45.95	48.60	31.71	33.95	15.18	17.53
25	16.38	11.79	22.15	26.98	32.23	25.70	19.15	7.82	12.89
26	9.39	6.23	11.07	15.38	17.86	12.55	10.00	3.89	6.92
27	6.11	3.66	5.77	6.93	9.94	10.45	4.90	1.63	3.46
28	2.55	2.60	4.13	5.32	7.78	4.69	3.42	0.39	2.09
29	1.55	1.30	1.96	2.24	6.10	2.63	1.52	1.40	0.90
30	0.37	0.49	0.41	1.04	1.57	0.29	0.20	0.12	0.36
31	0.13	0.10	0.87	0.19	0.99	0.78	0.53	0.48	1.10
32	0.00	0.00	0.00	0.14	0.71	0.25	0.00	0.12	0.00
33	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.03
34	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.18	0.20
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.04

Table 6.4.2.3. *Mullus surmuletus* in GSA 5. Length structure (TL cm) reported in DCF (2011-2019) for total landings.

Length (cm)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	2.21	0.00	0.00	0.50	1.02	1.79	0.00	0.00	0.00	0.00
10	12.40	1.17	0.44	1.08	3.22	9.71	3.35	0.00	0.00	0.39
11	37.21	2.79	3.67	9.21	9.06	10.22	56.21	0.52	0.00	0.97
12	63.77	14.70	23.99	26.00	15.09	25.50	56.64	5.08	8.52	0.39
13	112.64	49.11	41.69	56.44	29.51	87.49	118.56	17.11	10.15	1.57
14	116.40	105.74	72.52	50.94	83.75	99.54	174.63	59.56	77.17	2.47
15	158.26	202.64	109.52	85.64	132.40	198.18	155.57	161.67	121.79	6.19
16	170.48	245.89	133.45	143.78	179.87	311.39	211.61	307.24	178.52	46.18
17	158.24	183.16	126.55	158.67	185.74	245.44	217.63	320.26	187.79	103.66
18	151.66	148.13	144.96	165.12	153.46	193.11	191.57	277.46	185.51	104.53
19	139.38	143.62	142.13	163.88	117.84	118.48	154.98	177.58	105.93	68.86
20	148.20	115.76	121.49	124.70	89.59	83.27	87.55	110.88	75.44	78.86
21	121.30	77.84	84.72	88.63	58.83	65.44	70.97	68.01	46.62	25.45
22	87.04	55.48	61.69	67.14	55.90	38.96	43.05	61.91	35.42	19.46
23	68.55	37.57	37.90	36.39	30.88	23.87	33.44	30.14	21.26	28.54
24	45.50	20.93	28.21	27.16	34.17	13.14	21.48	16.13	16.68	8.67
25	28.67	14.93	17.32	21.16	10.51	14.04	9.61	16.54	6.97	5.19
26	20.30	6.71	8.44	11.12	7.52	4.32	5.30	14.42	6.11	1.34
27	13.08	5.40	8.26	8.00	6.36	3.83	1.61	3.46	3.67	3.11
28	7.37	4.92	3.52	5.27	4.78	1.92	1.30	5.65	0.51	0.88
29	4.62	0.59	1.53	2.26	3.44	0.81	5.26	0.82	0.39	0.87
30	0.60	0.12	0.80	1.72	0.25	1.34	0.37	0.31	0.49	0.00
31	0.34	0.16	0.25	0.39	0.08	0.03	0.00	0.00	0.54	0.00
32	0.16	0.04	0.00	0.12	0.42	0.00	0.00	0.00	0.08	0.00
33	0.15	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
34	0.09	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Age composition is mainly formed by age 1 individuals, although age 0 and age 2 are also frequent in the catches (Figure 6.4.2.4, Table 6.4.2.4). Cohorts showed low consistency, only goog for the youngest classes (figure 6.4.2.5).

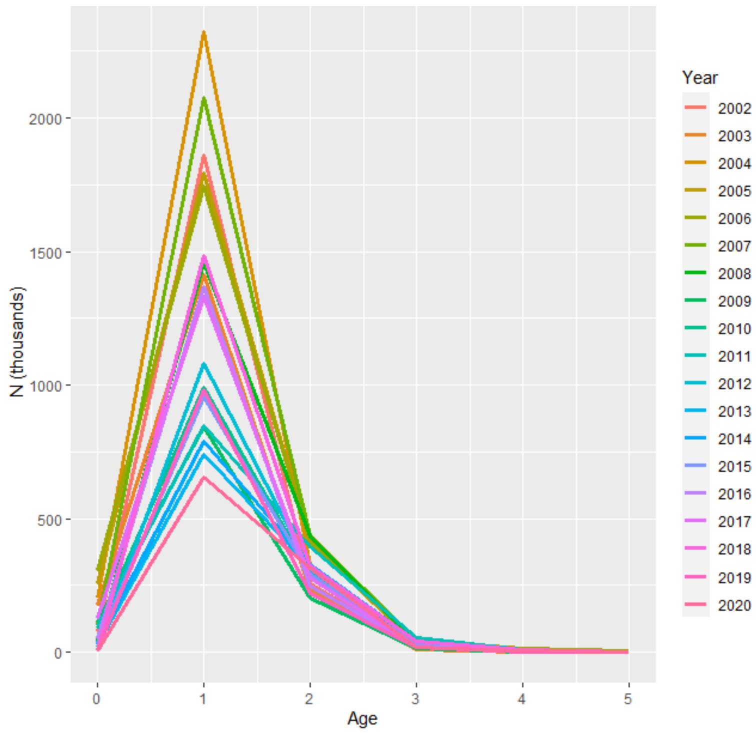


Figure 6.4.2.4. Striped red mullet in GSA 5. Catch-at-age.

Table 6.4.2.4. Striped red mullet in GSA 5. Catch-at-age.

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	78.54	175.50	203.22	257.91	307.50	104.95	40.97	112.33	88.35
1	1861.09	1414.99	2323.48	1795.50	1744.40	2075.75	1456.90	843.93	991.04
2	256.59	233.09	330.03	410.73	415.00	435.04	433.62	201.76	297.67
3	16.42	9.12	22.48	30.71	44.87	44.68	29.92	13.40	23.28
4	1.01	1.72	3.01	3.94	12.21	6.54	4.14	1.80	2.99
5	0.17	0.35	1.71	0.87	3.83	1.21	0.60	0.91	1.72

age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	97.35	18.67	26.92	35.24	30.77	51.50	126.63	6.29	9.65	3.44
1	848.18	1079.11	738.61	789.90	956.67	1367.01	1334.39	1484.15	981.90	655.87
2	396.35	307.81	320.05	329.60	291.99	244.99	279.49	322.57	221.35	316.47
3	52.26	27.07	32.60	38.58	26.43	24.20	18.00	38.67	18.97	18.94
4	10.10	5.51	4.84	7.21	8.91	2.98	7.15	7.27	1.03	3.43
5	1.16	0.32	1.00	2.14	1.10	1.49	0.40	0.35	1.25	0.27

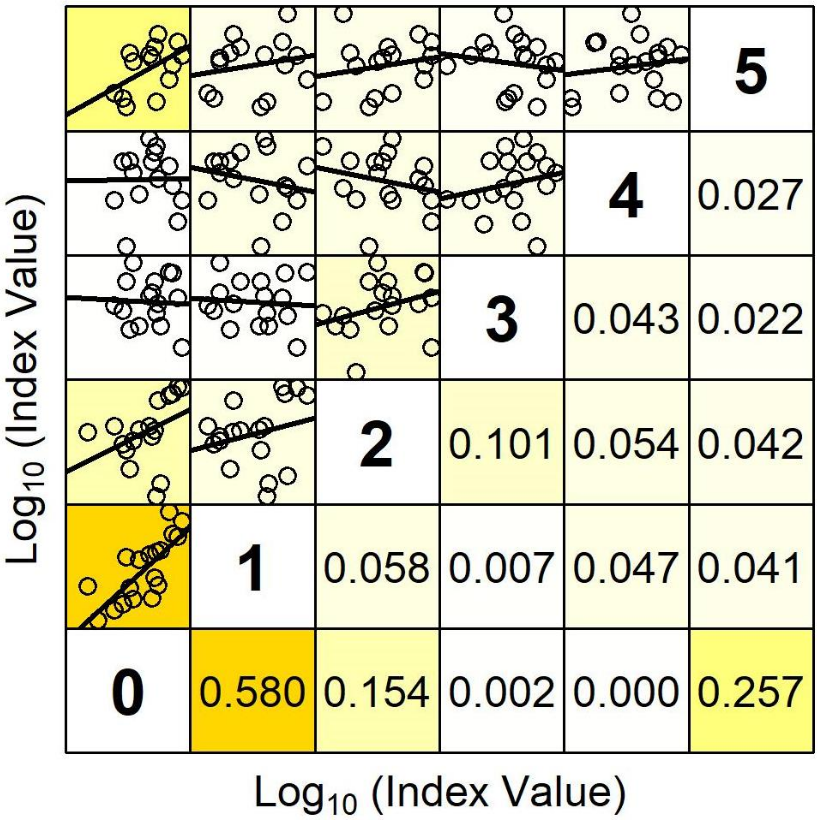


Figure 6.4.2.5. Striped red mullet in GSA 5. Cohort consistency for the commercial catches.

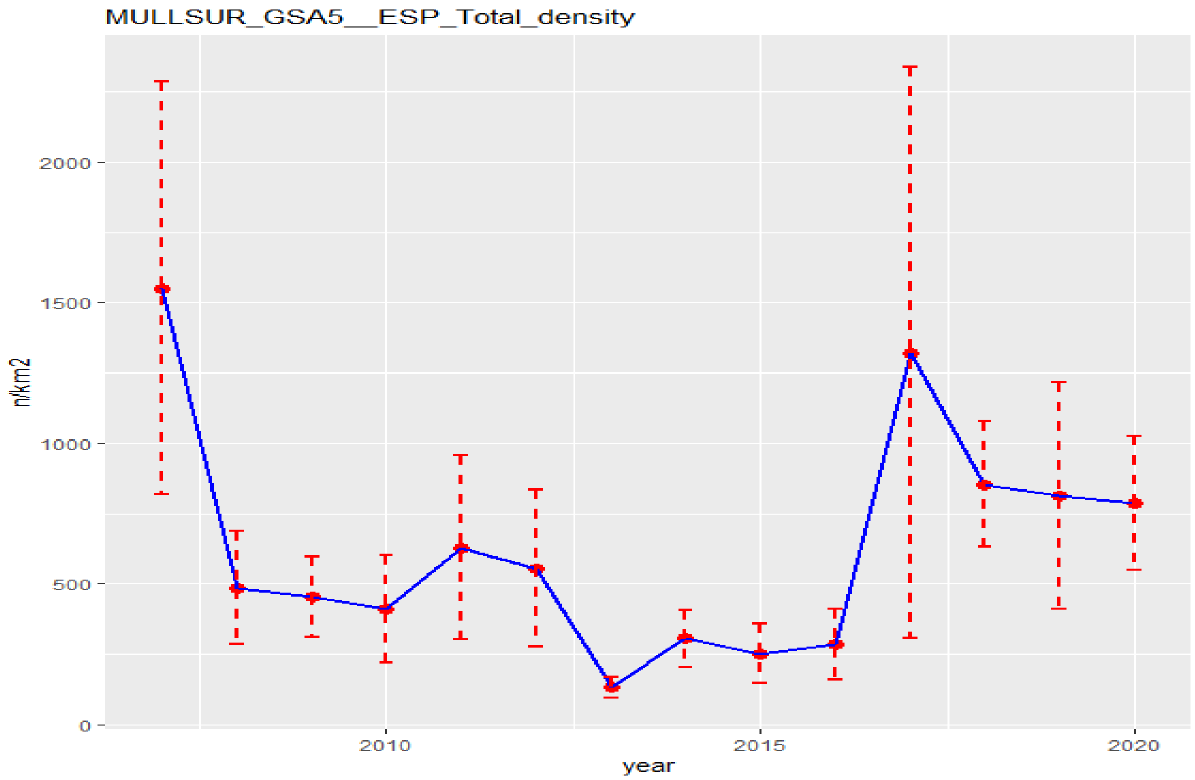
6.4.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 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 biomasses by km^2 have been computed using the methodology described by Grosslein and Laurec (1982). At the same time, after checking the year where the variance was high, finally the hauls 134 and 149 in 2009 were removed. Density and biomass indices showed variations along the data series, with high values for 2007 and 2017 (Figure 6.4.2.7). Length frequency distributions are shown in Figure 6.4.2.8 and table 6.4.2.6.



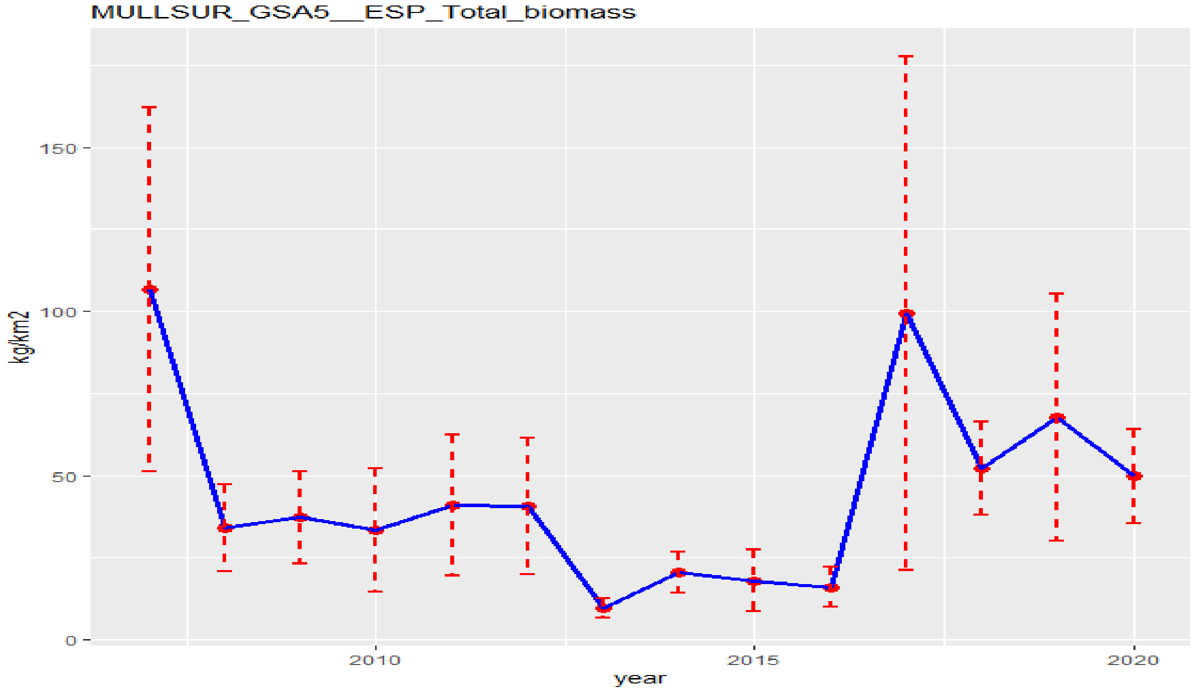


Figure 6.4.2.7. Striped red mullet in GSA 5. MEDITS abundance (n/km^2) and biomass (kg/km^2) indices over 2007-2020.

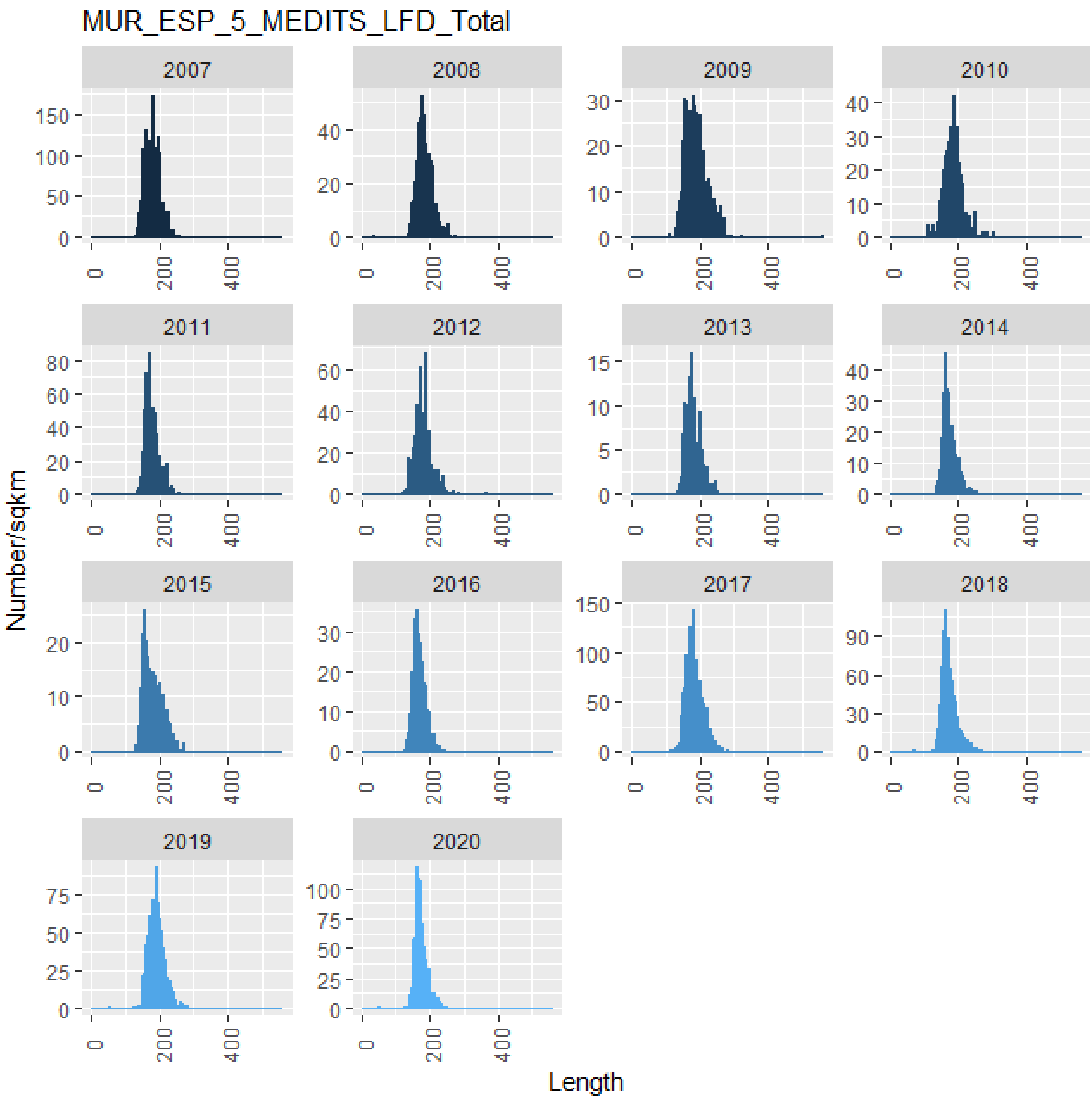


Figure 6.4.2.8. Striped red mullet in GSA 6. MEDITS length frequency distribution (n/km^2).

Table 6.4.2.6. Striped red mullet in GSA5. Length structure (TL mm) reported in MEDITS (2007-2020) for survey data.

Length (mm)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
35	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87
55	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.44
60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.44
65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
105	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
110	0.00	0.00	0.66	3.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
115	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00
120	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.76	0.44	0.00	0.00
125	0.75	0.00	0.00	3.52	0.00	1.67	0.00	0.00	0.00	0.37	1.14	0.87	0.81	1.30
130	2.02	0.00	1.92	0.00	0.47	2.75	0.00	0.00	1.26	2.96	3.34	1.23	0.45	0.00
135	9.74	1.39	5.66	1.70	1.74	17.75	0.42	2.87	1.26	4.57	4.62	9.34	0.00	0.81
140	28.90	5.10	7.97	4.43	3.62	10.50	1.13	4.41	4.78	9.54	9.46	17.90	2.34	11.69
145	43.70	12.86	9.97	10.65	10.82	16.92	1.96	7.94	11.77	19.98	36.96	37.04	0.81	17.42
150	108.87	13.77	21.05	14.25	26.41	22.31	6.92	18.29	21.47	19.11	59.03	66.77	21.27	56.87
155	108.78	20.55	30.35	19.98	51.29	28.26	10.30	32.83	26.10	33.38	65.41	94.17	22.72	59.54
160	130.73	28.65	29.89	24.32	72.54	42.65	10.08	45.39	20.43	35.56	97.33	111.24	42.26	118.58
165	113.61	42.62	27.44	25.78	72.08	41.16	9.25	33.72	17.30	29.59	91.63	83.77	47.79	108.57
170	118.31	44.52	27.74	28.53	85.14	61.13	13.24	32.38	15.24	27.10	126.20	89.71	61.67	107.03
175	96.86	52.93	26.17	32.75	50.24	38.58	16.05	19.20	14.35	22.43	87.37	65.23	49.02	70.59
180	174.00	45.91	31.04	27.32	51.92	35.53	10.85	22.27	14.50	17.26	143.71	55.65	72.01	51.66
185	86.64	35.03	28.89	42.32	49.00	68.02	10.99	16.96	14.11	16.29	88.00	42.68	49.85	39.74
190	109.95	22.34	27.28	23.21	36.51	29.56	5.83	12.64	9.99	10.35	93.38	39.36	94.05	24.19
195	122.97	31.17	22.35	32.97	21.56	30.70	5.50	11.59	12.00	10.07	70.63	26.57	69.62	33.65
200	103.64	20.84	26.96	22.03	22.38	18.68	9.41	11.61	12.56	9.50	71.66	17.30	59.16	18.08
205	29.69	28.19	18.89	18.77	16.89	14.15	5.00	7.10	9.19	4.09	53.59	14.66	51.67	12.48
210	42.41	26.30	18.87	8.15	16.33	6.49	3.34	5.91	10.59	4.20	49.31	15.52	39.88	11.97
215	31.37	6.01	12.03	15.81	10.67	11.81	2.67	6.11	5.04	4.10	36.87	13.48	31.83	13.28
220	29.40	11.97	10.27	7.43	18.60	10.79	3.12	4.57	7.60	1.68	42.97	11.02	20.25	8.10
225	32.62	8.93	12.81	7.07	3.95	11.51	1.13	1.24	5.42	0.64	17.97	8.43	11.62	8.54
230	3.90	5.54	11.13	4.19	2.61	5.28	1.09	1.69	5.04	1.11	22.60	9.70	18.51	6.08
235	8.86	3.33	7.06	6.39	5.18	5.78	0.67	2.13	2.92	0.00	15.22	3.33	13.58	4.24
240	9.19	3.78	8.52	1.50	2.83	8.87	1.17	1.69	3.06	0.47	4.13	7.14	11.41	0.00
245	1.39	2.61	6.65	2.41	0.32	3.21	1.58	1.24	1.68	0.37	9.82	2.33	5.07	1.19
250	0.38	3.52	2.44	7.68	0.00	1.47	0.42	0.89	1.75	0.00	4.62	1.75	2.14	0.89
255	1.75	5.29	5.25	0.00	0.79	1.00	0.00	0.84	0.00	0.00	5.68	2.19	2.14	0.44
260	0.00	0.88	6.95	0.38	0.00	0.00	0.00	0.00	0.44	0.00	0.76	1.45	4.29	0.00
265	0.00	0.28	2.95	0.47	0.00	0.50	0.00	0.24	0.37	0.00	4.15	0.44	3.38	0.00
270	0.00	0.35	4.01	0.00	0.47	1.47	0.00	0.00	1.68	0.00	0.31	0.87	0.00	0.44
275	0.00	0.88	0.26	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	1.69	0.44
280	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.44	1.69	0.00
285	0.38	0.00	0.26	1.76	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
290	0.38	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
295	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
305	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
310	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00
315	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
320	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
325	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
330	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
335	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
340	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
345	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
350	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
355	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

360	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
365	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
370	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
375	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
380	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
385	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
390	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
395	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
405	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
410	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
415	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
420	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
425	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
430	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
435	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
440	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
445	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
450	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
455	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
460	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
465	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
470	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
475	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
480	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
485	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
490	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
495	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
505	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
510	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
515	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
520	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
525	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
530	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
535	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
540	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
545	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
550	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
555	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
560	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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 6.4.2.9 and Table 6.4.2.6). Cohorts showed no consistency (Figure 6.4.2.10).

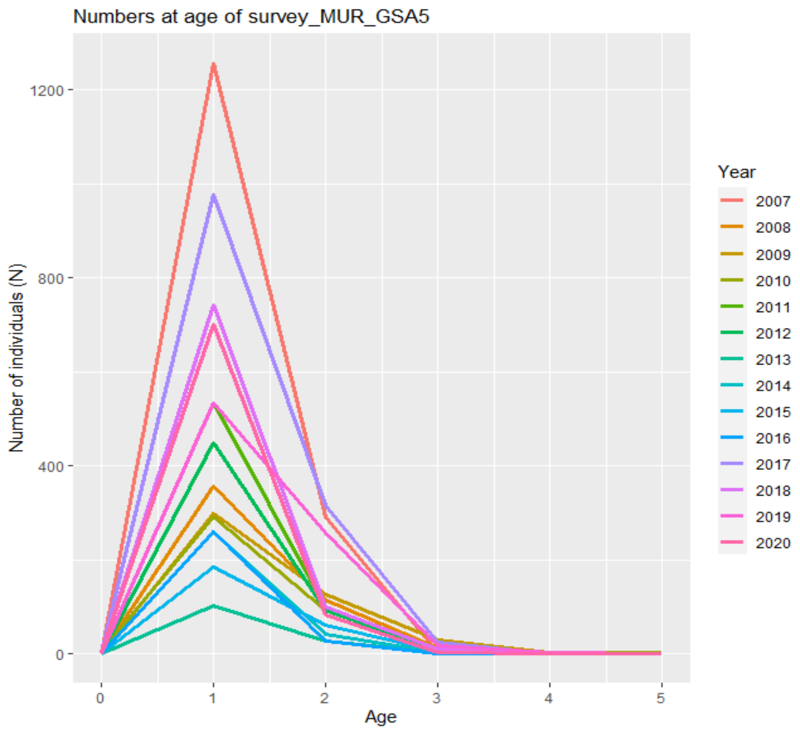


Figure 6.4.2.9. Striped red mullet in GSA 6. Age composition of MEDITS estimated by length slicing from length frequency distribution.

Table 6.4.2.6. Striped red mullet in GSA 5. Age composition of MEDITS estimated by length slicing from length frequency distribution used with plus group at age 5.

Age	2007	2008	2009	2010	2011	2012	2013
0	0.19	0.38	0.66	5.28	0.47	0.83	0.19
1	1255.83	356.82	297.73	291.73	533.35	447.49	102.51
2	291.09	114.89	126.55	91.35	99.43	93.34	27.60
3	3.52	12.93	28.25	10.94	1.58	7.66	2.00
4	0.76	0.88	1.50	3.52	0.22	0.50	0.22
5	0.11	0.11	0.76	1.76	0.11	0.50	0.11

age	2014	2015	2016	2017	2018	2019	2020
0	0.19	0.19	0.19	1.84	1.63	0.45	1.75
1	260.49	184.56	258.56	978.22	741.52	534.67	701.64
2	42.04	61.43	25.78	314.33	100.57	257.91	82.79
3	3.21	5.92	0.37	25.34	9.03	17.03	2.95
4	0.22	0.22	0.22	0.76	0.87	3.38	0.44
5	0.11	0.11	0.11	0.11	0.11	0.22	0.11

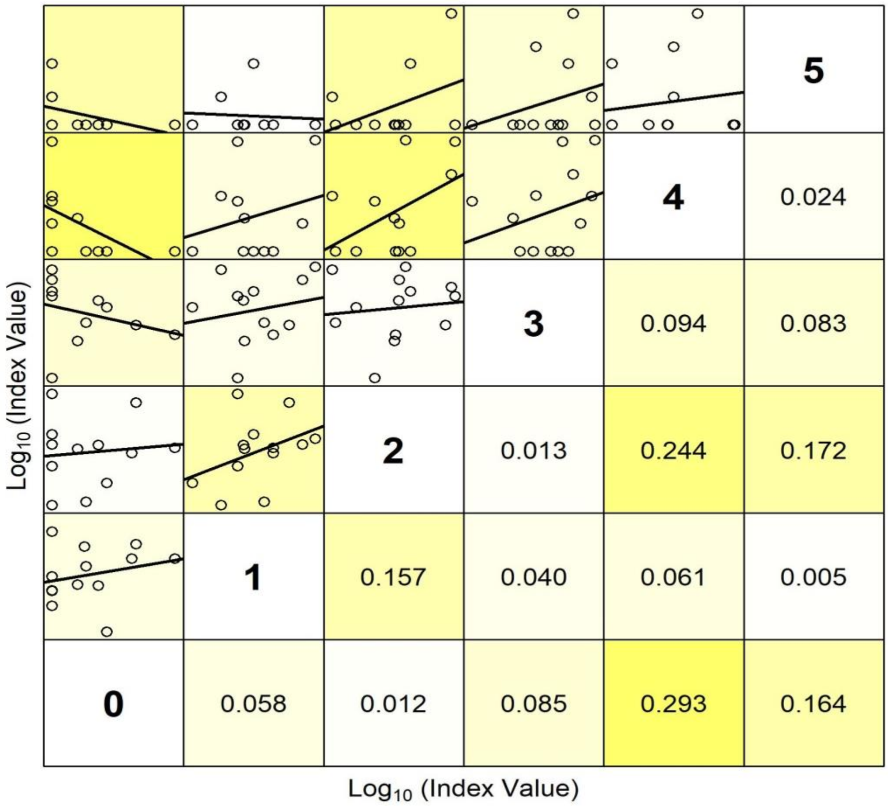


Figure 6.4.2.10. Striped red mullet in GSA 5. Cohort consistency for the MEDITS data.

6.4.3 STOCK ASSESSMENT

Striped red mullet in GSA 5 was assessed with a4a.

Method: a4a

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.

Input data

The a4a model was carried out using the biological data, age structures for survey and catches and catch data above presented for combined sex. Input data come from DCF catches. Natural mortality and maturity at age values are the presented in previous sections. SoP corrections by year were applied to numbers at age in the catch.

Table 6.4.3.1. Striped red mullet in GSA 5: Values of mean weight at age per year used in the assessment.

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.018	0.016	0.018	0.017	0.015	0.018	0.018	0.017	0.017
1	0.052	0.049	0.045	0.049	0.048	0.051	0.055	0.052	0.051
2	0.113	0.114	0.115	0.118	0.120	0.118	0.118	0.117	0.117
3	0.211	0.207	0.205	0.206	0.208	0.210	0.206	0.206	0.207
4	0.282	0.280	0.279	0.277	0.288	0.284	0.282	0.298	0.283
5	0.375	0.431	0.435	0.354	0.381	0.378	0.370	0.401	0.391

age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.017	0.018	0.019	0.018	0.017	0.016	0.017	0.019	0.019	0.015
1	0.051	0.053	0.056	0.057	0.054	0.052	0.051	0.057	0.056	0.064
2	0.121	0.117	0.118	0.118	0.121	0.116	0.119	0.116	0.117	0.115
3	0.211	0.208	0.211	0.209	0.213	0.206	0.205	0.208	0.212	0.212
4	0.285	0.277	0.283	0.283	0.286	0.283	0.299	0.277	0.287	0.289
5	0.392	0.367	0.348	0.349	0.404	0.340	0.339	0.339	0.362	0.375

Assessment Results

Different a4a models were investigated in terms of fishing mortality, catchability of the index and stock–recruitment relationship models (fmodel, qmodel, srmodel). The following model was selected on the basis of best fit, both for residuals as well as fitted vs observed data and retrospective. The contribution of the index was underweighted because low cohort consistence and poor model fitting of the observed data as below presented.

```
Fmod <- ~ s(replace(age,age>2,2), k=3) + s(year,k=6)
qmod <- list(~ factor(replace(age,age>2,2)))
srmod <- ~factor(year)
index.var(mur.idx.19[[1]])=0.5
```

Figure 6.4.3.1 show the summary of the stock object after the fit of the model. F, SSB and catches showed a stable fluctation trend along years. Recruitment showed the highest values in 2002-2007 and after a general decrease and a stable fluctuation since then.

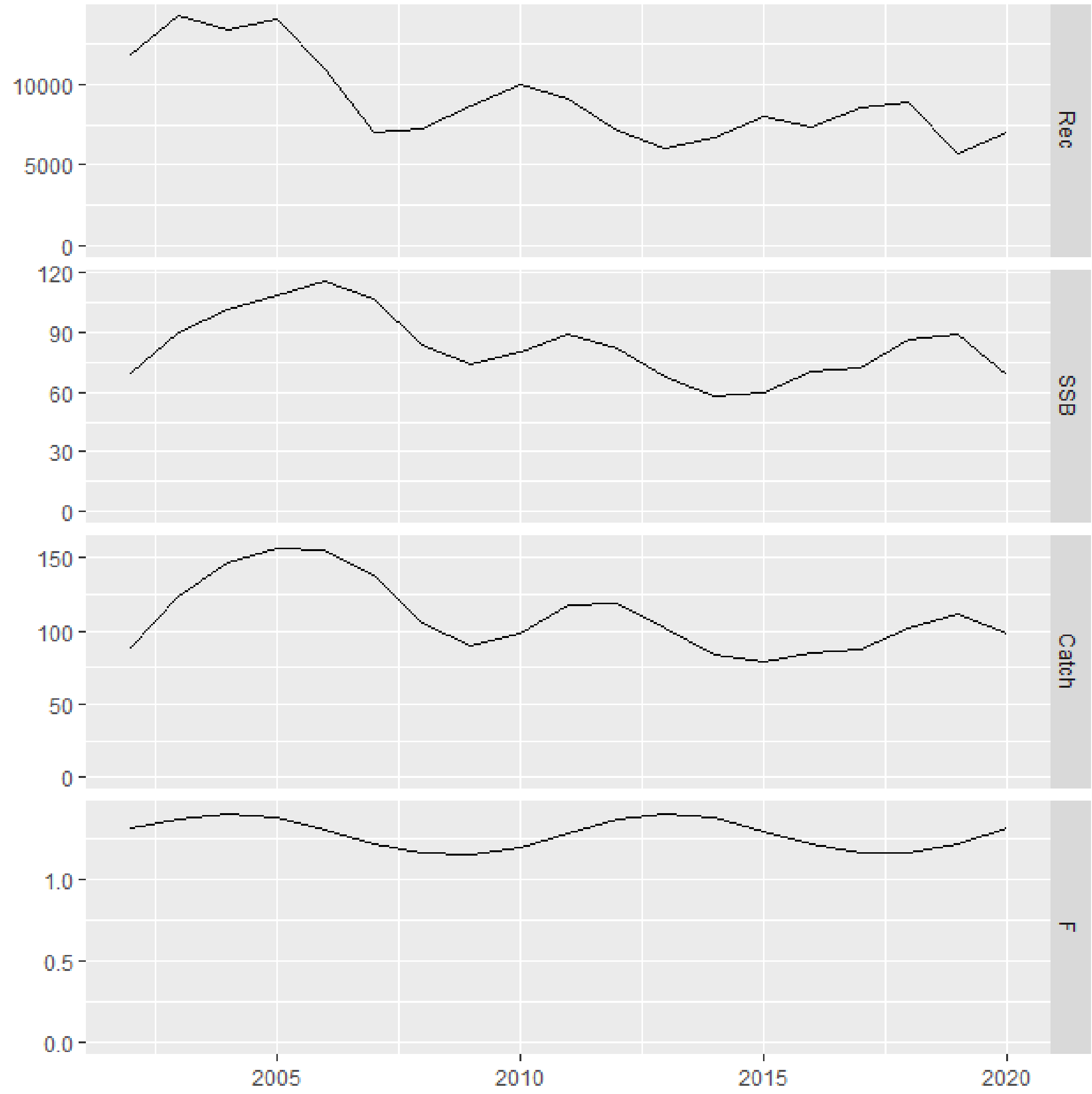


Figure 6.4.3.1. Striped red mullet in GSA 5. Stock summary from the a4a model: recruitmend (thousands), SSB (Stock Spawning Biomass, tonnes), catch (tonnes) and fishing mortality for ages 1 to 2).

Table 6.4.3.2. Striped red mullet in GSA 5. Estimation of N at age from the a4a assessment model.

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	11786.00	14191.00	13296.00	13966.00	10998.00	7032.70	7256.70	8638.70	9979.70
1	2739.20	3729.50	4488.50	4204.20	4416.90	3480.30	2227.00	2299.10	2737.10
2	270.00	439.19	573.66	676.02	643.97	712.37	597.30	399.40	415.29
3	25.07	27.30	41.38	52.15	63.24	65.78	80.88	73.08	49.47
4	2.14	2.77	2.81	4.12	5.34	7.07	8.17	10.83	9.90
5	0.17	0.27	0.33	0.33	0.48	0.69	1.02	1.30	1.73

age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	9082.60	7065.20	6000.70	6629.70	7980.90	7385.50	8492.10	8904.50	5746.90	7052.90
1	3160.80	2874.70	2234.70	1897.40	2096.70	2525.70	2338.90	2690.50	2821.00	1819.80
2	478.14	519.00	443.39	334.58	290.04	339.79	436.08	419.53	481.41	483.77
3	48.59	50.35	49.13	39.90	31.19	29.87	38.97	53.37	51.13	54.58
4	6.33	5.60	5.21	4.84	4.07	3.51	3.75	5.22	7.12	6.34
5	1.57	0.96	0.72	0.62	0.59	0.55	0.54	0.61	0.82	1.04

Table 6.4.3.3. Striped red mullet in GSA 5. Estimation of F at age from the a4a assessment model.

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1	0.97	1.01	1.03	1.02	0.96	0.90	0.86	0.85	0.88
2	1.65	1.72	1.76	1.73	1.64	1.54	1.46	1.45	1.51
3	1.65	1.72	1.76	1.73	1.64	1.54	1.46	1.45	1.51
4	1.65	1.72	1.76	1.73	1.64	1.54	1.46	1.45	1.51
5	1.65	1.72	1.76	1.73	1.64	1.54	1.46	1.45	1.51

age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1	0.95	1.01	1.04	1.02	0.96	0.90	0.86	0.86	0.90	0.97
2	1.61	1.72	1.77	1.73	1.63	1.53	1.46	1.46	1.54	1.65
3	1.61	1.72	1.77	1.73	1.63	1.53	1.46	1.46	1.54	1.65
4	1.61	1.72	1.77	1.73	1.63	1.53	1.46	1.46	1.54	1.65
5	1.61	1.72	1.77	1.73	1.63	1.53	1.46	1.46	1.54	1.65

Figure 6.4.3.2 and 6.4.3.3 show the estimated fishing mortality by age and year and estimated survey catchability by age and year, respectively.

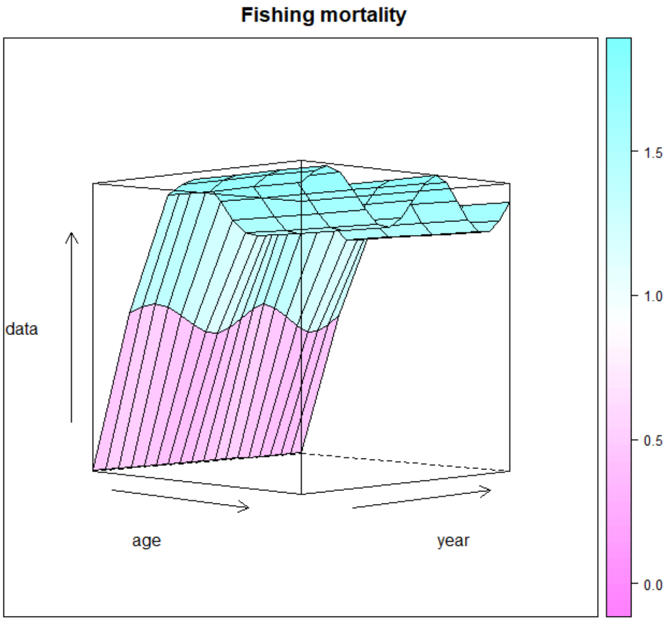


Figure 6.4.3.2. Striped red mullet in GSA 5. 3D contour plot of estimated fishing mortality by age and year.

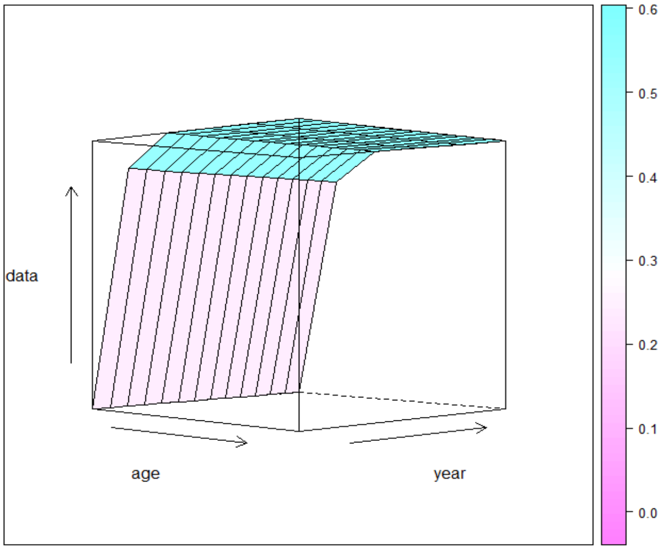


Figure 6.4.3.3 Striped red mullet in GSA 5. 3D contour plot of survey catchability by age and year.

Diagnostics

Figures 6.4.3.4, 6.4.3.5, 6.4.3.6, 6.4.3.7 and 6.4.3.8 show several diagnostic plots for the goodness of fit of the selected model for the assessment of striped red mullet in GSA 5.

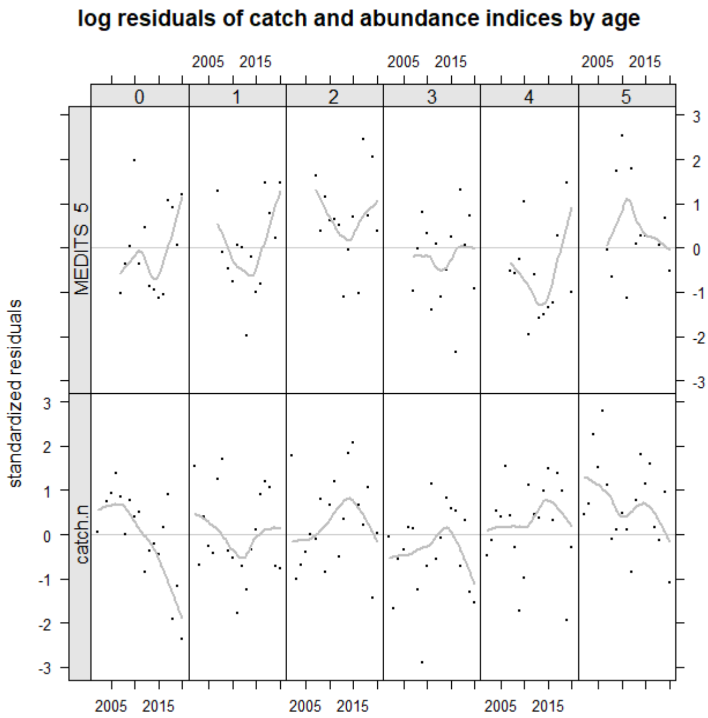


Figure 6.4.3.4. Striped red mullet in GSA 5. Standardized residuals for catch, abundance indices and for catch numbers.

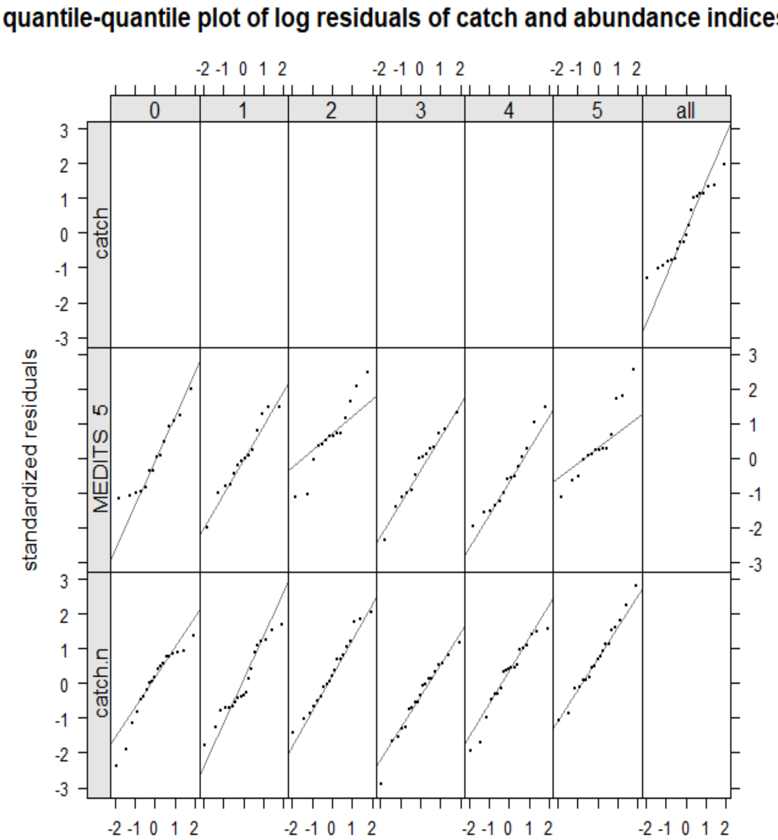


Figure 6.4.3.5. Striped red mullet in GSA 5. Quantile-quantile plot of standardized residuals for catch, abundance indices and for catch numbers.

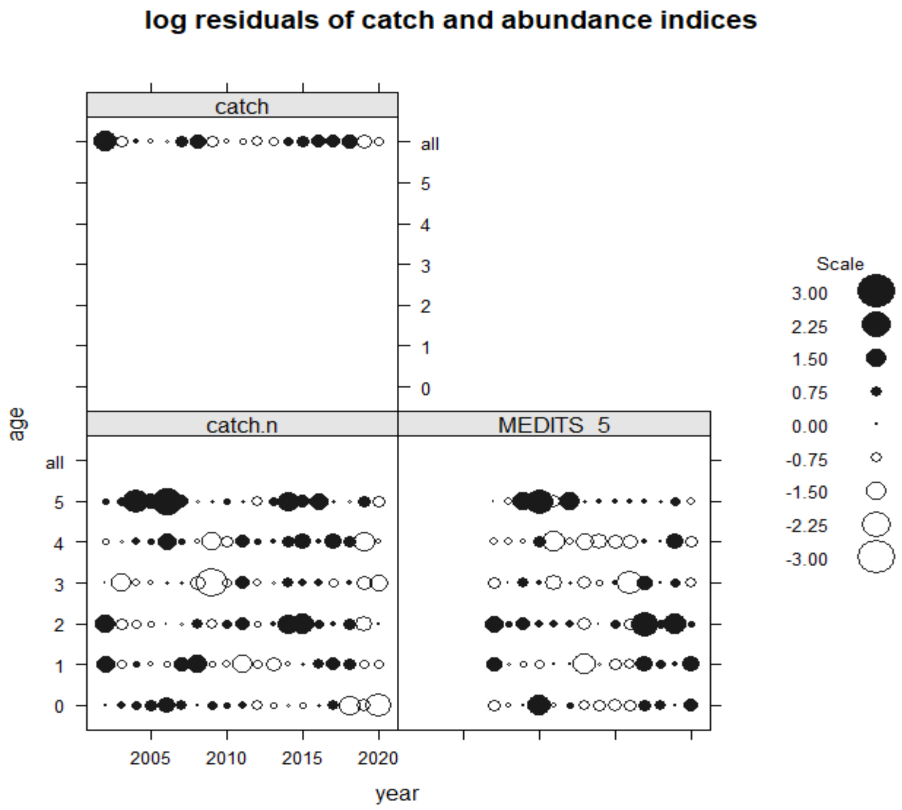


Figure 6.4.3.6. Striped red mullet in GSA 5. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

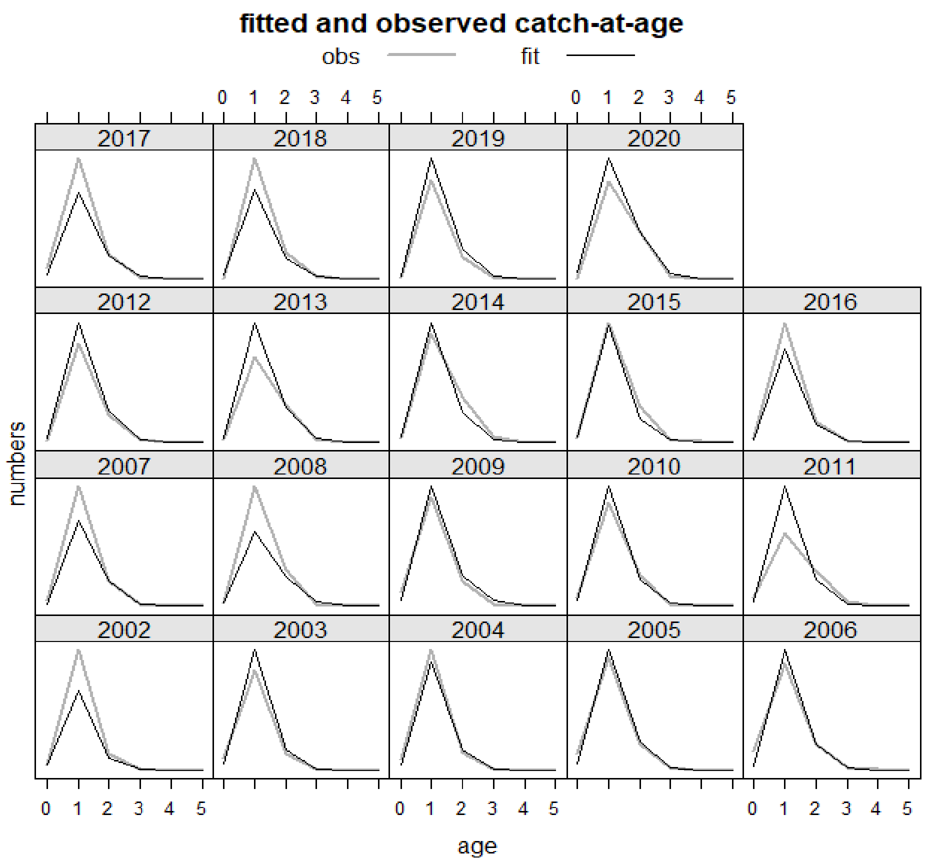


Figure 6.4.3.7. Striped red mullet in GSA 5. Fitted and observed catch at age.

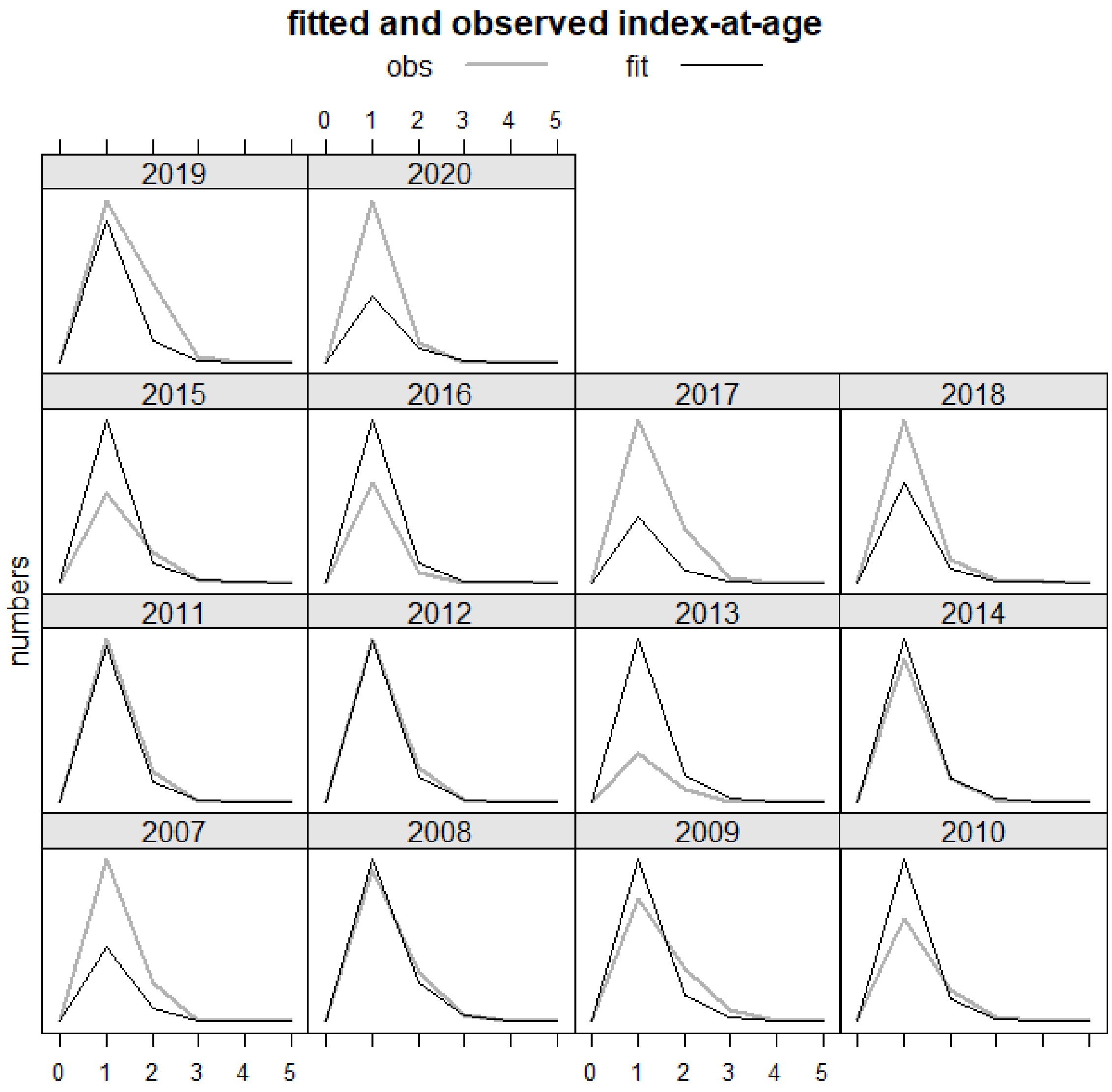


Figure 6.4.3.8. Striped red mullet in GSA 6. Fitted and observed index at age

RETROSPECTIVE

The retrospective analysis was applied up to 3 years back (Figure 6.4.3.9). Outcomes are unstable for each of the analyzed variables. This retrospective performance is too poor to allow this to be acceptable as an assessment.

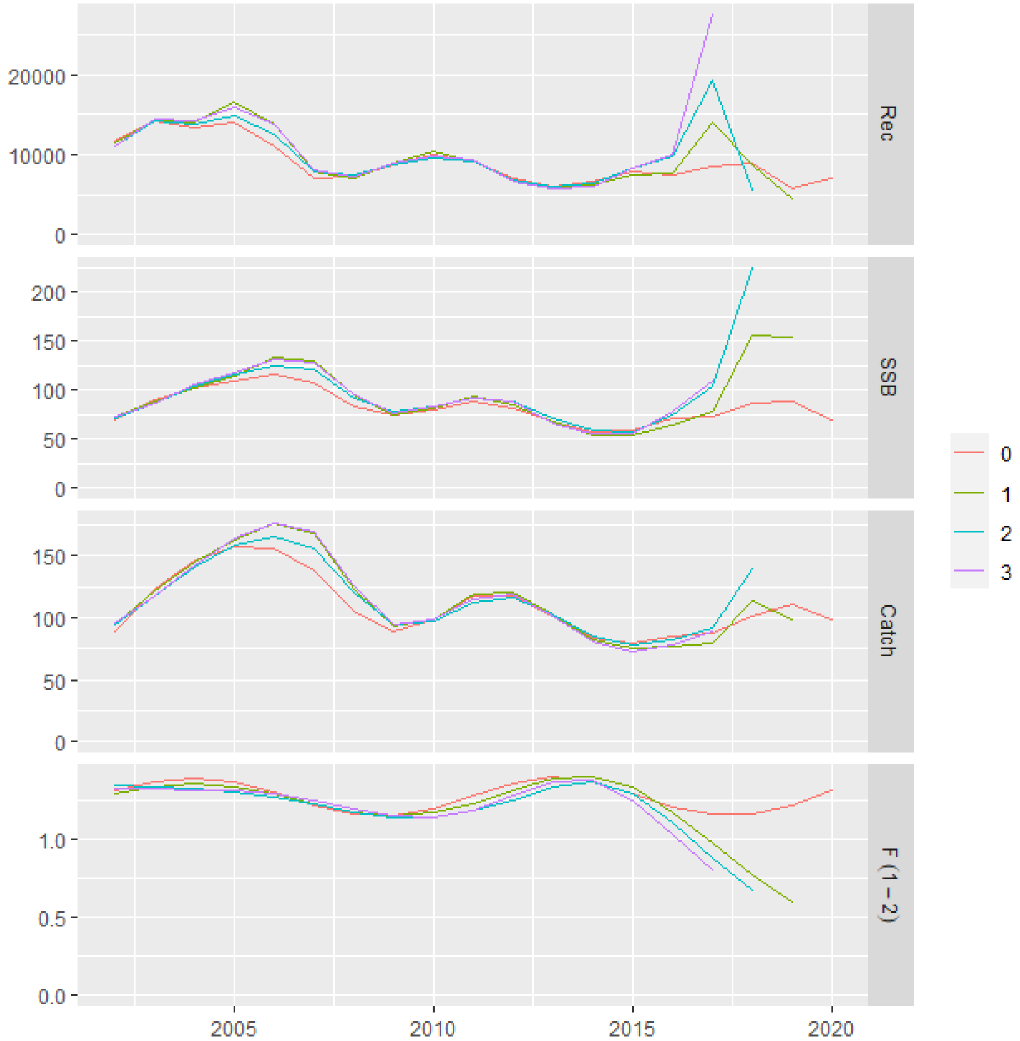


Figure 6.4.3.9. Striped red mullet in GSA 5. Retrospective analysis for the a4a model.

SIMULATIONS

Figure 6.4.3.10 shows the simulations carried out for striped red mullet in GSA 5.

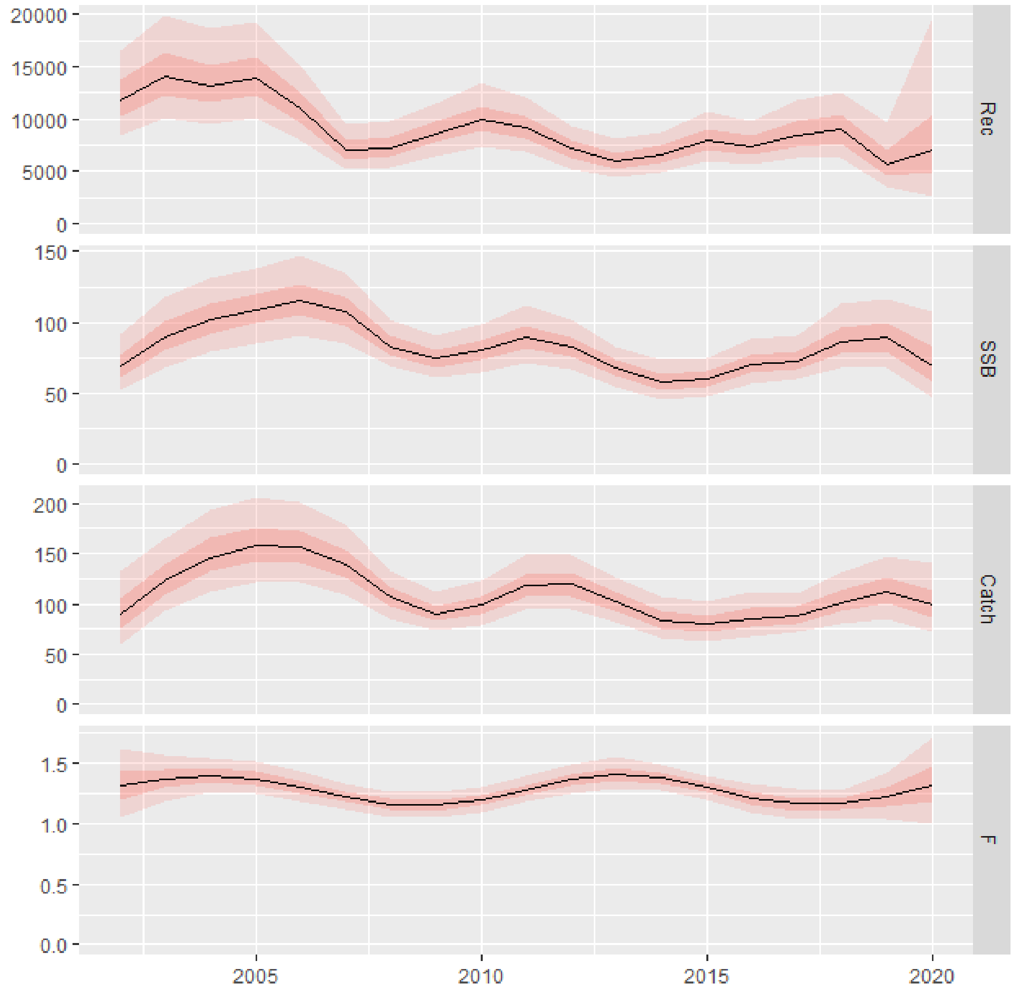


Figure 6.4.3.10. Striped red mullet in GSA 5. Stock summary of the simulated and fitted data for the a4a model.

Given the poor fitting results of the model, several differents models with different parametrizations was tested (modifying fmodel, gmodel and srmodel), but better results were not found. The retropseective performance was poor and the resisdual plots show groupings of 4 years of positive and then four years of negative residuals in the survey (Figure 6.4.3.6.). All this suggests that the survey and fishery are not giving coherent results. Therefore, although the present model was the best in terms of fitting, it was too poor to be considered as an acceptable assessment and not stable enough for provide short term forecast advice.

6.4.4 Reference Points

As the assessment was not accepted for advice, reference points were not calculated.

6.4.5 Short term Forecast and Catch Options

In the last years, biomass of red striped mullet in GSA 5 has displayed a stable trend, although from 2017 biomass showed an noticeable increase in comparison to the previous years (figure 6.4.5.1). The change in biomass over the last five years was used to provide an index for change (1.05). As the biomass index change is lower than 1.2 and greater than 0.8, following the ICES approach no uncertainty cap is applied. Following the ICES approach, STECF EWG 21-11 has used the index of change of 1.05 applied to the mean catch advice from last 3 years (2018-2020), what was from 100.54 tonnes. Then, the catch advice is 84.6 tonnes, which supposes a increase of 1% from the catch from 2020 (Table 6.4.5.1).

Table 6.4.5.1 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
Catch Advice (2018–2020)		100.54
Discard rate (2016–2018)		0 (negligible)
-20% Precautionary buffer		Applied
Catch advice **		84.6
Landings advice ***		84.6
% advice change ^		-30%

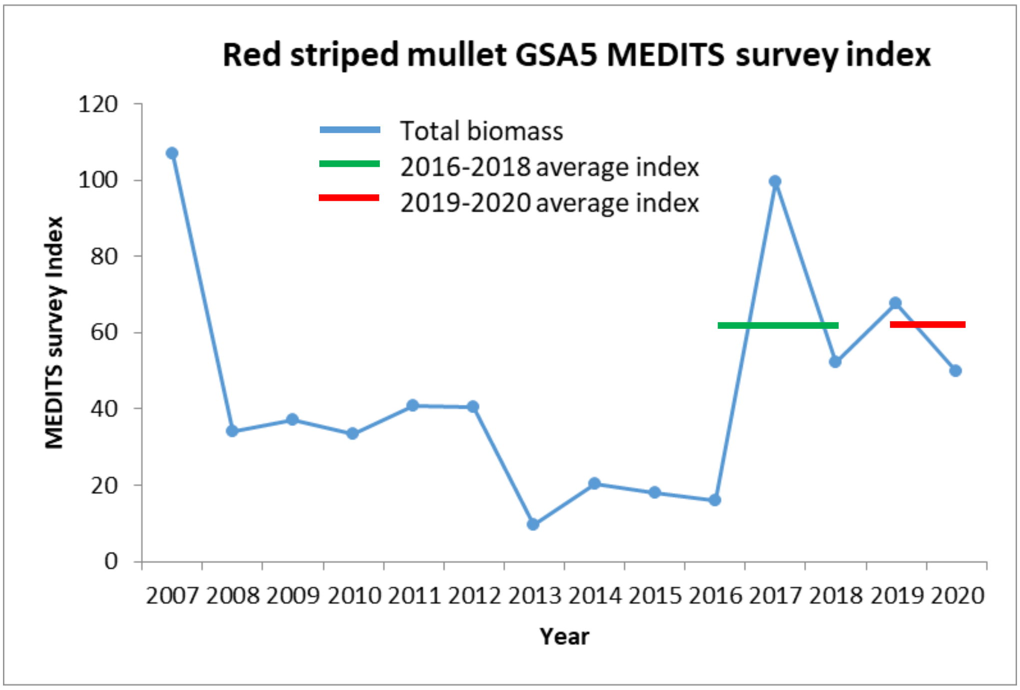


Figure 6.4.5.1 Red stirped mullet GSA 5. Biomass index (kg/km2) in blue estimated from MEDITS survey. The mean of the last two years (58.70, in green) compared to the previous three years in green (55.82, in red) gives a factor of 1.05.

6.5 RED MULLET IN GSA 6

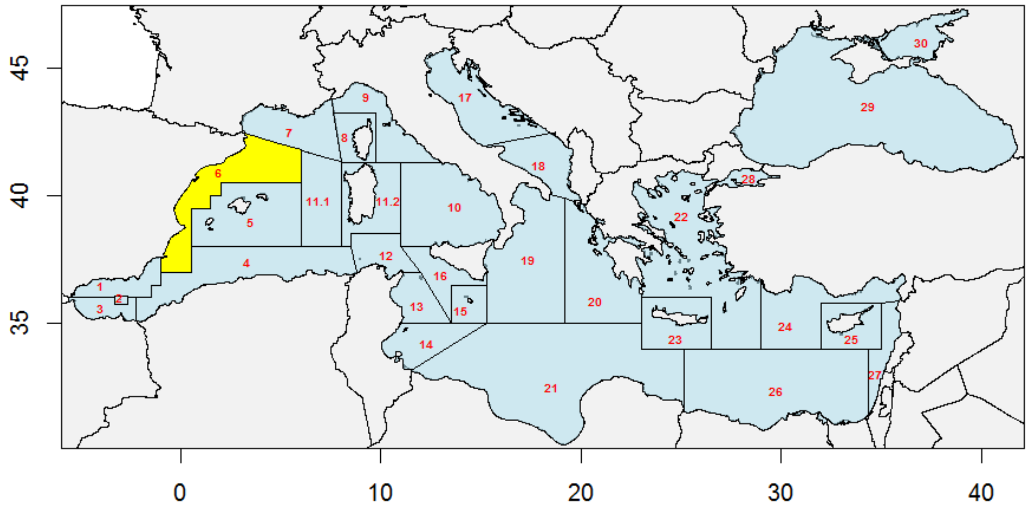


Figure 6.5.1 Red mullet in GSA 6: Location of GSA 6 in the Mediterranean Sea.

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, 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).

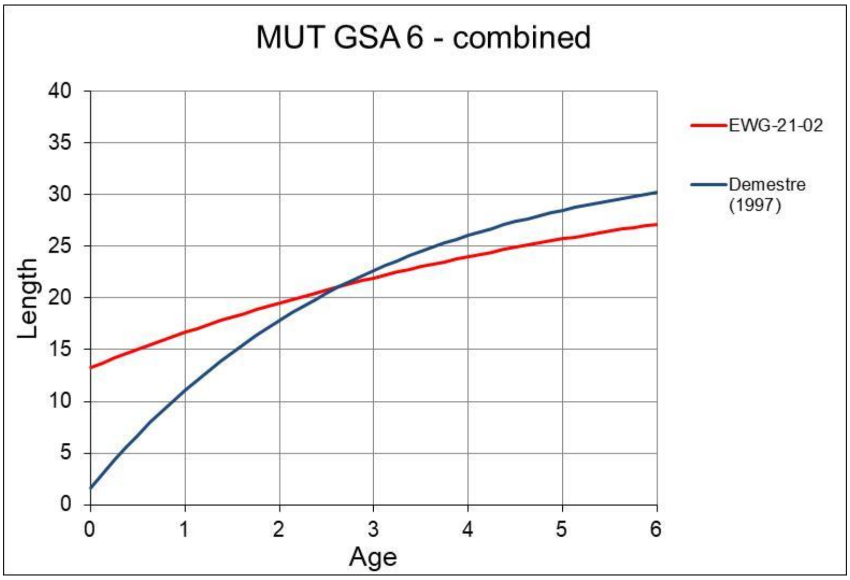


Figure 6.5.1.1 Red mullet in GSA 6: Growth curves according to the parameters used by EWG-21-02 and Demestre *et al.* (1997).

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.

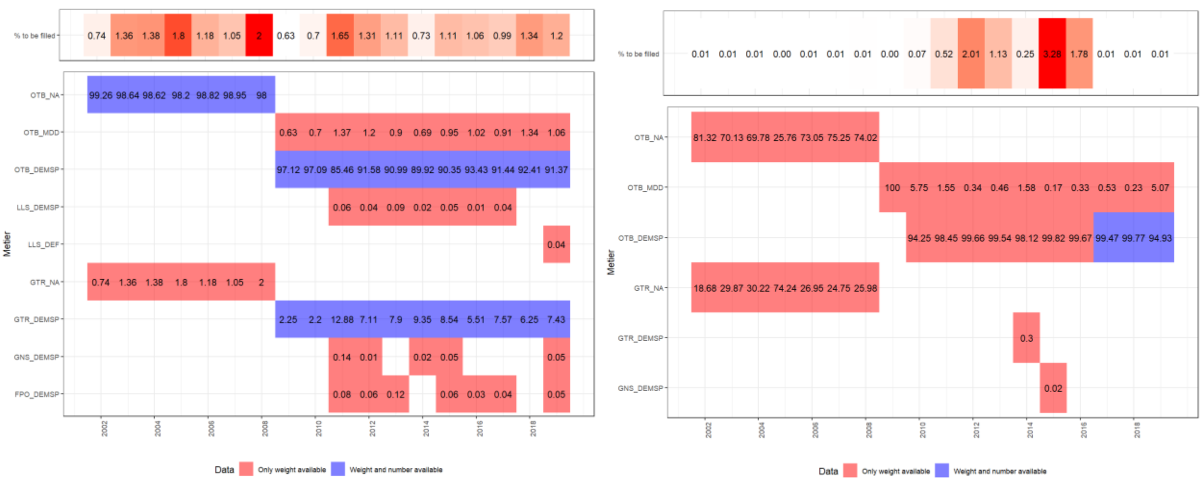


Figure 6.5.2.1.1 Red mullet in GSA 6: Summary of the reconstruction of landings and discards data carried by EWG-21-02.

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 2002-2019 (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

Table 6.5.2.1.2 Red mullet in GSA 6. Discards (t) by fishing gear (left) and total catch (right) over 2002-2019 (tonnes; GNS=gillnet; GTR=trammel net; OTB=otter bottom trawl).

	GNS	GTR	OTB	DISCARDS
2002				
2003				
2004				
2005			0.0	0.0
2006				
2007		0.0		0.0
2008			0.1	0.1
2009		0.0	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			14.7	14.7
2018			43.9	43.9

	CATCH
2002	305.4
2003	1400.0
2004	919.5
2005	995.0
2006	1387.8
2007	1183.6
2008	872.2
2009	520.9
2010	514.5
2011	1068.5
2012	1091.8
2013	1262.2
2014	1312.5
2015	1570.1
2016	1704.1
2017	1464.0
2018	1324.6

2019	1.8	1.8		2019	1503.6
2020	7.7	7.7		2020	1453.9

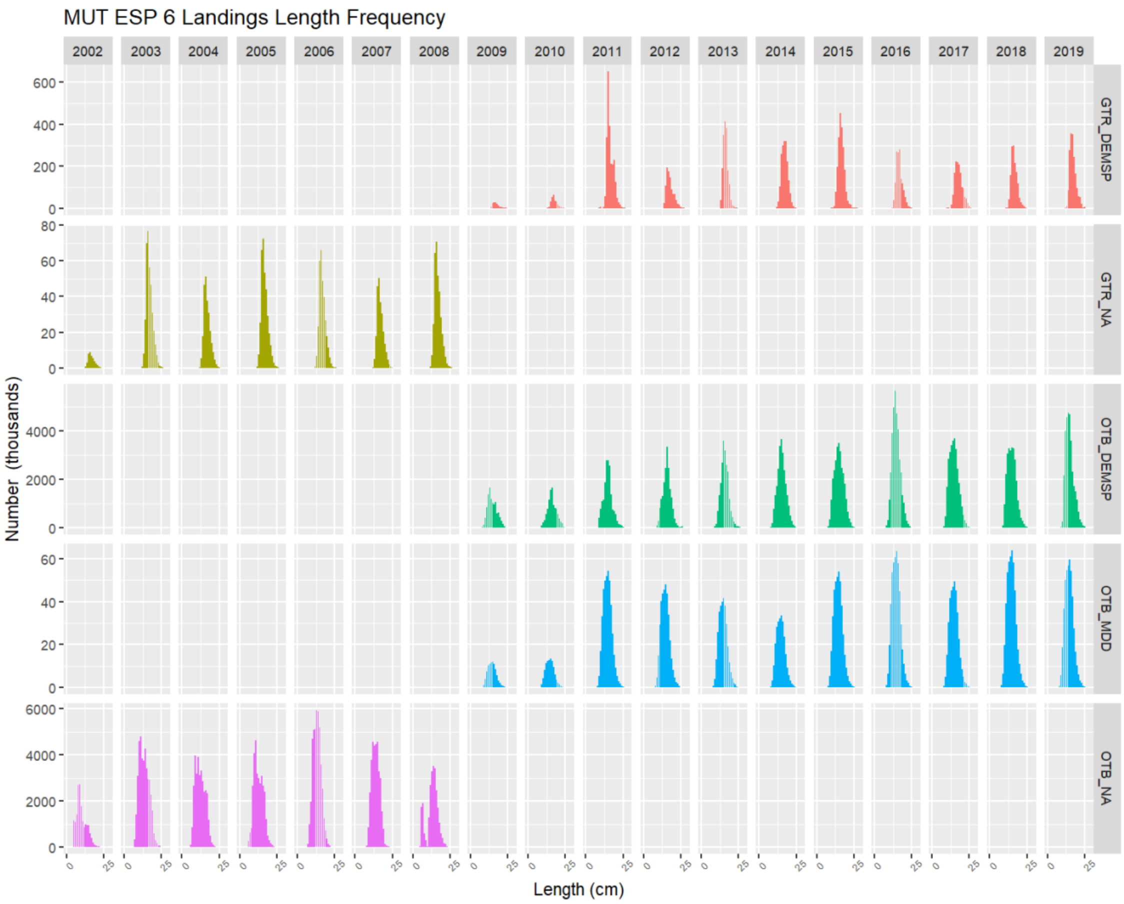


Figure 6.5.2.1.2 Red mullet in GSA 6. Landings length frequency distribution, by year and gear (TL cm) as reconstructed by EWG21-02

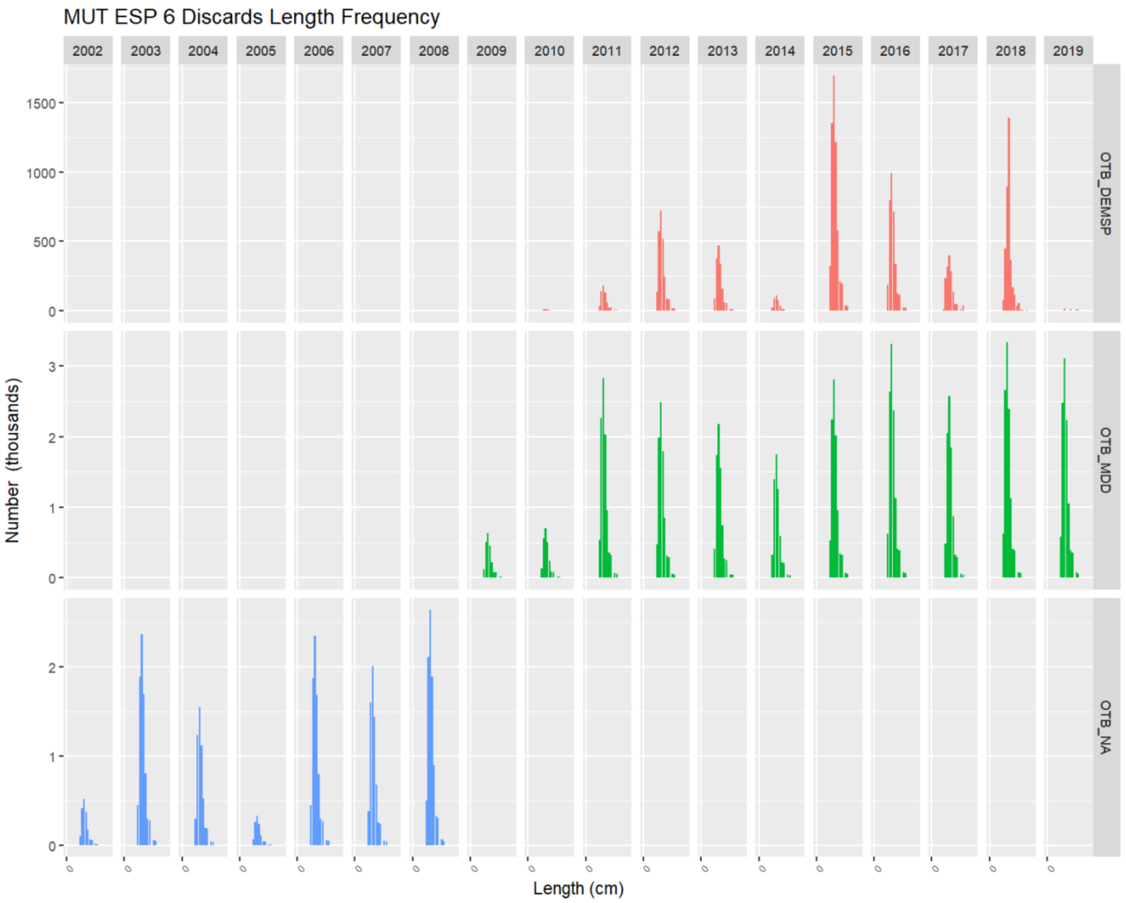


Figure 6.5.2.1.3 Red mullet in GSA 6. Discards length frequency distribution, by year and gear (TL cm) as reconstructed by EWG21-02.

For the assessment, 2020 LFDs of landings and discards were added to the reconstructed data series.

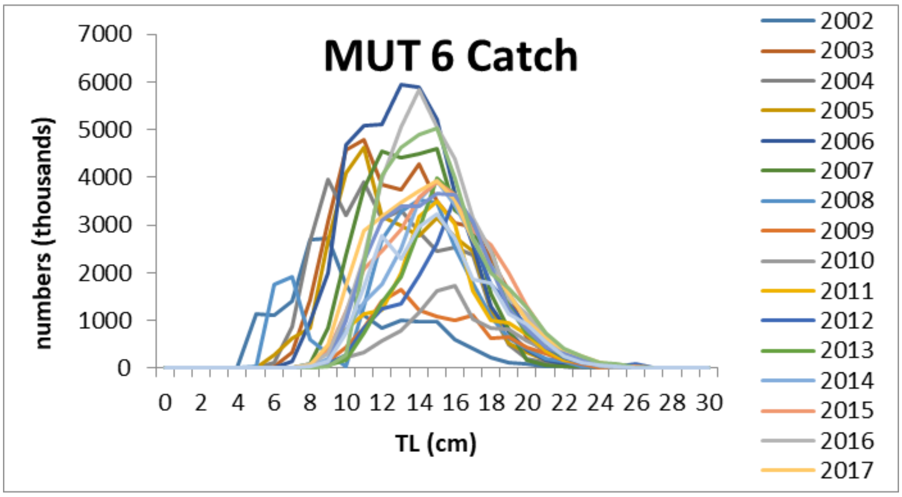


Figure 6.5.2.1.4 Red mullet in GSA 6. Catch length frequency distribution (TL cm).

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

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	26.9	27.5	25.1	19.6	14.0	10.5	9.5	10.6	13.5
1	23243.2	21803.4	21917.8	19559.2	15022.4	10775.2	8398.2	8035.5	9564.3
2	12808.2	14067.3	13352.3	13822.1	13172.7	11202.8	9067.7	7935.4	8286.5
3	1301.3	541.7	619.2	644.6	800.2	982.5	1093.2	1111.0	1128.8
4	57.4	62.5	29.0	34.1	42.8	68.4	111.5	160.5	196.7
	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	17.3	20.2	21.3	21.1	21.0	21.3	21.7	21.5	20.9
1	12818.9	16767.3	19405.8	19735.9	18782.3	17960.2	17773.2	17909.2	17869.3
2	10276.9	13623.1	16919.3	18314.0	17660.3	16472.6	16024.7	16613.5	17832.0
3	1243.5	1481.5	1763.1	1927.4	1902.4	1799.8	1781.8	1948.4	2332.3
4	216.4	229.0	240.8	248.4	246.0	238.3	240.0	267.5	338.4

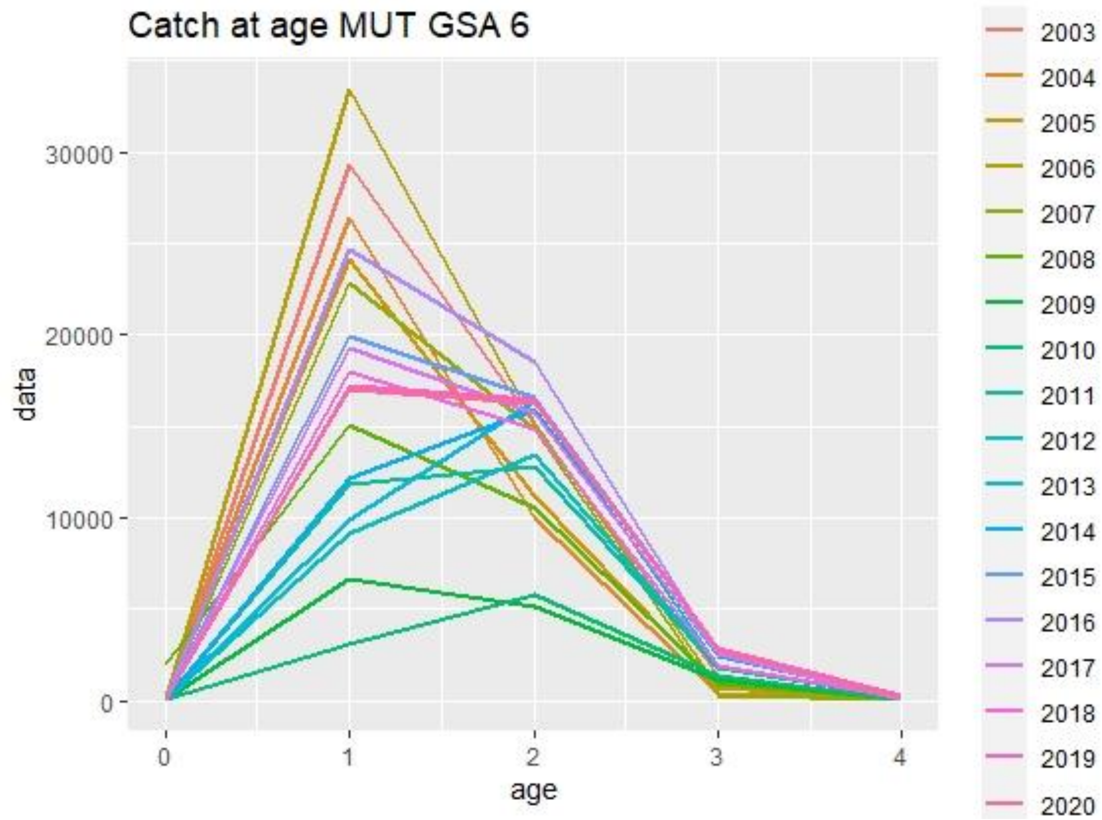


Figure 6.5.2.1.5 Red mullet in GSA 6. Catch at age, input to a4a.

6.5.2.2 Effort

Table 6.5.2.2.1 Fishing effort in GSA 6, expressed in number of fishing days, for trammel net (GTR) and bottom trawl (OTB), the fishing gears that target red mullet.

YEAR	GTR (ESP)	OTB (ESP)	TOTAL
2004	32265	118076	150341
2005	33776	110957	144733
2006	31549	110008	141557
2007	26272	99638	125910
2008	31284	106867	138151
2009	39808	102005	141813
2010	37174	95438	132612
2011	40269	90470	130739
2012	38942	86587	125529
2013	41230	84882	126112
2014	44309	88528	132837
2015	44237	79421	123658
2016	43357	81649	125006
2017	39691	78530	118221
2018	31071	74820	105891

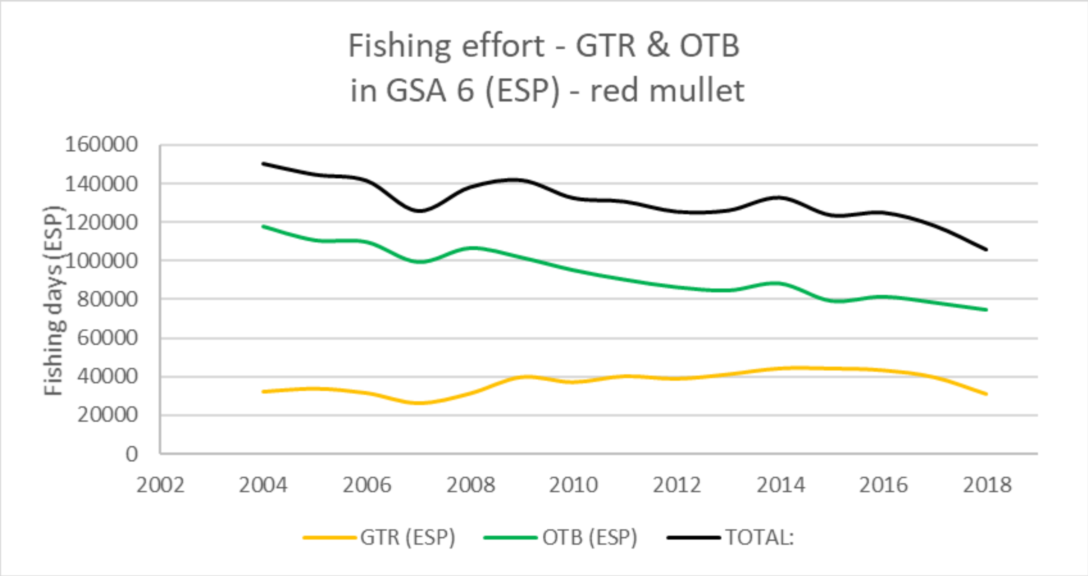


Figure 6.5.2.2.1 Fishing effort in GSA 6, expressed in number of fishing days, for trammel net (GTR) and bottom trawl (OTB), the fishing gears that target red mullet.

6.5.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI datacall 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 1994-2020 (Fig. 6.5.2.3.1).

Because of the Covid-19, MEDITS survey started later than the previous years. The decision was to maintain the survey timing where possible. Thus, it was not possible to collect information from GSA 1 and the area surveyed in GSA 6 was about half of the usual coverage (Fig.6.5.2.3.2). The assessment was checked for sensitivity to the survey results by fitting the assessment model with and without the 2020 survey point.

Figure 6.5.2.3.1 MEDITS survey period in GSA 6.

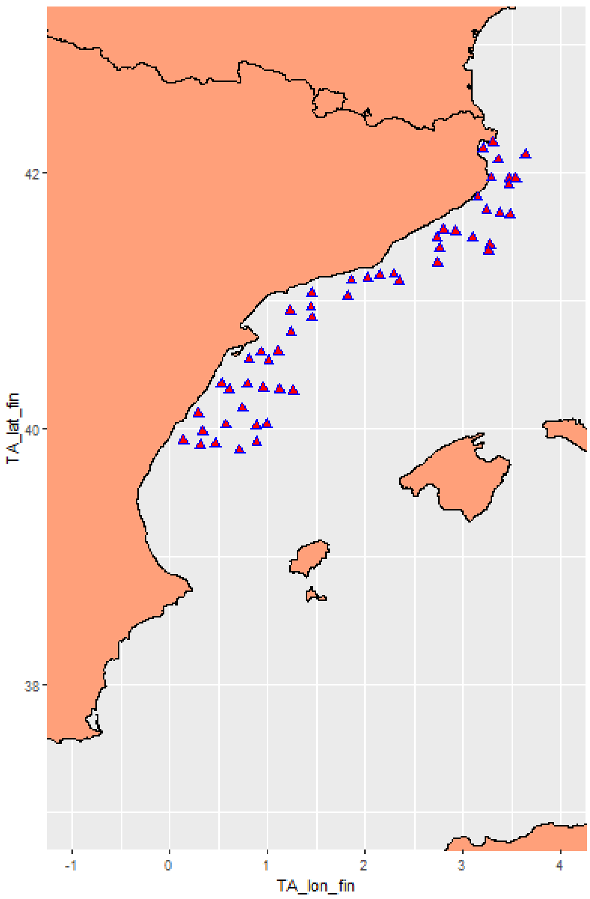
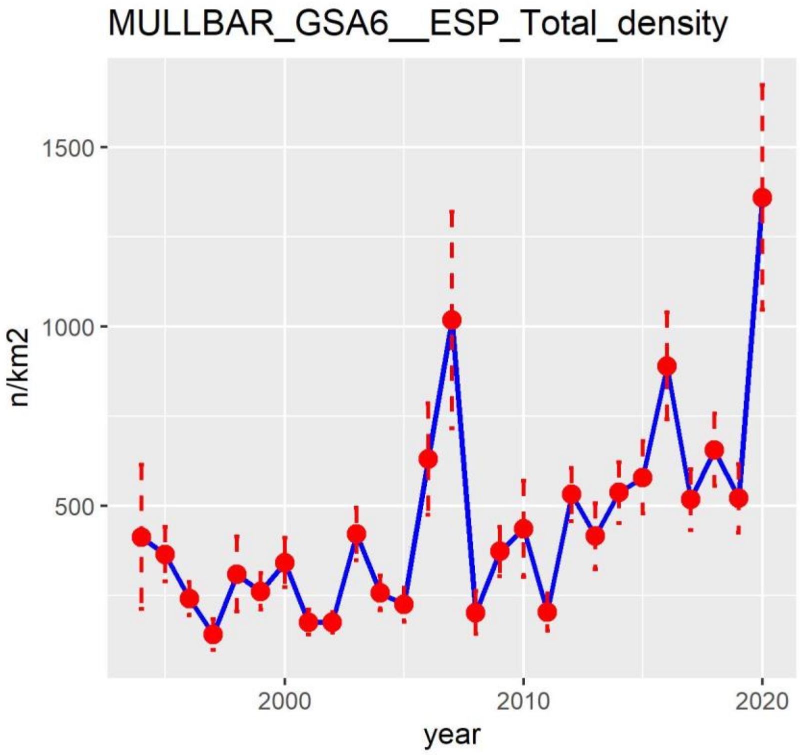


Figure 6.5.2.3.2 MEDITS survey in GSA 6 in 2020, distribution of hauls showing that coverage in 2020 was in the north of the area only.



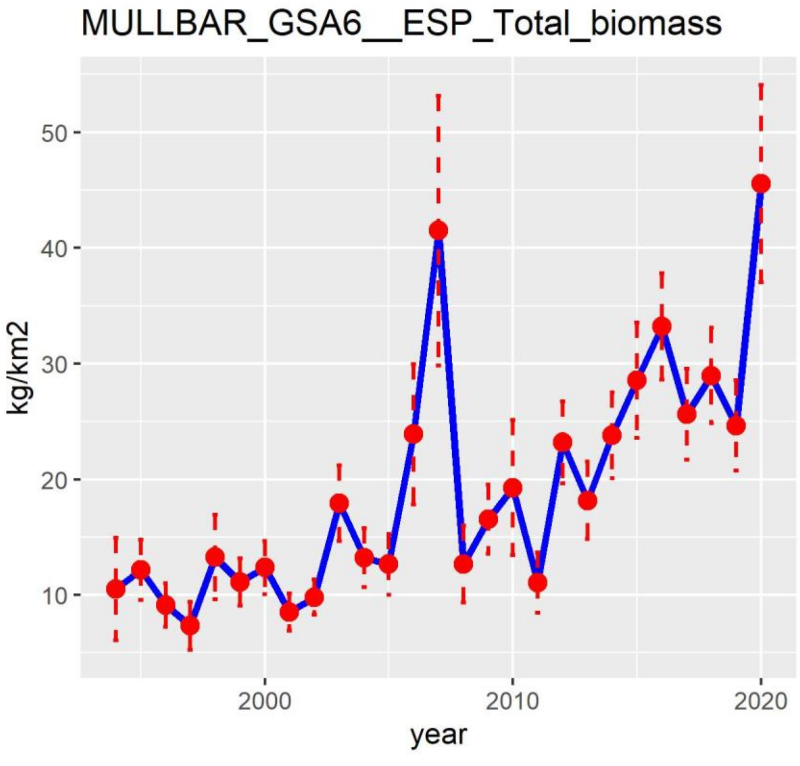


Figure 6.5.2.3.3 Red mullet in GSA 6. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2019.

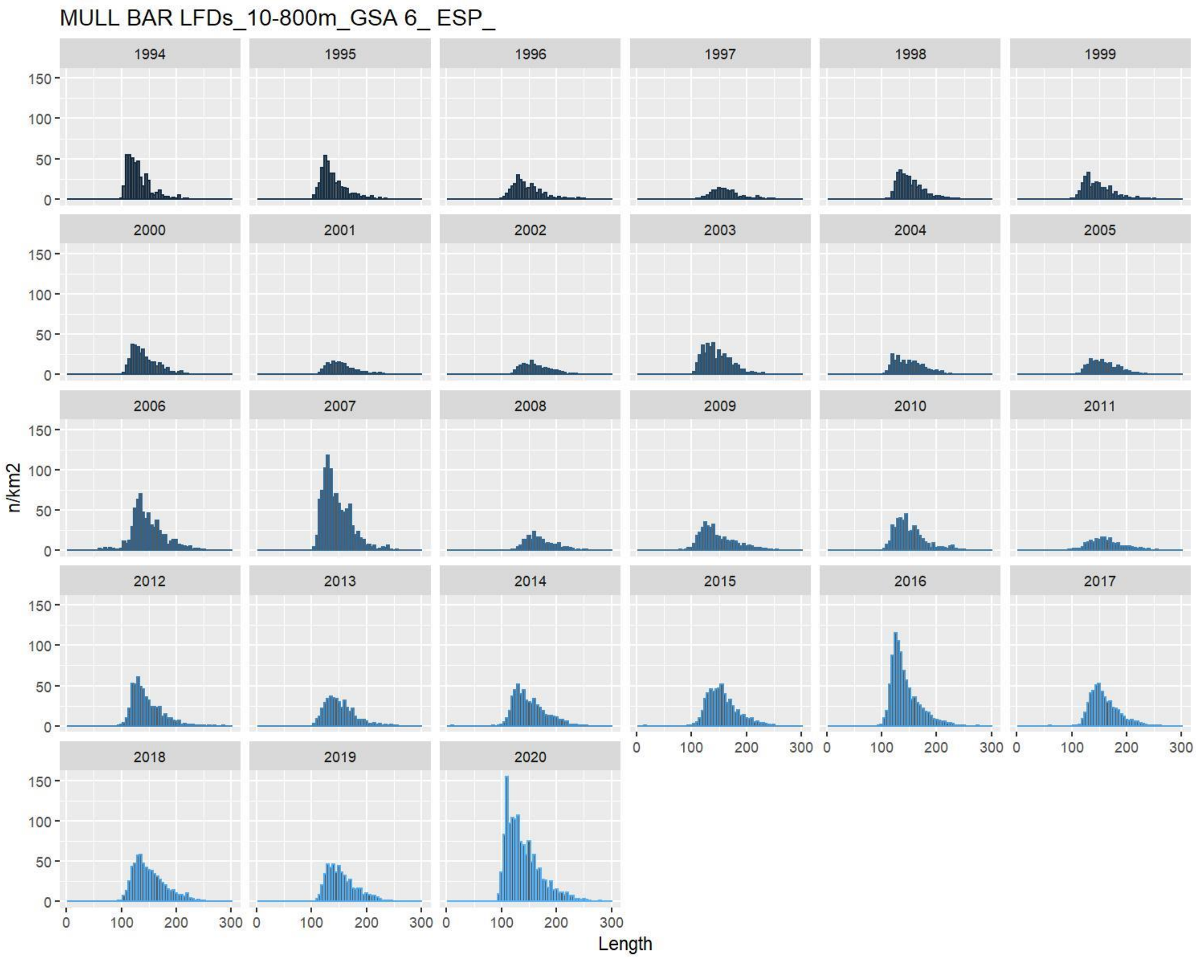


Figure 6.5.2.3.4 Red mullet in GSA 6. MEDITS length frequency distribution n/km^2).

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	11.18	0	0	0.95	0	0.23
1	290.28	159.7	120.6	414.57	722.56	68.73	257.19	287.72	96.3
2	123.81	91.47	94.36	184.62	272.15	117.49	98.72	129.2	93.7
3	7.95	5.86	8.97	20.22	24	14.45	14.28	20.06	13.86
4	0.83	0.94	1	1.09	0.64	2.33	2.49	1.7	1.36
	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0	0	0.2	0.24	0	0.2	0.09	0	0
1	385.66	262.51	341.2	341.38	684.29	287.2	419.91	317.25	1020.5
2	136.88	139.86	176.62	214.27	187.16	208.36	206.32	181.72	285.72
3	9.06	12.05	18.49	22.49	18.26	21.3	28.63	21.04	44.53
4	2.07	1.63	0.92	1.6	1.21	1.03	2.08	1.75	10.14

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).

Medits values of density and abundance were very high in 2020. Because of this, the assessment was done with and without 2020 Medits data in the index survey, to check the sensibility to these high values. Results are presented for the assessment including 2020 in the survey index.

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
	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	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
2	0.050	0.050	0.050	0.051	0.049	0.050	0.050	0.049	0.049
3	0.098	0.100	0.098	0.099	0.098	0.100	0.100	0.099	0.098
4	0.176	0.169	0.160	0.165	0.161	0.164	0.166	0.163	0.159

Assessment Results

This assessment is an update of the EWG-20-09 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-20-09, 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)))

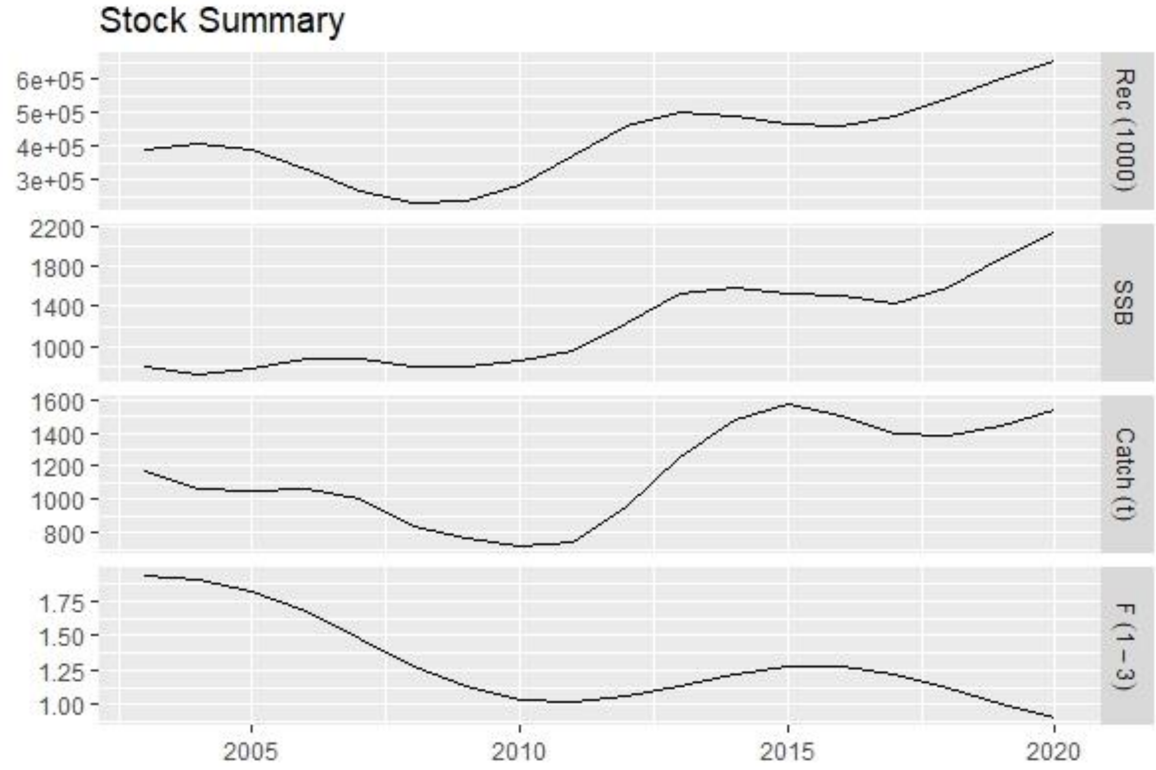


Figure 6.5.3.1 Red mullet in GSA 6. Stock summary from the a4a model for Red mullet in GSA 6, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

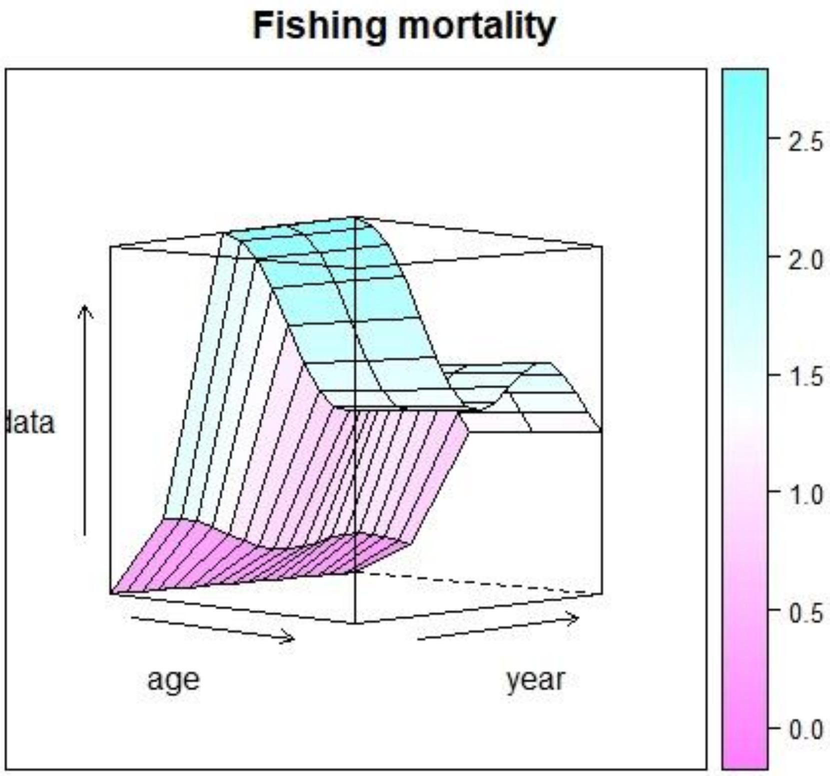


Figure 6.5.3.2 Red mullet in GSA 6. 3D contour plot of estimated fishing mortality by age and year.

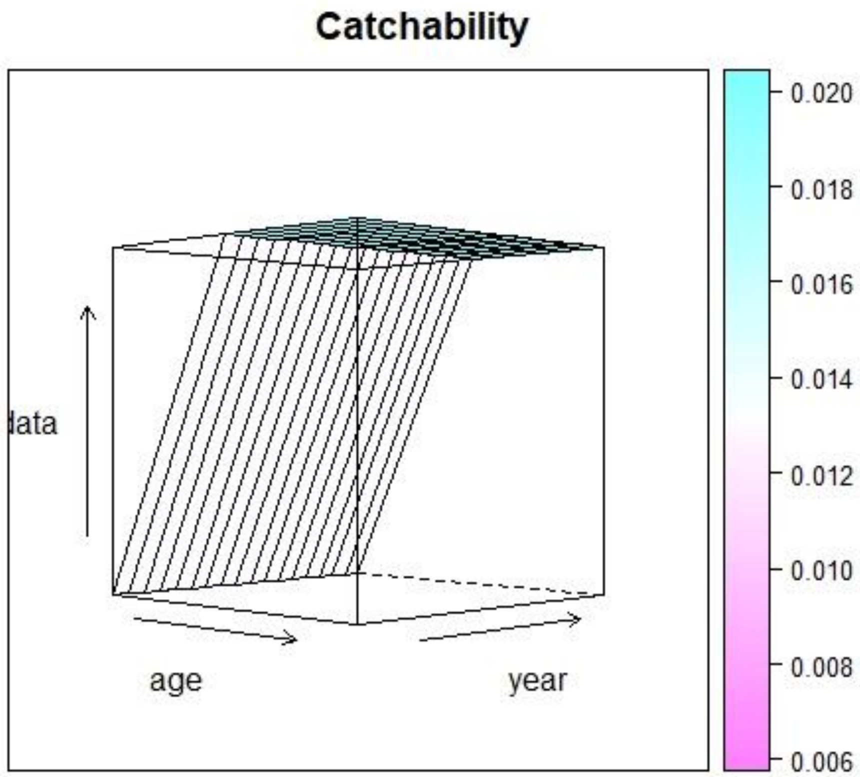


Figure 6.5.3.3 Red mullet in GSA 6. 3D contour plot of estimated catchability by age and year.

Diagnostics

Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of red mullet stock.

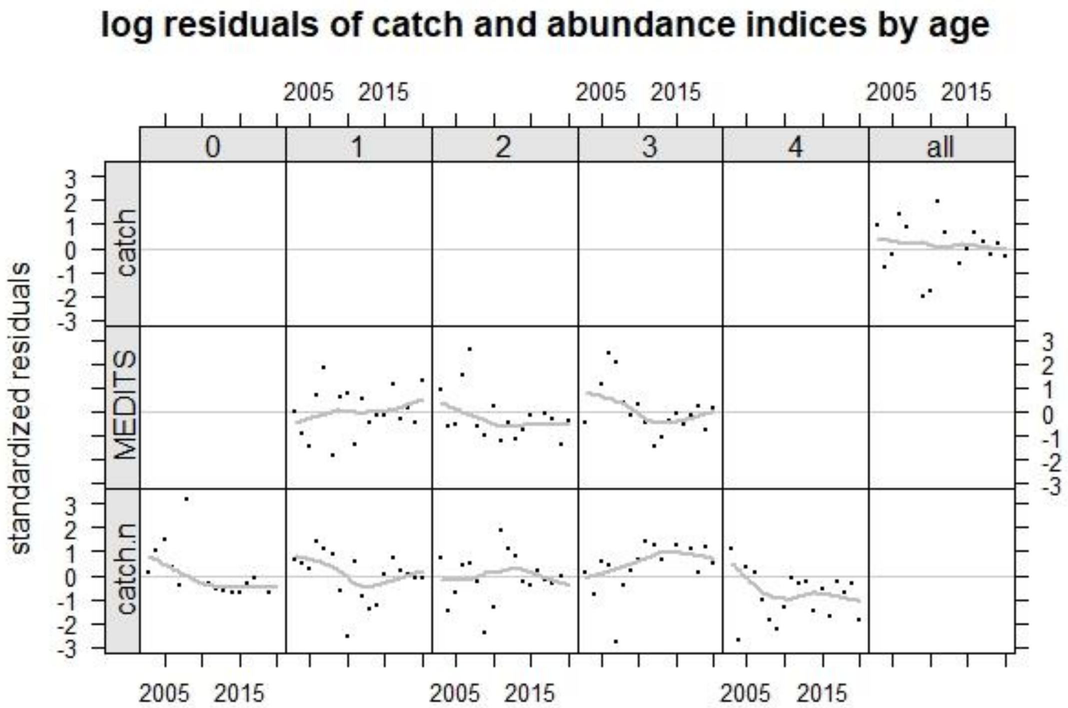


Figure 6.5.3.4
Red mullet in GSA 6. Standardized residuals for catch, abundance indices and for catch numbers.

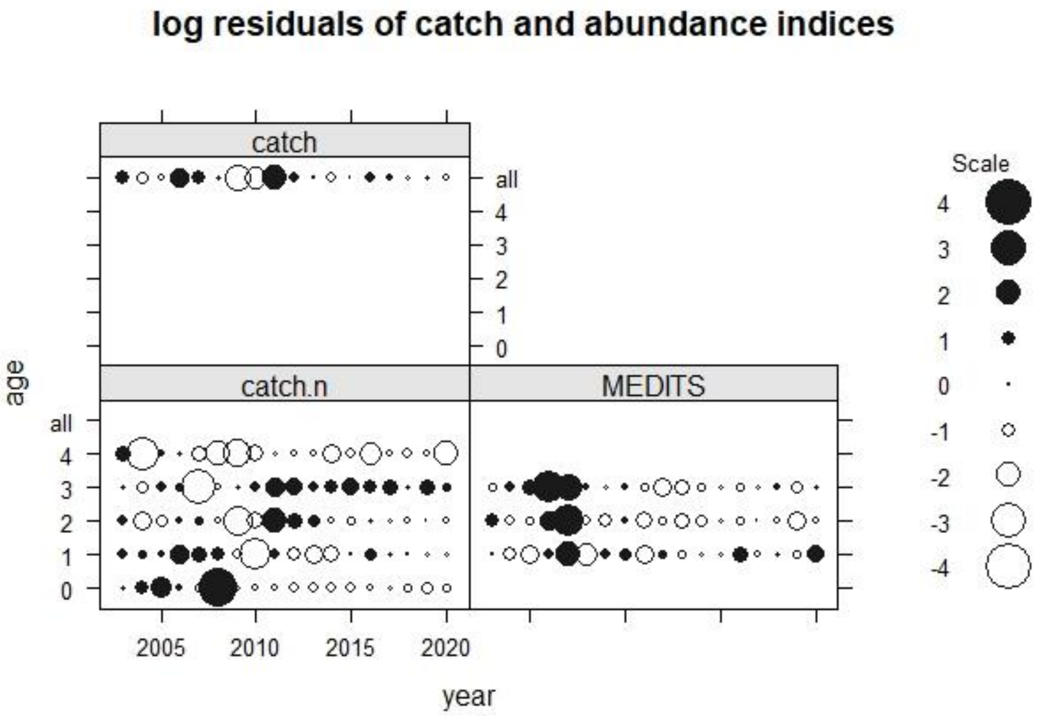


Figure 6.5.3.5 Red mullet in GSA 6. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

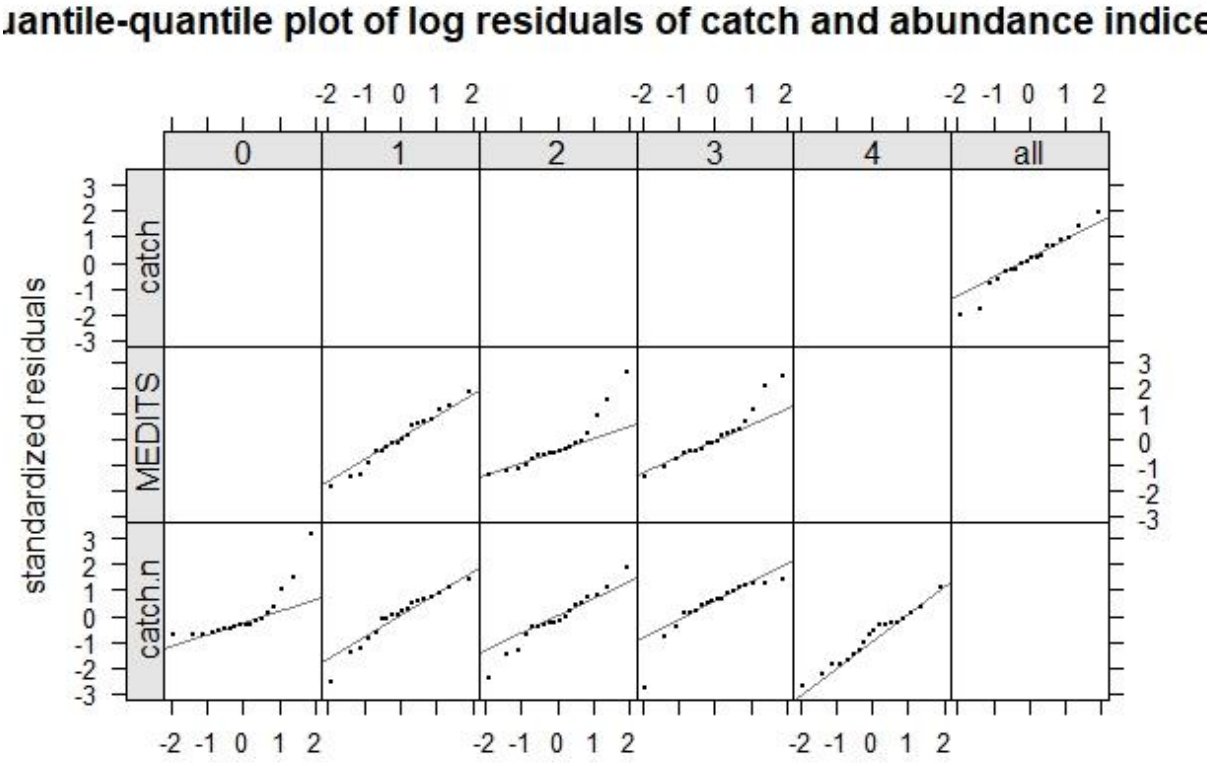


Figure 6.5.3.6 Red mullet in GSA 6. QQ-plot of the log residuals of catch and abundance indices in GSA 6.

Table 6.5.3.2 Red mullet in GSA 6. Catches log residuals.

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0.1168	0.9991	1.5242	0.3279	-0.4529	3.1867	-0.1926	-0.3721	-0.3471
1	0.6239	0.5128	0.2597	1.4375	1.1191	0.8978	-0.6333	-2.5324	0.5769
2	0.7025	-1.4489	-0.7450	0.3891	0.4974	-0.2848	-2.4162	-1.3479	1.8665
3	0.1334	-0.8293	0.5627	0.4256	-2.8107	-0.3930	0.1578	0.6693	1.3906
4	1.1365	-2.6926	0.3676	0.1245	-1.0502	-1.8549	-2.2381	-1.3505	-0.1236
	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	-0.575	-0.662	-0.685	-0.710	-0.326	-0.095	-0.492	-0.738	-0.507
1	-0.913	-1.418	-1.258	0.030	0.729	0.195	0.032	-0.112	-0.134
2	1.142	0.790	-0.269	-0.439	0.194	-0.191	-0.333	-0.034	-0.389
3	1.261	0.674	0.981	1.248	0.901	1.125	0.134	1.177	0.536
4	-0.341	-0.257	-1.504	-0.571	-1.723	-0.248	-0.705	-0.371	-1.840

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	0.028	-0.905	-1.459	0.681	1.857	-1.801	0.638	0.767	-1.408
2	0.946	-0.639	-0.524	1.497	2.596	-0.572	-0.951	0.250	-1.198
3	-0.435	0.659	1.137	2.475	2.099	0.363	-0.145	0.333	-0.472
	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.509	-0.477	-0.162	-0.118	1.141	-0.328	0.193	-0.471	1.314
2	-0.425	-1.127	-0.777	-0.169	-0.546	-0.065	-0.331	-1.368	-0.377
3	-1.432	-1.065	-0.409	-0.104	-0.494	-0.175	0.260	-0.751	0.148

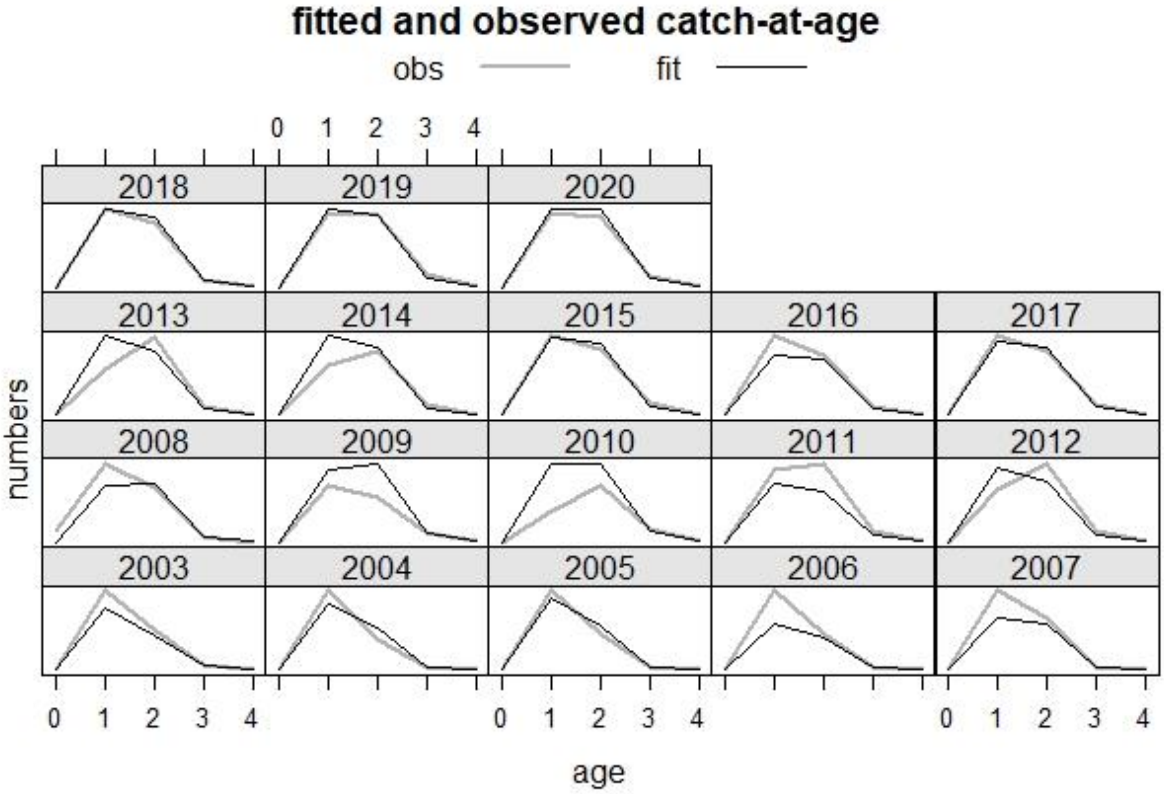


Figure 6.5.3.7 Red mullet in GSA 6. Fitted and observed catch at age.

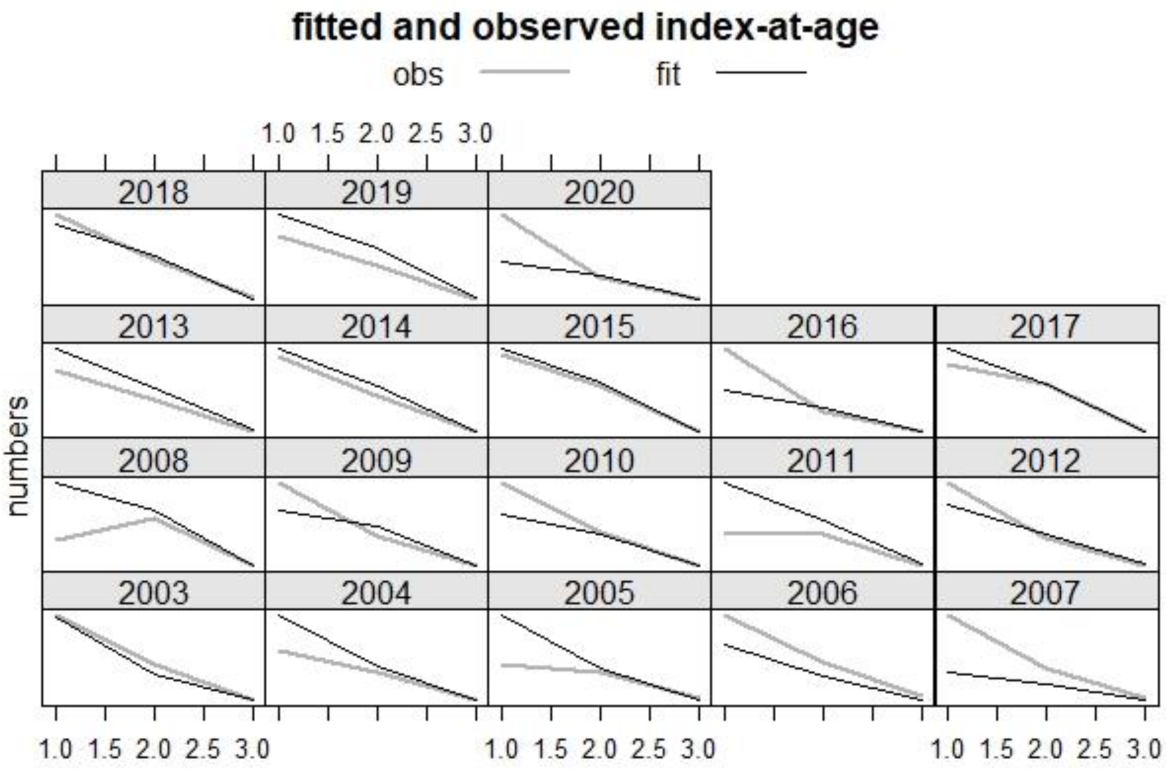


Figure 6.5.3.8 Red mullet in GSA 6. Fitted and observed index at age

RETROSPECTIVE

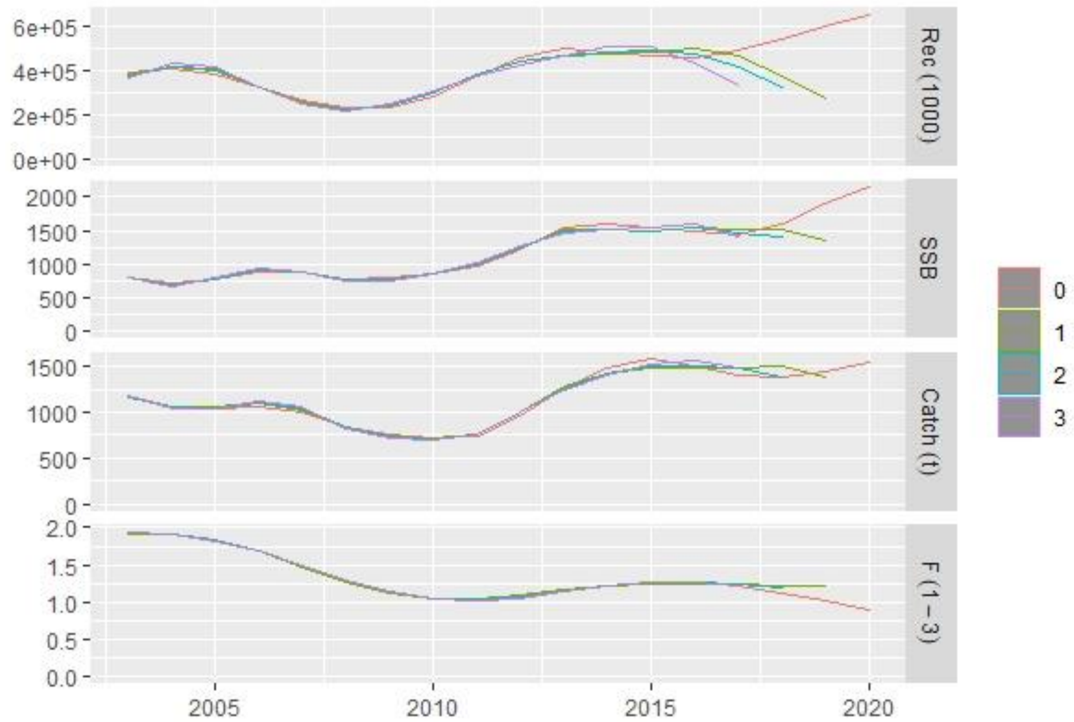


Figure 6.5.3.9 Red mullet in GSA 6. Retrospective analysis for the a4a model.

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 2020 and the results are consistent. A sensitivity test without the survey gave estimates of F and SSB that ovelap with the confidence interval for the assessment including the survey. Thus the survey is full consistent with the other data and its inclusion improves the precision of the estimate.

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	0.595	0.584	0.560	0.515	0.454	0.394	0.346	0.319	0.314
2	2.610	2.563	2.457	2.259	1.993	1.726	1.518	1.400	1.376
3	2.610	2.563	2.457	2.259	1.993	1.726	1.518	1.400	1.376
4	2.610	2.563	2.457	2.259	1.993	1.726	1.518	1.400	1.376
	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.326	0.350	0.376	0.393	0.392	0.375	0.345	0.310	0.276
2	1.430	1.536	1.649	1.722	1.721	1.643	1.513	1.360	1.211
3	1.430	1.536	1.649	1.722	1.721	1.643	1.513	1.360	1.211
4	1.430	1.536	1.649	1.722	1.721	1.643	1.513	1.360	1.211

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	391427	406613	387767	329526	266372	231525	237537	287118	372012
1	72307	68786	71454	68143	57909	46811	40688	41745	50459
2	16299	17998	17306	18418	18376	16592	14255	12991	13692
3	1614	675	781	835	1084	1411	1664	1760	1804
4	70	77	36	43	57	97	167	250	309
	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	457679	498568	488918	465505	462765	491505	542984	600178	654577
1	65378	80433	87618	85922	81807	81326	86377	95425	105476
2	16643	21296	25579	27155	26191	24942	25237	27614	31585
3	1949	2243	2583	2771	2735	2641	2717	3132	3992
4	333	341	347	351	348	344	360	422	568

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	391427	801	1170.4	1.938
2004	406613	711	1066.0	1.904
2005	387767	774	1047.6	1.825
2006	329526	877	1063.0	1.678
2007	266372	882	1003.0	1.480
2008	231525	790	837.8	1.282
2009	237537	800	765.2	1.127
2010	287118	861	718.7	1.040
2011	372012	963	743.2	1.022
2012	457679	1225	960.0	1.062
2013	498568	1532	1255.1	1.141
2014	488918	1595	1480.0	1.225
2015	465505	1535	1573.4	1.278
2016	462765	1499	1496.6	1.278
2017	491505	1429	1398.9	1.220
2018	542984	1588	1383.8	1.123
2019	600178	1891	1445.8	1.010
2020	654577	2146	1539.0	0.899

6.5.4 Reference Points

The time series is too short to give stock recruitment rationship, so reference points are based on equilibrium methods. 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 0.317. Current F values (2020), as calculated by model a4a, is 0.899 indicating that the stock is being overfished.

6.5.5 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 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} =0.899 terminal F (2020) from the a4a assessment was used for F in 2021 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 2021 to 2022 has been estimated from the population results as the geometric mean of the whole series (403443.5).

EWG advises that when the MSY approach is applied, catches in 2022 should be no more than 842.1 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 (2021)	0.899	Fsq = F in the last year
SSB (2021)	2459.1	SSB intermediate year from STF output
Rage0 (2021,2022)	403443.5	Recruitment will be set as geometric mean of the last 18 years
Total Catch (2021)	1809.7	Catch intermediate year from STF output

The short term forecast was carried out estimating a catch for 2021-2022 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 1809.7 and 2459.1 tons, respectively.

Table 6.5.5.2 Red mullet GSA 6. Short term forecast in different F scenarios.

Rational	Ffactor	Fbar	Catch 2021	Catch 2022	SSB 2021	SSB 2023	SSB_change_ 2021-2023(%)	Catch_change_ 2020-2022(%)
High long term yield ($F_{0.1}$)	0.4	0.317	1809.7	842.1	2459.1	3060.8	24.5	-45.3
F upper	0.5	0.435	1809.7	1089.6	2459.1	2688.4	9.3	-29.2
F lower	0.2	0.212	1809.7	595.6	2459.1	3457.7	40.6	-61.3
F_{MSY} transition	0.7	0.664	1809.7	1487.4	2459.1	2146.3	-12.7	-3.3
Zero catch	0	0.000	1809.7	0.0	2459.1	4519.3	83.8	-100.0
Status quo	1	0.899	1809.7	1812.7	2459.1	1756.8	-28.6	17.8
Different Scenarios	0.1	0.090	1809.7	269.6	2459.1	4021.1	63.5	-82.5
	0.2	0.180	1809.7	513.6	2459.1	3595.4	46.2	-66.6
	0.3	0.270	1809.7	734.5	2459.1	3230.8	31.4	-52.3
	0.4	0.360	1809.7	935.0	2459.1	2917.9	18.7	-39.2
	0.5	0.450	1809.7	1117.1	2459.1	2648.6	7.7	-27.4
	0.6	0.540	1809.7	1282.7	2459.1	2416.3	-1.7	-16.6
	0.7	0.629	1809.7	1433.7	2459.1	2215.4	-9.9	-6.8
	0.8	0.719	1809.7	1571.4	2459.1	2041.0	-17.0	2.1
	0.9	0.809	1809.7	1697.4	2459.1	1889.3	-23.2	10.3
	1.1	0.989	1809.7	1918.5	2459.1	1640.8	-33.3	24.7
	1.2	1.079	1809.7	2015.7	2459.1	1538.8	-37.4	31.0
	1.3	1.169	1809.7	2105.3	2459.1	1448.8	-41.1	36.8
	1.4	1.259	1809.7	2187.9	2459.1	1369.1	-44.3	42.2
	1.5	1.349	1809.7	2264.2	2459.1	1298.2	-47.2	47.1
	1.6	1.439	1809.7	2334.9	2459.1	1235.0	-49.8	51.7
	1.7	1.529	1809.7	2400.5	2459.1	1178.4	-52.1	56.0
	1.8	1.619	1809.7	2461.5	2459.1	1127.5	-54.1	59.9
	1.9	1.709	1809.7	2518.4	2459.1	1081.6	-56.0	63.6
	2	1.798	1809.7	2571.5	2459.1	1039.9	-57.7	67.1

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).

MUT 6- LFDs- numbers in 2020

Regarding the high SoP value in 2020, it is worth noting that the landings numbers by size (thousands) reported in 2020 in the DCF appear to be low (23309) when compared, for instance, with 2019 (34341), while the LFDs range and shape as well as landings weight (t) were similar in these two years (1501.8 t and 1446.3 t in 2019 and 2020 respectively). No measurements were available for the second quarter and in the fourth quarter numbers were around half of those the previous year 2019.

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.

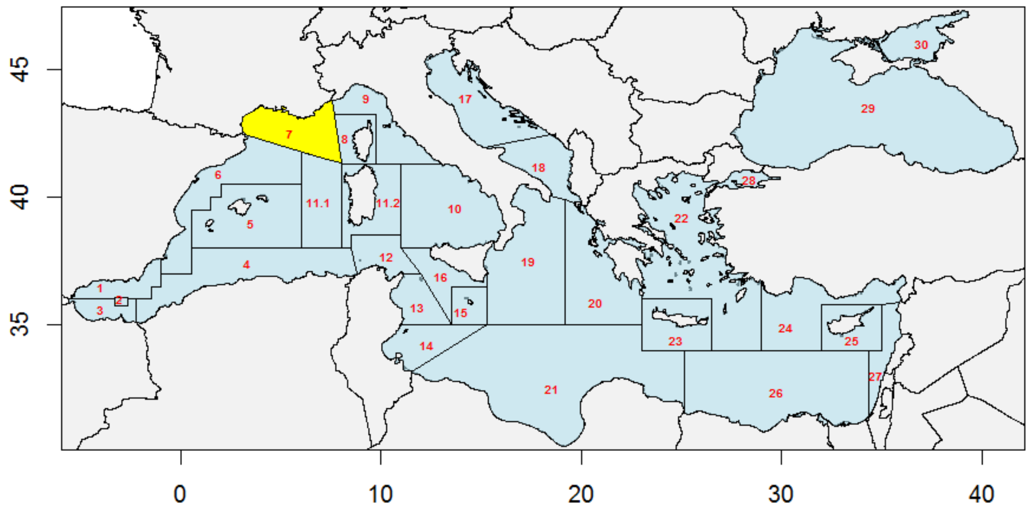


Figure 6.6.1. Localisation of GSA 7 (in Yellow) in the Mediterranean Sea.

6.6.2 Age-slicing and growth

The process of age slicing has been performed using a global Age-Length-Key obtained from age reading data since 2010 (Figure 6.6.2).

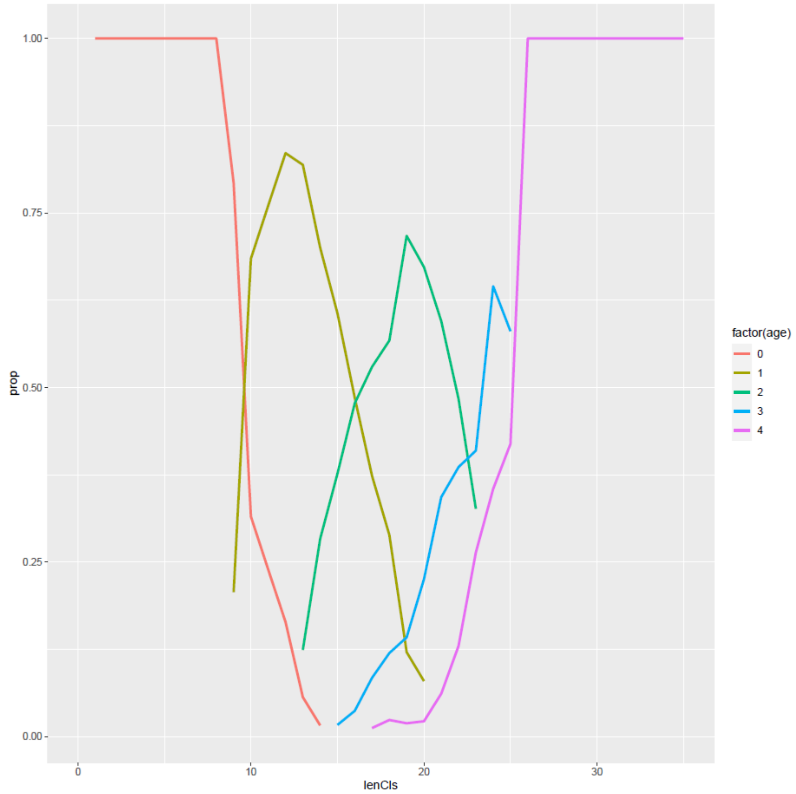


Figure 6.6.2. Age-length Key derived from age-reading data. The purple line corresponds to age 4 or more.

These data were also used to fit a Von Bertalanffy growth model that we used to correct MEDITS 2020 abundances - further details in MEDITS 2020 section. The model has estimated parameters L_{inf} = 25.65cm, k = 0.43 $years^{-1}$, and t_0 = -0.79cm and is plotted in Figure 6.6.3.

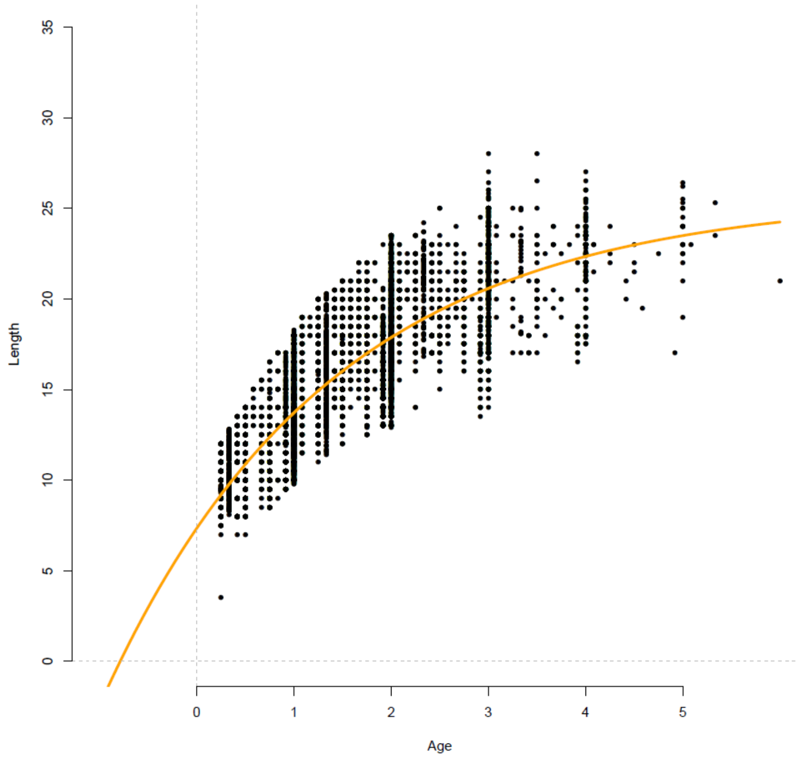


Figure 6.6.3. Fitted VB growth curve (orange) compared to age-reading data (dots).

6.6.3 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 (Figure 6.6.4) has parameters ln(a)=-4.39, and b=3.02.

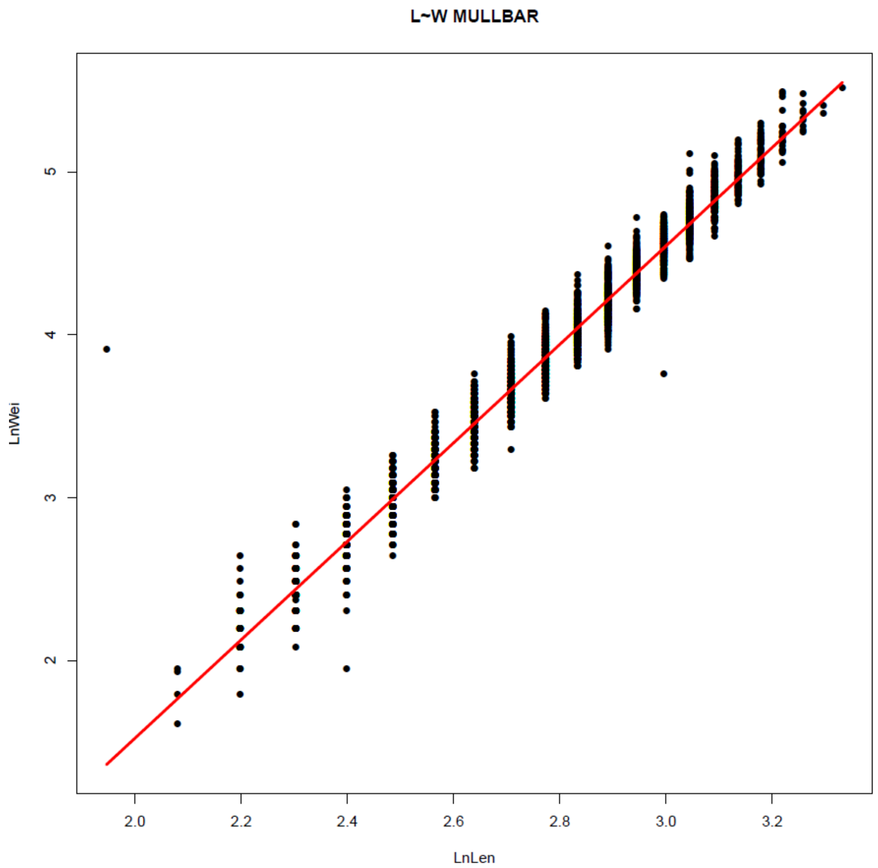


Figure 6.6.4. Length-Weight relationship obtained for Red Mullet in GSA 7 from DCF samples (2010 - 2019).

6.6.4 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 6.6.6).

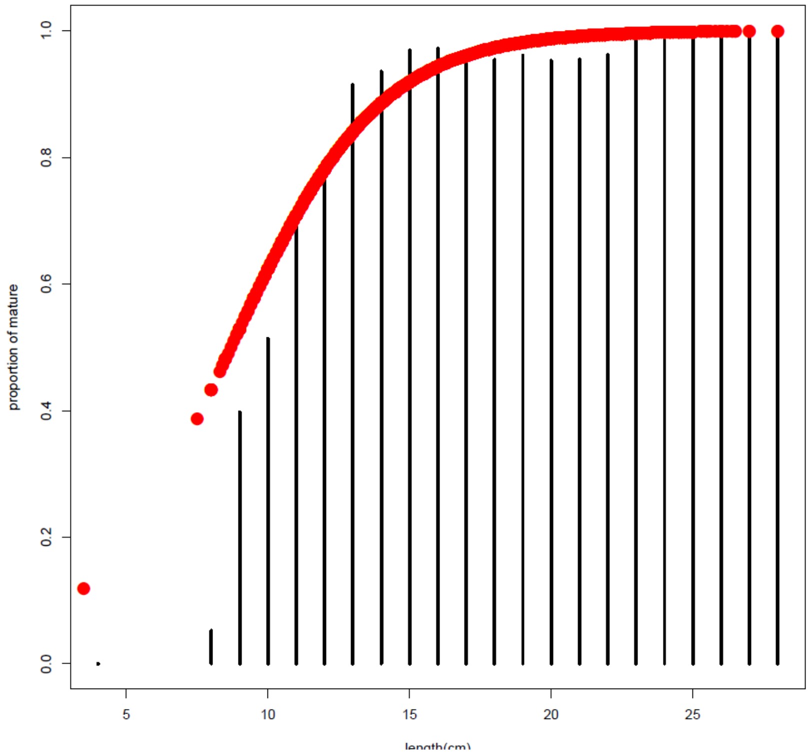


Figure 6.6.5. Proportion of mature Red Mullet per length in GSA 7. The red line corresponds to the predicted proportion following a logistic regression model.

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.

6.6.5 Data

Available catch, landing and discards data are from DCF. EWG 21-11 received French and Spanish data for GSA 7 by fishing gears. French and Spanish data are provided since 2002 to 2020 (Fig 6.6.6 & 6.6.7).

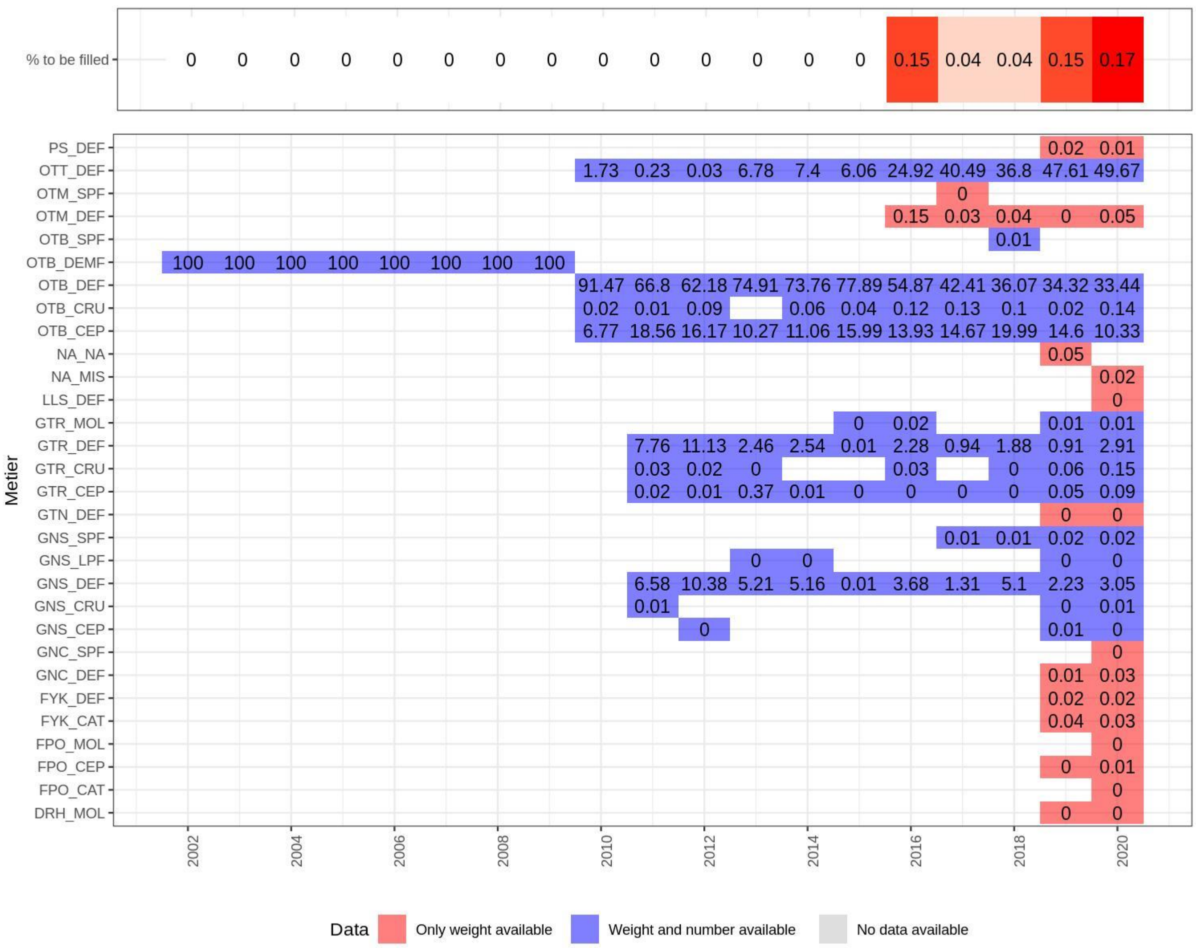


Figure 6.6.6. Summary of data provided by France on GSA 7

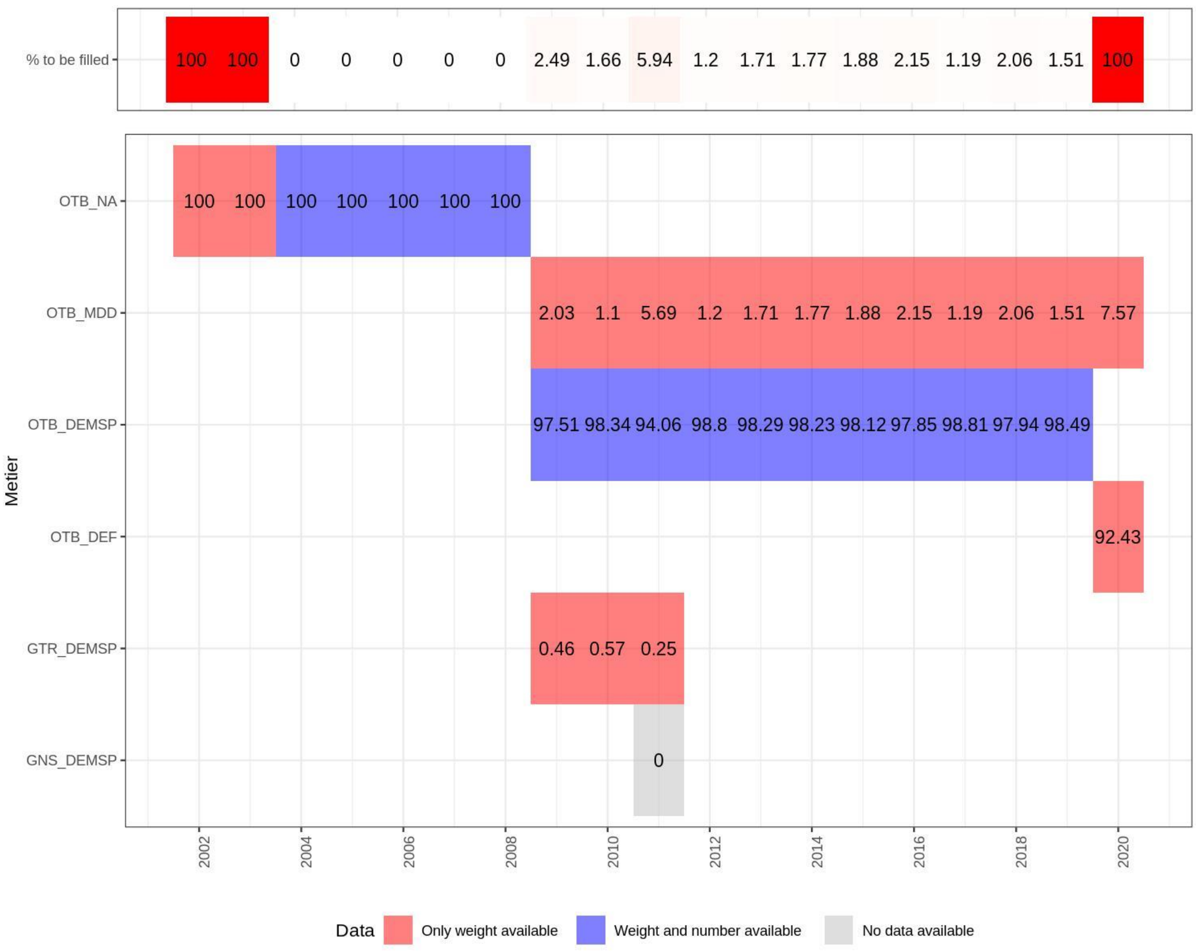
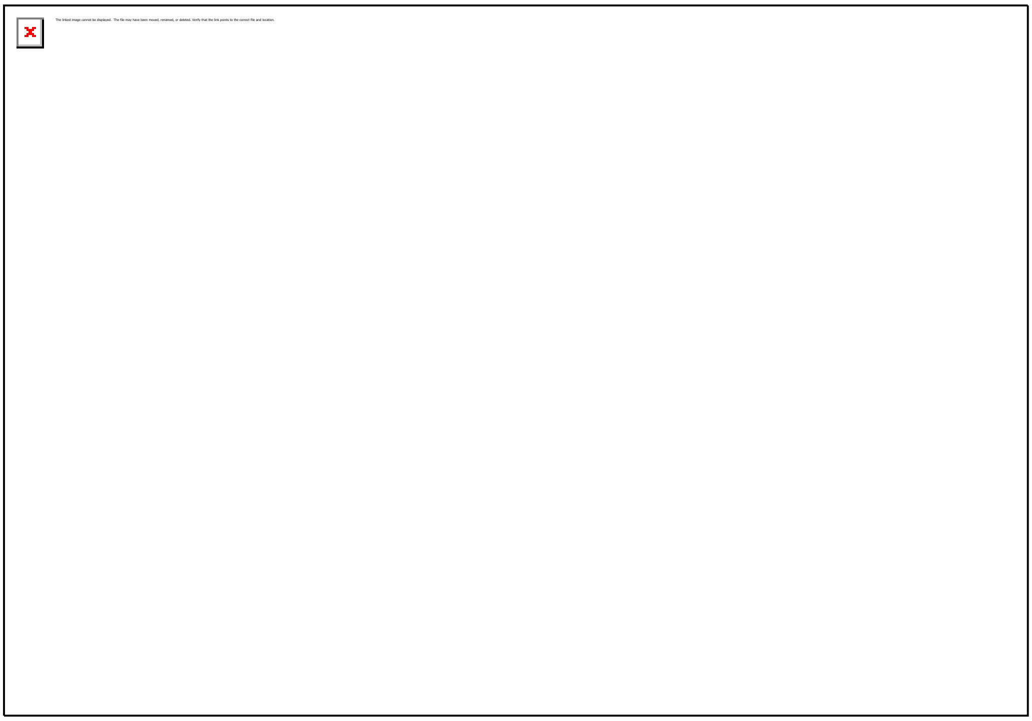


Figure 6.6.7. Summary of data provided by Spain on GSA 7

6.6.5.1 Catch, landings and discards at length

Total catch by year is reported in Table 6.6.1 (in terms of landings and discards). The OTB fleet is usually responsible for ~90% of the catch, most of which results from trawlers (>95%, Figure 6.6.8 & Table 6.6.2). Trawlers exploit smaller size classes than nets (T: [7cm – 25cm]; G: [12cm – 30 cm], Figure 6.6.9).

