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Scientific, Technical and Economic Committee for Fisheries (STECF) - Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-20-09)

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Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report is from STECF Expert Working Group 20-09: 2020 stock assessments of demersal stocks in the western Mediterranean Sea from the meeting held remotely from 7th to 18 rd September 2020. A total of 19 fish stocks were evaluated. The EWG reports age based assessments and short term forecasts for 15 of the 19 stocks. Catch advice for the other four 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 15 assessments, the exploration of assessments and category 3 evaluations for the remaining four stocks. The report also contains the STECF observations and conclusions on the assessment report. These conclusions come from the STECF Plenary meeting November 2020.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-20-09)

Request to the STECF

STECF is requested to review the report of the STECF Expert Working Group meeting, evaluate the findings and make any appropriate comments and recommendations

STECF observations

The working group was held remotely, from 7 to 18 September 2020. The meeting was attended by 20 experts in total, including three STECF members and four JRC experts. One DG MARE representative and two observers also attended the meeting. The objective of the EWG 20-09 was to carry out demersal stock assessments in the western Mediterranean as defined in the EWG ToRs.

STECF comments

STECF acknowledges that the EWG has addressed adequately all ToRs. STECF notes that the EWG has carefully reviewed the quality of the assessments produced. Some analyses have been considered suitable for short term forecasts.

Table 1 Summary of the work attempted and basis for any advice. A4a is an age based assessment method, 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[1].

Area	Common Species name	2019 Assessment	2020 Assessment
1_5_6_7	Hake	a4a STF	**a4a STF**
1_5_6_7	Deep-water rose shrimp	2018 Index	A4a, XSA **Index**
1	Red Mullet	a4a STF	**a4a STF**
5	Striped Red Mullet	a4a STF	**a4a STF**
6	Red Mullet	a4a STF	**a4a STF**
7	Red Mullet	a4a STF	**a4a STF**
5	Norway lobster	Index (2019)*	a4a, XSA, **Index (2019)**
6	Norway lobster	a4a STF	**a4a STF**

[1] https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/Introduction_to_advice_2018.pdf

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	2018 Index	a4a, **Index**
1	Blue and red shrimp	a4a STF	**a4a STF**
5	Blue and red shrimp	2018 Index	a4a, XSA, **Index**
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**

* advice based on STECF EWG 19 10 held in 2019

A total of 19 area/species combinations were evaluated (Tables 1 and 2). The EWG carried out short term forecasts for 15 age-based assessments. Catch advice for four 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 13 out of the 19 stocks are being significantly overfished, five are being fished close to F_{MSY} and one is under-exploited.

- Hake in GSA 1_5_6_7: the biomass is increasing. Catches should be reduced by at least 77% to reach F_{MSY} in 2021.
- Deep-water rose shrimp in GSA 1_5_6_7: the biomass is decreasing. Catches should be reduced by at least 41% to conform to precautionary consideration in 2021.
- Red Mullet in GSA 1: the biomass is declining. Catches should not be increased in order to reach F_{MSY} in 2021.
- Striped Red Mullet in GSA 5: the biomass is increasing. Catches may be increased by no more than 61% to reach F_{MSY} in 2021.
- Red Mullet in GSA 6: the biomass is declining. Catches should be reduced by at least 80% to reach F_{MSY} in 2021.
- Red Mullet in GSA 7: the biomass is increasing. Catches should be reduced by at least 21% to reach F_{MSY} in 2021.
- Norway lobster in GSA 5: the biomass is fluctuating. Catches should be reduced by at least 55% to conform to precautionary consideration in 2021.
- Norway lobster in GSA 6: the biomass is increasing. Catches should be reduced by at least 72% to reach F_{MSY} in 2021.

- Hake in GSA 8_9_10_11: the biomass is increasing. Catches should be reduced by at least 54% to reach F_{MSY} in 2021.
- Deep-water rose shrimp in GSA 9_10_11: the biomass is increasing. Catches may be increased by no more than 8% to reach F_{MSY} in 2021.
- Red Mullet in GSA 9: the biomass is increasing. Catches should be reduced by at least 34% to reach F_{MSY} in 2021.
- Red Mullet in GSA 10: the biomass is declining. Catches should be reduced by at least 6% to reach F_{MSY} in 2021.
- Norway lobster in GSA 9: the biomass is stable. Catches should be reduced by at least 6% to reach F_{MSY} in 2021.
- Norway lobster in GSA 11: the biomass is fluctuating. Catches should be reduced by at least 67% to conform to precautionary consideration in 2021.
- Blue and red shrimp in GSA 1: the biomass is declining. Catches should be reduced by at least 73% to reach F_{MSY} in 2021.
- Blue and red shrimp in GSA 5: the biomass is declining. Catches should be reduced by at least 33% to conform to precautionary consideration in 2021.
- Blue and red shrimp in GSA 6_7: the biomass is declining. Catches should be reduced by at least 67% to reach F_{MSY} in 2021.
- Blue and red shrimp in GSA 9_10_11: the biomass is declining. Catches should be reduced by at least 83% to reach F_{MSY} in 2021.
- Giant red shrimp in GSA 9_10_11: the biomass is declining. Catches should be reduced by at least 43% to reach F_{MSY} in 2021.

Table 2 Summary of advice from EWG 20-09 by area and species. F 2019 is estimated F in the assessment. Change in F is the difference (%) between target F (F_{MSY}) in 2021 and the estimated F for 2019. Change in catch is the difference (%) between catch 2019 and catch 2021. Biomass and catch 2017-2019 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 (GSA)	**Species**	**Method/ Basis**	**Age Fbar**	**Biomass 2017-2019**	**Catch 2017-2019**	**F 2019**	**F 2021**	**Change in F**	**Catch 2019***	**Catch 2021**	**Change in catch**
1_5_6_7	Hake	a4a	1-3	increasing	stable	1.59	0.39	-75%	3148	721	-77%
1_5_6_7	Deep-water rose shrimp	Index 2020		declining	increasing				1161	681	-41%
1	Red Mullet	a4a	1-3	declining	declining	1.03	0.70	-32%	115	114	0%
5	Striped Red Mullet	a4a	1-2	increasing	declining	0.23	0.44	91%	75	121	61%
6	Red Mullet	a4a	1-3	declining	stable	1.53	0.31	-80%	1546	306	-80%
7	Red Mullet	a4a	1-3	increasing	declining	0.67	0.42	-37%	320	252	-21%

5	Norway lobster	Index 2019		fluctuating	increasing				1407#	638	-55%
6	Norway lobster	a4a	3-6	increasing	declining	0.62	0.11	-82%	245	68	-72%
8_9_10_11	Hake	a4a	1-3	increasing	declining	0.57	0.17	-70%	2075	954	-54%
9_10_11	Deep-water rose shrimp	a4a	1-2	increasing	increasing	1.03	1.09	6%	1606	1741	8%
9	Red Mullet	a4a	1-3	increasing	declining	0.85	0.51	-40%	1011	668	-34%
10	Red Mullet	a4a	1-3	declining	declining	0.48	0.39	-18%	334	314	-6%
9	Norway lobster	a4a	2-6	stable	increasing	0.28	0.28	0%	193	181	-6%
11	Norway lobster	Index 2020		fluctuating	increasing				40	13	-67%
1	Blue and red shrimp	a4a	1-2	declining	declining	1.82	0.29	-84%	120	32	-73%
5	Blue and red shrimp	Index 2020	1-2	declining	increasing				206	137	-33%
6_7	Blue and red shrimp	a4a	1-2	declining	declining	1.30	0.29	-78%	566	188	-67%
9_10_11	Blue and red shrimp	a4a	2-5	declining	stable	1.78	0.33	-81%	366	61	-83%
9_10_11	Giant red shrimp	a4a	1-3	declining	stable	0.73	0.48	-35%	571	323	-43%

*Estimated Catch

Reference value from 2019 advice

STECF considers that for all the 15 age-based assessments presented in the report, the assessments can be used to provide advice on stock status in terms of F relative to F_{MSY}, and to provide catch advice for 2020. STECF notes that the assessments are based on short data series and some degree of uncertainty therefore remains, but STECF considers overall that they provide a robust guidance on the magnitude of changes in F and catches required to reach F_{MSY} by 2021. The 15 age-based assessments form the basis of the advice in section 5 of the EWG 20-09 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 20-09 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 the short-term forecast table. These are the best estimates of F and catch required in 2021 to follow a linear transition, but they do not take into account uncertainty in estimates or the current progress in transition. They should be considered as guide for current progress towards F_{MSY} in 2025.

STECF notes that for some stocks, particularly hake in GSA 1_5_6&7 and blue and red shrimp in GSA 1 recruitment has declined significantly in recent years, though for other stocks such as red mullet in GSA 7 and deepwater rose shrimp in GSAs 9_10&11 recruitment has increased. STECF notes that in these circumstances the short term forecast advice for catch accounts for these 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.

STECF notes that the EWG routinely updates every year the values for $F_{0.1}$ which is used as a proxy for F_{MSY}. 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 the four stocks with advice based on abundance index, a precautionary buffer of -20% catch reduction was already included in 2018 or 2019 and is not required this year. The advised change in catch is based on the change in stock over the last two years. The catch advice is related to previously advised catches in 2018/2019, and maintains the harvest rate advised for 2019 and 2020. The STECF notes that this approach is consistent with the procedures applied in the North East Atlantic (ICES stocks). For one of these stocks (Norway lobster in GSA 5, Table 5.1.1) catch advice for 2021 was already provided in 2019 and is unchanged (assessments based on abundance index are routinely performed biannually by the STECF EWGs).

STECF notes that F_{MSY} values for red mullet stocks cover a large range (between 0.30 and 0.70) in the different GSAs. These differences come partly from the Fbar range which differs across the stocks, but could also be linked to differences in selection pattern i.e. F at age structure, as well as differences in the growth parameters and natural mortality across the different GSAs. STECF advises that sensitivity analyses could be performed to fully understand the effect of using different growth parameters on the assessment results.

STECF notes that some uncertainties remain, regarding landings of Norway lobster and blue and red shrimp in GSA 11. Although these are not influencing the current advice, they may influence future assessments and advice.

STECF notes that MEDITS biomass indices as well as catches of deep-water rose shrimp in GSA 1_5_6_7 are increasing at different rates in the four respective GSAs. Although the general trend is mostly driven by data from GSAs 5 and 6, this species is showing a pronounced increase in biomass also in GSAs 7 and 1 in the recent years. STECF notices that exploration of assessment options of smaller stock units might be appropriate for this species in these areas.

STECF notes that data quality deficiencies were comprehensively addressed by the EWG for each stock. STECF observes that biological data deficiencies were not yet entered into the DTMT (Data Transmission Monitoring Tool) by the time of the STECF PLEN 20-03 plenary, but this should occur soon afterwards following updates to the online system. STECF notes that data transmission issues should be addressed by data providers and corrected or explained before the next data submission.

STECF notes that the specific STECF EWG data processing workshop proposed for March 2020, that was cancelled due to covid-19, needs to be rescheduled and hold at a suitable time in 2021, in order to cope with persisting data problems in the western Mediterranean and others areas where stock assessments are required.

STECF conclusions

STECF concludes that the EWG 20-09 addressed all the ToRs appropriately. STECF endorses the assessments and evaluations of stock status produced by the EWG. STECF concludes that the results of the assessments accepted by EWG 20-09 provide reliable information on the status of the stocks and the trends in stock biomass and fishing mortality. In four stocks where assessments have been rejected by the EWG, advice has been provided using survey index trends. These same four stocks were already assessed using survey indices in the previous two years. STECF recommends that the data deficiencies reported by the EWG are addressed, and where possible corrected, before the next data submission.

STECF concludes that in future the EWG should tabulate annual values of the advised catch and F based on $F_{MSY\ Transition}$ and the status of F in the most recent year relative to the $F_{MSY\ Transition}$.

STECF notes that effort data is no longer included within the Med and Black Sea data call and that overall effort estimates are best provided by the FDI EWG. The Commission should advise if the effort tabulation which is currently provided in Section 5 of the Med Assessment EWG report should be discontinued, and the ToRs for effort given only to FDI EWG.

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

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REPORT TO THE STECF

EXPERT WORKING GROUP ON Stock Assessments: demersal stocks in the western Mediterranean Sea (EWG-20-09)

Virtual meeting, 7-18 Sept 2020

1 INTRODUCTION

1.1 Approach to the work

The working group was held in remotely, from 7th to 18th Sept 2020. The meeting was attended by 21 experts in total, including three STECF members and four JRC experts. The EWG had two observers who attended part time.

The objective of the Mediterranean Methodology EWG 20-09 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:30 on the first day. The ToRs were discussed and examined in detail. Stocks were allocated to participants based on expertise. An ftp repository was created ad-hoc to share documents, data and scripts and prepare the report. The stock assessments were evaluated by the by all participants. Most of the work was concluded by Tuesday 15 Sept, after 7 full days of work, and some additional work at the weekend. However, two stocks remained to be completed, this extra work was carried out largely by two participant with support from small subgroups. The WG met for a final session on Friday 18 Sept. to conclude the work on one stock. Following extensive trials the last stock could not be assessed with an analytic age based assessment and advice was based on the MEDITS index.

Over the first 7 working days 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 Tuesday, though the last assessment was finalised on the following Friday, the last day of the meeting.

1.2 Impact of Coronavirus / Remote meeting

The Mediterranean Assessment Group had planned to hold a data preparation meeting early in the year. This was cancelled due to the difficulties in access to data and travel restrictions.

The EWG 20-09 was extended to 10 working days (2 weeks) to account for the uncertainty in working remotely. Most of the work was carried out within the first 7 working days, though some additional work was done at the weekend, exceeding the STECF allocation by only a single ½ day session. However, mostly due to data preparation issues one stock required the full 10 working days allocated to complete, and the final stock was only completed for ICES category 3 advice one week after the end of the meeting

While there were savings in cost and travel time and travel CO_2 impact by following a remote meeting format, there were a number of negative issues:

Individuals noted that they found themselves more isolated in their work, unable to benefit so easily from help from other participants. This added some frustrations and also greatly increased to work for JRC staff who support the group.

Overall the meeting was less interactive, particularly for those less assertive individuals, as it is much more difficult to participate in discussions in a remote meeting setting with 20 people.

The time taken in plenaries was longer and less work was done overall and for some even this greatly exceeded to allocated time. The ToRs had been reduced to account for anticipated difficulties, so overall the meeting was less efficient and less effective.

Overall the remote approach was considered by the group to be on balance negative.

1.3 Terms of Reference for EWG-20-09

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) 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 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.

Table 1– List of suggested stocks to be assessed by the EWG 20-09.

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

GSA 9-10-11	Blue and red shrimp	Aristeus antennatus

2 FINDINGS AND CONCLUSIONS OF THE WORKING GROUP

A total of 19 area/species combinations were evaluated. The EWG has carried out and accepted 15 age based analytical assessments with short term forecasts, F target and catch advice for 2021. All fifteen of these were for the same stocks that were given advice based on analytical age based assessments as last year. Of the four remaining stocks index evaluations with catch advice are provided, one is taken from last year's report, for this stock the survey time series and catches were examined and found to be consistent with the data analysed last year, so the advice from last year was considered valid (Nephrops in GAS 5) the results are considered fully acceptable. Four other stocks were examined in detail (Deepwater rose shrimp in GSA 1,5,6&7, blue and red shrimp in GSA 5 and Nephrops in GSA 11 and Nephrops in GSA 5), assessments were attempted but these were not considered useful for giving advice, and 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 and relative changes from 2019 to 2021 are provided in Table 2.2.

Table 2.1 Summary of work was attempted and basis for any advice. A4A and XSA are 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	2019 Assessment	2020 Assessment
1_5_6_7	Hake	a4a STF	**a4a STF**
1_5_6_7	Deep-water rose shrimp	2018 Index	A4a, XSA **Index**
1	Red Mullet	a4a STF	**a4a STF**
5	Striped Red Mullet	a4a STF	**a4a STF**
6	Red Mullet	a4a STF	**a4a STF**
7	Red Mullet	a4a STF	**a4a STF**
5	Norway lobster	Index (2019)	a4a, XSA, **Index (2019)**
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	2018 Index	a4a, **Index**
1	Blue and red shrimp	a4a STF	**a4a STF**

5	Blue and red shrimp	2018 Index	a4a, XSA, **Index**
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 20-09 by area and species. F 2019 is the estimated F in the assessment, and used in the short term forecast for 2020. Change in F is the difference (as a fraction) between target F in 2021 and the estimated F for 2019. Change in catch is from catch 2019 to catch 2021. Biomass status is given as an indication of trend over the last 3 years for stocks with time series analytical assessments or biomass indices. If the stock is considered to be in a low state or high state due to exploitation rate this is noted too. Biomass reference points are not available for any of these stocks.

Area	Species	Method/ Basis	Age Fbar	Biomass 2017-2019	Catch 2017-2019	F 2019	F 2021	Change in F	Catch 2019*	Catch 2021	Change in catch
1_5_6_7	Hake	a4a	1-3	increasing	stable	1.59	0.39	-75%	3148	721	-77%
1_5_6_7	Deep-water rose shrimp	Index 2020		declining	increasing				1161	681	-41%
1	Red Mullet	a4a	1-3	declining	declining	1.03	0.70	-32%	115	114	0%
5	Striped Red Mullet	a4a	1-2	increasing	declining	0.23	0.44	91%	75	121	61%
6	Red Mullet	a4a	1-3	declining	stable	1.53	0.31	-80%	1546	306	-80%
7	Red Mullet	a4a	1-3	increasing	declining	0.67	0.42	-37%	320	252	-21%
5	Norway lobster	Index 2019		fluctuating	increasing				1407#	638	-55%
6	Norway lobster	a4a	3-6	increasing	declining	0.62	0.11	-82%	245	68	-72%
8_9_10_11	Hake	a4a	1-3	increasing	declining	0.57	0.17	-70%	2075	954	-54%
9_10_11	Deep-water rose shrimp	a4a	1-2	increasing	increasing	1.03	1.09	6%	1606	1741	8%
9	Red Mullet	a4a	1-3	increasing	declining	0.85	0.51	-40%	1011	668	-34%
10	Red Mullet	a4a	1-3	declining	declining	0.48	0.39	-18%	334	314	-6%
9	Norway lobster	a4a	2-6	stable	increasing	0.28	0.28	0%	193	181	-6%
11	Norway lobster	Index 2020		fluctuating	increasing				40	13	-67%
1	Blue and red shrimp	a4a	1-2	declining	declining	1.82	0.29	-84%	120	32	-73%
5	Blue and red shrimp	Index 2020	1-2	declining	increasing				206	137	-33%
6_7	Blue and red shrimp	a4a	1-2	declining	declining	1.30	0.29	-78%	566	188	-67%
9_10_11	Blue and red shrimp	a4a	2-5	declining	stable	1.78	0.33	-81%	366	61	-83%
9_10_11	Giant red shrimp	a4a	1-3	declining	stable	0.73	0.48	-35%	571	323	-43%

*Estimated Catch

Reference value from 2019 advice

2.2 Quality of the assessments

Hake

The assessment of hake in GSA 1567 is an update from last year and also the GFCM December 2019 Benchmark taking into account new revised data from France. The model structure same as to last year. The overall assessment is very similar to last year and shows F has decreased in recent years.

The assessment for hake in GSA 8,9,10 & 11 now includes GSA 8 for the first time, following the benchmark from GFCM in December 2019. This adds only minor amounts of additional catch. This adds only minor amounts of additional catch. The model setting unchanged from the model used during the benchmark meeting and the model results are in line with results from Benchmark.

Red Mullet

The assessment for red mullet in GSA 1 has a small modification to the model to which overall improves the catch residuals. 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 5 times F0.1.

Red mullet in GSA 7 was extensively reworked with growth based on otolith data with a new assessment throughout. The general perception of the stock is unchanged, with increasing recruitment and SSB with F declining in recent years.

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/F0.1 is estimated to be declining to around 1.6.

The assessment of red mullet in GSA 10 is an updated assessment with the same input values for years to 2018 with 2019 data added. Some of the biological information is only available in very recent years and starts in 2017 these recent values are also used for the year 2019. Model parameterisation and model formulation are the same as 2019 and the model performs in a similar way. There is an increase in the proportion of biomass in the oldest age which implies improvements to the state of the stock biomass. F current is estimated to be similar to last year and close to F0.1.

Striped Red Mullet

This stock assessment is not of high quality, there were some minor input data issues still which needed to resolved, with strange values for single hauls in 2007 2009 2017 and 2019 in the survey data. Requests have been made for checking the data for some hauls in the MEDITS survey data. Landings had to be reconstructed for GTR fleet from 2002-2008. Cohort consistency in the catch has improved. Model used this year are similar to the one used 2019 but the survey weighting was changed and the diagnostics have improved. The declining F seen in last year's assessment continues to be observed this year. The observed big increase in recruitment in 2018 contributes considerably to the estimated increase in biomass, but the value of this 2018 recruitment is uncertain, so the advised potential increase in catches for 2021 should be treated with caution.

Nephrops

For Nephrops in GSA 5 there is no analytical assessment the advice. The data was re-evaluated and problems were found, mainly there were age distribution inconsistencies in the survey. However, there are also increases in the reported catch in last few years, that are not seen as increases in abundance the survey. It is unclear if the issue is catch reporting or partial area coverage for the survey. Advice for this GSA was given in 2019 for two years (2020 and 2021), the basis for this advice is considered to be acceptable, and the advice is not updated but taken from the 2019 evaluation.

The assessment for Nephrops in GSA 6 is unchanged, 2019 catch and index data are added to the time series. Overall the assessment is noisy and of poor quality, and considered marginal partly due to short time series. The results need to be treated with caution, the assessment shows a slight recover with decline in catches over last 4 years. The assessment and forecast should treated with caution of provision of catch advice in 2021, but the conclusion that exploitation in 2019 is well above F_{MSY} is clear.

The assessment for Nephrops in GSA 9 is an updated assessment with the extra data from 2019. The model has a minor change; the smoothing has been amended and improved model statistics. The assessment unchanged and results are in line with last year.

For Nephrops in GSA 11 index advice is given which is in line with last year. The data was re-evaluated, new assessments tested but not accepted due to poor cohort consistencies in catches, making the assessment unreliable. The survey data was found to be more internally consistent that the catch, and it seems reasonable to use this as an indicator of biomass. The survey remains stable and does not observe the increase in catches reported in the landings data. The advice, does not support the increased catches observed.

Deep-water Rose Shrimp

The basis for advice for DWRS in GSA 1567 is unchanged. Data were re-evaluated but similar assessment issues were found and Index advice similar to that given in 2018 is given this year. In future this species should be considered for evaluations at a finer spatial scale if WG resources allow.

The assessment for DWRS in GSA 9 10 11 is similar to last year. Data for 2019 was added to the stock object from 2019. Some revisions were required to 2019 data due to the missing information of landings at length on the main gear which contributes around 50% of landings. The model was similar to the one used 2019 modified only with a small change to smoothing, and a different recruitment model changed to improve the recruitment estimates in the final year of the assessment. The assessment results are in line with last year with similar trends in biomass with increased catches, recruitment and fishing mortality, with SBB stable over last two years.

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 2007,2008, 2009 and 2011 and 2013. For the initial runs all these were excluded from survey index due to high uncertainty. A model was fitted, then the sensitivity of the model tested to the inclusion/exclusion of this data. The model without the poor years gave more reliable estimates of catch. Based on this these data were not included in the assessment. Other parts of the model are unchanged, This results in F and F0.1 higher than last year but the ratio is similar.

For blue and red shrimp in GSA 5 advice in 2018/2019 based on biomass Index. An extensive data exploration was carried out, the spawning season was correctly aligned and the age structure reworked which improved the model relative to previous evaluations. First survey data point from 2007 was removed, which improved retrospective performance. Recruitment modelling was tested with a variety of smoothing options and the recruitment relationship changed to mean and variance model. However, the conflict between the catch and survey data could not be resolved and advice was again given based on a biomass index method.

For Blue and Red in GSA 6 the assessment was updated with data added for 2019. The reported sampled catch is low, with high SoP. The new assessment is improved from last year. The change was made in the fishing mortality model with small changes to the MEDITS index model keeping it consistent over the whole time series. Smoothing on fishing mortality was reduced to give improved model statistics and better retrospective performance. The assessment results are in line with estimates from last year.

For blue and red shrimp in GSA 9 10 & 11 the data was updated with 2019 values. The earlier index values are unchanged but catch is changed slightly particularly for 2018 and for the new data added for 2019. Catch data for 2018 is reported as being high relative to other years, but this increase is inconsistent with the modelled catch, and it is unclear what is responsible for the changes. Overall the assessment model results are in line with previous years. As recent values (2018/2019) change so much from earlier values there may still be issues with reported landings in GSA 11 for 2019.

Giant Red Shrimp.

For Red shrimp in GSA 9 10 & 11 the assessment is updated with new 2019 data and the model remains unchanged from the formulation used in 2019. The assessment model output is in line with last year's assessment. F0.1 is estimated to be similar to 2019 value, and F current is lower than last year.

3 FOLLOW UP ITEMS

For the future assessment areas for DWRS in GSAs 1,5,6 and 7 need to be considered. In this EWG (20-09) there were insufficient resources to evaluate different spatial separation, or to test models by GSA but for the future efforts need to be made to examine if this can help.

Further development of the model for red mullet in GSA 7 is required, to evaluate age slicing by sex.

4 BASIS OF THE REPORT

4.1 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 1 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.

4.2 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.

4.2.1 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}.

4.2.2 *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)

4.3 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

4.3.1 *MSY Transition*

The EWG continues to provide the main catch option presented in section 5 based on the target of FMSY in 2021. This remains the primary advice. However, in Plenary November 2019 The STECF considered the 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.

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

whereas for the following years:

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

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

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

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

$F_{MSY-transition}$ (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).

5 SUMMARY SHEETS BY STOCK

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 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.*

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

STECF advice on fishing opportunities

STECF EWG 20-10 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.388 and corresponding catches in 2021 should be no more than 721 tons.

Stock development over time

Catches and SSB of European hake show a decreasing trend from 2009 to 2016, with a slight increase in 2017 and 2018 which then stabilized in 2019. The assessment shows a decreasing trend in the number of recruits reaching minimum value in 2019 lower than any other in the historical range. Fbar (1-3) shows a sharp increase until 2010 and a slight upward trend until 2015, followed by a slight decrease until 2019 when estimated F is 1.585.

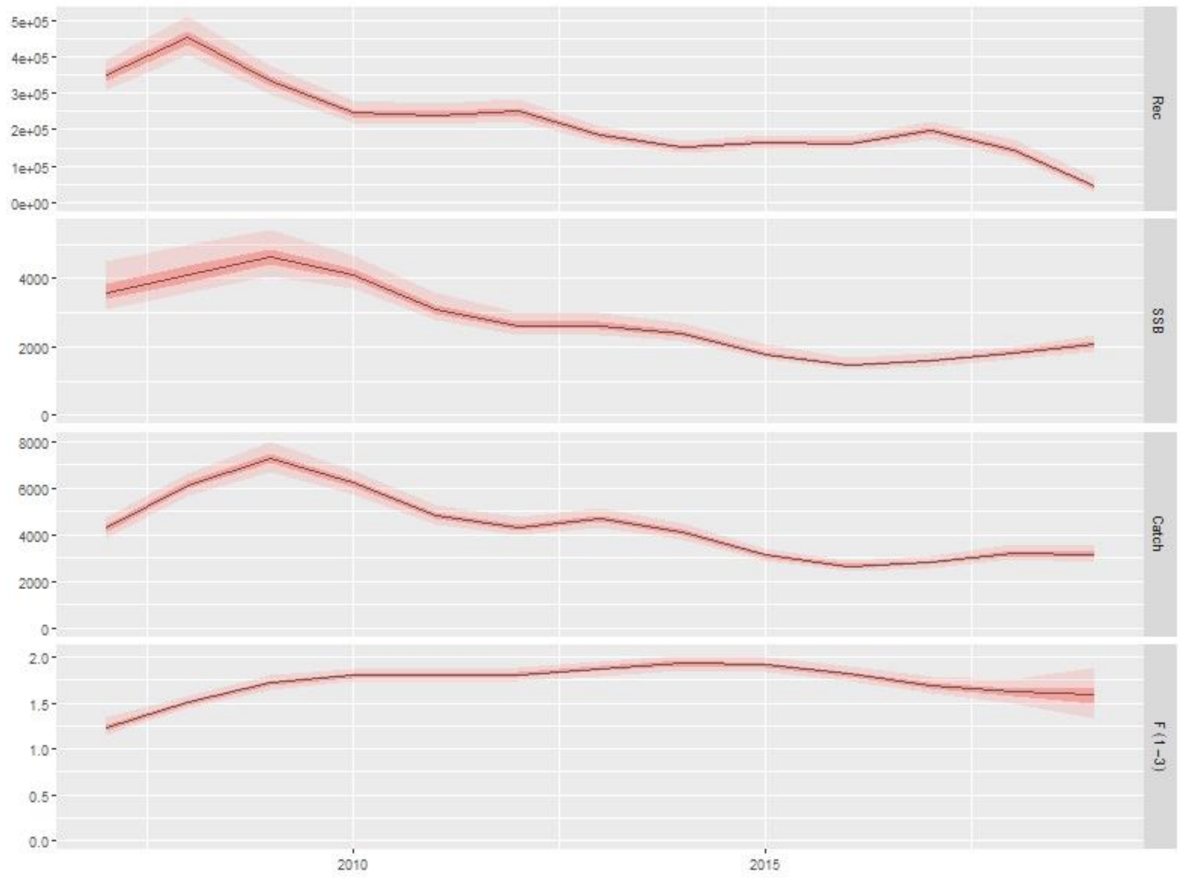


Figure 5.1.1 European hake in GSAs 1, 5, 6 and 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.585) is 4 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.388).

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

Status	2017	2018	2019
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

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
$F_{ages\ 1\text{-}3}$ (2020)	1.58	F 2019 used to give F status quo for 2020
SSB (2020)	2076	Stock assessment 1 January 2020
R_{age0} (2020,2021)	128501	Mean of the last 3 years
Total catch (2020)	1683	Assuming F status quo for 2020

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* (2021)	F_{total}# (ages 1-3) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	721	0.388	3452	119	-77
$F_{MSY\ Transition}$	1677	1.186	1887	19.8	-47
$F_{MSY\ lower}$	505	0.26	3831	143	-84
$F_{MSY\ upper**}$	1677	0.53	3080	96	-70
Other scenarios					
Zero catch	0.00	0.00	4747	201	-100
Status quo	1988	1.585	1441	-9	-37
	1874	1.43	1599	1.5	-40.5
	1607	1.11	1992	26.5	-49
	1275	0.79	2517	59.8	-59.5
	855	0.48	3219	104	-72.8

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

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

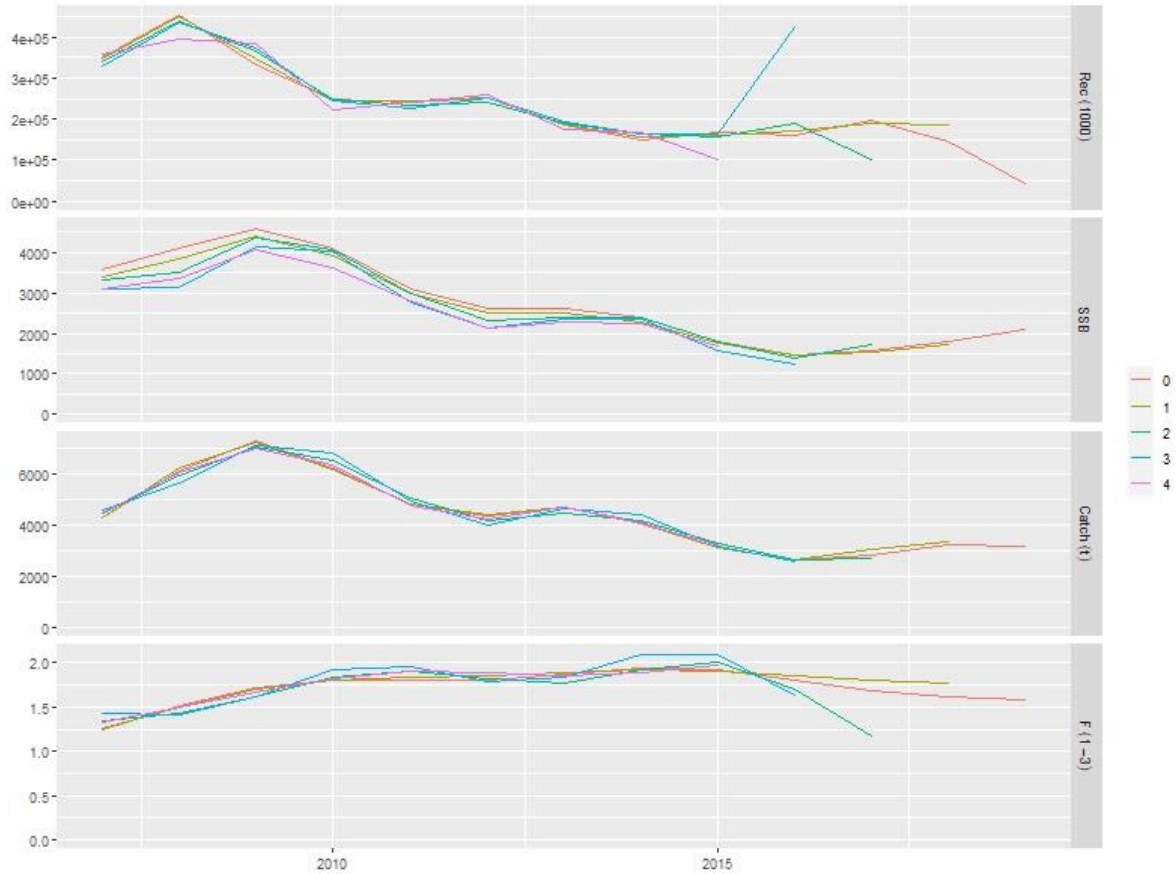


Figure 5.1.2 European hake in GSAs 1, 5, 6 and 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.388	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management	MSY $B_{trigger}$		Not Defined	

plan	B_{lim}		Not Defined	
	F_{MSY}	0.388	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	target range F_{lower}	0.26	Based on regression calculation (see section 2)	STECF EWG 20-09
	target range F_{upper}	0.53	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

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 20-09

*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		
2021	$F = F_{MSY}$		721		

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.

2019		Wanted catch				Discards
Catch (t)	3159	Otter trawl 86%	Gillnets 8%	Trammel nets 4%	Other 2%	69.25t
Effort	NA	NA	NA	NA	NA	
		NA				

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	
2003	398	48	4633	315	2273	7666	
2004	503	63	3151	182	1140	5039	204762
2005	359	98	3473	223	1002	5156	188512
2006	385	125	3627	261	1160	5558	187586
2007	340	185	2540	237	1394	4697	168111
2008	330	121	3341	280	2009	6082	173619
2009	619	67	3847	345	2485	7362	194550
2010	576	99	2822	195	2088	5780	190897
2011	683	85	3182	134	1415	5498	181572
2012	463	61	2641	180	1078	4423	175275
2013	375	109	2950	216	1580	5230	171356
2014	283	118	2489	224	1702	4816	176312
2015	183	102	1726	126	1003	3141	216479
2016	176	67	1810	120	895	3067	205775
2017	299	72	1728	95	768	2962	200855
2018	410	97	2443	87	794	3831	181794
2019	290	107	1630	73	1058	3159	

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	349287			3569			4271	1.239		
2008	453104			4096			6125	1.507		
2009	334177			4601			7286	1.72		
2010	246788			4097			6228	1.802		
2011	241790			3083			4808	1.797		
2012	250856			2605			4317	1.808		
2013	185505			2613			4682	1.871		
2014	151108			2386			4103	1.934		
2015	165997			1791			3115	1.917		
2016	161055			1462			2643	1.812		
2017	196687			1582			2824	1.691		
2018	145966			1812			3217	1.616		
2019	42849			2076			3148	1.585		

Sources and references

STECF	EWG	20-09

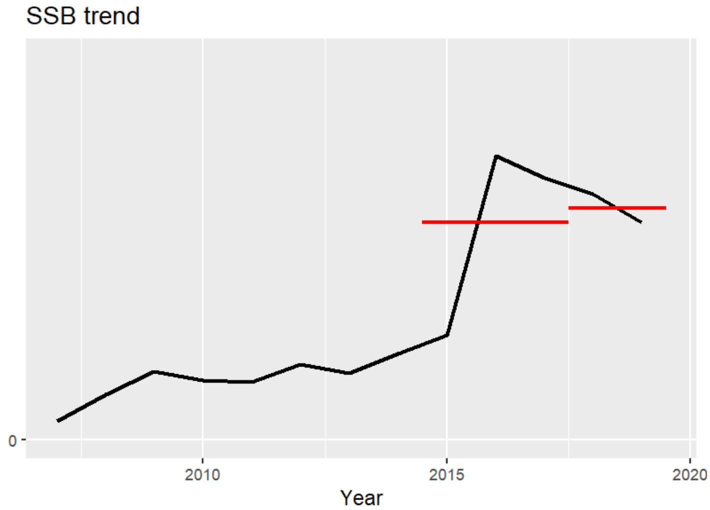
5.2 Summary Sheet for Deep-Water Rose Shrimp in GSAs 1, 5, 6 & 7

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.



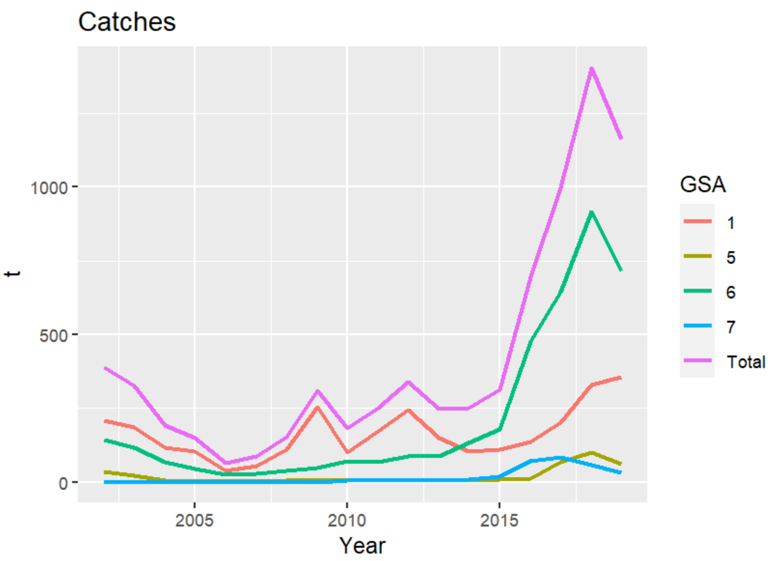


Figure 5.2.1 Deep water rose shrimp in GSA 1, 5, 6 & 7: Summary of the combined a4a and XSA assessments stock indicator and catch by year.

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.

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

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
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

5.3 Summary sheet for Red mullet in GSA 1

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.70 and corresponding catches in 2021 should be no more than 114 tons.

Stock development over time

The SSB shows a decline during the past four years, reaching its historical minimum of 161 tonnes in 2019. The recruitment also shows similar sharp declining pattern since the maximum of the whole time series in 2016. Catch also shows a similar fluctuating pattern one year behind increasing to 2017 and a decline in the last two years, close to long term minimum.

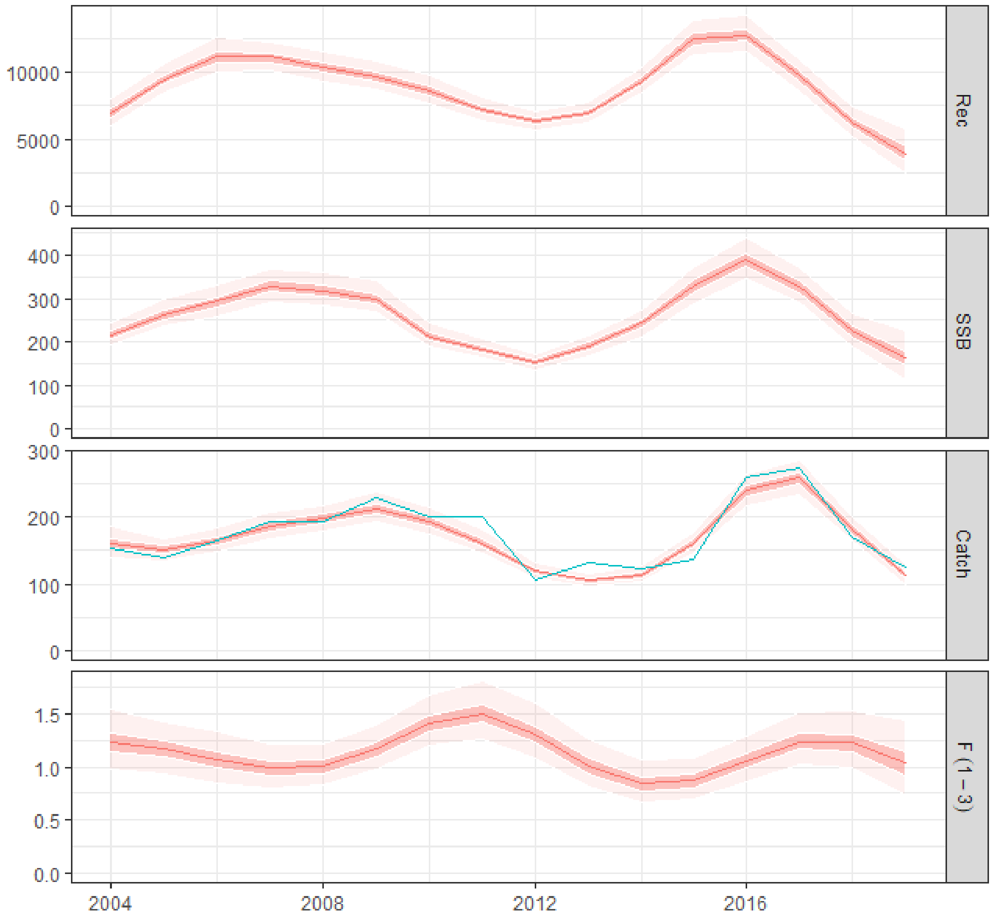


Figure 5.3.1 Red mullet in GSA 1: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality F_{curr} (=1.02) is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.70).

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

Status	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	1.03	F2019 used to give F status quo for 2020
SSB (2020)	222	Stock assessment 1 January 2020
R_{age1} (2020,2021)	8912	Mean of all the time series
Total catch (2020)	103	Assuming F status quo for 2020

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

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

Basis	Total catch* (2021)	F_{total}# (ages 1 - 3) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	114	0.7	324	46	-0.34
$F_{MSY\ Transition}$	137	0.92	290	30	20
$F_{MSY\ lower}$	84	0.47	374	68	-27
$F_{MSY\ upper}$**	141	0.96	285	28	23
Other scenarios					
Zero catch	0	0	530	139	-100
Status quo	148	1.03	275	24	29
0.2	41	0.21	449	102	-64
0.4	75	0.41	387	75	-34
0.6	104	0.62	341	53	-9
0.8	127	0.82	304	37	11

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

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

The retrospective of the assessment shows a quite unstable last year, but the F estimated for 2018 is consistent with the F estimated by last year assessment. F is estimated to be above F_{MSY}.

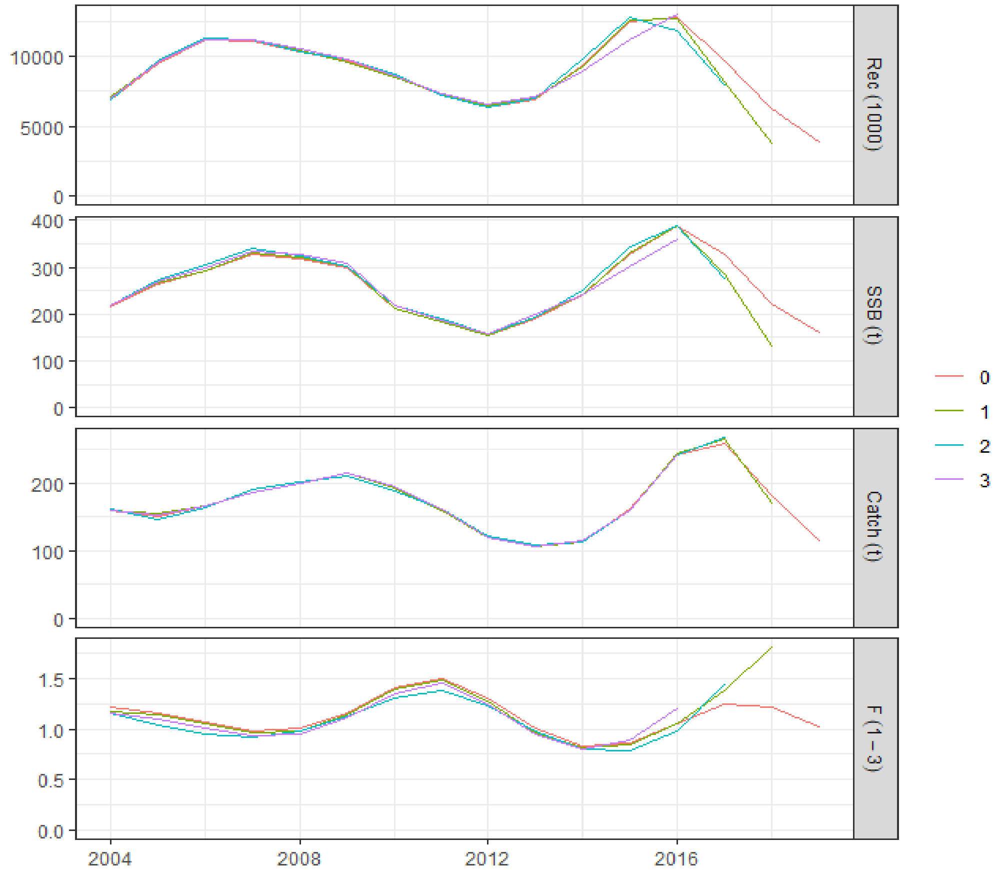


Figure 5.3.2 Red mullet in GSA 1: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.7	$F_{0.1}$ 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	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.7	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	MAP target range F_{lower}	0.47	Based on regression calculation (see section 2)	STECF EWG 20-09
	MAP target range F_{upper}	0.96	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

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

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards did not exceed 2% of the catch, were considered negligible and where set to zero due to incomplete time series.
Indicators	
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

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

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	$F = F_{MSY}$		99	148	
2020	$F = F_{MSY}$		53.5		
2021	$F = F_{MSY}$		114		

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.

2019		Wanted catch				Discards
Catch (t)		Otter trawl 86%	Gillnets 0%	Trammel nets 14%	Other 0%	t
	125	17.5		107.5		-
Effort	NA	NA		NA		
		Days at sea				

Table 5.3.9 Red mullet in GSA 1: 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	SPAIN GSA1	Total landings	STECF Total landings	Total Effort
2004	154	154	160	40760
2005	140	140	151	37895
2006	165	165	166	37380
2007	194	194	187	35391
2008	194	194	199	32165
2009	228	228	214	36472
2010	202	202	194	37515
2011	201	201	162	38558
2012	107	107	120	36023
2013	132	132	106	36737
2014	124	124	114	36058
2015	136	136	162	31397
2016	260	260	241	31534
2017	275	275	260	33123
2018	170	170	183	30057
2019	125	125	115	

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
2004	6962			215			160	1.22		
2005	9507			263			151	1.16		
2006	11183			293			166	1.06		
2007	11121			329			187	0.98		
2008	10373			318			199	1.00		
2009	9677			299			214	1.17		
2010	8643			213			194	1.41		
2011	7220			183			162	1.50		
2012	6356			153			120	1.31		
2013	6954			191			106	1.01		
2014	9390			242			114	0.84		
2015	12481			328			162	0.87		
2016	12822			389			241	1.05		
2017	9746			328			260	1.24		
2018	6271			223			183	1.22		
2019	3890			161			115	1.03		

Sources and references

5.4. Summary sheet for striped red mullet in GSA 5

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.44 and corresponding catches in 2021 should be no more than 120.6 tons.

Stock development over time

Catches show a decreasing pattern along the time series. In 2018, a recruitment peak was observed, promoting that SSB rises and, consequently, fishing mortality keeps the decreasing trend observed since 2015.

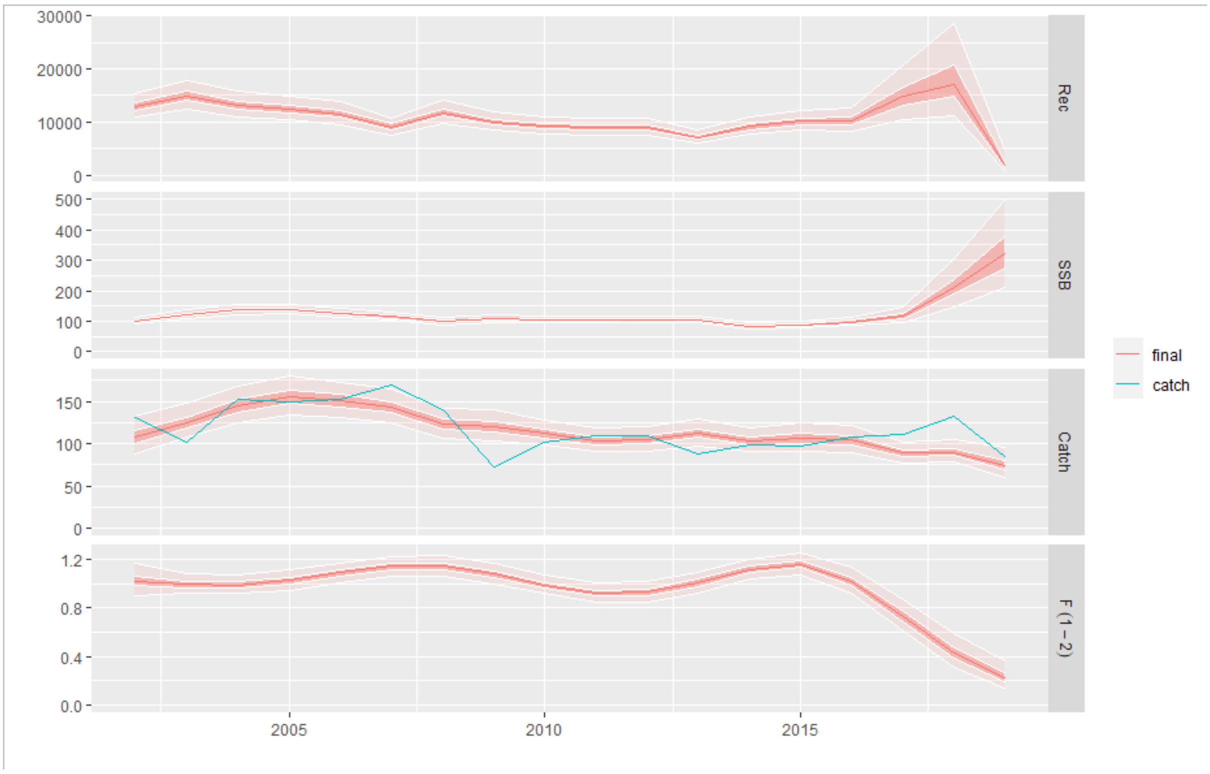


Figure 5.4.1. Striped red mullet in GSA 5: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality (0.22) is below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.44).

Table 5.4.1 Striped red mullet in GSA 5: State of the stock and fishery relative to reference points.

Status	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$

Catch scenarios

Table 5.4.2 Striped red mullet in GSA 5: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-2}$ (2020)	0.23	F current in the last year used to give F status quo for 2020
SSB (2020	253.8 t	Stock assessment 1 January 2020
R_0 (2020)	10750.17 thousands	Geometric mean of the period 2002-2019
R_0 (2022)	10750.17 thousands	Geometric mean of the period 2002-2019
Total catch (2020)	70 t	Assuming F status quo for 2020

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

Table 5.4.3 Striped red mullet in GSA 5: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2021)	F_{total}# (ages 1-2) (2021)	SSB (2022; middle year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	120.6	0.44	235.37	-7.26	61.06
$F_{MSY\ Transition}$	87.24	0.30	275.79	8.66	16.48
$F_{MSY\ lower}$	85.89	0.29	277.49	9.33	14.68
$F_{MSY\ upper}$**	153.81	0.60	198.14	-21.93	105.36
Other scenarios					
Zero catch	0.0	0.0	394.91	55.6	-100.0
Status quo	68.81	0.22	299.35	17.94	-8.12

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

Basis of the advice

Table 5.4.4 Striped red mullet in GSA 5: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Catch-at-age showed good internal consistency, while the survey index did not it. Therefore, the survey index was underweighted. The retrospective analysis run on the a4a model showed consistent results with exception of recruitment which is poorly estimated since 2016 because an outstanding recruitment in 2018 compared to the whole time series. All the diagnostics were considered acceptable.

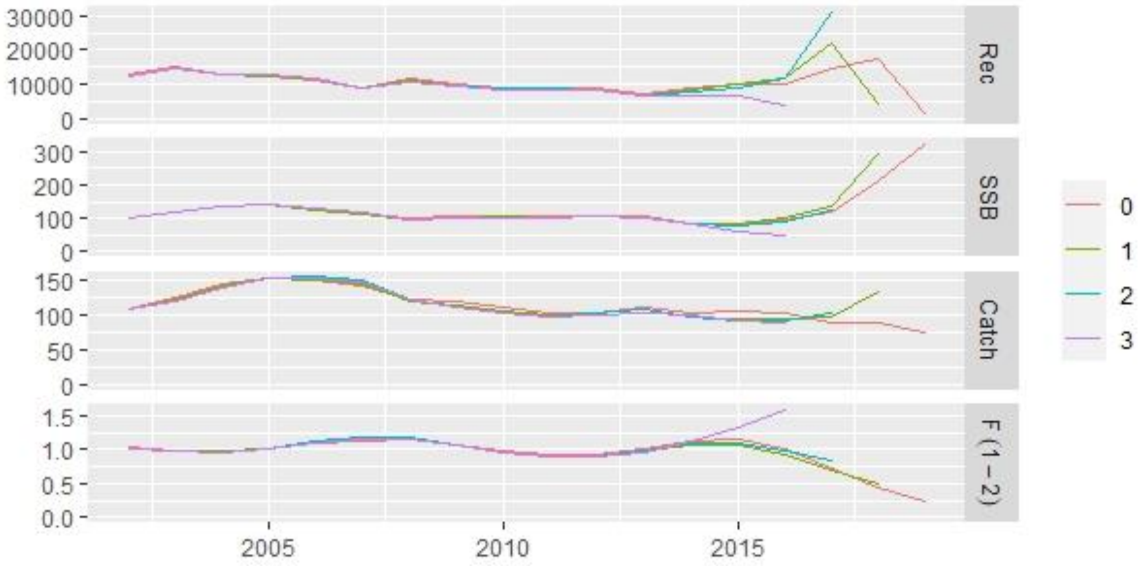


Figure 5.4.2 Striped red mullet in GSA 5: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

- There is high variance for the abundance index estimated in 2007, 2009, 2017 and 2019 that match with issues identified in the TB to TC check.
- The recruitment peak estimated in 2018 may promote that fishing mortality looks very low after this year. At the same time, recruitment in 2019 is too low regarding the available time series, despite fishing mortality is the lowest as well.

Reference points

Table 5.4.5 Striped red mullet in GSA 5: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.44	$F_{0.1}$ 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}	0.44	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	target range F_{lower}	0.29	Based on regression calculation (see section 2)	STECF EWG 20-09
	target range F_{upper}	0.60	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

Table 5.4.6 Red mullet in GSA 5: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.4.7 Striped red mullet 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 catch	STECF discards
2019	$F = F_{MSY}$		113	74.9	
2020	$F = F_{MSY}$		110		
2021	$F = F_{MSY}$		121		

History of the catch and landings

Table 5.4.8 Striped red mullet in GSA 5: Catch in 2019 and effort distribution by fleet in 2018 as estimated by and reported to STECF.

2019		Wanted catch				Discards
Catch (t)		Otter trawl 85.21%	Gillnets 14.79%	Trammel nets 0%	Others 0%	t
		72.89	12.65	0	0	0
Effort						
		Fishing Days				

Table 5.4.9 Striped red mullet 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	ESP	Total landings	Total Effort
	GSA5		Fishing Days
2002	131.68	131.68	
2003	101.62	101.62	
2004	152.95	152.95	24948
2005	148.51	148.51	26035
2006	152.88	152.88	24075
2007	170.06	170.06	14187
2008	139.16	139.16	14784
2009	72.97	72.97	22438
2010	93.15	93.15	22508
2011	107.36	107.36	20759
2012	100.36	100.36	20509
2013	87.88	87.88	21081
2014	95.35	95.35	23844
2015	96.6	96.6	22957
2016	106.46	106.46	20919
2017	109.91	109.91	21539
2018	132.4	132.4	17158
2019	85.54586	85.54586	

Summary of the assessment

Table 5.4.10 Striped red mullet in GSA 5: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2002	12899.10			100.90			107.60	1.02		
2003	14936.00			121.34			125.50	1.00		
2004	13140.60			137.65			144.13	0.99		
2005	12465.90			139.52			155.01	1.02		
2006	11488.90			127.15			150.63	1.09		
2007	9029.50			115.02			143.00	1.14		
2008	11700.50			98.56			123.06	1.14		
2009	9986.00			106.20			119.84	1.08		
2010	9178.80			105.74			111.83	0.99		
2011	8953.00			104.49			103.49	0.92		
2012	9043.40			105.51			104.45	0.93		
2013	7117.10			104.38			112.18	1.01		
2014	9142.30			84.26			103.68	1.12		
2015	10110.20			86.73			106.37	1.16		
2016	10140.20			97.64			103.87	1.02		
2017	14729.60			118.38			88.76	0.73		
2018	17569.80			212.51			90.12	0.43		
2019	1872.30			322.61			74.90	0.23		

Sources and references

STECF EWG 20-09

5.5. Summary sheet for red mullet in GSA 6

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when the MSY considerations are applied, the fishing mortality should not be more than 0.313 and catches in 2021 should be no more than 306 tonnes.

Stock development over time

Catches of red mullet oscillated along the analysed period; in the most recent years catches were higher than at the beginning of the period. SSB reached a maximum value in 2016, decreasing in 2017-2019. F slightly increased in the last three years 2017-2019.

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 is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.313).

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

Status	2017	2018	2019
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	1.53	F current in the last year used to give F status quo for 2020
SSB (2020)	834.7	Stock assessment 1 January 2020
R_{age0} (2020,2021)	361482.5	Geometric mean of the period 2003-2019 (thousands)
Total catch (2020)	1133	Assuming F status quo for 2020

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* (2021)	F_{total}# (ages 1-3) (2021)	SSB (2022; middle year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	306.2	0.31	1981.5	137.4	-80.2
$F_{MSY\ Transition}$	797.3	1.12	1146.0	37.3	-48.4
$F_{MSY\ lower}$	215.0	0.21	2167.7	159.7	-86.1
$F_{MSY\ upper}$**	399.7	0.43	1800.6	115.7	-74.1
Other scenarios					
Zero catch	0	0	2643.3	216.7	-100
Status quo	950.7	1.53	944.5	13.2	-38.5
Factor 0.5	618.8	0.76	1416.4	69.7	-60.0
Factor 1.5	1156.5	2.29	717.9	-14.0	-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 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

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 EWG19-10 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.

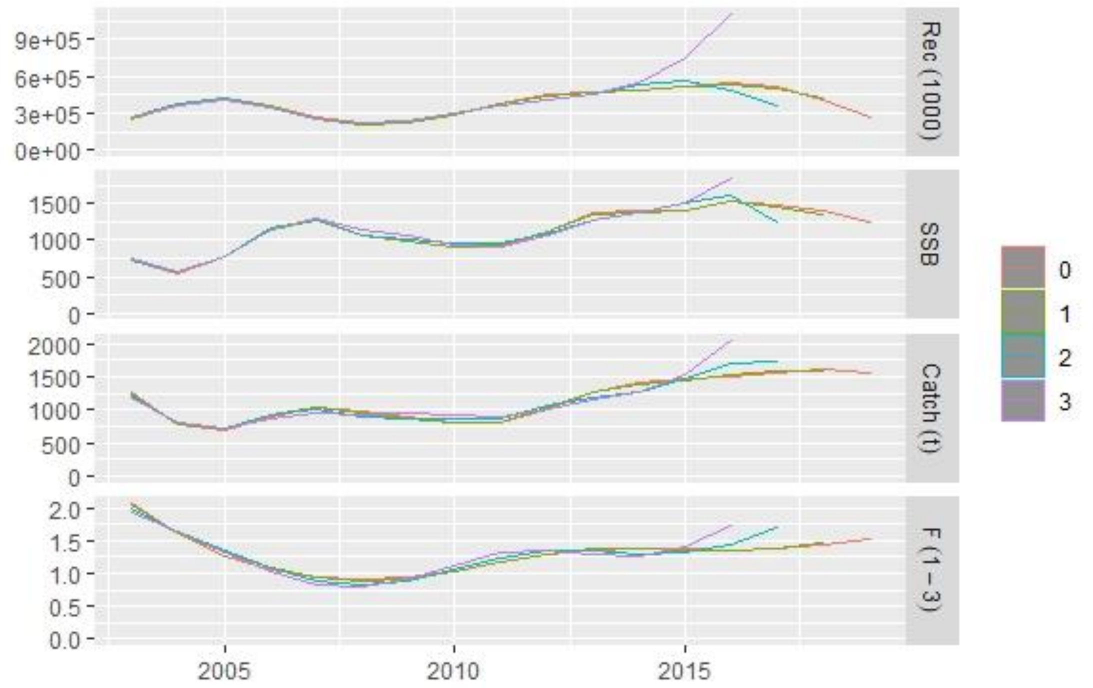


Figure 5.5.2 Red mullet GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the 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}	0.313	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
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}	0.313	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	MAP target range F_{lower}	0.21	Based on regression calculation (see section 2)	STECF EWG 20-09
	MAP target range F_{upper}	0.43	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

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
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 20-09

*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	1546	
2020	F = F_{MSY}		448		
2021	F = F_{MSY}		306		

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 (2019) (t)		Otter trawl 93%		Trammel nets 7%		t
		1388.2		111.6		1.8 (OTB)
Effort (2018)		74820		31071		
		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
2003	1400.0	
2004	919.5	150341
2005	995.0	144733
2006	1387.8	141557
2007	1183.6	125910
2008	872.1	138151
2009	520.9	141813
2010	514.5	132612
2011	1068.5	130739
2012	1091.8	125529
2013	1262.2	126112
2014	1312.5	132837
2015	1570.1	123658
2016	1704.1	125006
2017	1464.0	118121
2018	1324.6	105891
2019	1503.6	

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	254466			722.6			1264.6	2.062		
2004	361740			551.8			776.8	1.601		
2005	416890			770.2			694.3	1.269		
2006	360432			1148.0			899.5	1.054		
2007	267182			1294.5			1045.7	0.937		
2008	215968			1072.3			969.1	0.904		
2009	222599			984.9			908.3	0.942		
2010	282874			895.8			814.4	1.036		
2011	375092			907.1			796.0	1.162		
2012	448270			1117.2			1011.2	1.282		
2013	474428			1363.0			1274.9	1.360		
2014	484875			1398.6			1410.7	1.383		
2015	513839			1407.6			1468.8	1.370		
2016	544816			1520.2			1507.1	1.358		
2017	514937			1465.9			1567.1	1.378		
2018	402040			1392.3			1622.7	1.437		
2019	272722			1254.9			1545.7	1.527		

Sources and references

EWG 20-09

5.6. Summary sheet for Red Mullet in GSA 7

STECF advice on fishing opportunities

STECF EWG 20-10 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.42 and corresponding catches in 2021 should be no more than 252 tons.

Stock development over time

Catches and SSB of Red Mullet show an slow but increasing initiated in 2007, with a slowing down in 2012, a date since which the number of recruits seems to have reached a plateau and is associated to quite large uncertainties. Fbar (0-3) shows some small fluctuation then tends to decrease in the last year. However, given increased uncertainties, such decrease needs to be confirmed in the coming years.

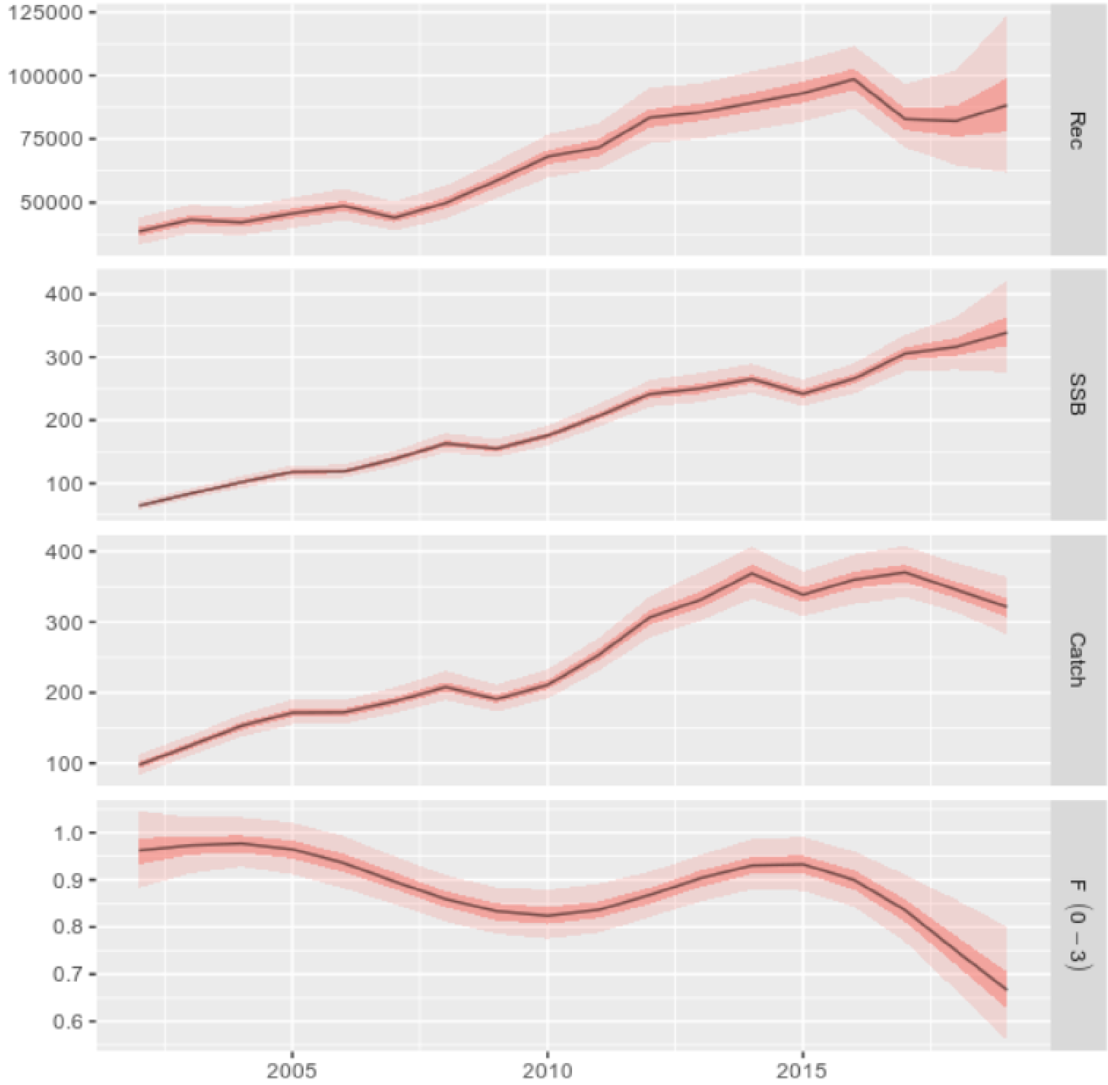


Figure 5.6.1 Red Mullet in GSA 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.668) is 1.58 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.423).

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

Status	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 0\text{-}3}$ (2020)	0.668	F 2019 used to give F status quo for 2020
SSB (2020)	362	Stock assessment 1 January 2020
R_{age0} (2020,2021)	88300	Geometric mean of the last 7 years
Total catch (2020)	340	Assuming F status quo for 2020

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* (2021)	F_{total}# (ages 0-3) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	252	0.423	516	43	-21
$F_{MSY\ Transition}$	323	0.586	421	16	0.70
$F_{MSY\ lower}$	181	0.28	621	72	-43
$F_{MSY\ upper}$**	319	0.58	425	17	-1
Other scenarios					
Zero catch	0	0	923	155	-100
Status quo	353	0.668	382	6	10

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

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

A significant effort has been made to improve the data quality on which the current assessment is based, notably regarding the establishment of an Age-Length Key for Red Mullet in GSA 7. When compared with last year assessment, past time series have been elongated (from 2004 to 2002), age structure has been refined (from ages 0,1,2,3+ to ages 0,1,2,3,4+) and model specifications have evolved to better account for the survey catchability pattern regarding the oldest ages. In addition, a stock-recruitment model (geometric mean) has been explicitly specified. All the diagnostics were considered acceptable.

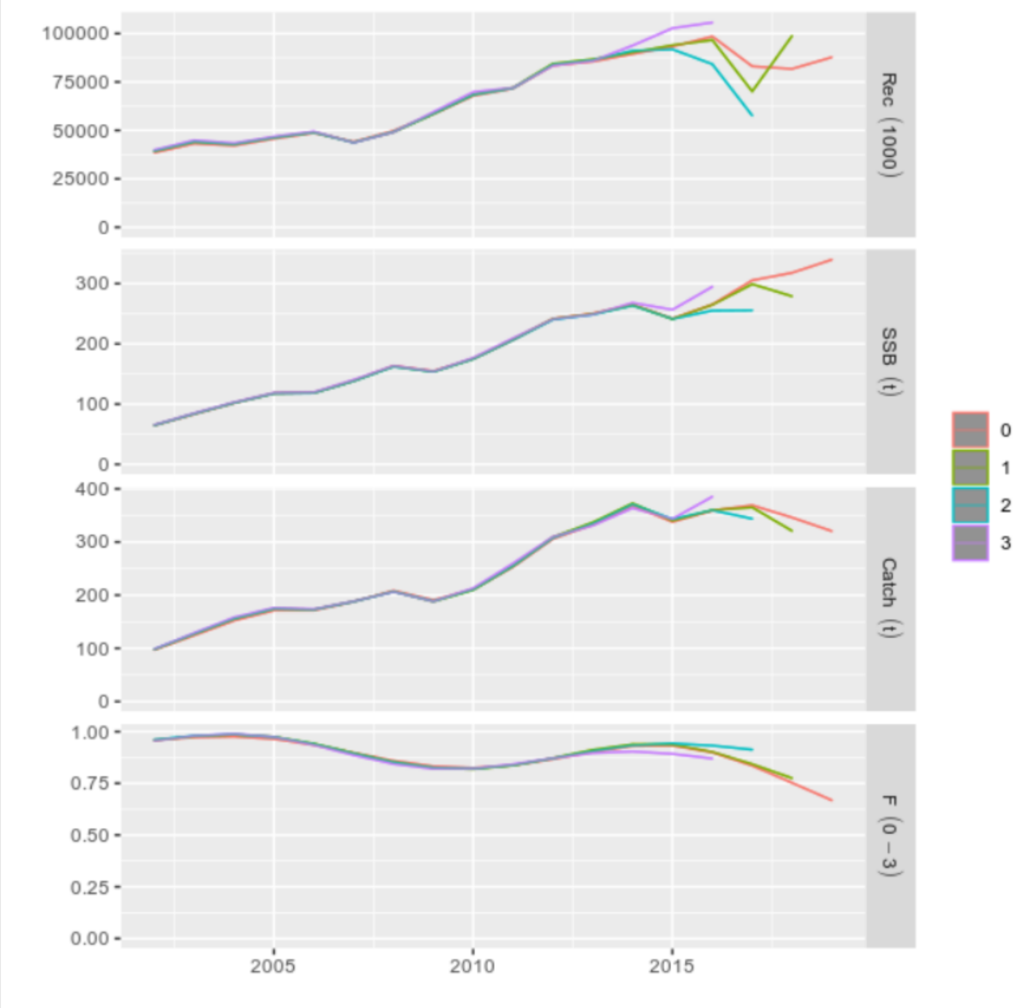


Figure 5.6.2 Red Mullet in GSA 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.423	$F_{0.1}$ 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}	0.423	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	target range F_{lower}	0.28	Based on regression calculation (see section 2)	STECF EWG 20-09
	target range F_{upper}	0.58	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

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

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

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

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	$F = F_{MSY}$		191	320	
2020	$F = F_{MSY}$		364		
2021	$F = F_{MSY}$		252		

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.

2019		Wanted catch				Discards
Catch	326	Otter trawl 96.9%	Gillnets 2.1%	Trammel nets 1%	Other <0.1%	16.39t

(t)						
Effort						

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

Year	Fra_GSA7	Spa_GSA7
2002	111.4235	11.08
2003	164.1414	11.87
2004	151.6462	25.84
2005	148.0861	27.48
2006	183.4775	31.4
2007	171.5263	36.16
2008	110.4939	20.73
2009	122.555	26.13
2010	236.0344	28.23
2011	241.682	28.13
2012	176.729	29.17
2013	260.4234	37.53
2014	308.912	41.18
2015	335.3809	33.05
2016	368.0765	43.31
2017	261.364	31.09
2018	308.7052	23.83
2019	278.6148	22.1682

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	38498.39	64.63	0.96	97.079
2003	43186.58	83.324	0.972	124.382
2004	42123.24	101.556	0.976	152.084
2005	45665.58	117.767	0.964	171.22
2006	48679.63	118.629	0.936	171.252
2007	44080.7	138.444	0.897	187.604
2008	49756.48	163.293	0.859	208.329
2009	58412.94	154.838	0.832	190.688
2010	67820.13	175.184	0.824	210.795
2011	71616.29	206.403	0.837	253.018
2012	83535.86	241.602	0.866	305.776
2013	85516.76	250.394	0.903	332.633
2014	89440.43	265.023	0.93	368.233
2015	93273.93	241.899	0.932	337.783
2016	98472.65	265.24	0.9	359.01
2017	83072.71	305.43	0.835	368.986
2018	81741.65	317.93	0.752	346.022
2019	87734.8	339.787	0.668	320.365

Sources and references

STECF EWG 20-09

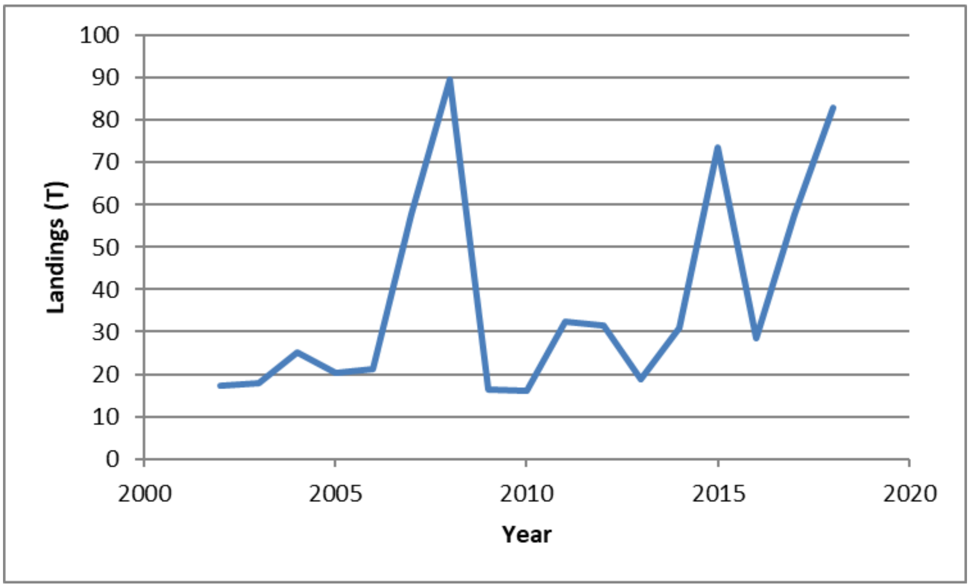
5.7 Summary sheet for Norway lobster in GSA 5

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 19-10 advises to decrease the total catch to 98% of the average 2016-2018 catches equivalent to catches of no more than 44.1 tons in each of 2020 and 2021 implemented either through 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.



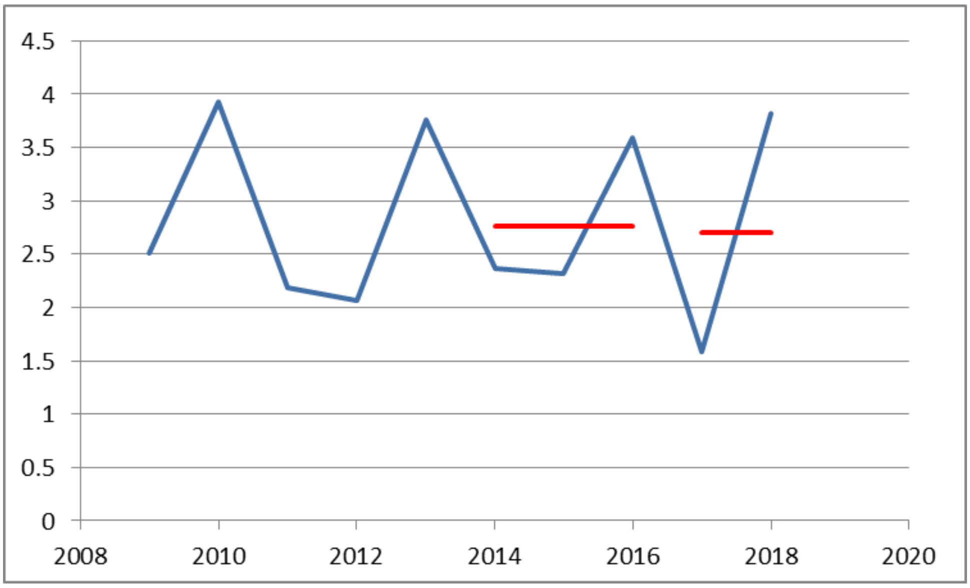


Figure 5.7.1 Norway lobster in GSA 5: Landing (t) from 2002 to 2018. MEDITS estimated biomass in the last ten years (blue) and recent changes (red) showing mean of last two years (2017-2018) and previous three years (2014-2016) used for calculating catch advice.

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 2019 and 2020 is based on the recent observed catch adjusted to the change in the stock size index (MEDITS) for the two most recent values relative to the three preceding values (table 5.9.1). The precautionary buffer of -20% is applied because the precautionary status of the stock is not known.

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

Index A (2017–2018)		2.70
Index B (2014–2016)		2.75
Index ratio (A/B)		0.98
-20% Uncertainty cap		Not applied
Average catch (2016–2018)		56.3
Discard rate (2016–2018)		0 (negligible)
-20% Precautionary buffer		Applied
Catch advice **		44
Landings advice ***		44
% advice change ^		-47%

* 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 × index ratio x precautionary buffer of 0.8)
*** catch advice × (1 − discard rate)
^ Advice value 2020 relative to advice value 2018.

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 19-10 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 - 2018)
Discards and bycatch	
Indicators	MEDITS indices
Other information	
Working group	EWG 19 - 10

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 reduce catch	56.3				
2021	precautionary advice	56.3				

	reduce catch					

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 (current year-1)	Wanted catch				Discards
2017	Otter trawl 100%	0%	0%	Other 0%	0 t
	t				

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

Year	Spain GSA5	STECF total landings
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	16.39	16.39
2010	16.19	16.19
2011	32.33	32.33
2012	31.61	31.61
2013	18.82	18.82
2014	30.83	30.83
2015	73.61	73.61
2016	28.35	28.35
2017	57.84	57.84
2018	82.91	82.91

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	2.51	16.34	0.05	16.39
2010	3.93	16.19	0	16.19
2011	2.18	32.26	0.07	32.33
2012	2.06	29.5	2.11	31.61
2013	3.76	18.82	0	18.82
2014	2.37	30.8	0.03	30.83
2015	2.32	72.87	0.74	73.61
2016	3.59	28.33	0.02	28.35
2017	1.59	57.82	0.02	57.84
2018	3.82	82.91	0	82.91

Sources and references

Reproduced from STECF EWG 19-10 for use in this year's WG. For original analysis and data supporting this summary sheet see STECF EWG 19-10.

5.8 Summary sheet for Norway lobster in GSA 6

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.11 and corresponding catches in 2021 should be no more than 67.8 tons.

Stock development over time

The Nephrops norvegicus in GSA 6 shows decreasing catch from 2011 to 2016, stable in 2017-2018 and a recent increasing trend in SSB since 2016. F decrease in the last 3 years.

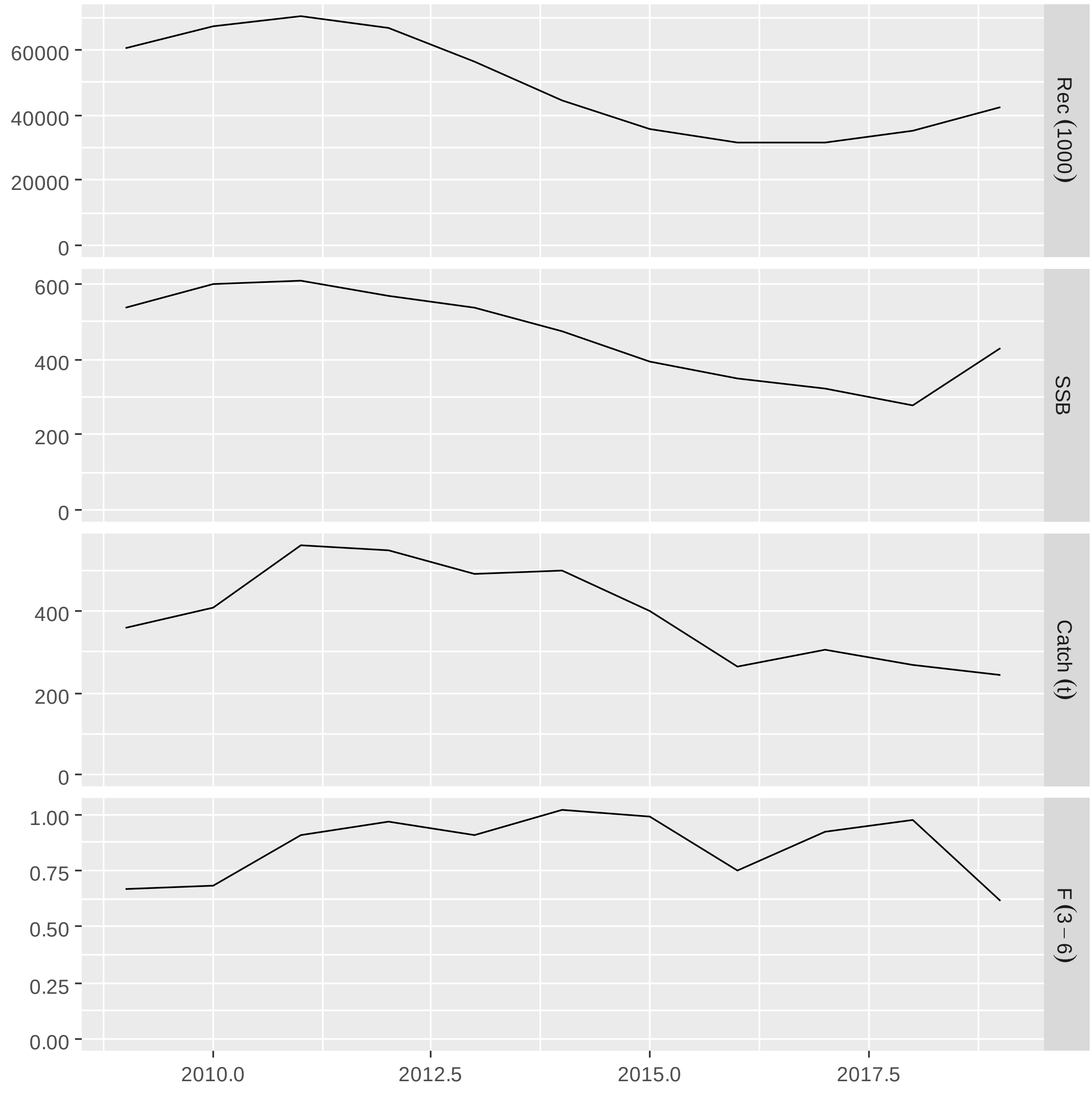


Figure 5.8.1 Norway lobster in GSA 6: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is well above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.11). SSB is increasing and F is at the lowest level for the time series.

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

Status	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 3\text{-}6}$ (2020)	0.62	F(2019) used to give F status quo for 2020
SSB (2020)	442.20	Stock assessment 1 January 2020
R_{age2} (2020,2021)	36348	Geometric mean of the 3 years series 2017-2019
Total catch (2020)	268.28	Assuming F status quo for 2020

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

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

Basis	Total catch* (2021)	F_{bar}# (ages 3-6) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	67.7	0.11	909	105	-72%
$F_{MSY\ Transition}$	237	0.45	606	37	-3%
$F_{MSY\ lower}$	47.34	0.08	948	114	-80%
$F_{MSY\ upper}$**	94.16	0.16	857	94	-61%
Other scenarios					
Zero catch	0	0	1044	136	-100%
Status quo	303	0.62	442	13.6	24%
$F=F_{2018}*0.8$	203	0.49	576	30	5%
$F=F_{2018}*0.6$	255	0.37	663	50	-17%
$F=F_{2018}*0.4$	143	0.25	767	73	-41%
$F=F_{2018}*0.2$	75	0.12	893	102	-69%

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

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Both catches and survey indices did not show good internal consistency. The retrospective analysis run on the a4a model indicates limited stability for the model, with F revised upwards and SSB downwards, but these revisions do not change estimation of stock status over the whole time series. The results of the stock assessment model need to be interpreted with caution, although the level of over-fishing is so high that it is safe to accept that finding.

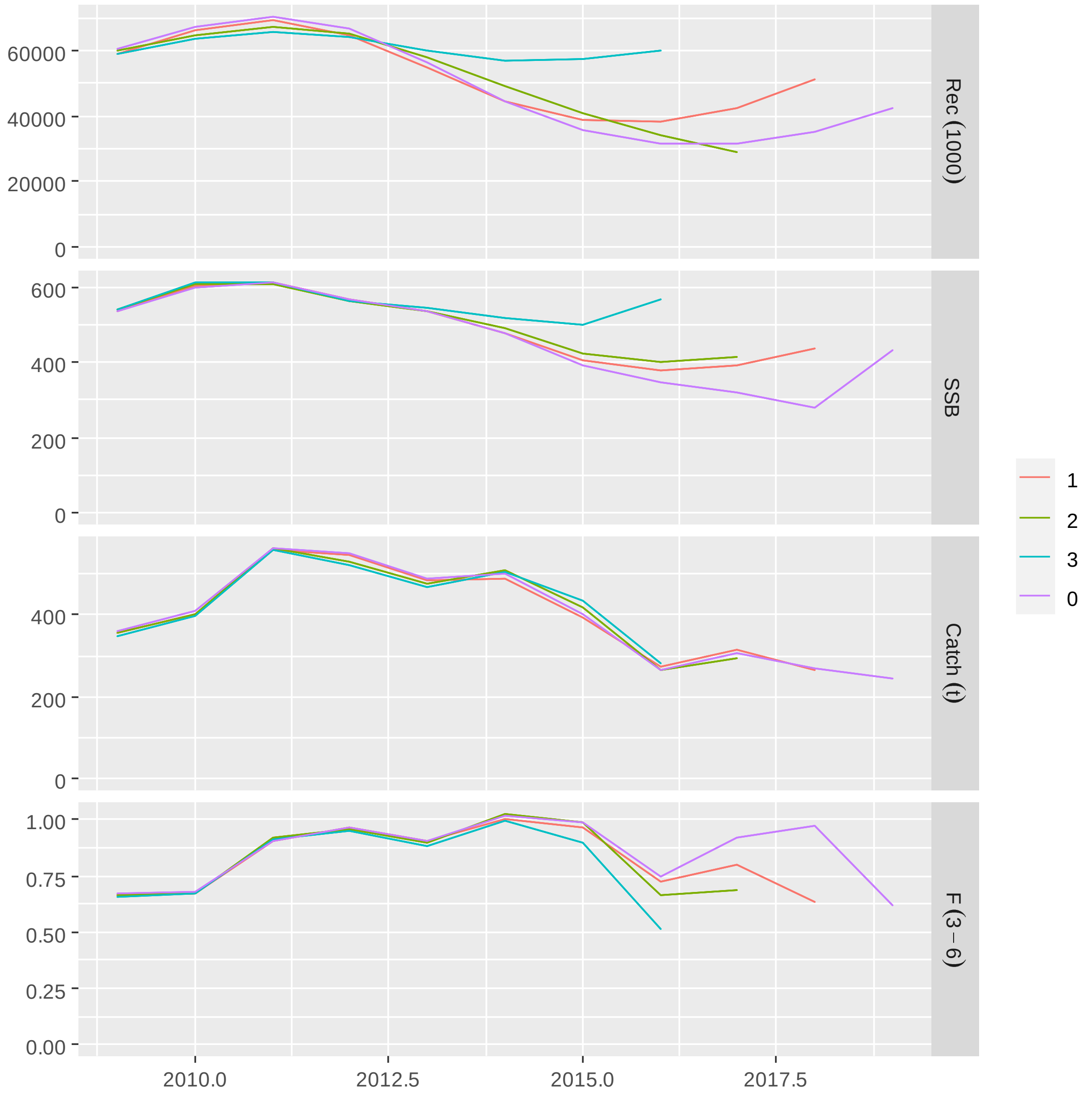


Figure 5.8.2 Norway lobster in GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

Unstable assessment model – quantitative advice needs to be handled with care. Age slicing was undertaken, but last year's MEDITS index could not be recreated, thus the age distribution of 2019 was added to the previous index data.

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}	0.11	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
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}	0.11	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	target range F_{lower}	0.08	Based on regression calculation (see section 2)	STECF EWG 20-09
	target range F_{upper}	0.16	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

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

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards were included in the landing for the purpose of the stock assessment as no length distribution was available
Indicators	
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

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

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		125	245	
2020	F = F_{MSY}		77		
2021	F = F_{MSY}		68		

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.

2018		Wanted catch				Discards
Catch (t)		Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	t
		265				
Effort		74820				
		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	STECF total landings	Total Effort
2004			118076
2005			110957
2006			110008
2007			99638
2008			106867
2009	355.61	355.61	102005
2010	406.51	406.51	95438
2011	508.21	508.21	90470
2012	571.89	571.89	86587
2013	490.7	490.7	84882
2014	500.79	500.79	88528
2015	361.58	361.58	79421
2016	314.47	314.47	81649
2017	293.24	293.24	78530
2018	287.03	287.03	74820
2019	244.56	244.56	

Summary of the assessment

Table 5.8.10 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 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 3-6	High	Low
2009	60437			536.46			360.4	0.67		
2010	67296			601.71			408.6	0.68		
2011	70666			611.07			562.11	0.91		
2012	66750			568.22			550.31	0.97		
2013	56383			536.43			489.77	0.91		
2014	44575			476.98			500.67	1.02		
2015	35697			394.36			400.91	0.99		
2016	31296			348.7			264.86	0.75		
2017	31305			320.83			305.04	0.92		
2018	35288			279.16			270.34	0.97		
2019	42451			431.29			244.56	0.62		

Sources and references

STECF EWG 20-09

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

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.17 and corresponding catches in 2021 should be no more than 954 tons.

Stock development over time

Catches of European hake show a decreasing trend in the whole time series. SSB declines in the first half of the time series and slightly increases in the last six years. The assessment shows a decreasing trend in the number of recruits with the minimum value reached in 2018. Fbar (1-3) shows a fluctuating pattern with a slightly decreasing trend in the time series, with the lowest value of 0.57 reached in 2018 and 2019.

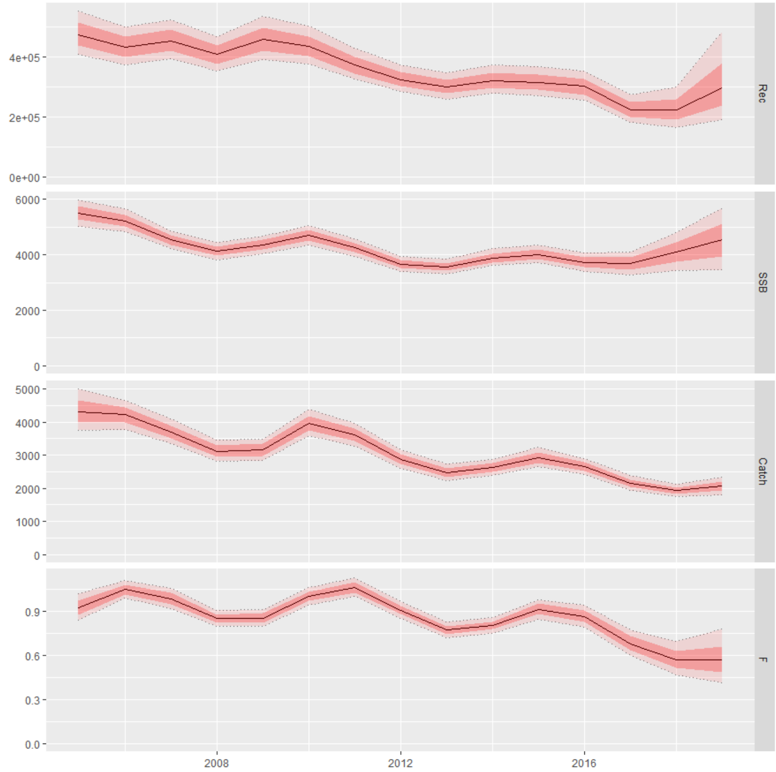


Figure 5.9.1. European hake in GSAs 8, 9, 10 & 11. Trends in catch, recruitment, fishing mortality resulting from the a4a model.

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).

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

Status	2017	2018	2019
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	0.57	The F estimated in 2019 was used to give F status quo for 2020.
SSB (2020)	5050.29	Stock assessment 1 January 2020
R_{age0} (2020,2021)	356134.6	Mean of the time series
Total catch (2020)	2384	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* (2021)	F_{total}# (ages 1-3) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	953.6	0.17	9418.3	86.49	-54.04
$F_{MSY\ Transition}$	2234.25	0.43	7496.51	48.44	7.68
$F_{MSY\ lower}$	660.39	0.11	9869.11	95.42	-68.17
$F_{MSY\ upper}$**	1297.4	0.23	8894.56	76.12	-37.47
Other scenarios					
Zero catch	0	0	10897.4	115.78	-100
Status quo	2781.65	0.57	6701.86	32.7	34.07

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

*** % change in SSB 2020 to 2020

^Total catch in 2021 relative to catch in 2019.

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.

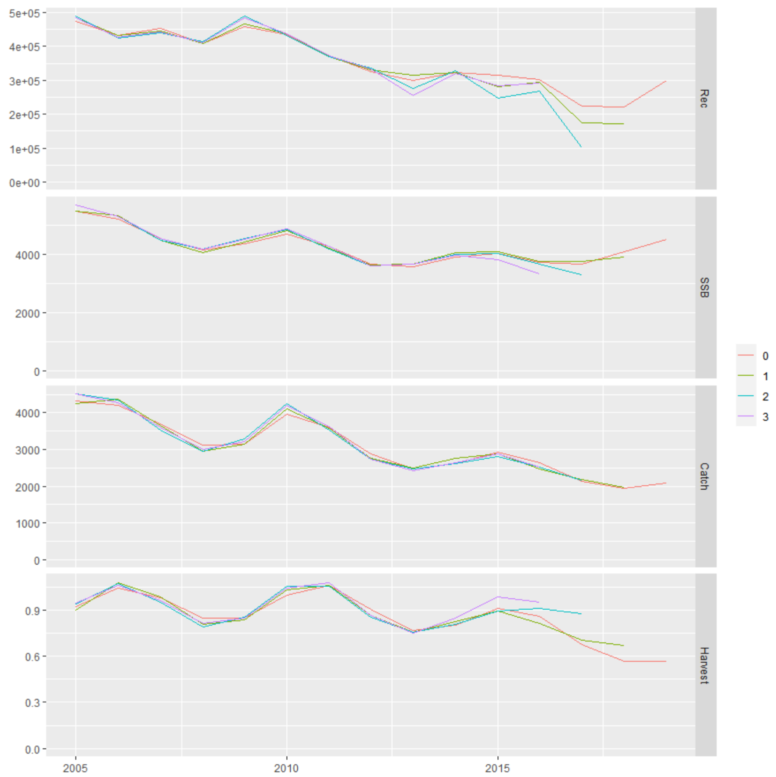


Figure 5.9.2. European hake in GSAs 8, 9, 10 & 11. Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	
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 20-09
	target range F_{lower}	0.11	Based on regression calculation (see section 2)	STECF EWG 20-09
	target range F_{upper}	0.23	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

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

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

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

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		494	2075	
2020	F = F_{MSY}		772		

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	$F = F_{MSY}$		953.6		

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.

2019		Wanted catch				Discards
Catch (t)		Beam trawl 63%	Gillnets 23%	Trammel nets 6%	Other 8%	t
	2197	1393	498	124	182	193
Effort		NA	NA	NA	NA	
		NA				

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

Year	FRANCE GSA8	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total landings	Total Effort
2005		1859.98	1484.74	397.39	3757.11	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	716822
2011	13.24	1351.74	1278.52	277.42	2920.92	780290
2012	13.01	1011.52	1107.24	176.05	2307.83	661755
2013	3.52	1341.63	1052.19	195.79	2593.13	638490
2014	12.61	1264.95	1271.11	44.96	2593.63	660790
2015	12.19	1047.70	1043.44	220.04	2323.36	705043
2016	39.85	782.25	1051.95	339.15	2213.19	727409
2017	14.60	572.37	870.43	356.52	1813.92	654761
2018	21.09	605.35	819.86	391.98	1838.28	650271
2019	18.00	722.26	765.17	445.53	1950.96	

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	474690			5487			4310.1	0.92		
2006	431706			5217.9			4202.5	1.04		
2007	453659			4526.4			3689.2	0.98		
2008	407568			4134.4			3110.4	0.85		
2009	458148			4354			3151.6	0.85		
2010	435035			4694.7			3959.8	1.00		
2011	372476			4252.2			3606.3	1.06		
2012	325615			3658.4			2868.9	0.91		
2013	300182			3560.9			2458.7	0.77		
2014	321953			3896			2623.9	0.80		
2015	315485			4023.7			2927.1	0.91		
2016	300884			3725.5			2643	0.86		
2017	223545			3671.2			2145.1	0.68		
2018	222163			4077.8			1929.6	0.57		
2019	298908			4509.1			2074.8	0.57		

Sources and references

STECF EWG 20-09

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

STECF advice on fishing opportunities

Based on the stock assessment outputs and reference points, STECF EWG 20-09 advises that the catches of Deep-water rose shrimp in 2021, consistent with $F_{0.1}$ (1.09), should not exceed 1741 tonnes.

Stock development over time

Recruitment
Recruitment (age 0) is characterised by an increasing trend with a peak in the last two years of the data series (4,302,305 thousands individuals in 2019).

Spawning stock biomass (SSB)
The spawning stock biomass shows an increasing trend reaching the maximum value in 2018 (2648 tons).

Catch
After the minimum value in 2009 (720 tons), the catches have shown a consistent increase over the years, until reaching the maximum value in 2019, corresponding to 1606 tons.

Fishing mortality (F)
The lowest value of fishing mortality (0.67) is observed at the beginning of the data series (2009-2010). After that, a constant increase of F was showed, reaching the maximum value of 1.12 in 2014. In the following three years the F decreased. In 2018 and 2019 a new increase in respect to the previous year was observed reaching 1.03 in 2019.

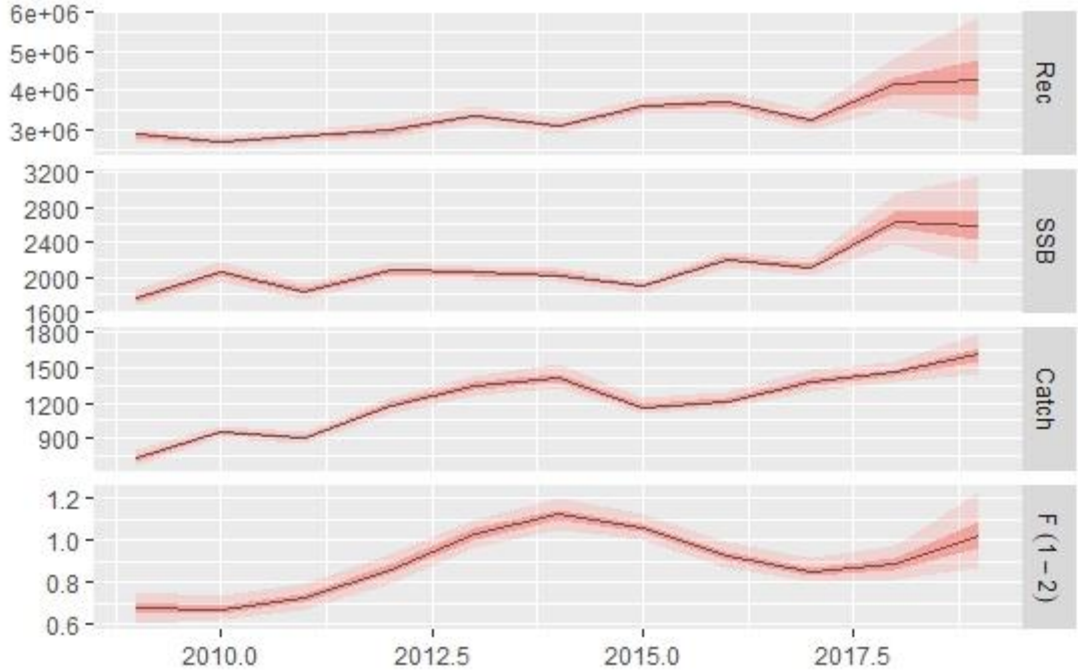


Figure 5.10.1 Deep-water rose shrimp in GSAs 9, 10 & 11. Outputs of the a4a assessment.

Stock and exploitation status

Current F (1.03), estimated by the model as $F_{bar1\text{-}2}$ in the last year of the time series (2019), is lower than $F_{0.1}$ (1.09), 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 exploited sustainably.

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

Method	2017	2018	2019
F / F_{MSY}	F < F_{MSY}	F< F_{MSY}	F < F_{MSY}

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-2}$ (2020)	1.03	F current in the last year (2019) used to give F status quo for 2020
SSB (2020)	2519 t	
R_0 (2020)	3,862,046 thousands	Geometric mean of the period 2017-2019
R_0 (2022)	3,862,046 thousands	Geometric mean of the period 2017-2019
Total catch (2020)	1798 t	Catch at Fstatus quo

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

Basis	Total catch* (2021)	F_{total}# (ages 1-2) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	1741	1.09	2334	-7.4	8.4
$F_{MSY\ Transition}$	1697	1.05	2373	-5.8	5.7
$F_{MSY\ lower}$	1314	0.72	2736	8.6	-18.2
$F_{MSY\ upper}$	2081	1.48	2043	-18.9	29.6
Other scenarios					
Zero catch	0.0	0.0	4260	69.1	-100.0
Status quo	1675	1.03	2393	-5.0	4.3

*** % change in SSB 2022 to 2020
^ Total catch in 2021 relative to catch in 2019.

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.

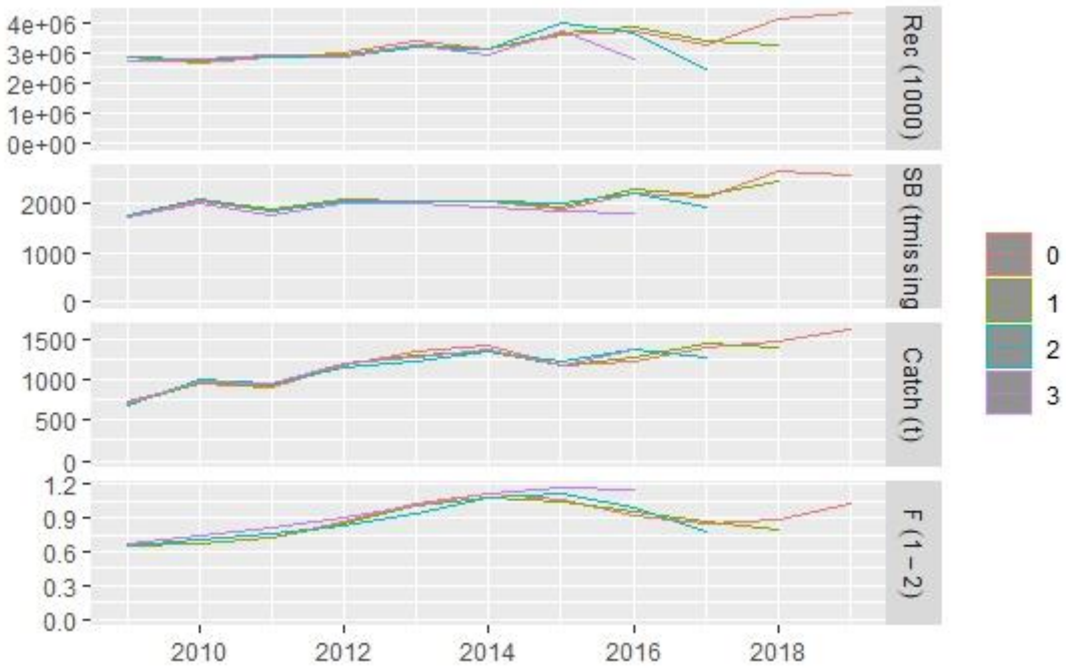


Figure 5.10.2 Deep-water rose shrimp in GSAs 9, 10 & 11 Results of the retrospective analysis (a4a).

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 is limited to the period with full data across GSAs (2009-2018) In GSA10, length frequency distributions for the main metier targeting DPS in the area (OTB_DEMSP) was not available for 2019.
The biomass discarded and the related length frequency distributions of Deep-water rose shrimp in GSA09 are available for the period 2009-2019. In GSA10, the data on discard are available for 2006 and for the years 2009-2017. With regard to GSA11, there are no data on this fraction of the catch. Missing discard data were not reconstructed.
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 Deep-water rose shrimp in GSAs 9, 10 & 11 Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	1.09	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
Precautionary approach	B_{lim}			
	B_{pa}			
	F_{lim}			
	F_{pa}			
Management plan	MSY $B_{trigger}$			
	B_{lim}			
	F_{MSY}	1.09	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	MAP target range F_{lower}	0.72		STECF EWG 20-09
	MAP target range F_{upper}	1.48		STECF EWG 20-09

Basis of the assessment

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

Assessment type	Statistical catch-at-age (a4a)
Input data	Landings at length to landings at age (age slicing) from DCF data
Discards, BMS landings*, and bycatch	Discards included
Indicators	MEDITS in GSAs 9, 10 & 11
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

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

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}	644	644	1606	
2020	F = F_{MSY}	1301	1301		
2021	F = F_{MSY}	1741	1741		

History of the catch and landings

Table 5.10.8 Deep-water rose shrimp in GSAs 9, 10 & 11 Catch and effort distribution by fleet in 2019 as estimated by and reported to STECF.

2019		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets %	Trammel nets %	Other %	t
	1653	tonnes				285
Effort (2018)	20687	100%				
		Nominal effort ('000 kW*fishing days)				

Table 5.10.9 Deep-water rose shrimp in GSAs 9, 10 & 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. Nominal effort: kW*Days at sea (x 1000).

Year	GSA9 ITA	GSA10 ITA	GSA11 ITA	Total landings	Discards	STECF total catches	Total Effort
2009	303	379	22	704	46	750	23502
2010	473	370	23	866	30	896	21462
2011	551	405	53	1010	66	1076	20112
2012	621	459	34	1114	12	1126	19770
2013	576	597	21	1194	39	1233	20027
2014	561	509	16	1086	48	1134	22644
2015	791	547	26	1365	103	1468	19640
2016	836	542	18	1396	41	1437	19969
2017	857	496	29	1382	46	1428	20948
2018	904	555	68	1527	50	1577	20687
2019	896	667	89	1653	285	1938	-

Summary of the assessment

Table 5.10.10 Deep-water rose shrimp in GSAs 9, 10 & 11 Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2009	2870173			1756			720	0.67		
2010	2677265			2059			947	0.67		
2011	2831373			1841			901	0.73		
2012	2977108			2079			1175	0.86		
2013	3359622			2054			1343	1.03		
2014	3105821			2028			1415	1.12		
2015	3593098			1898			1163	1.06		
2016	3692911			2210			1219	0.93		
2017	3236565			2113			1382	0.85		
2018	4136822			2648			1460	0.89		
2019	4302305			2575			1606	1.03		

Sources and references

EWG 20-09

5.11 Summary sheet for red mullet in GSA 9

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.51 and corresponding catches in 2021 should be no more than 667.6 tons.

Stock development over time

Catches show an increasing pattern up to 2016, then they slightly decrease. SSB shows an almost continuous increasing trend. F follows the pattern of catches: it stays at high levels up to 2016, then it decreases.

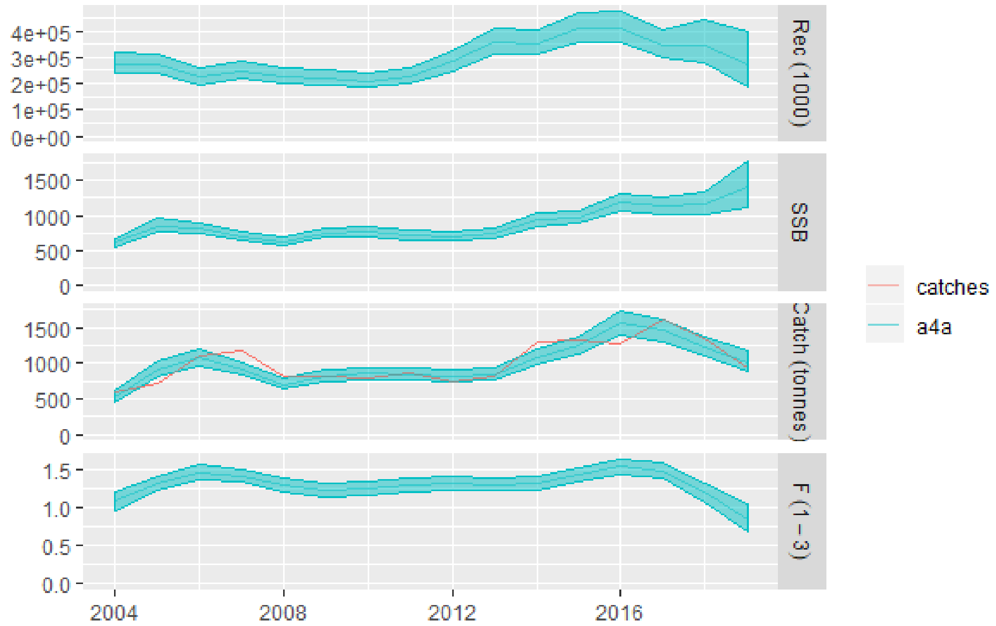


Figure 5.11.1 Red mullet in GSA 9: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.51).

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

Status	2017	2018	2019
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-3}$ (2020)	0.85	F current in the last year used to give F status quo for 2020
SSB (2020; middle year)	1289.9 t	Stock assessment 1 January 2020
R_0 (2020)	285136 thousands	Geometric mean of the period 2004-2019
R_0 (2022)	285136 thousands	Geometric mean of the period 2004-2019
Total catch (2020)	1011.2 t	Assuming F status quo for 2020

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* (2021)	F_{total}# (ages 1-3) (2021)	SSB (2022; middle year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	667.6	0.51	1650.7	28.0	-34.0
$F_{MSY\ lower}$	474.7	0.34	1906.0	47.8	-53.1
$F_{MSY\ upper}$**	851.1	0.69	1426.5	10.6	-15.8
$F_{MSY\ Transition}$	889.0	0.73	1382.5	7.2	-12.1
Other scenarios					
Zero catch	0.0	0.0	2618.4	103.0	-100.0
Status quo	986.2	0.85	1273.0	-1.3	-2.5

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	0.51

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.

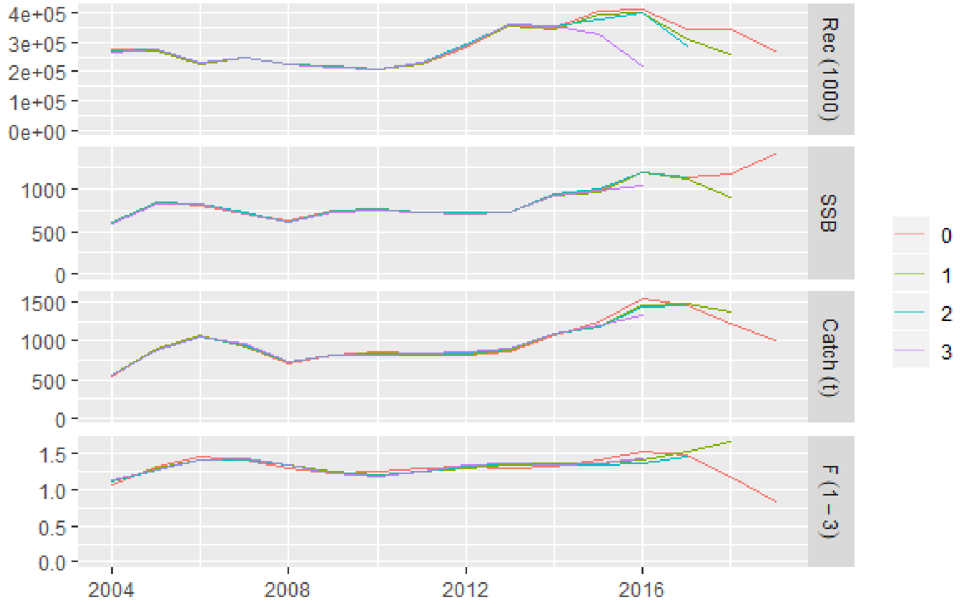


Figure 5.11.2 Red mullet in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.51	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
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}	0.51	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	target range F_{lower}	0.34	Based on regression calculation (see section 2)	STECF EWG 20-09
	target range F_{upper}	0.69	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

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

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

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

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}		821	1011	
2020	F = F_{MSY}		521		
2021	F = F_{MSY}		667.6		

History of the catch and landings

Table 5.11.8 Red mullet in GSA 9: Catch in 2019 and effort distribution by fleet in 2018 as estimated by and reported to STECF.

2019		Wanted catch				Discards
Catch (t)		Otter trawl 93%	Gillnets 1%	Trammel nets 5%	Others 1%	t
		782.8	9.3	39.9	12.0	98.1
Effort (2018)		44321	35705	63723		
		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	**327265**
2004	580.7	580.7	**320969**
2005	708.5	708.5	**230645**
2006	1049.6	1049.6	**217493**
2007	1096.0	1096.0	**209531**
2008	727.1	727.1	**204518**
2009	728.3	728.3	**153414**
2010	747.9	747.9	**179299**
2011	805.5	805.5	**162036**
2012	692.9	692.9	**193843**
2013	693.3	693.3	**159700**
2014	1181.4	1181.4	**168711**
2015	1183.4	1183.4	**169043**
2016	1221.6	1221.6	**186578**
2017	1460.7	1460.7	**166226**
2018	1204.8	1204.8	**148962**
2019	844.0	844.0	**-**

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
2004	274237	305251	243223	609.8	660.9	558.7	528.5	1.08	1.18	0.98
2005	274554	304905	244203	849.5	927.2	771.8	910.8	1.32	1.38	1.26
2006	222784	247444	198124	810.1	875.2	745	1078.0	1.46	1.53	1.39
2007	246943	272036	221850	700.8	757.6	644	915.3	1.42	1.49	1.35
2008	226577	248693	204461	620.4	668.4	572.4	703.9	1.30	1.37	1.23
2009	220550	242780	198320	753.5	810.9	696.1	822.9	1.23	1.30	1.16
2010	210358	231804	188912	760.9	819.4	702.4	852.5	1.25	1.31	1.19
2011	225954	249889	202019	718.9	772	665.8	843.8	1.30	1.37	1.23
2012	283974	311207	256741	705.3	761.8	648.8	814.1	1.32	1.39	1.25
2013	356827	394153	319501	733.0	786.2	679.8	846.6	1.30	1.36	1.24
2014	351139	386899	315379	947.0	1021.2	872.8	1080.5	1.32	1.39	1.25
2015	408721	450445	366997	973.0	1048.1	897.9	1236.5	1.43	1.50	1.36
2016	410882	451317	370447	1186.1	1280.4	1091.8	1554.8	1.54	1.61	1.47
2017	344590	386307	302873	1136.7	1231.6	1041.8	1453.0	1.48	1.56	1.40
2018	346897	413619	280175	1174.6	1298.9	1050.3	1230.1	1.20	1.29	1.11
2019	271663	351613	191713	1408.9	1669.3	1148.5	1011.2	0.85	0.99	0.71

Sources and references

EWG 20-09

5.12 Summary sheet for red mullet in GSA 10

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.39 and corresponding catches in 2021 should be no more than 314 tons.

Stock development over time

Catches and SSB of Red mullet show that after a gradual increase since 2011, the trend reached a peak with stable catch and SSB, and decreasing F. However, recent reduced recruitment suggests that there is potential for stock to decline.

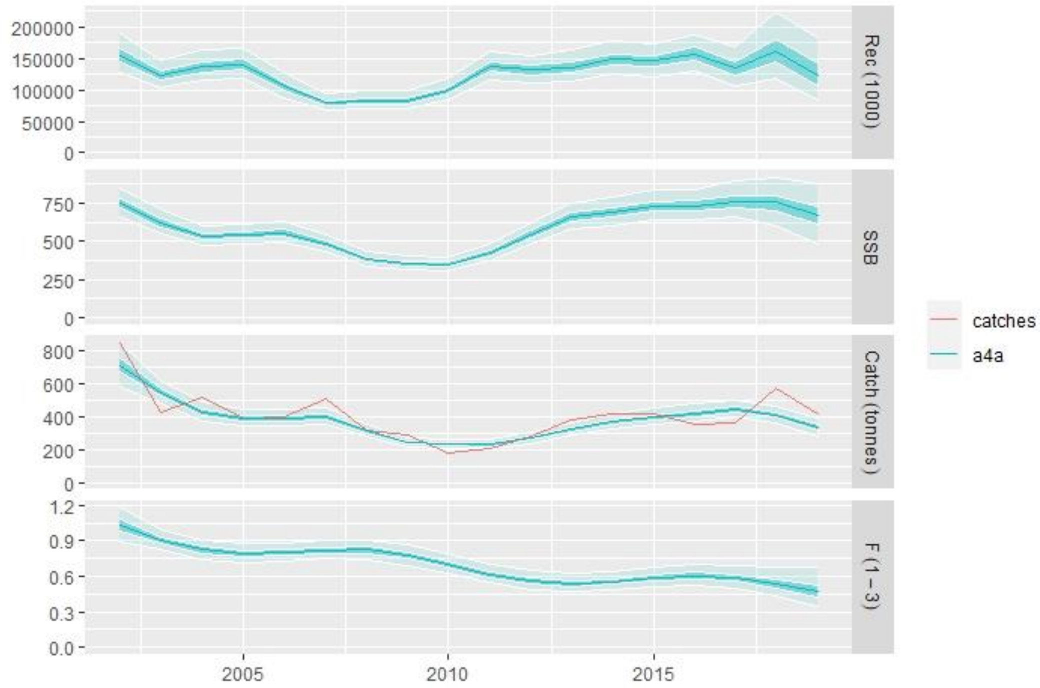


Figure 5.12.1 Red mullet in GSA 10: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.39).

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

Status	2017	2018	2019
F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	0.48	F2019 used to give F status quo for 2020
SSB (2020)	765	Stock assessment 1st July 2020
R_{age0} (2020,2021)	126740	Mean of the last 18 years
Total catch (2020)	392	Assuming F status quo for 2020

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* (2021)	F_{total}# (ages 1-3) (2021)	SSB -2022	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	314	0.39	799	4.5	-6.2
$F_{MSY\ Transition}$	348	0.45	753	-1.6	4.2
$F_{MSY\ lower}$	222	0.26	927	21.1	20.5
$F_{MSY\ upper**}$	403	0.54	683	-10.7	-33.5
Other scenarios					
Zero catch	0	0	1272	66.2	-100
Status quo	365	0.48	731	-4.4	9.2
0.1	45	0.05	1199	56.7	-86.7
0.2	87	0.1	1131	47.8	-74
0.3	128	0.14	1068	39.6	-61.8
0.4	166	0.19	1009	31.9	-50.2
0.5	203	0.24	954	24.7	-39.2
0.6	239	0.29	903	18	-28.6
0.7	272	0.33	855	11.8	-18.5
0.8	305	0.38	811	6	-8.8
0.9	336	0.43	770	0.6	0.4

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

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 catch of 2019 (SOP correction of 5) which leads to some instability in the assessment relative to last year. A slight increase in the last year cryptic biomass was also observed (~25% from ~15%).

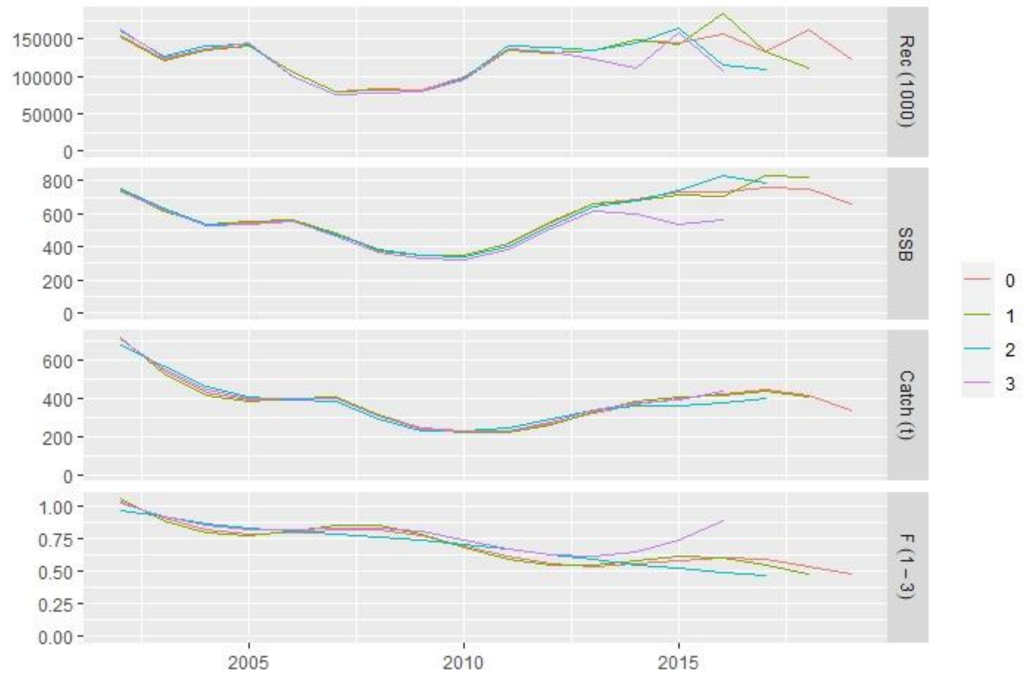


Figure 5.12.2 Red mullet in GSA 10: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.39	$F_{0.1}$ 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}	0.39	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	target range F_{lower}	0.26	Based on regression calculation (see section 2)	STECF EWG 20-09
	target range F_{upper}	0.54	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

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 20-09

*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		
2021	F = F_{MSY}		314		

History of the catch and landings

Table 5.12.8 Red mullet in GSA 10: Catch and effort distribution by fleet in 2018 as reported to STECF.

2019		Wanted catch				Discards
Catch (t)		Otter trawl 73%	Gillnets 8%	Trammel nets 19%		t
		304	34.5	76.8		0.26
Effort (2018)		33690	43650	132442		
		Fishing Days				

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

Year	ITA GSA10	Total landings	Total Effort
2002	847	847	**395844**
2003	424	424	**349608**
2004	522	522	**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	**199475**
2015	417	417	**191748**
2016	353	353	**204448**
2017	364	364	**195720**
2018	576	576	**209782**
2019	416	416	-

Summary of the assessment

Table 5.12.10 Red mullet in GSA 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 1-3	High	Low
2002	155638	203898	107378	744	890	598	705	1.03	1.25	0.81
2003	123383	157617	89149	622	744	500	546	0.91	1.04	0.77
2004	136719	175051	98387	535	635	436	428	0.82	0.95	0.70
2005	140267	180047	100487	545	647	442	388	0.79	0.92	0.66
2006	105890	135520	76260	557	662	452	392	0.80	0.92	0.68
2007	79255	101495	57015	482	569	394	398	0.82	0.94	0.70
2008	82960	105758	60162	382	453	311	312	0.82	0.96	0.68
2009	82603	104917	60289	353	421	285	241	0.78	0.92	0.64
2010	99198	125560	72836	350	419	281	231	0.70	0.83	0.57
2011	136821	172975	100667	424	509	339	230	0.62	0.74	0.49
2012	131526	167482	95570	548	658	438	269	0.56	0.68	0.44
2013	135770	172978	98562	661	798	524	323	0.54	0.66	0.42
2014	148846	189446	108246	690	836	545	367	0.56	0.67	0.44
2015	145587	186605	104569	731	881	581	396	0.58	0.71	0.46
2016	156958	203732	110184	731	891	571	420	0.60	0.74	0.46
2017	133917	183313	84521	762	948	576	444	0.59	0.74	0.44
2018	161913	247055	76771	747	989	506	412	0.54	0.73	0.35
2019	124070	204434	43706	661	955	367	334	0.48	0.73	0.22

Sources and references

STECF EWG 20-09

5.13 Summary sheet for Norway lobster in GSA 9

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.28 and corresponding catches in 2021 should be no more than 180.5 tons.

Stock development over time

Catches of Norway lobster slows a decreasing pattern until 2015, then they slightly increase in the last years. SSB shows a slightly increasing pattern, then shows a sharp increase in 2018. Recruitment follows a general decreasing pattern, with some oscillation. F shows an increasing trend from 2015.

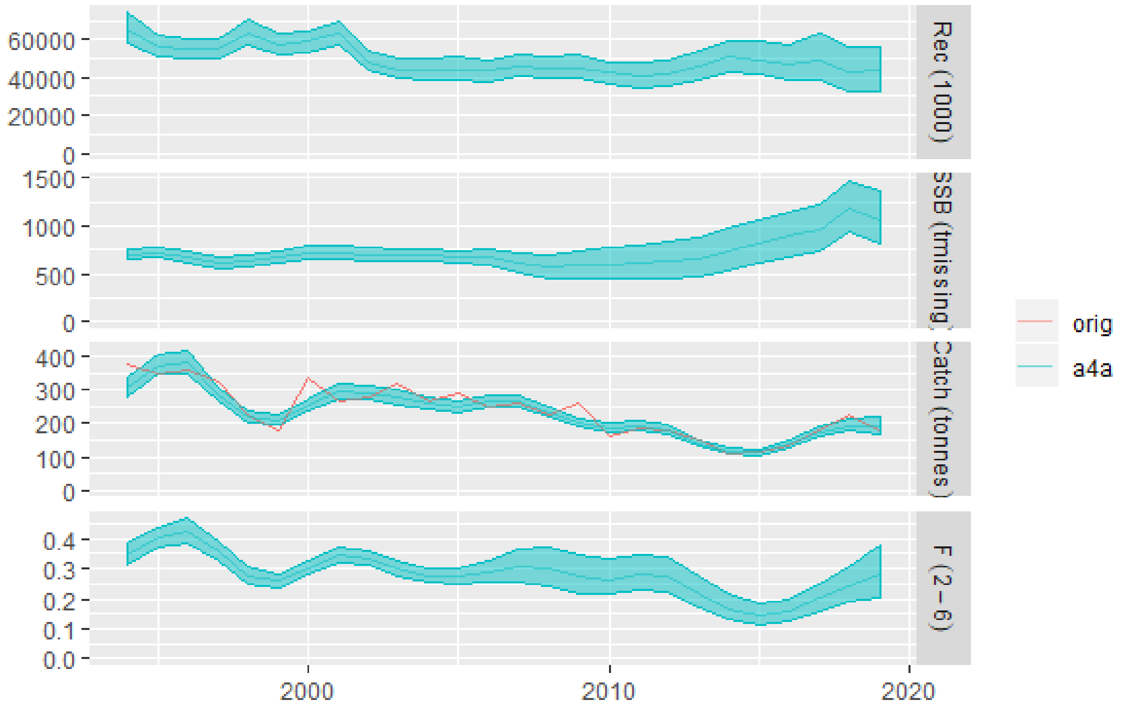


Figure 5.13.1 Norway lobster in GSA 9: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is at the level of the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.28).

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

Status	2017	2018	2019
F / F_{MSY}	F < F_{MSY}	F < F_{MSY}	F at F_{MSY}

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 2-6}$ (2020)	0.28	F2019 used to give F status quo for 2020
SSB (2020)	1046.4 t	Stock assessment 1 January 2020
R_{age0} (2020,2021)	44943	Geometric mean of years 2003 to 2019
Total catch (2020)	189	Assuming F status quo for 2020

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

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

Basis	Total catch* (2021)	F_{total}# (ages 2-6) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	180.5	0.28	980.5	-6.3	-6.5
$F_{MSY\ Transition}$	177.3	0.28	984.9	-5.9	-8.2
$F_{MSY\ lower}$	127.0	0.19	1056.9	1.0	-34.3
$F_{MSY\ upper}$**	235.9	0.39	905.6	-13.5	22.1
Other scenarios					
Zero catch	0	0	1253.9	19.8	-100
Status quo	175.7	0.28	987.2	-5.7	-9.0

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

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.

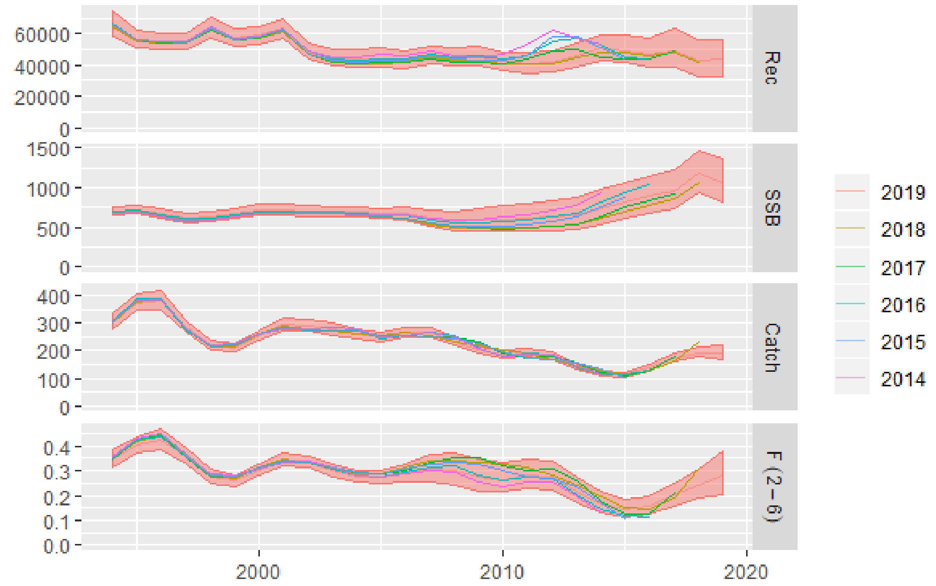


Figure 5.13.2 Norway lobster in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

The SSB presented here differs from the SSB presented last year, this is due to in error in assigning maturity at age in 2019 assessment. The values have been corrected here. These changes rescale the SSB but otherwise there are no changes to the forecast, F or catch advice or stock status.

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}	0.28	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	STECF EWG 19-10
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.28	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	MAP target range F_{lower}	0.19	Based on regression calculation (see section 2)	STECF EWG 19-10
	MAP target range F_{upper}	0.39	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.13.7 ENTER STOCK NAME: 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	193	0.5
2020	F = F_{MSY}		142		
2021	F = F_{MSY}		180		

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.

2019		Wanted catch				Discards
Catch (t)		Otter trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	t
		177	0	0	0	0.5
Effort (2018)		80027	0	0	0	
		Days at sea				

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	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	275072
2003	320.9	0.0	320.9	245490
2004	268.7	0.0	268.7	153842
2005	288.5	0.0	288.5	150567
2006	247.5	0.0	247.5	140975
2007	260.5	0.0	260.6	161640
2008	227.7	0.0	227.7	115043
2009	250.3	9.2	259.5	129469
2010	161.6	1.0	162.6	112325
2011	184.0	1.0	185	129189
2012	178.2	0.8	179	100299
2013	147.6	1.3	149	91737
2014	111.6	0.4	112	83342
2015	113.6	0.1	113.7	97794
2016	130.9	0.4	131.3	89249
2017	173.6	8.2	181.8	89025
2018	223.2	0.7	223.9	80027
2019	177	0.5	177.5	

landings and the TAC are presented. All weights are in tonnes. Effort in days at sea

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	65785.92	700.5	306.00	0.35	1310.01
1995	56516.87	721.9	374.65	0.41	1389.53
1996	55072.58	670.6	383.42	0.42	1286.72
1997	54944.64	619.3	287.29	0.36	1152.64
1998	63552.84	623.9	218.22	0.28	1056.92
1999	57217.07	670.9	211.97	0.26	1182.02
2000	58725.33	717.1	254.40	0.30	1268.62
2001	63399.47	718.5	295.00	0.34	1302.40
2002	48341.74	702.5	290.63	0.33	1269.06
2003	44324.17	694.8	276.83	0.30	1165.83
2004	43607.91	686.8	260.22	0.28	1126.30
2005	44128.24	671.5	247.89	0.27	1146.37
2006	43356.05	665.6	266.83	0.29	1112.31
2007	46096.34	606.6	266.70	0.31	1100.37
2008	45052.47	568.5	237.22	0.30	966.68
2009	45291.76	578.9	204.16	0.27	1033.19
2010	42181.82	596.7	188.81	0.26	1037.87
2011	40968.25	607.8	193.12	0.28	1025.39
2012	41978.94	623.4	182.97	0.28	1038.49
2013	45626.87	646.2	142.87	0.22	1039.30
2014	50964.54	730.4	116.75	0.16	1068.28
2015	49431.12	808.3	113.42	0.14	1223.38
2016	47088.02	886.5	139.56	0.16	1344.49
2017	49171.22	946.8	174.43	0.20	1440.00
2018	42712.32	1168.7	193.98	0.24	4588.45
2019	43411.45	1056.4	193.16	0.28	2721.59

Sources and references

STECF EWG 20-09

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 13.17 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 change in the biomass-estimated values 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.

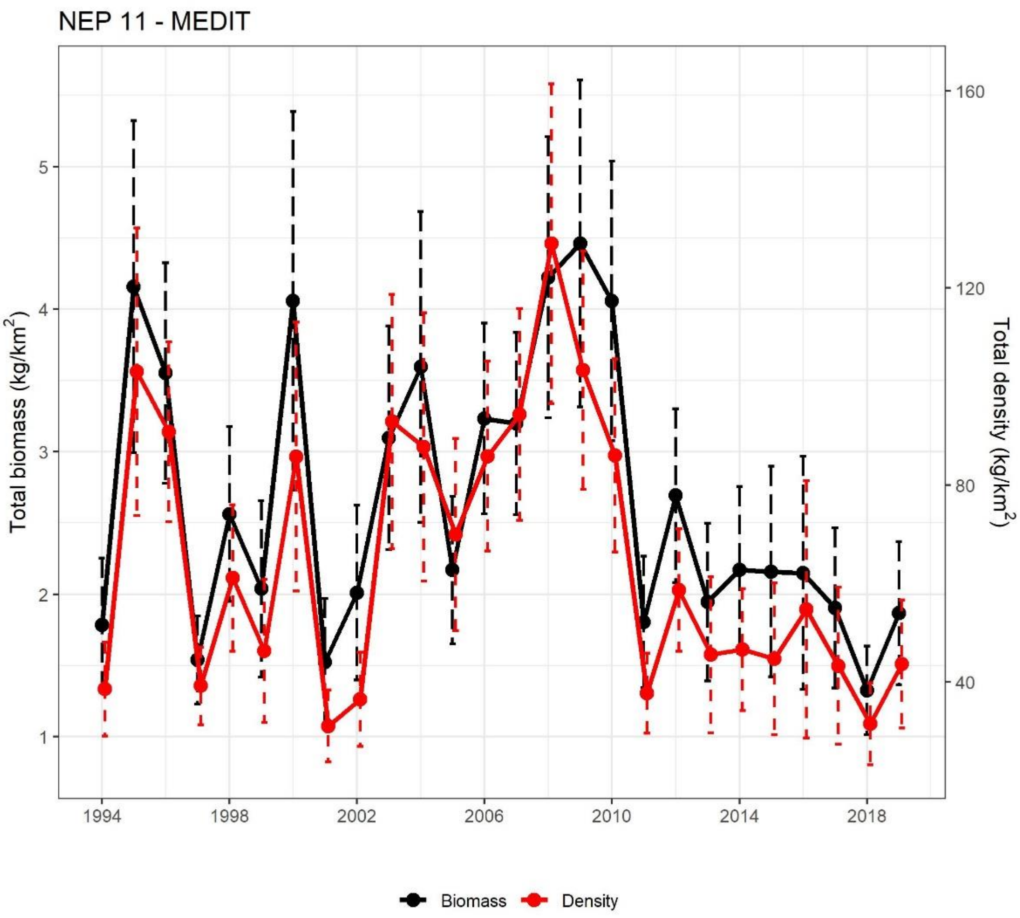


Figure 5.14.1 Norway lobster in GSA 11: MEDITS indices

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 as not acceptable due to incoherence in the landings cohorts, patterns in the residuals and diagnostic outputs. 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 Days at Sea
2005	6.3	6.3			28645
2006	42.3	42.3			22836
2007	31.3	31.3			22321
2008	36.2	36.2			19435
2009	44.4	44.4			20128
2010	22.8	22.8			19321
2011	50.5	50.5			17018
2012	41.1	41.1			15472
2013	20.6	20.6			15872
2014	17.2	17.2			17583
2015	18.2	18.2			15278
2016	15.8	15.8			16926
2017	28.3	28.3			16285
2018	37.8	37.8			21190
2019	40.1	40.1			

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

STECF EWG 20-09

5.15 Summary sheet for blue and red shrimp in GSA 1

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.29 and corresponding catches in 2021 should be no more than 32.23 tons.

Stock development over time

The Spawning stock biomass (SSB) shows a clear decreasing trend since 2014. The average SSB in the last 5 years of the dataset (2013-2019) is 87 t, which is considerably lower compared to the average SSB in the beginning of the time series (2002-2006) that was 132 t. The recruitment shows a declining pattern since 2005 (highest value in the time series). The recruitment in 2019 was 174,574 individuals, lower compared to the mean of the time series, 248,485 individuals. The average recruitment (2006-2019 years) that was used in the STF was 217,579 recruits. Catches have declined from around 200 t in 2002-2007 to around 120 t in 2019, with a declining trend from 2008 to 2010 and it appeared rather stable from 2011 to 2016. From 2017 to 2019 catch declined. F has fluctuated around 1.0-1.5 until 2017 but has increased in 2018 to 1.59 and the last year to 1.82.

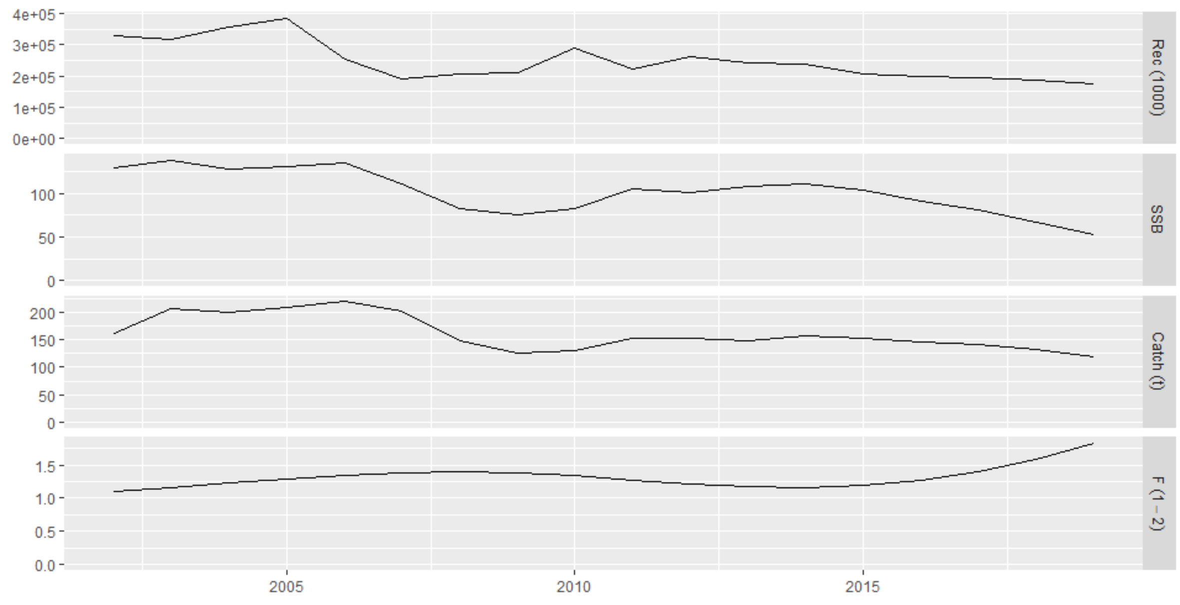


Figure 5.15.1. Blue and red shrimp in GSA 1. Stock summary of the assessment (a4a) results. SSB and catch are in tonnes, recruitment in number of individuals.

Stock and exploitation status

The current F (=1.82) equal to that of the terminal year (2019) 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.

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

Status	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-2}$ (2020)	1.82	F2019 used to give F status quo for 2020
SSB (2020)	50	Stock assessment 1 January 2020
R_0 (2020-2021)	217579	Geometric mean of years 2007 to 2019
Total catch (2020)	111	Assuming F status quo for 2020

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

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

Basis	Total catch* (2021)	F_{total}# (ages 1-2) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	32.23	0.29	184.74	269.46	-73
$F_{MSY\ Transition}$	102.2	1.31	81.34	62.67	-14.66
$F_{MSY\ lower}$	22.45	0.20	203.74	307.47	-81
$F_{MSY\ upper}$**	42.49	0.40	165.99	231.96	-65
Other scenarios					
Zero catch	0	0	251.65	403.28	-100
Status quo	123.05	1.82	60.87	21.73	4
0.10	21.04	0.18	206.59	313.17	-82
0.20	39.13	0.36	171.99	243.98	-67
0.30	54.79	0.55	145.15	190.30	-54
0.40	68.45	0.73	124.11	148.22	-43

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

Basis of the advice

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

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

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 2007,2008, 2009 and 2011 and 2013. For the initial runs all these were excluded from survey index due to high uncertainty. A model was fitted, then the sensitivity of the model tested to the inclusion/exclusion of this data. The model without the poor years gave more reliable estimates of catch. Based on this these data were not included in the assessment. Other parts of the model are unchanged. This results in F and F0.1 higher than last year but the ratio is similar.

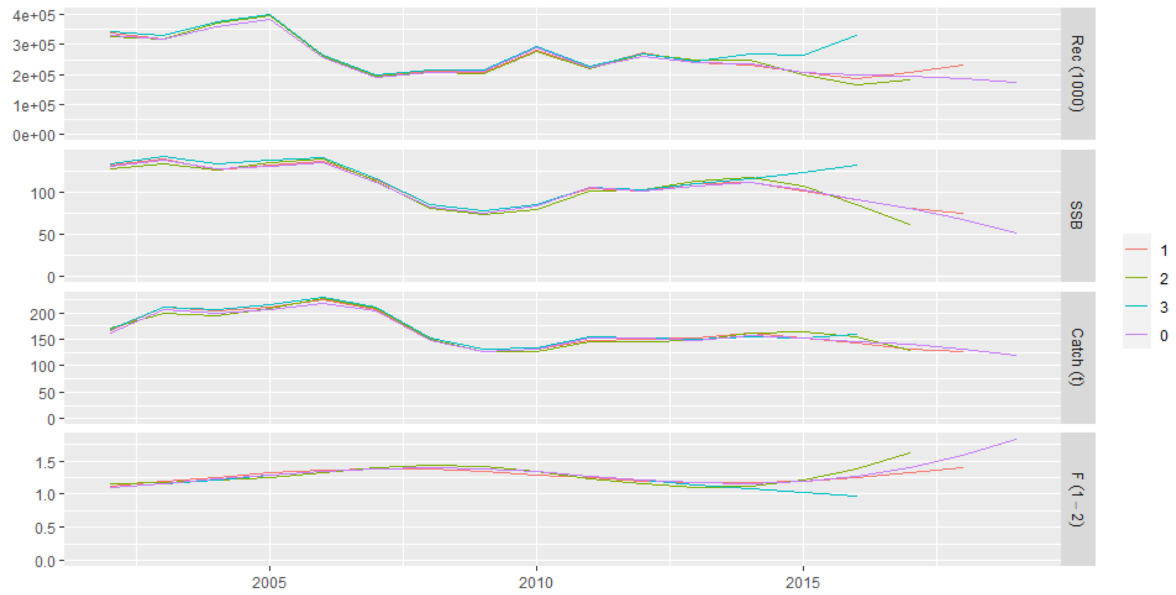


Figure 5.15.2 Blue and red shrimp in GSA 1. Results of the retrospective analysis (a4a).

Issues relevant for the advice

There are no additional issues for the advice.

Reference points

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

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.29	F0.1 used as proxy for F_{MSY}	EWG 20-09
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}	0.29	F0.1 used as proxy for F_{MSY}	STECF EWG 20-09
	MAP target range F_{lower}	0.20	Based on regression calculation (see section 2)	STECF EWG 20-09
	MAP target range F_{upper}	0.40	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

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

Assessment type	Statistical catch-at-age method (a4a)
Input data	Commercial catches (2002-2019) from one fleet (OTB) and one tuning index, MEDITS bottom trawl survey (CPUE, kg/km^2, 2002-2019). Percentage maturity from previous assessment, natural mortality estimated as a vector.
Discards and bycatch	Not included, considered negligible (less than 0.3%).
Indicators	None.
Other information	Previously assessed in 2019.
Working group	STECF EWG 20-09

History of the advice, catch, and management

Table 5.1.7 Blue and red shrimp 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

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		
2021	F = F F_{MSY}	32	32		

History of the catch and landings

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

(2019)	Landings				Discards
Catch (t)	OTB 100 %	Gillnets 0 %	Trammel nets 0 %	Other 0 %	Negligible
	120 (t)				
Effort (2018)	100%	-	-	-	
	21633 fishing days				

Table 5.15.9 Blue and red shrimp in GSA 1. History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort is in days fishing days.

Year	SPAIN GSA1	Total landings	Total Effort fishing days
2002	157	157	28002
2003	336	336	32892
2004	225	225	34951
2005	233	233	32295
2006	289	289	31443
2007	178	178	29917
2008	133	133	26201
2009	145	145	27017
2010	152	152	28476
2011	132	132	28170
2012	149	149	25851
2013	125	125	24334
2014	184	184	22395
2015	170	170	21587
2016	138	138	21345

2017	99	99	22537
2018	124	124	21633
2019	132	132	

Summary of the assessment

Table 5.15.10 Blue and red shrimp in GSA 1. Assessment summary. Weights are in tonnes.

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2002	330487			129.694			161.95	1.103		
2003	316933			138.13			205.45	1.166		
2004	356914			127.052			199.98	1.231		
2005	385503			130.551			207.18	1.295		
2006	254381			134.012			218.50	1.351		
2007	192639			111.036			202.62	1.390		
2008	207423			82.09			147.62	1.401		
2009	210674			75.058			126.09	1.382		
2010	288168			83.097			130.92	1.337		
2011	222641			104.701			151.77	1.275		
2012	261669			101.073			152.03	1.215		
2013	241334			107.283			148.32	1.171		
2014	237478			110.504			157.49	1.159		
2015	208771			102.988			152.69	1.188		
2016	200213			90.968			146.37	1.267		
2017	195924			80.534			140.15	1.401		
2018	187020			67.007			132.31	1.589		
2019	174574			52.085			119.70	1.823		

Sources and references

EWG 20-09

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.

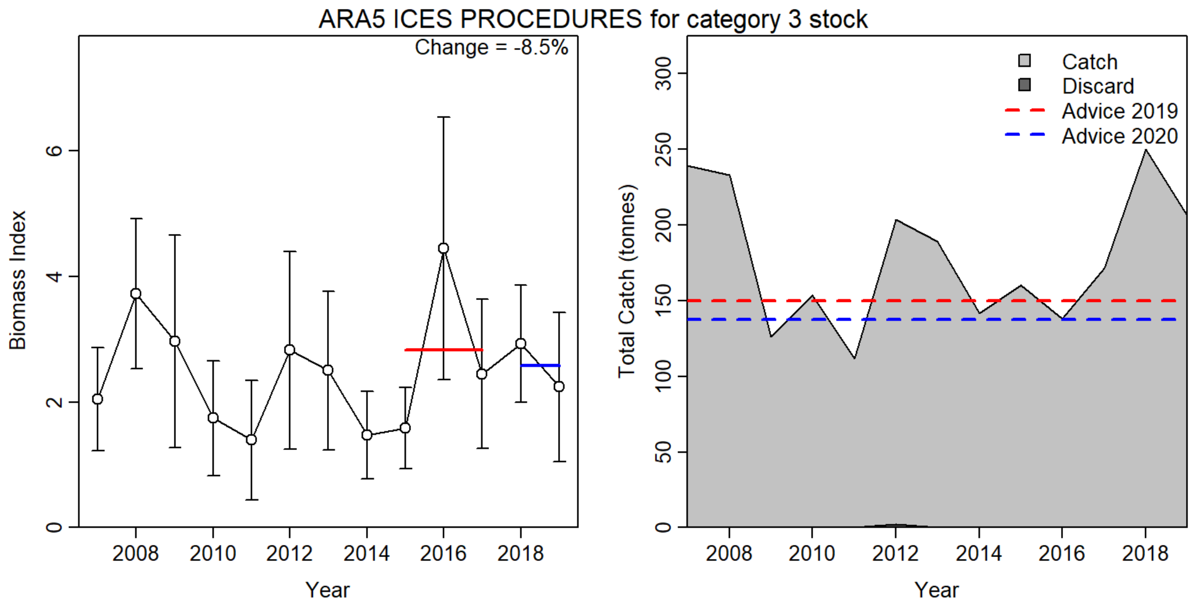


Figure 5.16.1 Blue and red shrimp in GSA 5: Trends in the MEDITS survey biomass index (kg/km2) with 95% Confidence Intervals (left) and time series of reported total catches (tonnes) for the period 2007-2019, denoting the 2019 and 2020 precautionary catch advice.

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 a 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

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.

2019		Wanted catch		Discards
Catch (t)		Otter trawl 100%		0 t
		206 t		
Effort				
		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	10936
2015	160	160	10714
2016	138	138	8952
2017	171	171	9158

2018	250	250	7947
2019	206	206	

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

STECF EWG 20-09

5.17 Summary sheet for blue and red shrimp in GSAs 6 & 7

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.29 and corresponding catches of blue and red shrimp in 2021 should not exceed 188 tonnes.

Stock development over time

The SSB shows some increase after 2015, but decreased again after 2017. Catch is estimated to be decreasing from a high in 2011 and has fluctuated at a high level from 2012 to 2019. Fishing mortality recently follows the fluctuations in catch is seen to slightly increase after 2015.

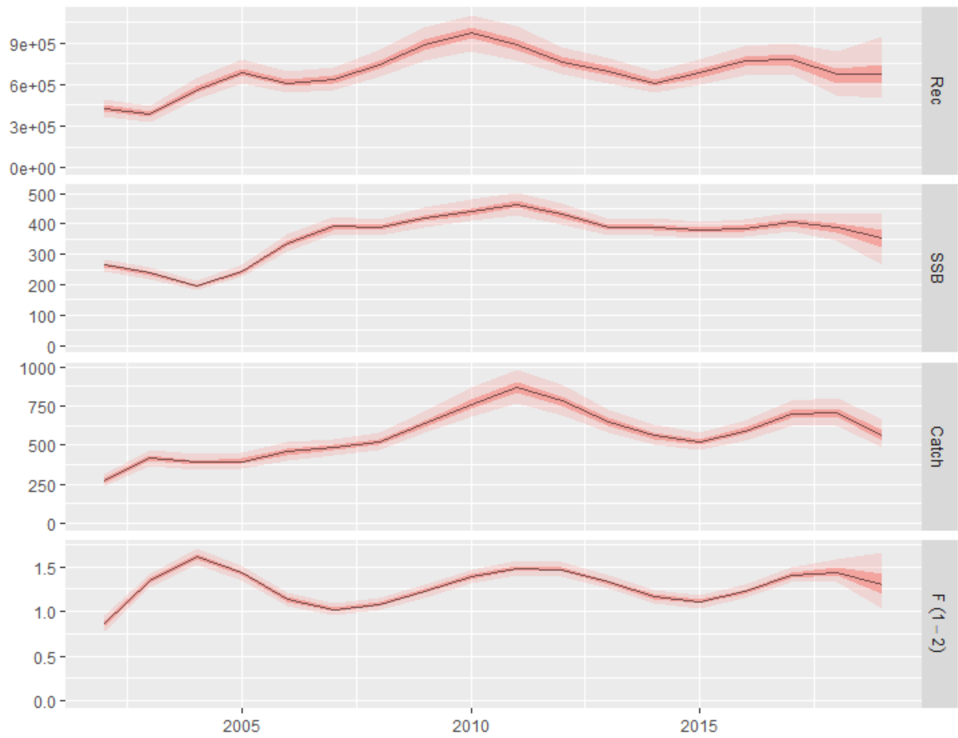


Figure 5.17.1 Blue and red shrimp (ARA) in GSAs 6 & 7. Outputs of the a4a assessment. SSB and catch are in tonnes, recruitment in number ('000) of individuals.

Stock and exploitation status

Current F (=1.30, in 2019) 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 GSAs 6 and 7 is over exploited.

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

Status	2017	2018	2019

F / F_{MSY}	F > F_{MSY}	F > F_{MSY}	F > F_{MSY}

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-2}$ (2020)	1.38	F2020 status quo assumed equal to geometric mean Fbar 2017-2019
SSB (2020)	353 t	SSB projection based on stock assessment
R_{age0} (2020)	694480	Geometric mean of R from time series years 2013 to 2019
Total catch (2020)	608 t	Catch at F status quo in 2020

Table 5.17.3 Blue and red shrimp in GSAs 6 & 7: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2021)	F_{total}# (ages 1-2) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	187.66	0.29	935	164.57	-66.83
F_{MSY} Transition	565	0.97	488	38.12	-14.11
F_{MSY} upper	247.15	0.40	833	135.80	-56.32
F_{MSY} lower**	130.91	0.19	1038	193.66	-76.86
Other scenarios					
Zero catch	0.00	0.00	1296	266.84	-100.00
Status quo	604.19	1.38	354	0.18	6.79

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

*** % change in SSB 2022 to 2020

^Total catch in 2021 relative to Catch in 2019.

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This is an updated a4a assessment with input data acounting for summer spawning of the stock, where the model parameters slightly differ from those used in 2019. The present assessment has improved diagnostics and retrospective patterns compared to the model formulation from 2019. The conclusion that F> F_{MSY} is kept by the 2020 assessment.

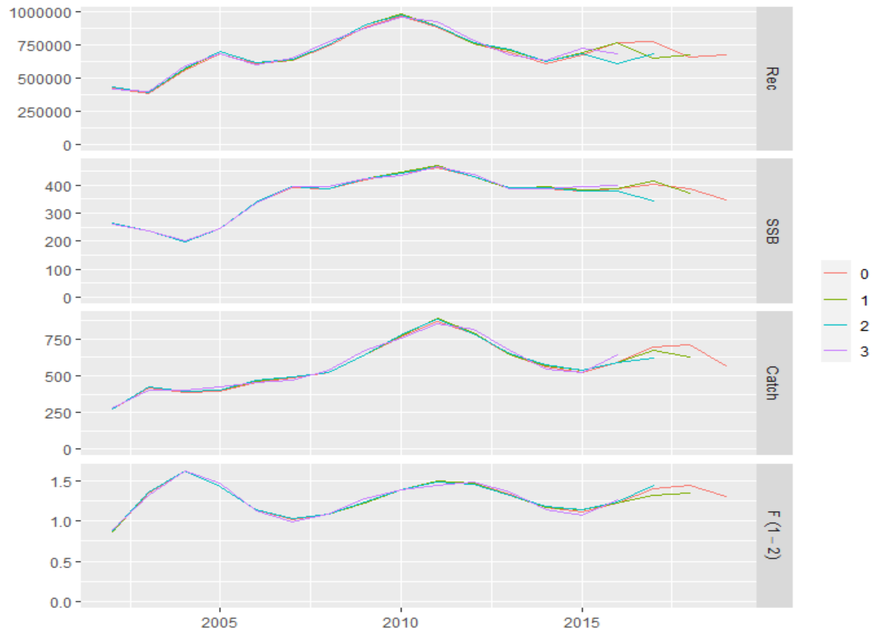


Figure 5.17.2 Blue and red shrimp in GSAs 6 & 7: Historical assessment results (final-year recruitment estimates included). Retrospective graph.

No VBGF parameters per sex were available, combined growth parameters were used despite assessing a species showing sex dimorphism. The same holds for LW relationship parameters and maturity at length.

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

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	-	Not Defined	
	F_{MSY}	0.29	$F_{0.1}$ 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	MAP MSY $B_{trigger}$	-	Not Defined	
	MAP B_{lim}	-	Not Defined	
	MAP F_{MSY}	0.29	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 2020-09
	MAP target range F_{lower}		Based on regression calculation (see section 2)	STECF EWG 2020-09
	MAP target range F_{upper}	0.4	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 2020-09

Basis of the assessment

Table 5.17.6 Blue and red shrimp in GSAs 6 & 7: Basis of the assessment and advice.

Assessment type	Age based
Input data	Landings at length to landings at age (age slicing)
Discards, BMS landings*, and bycatch	Discards included
Indicators	MEDITS in GSAs 6 & 7
Other information	-
Working group	STECF EWG 2020-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.17.7 Blue and red shrimp in GSAs 6 & 7: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF catch	STECF discards
2019	$F=F_{MSY}$	223	223		566	
2020	$F=F_{MSY}$	226	226			
2021	$F=F_{MSY}$	323	323			

History of the catch and landings

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

(2019)		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	t
		566 tonnes				Negligible
Effort		100%	0%	0%	0%	

Table 5.17.9 Blue and red shrimp in GSAs 6 & 7: History of commercial landings; both the official reported values are presented by country, official reported All weights are in tonnes. Effort is expressed in days at sea.

Year	SPAIN GSAs 6 & 7	Total landings	Total Effort
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	91494
2015	751	751	92424
2016	650	650	93704
2017	588	588	88858
2018	656	656	84370
2019	574	574	

Summary of the assessment

Table 5.17.10 Blue and red shrimp in GSAs 6 & 7: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 times the standard deviation (approximately 95% confidence intervals).

Year	Recruitment	Low	High	SSB, t	Low	High	Fbar 1-2	Low	High	Catch, t
2002	425893	325893	525893	264	228	300	0.86	0.72	1.00	271
2003	387845	295845	479845	238	208	268	1.34	1.22	1.46	415
2004	563566	439566	687566	196	172	220	1.61	1.47	1.75	388
2005	688575	552575	824575	243	211	275	1.43	1.31	1.55	397
2006	609483	483483	735483	338	300	376	1.14	1.04	1.24	457
2007	636820	498820	774820	392	350	434	1.02	0.90	1.14	486
2008	747955	597955	897955	387	347	427	1.08	0.96	1.20	521
2009	887635	695635	1079635	419	369	469	1.23	1.11	1.35	641
2010	968928	750928	1186928	441	385	497	1.39	1.27	1.51	764
2011	888933	690933	1086933	464	406	522	1.49	1.3	1.61	870
2012	765306	607306	923306	430	376	484	1.47	1.35	1.59	782
2013	694946	546946	842946	388	342	434	1.33	1.21	1.45	645
2014	614239	492239	736239	389	343	435	1.16	1.04	1.28	561
2015	681972	541972	821972	379	341	417	1.11	0.99	1.23	522
2016	766714	608714	924714	386	342	430	1.22	1.10	1.34	590
2017	779089	585089	973089	404	358	450	1.41	1.29	1.53	697
2018	660115	402115	918115	387	321	453	1.45	1.23	1.67	708
2019	678771	320771	1036771	348	208	488	1.30	0.80	1.80	566

Sources and references

STECF EWG 20-09

5.18 Summary sheet for blue and red shrimp in GSAs 9, 10 and 11

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.33 and corresponding catches in 2021 should be no more than 61 tons.

Stock development over time

SSB of blue and red shrimp show a fluctuating pattern reaching the lowest value in 2019 (232 tonnes). Recruitment fluctuates in a similar pattern with a minimum in 2018 (33840) but increased again in 2019. Fbar (2-5) shows a fluctuating pattern with a steep increase in the last years (Fbar 2019 = 1.78).

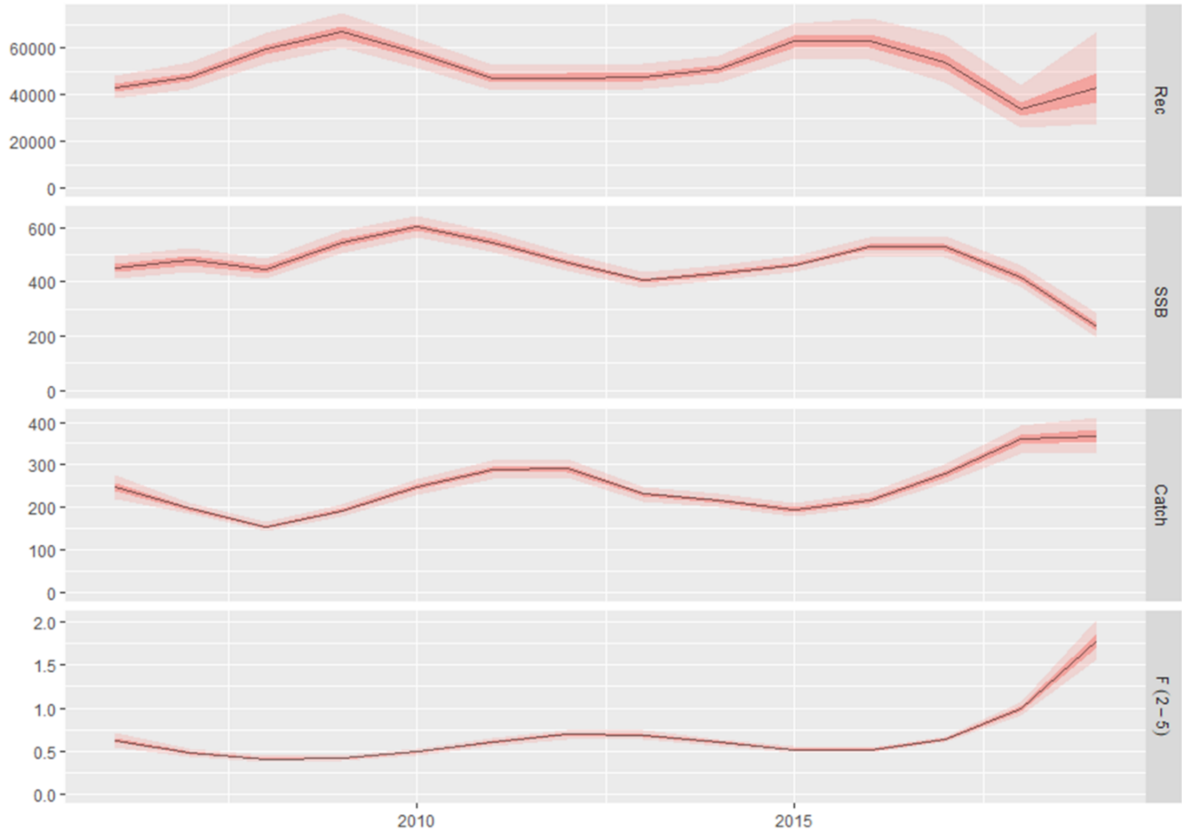


Figure 5.18.1 Blue and red shrimp in GSAs 9, 10 and 11: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.33).

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	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$

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
$F_{ages\ 2\text{-}5}$ (2020)	1.78	Last year value
SSB (2020)	187	Stock assessment September 2020
R_{age1} (2020,2021)	51741	Mean of years 2006 to 2019 (entire time series)
Total catch (2020)	221	Estimated by a4a, assuming F status quo for 2020

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of 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* (2021)	F_{total}# (ages 2-5) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	61	0.33	431	131	-83
$F_{MSY\ Transition}$	187	1.29	258	38	-49
$F_{MSY\ lower}$	42	0.22	463	147	-89
$F_{MSY\ upper}$**	81	0.45	400	113	-78
Other scenarios					
Zero catch	0	0	537	187	-100
Status quo	231	1.78	212	13	-37

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

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

Both catches and survey indices showed good internal consistency. The retrospective analysis run on the a4a model showed consistent results particularly for F. All the diagnostics were considered acceptable. No changes in the model from previous assessment except for the reconstruction of LFD in the catch of 2018 and 2019 to allow for a better SOP correction.

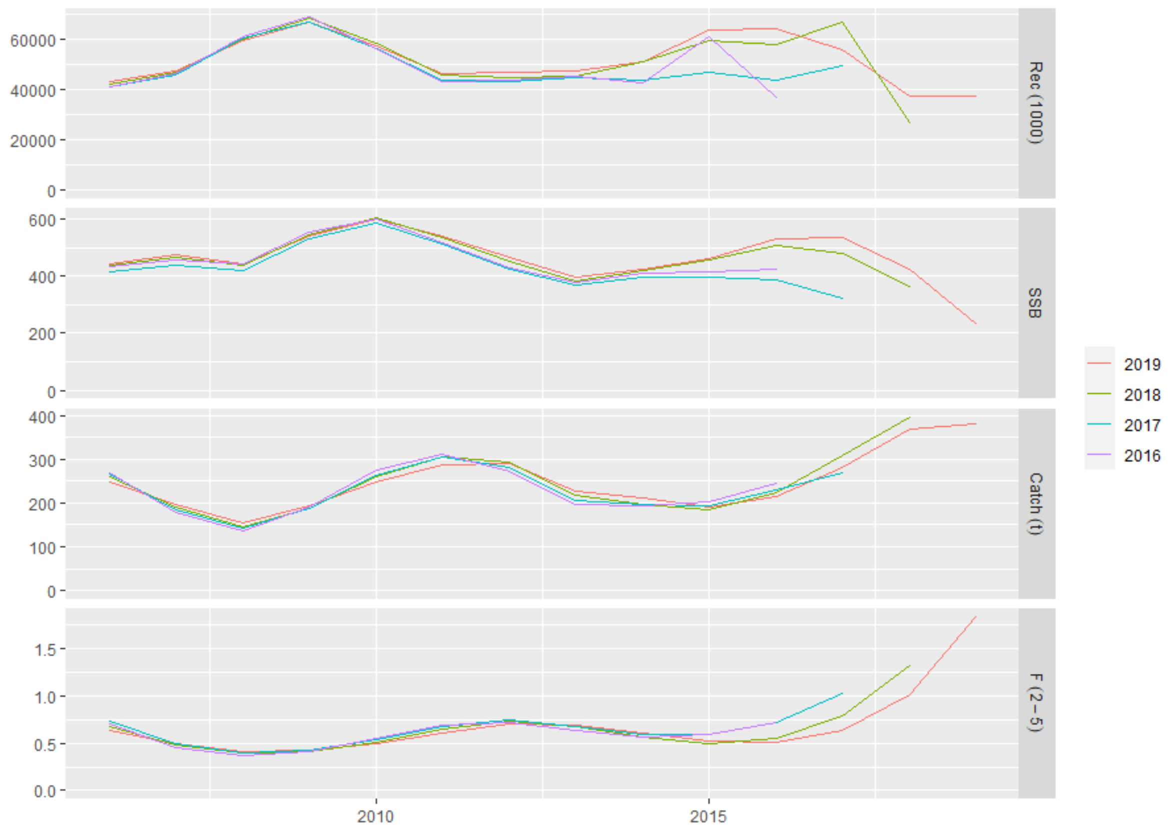


Figure 5.18.2 Blue and red shrimp in GSAs 9, 10 and 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.33	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
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}	0.33	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	MAP target range F_{lower}	0.22	Based on regression calculation (see section 2)	STECF EWG 20-09
	MAP target range F_{upper}	0.45	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

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 discards) and scientific survey (MEDITS) data.
Discards, BMS landings*, and bycatch	Discards included but were zero except for 2011 in GSA 9 (negligible).
Indicators	
Other information	
Working group	STECF EWG 20-09

*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
2020	F = F_{MSY}		72	366	
2021	F = F_{MSY}		61		

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.

2019		Wanted catch				Discards
Catch (t)		Otter bottom trawl (OTB) 100%				t
		366				0
Effort						
		Days at sea				

Table 5.18.9 Blue and red shrimp in GSAs 9, 10 and 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 GSA9	ITALY GSA10	ITALY GSA11	Total landings	Total Effort
2006	92.7	51.7	171.7	316.1	119749
2007	47.4	39.5	56.5	143.4	122654
2008	63.5	23.0	74.6	161.1	107345
2009	123.5	27.4	65.3	216.2	110223
2010	186.4	20.1	53.3	259.8	103749
2011	174.7	48.5	59.4	282.6	101190
2012	192.6	31.5	57.3	281.4	94577
2013	170.4	34.3	40.5	245.2	105927
2014	83.6	8.7	46.4	138.7	111288
2015	90.7	66.9	57.4	215.0	98969
2016	66.6	95.4	89.4	251.4	103845
2017	62.4	76.0	110.0	248.4	100037
2018	77.2	135.0	284.5	496.7	99251
2019	101.0	141.5	107.0	349.5	

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	42952			448			247	0.63		
2007	47743			477			197	0.484		
2008	59475			444			154	0.413		
2009	66719			543			192	0.419		
2010	57625			600			248	0.493		
2011	46897			543			288	0.608		
2012	47232			470			290	0.696		
2013	47549			403			231	0.689		
2014	51005			430			216	0.604		
2015	62832			461			194	0.522		
2016	63112			528			216	0.513		
2017	54283			526			278	0.636		
2018	33840			415			359	0.993		
2019	43108			232			366	1.778		

Sources and references

5.19 Summary sheet for giant red shrimp in GSA 9, 10 & 11

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied, the fishing mortality in 2021 should be no more than 0.48 and corresponding to catches of no more than 323 tons in 2020.

Stock development over time

Catches of giant red shrimp in GSAs 9, 10, 11 shows a fluctuating pattern, with peaks in 2006, 2014 and 2018. A slight decrease in catches has been observed the last year. Recruitment and SSB peaked in 2016 and 2017, respectively; after that, they showed an almost decreasing trend. Fishing mortality showed a rather constant pattern between 0.4 and 0.9; an increase in F values has been observed since 2016.

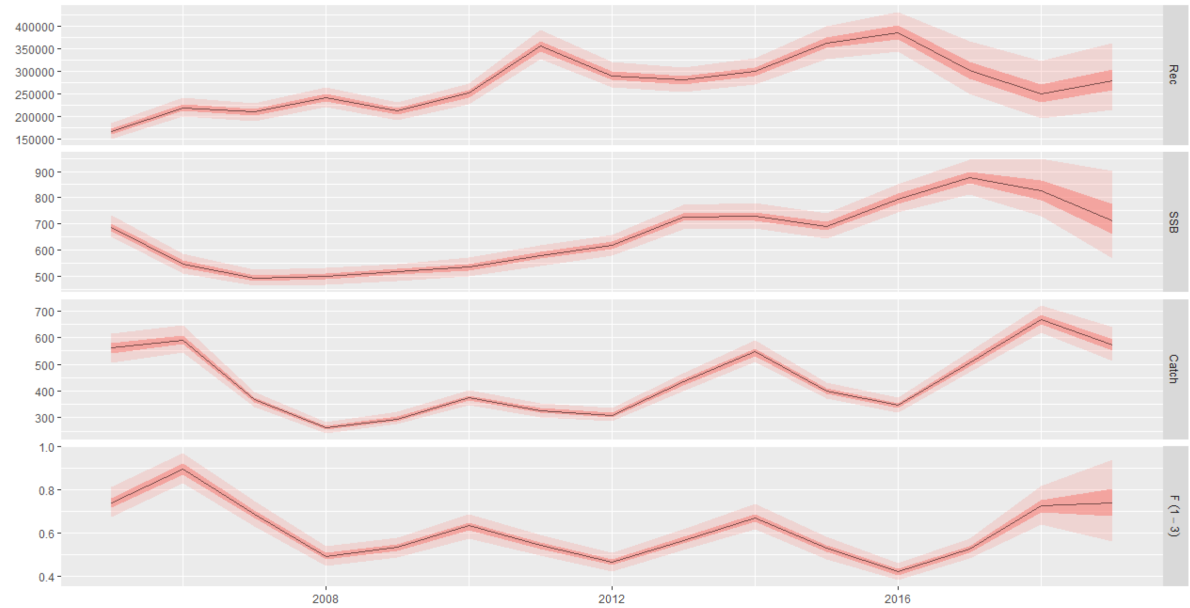


Figure 5.19.1 Giant red shrimp in GSAs 9, 10, 11: Output of the assessment.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (= 0.48).

Status	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$

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

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-3}$ (2020)	0.73	F status quo = F in the last year (2019)
SSB (2020)	590.8	Stock assessment 1 January 2020
R_{age0} (2020,2022)	266969thousands	Geometric mean of the whole time series (2005-2019)
Total catch (2020)	464 t	Assuming F status quo for 2020

Table 5.19.3 Giant red shrimp in GSA 9, 10, 11: Annual catch scenarios. All weights are in tons.

Basis	Total catch* (2021)	F_{total}# (ages 1-3) (2021)	SSB (2022 middle of the year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	322.85	0.48	706.1	19.5	-43.5
$F_{MSY\ Transition}$	409.8	0.65	617.3	4.5	-28.3
$F_{MSY\ lower}$	230.4	0.32	810.0	37.1	-59.7
$F_{MSY\ upper}$**	410.9	0.65	616.3	4.3	-28.1
Other scenarios					
Zero catch	0.0	0.0	1115.2	88.8	-100.00
Status quo	449.0	0.73	580.0	-1.8	-21.4
0.1	59.7	0.07	1029.5	74.3	-89.5
0.2	115.3	0.15	954.0	61.5	-79.8
0.3	167.1	0.22	887.2	50.2	-70.8
0.4	215.4	0.29	827.8	40.1	-62.3
0.5	260.7	0.37	774.8	31.1	-54.4
0.6	303.1	0.44	727.4	23.1	-47.0
0.7	342.9	0.51	684.8	15.9	-40.0
0.8	380.4	0.59	646.4	9.4	-33.4
0.9	415.7	0.66	611.6	3.5	-27.3

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2022 to 2020
^Total catch in 2021 relative to Catch in 2019.

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	0.48

Quality of the assessment

Catches showed good internal consistency, which is slightly lower in the survey indices. The retrospective analysis run on the a4a model showed moderately consistent results with some evidence of overestimation of SSB and underestimation of F, but in all cases the conclusion of F relative to F_{MSY} is maintained. All the diagnostics were considered acceptable.

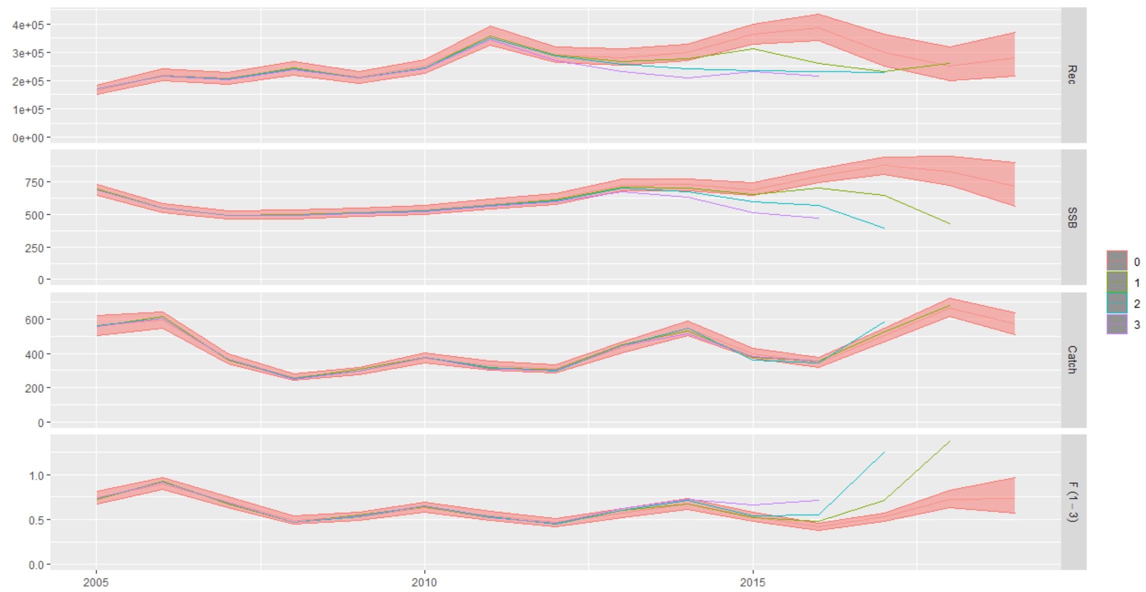


Figure 5.19.2 Giant red shrimp in GSA 9, 10, 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.19.5 Giant red shrimp in GSA 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}	0.48	$F_{0.1}$ as proxy for F_{MSY}	EWG 20-09
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}	0.48	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-09
	MAP target range F_{lower}	0.32	Based on regression calculation (see section 2)	STECF EWG 20-09
	MAP target range F_{upper}	0.65	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-09

Basis of the assessment

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

Assessment type	Age based
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 20-09

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.19.7 Giant red shrimp in GSA 9, 10, 11: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tons.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	$F = F_{MSY}$		171	571	
2020	$F = F_{MSY}$		199		
2021	$F = F_{MSY}$		323		

History of the catch and landings

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

2019		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets %	Trammel nets %	Other %	t
	571	tons				0.0
Effort (2018)						

Table 5.19.9 Giant red shrimp in GSA 9, 10, 11: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in days at sea.

Year	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total landings	Discards	STECF total catches	Total Effort
2005	77.4	505.1	55.2	637.7	0.0	637.7	146415
2006	62.6	419.6	98.1	580.3	0.0	580.3	123716
2007	36.7	300.3	42.0	379.0	0.0	379.0	124633
2008	33.8	120.1	38.6	192.5	0.0	192.5	107303
2009	34.3	211.7	117.4	363.4	0.0	363.4	110207
2010	54.6	190.2	98.6	343.4	0.0	343.4	103668
2011	68.4	140.9	94.7	304.0	0.1	304.1	101011
2012	62.0	159.8	72.7	294.5	0.9	295.4	94547
2013	23.1	399.4	63.3	485.8	0.0	485.8	105858
2014	16.8	454.1	61.1	532.0	0.0	532.0	111096
2015	44.2	232.1	97.8	374.1	0.0	374.1	98887
2016	35.8	179.1	127.6	342.5	0.0	342.5	103661
2017	33.6	325.9	249.2	608.7	1.0	608.7	100013
2018	36.4	416.2	188.4	640.9	0.0	640.9	99056
2019	46.2	450.2	73.6	570.0	0.0	570.0	

Summary of the assessment

Table 5.19.10 Giant red shrimp in GSA 9, 10, 11: 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
2005	166140	179938	152342	686.7	719.8	653.6	560	0.74	0.79	0.69
2006	218929	234978	202880	548.1	578.9	517.3	593	0.90	0.95	0.84
2007	209881	225306	194456	492.9	517.2	468.6	367	0.69	0.73	0.64
2008	241636	260050	223222	499.4	526.0	472.8	262	0.49	0.53	0.45
2009	211177	226838	195516	516.1	541.3	490.9	297	0.53	0.57	0.49
2010	249403	268617	230189	535.2	563.9	506.5	373	0.63	0.67	0.59
2011	356254	384861	327647	578.5	609.1	547.9	327	0.54	0.58	0.50
2012	290658	312813	268503	616.4	648.3	584.5	309	0.46	0.50	0.43
2013	281048	302928	259168	725.0	760.3	689.7	433	0.56	0.60	0.53
2014	299053	321339	276767	729.3	769.6	689.0	546	0.67	0.71	0.63
2015	362940	389650	336230	692.5	730.5	654.5	399	0.53	0.57	0.49
2016	386899	422841	350957	796.9	837.7	756.1	345	0.42	0.45	0.39
2017	300348	346403	254293	879.5	931.3	827.7	507	0.52	0.56	0.49
2018	252749	299078	206420	831.2	917.1	745.3	669	0.72	0.80	0.65
2019	279654	335369	223939	716.2	848.3	584.1	571	0.73	0.88	0.58

Sources and references

STECF EWG 20-09

6 ASSESSMENTS BY STOCK

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 FMSY point value, range of FMSY (i.e. MSY FLOWER and MSY FUPPER) 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 FMSY range (i.e. FMSY point value, MSY FLOWER and MSY FUPPER) or other appropriate proxy by 2021 and 2025.*

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 20-09 considered the stock shared by GSAs 1, 5, 6 and 7.

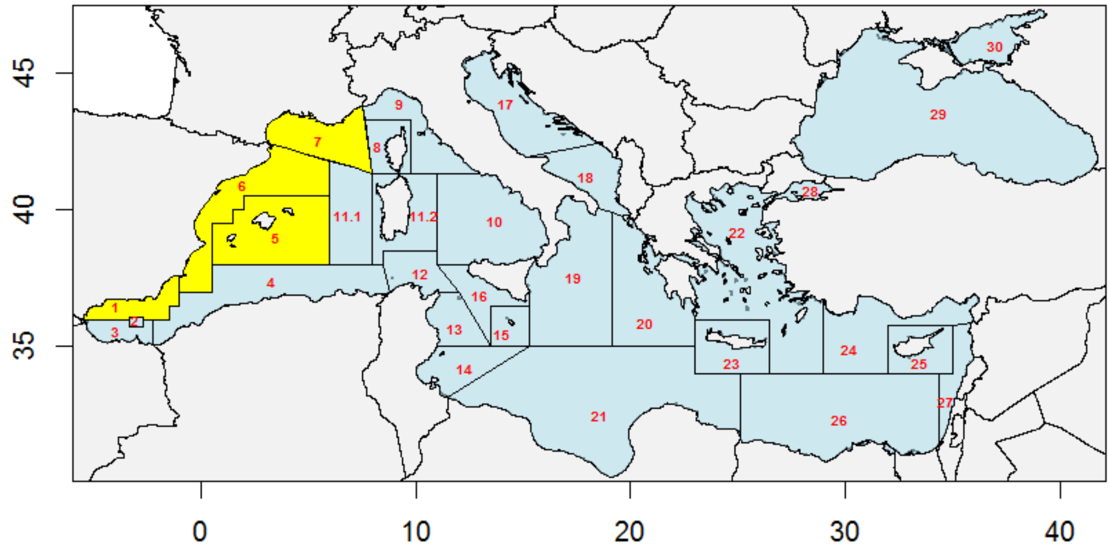


Figure 6.1.1.1 Geographical location of GSAs 1, 5, 6 and 7.

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

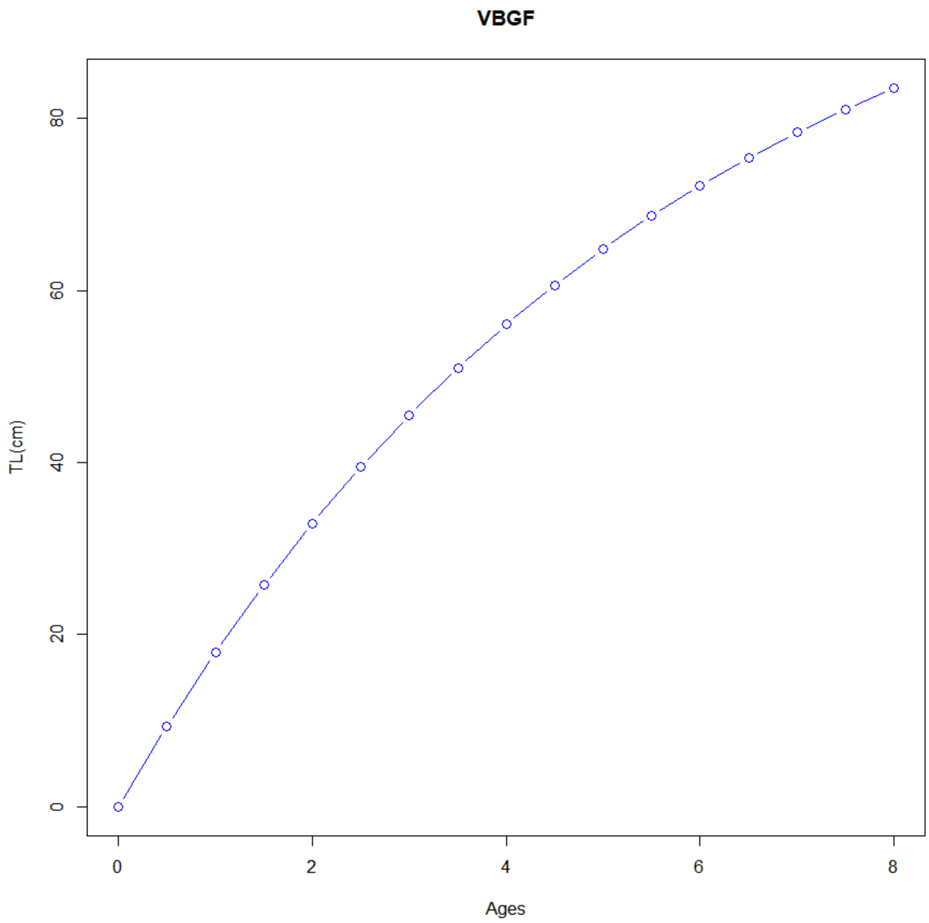


Figure 6.1.1.2. European hake in GSAs 1, 5, 6 and 7. Von Bertalanffy growth curve.

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

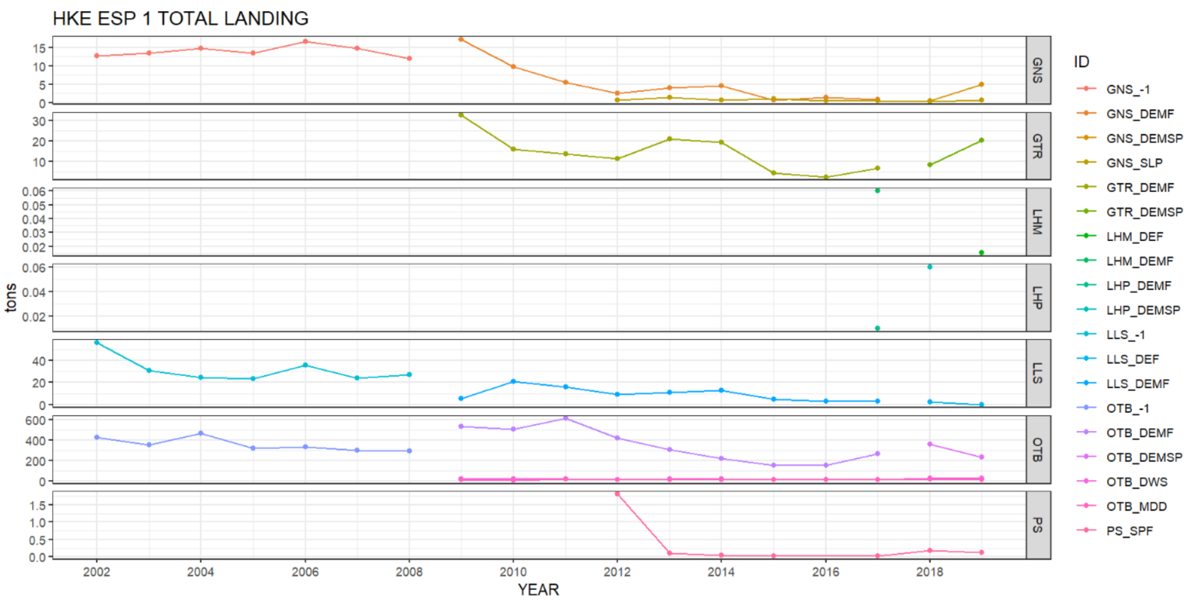
6.1.2 Data

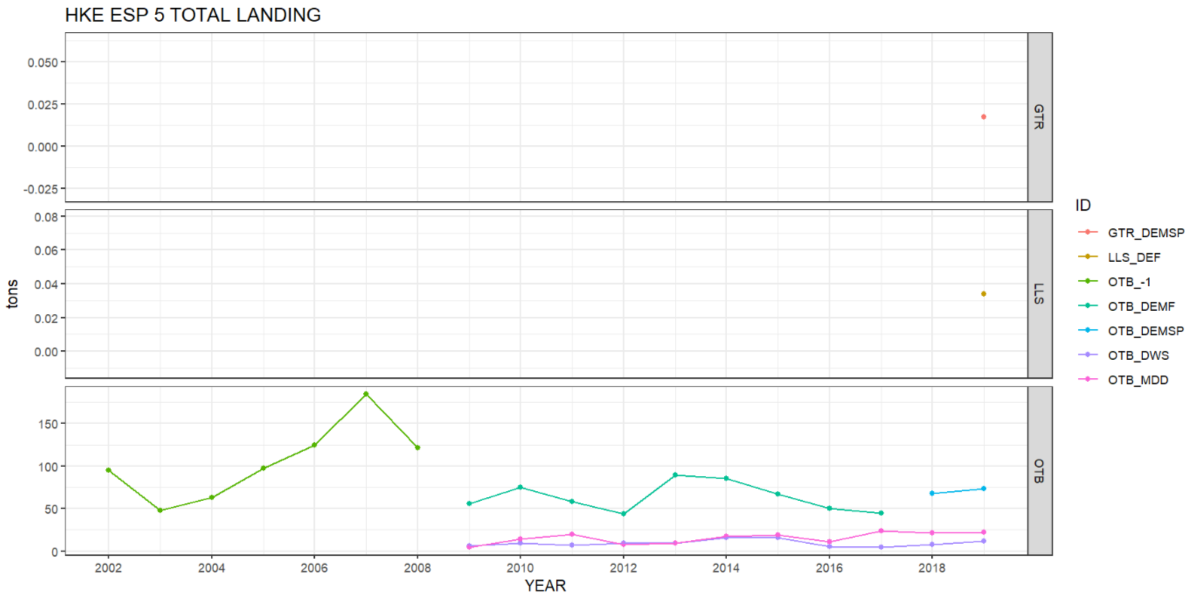
6.1.2.1 Catch (landings and discards)

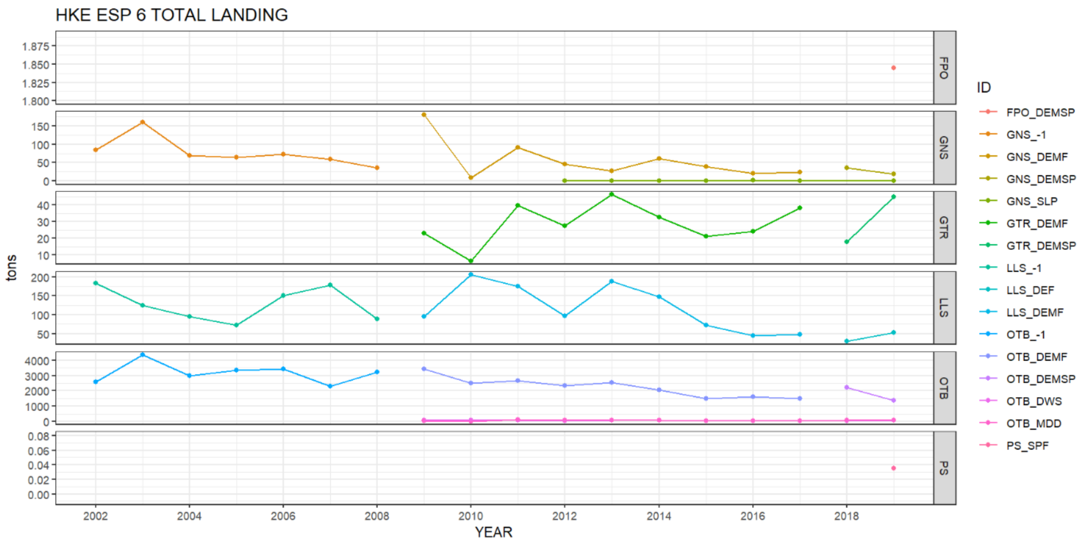
European hake is largely exploited in GSAs 1 and 6, mainly by trawlers on the shelf and slope, but also by small-scale fisheries using long lines, gill nets and trammel nets. In GSA 5, hake catches come exclusively from bottom trawlers. They show important variation along the data series, between 50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

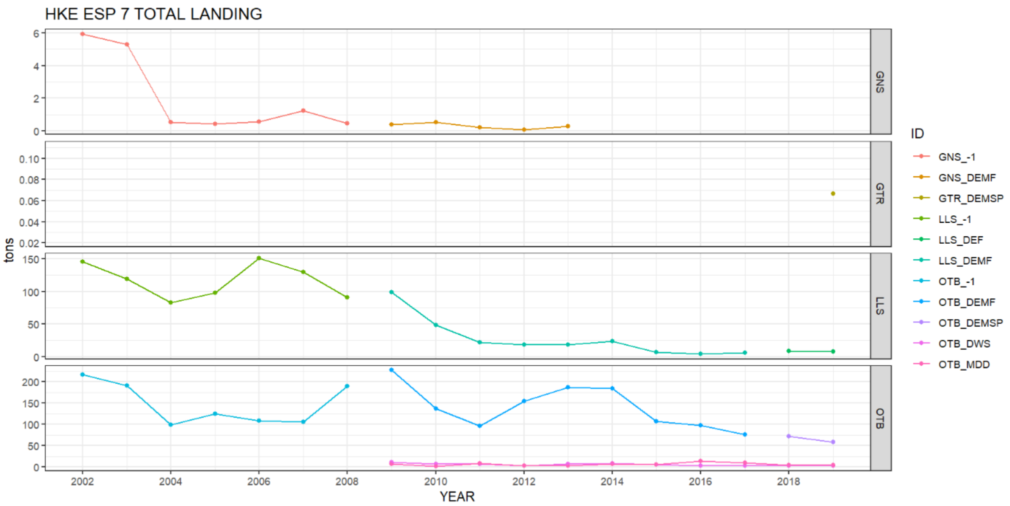
Landings

Landings data were reported to STECF EWG 18-12 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
GTR
LLS
OTB
ID
GTR_DEMSP
LLS_DEF
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_DWS
OTB_MDD


HKE ESP 6 TOTAL LANDING
tons
YEAR
FPO
GNS
GTR
LLS
OTB
PS
ID
FPO_DEMSP
GNS_-1
GNS_DEMF
GNS_DEMSP
GNS_SLP
GTR_DEMF
GTR_DEMSP
LLS_-1
LLS_DEF
LLS_DEMF
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_DWS
OTB_MDD
PS_SPF


HKE ESP 7 TOTAL LANDING
tons
YEAR
GNS
GTR
LLS
OTB
ID
GNS_-1
GNS_DEMF
GTR_DEMSP
LLS_-1
LLS_DEF
LLS_DEMF
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_DWS
OTB_MDD

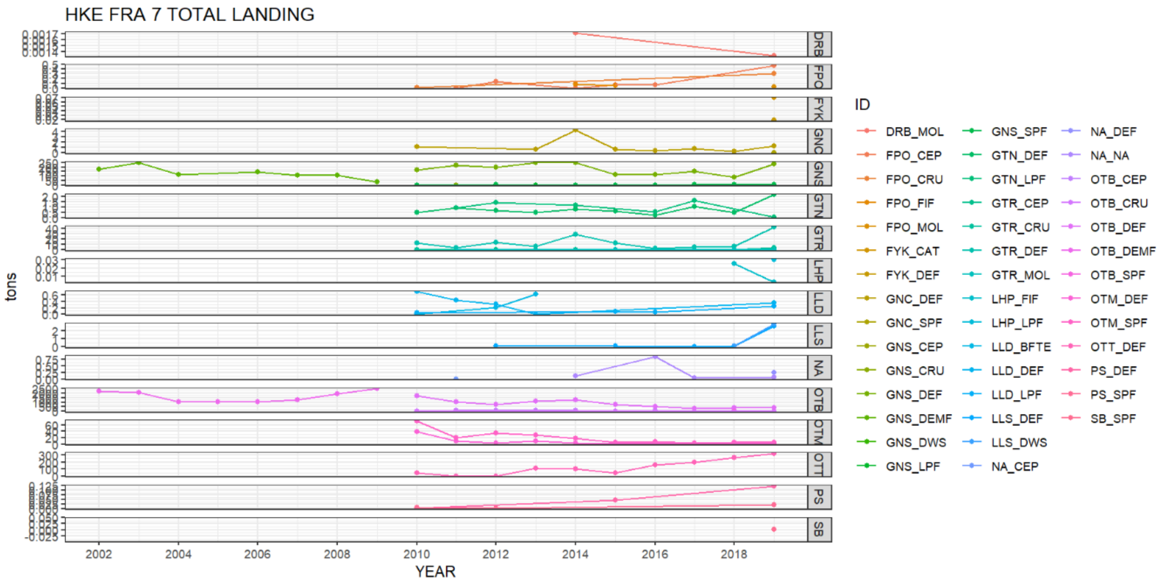
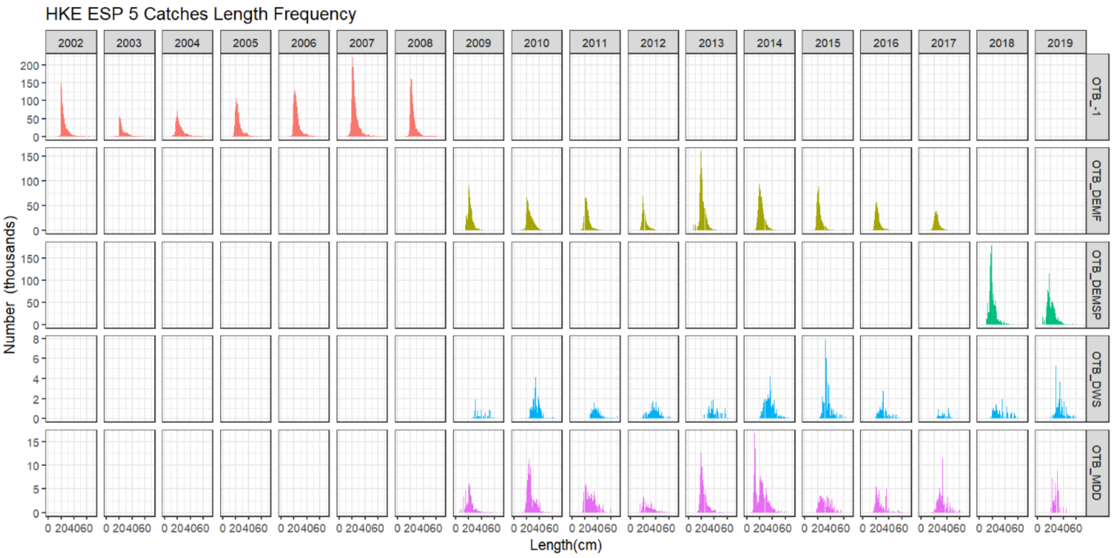


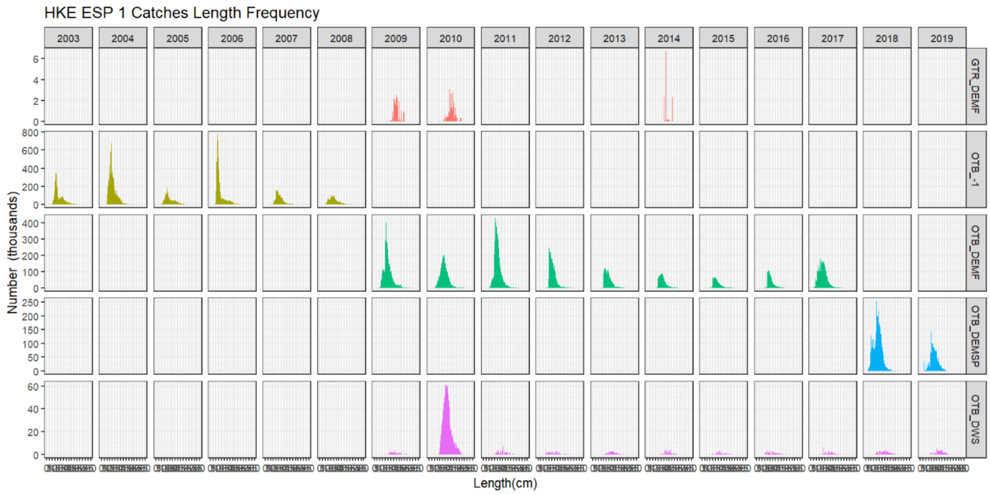
Figure 6.1.2.1.1. European hake in GSAs 1, 5, 6 and 7. Landings data in tons by year GSA country and fleet (for France in GSA 7 landings data are shown by year and gear for visualization reasons). From 2015 onwards there can be two points in the same year due to the increase in "fishery classes" for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

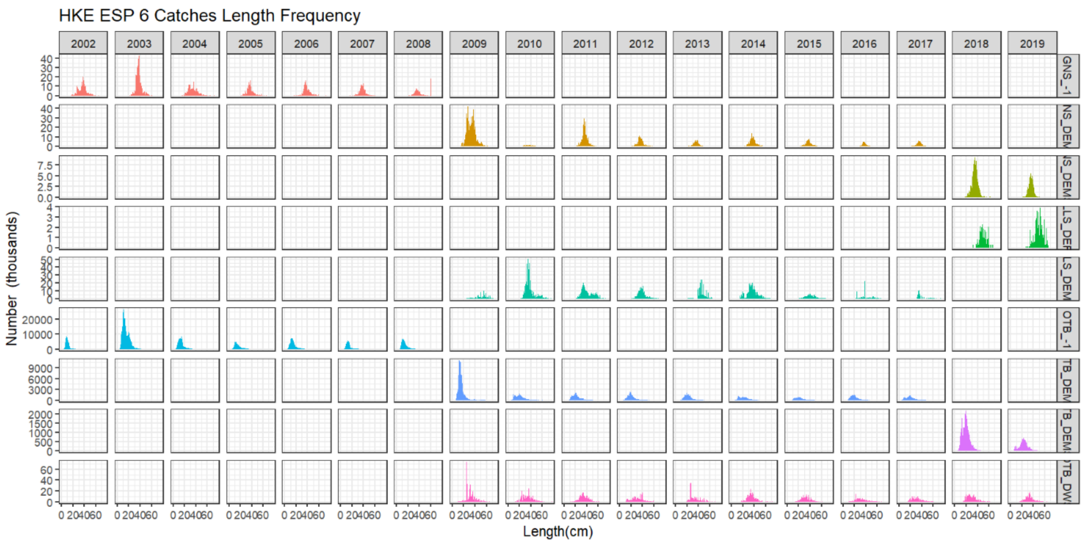
Table 6.1.2.1.1. European hake in GSAs 1, 5, 6 and 7. Total landings data in tons by year.