Table 6.6.1. Landings per country, discards and catch per year, in tons.



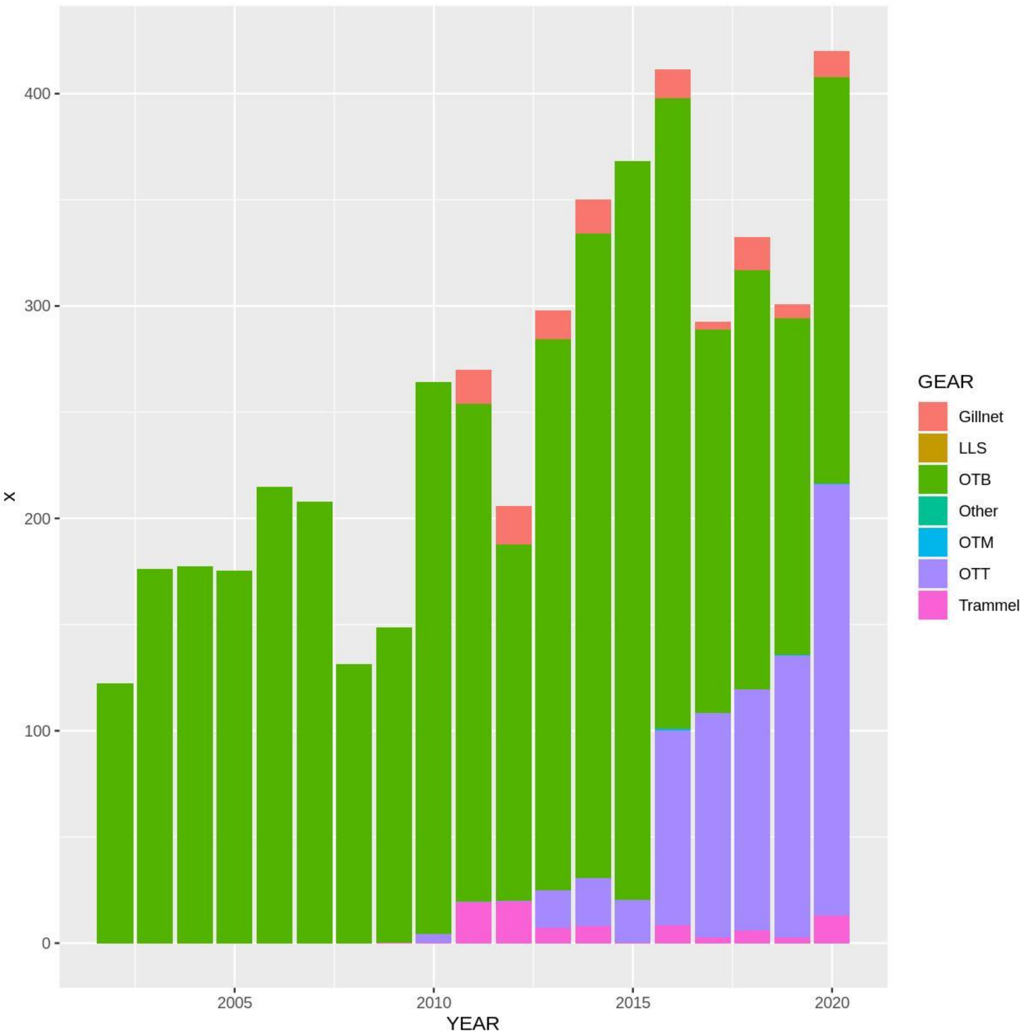
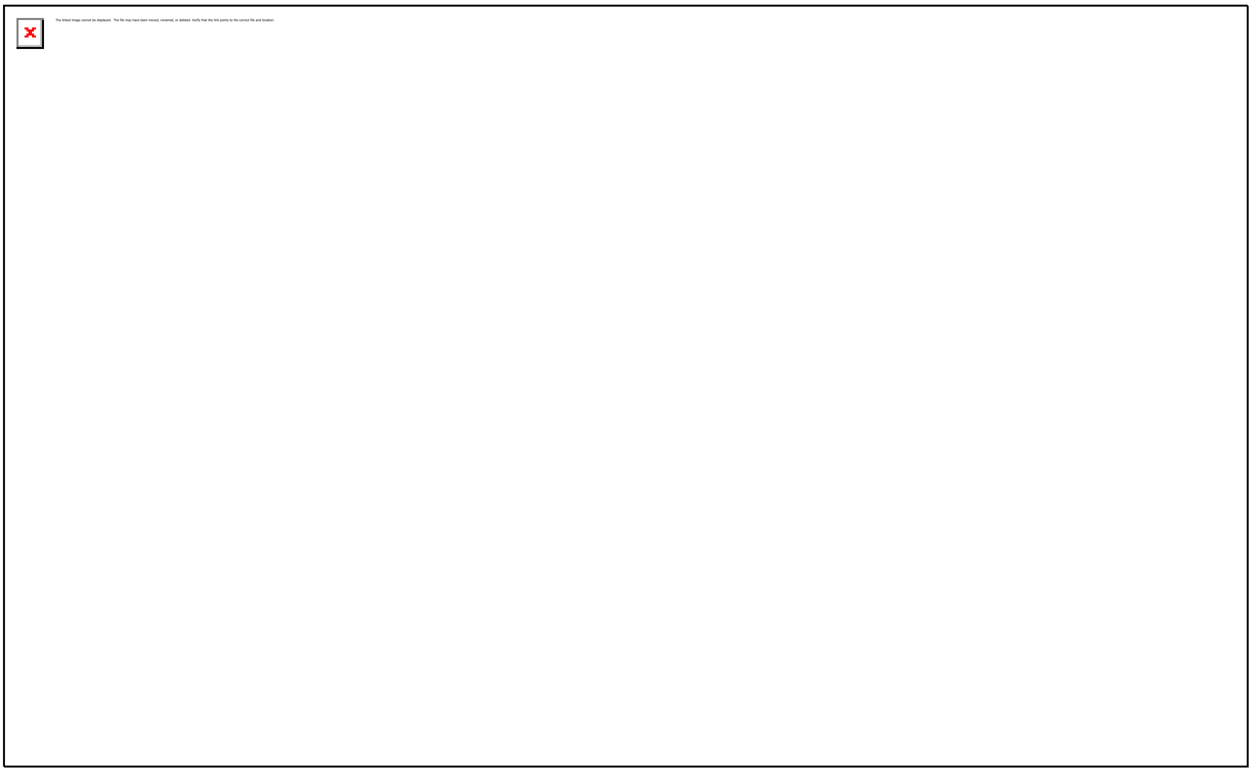


Figure 6.6.8. Red Mullet Landings per year and gear in GSA 7 (French and Spanish fleet combined).

Figure 6.6.9. Size-Class distribution of Red Mullet landings per year, for gillnets & trammel nets (left) and trawlers (right). The thick black line corresponds to the most recent year (2019).

Table 6.6.2. Red Mullet Landings per Year, Gear and country



Landings in recent years vary around 300 tons with a maximum in 2016 and the minimum in 2002 (Table 6.6.2). The majority of the landings of red mullet come from trawlers, and the other part is mainly set nets. Landings of gears other than OTB, GNS and GTR are on average less than 1%. Since 2014, the French Trawl fleet are separated by OTB, OTM and OTT trawlers. The majority of landings were initially due to OTB, but OTT displayed an increasing importance over the last years and became on par with OTB in 2020 (Figure 6.6.8).

Discards were regularly reported since 2010 (Table 6.6.1). They are mostly composed of small individuals (Fig.9) and account for [1-5]% of the landed biomass, depending on year. In 2019 and 2020, discards of small individuals have been particularly important (Figure 6.6.10).

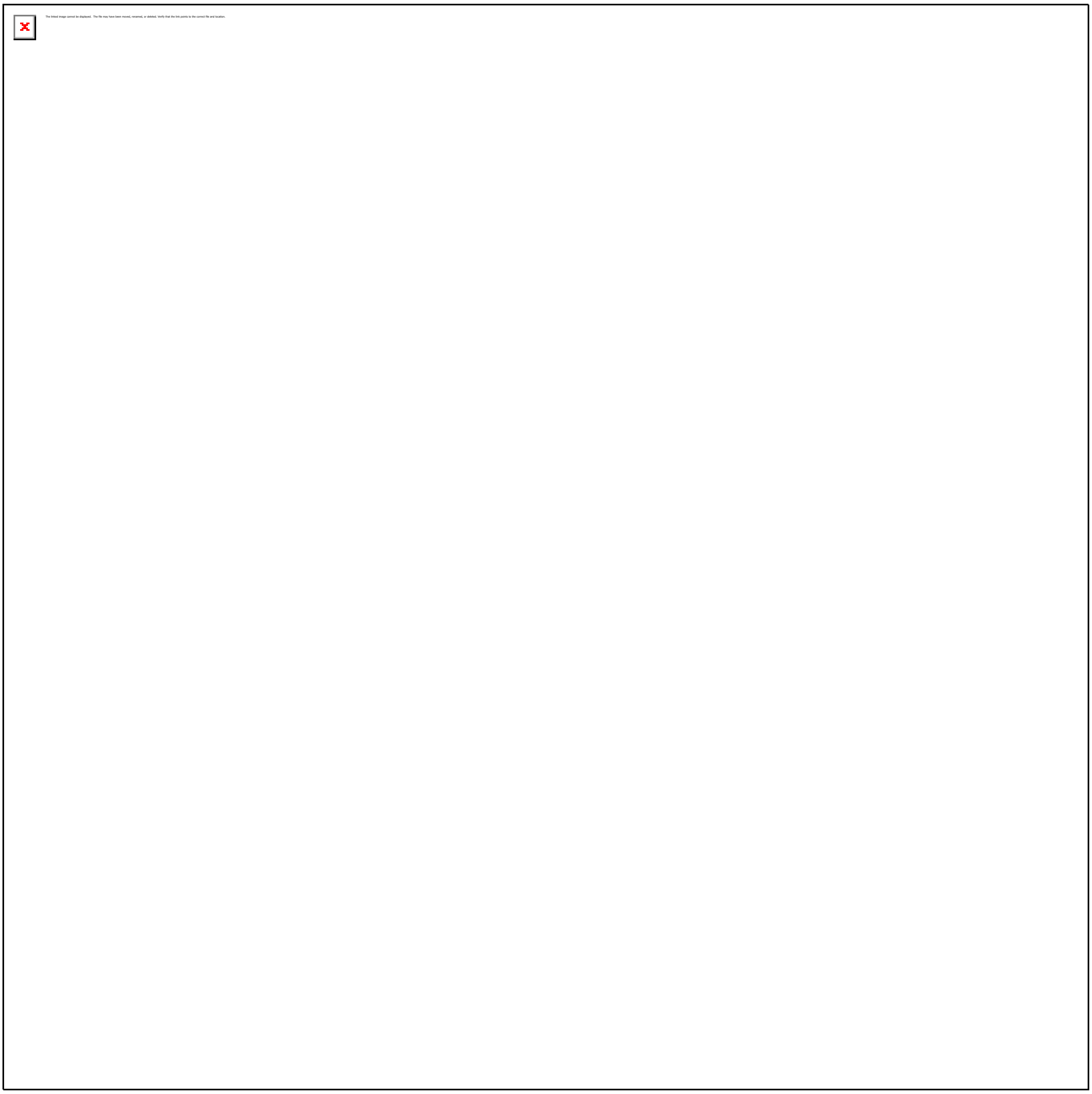


Figure 6.6.10. Size-Class distribution of Red Mullet discards per year

6.6.5.2 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 6.6.2) and the length-weight relationship (Figure 6.6.6). The resulting numbers and average weight at age are summarized below (Tables 6.6.3 – 6.6.6), and the resulting catch at age is displayed in Figure 6.6.11.

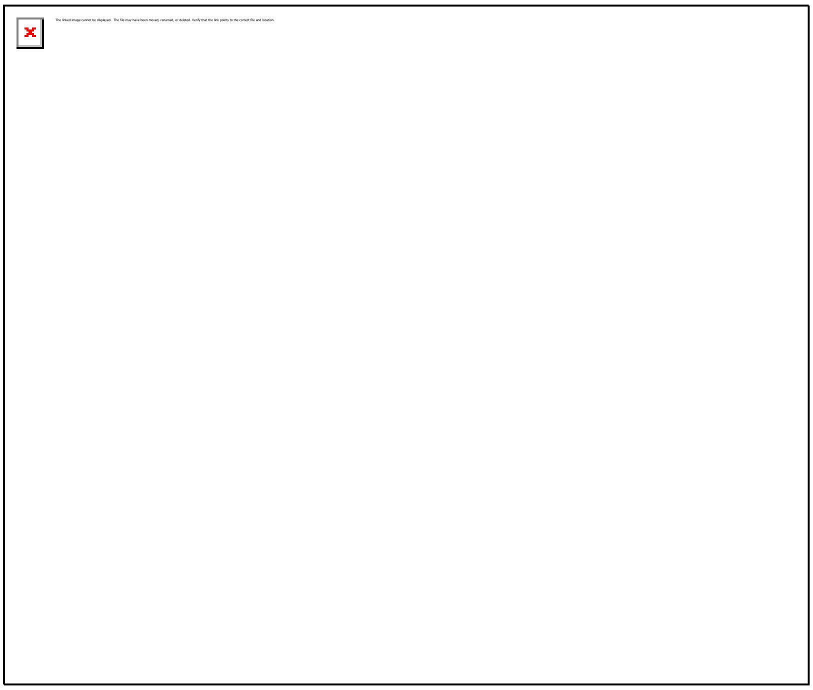


Table 6.6.3. Landings at age (Thousands of individuals)

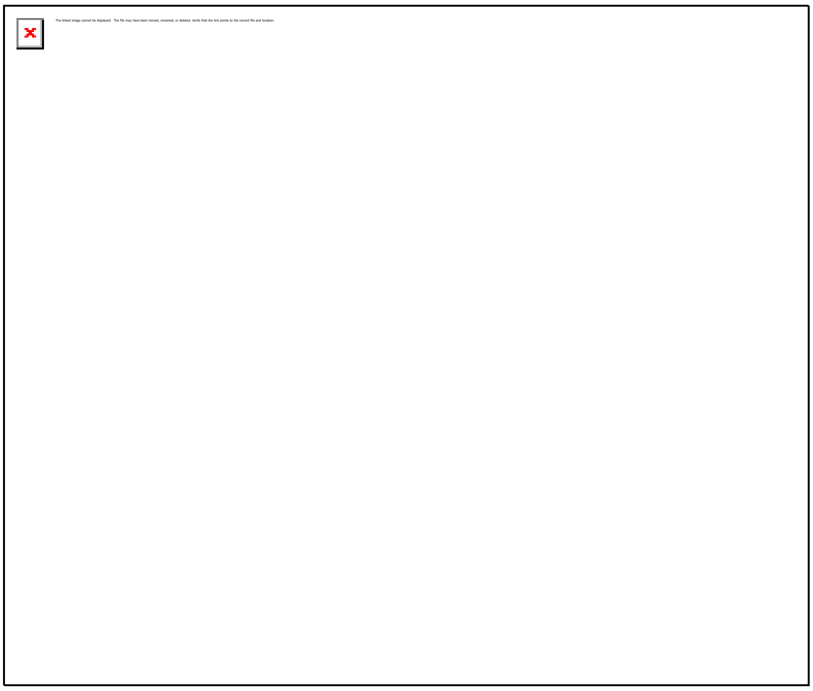


Table 6.6.4. Average weight of landings at age (Kg)

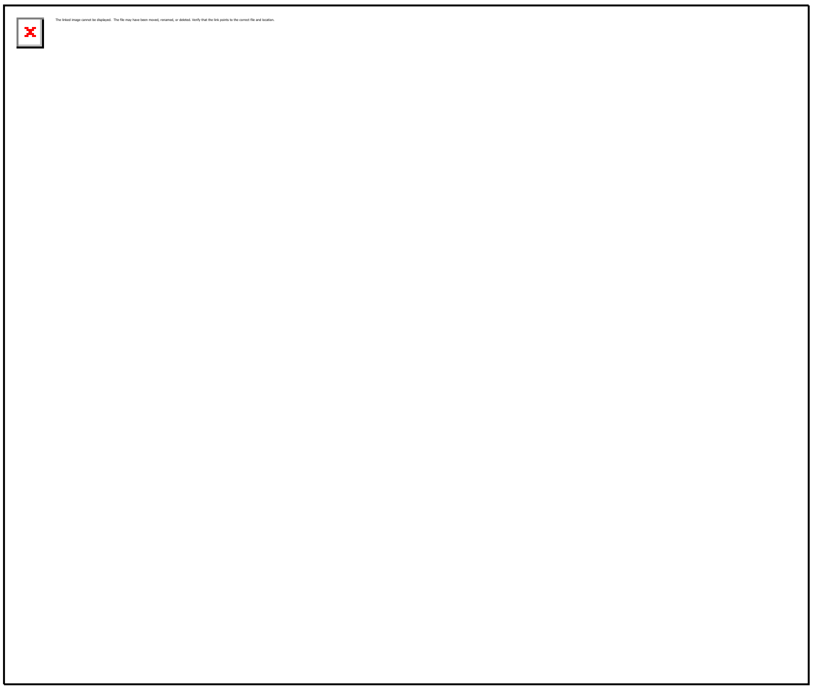


Table 6.6.5. Discards at age (Thousands of individuals)

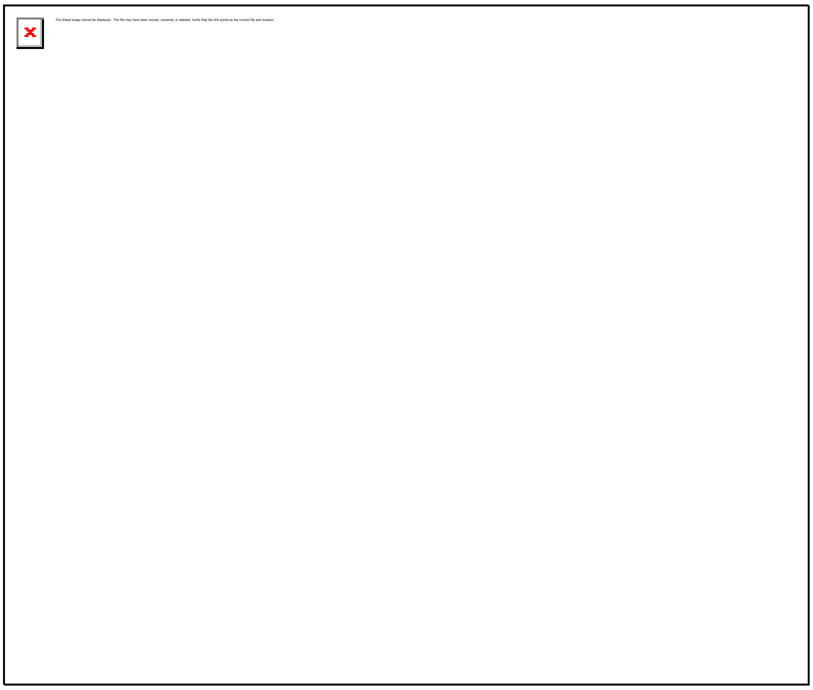


Table 6.6.6. Average weight of discards at age (Kg)

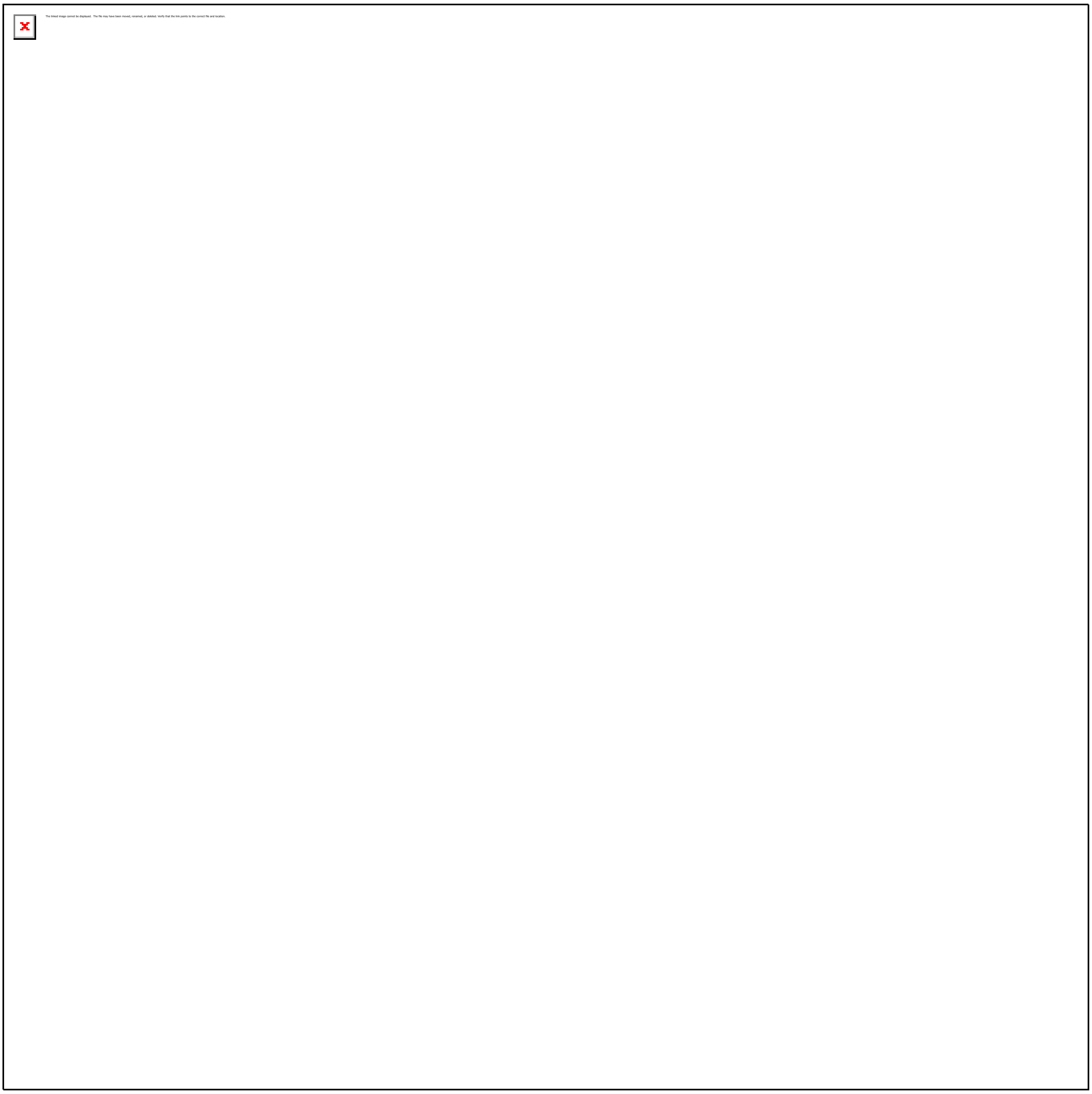


Figure 6.6.11. Catch at age of Red Mulled in GSA 7. Y-axis is standardised.

6.6.5.3 Effort

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

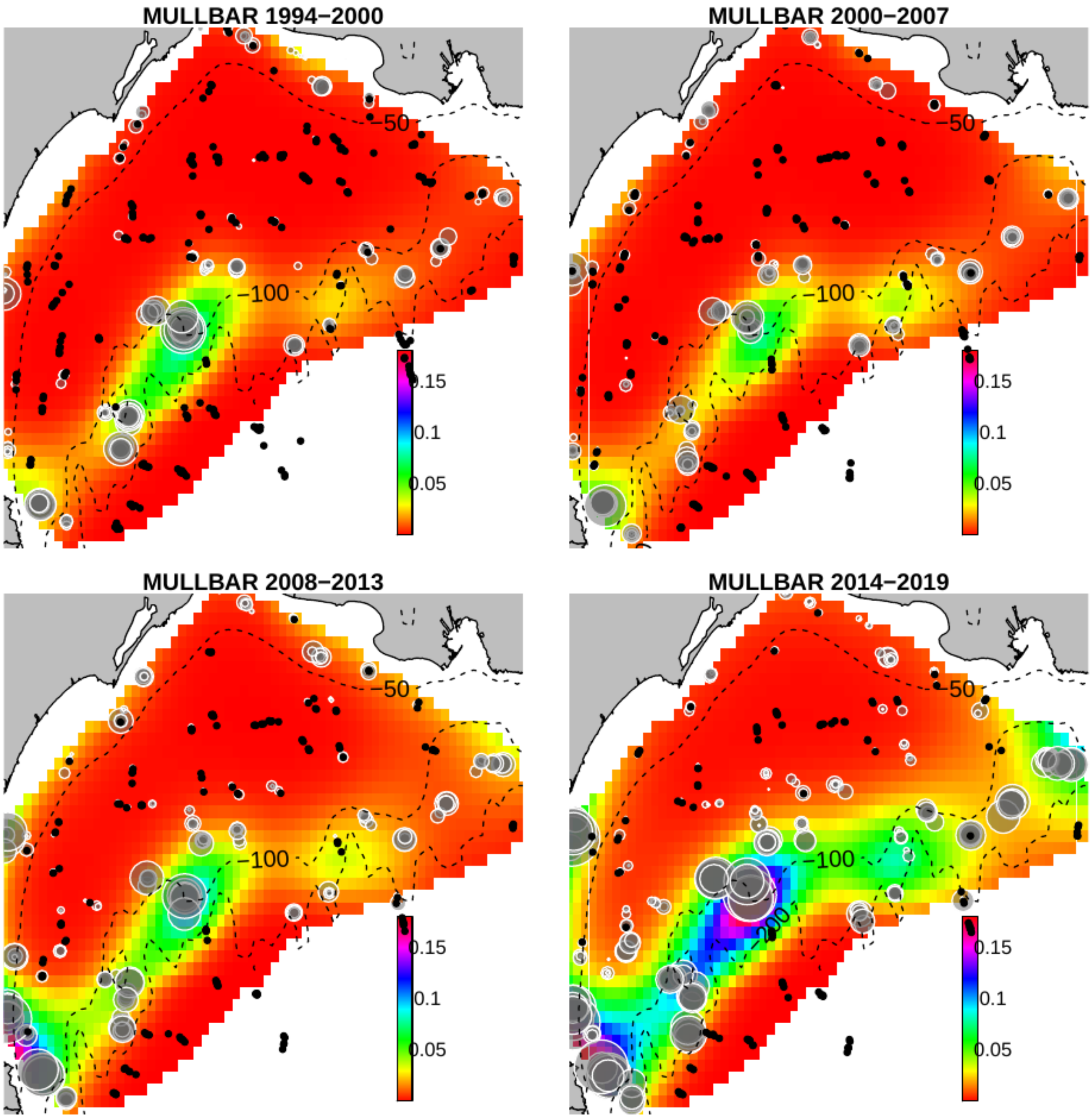
6.6.2.3 Survey data

6.6.2.3.1 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. Abundances at trawl were standardized to square kilometre, using the swept area method, then MEDITS abundances (numbers of fish at length over the GSA 7 area) were computed.

Figure 6.6.12. Colours: Biomasses of Red Mullet from MEDITS survey in t/km^2 (ordinary kriging). Circles correspond to data points. Black dots locate trawls without red

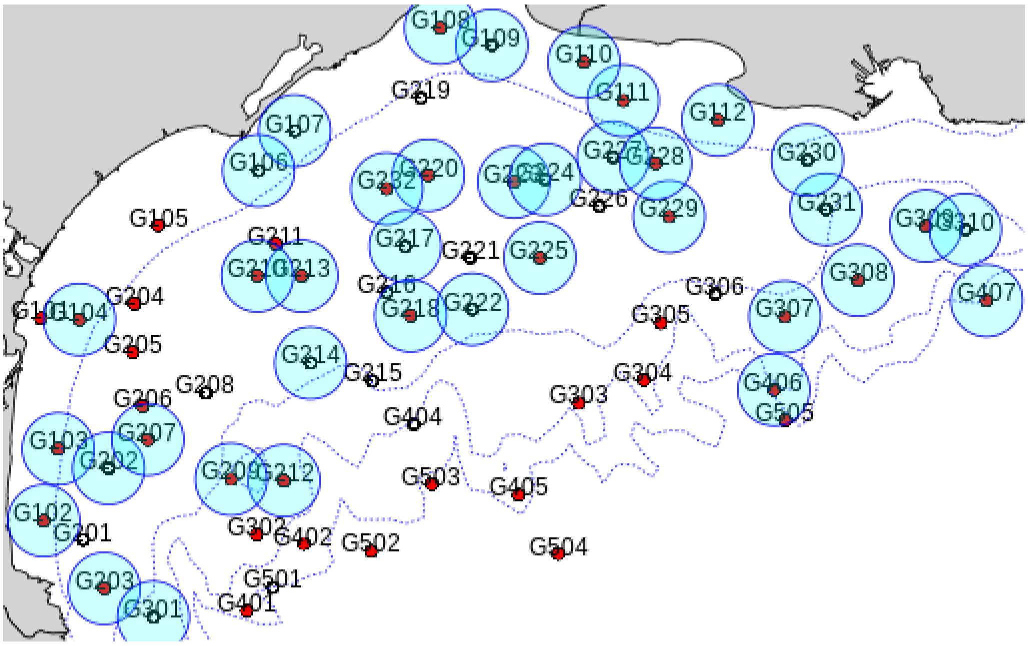


mullet.

Figure 6.6.12 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 increased numbers since 1994.

6.6.5.4 MEDITS 2020

In 2020, the COVID situation led to a 4 month delay with MEDITS delayed to October and with a restricted sampling scheme. Only 42 stations were planned out of 65 in the Gulf of Lion, and no survey was carried out in Corsica (GSA 8). The 42 trawls were selected so as to minimize bias regarding abundance estimates. However, the survey was plagued with bad weather, restricting our prospection range to mostly coastal and



inner shelf area (Figure 6.6.13)

Figure 6.6.13. MEDITS under COVID in 2020. Black dots: original sampling scheme. Red dots: restricted planned sampling scheme. Blue circles: realized stations. In 2020, MEDITS was restricted to 42 stations and 3 weeks instead of 6, and bad weather conditions constrained the activity to the inner shelf.

The resulting MEDITS abundance in 2020 are therefore biased in at least three ways: fishes are 4 month older than usual; recruits were present in the catch while usually not available to the survey in June; and the spatial sampling scheme was not representative in the same way as the previous survey of the study area. Indeed, the observed length frequency distribution of MEDITS 2020 is quite an outlier when compared to other years (Figure 6.6.14)

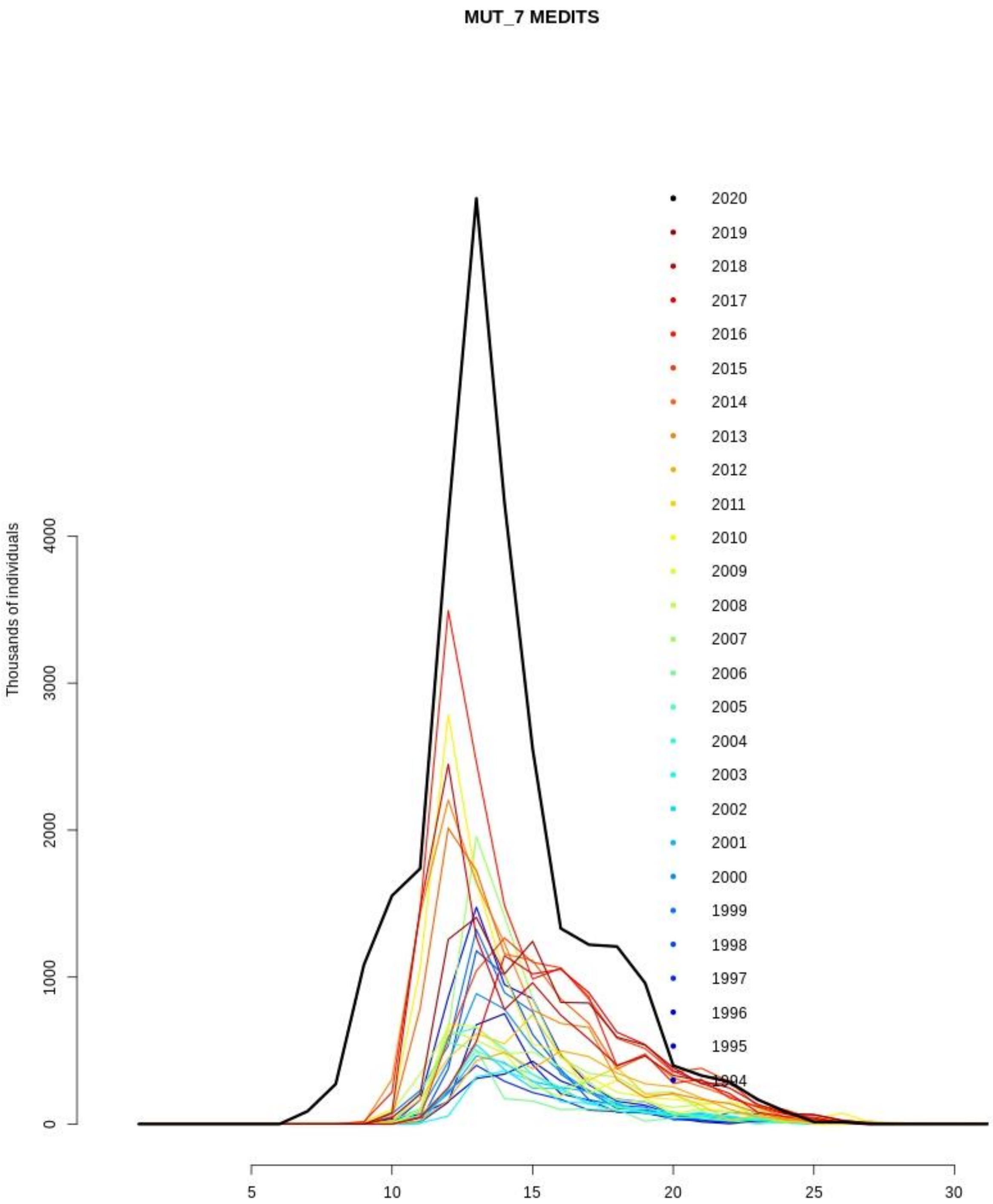


Fig 14. Length distribution of MEDITS abundance index over the years. The black thick line corresponds to 2020.

Therefore, MEDITS 2020 data for red mullet in GSA 7 can't be used "as is" for the stock assessment, as it would lead to a massive overestimate of the recruitment this year. To correct MEDITS 2020 data, we implemented a three step procedure:

(1) Reduce the size of the fishes according to the VB growth curve, so that they undergo a size reduction of 4 month growth, from their observed size. Such process is shown in Figure 6.6.15.

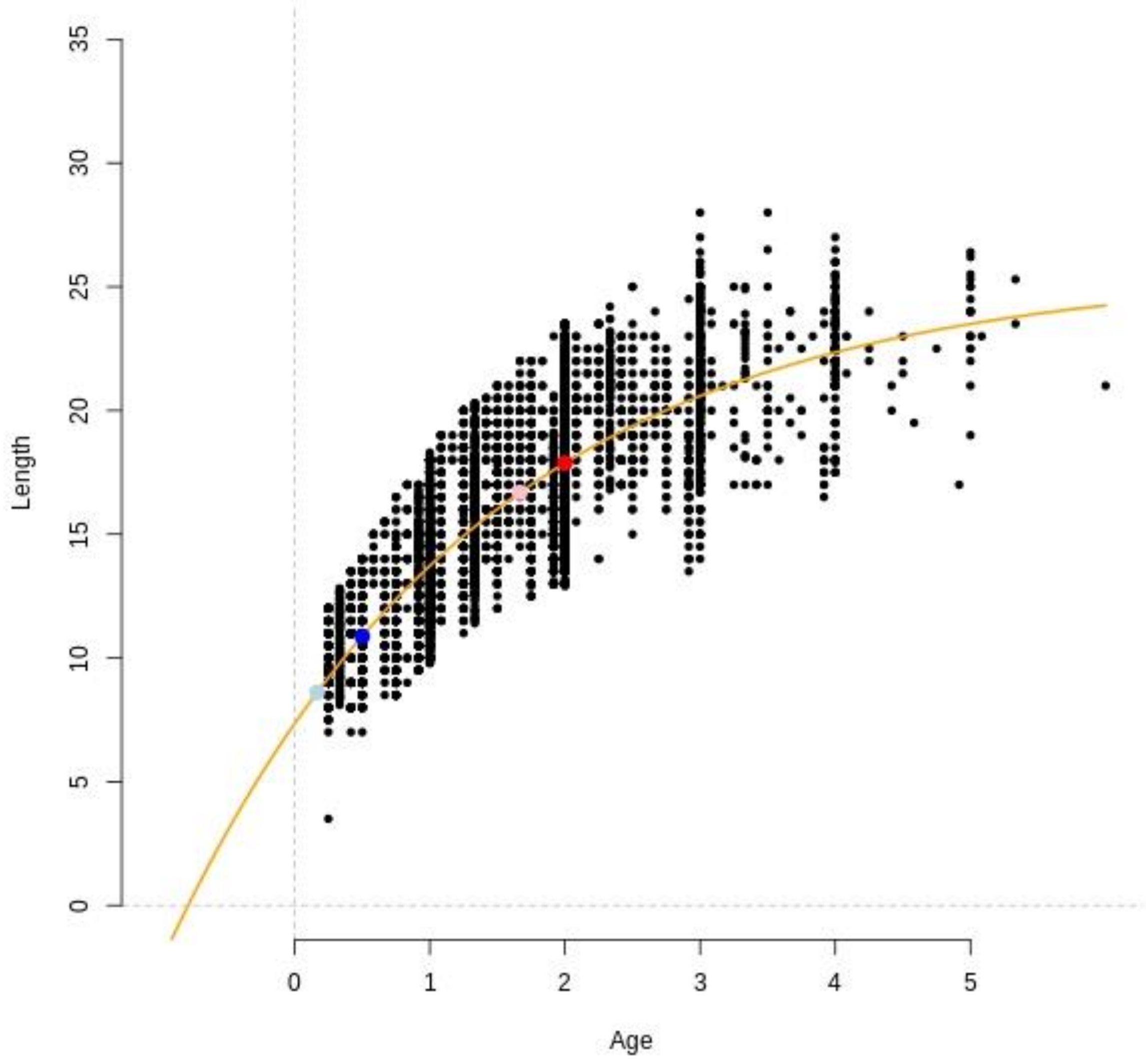


Figure 6.6.15. Fitted VB growth curve (orange) compared to age-reading data (dots). According to this curve, a 2 year fish (red dot) would incur a size reduction of 0.5 cm (pink dot), while a one year fish (dark blue dot) would incur a size reduction of 1 cm (light blue dot).

This size reduction process led to a slightly different size distribution (Figure 6.6.16, dashed black line). From this, it is quite obvious that a large range of the fish caught in October would never have been caught in June simply because they would have been too small. To correct for this selectivity issue, we tracked the selectivity pattern in MEDITS in the previous years, by computing the ratio between abundance at length x / abundance at length x+1 (Figure 6.6.17). These showed that abundance at length 10 or less is usually a small proportion of abundance at length 11 (average 0.12), the same is true for abundance at length 11 (average 0.26), but the pattern stops at length 12 where abundance can be anywhere between 0.2 and 2 times the abundance at length 13, which is also true for subsequent length classes. We interpret this pattern as a selectivity signature of the MEDITS trawl, and we therefore corrected MEDITS reduced size abundances at 11cm and 10cm in the following way: abundance at 11cm = 0.26* abundance at 12cm, and abundance at 10cm = 0.12 * abundance at 11cm, which led to the purple dashed line in Figure 6.6.16. Lastly, the problem of the biased sampling scheme (Figure 6.6.13) has been tackled by looking at abundance estimates obtained with all samples and with the 2020 subset. It appeared that abundance estimates based on the 2020 sampling scheme systematically over-estimated red mullet abundances in a size-dependent way. By regressing abundance at size based on all samples against abundance at size based on 2020 subsets, slopes were systematically <1. Hence, we used these regression coefficients to correct abundance at size for 2020 to account for the modified sampling scheme. The resulting size distribution led to the green dashed line in Figure 6.6.16, which is now considered to be in line with abundance at size observed during the previous years. These final corrected abundances were used to fit the stock assessment model.

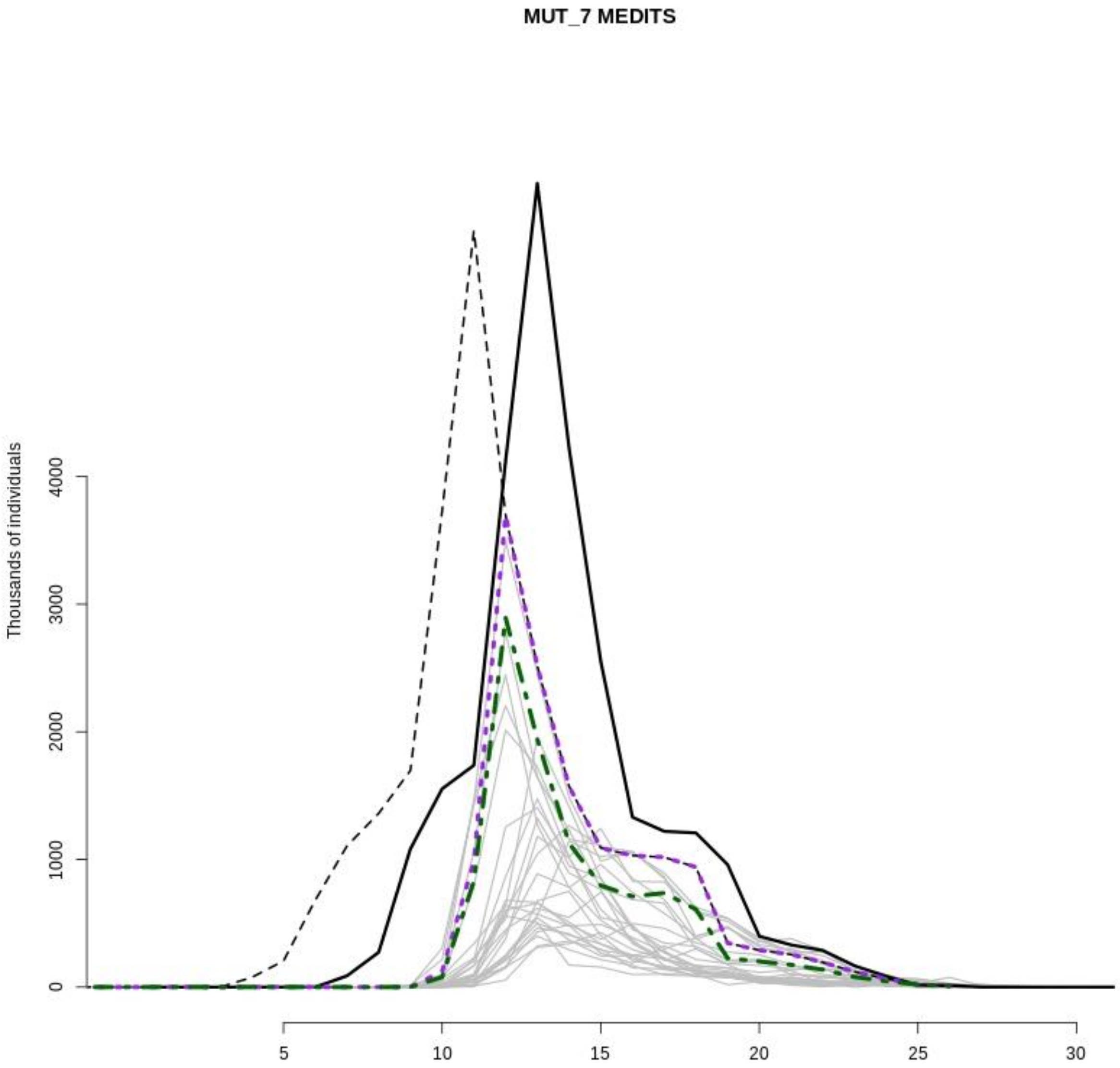


Fig 6.6.16. Thick black line: observed abundance (y-axis) at size (x-axis) during MEDITS 2020 (October). Dashed black line: abundance at size when fishes have been rejuvenated of 4 month. Purple dashed line: abundance at size when accounting for the selectivity of the MEDITS trawl. Green dashed line: abundance at size when accounting for biased sampling scheme in 2020. Grey lines: abundance at size observed during the previous years.

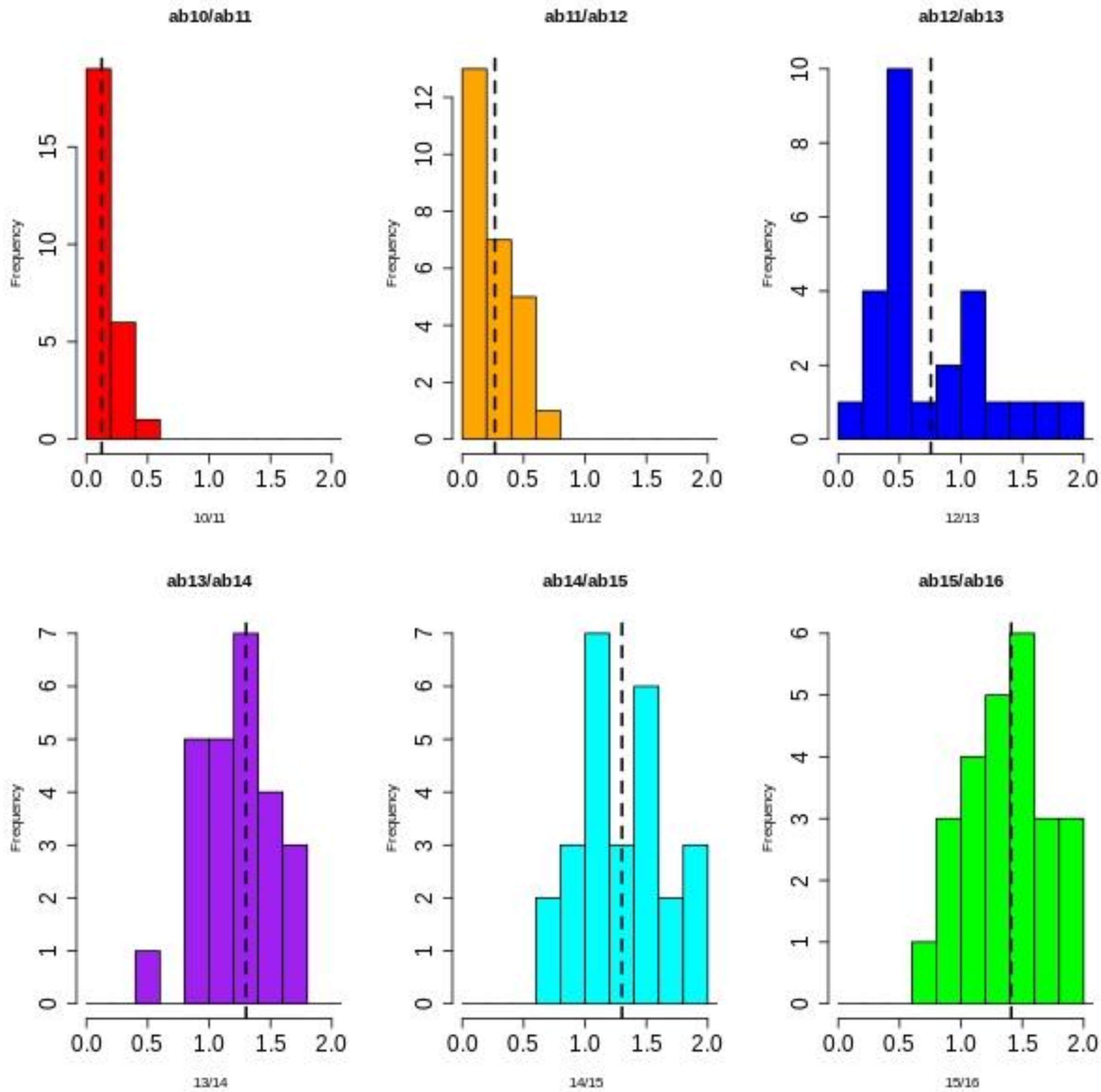


Fig 6.6.17. Statistical distribution of the ratio of abundance at size x over abundance at size x+1, based on 1994 – 2019 MEDITS data. For x = 10 and x = 11, the ratio is systematically below 1, while it can go anywhere between 0 and 2 for the other size classes. The vertical dashed line shows the average ratio.

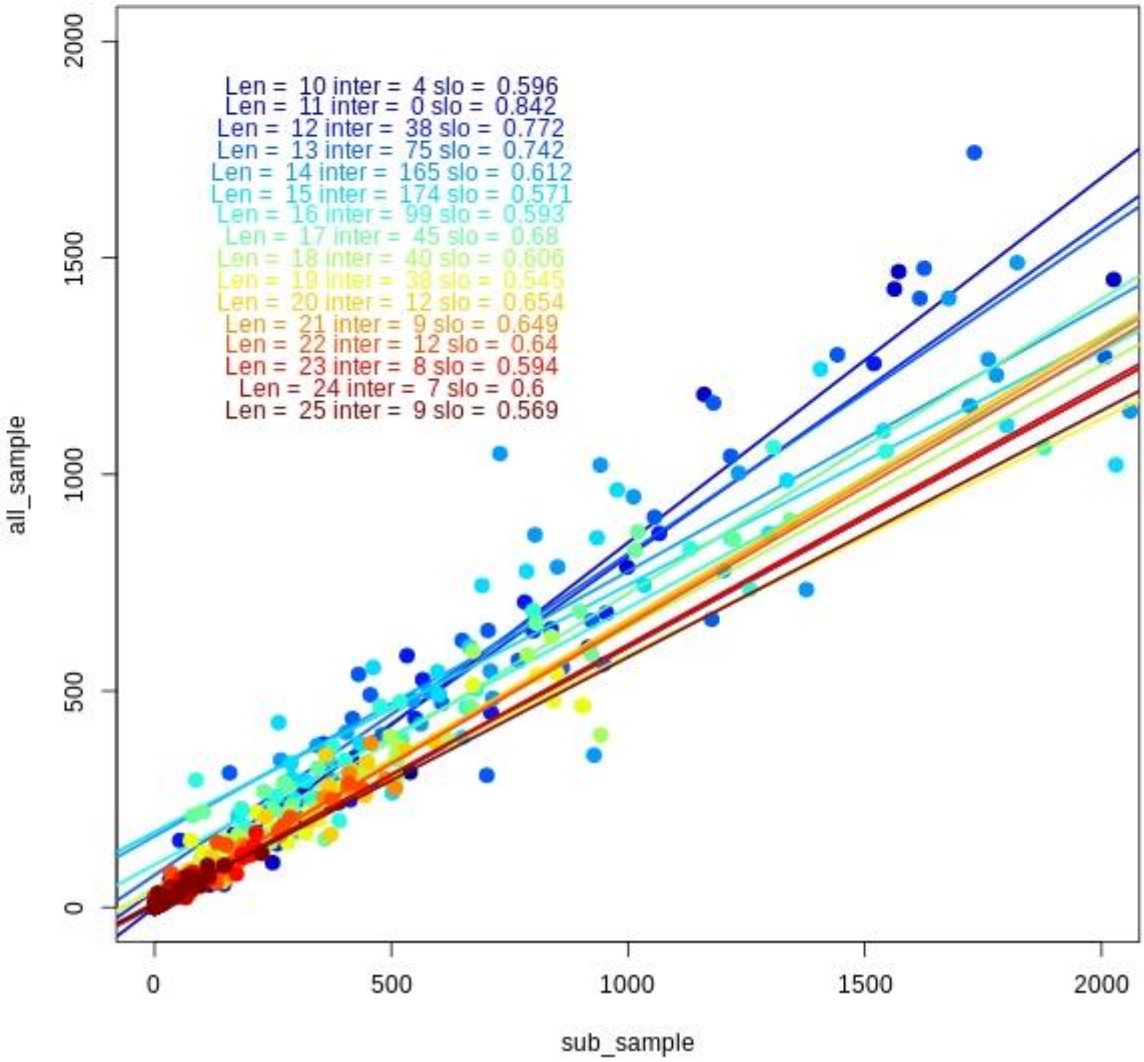


Figure 6.6.18. Regression of abundance at length from all samples ~ abundance at length from 2020 sampling scheme. Colours indicate size classes, from 10 (dark blue) to 25 (dark red). Intercepts and slopes of the regression coefficients are those used to correct MEDITS 2020 abundance at length.

6.6.5.5 MEDITS at age data preparation

Numbers and average weight at age issued from the MEDITS survey are summarized below in tables 7 and 8. For 2020, since abundance at length was corrected, biomass at length was reconstructed from the corrected abundance at length using the LW relationship (Figure 6.6.4). The evolution of the MEDITS index at age is shown in Figure 6.6.19.

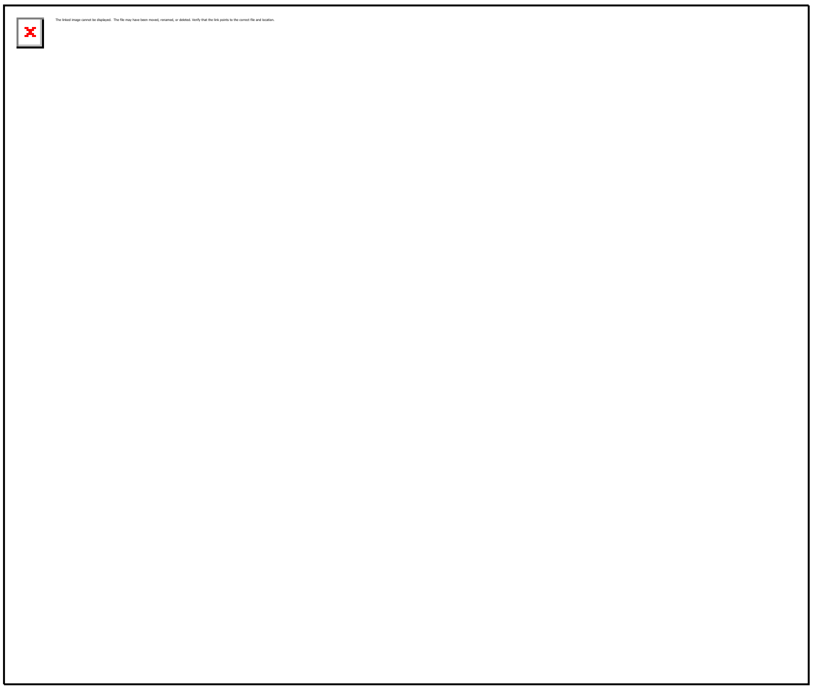


Table 6.6.7. MEDITS index at age (Numbers in thousands for the 13800 km^2 of the Gulf of Lion)

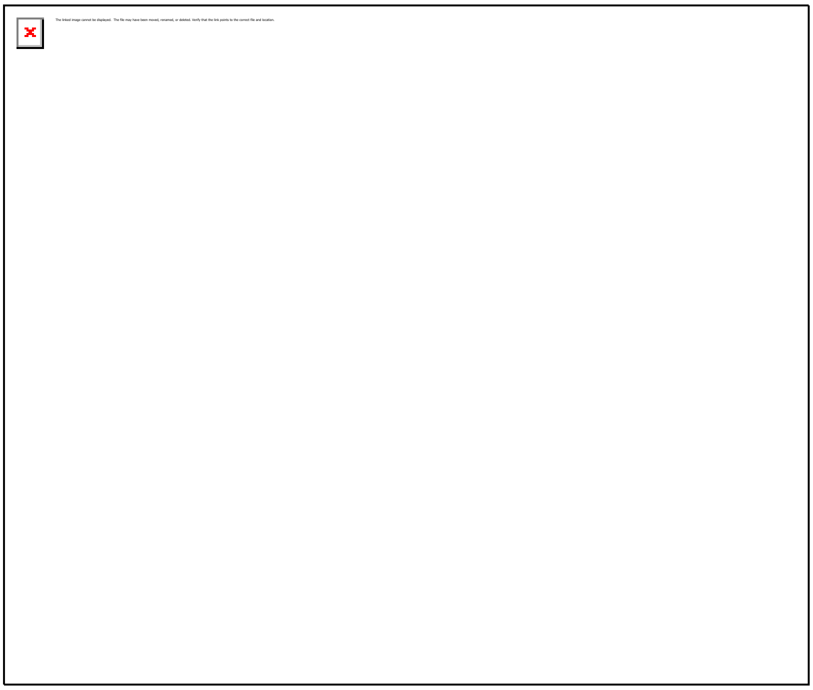


Table 6.6.8. MEDITS average weight at age.

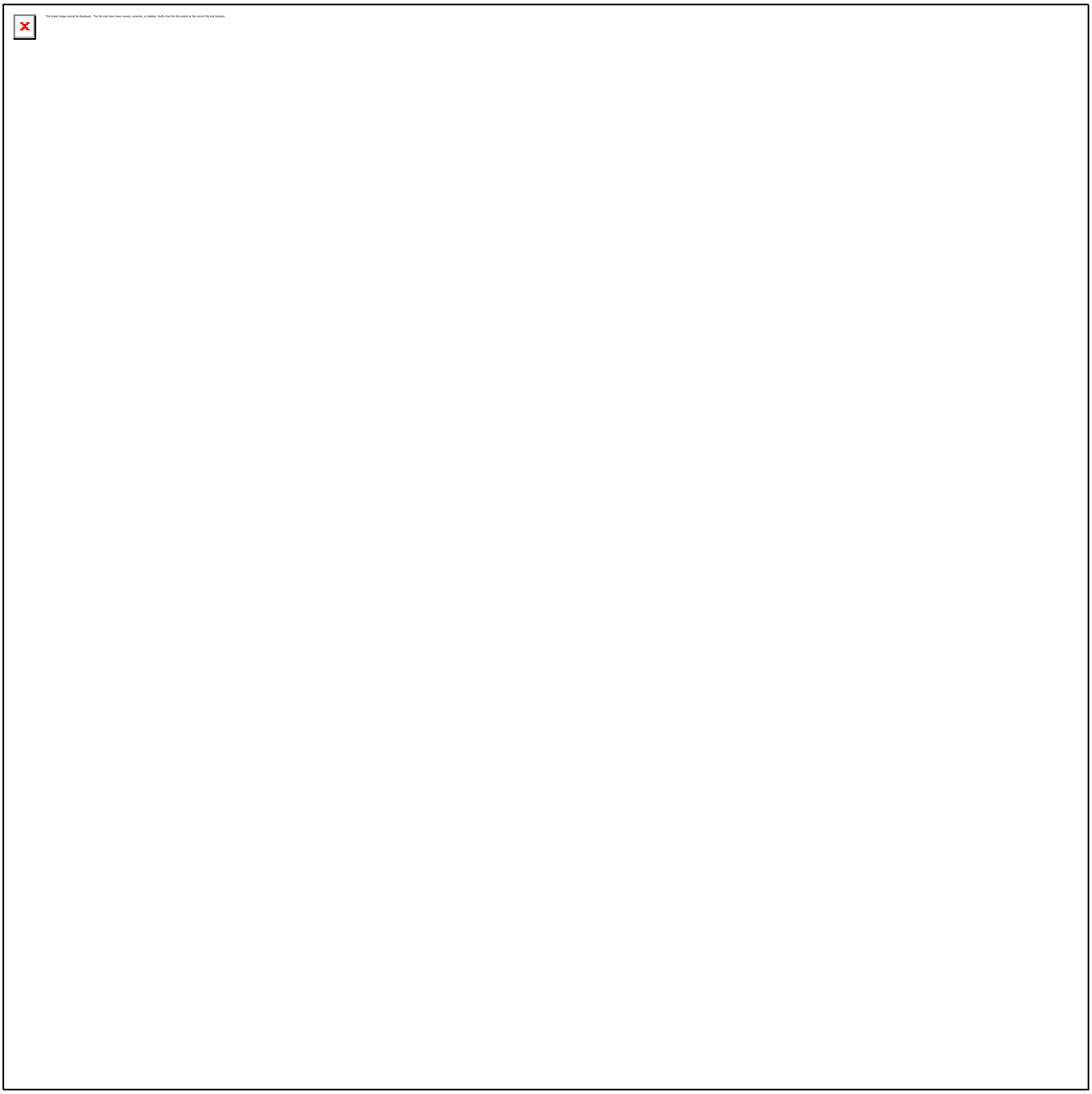


Figure 6.6.19. MEDITS index at age of Red Mulled in GSA 7. Y-axis is standardised.

6.6.3 Stock assessment: a4a.

6.6.3.1 Input data & model specifications.

Input data for the stock assessment are those summarised in tables 3 – 8 above, together with assumed maturity and natural mortality (see section 6.4).

To select the final model for assessment, we followed the exact same process than for the previous assessment, and investigated combinations of various options for the three submodels regarding fishing mortality, survey catchability and stock-recruitment.

For fishing mortality, all investigated options considered age as a factor, but proposed different smoother for the year effect:

```
fmodel_list<-list(~ factor(age) + s(year, k = 3),
                  ~ factor(age) + s(year, k = 4),
                  ~ factor(age) + s(year, k = 5),
                  ~ factor(age) + s(year, k = 6),
                  ~ factor(age) + s(year, k = 7),
                  ~ factor(age) + s(year, k = 8))
```

For catchability, two options allowed to test for a catchability threshold at age 2 or age 3:

```
qmodel_list<-list(list(~factor(replace(age,age>2,2))),
                  list(~factor(replace(age,age>3,3))))
```

For stock recruitment, the default option (year as a factor) has been compared to forcing a geometric mean model, with different options corresponding to different variability (CV ranging from 0.1 to 0.5).

```
srmodel_list<-list(~factor(year),
                   ~geomean(CV=0.1),
                   ~geomean(CV=0.15),
                   ~geomean(CV=0.2),
                   ~geomean(CV=0.25),
                   ~geomean(CV=0.3),
                   ~geomean(CV=0.35),
                   ~geomean(CV=0.4),
                   ~geomean(CV=0.45),
                   ~geomean(CV=0.5))
```

All combinations of options for the three submodels were tested, recovering BIC and GCV score for each combination. Model comparison regarding these two criterions is summarized in Figure 6.6.19. At first glance, models using stock recruitment factorized by years (grey bubbles) seemed to outperform the rest. However, retrospective analysis for these models led us to reject their use, as recruitment proved to be fairly unstable. Regarding the effect of the number of knots on the smoother of the fishing mortality model, models with low to intermediate number of knots (smaller bubbles) were favoured by both BIC and GCV, and especially k=6 appeared to be the best trade-off (5 was used in the previous year). Regarding the age threshold for survey catchability, models with threshold at age 3 systematically outperformed their counterpart with 341threshold at age 2, so age 3 was selected. Finally, regarding the amount of variability within the stock-recruitment geometric mean model (bubble colours), increasing variability decreased GCV, but BIC was minimized for intermediate variability. Therefore, geomean(CV=0.35) was selected for the recruit model.

The final model for stock assessment was therefore the following:

```
fmodel =  ~ factor(age) + s(year, k = 6)
qmodel = ~factor(replace(age,age>3,3))
```

srmodel = ~geomean(CV=0.35)

and it is almost the same than the previous year, the only difference being the numbers of knots in the fmodel which changed from 5 to 6, which is consistent with increasing number of observations in the data set.

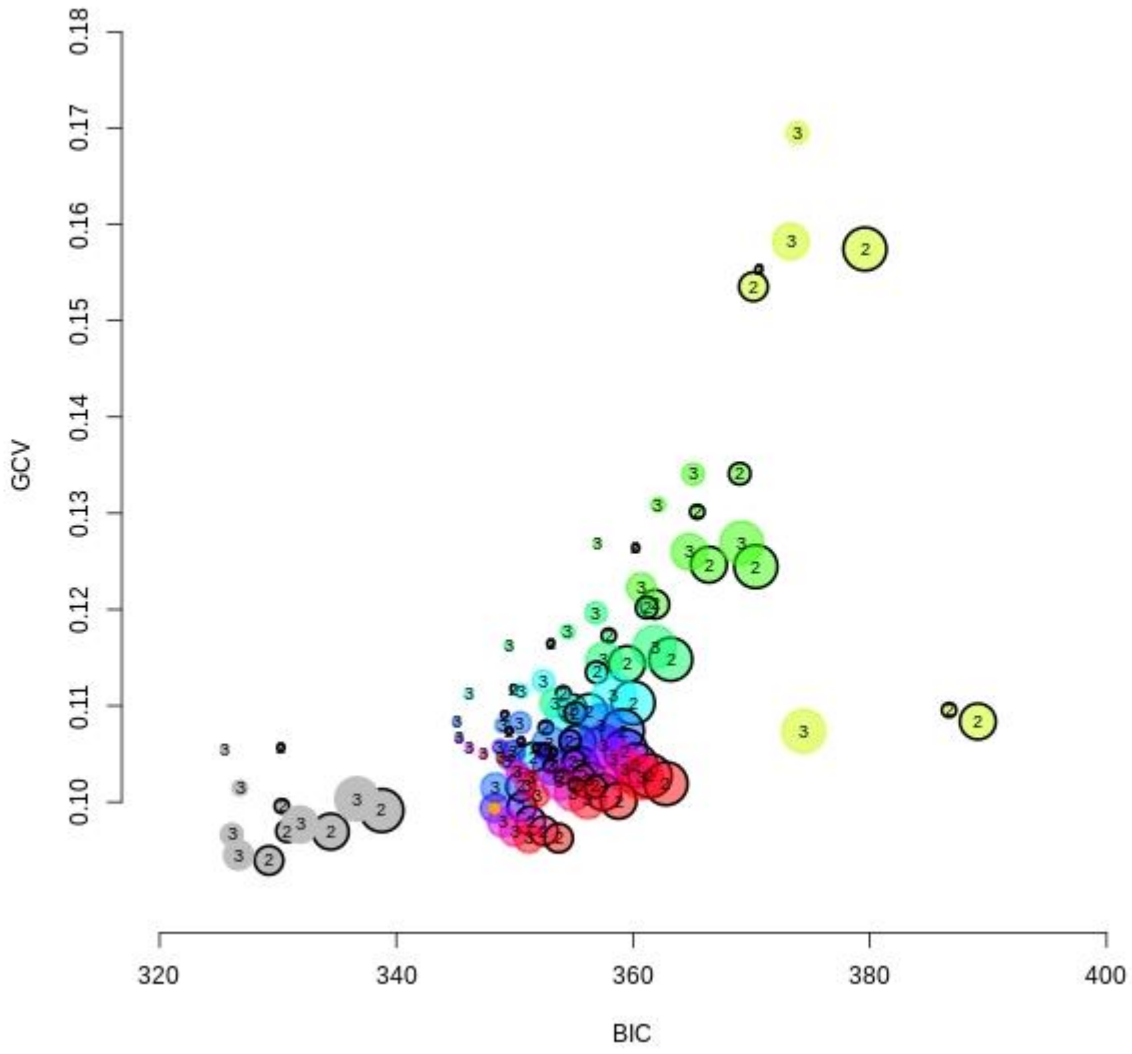


Figure 6.6.20. Performance of the different modelling options tested. Models are evaluated according to BIC (x-axis) and GCV-score (y-axis). Bubble size corresponds to the number of smoother knots in the fishing mortality submodel. Colours corresponds to the amount of variability in the stock-recruitment submodel (from yellow→ low variability, to red → high variability), with grey corresponding to stock recruitment being governed by factor (year); numbers represents the age threshold used for the survey catchability submodel. The orange dot corresponds to the final selected model.

6.6.3.2 Final Run

Recruitment, SSB, catch and Fbar (ages 0-3) estimates from the final model are provided in Table 6.6.9, the resulting fishing mortality at age in Table 6.6.10 and the estimated stock abundance in Table 6.6.11.

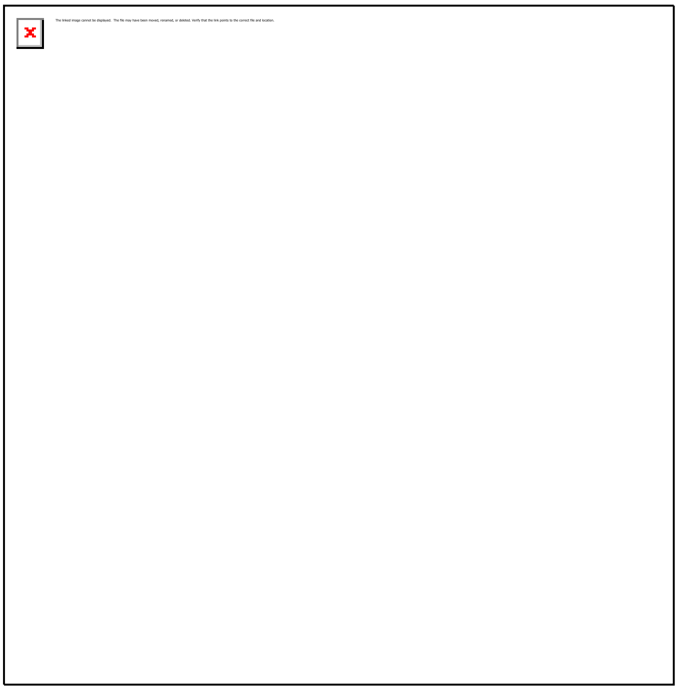


Table 6.6.9. Recruitment (rec, in thousands), spawning stock biomass (ssb, in tons), catch (in tons) and fbar estimated by the stock assessment model.

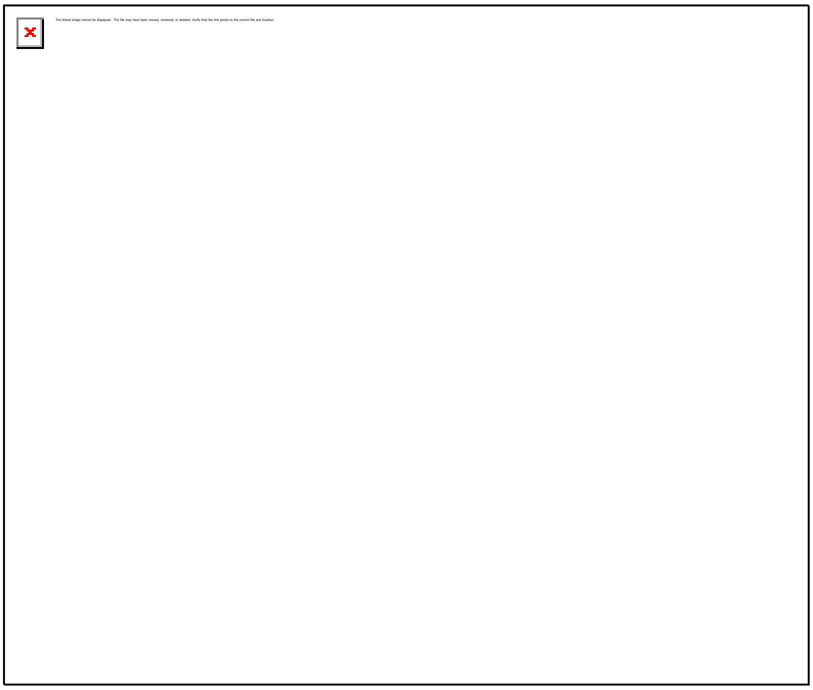


Table 6.6.10. Fishing mortality at age resulting from the stock assessment model.

Table 6.6.11. Stock abundance (in thousands) at age estimated by the model

Through the years, the fishing mortality at age has been quite constant on Red Mullet, and seems to follow a downward trend in the recent years that remains to be confirmed in the coming years (Figure 6.6.21). Such trend is probably not tied to a reduction of fishing effort, but is rather explained by increased productivity of the stock (Fig 21), as exemplified in the estimated recruitment, since 2012 (Table 6.6.9). Factors responsible for this high recruitment are up to know not identified. The model is consistent with last year's assessment.

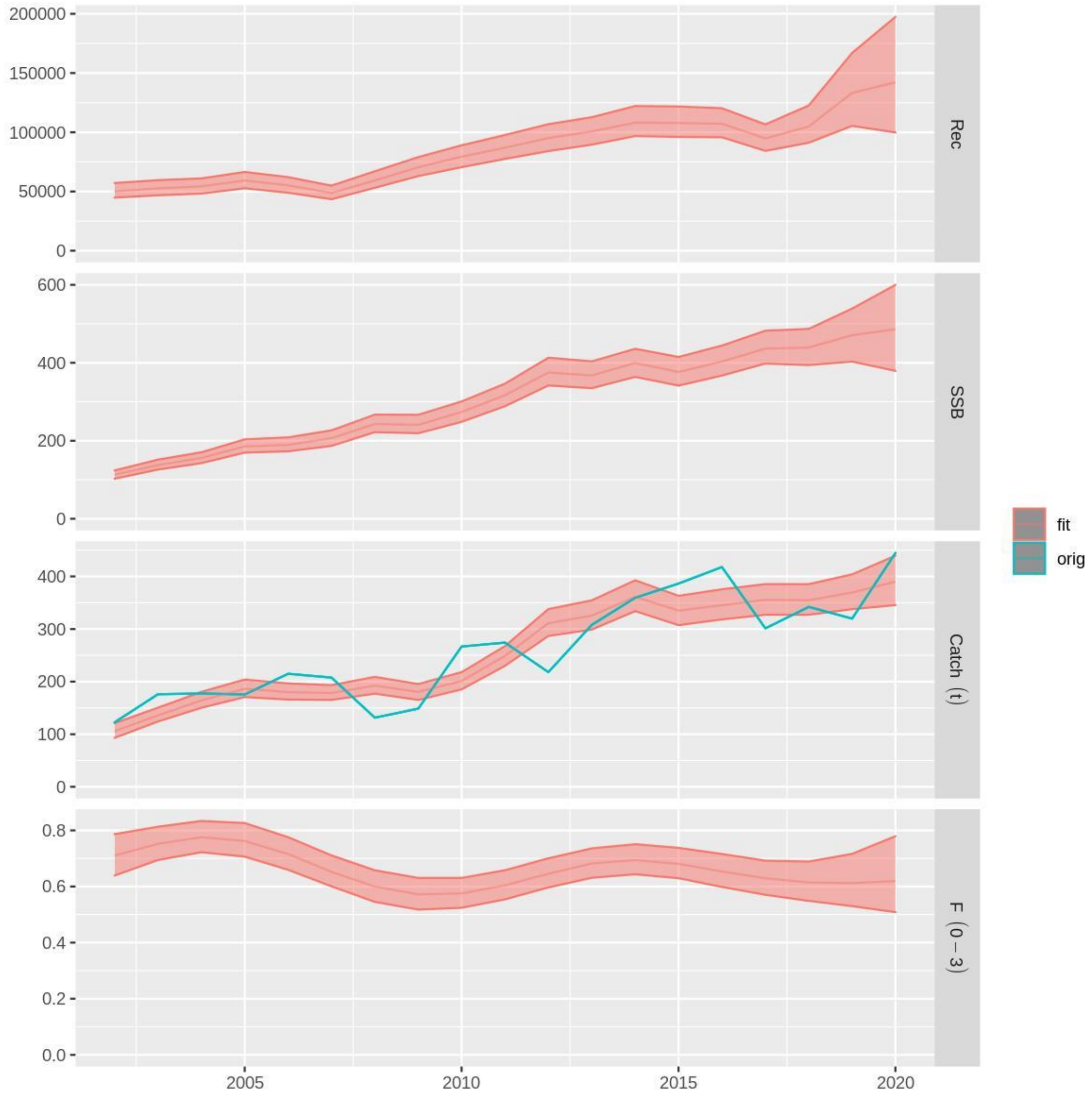


Fig 6.6.21. Time series and confidence intervals of Recruitment, SSB, Catch and Fbar estimated by the model, together with confidence intervals. The blue line corresponds to the observed catch.

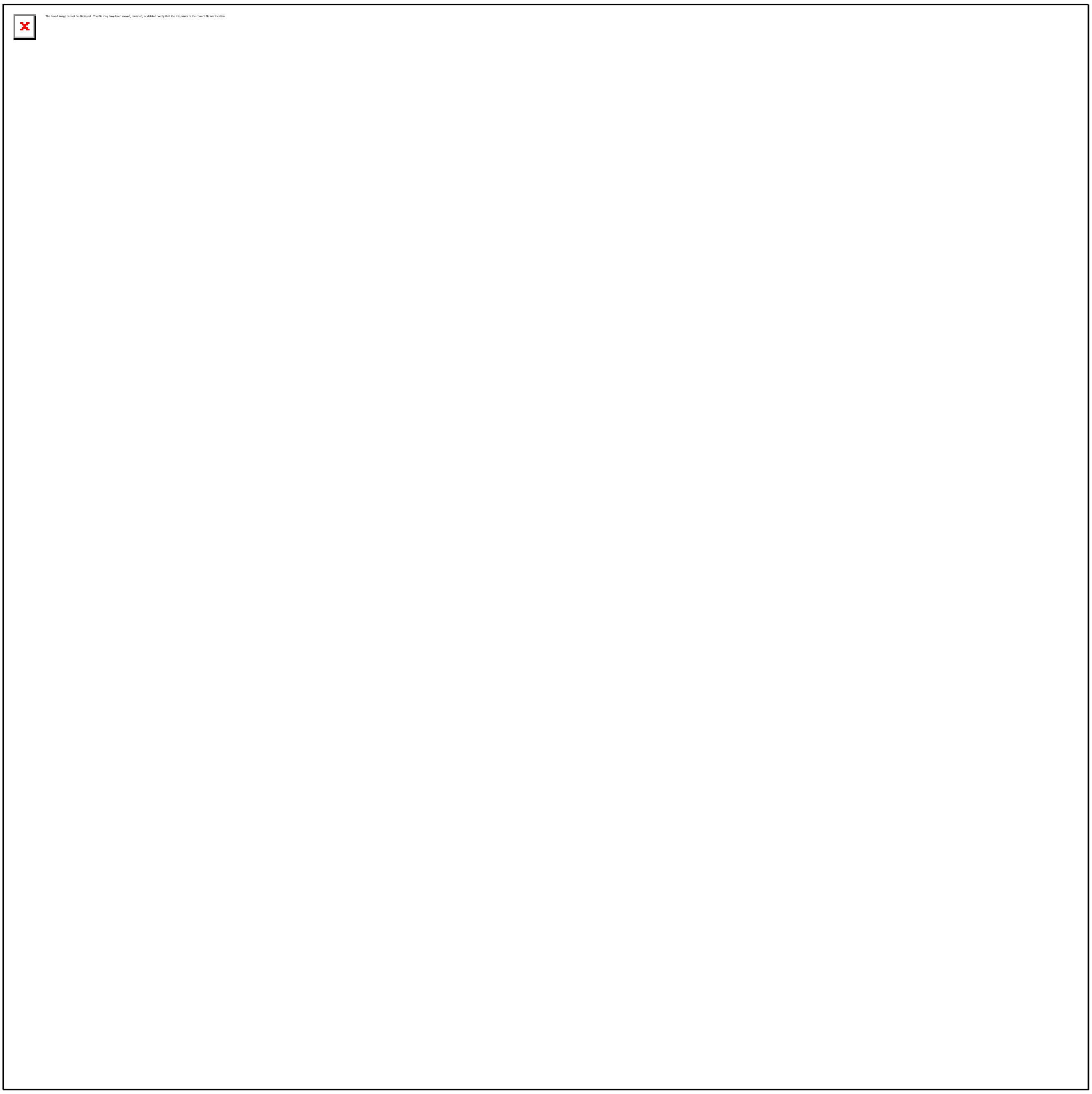


Fig 6.6.22. Log residuals from the stock assessment model.

Log-residuals (Figure 6.6.22) exhibited few patterns, except for positive residuals at age 1 for the catch at the first half of the series (up to 2010). Despite our modelling efforts, this pattern could not be avoided. Further investigations might be carried out next year to solve this somewhat moderate issue if possible.

Tri-dimensional representation of fishing mortality at age through the years (Fig 23) 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 6.6.24) is assumed constant through the years, but increases with age up to age 3, in accordance with the catchability submodel specification.

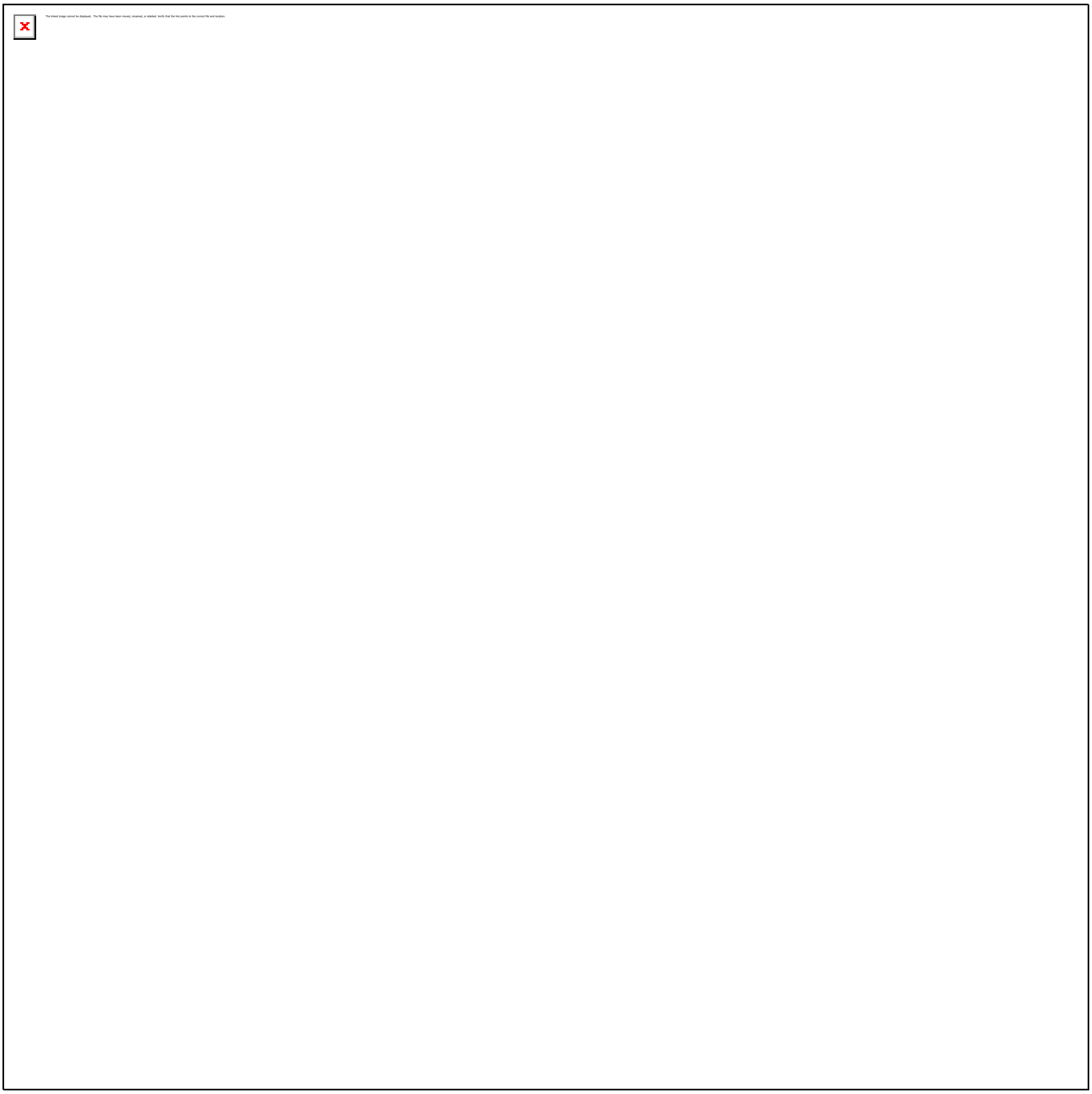


Figure 6.6.23. Fishing mortality at age through the years

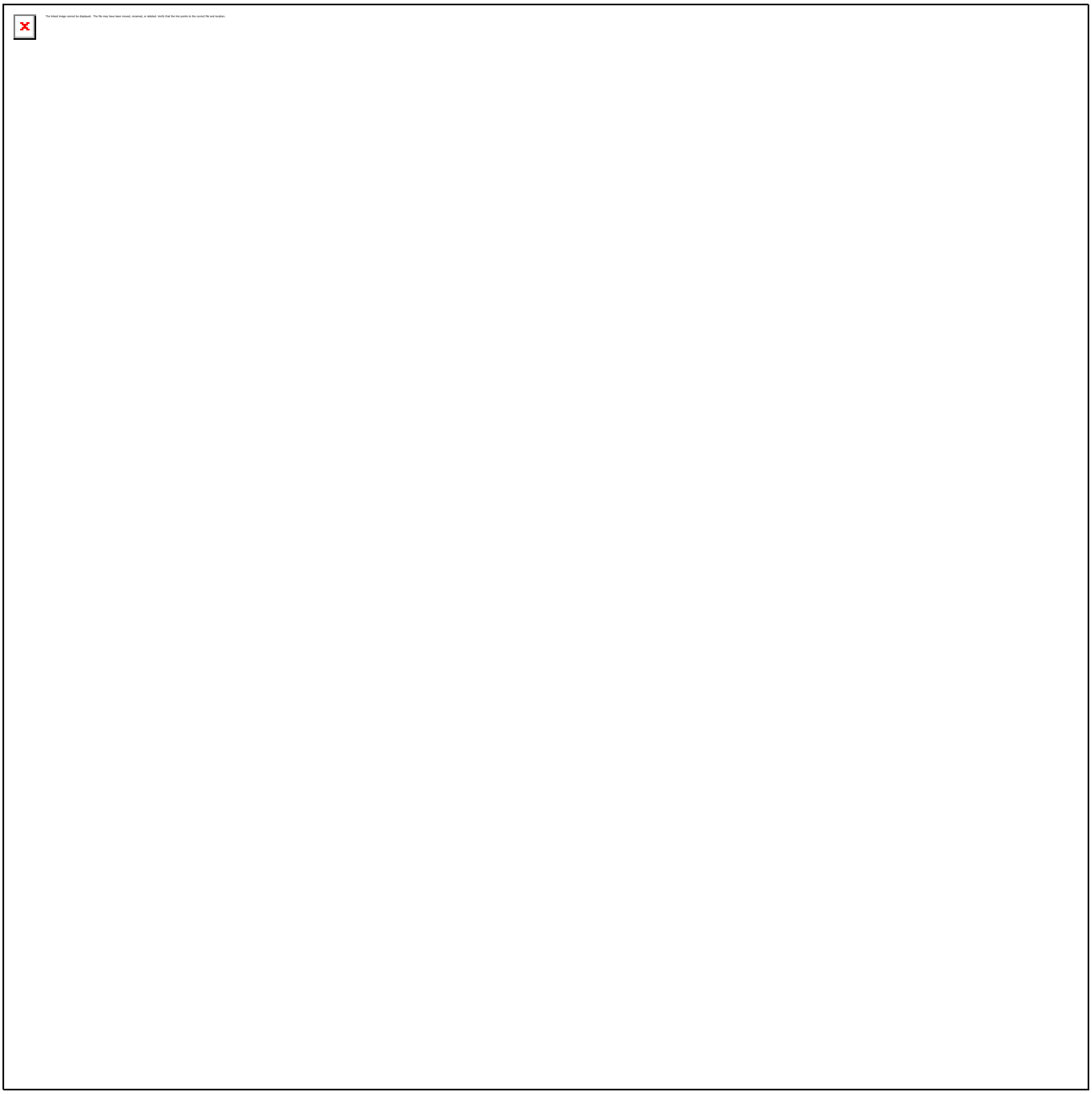


Figure 6.6.24. Survey catchability at age through the years

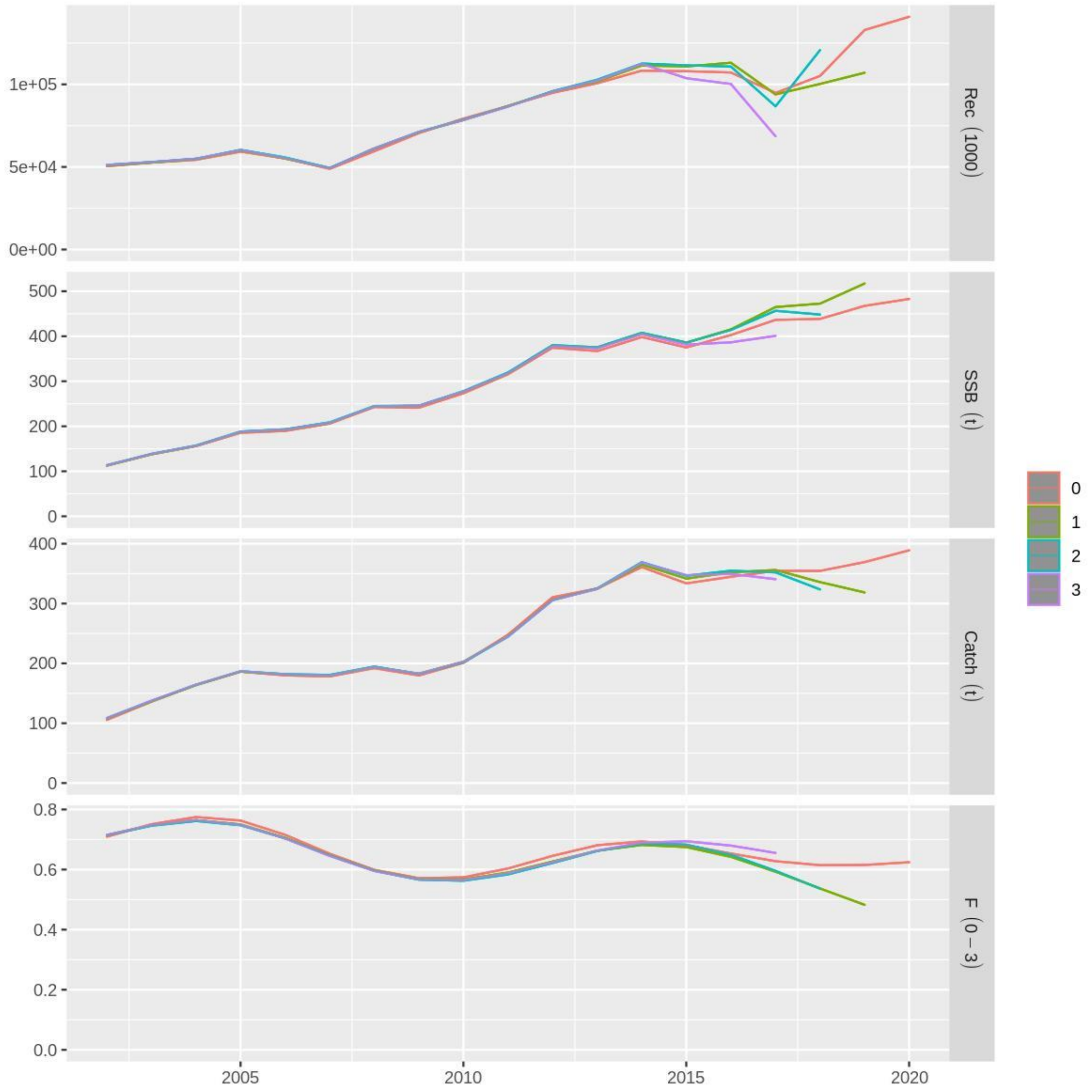


Figure 6.6.25. Retrospective analysis carried out for the selected model.

6.6.4 Reference Points

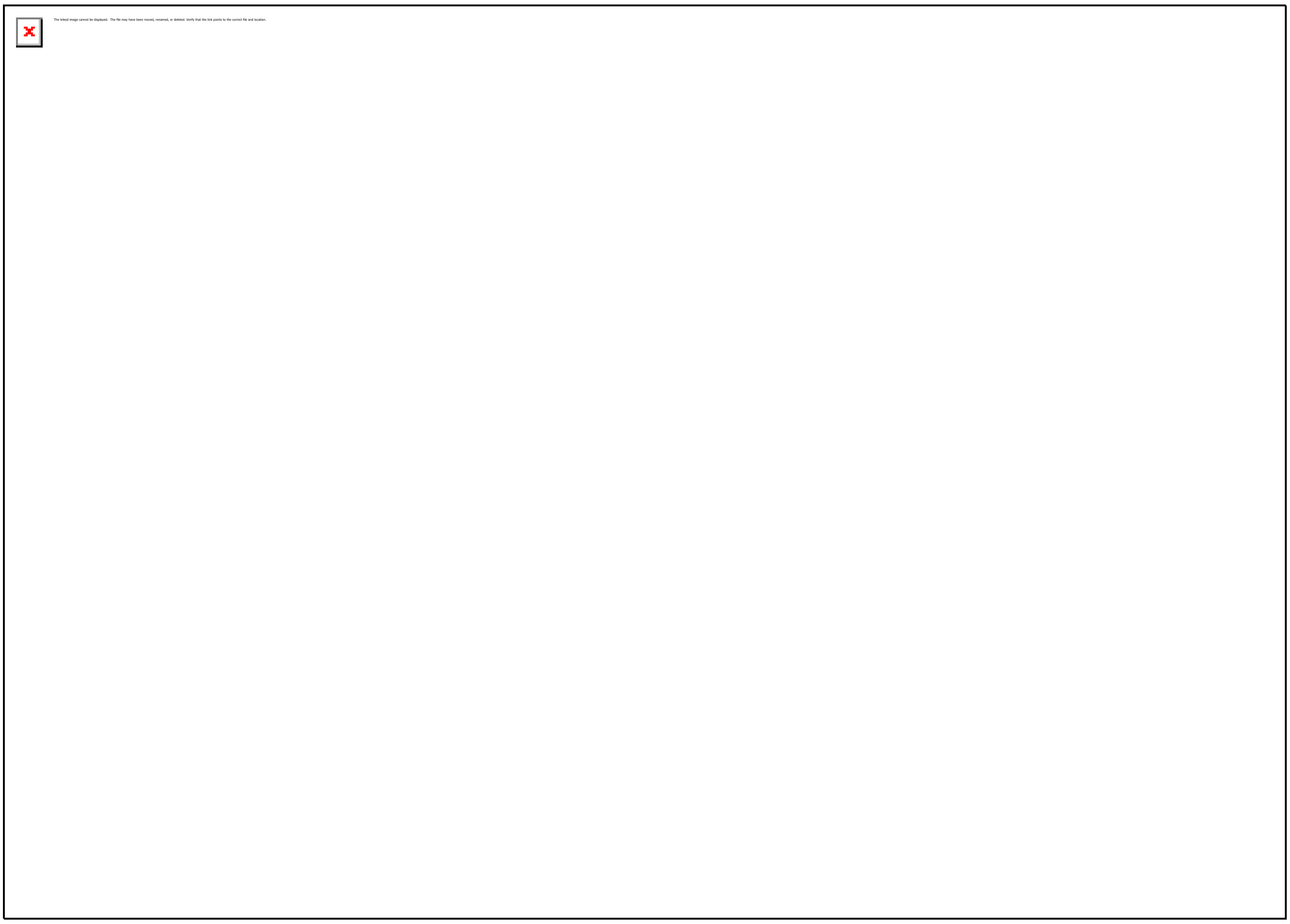
To define reference points F_{01} (as a proxy for F_{MSY}) and F_{max} as Yield per Recruit analysis (YPR) was carried out in R using FLBRP. As input the same population parameters used for the stock assessment model and its output of the exploitation pattern for last three years of the assessment. This led to the following estimates: $F_{01} =$ 0.456; $F_{current}$ = 0.624 and the resulting ratio F_{01} / $F_{current}$ = 1.369, suggesting that the stock is currently over-harvested.

6.6.5 Short-term forecast

Input parameters used in the stock assessment were used for the STF. Different scenarios of constant harvest strategy with F_{bar} calculated as the average of ages 0 to 3 and F status quo (F_{stq} = 0.624 based on F in 2020) 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 gradual linear transition to reach F_{MSY} in 2025.

Table 6.6.12. Short-term forecast

Fishing at $F_{0.1}$ (0.42) generates a decrease of the catch of 9.7% from 2020 to 2022 and an increase of the spawning stock biomass of 6.8 % from 2020 to 2022.



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) 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; 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.

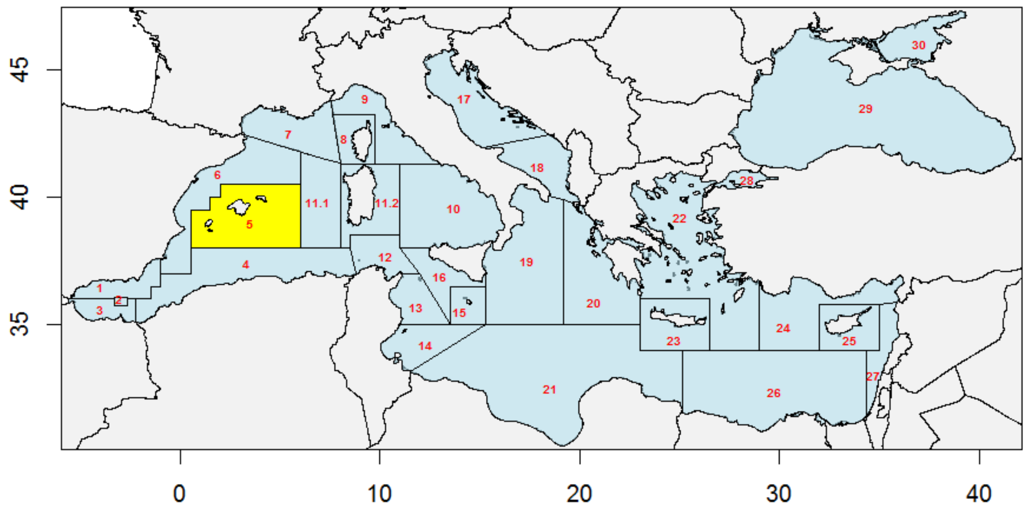


Figure 6.7.1.1. Geographical localization of GSA 5.

As 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 Data Call. 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	0.000229
b	3.25

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 two year (Figure 6.7.2.1, Table 6.7.2.1.) Discards are reported at very low levels in some years. In 2020 no discards were reported. Overal discards can be considered negligible (Table 6.7.2.2)

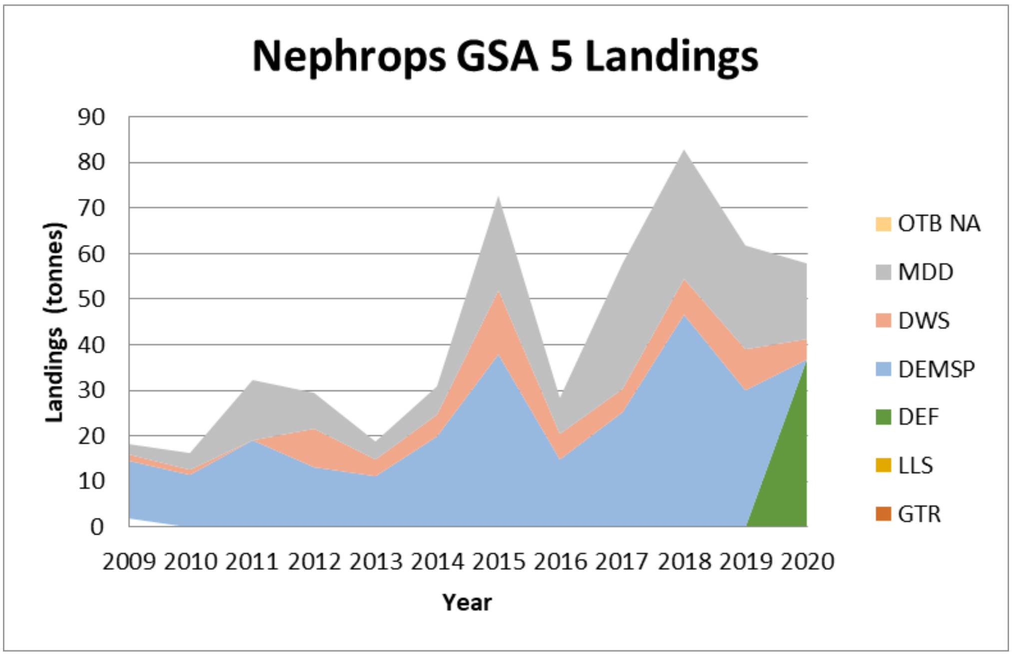


Figure 6.7.2.1. Norway lobster in GSA 5. Reported Landings from the DCF Data call by gear.

Evaluation of length frequency distribution data in DCF for the Norway lobster in GSA 5 shows that most of the information comes from OTB_DEMSP up to 2019 and OTB_DEF in 2020 (Figure 6.7.2.2), there is no sample data before 2009. The change in gear vtype results not from a change in the fishery, just a redefinition of the gear designations.

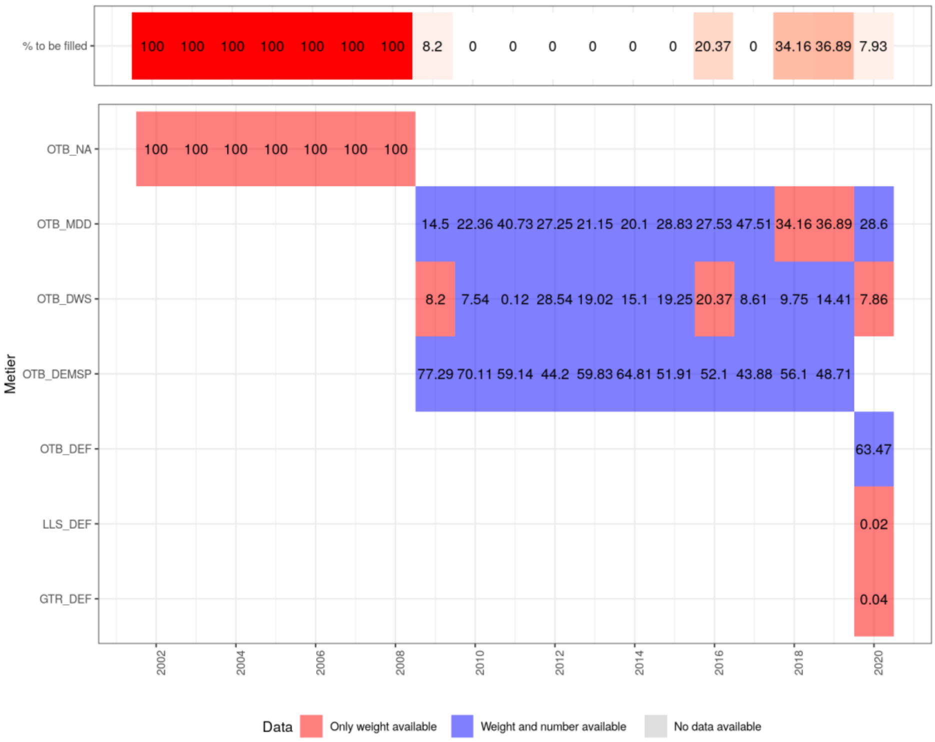


Figure 6.7.2.2. Norway lobster in GSA 5. Sampling of Landings from the DCF Data call by gear.

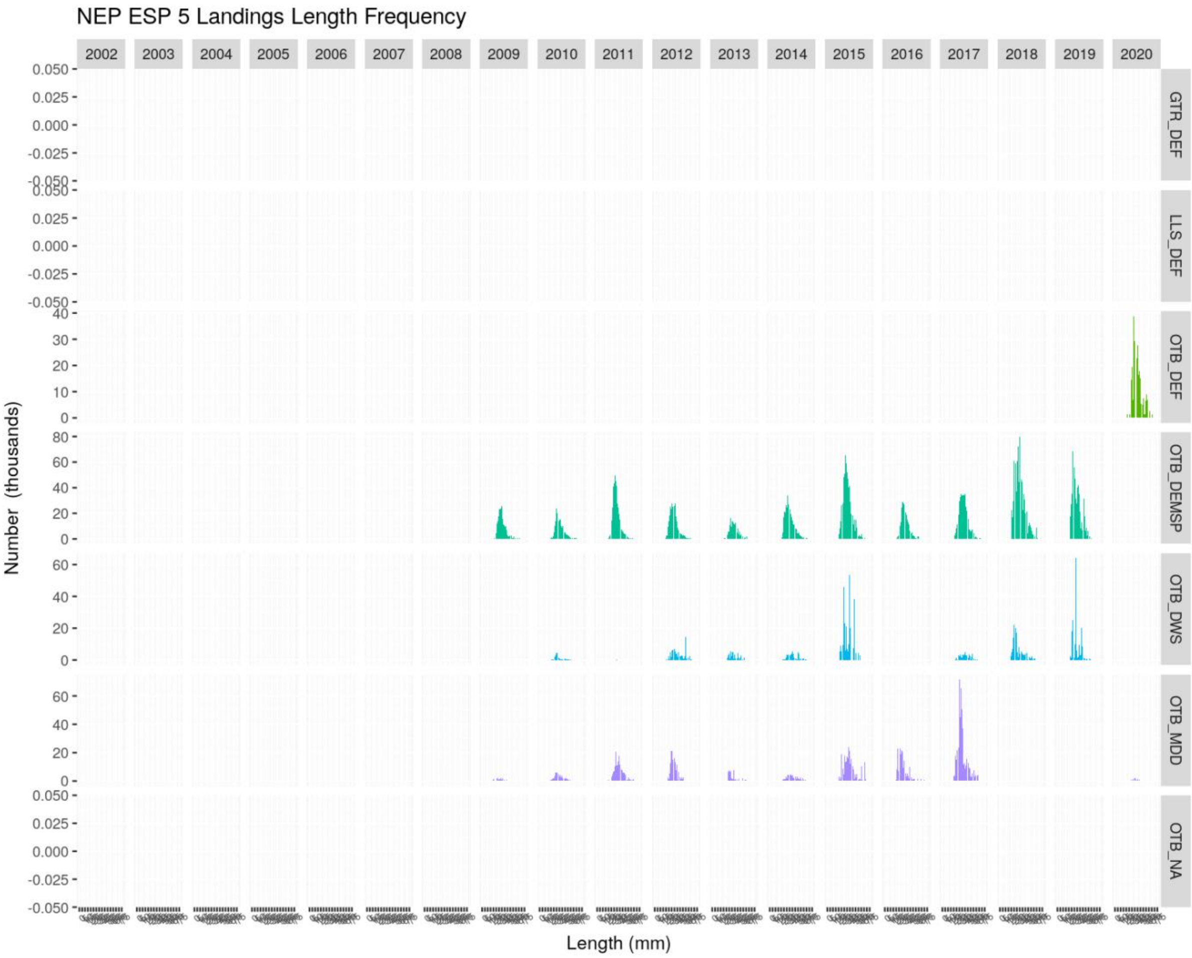


Figure 6.7.2.3. Norway lobster in GSA5. Landing length frequency distribution, by year and métier (TL cm).

Table 6.7.2.2. Norway lobster in GSA5. Landings by year and métier.

Year	GTR	LLS	OTB	DEMSP	DWS	MDD	OTB NA	Total
2002							17.32	17.32
2003							17.77	17.77
2004							25.09	25.09
2005							20.17	20.17
2006							21.27	21.27
2007							57.78	57.78
2008							89.63	89.63
2009				12.63	1.34	2.37		16.34
2010				11.35	1.22	3.62		16.19
2011				19.08	0.04	13.14		32.26
2012				13.04	8.42	8.04		29.50
2013				11.26	3.58	3.98		18.82
2014				19.96	4.65	6.19		30.80
2015				37.83	14.03	21.01		72.87
2016				14.76	5.77	7.80		28.33
2017				25.37	4.98	27.47		57.82
2018				46.51	8.08	28.32		82.91
2019				30.12	8.91	22.81		61.85
2020	0.02	0.01	36.69		4.55	16.53		57.80

Table 6.7.2.2. Norway lobster in GSA5. Discards (t) by year

Year	discards
2009	0.05
2010	0.00
2011	0.07
2012	2.11
2013	0.00
2014	0.03
2015	0.74
2016	0.02
2017	0.02
2018	0.00
2019	0.11
2020	---

6.7.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 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, so only these stations are used for the MEDITs biomass index used for this stock. The usual number of atations were completed in 2020 (Figure 6.7.2.4.) Mean stratified abundances and biomasses by km^2 have been computed using the methodology described by Grosslein and Laurec (1982).

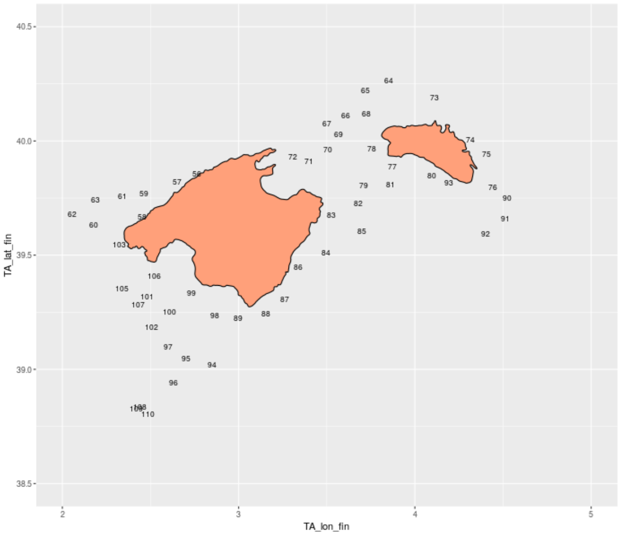


Figure 6.7.2.4. Norway lobster in GSA 5. MEDITS stations used in index calculations, (example distribution 2020) .

Density and biomass indices showed variations along the data series, with the highest values of abundance in 2009, 2010 and 2018 (Figure 6.7.2.5). Length frequency distributions are shown in Figure 6.7.2.6. 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 6.7.2.8).

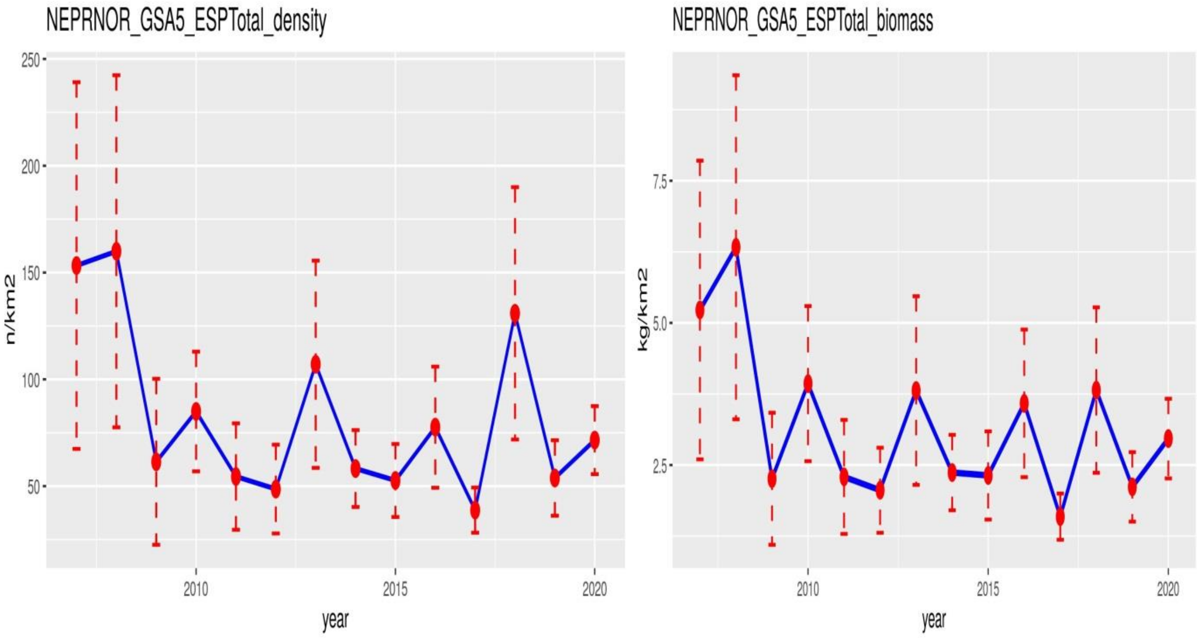


Figure 6.7.2.5. Norway lobster in GSA 5. MEDITS abundance (n/km^2) and biomass (kg/km^2) indices over 2007-2020.

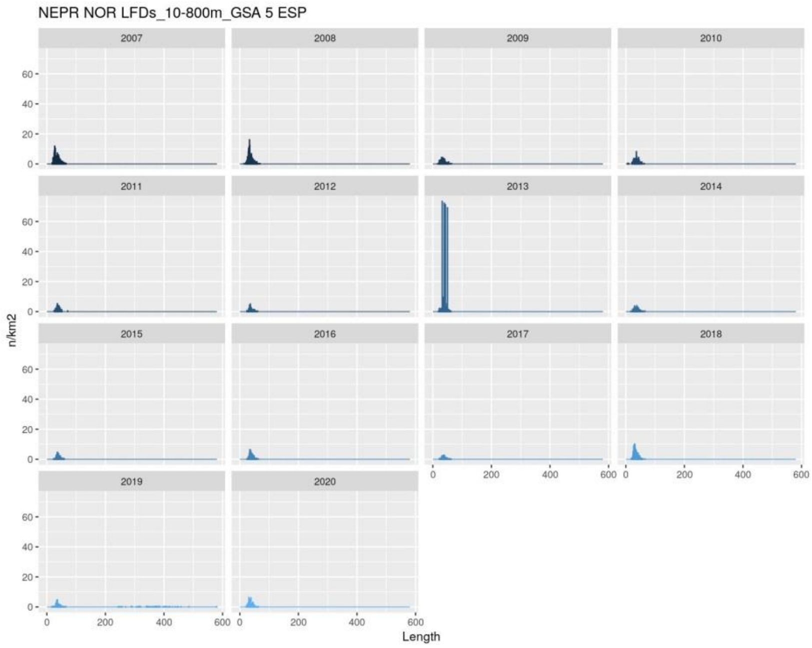


Figure 6.7.2.6 Norway lobster in GSA 5. MEDITS Length Frequency data 2007-2020.

The LFD data showes a possible errors in 2013 and 2019 that may inflence the abundance index, but do not affect the biomass index used for advice. These potential errors are reported in Section 7.

6.7.3 STOCK ASSESSMENT

In 2020 an analytical assessment for Norway lobster in GSA 5 was attempted with XSA (Method 1) and a4a (Method 2) but the assessment was not acceptable for advice. The final advice was based in index data following the ICES category 3 approach. This year the same index based approach has been used see Section 5.7.5.

6.7.4 REFERENCE POINTS

As the assessment was not accepted for advice, reference points were not calculated.

6.7.5 SHORT TERM FORECAST AND CATCH OPTIONS

Biomass Index refers to the ICES data limited approach using a stock status indicator (ICES 2012). In the last years biomass of norway lobster in GSA 5 has displayed a stable/sligthly decreasing trend (figure 6.9.5.1). The change in biomass over the last five years was used to provide an index for change (0.85). As the biomass index change is lower than 1.2 and greater than 0.8, following the ICES approach no uncertainty cap is applied. STECF EWG 19-09 applied a precautionary buffer and advised a catch of 44.1 tonnes for 2020 and 2021. Again this year following the ICES proceedure, STECF EWG 21-11 has used the index of change of 0.85 applied to the previous catch advice of 44.1 tonnes. The catch advice, which is applicable for two years (2019 and 2020) is 37.4 tonnes (Table 6.9.5.1).

Table 6.7.5.1: Nephrops in GSA 5 Assumptions made for the interim year and in the forecast

Index A (2019–2020)	2.54
Index B (2014–2016)	2.97
Index ratio (A/B)	0.85
-20% Uncertainty cap	Not applied
Catch Advice (2020–2021)	56.35
Discard rate (2016–2018)	0 (negligible)
-20% Precautionary buffer	Applied in 2018
Catch advice **	37.4
Landings advice ***	37.4
% advice change ^	-15%

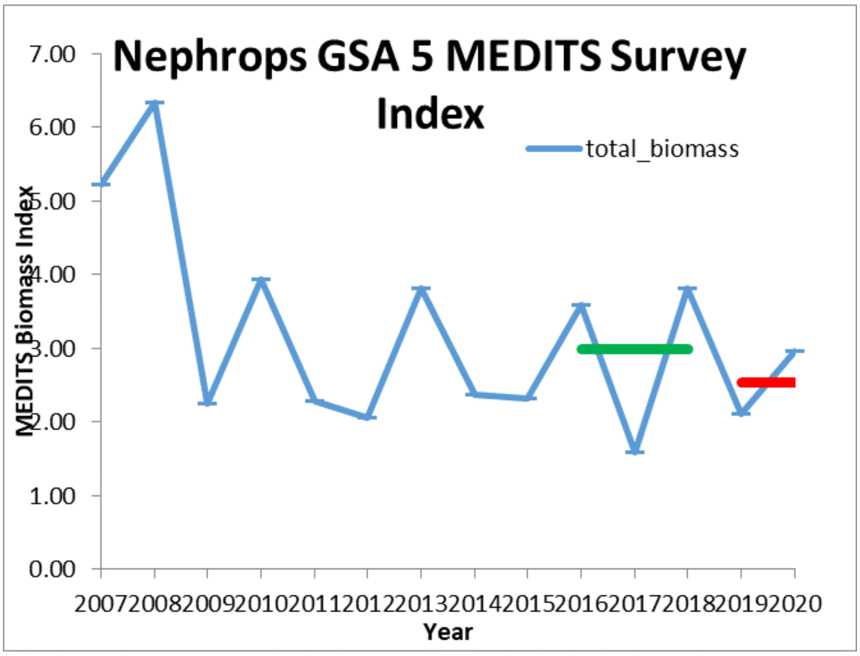


Figure 6.7.5.1 Norway lobster GSA 5. Biomass index (kg/km2) in blue estimated from MEDITS survey. The mean of the last two years (2.54 green) compared to the previous three years in green (2.97 red) gives a factor of 0.85.

6.7.6 Data Issues

Medits data show odd length frequency values for two year :-

2013 Four abundances are very high in hail 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

2019 max length is 580mm with a number of lengths at about 10x the normal size.

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 (Fig. 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.

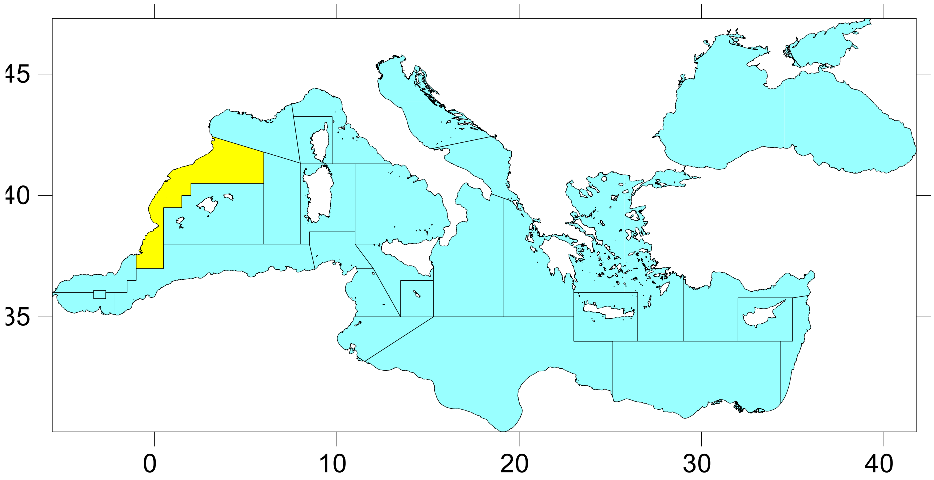


Fig. 6.8.1.1. Geographical location of GSA 6.

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 were not available in the DCF data set. As in previous assessments, the parameters of the von Bertalanffy growth function were taken from those estimated for GSA 5 (reproduced in Table 6.8.1.1) that correspond to both sexes combined. The parameters of the weight-at-length equation were available in the DCF for the 2019-2020 sampling, not separated by sex.

Table 6.8.1.1. Norway lobster in GSA 6: Parameters used for growth and weight at length.

Growth model	$L\infty$	k	t_0
$L_t = L_\infty\left(1 - e^{-k(t-t_0)}\right)$	86.1 mm CL	0.126 yr^{-1}	0 + 0.5
Weight at length	a	b	
$W = a\,L^b$	0.0003 g mm^{-1}	3.248	

The species spawns mainly in late autumn and winter in GSA 6, but spawning can take place along the year and the spawning time was set at the mid-point of the year, with 50% of natural (M) and fishing (F) mortalities occurring before spawning.

Length data from DCF (and from the MEDITS series, below) were age-sliced with the standard **l2a** routine in Fla4a, adding 0.5 to the value of t_0.

Maturity and natural mortality

The maturity vector at age was obtained from the previous assessment (Table 6.8.1.2), due to inconsistencies in the data reported in the DCF files. Natural mortality was obtained by application of the Chen-Watanabe formula, as in previous assessments of this stock (Table 6.8.1.2).

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+
maturity	0.1	0.25	0.8	1.	1.	1.	1.	1.	1.
M: Chen-Watanabe	0.732	0.466	0.353	0.291	0.252	0.225	0.206	0.192	0.181

All data were obtained from the 2021 DCF data call.

6.8.2 Data

6.8.2.1 Catch (Landings and Discards)

Data on catches are available from 2002 to 2020 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 500 m. 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 269.1 t in 2019. The landings for 2020, for an amount of 198.8 t, have been the lowest in the data series. Discards, reported since 2009, are negligible, normally below 5% of the catches, but note anomalously high value in 2012.

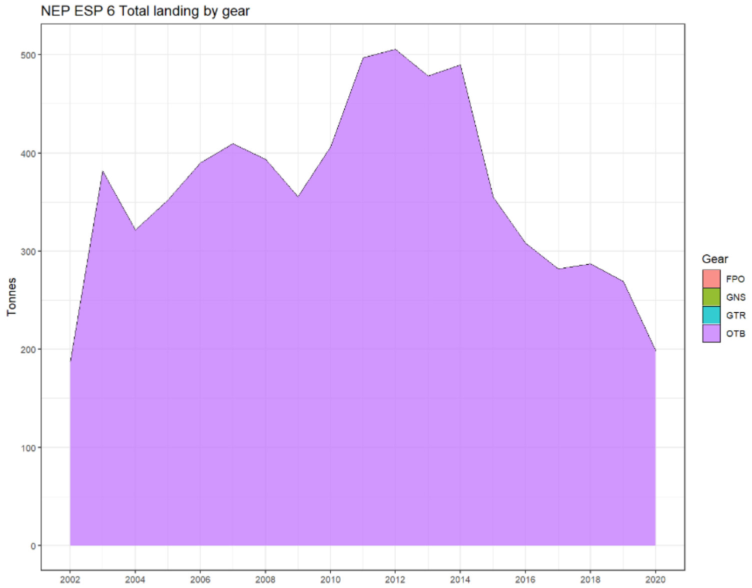


Fig. 6.8.2.1.1. Norway lobster in GSA6: Total landings per year.

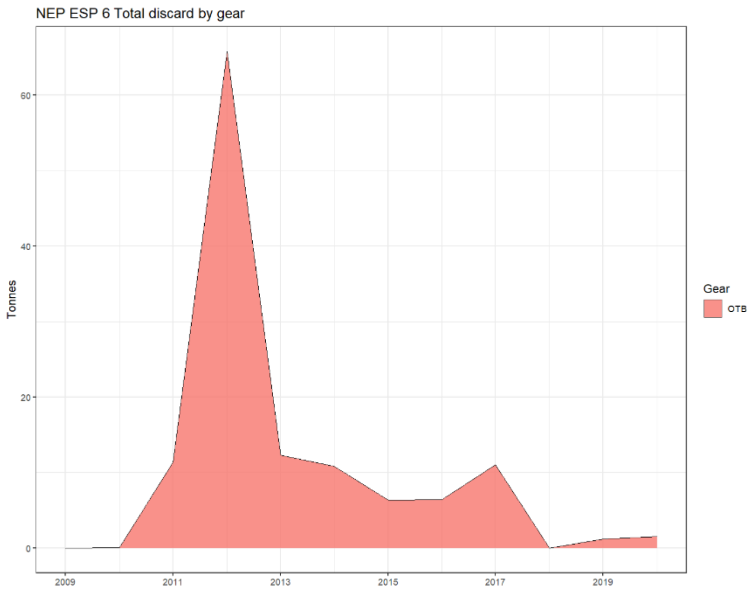


Fig. 6.8.2.1.2. Norway lobster in GSA 6: Total discards per year.

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	187.5		187.5	
2003	381.8		381.8	
2004	321.7		321.7	

2005	352.0		352.0	
2006	390.2		390.2	
2007	409.4		409.4	
2008	393.8		393.8	
2009	355.6	0.0	355.6	0.0%
2010	406.5	0.1	406.5	0.0%
2011	496.8	11.4	508.2	2.2%
2012	506.1	65.8	571.9	11.5%
2013	478.4	12.3	490.7	2.5%
2014	490.0	10.8	500.8	2.2%
2015	355.2	6.3	361.6	1.8%
2016	308.1	6.4	314.5	2.0%
2017	282.2	11.0	293.2	3.8%
2018	287.0	0.0	287.0	0.0%
2019	269.1	1.2	270.3	0.5%
2020	198.8	1.5	200.3	0.8%

Information on the demographic structure of the exploited population is available as quarterly length frequencies from 2009 to 2020. The R code from EWG 2102 was used to fill-in length frequency distribution for those years or métiers where no length frequencies were available in DCF. 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, but not for métier OTB_MDD (Figure 6.8.2.1.3.) Discards are generally not sampled, with available length frequencies for 2019 and 2020 only (Figure 6.8.2.1.4).

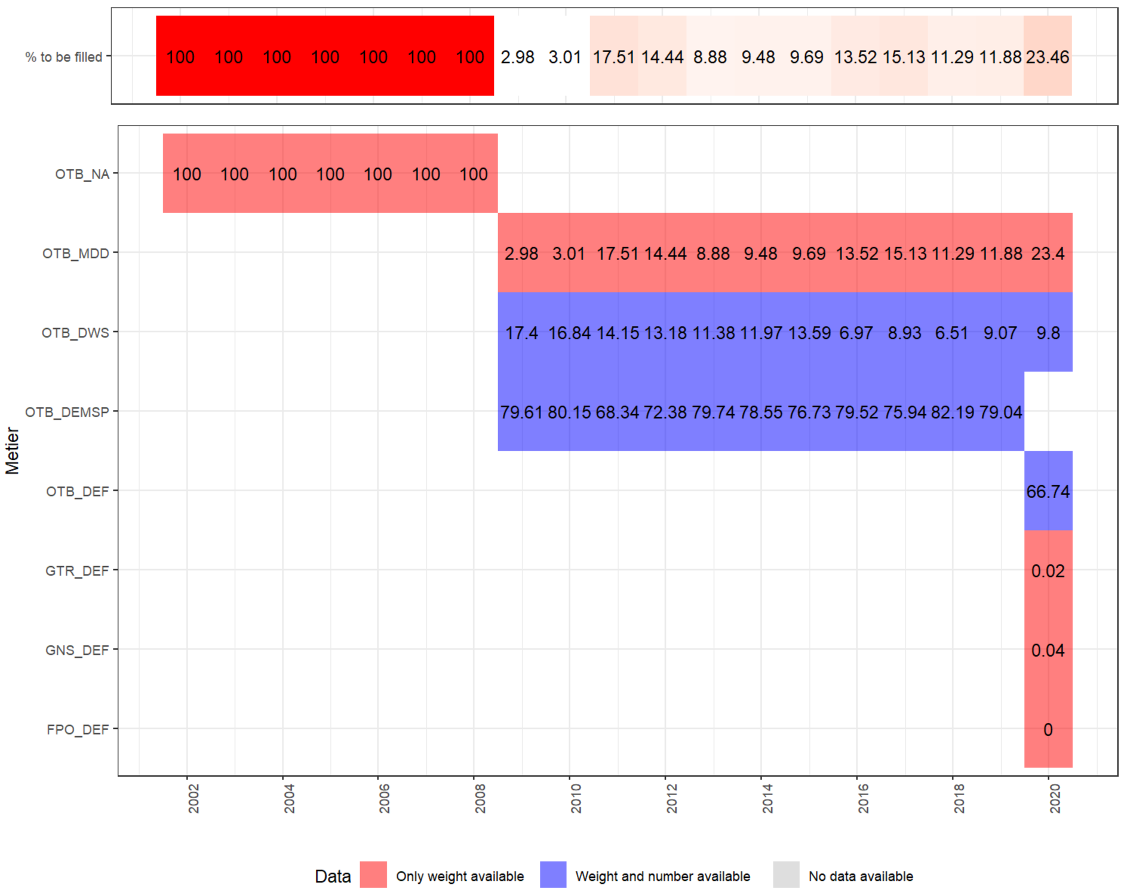


Fig. 6.8.2.1.3. Norway lobster in GSA 6: Available and reconstructed length frequencies for landings. Series of data with weight and length frequencies available in the DCF in blue; series with weight only for which length frequencies were reconstructed using median values in red.

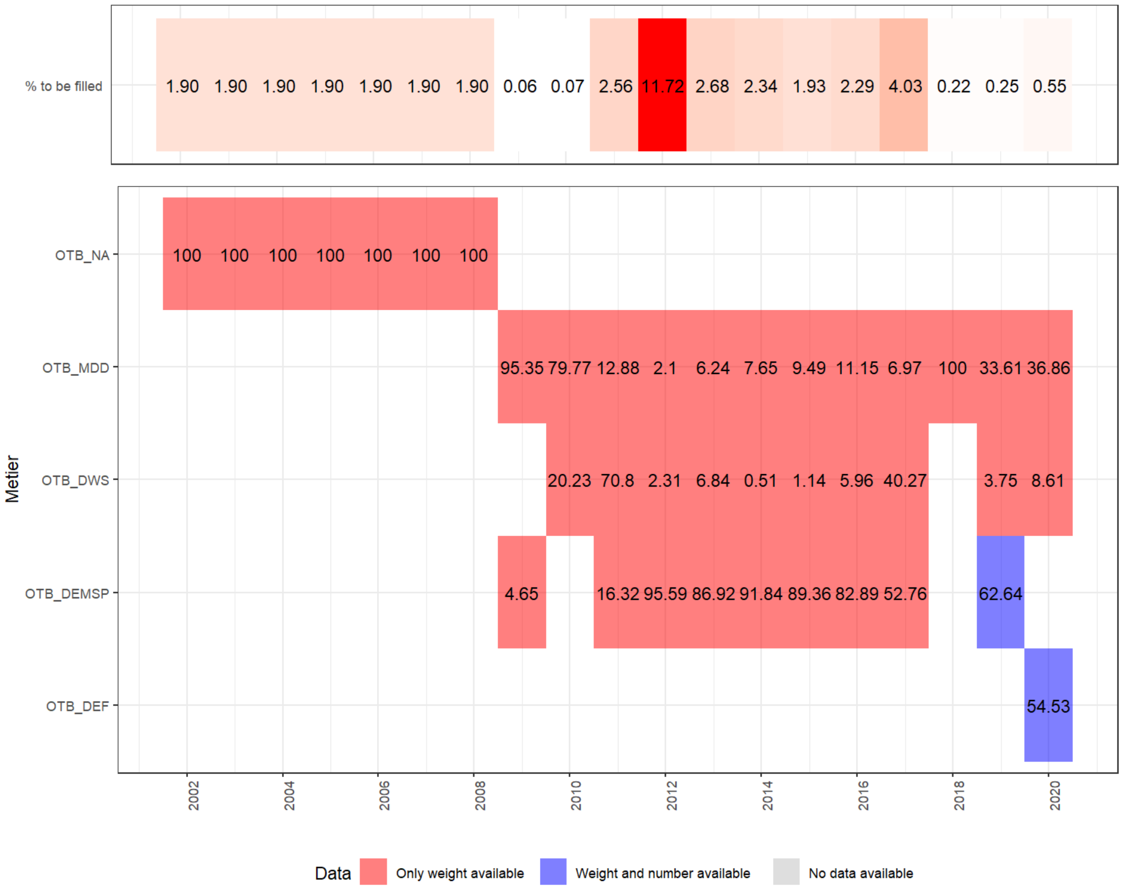


Fig. 6.8.2.1.4. Norway lobster in GSA 6: Available and reconstructed length frequencies for discards. Series of data with weight and length frequencies available in the DCF in blue; series with weight only for which length frequencies were reconstructed using median values in red.

Length frequencies for the catches for all years were recalculated, not only extended to 2020, because the member state had submitted newer data after EWG 2102. The annual length frequencies by gear are shown in Fig. 6.8.2.1.5.

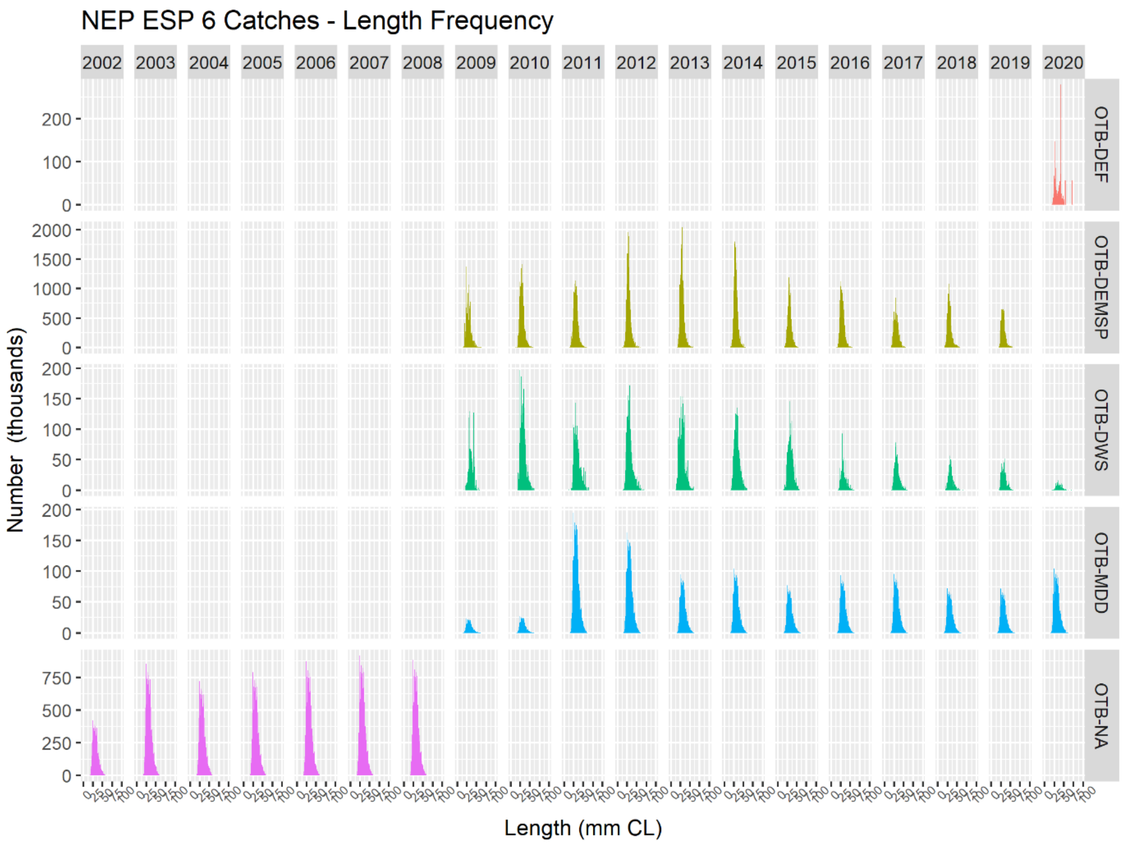


Fig. 6.8.2.1.5. Norway lobster in GSA 6: Reconstructed length frequency distribution of catches. Note that corrections for OTB_DEF in year 2020 were made for the stock assessment exercise; the accepted length distribution is shown in Fig. 6.8.2.1.6.

Several anomalous values were detected (they can be seen in Fig. 6.8.2.1.5, top-right panel) in the length frequency distribution of OTB_DEF for 2020 and corrected by smoothing the data with the average of the previous and following value in each length class (Fig. 6.8.2.1.6). Note that in addition to this issue, the remaining length frequency distribution is bimodal, which is quite different from the unimodal length frequency distributions normally observed for this species (cf. Fig. 6.8.2.1.5).

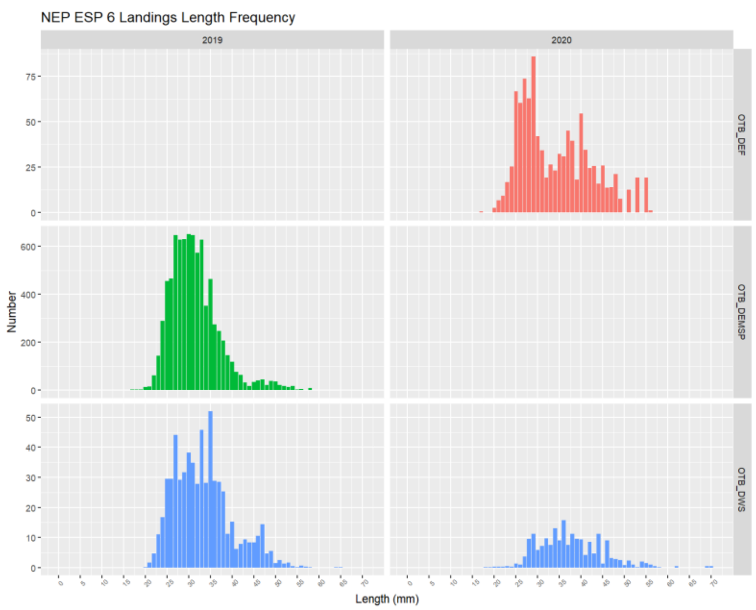


Fig. 6.8.2.1.6. Norway lobster in GSA 6: corrected length frequency distribution of landings of metier OTB_DEF for 2020, with length frequencies of other métiers in 2019 – 2020 for comparison.

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 were higher (Table 6.8.2.1.2) this is thought to be due to poor sampling in 2020.

Table 6.8.2.1.2. Norway lobster in GSA 6: values of SOP correction used to raise the annual catches in the length frequency data to total catches.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SOP	1.35	1.19	1.50	1.58	1.39	1.42	1.35	1.42	1.55	1.38	1.58	2.27

6.8.2.2 Effort

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

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 (Fig. 6.8.2.3.1). Note that in 2020 only the northern half of GSA 6 could be covered by the survey (approximately from 40 º latitude). Fig. 6.8.2.3.2 shows the distribution of trawl hauls in 2019 (as representative of the normal spatial coverage of the MEDITS sampling) and 2020.

Fig. 6.8.2.3.1. Time of MEDITS surveys in GSA 6.

2019	2020

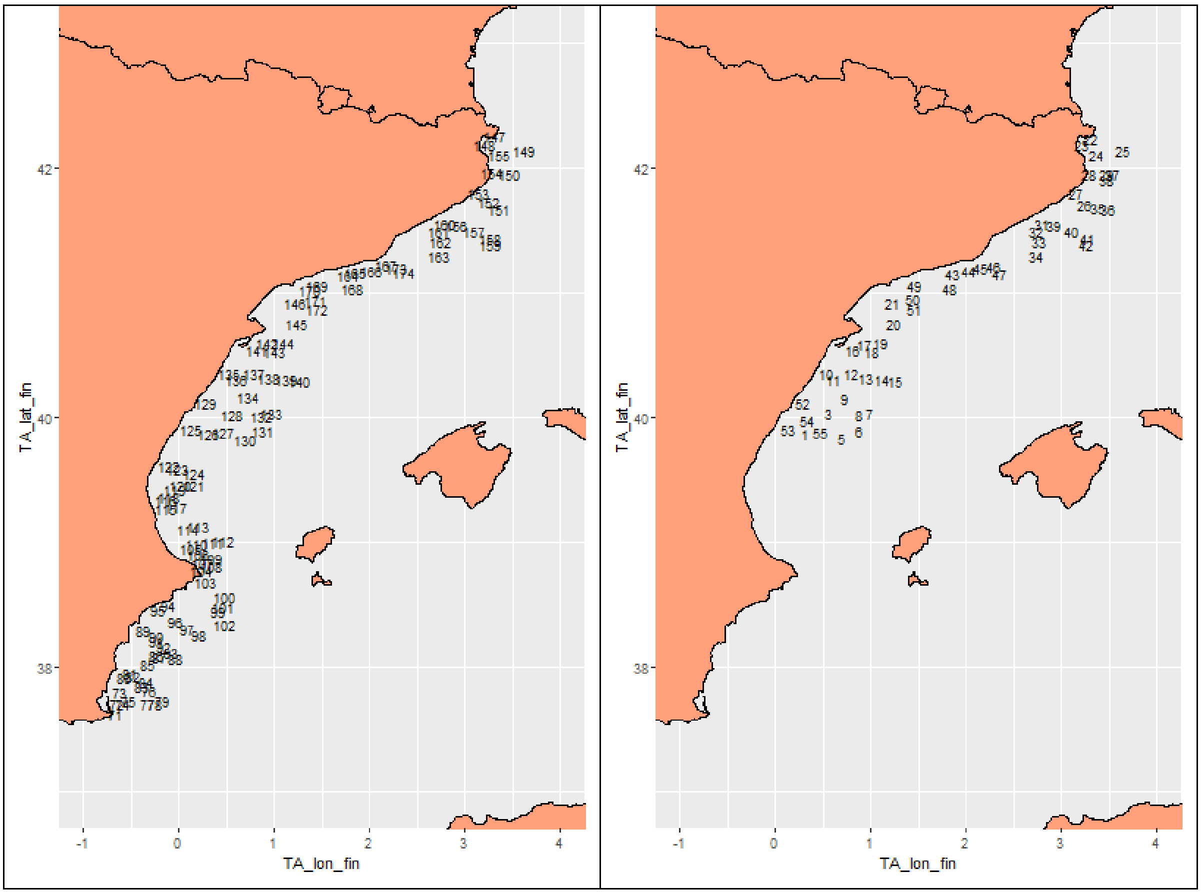


Fig. 6.8.2.3.2. GSA 6: Spatial distribution of trawl hauls in the 2019 MEDITS survey (left) compared with 2020 (right).

The length frequency distribution obtained during the MEDITS survey samplings is shown in Fig. 6.8.2.3.3.

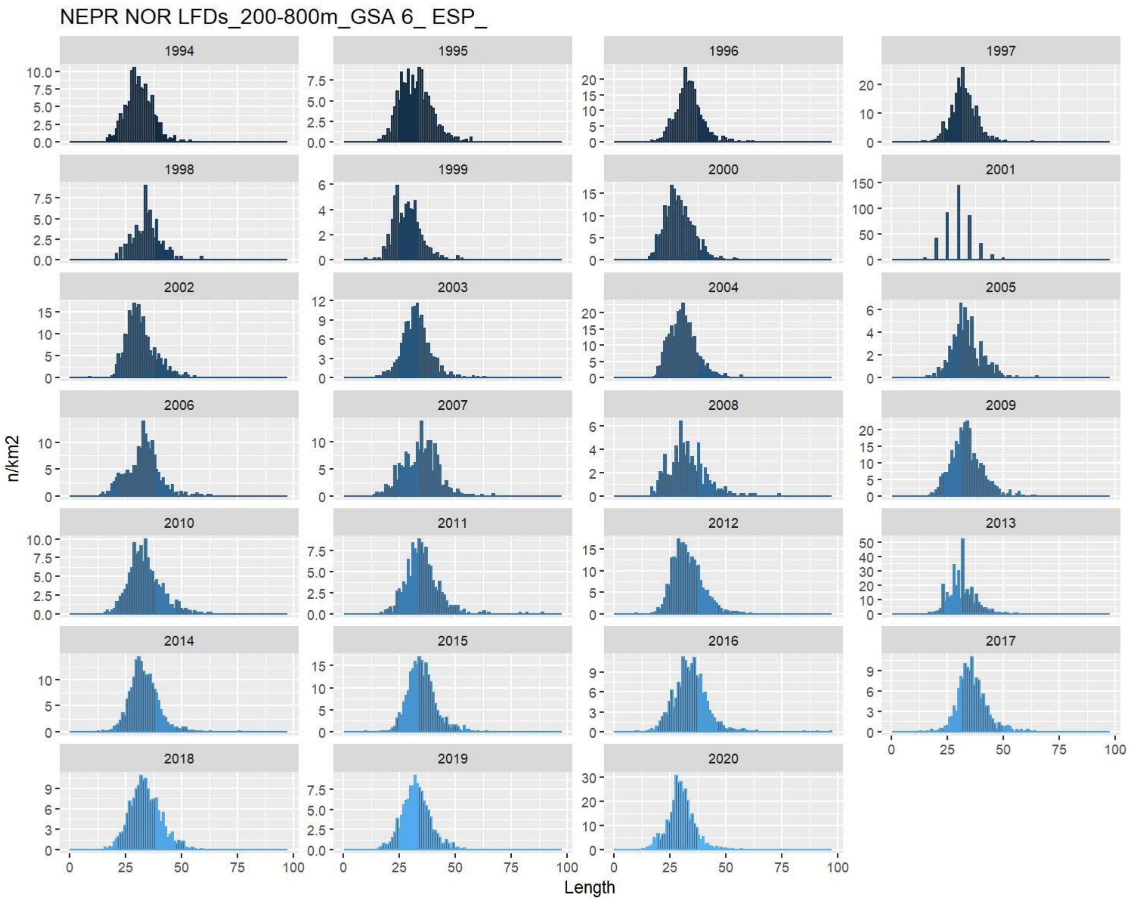


Figure 6.8.2.3.3. Norway lobster in GSA 6: Length frequency distribution by year in the MEDITS sampling. (Note that length frequencies in 2001 were reported in 5-mm bins, while 1-mm bins are used normally in all years for crustaceans).

The abundance indices derived from the MEDITS survey, in number of individuals / km^2 and kg / km^2, are shown in Figs. 6.8.2.3.4 and 6.8.2.3.5. The abundance of Norway lobster fluctuated without a trend over the 27-year period. The indicator n/km^2 in 2020 was the 3rd highest in the series, while the indicator kg/km^2 was not much higher than the average value in the series, indicating low average individual weight, which would suggest that 2020 was a year of higher-than-average recruitment.