	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

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 5 Catches Length Frequency
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_DWS
OTB_MDD
Number (thousands)
Length(cm)


HKE ESP 1 Catches Length Frequency
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
GTR_DEMF
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_DWS
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
GNS_-1
OTB_-1
Number (thousands)
Length(cm)

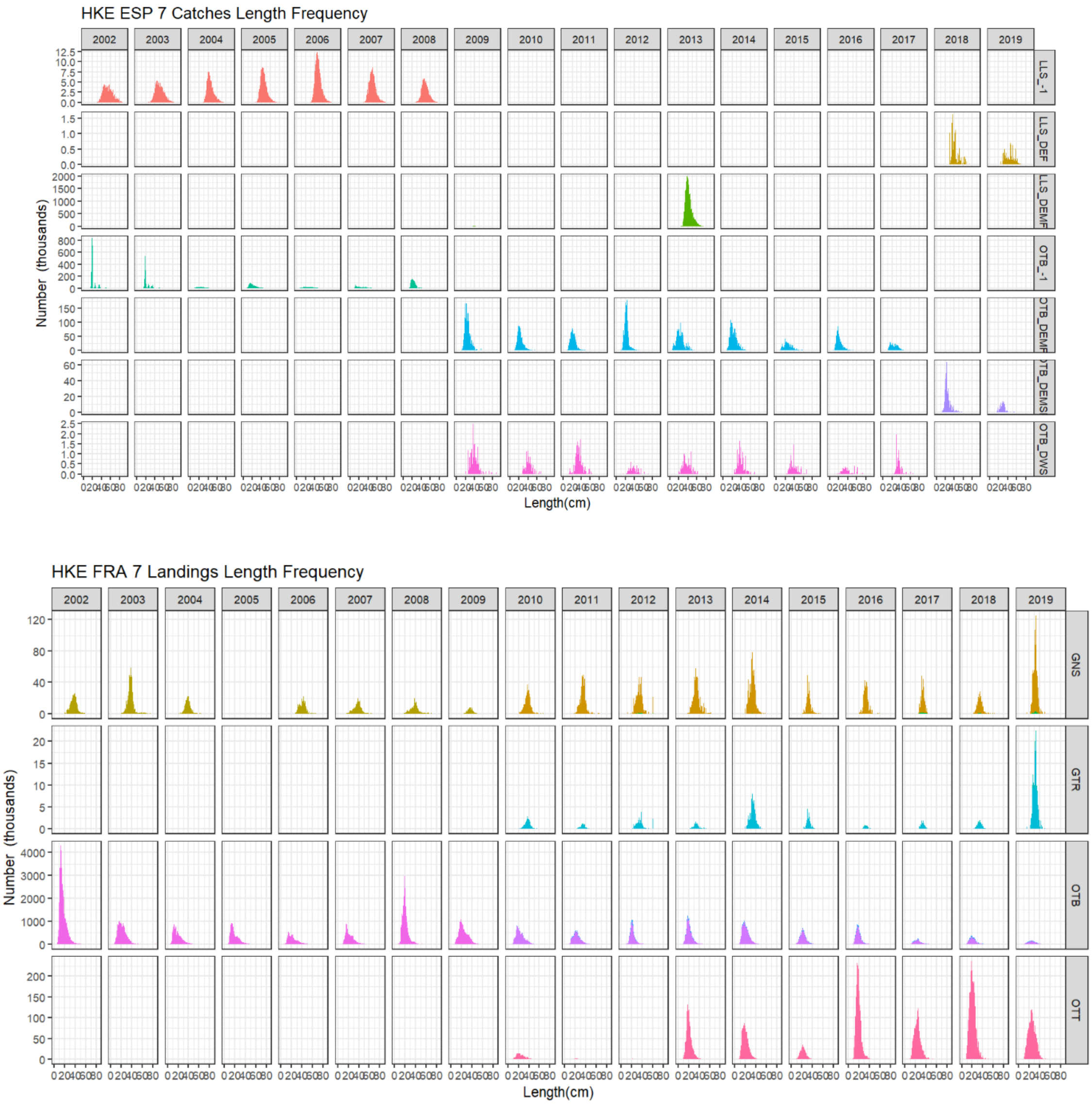


Figure 6.1.2.1.2. European hake in GSAs 1, 5, 6 and 7. Length frequency distribution of the landings by year and gear or fleet.

Discards

Discards data were reported to STECF EWG 20-09 through the DCF, and they were included in the stock assessment. For the years in which discards data were missing, they were estimated on the basis of the discard ratio (discard/landing) of the available years and the landing time series.

The highest discard rates were represented by the bottom trawl fishery; for the other gears the discards were negligible. 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**
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
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
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
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
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**

Length and age frequency distributions of discards were available from DCF data only for France in GSA 7 while for Spain only the last two years in GSAs 1 and 6 the last year in GSA 5 were available so landings LFDs were used for the assessment and numbers corrected through SoP correction..

6.1.2.2 EFFORT

Fishing effort data for 2019 will be reported to STECF EWG 20-13 through the FDI data call within the DCF framework.

Table 6.1.2.2.1. European hake in GSAs 1, 5, 6 and 7. Fishing effort in GT*Days at sea by year and fishing gear.

	GSA1_ESP_OTB	GSA5_ESP_OTB	GSA6_ESP_OTB	GSA7_ESP_OTB	GSA7_FRA_OTB
2002	1333918				
2003	1684655				
2004	1894693	657513	6681984	322841	
2005	1761339	649028	6438093	308926	
2006	1685266	601140	6465424	308266	
2007	1631930	699565	5922542	316488	
2008	1495816	725977	6375021	322027	
2009	1520713	648577	6063795	313450	
2010	1568334	672071	5673235	275498	
2011	1507685	616593	5343285	310191	
2012	1395133	630595	5109806	268789	
2013	1295309	641523	5021556	248107	
2014	1159530	670025	5216517	268090	
2015	1102193	663308	4685445	276490	949262
2016	1083165	537128	4842663	294524	830898
2017	1131873	570157	4650788	272192	662204
2018	1079838	495565	4424004	226279	641292

	GSA1_ESP_GTR	GSA5_ESP_GTR	GSA6_ESP_GTR	GSA7_ESP_GTR	GSA7_FRA_GTR
2002	16851				
2003	20530				
2004	18075	37457	162746	697	
2005	19536	42166	179004	784	
2006	20914	40477	171941	665	
2007	18456	7849	148033	560	
2008	19906	8393	180315	574	
2009	33983	32156	221810	14	
2010	29579	31771	208928	1417	
2011	31878	28469	244024	754	
2012	31833	27487	204242	286	
2013	37276	29576	214471	171	
2014	38856	36650	230865	211	
2015	28649	34225	230907	365	3250503
2016	28699	33871	214906	384	3227171
2017	31995	34946	202169	1099	116595
2018	23408	25510	153426	1387	89867

	GSA1_ESP_GNS	GSA5_ESP_GNS	GSA6_ESP_GNS	GSA7_ESP_GNS	GSA7_FRA_GNS
2002	16858				
2003	22350				
2004	21517	7310	51024	513	
2005	19264	8157	44977	436	
2006	21325	8378	49692	513	
2007	14655	2258	43242	591	
2008	15505	1717	46842	611	
2009	21682	13479	106091	151	
2010	26528	12546	106122	2437	
2011	17845	12541	99197	1982	
2012	17420	14133	107697	671	
2013	21104	14012	99882	989	
2014	20292	13903	107746	649	
2015	19421	14906	119436	402	2934287
2016	18159	13926	110082	235	2623954
2017	12688	13714	109560	334	91391
2018	7296	9482	72501	635	85260

	GSA1_ESP_LLS	GSA5_ESP_LLS	GSA6_ESP_LLS	GSA7_ESP_LLS	GSA7_FRA_LLS
2002	32173				
2003	22725				
2004	23222	24442	31913	18304	
2005	24662	21245	22511	16607	
2006	26722	18324	24522	15701	
2007	37838	2000	27935	15596	
2008	35310	1744	26852	17007	
2009	9910	13650	83586	5527	
2010	14641	9596	77758	17660	
2011	11542	8799	63810	12605	
2012	6687	10747	53268	11793	
2013	6208	10450	55777	11644	
2014	7756	10433	59441	12863	
2015	7877	8978	45720	10359	392032
2016	3864	8476	57354	6251	298872
2017	2276	6941	27557	7054	15263
2018	1220	5052	41326	1903	13589

Table 6.1.2.2.2. European hake in GSAs 1, 5, 6 and 7. Fishing effort in Days at sea by year and fishing gear.

	GSA1_ESP_OTB	GSA5_ESP_OTB	GSA6_ESP_OTB	GSA7_ESP_OTB	GSA7_FRA_OTB
2002	28002				
2003	32892				
2004	34951	12012	118076	3714	
2005	32295	11497	110957	3626	
2006	31443	10507	110008	3550	
2007	29917	11907	99638	3553	
2008	26201	12226	106867	3694	
2009	27017	10934	102005	3008	
2010	28476	11239	95438	3097	
2011	28170	10498	90470	3486	
2012	25851	10568	86587	2966	
2013	24334	10769	84882	2791	
2014	22395	10936	88528	2966	
2015	21587	10714	79421	3064	9939
2016	21345	8952	81649	3090	8965
2017	22537	9158	78530	2840	7488
2018	21633	7947	74820	2357	7193

	GSA1_ESP_GTR	GSA5_ESP_GTR	GSA6_ESP_GTR	GSA7_ESP_GTR	GSA7_FRA_GTR
2002	4747				
2003	5534				
2004	5809	12936	32265	293	
2005	5600	14538	33776	285	
2006	5937	13568	31549	208	
2007	5474	2280	26272	179	
2008	5964	2558	31284	157	
2009	9455	11504	39808	4	
2010	9039	11269	37174	212	
2011	10388	10261	40269	119	
2012	10172	9941	38942	70	
2013	12423	10312	41230	59	
2014	13663	12908	44309	65	
2015	9810	12243	44237	143	43299
2016	10189	11967	43357	88	41890
2017	10586	12381	39691	176	41837
2018	8424	9211	31071	287	31963

	GSA1_ESP_GNS	GSA5_ESP_GNS	GSA6_ESP_GNS	GSA7_ESP_GNS	GSA7_FRA_GNS
2002	4583				
2003	5885				
2004	6016	1594	9033	192	
2005	4844	1566	7805	162	
2006	5700	1758	8057	167	
2007	4531	467	7172	194	
2008	4709	467	7864	228	
2009	5756	4408	19462	11	
2010	7667	4324	19372	453	
2011	5913	4271	19824	411	
2012	5416	4659	21417	188	
2013	6204	4540	20583	234	
2014	6431	4559	21297	240	
2015	6430	5001	22867	185	36188
2016	5959	4765	21957	97	31298
2017	3973	4386	23189	216	30913
2018	2572	3093	15104	257	28286

	GSA1_ESP_LLS	GSA5_ESP_LLS	GSA6_ESP_LLS	GSA7_ESP_LLS	GSA7_FRA_LLS
2002	3356				
2003	2943				
2004	3038	8039	4731	1362	
2005	2826	6559	3196	1174	
2006	3459	6172	3595	1164	
2007	3569	387	3632	1137	
2008	4204	392	3509	1250	
2009	1888	3562	14088	402	
2010	2154	2875	12398	1394	
2011	2179	2871	10519	949	
2012	1317	2929	10493	872	
2013	1376	2743	9979	908	
2014	1358	3098	11442	1048	
2015	2308	2940	8096	939	5202
2016	897	2711	7308	590	4627
2017	593	2329	5717	626	6536
2018	259	1702	9428	184	5148

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).

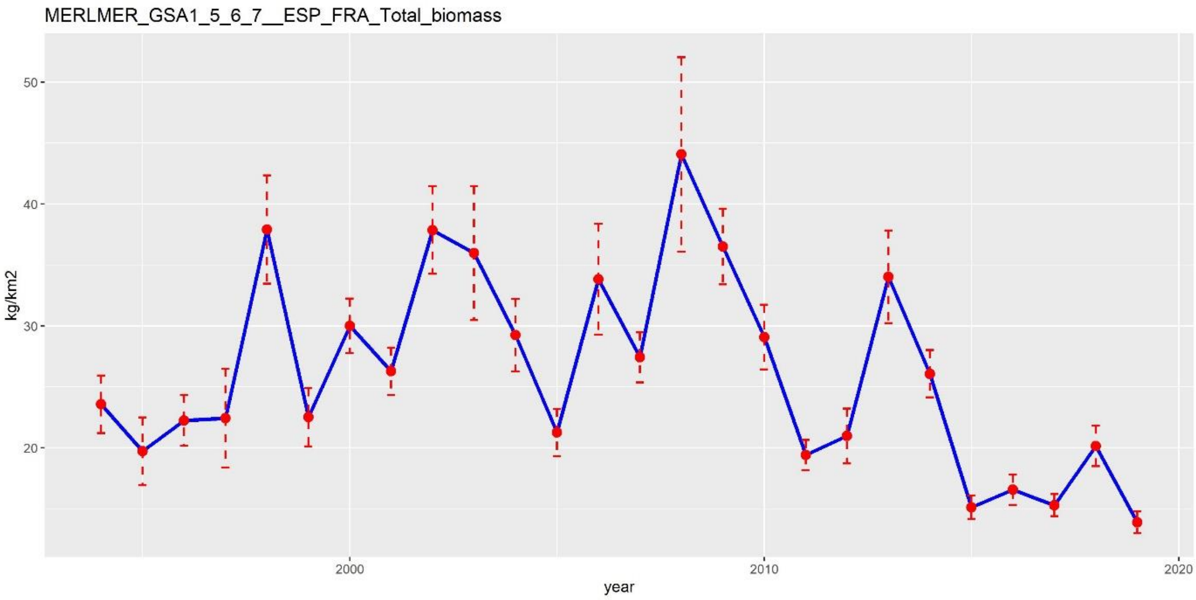


Figure 6.1.2.3.1. European hake in GSAs 1, 5, 6 and 7. Estimated biomass indices from the MEDITS survey (kg/km^2).

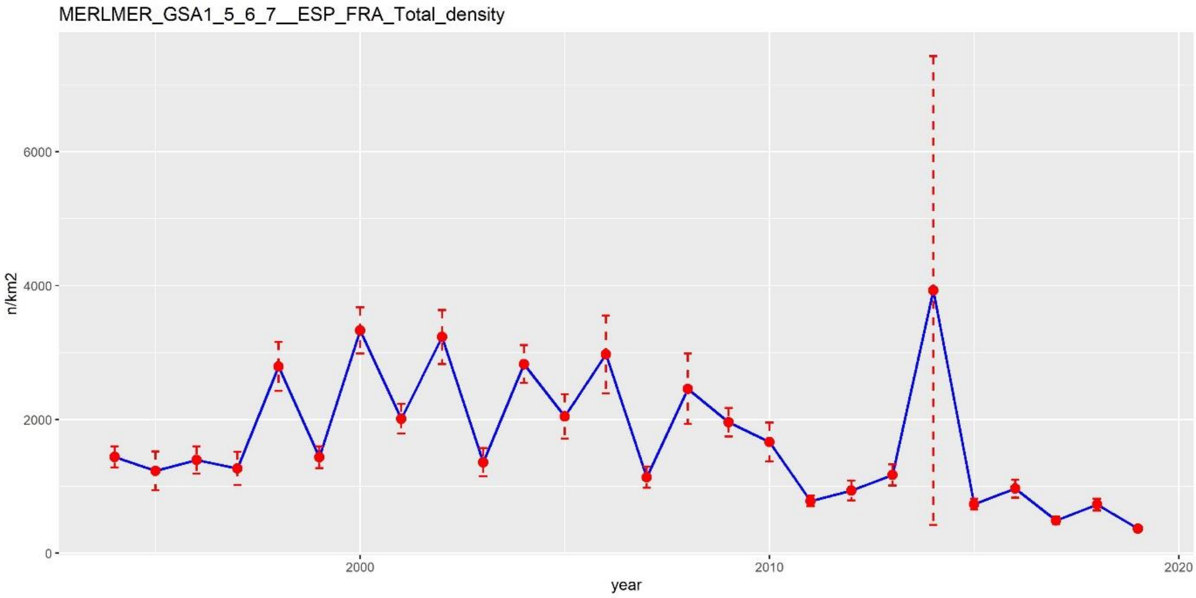


Figure 6.1.2.3.2. European hake in GSAs 1, 5, 6 and 7. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series and a slight decrease in the last year.

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.

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 2007-2019 for catch data and tuning file, as survey indices data were available only from 2007 for GSA 5. Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR. The analyses were carried out for the ages 0 to 5+. Concerning the Fbar, the age range used was 1-3 age classes.

Input data

The growth parameters used for VBGF were the one reported in table 6.1.1.1.

Total catches and catch numbers at age from the single GSAs were used as input data. SOP correction was applied to catch numbers at age (Table 6.1.3.1).

Table 6.1.3.1. European hake in GSAs 1, 5, 6 and 7. SOP correction vector.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
SOP	1.02	1.10	1.00	0.95	1.06	1.14	0.23	1.12	1.12	1.14	1.13	1.10	1.13

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
4697	6289	7409	5836	5662	4654	5438	5061	3243	3195	3063	4077	3228

Catch numbers at age (thousands)

	0	1	2	3	4	5+
2007	40234	17535	3377	503	92	23
2008	63755	35335	2598	272	94	16
2009	70862	32069	5381	527	125	14
2010	15578	26492	5860	443	101	10
2011	9303	28094	4431	345	63	10
2012	9682	27401	2584	212	59	4
2013	9795	28791	3101	313	39	3
2014	15155	22586	3819	234	26	4
2015	8043	16139	2143	158	24	2
2016	13253	19749	1537	104	18	1
2017	9119	16292	1934	125	16	3
2018	15246	25039	2096	175	12	1
2019	4436	12479	2888	203	15	2

Weights at age (Kg)

	0	1	2	3	4	5+
2007	0.02	0.10	0.40	0.94	1.60	2.76
2008	0.02	0.09	0.40	0.96	1.61	2.67
2009	0.02	0.09	0.41	0.95	1.52	2.79
2010	0.02	0.11	0.40	0.93	1.61	2.43
2011	0.02	0.10	0.39	0.92	1.63	2.48
2012	0.02	0.09	0.39	0.90	1.68	2.48
2013	0.03	0.10	0.38	0.92	1.63	2.90
2014	0.02	0.11	0.39	0.92	1.56	2.62
2015	0.02	0.11	0.38	0.92	1.58	2.67
2016	0.02	0.09	0.38	0.93	1.57	2.54
2017	0.02	0.10	0.37	0.91	1.53	2.71
2018	0.02	0.10	0.39	0.92	1.59	2.47
2019	0.02	0.12	0.37	0.90	1.66	2.33

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)

	0	1	2	3	4
2007	752.35	135.03	22.02	1.98	0.91
2008	2042.50	181.64	10.72	3.96	0.68
2009	1241.50	222.98	23.13	2.73	0.42
2010	1377.80	75.23	12.11	0.91	0.07
2011	686.32	85.75	7.02	0.60	0.01
2012	818.95	68.29	4.05	0.61	0.12
2013	932.74	128.49	8.36	0.31	0.11
2014	820.23	101.32	11.28	1.47	0.34
2015	672.74	49.77	7.03	0.75	0.18
2016	901.94	54.32	4.83	0.45	0.13
2017	408.95	67.95	8.36	0.48	0.22

2018	623.98	92.18	4.59	0.37	0.08
2019	11577.65	1320.02	133.44	15.16	3.6

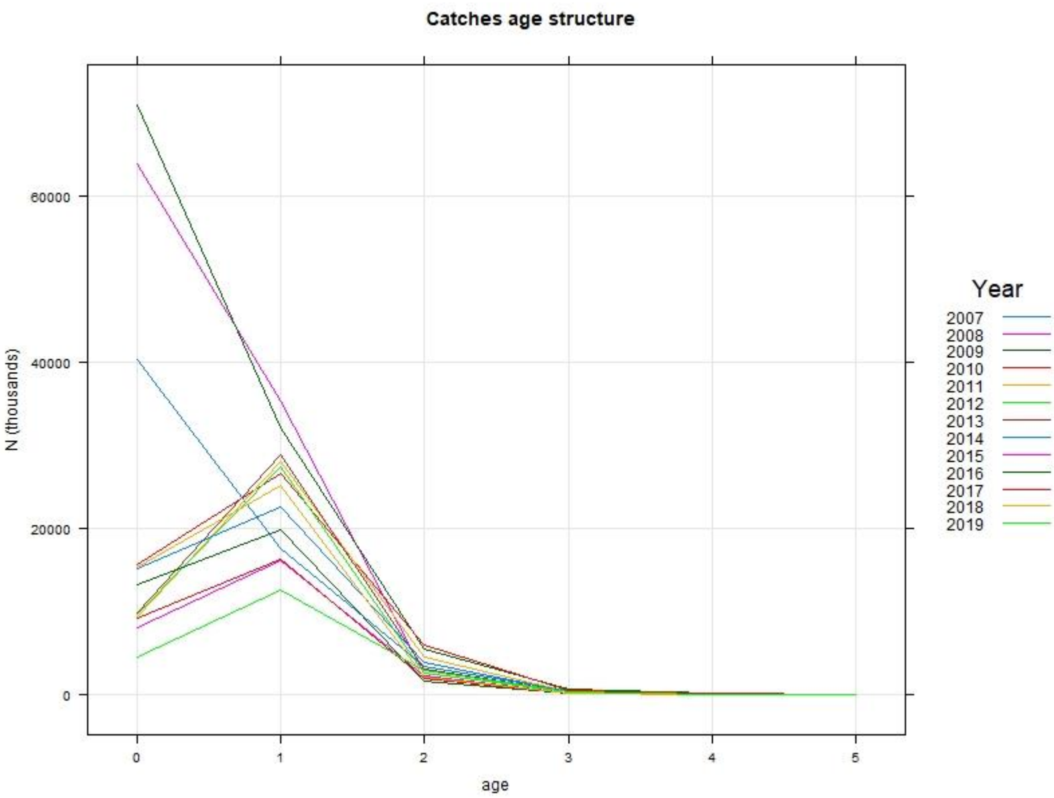


Figure 6.1.3.1. European hake in GSAs 1, 5, 6 and 7. Catch at age input data.

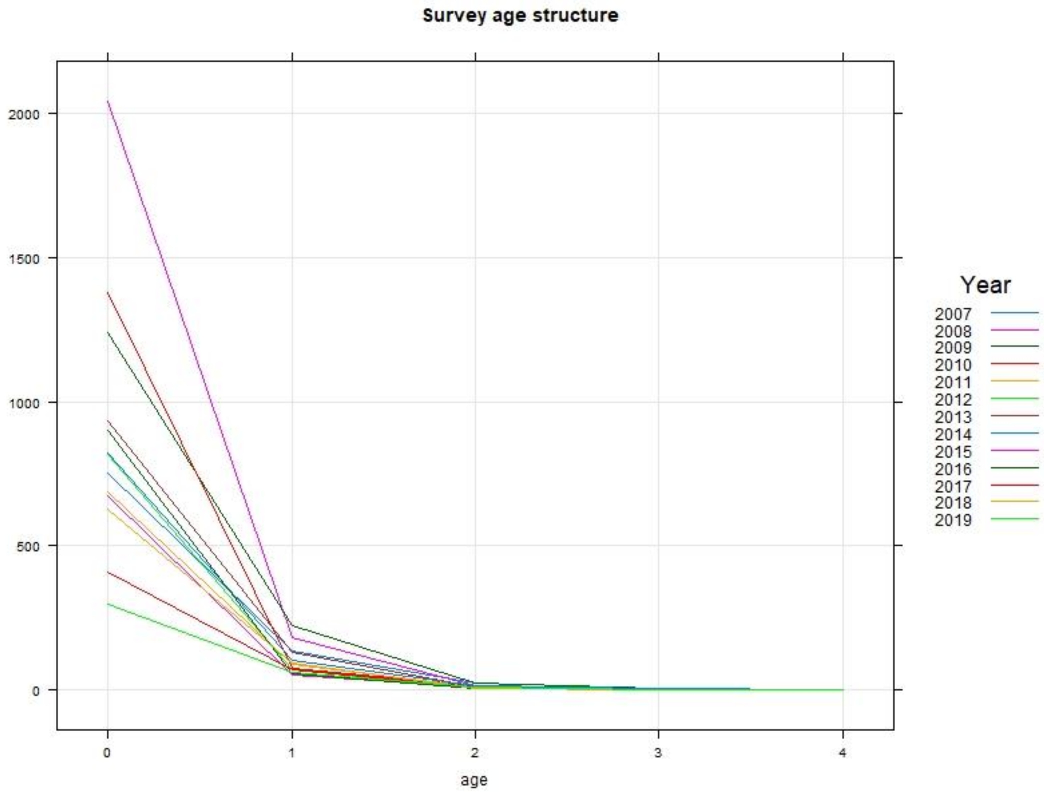


Figure 6.1.3.2. European hake in GSAs 1, 5, 6 and 7. Age structure of the index.

Assessment results

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 = 6, by = as.numeric(age == 0)) +

+ s(year, k = 6, 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.

Assessment results are shown in Figures 6.1.3.3 – 6.1.3.9

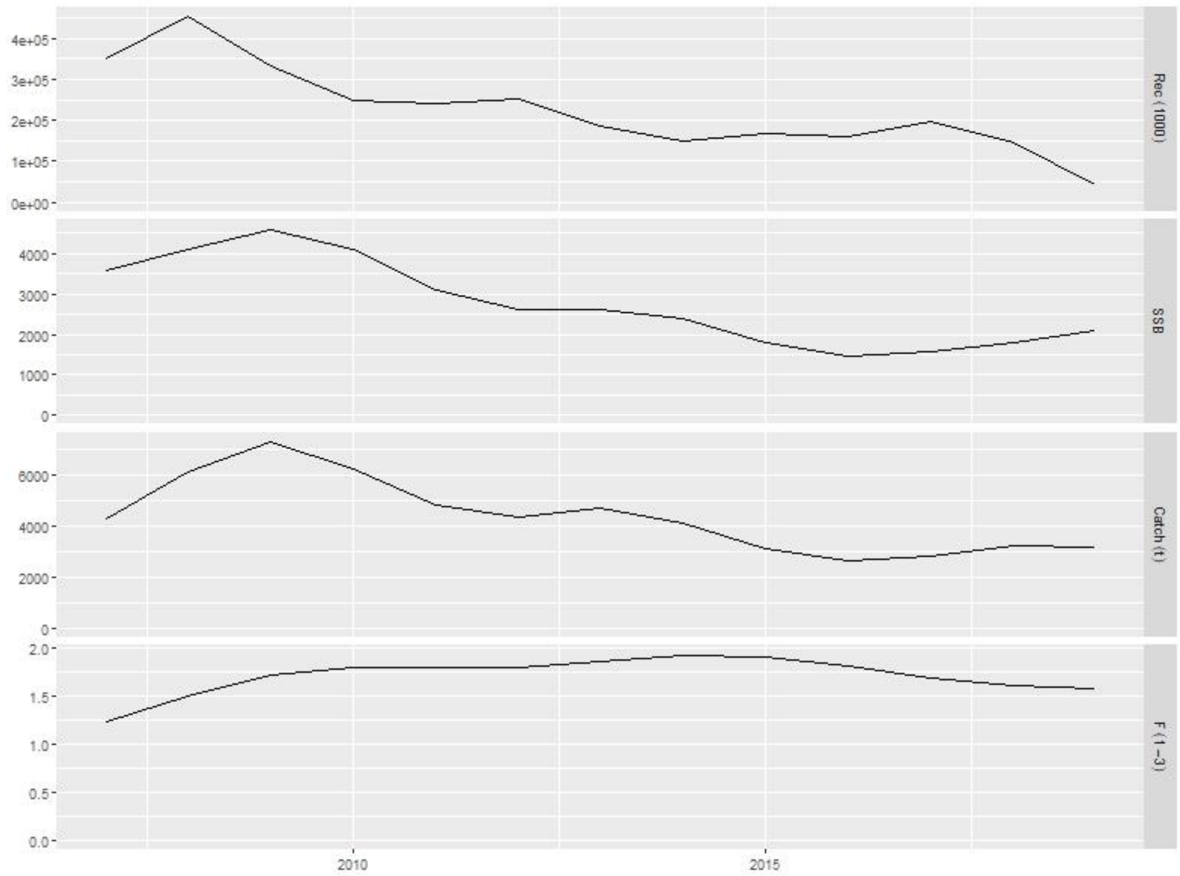
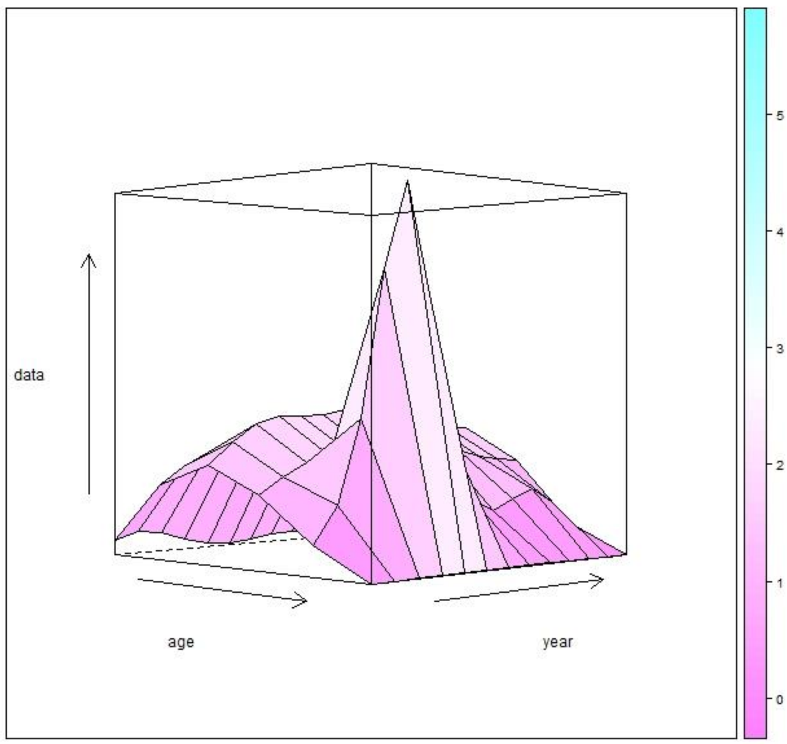


Figure 6.1.3.3. European hake in GSAs 1, 5, 6 and 7. Stock summary from the final a4a model.



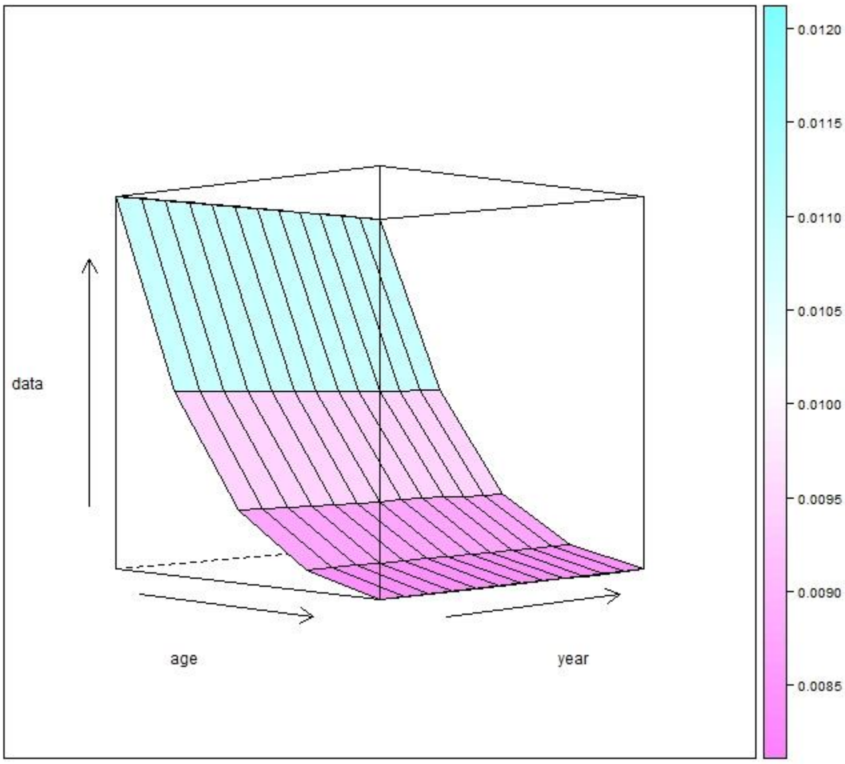
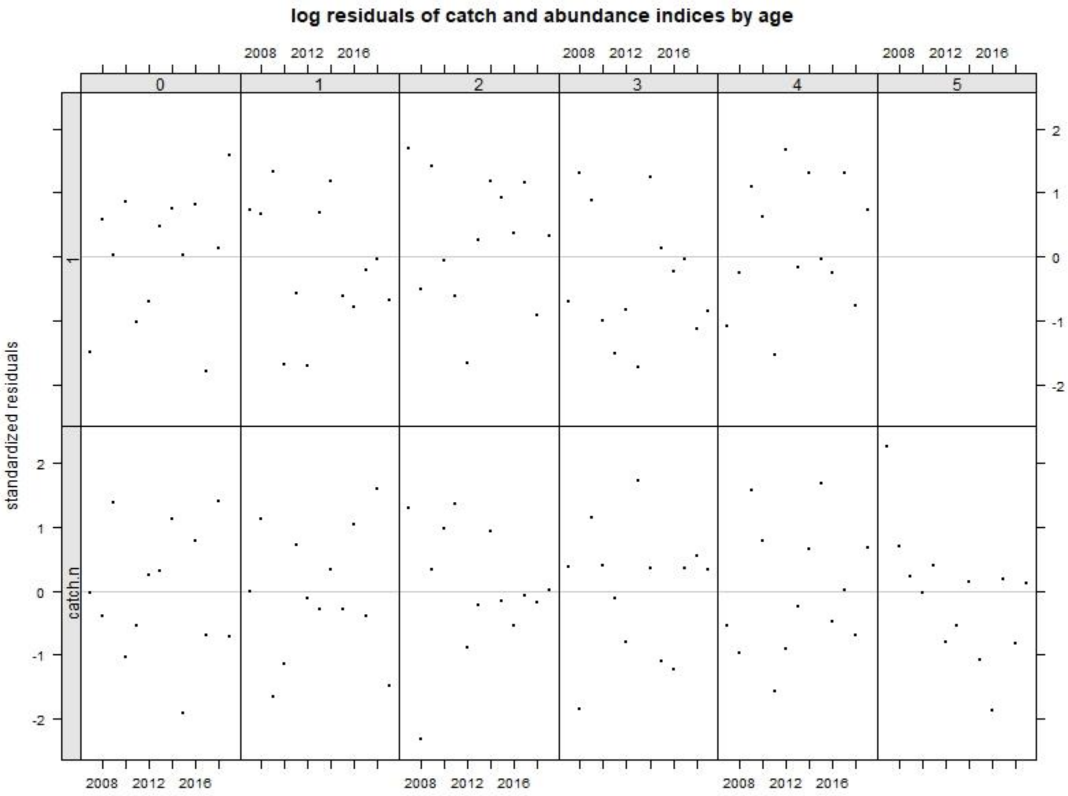


Figure 6.1.3.4. European hake in GSAs 1, 5, 6 and 7. 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.


log residuals of catch and abundance indices by age
0
1
2
3
4
5
standardized residuals
catch.n
2008 2012 2016

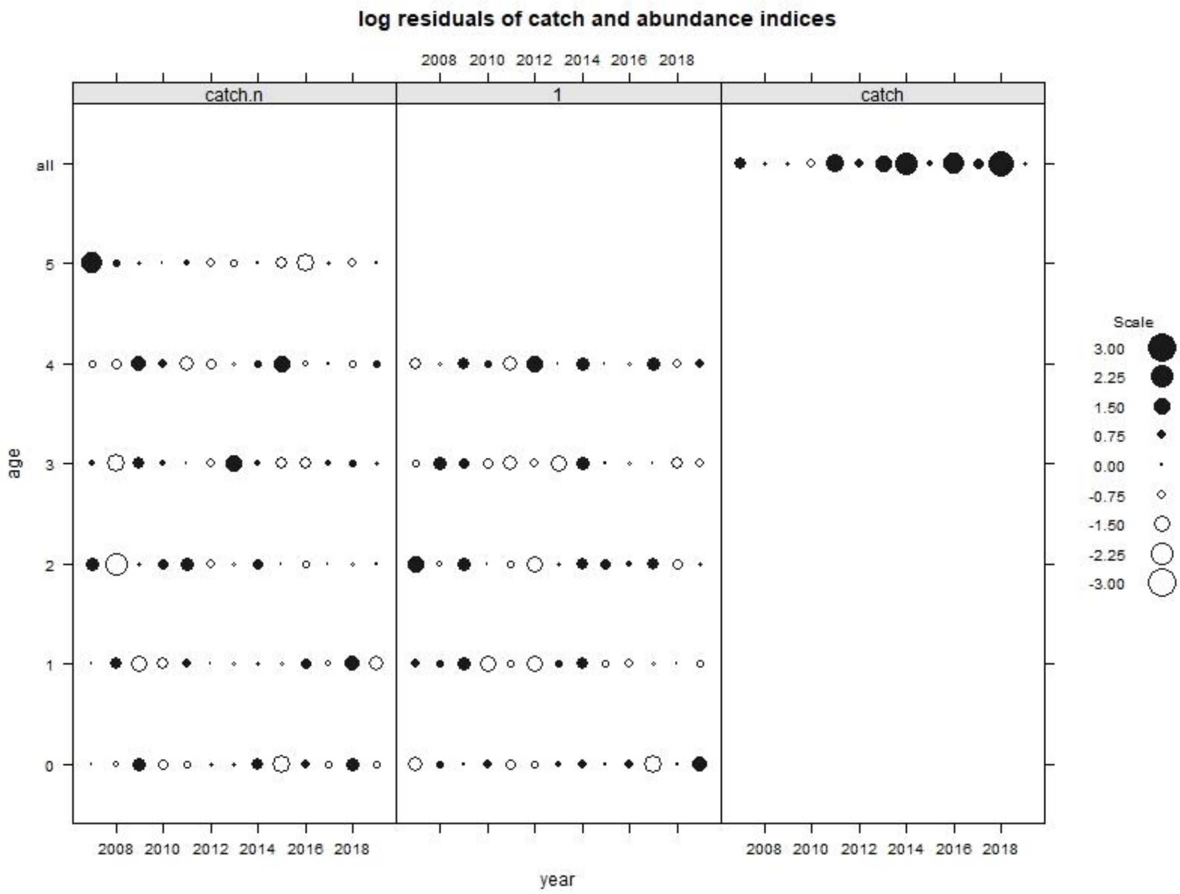

log residuals of catch and abundance indices
catch.n
1
catch
all
age
year
2008 2010 2012 2014 2016 2018
Scale
3.00
2.25
1.50
0.75
0.00
-0.75
-1.50
-2.25
-3.00

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

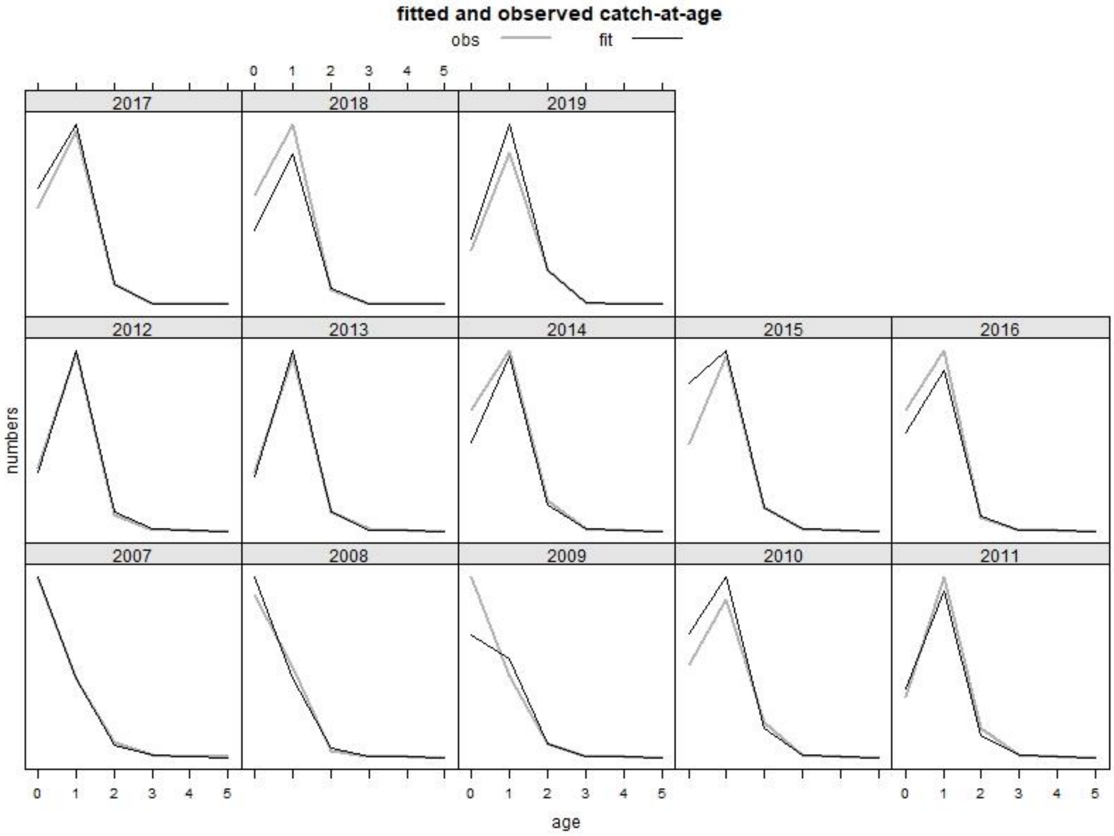
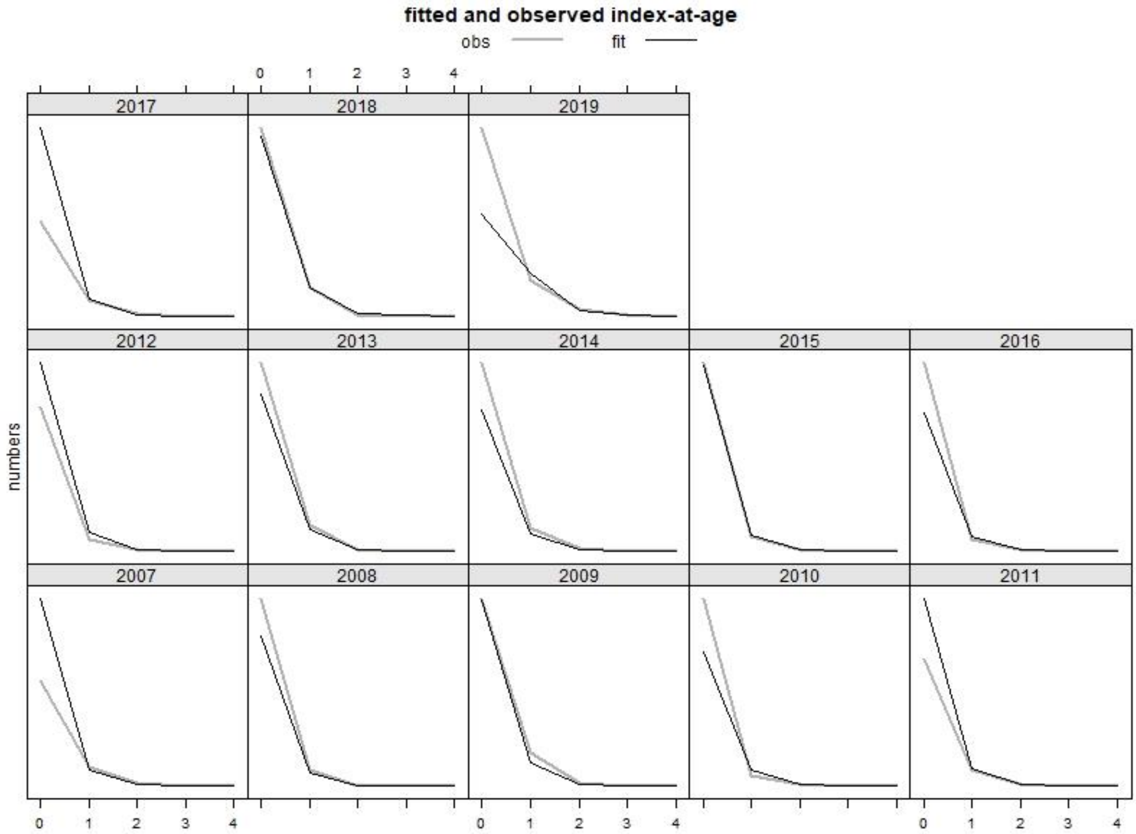


Figure 6.1.3.6. European hake in GSAs 1, 5, 6 and 7. Fitted and observed catch at



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. Models results were quite stable (Figure 6.1.3.8) except for recruitment which is estimated poorly in the terminal year of the assessment.

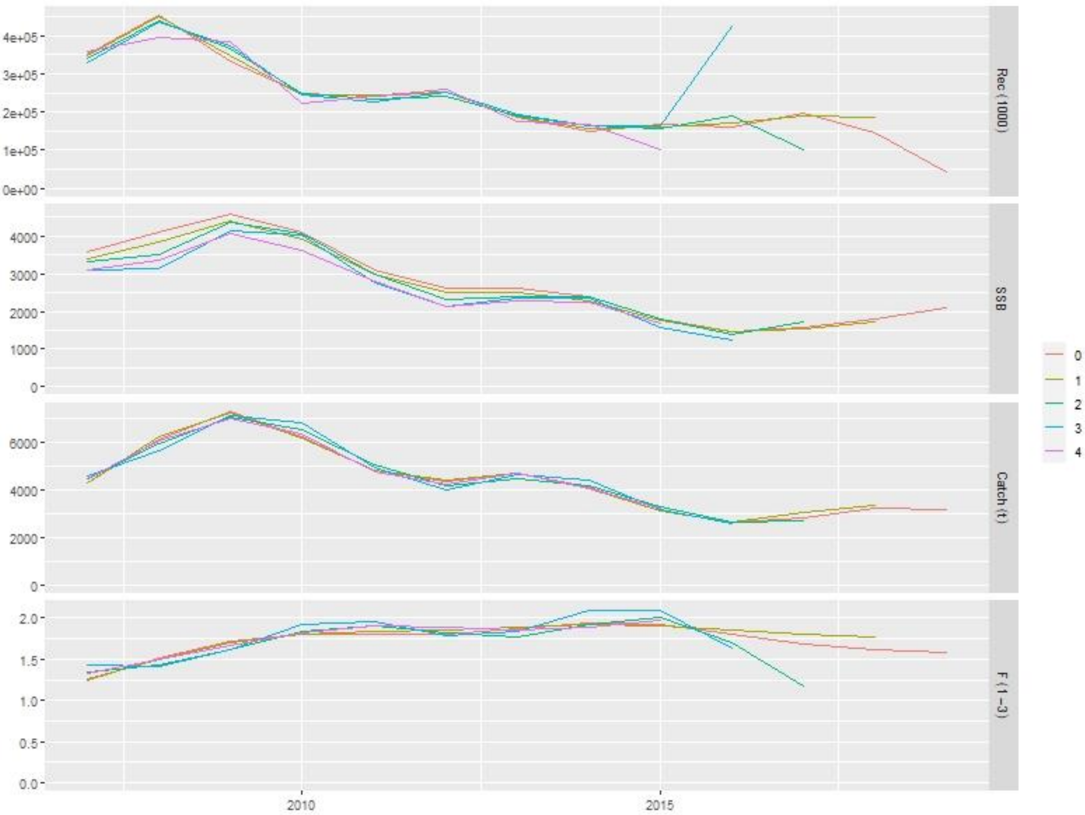


Figure 6.1.3.8. European hake in GSAs 1, 5, 6 and 7. Retrospective analysis

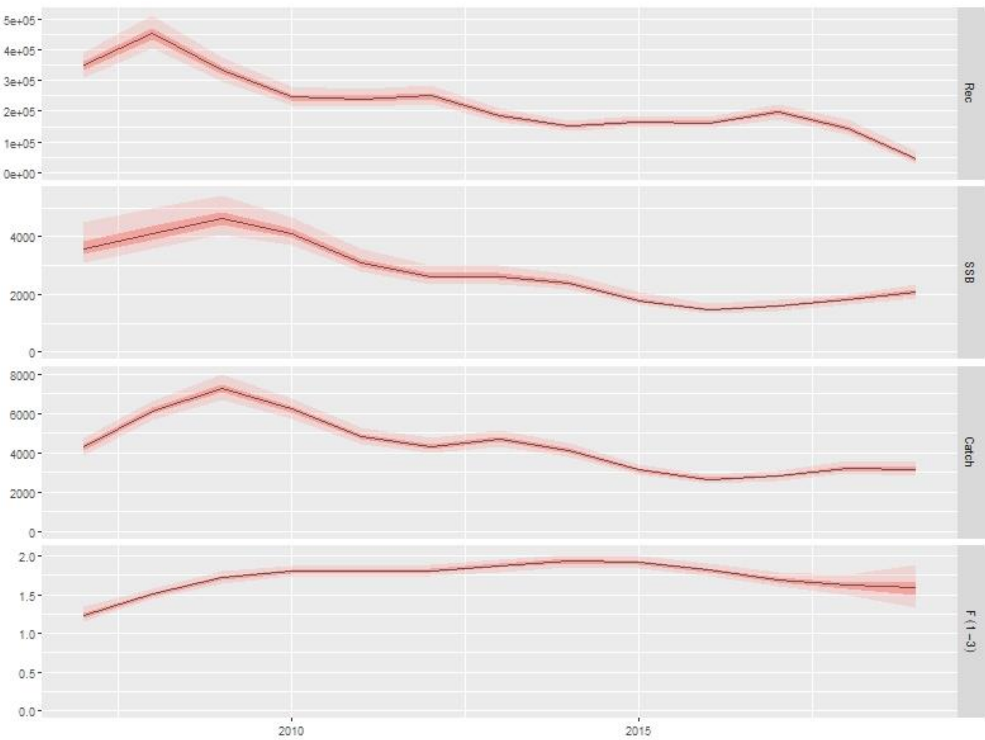


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Figure 6.1.3.9. European hake in GSAs 1, 5, 6 and 7. Simulations over summary results.

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	349287.5	33352.6	4064.34	790.5	297.23	178.37
2008	453103.5	52852.83	5376.62	616.71	193.44	282.08
2009	334177.4	61761.62	6655.51	593.43	119.1	272.89
2010	246788.5	47091.36	6387.55	569.99	94.89	219.28
2011	241789.7	40314.74	4515.69	496.26	84.77	168.23
2012	250855.7	43142.8	3881.31	352.64	74.09	128.53
2013	185505.2	45600.16	4114.75	299.45	52.18	99.11
2014	151107.5	32821.95	4103.5	294.55	41.9	81.83
2015	165996.7	25285.94	2786.2	272.47	38.98	74.92
2016	161055.4	27233.31	2179.97	188.73	36.59	71.25
2017	196686.9	27385.67	2586.54	167.29	27.81	65.99
2018	145965.7	34207.72	2908.56	229.23	27.44	58.21
2019	42849.21	24558.46	3894.17	281.88	40.19	54.14

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	1.239	349287	3569	13118	4271
2008	1.507	453104	4096	16381	6125
2009	1.72	334177	4601	16799	7286
2010	1.802	246788	4097	13410	6228
2011	1.797	241790	3083	12723	4808
2012	1.808	250856	2605	12340	4317
2013	1.871	185505	2613	11479	4682
2014	1.934	151108	2386	8734	4103
2015	1.917	165997	1791	7468	3115
2016	1.812	161055	1462	7370	2643
2017	1.691	196687	1582	7845	2824
2018	1.616	145966	1812	7674	3217
2019	1.585	42849	2076	5540	3148

	F at age					
	0	**1**	**2**	**3**	**4**	**5+**
2007	0.26	1.15	1.48	1.1	0.48	0.04
2008	0.36	1.39	1.79	1.33	0.99	0.04
2009	0.33	1.59	2.05	1.52	2.15	0.05
2010	0.18	1.66	2.15	1.6	4.24	0.05
2011	0.09	1.66	2.14	1.59	5.51	0.05
2012	0.07	1.67	2.15	1.6	3.92	0.05
2013	0.1	1.73	2.23	1.66	1.85	0.05
2014	0.16	1.79	2.3	1.71	0.94	0.06
2015	0.18	1.77	2.28	1.7	0.75	0.05
2016	0.14	1.67	2.16	1.6	0.89	0.05
2017	0.12	1.56	2.01	1.5	1.03	0.05
2018	0.15	1.49	1.92	1.43	0.81	0.05

2019	0.28	1.46	1.89	1.4	0.45	0.05

Based on the a4a results, the European hake SSB shows a decreasing trend from 2009 to 2016 (from 4601 to 1462 tons), with a slight increase in the last three years (2076 tons in 2019). The assessment shows a declining trend in the number of recruits in the time series. The recruitment (age 0) reached a minimum of 42849 thousands individuals in 2019, not showing any sign of recovery at the moment. F_{bar} (1-3) shows an upward trend from 2007 (1.239) until 2014 (1.934) which than declines until 2019 with a value of 1.585.

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 (1.585, F_{bar1-3} in the last year (2019) of the time series as F is declining over the previous 3 years) is 4 times higher than $F_{0.1}$ (0.388), 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 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_{bar1-3} =1.585 (the last year's F estimated by the assessment model) was used for F in 2020, as F shows a declining trend (See section 4.3). Recruitment is observed to decline over the period of the assessment (Figure 6.1.3.9), so the last 3 years are used as an estimate of recruits in 2020 to 2021. As recruitment is observed to be declining recruitment (age 0) for the STF was estimated from the population results as the geometric mean of the last 3 years (128501).

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
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, are based average of years 2017-2019
$F_{ages\ 1-3}$ (2020)	1.58	The F estimated in 2019 was used to give F status quo for 2020
SSB (2020)	2076	Stock assessment 1 January 2020
R_{age0} (2020,2021)	128501	Mean of the last 3 years
Total catch (2020)	1683	Assuming F status quo for 2020

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

Scenario	Fbar	Recruitment 2020	Fsq 2020	Catch 2019	Catch 2021	SSB 2020	SSB 2022	SSB_2020-2022(%)	Catch_2019-2021(%)
F0.1	0.388	128501	1.585	3148	721	1575	3452	119.14	-77.10
F upper	0.531	128501	1.585	3148	937	1575	3080	95.52	-70.24
F lower	0.259	128501	1.585	3148	505	1575	3831	143.23	-83.95
FMSY transition	1.186	128501	1.585	3148	1677	1575	1887	19.80	-47.00
Zero catch	0.000	128501	1.585	3148	0	1575	4747	201.40	-100.00
Status quo	1.585	128501	1.585	3148	1988	1575	1441	-8.51	-36.84
Different Scenarios	0.159	128501	1.585	3148	321	1575	4161	164.16	-89.79
	0.317	128501	1.585	3148	605	1575	3655	132.06	-80.79
	0.476	128501	1.585	3148	855	1575	3219	104.36	-72.83
	0.634	128501	1.585	3148	1077	1575	2842	80.45	-65.77
	0.793	128501	1.585	3148	1275	1575	2517	59.79	-59.50
	0.951	128501	1.585	3148	1450	1575	2236	41.94	-53.92
	1.110	128501	1.585	3148	1607	1575	1992	26.49	-48.94
	1.268	128501	1.585	3148	1748	1575	1782	13.12	-44.47
	1.427	128501	1.585	3148	1874	1575	1599	1.54	-40.46
	1.744	128501	1.585	3148	2091	1575	1304	-17.23	-33.57
	1.902	128501	1.585	3148	2184	1575	1184	-24.82	-30.61
	2.061	128501	1.585	3148	2269	1575	1080	-31.41	-27.91
	2.219	128501	1.585	3148	2347	1575	990	-37.16	-25.44
	2.378	128501	1.585	3148	2418	1575	911	-42.18	-23.18
	2.536	128501	1.585	3148	2483	1575	842	-46.56	-21.11
	2.695	128501	1.585	3148	2544	1575	781	-50.40	-19.19
	2.853	128501	1.585	3148	2600	1575	728	-53.76	-17.42
	3.012	128501	1.585	3148	2651	1575	682	-56.72	-15.77
	3.170	128501	1.585	3148	2700	1575	641	-59.32	-14.24

6.2 Deep-water rose shrimp in GSA 1, 5, 6 & 7

6.2.1 Stock Identity and Biology

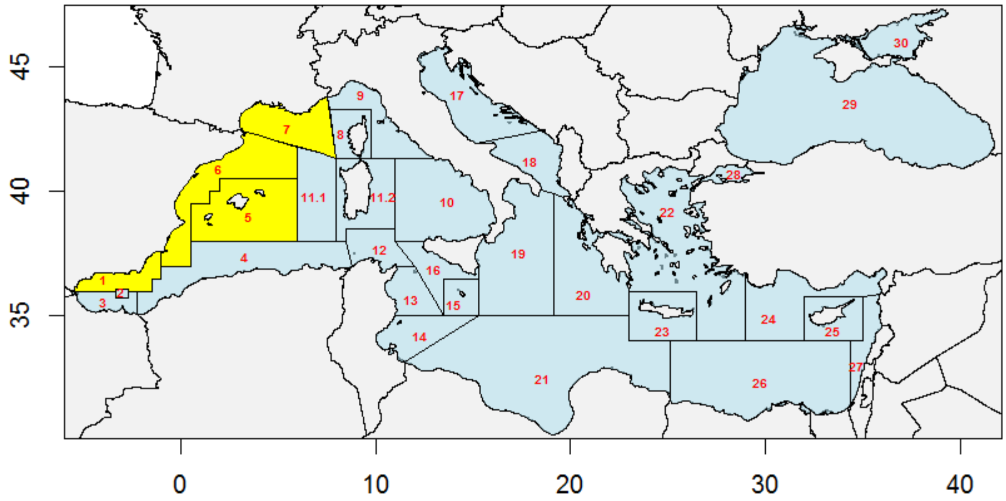


Figure 6.2.1.1. Geographical location of GSAs 1-5-6-7.

STECF EWG 20-09 was asked to assess the state of Deep-water rose shrimp stocks in the combined GSAs 1, 5, 6 & 7.
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. The same parameters of GSA 6 were applied to the data from GSA 7.

Table 6.2.1.1. Deep-water rose shrimp GSAs 1-5-6-7. Growth parameters and length-weight relationship parameters.

Country	Area	Year	L_∞	K	t_0	a	b
ESP	GSA 1	2017	47	0.76	-0.19	0.0089	2.155
ESP	GSA 5	2017	47	0.81	0	0.0023	2.515
ESP	GSA 6 & 7	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 6.2.1.2. Deep-water rose shrimp GSAs 1-5-6-7. Proportion of mature specimens at age and natural mortality at age by GSA.

Age	Area	0	1	2	3+
Maturity	GSA 1-5-6-7	0	1	1	1
M	GSA 1	1.52	0.84	0.7	0.65
M	GSA 5	1.65	0.89	0.74	0.67
M	GSA 6-7	1.62	0.88	0.73	0.67

6.2.2 DATA

6.2.2.1 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.

In GSA 5 the deep-water rose shrimp is an important by-catch species in the upper slope.

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).

In GSA 7, Deep-water rose shrimp is exploited mainly by Spanish and French trawlers.

Landings

Landings data were reported to STECF EWG 20-09 through the DCF. In GSAs 1, 5, 6 and 7, most of the landings come from otter trawls. DCF data coming from other gear were considered inaccurate or sampled inconsistently; anyway, their catches were included in the stock assessment due to the low amounts (Table 6.2.2.1.1).

Table 6.2.2.1.1. Deep-water rose shrimp GSAs 1-5-6-7. Landings data in tonnes by fleet.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GSA1 ESP_GTR																0.02		
GSA1 ESP_OTB	209.8	187.2	118.1	103.0	37.6	56.2	108.9	253.9	97.6	171.6	241.5	149.1	100.4	108.6	136.8	201.8	329.6	354.2
GSA5 ESP_OTB	36.2	22.1	6.5	1.6	1.0	1.4	5.2	5.1	6.3	4.5	4.2	6.2	5.6	7.6	9.1	68.0	101.2	59.8
GSA6 ESP_OTB	144.1	116.0	66.2	44.7	25.2	28.8	39.0	49.1	71.9	66.3	85.6	86.8	131.3	174.6	471.3	634.7	914.6	704.0
GSA6 FRA_OTT																		0.03
GSA7 ESP_OTB							0.1	0.1	0.4	1.2	2.0	2.3	3.4	4.7	27.1	36.3	17.9	7.3
GSA7 FRA_-1																0.17		
GSA7 FRA_OTB									3.4	6.1	3.4	2.3	3.8	12.7	35.7	21.2	16.6	7.0
GSA7 FRA_OTM									0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0
GSA7 FRA_OTT									0.1	0.0		0.0	0.4	1.0	7.0	25.3	21.7	16.9

Landings data by year are presented in Table 6.2.2.1.2. Landings by year and fleet are presented in Figures 6.2.2.1.1.-3.

Table 6.2.2.1.2. Deep-water rose shrimp GSAs 1-5-6-7. Landings data in tonnes by year.

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
390.0	325.3	190.9	149.3	63.8	86.4	153.2	308.3	179.9	249.7
2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**		
336.7	246.7	244.9	309.2	687.1	987.7	1401.6	1149.2		

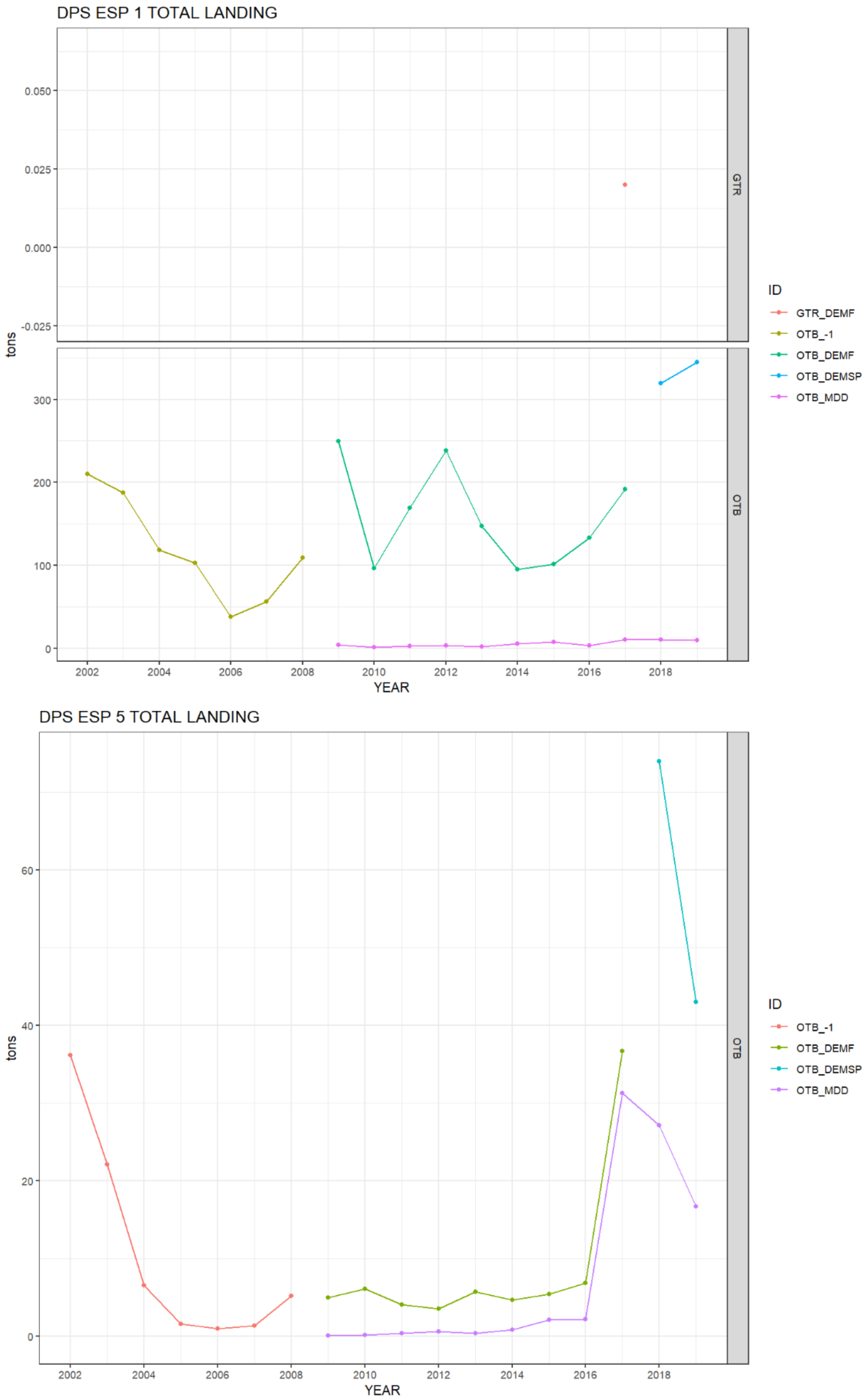


Figure 6.2.2.1.1. Deep-water rose shrimp GSAs 1-5-6-7. Landings data in tonnes by year and fleet in GSAs 1 and 5.

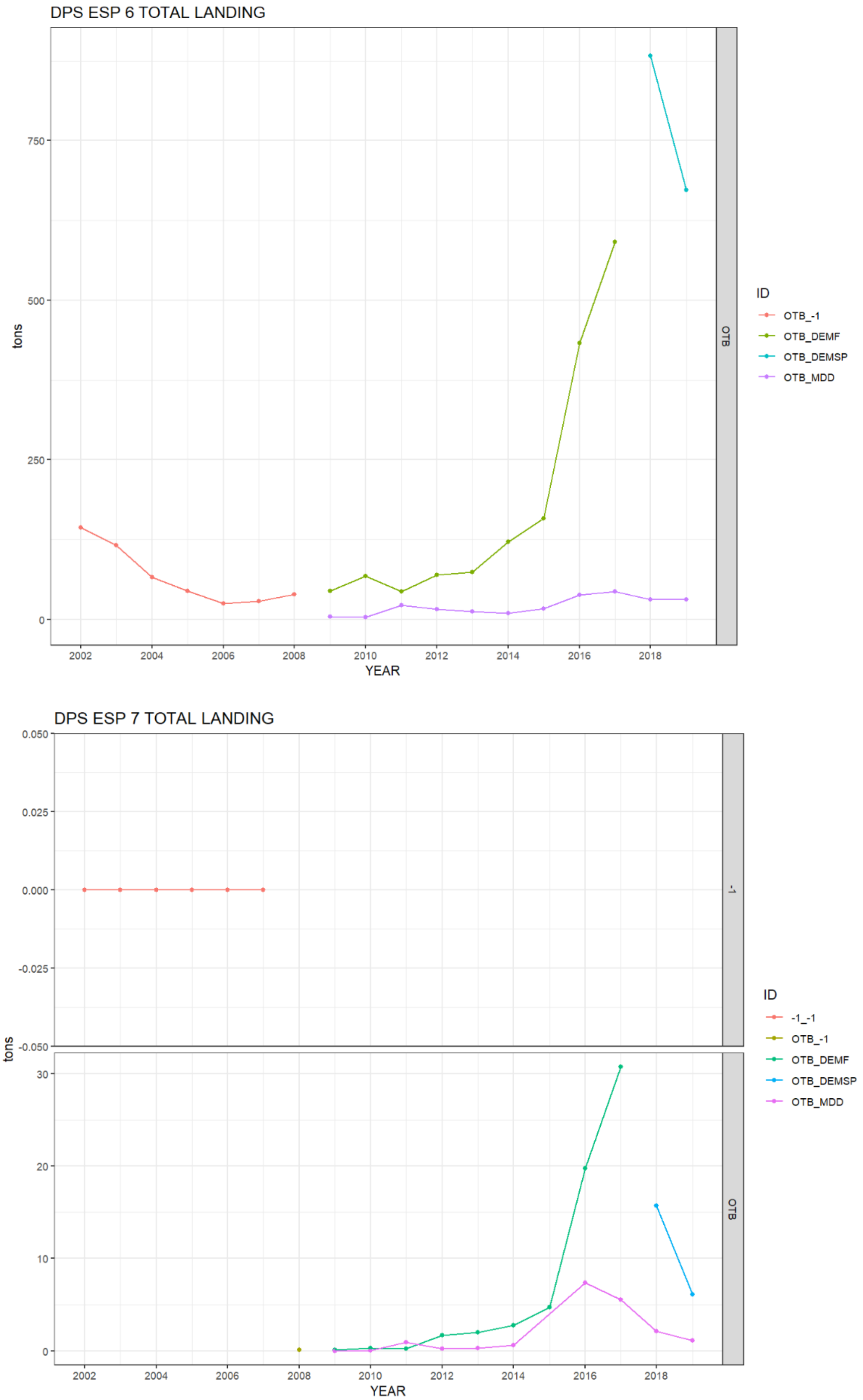


Figure 6.2.2.1.2. Deep-water rose shrimp GSAs 1-5-6-7. Landings data in tonnes by year and fleet in GSAs 6 and 7 (Spain).

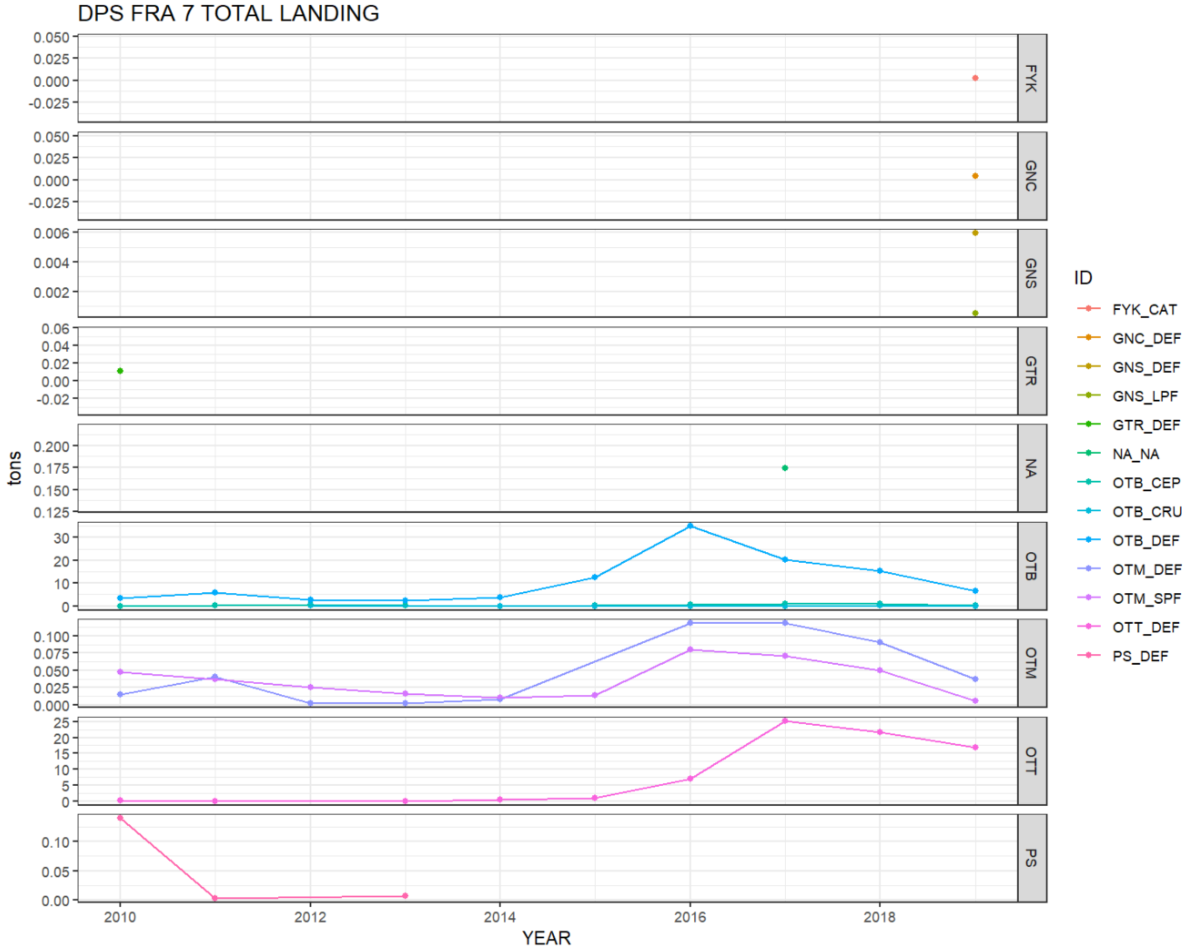


Figure 6.2.2.1.3. Deep-water rose shrimp GSAs 1-5-6-7. Landings data in tonnes by year and fleet in GSA 7 (France).

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figures 6.2.2.1.4.-5.

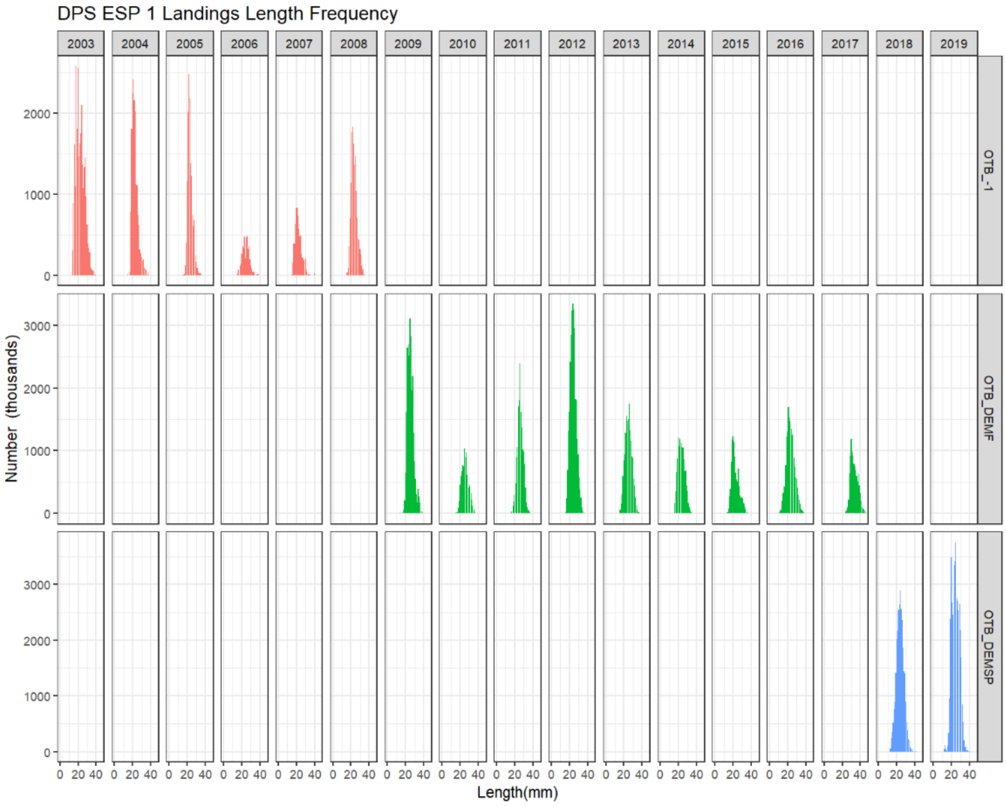
In GSA 1, length frequency distributions were not available for 2002.

In GSA 5, length frequency distributions were not available for 2016. For OTB-MDD data were lacking for the years 2009 and 2018-2019 as it is not a selected metier for sampling in this GSA.

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. The length frequency distribution in 2015 had a recurring error that was corrected during the working group.

In GSA 7, only the length frequency distributions for Spanish OTB were available. This is due to the fact that sampling is not compulory for landings less than 200 tons.

The group decided not to fill the missing length frequency distributions with length frequency distributions coming from other gears or years or country but to deal with them during the SOP correction, which therefore applies the lengths/ages from other areas based on relative catch proportions by GSA (see below).


DPS ESP 1 Landings Length Frequency
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
OTB_-1
OTB_DEMF
OTB_DEMSP
Number (thousands)
Length(mm)

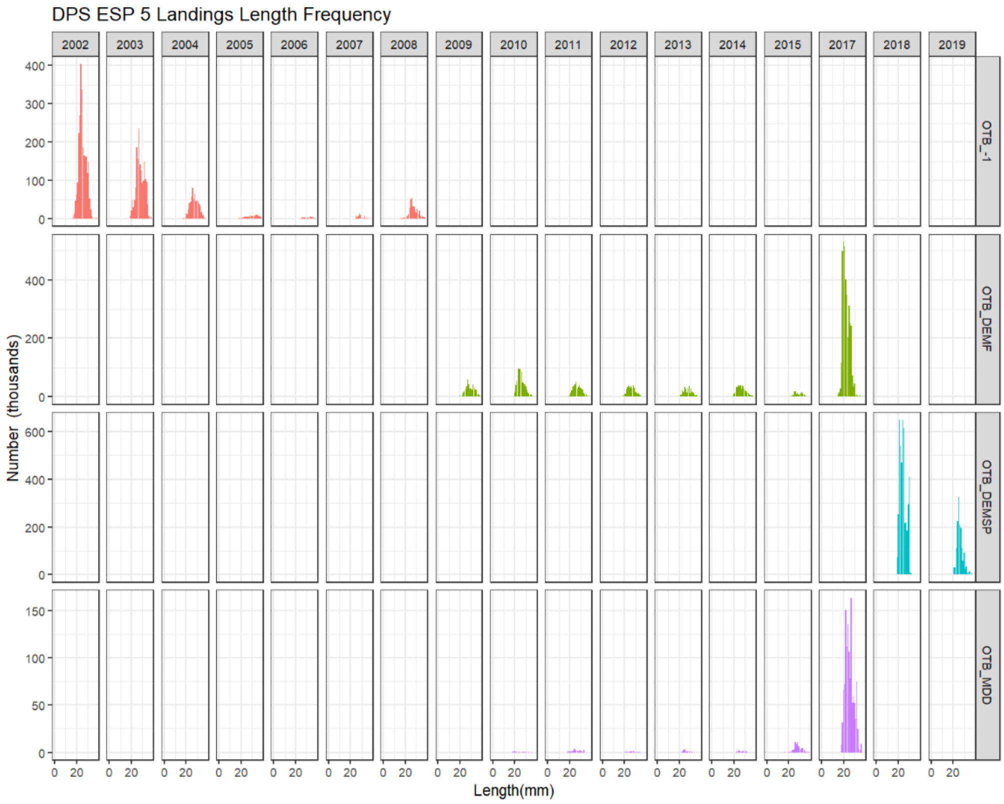
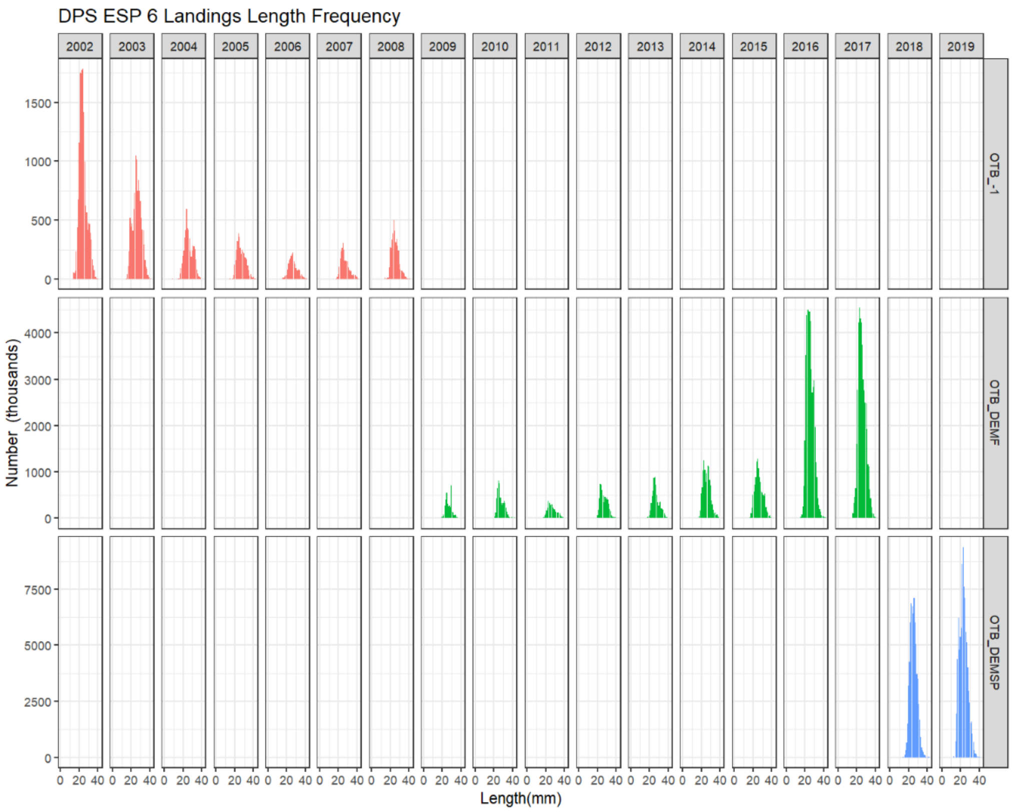

DPS ESP 5 Landings Length Frequency
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2017
2018
2019
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_MDD
Number (thousands)
Length(mm)

Figure 6.2.2.1.4. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution of the landings by year and fleet in GSAs 1 and 5.



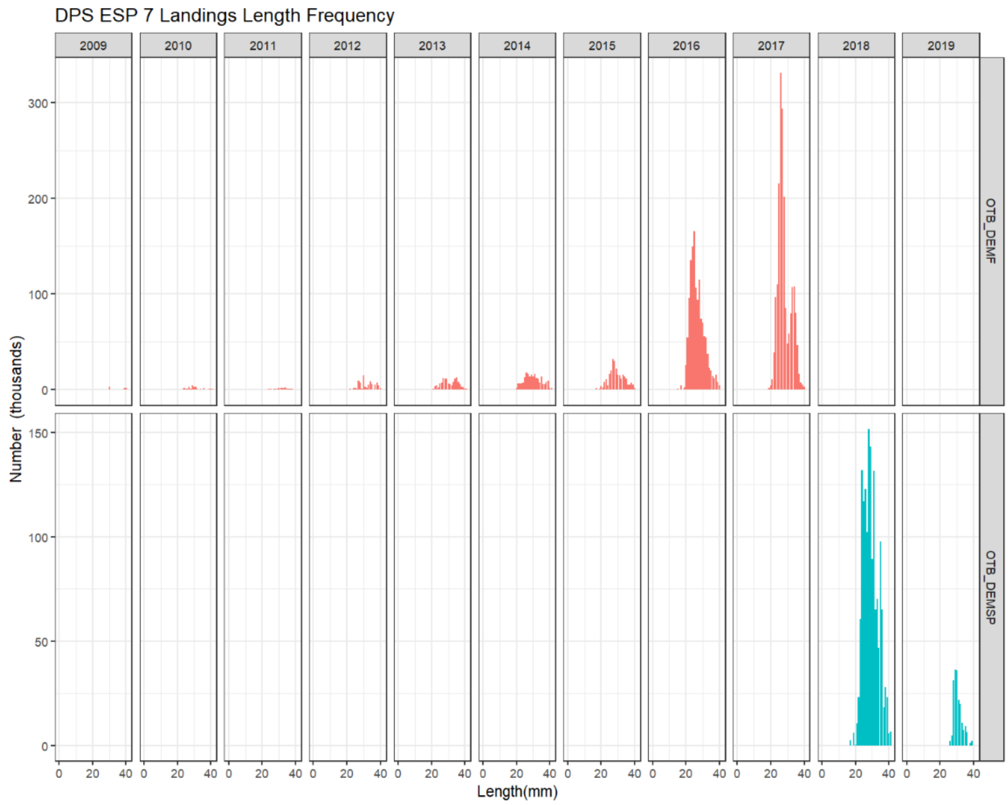


Figure 6.2.2.1.5. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution of the landings by year and fleet in GSAs 6 and 7 (Spain).

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GSA1 ESP_OTB	1.71	0	0	0.55	1.74	1.81	0.38	1.65	0.87	4.25	1.17	0.88	1.71	0.66	1.07
GSA5 ESP_OTB	0	0	0	0	0	0	0.13	0.41	0.32	0.01	0.01	1.98	0.6	0	0
GSA6 ESP_OTB	0.01	0	0	0	0	0.28	2.26	0.74	0.82	2.26	2.8	5.96	8.02	2.45	10.55
GSA7 ESP_OTB	0	0	0	0.01	0	0	0.07	0.3	0.29	0.03	0.03	0.1	0.23	0.04	0
Total	**1.72**	**0.00**	**0.00**	**0.56**	**1.74**	**2.09**	**2.84**	**3.10**	**2.30**	**6.55**	**4.01**	**8.92**	**10.56**	**1.72**	**0.00**

Discards

Discards data were reported to STECF EWG 19-10 through the DCF. Total discard by fleet and year are presented in table 6.2.2.1.3. France reported zero discards.

Table 6.2.2.1.3. Deep-water rose shrimp GSAs 1-5-6-7. Discards data in tonnes by fleet.

Missing discards data were not reconstructed.

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 available in the DCF data only for GSA 6 for Spain in 2019 but were deemed unreliable and removed from the assessment.

SoP corrections were applied to fill in for missing sampling (see above).

6.2.2.2 EFFORT

Fishing effort data were reported to STECF EWG 20-09 through DCF. Only effort from OTB is reported. No data was available for 2019.

Table 6.2.2.2.1. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in Days at sea by year and fishing gear.

GSA	2002	2003	2004	2005	2006	2007	2008	2009	2010

GSA1_ESP_OTB	28002	32892	34951	32295	31443	29917	26201	27017	28476
GSA5_ESP_OTB			12012	11497	10507	11907	12226	10934	11239
GSA6_ESP_OTB			118076	110957	110008	99638	106867	102005	95438
GSA7_ESP_OTB			3714	3626	3550	3553	3694	3008	3097
GSA7_FRA_OTB									15542
Total	**28002**	**32892**	**168753**	**158375**	**155508**	**145015**	**148988**	**142964**	**153792**

GSA	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ESP_OTB	28170	25851	24334	22395	21587	21345	22537	21633
GSA5_ESP_OTB	10498	10568	10769	10936	10714	8952	9158	7947
GSA6_ESP_OTB	90470	86587	84882	88528	79421	81649	78530	74820
GSA7_ESP_OTB	3486	2966	2791	2966	3064	3090	2840	2357
GSA7_FRA_OTB	14934	10995	10133	10073	10920	9610	7759	7193
Total	**147558**	**136969**	**132909**	**134921**	**125707**	**124657**	**120862**	**113950**

Table 6.2.2.2.2. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in GT*Days at sea by year and fishing gear.

GSA	2002	2003	2004	2005	2006	2007	2008	2009	2010
GSA1_ESP_OTB	1333918	1684655	1894693	1761339	1685266	1631930	1495816	1520713	1568334
GSA5_ESP_OTB			657513	649028	601140	699565	725977	648577	672071
GSA6_ESP_OTB			6681984	6438093	6465424	5922542	6375021	6063795	5673235
GSA7_ESP_OTB			322841	308926	308266	316488	322027	313450	275498
GSA7_FRA_OTB									1484667
Total	**1333918**	**1684655**	**9557032**	**9157386**	**9060096**	**8570525**	**8918841**	**8546535**	**9673805**

GSA	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ESP_OTB	1507685	1395133	1295309	1159530	1102193	1083165	1131873	1079838
GSA5_ESP_OTB	616593	630595	641523	670025	663308	537128	570157	495565
GSA6_ESP_OTB	5343285	5109806	5021556	5216517	4685445	4842663	4650788	4424004
GSA7_ESP_OTB	310191	268789	248107	268090	276490	294524	272192	226279

GSA7_FRA_OTB	1447425	1004818	910721	947715	1036167	890440	691511	641292
Total	**9225181**	**8409377**	**8117216**	**8265326**	**7763720**	**7649177**	**7321186**	**6866977**

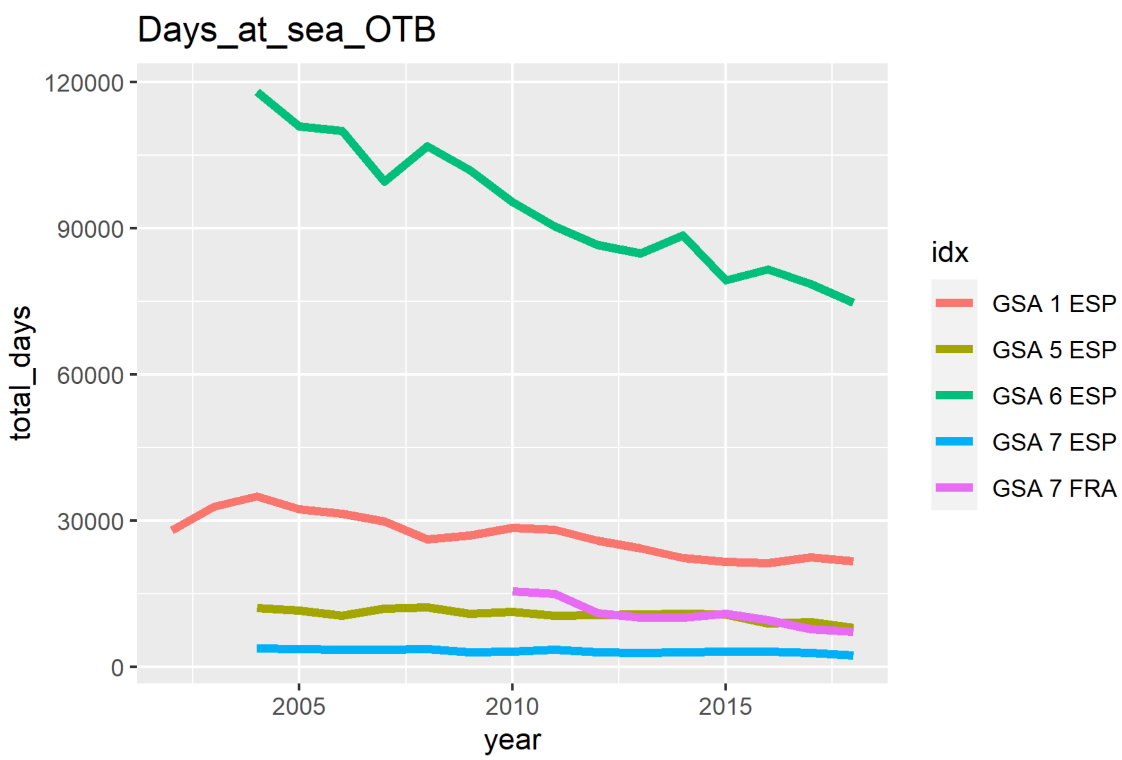


Figure 6.2.2.2.1. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in Days at sea by year and fishing gear.

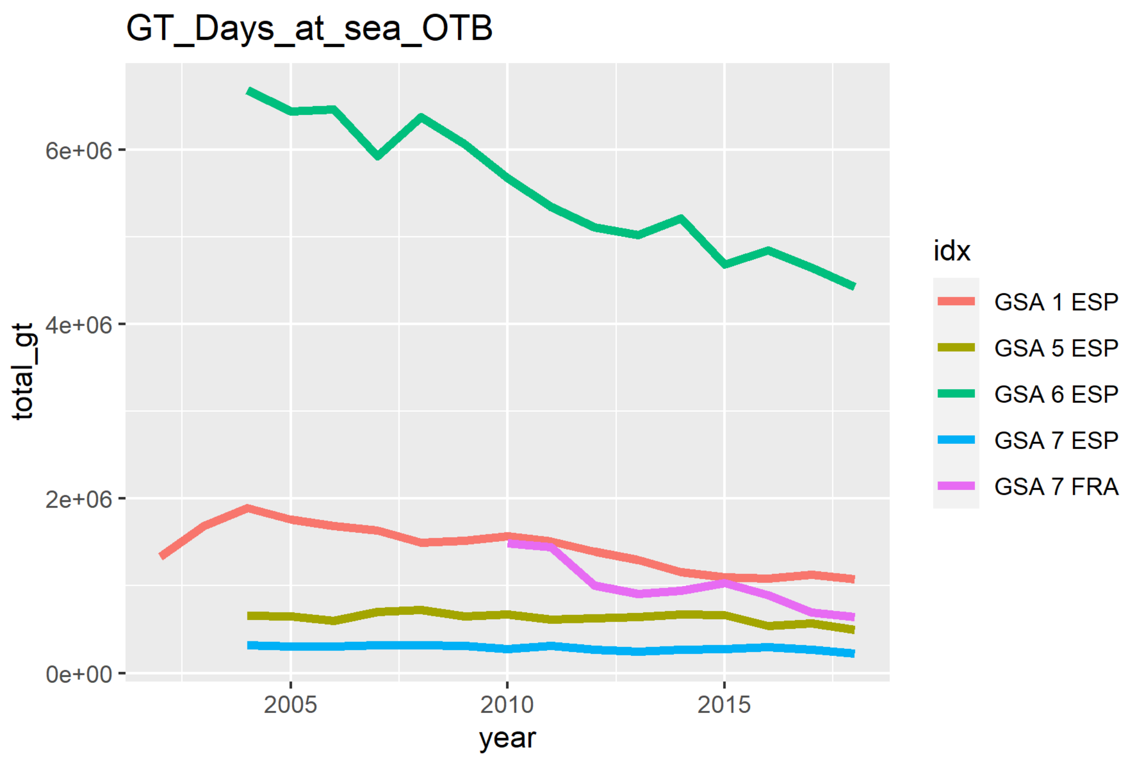


Figure 6.2.2.2.2. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in GT*Days at sea by year and fishing gear.

6.2.2.3 SURVEY DATA

Since 1994, MEDITS trawl surveys have 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 were removed from the index due to lack of consistent coverage. Therefore, in the current assessment combined MEDITS data for GSAs 1-5-6-7 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 both for single GSA and combined GSAs (Figures 6.2.2.3.1-10).

Both estimated abundance and biomass indices show similar trends in GSAs 5, 6 and 7, with a sharp increase in the last years. In GSA 1 the trend is more variable throughout the time series; however, also in this area a high value is observed in 2018.

Considering the whole area (GSAs 1-5-6-7) the density and biomass indices showed a sharp increase in 2016-2018 and a slight decrease in the last year of the data series.

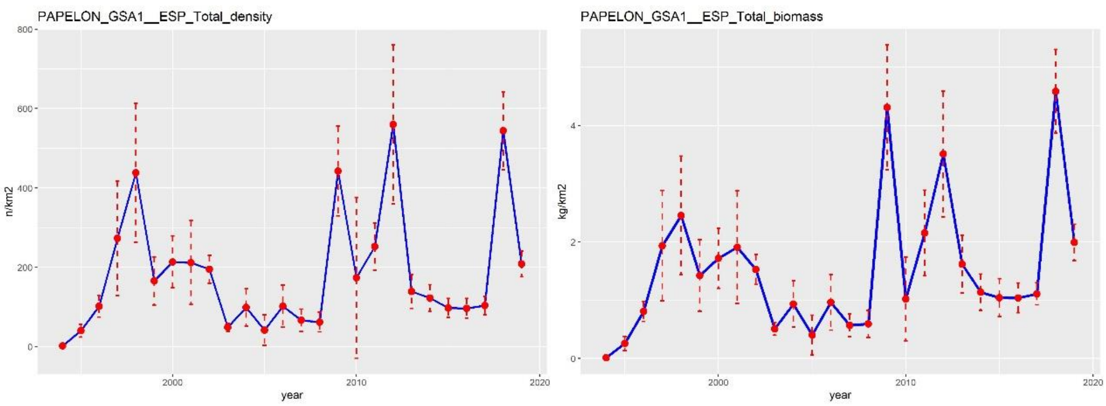


Figure 6.2.2.3.1. Deep-water rose shrimp GSAs 1-5-6-7. Estimated density (N/km^2) and biomass (kg/km^2) indices in GSA 1.

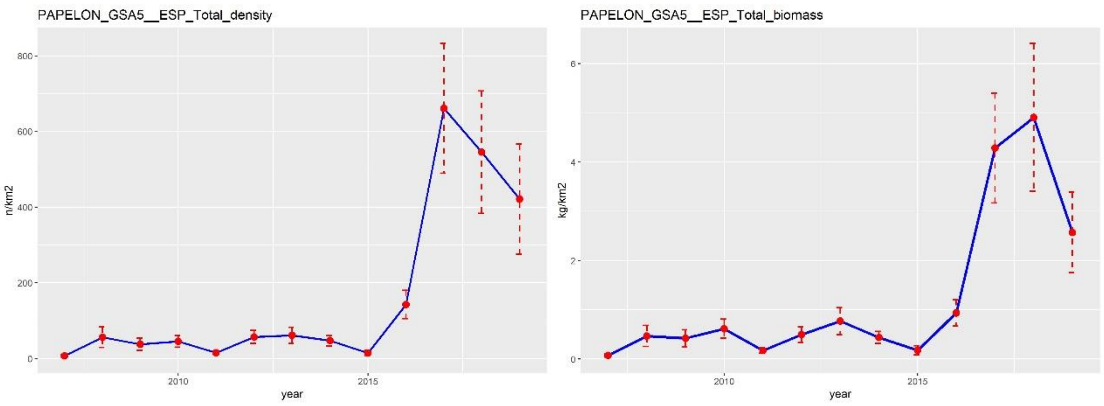


Figure 6.2.2.3.2. Deep-water rose shrimp GSAs 1-5-6-7. Estimated density (N/km^2) and biomass (kg/km^2) indices in GSA 5.

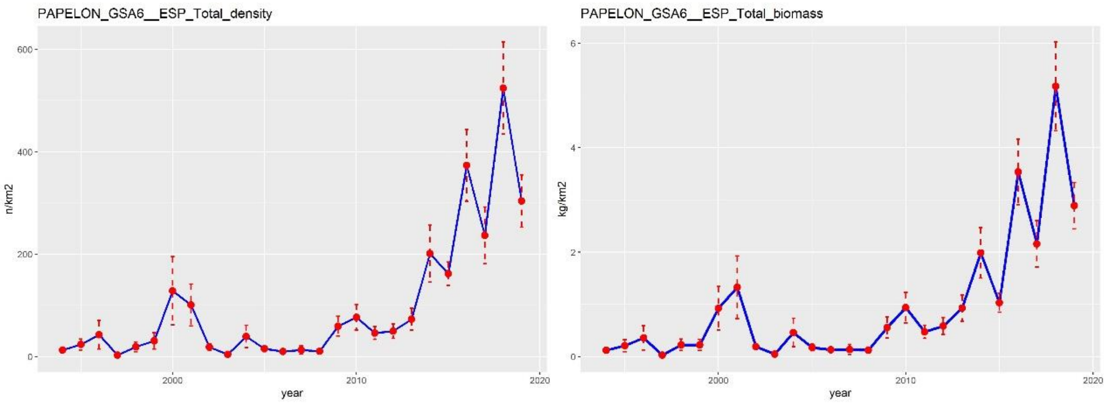


Figure 6.2.2.3.3. Deep-water rose shrimp GSAs 1-5-6-7. Estimated density (N/km^2) and biomass (kg/km^2) indices in GSA 6.

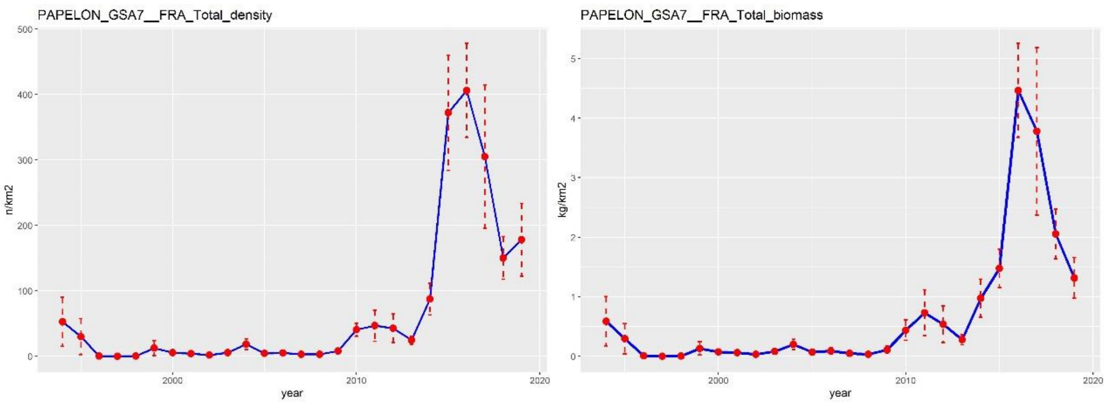


Figure 6.2.2.3.4. Deep-water rose shrimp GSAs 1-5-6-7. Estimated density (N/km^2) and biomass (kg/km^2) indices in GSA 7.

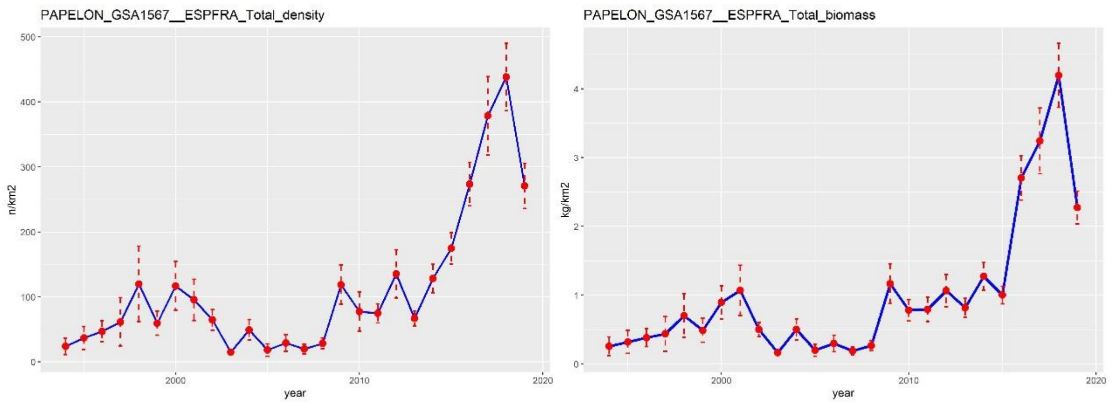


Figure 6.2.2.3.5. Deep-water rose shrimp GSAs 1-5-6-7. Estimated density (N/km^2) and biomass (kg/km^2) combined MEDITS indices.

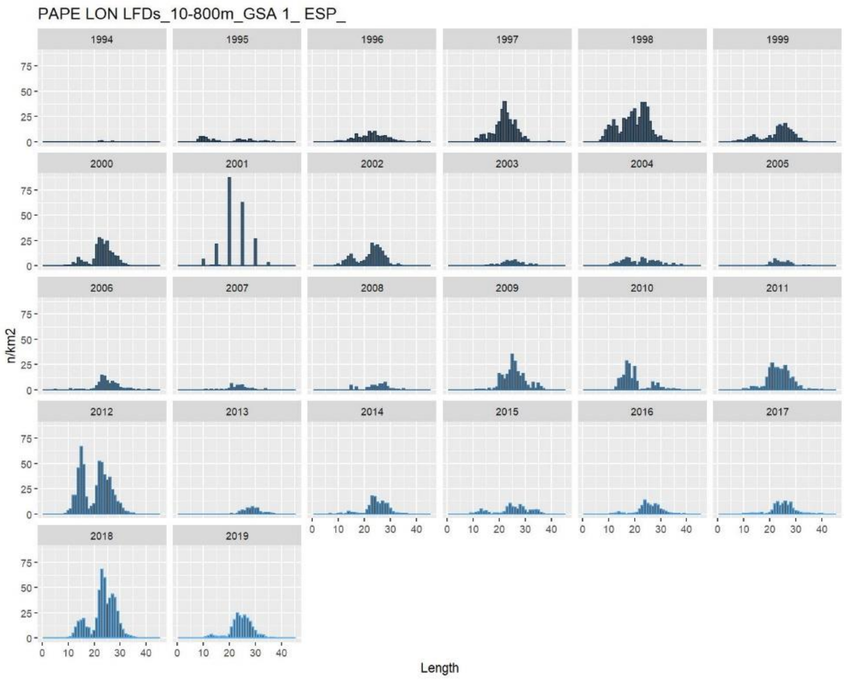


Figure 6.2.2.3.6. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution by year of MEDITS GSA 1.

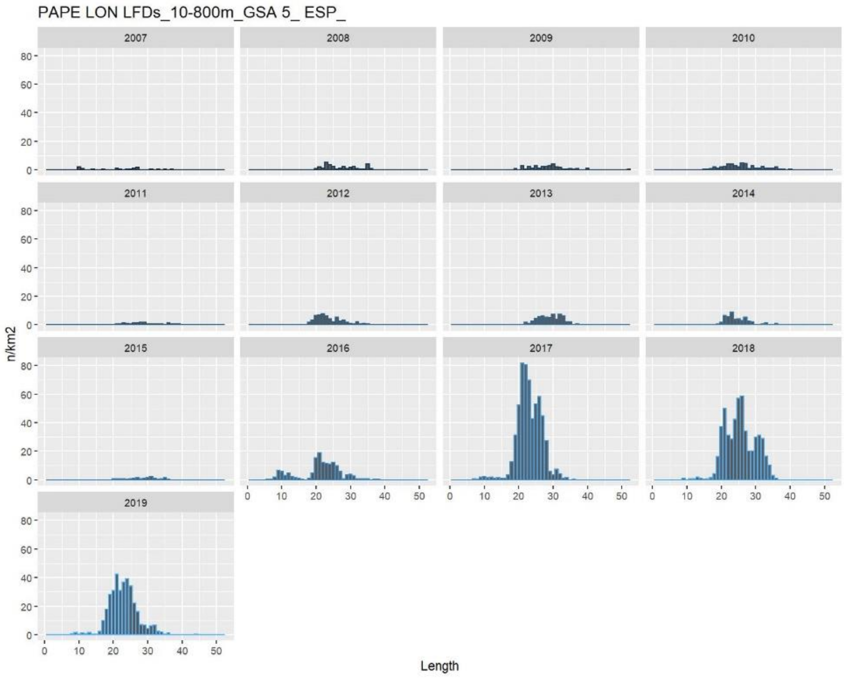


Figure 6.2.2.3.7. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution by year of MEDITS GSA 5.

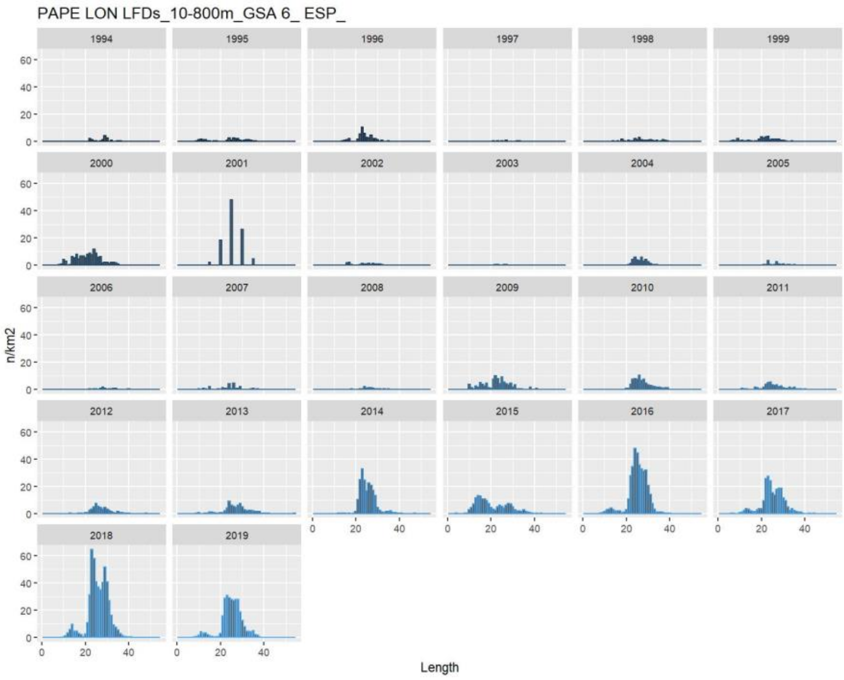


Figure 6.2.2.3.8. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution by year of MEDITS GSA 6.

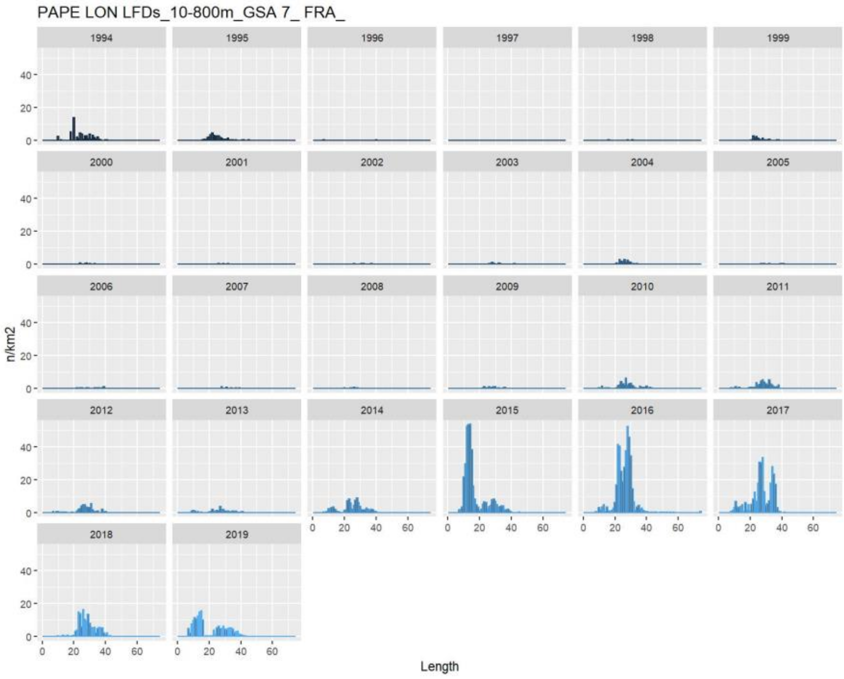


Figure 6.2.2.3.9. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution by year of MEDITS GSA 7.

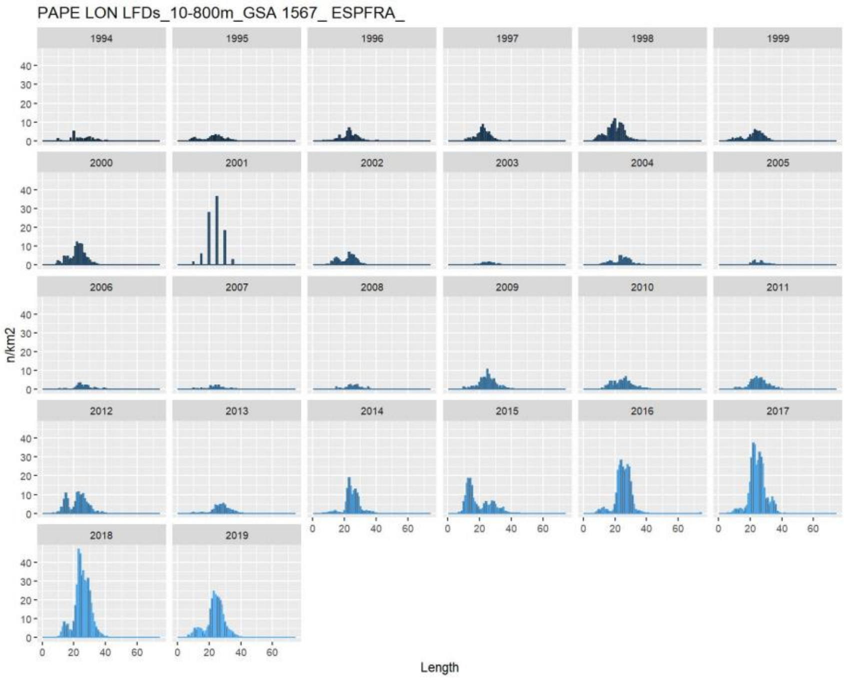


Figure 6.2.2.3.10. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution by year of MEDITS.

In the MEDITS length frequency distributions there are outliers (i.e. animals larger than 80 mm). The length classess of these animals have been assumed to be entered incorrectly and divided by 10. In GSA 1 hauls 16 and 38 in 2013 were removed due to wrong data, the same was done for haul 51 in 2012 in GSA 6. The length frequency distributions of the Spanish MEDITS in 2001 are wrong. All these issues have been recurring and needs to be fixed.

6.2.3 STOCK ASSESSMENT

Two age based methods were 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 GSAs 1-5-6-7 we used a) the Assessment for All Initiative (a4a) (Jardim et al., 2015) and b) the Extended Survivor Analysis (XSA) in FLR environment. Both models were carried out using as input data the period 2007-2019 for the catch data (landings + discards) and 2007-2019 for the tuning file. Both catch numbers at length and index number at length were sliced using the l2a routine in FLR for each GSA using the corresponding 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 in both methods based on the biomass at age estimates from MEDITS GSAs 1-5-6-7. The different GSAs MEDITS indexes were merged using an average weighted by the GSA area.

The analyses were carried out for the ages 0 to 3+. Concerning the Fbar, the age range used was 1-2 age groups for both methods.

Input data

The growth parameters used for VBGF were the one reported in table 6.2.1.1.

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. Table 6.2.3.1 present the SOP correction vector applied. The SOP correction is quite high in 2015, 2017 and 2018 because of missing or errors in length frequency distributions in the catches of those years.

Table 6.2.3.1. Deep-water rose shrimp GSAs 1-5-6-7. SOP correction vector.

	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
SOP	1.08	0.98	1.08	1.12	1.22	1.02	1.04	1.12	1.49	1.13	1.48	1.47	1.06

Table 6.2.3.2 lists the input data for the a4a and XSA, 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 6.2.3.2. Deep-water rose shrimp GSAs 1-5-6-7. Input data for the a4a and XSA models.

Catches (t)

2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
86.4	153.7	310.0	182.0	252.6	339.8	249.0	251.5	313.2	696.1	998.2	1404.7	1160.8

Catch numbers-at-age matrix (thousands)

age	2007	2008	2009	2010	2011	2012	2013
0	1011.925	488.0397	94.66882	149.5039	223.5534	974.4984	542.774
1	8627.644	17052.3	29540.96	16062.4	22742.96	34683.51	22688.66
2	399.3687	294.4694	1324.248	886.2348	932.1551	779.4043	1148.753
3+	9.70145	7.51992	0.96318	41.18228	62.11678	29.23122	3.24037
age	2014	2015	2016	2017	2018	2019	
0	1322.212	2393.779	2600.488	67.17718	4153.199	2512.175	
1	25039.05	28898	66920.69	78397.84	141606	130831.2	
2	829.2774	2048.938	2864.374	10392.24	4154.176	3109.919	
3+	3.51708	0.66287	57.24482	795.5096	49.58993	21.56756	

Weights-at-age (kg)

age	2007	2008	2009	2010	2011	2012	2013
0	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1	0.008	0.009	0.010	0.010	0.010	0.009	0.010
2	0.022	0.020	0.019	0.020	0.020	0.020	0.020
3+	0.034	0.033	0.033	0.038	0.038	0.038	0.040
age	2014	2015	2016	2017	2018	2019	
0	0.004	0.004	0.004	0.001	0.004	0.004	
1	0.009	0.009	0.009	0.010	0.009	0.008	
2	0.021	0.020	0.020	0.021	0.020	0.020	
3+	0.033	0.034	0.033	0.029	0.030	0.029	

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

age	2007	2008	2009	2010	2011	2012	2013
0	1.52	1.52	1.52	1.52	1.52	1.52	1.52
1	0.85	0.85	0.85	0.86	0.85	0.85	0.85
2	0.73	0.73	0.71	0.72	0.72	0.72	0.72
3+	0.67	0.67	0.67	0.67	0.67	0.67	0.67
age	2014	2015	2016	2017	2018	2019	
0	1.52	1.52	1.52	1.62	1.52	1.55	
1	0.86	0.86	0.87	0.88	0.87	0.87	
2	0.73	0.73	0.73	0.71	0.73	0.73	
3+	0.67	0.67	0.67	0.65	0.66	0.66	

Deep-water rose shrimp GSAs 1-5-6-7. MEDITS number (n/km^2) at age for GSAs 1-5-6-7.

age	2007	2008	2009	2010	2011	2012	2013
0	2.90	1.26	7.79	16.50	5.08	38.92	2.01
1	14.71	16.54	76.19	54.99	64.15	92.69	45.94
2	1.52	1.72	4.87	7.59	5.87	3.81	8.79
3+	0.05	0.03	0.52	0.22	0.12	0.06	0.31
age	2014	2015	2016	2017	2018	2019	
0	4.96	77.12	16.89	14.33	28.85	29.84	
1	126.81	77.32	266.88	252.05	394.78	226.70	
2	6.12	9.91	7.84	24.32	25.97	15.41	
3+	0.12	0.29	0.46	0.16	0.98	0.47	

Figures 6.2.3.1-6.2.3.2-6.2.3.3 show the age structure of the catches, of the index and the weight at age matrix.

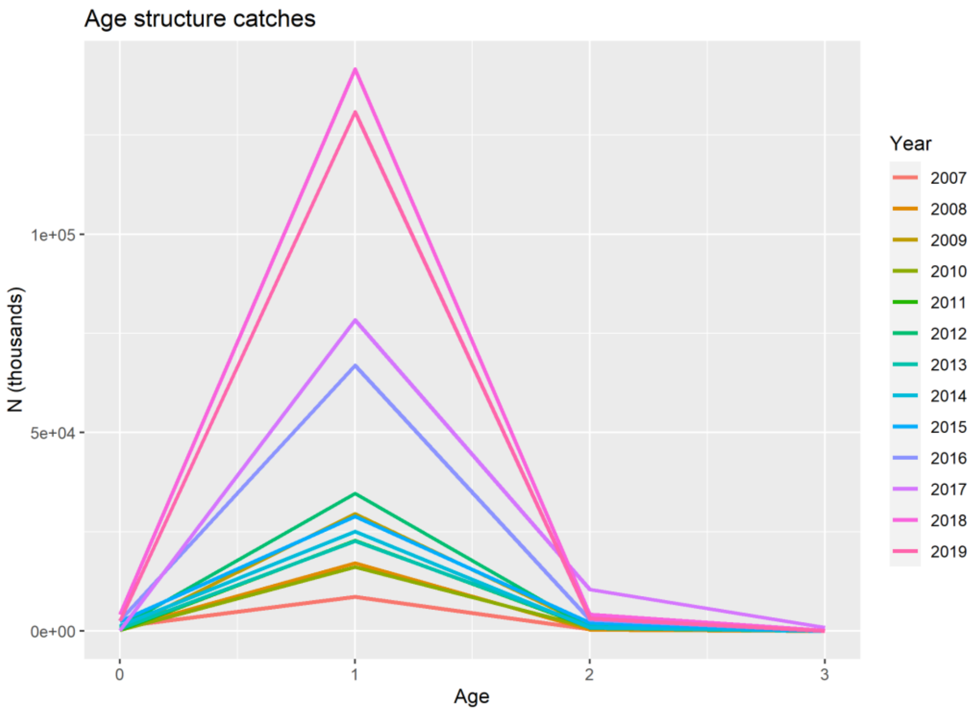


Figure 6.2.3.1. Deep-water rose shrimp GSAs 1-5-6-7. Age structure of the catches.

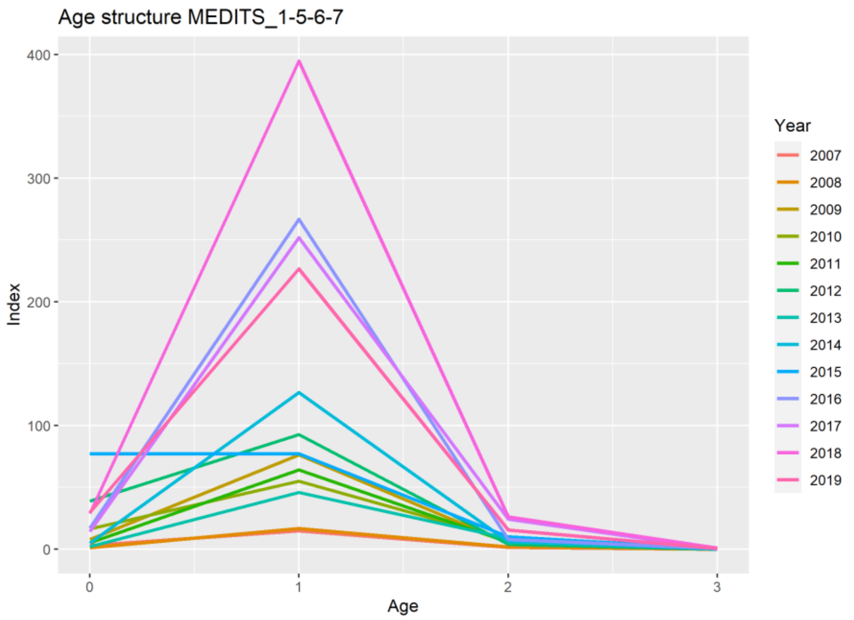


Figure 6.2.3.2. Deep-water rose shrimp GSAs 1-5-6-7. Age structure of the index.

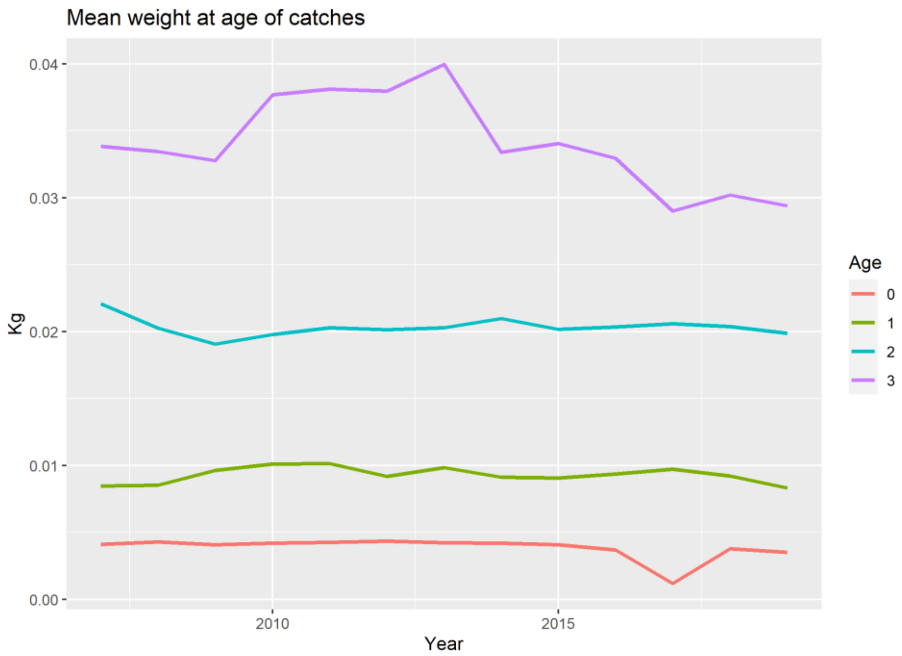


Figure 6.2.3.3. Deep-water rose shrimp GSAs 1-5-6-7. Weight at age matrix.

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

sr ~ factor(year)

Results are shown in Figures 6.2.3.4-6.2.3.10.

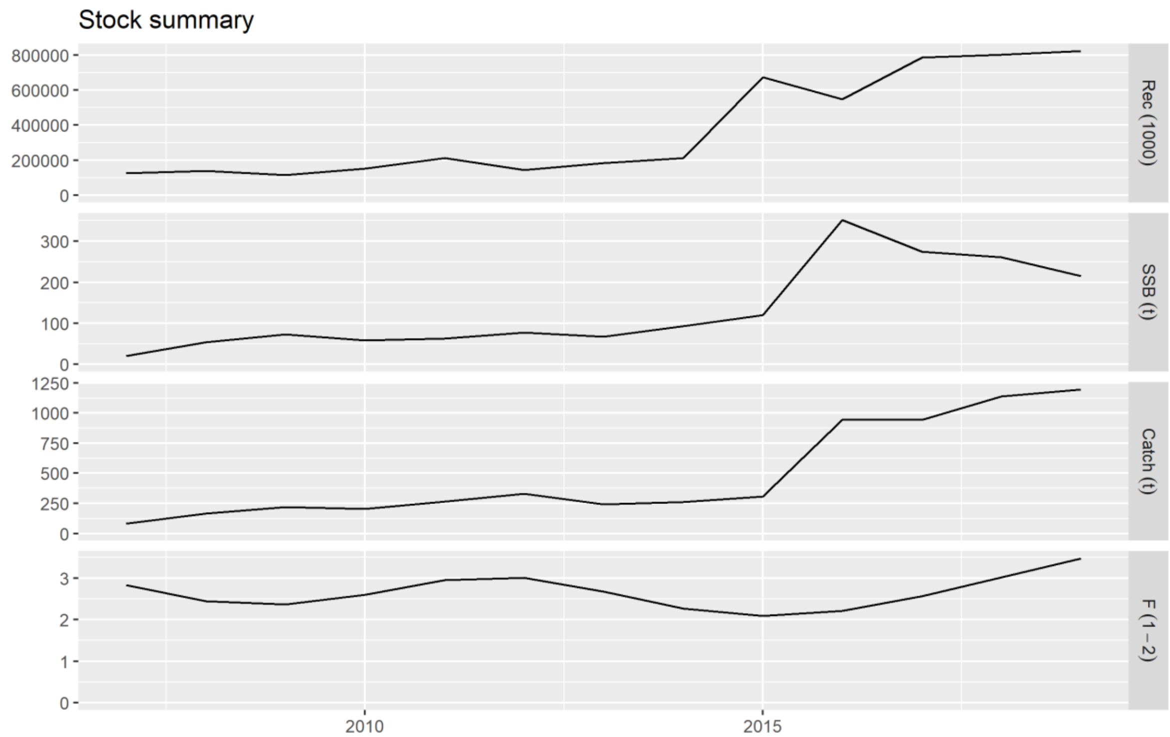


Figure 6.2.3.4. Deep-water rose shrimp GSAs 1-5-6-7. Stock summary from the a4a model for Deep-water rose shrimp GSAs 1-5-6-7 recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 2).

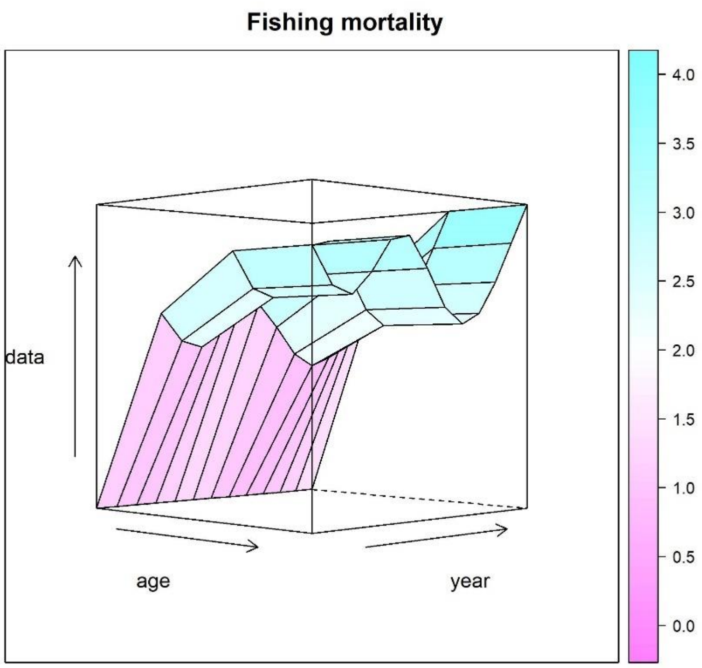


Figure 6.2.3.5. Deep-water rose shrimp GSAs 1-5-6-7. 3D contour plot of estimated fishing mortality at age and year.

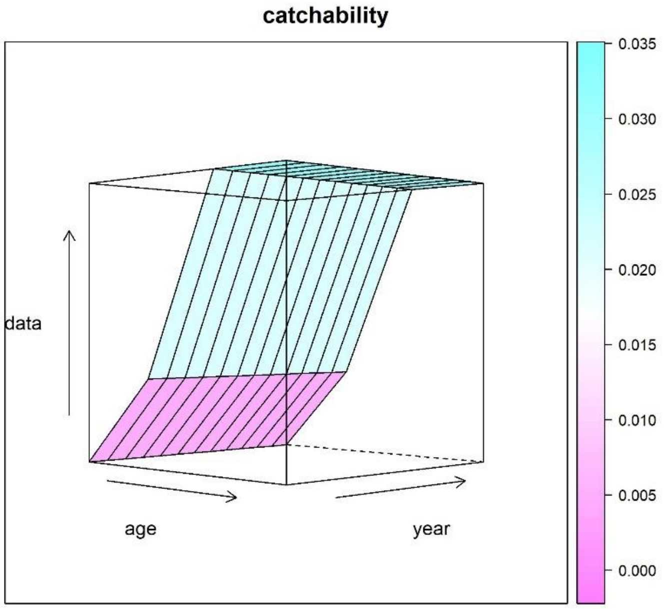


Figure 6.2.3.6. Deep-water rose shrimp GSAs 1-5-6-7. 3D contour plot of estimated catchability at age and year.

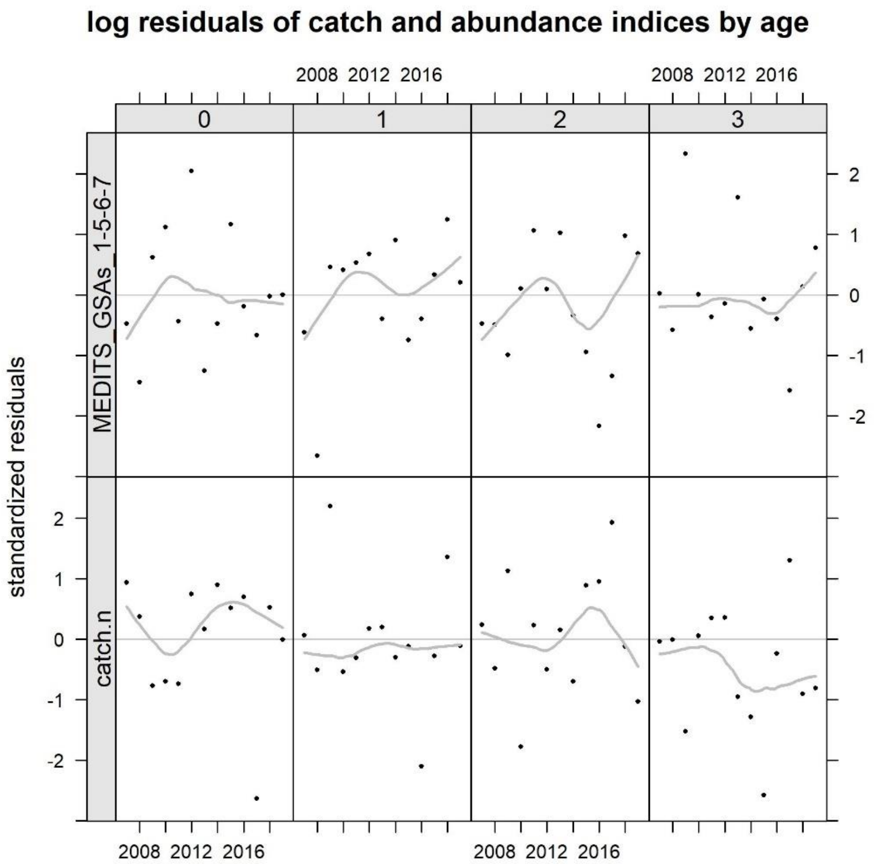


Figure 6.2.3.7. Deep-water rose shrimp GSAs 1-5-6-7. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines simple smoothers.

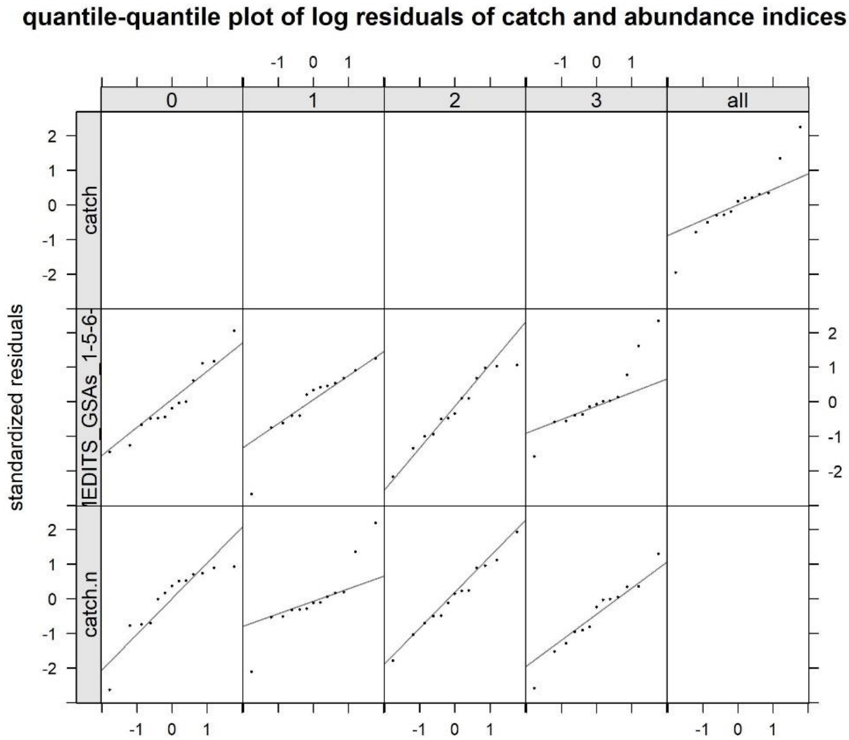


Figure 6.2.3.8. Deep-water rose shrimp GSAs 1-5-6-7. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

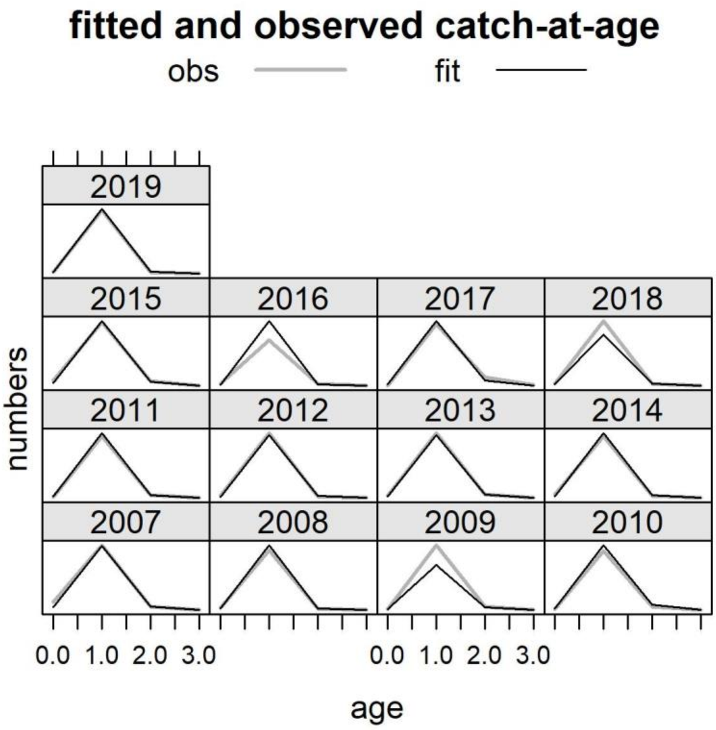


Figure 6.2.3.9. Deep-water rose shrimp GSAs 1-5-6-7. Fitted and observed catch at age.

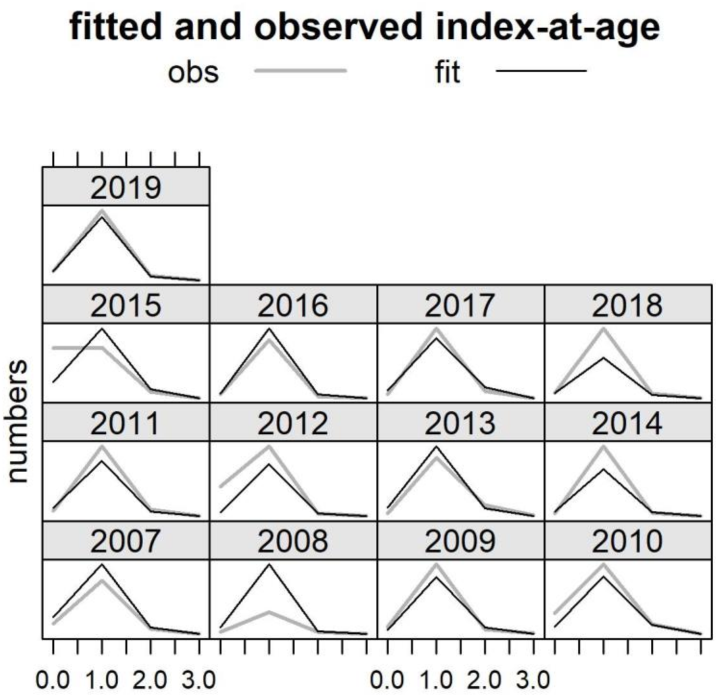


Figure 6.2.3.10. Deep-water rose shrimp GSAs 1-5-6-7. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 2 years back. Models results were quite stable (Figure 6.2.3.11).

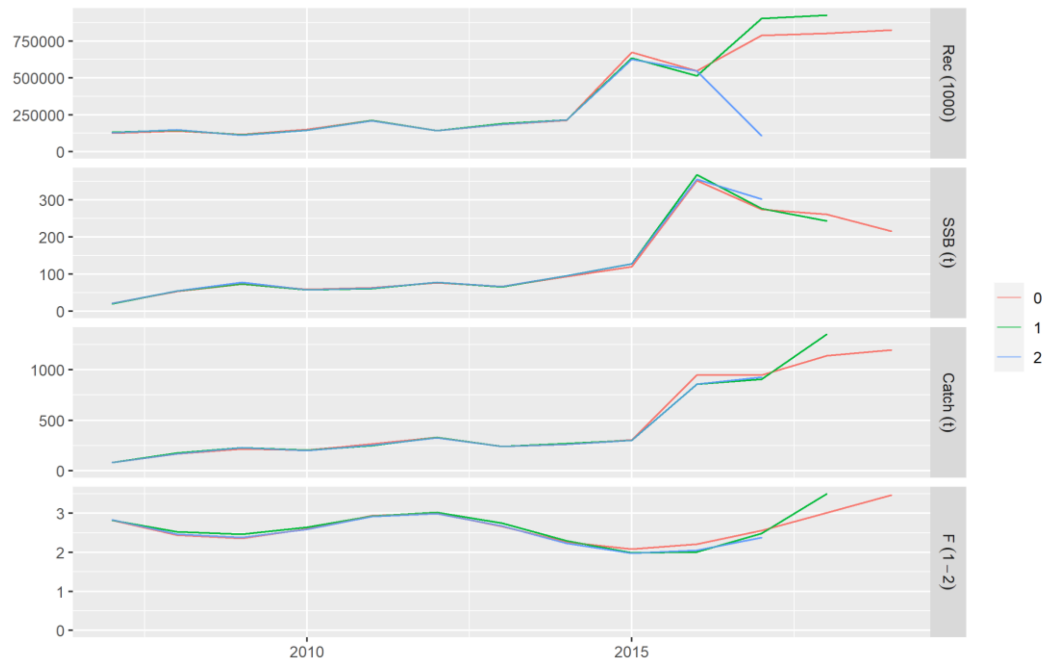


Figure 6.2.3.11. Deep-water rose shrimp GSAs 1-5-6-7. Retrospective analysis output for the a4a model.

Simulations

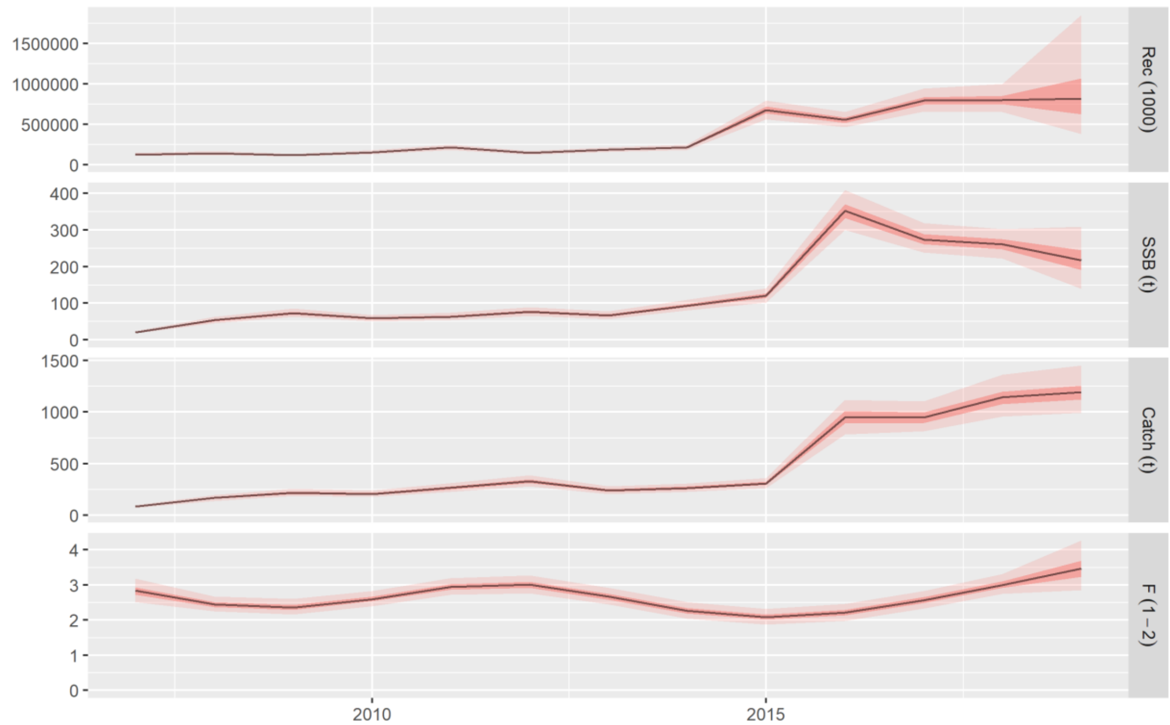


Figure 6.2.3.12. Deep-water rose shrimp GSAs 1-5-6-7. Stock summary of the simulated and fitted data for the a4a model.

In the tables 6.2.3.3 and 4 the population estimates of Deep-water rose shrimp obtained by a4a are provided.

Table 6.2.3.3. Deep-water rose shrimp GSAs 1-5-6-7. Stock numbers at age (thousands) as estimated by a4a.

age	2007	2008	2009	2010	2011	2012	2013
0	125447	140107	116111	151196	211397	143562	184282
1	11895	27301	30456	25290	32918	45948	31234
2	476	426	1371	1652	1101	1070	1416
3+	13	10	13	48	44	20	18
age	2014	2015	2016	2017	2018	2019	
0	213502	674289	549278	788062	803816	823853	
1	40116	46511	146845	119505	154599	174767	
2	1285	2333	3153	8872	5261	4627	
3+	35	50	110	132	247	90	

Table 6.2.3.4. Deep-water rose shrimp GSAs 1-5-6-7. a4a summary results and F at age.

	Fbar1-2	**Recruitment (thousands)**	**SSB (t)**	**TB (t)**	**Catch (t)**
2007	2.83	125447	20.61	628.48	82.33
2008	2.45	140107	53.74	843.31	166.50
2009	2.36	116111	73.22	792.33	218.07
2010	2.60	151196	58.89	923.11	206.03
2011	2.95	211397	63.30	1258.87	264.57
2012	3.01	143562	76.99	1070.24	329.36
2013	2.67	184282	66.92	1118.82	241.13
2014	2.27	213502	93.71	1292.28	263.24
2015	2.09	674289	120.29	3228.04	307.90
2016	2.21	549278	351.40	3469.02	945.35
2017	2.57	788062	274.31	2285.44	945.42
2018	3.01	803816	260.75	4580.80	1138.95
2019	3.47	823853	215.66	4446.90	1197.29

F at age	0	1	2	3+
2007	0.005	2.478	3.182	3.182
2008	0.004	2.142	2.750	2.750
2009	0.004	2.069	2.656	2.656
2010	0.005	2.278	2.924	2.924
2011	0.005	2.579	3.311	3.311
2012	0.005	2.633	3.380	3.380
2013	0.005	2.339	3.003	3.003
2014	0.004	1.984	2.547	2.547
2015	0.004	1.829	2.348	2.348
2016	0.004	1.936	2.486	2.486
2017	0.004	2.247	2.884	2.884
2018	0.005	2.639	3.388	3.388
2019	0.006	3.039	3.902	3.902

Based on the a4a results, the Deep-water rose shrimp SSB fluctuated over 2007-2014 around 60 tons and in the last 5 years showed an increase up to 351 tons. The assessment shows an increasing trend in the number of recruits in the last years. The recruitment (age 0) reached a maximum of 823853 thousands individuals in 2019. F_{bar} (1-2) shows an increasing trend from around 2 in 2015 up to a value of 3.47 in 2019. The values of F at age show extremely high values for ages 1, 2 and 3. Therefore, the EWG 20-09 concluded that the output of this model was not suitable to provide the basis of the current status of the stock but could be used as indicative of a trend.

Method XSA

The same input data used for the a4a assessment were used for XSA. Sensitivity analyses were conducted to assess the effect of the main parameters. Values ranging from 0.5 to 3 (0.5 increasing) for the shrinkage, values ranging from 1 to 3 for shrinkage years and ages, and a combination of values between 1 to 3 for the qage parameter and from -1 to 1 for the rage parameter have been tested. Comparison of trends between the settings has been done. Different combinations between the settings that looked more stable were tested.

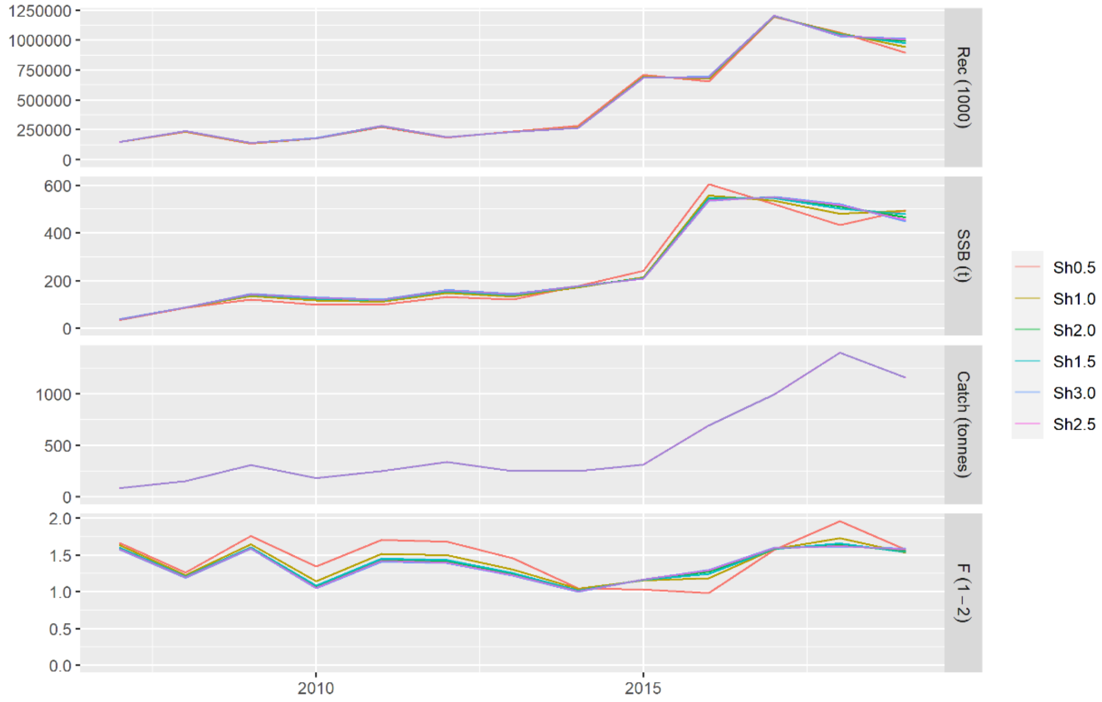


Figure 6.2.3.13. Deep-water rose shrimp GSAs 1-5-6-7. Sensitivity on shrinkage weight.

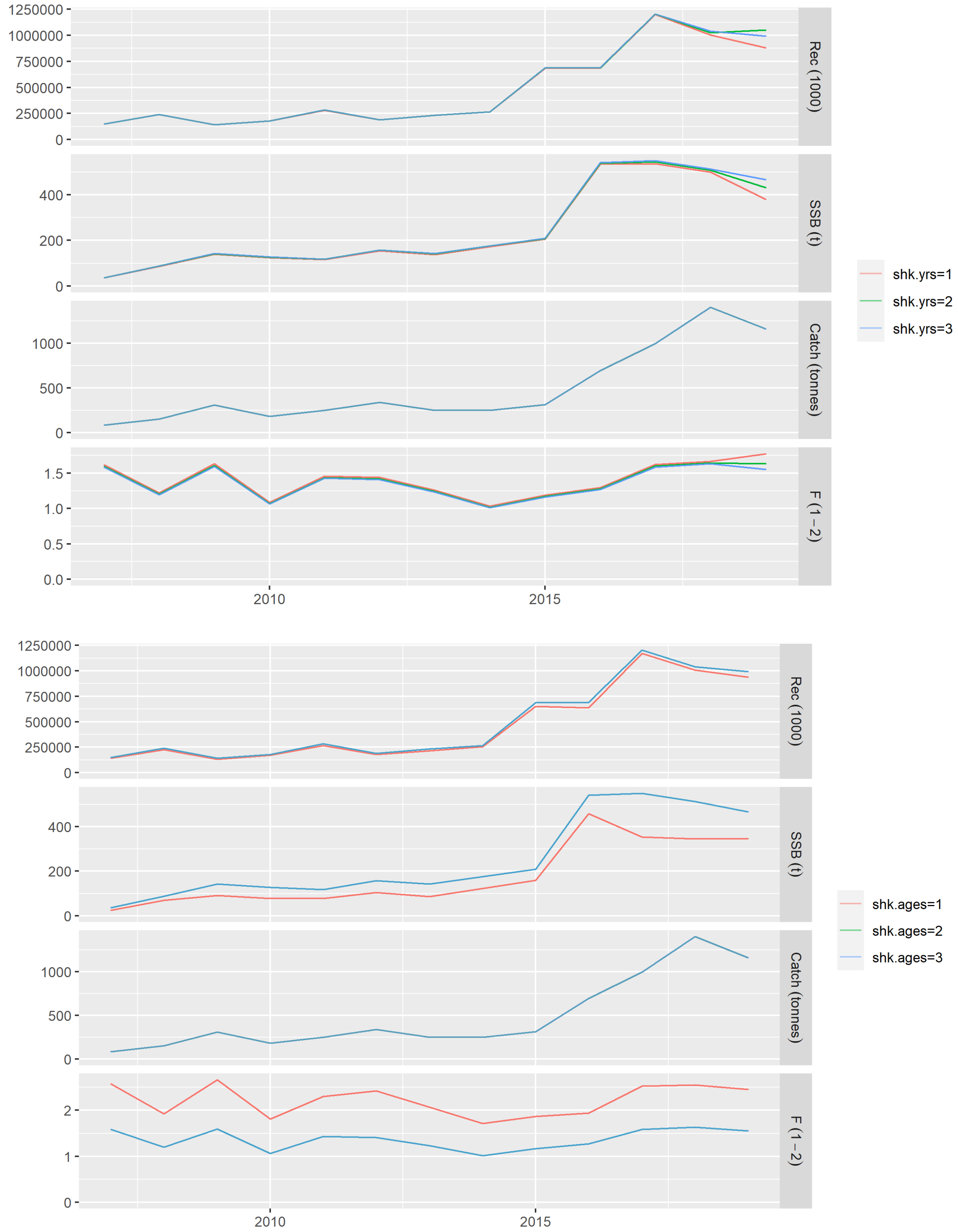


Figure 6.2.3.14. Deep-water rose shrimp GSAs 1-5-6-7. Sensitivity on shrinkage ages and shrinkage years.

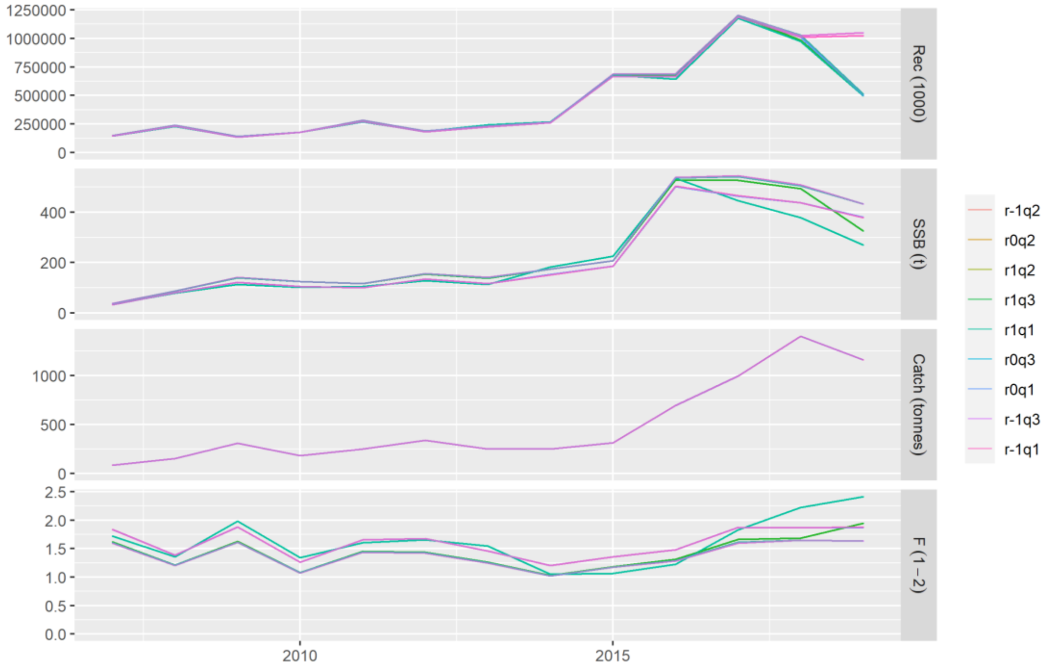


Figure 6.2.3.15. Deep-water rose shrimp GSAs 1-5-6-7. Sensitivity on qage and rage.

As a result, the settings that minimized the residuals and showed the best diagnostics output were used for the final assessment, and are the following:

Fbar	fse	rage	qage	shk.yrs	shk.age
1-2	2	-1	2	3	2

The residuals pattern of the MEDITS trawl survey is shown in Figure 6.2.3.16 and the results of the retrospective analysis are shown in Figure 6.12.3.17.

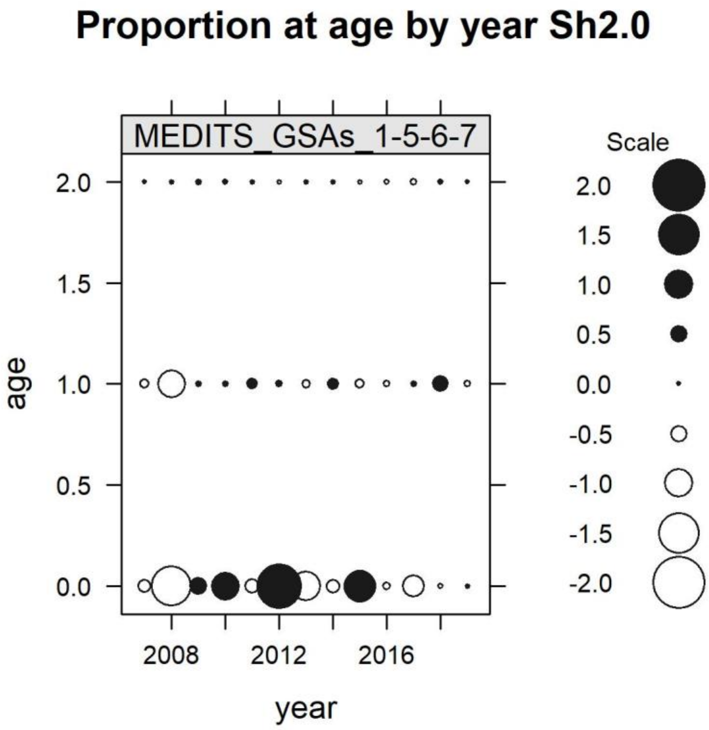


Figure 6.2.3.16. Deep-water rose shrimp GSAs 1-5-6-7. XSA residuals for the MEDITS survey from 2007 to 2019.

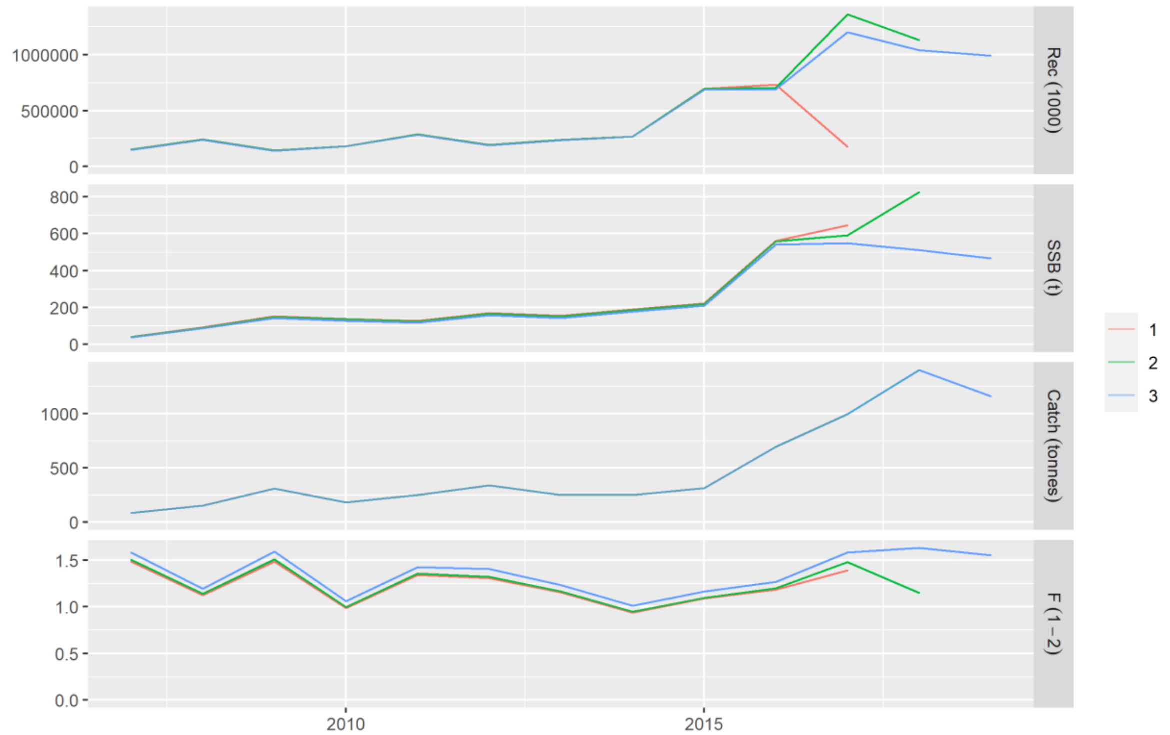


Figure 6.2.3.17. Deep-water rose shrimp GSAs 1-5-6-7. XSA retrospective analysis.

The results of the XSA are shown in the following figure.

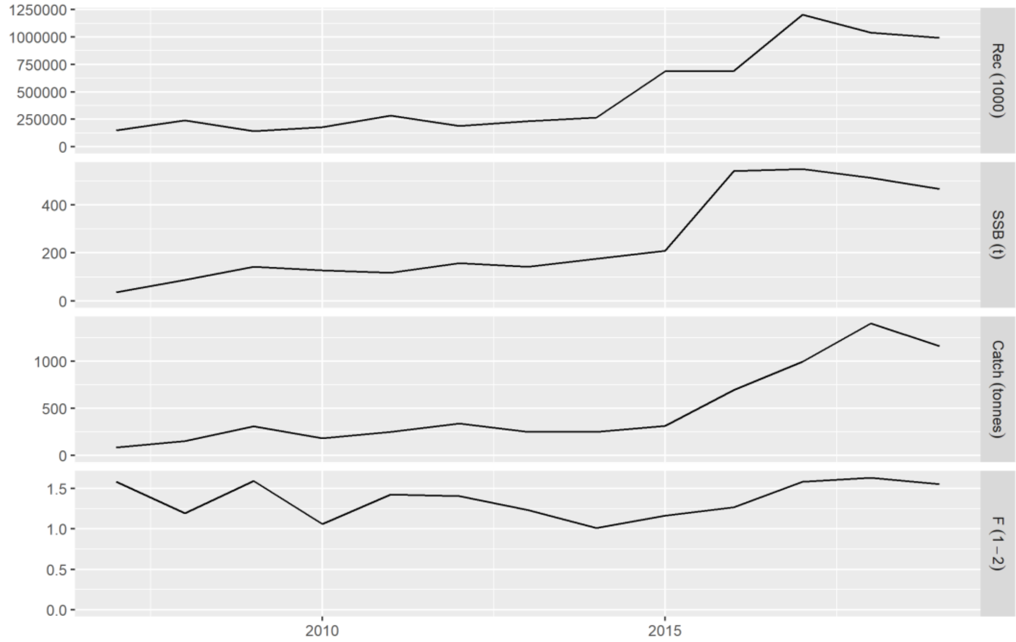


Figure 6.2.3.18. Deep-water rose shrimp GSAs 1-5-6-7. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

In the Tables 6.2.3.5 and 6.2.3.6 the population estimates of Deep water rose shrimp obtained by XSA are provided.

Table 6.2.3.5. Deep-water rose shrimp GSAs 1-5-6-7. Stock numbers at age (thousands) as estimated by XSA.

age	2007	2008	2009	2010	2011	2012	2013
0	150194	240492	141491	179933	282712	189392	232954
1	15074	32376	52274	30901	39284	61662	40966
2	867	798	2694	3085	2659	1944	3723
3+	19	19	2	136	166	68	10
age	2014	2015	2016	2017	2018	2019	
0	266203	686799	690522	1204111	1041763	992798	
1	50696	57603	148998	149603	237252	225759	
2	2659	5156	5543	19106	11691	7742	
3+	11	2	100	1318	131	50	

Table 6.2.3.6. Deep-water rose shrimp GSAs 1-5-6-7. XSA summary results and F at age.

	Fbar1-2	**Recruitment (thousands)**	**SSB (t)**	**TB (t)**
2007	1.59	150194	37.38	766.21
2008	1.20	240492	87.63	1325.44
2009	1.60	141491	141.99	1130.49
2010	1.06	179933	126.99	1131.81
2011	1.43	282712	118.23	1663.71
2012	1.41	189392	158.21	1433.81
2013	1.23	232954	142.20	1467.63
2014	1.01	266203	176.43	1638.55
2015	1.16	686799	209.36	3435.09
2016	1.27	690522	540.31	4058.74
2017	1.59	1204111	549.11	3318.34
2018	1.63	1041763	512.18	6369.79
2019	1.55	992798	466.04	5526.41

F at age	0	1	2	3+
2007	0.0145	2.09	1.08	1.08
2008	0.0044	1.64	0.76	0.76
2009	0.0014	1.98	1.21	1.21
2010	0.0018	1.60	0.53	0.53
2011	0.0017	2.16	0.70	0.70
2012	0.0111	1.96	0.86	0.86
2013	0.0050	1.88	0.59	0.59
2014	0.0107	1.43	0.60	0.60
2015	0.0075	1.48	0.85	0.85
2016	0.0081	1.18	1.36	1.36
2017	0.0001	1.67	1.50	1.50
2018	0.0086	2.55	0.72	0.72
2019	0.0055	2.25	0.86	0.86

The XSA results, summarized in Table 6.2.3.6 and in Figure 6.2.3.18, show an increasing trend in the catches, SSB and an estimated F_{curr} of 1.55.

The XSA assessment is in very good agreement with the trends in the a4a assessment but has lower F at ages 2 and 3, giving overall lower mean Fbar. However, the catchability at age of the XSA shown in Figure 6.2.3.19 was not deemed acceptable.

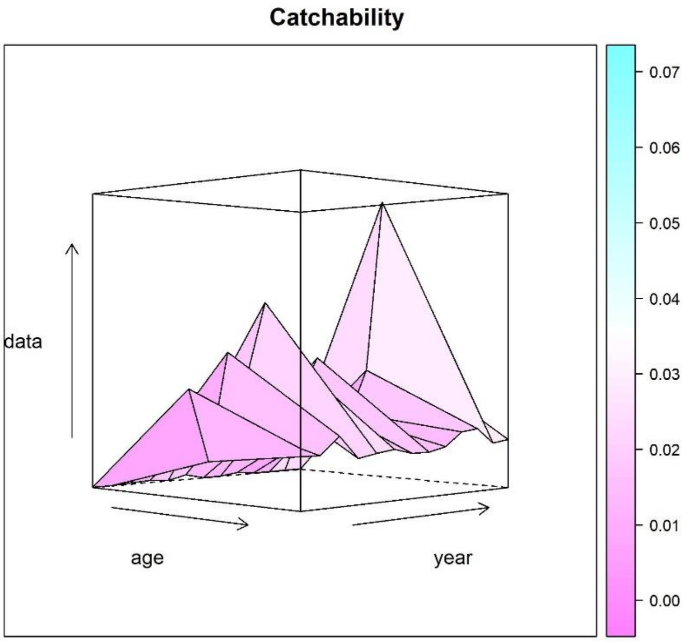


Figure 6.2.3.19. Deep-water rose shrimp GSAs 1-5-6-7. 3D contour plot of estimated catchability at age and year from XSA.

Therefore, the EWG 20-09 concluded that the output of this model was not suitable to provide the basis of the current status of the stock but, as for a4a, could be used as indicative of a trend.

6.2.4 Reference Points

As the assessment carried out during EWG 20-09 was not accepted for advice, reference points were not calculated.

6.2.5 Short term Forecast and Catch Options

Since the a4a and XSA models were accepted as indicative of trends, the mean of the SSB estimates from the two models was used as a biomass index.

Following the ICES procedures the change in the estimated SSB over the last five years was used to provide an index for change (Figure 6.2.5.1).

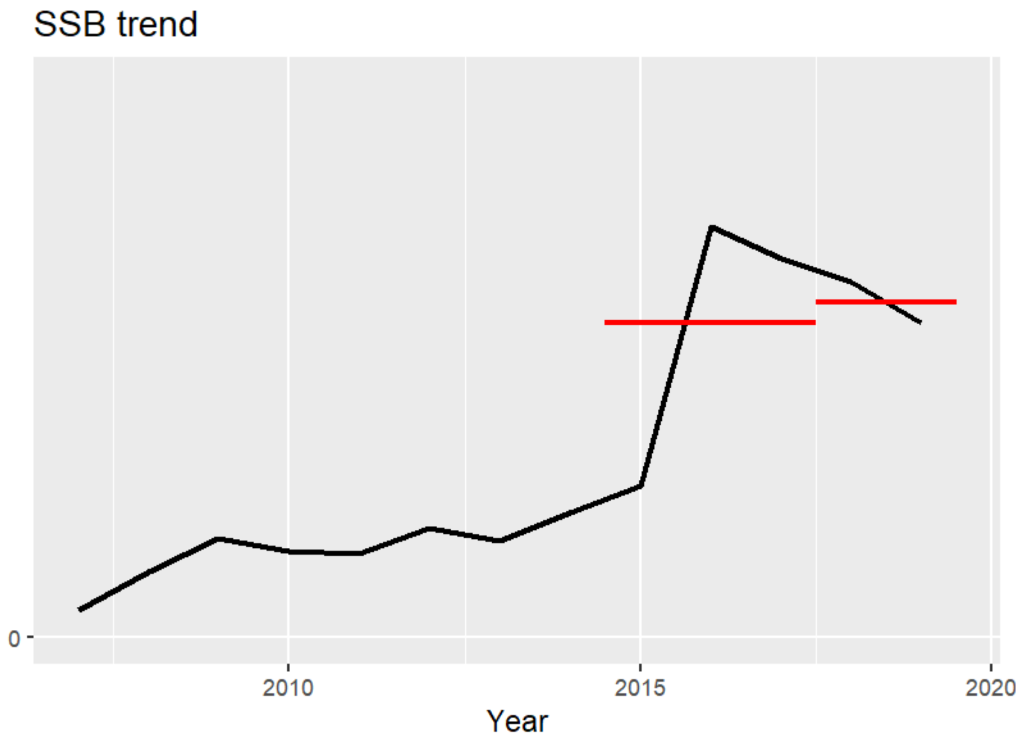


Figure 6.2.5.1 Deep-water rose shrimp GSAs 1-5-6-7. Biomass index based on the average SSB estimated by a4a and XSA models.

The index obtained by dividing the mean of the last two years by the mean of the previous three results in a value of 1.07. As this index is not higher than 1.2, STECF EWG 20-09 advises to increase the total catch by 7% relative to the advised catches in 2019-2020 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. The precautionary buffer of -20% is not applied because it was applied in 2018. Overall the advice is a reduction in catch of 41%, because in 2018 and 2019 the catches have increased above the advised level, thus requiring a reduction to mean the smaller 7% increase advised.

6.3 Red Mullet in GSA 1

6.3.1 Stock Identity and Biology

Due to a lack of information about the structure of red mullet population in the western Mediterranean, this stock was assumed to be confined within the GSA 1 boundaries

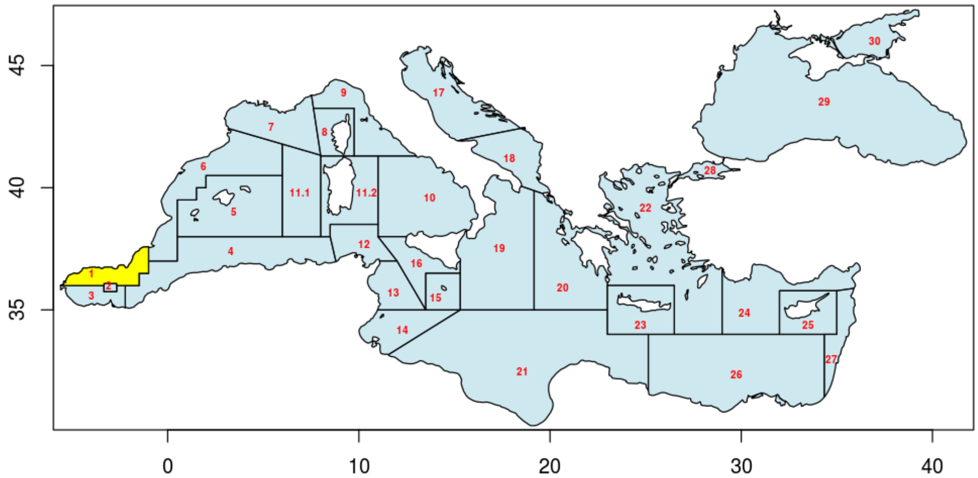


Figure 6.3.1.1 Geographical location of GSA 1

Red mullet 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 composed by 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 continental shelf and slope fishing grounds. Red mullet is intensively exploited during its recruitment from August to November.

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.
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 (Linf=34.5, k=0.34, t0=-0.143) with a 0.5 added in the t_0 according to the suggestions of the EWG in order to align the growth correctly with the length slice based on the calendar year Jan-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. These parameters were used in the statistical catch at age assessment (a4a).

A vector of natural mortality was estimated by Chen Watanaby method (Chen S. & Watanabe S., 1989) using growth and length-weight relationship parameters for sex combined.

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 6.3.1.1 Red mullet GSA 1. Maturity and natural mortality.

Age	1	2	3	4+
Maturity	1	1	1	1
M	0.79	0.57	0.47	0.42

6.3.2 Data

6.3.2.1 Catch (landings and discards)

Total landings of Red mullet in GSA 1 as reported in the DCF.

Table 6.3.2.1.1 Red mullet GSA 1. Landings data in tonnes by year.

Year	2002	2003	2004	2005	2006	2007
Landings	111.28	159.68	154.07	140.21	164.54	194.01
	2008	2009	2010	2011	2012	2013
	193.65	228.37	201.65	201.18	107.31	131.63
	2014	2015	2016	2017	2018	2019
	123.87	135.9	260.49	274.67	170.23	124.63

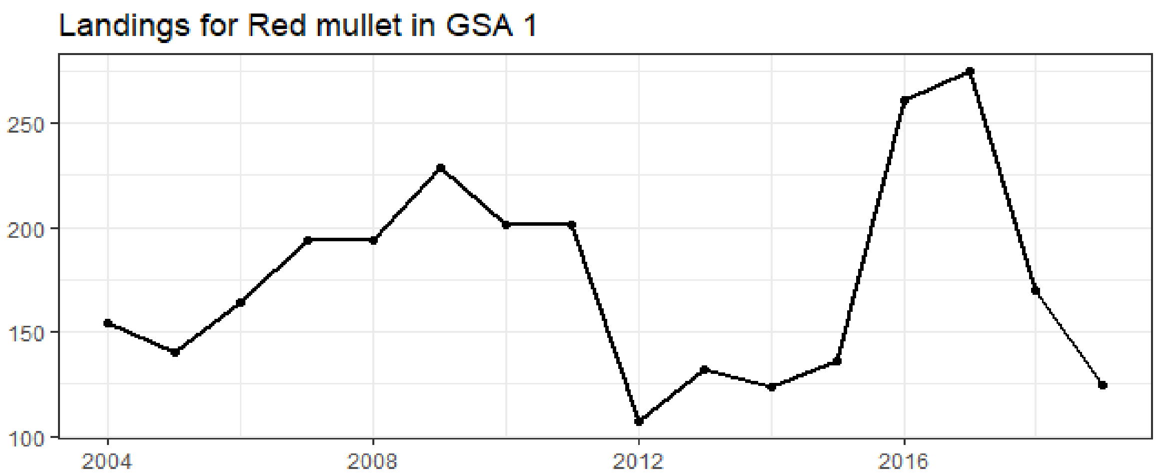


Figure 6.3.2.1.1 Total landings by year for Red mullet in GSA 1

The maximum catch through the years occurs in 2017 with a value of 275 tonnes while the minimum occurs in 2012 with a value of 107 tonnes. Catches in 2019 are close to long term minimum.

Table 6.3.1.1.2 Red mullet GSA 1. Landings by year and gear.

Year	GNS	GTR	LHP	OTB	PS
2002	0	10.02	0	101.26	0
2003	0	16.8	0	142.88	0

2004	0	11.9	0	142.17	0
2005	0	12.49	0	127.72	0
2006	0	13.07	0	151.47	0
2007	0	12.48	0	181.53	0
2008	0	12.59	0	181.06	0
2009	0	23.39	0	202.98	2
2010	0	13.68	0	186.61	1.36
2011	0	17.8	0	182.35	1.03
2012	0	33.84	0	72.94	0.53
2013	0	14.22	1.34	115.76	0.31
2014	0	0.98	0	122.37	0.52
2015	0.03	8.97	0.22	126.06	0.62
2016	0.46	78.29	1.13	180.61	0
2017	0	63.89	0	210.78	0
2018	0	21.88	0	148.35	0
2019	0	17.49	0	107.13	0

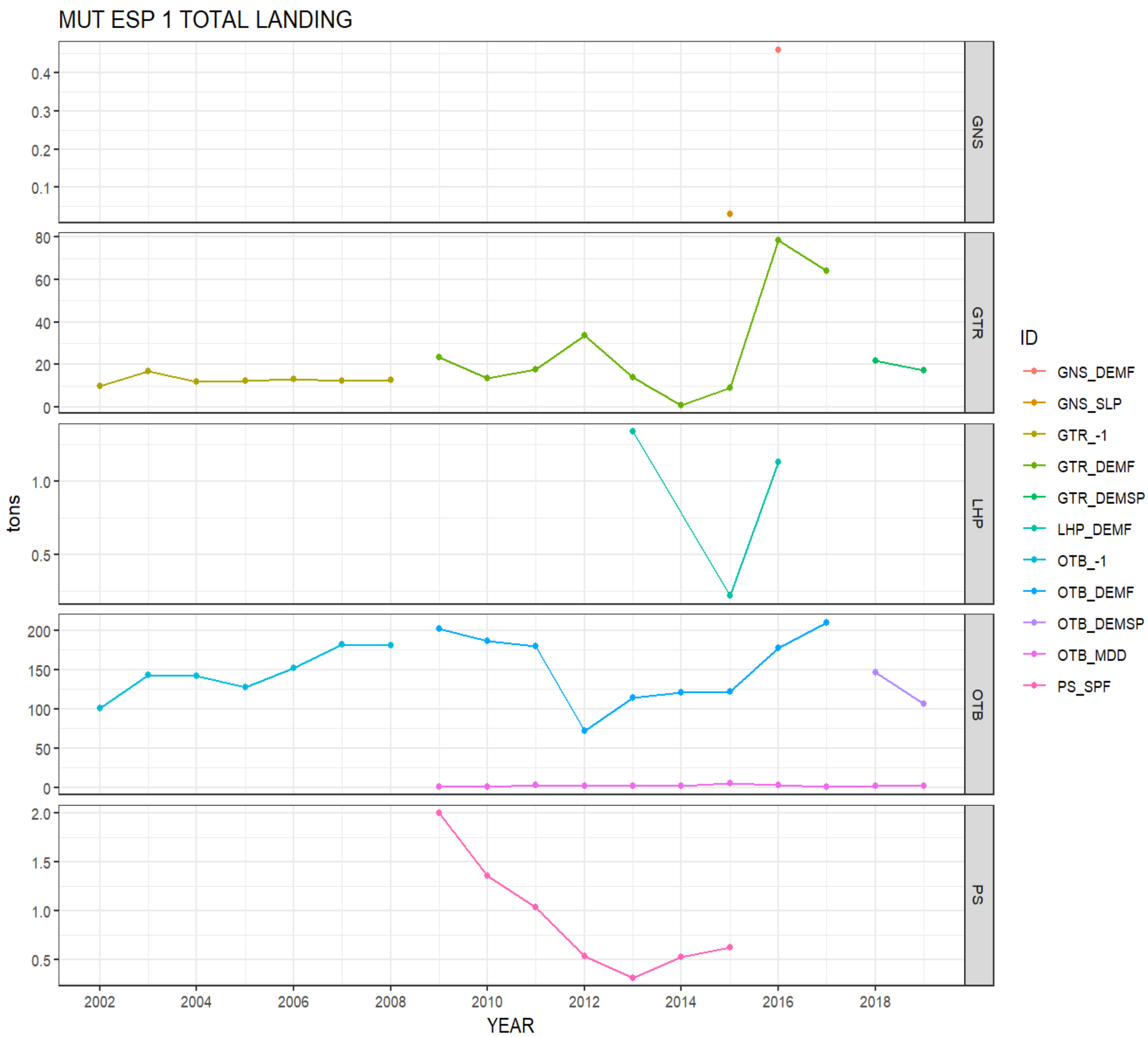


Figure 6.3.2.1.2 Total landings by year and gear for Red mullet in GSA 1.

Length frequency distributions of the landings by year and by fleet and year for the Red mullet are presented in figures 6.3.2.1.3 and 6.3.2.1.4

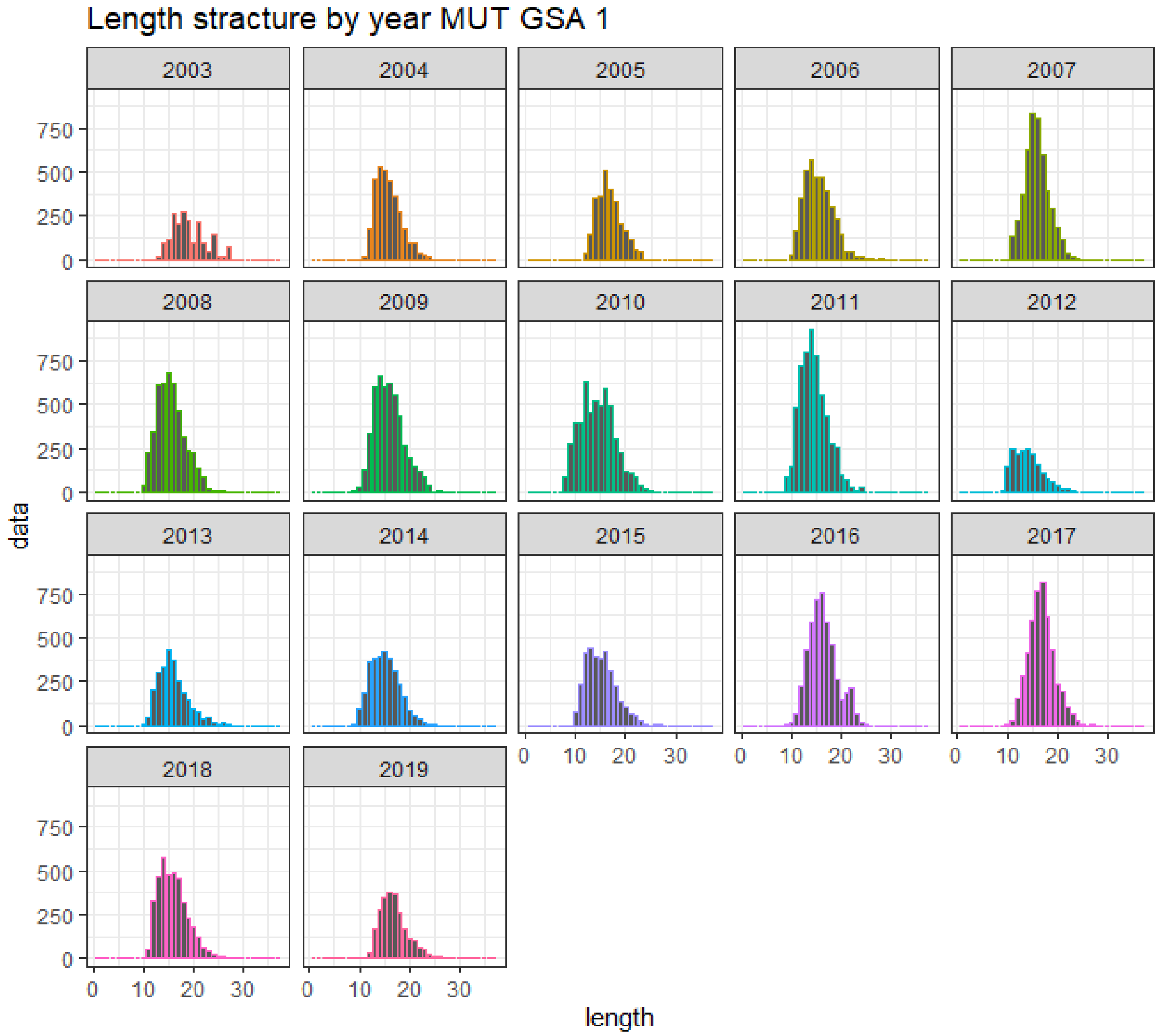


Figure 6.3.2.1.3 Length frequency distribution of Red mullet landings in GSA 1.
Length frequency distribution of Red mullet in GSA 1 in 2012 provided by the Spanish DCF was wrong. A corrected version was provided by Spanish experts during the EWG, only LFD for the OTB, which was used in the assessment.

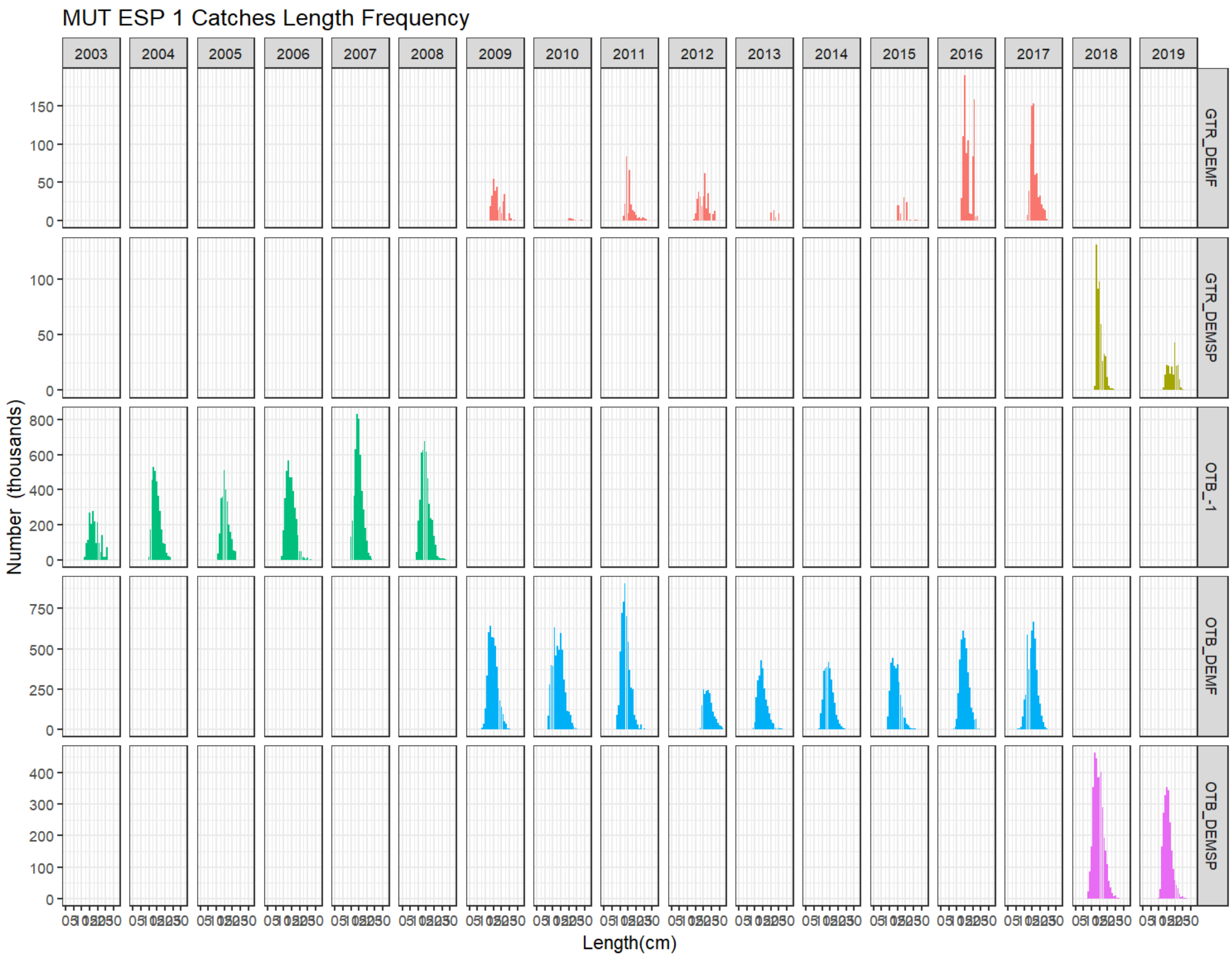


Figure 6.3.2.1.4 Length frequency distribution of Red mullet landings by year & gear in GSA 1.

DISCARDS

Discards of Red mullet in GSA 1 provided by the Spanish DCF. Discards for Red mullet in GSA 1 are considered to be negligible due to very low percentage in catch and also due to misreporting especially in the beginning of the time series. The highest percentage in the catch is reported in 2016 at 3% and the average throughout the years is 1%. Also no length frequency distribution was provided from the Spanish DCF except for the years 2017 and 2018.

Table 6.3.2.1.2 Red mullet GSA 1. Discards by year.

year	discards
2008	0.16
2009	1.09
2010	0.01
2011	0.13
2012	1.65
2013	0.28
2014	3.28
2015	1.76
2016	7.61
2017	3.48

2018	2.79
2019	0.4

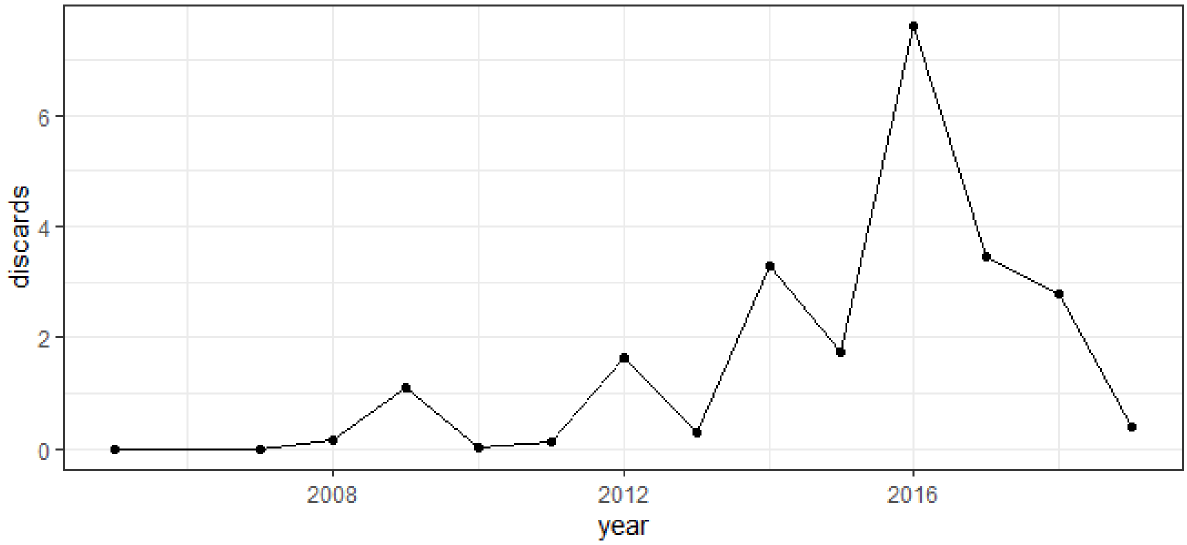


Figure 6.3.2.1.5 Red mullet in GSA 1. Discards by year.

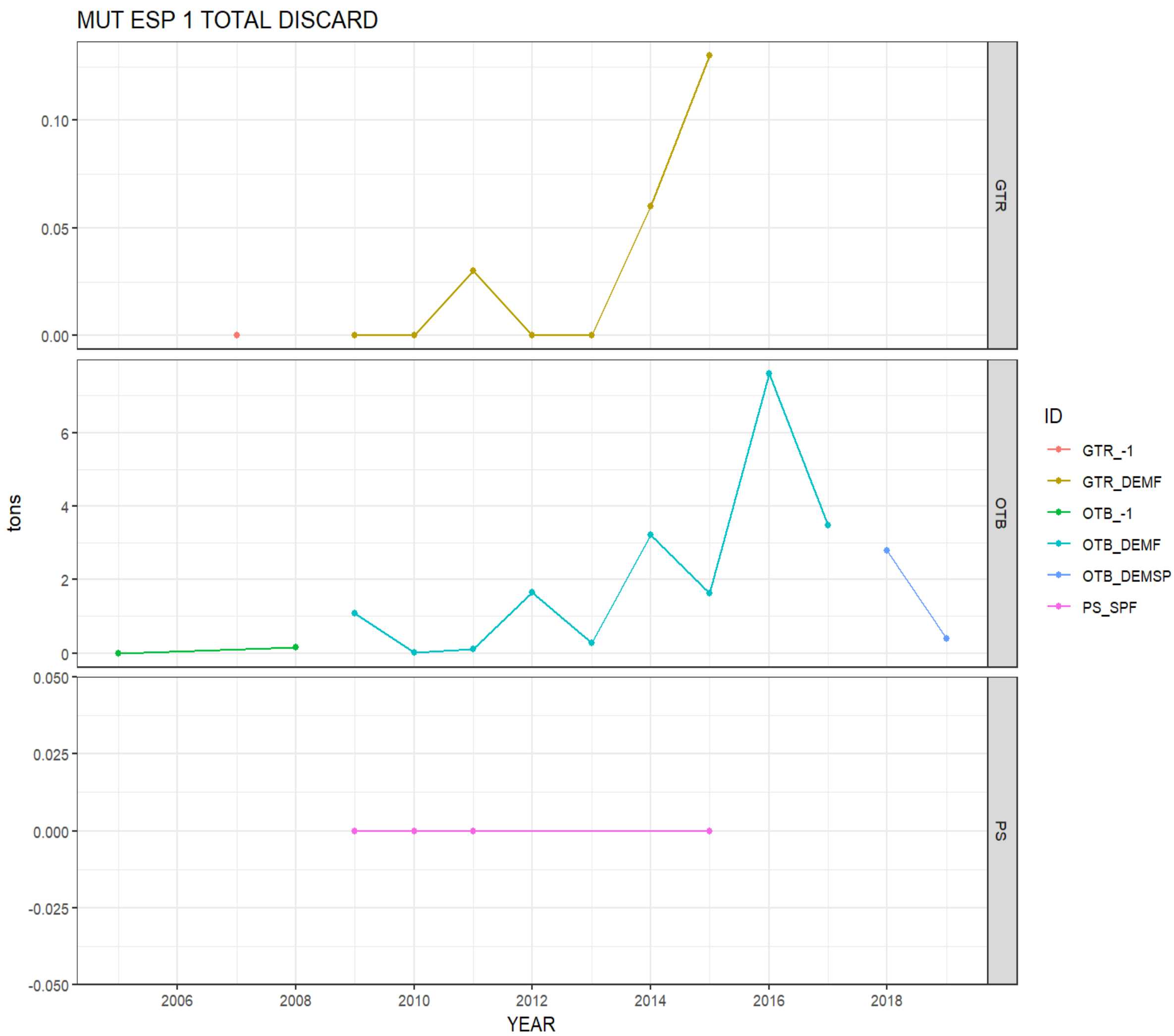


Figure 6.3.2.1.6 Red mullet in GSA 1. Discards by year and gear.

Spanish DCF reported length frequency distribution of discarded Red mullet only for the years 2017 and 2018.

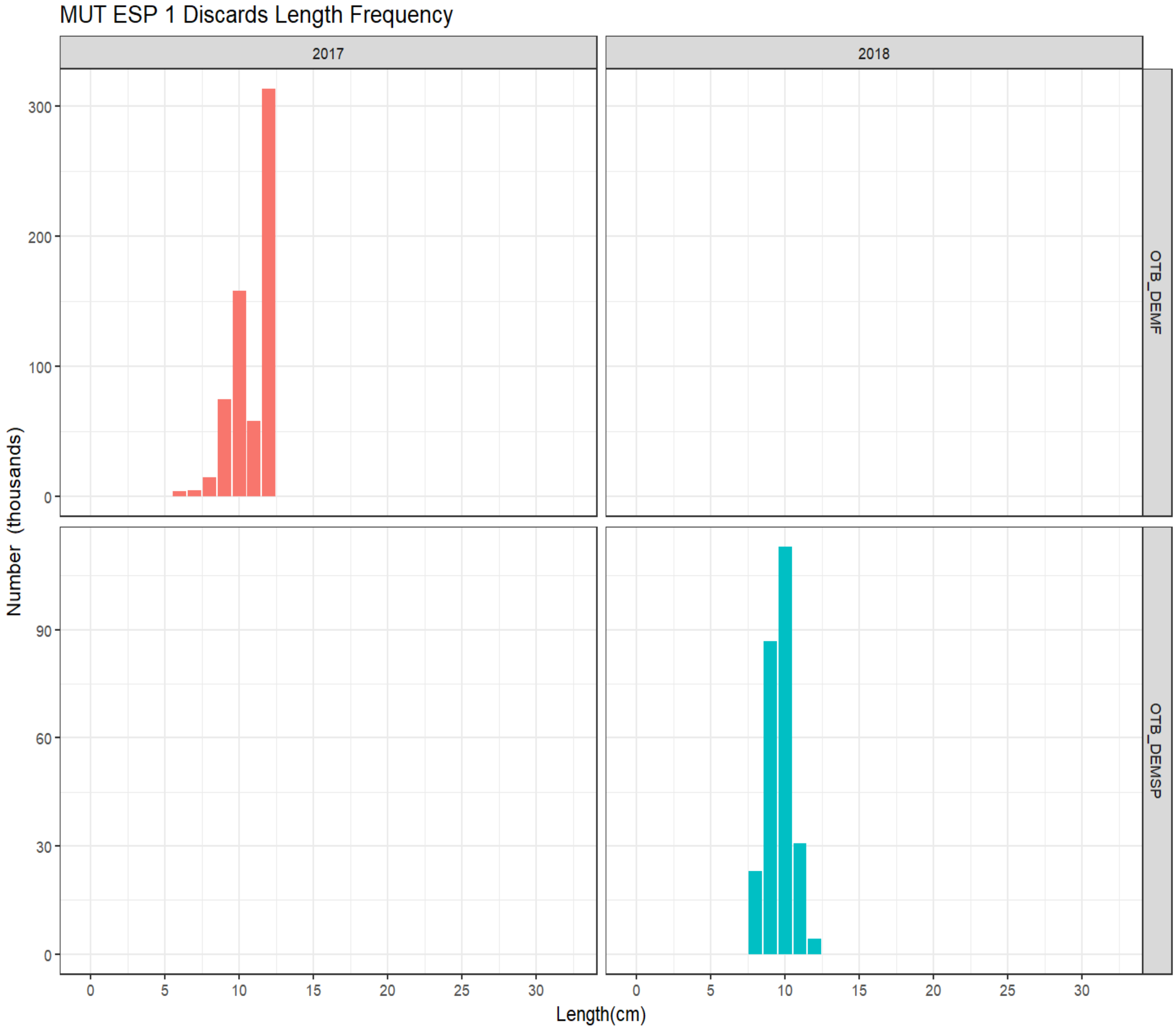


Figure 6.3.2.1.7 Red mullet in GSA 1. Discards length frequency distribution by year and gear.

6.3.2.2 Effort

Red mullet is caught by mixed fisheries, using a variety of fishing gears (trammel nets, trawls), by fishing boats of different sizes and métiers. Although the main bulk of the catch comes from the trawlers. In such situation, red mullet is only one component of entire catch, fishing effort specifically related to red mullet only cannot be obtained independent of other fisheries.

Table 6.3.2.2.1 Effort in gt X days at sea, days at sea and fishing days for GSA 1 for trammel nets.

GTR			
Years	**GT * days at sea**	**days at sea**	**fishing days**
2002	16851	4747	4747
2003	20530	5534	5534
2004	18075	5809	5809
2005	19536	5600	5600
2006	20914	5937	5937
2007	18456	5474	5474
2008	19906	5964	5964
2009	33983	9455	9455
2010	29579	9039	9039
2011	31878	10388	10388
2012	31833	10172	10172
2013	37276	12423	12423
2014	38856	13663	13663
2015	28649	9810	9810
2016	28699	10189	10189
2017	31995	10586	10586
2018	23408	8424	8424

Table 6.3.2.2.2 Effort in gt X days at sea, days at sea and fishing days for GSA 1 for trawlers.

OTB			
Years	**GT * days at sea**	**days at sea**	**fishing days**
2002	1333918	28002	28002
2003	1684655	32892	32892
2004	1894693	34951	34951
2005	1761339	32295	32295
2006	1685266	31443	31443
2007	1631930	29917	29917
2008	1495816	26201	26201
2009	1520713	27017	27017
2010	1568334	28476	28476
2011	1507685	28170	28170
2012	1395133	25851	25851

2013	1295309	24334	24334
2014	1159530	22395	22395
2015	1102193	21587	21587
2016	1083165	21345	21345
2017	1131873	22537	22537
2018	1079838	21633	21633

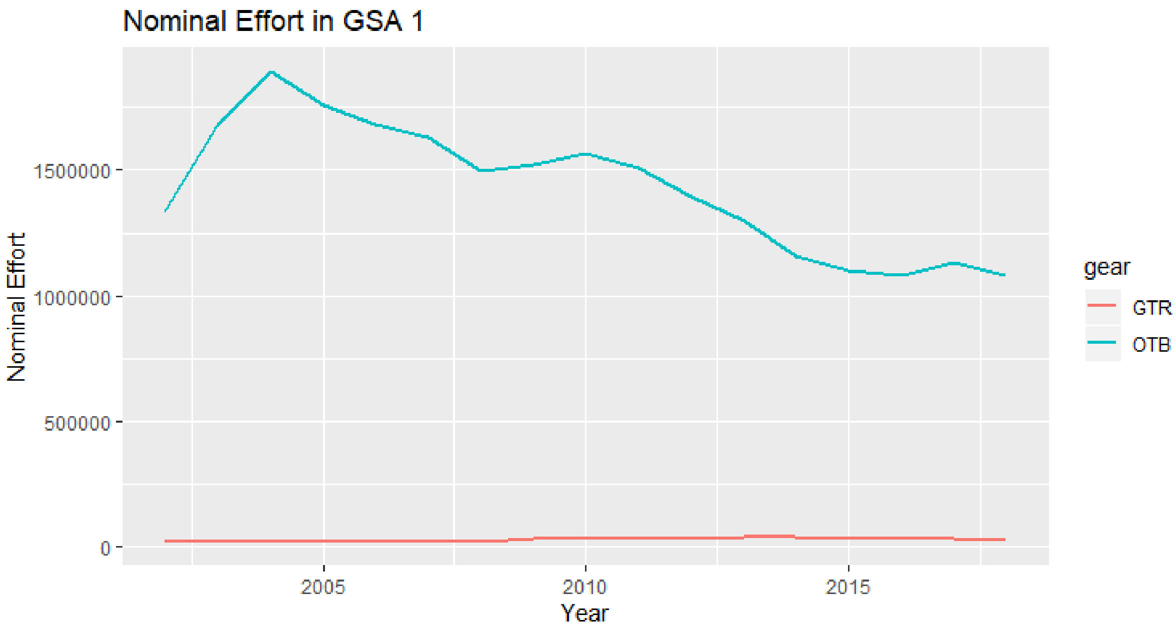


Figure 6.3.2.2.1 Nominal effort for GSA 1 for trawlers and trammel nets.

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). 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 were calculated.

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.

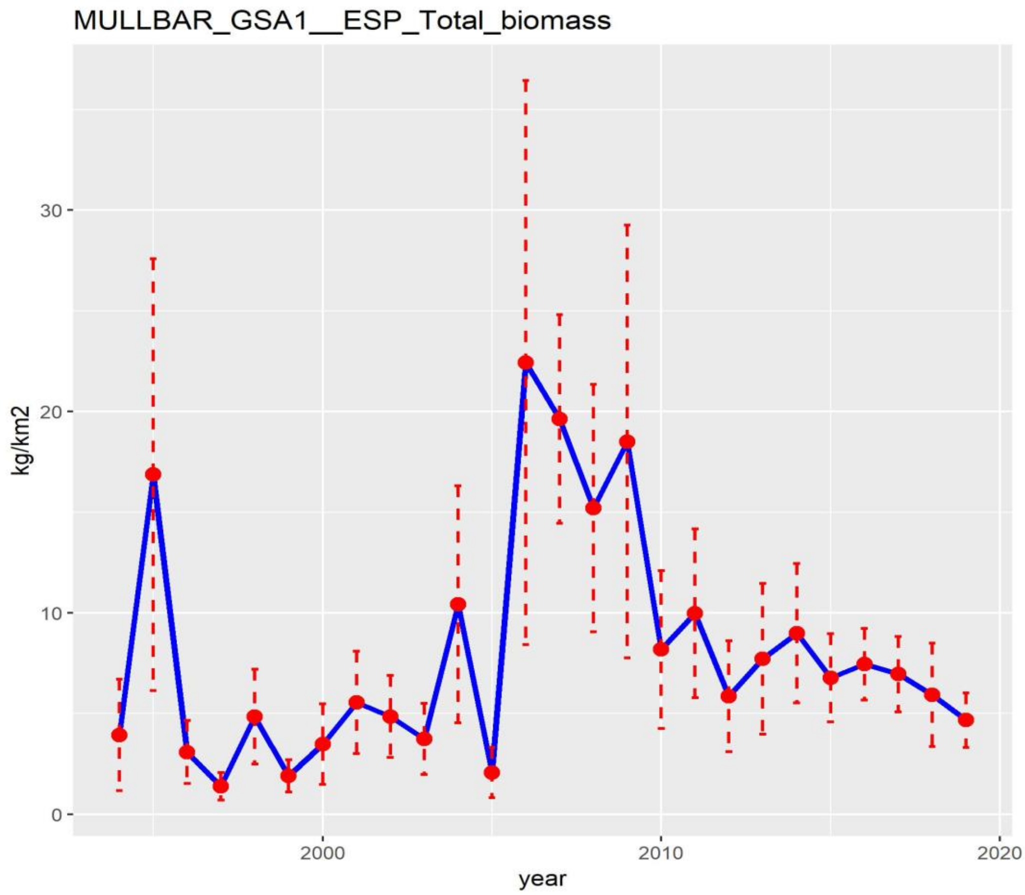


Figure 6.3.2.3.1. Red mullet in GSA 1. Estimated biomass index.

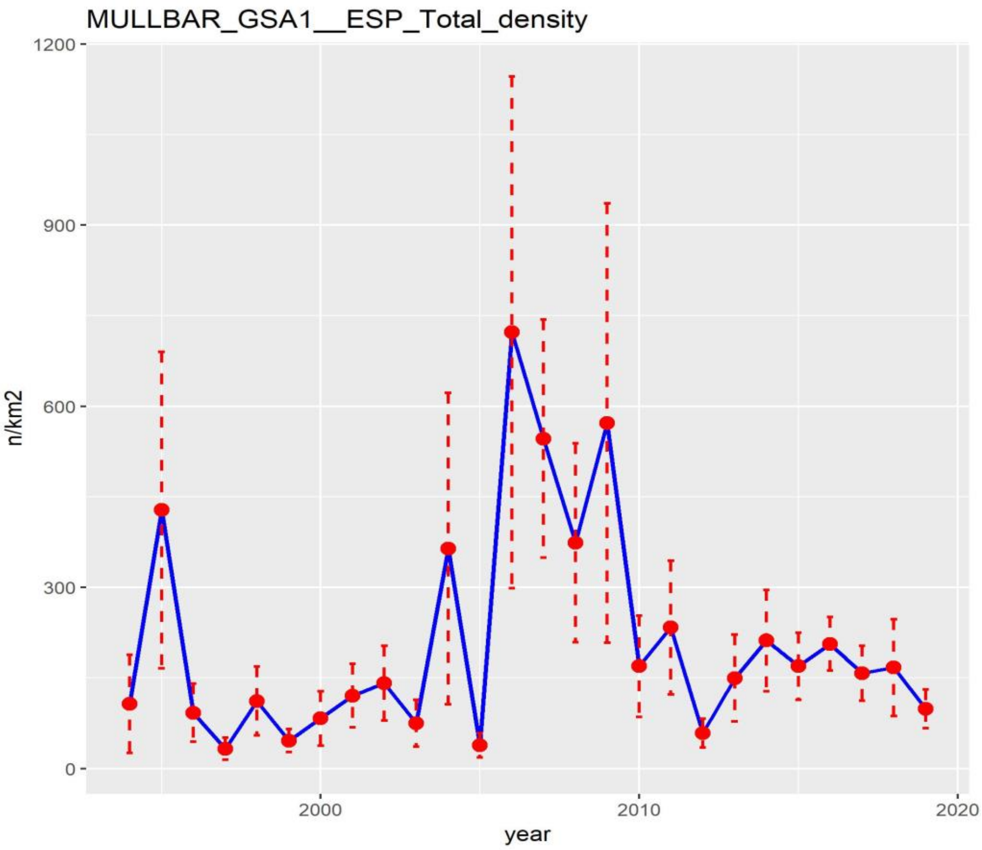


Figure 6.3.2.3.2. Red mullet in GSA 1. Estimated abundance index.

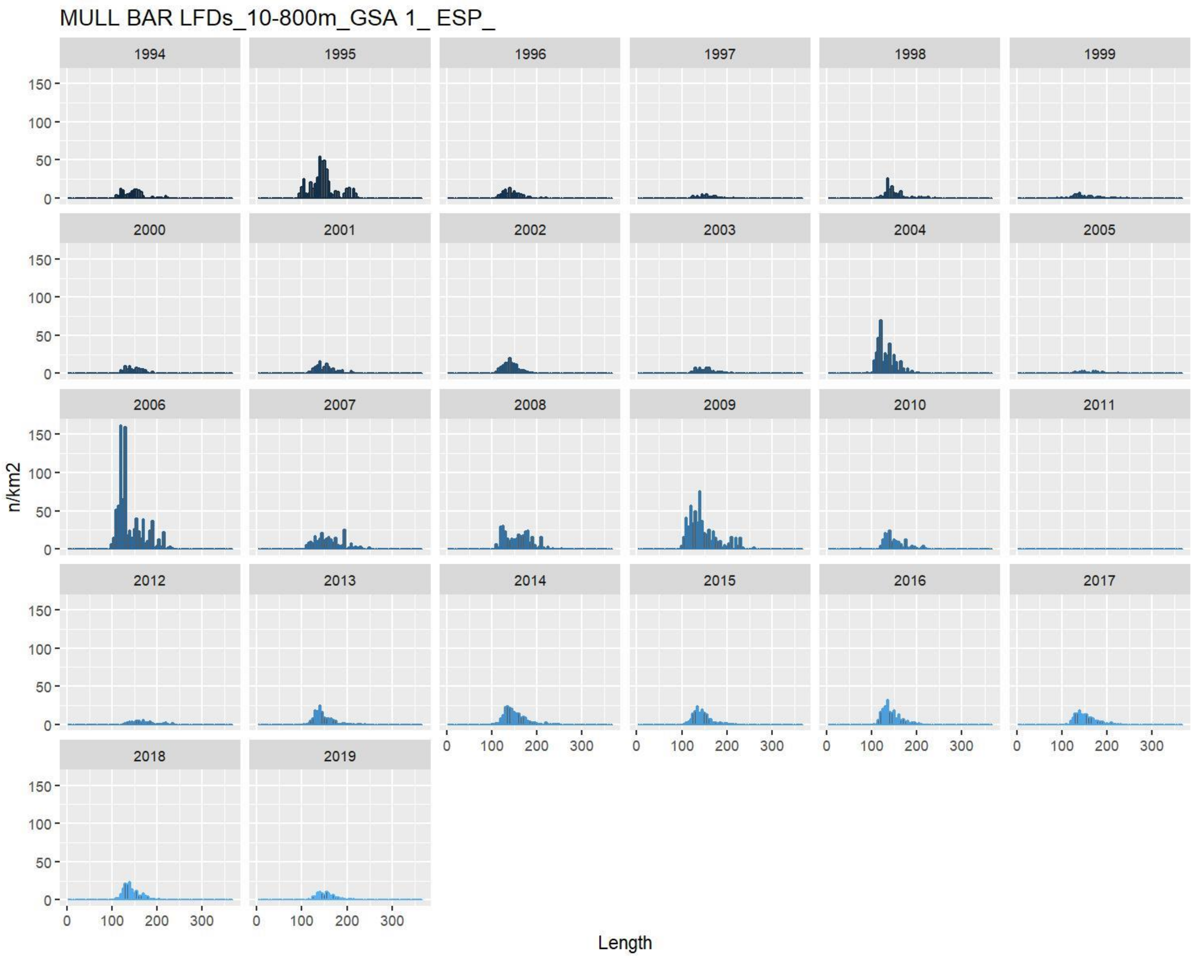


Figure 6.3.2.3.3. Red mullet in GSA 1. Length frequency distribution for the medits index for the years 1994 – 2018.

6.3.3 STOCK ASSESSMENT

STECF EWG 20-09 was asked to assess the status of Red mullet in GSA 1. Only one method was used to assess the status of Red mullet, a statistical catch at age 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 as input catch data from 2004 to 2019 due to misreported length frequency distribution of catch in 2003. For the tuning fleet, MEDITS survey was used for the years 2004 – 2019.

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 (6.2.1.1) 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 varies between 3 – 10% but in the year 2012 the value seem very high probably due to the misreported length frequency that year.

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

year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
SoP	1.01	1.03	0.93	0.99	0.89	0.89
year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
SoP	0.94	0.98	0.94	1.67	1.03	0.94
year	**2015**	**2016**	**2017**	**2018**	**2019**	
SoP	0.96	1.05	1.03	0.90	0.91	

The following tables lists the input parameters to the a4a, namely catches, catch numbers at age, mean weight at age, natural mortality at age, maturity at age and proportion of F and M before spawning, along with their figures.

Table 6.3.3.2 Red mullet in GSA 1. Total catch by year.

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Catch	111.28	159.68	154.07	140.21	164.54	194.01
	2008	**2009**	**2010**	**2011**	**2012**	**2013**
	193.65	228.37	201.65	201.18	107.31	131.63
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
	123.87	135.9	260.49	274.67	170.23	124.63

Table 6.3.3.3 Red mullet in GSA 1. Catch numbers at age by year.

age	**year**				
	2004	**2005**	**2006**	**2007**	**2008**
1	1217	502	1598	1203	1657
2	1823	1683	1840	2596	2073
3	275	358	264	318	438
4	1	1	11	1	14
	2009	**2010**	**2011**	**2012**	**2013**
1	1668	2708	2966	1849	913
2	2348	2070	2163	1065	1426
3	551	372	226	151	280
4	17	12	9	2	24
	2014	**2015**	**2016**	**2017**	**2018**
1	1328	1496	1398	908	1277
2	1410	1417	2940	3333	1772

3	200	257	658	647	384
4	4	6	6	8	18
	2019				
1	431				
2	1381				
3	324				
4	17				

Table 6.3.3.4 Red mullet in GSA 1. Mean weight at age.

age	year				
	2004	**2005**	**2006**	**2007**	**2008**
1	0.026	0.028	0.024	0.025	0.024
2	0.051	0.053	0.052	0.051	0.051
3	0.106	0.104	0.104	0.101	0.102
4	0.186	0.186	0.195	0.186	0.187
	2009	**2010**	**2011**	**2012**	**2013**
1	0.024	0.019	0.022	0.020	0.025
2	0.052	0.052	0.050	0.050	0.050
3	0.110	0.109	0.108	0.106	0.109
4	0.191	0.182	0.188	0.182	0.191
	2014	**2015**	**2016**	**2017**	**2018**
1	0.022	0.022	0.025	0.026	0.025
2	0.051	0.051	0.051	0.054	0.052
3	0.105	0.106	0.110	0.106	0.105
4	0.177	0.192	0.180	0.178	0.187
	2019				
1	0.027				
2	0.053				
3	0.111				
4	0.188				

Table 6.3.3.4 Red mullet in GSA 1. Maturity, natural mortality, proportion of F and M before spawning.

age	1	2	3	4+
maturity	1	1	1	1
M	0.79	0.57	0.47	0.42

Prop M	0.375	0.375	0.375	0.375
Prop F	0.375	0.375	0.375	0.375

For the tuning index of the a4a method the STECF EWG decided to use the MEDITS abundance index for the period 2004 – 2019 in order to correspond to the existing data for the distribution of catches at age. Age slicing was also performed to the length frequency distribution of abundance index. The following table presents the estimated numbers at age for the MEDITS tuning index.

Table 6.3.3.5 Red mullet in GSA 1. Survey index at age.

age	**year**				
	2004	**2005**	**2006**	**2007**	**2008**
1	280.13	12.59	204.17	91.40	131.47
2	80.09	21.68	43.76	118.54	157.34
3	3.89	3.66	1.15	22.85	27.77
	2009	**2010**	**2011**	**2012**	**2013**
1	351.16	94.47	NA	13.84	93.79
2	131.86	65.16	NA	33.38	50.94
3	59.71	9.96	NA	11.24	5.05
	2014	**2015**	**2016**	**2017**	**2018**
1	114.43	105.98	132.25	76.23	108.06
2	88.56	58.72	70.43	72.20	55.84
3	8.85	4.85	3.74	9.31	3.30
	2019				
1	20.67				
2	68.46				
3	9.10				

The following figures show the age structure of the catches and of the index.

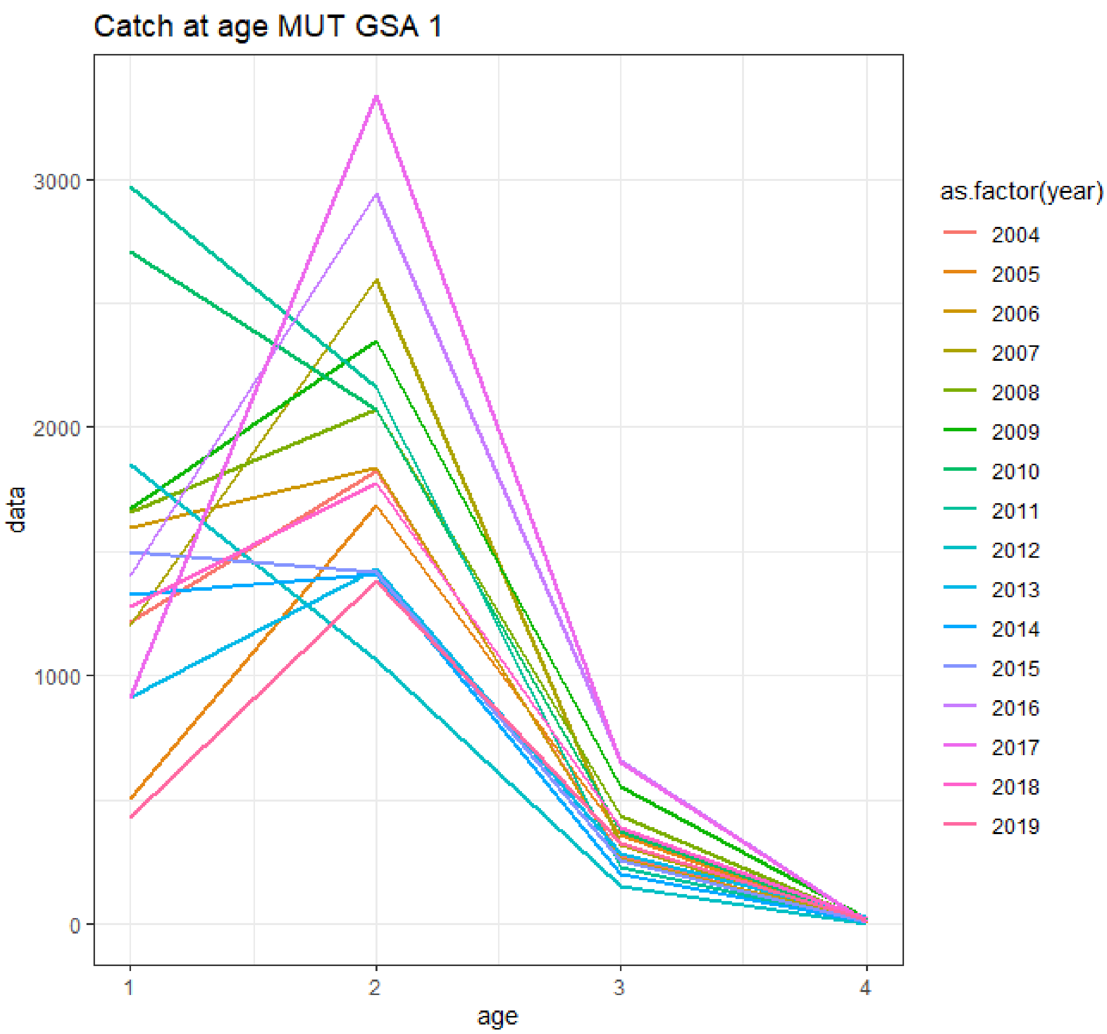


Figure 6.3.3.1. Red mullet in GSA 1. Catch number at age for the years 2004 – 2019.

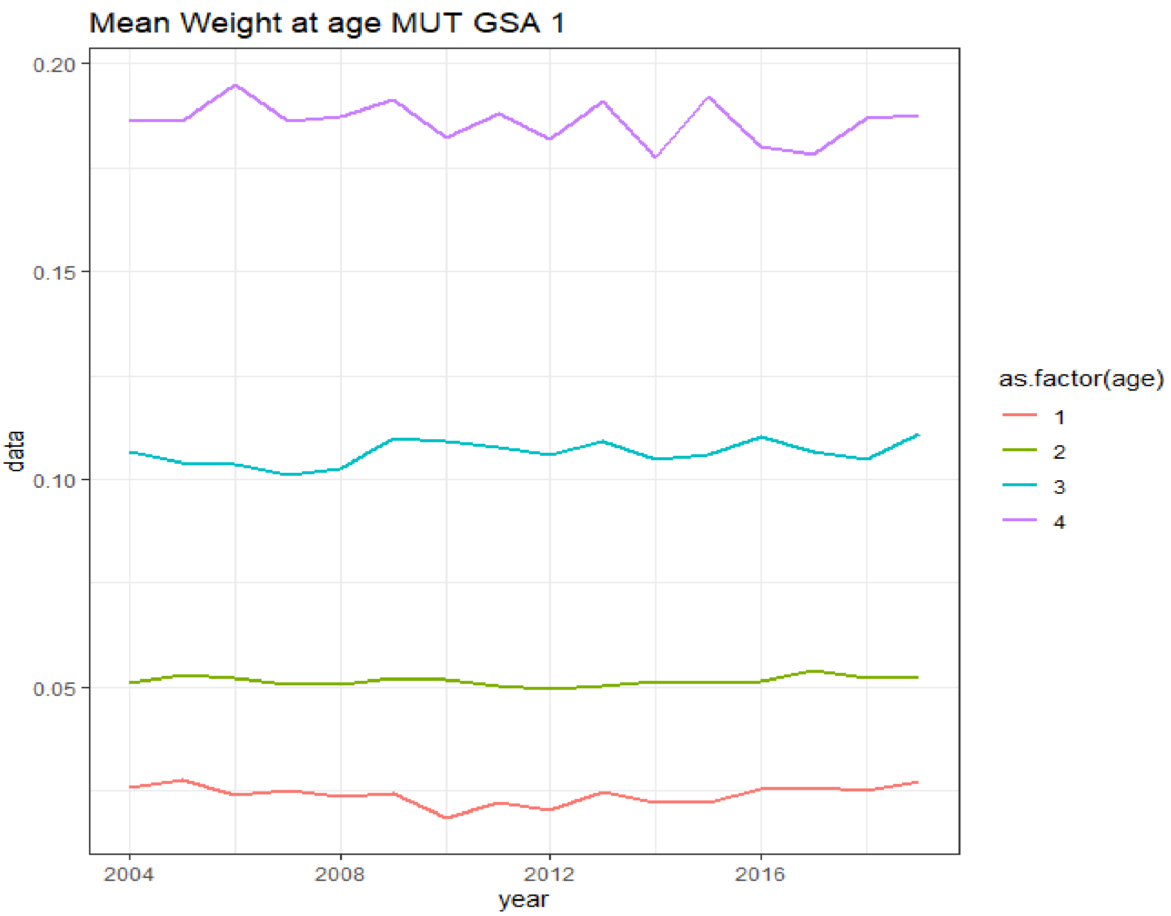


Figure 6.3.3.3. Red mullet in GSA 1. Mean weight for each year and age.

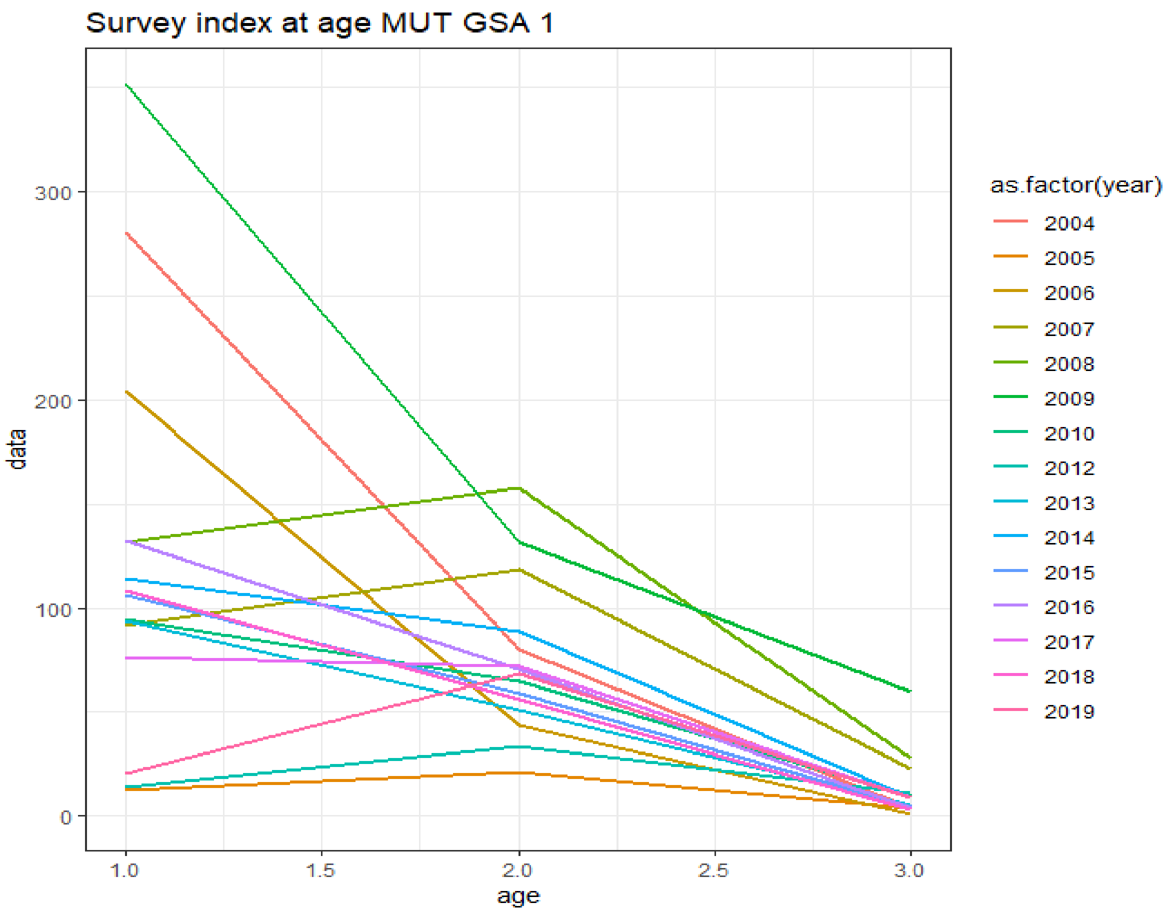


Figure 6.3.3.4. Red mullet in GSA 1. Survey index at age for the years 2004 -2019

Assessment Results

Different a4a models were investigated in terms of fishing mortality, catchability of the survey index and stock – recruitment relationship models (fmodel, qmodel, srmodel). 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 19-10. A factor was selected to model years in the fmodel and a k = 8 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.

```
qmod <- list(~ factor(replace(age, age>2, 2)))
fmod1 <- ~ factor(age) + s(year, k =7)
srmod <- ~ s(year, k=8)
```

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 6.3.3.5. Red mullet in GSA 1. Stock summary from the a4a model for Red mullet in GSA 20, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

The following plots present estimated fishing mortality by age and year and estimated catchability by age and year.

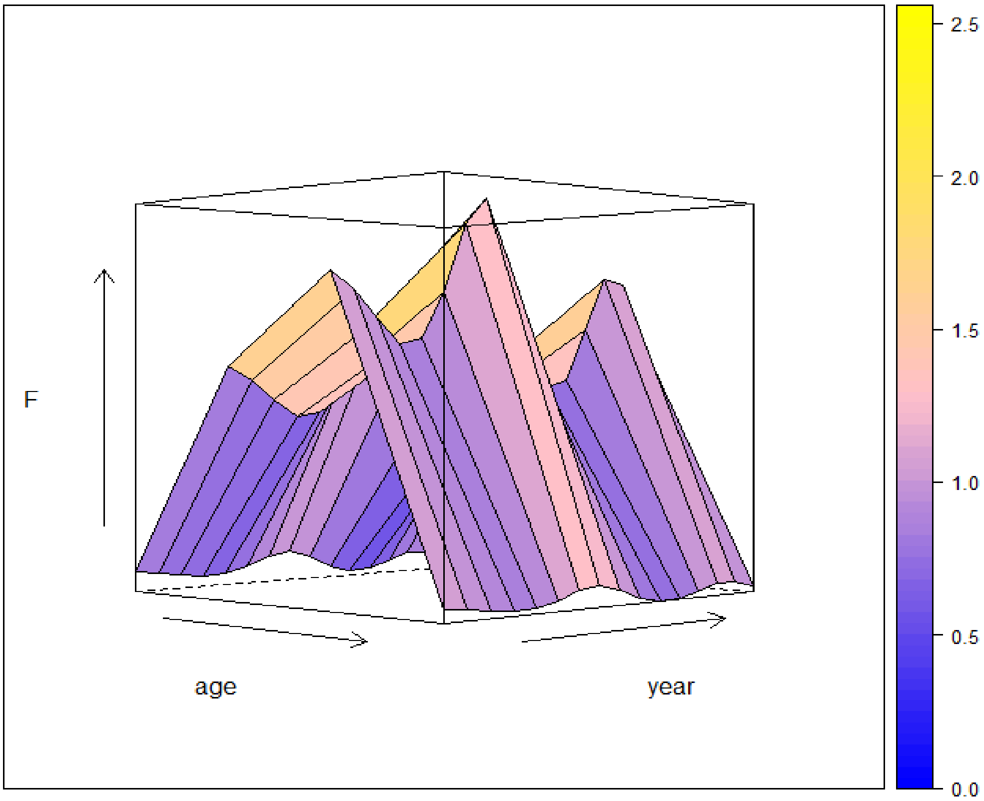


Figure 6.3.3.6. Red mullet in GSA 1. 3D contour plot of estimated fishing mortality by age and year.

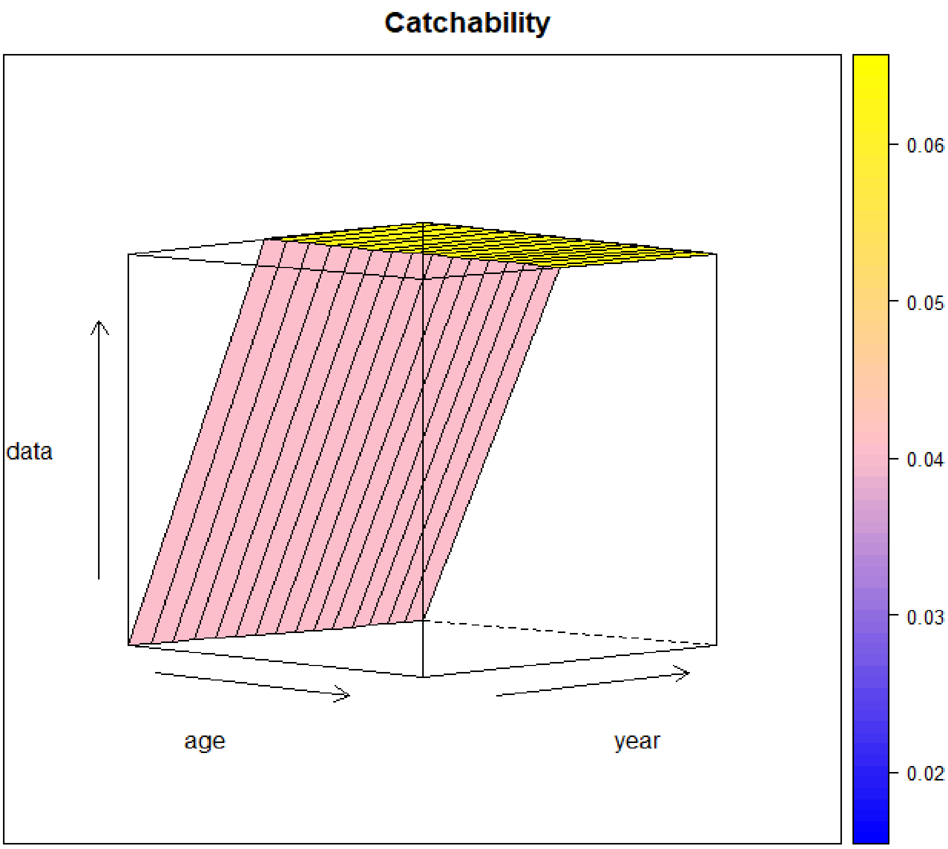


Figure 6.3.3.7. Red mullet in GSA 1. 3D contour plot of catchability by age and year.

Diagnostics
Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of Red mullet stock. Residuals of index showed a slight descending trend especially for the ages 2 and 3, due to the constraint of index catchability model. EWG 20-09 considered the fact that there is a trade of between a better fit and the best representative model of the catchability of the survey, and used a flat catchability ages 2 and 3 for the index.

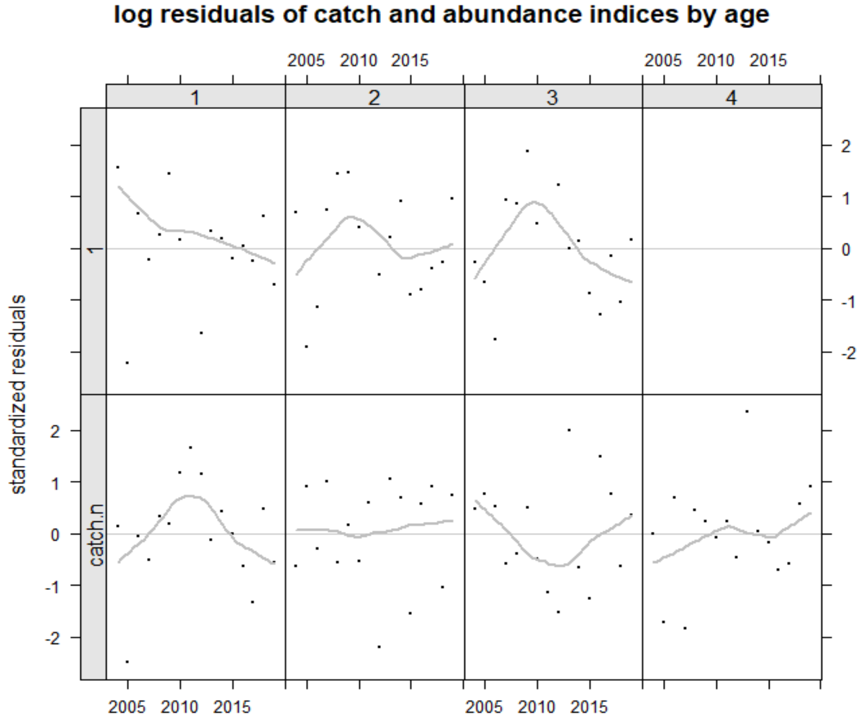


Figure 6.3.3.8. Red mullet in GSA 1. Standardized residuals for catch, abundance indices and for catch numbers.

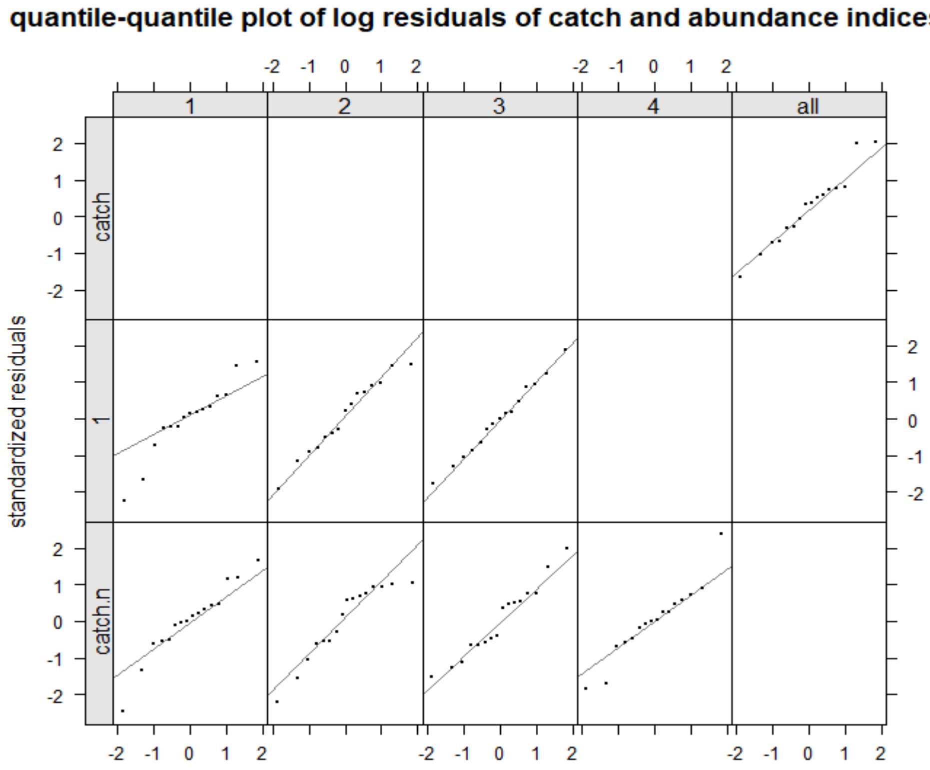


Figure 6.3.3.9. Red mullet in GSA 1. Quantile-quantile plot of standardized residuals for catch, abundance indices and for catch numbers.

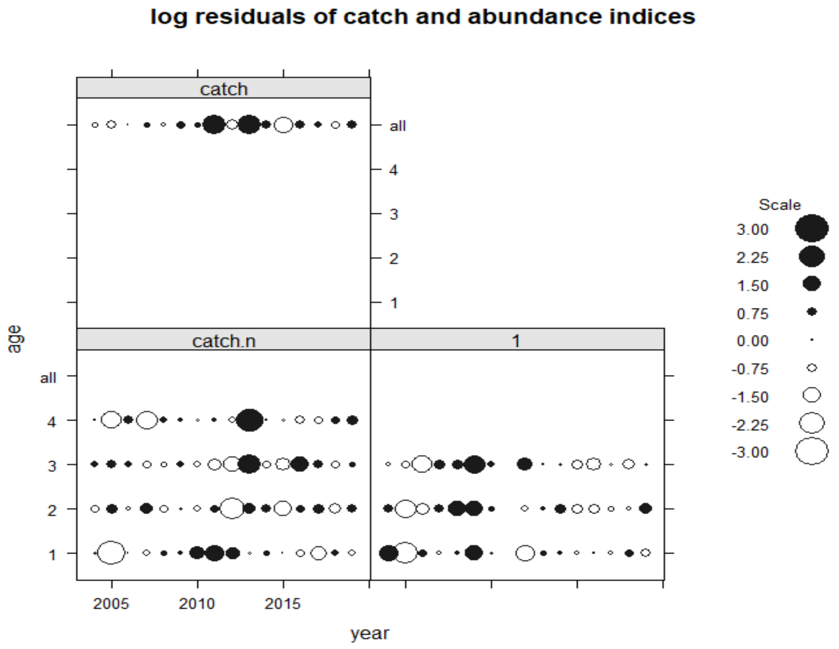


Figure 6.3.3.10. Red mullet in GSA 1. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

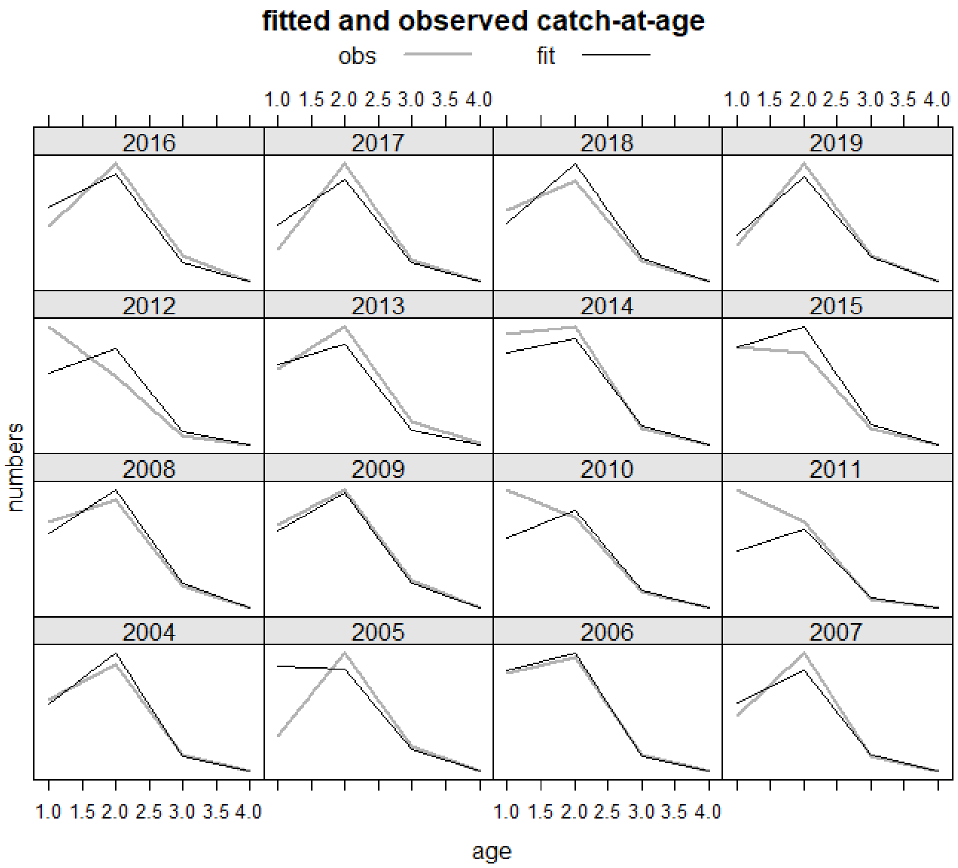


Figure 6.3.3.11. Red mullet in GSA 1. Fitted and observed catch at age.

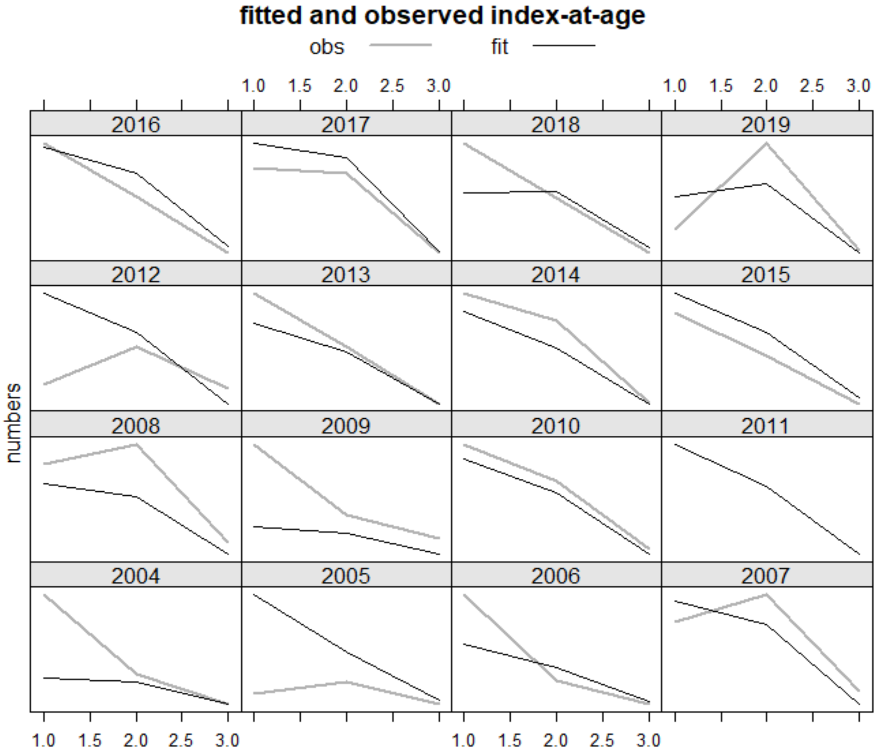


Figure 6.3.3.12. Red mullet in GSA 1. Fitted and observed index at age

RETROSPECTIVE

The retrospective analysis was applied only up to 3 years back due to the short time series. Models results were considered acceptably stable.

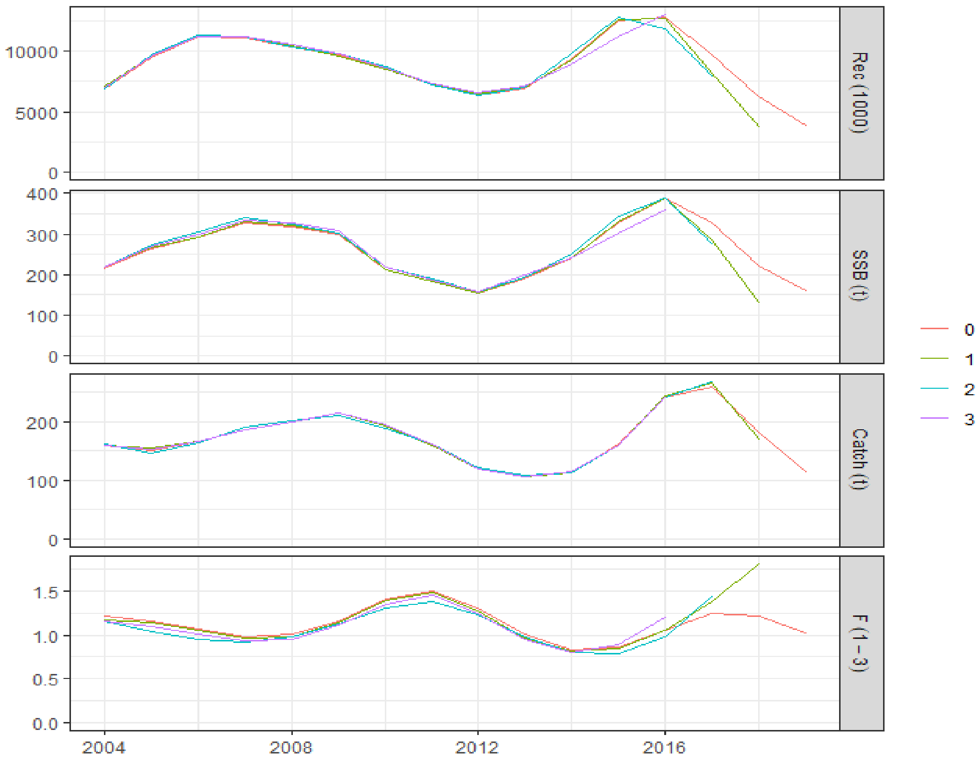


Figure 6.3.3.13. Red mullet in GSA 1. Retrospective analysis for the a4a model.

SIMULATIONS

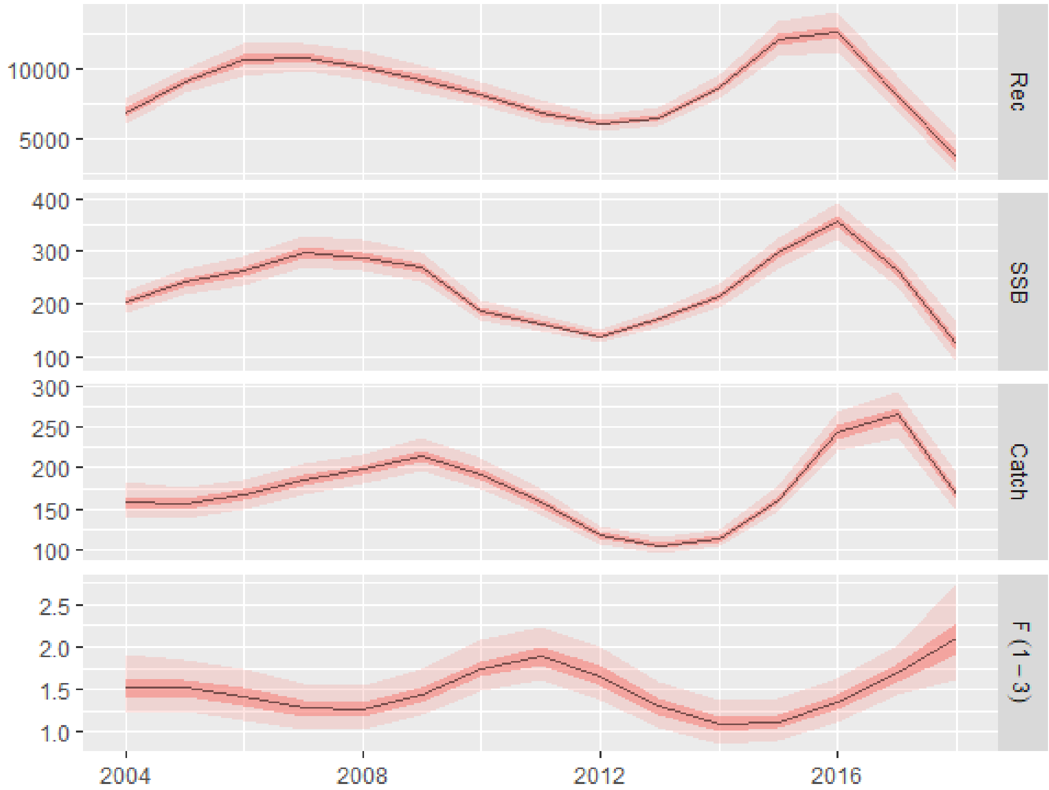


Figure 6.3.3.14. Red mullet in GSA 1. Stock summary of the simulated and fitted data for the a4a model.

Table 6.3.3.6. Red mullet GSA 1. F at age.

age	**year**				
	2004	**2005**	**2006**	**2007**	**2008**
1	0.27	0.27	0.25	0.23	0.22
2	1.54	1.53	1.43	1.29	1.27
3	2.74	2.73	2.55	2.31	2.27
4	1.54	1.53	1.43	1.29	1.27
	2009	**2010**	**2011**	**2012**	**2013**
1	0.26	0.31	0.34	0.30	0.23
2	1.45	1.76	1.91	1.68	1.31
3	2.60	3.15	3.40	2.99	2.34
4	1.46	1.77	1.91	1.68	1.31
	2014	**2015**	**2016**	**2017**	**2018**
1	0.19	0.20	0.24	0.30	0.37
2	1.10	1.13	1.36	1.72	2.12
3	1.97	2.02	2.43	3.07	3.79
4	1.11	1.13	1.36	1.72	2.13
	2019				

1	0.22				
2	1.22				
3	1.64				
4	1.19				

Table 6.3.3.7. Red mullet GSA 1. Estimated numbers at age.

	year					
age	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1	1147	1493	1626	1508	1432	1529
2	2016	1456	1926	2214	2265	2284
3	251	308	238	355	473	499
4	1	5	6	5	9	14
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
1	1614	1428	1111	962	1099	1505
2	2254	1966	1508	1208	1266	1809
3	410	283	204	190	227	330
4	12	7	4	3	4	7
	2016	**2017**	**2018**	**2019**		
1	1848	1629	1034	549		
2	2680	2884	2087	1229		
3	491	556	435	302		
4	12	14	11	7		

Table 6.3.3.8 Red mullet in GSA 1. Summary results of Recruitment, Spawning stock biomass, Catch and Fbar (ages 1 – 3).

Year	Recruitment	SSB	Catch	Fbar ages 1 – 3
2004	6962	215	160	1.22
2005	9507	263	151	1.16
2006	11183	293	166	1.06
2007	11121	329	187	0.98
2008	10373	318	199	1.00
2009	9677	299	214	1.17
2010	8643	213	194	1.41
2011	7220	183	162	1.50
2012	6356	153	120	1.31
2013	6954	191	106	1.01
2014	9390	242	114	0.84
2015	12481	328	162	0.87

2016	12822	389	241	1.05
2017	9746	328	260	1.24
2018	6271	223	183	1.22
2019	3890	161	115	1.03

6.3.4 REFERENCE POINTS

Due to the short time series full evaluation of reference points is not possible, and recent equilibrium values are used. In Red mullet assessment in GSA 1, f0.1 has been considered as the best proxy of F_{MSY} reference point. F0.1 had been calculated using the FLBRP package of the FLR library on the assessment results. FLBRP allows Yield per Recruit analysis and the estimation of f-based reference points. Using the assessment the value of f0.1 was calculated equal to 0.7.

6.3.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2020 to 2022 was performed using the FLR routines provided by JRC and based on the results of the a4a stock assessments performed during EWG 20-09.
The input parameters for the STF were taken following the procedure in Section 4.3. The input parameters for selection, mean weights, maturity and natural mortality were means of the full time series from the a4a stock assessment and its results. F status quo for F_{2020} is equal to F_{2019}, equal to 1.03 and corresponding to a $catch_{2020}$ of 114t. Recruitment was estimated to be 8912 and was calculated as geometric mean of all the years of the time series. STF results are given table 6.3.5.2 for a range of options between 0 and $F=2*F_{2019}$

Table 6.3.5.1 Red Mullet in GSAs 1: 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, based average of 2016-2018
$F_{ages\ 1\text{-}3}$ (2019)	1.03	F2019
SSB (2020)	221 t	Stock assessment 1 January 2020
R_{age0} (2019,2020)	8912	Mean of time series, years 2004-2019
Total catch (2019)	103	Assuming F status quo for 2020

Table 6.3.5.2. Red mullet GSA 1. Short term forecasts showing catch options for different fishing mortalities.

Rationale	Ffactor	Fbar	Recruitment 2020	Fsq2020	Catch 2019	Catch 2021	SSB* 2020	SSB* 2022	SSB change 2020-2022(%)	Catch change 2019-2021(%)
High long term yield (F0.1)	0.68	0.70	8912	1.03	115	114	222	324	46	0
F upper	0.93	0.96	8912	1.03	115	141	222	285	28	23
F lower	0.45	0.47	8912	1.03	115	84	222	374	68	-27
FMSY transition	0.89	0.92	8912	1.03	115	137	222	290	31	20
Zero catch	0.00	0.00	8912	1.03	115	0	222	530	139	-100
Status quo	1.00	1.03	8912	1.03	115	148	222	276	24	29
Different Scenarios	0.10	0.10	8912	1.03	115	22	222	487	119	-81
	0.20	0.21	8912	1.03	115	41	222	449	102	-64
	0.30	0.31	8912	1.03	115	59	222	416	87	-48
	0.40	0.41	8912	1.03	115	75	222	388	75	-34
	0.50	0.51	8912	1.03	115	90	222	363	63	-21
	0.60	0.62	8912	1.03	115	104	222	341	53	-9
	0.70	0.72	8912	1.03	115	116	222	321	45	1
	0.80	0.82	8912	1.03	115	128	222	304	37	11
	0.90	0.93	8912	1.03	115	138	222	289	30	20
	1.10	1.13	8912	1.03	115	157	222	264	19	37
	1.20	1.23	8912	1.03	115	165	222	253	14	44
	1.30	1.34	8912	1.03	115	173	222	243	10	51
	1.40	1.44	8912	1.03	115	180	222	234	6	57
	1.50	1.54	8912	1.03	115	187	222	226	2	63
	1.60	1.64	8912	1.03	115	193	222	219	-1	68
	1.70	1.75	8912	1.03	115	199	222	212	-4	73
	1.80	1.85	8912	1.03	115	204	222	206	-7	78
	1.90	1.95	8912	1.03	115	210	222	200	-10	83
	2.00	2.06	8912	1.03	115	215	222	195	-12	87

*SSB at mid-year

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.

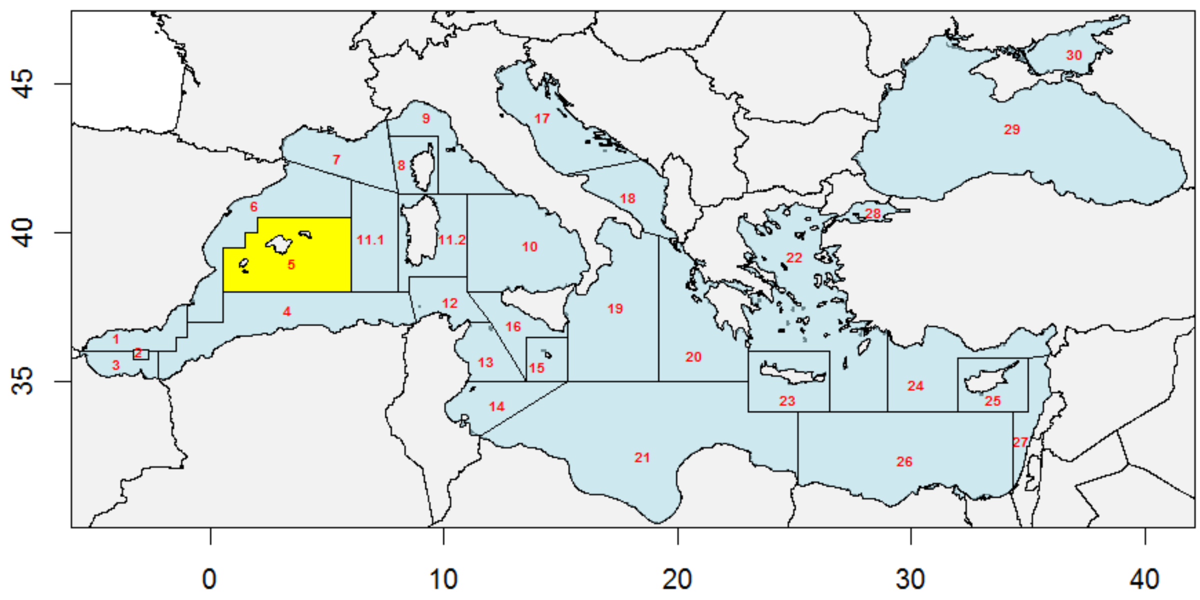


Figure 6.4.1.1. Geographical localization of GSA 5.

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) were those used in the last assessment of this stock carried out by the Working Group of Stock Assessment of Demersal Species of the General Fisheries Commission for the Mediterranean (GFCM), from Campillo (1992). Length-weight relationship was obtained from the Data Collection. For t_0, 0.5 has been added in order to adjust the curve as the spawning period of the species is in spring and not at the beginning of the year. Natural mortality (Table 6.4.1.2) has been calculated using PRODBIOM. 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 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, 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 (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	12.652	72.89386	85.54586

Discards for this stock was considered as neliglible 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.

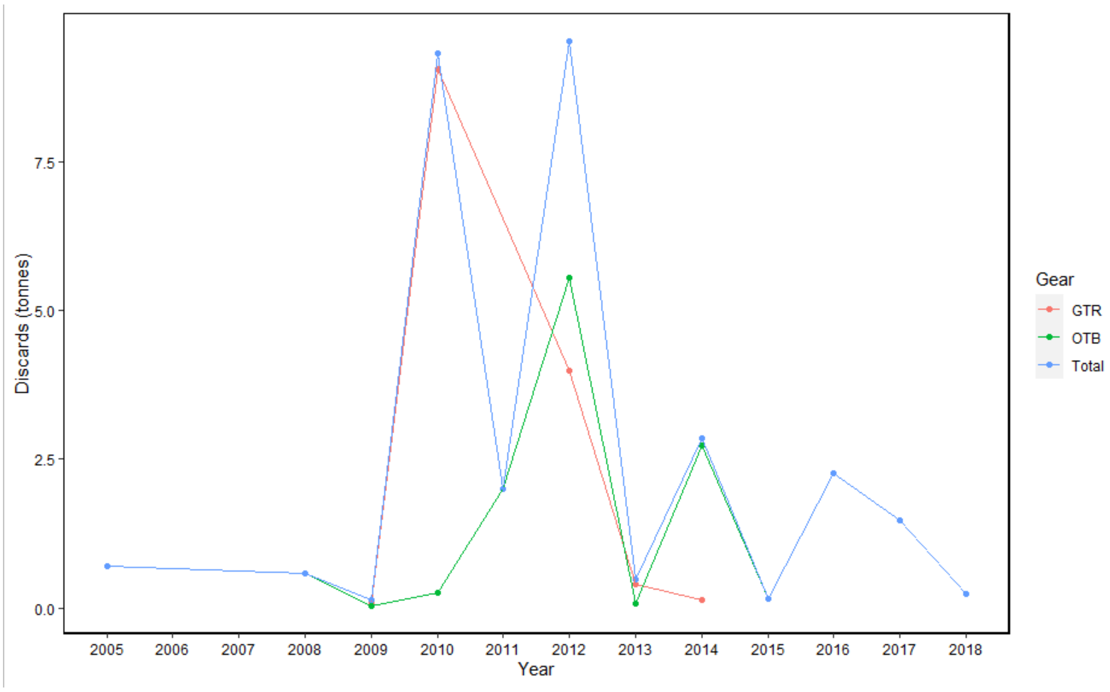


Figure 6.4.2.2. *Mullus surmuletus* in GSA 5. Reported discards from the DCF Data call by gear.

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). Please note that there are not length structure to trammelnets from 2002 to 2008. Instead, this métier presented the highest landings during this period (Figure 6.4.2.1). Therefore, the mean length structure from 2009 to 2012 was used to reconstructed the length structure until 2008 by weighting annual landings (Table 6.4.2.2).

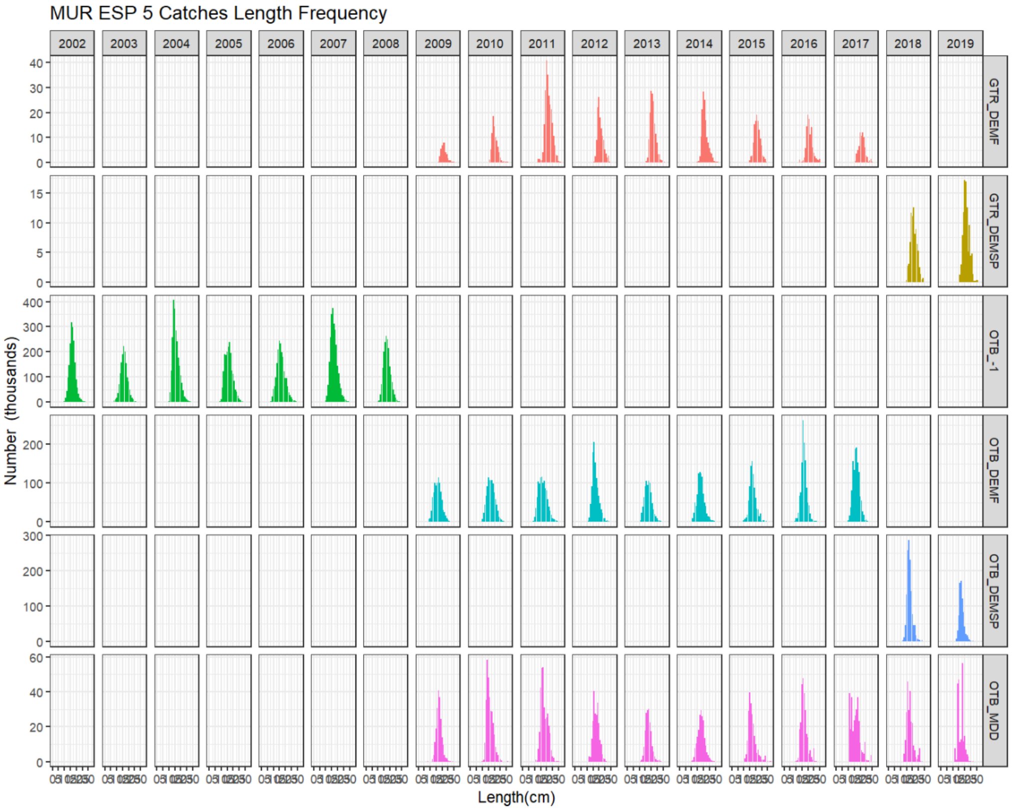


Figure 6.4.2.3. Striped red mullet in GSA5. Catch length frequency distribution, by year and métier (TL cm).

Table 6.4.2.2. *Mullus surmuletus* in GSA 5. Length structure (TL cm) reconstructed (2002-2008) and reported in DCF (2009-2010) for total landings.

Length (cm)	2002	2003	2004	2005	2006	2007	2008	2009	2010
7	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.28
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	233.49	189.53	371.96	201.10	244.24	350.27	200.68	113.06	163.83
16	319.64	223.57	287.83	222.81	237.28	374.37	239.19	131.54	145.01
17	307.67	207.67	251.65	251.47	211.65	314.02	265.23	156.51	142.71
18	269.38	174.01	204.07	230.86	213.36	294.69	257.14	139.69	148.50
19	200.03	130.18	191.49	184.22	177.90	241.99	228.76	107.44	138.55
20	126.53	109.87	146.64	162.98	146.48	156.57	153.66	77.73	105.79
21	88.80	72.97	111.67	129.65	138.21	125.37	119.88	48.40	77.94
22	61.03	51.02	78.47	88.57	101.79	82.08	86.91	36.23	57.91
23	34.91	31.47	43.53	66.46	62.97	61.07	55.06	23.34	38.37
24	23.85	21.06	30.61	43.14	45.86	31.03	33.31	15.18	17.53
25	12.76	9.01	18.13	21.94	27.29	24.46	18.01	7.82	12.89

26	6.64	4.11	8.01	11.54	14.10	11.61	9.14	3.89	6.92
27	4.77	2.64	4.28	5.06	8.11	10.00	4.47	1.63	3.46
28	1.97	2.15	3.49	4.51	6.99	4.49	3.23	0.39	2.09
29	1.19	1.03	1.56	1.73	5.61	2.50	1.40	1.40	0.90
30	0.74	0.78	0.82	1.56	2.08	0.42	0.32	0.12	0.36
31	0.20	0.16	0.95	0.29	1.09	0.80	0.55	0.48	1.10
32	0.04	0.03	0.04	0.19	0.76	0.26	0.01	0.12	0.00
33	0.05	0.04	0.06	0.08	0.43	0.02	0.02	0.00	0.03
34	0.09	0.07	0.76	0.13	0.13	0.03	0.03	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	0.06	0.12	0.07	0.09	0.09	0.02	0.02	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
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	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
10	12.40	1.17	0.44	1.08	3.22	9.71	3.35	0.00	0.00
11	37.21	2.79	3.67	9.21	9.06	10.22	56.21	0.52	0.00
12	63.77	14.70	23.99	26.00	15.09	25.50	56.64	5.08	8.52
13	112.64	49.11	41.69	56.44	29.51	87.49	118.56	17.11	10.15
14	116.40	105.74	72.52	50.94	83.75	99.54	174.63	59.56	77.17
15	158.26	202.64	109.52	85.64	132.40	198.18	155.57	161.67	121.79
16	170.48	245.89	133.45	143.78	179.87	311.39	211.61	307.24	178.52
17	158.24	183.16	126.55	158.67	185.74	245.44	217.63	320.26	187.79
18	151.66	148.13	144.96	165.12	153.46	193.11	191.57	277.46	185.51
19	139.38	143.62	142.13	163.88	117.84	118.48	154.98	177.58	105.93
20	148.20	115.76	121.49	124.70	89.59	83.27	87.55	110.88	75.44
21	121.30	77.84	84.72	88.63	58.83	65.44	70.97	68.01	46.62
22	87.04	55.48	61.69	67.14	55.90	38.96	43.05	61.91	35.42
23	68.55	37.57	37.90	36.39	30.88	23.87	33.44	30.14	21.26
24	45.50	20.93	28.21	27.16	34.17	13.14	21.48	16.13	16.68
25	28.67	14.93	17.32	21.16	10.51	14.04	9.61	16.54	6.97
26	20.30	6.71	8.44	11.12	7.52	4.32	5.30	14.42	6.11
27	13.08	5.40	8.26	8.00	6.36	3.83	1.61	3.46	3.67
28	7.37	4.92	3.52	5.27	4.78	1.92	1.30	5.65	0.51
29	4.62	0.59	1.53	2.26	3.44	0.81	5.26	0.82	0.39
30	0.60	0.12	0.80	1.72	0.25	1.34	0.37	0.31	0.49
31	0.34	0.16	0.25	0.39	0.08	0.03	0.00	0.00	0.54
32	0.16	0.04	0.00	0.12	0.42	0.00	0.00	0.00	0.08
33	0.15	0.00	0.00	0.00	0.23	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
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	0.05	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). Cohorts showed a good consistency, especially for the youngest classes (figure 6.4.2.5).

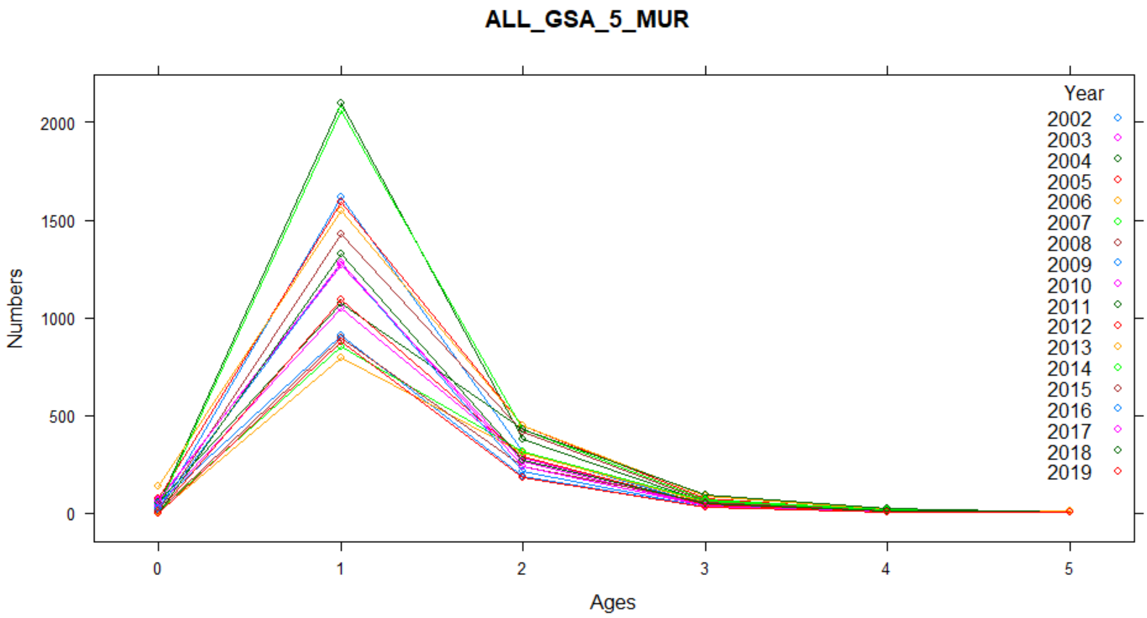


Figure 6.4.2.4. Striped red mullet in GSA 5. Catch-at-age.

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	20.63	23.21	20.33	19.94	19.50	16.09	20.89	16.84	14.17
1	1302.64	1620.48	1870.48	1684.55	1664.23	1585.11	1247.18	1555.17	1248.16
2	255.78	323.70	419.64	497.21	439.97	407.38	359.41	273.33	354.59
3	41.77	40.64	54.00	71.91	82.98	67.72	57.28	48.84	39.30
4	7.77	7.16	7.31	9.98	12.95	13.78	10.28	8.40	7.58
5	1.59	1.68	1.67	1.74	2.21	2.63	2.61	1.98	1.69

age	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	12.92	13.10	11.18	15.97	18.35	16.21	16.75	11.80	0.67
1	1094.14	1070.07	1144.69	969.17	1276.51	1294.84	1011.20	954.10	649.63
2	313.53	304.29	310.52	312.43	228.75	264.47	264.80	229.13	250.20
3	57.50	57.18	57.83	54.40	45.99	29.26	34.66	41.41	44.43
4	6.88	11.31	11.72	10.92	8.64	6.35	4.14	5.85	8.65
5	1.70	1.77	2.80	2.87	2.30	1.58	1.18	0.94	1.48

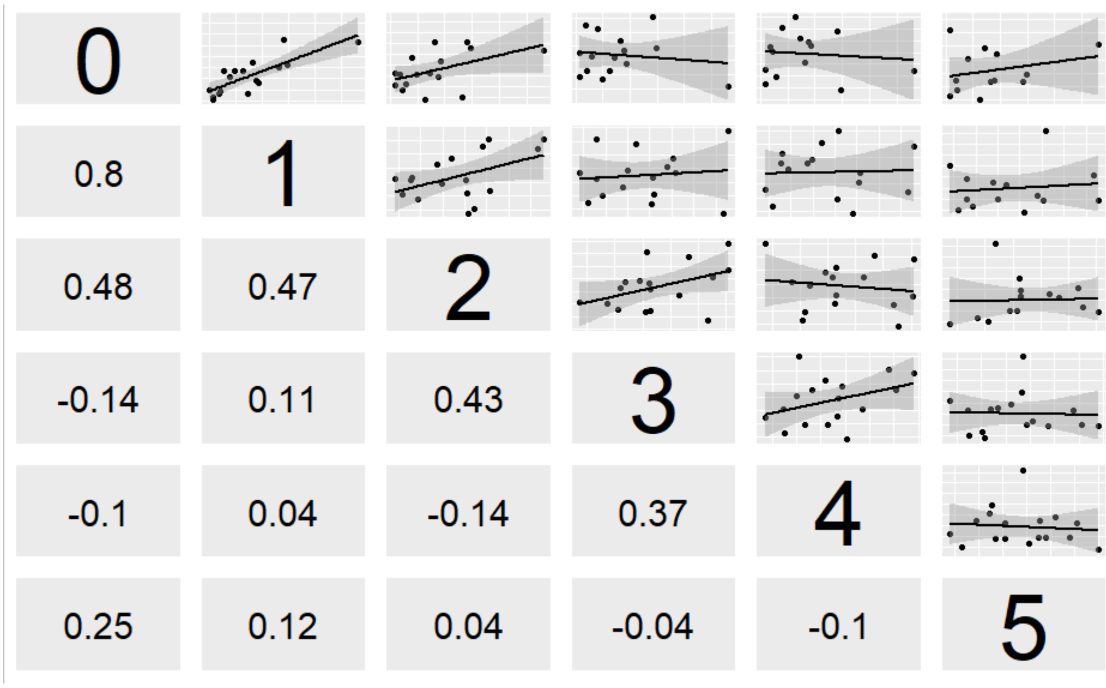


Figure 6.4.2.5. Striped red mullet in GSA 5. Cohort consistency for the commercial catches.

6.4.2.2 EFFORT

Fishing effort, as days at sea, by fishing gear (OTB and GTR) is shown in Figure 6.4.2.6 and Table 6.4.2.5. Effort data has not been updated this year. These values correspond to all the fishing trips from these gears, not to those days directed to the catch of this species. Both for 2007 and 2008, values are consideribly lower than the rest of the data series and thus this should be checked (see Quality section).

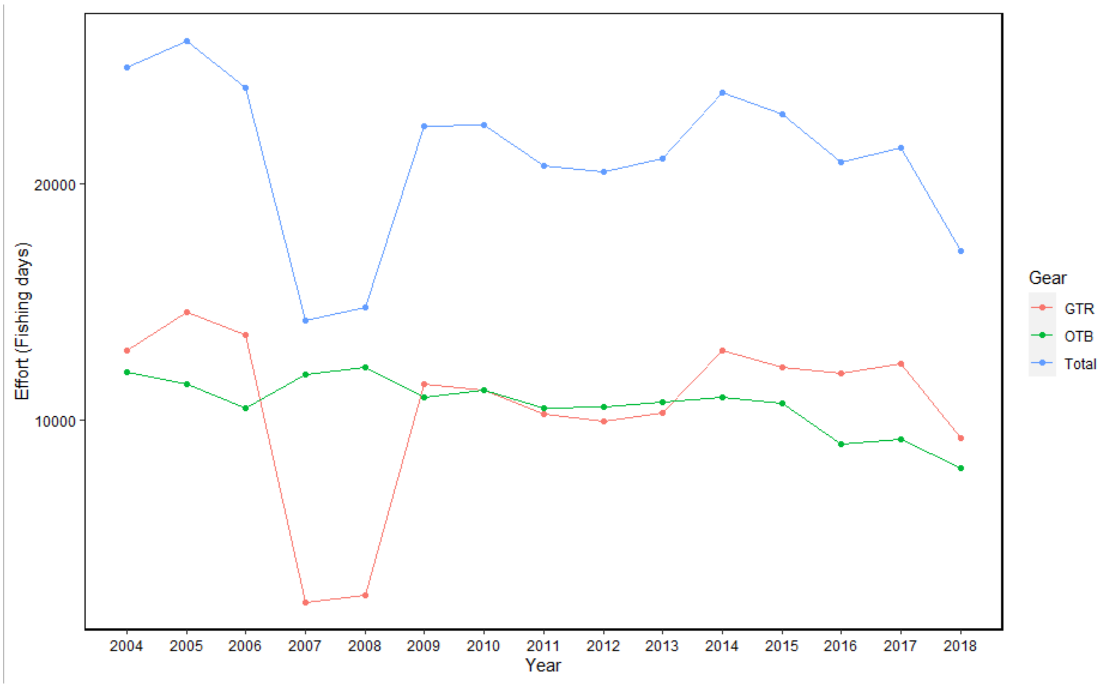


Figure 6.4.2.6. Fishing effort (in fishing days) for the fleet operating in GSA 5: trawlers (OTB) and trammel net (GTR).

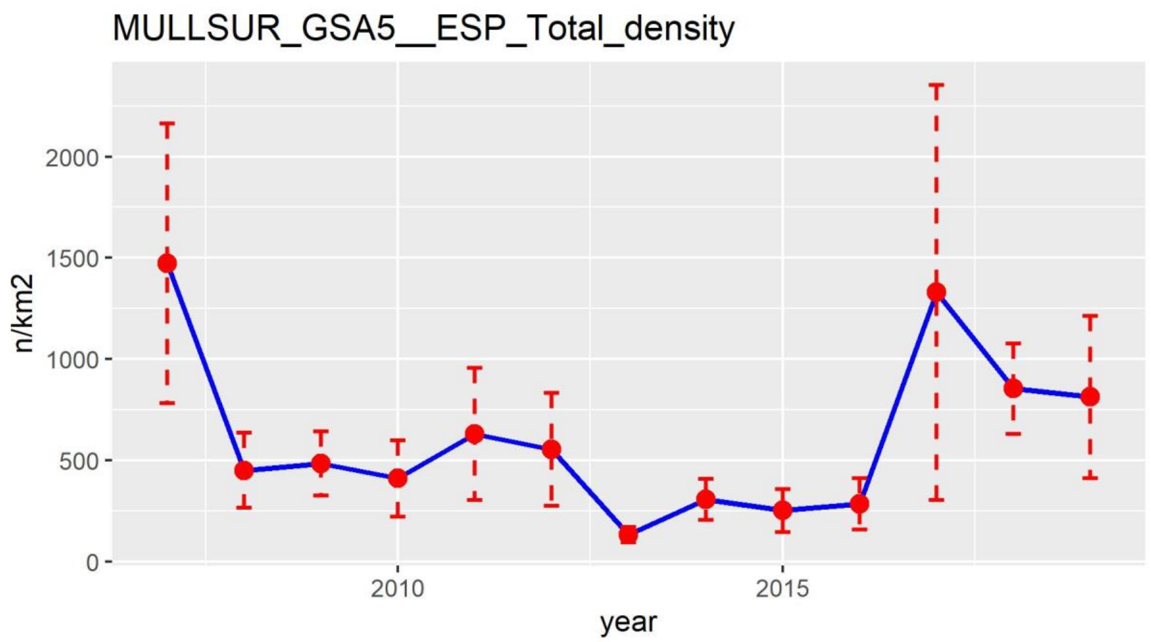
Table 6.4.2.5. Fishing effort (in fishing days) for the fleet operating in GSA 5: trawlers (OTB) and trammel net (GTR).

Year	GTR	OTB	Total
2004	12936	12012	24948
2005	14538	11497	26035
2006	13568	10507	24075
2007	2280	11907	14187
2008	2558	12226	14784
2009	11504	10934	22438
2010	11269	11239	22508
2011	10261	10498	20759
2012	9941	10568	20509
2013	10312	10769	21081
2014	12908	10936	23844
2015	12243	10714	22957
2016	11967	8952	20919
2017	12381	9158	21539
2018	9211	7947	17158

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 are considered non representative. 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.



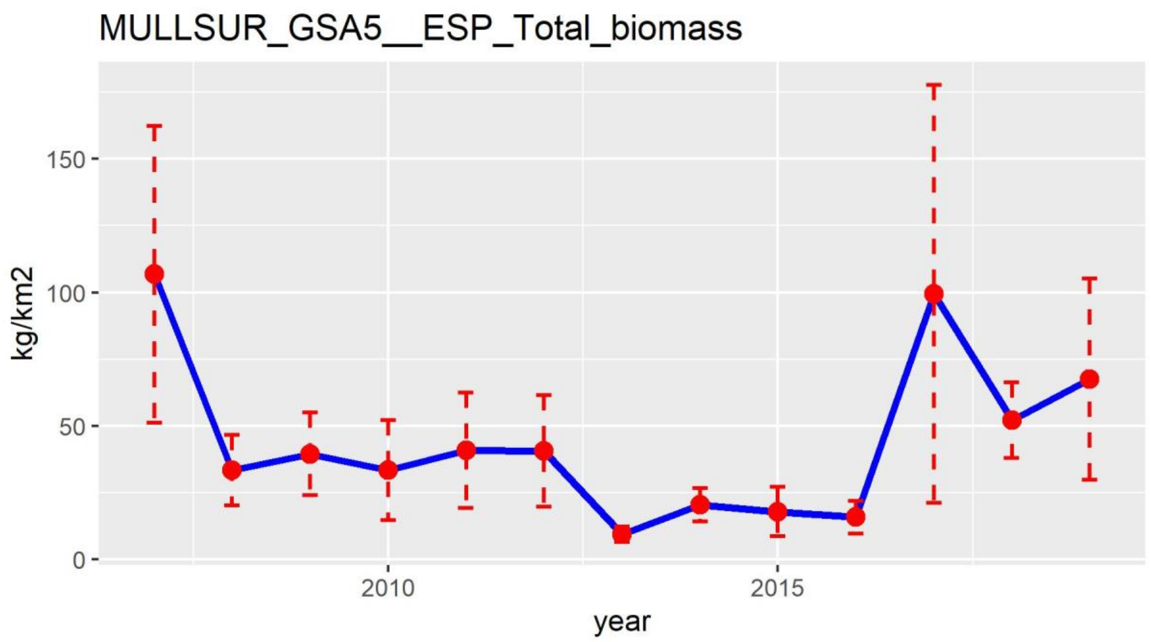


Figure 6.4.2.7. Striped red mullet in GSA 5. MEDITS abundance (n/km^2) and biomass (kg/km^2) indices over 2007-2018.

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 GSA 6. Age composition of MEDITS estimated by length slicing from length frequency distribution n/km²) used with plus group at age 4.

Length (cm)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2	0.00	0.00	2.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	1.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	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
5	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
6	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
7	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
8	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
9	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
10	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
11	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
12	0.00	0.00	1.59	5.28	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00
13	0.75	0.00	0.00	3.52	0.00	2.50	0.00	0.00	0.00	0.37	1.90	1.31	0.81
14	8.71	2.43	10.86	1.70	2.22	20.50	0.42	2.87	2.51	7.52	7.96	10.57	0.45
15	77.19	26.41	24.58	15.08	14.44	27.42	3.08	12.35	16.55	29.52	46.43	54.94	3.15
16	114.67	47.49	63.82	34.23	77.70	50.57	17.21	51.13	47.57	52.49	128.59	160.94	43.99
17	122.33	51.37	77.44	50.11	144.62	83.81	19.33	79.11	37.74	65.15	188.96	195.00	90.04
18	232.89	84.67	62.14	61.27	135.39	99.71	29.29	51.58	29.59	49.53	213.57	154.94	110.69
19	92.85	50.22	55.82	69.64	100.92	103.55	21.84	39.23	28.60	33.55	235.87	98.33	121.86
20	126.48	112.15	42.38	56.18	58.07	60.26	11.33	24.23	21.99	20.42	164.01	65.93	163.67
21	75.46	75.28	32.43	40.80	39.27	32.82	14.41	18.71	21.75	13.59	125.25	31.96	110.83
22	101.40	49.73	31.06	23.96	27.00	18.30	6.01	12.01	15.63	8.29	86.19	28.99	71.71
23	73.33	16.63	16.91	14.50	22.55	22.29	4.25	5.81	13.02	2.31	60.94	19.45	31.87
24	16.36	14.39	16.11	10.59	7.78	11.06	1.76	3.82	7.97	1.11	37.81	13.03	32.09
25	9.43	9.42	10.43	3.91	3.14	12.08	2.75	2.93	4.74	0.84	13.96	9.46	16.49
26	8.01	5.57	7.19	7.68	0.79	2.47	0.42	1.74	1.75	0.00	10.29	3.94	4.29
27	0.00	7.39	5.01	0.85	0.00	0.50	0.00	0.24	0.81	0.00	4.91	1.89	7.67
28	0.00	3.34	1.42	1.76	0.47	1.47	0.00	0.00	1.68	0.00	0.31	1.31	1.69
29	0.38	0.00	0.90	1.76	0.00	0.50	0.00	0.00	0.00	0.00	0.76	0.44	1.69
30	0.76	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	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
32	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
33	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	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
35	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
36	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
37	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

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). Cohorts showed no consistency (Figure 6.4.2.10).

Table 6.4.2.6. Striped red mullet in GSA 6. Age composition of MEDITS estimated by length slicing from length frequency distribution n/km^2) used with plus group at age 4.

age	2007	2008	2009	2010	2011	2012	2013
0	0.23	0.49	6.18	5.28	0.47	0.83	0.23
1	775.87	374.75	1882.52	291.73	533.35	447.49	102.51
2	276.00	162.84	220.40	91.35	99.43	93.34	27.60
3	8.24	16.49	45.89	10.94	1.81	7.66	2.23
4	1.14	2.83	3.47	5.28	0.43	1.00	0.43

age	2014	2015	2016	2017	2018	2019
0	0.23	0.23	0.23	1.84	1.63	0.45
1	260.49	184.56	258.56	986.52	741.52	534.67
2	42.04	61.43	25.78	314.33	100.57	257.91
3	3.45	6.15	0.60	25.34	9.03	17.03
4	0.43	0.43	0.43	0.95	1.06	3.78

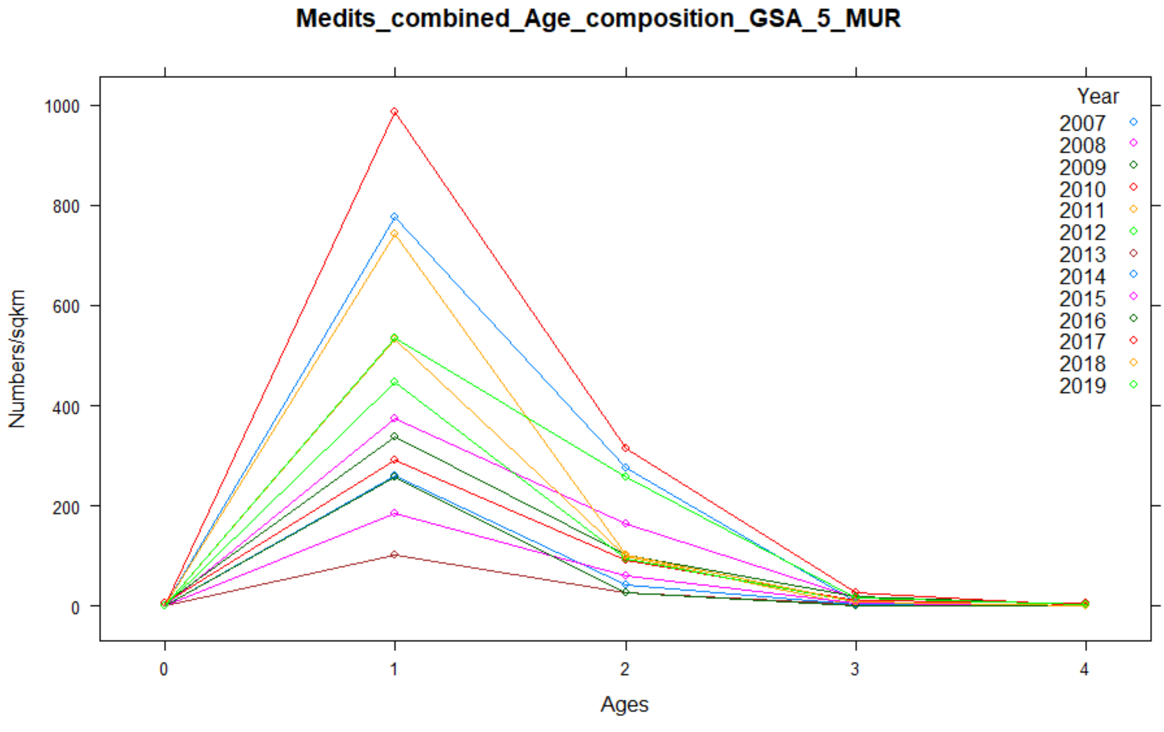


Figure 6.4.2.9. Striped red mullet in GSA 6. Age composition of MEDITS estimated by length slicing from length frequency distribution (n/km^2).

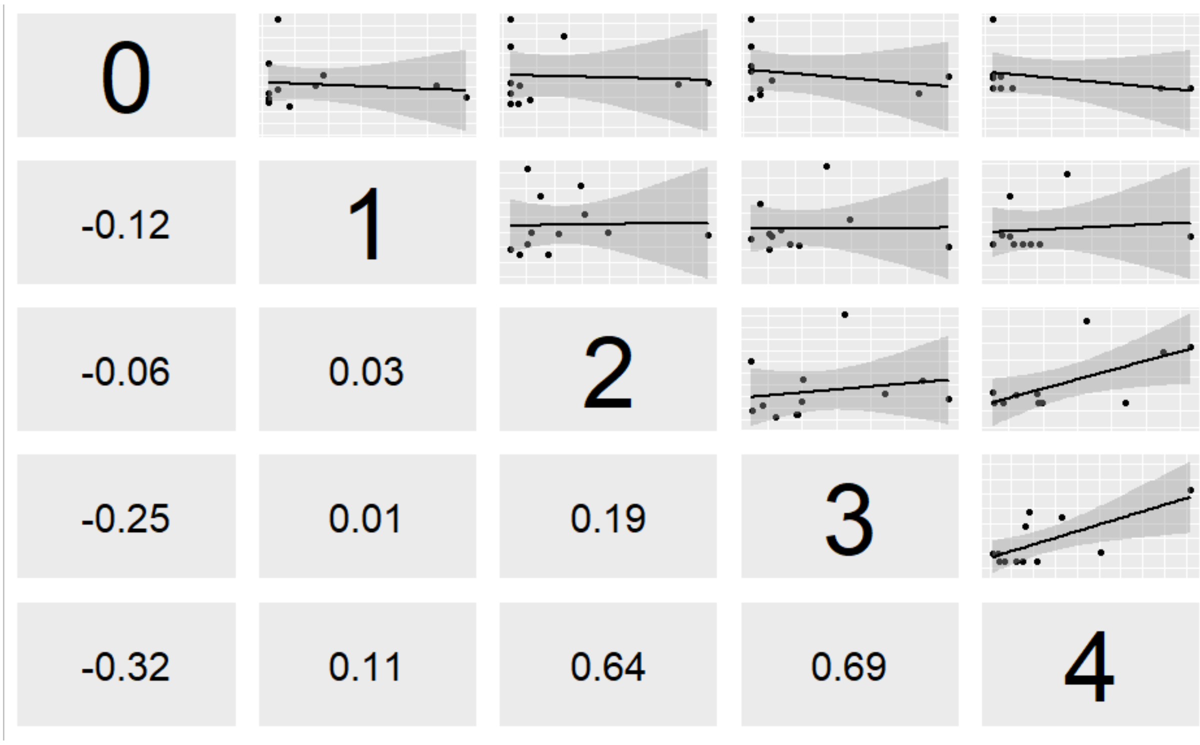


Figure 6.4.2.10. Striped red mullet in GSA 5. Cohort consistency for the MEDITS data.

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. The values of mean weight were used as presented in the table 6.4.3.1. SoP corrections by year were applied to numbers at age in the catch.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
SoP	1.01	1.01	1.01	1.01	1.01	1.00	1.01	1.01	1.10	0.86	1.10	0.96	0.99	1.09	1.11	1.10	1.13	1.13

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	0.014	0.012	0.014	0.014	0.012	0.014	0.014	0.013	0.014
1	0.052	0.049	0.045	0.048	0.048	0.050	0.054	0.050	0.049
2	0.113	0.113	0.113	0.115	0.115	0.114	0.114	0.113	0.114
3	0.183	0.181	0.183	0.183	0.184	0.186	0.183	0.183	0.186
4	0.252	0.257	0.257	0.258	0.257	0.253	0.256	0.250	0.255
5	0.345	0.354	0.372	0.346	0.340	0.334	0.333	0.343	0.361

age	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.014	0.014	0.014	0.014	0.013	0.013	0.015	0.015	0.000
1	0.049	0.052	0.054	0.056	0.054	0.051	0.050	0.057	0.055
2	0.115	0.113	0.113	0.113	0.114	0.113	0.114	0.113	0.113
3	0.186	0.185	0.184	0.186	0.180	0.186	0.182	0.192	0.184
4	0.254	0.258	0.253	0.256	0.257	0.254	0.257	0.262	0.248
5	0.325	0.326	0.322	0.327	0.327	0.327	0.307	0.314	0.347

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 and Table 6.4.3.2 show the summary of the stock object after the fit of the model. F shows a clear decreasing trend since 2015. Recruitment showed the highest values in 2017 and the lowest in 2019. SSB showed an increasing trend since 2014.

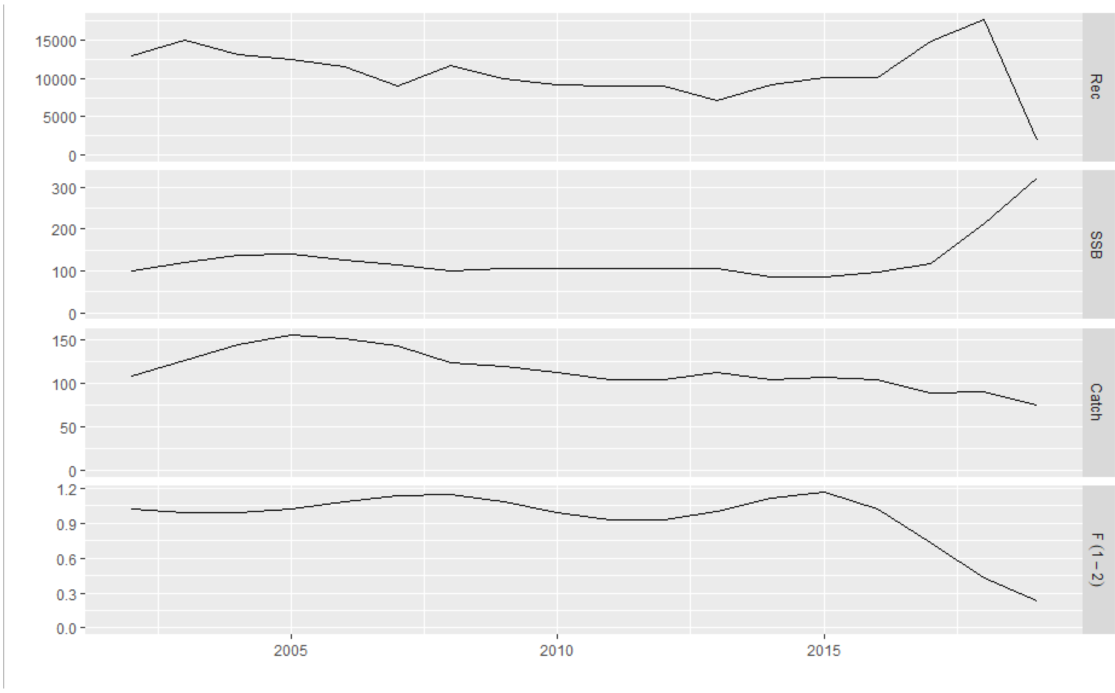


Figure 6.4.3.1. Striped red mullet in GSA 5. Stock summary from the a4a model: recruitmend (thousands), SSB (Stock Spawning Biomass, tonnes), catch (tonnes) and fishing mortality for ages 1 to 2).

Table 6.4.3.2. Striped red mullet in GSA 5. Summary results of the estimations from the a4a assessment model. Catch and SSB in tonnes, recruits in thousands, F_{bar} ages 1-2.

Year	Recruitment	SSB	Catch tonnes	F
	age 1	tonnes		ages 1-2
	thousands			
2002	12899.10	100.90	107.60	1.02
2003	14936.00	121.34	125.50	1.00
2004	13140.60	137.65	144.13	0.99
2005	12465.90	139.52	155.01	1.02
2006	11488.90	127.15	150.63	1.09
2007	9029.50	115.02	143.00	1.14
2008	11700.50	98.56	123.06	1.14
2009	9986.00	106.20	119.84	1.08
2010	9178.80	105.74	111.83	0.99
2011	8953.00	104.49	103.49	0.92
2012	9043.40	105.51	104.45	0.93
2013	7117.10	104.38	112.18	1.01
2014	9142.30	84.26	103.68	1.12
2015	10110.20	86.73	106.37	1.16
2016	10140.20	97.64	103.87	1.02
2017	14729.60	118.38	88.76	0.73
2018	17569.80	212.51	90.12	0.43
2019	1872.30	322.61	74.90	0.23

Table 6.4.3.3. 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	12899.11	14935.95	13140.56	12465.89	11488.91	9029.45	11700.50	9985.96	9178.76
1	3241.29	4114.32	4764.35	4191.70	3976.14	3663.92	2879.17	3730.85	3184.68
2	462.90	595.61	774.20	899.83	770.29	694.49	612.09	480.14	655.12
3	73.21	72.41	96.44	126.04	140.76	111.90	94.55	83.12	70.29
4	13.37	12.53	12.83	17.18	21.57	22.37	16.67	14.05	13.31
5	2.70	2.91	2.89	2.96	3.64	4.23	4.19	3.28	2.93

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	8953.00	9043.41	7117.06	9142.33	10110.23	10140.22	14729.62	17569.79	1872.32
1	2927.95	2856.41	2885.23	2270.19	2915.34	3223.60	3234.35	4701.85	5612.84
2	602.66	583.69	567.94	538.34	386.24	478.84	592.74	756.47	1402.30
3	106.96	106.14	102.41	90.84	75.27	51.30	74.97	131.76	239.61
4	12.56	20.61	20.38	17.92	13.90	10.94	8.79	18.23	45.66
5	3.07	3.18	4.82	4.66	3.66	2.70	2.47	2.90	7.73

Table 6.4.3.4. 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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.83	0.81	0.81	0.83	0.88	0.93	0.93	0.88	0.80
2	1.22	1.18	1.18	1.22	1.29	1.35	1.36	1.28	1.17
3	1.22	1.18	1.18	1.22	1.29	1.35	1.36	1.28	1.17
4	1.22	1.18	1.18	1.22	1.29	1.35	1.36	1.28	1.17
5	1.22	1.18	1.18	1.22	1.29	1.35	1.36	1.28	1.17

Age	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.75	0.76	0.82	0.91	0.95	0.83	0.59	0.35	0.19
2	1.10	1.10	1.19	1.33	1.38	1.21	0.86	0.51	0.27
3	1.10	1.10	1.19	1.33	1.38	1.21	0.86	0.51	0.27
4	1.10	1.10	1.19	1.33	1.38	1.21	0.86	0.51	0.27
5	1.10	1.10	1.19	1.33	1.38	1.21	0.86	0.51	0.27

Figure 6.4.3.2 and 6.4.3.3 show the estimated fishing mortality by age and year and estimated catchability by age and year, respectively.

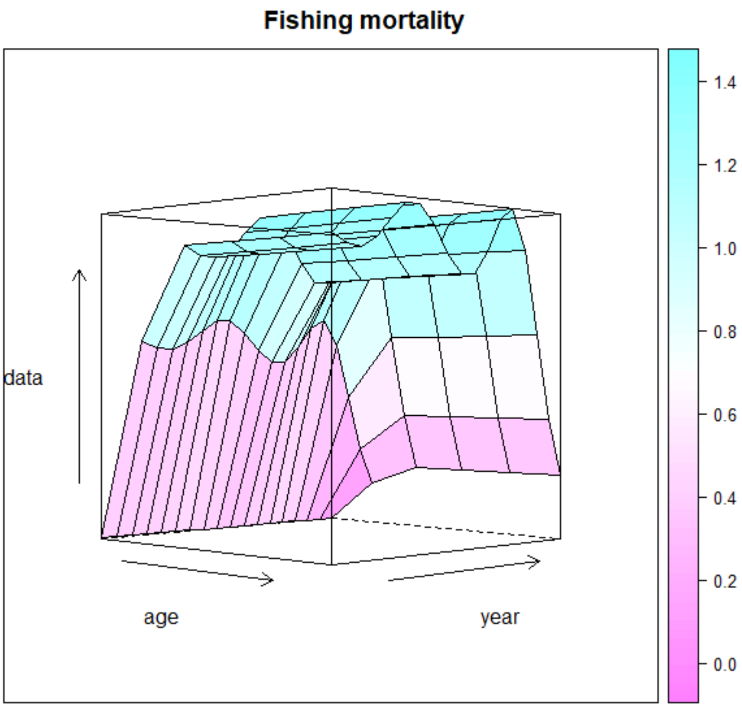


Figure 6.4.3.2. Striped red mullet in GSA 5. 3D contour plot of estimated fishing mortality by age and year.

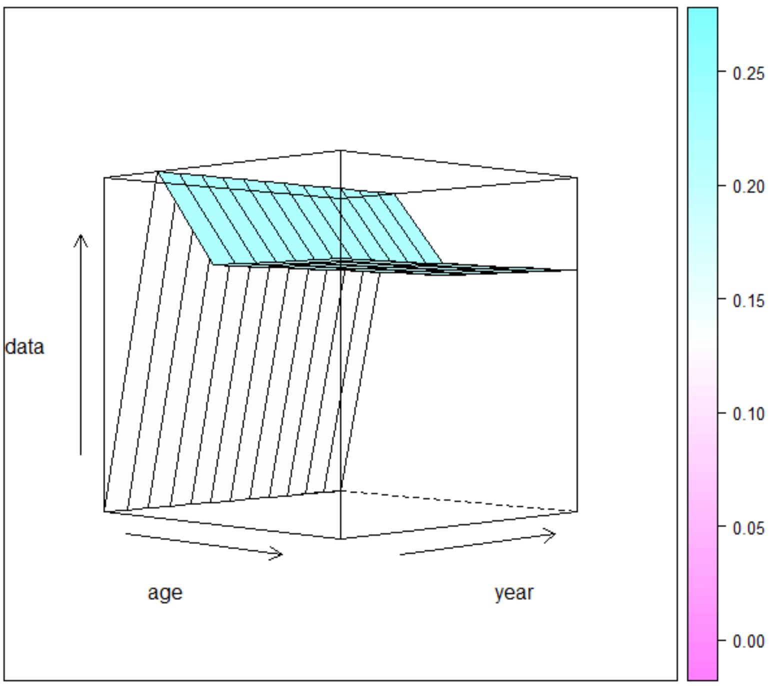


Figure 6.4.3.3 Striped red mullet in GSA 5. 3D contour plot of catchability by age and year.

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.

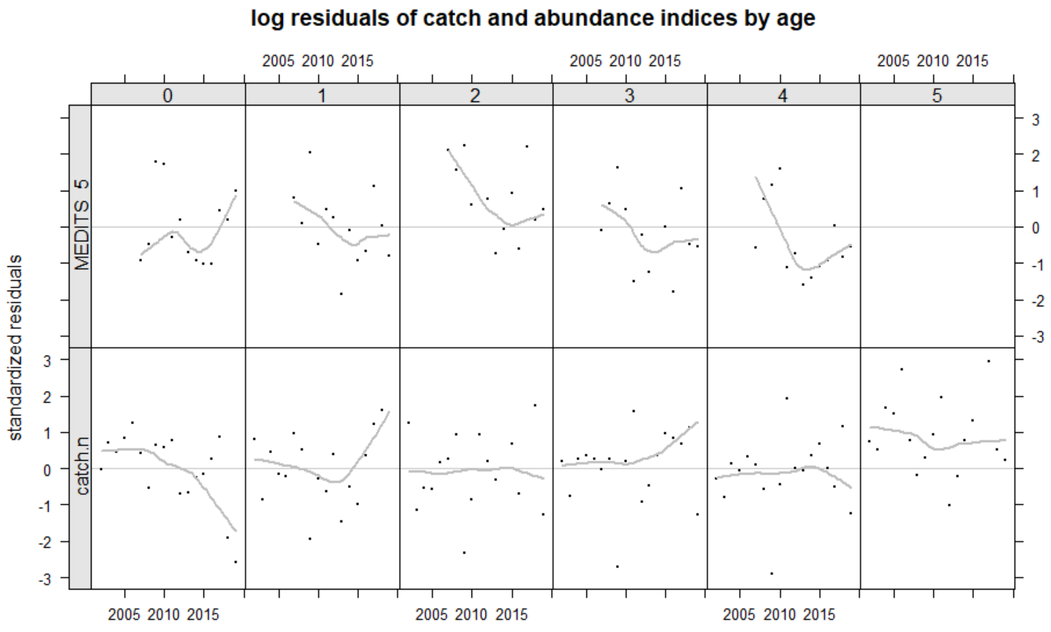


Figure 6.4.3.4. Striped red mullet in GSA 5. Standardized residuals for catch, abundance indices and for catch numbers.

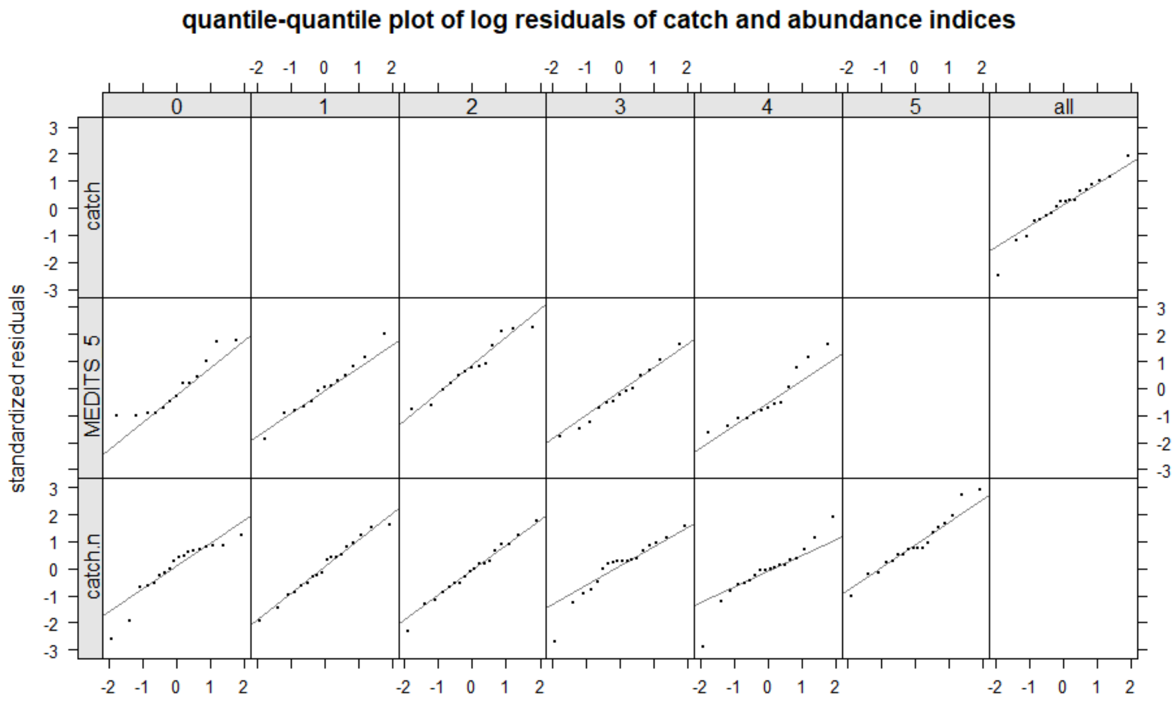


Figure 6.4.3.5. Striped red mullet in GSA 5. Quantile-quantile plot of standardized residuals for catch, abundance indices and for catch numbers.

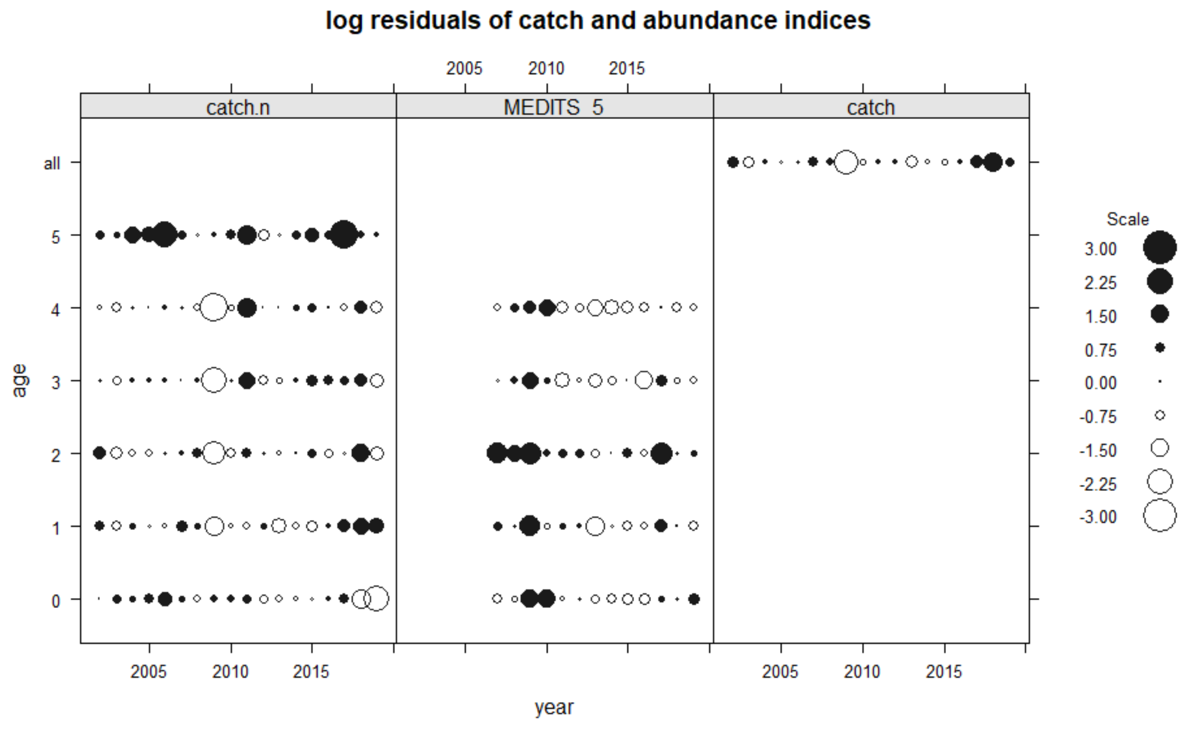


Figure 6.4.3.6. Striped red mullet in GSA 5. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

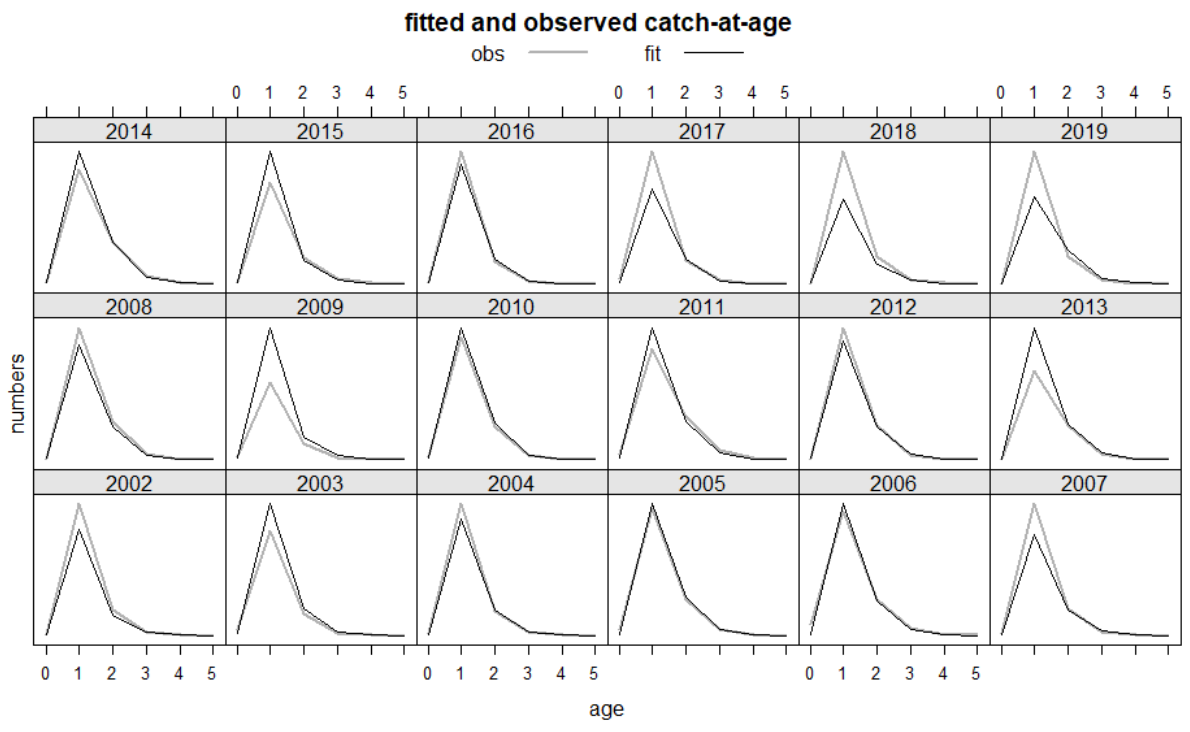


Figure 6.4.3.7. Striped red mullet in GSA 5. Fitted and observed catch at age.

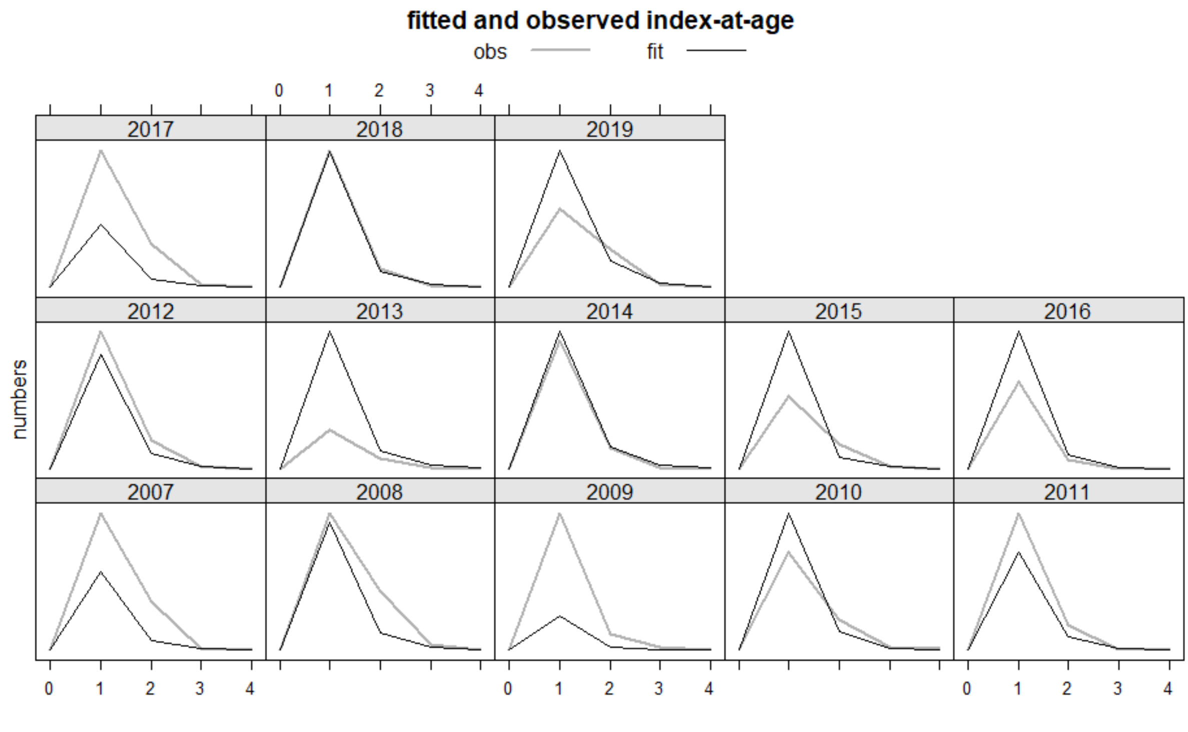


Figure 6.4.3.8. Striped red mullet in GSA 6. Fitted and observed index at age

RETROSPECTIVE

The retrospective analysis was applied up to 3 years back (Figure 6.4.3.9). They shown a good analysis for fishing mortality, catch and SSB. Recruitment presented a worse analysis probably promoted by the high peak that was observed in 2018.

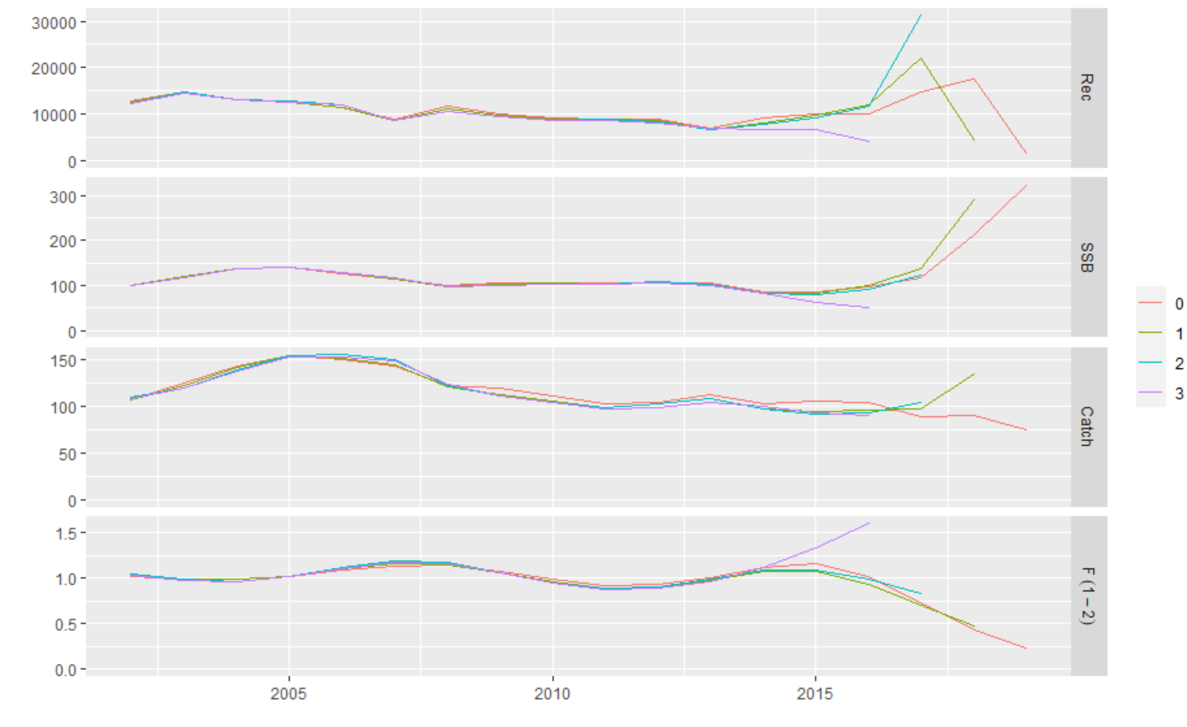


Figure 6.4.3.9. Striped red mullet in GSA 5. Retrospective analysis for the a4a model.

SIMULATIONS

Figure 6.4.3.10 shows the simulations carried out for striped red mullet in GSA 5.The model follows the general trend for the observed catch. Nevertheless, some years overlook the confidence interval that were estimated by the model.

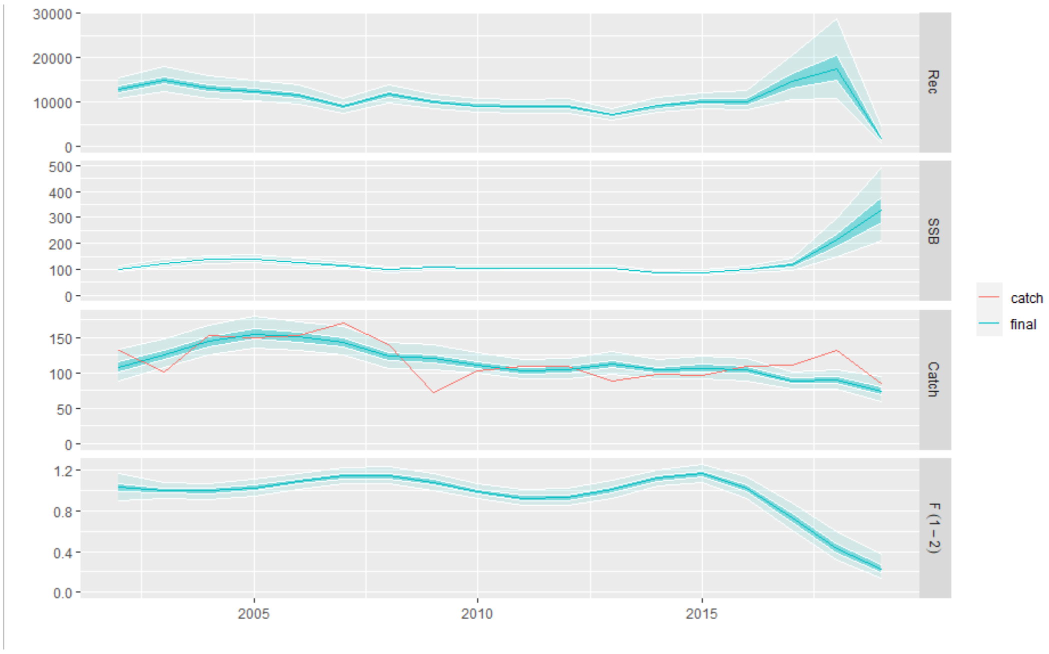


Figure 6.4.3.10. Striped red mullet in GSA 5. Stock summary of the simulated and fitted data for the a4a model.

Comparison between XSA and a4a

Figure 6.4.3.11 show the results for different k values for the fmodel. This analysis provides comparable indicators trend. However, k= 6 offers a closer following of catches while the results of AIC and BIC are one of the lower. k= 8 presented the lowest values of AIC and BIC but instead the observed catches were worse followed. Therefore, the model holding a k value equal to 6 for the fmodel was selected.

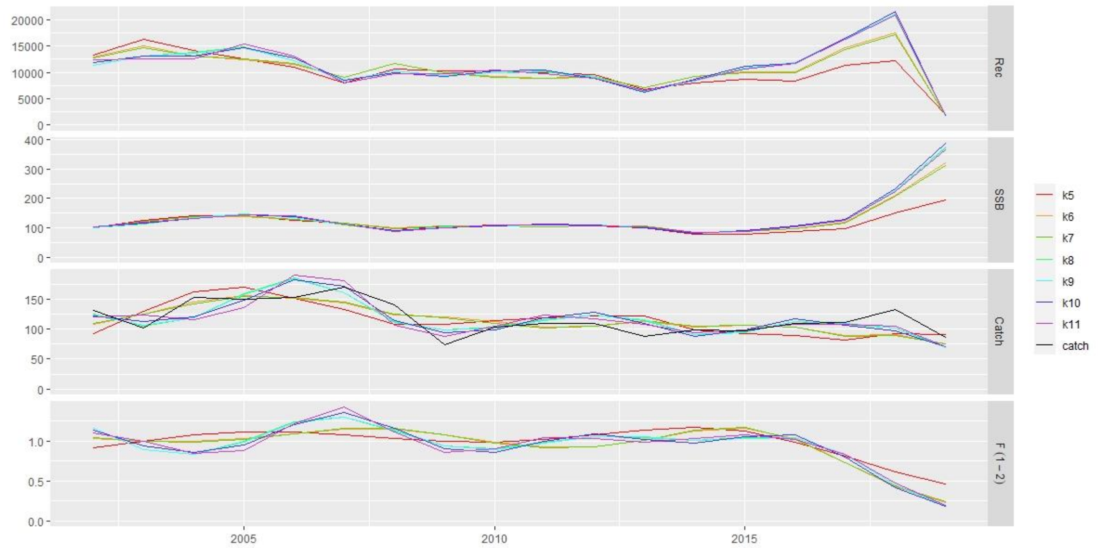


Figure 6.4.3.11. Striped red mullet in GSA 5. Results for sensitivity analysis of k value for the fmodel. Recruitmend (thousands), SSB (Stock Spawning Biomass, tonnes), catch (tonnes) and fishing mortality for ages 1 to 2).

Overal the asssessment is marginal, the fit to the catch is much better than the fit to the survey which showes both year effects in 2009 and 2013, and some trend particularly in ages 2 and 4, where the catch data is prefered. Overall the retrospective performance is adequate, and the assessment is accepted for advice.

6.4.4 REFERENCE POINTS

The assessment is considered suitable for full evaluation of F_{MSY}. In the assessment of striped red mullet in GSA 5, $F_{0.1}$ has been considered as the best proxy of F_{MSY} reference point. The values of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is 0.44. Current F (2019), as calculated by model a4a, is 0.229 indicating that the stock is not being overfished (Fcurrent/F0.1 = 0.51).

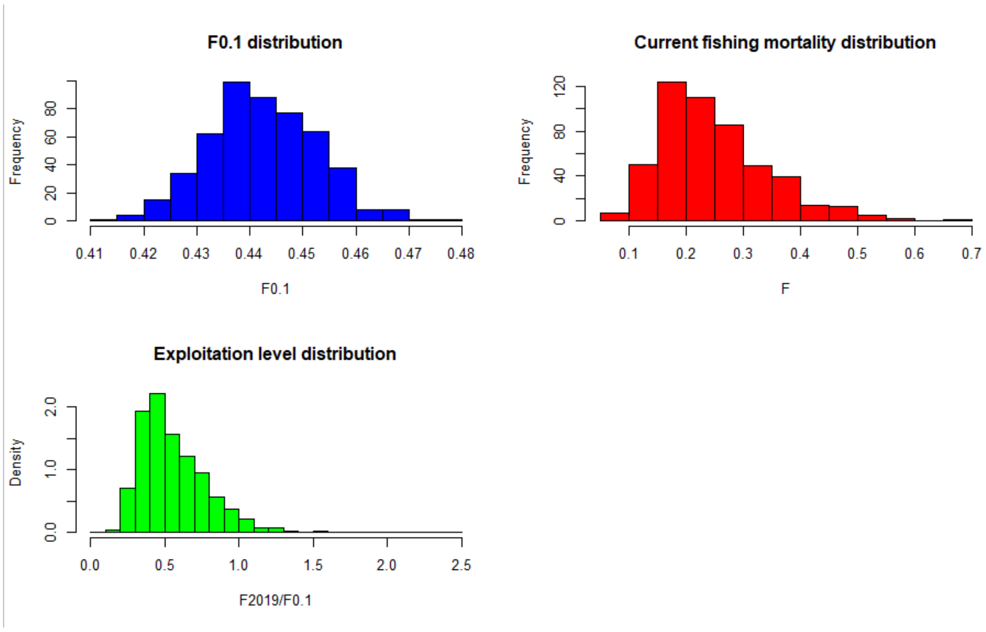


Figure 6.4.3.12 Striped red mullet in GSA 5**:** Histograms of probability for F0.1, Fcurr and level of exploitation (Fcurr/F01 ratio) values.

6.4.5 SHORT TERM FORECAST AND CATCH OPTIONS

A short term forecast was carried out following the parameter choices given in section 4.3. The three-year mean values for mean weights, maturity, natural mortality and selection were taken from the last three years of the assessment. Due to the clear decreasing trend of F during the last 2 years, status quo F was calculated as the last year. Recruitment 2020 and 2022 was estimated as the geometric mean of the timeseries. Table 6.4.5.1 summarizes the results of the short term forecast.

Table 6.4.5.1 Striped red mullet GSAs 5: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2017-2019	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}2}$ (2020)	0.229	F 2019 used to give F status quo for 2020
SSB (2020)	253.80	Stock assessment 1 January 2020
R_{age0} (2020-2022)	10750.17	Mean of the time series (18 years)
Total catch (2020)	70 t	Assuming F status quo for 2020

Table 6.4.5.2. Striped red mullet GSA 5. Short term forecasts showing catch options for different fishing mortalities.

*SSB at mid year

Rationale	Ffactor	Fbar	Recruitment2020	Fsq2020	Catch2019	Catch2021	SSB2020	SSB2022	SSB change 2020-2022 (%)	Catch change 2019-2021 (%)
High long term yield (F0.1)	1.93	0.44	10750.17	0.23	74.90	120.64	253.80	235.37	-7.26	61.07
F upper	2.64	0.60	10750.17	0.23	74.90	153.82	253.80	198.14	-21.93	105.36
F lower	1.29	0.29	10750.17	0.23	74.90	85.90	253.80	277.49	9.33	14.68

FMSY transition	1.31	0.30	10750.17	0.23	74.90	87.25	253.80	275.80	8.67	16.49
Zero catch	0.00	0.00	10750.17	0.23	74.90	0.00	253.80	394.92	55.60	-100.00
Status quo	1.00	0.23	10750.17	0.23	74.90	68.82	253.80	299.36	17.95	-8.12
Different Scenarios	0.10	0.02	10750.17	0.23	74.90	7.58	253.80	383.81	51.23	-89.88
	0.20	0.05	10750.17	0.23	74.90	15.00	253.80	373.09	47.00	-79.98
	0.30	0.07	10750.17	0.23	74.90	22.25	253.80	362.73	42.92	-70.29
	0.40	0.09	10750.17	0.23	74.90	29.35	253.80	352.72	38.98	-60.82
	0.50	0.11	10750.17	0.23	74.90	36.29	253.80	343.05	35.17	-51.55
	0.60	0.14	10750.17	0.23	74.90	43.08	253.80	333.71	31.48	-42.48
	0.70	0.16	10750.17	0.23	74.90	49.73	253.80	324.68	27.93	-33.61
	0.80	0.18	10750.17	0.23	74.90	56.23	253.80	315.95	24.49	-24.93
	0.90	0.21	10750.17	0.23	74.90	62.59	253.80	307.51	21.16	-16.43
	1.10	0.25	10750.17	0.23	74.90	74.91	253.80	291.47	14.84	0.01
	1.20	0.28	10750.17	0.23	74.90	80.87	253.80	283.85	11.84	7.97
	1.30	0.30	10750.17	0.23	74.90	86.71	253.80	276.48	8.94	15.76
	1.40	0.32	10750.17	0.23	74.90	92.42	253.80	269.35	6.13	23.39
	1.50	0.34	10750.17	0.23	74.90	98.01	253.80	262.45	3.41	30.85
	1.60	0.37	10750.17	0.23	74.90	103.48	253.80	255.78	0.78	38.15
	1.70	0.39	10750.17	0.23	74.90	108.83	253.80	249.33	-1.76	45.30
	1.80	0.41	10750.17	0.23	74.90	114.07	253.80	243.09	-4.22	52.30
	1.90	0.44	10750.17	0.23	74.90	119.20	253.80	237.05	-6.60	59.15
	2.00	0.46	10750.17	0.23	74.90	124.23	253.80	231.20	-8.90	65.86

EWG advises that when the MSY approach is applied, catches in 2021 should be no more than 120.64 tonnes.

6.4.6 DATA DEFICIENCIES

The EWG 20-09 found some relevant data deficiency for this stock in terms of data quality.

- Catches for the GTR métiers are important during the period 2002-2008. However, the DCF does not hold length structure for this period. Accordingly, the length structure by year was reconstructed as indicated in this report.
- There is high variance for the abundance index estimated in 2007, 2009, 2017 and 2019 that match with issues identified in the TB to TC check. It is highly recommended request fitting the biomass of several hauls holding TB/TC ratios away from 1.
- After inspect the hauls for the above-mentioned years, the hauls 134 and 149 in 2009 were removed. Hauls in other years were kept despite they are contributing a high annual variance because were jointly checked with the country expert.
- The recruitment peak estimated in 2018 may promote that fishing mortality looks very low after this year. At the same time, recruitment in 2019 is too low regarding the available time series, despite fishing mortality is the lowest as well.

6.5 Red mullet in GSA 6

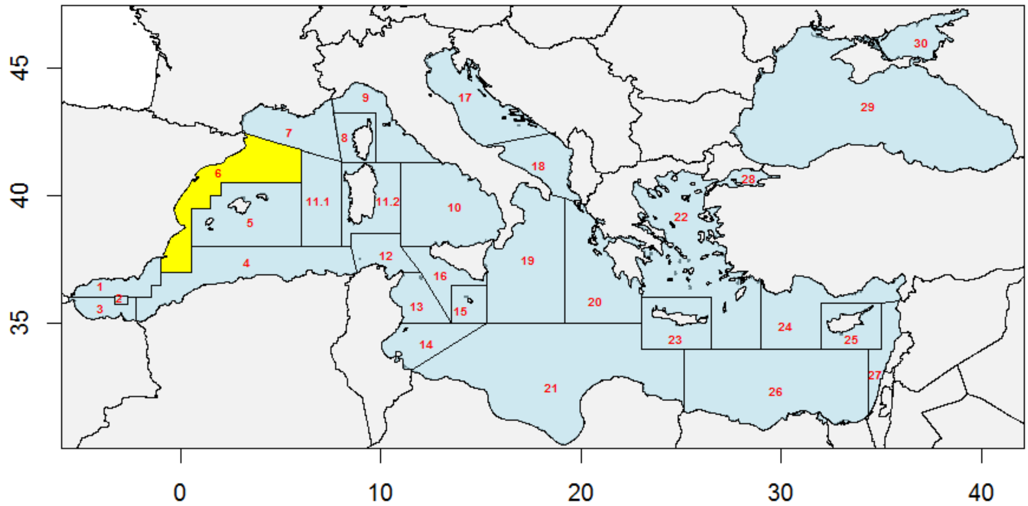


Figure 6.5.1.1 Red mullet in GSA 6: Location of GSA 6 in the Mediterranean Sea.

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. After discussion, 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). 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 (t0 +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 EWG19-10 assessment).

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)

Red mullet landings in GSA 6 come predominantly from OTB; a small amount is reported for small-scale fishing gears (trammel-net). 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 by fishing gear over 2002-2019 (tonnes; FPO=pots and traps; GNS=gillnet; GTR=trammel net; LLS=longlines; OTB=otter bottom trawl).

	FPO	GNS	GTR	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	1.52	137.0	0.6	923.1	1063.1
2012	0.6	0.13	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

Table 6.5.2.1.2 Red mullet in GSA 6. Discards 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	
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

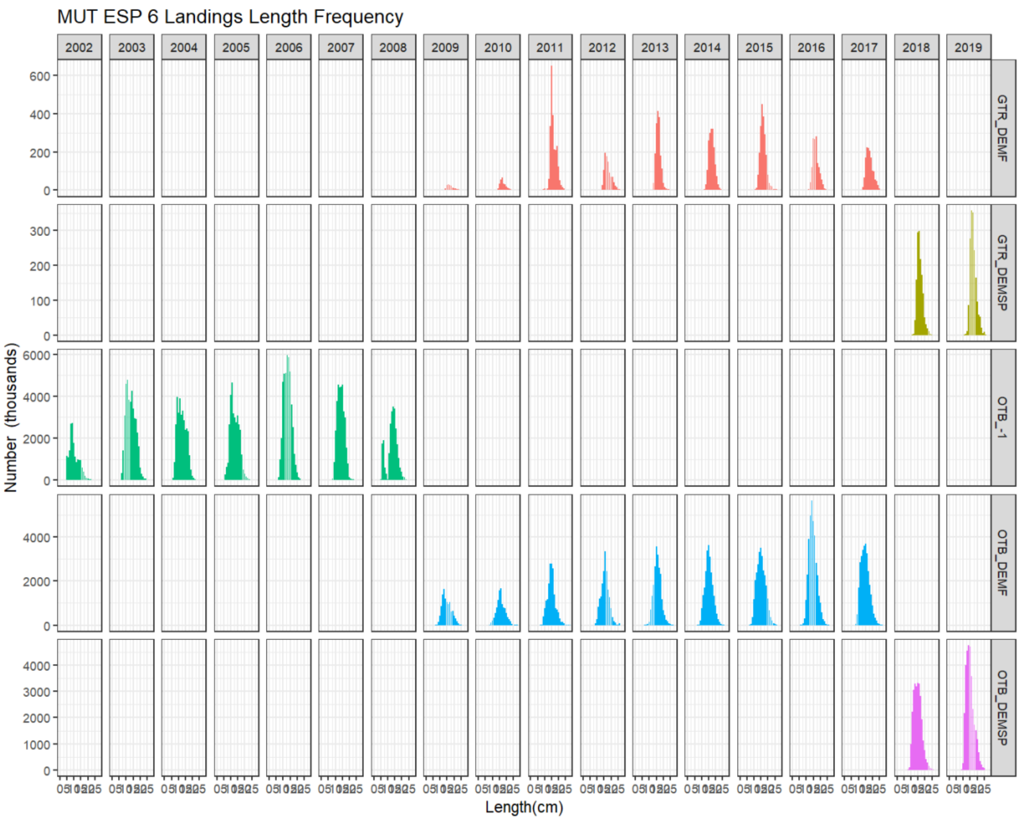


Figure 6.5.2.1.1 Red mullet in GSA 6. Landings length frequency distribution, by year and gear (TL cm).

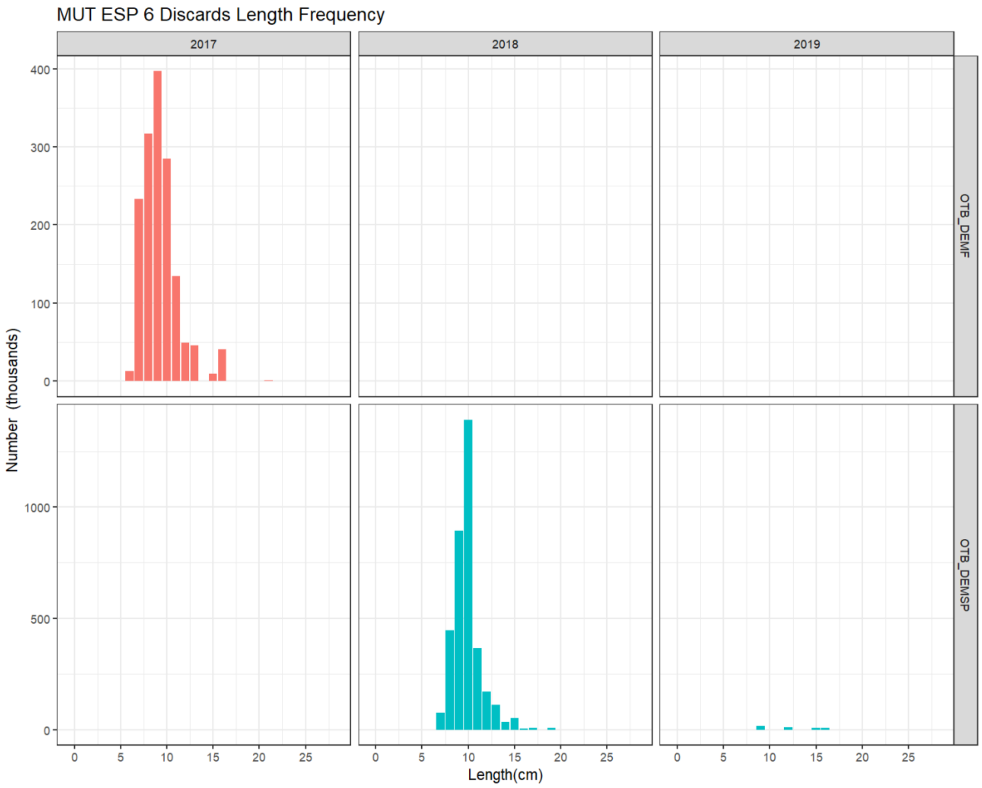


Figure 6.5.2.1.2 Red mullet in GSA 6. Discards length frequency distribution, by year and gear (TL cm).

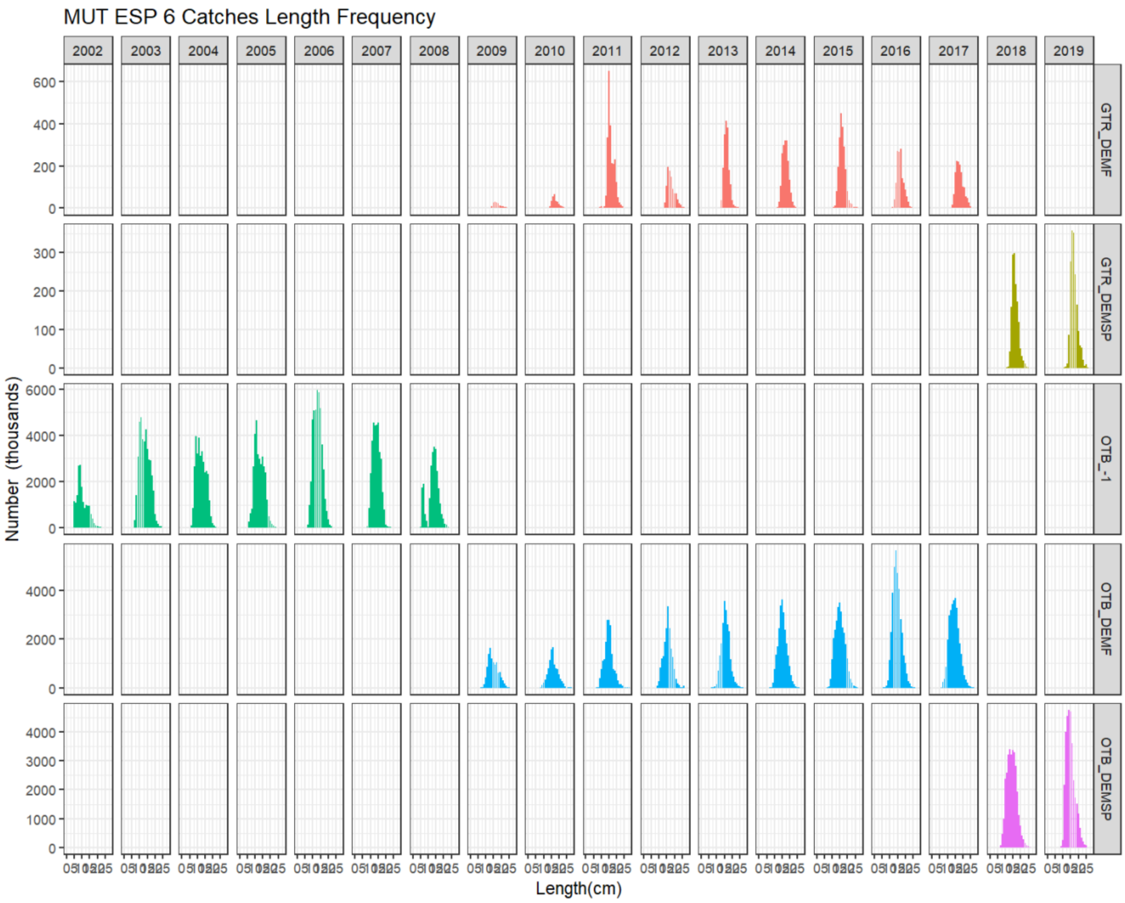


Figure 6.5.2.1.3 Red mullet in GSA 6. Catch length frequency distribution, by year and gear (TL cm).

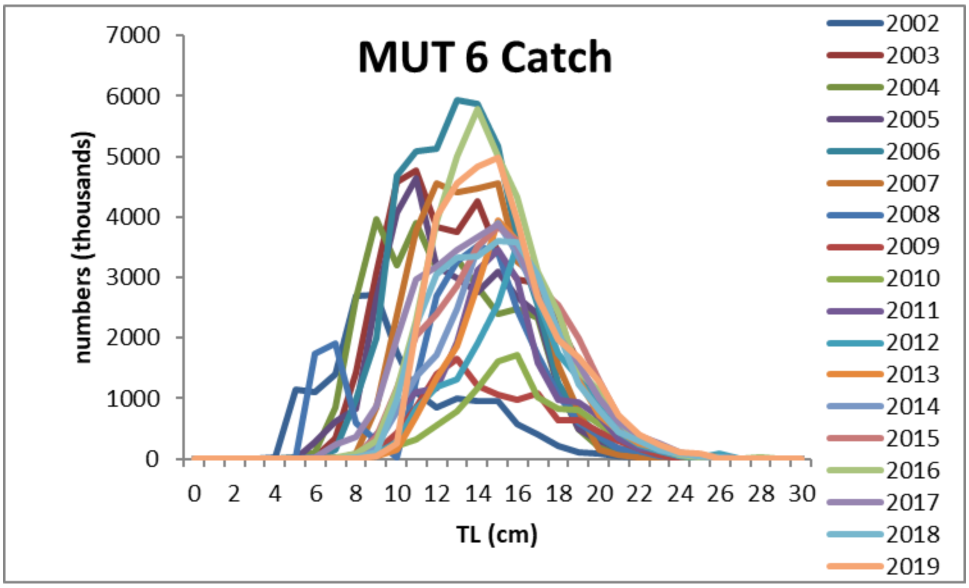


Figure 6.5.2.1.4 Red mullet in GSA 6. Catch length frequency distribution (TL cm). SOP correction was applied in the preparation of the input data for the a4a assessment.

Table 6.5.2.1.3 Red mullet in GSA 6. SoP correction.

SoP correction	
2003	1.14
2004	1.12
2005	1.13
2006	1.14
2007	1.12
2008	1.12
2009	1.16
2010	0.97
2011	1.31
2012	1.20
2013	1.19
2014	1.17
2015	1.21
2016	1.19
2017	1.17
2018	1.12
2019	1.08

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
0	1.2	1.3	1.2	0.9	0.6	0.4
1	21497.0	12490.0	14667.0	14419.0	11253.0	8081.3
2	15477.0	11084.0	8244.1	11884.0	13759.0	12089.0
3	1232.7	517.4	681.5	796.9	1578.4	2230.3
4	24.6	45.8	37.7	75.6	125.9	299.8
age	2009	2010	2011	2012	2013	2014
0	0.5	0.7	1.0	1.3	1.5	1.5
1	6771.4	7584.7	10640.0	15339.0	19259.0	20665.0
2	9262.0	7785.9	8252.8	10554.0	13828.0	16241.0
3	2137.7	1600.2	1191.7	1052.8	1121.5	1298.3
4	486.0	493.5	349.5	214.5	146.8	129.6
age	2015	2016	2017	2018	2019	
0	1.6	1.7	1.6	1.3	0.9	
1	20958.0	22053.0	23655.0	23156.0	18993.0	
2	17002.0	17383.0	18597.0	19944.0	18944.0	
3	1463.3	1559.0	1634.2	1722.9	1714.3	
4	140.0	159.9	175.8	182.4	178.2	

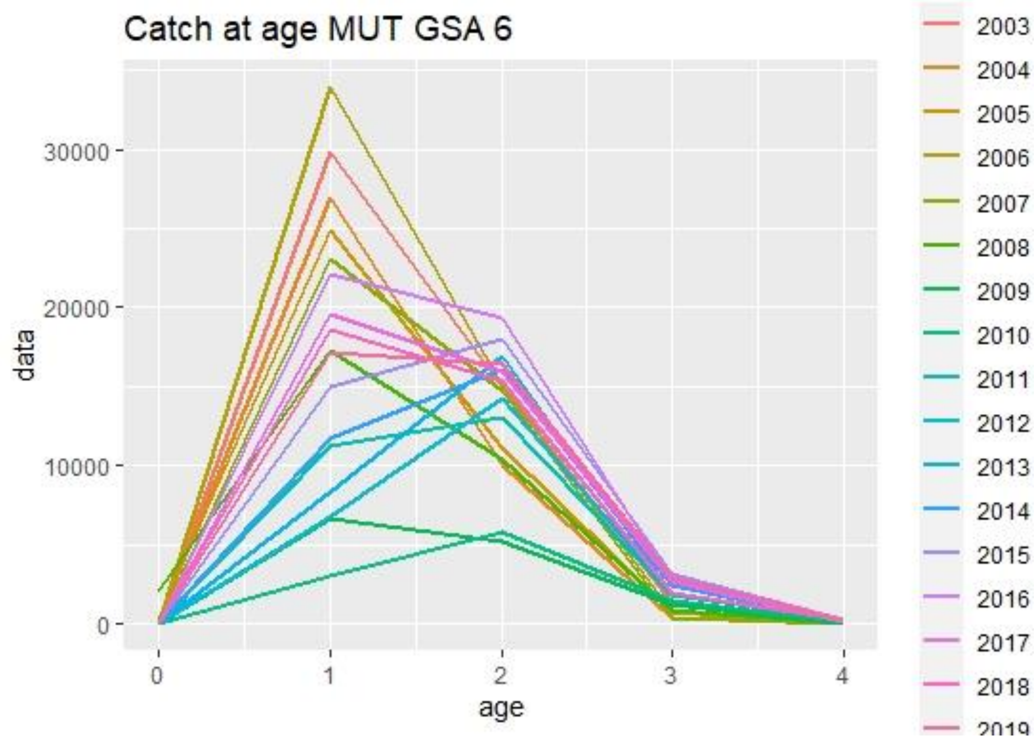


Figure 6.5.2.1.5 Red mullet in GSA 6. Catch at age, input to a4a.

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

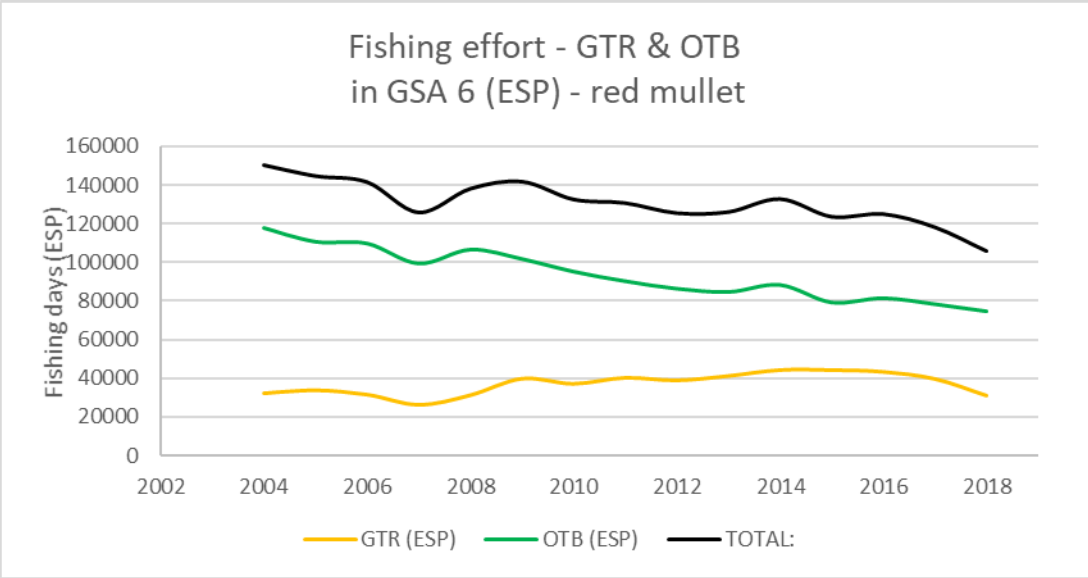


Figure 6.5.2.2.1 Fishing effort in GSA 6, expressed in number of fishing days, for trammel net (GTR) and bottom trawl (OTB), the fishing gears that target red mullet.

6.5.1.1 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 1994-2019 (Fig. 6.5.2.3.1).

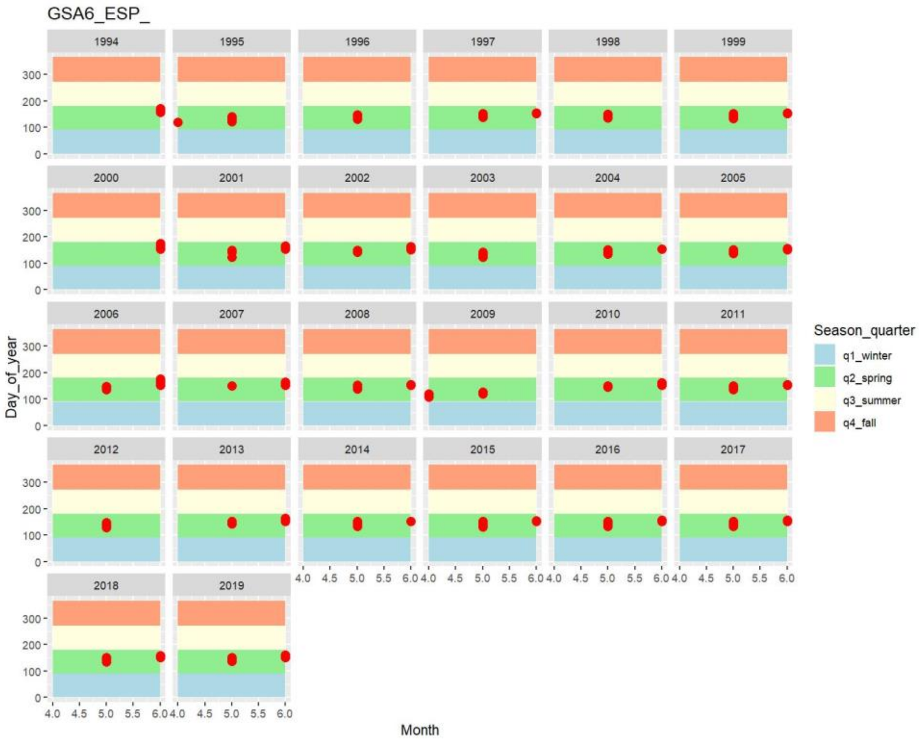
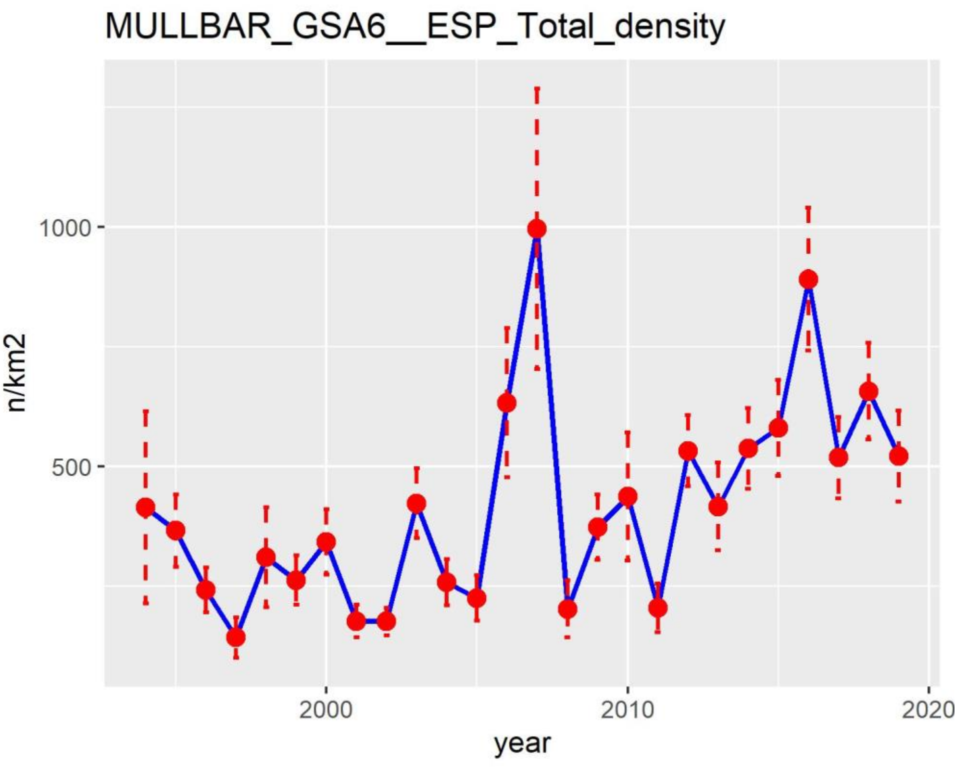


Figure 6.5.2.3.1 MEDITS survey period in GSA 6.



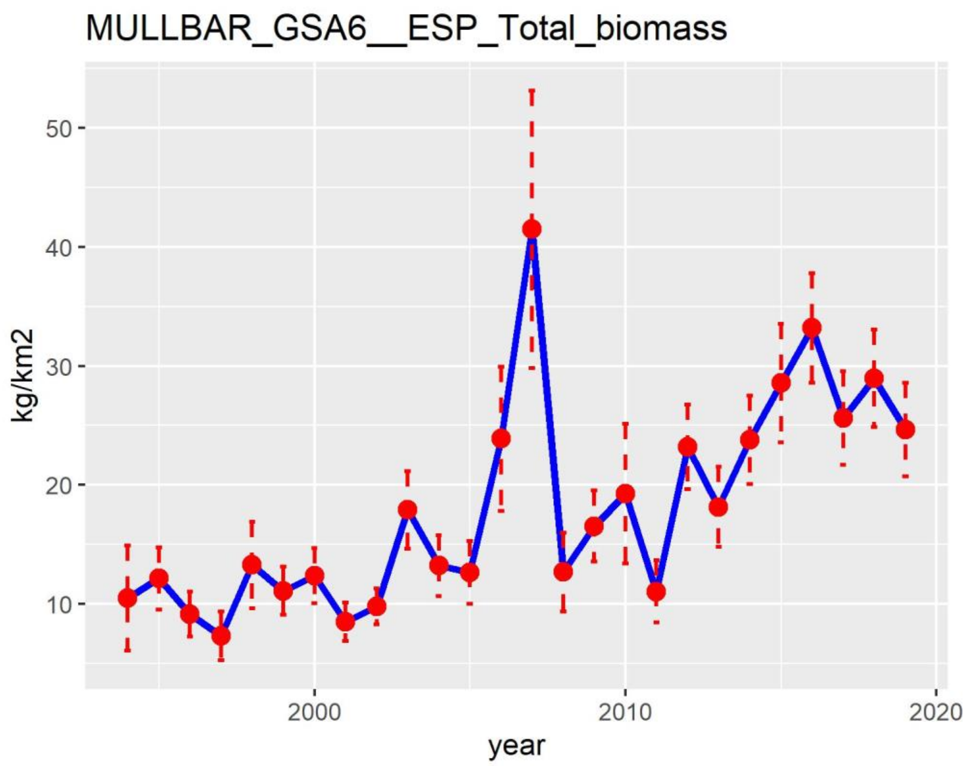


Figure 6.5.2.3.2 Red mullet in GSA 6. MEDITS abundance (n/km²) and biomass (kg/km²) over 1994-2019.

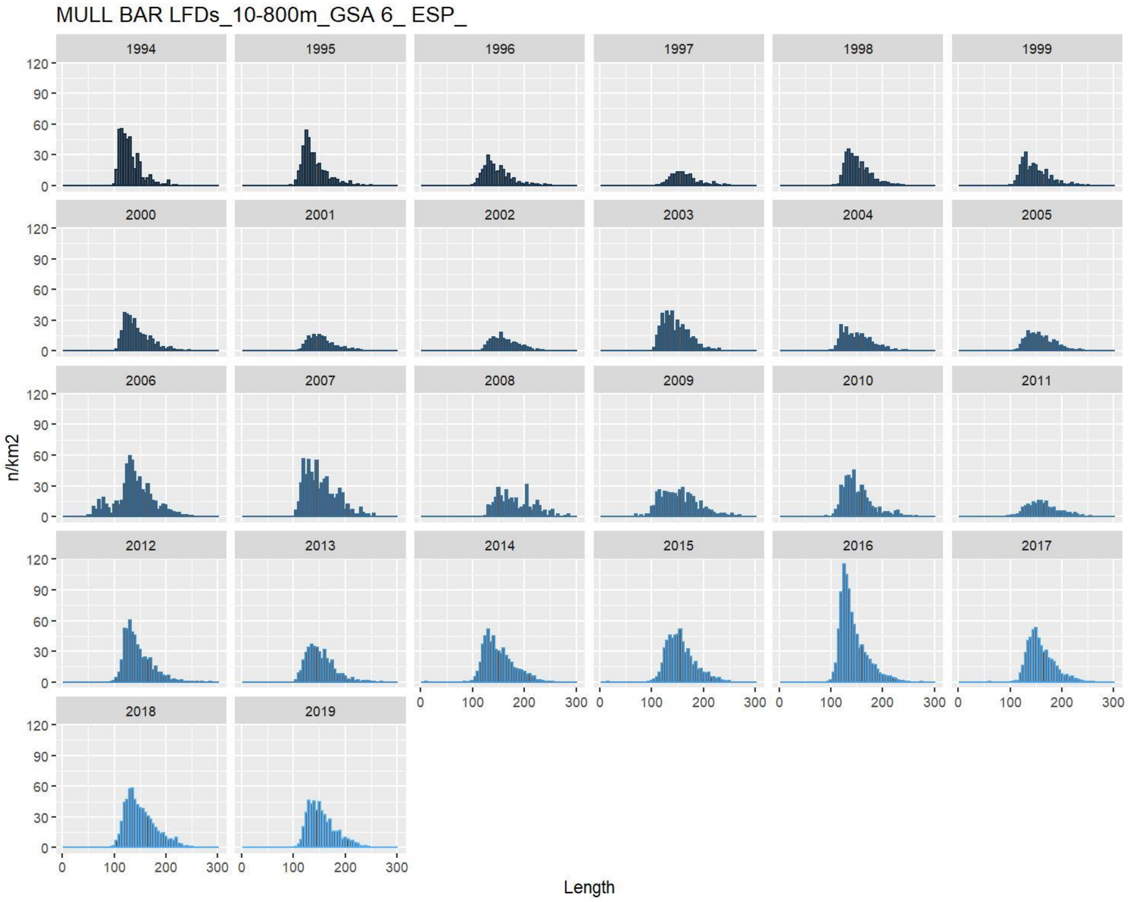


Figure 6.5.2.3.3 Red mullet in GSA 6. MEDITS length frequency distribution n/km²).

Table 6.5.2.3.1 Red mullet in GSA 6. MEDITS age structure as resulting from slicing.

age	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	0.3	0	0	0	0	0.9	0	0	0.5
1	335.7	216.2	112.2	268.5	228.4	305.8	143.5	122.8	368.2
2	28.6	22.5	26.7	39.6	31.2	34.5	30.0	43.4	51.0
3	1.2	2.6	3.2	2.0	2.2	1.9	3.0	3.4	3.7
4	0	0	0	0	0	0	0	0	0
age	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	0	0	84.8	0	0.3	8.9	0.4	1.2	0.2
1	213.1	170.6	568.8	514.6	176.8	345.1	374.9	148.7	467.2
2	41.5	49.8	79.4	124.5	132.2	88.6	52.2	50.5	61.5
3	3.1	4.3	6.3	20.3	36.1	14.9	11.6	6.3	4.3
4	0.2	0.3	0	0	2.8	2.1	0	0	0.7
age	2013	2014	2015	2016	2017	2018	2019		
0	0	0.8	0.5	0.4	0.2	0	0		
1	355.8	441.0	466.5	796.0	406.0	533.3	417.0		
2	54.1	90.4	103.5	88.9	104.4	111.1	97.6		
3	5.9	6.0	10.0	5.7	7.7	9.2	7.1		
4	0.2	0	0	0.4	0	0.3	0		

6.5.3 STOCK ASSESSMENT

Method a4a

Assessment for All Initiative (a4a) (Jardim et al., 2015) is a statistical catch–at– age method that utilizes catch at age data to derive estimates of historical population size and fishing mortality. Model parameters are estimated by working forward in time and analyses do not require the assumption that removals from the fishery are known without error. A4a is implemented as a package (Fla4a) of the FLR library.

Input data growth parameters, total catch, numbers at age, natural mortality M, maturity at age and survey index are given in previous sections. Fbar was set to F(1-3).

Table 6.5.3.1 Red mullet in GSA 6. Input data. Catch and stock s at age (kg)

	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0.002	0.002	0.002	0.002	0.000	0.002	0.000	0.002	0.000
1	0.017	0.015	0.016	0.018	0.020	0.017	0.021	0.022	0.022
2	0.051	0.048	0.047	0.046	0.047	0.047	0.051	0.050	0.047
3	0.097	0.096	0.099	0.096	0.097	0.098	0.099	0.102	0.099
4	0.159	0.156	0.170	0.166	0.170	0.158	0.167	0.189	0.163
	2012	2013	2014	2015	2016	2017	2018	2019	
0	0.000	0.001	0.000	0.000	0.002	0.002	0.002	0.000	
1	0.022	0.023	0.022	0.021	0.022	0.019	0.019	0.022	
2	0.050	0.050	0.050	0.051	0.049	0.050	0.049	0.049	
3	0.098	0.100	0.098	0.099	0.098	0.100	0.100	0.099	
4	0.176	0.169	0.160	0.165	0.161	0.164	0.166	0.163	

Assessment Results

This assessment is an update of the EWG-19-10 assessment, when different a4a models were performed (combination of different f, q and sr). During this EWG different k values for the fmodel were also explored. The following model, the same as in EWG-19-10, 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)))

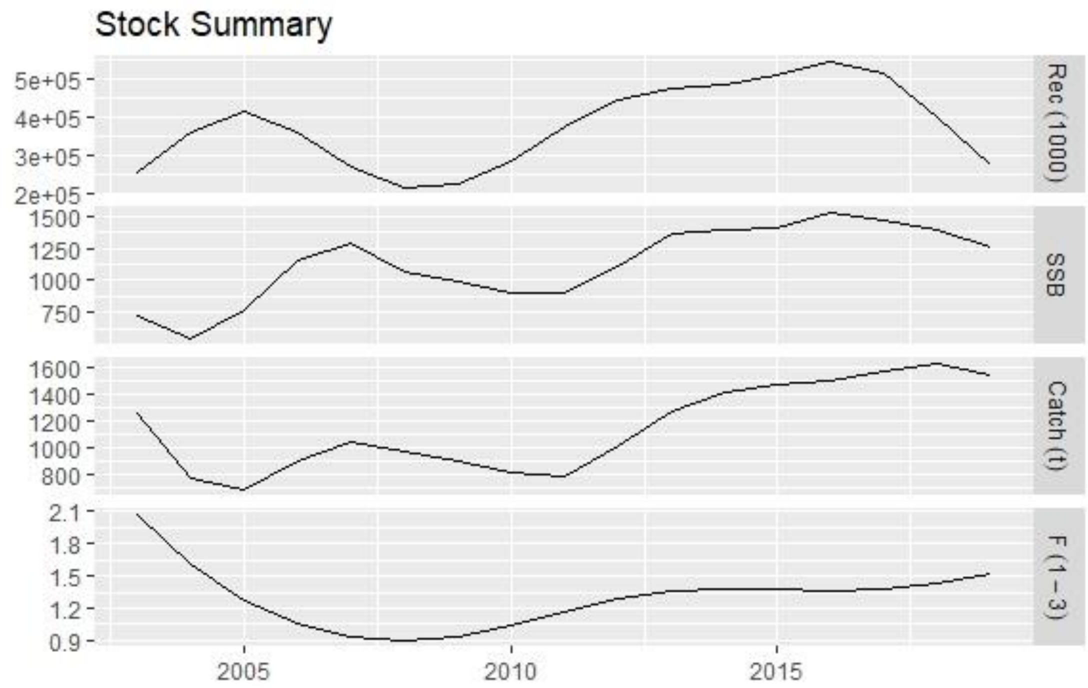


Figure 6.5.3.1 Red mullet in GSA 6. Stock summary from the a4a model for Red mullet in GSA 6, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

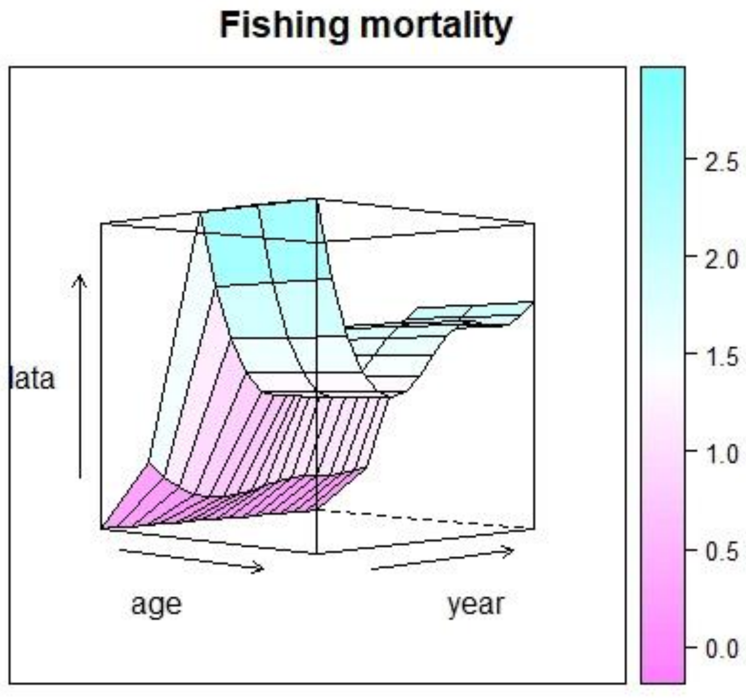


Figure 6.5.3.2 Red mullet in GSA 6. 3D contour plot of estimated fishing mortality by age and year.

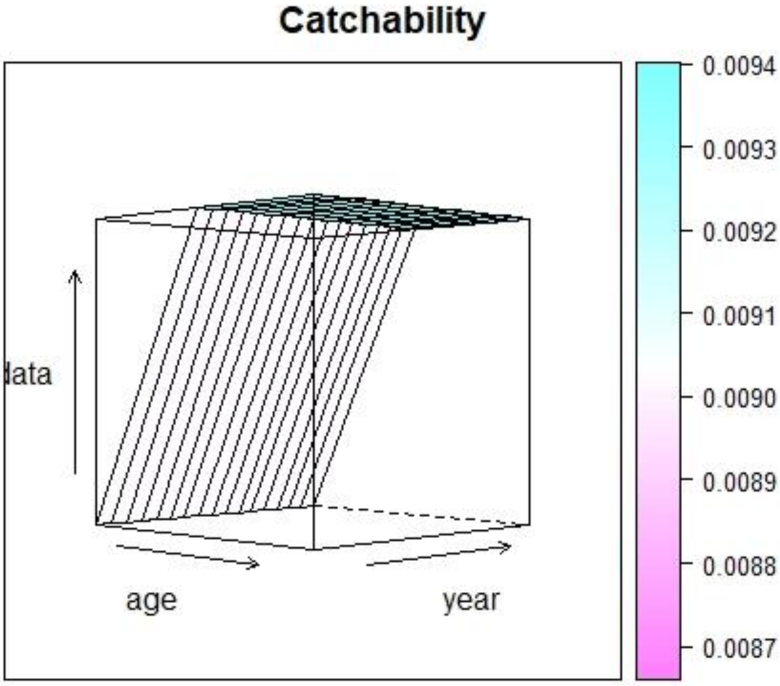


Figure 6.5.3.3 Red mullet in GSA 6. 3D contour plot of estimated catchability by age and year.

Diagnostics

Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of red mullet stock.

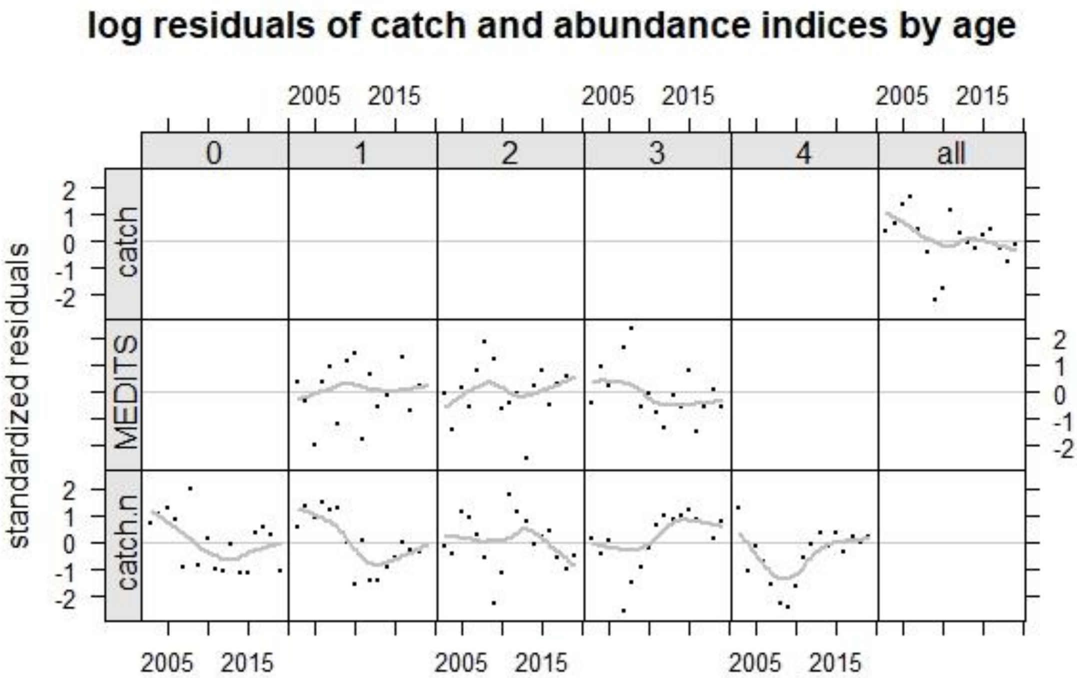


Figure 6.5.3.4 Red mullet in GSA 6. Standardized residuals for catch, abundance indices and for catch numbers.

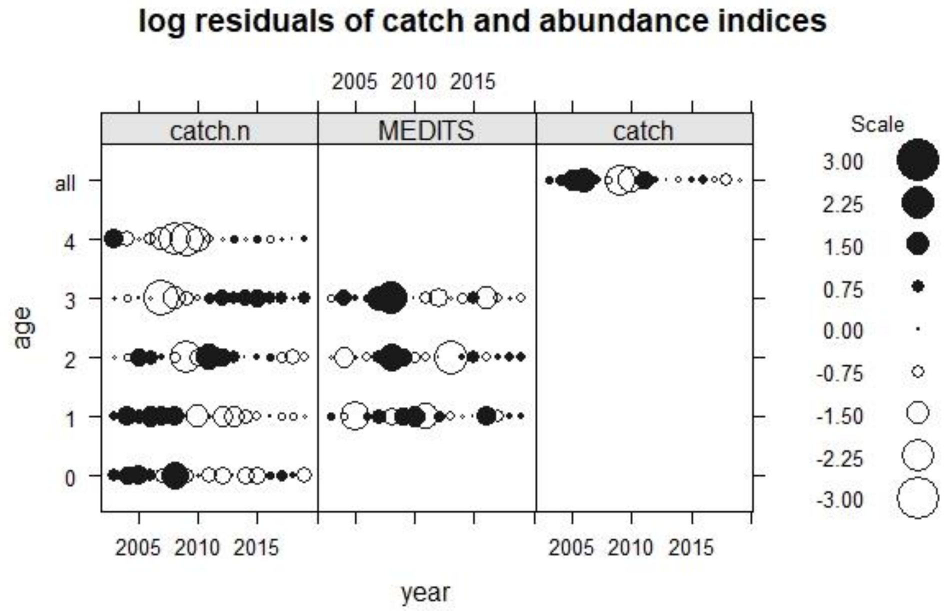


Figure 6.5.3.5 Red mullet in GSA 6. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

Table 6.5.3.2 Red mullet in GSA 6. Catches log residuals.

	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0.730	1.090	1.298	0.821	-0.916	1.968	-0.866	0.157	-1.009
1	0.555	1.306	0.901	1.453	1.220	1.293	-0.036	-1.541	0.091
2	-0.114	-0.405	1.158	0.914	0.274	-0.582	-2.256	-1.132	1.751
3	0.115	-0.440	0.060	-0.188	-2.560	-1.501	-0.944	-0.223	0.628
4	1.302	-1.060	-0.123	-0.728	-1.544	-2.303	-2.405	-1.663	-0.565
	2012	2013	2014	2015	2016	2017	2018	2019	
0	-1.095	-0.053	-1.137	-1.140	0.322	0.594	0.279	-1.044	
1	-1.402	-1.429	-0.959	-0.565	0.000	-0.320	-0.375	-0.175	
2	1.136	0.782	-0.058	0.206	0.412	-0.589	-1.021	-0.537	
3	0.964	0.809	0.963	1.172	0.824	0.724	0.167	0.778	
4	-0.091	0.329	-0.120	0.350	-0.361	0.183	-0.040	0.209	

Table 6.5.3.3 Red mullet in GSA 6. MEDITS survey log residuals.

	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.371	-0.321	-1.993	0.396	0.923	-1.188	1.161	1.402	-1.752
2	-0.094	-1.420	0.143	-0.556	0.754	1.856	1.191	-0.663	-0.452
3	-0.431	0.962	0.222	0.343	1.644	2.345	-0.549	-0.049	-0.780
	2012	2013	2014	2015	2016	2017	2018	2019	
1	0.660	-0.543	-0.110	-0.019	1.278	-0.712	0.207	0.239	
2	-0.041	-2.444	0.235	0.809	-0.524	0.268	0.552	0.486	
3	-1.339	-0.160	-0.576	0.797	-1.489	-0.540	0.102	-0.552	

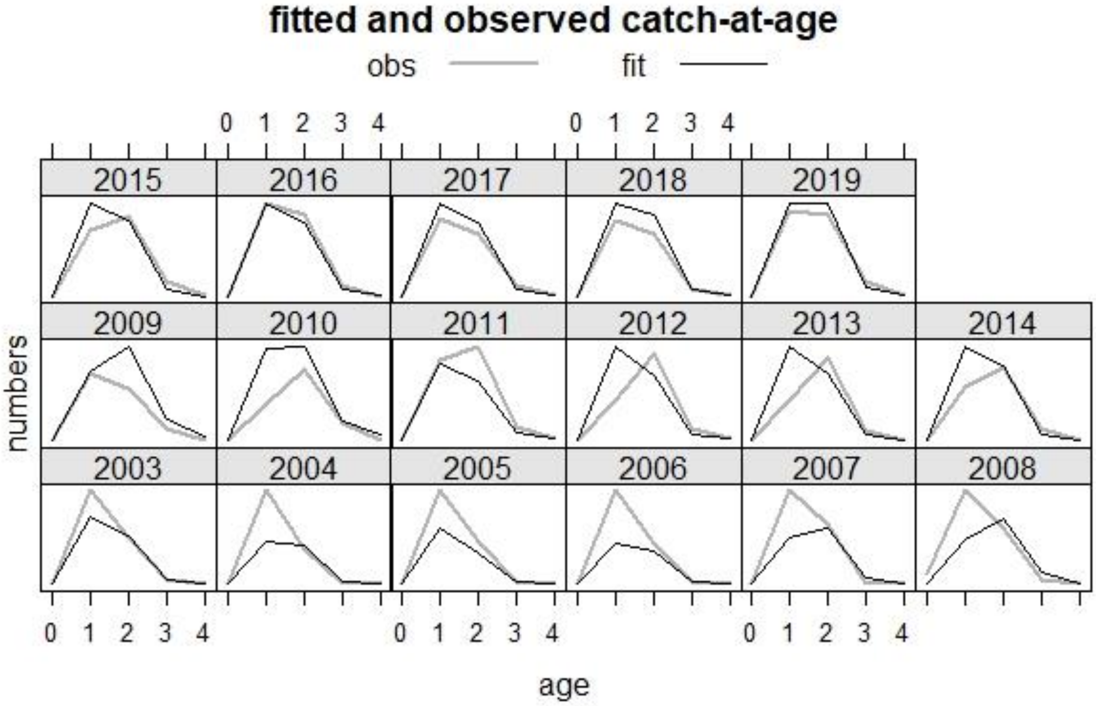


Figure 6.5.3.6 Red mullet in GSA 6. Fitted and observed catch at age.

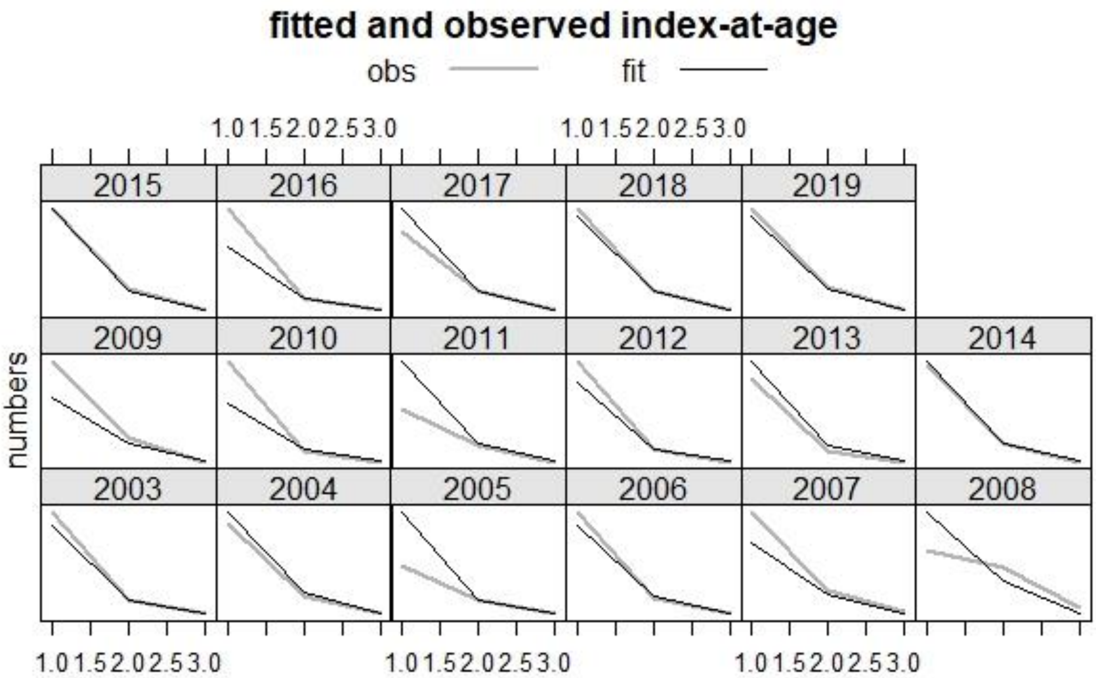


Figure 6.5.3.7 Red mullet in GSA 6. Fitted and observed index at age

RETROSPECTIVE

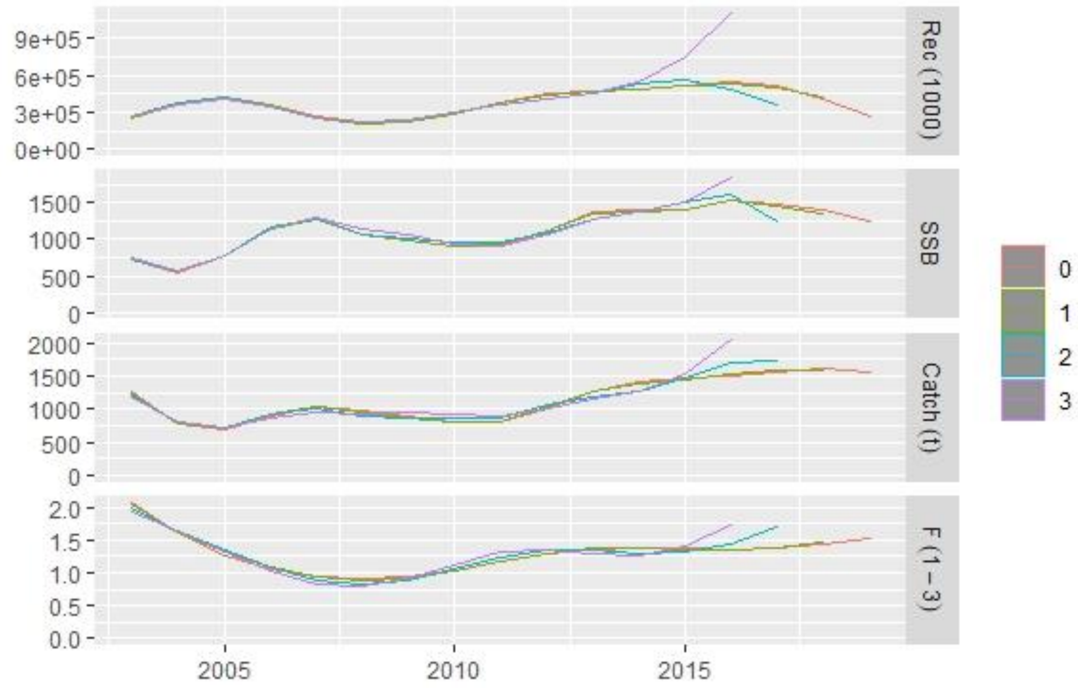


Figure 6.5.3.8 Red mullet in GSA 6. Retrospective analysis for the a4a model.

SIMULATIONS

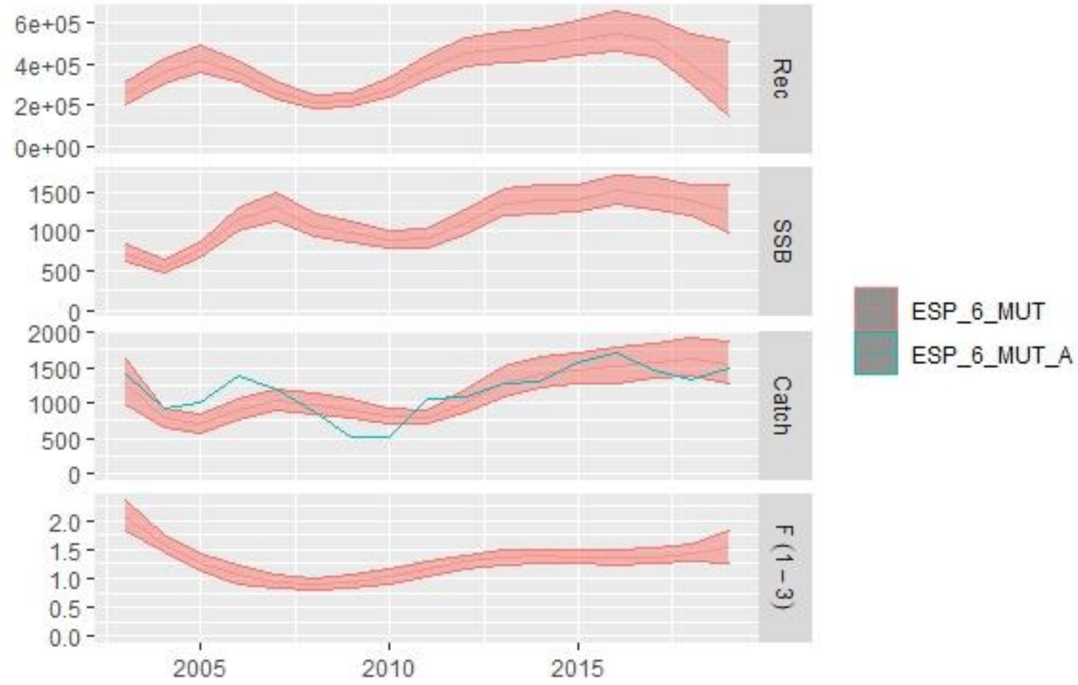


Figure 6.5.3.9 Red mullet in GSA 6. Stock summary of the simulated and fitted data for the a4a model.

Table 6.5.3.4 Red mullet in GSA 6. F at age from a4a assessment.

	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	0.641	0.498	0.395	0.328	0.291	0.281	0.293	0.322	0.361
2	2.773	2.153	1.706	1.417	1.260	1.215	1.266	1.392	1.562
3	2.773	2.153	1.706	1.417	1.260	1.215	1.266	1.392	1.562
4	2.773	2.153	1.706	1.417	1.260	1.215	1.266	1.392	1.562
	2012	2013	2014	2015	2016	2017	2018	2019	
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
1	0.399	0.423	0.430	0.426	0.422	0.428	0.447	0.475	
2	1.724	1.829	1.859	1.842	1.827	1.852	1.933	2.053	
3	1.724	1.829	1.859	1.842	1.827	1.852	1.933	2.053	
4	1.724	1.829	1.859	1.842	1.827	1.852	1.933	2.053	

Table 6.5.3.5 Red mullet in GSA 6. N at age from a4a assessment.

	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	254466	361740	416890	360432	267182	215968	222599	282874	375092

1	63191	44723	63578	73270	63348	46959	37957	39123	49717
2	19361	15022	12272	19341	23835	21367	16003	12785	12798
3	1504	682	983	1255	2643	3809	3570	2542	1790
4	30	59	54	117	207	503	797	770	516
	2012	2013	2014	2015	2016	2017	2018	2019	
0	448270	474428	484875	513839	544816	514937	402040	272722	
1	65924	78785	83383	85219	90310	95753	90502	70661	
2	15639	19974	23298	24484	25123	26720	28163	26128	
3	1512	1572	1807	2044	2186	2278	2362	2297	
4	303	202	178	192	221	241	246	235	

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	254466	722.6	1264.6	2.062
2004	361740	551.8	776.8	1.601
2005	416890	770.2	694.3	1.269
2006	360432	1148.0	899.5	1.054
2007	267182	1294.5	1045.7	0.937
2008	215968	1072.3	969.1	0.904
2009	222599	984.9	908.3	0.942
2010	282874	895.8	814.4	1.036
2011	375092	907.1	796.0	1.162
2012	448270	1117.2	1011.2	1.282
2013	474428	1363.0	1274.9	1.360
2014	484875	1398.6	1410.7	1.383
2015	513839	1407.6	1468.8	1.370
2016	544816	1520.2	1507.1	1.358
2017	514937	1465.9	1567.1	1.378
2018	402040	1392.3	1622.7	1.437
2019	272722	1254.9	1545.7	1.527

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 0.313. Current F values (2019), as calculated by model a4a, is 1.53 indicating that the stock is being overfished.

6.5.5 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 basis for the choice of values is given in Section 4.3. An average of the last three years has been used for the biological parameters, while the F_{bar} =1.53 terminal F (2019) from the a4a assessment was used for F in 2020 because F increased in the last three years. Recruitment is observed to fluctuate over the period of the assessment and did not display any clear trend

(Figure 6.5.3.1). Recruitment for 2020 to 2022 has been estimated from the population results as the geometric mean of the whole series (361482.5).

EWG advises that when the MSY approach is applied, catches in 2021 should be no more than 306.2 tonnes.

Table 6.5.5.1 Red mullet GSA 6: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average 2017-2019	mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2017-2019
$F_{ages\ 1\text{-}3}$ (2020)	1.53	F2019 used to give F status quo for 2020
SSB (2020)	834.7	Stock assessment 1 January 2020
R_{age0} (2020,2021)	361482.5	Geometric mean of the whole series 2003-2019
Total catch (2020)	1133	Assuming F status quo for 2020

The short term forecast was carried out estimating a catch for 2020-2022 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 2020 equal to 1545.7 and 834.7 tons, respectively.

Table 6.5.5.2 Red mullet GSA 6. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2021	SSB 2020	SSB 2022	SSB_change 2020-2022(%)	Catch_change 2019-2021(%)
High long term yield (F0.1)	0.2	0.31	1545.7	306.2	834.7	1981.5	137.4	-80.2
F upper	0.3	0.43	1545.7	399.7	834.7	1800.6	115.7	-74.1
F lower	0.1	0.21	1545.7	215.0	834.7	2167.7	159.7	-86.1
FMSY transition	0.7	1.12	1545.7	797.3	834.7	1146.0	37.3	-48.4
Zero catch	0	0.00	1545.7	0.0	834.7	2643.3	216.7	-100.0
Status quo	1	1.53	1545.7	950.7	834.7	944.5	13.2	-38.5
Different Scenarios	0.1	0.15	1545.7	160.9	834.7	2282.7	173.5	-89.6
	0.2	0.31	1545.7	299.8	834.7	1994.2	138.9	-80.6
	0.3	0.46	1545.7	420.6	834.7	1761.4	111.0	-72.8
	0.4	0.61	1545.7	526.0	834.7	1572.0	88.3	-66.0
	0.5	0.76	1545.7	618.8	834.7	1416.4	69.7	-60.0
	0.6	0.92	1545.7	700.7	834.7	1287.5	54.2	-54.7
	0.7	1.07	1545.7	773.6	834.7	1179.6	41.3	-50.0
	0.8	1.22	1545.7	838.9	834.7	1088.6	30.4	-45.7
	0.9	1.37	1545.7	897.6	834.7	1011.1	21.1	-41.9
	1.1	1.68	1545.7	999.1	834.7	886.9	6.3	-35.4
	1.2	1.83	1545.7	1043.4	834.7	836.6	0.2	-32.5
	1.3	1.98	1545.7	1084.0	834.7	792.3	-5.1	-29.9
	1.4	2.14	1545.7	1121.6	834.7	753.0	-9.8	-27.4
	1.5	2.29	1545.7	1156.5	834.7	717.9	-14.0	-25.2
	1.6	2.44	1545.7	1188.9	834.7	686.4	-17.8	-23.1
	1.7	2.60	1545.7	1219.3	834.7	657.9	-21.2	-21.1
	1.8	2.75	1545.7	1247.7	834.7	632.0	-24.3	-19.3

	1.9	2.90	1545.7	1274.5	834.7	608.2	-27.1	-17.5
	2	3.05	1545.7	1299.7	834.7	586.3	-29.8	-15.9

6.6 RED MULLET IN GSA 7

6.6.1 STOCK IDENTITY AND BIOLOGY

Red mullet (*Mullus barbatus*) in the Gulf of Lions (GSA 7) is a shared stock exploited by both Spanish and French trawlers, and since 2011 also by French artisanal gears.

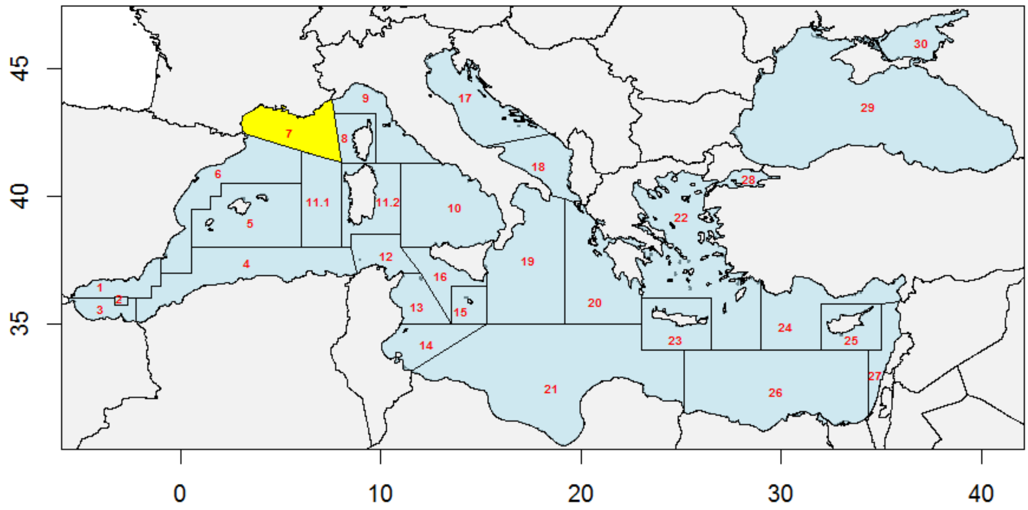


Figure 6.6.1.1. Localisation of GSA 7 (in Yellow) in the Mediterranean Sea.