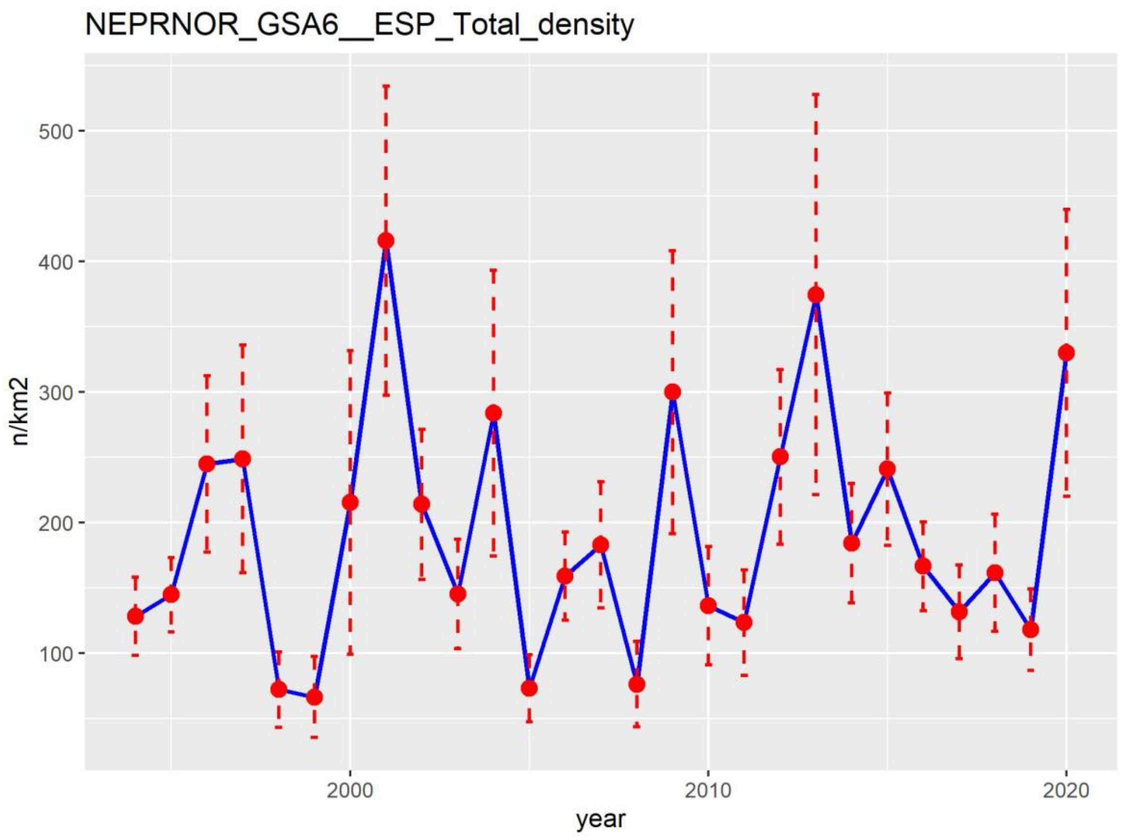


Figure 6.8.2.3.4. Norway lobster in GSA 6: Abundance index (n/km^2) estimated from MEDITS survey over the period 1994-2020.

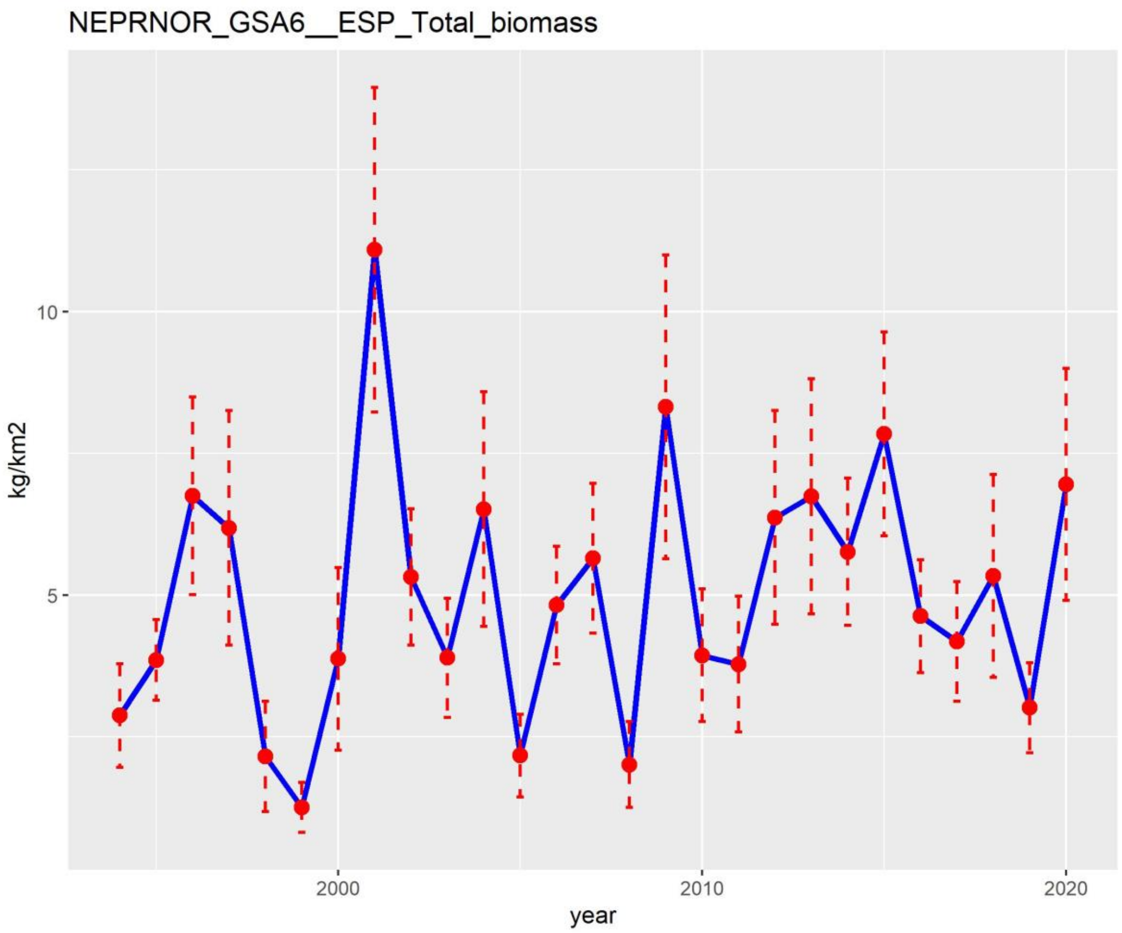


Figure 6.8.2.3.5. Norway lobster in GSA 6: Abundance index (kg/km^2) estimated from MEDITS survey over the period 1994-2020.

The length frequencies from the MEDITS series were converted to age frequencies with the standard **l2a** routine in Fla4a, adding 0.5 to the value of t_0. The resulting catch at age matrix is shown in Fig. 6.8.2.3.6. The figure shows that the abundance in age classes 2 and 3 in 2020 were the highest in the period 2009-2020.

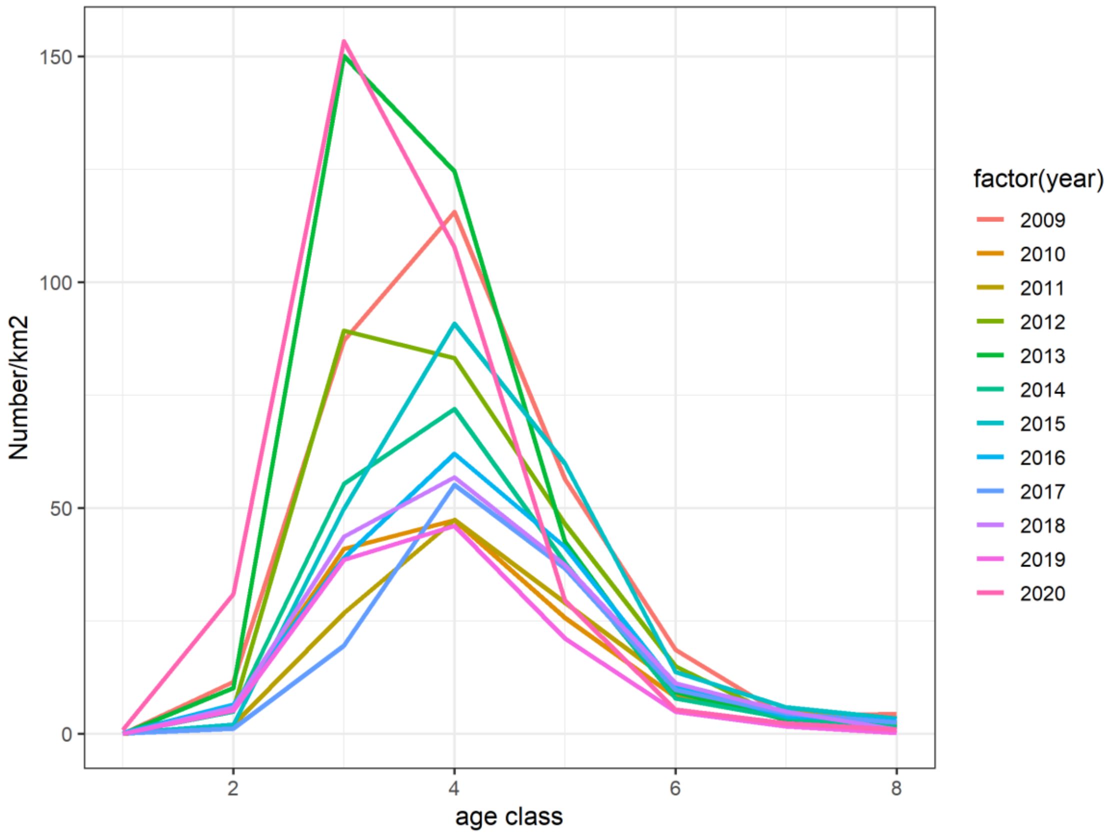


Figure 6.8.2.3.6. Norway lobster in GSA 6: Catch at age distribution in the MEDITS survey samples (data for years before 2009 have been omitted for clarity).

6.8.3 Stock assessment

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 2009-2020 for which data on length frequencies are available and of reasonably good quality.

Table 6.8.3.1. Norway lobster in GSA 6: Total Catch by year in tonnes.

2009	2010	2011	2012	2013	2014	2015	2016
355.61	406.51	508.21	571.89	490.70	500.79	361.58	314.47
2017	2018	2019	2020				
293.24	287.03	270.34	200.33				

Table 6.8.3.2. Norway lobster in GSA 6: Catch in numbers by age and by year.

Age	2009	2010	2011	2012	2013	2014	2015	2016
2	933.63	1117.80	2033.50	1539.60	1423.20	733.89	473.56	1228.00
3	7202.50	9743.80	8822.70	13217.00	12894.00	11339.00	6163.00	8374.90
4	4263.40	5778.10	6912.20	6219.70	6230.30	7046.40	5563.10	4182.30
5	1389.60	1815.10	2392.80	1933.20	1858.00	2095.80	1888.70	1216.10
6	586.69	563.70	739.84	626.35	551.77	544.95	504.05	343.94

7	240.40	228.14	357.18	255.37	195.73	275.22	145.59	121.84
8	53.13	86.47	116.63	117.68	57.93	43.30	36.40	37.88
9+	20.75	22.84	32.38	24.98	39.33	15.34	3.80	6.84
age	2017	2018	2019	2020				
2	1196.60	531.45	224.82	301.86				
3	5610.70	6646.60	4605.50	1173.20				
4	3751.30	3909.30	3512.20	748.65				
5	1426.30	1161.30	1117.30	510.61				
6	435.24	325.45	285.59	220.59				
7	184.08	211.72	178.42	93.46				
8	44.03	68.05	46.64	57.19				
9+	9.09	7.08	12.48	3.12				

The catch at age in numbers is also shown in Fig. 6.8.3.1. Note that the years 2019 and 2020 had the lowest values in the 2009-2020 period.

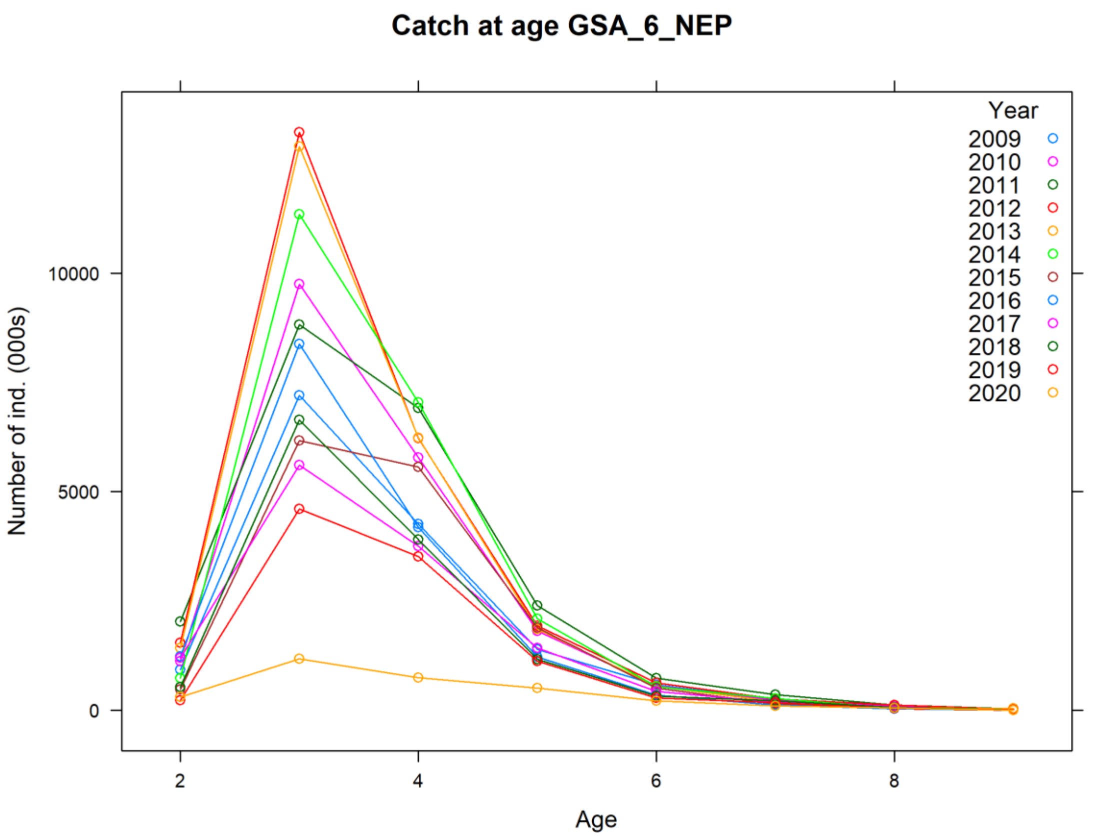


Fig. 6.8.3.1. Norway lobster in GSA 6: Catch in numbers by age and by year.

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	0.0057	0.0060	0.0056	0.0059	0.0057	0.0060	0.0060	0.0061

3	0.0133	0.0135	0.0140	0.0138	0.0137	0.0142	0.0145	0.0131
4	0.0271	0.0261	0.0266	0.0258	0.0259	0.0261	0.0261	0.0261
5	0.0446	0.0446	0.0441	0.0448	0.0445	0.0443	0.0441	0.0441
6	0.0666	0.0688	0.0694	0.0695	0.0690	0.0693	0.0687	0.0687
7	0.0944	0.0972	0.0986	0.0985	0.0960	0.0959	0.0953	0.0984
8	0.1278	0.1280	0.1315	0.1310	0.1276	0.1282	0.1263	0.1275
9+	0.1611	0.1603	0.1601	0.1570	0.1589	0.1599	0.1570	0.1566
age	2017	2018	2019	2020				
2	0.0061	0.0061	0.0062	0.0061				
3	0.0136	0.0138	0.0140	0.0135				
4	0.0268	0.0258	0.0263	0.0272				
5	0.0443	0.0446	0.0436	0.0490				
6	0.0685	0.0697	0.0714	0.0694				
7	0.0998	0.0972	0.0977	0.0955				
8	0.1287	0.1278	0.1266	0.1276				
9+	0.1611	0.1553	0.1593	0.1581				

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	0.25	0.8	1.	1.	1.	1.	1.	1.
M: Chen-Watanabe	0.466	0.353	0.291	0.252	0.225	0.206	0.192	0.181

Average spawning time set 0.5

Catch 2009 to 2020 age range 2 to 9+

Fbar set 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	11.55	5.25	2.03	5.50	10.13	4.95	2.02	6.49
3	87.11	41.00	26.79	89.27	150.17	55.35	49.77	38.98
4	115.59	47.35	47.38	83.24	124.60	71.97	90.87	62.04
5	56.44	25.73	29.02	46.45	42.53	37.95	59.85	41.38
6	18.66	8.19	10.74	14.93	9.26	7.82	13.69	10.53
7	3.78	5.22	4.00	3.19	3.14	3.50	5.88	3.92
8	4.38	2.36	2.03	2.52	1.03	1.49	3.39	3.04
age	2017	2018	2019	2020				
2	1.16	5.89	5.14	30.94				
3	19.53	43.61	38.57	153.37				
4	55.13	56.80	46.07	107.79				

5	36.64	37.40	21.13	29.51				
6	9.72	11.23	4.95	5.39				
7	4.49	4.92	1.65	2.38				
8	2.57	0.99	0.29	0.96				

The internal consistency of the catch at age data is good (Fig. 6.8.3.2) but the index at age data is not (Fig. 6.8.3.3)

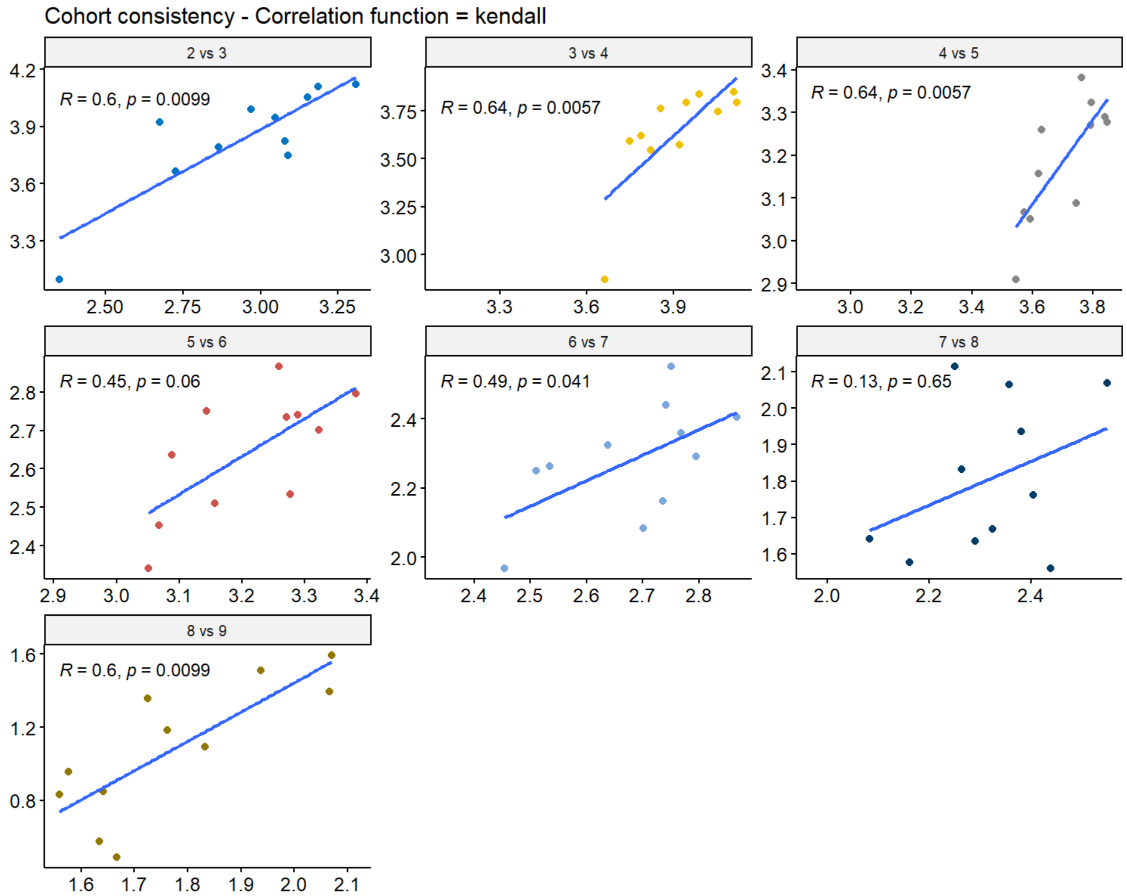


Fig. 6.8.3.2. Norway lobster in GSA6: Consistency of cohorts of the catch-at-age data.

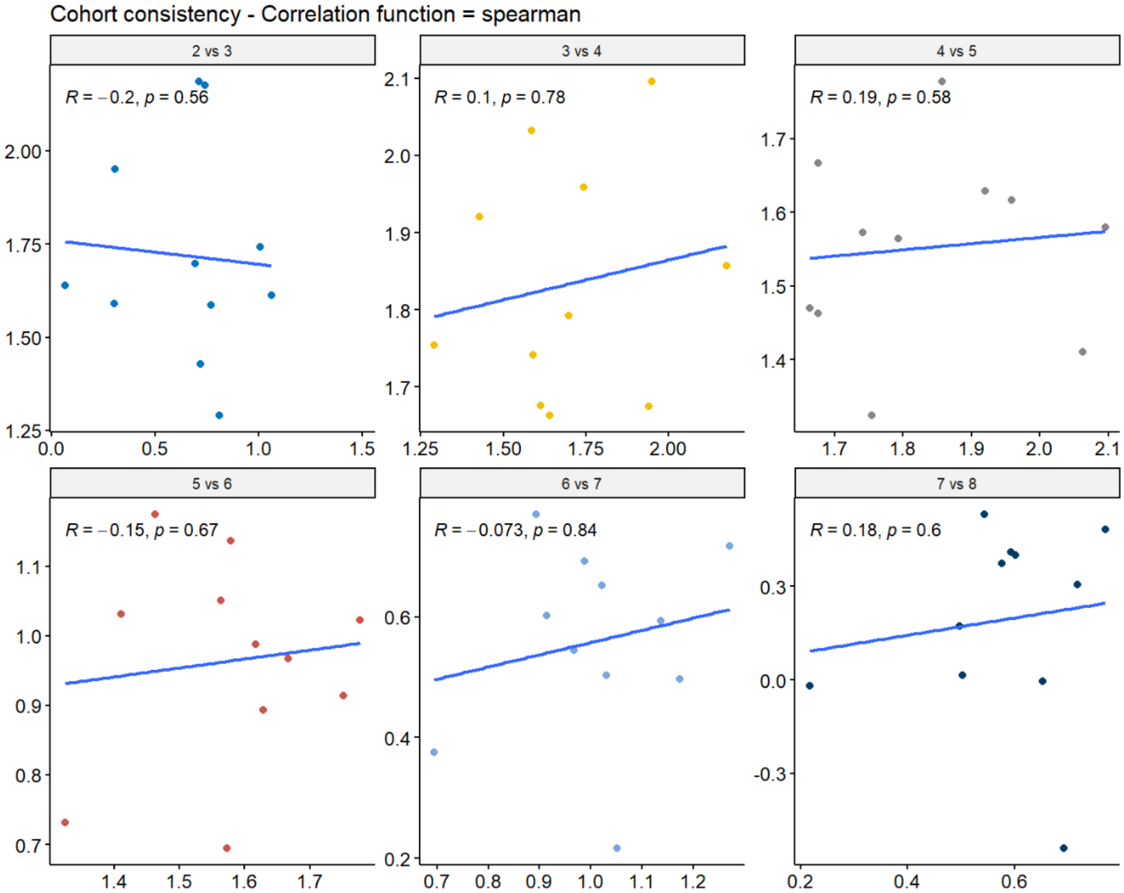


Fig. 6.8.3.3. Norway lobster in GSA6: Consistency of cohorts of the index-at-age data.

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)))

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. Note that the sensitivity of the model's results to the incomplete MEDITS 2020 survey was tested and it was deemed not significant (model runs with or without MEDITS 2020 index). In the results reported here, the MEDITS data for 2020 are included.

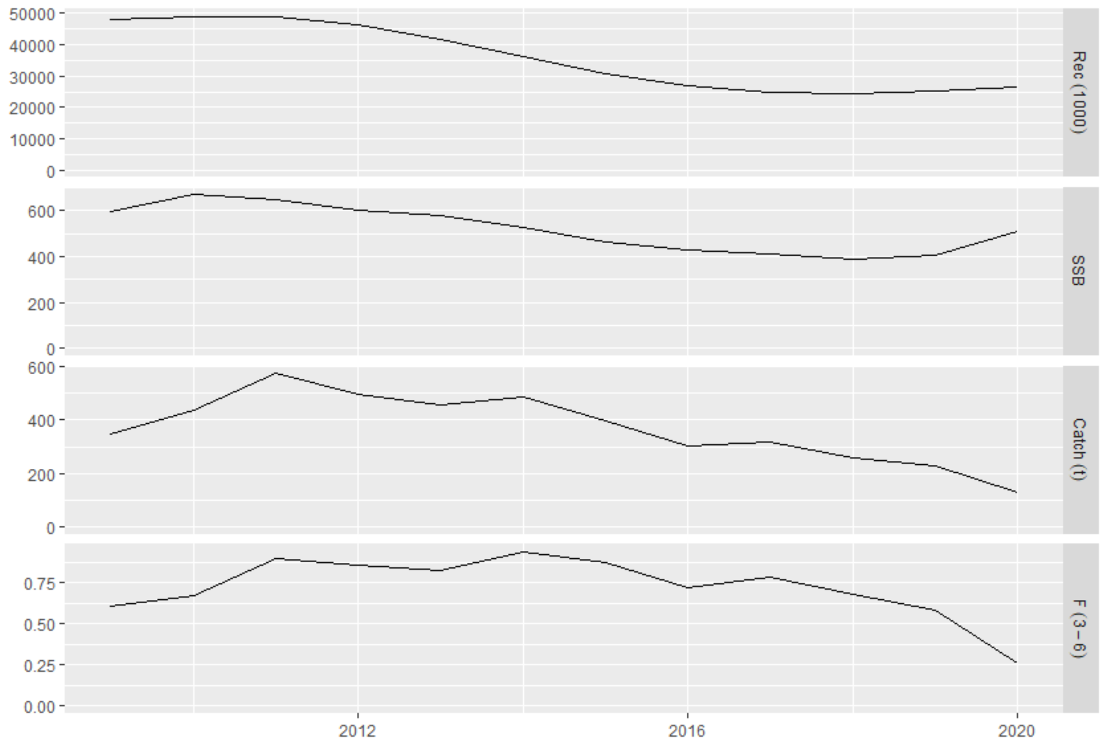


Figure 6.8.3.2. Norway lobster in GSA 6: Stock summary from the final a4a model.

Table 6.8.3.6. Norway lobster in GSA 6: Stock summary from the a4a assessment.

	Fbar	Rec. (000)	SSB (t)	TB (t)	Catch (t)
2009	0.603	48157	595.5	1178.11	348.95
2010	0.673	49082	667.7	1346.22	434.33
2011	0.897	48825	649.3	1411.96	572.47
2012	0.860	46377	599.1	1297.32	495.22
2013	0.821	41736	575.4	1212.46	455.90
2014	0.936	36037	527.4	1159.41	483.52
2015	0.877	30750	465.6	997.26	397.82
2016	0.722	26874	427.5	856.33	301.02
2017	0.785	24749	409.1	834.77	317.49
2018	0.681	24267	387.3	761.79	256.98
2019	0.579	25063	406.3	767.56	227.24
2020	0.258	26591	510.0	826.53	128.14

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	48157	49082	48825	46377	41736	36037	30750	26874
3	25343	29428	29901	29456	28025	25263	21705	18568
4	9174	11744	12994	11316	11438	11179	9307	8328
5	3369	3540	4197	3634	3296	3477	2995	2660
6	1270	1272	1229	1114	1009	959	881	814

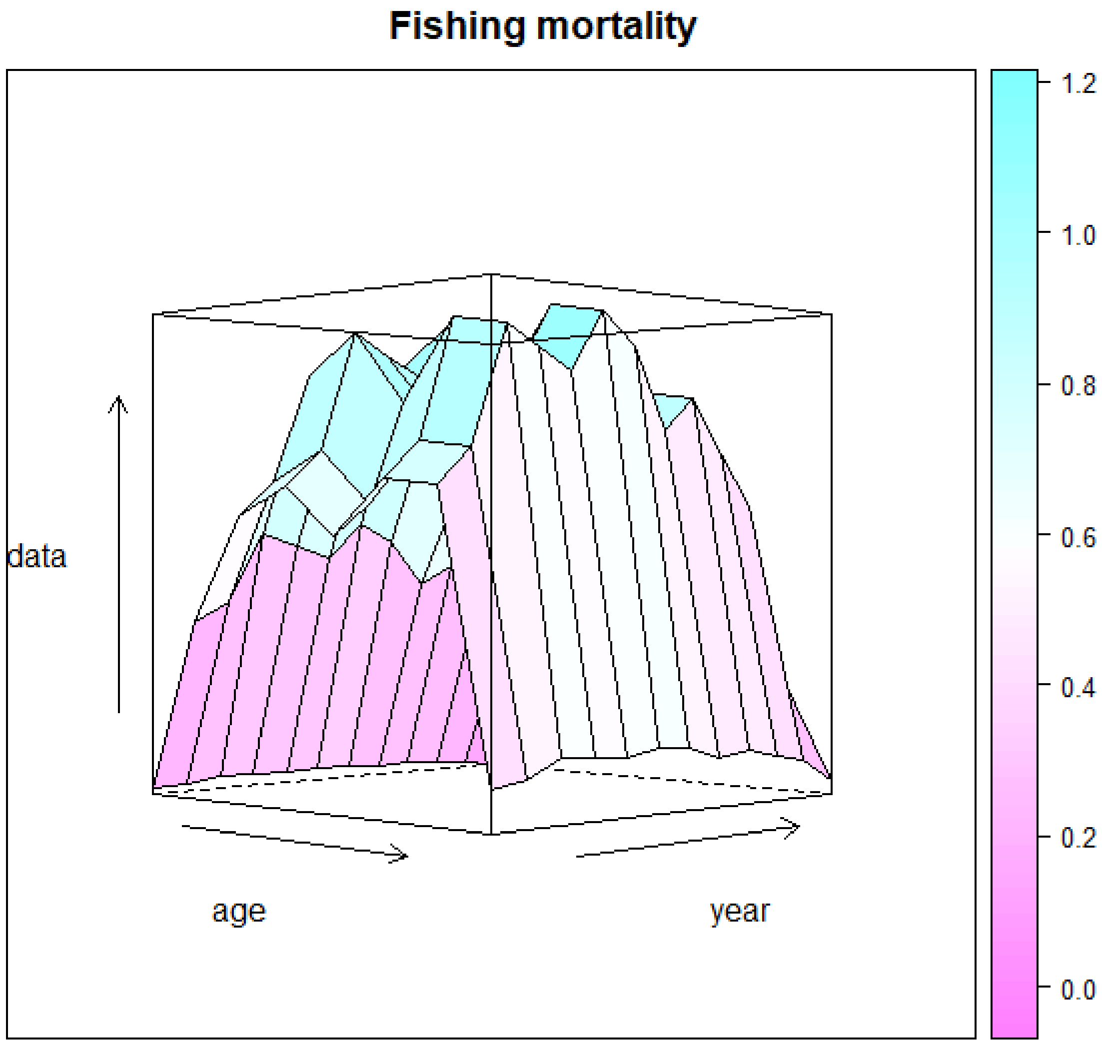
7	493	549	512	394	371	349	295	288
8	197	193	197	140	113	112	91	83
9+	80	140	176	183	174	162	146	132

age	2017	2018	2019	2020
2	24749	24267	25063	26591
3	16337	15004	14779	15332
4	7926	6677	6591	6966
5	2820	2505	2366	2613
6	870	856	861	920
7	312	313	342	382
8	98	98	111	138
9+	127	124	129	144

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	0.026	0.029	0.039	0.037	0.036	0.041	0.038	0.031
3	0.416	0.464	0.618	0.593	0.566	0.645	0.605	0.498
4	0.661	0.738	0.983	0.942	0.899	1.026	0.961	0.792
5	0.722	0.806	1.074	1.030	0.983	1.121	1.050	0.865
6	0.613	0.685	0.912	0.874	0.835	0.952	0.892	0.735
7	0.732	0.817	1.088	1.043	0.996	1.136	1.064	0.877
8	0.716	0.799	1.064	1.020	0.974	1.111	1.041	0.857
9+	0.100	0.112	0.149	0.143	0.137	0.156	0.146	0.120

age	2017	2018	2019	2020
2	0.034	0.030	0.025	0.011
3	0.541	0.469	0.399	0.178
4	0.861	0.746	0.634	0.282
5	0.941	0.815	0.693	0.308
6	0.799	0.692	0.588	0.262
7	0.953	0.826	0.702	0.313
8	0.932	0.808	0.687	0.306
9+	0.131	0.113	0.096	0.043


Fishing mortality
data
age
year
1.2
1.0
0.8
0.6
0.4
0.2
0.0

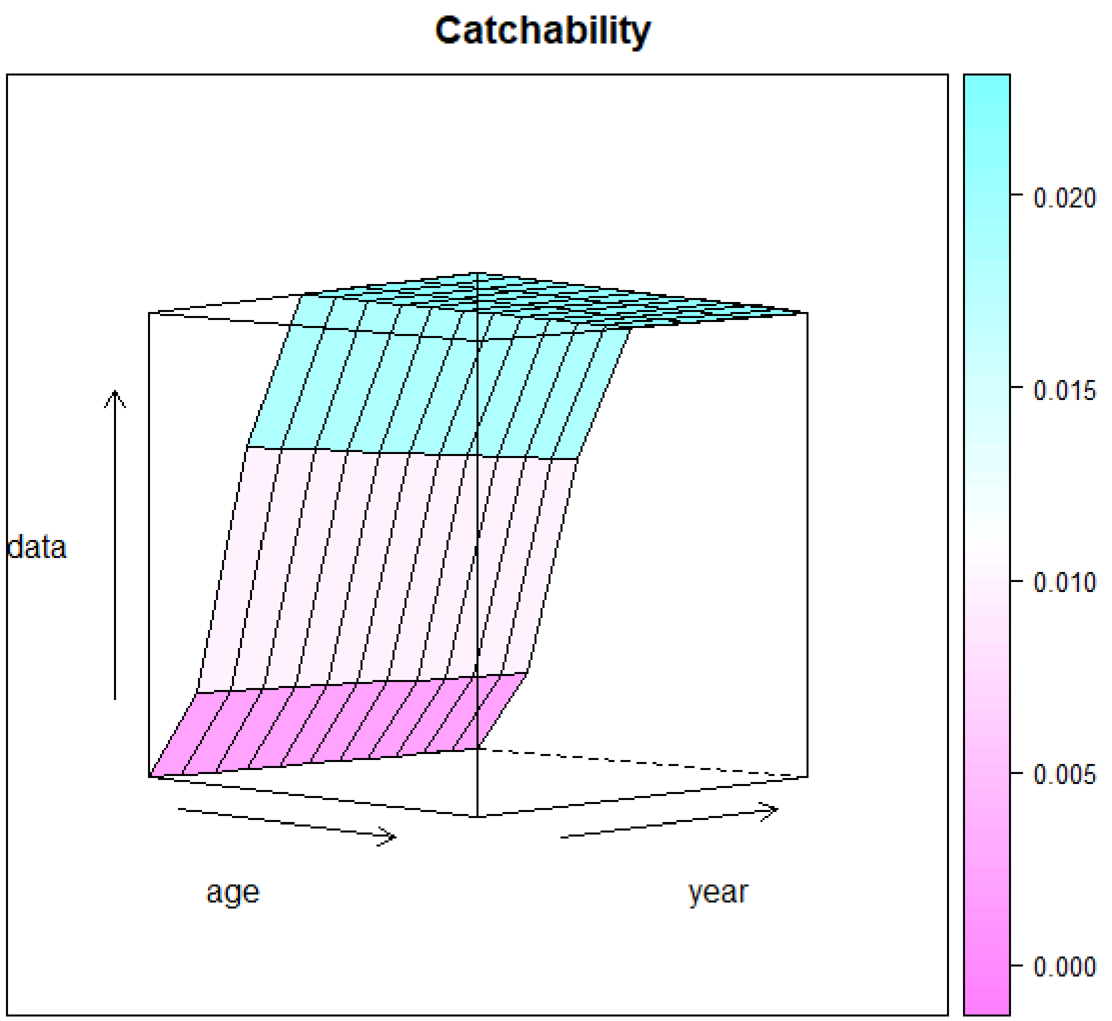


Figure 6.8.3.3. Norway lobster in GSA6: 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.

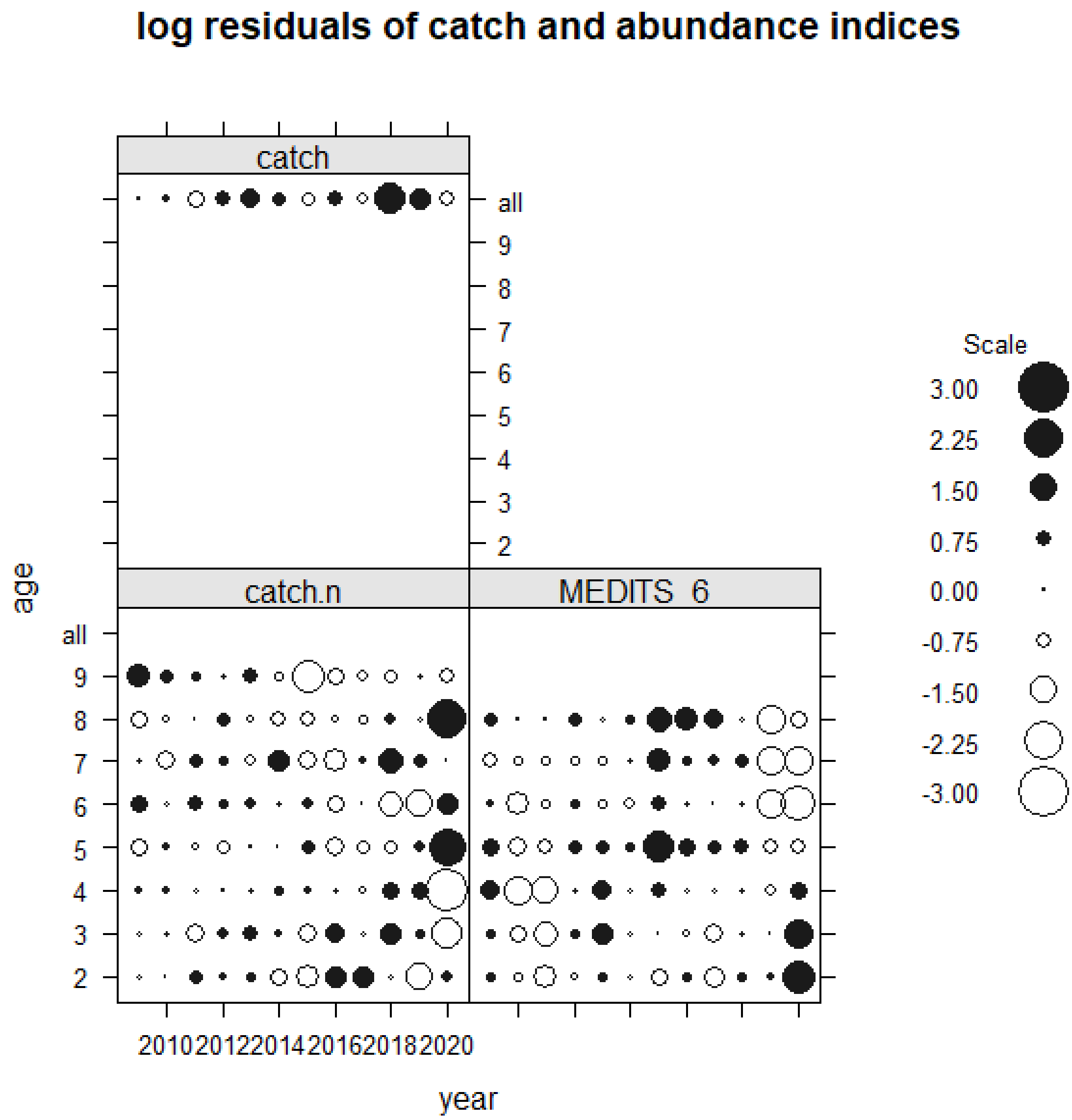


Figure 6.8.3.4. Norway lobster in GSA6: Standardized residuals for abundance indices and for catch numbers.

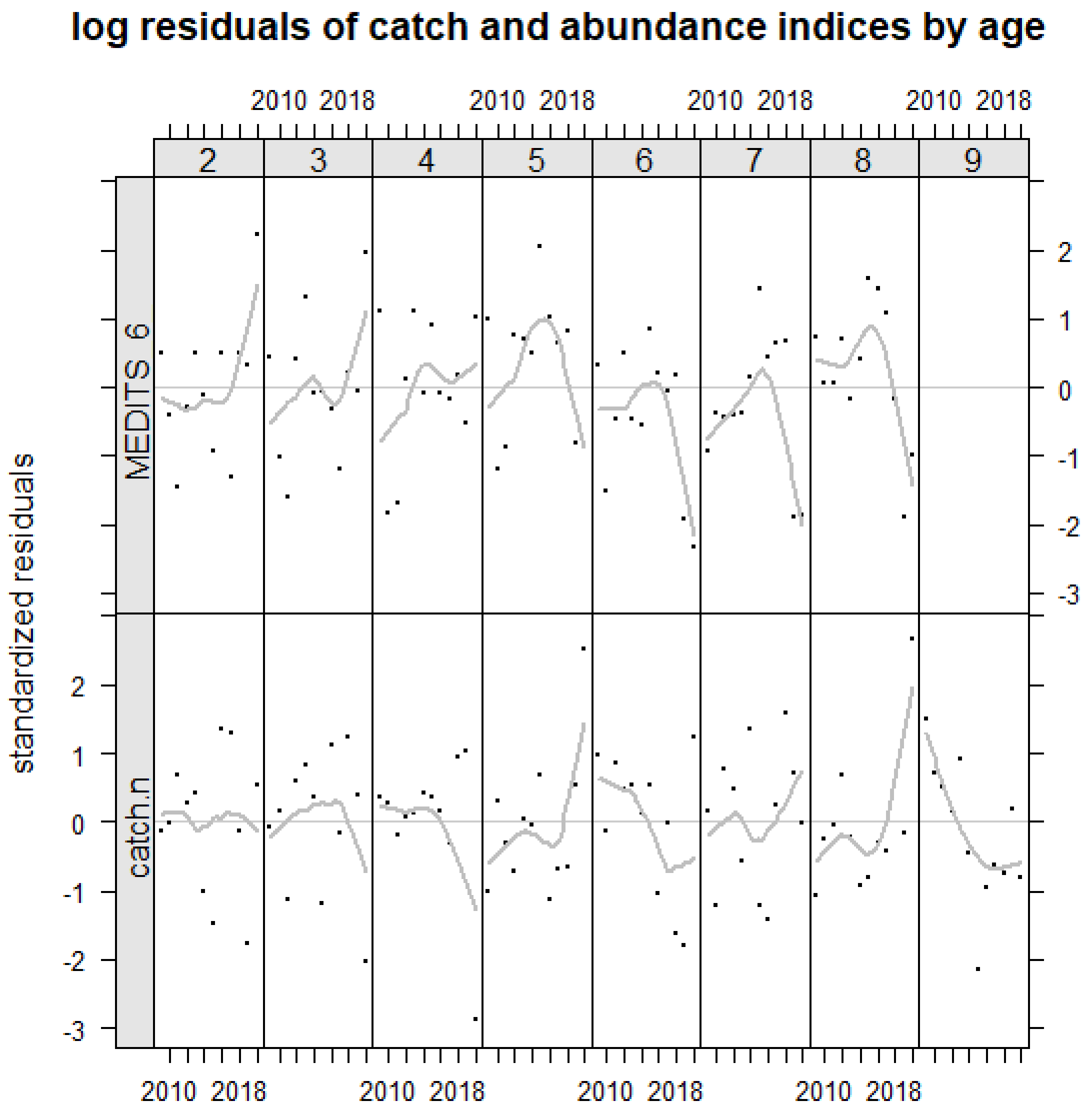


Figure 6.8.3.5. Norway lobster in GSA6: Standardized residuals for abundance indices and for catch numbers.

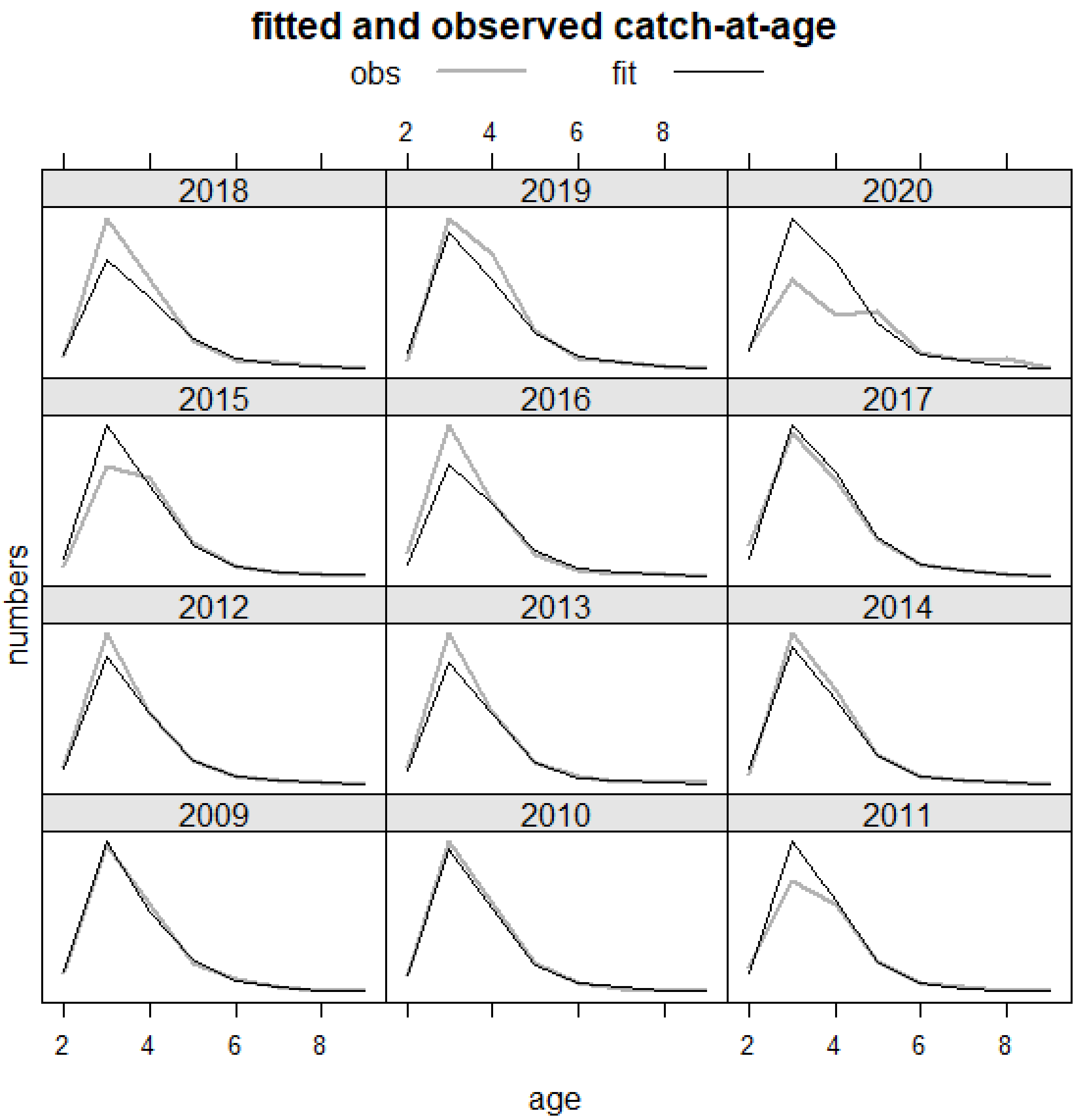


Figure 6.8.3.6. Norway lobster in GSA6: Fitted and observed catch-at-age.

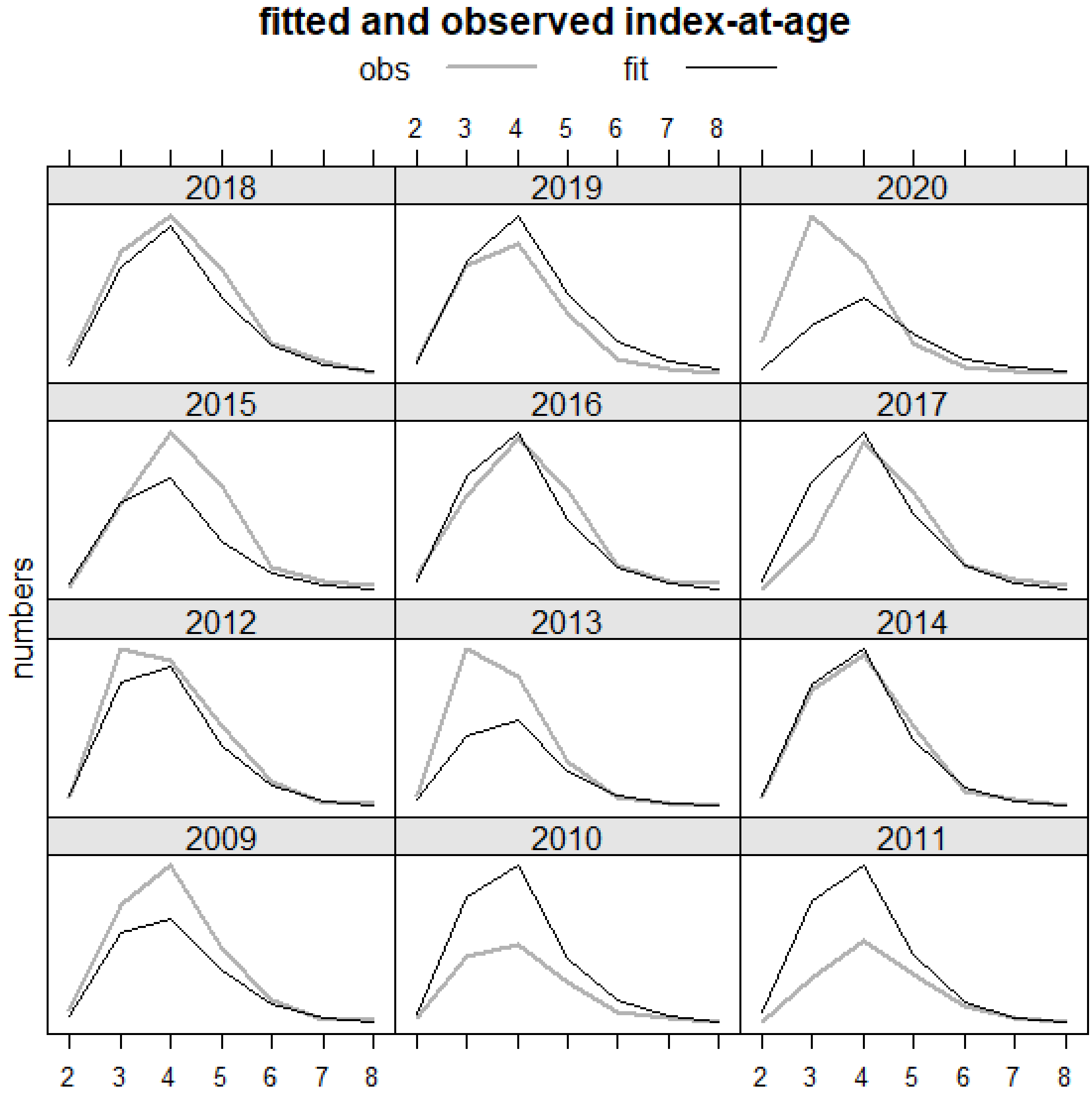


Figure 6.8.3.7. Norway lobster in GSA6: Fitted and observed index-at-age.

Retrospective

The retrospective analysis was applied up only to 2 years back, due to the short time series. Models results were not especially good (Figure 6.8.3.8) probably because of the relatively short data series (12 years) for a long-lived species.

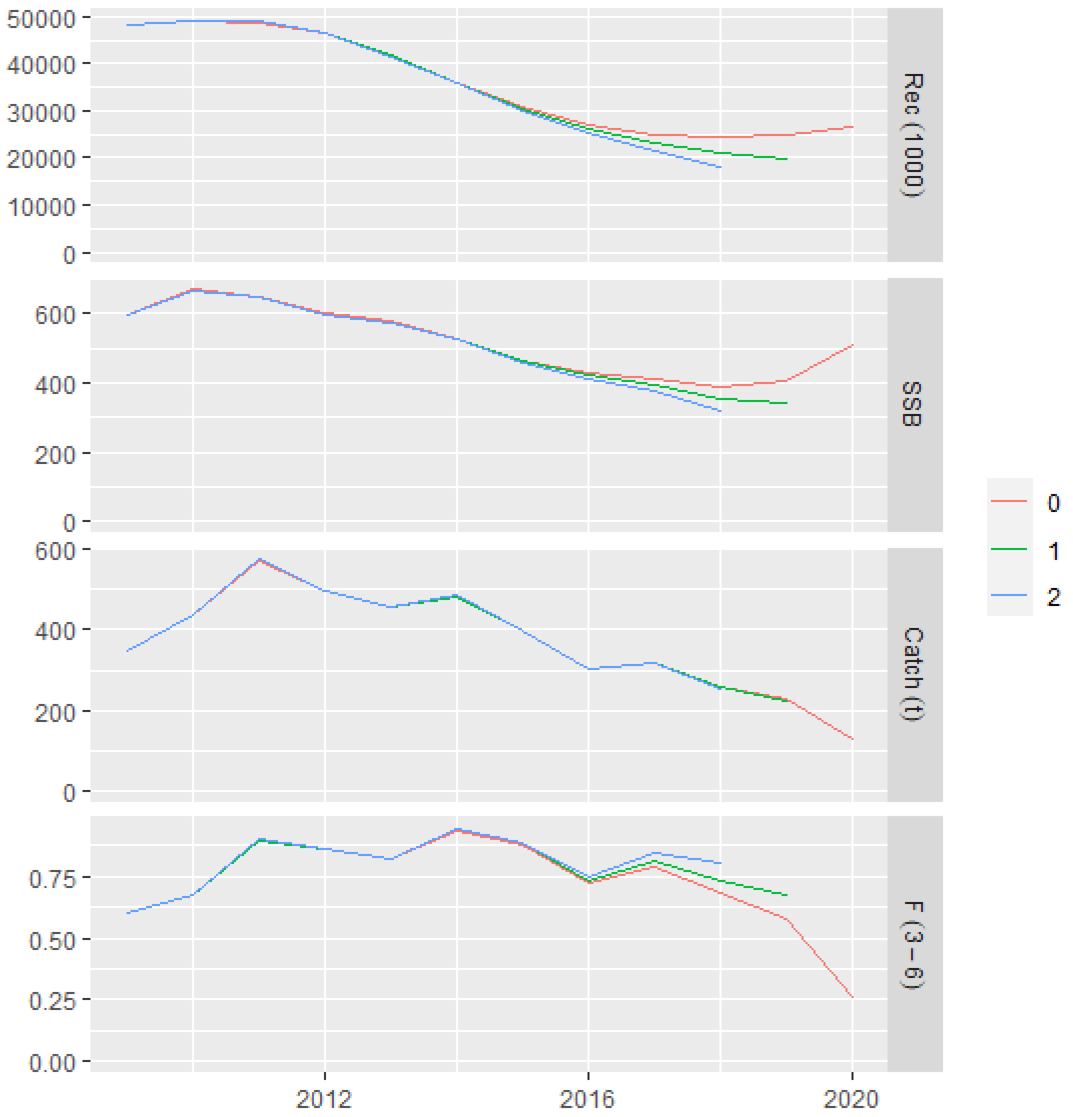


Figure 6.8.3.8. Norway lobster in GSA 6: Retrospective analysis.

Conclusions to the assessment

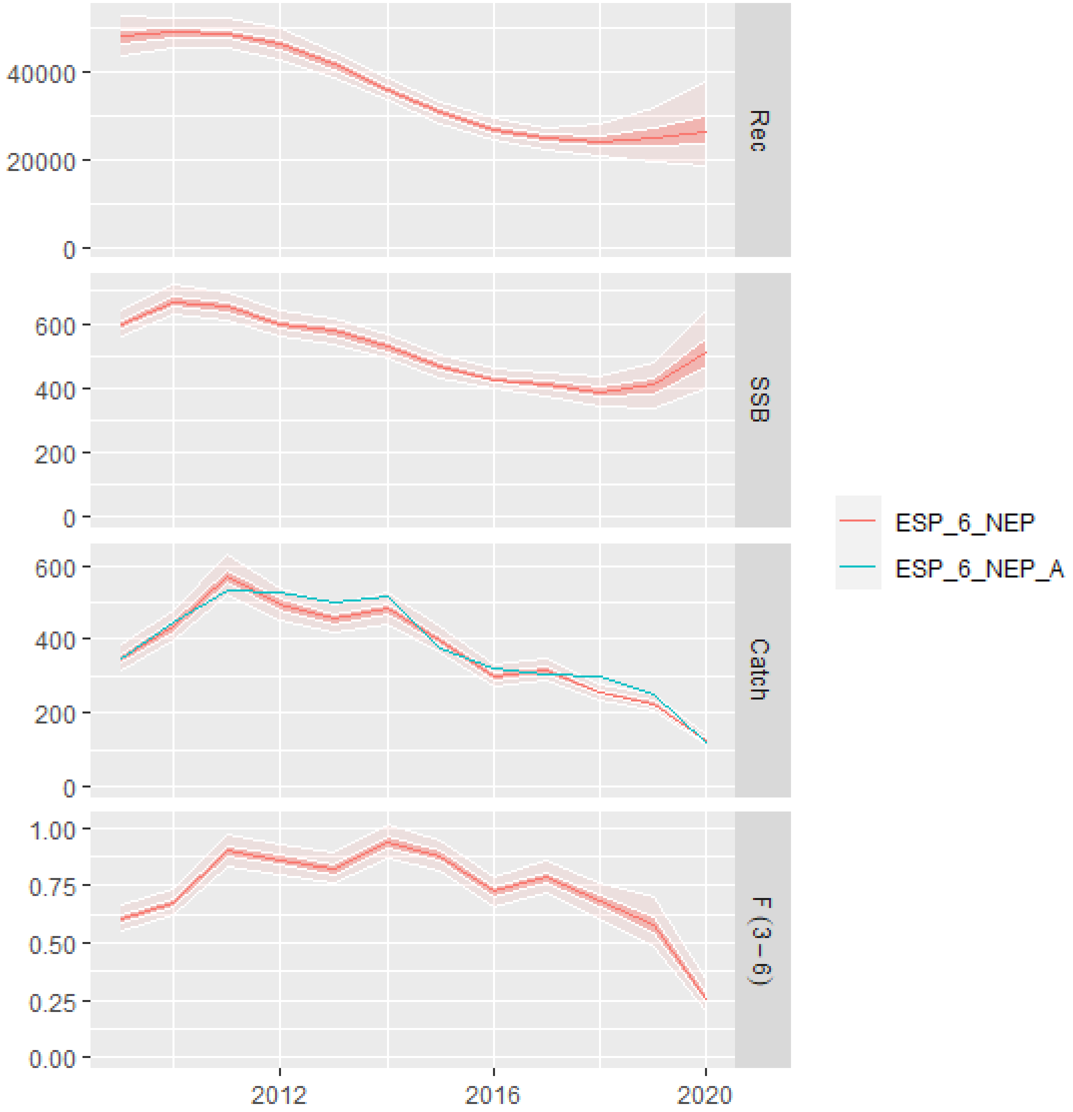


Figure 6.8.3.9. Norway lobster in GSA 6: Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals for the period 2009 to 2020.

The stock assessment results show that fishing mortality Fbar (3-6) has been decreasing progressively between 2014 and 2019 and fell abruptly in 2020 both because catches were reported reduced, but also because the MEDITS survey index shows an increase in 2020. The survey index is more uncertain than usual due to partial area coverage (Section 6.6.2.3). Fishing mortality was above F_{MSY} (using the F_{01} proxy, see section 6.8.4) for all years except 2020, when it reached a value very near F_{MSY}, cf. Fbar(3:6) [2000] = 0.258 with F_{01} = 0.257. Recruitment and SSB appear to be increasing since 2018, although they are still at low levels compared with the early years of the data series (2009 – 2012).

6.8.4 Reference Points

Based on the stock assessment results, the reference points obtained are shown in Table 6.8.4.1, calculated with the methods in library FLBRP. Because the data series is short and insufficient to fit a stock-recruitment relationship, the reference points were calculated based on equilibrium methods. As recommended in STECF EWG 18-02, F_{01} is used as a proxy for F_{MSY}.

Table 6.8.4.1. Norway lobster in GSA 6: Reference points.

Refpt	harvest	yield	rec	ssb	biomass
virgin	0	0	45900	4310	4520
msy	0.096	306	45900	3310	3550
crash	0.535	0	45900	0	0
$F_{0.1}$	0.257	476	45900	1870	2090
fmax	0.396	334	45900	845	993
spr.30	0.351	405	45900	1150	1340

Current F was taken as F_c = 0.258, based on Fbar(3-6) for 2020, because the fishing mortality had been decreasing for the previous 3 years. This value is practically the same as F_{01} = 0.257, suggesting that the Norway lobster in GSA 6 is fully exploited at a level consistent with high long-term yield. Assessment results are consistent with the previous year (EWG 2009), but the exploitation ratio F_c / F_{MSY} in the present assessment is practically 1.0, while in the previous assessment it was estimated at 5.64. This difference is due to the important reduction in catches observed in 2020; the estimated exploitation ratio for 2009-2019 is very similar in both the previous and the current assessment.

The quality of the assessment is not worse than the one in EWG 2009 despite incomplete MEDITS survey in 2020. The diagnostics of the selected model are good.

6.8.5 Short Term Forecast and Catch Options

A deterministic short term prediction for the period 2021 to 2023 was performed using the standard FLR libraries and scripts, 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 increasing in the last two years, and a geometric mean of the estimated recruitments for the last five years was considered (2016 to 2020), corresponding to a value of 25,487.91 x 10^3 individuals. The Fsq was taken as the Fbar(3-6) for 2021, given the decreasing pattern observed in F, Fsq = 0.258.

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 (2021)	0.258	Fsq = F in the last year (2020)
SSB (2021)	643.42	SSB intermediate year from STF output
R age2 (2021, 2022)	25487.91	Recruitment will be set as geometric mean of the last 5 years
Total Catch (2021)	168.84	Catch intermediate year from STF output

Table 6.8.5.2. Norway lobster in GSA 6: Short Term Forecast.

Rationale	Ffactor	Fbar	Recruitment 2021	Fsq 2021	Catch 2020	Catch 2021	Catch 2022	SSB 2021	SSB 2023	SSB_change 2021-2023(%)	Catch_change 2020-2022(%)
$F_{0.1}$	0.997	0.257	25487.91	0.258	128	169	206	643	884	37.41	60.99
F upper	1.376	0.354	25487.91	0.258	128	169	272	643	778	20.85	112.04
F lower	0.670	0.173	25487.91	0.258	128	169	144	643	990	53.87	12.67
F_{MSY} transition	1.622	0.418	2547.91	0.258	128	169	311	643	716	11.35	142.63
Zero catch	0	0	25487.91	0.258	128	169	0	643	1255	95.05	-100.00
Status quo	1	0.258	25487.91	0.258	128	169	207	643	883	37.29	61.37
Different Scenarios	0.1	0.026	25487.91	0.258	128	169	23	643	1211	88.18	-81.91
	0.2	0.052	25487.91	0.258	128	169	46	643	1168	81.58	-64.28
	0.3	0.077	25487.91	0.258	128	169	68	643	1128	75.24	-47.11
	0.4	0.103	25487.91	0.258	128	169	89	643	1088	69.15	-30.38
	0.5	0.129	25487.91	0.258	128	169	110	643	1051	63.30	-14.08
	0.6	0.155	25487.91	0.258	128	169	130	643	1015	57.67	1.80
	0.7	0.180	25487.91	0.258	128	169	150	643	980	52.27	17.28
	0.8	0.206	25487.91	0.258	128	169	170	643	946	47.08	32.36
	0.9	0.232	25487.91	0.258	128	169	188	643	914	42.08	47.05
	1.1	0.283	25487.91	0.258	128	169	225	643	854	32.67	75.33
	1.2	0.309	25487.91	0.258	128	169	242	643	825	28.24	88.93
	1.3	0.335	25487.91	0.258	128	169	259	643	798	23.98	102.19
	1.4	0.361	25487.91	0.258	128	169	276	643	771	19.88	115.11
	1.5	0.386	25487.91	0.258	128	169	292	643	746	15.94	127.71
	1.6	0.412	25487.91	0.258	128	169	308	643	722	12.16	139.98
	1.7	0.438	25487.91	0.258	128	169	323	643	698	8.51	151.95
	1.8	0.464	25487.91	0.258	128	169	338	643	676	5.01	163.62
	1.9	0.489	25487.91	0.258	128	169	352	643	654	1.64	175.00
	2	0.515	25487.91	0.258	128	169	367	643	633	-1.60	186.09

6.8.6. Data deficiencies

The quality of the stock assessment is acceptable, despite some data deficiencies that were identified during the exercise. The data deficiencies due to issues with the length frequency distributions were corrected for the exercise, but the member state should consider the following:

- length frequency distribution of landings should be revised for 2020, OTB_DEF. There are some evident errors, but there may be more not easily spotted.

- length frequency distribution of discards for 2019, OTB_DEMSP contain unbelievable large values.

- 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.

6.9 HAKE IN GSA 8, 9, 10 AND 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.

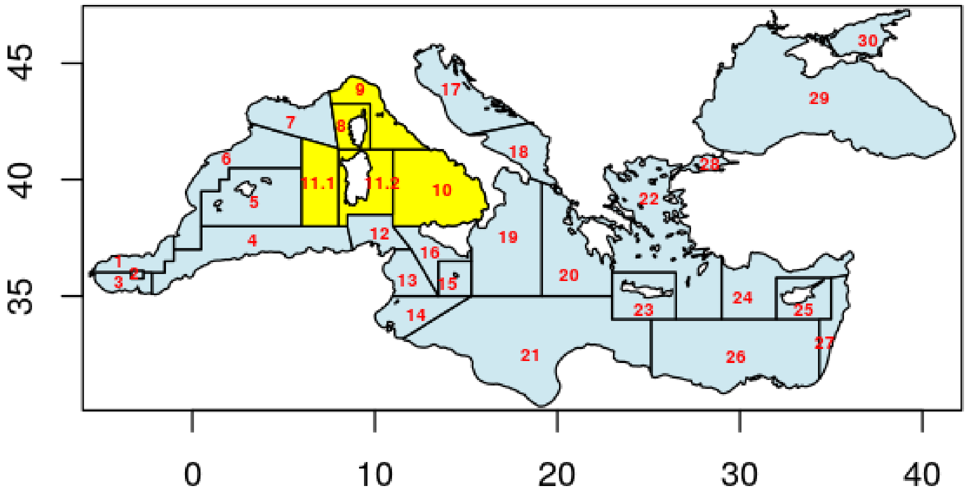


Figure 6.9.1.1. **European hake in GSAs 8, 9, 10 & 11.** Map of the stock unit.

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 GFCM benchmark meeting in 2019 and EWG 20-09 in 2020 (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 or finfish living on hard bottoms. There are no available data for the size structure of the landings of hake from GSA 8, 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 21-11 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 landing is around the 35% in GSAs 9 and 10; longlines in GSA 10 contribute for around the 17% to the total landing. In GSA 11 landing data come exclusively from the bottom trawl fishery. In GSA8, catch data, proceeding from the limited number of trawlers cover only the period 2009-2019. Landings are very low in all the years where data are available and the discards are not included in the catch because no information is available. Reconstructed data were estimated from 2005 to 2008, considering an average of the available information.
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.

	GSA9		GSA11		GSA10		GSA8	Total		
Year	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Landings	Discards	Total catches
2005	1859.98	**348.30**	397.39	158.59	1484.74	**66.70**	**15.00**	3757.11	573.59	4330.70
2006	2176.49	105.20	341.06	595.48	1544.07	26.57	**15.00**	4076.63	727.26	4803.88
2007	1733.03	**338.74**	169.58	**106.57**	1268.66	**69.84**	**15.00**	3186.28	515.14	3701.42
2008	1321.13	**302.32**	138.77	**87.20**	1122.85	**54.57**	**15.00**	2597.74	444.09	3041.83
2009	1308.47	697.27	260.54	106.87	1090.51	99.78	15.10	2674.61	903.92	3578.53
2010	1467.11	116.41	175.88	164.79	1329.45	68.06	11.97	2984.41	349.27	3333.67
2011	1351.74	527.79	277.42	268.67	1278.52	54.93	13.24	2920.92	851.39	3772.31
2012	1011.52	174.23	176.05	16.72	1107.24	117.90	13.01	2307.83	308.85	2616.68
2013	1341.63	242.43	195.79	32.27	1052.19	35.63	3.52	2593.13	310.33	2903.46
2014	1264.95	285.84	44.96	24.51	1271.11	17.00	12.61	2593.63	327.36	2920.99
2015	1047.70	231.04	220.04	102.85	1043.44	29.71	12.19	2323.36	363.60	2686.96
2016	782.25	305.13	339.15	102.29	1051.95	28.38	39.85	2213.19	435.79	2648.98
2017	572.37	75.68	356.52	212.34	870.43	3.18	14.60	1813.92	291.21	2105.12
2018	605.35	114.35	391.98	166.70	819.86	0.18	21.09	1838.28	281.22	2119.50
2019	722.26	199.60	445.53	45.99	765.17	0.37	18.00	1950.96	245.96	2196.92
2020	630.58	132.68	260.61	63.61	820.40	6	18.87	1730.46	202.29	1932.75

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.

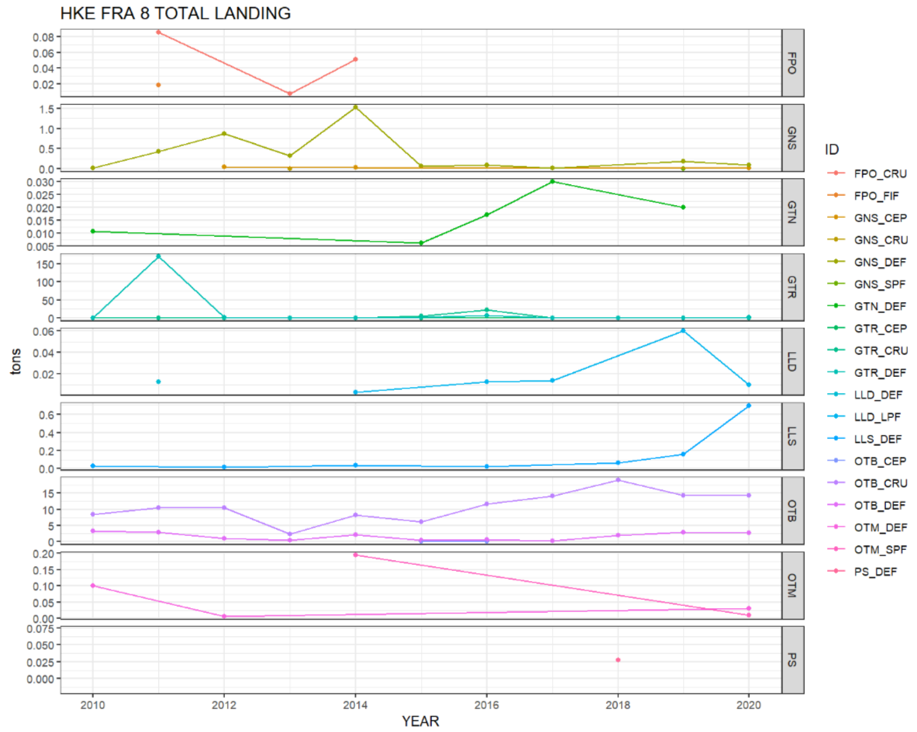


Figure 6.9.2.1.1. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 8.

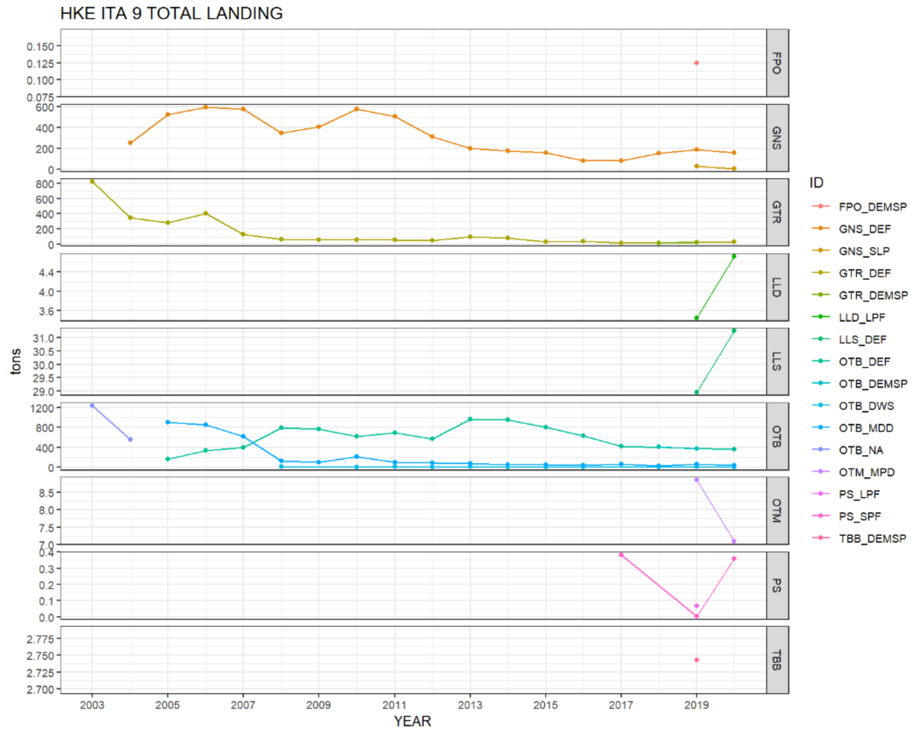


Figure 6.9.2.1.2. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 9.

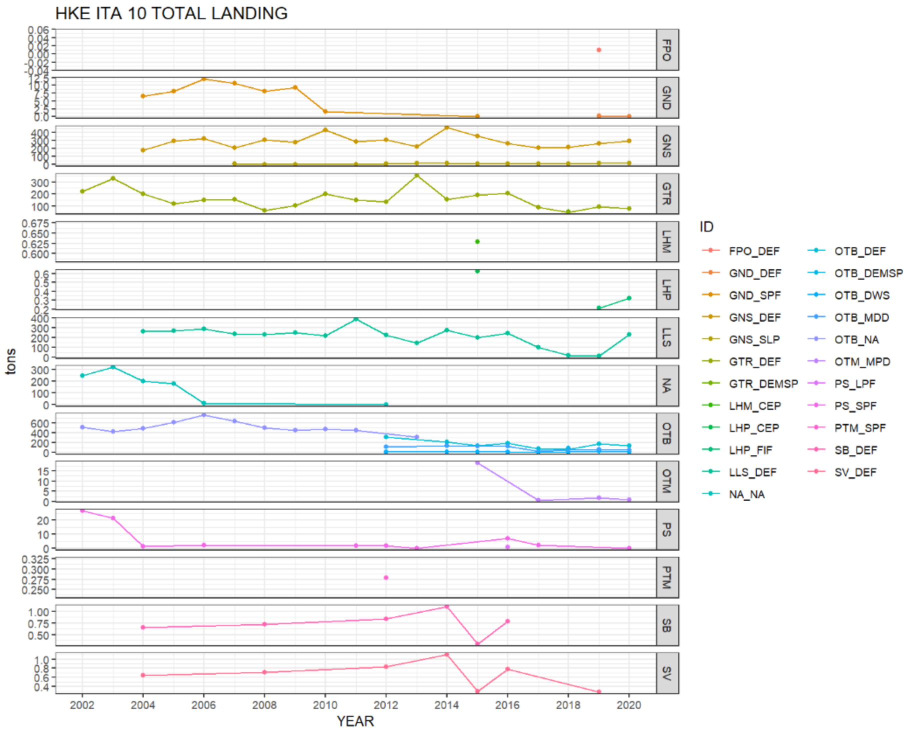


Figure 6.9.2.1.3. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 10.

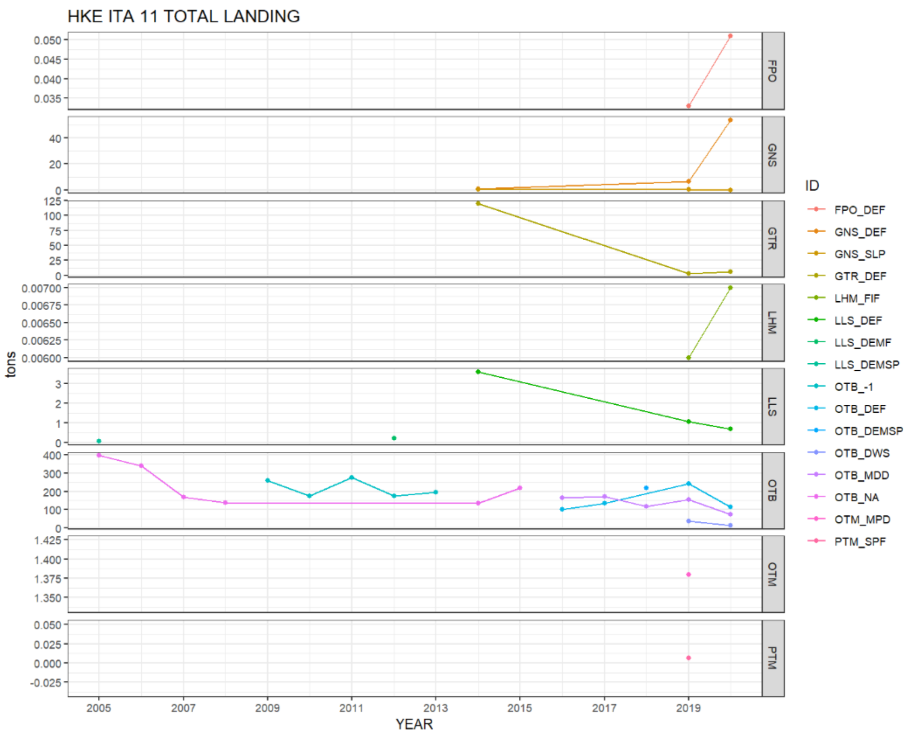


Figure 6.9.2.1.4. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 11.

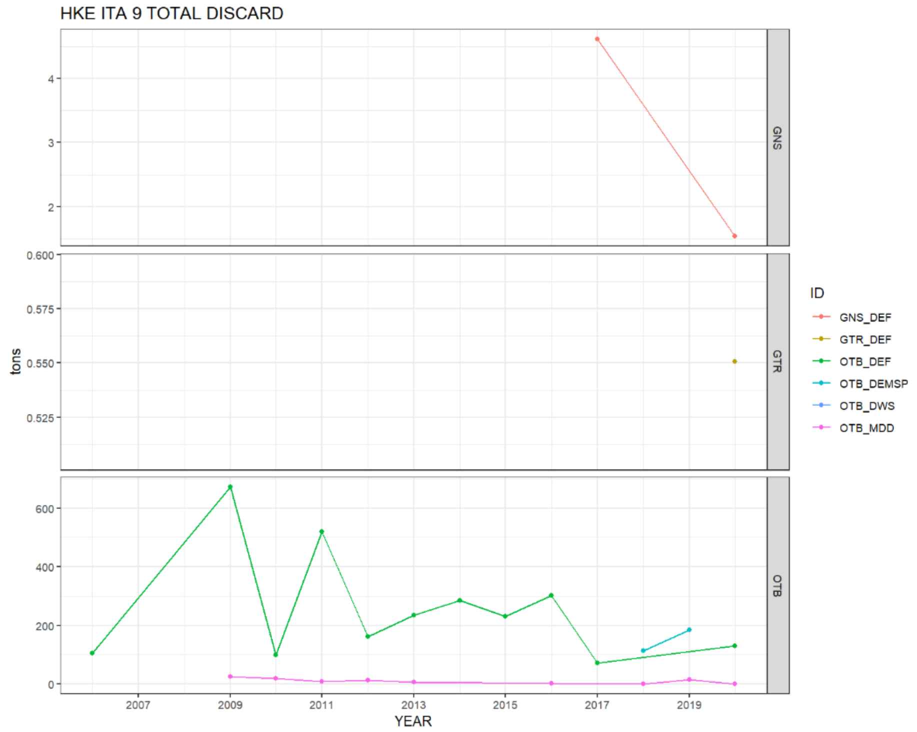


Figure 6.9.2.1.5. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 9.

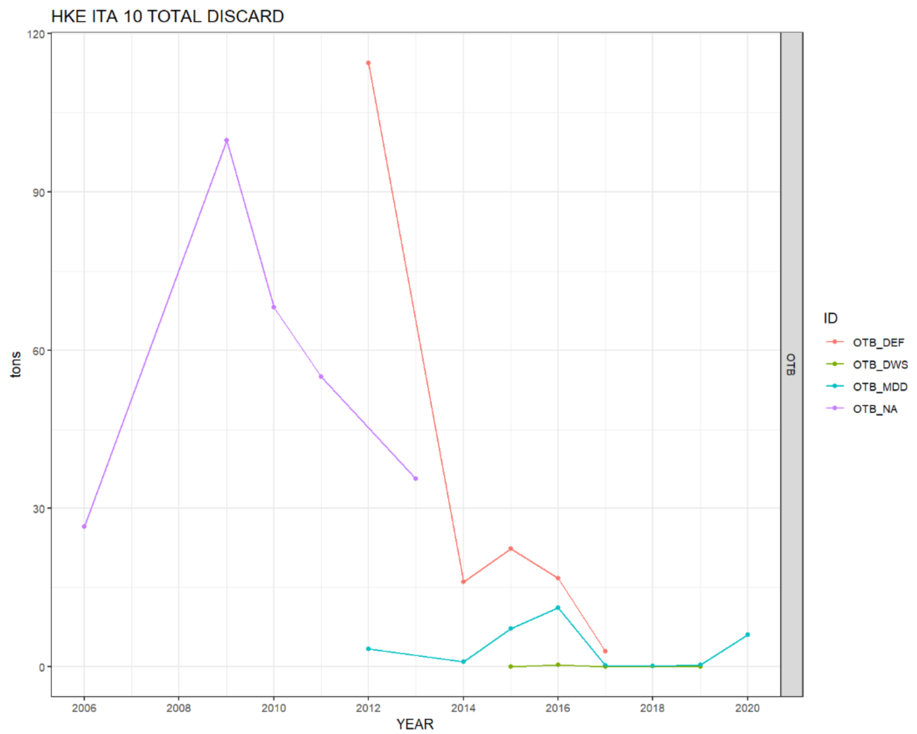


Figure 6.9.2.1.6. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 10.

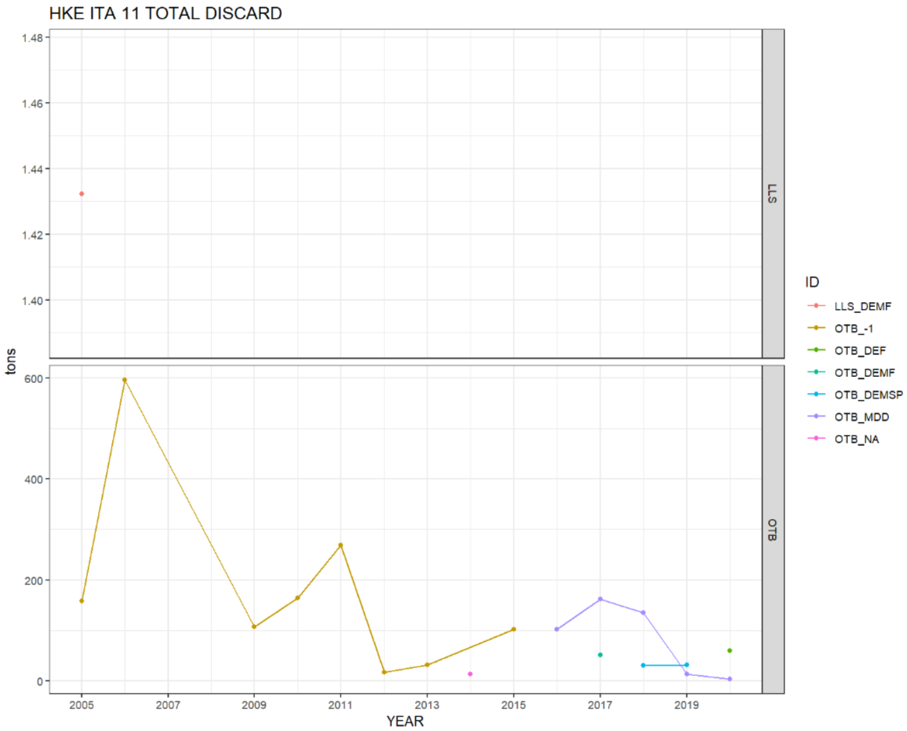


Figure 6.9.2.1.7. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 11.

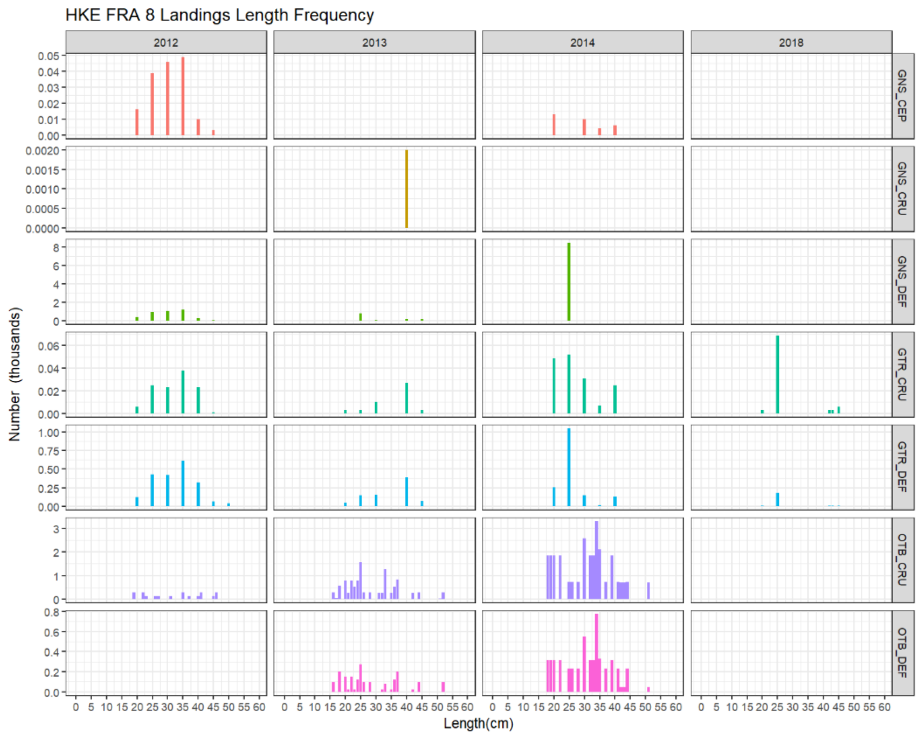


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Figure 6.9.2.1.8. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 8.

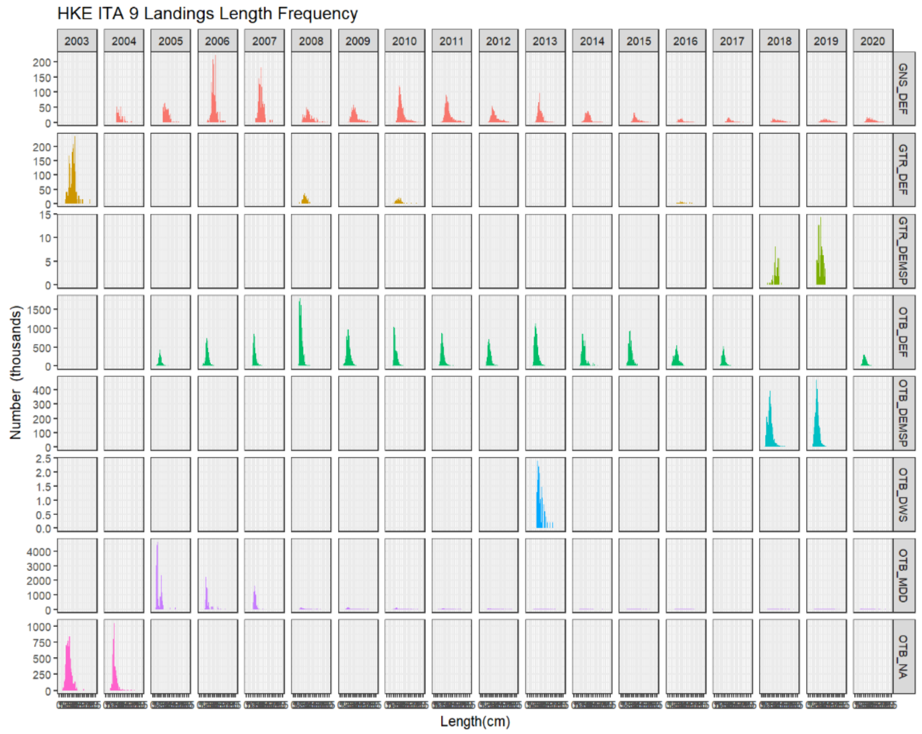


Figure 6.9.2.1.9. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 9.

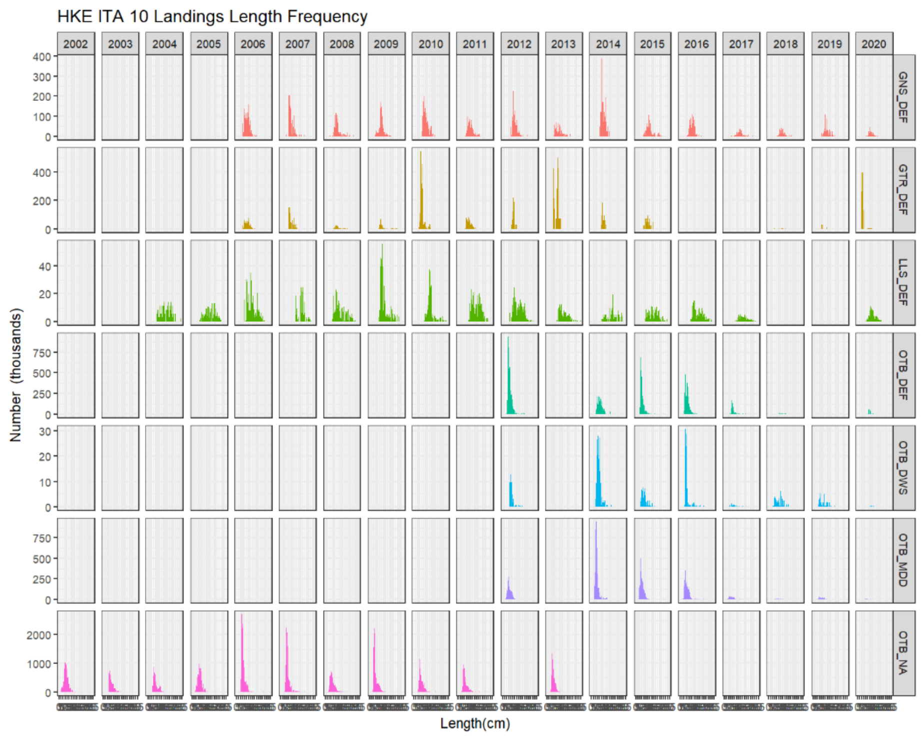


Figure 6.9.2.1.10. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 10.

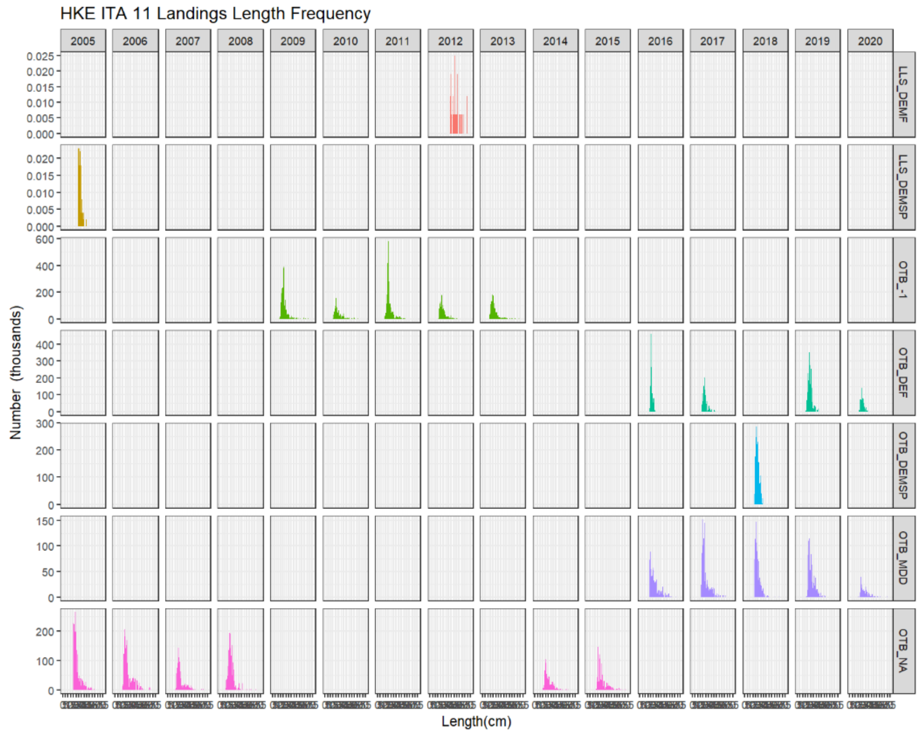


Figure 6.9.2.1.11. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 11.

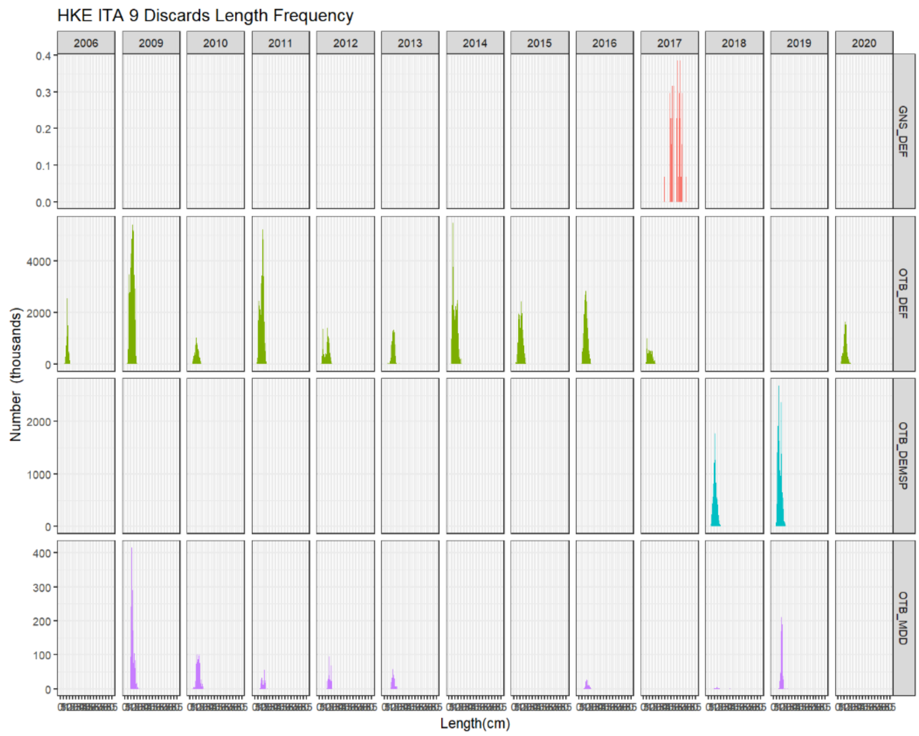


Figure 6.9.2.1.12. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 9.

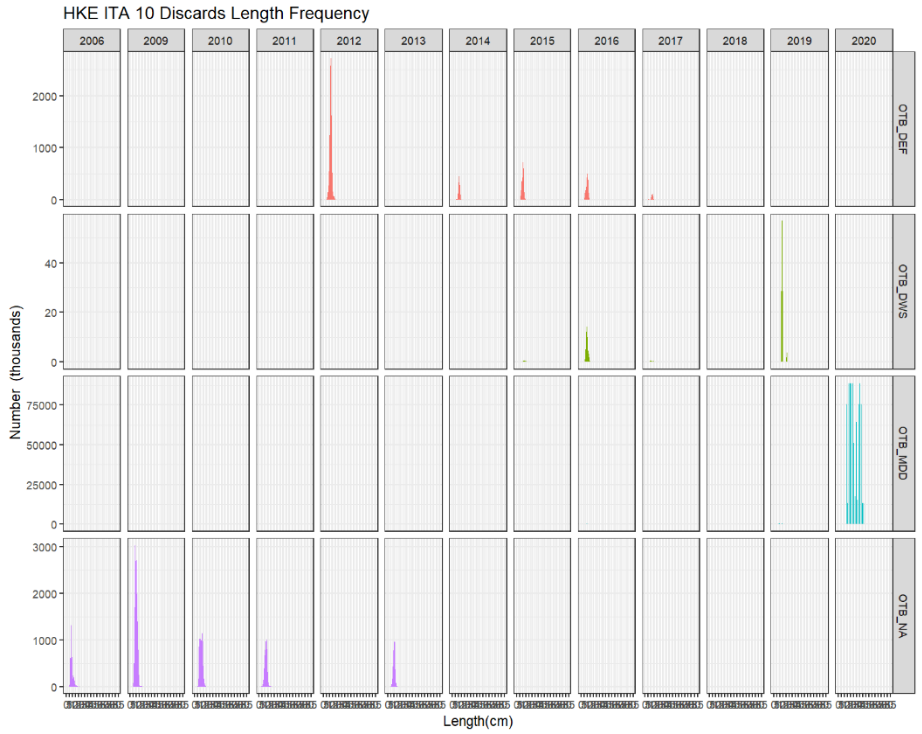


Figure 6.9.2.1.13. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 10.

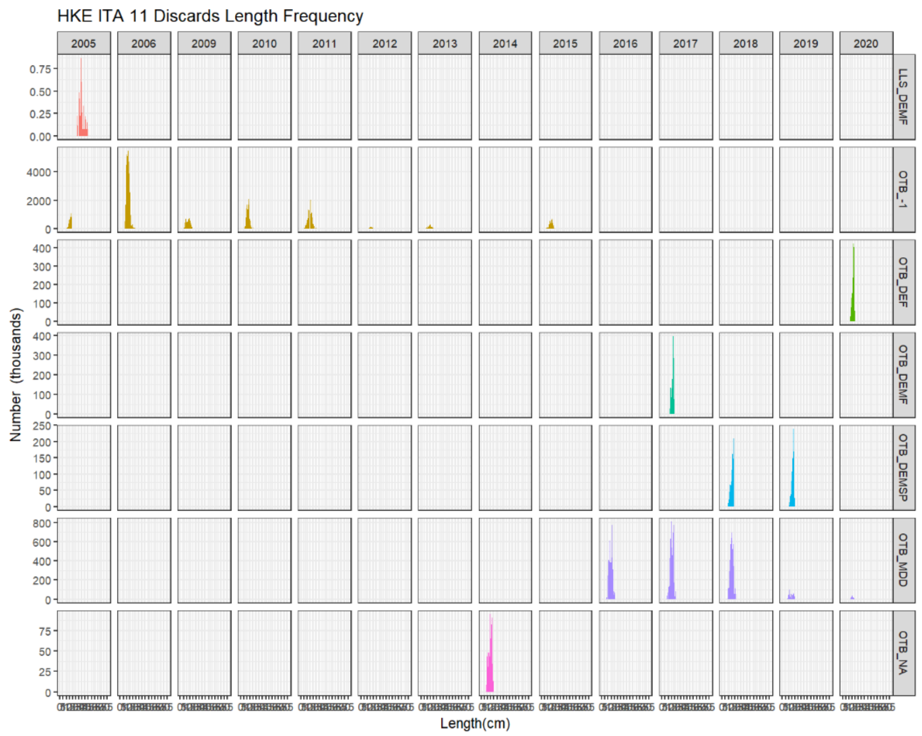


Figure 6.9.2.1.14. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 11.

6.9.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

6.9.2.3 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.
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 three 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.
In order to evaluated the influence of the lack of these data, a comparison was carried out using 2020 survey indices, calculated using three different approaches:

1- Option 1: the 2020 index was calculated combining GSAs 8, 9, 10 and 11 in terms of total surface, also for years with no data for GSA8.
2- Option 2: the 2020 index was calculated excluding GSA 8 surface, as there were not data for that area.
3- Option 3: the 2020 index was calculated including GSA 8 data, calculated as mean of the previous years for that area.

Thus GSA 8 is always included in the time series up to 2019. The difference between option 1 and option 2 is the inclusion of GSA8 surface even if there were not dataThe results for Index at age were similar in terms of number of individuals for each age class (see below). All these options give little influence for any assessment data set, but the largest changes occur with option 3.

approach	1	2	3
age class			
0	435.06	440.81	450.66
1	222.64	223.39	261.06
2	26.42	26.61	35.30
3	6.52	6.51	11.29
4	1.78	1.77	3.53
5	0.35	0.34	1.54
6	0.11	0.11	0.42
7+	0.49	0.48	1.25

As the contribution of GSA8 in terms of biomass and density is less then 10% of the whole area, EWG 21-11 decided to adopt approach 2, not including GSA8 area in the computation of 2020 survey index.

The combined MEDITS indexes were calculated using the script provided by JRC (Figures 6.9.2.2.1 and 6.9.2.2.2).

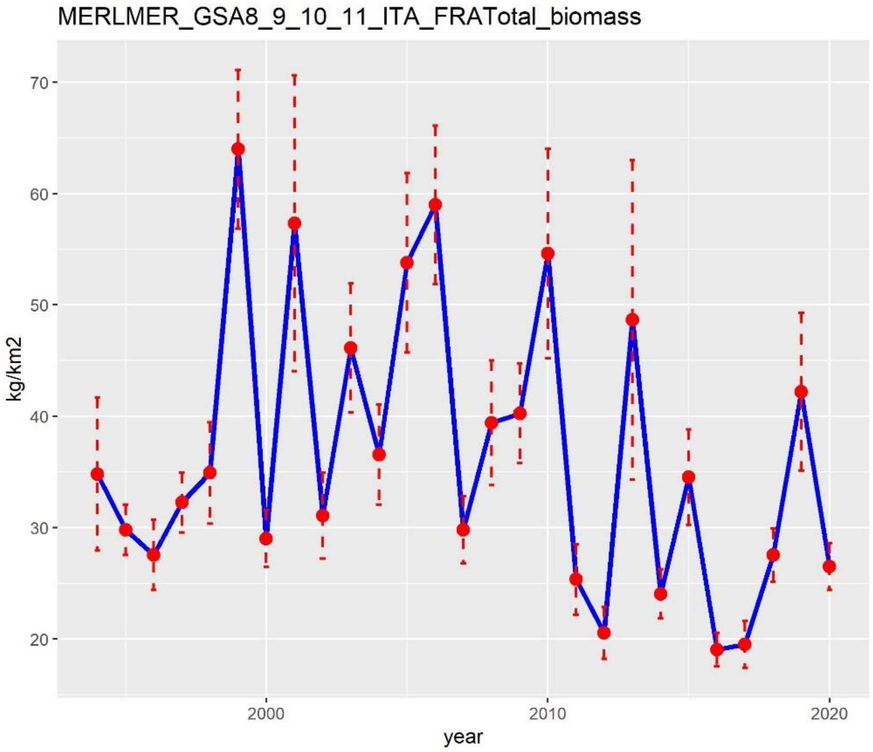


Figure 6.9.2.2.1. European hake in GSAs 8, 9, 10 & 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

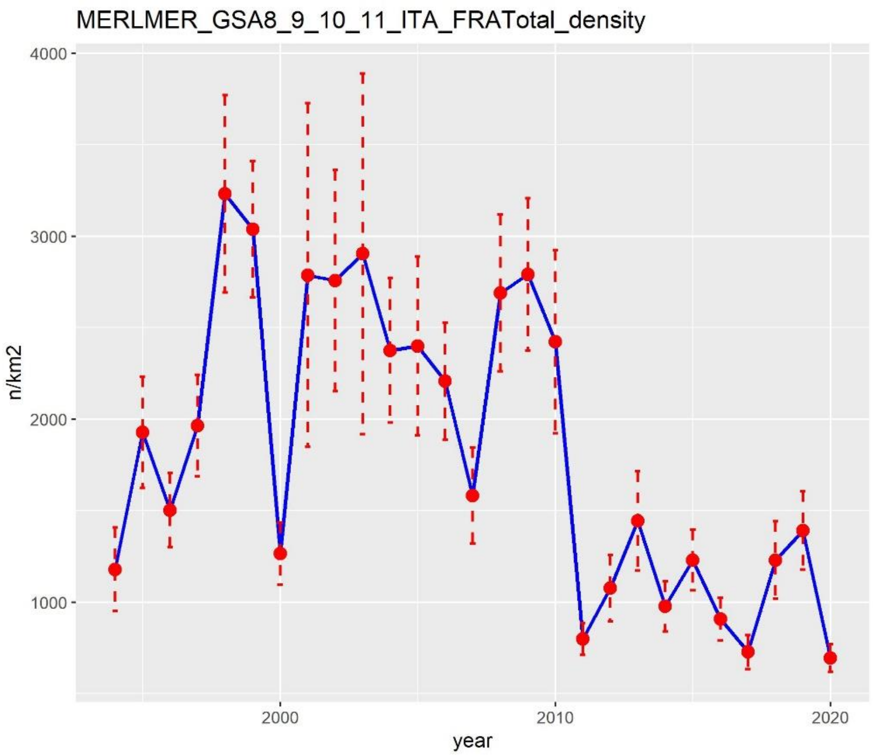


Figure 6.9.2.2.2. European hake in GSAs 8, 9, 10 & 11. Estimated density indices from the MEDITS survey (n/km^2).

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.

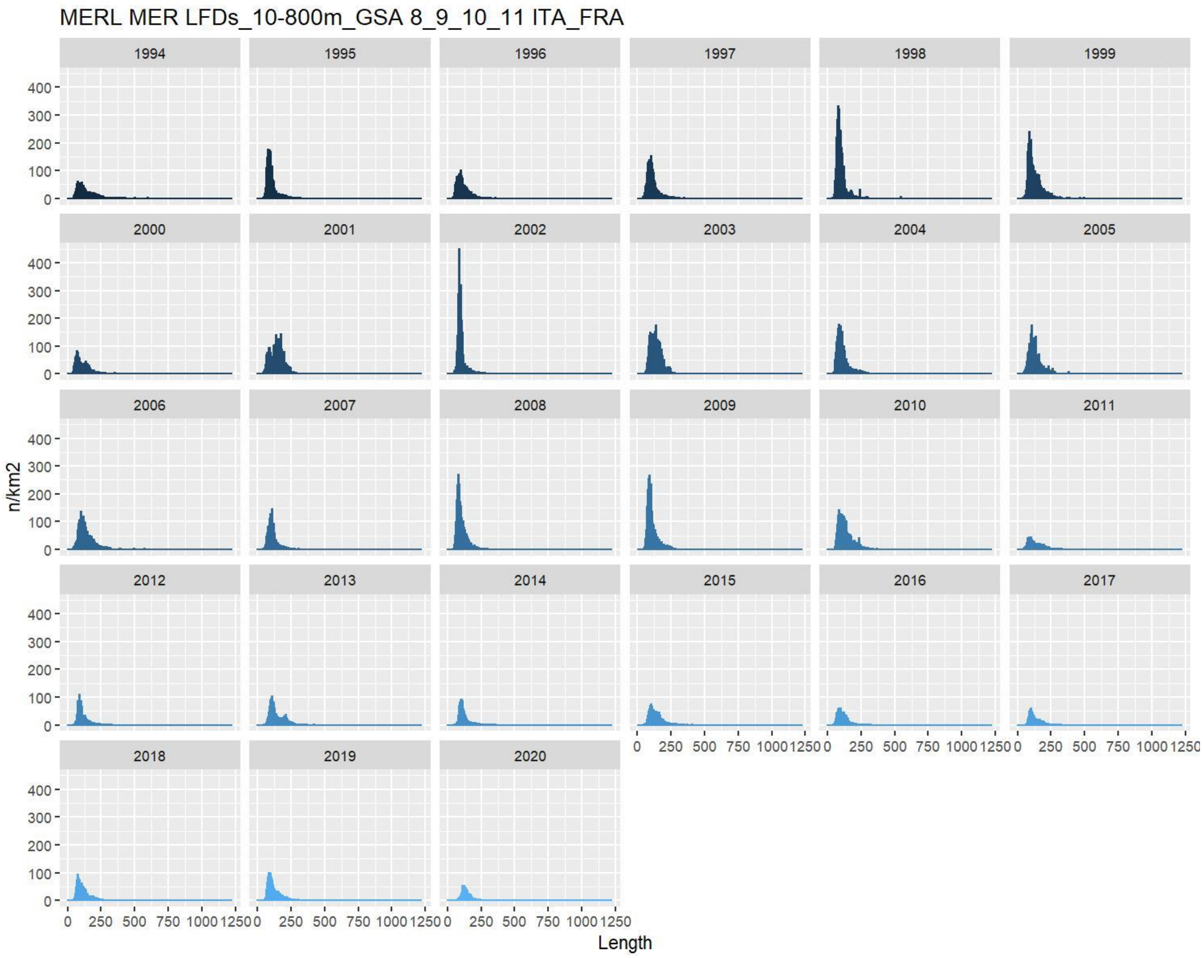


Figure 6.9.2.2.3. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution by year of MEDITS survey.

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 2005-2020 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).

SOP landings

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA9	1.04	1.72	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
GSA10	2.70	1.88	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
GSA11	1.01	0.95	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

SOP Discards

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA9	1.19	1.19	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
GSA10	1.05	1.05	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

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
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

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

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

Maturity vector

	0	1	2	3	4	5	6	7+
2005	0	0.25	0.8	1	1	1	1	1
2006	0	0.25	0.8	1	1	1	1	1
2007	0	0.25	0.8	1	1	1	1	1
2008	0	0.25	0.8	1	1	1	1	1
2009	0	0.25	0.8	1	1	1	1	1
2010	0	0.25	0.8	1	1	1	1	1
2011	0	0.25	0.8	1	1	1	1	1
2012	0	0.25	0.8	1	1	1	1	1
2013	0	0.25	0.8	1	1	1	1	1
2014	0	0.25	0.8	1	1	1	1	1
2015	0	0.25	0.8	1	1	1	1	1
2016	0	0.25	0.8	1	1	1	1	1
2017	0	0.25	0.8	1	1	1	1	1
2018	0	0.25	0.8	1	1	1	1	1
2019	0	0.25	0.8	1	1	1	1	1
2020	0	0.25	0.8	1	1	1	1	1

Natural Mortality vector

	0	1	2	3	4	5	6	7+
2005	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2006	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2007	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2008	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2009	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2010	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2011	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2012	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2013	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2014	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2015	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2016	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2017	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2018	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2019	1.85	0.8	0.48	0.37	0.3	0.27	0.24	0.22
2020	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

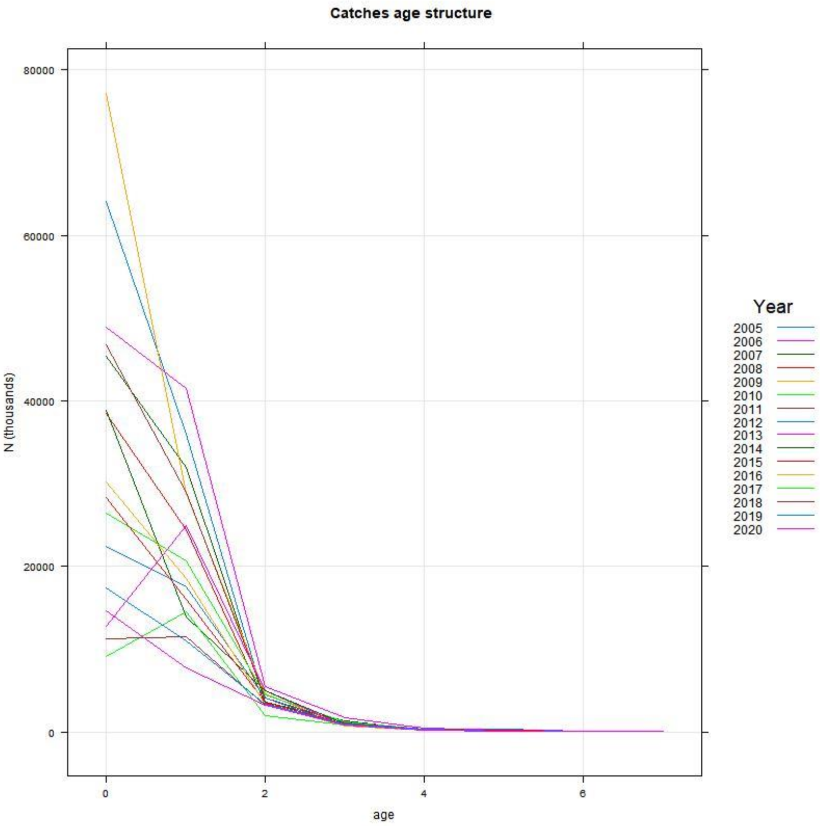


Figure 6.9.3.1. European hake in GSAs 8, 9, 10 & 11. Catch at age input data.

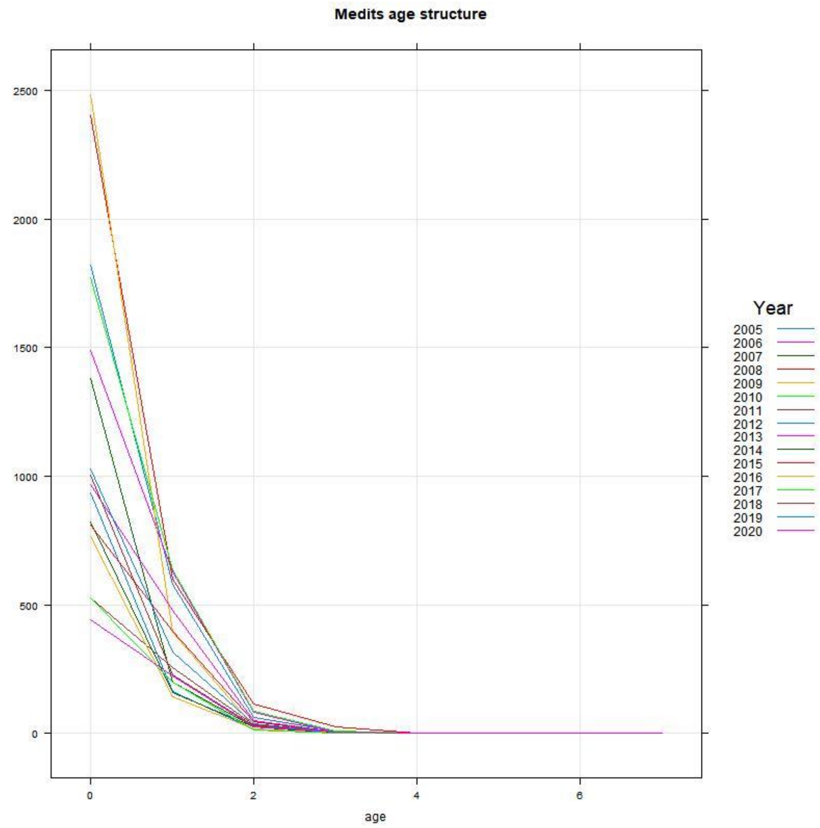


Figure 6.9.3.2. European hake in GSAs 8, 9, 10 & 11. Age structure of the index.

Assessment results

The model applied was the same as the one adopted during the benchmark meeting and the EWG 20-09. 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.

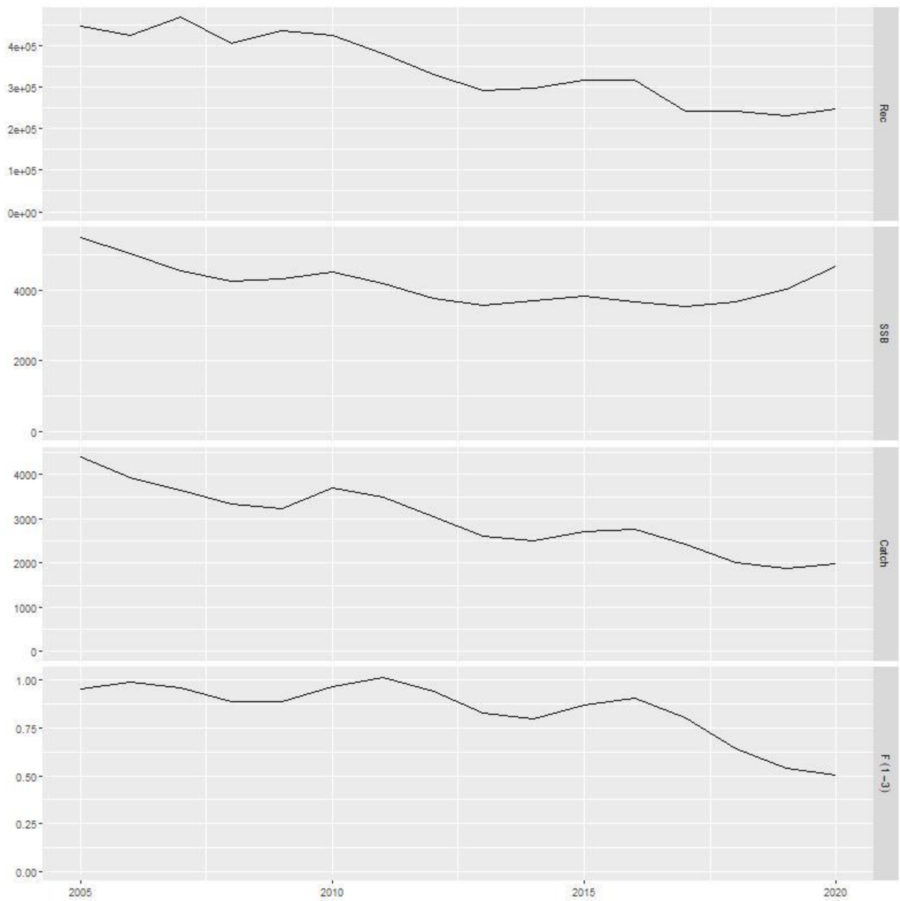


Figure 6.9.3.5. European hake in GSAs 8, 9, 10 & 11. Stock summary from the final a4a model.

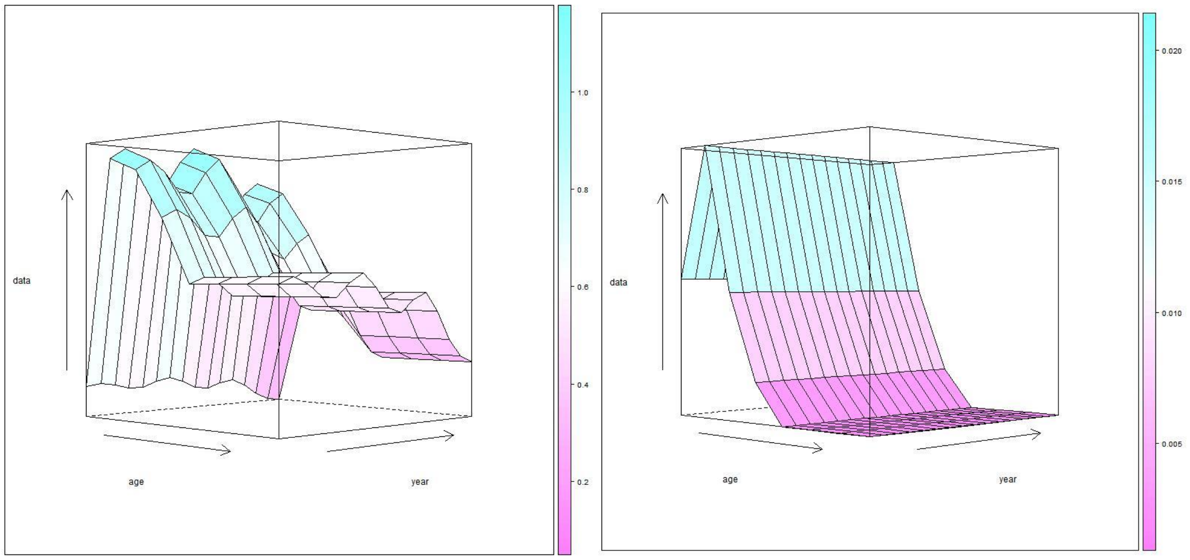


Figure 6.9.3.6. European hake in GSAs 8, 9, 10 & 11. 3D contour plot of estimated fishing mortality (left) and 3D contour plot of estimated catchability (right) at age and year.

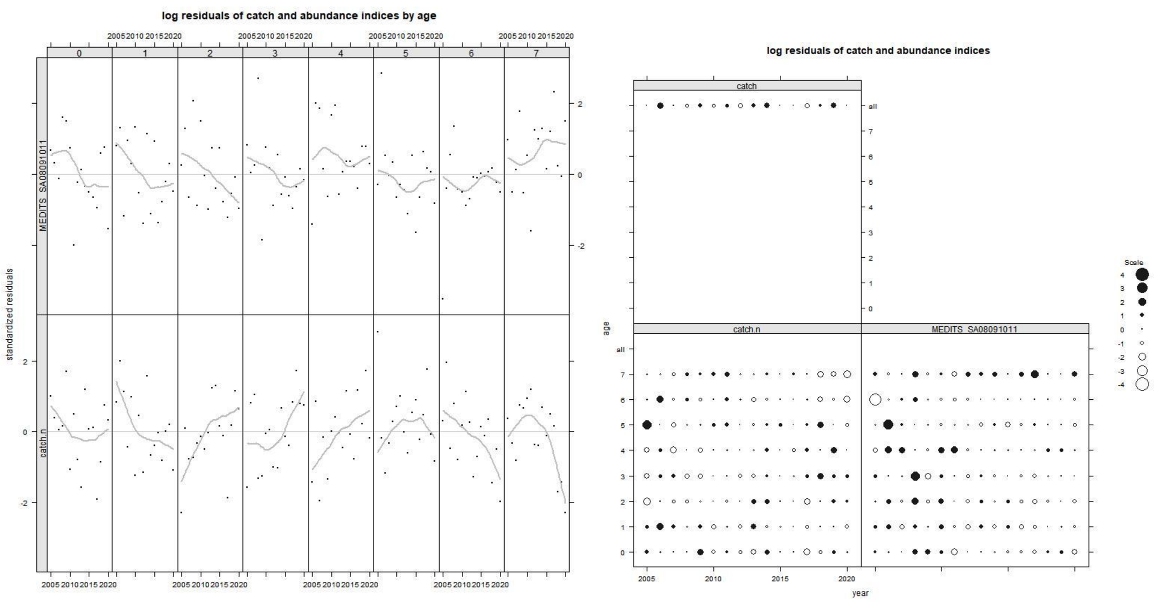


Figure 6.9.3.7. European hake in GSAs 8, 9, 10 & 11. Standardized residuals for abundance indices and for catch numbers.

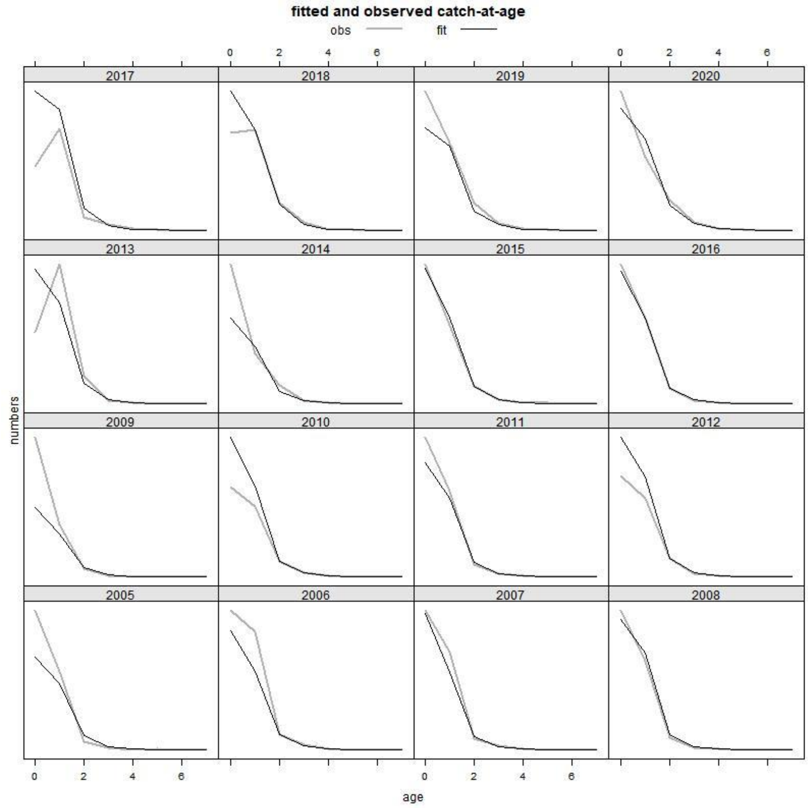


Figure 6.9.3.8. European hake in GSAs 8, 9, 10 & 11. Fitted and observed catch at age.

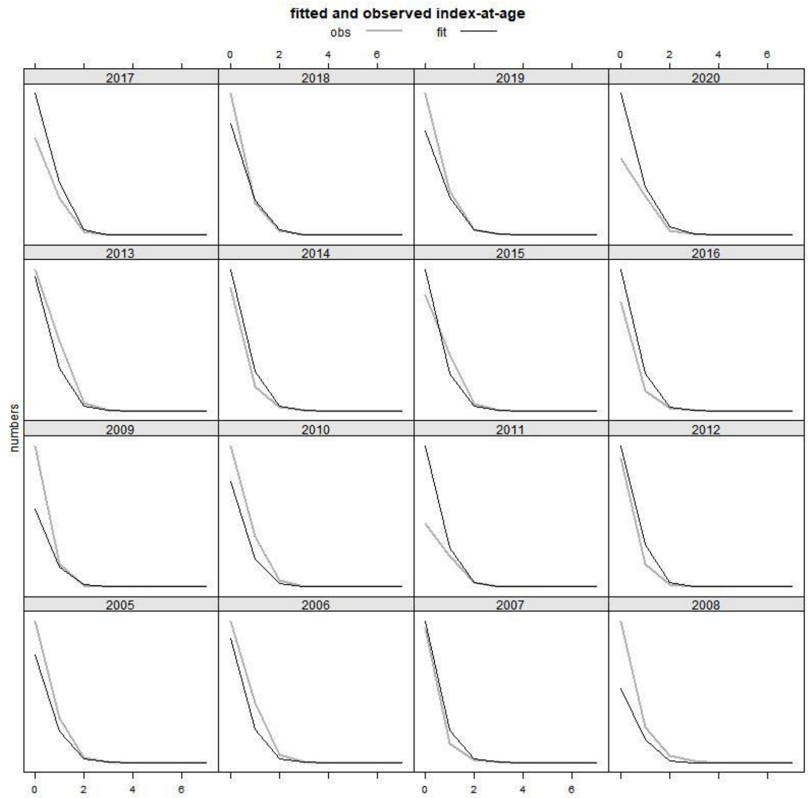


Figure 6.9.3.9. European hake in GSAs 8, 9, 10 & 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 5 years back. Models results were quite stable (Figure 6.9.3.10).

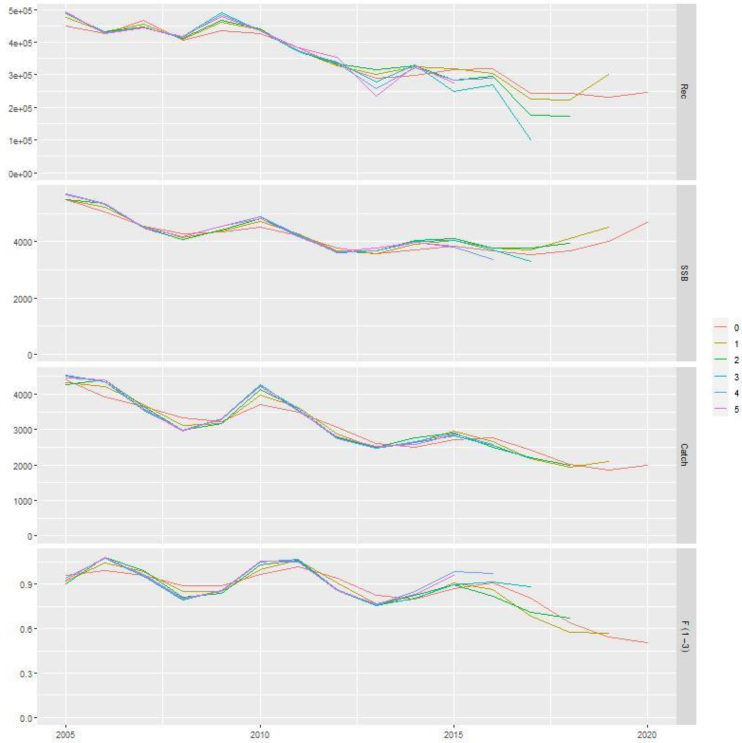


Figure 6.9.3.10. European hake in GSAs 8, 9, 10 & 11. Retrospective analysis.

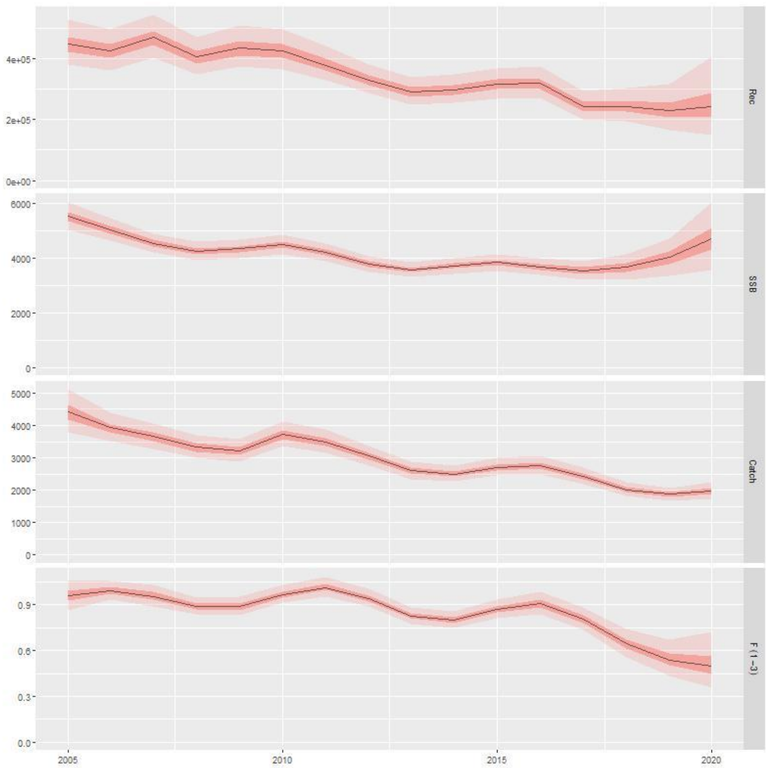


Figure 6.9.3.11. European hake in GSAs 8, 9, 10 & 11. Stock summary of the simulated and fitted data for the a4a model.

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	448561	63492	12686	2899	844	326	161	91
2006	425227	56269	10038	2895	876	343	137	109
2007	468246	52895	8557	2207	849	348	140	105
2008	405758	58737	8362	1953	667	345	146	107
2009	436120	51715	9995	2047	626	283	150	114
2010	425479	55613	8820	2452	657	265	124	120
2011	381144	53272	8715	1996	736	266	111	106
2012	330331	47160	7904	1872	574	288	107	91
2013	290917	41595	7588	1834	574	235	122	87
2014	297919	37633	7580	1983	620	253	107	99
2015	316100	38780	7060	2037	686	278	117	99
2016	318298	40489	6752	1767	664	295	123	99
2017	243616	40393	6753	1622	557	278	127	100
2018	243298	31680	7543	1807	559	249	128	109
2019	230467	32877	7064	2391	717	277	127	126
2020	246605	31895	8187	2488	1035	378	150	143

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	0.96	448561	5499.3	12468.6	4389.7
2006	0.99	425227	5042.6	11944.9	3919.5
2007	0.96	468246	4558.1	11565.5	3654.3
2008	0.89	405758	4269.8	10711.2	3321.8
2009	0.89	436120	4340.5	10193.9	3220.4
2010	0.96	425479	4508	11200.3	3704.7
2011	1.01	381144	4211.1	10210.7	3485.5
2012	0.94	330331	3786.6	9171.8	3050.1
2013	0.83	290917	3576.7	9016.3	2599.6
2014	0.80	297919	3719.7	7641.2	2498.5
2015	0.87	316100	3840.3	8407	2702.9
2016	0.91	318298	3685.8	8585	2752.3
2017	0.80	243616	3552.6	7466.1	2428.2

2018	0.64	243298	3664.9	7610.7	2015.2
2019	0.54	230467	4017.5	7646.8	1869.7
2020	0.50	246605	4689.9	8983	1983

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	0.23	1.04	1.00	0.83	0.60	0.60	0.60	0.60
2006	0.23	1.08	1.03	0.86	0.62	0.62	0.62	0.62
2007	0.23	1.04	1.00	0.83	0.60	0.60	0.60	0.60
2008	0.21	0.97	0.93	0.77	0.56	0.56	0.56	0.56
2009	0.21	0.97	0.93	0.77	0.56	0.56	0.56	0.56
2010	0.23	1.05	1.01	0.83	0.61	0.61	0.61	0.61
2011	0.24	1.11	1.06	0.88	0.64	0.64	0.64	0.64
2012	0.22	1.03	0.98	0.81	0.59	0.59	0.59	0.59
2013	0.20	0.90	0.86	0.71	0.52	0.52	0.52	0.52
2014	0.19	0.87	0.83	0.69	0.50	0.50	0.50	0.50
2015	0.21	0.95	0.91	0.75	0.55	0.55	0.55	0.55
2016	0.21	0.99	0.95	0.78	0.57	0.57	0.57	0.57
2017	0.19	0.88	0.84	0.69	0.51	0.51	0.51	0.51
2018	0.15	0.70	0.67	0.55	0.40	0.40	0.40	0.40
2019	0.13	0.59	0.56	0.47	0.34	0.34	0.34	0.34
2020	0.12	0.55	0.53	0.44	0.32	0.32	0.32	0.32

Based on the a4a results, the European hake SSB shows a decreasing trend in the first half of the time series, from a maximum of 5499 tons in 2005 to a minimum of 3553 tons in 2017, with a slightly increasing trend in the last seven years. The assessment shows a decreasing trend in the number of recruits in the time series. The recruitment (age 0) reached a minimum of 230467 thousands individuals in 2019. F_{bar} (1-3) shows a fluctuating pattern with a slightly decreasing trend until 2016 and a strong decrease in the last four years, with the lowest value of 0.50 reached in 2020. The retrospecive performance is moderate, but shows that the F is high, well above F_{MSY} over the whole time series. The differences between the assessment results for the three options for survey treatment in 2020 were negligible, and lay within the intervals for main assessment parameters of F and SSB.

6.9.4 REFERENCE POINTS

The time series is too short to give stock recruitment rationship, so reference points are based on equilibrium methods. The STECF EWG 21-11 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 (0.50, estimated as the F_{bar1-3} in the last year of the time series, 2020) 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.

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}=0.50 (last year's F estimated by the assessment model) was used for F in 2021, as F shows a declining trend (see section 4.3). Recruitment shows a declining pattern over the period of the assessment, with a more stable pattern in the second half of the time series, so it has been estimated from the population results as the mean of the last 8 years (273403 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
Biological Parameters	3	mean weights at age, maturation at age, natural mortality at age and selection at age, are based average of years 2017-2019
$F_{ages\ 1-3}$ (2021)	0.50	The F estimated in 2020 was used to give F status quo for 2021
SSB (2021)	5422	Stock assessment 1 January 2020
R_{age0} (2021,2022)	273403	Mean of the last 8 years
Total catch (2021)	2200	Catch in 2020 at F status quo

Table 6.9.5.1: European hake in GSAs 8, 9, 10 & 11. Short term forecast in different F scenarios.

Rationale	F factor	Fbar	Recruitment 2021	Fsq 2021	Catch 2020	Catch 2022	SSB 2021	SSB 2023	SSB 2020-2023(%)	Catch 2019-2023(%)
$F_{0.1}$	0.33	0.17	273402.51	0.50	1982.98	920.31	5421.5	8980.7	65.65	-53.59
F upper	0.47	0.23	273402.51	0.50	1982.98	1252.28	5421.5	8487.99	56.56	-36.85
F lower	0.23	0.11	273402.51	0.50	1982.98	637.08	5421.5	9404.61	73.47	-67.87
F_{MSY} transition	0.70	0.35	273402.51	0.50	1982.98	1807.74	5421.5	7674.3	41.55	-8.84
Zero catch	0	0	273402.51	0.50	1982.98	0	5421.5	10369.17	91.26	-100
Status quo	1	0.5	273402.51	0.50	1982.98	2434.13	5421.5	6774.51	24.96	22.75
Different Scenarios	0.1	0.05	273402.51	0.50	1982.98	288.84	5421.5	9930.02	83.16	-85.43
	0.2	0.1	273402.51	0.50	1982.98	566.37	5421.5	9510.92	75.43	-71.44
	0.3	0.15	273402.51	0.50	1982.98	833.08	5421.5	9110.91	68.05	-57.99
	0.4	0.2	273402.51	0.50	1982.98	1089.44	5421.5	8729.1	61.01	-45.06
	0.5	0.25	273402.51	0.50	1982.98	1335.91	5421.5	8364.6	54.29	-32.63
	0.6	0.3	273402.51	0.50	1982.98	1572.9	5421.5	8016.6	47.87	-20.68
	0.7	0.35	273402.51	0.50	1982.98	1800.84	5421.5	7684.32	41.74	-9.19
	0.8	0.4	273402.51	0.50	1982.98	2020.11	5421.5	7367.01	35.89	1.87
	0.9	0.45	273402.51	0.50	1982.98	2231.09	5421.5	7063.96	30.3	12.51
	1.1	0.55	273402.51	0.50	1982.98	2629.57	5421.5	6498	19.86	32.61
	1.2	0.6	273402.51	0.50	1982.98	2817.74	5421.5	6233.83	14.98	42.1
	1.3	0.65	273402.51	0.50	1982.98	2998.94	5421.5	5981.42	10.33	51.23
	1.4	0.71	273402.51	0.50	1982.98	3173.48	5421.5	5740.22	5.88	60.04
	1.5	0.76	273402.51	0.50	1982.98	3341.62	5421.5	5509.7	1.63	68.51
	1.6	0.81	273402.51	0.50	1982.98	3503.65	5421.5	5289.37	-2.44	76.69
	1.7	0.86	273402.51	0.50	1982.98	3659.82	5421.5	5078.75	-6.32	84.56
	1.8	0.91	273402.51	0.50	1982.98	3810.37	5421.5	4877.38	-10.04	92.15
	1.9	0.96	273402.51	0.50	1982.98	3955.54	5421.5	4684.85	-13.59	99.47
	2	1.01	273402.51	0.50	1982.98	4095.56	5421.5	4500.72	-16.98	106.53

6.10 DEEP-WATER ROSE SHRIMP IN GSA 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 09, 10 and 11 boundaries.

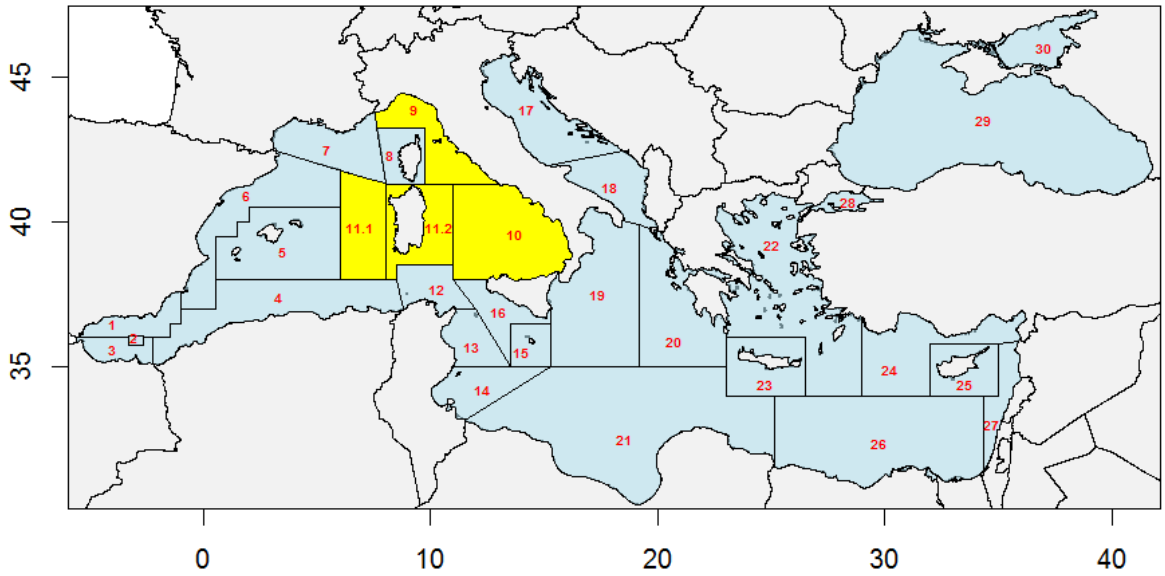


Figure 6.10.1.1 Deep-water rose shrimp in GSAs 09, 10 & 11.Geographical location of the GSAs.

The Deep-water rose shrimp is an epibenthic species and inhabits the muddy or sandy- muddy bottom 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 418odell (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 419odelli (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.

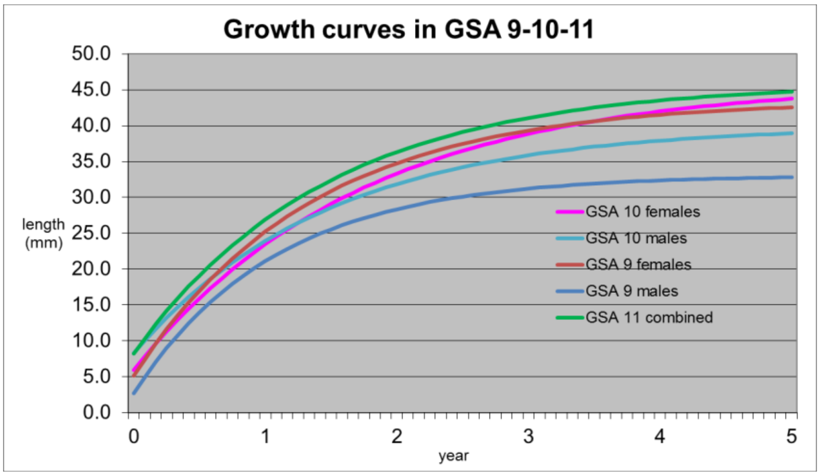


Figure 6.10.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Von Bertalanffy curves.

For the present assessment the growth parameters reported in Tab. 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 09, 10 & 11. Growth parameters used in the present assessment.

GSA	Sex	VB_LINF	VB_K	VB_T0
09	Females	43.5	0.74	-0.13
09	Males	33.1	0.93	-0.05
10 & 11	Females	46.0	0.575	-0.2
10 & 11	Males	40.0	0.68	-0.25

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 Tab. 6.10.1.2.

Table 6.10.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Maturity proportion at age adopted in the present assessment.

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
1	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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 curve by sex for each GSA has been estimated, and then a single M vector was produced combining the vectors obtained by sex. The input growth parameters (k and t_0) used are reported in Tab. 6.10.1.1. The natural mortality vector by age is reported in Tab. 6.10.1.3.

Table 6.10.1.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Vector of natural mortality used in the present assessment.

Age	0	1	2	3	4
M	2.21	1.08	0.87	0.79	0.76

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 2019 is reported in Fig. 6.10.2.1.1 and Tab. 6.10.2.1.1. The time series available in the DCF database are different for the three GSAs: 2003-2019 for GSA09, 2002-2019 for GSA10 and 2009-2019 for GSA11.

The landings coming from GSA11 resulted low in comparison with the other two GSAs. 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 trend of the landing for the combined GSAs shows a significant decrease at the beginning of the series followed by some years of stability. Starting from 2010, a constant increase is observed until the maximum value registered in 2019. Anomalous values have been observed in 2002 and 2006 in GSA10.

Discard data (Fig. 6.10.2.1.2 and Tab. 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 and 2019 in GSA10 and for all the data series in GSA11. Missing discard data were not reconstructed.

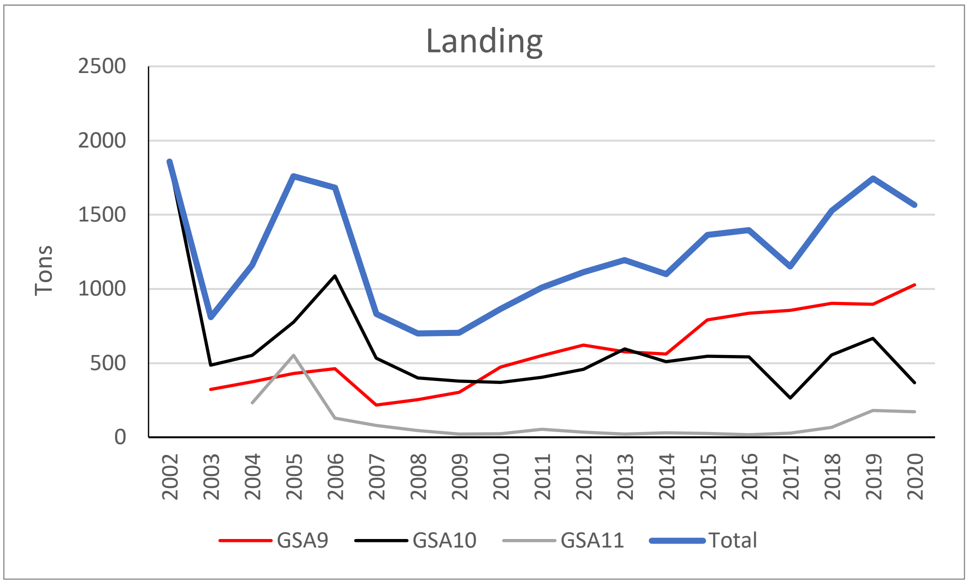


Figure 6.10.2.1.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings from 2002 to 2020 by GSA and Total.

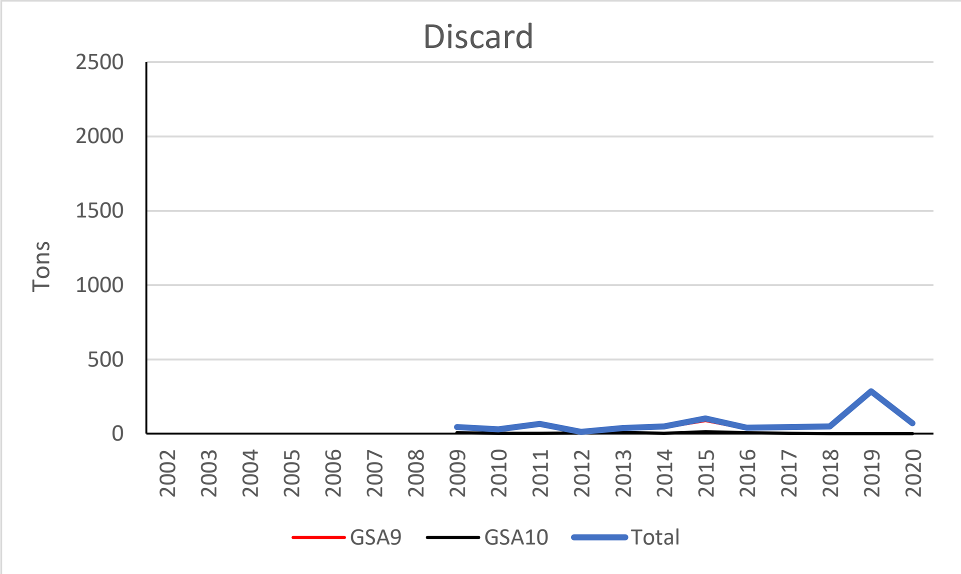


Figure 6.10.2.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual discards from 2002 to 2020 by GSA and Total; there are no discard data from GSA 8 and 11.