6.6.1.1 METHOD FOR AGE-SLICING

The process of age slicing is central to the data preparation of stock assessment. In previous assessment for this GSA, age slicing was based on a Von Bertalanffy growth curve estimated by Demestre et al. (1997), denoted “fast growth model” (FGM, with parameters L_{inf} = 34.5cm, k = 0.34 $years^{-1}$, and t_0 = -0.14cm).

In the present assessment, we questioned the use of the FGM and compared its use with two alternatives, (1) fitting a Von Bertalanffy model to the age-reading data available for GSA 7; and (2) building a global Age-Length-Key directly from the data (Figure 6.6.1.2).

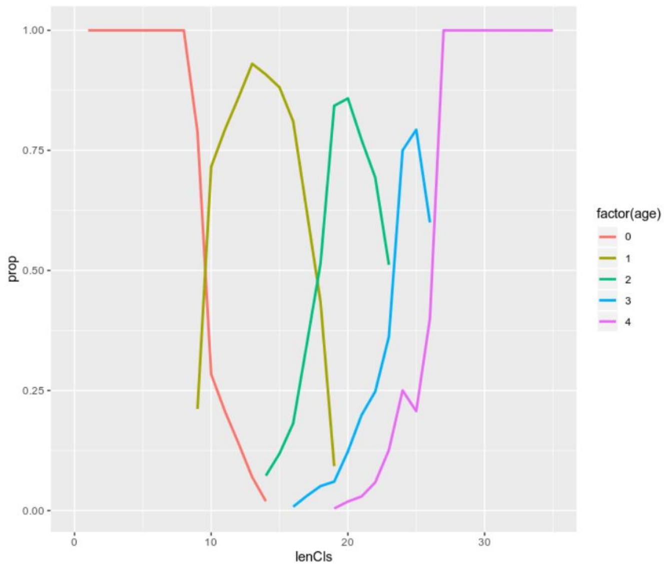


Figure 6.6.1.2. Age-length Key derived from age-reading data. The purple line corresponds to age 4 or more.

The fitted Von Bertalanffy growth model provided a slightly different set of parameters (L_{inf} = 26.25cm, k = 0.5 years^{-1}, and t_0 = -0.55cm), and the comparison between both models suggested that the FGM was not well suited for Red Mullet in GSA 7 (Figure 6.6.1.3).

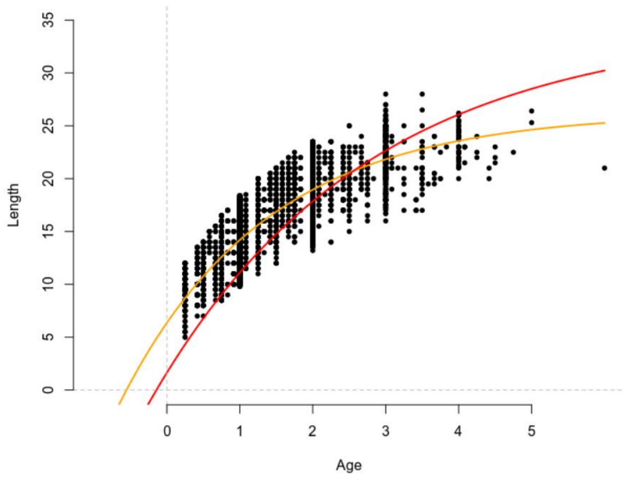


Figure 6.6.1.3. Fast growth model (red) and fitted VB growth curve (orange) compared to age-reading data (dots).

The consequence of the choice of the age-slicing methods can be observed on the time series of reconstructed landings at age (fig 4). The fast growth model tends to greatly under-estimate the abundance of age-0 individuals, while inflating the abundance of age 2 individuals. Abundance of age 0 individuals peaks with fitted growth model.

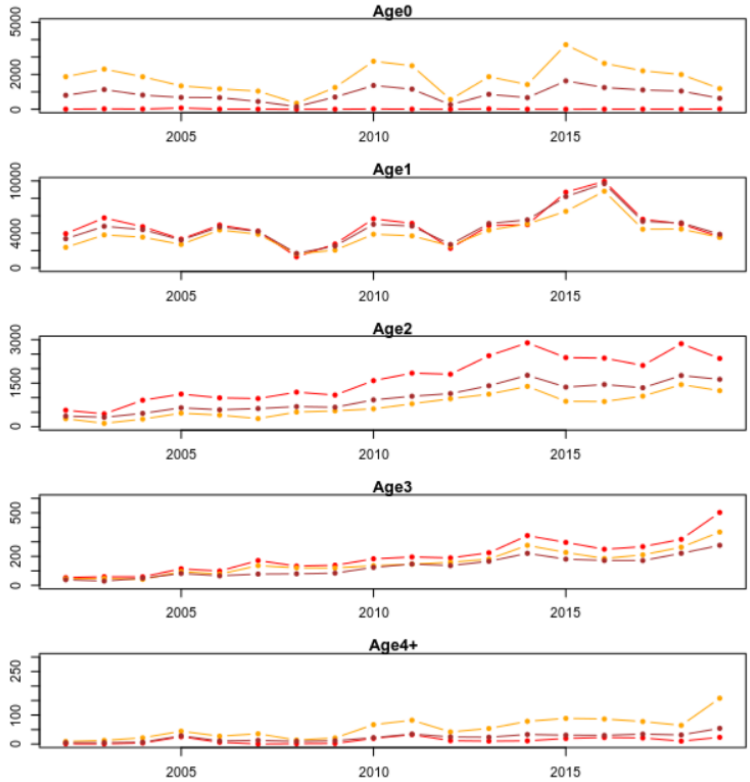
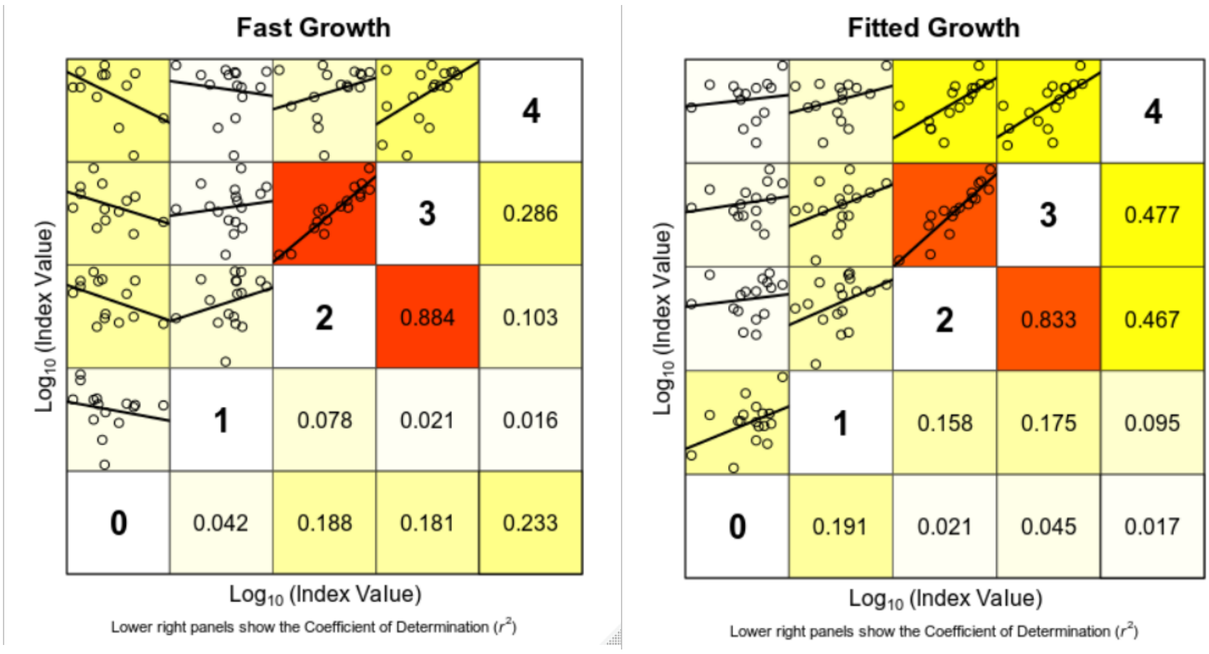


Figure 6.6.1.4. Landings at age in thousands of individuals, obtained with age slicing based on fast growth (red), fitted growth (orange) and global age-length-key (brown).

Further discrepancies appear in cohort-consistency plots (Figure 6.6.1.5) based on each slicing methods.



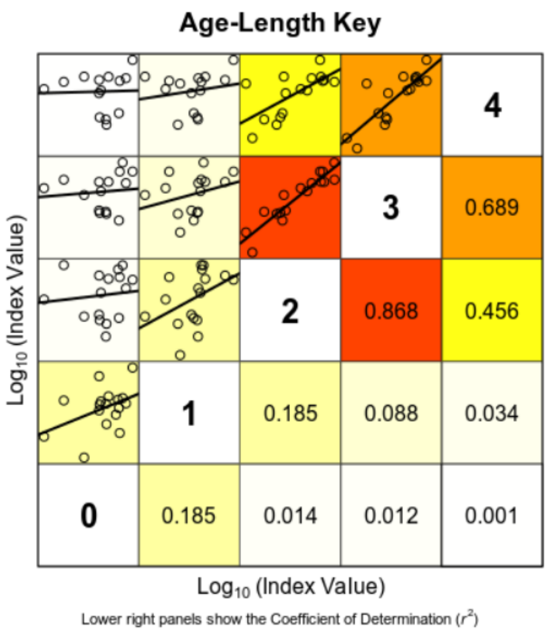


Figure 6.6.1.5. cohort-consistency plots for the three age slicing options: Fast growth (upper left), fitted growth (upper right), and age-length key (lower left).

Cohort consistency is clearly improved when age slicing is performed with either the fitted growth model or the ALK. Between both, ALK provides a slightly better cohort consistency. We therefore chose to proceed with ALK to perform the assessment.

6.6.1.2 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 6.6.1.6) has parameters ln(a)=-4.55, and b=3.03.

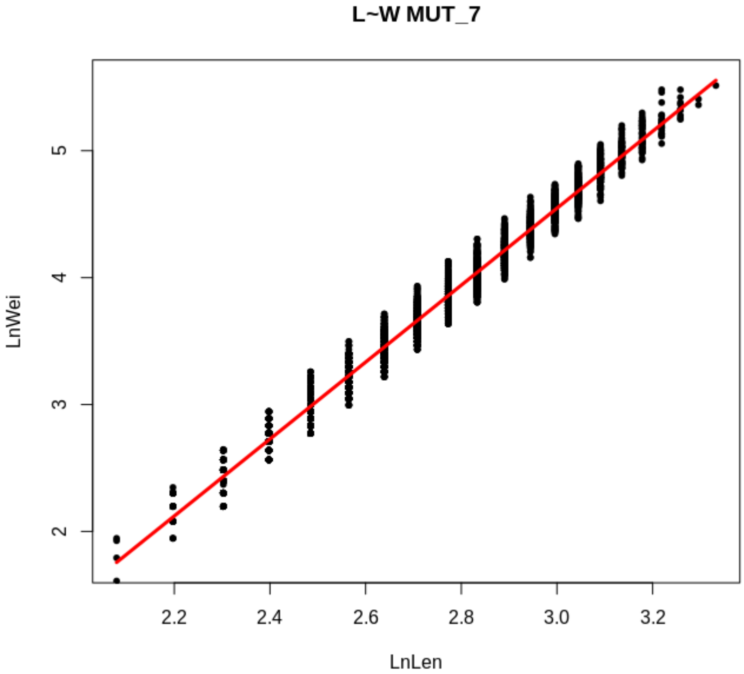


Figure 6.6.1.6. Length-Weight relationship obtained for Red Mullet in GSA 7 from DCF samples (2010 - 2019).

6.6.1.3 MATURITY AND NATURAL MORTALITY

Regarding maturity, spawning red mullet season is quite short (April-July, Figure 6.6.1.7), so we decided to assume that young individuals reach maturity when they arrive to Age 1 on 1st of July. For ages >1 all individuals are therefore considered as adults.

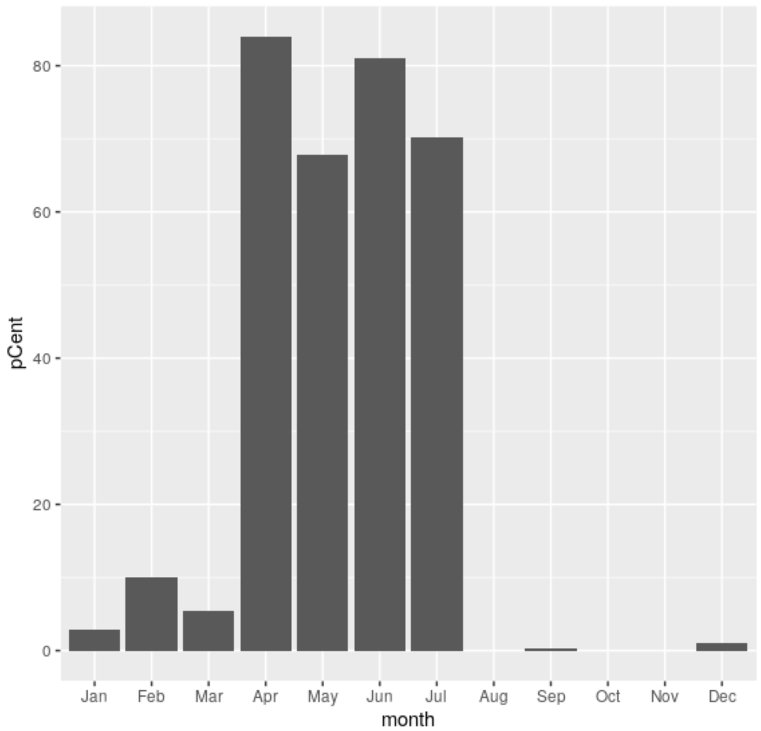


Figure 6.6.1.7. Proportion of mature Red Mullet per Month in GSA 7. Note that no samples were available for August.

Natural mortality was obtained from Rscript provided during the meeting and it is based on Chen Watanabe formula, with M=1.74, 0.8, 0.57, 0.48 and 0.43 at ages 0, 1, 2, 3 and 4+, respectively.

6.6.2 DATA

Available catch, landing and discards data are from DCF. EWG 20-09 received French and Spanish data for GSA 7 by fishing gears. French and Spanish data are provided since 2002 to 2019.

6.6.2.1 CATCH, LANDINGS AND DISCARDS AT LENGTH

Total catch by year is reported in Table 6.6.2.1 (in terms of landings and discards). The French fleet is usually responsible for ~90% of the catch, most of which results from trawlers (>95%, Figure 6.6.2.1 & Table 6.6.2.2). Trawlers exploit smaller size classes than nets (T: [7cm – 25cm]; G: [12cm - 30 cm], Figure 6.6.2.2).

Year	Fra_GSA7	Spa_GSA7	Total landings	Discards	Catch
2002	111.424	11.08	122.504	0	122.504
2003	164.141	11.87	176.011	0	176.011
2004	151.646	25.84	177.486	0	177.486
2005	148.086	27.48	175.566	0	175.566
2006	183.478	31.4	214.878	0	214.878
2007	171.526	36.16	207.686	0	207.686
2008	110.494	20.73	131.224	0.18	131.404
2009	122.555	26.13	148.685	0	148.685
2010	236.034	28.23	264.264	2.505	266.769
2011	241.682	28.13	269.812	4.388	274.2
2012	176.729	29.17	205.899	12.176	218.075
2013	260.423	37.53	297.953	10.068	308.021
2014	308.912	41.18	350.092	9.359	359.451
2015	335.381	33.05	368.431	18.043	386.474
2016	368.077	43.31	411.387	6.457	417.844
2017	261.364	31.09	292.454	8.843	301.297
2018	308.705	23.83	332.535	9.543	342.078
2019	278.615	22.168	300.783	19.023	319.806

Table 6.6.2.1. Landings per country, discards and catch per year, in tons.

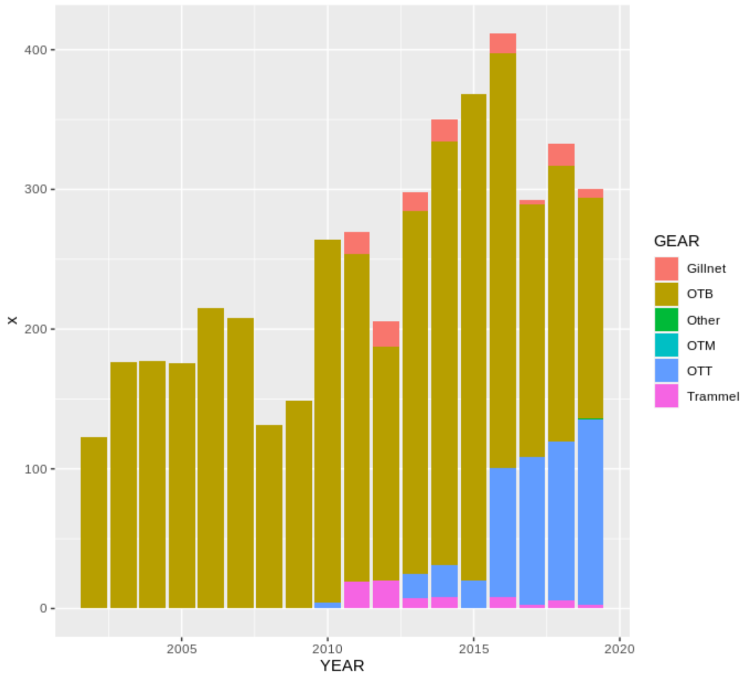


Fig 6.6.2.1. Red Mullet Landings per year and gear in GSA 7 (French and Spanish fleet confounded).

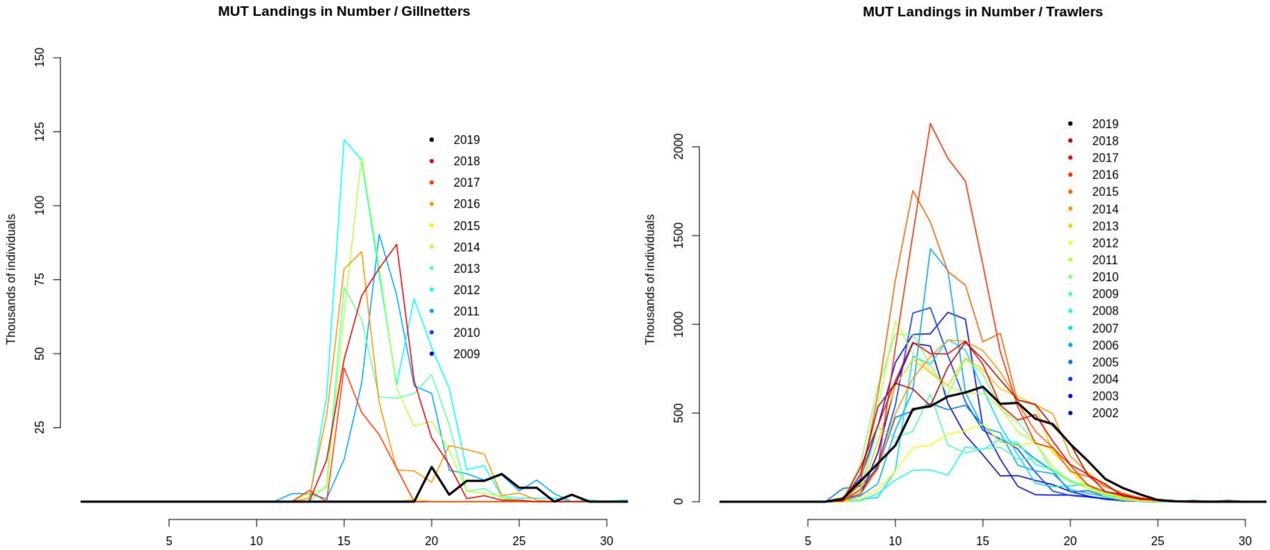


Fig 6.6.2.2. Size-Class distribution of Red Mullet landings per year, for gillnets & trammel nets (left) and trawlers (right). The thick black line corresponds to the most recent year (2019).

Year	ESP Gillnet	ESP Trammel	ESP Trawl	FRA Gillnet	FRA Other	FRA Trammel	FRA Trawl
2002	0	0	11.08	0	0	0	111.424
2003	0	0	11.87	0	0	0	164.141
2004	0	0	25.84	0	0	0	151.646
2005	0	0	27.48	0	0	0	148.086
2006	0	0	31.4	0	0	0	183.478
2007	0	0	36.16	0	0	0	171.526
2008	0	0	20.73	0	0	0	110.494
2009	0	0.12	26.01	0	0	0	122.555
2010	0	0.16	28.07	0	0	0	236.034
2011	0	0.07	28.06	15.924	0	18.878	206.881
2012	0	0	29.17	18.343	0	19.713	138.673
2013	0	0	37.53	13.57	0	7.388	239.465
2014	0	0	41.18	15.942	0	7.886	285.084
2015	0	0	33.05	0.041	0	0.025	335.315
2016	0	0	43.31	13.556	0	8.581	345.939
2017	0	0	31.09	3.444	0	2.47	255.45
2018	0	0	23.83	15.785	0	5.818	287.103
2019	0	0	22.168	6.335	0.363	2.878	269.039

Table 6.6.2.2. 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 6.6.2.2). The majority of the landings of red mullet comes from trawlers, and the other part are mainly 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 are due to OTB, but OTT have an increasing importance on the last years (Figure 6.6.2.1).

Discards were regularly reported since 2010 (Table 6.6.2.1). They are mostly composed of small individuals (Fig.9) and account for [1-5]% of the landed biomass, depending on year. In 2019, discards of small individuals have been particularly important (Figure 6.6.2.3).

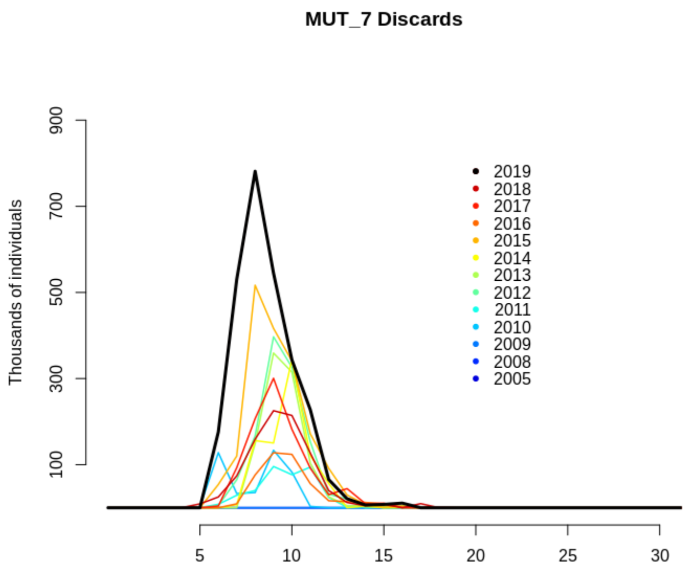


Figure 6.6.2.3. Size-Class distribution of Red Mullet discards per year

6.6.2.2 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 6.6.1.2) and the length-weight relationship (Figure 6.6.1.6). SoP corrections to N at age in the catch were applied by year. The resulting numbers and average weight at age are summarized below (Tables 3 – 6), and the resulting catch at age is displayed in Figure 6.6.2.4.

Year	0	1	2	3	4+
2002	809.73	3395.917	369.807	39.298	4.781
2003	1274.411	5387.557	363.285	33.813	5.543
2004	886.986	4802.032	499.869	53.809	7.105
2005	725.26	3433.611	695.798	87.715	30.538
2006	763.777	5390.863	666.692	75.775	12.354
2007	504.445	4723.495	702.504	87.591	14.378
2008	162.317	1758.901	728.367	83.983	9.857
2009	730.468	2619.198	696.102	87.89	11.9
2010	1492.944	5489.225	1010.569	135.53	24.101
2011	1235.718	5145.387	1120.604	156.815	36.904
2012	261.019	2700.563	1139.457	136.106	24.619
2013	860.234	5113.597	1411.999	166.345	23.768
2014	662.199	5473.461	1752.808	218.625	32.771
2015	1622.748	8164.393	1358.382	180.066	30.606
2016	1220.512	9462.887	1418.427	167.609	29.266
2017	1078.982	5206.711	1304.911	166.66	33.457
2018	1011.819	5015.077	1706.502	213.839	30.506
2019	605.768	3725.142	1569.267	265.788	52.27

Table 6.6.2.3. Landings at age (Thousands of individuals)

Year	0	1	2	3	4+
2002	0.013	0.024	0.071	0.095	0.123
2003	0.013	0.025	0.062	0.106	0.131
2004	0.014	0.026	0.064	0.101	0.142
2005	0.012	0.03	0.07	0.107	0.215
2006	0.016	0.027	0.07	0.103	0.152
2007	0.017	0.029	0.071	0.106	0.13
2008	0.015	0.037	0.075	0.093	0.118
2009	0.011	0.029	0.077	0.099	0.125
2010	0.011	0.029	0.071	0.111	0.153
2011	0.012	0.029	0.073	0.112	0.18
2012	0.015	0.036	0.076	0.098	0.206
2013	0.013	0.032	0.073	0.098	0.141
2014	0.015	0.033	0.075	0.102	0.135
2015	0.013	0.028	0.072	0.109	0.145
2016	0.016	0.029	0.069	0.108	0.164
2017	0.012	0.03	0.074	0.104	0.167
2018	0.011	0.033	0.076	0.101	0.131
2019	0.012	0.034	0.081	0.115	0.145

Table 6.6.2.4. Average weight of landings at age (Kg)

Year	0	1	2	3	4+
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	358.37	98.448	0	0	0
2011	211.065	189.221	0.48	0	0
2012	679.61	487.202	0.47	0.01	0
2013	547.566	418.21	1.104	0.035	0
2014	408.488	422.632	0.268	0	0
2015	1162.339	583.247	1.321	0.029	0
2016	230.636	202.463	2.118	0.009	0
2017	603.027	343.748	2.625	0.074	0
2018	521.458	352.56	4.374	0.281	0
2019	1995.538	615.184	3.2	0.083	0

Table 6.6.2.5. Discards at age (Thousands of individuals)

Year	0	1	2	3	4+
2002	0.013	0.024	0.071	0.095	0.123
2003	0.013	0.025	0.062	0.106	0.131
2004	0.014	0.026	0.064	0.101	0.142
2005	0.012	0.03	0.07	0.107	0.215
2006	0.016	0.027	0.07	0.103	0.152
2007	0.017	0.029	0.071	0.106	0.13
2008	0.015	0.037	0.075	0.093	0.118
2009	0.011	0.029	0.077	0.099	0.125
2010	0.005	0.011	0.071	0.111	0.153
2011	0.008	0.014	0.032	0.112	0.18
2012	0.008	0.013	0.043	0.048	0.206
2013	0.008	0.013	0.043	0.048	0.141
2014	0.009	0.013	0.032	0.102	0.135
2015	0.007	0.014	0.041	0.048	0.145
2016	0.008	0.016	0.037	0.048	0.164
2017	0.007	0.015	0.046	0.069	0.167
2018	0.007	0.015	0.052	0.058	0.131
2019	0.006	0.014	0.043	0.048	0.145

Table 6.6.2.6. Average weight of discards at age (Kg)

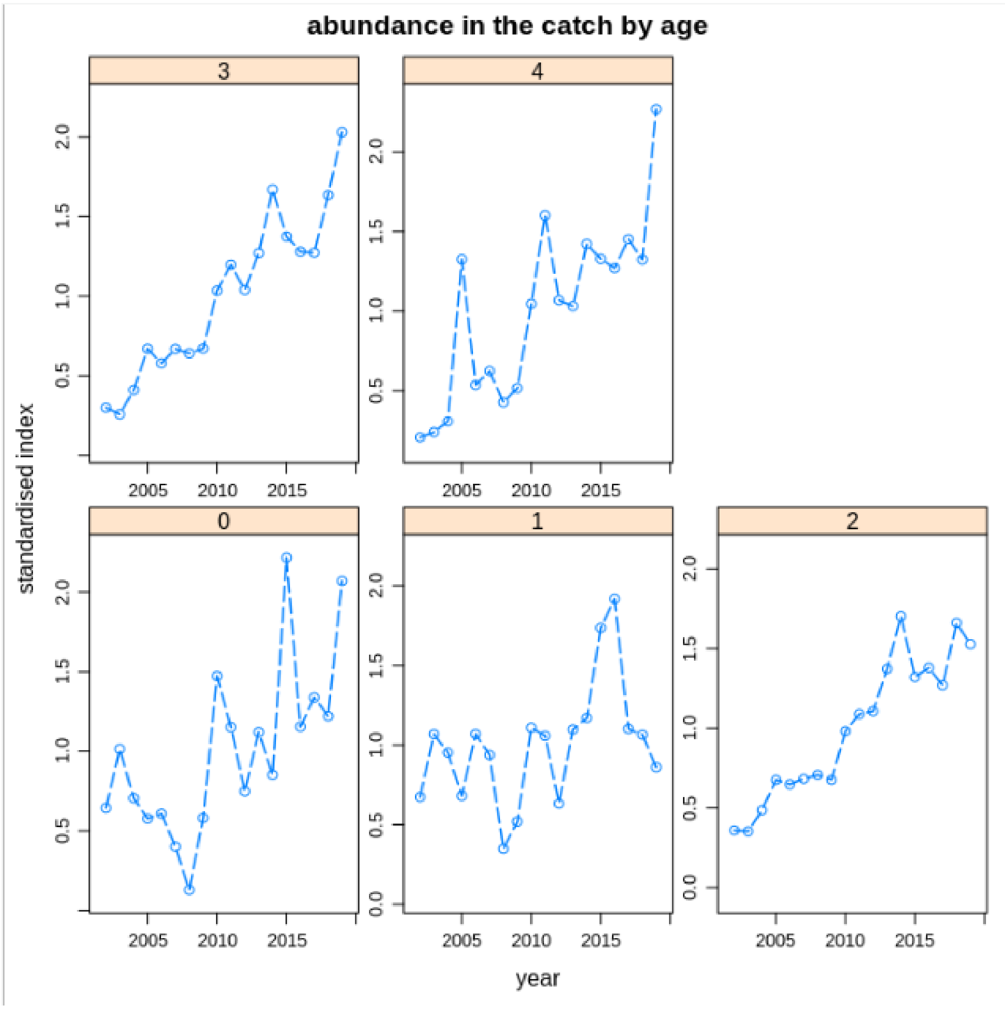


Figure 6.6.2.4. Catch at age of Red Mulled in GSA 7. Y-axis is standardised.

6.6.2.3 Effort

No analysis on effort data have been carried out during the meeting

6.6.2.4 Survey data

6.6.2.4.1 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.

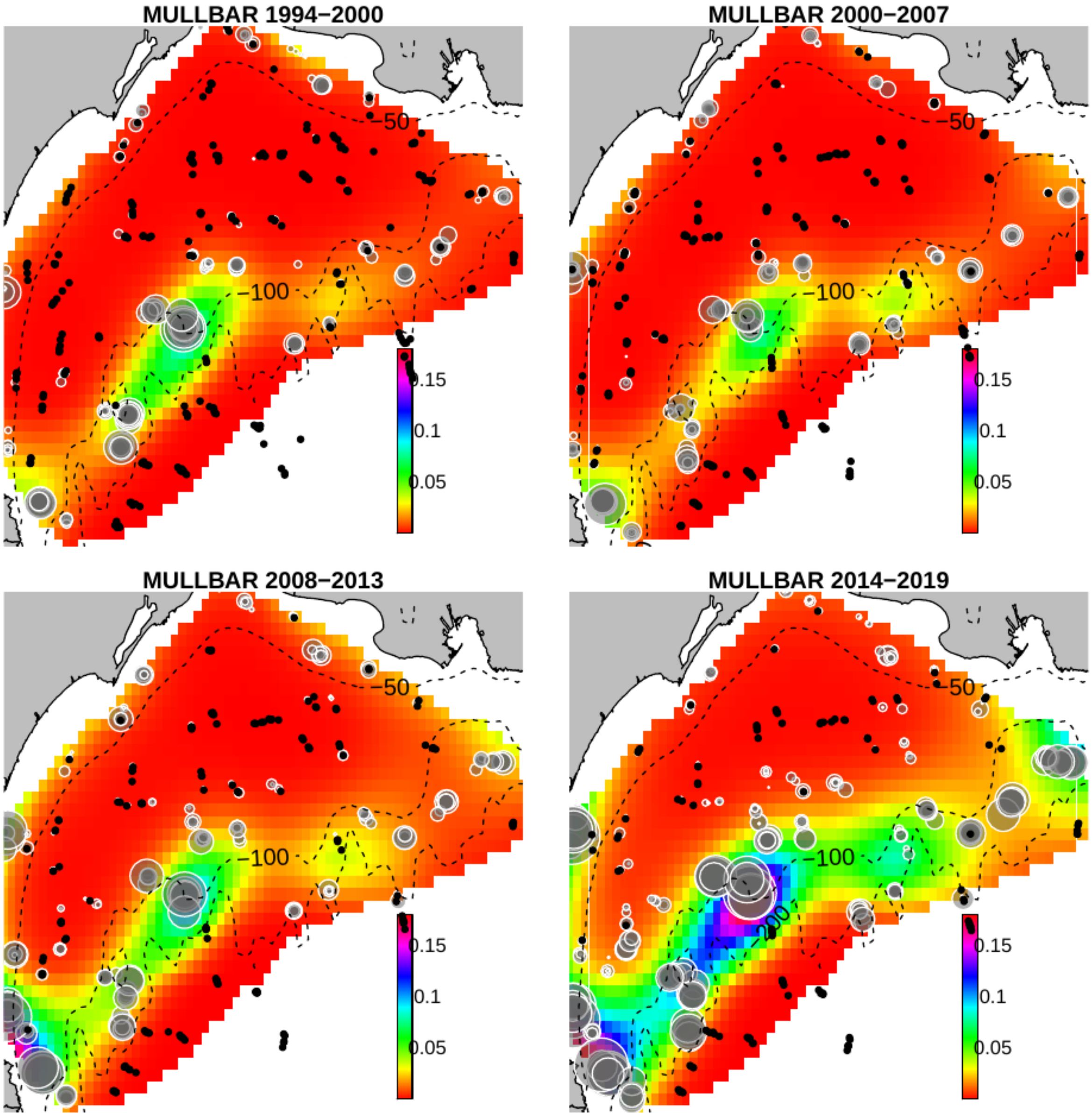


Fig. 12. Colours: Biomasses of Red Mullet from MEDITS survey in t/km2 (ordinary kriging). Circles corresponds to data points. Black dots locate trawls without red mullet.

Fig. 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.

MEDITS abundance estimates at length over the years is shown in Fig. 13. The size range caught by the survey is quite constant [8 – 27cm] over the years, with a doubling of abundance of young individuals in the most recent years.

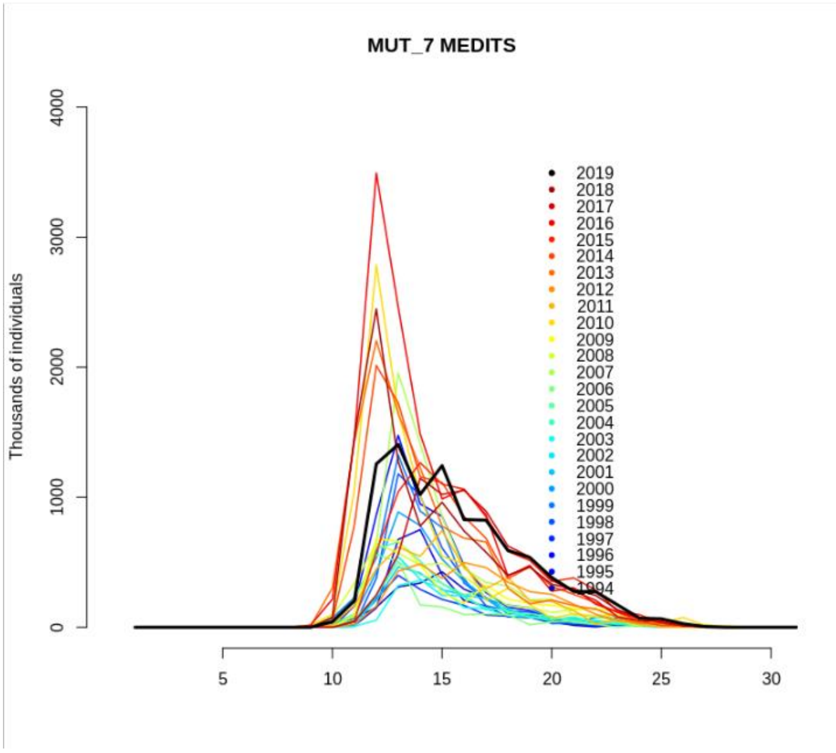


Fig. 13. Length distribution of MEDITS abundance index over the years.

Standardized abundances are computed from a stratified mean, with bootstrap-estimated confidence intervals (Fig. 14), and displays an increasing trends in the recent years.

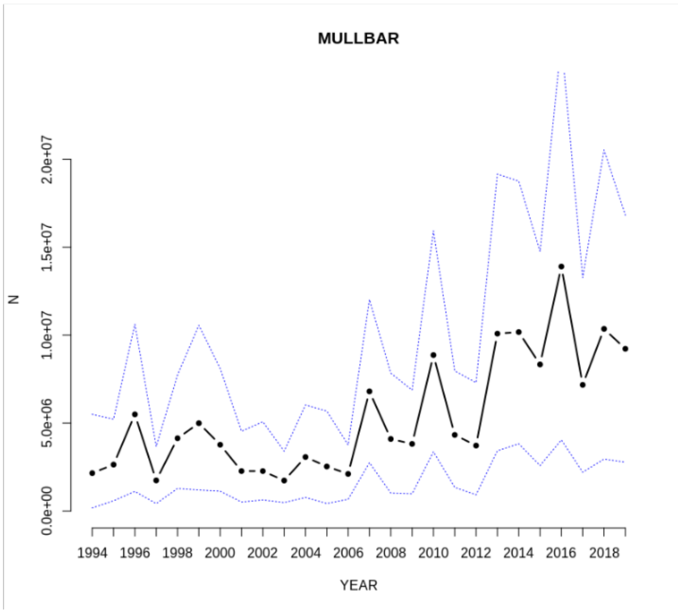


Fig. 14. MEDITS abundance index (in number of individuals over the Gulf of Lion area). Dotted lines corresponds to 95% bootstrapped confidence intervals.

6.6.2.4.2 MEDITS at age data preparation

Numbers and average weight at age issued from the MEDITS survey are summarized below in tables 7 and 8.

Year	0	1	2	3	4
2002	78.639	1614.254	439.794	110.052	28.336
2003	38.677	1198.022	412.054	66.062	18.123
2004	168.266	2326.477	456.533	96.826	22.95
2005	91.695	1835.713	493.379	88.011	22.663
2006	164.518	1612.707	240.758	70.759	22.347
2007	272.386	5213.972	1088.391	172.527	54.106
2008	233.165	2852.414	800.903	168.678	42.116
2009	170.74	2411.65	896.397	250.727	88.309
2010	783.524	6921.276	851.761	219.618	90.225
2011	156.817	3004.863	1004.385	139.032	22.811
2012	67.87	2200.52	1188.019	206.457	58.025
2013	834.776	7686.893	1285.136	230.465	47.847
2014	601.813	7349.852	1849.54	306.247	67.186
2015	188.038	5315.959	2301.126	435.107	92.703
2016	1063.704	10437.178	1978.928	349.876	69.939
2017	104.996	4441.888	2194.776	360.581	70.666
2018	771.655	7236.566	1853.415	396.429	97.921
2019	347.856	6093.827	2234.239	446.775	101.853

Table 6.6.2.7. MEDITS index at age (Numbers in thousands for the 13800 km^2 of the Gulf of Lion)

Year	0	1	2	3	4
2002	0.02	0.029	0.069	0.123	0.147
2003	0.02	0.029	0.066	0.099	0.161
2004	0.017	0.025	0.066	0.119	0.142
2005	0.018	0.029	0.064	0.11	0.152
2006	0.016	0.023	0.067	0.129	0.17
2007	0.019	0.026	0.062	0.105	0.157
2008	0.015	0.026	0.071	0.114	0.15
2009	0.019	0.028	0.078	0.124	0.169
2010	0.015	0.021	0.064	0.126	0.165
2011	0.016	0.029	0.063	0.091	0.114
2012	0.02	0.034	0.07	0.104	0.161
2013	0.014	0.023	0.067	0.109	0.132
2014	0.016	0.026	0.069	0.104	0.137
2015	0.018	0.031	0.068	0.103	0.128
2016	0.016	0.024	0.068	0.11	0.134
2017	0.019	0.034	0.066	0.1	0.13
2018	0.015	0.024	0.072	0.114	0.142
2019	0.016	0.027	0.065	0.104	0.129

Table 6.6.2.8. MEDITS average weight at age.

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 6.6.2.3 – 6.6.2.8 above, together with assumed maturity and natural mortality (see section 6.6.4).

To select the final model for assessment, we investigated combinations of various options for the three submodels regarding fishing mortality, survey catchability and stock-recruitment inspired from previous assessment and other areas (notably GSA 5 & 6).

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 6.6.3.1. 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 (Figure 6.6.3.2.). 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=5 appeared to be the best trade-off. Regarding the age threshold for survey catchability, models with threshold at age 3 systematically outperformed their counterpart with threshold 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.

The final model for stock assessment was therefore the following:

fmodel = ~ factor(age) + s(year, k = 5)

qmodel = ~factor(replace(age, age>3,3))

srmodel = ~geomean(CV=0.35)

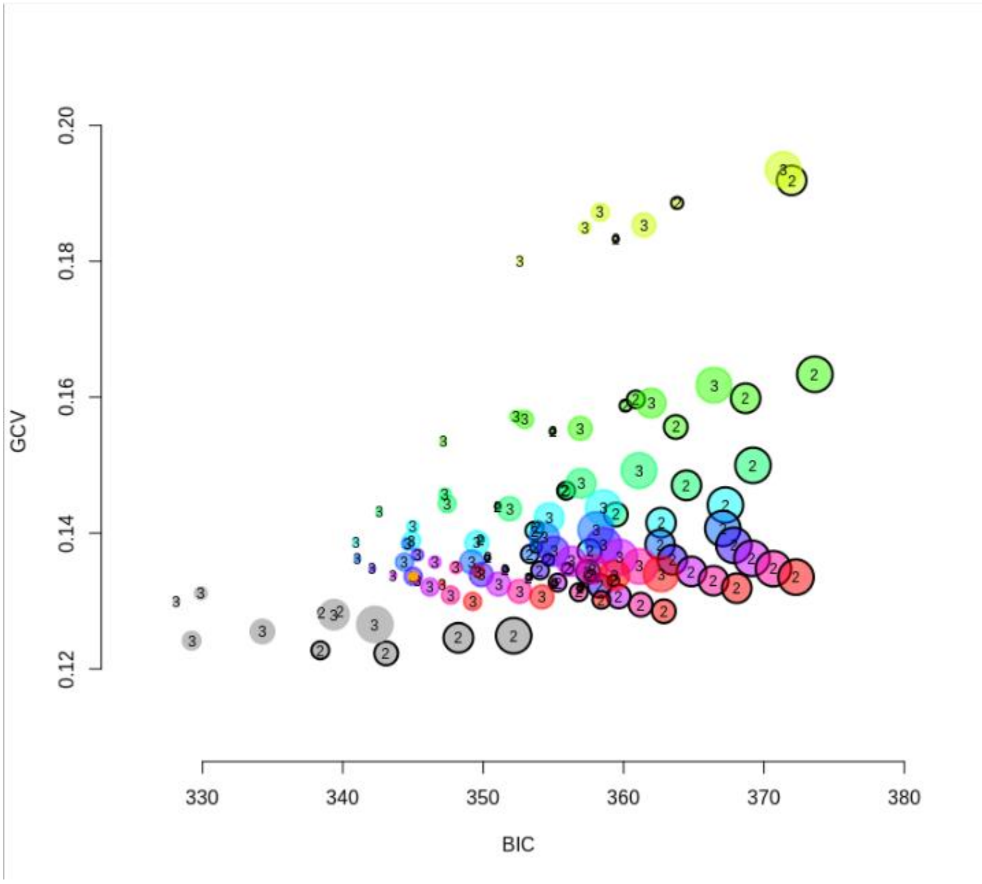


Figure 6.6.3.14. Performance of the different modelling options tested. Models are evaluated according to BIC (x-axis) and GCV-score (y-axis). Bubble size corresponds to the number of smoother knots in the fishing mortality submodel. Colours corresponds to the amount of variability in the stock-recruitment 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.

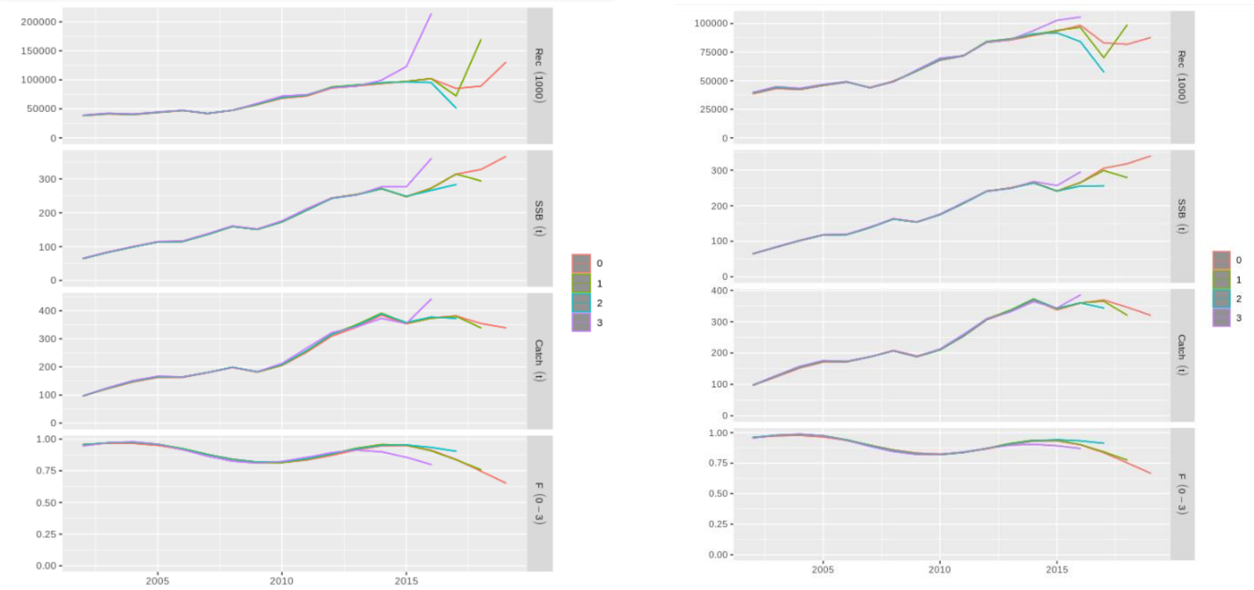


Figure 6.6.3.2. Retrospective analysis carried out for the selected model with stock recruitment factorized by year (left panel) and stock recruitment modelled as a geometric mean of previous years (right panel). Unstable retrospective on the recruitment estimates (upper-left) led to the rejection of the use of stock recruitment factorized by year.

6.6.3.2 Final Run

Recruitment, SSB, catch and Fbar (ages 0-3) estimates from the final model are provided in Table 6.6.3.1, the resulting fishing mortality at age in Table 6.6.3.2 and the estimated stock abundance in Table 6.6.3.3.

year	rec	ssb	catch	fbar
2002	38498.39	64.63	97.079	0.96
2003	43186.58	83.324	124.382	0.972
2004	42123.24	101.556	152.084	0.976
2005	45665.58	117.767	171.22	0.964
2006	48679.63	118.629	171.252	0.936
2007	44080.7	138.444	187.604	0.897
2008	49756.48	163.293	208.329	0.859
2009	58412.94	154.838	190.688	0.832
2010	67820.13	175.184	210.795	0.824
2011	71616.29	206.403	253.018	0.837
2012	83535.86	241.602	305.776	0.866
2013	85516.76	250.394	332.633	0.903
2014	89440.43	265.023	368.233	0.93
2015	93273.93	241.899	337.783	0.932
2016	98472.65	265.24	359.01	0.9
2017	83072.71	305.43	368.986	0.835
2018	81741.65	317.93	346.022	0.752
2019	87734.8	339.787	320.365	0.668

Table 6.6.3.1. Recruitment (rec, in thousands), spawning stock biomass (ssb, in tons), catch (in tons) and fbar estimated by the stock assessment model.

Year	0	1	2	3	4+
2002	0.039	1.089	1.475	1.237	0.66
2003	0.039	1.103	1.494	1.253	0.668
2004	0.04	1.107	1.5	1.258	0.671
2005	0.039	1.094	1.481	1.243	0.662
2006	0.038	1.061	1.438	1.206	0.643
2007	0.036	1.018	1.378	1.156	0.616
2008	0.035	0.974	1.32	1.107	0.59
2009	0.034	0.944	1.279	1.073	0.572
2010	0.033	0.935	1.267	1.062	0.566
2011	0.034	0.95	1.286	1.079	0.575
2012	0.035	0.983	1.331	1.117	0.595
2013	0.037	1.024	1.387	1.163	0.62
2014	0.038	1.055	1.429	1.198	0.639
2015	0.038	1.057	1.432	1.201	0.64
2016	0.036	1.021	1.382	1.159	0.618
2017	0.034	0.947	1.283	1.076	0.574
2018	0.03	0.853	1.156	0.97	0.517
2019	0.027	0.757	1.026	0.86	0.459

Table 6.6.3.2. Fishing mortality at age resulting from the stock assessment model.

Year	0	1	2	3	4
2002	38498.39	5052.945	529.882	76.292	15.081
2003	43186.58	6499.396	764.138	68.562	18.774
2004	42123.24	7287.228	969.255	97.021	18.381
2005	45665.58	7106.735	1082.064	122.347	23.181
2006	48679.63	7708.075	1069.543	139.096	29.626
2007	44080.7	8226.279	1198.173	143.643	35.906
2008	49756.48	7460.81	1336.105	170.775	40.588
2009	58412.94	8434.419	1265.115	201.876	49.561
2010	67820.13	9912.488	1473.982	199.116	60.925
2011	71616.29	11512.62	1748.126	234.866	65.075
2012	83535.86	12150.822	2001.5	273.208	73.236
2013	85516.76	14156.231	2043.08	298.975	81.615
2014	89440.43	14470.744	2284.689	288.706	86.366
2015	93273.93	15117.923	2264.102	309.562	83.547
2016	98472.65	15764.506	2359.361	305.719	86.262
2017	83072.71	16665.028	2552.744	334.908	89.582
2018	81741.65	14095.656	2903.475	400.117	103.47
2019	87734.8	13916.473	2697.671	516.83	134.037

Table 6.6.3.3. 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 6.6.3.3). Such trend is probably not tied to a reduction of fishing effort, but is rather explained by increased productivity of the stock (Fig 16), as exemplified in the estimated recruitment, since 2012. Factors responsible for these high recruitment are up to know not identified.

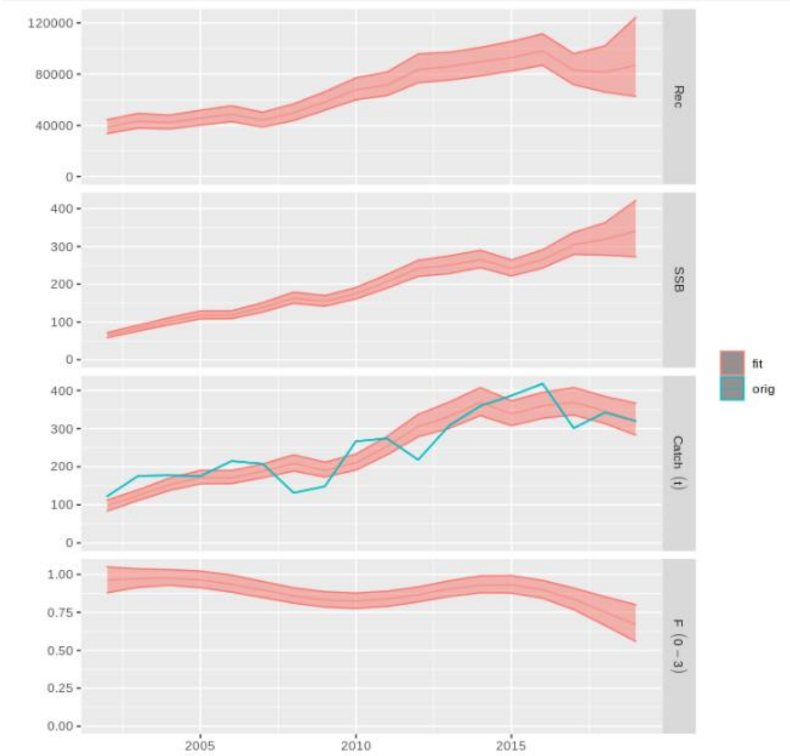


Figure 6.6.3.3. Time series and confidence intervals of Recruitment, SSB, Catch and Fbar estimated by the model, together with confidence intervals. The blue line corresponds to the observed catch.

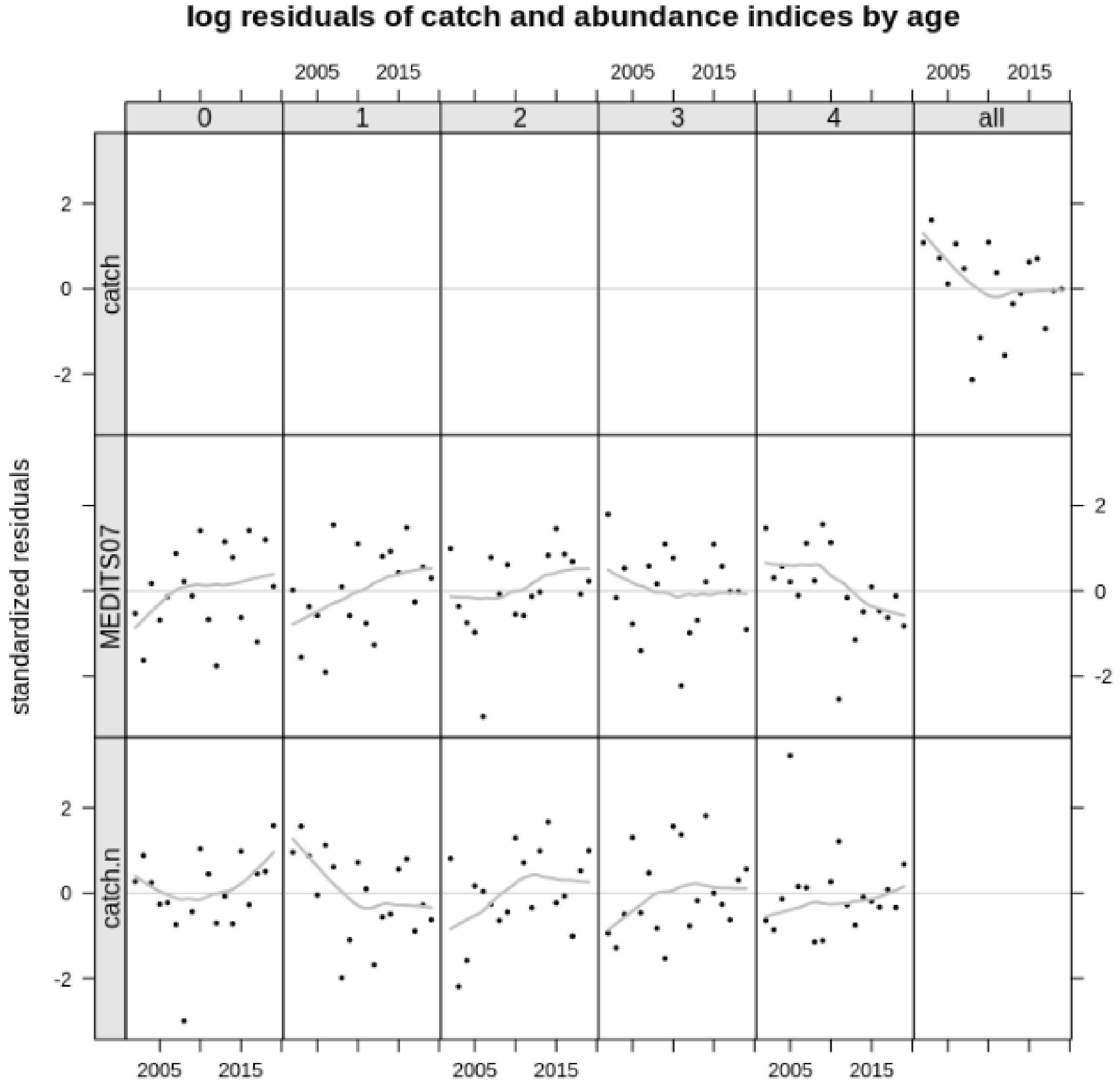


Figure 6.6.3.4. Log residuals from the stock assessment model.

Log-residuals (Figure 6.6.3.4) 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 should be carried out next year to solve this somewhat moderate issue if it remains.

Tri-dimensional representation of fishing mortality at age through the years (Fig. 6.6.3.5) suggests that fishing mortality is quite low at age 0 compared to other ages, and is also somewhat reduced at older ages. Survey catchability (Figure 6.6.3.6) is assumed constant through the years, but increases with age up to age 3, in accordance with the catchability submodel specification.

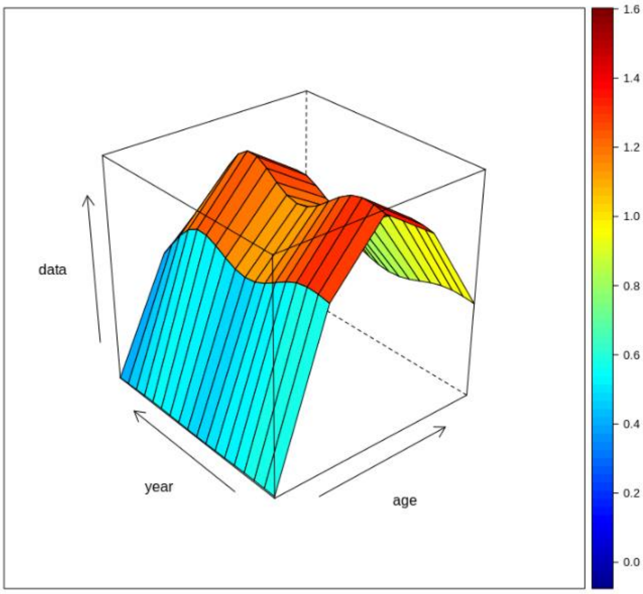


Figure 6.6.3.5. Fishing mortality at age through the years

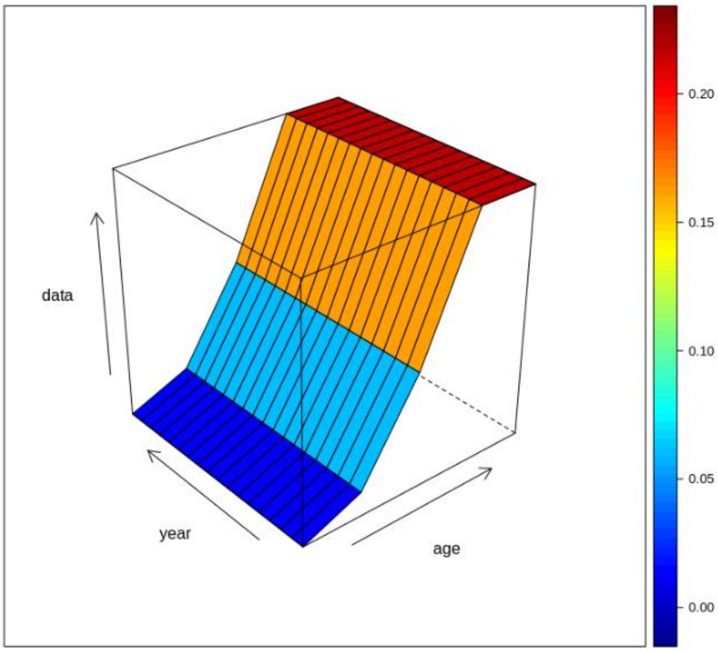


Figure 6.6.3.6. Survey catchability at age through the years

6.6.4 REFERENCE POINTS

To define reference points F_{01} (as a proxy for F_{MSY}) and F_{max} a 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: $F_{01} = 0.423$; $F_{current} = 0.668$ and the resulting ratio $F_{01} / F_{current} = 1.579$, 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_{sq} = 0.668 based on F in 2019) were performed. Recruitment (class 0) has been estimated as the geometric mean of the stock assessment output since 2012 as it corresponds to the high-recruitment time period. Fishing at $F_{0.1}$ (0.42) generates a decrease of the catch of 21.3% from 2019-2021 and an increase of the spawning stock biomass of 42.63% from 2020 to 2022.

Table 6.6.5.1 Red mullet GSA 7: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average 2017-2019	mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2017-2019
$F_{ages\ 1\text{-}3}$ (2020)	0.67	F2019 used to give F status quo for 2020
SSB (2020)	361.8	Stock assessment 1 January 2020
R_{age0} (2020,2021)	88300	mean of the years 2012-2019
Total catch (2020)	340	Assuming F status quo for 2020

Table 6.6.5.2 Red mullet GSA 7: Short-term forecast

Rationale	Ffactor	Fbar	Catch 2019	Catch 2021	SSB 2020	SSB 2022	SSB_change 2020-2022(%)	Catch_change 2019-2021(%)
High long term yield (F0.1)	0.63	0.423	320	252	362	516	42.6	-21.3
F upper	0.87	0.578	320	320	362	425	17.5	-0.3
F lower	0.42	0.282	320	181	362	621	71.6	-43.6
FMSY transition	0.88	0.586	320	323	362	421	16.4	0.7
Zero catch	0.00	0.000	320	0	362	923	155.2	-100.0
Status quo	1.00	0.668	320	354	362	382	5.6	10.4
Different Scenarios	0.10	0.067	320	48	362	838	131.6	-85.0
	0.20	0.134	320	93	362	762	110.6	-71.1
	0.30	0.200	320	134	362	694	91.8	-58.2
	0.40	0.267	320	173	362	633	75.1	-46.2
	0.50	0.334	320	208	362	579	60.1	-35.0
	0.60	0.401	320	242	362	531	46.8	-24.6
	0.70	0.467	320	273	362	488	34.8	-14.9
	0.80	0.534	320	302	362	449	24.0	-5.9
	0.90	0.601	320	328	362	414	14.3	2.5
	1.10	0.734	320	377	362	354	-2.3	17.7
	1.20	0.801	320	399	362	328	-9.4	24.6
	1.30	0.868	320	420	362	305	-15.8	31.0
	1.40	0.935	320	439	362	284	-21.6	37.0
	1.50	1.002	320	457	362	264	-26.9	42.6
	1.60	1.068	320	474	362	247	-31.8	47.9

	1.70	1.135	320	490	362	231	-36.2	52.9
	1.80	1.202	320	505	362	216	-40.2	57.6
	1.90	1.269	320	519	362	203	-43.9	62.0
	2.00	1.335	320	532	362	191	-47.3	66.1

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.

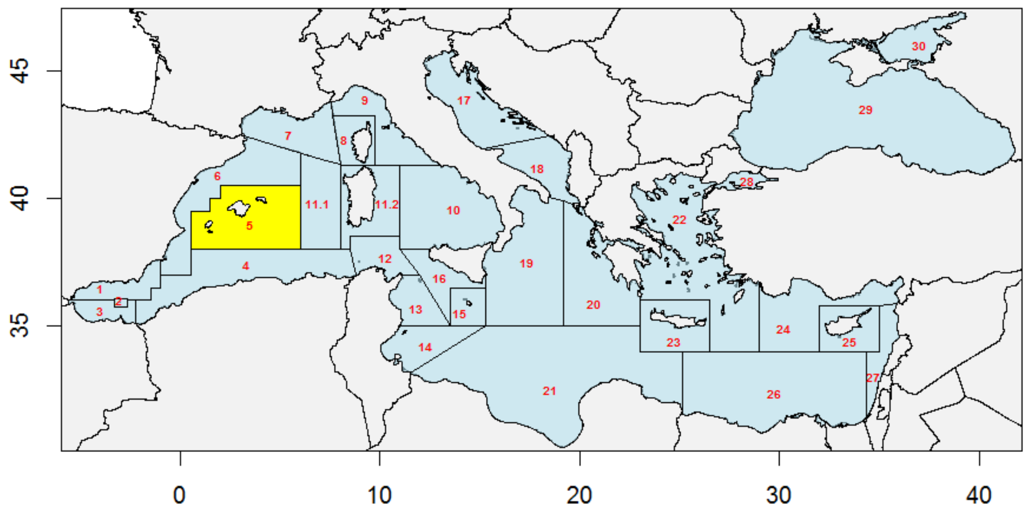


Figure 6.7.1.1. Geographical localization of GSA 5.

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 used in 2019.

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, with important oscillations (Figure 6.7.2.1).

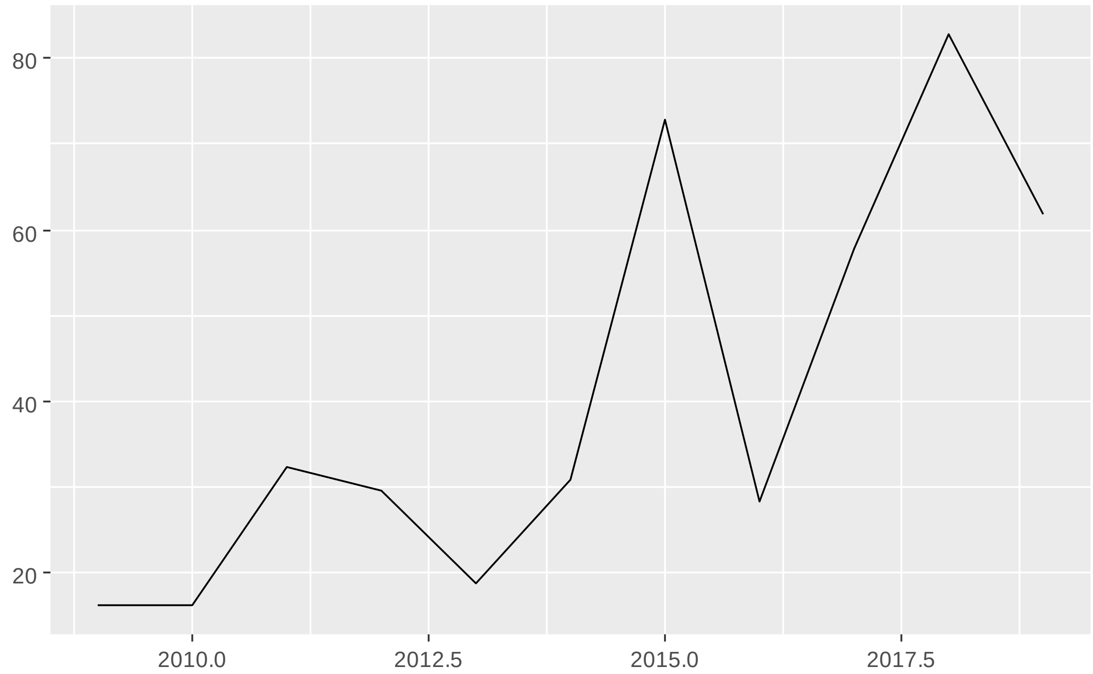


Figure 6.7.2.1. Norway lobster in GSA 5. Reported Landings from the DCF Data call by gear.

Discards for this stock can be considered as neliglible.

Length frequency distribution for the Norway lobster in GSA 5 shows that most of the information comes from OTB_DEMF (Figure 6.7.2.2). Age composition is mainly formed by individuals from ages 1-3, although ages 4 and 5 are also frequent in the catches (Figure 6.7.2.3). Cohorts consistency is not good for the youngests ages, but for the rest is fairly good (figure 6.7.2.4).

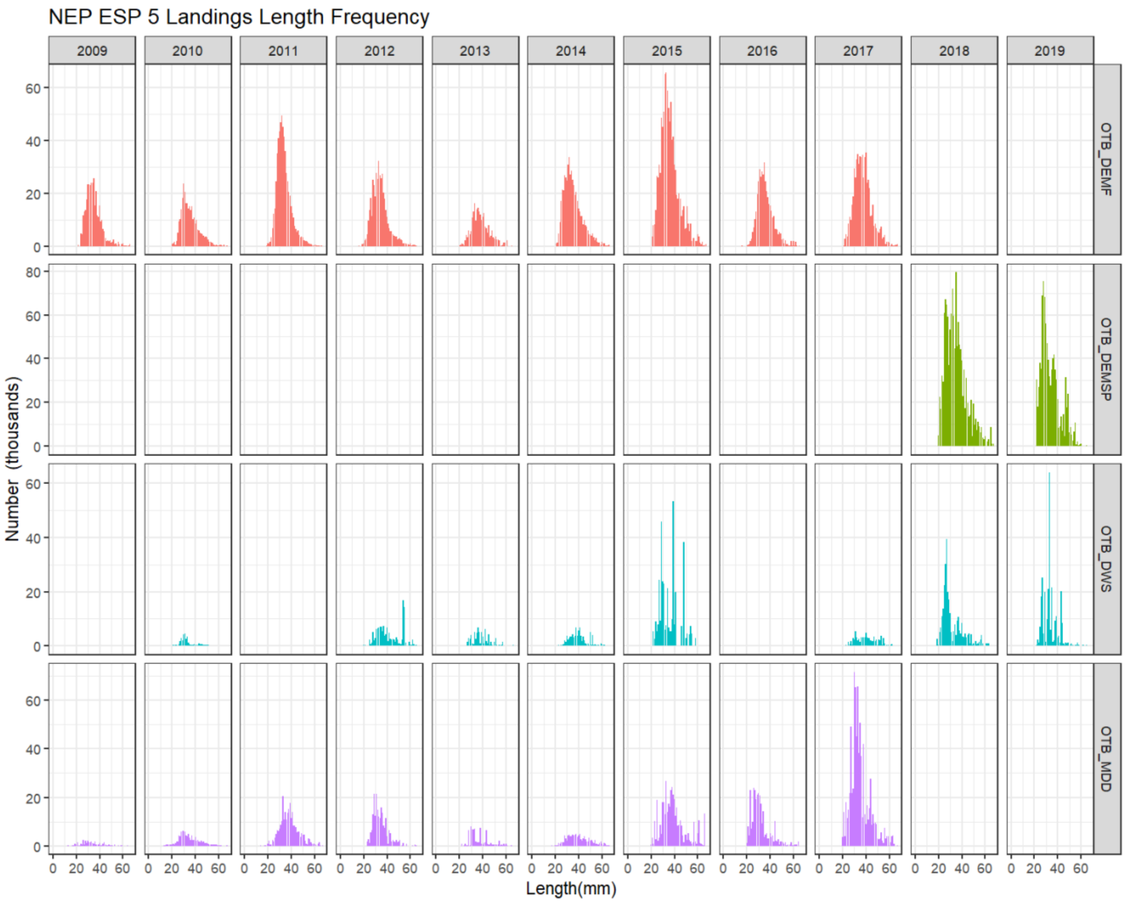


Figure 6.7.2.2. Norway lobster in GSA5. Catch length frequency distribution, by year and métier (TL cm).

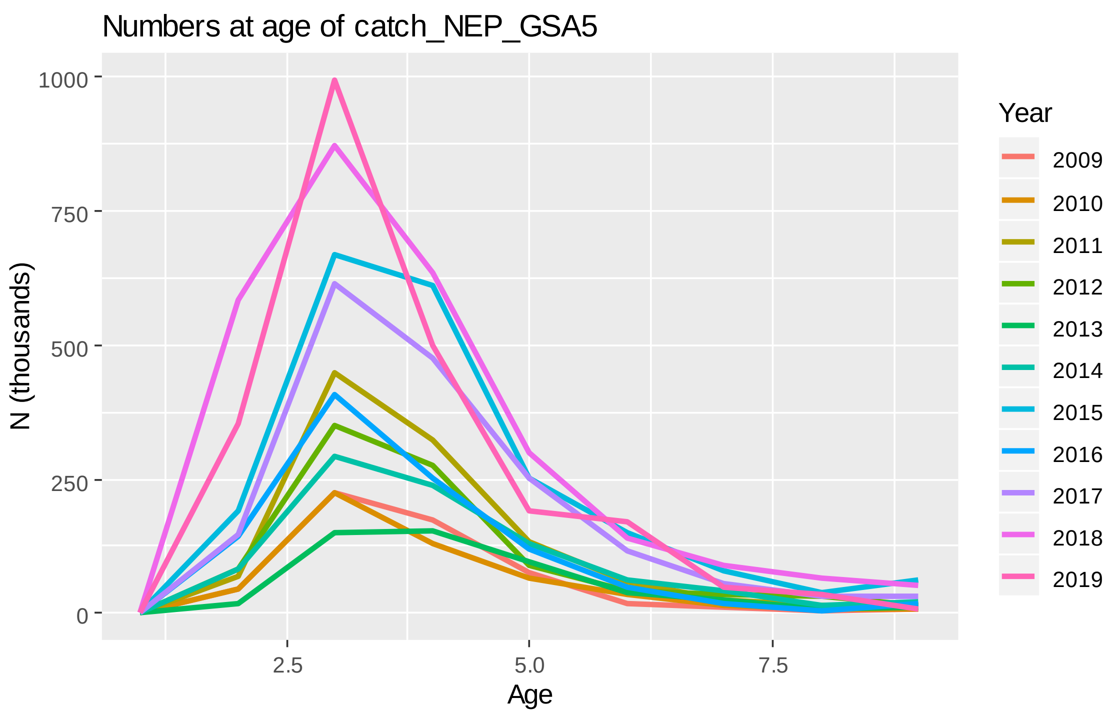


Figure 6.7.2.3. Norway lobster in GSA 5. Catch-at-age.

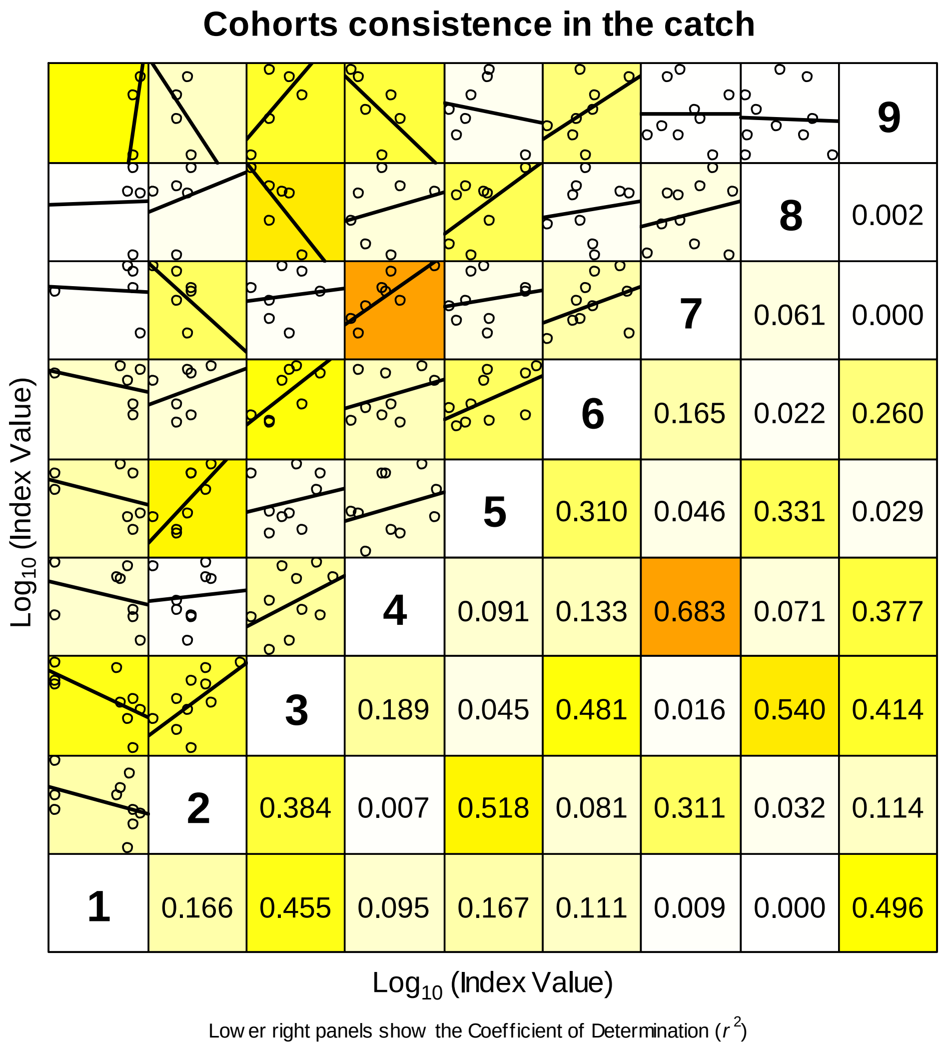


Figure 6.7.2.4. Norway lobster in GSA 5. Cohort consistency for the commercial catches.

6.7.2.2 EFFORT

Fishing effort, as days at sea, by métier (DEMSP, DWS and MDD) for trawlers (OTB) is shown in Figure 6.7.2.5 and Table 6.7.2.1. These values correspond to all the fishing trips from these gears, not to those days directed to the catch of this species. Between 2009 and 2015, values were quite stable, around 10000-11000 fishing days by year, with a decrease in the last three years. Some registers assigned to this GSA has been identify from France, which may be an error than should be reviewed (see Quality section).

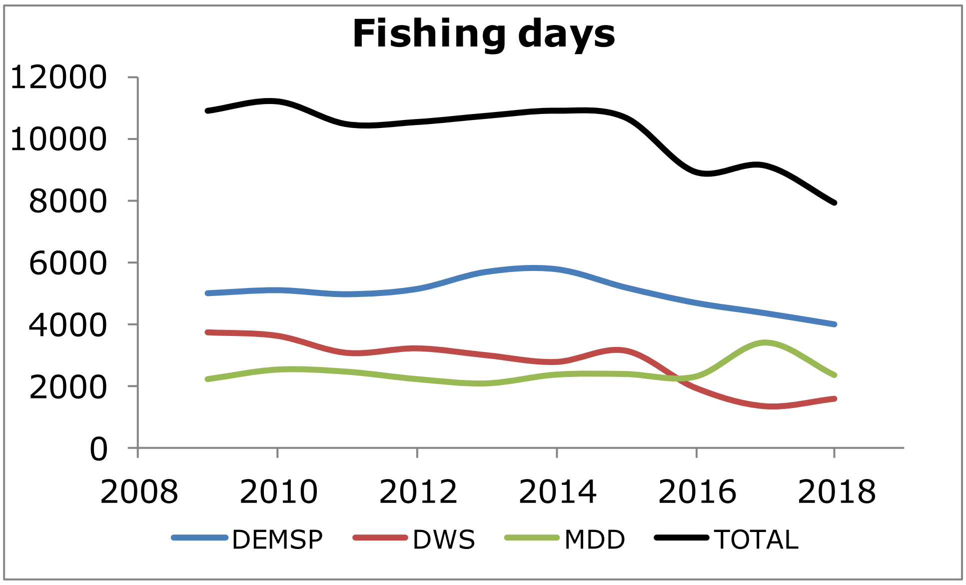


Figure 6.7.2.5. Fishing effort (in fishing days) by métier for the trawlers (OTB) operating in GSA 5.

Table 6.7.2.1. Fishing effort (in fishing days) by métier for the trawlers (OTB) operatin in GSA 5.

OTB	CRU	DEF	DEMSP	DWS	MDD
year	FRA	FRA	ESP	ESP	ESP
2009			5001	3708	2225
2010			5101	3597	2541
2011			4969	3058	2471
2012			5140	3201	2227
2013			5701	2984	2084
2014	13.0		5792	2770	2374
2015		1.0	5192	3128	2394
2016		4.7	4690	1957	2305
2017		5.1	4350	1371	3437
2018			3981	1606	2360

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. Mean stratified abundances and biomasses by km^2 have been computed using the methodology described by Grosslein and Laurec (1982).

Density and biomass indices showed variations along the data series, with the highest values of abundance in 2009, 2010 and 2018 (Figure 6.7.2.6). Length frequency distributions are shown in Figure 6.7.2.7. 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). Cohorts showed no consistency (Figure 6.7.2.9).

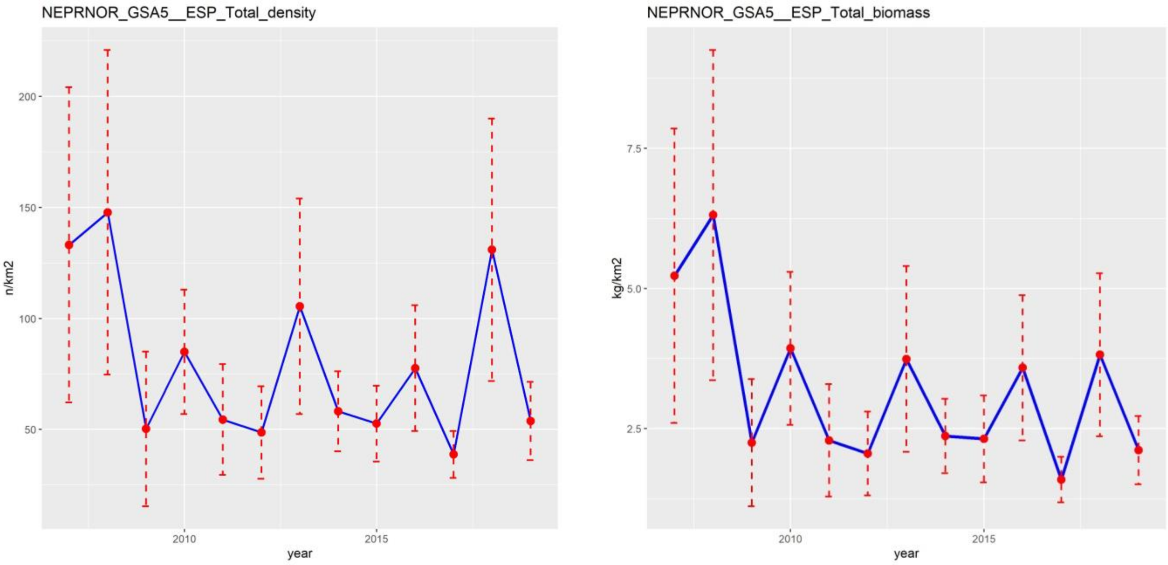


Figure 6.7.2.6. Norway lobster in GSA 5. MEDITS abundance (n/km^2) and biomass (kg/km^2) indices over 2007-2019.

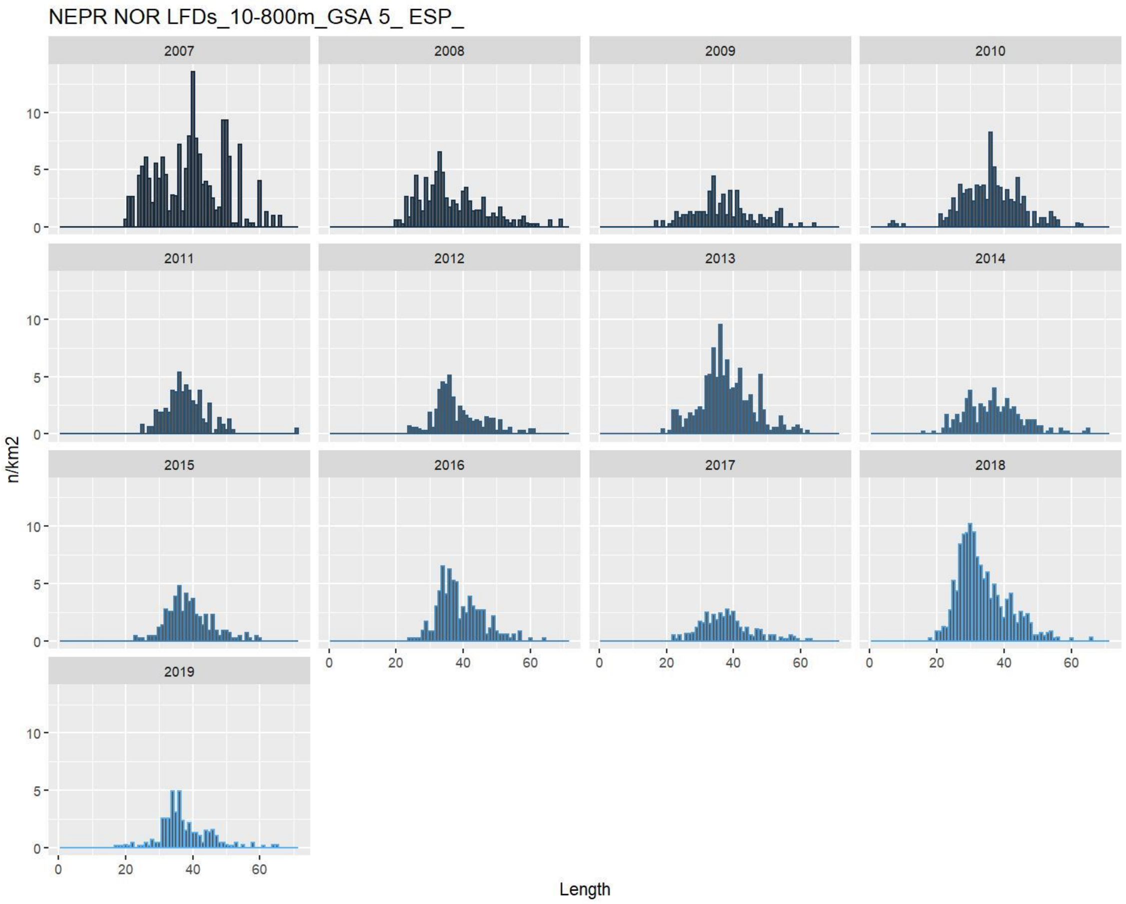


Figure 6.7.2.7. Norway lobster in GSA 5. MEDITS length frequency distribution (n/km^2).

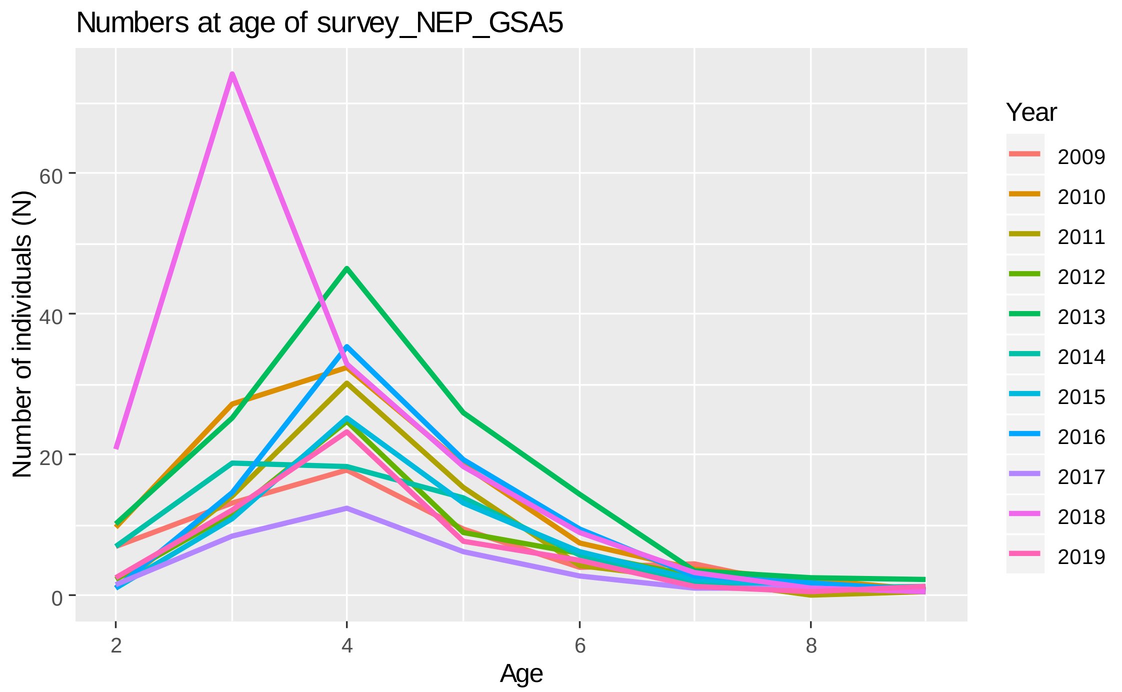


Figure 6.7.2.8. Norway lobster in GSA 5. Age composition of MEDITS length frequency distribution.

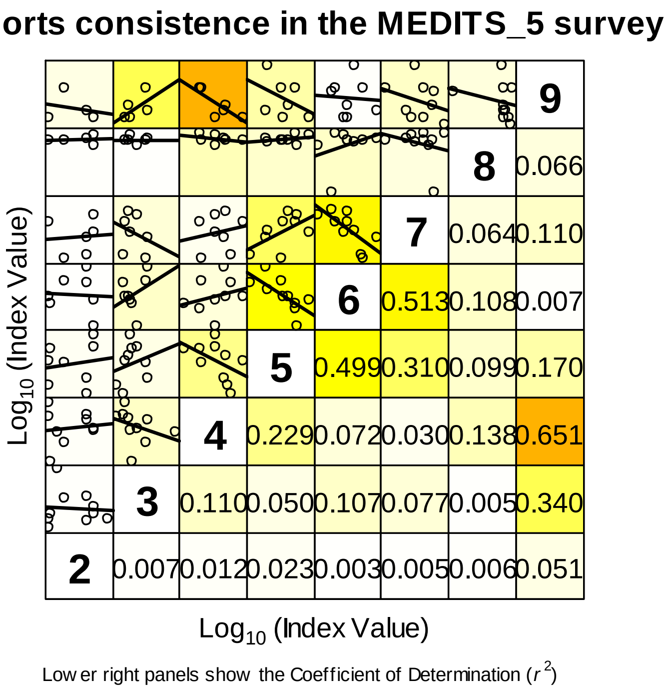


Figure 6.7.2.9. Norway lobster in GSA 5. Cohort consistency for the MEDITS data.

6.7.3 STOCK ASSESSMENT

Analytical assessment for Norway lobster in GSA 5 was tried to be performed with XSA (Method 1) and a4a (Method 2). However, the final advice is based in index data.

Method 1: XSA

Input data come from the DCF. Norway lobster catches, natural mortality and maturity at age are presented in previous sections. Slicing of the LFDs was done considering both sexes combined, using L2AGE4. A SOP correction was applied to the original catch data.

Several sensitivity analyses were performed before the final XSA run, considering different combinations for the settings, being the variations on rage and qage those which showed highest variability among the different runs (Figure 6.7.3.1). The final settings considered were the following:

fse	Rage	qage	shk.n	shk.f	shk.yrs	shk.ages
1.5	1	5	TRUE	TRUE	3	3

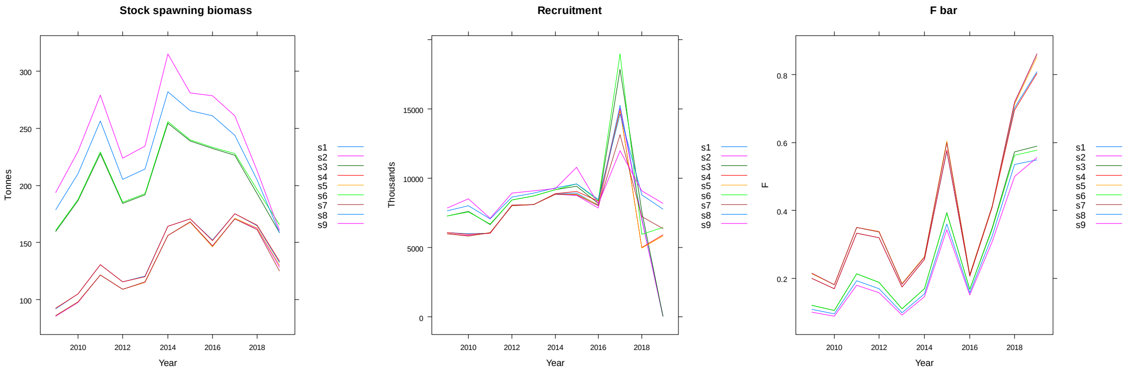


Figure 6.7.3.1. Norway lobster in GSA 5. XSA sensitivity analyses consdering different combinations for rage and qage.

Residuals showed low values but significant trends for some of the years (Figure 6.7.3.2). Retrospective analysis show the inestability of the model (Figure 6.7.3.3).

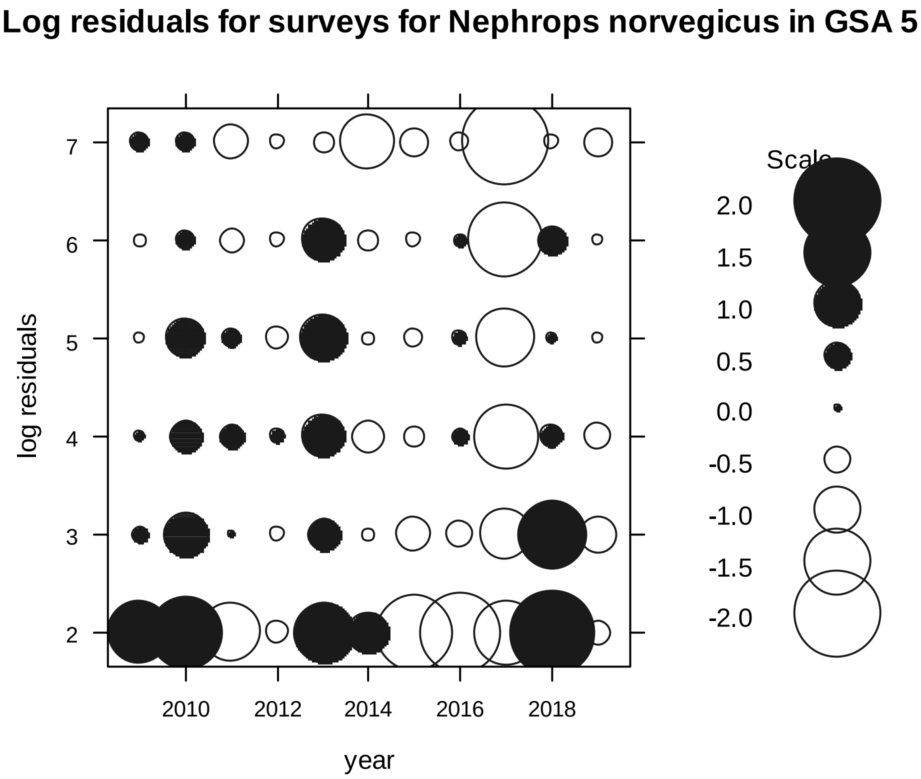


Figure 6.7.3.2 Norway lobster in GSA 5. Residuals pattern of MEDITS survey.

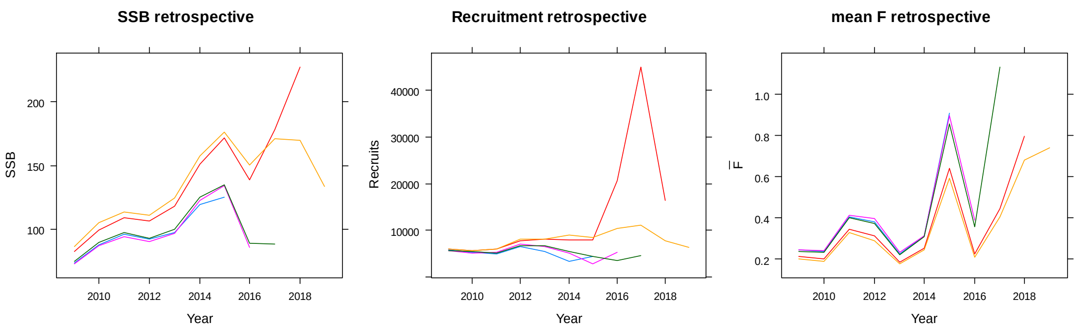


Figure 6.7.3.3 Norway lobster in GSA5. XSA retrospective analysis.

XSA results for Norway lobster in GSA5 showed an increasing trend in recruitment during most part of the data series, with a decreasing trend in the last years. SSB and F showed an increasing trend (Figure 6.7.3.4, Table 6.7.3.1).

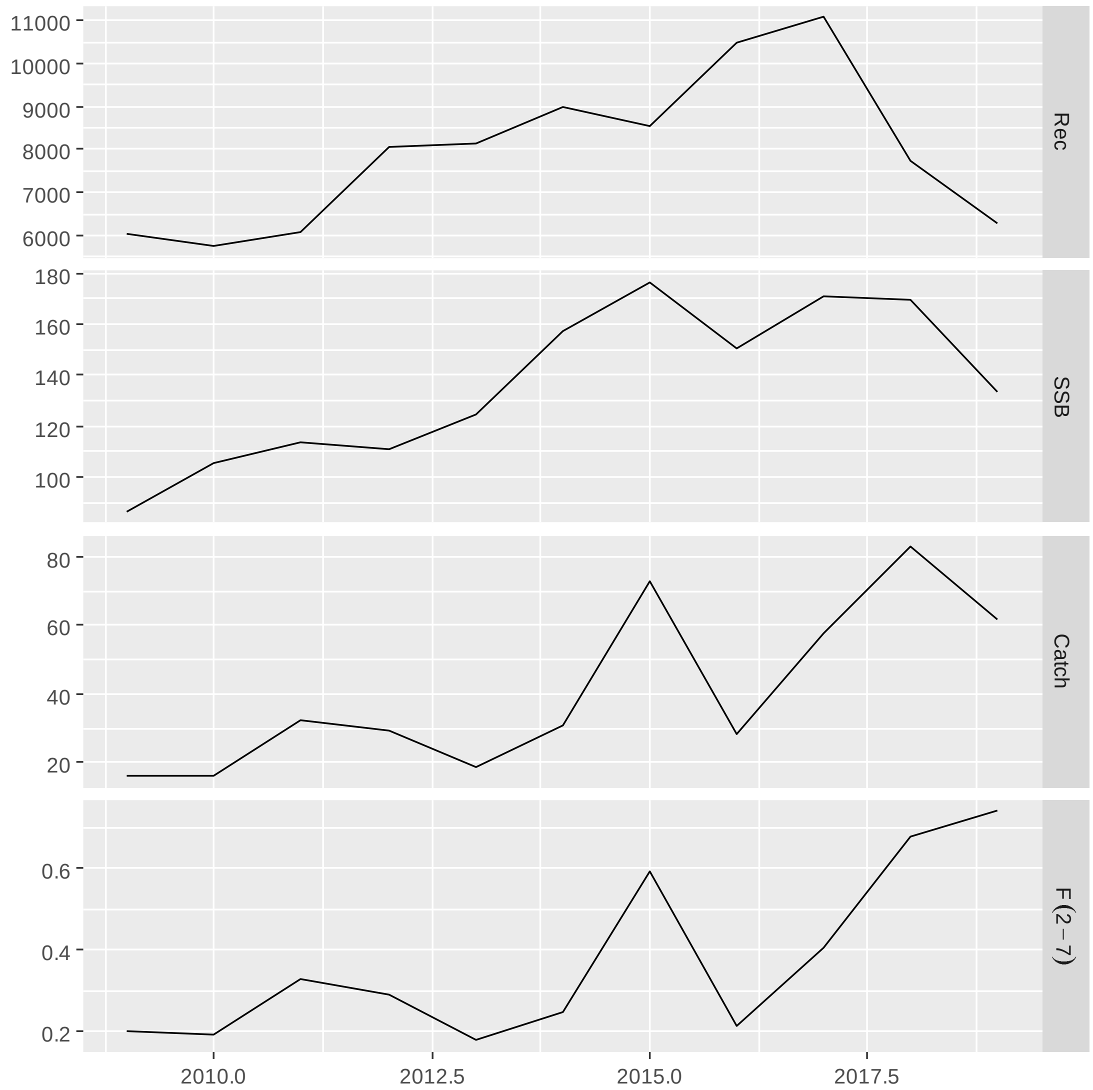


Figure 6.7.3.4. Norway lobster in GSA 5. XSA assessment summary results.

Table 6.7.3.1. Norway lobster in GSA 5. XSA assessment summary results. Biomass, catch and SSB in tonnes, recruits in thousands, F_{bar} ages 2-7.

	Biomass	Catch	SSB	Recruits	Fbar
2009	118.89	16.3	86.6	6053.3	0.20
2010	138.02	16.2	105.2	5748.6	0.19
2011	146.98	32.3	113.7	6079.9	0.33
2012	155.54	29.5	110.8	8071.1	0.29
2013	176.18	18.8	124.8	8161.2	0.18
2014	216.2	30.8	157.6	9006.6	0.25
2015	233.31	72.9	176.5	8556.7	0.59
2016	202.13	28.3	150.3	10490.5	0.21
2017	239.31	57.8	171.2	11071.6	0.41
2018	238.49	82.9	169.5	7743.2	0.68
2019	181.72	61.8	133.7	6298.5	0.74

Method 2: 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 as input catch the same input as the XSA method presented previously.

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; 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.

```
f<- ~factor(replace(age,age>6,6)) + factor(year)
q <- list(~factor(replace(age,age>5,5)))
sr <- ~ geomean(CV= 0.2)
```

Figure 6.7.3.5 and Table 6.7.3.2 show the summary of the stock object after the fit of the model. F shows a clear decreasing trend in the last three years. Recruitment (which corresponds to age 1) showed the highest values in 2011-2013 and certain stability in last years. SSB showed an increasing trend until 2015 and decreasing since then.

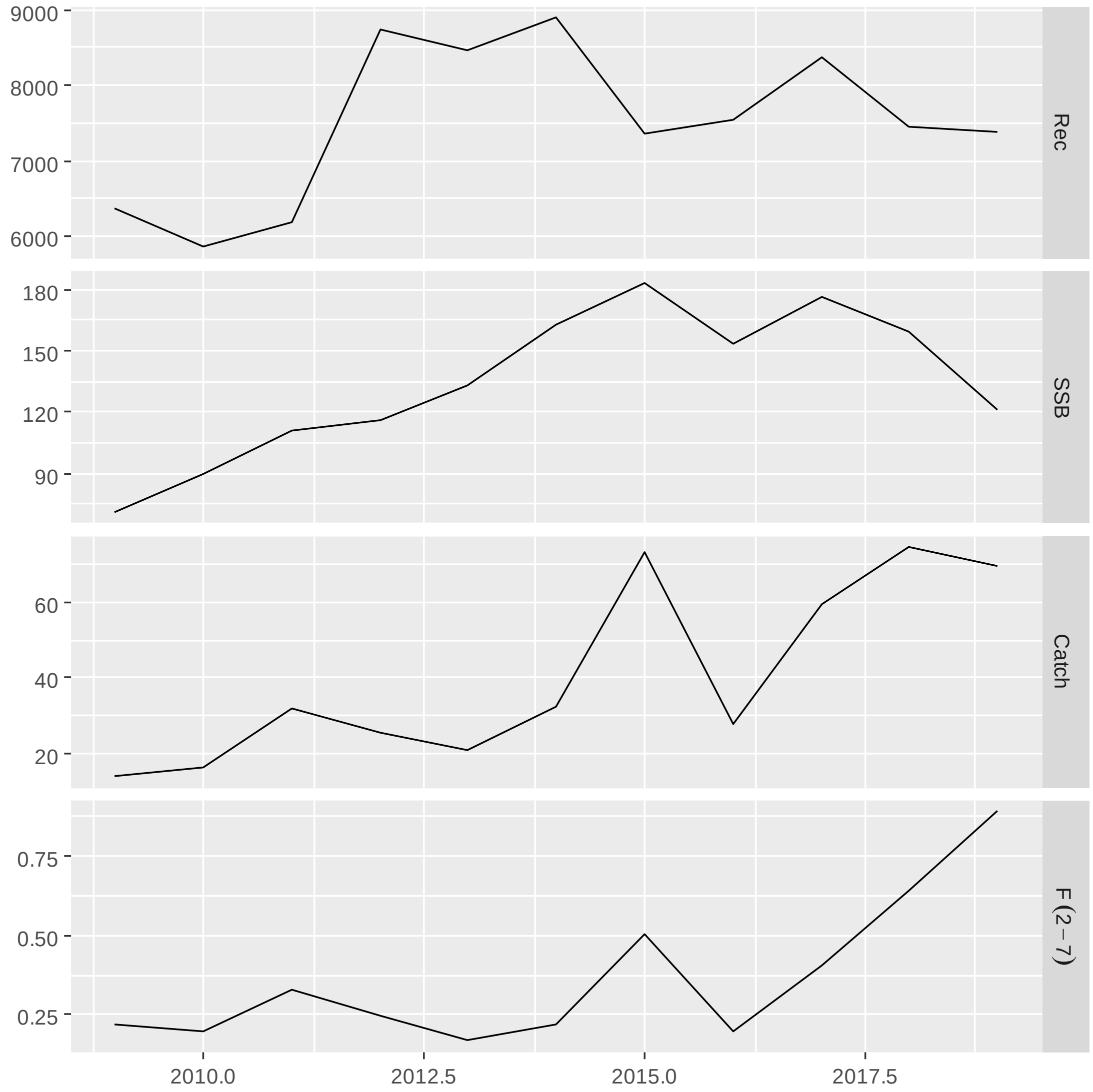


Figure 6.7.3.5. Norway lobster in GSA 5. Stock summary from the a4a model: recruitmend (thousands), SSB (Stock Spawning Biomass, tonnes), catch (tonnes) and fishing mortality (for ages 2 to 7).

Figure 6.7.3.6 and 6.7.3.7 show the estimated fishing mortality by age and year and estimated catchability by age and year, respectively.

Table 6.7.3.2. Norway lobster in GSA 5. Summary results of the estimations from the a4a assessment model. Biomass, catch and SSB in tonnes, recruits in thousands, F_{bar} ages 2-7.

	Biomass	Catch	SSB	Recruits	Fbar
2009	103.93	13.9	71.4	6372.3	0.22
2010	123.61	16.2	89.8	5862.2	0.20
2011	145.07	31.7	111.0	6197.8	0.33
2012	163.01	25.4	116.1	8746.3	0.25
2013	187.22	20.7	133.0	8456.1	0.17
2014	222.31	32.3	162.6	8889.7	0.22
2015	236.71	73.3	183.2	7355.0	0.51
2016	196.18	27.9	153.3	7553.6	0.20
2017	227.67	59.5	176.3	8382.0	0.40
2018	216.54	74.6	159.0	7447.2	0.64
2019	169.51	69.8	121.0	7392.0	0.89

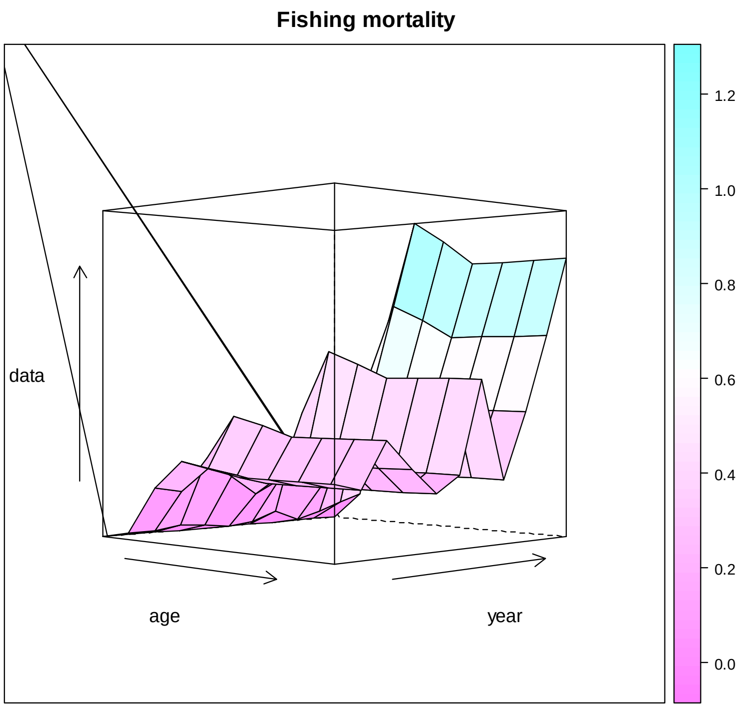


Figure 6.7.3.6. Norway lobster in GSA 5. 3D contour plot of estimated fishing mortality by age and year.

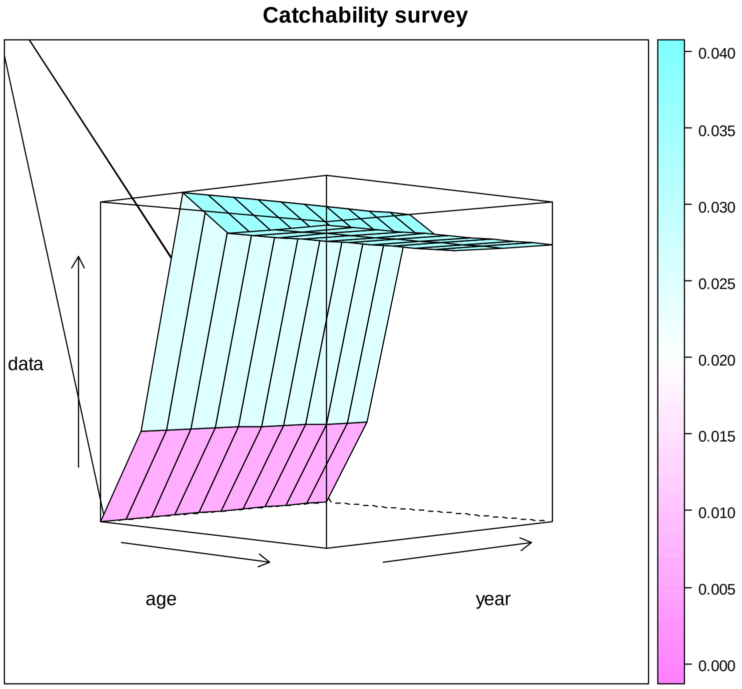


Figure 6.7.3.7 Norway lobster in GSA 5. 3D contour plot of catchability by age and year.

Diagnostics

Figures 6.7.3.8, 6.7.3.9, 6.7.3.10 and 6.7.3.11 show several diagnostic plots for the goodness of fit of the selected model for the assessment of Norway lobster in GSA 5.

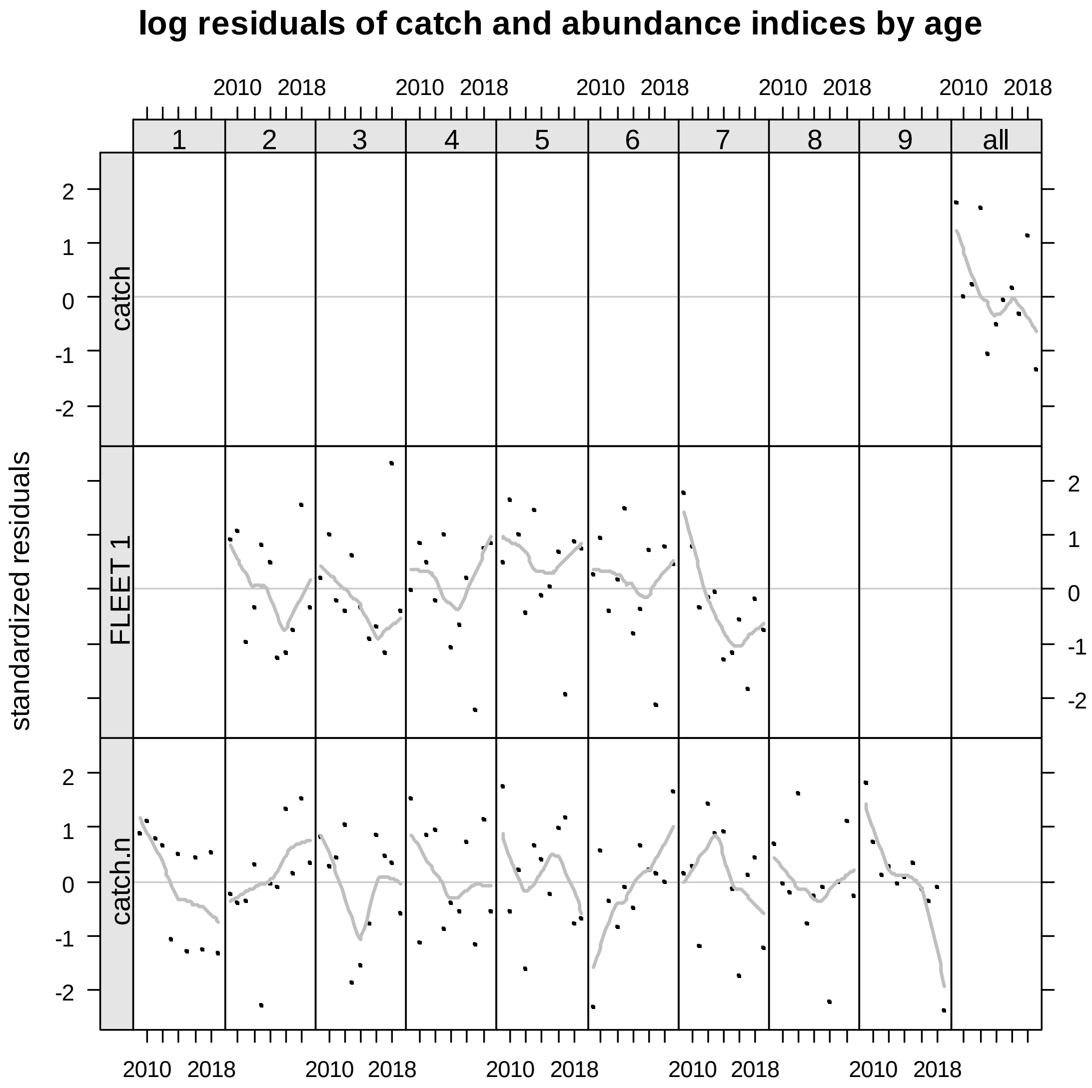


Figure 6.7.3.8. Norway lobster in GSA 5. Standardized residuals for catch, abundance indices and for catch numbers.

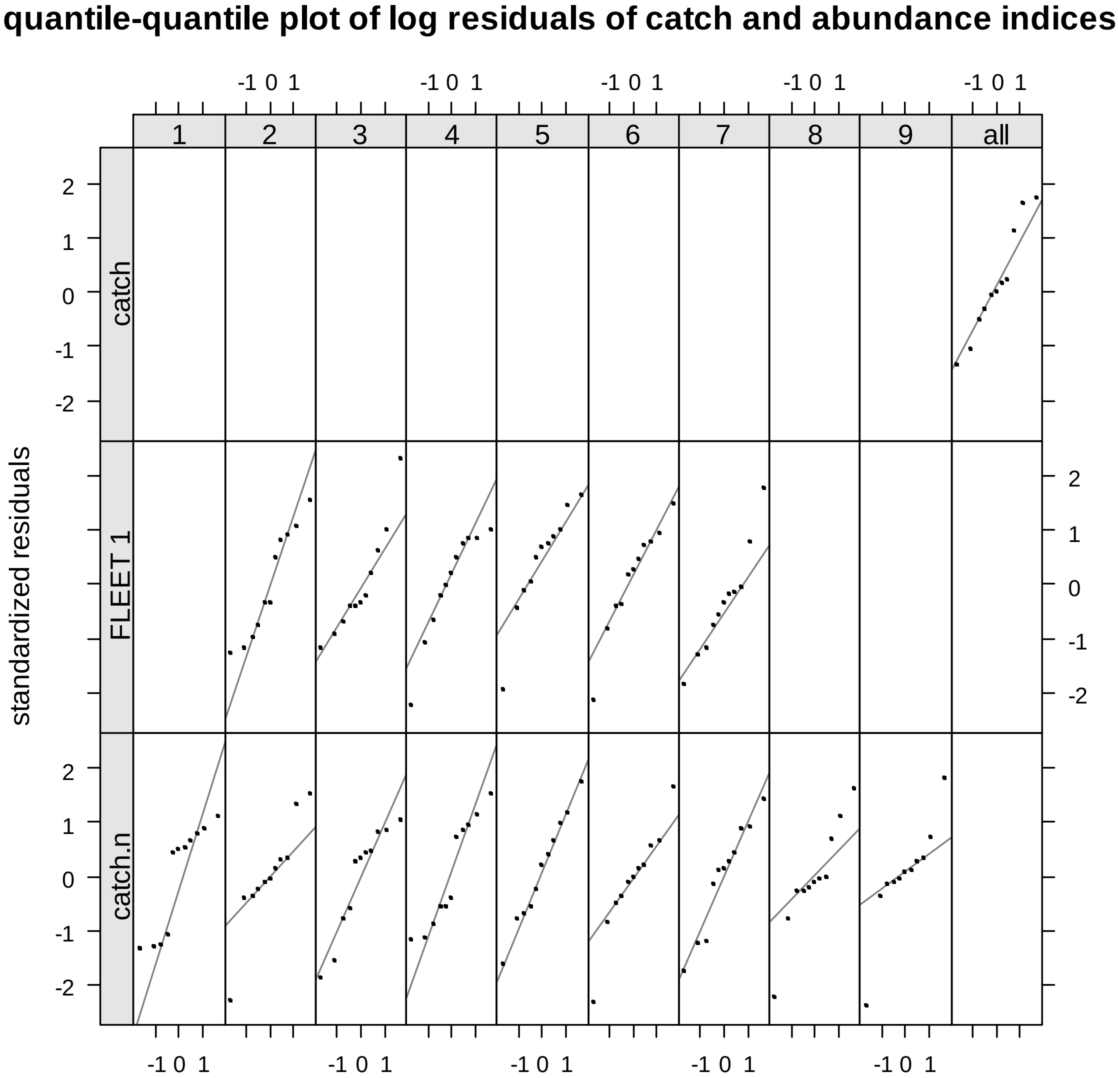


Figure 6.7.3.9. Norway lobster in GSA 5. Quantile-quantile plot of standardized residuals for catch, abundance indices and for catch numbers.

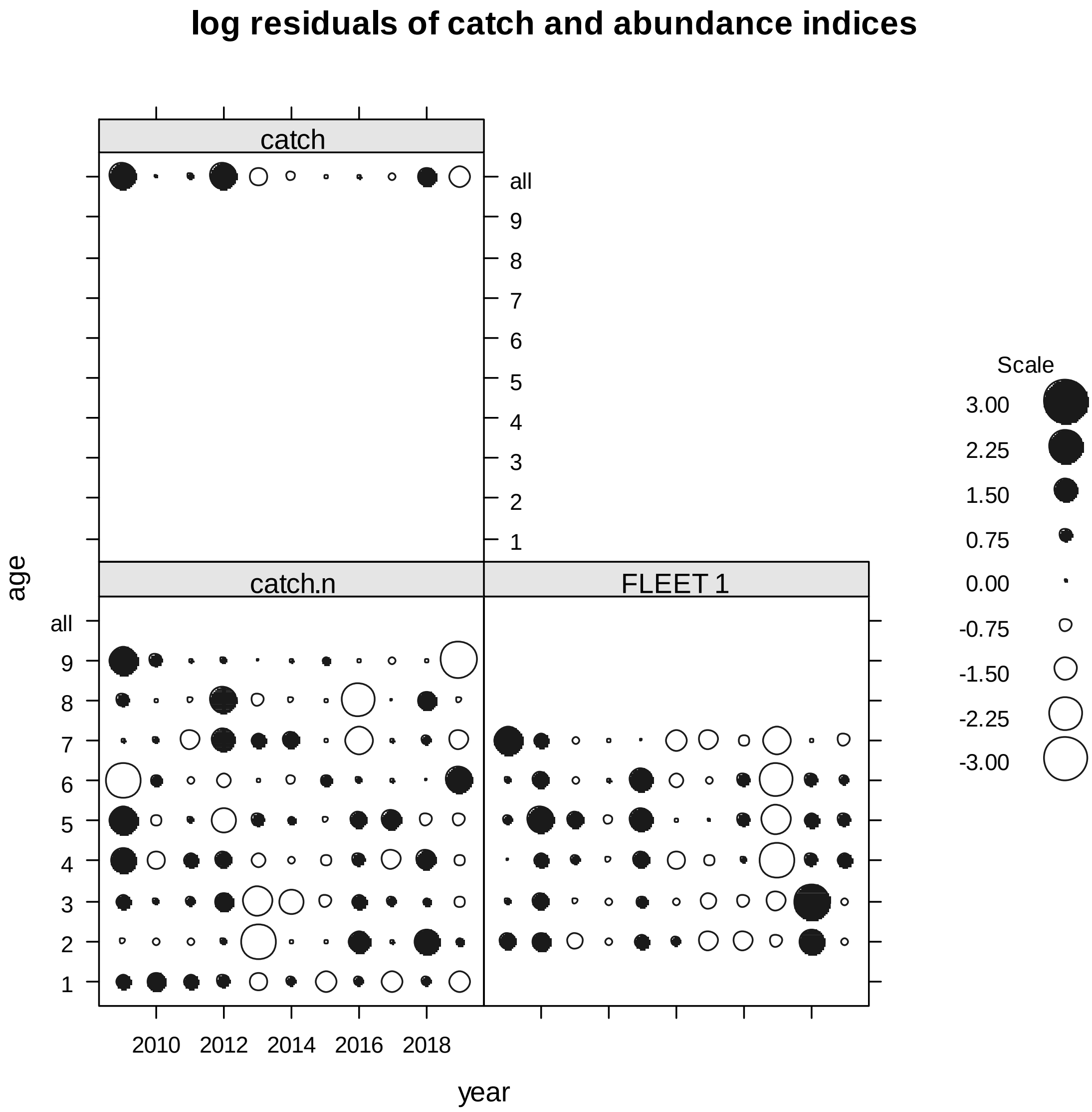


Figure 6.7.3.10. Norway lobster in GSA 5. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

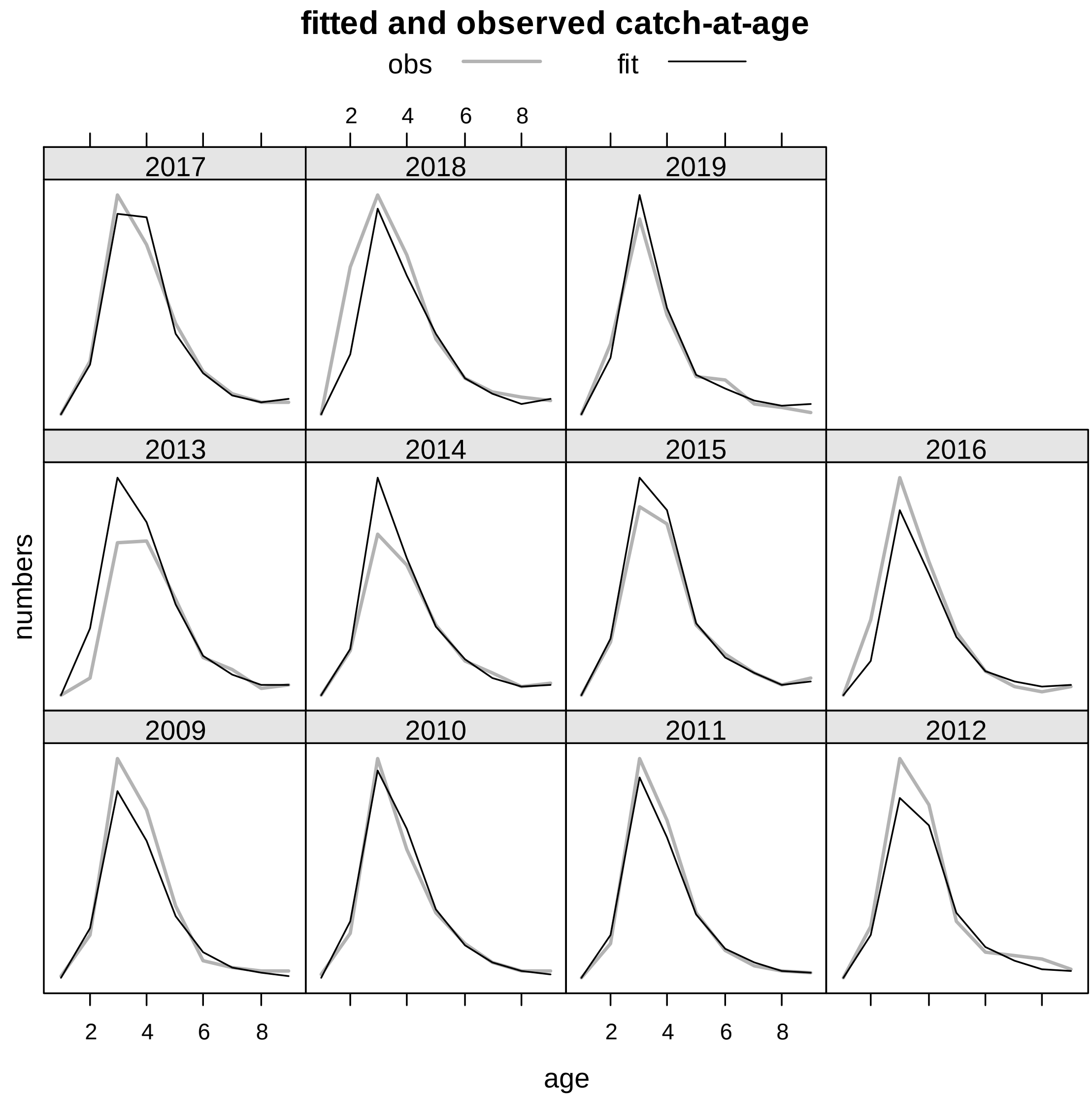


Figure 6.7.3.11. Norway lobster in GSA 5. Fitted and observed catch at age.

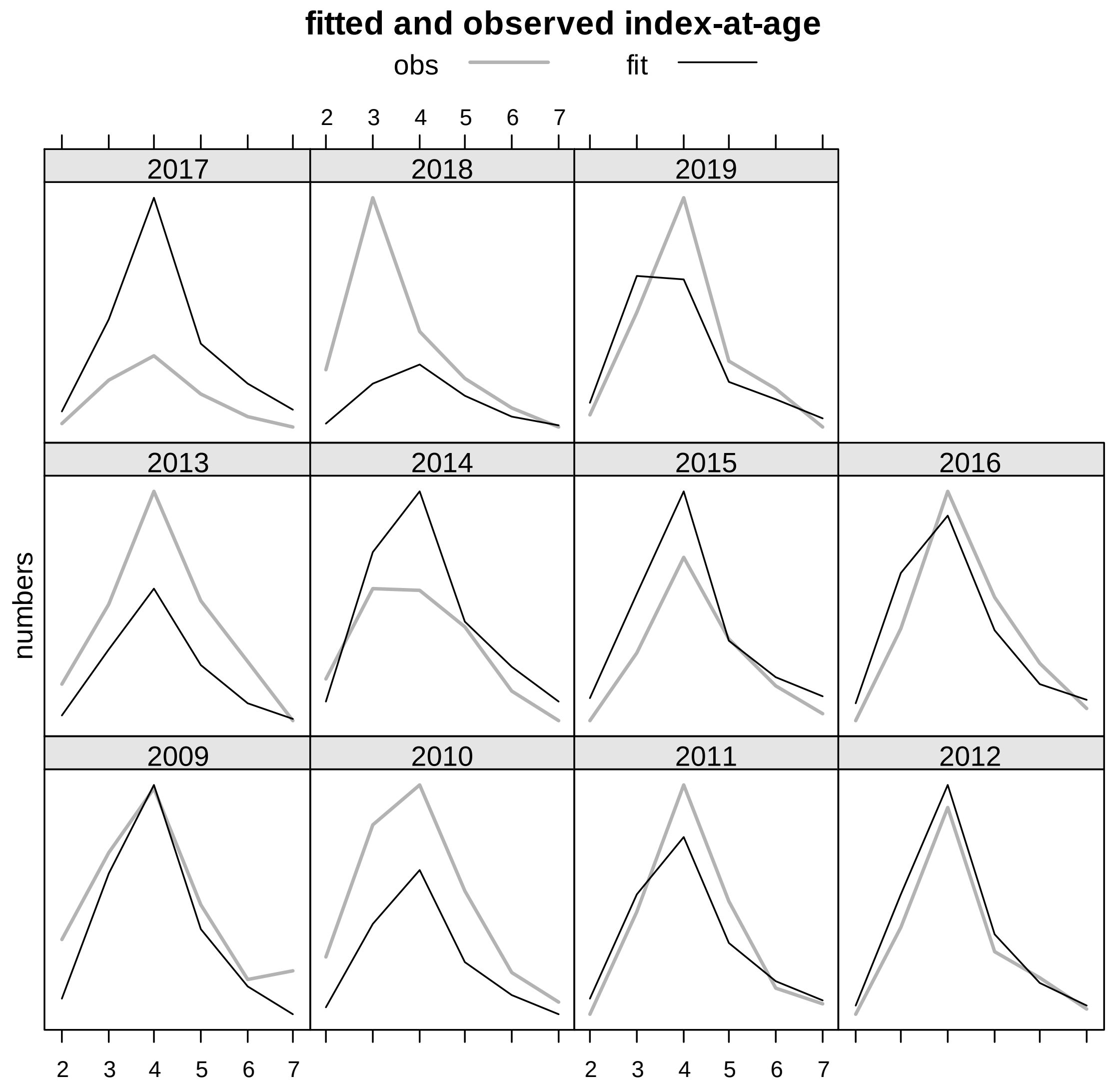


Figure 6.7.3.11. Norway lobster in GSA 5. Fitted and observed index at age

RETROSPECTIVE

The retrospective analysis was applied up to 3 years back (Figure 6.7.3.12). They shown an underestimation trend for recruitment and SSB and an overestimation for F, probably due to the short data series available. The restrospective performance is too poor to allow this to be acceptable as an assessment.

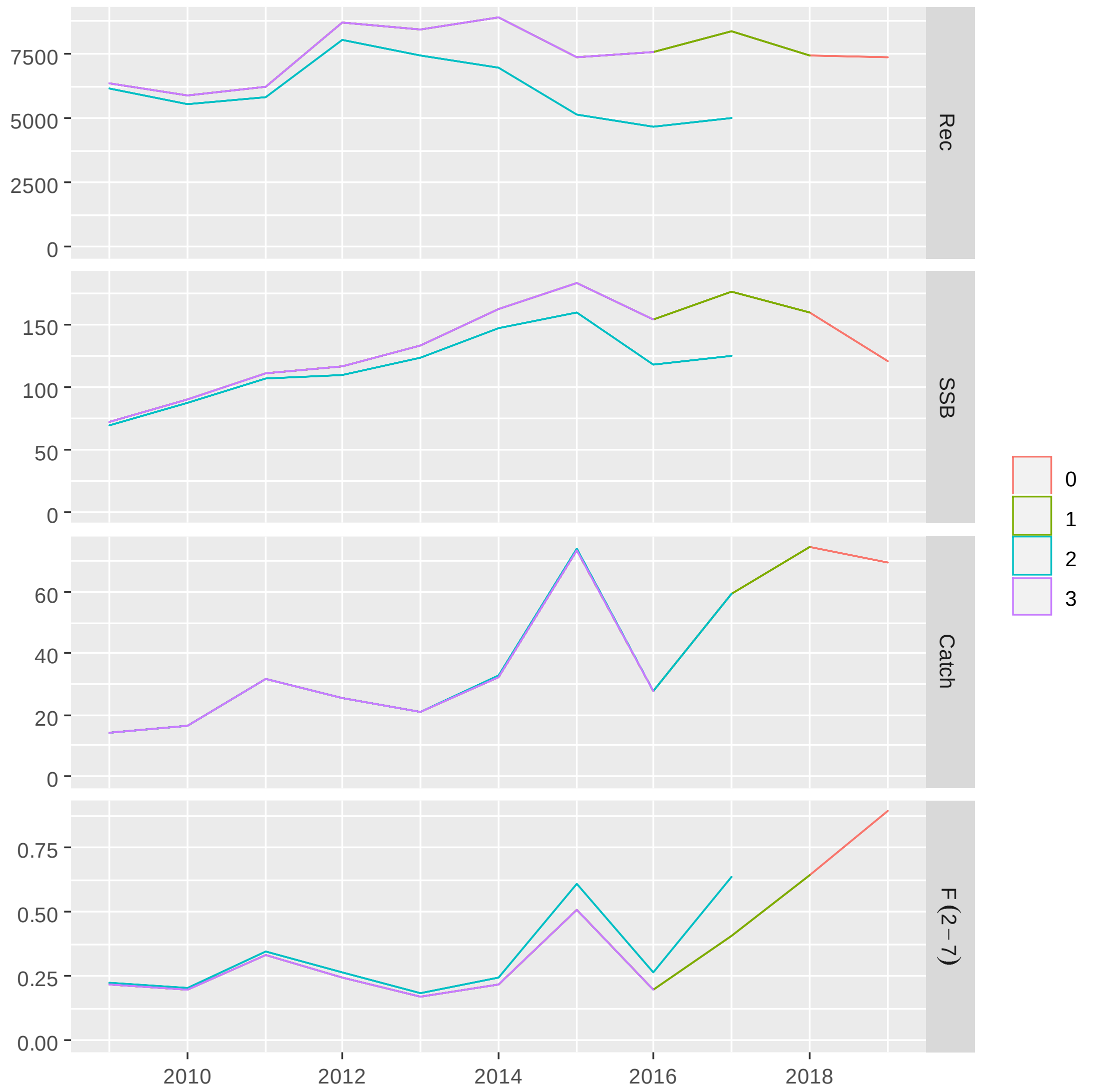


Figure 6.7.3.12. Norway lobster in GSA 5. Retrospective analysis for the a4a model.

SIMULATIONS

Figure 6.7.3.13 shows the simulations carried out for Norway lobster in GSA 5.

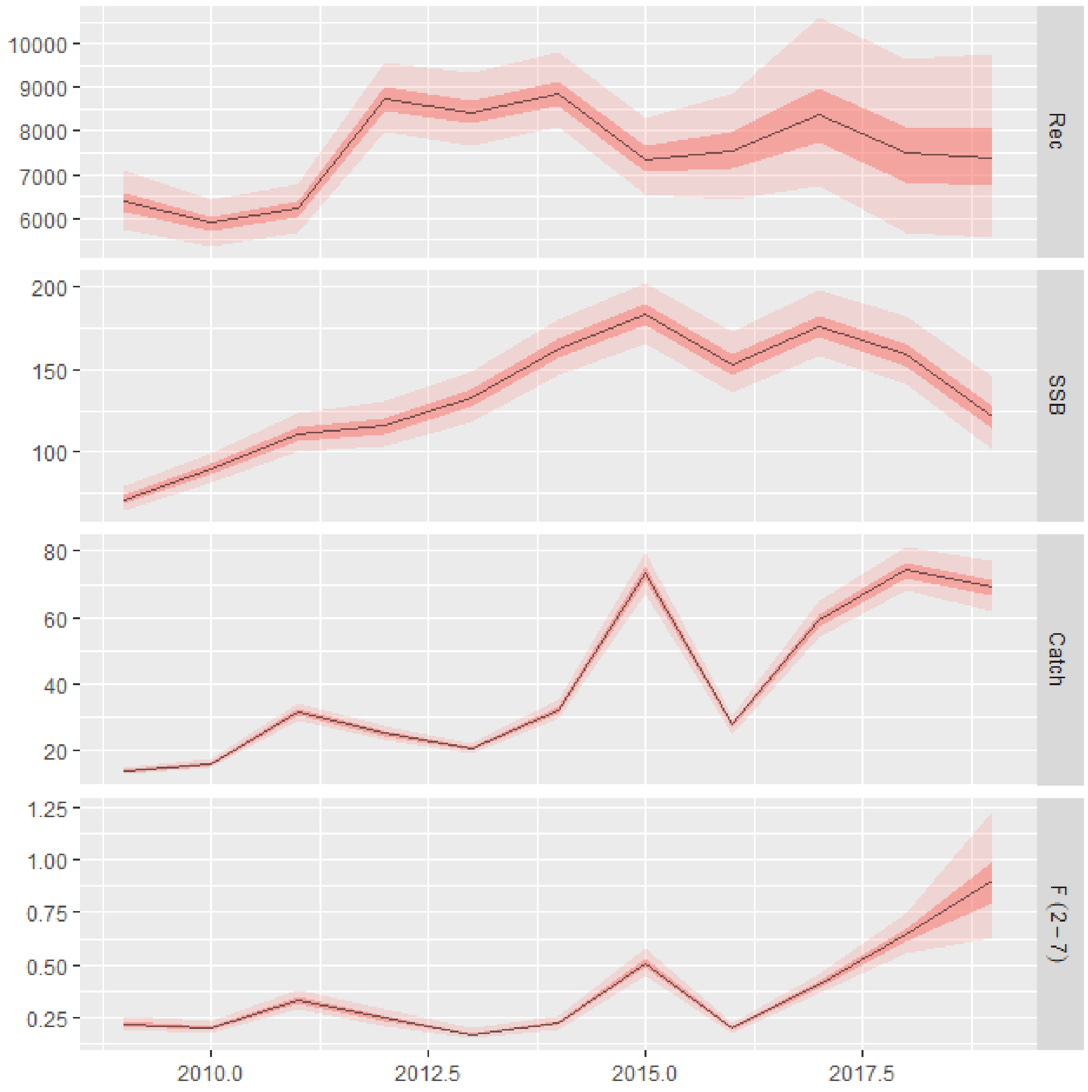


Figure 6.7.3.13. Norway lobster in GSA 5. Stock summary of the simulated and fitted data for the a4a model.

Comparison between XSA and a4a

Figure 6.7.3.14 show the results for XSA and a4a models. They showed very similar valules in all cases, except for recruitment in 2015 and 2016. This suggests that the poor performance of the assessment is due to the differing patterns in the data between survey and catch and poor consistency among year classes in the survey. The observed year to year consistency in cohorts in the catch is better. The cause of differences between the sources of data is not known, but may be due to differences in the area fished and the area surveyed. There are also unexplained recent fluctuations in catch which are not seen in the survey data. In conclusion neither of these assessments are considered suitable as an assessment and the as last year advice is based in the ICES category 3 Index method and advice given last year for 2020 and 2021 is used for

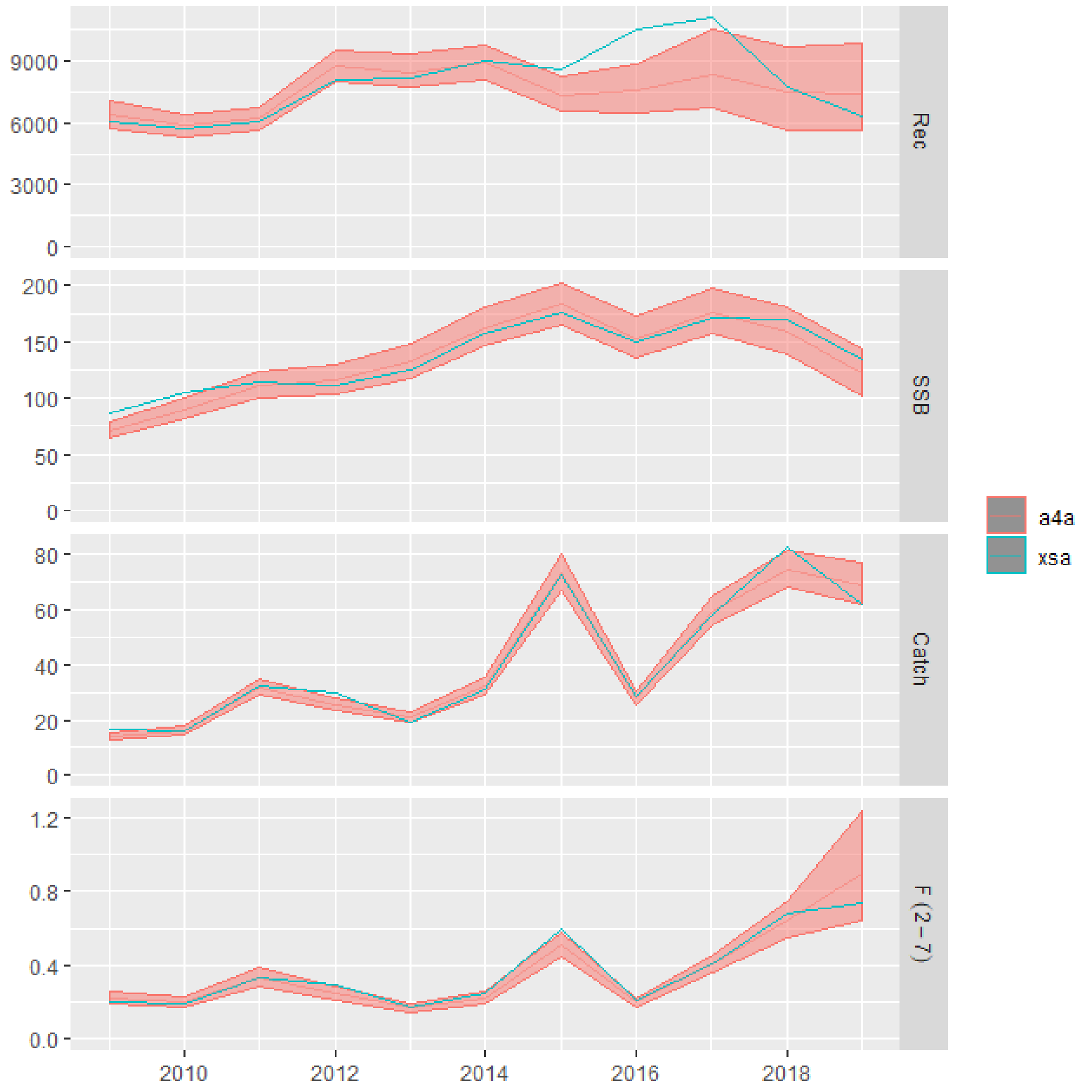


Figure 6.7.3.14. Norway lobster in GSA 5. Results for the XSA and a4a models: recruitmend (thousands), SSB (Stock Spawning Biomass, tonnes), catch (tonnes) and fishing mortality for ages 1 to 2).

6.7.4 Reference Points

As the assessment was not accepted for advice, reference points were not calculated.

6.8 NORWAY LOBSTER IN GSA 6

6.8.1 STOCK IDENTITY AND BIOLOGY

Due to the lack of information about the structure of the *N. norvegicus* population in the western Mediterranean, this stock was assumed to be confined within the GSA 6 boundaries (Figure 6.8.1.1). Generally, managing Norway Lobster is considered to be suited to local small scale management issue, as stocks are linked to suitable benthic conditions, and occupy specific areas only.

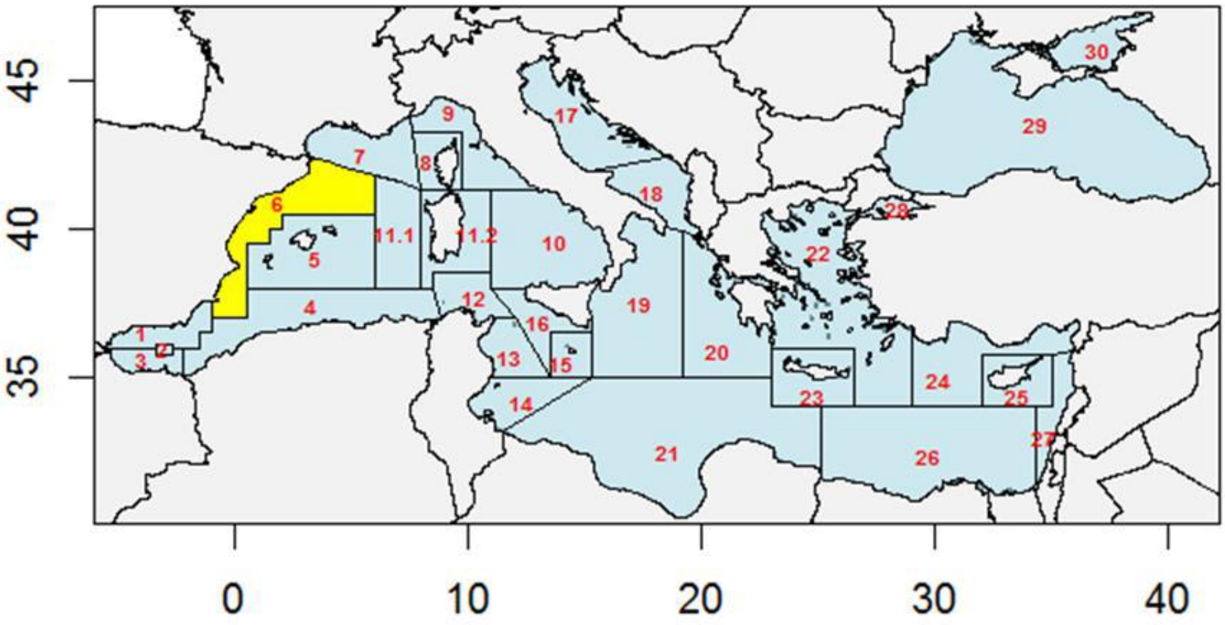


Figure 6.8.1.1. Geographical location of GSA 6.

Age and growth

For *N. norvegicus*, males and females are known to have different growth profiles, with males growing slower and reaching greater size than females. The DCF data did not include any information on the growth parameters of *N. norvegicus* in GSA 6. For this reason, the same parameters of the last assessment, from DCF for GSA 5 (see Table 6.8.1.1) were used again.

Table 6.8.1.1. Norway lobster in GSA 6: Parameters used for growth and weight at length.

Growth Equation	**L_∞**	**k**	**t_0**
$L(t) = L_\infty *[1 - \exp(-K*(t-t_0))]$	86.1	0.126	0
Weight at Length	**a**	**b**	
aL^b	0.000229	3.25	

Spawning is considered to occur through the year so spawning time was set at the mid-point of the year with 50% F and M occurring before spawning.

As agreed by EWG20-09, length data from catches and MEDITS survey were age sliced using the standard length slicing software (L2a) and then the new year added to the existing medits series as it was impossible to recreate last year's MEDITS data.

Maturity and natural mortality were taken from the previous assessment (Table 6.8.2).

Table 6.8.1.2. Norway lobster in GSA 6: Maturity and Natural mortality parameters used in the assessment

Age	1	2	3	4	5	6	7
Maturity	0.1	0.25	0.8	1.0	1.0	1.0	1.0
Natural mortality	0.732	0.466	0.353	0.291	0.252	0.226	0.206

6.8.2 Data

All data were taken from 2019 DCF data call.

6.8.2.1 Catch (landings and discards)

Catch data are available from GSA 6, since 2002. Reported discards are low relative to landings (Figure 6.8.2.1, Table 6.8.2.1).

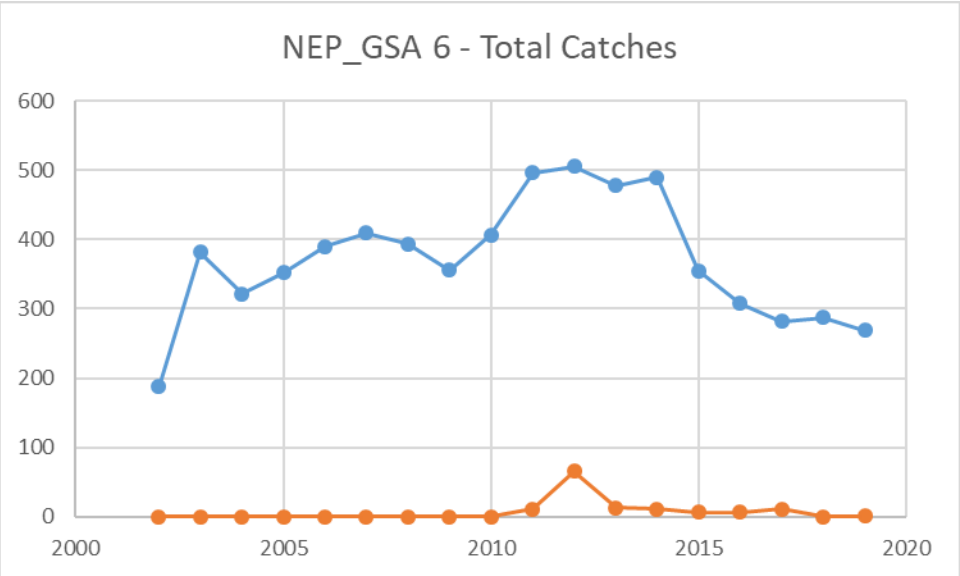


Figure 6.8.2.1. Norway lobster in GSA 6: Total landing discards and total catch by year reported by Spain.

Table 6.8.2.1. Norway lobster in GSA 6: Total landing discards and total catch by year reported by Spain.

	landings	discards	total
2002	187.5	0	187.5
2003	381.81	0	381.81
2004	321.72	0	321.72
2005	351.99	0	351.99
2006	390.18	0	390.18
2007	409.4	0	409.4
2008	393.77	0	393.77
2009	355.6	0.01	355.61
2010	406.45	0.06	406.51
2011	496.84	11.37	508.21
2012	506.09	65.8	571.89
2013	478.36	12.34	490.7
2014	489.95	10.84	500.79
2015	355.24	6.34	361.58
2016	308.06	6.41	314.47
2017	282.22	11.02	293.24
2018	287.03	0	287.03
2019	269.12	1.22	270.34

Information at length is available from 2009 onwards (Figure 6.8.2.2).

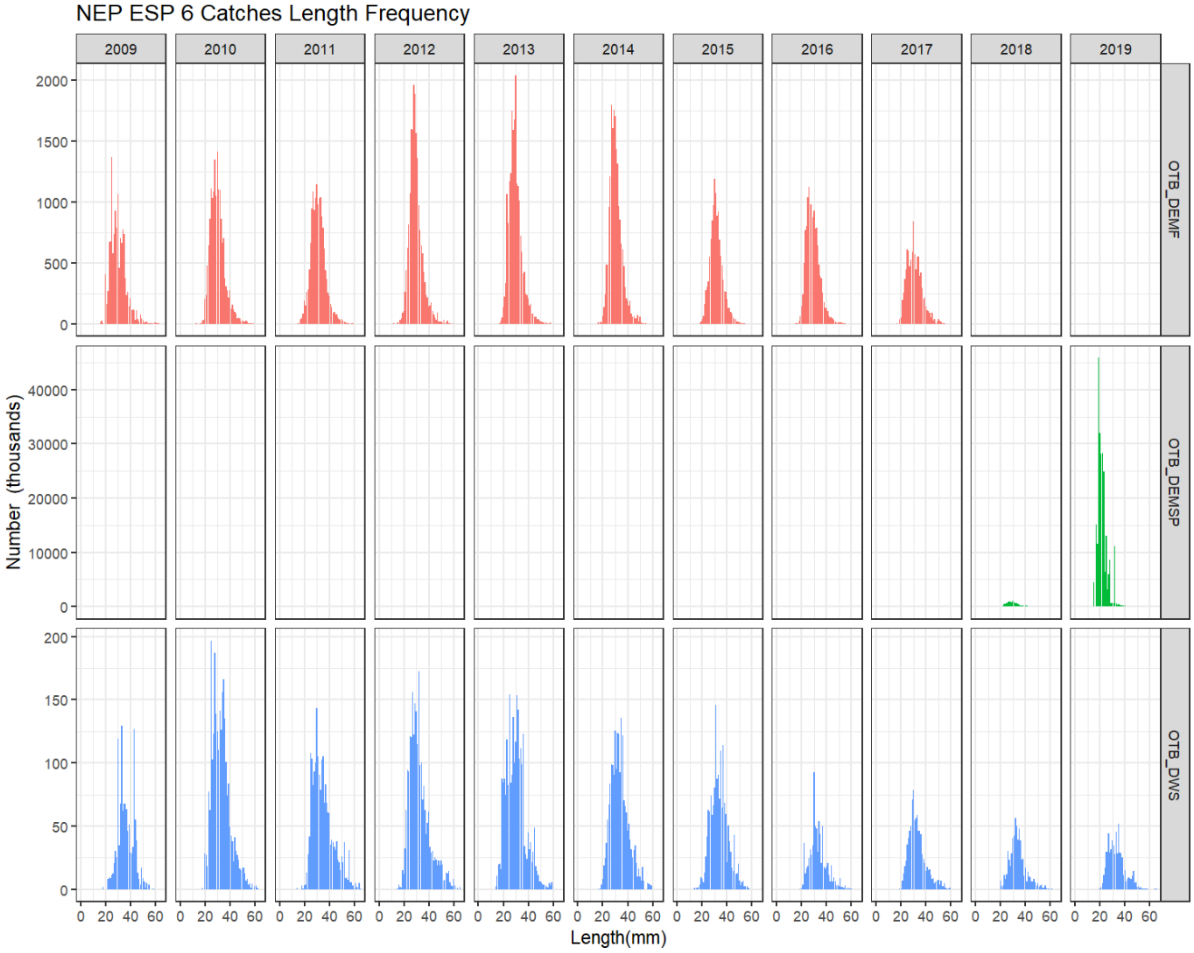


Figure 6.8.2.2. Norway lobster in GSA 6: Total catch by lengths and year reported by Spain for GSA 6.

Discards have been included in the total catches and the catches at length raised to the total with the sum of products correction. SOP corrections were similar in all years (Table 6.8.2.2).

Table 6.8.2.2. Norway lobster in GSA 6: SOP corrections for years applied to raised catch at length/age used in the assessment.

year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
SOP	1.34	1.21	1.52	1.63	1.40	1.40	1.39	1.47	1.51	1.39	1.60

6.8.2.2 Effort

Fishing effort data were reported to STECF EWG 19-10 through DCF. Nominal effort by fleet that report catches of some norway lobster in GSA 6, is almost exclusively related to bottom trawl gears (Table 6.8.2.2.1 and figure 6.8.2.2.2). Catches by other gears are negligible. 2019 data were not available to EWG 20-09 and this sectionn is not updated for 2019.

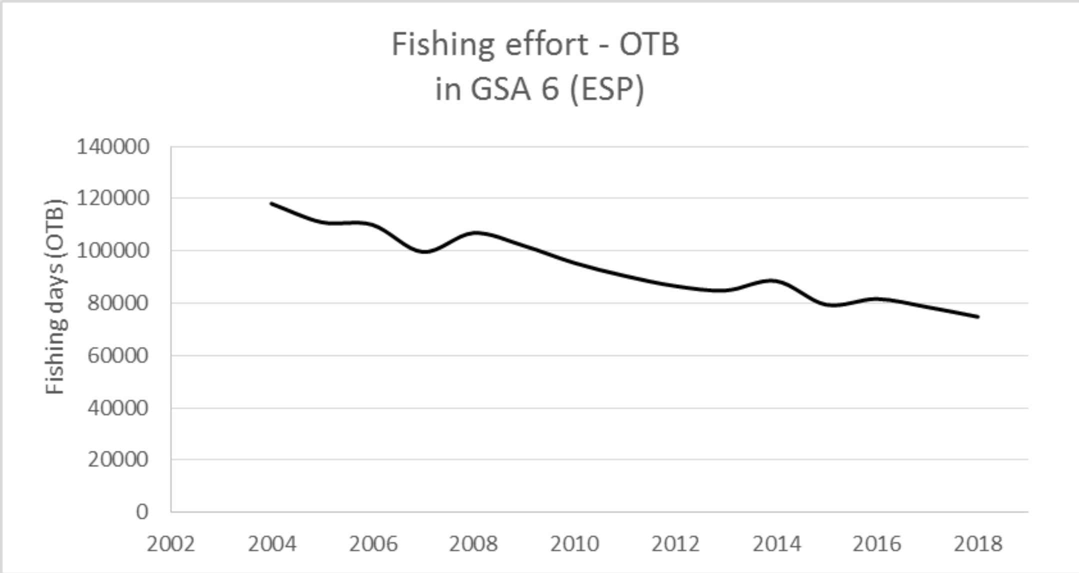


Figure 6.8.2.2.1 Norway lobster in GSA 6: Fishing days by OTB and year.

Table 6.8.2.2.1. Norway lobster in GSA 6: Fishing effort in nominal effort, GT*Days at sea and Days at sea by year and fishing gear.

OTB/ Year	**2004**	**2005**	**2006**	**2007**	**2008**
nominal effort	33561273	31446673	31080081	27966130	29956899
gt_days_at_sea	6681984	6438093	6465424	5922542	6375021
days_at_sea	118076	110957	110008	99638	106867
Year	**2009**	**2010**	**2011**	**2012**	**2013**
nominal effort	28339356	26306047	24805884	23553925	22821990
gt_days_at_sea	6063795	5673235	5343285	5109806	5021556
days_at_sea	102005	95438	90470	86587	84882
Year	**2014**	**2015**	**2016**	**2017**	**2018**
nominal effort	23422870	20513126	21352282	20593059	19751861
gt_days_at_sea	5216517	4685445	4842663	4650788	4424004
days_at_sea	88528	79421	81649	78530	74820

6.8.2.3 SURVEY DATA

Since 1994, MEDITS trawl surveys have been carried out each year during the spring season in GSA 6 (Figure 6.8.2.3.1).

Figure 6.8.2.3.1. Medits survey periods (1994-2019) in GSA 6.

Length frequency distributions and observed abundance and biomass indices of Norway lobster in GSA 6 are given in the figures below (Figures 6.8.2.3.2-4). Both estimated abundance and biomass indices show similar trends, with a slight increase in the last year (2018). MEDITS numbers at length data were length sliced to give catch at age matrix (Figure 6.8.2.3.5).

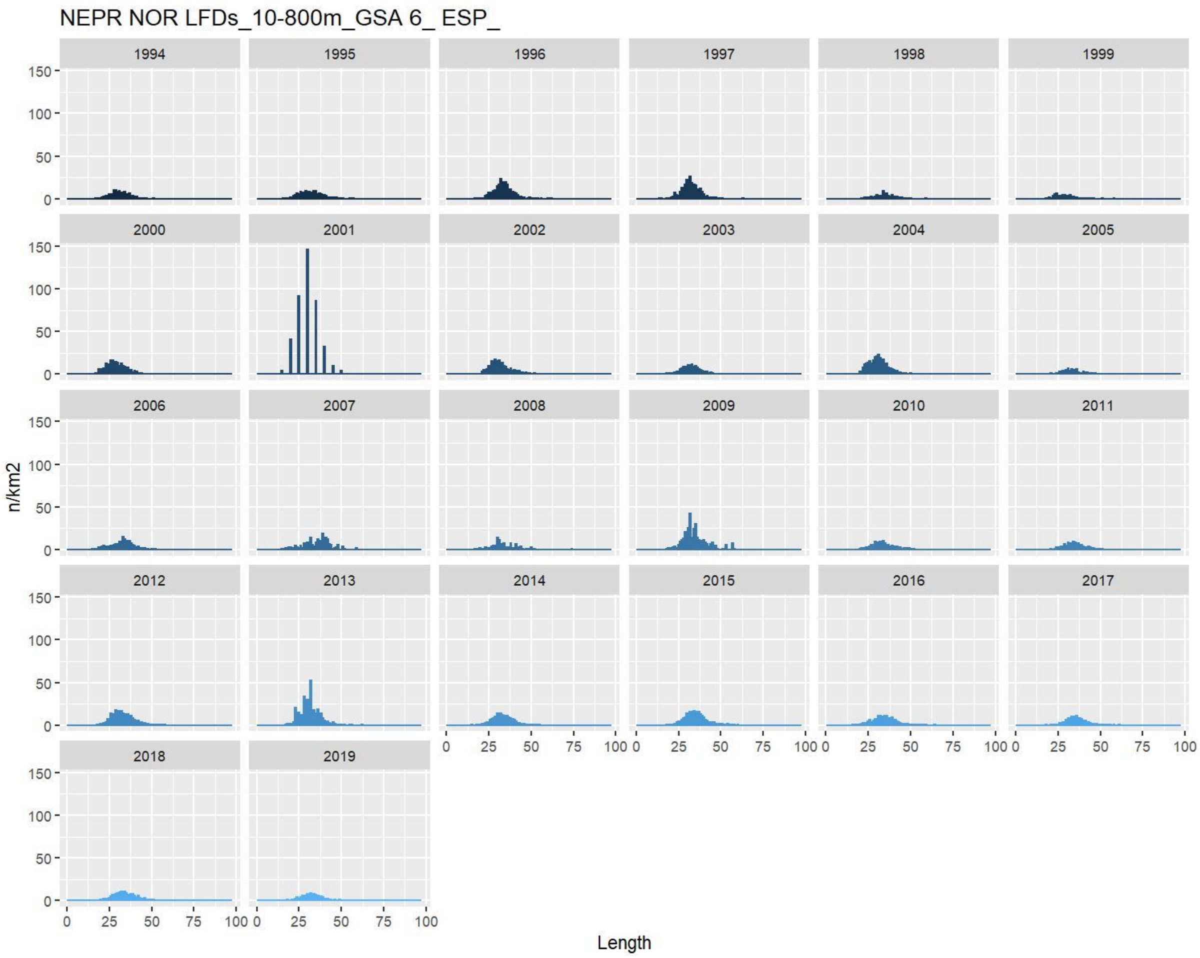


Figure 6.8.2.3.2. Norway lobster in GSA 6: length frequency distribution by year of MEDITS. (sampling in 2006 was by 5mm giving fewer higher values, and at 1mm in all other years)

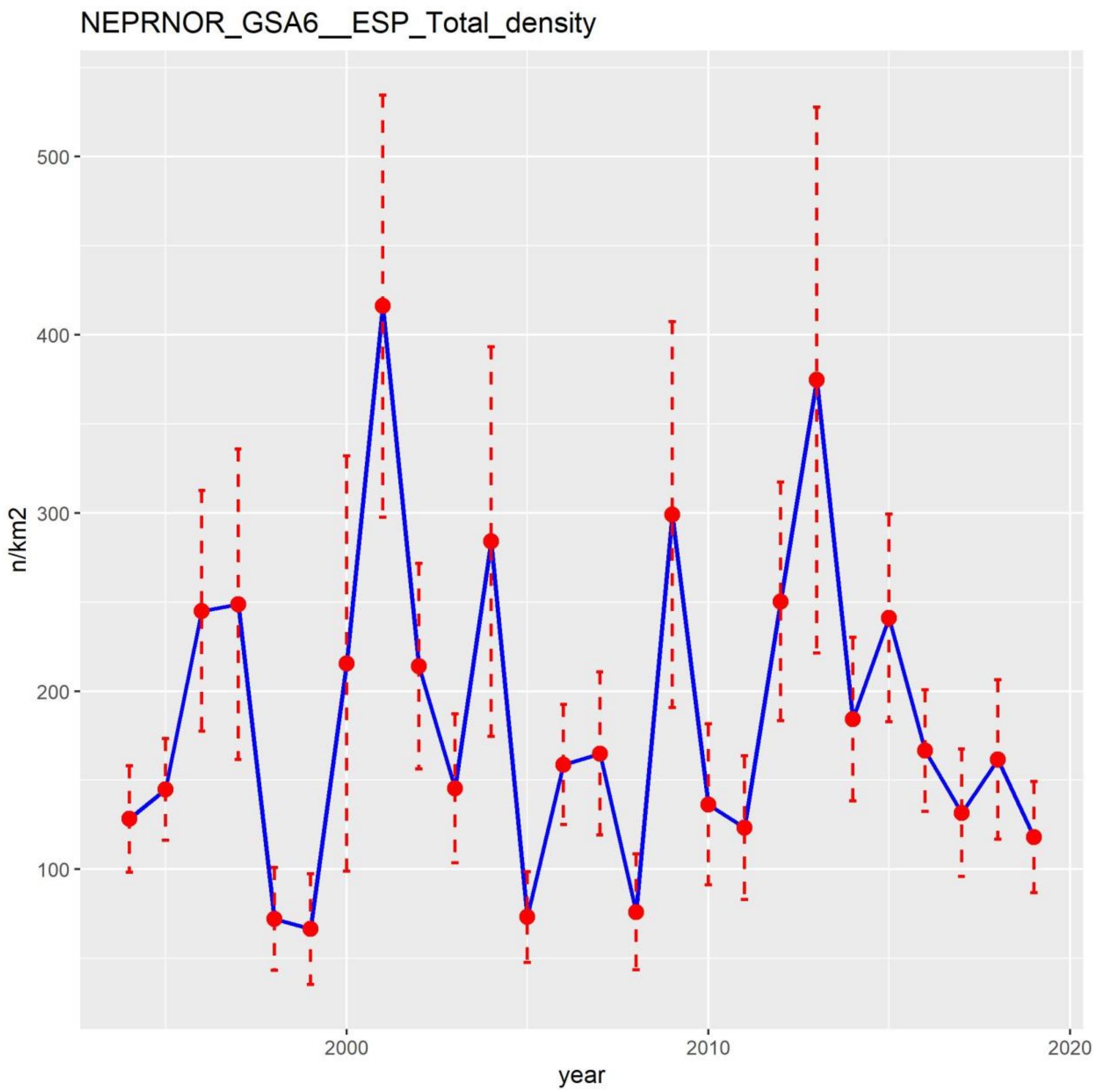


Figure 6.8.2.3.3. Norway lobster in GSA 6: estimated abundance indices (n/km^2).

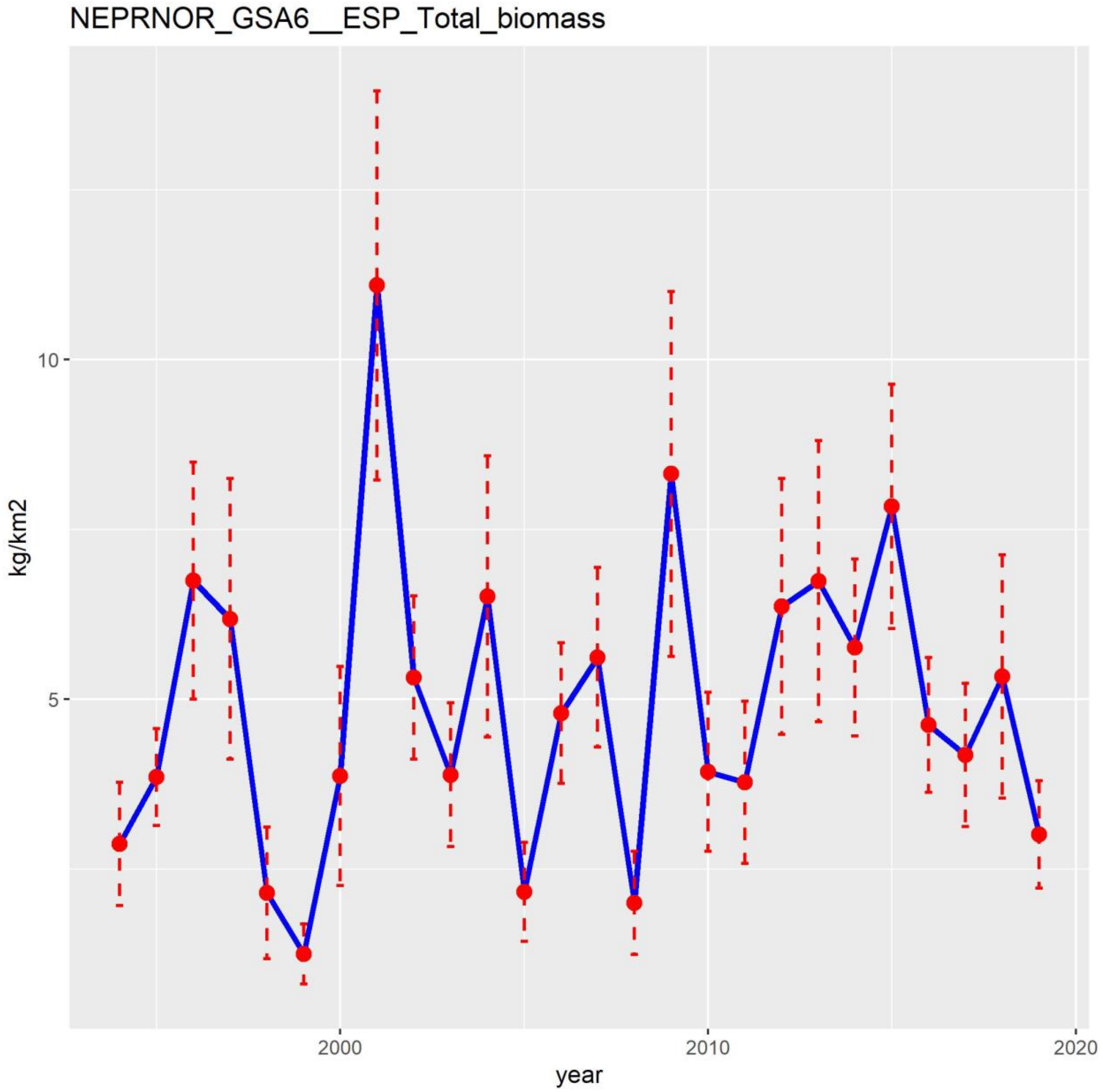


Figure 6.8.2.3.4. Norway lobster in GSA 6: estimated biomass indices (kg/km²).

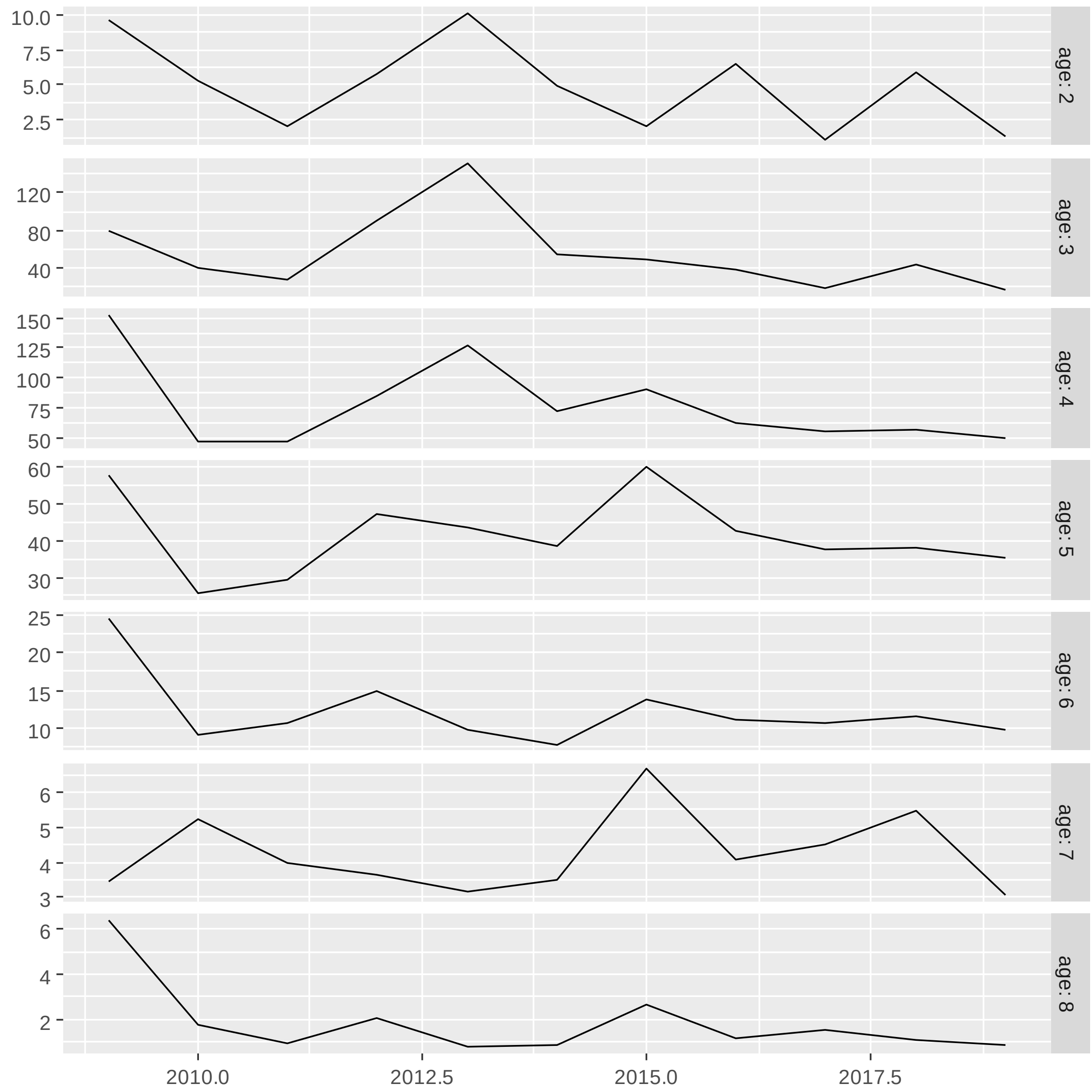
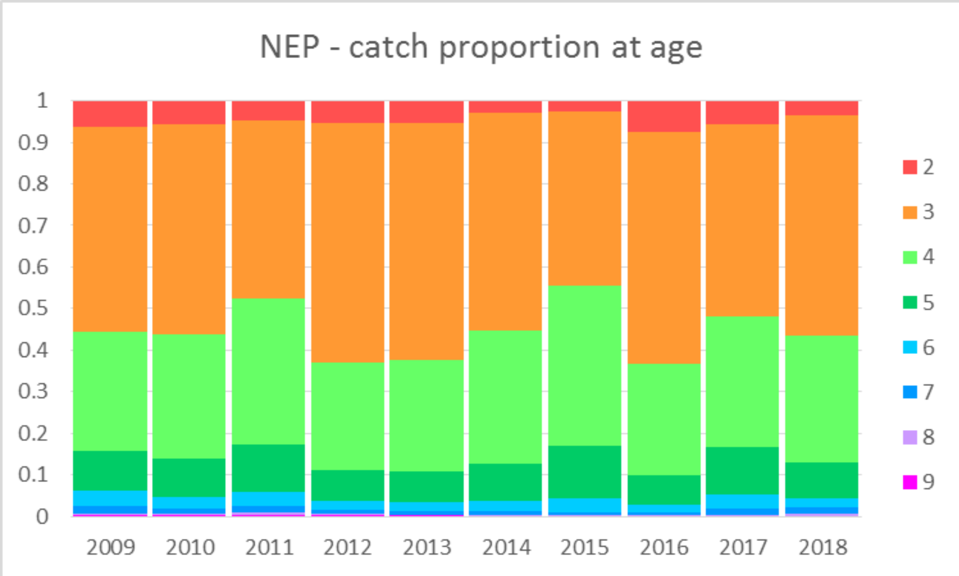


Figure 6.8.2.3.5. Norway lobster in GSA 6: Medits catch at age by year derived by age slicing.

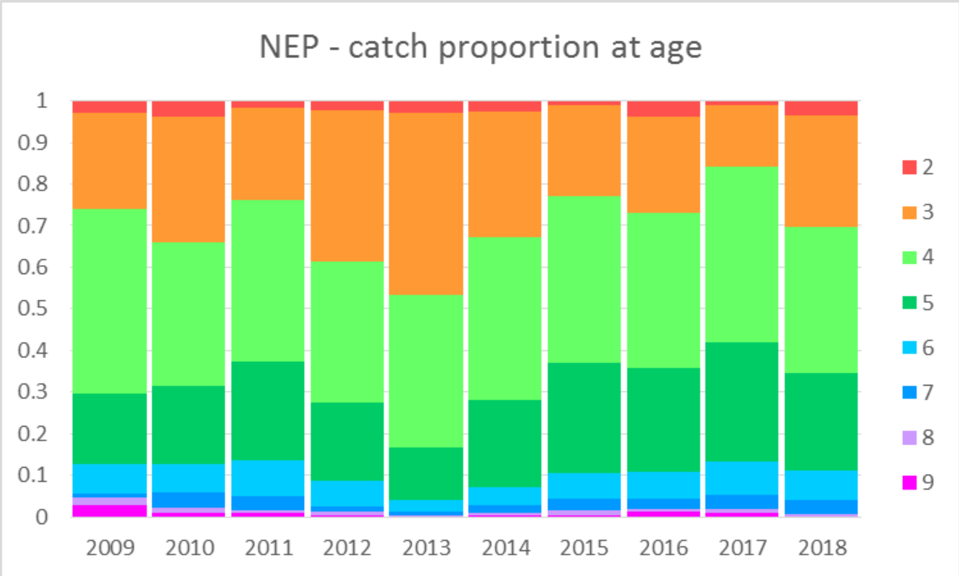
6.8.3 STOCK ASSESSMENT

The statistical catch-at-age method Assessment for All (a4a) (Jardim et al., 2015) was used to estimate historical population size.

Using the l2a routine in FLR, catch at length was deterministically length sliced to obtain numbers and mean weights at age for the assessment using the growth parameters and weight length relationship given in Table 6.8.1.1. (figures 6.8.3.1-2).



a



b

Figure 6.8.3.1. Norway lobster in GSA 6: Proportion at age by year from length sliced catch at length (a) and index at length (b).

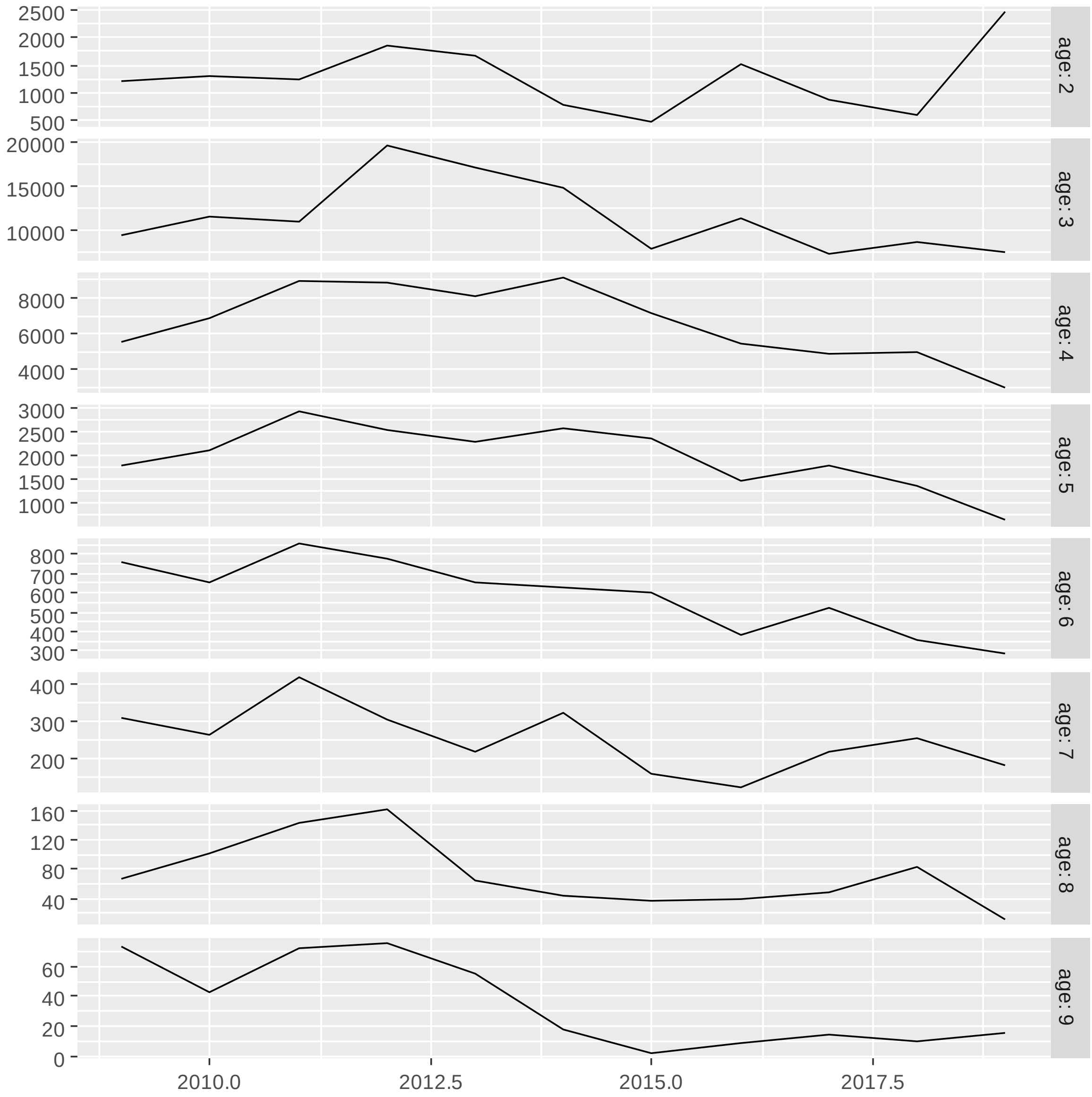


Figure 6.8.3.2. Norway lobster in GSA 6: Catch at age by year from length sliced catch at length.

Input data

Stock assessment input data for the a4a model are given in Tables 6.8.3.1 to 6.8.3.5.

Table 6.8.3.1. Norway lobster in GSA 6: Total Catch by year in tonnes.

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
355.61	406.51	508.21	571.89	490.7	500.79	361.58	314.47	293.24	287.03	270.34

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2	1196.7	1296.0	1230.2	1844.1	1658.5	788.7	477.8	1526.4	861.8	580.6	2465.2
3	9411.1	11597.0	10982.0	19775.0	17147.0	14902.0	7852.9	11396.0	7253.3	8593.5	7452
4	5534.9	6840.8	8941.5	8818.6	8054.6	9126.1	7186.7	5460.8	4884.2	4937.9	2979.9
5	1781.5	2123.5	2945.7	2536.0	2291.5	2590.5	2371.5	1467.7	1811.0	1380.6	636.3
6	754.2	653.0	852.0	777.7	650.2	628.0	601.1	379.4	522.7	360.0	286.2
7	308.0	263.0	421.3	307.6	219.4	325.0	158.1	122.8	218.0	253.2	180.7
8	67.2	100.9	142.1	160.6	65.3	43.3	37.8	39.4	49.2	82.7	11.3
9	73.5	42.6	72.0	75.3	55.4	17.9	2.7	9.1	14.9	10.1	15.8

Table 6.8.3.2. 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	2017	2018	2019
2	0.004	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.008
3	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.010	0.010	0.011	0.015
4	0.021	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.021	0.020	0.026
5	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.042
6	0.051	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.052	0.054	0.064
7	0.073	0.075	0.076	0.076	0.074	0.074	0.073	0.076	0.077	0.075	0.084
8	0.098	0.099	0.102	0.101	0.098	0.099	0.097	0.098	0.099	0.098	0.110
9	0.141	0.133	0.142	0.140	0.123	0.123	0.119	0.124	0.131	0.131	0.125

Table 6.8.3.4. Norway lobster in GSA 6: Maturity and Natural mortality at age

	2	3	4	5	6	7	8	9
Maturity	0.25	0.8	1.0	1.0	1.0	1.0	1.0	1.0
Natural mortality	0.4663	0.35333	0.29114	0.25204	0.22535	0.20611	0.19168	0.18054

Average spawning time set 0.5
Catch 2009 to 2018 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	2017	2018	2019
2	9.54	5.25	2.03	5.71	10.13	4.95	2.02	6.49	1.16	5.89	1.33
3	79.31	41.00	27.40	90.75	150.38	55.35	49.96	39.14	19.69	43.61	16.66
4	152.04	47.35	47.79	84.97	126.93	72.34	91.09	63.05	55.73	56.97	50.91
5	57.59	25.73	29.43	47.40	43.69	38.68	60.07	42.68	37.40	38.25	35.39
6	24.58	9.05	10.74	14.93	9.65	7.82	13.69	11.01	10.57	11.57	9.82
7	3.47	5.22	4.00	3.66	3.14	3.50	6.66	4.08	4.49	5.46	3.04
8	6.39	1.71	0.93	2.06	0.74	0.81	2.64	1.12	1.51	1.04	0.83

Assessment results (method a4a)

The stock assessment was based on the following submodels:

fmodel: ~factor(age) + factor(year)

srmodel: ~s(year, k = 4)

qmodel: ~factor(replace(age, age > 5, 5))

Norway lobster in GSA 6: Assessment results are shown in Figures 6.8.3.3 to 6.10.3.3.10 and given in Table 6.8.3.6 to 6.8.3.8.

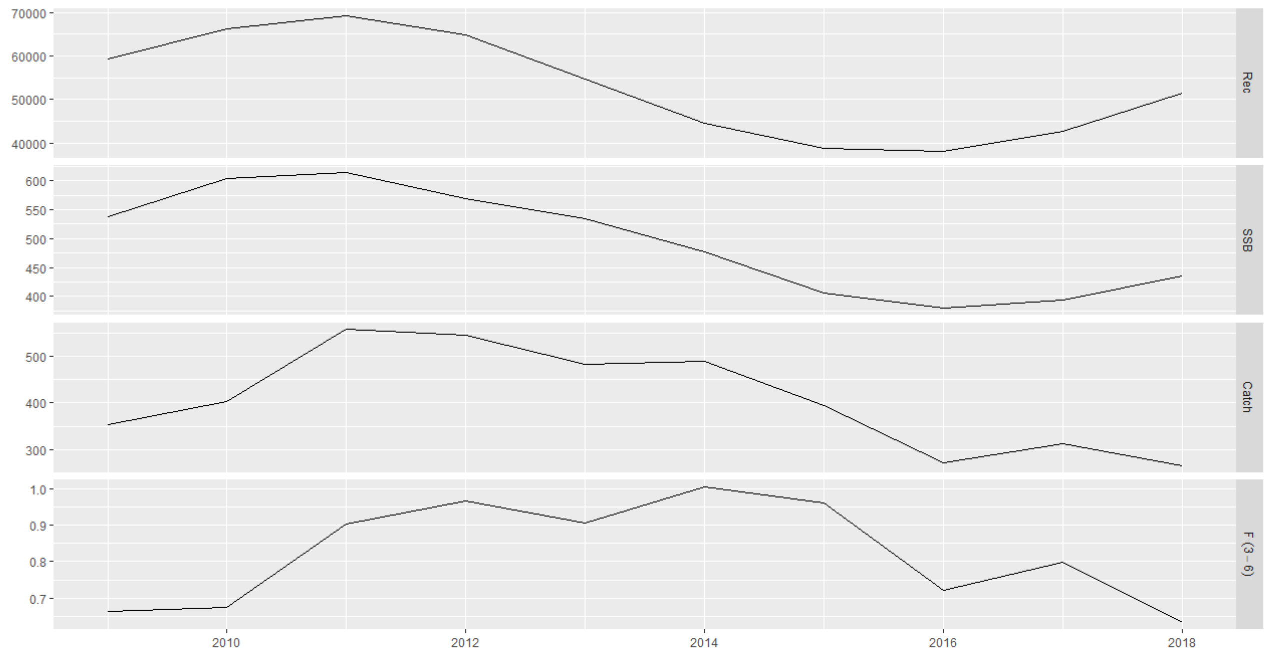


Figure 6.8.3.3. Results of the best a4a model for norway lobster in GSA 6.

Table 6.8.3.6. Norway lobster in GSA 6: Stock summary from the assessment

Year	Fbar	Recruitment	SSB	TB	Catch
2009	0.67	60437	536	1111	360
2010	0.68	67296	602	1266	409
2011	0.91	70666	611	1389	562
2012	0.97	66750	568	1336	550
2013	0.91	56383	536	1210	490
2014	1.02	44575	477	1114	501
2015	0.99	35697	394	906	401
2016	0.75	31296	349	726	265
2017	0.92	31305	321	723	305
2018	0.97	35288	279	666	270
2019	0.62	42451	431	964	245

Table 6.8.3.7. Norway lobster in GSA 6: Stock number by age and by year.

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2	60437	67296	70666	66750	56383	44575	35697	31296	31305	35288	42451
3	31881	37000	41181	42893	40427	34224	26946	21604	19108	18992	21370
4	11382	13995	16102	15319	15292	15043	11768	9472	8997	7044	6757
5	4085	3962	4803	4282	3802	4069	3520	2854	3026	2358	1742
6	1480	1482	1417	1332	1108	1055	993	891	951	827	608
7	542	595	588	447	395	350	297	288	331	296	244
8	201	178	192	140	98	94	72	63	85	78	65
9	75	97	93	73	50	38	30	24	28	30	26

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	2017	2018
2	0.021	0.021	0.029	0.031	0.029	0.032	0.031	0.023	0.025	0.020
3	0.450	0.459	0.614	0.657	0.616	0.684	0.654	0.491	0.543	0.429
4	0.747	0.762	1.019	1.091	1.022	1.135	1.086	0.815	0.902	0.713
5	0.770	0.786	1.051	1.125	1.054	1.171	1.119	0.840	0.930	0.736
6	0.681	0.695	0.929	0.995	0.932	1.035	0.990	0.743	0.822	0.650
7	0.860	0.877	1.173	1.256	1.177	1.307	1.250	0.938	1.038	0.821
8	0.855	0.873	1.167	1.249	1.171	1.300	1.243	0.933	1.033	0.817
9	0.979	0.999	1.336	1.431	1.341	1.489	1.424	1.069	1.183	0.936

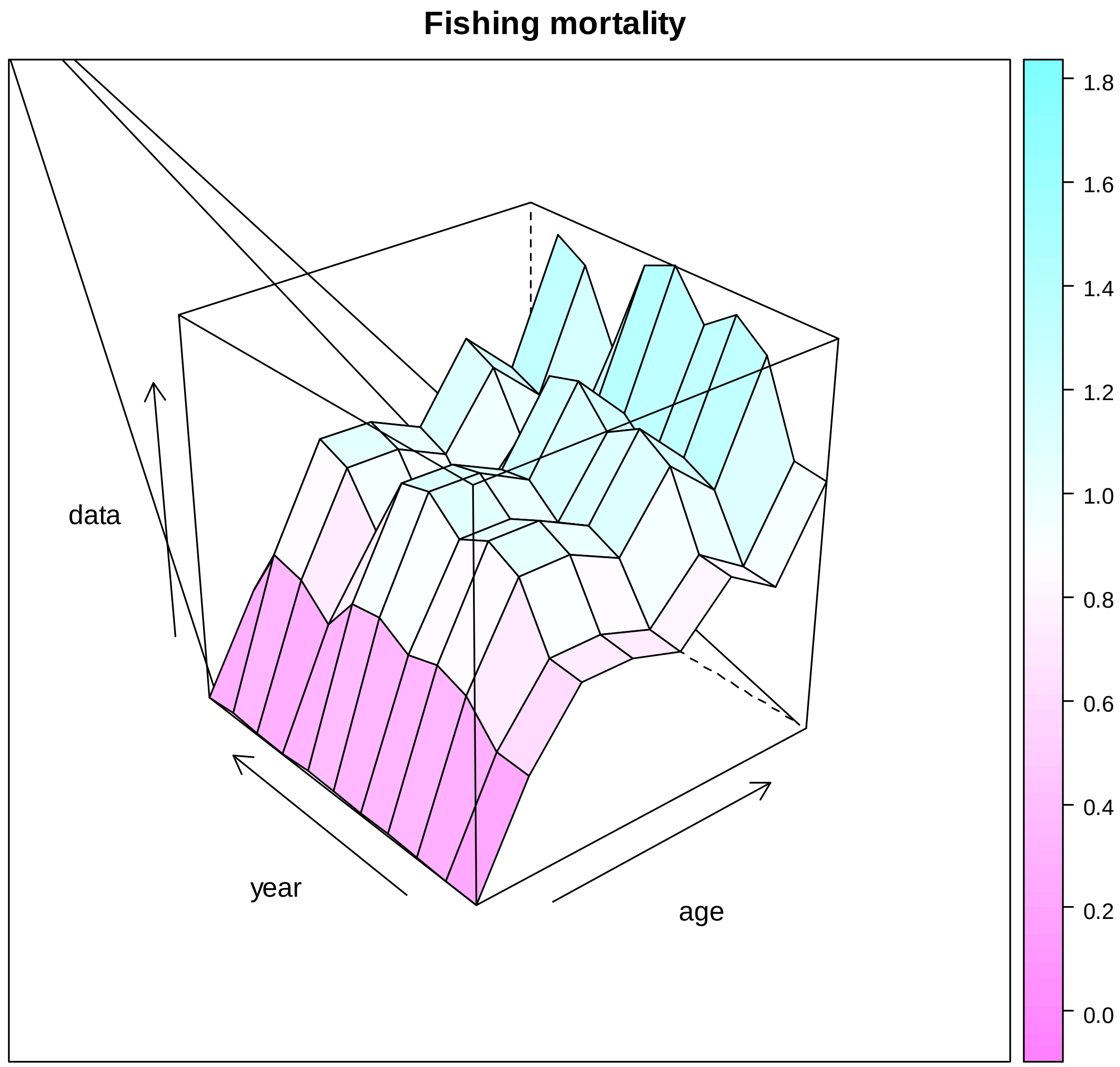


Figure 6.8.3.4. Norway lobster in GSA 6. 3D contour plot of estimated fishing mortality at age and year

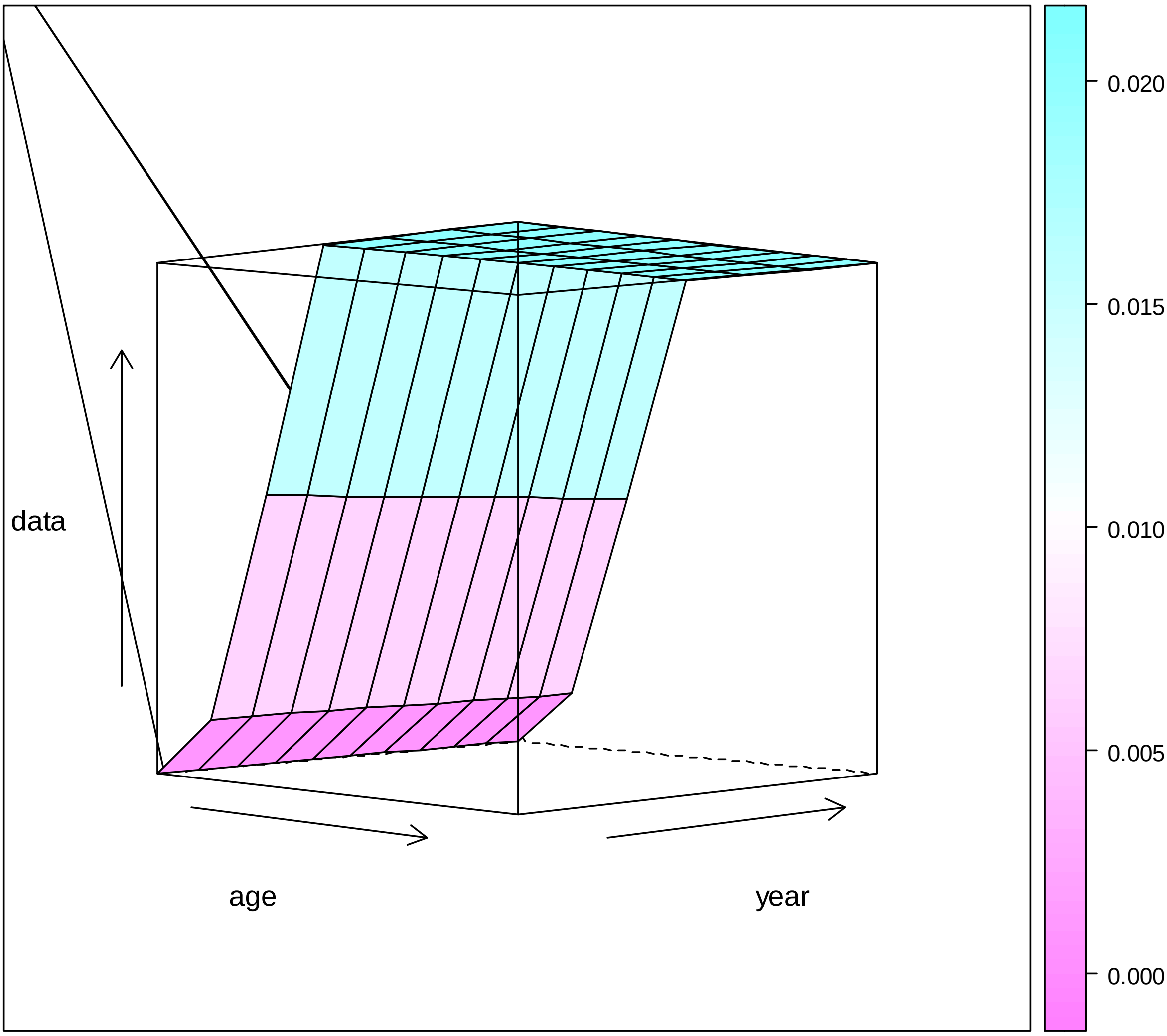


Figure 6.8.3.5. Norway lobster in GSA 6. 3D contour plot of estimated catchability at age and year.

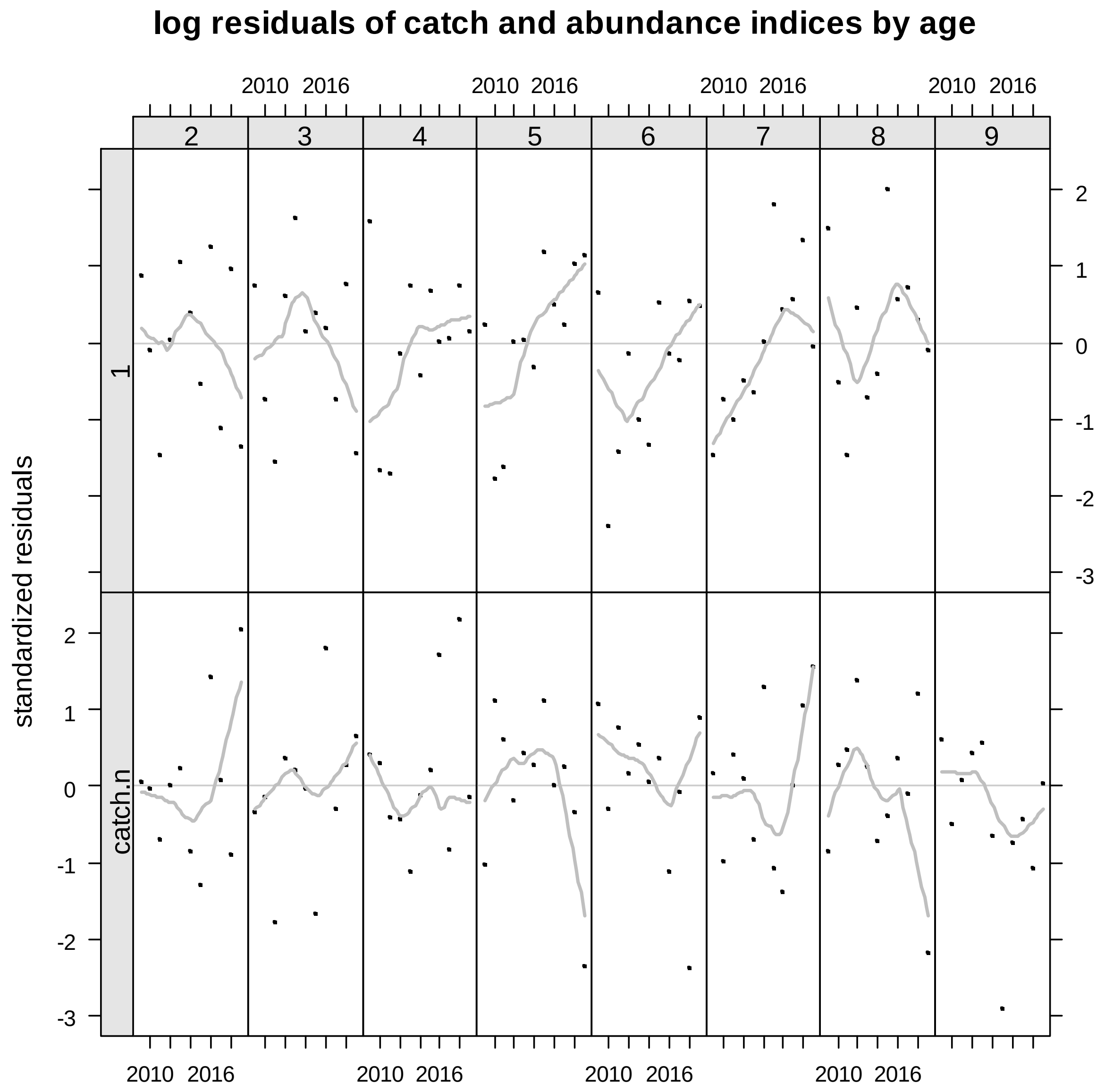


Figure 6.8.3.6. Norway lobster in GSA 6. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother

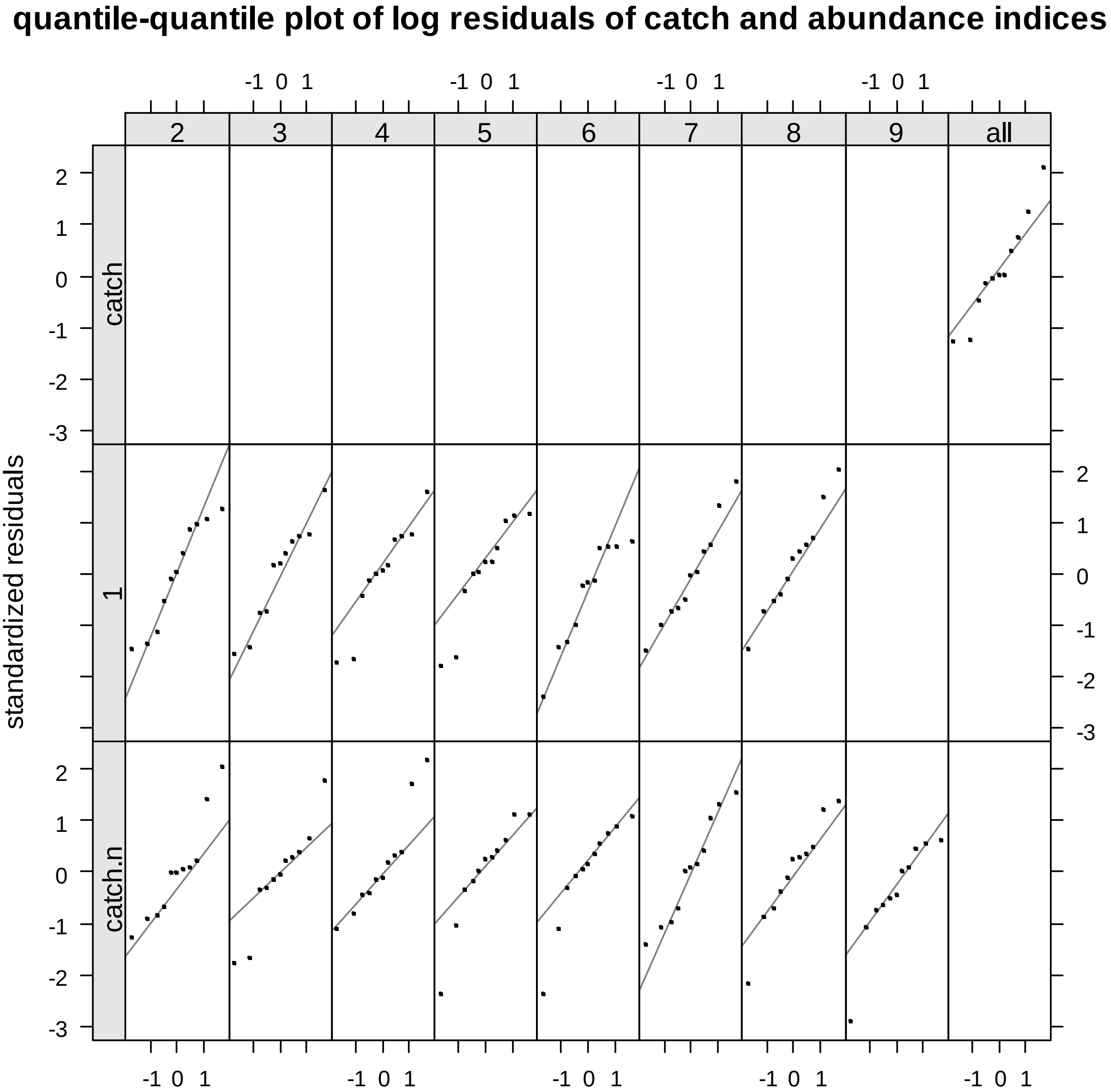


Figure 6.8.3.7. Norway lobster in GSA 6. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

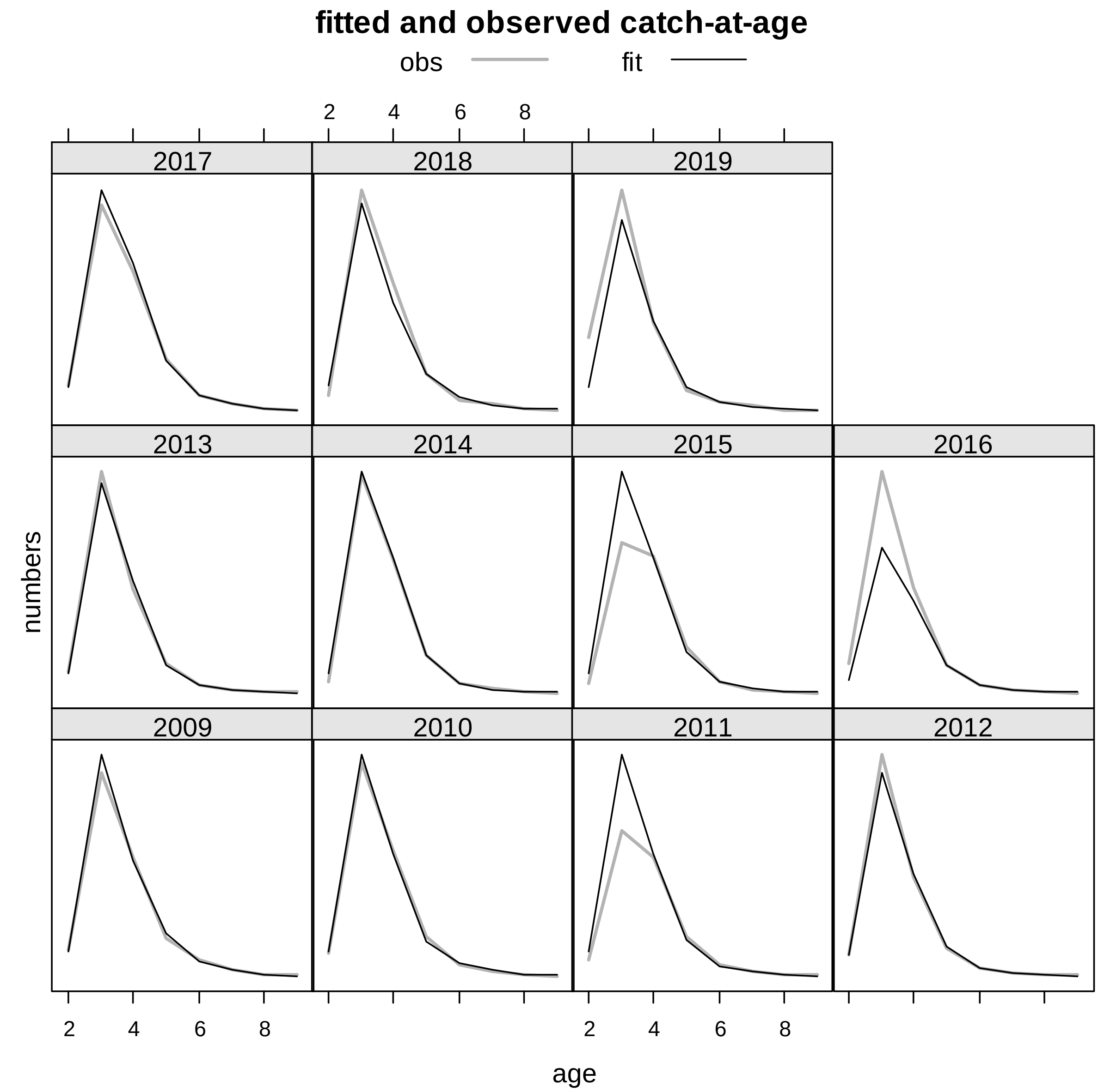


Figure 6.8.3.8. Norway lobster in GSA 6. Fitted and observed catch at age.

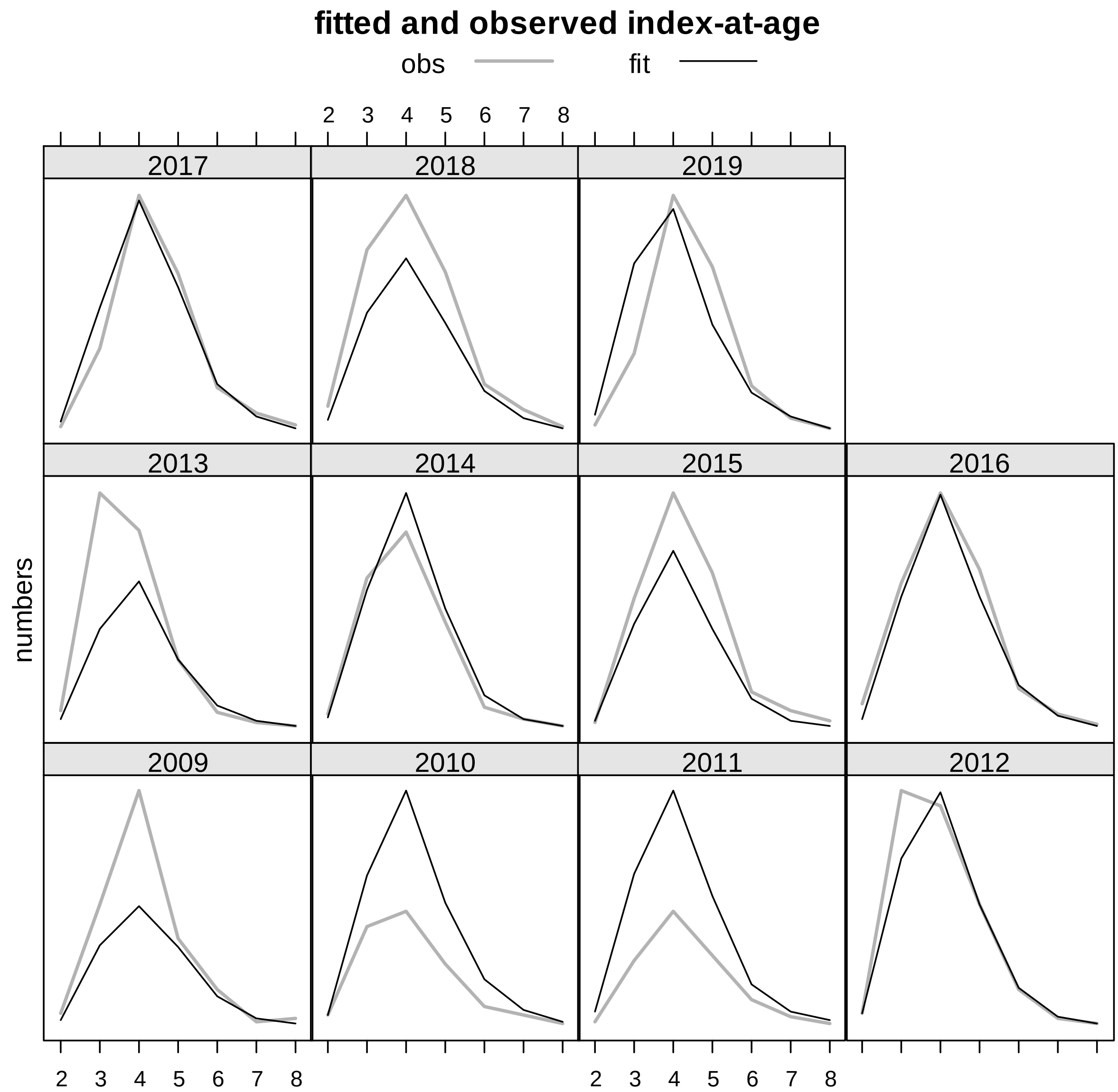


Figure 6.8.3.9. Norway lobster in GSA 6. Fitted and observed index at age.

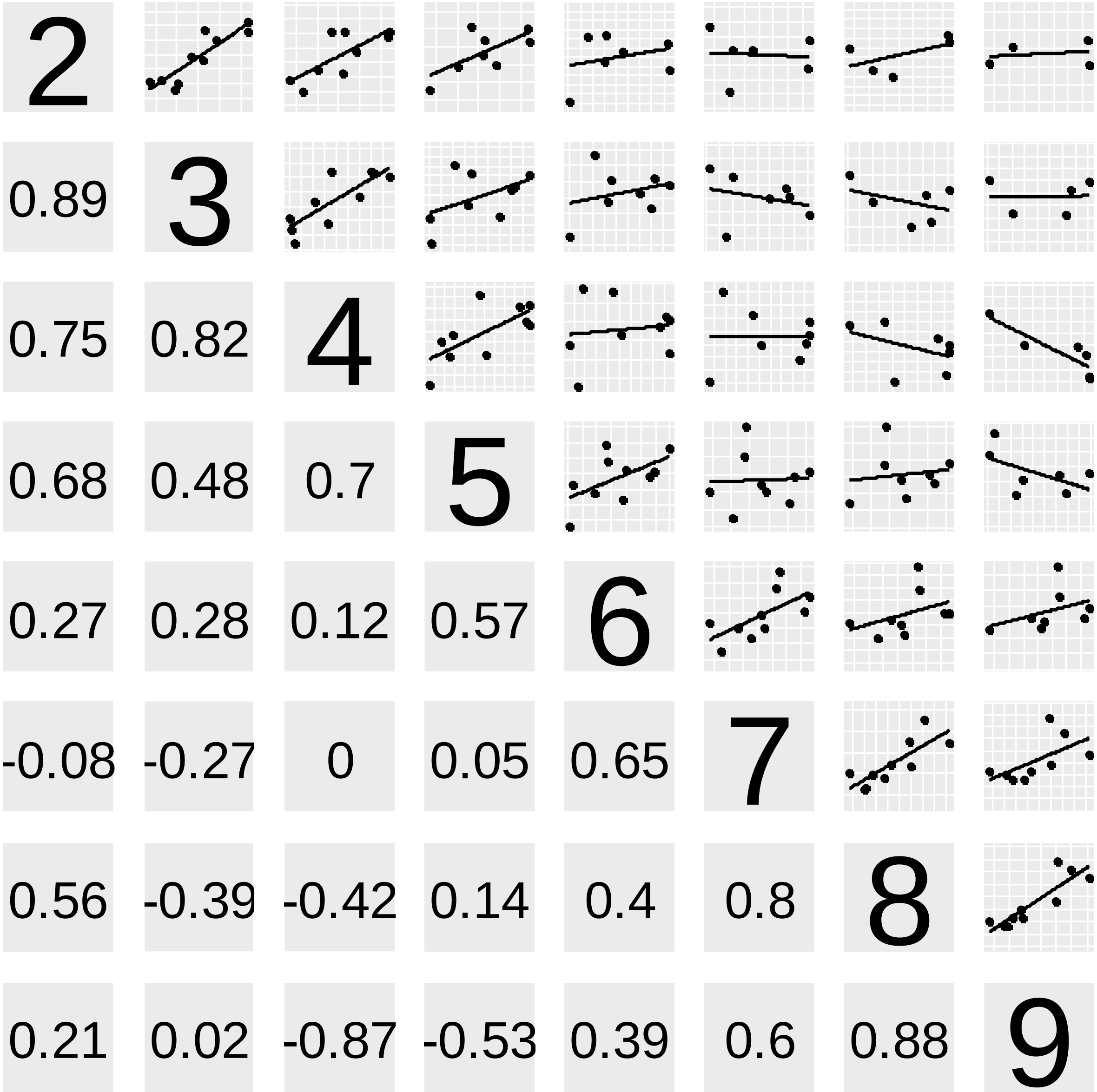


Figure 6.8.3.10. Norway lobster in GSA 6. Internal consistency of the catch at age data

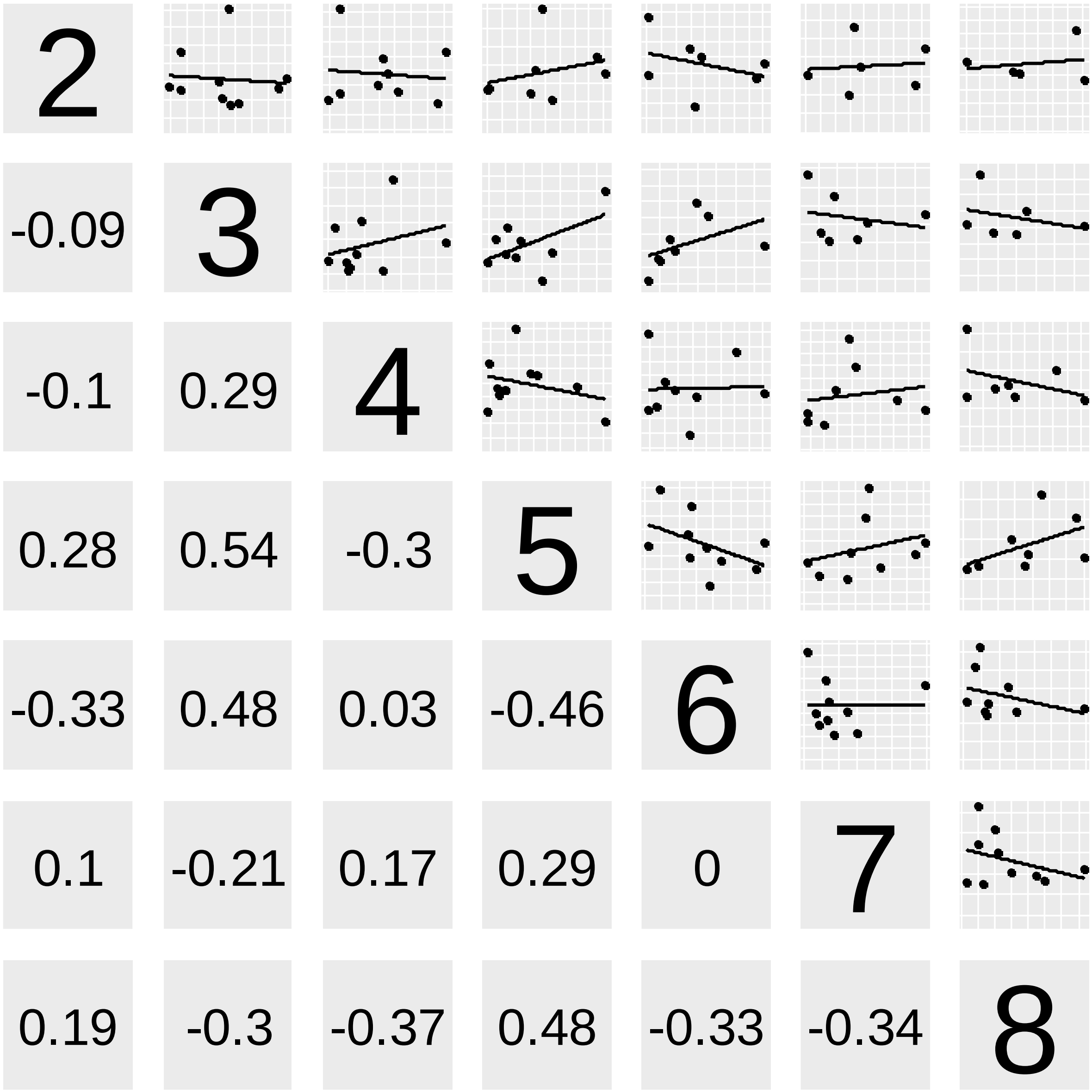


Figure 6.8.3.11. Norway lobster in GSA 6. Internal consistency of the MEDITS index at age data

Retrospective

The retrospective analysis applied up to 3 years back shows quite moderate stability for the models (Figure 6.8.3.12), however, the conclusions on stock exploitation status of $F>F_{0.1}$ is maintained throughtout.

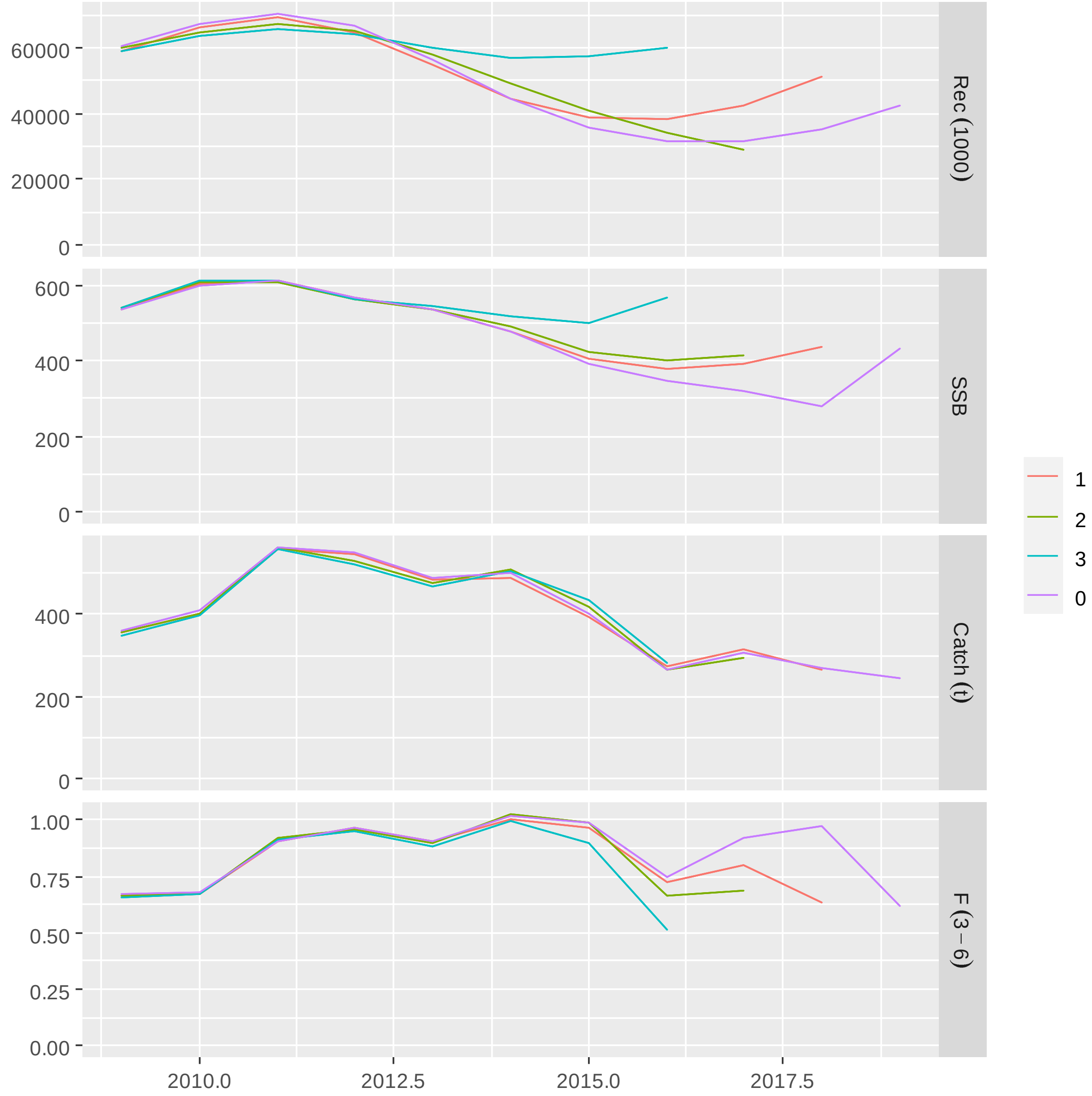


Figure 6.8.3.12. Norway lobster in GSA 6: Analytical retrospective 2009 to 2018, Recruitment, SSB, catch and Fishing mortality.

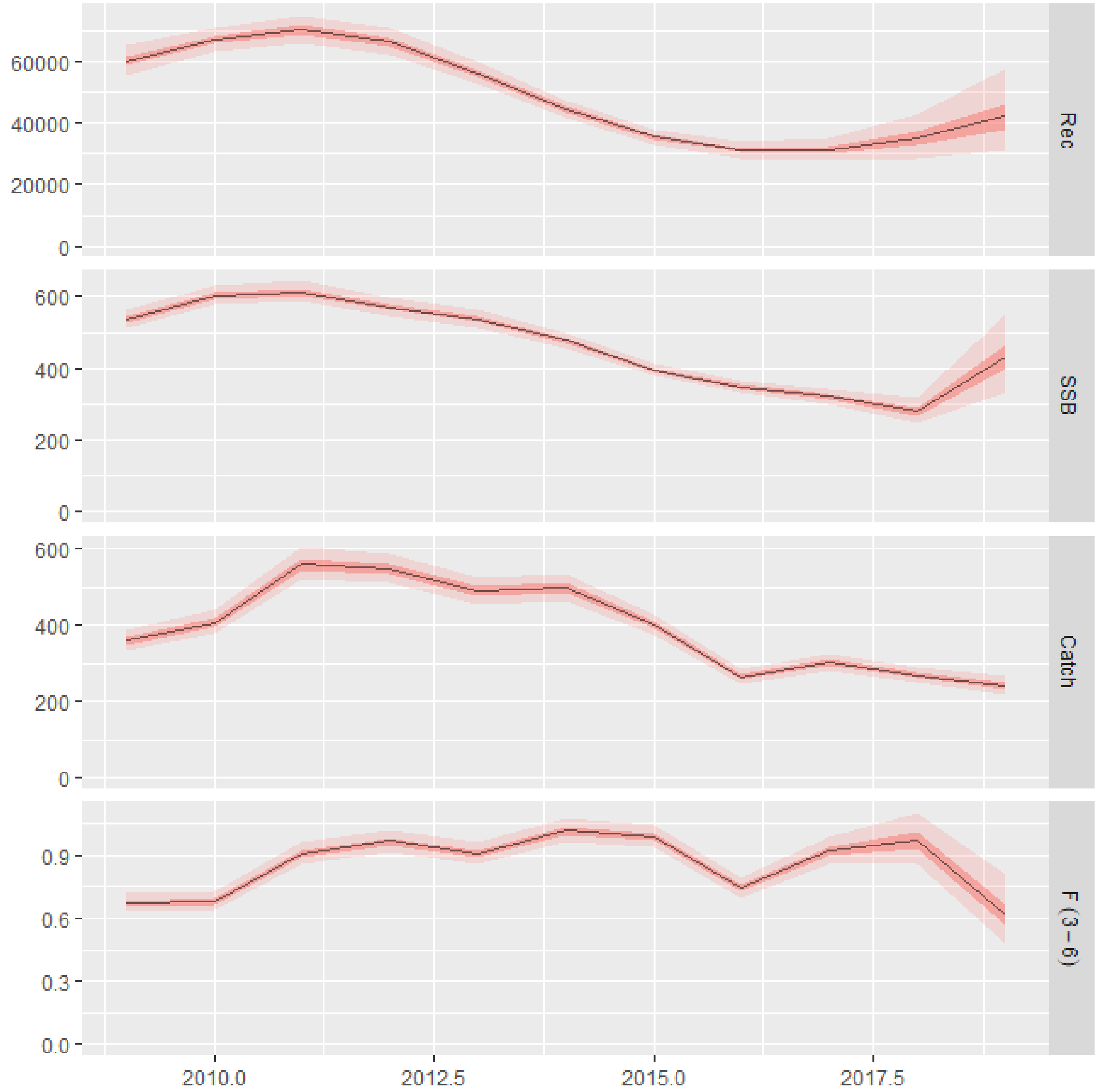


Figure 6.8.3.13. Norway lobster in GSA 6: Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals 2009 to 2018.

Conclusions to the assessment

This assessment is considered borderline acceptable, the inconsistencies in the index data compared to last year need to be addressed. Retrospective performance is not good, which is to be expected in such a short time-series and the structure of the model. Nevertheless the assessment allows us to conclude that the stock exploitation is well above F_{MSY} throughout the time series.

Based on the a4a results, the Norway lobster in GSA 6 shows SSB and recruits with a decreasing trend since 2016 and a very slight increase from 2017 onwards. Fbar (3-6) fluctuated and shows a decreasing trend in the last years down to a value of 0.62 in 2019.

In conclusion, the biomass status for the Norway lobster in GSA 6 appears low and slightly increasing.

6.8.4 Reference Points

Based on input data the reference points are given in Table 6.8.4.1.

refpt	harvest	yield	rec	ssb	biomass
virgin	0.00	0.00	44000.00	7310.00	7520.00
msy	0.20	481.00	44000.00	1960.00	2160.00
crash	880.00	248.00	44000.00	0.00	0.00
$F_{0.1}$	0.11	444.00	44000.00	3110.00	3310.00
fmax	0.20	481.00	44000.00	1960.00	2160.00
spr.30	0.18	479.00	44000.00	2190.00	2390.00

6.8.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2019 to 2021 was performed using the FLR libraries and scripts, and based on the results of the NEP GSA 6 stock assessment.
For mean weights, maturity, natural mortality and selection pattern, an average of the last three years was used. Recruitment is observedto be quite stable over the examined period, so recruitment for 2019 to 2021 has been estimated from the population results as the geometric mean of the whole time series (51814). The averaged F_{bar} =0.71 (2016-2018) from the a4a assessment was used for F in 2019.

Table 6.8.5.1 Norway lobster in GSA 6: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		average of 2017-2019
$F_{ages\ 3\text{-}6}$ (2020)	0.62	average of 2017-2019
SSB (2020)	442.20	mean F 2016-18 used to give F status quo for 2019
R_{age2} (2020,2021)	36348	Stock assessment 1 January 2020
Total catch (2020)	268.28	Geometric mean of the last 3 years

Table 6.8.5.2 Norway lobster in GSA 6: Catch options.

Rationale	Ffactor	Fbar	Catch 2021	SSB 2020	SSB 2022	SSB change 2020-2022(%)	Catch change 2019-2021 (%)
High long term yield (F0.1)	0.18	0.11	67.75	442.20	908.51	105.45	-72.30
F upper	0.25	0.16	94.16	442.20	857.93	94.01	-61.50
F lower	0.12	0.08	47.34	442.20	948.44	114.48	-80.64
FMSY transition	0.73	0.45	237.24	442.20	606.04	37.05	-3.00
Zero catch	0	0.00	0.00	442.20	1043.81	136.05	-100.00
Status quo	1	0.62	303.55	442.20	502.63	13.67	24.12
Different Scenarios	0.1	0.06	39.12	442.20	964.71	118.16	-84.00
	0.2	0.12	75.96	442.20	892.66	101.87	-68.94
	0.3	0.19	110.64	442.20	826.99	87.02	-54.76
	0.4	0.25	143.31	442.20	767.12	73.48	-41.40
	0.5	0.31	174.09	442.20	712.50	61.13	-28.82
	0.6	0.37	203.10	442.20	662.64	49.85	-16.95
	0.7	0.43	230.46	442.20	617.11	39.55	-5.77
	0.8	0.49	256.25	442.20	575.50	30.14	4.78
	0.9	0.56	280.59	442.20	537.45	21.54	14.73
	1.1	0.68	325.24	442.20	470.76	6.46	32.99
	1.2	0.74	345.71	442.20	441.56	-0.14	41.36
	1.3	0.80	365.05	442.20	414.79	-6.20	49.27
	1.4	0.86	383.33	442.20	390.23	-11.75	56.74
	1.5	0.93	400.60	442.20	367.68	-16.85	63.80
	1.6	0.99	416.94	442.20	346.96	-21.54	70.48
	1.7	1.05	432.40	442.20	327.90	-25.85	76.80
	1.8	1.11	447.02	442.20	310.37	-29.81	82.78
	1.9	1.17	460.87	442.20	294.21	-33.47	88.45
	2	1.23	473.98	442.20	279.32	-36.83	93.81

*SSB at mid year

6.8.6 DATA DEFICIENCIES

A lack of growth parameters and length weight relationship coefficient has been detected. As previously observed, the length distribution in 2001 is very different from all the other years and reported for greater bins than usual.

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 20-09 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.

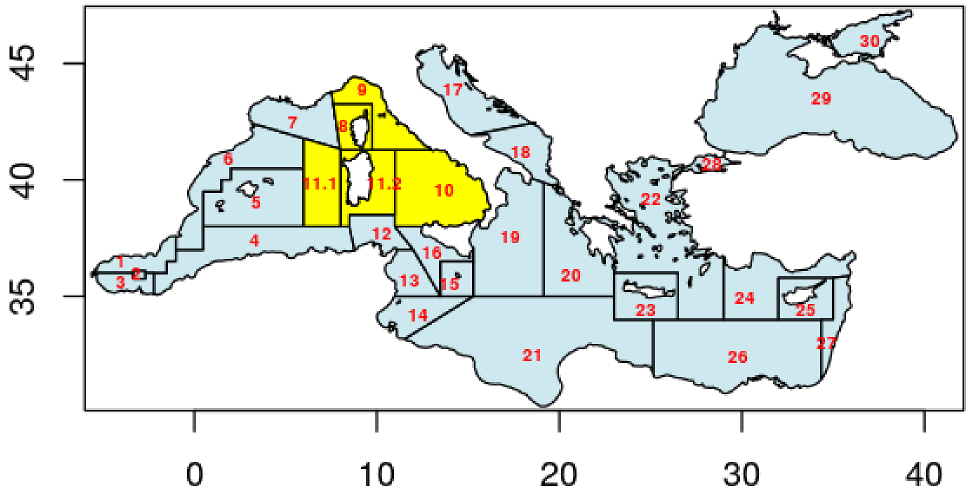


Figure 6.9.1.1. **European hake in GSAs 8, 9, 10 & 11.** Map of the stock unit.

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 Becauuse project), was between 2.9 and 2.3 BW%.
In GSA 10, European hake ranks among the species with highest abundance indices in the trawl surveys (e.g. Spedicato and Lembo, 2011). It is a long lived fish mainly exploited by trawlers, especially on the continental shelves of the Gulfs (e.g. Gaeta, Salerno, Palermo) but also by artisanal fishers using fixed gears (gillnets, bottom long-line).
Trawl-survey data have evidenced highest biomass indices on the continental shelf of the GSA 10 (100-200 m; Spedicato and Lembo, 2011), where juveniles (less than 12 cm total length) are mainly concentrated. During autumn trawl surveys, one of the main recruitment pulses of this species is observed. Two main recruitment events (in spring and autumn; Spedicato and Lembo, 2011) are reported in GSA 10 as for other Mediterranean areas. European hake is considered fully recruited to the bottom at 10 cm TL (from SAMED, 2002). The length structures from trawl surveys are generally dominated by juveniles, while large size individuals are rare. This pattern might be also due to the different vulnerability of older fish beside the effect of high exploitation rates. The few large European hake caught during trawl surveys are generally females and inhabit deeper waters. The overall sex ratio (~0.41-0.47) estimated from trawl survey data is slightly skewed towards males. The size at first maturity for females was recently estimated by Carbonara et. al. (2019) at 33 cm, with a maturity range of 2.55 cm, and is in line with previous studies in the area (Recasens et al., 2008).
In GSA 11, hake is distributed in the whole area between 10 and 800 m depth. Recruits peak in abundance over the continental shelf-break (between 150 and 250 m depth). The stock is mainly exploited by the local fishing fleet, although seasonally and occasionally some other Italian fleet use to fish in some areas of the GSA 11. Spawning is taking place almost all year round, with a peak during winter–spring.
Juveniles showed a patchy distribution with some main density hot spots (nurseries) showing a high spatio-temporal persistence (Murenu et al., 2010) in western areas.
In GSA 8, hake is distributed along the narrow shelf and slope at depths up to 1000 m, but is mainly concentrated in the depth range 0-400 m. There is not any evidence that inside GSA8 boundaries inhabits a single, homogeneous hake stock that behaves as a single well-mixed and self-perpetuating population. The GSA boundaries are, as for other areas, arbitrary and do not consider neither the existence of local biological features nor differences in the spatial allocation in fishing pressure within it. It is likely some connectivity exists as larval drifts, movements of individuals and sharing of spawning areas in particular with GSA9, 10 and 11.

Growth parameters and length-weight parameters were those used for the assessment carried out during the benchmark meeting.
During the preparatory work in the view of the benchmark meeting, different approaches were used to estimate new growth parameters combining the information available in GSAs 9, 10 and 11.
It was decided to use the sets of VBGF parameters by sex calculated using otoliths data (including juveniles) to perform the deterministic age slicing to convert LFDs from landings, discards and survey into age distributions, as well as to estimate mean-weights-at-age, natural mortality and proportion of matures-at-age (Table 6.9.1.1).

Table 6.9.1.1. **European hake in GSAs 8, 9, 10 & 11.** VBGF parameters used in the assessment.

GSAs	Sex	L_∞	k	t_0	Source	Notes

9, 10, 11	M	60.00	0.265	-0.06	Otolith reading	Benchmark data preparation
	F	95.00	0.16	-0.06	Otolith reading	Benchmark data preparation

Length-weight relationship parameters were estimated by sex as the average of those available in GSAs 9, 10, 11 under EU DCR/DCF (Table 6.9.1.2). No biological data are available for hake in GSA 8.

Table 6.9.1.2. European hake in GSAs 8, 9, 10 & 11. Length-weight relationship parameters used in the assessment.

GSAs	Sex	a	b
8, 9, 10, 11	M	0.004645	3.133
	F	0.005009	3.107705

Using the selected VBGF parameters, a combined vector of proportion of matures-at-age was estimated starting from the vectors of maturity-at-length available under the EU DCR/DCF. The maturity vector used for the assessment carried out during the benchmark session is shown in Table 6.9.1.3.

Table 6.9.1.3. European hake in GSAs 8, 9, 10 & 11. Maturity vector used in the assessment.

Age	0	1	2	3	4	5	6	7+
Mat-at-age	0.00	0.25	0.80	1.00	1.00	1.00	1.00	1.00

During the benchmark meeting, the selected VBGF and LW relationship parameters were used to estimate a range of natural mortality (M) vectors using different models and empirical formulas, and their mean was used as final M vector. The combined M vector used for the assessment is shown in Table 6.9.1.4.

Table 6.9.1.4. European hake in GSAs 8, 9, 10 & 11. Natural mortality vector combined by sex used in the assessment.

Age	0	1	2	3	4	5	6	7+
M	1.85	0.80	0.48	0.37	0.30	0.27	0.24	0.22

6.9.2 DATA

6.9.2.1 CATCH (LANDINGS AND DISCARDS)

European hake is one of the main target species in terms of landings, incomes and vessel involved in the area. In GSAs 9 and 10, it is mainly exploited by trawlers on the shelf and slope, but also by small-scale fisheries using set nets (gillnets and trammel nets) and bottom long-lines. In GSA 11, although hake is not target of a specific fishery, it is one of the most important species in terms of biomass landed. It is caught exclusively by a mixed bottom trawl fishery that operates at depth between 50 and 800 m. No gillnet or longline fleets target this species, but it can be find as by catch of gillnet fleets targeting other species. In Corsica (GSA 8), six trawlers are active and their average length is 15 m, these ships operate with bottom trawls with panels (OTB) and are targeting demersal species (Norway lobster, striped red mullet, deep-water rose shrimp, etc.) including some very few catches of hake (average 8.2 t per year on the period 2015-2017). Even though small-scale fisheries are quite important along the coasts, fishers target other resources such as lobster, finfish living on hard bottoms. There are no available data for the size structure of the landings of hake, since it is not a target species of trawlers and it is mainly absent from other gears catches (very few catches from gillnetters). Moreover, it is important to notice that trawlers can only work on the eastern part of Corsica since the western part is characterized by a very narrow continental shelf and steep slopes.

Landings and discards

Landings data were reported to STECF EWG 20-09 through the DCF. In GSAs 9, 10 and 11, most of the landings come from otter trawls. The contribution of set nets to the total 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

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.

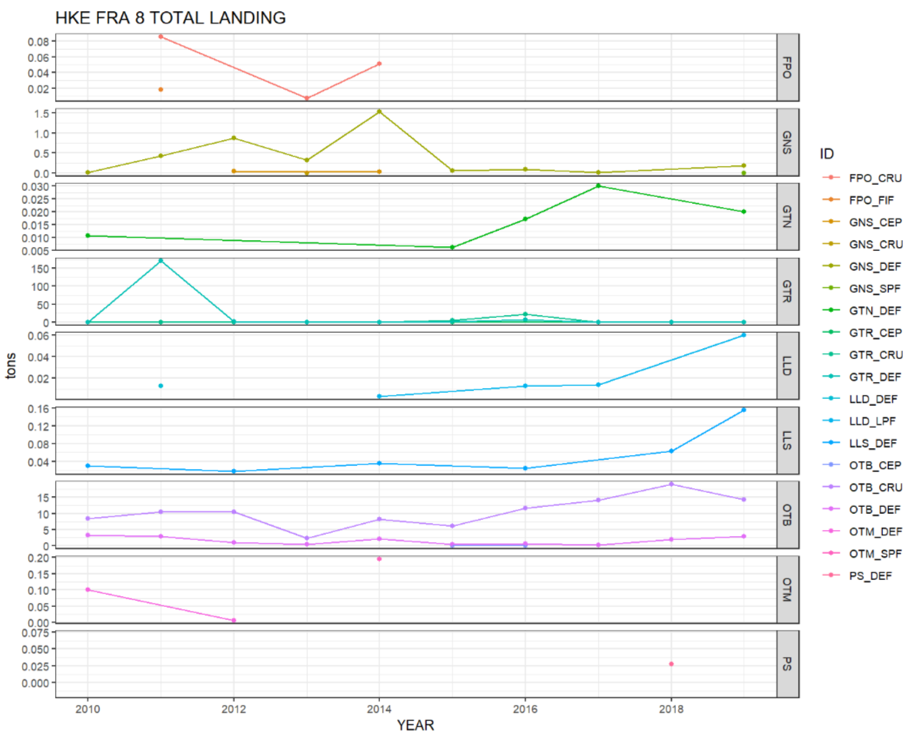


Figure 6.9.2.1.1. **European hake in GSAs 8, 9, 10 & 11.** Landings data in tons by year and fleet in GSA 8.

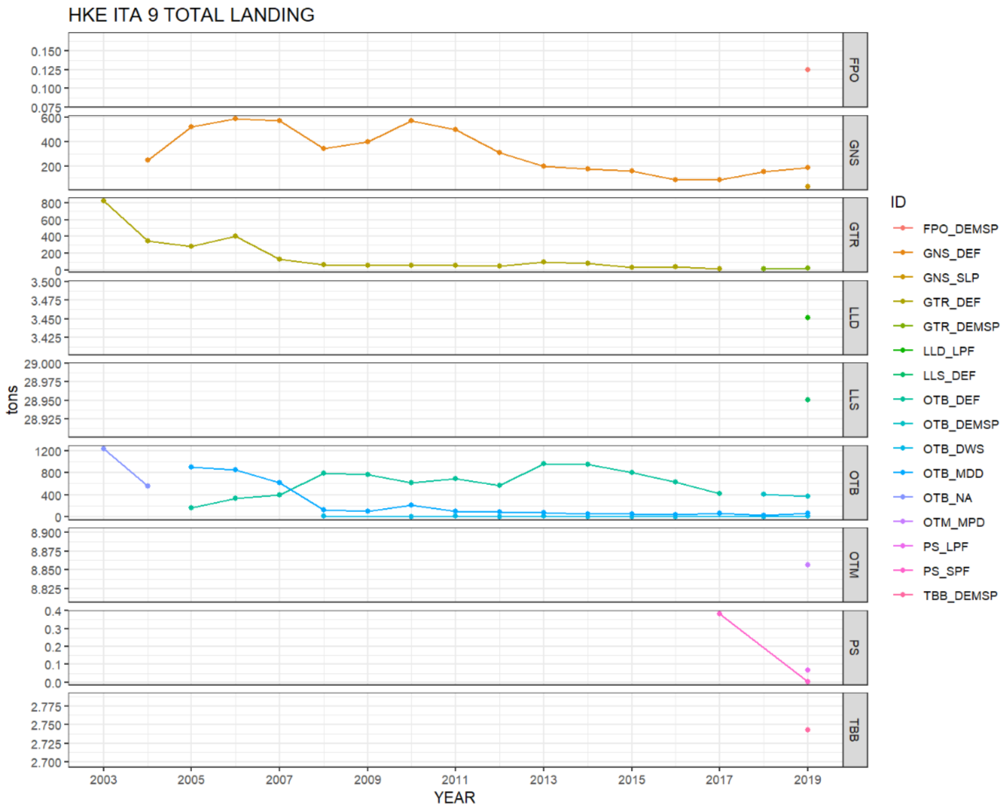


Figure 6.9.2.1.2. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 9.

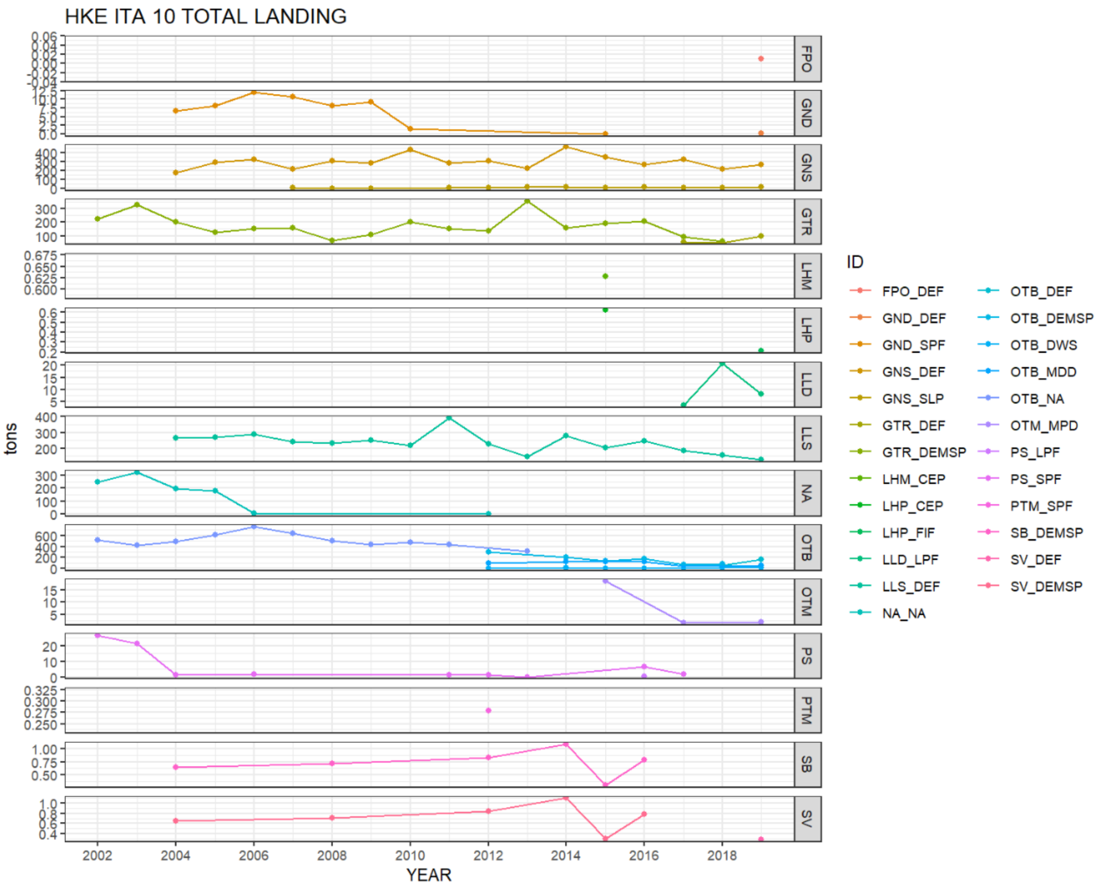


Figure 6.9.2.1.3. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 10.

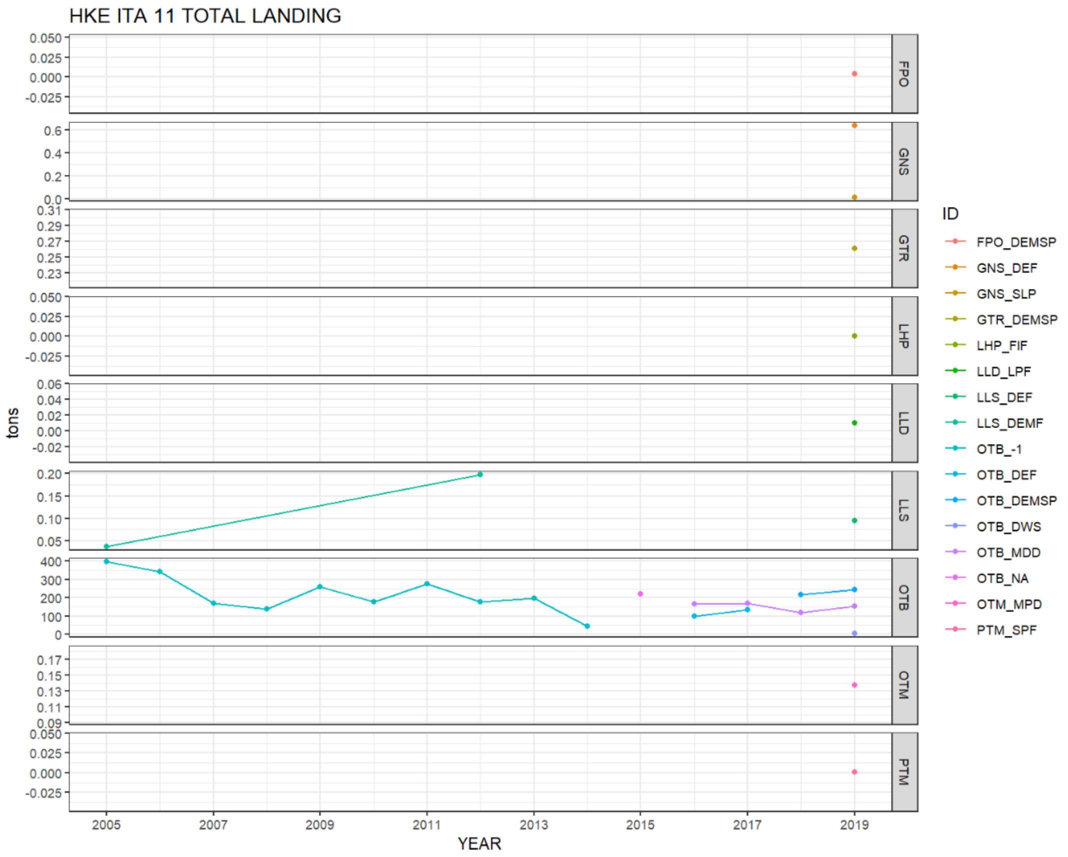


Figure 6.9.2.1.4. European hake in GSAs 8, 9, 10 & 11. Landings data in tons by year and fleet in GSA 11.

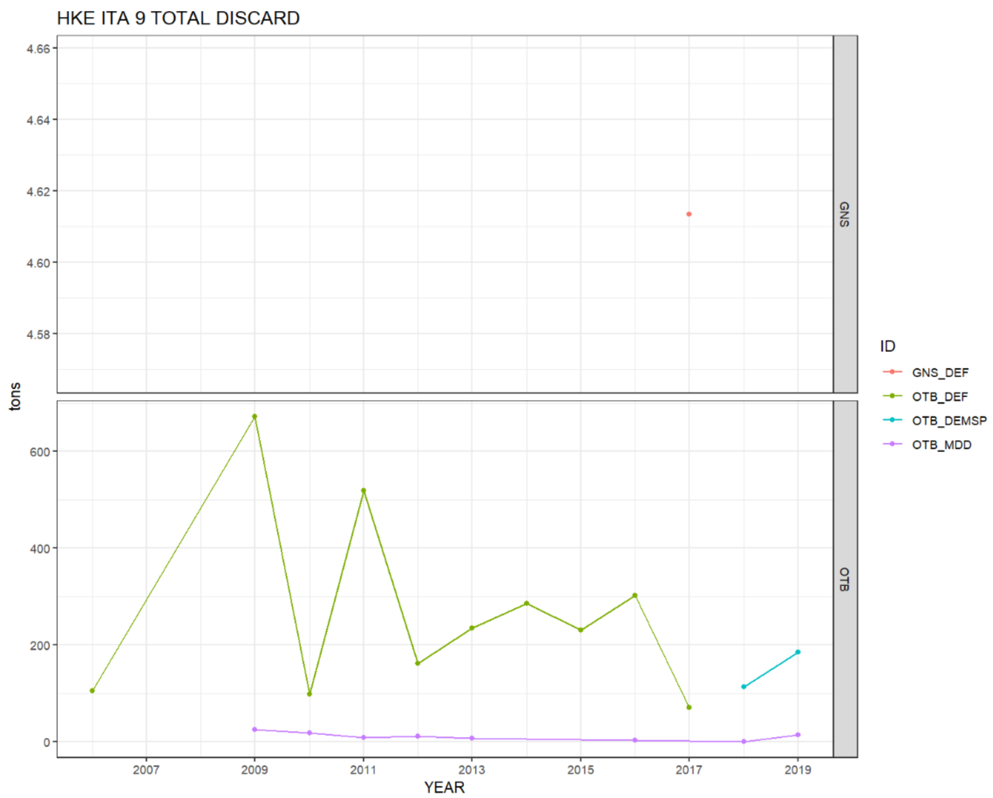


Figure 6.9.2.1.5. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 9.

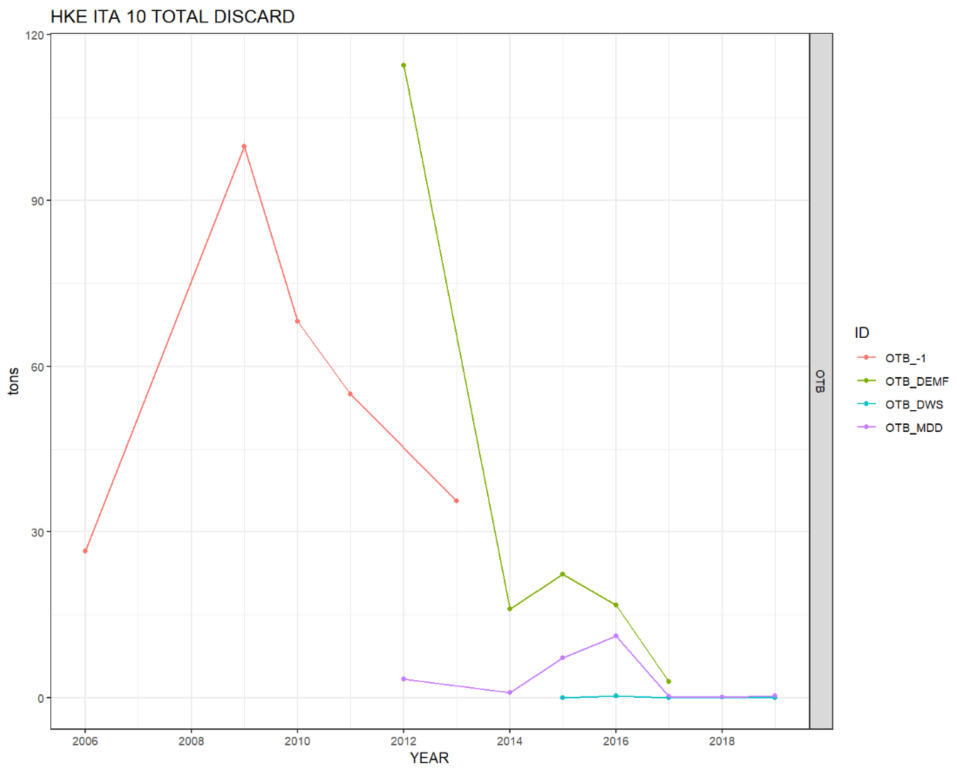


Figure 6.9.2.1.6. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 10.

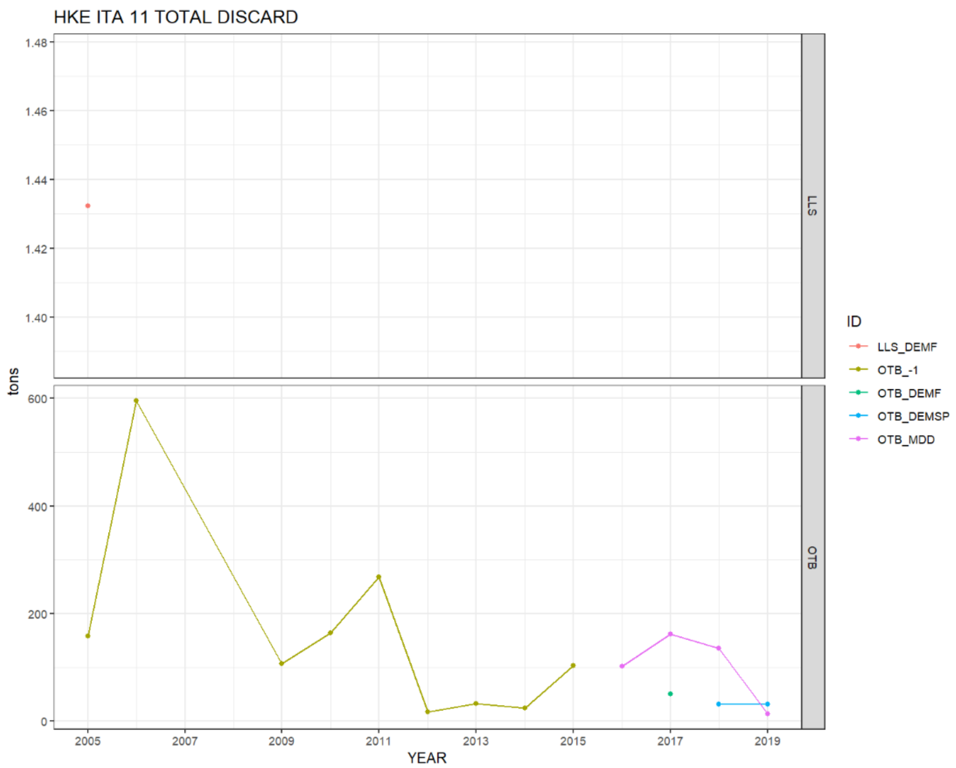


Figure 6.9.2.1.7. European hake in GSAs 8, 9, 10 & 11. Discards data in tons by year and fleet in GSA 11.

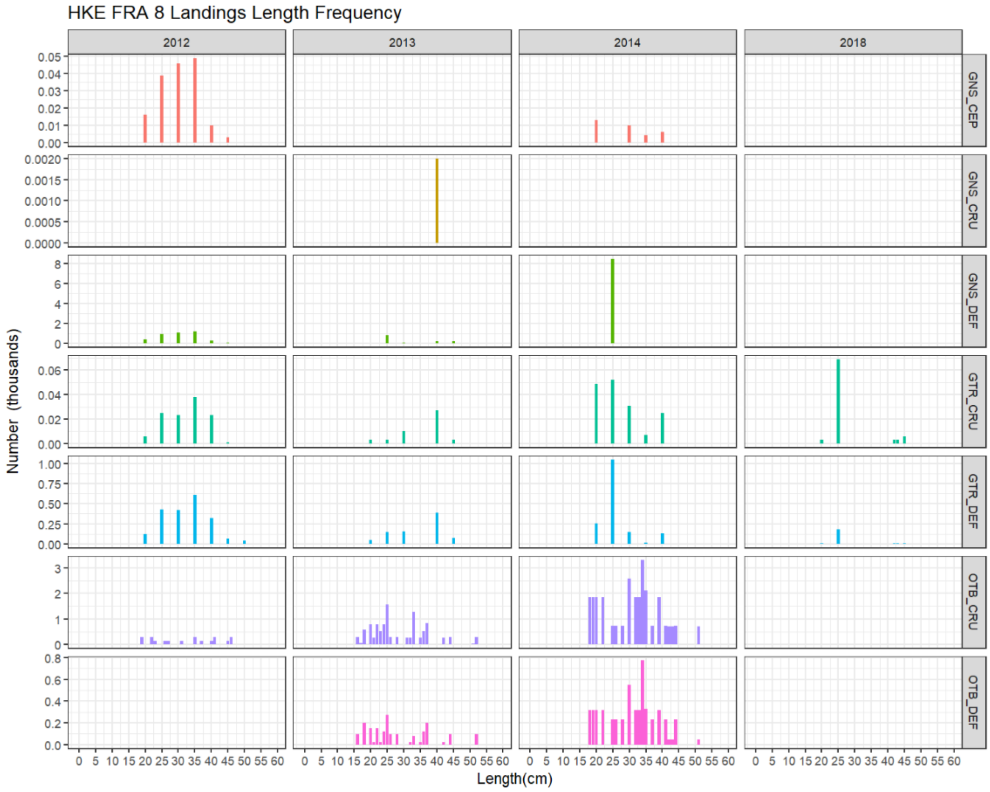


Figure 6.9.2.1.8. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 8.

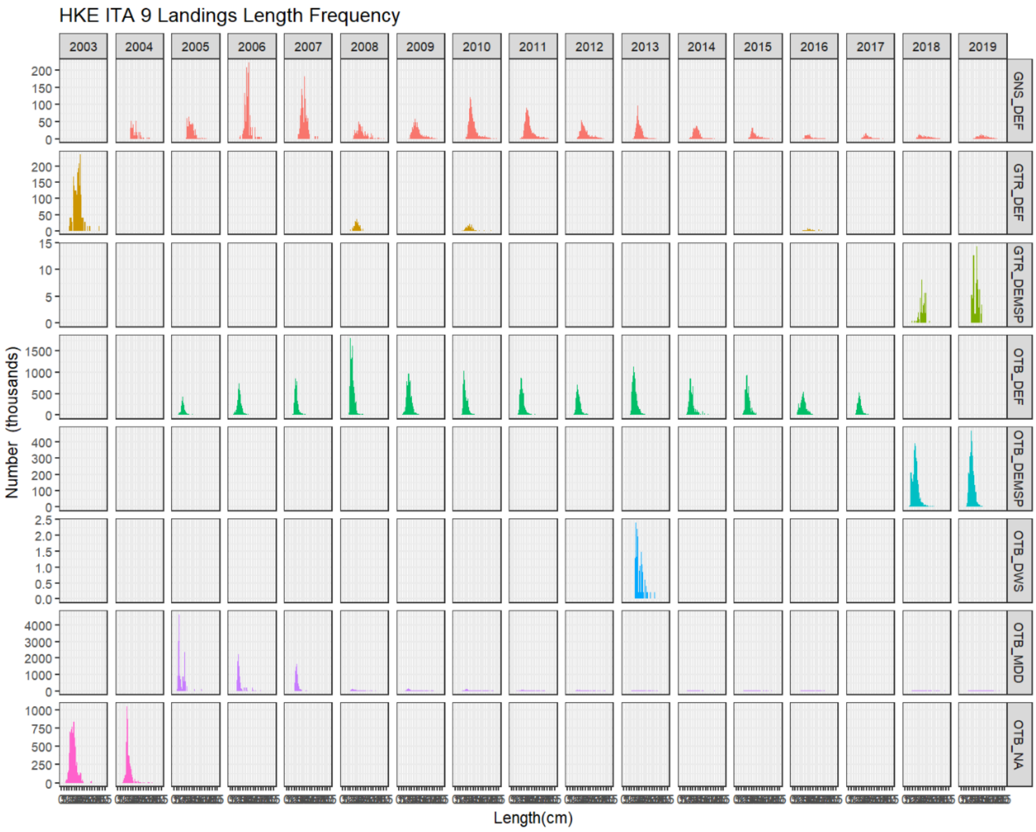


Figure 6.9.2.1.9. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 9.

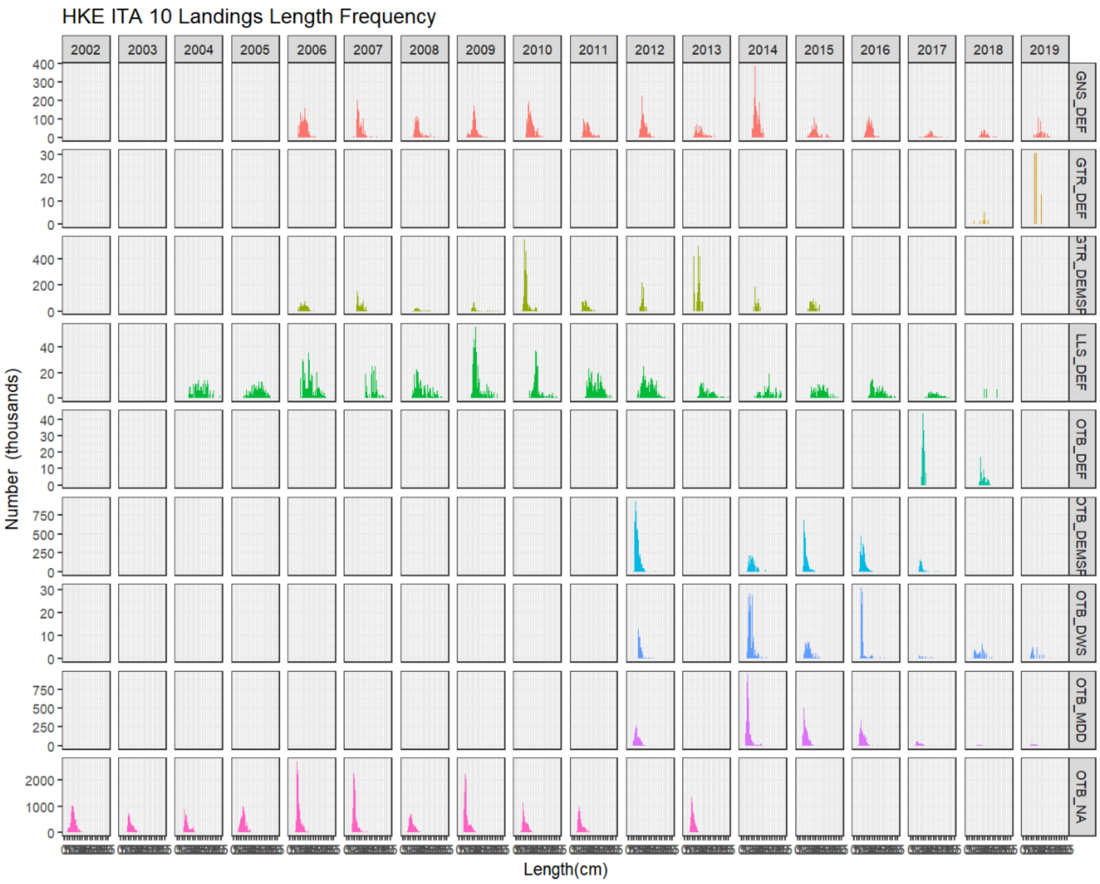


Figure 6.9.2.1.10. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 10.

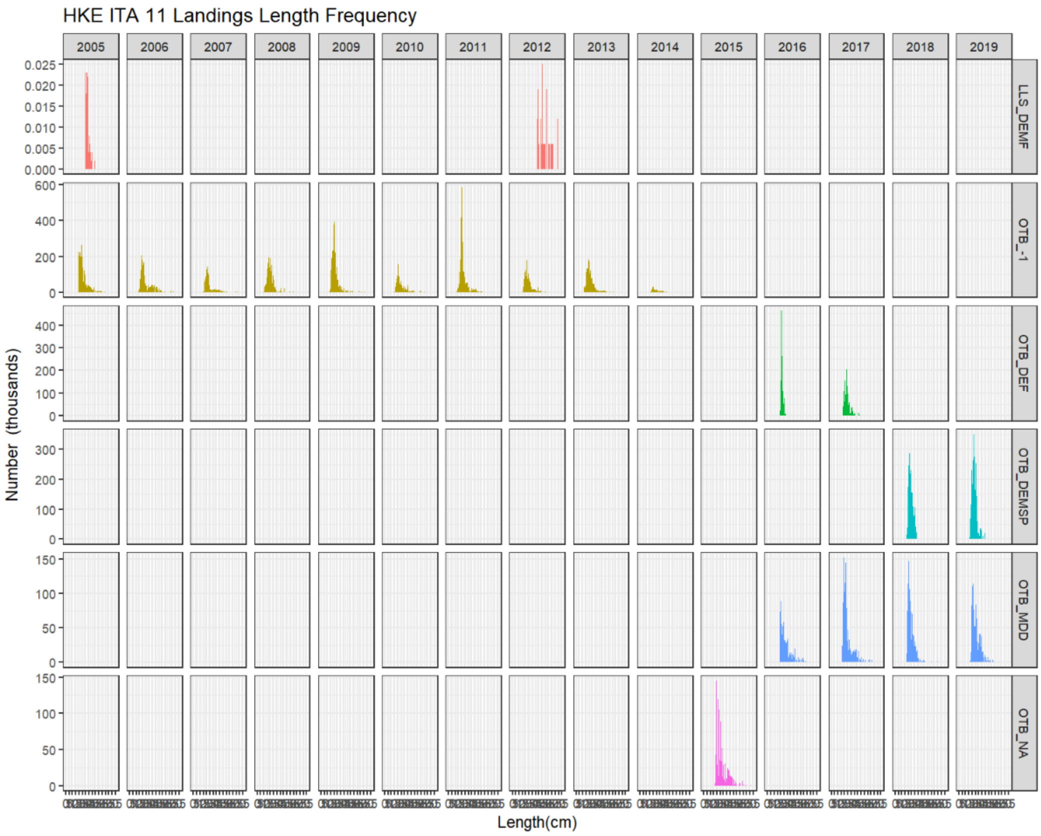


Figure 6.9.2.1.11. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the landings by year and fleet in GSA 11.

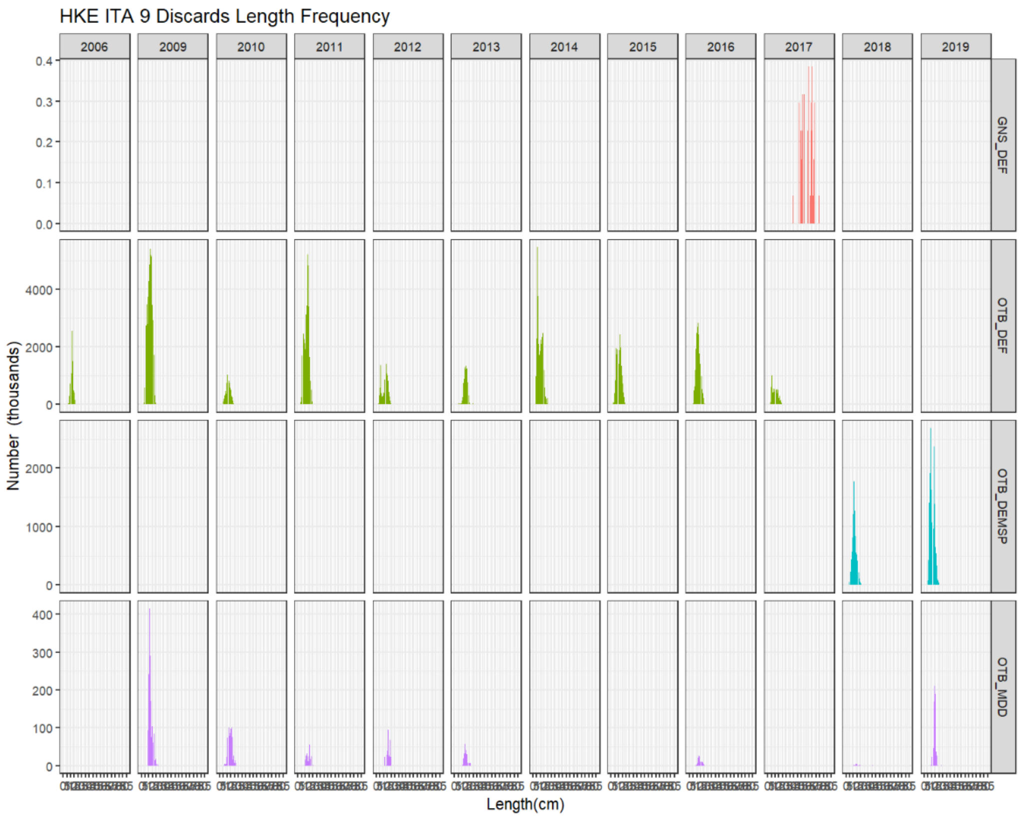


Figure 6.9.2.1.12. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 9.

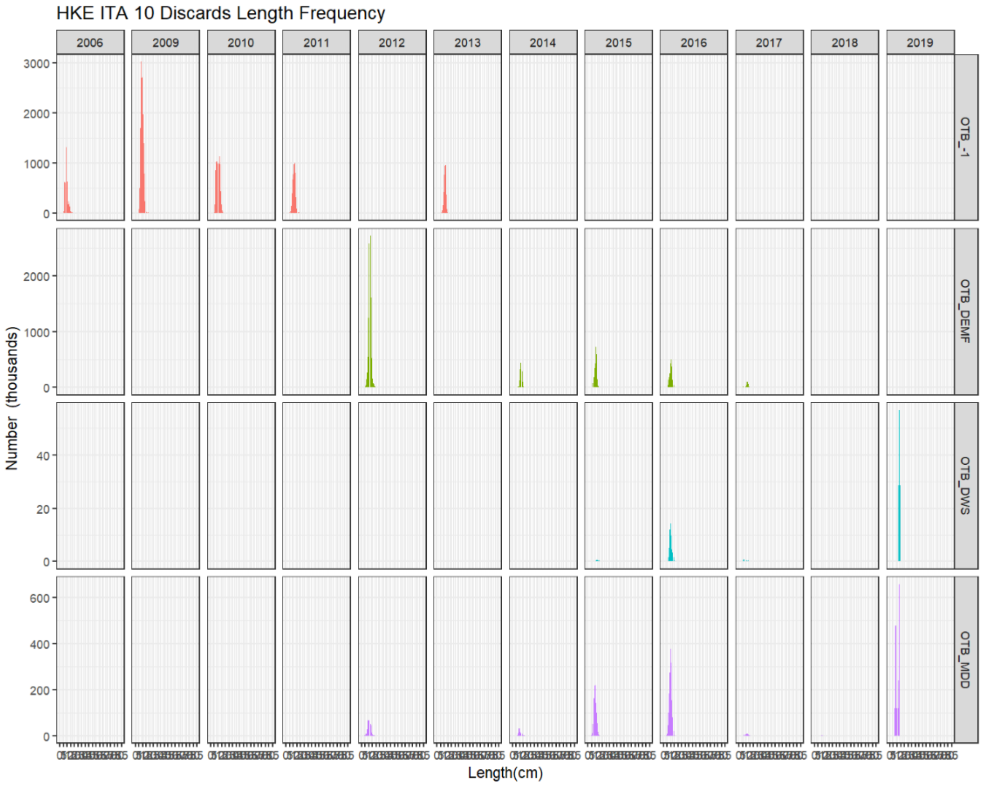


Figure 6.9.2.1.13. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 10.

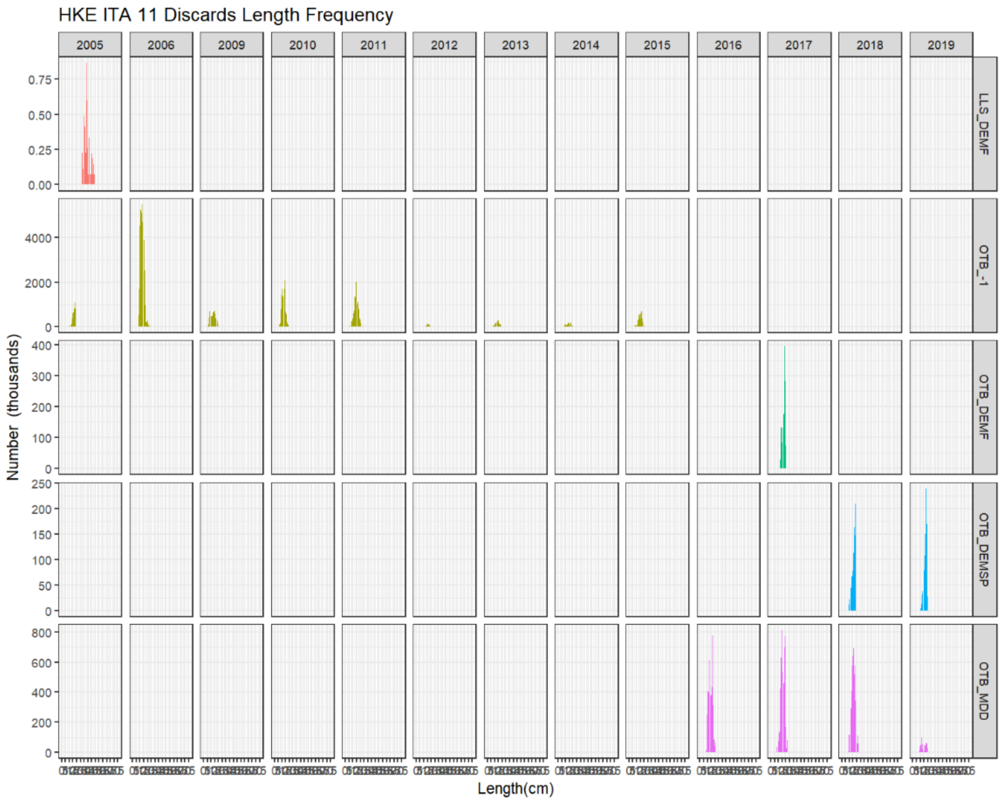


Figure 6.9.2.1.14. European hake in GSAs 8, 9, 10 & 11. Length frequency distribution of the discards by year and fleet in GSA 11.

6.9.2.2 EFFORT

Tables 6.9.2.2.1, 6.9.2.2.2 and 6.9.2.2.3 show the fishing effort by year and fishing gear in the GSAs. Fishing effort data for 2019 will be reported to STECF EWG 20-13 through the FDI data call within the DCF framework.

Table 6.9.2.2.1. European hake in GSAs 8, 9, 10 & 11. Fishing effort in GT*Days at sea by year and fishing gear.

	GSA8_OTB	GSA9_OTB	GSA10_OTB	GSA11_OTB
2004		2460274	1274428	1721988
2005		2423342	1447582	1785484
2006		2226848	1370881	1358732
2007		2167545	1354061	1414387
2008		1964931	1220374	1144879
2009		2033908	1212648	1048044
2010		1947511	981102	973315
2011		1836069	975899	946564
2012		1883367	1130432	916434
2013		1937157	1201092	695262
2014		1864327	1541221	847934
2015	39258.66	1879470	969054	760006

2016	39381.96	1810294	1149217	829858
2017	34751.51	1890758	1110902	864739
2018	42682.28	1673855	1164354	1221171

	GSA8_GNS	**GSA9_GNS**	**GSA10_GNS**	**GSA11_GNS**
2004		289033	333949	71705
2005		258808	365776	71113
2006		236405	213574	19756
2007		252525	148766	69808
2008		199972	161564	42520
2009		224601	147145	79483
2010		198827	162574	42303
2011		229583	177575	23070
2012		155716	180128	38974
2013		70203	165760	4186
2014		96211	168580	61652
2015	6647.97	115584	113065	33606
2016	4444.35	94490	148369	59837
2017	3090.24	133845	159071	47616
2018	3402.31	95419	92917	59601

	GSA8_GTR	GSA9_GTR	GSA10_GTR	GSA11_GTR
2004		215694	264201	444988
2005		192925	158576	480170
2006		204088	377004	476861
2007		150724	327315	332156
2008		119393	245158	256192
2009		144291	231476	252227
2010		158570	199821	263745
2011		185059	214740	275917
2012		147348	170235	260858
2013		242022	198539	329591
2014		216788	164897	231834
2015	46634	206746	169198	187799
2016	41796	180231	179494	134018
2017	39496	124705	202825	169094
2018	20290	120872	214251	122729

	GSA8_LLS	GSA9_LLS	GSA10_LLS	GSA11_LLS
2004		25417	204675	51966
2005		28325	130253	45612
2006		15249	128861	111680
2007		7462	96753	93618
2008		1419	116618	46656
2009		1173	81409	37037
2010		865	92870	36712
2011		1405	140482	25553
2012		1601	100958	30681
2013		752	90922	23747
2014		1043	181068	33191
2015	5302	5531	104388	23528
2016	5920	7613	103283	19117
2017	4819	15023	116162	24146
2018	8468	20718	72511	11155

Table 6.9.2.2.2. European hake in GSAs 8, 9, 10 & 11. Nominal effort by year and fishing gear.

	GSA8_OTB	GSA9_OTB	GSA10_OTB	GSA11_OTB
2002		14583556	7344089	3679604
2003		14671042	7231486	4652647
2004		14820339	8070376	7706431
2005		14700599	8029362	7324728
2006		12404787	7500584	5752588
2007		12782144	7287211	5867826
2008		11083521	7017668	4498889
2009		12190003	6921061	4390811
2010		11403131	5934581	4124461
2011		10687896	5609667	3814899
2012		9949155	6036034	3784372
2013		10725751	6162546	3138792
2014		10989815	8354825	3299652
2015	164833.65	11054468	5476707	3108641
2016	178420.81	10546689	6202964	3219773
2017	129762.89	10594055	6526582	3827523
2018	169002.84	9443736	6099176	5144513

	GSA8_GNS	GSA9_GNS	GSA10_GNS	GSA11_GNS
2002		6504000.86		
2003		6925652.52		
2004		3758570	4049992	1157504
2005		3903858	5028180	1027658
2006		3261681	2954204	213439
2007		3761065	2154086	778308
2008		3230378.68	2281588	598769.11
2009		3430239.62	2219243	1128743.22
2010		2802601.42	2338061	643765.97
2011		3989327.13	2458316	380478.36
2012		2220597.49	2669037	587788.31
2013		1233183.72	2129107	16648.8
2014		1624649.64	2476131	1088483.3
2015	188871.14	1946625.68	1511278	481406.65
2016	129188.96	1668387.23	1980063	890097.26
2017	99888.35	2150649.2	2219366	671953.95
2018	122126.24	1532938.43	1189583	880222.89

	GSA8_GTR	GSA9_GTR	GSA10_GTR	GSA11_GTR
2002		4715565.4	6440217.1	2865738.14
2003		4051809.37	7222145.47	5099813.65
2004		3279499	3310756	6546696
2005		3814735	1740353	7186648
2006		3861839	4295352	7221990
2007		2761471	3857329	4932513
2008		2269792.79	3281680.26	3389122.66
2009		2727586.56	3158347.29	3637169.57
2010		2846969.68	2812729.11	3982661.69
2011		3079067.67	2859416.24	4323701.15
2012		2601426.57	2447668.61	3617347.75
2013		3794136.99	2592045.18	4830964.17
2014		3261275.64	2372825.58	4203615.81
2015	1268070.47	3597446.46	2285913.64	2907172.97
2016	1202048.53	3241336.12	2295862.06	2020539.87
2017	1107766.43	1799467.05	3016437.59	2423966.99
2018	622781.34	1900921.94	2795655.64	1810373

		GSA9_LLS	GSA10_LLS	GSA11_LLS
2002				
2003				
2004		424132	4563626	1048740
2005		495263	1812527	941723
2006		383146	1436447	1330567
2007		118928	1204444	1139974
2008		32326.07	1156974.31	578172.9
2009		24774.9	817432.19	526344.63
2010		16309.78	950426.74	522301.15
2011		22536.83	1418805.16	348258.81
2012		22475.79	1048394.52	421968.22
2013		8039.04	1057702.49	323497.38
2014		15438.92	2133000.15	511231.25
2015	136019.13	78693.28	1291327.08	363011.67
2016	173367.75	98224.17	1287431.84	296066.97
2017	132812.73	230496.05	1516092.62	335202.07
2018	137527.99	313448.6	843182.28	151553.2

Table 6.9.2.2.3. European hake in GSAs 8, 9, 10 & 11. Days at sea by year and fishing gear.

		GSA9_OTB	GSA10_OTB	GSA11_OTB
2002		62616	37949	14539
2003		63331	38134	18957
2004		67828	32555	24827
2005		67714	50056	28645
2006		62517	38364	22836
2007		64161	38151	22321
2008		49759	38109	19435
2009		53330	36749	20128
2010		52606	31741	19321
2011		50737	33256	17018
2012		47851	31223	15472
2013		51715	38270	15872
2014		51286	42227	17583
2015	678	52900	30709	15278
2016	727	51257	35479	16926
2017	523	47457	36271	16285
2018	657	44296	33570	21190

	GSA8_GNS	GSA9_GNS	GSA10_GNS	GSA11_GNS
2002		212455		
2003		182159		
2004		82163	81333	29164
2005		83555	107011	20713
2006		81689	77224	7357
2007		99988	57771	25301
2008		64755	61523	13594
2009		74733	57400	29522
2010		58778	56551	19058
2011		77407	63445	9951
2012		50561	76737	17886
2013		35473	63474	3557
2014		30015	67356	22603
2015	1724	43630	49189	19003
2016	1184	37026	58865	25768
2017	960	41019	53789	15862
2018	1173	34219	40737	31629

	GSA8_GTR	GSA9_GTR	GSA10_GTR	GSA11_GTR
2002		52193	357895	102826
2003		75479	311474	126272
2004		74235	113960	125543
2005		65818	67479	121154
2006		65938	134378	122557
2007		42745	140726	78574
2008		37908	106999	63037
2009		48728	107162	79095
2010		49087	84401	82093
2011		63910	103149	86447
2012		57420	79955	70952
2013		74997	82305	99206
2014		80963	81966	70957
2015	11901	86418	106350	58899
2016	10931	74174	99466	51698
2017	10095	59024	103390	56620
2018	5722	62728	129714	38286

	GSA8_LLS	GSA9_LLS	GSA10_LLS	GSA11_LLS
2002				
2003				
2004		7825	65168	13151
2005		7844	36921	9665
2006		4841	32632	14491
2007		4419	32737	18457
2008		819	31701	9136
2009		583	31460	9602
2010		660	24833	14178
2011		706	37811	10579
2012		926	32786	6496
2013		100	22794	6143
2014		782	40640	6422
2015	1141	2269	28118	5049
2016	1395	1768	29336	3318
2017	1116	3288	25357	6362
2018	1067	4381	18912	2270

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.
The combined MEDITS indexes were calculated using the script provided by JRC (Figures 6.9.2.3.1 and 6.9.2.3.2).

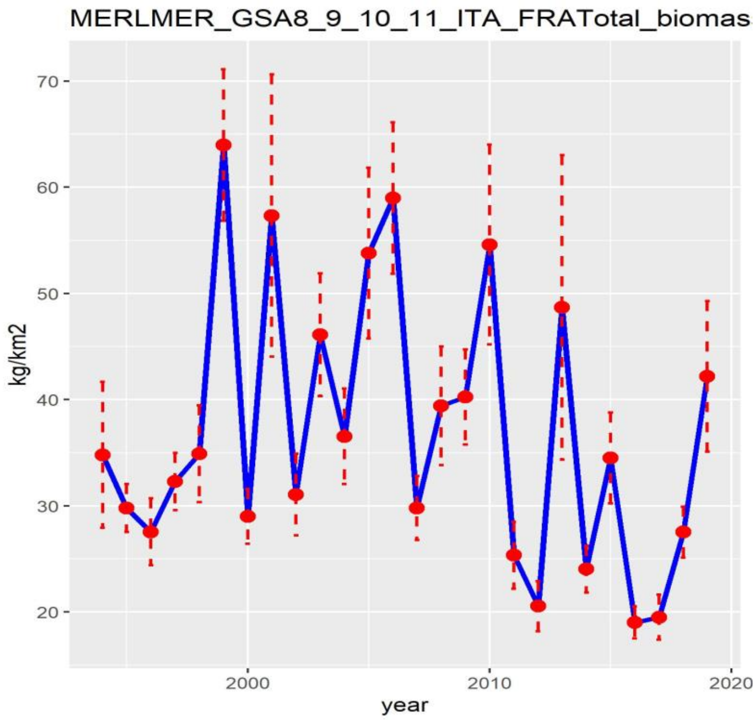


Figure 6.9.2.3.1. European hake in GSAs 8, 9, 10 & 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

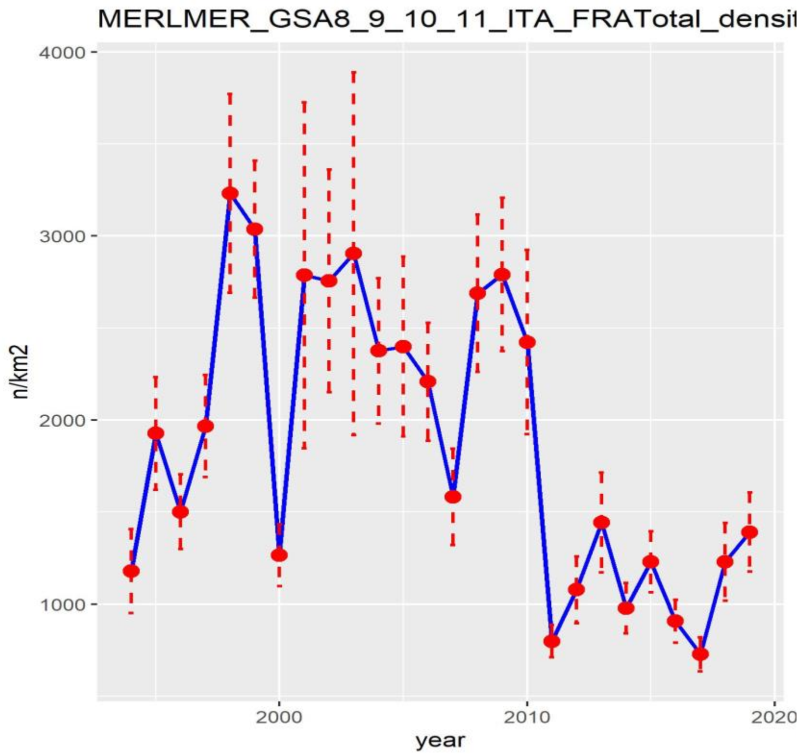


Figure 6.9.2.3.2. European hake in GSAs 8, 9, 10 & 11. Estimated density indices from the MEDITS survey (n/km^2).

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, even if a slight increase can be seen in the last two years.
Size structure indices are shown in Figure 6.9.2.3.3.

Figure 6.9.2.3.3. 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 2005-2018 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 yea (see below)r.

SOP landings

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GSA9	1.04	1.72	1.55	1.34	1.19	1.10	1.14	1.08	1.13	1.15	1.19	1.16	1.08	1.04	1.20	1.01	1.17

GSA10	2.67	1.83	1.73	1.02	1.03	1.04	0.97	1.03	1.08	0.99	1.00	0.95	1.02	1.27	1.97	3.96	3.24
GSA11	1.01	0.95	1.07	1.07	1.07	1.06	1.05	1.06	1.06	1.06	1.07	1.07	1.09	1.36	1.24	1.24	1.14

SOP Discards

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GSA9	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.18	1.19	1.17	1.16	1.20	1.18	1.18	1.17	1.08	1.13
GSA10	0.56	0.56	0.56	0.56	0.56	0.54	0.54	0.54	0.57	0.56	0.54	0.55	0.55	0.53	0.43	3.05	0.02
GSA11			1.00	0.70	0.70	0.78	0.78	0.64	0.87	0.97	0.78	0.83	0.87	0.85	0.96	0.93	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**
4330.7	4803.9	3701.4	3041.8	3578.5	3333.7	3772.3	2616.7	2903.5	2921	2687	2649	2105.1	2119.5	2196.9

Catch numbers at age (thousands)

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2005	63859	35900	3562	999	221	322	71	44
2006	48782	41352	5454	1694	456	133	98	39
2007	45146	31800	3614	1318	190	95	50	29
2008	38308	24278	3406	673	238	117	70	60
2009	76875	28679	4522	716	158	116	46	61
2010	26297	20570	4444	1173	262	134	53	78
2011	46661	28821	4109	1007	342	152	64	81
2012	22281	17410	4011	718	221	113	46	31
2013	12744	24925	5019	643	178	69	31	26
2014	38659	13843	4965	967	297	105	31	49
2015	28208	15940	3590	890	246	138	46	35
2016	29796	18283	3242	747	199	104	46	49
2017	8997	14391	1884	821	268	113	50	38
2018	11098	11407	3120	929	171	127	25	14
2019	17202	10848	3344	885	293	68	28	16

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

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

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

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

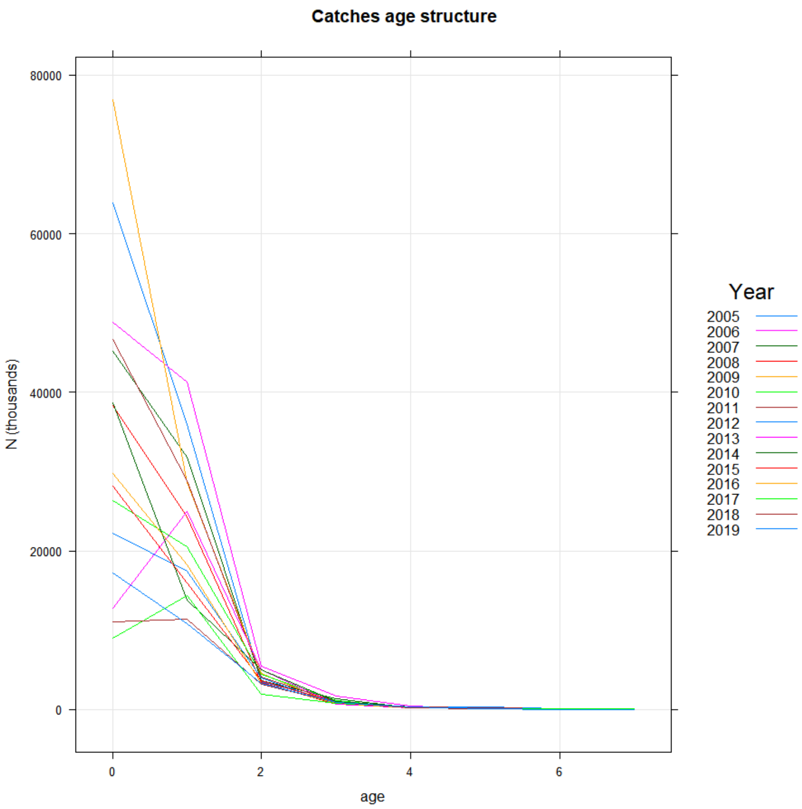


Figure 6.9.3.1. European hake in GSAs 8, 9, 10 & 11. Catch at age input data.

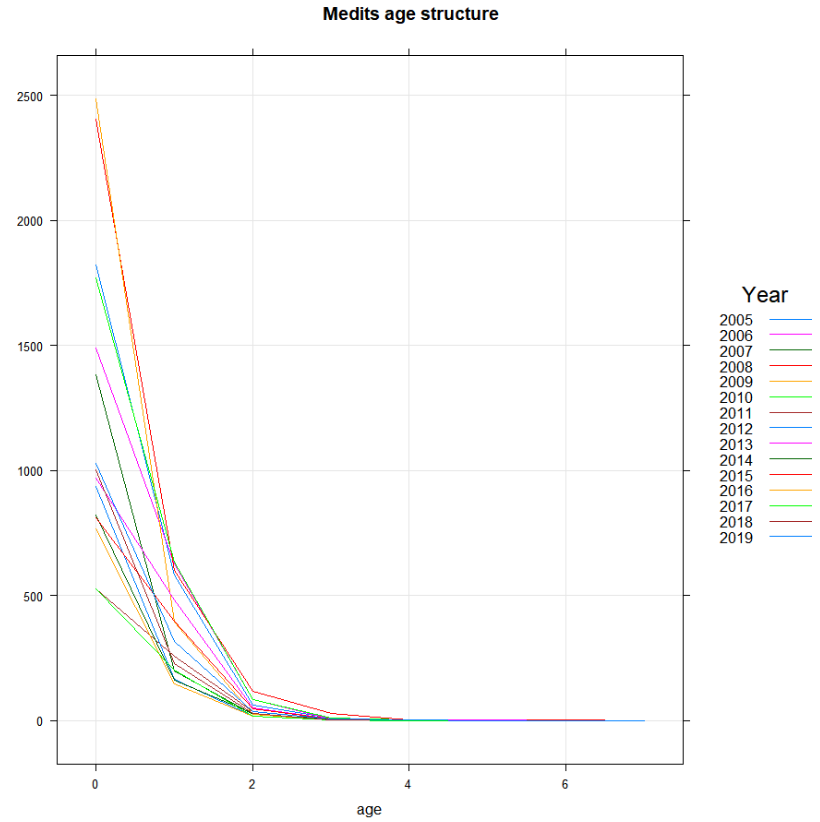


Figure 6.9.3.2. European hake in GSAs 8, 9, 10 & 11. Age structure of the index.

Assessment results

The model applied was the same as the one adopted during the benchmark meeting. 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

Different models were performed, focusing the check on the number of knots (k) of the smoother on year in the fmodel. A test based on AIC, BIC and GCV was performed on k ranging between 5 and 11. This analysis confirmed that the k value performing the best is 8, as specified in the final model selected (Figure 6.9.3.3). Nonetheless, all the model specifications highlight a consistent behavior in terms of main outcomes (Figure 6.9.3.4).

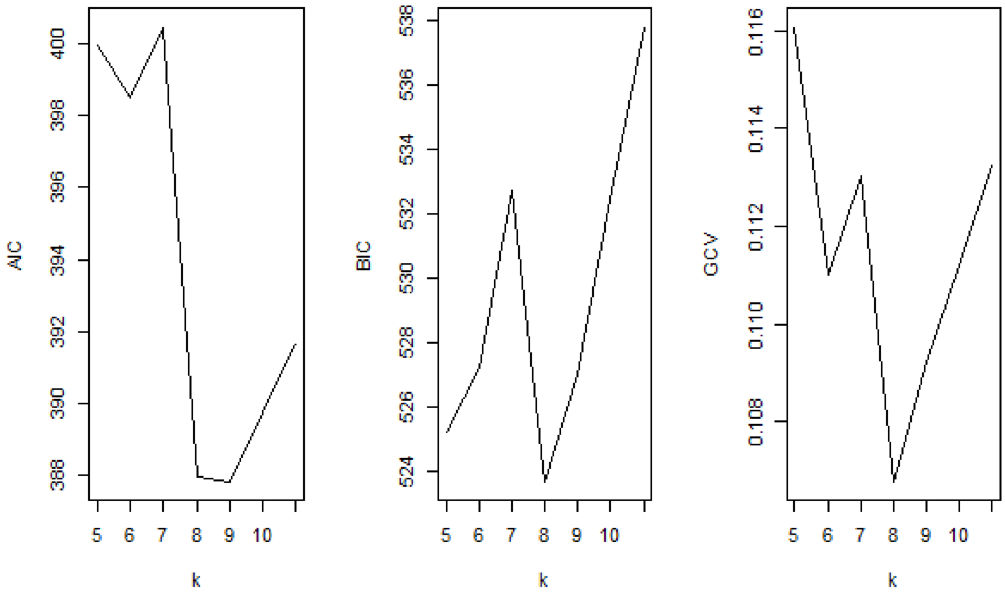


Figure 6.9.3.3 - European hake in GSAs 8, 9, 10 & 11. AIC, BIC and GCV values estimated on a range of k values of the smoother on year of the fmodel.

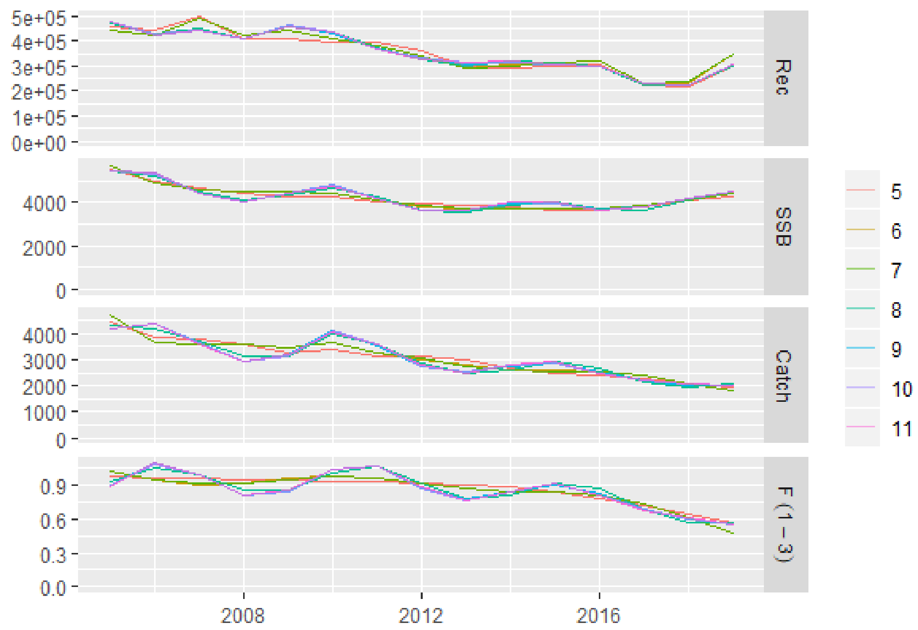


Figure 6.9.3.4. European hake in GSAs 8, 9, 10 & 11. Outputs of model runs with different k values on the smoother on year in the fmodel.

Results of the final model are shown in Figures 6.9.3.5 – 6.9.3.11.

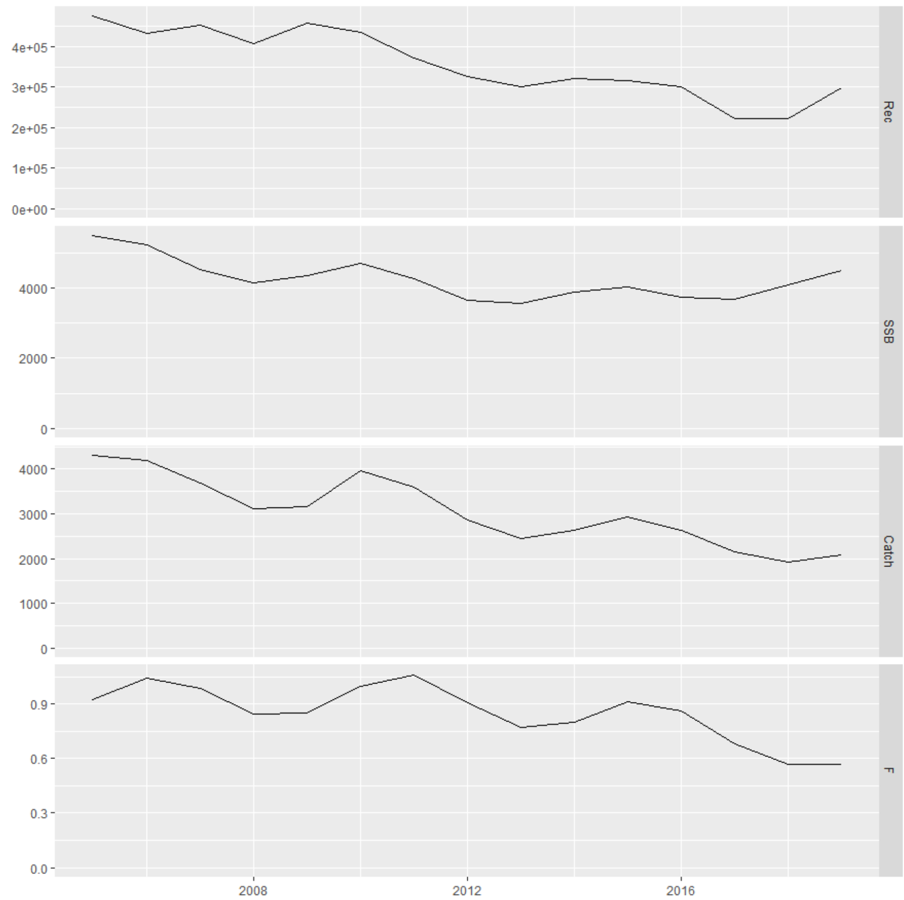


Figure 6.9.3.5. European hake in GSAs 8, 9, 10 & 11. Stock summary from the final a4a model.

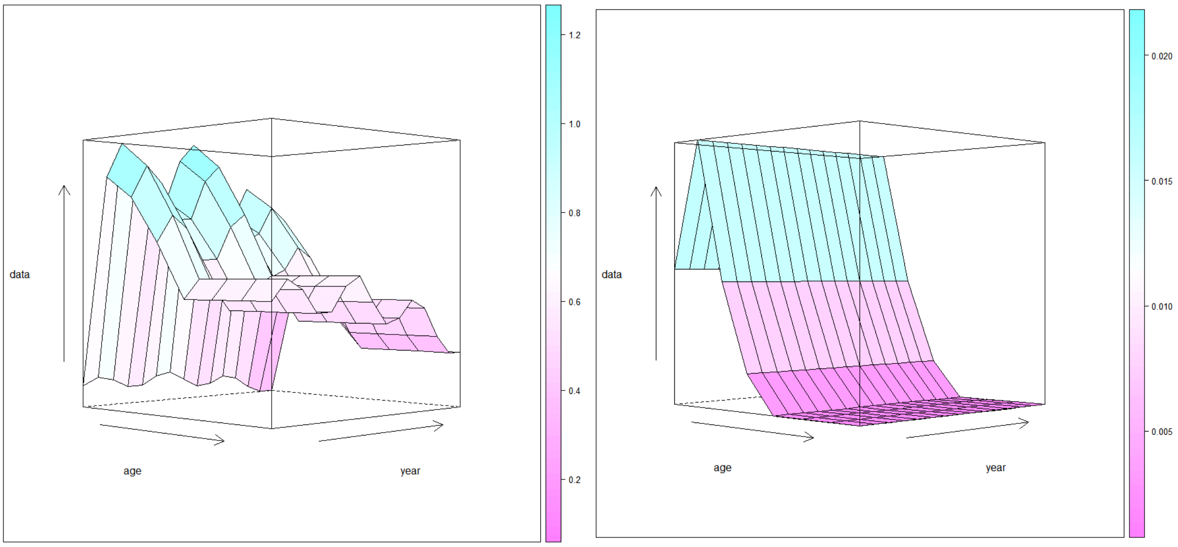


Figure 6.9.3.6. European hake in GSAs 8, 9, 10 & 11. 3D contour plot of estimated fishing mortality (left) and 3D contour plot of estimated catchability (right) at age and year.

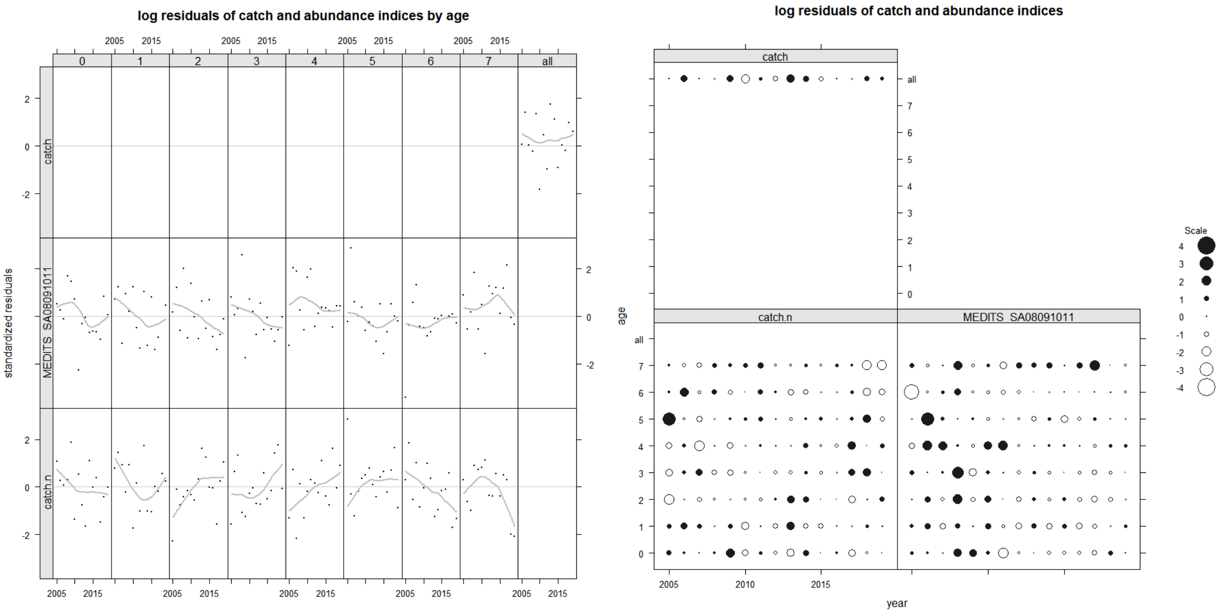


Figure 6.9.3.7. European hake in GSAs 8, 9, 10 & 11. Standardized residuals for abundance indices and for catch numbers.

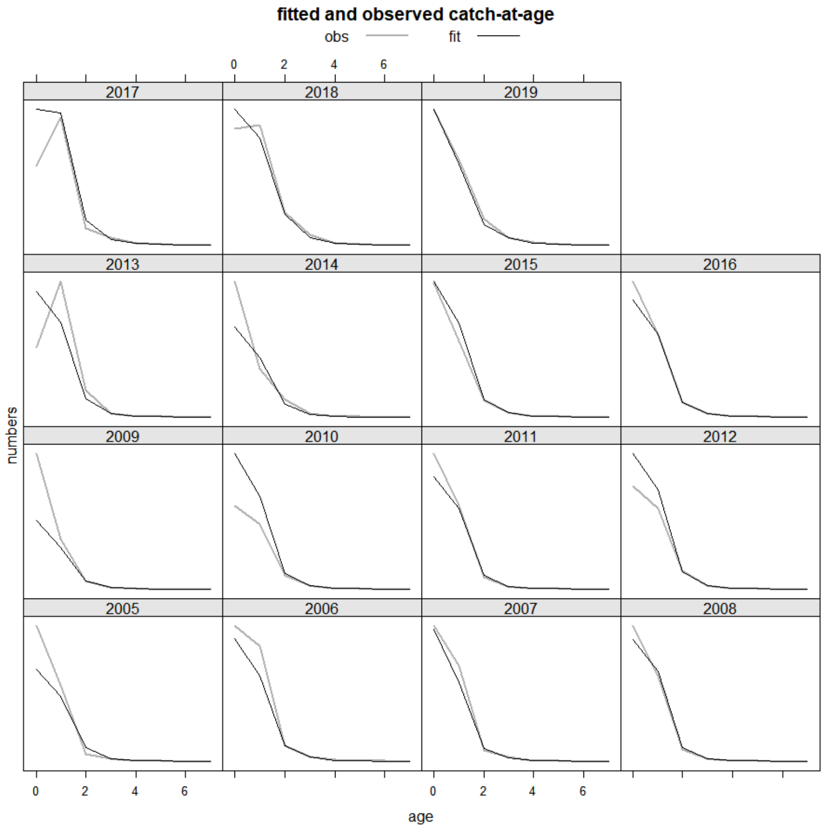


Figure 6.9.3.8. European hake in GSAs 8, 9, 10 & 11. Fitted and observed catch at age.

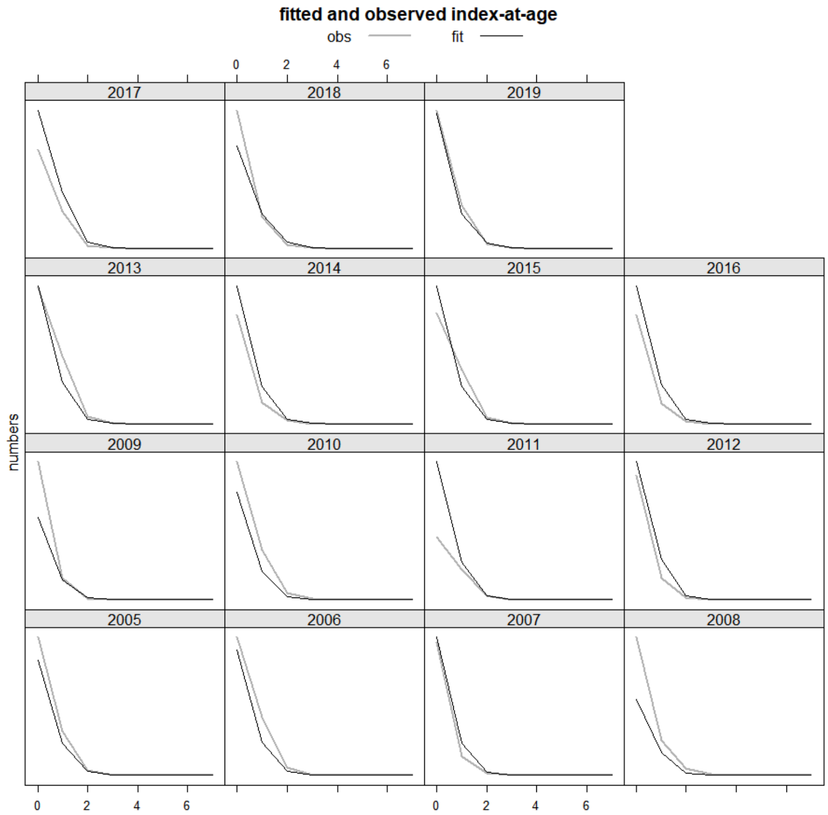


Figure 6.9.3.9. European hake in GSAs 8, 9, 10 & 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 3 years back. Models results were quite stable (Figure 6.9.3.10).

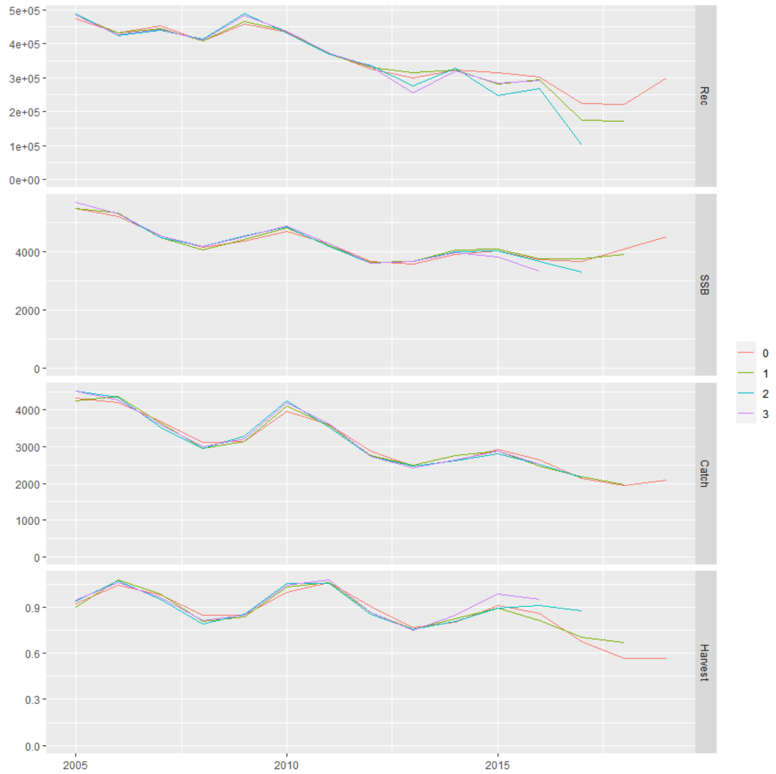


Figure 6.9.3.10. European hake in GSAs 8, 9, 10 & 11. Retrospective analysis.

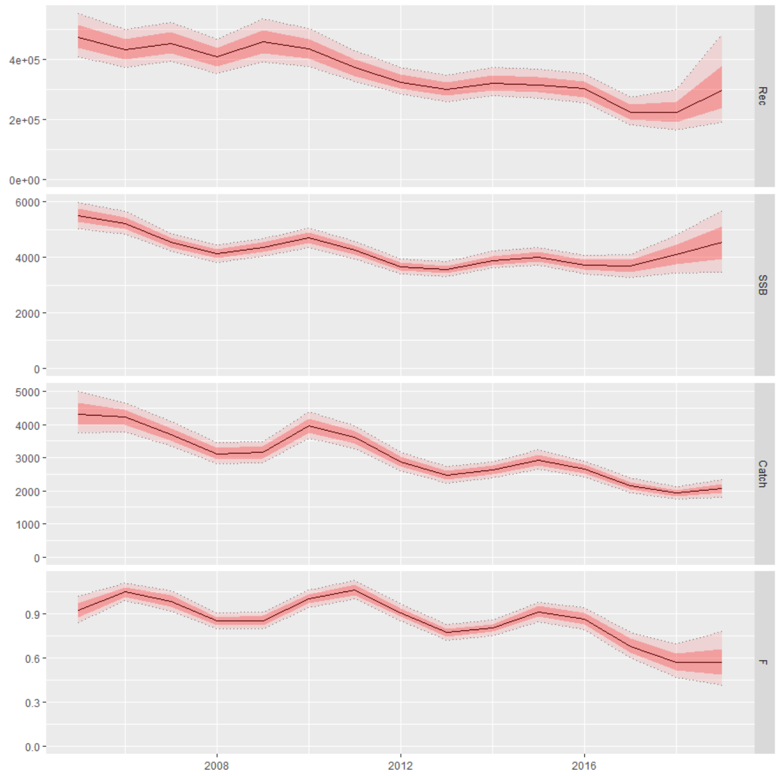


Figure 6.9.3.11. European hake in GSAs 8, 9, 10 & 11. Stock summary of the simulated and fitted data for the a4a model.

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	474690	64275	12580	2840	830	327	167	98
2006	431706	60120	10237	3003	900	348	142	119
2007	453659	53137	8351	2155	859	351	140	109
2008	407568	56637	7901	1871	649	347	146	108
2009	458148	52540	9820	2039	632	285	157	119
2010	435035	59010	9072	2524	687	277	129	130
2011	372476	54114	8621	2001	750	275	114	111
2012	325615	45673	7381	1785	564	289	109	93
2013	300182	41410	7420	1794	574	239	126	92
2014	321953	39416	7842	2077	648	265	114	108
2015	315485	41943	7188	2120	729	293	123	108
2016	300884	40072	6774	1738	679	308	128	105
2017	223545	38660	6838	1723	580	296	138	109

2018	222163	29981	8103	2101	671	283	149	129
2019	298908	30565	7102	2785	897	350	152	155

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	0.92	474690	5487	12718.8	4310.1
2006	1.04	431706	5217.9	12315.4	4202.5
2007	0.98	453659	4526.4	11385.8	3689.2
2008	0.85	407568	4134.4	10505	3110.4
2009	0.85	458148	4354	10419.3	3151.6
2010	1.00	435035	4694.7	11620	3959.8
2011	1.06	372476	4252.2	10187.1	3606.3
2012	0.91	325615	3658.4	8921	2868.9
2013	0.77	300182	3560.9	9103.6	2458.7
2014	0.80	321953	3896	8068.2	2623.9
2015	0.91	315485	4023.7	8709.2	2927.1
2016	0.86	300884	3725.5	8438.9	2643
2017	0.68	223545	3671.2	7349.6	2145.1
2018	0.57	222163	4077.8	7771.1	1929.6
2019	0.57	298908	4509.1	8624.3	2074.8

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	0.22	1.04	0.95	0.78	0.57	0.57	0.57	0.57
2006	0.24	1.17	1.08	0.88	0.64	0.64	0.64	0.64
2007	0.23	1.11	1.02	0.83	0.61	0.61	0.61	0.61
2008	0.20	0.95	0.87	0.72	0.52	0.52	0.52	0.52
2009	0.20	0.96	0.88	0.72	0.52	0.52	0.52	0.52
2010	0.23	1.12	1.03	0.84	0.62	0.62	0.62	0.62
2011	0.25	1.19	1.09	0.90	0.65	0.65	0.65	0.65
2012	0.21	1.02	0.93	0.76	0.56	0.56	0.56	0.56
2013	0.18	0.86	0.79	0.65	0.47	0.47	0.47	0.47
2014	0.19	0.90	0.83	0.68	0.49	0.49	0.49	0.49
2015	0.21	1.02	0.94	0.77	0.56	0.56	0.56	0.56
2016	0.20	0.97	0.89	0.73	0.53	0.53	0.53	0.53
2017	0.16	0.76	0.70	0.57	0.42	0.42	0.42	0.42
2018	0.13	0.64	0.59	0.48	0.35	0.35	0.35	0.35
2019	0.13	0.64	0.58	0.48	0.35	0.35	0.35	0.35

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 5487 tons in 2005 to a minimum of 3561 tons in 2013, with a slightly increasing trend in the last six years. The assessment shows a decreasing trend in the number of recruits in the time series. The recruitment (age 0) reached a minimum of 222163 thousands individuals in 2018, followed by a slight increase up to 298908 thousands individuals in 2019. F_{bar} (1-3) shows a fluctuating pattern with a slightly decreasing trend in the time series, with the lowest value of 0.57 reached in 2018 and 2019. The retrospecive performance is moderate, but shows that the F is high, well above F_{MSY} over the whole time series.

6.9.4 REFERENCE POINTS

The time series is too short to give stock recruitment rationship, so reference points are based on equilibrium methods. The STECF EWG 20-09 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.
Current F (0.57, estimated as the F_{bar1-3} in the last year of the time series, 2018) 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 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 has been used for weight at age and maturity at age, while F_{bar}=0.57 (last year's F estimated by the assessment model) was used for F in 2020, as F shows a declining trend (see section 4.3). Recruitment shows a declining pattern over the period of the assessment with an increase in the last years, so it has been estimated from the population results as the geometric mean of the whole time series years (356134.6 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		mean weights at age, maturation at age, natural mortality at age and selection at age, are based average of years 2017-2019
$F_{ages\ 1-3}$ (2020)	0.57	The F estimated in 2019 was used to give F status quo for 2020
SSB (2020)	5050.29	Stock assessment 1 January 2020
R_{age0} (2020,2021)	356134.6	Geometric mean of the time series
Total catch (2020)	2384	Assuming F status quo for 2020

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 2020	Fsq 2020	Catch 2019	Catch 2021	SSB 2020	SSB 2022	SSB 2020-2022(%)	Catch 2019-2021(%)
F0.1	0.29	0.17	356134.56	0.57	2074.83	953.6	5050.29	9418.3	86.49	-54.04
F upper	0.41	0.23	356134.56	0.57	2074.83	1297.4	5050.29	8894.56	76.12	-37.47
F lower	0.2	0.11	356134.56	0.57	2074.83	660.39	5050.29	9869.11	95.42	-68.17
FMSY transition	0.76	0.43	356134.56	0.57	2074.83	2234.25	5050.29	7496.51	48.44	7.68
Zero catch	0	0	356134.56	0.57	2074.83	0	5050.29	10897.4	115.78	-100
Status quo	1	0.57	356134.56	0.57	2074.83	2781.65	5050.29	6701.86	32.7	34.07
Different Scenarios	0.1	0.06	356134.56	0.57	2074.83	337.84	5050.29	10369.2	105.32	-83.72
	0.2	0.11	356134.56	0.57	2074.83	660.57	5050.29	9868.84	95.41	-68.16
	0.3	0.17	356134.56	0.57	2074.83	968.94	5050.29	9394.83	86.03	-53.3
	0.4	0.23	356134.56	0.57	2074.83	1263.67	5050.29	8945.7	77.13	-39.1
	0.5	0.28	356134.56	0.57	2074.83	1545.46	5050.29	8520.07	68.7	-25.51
	0.6	0.34	356134.56	0.57	2074.83	1814.95	5050.29	8116.67	60.72	-12.53
	0.7	0.4	356134.56	0.57	2074.83	2072.75	5050.29	7734.26	53.14	-0.1
	0.8	0.45	356134.56	0.57	2074.83	2319.43	5050.29	7371.71	45.97	11.79
	0.9	0.51	356134.56	0.57	2074.83	2555.56	5050.29	7027.92	39.16	23.17
	1.1	0.62	356134.56	0.57	2074.83	2998.18	5050.29	6392.59	26.58	44.5
	1.2	0.68	356134.56	0.57	2074.83	3205.64	5050.29	6099.18	20.77	54.5
	1.3	0.74	356134.56	0.57	2074.83	3404.47	5050.29	5820.77	15.26	64.08
	1.4	0.79	356134.56	0.57	2074.83	3595.07	5050.29	5556.55	10.02	73.27
	1.5	0.85	356134.56	0.57	2074.83	3777.85	5050.29	5305.75	5.06	82.08
	1.6	0.91	356134.56	0.57	2074.83	3953.19	5050.29	5067.66	0.34	90.53
	1.7	0.96	356134.56	0.57	2074.83	4121.45	5050.29	4841.58	-4.13	98.64
	1.8	1.02	356134.56	0.57	2074.83	4282.95	5050.29	4626.87	-8.38	106.42
	1.9	1.08	356134.56	0.57	2074.83	4438.03	5050.29	4422.92	-12.42	113.9
	2	1.13	356134.56	0.57	2074.83	4586.99	5050.29	4229.16	-16.26	121.08

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.

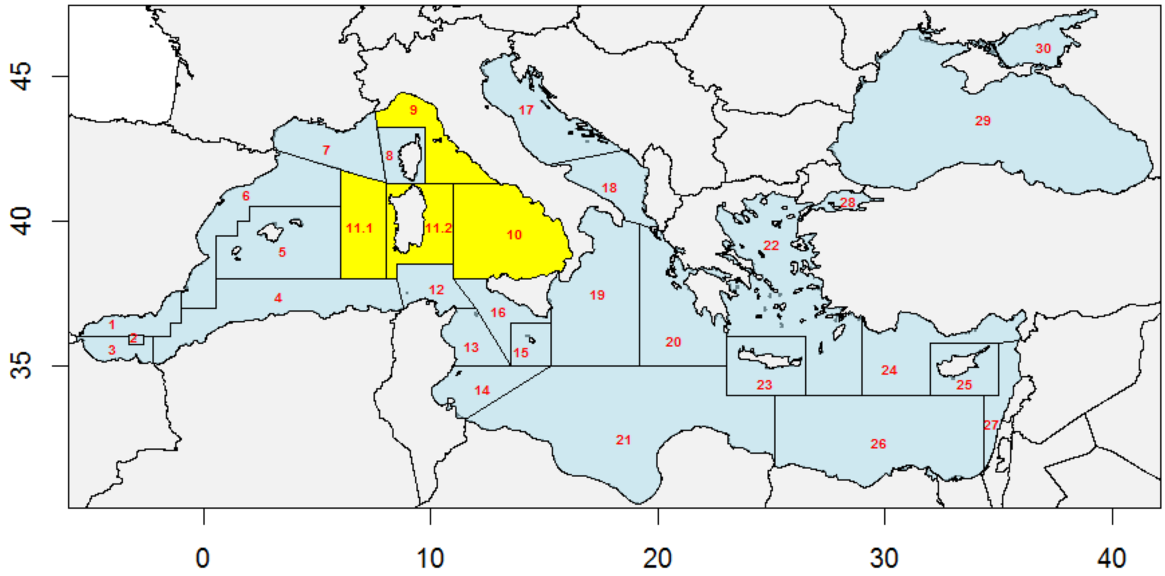


Figure 6.10.1.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Geographical location of the GSAs.

The Deep-water rose shrimp is an epibenthic species and inhabits the muddy or sandy- muddy bottoms of the continental shelf. A gradient of size increasing with depth has been observed in the area, being the smallest specimens fished more frequently in the upper part of the continental shelf (100-200 m), while the largest ones are mainly distributed along the slope at depths greater than 200 m (Ardizzone *et al*., 1990; Spedicato *et al*., 1996).

In GSA09, the species shows a wide bathymetric distribution, being present from 50 to 650 m depth with greatest abundance between 150 and 400 m depth over muddy or sandy-muddy bottoms (Ardizzone and Corsi, 1997; Biagi *et al*., 2002). The highest abundances have been found in the Tyrrhenian part of the GSA (south Tuscany and Latium). In GSA10, aggregations with higher abundance were localised between 100 and 200 m depth, with some intrusions in the deeper waters in three sub-areas. Two most important patches were located in the Gulf of Naples and along the Calabrian coasts in correspondence with Cape Bonifati, while a third one in the Gulf of Salerno (Lembo *et al*., 1999). These are the areas where also the main nurseries are localised.

The Deep-water rose shrimp with hake and red mullet is a key species of fishing assemblages in the area. In the last decade it was generally also ranked among the species with higher abundance indices (number of individuals) in the trawl surveys as observed for different Mediterranean areas (Abelló *et al*., 2002). The species is caught on the same fishing grounds as European hake and the production of this shrimp is steadily growing in the last decade in the southern basin and it reached in 2006 about 10% of the demersal landings. The core of nursery areas in GSA09 overlap with crinoid beds (*Leptometra phalangium*) areas over the shelf-break (Colloca *et al*., 2004, 2006a; Reale *et al*., 2005). This is a peculiar habitat in the GSA09, which is also an essential fish habitat for other commercially important species as the European hake, *Merluccius merluccius*.

Growth

The structure of the sizes of *P. longirostris* is characterised by differences in growth between the sexes, the larger individuals being females. The Deep-water rose shrimp is a short-living crustacean with a life span of about 4 years (Carbonara *et al*., 1998).

The growth of *P. longirostris* has been studied in the southern part of the GSA09 (central Tyrrhenian Sea) using modal progression analysis (Ardizzone *et al*., 1990). The following sets of Von Bertalanffy growth parameters were estimated: Females: L∞ = 43.5, K=0.74, t0=-0.13; Males: L∞ = 33.1, K=0.93, t0=-0.05. Females grow faster than males attaining larger size-at-age.

In GSA10, past estimates of the growth pattern of the Deep-water rose shrimp females were obtained using different methods based on the LFD analysis (modal progression analysis-MPA, Elefan, Multifan) applied to GRUND data from 1990 to 1995. Parameters of VBGF were as follows: L∞=45.9; K=0.673 t0=-0.251 (Carbonara *et al*., 1998). VBGF parameters were also re-estimated during the Samed project (SAMED, 2002) using the MEDITS time series from 1994 to 1999, that gave the following values: females: CL∞=45.0 mm, K=0.7, t0= -0.15; males: CL∞=40.0 mm; K=0.78; t0= -0.2.

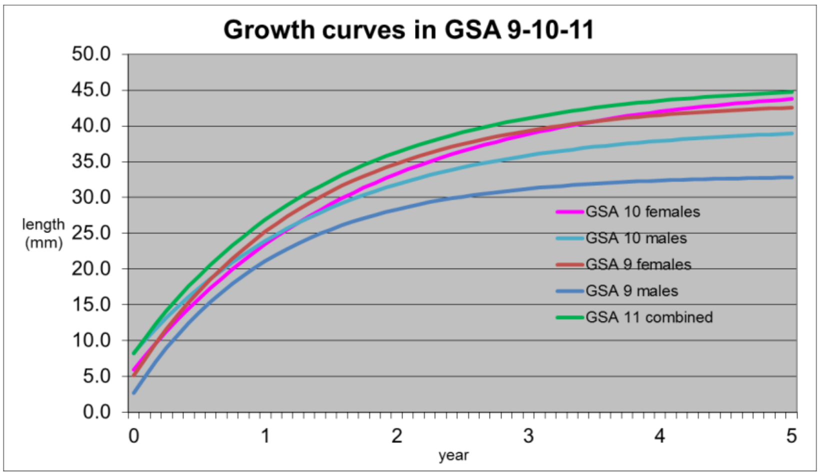


Figure 6.10.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Von Bertalanffy curves.

For the present assessment the growth parameters reported in 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 GSA 09, 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 (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.

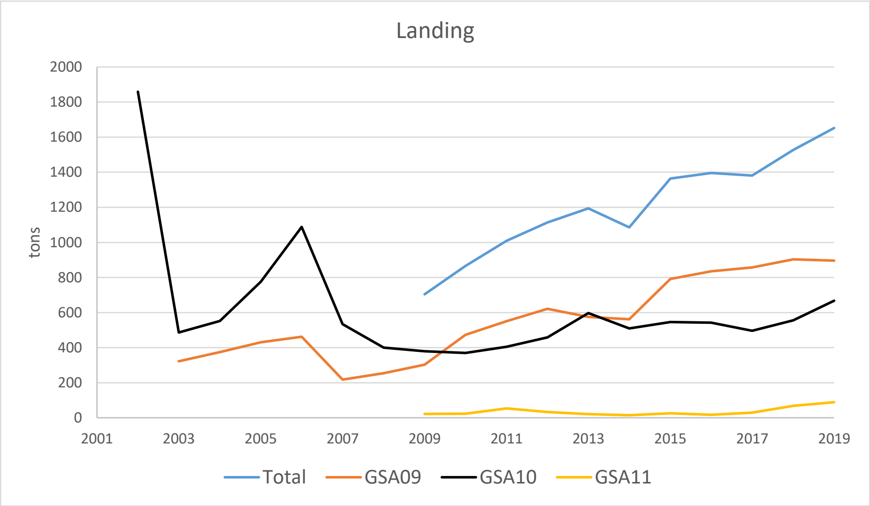


Figure 6.10.2.1.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings from 2002 to 2019 by single and combined GSAs.

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.

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GSA9-OTB		NA	317	367	430	462	215	253	303	473	551	621	576	561	791	836	857	904	896
GSA9-GNS		NA	0	4	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
GSA9-GTR		NA	6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GSA10-OTB		1452	416	544	743	1088	534	400	379	370	402	455	597	509	547	542	496	555	667
GSA10-GNS		0	0	3	6	0	0	0	0	0	3	4	0	0	0	0	0	0	0
GSA 11-OTB		NA	NA	NA	NA	NA	NA	NA	22	23	53	34	21	16	26	18	29	68	89
Total-ALL		1452	739	922	1180	1550	751	654	704	866	1010	1114	1194	1086	1365	1396	1382	1527	1653
GSA9-OTB		NA	NA	NA	NA	NA	NA	NA	38	27	63	8	30	45	89	35	41	50	285
GSA10-OTB		NA	NA	NA	NA	4	NA	NA	7	3	3	5	9	3	13	6	4	0	0

GSA11-OTB		NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0
Total-OTB		0	0	0	0	4	0	0	46	30	66	12	39	48	103	41	46	50	285
TOTAL-ALL	Catch	1452	739	922	1180	1554	751	654	750	896	1076	1126	1233	1134	1468	1437	1428	1577	1938

Annual landings in tonnes by year and fleet for the three GSAs are reported in Figs. 6.10.2.1.2-4. Annual discards in tonnes by year and fleet for GSA09 and GSA10 are displayed in Figs. 6.10.2.1.5-6.

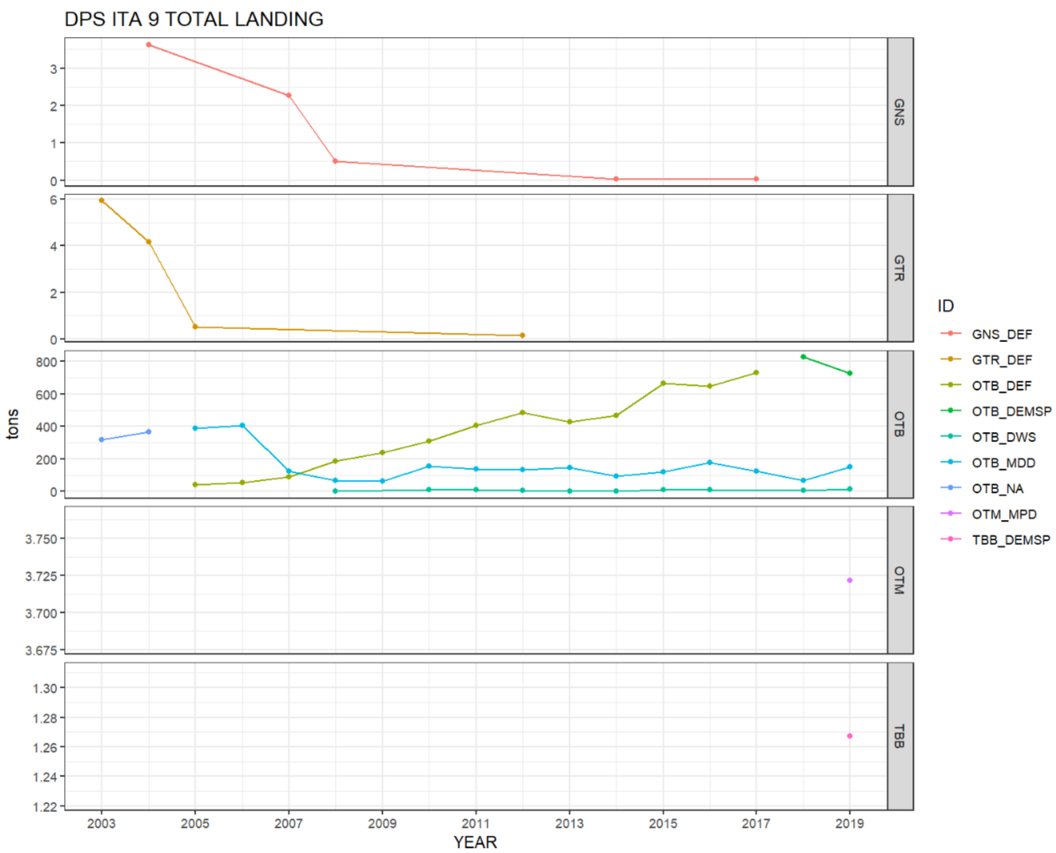


Figure 6.10.2.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA09.

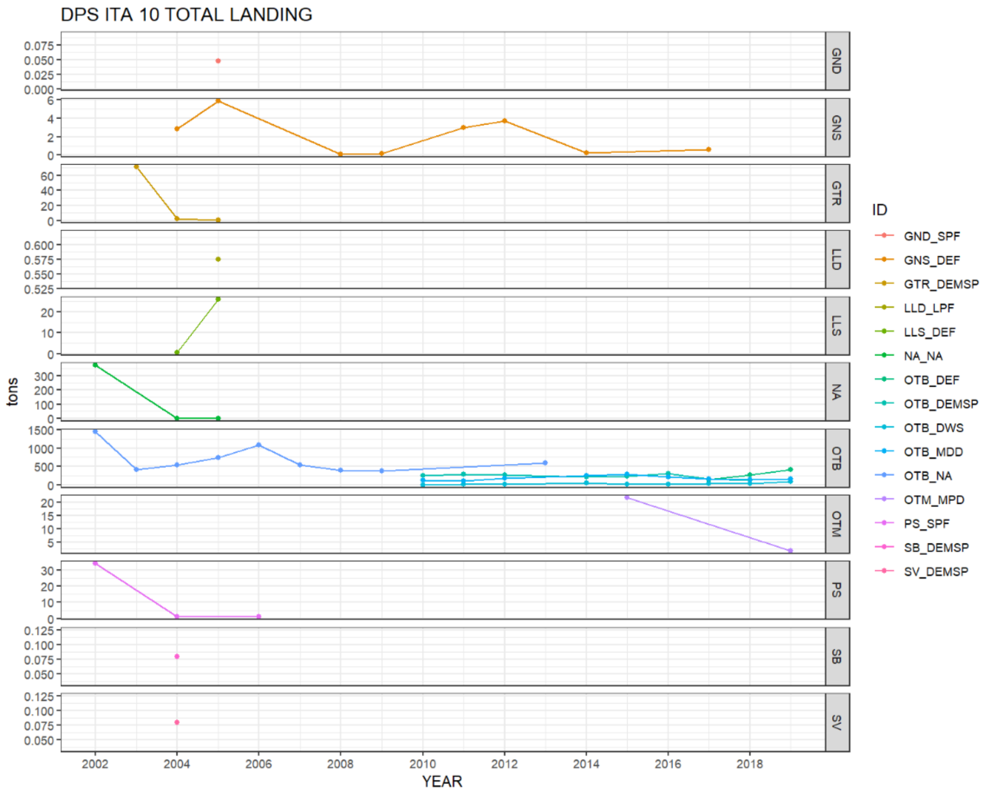


Figure 6.10.2.1.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA10.

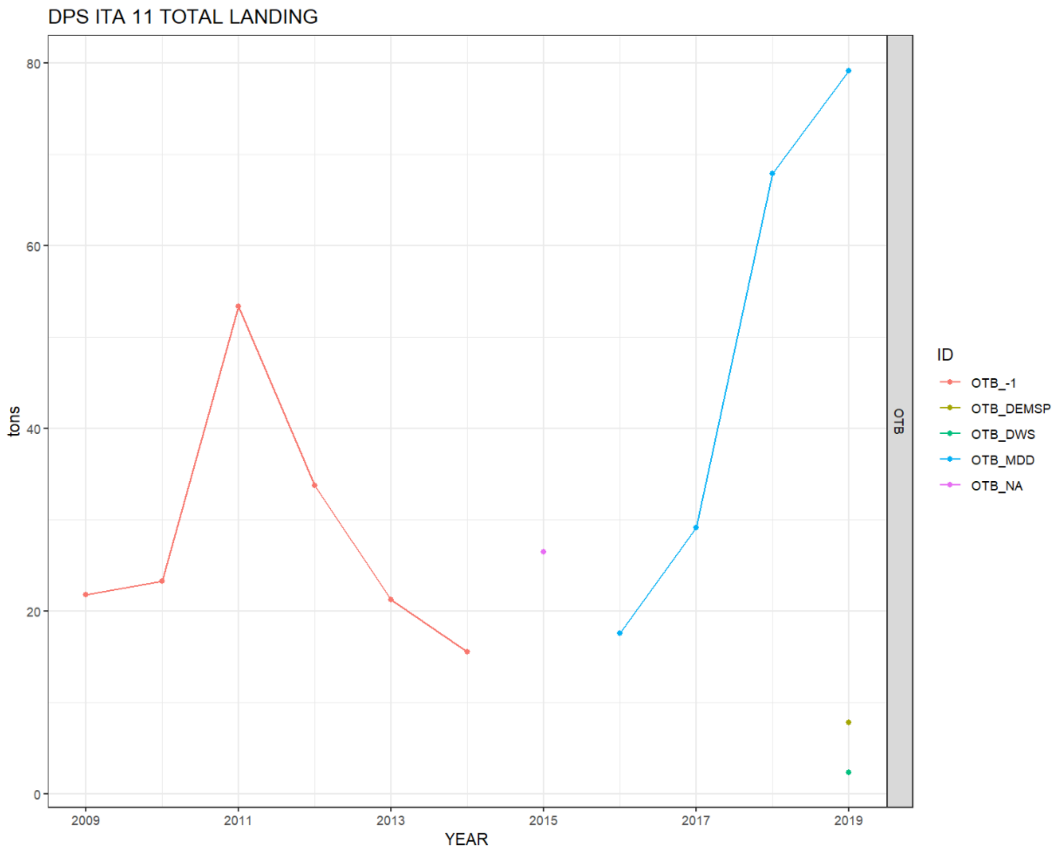


Figure 6.10.2.1.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA11.

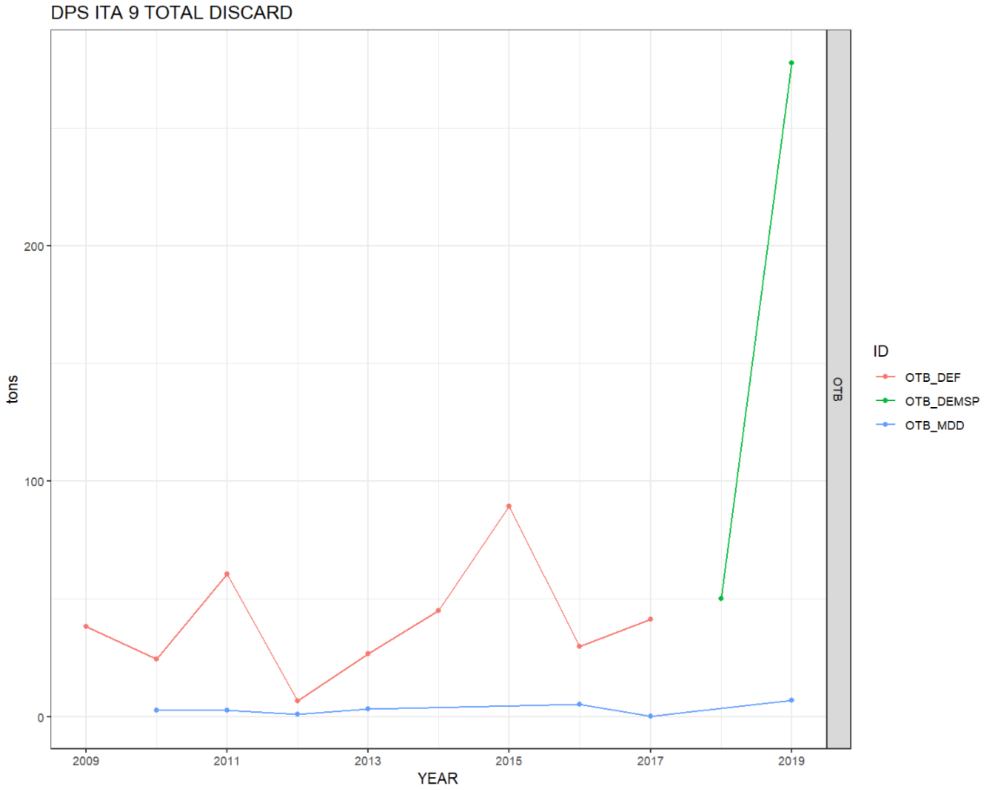


Figure 6.10.2.1.5 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA09.

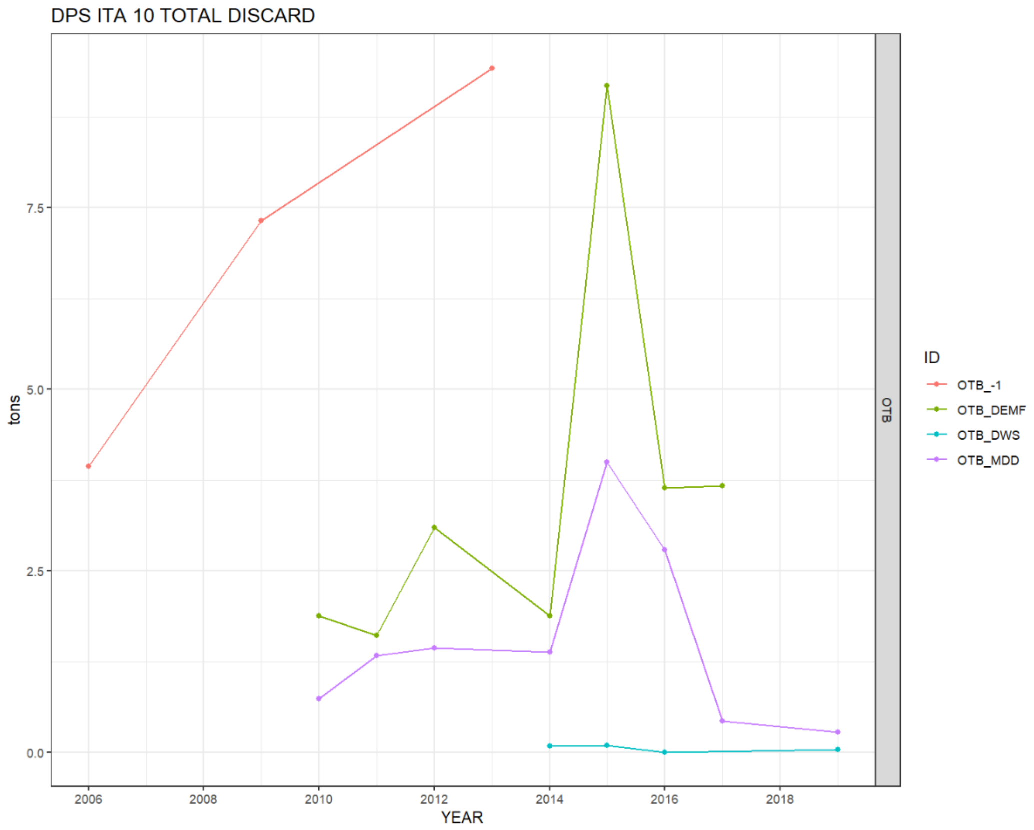
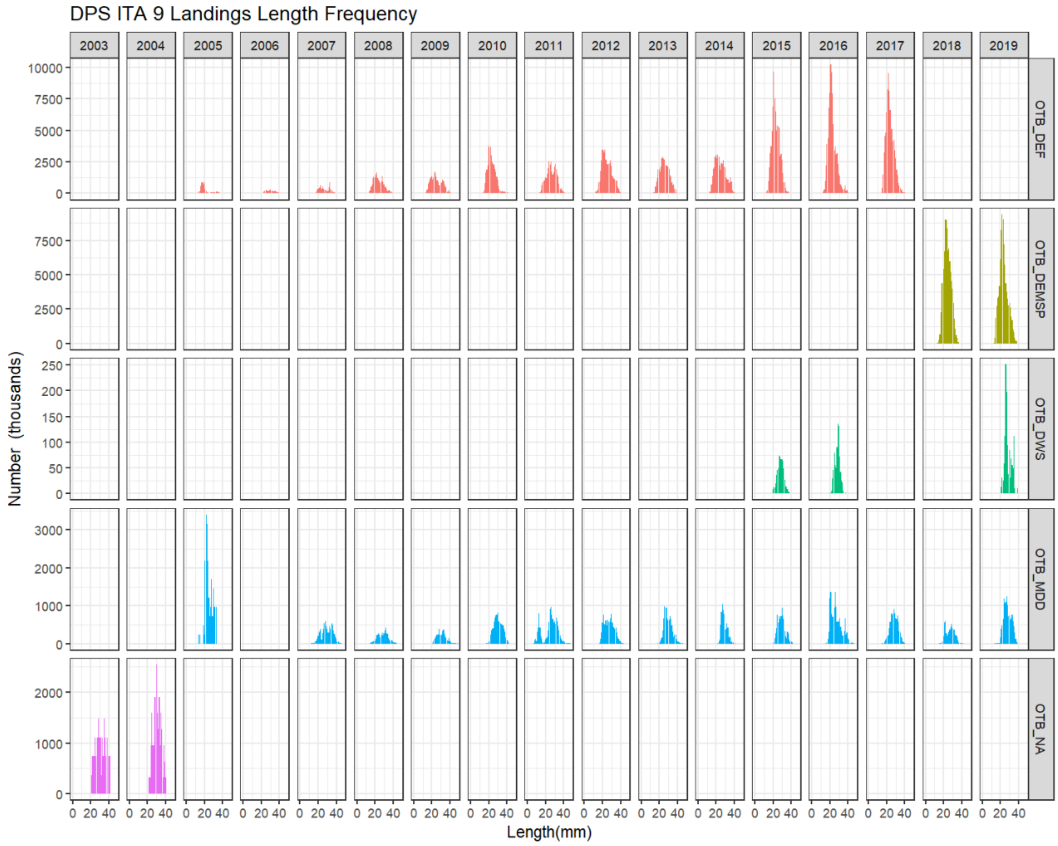


Figure 6.10.2.1.6 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA10.

Length frequency distributions of the commercial and discard fractions are displayed in Figs. 6.10.2.1.7-9.



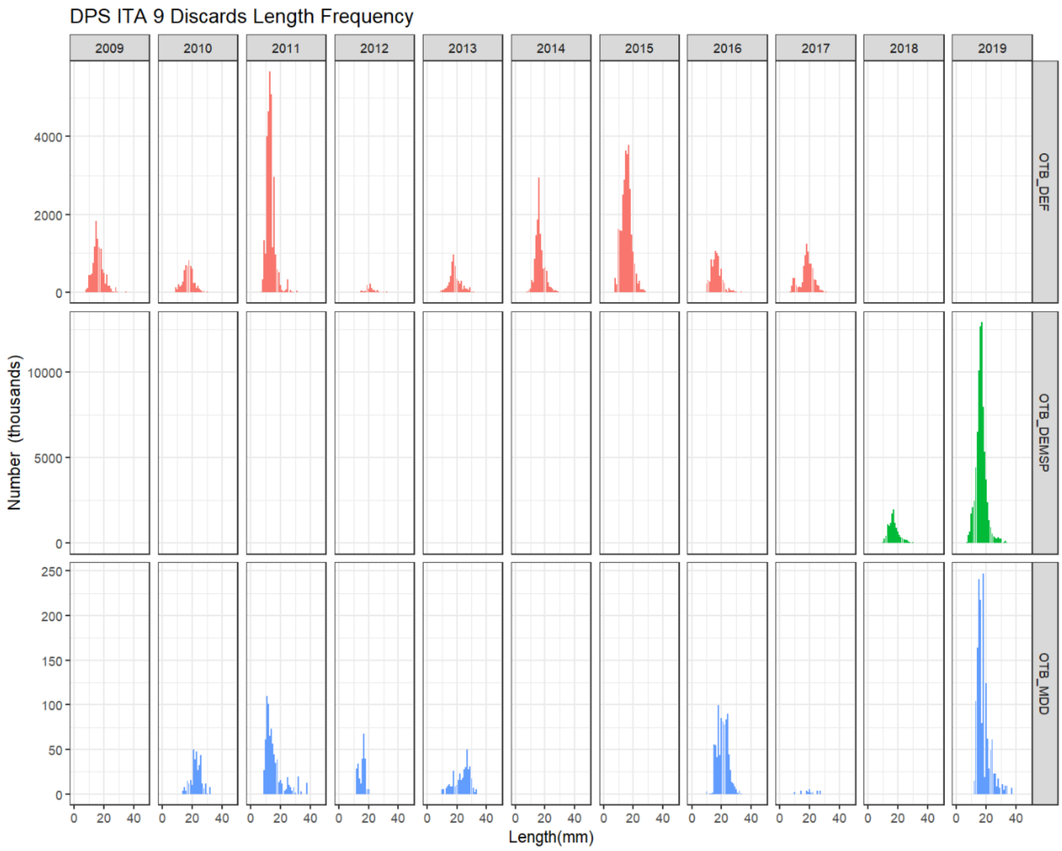
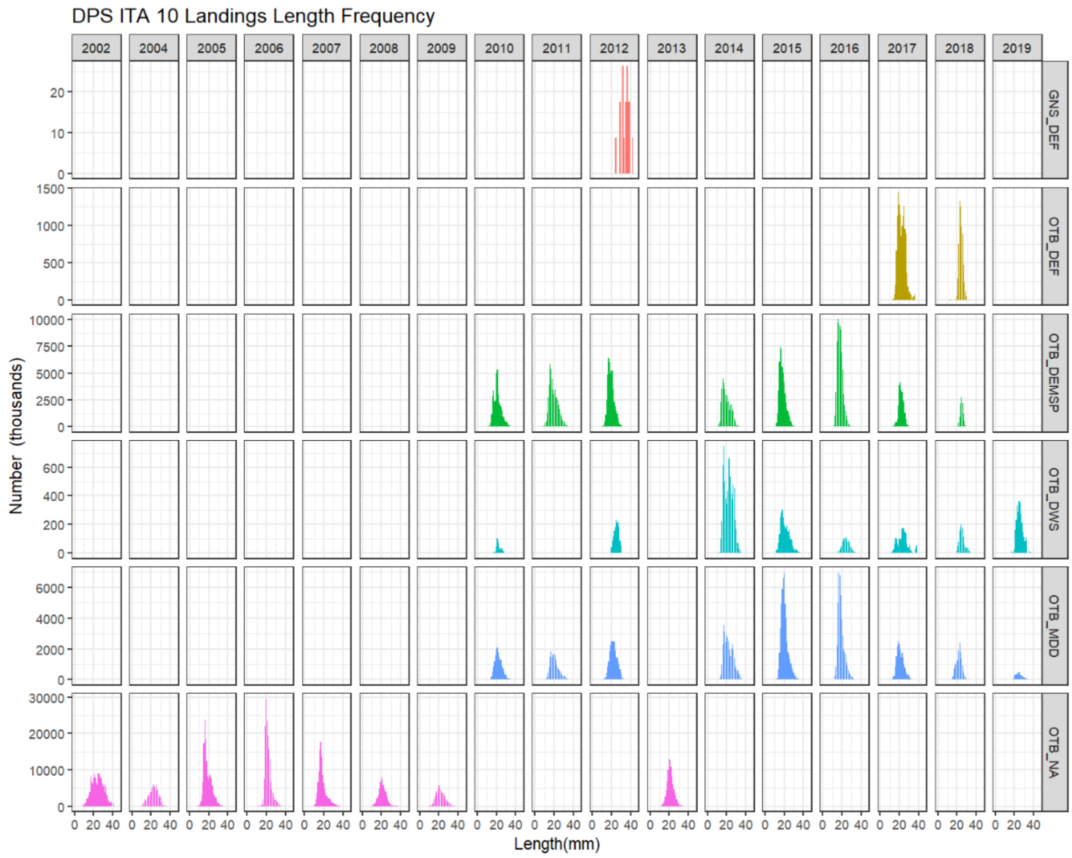


Figure 6.10.2.1.7 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing (above) and discard (below) in GSA09.


DPS ITA 10 Landings Length Frequency
2002
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
GNS_DEF
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
Number (thousands)
Length(mm)

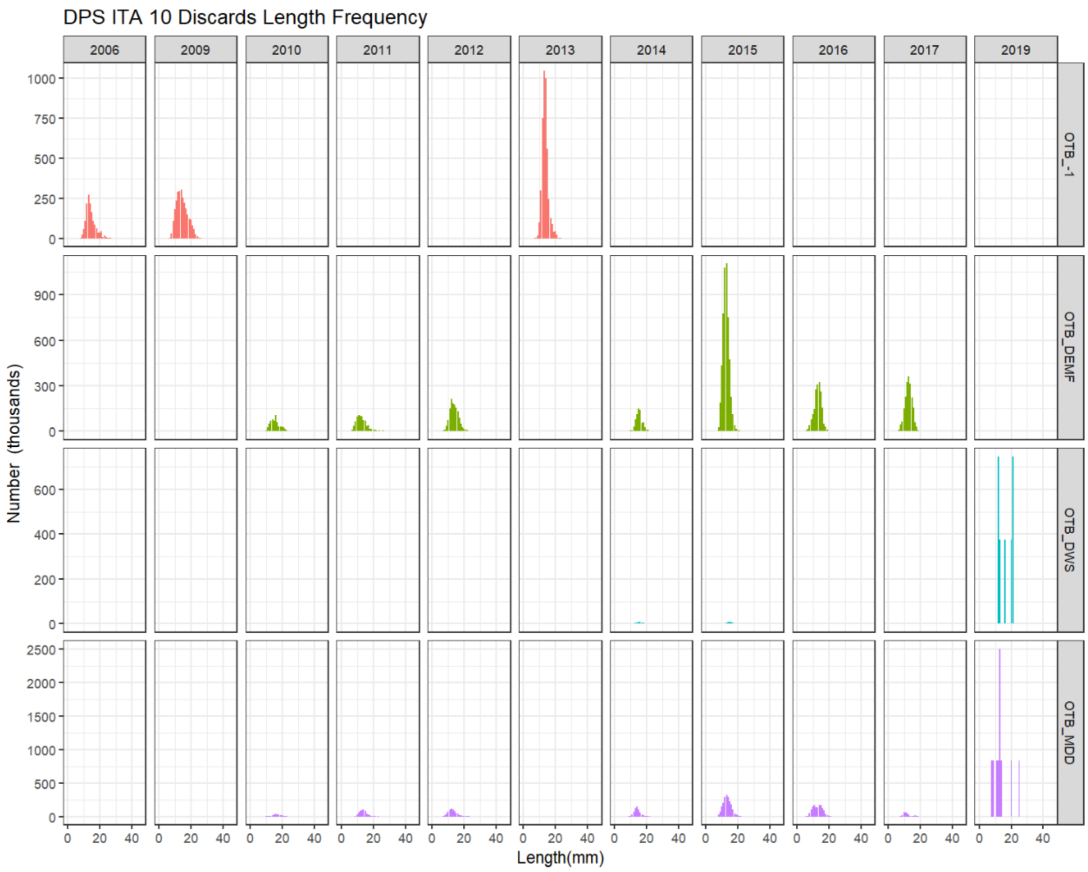

DPS ITA 10 Discards Length Frequency
2006
2009
2010
2011
2012
2013
2014
2015
2016
2017
2019
OTB_-1
OTB_DEMF
OTB_DWS
OTB_MDD
Number (thousands)
Length(mm)

Figure 6.10.2.1.8 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing (above) and discard (below) in GSA10.

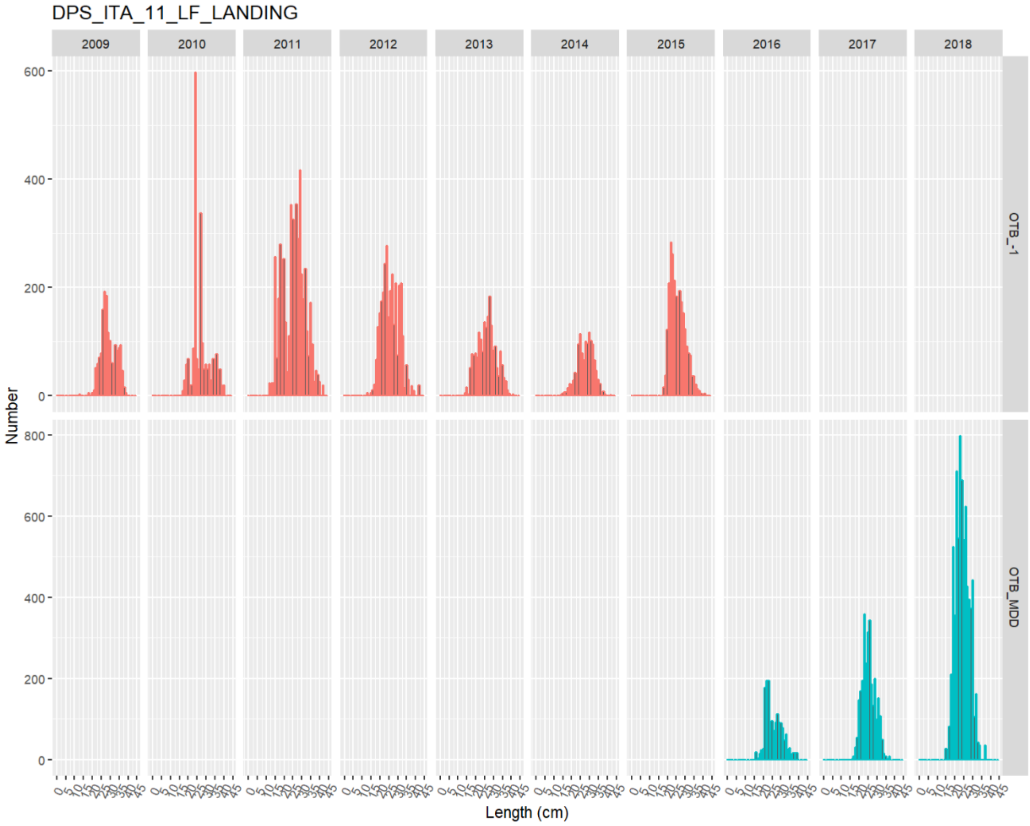


Figure 6.10.2.1.9 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing in GSA11.

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_DWSP and OTB_MDDWSP). Length frequency distributions of discard by metier are available from 2009.

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. The size distribution of the main metier targeting DPS in the area (OTB_DEMSP) is not available for 2019. Length frequency distributions for the other metiers are available for 2012 (gillnet). Size structure of the discard is available for 2006 and for the period 2009-2017. Length frequency distributions for 2019 are not reliable.

In GSA11, length frequency distributions are present in the DCR-DCF database only for landing in the period 2009-2019.

6.10.2.2 Effort

Fishing effort data were reported through DCR-DCF database. Data for 2019 were not available.

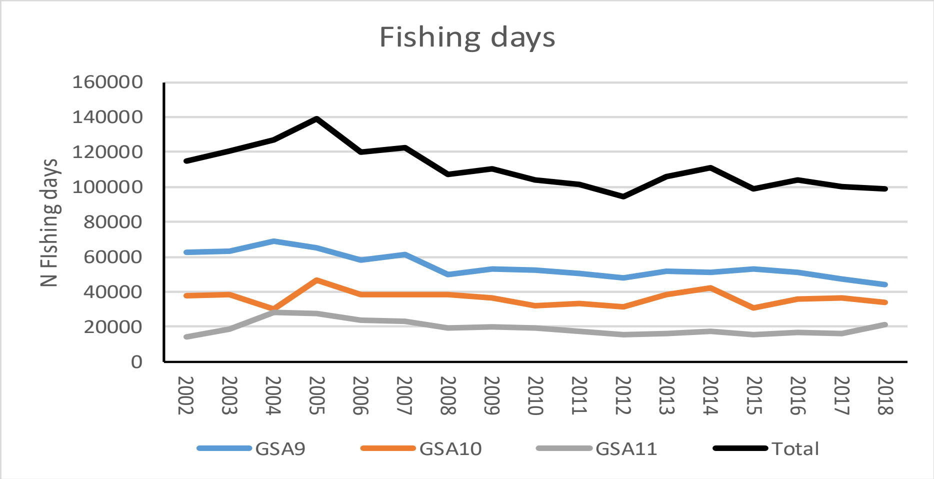
All the indicators related to the fishing effort showed a decreasing trend along the time series, more evident in the period 2004-2008. A similar trend is observed comparing the three GSAs.

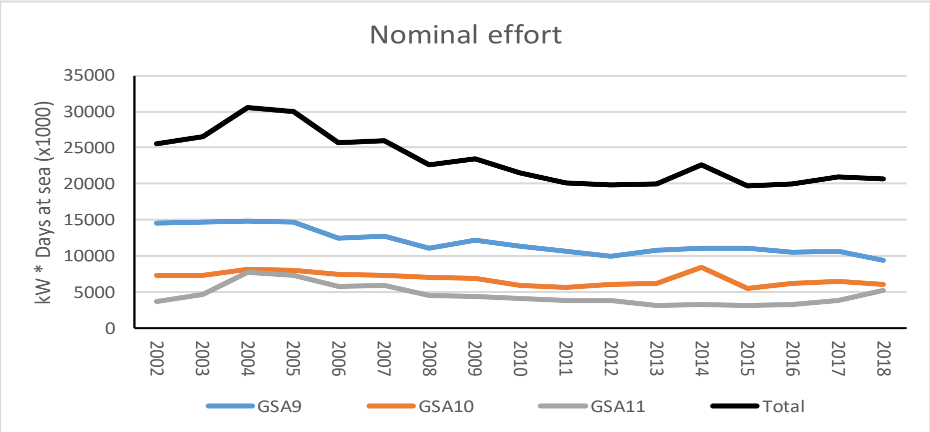
The total fishing days of bottom trawling decreased in the period 2004-2012, passing from 146,048 to 91,913. However, a slight recovery has been observed in recent years (100116 fishing days in 2017).

The nominal fishing effort of the trawl fleets operating in the three GSAs (kW*days at sea), has shown a progressive decrease in the period 2004-2011. It varied from about 30,597,000 in 2004 to 19,694,000 in 2015. In the last years the value remained quite constant.

The fishing effort expressed as GT*days at sea showed a decreasing trend from 2004 (5,456,690) to 2011 (3,687,969). In the last years the value fluctuated around 4,000,000 and a slightly increase due to changes in the fleets of GSAs 10 and 11.

Anyway, there is no information on the specific effort directed to *P. longirostris*.





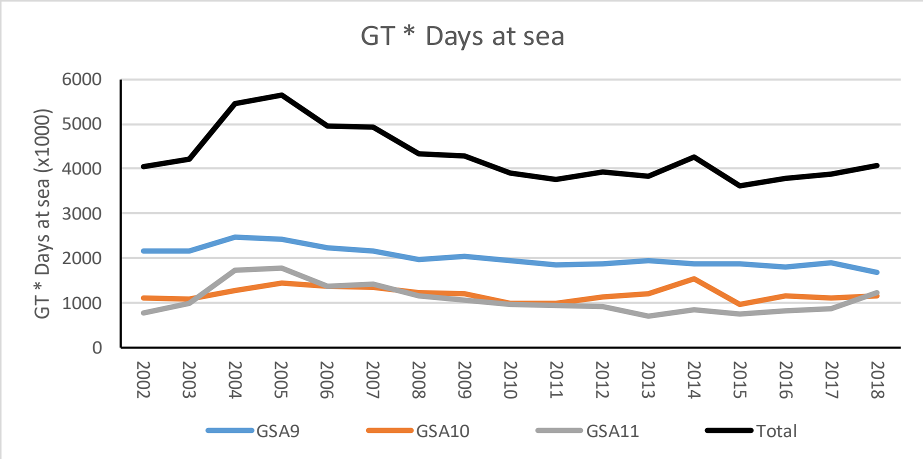


Figure 6.10.2.2.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Trends of fishing days, nominal effort and effort expressed in GT*days at sea for the three GSAs and for the whole area.

6.10.2.3 Survey data

Survey #1 (MEDITS)

Since 1994 MEDITS trawl surveys have been regularly carried out each year during the spring-summer season.

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 Tabs. 6.10.2.3.1.1-2 the number of hauls was 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 1994-2019.

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

Table 6.10.2.3.1.2 Number of hauls per year and depth stratum in GSA10, period 1994-2019.

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

Table 6.10.2.3.1.3 Number of hauls per year and depth stratum in GSA11, period 1994-2019.

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

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:

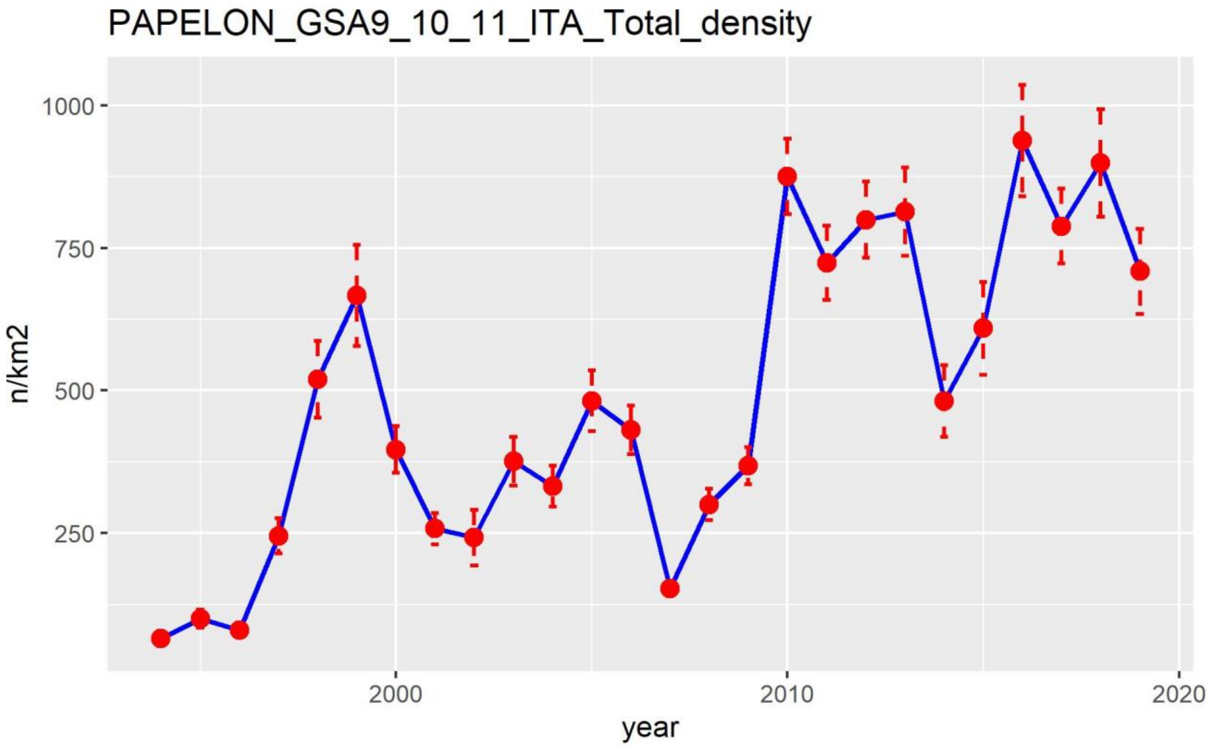
A=total survey area	Ai=area of the i-th stratum
si=standard deviation of the i-th stratum	ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA	Yi=mean of the i-th stratum
Yst=stratified mean abundance	V(Yst)=variance of the stratified mean

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.

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. 6.10.2.3.3.1. Both indices showed an evident increasing trend with very high values in the periods 2010-2013 and 2015-2019.



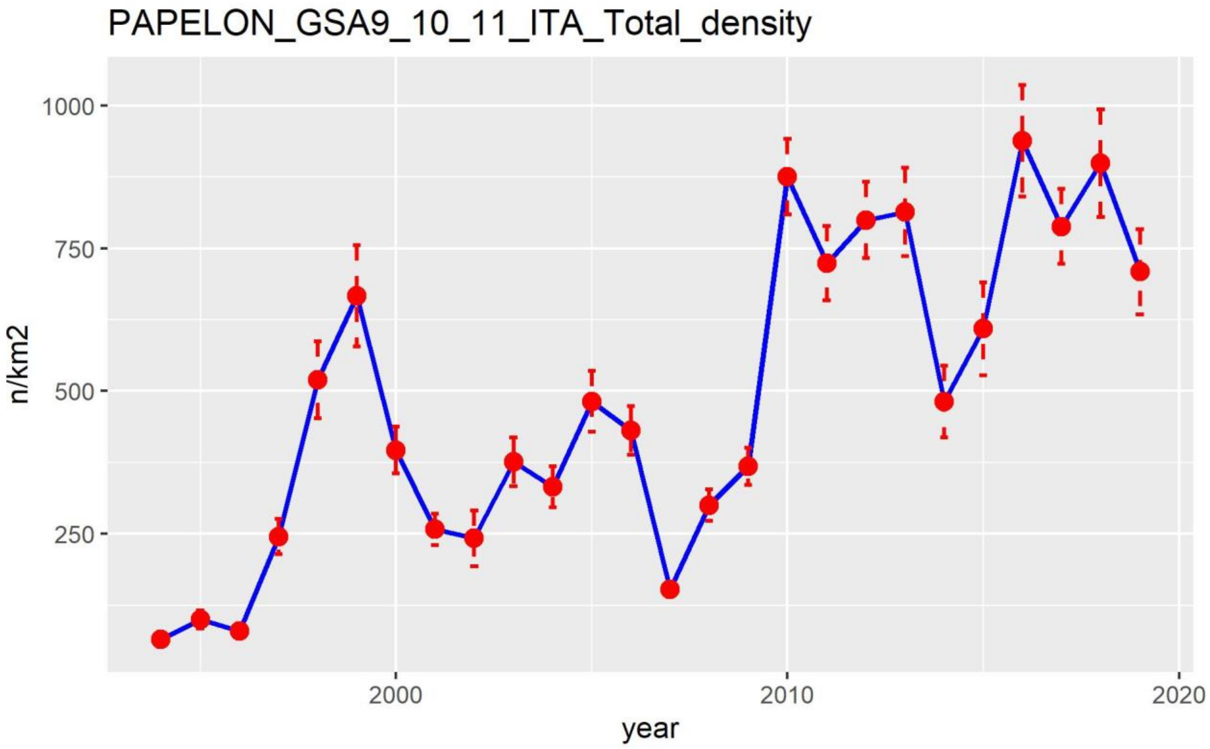


Figure 6.10.2.3.3.1 Deep-water rose shrimp in GSAs 09, 10 & 11. MEDITS standardized abundance and biomass indices (10-800 m).

6.10.2.3.4 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 2019.

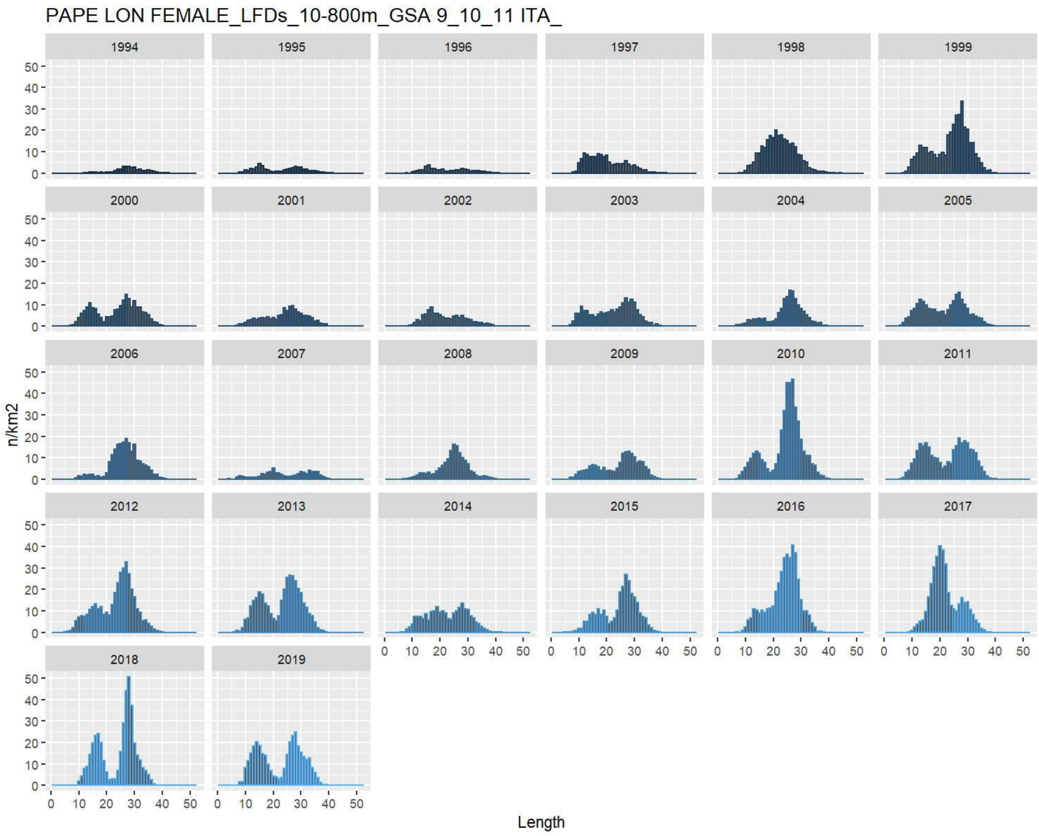


Figure 6.10.2.3.4.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for females, period 1994-2019.

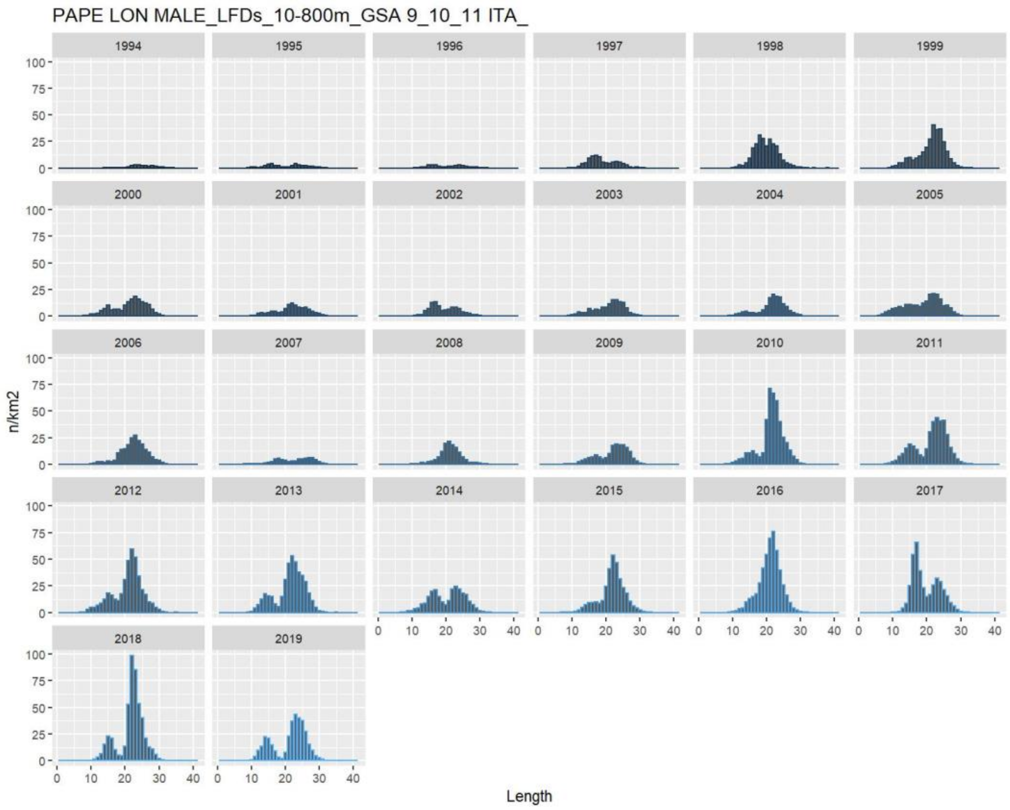


Figure 6.10.2.3.4.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for males, period 1994-2019.

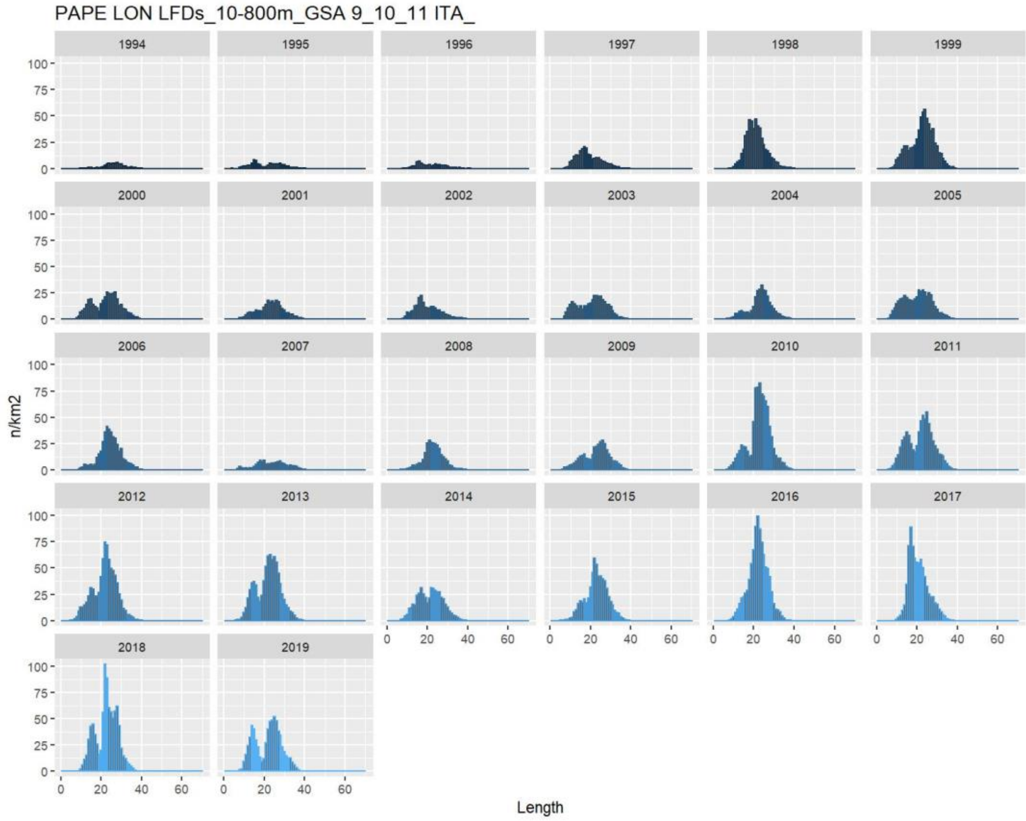


Figure 6.10.2.3.4.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for the total population, period 1994-2019.

6.10.3 STOCK ASSESSMENT

A Statistical Catch-at-age (a4a) assessment was carried out during STECF EWG 20-09 using catch data collected under DCR-DCF from 2009 to 2019 and calibrated with survey data (MEDITS 2009-2019). 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 = Landings / Σa (total catch numbers at age a x catch weight-at-age a)]. The correction factor resulted low. MEDITS data from the three GSAs for the period 2009-2019 were used for tuning.

Discards were included in the analysis with the exception of GSA11 for which data are not available. This information was not available in some years also for GSAs 09 and 10.

Given that the catches were composed mainly of individuals between 1 and 2 years, these ages were selected as the F_{bar}.

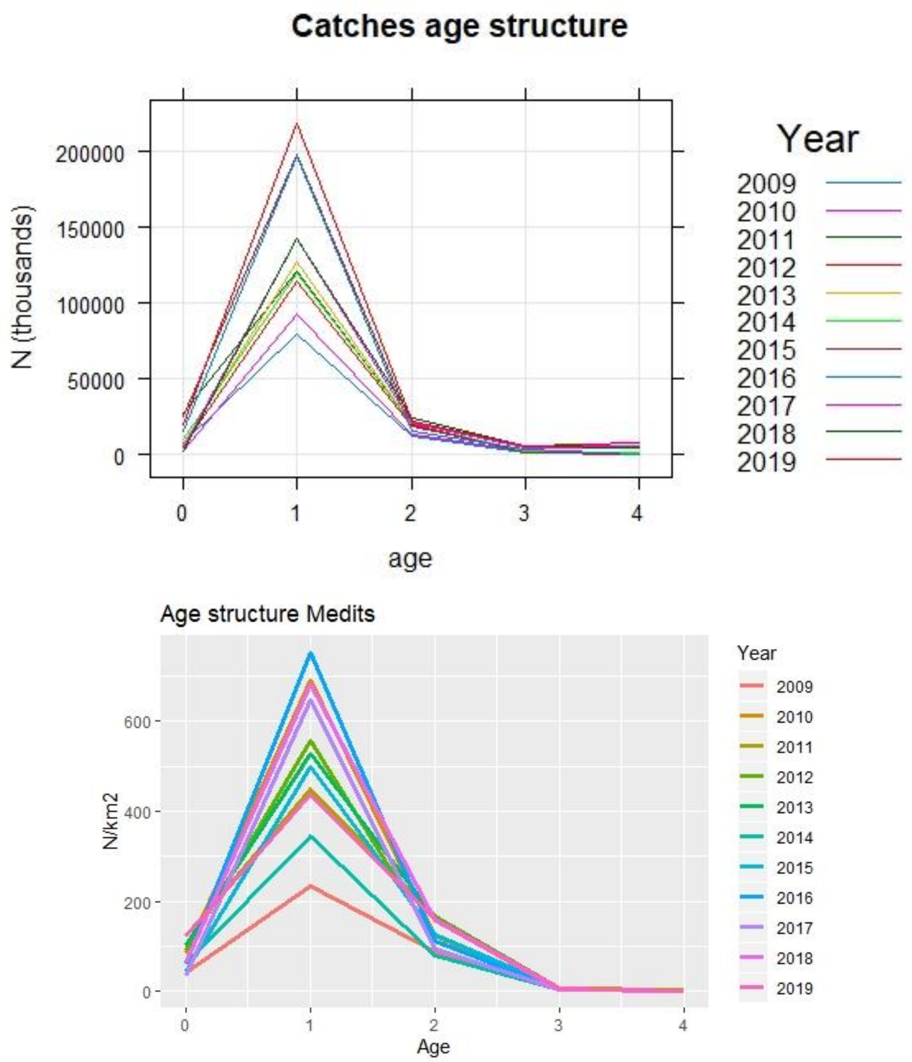


Figure 6.10.3.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Age frequency distributions of the total commercial catches (above) and of the Medits catches (below) by year.

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	7705.85	79631.47	12764.91	1537.94	808.95
2010	2948.18	92714.35	13809.98	2134.81	823.83
2011	27734.59	121076.8	20420.58	2618.74	1344.86
2012	5952.46	114481.4	18634.24	2658.01	1298.29
2013	6656.01	127177.7	19768.1	2590.23	1240.33
2014	9981.76	119446.4	19668.69	2265.64	1095.22
2015	25925.01	198246.5	20108.02	2012.6	667.17
2016	16029.13	196700.4	15558.51	3170.55	883.64
2017	5163.7	142545.7	20630.85	4777.95	5375.69

2018	2774.11	143059.3	24418.72	5843.7	4329.96
2019	20172.11	218336.6	22540.91	5747.5	7818.44

	Catches (in tons)
2009	749.60
2010	895.97
2011	1075.82
2012	1125.67
2013	1233.01
2014	1134.45
2015	1467.25
2016	1436.99
2017	1427.52
2018	1577.19
2019	1937.50

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

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
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

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

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

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=0.3)

Model <- a4aSCA(stock = stk, indices = idx, fmodel, qmodel, srmodel)

The results are shown in Figs. 6.10.3.2-12 and Tabs. 6.10.3.2-4.

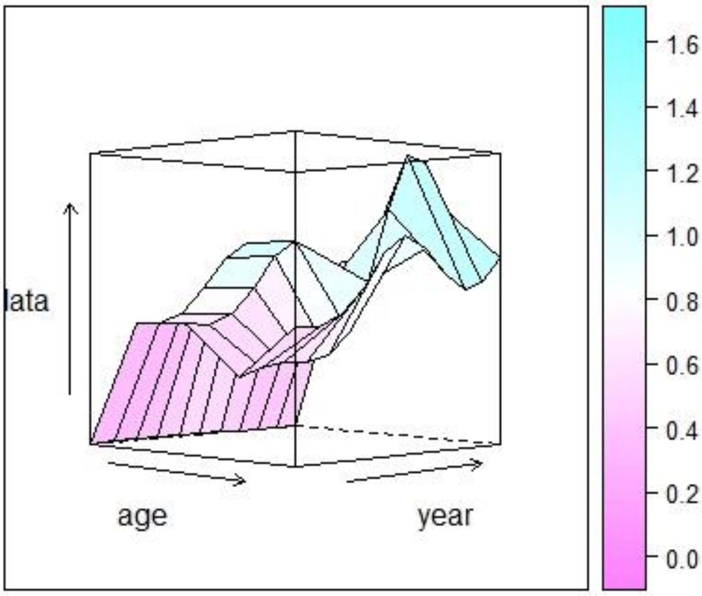


Figure 6.10.3.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Fishing mortality by age and year obtained from the a4a model (2009-2019).

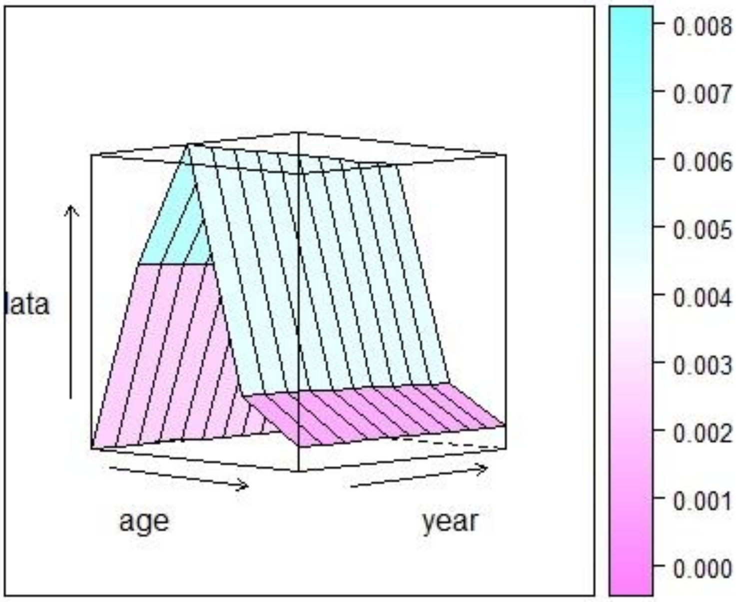


Figure 6.10.3.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Catchability by age and year obtained from the a4a model (2009-2019).

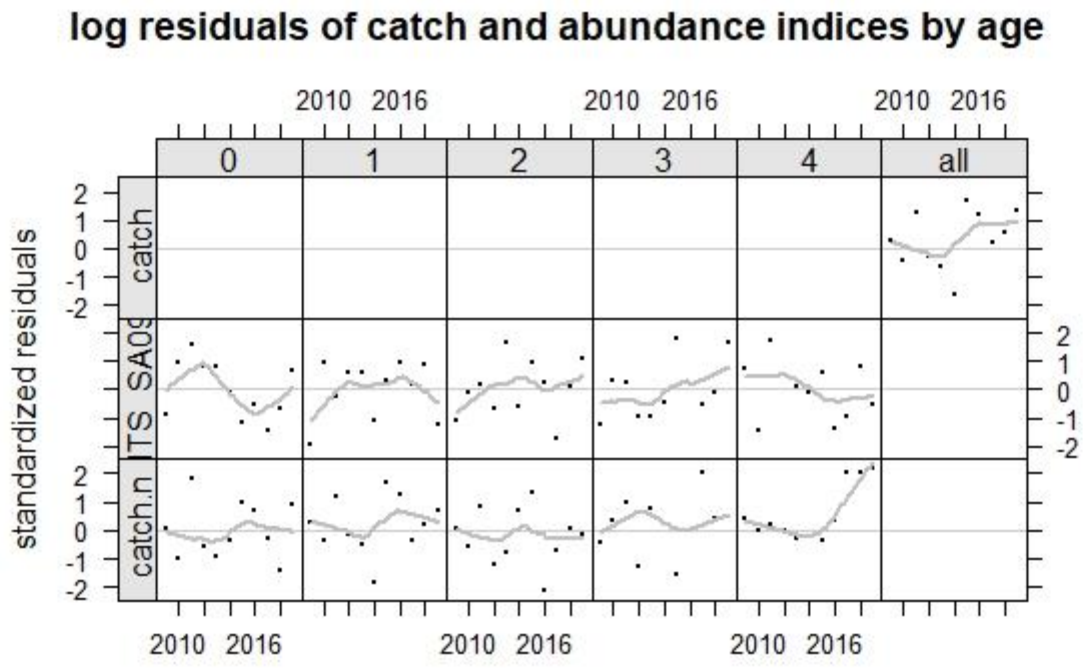


Figure 6.10.3.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Log residuals of the fishery and the survey data by age, and of the total catches.

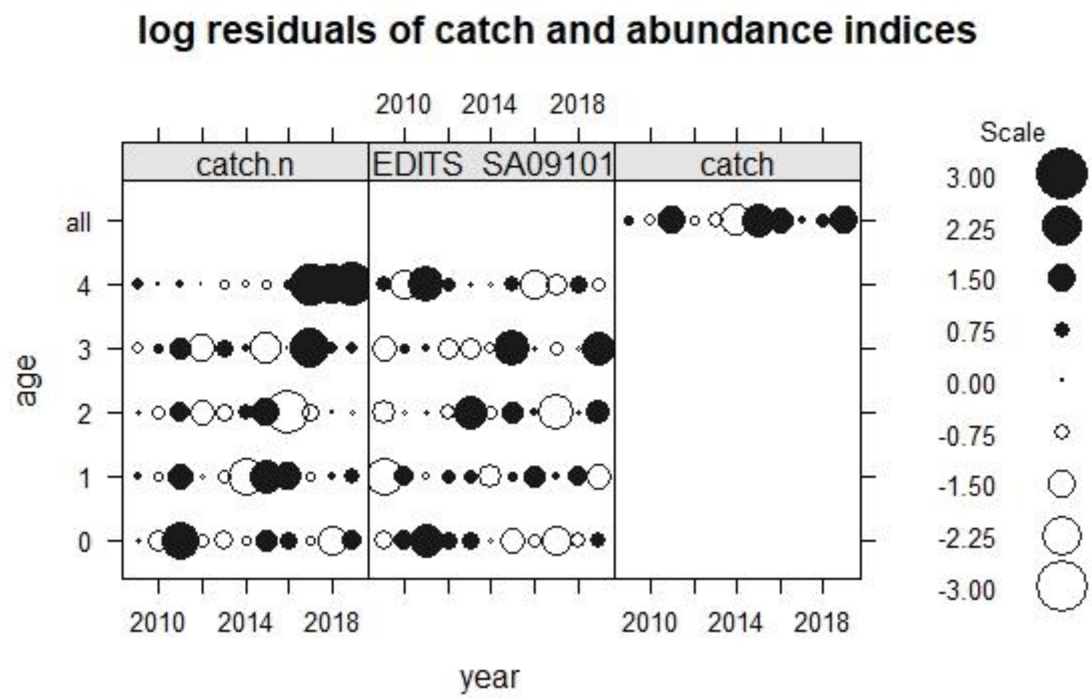


Figure 6.10.3.5 Deep-water rose shrimp in GSAs 09, 10 & 11. Bubble plot of the log residuals of the fishery and the survey data by age, and of the total catches.

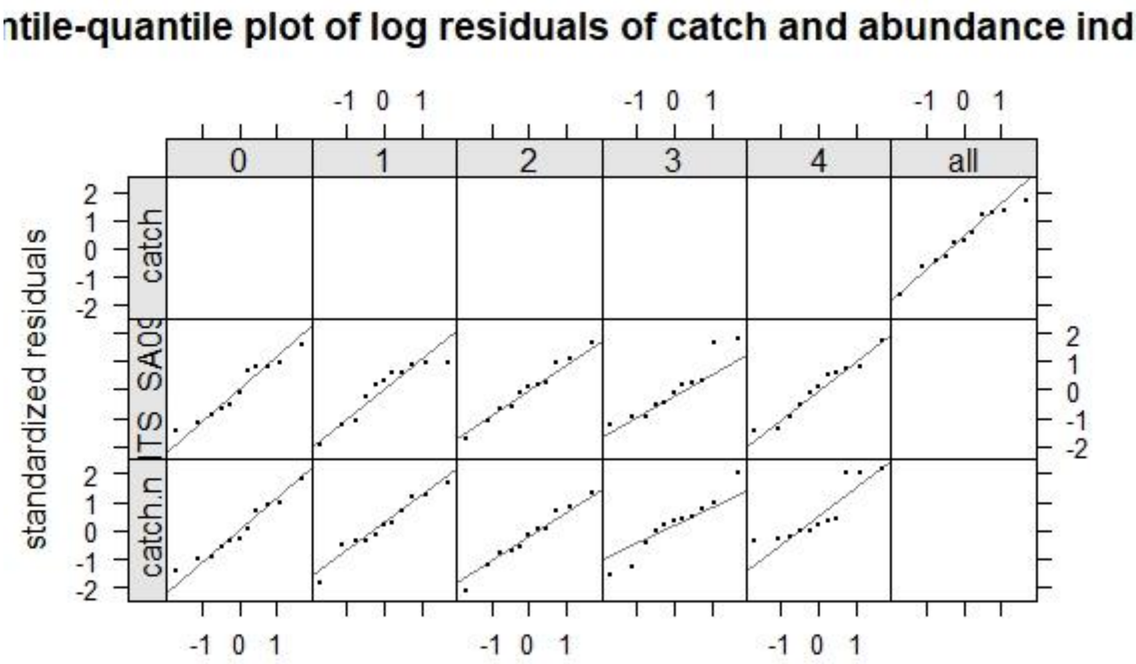


Figure 6.10.3.6 Deep-water rose shrimp in GSAs 09, 10 & 11. QQ-plot of the log residuals of the fishery and the survey data by age, and of the total catches.