Table 6.10.2.1.1 Deep-water rose shrimp in GSAs 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	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA9-GNS-DEF			3.6			2.3	0.5						0.0			0.0			0.1
GSA9-GTR-DEF		5.9	4.2	0.5							0.2								0.6
GSA9-OTB-DEF				42.0	55.3	89.8	187.3	238.5	309.6	404.5	483.4	426.4	466.7	663.6	648.6	730.1			905.7
GSA9-OTB-DEMSP																	827.8	725.3	
GSA9-OTB-DWS							0.2		9.7	9.7	5.5	3.8	2.1	8.5	10.5		7.7	15.4	7.7
GSA9-OTB-MDD				388.5	407.1	125.3	66.1	64.6	154.0	136.9	132.1	145.5	92.6	119.3	176.6	126.7	68.3	150.1	114.0
GSA9-OTB-NA		316.6	367.4																
GSA9-OTM-MPD																		3.7	0.0
GSA9-TBB-DEMSP																		1.3	
GSA10-GND-SPF				0.0															
GSA10-GNS-DEF			2.9	5.9			0.1	0.2		3.0	3.7		0.3			0.3			
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	262.0		211.0	224.2	311.8	164.0	265.0	410.6	224.0
GSA10-OTB-DEMSP																	120.1		
GSA10-OTB-DWS									3.1	6.6	15.3		52.3	18.0	9.3	10.9	34.4	89.1	25.5
GSA10-OTB-MDD									124.6	113.1	177.7		245.6	282.7	221.3	89.8	135.9	166.2	117.7
GSA10-OTB-NA	1451.6	416.0	544.2	742.7	1087.7	534.3	400.2	378.9				596.7							
GSA10-OTM-MPD														21.8				1.6	
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-DEF																		78.3	94.6
GSA11-OTB-DEMSP			45.2	46.3	23.0	1.1	5.1												
GSA11-OTB-DWS							0.5											23.4	9.7
GSA11-OTB-MDD			187.2	501.8	104.5	78.4	40.2								17.6	29.1	67.9	79.2	67.3
GSA11-OTB-NA								21.7	23.3	53.3	33.8	21.2	30.2	26.5					
Total	1858.7	809.7	1159.6	1758.8	1681.4	831.2	700.1	703.9	866.3	1009.6	1113.6	1193.5	1100.8	1364.7	1395.6	1151.0	1527.0	1744.2	1566.1

DISCARD	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA9-OTB-DEF								38.4	24.4	60.5	6.6	26.8	45.0	89.3	29.7	41.3			68.9
GSA9-OTB-DEMSP																	50.2	277.8	
GSA9-OTB-MDD									2.7	2.7	1.0	3.3			5.2	0.2		6.8	1.7
GSA10-OTB-DEF									1.9	1.6	3.1		1.9	9.2	3.6	3.7			
GSA10-OTB-DWS													0.1	0.1	0.0			0.0	
GSA10-OTB-MDD									0.7	1.3	1.4		1.4	4.0	2.8	0.4		0.3	
GSA10-OTB-NA					3.9			7.3				9.4							
Total					3.9			45.7	29.7	66.2	12.1	39.5	48.3	102.6	41.4	45.6	50.2	284.9	70.6

The landings of DPS in GSA 8 are negligible. The time series available in the DCF database for this area starts from 2010. The contribution of GSA 8 to the total landing of GSA8-9-10-11 contributes to around 0.5% of the total landing per year (Tab. 6.10.2.1.2). Inclusion or not of GSA makes no significant contribution to the catch data in the assessment. Discard data are not available as well as length frequency distributions of size of both landed and discarded specimens. Given the negligible importance of the landing and the lack of demographic and biological data for GSA 8, and because the GSA 8 survey was not carried out in 2020 (See Section 6.10.2.2) GSA 8 was not included in the stock assessment.

Table 6.10.2.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landing (t) of GSA08 as provided through the official DCR-DCF database and comparison with the total landing of GSA8-9-10-11.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GSA8 – Landing	NA	NA	NA	NA	NA	NA	NA	NA	4.0	5.0
GSA8-9-10-11 Landing	1858.7	809.7	1159.6	1758.8	1681.4	831.2	700.1	703.9	870.2	1014.6
% of GSA8 on the total									0.5	0.5

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA8 – Landing	6.4	4.3	2.4	6.7	7.9	8.5	7.8	6.3	6.5
GSA8-9-10-11 Landing	1119.9	1197.8	1103.2	1371.3	1403.6	1159.4	1534.9	1750.5	1572.6
% of GSA8 on the total	0.6	0.4	0.2	0.5	0.6	0.7	0.5	0.4	0.4

Annual landings in tonnes by year and fleet for GSAs 09, 10 and 11 are reported in Figs. 6.10.2.1.3-5. Annual discards in tonnes by year and fleet for GSA09 and GSA10 are displayed in Figs. 6.10.2.1.6-7.

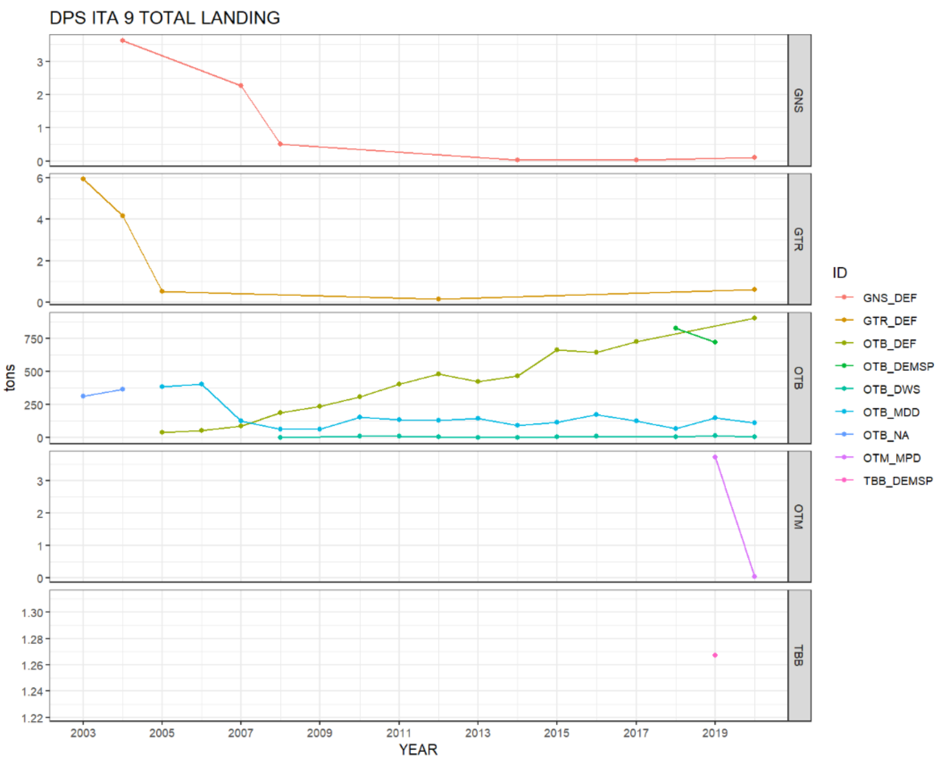


Figure 6.10.2.1.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA09.

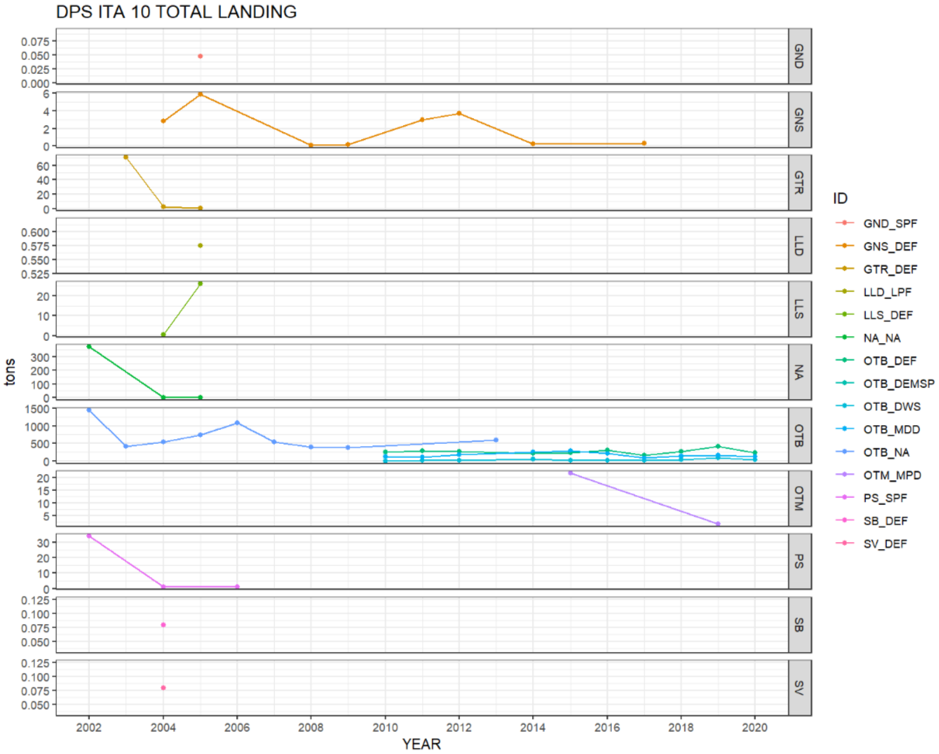


Figure 6.10.2.1.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA10.

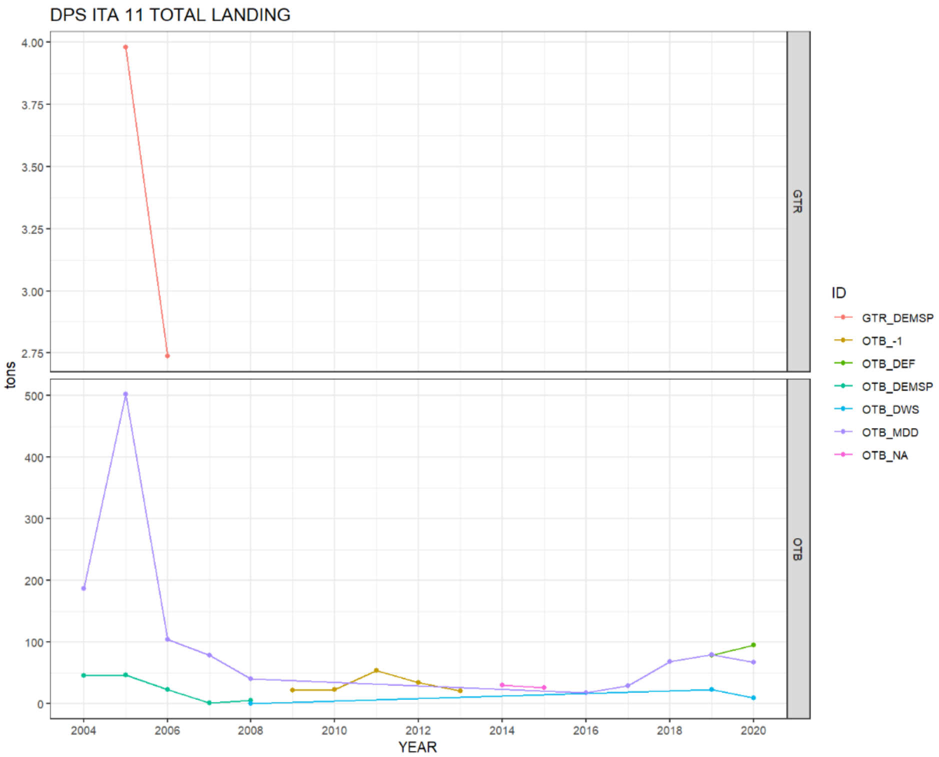


Figure 6.10.2.1.5 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA11.

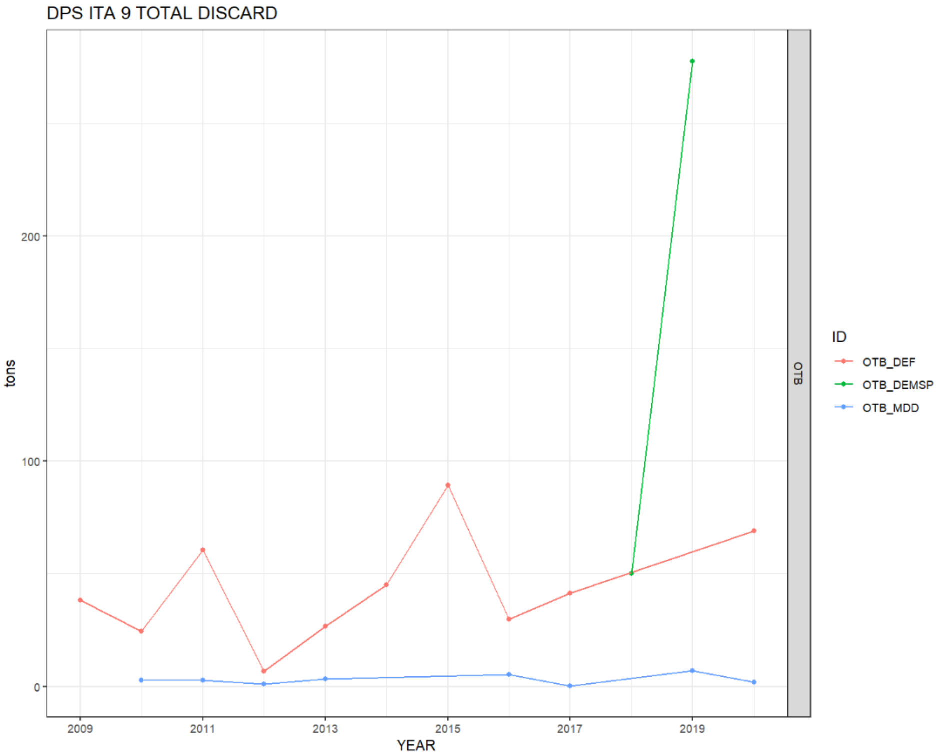


Figure 6.10.2.1.6 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA09.

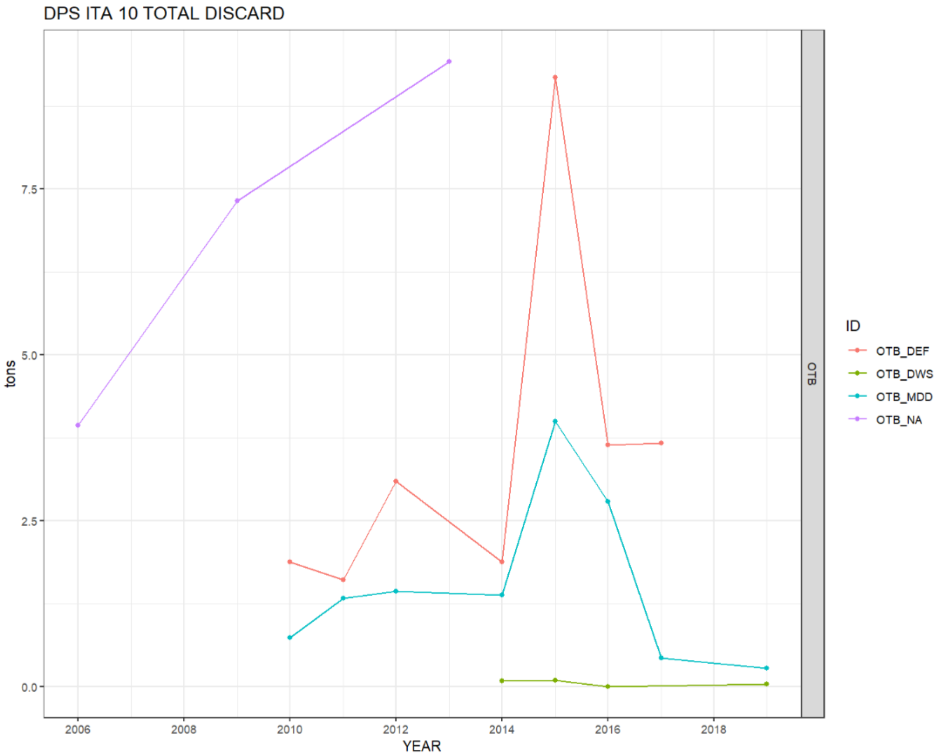


Figure 6.10.2.1.7 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA10.

Length frequency distributions (LFDs) and tables summarising the LFDs available and those to be reconstructed of the commercial and discard fractions are displayed in Figs. 6.10.2.1.8-17. The LFDs have been reconstructed according to the methodology developed during STECF EWG-2021-02.

In GSA09, demographic structure of the landing is available for OTB in 2003 and 2004 and by metier from 2005 to 2019 (OTB_DEF, OTB_DEMSP, OTB_DWS and OTB_MDD). LFDs have been reconstructed for OTB_DWS (years 2008, 2010-2014 and 2018) and for OTB_MDD (2006). For TBB_DEMSP, OTM_MPD, GTR_DEF and GNS_DEF, the LFDs were not reconstructed but the contribution of those metiers to the total landing of DPS in the area is negligible.

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 2014-2019. Length frequency distributions for the other metiers are available for 2012 (GNS_DEF). LFDs have been reconstructed for OTB_NA (year 2003), OTB_DWS (2011), OTB_DEF (2019) and GNS_DEF for some years. For the other metiers, LFDs were not reconstructed; however, their contribution to the total landing of the species is negligible.

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. LFDs have been reconstructed for OTB_DWS (years 2008, 2010-2016 and 2018-2020), OTB_MDD (2005-2009, 2014-2015 and 2018-2020), OTB_NA (2003-2004) and OTB_DEF (2005-2008).

Size structure of the discard in GSA10 is available for 2006 and for the period 2009-2017. LFDs have been reconstructed for OTB_NA (2002-2008), OTB_DWS (2010-2012, 2017-2018 and 2020), OTB_MDD (2018 and 2020), OTB_DEMSP (2018) and OTB_DEF (2018 and 2020).

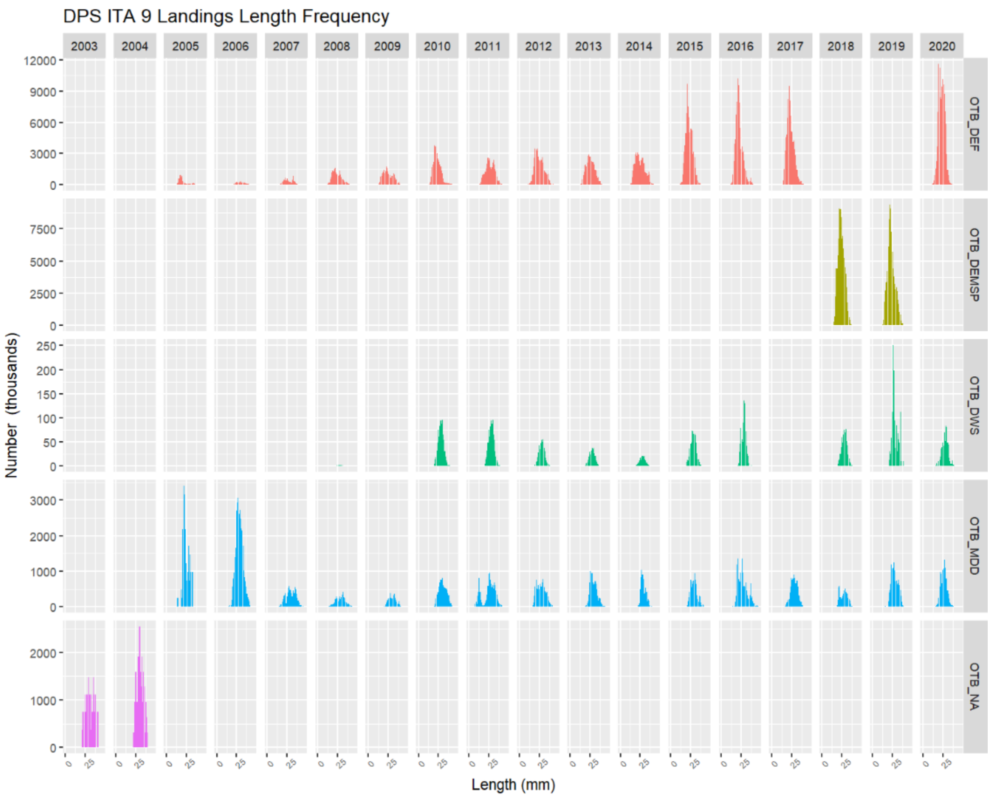


Figure 6.10.2.1.8 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing in GSA09.

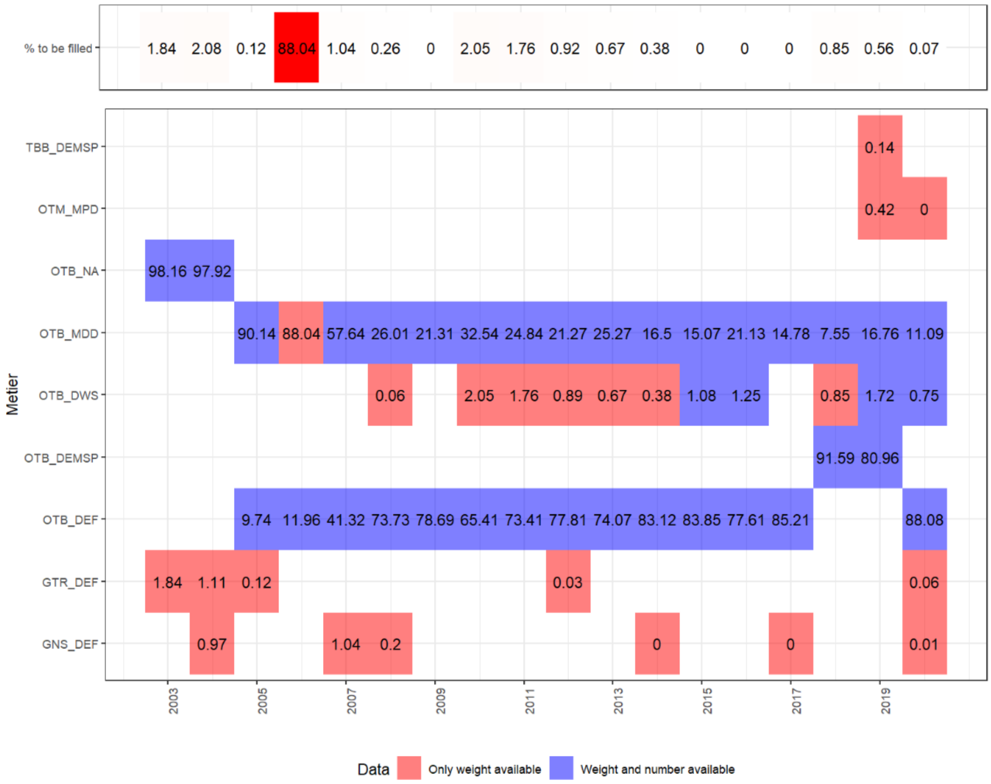


Figure 6.10.2.1.9 Deep-water rose shrimp in GSAs 09, 10 & 11. Table summarising the LFDs available and those to be reconstructed (below) in GSA09.

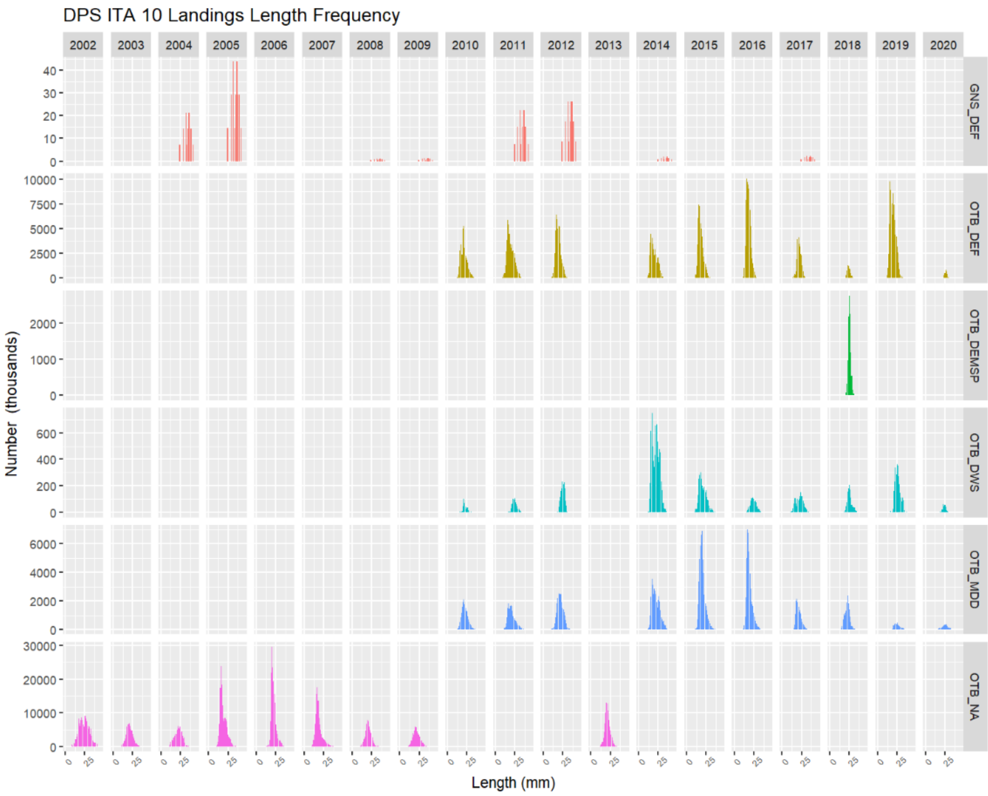


Figure 6.10.2.1.10 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing in GSA10.

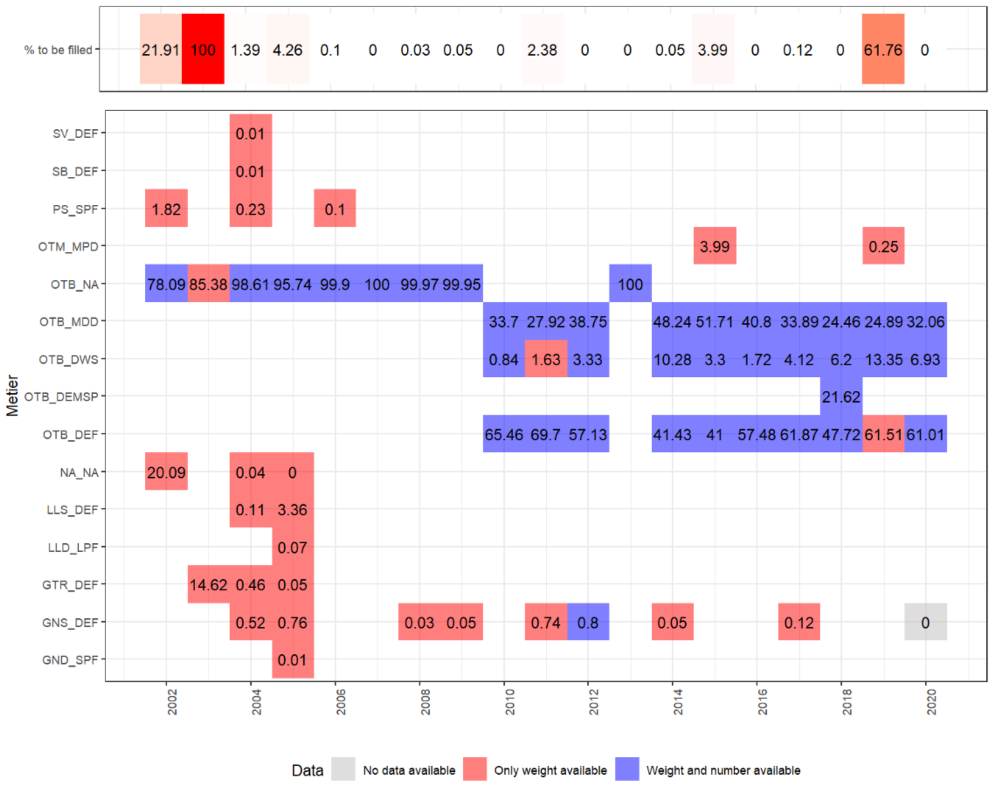


Figure 6.10.2.1.11 Deep-water rose shrimp in GSAs 09, 10 & 11. Table summarising the LFDs available and those to be reconstructed (below) in GSA10.

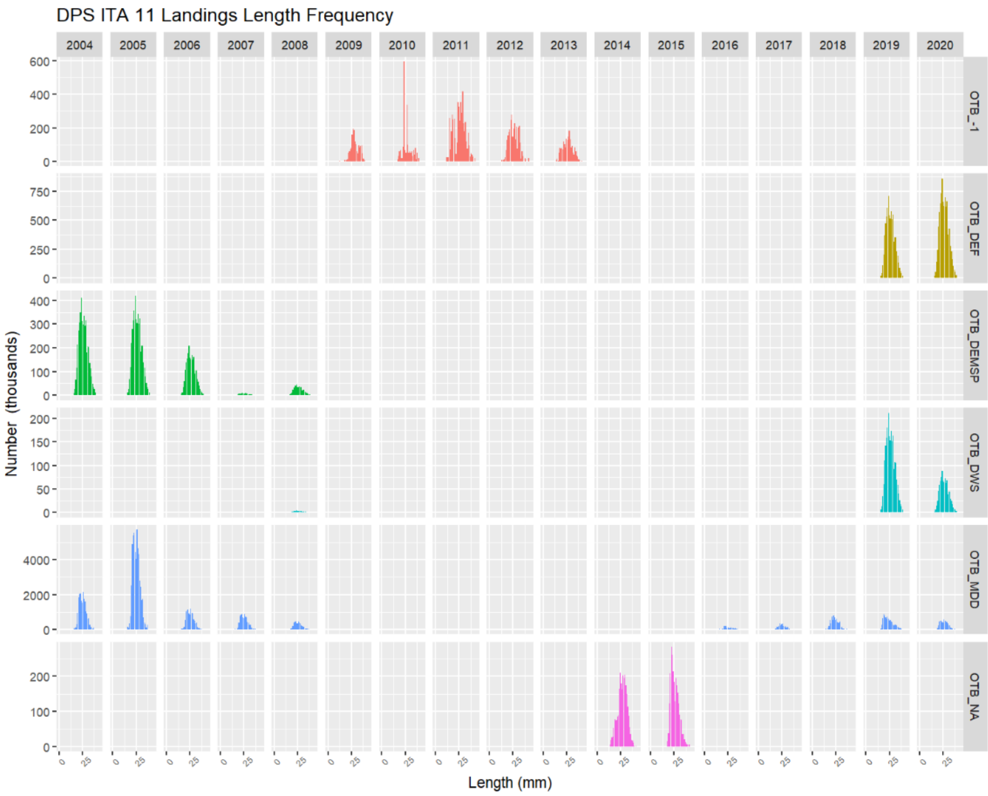


Figure 6.10.2.1.12 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing in GSA11.

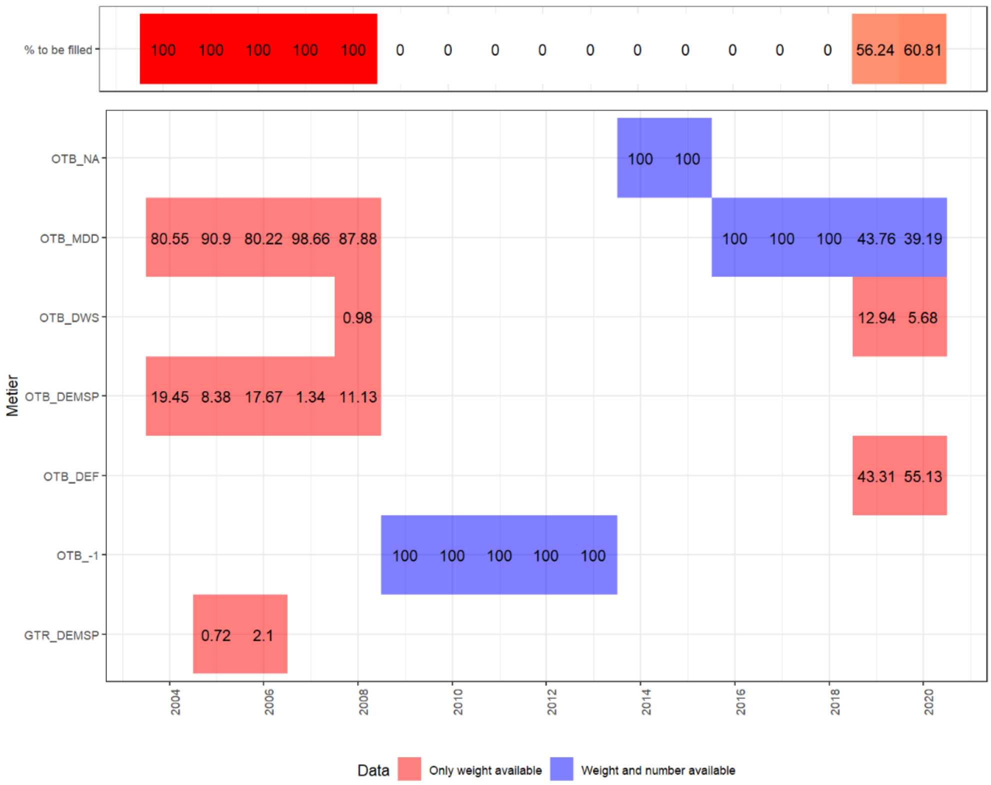


Figure 6.10.2.1.13 Deep-water rose shrimp in GSAs 09, 10 & 11. Table summarising the LFDs available and those to be reconstructed (below) in GSA11.

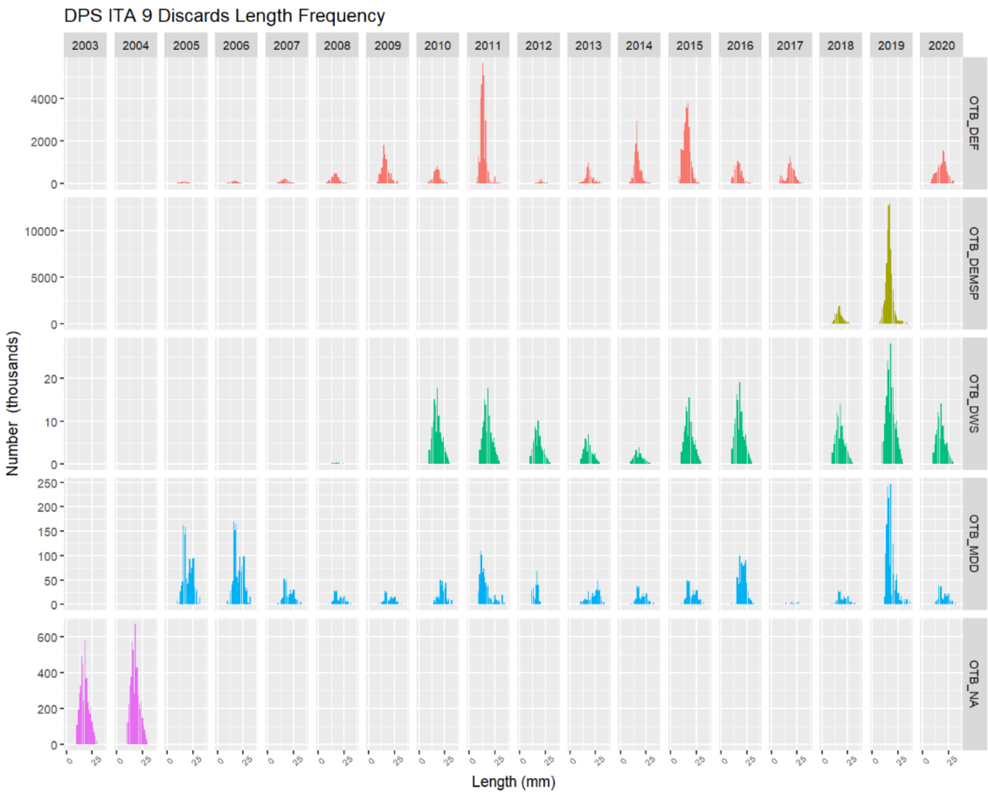


Figure 6.10.2.1.14 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of discards in GSA09.

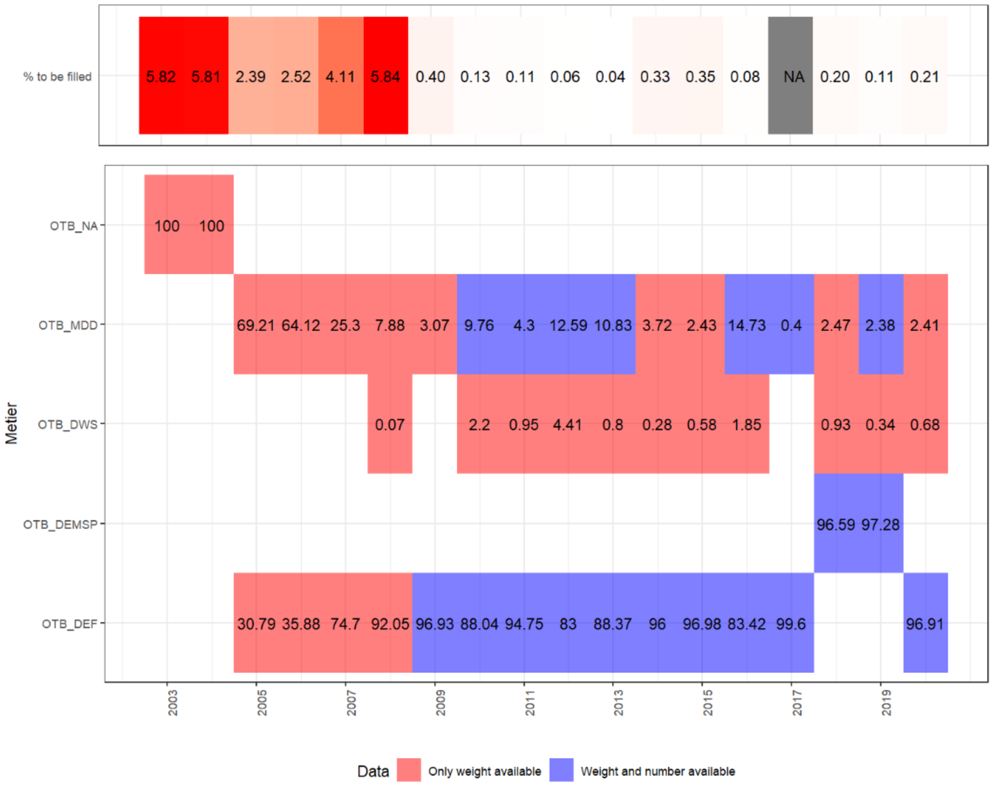


Figure 6.10.2.1.15 Deep-water rose shrimp in GSAs 09, 10 & 11. Table summarising the LFDs available and those to be reconstructed (below) in GSA09.

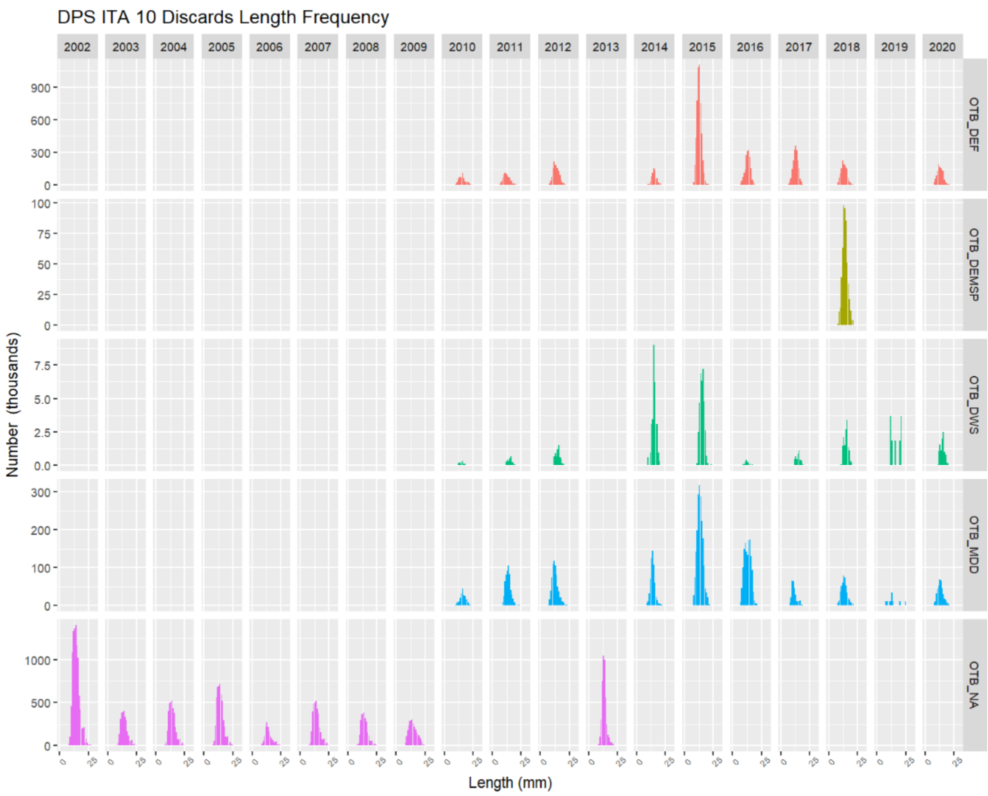


Figure 6.10.2.1.16 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of discard in GSA10.

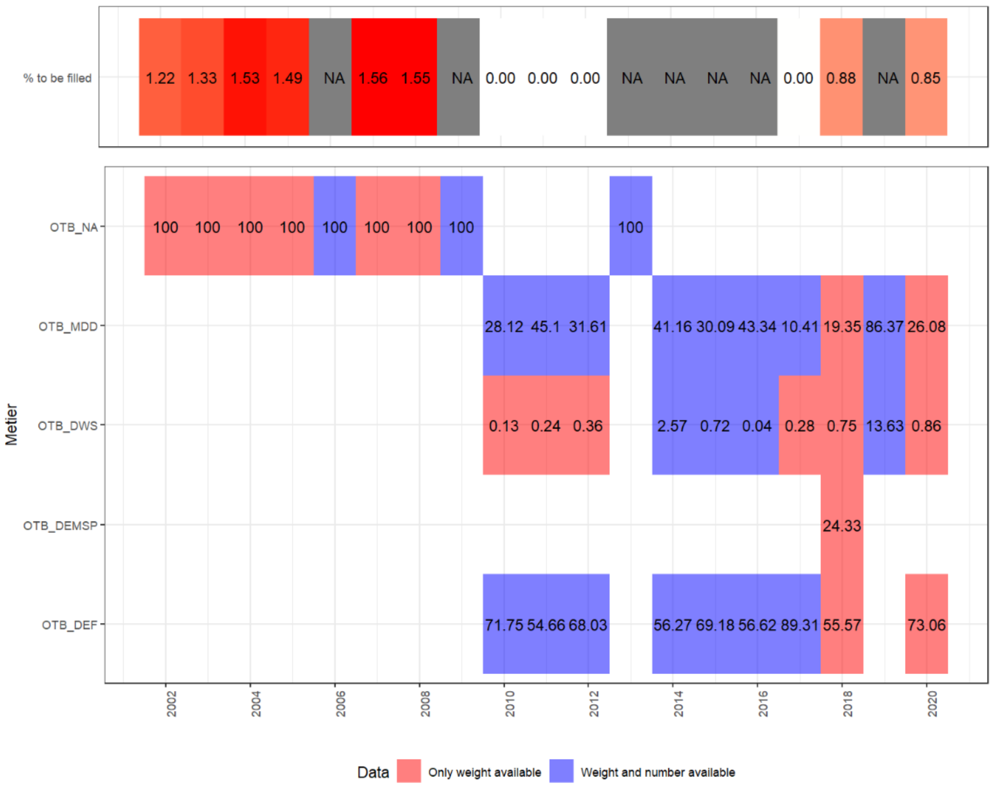


Figure 6.10.2.1.17 Deep-water rose shrimp in GSAs 09, 10 & 11. Table summarising the LFDs available and those to be reconstructed (below) in GSA10.

6.10.2.2 Effort Data

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

6.10.2.3 Survey Data (MEDITS)

Since 1994, MEDITS trawl surveys has been regularly carried out each year, generally during the spring-summer season. In 2020, the survey was carried out very late (autumn) and about half hauls were performed in GSA10.

6.10.2.3.1 Methods

Based on the DCF data, abundance and biomass indices for GSAs 09, 10 and 11 combined were calculated. In Tables. 6.10.2.3.1.1-2 the number of hauls are reported per depth stratum in each GSA.

Table 6.10.2.3.1.1 Number of hauls per year and depth stratum in GSA09, period 1994-2020.

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
10-50	14
50-100	19
100-200	30
200-500	37
500-800	20
Total	120

Table 6.10.2.3.1.2 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
10-50	3
50-100	4
100-200	9
200-500	10
500-800	11
Total	37

Table 6.10.2.3.1.3 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
10-50	20
50-100	19
100-200	24
200-500	21
500-800	17
Total	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, and assumptions over the distribution of data affect the 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.

6.10.2.3.3 Trends in abundance and biomass

The trends of the MEDITS indices (density and biomass) for the three GSAs combined are displayed in Fig. 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.

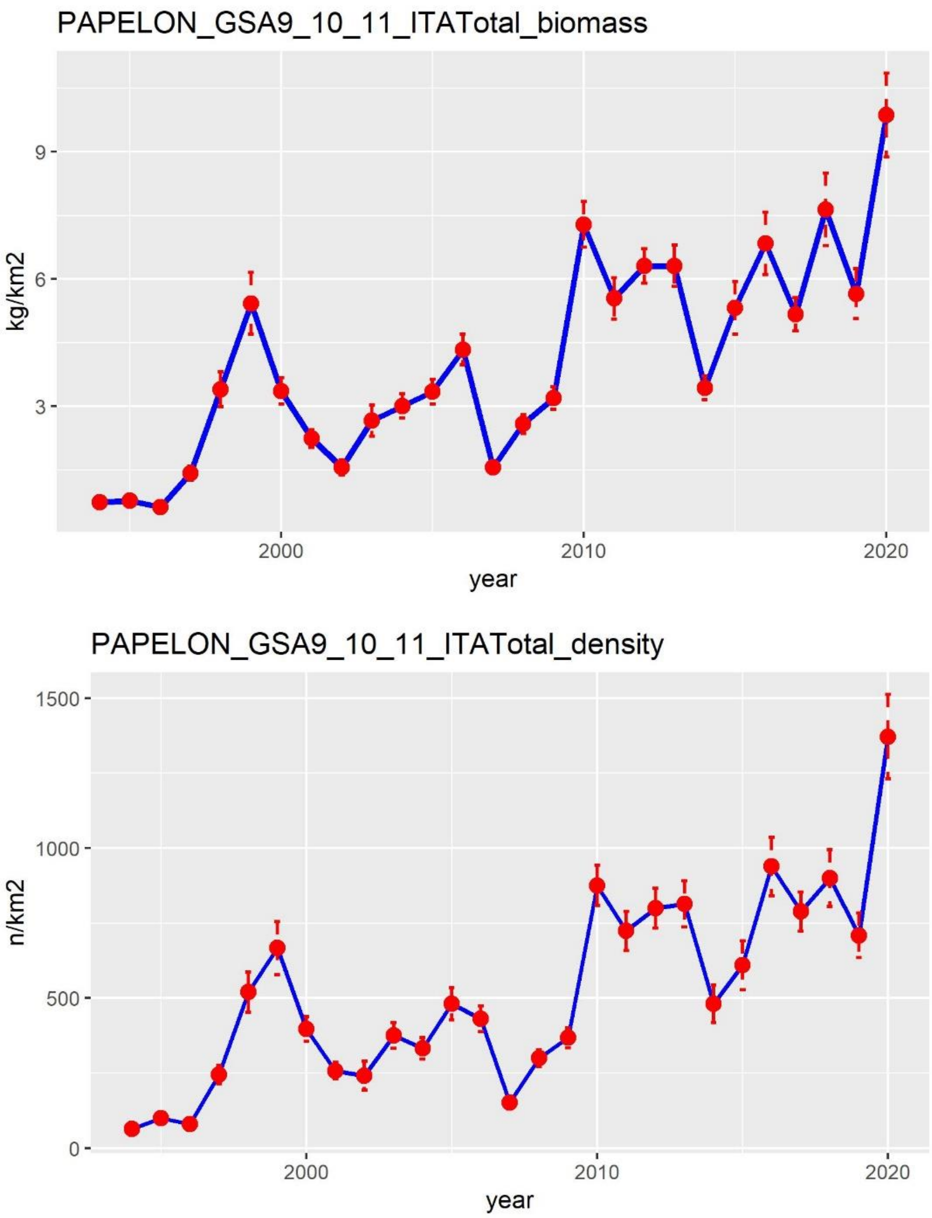


Figure 6.10.2.3.3.1 Deep-water rose shrimp in GSAs 09, 10 & 11. MEDITS standardized abundance and biomass indices (10-800 m).

6.10.2.2.4 Trends in abundance and biomass by length

Figs. 6.10.2.3.4.1-3 display the stratified abundance indices by length for the three GSAs combined during the MEDITS surveys from 1994 to 2020.

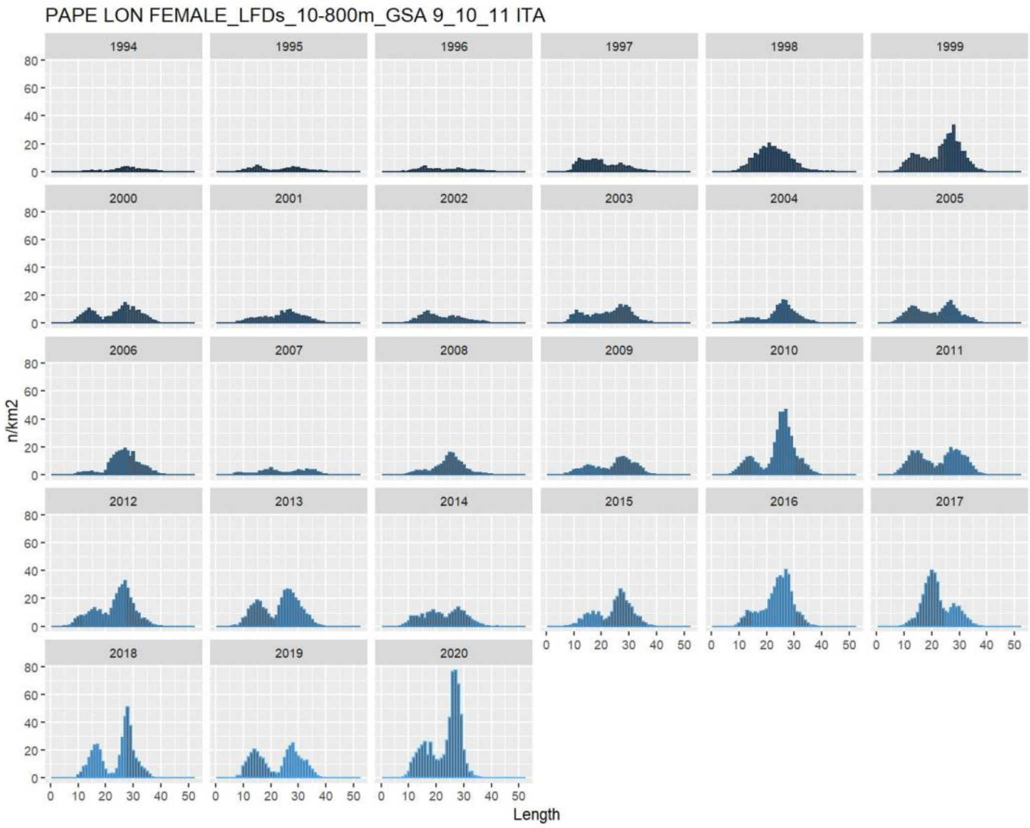


Figure 6.10.2.3.4.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for females, period 1994-2020.

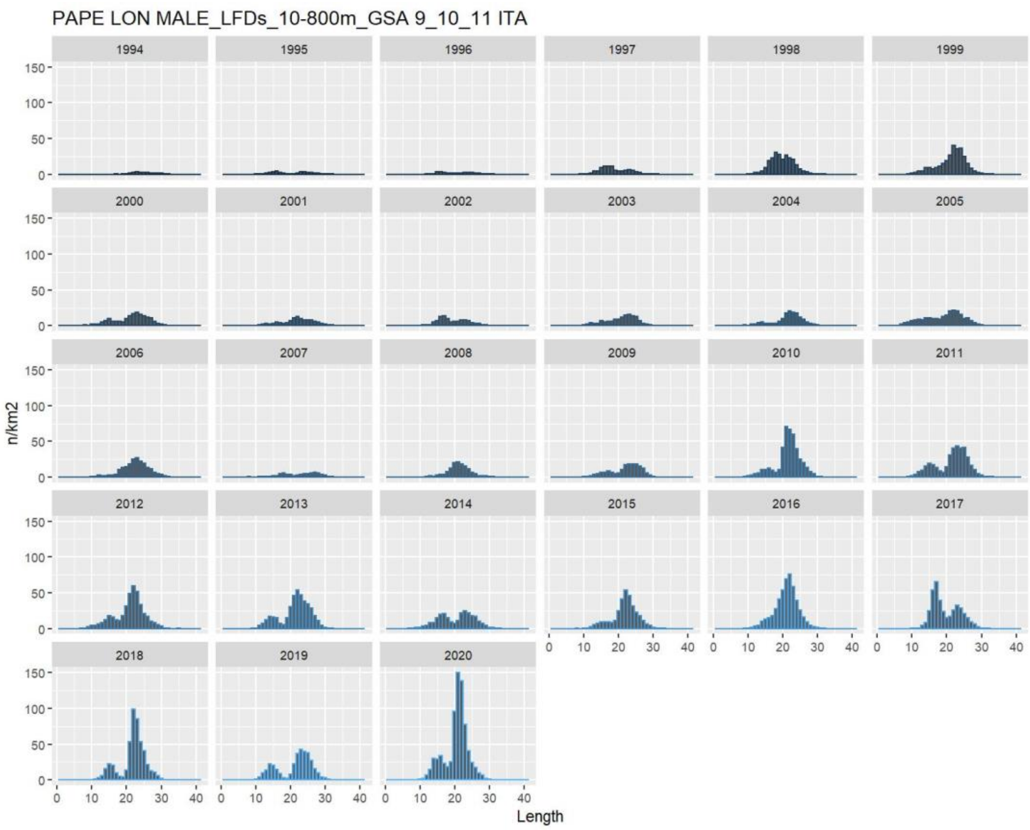


Figure 6.10.2.3.4.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for males, period 1994-2020.

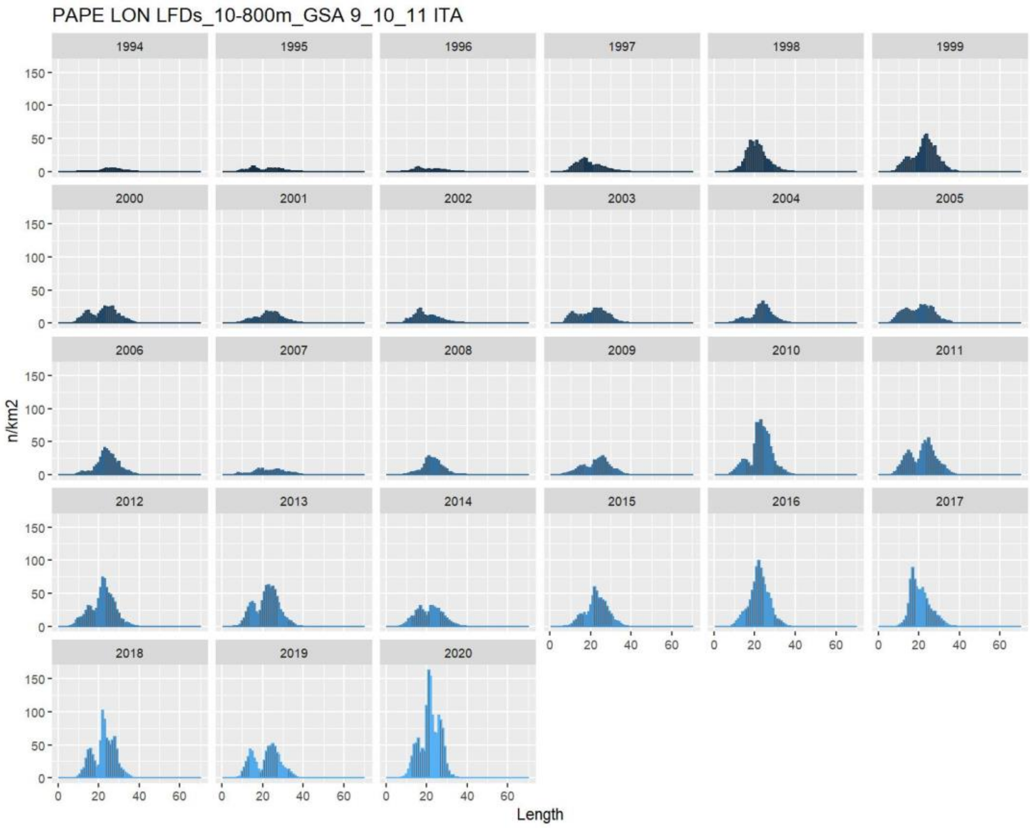


Figure 6.10.2.3.4.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for the total population, period 1994-2020.

The MEDITS survey for GSA 8 has not been included in the assessment because there was no survey in 2020, and inclusion of a partial series would have raised other issues. GSA 8 contributes little to the catch (<.5%) and the survey contributes little to a stock index.

6.10.3 STOCK ASSESSMENT

A Statistical Catch-at-age (a4a) assessment was carried out during STECF EWG 21-11 using catch data collected under DCR-DCF from 2009 to 2020 and calibrated with survey data (MEDITS 2009-2020). 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 4 for commercial data. The number of individuals by age was SOP corrected [SOP = catch / Σa (total catch numbers at age a x catch weight-at-age a)].

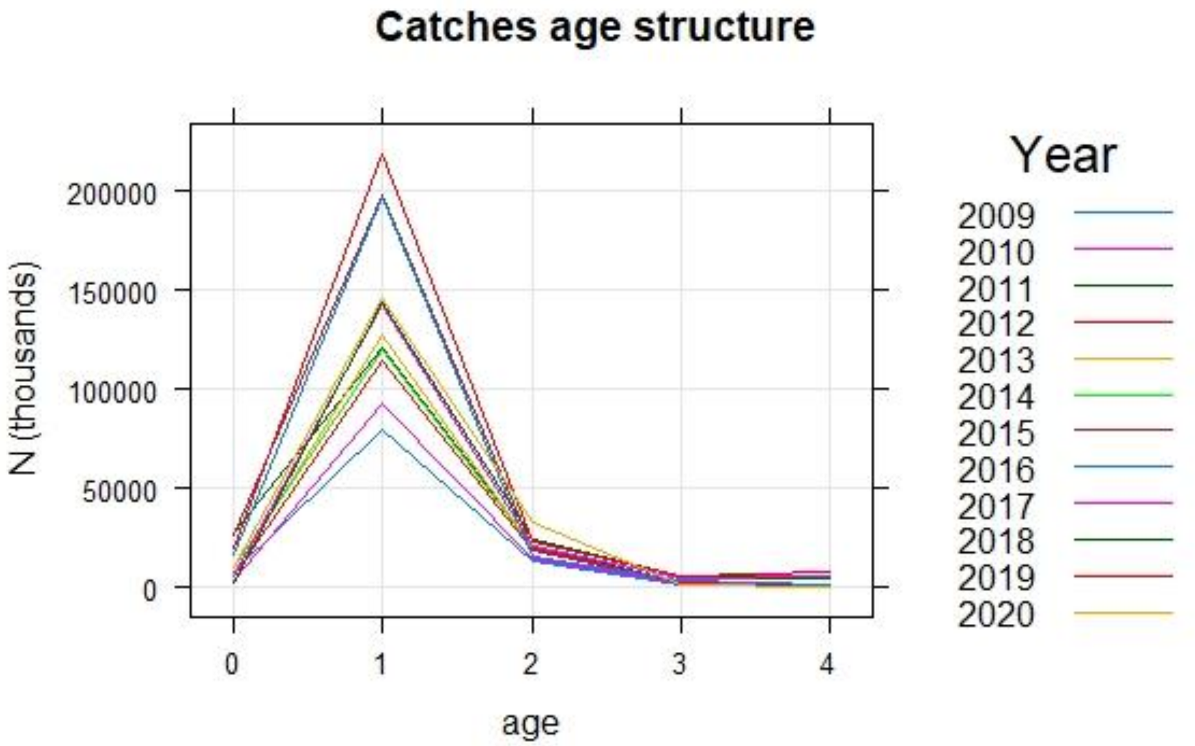
Tab. 6.10.3.1 Deep-water rose shrimp in GSAs 09, 10 and 11.

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.95	0.94	0.93	0.92	0.94	0.93	0.90	1.29	1.36	1.24	1.05	2.76

The correction factors that resulted were low, with the exception of 2020; in the last year a value of 2.76 was observed due to the lack of the LFDs for the main metiers exploiting DPS in GSA10. MEDITS data from the three GSAs for the period 2009-2020 were used for tuning.

Discards were included in the analysis with the exception of GSA11 for which data is not available. This information was not available in some years also for GSAs 09 and 10 but LFDs were reconstructed.

Given that the catches were composed mainly of individuals between 1 and 2 years, these ages were selected as the F_{bar}.



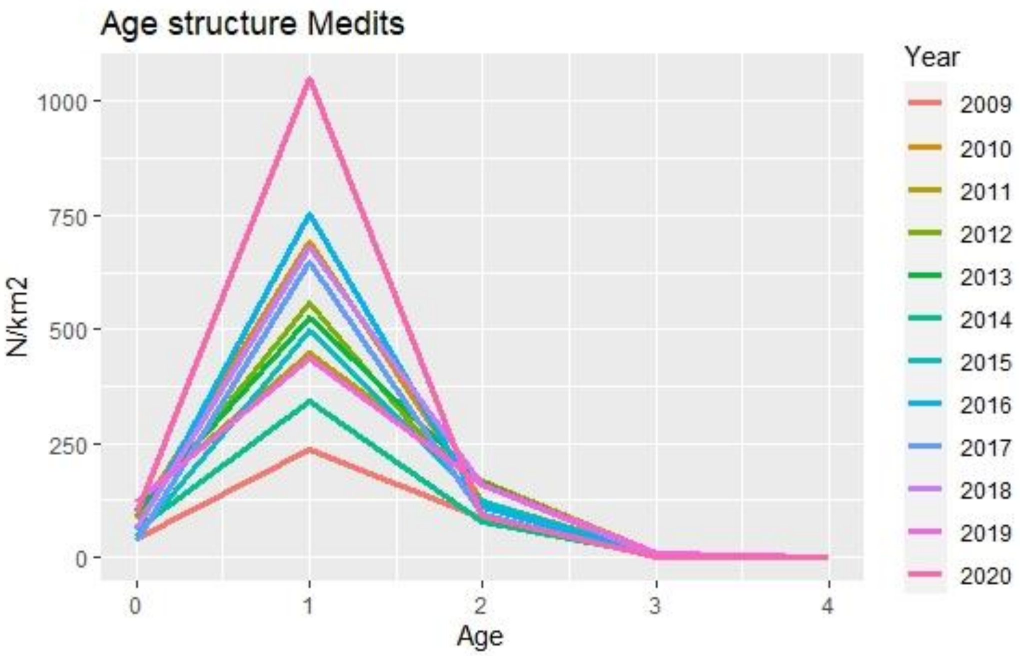


Figure 6.10.3.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Age frequency distributions of the total commercial catches (above) and of the Medits catches (below) by year.

Tab. 6.10.3.1 Deep-water rose shrimp in GSAs 09, 10 and 11. Input parameters for a4a.

Catch at age (thousands)	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	7239.1	73904.3	12829.0	1560.1	609.8
2010	6272.3	97957.2	14197.2	2061.7	981.8
2011	6871.7	97240.8	19727.3	2441.1	1169.7
2012	8784.6	112914.5	19728.8	3018.9	1383.9
2013	12699.8	130772.1	20537.9	2384.1	1858.7
2014	13373.8	155308.5	19332.7	2123.4	1668.6
2015	13719.8	143107.2	19184.4	2222.0	1229.5
2016	10035.2	156424.6	17195.6	3130.3	768.9
2017	5990.8	149824.0	21372.3	4063.6	507.3
2018	8317.7	126591.1	24477.9	5797.2	372.5
2019	7077.3	218631.4	22273.2	4877.8	536.4
2020	13792.3	173661.8	31912.7	1886.5	1093.7

	Catches (in tons)
2009	749.6
2010	896.0
2011	1075.8
2012	1125.7
2013	1233.0
2014	1149.1
2015	1467.3
2016	1437.0
2017	1196.5
2018	1577.2
2019	2029.1
2020	1637.7

Mean weight at age (Catches)	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	0.002	0.006	0.016	0.025	0.023
2010	0.002	0.006	0.015	0.024	0.027
2011	0.002	0.005	0.016	0.023	0.023
2012	0.002	0.006	0.017	0.023	0.024
2013	0.002	0.006	0.016	0.023	0.023
2014	0.002	0.006	0.016	0.023	0.023
2015	0.002	0.005	0.015	0.020	0.021
2016	0.002	0.005	0.015	0.025	0.026
2017	0.002	0.007	0.013	0.017	0.021
2018	0.002	0.008	0.013	0.016	0.020
2019	0.002	0.006	0.013	0.017	0.021
2020	0.002	0.008	0.013	0.017	0.019

Mean weight at age (Stock)	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	0.002	0.006	0.016	0.025	0.023
2010	0.002	0.006	0.015	0.024	0.027
2011	0.002	0.005	0.016	0.023	0.023
2012	0.002	0.006	0.017	0.023	0.024
2013	0.002	0.006	0.016	0.023	0.023
2014	0.002	0.006	0.016	0.023	0.023
2015	0.002	0.005	0.015	0.020	0.021
2016	0.002	0.005	0.015	0.025	0.026
2017	0.002	0.007	0.013	0.017	0.021
2018	0.002	0.008	0.013	0.016	0.020
2019	0.002	0.006	0.013	0.017	0.021
2020	0.002	0.008	0.013	0.017	0.019

Natural mortality	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	2.21	1.08	0.87	0.79	0.76
2010	2.21	1.08	0.87	0.79	0.76
2011	2.21	1.08	0.87	0.79	0.76
2012	2.21	1.08	0.87	0.79	0.76
2013	2.21	1.08	0.87	0.79	0.76
2014	2.21	1.08	0.87	0.79	0.76
2015	2.21	1.08	0.87	0.79	0.76
2016	2.21	1.08	0.87	0.79	0.76
2017	2.21	1.08	0.87	0.79	0.76
2018	2.21	1.08	0.87	0.79	0.76
2019	2.21	1.08	0.87	0.79	0.76
2020	2.21	1.08	0.87	0.79	0.76

Proportion of mature	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	0.45	0.95	1	1	1
2010	0.45	0.95	1	1	1
2011	0.45	0.95	1	1	1
2012	0.45	0.95	1	1	1
2013	0.45	0.95	1	1	1
2014	0.45	0.95	1	1	1
2015	0.45	0.95	1	1	1
2016	0.45	0.95	1	1	1
2017	0.45	0.95	1	1	1
2018	0.45	0.95	1	1	1
2019	0.45	0.95	1	1	1
2020	0.45	0.95	1	1	1

Tuning Medits index	Age 0	Age 1	Age 2	Age 3	Age 4
2009	40.88	235.17	86.97	4.12	0.55
2010	85.92	691.62	122.90	6.87	0.27
2011	124.15	448.64	167.22	7.56	2.03
2012	91.45	556.64	111.42	7.09	1.02
2013	100.98	527.28	164.83	5.36	0.86
2014	61.57	343.57	79.21	4.36	0.58
2015	44.50	497.87	124.36	5.06	0.63
2016	62.45	752.99	110.35	2.99	0.14
2017	36.33	649.03	92.95	2.37	0.14
2018	65.75	682.13	158.98	3.82	0.30
2019	122.00	436.62	159.34	7.19	0.17
2020	98.40	1050.80	90.40	1.27	0.12

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 <- ~ s(year, k=5) + s(year, k=5, by=as.numeric(age==3))+ s(year, k=5, by=as.numeric(age==0))

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 Figures. 6.10.3.2-12 and Tables. 6.10.3.2-4.

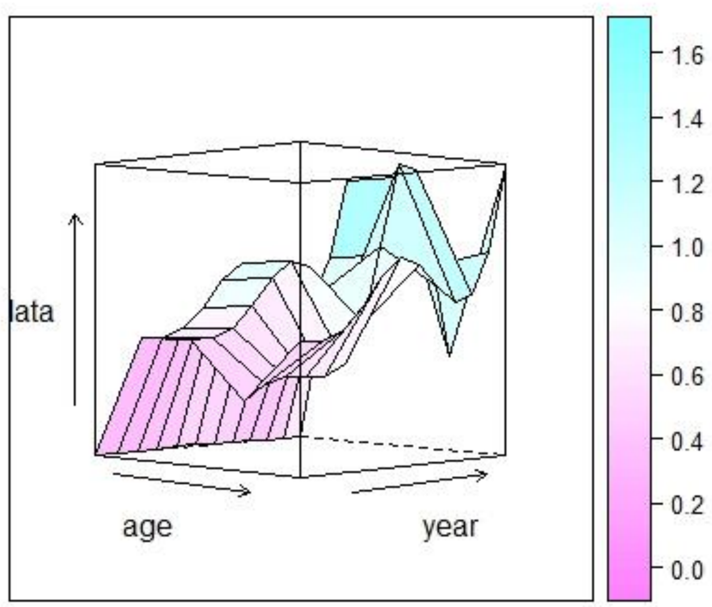


Figure 6.10.3.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Fishing mortality by age and year obtained from the a4a model (2009-2020).

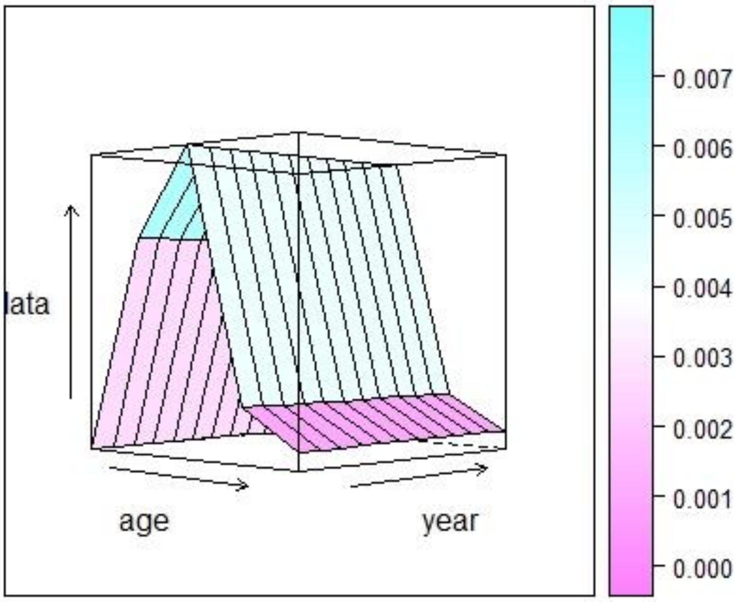


Figure 6.10.3.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Catchability by age and year obtained from the a4a model (2009-2020).

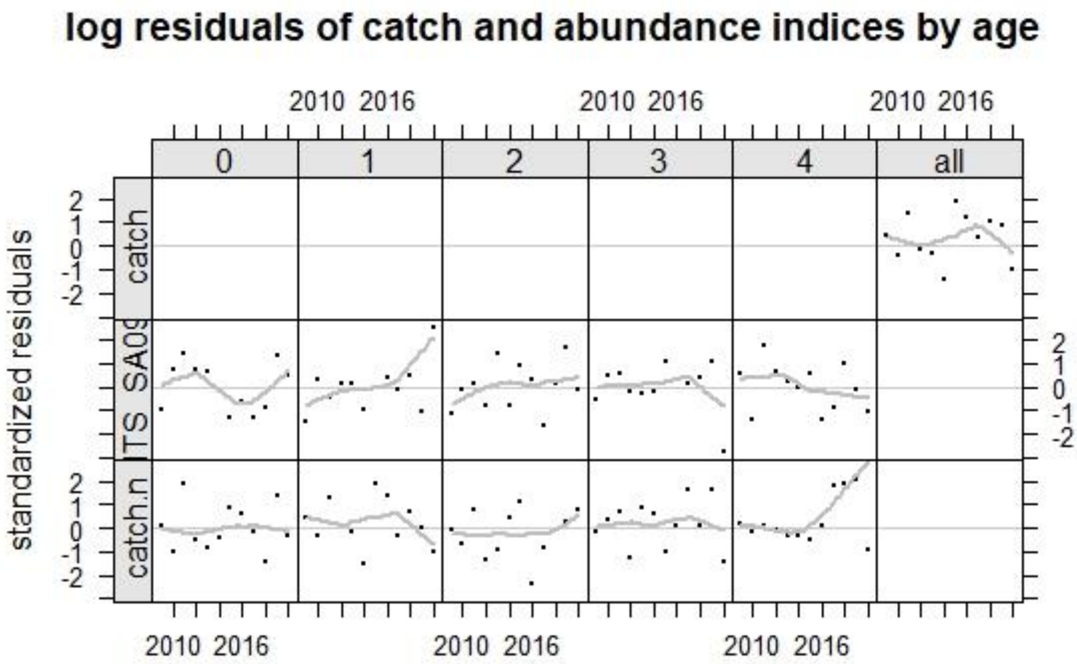


Figure 6.10.3.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Log residuals of the fishery and the survey data by age, and of the total catches.

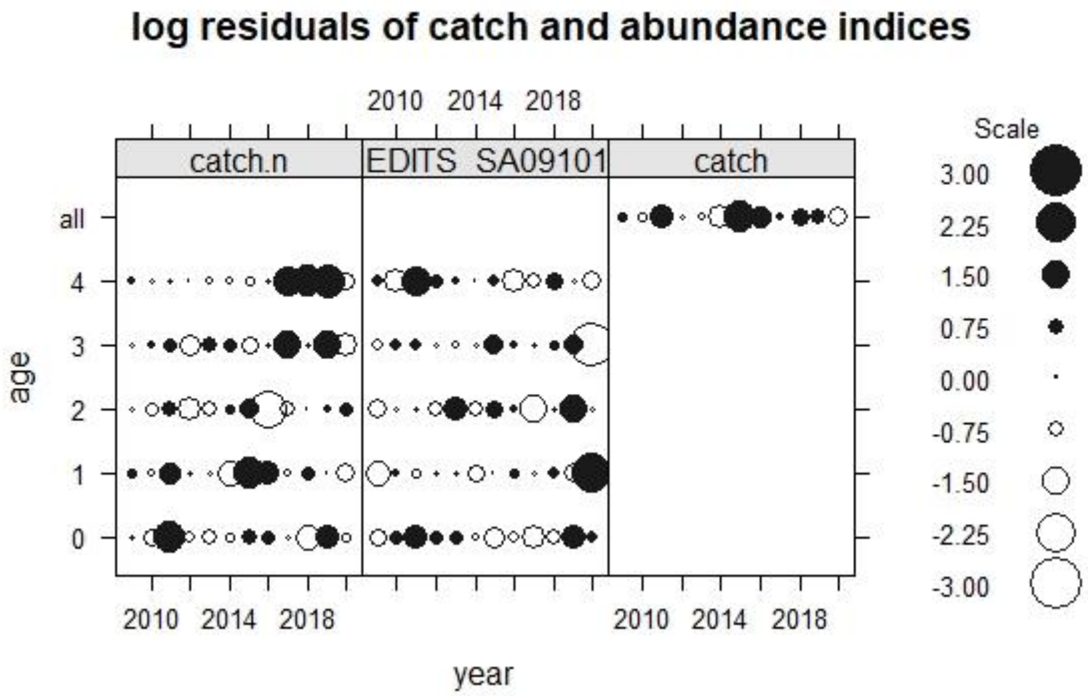


Figure 6.10.3.5 Deep-water rose shrimp in GSAs 09, 10 & 11. Bubble plot of the log residuals of the fishery and the survey data by age, and of the total catches.

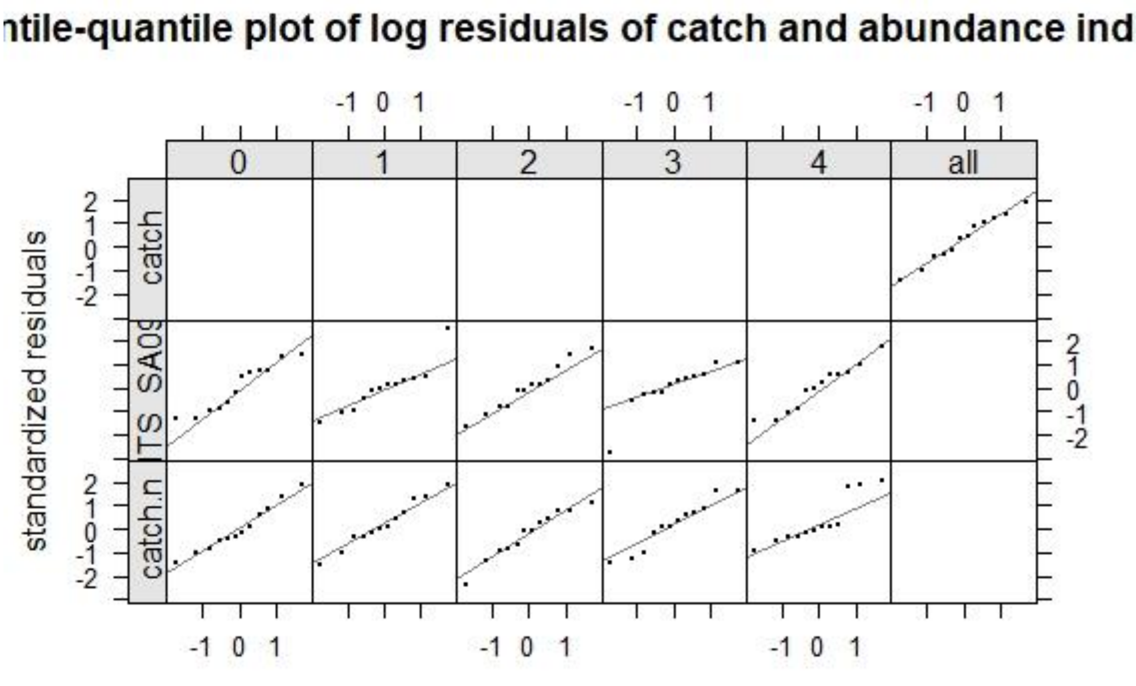


Figure 6.10.3.6 Deep-water rose shrimp in GSAs 09, 10 & 11. QQ-plot of the log residuals of the fishery and the survey data by age, and of the total catches.

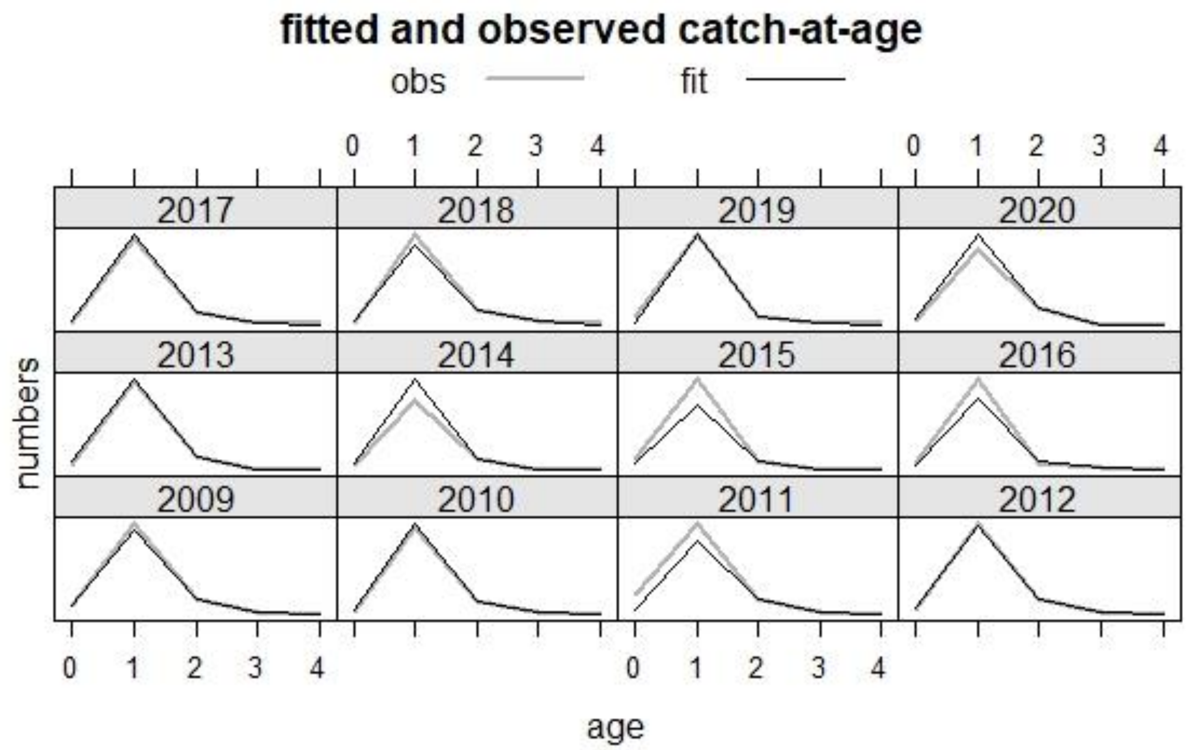


Figure 6.10.3.7 Deep-water rose shrimp in GSAs 09, 10 & 11. Fitted and observed catches at age by year.

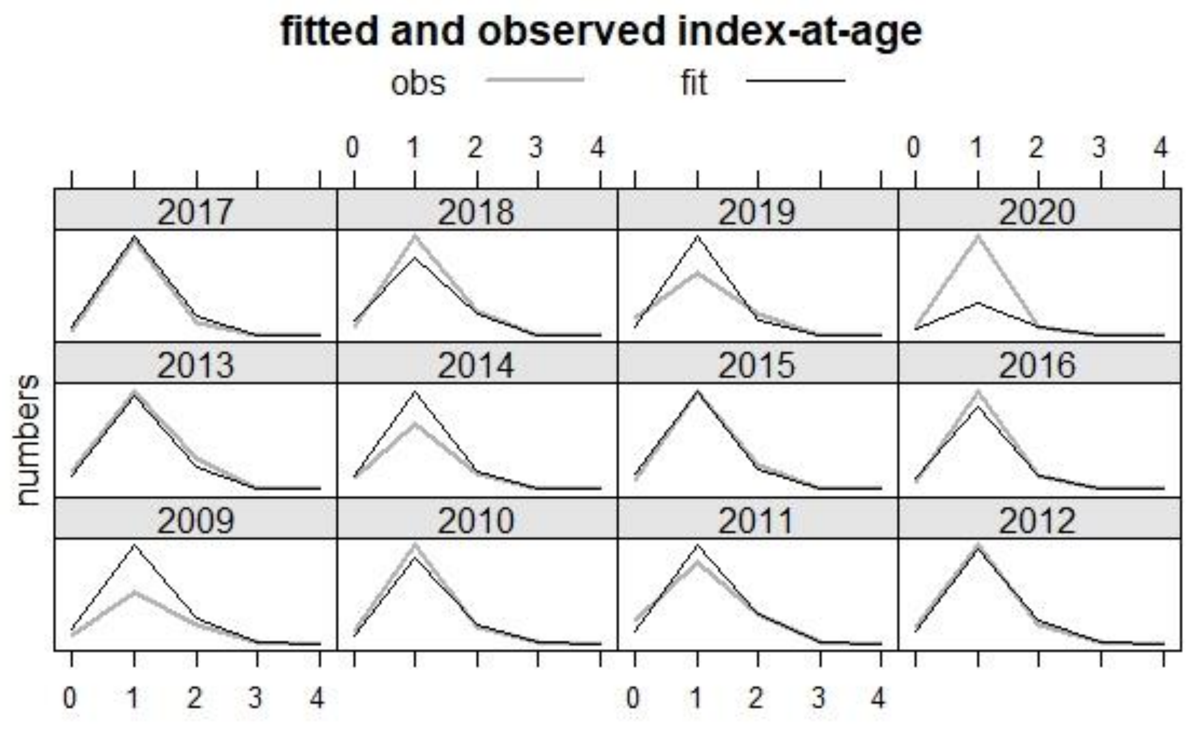


Figure 6.10.3.8 Deep-water rose shrimp in GSAs 09, 10 & 11. Fitted and observed Medits index at age by year.

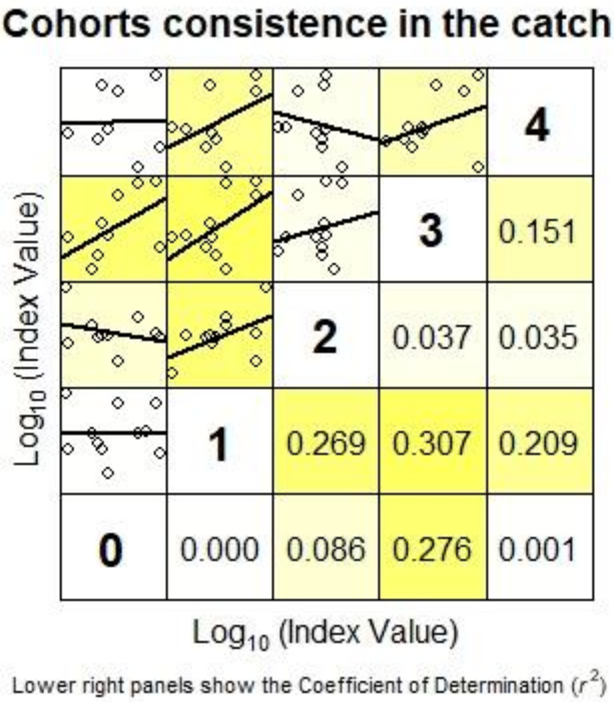


Figure 6.10.3.9 Deep-water rose shrimp in GSAs 09, 10 & 11. Internal consistency of the catch at age data.

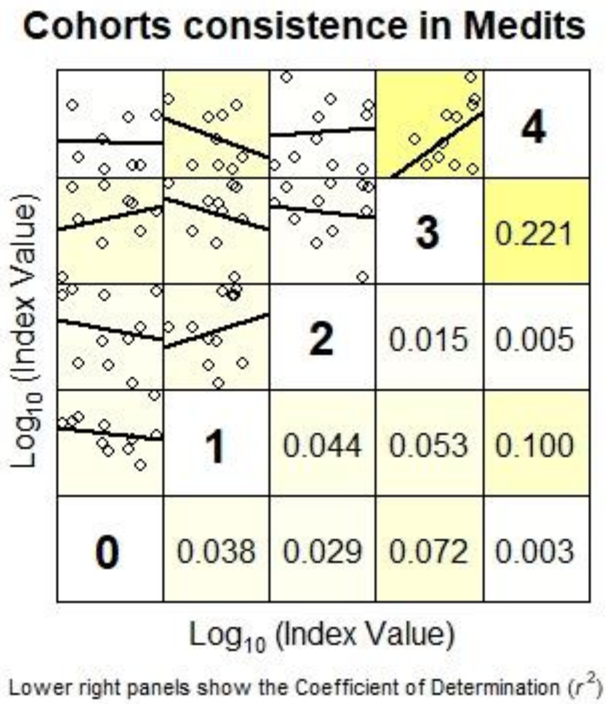


Figure 6.10.3.10 Deep-water rose shrimp in GSAs 09, 10 & 11. Internal consistency of the Medits index at age data.

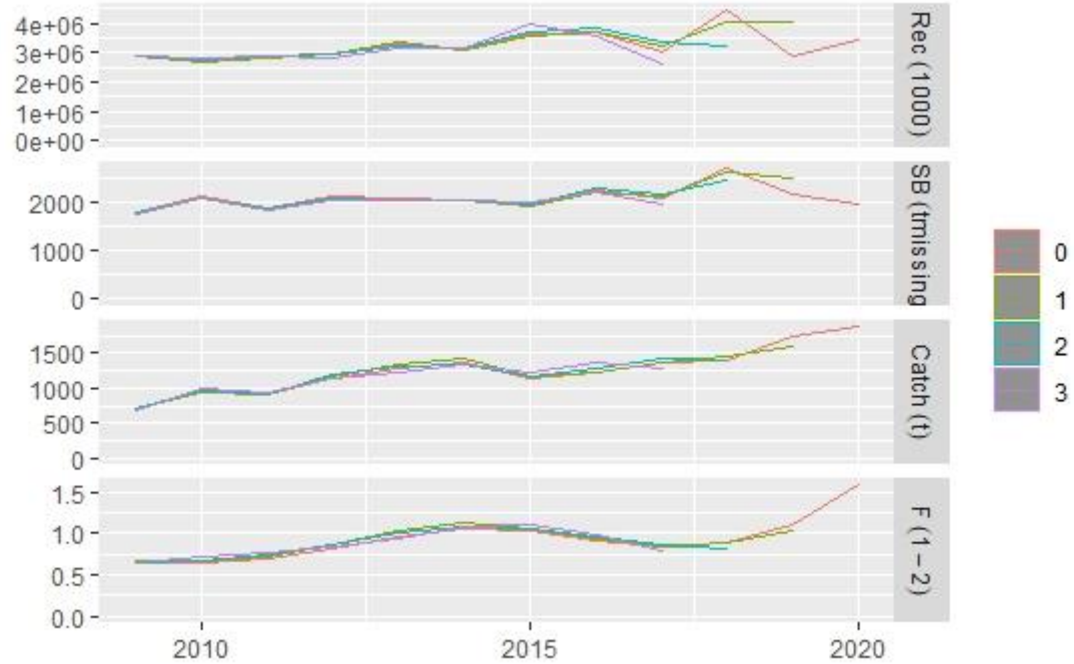


Figure 6.10.3.11 Deep-water rose shrimp in GSAs 09, 10 & 11. Retrospective analysis.

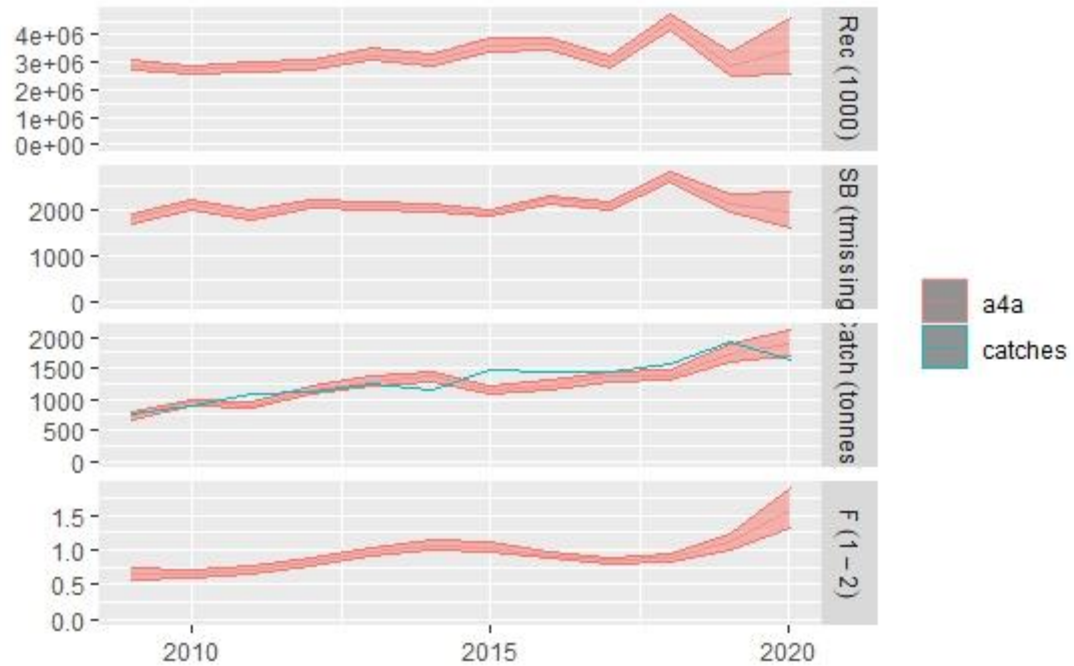


Figure 6.10.3.12 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment model with uncertainty. Green line represents the catches observed.

Table. 6.10.3.2 Deep-water rose shrimp in GSAs 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	Age 4+
2009	2896475	238965.4	38379.36	7452.08	1749.33
2010	2724072	315775.5	42346.76	8390.45	2807.77
2011	2832808	297126	55812.92	9233.75	3174.47
2012	2919830	308891.5	50059.27	11600.61	3371.58
2013	3261327	317918.5	46415.09	9279.83	4037.93
2014	3064789	354317.8	41059.22	7395.3	3409.17
2015	3615495	332574.4	41486.72	5931.01	2557.34
2016	3682025	392892.7	40123.54	6174.77	1724.1
2017	3000511	401190.9	53102.05	6690.2	1210.41
2018	4440774	327528.1	58800.79	9601.63	859.69
2019	2880279	484893	46018.89	10192.3	1066.64
2020	3422245	314043.4	54106.66	6334.94	1790.81

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	Age 4+
2009	0.01	0.65	0.65	0.35	0.65
2010	0.01	0.65	0.65	0.42	0.65
2011	0.01	0.70	0.70	0.46	0.70
2012	0.01	0.82	0.82	0.46	0.82
2013	0.01	0.97	0.97	0.45	0.97
2014	0.01	1.06	1.06	0.51	1.06
2015	0.01	1.03	1.03	0.73	1.03
2016	0.01	0.92	0.92	1.15	0.92
2017	0.00	0.84	0.84	1.60	0.84
2018	0.00	0.88	0.88	1.58	0.88
2019	0.01	1.11	1.11	1.04	1.11
2020	0.01	1.58	1.58	0.54	1.58

Table. 6.10.3.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment.

	$F_{bar\ 1-2}$	Recruitment (thousands	SSB (t)	Total Biomass (t)	Catch
2009	0.65	2896475	1803.3	7794.5	712
2010	0.65	2724072	2112.3	8630.2	945
2011	0.70	2832808	1883.5	7681.2	901
2012	0.82	2919830	2112.1	8935.9	1150
2013	0.97	3261327	2074.3	9344.7	1289
2014	1.06	3064789	2050.2	9690.3	1362
2015	1.03	3615495	1925.7	9464.2	1149
2016	0.92	3682025	2227.9	10743.8	1226
2017	0.84	3000511	2065.2	8549.1	1371
2018	0.88	4440774	2685.7	13073.6	1385
2019	1.11	2880279	2140.5	9798.3	1740
2020	1.58	3422245	1960.0	10493.5	1878

Based on a4a results, the Deep-water rose shrimp SSB showed an increasing trend, reaching the maximum value in 2018 (2686 tons). The recruitment (age 0) showed a similar trend of SSB, with a value of 4,440,774 thousands individuals in 2018. The lowest value of fishing mortality (Fbar = 0.65) is observed at the beginning of the time series. After that, a constant increase of F was showed reaching a peak of 1.06 in 2014. Then, a decreasing trend is observed followed by a new increase until reaching the maximum value of F in 2020 (1.58).

6.10.4 Reference Points

The STECF EWG 21-11 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 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 Fig. 6.10.4.1.

Current F (1.58), estimated as the F_{bar1-2} in the last year of the time series (2020), is higher than $F_{0.1}$ (1.29), which indicates that Deep-water rose shrimp stock in GSAs 09, 10 and 11 is in overexploitation.

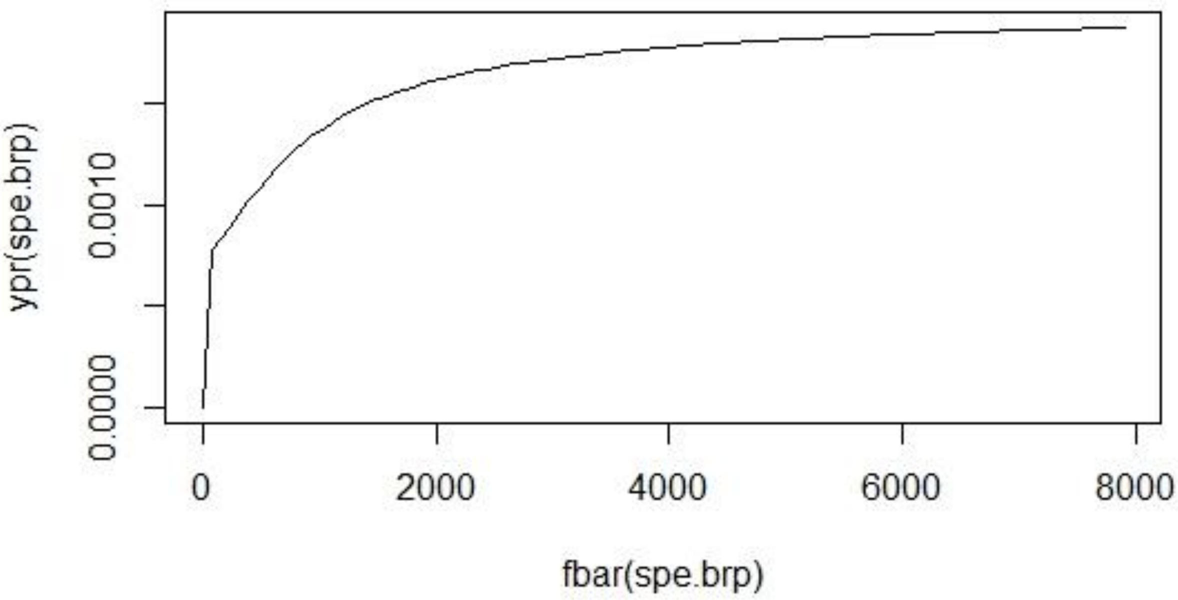


Figure 6.10.4.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Yield per Recruit curve.

6.10.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2020 to 2022 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 2018 to 2020 were the same used for the a4a stock assessment and its results (Table 6.10.5.1). An average of the last three years has been used for weight at age and maturity at age, while the F_{bar} = 1.58 terminal F (2020) from the a4a assessment was used for F in 2021.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the whole data series (3,197,123 thousand individuals).

The short term forecast (Tab. 6.10.5.2) was carried out estimating a catch for 2021-2023 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 2021 equal to 1740.5 and 1798.9 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (= 1.29) would increase SSB of 5.73% from 2021 to 2023, while decreasing the catch of 22.52% from 2020 to 2022.

A catch option for $F_{MSY\ Transition}$ is provided in the table based on a linear transition from F2019 to F_{MSY} in 2025. F 2019 is estimated as below F_{MSY}, and the transition algorithm gives an intermediate level increase in F in 2022 half way between F2019 and F_{MSY}, for this option it may be more reasonable to substitute the F_{MSY} as the F target.

Table 6.10.5.1 Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological parameters	3 year	Mean weight, Maturity, Natural maturity and F at age are calculated as mean of last three years (2018-2020)
$F_{ages\ 1-2}$ (2020)	1.58	F current in the last year (2020) used to give F status quo for 2021
SSB (2021)	1799 t	
R_0 (2021)	3,197,123 thousands	Geometric mean of the period 2009-2020
R_0 (2023)	3,197,123 thousands	Geometric mean of the period 2009-2020
Total catch (2021)	1741 t	

Tab. 6.10.5.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Short term forecast in different F scenarios. SSB refers to the middle of the year.

Rationale	Ffactor	Fbar	Recr. 2021	Fsq2021	Catch 2020	Catch 2021	Catch 2022	SSB 2021	SSB 2023	SSB change 2021-2023(%)	Catch change 2020-2022(%)
High long term yield ($F_{0.1}$)	0.81	1.29	3197123	1.58	1878.0	1740.5	1455.0	1798.9	1901.9	5.73	-22.52
F upper	1.10	1.74	3197123	1.58	1878.0	1740.5	1717.9	1798.9	1668.1	-7.27	-8.53
F lower	0.54	0.85	3197123	1.58	1878.0	1740.5	1112.9	1798.9	2233.2	24.14	-40.74
F_{MSY} transition	0.76	1.20	3197123	1.58	1878.0	1740.5	1394.8	1798.9	1957.9	8.84	-25.73
Zero catch	0	0.00	3197123	1.58	1878.0	1740.5	0.0	1798.9	3538.2	96.69	-100.00
Status quo	1	1.58	3197123	1.58	1878.0	1740.5	1634.3	1798.9	1740.6	-3.24	-12.98
Different Scenarios	0.1	0.16	3197123	1.58	1878.0	1740.5	267.4	1798.9	3192.6	77.48	-85.76
	0.2	0.32	3197123	1.58	1878.0	1740.5	502.6	1798.9	2905.3	61.51	-73.24
	0.3	0.47	3197123	1.58	1878.0	1740.5	710.0	1798.9	2665.1	48.15	-62.20
	0.4	0.63	3197123	1.58	1878.0	1740.5	893.1	1798.9	2463.1	36.92	-52.44
	0.5	0.79	3197123	1.58	1878.0	1740.5	1055.3	1798.9	2292.2	27.42	-43.81
	0.6	0.95	3197123	1.58	1878.0	1740.5	1199.1	1798.9	2146.7	19.34	-36.15
	0.7	1.11	3197123	1.58	1878.0	1740.5	1327.1	1798.9	2022.2	12.41	-29.34
	0.8	1.27	3197123	1.58	1878.0	1740.5	1441.1	1798.9	1914.8	6.44	-23.27
	0.9	1.42	3197123	1.58	1878.0	1740.5	1543.0	1798.9	1821.7	1.27	-17.84
	1.1	1.74	3197123	1.58	1878.0	1740.5	1716.3	1798.9	1669.4	-7.20	-8.61
	1.2	1.90	3197123	1.58	1878.0	1740.5	1790.2	1798.9	1606.7	-10.69	-4.68
	1.3	2.06	3197123	1.58	1878.0	1740.5	1856.9	1798.9	1551.1	-13.78	-1.13
	1.4	2.22	3197123	1.58	1878.0	1740.5	1917.4	1798.9	1501.6	-16.53	2.09
	1.5	2.37	3197123	1.58	1878.0	1740.5	1972.3	1798.9	1457.3	-18.99	5.02
	1.6	2.53	3197123	1.58	1878.0	1740.5	2022.4	1798.9	1417.6	-21.20	7.68
	1.7	2.69	3197123	1.58	1878.0	1740.5	2068.1	1798.9	1381.8	-23.19	10.12
	1.8	2.85	3197123	1.58	1878.0	1740.5	2110.0	1798.9	1349.5	-24.98	12.35
	1.9	3.01	3197123	1.58	1878.0	1740.5	2148.6	1798.9	1320.2	-26.61	14.40
	2	3.17	3197123	1.58	1878.0	1740.5	2184.1	1798.9	1293.5	-28.09	16.30

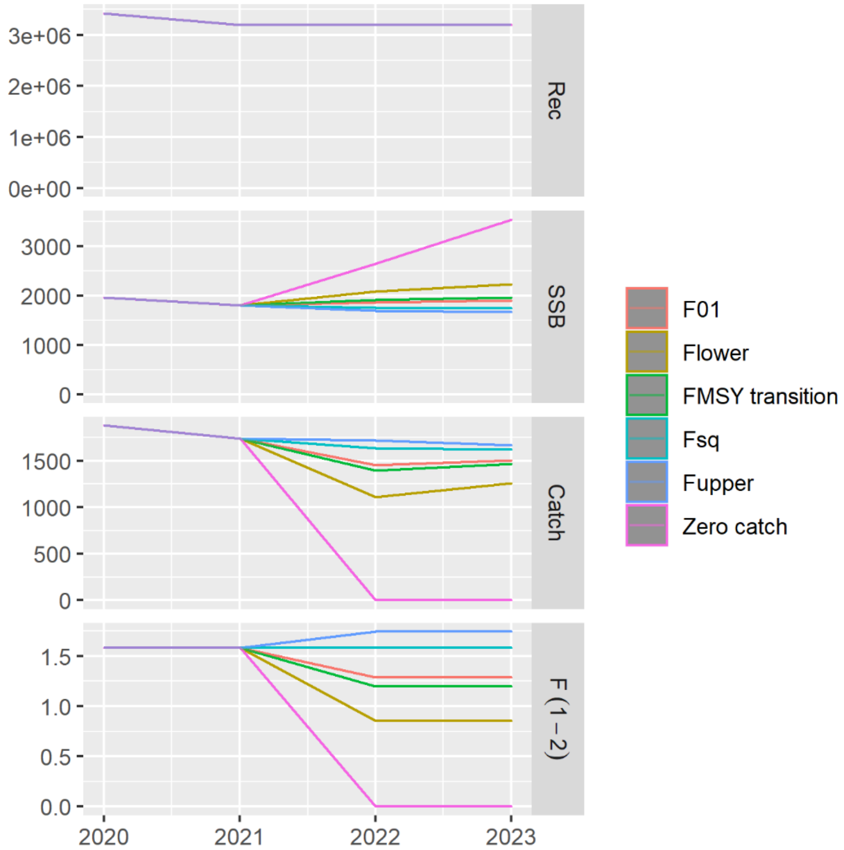


Fig. 6.10.5.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Short-term forecast in different F scenarios.

6.10.6 Data Deficiencies

Data from DCR-DCF database as submitted through the Official data call in 2021 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: 2003-2020 for GSA09, 2002-2020 for GSA10 and 2009-2020 for GSA11.

Stock assessment was performed on the time series from 2009 to 2020.

For some metiers, the length frequency distributions were not available and had to be reconstructed. In particular, the LFD of OTB_DEF for 2019 in GSA10 was not available; this metier represented a high percentage of the total landing (61.51%). In GSA11, the LFDs of OTB_DWS and OTB-DEF were not available for the years 2019 and 2020. These two metiers together contributed to 56.24% and 60.81% of the total landing in the two years respectively. In other cases, the reconstructions in the three GSAs involved metiers who contribute marginally to the total landing.LFDs for GSA 8 are not available.

Discard data. For some years, the LFDs of discard were not available and had to be reconstructed. However, the discarded quantities of this species are quite low, especially in GSA10. Demographic information on discards of DPS in GSA11 was not reported in the DCF database.

MEDITS data. In 2020, the MEDITS SURVEY was carried out with considerable delay in all three GSAs: October-November in GSAs 09 and 11, December in GSA10. Moreover, in the latter GSA about half of the planned hauls were carried out (37 instead of 70). A sensitivity analysis was carried out to assess the effects of the problems relating to the 2020 survey on the stock assessment. The results did not show particular issues for this species and, therefore, the 2020 survey was included in the final model. In 2020, the MEDITS SURVEY was not performed in GSA 8.

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).

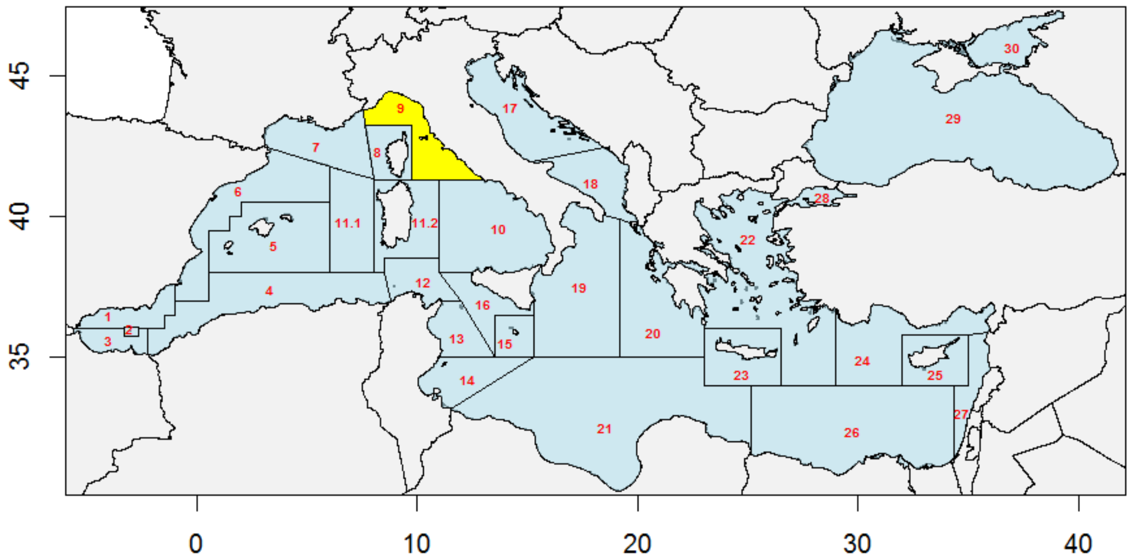


Figure 6.11.1.1 Red mullet in GSA 9: Location of GSA 9 in the Mediterranean Sea.

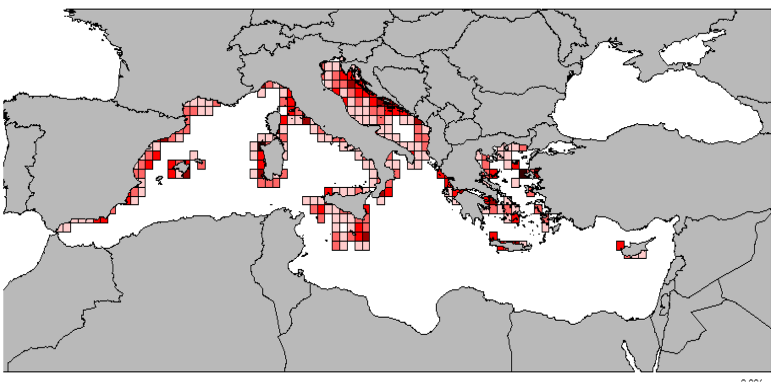


Figure 6.11.1.2 Red mullet in GSA 9: Geographical distribution of red mullet in the Mediterranean basin (kg/km^2, average 2004-2014 by GFCM rectangle), STOCKMED Project.

However, in line with ToR given, EWG 21-11 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). However, catch data is not currently reported at finer scale under the DCF and the issue cannot currently be fully evaluated or resolved.

Growth

Growth parameters of red mullet in GSA 9 are available from 2006 to 2020 (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).

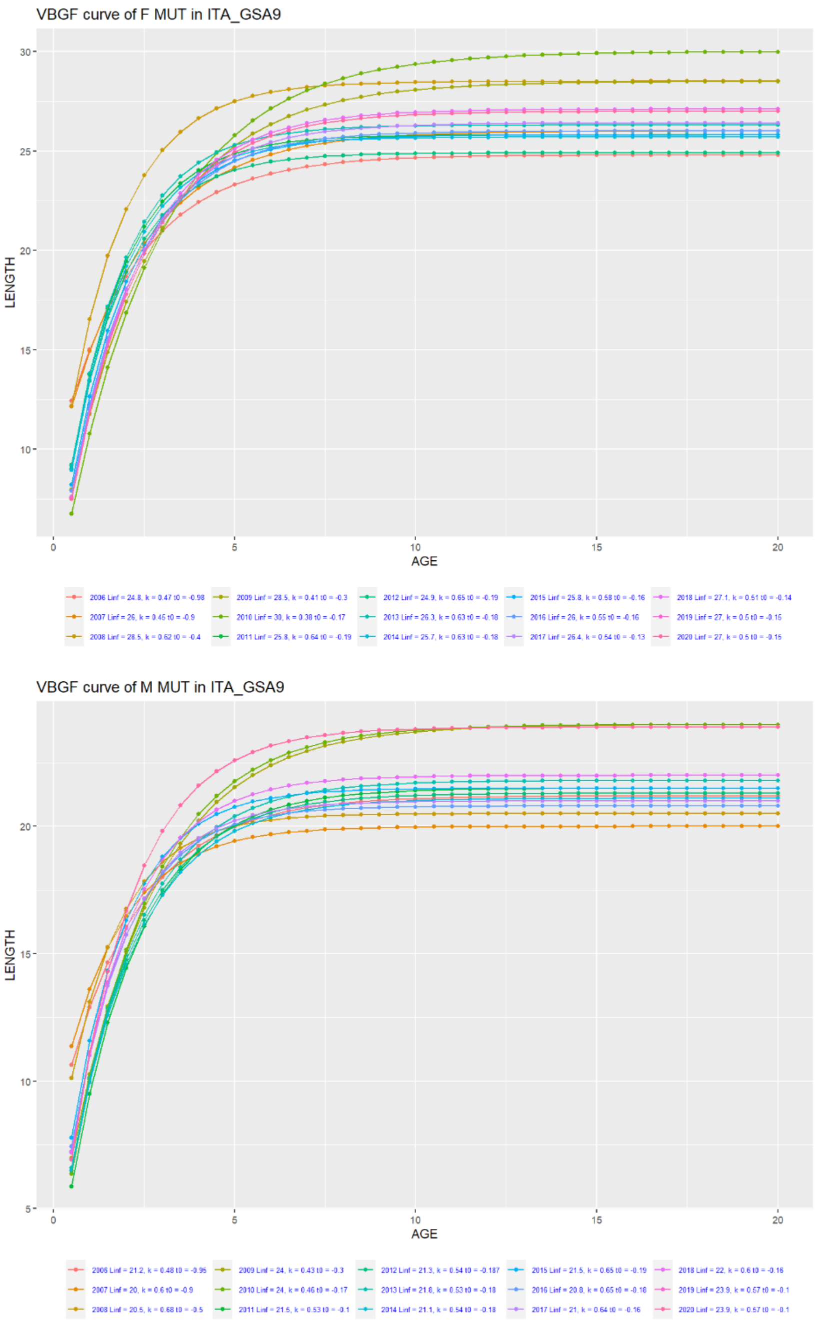


Figure 6.11.1.3 Red mullet in GSA 9: Estimated growth curves of red mullet in GSA9.

Differently from the previous assessment, the mean length at age 0 were re-examined in order to associate the age classes to the mean length at the end of the year, being the a4a model parameterized with calendar year. On the basis of the discussions, the EWG 21-11 agreed to shift length slicing by adding a value of 0.5 to the t0 value used in previous assessment (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 21-11 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.

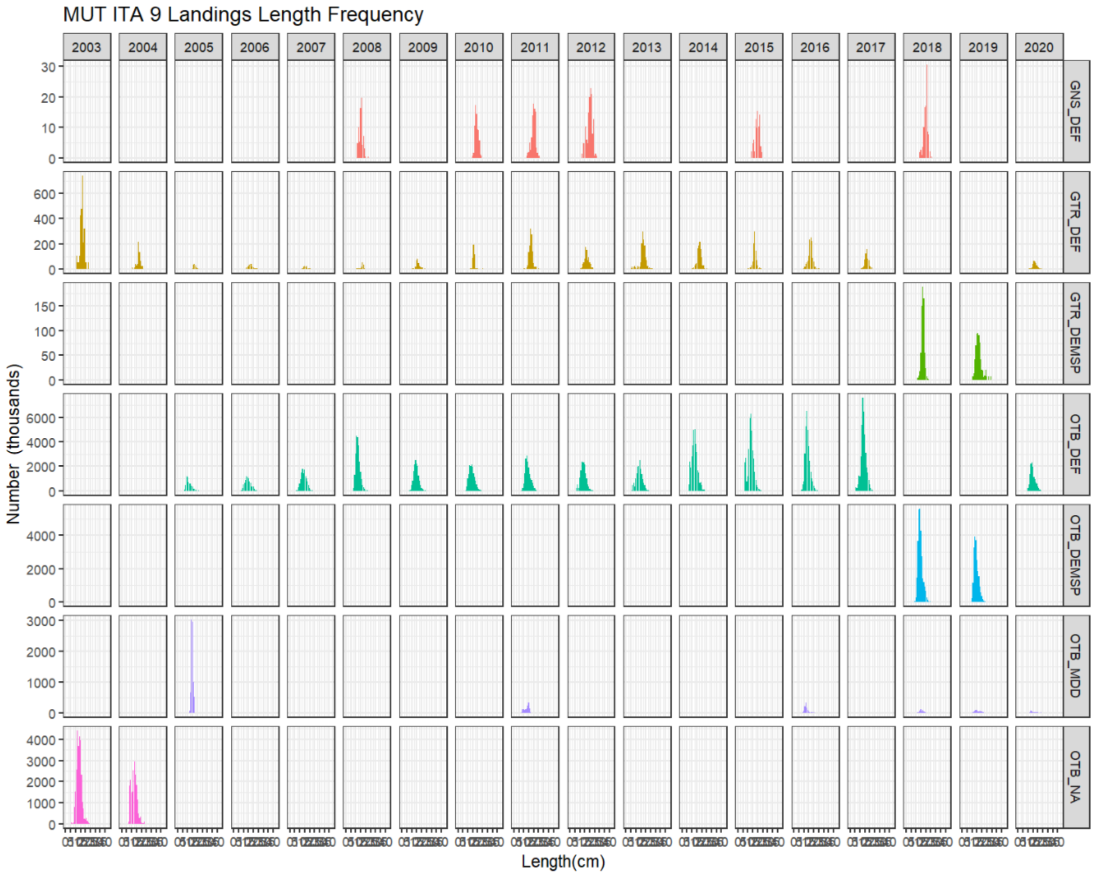


Figure 6.11.2.1.1 Red mullet in GSA 9: Length structure of red mullet landed in GSA 9 in the period from 2003 to 2020 by fishing gear and fishery.

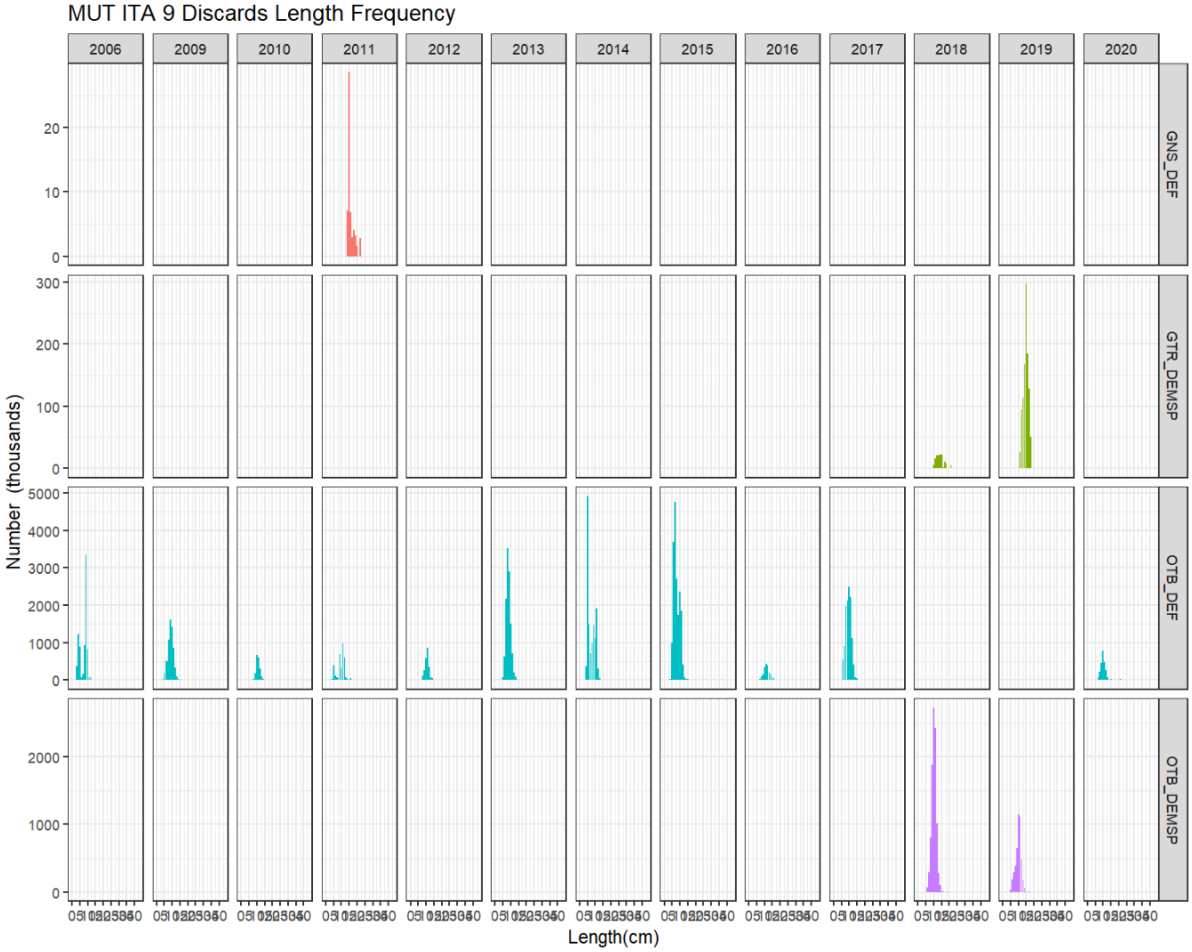


Figure 6.11.2.1.2 Red mullet in GSA 9: Length structure of red mullet catch discarded in GSA 9 in the period from 2006 to 2020 by fishing gear and fishery.

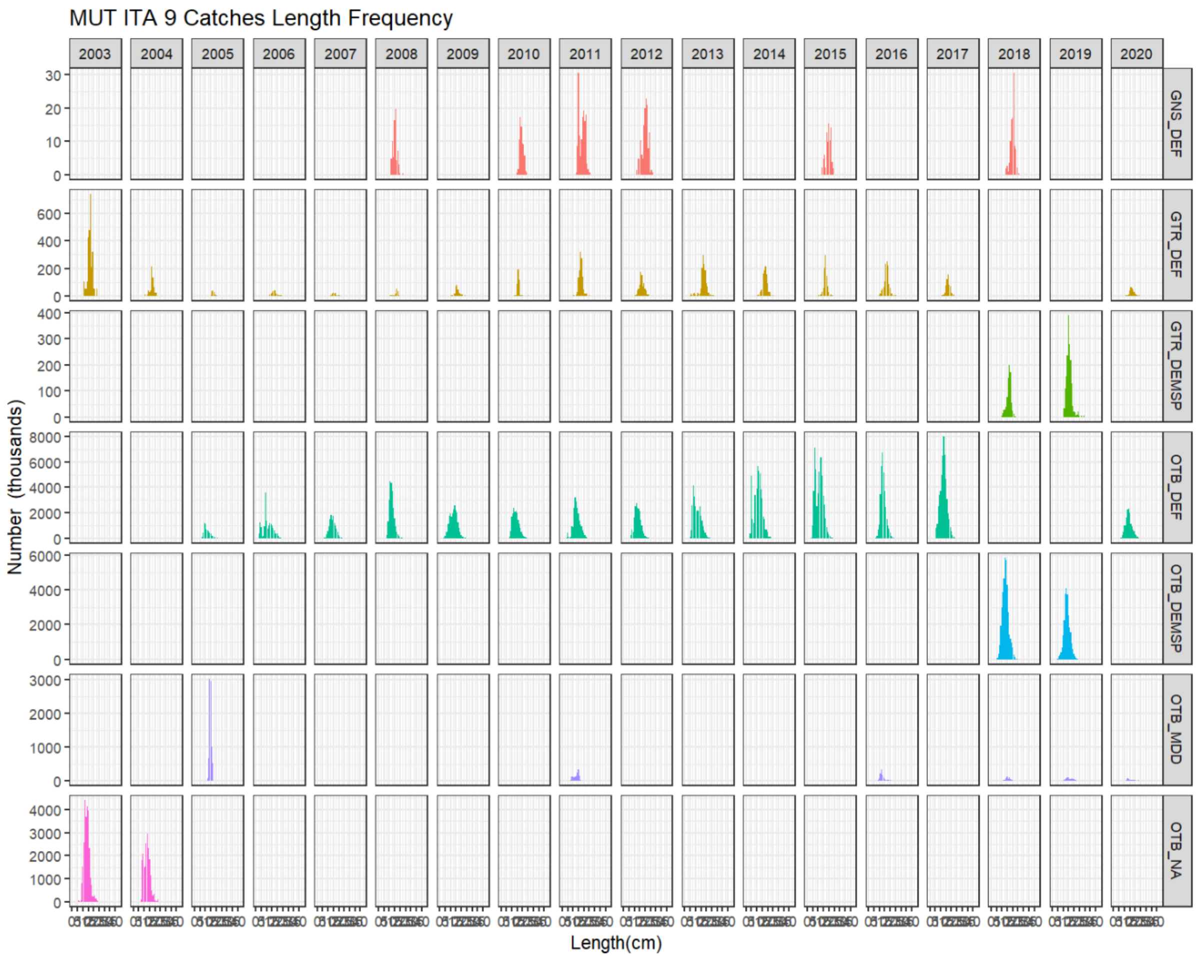


Figure 6.11.2.1.3 Red mullet in GSA 9: Length structure of red mullet total catch (landing plus discard) in GSA 9 in the period from 2003 to 2020 by fishing gear and fishery.

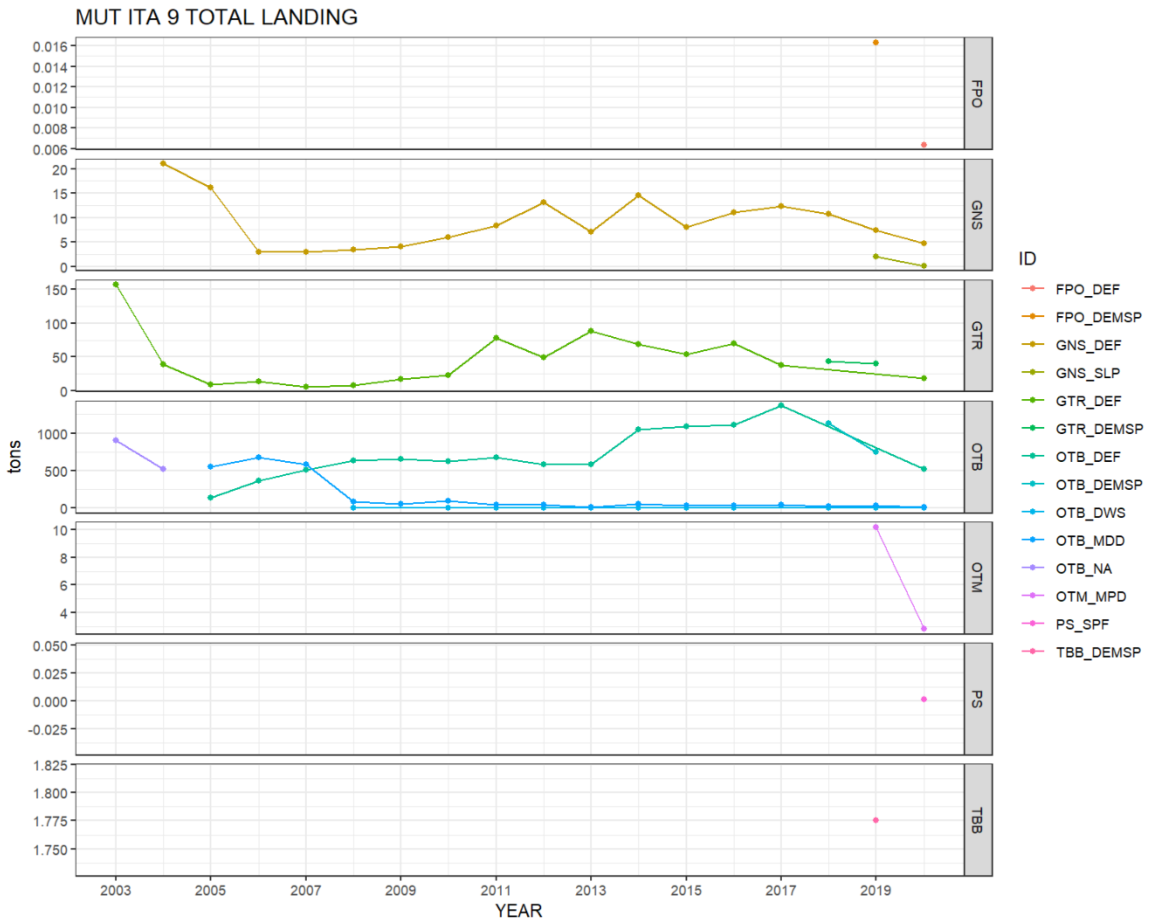


Figure 6.11.2.1.4 Red mullet in GSA 9: Landings (t) of red mullet in GSA 9 in the period from 2003 to 2020 by fishing gear and fishery.

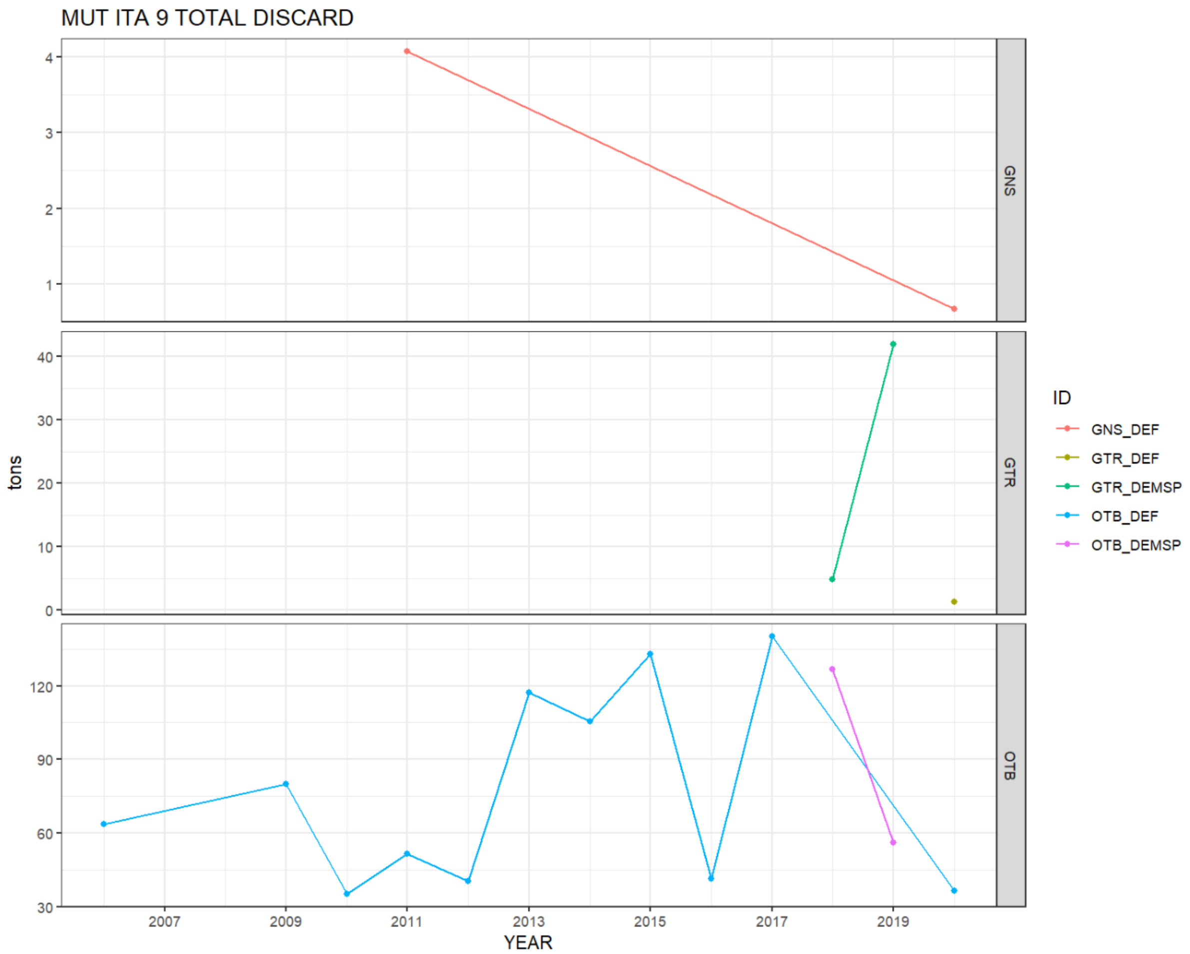


Figure 6.11.2.1.5 Red mullet in GSA 9: Discards (t) of red mullet in GSA 9 in the period from 2003 to 2020 by fishing gear and fishery.

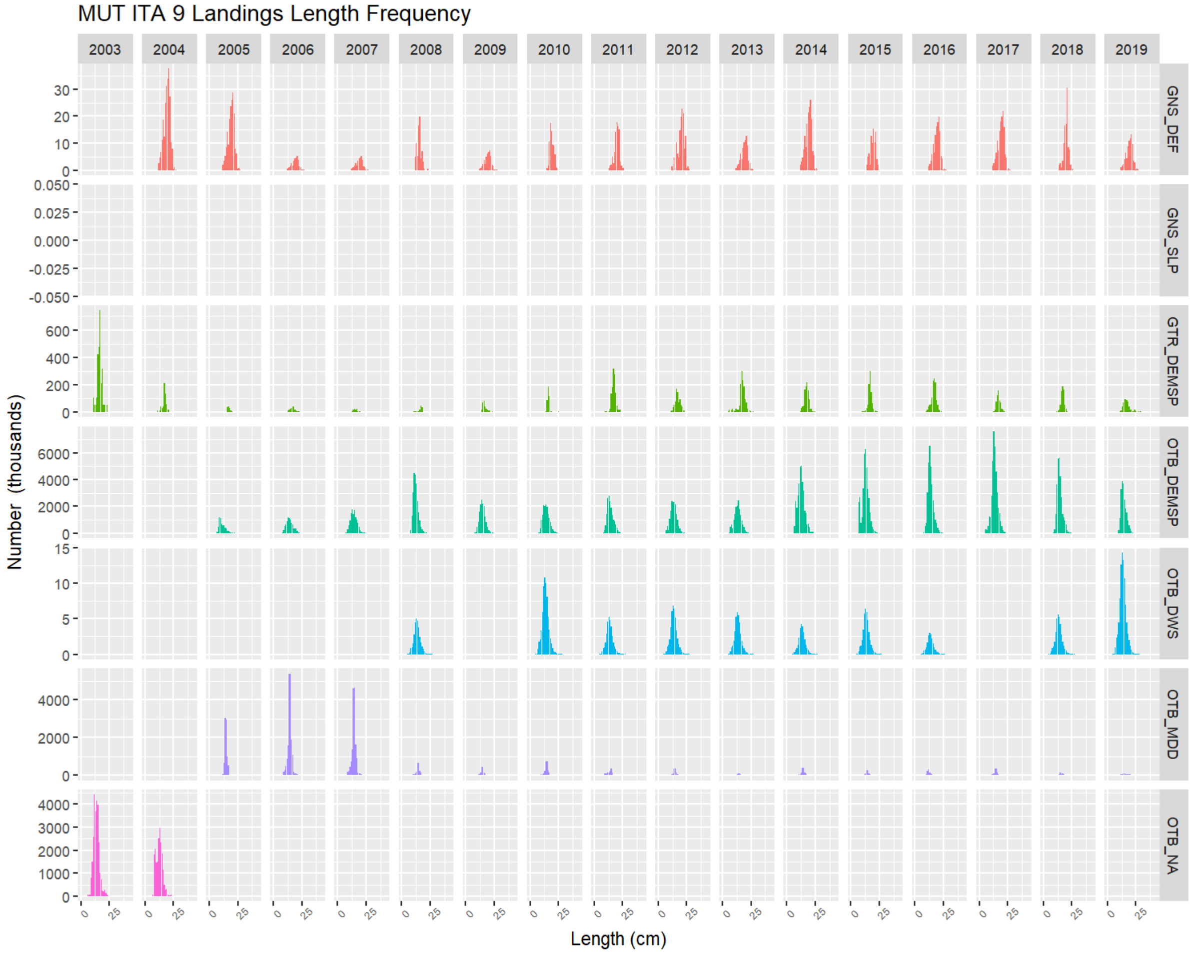


Figure 6.11.2.1.6 Red mullet in GSA 9: Length structure of red mullet landed in GSA 9 in the period from 2003 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02.

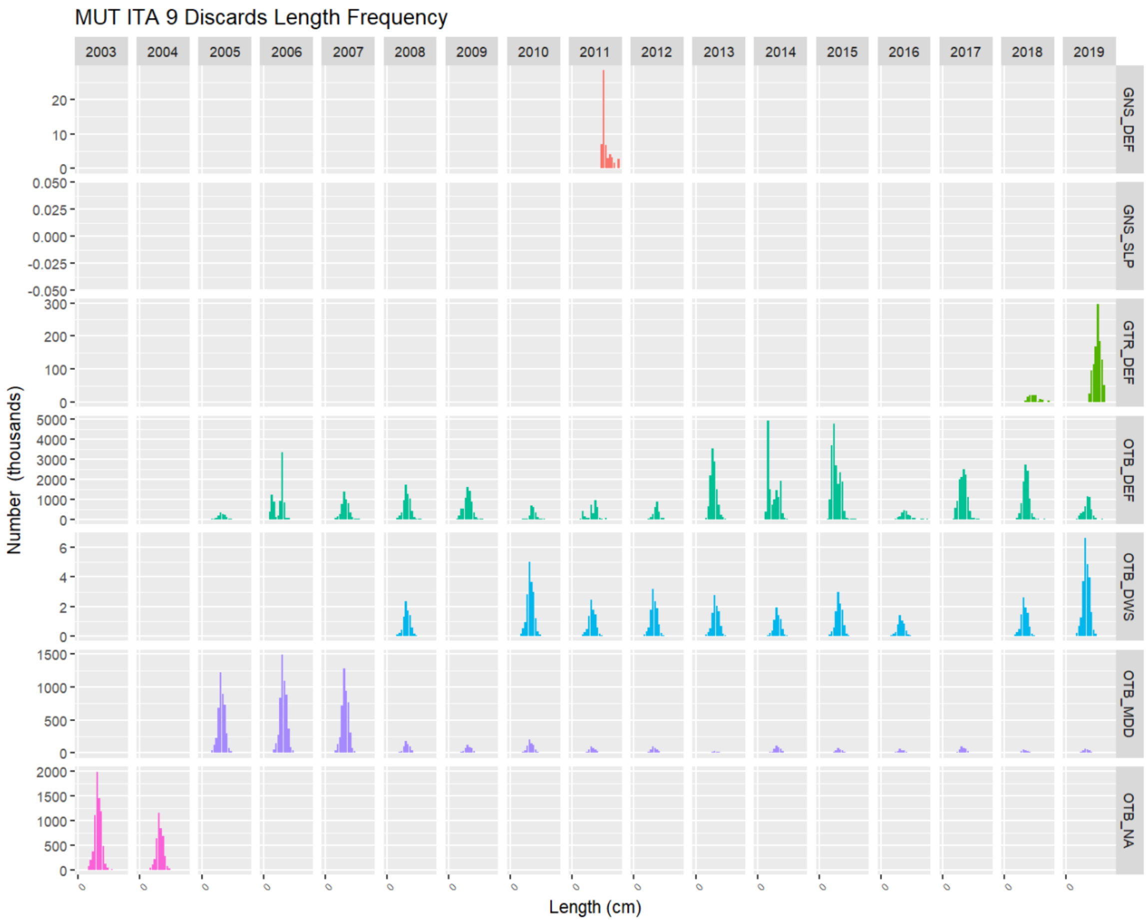


Figure 6.11.2.1.7 Red mullet in GSA 9: Length structure of red mullet catch discarded in GSA 9 in the period from 2006 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02.

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 2020. 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

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.

The catch data was SoP corrected for use in the assessment. These are typically less than 5% in recent years, with poorer consistency 2014 and earlier where landings are all below 11% corrected except for 2005 at 55%

Table 6.11.2.1.1 Red mullet in GSA 9: Sop corrections for catches

	SOPs Landings	SOPs Discards
2003	1.05	0.99
2004	1.04	0.99
2005	1.55	1.00
2006	1.05	0.58
2007	1.05	0.99
2008	1.11	1.00
2009	1.07	1.13
2010	1.07	0.93
2011	1.07	1.10
2012	1.08	1.06
2013	1.07	1.22
2014	1.09	1.18
2015	1.04	0.97
2016	1.04	0.98
2017	1.05	0.98
2018	1.05	0.99
2019	1.01	0.97
2020	1.02	1.04

6.11.2.2 EFFORT

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

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 (Fig. 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.

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 21-11 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, 1994-2020), 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.

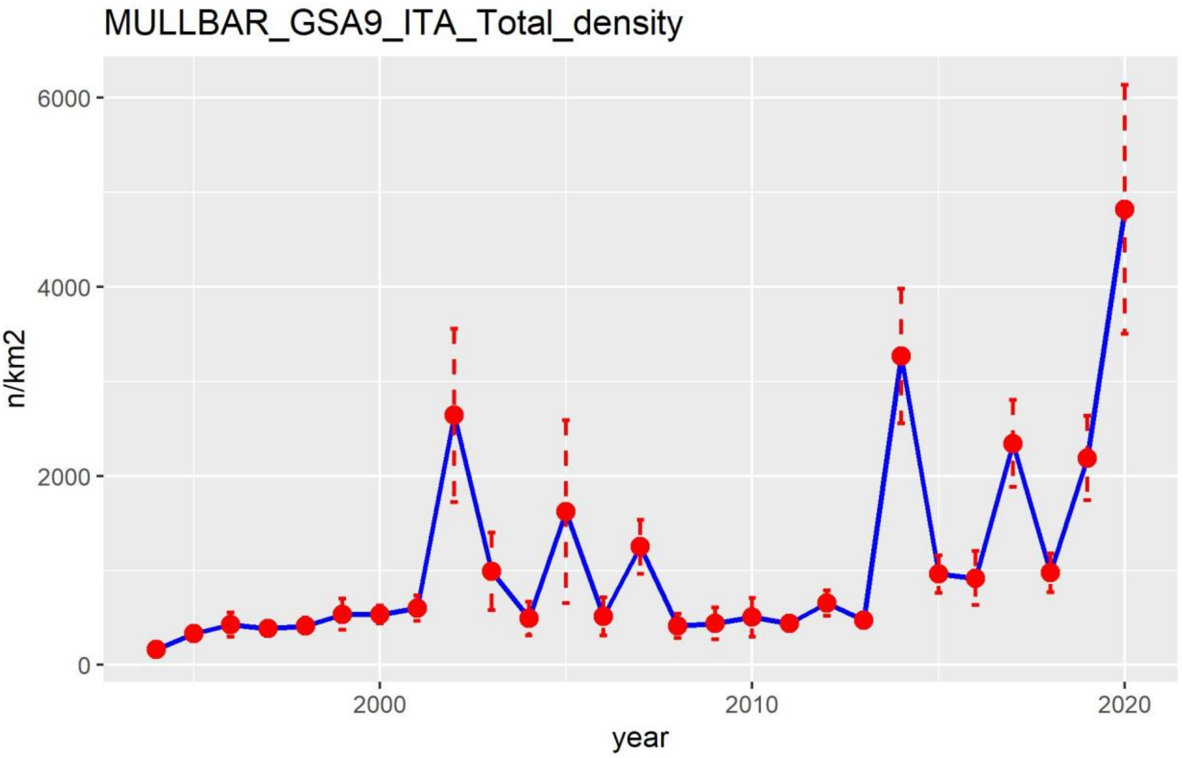


Figure 6.11.2.3.2 Red mullet in GSA 9: Abundance indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2020).

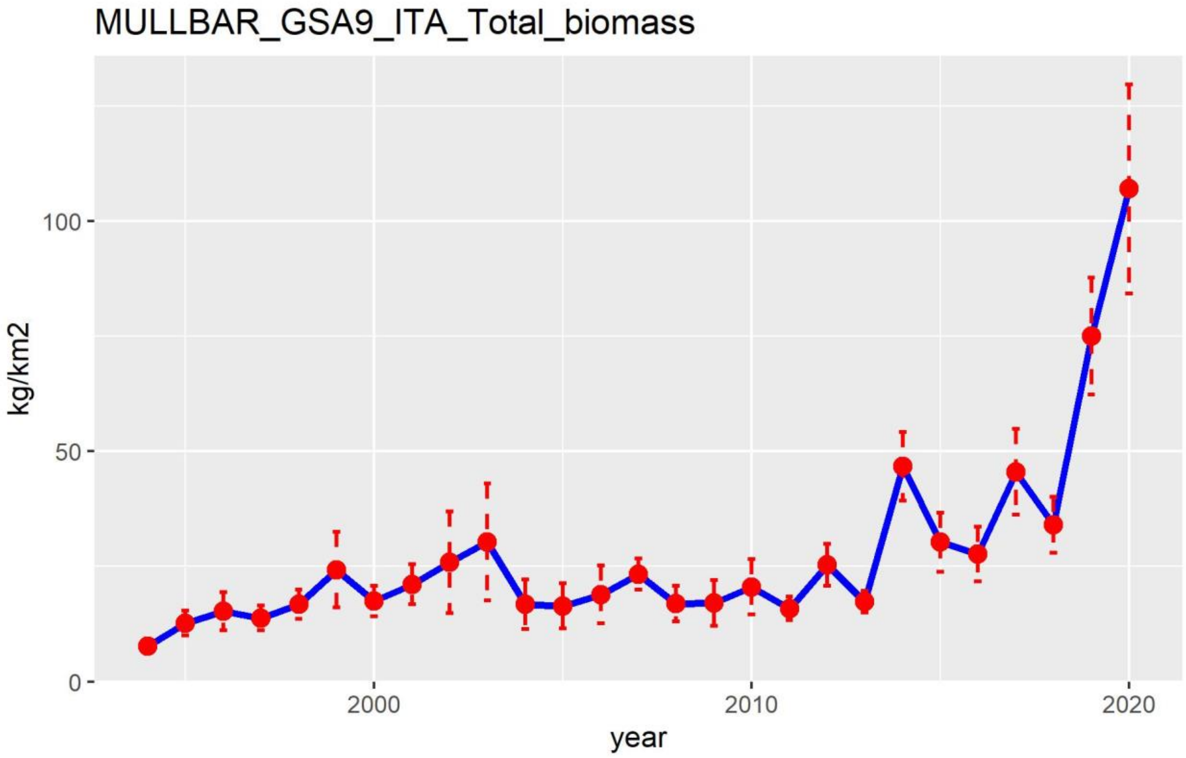


Figure 6.11.2.3.3 Red mullet in GSA 9: Biomass indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2020).

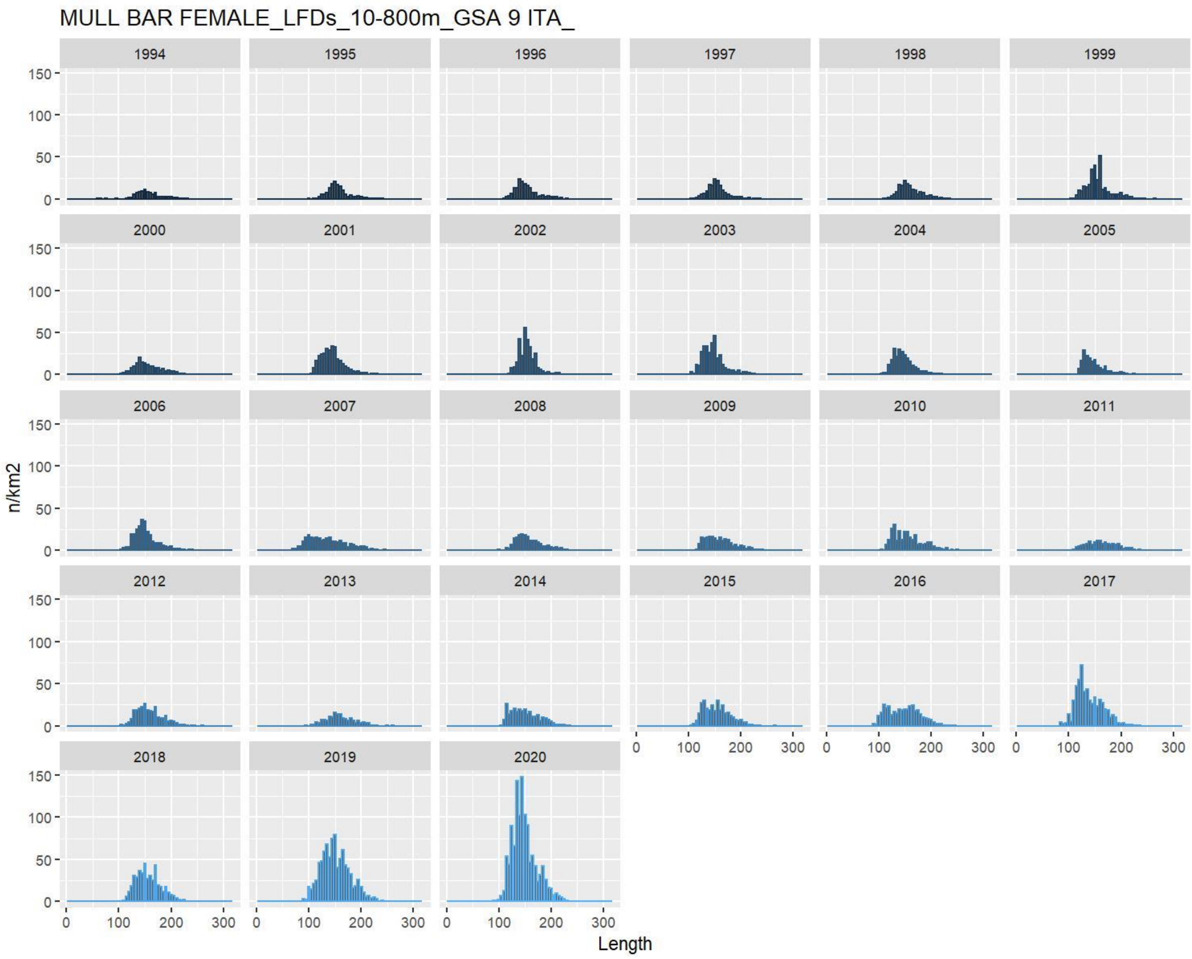


Figure 6.11.2.3.6 Red mullet in GSA 9: Size structure indices (females) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2020).