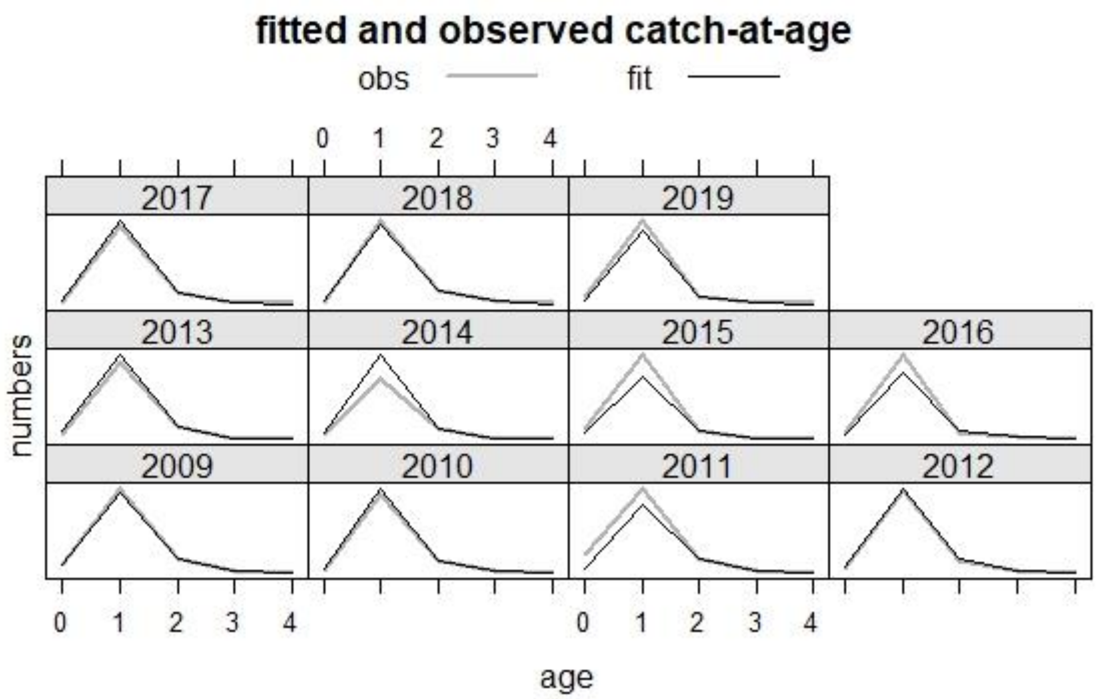


Figure 6.10.3.7 Deep-water rose shrimp in GSAs 09, 10 & 11. Fitted and observed catches at age by year.

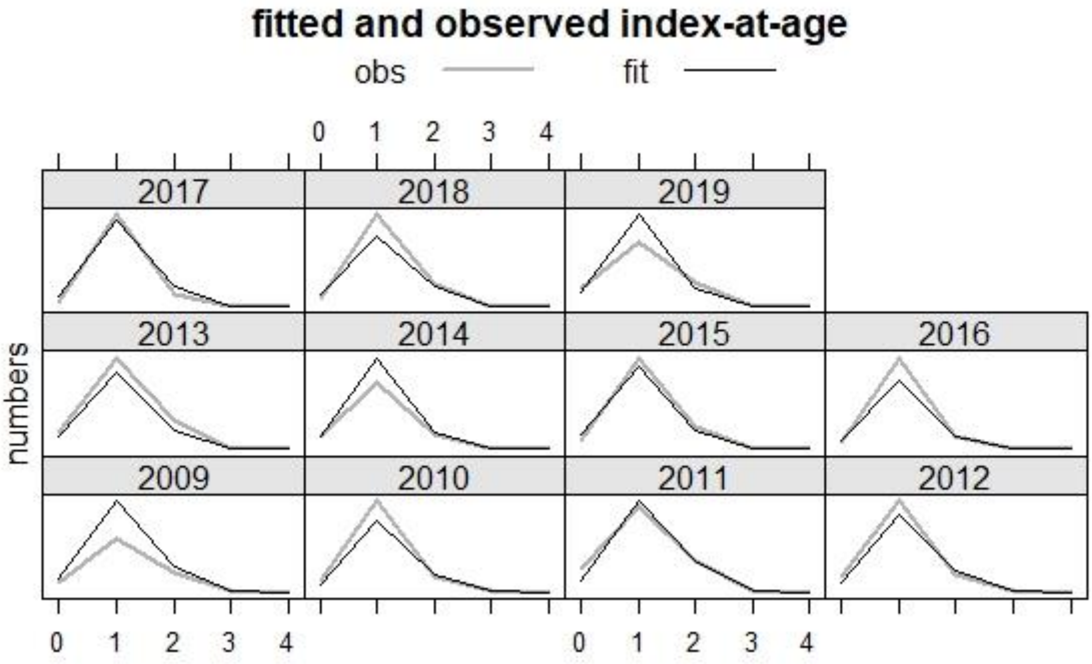


Figure 6.10.3.8 Deep-water rose shrimp in GSAs 09, 10 & 11. Fitted and observed Medits index at age by year.

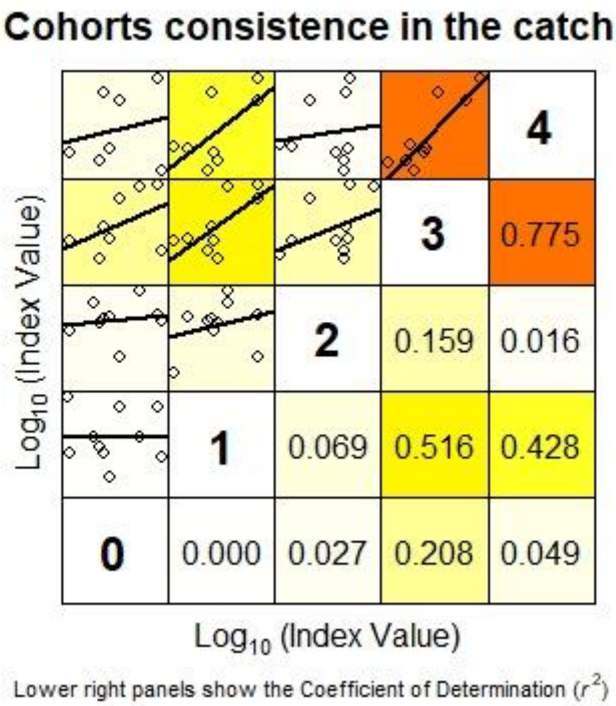


Figure 6.10.3.9 Deep-water rose shrimp in GSAs 09, 10 & 11. Internal consistency of the catch at age data.

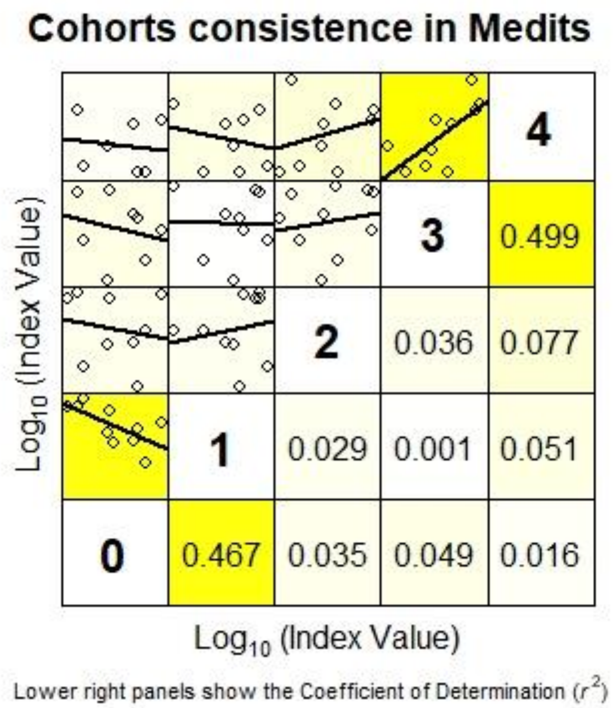


Figure 6.10.3.10 Deep-water rose shrimp in GSAs 09, 10 & 11. Internal consistency of the Medits index at age data.

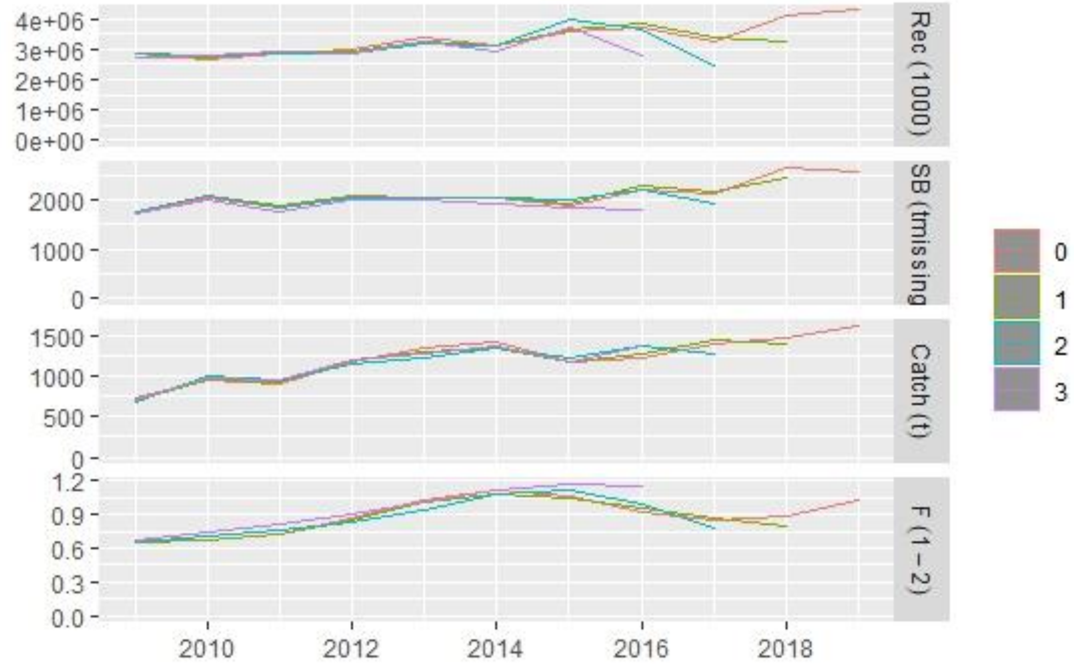


Figure 6.10.3.11 Deep-water rose shrimp in GSAs 09, 10 & 11. Retrospective analysis.

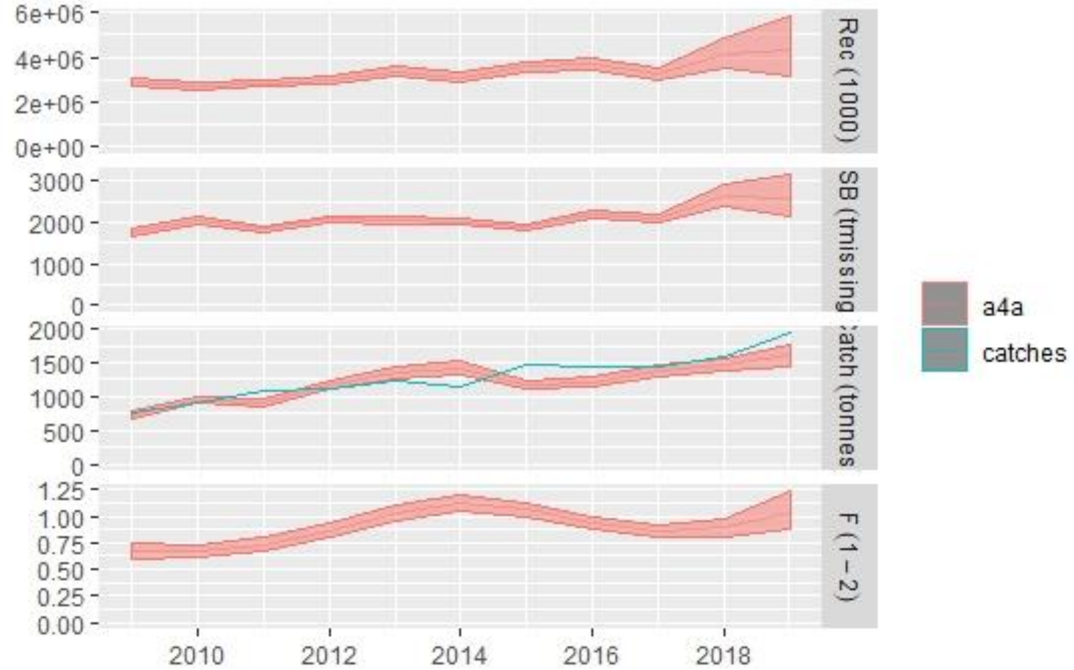


Figure 6.10.3.12 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment model with uncertainty. Green line represents the catches observed.

Tab. 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	2870173	238958	37057	6590	1344
2010	2677265	312885	41381	7917	2293
2011	2831373	292025	54353	8868	2822
2012	2977108	308728	48029	11028	3139
2013	3359622	324102	44336	8509	3727
2014	3105821	364940	39215	6618	2946
2015	3593098	337135	40381	5353	2053
2016	3692911	390748	39679	5863	1328
2017	3236565	402590	52416	6566	979
2018	4136822	353318	58268	9359	798
2019	4302305	451605	49329	10036	1036

Tab. 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	0.67	0.67	0.42	0.67
2010	0.01	0.67	0.67	0.46	0.67
2011	0.01	0.73	0.73	0.48	0.73
2012	0.01	0.86	0.86	0.48	0.86
2013	0.01	1.03	1.03	0.51	1.03
2014	0.01	1.12	1.12	0.63	1.12
2015	0.01	1.06	1.06	0.89	1.06
2016	0.01	0.93	0.93	1.29	0.93
2017	0.00	0.85	0.85	1.60	0.85
2018	0.00	0.89	0.89	1.57	0.89
2019	0.01	1.03	1.03	1.31	1.03

Tab. 6.10.3.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment.

	Catch (t)	$F_{bar\ 1-2}$	Recruitment (thousands	SSB (t)	Total Biomass (t)
2009	720	0.67	2870173	1756	7692
2010	947	0.67	2677265	2059	8474
2011	901	0.73	2831373	1841	7613
2012	1175	0.86	2977108	2079	8997
2013	1343	1.03	3359622	2054	9515
2014	1415	1.12	3105821	2028	9785
2015	1163	1.06	3593098	1898	9408
2016	1219	0.93	3692911	2210	10731
2017	1382	0.85	3236565	2113	8938
2018	1460	0.89	4136822	2648	12593
2019	1606	1.03	4302305	2575	12611

Based on a4a results, the Deep-water rose shrimp SSB showed an increasing trend, reaching the maximum value in 2018 (2648 tons). The recruitment (age 0) showed a similar trend of SSB, with a value of 4,302,305 thousands individuals in 2019. The lowest value of fishing mortality (Fbar = 0.67) is observed in 2009. After that, a constant increase of F was showed reaching a peak of 1.14 in 2015 The F value in 2019 was 1.03.

6.10.4 Reference Points

The STECF EWG 20-09 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

The yield per recruit (YpR) analysis was performed to estimate $F_{0.1}$, chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields. YpR output curve is illustrated in Fig. 6.10.4.1.

Current F (1.03), estimated as the F_{bar1-2} in the last year of the time series (2019), is lower than $F_{0.1}$ (1.08), which indicates that Deep-water rose shrimp stock in GSAs 9, 10 and 11 is exploited sustainability.

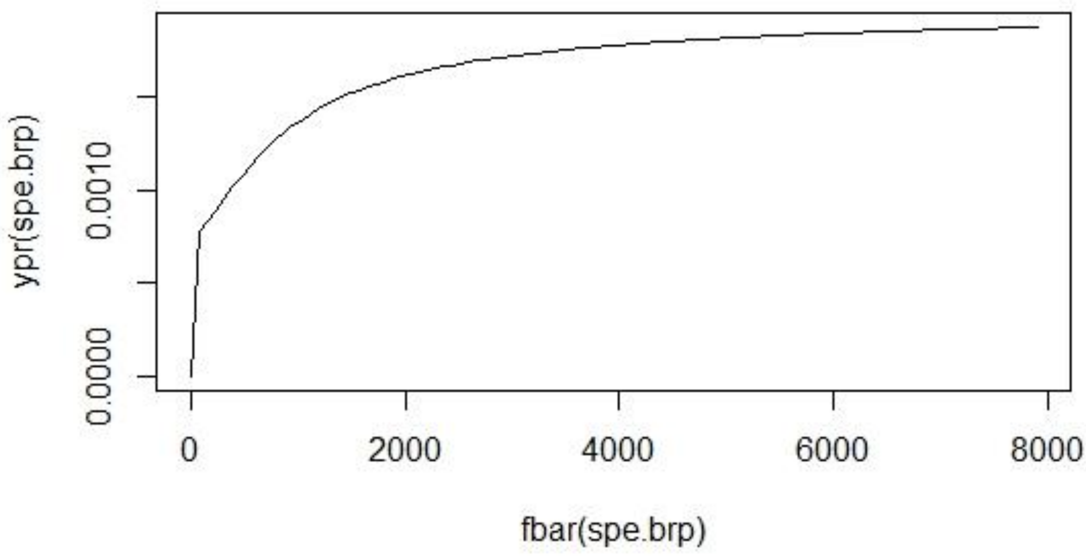


Figure 6.10.4.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Yield per Recruit curve.

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 2017 to 2019 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 and maturity at age, while the F_{bar} = 1.03 terminal F (2019) from the a4a assessment was used for F in 2020.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the last three years of the data series (3,862,046 thousand individuals).

The short term forecast (Tab. 6.10.5.2) was carried out estimating a catch for 2020-2022 on the basis of a recruitment constant and equal to the mean on the last three of the time series and an F by age equal to that of the terminal year. These assumptions resulted in a catch and a SSB in 2020 equal to 1606 and 2519 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (= 1.09) would decrease SSB of 7.35% from 2020 to 2022, while increasing the catch of the 8.41% from 2019 to 2021.

Table 6.10.5.1: Deep water rose shrimp in GSAs 9, 10 & 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
$F_{ages\ 1\text{-}3}$ (2020)	1.03	The F estimated in 2019 was used to give F status quo for 2020
SSB (2020)	2519	Stock assessment 1 January 2020
R_{age0} (2020,2021)	3862046	Geometric mean of the most recent three years 2017-2019
Total catch (2020)	1798	Assuming F status quo for 2020

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	Catch 2019	Catch 2021	SSB 2020	SSB 2022	Change SSB 2020-2022(%)	Change Catch 2019-2021(%)
High long term yield ($F_{0.1}$)	1.06	1.09	1606	1741	2519	2334	-7.35	8.41
Fupper	1.44	1.48	1606	2081	2519	2043	-18.88	29.58
Flower	0.70	0.72	1606	1314	2519	2736	8.64	-18.16
FMSY transition (intermediate year)	1.02	1.05	1606	1697	2519	2373	-5.79	5.69
Zero catch	0	0	1606	0	2519	4260	69.13	-100.00
Status quo	1	1.03	1606	1675	2519	2393	-4.98	4.29
Different Scenarios	0.1	0.10	1606	238	2519	3952	56.89	-85.17
	0.2	0.21	1606	456	2519	3682	46.16	-71.58
	0.3	0.31	1606	657	2519	3444	36.75	-59.11
	0.4	0.41	1606	840	2519	3236	28.46	-47.66
	0.5	0.51	1606	1009	2519	3051	21.13	-37.14
	0.6	0.62	1606	1165	2519	2888	14.64	-27.46
	0.7	0.72	1606	1308	2519	2742	8.87	-18.54
	0.8	0.82	1606	1440	2519	2613	3.73	-10.32
	0.9	0.92	1606	1562	2519	2497	-0.86	-2.73
	1.1	1.13	1606	1779	2519	2300	-8.69	10.78
	1.2	1.23	1606	1876	2519	2216	-12.04	16.79
	1.3	1.33	1606	1965	2519	2139	-15.07	22.37
	1.4	1.44	1606	2048	2519	2070	-17.82	27.55
	1.5	1.54	1606	2126	2519	2007	-20.32	32.36
	1.6	1.64	1606	2197	2519	1949	-22.61	36.84
	1.7	1.74	1606	2264	2519	1897	-24.70	41.01
	1.8	1.85	1606	2327	2519	1848	-26.62	44.91
	1.9	1.95	1606	2385	2519	1804	-28.39	48.54

	2.0	2.05	1606	2440	2519	1763	-30.02	51.95

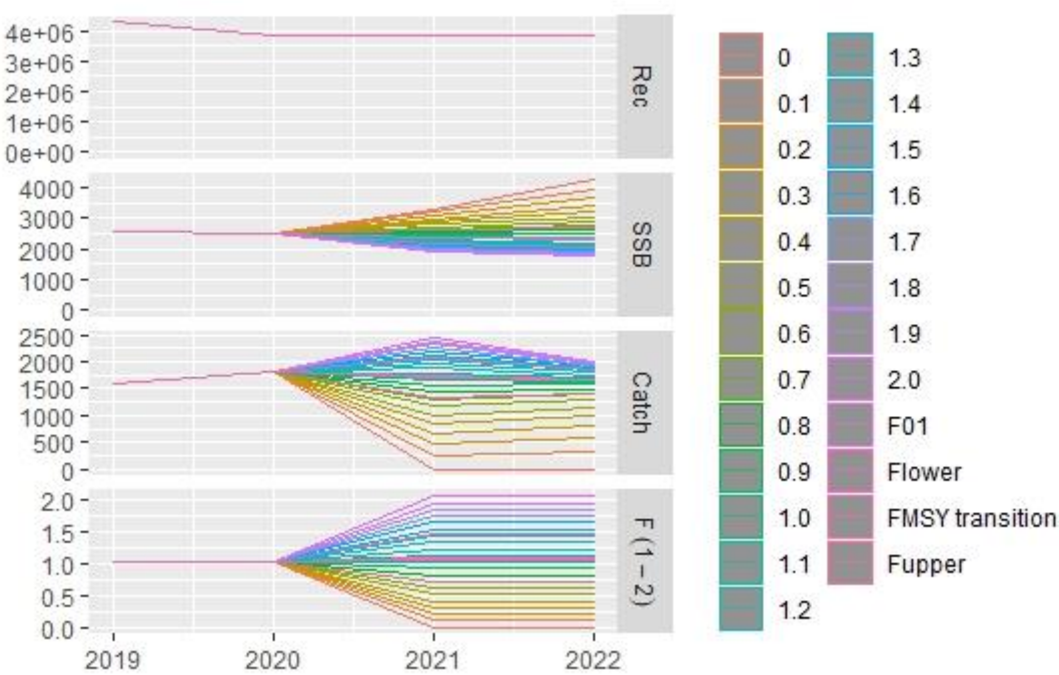


Fig. 6.10.5.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Short-term forecast in different F scenarios.

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).

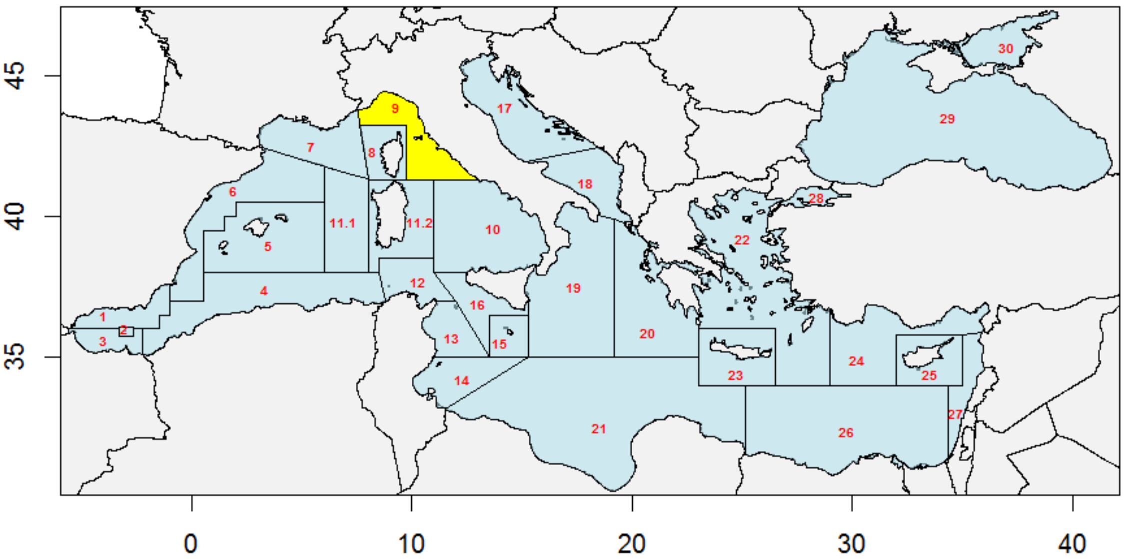


Figure 6.11.1.1 Red mullet in GSA 9: Location of GSA 9 in the Mediterranean Sea.

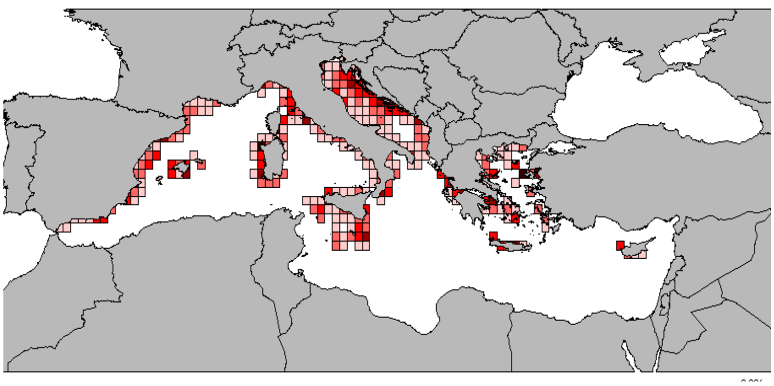


Figure 6.11.1.2 Red mullet in GSA 9: Geographical distribution of red mullet in the Mediterranean basin (kg/km^2, average 2004-2014 by GFCM rectangle), STOCKMED Project.

However, in line with ToR given, EWG 20-09 assumed here that inside the GSA 9 boundaries inhabits a single, homogeneous red mullet stock that behaves as a single well-mixed and self-perpetuating population. The hypothesis of a single stock of red mullet in GSA 9, which includes waters belonging to 2 different seas (Ligurian and Tyrrhenian) separated by the Elba Island as well as fleets that do not show any spatial overlapping is unlikely. The inability to account for spatial structure reduces flexibility and can lead to uncertainty in the definition of the status of the stocks, due to the possibility of local depletions and to a worse utilization of the potential productivity of the resources (STECF, 2014).

Growth

Growth parameters of red mullet in GSA 9 were available from 2006 to 2019 (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).

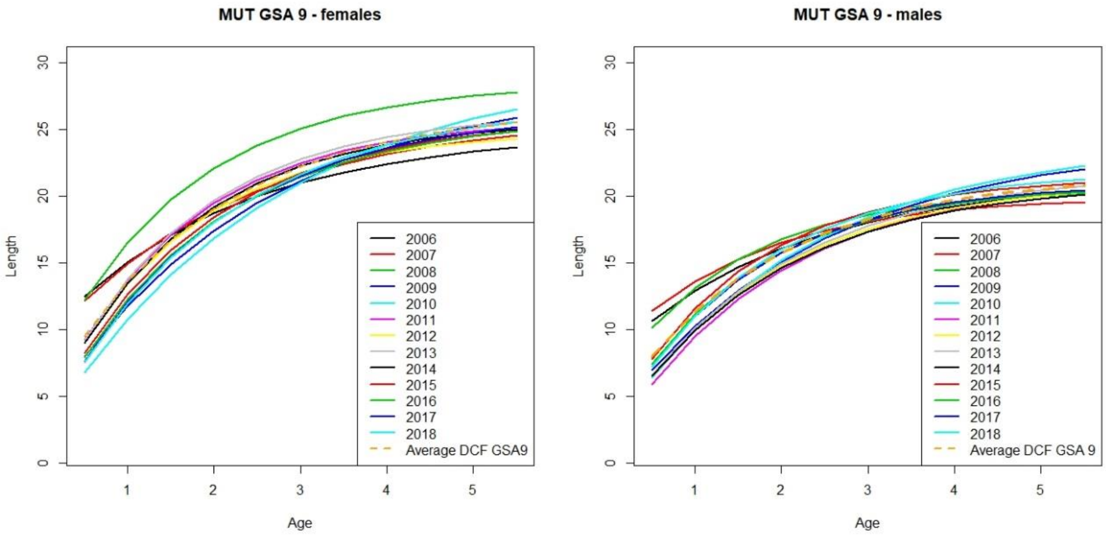


Figure 6.11.1.3 Red mullet in GSA 9: Estimated growth curves of red mullet in GSA9.

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 20-09 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 20-09 preferred to use the vector of maturity agreed and used for all the red mullet stocks assessed in the working group. Mortality and maturity parameters used in assessment are shown in Table 6.11.1.1.

Table 6.11.1.1 Red mullet in GSA 9: natural mortality and maturity vector at age.

Age	0	1	2	3	4+
M *	1.52	0.87	0.7	0.63	0.59
Proportion mature	0	1	1	1	1

6.11.2 DATA

6.11.2.1 CATCH (LANDINGS AND DISCARDS)

Principal fishing gears used to catch red mullet in GSA 9 together with other species (mixed catches) are gillnets (GNS), trammel nets (GTR) and bottom trawls (OTB). Length structure of red mullet catches (landings and discards) for all gears in the period from 2003 to 2019 are shown in Figures 6.11.2.1.1 - 6.11.2.1.3 for landings, discards and catches respectively.

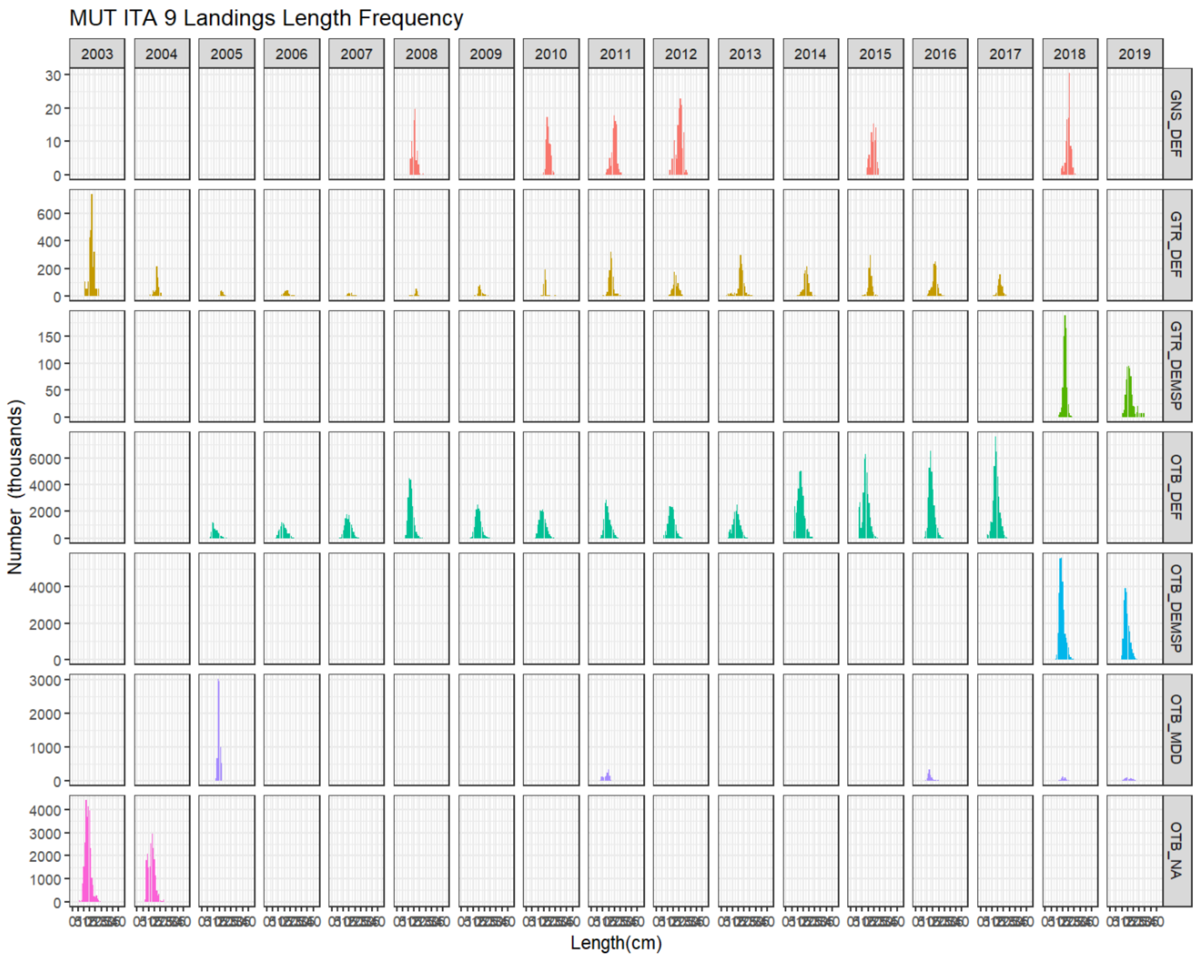


Figure 6.11.2.1.1 Red mullet in GSA 9: Length structure of red mullet landed in GSA 9 in the period from 2003 to 2019 by fishing gear and fishery.

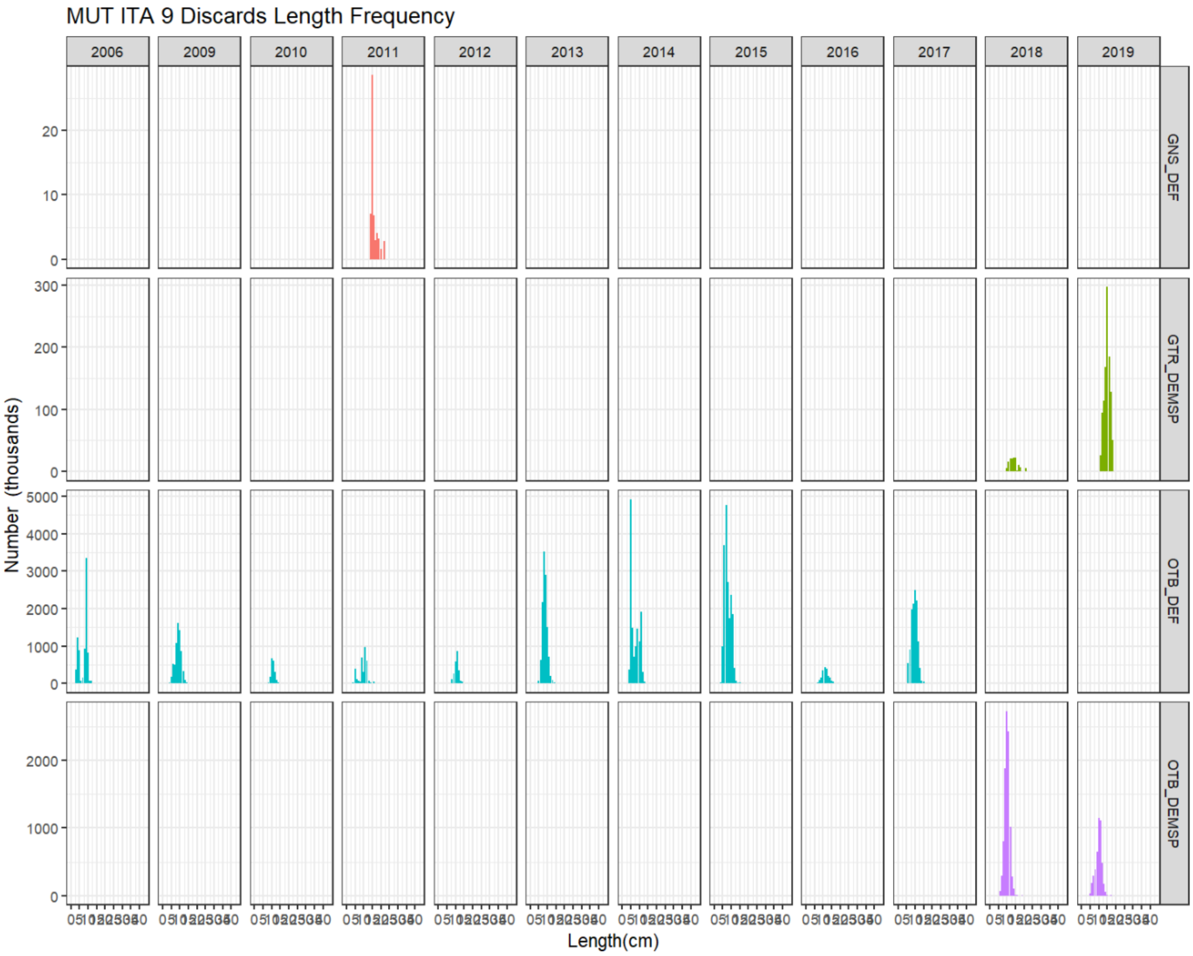


Figure 6.11.2.1.2 Red mullet in GSA 9: Length structure of red mullet catch discarded in GSA 9 in the period from 2006 to 2019 by fishing gear and fishery.

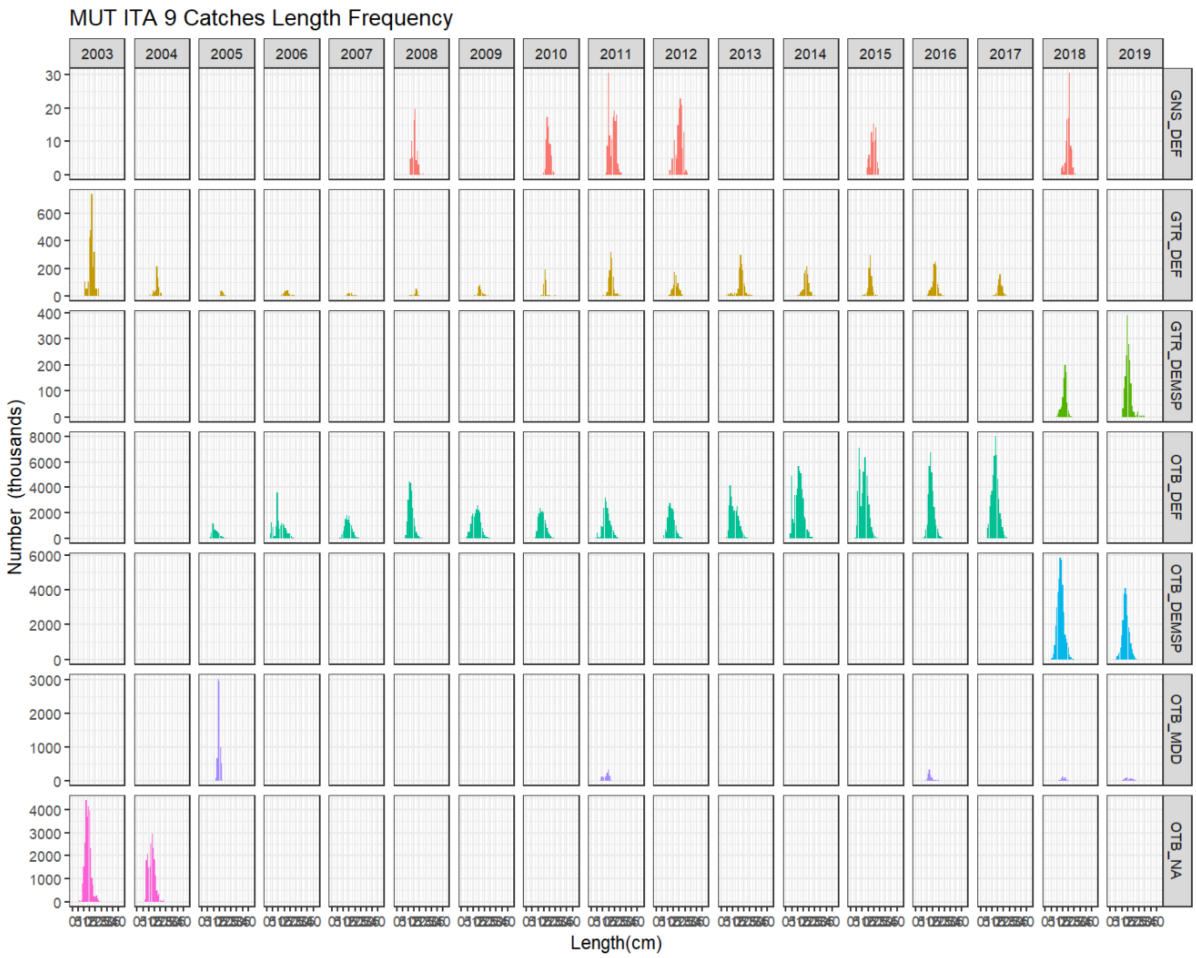


Figure 6.11.2.1.3 Red mullet in GSA 9: Length structure of red mullet total catch (landing plus discard) in GSA 9 in the period from 2003 to 2019 by fishing gear and fishery.

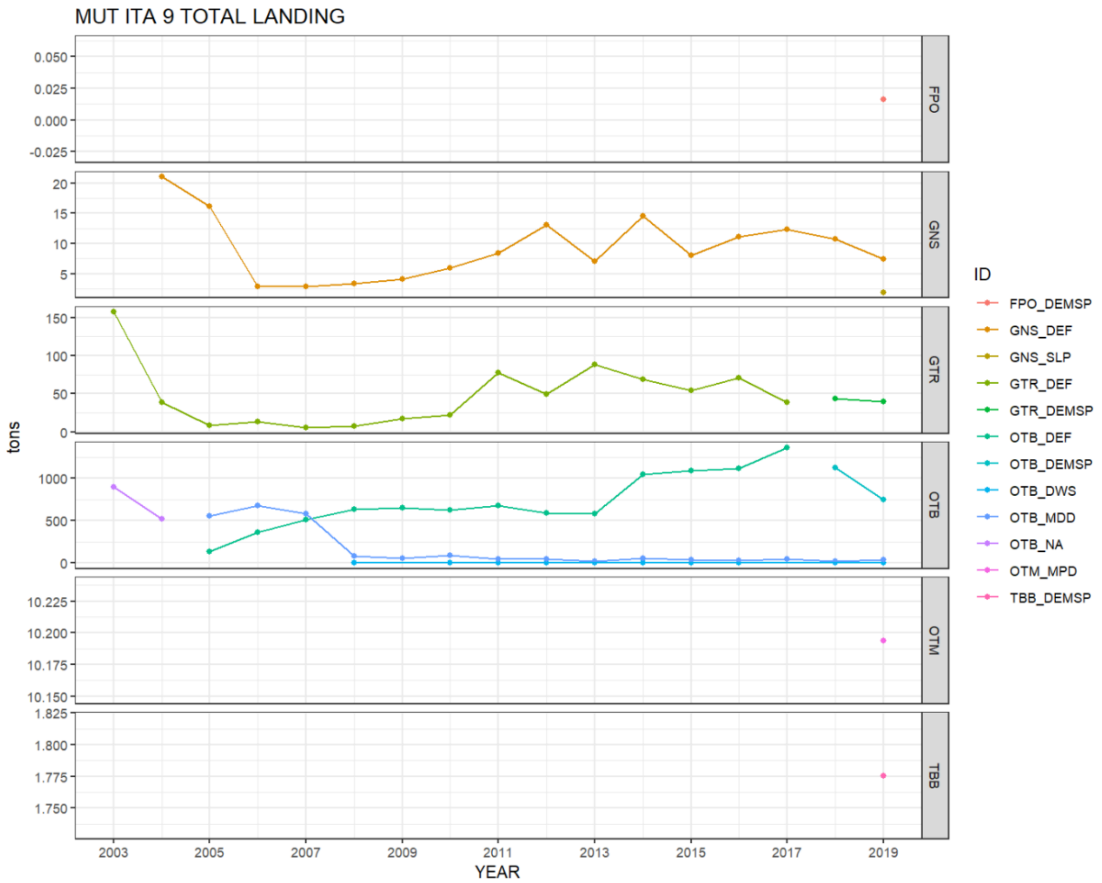


Figure 6.11.2.1.4 Red mullet in GSA 9: Landings (t) of red mullet in GSA 9 in the period from 2003 to 2019 by fishing gear and fishery.

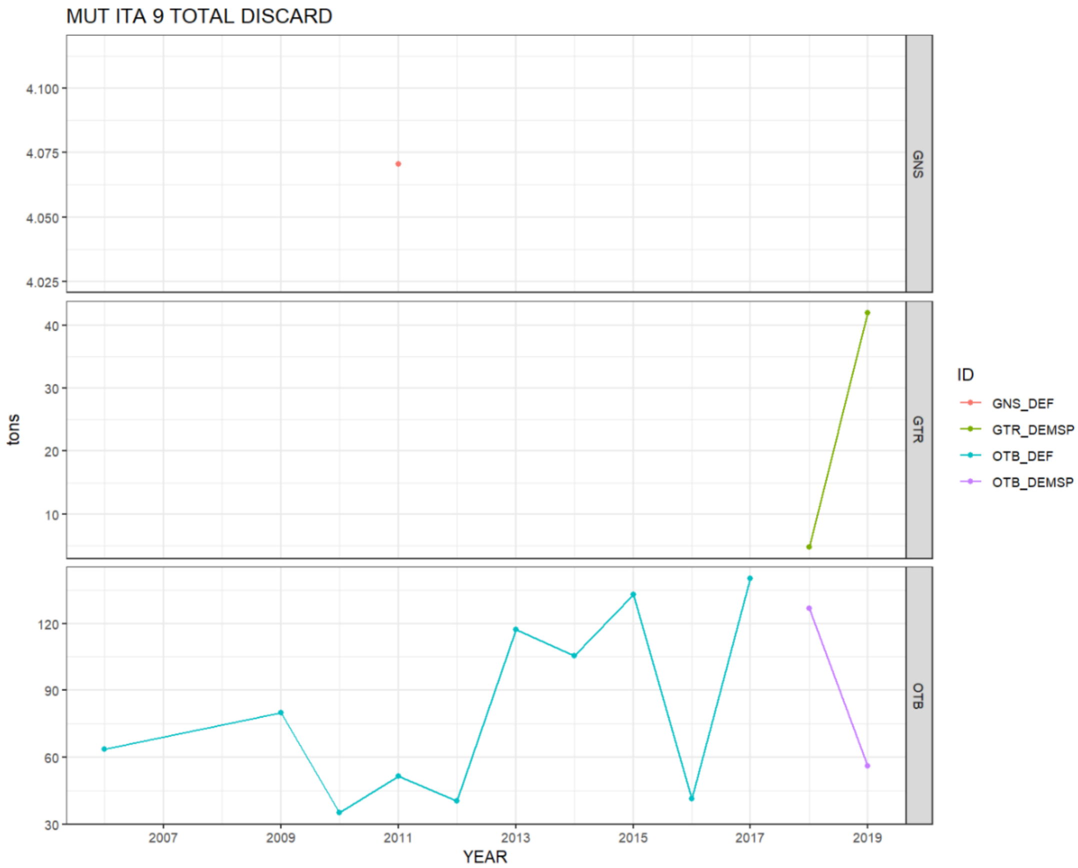


Figure 6.11.2.1.5 Red mullet in GSA 9: Discards (t) of red mullet in GSA 9 in the period from 2003 to 2019 by fishing gear and fishery.

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 2019. Values in red were reconstructed. Discards in 2003 were not reconstructed as 2003 was not used in the assessment.

	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	0.0	0.0	0.0	-
2004	21.0	38.6	521.1	0.0	580.7	0.0	0.0	**17.0**	**17.0**
2005	16.1	8.4	684.0	0.0	708.5	0.0	0.0	**19.5**	**19.5**
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	0.0	0.0	**77.0**	**77.0**
2008	3.4	7.4	716.3	0.0	727.1	0.0	0.0	**92.0**	**92.0**
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

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, approximations were made taking into account percentage of catch discarded in previous and/or following year.

6.11.2.2 Effort

Red mullet is caught by mixed fisheries, using more than a fishing gear (gillnets, trammel nets, trawls), by fishing boats of different sizes (different metiers, VL0006 - VL1824). With the aim to associate effort data with particular stock assessments, based on local expert knowledge, EWG 20-09 made a selection of gear types in different GSAs. Effort data for *Mullus barbatus* for GSA 9 are reported in Figure 6.11.2.2.1 and in Tables 6.11.2.2.1. and 6.11.2.2.2 for fishing days and days at sea respectively.

However, EWG 20-09 also highlights that gears indicated in the table are used in framework of different fisheries where multispecies catches are obtained. So, it is important to keep in mind that fishing effort data, that according to the ToR is analysed on fishing gear level, are related to multifisheries and multispecies aspects, and not just to one single species considered in the assessments.

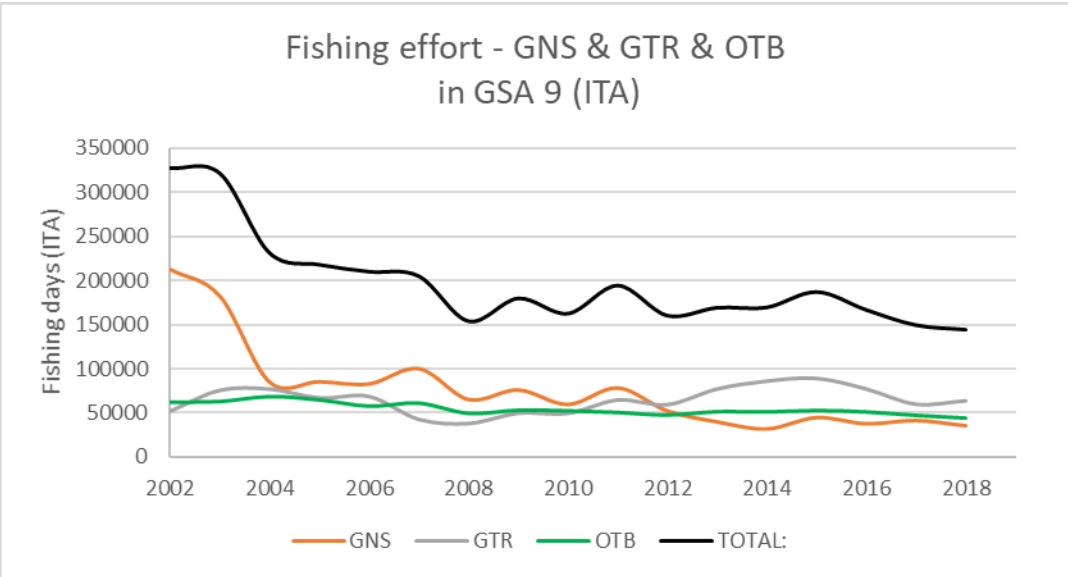


Figure 6.11.2.2.1 Red mullet in GSA 9: Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 9 in the period 2002-2018.

Table 6.11.2.2.1 Red mullet in GSA 9: Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 9 in the period 2002-2018.

YEAR	GNS (GSA9)	GTR (GSA9)	OTB (GSA9)	**TOTAL:**
2002	212455	52193	62616	**327265**
2003	182159	75479	63331	**320969**
2004	84893	76802	68950	**230645**
2005	85487	66927	65080	**217493**
2006	82971	68556	58004	**209531**
2007	100280	42878	61360	**204518**
2008	65286	38371	49757	**153414**
2009	76140	49830	53329	**179299**
2010	59708	49711	52617	**162036**
2011	78452	64654	50736	**193843**
2012	52450	59401	47849	**159700**
2013	40024	76974	51713	**168711**
2014	32058	85701	51284	**169043**
2015	44857	88784	52936	**186578**
2016	37949	76977	51301	**166226**
2017	41566	59937	47459	**148962**
2018	35705	63723	44321	**143749**

Table 6.11.2.2.2 Red mullet in GSA 9: Effort (days at sea) associated to *Mullus barbatus* in GSA 9 in the period 2002-2018.

	GNS	GTR	OTB	Total
2002	212455.4	52193.11	62616.5	327265
2003	182158.7	75479.02	63331.27	320969
2004	82163.11	74235.07	67827.51	224225.7
2005	83554.54	65817.63	67713.57	217085.7
2006	81688.8	65937.85	62516.75	210143.4
2007	99988.2	42745	64161.07	206894.3
2008	64754.85	37908.23	49758.79	152421.9
2009	74733.06	48728.33	53330.45	176791.8
2010	58778.3	49086.67	52606.12	160471.1
2011	77406.5	63909.87	50736.79	192053.2
2012	50560.92	57420.22	47851.04	155832.2
2013	35473.43	74997.49	51715.36	162186.3
2014	30015.32	80963.25	51285.86	162264.4
2015	43630.29	86417.56	52900.08	182947.9
2016	37026.27	74173.6	51256.7	162456.6
2017	41019.37	59023.62	47456.85	147499.8
2018	34218.53	62727.54	44296.1	141242.2

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 20-09 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 20-09 also noted very different survey periods in these two years, concluding that autumn survey in 2017 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, 1994-2018), 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.

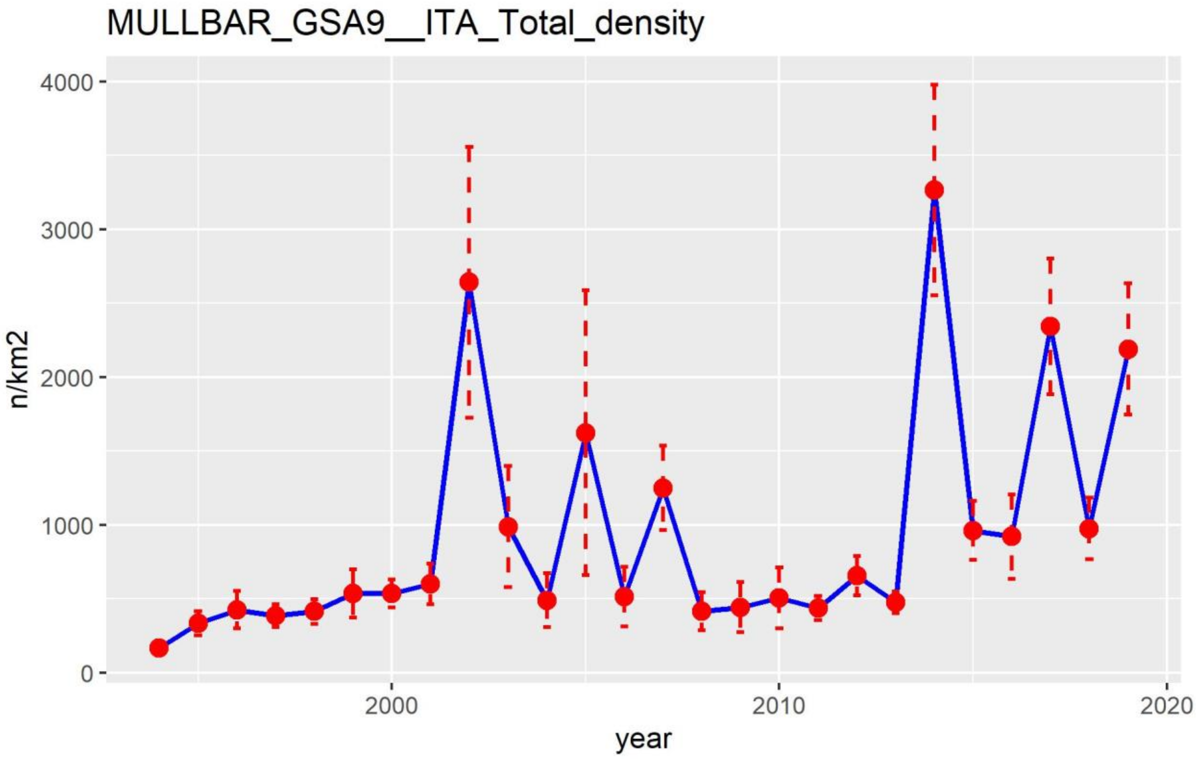


Figure 6.11.2.3.2 Red mullet in GSA 9: Abundance indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).

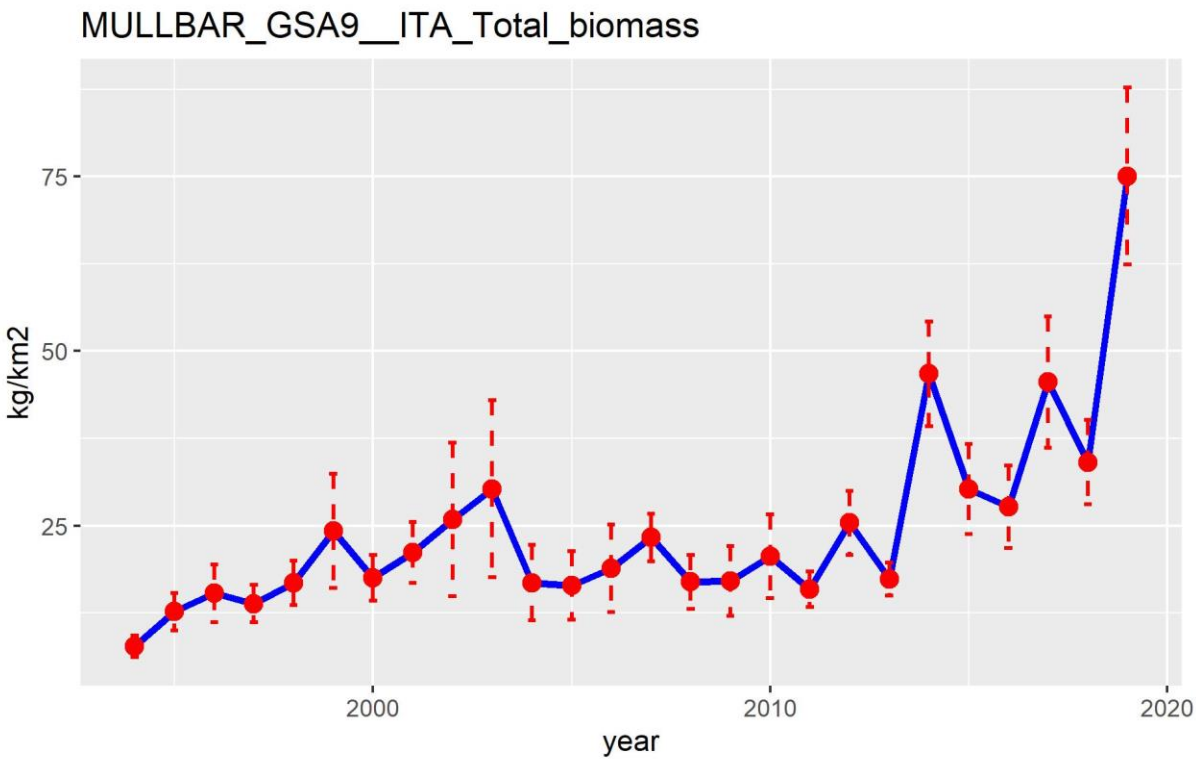


Figure 6.11.2.3.3 Red mullet in GSA 9: Biomass indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).

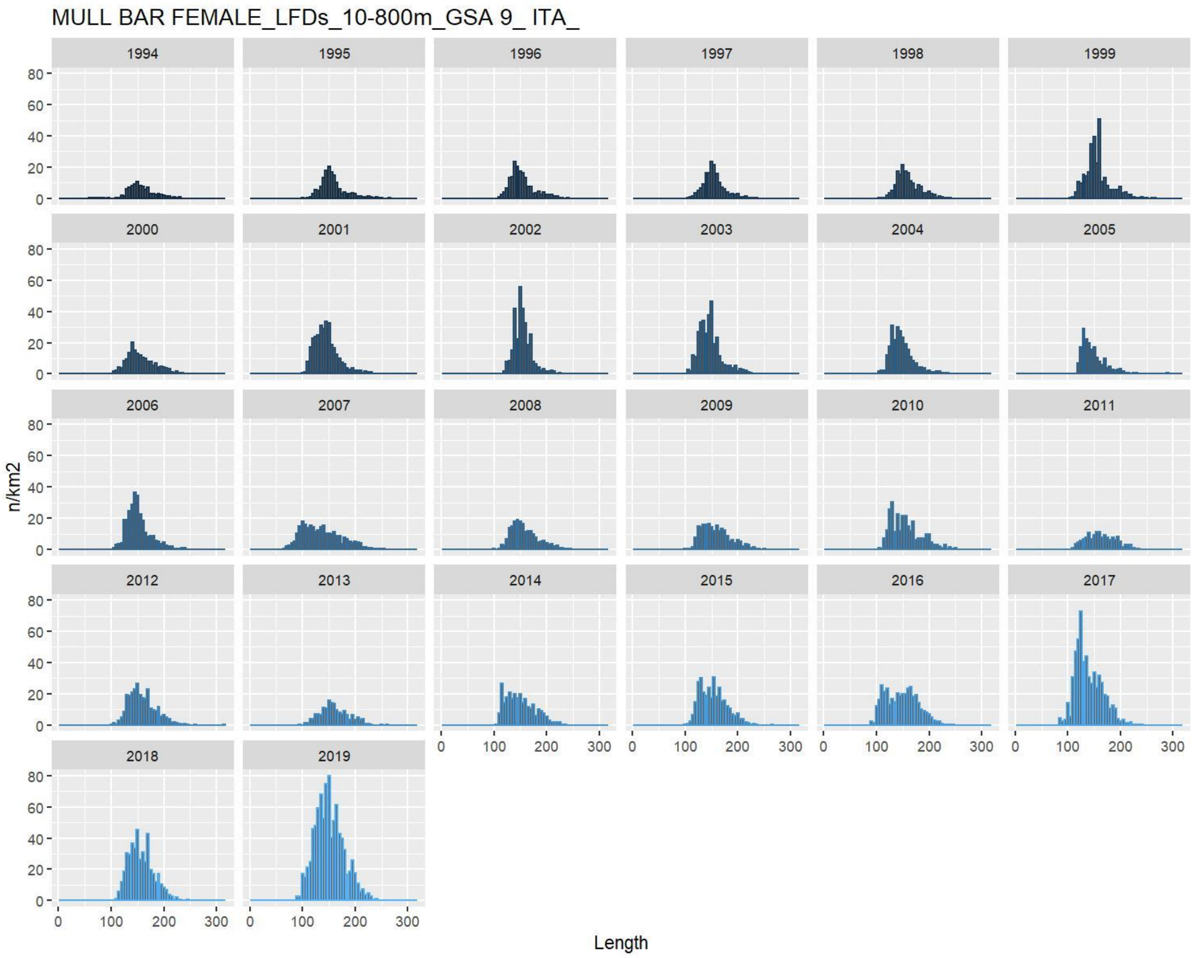


Figure 6.11.2.3.6 Red mullet in GSA 9: Size structure indices (females) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).

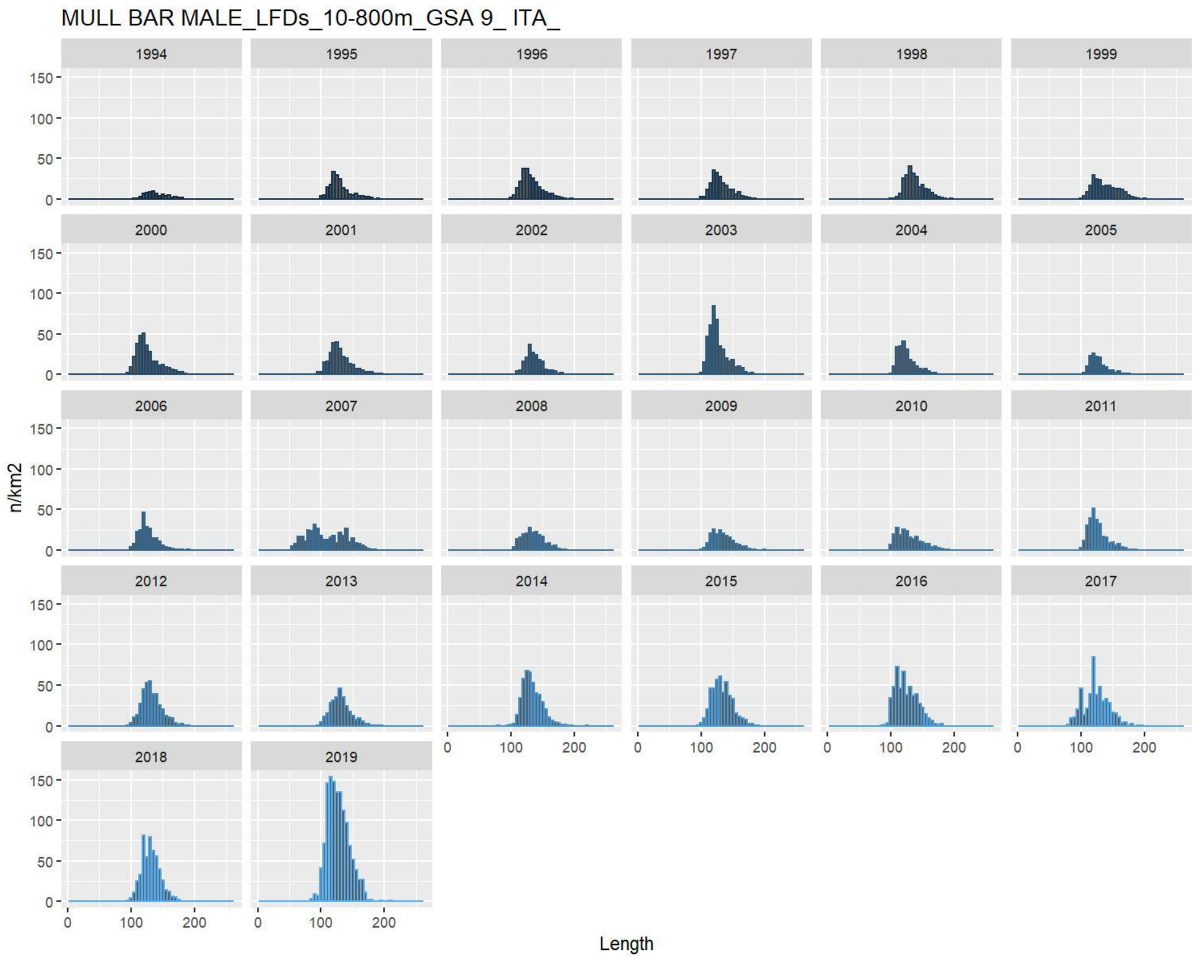


Figure 6.11.2.3.7 Red mullet in GSA 9: Size structure indices (males) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).

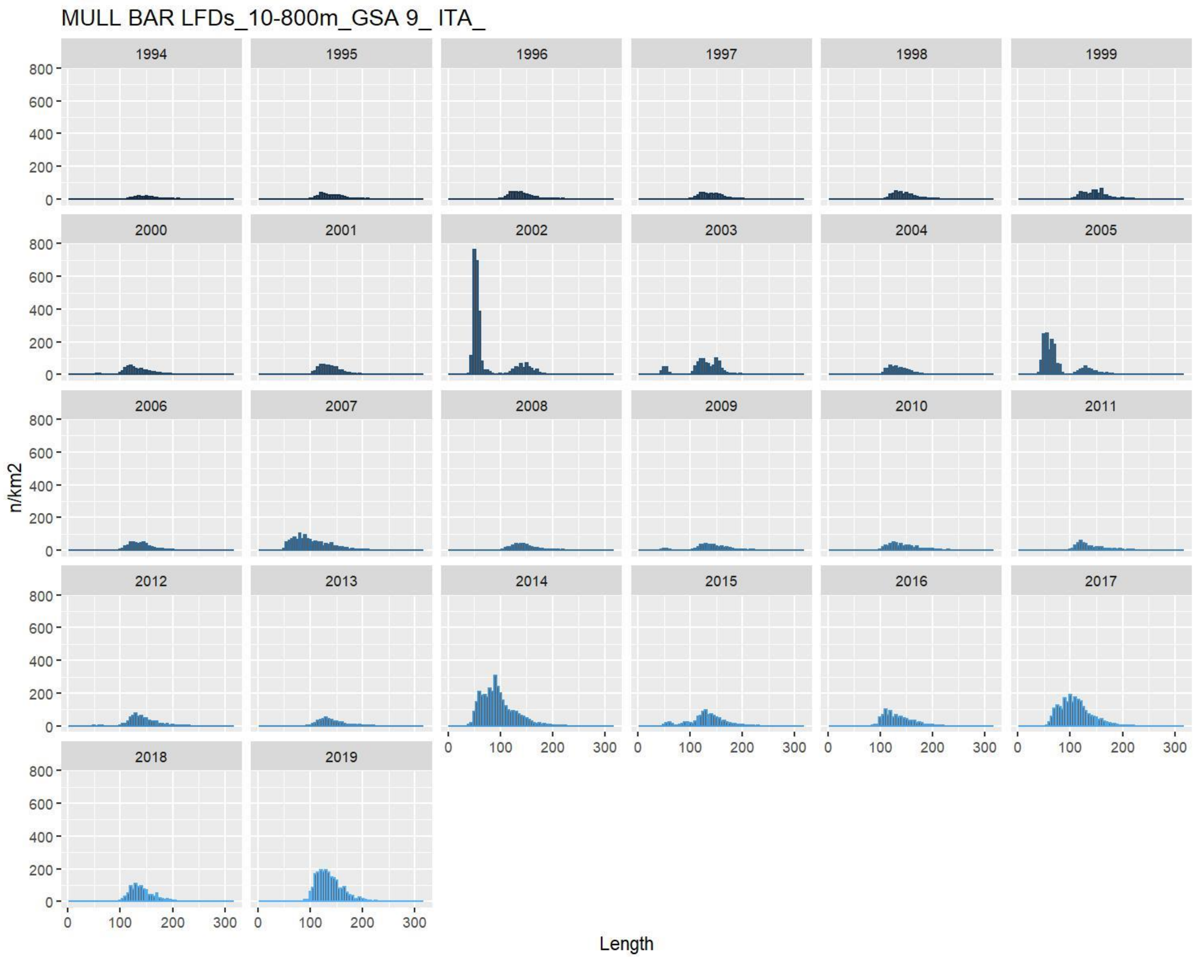


Figure 6.11.2.3.8 Red mullet in GSA 9: Size structure indices (total) of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2019).

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 2003-2019. Despite availability of commercial fishery data since 2003, the assessment was carried out from 2004 in accordance with EWG 18-12 and EWG 19-10, for which the inclusion of 2003 resulted in worse model fit than excluding this year.

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. SoP corrections were applied separately to landings numbers at age by year, and discards numbers at age by year. 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+
2004	3214.1	16571.6	3774.3	288.4	110.4
2005	2900.0	16684.4	6222.3	300.6	8.8
2006	5768.4	20336.8	8284.8	1130.4	228.2
2007	3109.7	22881.6	8738.3	1035.6	238.1
2008	3993.7	30744.8	3693.5	291.6	37.1
2009	2894.8	16489.4	5951.2	685.6	156.9
2010	303.3	14872.5	5853.9	709.9	173.8
2011	1258.9	16181.4	6430.1	807.2	123.3
2012	839.7	16205.4	5198.0	579.1	110.6
2013	7705.3	19975.5	5520.9	683.0	109.1
2014	13129.1	34694.1	8061.8	750.0	177.9
2015	15211.0	35045.2	8097.5	777.8	98.3
2016	389.2	27084.7	8883.0	884.4	168.6
2017	4410.7	38164.0	11042.0	1023.7	161.4
2018	1441.3	28316.7	9881.6	934.3	141.9
2019	910.0	18553.7	7185.9	746.2	115.9

Total catches used in the assessment:

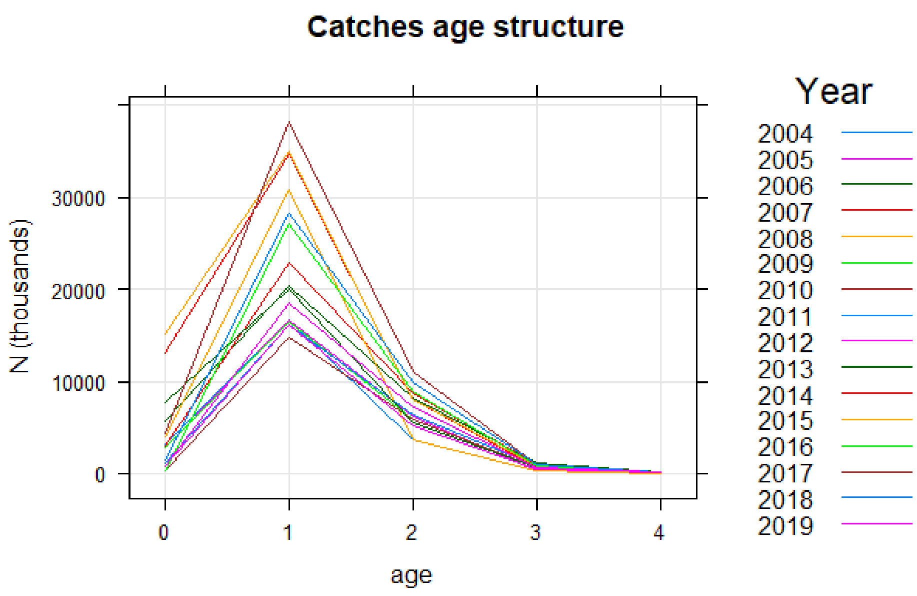
Year	Catches (t)
2004	597.71
2005	727.99
2006	1113.21
2007	1172.97
2008	819.06
2009	808.45
2010	783.06
2011	861.12
2012	733.23
2013	810.46
2014	1287.03
2015	1316.30
2016	1262.84
2017	1600.77
2018	1336.30
2019	942.12

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+
2004	0.006	0.022	0.049	0.077	0.132
2005	0.005	0.026	0.040	0.068	0.135
2006	0.004	0.023	0.059	0.089	0.138
2007	0.005	0.024	0.056	0.081	0.139
2008	0.006	0.019	0.046	0.082	0.136
2009	0.005	0.024	0.053	0.083	0.146
2010	0.008	0.025	0.055	0.083	0.156
2011	0.005	0.025	0.057	0.086	0.126
2012	0.006	0.024	0.052	0.083	0.141
2013	0.005	0.020	0.055	0.085	0.136
2014	0.003	0.021	0.054	0.080	0.127
2015	0.004	0.022	0.050	0.079	0.129
2016	0.008	0.026	0.052	0.084	0.130
2017	0.006	0.024	0.051	0.082	0.126
2018	0.007	0.025	0.053	0.085	0.123
2019	0.005	0.026	0.053	0.079	0.146

Table 6.11.3.3 Red mullet in GSA 9: Survey index (MEDITS) values at age per year used in the assessment.

	Age				
Year	0	1	2	3	4
2004	0.0	407.7	71.7	9.1	1.22
2005	1242.9	308.5	60.4	7.3	1.1
2006	1.5	410.7	89.1	9.4	2.4
2007	435.4	668.6	124.0	17.8	1.6
2008	0.0	261.1	132.3	19.6	0.7
2009	23.2	266.7	127.1	21.1	1.6
2010	0.0	347.7	128.0	23.7	2.9
2011	0.0	311.7	106.1	16.5	1.0
2012	6.9	429.0	199.0	18.0	1.9
2013	0.0	318.8	127.0	15.8	1.0
2014	1398.3	1632.8	213.5	18.8	0.7
2015	94.0	602.7	240.4	22.9	1.0
2016	4.6	687.7	209.5	16.2	1.2
2017	497.7	1620.6	188.0	13.3	1.9
2018	1.3	666.1	287.8	18.5	0.4
2019	2.9	1626.7	513.8	41.2	2.9



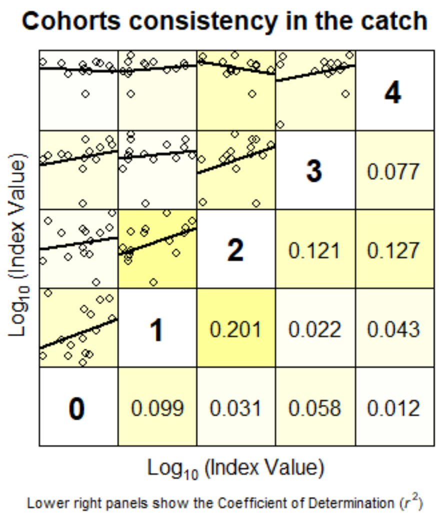
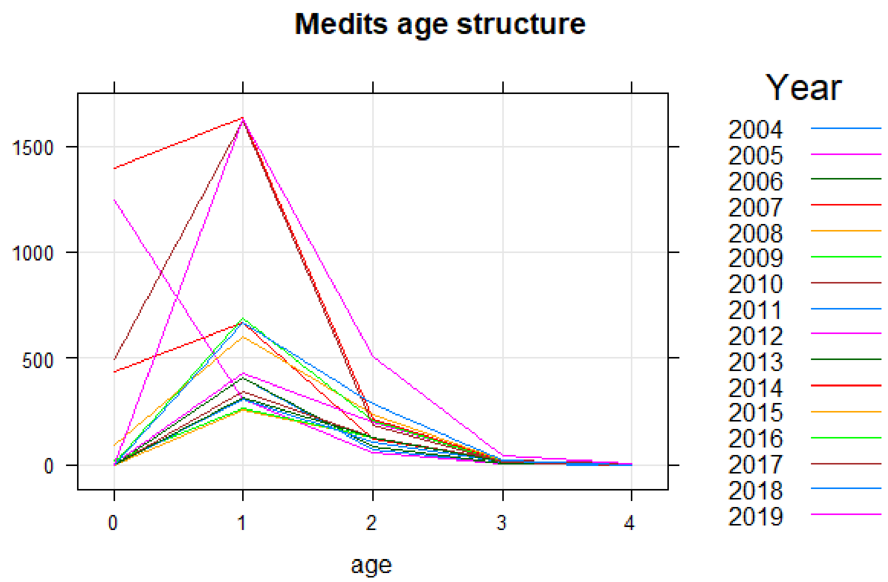


Figure 6.11.3.1 Red mullet in GSA 9: Catch-at-age data of red mullet in GSA9 used in assessment, and cohorts internal consistency.

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.



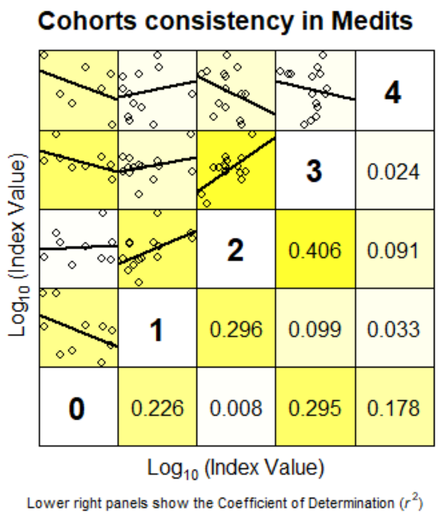


Figure 6.11.3.2 Red mullet in GSA 9: MEDITS indices describing density by age of red mullet in GSA9 by year, and cohorts internal consistency.

For the assessment purposes, the model selected by EWG 19-10 was used also by EWG 20-09. The only difference is the increase of k in the year smoother of the F sub-model from 6 to 7. The age0 was removed from the tuning index, as done at EWG 19-10. An Fbar range between age1 and age3 was used, as in previous assessments.

Sub-models of the a4a assessment used for MUT9 at EWG 20-09:

fmodel: ~s(replace(age, age > 2, 2), k = 3) + s(year, k = 7)

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         3.500000e+01
nlogl         7.512138e+01
maxgrad       4.435953e-07
nobs          1.440000e+02
gcv           5.162353e-01
convergence   0.000000e+00
accrate                 NA
nlogl_comp1   3.817010e+01
nlogl_comp2   3.701640e+01
nlogl_comp3  -6.511220e-02
```

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

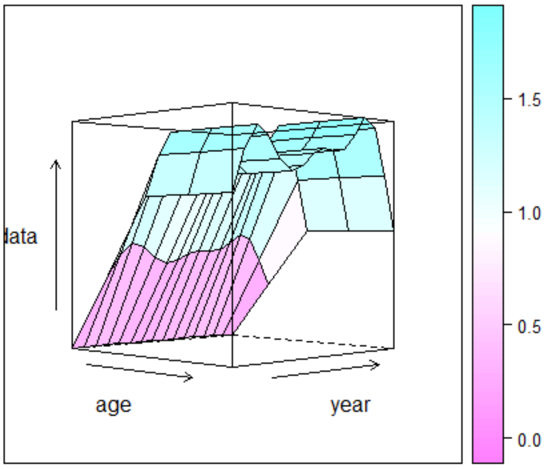


Figure 6.11.3.3 Red mullet in GSA 9: 3D-plot of the F-at-age for red mullet in GSA9.

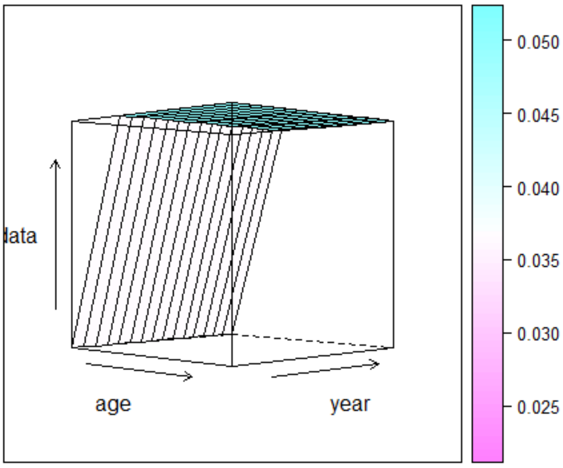


Figure 6.11.3.4 Red mullet in GSA 9: 3D-plot of the catchability of the MEDITS survey for red mullet in GSA9.

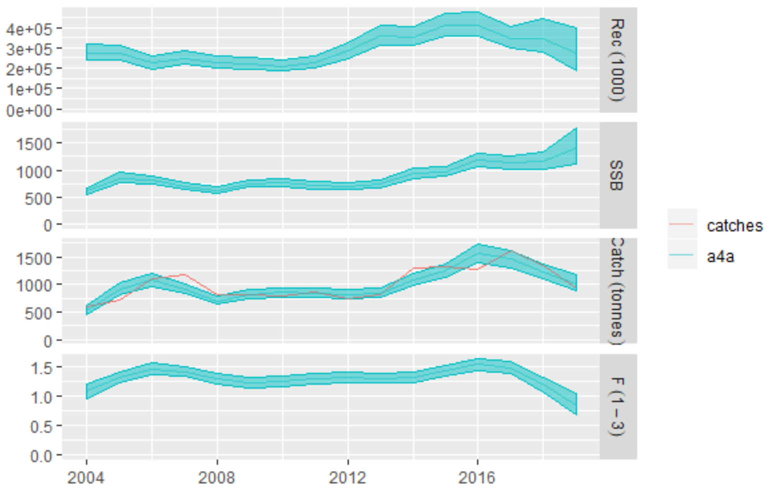


Figure 6.11.3.5 Red mullet in GSA 9: Results of the best a4a model for red mullet in GSA9. The observed catches are shown by the red line.

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
0.101	-0.118	-0.297

The Mohn's rho value is outside the acceptable range (-0.2 +0.2) for recruitment only.

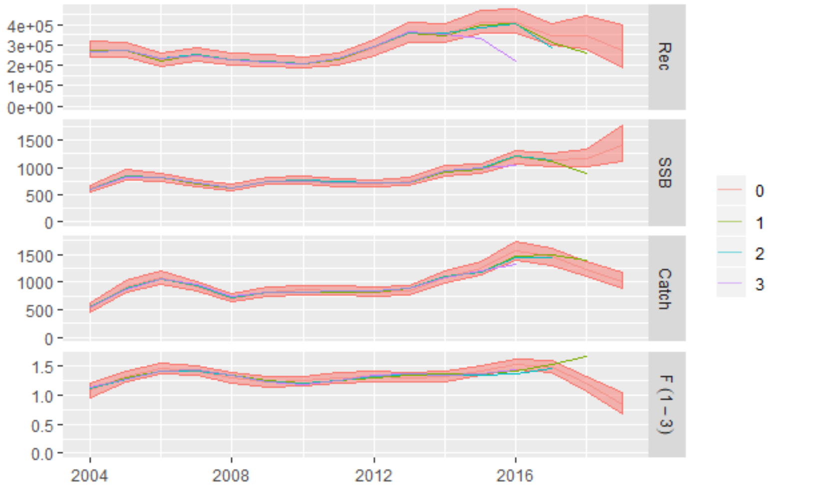


Figure 6.11.3.6 Red mullet in GSA 9: Retrospective analysis of the selected a4a model for red mullet in GSA9. Confidence intervals are also shown.

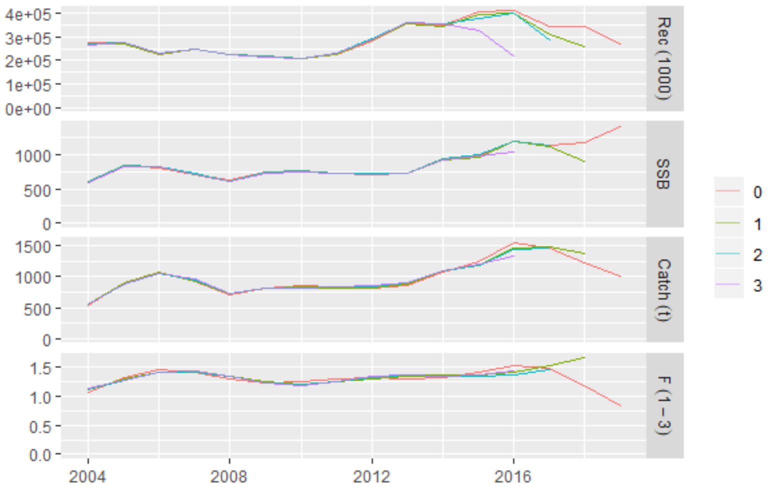


Figure 6.11.3.6bis Red mullet in GSA 9: Retrospective analysis of the selected a4a model for red mullet in GSA9.

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.

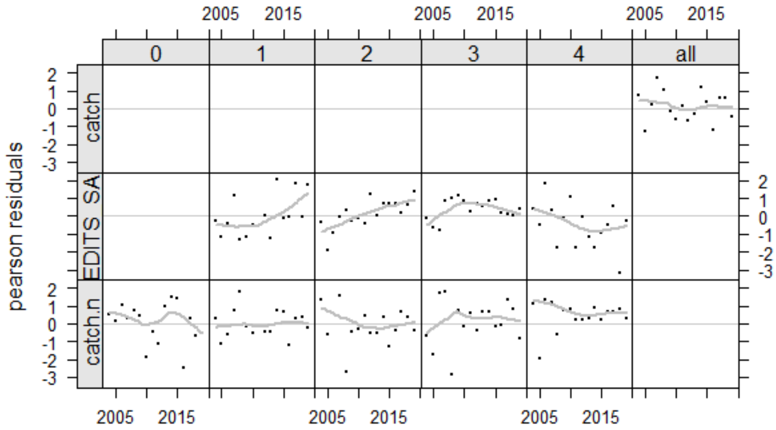


Figure 6.11.3.8 Red mullet in GSA 9: Pearson residuals of catch and abundance indices for red mullet in GSA9.

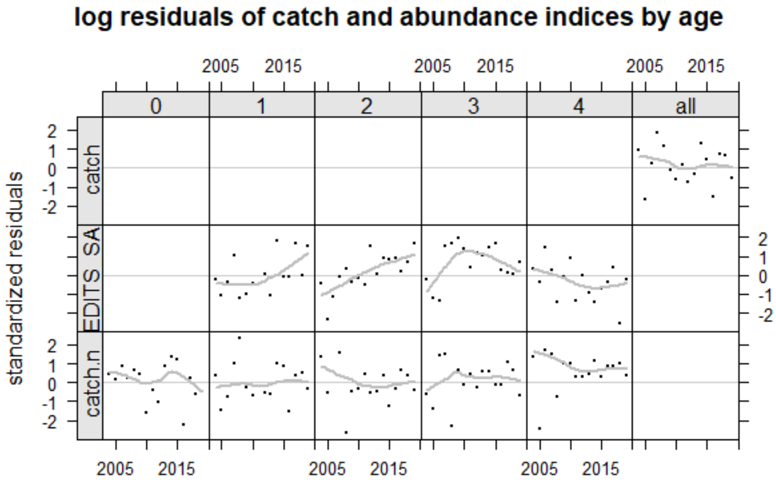


Figure 6.11.3.9 Red mullet in GSA 9: Log residuals of catch and abundance indices for red mullet in GSA9.

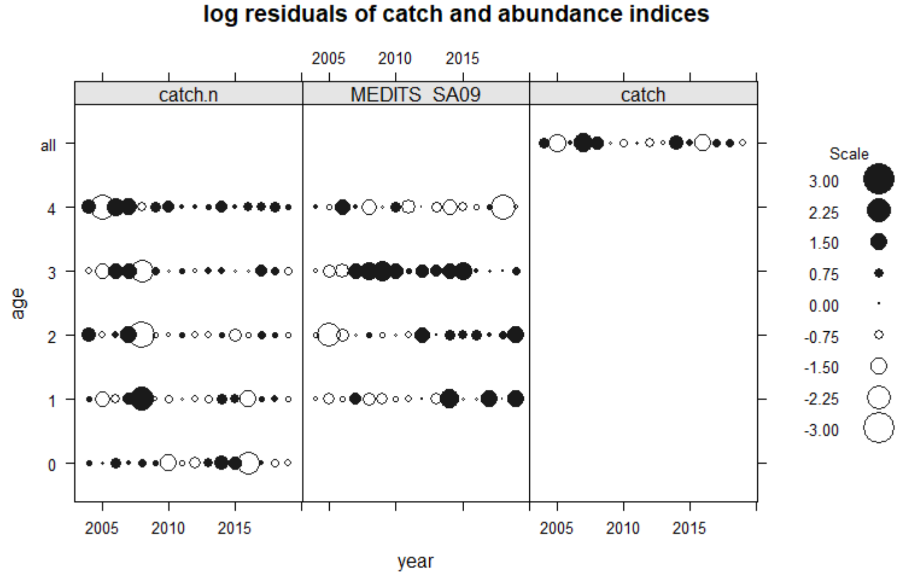


Figure 6.11.3.10 Red mullet in GSA 9: Bubble plot of the log residuals of catch and abundance indices for red mullet in GSA9.

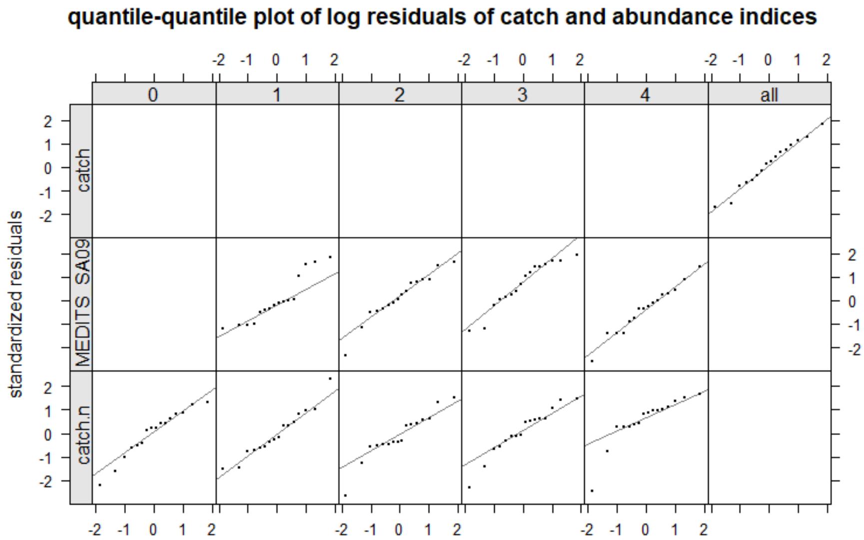


Figure 6.11.3.11 Red mullet in GSA 9: QQ-plot of the log residuals of catch and abundance indices for red mullet in GSA9.

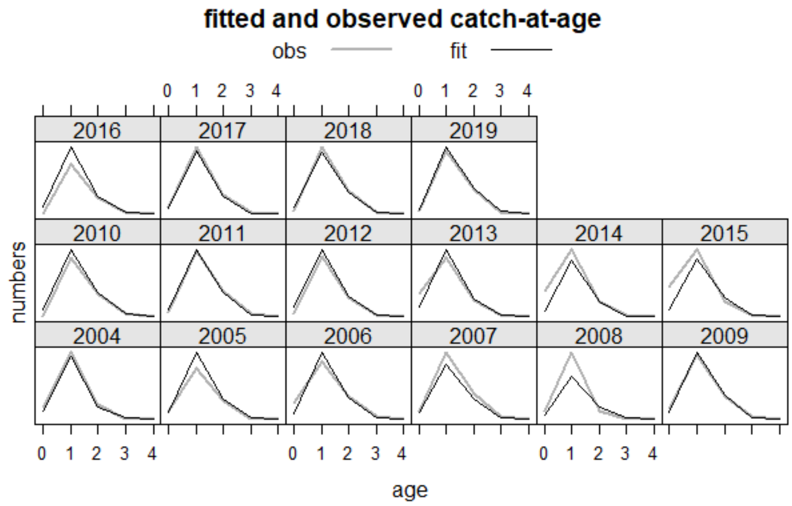


Figure 6.11.3.12 Red mullet in GSA 9: Fitting of the catch-at-age data for red mullet in GSA9.

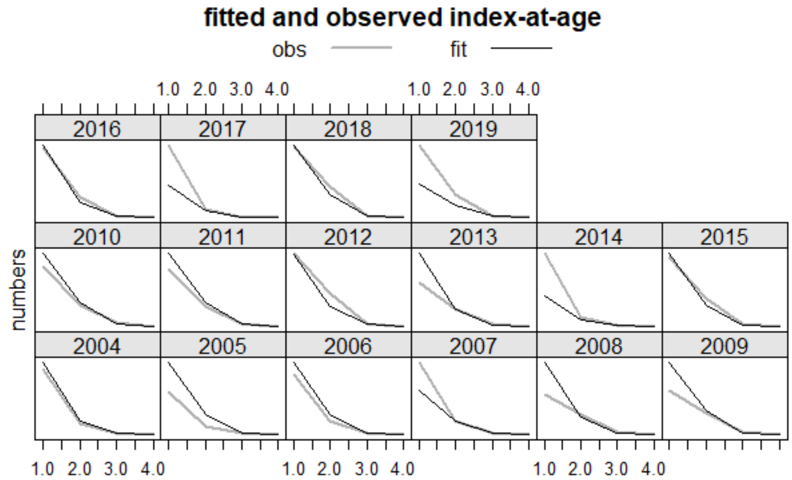


Figure 6.11.3.13 Red mullet in GSA 9: Fitting of the numbers-at-age data of the MEDITS survey for red mullet in GSA9.

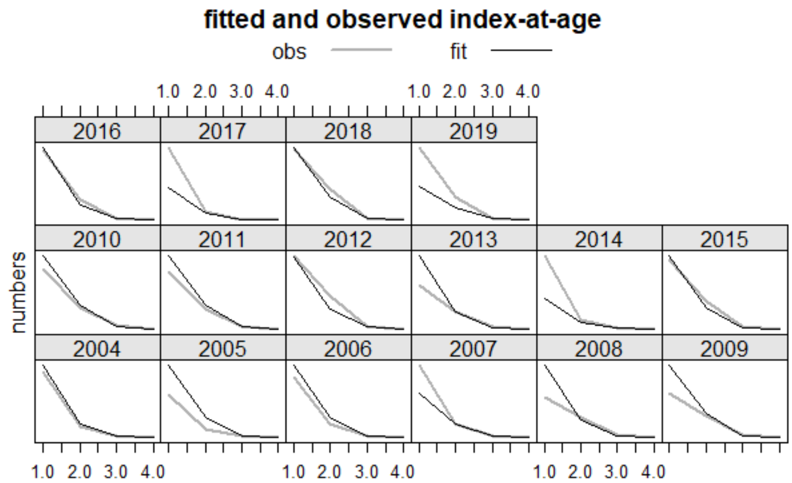


Figure 6.11.3.14 Red mullet in GSA 9: Variance contribution of model components: catches and survey for red mullet in GSA9.

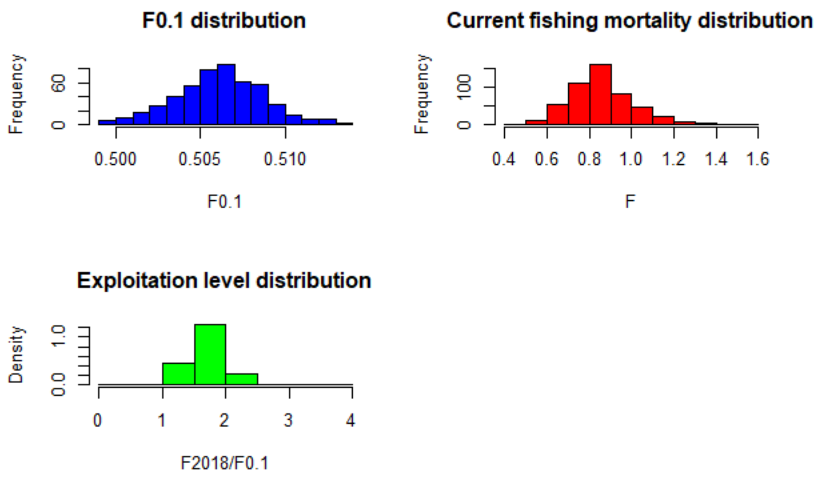


Figure 6.11.3.15 Red mullet in GSA 9: Histograms of probability for F0.1, Fcurr and level of exploitation (Fcurr/F01 ratio) values for red mullet in GSA9.

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
2004	274237	305251	243223	609.8	660.9	558.7	528.5	1.08	1.18	0.98
2005	274554	304905	244203	849.5	927.2	771.8	910.8	1.32	1.38	1.26
2006	222784	247444	198124	810.1	875.2	745	1078.0	1.46	1.53	1.39
2007	246943	272036	221850	700.8	757.6	644	915.3	1.42	1.49	1.35
2008	226577	248693	204461	620.4	668.4	572.4	703.9	1.30	1.37	1.23
2009	220550	242780	198320	753.5	810.9	696.1	822.9	1.23	1.30	1.16
2010	210358	231804	188912	760.9	819.4	702.4	852.5	1.25	1.31	1.19
2011	225954	249889	202019	718.9	772	665.8	843.8	1.30	1.37	1.23
2012	283974	311207	256741	705.3	761.8	648.8	814.1	1.32	1.39	1.25
2013	356827	394153	319501	733.0	786.2	679.8	846.6	1.30	1.36	1.24
2014	351139	386899	315379	947.0	1021.2	872.8	1080.5	1.32	1.39	1.25
2015	408721	450445	366997	973.0	1048.1	897.9	1236.5	1.43	1.50	1.36
2016	410882	451317	370447	1186.1	1280.4	1091.8	1554.8	1.54	1.61	1.47
2017	344590	386307	302873	1136.7	1231.6	1041.8	1453.0	1.48	1.56	1.40
2018	346897	413619	280175	1174.6	1298.9	1050.3	1230.1	1.20	1.29	1.11
2019	271663	351613	191713	1408.9	1669.3	1148.5	1011.2	0.85	0.99	0.71

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+
2004	274236.7	48043.1	5465.733	598.993	63.234
2005	274554	59125.87	10826.54	730.884	95.345
2006	222784.4	59005.76	11602.08	1080.261	88.834
2007	246943.4	47791.39	10688.67	977.458	105.964
2008	226576.7	53003.19	8867.751	947.465	103.411
2009	220549.6	48709.86	10541.09	910.286	116.16
2010	210358.4	47456.55	10070.76	1174.701	123.248
2011	225953.7	45252.46	9707.378	1097.198	152.251
2012	283974.2	48574.37	8987.456	993.62	137.845
2013	356826.9	61034.45	9561.101	902.647	122.483
2014	351138.6	76709.76	12129.62	979.973	113.24
2015	408721.1	75465.21	15055.7	1210.829	117.537
2016	410881.9	87720.89	13962.79	1326.533	125.98
2017	344589.8	88052.81	15211.85	1072.601	120.094
2018	346896.6	73899.45	15752.4	1248.14	105.388
2019	271663.1	74678.54	15597.4	1833.825	169.534

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+
2004	0.01	0.62	1.31	1.31	1.31
2005	0.02	0.76	1.60	1.60	1.60
2006	0.02	0.84	1.77	1.77	1.77
2007	0.02	0.81	1.72	1.72	1.72
2008	0.02	0.75	1.58	1.58	1.58
2009	0.02	0.71	1.49	1.49	1.49
2010	0.02	0.72	1.52	1.52	1.52
2011	0.02	0.75	1.58	1.58	1.58
2012	0.02	0.76	1.60	1.60	1.60
2013	0.02	0.75	1.58	1.58	1.58
2014	0.02	0.76	1.60	1.60	1.60
2015	0.02	0.82	1.73	1.73	1.73
2016	0.02	0.88	1.87	1.87	1.87
2017	0.02	0.85	1.80	1.80	1.80
2018	0.02	0.69	1.45	1.45	1.45
2019	0.01	0.48	1.03	1.03	1.03

6.11.4 EFERENCE 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 0.51. Current F values (2019), as calculated by model a4a, is 0.85 indicating that the stock is being overfished.

6.11.5 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 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} = 0.85 terminal F (2019) from the a4a assessment was used for F in 2020. Recruitment is observed to be fluctutating over the period of the assessment (Figure 6.11.3.5) so the average across the whole time series is used as an estimate of recruits from 2020. Recruitment (age 0) for 2020 to 2022 has been estimated from the population results as the geometric mean of the whole time series of 16 years (285136).

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 2017-2019	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-3}$ (2020)	0.85	F 2019 used to give F status quo for 2020
SSB (2020)	1289.9	Stock assessment 1 January 2020
R_{age0} (2020,2022)	285136	Geometric mean of the time series (16 years)
Total catch (2020)	1030	Assuming F status quo for 2020

The short term forecast was carried out estimating a catch for 2020-2022 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 2020 equal to 1011.2 and 1289.9 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.51) would increase biomass of 28% from 2020 to 2022, while decreasing the catch of the 34% from 2019 to 2021.

Table 6.11.5.2 Red mullet in GSA 9: Short term forecast table for red mullet in GSA 9.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2021	SSB* 2020	SSB* 2022	Change SSB 2020-2022 (%)	Change Catch 2019-2021 (%)
High long term yield ($F_{0.1}$)	0.6	0.51	1011.2	667.6	1290.0	1650.7	28.0	-34.0
F upper	0.8	0.69	1011.2	851.1	1290.0	1426.5	10.6	-15.8
F lower	0.4	0.34	1011.2	474.7	1290.0	1906.0	47.8	-53.1
F_{MSY} transition (intermediate year)	0.9	0.73	1011.2	889.0	1290.0	1382.5	7.2	-12.1
Zero catch	0.0	0.00	1011.2	0.0	1290.0	2618.4	103.0	-100.0
Status quo	1.0	0.85	1011.2	986.2	1290.0	1273.0	-1.3	-2.5
Different Scenarios	0.1	0.08	1011.2	131.9	1290.0	2408.5	86.7	-87.0
	0.2	0.17	1011.2	254.7	1290.0	2221.3	72.2	-74.8
	0.3	0.25	1011.2	369.2	1290.0	2054.0	59.2	-63.5
	0.4	0.34	1011.2	476.0	1290.0	1904.3	47.6	-52.9
	0.5	0.42	1011.2	575.7	1290.0	1769.9	37.2	-43.1
	0.6	0.51	1011.2	668.9	1290.0	1649.2	27.8	-33.9
	0.7	0.59	1011.2	756.1	1290.0	1540.4	19.4	-25.2
	0.8	0.68	1011.2	837.7	1290.0	1442.3	11.8	-17.2
	0.9	0.76	1011.2	914.3	1290.0	1353.5	4.9	-9.6
	1.1	0.93	1011.2	1053.7	1290.0	1200.0	-7.0	4.2
	1.2	1.01	1011.2	1117.1	1290.0	1133.4	-12.1	10.5
	1.3	1.10	1011.2	1176.9	1290.0	1072.7	-16.8	16.4
	1.4	1.18	1011.2	1233.2	1290.0	1017.1	-21.2	22.0
	1.5	1.27	1011.2	1286.3	1290.0	966.2	-25.1	27.2
	1.6	1.35	1011.2	1336.5	1290.0	919.3	-28.7	32.2
	1.7	1.44	1011.2	1383.9	1290.0	876.2	-32.1	36.9
	1.8	1.52	1011.2	1428.7	1290.0	836.4	-35.2	41.3
	1.9	1.61	1011.2	1471.1	1290.0	799.5	-38.0	45.5
	2.0	1.69	1011.2	1511.4	1290.0	765.3	-40.7	49.5

*SSB at mid year

EWG advises that when the MSY approach is applied, catches in 2021 should be no more than 667.6 tonnes.

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 show continuous distribution of the red mullets along western Italian coast (i.e. continuity in spatial distribution in GSA10 and GSA9).

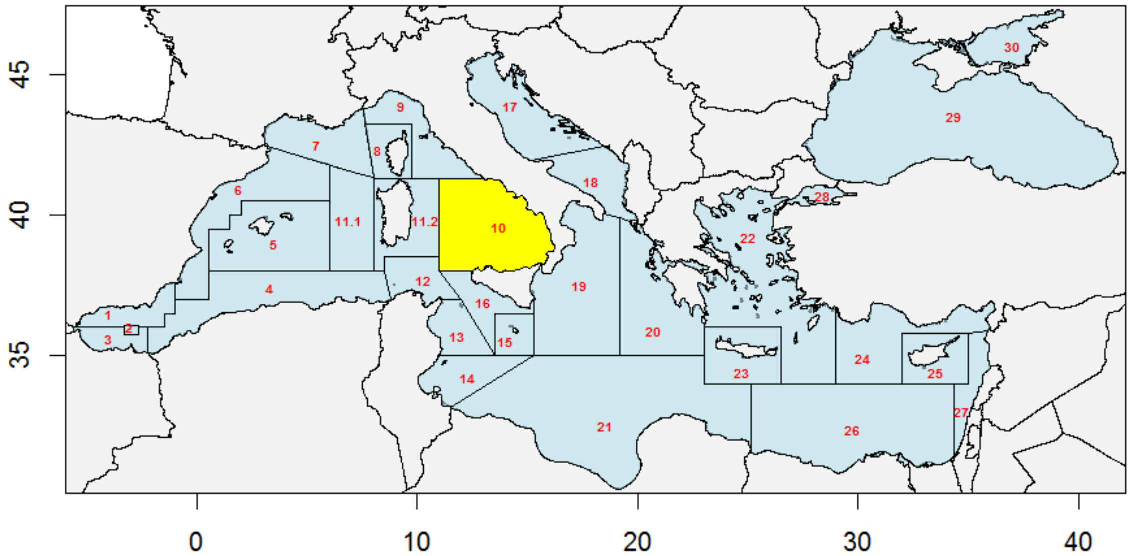


Figure 6.12.1.1 Red mullet in GSA 10. Spatial location of the stock.

Growth

The information on the age-length key (ALK) and on the growth von Bertalanffy parameters was available from 2017 to 2019. The parameters of 2017 appeared consistent with the recent study of Carbonara et al. (2018) on age validation of red mullet in Adriatic Sea and with the parameters used in the STECF last assessment of 2019.

The group agreed to use the 2017 growth parameters without correction on t_0 for consistency used in the last stock assessment: females: Linf=30, k=0.243, t0=-0.62; males: Linf=26, k=0.237, t0=-0.9.

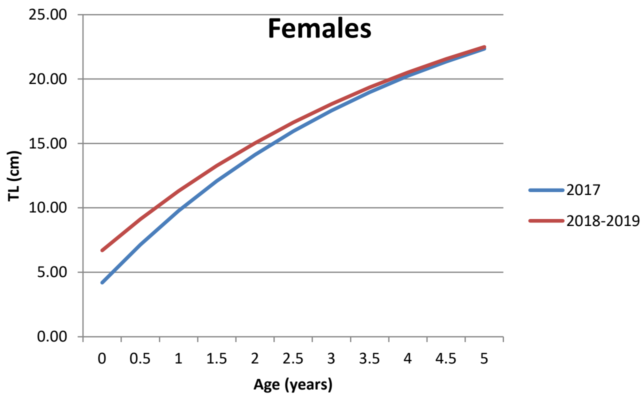


Figure 6.12.1.2 Red mullet in GSA 10. Growth curves (DCF).

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 same growth parameters used in the slicing.

Maturity

Maturity ogives by length and age were available from 2017 to 2019. 2018 and 2019 show a maturity at age different from what used in the last assessment and observed in 2017 (Figure 6.12.1.3). The EWG 20-09 aggreed to apply the vector used in previous years. Mortality and maturity parameters used in assessment are shown in Table 6.12.1.1.

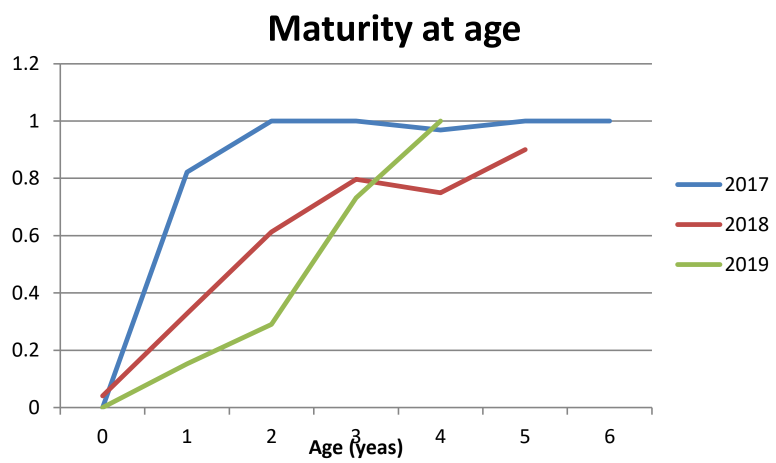


Figure 6.12.1.3 Red mullet in GSA 10. Maturity at age.

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 2019 are shown in Figures 6.12.2.1.1 and 6.12.2.1.2 for landing and discards, respectively, and in 6.12.2.1.3 for combined landing plus discards.

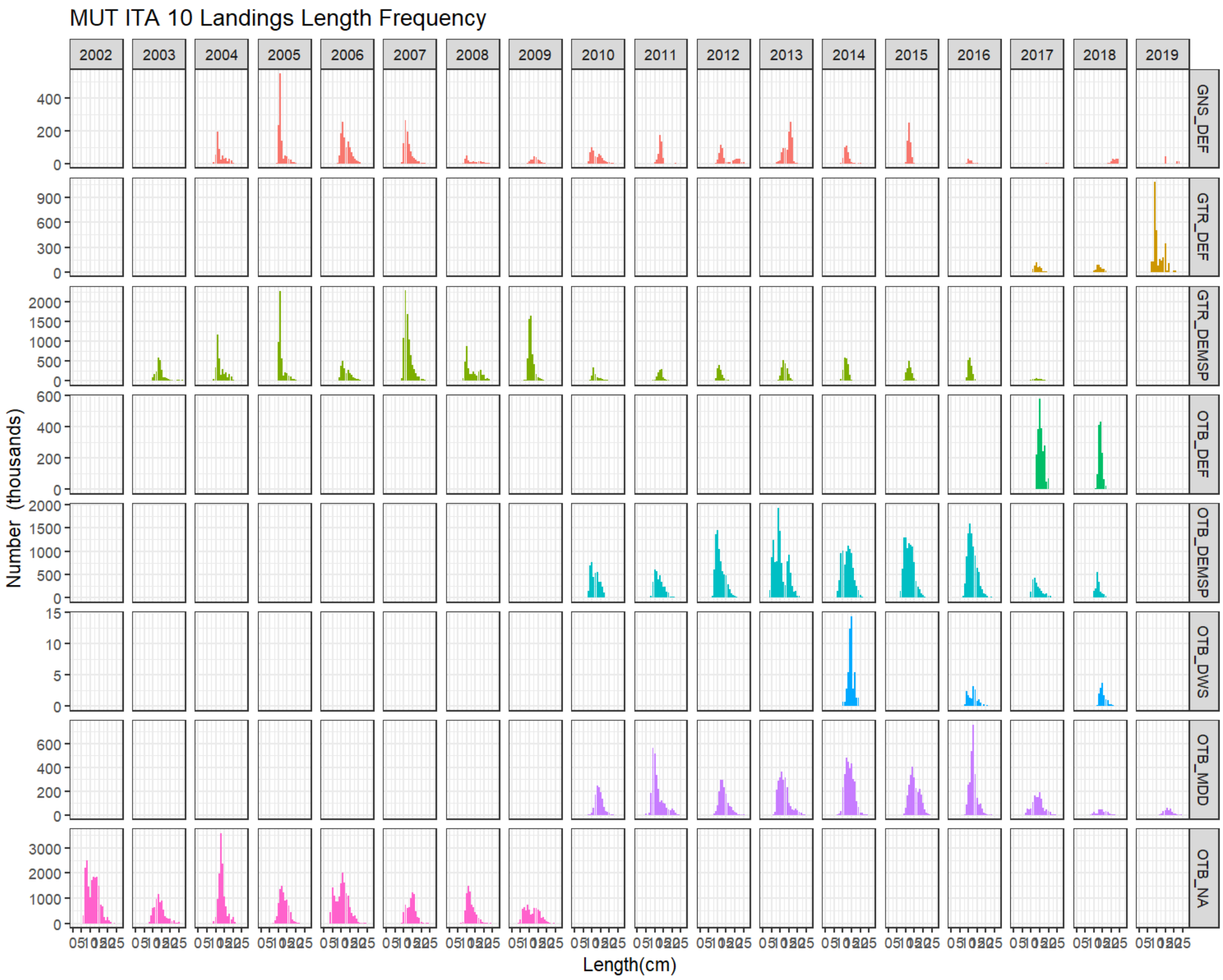


Figure 6.12.2.1.1 Red mullet in GSA 10. Length structure in the period from 2002 to 2019 by fishing gear and fishery.

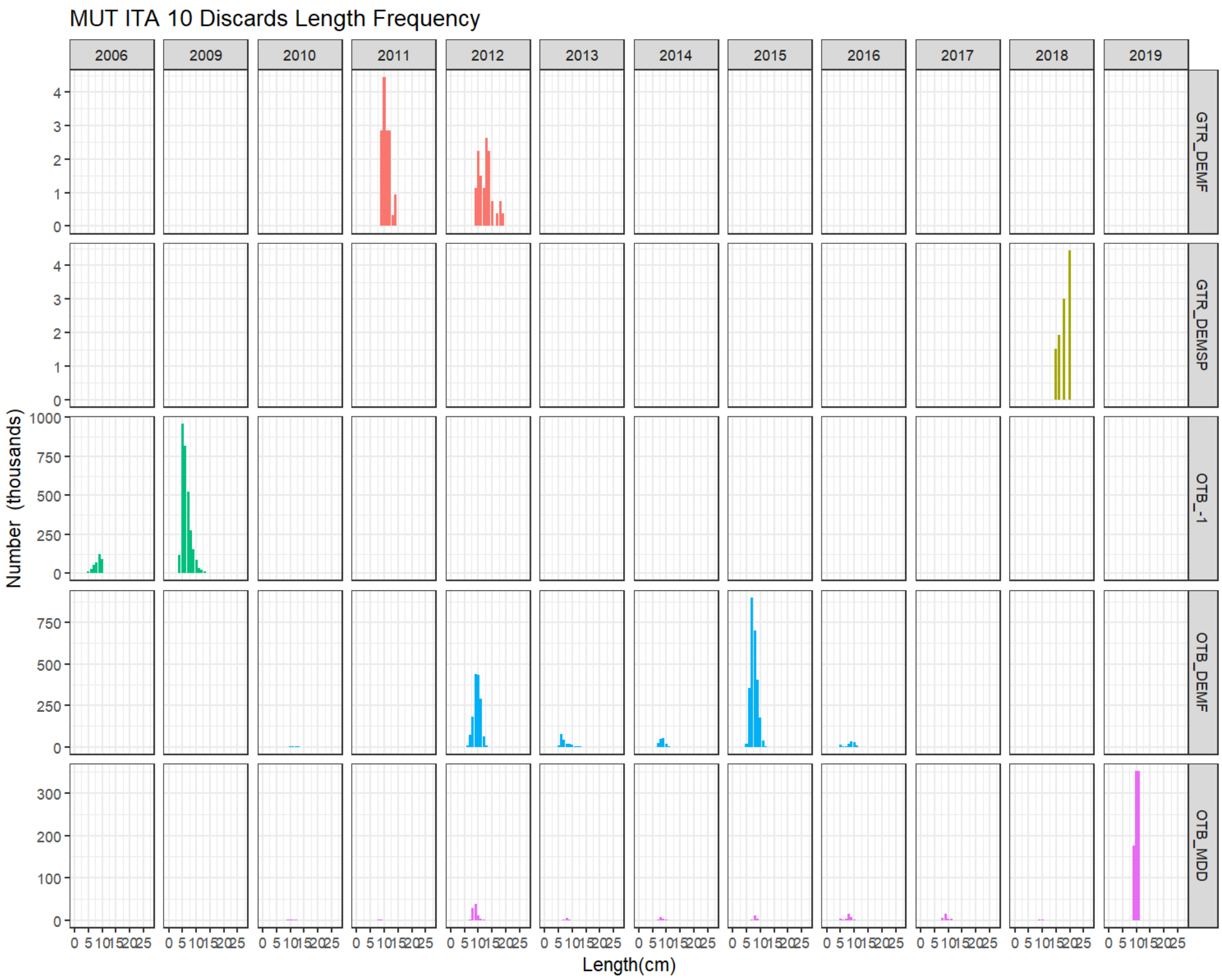


Figure 6.12.2.1.2 Red mullet in GSA 10. Length structure of discarded catch in the period from 2006 to 2019 by fishing gear and fishery.

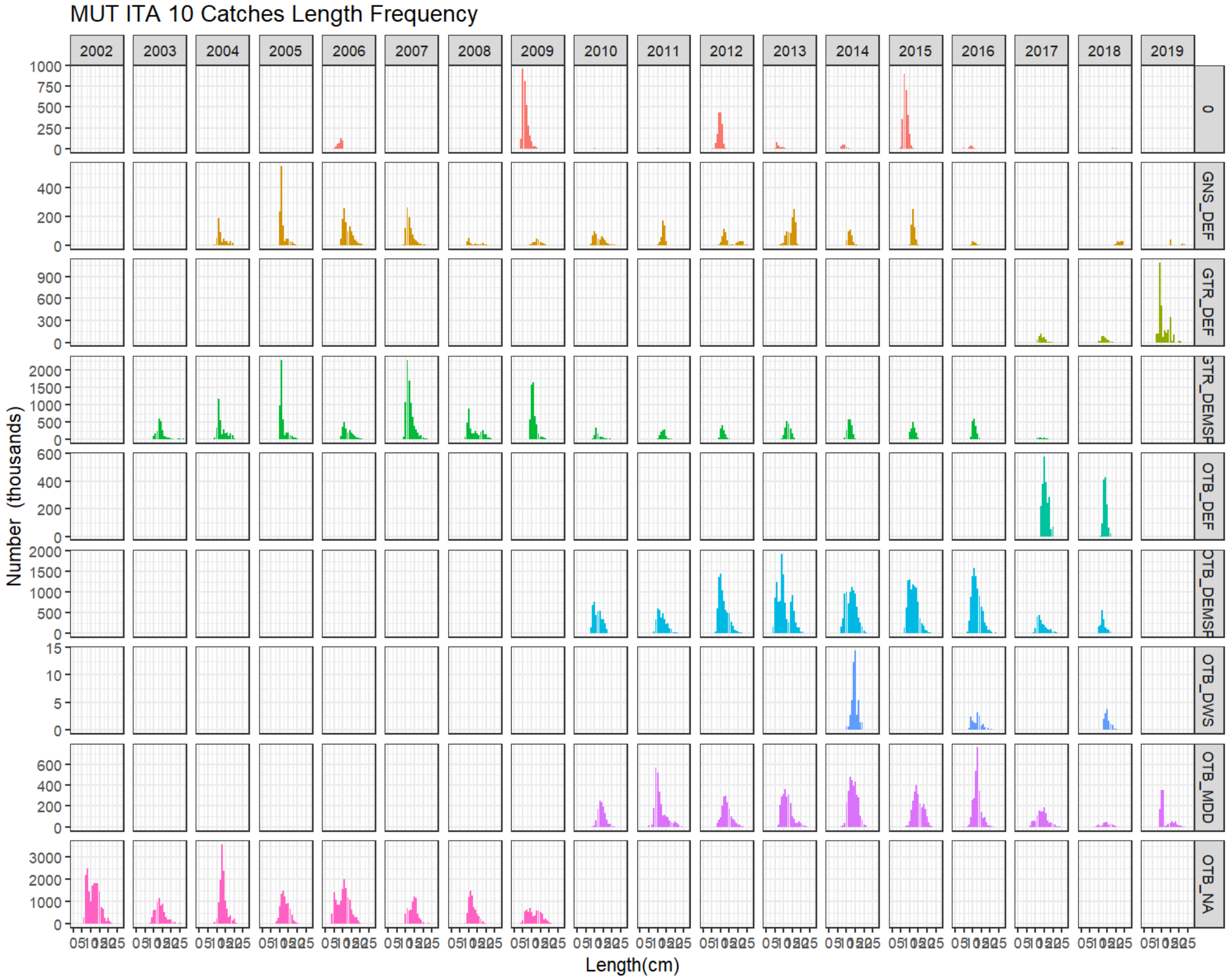


Figure 6.12.2.1.3 Red mullet in GSA 10. Length structure of catches (landing+discarded catch) in the period from 2002 to 2019 by fishing gear and fishery.

The discard data, in the years where it was not available, were reconstructed on the basis of the closest discard data available, and included in the assessment, according to what made in the previous assessment.

In Table 6.12.2.1.1 are reported the observed catch and the corresponding SOP corrections applied.

Table 6.12.2.1.1 Red mullet in GSA 10. Observed catch (DCF data) and SOP correction by year.

Years	Catch	SOP corrections
2002	839	2.1
2003	419	1.3
2004	524	1.1
2005	421	1.3
2006	396	1.1
2007	502	1.1
2008	315	1.1
2009	291	1.1
2010	177	1.1
2011	210	1.1
2012	283	1.1
2013	382	1.2
2014	439	1.2
2015	437	1.2
2016	354	1.1
2017	306	1.3
2018	309	2.7
2019	417	5.2

6.12.2.2. EFFORT

Red mullet is caught by mixed fisheries, using more than a fishing gear (gillnets, trammel nets, trawls), by fishing boats of different sizes (different metiers, VL0006 - VL1824). With the aim to associate effort data with particular stock assessments, based on local expert knowledge, EWG20-09 made a selection of gear types in different GSAs. Effort data for *Mullus barbatus* for GSA 10 are reported in figure 6.12.2.2.1 and table 6.12.2.2.1. However, EWG20-09 also highlights that gears indicated in the table are used in framework of different fisheries where multispecies catches are obtained.

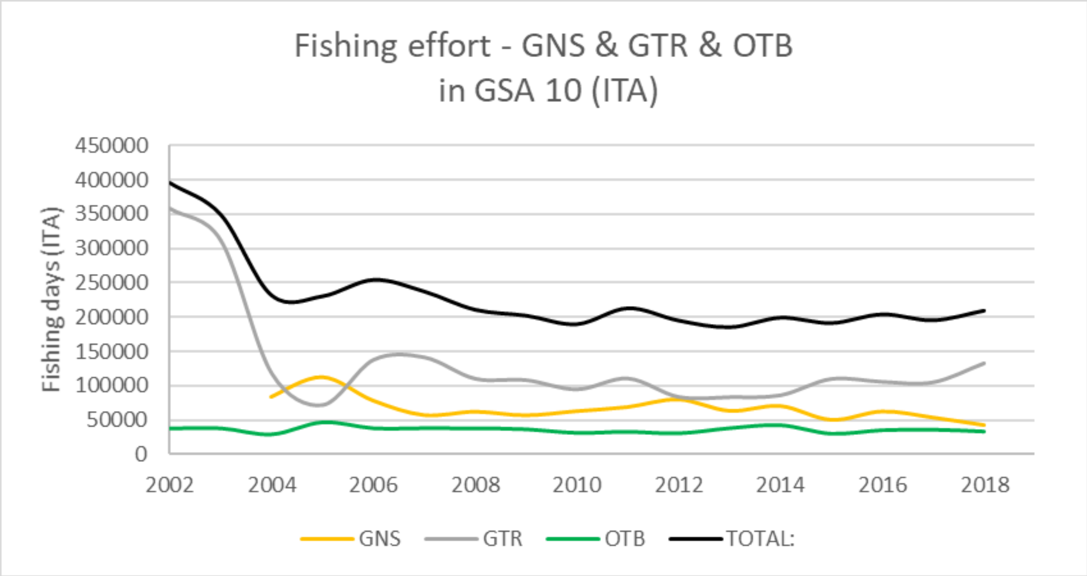


Figure 6.12.2.2.1 Red mullet in GSA 10. Nominal effort (fishing days) in the period from 2002 to 2018 by fishing gear.

Table 6.12.2.2.1 Red mullet in GSA 10. Nominal effort (fishing days) in the period from 2002 to 2018 by fishing gear.

YEAR	GNS (GSA10)	GTR (GSA10)	OTB (GSA10)	**TOTAL:**
2002		357895	37949	**395844**
2003		311474	38134	**349608**
2004	84180	117877	29860	**231917**
2005	112701	71667	46483	**230851**
2006	78946	137534	38242	**254722**
2007	58103	141201	38370	**237675**
2008	62861	110049	38154	**211065**
2009	57711	108039	36768	**202518**
2010	63732	94574	31810	**190116**
2011	69618	110386	33349	**213353**
2012	80519	83540	31233	**195291**
2013	64142	83101	38342	**185585**
2014	71083	85970	42422	**199475**
2015	51263	109730	30756	**191748**
2016	63272	105557	35619	**204448**
2017	54570	104857	36293	**195720**
2018	43650	132442	33690	**209782**

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 6.12.2.3.1). EWG20-09 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. Analyses of available MEDITS data show large variations between years (Figures 6.12.2.3.2- 6.12.2.3.3).

Figure 6.12.2.3.1 Red mullet in GSA 10. Survey periods (MEDITS, 1994-2019).

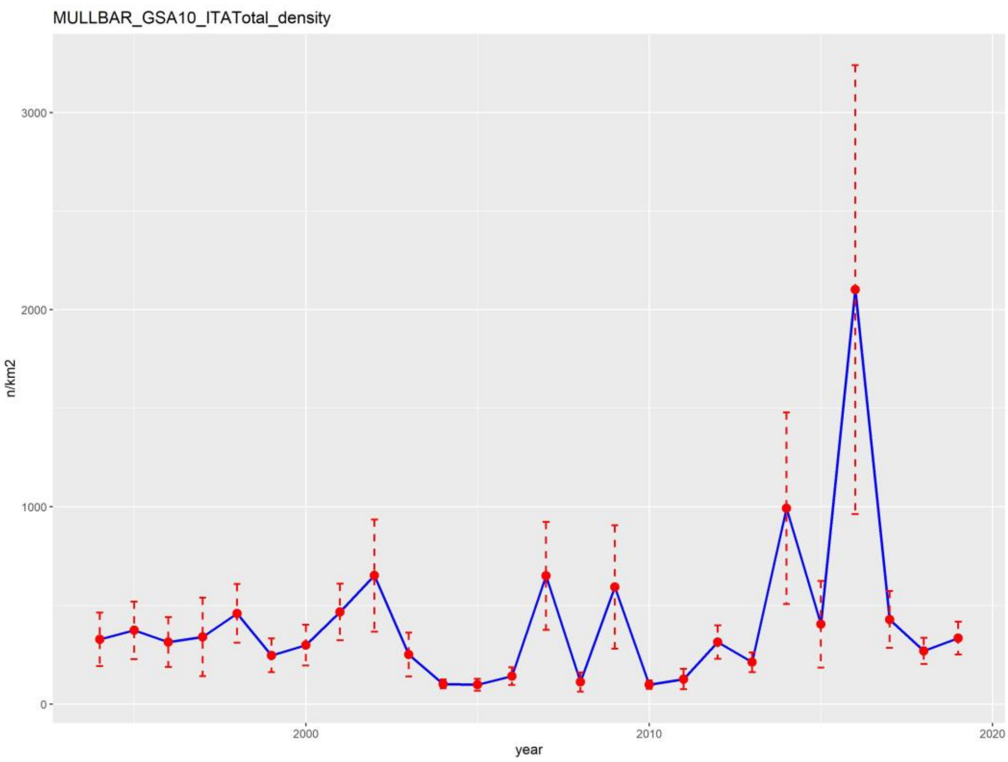


Figure 6.12.2.3.2 Red mullet in GSA 10. Abundance indices (N/km²) as derived from trawl surveys (MEDITS, 1994-2019).

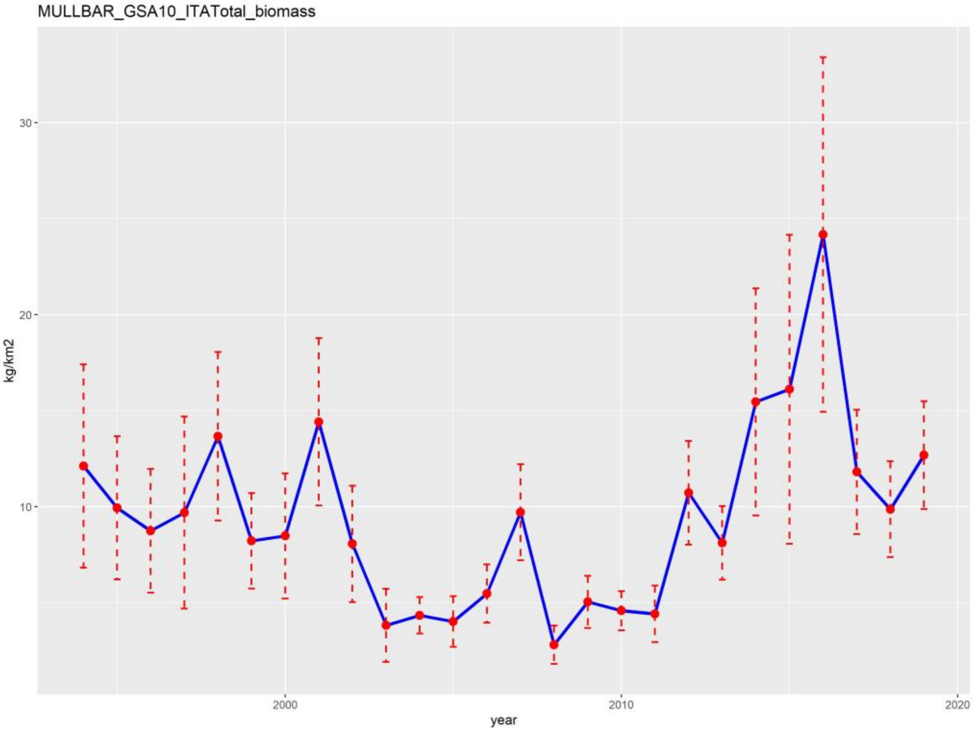


Figure 6.12.2.3.3 Red mullet in 10. Biomass indices (kg/km²)) as derived from trawl surveys (MEDITS, 1994-2019).

Size structure indices of red mullet in GSA 10, as derived from trawl surveys (MEDITS, 1994-2019), are shown in Figure 6.12.2.3.6. 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.

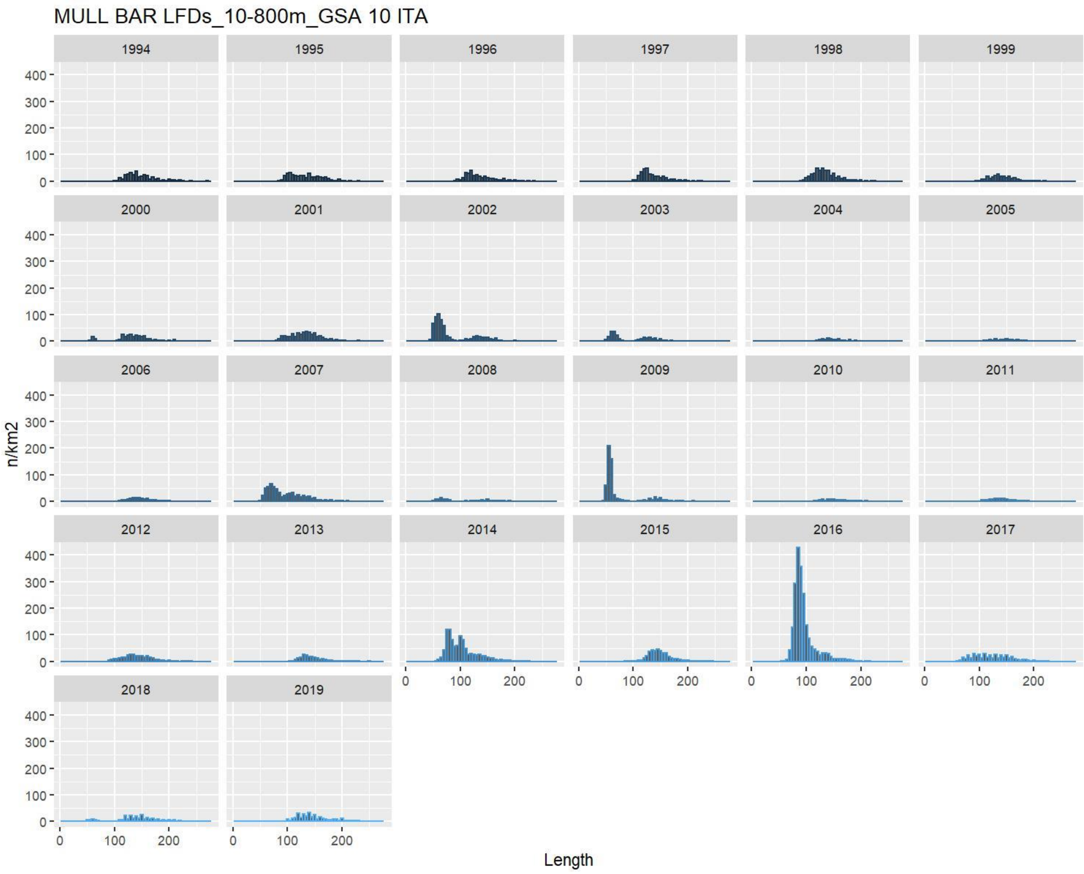


Figure 6.12.2.3.6. Size structure indices of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2019).

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 20-09 used all the input used in the last assessment until 2018 and updated the information, adding 2019 DCF available data.

Table 6.12.3.1 Red mullet in 10. Values of catch at age per year used in the assessment (SOP applied).

	Age				
	0	1	2	3	4+
2002	11175.51	12784.23	10986.13	1510.975	1012.068
2003	218.764	4802.272	5571.9	969.943	780.171
2004	54.489	7884.576	7729.827	1266.327	446.811
2005	270.588	10018.34	4510.168	777.804	147.892
2006	5647.042	9170.027	4324.052	910.158	250.267
2007	43.564	8946.964	6480.151	1388.604	371.383

2008	542.039	7088.288	2998.257	899.367	458.479
2009	5456.79	7213.59	2859.084	668.441	226.027
2010	451.155	3904.102	2428.733	311.536	82.312
2011	607.783	4442.322	2540.166	411.306	226.704
2012	1668.422	7868.386	2749.883	458.141	275.3
2013	5485.049	7316.707	4875.232	841.394	239.295
2014	1053.444	7492.582	5769.928	1073.723	209.195
2015	3580.994	8117.564	5091.039	933.053	359.279
2016	811.412	8973.757	4175.522	622.712	224.344
2017	148.019	2854.231	4913.046	1333.669	503.864
2018	68.697	7689.184	9048.408	682.065	731.135
2019	2641.854	12816.895	4468.179	739.593	615.896

Table 6.12.3.2 Red mullet in 10. Values of mean weight at age per year used in the assessment.

	Age				
age	0	1	2	3	4+
2002	0.004382	0.017929	0.038891	0.063656	0.089159
2003	0.004382	0.017929	0.038891	0.063656	0.089159
2004	0.004382	0.017929	0.038891	0.063656	0.089159
2005	0.004382	0.017929	0.038891	0.063656	0.089159
2006	0.004131	0.017554	0.038839	0.064362	0.09091
2007	0.004131	0.017554	0.038839	0.064362	0.09091
2008	0.004131	0.017554	0.038839	0.064362	0.09091
2009	0.004522	0.017998	0.038393	0.062151	0.086387
2010	0.004256	0.017411	0.03775	0.061763	0.086482
2011	0.00427	0.017858	0.039165	0.064539	0.090808
2012	0.004231	0.017264	0.037367	0.061064	0.08543
2013	0.003935	0.017571	0.039908	0.06723	0.096028
2014	0.003735	0.01693	0.038798	0.06574	0.094274
2015	0.003914	0.017116	0.038469	0.064389	0.091571
2016	0.00402	0.017175	0.038192	0.063521	0.089954
2017	0.00389	0.017074	0.038487	0.06455	0.091933
2018	0.00389	0.017074	0.038487	0.06455	0.091933
2019	0.0060095	0.0102065	0.0361738	0.0579345	0.1064425

Table 6.12.3.3 Red mullet in GSA 10. Survey index (MEDITS) values at age per year used in the assessment.

	Age				
age	0	1	2	3	4
2002	453.03	58.84	94.48	28.43	13.00
2003	137.38	46.57	52.24	12.73	2.57
2004	0.15	15.88	53.57	24.24	7.50
2005	0.00	18.76	43.73	25.86	9.16
2006	0.00	28.38	78.97	27.23	6.61
2007	359.09	168.94	90.83	23.04	7.59
2008	58.29	8.10	25.75	16.03	3.32
2009	485.70	15.86	62.39	18.72	8.45
2010	0.02	14.48	44.89	26.54	12.13
2011	0.44	35.12	62.39	21.02	7.31
2012	4.54	102.12	143.74	47.30	16.82
2013	0.00	43.10	122.23	33.15	13.73
2014	472.19	358.20	110.40	41.45	10.69
2015	1.98	71.19	246.51	67.17	17.56
2016	1377.22	545.45	135.39	37.11	6.70
2017	108.42	137.77	114.89	47.76	20.00

2018	31.15	49.95	111.31	48.03	27.68
2019	1.26842	99.3410	133.0125	62.5702	38.5751

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.

Last year, the landing and discard of 2017 data was incomplete, because the third quarter data was missing. After the request of the working group to the MS to provide the landing data, it was possible to derive the discard in the third quarter of 2017; this reconstruction was influential, being the third quarter the most important in terms of discard, due to the recruitment. The landing data, sent in due time by the MS, were also used to complete the official time series of 2018, for which the first quarter was missing. Having used the input of last year meeting, this corrections have been included also this year.

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.

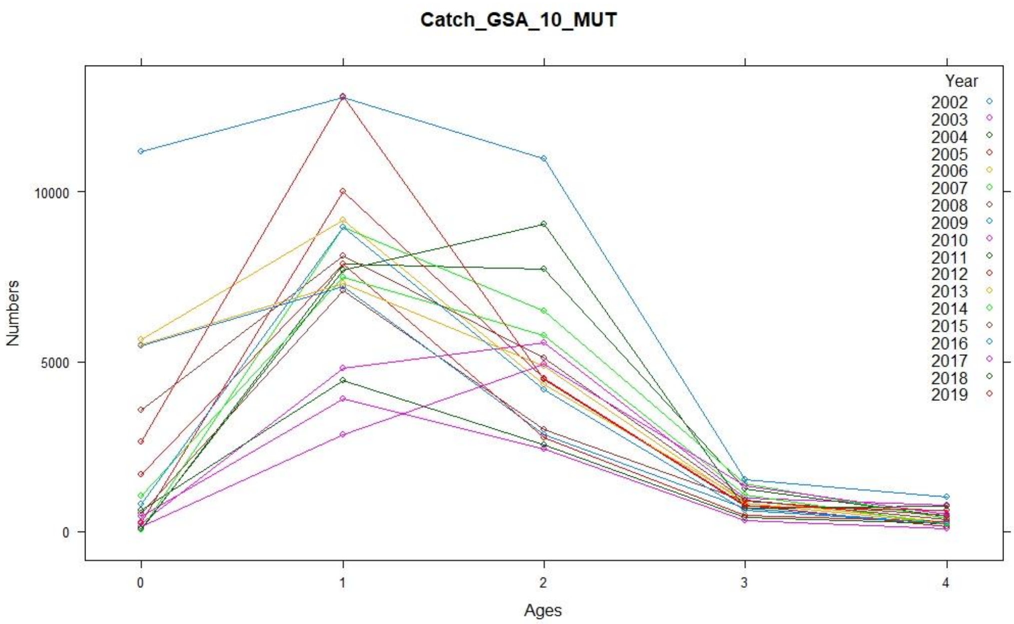


Figure 6.12.3.1 Red mullet in GSA10. Catch-at-age data.

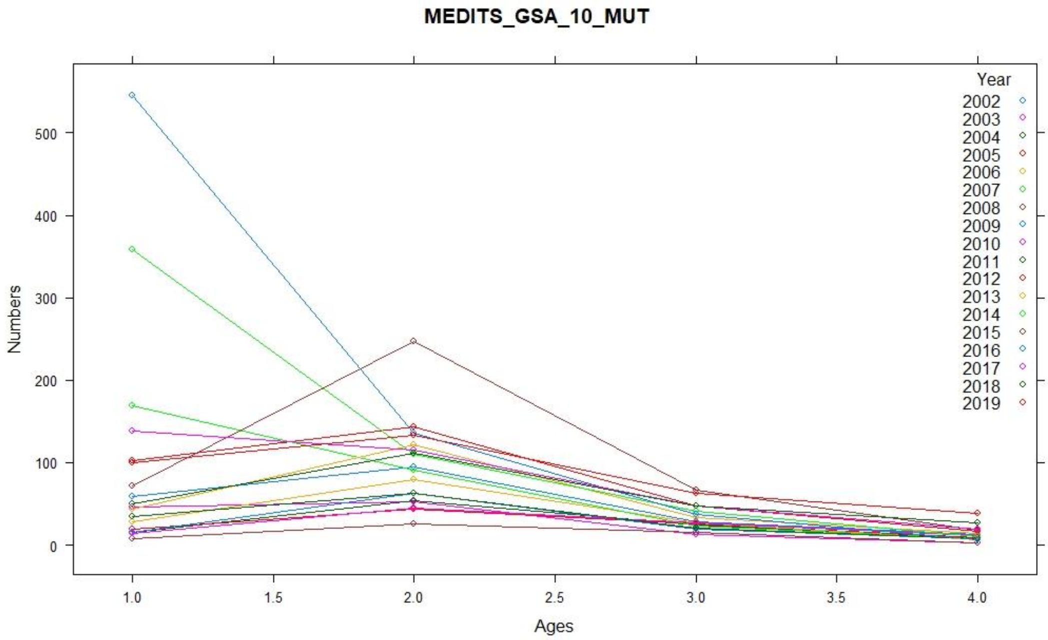


Figure 6.12.3.2 Red mullet in GSA10. MEDITS indices describing density by age by years.

For the assessment purposes, different F, q and sr sub-model were explored in EWG 19-10. Among them, the ones returning the most consistent results in terms of residuals and retrospective are:

Fmodels

- fmod1<- ~ s(age, k=3) + s(year, k = 4) + te(age, year)
- fmod2<- ~ s(age, k=3, by = breakpts(year, 2012)) + te(age, year)
- **fmod3<- ~ s(replace(age, age > 3, 3), k = 3) + s(year, k = 6)**

qmodels

- **qmod1<- list(~factor(replace(age, age > 2, 2)))**
- qmod2<- list(~1)

SRmodels

- srmod1 <- ~s(year,k=7)
- srmod2 <- ~geomean(CV=0.1)
- **srmod3 <- ~geomean(CV=0.3)**

All the combinations of the 8 sub-models were tested during tha last meeting (EWG 19-10, compared and evaluated according to the quality of residuals and retrospective analysis.

The best fit was obtained using:

fmodel: ~ s(replace(age, age > 3, 3), k = 3) + s(year, k = 6)

qmodel: list(~factor(replace(age, age > 2, 2)))

srmodel: ~geomean(CV = 0.3)

This year, the suitability of the same set of sub-models explored last year was explored, in order to verify if the addition of one year of data could change the choice of the best model. Despite of this, the same combination of sub-models resulted as the best performing.

Results are shown below (Figure 6.12.3.4).

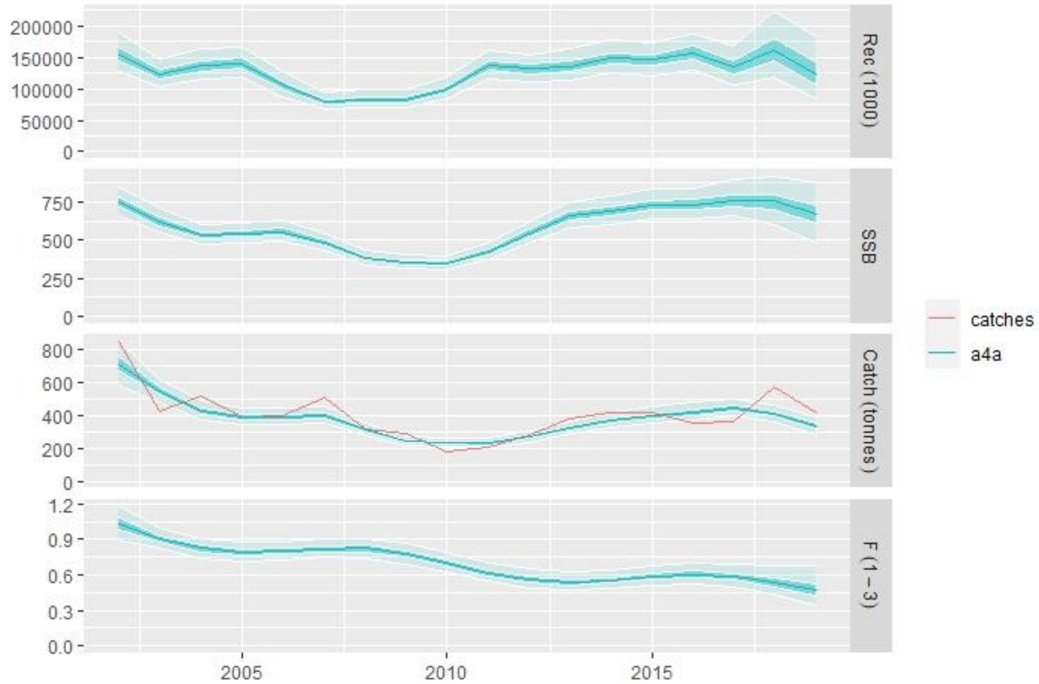


Figure 6.12.3.4 Red mullet in GSA10. Results of the best a4a model outcomes.

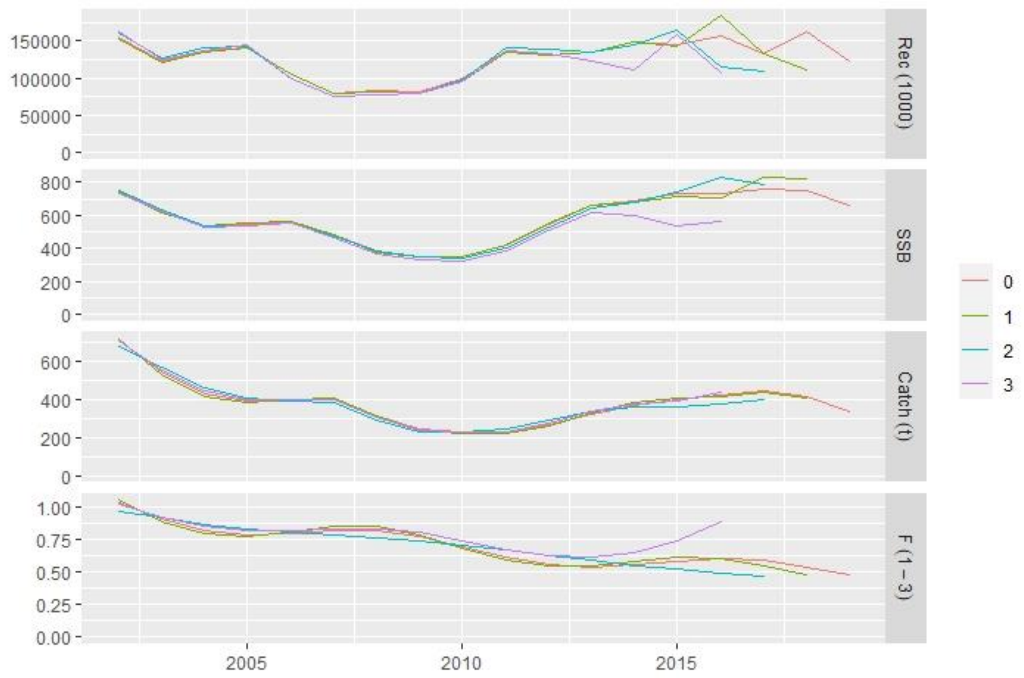


Figure 6.12.3.5 red mullet in GSA10. Retrospectve analysis of the best a4a model outcomes.

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. Anyway, the same diagnostic obtained last year was also observed this year, adding 2019 data, with the exception of an increase of criptic biomass in 2019 from about 15% to about 25%, tha was observed this year for the first time (Figure 6.12.3.6). 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.

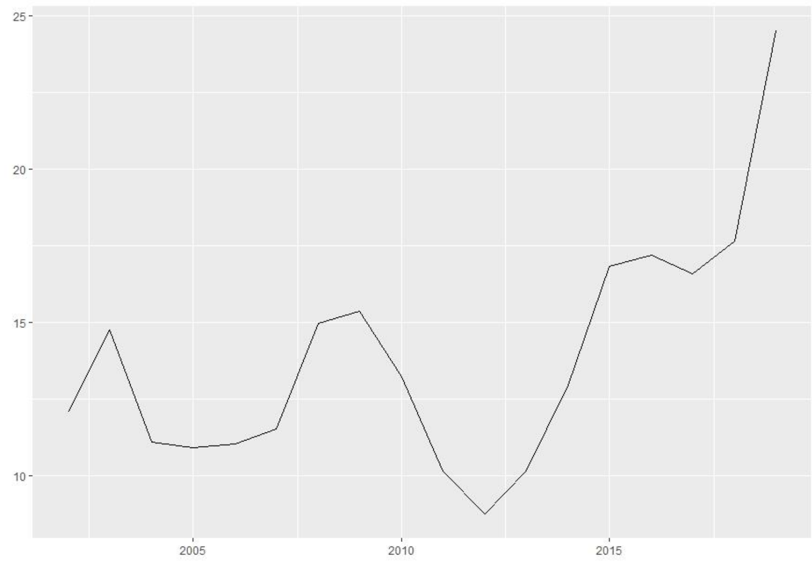
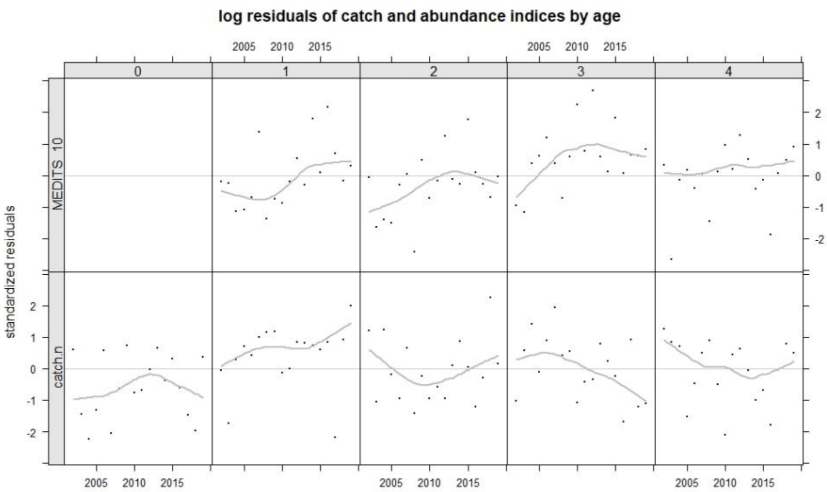


Figure 6.12.3.6 Red mullet in GSA 10. Criptic biomass (weight of age class 4+ respect to SSB).



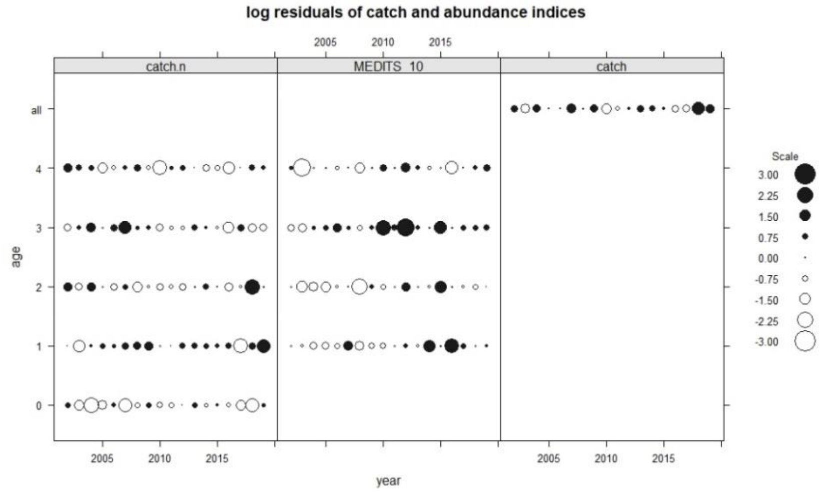


Figure 6.12.3.7 Red mullet in 10. Log residuals of catch and MEDITS abundance indices.

Table 6.12.3.4 Red mullet in GSA10. Final results of the assessment.

Year	Recruitment age 0 (thousands)	SSB tonnes	Catch tonnes (observed)	F ages 1-3
2002	155638	744	705	1.03
2003	123383	622	546	0.91
2004	136719	535	428	0.82
2005	140267	545	388	0.79
2006	105890	557	392	0.80
2007	79255	482	398	0.82
2008	82960	382	312	0.82
2009	82603	353	241	0.78
2010	99198	350	231	0.70
2011	136821	424	230	0.62
2012	131526	548	269	0.56
2013	135770	661	323	0.54
2014	148846	690	367	0.56
2015	145587	731	396	0.58
2016	156958	731	420	0.60
2017	133917	762	444	0.59
2018	161913	747	412	0.54
2019	124070	661	334	0.48

Table 6.12.3.5 Red mullet in GSA10. Stock number at age.

	Age				
	0	1	2	3	4+
2002	153260.2	43346.59	13358.48	3783.21	984.61

2003	120617.8	34602.62	11948.57	1656.33	981.64
2004	134856	27434.52	10350.69	1869.23	647.99
2005	141092.9	30808.76	8617.62	1860.75	681.28
2006	105411.4	32268.59	9793.99	1602.81	705.61
2007	78951.88	24073.13	10094.86	1740.4	620.71
2008	81515.85	17994.04	7364.41	1683.29	605
2009	80375.02	18577.09	5500.38	1225.25	585.41
2010	96465.78	18372.84	5872.73	1006.93	497.92
2011	134667.3	22156	6121.95	1248.62	461.77
2012	131414.2	31057.11	7725.17	1480.85	575.31
2013	134562.5	30368.59	11075.32	1992.24	725.03
2014	148762.9	31090.36	10807.54	2839.55	953.56
2015	142380.3	34315.88	10868.03	2633.31	1281.69
2016	183410.2	32795.97	11804.7	2530	1283.44
2017	132753.2	42263.42	11331.36	2782.49	1262.05
2018	110829.8	30668.46	15019.3	2893.49	1417.74
2019	124069.75	37419.96	10986.60	3243.01	1521.71

Table 6.12.3.6 Red mullet in GSA 10. Fishing mortality at age.

	Age				
	0	1	2	3	4+
2002	0.048208	0.533617	1.51755	1.10881	1.10881
2003	0.040823	0.451876	1.28508	0.938961	0.938961
2004	0.036408	0.402995	1.14607	0.837391	0.837391
2005	0.035327	0.391031	1.11205	0.812531	0.812531
2006	0.036775	0.407067	1.15765	0.845852	0.845852
2007	0.038796	0.429437	1.22127	0.892336	0.892336
2008	0.038868	0.430226	1.22351	0.893974	0.893974
2009	0.035831	0.39661	1.12792	0.824125	0.824125
2010	0.031077	0.343994	0.978279	0.714791	0.714791
2011	0.026979	0.298628	0.849264	0.620525	0.620525
2012	0.024944	0.276109	0.785222	0.573732	0.573732
2013	0.02513	0.278166	0.791074	0.578007	0.578007
2014	0.026748	0.296074	0.842001	0.615218	0.615218
2015	0.028197	0.312111	0.887607	0.648541	0.648541
2016	0.027801	0.307731	0.875152	0.63944	0.63944
2017	0.025258	0.279586	0.79511	0.580957	0.580957
2018	0.021818	0.241499	0.686797	0.501816	0.501816
2019	0.021958	0.245953	0.691368	0.487719	0.487719

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 0.39. The F value estimated for 2019, as calculated by a4a, is 0.48, indicating that the current fishing mortality (F) is slightly above $F_{0.1}$ reference point. Given that the fishing mortality has declined in the past years, and that catches are stable, this might be due to changes in the age structure of the stock.

6.12.5 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 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} =0.48 terminal F (2019) from the a4a assessment was used for F in 2020. 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 2020. Recruitment (age 0) for 2020 to 2022 has been estimated from the population results as the geometric mean of the whole time series of 18 years (126740 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 2017-2019	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-3}$ (2019)	0.48	F 2019 used to give F status quo for 2020
SSB (2020)	765	Stock assessment at 1st July 2020
R_{age0} (2020,2022)	126740	Mean of the time series 18 years 2002-2019
Total catch (2020)	391.62	Assuming F status quo for 2020

These assumptions resulted in a catch and a SSB in 2020 equal to 391.62 and 765 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.39) would increase the SSB of the 4.46% from 2020 to 2022, while decreasing the catch by the 6.20% from 2019 to 2021. Finally, fishing at a level equal to $F_{MSY\ transition}$ (=0.45) would decrease the SSB of the 1.6% from 2020 to 2022, while increasing the catch by the 4.22% from 2019 to 2021.

Table 6.12.5.2 – Short term forecast table for red mullet in GSA 10.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2021	SSB* 2020	SSB* 2022	Change SSB 2020-2022 (%)	Change Catch 2019-2021 (%)
High long term yield ($F_{0.1}$)	0.8282	0.39	334	314	765	799	4.5	-6.2
F upper	1.134	0.54	334	403	765	683	-10.7	20.5
F lower	0.553	0.26	334	222	765	927	21.1	-33.5
FMSY transition	0.9427	0.45	334	348	765	753	-1.6	4.2
Zero catch	0	0	334	0	765	1272	66.2	-100.0
Status quo	1	0.48	334	365	765	731	-4.4	9.2
Different Scenarios	0.1	0.05	334	45	765	1199	56.7	-86.7
	0.2	0.1	334	87	765	1131	47.8	-74.0
	0.3	0.14	334	128	765	1068	39.6	-61.8
	0.4	0.19	334	166	765	1009	31.9	-50.2
	0.5	0.24	334	203	765	954	24.7	-39.2
	0.6	0.29	334	239	765	903	18.0	-28.6
	0.7	0.33	334	272	765	855	11.8	-18.5
	0.8	0.38	334	305	765	811	6.0	-8.8
	0.9	0.43	334	336	765	770	0.6	0.4
	1.1	0.52	334	393	765	695	-9.2	17.7
	1.2	0.57	334	421	765	661	-13.6	25.8
	1.3	0.62	334	447	765	630	-17.7	33.6
	1.4	0.67	334	471	765	600	-21.6	41.0
	1.5	0.71	334	495	765	573	-25.2	48.2
	1.6	0.76	334	518	765	547	-28.5	55.1
	1.7	0.81	334	540	765	522	-31.7	61.6
	1.8	0.86	334	561	765	500	-34.7	68.0
	1.9	0.9	334	582	765	478	-37.5	74.0
	2	0.95	334	601	765	458	-40.1	79.9

*SSB at mid year

EWG advises that when the management strategy is applied, catches in 2021 should be no more than 314 tonnes.

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).

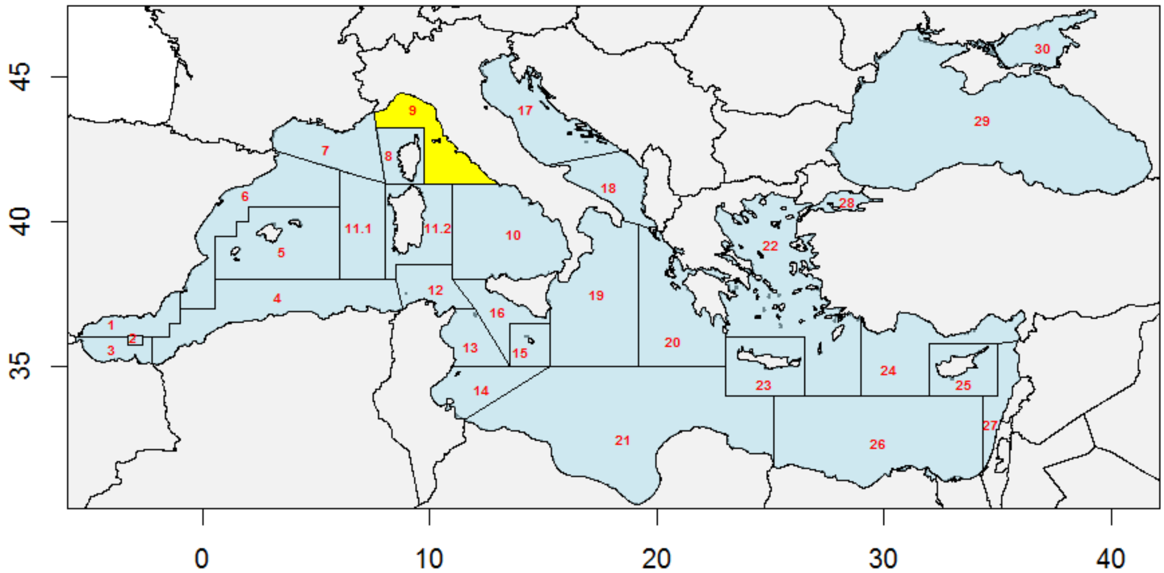


Figure 6.13.1.1 Limit of Geographical Sub-Area (GSA) 9.

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.

		Units	Females	Males
VBGF parameters	**L_∞**	mm	56.0	72.1
	k	years^{-1}	0.21	0.17

	t_0	years	0.0	0.0
LW relationship	**a**	mm/g	0.00032	0.00038
	b	mm/g	3.24848	3.18164

A vector of proportion of mature by age was computed as a weighed average of the vectors available from the DCF database in GSA 9.
A natural mortality vector was estimated by sex using the Chen and Watanabe equation and the growth parameters described above. A combined natural mortality vector was then computed as a weighed average of the vectors by sex.
The vector of proportion of mature and the natural mortality vector used in the assessment of Norway lobster in GSA 9 are shown in Table 6.13.1.2. The table below differs from the same table in the 2019 report, which had the prportion mature shifted by 1 year. That table was in error the correct table is given here.

Table 6.13.1.2 Norway lobster in GSA 9: natural mortality and proportion of mature vectors by age.

Age	Natural mortality	Proportion of matures
1	0.75	0.10
2	0.50	0.40
3	0.39	0.75
4	0.33	0.90
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, with a sharp increase in the last two years. 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).

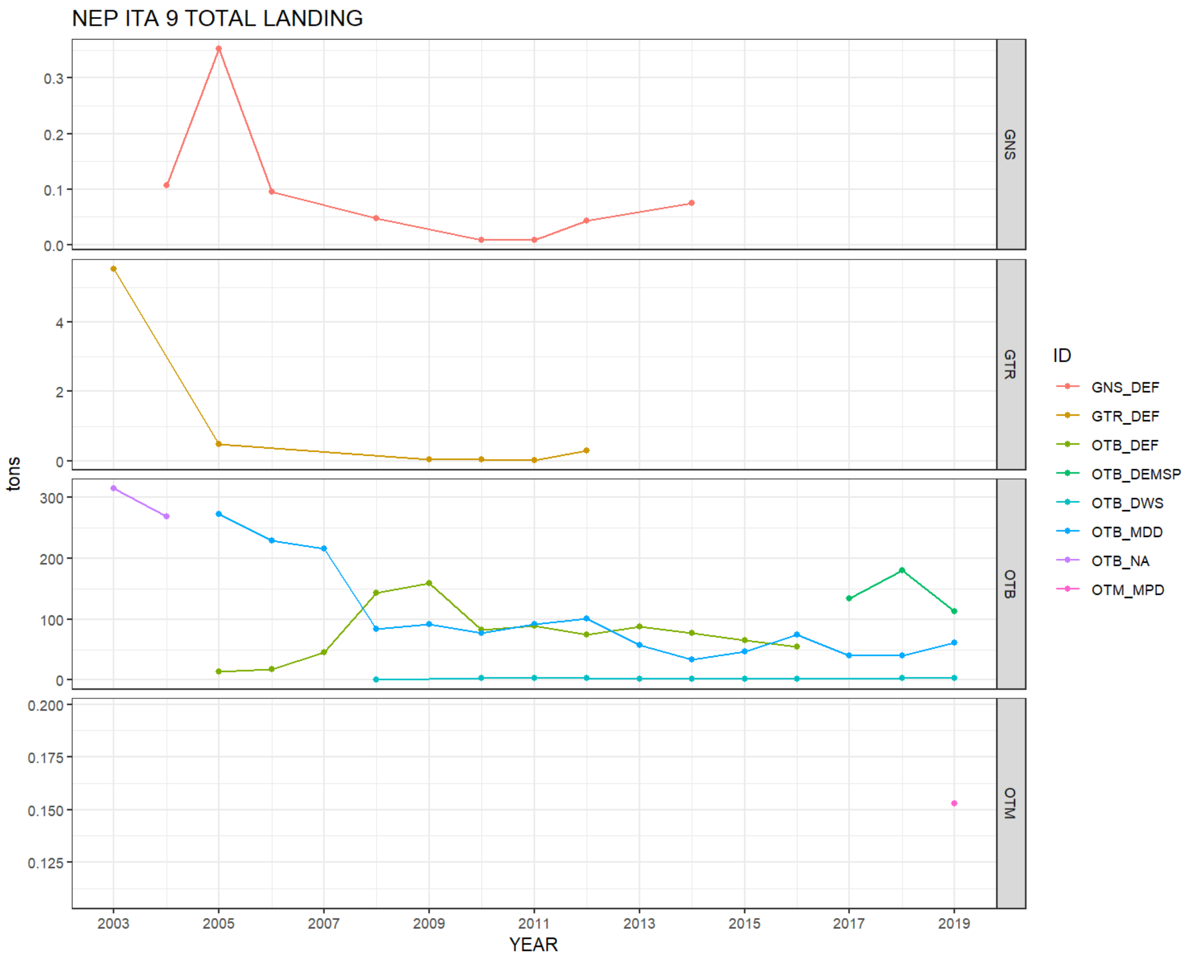


Figure 6.13.2.1.1. Norway lobster in GSA 9: landings trend by gear in GSA 9.

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 some 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

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.

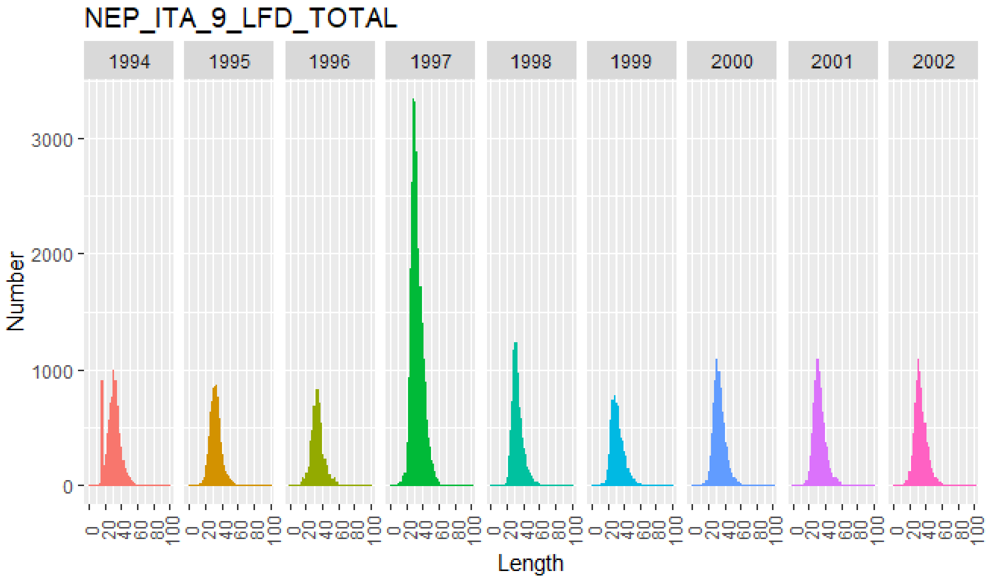


Figure 6.13.2.1.2. Norway lobster in GSA 9: LFDs of landings by year provided by the RECFISH project.

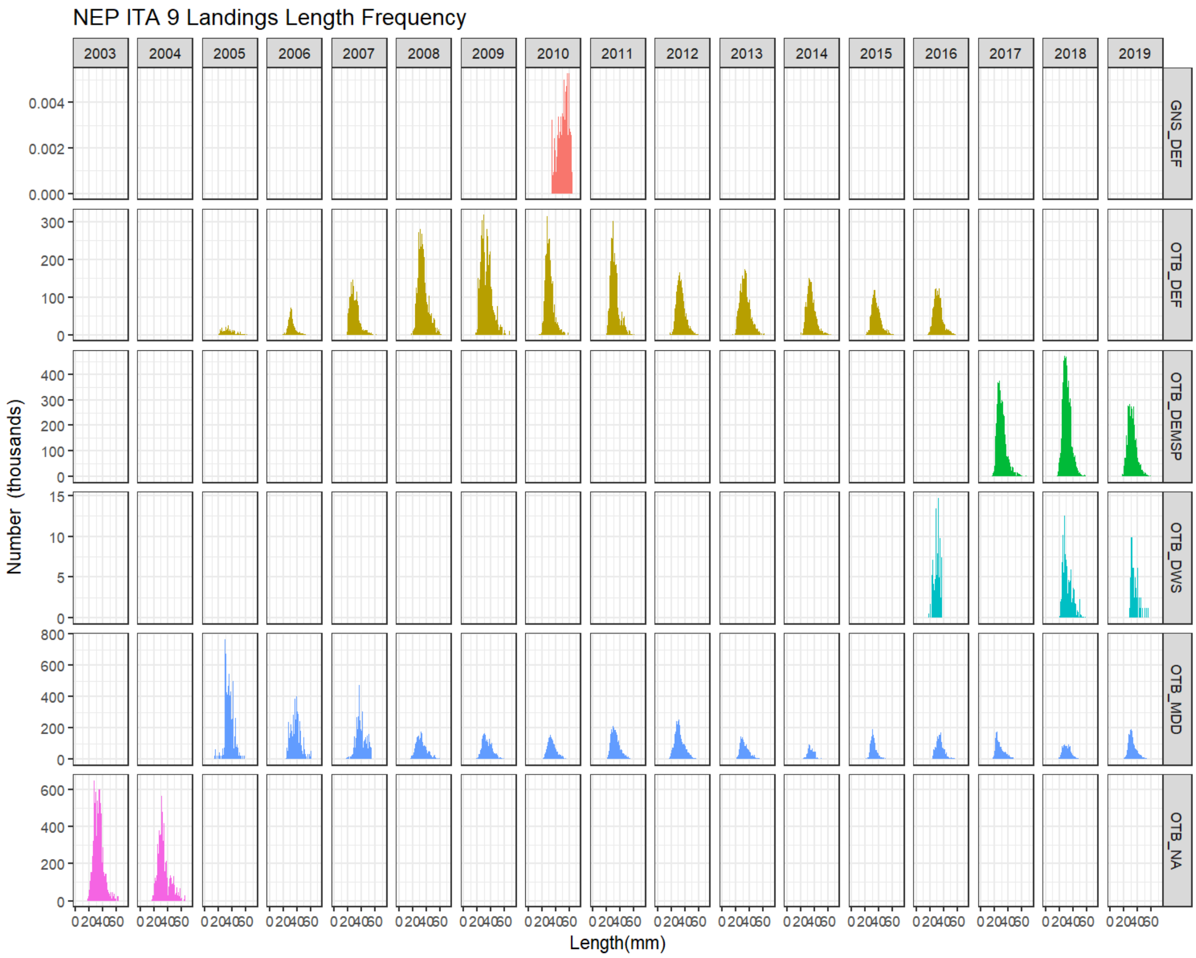


Figure 6.13.2.1.3. Norway lobster in GSA 9: LFDs of landings by year and gear of Norway lobster in GSA 9.

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

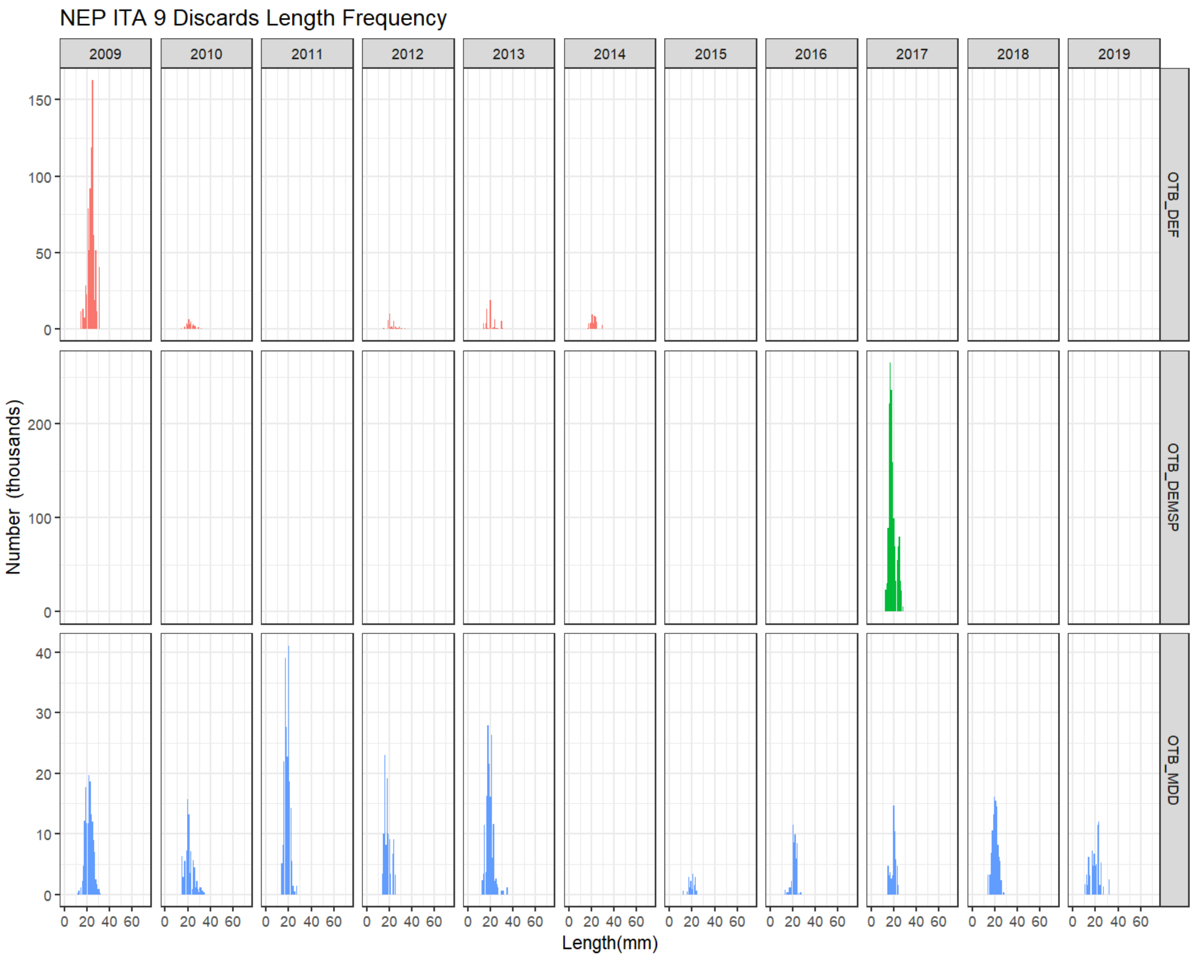


Figure 6.13.2.1.4 Norway lobster in GSA 9: LFDs of discards of Norway lobster in GSA 9.

6.13.2.2 Effort

The total nominal effort of the trawl fleets operating in GSA 9, expressed as kW*fishing days, has shown a progressive decrease in the period 2002-2018. It varied from about 15,000,000 in 2002 to 9,500,000 in 2018. In Table 6.13.2.2.1 and Figure 6.13.2.2.1, nominal effort is reported in '000 kW*fishing days, in Table 6.13.2.2.2 and Figure 6.13.2.2.2, nominal effort is reported in Days at sea. There is no information on the specific effort directed to giant red shrimp.

Table 6.13.2.2.1 Norway lobster in GSA 9: Summary of the OTB nominal effort (kW*fishing days, in thousands) by year in GSA 9.

Year	GSA 9
2002	14583.6
2003	14671.0
2004	14820.3
2005	14700.6
2006	12404.8
2007	12782.1
2008	11083.5
2009	12190.0
2010	11403.1
2011	10687.9
2012	9949.2
2013	10725.8
2014	10989.8
2015	11054.5
2016	10546.7
2017	10594.1
2018	9443.7
2019	-

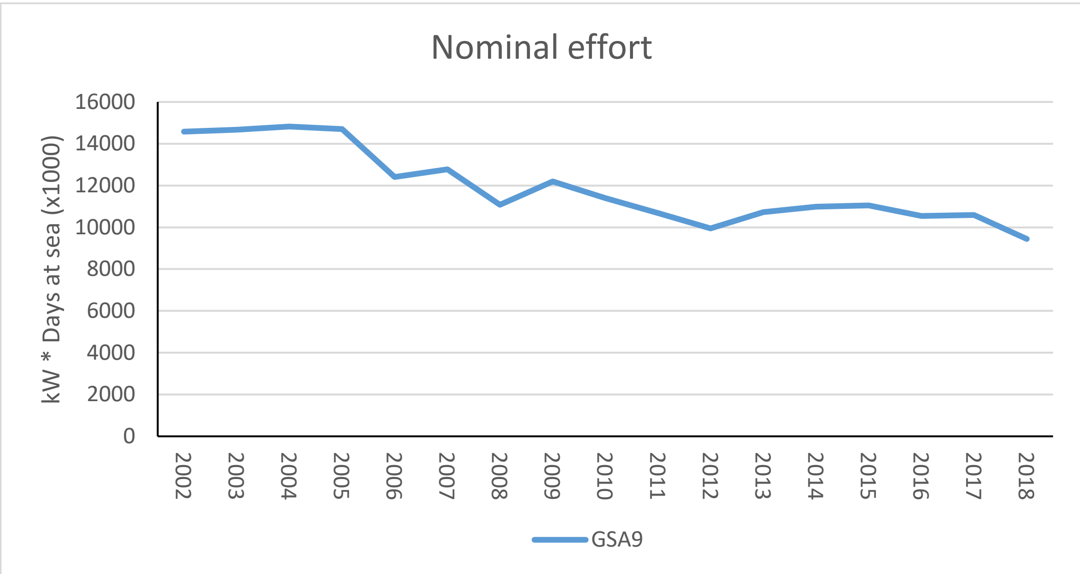


Figure 6.13.2.2.1. Norway lobster in GSA 9: Trend of OTB nominal effort ('000 kW*fishing days) in GSA 9.

Table 6.13.2.2.2. Norway lobster in GSA 9: Summary of the OTB effort (Days at sea) by year in GSA 9.

Year	GSA 9
2002	62616
2003	63331
2004	67828
2005	67714
2006	62517
2007	64161
2008	49759
2009	53330
2010	52606
2011	50737
2012	47851
2013	51715
2014	51286
2015	52900
2016	51257
2017	47457
2018	44296
2019	-

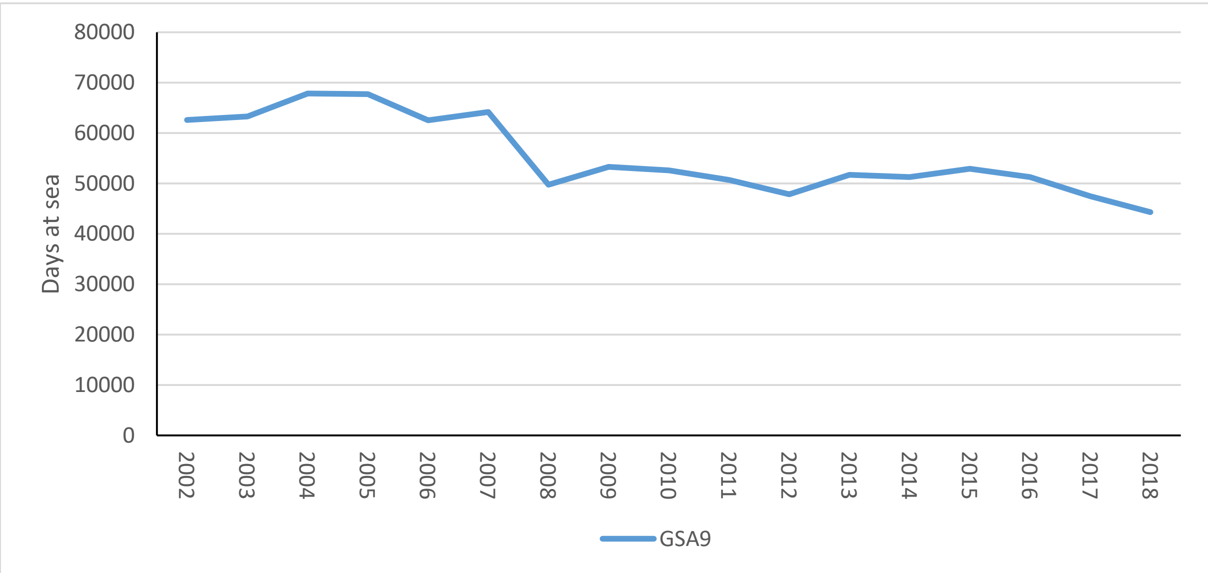


Figure 6.13.2.2.2. Norway lobster in GSA 9: Trend of OTB effort (Days at sea) in GSA 9.

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).

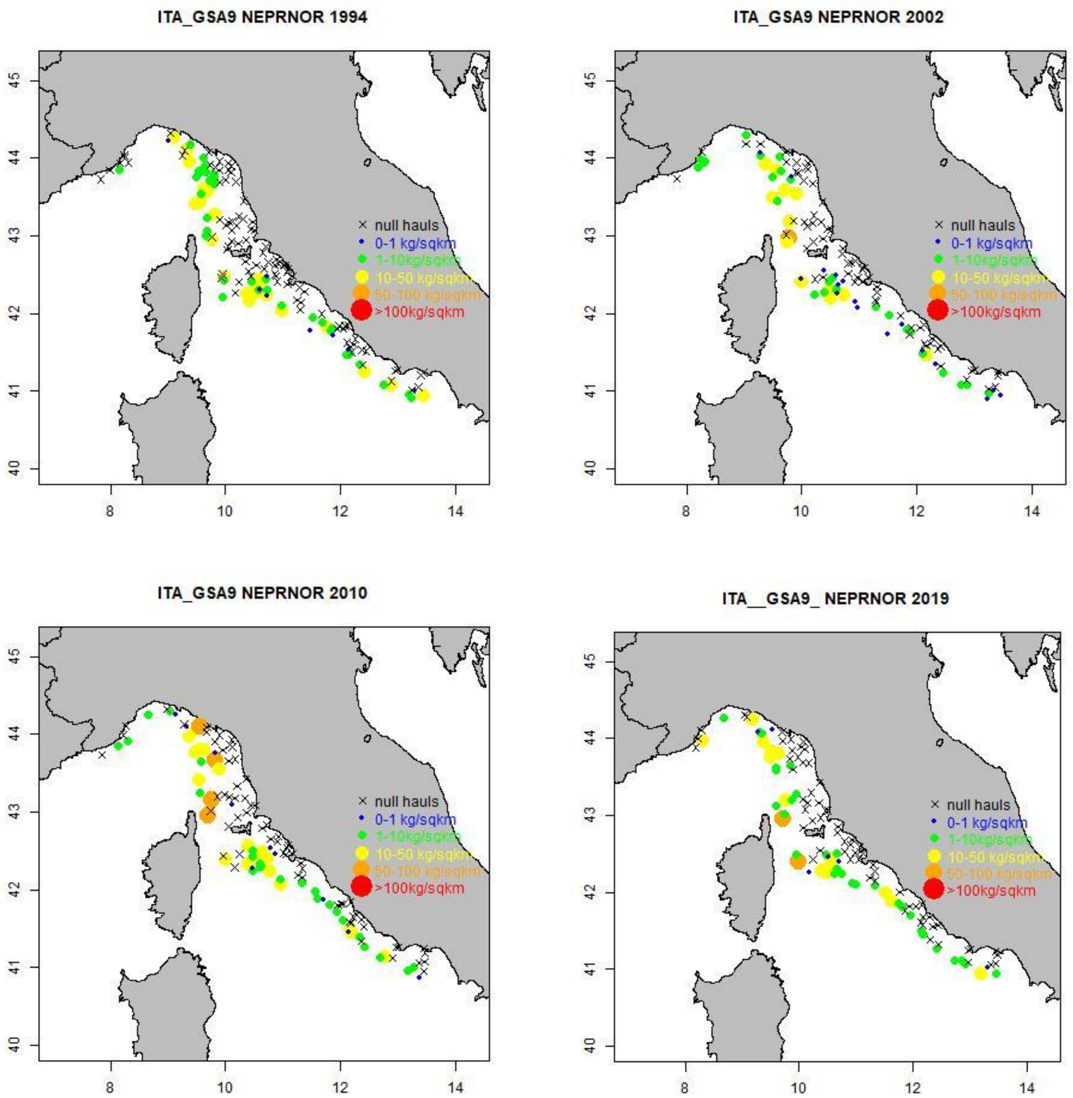
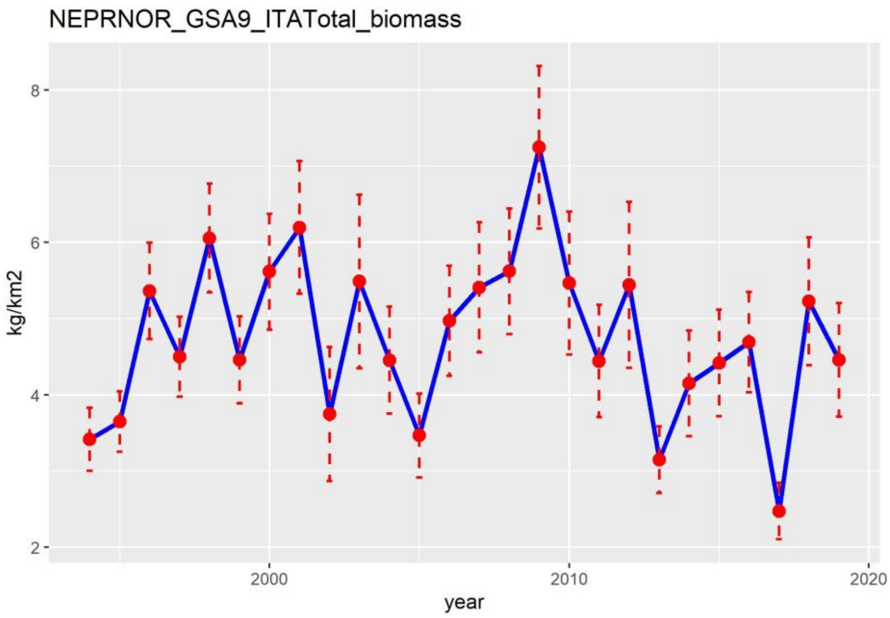


Figure 6.13.2.3.1. Norway lobster in GSA 9: distribution pattern in the period 1994-2019 (MEDITS survey). Maps for the years 1994, 2002, 2010 and 2019 are shown.

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 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.



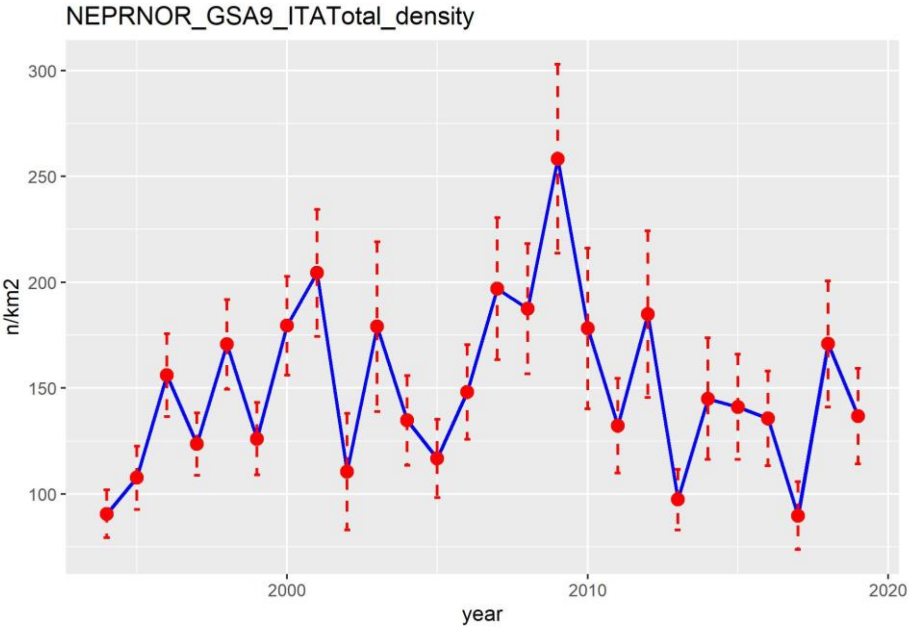


Figure 6.13.2.3.2. Norway lobster in GSA 9: MEDITS standardized biomass and density indices (10-800 m).

Trends in abundance and biomass by length

The stratified abundance indices by length (by sex and total) computed on the three GSAs combined during the MEDITS surveys from 1994 to 2018 are shown in Figures 6.113.2.3.3-6.13.2.3.5. 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.

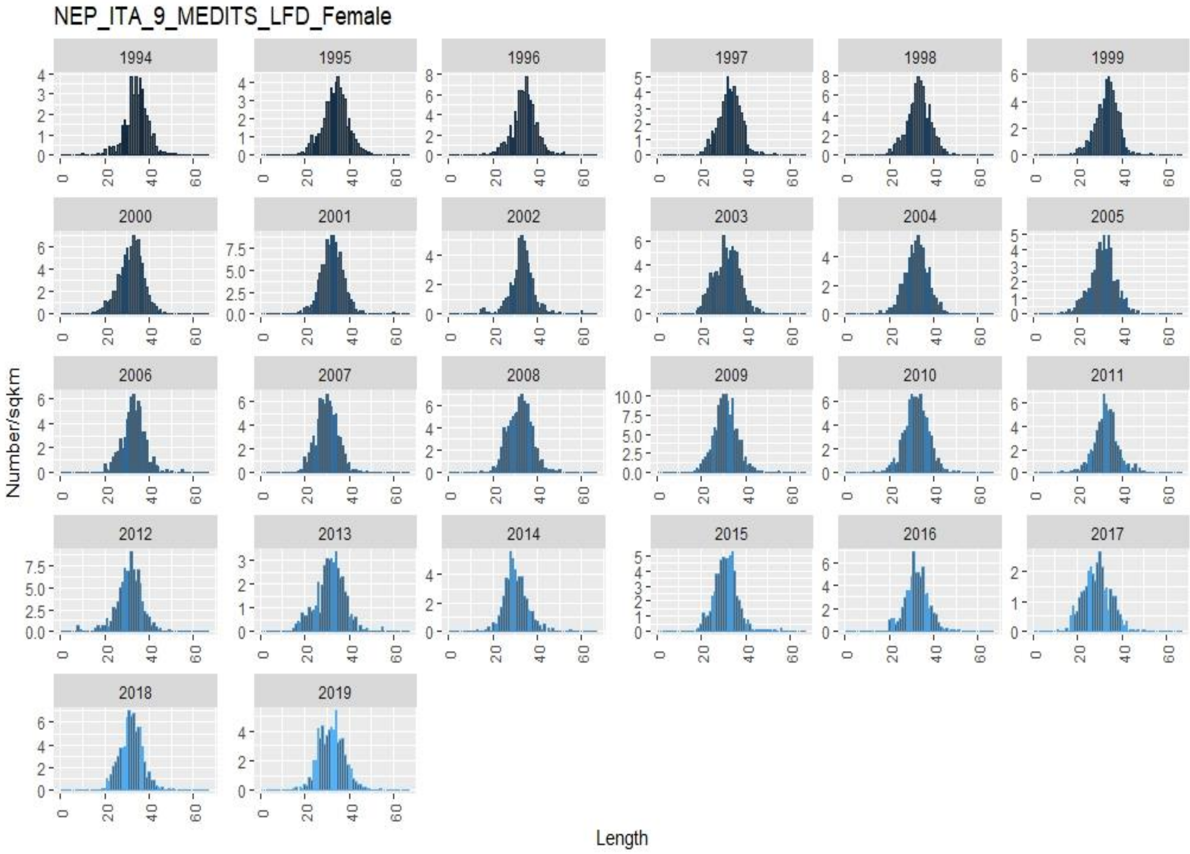


Figure 6.13.2.3.3. Norway lobster in GSA 9: stratified abundance indices by size for females, 1994-2018.

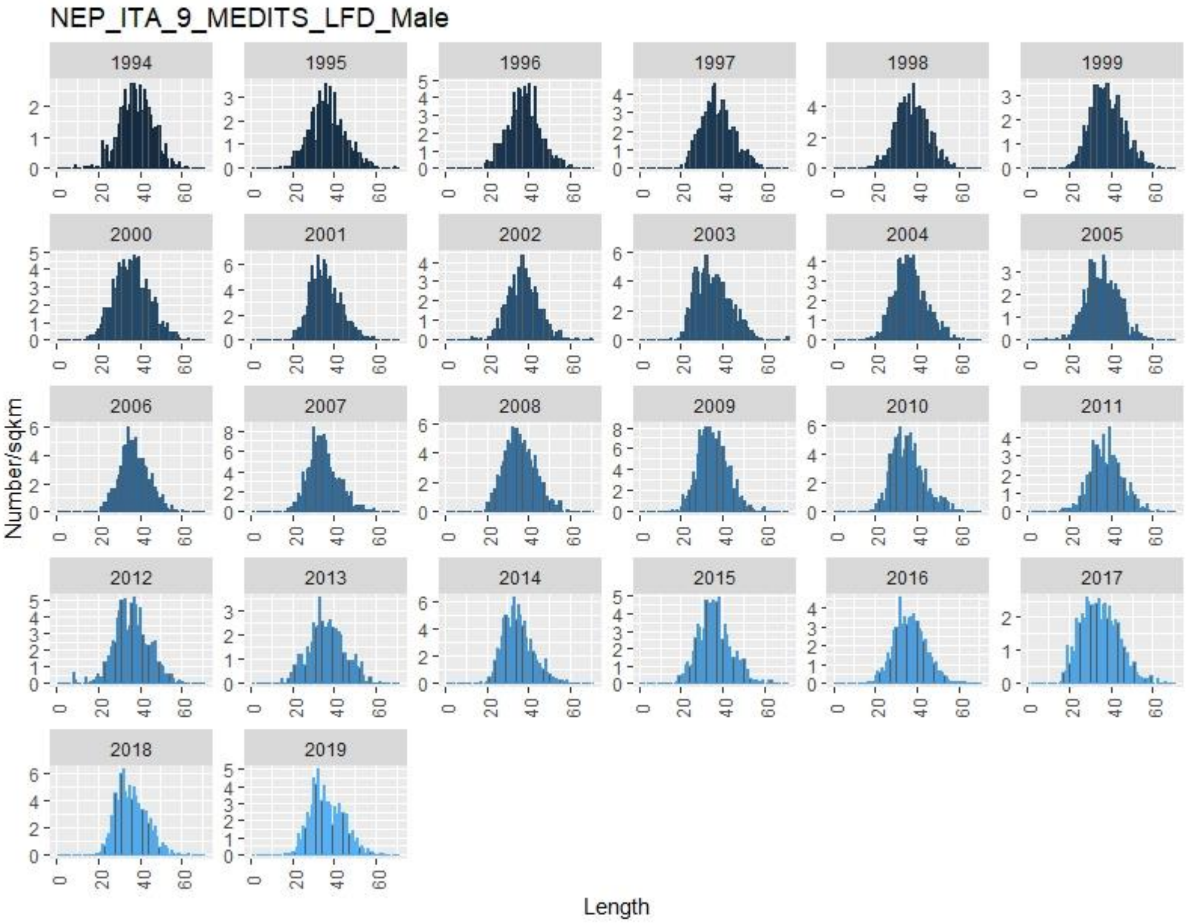


Figure 6.13.2.3.4. Norway lobster in GSA 9: stratified abundance indices by size for males, 1994-2018.

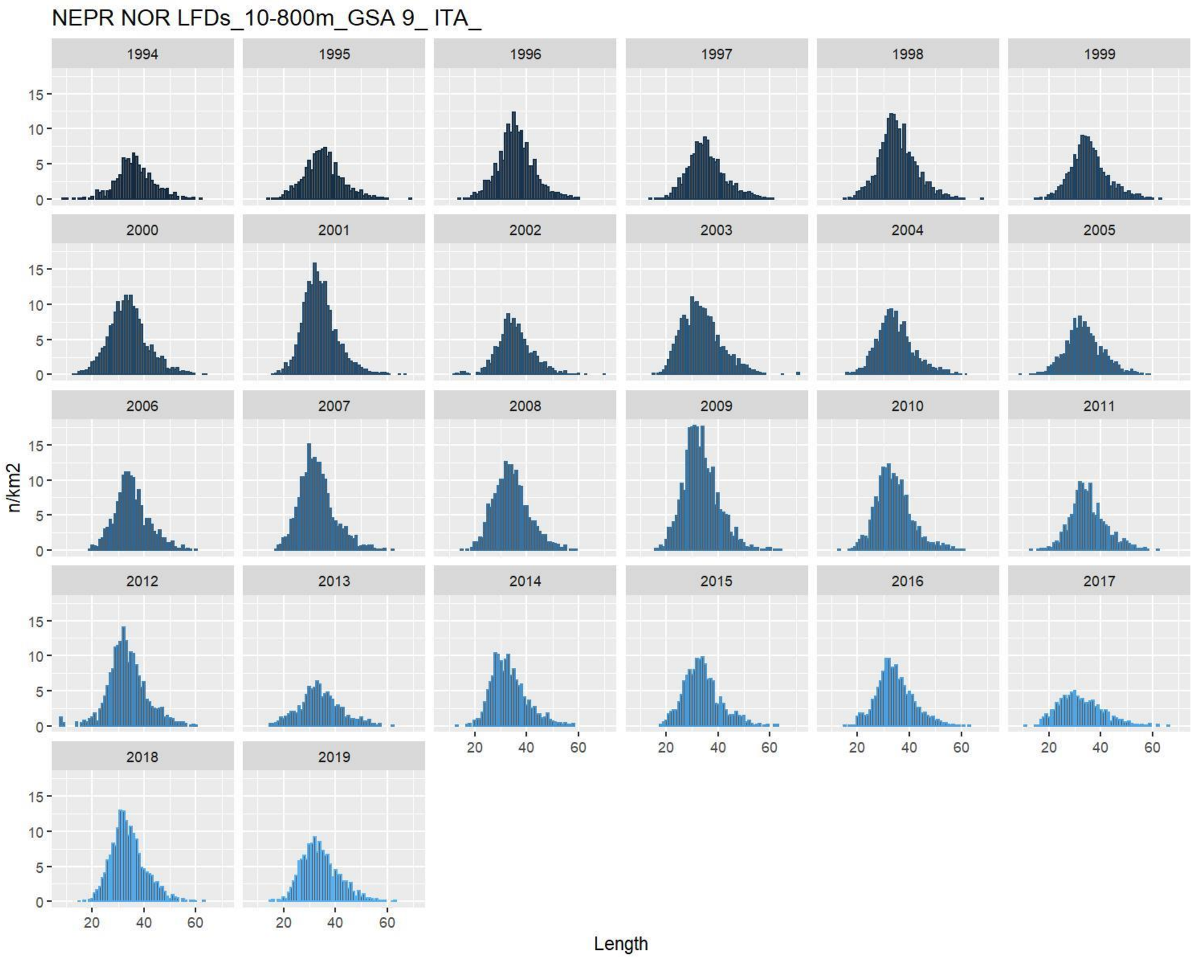


Figure 6.13.2.3.5 Norway lobster in GSA 9: total stratified abundance indices by size, 1994-2018.

6.13.3 STOCK ASSESSMENT

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 1994-2019 for the catch data and 1994-2019 for the tuning file (MEDITS indices). This is a considerable extention to the series used in 2018 which was 2003 to 2017.

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 = Landings / Σa (total catch numbers at age a x catch weight-at-age a)]. However, the correction factor resulted low.

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.

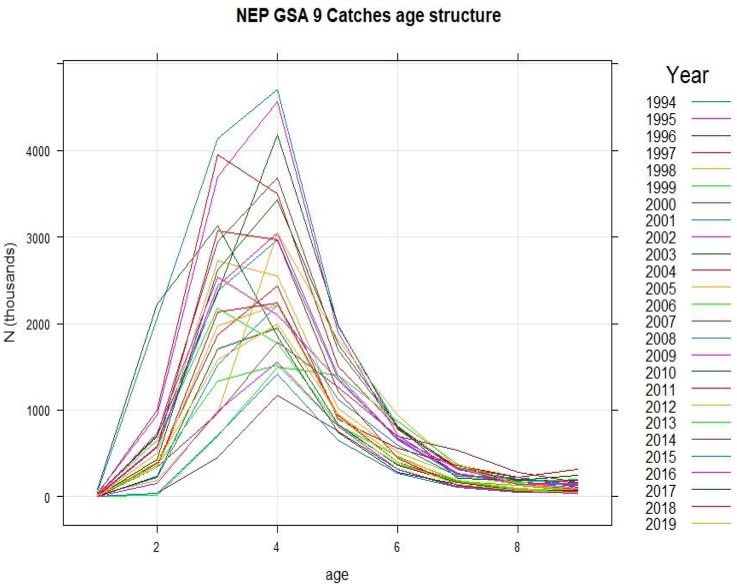


Figure 6.13.3.1. Norway lobster in GSA 9: catch-at-age distribution by year of the catches (1994-2018).

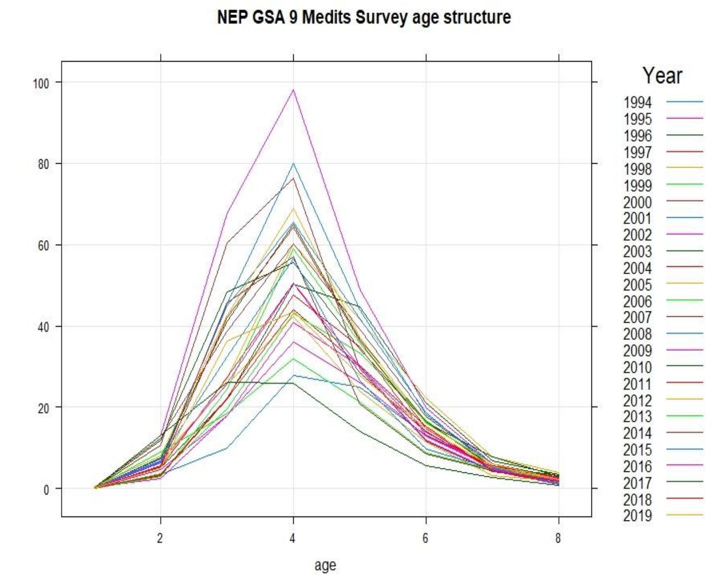


Figure 6.13.3.2. Norway lobster in GSA 9: catch-at-age distribution by year of the MEDITS survey (1994-2019).

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	52.954	44.038	15.866	28.962	0.020	28.518	22.556	18.150	18.643	0.021	0.021	29.663	0.019
2	2068.148	940.401	697.833	997.687	496.420	657.779	710.433	571.638	587.185	434.600	382.367	192.732	16.687
3	4130.569	3693.435	2349.245	3947.948	2722.827	2174.579	2947.573	2371.715	2436.218	2620.624	1864.634	967.749	702.520
4	4706.351	4563.823	4187.219	3494.079	2553.182	1771.003	3687.890	2967.400	3048.102	3433.132	2437.392	3043.550	1496.647
5	1973.473	1902.954	1986.654	1505.993	1020.683	820.928	1698.776	1366.892	1404.066	1760.812	890.198	1804.229	1402.445
6	818.649	707.864	780.781	791.728	510.769	462.324	807.515	649.754	667.425	811.335	553.897	946.607	876.360
7	315.251	266.575	312.324	340.155	250.853	179.663	328.549	264.362	271.551	214.782	368.553	340.407	371.258
8	175.665	147.233	194.767	223.045	147.597	130.764	204.538	164.578	169.054	188.104	220.038	158.831	168.056
9	95.381	85.848	245.604	110.102	73.734	62.786	170.191	136.942	140.666	193.163	316.526	92.353	197.078

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	6	0.019	4.945	2.890	7.880	7.339	13.368	0.019	0.705	0.942	88.950	3.640	13.467
2	336	229.157	737.916	236.768	337.780	394.084	360.657	43.892	36.947	149.962	2225.090	574.649	335.992
3	969	1519.771	2539.822	1709.130	2134.847	1578.937	1338.817	458.352	708.160	990.629	3127.002	3075.683	1971.715
4	1786	2219.039	2097.091	1942.863	2237.000	1992.224	1523.264	1168.840	1420.509	1555.557	1853.207	2963.394	2219.488
5	1271	1131.086	1350.606	836.481	940.487	951.330	810.063	753.403	656.603	817.105	748.566	1215.842	915.997
6	697	590.836	672.544	363.555	398.465	451.808	368.852	311.056	269.802	311.862	286.390	444.996	400.723
7	532	233.965	324.622	162.192	177.713	189.653	177.050	108.160	109.923	119.042	142.221	134.764	147.188
8	277	218.802	141.909	77.715	94.870	91.348	88.923	48.213	54.871	61.680	62.072	59.895	76.375
9	161	133.985	155.827	56.986	50.450	66.814	53.591	58.251	50.899	44.246	73.837	46.887	50.597

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
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
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
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
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
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
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
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
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

Table 6.13.3.3. Norway lobster in GSA 9: Catch (tons; discards are included).

1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
376.4	345.4	359.4	327.0	225.5	178.6	335.0	269.5	276.9	320.9	268.7	288.5	247.5
2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
260.6	227.7	259.5	162.6	185.0	179.0	149.0	112.0	113.7	131.3	181.8	223.9	177.5

Table 6.13.3.4. Norway lobster in GSA 9: Weight-at-age matrix (kg).

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.001	0.002	0.002	0.001	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.002	0.000
2	0.005	0.006	0.005	0.007	0.008	0.007	0.007	0.007	0.007	0.007	0.007	0.005	0.008
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
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
5	0.041	0.040	0.040	0.041	0.040	0.041	0.041	0.041	0.041	0.041	0.041	0.043	0.045
6	0.059	0.058	0.060	0.056	0.057	0.056	0.059	0.059	0.059	0.058	0.063	0.060	0.061
7	0.082	0.083	0.081	0.079	0.081	0.077	0.081	0.081	0.081	0.082	0.087	0.076	0.085
8	0.097	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.099	0.104	0.088	0.091
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	0.150

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.002	0.000	0.002	0.002	0.002	0.002	0.002	0.000	0.001	0.001	0.002	0.002	0.31
2	0.007	0.007	0.007	0.007	0.006	0.006	0.006	0.006	0.007	0.007	0.005	0.007	0.007
3	0.014	0.015	0.014	0.015	0.015	0.015	0.015	0.016	0.016	0.015	0.013	0.014	0.014
4	0.029	0.027	0.027	0.026	0.026	0.026	0.027	0.028	0.027	0.027	0.026	0.026	0.026
5	0.043	0.041	0.043	0.041	0.041	0.042	0.042	0.042	0.042	0.041	0.041	0.040	0.041
6	0.062	0.061	0.058	0.059	0.061	0.059	0.059	0.057	0.058	0.058	0.059	0.057	0.058

7	0.087	0.084	0.085	0.085	0.082	0.083	0.084	0.081	0.082	0.083	0.082	0.081	0.082
8	0.103	0.103	0.101	0.099	0.098	0.097	0.099	0.095	0.096	0.097	0.099	0.090	0.095
9+	0.121	0.137	0.145	0.130	0.127	0.129	0.127	0.147	0.134	0.131	0.139	0.132	0.135

The assessment was performed by sex combined. Given that the landings 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)

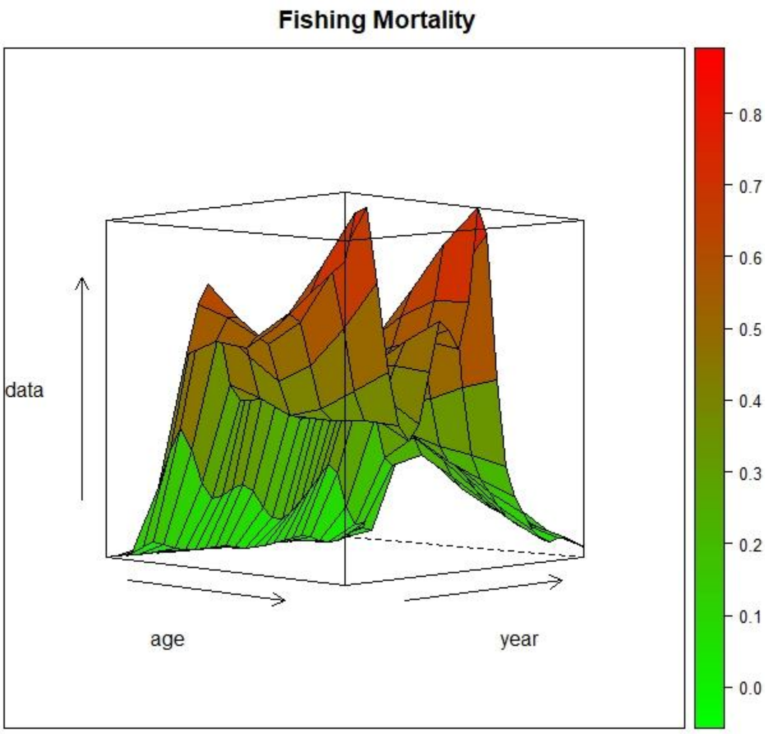


Figure 6.13.3.3. Norway lobster in GSA 9: fishing mortality by age and year obtained from the a4a model (1994-2019).

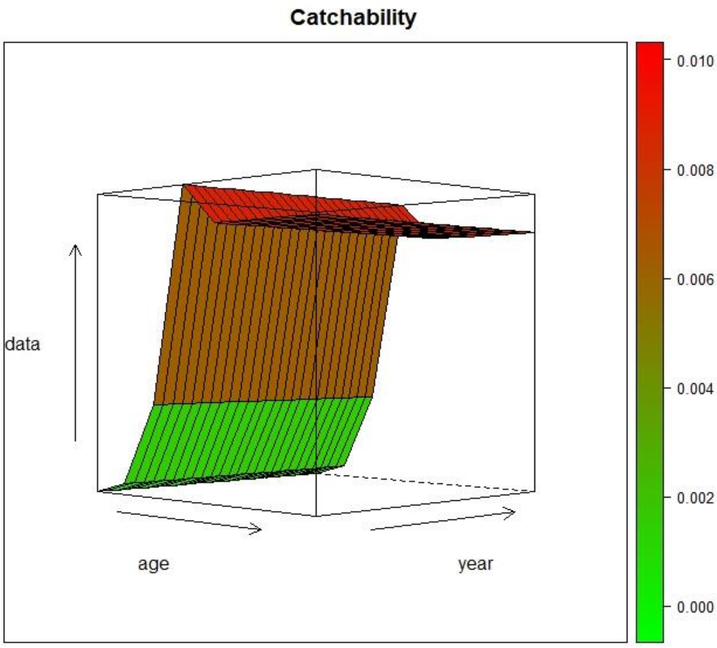


Figure 6.13.3.4. Norway lobster in GSA 9: catchability of the survey by age and year obtained from the a4a model.

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.

In general, the diagnostics are considered acceptable and the a4a model is acceptable as a basis for advice.

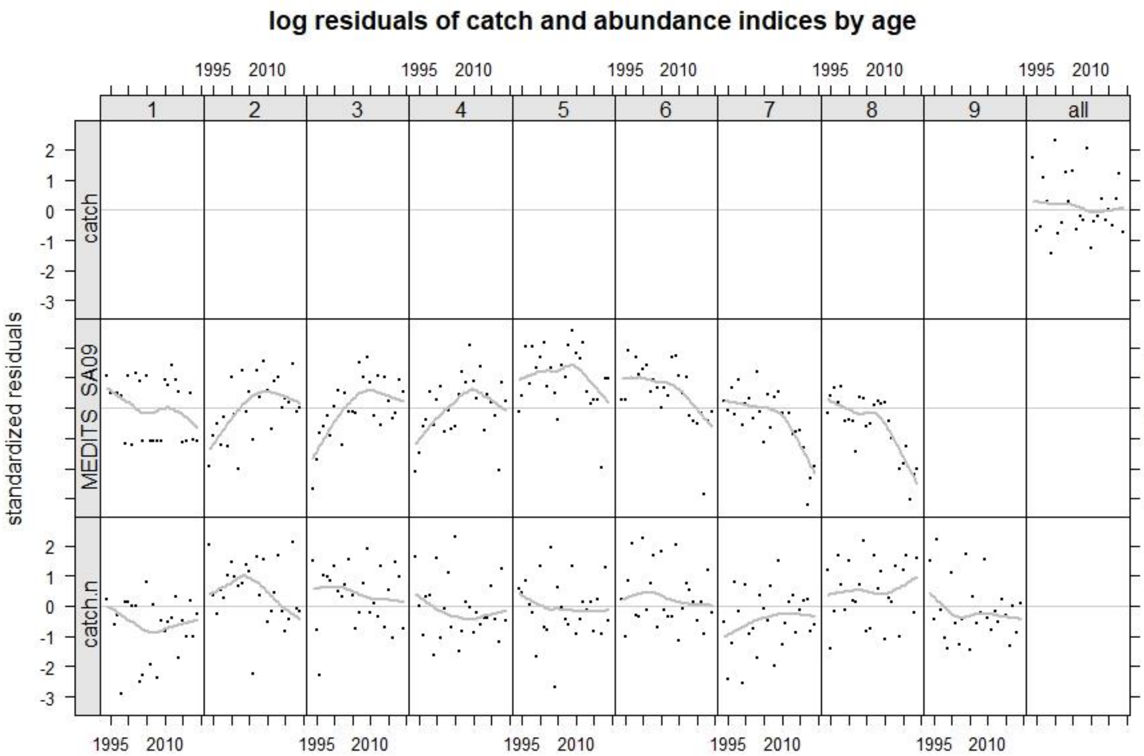


Figure 6.13.3.5. Norway lobster in GSA 9: log residuals for the catch-at-age data of the fishery and the survey, and the catches.

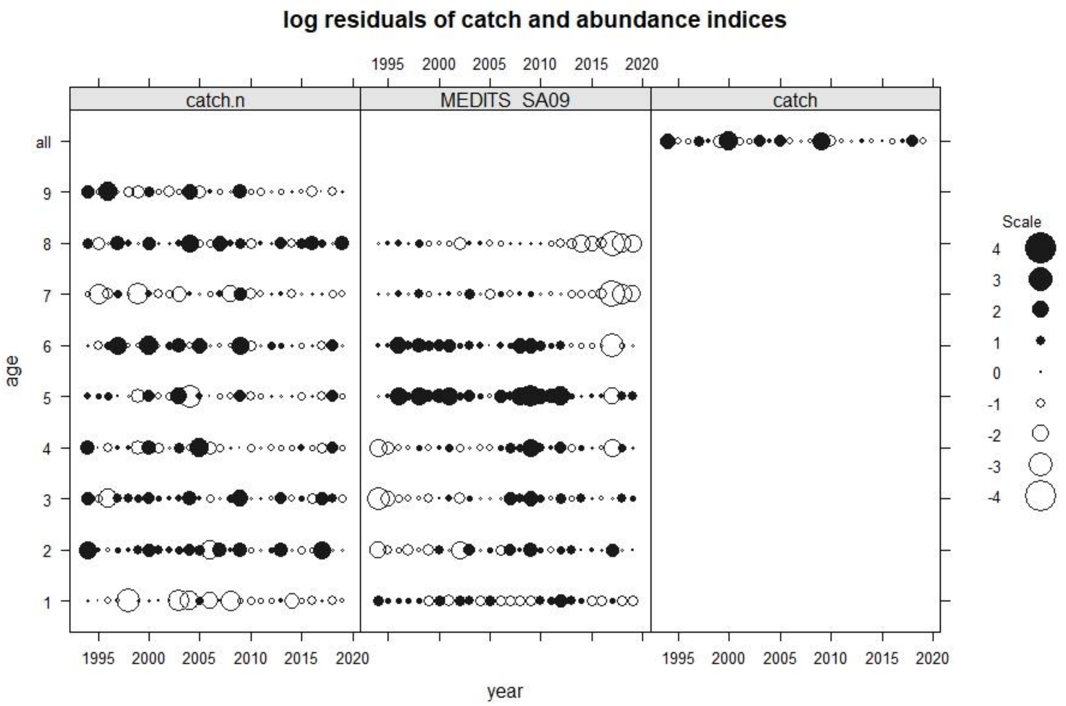


Figure 6.13.3.6. Norway lobster in GSA 9: bubble plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

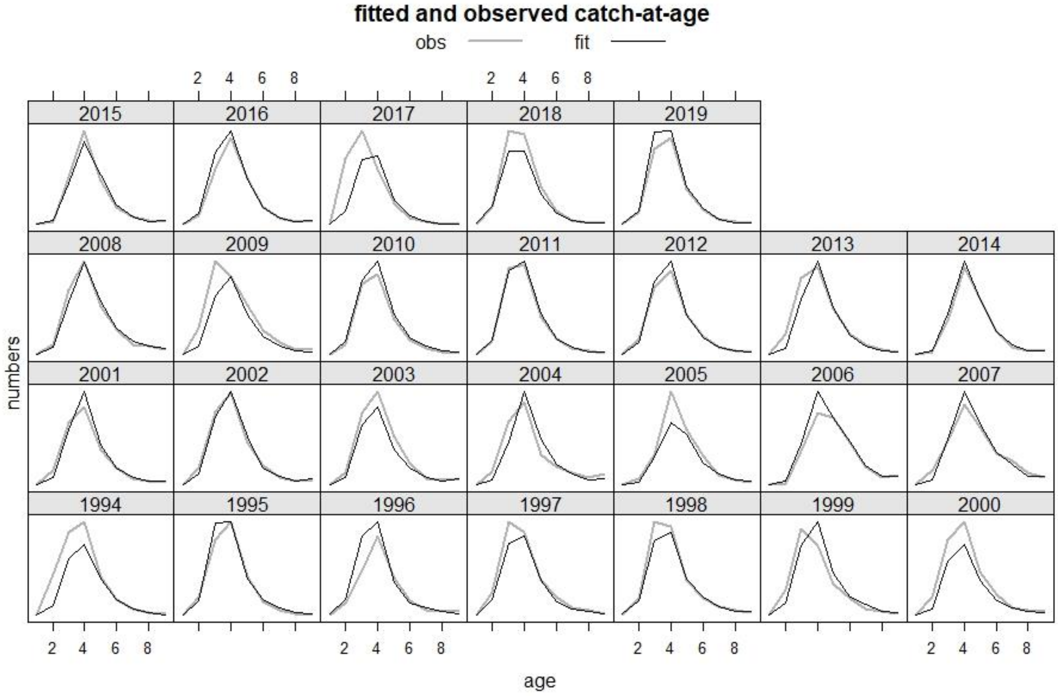


Figure 6.13.3.7. Norway lobster in GSA 9: fitted vs observed values by age and year for the catches.

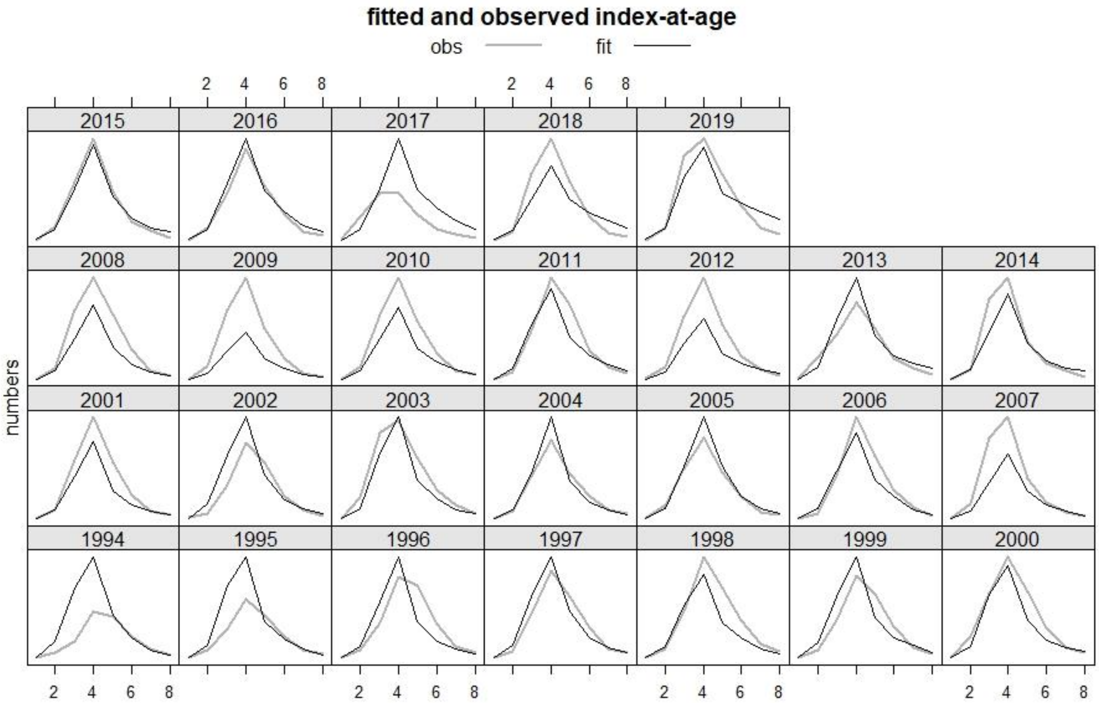


Figure 6.13.3.8. Norway lobster in GSA 9: fitted vs observed values by age and year for the survey.

The internal consistency of the catches is very 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.

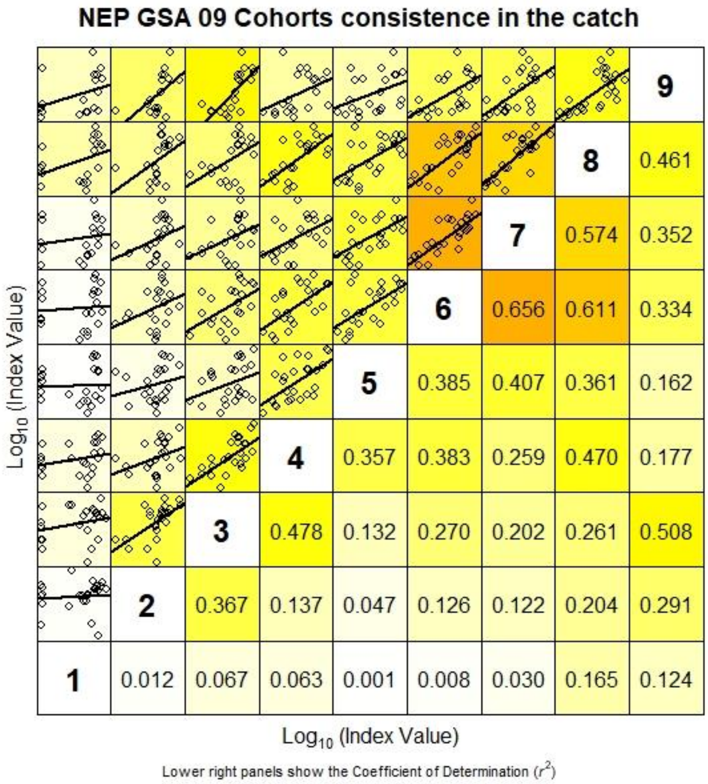


Figure 6.13.3.9. Norway lobster in GSA 9: internal consistency of the catch-at-age data.

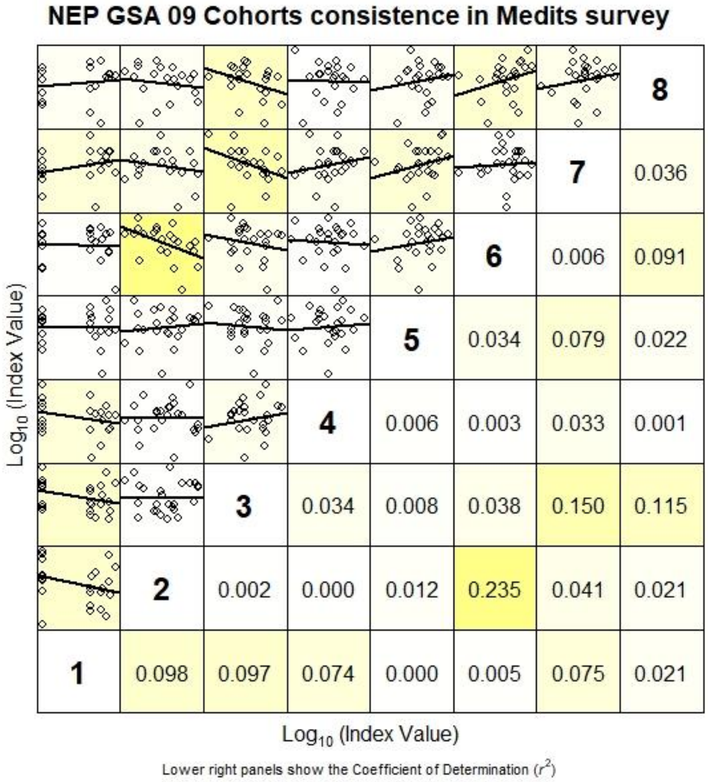


Figure 6.13.3.10. Norway lobster in GSA 9: internal consistency of the catch-at-age data of the MEDITS survey.

The retrospective analysis shows that the assessment model is stable with respect to F relative to F_{MSY} because survey residuals show blocks with consistent possitive or negative groups its likely the assessment with exhibit section of correlated errors in SSB and F. Nevertheless the conclusion that F at F_{MSY} is robust to all years in the retrospective. The assessment is considered acceptable for advice.

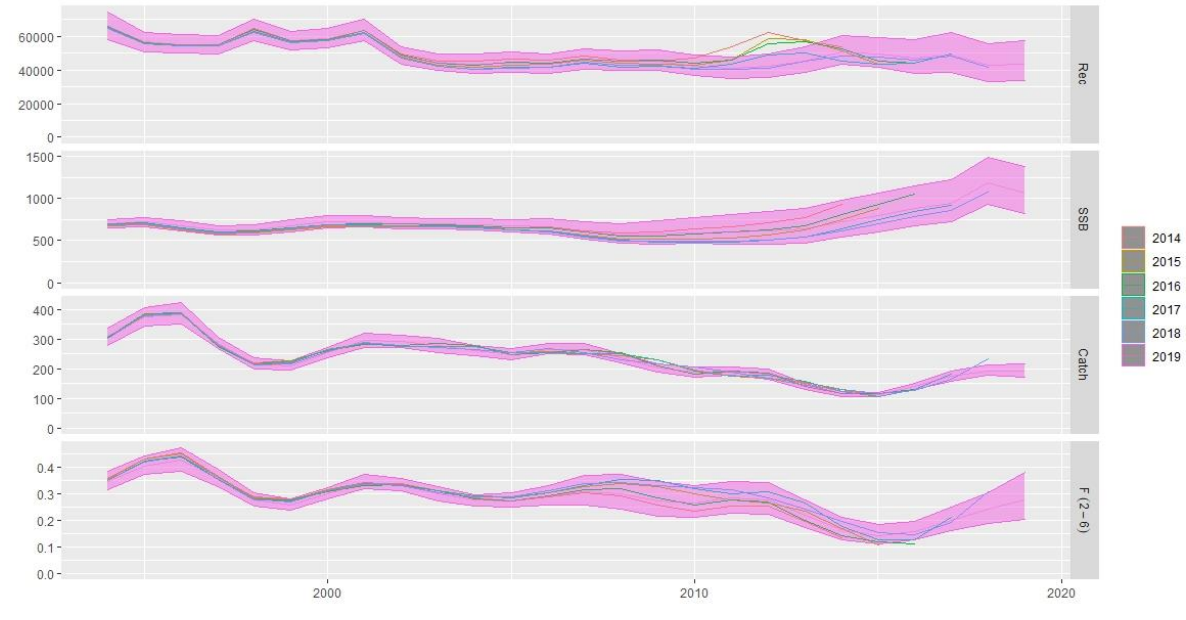


Figure 6.13.3.11. Norway lobster in GSA 9: retrospective analysis.

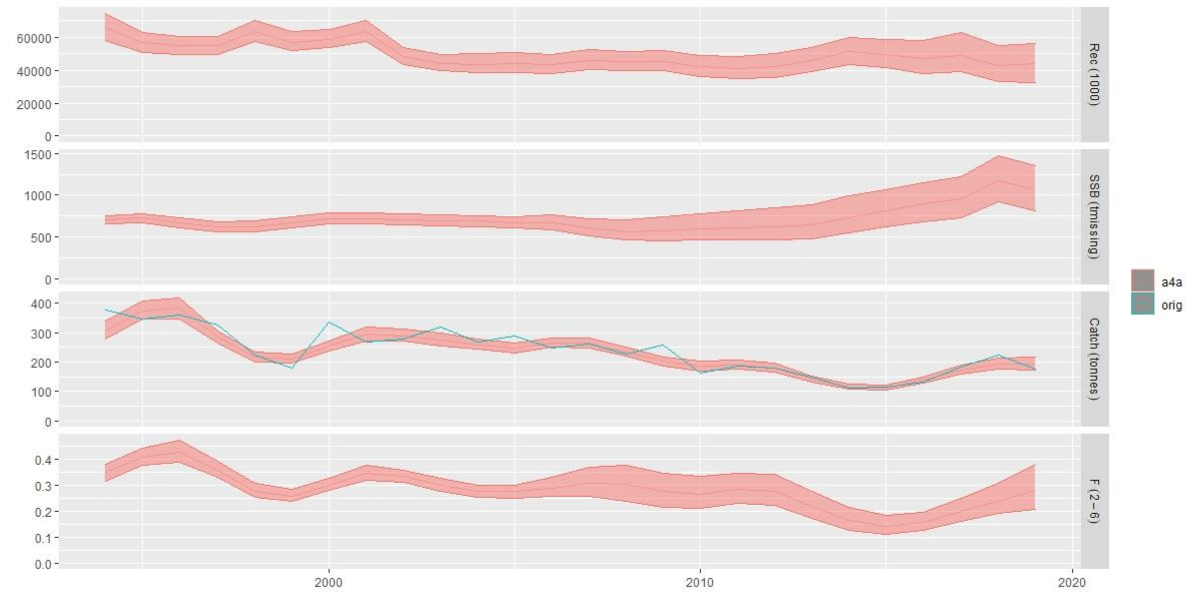


Figure 6.13.3.12. Norway lobster in GSA 9: outputs of the a4a stock assessment model, with uncertainty; input catch data (blue line) are plotted against the estimated catches.

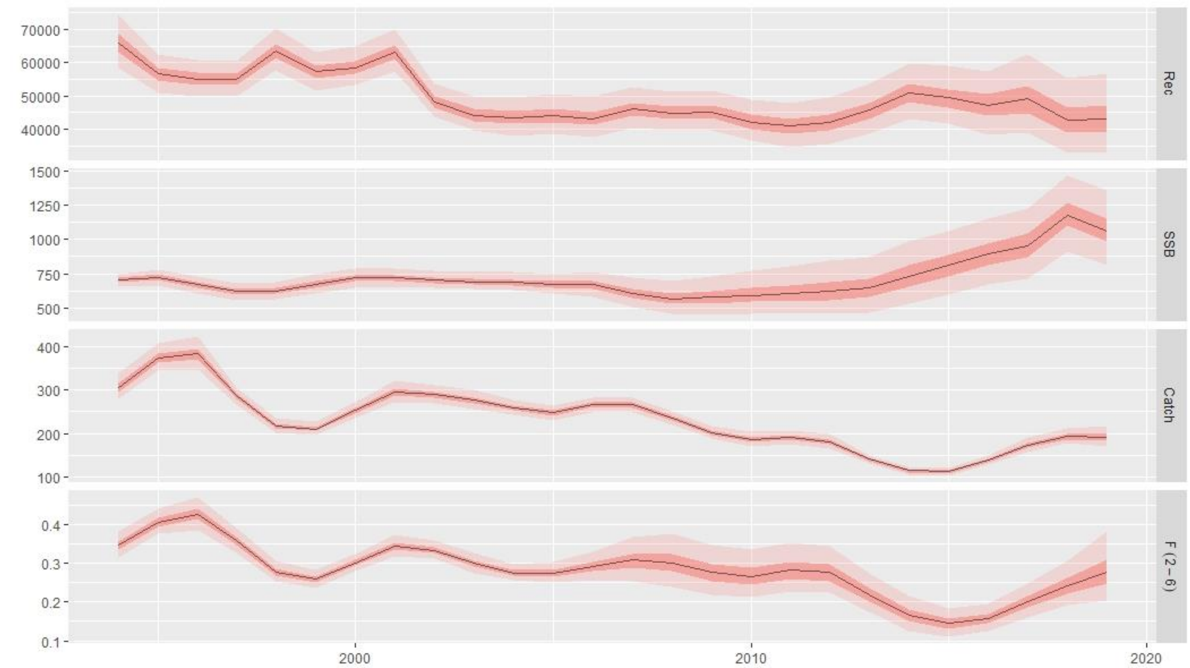


Figure 6.13.3.13. Norway lobster in GSA 9: outputs of the a4a stock assessment model (with uncertainty).

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
1	65786	56517	55073	54945	63553	57217	58725	63399	48342	44324	43608	44128	43356
2	38450	31056	26661	25960	25909	29993	27014	27729	29936	22823	20926	20593	20842
3	20394	22930	18277	15521	15220	15393	17941	16183	16593	17874	13640	12576	12423
4	10460	11499	11884	8983	8039	8565	8988	10431	9242	9406	10321	8201	7789
5	5030	4581	4474	4405	3698	3780	4174	4136	4513	4065	4399	5114	4197
6	2228	2228	1918	1871	2019	1862	1914	1946	1796	2023	1935	2130	2433
7	909	1033	1006	881	934	1092	1012	971	926	866	1009	960	1015
8	348	411	453	450	434	507	609	542	491	457	426	492	452
9	129	199	237	268	318	390	507	640	652	574	474	418	431

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	46096	45052	45292	42182	40968	41979	45627	50965	49431	47088	49171	42712	43411
2	20478	21771	21274	21382	19908	19331	19815	21549	24073	23348	22234	23189	20140
3	12580	12336	13065	12709	12705	11779	11503	11931	13032	14550	14004	13092	13596
4	7723	7681	7329	7560	7133	6916	6575	7002	7630	8320	8802	7710	6909
5	3968	3817	3706	3510	3545	3192	3124	3355	3978	4426	4572	4411	3551
6	1939	1808	1790	1841	1798	1789	1592	1631	1878	2332	2634	2677	2453
7	1100	860	854	946	1045	1036	1027	931	993	1194	1532	1745	1739
8	443	452	383	454	565	648	651	662	621	682	837	1085	1234
9	378	297	292	350	499	707	934	1138	1332	1461	1600	1822	2198

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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.2	0.3	0.3	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
4	0.5	0.6	0.7	0.6	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.3	0.3	0.4
5	0.5	0.6	0.6	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5
6	0.5	0.5	0.5	0.4	0.4	0.3	0.4	0.5	0.5	0.4	0.4	0.5	0.5	0.6
7	0.6	0.6	0.6	0.5	0.4	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6
8	0.6	0.7	0.7	0.5	0.4	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.6	0.8
9	0.7	0.8	0.8	0.6	0.5	0.3	0.3	0.3	0.5	0.6	0.5	0.5	0.6	0.8

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2
0.4	0.4	0.4	0.5	0.5	0.3	0.2	0.2	0.3	0.4	0.4	0.5
0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.2	0.2	0.2	0.3	0.4
0.5	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
0.6	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
0.7	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.8	0.4	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0

Table 6.13.3.7. Norway lobster in GSA 9: summary results of the a4a assessment.

year	Recruitment	SSB	Catch	Fbar	Total Biomass
1994	65786	701	306	0.3	1310
1995	56517	722	375	0.4	1390
1996	55073	671	383	0.4	1287
1997	54945	619	287	0.4	1153
1998	63553	624	218	0.3	1057
1999	57217	671	212	0.3	1182
2000	58725	717	254	0.3	1269
2001	63399	718	295	0.3	1302
2002	48342	703	291	0.3	1269
2003	44324	695	277	0.3	1166
2004	43608	687	260	0.3	1126
2005	44128	671	248	0.3	1146
2006	43356	666	267	0.3	1112
2007	46096	607	267	0.3	1100
2008	45052	568	237	0.3	967
2009	45292	579	204	0.3	1033
2010	42182	597	189	0.3	1038
2011	40968	608	193	0.3	1025
2012	41979	623	183	0.3	1038
2013	45627	646	143	0.2	1039
2014	50965	730	117	0.2	1068
2015	49431	808	113	0.1	1223
2016	47088	887	140	0.2	1344
2017	49171	947	174	0.2	1440

2018	42712	1169	194	0.2	4588
2019	43411	1056	193	0.3	2722

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 (0.28), estimated as the F_{bar2-6} in the last year of the time series, 2018) is at the level of $F_{0.1}$, 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 2019 to 2021 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 (2019from the a4a assessment was used.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the 2002-2019, 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
$F_{ages\ 2-6}$ (2020)	0.28	F2019 used to give F status quo for 2020
SSB (2020)	1046.4 t	Stock assessment 1 January 2020
R_0 (2020,2021)	44943 thousands	Geometric mean of the period 2003-2019
Total catch (2020)	189 t	Assuming F status quo for 2020

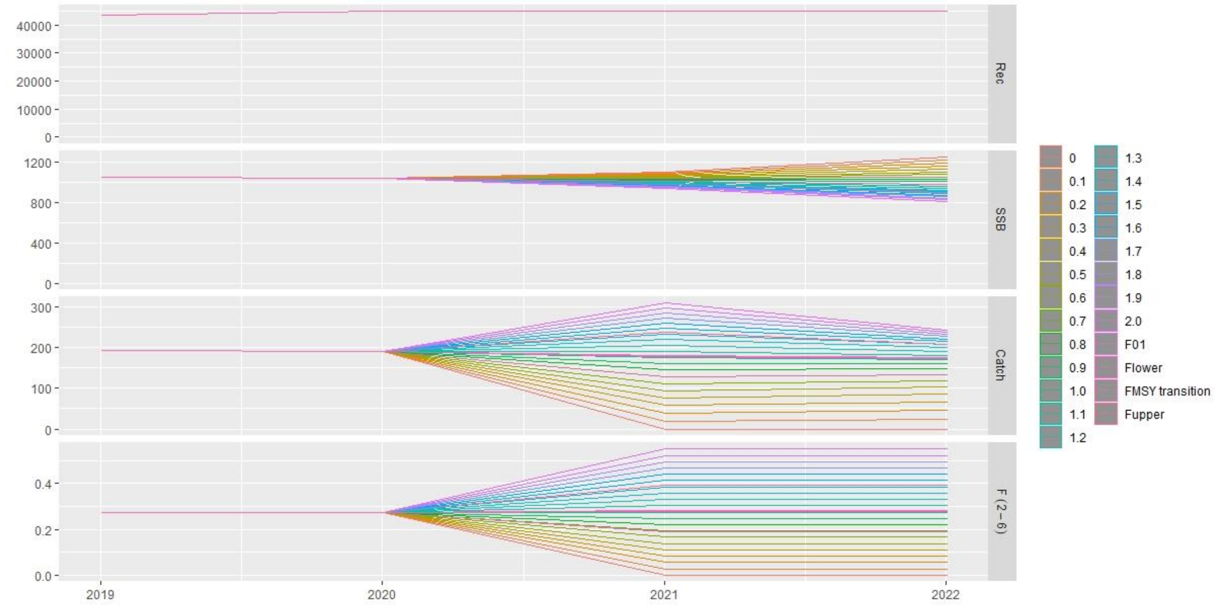


Figure 6.13.5.2 Norway lobster in GSA 9: short term forecast in different F scenarios. SSB estimates refer to middle year.

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 2020	Fsq2020	Catch2019	Catch2021	SSB2020	SSB2022	SSB_change_ 2020-2022(%)	Catch_change_ 2019-2021(%)
High long term yield (F0.1)	1.03	0.28	44943.0	0.28	193.2	180.5	1046.4	980.5	-6.3	-6.5
F upper	1.42	0.39	44943.0	0.28	193.2	235.9	1046.4	905.6	-13.5	22.1
F lower	0.69	0.19	44943.0	0.28	193.2	127.0	1046.4	1056.9	1.0	-34.3
FMSY transition	1.01	0.28	44943.0	0.28	193.2	177.3	1046.4	984.9	-5.9	-8.2
Zero catch	0.00	0.00	44943.0	0.28	193.2	0.0	1046.4	1253.9	19.8	-100.0
Status quo	1.00	0.28	44943.0	0.28	193.2	175.7	1046.4	987.2	-5.7	-9.0
	0.10	0.03	44943.0	0.28	193.2	20.0	1046.4	1221.4	16.7	-89.6
	0.20	0.06	44943.0	0.28	193.2	39.4	1046.4	1190.4	13.8	-79.6
	0.30	0.08	44943.0	0.28	193.2	58.3	1046.4	1160.8	10.9	-69.8
	0.40	0.11	44943.0	0.28	193.2	76.6	1046.4	1132.5	8.2	-60.4
	0.50	0.14	44943.0	0.28	193.2	94.3	1046.4	1105.5	5.6	-51.2
	0.60	0.17	44943.0	0.28	193.2	111.6	1046.4	1079.7	3.2	-42.2
	0.70	0.19	44943.0	0.28	193.2	128.3	1046.4	1055.0	0.8	-33.6
	0.80	0.22	44943.0	0.28	193.2	144.6	1046.4	1031.4	-1.4	-25.2
	0.90	0.25	44943.0	0.28	193.2	160.4	1046.4	1008.8	-3.6	-17.0
Different Scenarios	1.10	0.30	44943.0	0.28	193.2	190.6	1046.4	966.5	-7.6	-1.3
	1.20	0.33	44943.0	0.28	193.2	205.2	1046.4	946.6	-9.5	6.2
	1.30	0.36	44943.0	0.28	193.2	219.3	1046.4	927.6	-11.4	13.5
	1.40	0.39	44943.0	0.28	193.2	233.0	1046.4	909.4	-13.1	20.6
	1.50	0.41	44943.0	0.28	193.2	246.4	1046.4	891.8	-14.8	27.6
	1.60	0.44	44943.0	0.28	193.2	259.4	1046.4	875.0	-16.4	34.3
	1.70	0.47	44943.0	0.28	193.2	272.1	1046.4	858.9	-17.9	40.9
	1.80	0.50	44943.0	0.28	193.2	284.5	1046.4	843.4	-19.4	47.3
	1.90	0.52	44943.0	0.28	193.2	296.5	1046.4	828.4	-20.8	53.5
	2.00	0.55	44943.0	0.28	193.2	308.3	1046.4	814.1	-22.2	59.6

*SSB at mid year

6.14 Norway lobster in GSA 11

An advice on NEP in GSA 11 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.

6.14.1 Stock identity and biology

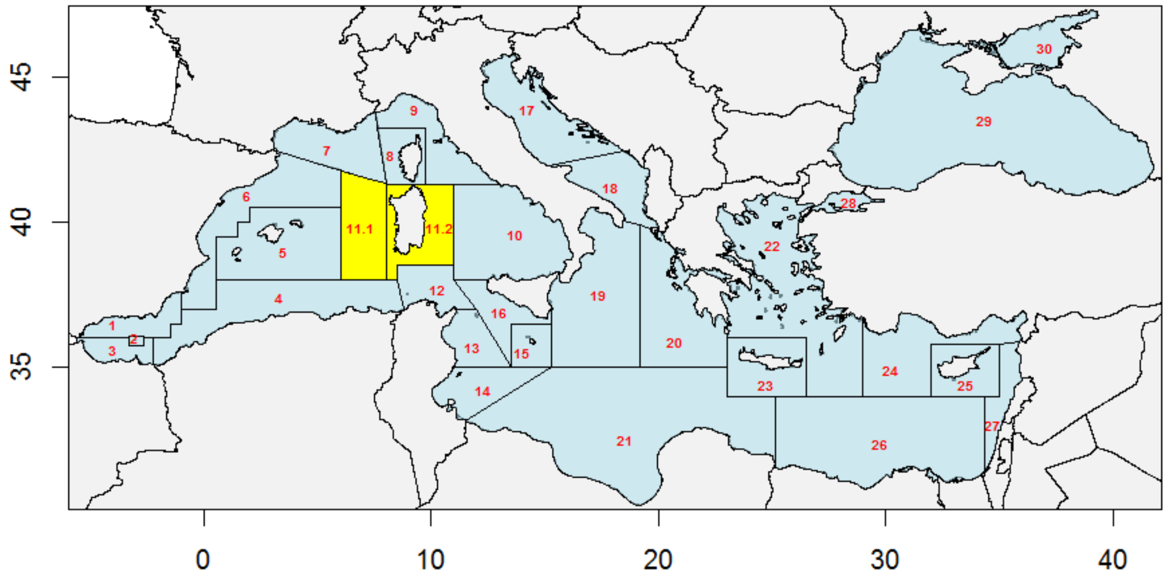


Figure 6.14.1.1. Geographical location of GSA 11

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.

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
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	40.1

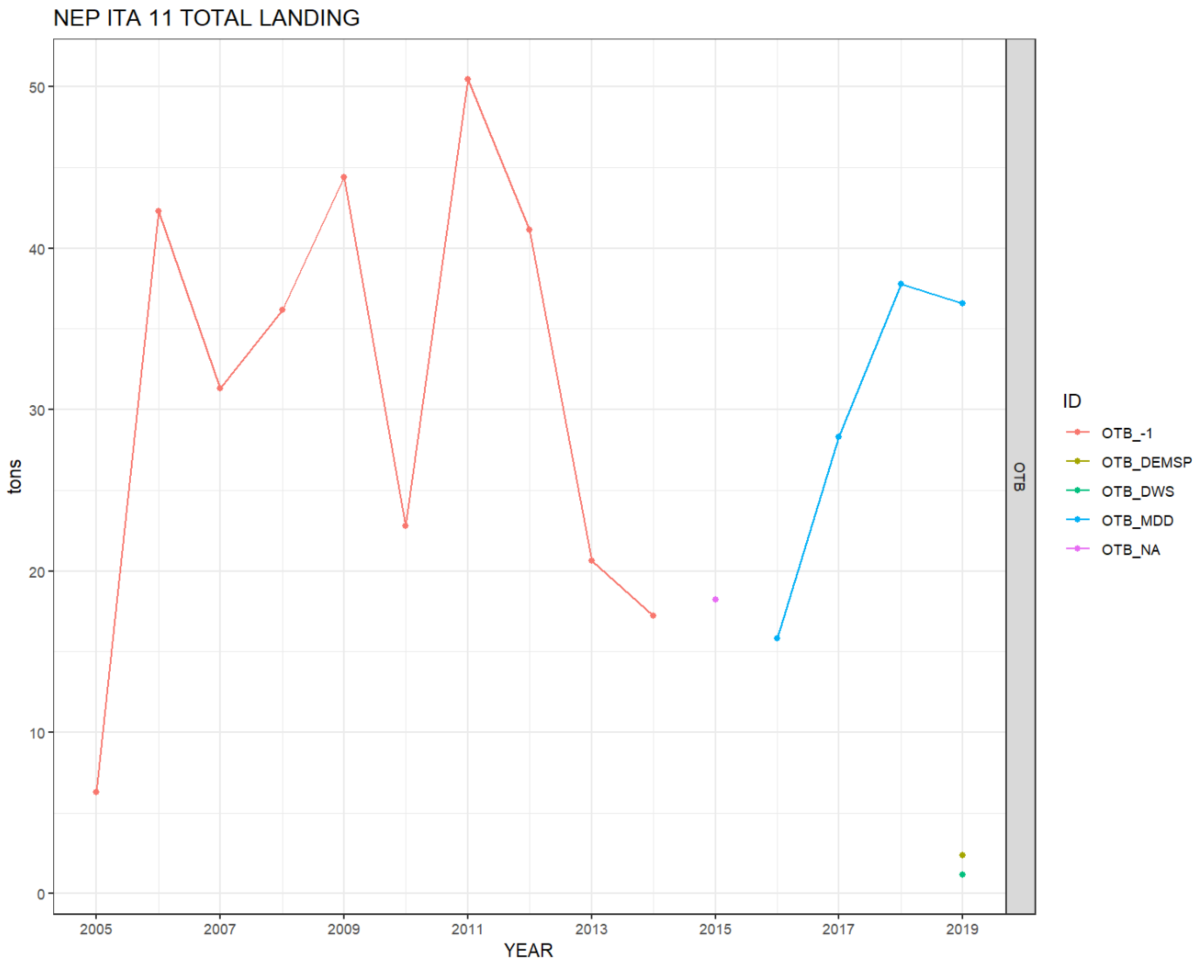


Figure 6.14.2.1.1. Norway lobster landing data (in tons) in GSA 11

As reported in the DCF, landings' length frequency distribution by year are presented in figure 6.14.2.1.2.

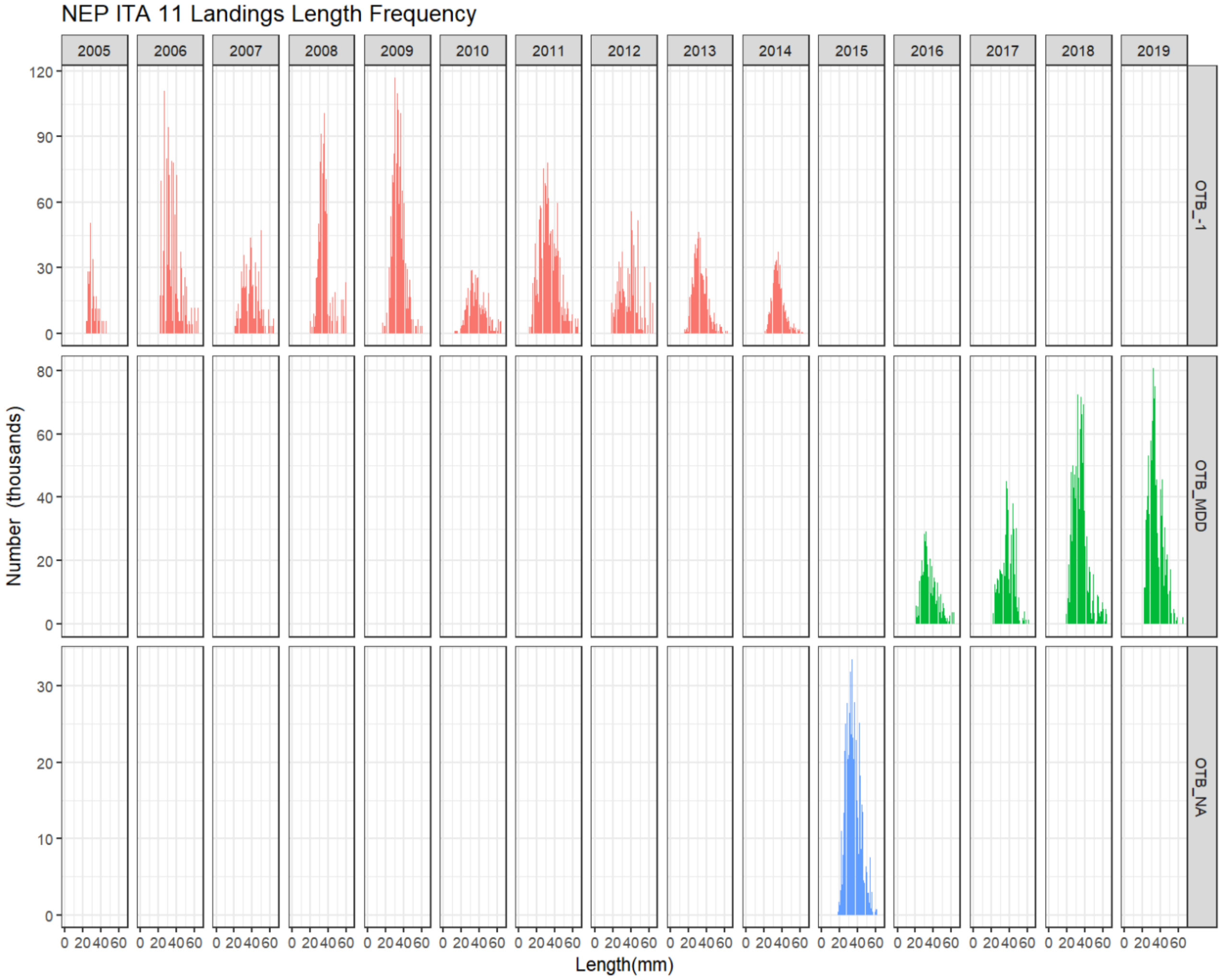
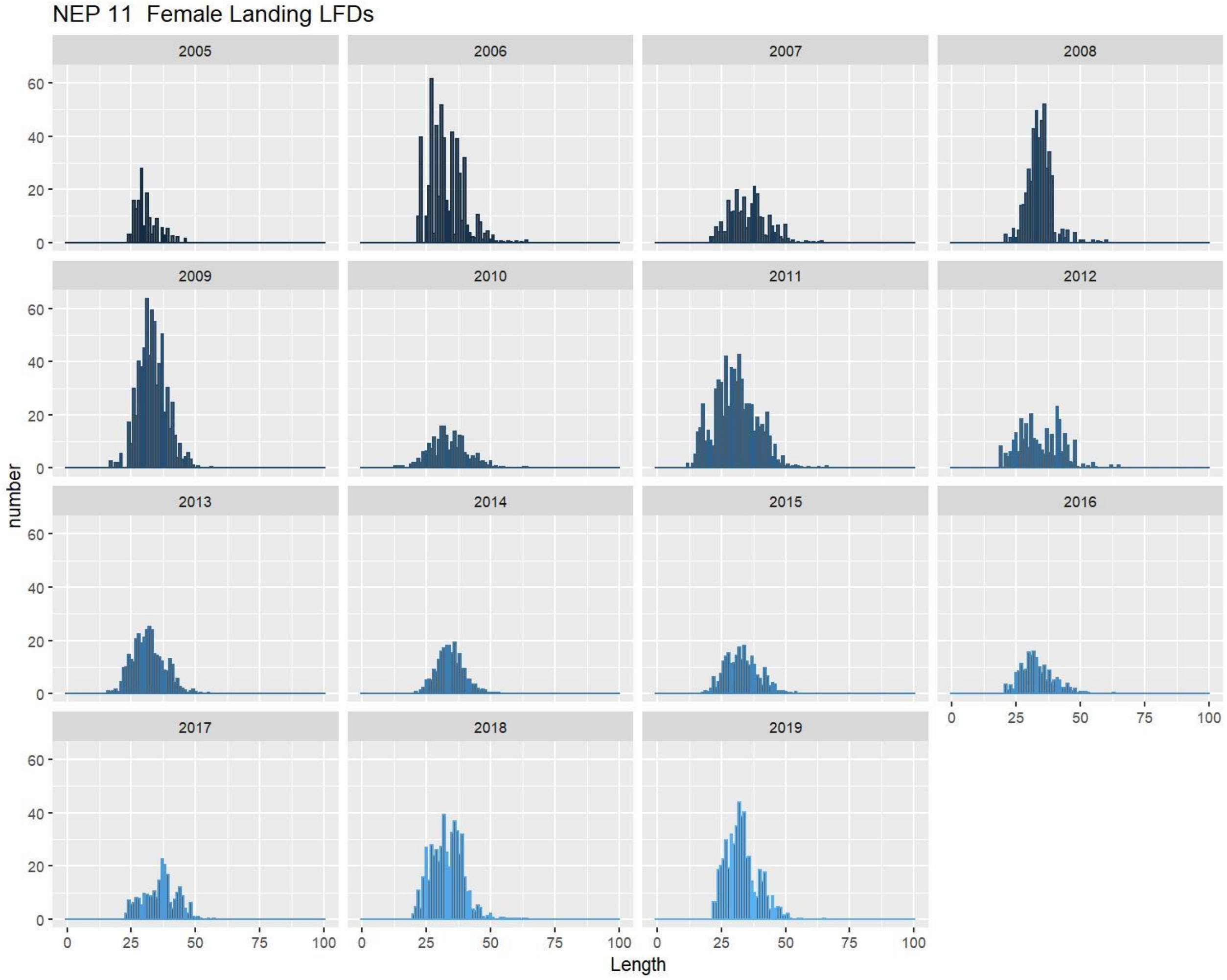


Figure 6.14.2.1.2. Norway lobster in GSA 11. Length frequency distribution of the landings by year and gear in GSA 11.

According to growth parameters and sex-ratio the reported length structure of landings was split by sex (Figure 6.14.2.1.3).


NEP 11 Female Landing LFDs
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
number
Length
0
20
40
60
0
25
50
75
100

A

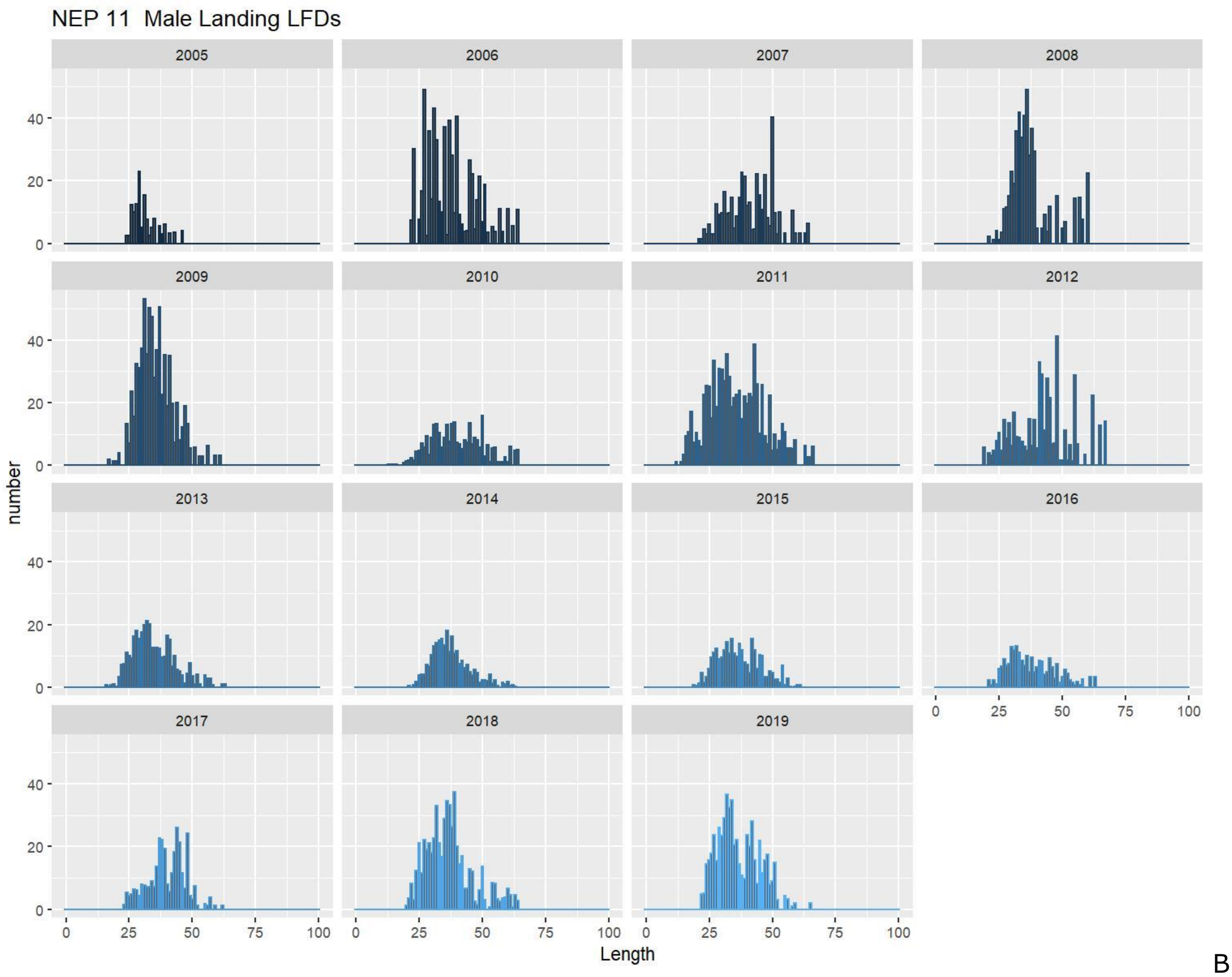


Figure 6.14.2.1.3. Norway lobster in GSA 11. Length frequency distribution of the landings by year in GSA 11 split by sex (A=female, B=male).

6.14.2.2 EFFORT

Fishing effort data were reported to STECF EWG 20-09 through DCF. Unexpected significant increase of OTB fishing effort has been detected in comparison with the previous years (Tables 6.14.2.2.1-3, Figures 6.14.2.2.1-3).

Table 6.14.2.2.1. Norway lobster in GSA 11. Fishing effort in Days at sea by year and fishing gear.

GSA	2002	2003	2004	2005	2006	2007	2008	2009	2010
GSA11_ITA_OTB	14539	18957	24827	28645	22836	22321	19435	20128	19321

GSA	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ESP_OTB	17018	15472	15872	17583	15278	16926	16285	21190

Table 6.14.2.2.2. Norway lobster in GSA 11. Fishing effort in GT*Days at sea by year and fishing gear.

GSA	2002	2003	2004	2005	2006	2007	2008	2009	2010
GSA11_ITA_OTB	772163	986387	1721988	1785484	1358732	1414387	1144879	1048044	973315

GSA	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ESP_OTB	946564	916434	695262	847934	760006	829858	864739	1221171

Table 6.14.2.2.3. Norway lobster in GSA 11. Fishing effort in kW*Days at sea (in thousands) by year and fishing gear.

GSA	2002	2003	2004	2005	2006	2007	2008	2009	2010
GSA11_ITA_OTB	3680	4653	7706	7325	5753	5868	4499	4391	4124

GSA	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ESP_OTB	3815	3784	3139	3300	3109	3220	3828	5145

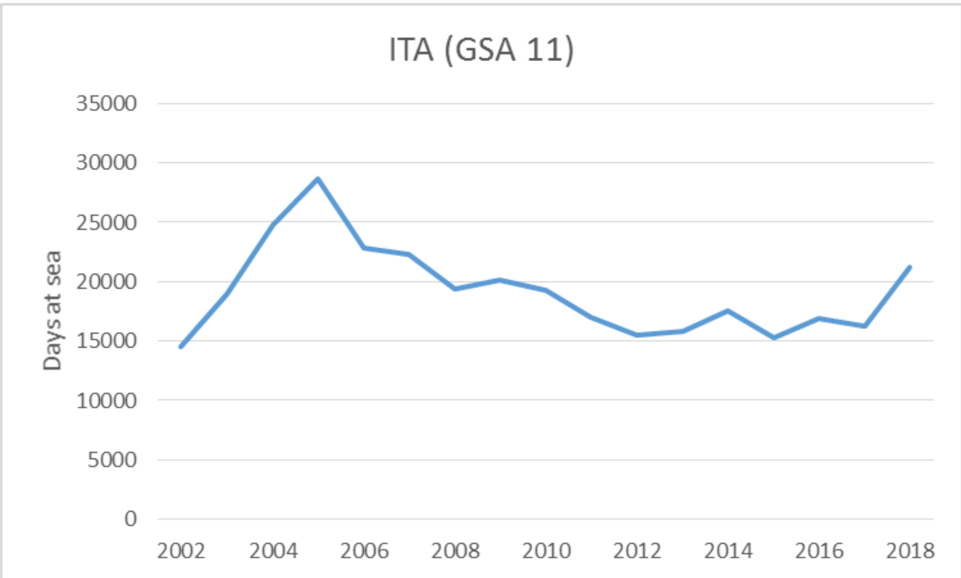


Figure 6.14.2.2.1. Norway lobster in GSA 11. Fishing effort in Days at sea by year and fishing gear.

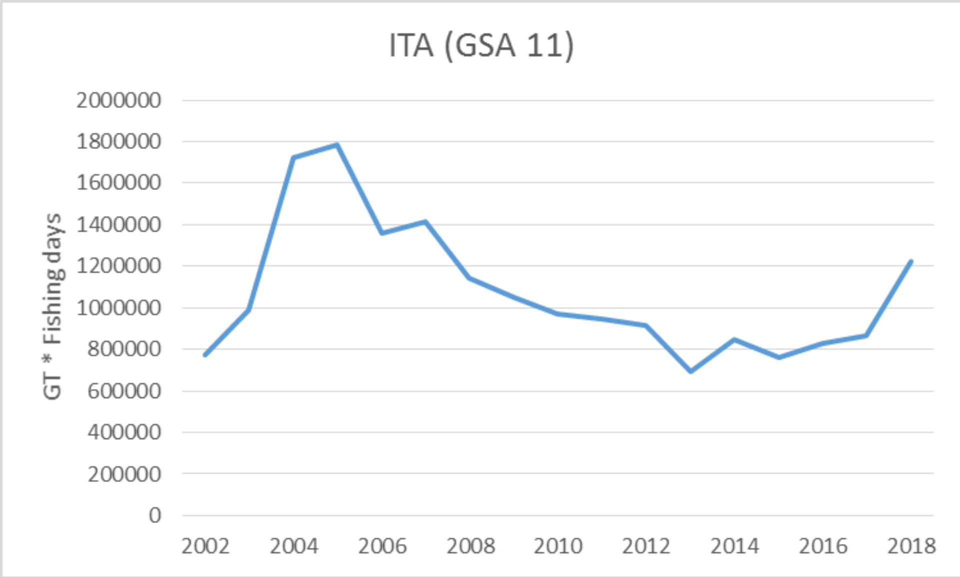


Figure 6.14.2.2.2. Norway lobster in GSA 11. Fishing effort in GT*Days at sea by year and fishing gear.

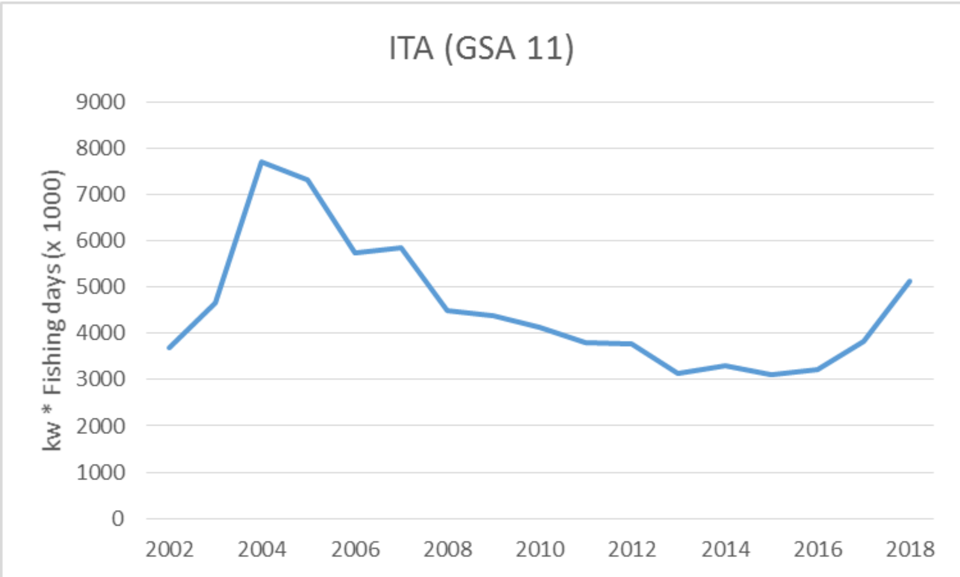


Figure 6.14.2.2.3. Norway lobster in GSA 11. Fishing effort in kW*Days at sea by year and fishing gear.

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. In these last 8 years biomass indices ranges from 1.3 to 2.7 (kg/Km2) and densities from 31.5 to 58.7 (n/Km2).

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.

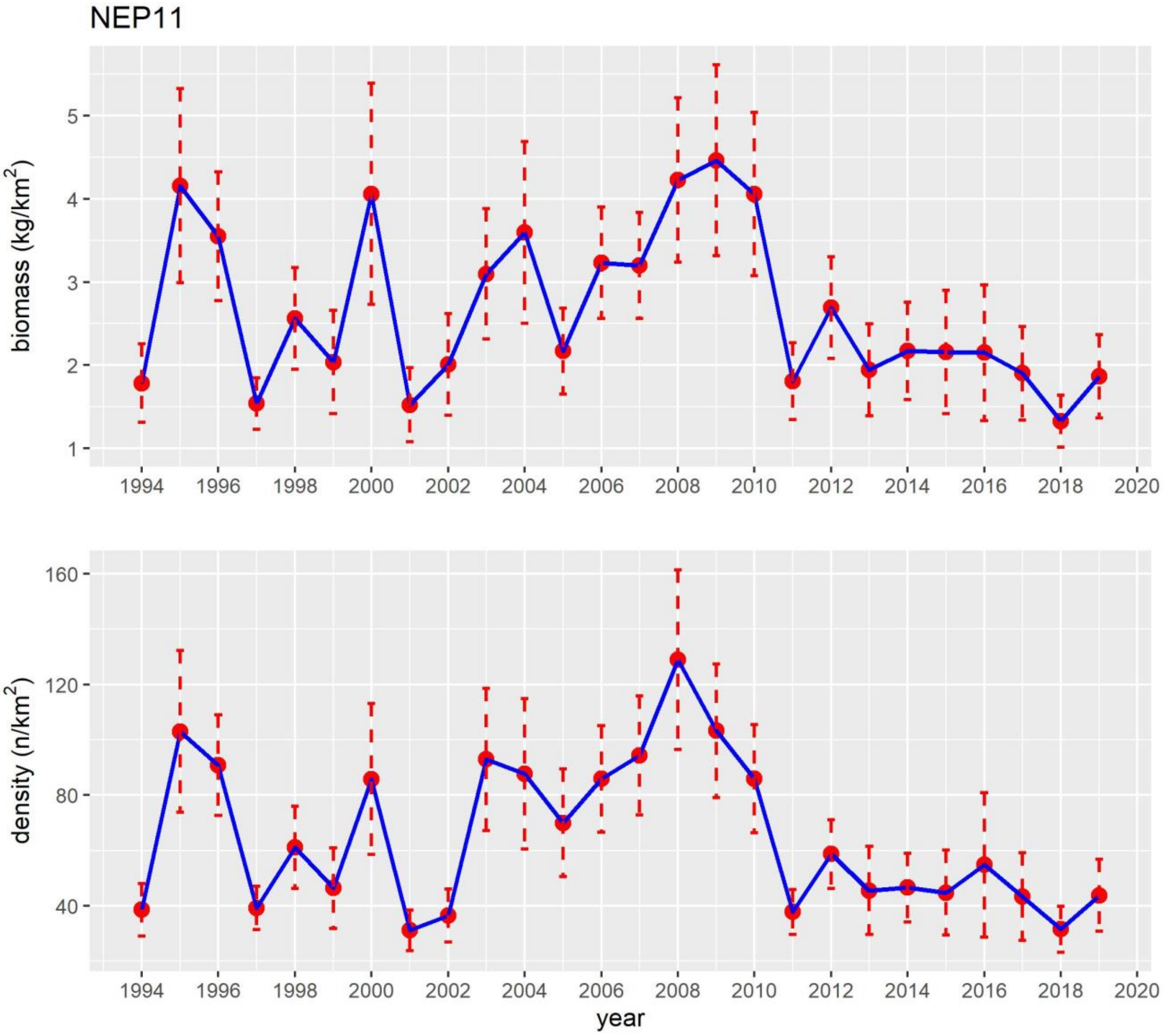


Figure 6.14.2.3.1. MEDITS indices for the period 1994-2019: relative biomass (kg km^2) and density (n km^2).

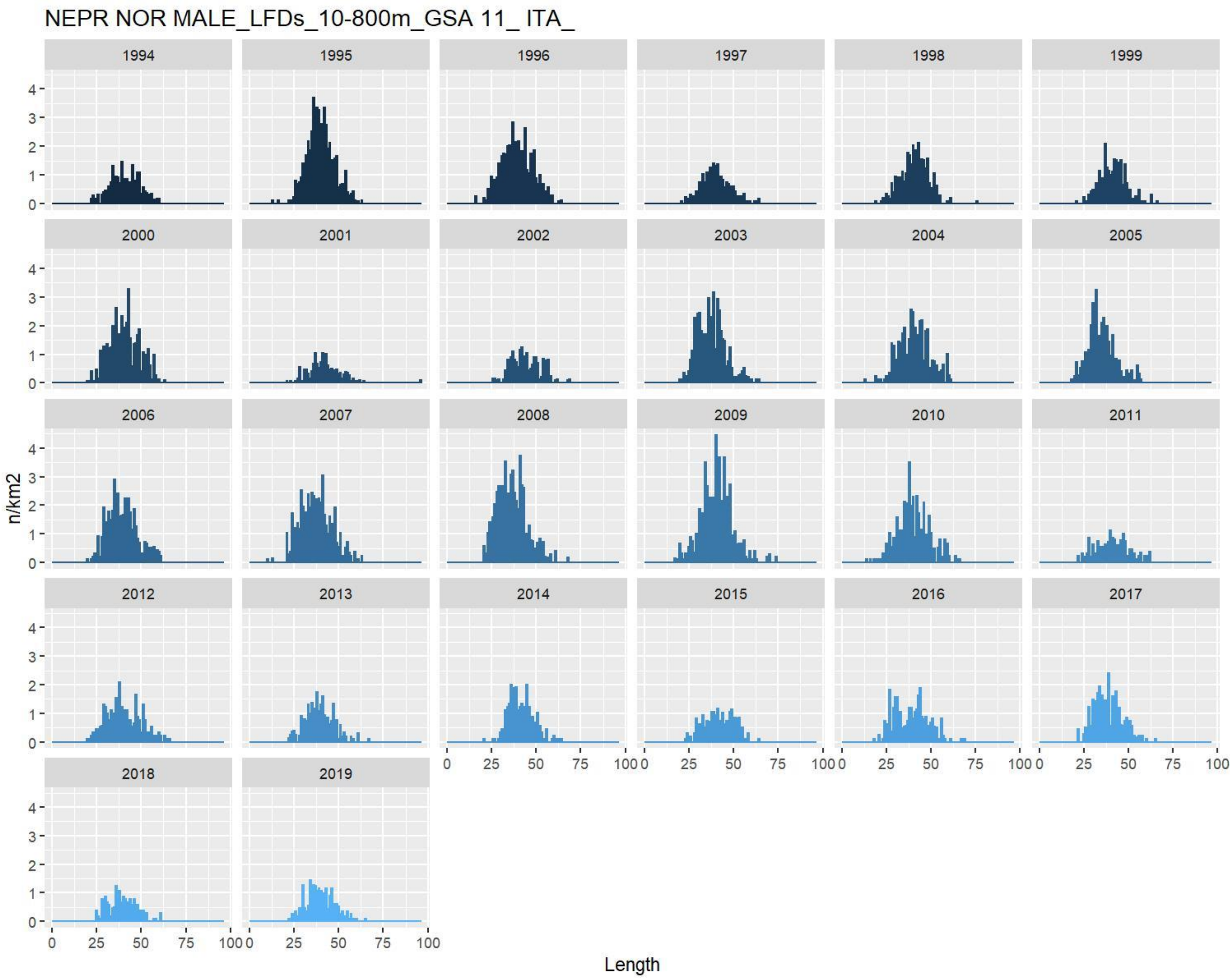


Figure 6.14.2.3.2. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for males.

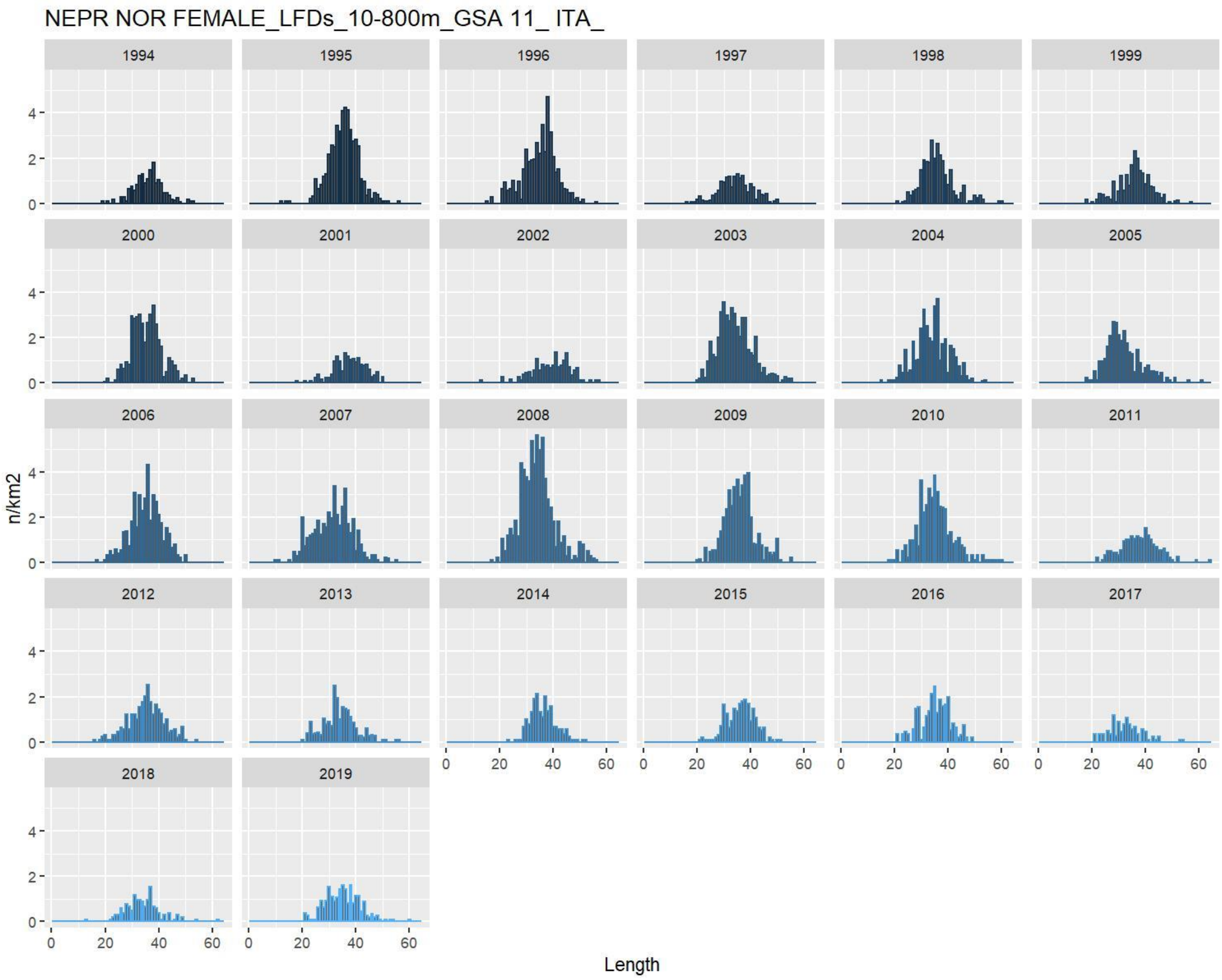


Figure 6.14.2.3.3. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for females.

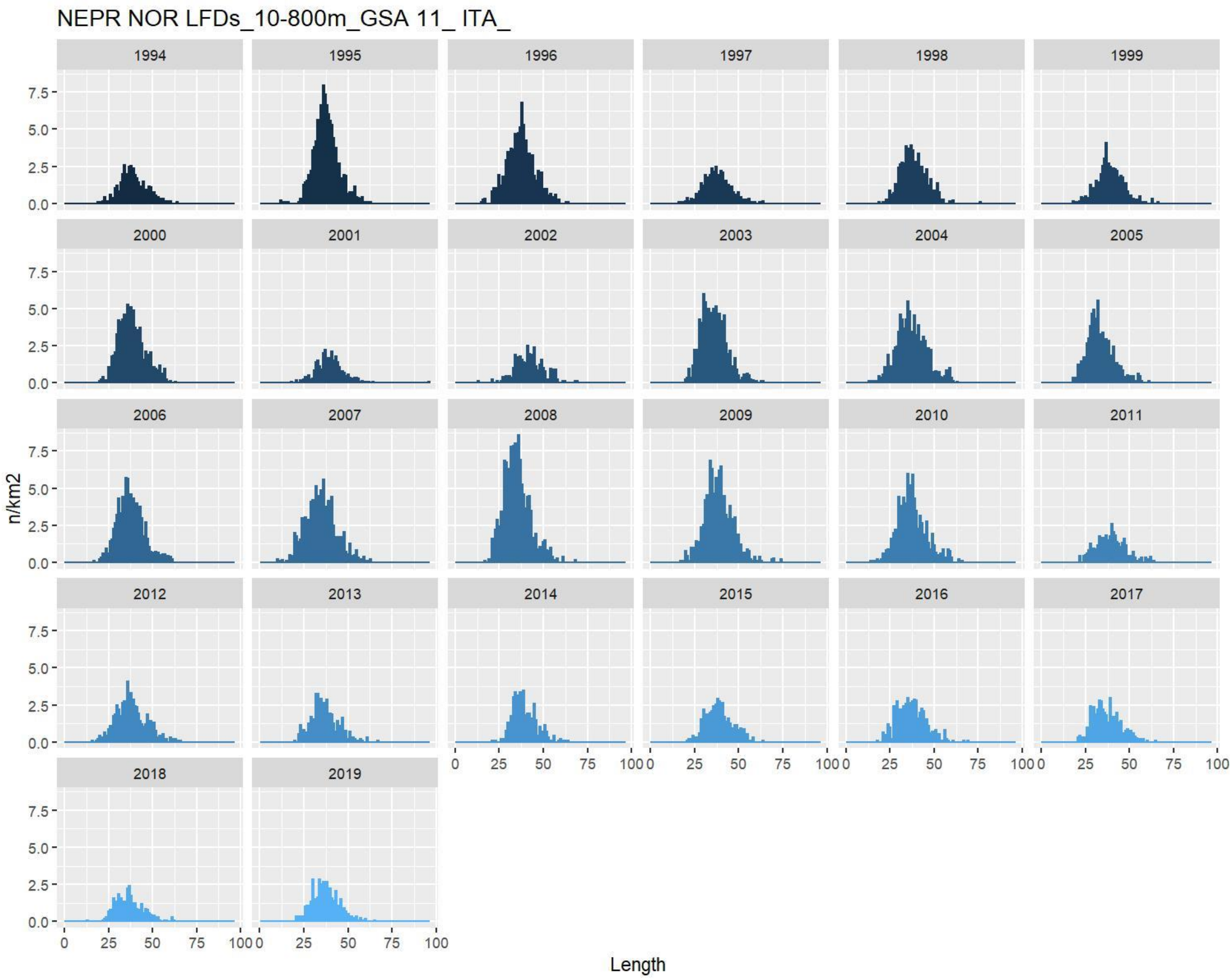


Figure 6.14.2.3.4. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data).

6.14.3 Stock Assessment

The EWG 18-12 concluded that XSA and a4a results were considered unacceptable due to incoherence in the landings cohorts and patterns in the residuals. F values estimated by XSA and a4a were also different. EWG 18-12 decided to apply a survey-based assessment following the approach adopted by ICES for category 3 stocks.

EWG 19-10 was required to do a short evaluation of survey and landing trends to determine if new data was 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 18-12 was confirmed.

EWG 20-09 was required to do a new assessment.

Input data

The Assessment for All Initiative (a4a) approach (Jardim et al., 2015) was used for Norway lobster in GSA11.

For the time series was 2005-2019 the a4a model was carried out using as input catch data from DCF and for the tuning fleet the abundance indices from the Medits survey. Both the length-frequency distributions of commercial catches and Medits survey were split by sex and then converted in age classes by using the l2a routine as implemeted in the package Fla4a of the FLR library. The growth parameters used for the deterministic slicing by sex are reported on table 6.14.3.6. Because the spawing of norway lobster occur in mid-summer, during the slicing procedure an adjustment was applied to the t_0 growth parameter by adding the fraction of the year before spawning (0.5). For the catches a plus group at age 12 was set.

The obtained catch numbers at age by sex and by total are presented in figures 6.14.3.1-3.

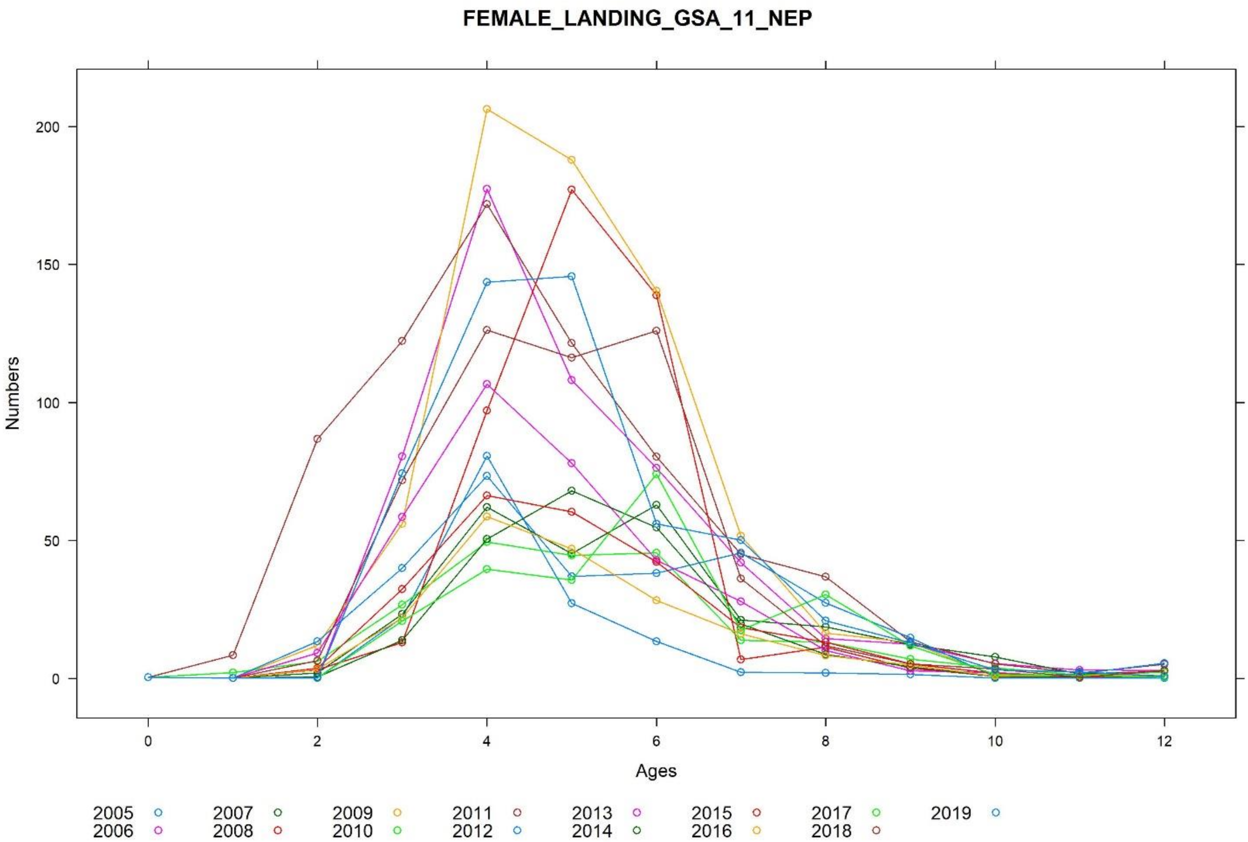


Figure 6.14.3.1. Norway lobster in GSA 11. Catch at age by year for female.

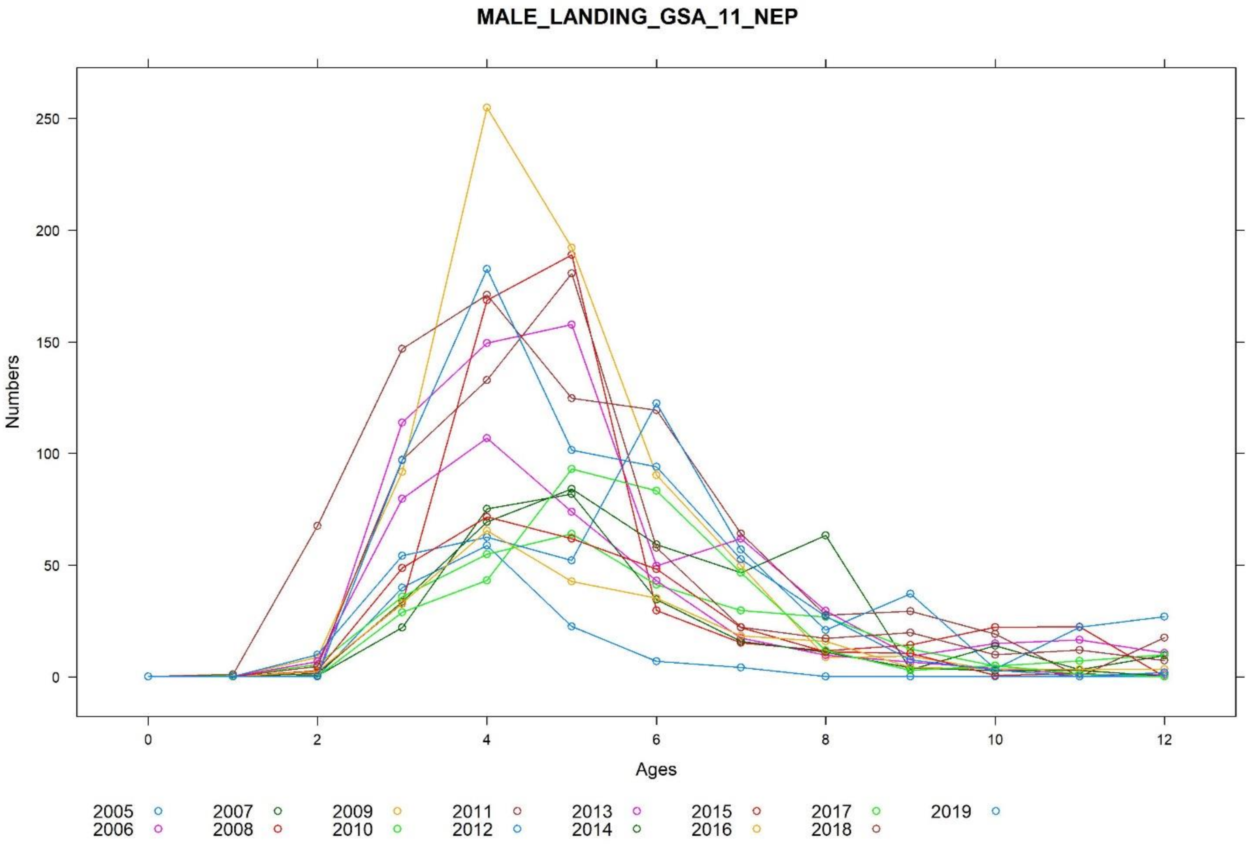


Figure 6.14.3.2. Norway lobster in GSA 11. Catch at age by year for male.

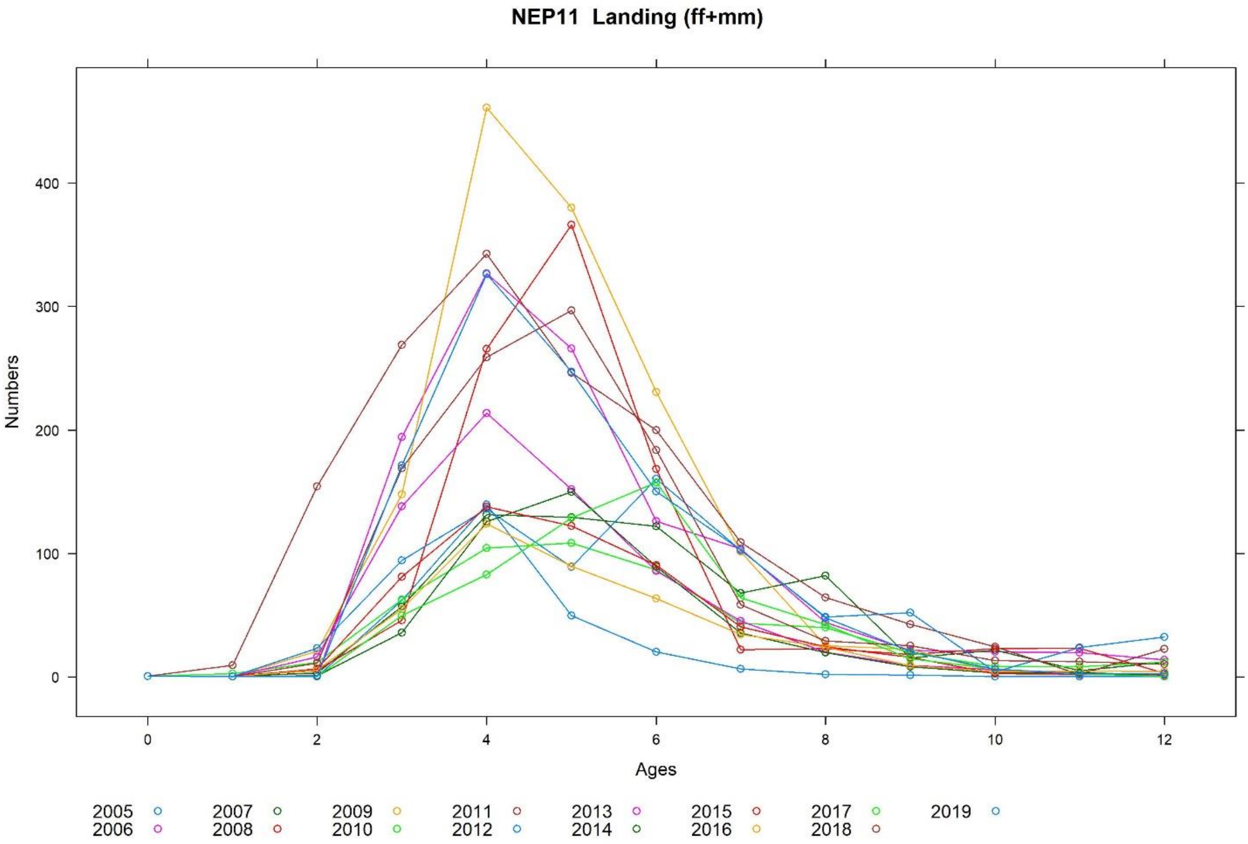


Figure 6.14.3.3. Norway lobster in GSA 11. Catch at age by year.

The gained Medits indices at age matrix by sex and by total are presented in figures 6.14.3.4-6.

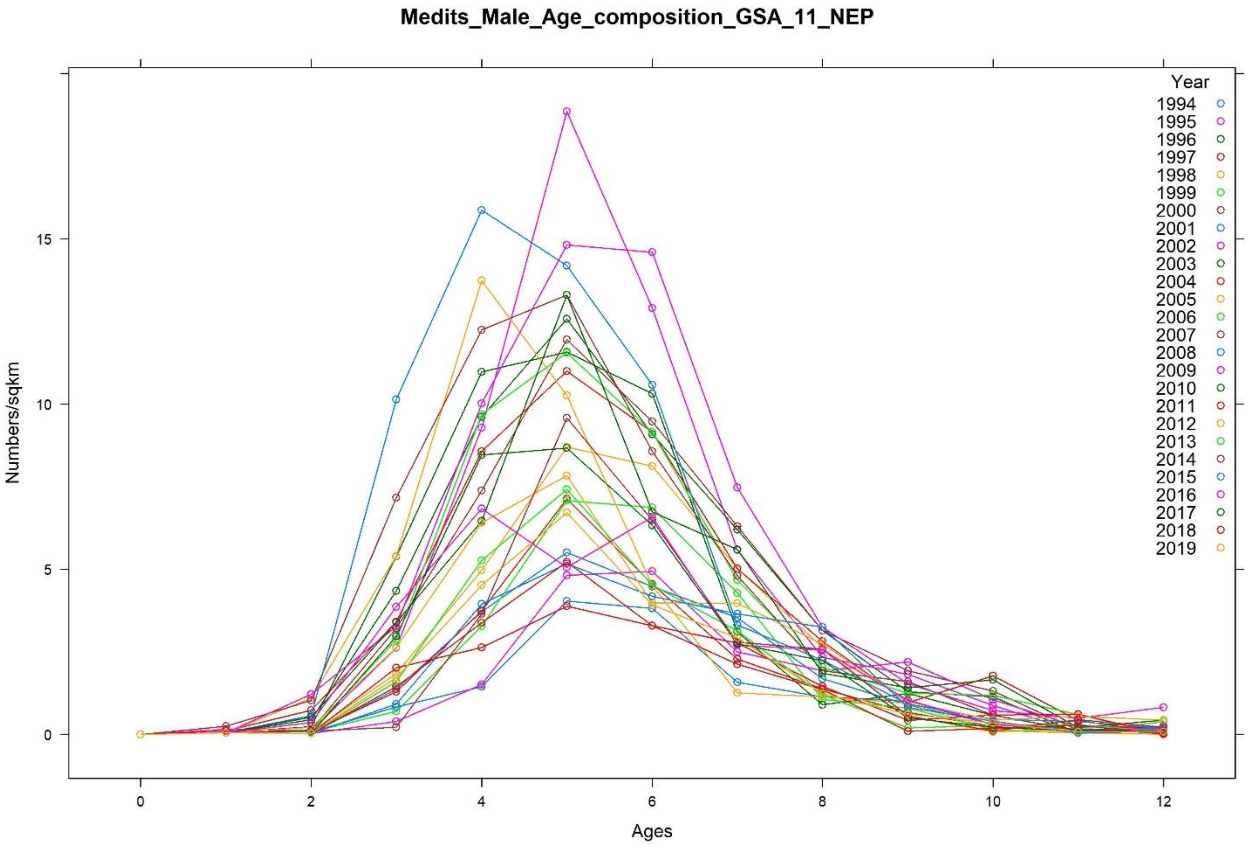


Figure 6.14.3.4. Norway lobster in GSA 11. Index at age by year for male.

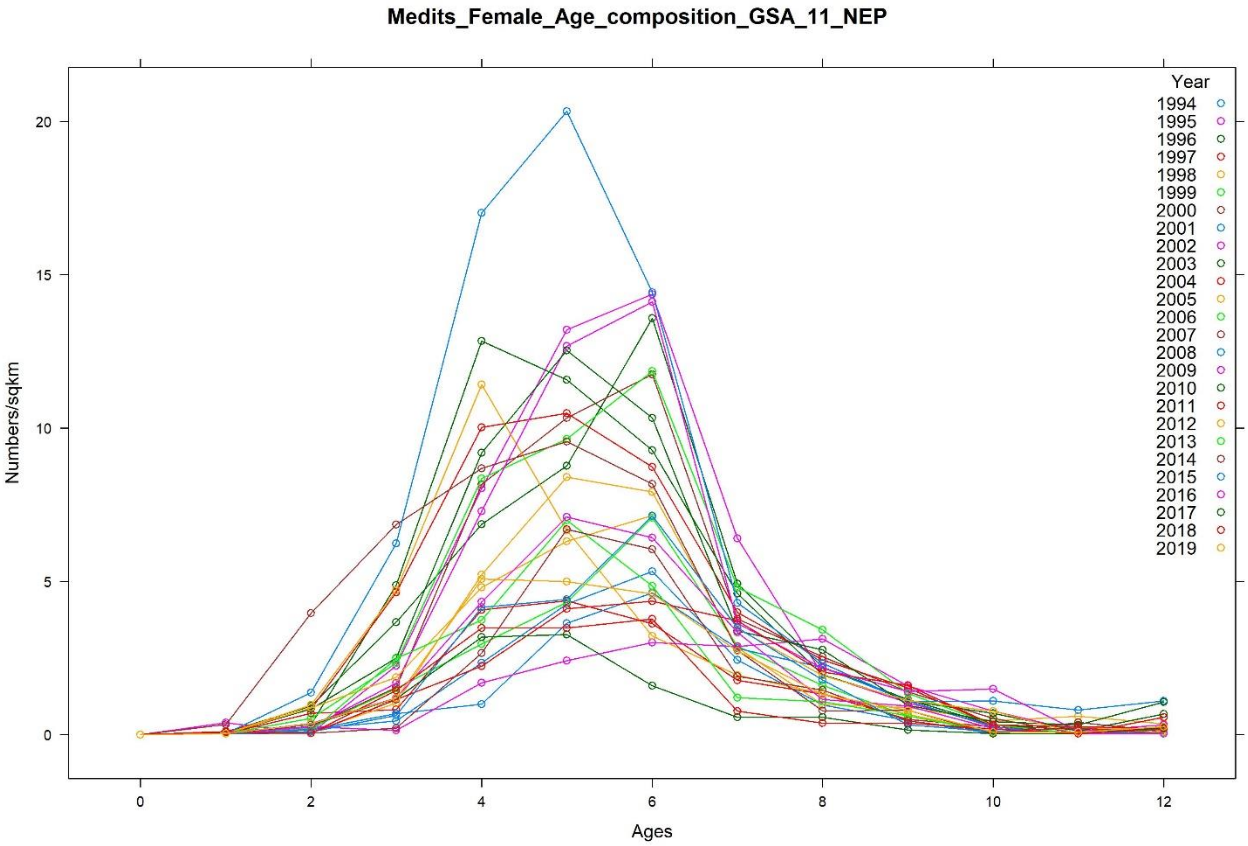


Figure 6.14.3.5. Norway lobster in GSA 11. Index at age by year for female.

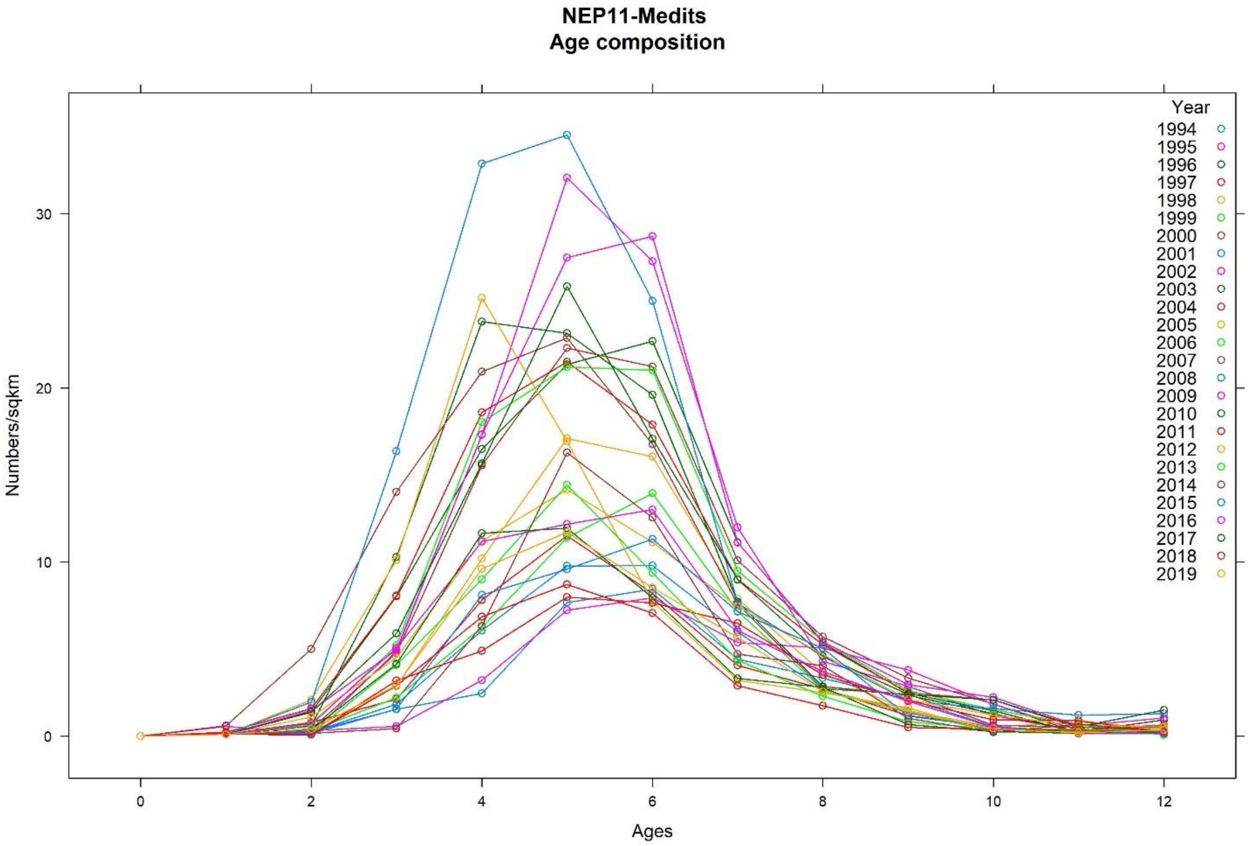


Figure 6.14.3.6. Norway lobster in GSA 11. Index at age by year.

Finally the Sum of Products "total catch numbers at age i x catch weight-at-age i" (SoP) was checked to match the total catch by year reported in the DCF. Catch numbers at age were SOP corrected. The adjustment factor applied was low (Table 6.14.3.1).

Table 6.14.2.1.1. . Norway lobster in GSA 11. SOP corrections factors applied to raise catch at length/age by year.

year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
factor	0.949	0.981	0.973	0.984	0.999	0.983	0.986	0.979	0.992	0.987	0.980	0.988	1.177	0.990	1.090

The final input data used for the assessement are reported below on Tables 6.14.3.2-6. Concerning the Fbar, the age range used was 2-6.

Table 6.14.3.2. Norway lobster in GSA 11. Catch (tons).

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
all	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	40.1

Table 6.13.3.3. Norway lobster in GSA 11. catch-at-age (thousands).

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.4	0.4	0.4	0.4	0.4	2.6	9.5	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5
1	0.4	0.4	3.3	5.4	20.8	11.6	152.2	22.9	16	1	6.4	5.7	0.5	11.1	0.5
2	58.9	190.6	55.5	45.3	147.7	61.5	265.2	92.4	137.1	35.4	79.5	54.4	58.5	167.2	186.8
3	132.4	320.5	128	261.7	460.6	102.6	337.8	133.2	211.8	124.2	135.2	122.6	97.6	256.4	355.7
4	47.4	260.7	126	360.4	379.7	106.8	242.8	87.3	150.7	148	119.9	88.7	151.6	293.8	269.6
5	19.5	123.6	118.9	166	230.5	85.4	197	157.3	85.2	88.2	88.7	62.9	185.2	181.9	163.7
6	6.2	101.8	66	21.7	101.4	42.9	107.6	100.5	45	35.3	39.8	34.2	75.6	58	112.1
7	2.1	43.2	80	22.8	25.2	39.4	63.5	47.4	19.8	19.5	24	24	49.9	28.9	52.5
8	1.6	21.2	15.1	17.9	22.4	19.3	42.1	50.9	9.5	8.2	15.6	9.1	17.5	25	22.5
9	0.4	20.1	21.2	22.7	4.3	8.5	24.1	4.1	5.9	3.4	2.5	4.4	7.7	13.2	6.7
10	0.4	19.3	4.8	23	3.9	8.3	2.1	23.5	1.7	3.6	2	4.7	2.8	12.3	2.9
11	0.4	13.5	11.9	3.1	1.4	12	22.4	31.8	1.9	1.4	1.2	4.5	0.8	10.2	3.1
12	0.4	0.4	0.4	0.4	0.4	2.6	9.5	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5

Table 6.14.1.4. Norway lobster in GSA 11. MEDITS tuning index of abundance by age/year.

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.1	0.1	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
1	2.1	0.6	5	1.9	1.5	1.4	0.1	1.1	0.1	0.2	0.1	0.7	0.4	0.1	0.4
2	10.1	5.2	14	16.4	5	5.9	3.2	4.5	4.1	0.4	1.6	5.1	4.1	2.9	2.9
3	25.2	18	20.9	32.9	17.3	15.7	4.9	11.2	9	6.3	8.1	11.2	11.7	6.9	9.6
4	16.9	21.2	22.9	34.5	27.5	25.8	8	14.1	14.4	16.3	9.6	12.2	11.9	8.7	11.7
5	7.7	21	16.8	25	28.7	17.1	7.6	11.1	9.4	12.5	11.3	13	7.9	7.1	8.5
6	3.2	9.5	7.6	7.6	11.1	9	6.5	7.4	4.3	4.7	7.1	6.1	3.3	2.9	5.7
7	2.5	5.5	2.7	4.6	5.4	4.6	3.5	4.7	2.3	4	5	3.7	2.8	1.7	2.6
8	1.6	2.6	2.4	2	3	2.4	2	2.1	0.8	1	1.2	2	0.7	0.5	1.4
9	0.2	1.5	0.6	1.6	2.2	2.1	0.9	1.2	0.4	0.2	0.5	0.5	0.3	0.4	0.4
10	0.3	0.7	0.5	1.2	0.6	0.5	0.9	0.6	0.4	0.7	0.1	0.1	0.2	0.3	0.2
11	0.2	0.1	0.3	1.3	1	1.5	0.2	0.5	0.3	0.3	0.1	0.2	0.3	0.2	0.4
12	0.1	0.1	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1

Table 6.13.3.5. Norway lobster in GSA 11. Weight-at-age matrix (kg).

age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
2	0.006	0.006	0.006	0.006	0.005	0.005	0.004	0.005	0.005	0.006	0.005	0.006	0.006	0.006	0.006
3	0.012	0.01	0.011	0.012	0.012	0.011	0.011	0.011	0.011	0.012	0.011	0.012	0.011	0.011	0.011
4	0.018	0.019	0.02	0.021	0.02	0.02	0.019	0.019	0.019	0.021	0.02	0.02	0.02	0.019	0.02
5	0.03	0.033	0.034	0.031	0.031	0.032	0.031	0.033	0.031	0.032	0.031	0.031	0.034	0.032	0.03
6	0.043	0.045	0.047	0.04	0.043	0.047	0.048	0.052	0.045	0.043	0.047	0.047	0.048	0.042	0.048
7	0.062	0.064	0.066	0.069	0.061	0.067	0.064	0.065	0.059	0.06	0.063	0.062	0.069	0.057	0.062
8	0.085	0.084	0.086	0.076	0.073	0.083	0.075	0.076	0.077	0.082	0.076	0.085	0.069	0.078	0.079
9	0.1	0.1	0.1	0.112	0.093	0.102	0.103	0.108	0.108	0.095	0.102	0.094	0.082	0.108	0.091
10	0.122	0.122	0.123	0.136	0.132	0.118	0.13	0.141	0.117	0.132	0.129	0.129	0.126	0.128	0.115
11	0.147	0.152	0.141	0.155	0.151	0.155	0.157	0.169	0.146	0.152	0.146	0.146	0.135	0.16	0.151

12	0.18	0.183	0.178	0.188	0.188	0.179	0.184	0.2	0.159	0.178	0.172	0.172	0.178	0.172	0.184

Table 6.14.3.6. Norway lobster in GSA 11. Maturity mature 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

Assessment results

Different models were tested but, due to the high variability in the observed number at age and the incoherence in the landings cohorts, all tests showed very poor performance.

The best model in terms of residuals and catch at age fitting was the one considering the following terms:

```
f <- ~ factor(age) + factor(year)

q <- list(~ s(replace(age, age>6, 6)))

sr <- ~geomean(CV=0.2)
```

Results are shown in the following figures (figures 6.14.3.7-16). As general consideration, the model residuals showed quite large scale and, in some cases, the presence of patterns (figures 6.14.3.8 and 6.14.3.9) or deviation from normality (6.14.3.10). Furthermore, the fitted numbers at age (for both landings and index) presented in most cases strong deviations from observed values (Figures 6.14.3.12 and 6.14.3.13).

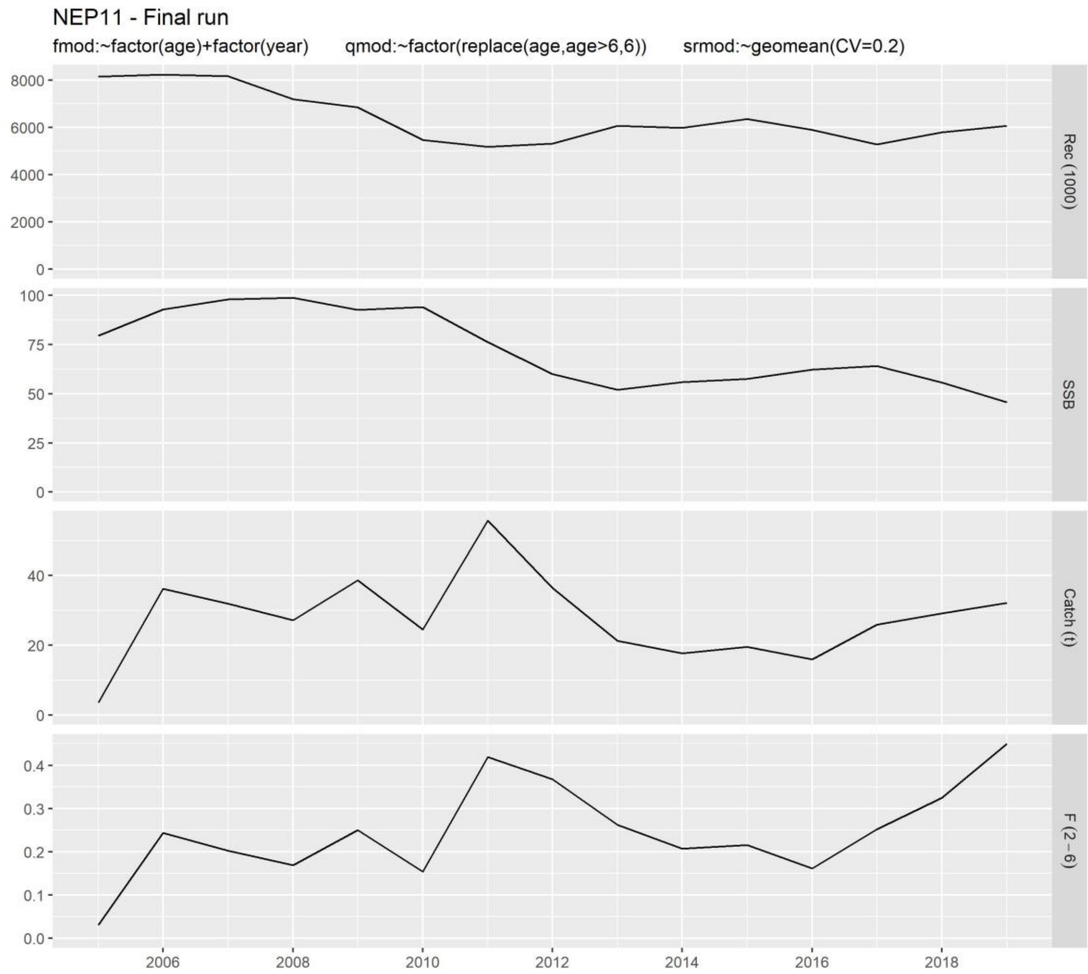


Figure 6.14.3.7. Norway lobster GSA 11. Model output for recruits, Spawning Stock Biomass, catch and F (Fbar 2-6).

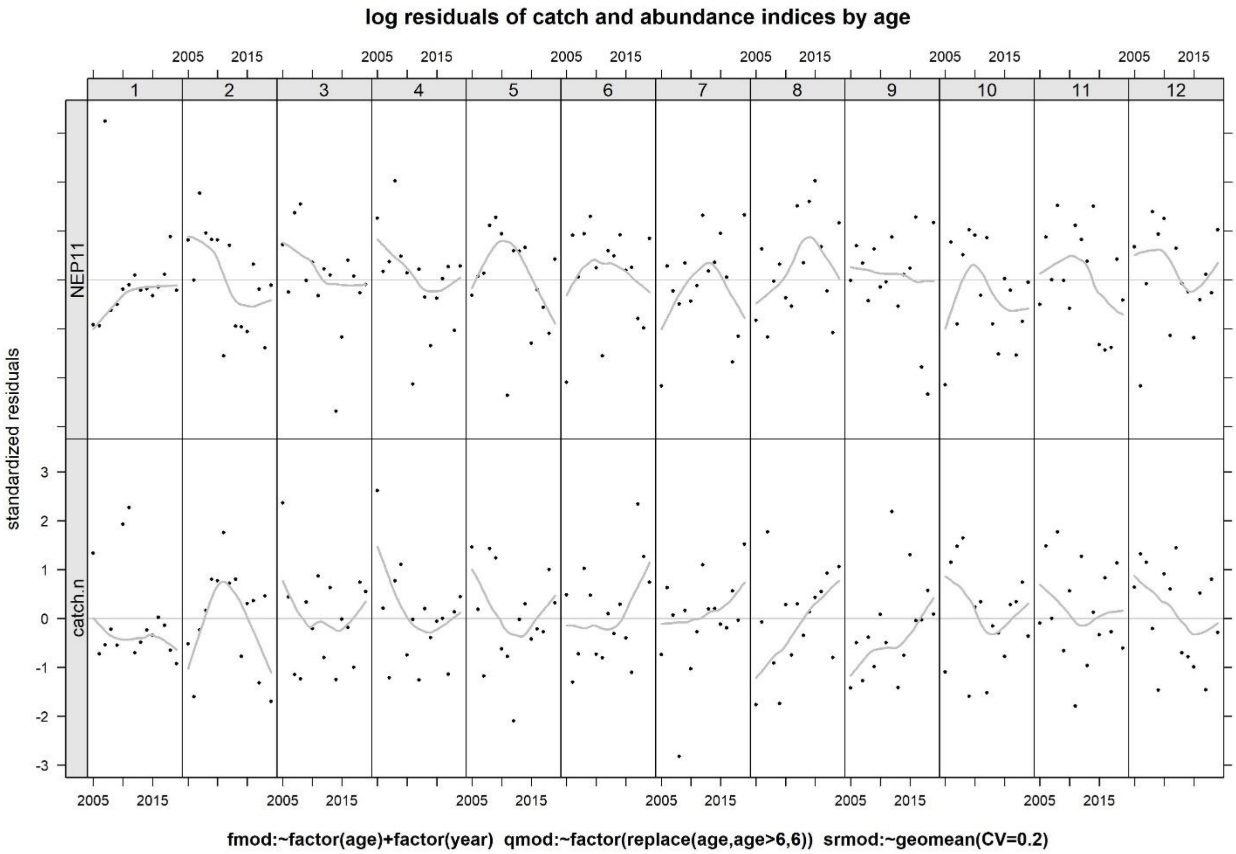


Figure 6.14.3.8. Norway lobster GSA11. Standardized residuals for abundance index and catch numbers. Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

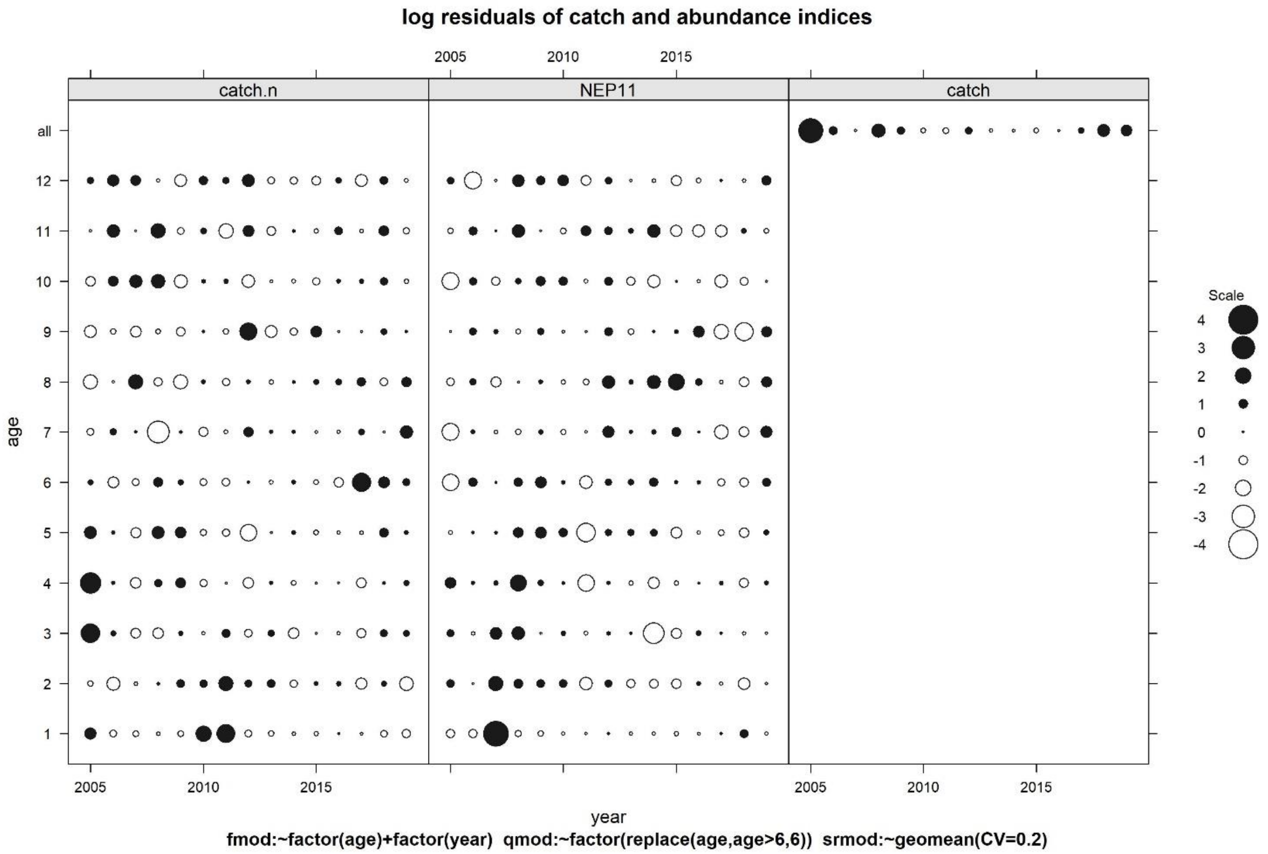


Figure 6.14.3.9. Norway lobster GSA11. Log residuals of catch and abundance indices

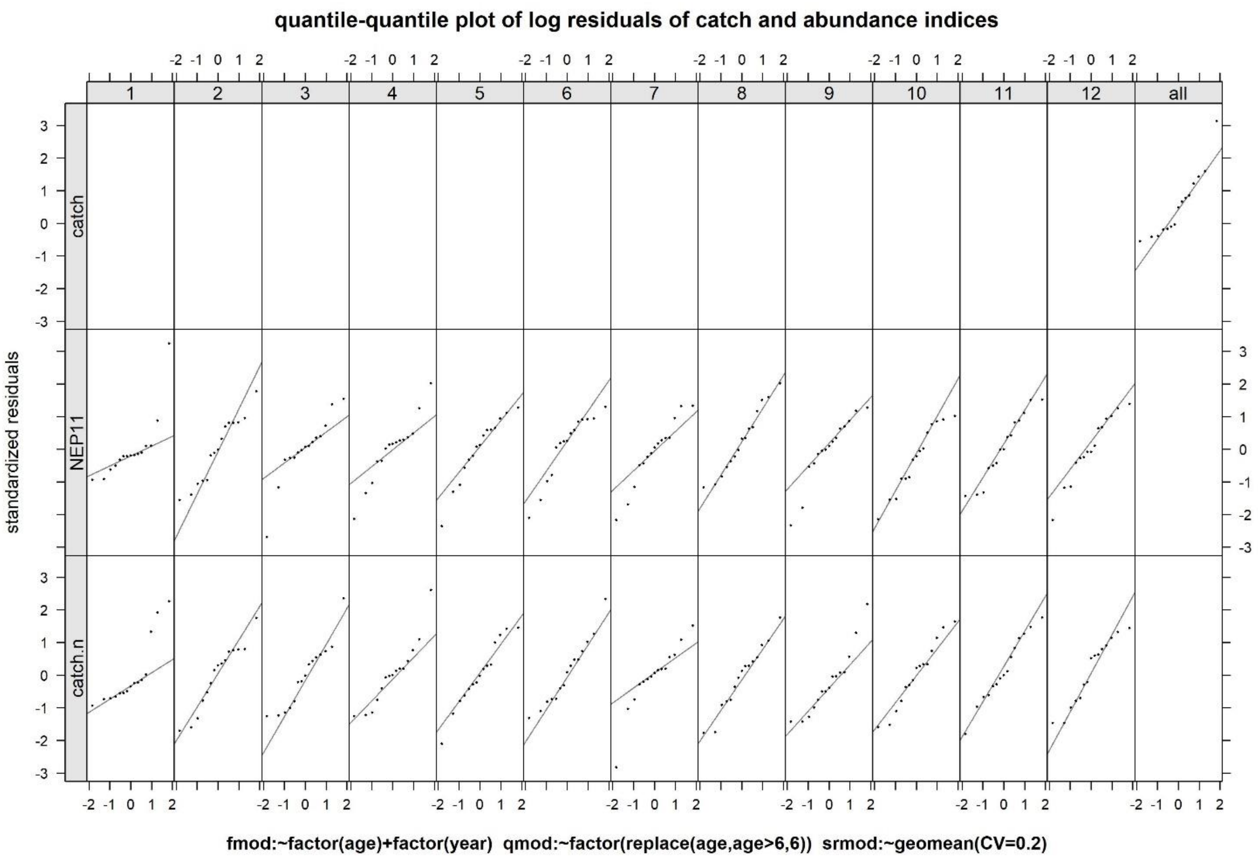


Figure 6.14.3.10. Norway lobster GSA11. Quantile-quantile plot of log-residuals of catch and abundance index. Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

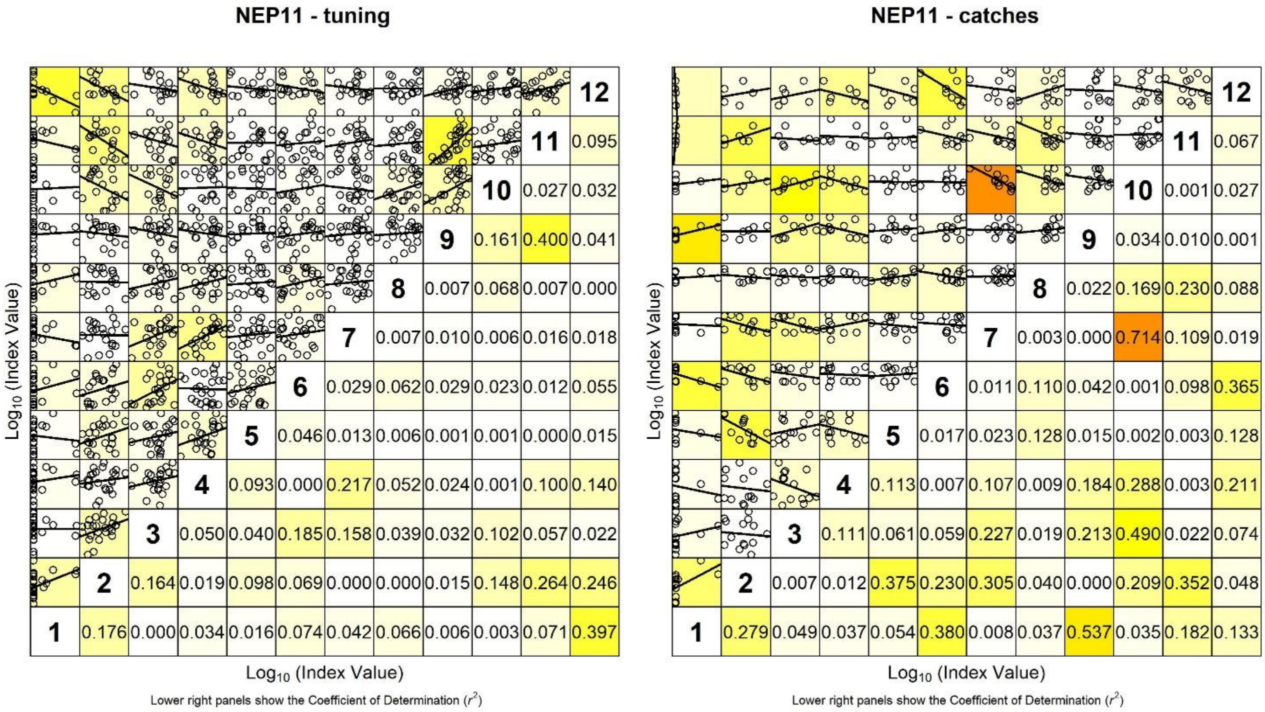


Figure 6.14.3.11. Norway lobster GSA11. Internal consistency in tuning index and catches.

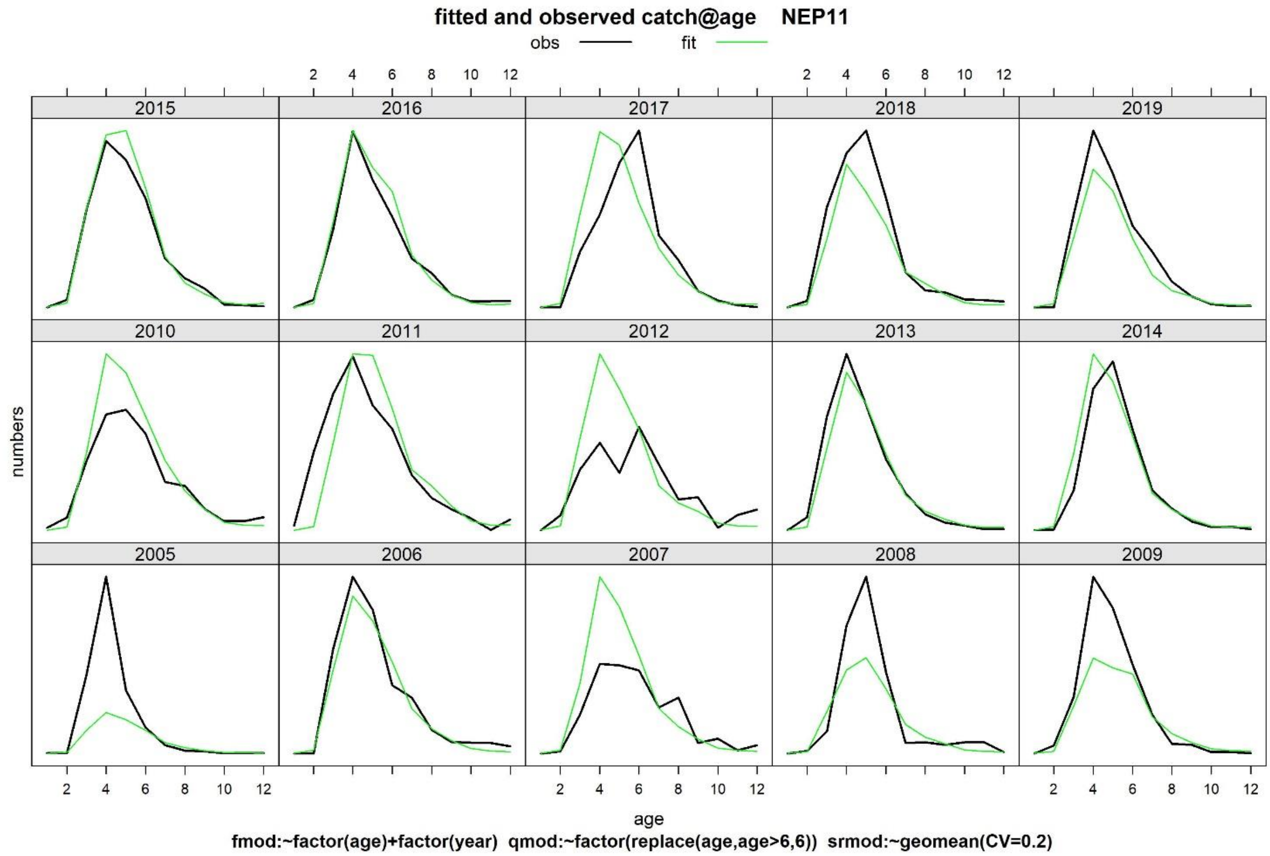


Figure 6.14.3.12. Norway lobster GSA11. Fitted and observed catch at age.

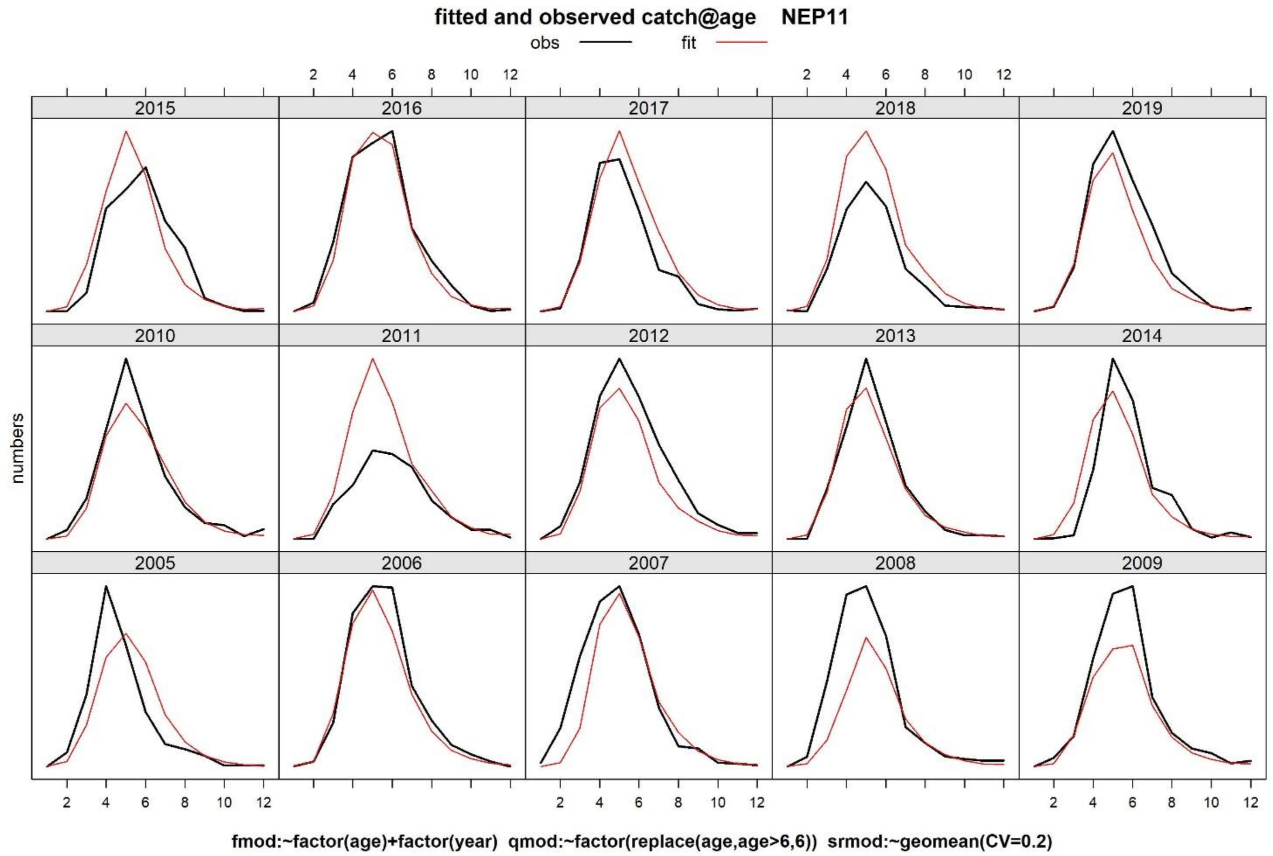


Figure 6.14.3.13. Norway lobster GSA11. Fitted and observed index at age.

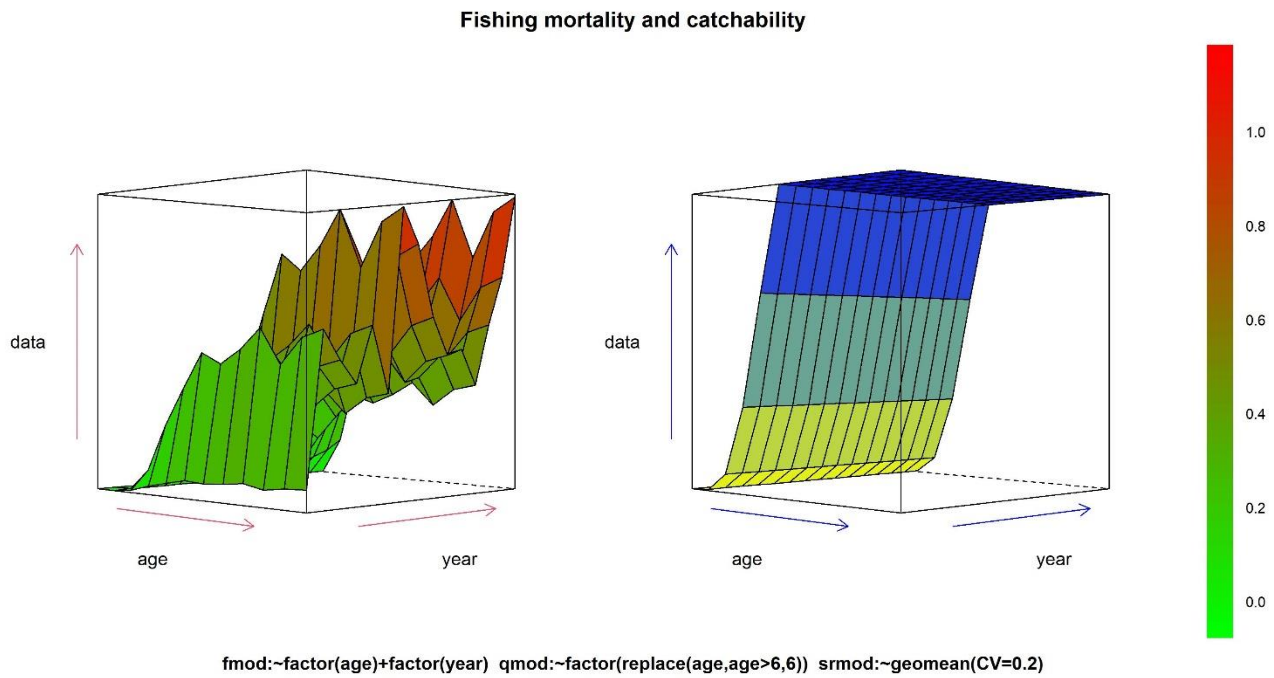


Figure 6.14.3.14. Norway lobster GSA11. 3D contour plot of (estimated) fishing mortality and catchability.

Retrospective

Retrospective analysis (3 years back) results are presented in Figure 6.14.3.15. Obtained results evidence a poor performance of the model. Moreover the stock summary shows the bad modelling of observed catches (Figure 6.14.3.16).

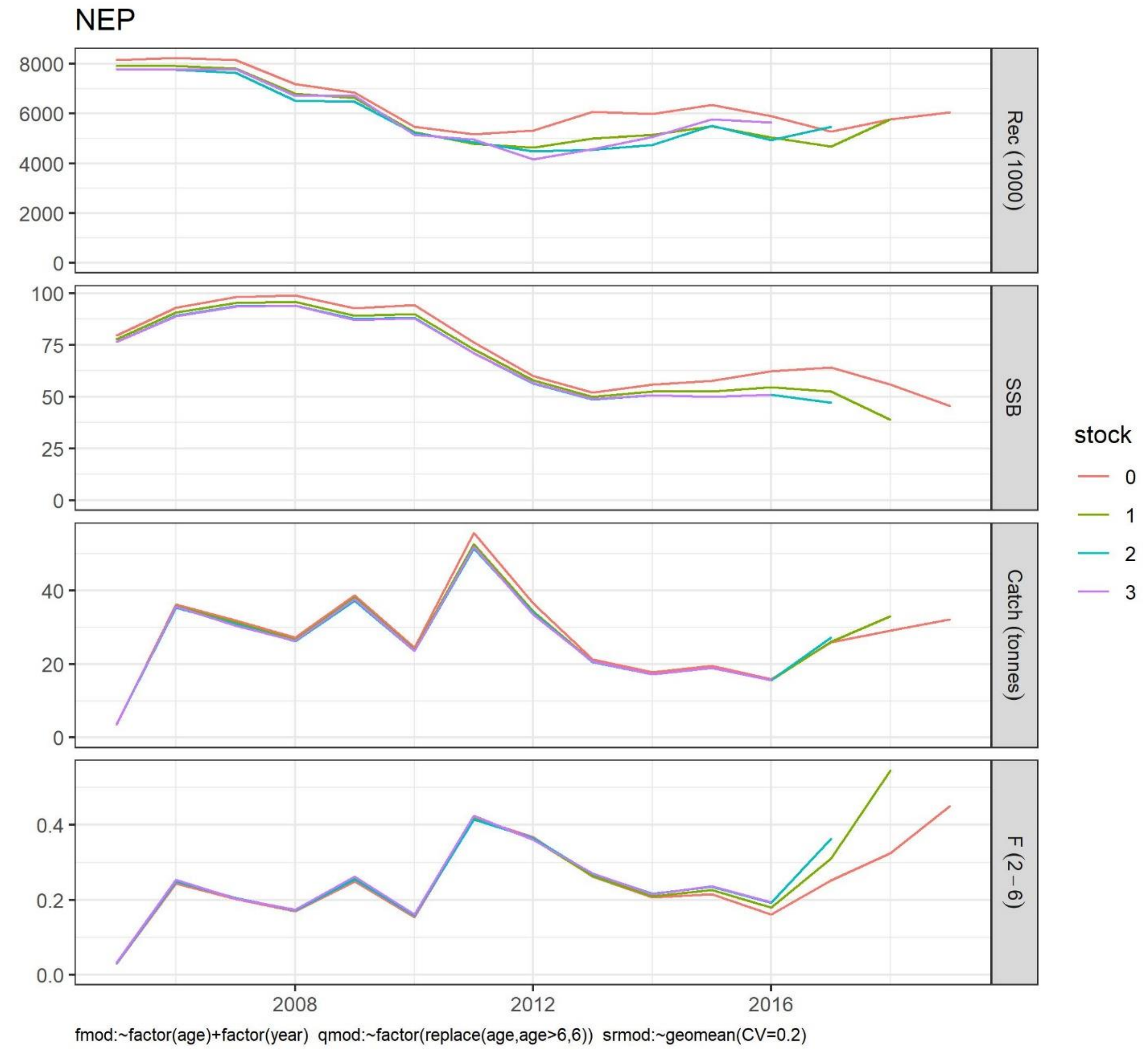


Figure 6.14.3.15. Norway lobster GSA11. Retrospective analysis output for the a4a model.

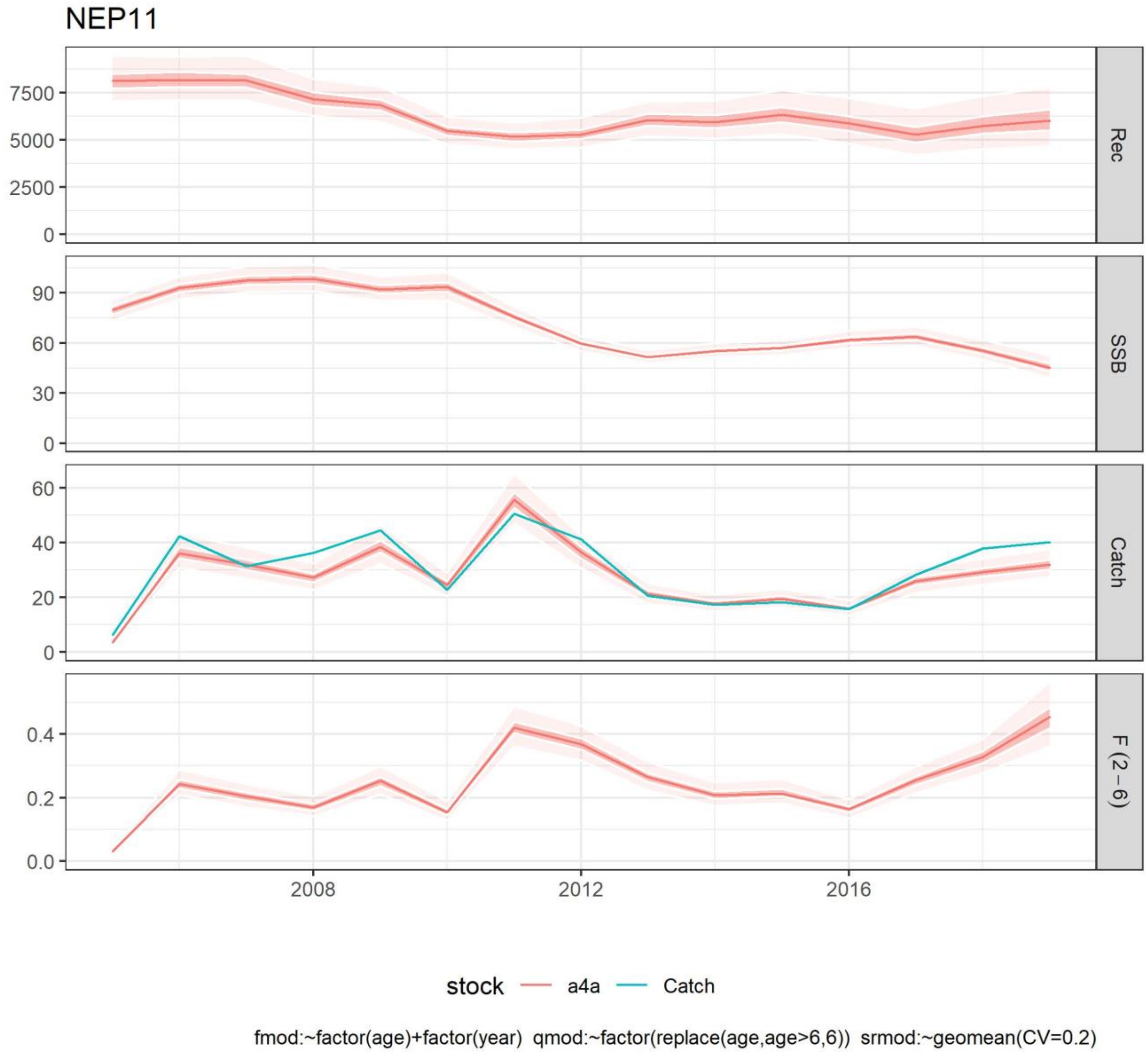


Figure 6.14.3.16. Norway lobster GSA11. Stock summary (Recruitment, SSB, catch and Fishing mortality) of the simulated and fitted data for the a4a model.

Conclusions to the stock assessment

The early part of the series is systematically different from the later years, with large blocks of similar residuals particularly in the survey. The catch data is lacking of coherent information comparing cohorts across years (Figure 6.14.3.11). The fitting often do not match either the observed catch (Figure 6.14.3.12) or the observed index at age (Figure 6.14.3.12). Also the retrospective evidence a poor performance of the model (Figure 6.14.3.15). EWG 20-09 advised to refuse the assessment overall and to use the ICES category 3 index method to give good indications of the state of the stock.

6.14.4 Reference Points

The assessment was not accepted for advice, therefore reference points were not calculated.

6.14.5 Short term Forecast and Catch Options

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) following the approach adopted for ICES category 3 stocks. The precautionary buffer of -20% was not applied because it was already 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.

6.15 BLUEAND RED SHRIMP IN GSA 1

6.15.1 STOCK IDENTITY AND BIOLOGY

This stock was assessed last year in 2019 (STECF EWG19-10) and in 2018 (STECF EWG 18-12) using the statistical catch-at-age method (a4a), before that in 2015 (STECF EWG 15-18) using Extended Survivors Analysis (XSA) and prior to that in 2011 (STECF EWG 11-05) using LCA with VIT software (Lleonart and Salat, 1997).

No information was documented during 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).

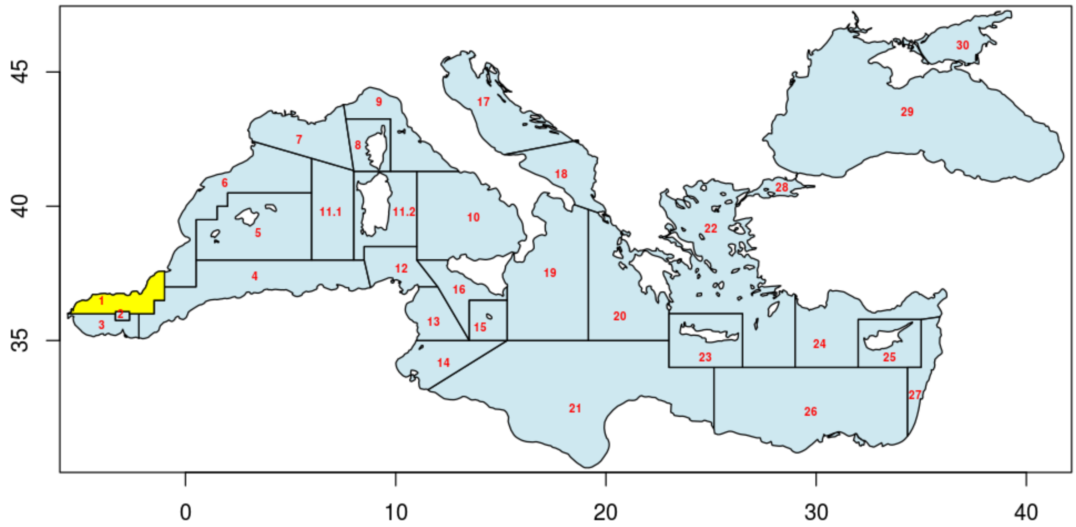


Figure 6.15.1.1. Geographical location of GSA 1.

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 (1^{st} 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 and in the present assessment the length slicing for assessment was run with 0.532 value of t_0 in order to provide correct length transitions for 1^{st} 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 intented 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 from which growth parameters and length-weight relationship was estimated ranged between 15 and 64 mm CL.

The calculated annual individual weight at age (kg) is applied at length and sliced to age for the entire period (2002-2019) and is presented in Table 6.15.1.1.

Table 6.15.1.1. Blue and red shrimp in GSA 1. Annual individual weight (kg) at age (2002-2019). Based on length slicing, weight at age zero filled in with 0.001 for years with no numbers at age.

year / age	0	1	2	3	4	5
2002	0.0010	0.0074	0.0195	0.0366	0.0550	0.0730
2003	0.0010	0.0074	0.0201	0.0369	0.0550	0.0730
2004	0.0010	0.0073	0.0206	0.0374	0.0550	0.0730
2005	0.0010	0.0077	0.0201	0.0397	0.0550	0.0730
2006	0.0010	0.0078	0.0189	0.0368	0.0550	0.0730
2007	0.0010	0.0084	0.0205	0.0377	0.0550	0.0730
2008	0.0010	0.0087	0.0200	0.0406	0.0550	0.0725
2009	0.0010	0.0082	0.0206	0.0408	0.0550	0.0754
2010	0.0010	0.0092	0.0195	0.0404	0.0550	0.0730
2011	0.0010	0.0087	0.0201	0.0392	0.0550	0.0730
2012	0.0010	0.0089	0.0197	0.0396	0.0550	0.0730
2013	0.0010	0.0086	0.0197	0.0387	0.0550	0.0730
2014	0.0010	0.0087	0.0208	0.0388	0.0550	0.0730
2015	0.0010	0.0082	0.0210	0.0404	0.0550	0.0730
2016	0.0010	0.0083	0.0206	0.0405	0.0550	0.0730
2017	0.0010	0.0088	0.0203	0.0398	0.0550	0.0725
2018	0.0010	0.0084	0.0200	0.0383	0.0550	0.0730
2019	0.0010	0.0077	0.0192	0.0396	0.0550	0.0730

The proportion of mature individuals at age was not available from the DCF data for blue and red shrimp in GSA 1 and in 2019 was taken from the 2015 assessment that was based on the DCF data this was applied in the present assessment (Table 6.15.1.2). A fixed maturity ogive is used for all years.

Table 6.15.1.2. 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 the natural mortality of blue and red shrimp in the present assessment was calculated as a vector using the Chen Watanabe (1989) model (Table 6.15.1.3). These are calculated using the t0 =+0.032. Its noted that age zero natural mortality is for a full 12 months while the actual mortality is lower, only occuring in the last 6 moths of the year after spawning.

Table 6.15.1.3. 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 Cape of Gata. The stock is exploited only by deep bottom otter trawl and particularly by the fleet segment composed by 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. The SoP correction is applied and catch is used throughout this report.

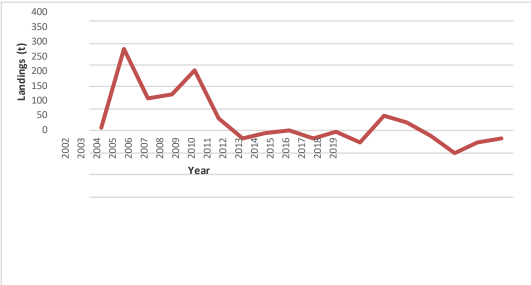


Figure 6.15.2.1.1. Blue and red shrimp in GSA 1. Blue and red shrimp DCF landings (t), in GSA 1.

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	-
2003	335.74	-
2004	225.2	-
2005	232.1	0.65
2006	288.82	-
2007	178.43	-
2008	133.48	0.01

The total OTB landings and discards per year, as reported by DCF, are shown below.

2009	144.59	0.01
2010	152.09	0.01
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

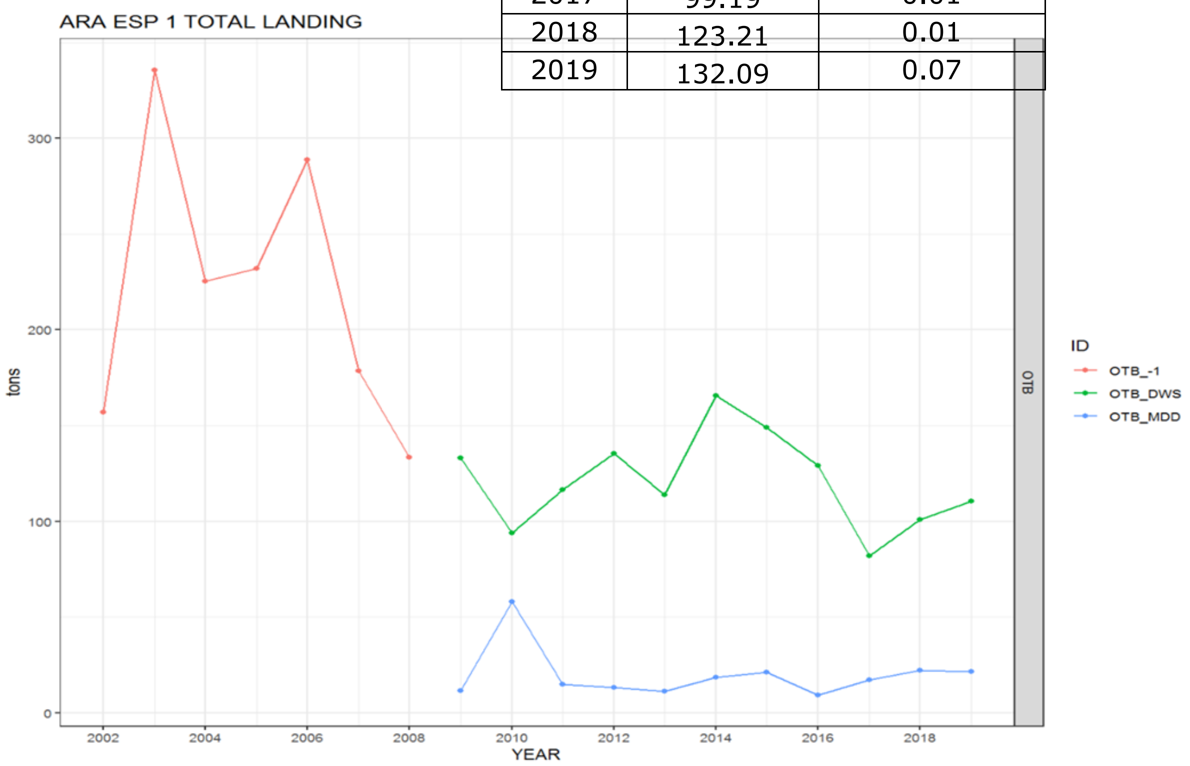


Figure 6.15.2.1.2. Blue and red shrimp in GSA 1. Blue and red shrimp DCF landings (t) in GSA 1 per gear (2002-2008) and metier (2009-2019).

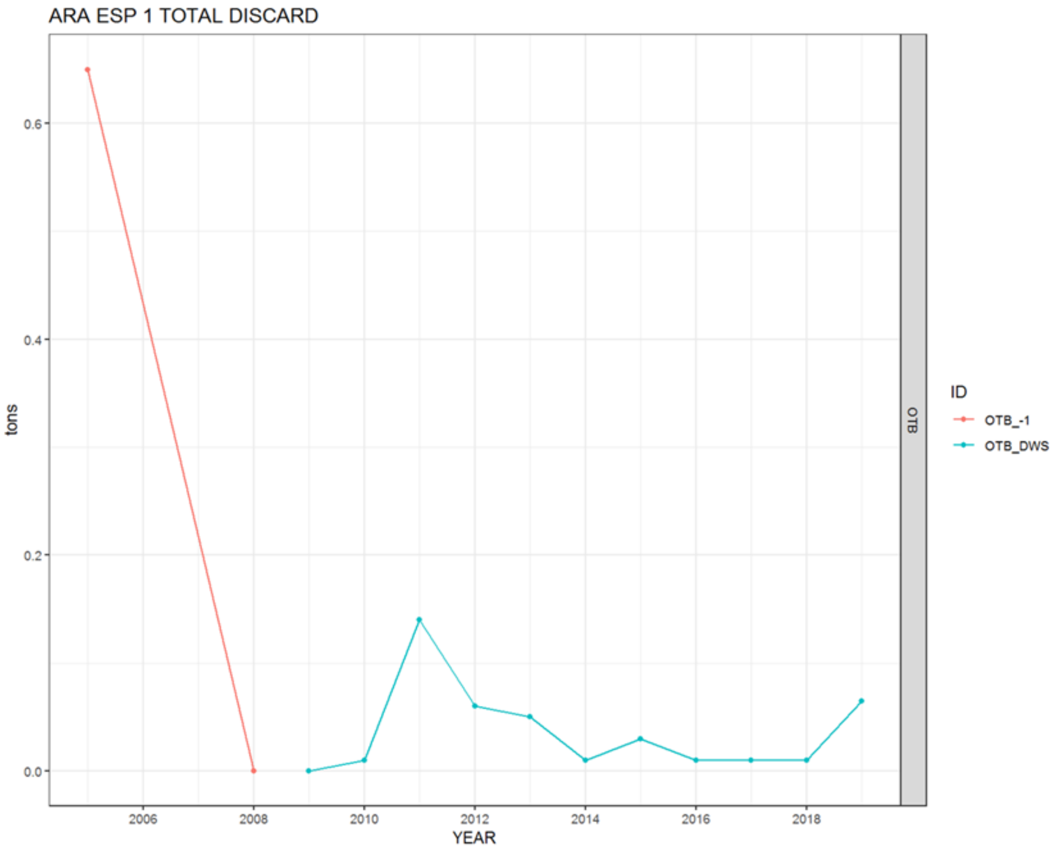


Figure 6.15.2.1.3. Blue and red shrimp in GSA 1. Blue and red shrimp DCF discards (t) in GSA 1 per gear (2002-2008) and metier (2009-2019).

The total LFD of the landings (=catch as discards were negligible) is shown in Figure 6.15.2.1.4 and the LFD per gear and metier in Figure 6.15.2.1.5.

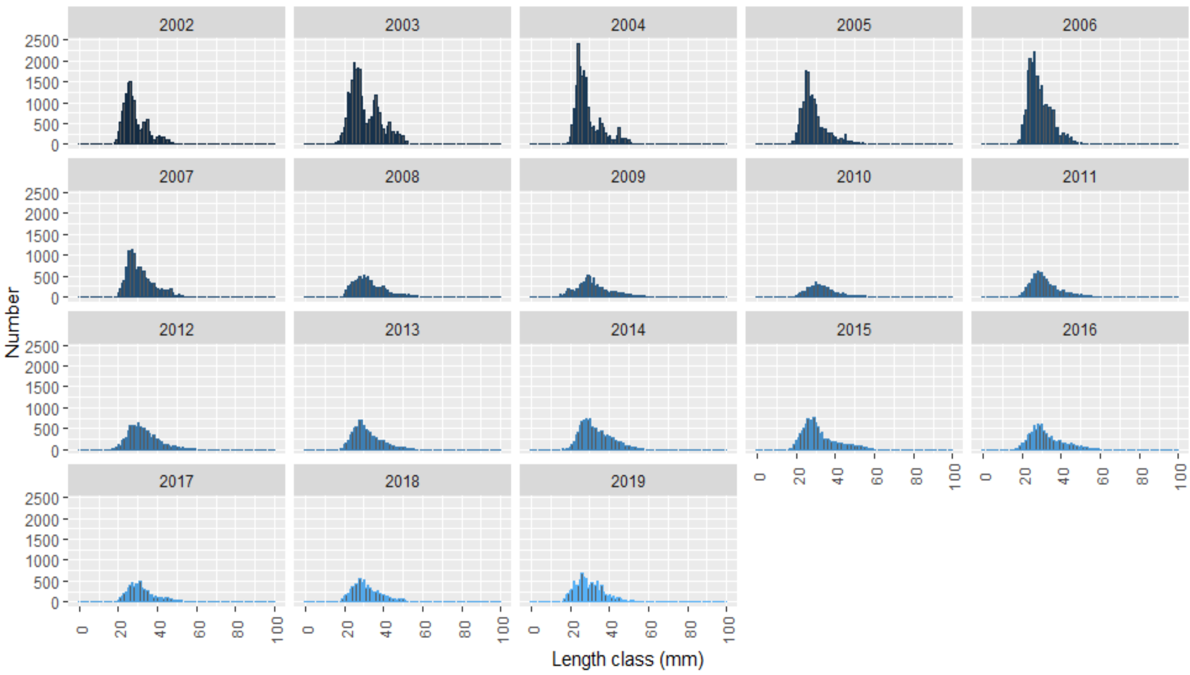


Figure 6.15.2.1.4. Blue and red shrimp in GSA 1. Blue and red shrimp length frequency distribution of catch (landings only) by year in GSA 1.

The variability of blue and red shrimp number of individuals (N, thousands) at age of the catch by year (Table 6.15.2.1.2) is shown in Figure 6.15.2.1.6 and the number of individuals (N, thousands) per year by age group of the catch in Figure 6.15.2.1.7. The age composition of the catch has mainly been composed of 0-2-year-olds, with 1-year-old individuals forming the majority of catch.

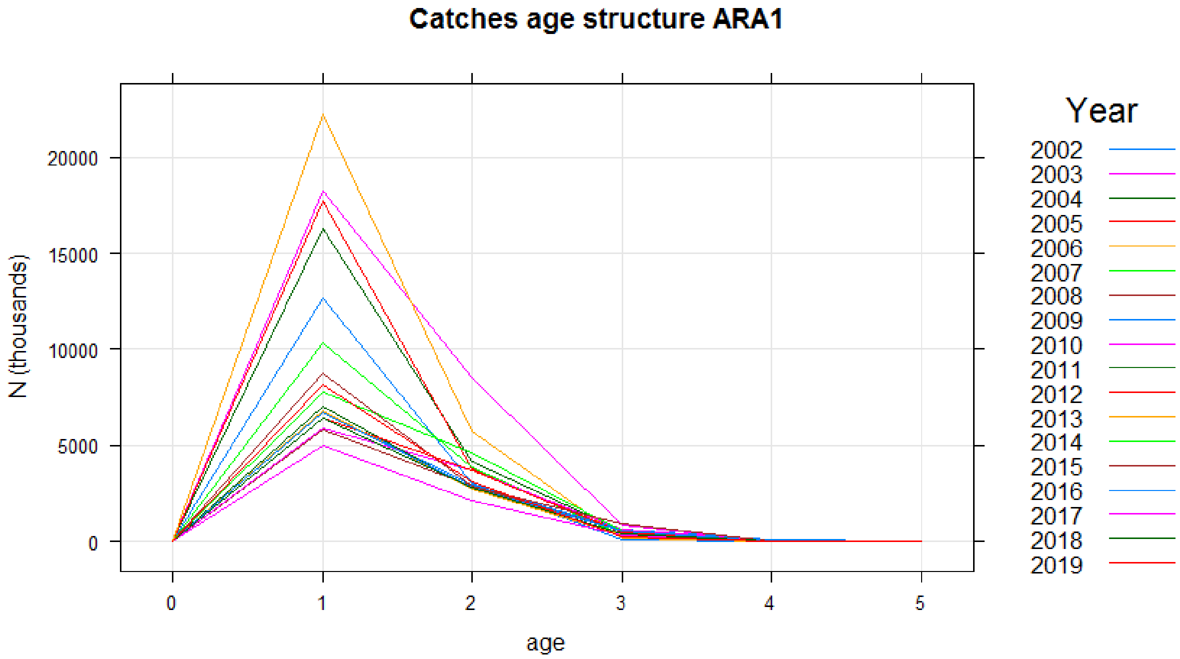


Figure 6.15.2.1.6. Blue and red shrimp in GSA 1. Blue and red shrimp number of individuals (N, thousands) at age of the catch in GSA 1 (2002-2019). Data from DCF.

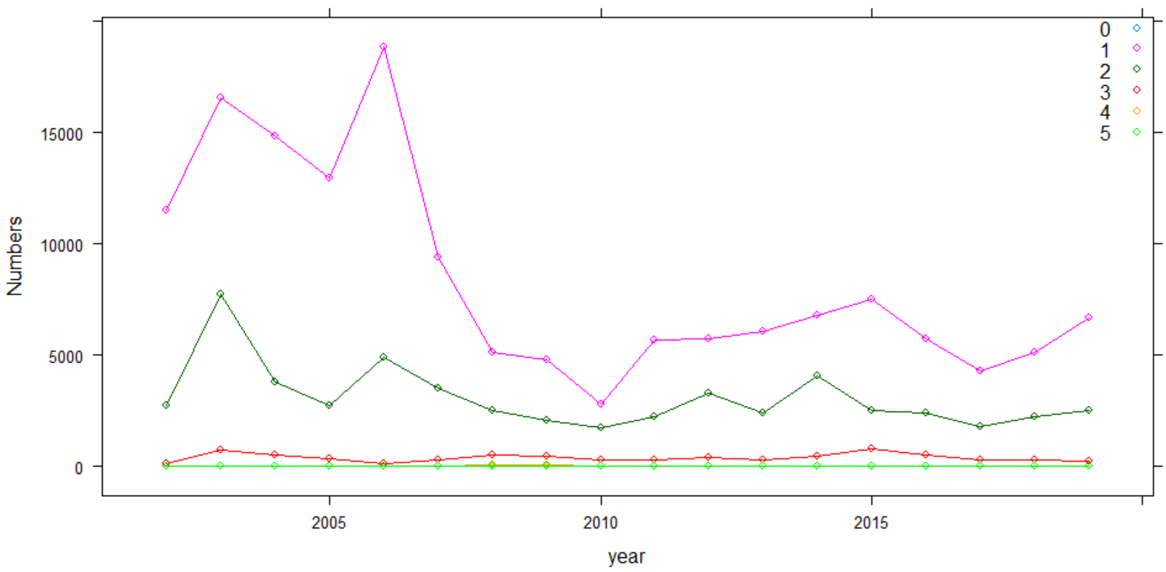


Figure 6.15.2.1.7. Blue and red shrimp in GSA 1. Blue and red shrimp number of individuals (N, thousands) per year by age group of the catch in GSA 1 (2002-2019). D ata from DCF.

Table 6.15.2.1.2. Blue and red shrimp in GSA 1. Blue and red shrimp number of individuals (N, thousands) per year by age group of the catch in GSA 1 (2002-2019). Length sliced from data from DCF.

Year/age	0	1	2	3	4	5
2002	0.221	12687	3037.7	101.86	0.221	0.221
2003	0.221	18249	8515.3	830.47	0.221	0.221
2004	0.220	16298	4151.0	529.58	3.171	0.220
2005	0.275	17747	3783.4	487.49	4.005	0.275
2006	0.236	22246	5772.4	165.95	4.678	0.236
2007	0.219	10312	3830.9	315.72	16.634	0.219
2008	0.229	5846.2	2884.1	549.60	42.232	1.274
2009	0.283	6742.4	2916.1	607.26	85.088	1.378
2010	0.425	5880.8	3708.2	588.88	37.059	0.425
2011	0.247	6980.1	2722.0	376.73	24.273	0.247
2012	0.225	6424.8	3677.3	457.30	21.004	0.225
2013	0.225	6825.7	2692.2	335.33	2.498	0.225
2014	0.228	7744.4	4590.4	531.01	5.872	0.228
2015	0.234	8731.7	2907.3	891.53	34.110	0.234
2016	0.235	6699.8	2825.4	566.94	22.872	0.235
2017	0.231	4952.2	2084.5	307.14	20.208	0.455
2018	0.250	6410.0	2764.2	352.43	9.105	0.250
2019	0.245	8145.2	3090.1	260.85	0.245	0.245

The calculated annual individual weight at age (kg) for the entire period (2002-2019) is presented in Figure 6.15.2.1.8 and the internal cohort consistency of the catch in Figure 6.15.2.1.9.

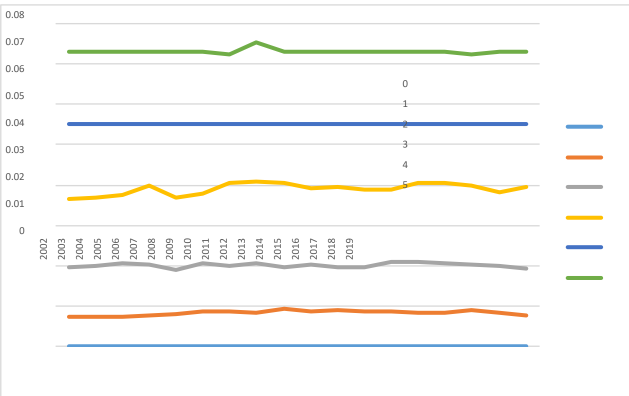


Figure 6.15.2.1.8. Blue and red shrimp in GSA 1. Blue and red shrimp mean weight (kg) at age of catches per year in GSA 1 (2002-2019). Data from DCF.

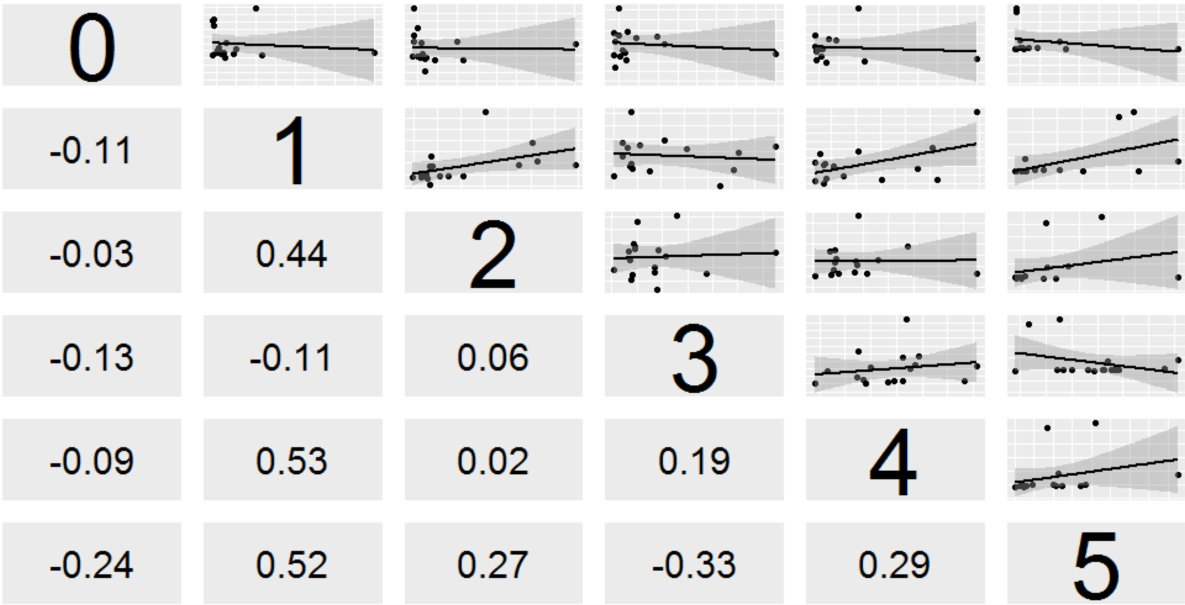


Figure 6.15.2.1.9. Blue and red shrimp in GSA 1. Cohorts consistency in the catch.

6.15.2.2 EFFORT

Fishing effort data were reported to STECF EWG 20-09 through DCF. Only effort from OTB is reported. No data was available for 2019.

The fisheries for Blue and red shrimp in GSA 1 are consiodered to be 100% OTB from Spain. However, not all OTB days at sea will be targeted at blue and red shrimp. The fishing effort (Table 6.15.2.2.1) expressed as number of fishing days, GTDays and Days at Sea, Fishing Days by year is presented in Figures 6.15.2.2.1, 6.15.2.2.2 and 6.15.2.2.3 respectively. All metrics are similar showing a gradual decline to 2014 and then fluctuations.

Table 6.15.2.2.1 Fishing effort expressed as number of GTDays, Days at Sea and fishing days by year for OTB from Spain in GSA1

Years	GT Days	Days at Sea	Fishing days
2002	1333918	28002	28002
2003	1684655	32892	32892
2004	1894693	34951	34951
2005	1761339	32295	32295
2006	1685266	31443	31443
2007	1631930	29917	29917
2008	1495816	26201	26201
2009	1520713	27017	27017
2010	1568334	28476	28476
2011	1507685	28170	28170
2012	1395133	25851	25851
2013	1295309	24334	24334
2014	1159530	22395	22395
2015	1102193	21587	21587
2016	1083165	21345	21345
2017	1131873	22537	22537
2018	1079838	21633	21633

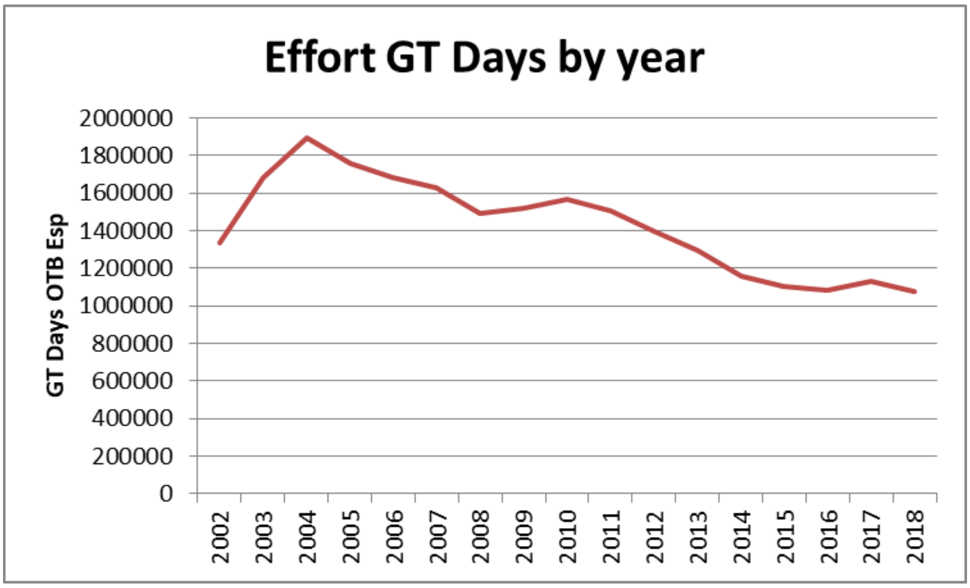


Figure 6.15.2.2.1. Blue and red shrimp in GSA 1. Effort (GT Days) of vessels operating with OTB in GSA 1 (DCF).

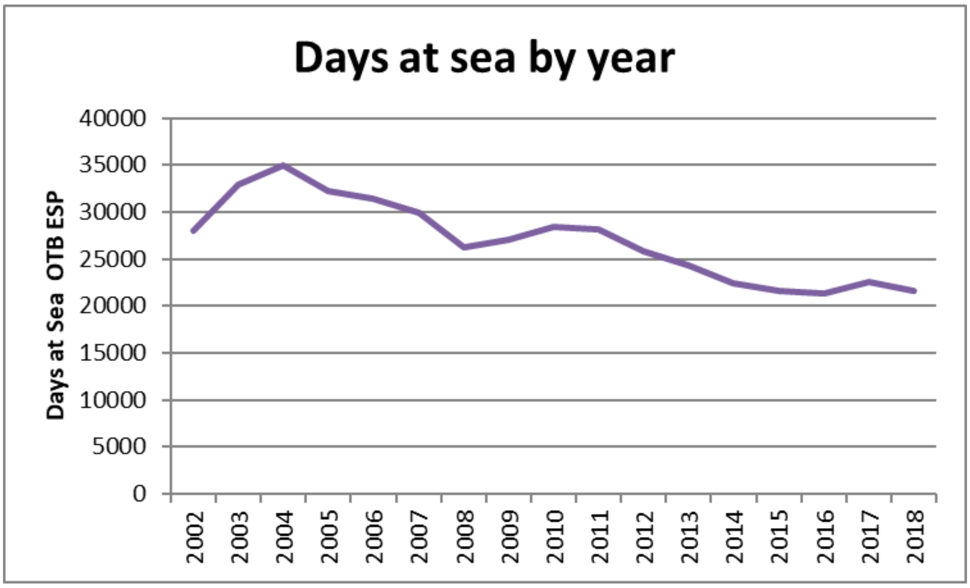


Figure 6.15.2.2.2. Blue and red shrimp in GSA 1. Effort (days at sea) of vessels operating with OTB

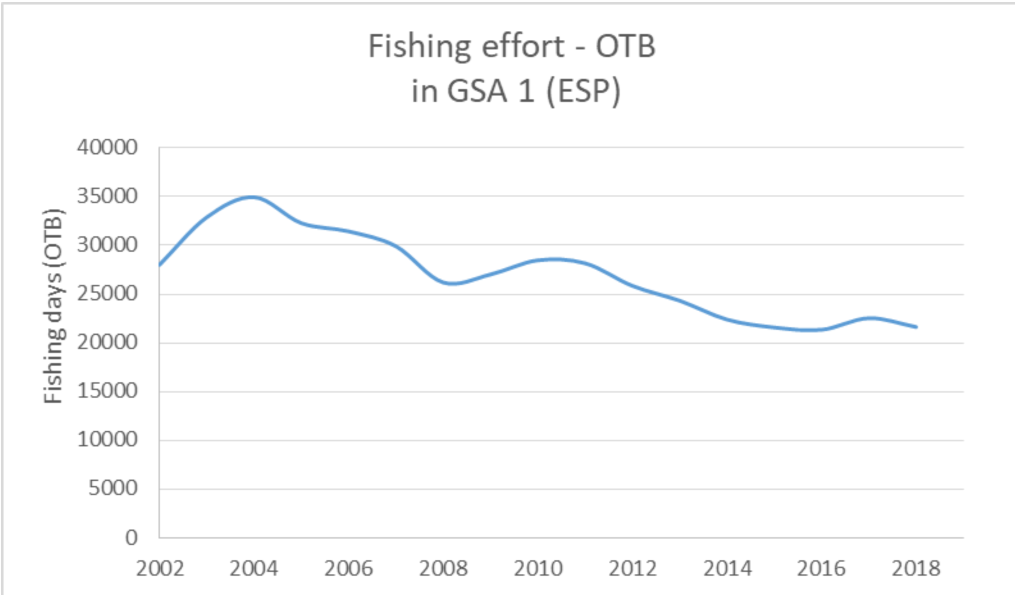


Figure 6.15.2.2.3. Blue and red shrimp in GSA 1. Effort (fishing days) of vessels operating with OTB (2002-2008) and OTB metiers (2009-2014) in GSA 1 (DCF). Dashed line is the cumulative of metiers.

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.

Few data errors had been noted on the dataset (regarding a large individual in 2009 and some hauls in 2007, 2008 and 2009) and were corrected prior to the analysis.

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 16.15.2.3.1 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) and table (Table 6.15.2.3.1). 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.
Please note the very low (near zero) total biomass and density in years 2007, 2008, 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 2011 and 2013.

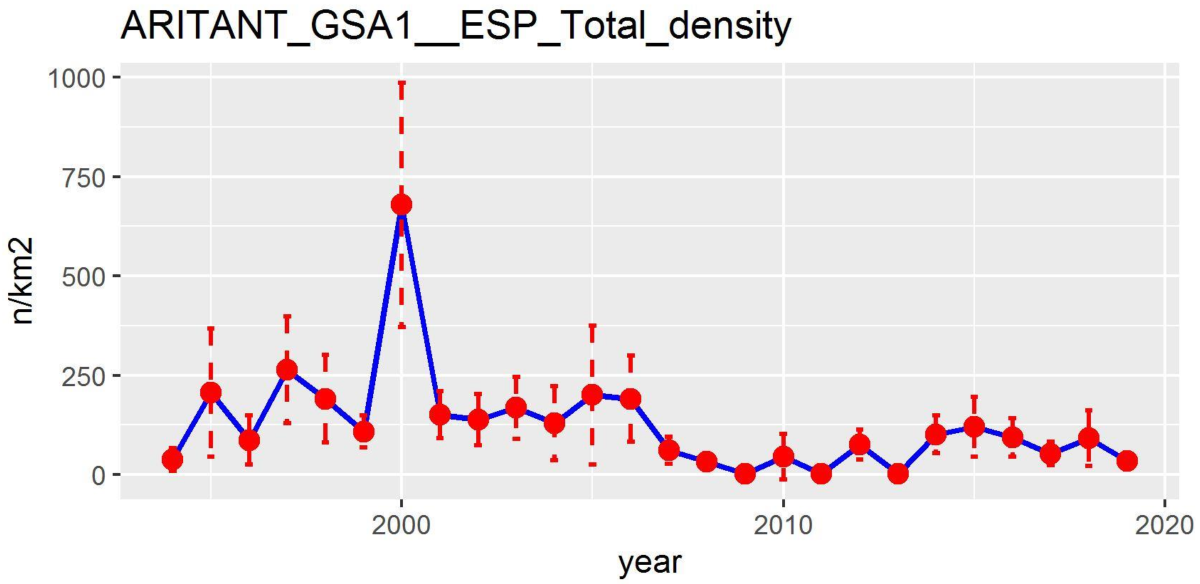


Figure 6.15.2.3.2. Blue and red shrimp in GSA 1. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

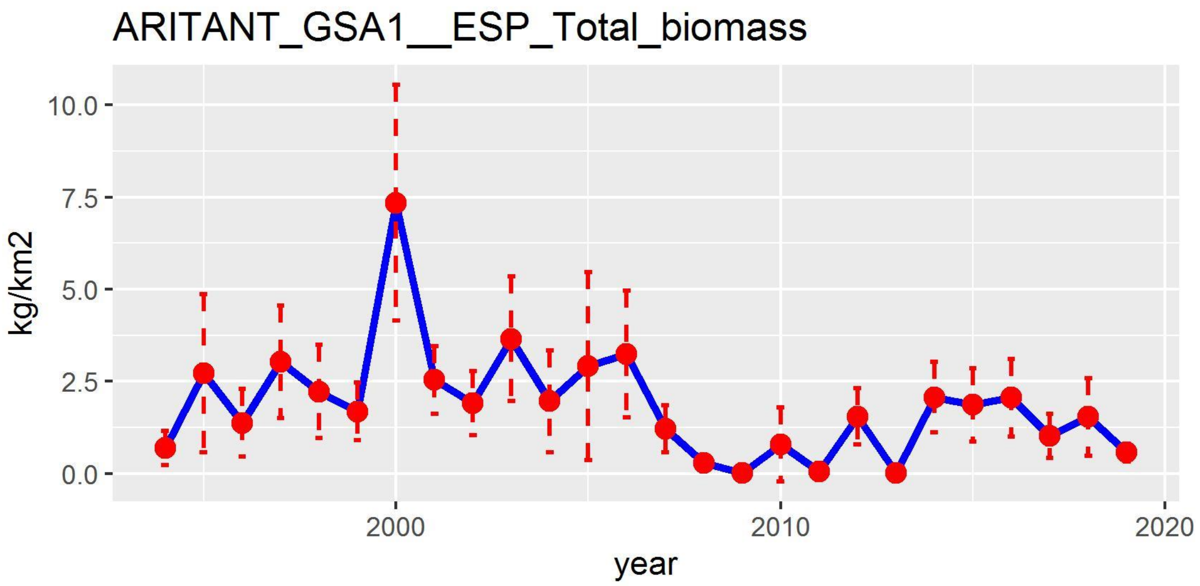


Figure 6.15.2.3.3. Blue and red shrimp in GSA 1. MEDITS survey biomass index (kg/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

Table 6.15.2.3.3.1 Blue and red shrimp in GSA 1. MEDITS survey abundance 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.

Year	Blue and red shrimp abundance (kg/km^2)
1994	0.686
1995	2.730
1996	1.373
1997	3.035
1998	2.225
1999	1.685
2000	7.346
2001	2.541
2002	1.913
2003	3.657
2004	1.959
2005	2.915
2006	3.245
2007	0.670
2008	0.276
2009	0.006
2010	0.793
2011	0.054
2012	1.545
2013	0.015
2014	2.067
2015	1.863
2016	2.060
2017	1.019
2018	1.541
2019	0.568

Trends in abundance by length (Figure 6.15.2.3.4), the cohorts consistency in MEDITS index (Figure 6.15.2.3.5), number of individuals per year by age (Figure 6.15.2.3.6), number of individuals per age by year (Figure 6.15.2.3.7) are shown below.

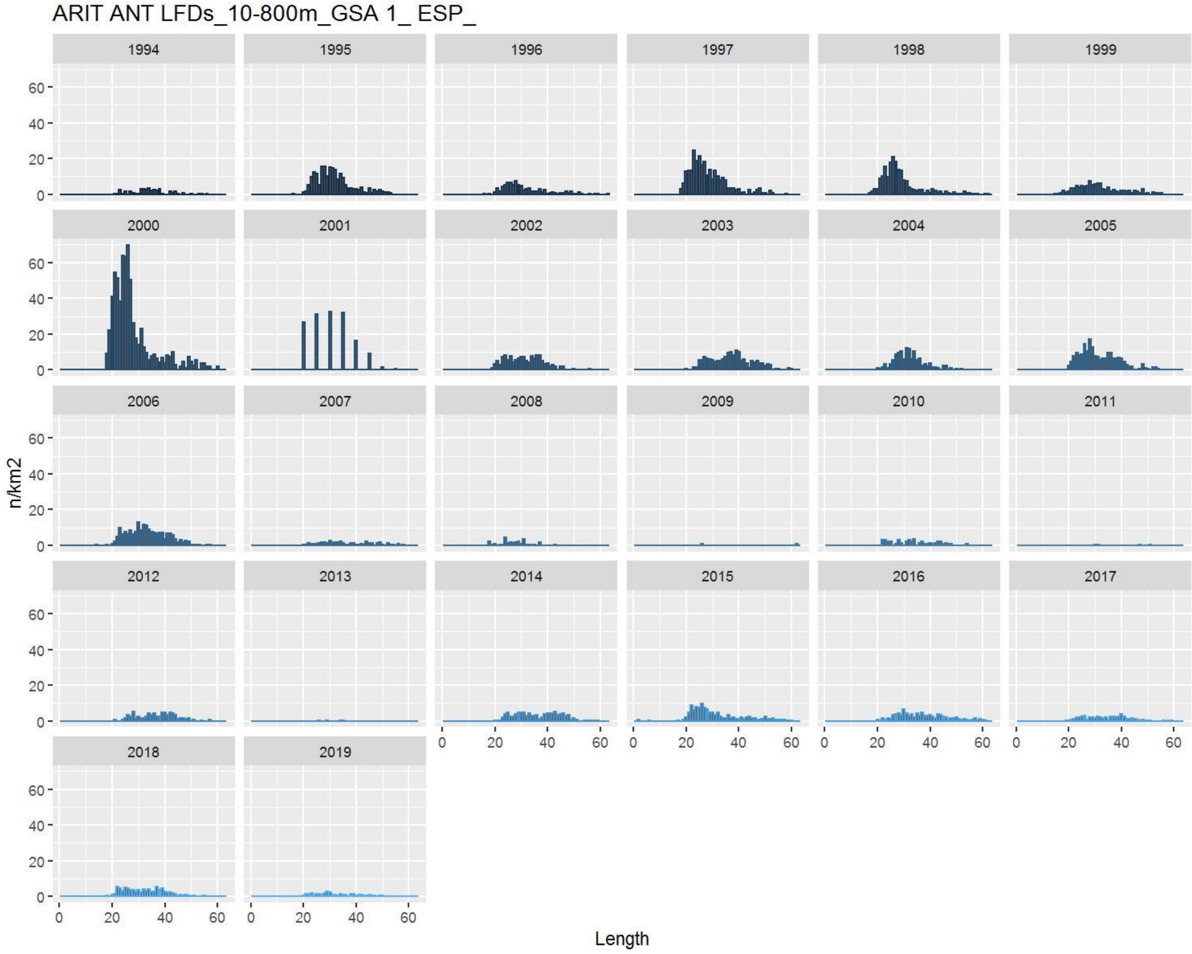


Figure 6.15.2.3.4. Blue and red shrimp in GSA 1. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

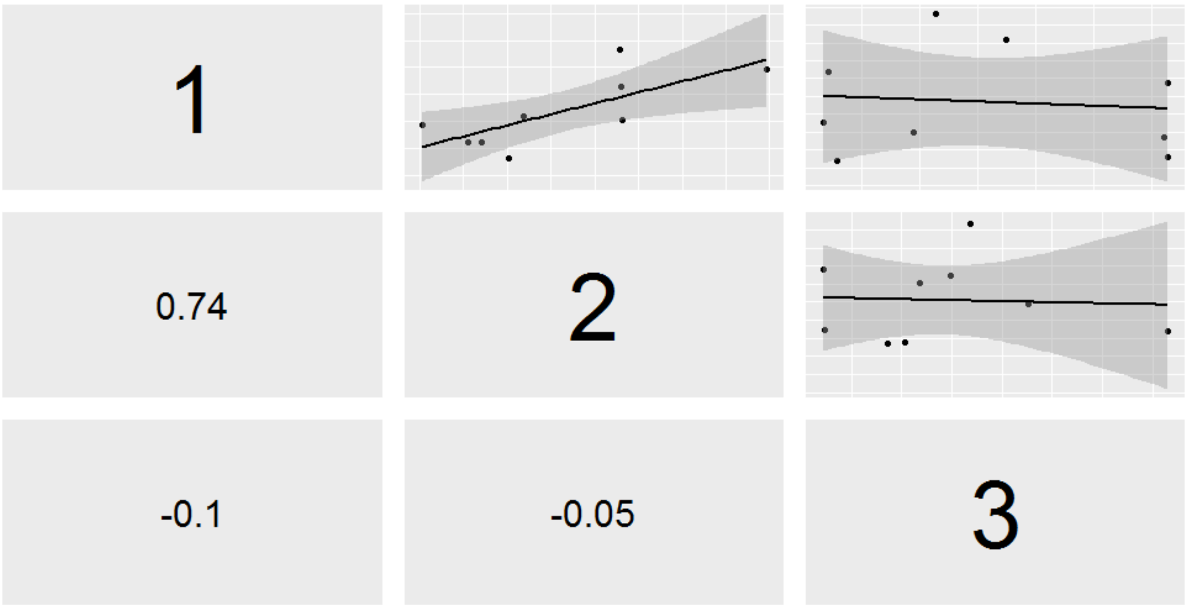


Figure 6.15.2.3.5. Blue and red shrimp in GSA 1. Cohorts consistency in MEDITS index

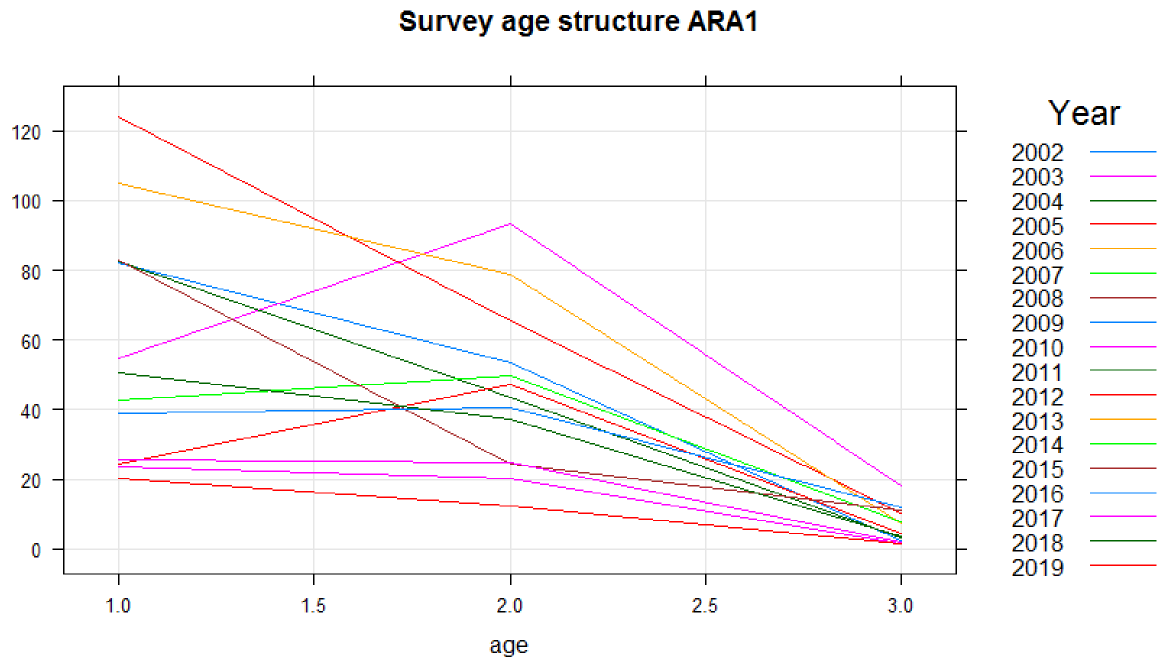


Figure 6.15.2.3.6. Blue and red shrimp in GSA 1. Age frequency distribution of the MEDITS survey of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June. Note that 2007, 2008, 2009, 2011 and 2013 were excluded from the analysis (see maintext for details).

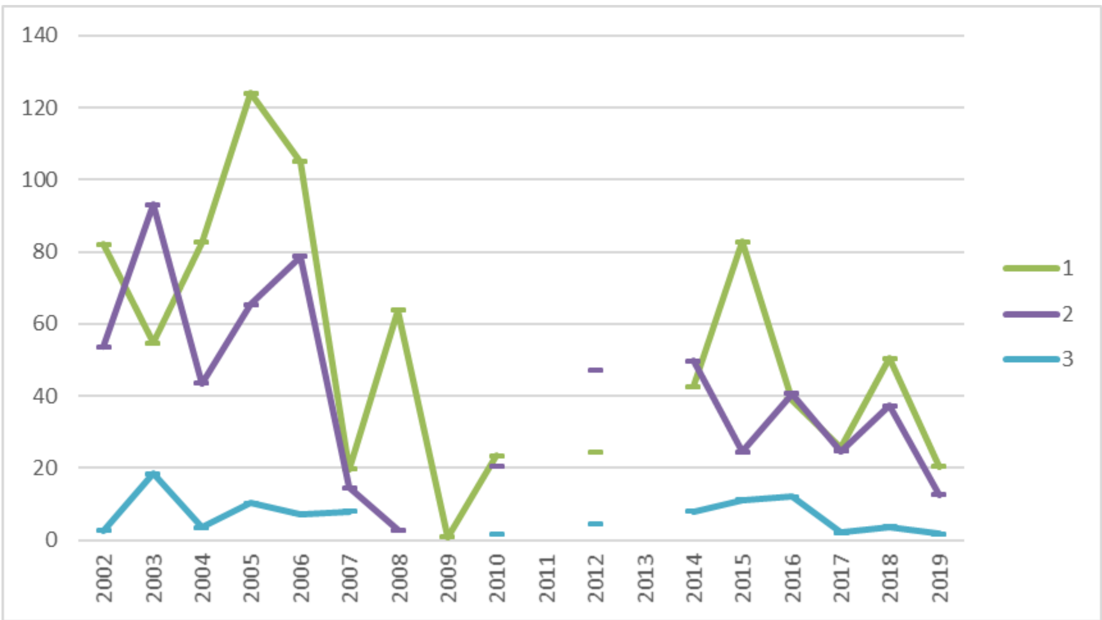


Figure 6.15.2.3.7. Blue and red shrimp in GSA 1. Number of individuals per year by age group (ages 1-3) according to MEDITS surveys. Age group 4 was excluded from the analysis due to the low or none values. Years 2007, 2008, 2009, 2011 and 2013 were excluded from the analysis.

Numbers at length were sliced to give numbers at age based on the same growth curves used for the catch. These were arranged to match 1st of January birthday, by adding 0.5 to t0 as with the catch data slicing. The numbers at age are given in Table 6.15.2.3.2. The same data is and shown by year and age in Figures 6.15.2.3.6 and 6.15.2.3.7 respectively.

Table 6.15.2.3.2. Blue and red shrimp in GSA 1. Number of individuals per year by age group (ages 1-3) according to MEDITS surveys. Age group 4 was excluded from the analysis due to the low or none values. Years 2007, 2008, 2009, 2011 and 2013 were excluded from the analysis, due to shortage or errors of hauls in some strata in this years.

	1	2	3
2002	82.06426	53.61917	2.6045
2003	54.75935	93.12369	18.36242
2004	82.62845	43.54377	3.40254
2005	124.1028	65.31726	10.20582
2006	105.04405	78.69487	7.20384
2007	-	-	-
2008	-	-	-
2009	-	-	-
2010	23.40023	20.38085	1.50969
2011	-	-	-
2012	24.32503	47.13194	4.45291
2013	-	-	-
2014	42.69805	49.7059	7.96956
2015	82.73878	24.46131	11.18995
2016	38.92225	40.65035	12.08044
2017	25.62647	24.62326	1.98513
2018	50.49887	37.31798	3.71039
2019	20.41544	12.50276	1.70809

6.15.3 STOCK ASSESSMENT

This stock was assessed last year 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 2019 catch and survey data. Treatment of length to age that better aligns the the birthday to 1st of January for stocks with summer spawing resultys in different age structure which is considered to better reflect the observed growth.

6.15.3.1. 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 1^{st} 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 6.15.1.2). 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 6.15.1.3. using the original growth parameters (without adding 0.5 to t_0)

6.15.3.3. a4a

The Assessment for All Initiative (a4a) (Jardim et al., 2014), a4a, a statistical catch-at-age analysis method were used for this stock that utilize catch-at-age data to derive estimates of historical population size and fishing mortality. Statistical catch-at-age analysis works forward in time and the methods do not require the assumption that removals from the fishery are known without error.

Input

Data that are typically used are: catch, abundance index, statistical sample of age composition of catch and abundance index.

Total catches and numbers at age in catches and mean weights at age in catch and stock are taken from the fishery as described above in Section 6.15.2.1.The landings data were considered as catch because discards were negligible as they are always less than 0.3% of the reported catch (Table 6.15.2.1.1).

A single tuning fleet was used based on the CPUE and weight at age estimates from summer bottom trawl surveys (MEDITS) conducted in the northern Alboran Sea (GSA 1) as reported in the DCF. Numbers at age for a tuning index are taken from MEDITS data (Section 6.15.2.3).

An assessment was performed with version 1.8.2 of FLa4a, together with version 2.6.13 of the FLR library (FLCore) in FLR environment. The 4.0.2 (64-bit) version of R was used.

Settings

The analysis was carried out for the ages 0 to 5 age class for the catch and 1 to 3 age for the survey (age group 5 was the plus group in the catch data and age group 3 was the true age group in the survey data) for the a4a. Concerning the Fbar, the age range used was 1-2 age groups that form the vast majority of the catch.

The a4a model was tested with the sub-models from the previous year. Finally, after a sensitivity test for fmodel with smoother to year with different k, it was decided to add a smoother k=5 (according to a combination of AIC, BIC and residuals).