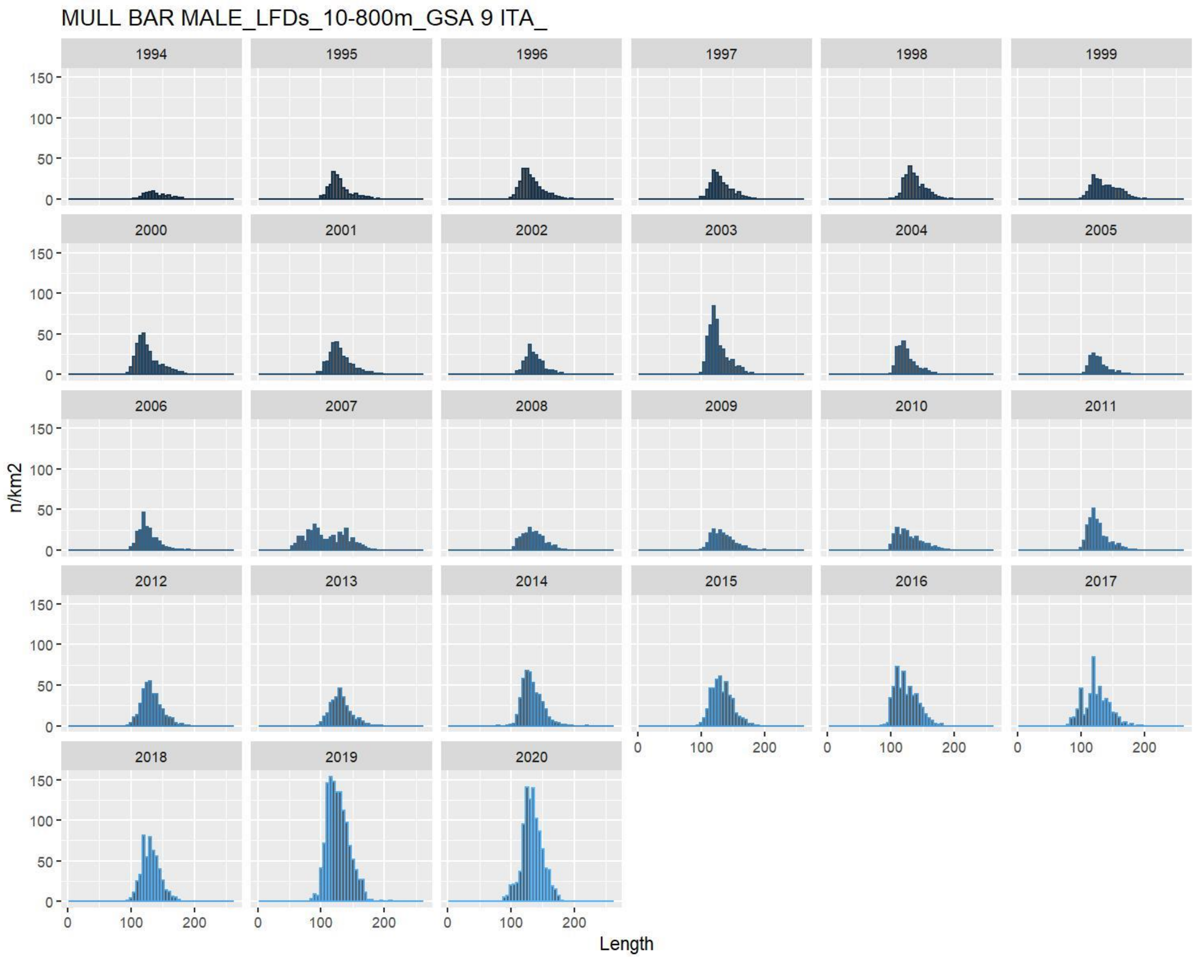


Figure 6.11.2.3.7 Red mullet in GSA 9: Size structure indices (males) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2020).

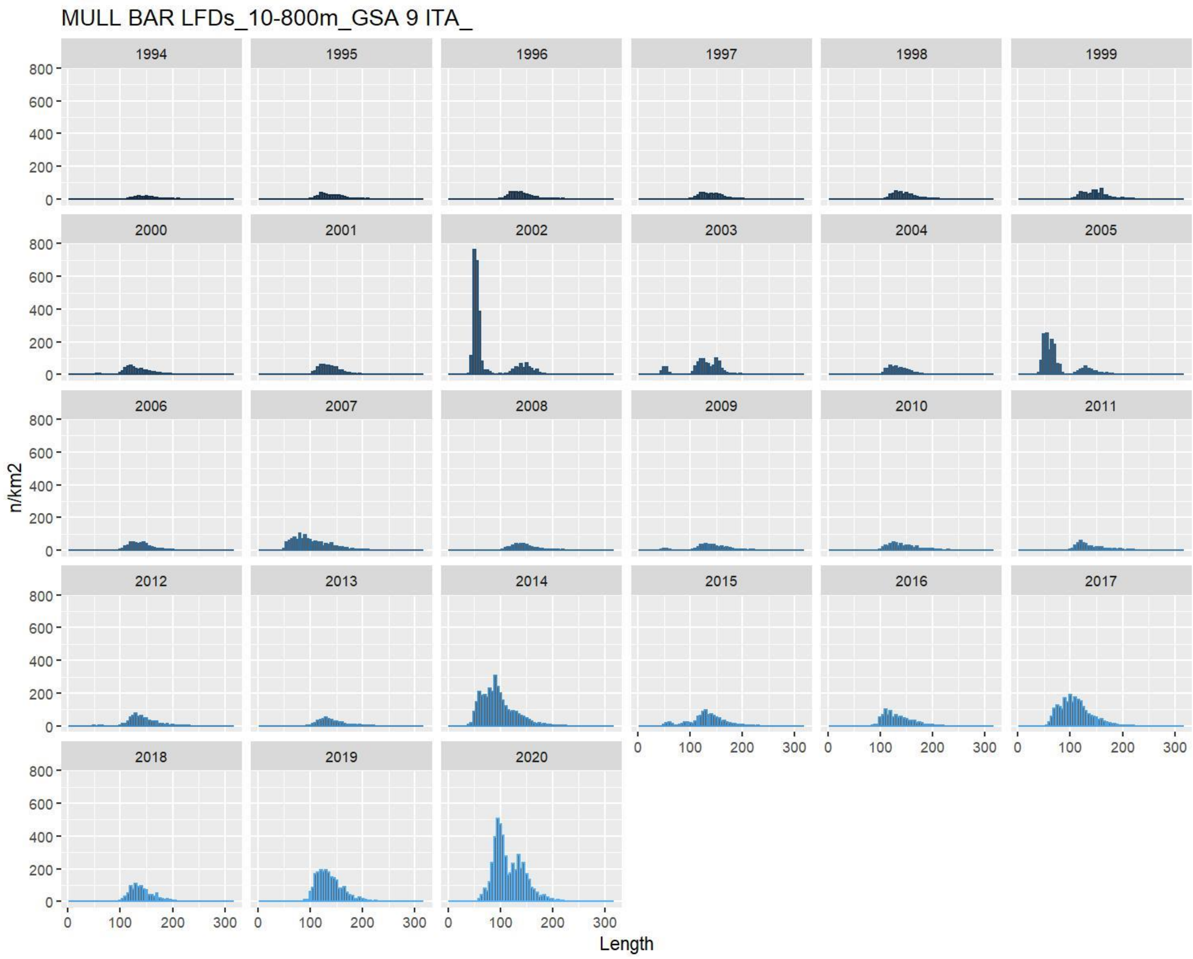


Figure 6.11.2.3.8 Red mullet in GSA 9: Size structure indices (total) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2020).

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 2003-2020. Catch data is SoP corrected.

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	2313.2	26153.2	7736.2	926.6	194.4
2004	2757.3	17820.5	3759.6	350.5	129.3
2005	2644.2	18896.8	6152.5	373.0	34.7
2006	3564.5	21506.0	9392.5	700.9	107.7
2007	2729.4	25085.9	9660.7	742.5	134.3
2008	2442.7	28084.5	4067.8	294.1	35.9
2009	2833.5	16532.7	6019.3	666.4	150.0
2010	449.6	14925.8	6010.1	660.8	155.1
2011	1277.0	16241.3	6426.3	806.5	123.2
2012	882.6	16103.3	5288.9	560.7	105.0
2013	7622.7	19856.3	5521.9	692.6	114.1
2014	12541.1	33976.4	8182.4	782.0	186.0
2015	14912.8	34856.7	8190.8	770.3	96.8
2016	436.7	26922.6	8853.1	914.1	178.8
2017	4371.6	37805.7	11103.5	1045.3	170.0
2018	1468.2	28328.8	9880.0	934.1	141.9
2019	955.2	18519.8	7151.5	763.6	122.7
2020	360.0	10076.5	4659.2	670.5	87.7

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

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	0.138
2004	0.007	0.021	0.050	0.085	0.136
2005	0.007	0.025	0.041	0.078	0.148
2006	0.005	0.027	0.047	0.081	0.140
2007	0.006	0.026	0.047	0.078	0.140
2008	0.007	0.020	0.045	0.081	0.137
2009	0.005	0.024	0.052	0.083	0.147
2010	0.007	0.026	0.053	0.082	0.157
2011	0.005	0.025	0.057	0.086	0.126
2012	0.006	0.025	0.051	0.082	0.142
2013	0.005	0.020	0.055	0.086	0.137
2014	0.003	0.021	0.053	0.082	0.130
2015	0.004	0.022	0.050	0.079	0.129
2016	0.008	0.026	0.052	0.085	0.131
2017	0.006	0.024	0.051	0.083	0.128
2018	0.007	0.025	0.053	0.085	0.123
2019	0.005	0.026	0.053	0.080	0.147
2020	0.007	0.027	0.055	0.092	0.122

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

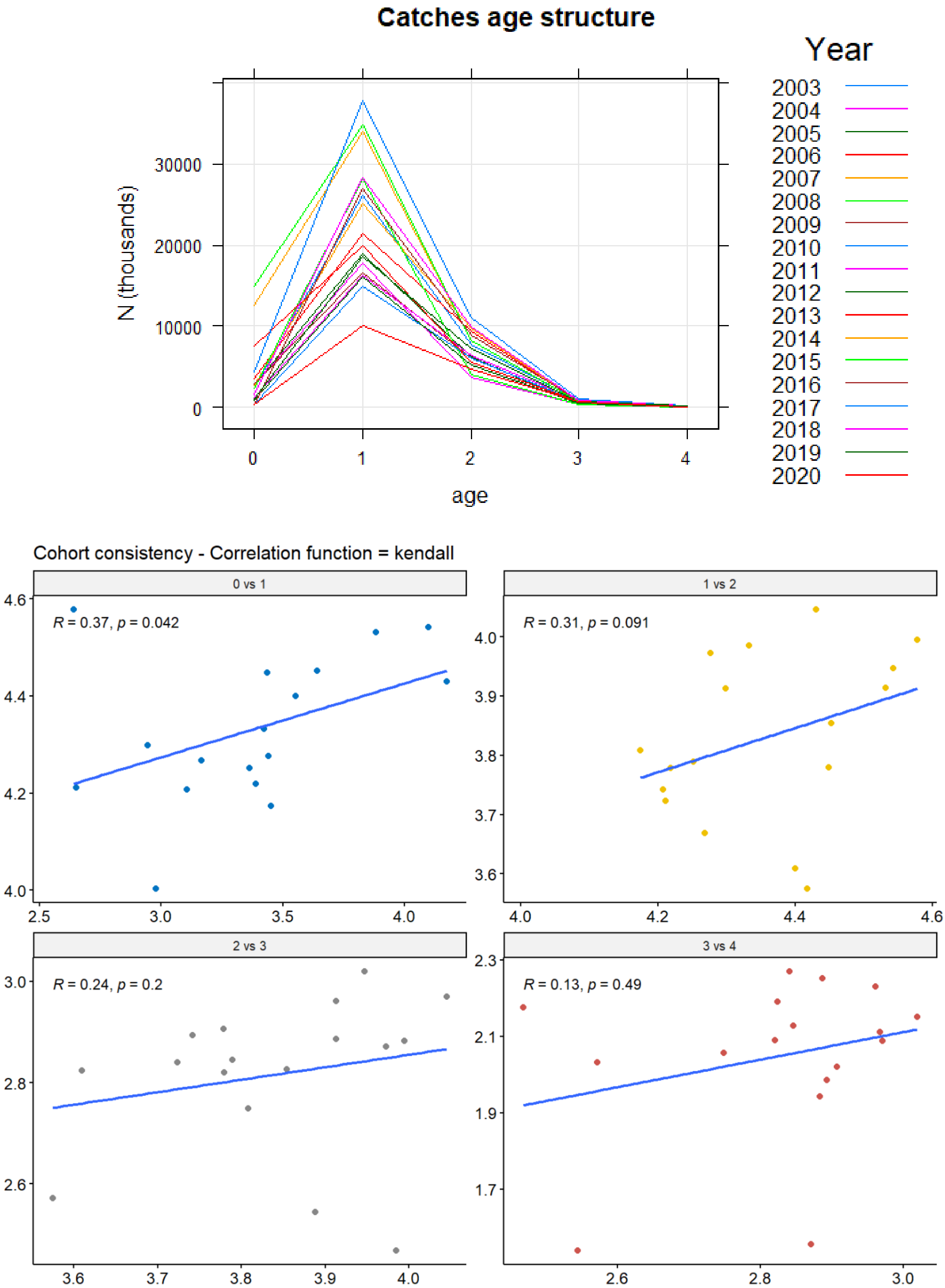


Figure 6.11.3.1 Red mullet in GSA 9: Catch-at-age data of red mullet in GSA9 used in assessment, and cohorts internal consistency.

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.

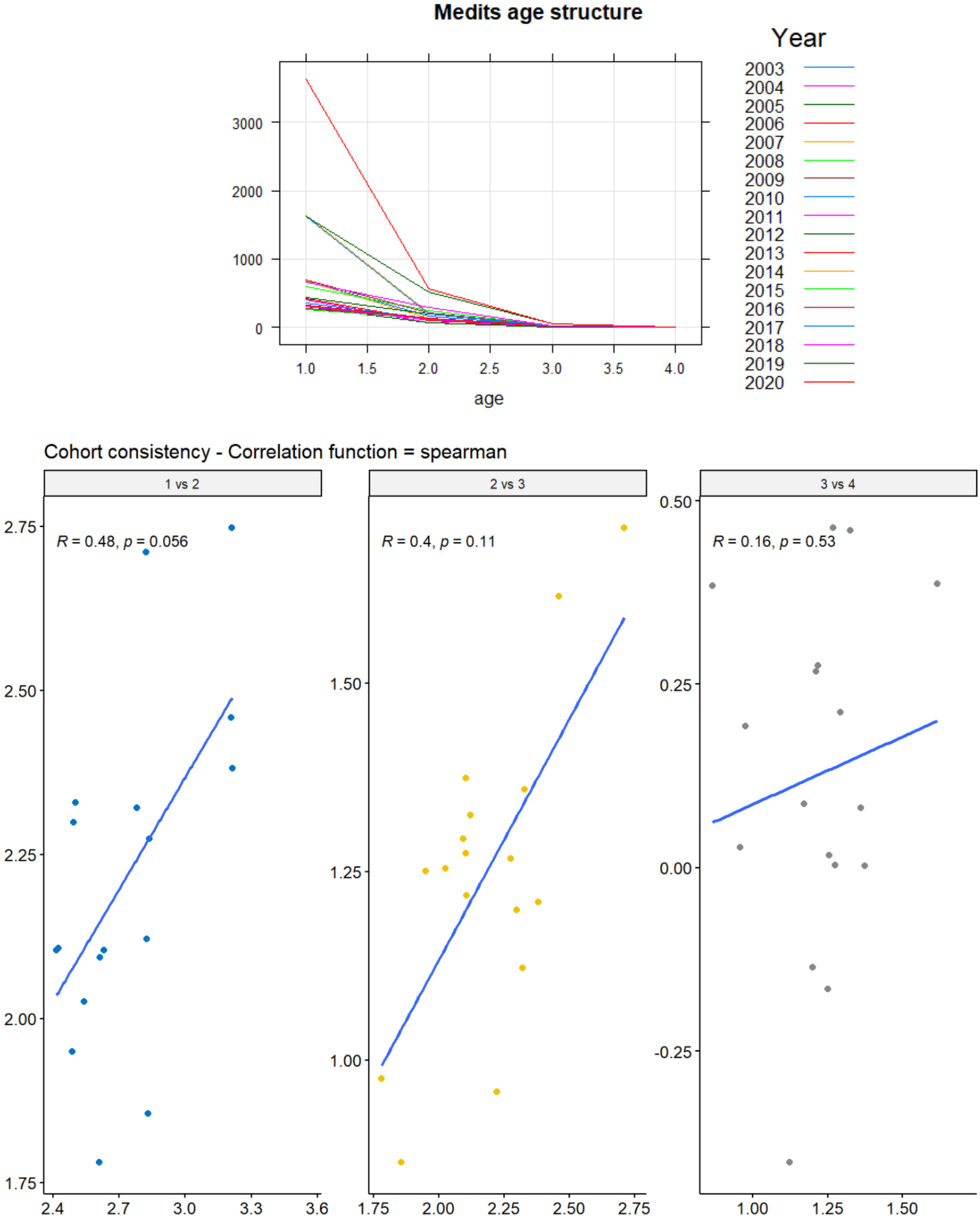


Figure 6.11.3.2 Red mullet in GSA 9: MEDITS indices describing density by age of red mullet in GSA9 by year, and cohorts internal consistency.

For the assessment purposes, the model selected by EWG 20-09 (and previous EWGs) was used also by EWG 21-11. The only difference is the increase of k in the year smoother of the F sub-model from 7 to 8 to account for the inclusion of years 2003 and 2020. The age0 was removed from the tuning index, as done in previous EWGs due to the variability of occuance in the survey data mostly due to irregular survey timing. 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        3.800000e+01
nlogl        7.260988e+01
maxgrad      1.637237e-07
nobs         1.620000e+02
gcv          3.082966e-01
convergence  0.000000e+00
accrate                NA
nlogl_comp1  2.224220e+01
nlogl_comp2  5.110330e+01
nlogl_comp3 -7.356160e-01
```

The results and diagnostics of the assessment model are shown below.

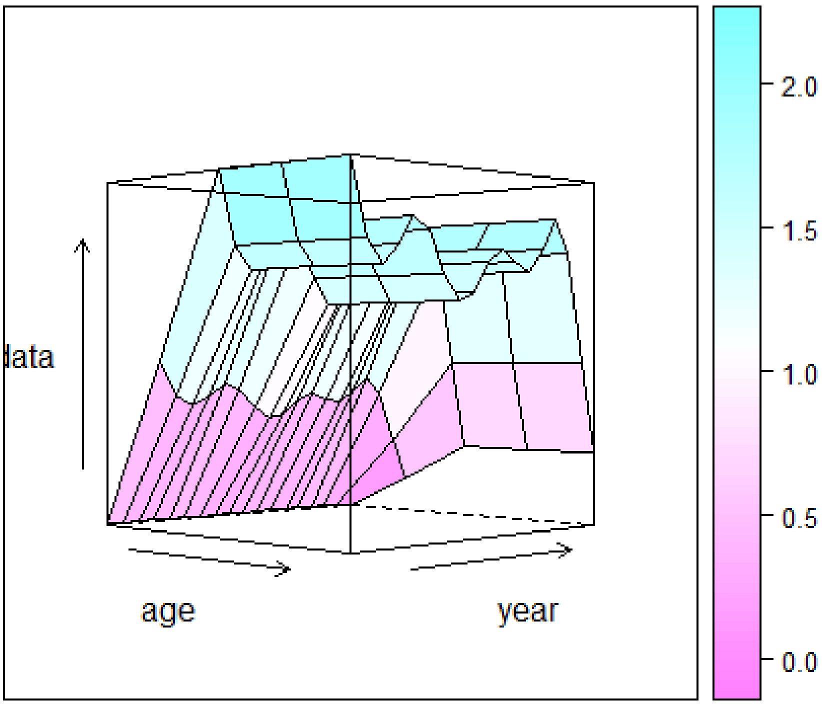


Figure 6.11.3.3 Red mullet in GSA 9: 3D-plot of the F-at-age for red mullet in GSA9.

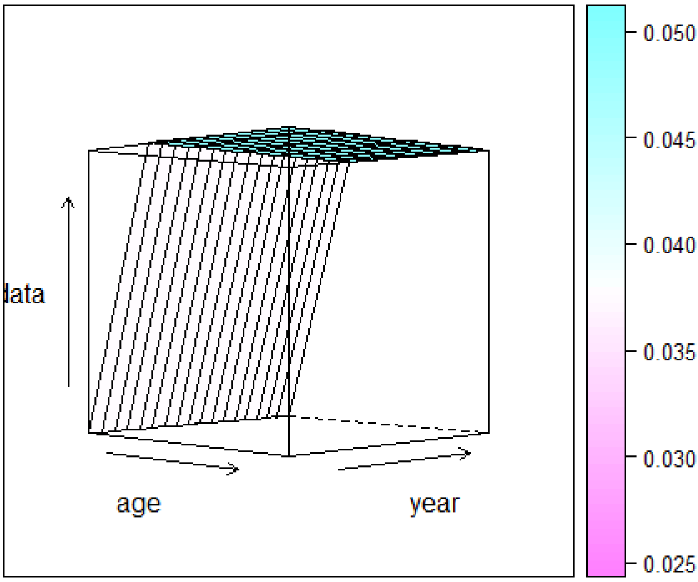


Figure 6.11.3.4 Red mullet in GSA 9: 3D-plot of the catchability of the MEDITS survey for red mullet in GSA9.

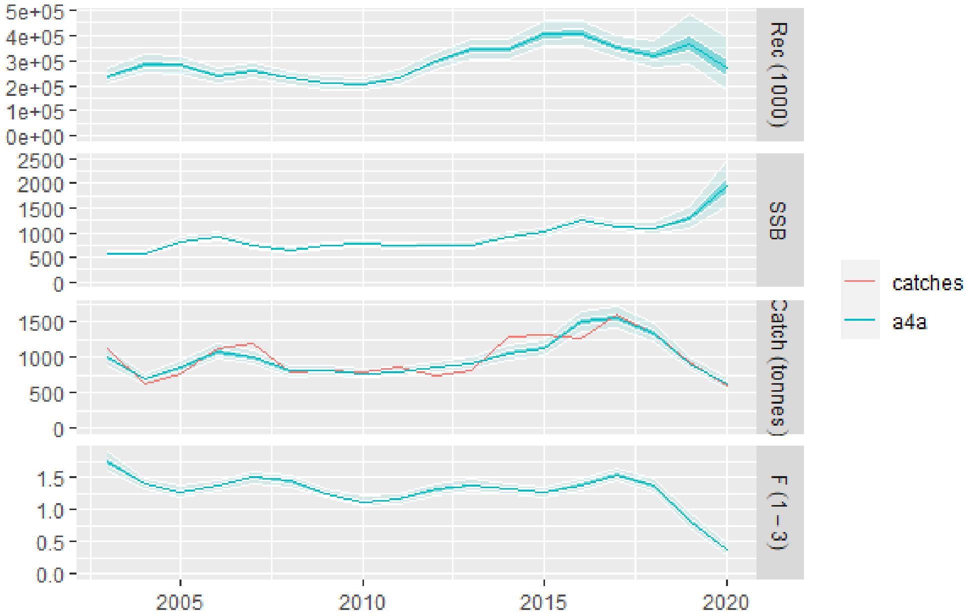


Figure 6.11.3.5 Red mullet in GSA 9: Results of the best a4a model for red mullet in GSA9. The observed catches are shown by the red line.

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
-0.042	0.039	-0.182

The Mohn's rho value is outside the acceptable range (-0.2 +0.2) for recruitment only.

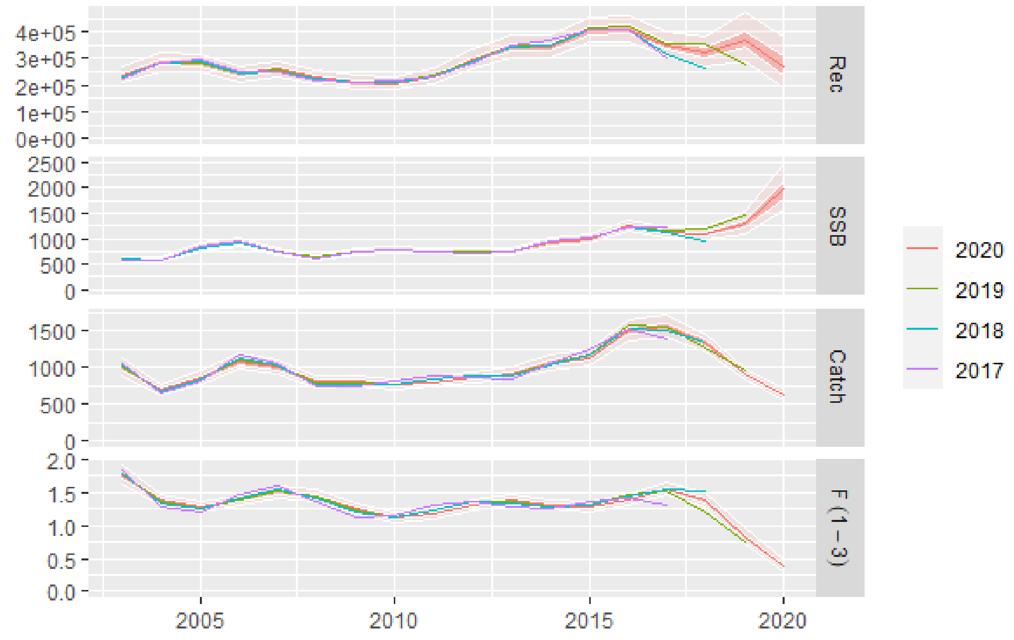


Figure 6.11.3.6 Red mullet in GSA 9: Retrospective analysis of the selected a4a model for red mullet in GSA9. Confidence intervals are also shown.

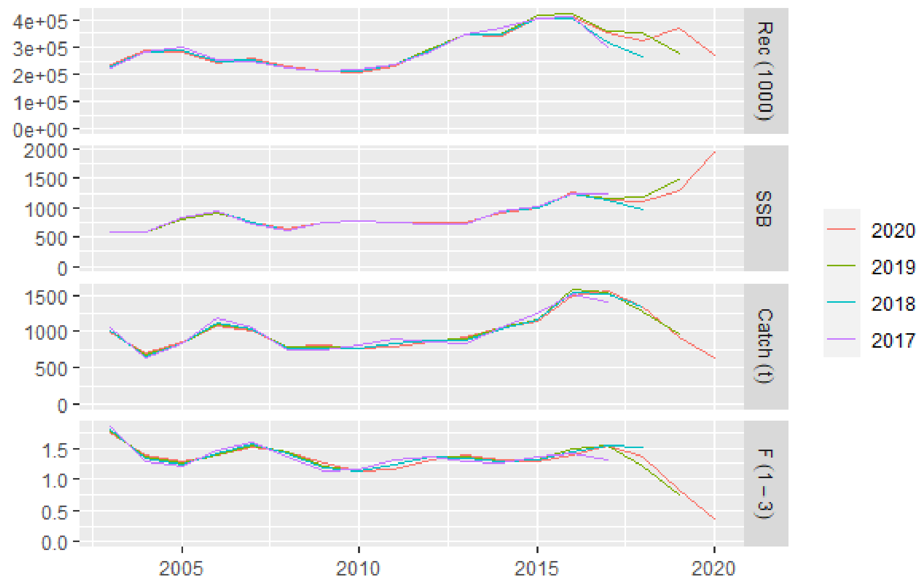


Figure 6.11.3.6bis Red mullet in GSA 9: Retrospective analysis of the selected a4a model for red mullet in GSA9.

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.

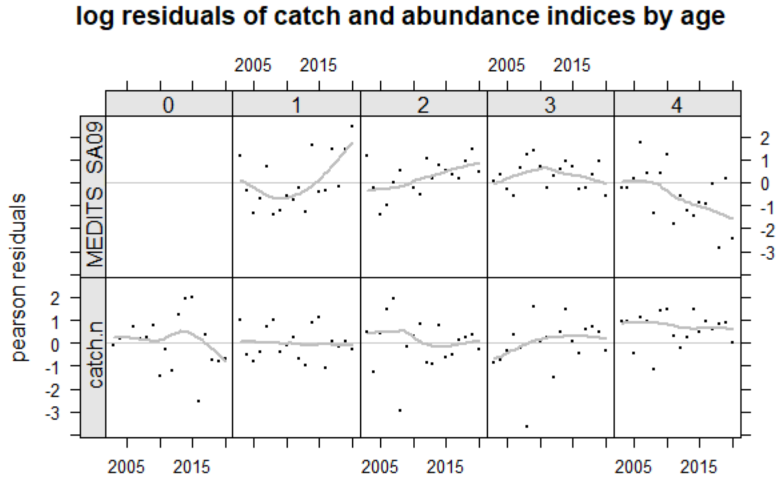


Figure 6.11.3.8 Red mullet in GSA 9: Pearson residuals of catch and abundance indices for red mullet in GSA9.

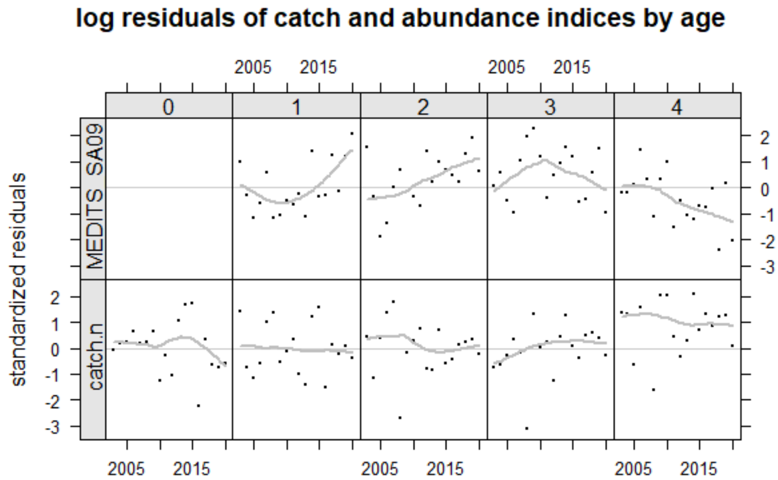


Figure 6.11.3.9 Red mullet in GSA 9: Log residuals of catch and abundance indices for red mullet in GSA9.

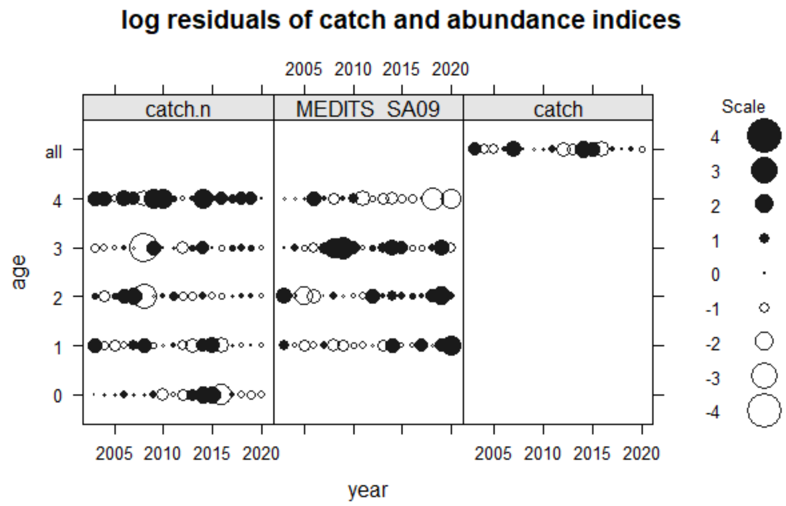


Figure 6.11.3.10 Red mullet in GSA 9: Bubble plot of the log residuals of catch and abundance indices for red mullet in GSA9.

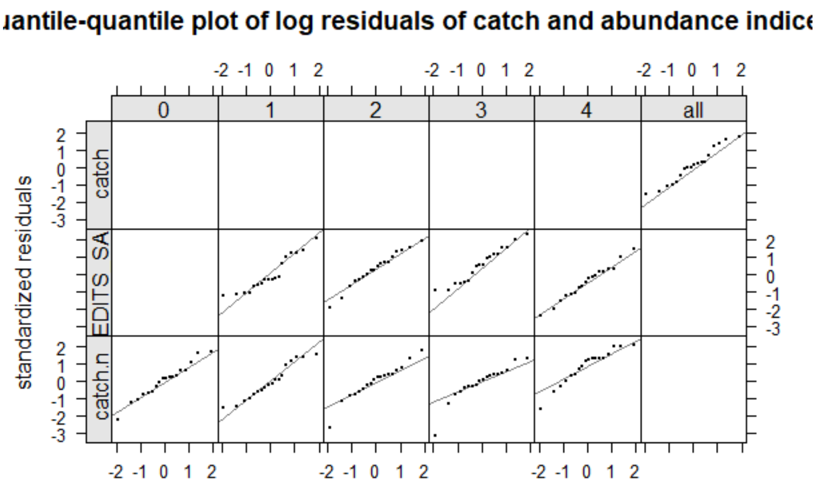


Figure 6.11.3.11 Red mullet in GSA 9: QQ-plot of the log residuals of catch and abundance indices for red mullet in GSA9.

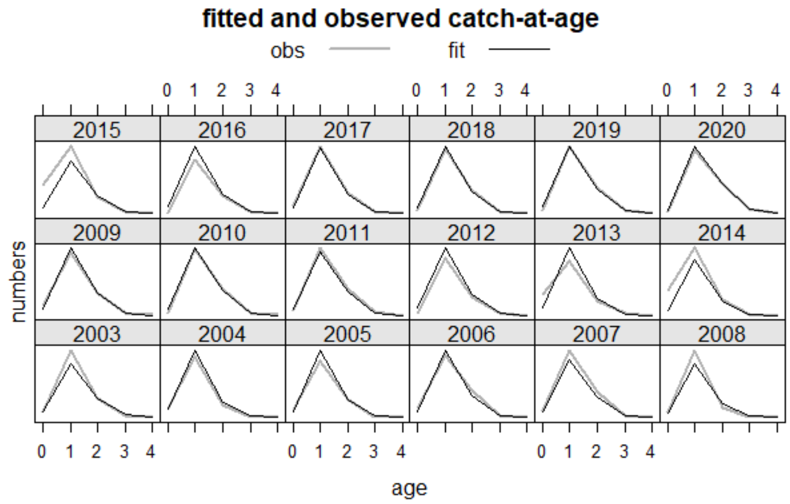


Figure 6.11.3.12 Red mullet in GSA 9: Fitting of the catch-at-age data for red mullet in GSA9.

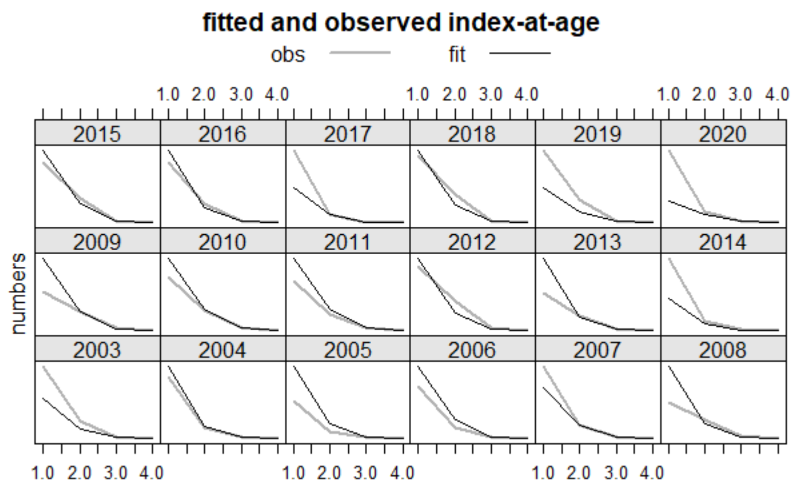


Figure 6.11.3.13 Red mullet in GSA 9: Fitting of the numbers-at-age data of the MEDITS survey for red mullet in GSA9.

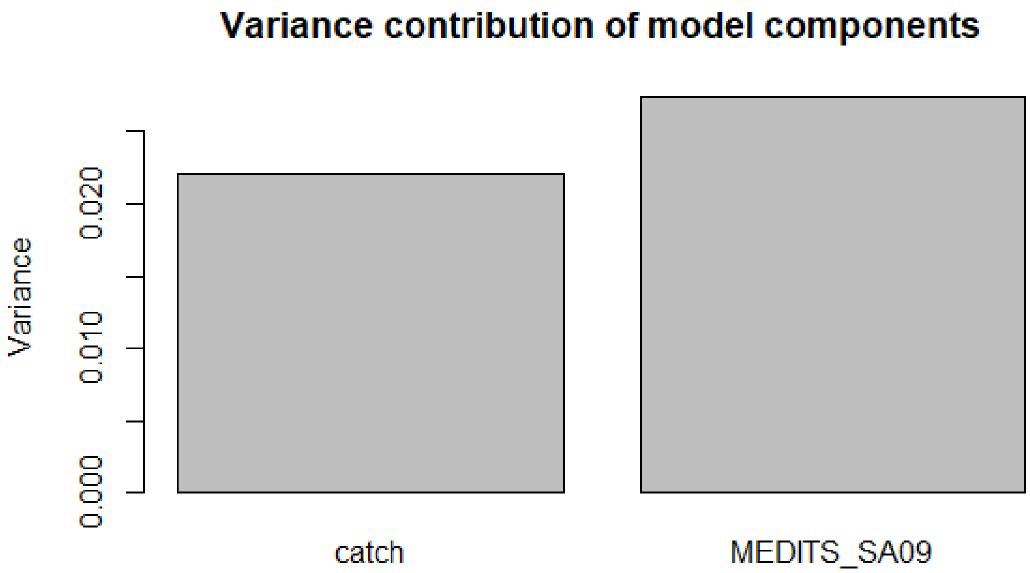


Figure 6.11.3.14 Red mullet in GSA 9: Variance contribution of model components: catches and survey for red mullet in GSA9.

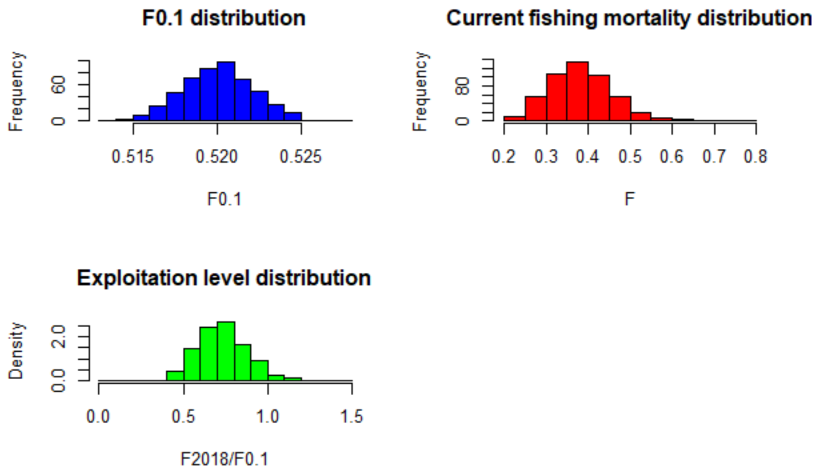


Figure 6.11.3.15 Red mullet in GSA 9: Histograms of probability for F0.1, Fcurr and level of exploitation (Fcurr/F01 ratio) values for red mullet in GSA9.

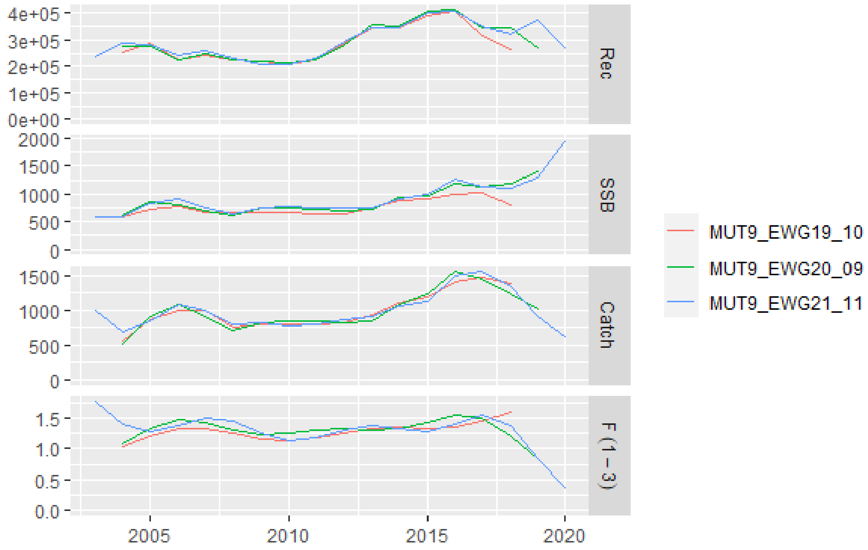


Figure 6.11.3.16 Red mullet in GSA 9: comparison among the assessment results obtained at EWG 19-10, EWG 20-09 and EWG 21-11.

A sensitivity analysis was performed on the number of knots (k, ranging from 6 to 9) in the smoother of the variable year in the F sub-model. The analysis showed that a k = 8 is the one performing the best statistical criteria AIC, BIC and GCV (Figure 6.11.3.18) and also on retrospective performance. This setting is also providing a better fitting of both the total catches and the catch numbers-at-age.

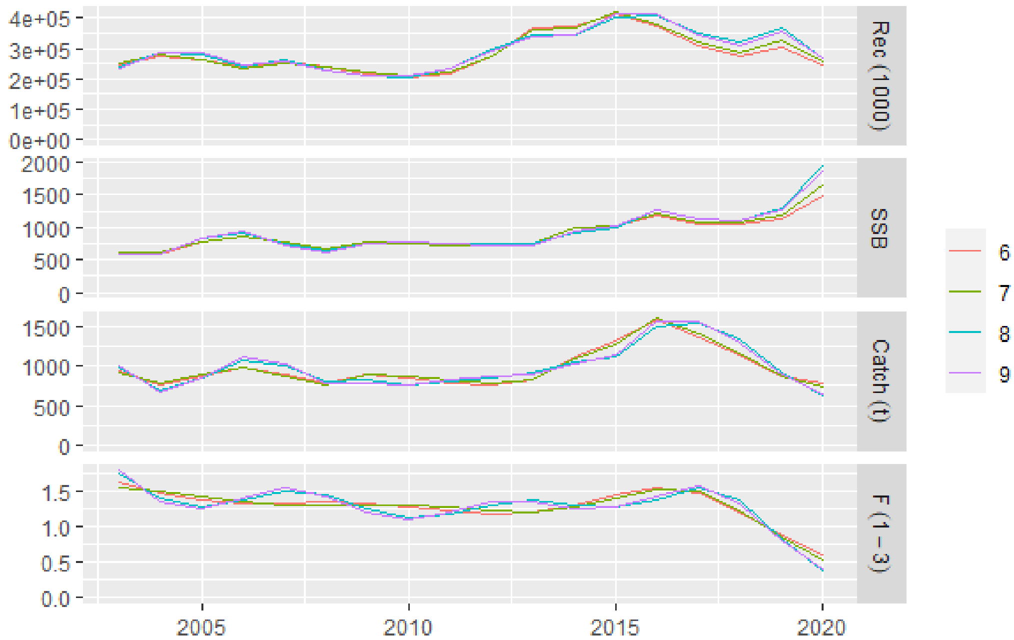


Figure 6.11.3.17 Red mullet in GSA 9: Outputs of model runs with different k values on the smoother on year in the fmodel.

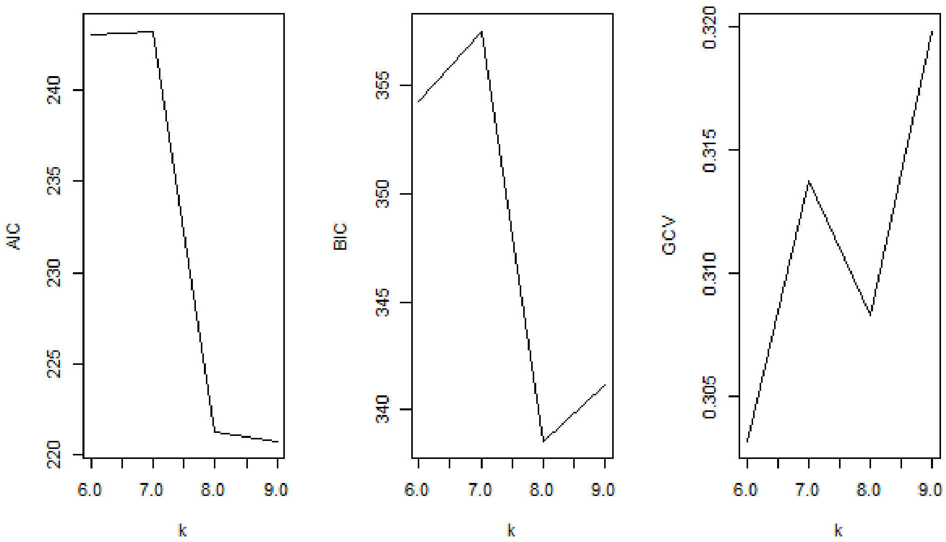


Figure 6.11.3.18 Red mullet in GSA 9: AIC, BIC and GCV values estimated on a range of k values of the smoother on year of the fmodel.

A sensitivity analysis was run to check the effect of the MEDITS survey 2020. The model was run with the same settings removing the 2020 data from the index (tuning file). The results, fitting and diagnostics of this test run did not show any major difference from the run including the whole time series of MEDITS data. Therefore, the run with the whole MEDITS time series was retained as the one for providing advice.

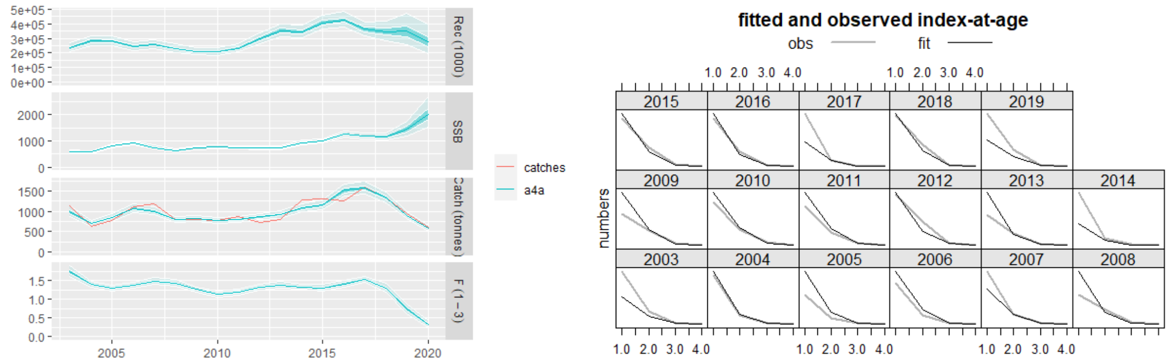


Figure 6.11.3.19 Red mullet in GSA 9: sensitivity analysis on the 2020 MEDITS survey; general outcomes of the model (left panel); fitting of the survey (right panel).

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	237051	258548	215554	589.4	632.5	546.3	988.9	1.75	1.86	1.64
2004	285217	313904	256530	581.6	623.9	539.3	697.1	1.39	1.45	1.34
2005	280539	306796	254282	819.4	883.0	755.8	849.7	1.28	1.35	1.22
2006	241362	264201	218523	919.0	983.8	854.2	1074.4	1.38	1.44	1.32
2007	261020	285902	236138	743.5	797.0	690.0	997.6	1.50	1.57	1.43
2008	230203	251237	209169	631.9	676.2	587.6	799.7	1.45	1.52	1.38
2009	209277	227326	191228	744.3	794.5	694.1	816.6	1.25	1.31	1.19
2010	206704	225030	188378	768.5	816.5	720.5	769.0	1.13	1.19	1.07
2011	231460	253168	209752	752.6	801.0	704.2	799.1	1.17	1.23	1.11
2012	295159	322334	267984	737.9	790.4	685.4	857.0	1.31	1.37	1.25
2013	345488	377147	313829	738.2	788.7	687.7	913.0	1.38	1.44	1.32
2014	343120	375070	311170	925.0	992.0	858.0	1057.9	1.32	1.38	1.26
2015	404472	441503	367441	1001.3	1070.2	932.4	1129.3	1.28	1.34	1.22
2016	409037	446039	372035	1255.6	1339.8	1171.4	1500.3	1.39	1.46	1.32
2017	351809	386661	316957	1132.0	1210.4	1053.6	1553.8	1.55	1.62	1.48
2018	321557	363607	279507	1099.9	1183.5	1016.3	1335.8	1.38	1.46	1.29
2019	370311	447668	292954	1293.0	1458.2	1127.8	911.4	0.83	0.92	0.74
2020	270739	347030	194448	1950.1	2321.2	1579.0	629.3	0.37	0.45	0.30

Table 6.11.3.5 Red mullet in GSA 9: Stock number at age for red mullet in GSA 9.

	Age				
Year	0	1	2	3	4+
2003	237050.6	45561.7	10327.2	1520.8	145.5
2004	285217.1	50791.4	6886.6	617.4	107.2
2005	280539.0	61367.5	9446.6	633.4	71.9
2006	241362.0	60441.9	12195.8	997.0	80.2
2007	261019.5	51942.9	11359.4	1146.2	108.9
2008	230202.6	56089.9	9068.0	916.0	108.9
2009	209276.8	49500.1	10117.7	782.6	95.3
2010	206704.3	45104.5	10010.3	1107.2	103.5
2011	231459.5	44614.6	9801.7	1271.9	165.6
2012	295159.3	49932.3	9456.4	1182.5	186.9
2013	345488.2	63568.8	9747.3	961.6	150.2
2014	343119.8	74347.9	11921.2	912.0	112.2
2015	404472.0	73892.7	14459.5	1202.9	111.3
2016	409036.7	87145.9	14710.0	1531.5	149.8
2017	351808.8	88013.3	16249.8	1360.1	167.3
2018	321557.1	75559.5	14972.6	1241.8	125.7
2019	370311.5	69202.4	14212.6	1409.7	138.6

2020	270738.6	80208.1	17900.7	2593.0	304.1

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	0.02	1.02	2.12	2.12	2.12
2004	0.02	0.81	1.69	1.69	1.69
2005	0.02	0.75	1.55	1.55	1.55
2006	0.02	0.80	1.66	1.66	1.66
2007	0.02	0.88	1.82	1.82	1.82
2008	0.02	0.84	1.75	1.75	1.75
2009	0.01	0.73	1.51	1.51	1.51
2010	0.01	0.66	1.36	1.36	1.36
2011	0.01	0.68	1.41	1.41	1.41
2012	0.02	0.76	1.59	1.59	1.59
2013	0.02	0.80	1.67	1.67	1.67
2014	0.02	0.77	1.59	1.59	1.59
2015	0.01	0.74	1.55	1.55	1.55
2016	0.02	0.81	1.68	1.68	1.68
2017	0.02	0.90	1.87	1.87	1.87
2018	0.02	0.80	1.66	1.66	1.66
2019	0.01	0.48	1.00	1.00	1.00
2020	0.00	0.22	0.45	0.45	0.45

6.11.4 REFERENCE POINTS

The time series is too short to produce meaningful stock recruitment rationship, so reference points are based on equilibrium methods. 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 0.52. Current F values (2020), as calculated by model a4a, is 0.37 indicating that the stock is exploited sustainably.

6.11.5 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 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} = 0.37 terminal F (2020) from the a4a assessment was used for F in 2021. 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 2021 (whole time series of 18 years; recruitment 287566 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 2018-2020	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-3}$ (2021)	0.37	F 2020 used to give F status quo for 2021
SSB (2021)	2054.0	Stock assessment 1 January 2020
R_{age0} (2021,2022)	287566 (thousands)	Geometric mean of the time series (18 years)
Total catch (2021)	765.9	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 765.9 and 2054.0 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.52) would reduce biomass by 8% from 2021 to 2023, while increasing catches by 64% from 2020 to 2022.

Table 6.11.5.2 Red mullet in GSA 9: Short term forecast table for red mullet in GSA 9.

Rationale	Ffactor	Fbar	Catch 2021	Catch 2022	SSB* 2021	SSB* 2023	Change SSB 2021-2023 (%)	Change Catch 2020-2022 (%)
High long term yield ($F_{0.1}$)	1.4	0.52	765.9	1032.5	2054.0	1891.6	-7.9	64.1
F upper	1.9	0.71	765.9	1306.4	2054.0	1600.3	-22.1	107.6
F lower	0.9	0.35	765.9	739.2	2054.0	2232.5	8.7	17.5
F_{MSY} transition (intermediate year)	1.8	0.67	765.9	1258.4	2054.0	1649.4	-19.7	100.0
Zero catch	0.0	0.00	765.9	0.0	2054.0	3221.2	56.8	-100.0
Status quo	1.0	0.37	765.9	790.6	2054.0	2170.7	5.7	25.6
Different Scenarios	0.1	0.04	765.9	91.7	2054.0	3088.7	50.4	-85.4
	0.2	0.07	765.9	180.3	2054.0	2963.3	44.3	-71.3
	0.3	0.11	765.9	265.9	2054.0	2844.5	38.5	-57.7
	0.4	0.15	765.9	348.7	2054.0	2732.1	33.0	-44.6
	0.5	0.19	765.9	428.7	2054.0	2625.6	27.8	-31.9
	0.6	0.22	765.9	506.0	2054.0	2524.7	22.9	-19.6
	0.7	0.26	765.9	580.7	2054.0	2429.1	18.3	-7.7
	0.8	0.30	765.9	653.0	2054.0	2338.4	13.8	3.8
	0.9	0.34	765.9	722.9	2054.0	2252.3	9.7	14.9
	1.1	0.41	765.9	856.0	2054.0	2093.2	1.9	36.0
	1.2	0.45	765.9	919.3	2054.0	2019.6	-1.7	46.1
	1.3	0.49	765.9	980.7	2054.0	1949.7	-5.1	55.8
	1.4	0.52	765.9	1040.0	2054.0	1883.3	-8.3	65.3
	1.5	0.56	765.9	1097.5	2054.0	1820.1	-11.4	74.4
	1.6	0.60	765.9	1153.2	2054.0	1760.0	-14.3	83.3
	1.7	0.64	765.9	1207.1	2054.0	1702.8	-17.1	91.8
	1.8	0.67	765.9	1259.3	2054.0	1648.4	-19.7	100.1
	1.9	0.71	765.9	1310.0	2054.0	1596.6	-22.3	108.2
	2.0	0.75	765.9	1359.1	2054.0	1547.2	-24.7	116.0

*SSB at mid year

EWG advises that when the MSY approach is applied, catches in 2022 should be no more than 1032.5 tonnes.

6.11.6 DATA DEFICIENCIES

The EWG 21-11 did not find any particular data deficiency for this stock in terms of data quality. A sensitivity analysis was run to test the effects of the late MEDITS survey performed in 2020. No major effect on the assessment model was detected.

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 mullets along western Italian coast (i.e. continuity in spatial distribution in GSA10 and GSA9).

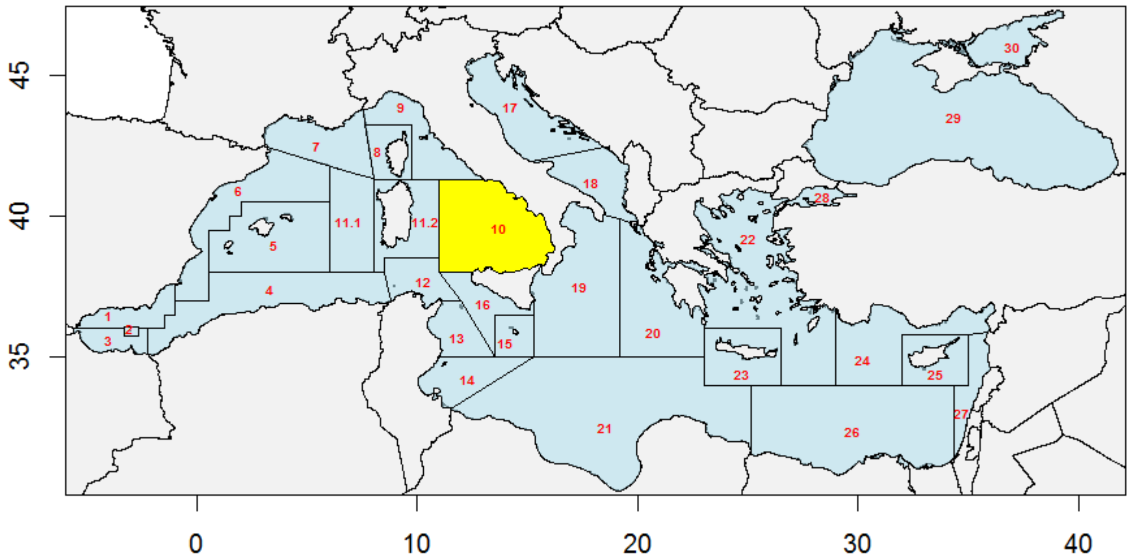


Figure 6.12.1.1. Map of GSA 10.

Growth

The information on the age-length key (ALK) and on the growth von Bertalanffy parameters was available from 2002 to 2020.

The group 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.

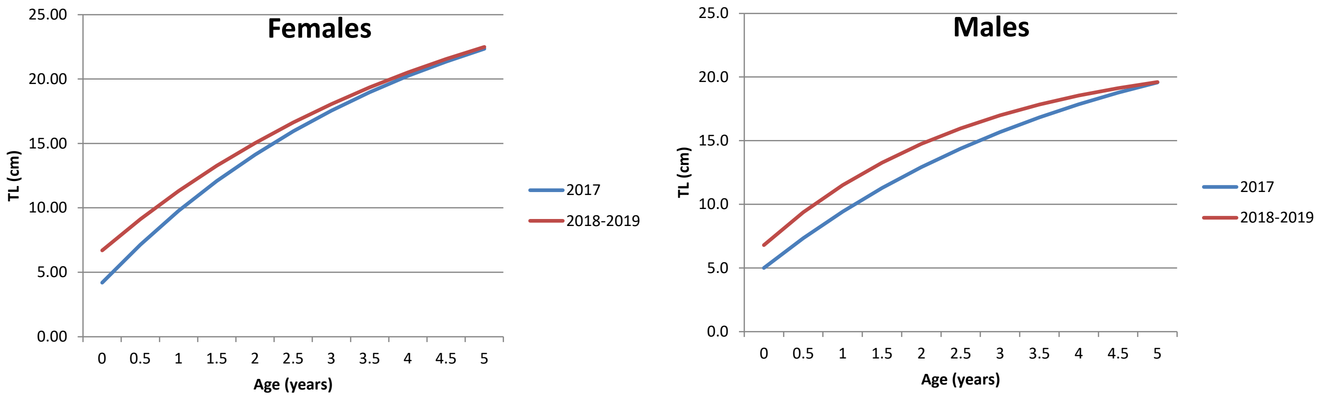


Figure 6.12.1.2. Growth curves for red mullet in GSA 10 (DCF).

Natural mortality

Natural mortality is the same used during EWG 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 2020. The group agreed to use the maturity vector used in EWG 20-09. Mortality and maturity parameters used in assessment are shown in Table 6.12.1.1.

Table 6.12.1.1 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 2020 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.

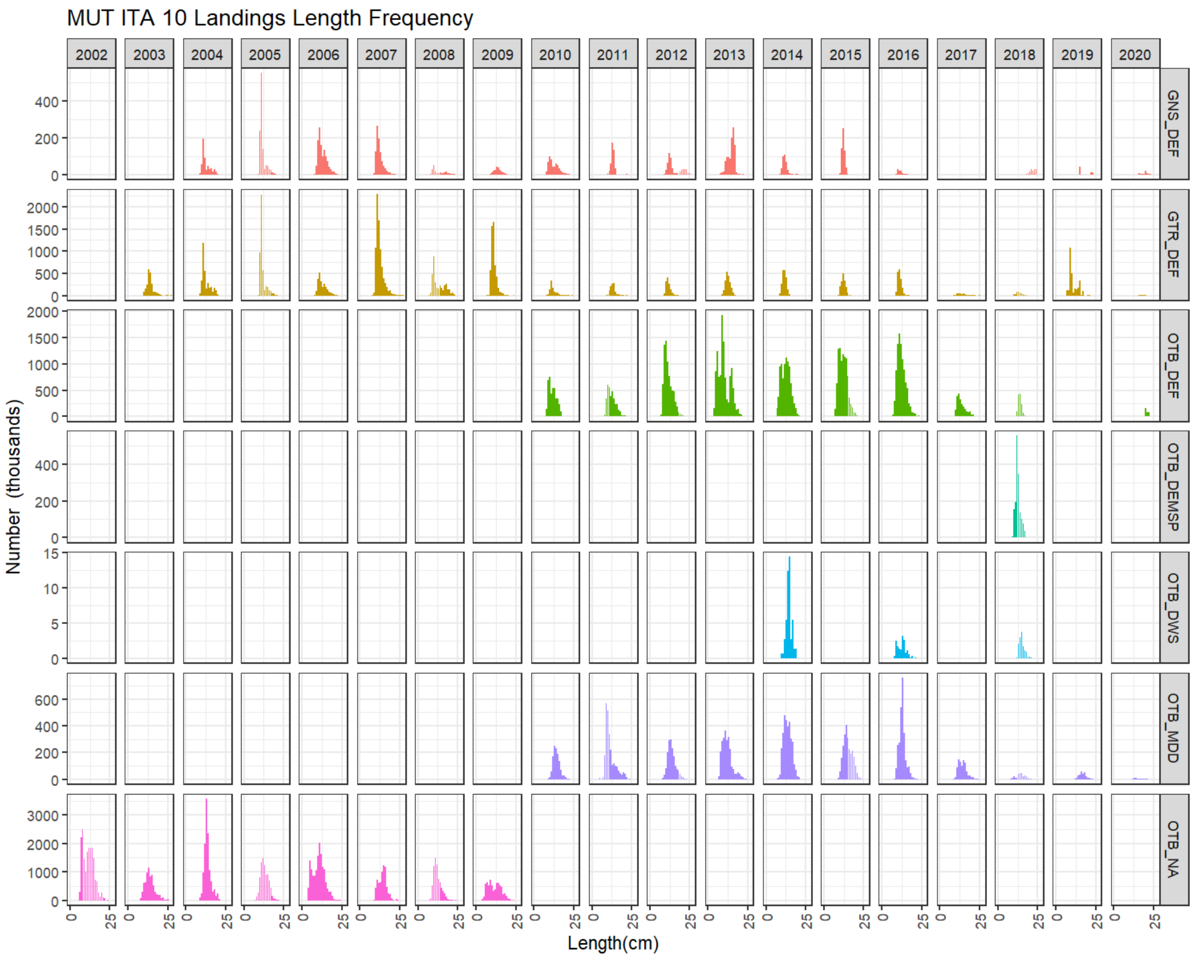


Figure 6.12.2.1.1. Length structure of red mullet landed in GSA 10 in the period from 2002 to 2020 by fishing gear and fishery.

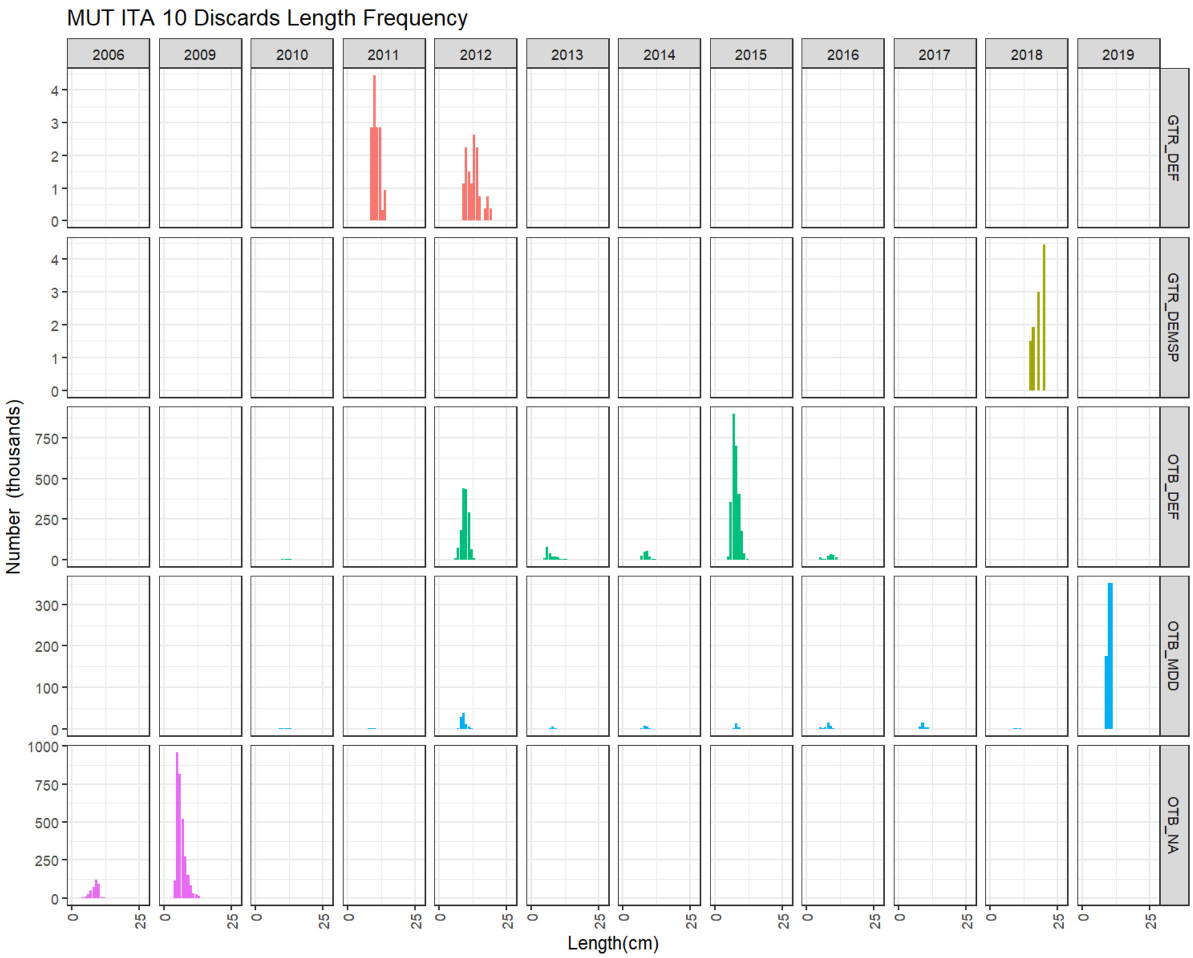


Figure 6.12.2.1.2. Length structure of discarded catch of red mullet in GSA 10 in the period from 2006 to 2019 by fishing gear and fishery. Discards in 2020 are null.

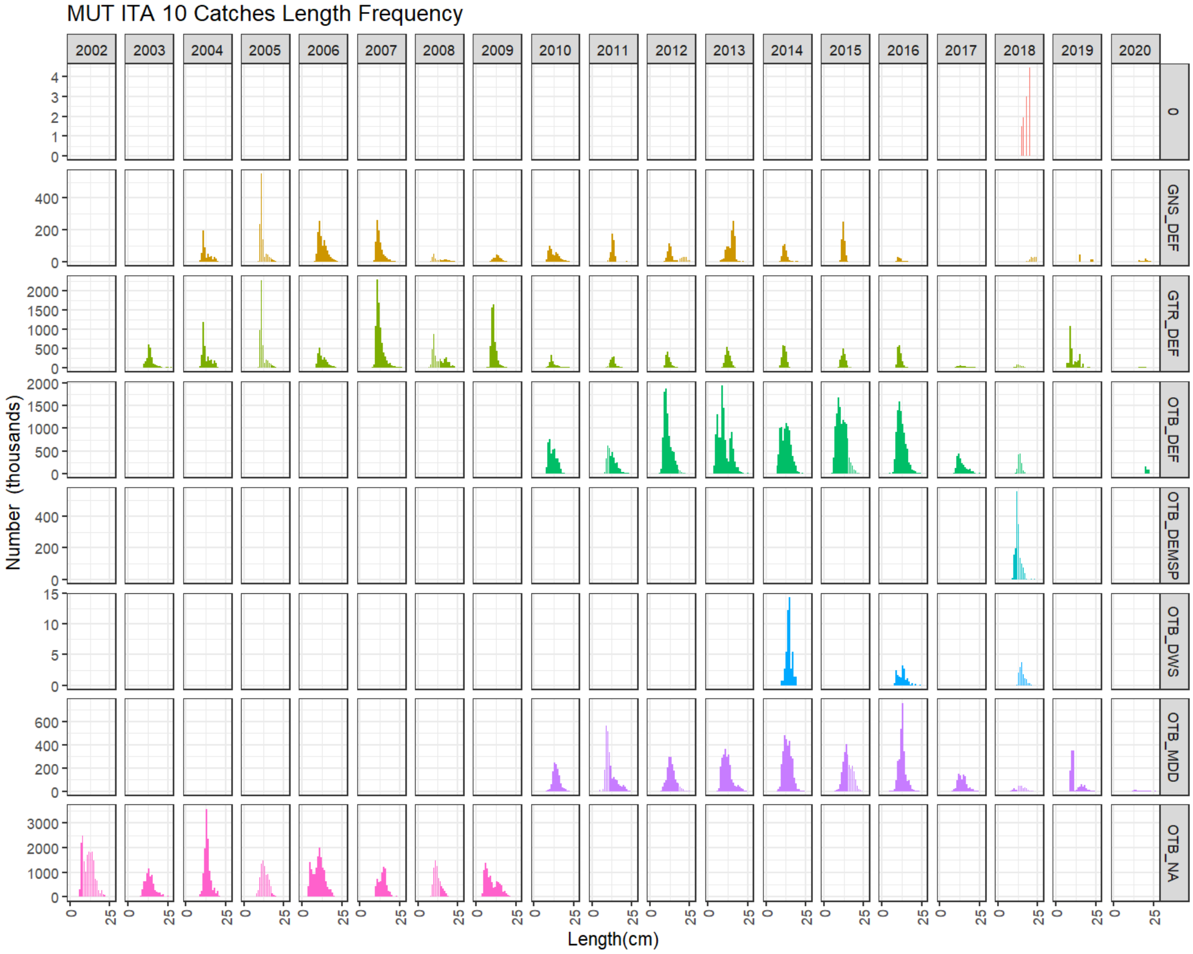


Figure 6.12.2.1.3. Length structure of catches (landing+discarded catch) of red mullet in GSA 10 in the period from 2002 to 2019 by fishing gear and fishery.

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 (Figure 6.12.2.1.4). The LFDs of discards 2002-2009 and 2017-2019 of OTB were reconstructed analogously during EWG 21-02 and used in the stock assessment.

For 2020 very few individuals were sampled and the LFDs obtained were sparce and different from previous years. The ifluence of these data were evaluated in the asessment.

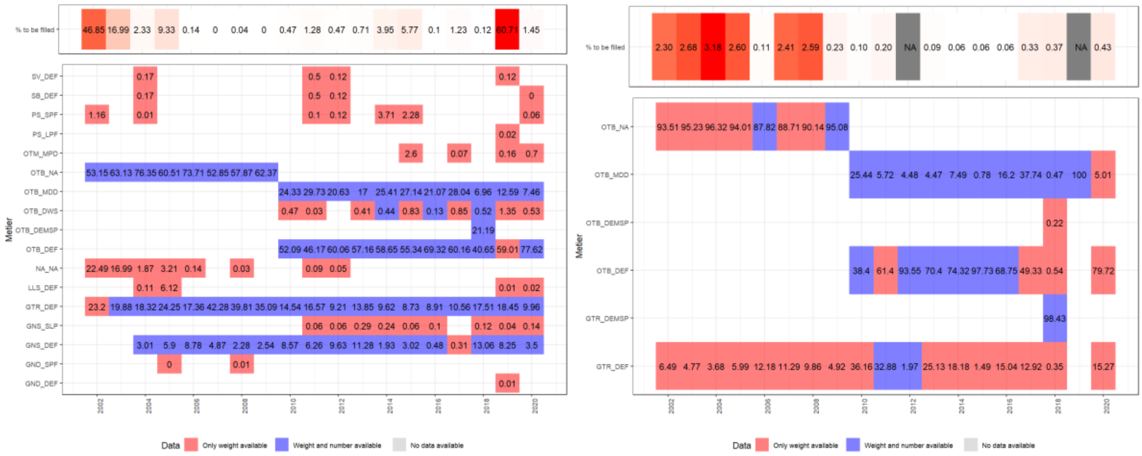


Figure 6.12.2.1.4 Landing and discard data availability for red mullet in GSA 10.

6.12.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

6.12.2.3 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. EWG 21-11 considered this fact 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. Analyses of available MEDITS data show large variations between years (Figures 6.12.2.2.2- 6.12.2.2.3).

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.

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).

Figure 6.12.2.2.1. Survey periods (MEDITS, 1994-2019) in GSA 10.

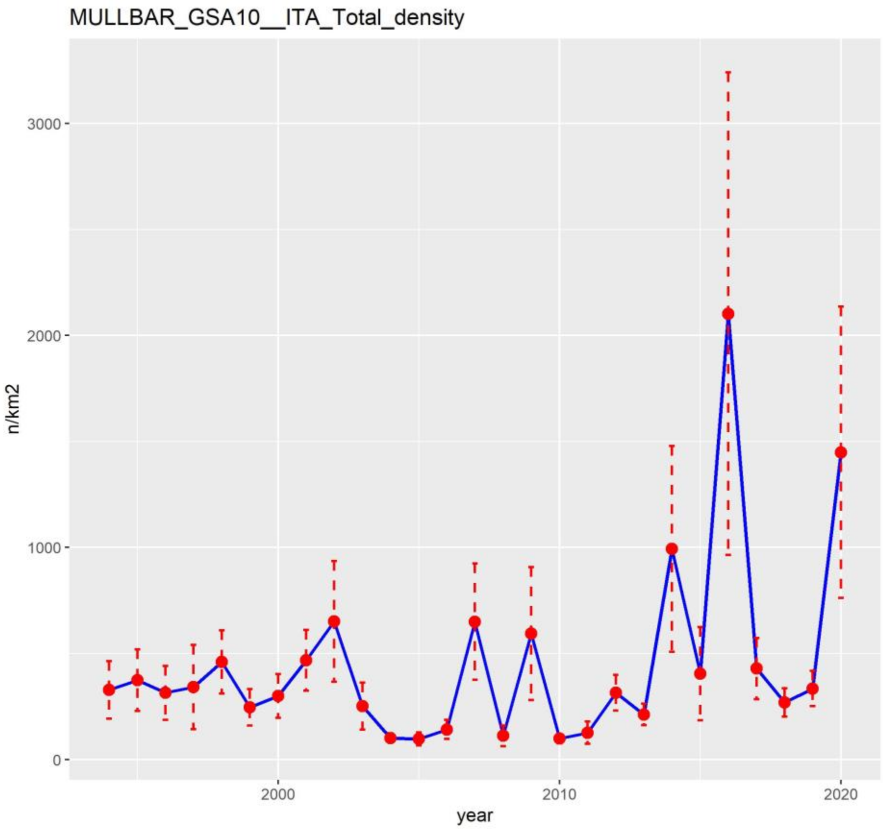


Figure 6.12.2.2.2. Abundance indices (N/km^2) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2020).

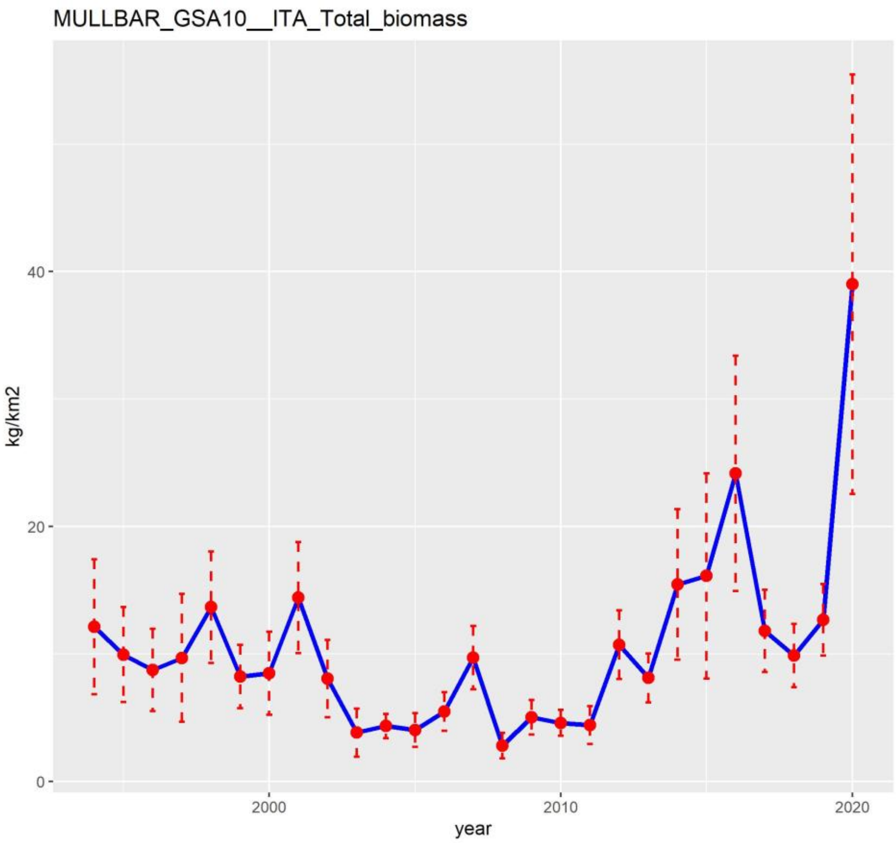


Figure 6.12.2.2.3. Biomass indices (kg/km^2)) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2020).

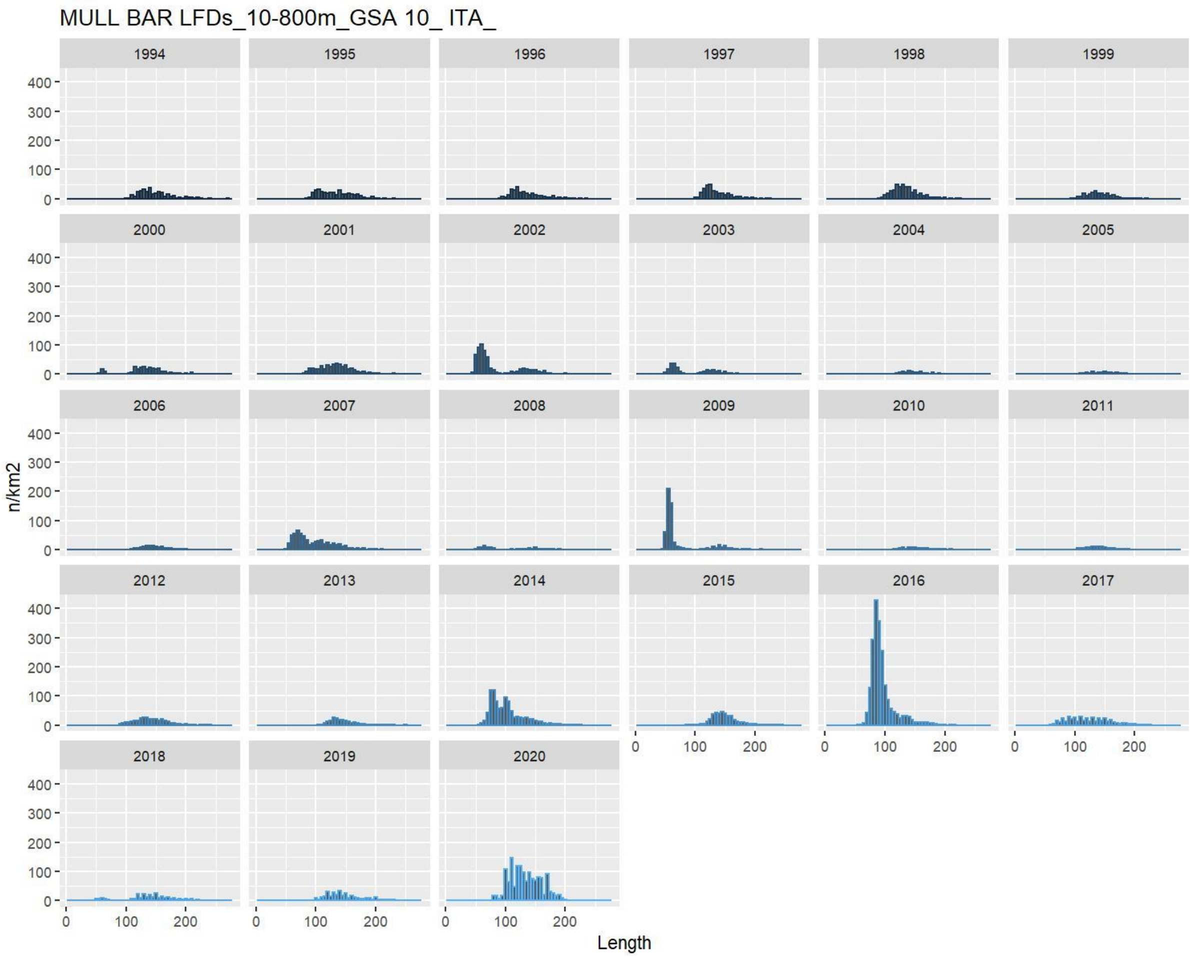


Figure 6.12.2.2.6. Size structure indices of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2020).

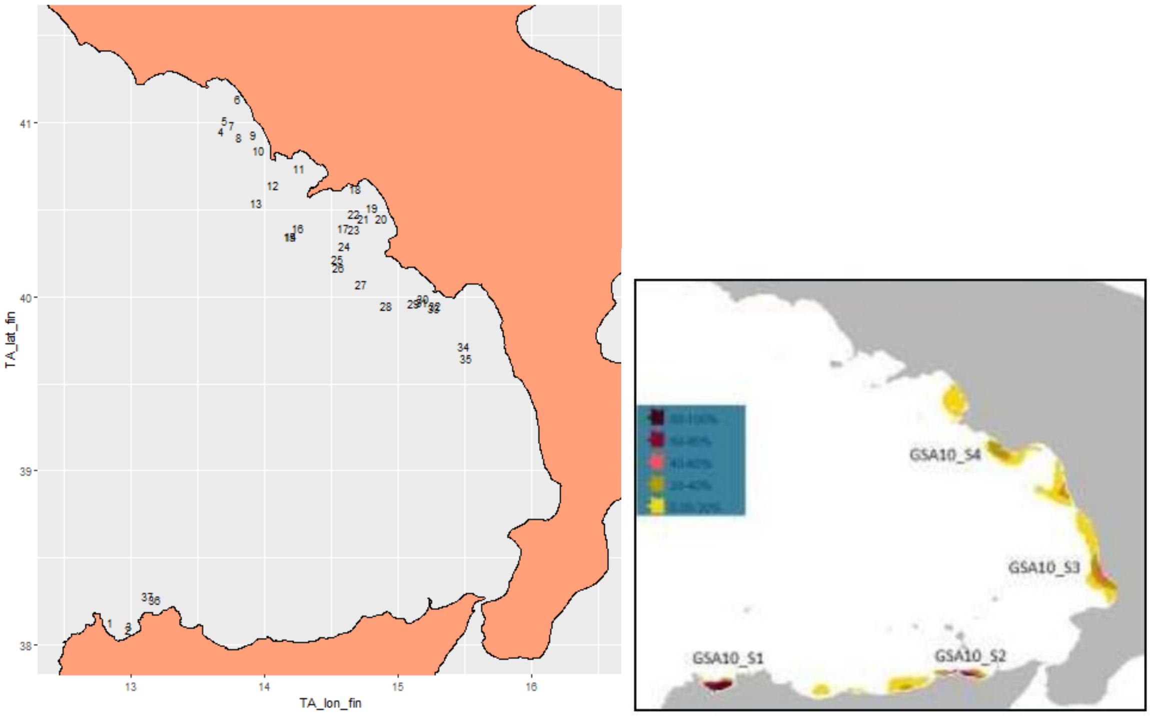


Figure 6.12.2.7 Position of the MEDITS hauls in 2020 (left) and of spawning grounds (right) from MEDISEH project.

A anomalous sex ratio was observed in 2020 respect to the previous years (Figure 6.12.2.8); for this reason the sex ratio of 2016-2019 was modelled and used to split the 2020 total LFDs in females and males.

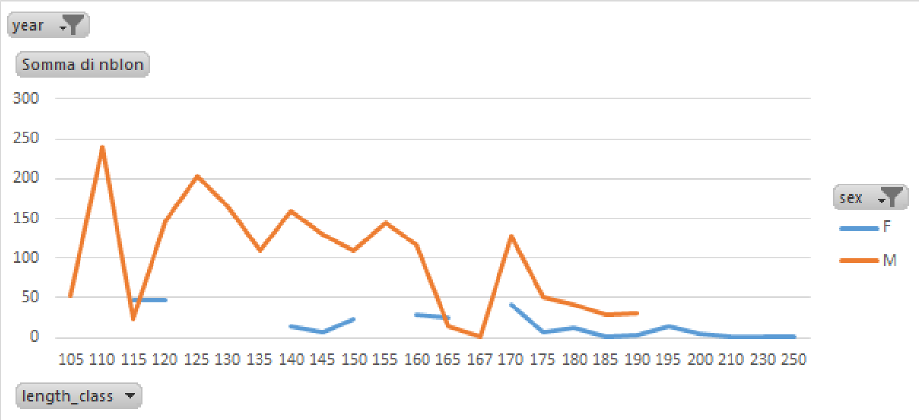


Figure 6.12.2.8 Sex ratio of MEDITS 2020 for MUT 10.

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.

year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
data	1.46	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**	
data	1.14	1.22	1.23	1.21	1.16	1.61	5.38	1.33	6.54	

6.12.3 STOCK ASSESSMENT

The present assessment of red mullet in GSA 10 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. 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.

Table 6.12.3.1. Values of catch at age per year used in the assessment (SOP applied).* 2020 catch at length/catch at age data were anomolous.

Year/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

Table 6.12.3.2. Values of mean weight at age per year used in the assessment.

Year/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

Table 6.12.3.3. 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

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. 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. For that reason, age 0 class was not included in the tuning indices used for the assessment. MEDITS indices (density by age) are shown in Figure 6.12.3.2 and Table 6.12.3.3.

Catch at age 2020 shows a sharp absence of age 1 and an increase in age 4+ individuals respect to the past. The number of samples taken and individuals measured were very few in 2020, indicationg the data might be considered unreliable. Several runs were carried out using the 2020 landing at age data, but the results were considered unreliable, showing an unrealistically low F respect to the 2019. For this reason the 2020 catch at age data were not used, allowing the model to estimate them according to the other available data.

A mismatch of 2017 and 2018 landing of FDI was observed and reported also in EWG 21-02. In the assessment the values of FDI were used, as in the previous assessment.

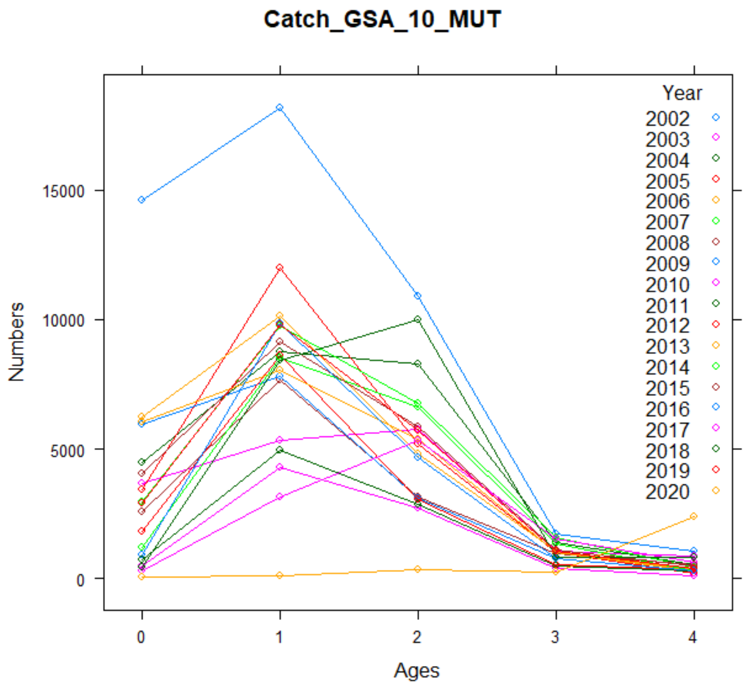


Figure 6.12.3.1. Catch-at-age data of red mullet in GSA10.

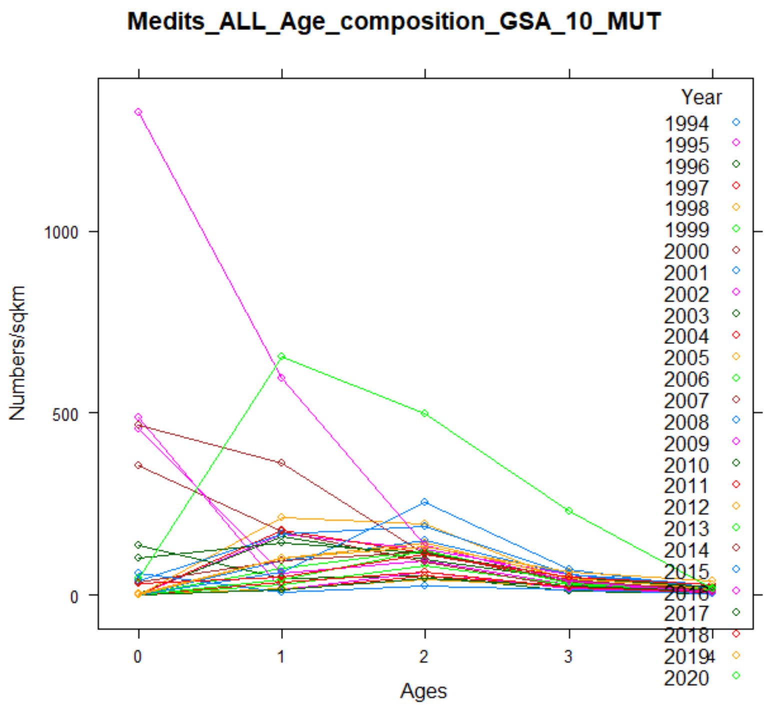


Figure 6.12.3.2. MEDITS indices describing density by age of red mullet in GSA10 by years.

Despite the first model explored was the final one of EWG 20-09, a 0-age dedicated spline was included in the f model, to improve residuals in age 0:

- `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 ~factor(replace(age, age > 2, 2))`

The extra term at age 0 allows the fishing mortality at that age to decline more rapidly than the older ages, this better fits the data. Age zero from the survey is not used in the assessment because the survey timing has changed over the recent years and age zero is particularly sensitive to that change, so there is no other data to confirm the changes observed. Decoupling age 0 from the older ages also improves the fit to the older ages (1 and 2), while the fit to the survey at these older ages is unaffected. The discards are responsible for a significant proportion of the O group, and the samples indicate a decline in discards, or at least in the reported discard data. The decline in F at age 0 may be due to the decline in reported discards, and is better explained by including the term for age 0.

Results are shown below (Figure 6.12.3.4).

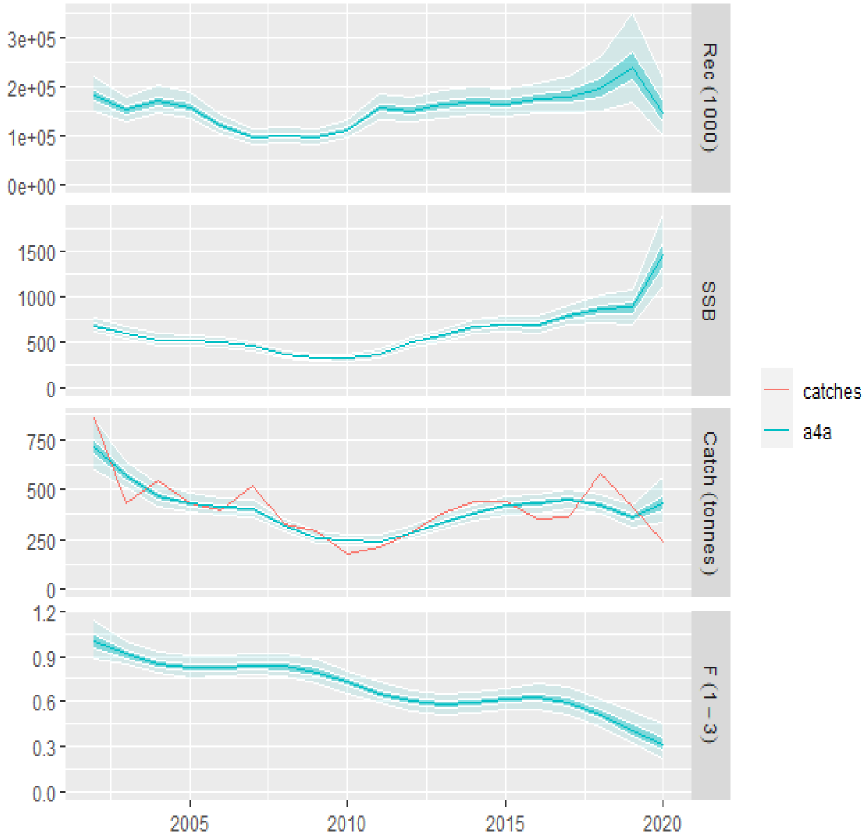


Figure 6.12.3.4. Results of the best a4a model outcomes for red mullet in GSA10.

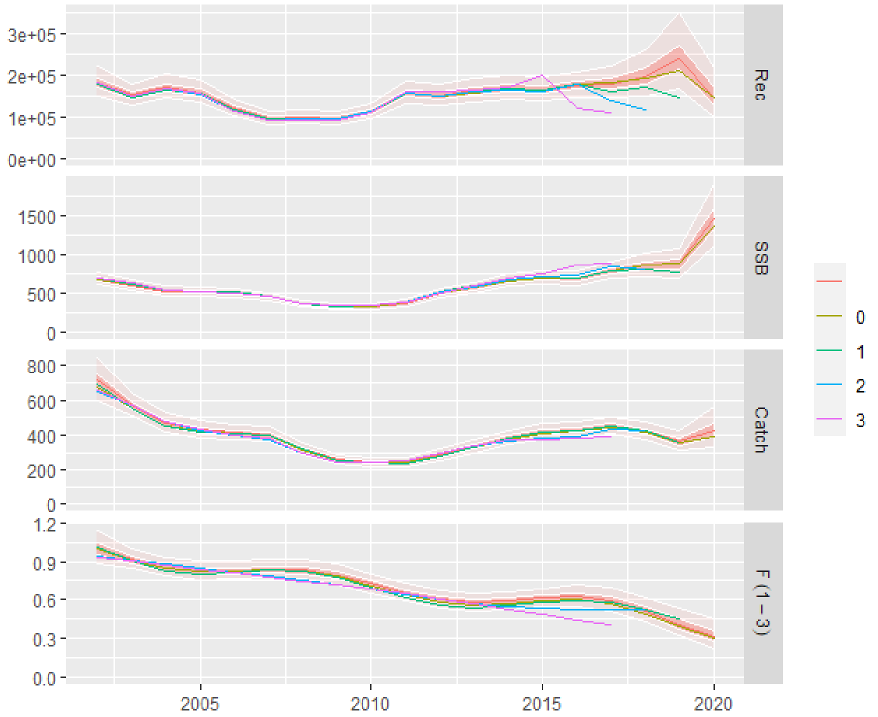


Figure 6.12.3.5. Retrospectve analysis of the best a4a model outcomes for red mullet in GSA10.

Log residuals of the catch and MEDITS abundance indices related to the best run do not show any particular trends over time with the possible exception of catch at ages 1 and 3 (Figure 6.12.3.7), however the fit to overall catch and to survey showed no trend. This choice is supported by the reasonable retrospective performance. The final assessment outcomes are given in summary in Table 6.12.3.4 and as N and F at age in Tables 6.12.3.5 and 6.12.3.6 respectively.

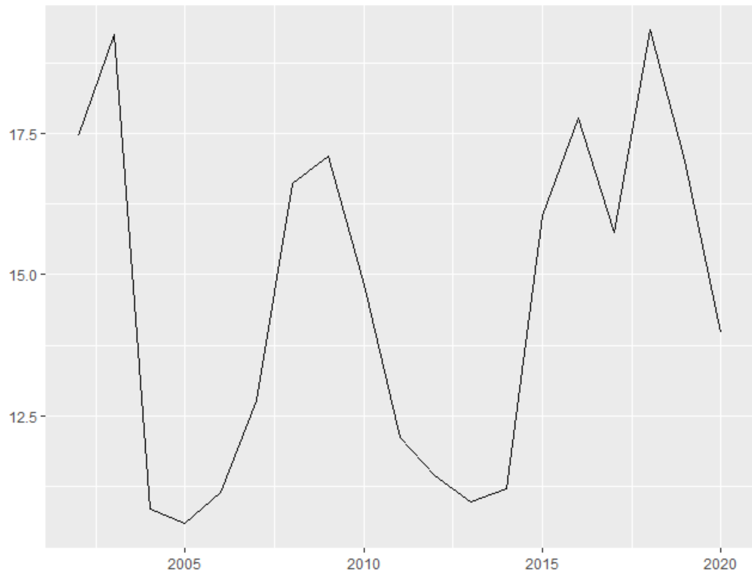


Figure 6.12.3.6 Criptic biomass (weight of age class 4+ respect to SSB).

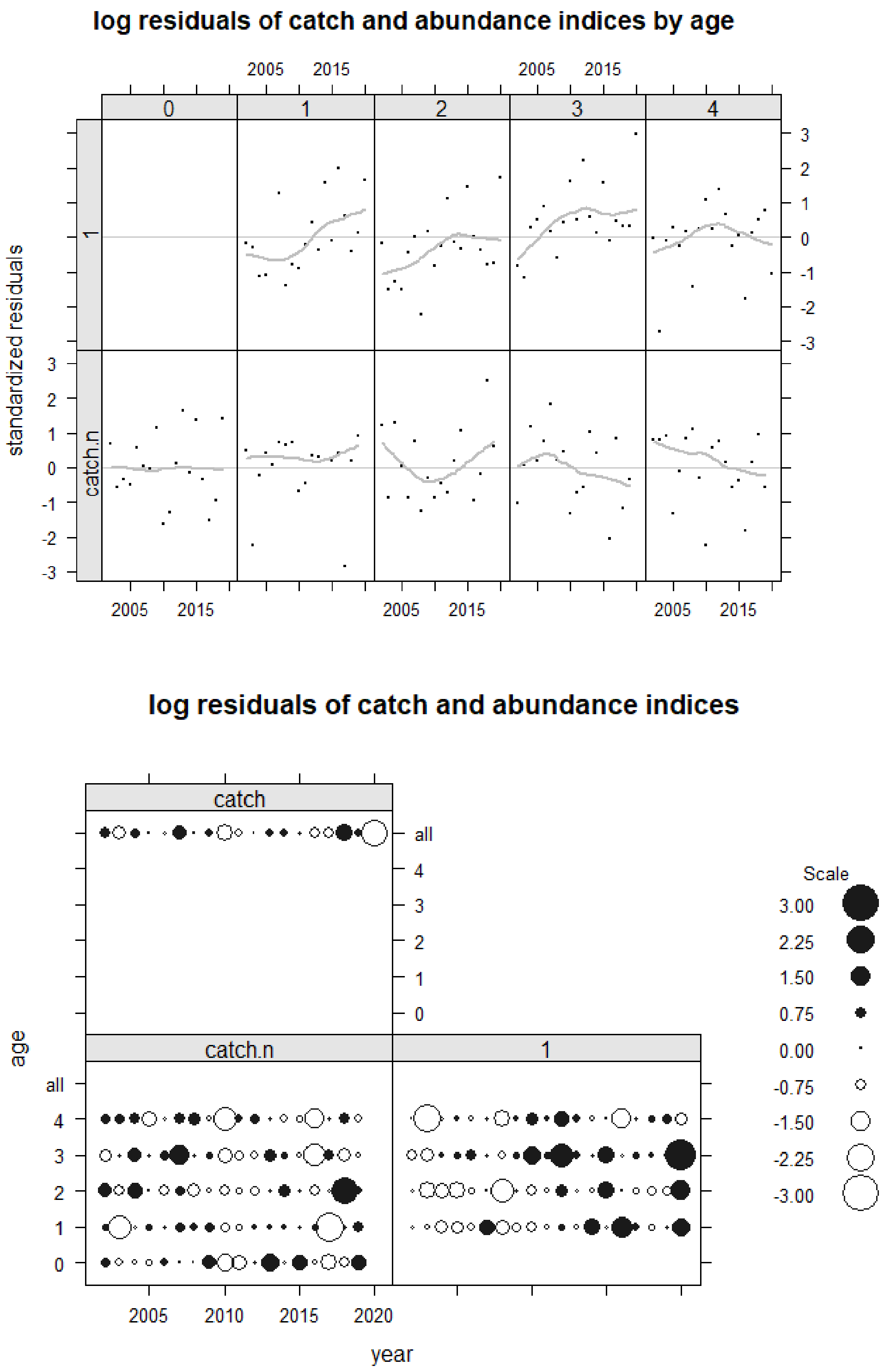


Figure 6.12.3.7 Log residuals of catch and MEDITS abundance indices.

Table 6.12.3.4. Final results of the red mullet assessment in GSA10.

Year	Recruitment age 0 (thousands)	SSB tonnes	Catch tonnes (estimated)	F ages 1-3
2002	182940	673	701	1.00
2003	152824	599	568	0.91
2004	170823	524	466	0.85
2005	159722	512	429	0.83
2006	121420	498	411	0.83
2007	98288	450	401	0.84
2008	100869	354	320	0.83
2009	97824	322	259	0.79
2010	112382	331	246	0.73
2011	156909	370	242	0.65
2012	152051	495	284	0.60
2013	163051	565	332	0.58
2014	169779	658	382	0.59
2015	166785	688	418	0.61
2016	177221	682	427	0.63
2017	181097	779	450	0.60
2018	198183	850	420	0.52
2019	243342	866	360	0.41
2020	149593	1449	426	0.31

Table 6.12.3.5. Stock number at age for red mullet in GSA10.

Year/Age	0	1	2	3	4+
2002	182940	47526	13520	4117	1342
2003	152824	39775	12488	1990	1165
2004	170823	33548	10992	2066	743
2005	159722	37777	9607	1974	703
2006	121420	35498	10991	1790	690
2007	98288	27080	10319	2044	639
2008	100869	22003	7820	1889	681
2009	97824	22709	6371	1441	657
2010	112382	22198	6725	1237	560
2011	156909	25725	6839	1431	516
2012	152051	36197	8272	1606	604
2013	163051	35276	12012	2090	727
2014	169779	37964	11855	3125	948
2015	166785	39610	12688	3045	1355
2016	177221	38960	13041	3148	1428
2017	181097	41447	12730	3179	1465
2018	198183	42428	13779	3230	1535
2019	243342	46536	14769	3889	1715

2020	149593	57273	17211	4796	2255

Table 6.12.3.6. Fishing mortality at age for red mullet in GSA10.

	Age				
	0	1	2	3	4+
2002	0.09	0.58	1.35	1.07	1.07
2003	0.08	0.53	1.23	0.98	0.98
2004	0.07	0.50	1.15	0.92	0.92
2005	0.06	0.48	1.11	0.89	0.89
2006	0.06	0.48	1.11	0.89	0.89
2007	0.06	0.49	1.13	0.90	0.90
2008	0.05	0.48	1.12	0.90	0.90
2009	0.04	0.46	1.07	0.85	0.85
2010	0.03	0.42	0.98	0.78	0.78
2011	0.03	0.38	0.88	0.70	0.70
2012	0.02	0.35	0.81	0.64	0.64
2013	0.02	0.34	0.78	0.62	0.62
2014	0.02	0.34	0.79	0.63	0.63
2015	0.01	0.36	0.82	0.66	0.66
2016	0.01	0.36	0.84	0.67	0.67
2017	0.01	0.35	0.80	0.64	0.64
2018	0.01	0.30	0.70	0.55	0.55
2019	0.01	0.24	0.55	0.44	0.44
2020	0.00	0.18	0.42	0.34	0.34

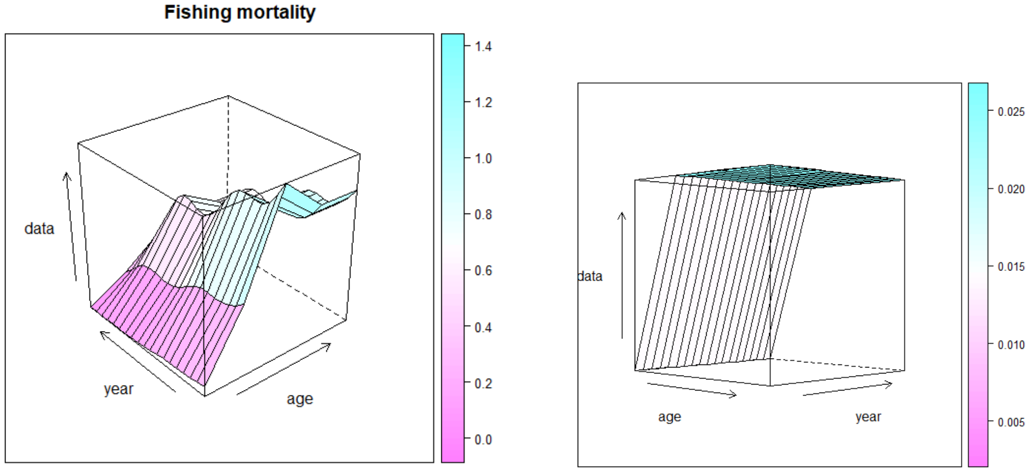


Figure 6.12.3.8 Fishing mortality at age and catchability at age.

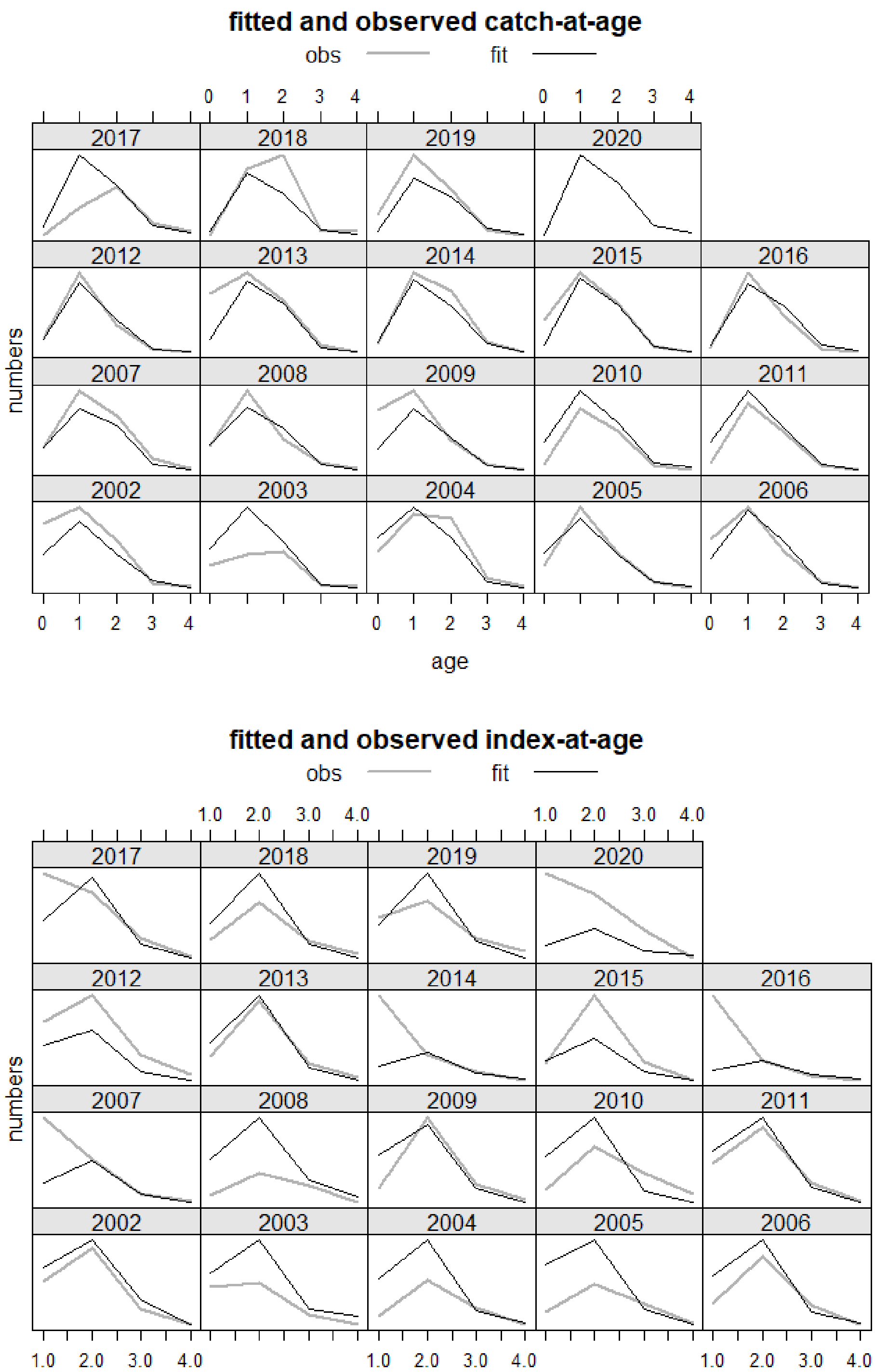


Figure 6.12.3.9 Comparison between catch at age estimated by the model and observed for the catch (top) and MEDITS (bottom).

6.12.4 REFERENCE POINTS

The time series is too short to produce meaningful stock recruitment rationship, so reference points are based on equilibrium methods. 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.

The value of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 0.4. The F value estimated for 2020, as calculated by a4a, is 0.31, indicating that the current fishing mortality (F) is below $F_{0.1}$ reference point. This might be due to changes in the age structure of the stock and in the exploitation patter of the fleet. The distribution of the reference point is reported in Figure 6.12.4.1.

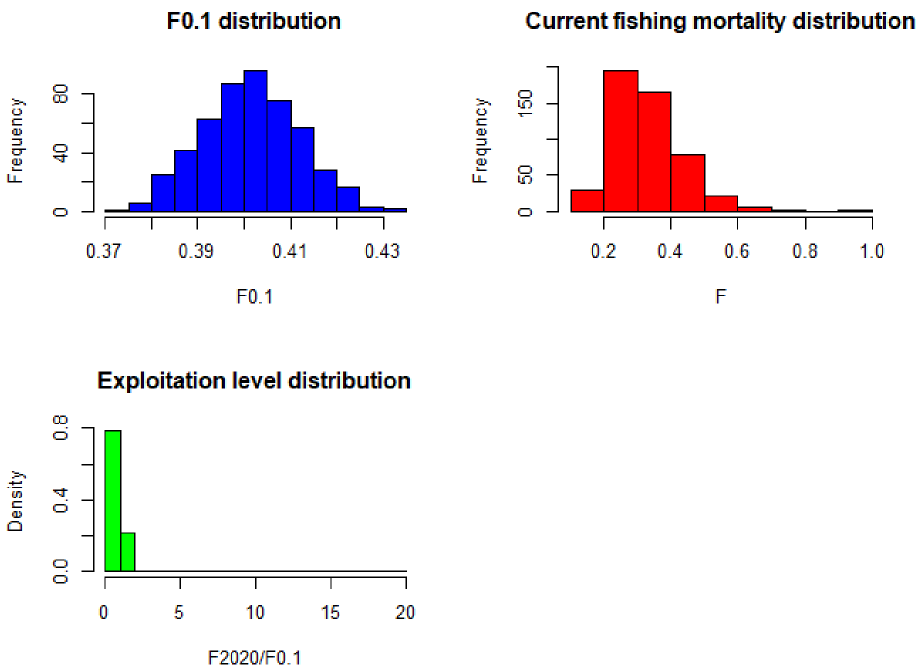


Figure 6.12.4.1 Reference point and F current distribution for the final run.

6.12.5 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 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} =0.315 terminal F (2020) from the a4a assessment was used for F in 2021. Recruitment is observed to be fluctutating over the period of the assessment (Figure 6.12.3.4) so the average across the whole time series is used as an estimate of recruits from 2021. Recruitment (age 0) for 2021 to 2023 has been estimated from the population results as the geometric mean of the whole time series of 19 years (151186 thousands).

Table 6.12.5.1 Red mullet in GSA 10: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2018-2020	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-3}$ (2019)	0.315	F 2020 used to give F status quo for 2021
SSB (2020)	1449	Stock assessment at 1^{st} July 2020
R_{age0} (2020,2022)	151186	Geometric mean of the time series 19 years 2002-2020
Total catch (2021)	423	Assuming F status quo for 2021

These assumptions resulted in a catch and a SSB in 2020 equal to 423 and 1449 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.4) would decrease the SSB of the 13% from 2021 to 2023, while increasing the catch by the 14% from 2020 to 2022. Finally, fishing at a level equal to $F_{MSY\ transition}$ (=0.407) would decrease the SSB of the 14% from 2020 to 2022, while increasing the catch by the 15% from 2020 to 2022.

Table 6.12.5.2 – Short term forecast table for red mullet in GSA 10.

Rationale	Ffactor	Fbar	Catch 2021	Catch 2022	SSB 2021	SSB 2023	SSB_change _2021-2023(%)	Catch_change _2020-2022(%)
High long term yield ($F_{0.1}$)	1.2747	0.401	423	485	1258	1089	-13.4	13.8
F upper	1.7449	0.549	423	622	1258	926	-26.4	46.1
F lower	0.851	0.268	423	344	1258	1270	0.9	-19.3
F_{MSY} **transition**	1.2922	0.407	423	490	1258	1082	-14.0	15.1
Zero catch	0	0	423	0	1258	1763	40.1	-100.0
Status quo	1	0.315	423	395	1258	1202	-4.4	-7.2
Different Scenarios	0.1	0.031	423	45	1258	1694	34.7	-89.4
	0.2	0.063	423	89	1258	1628	29.4	-79.1
	0.3	0.094	423	131	1258	1566	24.5	-69.1
	0.4	0.126	423	173	1258	1506	19.7	-59.5
	0.5	0.157	423	213	1258	1450	15.2	-50.1
	0.6	0.189	423	251	1258	1395	10.9	-41.0
	0.7	0.22	423	289	1258	1344	6.8	-32.1
	0.8	0.252	423	326	1258	1294	2.9	-23.6
	0.9	0.283	423	361	1258	1247	-0.9	-15.2
	1.1	0.346	423	429	1258	1159	-7.8	0.7
	1.2	0.378	423	461	1258	1118	-11.1	8.3
	1.3	0.409	423	493	1258	1079	-14.2	15.7
	1.4	0.441	423	523	1258	1042	-17.2	22.8
	1.5	0.472	423	553	1258	1006	-20.0	29.8
	1.6	0.504	423	582	1258	972	-22.7	36.6
	1.7	0.535	423	610	1258	940	-25.3	43.2
	1.8	0.567	423	637	1258	909	-27.8	49.6
	1.9	0.598	423	663	1258	879	-30.1	55.8
	2	0.63	423	689	1258	850	-32.4	61.8

*SSB at mid year

EWG advises that when the management strategy is applied, catches in 2022 should be no more than 485 tonnes.

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 2017 and 2018 landing of FDI was observed and reported also in EWG 21-02.

In 2020 no discard sample are present.

A SOP correction of 6.54 was applied to 2020 data, because the available LFDs represented only one fifth of the total production of the stock. Moreover, the LFDs show very few length classes.

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).

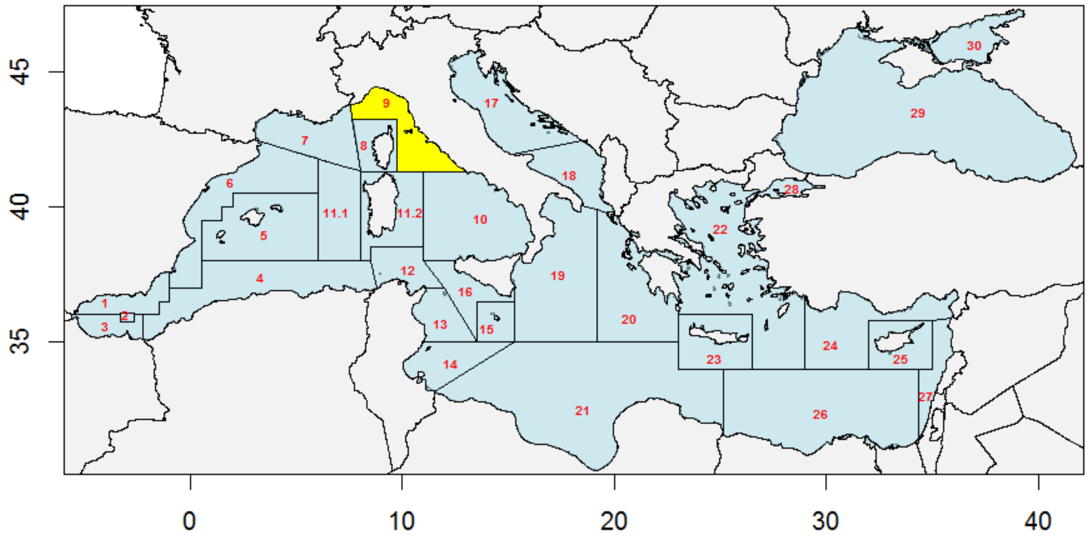


Figure 6.13.1.1 Limit of Geographical Sub-Area (GSA) 9.

6.13.1.1 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 6.18.1.1

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 6.18.1.1).

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.

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	0.40
2	0.50	0.75
3	0.39	1.00
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).

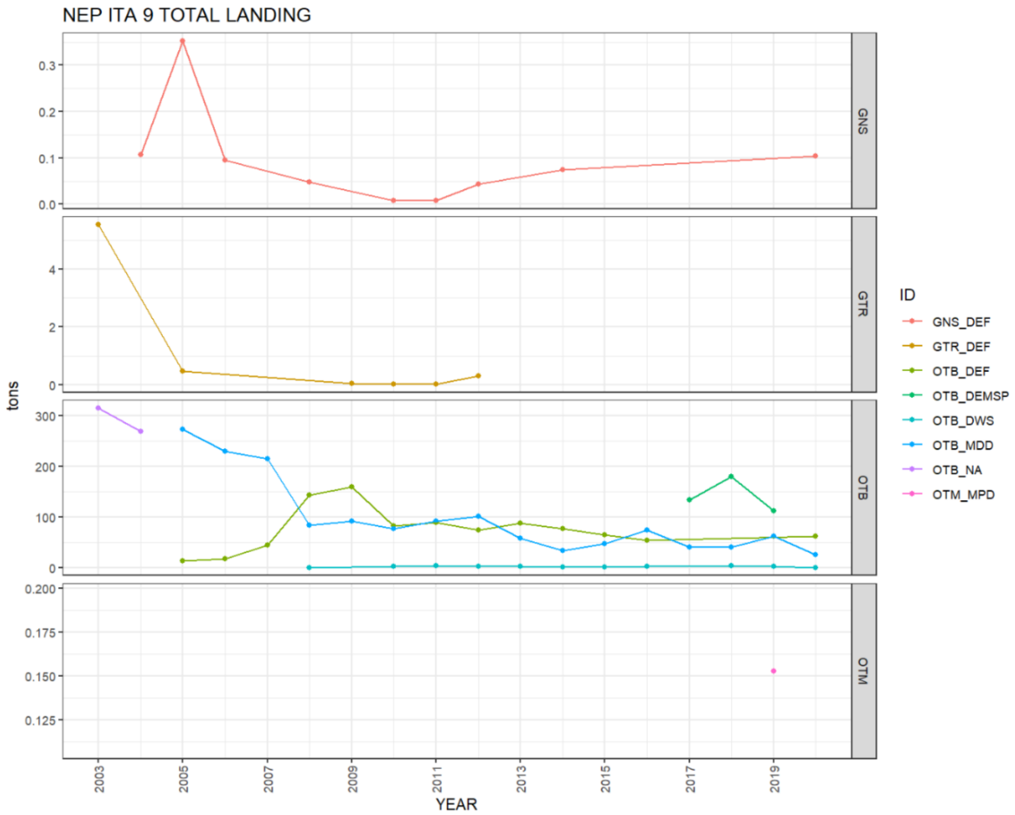


Figure 6.13.2.1.1. Norway lobster in GSA 9: landings trend by gear in GSA 9.

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	89.0	0.10

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.

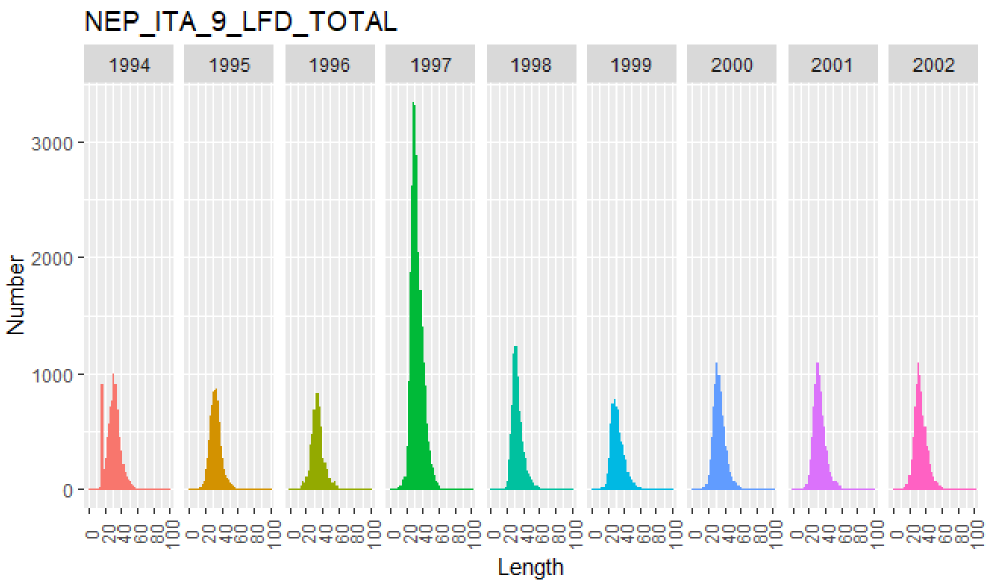


Figure 6.13.2.1.2. Norway lobster in GSA 9: LFDs of landings by year provided by the RECFISH project.

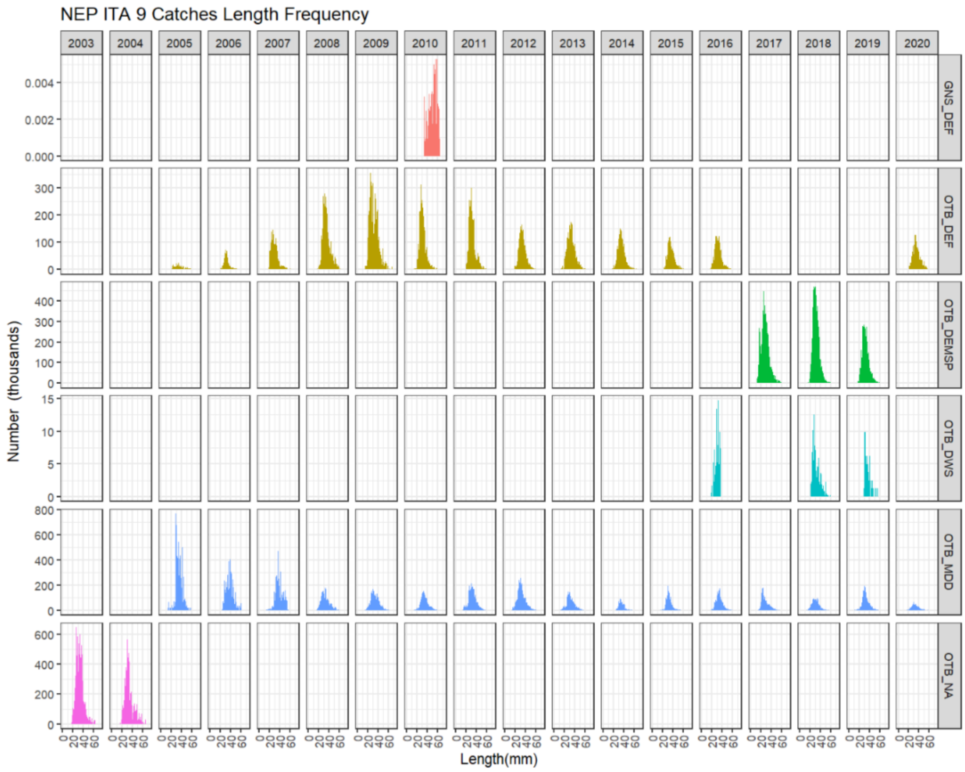


Figure 6.13.2.1.3. Norway lobster in GSA 9: LFDs of landings by year and gear of Norway lobster in GSA 9.

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)**
2003	0.0
2004	0.0
2005	0.0
2006	0.0
2007	0.0
2008	0.0
2009	9.2
2010	0.9
2011	1.0
2012	0.8
2013	1.3
2014	0.4
2015	0.1
2016	0.4
2017	8.2
2018	0.7
2019	0.5
2020	1.0

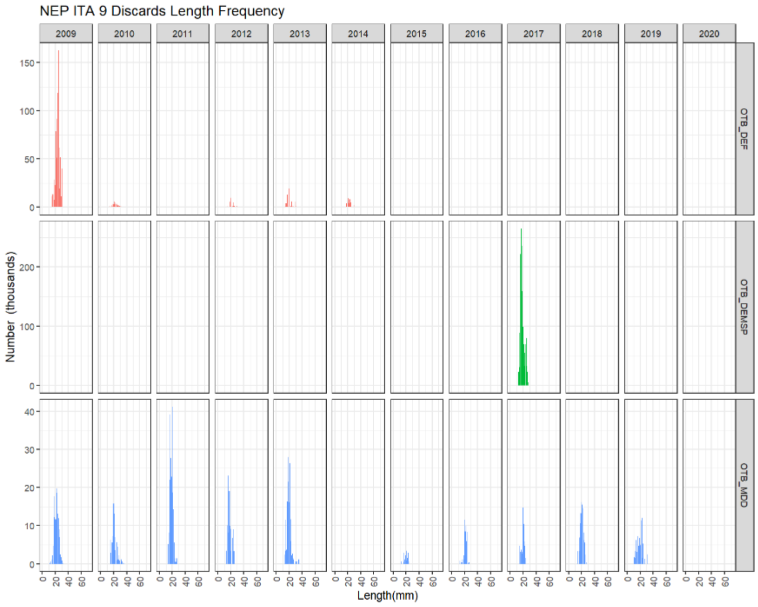


Figure 6.13.2.1.4 Norway lobster in GSA 9: LFDs of discards of Norway lobster in GSA 9. LFDs in 2020 are not available.

6.13.2.2 EFFORT

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

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. 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).

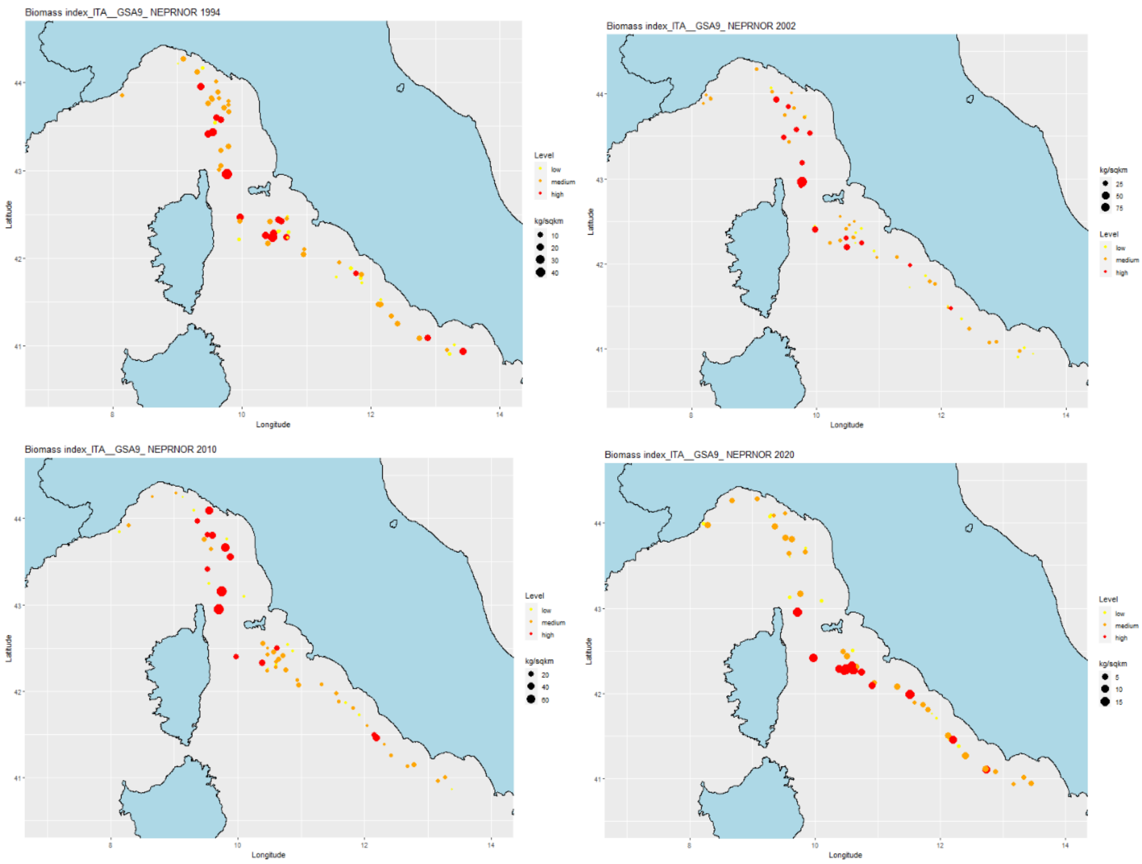
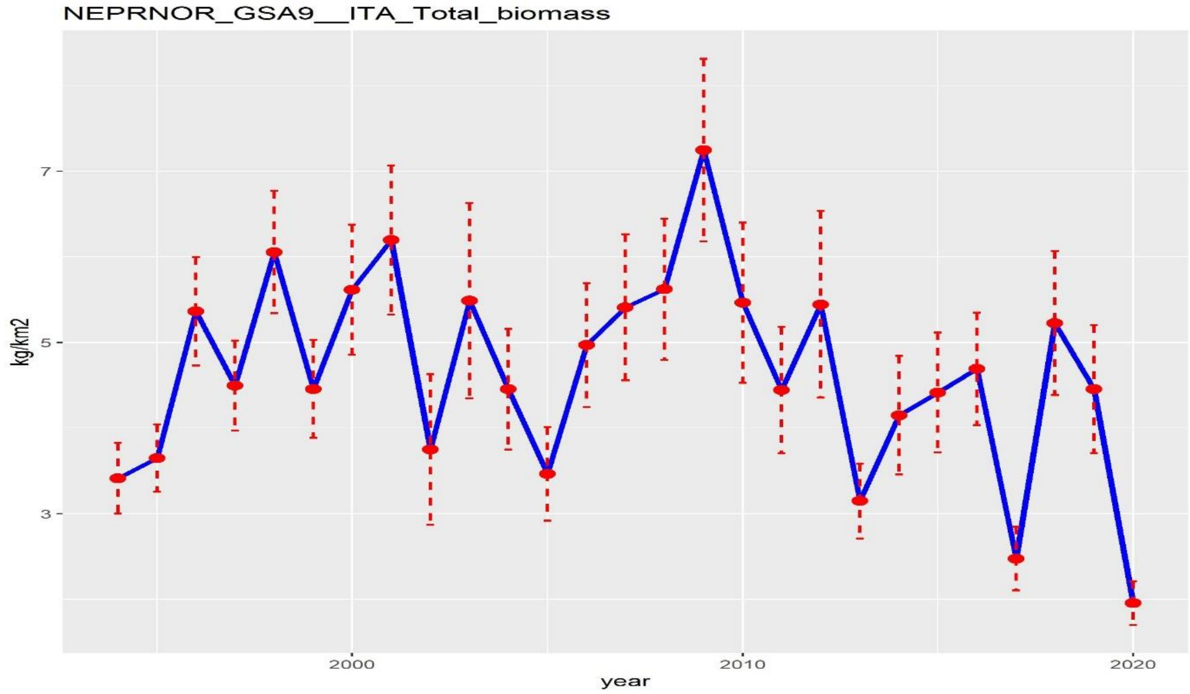


Figure 6.13.2.3.1. Norway lobster in GSA 9: distribution pattern in the period 1994-2019 (MEDITS survey). Maps for the years 1994, 2002, 2010 and 2020 are shown.

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 2020. The biomass and density indices obtained in 2020 are among the lowest observed in the whole time series of the MEDITS data in GSAs 9. This survey was carried delayed in 2020. A sensitivity check on inclusion or exclusion of the survey was conducted and is discussed in Section 6.13.3.



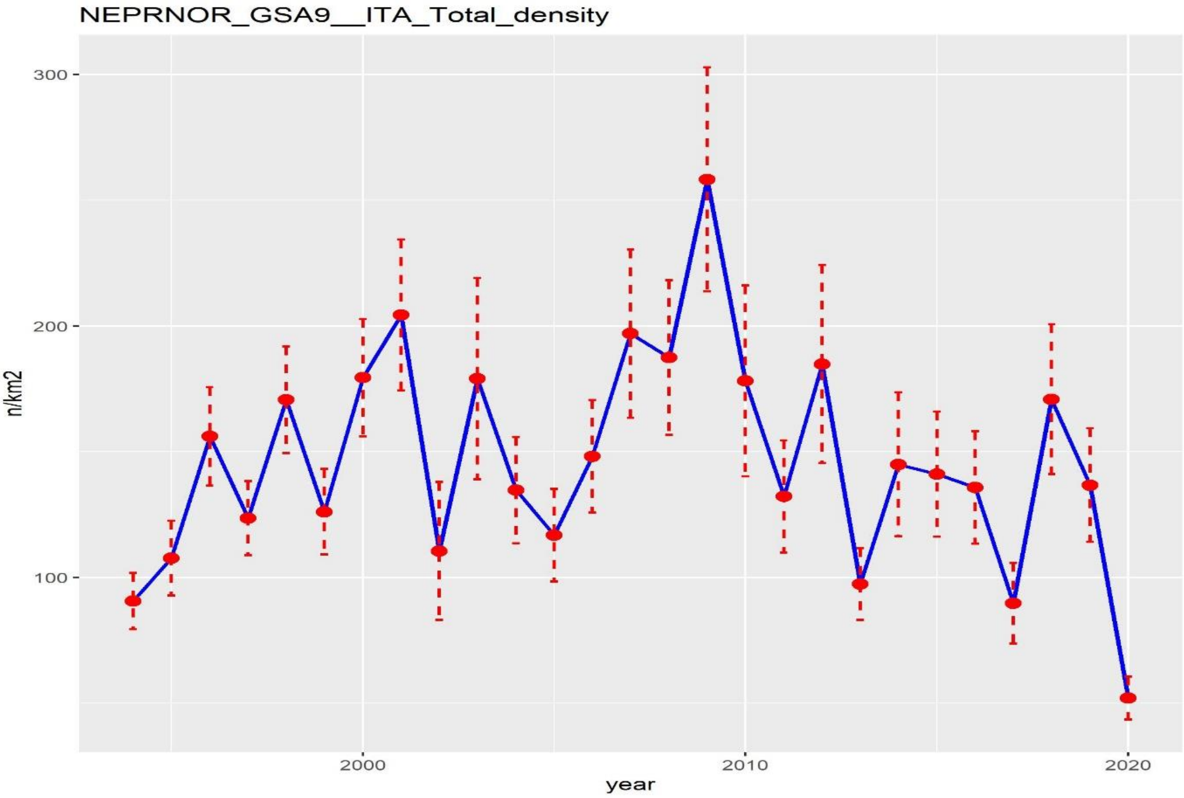


Figure Figure 6.13.2.3.2. Norway lobster in GSA 9: MEDITS standardized biomass and density indices (10-800 m).

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 2020 are shown in Figures 6.113.2.3.3-6.13.2.3.5. Also these plots show that the densities observed in 2013, 2017 and 2020 are among the lowest observed in the whole time series of the MEDITS survey in the GSAs 9.

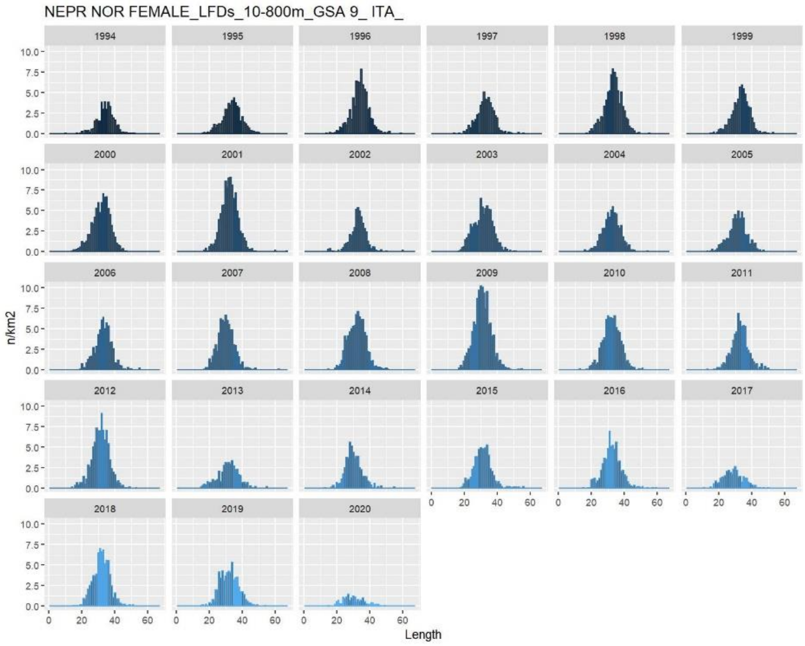


Figure 6.13.2.3.3. Norway lobster in GSA 9: stratified abundance indices by size for females, 1994-2020.

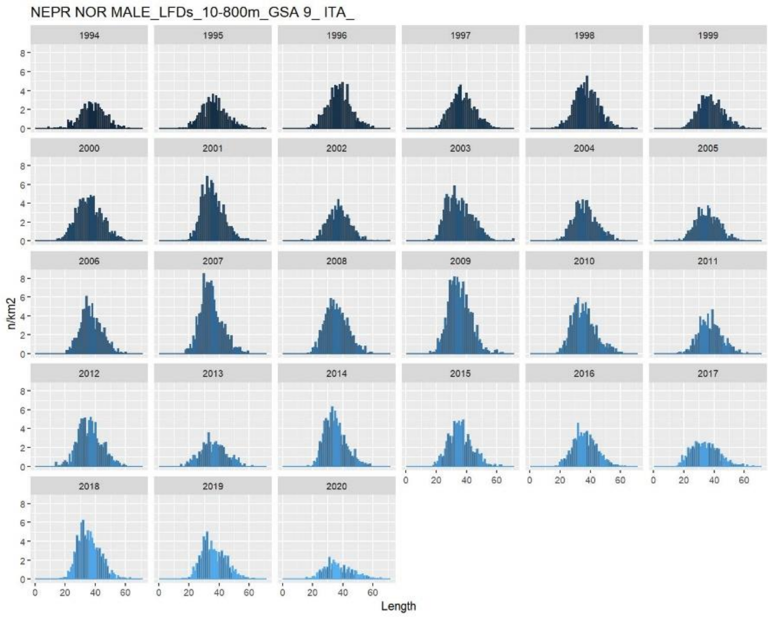


Figure 6.13.2.3.4. Norway lobster in GSA 9: stratified abundance indices by size for males, 1994-2020.

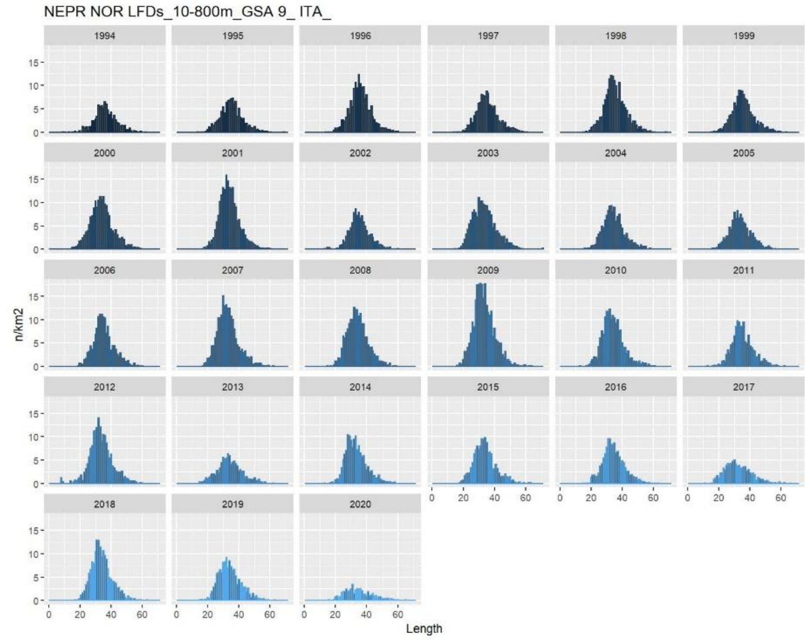


Figure 6.13.2.3.5 Norway lobster in GSA 9: total stratified abundance indices by size, 1994-2020.

6.13.3 STOCK ASSESSMENT

FLR libraries were employed in order to carry out a Statistical Catch-at-age (a4a) assessment.

Three a4a stock assessments were carried out. In the first it was adopt as input data the period 1994-2020 for the catch data with a reconstruction of missing LFDs, based on EWG 21-02, which uses fill-ins by fleet from data in other years and 1994-2020 for the tuning file (MEDITS indices). In the second it was adopt as input data the period 1994-2020 for the catch data without LFD reconstruction and 1994-2019 for the tuning file (MEDITS indices) in order to check sensitivity to the suvey in 2020 which was delayed. Both assessment produced poor results than the final assessment and were rejected by the team. The input data and the poor results of these two a4a stock assessment are presented in section 6.13.7. The third assessment was carried out using as input data the period 1994-2020 for the catch data without LFD reconstructed, but missing LFDs replaced by SoP which uses data by year from other fleets rather than data by fleet from other years. The full 1994-2020 for the tuning file (MEDITS indices) was used for tuning. This last one was considered the best one and adobted by the team.

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 2020 with a value of 0.98. The stock assessment was carried out updating the stock object used in the previous assessment (EWG 20-09).

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.

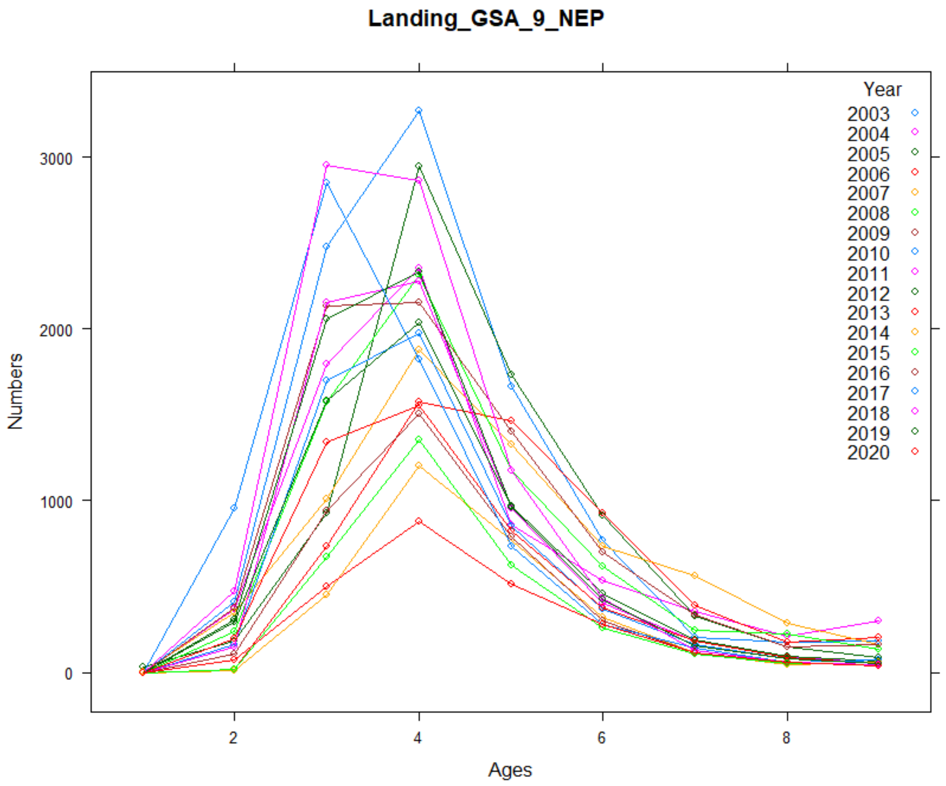


Figure 6.13.3.1. Norway lobster in GSA 9: catch-at-age distribution by year of the catches (1994-2020).

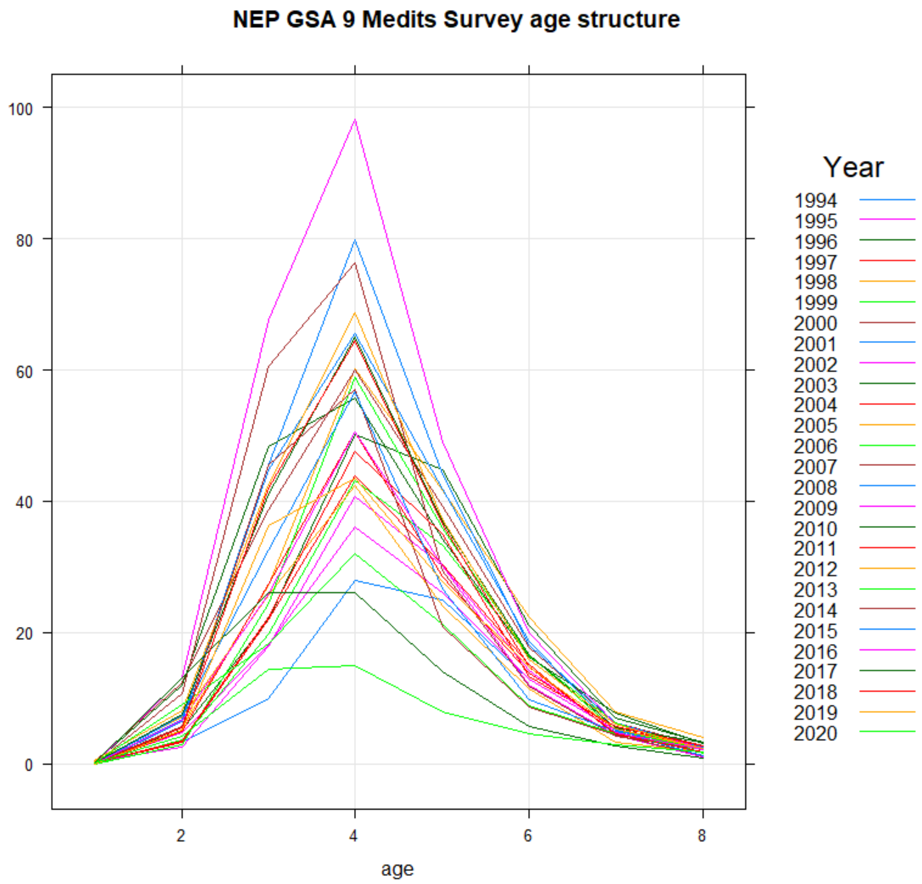


Figure 6.13.3.2. Norway lobster in GSA 9: catch-at-age distribution by year of the MEDITS survey (1994-2020).

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	2005	2006
1	52.95	44.04	15.87	28.96	0.60	28.52	22.56	18.15	18.64	0.02	0.02	29.66	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	192.73	16.69
3	4130.57	3693.43	2349.24	3947.95	2722.83	2174.58	2947.57	2371.72	2436.22	2620.62	1864.63	967.75	702.52
4	4706.35	4563.82	4187.22	3494.08	2553.18	1771.00	3687.89	2967.40	3048.10	3433.13	2437.39	3043.55	1496.65
5	1973.47	1902.95	1986.65	1505.99	1020.68	820.93	1698.78	1366.89	1404.07	1760.81	890.20	1804.23	1402.44
6	818.65	707.86	780.78	791.73	510.77	462.32	807.52	649.75	667.42	811.33	553.90	946.61	876.36
7	315.25	266.57	312.32	340.16	250.85	179.66	328.55	264.36	271.55	214.78	368.55	340.41	371.26
8	175.67	147.23	194.77	223.05	147.60	130.76	204.54	164.58	169.05	188.10	220.04	158.83	168.06
9+	95.38	85.85	245.60	110.10	73.73	62.79	170.19	136.94	140.67	193.16	316.53	92.35	197.08

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	6.07	0.02	4.94	2.89	7.88	7.34	13.37	0.02	0.70	0.94	88.95	3.64	13.47	0.55
2	335.97	229.16	737.92	236.77	337.78	394.08	360.66	43.89	36.95	149.96	2225.09	574.65	335.99	76.68
3	968.53	1519.77	2539.82	1709.13	2134.85	1578.94	1338.82	458.35	708.16	990.63	3127.00	3075.68	1971.72	491.00
4	1786.35	2219.04	2097.09	1942.86	2237.00	1992.22	1523.26	1168.84	1420.51	1555.56	1853.21	2963.39	2219.49	858.41
5	1270.58	1131.09	1350.61	836.48	940.49	951.33	810.06	753.40	656.60	817.10	748.57	1215.84	916.00	505.12
6	696.87	590.84	672.54	363.55	398.46	451.81	368.85	311.06	269.80	311.86	286.39	445.00	400.72	273.08
7	532.22	233.97	324.62	162.19	177.71	189.65	177.05	108.16	109.92	119.04	142.22	134.76	147.19	115.09
8	276.72	218.80	141.91	77.72	94.87	91.35	88.92	48.21	54.87	61.68	62.07	59.89	76.38	60.96
9+	161.23	133.98	155.83	56.99	50.45	66.81	53.59	58.25	50.90	44.25	73.84	46.89	50.60	38.47

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	2005	2006
1	0.338	0.067	0.064	0.064	0.065	0.001	0.323	0.001	0.315	0.154	0.001	0.243	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	7.237	2.990
3	9.959	18.055	21.953	21.984	27.120	19.713	38.673	45.479	17.882	48.320	27.302	25.777	24.449
4	27.894	36.119	50.213	43.950	60.245	43.146	60.076	79.863	40.812	55.665	50.602	42.383	58.893
5	24.898	26.055	44.789	30.299	41.635	33.301	39.263	44.113	30.080	34.328	28.499	24.092	35.850
6	13.005	12.913	21.050	15.236	22.391	16.690	17.669	18.123	11.988	16.201	13.931	11.420	16.369
7	5.169	5.100	6.911	4.403	7.925	5.158	6.205	6.195	4.395	7.767	5.247	3.229	6.240
8	1.584	2.559	3.358	2.645	3.962	2.262	2.814	2.377	1.066	3.073	2.781	1.786	1.612

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.001	0.001	0.001	0.156	0.100	0.525	0.177	0.074	0.001	0.001	0.062	0.001	0.001	0.064
2	10.739	6.874	13.039	7.534	3.435	8.122	9.060	5.655	7.418	6.696	13.059	5.500	5.200	4.218
3	60.542	44.890	67.584	41.081	22.403	42.608	18.352	45.580	32.492	25.881	26.054	42.110	36.225	14.366
4	76.251	65.505	98.156	64.962	47.581	68.760	32.000	57.123	56.616	50.470	26.008	64.386	43.482	14.936
5	29.501	41.775	49.126	36.821	34.918	37.211	21.239	20.952	26.687	30.091	14.118	36.402	27.815	7.868
6	11.756	18.663	19.968	16.552	13.211	15.915	8.784	8.583	9.822	14.145	5.657	14.758	14.832	4.548
7	4.139	5.203	6.127	5.432	5.676	6.125	4.604	4.450	4.926	4.746	2.786	4.541	5.290	2.988
8	2.206	2.554	2.400	3.229	2.738	2.248	2.138	1.243	1.324	2.126	0.842	1.847	2.358	1.820

Table 6.13.3.3. 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												
90.1												

Table 6.13.3.4. Weight-at-age matrix (kg).

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	0.002	0.002	0.002	0.001	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	0.005	0.006	0.006	0.007	0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.005	0.008	0.007
3	0.014	0.015	0.015	0.014	0.015	0.014	0.015	0.015	0.015	0.015	0.015	0.018	0.016	0.014
4	0.026	0.027	0.027	0.027	0.026	0.027	0.027	0.027	0.027	0.028	0.026	0.028	0.028	0.029
5	0.041	0.04	0.04	0.041	0.04	0.041	0.041	0.041	0.041	0.041	0.041	0.043	0.045	0.043
6	0.059	0.058	0.06	0.057	0.057	0.056	0.059	0.059	0.059	0.058	0.063	0.06	0.061	0.062
7	0.082	0.083	0.081	0.079	0.081	0.077	0.081	0.081	0.081	0.082	0.087	0.077	0.085	0.087
8	0.097	0.098	0.098	0.098	0.098	0.099	0.098	0.098	0.098	0.099	0.104	0.088	0.091	0.103
9	0.125	0.127	0.143	0.137	0.132	0.141	0.143	0.143	0.143	0.154	0.151	0.128	0.15	0.121

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.002	0.075	0.031	0.002
2	0.007	0.007	0.007	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007
3	0.015	0.014	0.015	0.015	0.015	0.015	0.016	0.016	0.015	0.014	0.014	0.015	0.015
4	0.027	0.028	0.026	0.026	0.026	0.027	0.028	0.027	0.028	0.026	0.026	0.026	0.028
5	0.041	0.043	0.041	0.041	0.042	0.042	0.042	0.042	0.041	0.041	0.04	0.041	0.042
6	0.061	0.058	0.059	0.061	0.059	0.059	0.057	0.058	0.058	0.059	0.057	0.058	0.061
7	0.084	0.085	0.085	0.082	0.083	0.084	0.081	0.082	0.083	0.082	0.081	0.083	0.085
8	0.104	0.101	0.099	0.098	0.097	0.099	0.095	0.096	0.097	0.1	0.09	0.095	0.099
9	0.137	0.145	0.13	0.127	0.129	0.127	0.147	0.134	0.131	0.139	0.132	0.136	0.125

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 = te(age, year, k = c(3,12))+s(age, k=5)

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)

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)

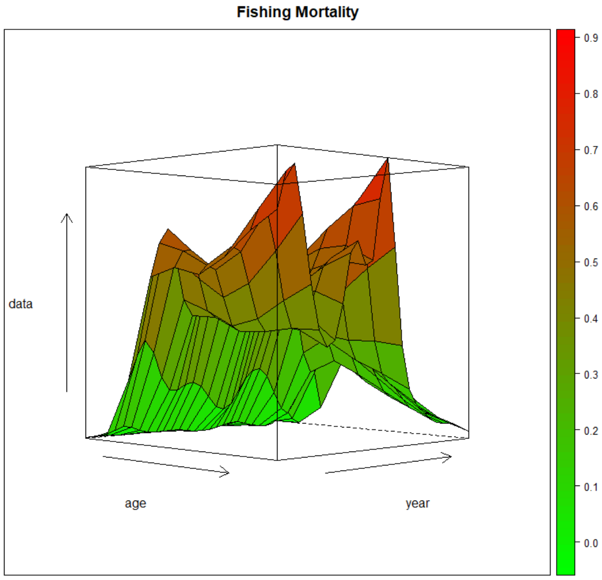


Figure 6.13.3.3. Norway lobster in GSA 9: fishing mortality by age and year obtained from the a4a model (1994-2020).

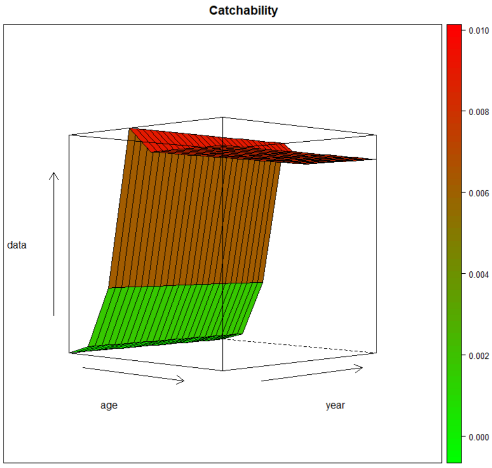


Figure 6.13.3.4. Norway lobster in GSA 9: catchability of the survey by age and year obtained from the a4a model.

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.

A sensetivity analysis to the inclusion of 2020 MEDITS suevey value was carried out, (see Section 6.13.7.2). The retrospective analysis shows that the exclusion of the survey value gives similar results and is overall quite similar to the assessment above. Exclusion of the survey gives a worst fit of F and SSB. In general, results shows that MEDITS data in 2020 are important for the model and should not be removed. In general, for the assessment above the diagnostics are considered acceptable and the a4a model is acceptable as a basis for advice.

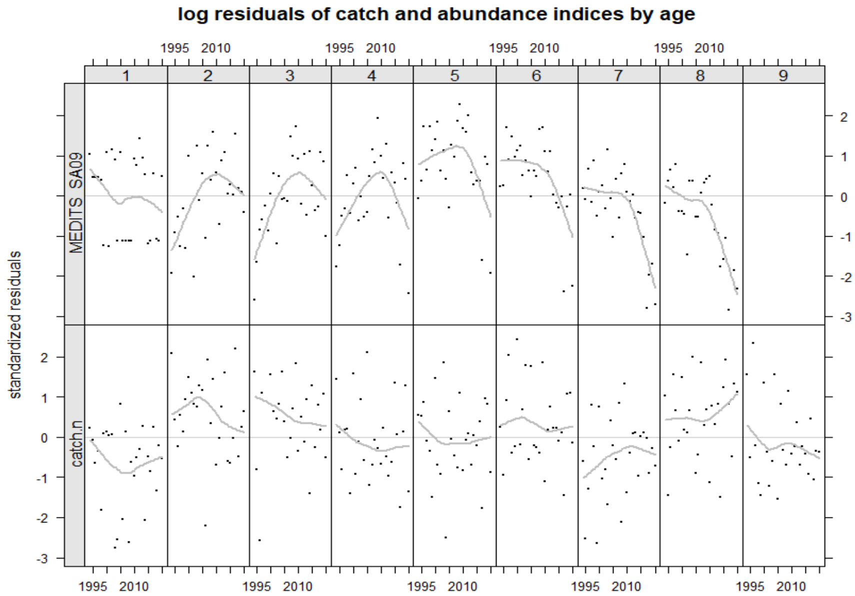


Figure 6.13.3.5. Norway lobster in GSA 9: log residuals for the catch-at-age data of the fishery and the survey, and the catches.

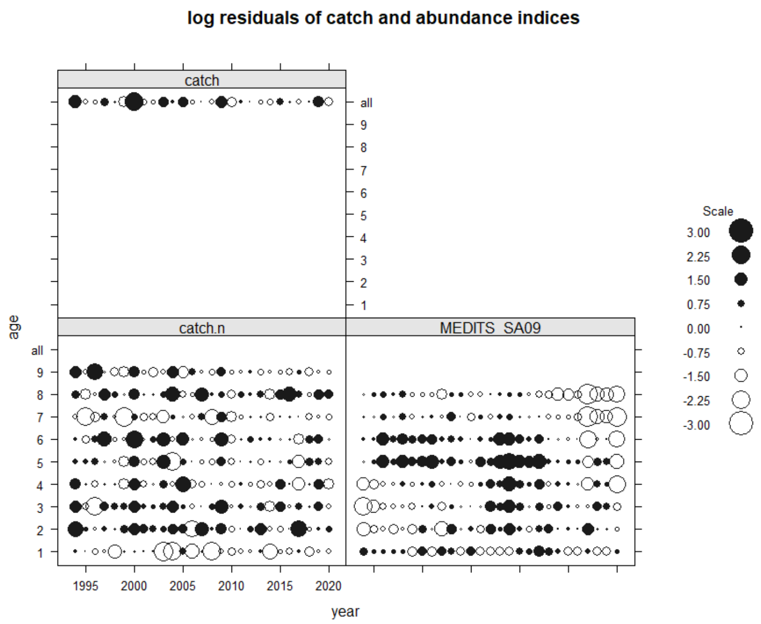


Figure 6.13.3.6. Norway lobster in GSA 9: bubble plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

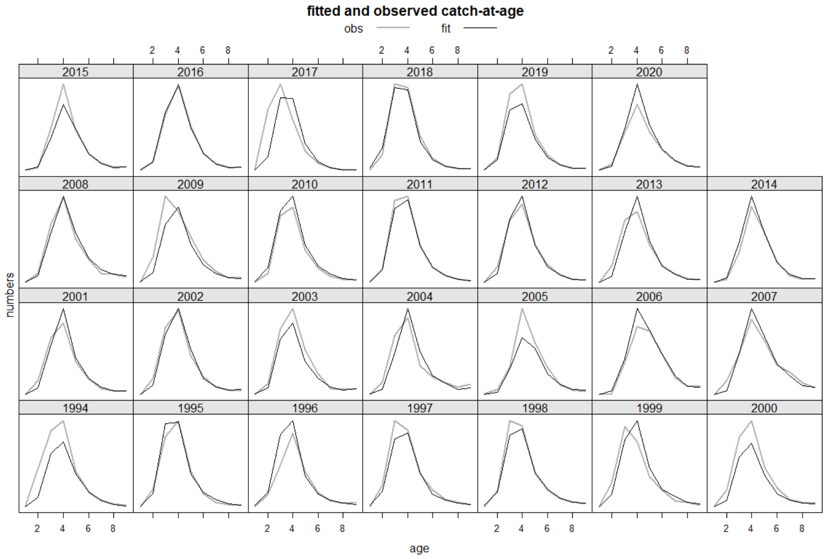


Figure 6.13.3.7. Norway lobster in GSA 9: fitted vs observed values by age and year for the catches.

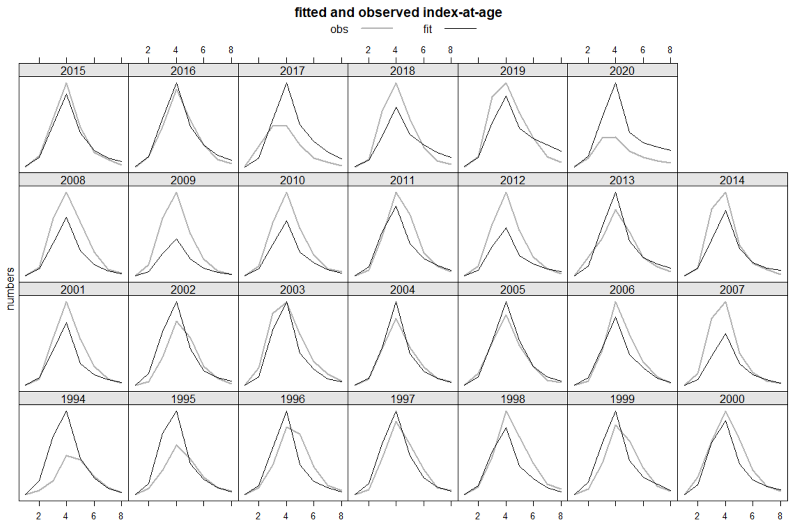


Figure 6.13.3.8. Norway lobster in GSA 9: fitted vs observed values by age and year for the survey.

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.

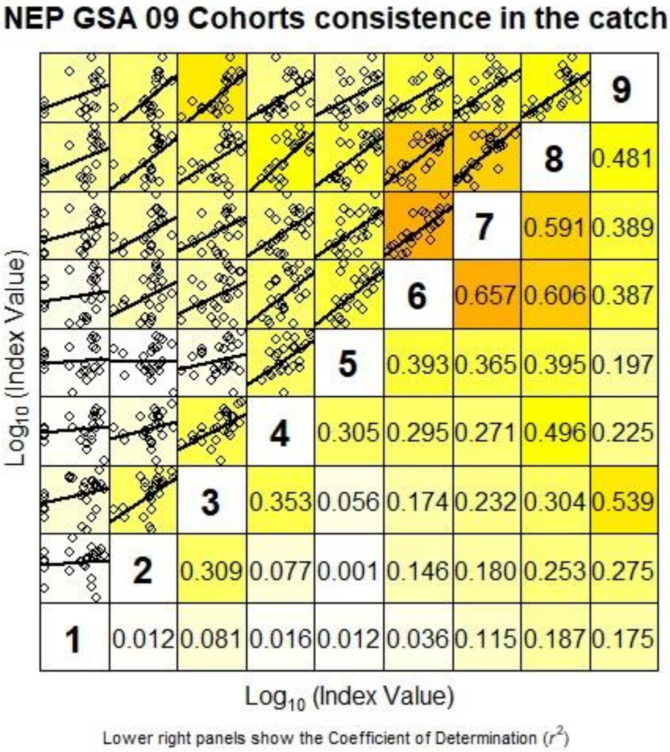


Figure 6.13.3.9. Norway lobster in GSA 9: internal consistency of the catch-at-age data.

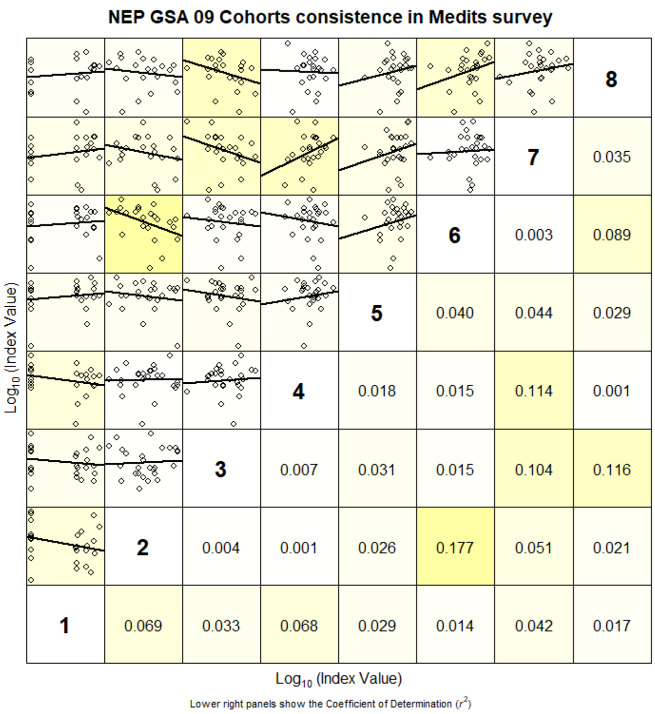


Figure 6.13.3.10. Norway lobster in GSA 9: internal consistency of the catch-at-age data of the MEDITS survey.

The retrospective analysis shows that the assessment model is quite stable with respect to catch and SSB. Because survey residuals show blocks with consistent possitive or negative groups its likely the assessment with exhibit section of correlated errors in REC and F. Nevertheless because the conclusion that F relative F_{MSY} is robust for all years in the retrospective. The assessment is considered acceptable for advice.

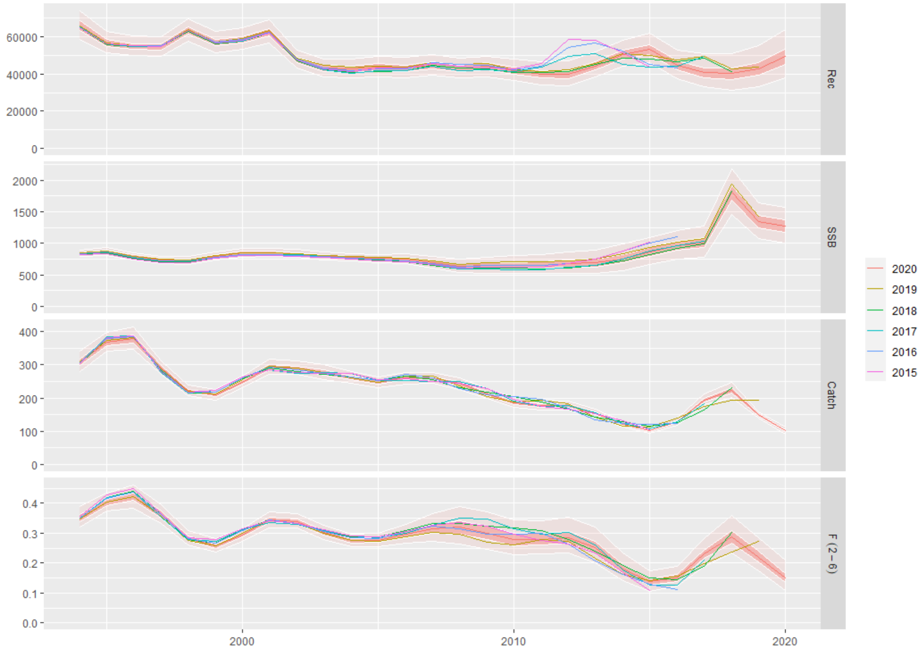


Figure 6.13.3.11. Norway lobster in GSA 9: retrospective analysis.

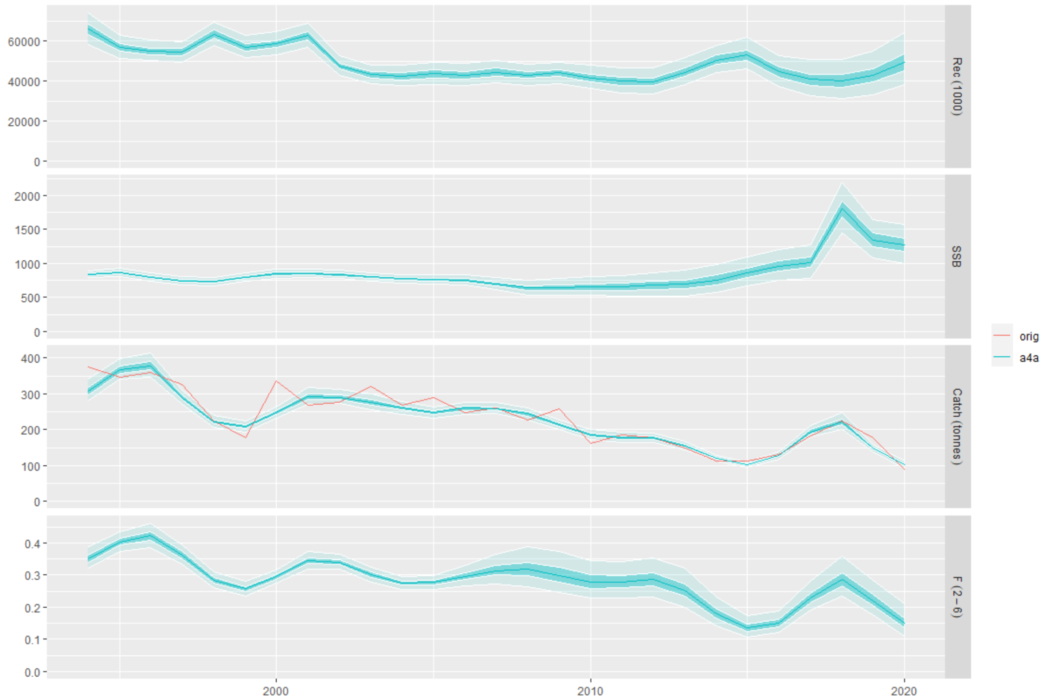


Figure 6.13.3.12. Norway lobster in GSA 9: outputs of the a4a stock assessment model, with uncertainty; input catch data (red) are plotted against the estimated catches (blue line).

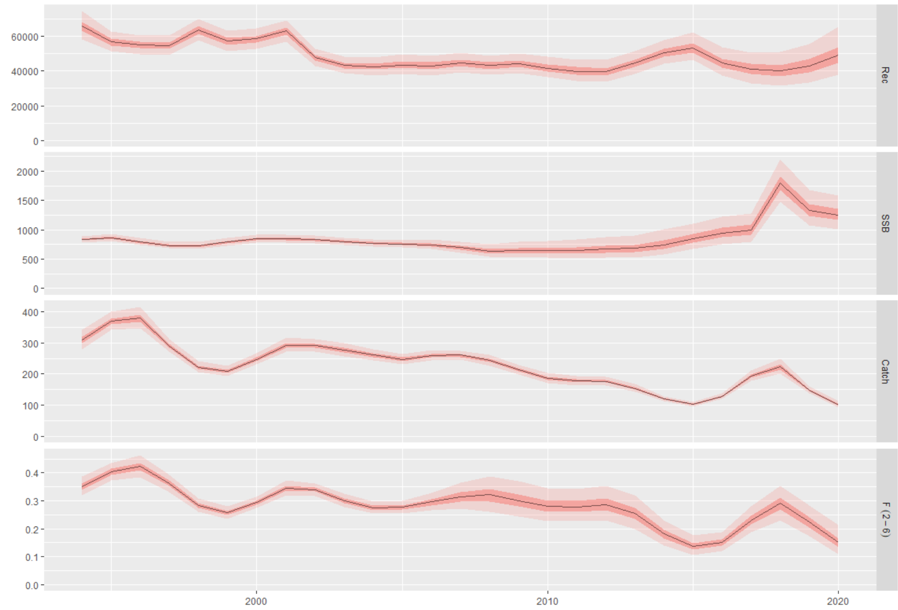


Figure 6.13.3.13. Norway lobster in GSA 9: outputs of the a4a stock assessment model (with uncertainty).

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	2004	2005	2006	2007
1	30	52	75	67	46	23	17	17	16	16	10	4	3	4
2	534	712	813	697	457	358	269	281	344	265	166	90	70	97
3	2906	4393	4090	3106	2249	1812	2110	2067	2209	2196	1314	891	784	972
4	3535	4456	4907	3374	2451	2339	2697	3565	3122	2843	2734	2000	1896	2046
5	1804	1744	1725	1530	1079	1047	1336	1530	1632	1300	1342	1625	1412	1369
6	788	812	683	589	540	479	568	667	604	626	600	733	902	722
7	350	412	390	297	261	283	289	316	312	287	343	353	408	460
8	149	186	203	174	133	133	161	160	166	169	160	184	180	205
9	59	100	120	117	105	97	112	154	204	232	196	148	154	178

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	10	22	30	26	15	7	3	2	7	49	91	23	2
2	184	288	373	346	242	128	65	56	152	531	789	286	50
3	1306	1706	1840	1911	1618	1091	621	536	1047	2635	2962	1559	549
4	2250	2214	2220	2141	2197	1850	1322	1088	1537	2623	2886	1719	1125
5	1283	1130	958	951	938	907	748	680	768	998	1039	802	583
6	626	514	427	388	405	357	301	274	307	354	381	342	279
7	336	259	205	190	187	174	128	109	117	143	157	154	130
8	209	127	93	84	87	78	61	45	45	54	65	62	51
9	165	110	65	54	60	66	63	58	59	64	65	56	43

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	0.0007	0.0013	0.0020	0.0017	0.0010	0.0006	0.0004	0.0004	0.0005	0.0005	0.0003	0.0001	0.0001	0.0001
2	0.0179	0.0295	0.0392	0.0347	0.0228	0.0153	0.0128	0.0130	0.0149	0.0151	0.0104	0.0057	0.0044	0.0061
3	0.1894	0.2629	0.3108	0.2715	0.1955	0.1541	0.1526	0.1671	0.1746	0.1612	0.1253	0.0917	0.0813	0.0990
4	0.5028	0.6060	0.6500	0.5613	0.4344	0.3874	0.4362	0.5051	0.4963	0.4315	0.3727	0.3426	0.3447	0.3781
5	0.5293	0.5796	0.5818	0.4972	0.4012	0.3828	0.4601	0.5497	0.5295	0.4560	0.4280	0.4559	0.4990	0.5180
6	0.5080	0.5346	0.5211	0.4415	0.3579	0.3412	0.4056	0.4847	0.4815	0.4370	0.4340	0.4852	0.5487	0.5725
7	0.5548	0.5871	0.5732	0.4821	0.3808	0.3429	0.3787	0.4415	0.4714	0.4743	0.4876	0.5276	0.5911	0.6511
8	0.6268	0.6877	0.6862	0.5734	0.4325	0.3543	0.3488	0.3900	0.4604	0.5310	0.5569	0.5526	0.5962	0.7164
9	0.6799	0.7852	0.8090	0.6719	0.4791	0.3505	0.3011	0.3203	0.4237	0.5699	0.6053	0.5361	0.5492	0.7320

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.0003	0.0007	0.0010	0.0009	0.0006	0.0002	0.0001	0.0001	0.0002	0.0017	0.0032	0.0008	0.0001
2	0.0111	0.0181	0.0231	0.0225	0.0165	0.0087	0.0039	0.0030	0.0077	0.0325	0.0533	0.0194	0.0032
3	0.1374	0.1769	0.2014	0.2061	0.1819	0.1242	0.0687	0.0522	0.0911	0.2339	0.3366	0.1849	0.0608
4	0.4198	0.4397	0.4452	0.4628	0.4706	0.3942	0.2605	0.1965	0.2481	0.4163	0.5303	0.4058	0.2363
5	0.4984	0.4431	0.3959	0.3987	0.4350	0.4151	0.3112	0.2346	0.2344	0.2870	0.3285	0.3107	0.2650
6	0.5263	0.4184	0.3267	0.3007	0.3226	0.3205	0.2563	0.1946	0.1717	0.1752	0.1837	0.1856	0.1835
7	0.6197	0.4597	0.3112	0.2496	0.2452	0.2357	0.1910	0.1470	0.1254	0.1189	0.1158	0.1109	0.1052
8	0.7447	0.5303	0.3096	0.2097	0.1798	0.1592	0.1264	0.0990	0.0866	0.0821	0.0752	0.0630	0.0504
9	0.8535	0.5918	0.2972	0.1672	0.1222	0.0973	0.0744	0.0594	0.0550	0.0541	0.0467	0.0329	0.0209

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	65851	837	308	0.35	1303
1995	56848	867	369	0.40	1379
1996	55013	795	379	0.42	1283
1997	54559	738	292	0.36	1155
1998	63541	728	223	0.28	1053
1999	57071	793	210	0.26	1172
2000	58564	846	248	0.29	1259
2001	62800	850	293	0.34	1299
2002	47587	831	292	0.34	1266
2003	43201	799	278	0.30	1159
2004	42487	774	261	0.27	1113
2005	43551	759	248	0.28	1126
2006	42964	747	260	0.30	1087
2007	44592	696	261	0.31	1077
2008	43038	636	245	0.32	946
2009	44000	645	216	0.30	992
2010	41753	651	188	0.28	977
2011	39904	654	179	0.28	961
2012	39699	674	179	0.29	984
2013	44502	689	156	0.25	986
2014	50649	753	122	0.18	992
2015	53264	856	103	0.14	1145
2016	44641	956	129	0.15	1287
2017	40878	1004	195	0.23	1380
2018	40090	1785	222	0.29	4301
2019	42864	1325	150	0.22	2568
2020	49315	1255	103	0.15	1346

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 (0.15), estimated as the F_{bar2-6} in the last year of the time series, 2020 is below the level of $F_{0.1}$(0.30), 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 sustainable level.

6.13.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2020 to 2022 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 (2020) from the a4a assessment was used.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the 2003-2020, 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
$F_{ages\ 2\text{-}6}$ (2021)	0.30	F 2020 used to give F status quo for 2021
SSB (2021)	1620 t	Stock assessment 1 January 2021
R_{age0} (2021,2022)	43828	Geometric mean of years 2003 to 2020
Total catch (2021)	111.5 t	Assuming F status quo for 2021

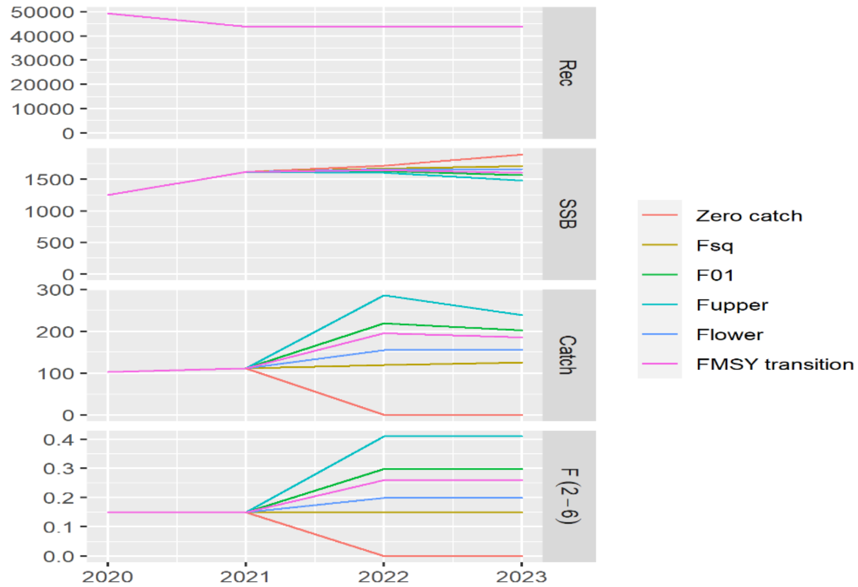


Figure 6.13.5.2 Norway lobster in GSA 9: short term forecast in different F scenarios. SSB estimates refer to middle year.

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 2021	Fsq2021	Catch2020	Catch2021	Catch2022	SSB2021	SSB2023	SSB_change 2021-2023(%)	Catch_change 2020-2022(%)
High long-term yield (F0.1)	2.0	0.30	43828	0.15	102.7	111.5	219.7	1620	1569	-3.1	114.0
F upper	2.7	0.41	43828	0.15	102.7	111.5	285.9	1620	1479	-8.7	178.4
F lower	1.3	0.20	43828	0.15	102.7	111.5	154.9	1620	1662	2.6	50.9
FMSY transition	1.7	0.26	43828	0.15	102.7	111.5	195.4	1620	1604	-1.0	90.3
Zero catch	0.0	0.00	43828	0.15	102.7	111.5	0.0	1620	1896	17.0	-100.0
Status quo	1.0	0.15	43828	0.15	102.7	111.5	119.6	1620	1713	5.8	16.4
	0.1	0.01	43828	0.15	102.7	111.5	12.9	1620	1876	15.8	-87.5
	0.2	0.03	43828	0.15	102.7	111.5	25.5	1620	1856	14.6	-75.1
	0.3	0.04	43828	0.15	102.7	111.5	38.0	1620	1837	13.4	-63.0
	0.4	0.06	43828	0.15	102.7	111.5	50.2	1620	1818	12.2	-51.1
	0.5	0.07	43828	0.15	102.7	111.5	62.3	1620	1800	11.1	-39.4
	0.6	0.09	43828	0.15	102.7	111.5	74.1	1620	1782	10.0	-27.8
	0.7	0.10	43828	0.15	102.7	111.5	85.8	1620	1764	8.9	-16.5
	0.8	0.12	43828	0.15	102.7	111.5	97.2	1620	1747	7.8	-5.3
	0.9	0.13	43828	0.15	102.7	111.5	108.5	1620	1730	6.8	5.6
Different Scenarios	1.1	0.16	43828	0.15	102.7	111.5	130.5	1620	1697	4.8	27.1
	1.2	0.18	43828	0.15	102.7	111.5	141.2	1620	1682	3.8	37.5
	1.3	0.19	43828	0.15	102.7	111.5	151.7	1620	1666	2.8	47.8
	1.4	0.21	43828	0.15	102.7	111.5	162.1	1620	1651	1.9	57.9
	1.5	0.22	43828	0.15	102.7	111.5	172.4	1620	1636	1.0	67.9
	1.6	0.24	43828	0.15	102.7	111.5	182.4	1620	1622	0.1	77.7
	1.7	0.25	43828	0.15	102.7	111.5	192.3	1620	1608	-0.8	87.3
	1.8	0.27	43828	0.15	102.7	111.5	202.1	1620	1594	-1.6	96.8
	1.9	0.28	43828	0.15	102.7	111.5	211.7	1620	1581	-2.4	106.1
	2.0	0.30	43828	0.15	102.7	111.5	221.1	1620	1567	-3.3	115.3

6.13.6 Data Deficiencies

No deficiencies in data were found.

6.13.7 Other assessments tested

a4a assessment with langings LFD reconstructed.

New reconstructed landing LFD are presented in (Figure 6.13.7.1.1) the main reconstructed gear is GNS and OTB DWS (Figure 6.13.7.1.3). The reconstructed percentage by year, gear and metier is shown in (Figure 6.13.7.1.2).

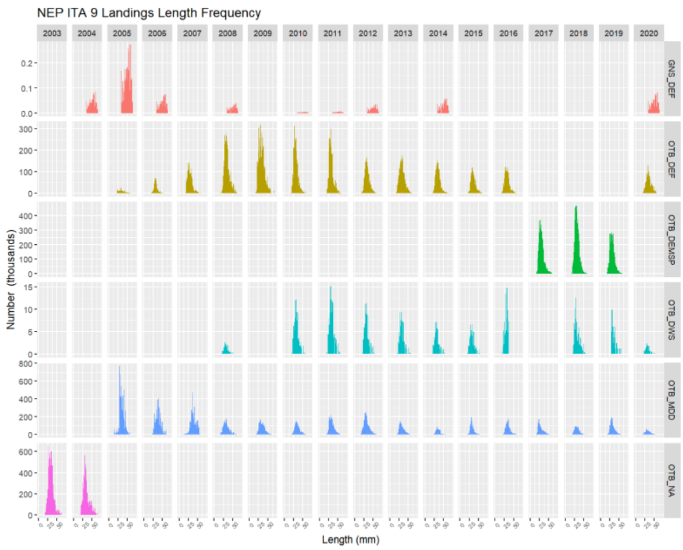


Figure 6.13.7.1.1 Norway lobster in GSA 9:

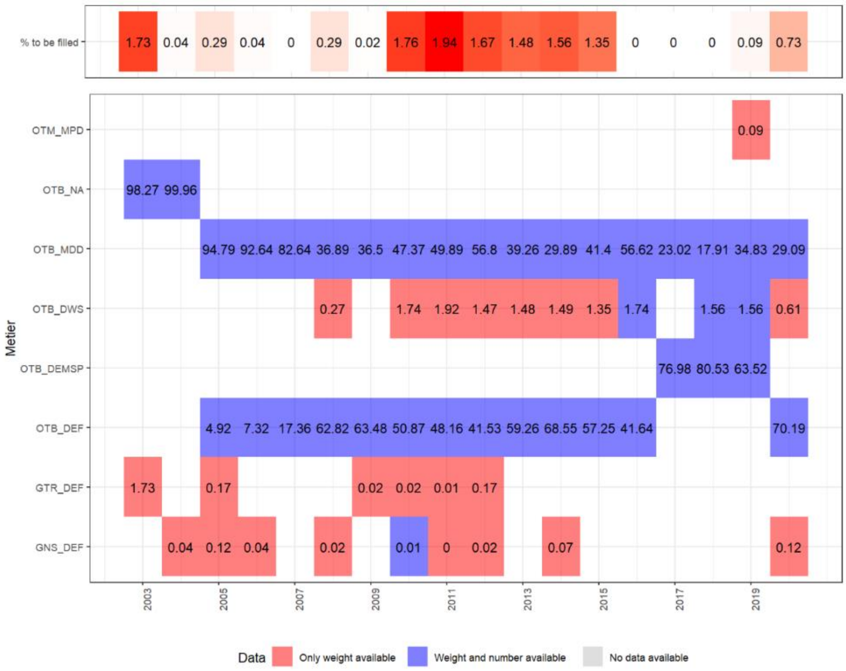


Figure 6.13.7.1.2 Norway lobster in GSA 9: available (blue) and missing LFDs (red) in landings.

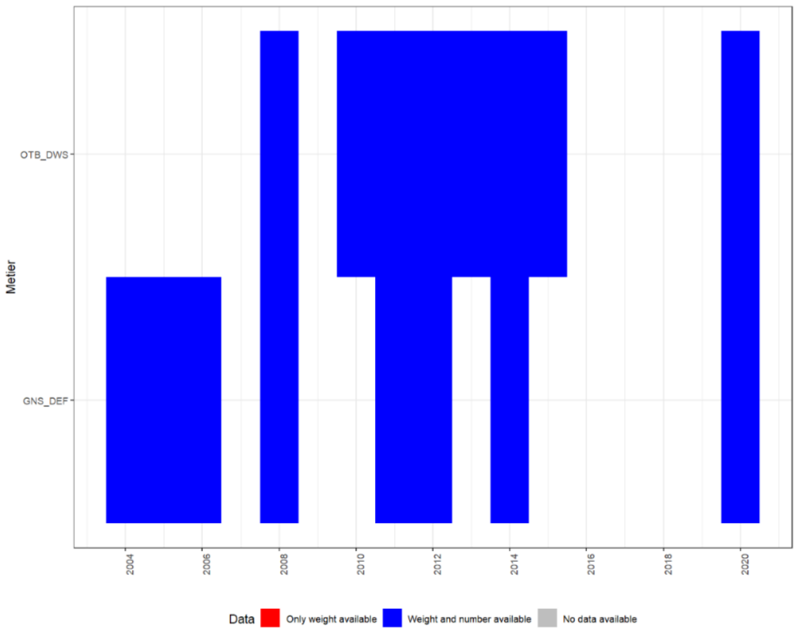


Figure 6.13.7.1.3 Norway lobster in GSA 9: : available (blue) and missing LFDs (red) in landings, and relative weight by metier.

A same a4a fmodel, qmodel, rmodel, n1model and vmodel was adopted (see section 6.13.3).

Figure 6.13.7.1.4 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.

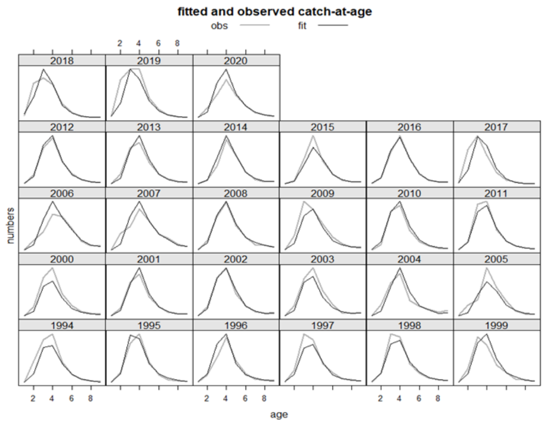


Figure 6.13.7.1.5 Norway lobster in GSA 9: fitted vs observed values by age and year for the catches.

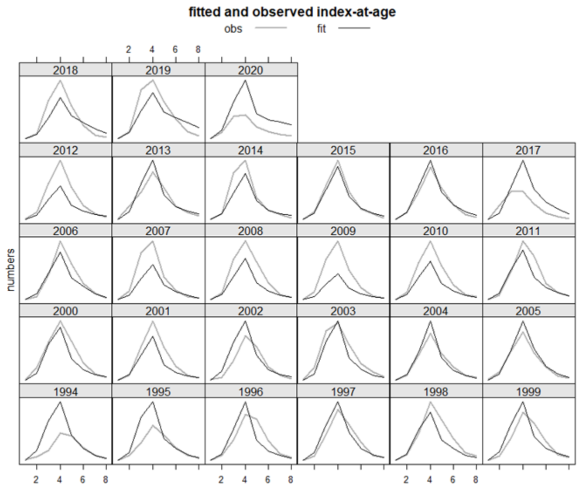


Figure 6.13.7.1.6 Norway lobster in GSA 9: fitted vs observed values by age and year for the survey.

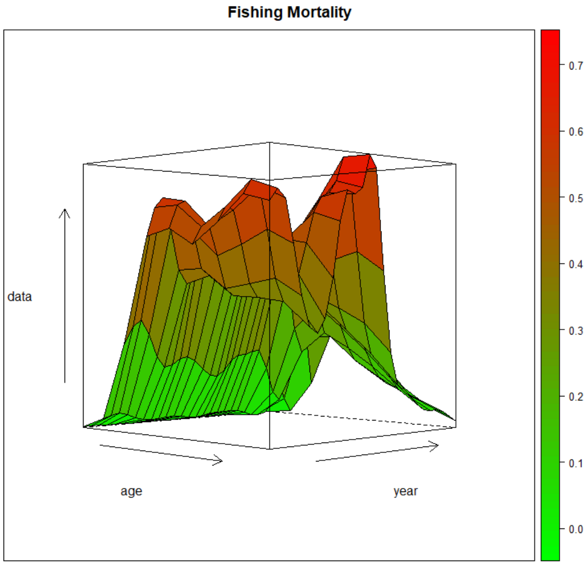


Figure 6.13.7.1.6 Norway lobster in GSA 9: fishing mortality by age and year obtained from the a4a model (1994-2020).

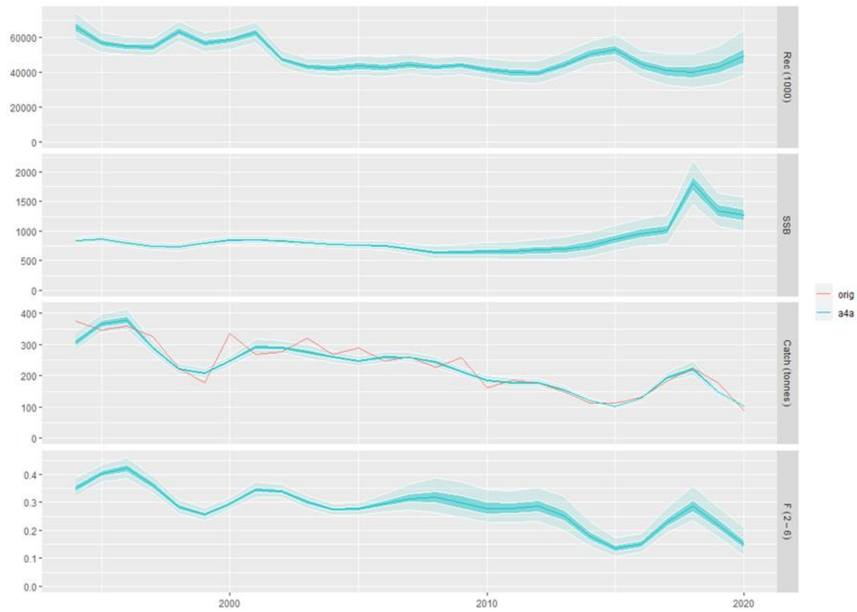


Figure 6.13.7.1.7 Norway lobster in GSA 9: outputs of the a4a stock assessment model, with uncertainty; input catch data (red) are plotted against the estimated catches (blue line).

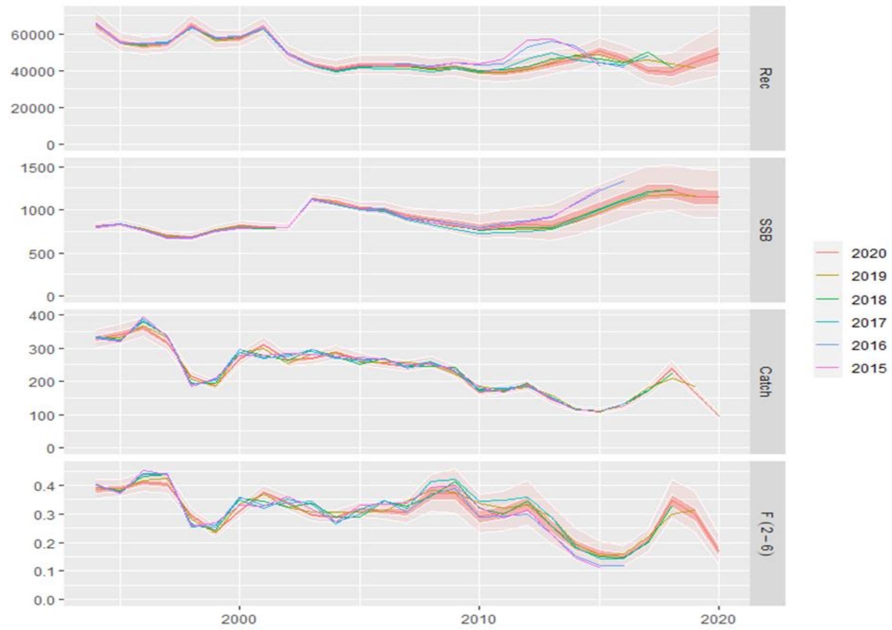


Figure 6.13.7.1.8 Norway lobster in GSA 9: retrospective analysis.

The log residuals for the survey and catch show a larger pattern (4 scale) and a poorer quality. The retrospective analysis also shows that the assessment model is quite similar and stable with a worst fit of F and SSB. In general, although the diagnostics are considered acceptable the assessment without LFD landing reconstruction was prefered.

6.13.7.2 a4a assessment without year 2020 in medits index object.

A sensitivity test without year index data in 2020 was performed. A possible lower quality of the data caused by CoVidD-19 was investigated.

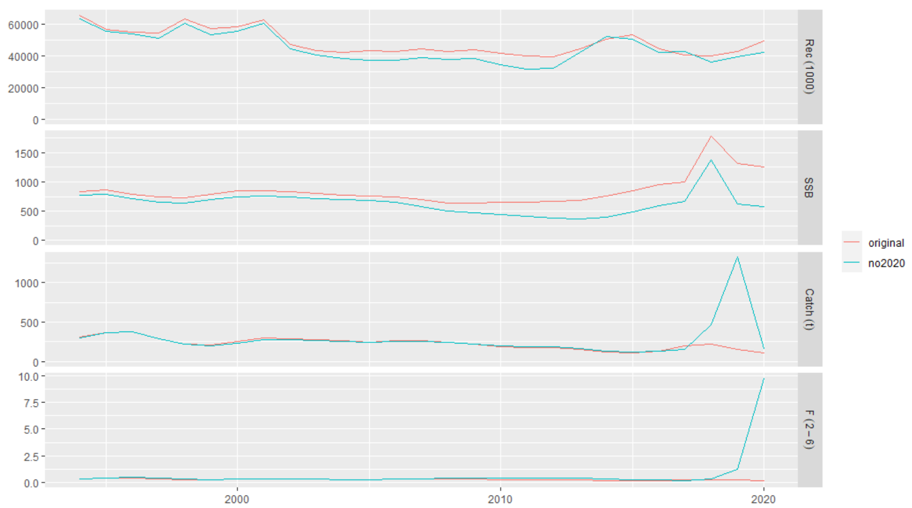


Figure 6.13.7.2.1 Norway lobster in GSA 9: outputs of the a4a stock assessment model; input catch data (red) are plotted against the estimated catches without year 2020 in Medits index (blue line).

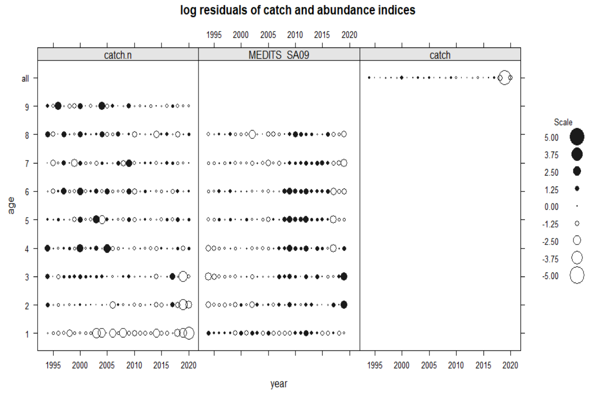


Figure 6.13.7.2.2 Norway lobster in GSA 9: bubble plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

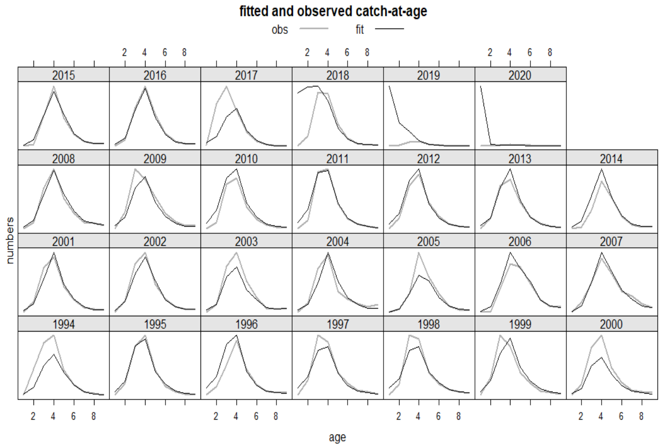


Figure 6.13.7.2.3 Norway lobster in GSA 9: fitted vs observed values by age and year for the catches.

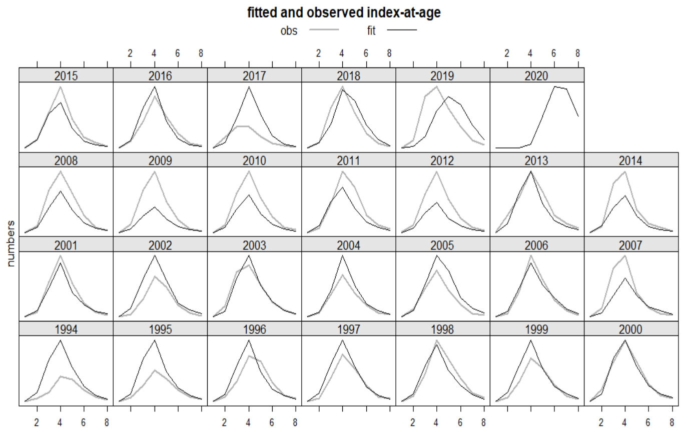


Figure 6.13.7.2.4 Norway lobster in GSA 9: fitted vs observed values by age and year for the survey.

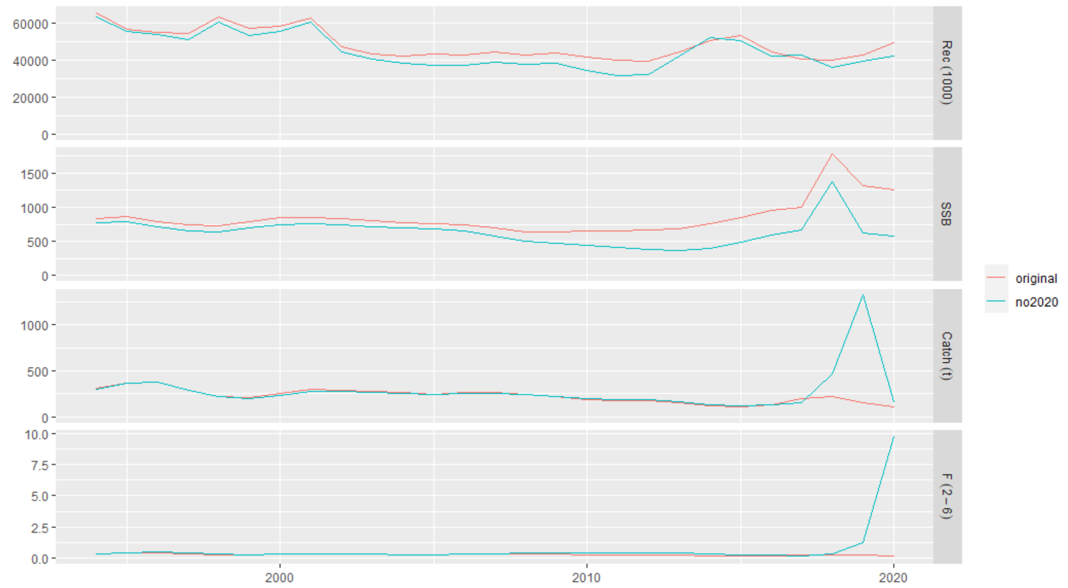


Figure 6.13.7.2.5 Norway lobster in GSA 9: outputs of the a4a stock assessment model; input catch data (red) are plotted against the estimated catches (blue line).

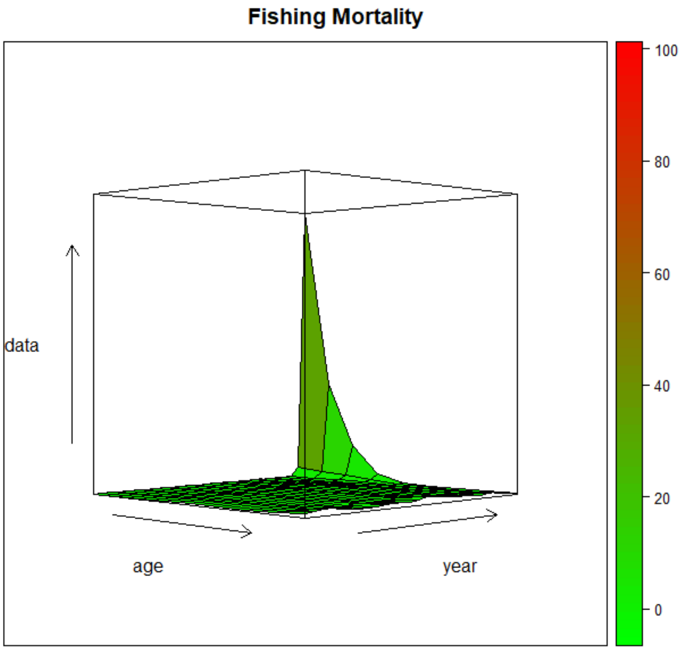


Figure 6.13.7.2.6 Norway lobster in GSA 9: fishing mortality by age and year obtained from the a4a model (1994-2020).

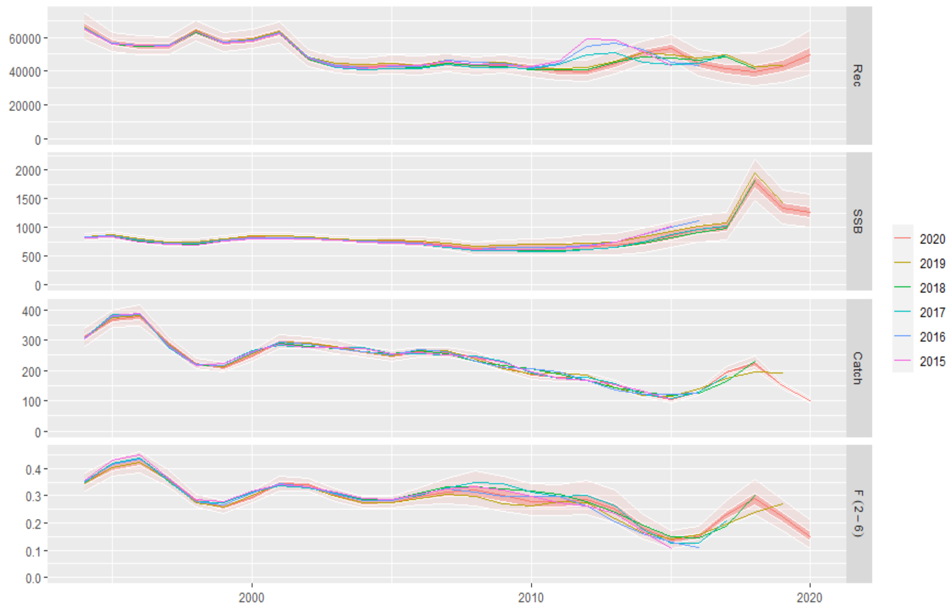


Figure 6.13.7.2.7 Norway lobster in GSA 9: : retrospective analysis.

The log residuals for the survey and catch show large patterns (5 scale) and a poorer quality (Figure 6.13.7.2.2). Fitted vs observed values by age and year for the survey and index show lower fits (Figure 6.13.7.2.3 and 6.13.7.2.4) respect to the assessment chosen by the team. F model has a huge peak in 2020 showing evident unstability (Figure 6.13.7.2.6). The retrospective analysis shows that the assessment model, although this f model peak in 2020 is overall quite similar to the prefered assessment. A worst fit of F and SSB is present. In general, results shows that Medits data in 2020 are important for the model and should not be removed. The team rejected this assessment in favour of the other assessment (Sectionn 6.13.3) due to these aspects.

6.14 Norway lobster in GSA 11

An advice on NEP in GSA 11 based on MEDITS indices trends was already given in 2018, 2019 and in 2020. STECF EWG 21-11 was asked to update the data available in 2021 from DCF.

6.14.1 Stock identity and biology

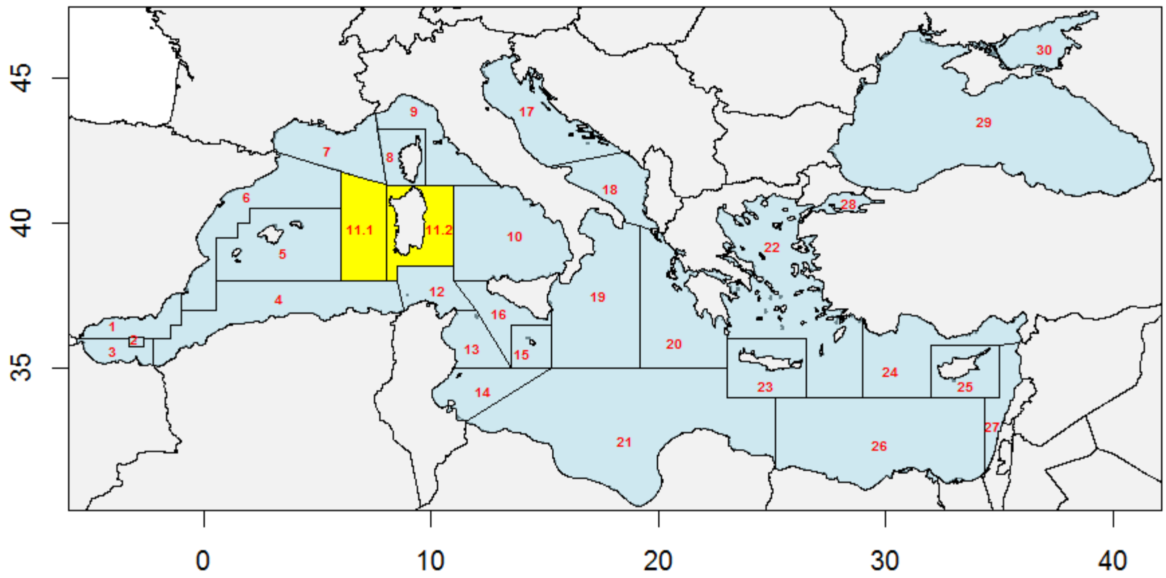


Figure 6.14.1.1. Geographical location of GSA 11

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. Although some gaps for some years are detected sex ratio in relation to the available landings time series (2005 -2019) is available from DCF for GSA11. 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.

Differently from the past, the assessment was carried out by sex. The growth parameters reported for GSA11 for 2019 and mean values along years for the "a" and "b" coefficients were used. To explore the benefit of using the approach by sex an explorative assessment (not reported here) were also carried out for sex combined using the growth parameter applied during the EWG 18-12, which belongs to GSA9.

Table 6.14.1.1. Growth parameters (Linf, K, t0) and parameters of the Length-Weight relationship (a, b) used for the assessment

Country	Area	Year	Sex	L_∞	K	t_0	a	b
IT	GSA 11	2019	F	69.4	0.12	-0.64	0.0006	3.05
IT	GSA 11	2019	M	80.8	0.13	0.07	0.0005	3.07

IT	GSA 9	2005-17	C	65	0.174	0.1	0.0003	3.2

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	0.1	0.25	0.5	0.8	1	1	1	1	1	1	1	1
Mortality	0.91	0.51	0.39	0.30	0.26	0.23	0.21	0.19	0.18	0.17	0.17	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 and were related exclusively to OTB (Table 6.14.2.1.1, Figure 6.14.2.1.1). No discards were reported.

For 2019 total landings' value was almost double of the value reported last year in EWG 20-09.

Table 6.14.2.1.1. Norway lobster landing data (in tons) in GSA 11

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Landings	6.3	42.3	31.3	36.2	44.4	22.8	50.5	41.1	20.6	17.2	18.2	15.8	28.3	37.8	72.0	44.2

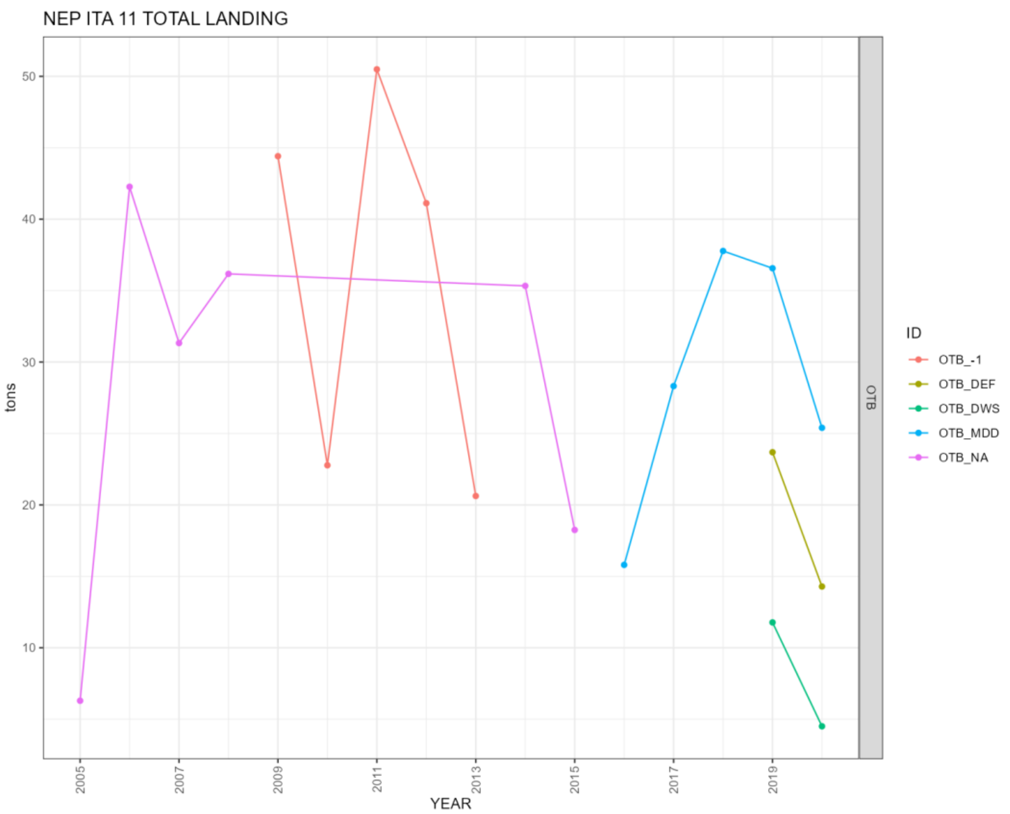


Figure 6.14.2.1.1. Norway lobster landing data (in tons) in GSA 11

As reported in the DCF, landings' length frequency distributions by year are presented in figure 6.14.2.1.2.

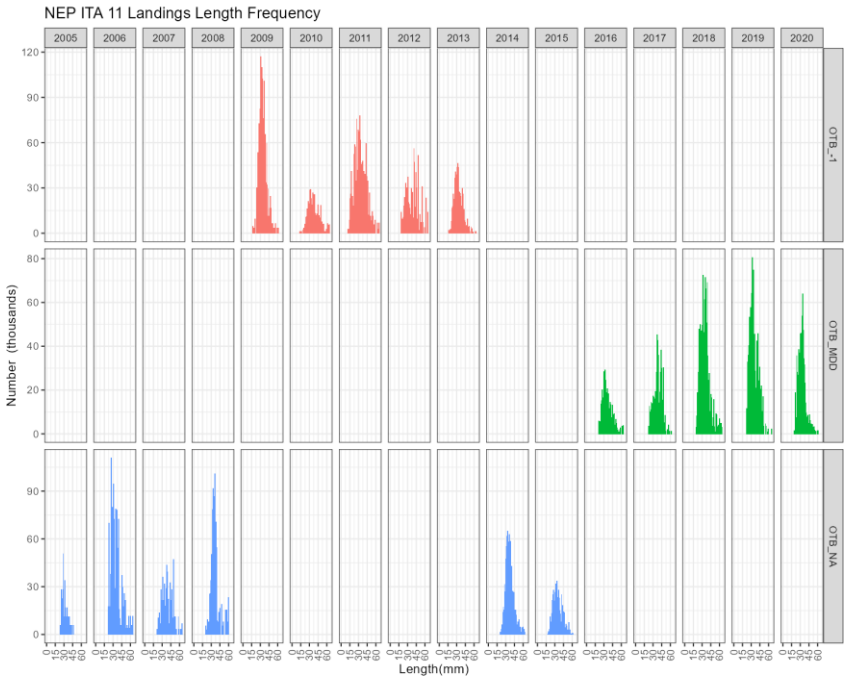


Figure 6.14.2.1.2. Norway lobster in GSA 11. Length frequency distribution of the landings by year and gear in GSA 11.

Using the same approach of EWG 21-02 the landings were reconstructed on metier basis for years where only weight were available (Figure 6.14.2.1.3-4)

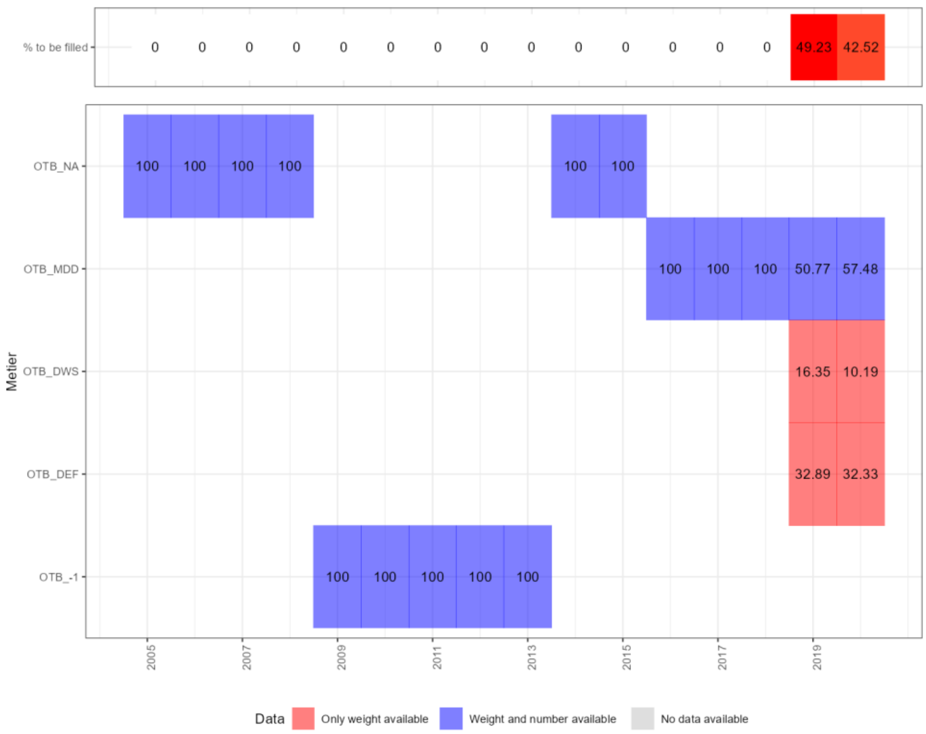


Figure 6.2.2.1.3. Deep-water rose shrimp GSAs 6. Summary of landings without length data and % filled in the reconstructions process.

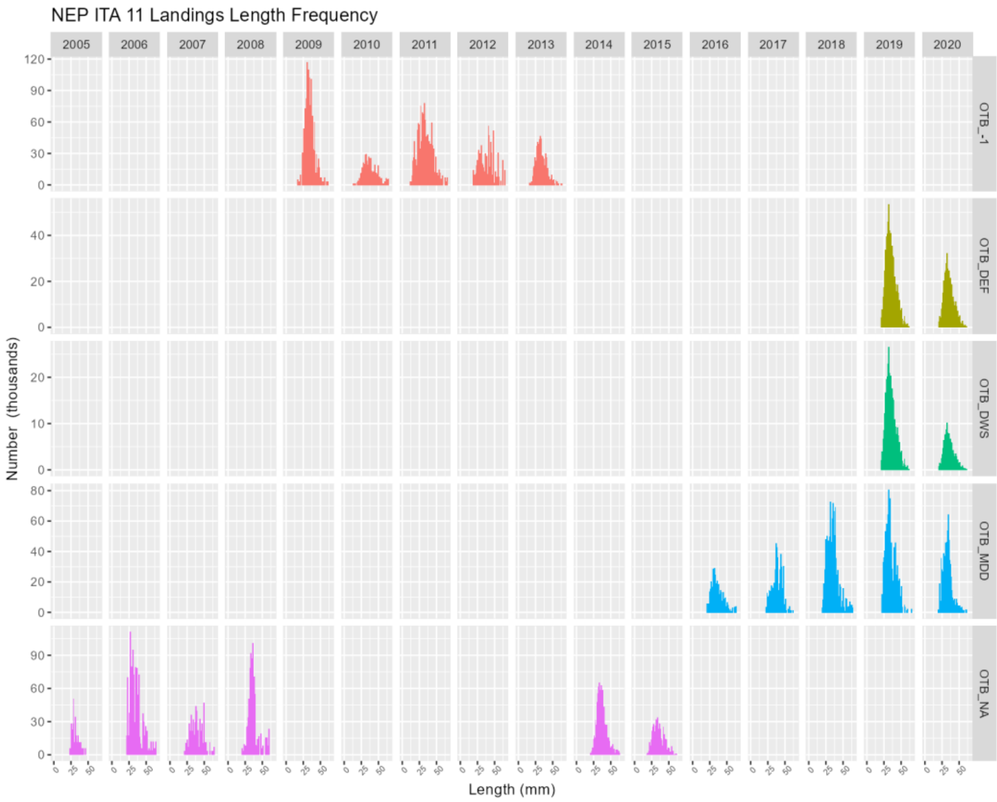


Figure 6.2.2.1.5. Deep-water rose shrimp GSAs 6. Length frequency distribution of the landings by year and fleet after the reconstruction process.

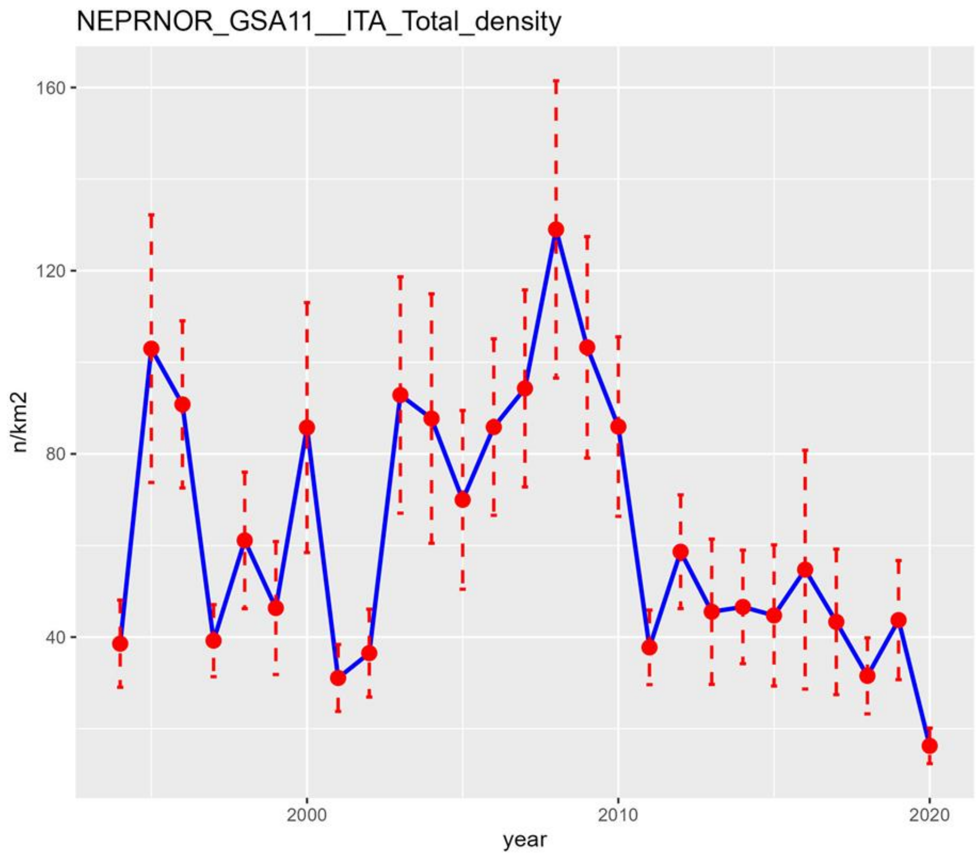
6.14.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

6.14.2.3 SURVEY DATA

MEDITS data are available in GSA 11 since 1994. In the period 1994 – 2010 MEDITS indices (Fig. 6.14.2.3.1) 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 behaviour both for biomass and densities than decline to the minimum values of the time series in the last year (0.79 kg/Km^2 16.2 n/Km^2).

Observed length frequency distribution for MEDITS data are reported in Figure 6.14.2.3.2 and 6.14.2.3.3 by sex and in Figure 6.14.2.3.4 as total.



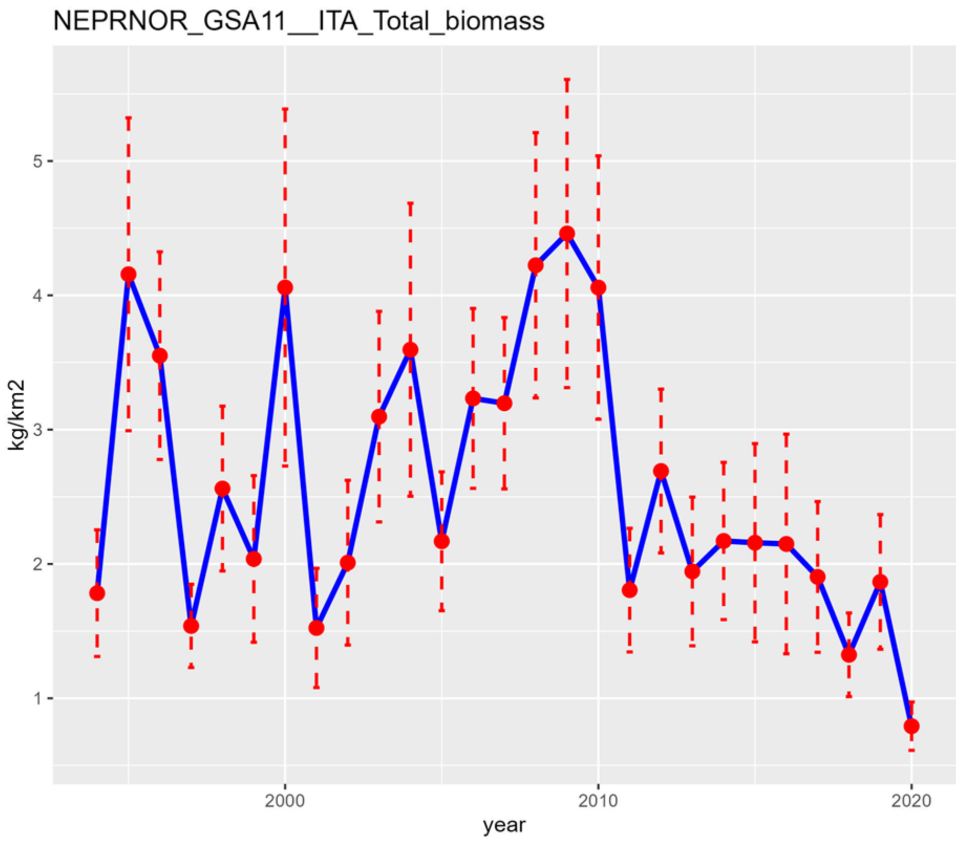


Figure 6.14.2.3.1. MEDITS indices for the period 1994-2020: relative biomass (kg km^2) and density (n km^2).

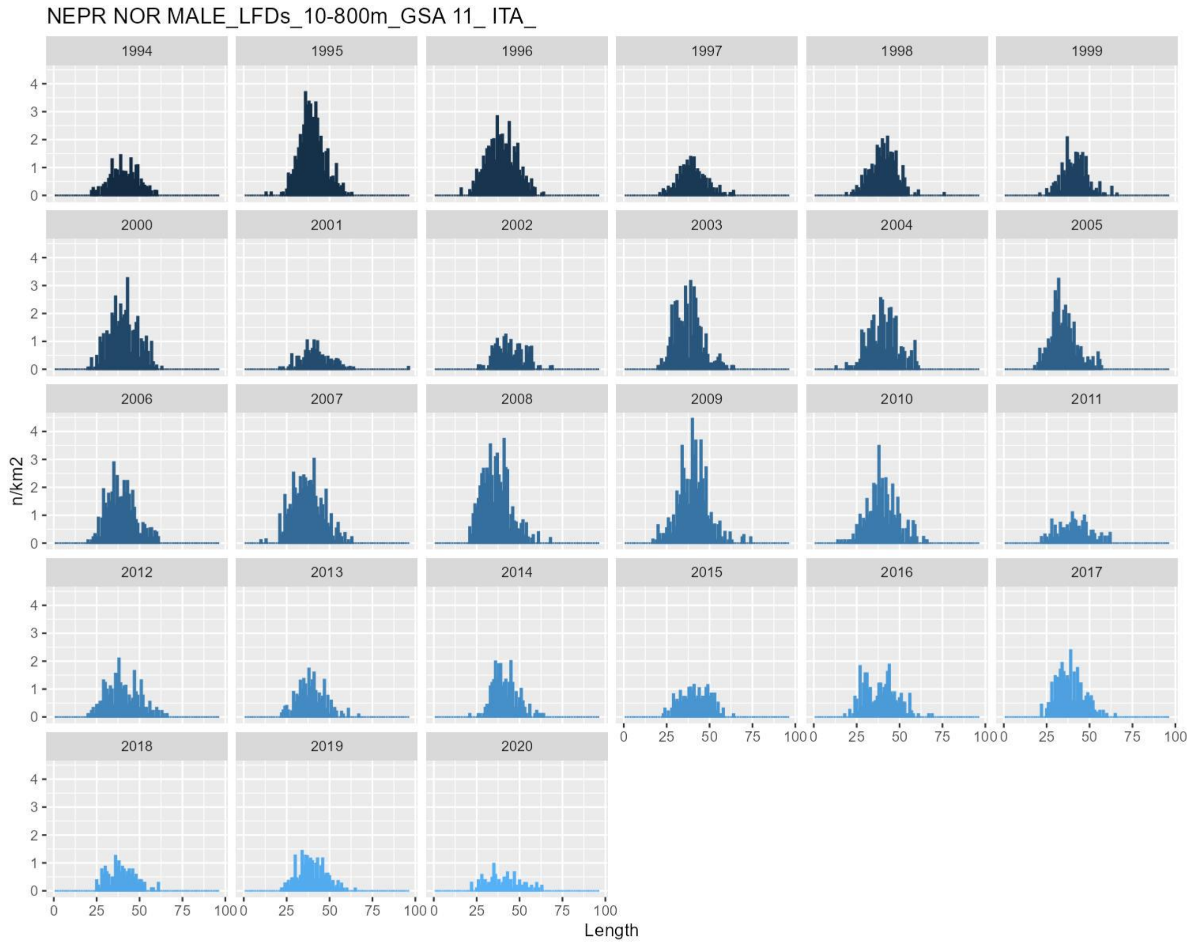


Figure 6.14.2.3.2. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for males.

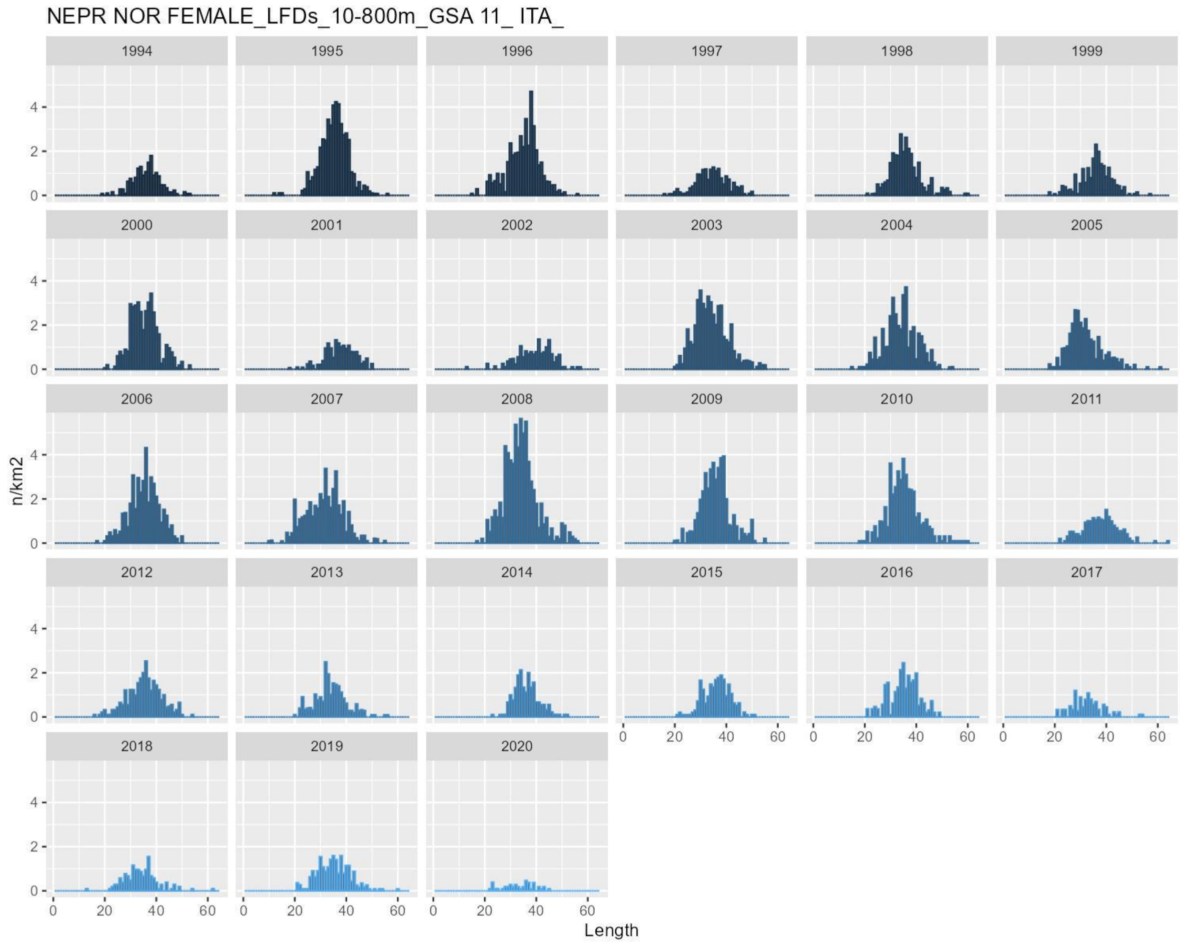


Figure 6.14.2.3.3. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for females.

Figure 6.14.2.3.4. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data).

6.14.3 ASSESSMENT AND ADVICE

Advice for this stock was provided in 2020 (EWG 20-09) for both 2021 and 2022. This advice is provided again in Section 5.14.

6.14.4 DATA ISSUES

For 2019 total landings' value was almost double of the value reported last year in EWG 20-09. It needs to be checked.

6.15 BLUE AND RED SHRIMP IN GSA 1

6.15.1 STOCK IDENTITY AND BIOLOGY

This stock was assessed for the last time in 2020 (STECF EWG20-09) using the statistical catch-at-age method (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 1 (Figure 6.15.1.1).

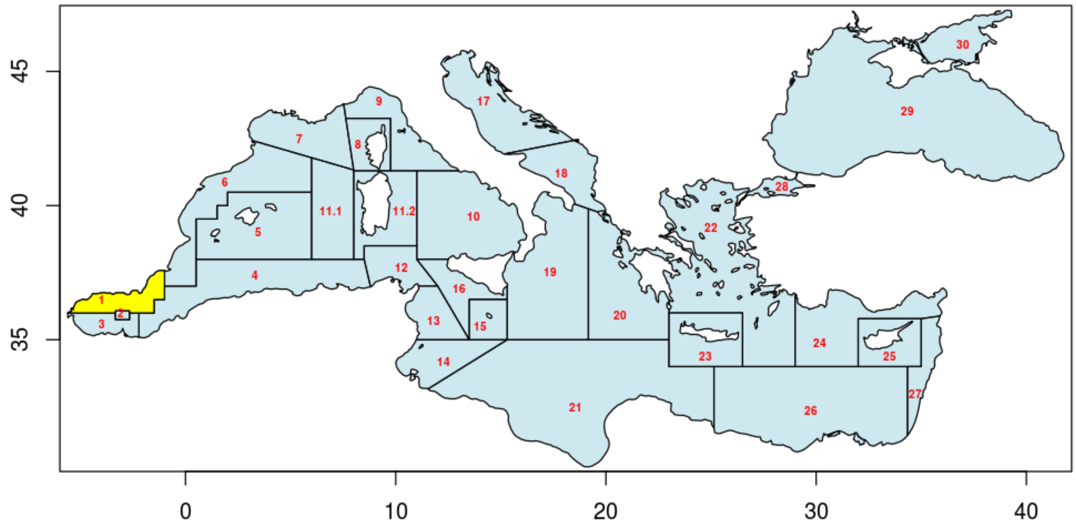


Figure 6.15.1.1. Blue and red shrimp in GSA 1. Geographical location of the stock.

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 15-18) were used because growth parameters were not available in the DCF dataset for blue and red shrimp in GSA 1. In 2019 the starting point for the growth curve is assumed to be mid-year (1st July) for length slicing of length to age. 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. In 2019, 2020, 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 red and blue shrimp at age zero in the commercial catch and they are never observed in the survey.

The parameters of the length-weight relationship (*a* = 0.002 and *b* = 2.515) were also used as in the previous assessment and had been calculated based on DCF data (DCF, 2014). The length of the sample f

rom 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 and in 2020 was taken from the 2015 assessment 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. 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. 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 the eastern part of GSA 1 at depths ranging from 400 to 800 m. It is particularly abundant in front of the Cape of Gata. The stock is exploited only by deep bottom otter trawl and particularly by the fleet segment composed of the largest trawlers (12-24 m). Around 50 vessels are targeting the blue and red shrimp in GSA 1 yielding around 100 tonnes per year. 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. Blue and red shrimp DCF landings (t) and discards (t) by OTB (all metiers) in GSA 1.

Year	OTB Landings (t)	OTB Discards (t)
2002	156.96	0.22
2003	335.74	0.47
2004	225.2	0.32
2005	232.1	0.65
2006	288.82	0.40
2007	178.43	0.25
2008	133.48	-
2009	144.59	0.00
2010	152.09	0.02
2011	131.42	0.14
2012	148.57	0.06
2013	124.96	0.05
2014	184.03	0.01
2015	170.23	0.03
2016	138.22	0.01
2017	99.19	0.01
2018	123.21	0.01
2019	132.09	0.07
2020	137.36	0.02

Figure 6.15.2.1.1. Blue and red shrimp in GSA 1. Blue and red shrimp DCF landings (t), in GSA 1 (2002-2020).

For the length-frequency distributions, the group decide to use the output of the EWG 21-02, where quality checks were performed for the DCF data. The EWG 21-02 developed a series of scripts for reconstructing missing LFDs. These scripts were used to derive the final LFDs used in this assessment.

The total LFD of the landings (=catch as discards were negligible) is shown in Figure 6.15.2.1.2 and the LFD per gear and metier before reconstruction in Figure 6.15.2.1.3. Length structure of blue and red shrimp landed in GSA 1 in the period from 2002 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02 is shown in Figure 6.15.2.1.4.

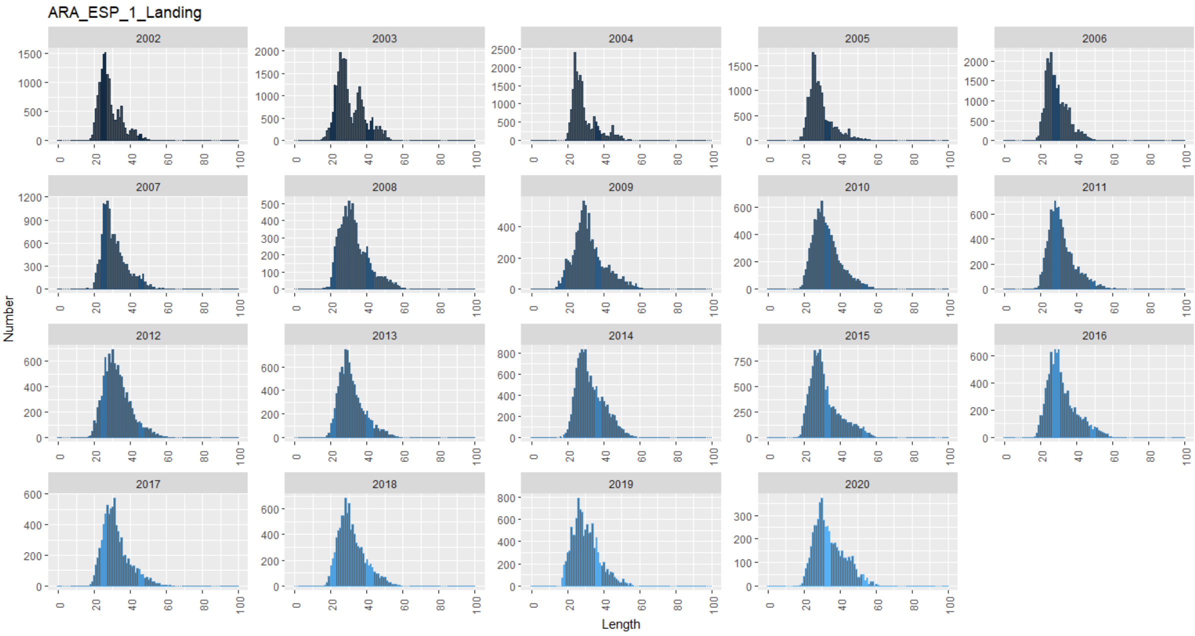


Figure 6.15.2.1.2. Blue and red shrimp in GSA 1. Blue and red shrimp length-frequency distribution of catch (landings only) by year in GSA 1.

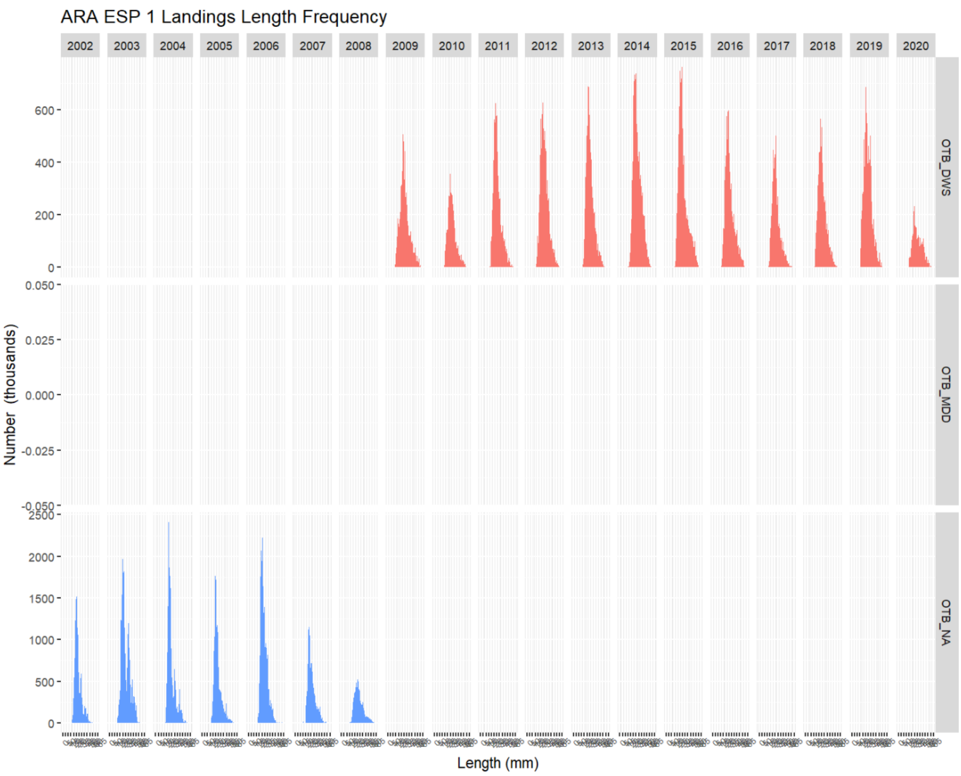


Figure 6.15.2.1.3. Blue and red shrimp in GSA 1: Length structure of Blue and red shrimp landed in GSA 1 in the period from 2002 to 2020 by fishing gear and fishery.

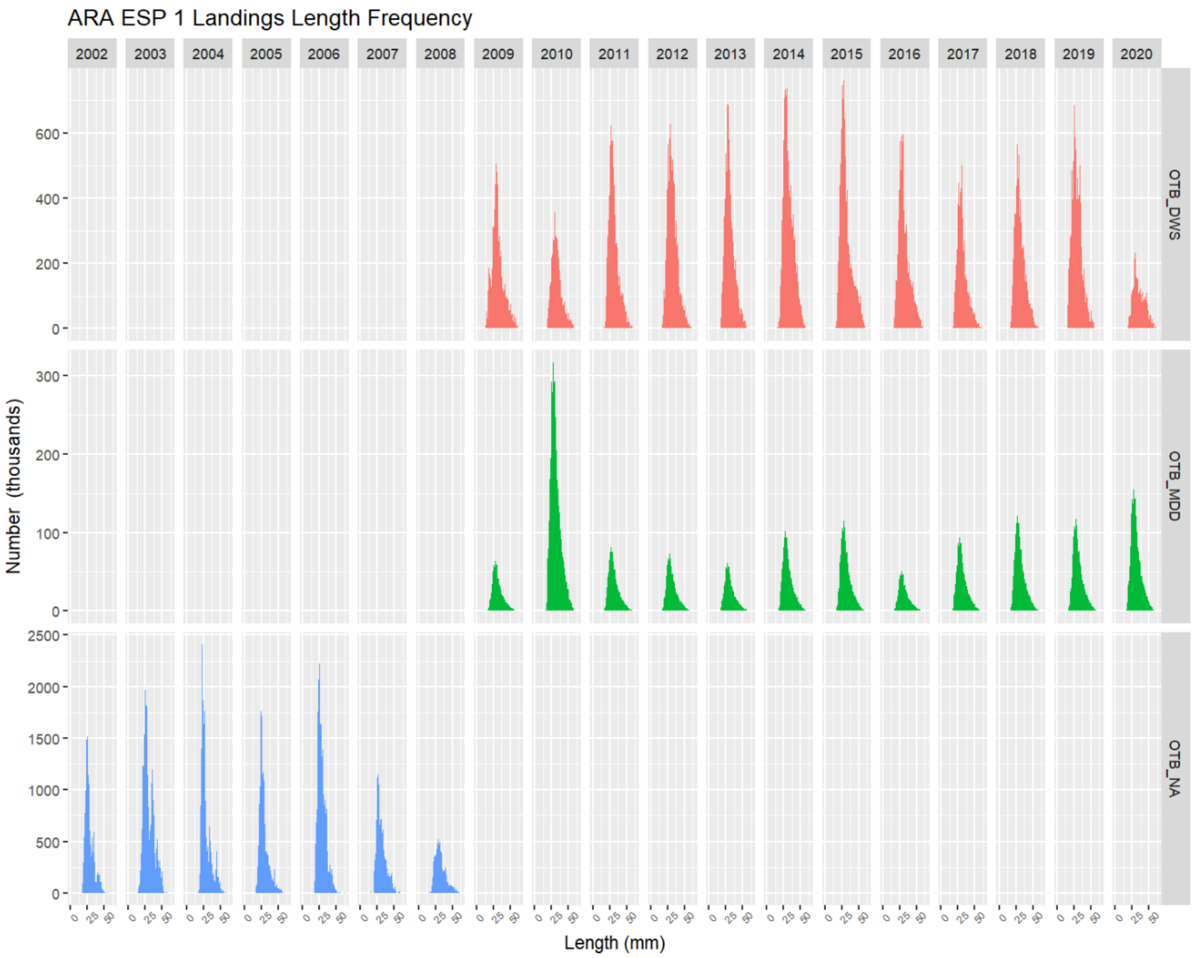


Figure 6.15.2.1.4. Blue and red shrimp in GSA 1: Length structure of blue and red shrimp landed in GSA 1 in the period from 2002 to 2020 by fishing gear and fishery as reconstructed by EWG 21-02.

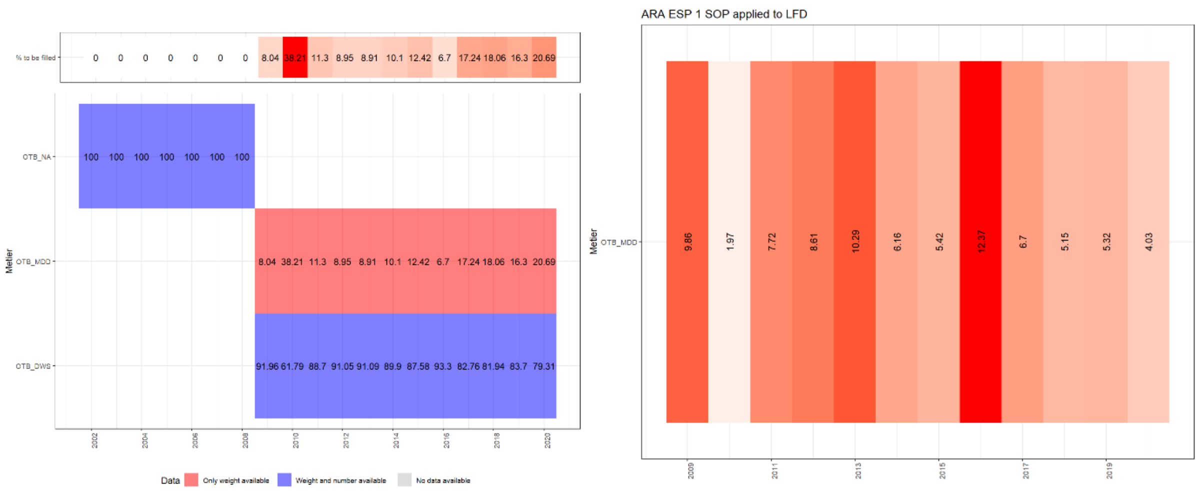


Figure 6.15.2.1.5. Blue and red shrimp in GSA 1. Percentages of total landings LFDs that were reconstructed by year and gear and SoP applied to LFD for Spain in GSA 1.

6.15.2.2 Effort

Fishing effort data for 2020 will be reported to STECF EWG 21-13 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.

The blue and red shrimp are mainly concentrated at the eastern part of the north Alboran Sea and deep waters.

The time series of abundance and biomass indices of blue and red shrimp from MEDITS bottom trawl survey in GSA 1 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 two 2019 the value is similar to the mean of the later period. No MEDITS sueey was carried out in 2020.

Please note the very low (near zero) total biomass and density in years 2009, 2011 and 2013 were excluded from the analysis. The number of individuals at age for this years from MEDITS were not used in the age based assessment, this was the same as previous report for 2009, 2011 and 2013.

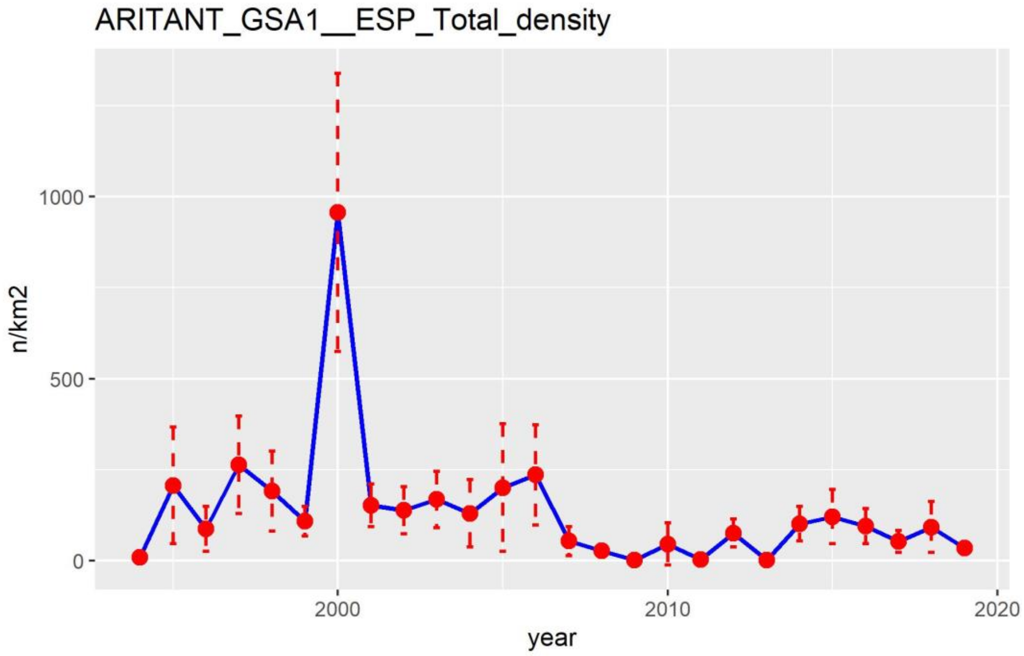


Figure 6.15.2.3.2. Blue and red shrimp in GSA 1. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

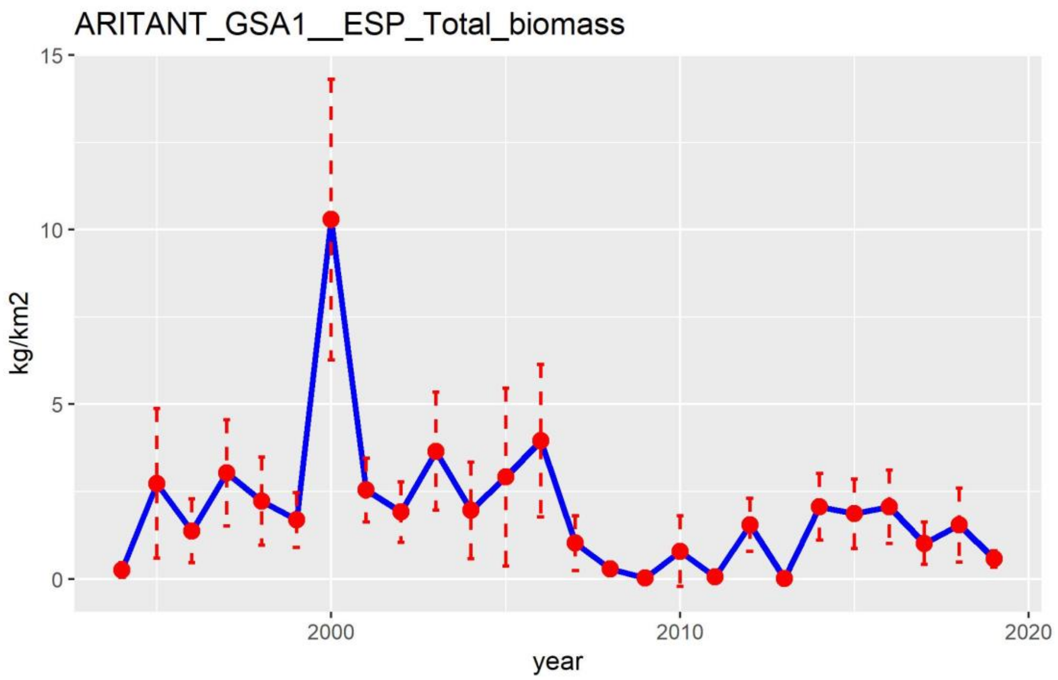


Figure 6.15.2.3.3. Blue and red shrimp in GSA 1. MEDITS survey biomass index (kg/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

Trends in abundance by length (Figure 6.15.2.3.4) are shown below.

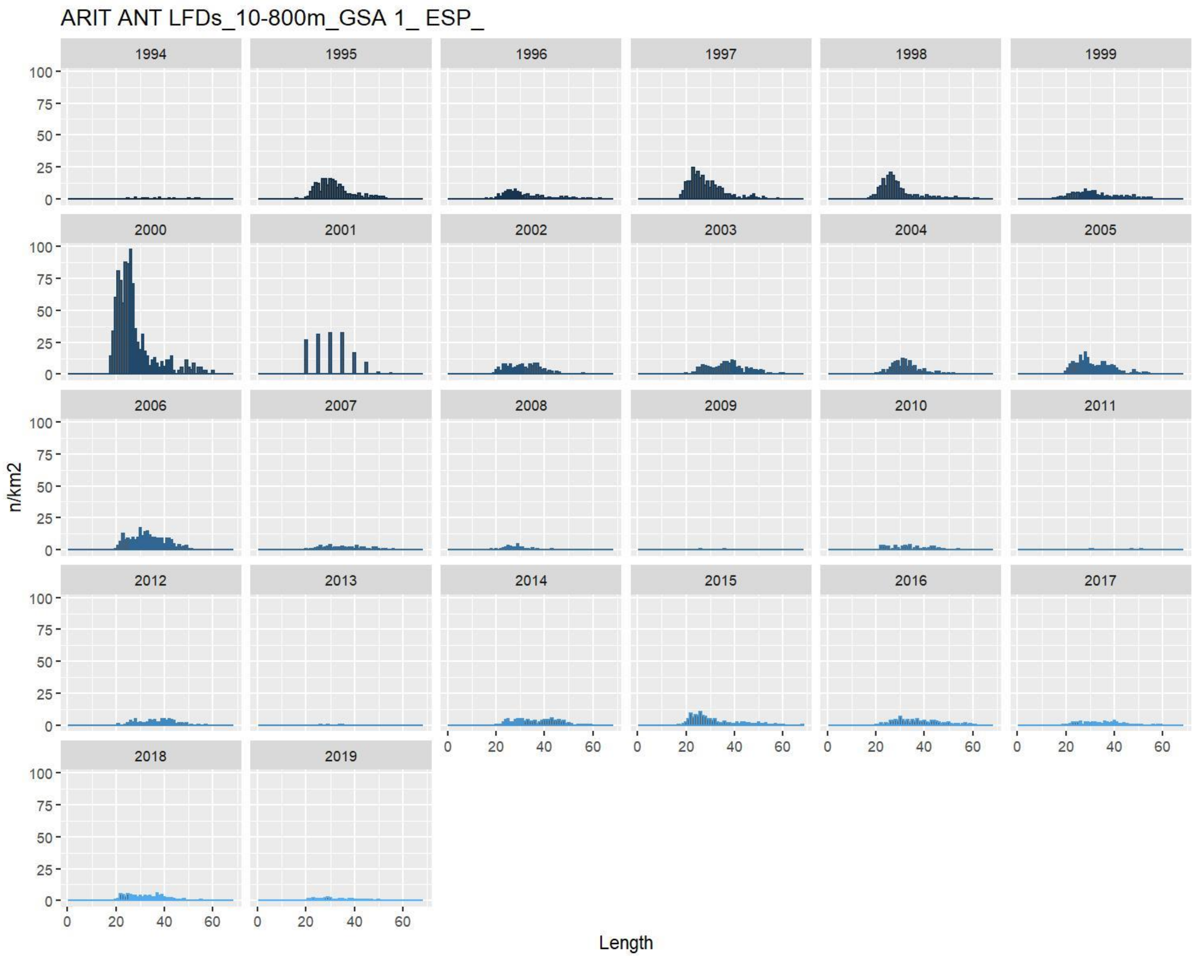


Figure 6.15.2.3.4. Blue and red shrimp in GSA 1. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

6.15.3 STOCK ASSESSMENT

This stock was assessed last year (STECF EWG20-09) and in 2019 (STECF EWG19-10) using a4a and in 2018 (STECF EWG 18-12) using XSA and a4a, prior to that in 2015 (STECF EWG 15-18) using XSA and 2011 (STECF EWG 11-05) using LCA with VIT software (Lleonart and Salat, 1997).

The present assessment was carried out using a statistical catch-at-age analysis (a4a) as this was the approach agreed in 2018. The same input data but re-evaluated was used this year with the addition of 2020 catch but 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 results 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 and 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 and was taken from the previous assessment that was based on the DCF data (Table 6.15.1.1).

The maturity at age ogive was used for blue and red shrimp assessment in GSA 1 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. Sum of Products (SoP) correction array.

Year	SoP		
2002	1.105	2012	1.021
2003	1.105	2013	1.023
2004	1.101	2014	1.021
2005	1.377	2015	1.020
2006	1.182	2016	1.089
2007	1.097	2017	0.963
2008	1.145	2018	1.020
2009	1.269	2019	1.022
2010	1.173	2020	1.533
2011	1.085		

Table 6.15.3.2. Blue and red shrimp in GSA 1: Values of catch at age per year used in the assessment.

	1	2	3	4	5+
2002	13140.00	2768.20	78.51	3.36	0.22
2003	19003.00	4804.70	145.13	4.49	0.21
2004	16675.00	6355.30	211.17	6.96	0.24
2005	18320.00	5144.40	238.32	8.65	0.31
2006	23338.00	5355.60	173.92	8.80	0.35
2007	10843.00	6713.70	176.40	6.26	0.35
2008	6285.80	3179.90	231.35	6.64	0.26
2009	7220.30	1920.60	119.48	9.50	0.30
2010	7324.90	2308.70	79.07	5.37	0.46
2011	7329.00	2426.70	101.79	3.81	0.29
2012	7047.70	2473.30	110.66	5.07	0.21
2013	7170.40	2382.80	112.95	5.52	0.28
2014	8423.50	2403.70	106.91	5.53	0.30
2015	9080.80	2793.00	105.58	5.13	0.29
2016	7085.60	2989.70	121.10	5.00	0.27
2017	5263.90	2330.80	129.55	5.73	0.26
2018	6754.20	1739.00	101.97	6.19	0.30
2019	8517.10	2247.10	77.20	4.94	0.33
2020	5043.00	2855.60	101.34	3.80	0.27

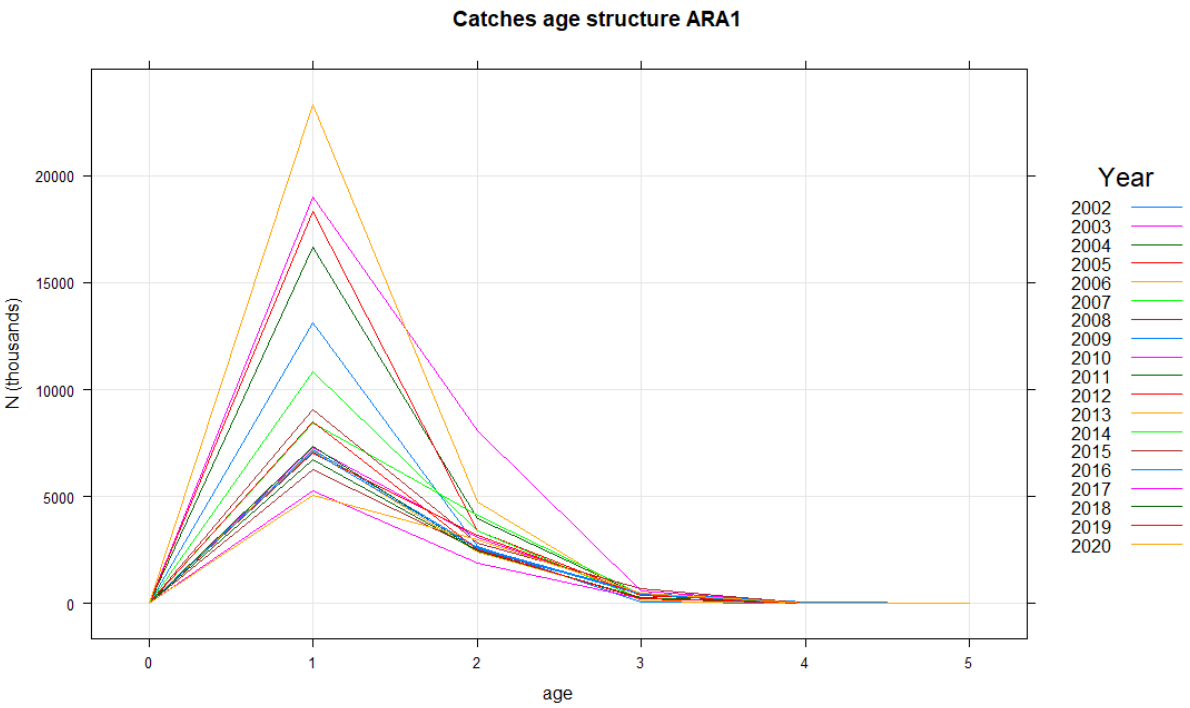


Figure 6.15.3.1. Blue and red shrimp in GSA1: Catch-at-age data of blue and red shrimp in GSA1 used in assessment.

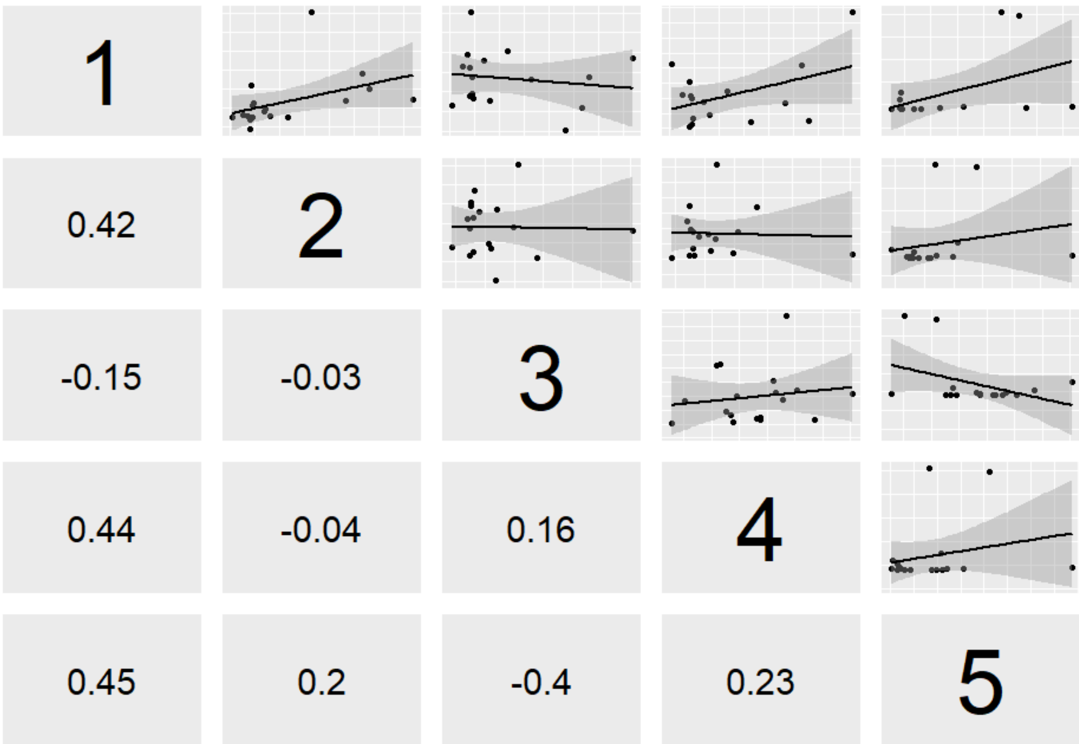


Figure 6.15.3.2. Blue and red shrimp in GSA 1. Cohort consistency of catches used in the assessment.

Table 6.15.3.2. Blue and red shrimp in GSA 1: Values of catch in the assessment.

Year	Catch
2002	157.18
2003	336.21
2004	225.515
2005	232.75
2006	289.224
2007	178.68
2008	133.48
2009	144.591
2010	152.106
2011	131.561
2012	148.631
2013	125.011
2014	184.042
2015	170.262
2016	138.231
2017	99.202
2018	123.222
2019	132.158
2020	137.38

Table 6.15.3.3. Blue and red shrimp in GSA 1: Values of mean weight at age per year used in the assessment.

	1	2	3	4	5+
2002	0.008	0.021	0.039	0.057	0.073
2003	0.008	0.021	0.038	0.057	0.073
2004	0.007	0.022	0.039	0.054	0.073
2005	0.008	0.021	0.041	0.054	0.073
2006	0.008	0.020	0.039	0.064	0.073
2007	0.009	0.022	0.039	0.054	0.073
2008	0.009	0.021	0.042	0.058	0.073
2009	0.009	0.022	0.042	0.057	0.075
2010	0.009	0.021	0.041	0.056	0.073
2011	0.009	0.021	0.041	0.057	0.073
2012	0.009	0.021	0.041	0.057	0.073
2013	0.009	0.021	0.040	0.055	0.073
2014	0.009	0.022	0.040	0.055	0.073
2015	0.008	0.022	0.042	0.055	0.073
2016	0.009	0.022	0.042	0.059	0.073
2017	0.009	0.021	0.041	0.059	0.073
2018	0.009	0.021	0.040	0.056	0.073
2019	0.008	0.021	0.041	0.055	0.073
2020	0.009	0.023	0.041	0.057	0.073

Table 6.15.3.3. Blue and red shrimp in GSA1: Survey index (MEDITS) values at age per year used in the assessment.

	1	2	3
2002	82.06	53.62	2.60
2003	54.76	93.12	18.36
2004	82.63	43.54	3.40
2005	124.10	65.32	10.21
2006	129.60	98.78	7.26
2007	23.22	22.77	7.14
2008	23.96	2.21	0.27
2009	-	-	-
2010	23.40	20.38	1.51
2011	-	-	-
2012	24.33	47.13	4.45
2013	-	-	-
2014	42.70	49.71	7.97
2015	83.33	24.46	11.19
2016	38.92	40.65	12.08
2017	25.63	24.62	1.99
2018	50.50	37.32	3.71
2019	20.42	12.50	1.71

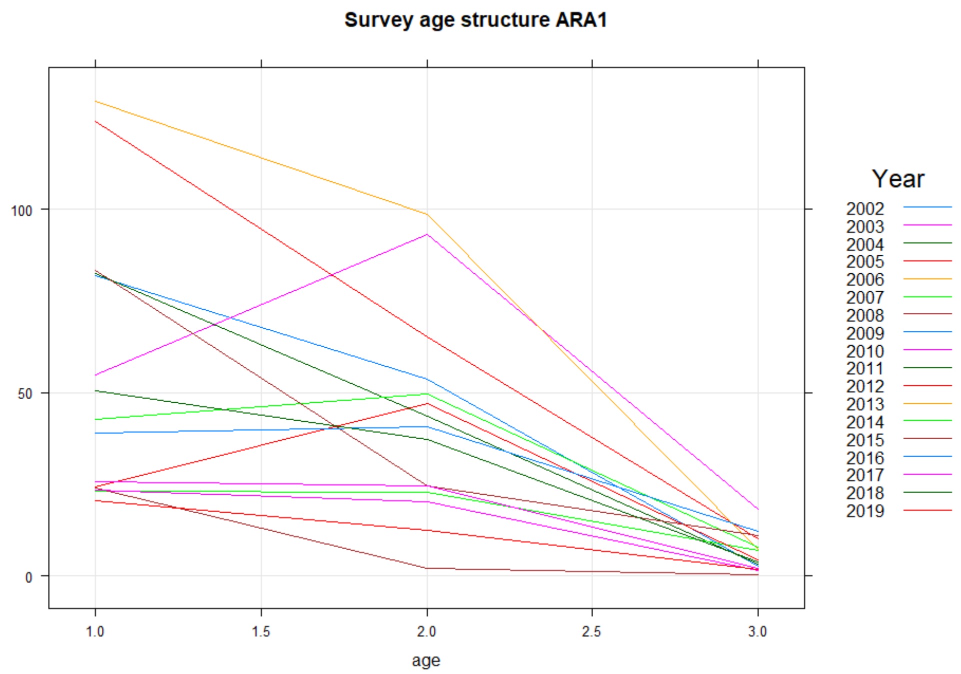


Figure 6.15.3.4. Blue and red shrimp in GSA1: MEDITS indices describing density by age of blue and red shrimp in GSA1 by year.

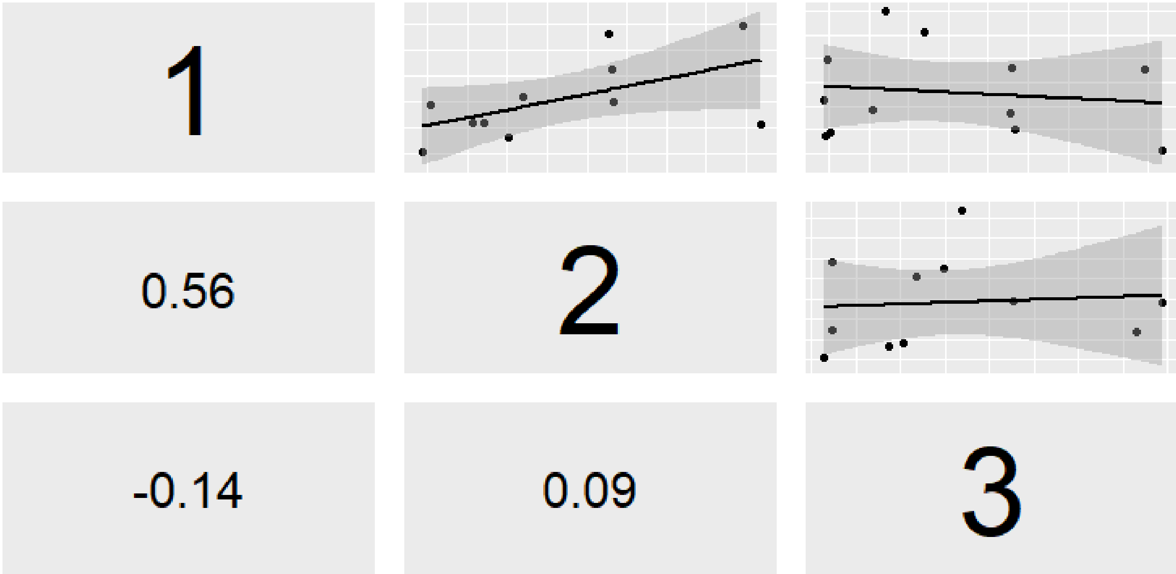


Figure 6.15.3.5. Blue and red shrimp in GSA1: Cohort consistency of survey data used in the assessment.

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).

Option 1 (free form gor q model)
fmodel <- ~ s(age, k=2) + s(year, k = 6)
qmodel <- list(~ factor(age))
srmodel <- ~ factor(year)
Option2,3,4 model similar to last year but with three options for k tested
fmodel <- ~factor(replace(age, age > 2, 2)) + s(year, k = 4)+
s(year, k =4, by = as.numeric(age == 2))
srmodel <- ~s(year, k=6)
qmodel <- list(~ factor(replace(age,age>2,2)))

Option 5 simplified f and q models but with more parameters for recruitment. (see below, selected model)

Option 1 gave peaked selection and survey q with maximum at age 2 and a sharp reduction in selectivity at older ages. This had good statistical properties by some measures (AIC and DIC) but not all (GCV was high) this was considered unrealistic in term of selection function and resulted in $F_{0.1}$ three times the value found last year and for other red and blue shrimp stocks assessed by the EWG. This model was rejected based on the perception of inappropriate survey and fishery selectivity.

Options 2,3,4 and 5 all gave very similar results without any clear statistical advantage of one model over the others (based on AIC,DIC and GCV) Overall option 5 provides the best retrospective and is a minimal modification of the one used by the EWG 20-09, with a different smoother (in this assessment, k=6) to improve the retrospective.

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 red and blue shrimp stocks in GSAs 6, 7 and 9, 10&11.

Final 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	3.500000e+01
nlogl	6.892657e+01
maxgrad	9.036372e-06
nobs	1.400000e+02
gcv	8.720015e-01
convergence	0.000000e+00
accrate	NA
nlogl_comp1	7.088810e+00
nlogl_comp2	6.183780e+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.

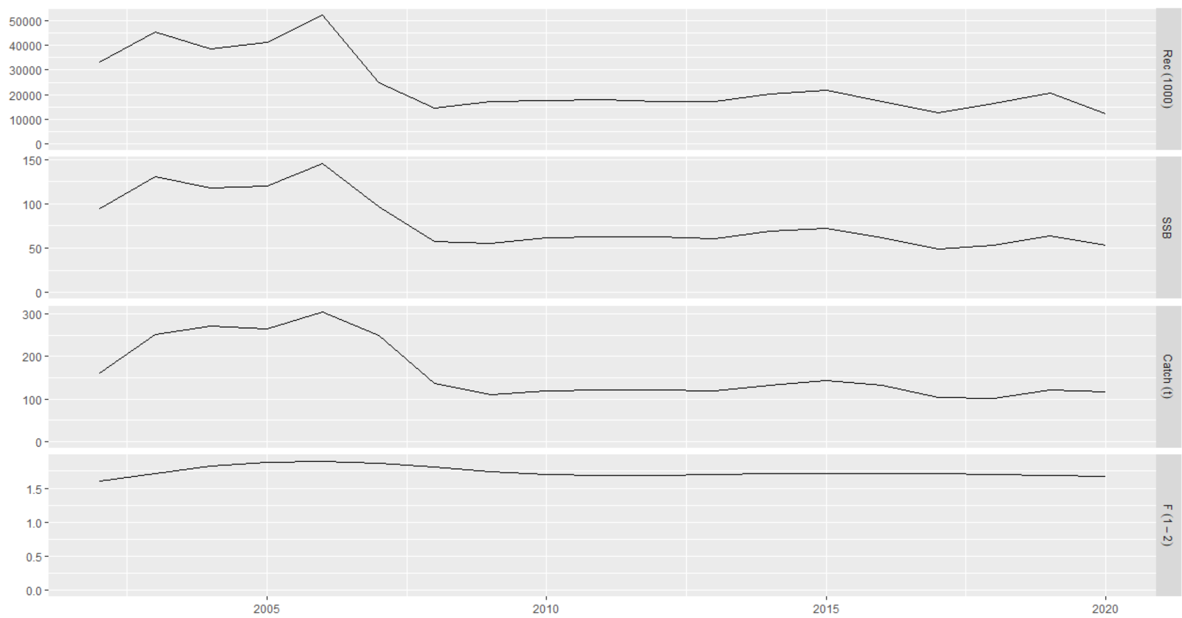


Figure 6.15.3.6. Blue and red shrimp in GSA1: Stock summary from the final a4a model.

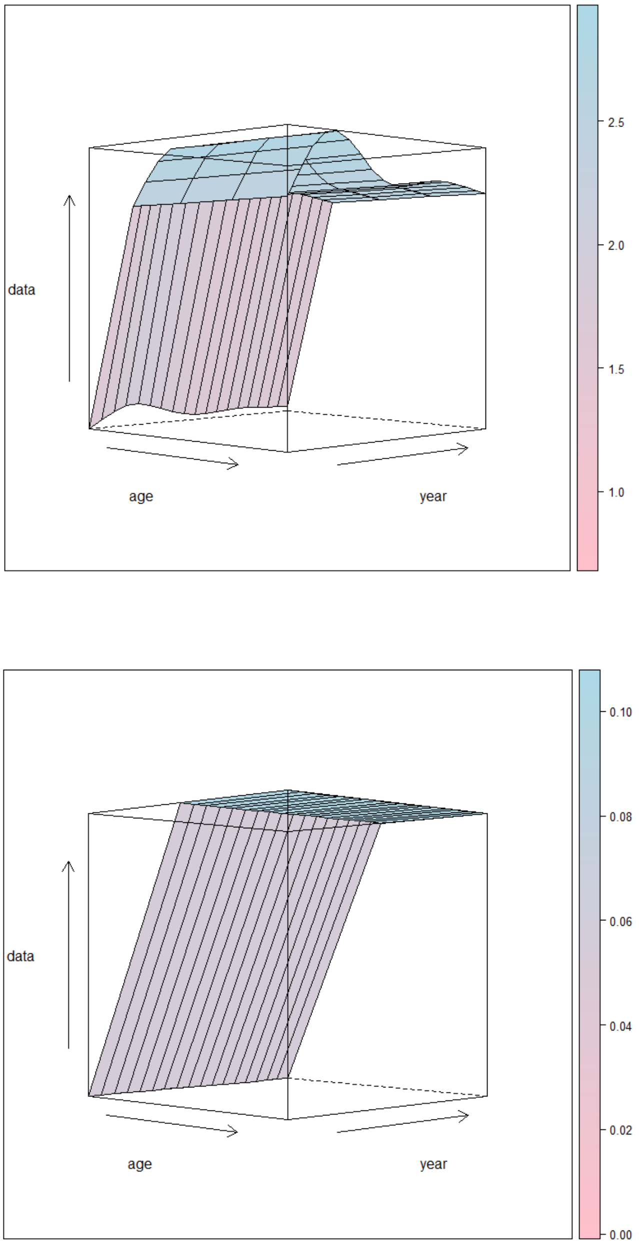
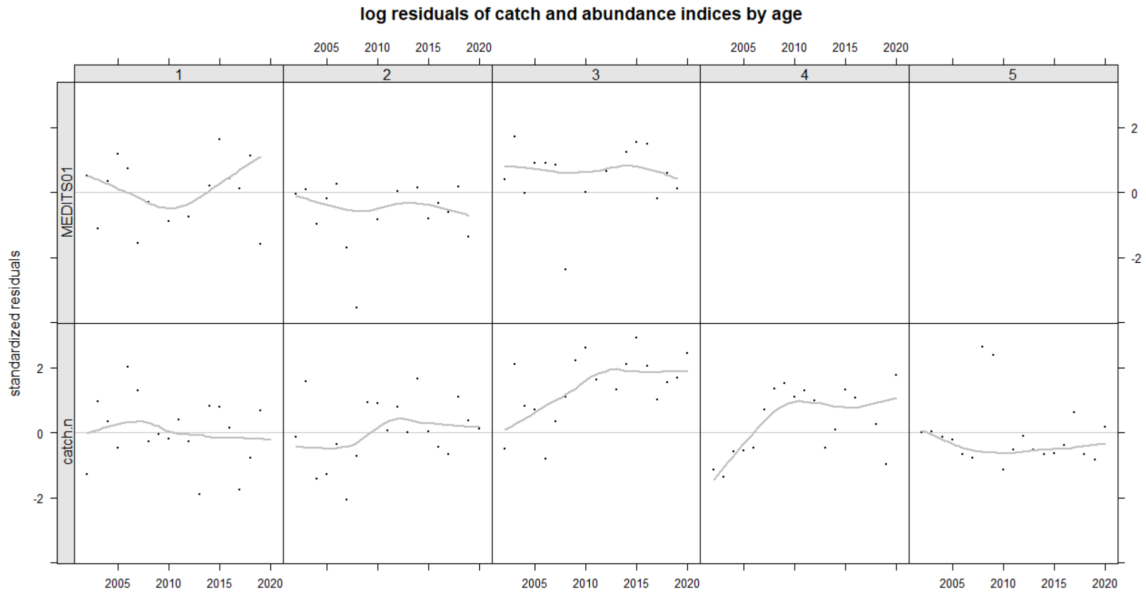


Figure 6.15.3.7. Blue and red shrimp in GSA1: 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.



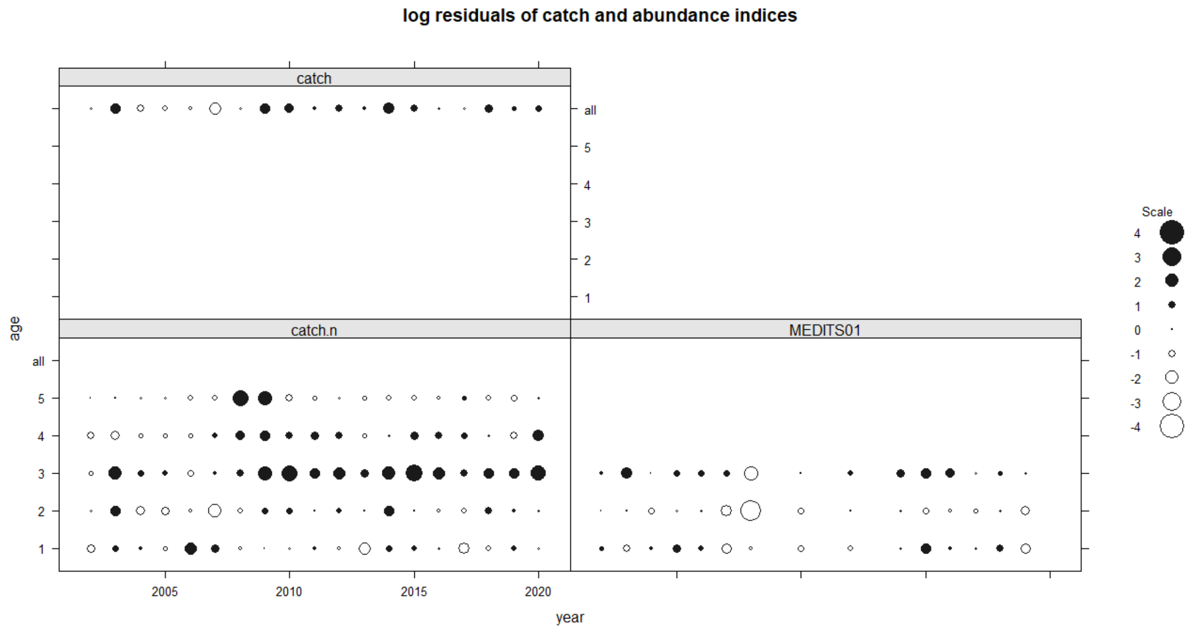


Figure 6.15.3.8. Blue and red shrimp in GSA1: Standardized residuals for abundance indices and for catch numbers.

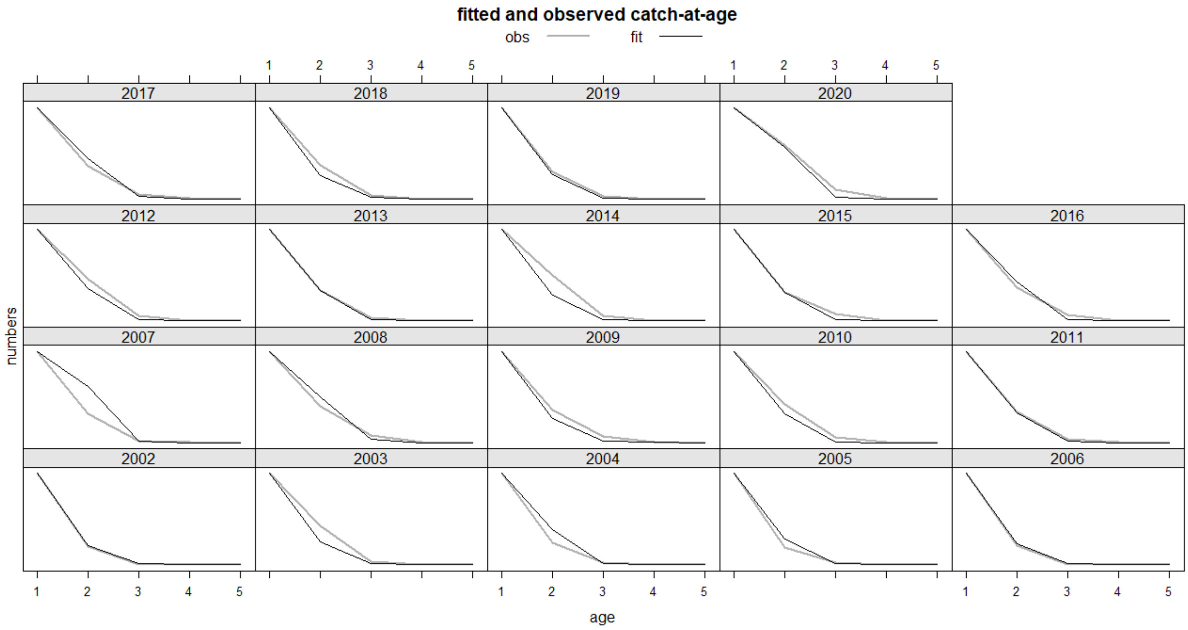


Figure 6.15.3.9. Blue and red shrimp in GSA1: Fitted and observed catch at age.

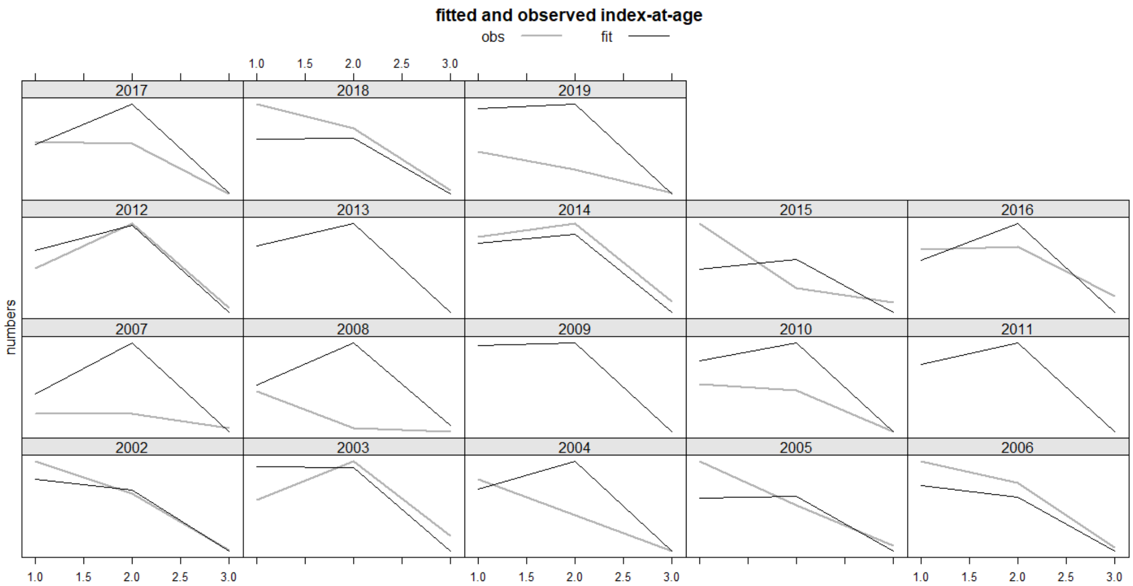


Figure 6.15.3.10. Blue and red shrimp in GSA1: Fitted and observed index at age.

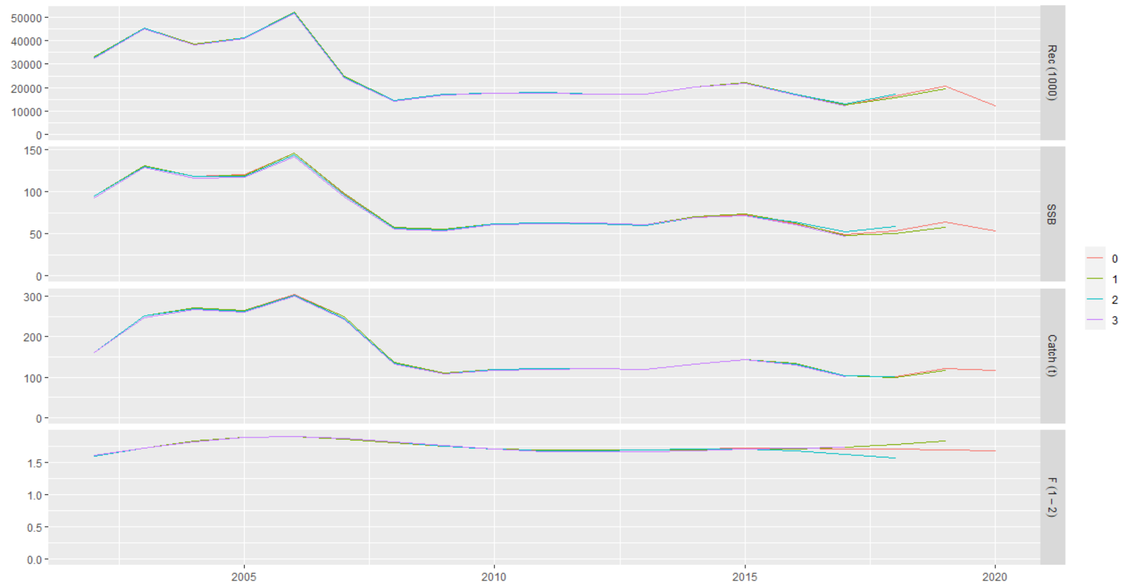


Figure 6.15.3.11. Blue and red shrimp in GSA1: Retrospective analysis

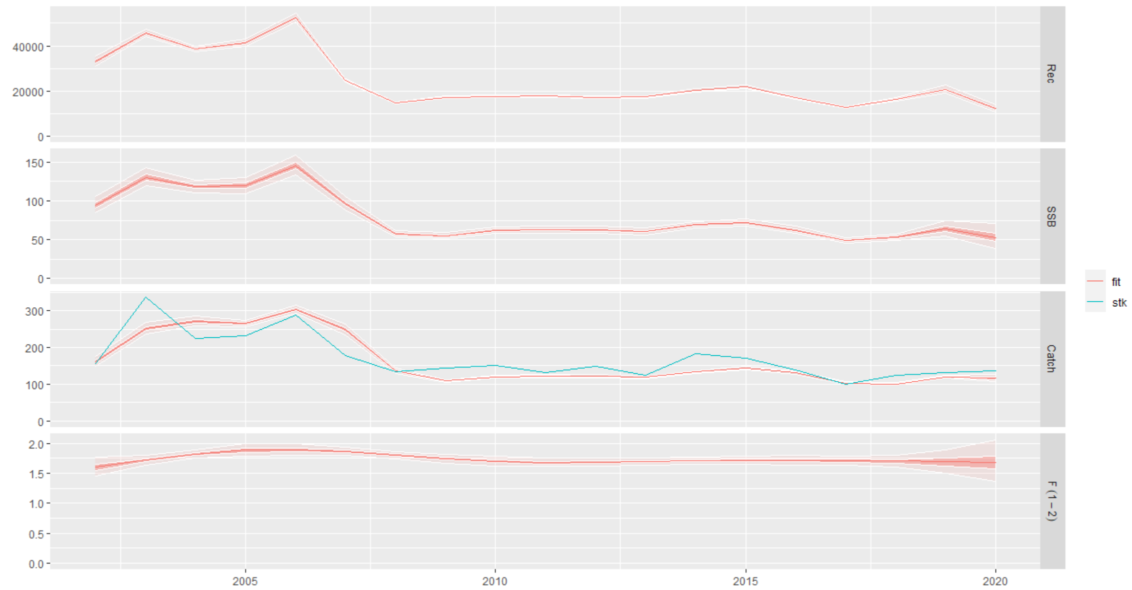


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Figure 6.15.3.12. Blue and red shrimp in GSA1: Simulations over summary results.

The Mohn' rho for F_{bar1-3}, SSB and recruitment are shown below:

fbar	ssb	rec
0.007755564	- 0.013955890	- 0.009305415

In the following tables the population estimates obtained by the a4a model are provided.

Table 6.15.3.4. Blue and red shrimp in GSA1: Stock numbers at age (thousands) as estimated by a4a.

	1	2	3	4	5+
2002	33083	3655.40	100.74	4.24	0.27
2003	45615	6207.70	182.38	5.56	0.26
2004	38509	8073.60	261.14	8.49	0.29
2005	41347	6472.20	292.01	10.45	0.37
2006	52431	6725.20	212.72	10.62	0.41
2007	24641	8470.90	216.74	7.58	0.41
2008	14590	4048.30	286.68	8.12	0.32
2009	17142	2469.40	149.45	11.71	0.36
2010	17690	2990.90	99.63	6.67	0.57
2011	17845	3155.50	128.70	4.74	0.36
2012	17157	3215.70	139.90	6.31	0.26
2013	17371	3091.30	142.50	6.86	0.34
2014	20296	3110.80	134.56	6.86	0.37
2015	21813	3609.70	132.71	6.35	0.36
2016	17023	3864.10	152.23	6.19	0.33
2017	12680	3016.10	163.05	7.11	0.32
2018	16334	2254.30	128.54	7.69	0.37
2019	20686	2918.60	97.50	6.15	0.41
2020	12300	3716.10	128.22	4.74	0.34

Table 6.15.3.5. Blue and red shrimp in GSA1: a4a summary results and F at age.

	Fbar(1-2)	Recruitment (thousands)	SSB (t)	Catch (t)
2002	1.604	33083	332.03	160.63
2003	1.718	45615	485.46	251.70
2004	1.820	38509	474.51	271.63
2005	1.884	41347	477.22	265.04
2006	1.897	52431	568.43	303.87
2007	1.864	24641	408.70	248.37
2008	1.806	14590	232.44	135.65
2009	1.746	17142	207.30	109.23
2010	1.703	17690	230.38	119.74
2011	1.683	17845	232.45	121.86
2012	1.683	17157	231.37	121.44
2013	1.695	17371	225.44	118.67
2014	1.709	20296	256.96	133.14
2015	1.717	21813	269.96	143.35
2016	1.716	17023	238.43	132.10
2017	1.710	12680	186.55	103.33
2018	1.700	16334	195.74	100.22
2019	1.689	20686	235.09	120.16
2020	1.679	12300	204.96	116.58

Table 6.15.3.13. Blue and red shrimp in GSA1: Fishing mortality at age for red mullet in GSA 9.

	1	2	3	4	5+
2002	0.818	2.389	2.389	2.389	2.389
2003	0.877	2.560	2.560	2.560	2.560
2004	0.928	2.711	2.711	2.711	2.711
2005	0.961	2.807	2.807	2.807	2.807
2006	0.968	2.827	2.827	2.827	2.827
2007	0.951	2.778	2.778	2.778	2.778
2008	0.921	2.691	2.691	2.691	2.691
2009	0.891	2.602	2.602	2.602	2.602
2010	0.869	2.537	2.537	2.537	2.537
2011	0.859	2.508	2.508	2.508	2.508
2012	0.859	2.508	2.508	2.508	2.508
2013	0.865	2.526	2.526	2.526	2.526
2014	0.872	2.546	2.546	2.546	2.546
2015	0.876	2.558	2.558	2.558	2.558
2016	0.875	2.557	2.557	2.557	2.557
2017	0.872	2.547	2.547	2.547	2.547
2018	0.867	2.532	2.532	2.532	2.532
2019	0.862	2.517	2.517	2.517	2.517
2020	0.856	2.501	2.501	2.501	2.501

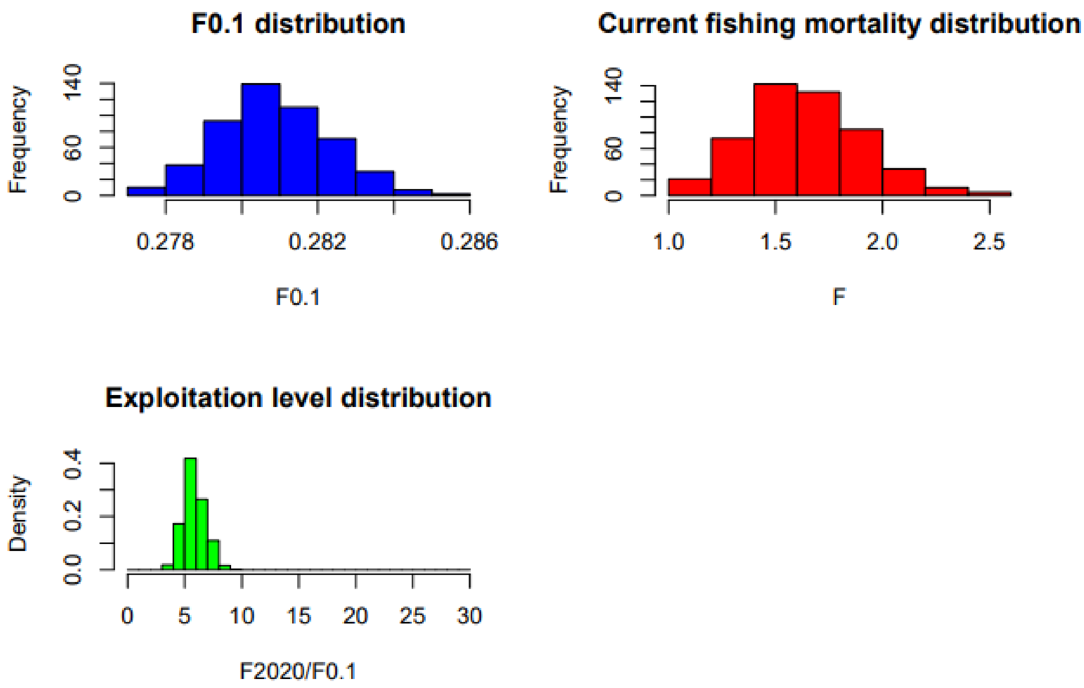


Figure 6.15.3.10. Blue and red shrimp in GSA 1. Histograms of probability for F0.1, Fcurr and level of exploitation (Fcurr/F01 ratio) values for Blue and red shrimp in GSA 1.

6.15.4 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 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 (=1.68) equal to that of the terminal year (2020) 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 is over exploited.

6.15.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2020 to 2022 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} =1.68 (the last year's F estimated by the assessment model) was used for F in 2021 as F shows a declining trend. Trend in recruitment for the period 2007-2020 is observed so is taken geometric mean of this time period. Recruitment has been estimated from the population results as the geometric mean of the last 13 years of the data series (16924 individuals).

Table 6.15.51. Blue and red shrimp in GSA1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2018-2020	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-2}$ (2021)	1.679	The F estimated in 2020 was used to give F status quo for 2021
SSB (2021)	55.77	Stock assessment 1 January 2021
R_{age1} (2021-2022)	16924	Geometric mean of years 2007 to 2020
Total catch (2021)	103.23	Assuming F status quo for 2021

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 last 13 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 55.77and 103.23 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. 29) would increase biomass by 206.9 % from 2021 to 2023, while reducing catches by 71.6 % from 2020 to 2022.

Table 6.15.5.2. Blue and red shrimp in GSA1: Short term forecast in different F scenarios.

Scenario	Fbar	Recruitment 2021	Fsq 2021	Catch 2020	Catch 2021	Catch 2022	SSB 2021	SSB 2023	SSB_2021-2023(%)	Catch_2020-2022(%)
F0.1	0.292	16924.210	1.679	116.580	103.232	33.054	55.768	171.145	206.886	-71.647
F upper	0.402	16924.210	1.679	116.580	103.232	43.340	55.768	152.877	174.130	-62.823
F lower	0.196	16924.210	1.679	116.580	103.232	23.151	55.768	189.858	240.441	-80.142
F_{MSY} transition	1.124	16924.210	1.679	116.580	103.232	91.795	55.768	83.231	49.244	-21.260
Zero catch	0.000	16924.210	1.679	116.580	103.232	0.000	55.768	237.825	326.454	-100.000
Status quo	1.679	16924.210	1.679	116.580	103.232	115.052	55.768	59.301	6.335	-1.310
Different Scenarios	0.168	16924.210	1.679	116.580	103.232	20.103	55.768	195.837	251.162	-82.756
	0.336	16924.210	1.679	116.580	103.232	37.256	55.768	163.537	193.244	-68.042
	0.504	16924.210	1.679	116.580	103.232	52.000	55.768	138.436	148.234	-55.395
	0.671	16924.210	1.679	116.580	103.232	64.766	55.768	118.725	112.890	-44.445
	0.839	16924.210	1.679	116.580	103.232	75.898	55.768	103.081	84.839	-34.896
	1.007	16924.210	1.679	116.580	103.232	85.672	55.768	90.531	62.336	-26.512
	1.175	16924.210	1.679	116.580	103.232	94.312	55.768	80.354	44.086	-19.101
	1.343	16924.210	1.679	116.580	103.232	101.995	55.768	72.010	29.124	-12.510
	1.511	16924.210	1.679	116.580	103.232	108.869	55.768	65.095	16.724	-6.614
	1.847	16924.210	1.679	116.580	103.232	120.641	55.768	54.396	-2.461	3.484
	2.014	16924.210	1.679	116.580	103.232	125.717	55.768	50.199	-9.986	7.838
	2.182	16924.210	1.679	116.580	103.232	130.346	55.768	46.572	-16.489	11.809
	2.350	16924.210	1.679	116.580	103.232	134.584	55.768	43.407	-22.164	15.444
	2.518	16924.210	1.679	116.580	103.232	138.477	55.768	40.620	-27.163	18.783
	2.686	16924.210	1.679	116.580	103.232	142.064	55.768	38.142	-31.606	21.860
	2.854	16924.210	1.679	116.580	103.232	145.379	55.768	35.923	-35.586	24.704
	3.022	16924.210	1.679	116.580	103.232	148.450	55.768	33.918	-39.180	27.338
	3.190	16924.210	1.679	116.580	103.232	151.302	55.768	32.096	-42.447	29.784
	3.357	16924.210	1.679	116.580	103.232	153.956	55.768	30.429	-45.437	32.061

6.15.6 DATA DEFICIENCIES

The input data and stock object were re-evaluated. For the commercial data, after catch reconstruction, the LFD for age 0 has 0 values for all years, and ages from 1 to 5 plus were used. For the survey, data was revised from 2006 to 2010 before EWG21-11. MEDITS index for 2020 was not available. It was observed that there were very low levels of sampling found in the survey in 2009 and 2011 and 2013. For the initial runs all these were excluded from survey index due to high uncertainty. The model without the poor years gave more reliable estimates of catch. Based on this these data were not included in the assessment. Also, this results in F lower than last year and the same $F_{0.1}$ but the ratio is similar.

The model from last year fits the data much as it did last year with similar issues. The flat Q for ages >2 gives residuals at three, as it did last year and this is not that unexpected for flat q across ages. It provides a very similar result to last year. After checking last year model for sensitivity to k etc. a smoother of k=6 gives the best retrospective.

6.16 BLUE AND RED SHRIMP IN GSA 5

An advice on blue and red shrip (ARA) in GSA 5 based on MEDITS indices trends was already given in 2018 and in 2019 (STECF EWG 18-12 and STECF EWG 20-09 reports). STECF EWG 20-09 was asked to perform a new analysis to determine if latest updated data could help with an assessment. EWG 20-09 was not able to perform an assessment, therefore, based on precautionary considerations, EWG 20-09 advised to decrease the catch by 33% from catch in 2019 equivalent to catches of no more than 137 tonnes in each of 2021 and 2022 implemented through either catch restrictions or effort reduction for the relevant fleets.

6.16.1 STOCK IDENTITY AND BIOLOGY

GSA 5 (Figure 6.16.1) 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) 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.

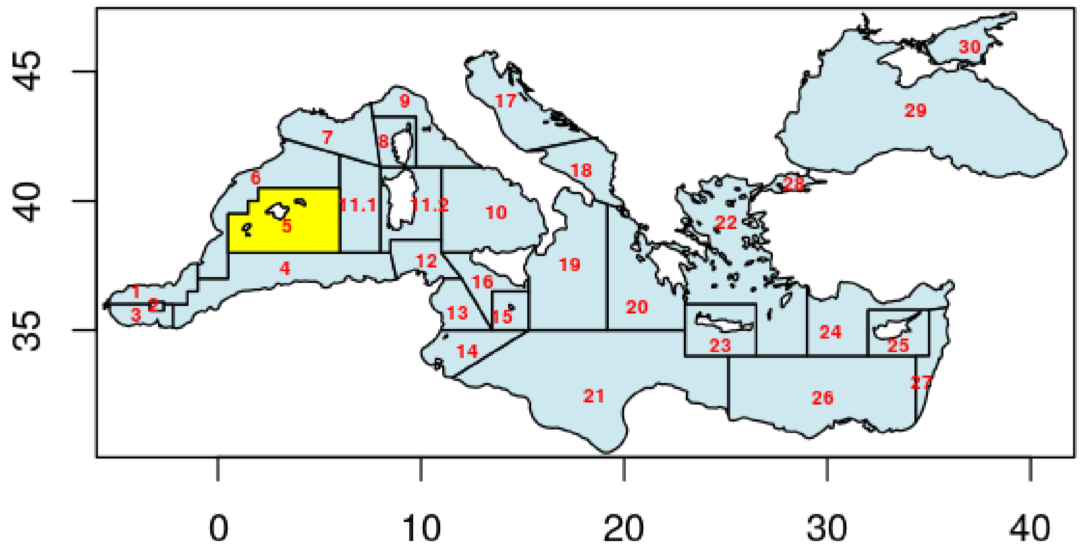


Figure 6.16.1.1 Geographical location of GSA 5

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 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. Growth parameters (L, K, t0) and parameters of the Length-Weight relationship (a, b) used for the assessment

Parameter	L_{∞}	k	t_0	a	b
Value	75	0.38	0.05	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
M	2.063	0.835	0.585	0.482	0.428	0.428

6.16.2 Data

6.16.2.1 Catch (Landings and discards)

Landings for GSA 5 were available through the DCF for the period 2002-2020 and were exclusively reported by OTB fishing operations (Table 6.16.2.1.1). Reported discards were negligible making up for < 0.01% of the total catch.

Table 6.16.2.1.1. Blue and red shrimp landing data (in tons) in GSA 5

Year	Landings	Discards	Total catches
2002	141.5	-	141.5
2003	122.0	-	122.0
2004	193.6		193.6
2005	191.5	0.0	191.5
2006	213.9	-	213.9
2007	239.1	-	239.1
2008	232.9	0.0	232.9
2009	126.2	0.0	126.2
2010	153.2	0.0	153.2
2011	111.2	0.4	111.7
2012	201.1	2.5	203.6
2013	188.6	0.2	188.8
2014	141.3	0.2	141.5
2015	160.2	0.1	160.3
2016	138.1	0.0	138.1
2017	171.4	0.1	171.5
2018	249.7	0.2	249.9
2019	205.9	0.0	205.9
2020	130.7	0.0	130.7

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.16.2.1.2.

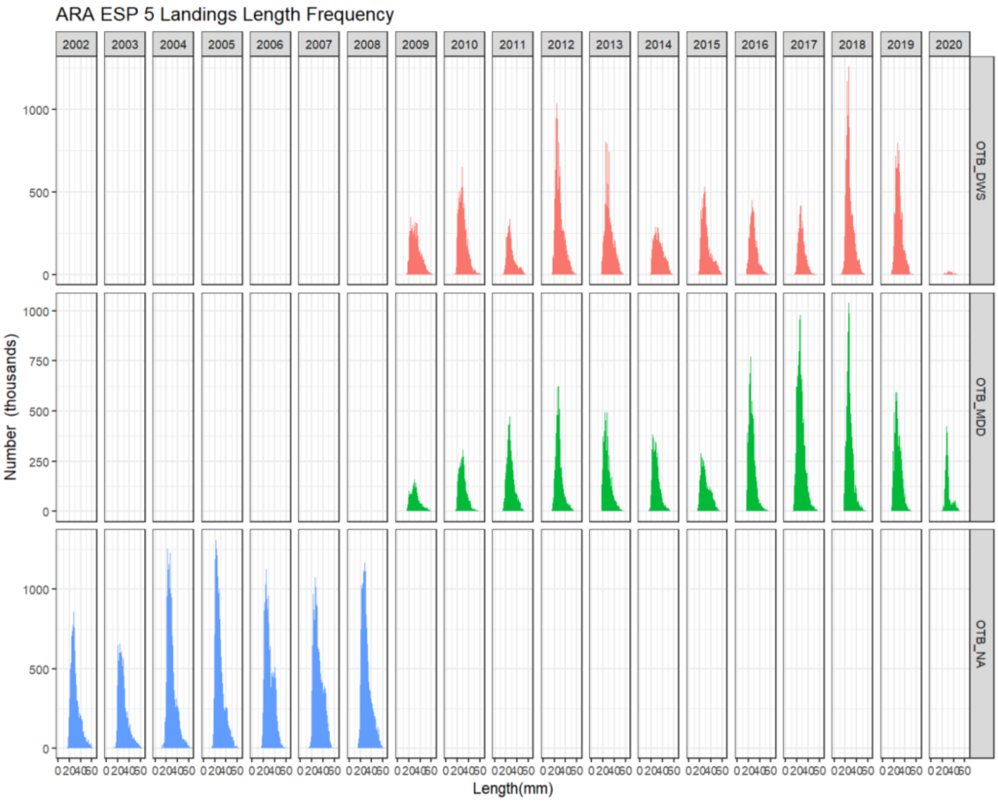


Figure 6.16.2.1.2. Blue and red shrimp in GSA 5. Length frequency distribution of the landings by year and gear in GSA 5.

6.16.2.2 SURVEY DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 through the FDI data call within the DCF framework.

6.16.2.3 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 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 analysis. Since 2007, the survey has taken place between April and May (Figure 6.16.2.3.1).

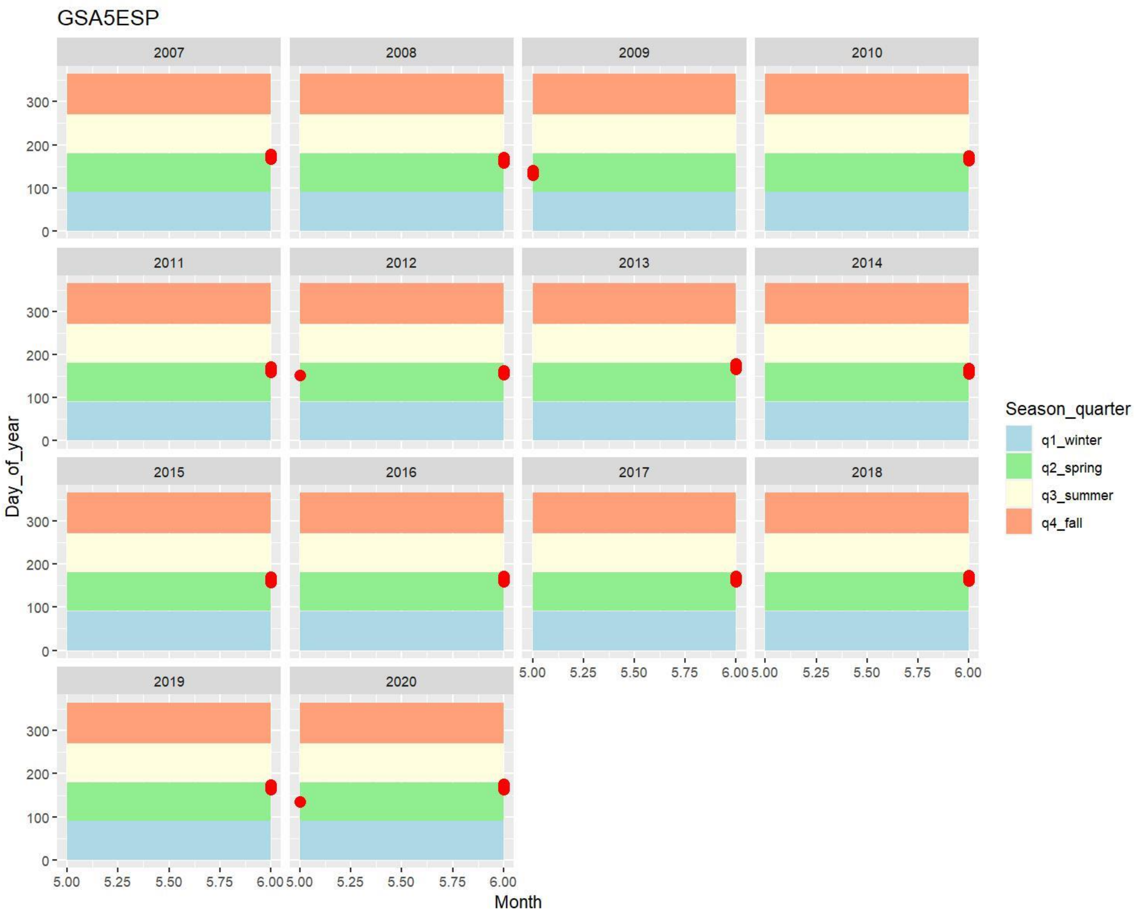
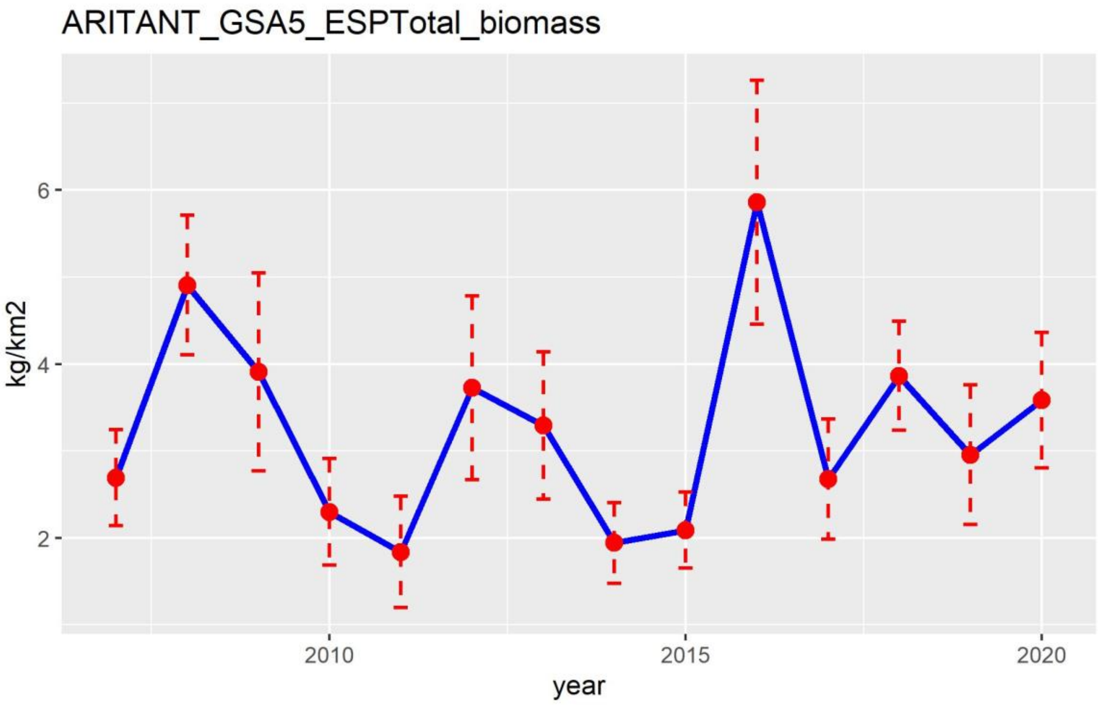


Figure 6.16.2.3.1 Survey periods of MEDITS in GSA 5.

Relative changes in the estimated MEDITS survey indices for biomass (kg/km2) and density (N/km2) in GSA 5 show fairly large variations and no clearly discernible trend over the available period (Figure 6.16.2.3.2). The last three years (2017-2019) show a decline compared to the peak in 2016. The observed length-frequency distributions from MEDITS survey in GSA 5 are illustrated in Figure 6.16.2.3.3.



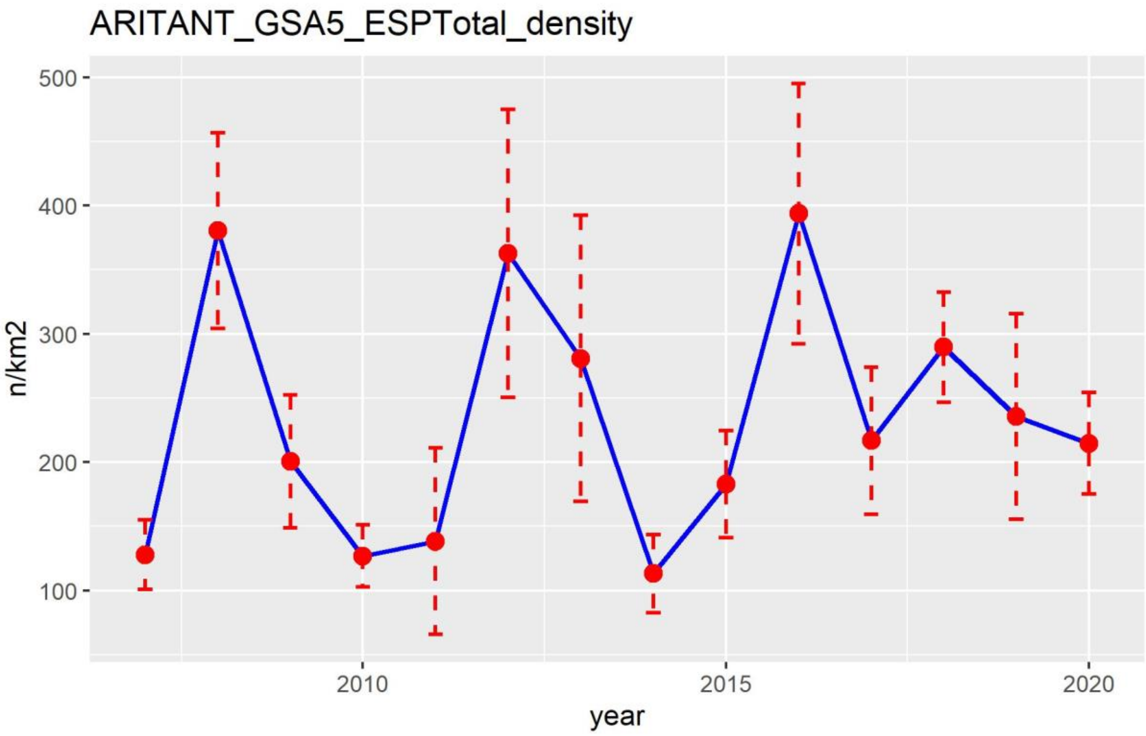


Figure 6.16.2.3.2. MEDITS indices for the period 2007-2020: relative biomass (kg km²) and density (n km²).

Size frequency distributions by years are shown in Figure 6.16.2.3.3.

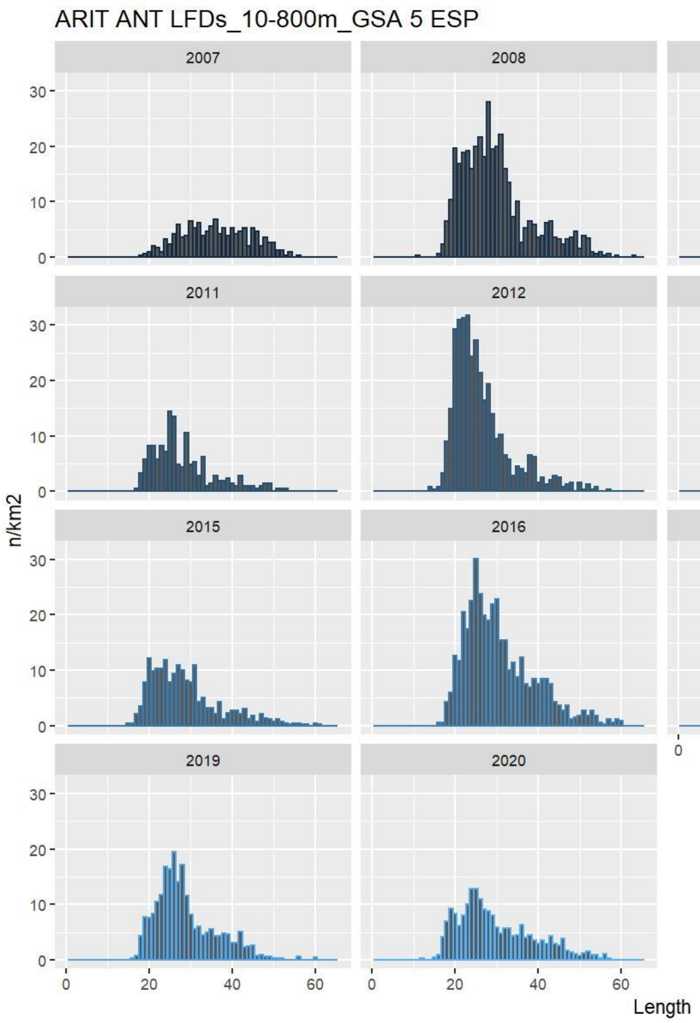


Figure 6.16.2.3.3. Blue and red shrimp in GSA 5. Observed Length-frequency distributions (MEDITS data).

6.16.3 Stock Assessment

The EWG 20-09 concluded that the outputs of a4a model attempted were not suitable to provide the basis of the current status of the stock but could be used as indicative of a trend. On this basis, advice was given for the years 2021 and 2022.

EWG 21-11 was required to do a short evaluation of survey and landing trends to determine if new data is different and could help with an assessment. As no substantive change in survey and landing signals was observed, a new assessment has not been performed and the advice done in EWG 20-09 has been confirmed.

6.16.4 Reference Points

As the assessment performed by EWG 20-09 was not accepted for advice, reference points were not calculated.

6.16.5 Short term Forecast and Catch Options

No new short-term forecast has been carried out as advice given last year is valid for 2021 and 2022. Details of the 2020 assessment attempted are available in STECF EWG 20-09 report.

6.16.6 Data Deficiencies

The survey numbers at age estimates show systematically biased fits to the data and poor cohort consistency. In addition, there seems to be some conflict in scale between density and biomass survey estimates during early years. To potentially improve the assessment in future, it is advisable to conduct checks of the survey raw data, in particular for the years 2007-2011, which appeared to be inconsistent with the more recent period. Additional information deficiencies pertain to the uncertainty about the biology, in particular somatic growth and potentially age-specific stock structuring.

6.17 BLUE AND RED SHRIMP IN GSA 6 AND 7

6.17.1 Stock Identity and Biology

This stock was assessed for the last time in 2020 (STECF EWG 20-09) 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).

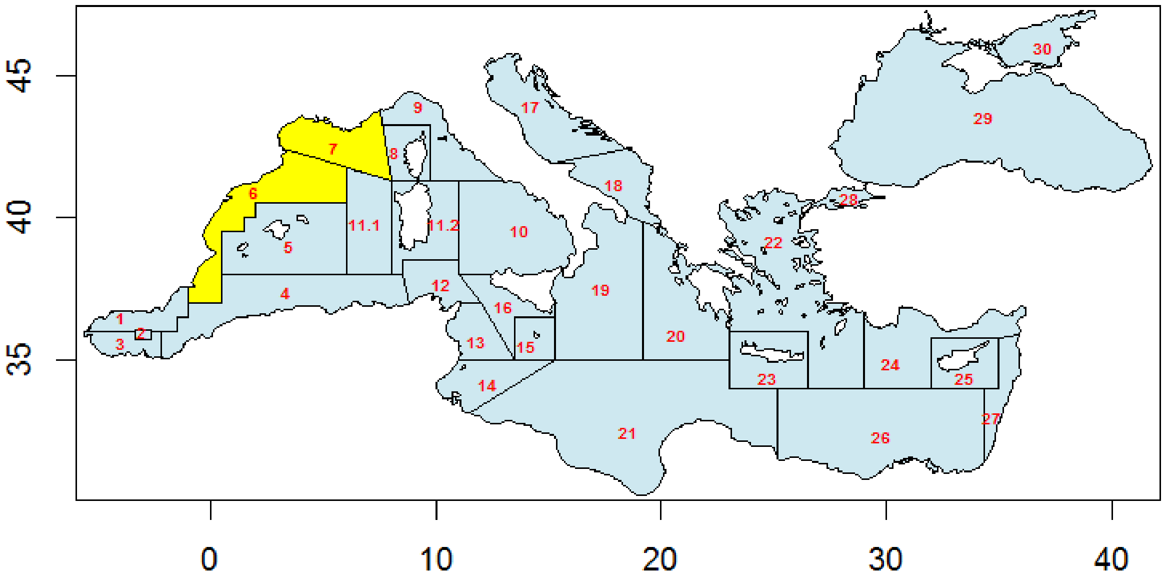


Figure 6.17.1.1. Blue and red shrimp in GSA 6&7. Geographical location of the stock.

The growth parameters used were taken from Garcia-Rodriguez (2003), just as in the previous assessment (STECF EWG 20-09); 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 19-10).

The proportion of mature individuals at age was available from the previous assessment report (STECF EWG 20-09, 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 nil because of the high commercial value of the species. 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. 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 LFD of the landings (=catch as discards were negligible) is shown in Figure 6.17.2.6 and 6.16.2.7.

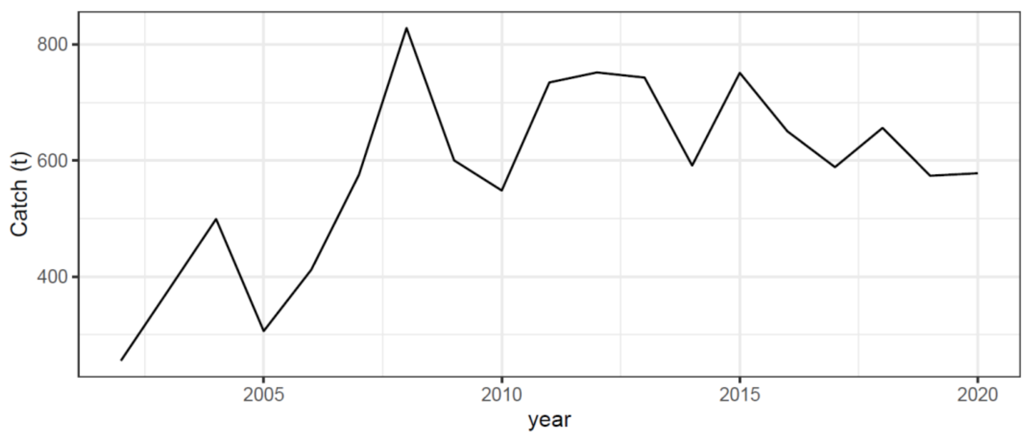


Figure 6.17.2.1. Blue and red shrimp in GSA 6&7. Blue and red shrimp DCF total catch (t), in GSA 6&7.

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)
2002	254.84	0.36
2003	376.57	0.38
2004	498.90	0.32
2005	306.26	0.00
2006	411.90	0.10
2007	574.94	0.30
2008	827.08	1.14
2009	599.59	0.56
2010	546.86	1.35
2011	726.19	8.24
2012	736.37	15.26
2013	730.56	12.24
2014	590.62	0.69
2015	750.46	0.47
2016	646.75	3.57
2017	581.04	7.40
2018	655.93	0.19
2019	570.74	2.98
2020	577.17	0.85

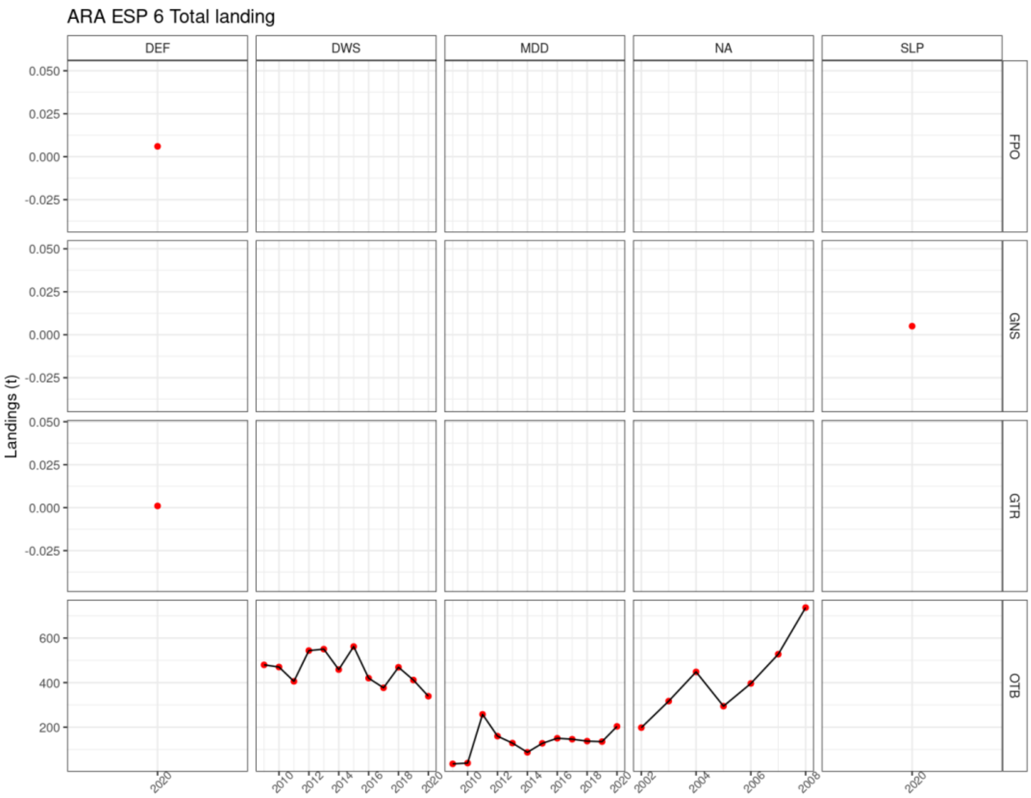


Figure 6.17.2.2. Blue and red shrimp in GSA 6&7. Total landing by metier in GSA 6.

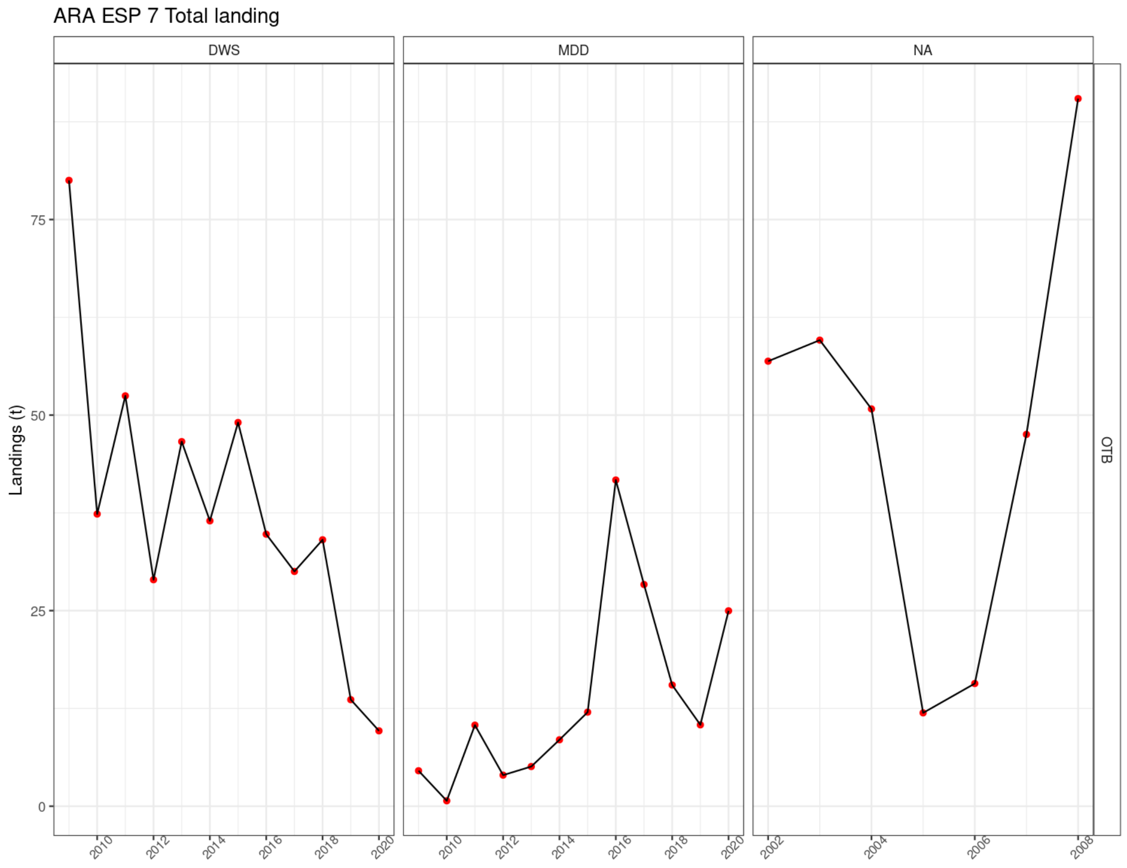


Figure 6.17.2.3. Blue and red shrimp in GSA 6&7. Total landing by metier in GSA 7.

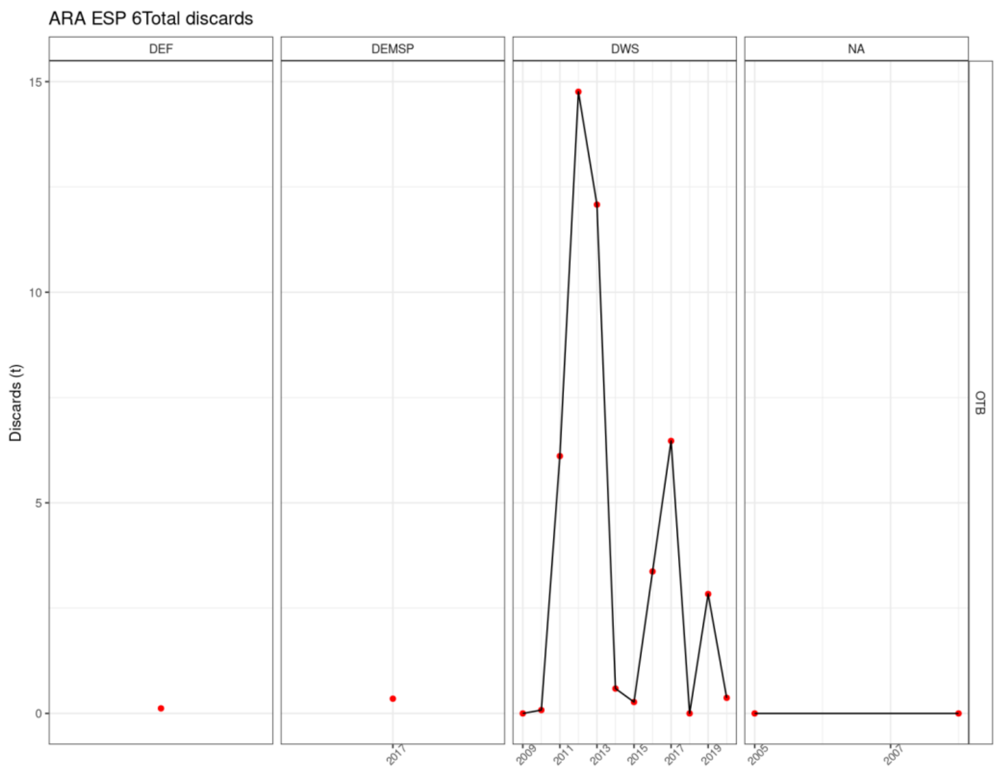


Figure 6.17.2.4. Blue and red shrimp in GSA 6&7: Total discards by metier in GSA 6.

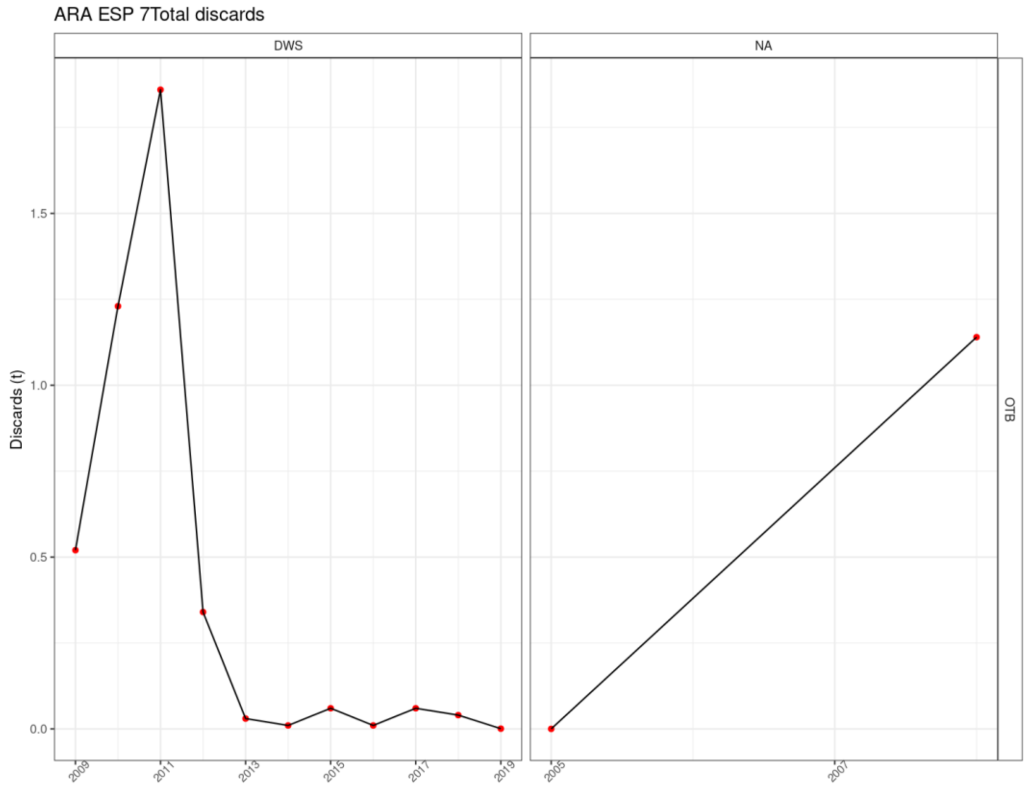


Figure 6.17.2.5. Blue and red shrimp in GSA 6&7: Total discards by metier in GSA 6.

For the length frequency distributions the group decide to use the output of the EWG 21-02, where quality checks were performed for the DCF data. The EWG 21-02 developed a series of scripts for reconstructing missing LFDs. These scripts were used to derive the final LFDs used in this assessment.

Figure 6.17.2.6. Blue and red shrimp in GSA 6&7. Reconstructed length frequency distribution of catch by metier in GSA 6.

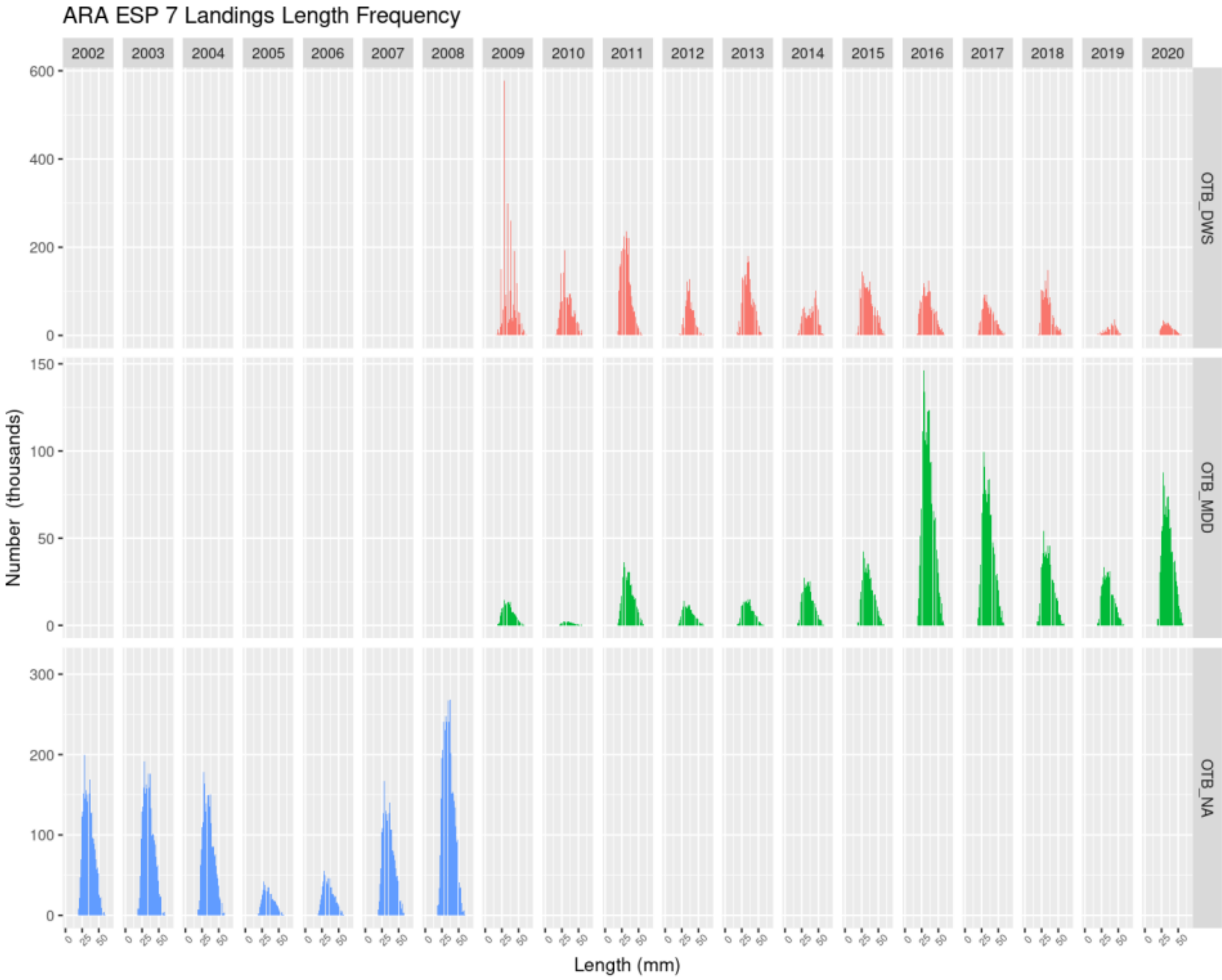


Figure 6.17.2.7. Blue and red shrimp in GSA 6&7. Reconstructed length frequency distribution of catch by metier in GSA 7.

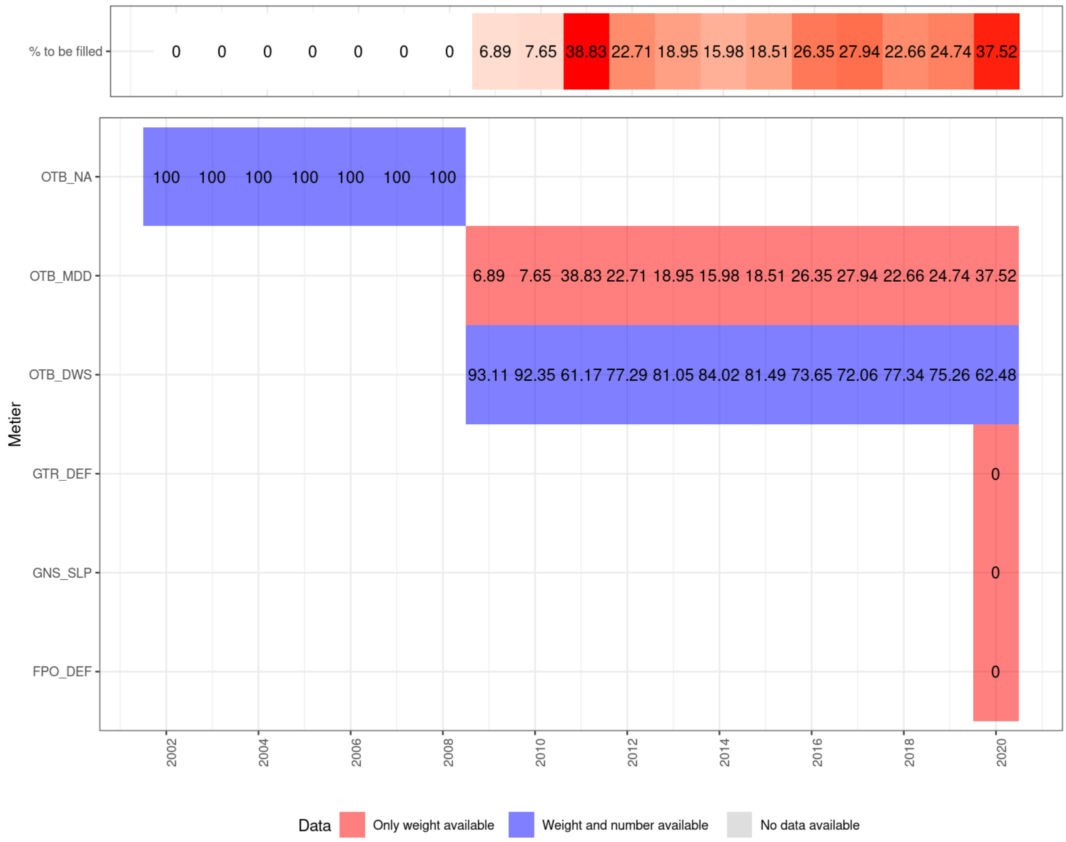


Figure 6.17.2.8. Blue and red shrimp in GSA 6&7. Percentages of reconstructed landings LFD in total and by metier for GSA 6

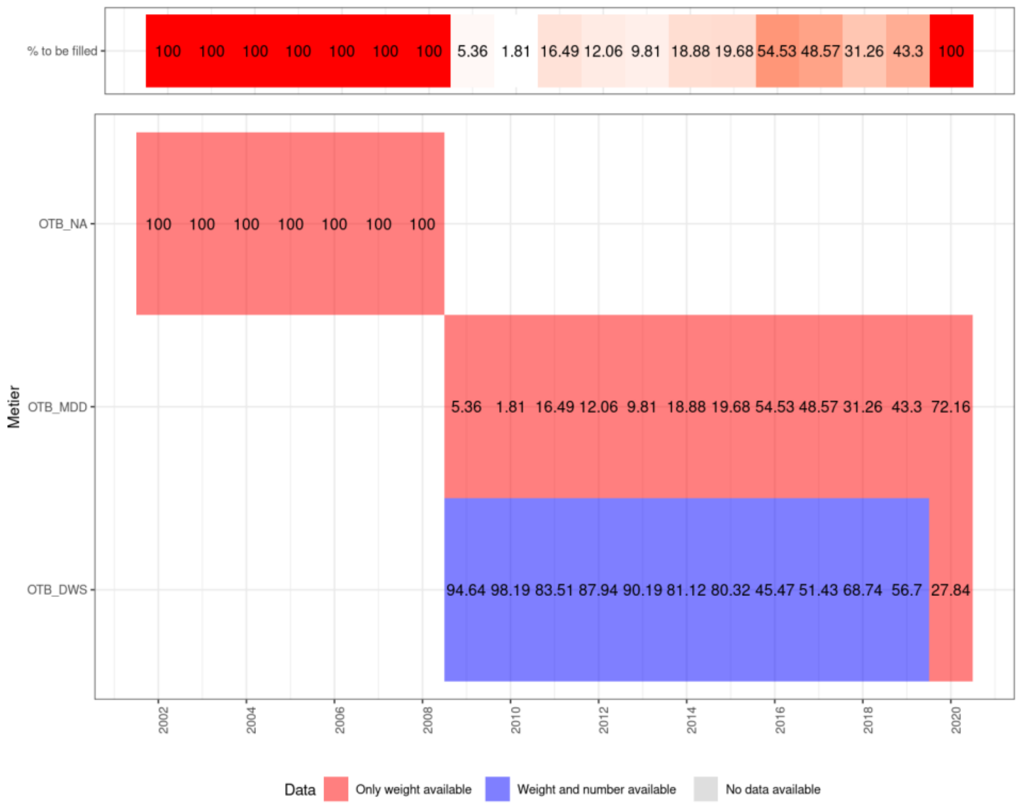


FIGURE 6.17.2.8. BLUE AND RED SHRIMP IN GSA 6&7. PERCENTAGES OF RECONSTRUCTED LANDINGS LFD IN TOTAL AND BY METIER FOR GSA 7.

6.17.2.2 EFFORT DATA

Fishing effort data for 2020 will be reported to STECF EWG 21-13 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 16.17.2.2.1). 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). Few obvious data errors (e.g. typos, duplicated records) had been noted (MEDITS issues 2009) 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 16.17.2.2.1. Blue and red shrimp in GSA 6&7. Month of the year when the MEDITS survey is conducted.

The MEDITS survey in GSA 7 was performed in October, due to covid restrictions, the number of stations was reduced and some of the deeper more offshore stations were omitted. The MEDITS survey in GSA 6 was performed at the usual time but with reduced coverage with only the Northern half of the area surveyed.

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 6.17.2.3.2), except for last year where in GSA 6 fewer hauls were performed due to covid restrictions.

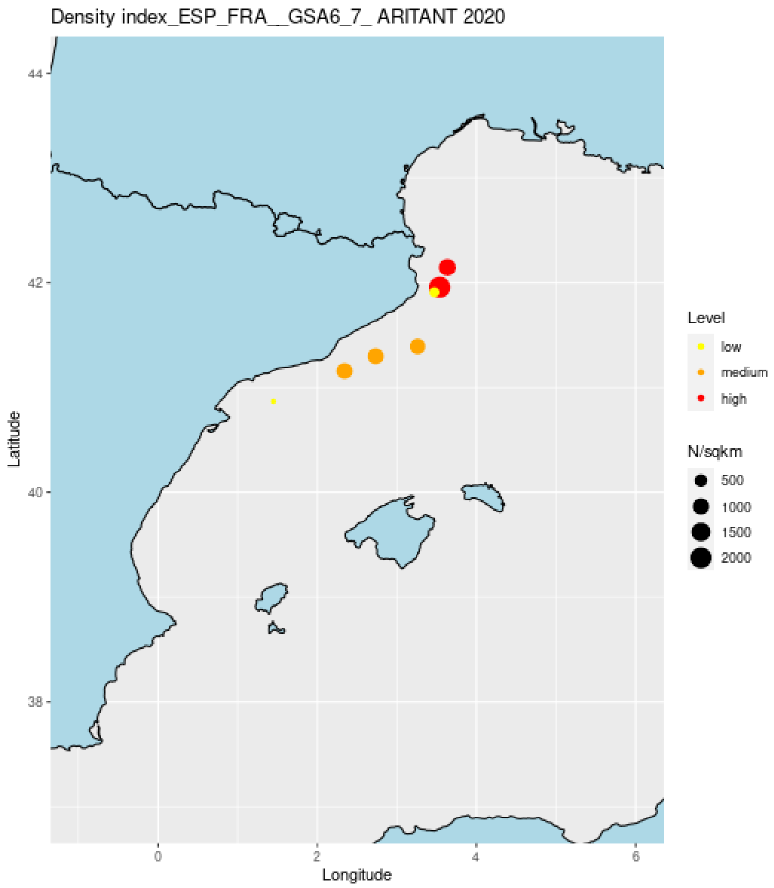


Figure 6.17.2.2.2. Blue and red shrimp in GSA 6&7. Geographical distribution based on the biomass index of MEDITS survey in 1994, 2003, 2012 and 2019.

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 are available since 1994 as shown in the Figures 6.17.2.2.3.1 and

6.17.2.2.3.2, 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 6.17.2.3.3.3.

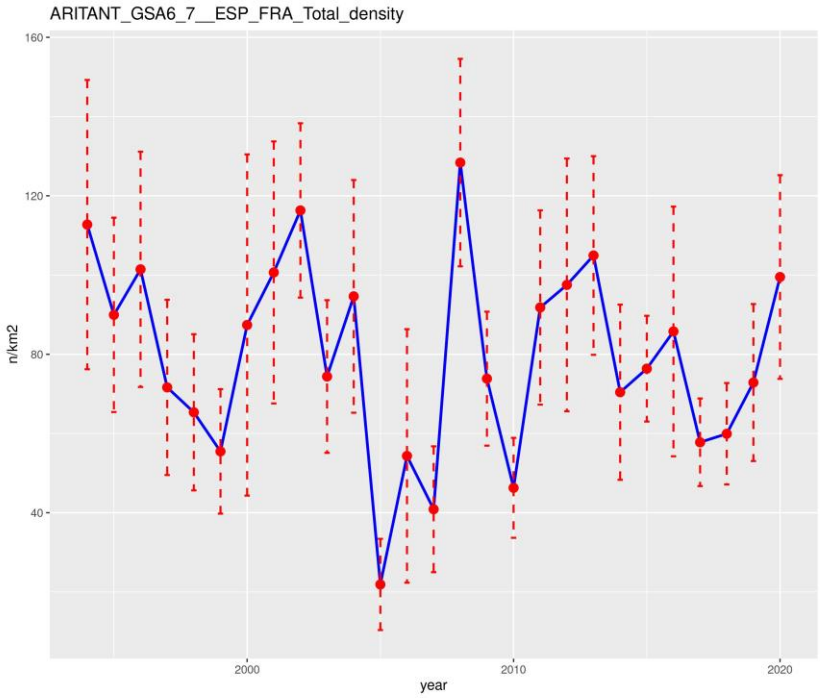


Figure 6.17.2.2.3.1 Blue and red shrimp in GSA 6&7. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 6&7 as reported by DCF.

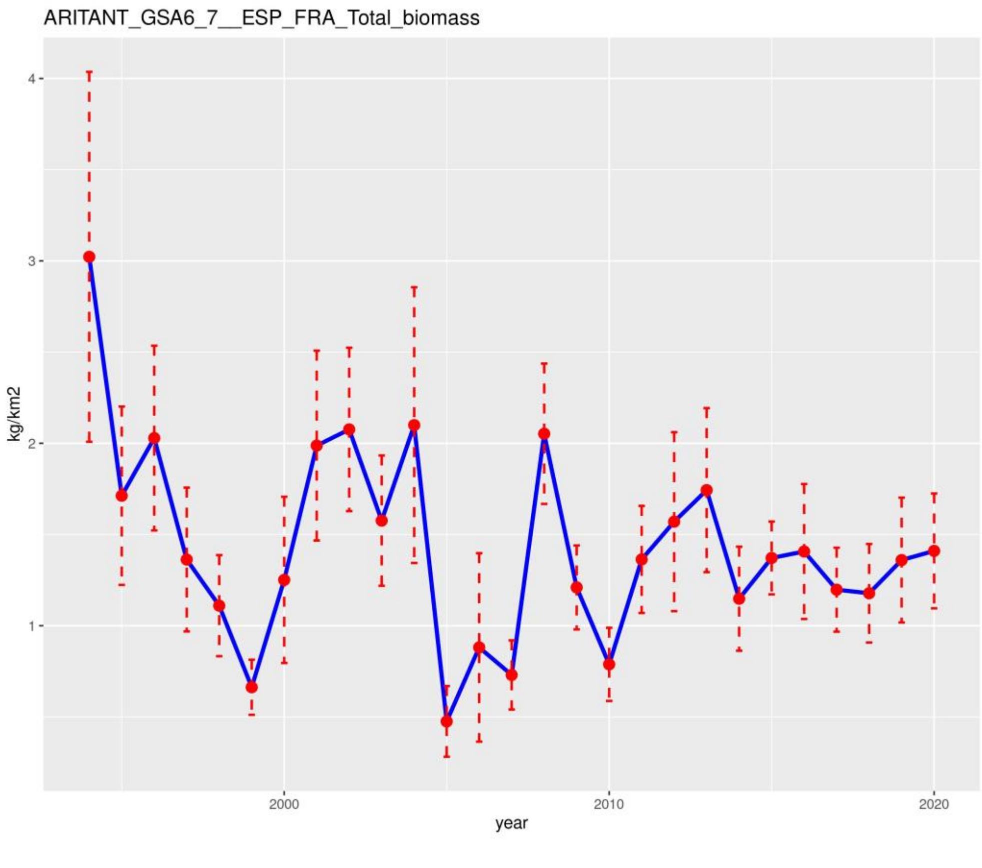


Figure 6.17.2.2.3.2 Blue and red shrimp in GSA 6&7. MEDITS survey biomass index (kg/km^2) as reported by DCF.

Table 6.17.2.2.3 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	112.73	3.02
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	99.50	1.41

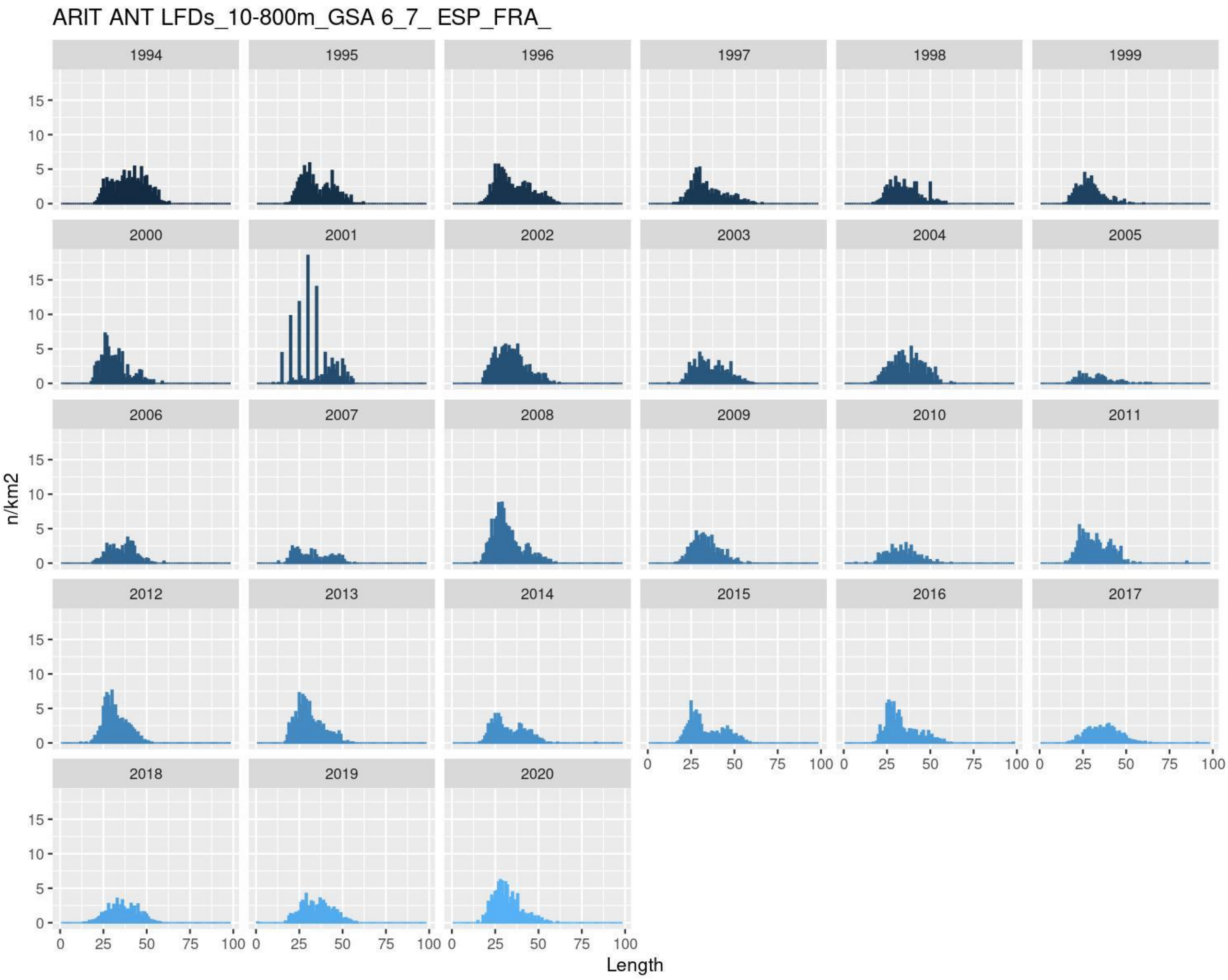


Figure 6.17.2.2.3.3 Blue and red shrimp in GSA 6&7. Length frequency distribution of the MEDITS survey abundance index (n/km^2) as reported by DCF.

6.17.3 STOCK ASSESSMENT

This is an update assessment of the one that was conducted in 2020 (STECF EWG 20-09) using a4a. 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 (Figures 6.17.3.1.1 – 6.17.3.1.2). 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 6.17.2.3.3) were used for tuning of the a4a models.

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 6.17.3.3.5. It is to note the lack of age 0 (young of the year) individuals in the catches and survey due to slicing the LFD by adding 0.5 years to t0.

The cohort consistency in the catch and survey data are shown in Fig. 6.17.3.3.6 . Low consistency between cohorts is observed in survey data, except between ages 3 & 4.

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.

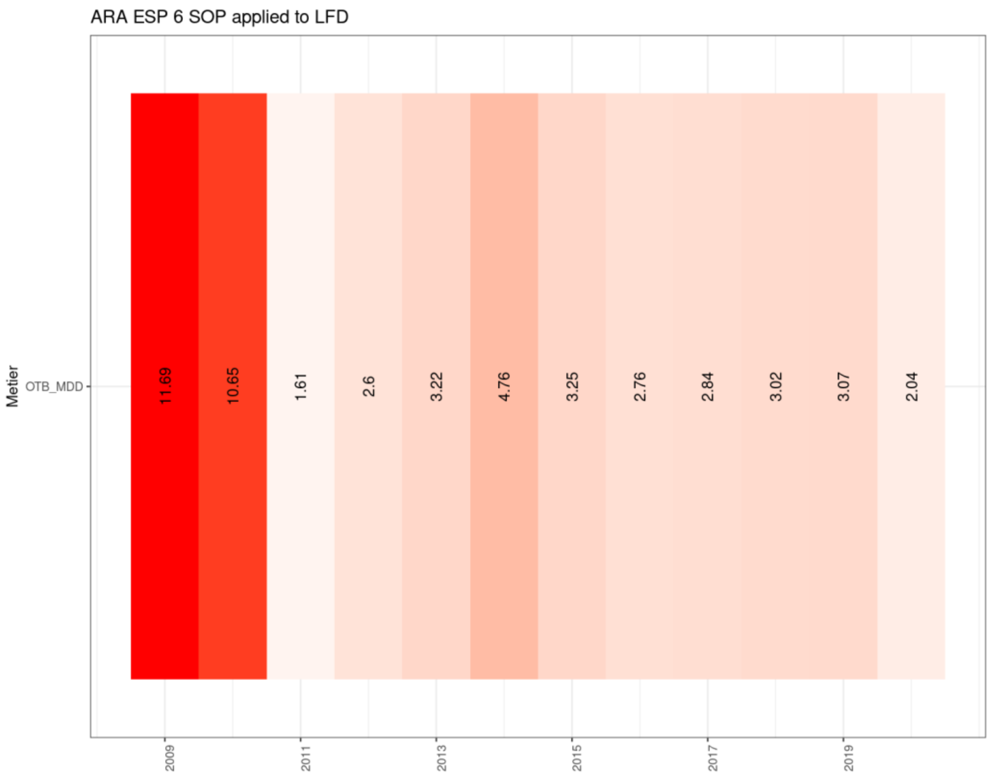


Figure 6.17.3.1.1 Blue and red shrimp in GSA 6&7. SoP correction applied to landings of Spain in GSA 6.

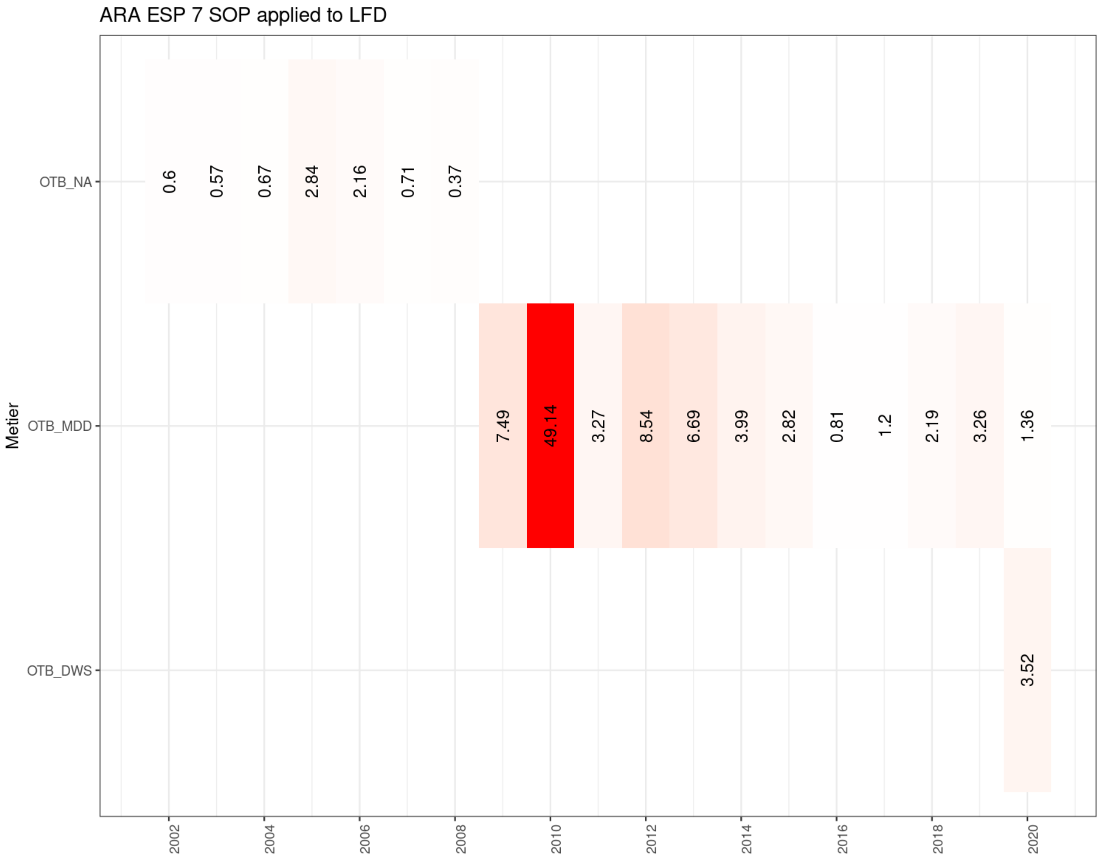


Figure 6.17.3.1.2 Blue and red shrimp in GSA 6&7. SoP correction applied to landings of Spain in GSA 7.

6.17.3.3 Stock assessment models and results

The exact same model settings were applied, as the ones used in EWG 20-09.

A4a submodels:

Fishing mortaliy: fmodel <- ~ s(year, k=9) + factor(replace(age,age>3,3))

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 0 and 1 and moderate through the rest of the ages. Cohort consistency of the index is poor across all ages except 3 and 4.

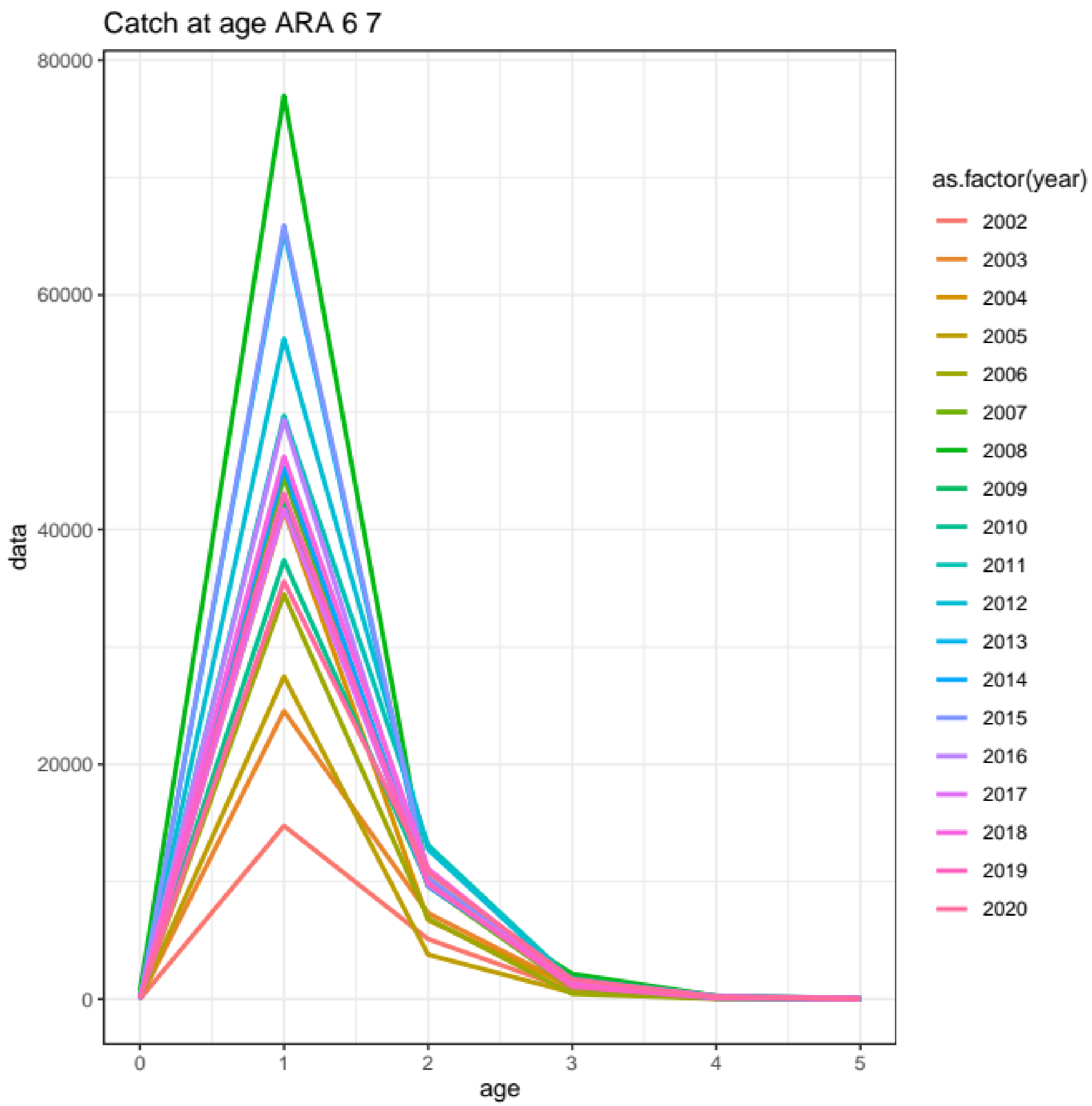


Figure 6.17.3.3.1 Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals (thousands) at age of the catch in GSA 6&7 (2002-2020). Data from DCF.

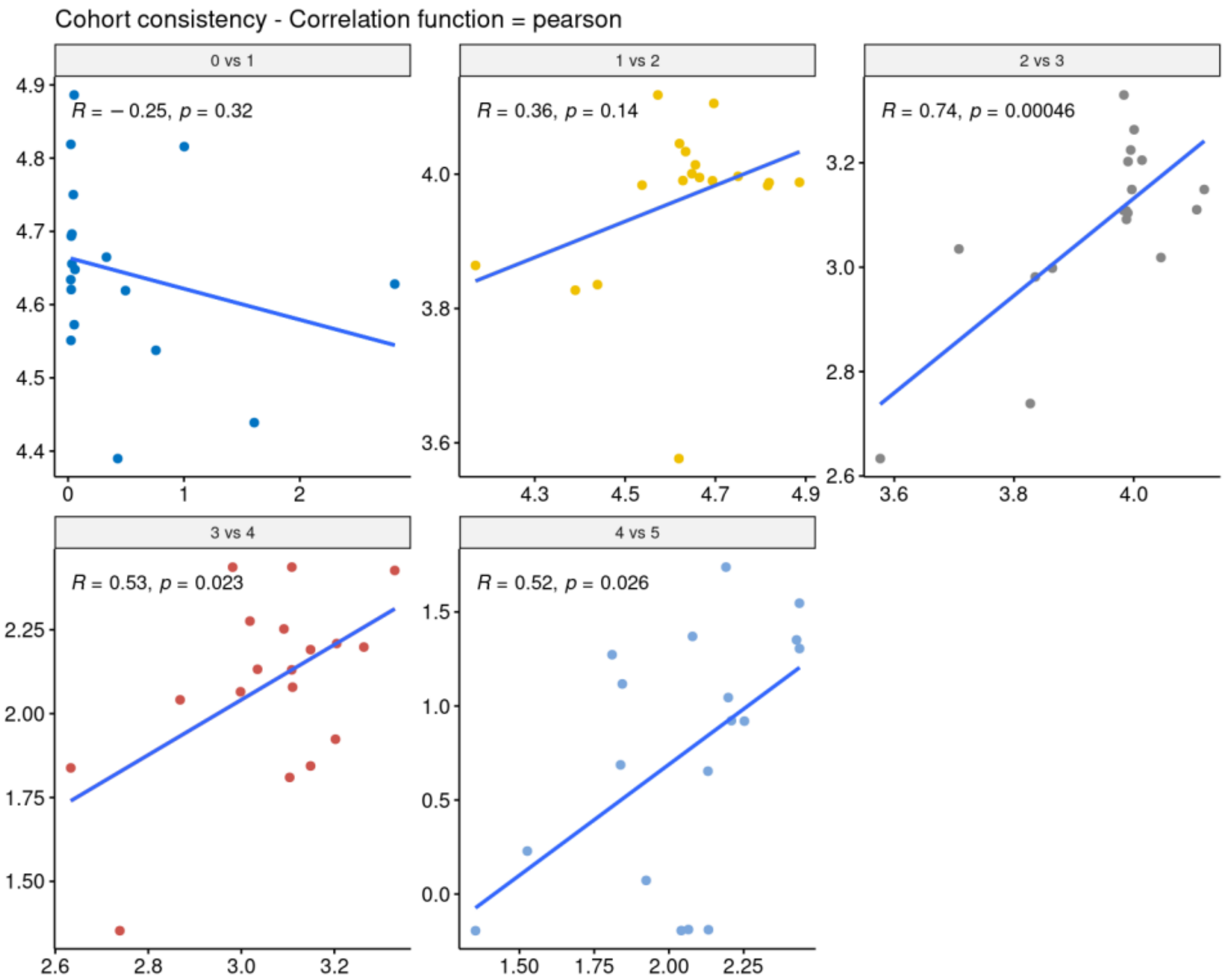


Figure 6.17.3.3.2 Blue and red shrimp in GSA 6&7. Cohort consistency in the catch.

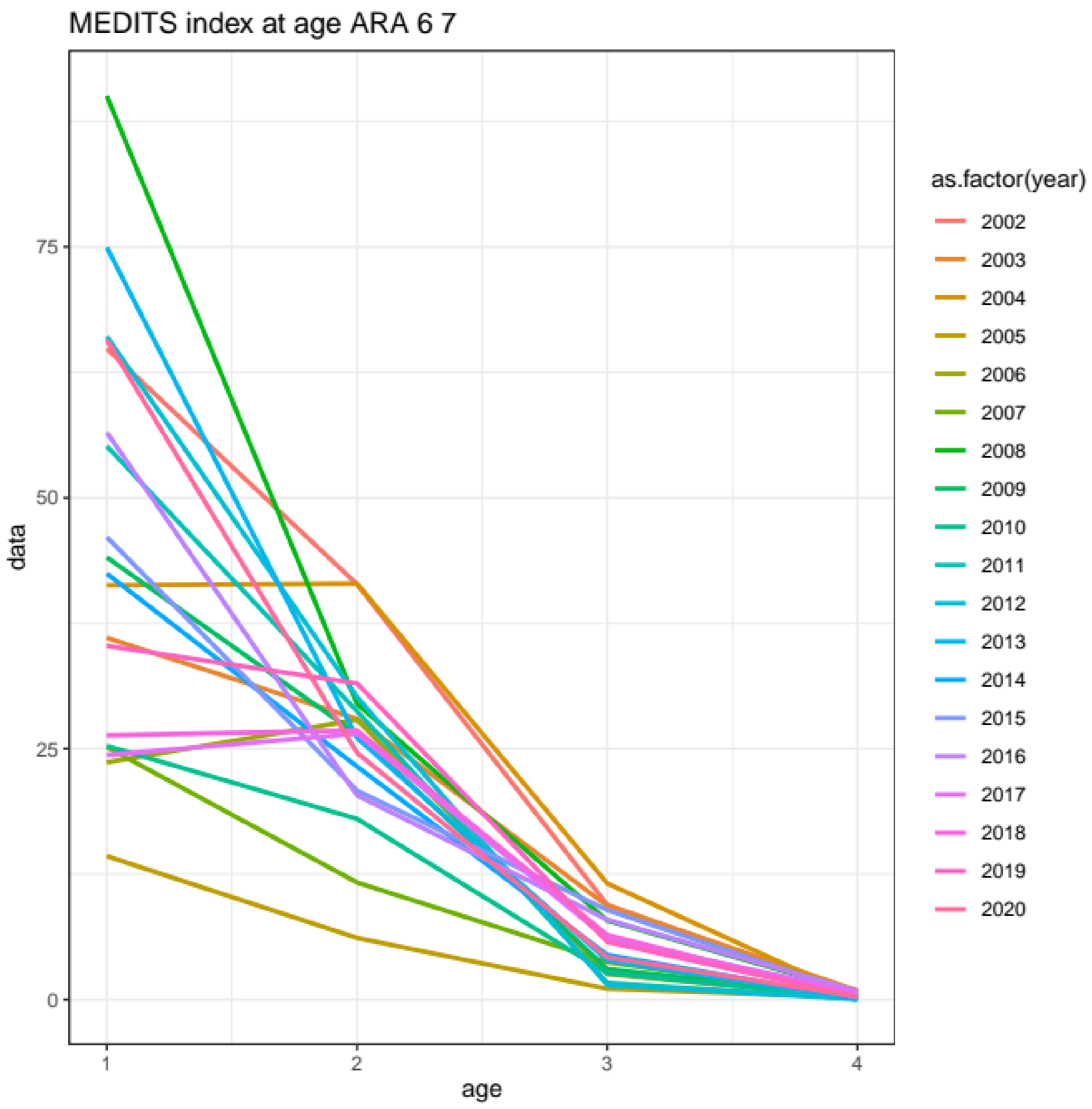


Figure 6.17.3.3.3 Blue and red shrimp in GSA 6&7. Age composition of the MEDITS survey as reported by DCF.

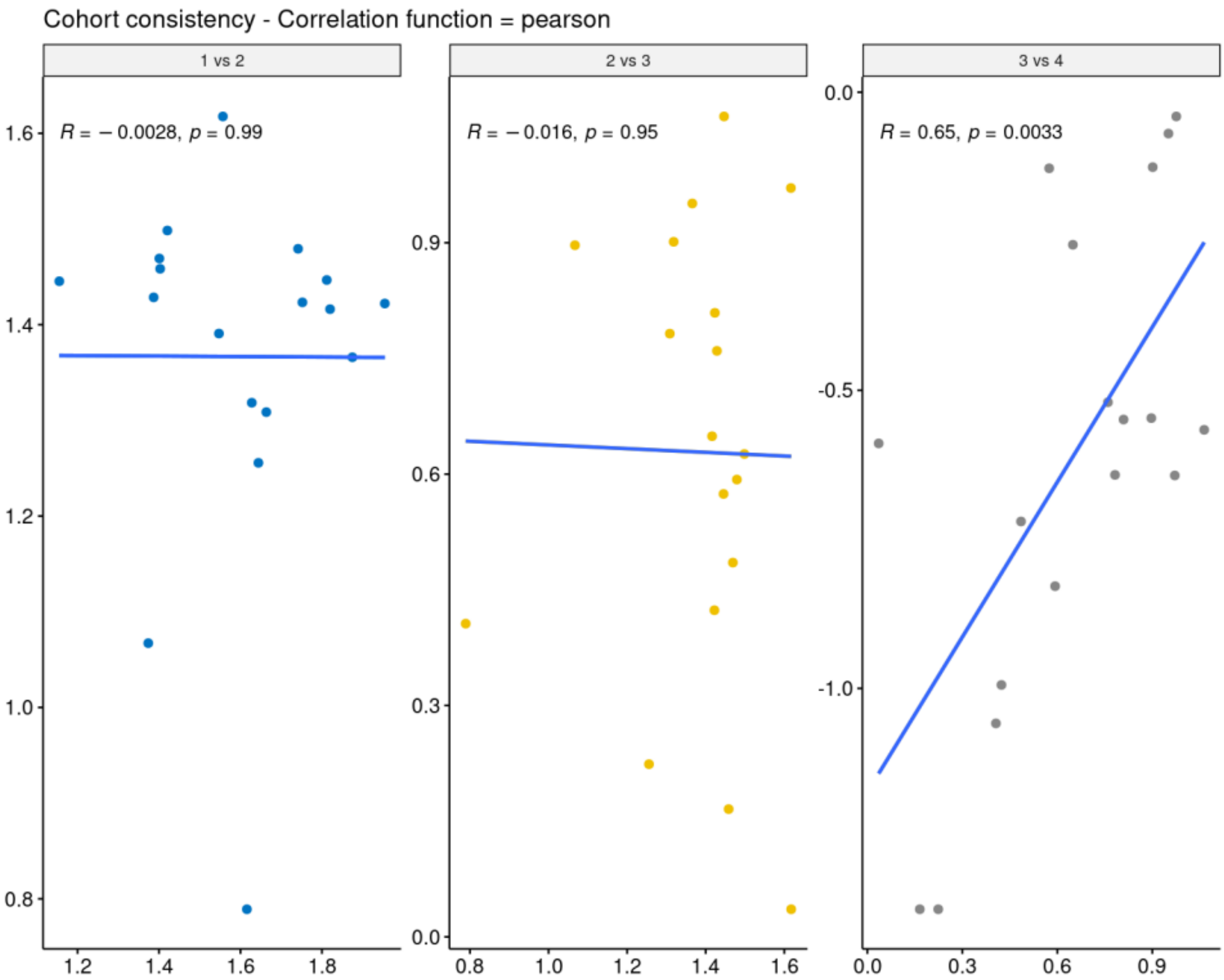


Figure 6.17.3.3.4 Blue and red shrimp in GSA 6&7. Cohort consistency of the inde4.

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 (Figure 6.17.3.3.8). In both years, the assessments did not appear to follow the observed catches, and discrepancies were noted in some years. Different models were tested to better match catches, but this was not possible, and the model settings from last year's assessment were considered the best fit.

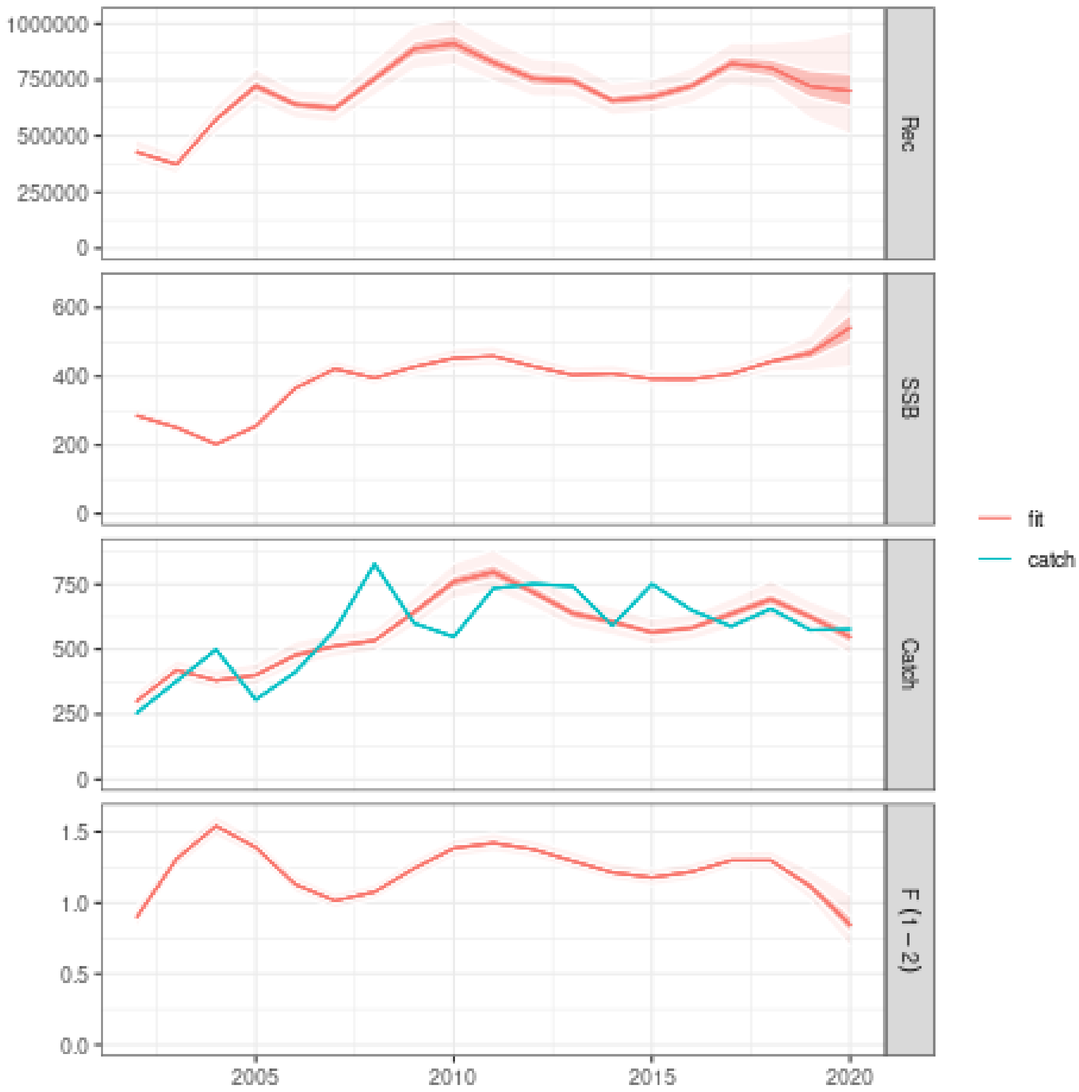


Figure 6.17.3.3.5 Blue and red shrimp in GSA 6&7. Results of the stock assessment with 95% confidence limits and the observed catch.

Compared to last year, this year there is a clear increasing trend in the biomass in the last three years while the F is declining to the minimum value of the whole time series. Recruitment, although is declining it is still remain in high levels, above 700.000 thousands.

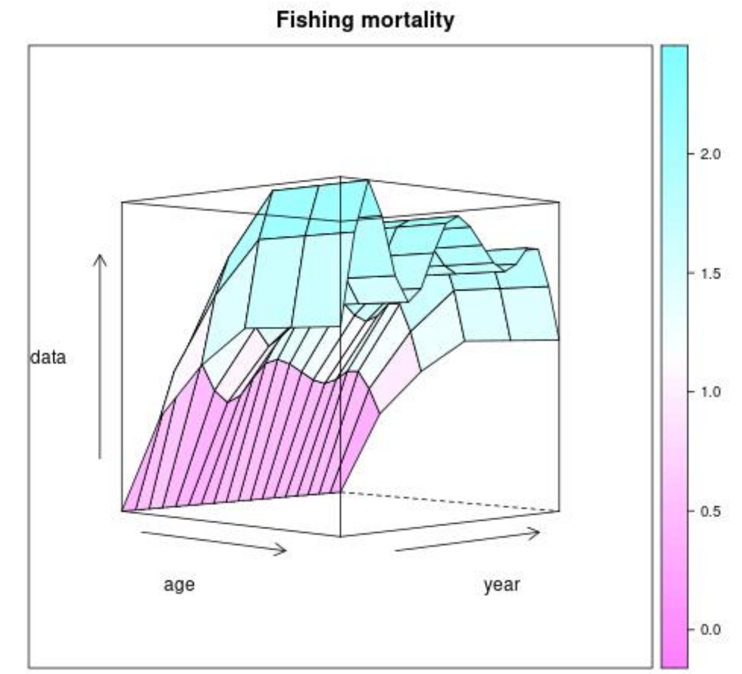


Figure 6.17.3.3.6 Blue and red shrimp in GSA 6&7. 3D plot of fishing mortality by age and year.

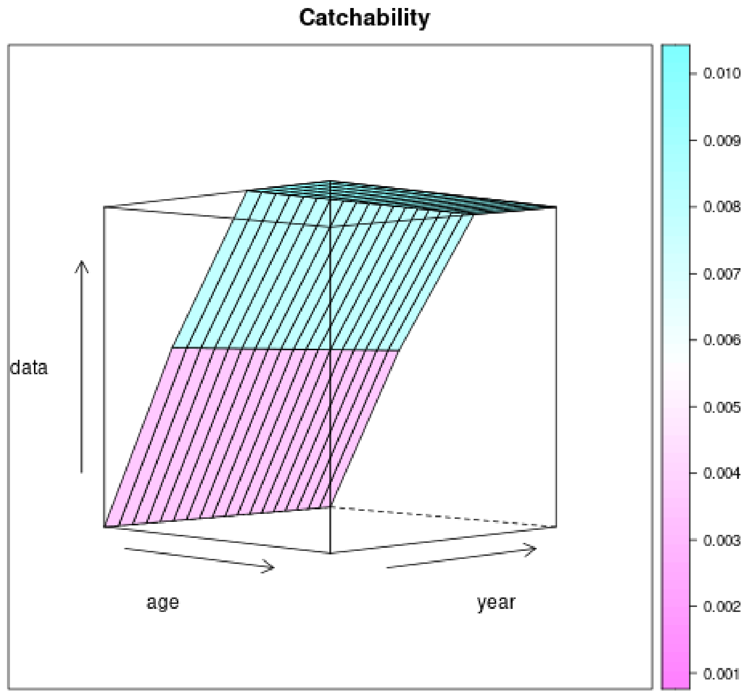


Figure 6.17.3.3.6 Blue and red shrimp in GSA 6&7. 3D plot of catchability by age and year.

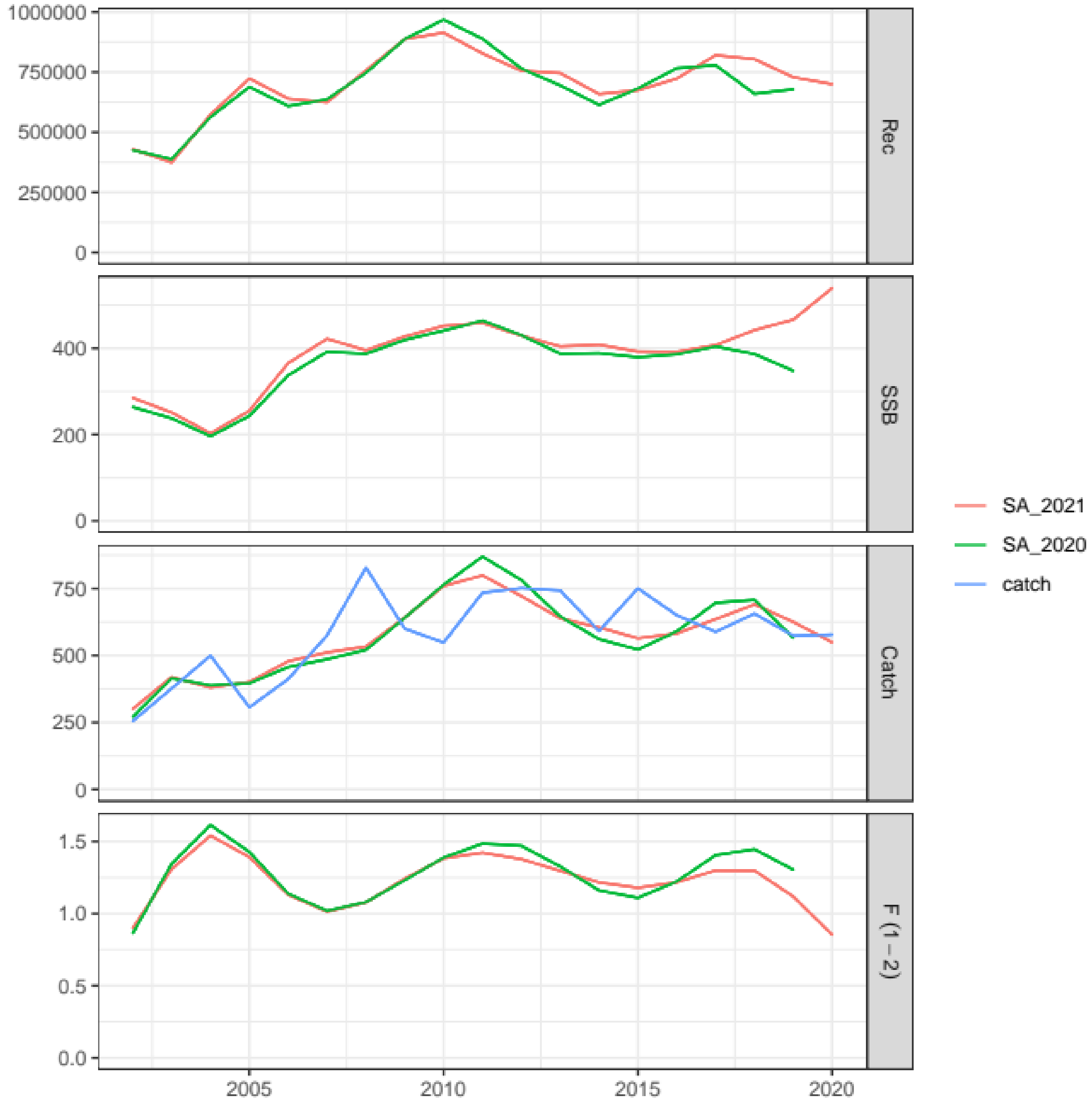


Figure 6.17.3.3.8 Blue and red shrimp in GSA 6&7. Comparison of the assessment of STECF EWG 20-09 and this year's assessment.

The Figures (6.17.3.3.9 – 6.17.3.3.13) 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 residuals of the catches and indices by age did not show any major problems, except for the catches of age 5, which showed a negative pattern at the beginning of the time series, partly due to the lack of a tuning index for this age. The fitted versus observed catch at age was good, with some discrepancies on age 1 in 2008, while the fitted versus observed index by age was poor in some cases especially in 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).

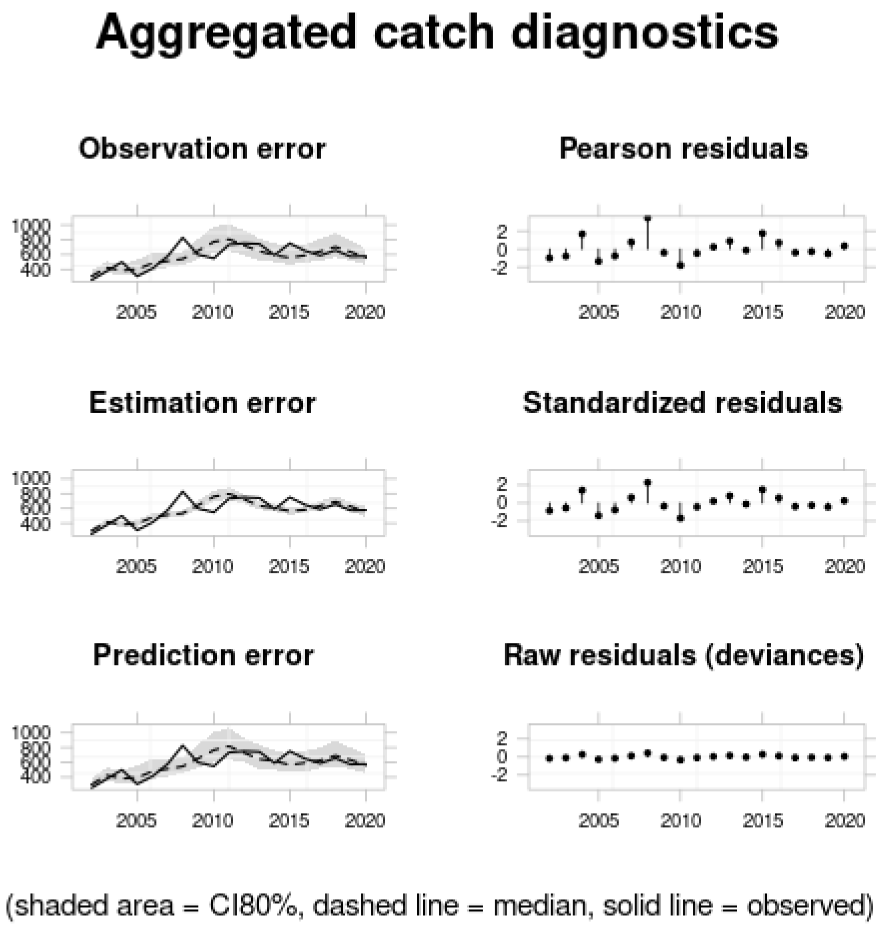


Figure 6.17.3.3.9 Blue and red shrimp in GSA 6&7. Catch diagnostics for the a4a assessment.

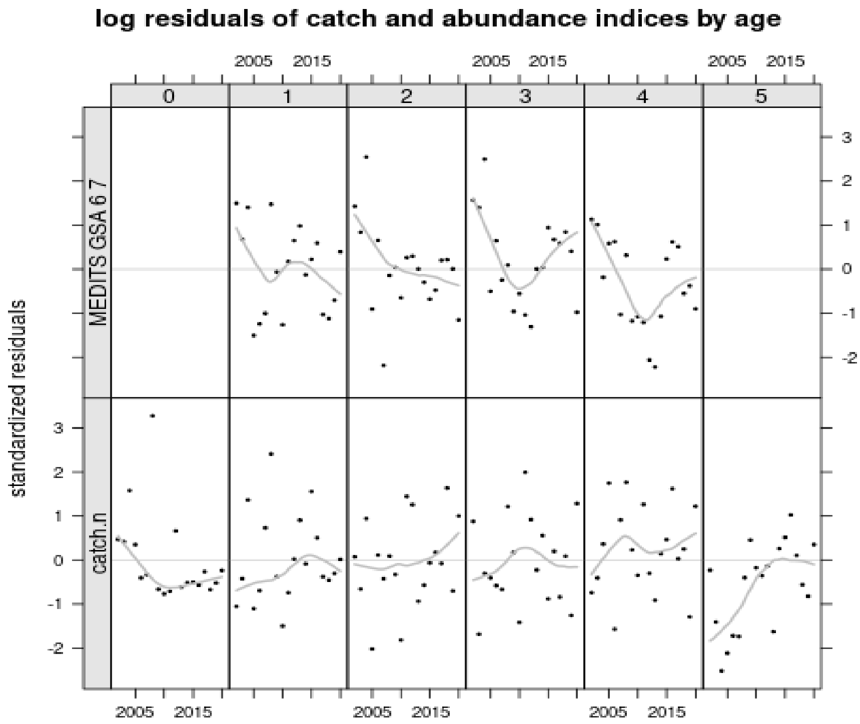


Figure 6.17.3.3.10 Blue and red shrimp in GSA 6&7. Catch at age and Index by age residuals.

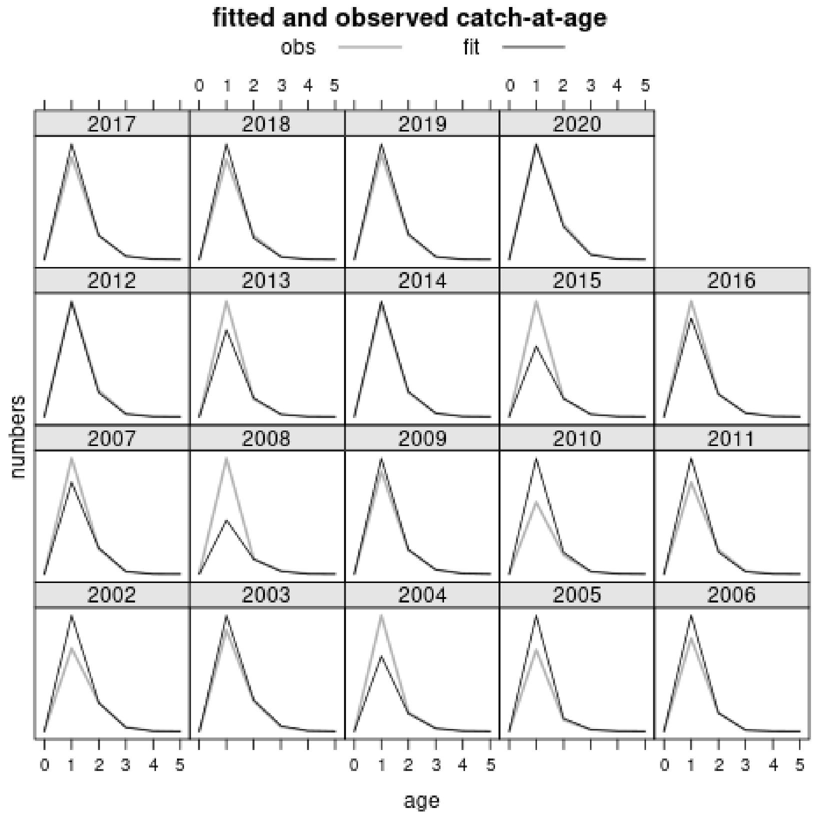


Figure 6.17.3.3.11 Blue and red shrimp in GSA 6&7. Fitted versus observed catch by age and year.

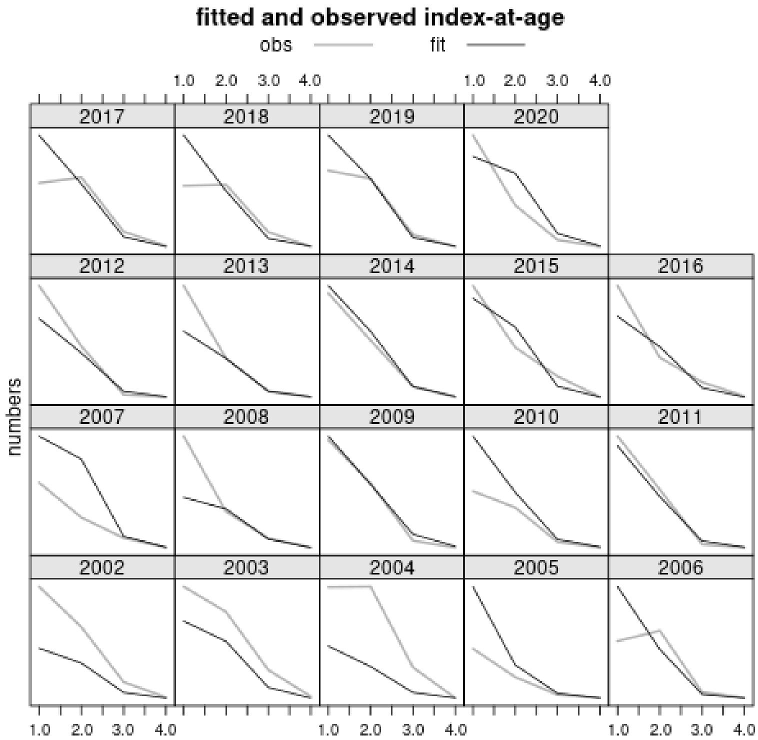


Figure 6.17.3.3.12 Blue and red shrimp in GSA 6&7. Fitted versus observed index by age and year.

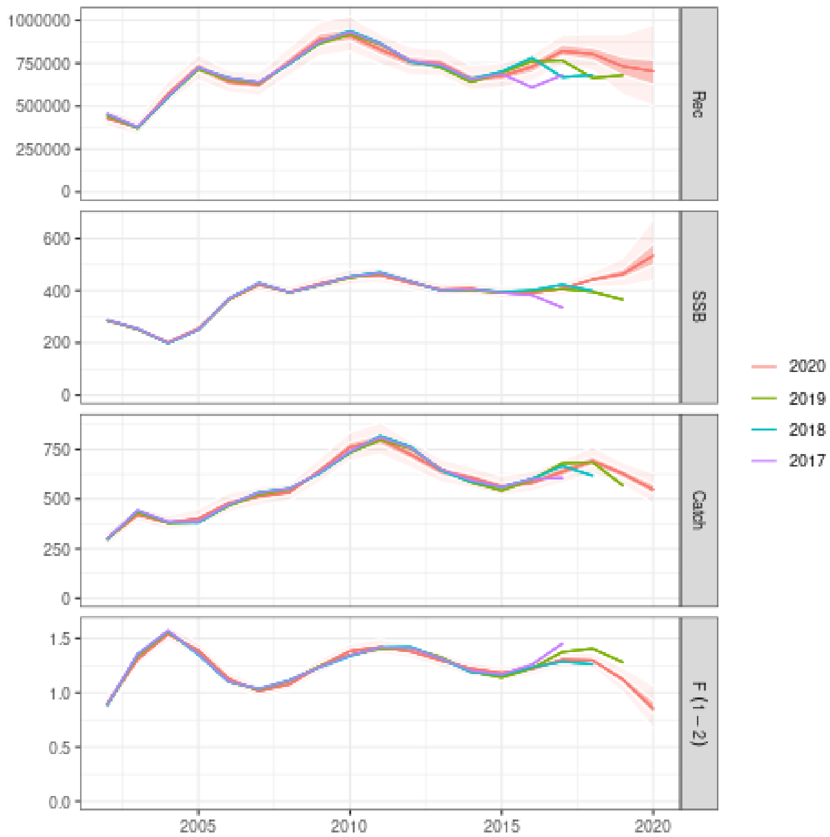


Figure 6.17.3.3.13 Blue and red shrimp in GSA 6&7. Retrospective plot for 3 years back.

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	0.078	-0.163	-0.131

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	0	1	2	3	4	5
2002	6.45738E-06	0.713192	1.08564	1.33972	1.33972	1.33972
2003	9.39967E-06	1.03816	1.5803	1.95016	1.95016	1.95016
2004	1.1061E-05	1.22164	1.85961	2.29484	2.29484	2.29484
2005	9.99106E-06	1.10347	1.67973	2.07286	2.07286	2.07286
2006	8.11637E-06	0.896421	1.36455	1.68391	1.68391	1.68391
2007	7.28462E-06	0.804558	1.22472	1.51135	1.51135	1.51135
2008	7.73628E-06	0.854442	1.30065	1.60506	1.60506	1.60506
2009	8.92014E-06	0.985194	1.49968	1.85067	1.85067	1.85067
2010	9.93268E-06	1.09703	1.66992	2.06075	2.06075	2.06075
2011	1.02099E-05	1.12764	1.71652	2.11826	2.11826	2.11826
2012	9.89025E-06	1.09234	1.66278	2.05194	2.05194	2.05194
2013	9.31074E-06	1.02833	1.56535	1.93171	1.93171	1.93171
2014	8.73382E-06	0.964616	1.46836	1.81202	1.81202	1.81202
2015	8.46564E-06	0.934997	1.42327	1.75638	1.75638	1.75638
2016	8.74106E-06	0.965416	1.46958	1.81352	1.81352	1.81352
2017	9.32949E-06	1.03041	1.5685	1.9356	1.9356	1.9356
2018	9.32272E-06	1.02966	1.56737	1.9342	1.9342	1.9342
2019	8.02858E-06	0.886725	1.34979	1.6657	1.6657	1.6657
2020	6.12608E-06	0.676602	1.02994	1.27099	1.27099	1.27099

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	0	1	2	3	4	5
2002	429176	56981	9712	1106	71	3
2003	374376	60049	11963	1782	174	12
2004	573899	52381	9109	1338	152	17
2005	723769	80298	6614	771	81	11
2006	639962	101267	11411	670	58	7
2007	624931	89541	17701	1584	75	8
2008	757433	87438	17157	2825	209	11
2009	887532	105977	15939	2538	340	28
2010	914297	124180	16951	1933	239	37
2011	828081	127924	17761	1734	147	22
2012	756117	115861	17745	1734	125	13
2013	746420	105792	16649	1828	133	11
2014	659242	104436	16207	1890	159	13
2015	674513	92238	17052	2028	185	18
2016	723276	94375	15513	2232	210	22
2017	820914	101198	15397	1938	218	24
2018	804422	114859	15471	1743	168	22
2019	729079	112551	17573	1753	151	17
2020	700194	102010	19865	2475	199	20

Table 6.17.3.3.3 Blue and red shrimp in GSA 6&7. Stock summary: number of recruits, SSB, Total Biomass, Fbar 1-2**,** estimated catch

Year	Recruitment (thousands)	SSB (t)	TB (t)	Fbar (1-2)	Catch (t)
2002	429176	285	1316	0.90	301
2003	374376	251	1289	1.31	419
2004	573899	203	1514	1.54	380
2005	723769	255	1856	1.39	401
2006	639962	366	1922	1.13	478
2007	624931	422	1987	1.01	512
2008	757433	395	1808	1.08	533
2009	887532	428	2480	1.24	642
2010	914297	452	2682	1.38	760
2011	828081	459	2622	1.42	799
2012	756117	429	2473	1.38	722
2013	746420	404	2254	1.30	638
2014	659242	408	2109	1.22	605
2015	674513	393	2056	1.18	564
2016	723276	392	2140	1.22	582
2017	820914	407	2443	1.30	636
2018	804422	442	2459	1.30	690
2019	729079	466	2317	1.12	625
2020	700194	540	2302	0.85	549

6.17.4 REFERENCE POINTS

The STECF EWG 21-11 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. Current F (0.85) F in 2020 is higher than $F_{0.1}$ (0.29), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that blue and red shrimp stock in GSAs 6 is being over-exploited.

6.17.5 SHORT TERM FORECAST AND CATCH OPTIONS

6.17.5.1 Method

A deterministic short term prediction for the period 2020 to 2023 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment (Ch. 6.17.3.2).F status quo used for F2021 is based on the F in 2020 because F is declining (see Section 4)

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 (2021)	0.853	Fsq = F in the last year
SSB (2021)	577	SSB intermediate year from STF output
Rage0 (2021,2022)	740193	Recruitment will be set as geometric mean of the last 6 years
Total Catch (2021)	600	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 Fig. 6.17.5.1. and Table 6.17.5.1.

The current Fbar (0.85), F in 2020, is 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 6&7 is over exploited. The catch of blue and red shrimp in 2021, consistent with $F_{0.1}$ (0.29), should not exceed 267 tonnes, 51% less than the current estimated catch (549 t).

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).

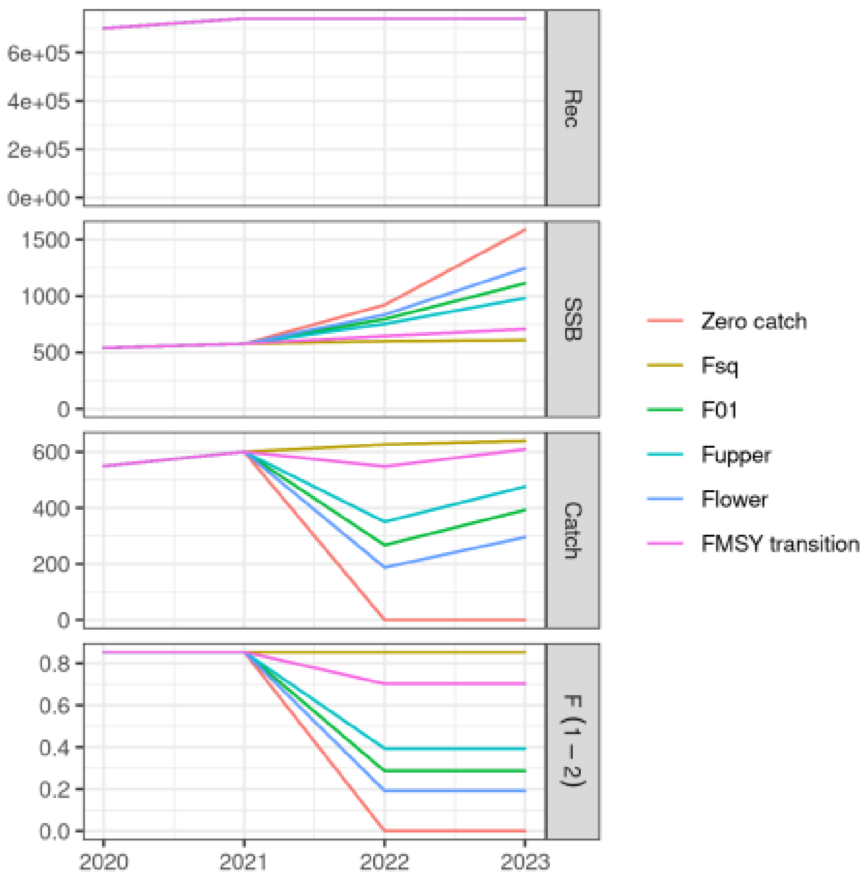


Table 6.17.5.1 Blue and red shrimp (ARA) in GSA 6&7. Short term forecast. Annual catch scenarios and predictions of catch and SSB. All weights are in tonnes. Basis: F(status quo) = F 2020 = 0.85 Catch (2020) = 566 t, Recruitment= geometric mean of Recruits 2015-F 2020.

Rationale	Ffactor	Fbar 2022	Catch 2022	SSB 2021	SSB 2023	SSB_change_ 2021-2023(%)	Catch_change_2 020-2022(%)
High long term yield ($F_{0.1}$)	0.33	0.286	267	577	1112	93	-51
F upper	0.46	0.393	351	577	982	70	-36
F lower	0.22	0.192	187	577	1246	116	-66
F_{MSY} transition	0.82	0.702	548	577	706	22	0
Zero catch	0	0	0	577	1587	175	-100
Status quo	1	0.853	626	577	610	6	14
Different Scenarios	0.1	0.085	88	577	1422	147	-84
	0.2	0.171	168	577	1278	122	-69
	0.3	0.256	243	577	1152	100	-56
	0.4	0.341	311	577	1042	81	-43
	0.5	0.427	375	577	946	64	-32
	0.6	0.512	433	577	861	49	-21
	0.7	0.597	487	577	786	36	-11
	0.8	0.683	537	577	720	25	-2
	0.9	0.768	583	577	662	15	6
	1.1	0.939	666	577	564	-2	21
	1.2	1.024	703	577	523	-9	28
	1.3	1.109	738	577	487	-16	34
	1.4	1.195	770	577	454	-21	40
	1.5	1.28	800	577	425	-26	46
	1.6	1.365	828	577	398	-31	51
	1.7	1.451	854	577	375	-35	56
	1.8	1.536	878	577	353	-39	60
	1.9	1.621	901	577	333	-42	64
	2	1.707	923	577	316	-45	68

*SSB at mid-year

6.18 BLUE AND RED SHRIMPS IN GSAS 9,10 AND 11

6.18.1 STOCK IDENTITY AND BIOLOGY

The assessment of Blue and red shrimp carried out during the STECF EWG 21-11 considered the stock shared by the GSAs 9, 10 and 11.

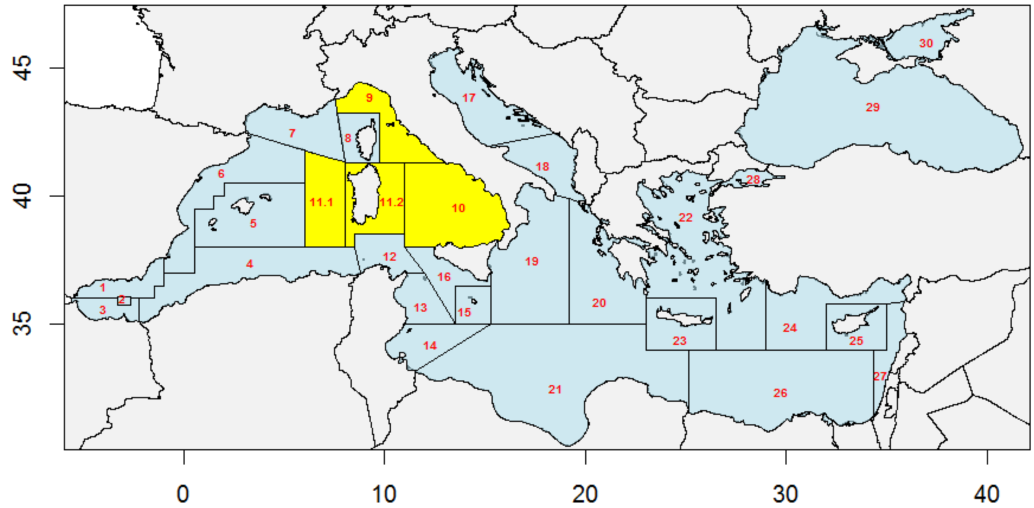


Figure 6.18.1.1. Geographical location of GSAs 9, 10 and 11.

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 one (STECF EWG 19-10, STECF EWG 20-09):

Females: $L\infty$= 76.9, K=0.21, t0=-0.02 and

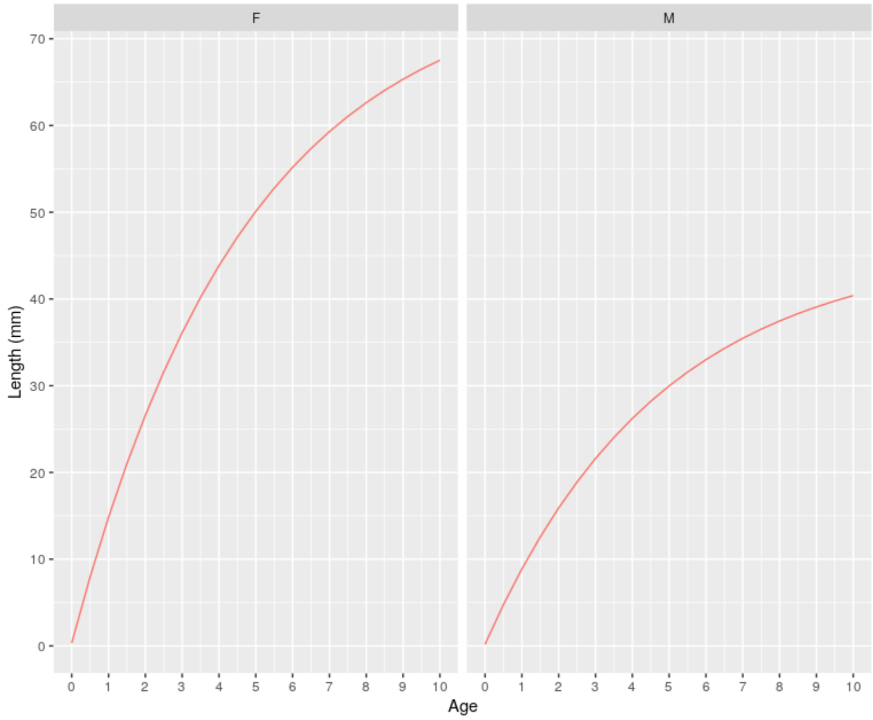
Males: $L\infty$= 46, K=0.21, t0=-0.02.

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 20-09 used the above set of growth parameters to convert catch in length into age (Figure 6.18.1.2).

LW relationship parameters by GSA were also very similar among GSAs. As in previous assessments 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 and STECF EWG 20-09).

The VBGF and LW relationship parameters used are summarized in the following Table (Tab. 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 9, 10 and 11. Von Bertalanffy growth curves by sex used in the assessment (Orsi Relini and Relini, 1998).

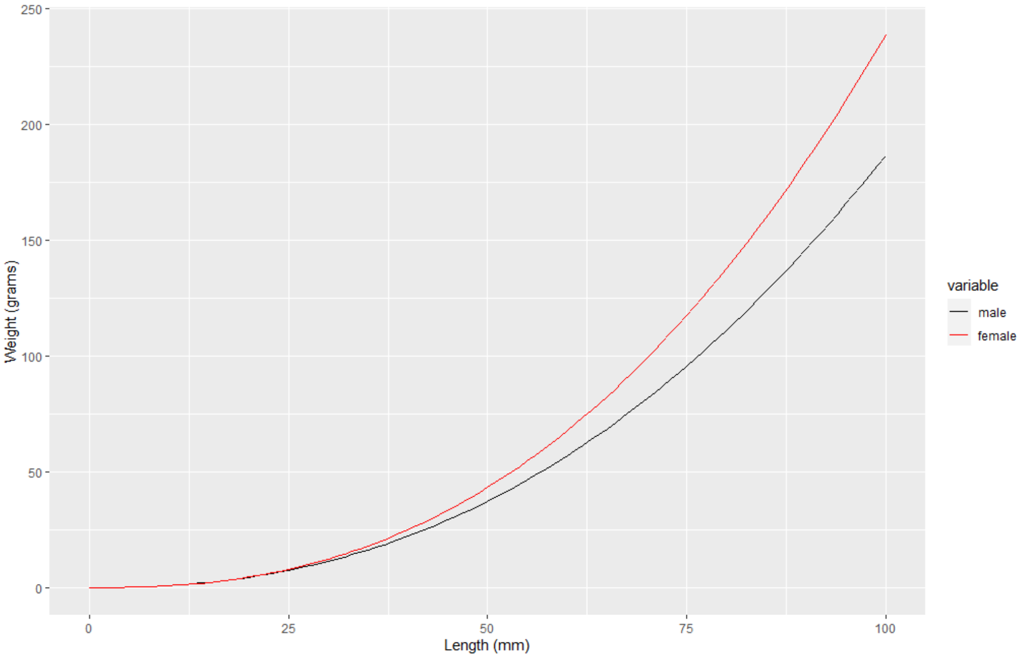


Figure 6.18.1.3. Blue and red shrimp in GSAs 9, 10 and 11. Length weight relationship by sex and GSA as median of a and b parameters provided through DCF for GSA 9.

Table 6.18.1.1. Blue and red shrimp in GSAs 9, 10 and 11. Growth parameters and length-weight relationship parameters used in the assessment.

GSA	Sex	Linf	k	t0	a	b
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 from GSA9 was used computed as median value by age classes (Tables 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 9, 10 and 11. Maturity vectors used in the assessment.

Maturity	0	1	2	3	4	5	6+
GSA 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 9, 10 and 11. Natural mortality vectors used in the assessment.

M	0	1	2	3	4	5	6+
GSA 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 otter bottom trawling. In the past, in particular in the GSA10 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 21-11 through the DCF. Landings data by year and fleet are presented in Figure 6.18.2.1.1, total landings by year are presented in Table 6.18.2.1.1.

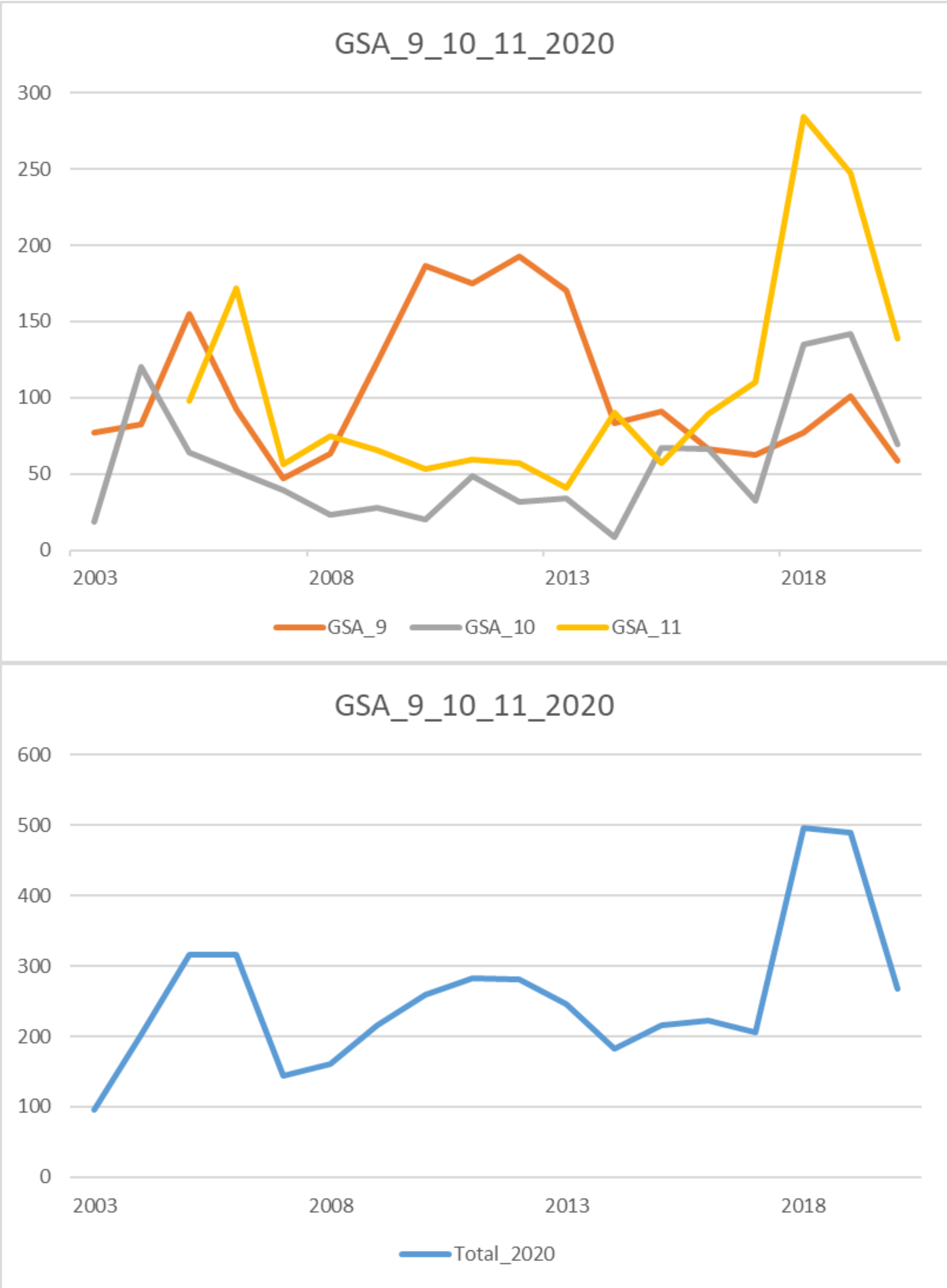


Figure 6.18.2.1.1. Blue and red shrimp in GSAs 9, 10 and 11. (top) Landings data in tons by year and area, (bottom) total landings for all GSAs.

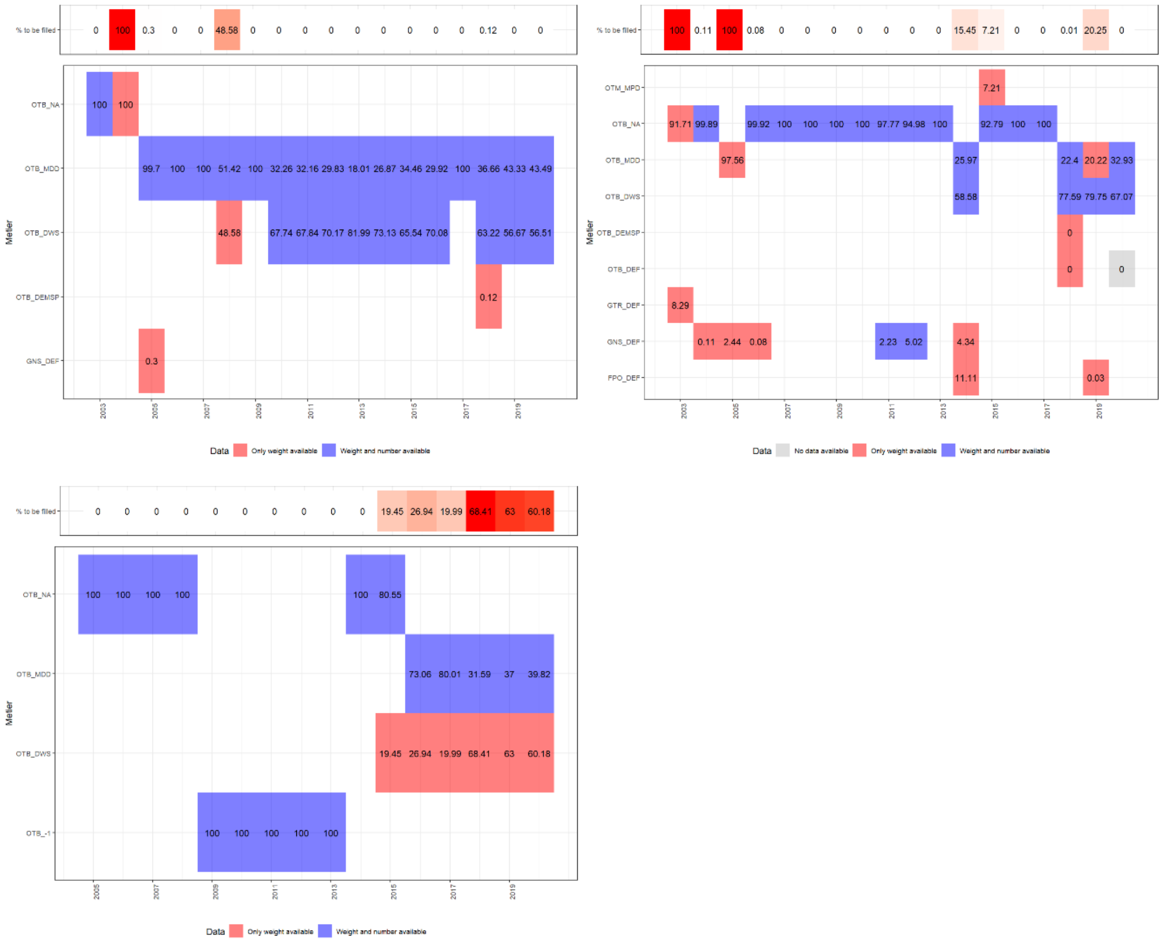
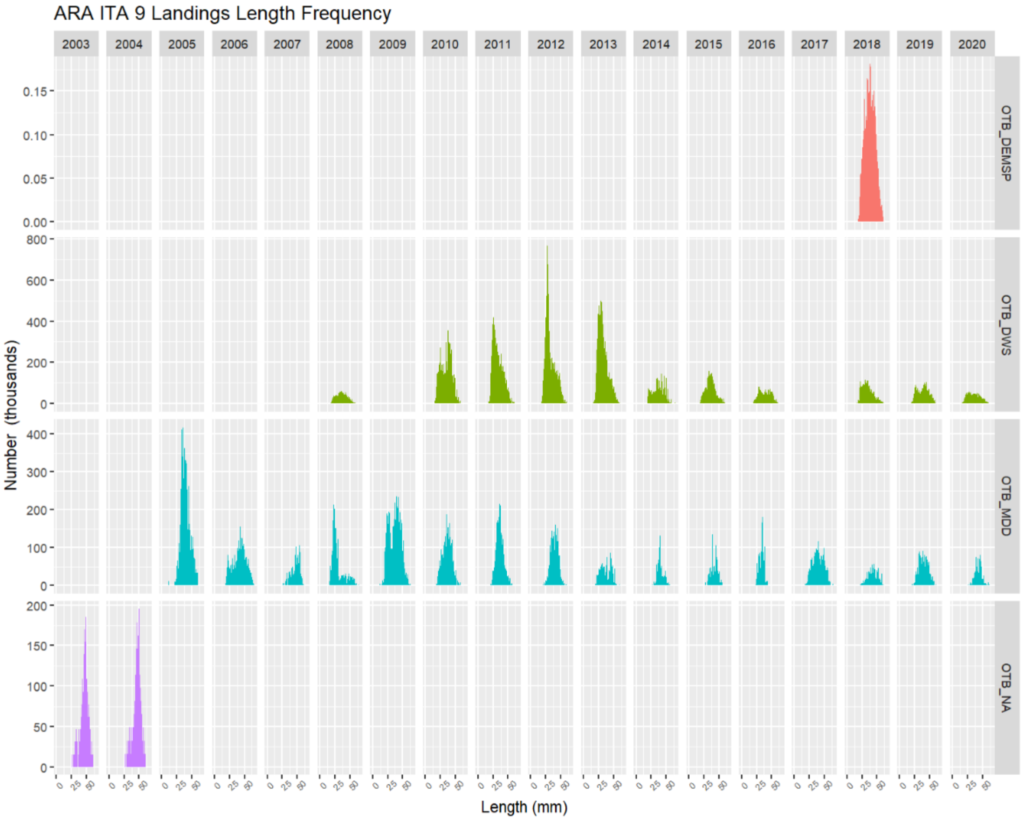


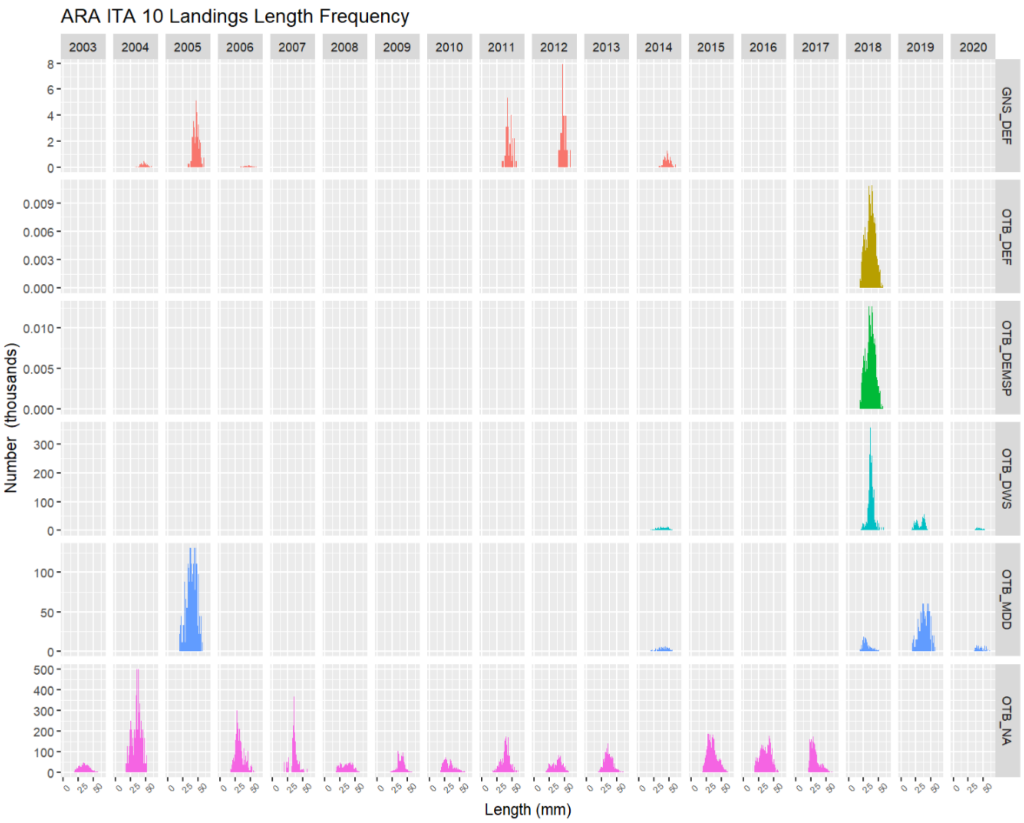
Figure 6.18.2.1.2. Blue and red shrimp in GSAs 9, 10 and 11. Missing years of landings per gear and percentage to be filled by SOP correction for GSA 9 (top left), GSA 10 (top right) and GSA 11 (bottom left).

Table 6.18.2.1.1. Blue and red shrimp in GSAs 9, 10 and 11. Landings data in tons by year and GSA.

Year	GSA9	GSA10	GSA11	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	186	20	53	260
2011	175	48	59	283
2012	193	31	57	281
2013	170	34	41	245
2014	84	9	90	182
2015	91	67	57	215
2016	67	66	89	222
2017	62	33	110	205
2018	77	135	284	497
2019	101	141	247	490
2020	59	69	139	267

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.18.2.1.2.


ARA ITA 9 Landings Length Frequency
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
Number (thousands)
Length (mm)


ARA ITA 10 Landings Length Frequency
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
GNS_DEF
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
Number (thousands)
Length (mm)

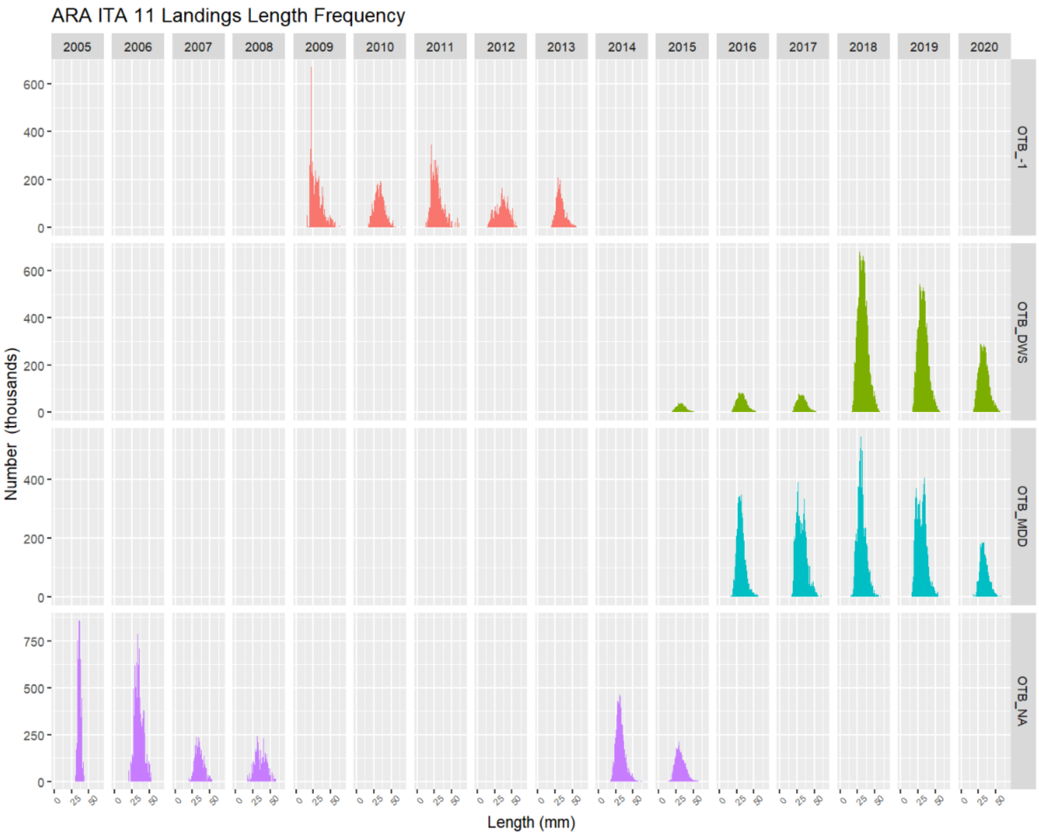


Figure 6.18.2.1.2. Blue and red shrimp in GSAs 9, 10 and 11. Length frequency distribution of the landings by year and fleet.

Discards

In general, blue and red shrimp is very rarely discarded. In the study area, very small quantities (<0.5% of the catch) of blue and red shrimp were only discarded in 2011 in GSA 9; no discard data are apparent for GSAs 10 and 11. Total discard by year for the bottom trawl fishery is presented in Table 6.18.2.1.2.

Table 6.18.2.1.2. Blue and red shrimp in GSAs 9, 10 and 11. OTB discards data in tons by GSA.

	Total Discard (tons)			
	GSA 9	**GSA10**	**GSA11**	**Total**
2003	**-**	**-**	**-**	**-**
2004	**-**	**-**	**-**	**-**
2005	**-**	**-**	**-**	**-**
2006	**-**	**-**	**-**	**-**
2007	**-**	**-**	**-**	**-**
2008	**-**	**-**	**-**	**-**
2009	**-**	**-**	**-**	**-**
2010	**-**	**-**	**-**	**-**
2011	0.403	**-**	**-**	0.403
2012	**-**	**-**	**-**	**-**
2013	**-**	**-**	**-**	**-**
2014	**-**	**-**	**-**	**-**
2015	**-**	**-**	**-**	**-**
2016	**-**	**-**	**-**	**-**
2017	**-**	**-**	**-**	**-**
2018	**-**	**-**	**-**	**-**
2019	**-**	**-**	**-**	**-**
2020	**-**	**-**	**-**	**-**

Total catch (=landings as discards were negligible and available only for GSA 9) and catch numbers at age from the single GSAs were used as input data. SOP correction was applied to catch numbers at age (Table 6.18.3.1).

Table 6.18.2.1.3. Blue and red shrimp in GSAs 9, 10 and 11. SOP correction vector.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA 9	-	0.95	-	-	-	2.23	-	-	-	-	-	-	-	-	-	-	-	-
GSA 10	2.22	-	-	0.04	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-
GSA 11	-	-	-	-	-	-	-	-	-	-	-	-	5.45	2.53	2.77	0.31	0.39	0.73

6.18.2.3 EFFORT DATA

Effort data is not available to this EWG, the effort analysis is now carried out by STECF EWG 21-13, 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 9, 10 and 11 from 2006 onwards were used, as commercial data were fully available for the three 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 6.18.2.3.1 and 6.18.2.3.2). MEDITS surveys in all three GSAs were delayed in 2020.

Figure 6.18.2.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Timing of the survey.

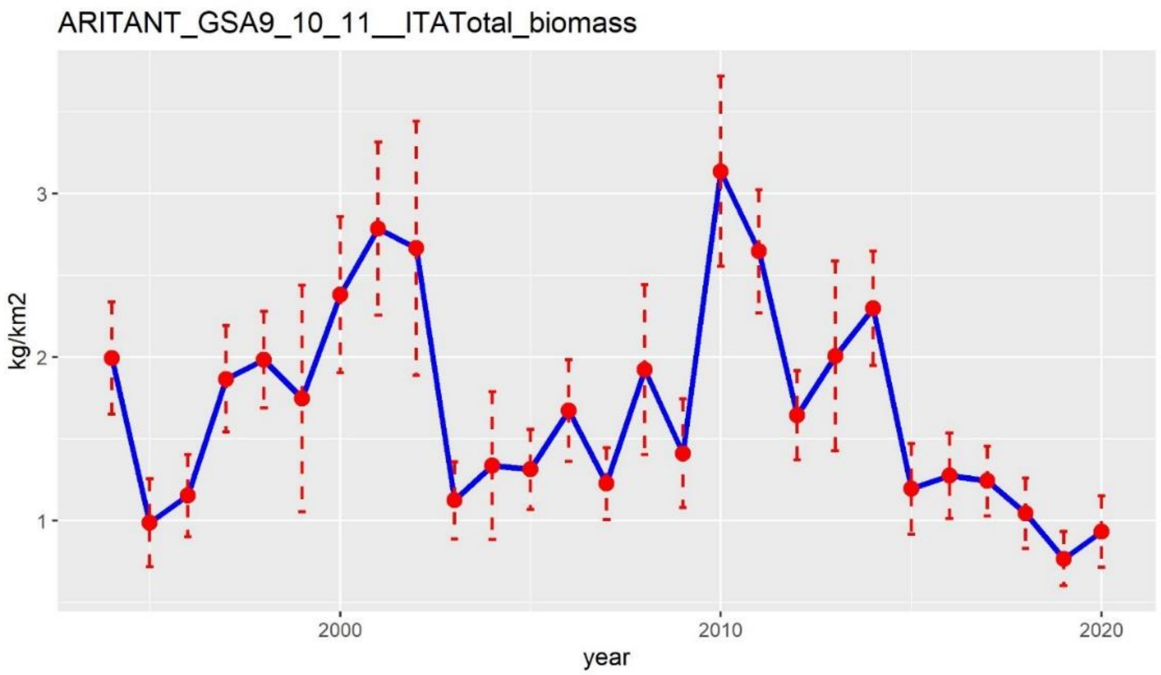


Figure 6.18.2.3.2. Blue and red shrimp in GSAs 9, 10 and 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

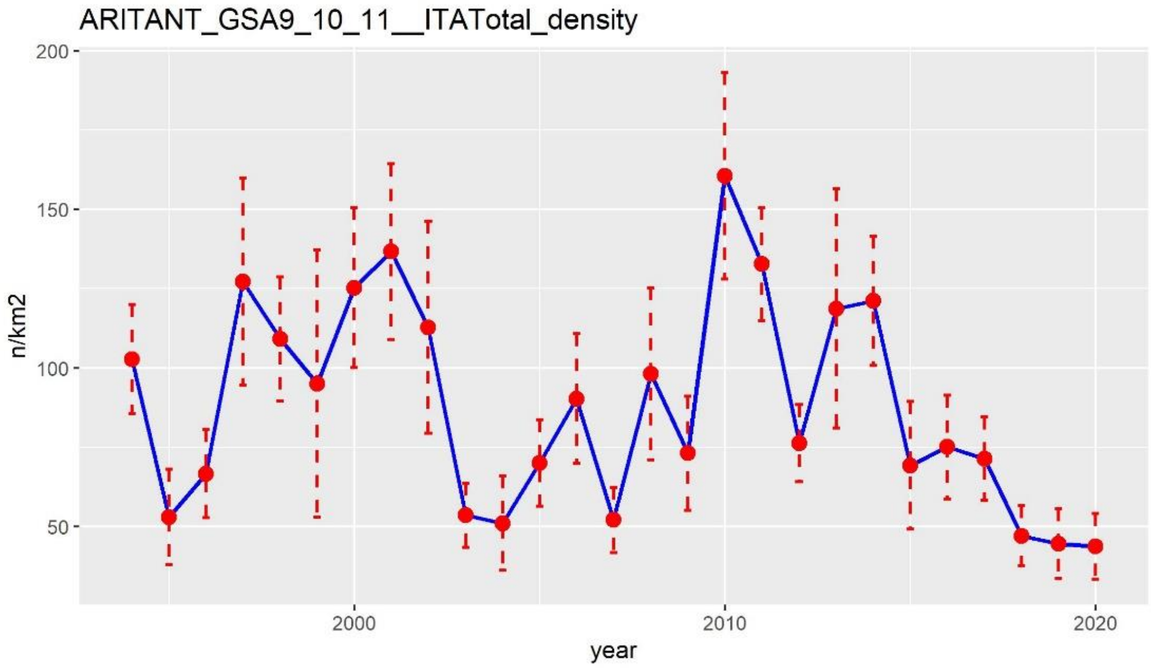
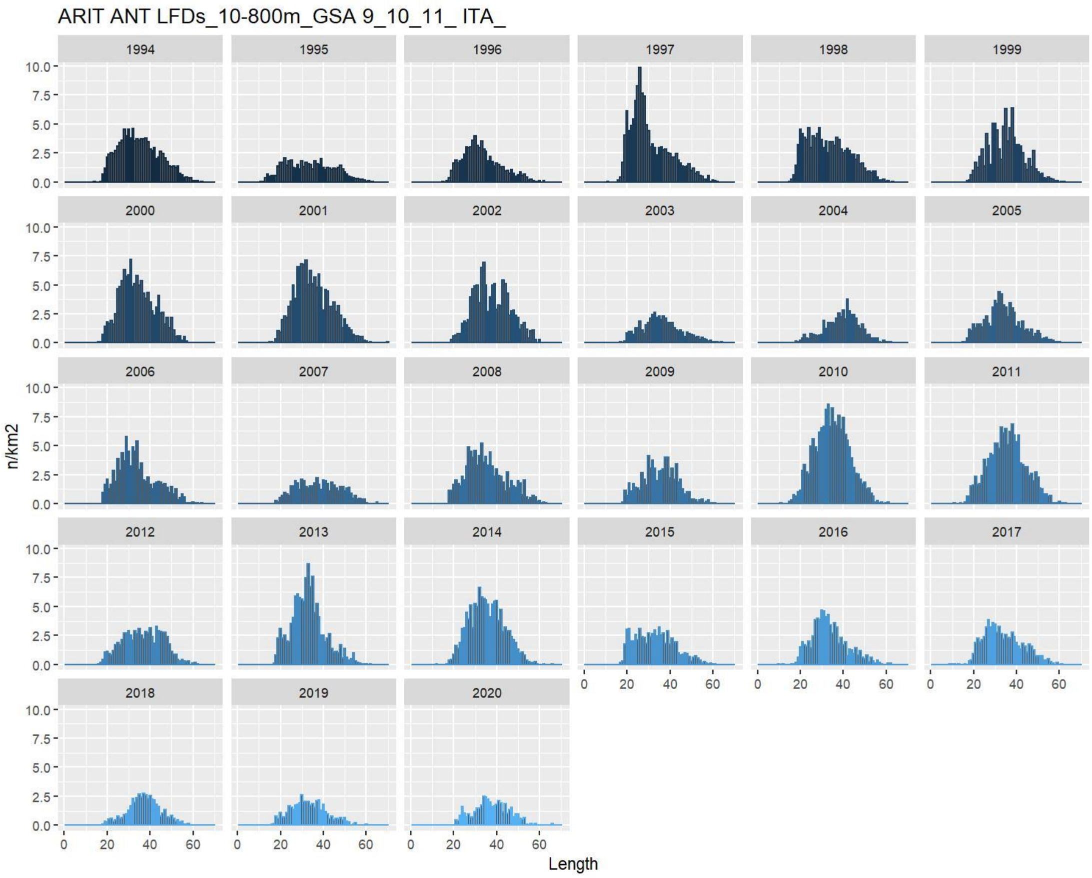
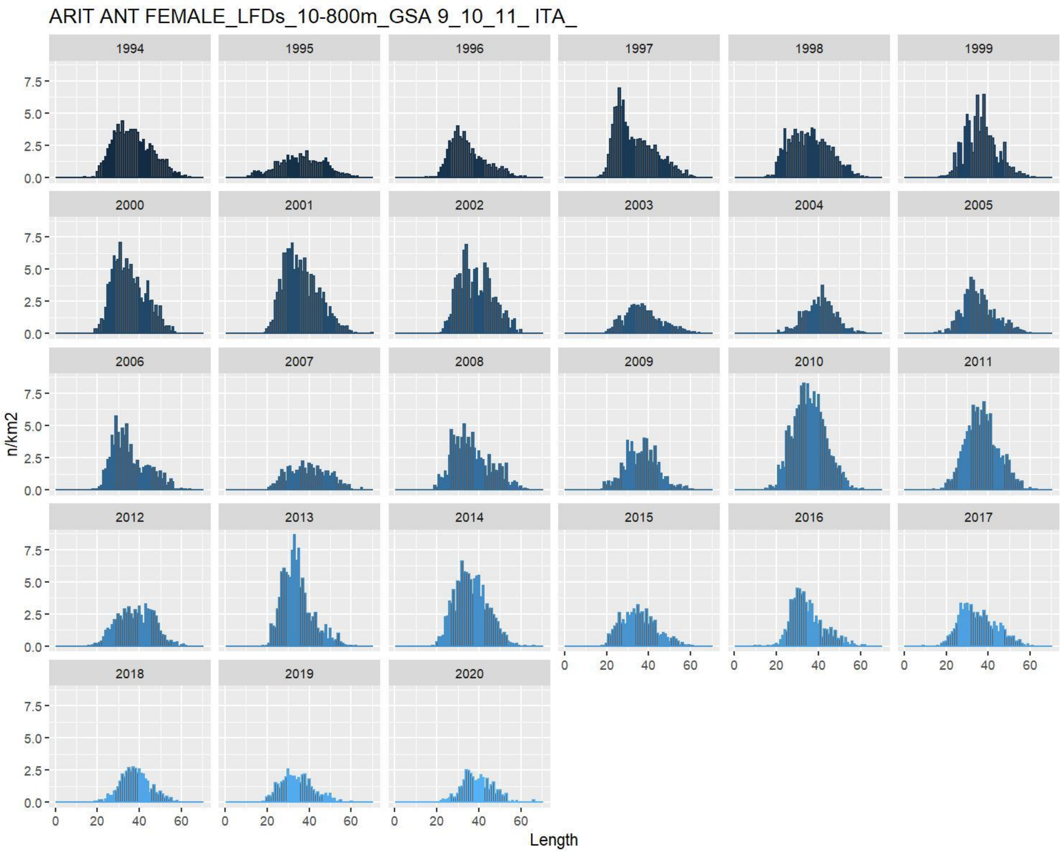


Figure 6.18.2.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series and a clear declining trend during the last five years.

Size structure indices are shown in Figure 6.18.2.3.3.


ARIT ANT LFDs_10-800m_GSA 9_10_11_ ITA_
n/km2
Length


ARIT ANT FEMALE_LFDs_10-800m_GSA 9_10_11_ ITA_
n/km2
Length

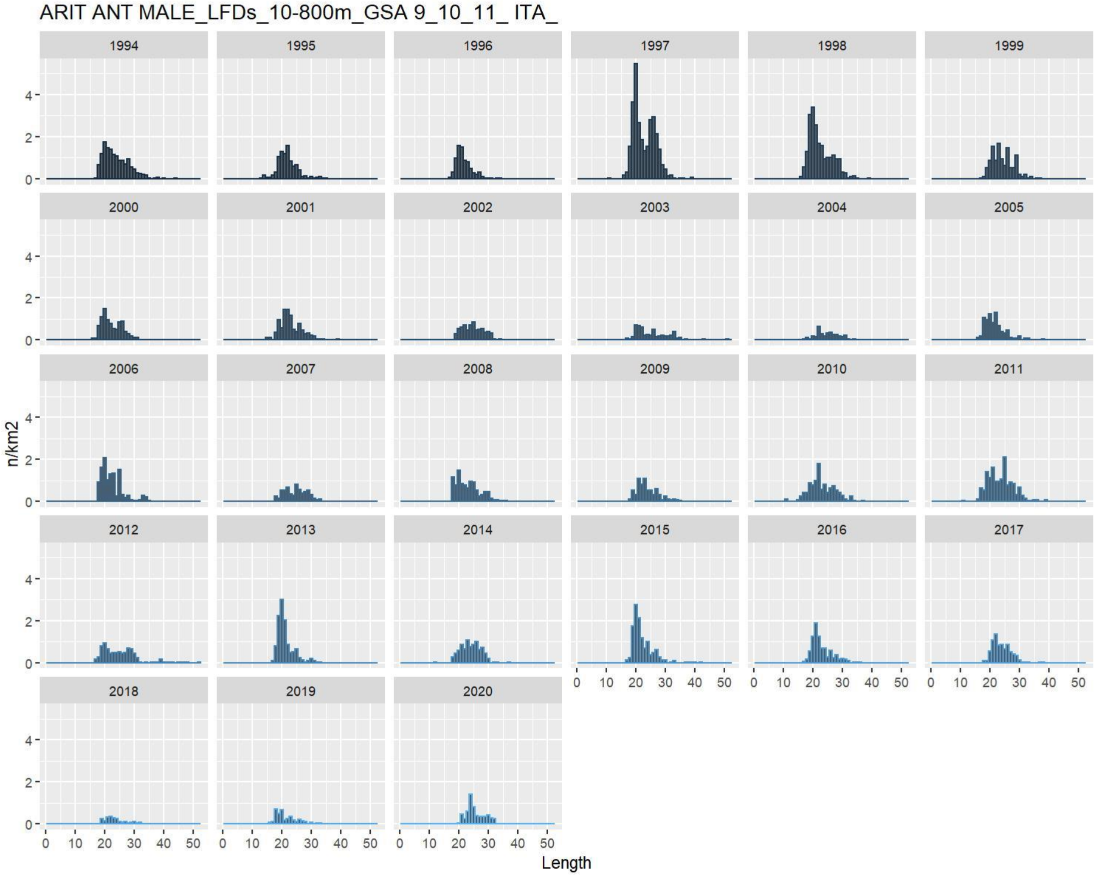


Figure 6.18.2.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Length frequency distribution by year and sex (sexes combined, females, males) of MEDITS survey.

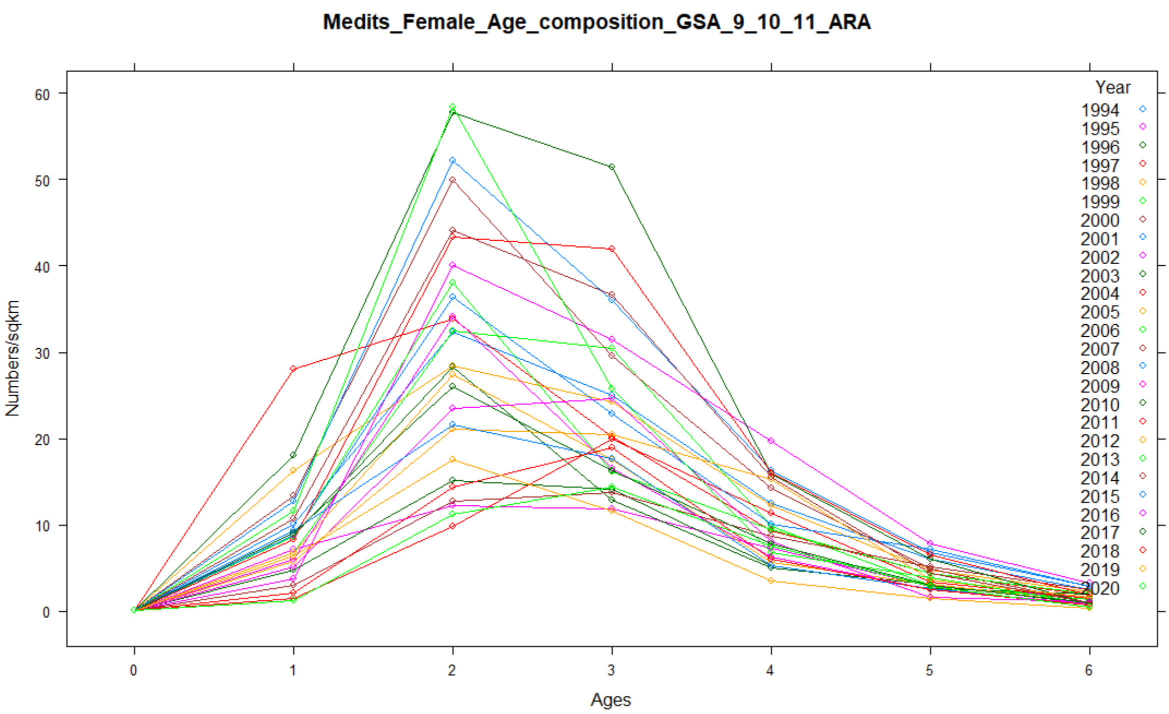


Figure 6.18.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Survey numbers at age input data (females).

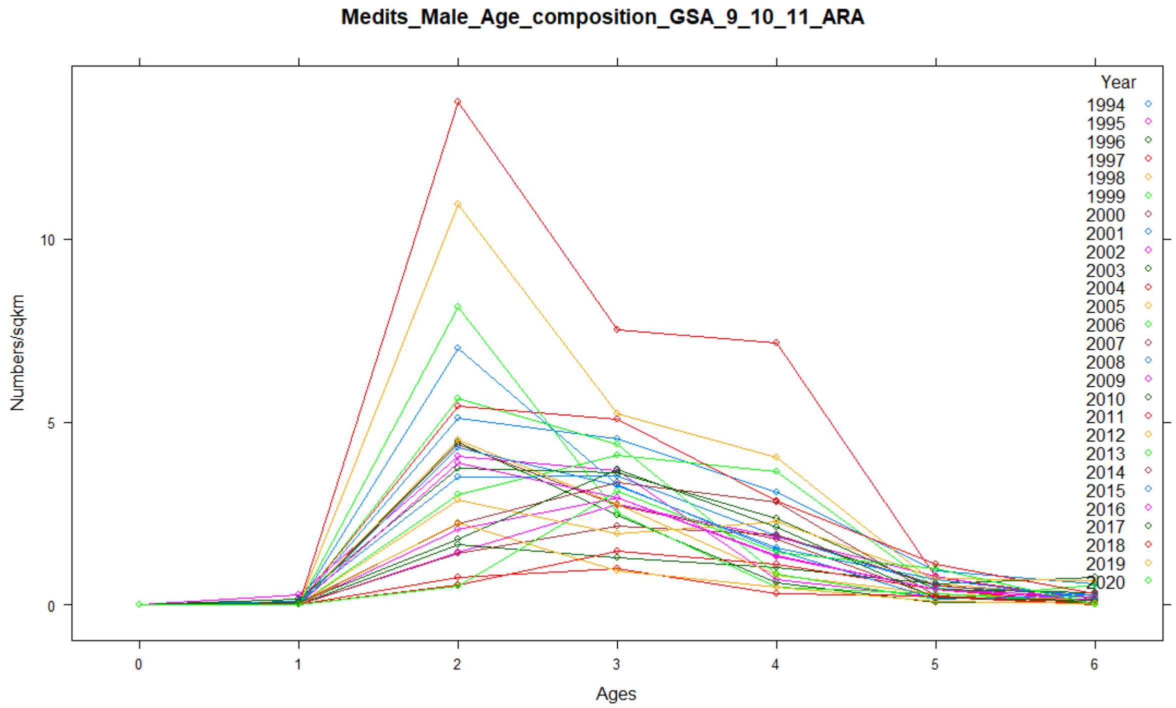


Figure 6.18.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Survey numbers at age input data (males).

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 assessment was carried out using the period 2006-2020 for catch data and tuning file for which data were fully available in the three GSAs.

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. Catch at age by sex were obtained splitting commercial total length distribution according to a sex-ratio vector model obtained from DCF available sex ratio vectors in the areas. The analyses were carried out for the ages 1 to 6. Concerning the Fbar, the age range used was 2-5 age groups.

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 from the single GSAs were used as input data.

Table 6.18.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Catch numbers at age (thousands)

Year/Age	0	1	2	3	4	5	6
2006	0.86	409.23	3127.28	2676.08	1269.93	613.90	395.63
2007	2.59	685.09	6192.49	6469.00	1996.38	1045.33	436.86
2008	2.15	2088.33	3832.52	4365.21	2499.61	1046.46	558.75
2009	1.63	1816.54	3126.31	3774.15	1743.04	632.55	316.10
2010	0.78	987.45	2939.88	2726.08	1156.30	381.86	159.40
2011	7.53	1421.01	2807.63	2325.59	1110.70	390.98	256.39
2012	1.46	927.57	2855.71	3234.38	2257.76	772.61	298.09
2013	1.48	1467.62	5411.86	3849.97	2444.91	1073.17	505.39
2014	1.72	772.75	3101.21	3967.87	2214.62	1052.34	430.57
2015	3.80	1468.81	4994.24	5178.74	2404.61	905.91	617.92
2016	2.18	868.64	5052.42	3378.35	1995.44	1102.38	642.09
2017	1.37	1150.12	3090.38	2753.08	1311.55	645.69	321.83
2018	1.07	1306.62	5093.60	5023.64	1565.96	706.81	384.00
2019	1.06	3201.58	9373.79	7162.00	2788.30	956.50	305.94
2020	1.76	1752.29	7528.37	5359.71	2332.76	771.74	267.63

Table 6.18.3.4. Blue and red shrimp in GSAs 9, 10 and 11. Weights at age (Kg)

Year/Age	0	1	2	3	4	5	6
2006	0.005	0.007	0.014	0.023	0.030	0.039	0.059
2007	0.008	0.007	0.015	0.023	0.031	0.043	0.062
2008	0.004	0.007	0.012	0.019	0.027	0.038	0.046
2009	0.005	0.006	0.013	0.020	0.030	0.040	0.045
2010	0.010	0.007	0.013	0.021	0.027	0.036	0.035
2011	0.002	0.006	0.012	0.020	0.025	0.031	0.037
2012	0.002	0.007	0.013	0.022	0.027	0.034	0.032
2013	0.007	0.007	0.013	0.020	0.024	0.029	0.029
2014	0.004	0.007	0.014	0.022	0.032	0.041	0.032
2015	0.002	0.007	0.013	0.022	0.029	0.036	0.034
2016	0.004	0.007	0.014	0.022	0.027	0.034	0.033
2017	0.005	0.007	0.013	0.021	0.028	0.039	0.045
2018	0.004	0.007	0.014	0.021	0.026	0.035	0.042
2019	0.008	0.007	0.013	0.021	0.027	0.037	0.041
2020	0.008	0.009	0.014	0.022	0.029	0.036	0.043

Table 6.18.3.5. Blue and red shrimp in GSAs 9, 10 and 11. Maturity vector

Year/Age	0	1	2	3	4	5	6
2006-2020	0	0.204	0.786	0.983	0.996	1.000	1.000

Table 6.18.3.5. Blue and red shrimp in GSAs 9, 10 and 11. Natural Mortality vector

Year/Age	0	1	2	3	4	5	6
2006-2020	2.023	0.768	0.511	0.402	0.342	0.306	0.281

Table 6.18.3.6. Blue and red shrimp in GSAs 9, 10 and 11. MEDITS numbers at age (n/km²)

Year/Age	1	2	3	4	5
2006	8.6744	43.7206	20.5425	10.2515	4.5646
2007	3.0273	14.213	15.8599	10.6594	5.6877
2008	8.7657	40.6725	26.137	11.6288	7.8886
2009	5.0946	25.5387	27.511	9.3371	2.0078
2010	18.1667	61.4861	55.0684	18.3164	6.4526
2011	8.3524	48.7728	46.9903	18.8657	7.594
2012	5.7263	23.9639	22.4375	17.5378	4.3271
2013	11.6195	66.6289	28.2521	7.2539	4.1927
2014	10.7616	46.283	40.0377	18.3276	4.6566
2015	9.2709	28.5585	20.9526	6.7163	2.7793
2016	6.0872	37.984	19.5149	7.5922	2.8548
2017	9.0978	27.8188	20.0001	9.9755	3.1649
2018	2.0846	15.135	19.9728	6.4097	2.7528
2019	6.4318	19.7415	12.5759	3.9419	1.534
2020	1.1995	11.7479	17.5532	8.9592	3.8178

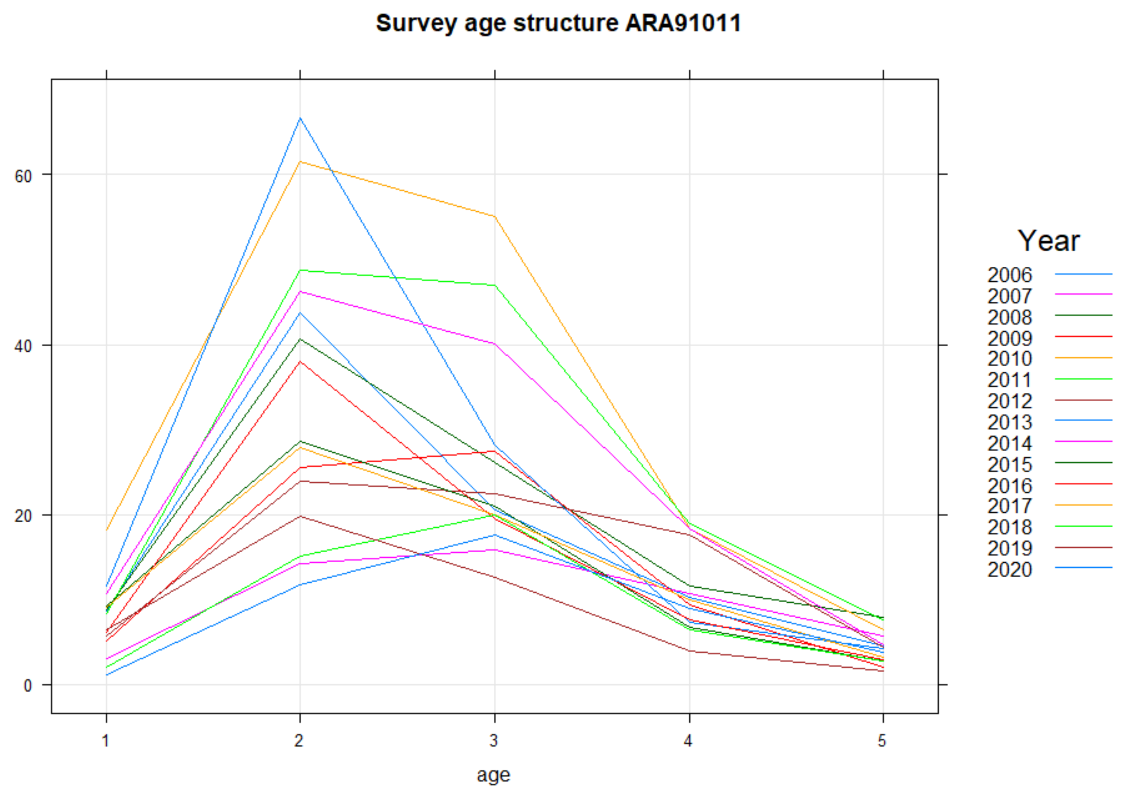


Figure 6.18.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Survey numbers at age input data.

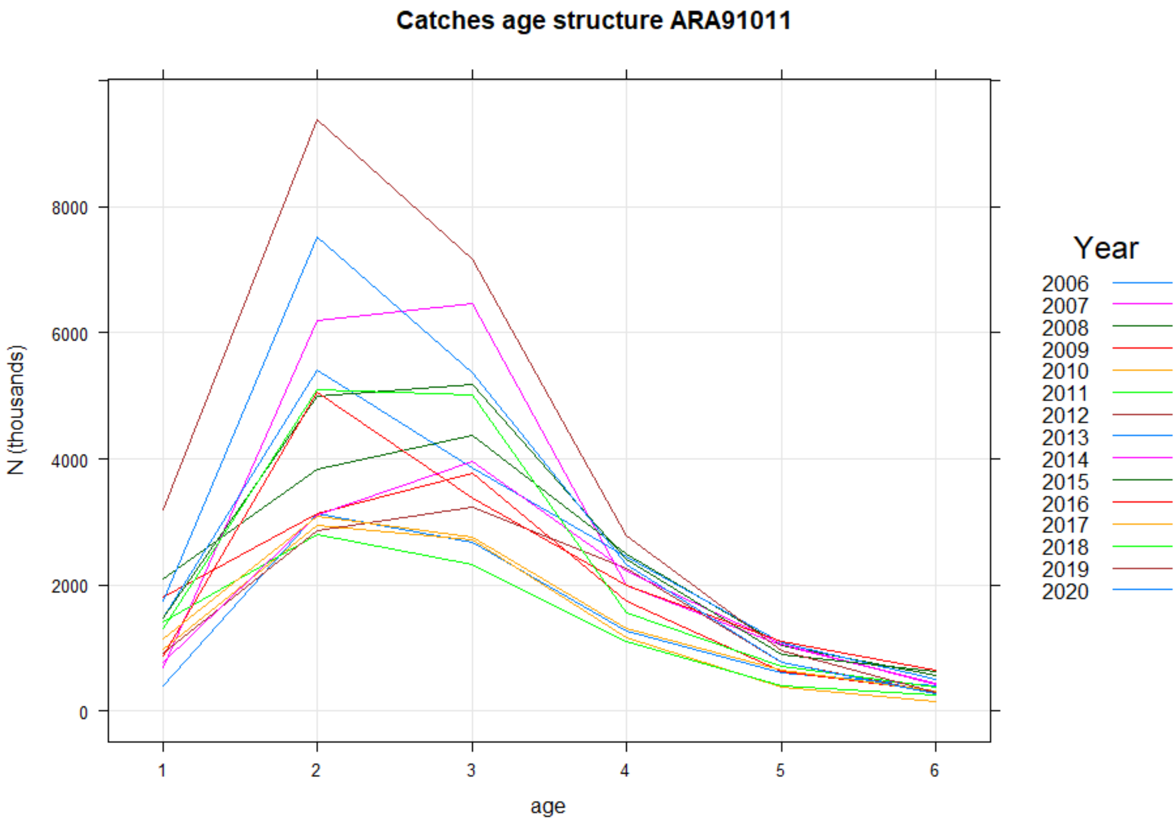


Figure 6.18.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Catch numbers at age input data.

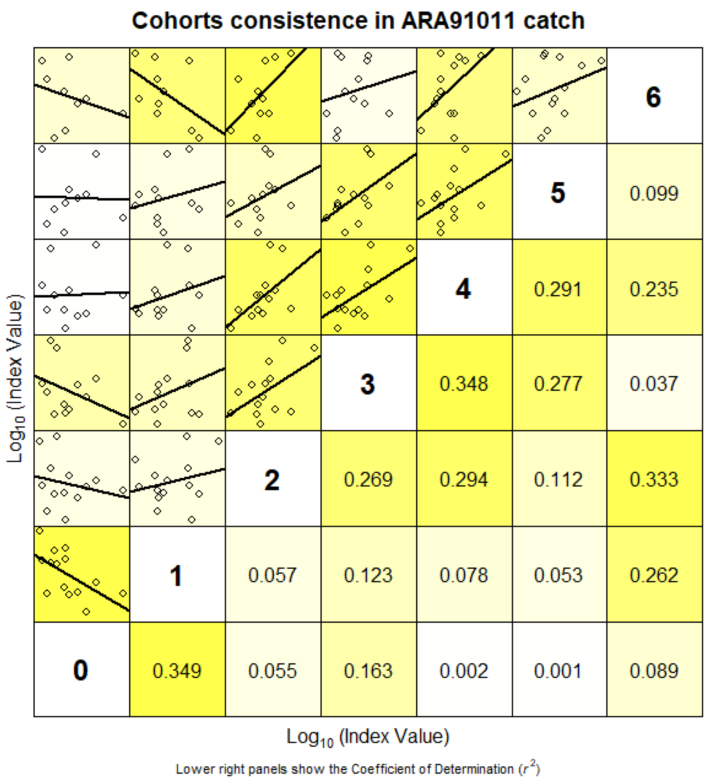


Figure 6.18.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Catch at age cohort consistency

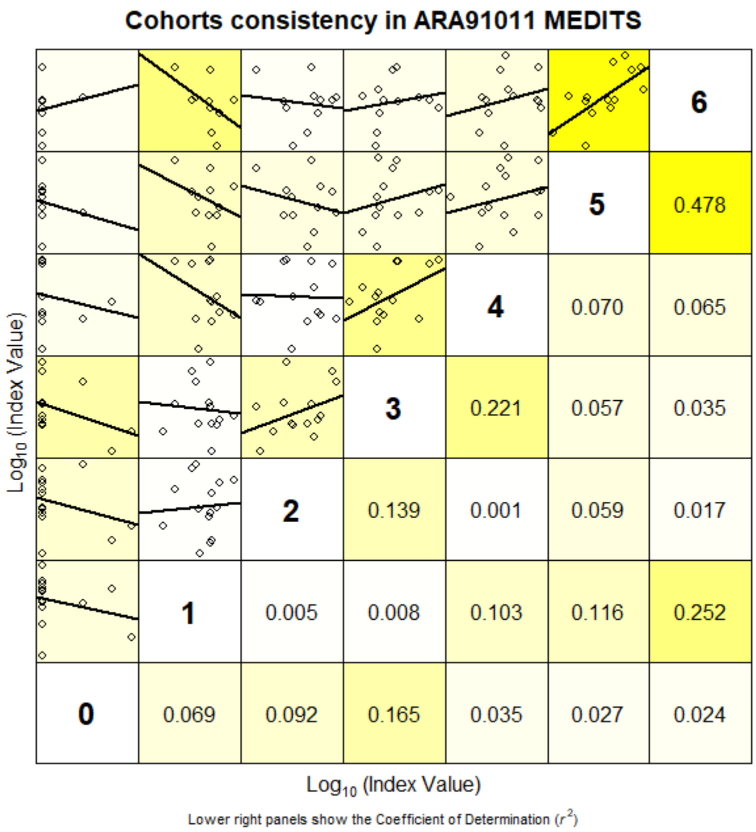


Figure 6.18.3.4. Blue and red shrimp in GSAs 9, 10 and 11. Index at age cohort consistency

Assessment results

Different a4a models were examined (combination of different f and q). The best model (according to residuals and retrospective) included:

a4a model fit for: ARA91011

Submodels:

fmodel: ~s(age, k = 6) + s(year, k = 6)

srmodel: ~factor(year)

n1model: ~s(age, k = 3)

qmodel:

IND: ~factor(replace(age, age > 4, 4))

vmodel:

catch: ~s(age, k = 3)

IND: ~1

Assessment results are shown in Figures 6.18.3.3-6.18.3.9 and Tables 6.18.3.3- 6.18.3.6,

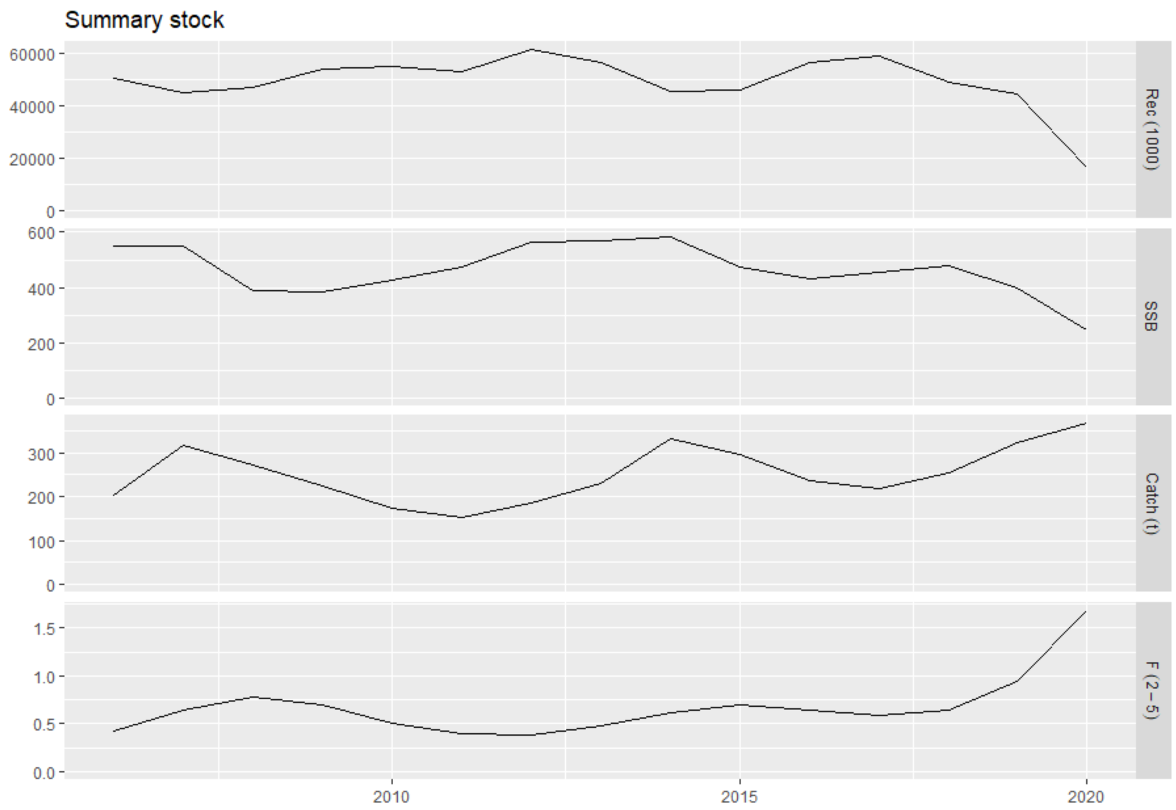


Figure 6.18.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Stock summary from the final a4a model.

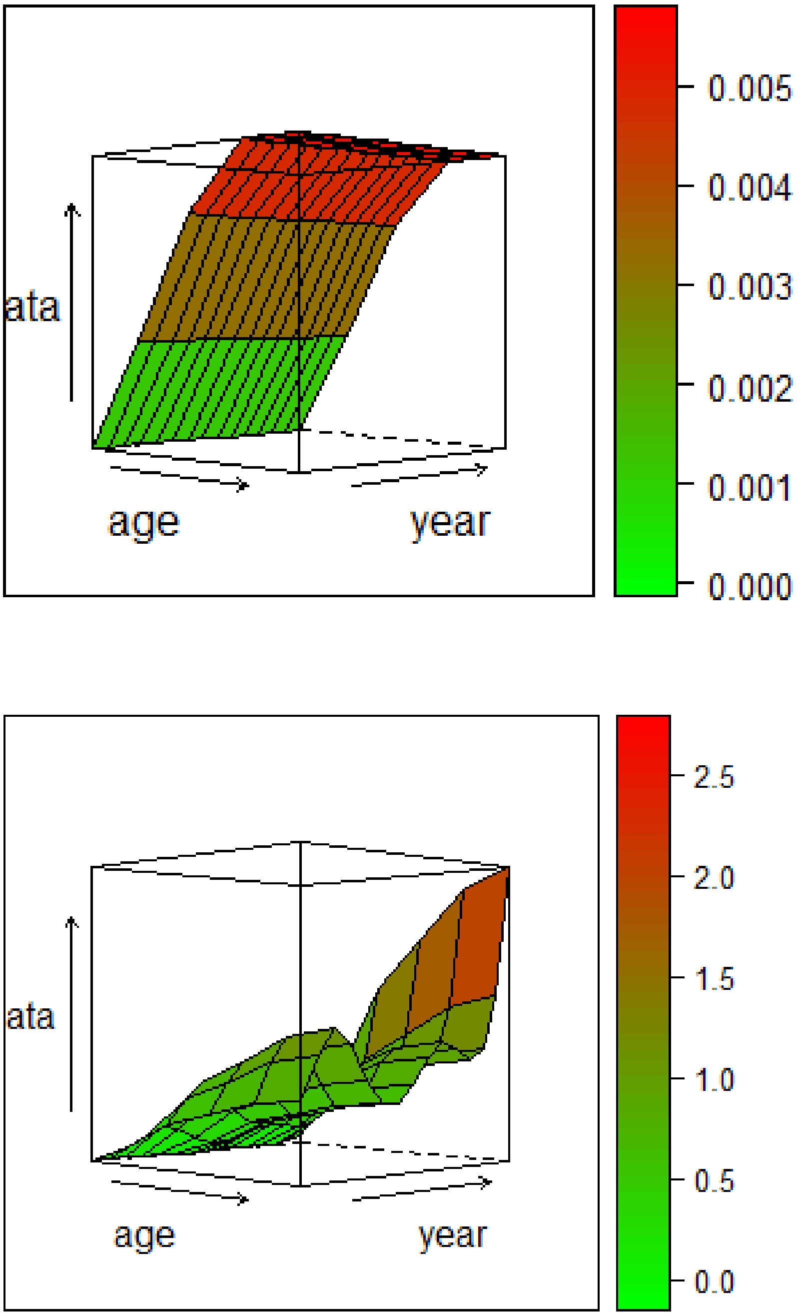


Figure 6.18.3.4. Blue and red shrimp in GSAs 9, 10 and 11. 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.

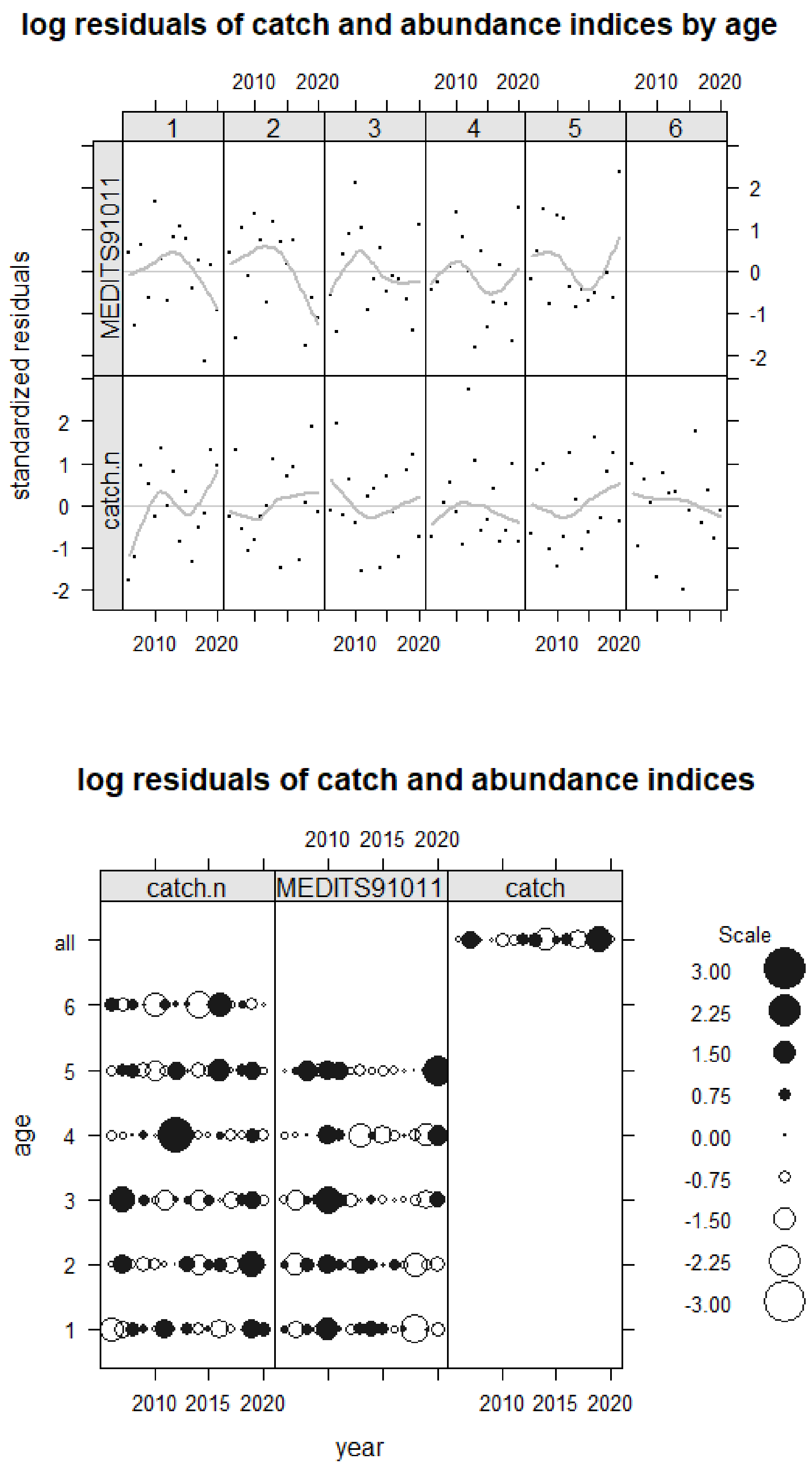


Figure 6.18.3.5. Blue and red shrimp in GSAs 9, 10 and 11. Standardized residuals for abundance indices and for catch numbers.

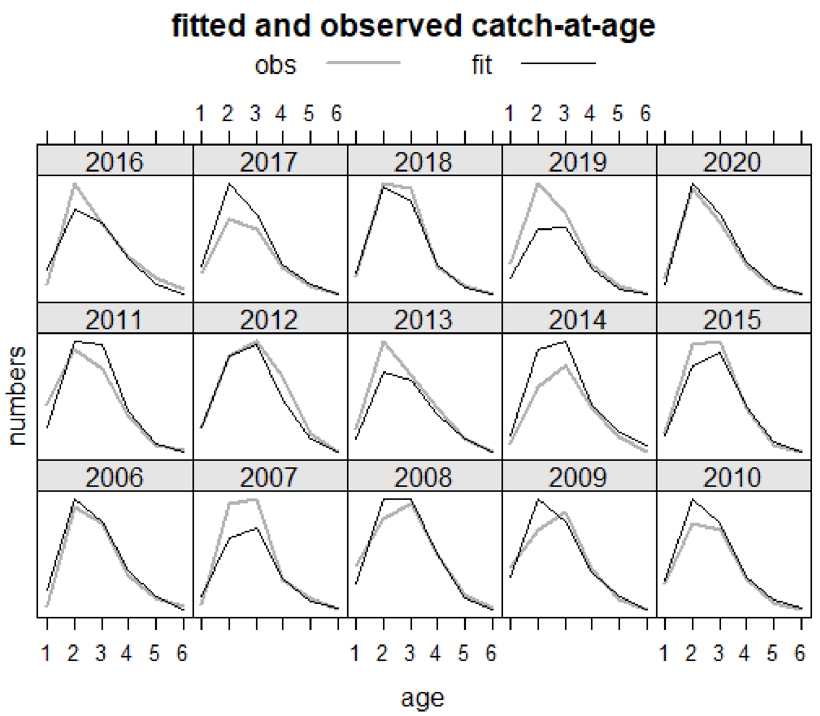


Figure 6.18.3.6. Blue and red shrimp in GSAs 9, 10 and 11. Fitted and observed catch at age.

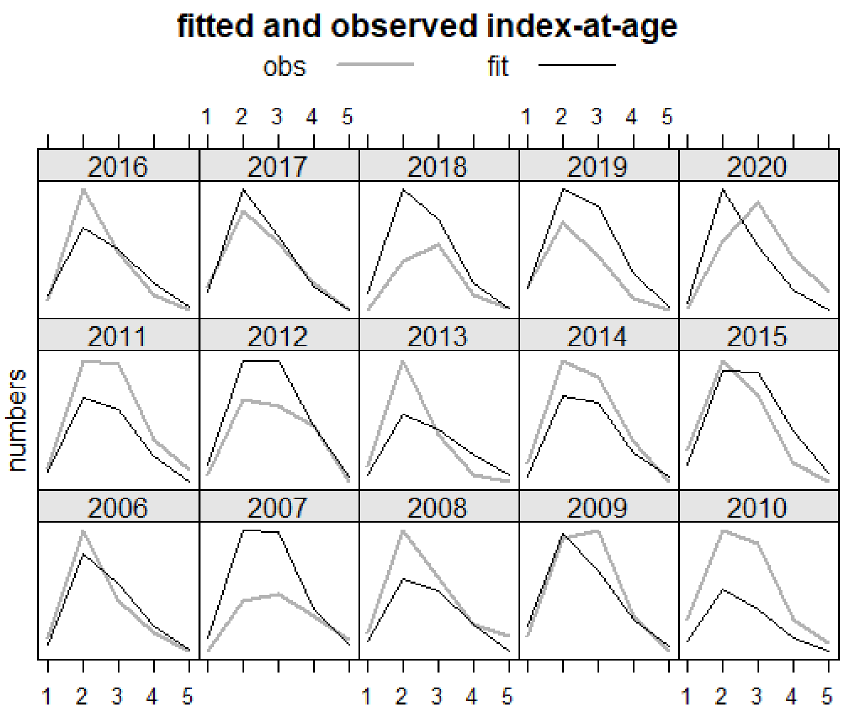


Figure 6.18.3.7. Blue and red shrimp in GSAs 9, 10 and 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up only to 3 years back, due to the short time series. Model results were quite stable (Figure 6.18.3.8) and in agreement with the previous assessment and still show a tendency to slightly over estimate F and under estimate SSB, but the model is still considered suitable for advice, as the conclusions for F status relative to F_{MSY} are unaffected by the small bias.

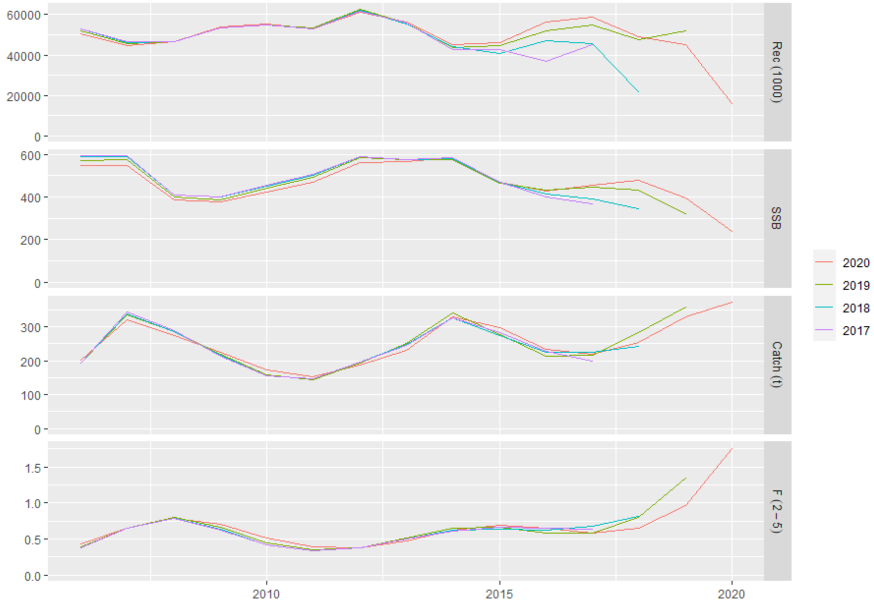


Figure 6.18.3.8. Blue and red shrimp in GSAs 9, 10 and 11. Retrospective analysis.

Simulations

In the following figures and tables, the population estimates obtained by the a4a model are provided.

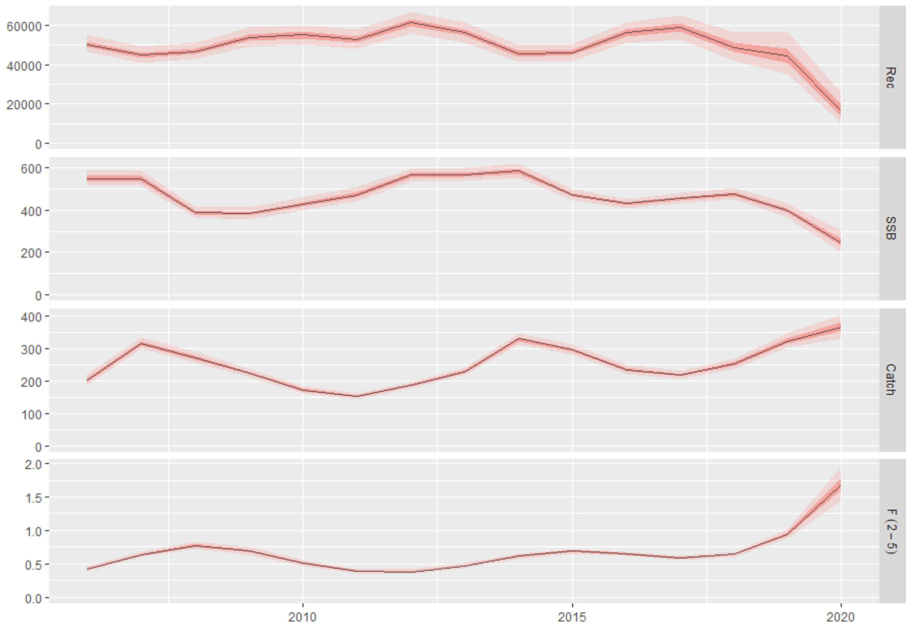


Figure 6.18.3.9. Blue and red shrimp in GSAs 9, 10 and 11. Simulations over summary results.

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 9, 10 and 11. Stock numbers at age (thousands) as estimated by a4a.

	1	2	3	4	5	6
2006	50459	25738	9995	4032	1716	759
2007	44757	22815	12876	4499	1727	990
2008	46745	19981	10417	4747	1494	796
2009	53834	20698	8599	3375	1337	549
2010	55031	23957	9236	3015	1051	511
2011	52737	24763	11578	3854	1173	556
2012	61148	23897	12582	5390	1723	729
2013	56335	27721	12182	5900	2432	1046
2014	45538	25401	13591	5246	2389	1299
2015	46076	20359	11714	5121	1791	1118
2016	56141	20505	9086	4109	1596	789
2017	58827	25052	9330	3324	1351	691
2018	48803	26344	11694	3610	1174	645
2019	44533	21781	12001	4290	1191	529
2020	16345	19523	8727	3326	990	323

Table 6.18.3.4. Blue and red shrimp in GSAs 9, 10 and 11. a4a summary results

	Fbar(2-5)	Recruitment (thousands)	SSB (t)	TB (t)	Catch (t)
2006	0.424	50459	549	1182	202
2007	0.638	44757	548	1229	317
2008	0.776	46745	390	972	273
2009	0.691	53834	381	955	225
2010	0.505	55031	428	1021	173
2011	0.388	52737	473	1021	153
2012	0.380	61148	564	1227	187
2013	0.471	56335	567	1263	230
2014	0.614	45538	584	1267	330
2015	0.691	46076	472	1098	297
2016	0.646	56141	430	1082	235
2017	0.586	58827	453	1113	218
2018	0.643	48803	477	1114	253
2019	0.943	44533	397	1022	323
2020	1.683	16345	244	753	366

Table 6.18.3.5. Blue and red shrimp in GSAs 9, 10 and 11: a4a results F at age.

	F at age					
	1	**2**	**3**	**4**	**5**	**6**
2006	0.025	0.182	0.396	0.505	0.613	0.629
2007	0.038	0.273	0.596	0.760	0.921	0.946
2008	0.046	0.332	0.725	0.925	1.121	1.150
2009	0.041	0.296	0.646	0.824	0.999	1.025
2010	0.030	0.216	0.472	0.602	0.729	0.749
2011	0.023	0.166	0.363	0.462	0.560	0.575
2012	0.023	0.163	0.355	0.453	0.549	0.564
2013	0.028	0.202	0.441	0.562	0.681	0.699
2014	0.037	0.263	0.574	0.732	0.887	0.911
2015	0.041	0.296	0.646	0.823	0.998	1.025
2016	0.038	0.276	0.604	0.770	0.933	0.958
2017	0.035	0.251	0.548	0.698	0.846	0.869
2018	0.038	0.275	0.601	0.766	0.929	0.953
2019	0.056	0.404	0.881	1.124	1.362	1.398
2020	0.100	0.721	1.574	2.007	2.432	2.497

Based on the a4a results, the blue and red shrimp recruitment shows a decreasing trend from 2012 to 2020 (from 61074 to 15076 individuals). SSB follows the same pattern with a time lag of one year declining from 564 tons in 2013 to 246 in 2020.

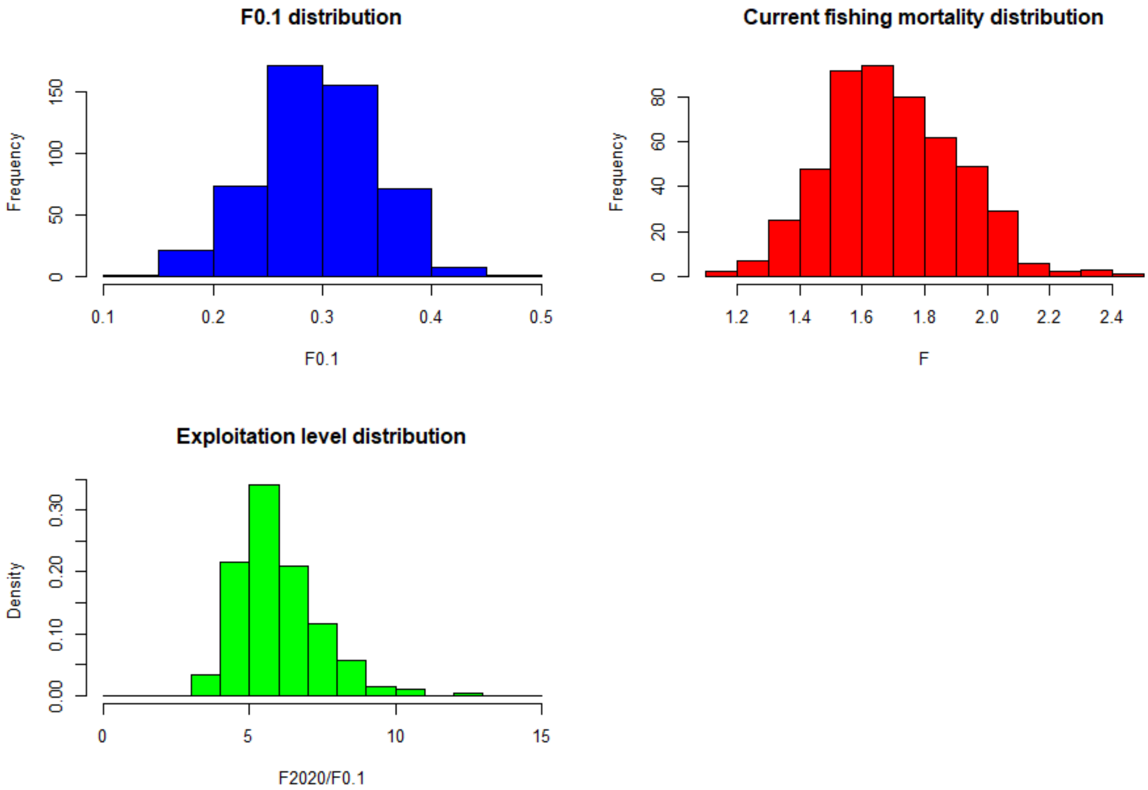


Figure 6.18.4.1. Blue and red shrimp in GSAs 9, 10 and 11. Histogram of probability/density for $F_{0.1}$, Fcurr and level of exploitation values (iter=300)

There were issues with MEDITS in GSA 10, and an index was calculated without GSA 10 in 2020 and the assessment rerun with this new index as a sensitivity test. The differences between the assessment results given above, the different survey treatment in 2020, was negligible and lay within the intervals for main assessment parameters of F and SSB. The assessment including MEDITS GSA 10 in 2020 was used.

6.18.4 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 (1.683, F_{bar2-5} in the last year (2020) of the time series as F is declining over the previous 3 years) is 5.7 times higher than $F_{0.1}$ (0.294), chosen as a proxy for F_{MSY} and as the exploitation reference point consistent with high long-term yields. This indicates that blue and red shrimp stock in GSAs 9, 10 and 11 is highly over-exploited.

6.18.5 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 was used for weight at age and maturity at age, while the F_{bar2-5} =1.683 (the last year's F estimated by the assessment model) was used for F in 2020, as F shows an increasing trend (See section 4.3). Although declining during the last five years, recruitment is fluctuating a lot during the entire time-series. So, in compliance to the previous assessment and the recruitment fluctuations 14 years were used as an estimate of recruits in 2020 to 2021. For the STF recruitment was estimated from the population results as the geometric mean of the last 14 years.

Table 6.18.5.1 Blue and red shrimp in GSAs 9, 10 and 11**:** Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, are based average of years 2017-2019
$F_{ages\ 2-5}$ (2021)	1.683	F 2020 used to give F status quo for 2021.
SSB (2021)	146	Stock assessment 1 January 2021
R_{age1} (2021,2022)	47259	Geometric mean of the last 14 years.
Total catch (2021)	184	Assuming F status quo for 2021

Table 6.18.5.2. Blue and red shrimp in GSAs 9, 10 and 11. Short term forecast in different F scenarios.

Scenario	Fbar	Recruitment 2021	Fsq 2021	Catch 2020	Catch 2022	SSB 2021	SSB 2023	SSB_2021-2023(%)	Catch_2020-2022(%)
$F_{0.1}$	0.294	47259	1.683	366	45	146	404	178	-87.86
F upper	0.405	47259	1.683	366	60	146	379	177.14	-87.72
F lower	0.197	47259	1.683	366	31	146	428	159.83	-83.61
F_{MSY} transition	0.619	47259	1.683	366	87	146	337	193.90	-91.55
Zero catch	0	47259	1.683	366	0	146	486	131.07	-76.33
Status quo	1.683	47259	1.683	366	186	146	210	233.36	-100.00
Different Scenarios	0.17	47259	1.683	366	27	146	436	44.04	-49.33
	0.34	47259	1.683	366	51	146	394	199.24	-92.73
	0.51	47259	1.683	366	73	146	358	170.34	-86.13
	0.67	47259	1.683	366	93	146	327	145.69	-80.10
	0.84	47259	1.683	366	112	146	301	124.54	-74.58
	1.01	47259	1.683	366	129	146	278	106.27	-69.52
	1.18	47259	1.683	366	145	146	257	90.40	-64.84
	1.35	47259	1.683	366	159	146	240	76.53	-60.53
	1.52	47259	1.683	366	173	146	224	64.35	-56.52
	1.85	47259	1.683	366	198	146	198	53.59	-52.80
	2.02	47259	1.683	366	209	146	186	35.53	-46.08
	2.19	47259	1.683	366	219	146	176	27.91	-43.04
	2.36	47259	1.683	366	229	146	167	21.05	-40.19
	2.53	47259	1.683	366	238	146	159	14.86	-37.50
	2.69	47259	1.683	366	247	146	152	9.24	-34.97
	2.86	47259	1.683	366	255	146	145	4.13	-32.58
	3.03	47259	1.683	366	263	146	139	-0.54	-30.32
	3.20	47259	1.683	366	271	146	133	-4.82	-28.18
	3.37	47259	1.683	366	278	146	128	-8.76	-26.15

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.

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).

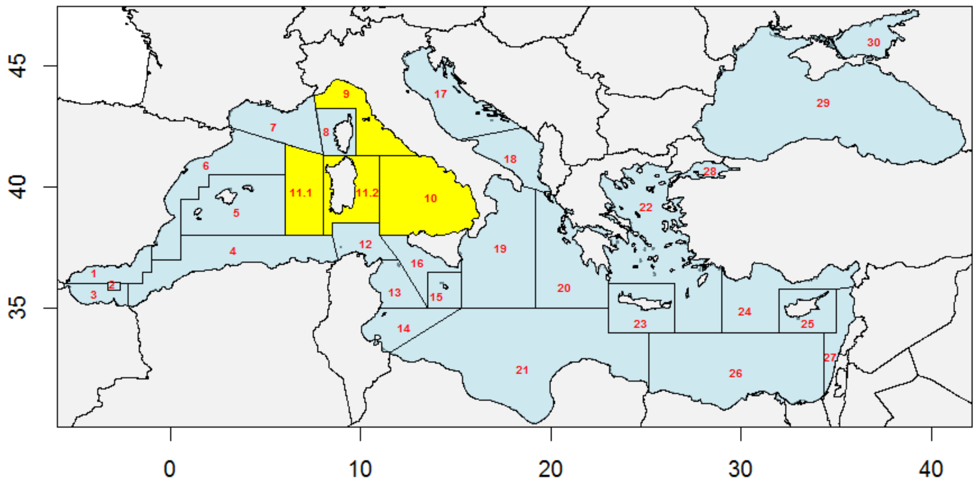


Figure 6.19.1.1 Limit of Geographical Sub-Areas (GSAs) 9, 10, 11.

6.19.1.1 GROWTH, MATURITY AND NATURAL MORTALITY

Several sets of VBGF parameters have been reported in the DCF database. In GSAs 9 and 10, VBGF curves by sex are available, while in GSA 11 a growth curve for females is provided. 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 assessment, to slice the size frequency distributions by sex in the three GSAs. As done in the last

assessment, 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. However, the group agreed to use the average of LW parameters (a and b) used by EWG 19-10 assessment to estimate mean weight at length and mean weight at age by sex.
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	0.004	0.003
	b	mm/g	2.52	2.65

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 data 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 2018. 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 the this lack of landings, demographic and biological data, GSA08 was not included in the stock assessment

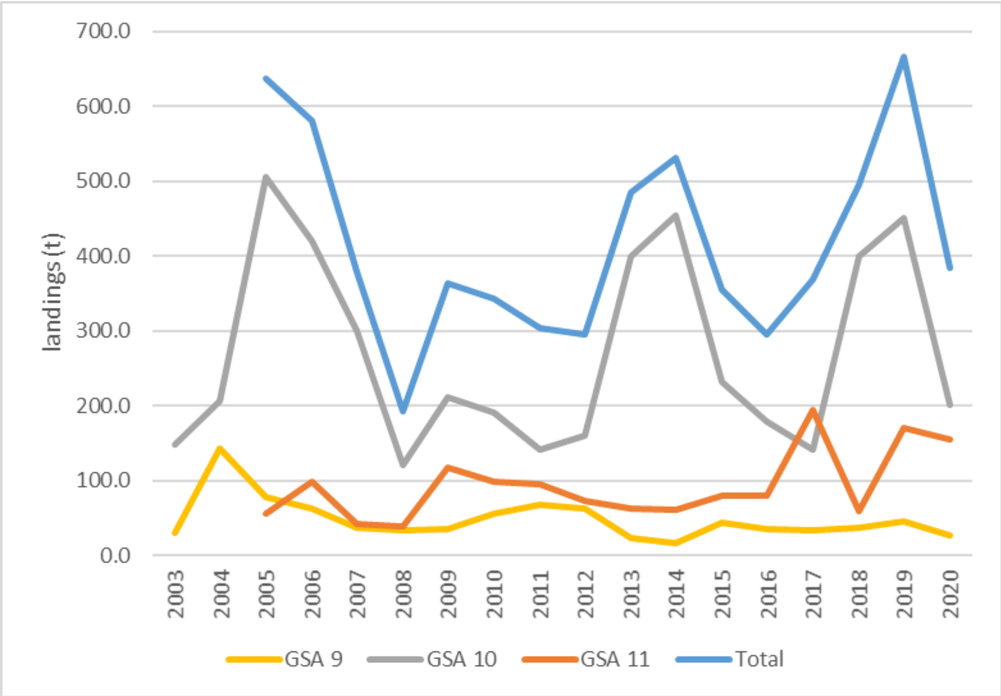


Figure 6.19.2.1.1 Giant red shrimp in GSAs 9, 10, 11: landings by GSA and total landings.

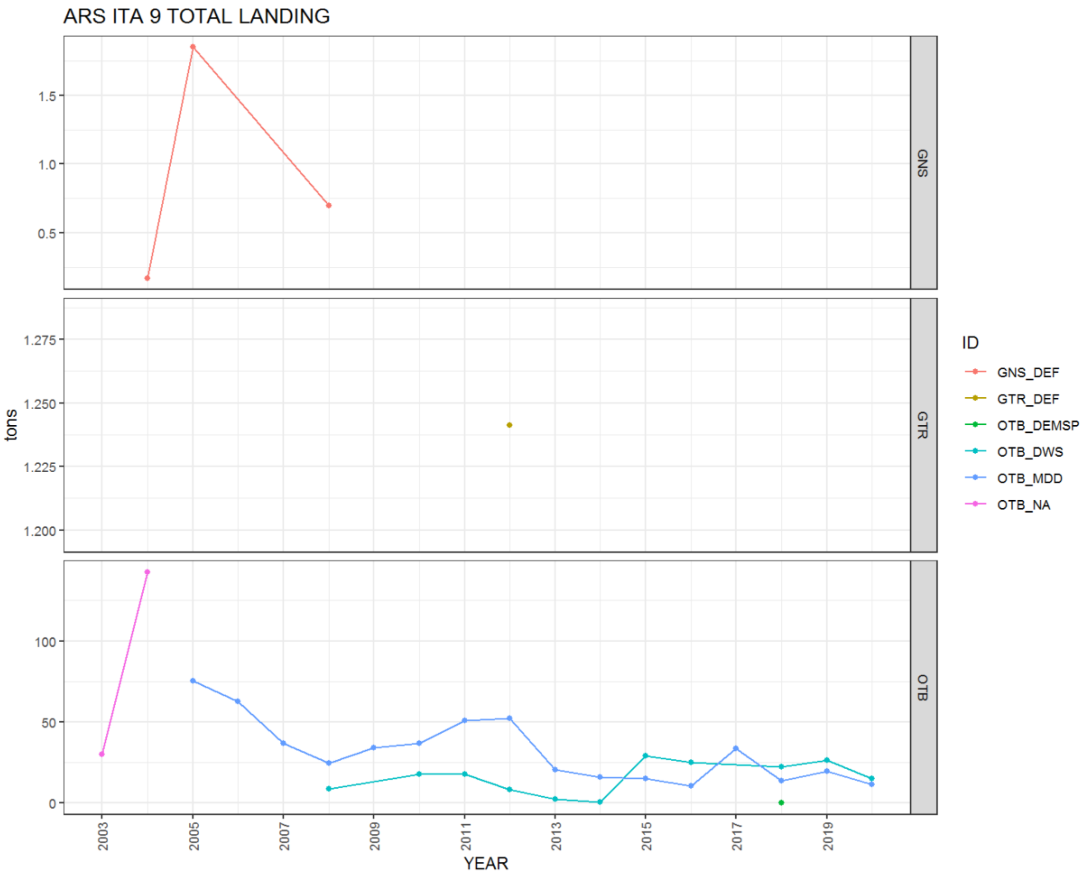


Figure 6.19.2.1.2. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 9.

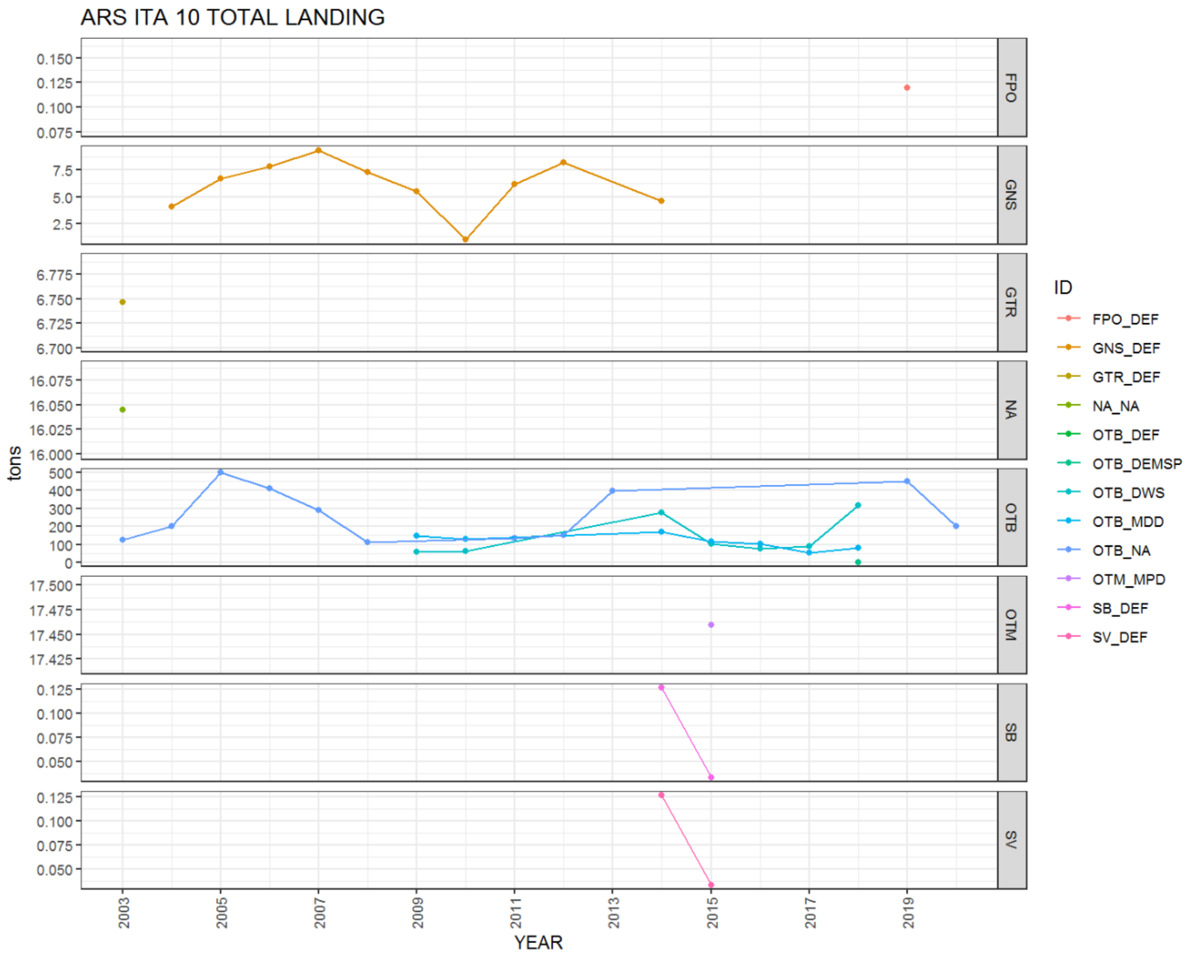


Figure 6.19.2.1.3. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 10.

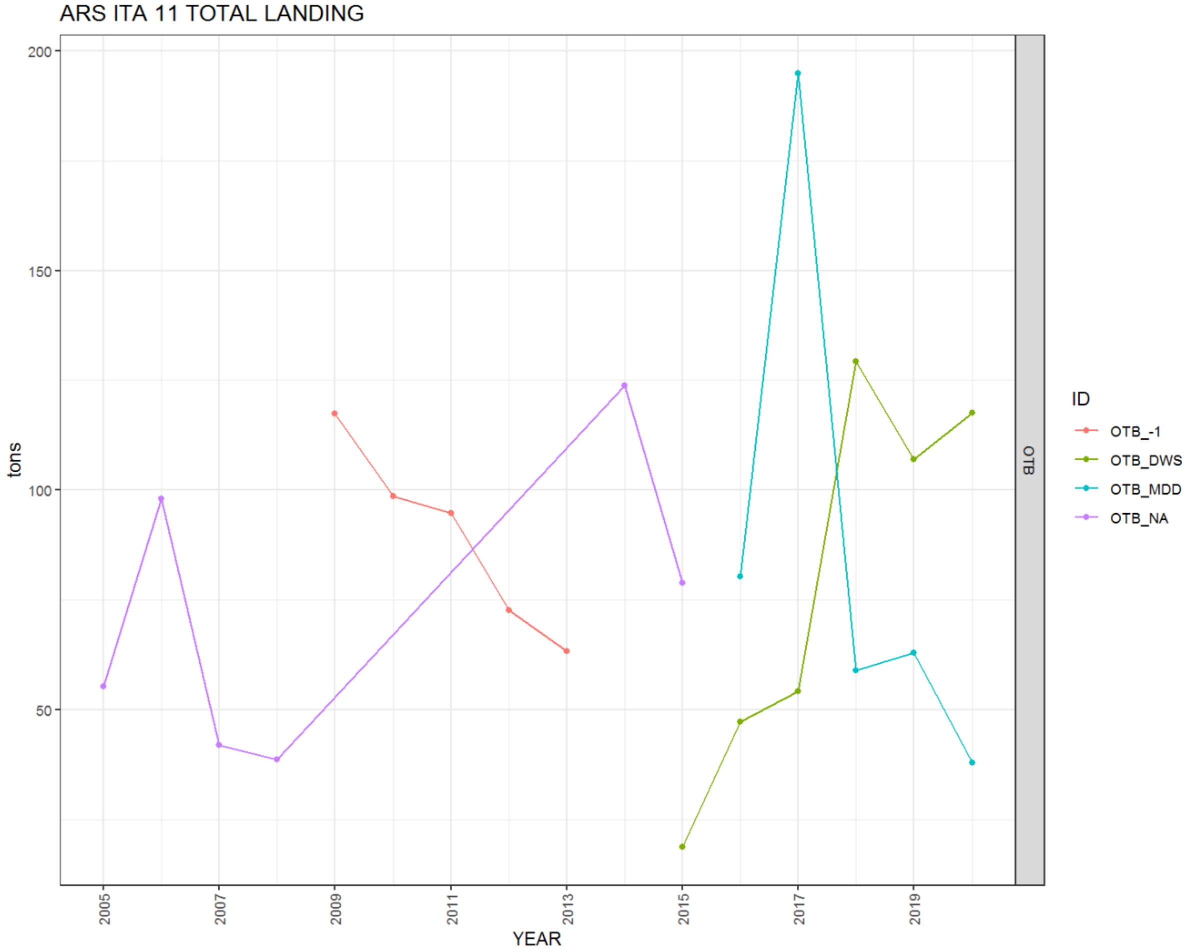


Figure 6.19.2.1.4. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 11.

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) provide 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 only.

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	63.3	399.4		23.1	
2014	61.1	449.3	4.8	16.8	
2015	78.8	214.6	17.5	44.2	
2016	80.3	179.1		35.8	
2017	194.9	139.4		33.6	
2018	59.0	400.2		36.4	
2019	169.9	450.1	0.1	46.2	0.0
2020	155.6	202.5		26.4	

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	GSA11 discards (t)	GSA10 discards (t)	GSA9 discards (t)
2003	0.0	0.0	0.0
2004	0.0	0.0	0.0
2005	0.0	0.0	0.0
2006	0.0	0.0	0.0
2007	0.0	0.0	0.0
2008	0.0	0.0	0.0
2009	0.0	0.0	0.0
2010	0.0	0.0	0.5
2011	0.0	0.1	0.0
2012	0.0	0.4	0.0
2013	0.0	0.0	0.0
2014	0.0	0.0	0.0
2015	0.0	0.0	0.0
2016	0.0	0.0	0.0
2017	0.0	1.0	0.0
2018	0.0	0.0	0.0
2019	0.0	0.0	0.0

2020	0.0	0.0	0.0

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.

landings	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA 10-FPO-DEF																	0.1	
GSA 10-GNS-DEF		4.0	6.7	7.9	9.3	7.3	5.5	1.0	6.2	8.2		4.6						
GSA 10-GTR-DEF	6.7																	
GSA 10-NA-NA	16.0																	
GSA 10-OTB-DEF																0.0		
GSA 10-OTB-DEMSP																0.0		
GSA 10-OTB-DWS							57.9	62.1				278.5	101.0	76.8	88.4	319.2	360.6	141.0
GSA 10-OTB-MDD							148.3	127.2				170.7	113.6	102.3	51.1	81.0	89.6	61.4
GSA 10-OTB-NA	125.2	202.6	498.4	411.8	290.9	112.8			134.7	151.6	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			55.2	98.1	42.0	38.6	117.4	98.6	94.7	72.7	63.3	61.1	78.8					
GSA 11-OTB-DWS																	107.1	117.6
GSA 11-OTB-MDD														80.3	194.9	59.0	62.9	37.9
GSA 9-GNS-DEF		0.2	1.8			0.7												
GSA 9-GTR-DEMSP										1.2								
GSA 9-OTB-DEMSP	30.0															0.0		
GSA 9-OTB-DWS						8.7		17.7	17.6	8.3	2.6	0.6	29.0	25.1		22.4	26.3	15.0
GSA 9-OTB-MDD			75.5	62.6	36.7	24.4	34.3	36.9	50.8	52.4	20.5	16.2	15.2	10.7	33.6	13.9	19.8	11.4
GSA 9-OTB-NA		142.5																
discards	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GSA 10-OTB-DWS															1.0			
GSA 10-OTB-NA									0.1	0.4								
GSA 9-OTB-MDD								0.5										
GSA 9-OTB-NA																		

Since data from GSA 10 in 2019 and 2020 is derived from a few quarters only, the group decided to substitute this LFD data with the one derived from the average of the LFD of by year from GSA 9 and 11, however, expanding it to the production of GSA 10. The 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.

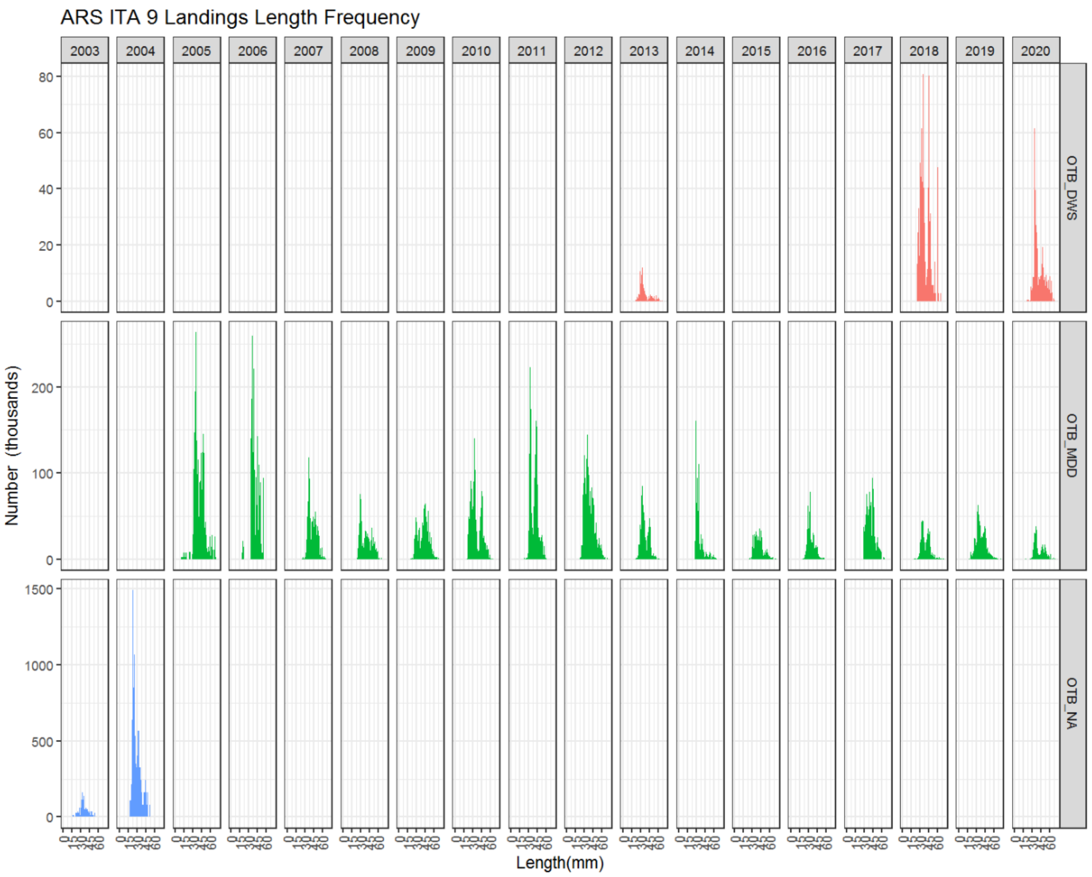


Figure 6.19.2.1.5. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 9.

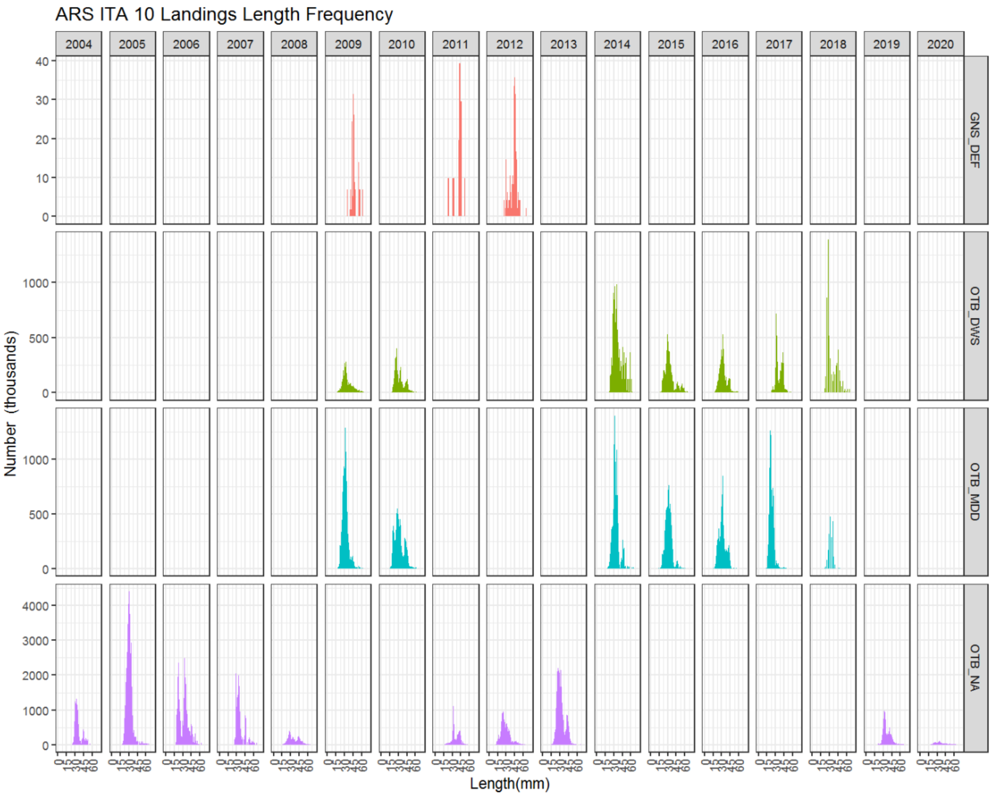


Figure 6.19.2.1.6. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 10.

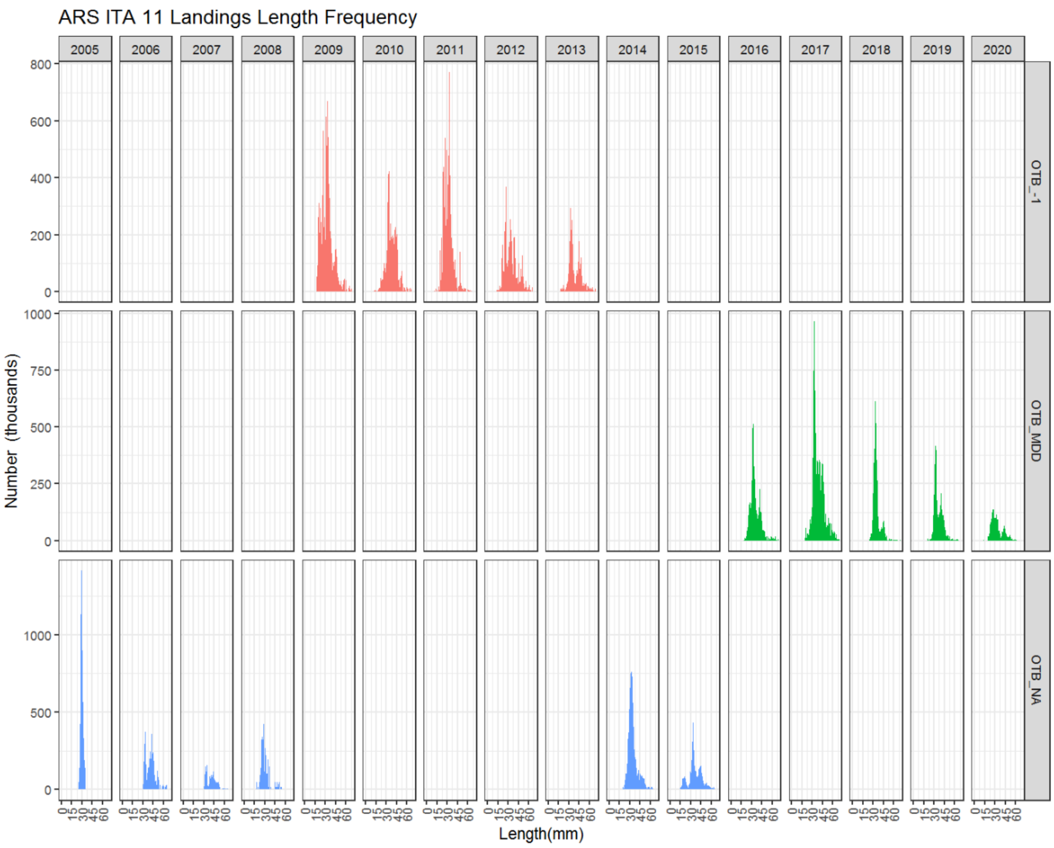


Figure 6.19.2.1.7. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 11.

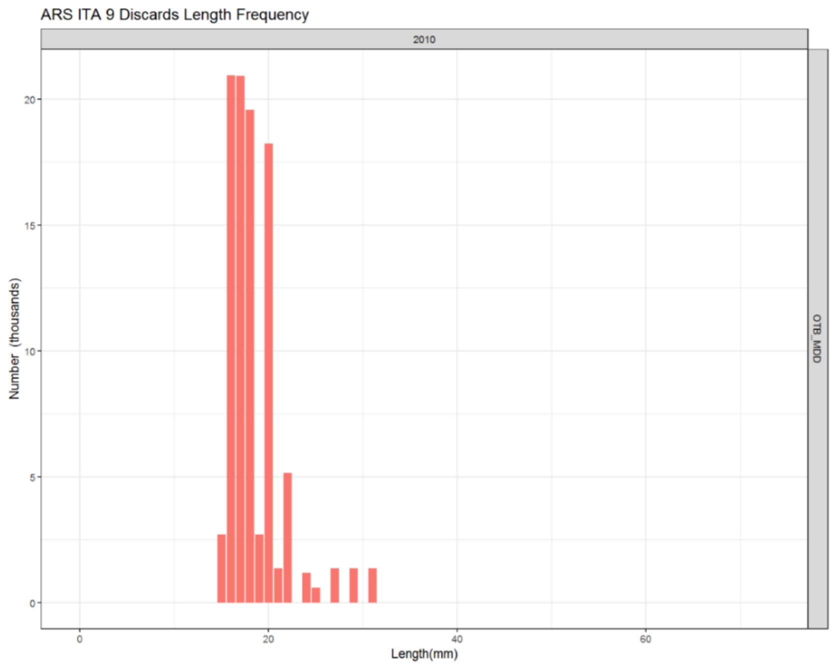


Figure 6.19.2.1.8. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 9

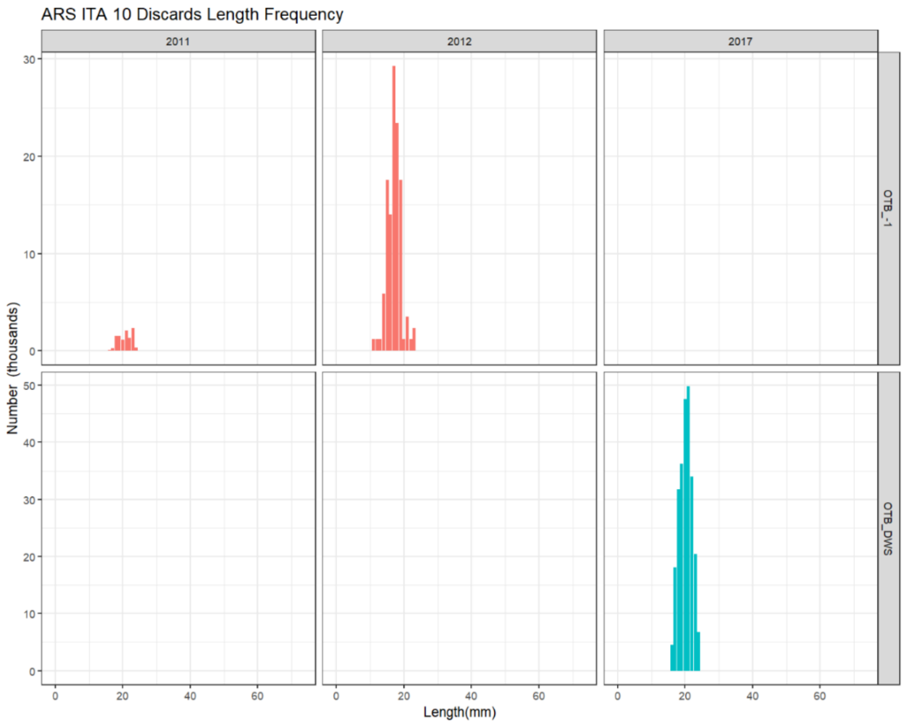


Figure 6.19.2.1.9. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 10.

6.19.2.2 EFFORT DATA

Effort data is not available to this EWG, the effort analysis is now carried out by STECF EWG 21-13, and effort results are available from that meeting.

6.19.2.3 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 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 2020 surveys in all three GSAs were delayed, however, distributions observed by the later surveys are not noticeably different from earlier years (Figure 6.19.2.3.1)

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).

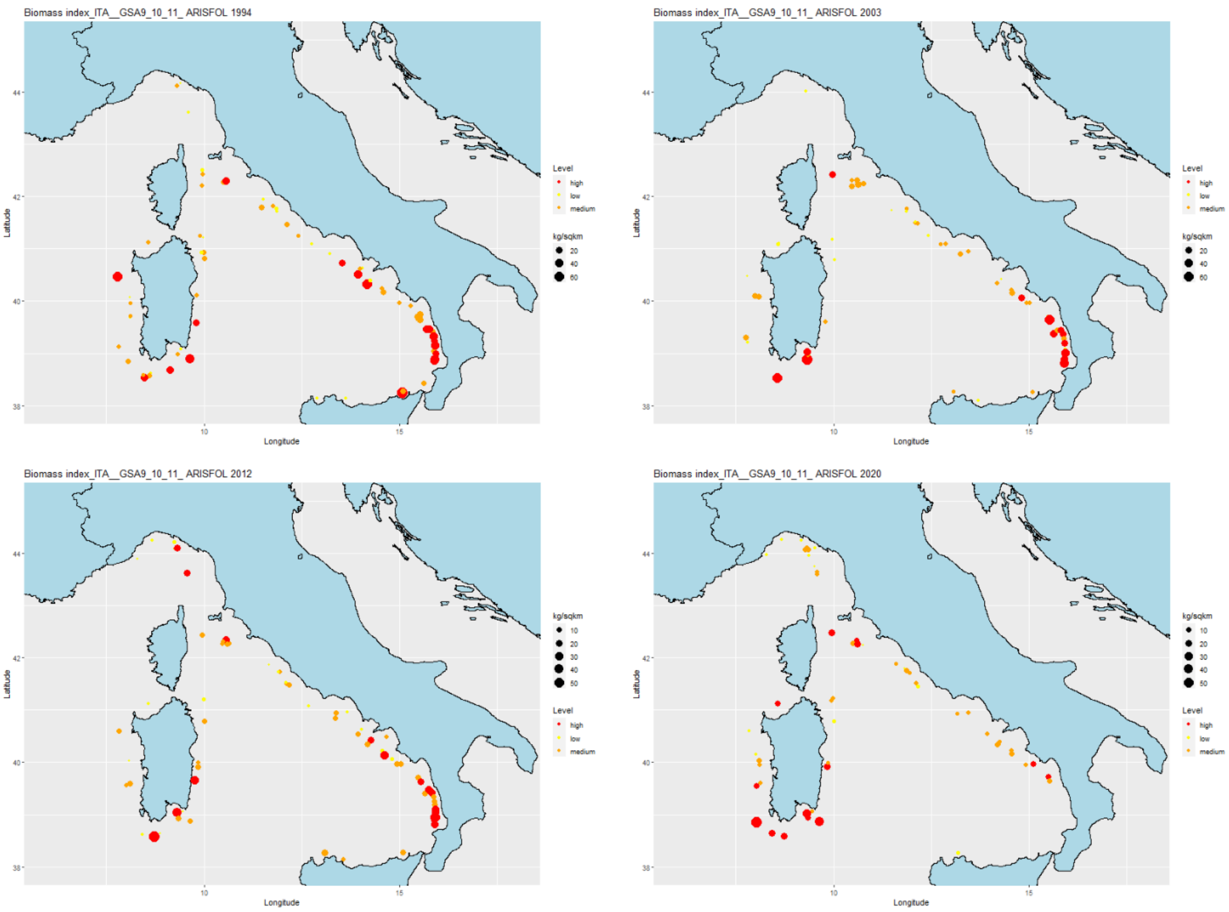
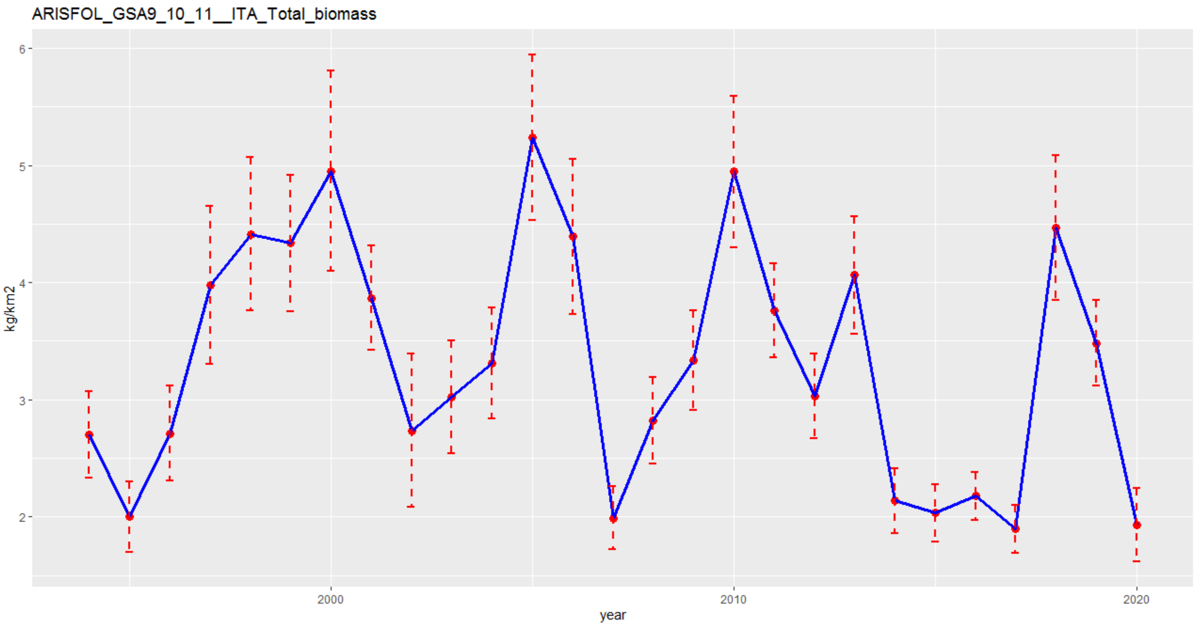


Figure 6.19.2.3.1 Giant red shrimp in GSAs 9, 10, 11: distribution pattern in the period 1994-2020 (MEDITS survey). Maps for the years 1994, 2003, 2012 and 2020 are shown.

Trends in abundance and biomass

The trends of the MEDITS indices (biomass and density) computed on the three GSAs combined are shown in Figure 6.19.2.3.2.

The time series are characterized by wide fluctuations. A first evident peak is observed in 2000, then in 2005 and 2010. Despite a further peak in 2013, the trend from 2010 onward follows a decreasing pattern. The biomass and density indices obtained from 2014 onwards are among the lowest observed in the whole time series of the MEDITS data in GSAs 9, 10 and 11. In 2018, a sharp increase in biomass and density was observed, followed by a new decrease in values in 2019 and 2020.



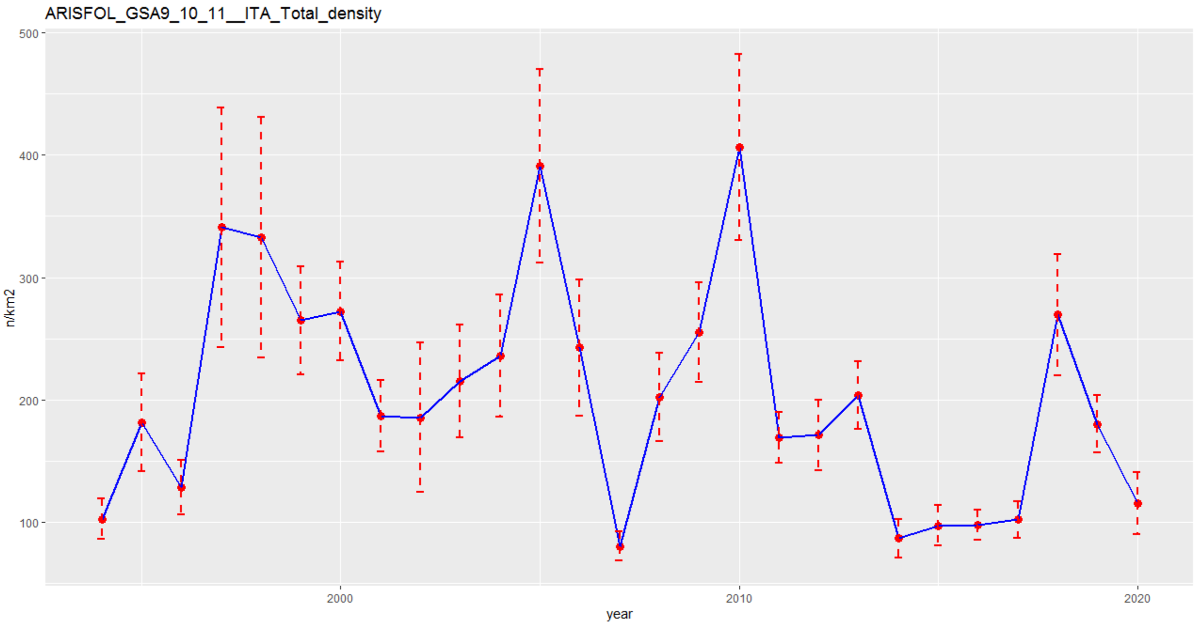


Figure 6.19.2.3.2. Giant red shrimp in GSAs 9, 10 and 11: MEDITS standardized biomass and density indices (10-800 m).

Trends in abundance and biomass by length

The stratified abundance indices by length (by sex and total) computed on the three GSAs combined during the MEDITS surveys from 1994 to 2020 are shown in Figures 6.19.2.3.3-6.19.2.3.5. Also these plots show that the densities observed from 2014 onwards are among the lowest observed in the whole time series of the MEDITS survey in the GSAs 9, 10, 11.

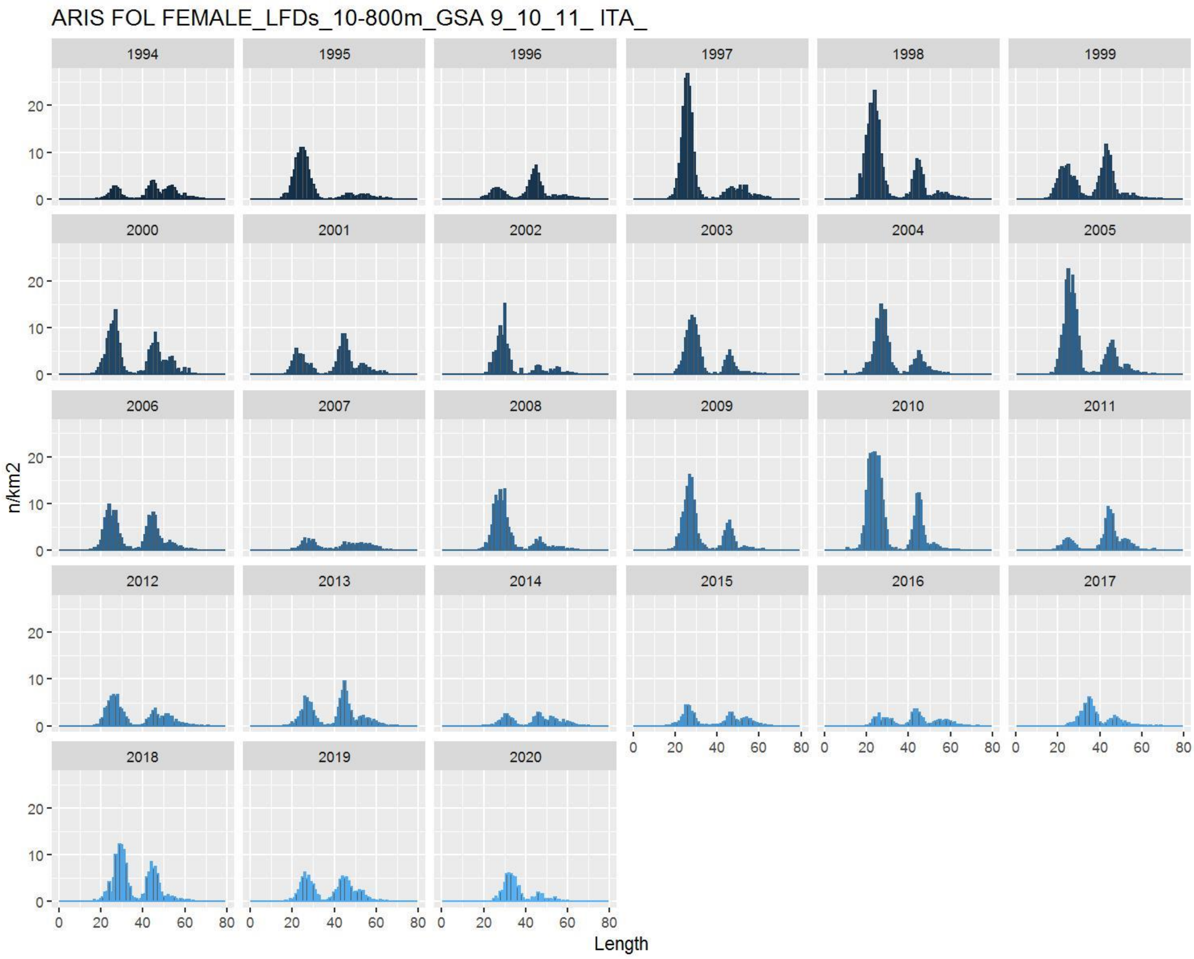


Figure 6.19.2.3.3. Giant red shrimp in GSAs 9, 10 and 11: stratified abundance indices by size for females, 1994-2020.

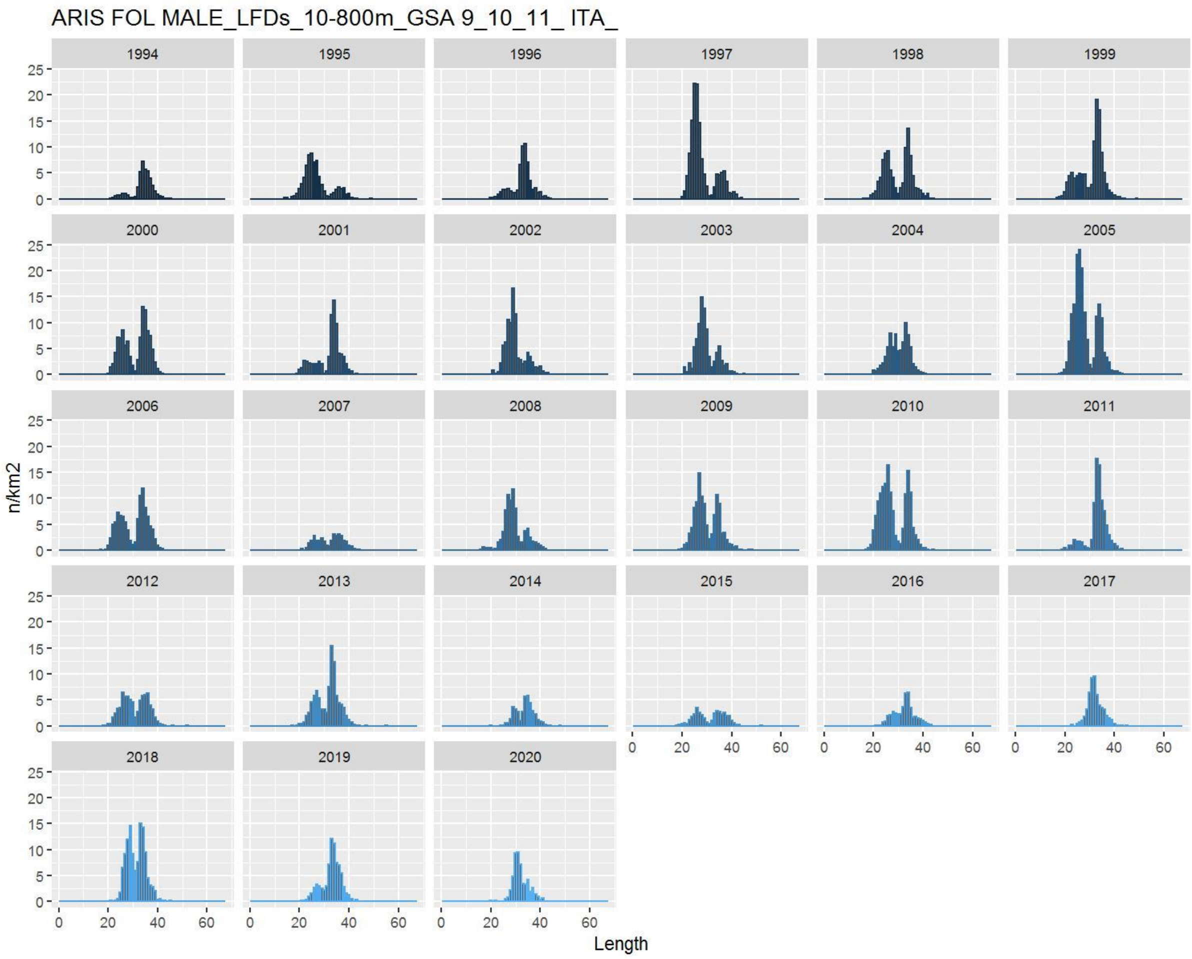


Figure 6.19.2.3.4. Giant red shrimp in GSAs 9, 10 and 11: stratified abundance indices by size for males, 1994-2020.

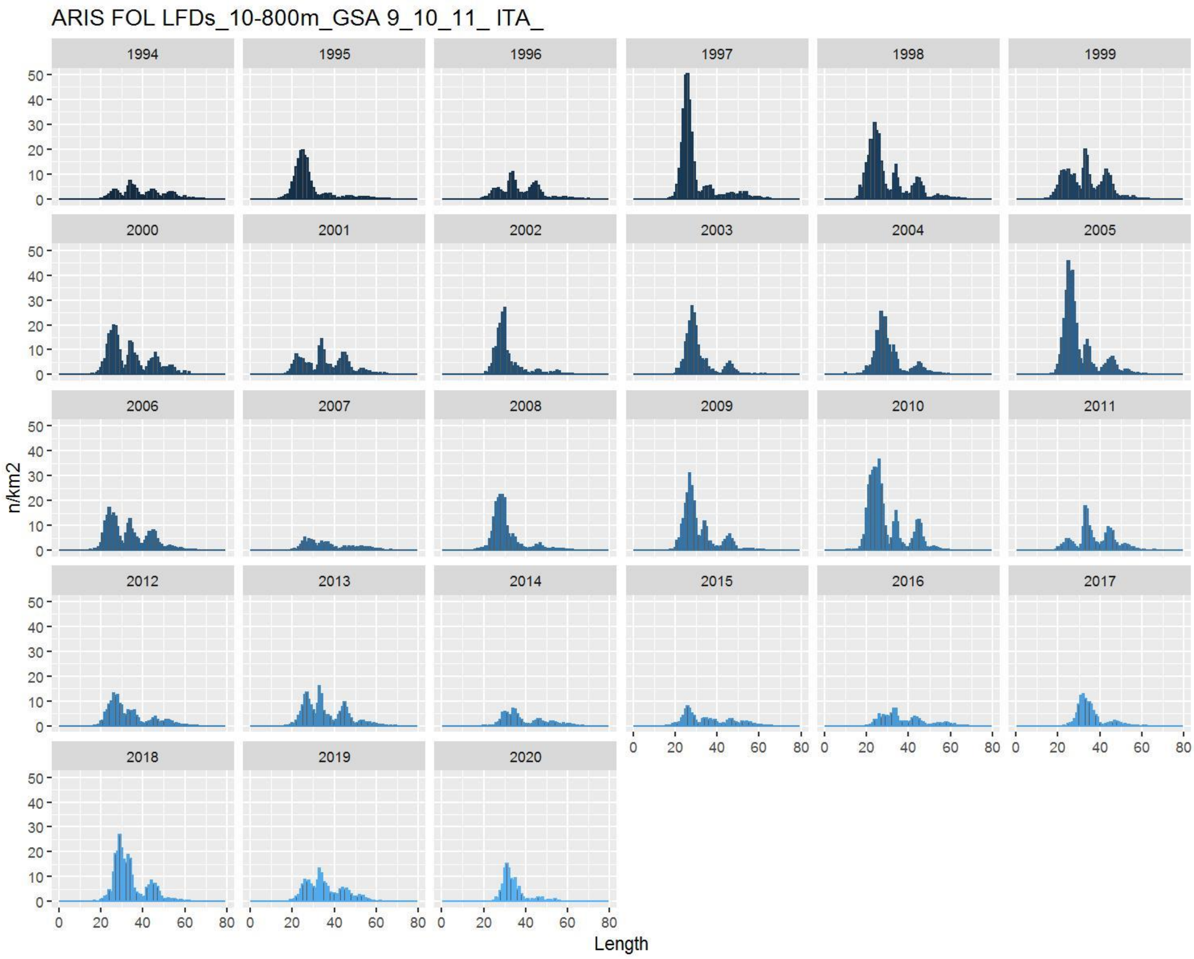


Figure 6.19.2.3.5 Giant red shrimp in GSAs 9, 10 and 11: total stratified abundance indices by size, 1994-2020.

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 2005-2020 for the catch data and 2005-2020 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).

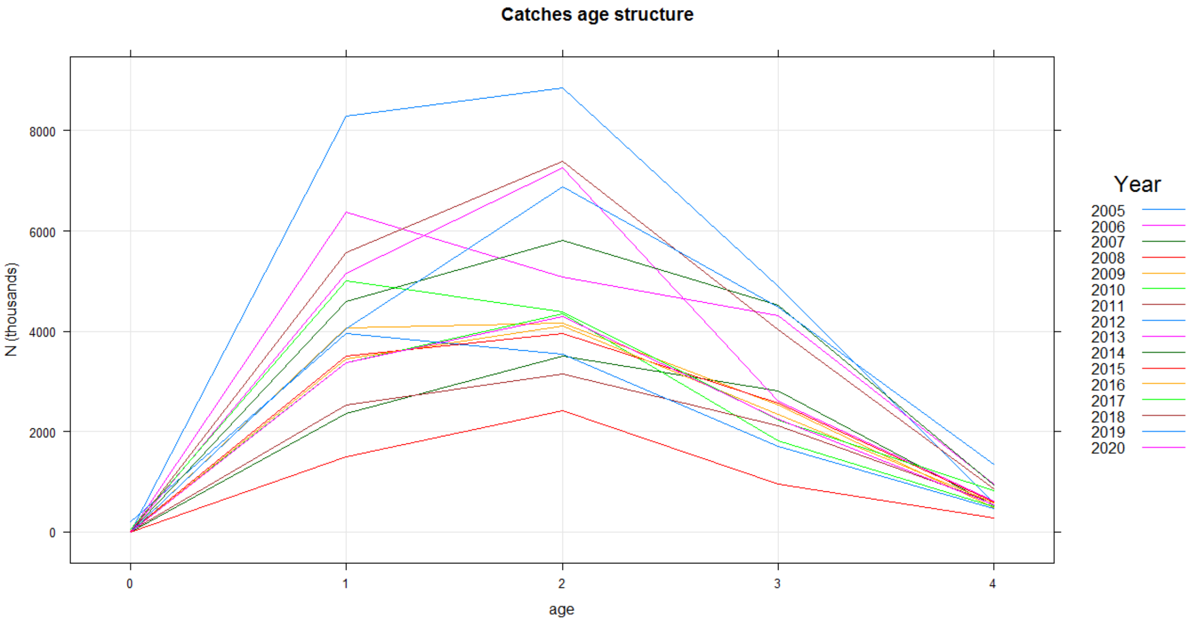


Figure 6.19.3.1 Giant red shrimp in GSAs 9, 10 and 11: catch-at-age distribution by year of the catches (2005-2020).

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	0.51	8.20	0.41
2004	0.52	0.50	0.49
2005	0.53	0.47	0.49
2006	0.55	0.49	0.45
2007	0.55	0.50	0.47
2008	0.77	0.53	0.48
2009	0.55	0.47	0.46
2010	0.83	0.50	0.48
2011	0.74	0.51	0.49
2012	0.65	0.50	0.47
2013	0.55	0.47	0.60
2014	0.58	0.48	0.75
2015	1.50	0.52	0.62
2016	1.71	0.48	1.46
2017	0.52	0.48	1.26
2018	0.50	1.61	2.47
2019	1.21	5.87	0.41
2020	0.57	5.73	0.49

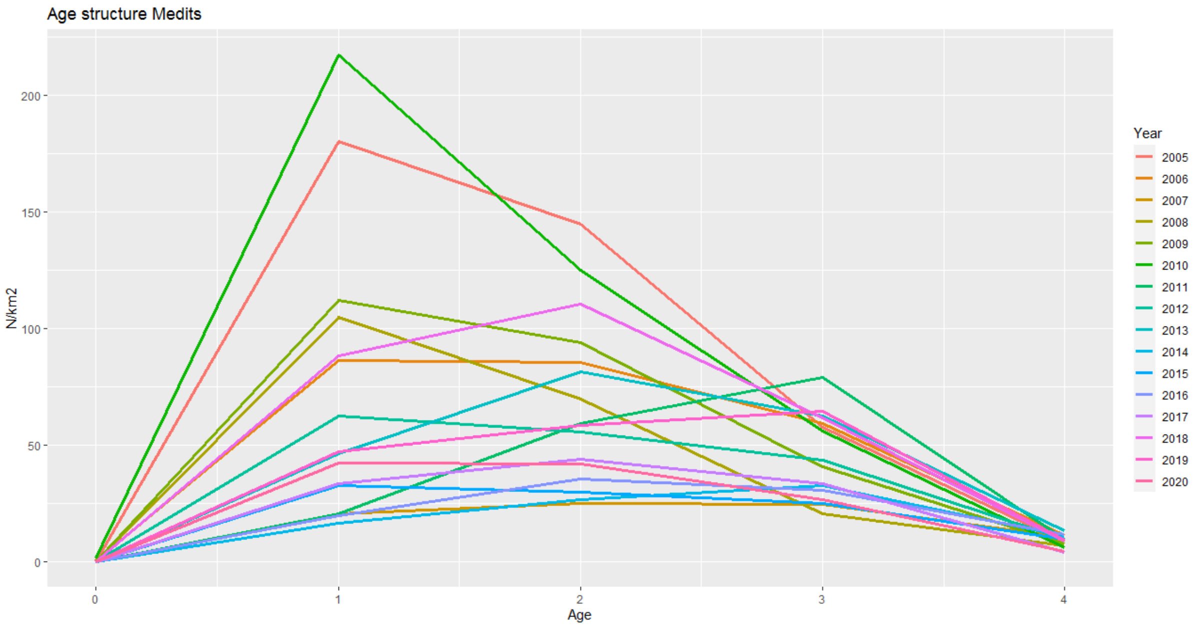


Figure 6.19.3.2 Giant red shrimp in GSAs 9, 10 and 11: Medits index-at-age distribution by year (2005-2020).

Table. 6.19.3.2. Giant red shrimp in GSAs 9, 10 and 11: Values of catch numbers at age per year used in the assessment (SOP applied).

Age	2005	2006	2007	2008
0	4.67	1.86	1.87	2.55
1	8288.40	6379.70	2352.89	1502.15
2	8847.29	5081.62	3500.09	2411.22
3	4896.49	4304.32	2815.22	954.96
4+	580.83	956.19	522.05	278.39
Age	2009	2010	2011	2012
0	1.99	18.77	8.84	198.94
1	4072.70	3370.39	2530.07	3955.31
2	4166.58	4351.52	3141.90	3540.20
3	2533.11	1821.43	2119.17	1707.47
4+	493.51	502.37	580.89	470.82
Age	2013	2014	2015	2016
0	5.62	1.95	21.70	6.43
1	5161.85	4597.28	3498.29	3445.94
2	7255.38	5806.84	3950.99	4097.62
3	2607.57	4521.23	2566.55	2336.86
4+	618.55	940.43	596.67	574.12
Age	2017	2018	2019	2020
0	57.49	2.21	4.17	7.08
1	5009.46	5561.59	4056.96	3378.45
2	4382.07	7389.65	6883.58	4300.96
3	2221.67	4036.79	4486.79	2257.37
4+	826.79	868.46	1356.35	548.07

Table. 6.19.3.3. Giant red shrimp in GSAs 9, 10 and 11: Values of mean weight at age per year used in the assessment.

Age	2005	2006	2007	2008
0	0.000	0.000	0.000	0.000
1	0.021	0.018	0.026	0.019
2	0.026	0.043	0.041	0.037
3	0.037	0.044	0.046	0.057
4+	0.076	0.063	0.081	0.071
Age	2009	2010	2011	2012
0	0.000	0.000	0.000	0.000
1	0.016	0.023	0.025	0.020
2	0.042	0.036	0.043	0.037
3	0.045	0.041	0.040	0.051
4+	0.074	0.068	0.060	0.071
Age	2013	2014	2015	2016
0	0.000	0.000	0.000	0.000
1	0.019	0.024	0.021	0.022
2	0.034	0.037	0.036	0.035
3	0.037	0.042	0.045	0.036
4+	0.066	0.078	0.074	0.066
Age	2017	2018	2019	2020
0	0.000	0.000	0.000	0.000
1	0.016	0.023	0.025	0.020
2	0.042	0.036	0.043	0.037
3	0.045	0.041	0.040	0.051
4+	0.075	0.075	0.063	0.079

Table. 6.19.3.4. Giant red shrimp in GSAs 9, 10 and 11: Survey index (MEDITS) values of numbers at age per year used in the assessment.

Age	2005	2006	2007	2008
0	0.178	0.377	0.031	0.048
1	180.141	86.310	20.440	105.050
2	144.642	85.376	24.921	69.670
3	57.538	59.137	24.574	20.658
4+	8.392	11.390	10.620	6.859
Age	2009	2010	2011	2012
0	0.094	1.517	0.129	0.048
1	112.061	217.377	20.786	62.399
2	94.008	125.252	59.448	55.511
3	40.582	56.139	79.142	43.593
4+	7.754	6.074	9.632	9.742
Age	2013	2014	2015	2016
0	0.054	0.031	0.095	0.031
1	46.364	16.618	32.856	19.761
2	81.656	26.744	29.711	35.665
3	62.427	32.862	24.856	30.731
4+	13.416	10.748	9.585	11.706
Age	2017	2018	2019	2020
0	0.031	0.158	0.126	0.031
1	33.662	88.489	47.173	42.516
2	43.869	110.538	58.549	41.969
3	33.437	61.574	64.757	26.746
4+	4.231	8.844	9.133	4.526

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, as 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 always around 6% of the total SSB.

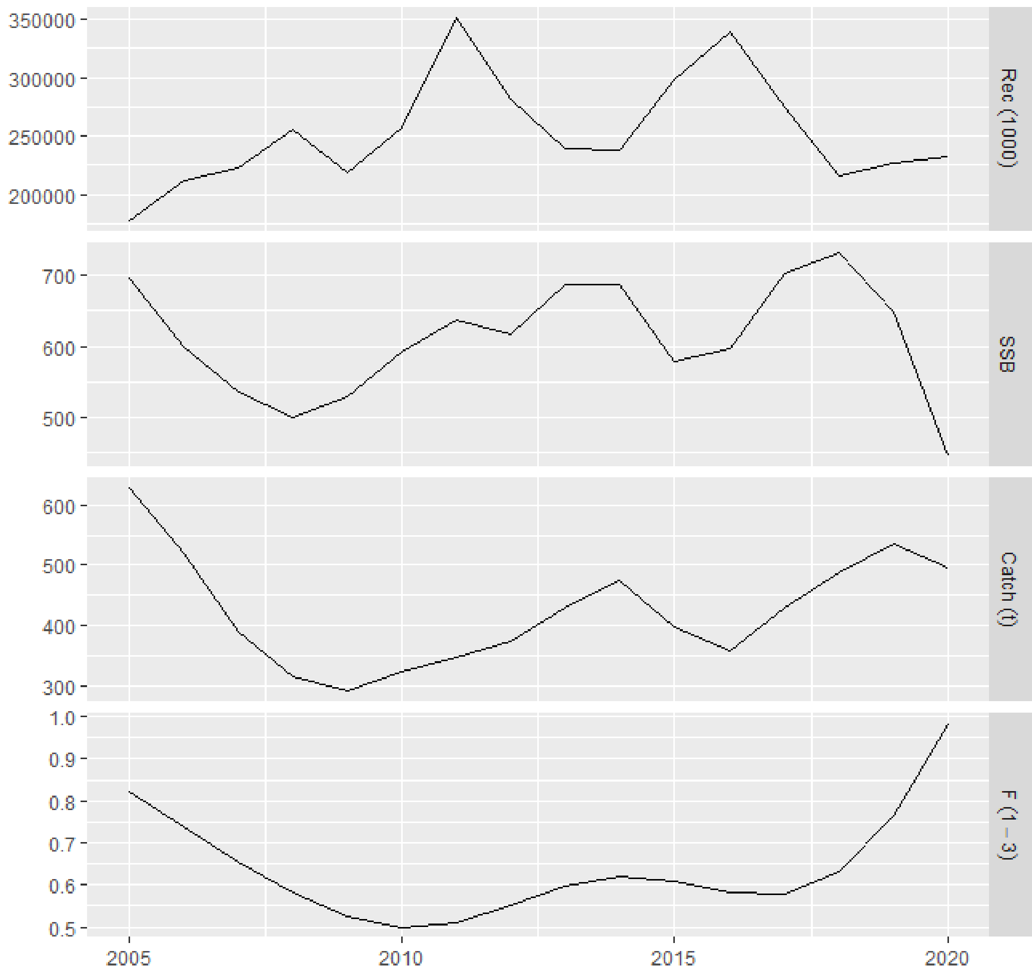


Figure 6.19.3.3. Giant red shrimp in GSAs 9, 10 and 11. Stock summary from the final a4a model.

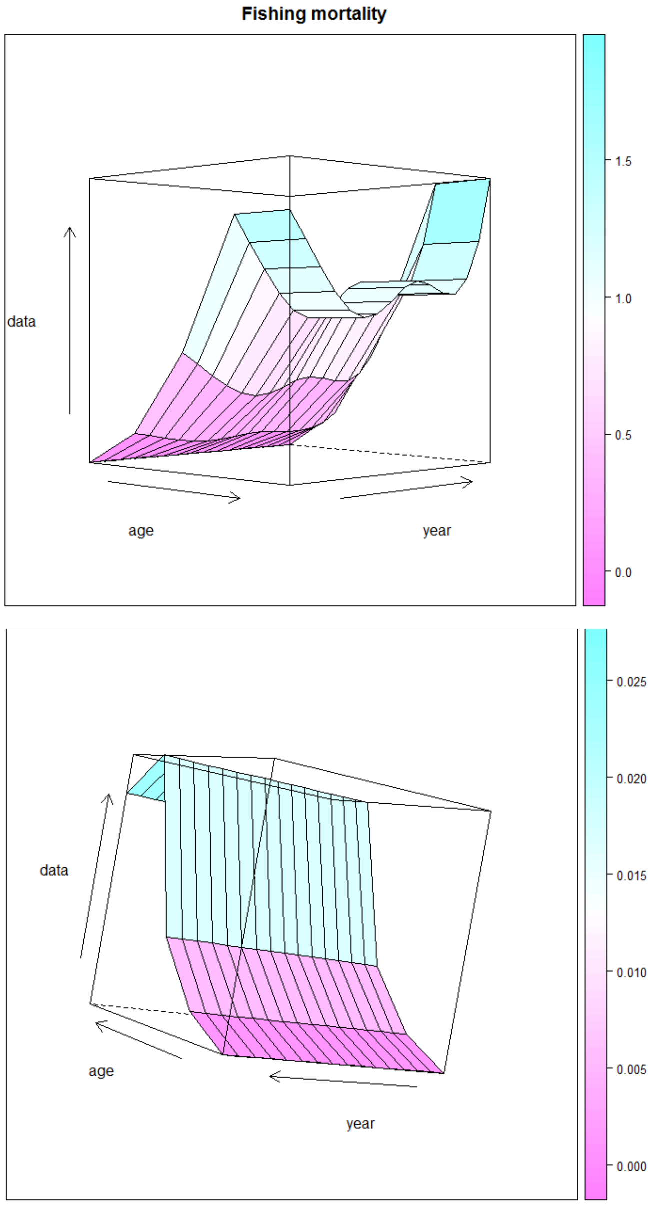


Figure 6.19.3.4. Giant red shrimp in GSAs 9, 10 and 11. 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.

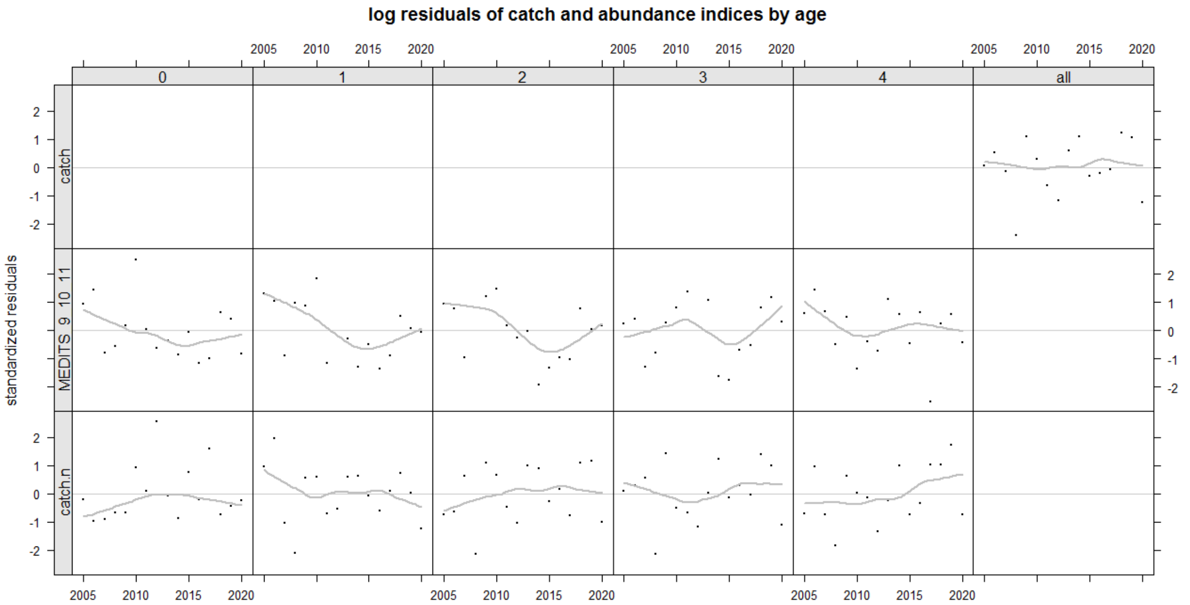


Figure 6.19.3.5. Giant red shrimp in GSAs 9, 10 and 11. log residuals for the catch-at-age data of the fishery and the survey.

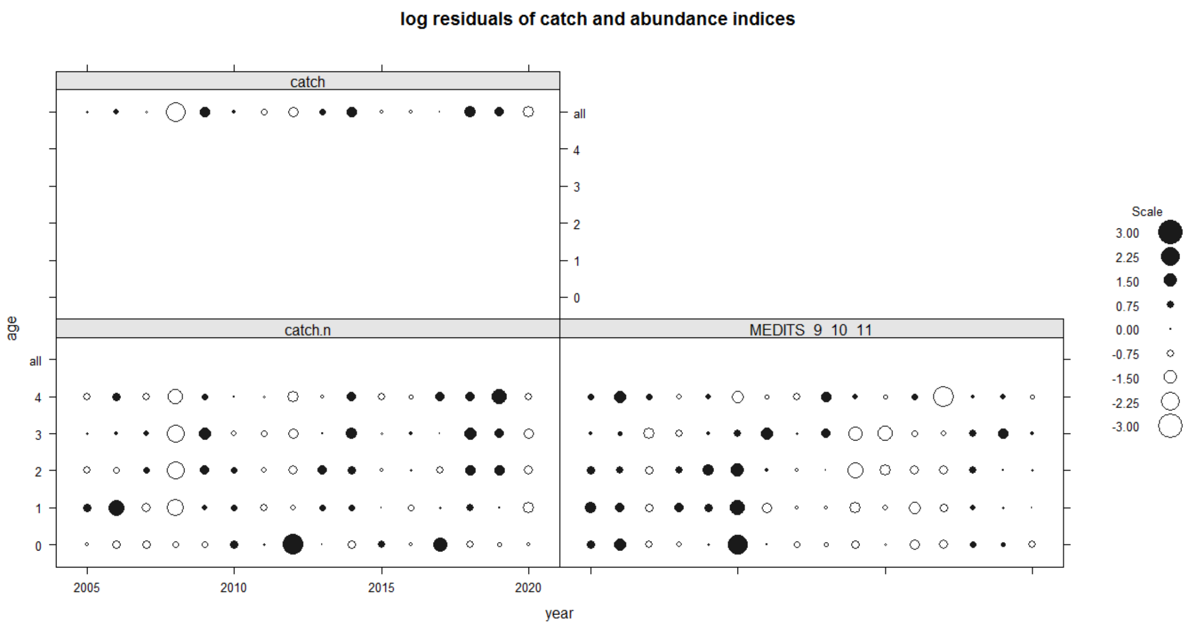


Figure 6.19.3.6. Giant red shrimp in GSAs 9, 10 and 11. Bubble plot of the log residuals for the catch-at-age data of the fishery and the survey.

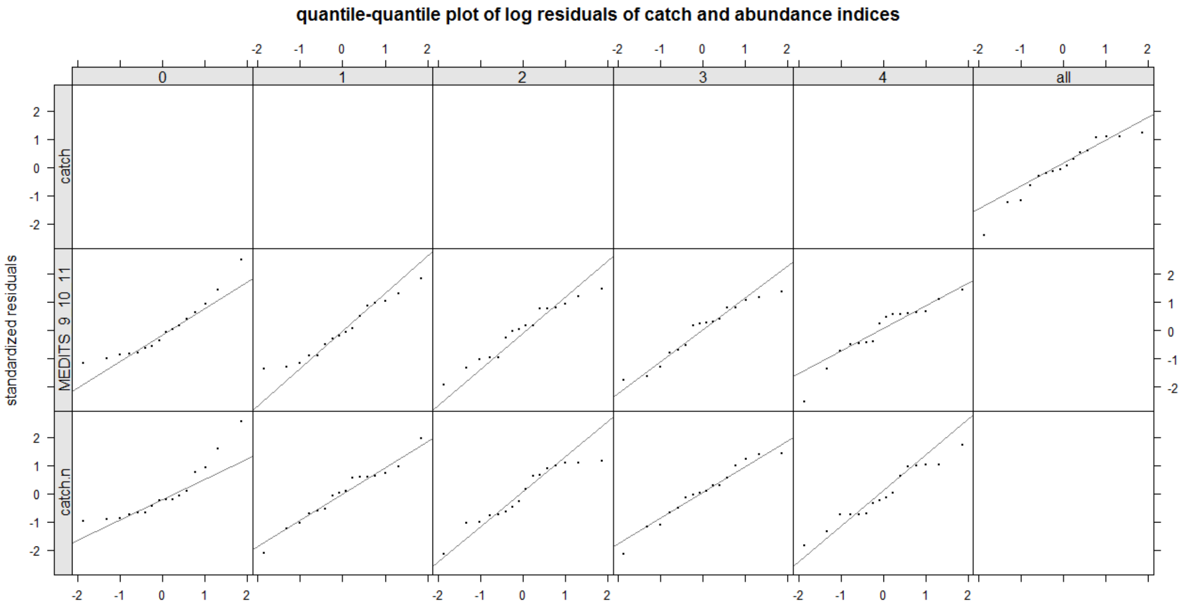


Figure 6.19.3.7. Giant red shrimp in GSAs 9, 10 and 11: QQ-plot of the log residuals for the catch-at-age data of the fishery and the survey.

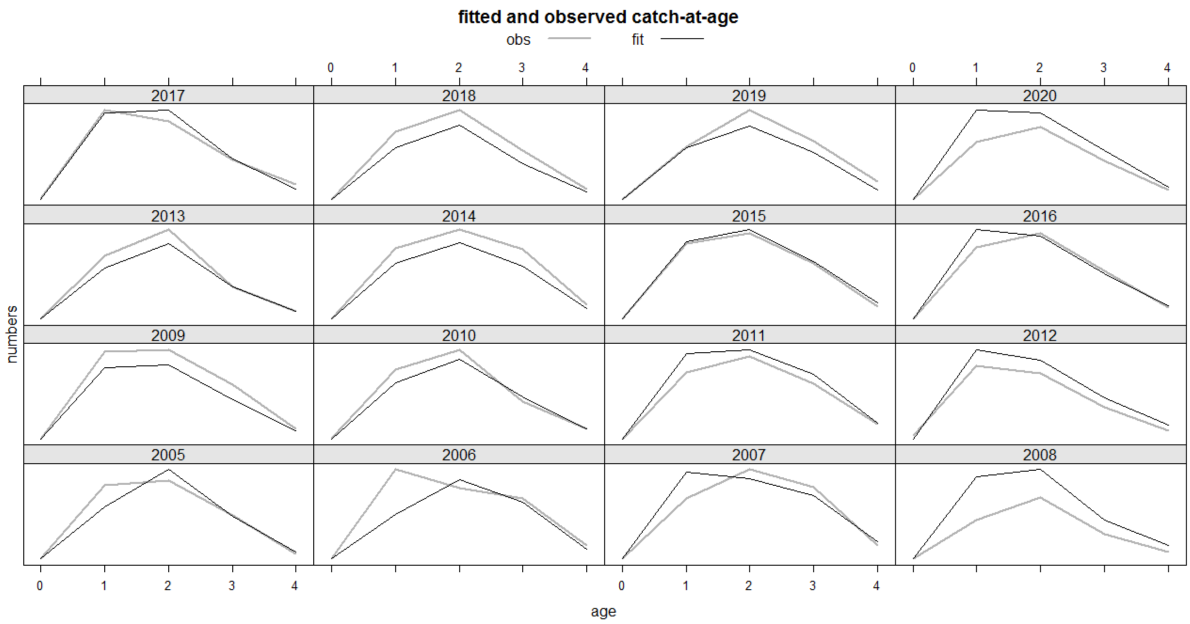


Figure 6.19.3.8. Giant red shrimp in GSAs 9, 10 and 11: fitted vs observed values by age and year for the catches.

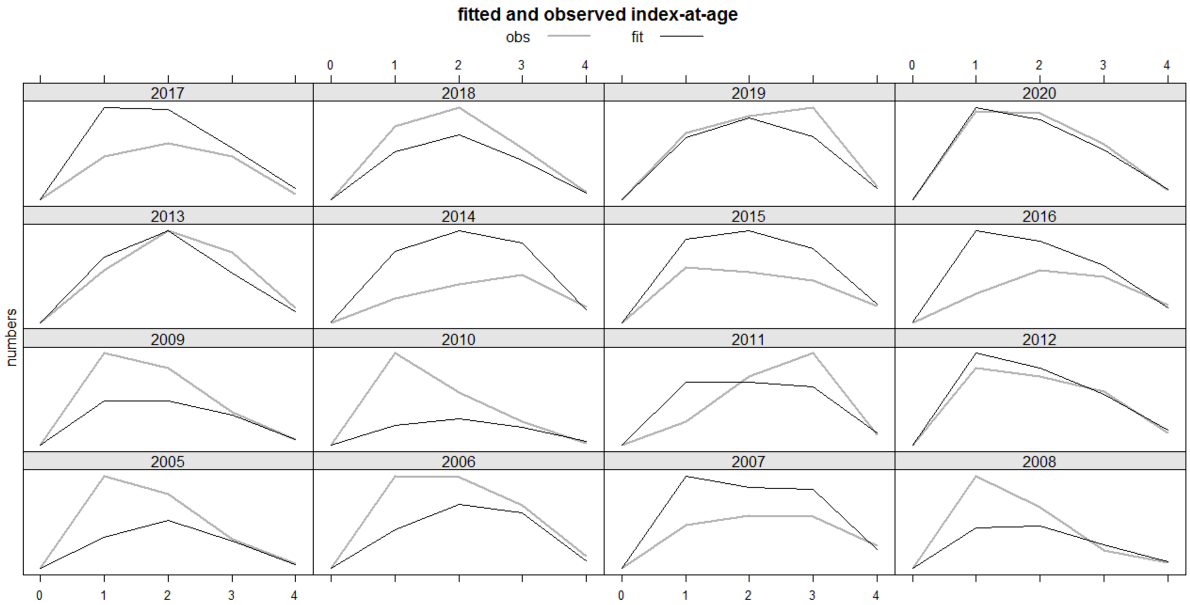


Figure 6.19.3.9. Giant red shrimp in GSAs 9, 10 and 11: fitted vs observed values by age and year for the survey.

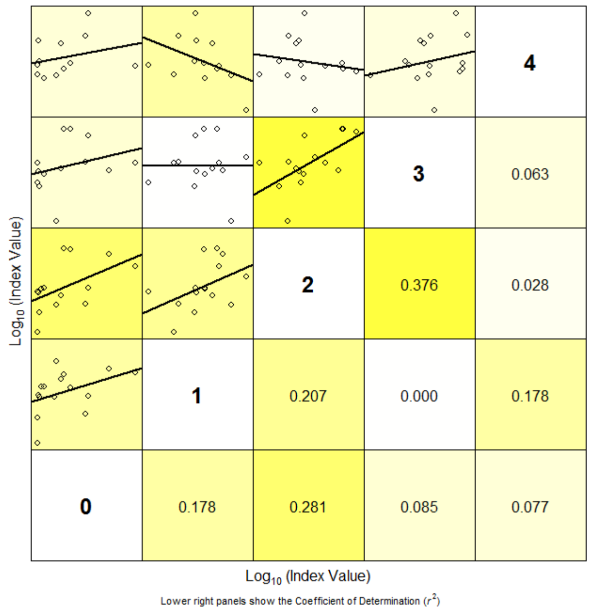


Figure 6.19.3.10. Giant red shrimp in GSAs 9, 10 and 11: internal consistency of the catch-at-age data.

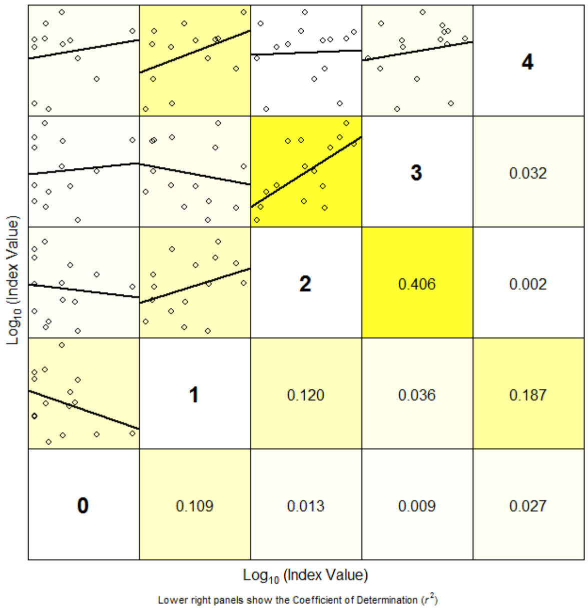


Figure 6.19.3.11. Giant red shrimp in GSAs 9, 10 and 11: internal consistency of the catch-at-age data of the MEDITS survey.

Retrospective

The retrospective analysis was applied up only 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, overestimation of SSB and 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} = 0.462, F in 2020 is estimated as $F_{current}$=0.983.

A sensitivity run with 2020 survey omitted was carried out. The outcomes were very similar to each other, as the kept the survey was regarded as informative the analysis with MEDITS 2020 was used.

Based on the a4a results, the Giant red shrimp showed a slight decrease in the SSB since 2018 (from 732 to 445 tons) and an increase in F_{bar} (1-3) that reached its maximum values in the last year (0.983).

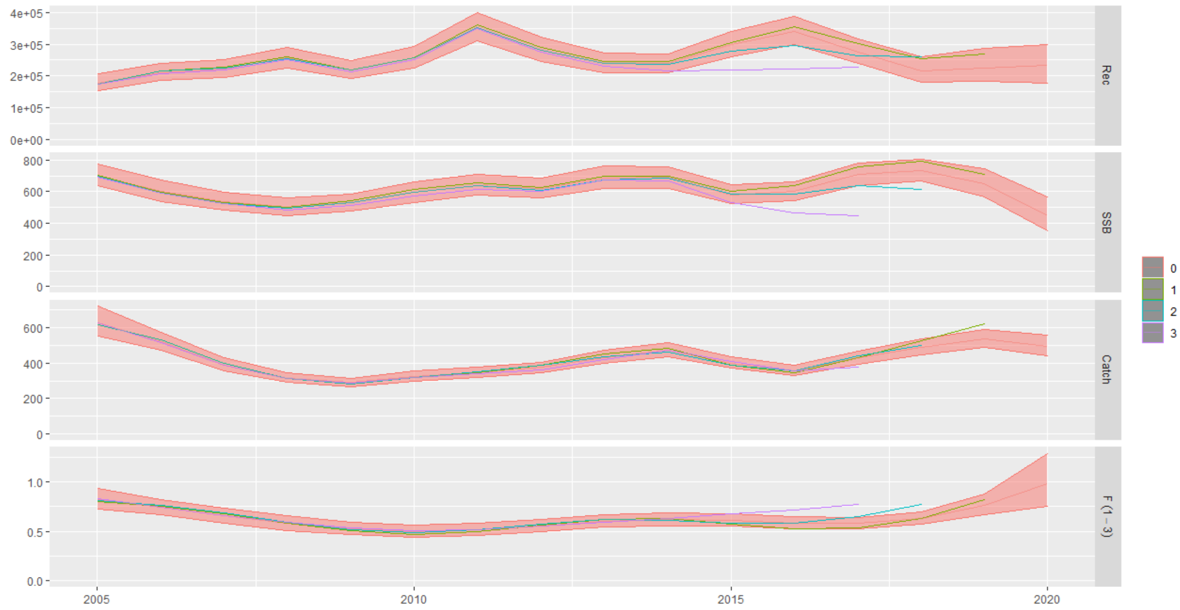


Figure 6.19.3.12. Giant red shrimp in GSAs 9, 10 and 11. Retrospective analysis

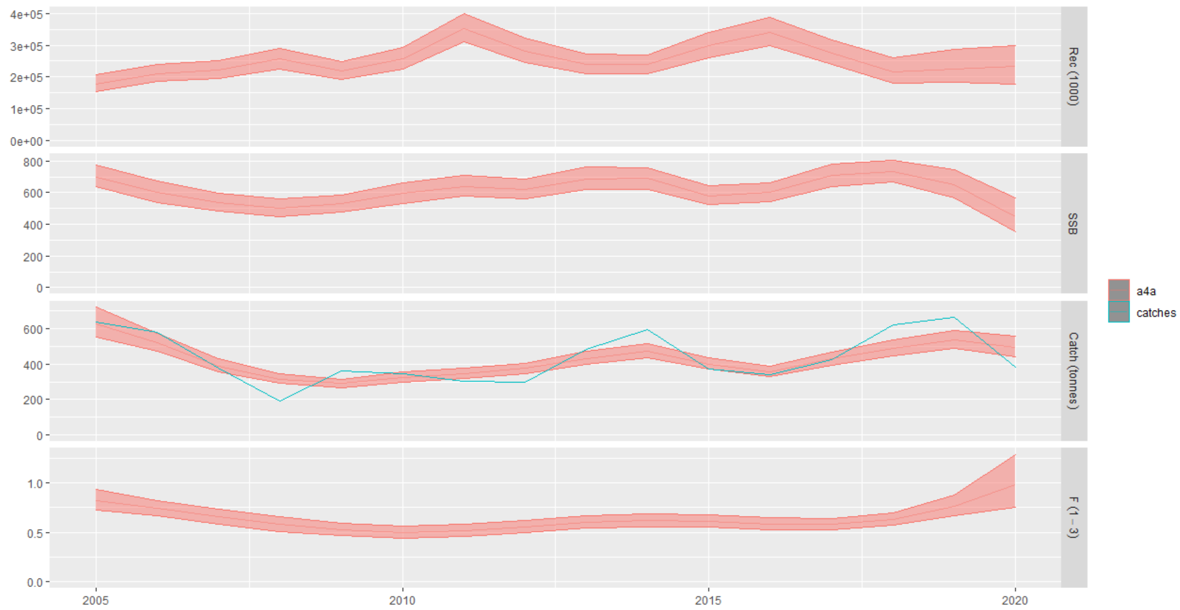


Figure 6.19.3.13. Giant red shrimp in GSAs 9, 10 and 11. Simulations over summary results.

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 and 11. Stock numbers at age (thousands) as estimated by a4a.

	0	**1**	**2**	**3**	**4+**
2005	177364	44984	25278	7407	1132
2006	211314	26793	15372	6593	1096
2007	223150	31921	9360	4320	1156
2008	256130	33710	11391	2827	962
2009	219335	38692	12268	3676	768
2010	256459	33134	14287	4159	995
2011	351364	38742	12312	4949	1209
2012	281626	53079	14352	4221	1413
2013	238766	42544	19458	4749	1203
2014	238090	36069	15409	6179	1162
2015	297634	35967	12985	4794	1370
2016	339906	44962	12990	4085	1181
2017	274881	51347	16353	4184	1061
2018	216632	41525	18693	5284	1063
2019	227033	32725	14911	5766	1164
2020	232523	34296	11354	4093	993

Table 6.19.3.6. Giant red shrimp in GSAs 9, 10 and 11. Fishing mortality-at-age.

	0	**1**	**2**	**3**	**4+**
2005	0.000	0.214	0.724	1.529	1.529
2006	0.000	0.192	0.649	1.372	1.372
2007	0.000	0.170	0.577	1.220	1.220
2008	0.000	0.151	0.511	1.079	1.079
2009	0.000	0.136	0.462	0.975	0.975
2010	0.000	0.130	0.440	0.930	0.930
2011	0.000	0.133	0.451	0.952	0.952
2012	0.000	0.143	0.486	1.027	1.027
2013	0.000	0.156	0.527	1.114	1.114
2014	0.000	0.162	0.547	1.157	1.157
2015	0.000	0.158	0.537	1.134	1.134
2016	0.000	0.151	0.513	1.084	1.084
2017	0.000	0.150	0.510	1.077	1.077
2018	0.000	0.164	0.556	1.175	1.175
2019	0.000	0.199	0.673	1.421	1.421
2020	0.000	0.256	0.866	1.829	1.829

Table 6.19.3.7. Giant red shrimp in GSAs 9, 10 and 11. a4a summary results and F at age.

	Fbar(1-3)	**Recruitment (thousands)**	**SSB (t)**	**Catch (t)**
2005	0.822	177364	697	628
2006	0.738	211314	600	520
2007	0.656	223150	536	389
2008	0.580	256130	500	315
2009	0.524	219335	529	289
2010	0.500	256459	593	323
2011	0.512	351364	638	346
2012	0.552	281626	617	374
2013	0.599	238766	686	430
2014	0.622	238090	686	474
2015	0.609	297634	578	398
2016	0.583	339906	598	357
2017	0.579	274881	704	429
2018	0.632	216632	732	486
2019	0.764	227033	648	536
2020	0.983	232523	445	496

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 0.462. The current F, estimated as the F_{bar1-3} in the last year of the time series, 2020, is 0.983, well above the $F_{0.1}$. This indicates that the giant red shrimps in GSAs 9, 10 & 11 is over – exploited.

6.19.5 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 was used for weight at age, natural mortality and maturity at age, while the F_{bar1-3} =0.983 (the last year's F estimated by the assessment model) was used for F in 2021, 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 (248799 thousand individuals, 16 years) has been used as an estimate of recruits in 2021-2022.

able 6.19.5.1 Giant red shrimp in GSAs 9, 10 and 11: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2018-2020	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-3}$ (2021)	0.983	F 2020 used to give F status quo for
SSB (2021)	437	Stock assessment 1 January 2020
R_{age0} (2021,2022)	248799	Mean of the last 3 years
Total catch (2021)	424	Catch intermediate year from STF output

Table 6.19.5.2 Giant red shrimp in GSAs 9, 10 and 11.: Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2021	Catch 2022	SSB 2021	SSB 2023	SSB change 2021-2023(%)	Catch change 2020-2022(%)
High long term yield ($F_{0.1}$)	0.47	0.462	424.1	240.9	436.7	654.1	49.8	-51.5
F upper	0.64	0.631	424.1	308.9	436.7	579.2	32.6	-37.8
F lower	0.31	0.308	424.1	170.8	436.7	738.7	69.2	-65.6
F_{MSY} transition (intermediate year)	0.62	0.613	424.1	302.0	436.7	586.5	34.3	-39.2
Zero catch	0.00	0.000	424.1	0.0	436.7	979.2	124.3	-100.0
Status quo	1.00	0.983	424.1	426.7	436.7	464.9	6.5	-14.1
Different Scenarios	0.10	0.098	424.1	59.7	436.7	889.4	103.7	-88.0
	0.20	0.197	424.1	114.3	436.7	812.7	86.1	-77.0
	0.30	0.295	424.1	164.5	436.7	746.7	71.0	-66.9
	0.40	0.393	424.1	210.7	436.7	689.5	57.9	-57.6
	0.50	0.492	424.1	253.5	436.7	639.7	46.5	-48.9
	0.60	0.590	424.1	293.2	436.7	596.0	36.5	-41.0
	0.70	0.688	424.1	330.0	436.7	557.3	27.6	-33.5
	0.80	0.787	424.1	364.4	436.7	523.0	19.8	-26.6
	0.90	0.885	424.1	396.6	436.7	492.4	12.8	-20.1
	1.10	1.082	424.1	455.0	436.7	440.1	0.8	-8.4
	1.20	1.180	424.1	481.7	436.7	417.6	-4.4	-3.0
	1.30	1.278	424.1	506.9	436.7	397.2	-9.0	2.1
	1.40	1.377	424.1	530.6	436.7	378.5	-13.3	6.9
	1.50	1.475	424.1	553.2	436.7	361.4	-17.2	11.4
	1.60	1.573	424.1	574.6	436.7	345.6	-20.9	15.7
	1.70	1.672	424.1	594.9	436.7	331.0	-24.2	19.8
	1.80	1.770	424.1	614.3	436.7	317.6	-27.3	23.7
	1.90	1.868	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 2019 was present only for quarter I and IV, as reported also in the previous EWG, while for 2020 for quarters II and IV. This required the reconstruction on the LFD by using data from the other two GSAs and a SOP correction. The impact on the assessment was low.

A sensitivity analysis was run to test the effects of the late MEDITS survey performed in 2020. No major effect on the assessment model was detected.

7 CONTACT DETAILS OF EWG-21-11 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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8 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/ewg2111

List of electronic annexes documents:

EWG-21-11 – Annex 1 – Stock objects

EWG-21-11 – Annex 2 - Rscripts

9 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/ewg2111

List of background documents:

EWG-21-11 – Doc 1 - Declarations of invited and JRC experts (see also section 7 of this report – List of participants)

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