```
fmodel <- ~ s(replace(age,age>2,2), k=3) + s(year,k=5)
qmodel <- list(~ factor(replace(age,age>2,2)))
srmodel <- ~factor(year)
```

All diagnostic tests and retrospective analysis were applied.

Results

The stock summary (Table 6.15.3.1, Figure 6.15.3.1) estimated N at age (Table 6.15.3.2) and F at age (Table 6.15.3.3) from the a4a assessment are provided. The diagnostics can be seen below :- the 3D contour plot (wireframe) of fishing mortality with age and year (Figure 6.15.3.2), and the wireframe of catchability (Figure 6.15.3.3), the residuals of catch and abundance indices by age (Figure 6.15.3.4), the fitted and observed catch at age (Figure 6.15.3.5) and index at age (Figure 6.15.3.6), the residuals of catch and abundance index (Figure 6.15.3.7) as well as the retrospective analysis (Figure 6.15.3.8) and the stock summary of the simulated and fitted data (Figure 6.15.3.9). Histograms of probability for F0.1, Fcurr and level of exploitation (Fcurr/F01 ratio) (Figure 6.15.3.10).

Historical stock trends

Spawning stock biomass (SSB)
The SSB shows a clear decreasing trend since 2014. The average SSB in the last 5 years of the dataset (2013-2019) is 87 t, which is considerably lower compared to the average SSB in the beginning of the time series (2002-2006) that was 132 t (Figure 6.15.3.1).

Recruitment
Recruitment shows a declining pattern since 2005 (highest value in the time series). The recruitment in 2019 was 174,574 individuals, lower compared to the mean of the time series, 248,485 individuals (Figure 6.15.3.1). The average recruitment (2006-2019 years) that was used in the STF was 217,579 recruits.

Catch
Catch declined from around 200 t in 2002-2007 to around 120 t in 2019, with a declining trend from 2008 to 2010 and it appeared rather stable from 2011 to 2016. From 2017 to 2019 catch declined.

Fishing mortality (F)
F has been exceeding $F_{0.1}$ since 2002. It has fluctuated around 1.0-1.5 until 2017 but has increased in 2018 to 1.59 and the last year to 1.82.

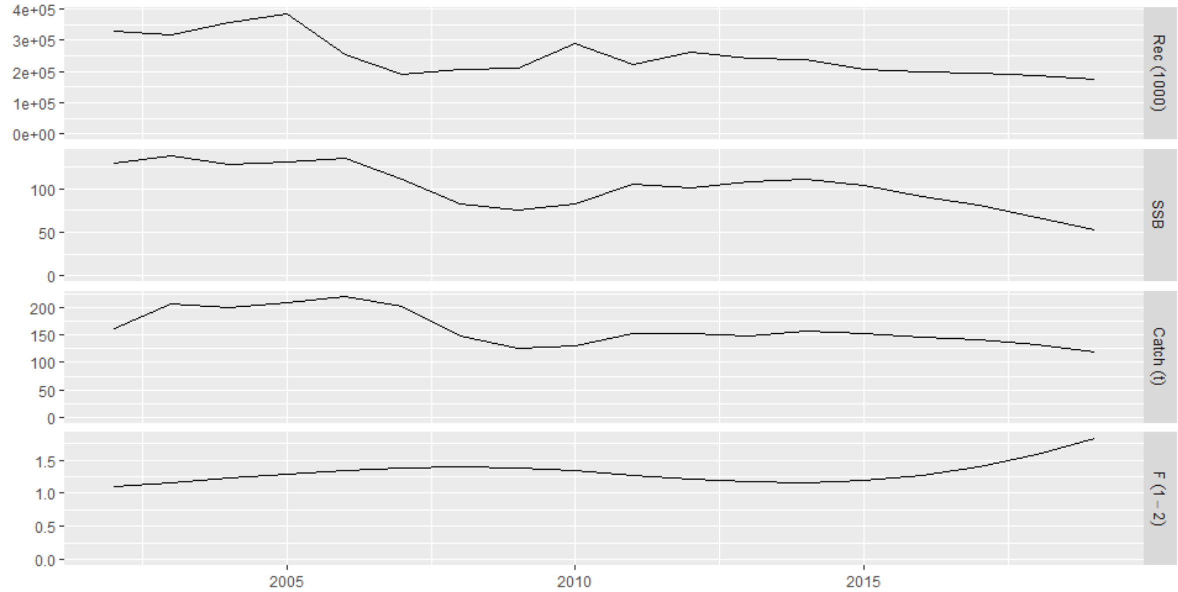


Figure 6.15.3.1. Blue and red shrimp in GSA 1. Stock summary for blue and red shrimp in GSA 1, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 2).

Table 6.15.3.1 Stock Summary blue and red shrimp in GSA 1 recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality).

year	rec age 0	SSB (t)	Catch (t)	F 1-2
2002	330487	129.694	161.95	1.103
2003	316933	138.13	205.45	1.166
2004	356914	127.052	199.98	1.231
2005	385503	130.551	207.18	1.295
2006	254381	134.012	218.50	1.351
2007	192639	111.036	202.62	1.390
2008	207423	82.09	147.62	1.401
2009	210674	75.058	126.09	1.382
2010	288168	83.097	130.92	1.337
2011	222641	104.701	151.77	1.275
2012	261669	101.073	152.03	1.215
2013	241334	107.283	148.32	1.171
2014	237478	110.504	157.49	1.159
2015	208771	102.988	152.69	1.188
2016	200213	90.968	146.37	1.267
2017	195924	80.534	140.15	1.401
2018	187020	67.007	132.31	1.589
2019	174574	52.085	119.70	1.823

Table 6.15.3.2 Stock Summary blue and red shrimp in GSA 1 N at age from a4a assessment including survivors list of January 2020 (Geometric mean recruitment).

year/age	0	1	2	3	4	5
2002	330486.99	37471.98	5505.65	181.37	0.73	0.00
2003	316933.42	32248.67	8362.27	605.26	22.17	0.09
2004	356914.15	30926.10	6948.78	839.91	67.60	2.63
2005	385502.84	34827.41	6425.54	635.44	85.40	7.55
2006	254380.98	37617.07	6981.65	535.81	58.92	9.12
2007	192639.17	24822.30	7308.67	537.10	45.83	6.17
2008	207423.39	18797.57	4720.50	532.06	43.48	4.46
2009	210673.69	20240.22	3551.29	337.85	42.34	4.04
2010	288168.24	20557.33	3864.39	261.18	27.63	4.02
2011	222641.05	28119.23	4026.78	303.59	22.82	2.93
2012	261668.84	21725.13	5699.83	345.53	28.97	2.60
2013	241334.37	25533.44	4555.48	533.71	35.98	3.48
2014	237477.62	23549.21	5485.93	454.16	59.16	4.63
2015	208771.27	23172.88	5095.06	556.85	51.26	7.62
2016	200213.39	20371.72	4931.94	495.74	60.25	6.75
2017	195923.64	19536.65	4147.99	428.13	47.85	6.85
2018	187020.14	19118.06	3691.61	297.02	34.09	4.62

2019	174573.94	18249.25	3252.90	201.75	18.05	2.49
2020	217579.14	17035.00	2723.50	126.81	8.75	0.94

Table 6.15.3.3 Stock Summary blue and red shrimp in GSA 1 F at age from a4a assessment.

Year/age	1	2	3	4	5
2002	0.62	1.59	1.59	1.59	1.59
2003	0.65	1.68	1.68	1.68	1.68
2004	0.69	1.77	1.77	1.77	1.77
2005	0.72	1.87	1.87	1.87	1.87
2006	0.76	1.95	1.95	1.95	1.95
2007	0.78	2.00	2.00	2.00	2.00
2008	0.78	2.02	2.02	2.02	2.02
2009	0.77	1.99	1.99	1.99	1.99
2010	0.75	1.93	1.93	1.93	1.93
2011	0.71	1.84	1.84	1.84	1.84
2012	0.68	1.75	1.75	1.75	1.75
2013	0.65	1.69	1.69	1.69	1.69
2014	0.65	1.67	1.67	1.67	1.67
2015	0.66	1.71	1.71	1.71	1.71
2016	0.71	1.83	1.83	1.83	1.83
2017	0.78	2.02	2.02	2.02	2.02
2018	0.89	2.29	2.29	2.29	2.29
2019	1.02	2.63	2.63	2.63	2.63

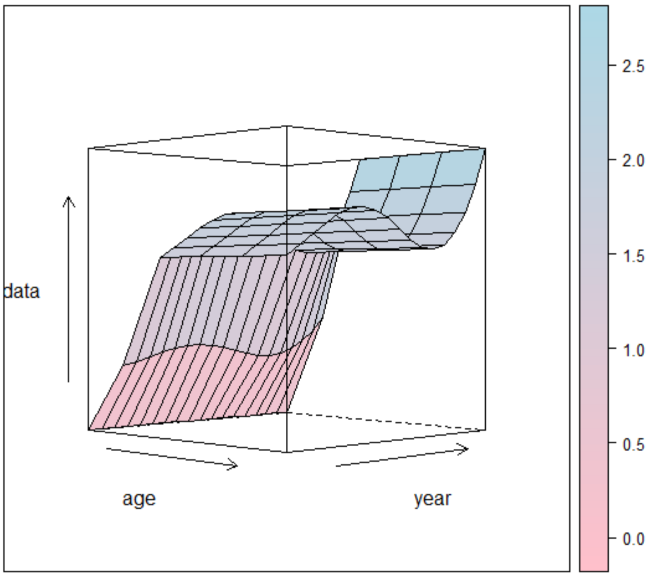


Figure 6.15.3.2. Blue and red shrimp in GSA 1. 3D contour plot of estimated fishing mortality at age and year.

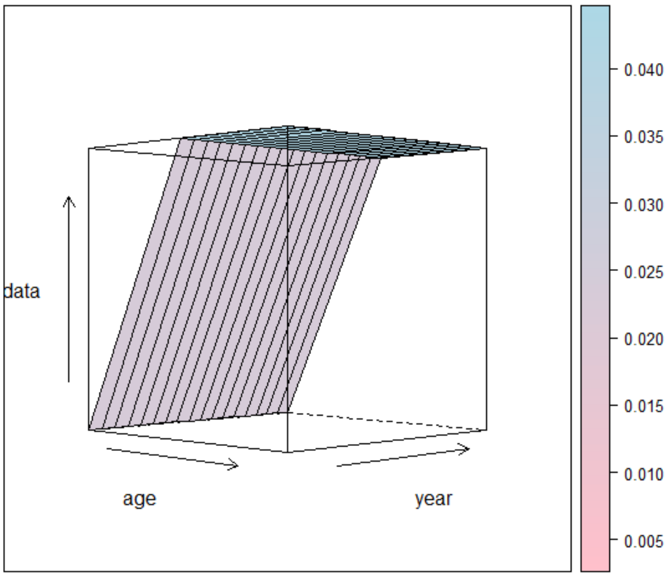


Figure 6.15.3.3. Blue and red shrimp in GSA 1. 3D contour plot of estimated catchability at age and year.

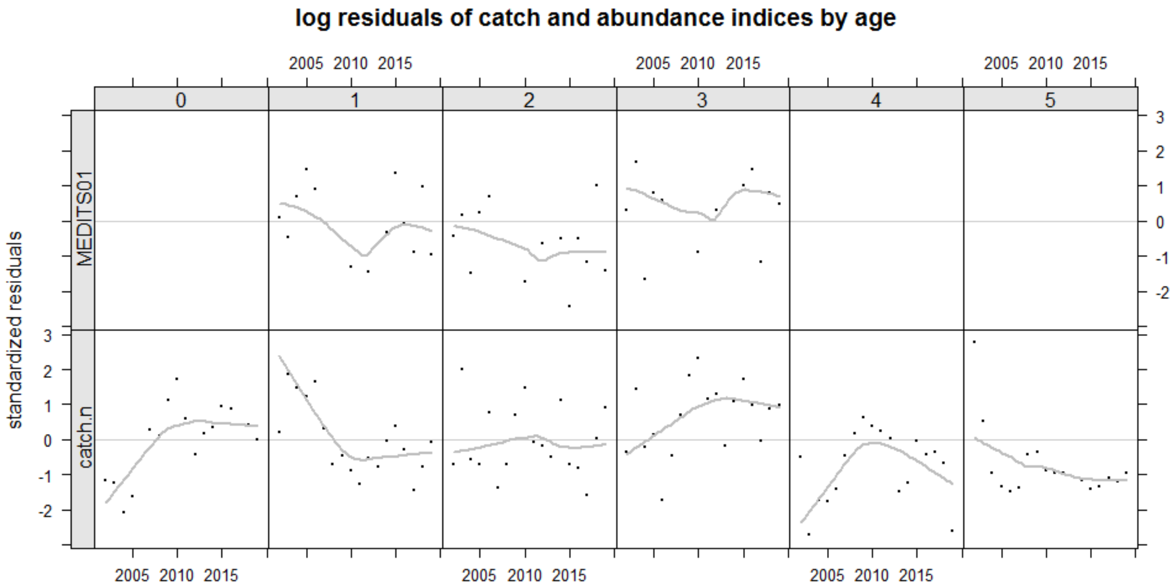


Figure 6.15.3.4. Blue and red shrimp in GSA 1. Standardized residuals for abundance indices (MEDITS) and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

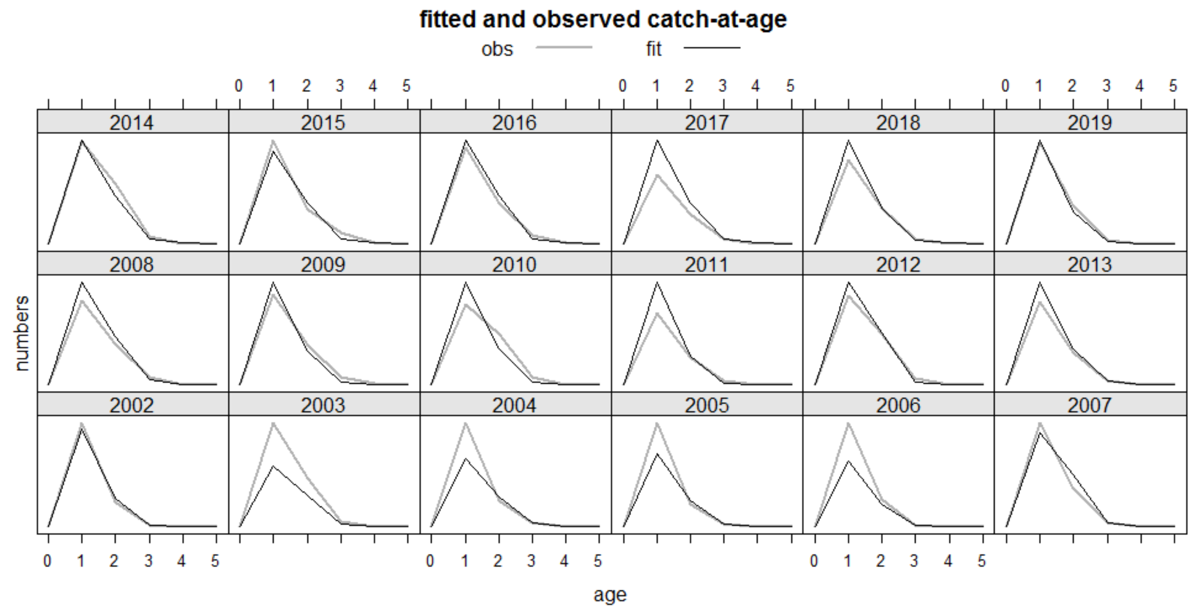


Figure 6.15.3.5. Blue and red shrimp in GSA 1. Fitted and observed catch at age.

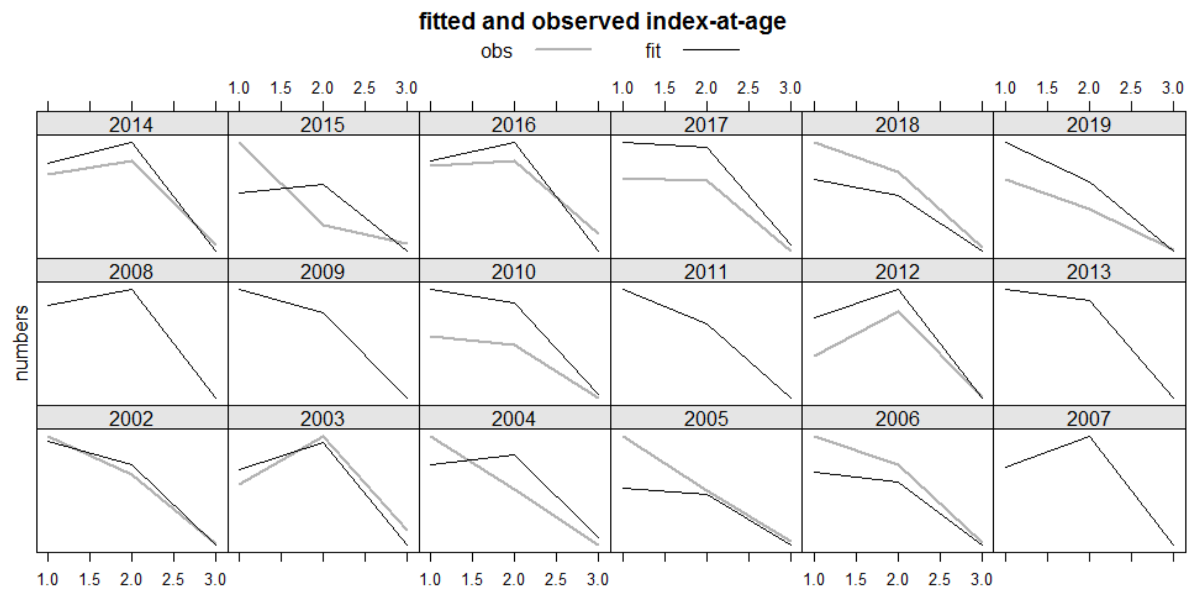


Figure 6.15.3.6. Blue and red shrimp in GSA 1. Fitted and observed index at age.

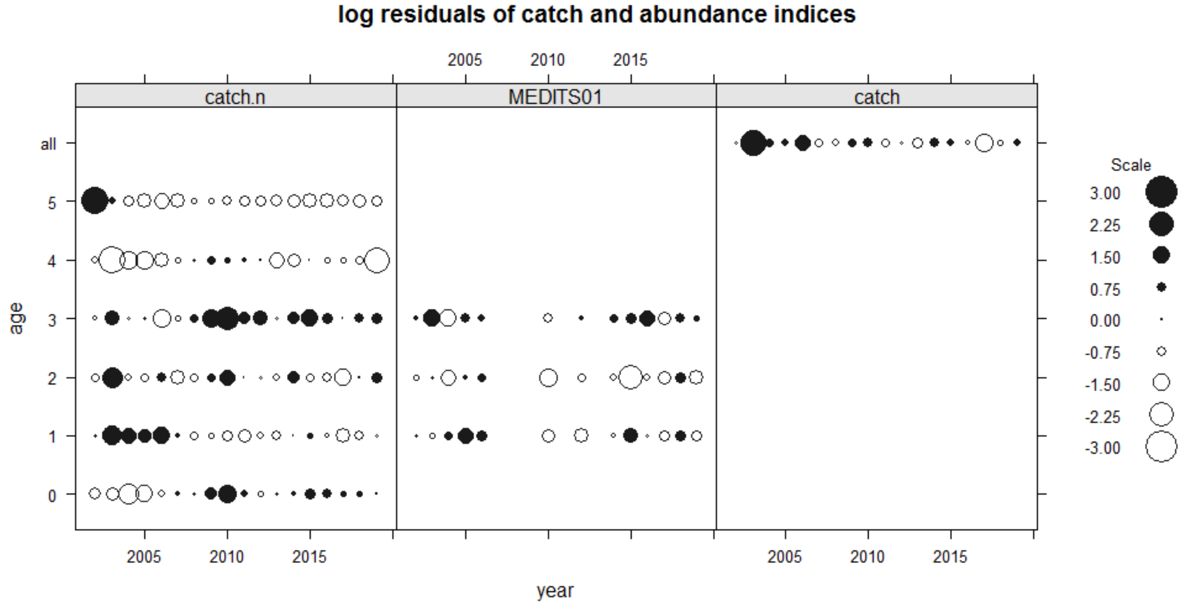


Figure 6.15.3.7. Blue and red shrimp in GSA 1. Residuals of catch and abundance index (a4a).

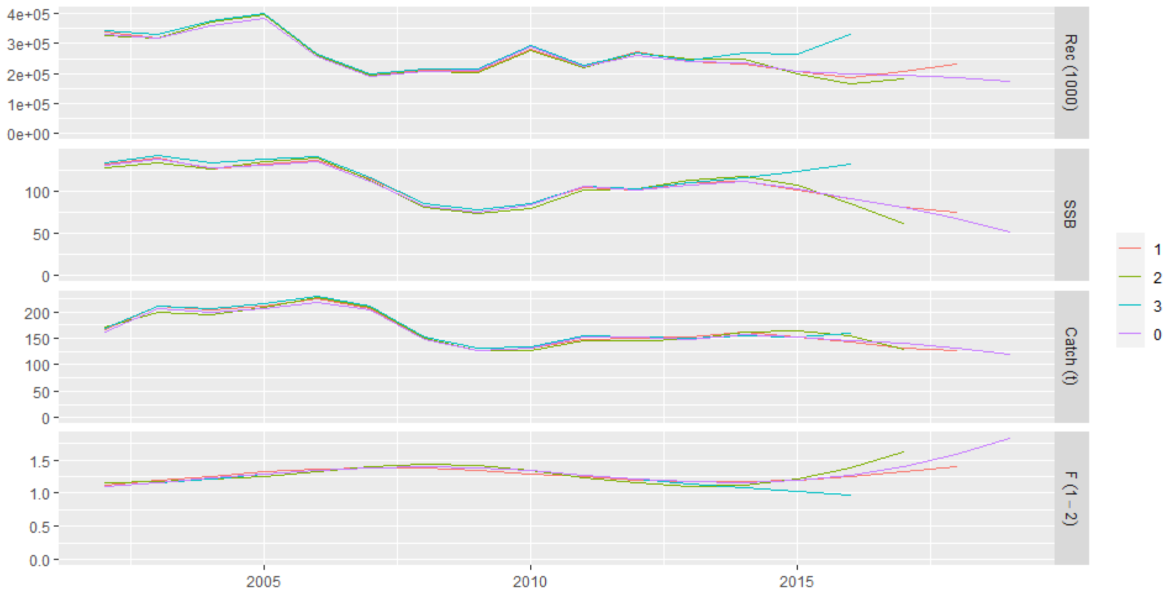


Figure 6.15.3.8. Blue and red shrimp in GSA 1. Retrospective analysis output from a4a.

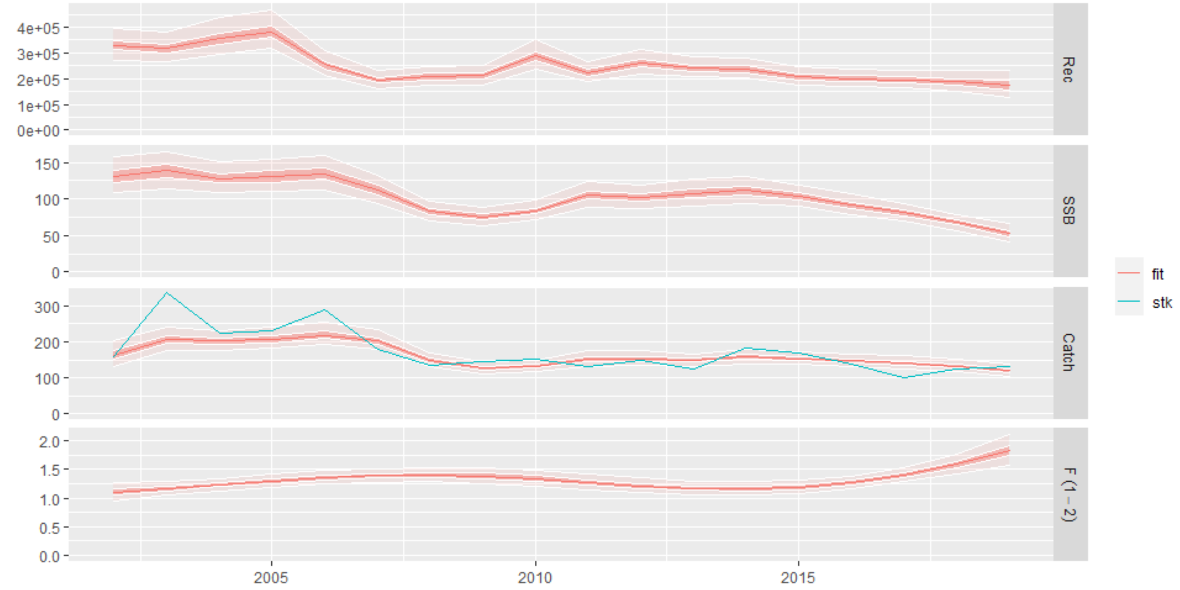


Figure 6.15.3.9. Blue and red shrimp in GSA 1. Stock summary of the simulated and fitted data from a4a.

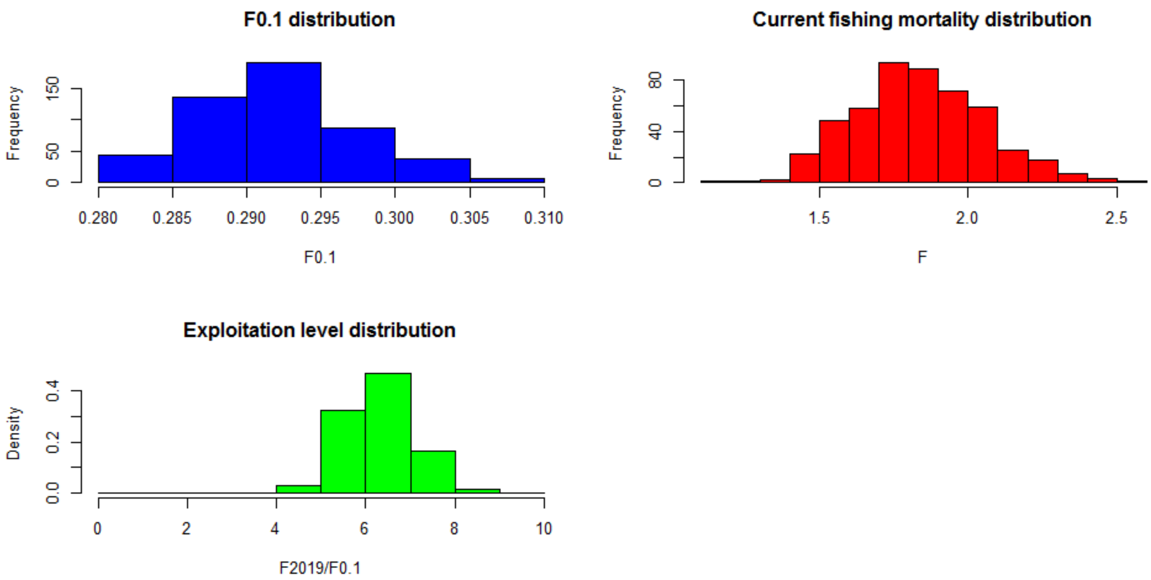


Figure 6.15.3.10. Blue and red shrimp in GSA 1. Histograms of probability for F0.1, Fcurr and level of exploitation (Fcurr/F01 ratio) values for Blue and red shrimp in GSA 1.

6.15.4 Reference Points

The stock of blue and red shrimp in GSA 1 was assessed using the statistical catch-at-age method (a4a) that was applied to catch data for the period 2002-2019 and tuned with MEDITS survey data.

6.15.4.1. Methods

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as Fmax and $F_{0.1}$. In all cases biological and parameters, F and Ms were taken as mean of last three years.

The reference points $F_{0.1}$ is estimated as 0.29 for F ages 1-2

The fishing mortality rate corresponding to $F_{0.1}$ is considered by STECF as a proxy of F_{MSY}.

6.15.5 SHORT TERM FORECAST AND CATCH OPTIONS

6.15.5.1. Method

A deterministic short term prediction for the period 2020 to 2022 was performed using the FLR routines provided by JRC and based on the results of the a4a stock assessment.

6.15.5.2. Input parameters

THE SAME INPUT PARAMETERS OF THE A4A MODEL AND THE MODEL OUTPUT WERE USED FOR RUNNING THE short term forecast. The intermediate year assumptions are given in Table 6.15.5.1. The F status quo is estimated as Fbar 2019 = 1.82. Trend in recruitment for the period 2006-2019 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 (217,579 individuals).

Table 6.15.5.1 Blue and red shrimp in GSAs 1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	Average of 2017-2019	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-2}$ (2020)	1.82	F 2019 is used to give F status quo for 2020
SSB (2020)	50.0	Stock assessment 1 January 2020
R_{age0} (2020,2022)	217579	Geometric mean of the last 13 years
Total catch (2020)	111	Assuming F status quo for 2020

The short term forecast (Table. 6.15.5.2) was carried out estimating a catch for 2020-2022 on the basis of a recruitment constant and equal to the mean on the last 13 years of the time series and an F by age equal to that of the terminal year.

Table 6.15.5.2. Results of STF

	Ffactor	Fbar	Catch 2019	Catch 2021	SSB 2020	SSB 2022	Change SSB 2020-2022(%)
High long term yield ($F_{0.1}$)	0.16	0.29	119.70	32.23	50.00	184.74	269.46
Fupper	0.22	0.40	119.70	42.49	50.00	165.99	231.96
Flower	0.11	0.20	119.70	22.45	50.00	203.74	307.47
F_{MSY} transition	0.72	1.31	119.70	102.15	50.00	81.34	62.67
Zero catch	0.00	0.00	119.70	0.00	50.00	251.65	403.28
Status quo	1.00	1.82	119.70	123.05	50.00	60.87	21.73
Different Scenarios	0.10	0.18	119.70	21.04	50.00	206.59	313.17
	0.20	0.36	119.70	39.13	50.00	171.99	243.98
	0.30	0.55	119.70	54.79	50.00	145.15	190.30
	0.40	0.73	119.70	68.45	50.00	124.11	148.22
	0.50	0.91	119.70	80.43	50.00	107.44	114.87
	0.60	1.09	119.70	91.01	50.00	94.08	88.15
	0.70	1.28	119.70	100.40	50.00	83.26	66.51
	0.80	1.46	119.70	108.78	50.00	74.38	48.76
	0.90	1.64	119.70	116.29	50.00	67.03	34.06
	1.10	2.01	119.70	129.17	50.00	55.64	11.27
	1.20	2.19	119.70	134.72	50.00	51.16	2.31
	1.30	2.37	119.70	139.77	50.00	47.27	-5.45
	1.40	2.55	119.70	144.39	50.00	43.88	-12.25
	1.50	2.73	119.70	148.62	50.00	40.87	-18.25
	1.60	2.92	119.70	152.50	50.00	38.20	-23.61
	1.70	3.10	119.70	156.08	50.00	35.79	-28.41
	1.80	3.28	119.70	159.38	50.00	33.62	-32.77
	1.9	3.46	119.70	162.43	50.00	31.63	-36.74
	2.0	3.65	119.70	165.26	50.00	29.81	-40.38

*SSB at mid year

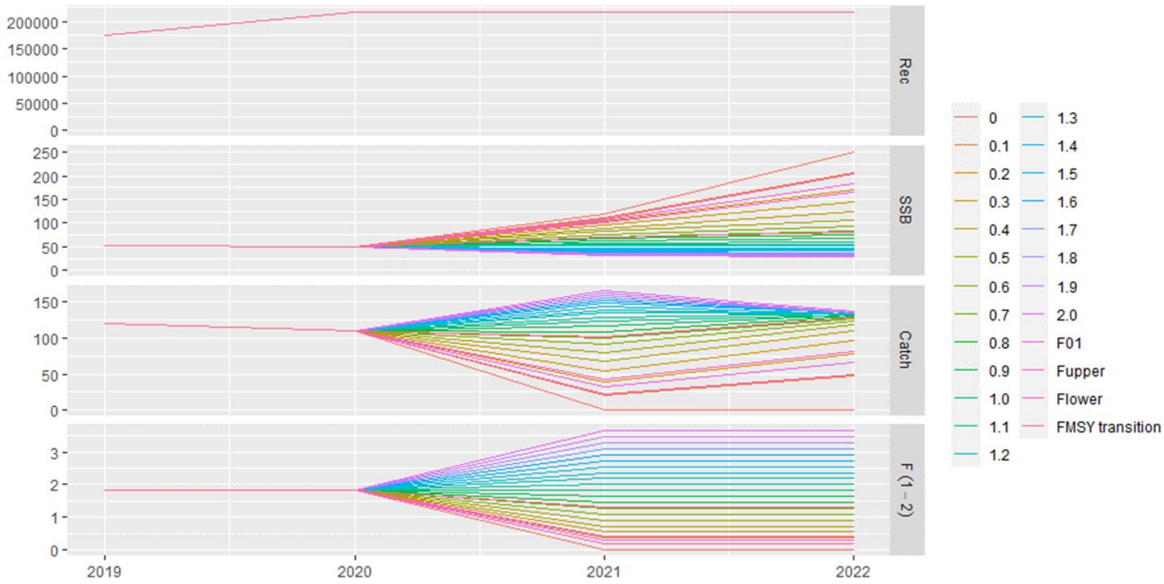


Figure 6.15.5.1. Blue and red shrimp in GSA 1. Annual catch scenarios and predictions of catch and SSB for blue and red shrimp (GSA 1).

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.

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.

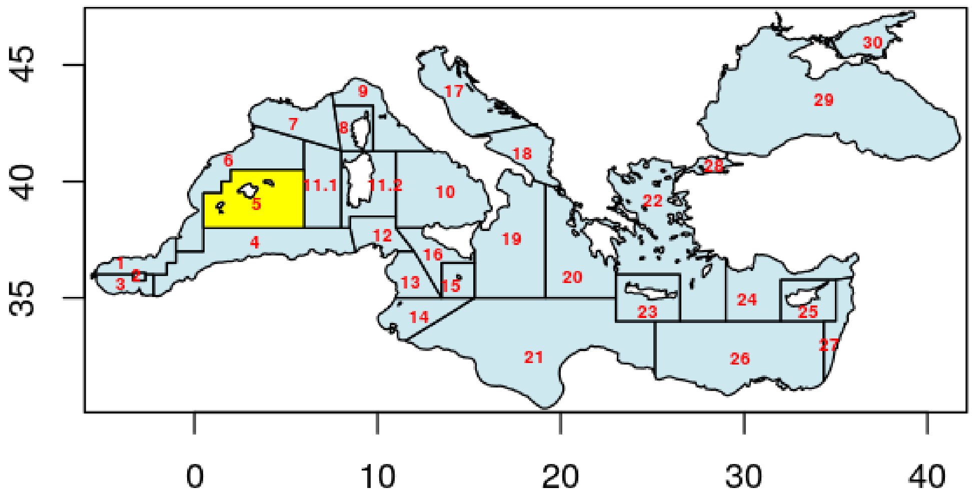


Figure 6.16.1.1 Geographical location of GSA 5

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. Blue and red shrimp in GSA 5: 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 2002-2019 and were exclusively reported by OTB fishing operations (Table 6.16.2.1.1, Figure 6.16.2.1.1). Reported discards were negligible making up for < 0.01% of the total catch (Figure 6.16.2.1.1).

Table 6.16.2.1.1. Blue and red shrimp in GSA 5: landing data (in tons)

Year	SPAIN OTB GSA 5	Total landings
2002	141.5	141.5
2003	122.0	122.0
2004	193.6	193.6
2005	191.5	191.5
2006	213.9	213.9
2007	239.1	239.1
2008	232.9	232.9
2009	126.2	126.2
2010	153.2	153.2
2011	111.2	111.2
2012	201.1	201.1
2013	188.6	188.6
2014	141.3	141.3
2015	160.2	160.2
2016	138.1	138.1
2017	171.4	171.4
2018	249.7	249.7
2019	205.9	205.9

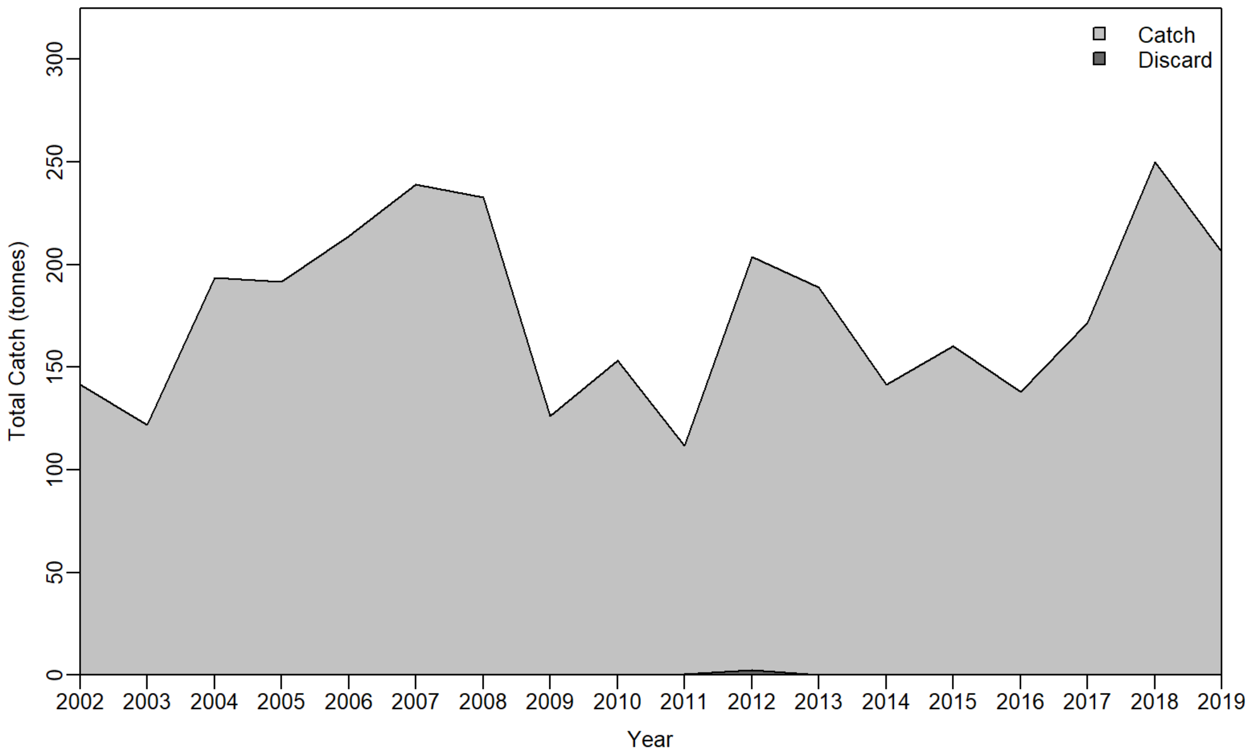


Figure 6.16.2.1.1. Blue and red shrimp in GSA 5: landing data (in tons)

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.16.2.1.2.

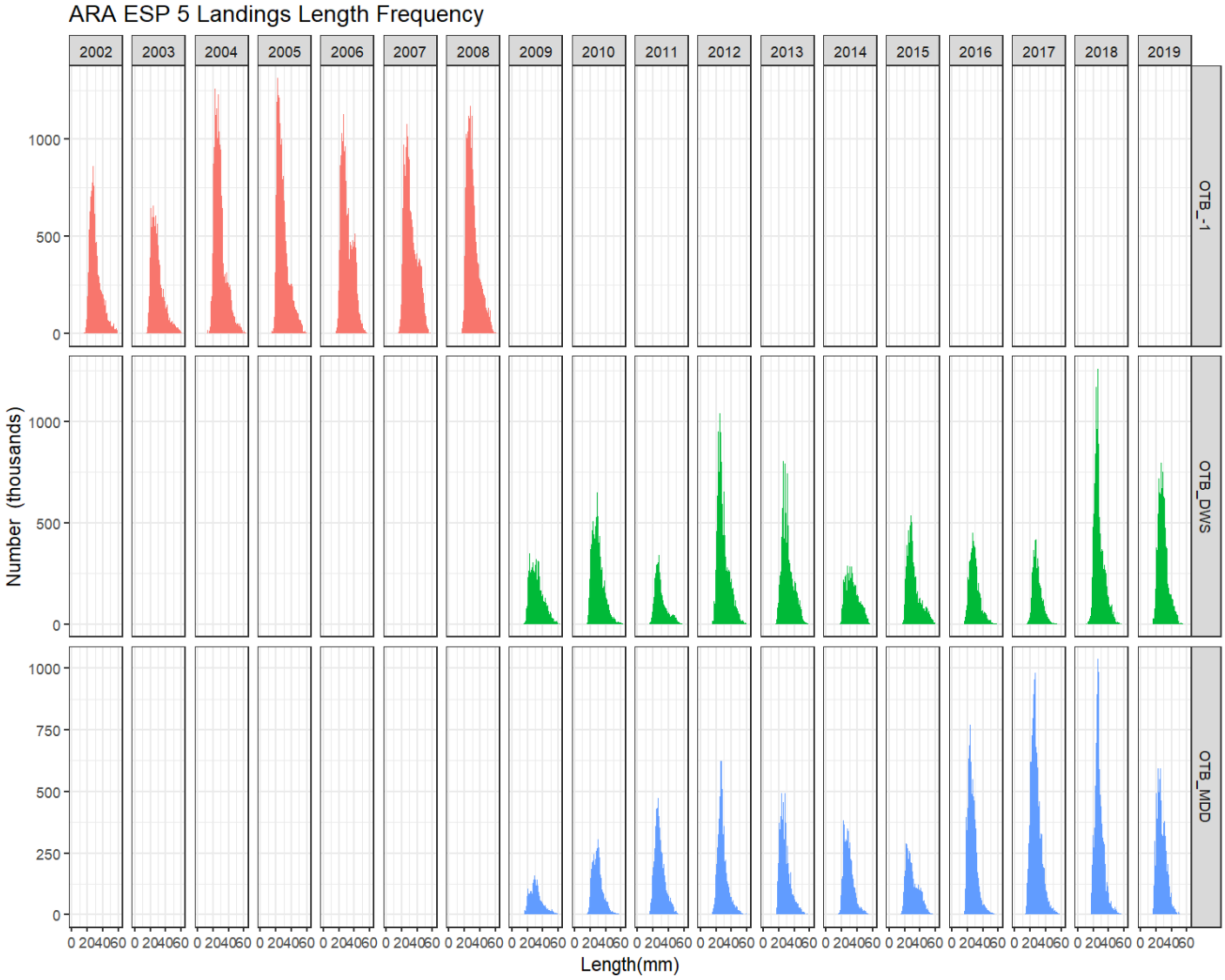


Figure 6.16.2.1.2. Blue and red shrimp in GSA 5: Length frequency distribution of the landings by year and gear in GSA 5.

6.16.2.2 EFFORT

Fishing effort data were reported to STECF EWG 20-09 through DCF and was available for the period 2004-2018 (Tables 6.16.2.2.1, Figures 6.16.2.2.1). Fishing effort data were reported to STECF EWG 20-09 through DCF (Table 6.18.2.2.1 and 6.18.2.2.2). The trend effort shows a consistent decrease over period 2004-2018 by more than 30%.

Table 6.16.2.2.1. Blue and red shrimp in GSA 5: Fishing effort in Days at sea and Nominal (kw ×Sea day) by year and fishing gear.

Year	Gear	Sea Days	Nominal
2004	OTB	12012	2911741
2005	OTB	11497	2694713
2006	OTB	10507	2509394
2007	OTB	11907	2939082
2008	OTB	12226	3035582
2009	OTB	10934	2784175
2010	OTB	11239	2927650
2011	OTB	10498	2694399
2012	OTB	10568	2675591
2013	OTB	10769	2745967
2014	OTB	10936	2828550
2015	OTB	10714	2821286
2016	OTB	8952	2273215
2017	OTB	9158	2330433
2018	OTB	7947	2053867
2019	OTB		

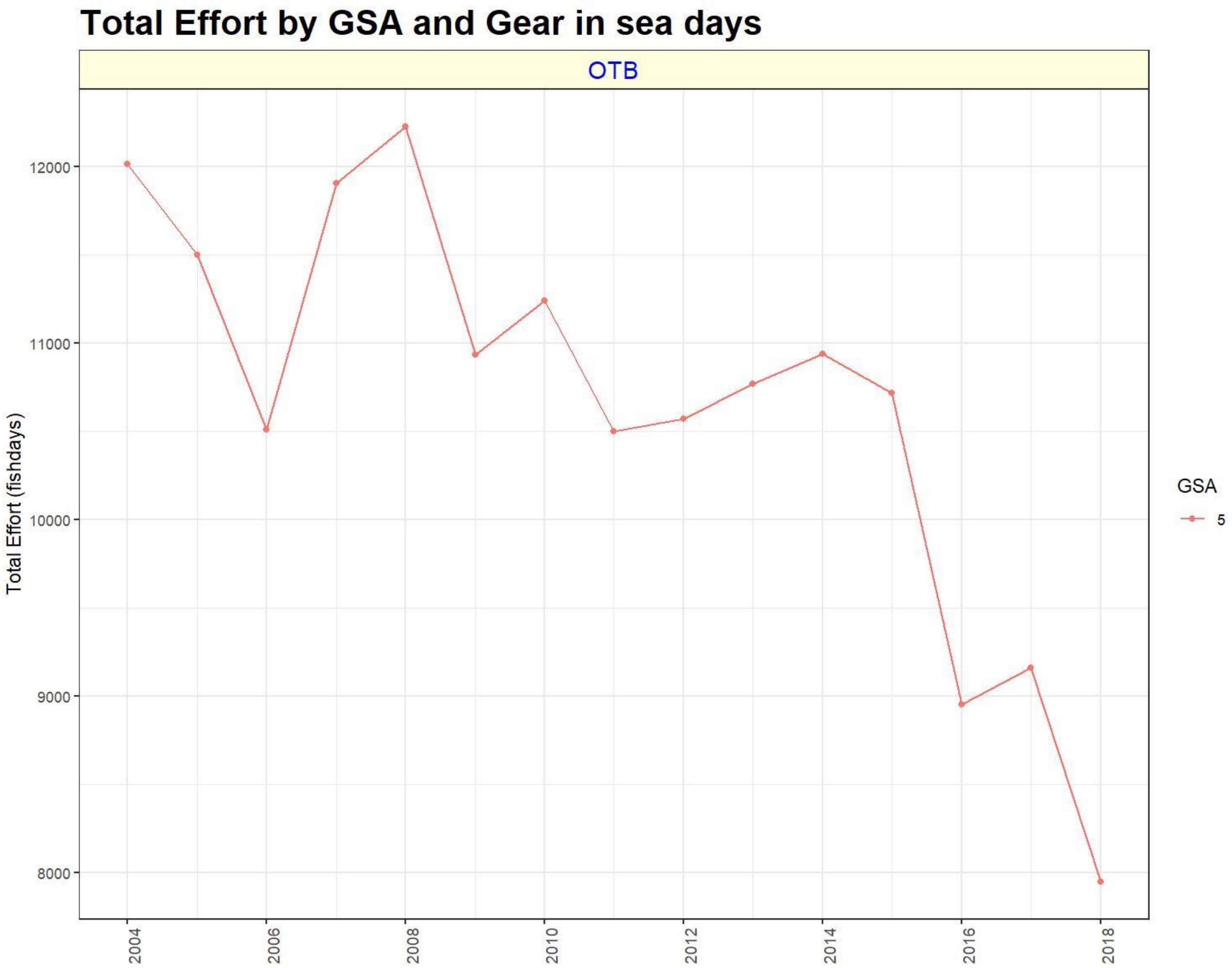


Table 6.16.2.2.1. Blue and red shrimp in GSA 5: Fishing effort in days at sea by gear over the period 2004-2019.

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).

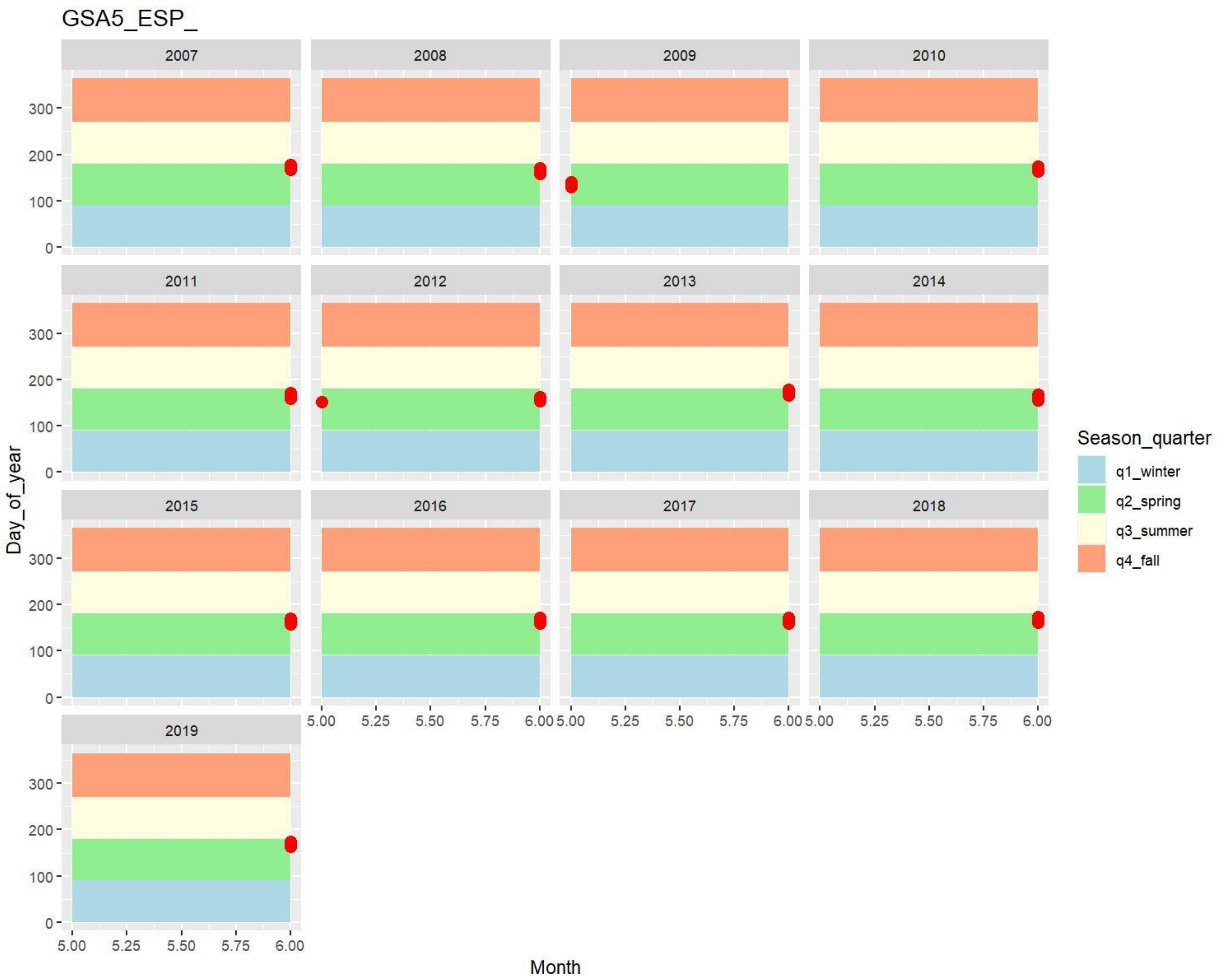
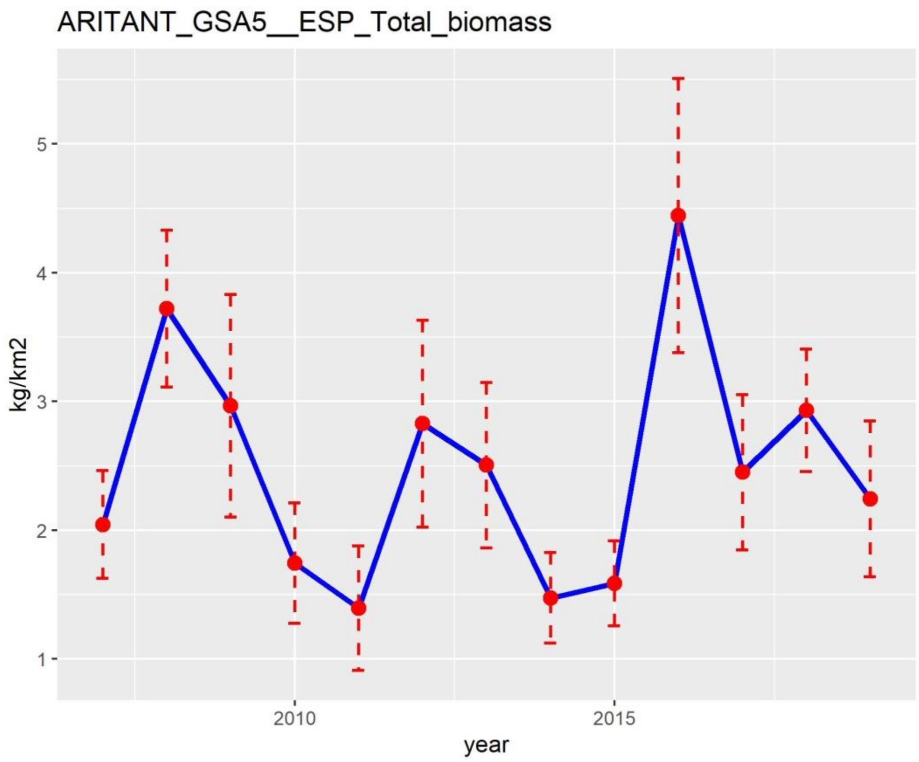


Figure 6.16.2.3.1 Blue and red shrimp in GSA 5: Survey periods of MEDITS in GSA 5.

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.



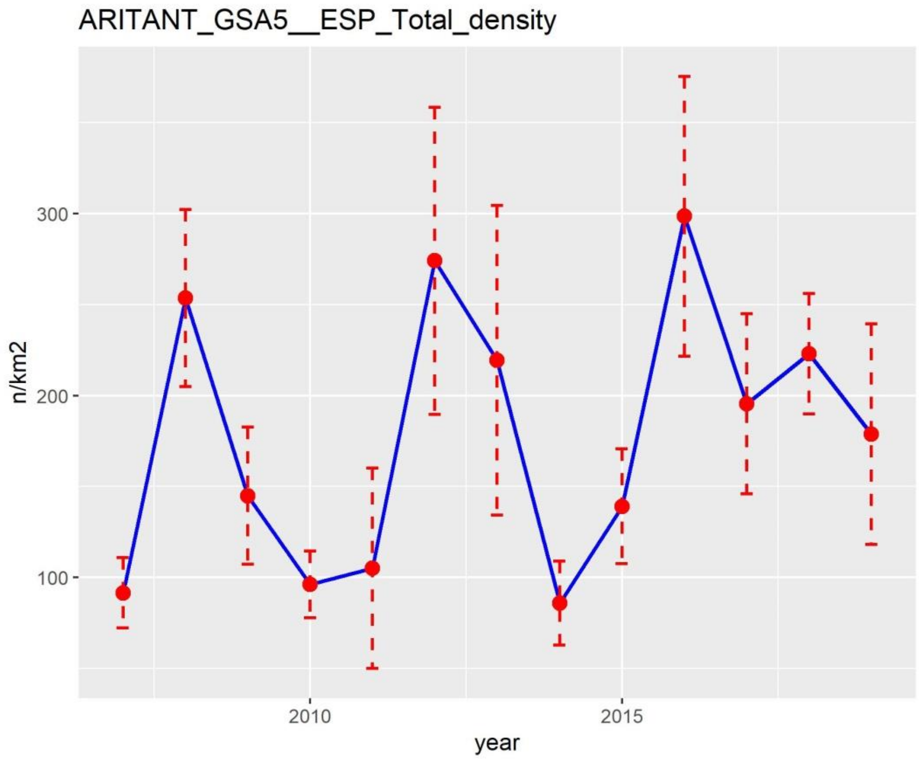


Figure 6.16.2.3.2. Blue and red shrimp in GSA 5: MEDITS indices for the period 1994-2019: relative biomass (kg km^2) and density (n km^2).

Size frequency distributions by years are shown in Figure 6.16.2.3.3.

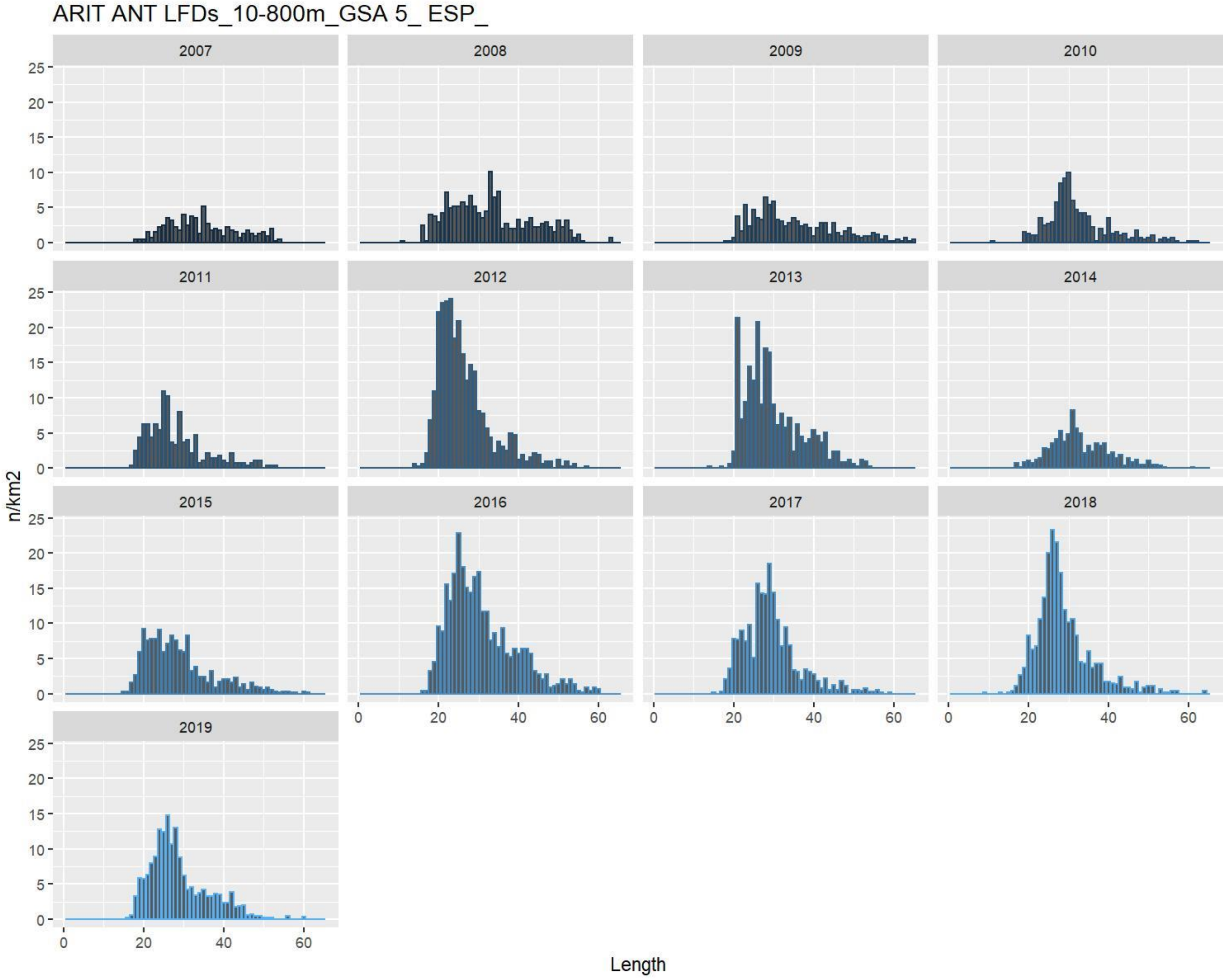


Figure 6.16.2.3.3. Blue and red shrimp in GSA 5: Observed Length-frequency distributions (MEDITS data).

6.16.3 STOCK ASSESSMENT

The EWG 18-12 concluded that XSA and a4a results were considered as not acceptable. Both models showed oscillations along the data series, both for recruitment and SSB. However, a4a showed an increase of both quantaties for the last years. Fishing mortality values were higher for a4a than for XSA, but this was considered as the most unstable parameter.

EWG 19-10 was required to do a short evaluation of survey and landing trends to determine if new data was 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 18-12 was confirmed.

EWG 20-09 was required to conduct a new assessment.

Input data

The Assessment for All Initiative (a4a) statistical catch-age model (Jardim et al., 2015) was used for Blue and red shrimp in GSA 5.

A difference to the previous 2018 assessment was that the somatic growth parameter t_0 = 0.05 was adjusted by t_0 = 0.05 + 0.5 to account for an assumed nominal birth date mid-year (1st July). This was applied for converting length to age by way of deterministic length slicing using the l2a() function as implemeted in the package Fla4a of the FLR library. As a result of this adjustment, the numbers at age obtained for age-0 through length slicing were negligible and the age range was therefore set to age classes 1-5, where age 5 was treated as plus group, but as real age in the length to age converted survey numbers-at-age. Initial trials confirmed that this adjustment notably improved the fit.

Also in contrast to the previous assessment, catches were included from 2003 onwards, whereas the first year of survey data from 2007 was excluded due to inexplicable low numbers at length compared to the subsequent years 2008-2019. The expected maturity-, natural mortality- and weight-at-age by year are show in Figure 6.16.3.1, where M for the plus group was taken as the M estimate for age-4 (compare to Table 6.16.1.2)

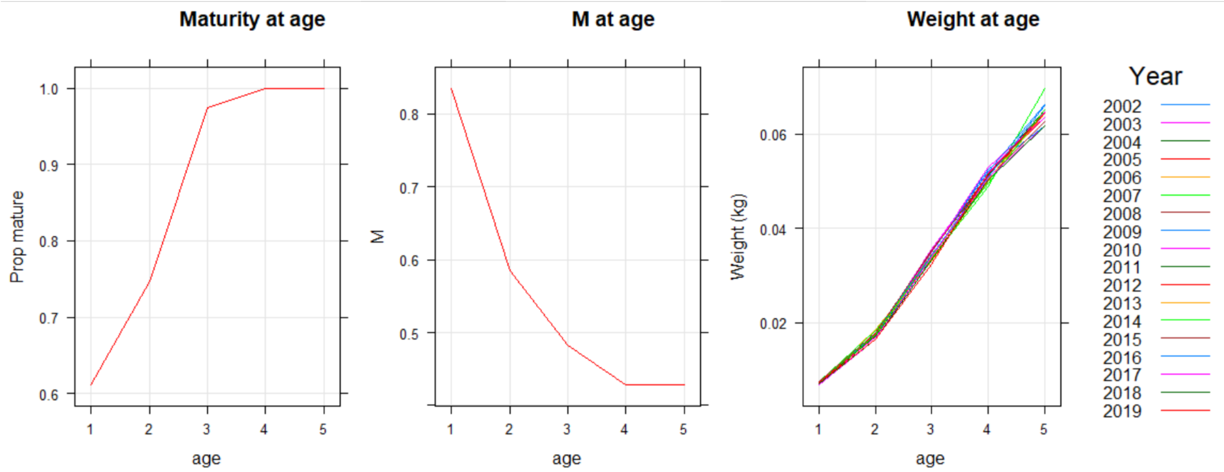


Figure 6.16.3.1. Blue and red shrimp in GSA 5:. Expected Maturity-at-age, M-at age and estimated Weight-at-age by year.

The estimated catch-at-age for commercial landings and surveys by year are shown in Figure 6.16.3.2.

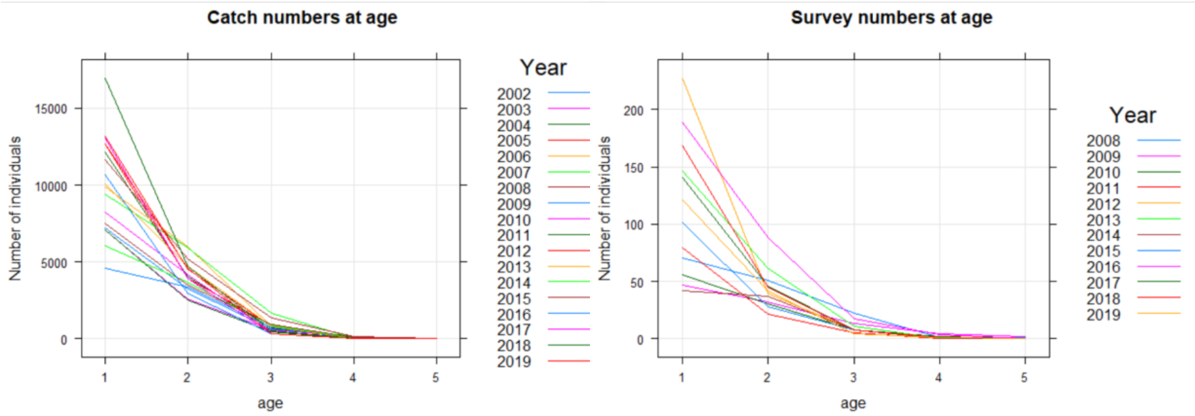


Figure 6.16.3.2. Blue and red shrimp in GSA 5: Commercial catch numbers at age and survey index numbers at age.

Commercial catches showed reasonable internal consistency among cohorts (Figure 6.16.3.3), whereas the consistency in MEDITS survey index was poor, indicating conflicting signals of cohort strengths between ages 2 and 3 as well as ages 4 and 5 (Figure 6.16.3.4).

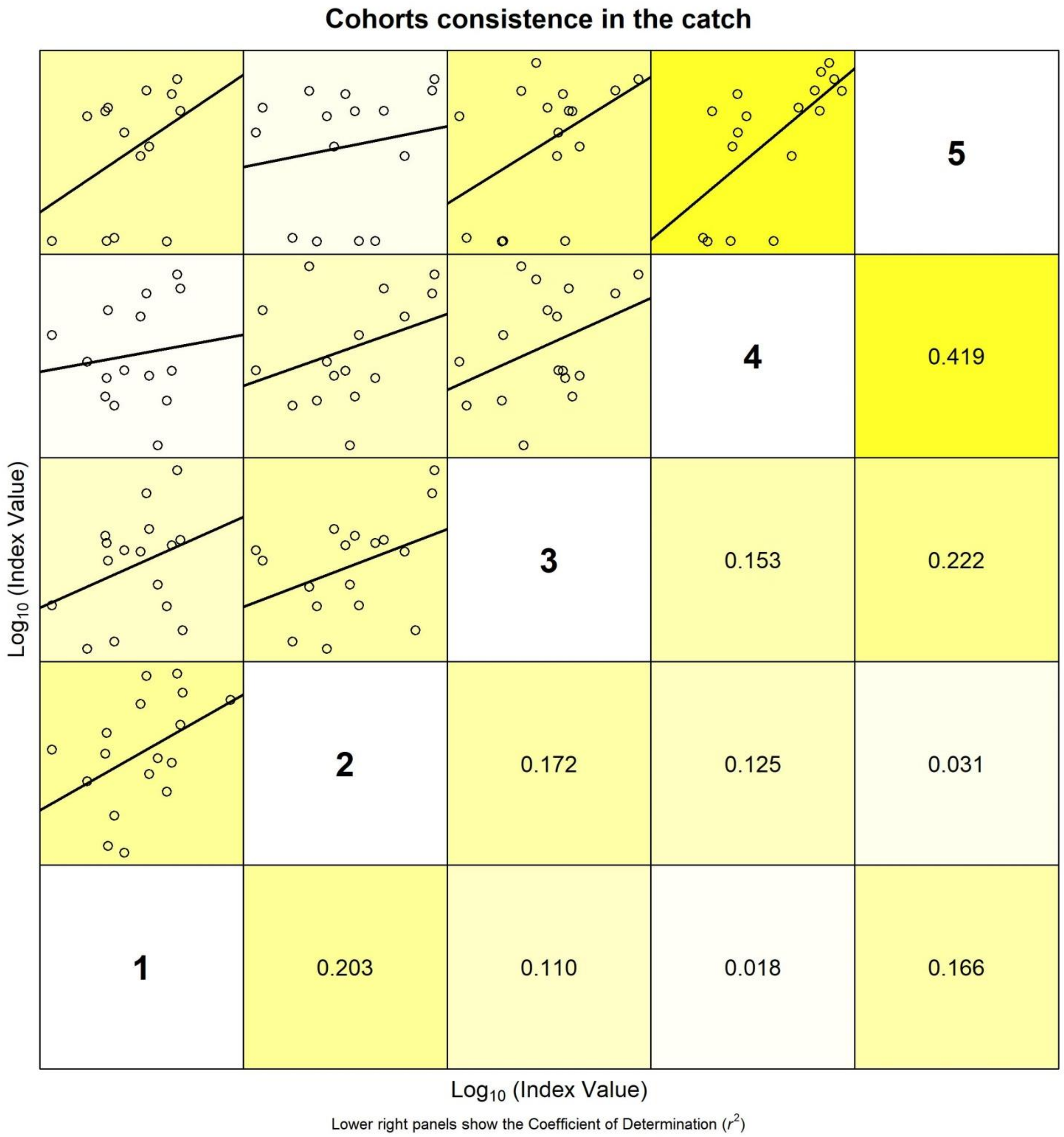


Figure 6.16.3.3. Blue and red shrimp in GSA 5: Catch at age cohort consistency

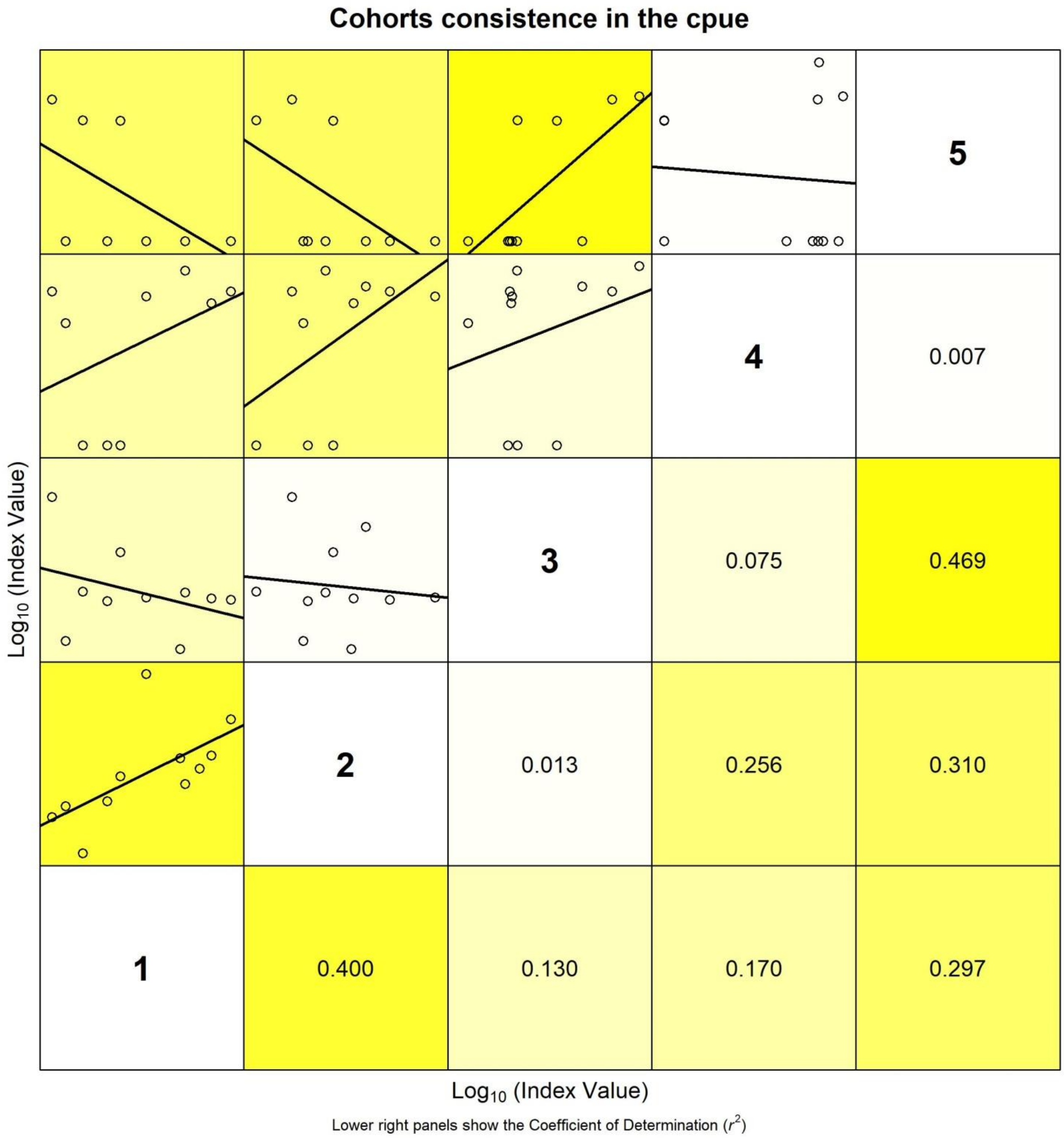


Figure 6.16.3.4. Blue and red shrimp in GSA 5: Index numbers at age cohort consistency

The Sum of Products "total catch numbers at age i x catch weight-at-age i" (SoP) was checked to match the total catch by year reported in the DCF with the estimated catch numbers at age. The relatively high SOP for the two terminal years required SOP correction of the catch numbers at age to match the total reported catch in tonnes (Table 6.16.3.1).

Table 6.16.3.1. Blue and red shrimp in GSA 5: Total catches (tonnes) and SOP corrections factors applied to raise the estimated catch at age by year.

Year	Catch	SOP
2002	141	1.01
2003	122	1.01
2004	194	1.01
2005	191	1.01
2006	214	1.01
2007	239	1.01
2008	233	1.01
2009	126	1.01
2010	153	1.01
2011	112	1.02
2012	204	1.00
2013	189	1.01
2014	142	1.01
2015	160	1.02
2016	138	1.03
2017	171	1.03
2018	250	1.17
2019	206	1.16

The final input data used for the FLR stock object are presented in Tables 6.16.3.2-5. Spawning was assumed to occur in the middle of the year (m.spawn = 0.5) and fbar was set to age classes 1 and 2 consistent with the GSA 1 and GSAs 5 and 6 assessments for blue and red shrip.

Table 6.13.3.2. Blue and red shrimp in GSA 5: catch-at-age (thousands).

Year/Age	1	2	3	4	5
2002	7283.6	3295.1	645.9	111.7	2.6
2003	7135.1	2623.3	562.3	127.3	12.1
2004	12278.6	4113.7	719.9	158.2	18.0
2005	12843.6	3933.7	908.0	76.2	5.5
2006	9977.2	6070.5	831.8	17.8	2.7
2007	9518.4	6006.7	1686.2	27.4	2.4
2008	11790.7	5246.0	1358.0	138.7	4.8
2009	4614.6	3418.7	785.5	100.4	9.1
2010	8342.4	4196.4	468.2	68.1	5.6
2011	7213.7	2538.1	473.0	16.6	0.4
2012	13181.4	4550.4	794.8	50.2	0.0
2013	10223.7	4740.2	849.8	27.6	0.0
2014	6145.5	3723.4	876.0	24.3	1.0
2015	7668.0	3593.5	970.8	108.9	0.0
2016	10970.3	3036.6	314.1	25.2	2.4
2017	13420.8	4018.5	336.1	31.8	0.5

2018	19890.3	5535.6	574.8	15.3	1.9
2019	14682.5	5346.6	374.9	7.9	0.0

Table 6.13.3.3. Blue and red shrimp in GSA 5: Weight-at-age estimated (kg).

Year/Age	1	2	3	4	5
2002	0.007	0.018	0.035	0.052	0.062
2003	0.007	0.017	0.036	0.052	0.065
2004	0.007	0.018	0.035	0.051	0.065
2005	0.007	0.018	0.035	0.051	0.063
2006	0.007	0.019	0.033	0.050	0.064
2007	0.007	0.018	0.033	0.049	0.070
2008	0.007	0.017	0.035	0.051	0.063
2009	0.007	0.017	0.035	0.052	0.066
2010	0.007	0.017	0.035	0.053	0.064
2011	0.007	0.017	0.034	0.051	0.064
2012	0.007	0.017	0.034	0.051	0.064
2013	0.007	0.017	0.034	0.051	0.064
2014	0.007	0.017	0.034	0.049	0.065
2015	0.007	0.018	0.035	0.051	0.064
2016	0.007	0.016	0.034	0.051	0.066
2017	0.007	0.017	0.034	0.051	0.062
2018	0.007	0.017	0.033	0.050	0.062
2019	0.007	0.016	0.032	0.052	0.064

Table 6.16.3.4. Blue and red shrimp in GSA 5: Proportion of mature specimens and natural mortality at age.

Age	1	2	3	4	5+
Maturity	0.611	0.747	0.974	1	1
M	0.835	0.585	0.482	0.428	0.428

Table 6.16.3.5. Blue and red shrimp in GSA 5: MEDITS tuning index numbers-at-age by year.

Year/Age	1	2	3	4	5
2008	70.20	50.89	22.46	1.46	0.73
2009	47.10	31.96	13.73	4.50	2.13
2010	55.66	30.81	7.21	1.74	0.50
2011	79.42	21.13	5.10	0.00	0.00
2012	227.55	39.07	7.81	0.31	0.00
2013	146.82	61.57	11.02	0.00	0.00
2014	41.51	36.79	7.31	0.00	0.18
2015	101.56	28.18	7.78	1.38	0.17
2016	188.70	88.43	17.78	3.65	0.00
2017	140.51	46.07	7.44	1.37	0.00

2018	168.61	45.20	7.39	1.09	0.43
2019	121.41	41.54	4.75	0.79	0.00

Assessment results

Several different models were tested. In particular, alternative formulations for the a4a f-models were explored, including the application of spline functions with various degrees of smoothing as well as allowing specific age classes to exhibit bit more flexible fishing mortality patterns. The sensitivity tests also included truncation of the catch time series to the period 2007-2019, but this resulted in generally poorer converge properties under several of the model formulations that worked with the longer catch time series 2002-2019. None of the explored model scenarios were able to resolve the poor fits to the survey index. In addition, the estimated fishing mortality trajectory indicated concerning sensitivity to the f-model parameterization. A persistent trade-off in terms of model formulations was the choice between allowing for a more flexible in the annual variation of fishing mortality, but restricting recruitment variability, or relaxing the constraints for the latter, which in turn required higher degree of smoothing in the f-model functions to achieve model convergence.

The best performing model was selected based on residual diagnostics and retrospective pattern with focus on fbar (ages 1-2), while also considering plausibility of the emerging fishing mortality pattern.

This model was specified as follows

```
f <- ~ factor(age) + factor(year)

q <- list(~ s(replace(age, age>2, 2)))

sr <- ~geomean(CV=0.1)
```

A less restrictive non-parametric f-model was chosen to more adequately reflect the changes in fishing mortality over the last three years (Figure 6.16.3.5). To achieve convergence the recruitment function was specified to vary around the geometric mean associated with a relatively low CV = 0.1. A more flexible parameterization based on a larger CV or treating recruitment as factor failed to converge.

The model results are shown in Figures 6.16.3.5-11. The model fits show that the catch data fitted reasonably well Figures 6.16.3.6), which was in strong contrast to the fits to the survey data, failing to fit the observed numbers-at-age in most of the years (Figures 6.16.3.7). Accordingly, residual diagnostic plots for the catch-at-age data showed no evidence for a systematic residual pattern (Figures 6.16.3.8-10). The survey data, however, revealed a systematic residual pattern between the first and second half of the available survey period for the most abundant age-1 class and a systematic over- and under-estimation of age classes 2 and 3, respectively (Figures 6.16.3.8-10). The estimated fishing mortality pattern showed strong dome-shaping resulting in very high fishing mortality on age-4 animals and very low fishing mortality on the plus group. Although a strong dome-shaped fishery selectivity may not be implausible for this species, there is also risk that the selectivity pattern may an artefact of the poor fits to the survey data, for which catchability estimates plateaued at age 2 (Figures 6.16.3.11).

Table 6.16.3.1 Blue and red shrimp in GSA 5. Model estimates of number of recruits ('000), SSB (tonnes)**,** estimated total catch (tonnes) and Fbar for ages 1-2

Year	Recruits ('000)	SSB (tonnes)	Catch (tonnes)	Fbar (Ages 1-2)
2002	20635	89	132	0.877
2003	27626	104	121	0.738
2004	30133	111	183	0.994
2005	38705	124	187	0.955
2006	34747	149	185	0.772
2007	31412	146	208	0.832
2008	26360	105	214	1.125
2009	26869	92	158	1.053
2010	26595	82	173	1.300
2011	28959	98	123	0.844
2012	34107	111	195	1.105
2013	29976	108	182	1.050
2014	24532	101	149	0.900
2015	25427	78	193	1.427
2016	29316	79	138	1.180
2017	32138	91	160	1.155
2018	35013	85	213	1.562
2019	29995	67	192	1.788

Table 6.16.3.2 Blue and red shrimp in GSA 5. Model estimates of stock numbers-at-age (thousands)

Year	Age-1	Age-2	Age-3	Age-4	Age-5+
2002	20634.5	5602.5	956.3	134.9	15.7
2003	27626.1	5245.3	921.6	76.6	10.0
2004	30133.2	7645.8	1047.6	102.2	8.1
2005	38704.7	7131.8	1068.6	63.9	5.0
2006	34747.3	9384.4	1053.2	71.5	3.4
2007	31412.2	9420.5	1788.1	108.0	5.2
2008	26359.5	8208.7	1650.5	159.3	6.7
2009	26869.0	5761.4	956.7	74.3	4.5
2010	26595.5	6136.5	742.3	50.9	2.9
2011	28959.4	5224.8	560.7	22.2	1.1
2012	34107.0	7510.9	899.8	48.5	1.3
2013	29976.4	7544.2	899.5	42.4	1.3
2014	24531.8	6857.0	975.5	48.2	1.3
2015	25426.7	6150.9	1093.1	74.2	2.3
2016	29315.5	4621.9	470.8	24.3	0.9
2017	32138.4	6195.5	498.9	18.6	0.6

2018	35013.1	6896.1	692.3	20.9	0.5
2019	29994.8	5862.9	437.6	11.3	0.2

Table 6.16.3.2 Blue and red shrimp in GSA 5. Model estimates of fishing mortality (F) at age

Year	Age-1	Age-2	Age-3	Age-4	Age-5+
2002	0.53	1.22	2.04	2.74	0.87
2003	0.45	1.03	1.72	2.30	0.73
2004	0.61	1.38	2.31	3.10	0.98
2005	0.58	1.33	2.22	2.98	0.94
2006	0.47	1.07	1.80	2.41	0.76
2007	0.51	1.16	1.94	2.60	0.82
2008	0.69	1.56	2.62	3.51	1.11
2009	0.64	1.46	2.45	3.29	1.04
2010	0.79	1.81	3.03	4.06	1.28
2011	0.51	1.17	1.97	2.64	0.83
2012	0.67	1.54	2.57	3.45	1.09
2013	0.64	1.46	2.44	3.28	1.04
2014	0.55	1.25	2.09	2.81	0.89
2015	0.87	1.99	3.32	4.46	1.41
2016	0.72	1.64	2.75	3.68	1.16
2017	0.70	1.61	2.69	3.61	1.14
2018	0.95	2.17	3.64	4.88	1.54
2019	1.09	2.49	4.16	5.58	1.76

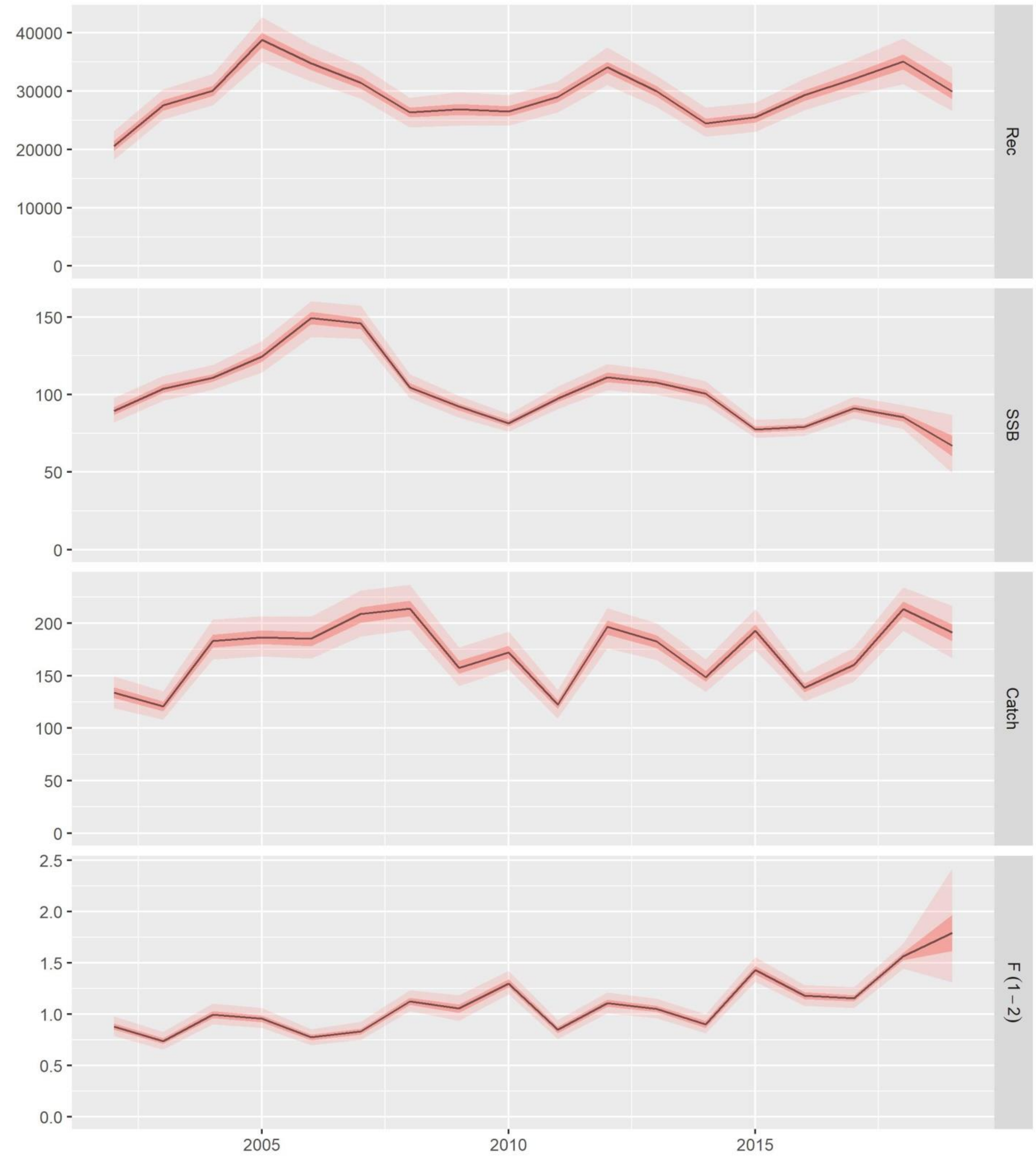


Figure 6.16.3.5. Blue and red shrimp in GSA 5: Model output for recruits, Spawning Stock Biomass, catch and F (Fbar 1-2).

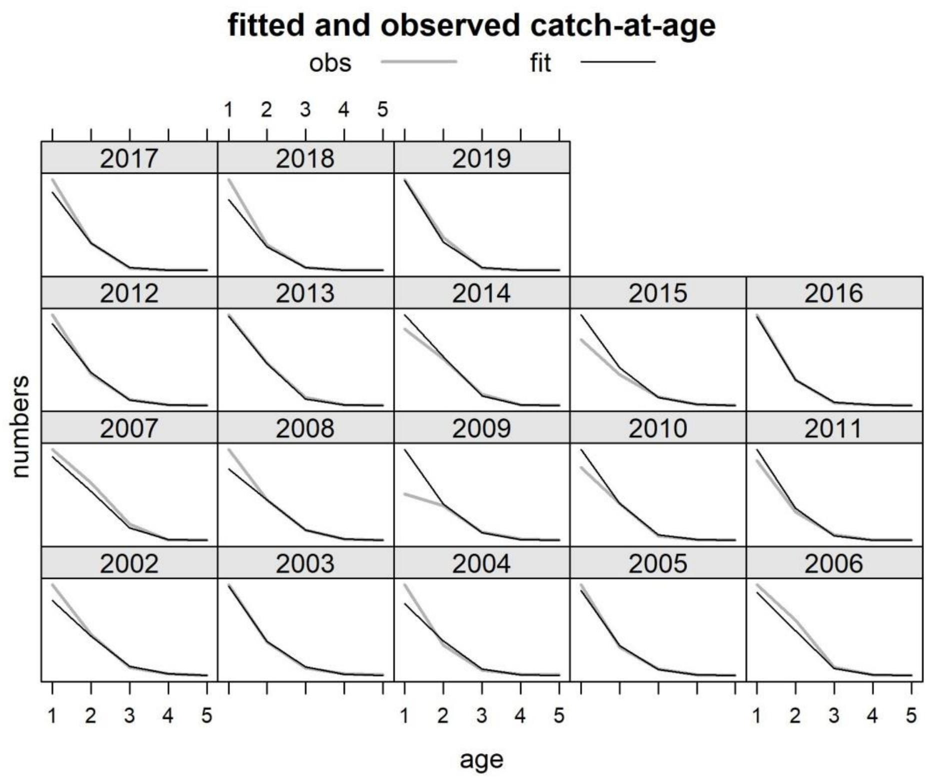


Figure 6.16.3.6. Blue and red shrimp in GSA 5: Fitted and observed catch at age time series.

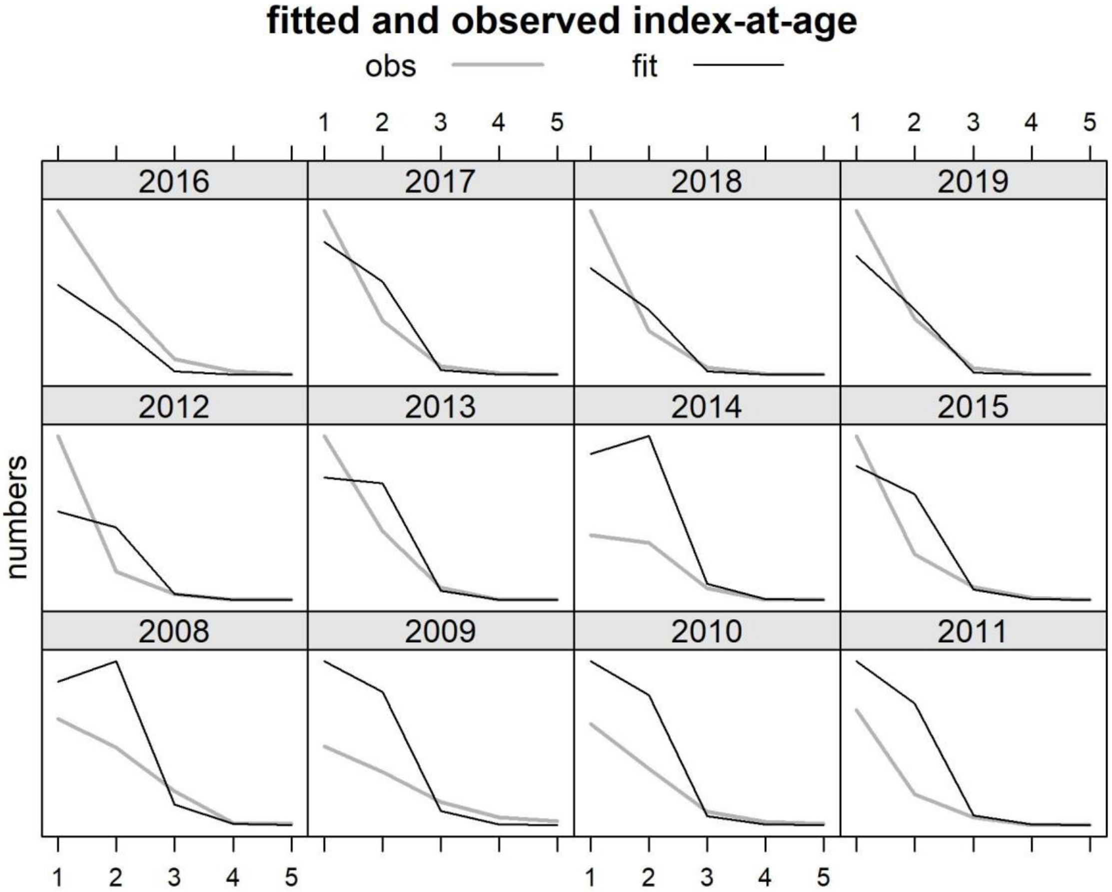


Figure 6.16.3.7. Blue and red shrimp in GSA 5: Fitted and observed survey index numbers at age time series.

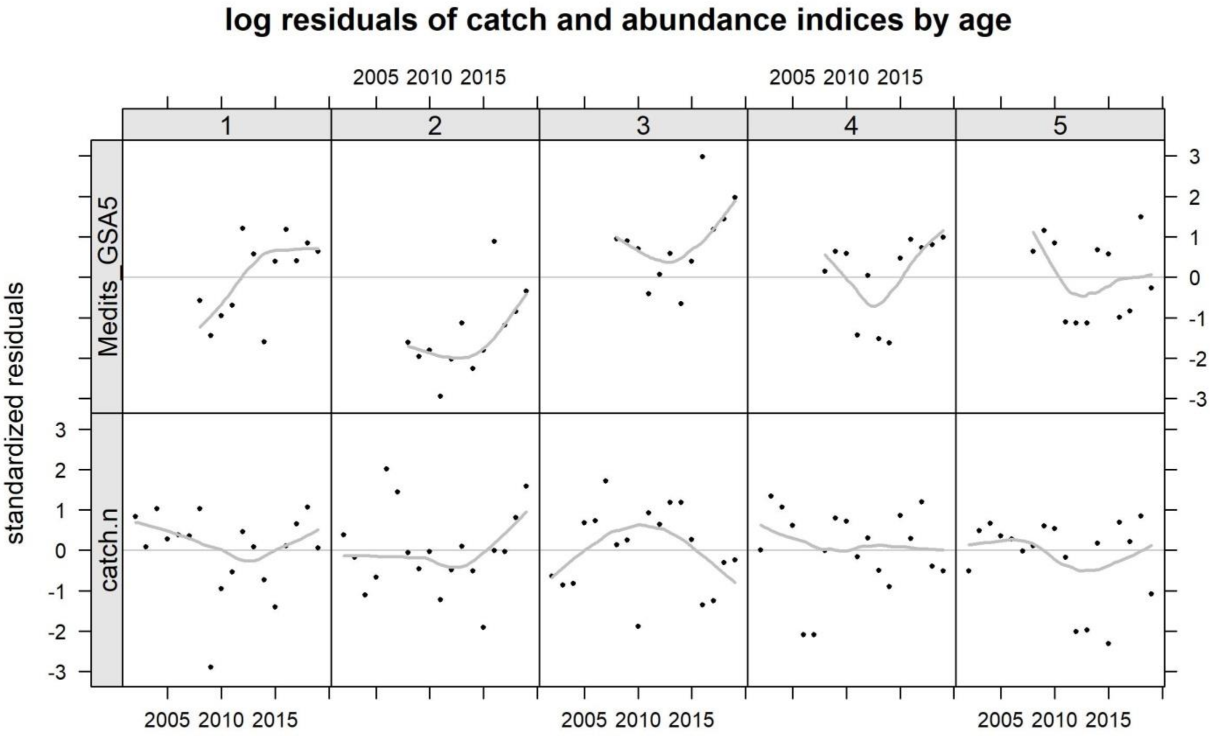


Figure 6.16.3.8. Blue and red shrimp in GSA 5: Standardized residuals for abundance index and catch numbers. Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

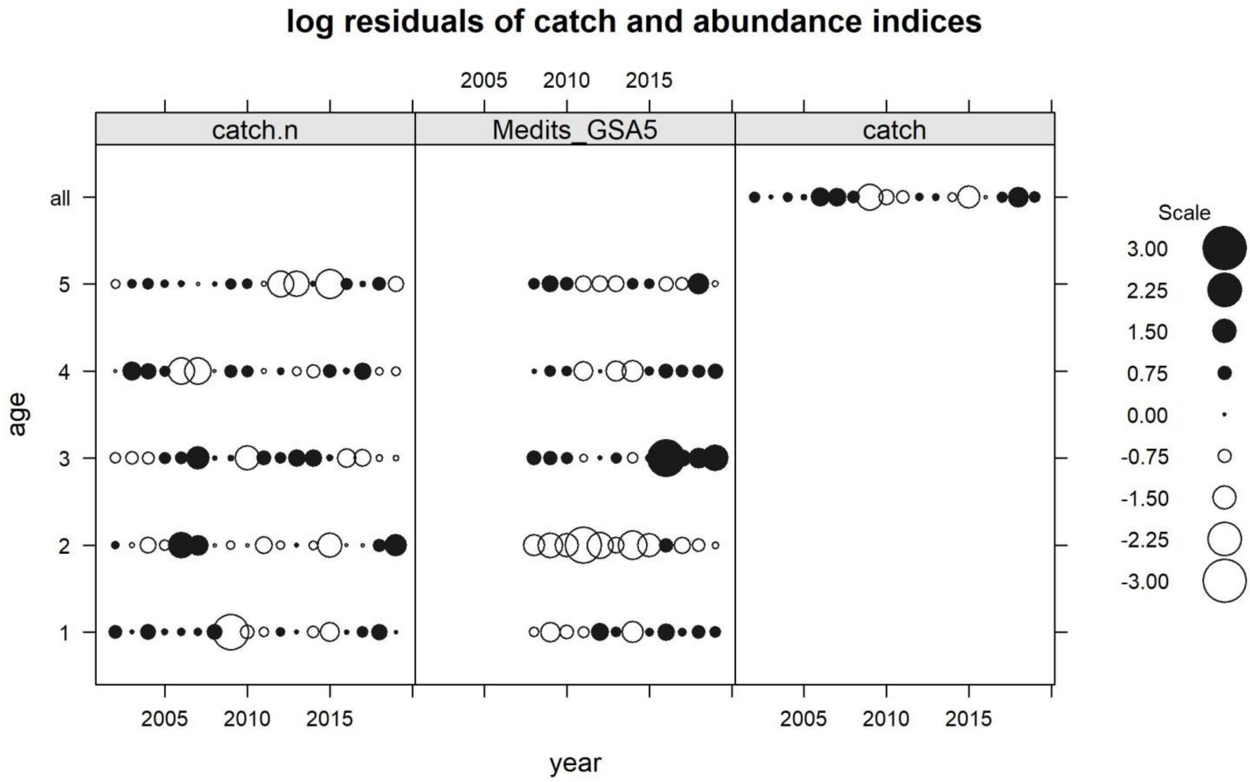


Figure 6.16.3.9. Blue and red shrimp in GSA 5: Standardized log residuals of catch and abundance indices

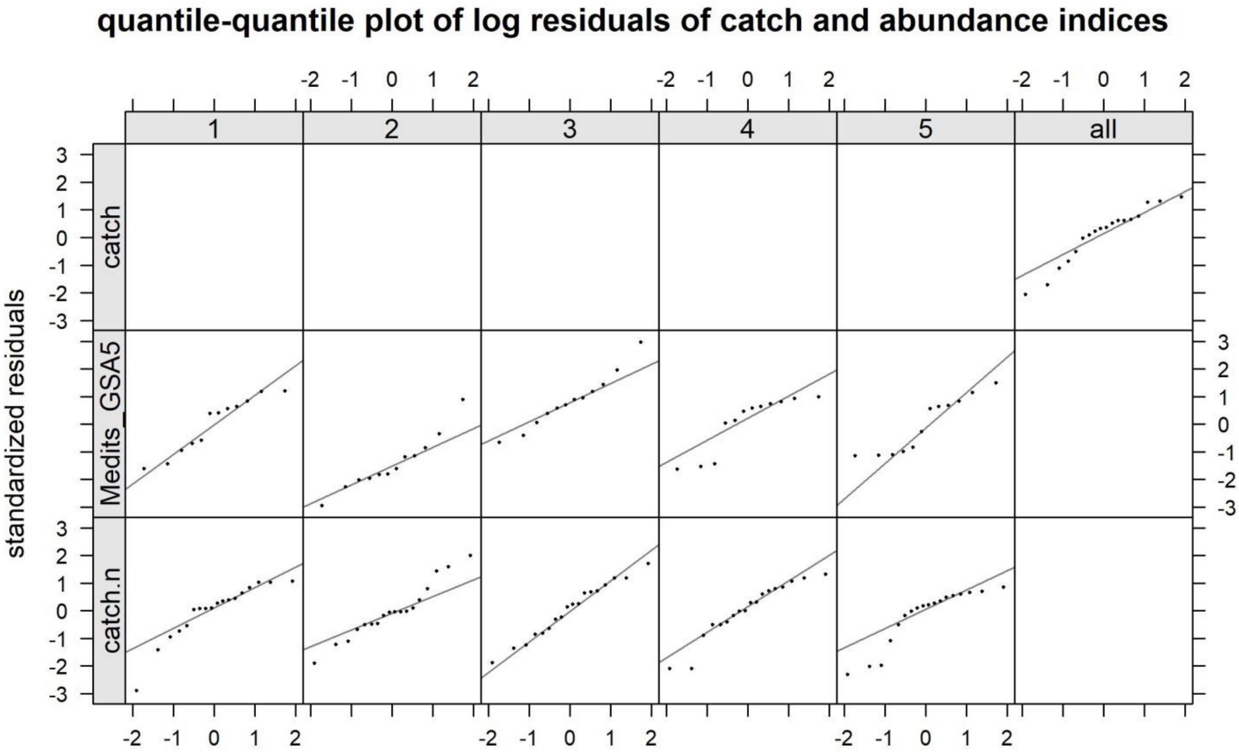


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Figure 6.16.3.10. Blue and red shrimp in GSA 5: Quantile-quantile plot of log-residuals of catch and abundance index. Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

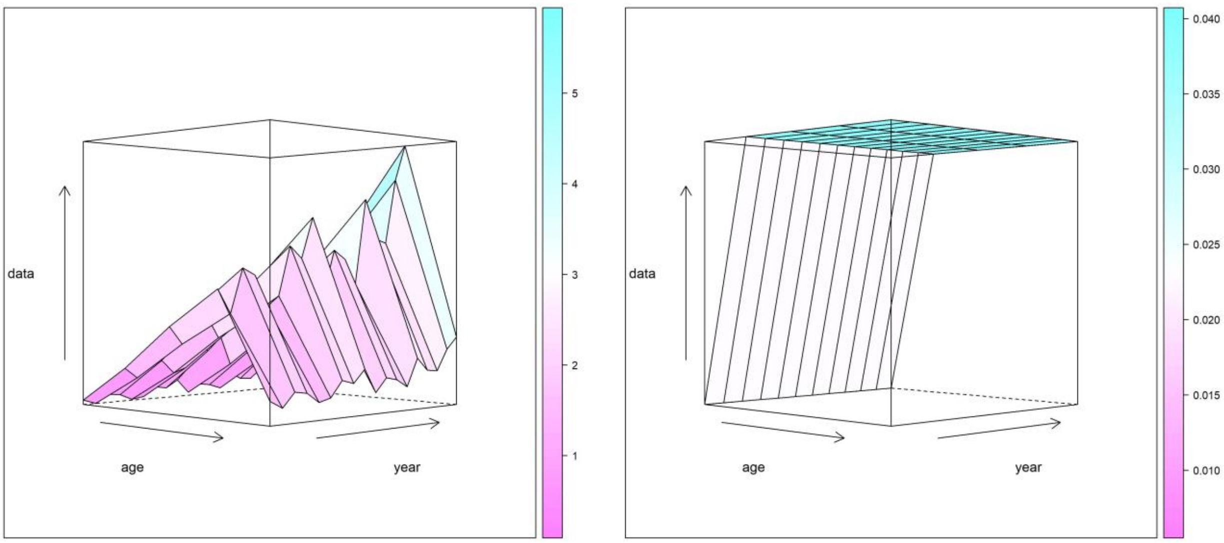


Figure 6.16.3.11. Blue and red shrimp in GSA 5: 3D contour plot of (estimated) fishing mortality and catchability.

Retrospective Analysis

Retrospective analysis over a horizon of three year is shown in Figure 6.16.3.12. Retrospective bias for Fbar and SSB was computed in the form of the Mohn's Rho statistic (Fbar = -0.09, SSB = 0.04) and generally fell within the acceptable range between -0.15 and +0.2 (Hurtado-Ferro et al., 2015). Of concern was however the strong retrospective bias on Fbar in 2018, resulting in high uncertainty about the most recent fishing mortality levels (Figure 6.16.3.12).

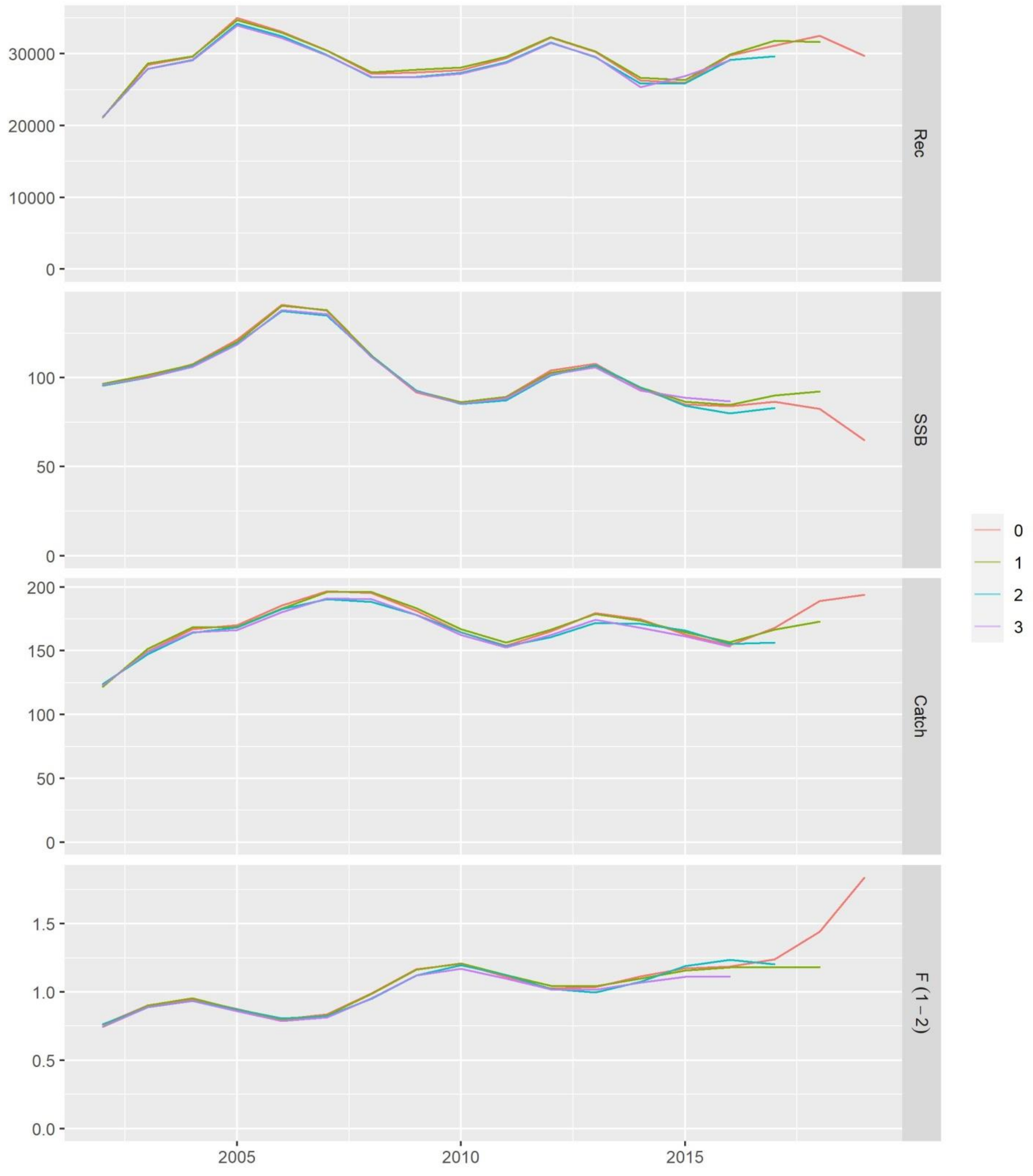


Figure 6.16.3.12. Blue and red shrimp in GSA 5: Retrospective analysis output for the a4a model with 3 years of retrospective peels.

Conclusions to the stock 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.

6.16.4 Reference Points

The assessment was not accepted for advice, therefore reference points were not calculated.

6.16.5 Short term Forecast and Catch Options

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 2019. 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 6.16.5.1 Blue and red 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.

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 2019 (STECF EWG 19-10) 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).

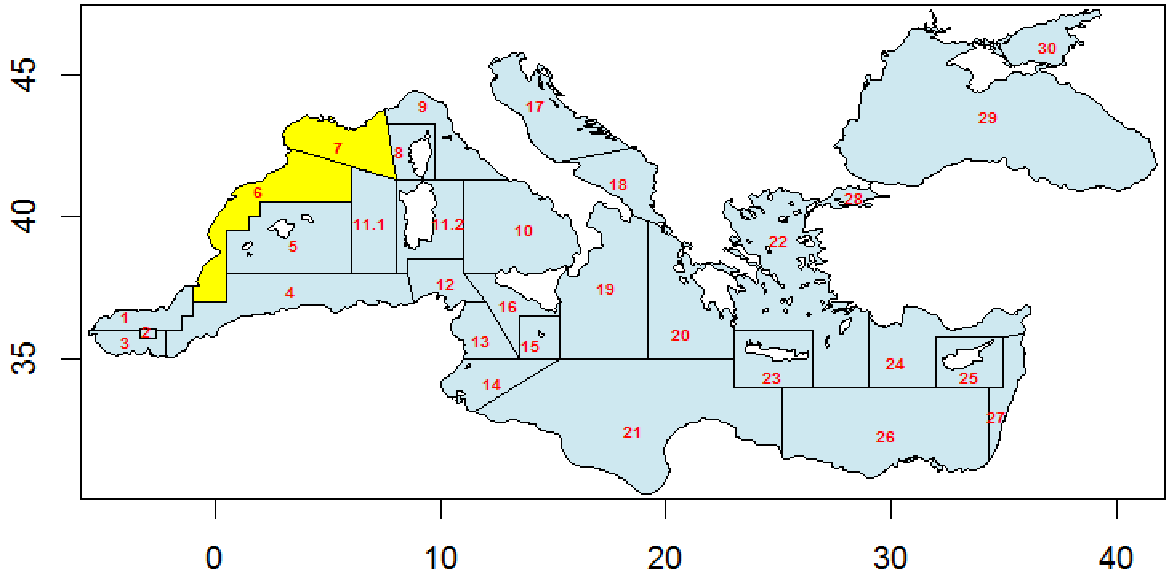


Figure 6.17.1.1. Blue and red shrimp in GSA 6&7. Geographical location of the stock.

The growth parameters used were taken from Garcia-Rodriguez (2003), just as in the previous assessment (STECF EWG 19-10); 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 19-10, 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 6.17.2.4.

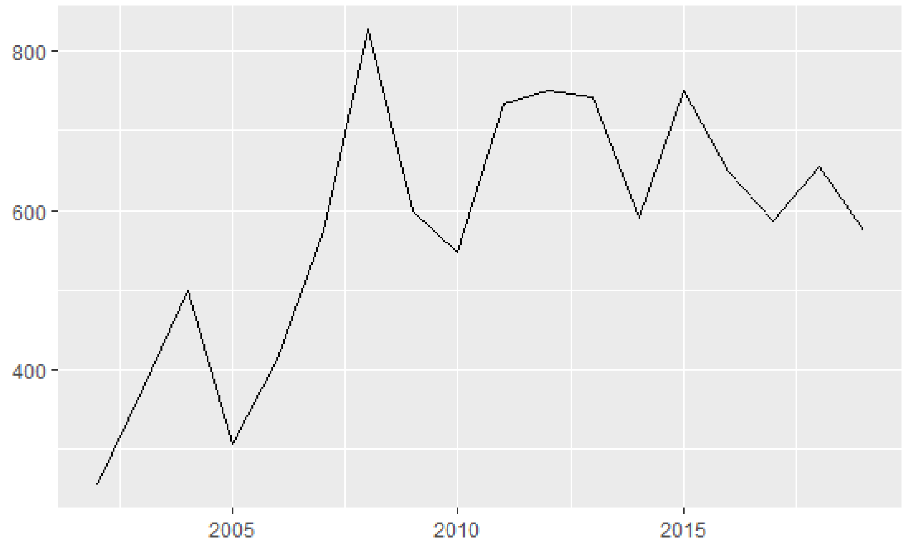
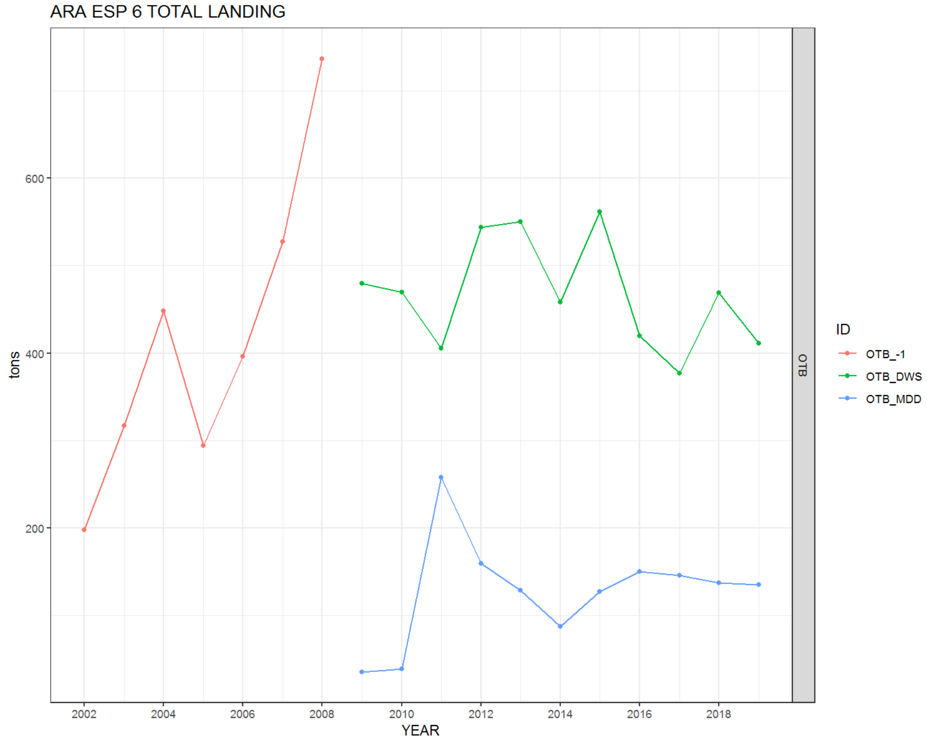


Figure 6.17.2.1. Blue and red shrimp in GSA 6&7. Blue and red shrimp DCF total catch (t), in GSA 6&7.

Table 6.17.2.1. Blue and red shrimp in GSA 6&7. DCF landings (t) and discards (t) by OTB (all metiers).

Year	OTB Landings (t)	OTB Discards (t)
2002	254.84	0
2003	376.57	0
2004	498.9	0
2005	306.26	0
2006	411.9	0
2007	574.94	0
2008	827.08	1.14
2009	599.59	0.52
2010	546.86	1.31
2011	726.19	7.97
2012	736.37	15.1
2013	730.56	12.11
2014	590.62	0.6
2015	750.46	0.33
2016	646.75	3.38
2017	581.04	6.88
2018	655.93	0.04
2019	570.74	2.84

A.


ARA ESP 6 TOTAL LANDING
tons
600
400
200
2002
2004
2006
2008
2010
2012
2014
2016
2018
YEAR
OTB
ID
OTB_-1
OTB_DWS
OTB_MDD

B.

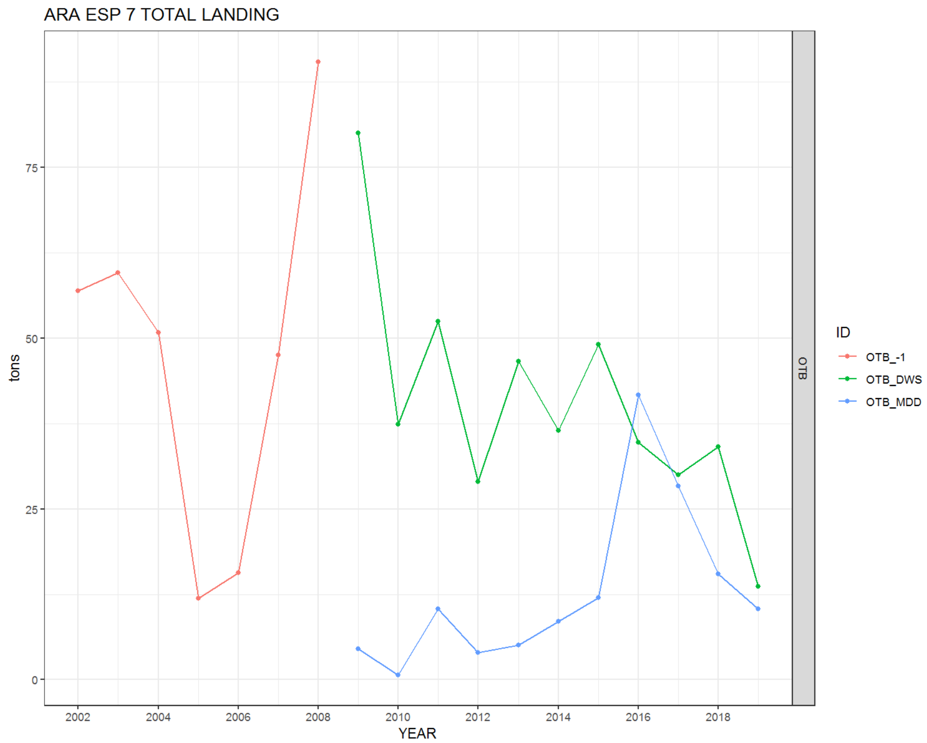
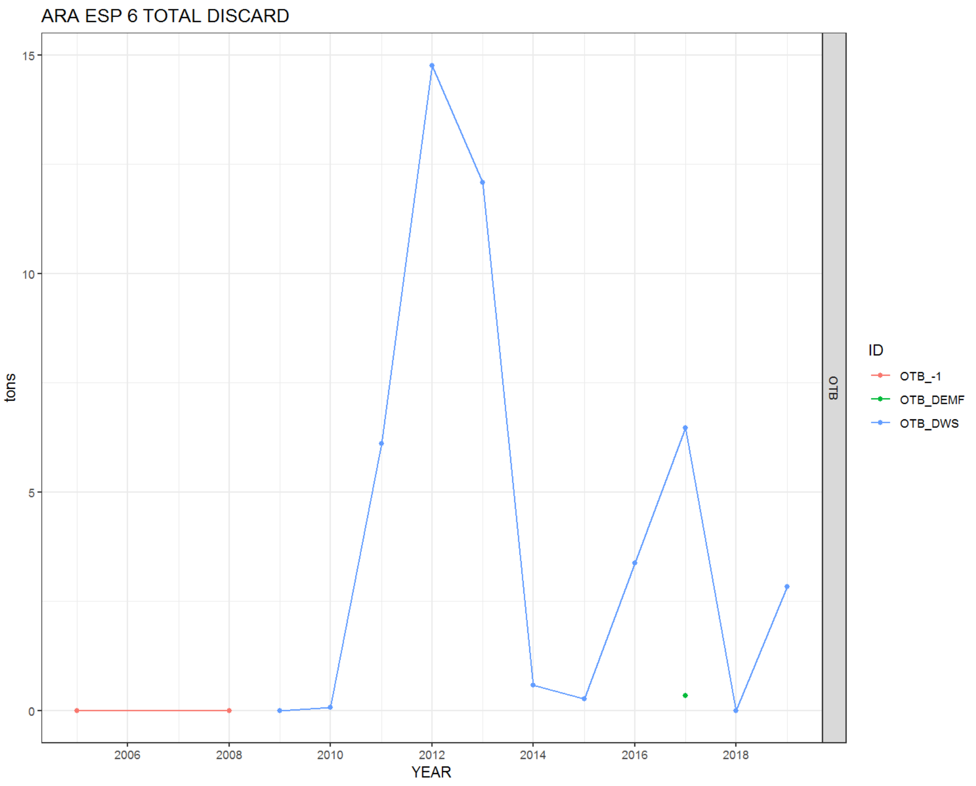

ARA ESP 7 TOTAL LANDING
tons
75
50
25
0
2002
2004
2006
2008
2010
2012
2014
2016
2018
YEAR
OTB
ID
OTB_-1
OTB_DWS
OTB_MDD

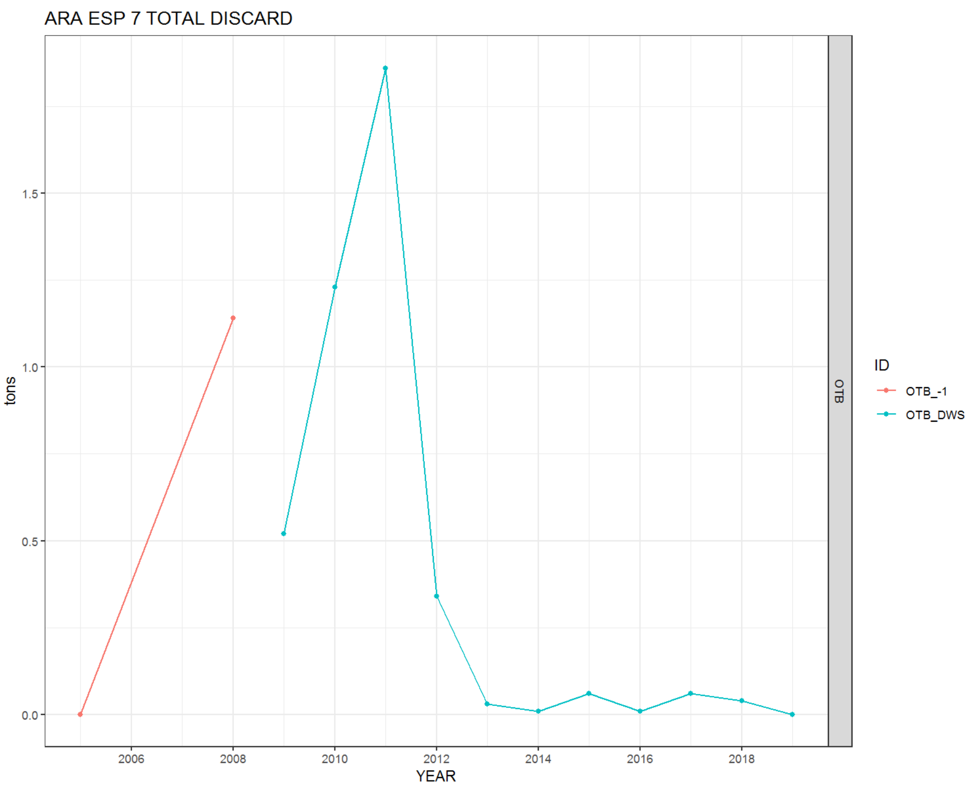
Figure 6.17.2.2. Blue and red shrimp in GSA 6&7. Total landing by metier A. GSA 6, B. GSA 7.

A.



ARA ESP 6 TOTAL DISCARD
tons
15
10
5
0
2006
2008
2010
2012
2014
2016
2018
YEAR
OTB
ID
OTB_-1
OTB_DEMF
OTB_DWS

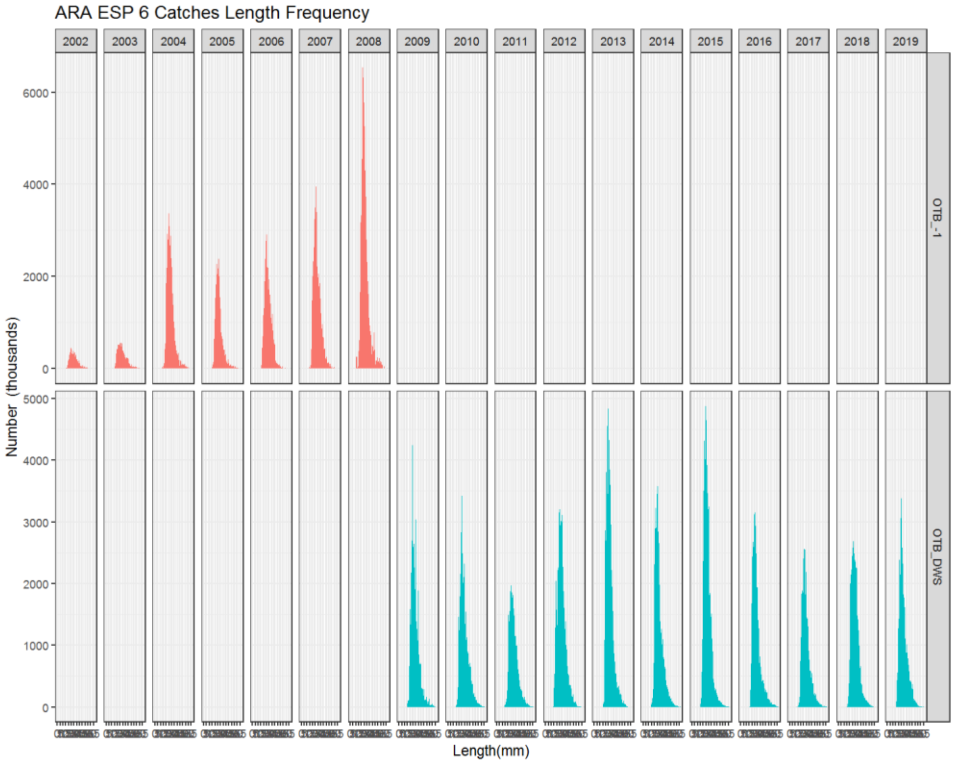
B.



ARA ESP 7 TOTAL DISCARD
tons
1.5
1.0
0.5
0.0
2006
2008
2010
2012
2014
2016
2018
YEAR
OTB
ID
OTB_-1
OTB_DWS

Figure 6.17.2.3. Blue and red shrimp in GSA 6&7: Total discards by metier A. GSA 6, B. GSA 7.

A.



B.

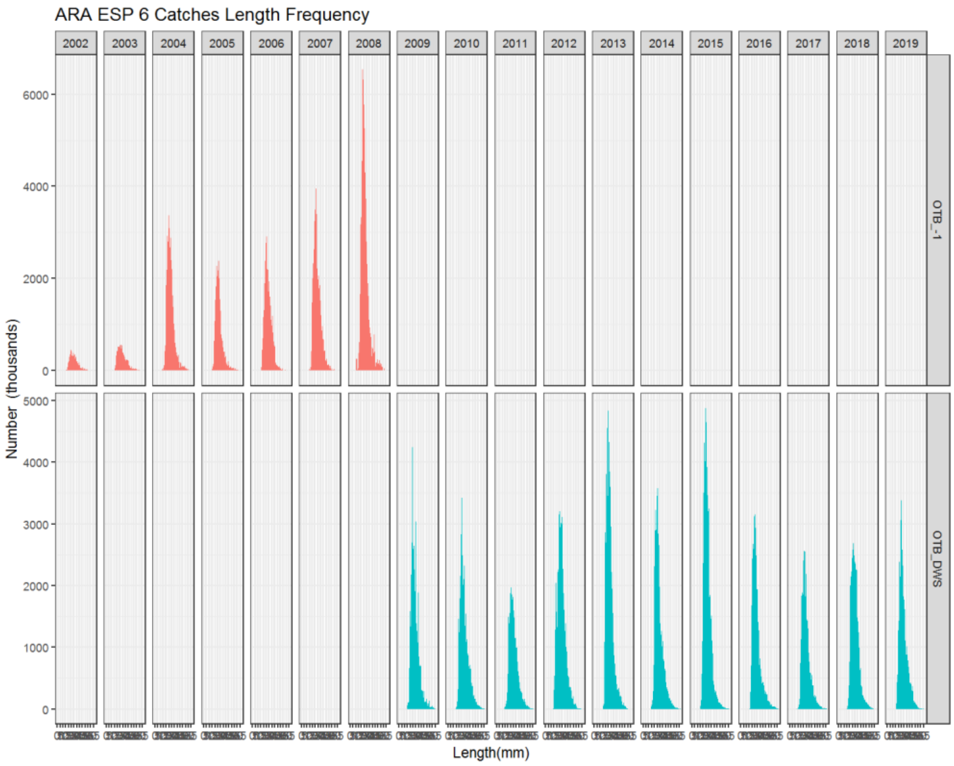


Figure 6.17.2.4. Blue and red shrimp in GSA 6&7. Length frequency distribution of catch by metier. A. GSA 6, B. GSA 7.

6.17.2.2 EFFORT

Blue and red shrimp in GSA 6&7 is exploited only by bottom trawlers. Effort data are available from 2004 to 2008 as combined data from bottom trawling gears, while from 2009 to 2018 the data are reported as single fishery types. Fishing effort is presented in Figure 6.17.2.2.1 and in Table 6.17.2.2.1. The lack of FRA effort data for the period before 2015 were noticed before (see STECF EWG 19-10) and France was requested to provide missing data, but these data was not submitted and thus not available to EWG19-10.

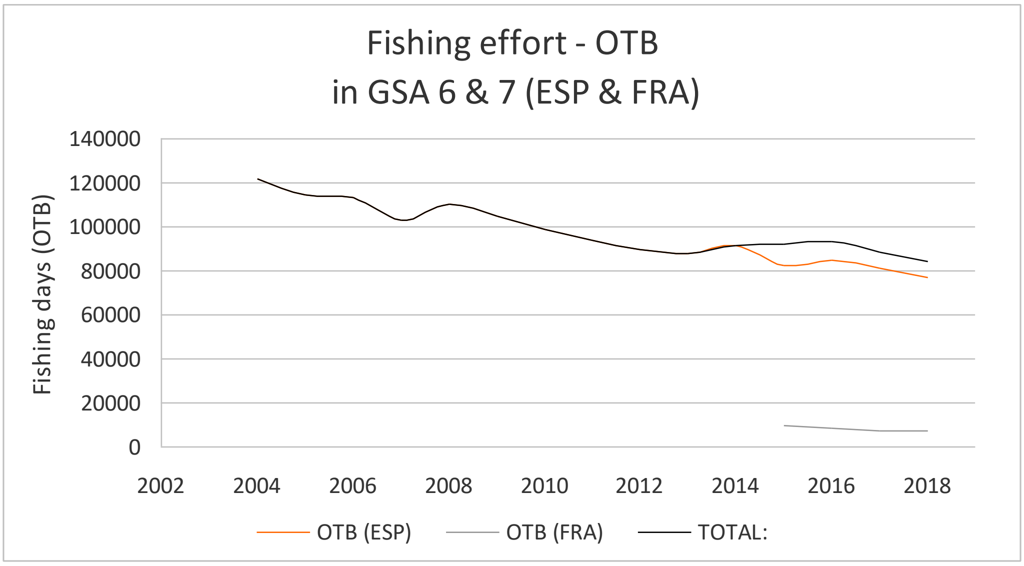


Figure 6.17.2.2.1. Blue and red shrimp in GSA 6&7 . Effort data (days at sea) of OTB as reported by DCF.

YEAR	OTB (ESP)	OTB (FRA)	TOTAL:
2004	121790		121790
2005	114583		114583
2006	113558		113558
2007	103191		103191
2008	110561		110561
2009	105013		105013
2010	98535		98535
2011	93956		93956
2012	89553		89553
2013	87673		87673
2014	91494		91494
2015	82485	9939	92424
2016	84739	8965	93704
2017	81370	7488	88858

2018	77177	7193	84370

Table 6.17.2.2.1 Blue and red shrimp in GSA 6&7. Effort data (days at sea) of OTB in as reported by DCF.

6.17.2.3 SURVEY DATA

6.17.2.3.1 Description and timing

The MEDITS surveys are carried mainly from May to July (Figure 16.17.2.3.1). Tables TA, TB, TC were provided according to the MEDITS protocol. Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). 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.

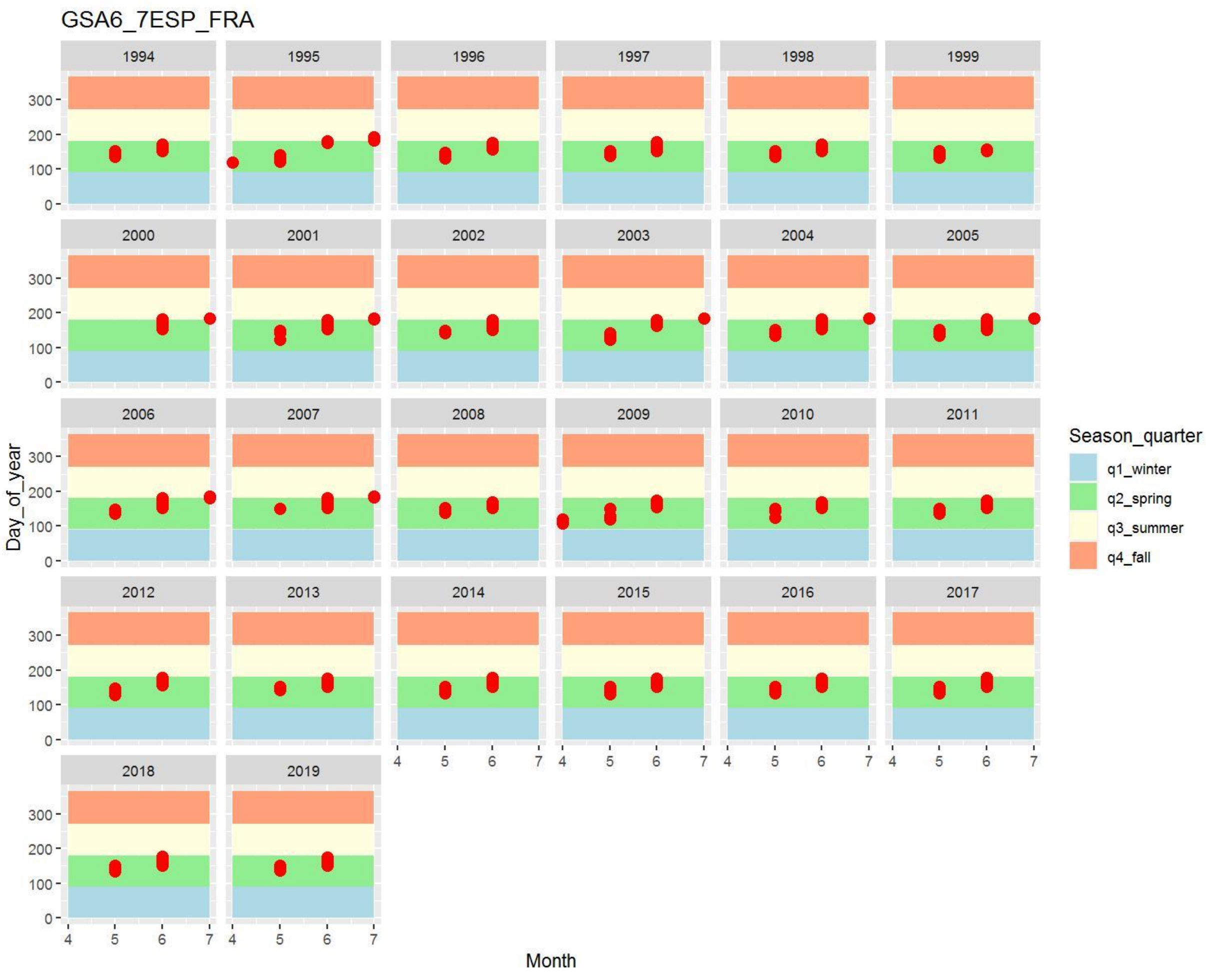


Figure 16.17.2.3.1. Blue and red shrimp in GSA 6&7. Month of the year when the MEDITS survey is conducted.

6.17.2.3.2 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).

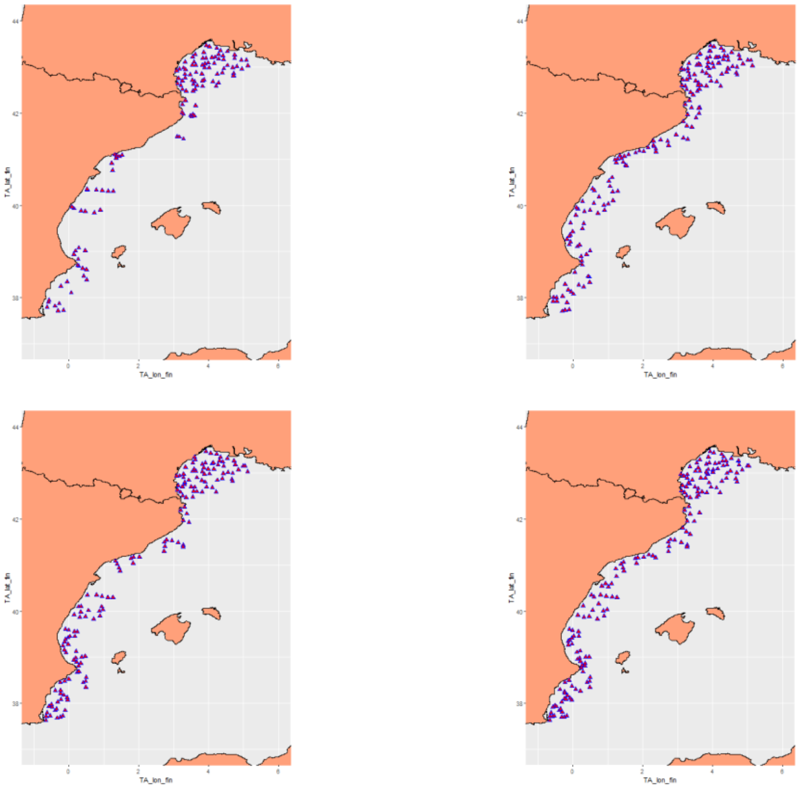


Figure 6.17.2.3.2. Blue and red shrimp in GSA 6&7. Geographical distribution based on the biomass index of MEDITS survey in 1994, 2003, 2012 and 2019.

6.17.2.3.3 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 6.17.2.3.3.1 and 6.17.2.3.3.2, and Table 6.17.2.3.3. Both estimated abundance and biomass indices show similar trends as both declined consistently from 2012 onwards, and showing a quite variable trend before 2012. The trends in abundance by length are shown on Figure 6.17.2.3.3.3.

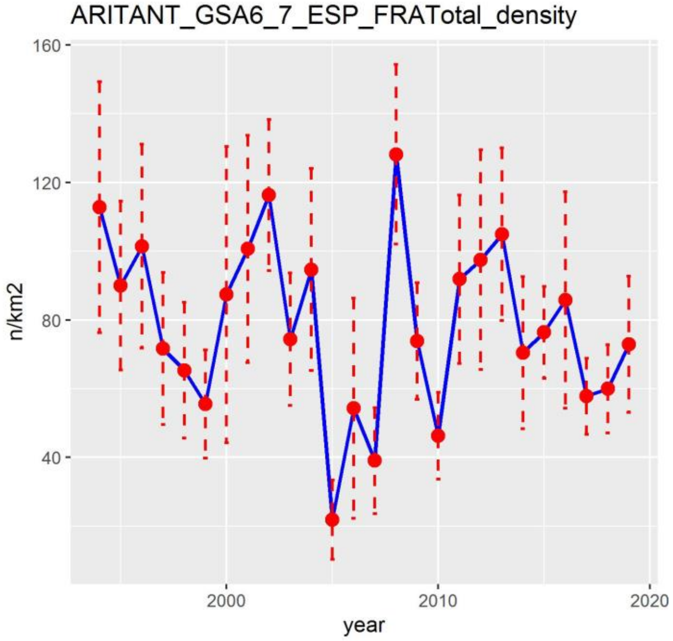


Figure 6.17.2.3.3.1 Blue and red shrimp in GSA 6&7. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 6&7 as reported by DCF.

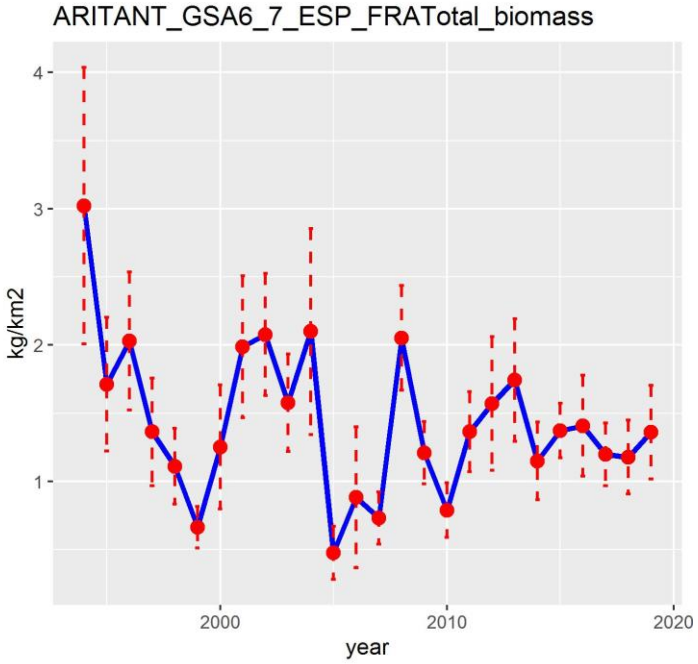


Figure 6.17.2.3.3.2 Blue and red shrimp in GSA 6&7. MEDITS survey biomass index (kg/km^2) as reported by DCF.

Table 6.17.2.3.3 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	Blue and red shrimp biomass
1994	3.022
1995	1.713
1996	2.029
1997	1.363
1998	1.110
1999	0.663
2000	1.251
2001	1.987
2002	2.076
2003	1.576
2004	2.100
2005	0.475
2006	0.881
2007	0.730
2008	2.052
2009	1.210
2010	0.788
2011	1.363
2012	1.570
2013	1.743
2014	1.148
2015	1.371
2016	1.407
2017	1.198
2018	1.178
2019	1.36

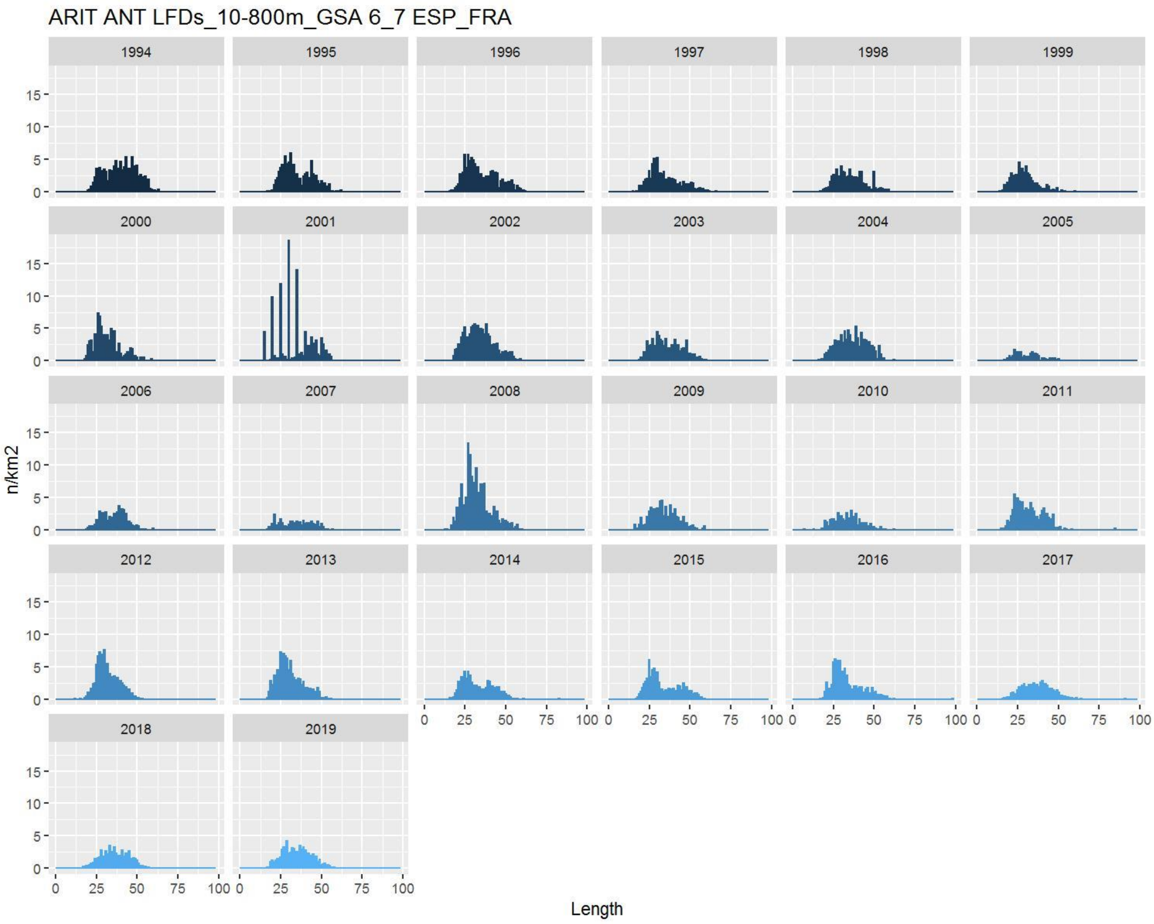


Figure 6.17.2.3.3.3 Blue and red shrimp in GSA 6&7. Length frequency distribution of the MEDITS survey abundance index (n/km^2) as reported by DCF.

6.17.3 Stock assessment

This stock was assessed for the last time in 2019 (STECF EWG 19-10) using a4a. The present assessment was carried out using a statistical catch-at-age modeling 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 assessmemnt 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 Januay 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. 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 tunning 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 assesement model. The age range of Fbar was set to age 1-2 as the majority of the catches were represented within these age classes.

6.17.3.3 Stock assessment models and results

Different a4a models were tested and the best model (according to model diagnostcs) included the following submodels:

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<- ist(~s(age,k=3),~s(age, k=3))

Stock-recruit: srmodel <- ~ geomean(CV=0.25)

Summary results and diagnostics from the a4a model are presented in Figure 6.17.3.3.8 to Figure 6.17.3.3.12.

The 3D plots of fishing mortality (survey catchability) at age (Fig. 6.17.3.3.7) reflect the assumption of constant F (q) after age 3. The residuals show major year effects in 2008 and 2011 (Figs. 6.17.3.3.8, 6.17.3.3.9, 6.17.3.3.11). The fit to the catch numbers show major discrepencies in several years (Fig. 6.17.3.3.9). The estimated catch looks somehow out of phase with the observed catches (Figure 6.17.3.3.11).The retrospective analysis shows no tendency to consistently under- or overestimate the fishing mortality (Figure 6.17.3.3.10).

The stock summary with simulated confidence intervals is presented at Figure 6.17.3.3.12. The recrutment has an increasing trend until 2010, then decreased and stayed above 600 billions. Similarly the SSB increased until 2011 then decreased and stayed around 400 t. Fbar displays long-term fluctuations and in 2019 sligthly decreases comparing to 2017 and 2018.

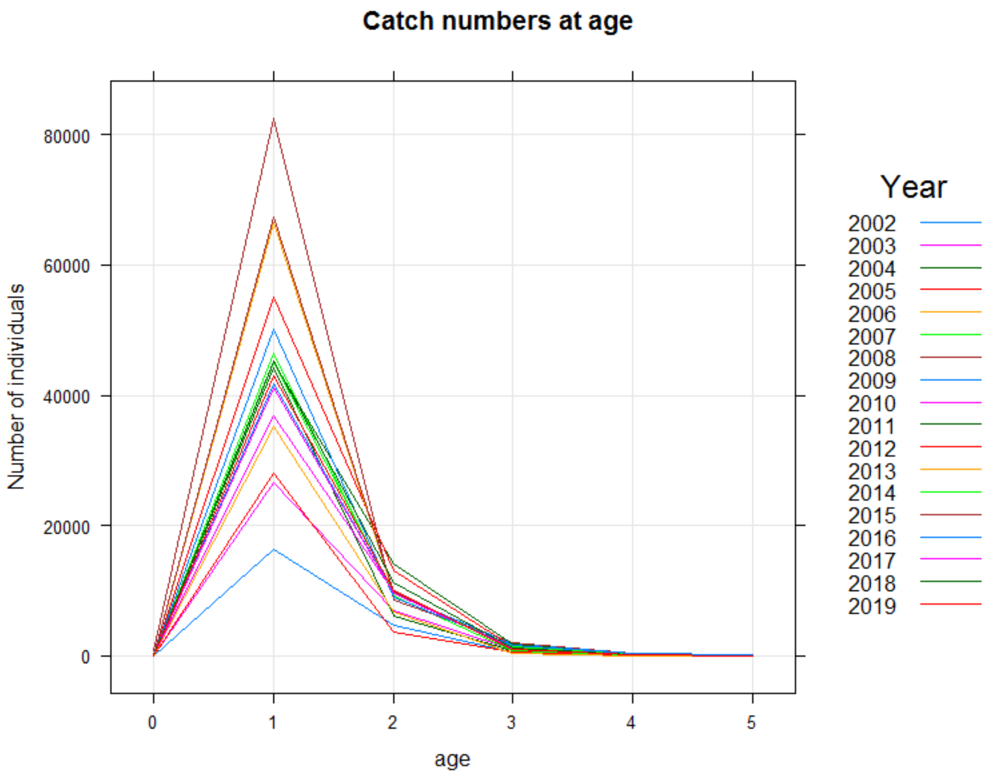


Figure 6.17.3.3.1 Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals (thousands) at age of the catch in GSA 6&7 (2002-2019). Data from DCF.

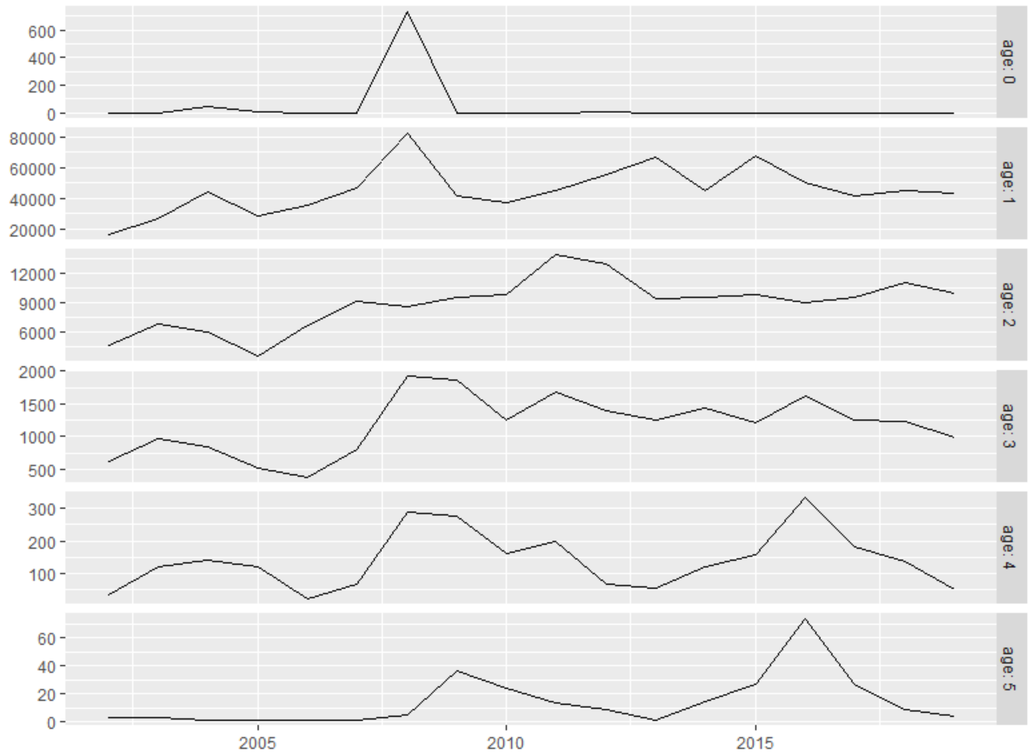


Figure 6.17.3.3.2 Blue and red shrimp in GSA 6&7. Number of individuals per year by age group of the catch (2002-2019). Data from DCF.

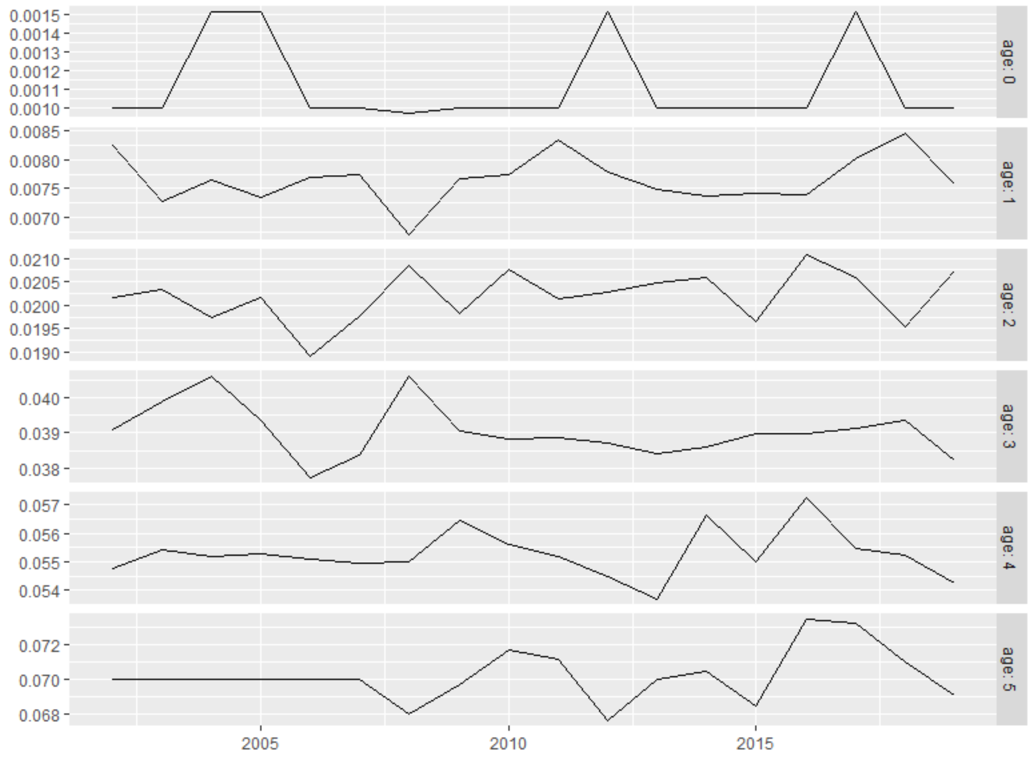


Figure 6.17.3.3.3. Blue and red shrimp in GSA 6&7. Mean weight (kg) at age of catches per year (2002-2019). Data from DCF.

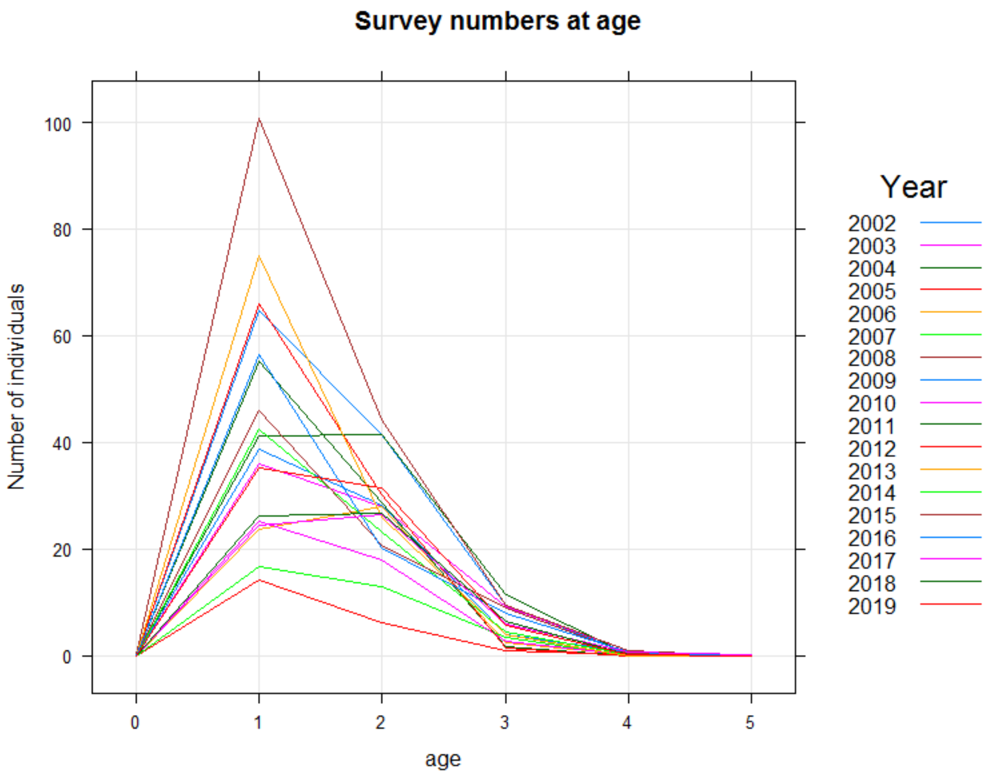


Figure 6.17.3.3.4 Blue and red shrimp in GSA 6&7. Age composition of the MEDITS survey as reported by DCF.

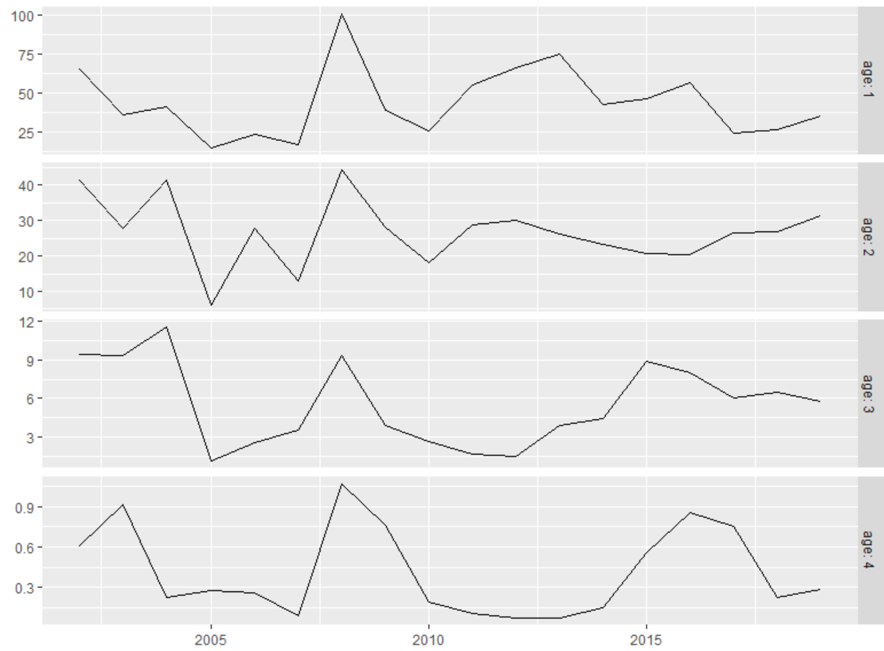


Figure 6.17.3.3.5 Blue and red shrimp in GSA 6&7. Number of individuals per year by age group (ages 1-4) according to MEDITS surveys (2002-2019.

A. B.

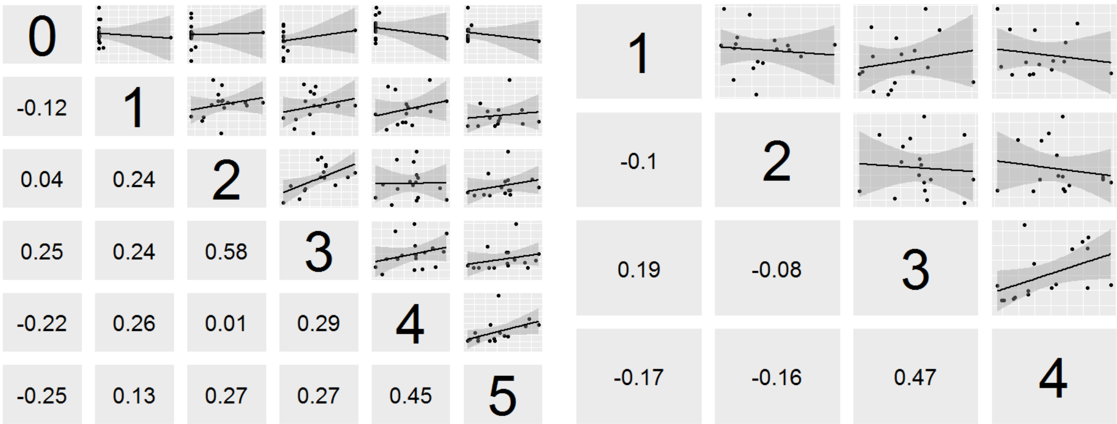


Figure 6.17.3.3.6 Blue and red shrimp in GSA 6&7. A.Cohorts consistency in the catch, and B. in MEDITS survey.

A B

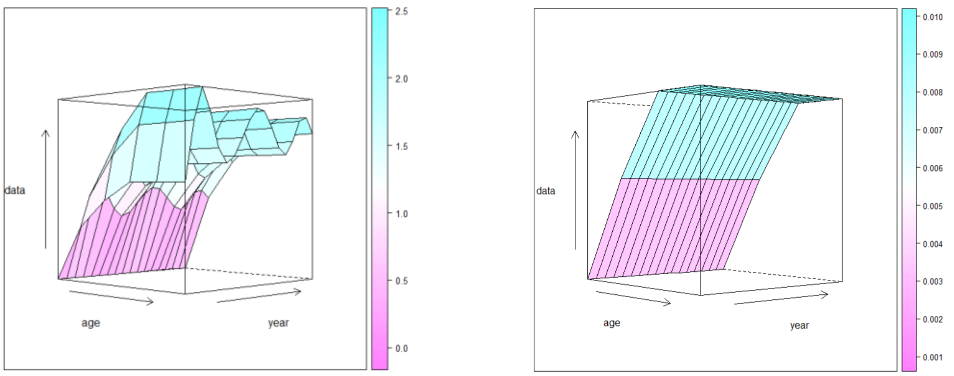
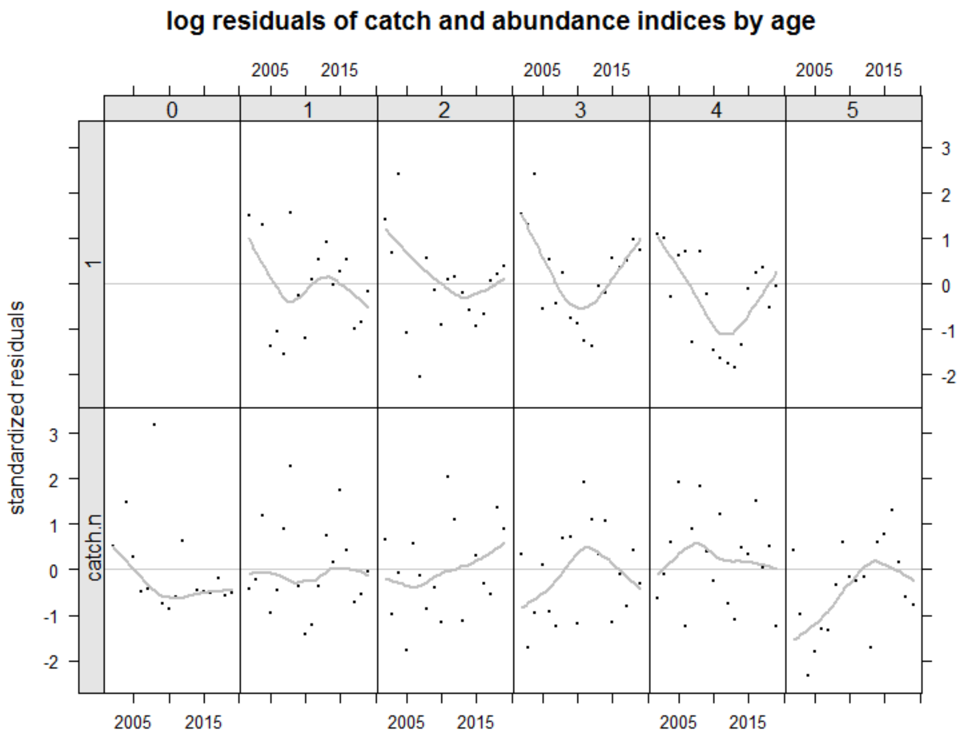


Figure 6.17.3.3.7 Blue and red shrimp in GSA 6&7. 3D plots of fishing mortality (A), and survey catchability (B) at age and year

A.



B.

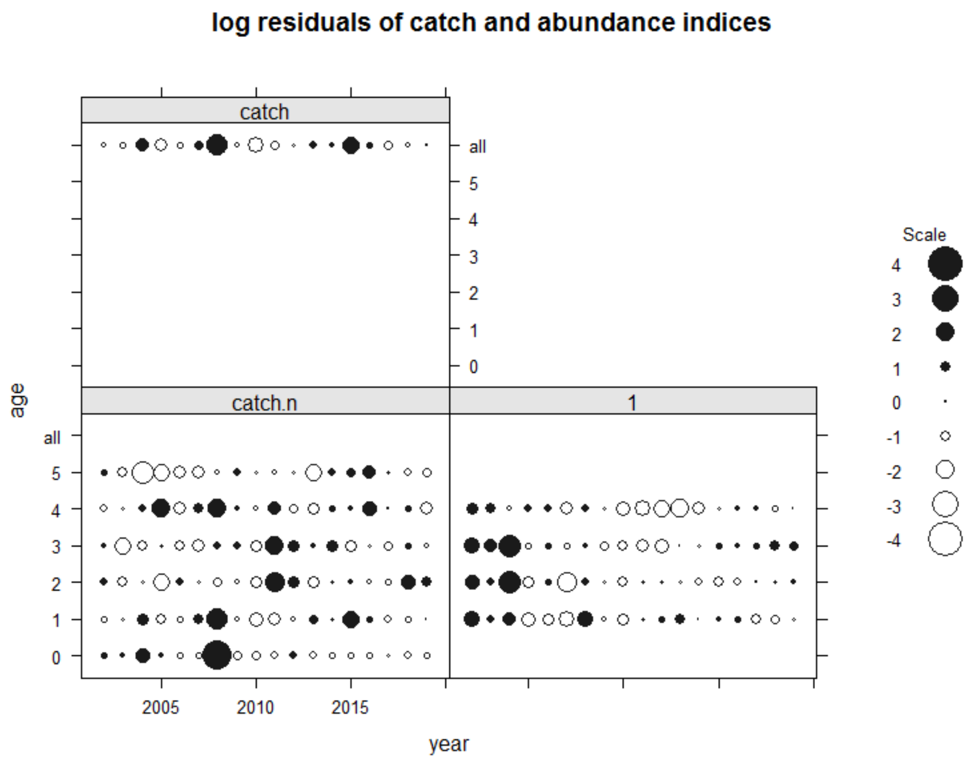
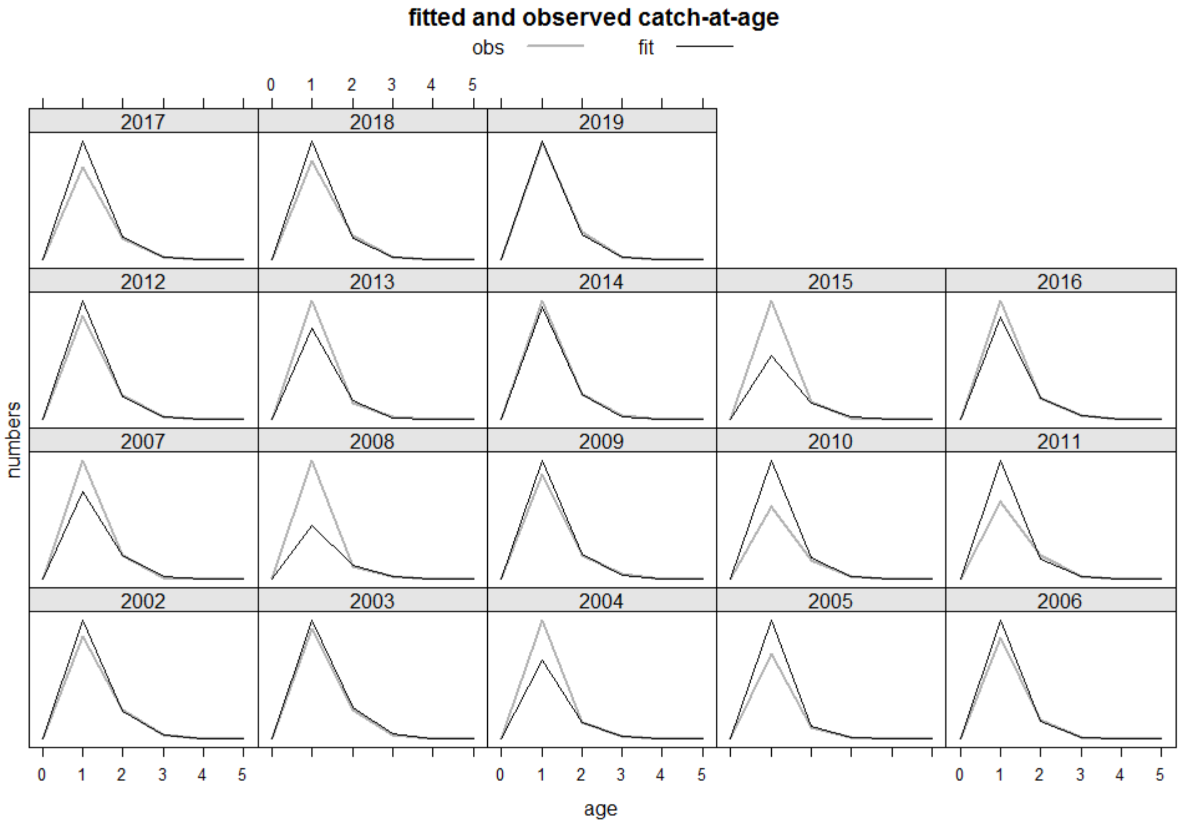


Figure 6.17.3.3.8 Blue and red shrimp in GSA 6&7. Standardized residuals for abundance indices (MEDITS) and catch at age data. Each panel present residuals by age and year.

A.



fitted and observed catch-at-age
obs
fit
2017
2018
2019
2012
2013
2014
2015
2016
2007
2008
2009
2010
2011
2002
2003
2004
2005
2006
numbers
age
0 1 2 3 4 5

B.

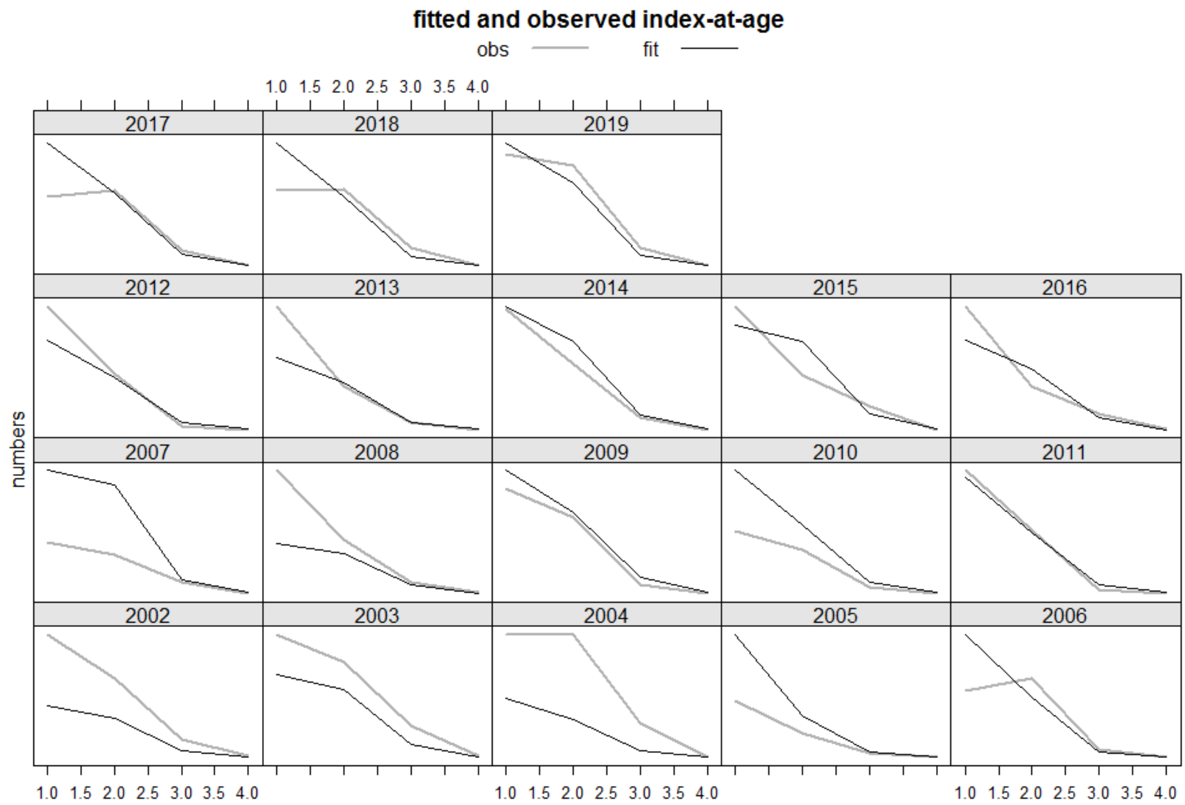


Figure 6.17.3.3.9 Blue and red shrimp in GSA 6&7. Fitted and observed catch (A.) and survey (B) numbers at age.

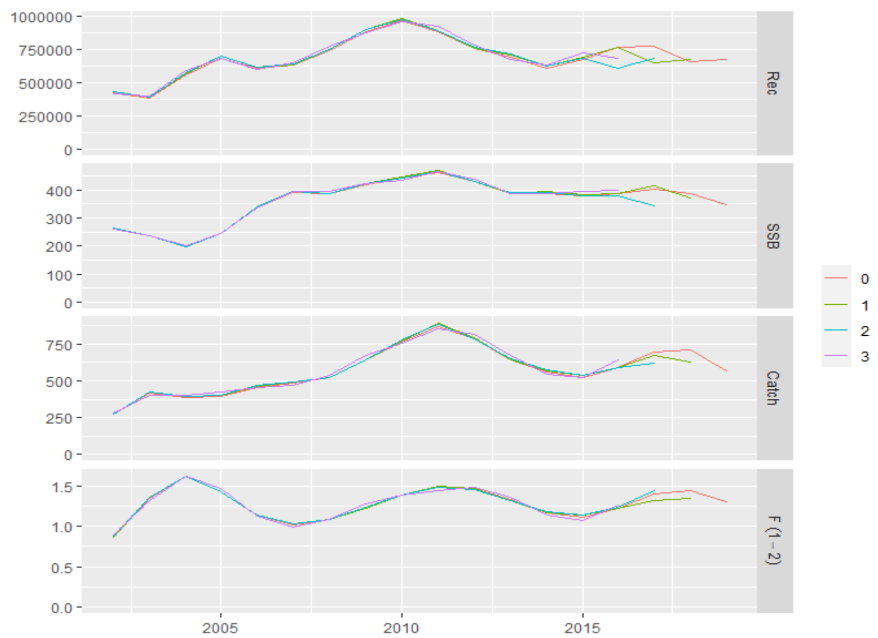


Figure 6.17.3.3.10 Blue and red shrimp in GSA 6&7. Retrospective analysis output.

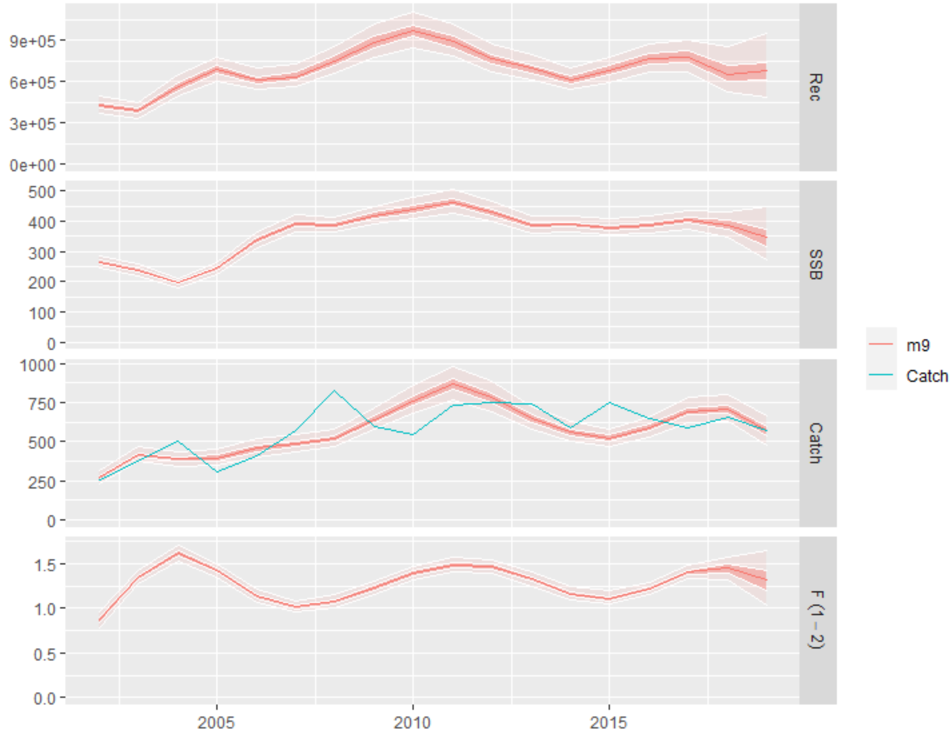


Figure 6.17.3.3.11 Blue and red shrimp in GSA 6&7. Stock summary for blue and red shrimp in GSA 6&7, recruits (‘000), SSB (t), catch (t) and Fbar (age 1-2). Estimated catch is compared to recorded catch.

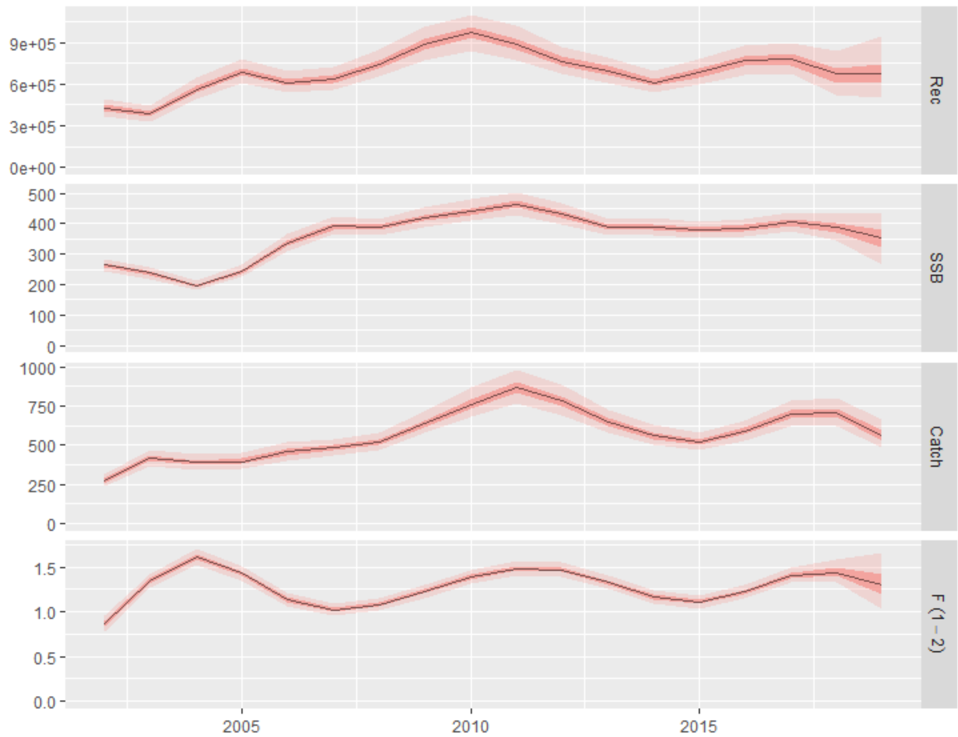


Figure 6.17.3.3.12 Blue and red shrimp in GSA 6&7. Stock summary of the simulated and fitted model from a4a. Stock summary for blue and red shrimp in GSA 6&7, recruits ('000), SSB (t), catch (t) and Fbar (age 1-2).

Table **6.17.3.3.1 Blue and red shrimp in GSA 6&7.** Number of individuals per year by age group (ages 0-5) in the catch in GSA 6&7 (2002-2019). Data from DCF.

Year / Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	3	4	45	6	1	1	734	1	1	2	13	1	1	1	1	3	1	1
1	16402	26510	44133	28093	35171	46459	82468	41656	36867	45003	55156	66527	44983	67411	50238	41090	45209	42910
2	4650	6803	6002	3603	6679	9126	8599	9570	9839	14004	12994	9498	9541	9830	9040	9603	11123	10027
3	613	957	849	514	373	807	1928	1859	1242	1683	1397	1248	1435	1219	1625	1254	1222	984
4	33	119	142	119	21	68	291	275	162	200	67	53	121	157	334	183	138	49
5	3	4	1	1	1	1	5	37	24	14	9	1	15	27	74	27	9	4

Table **6.17.3.3.2 Blue and red shrimp in GSA 6&7.** Blue and red shrimp Weight of individuals at age in the catch in GSA 6&7 (2002-2019). Data from DCF.

Year/ Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.001
1	0.008	0.007	0.008	0.007	0.008	0.008	0.007	0.008	0.008	0.008	0.008	0.007	0.007	0.007	0.007	0.008	0.008
2	0.020	0.020	0.020	0.020	0.019	0.020	0.021	0.020	0.021	0.020	0.020	0.020	0.021	0.020	0.021	0.021	0.020
3	0.039	0.040	0.041	0.039	0.038	0.038	0.041	0.039	0.039	0.039	0.039	0.038	0.039	0.039	0.039	0.039	0.039
4	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.056	0.056	0.055	0.054	0.054	0.057	0.055	0.057	0.055	0.055
5	0.070	0.070	0.070	0.070	0.070	0.070	0.068	0.070	0.072	0.071	0.068	0.070	0.070	0.068	0.073	0.073	0.071

Table **6.17.3.3.3 Blue and red shrimp in GSA 6&7.** Number of individuals per year by age group (ages 1-4) according to MEDITS surveys.

Year/ Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	65	36	41	14	24	17	101	39	25	55	66	75	42	46	57	24	26	35
2	41	28	41	6	28	13	44	28	18	29	30	26	23	21	20	27	27	32
3	9	9	12	1	3	4	9	4	3	2	1	4	4	9	8	6	6	6
4	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0

Table **6.17.3.3.4 Blue and red shrimp in GSA 6&7.** Number of individuals at age in the stock (2002-2019)

Year/ Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	425893	387845	563566	688575	609483	636820	747955	887635	968928	888933	765306	694946	614239	681972	766714	779089	660115	678771
1	53772	59572	54250	78828	96314	85251	89075	104620	124157	135528	124338	107047	97205	85916	95390	107244	108975	92333
2	8655	11482	8638	6333	10697	16511	16068	15995	16605	17387	17556	16306	15745	16347	15058	15260	14813	14569
3	994	1675	1251	682	625	1494	2655	2404	1993	1718	1602	1648	1814	2137	2359	1898	1547	1431
4	71	169	142	72	51	72	203	331	240	158	119	113	143	201	255	239	147	113
5	4	13	16	10	6	7	11	28	38	23	13	10	11	18	28	30	22	13

Table **6.17.3.3.5 Blue and red shrimp in GSA 6&7.** Fishing mortality at age (2002-2019)

Year / Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	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	0.00	0.00	0.00	0.00
1	0.70	1.08	1.30	1.15	0.92	0.82	0.87	0.99	1.12	1.20	1.18	1.07	0.93	0.89	0.98	1.13	1.16	1.05
2	1.03	1.61	1.93	1.71	1.36	1.22	1.29	1.47	1.66	1.77	1.76	1.59	1.39	1.33	1.46	1.68	1.73	1.56
3	1.26	1.96	2.35	2.08	1.65	1.48	1.57	1.79	2.02	2.16	2.14	1.93	1.69	1.61	1.78	2.04	2.10	1.90
4	1.26	1.96	2.35	2.08	1.65	1.48	1.57	1.79	2.02	2.16	2.14	1.93	1.69	1.61	1.78	2.04	2.10	1.90
5	1.26	1.96	2.35	2.08	1.65	1.48	1.57	1.79	2.02	2.16	2.14	1.93	1.69	1.61	1.78	2.04	2.10	1.90

Table **6.17.3.3.6 Blue and red shrimp in GSA 6&7.** Stock summary: number of recruits, SSB, Fbar 1-2**,** estimated catch

Year	Recruitment age 0 '000	Low	High	SSB, t	Low	High	Fbar 1-2	Low	High	Catch, t
2002	425893	325893	525893	264	228	300	0.86	0.72	1.00	271
2003	387845	295845	479845	238	208	268	1.34	1.22	1.46	415
2004	563566	439566	687566	196	172	220	1.61	1.47	1.75	388
2005	688575	552575	824575	243	211	275	1.43	1.31	1.55	397
2006	609483	483483	735483	338	300	376	1.14	1.04	1.24	457
2007	636820	498820	774820	392	350	434	1.02	0.90	1.14	486
2008	747955	597955	897955	387	347	427	1.08	0.96	1.20	521
2009	887635	695635	1079635	419	369	469	1.23	1.11	1.35	641
2010	968928	750928	1186928	441	385	497	1.39	1.27	1.51	764
2011	888933	690933	1086933	464	406	522	1.49	1.37	1.61	870
2012	765306	607306	923306	430	376	484	1.47	1.35	1.59	782
2013	694946	546946	842946	388	342	434	1.33	1.21	1.45	645
2014	614239	492239	736239	389	343	435	1.16	1.04	1.28	561
2015	681972	541972	821972	379	341	417	1.11	0.99	1.23	522
2016	766714	608714	924714	386	342	430	1.22	1.10	1.34	590
2017	779089	585089	973089	404	358	450	1.41	1.29	1.53	697
2018	660115	402115	918115	387	321	453	1.45	1.23	1.67	708
2019	678771	320771	1036771	348	208	488	1.30	0.80	1.80	566

6.17.4 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. Current F (1.30) F in 2019 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 2019 to 2021 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 F2020 is based on the mean of F 2017 to 2019 because F is fluctuationg (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.

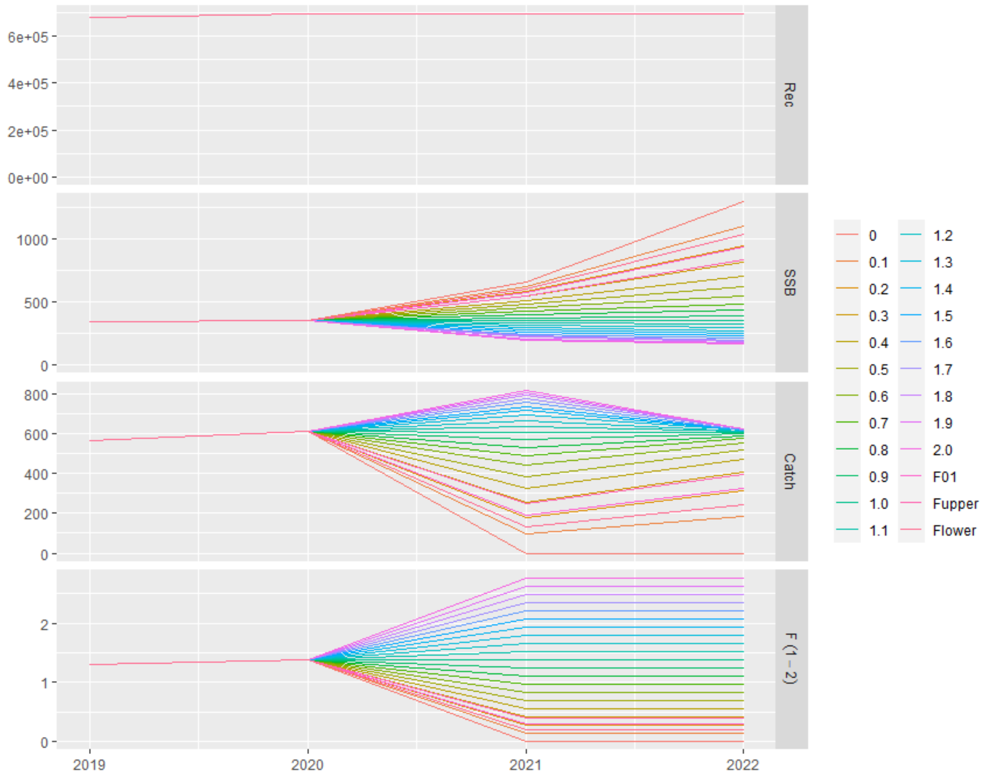
Variable	Value	Notes
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2017-2019
$F_{ages\ 1-2}$ (2020)	1.38	F2020 status quo is geometric mean Fbar 2017-2019
SSB (2020)	353 t	SSB projection based on stock assessment
R_{age0} (2020)	694480	Geometric mean of R from time series years 2013 to 2019
Total catch (2020)	608 t	Catch at F status quo in 2020

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 (1.30), F in 2019, 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 247 tonnes, 67% less than the current estimated catch (566 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).



6e+05
4e+05
2e+05
0e+00
Rec
1000
500
0
SSB
800
600
400
200
0
Catch
2
1
0
F (1 - 2)
2019
2020
2021
2022
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
F01
Fupper
Flower

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) = geometric mean of F 2017-F 2019 = 1.38, Catch (2019) = 566 t, Recruitement= geometric mean of Recruits 2013-F 2019.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2020	Catch 2021	Catch 2022	SSB 2020	SSB 2022	SSB change 2020-2022 (%)	Catch change 2019-2021 (%)
High long term yield ($F_{0.1}$)	0.21	0.29	565.78	608.35	187.66	322.87	353.49	935.22	164.57	-66.83
F_{upper}	0.29	0.40	565.78	608.35	247.15	396.25	353.49	833.51	135.80	-56.32
F_{lower}	0.14	0.19	565.78	608.35	130.91	240.37	353.49	1038.06	193.66	-76.86
FMSY transition	0.70	0.97	565.78	608.35	485.96		353.49	488.22	38.12	-14.11
Zero catch	0	0.00	565.78	608.35	0.00	0.00	353.49	1296.72	266.84	-100.00
Status quo	1	1.38	565.78	608.35	604.19	606.12	353.49	354.12	0.18	6.79
Scenarios	0.1	0.14	565.78	608.35	96.17	183.57	353.49	1103.79	212.26	-83.00
	0.2	0.28	565.78	608.35	181.46	314.47	353.49	946.18	167.67	-67.93
	0.3	0.42	565.78	608.35	257.25	407.44	353.49	816.85	131.09	-54.53
	0.4	0.55	565.78	608.35	324.74	473.15	353.49	710.26	100.93	-42.60
	0.5	0.69	565.78	608.35	384.94	519.32	353.49	621.98	75.96	-31.96
	0.6	0.83	565.78	608.35	438.76	551.50	353.49	548.49	55.17	-22.45
	0.7	0.97	565.78	608.35	486.96	573.74	353.49	486.99	37.77	-13.93
	0.8	1.11	565.78	608.35	530.22	588.95	353.49	435.24	23.13	-6.28
	0.9	1.25	565.78	608.35	569.13	599.24	353.49	391.43	10.73	0.59
	1.1	1.52	565.78	608.35	635.84	610.67	353.49	322.16	-8.86	12.38
	1.2	1.66	565.78	608.35	664.48	613.68	353.49	294.60	-16.66	17.44
	1.3	1.80	565.78	608.35	690.44	615.68	353.49	270.70	-23.42	22.03
	1.4	1.94	565.78	608.35	714.02	617.08	353.49	249.83	-29.32	26.20
	1.5	2.08	565.78	608.35	735.48	618.14	353.49	231.50	-34.51	29.99
	1.6	2.21	565.78	608.35	755.05	619.03	353.49	215.30	-39.09	33.45
	1.7	2.35	565.78	608.35	772.94	619.89	353.49	200.90	-43.17	36.61
	1.8	2.49	565.78	608.35	789.31	620.80	353.49	188.03	-46.81	39.51
	1.9	2.63	565.78	608.35	804.33	621.79	353.49	176.47	-50.08	42.16
	2	2.77	565.78	608.35	818.14	622.90	353.49	166.02	-53.03	44.60

*SSB at mid year

6.18 BLUE AND RED SHRIMP IN GSA 9, 10 & 11

6.18.1 STOCK IDENTITY AND BIOLOGY

The assessment of Blue and red shrimp carried out during the STECF EWG 20-09 considered the stock shared by the GSAs 9, 10 and 11.

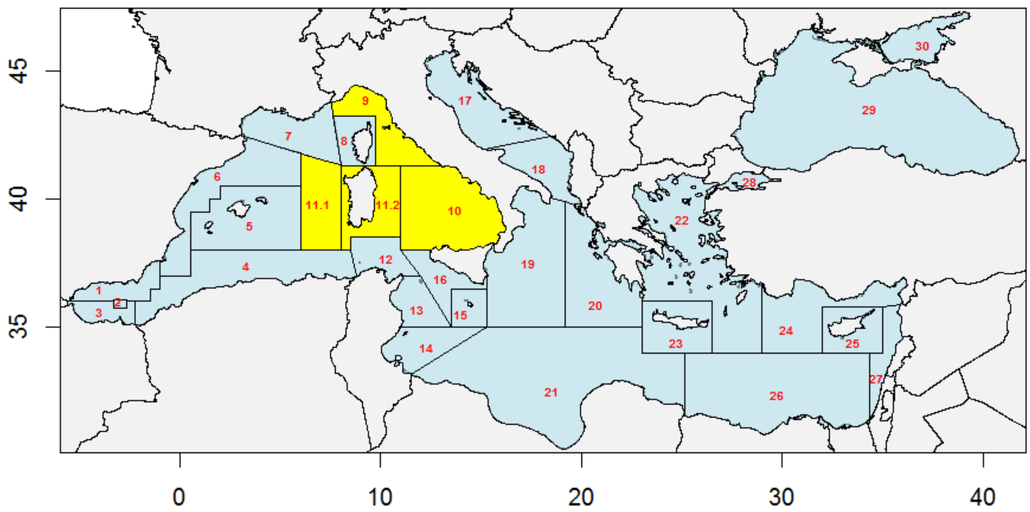


Figure 6.18.1.1. Blue and red shrimp in GSAs 9, 10 and 11. Geographical location of the stock.

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):

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 input for the assessment the median values of a and b from GSA9 (Figure 6.18.1.3) were used that have also been used in the previous assessment (STECF EWG 19-10).

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.

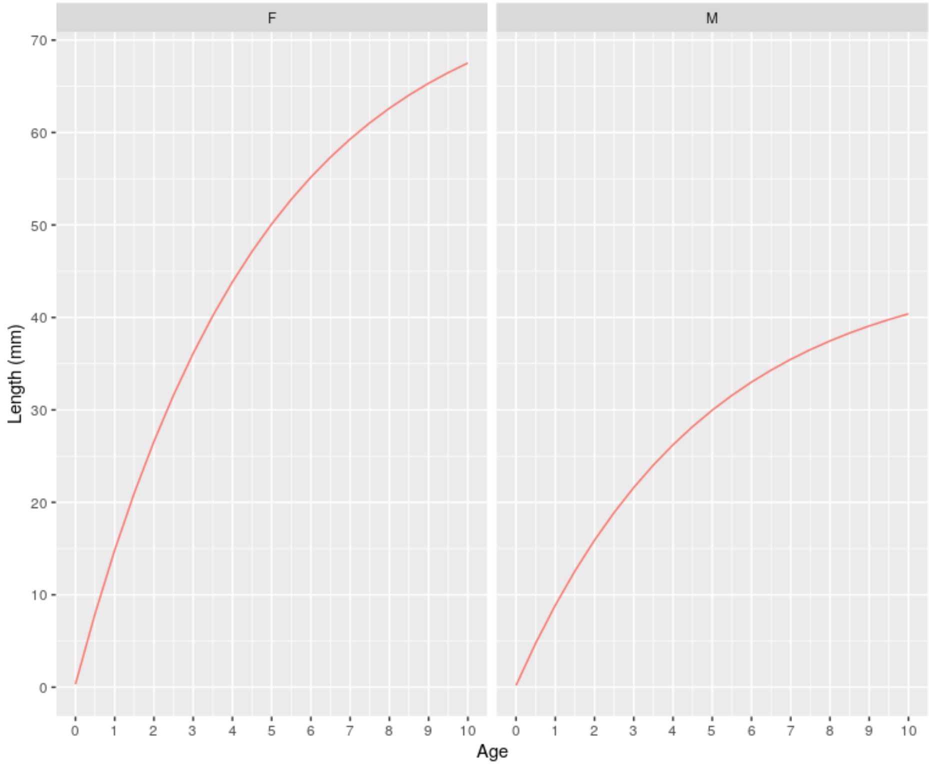


Figure 6.18.1.2. Blue and red shrimp in GSAs 9, 10 and 11. Von Bertalanffy growth curves by sex used in the assessment (Orsi Relini and Relini, 1998).

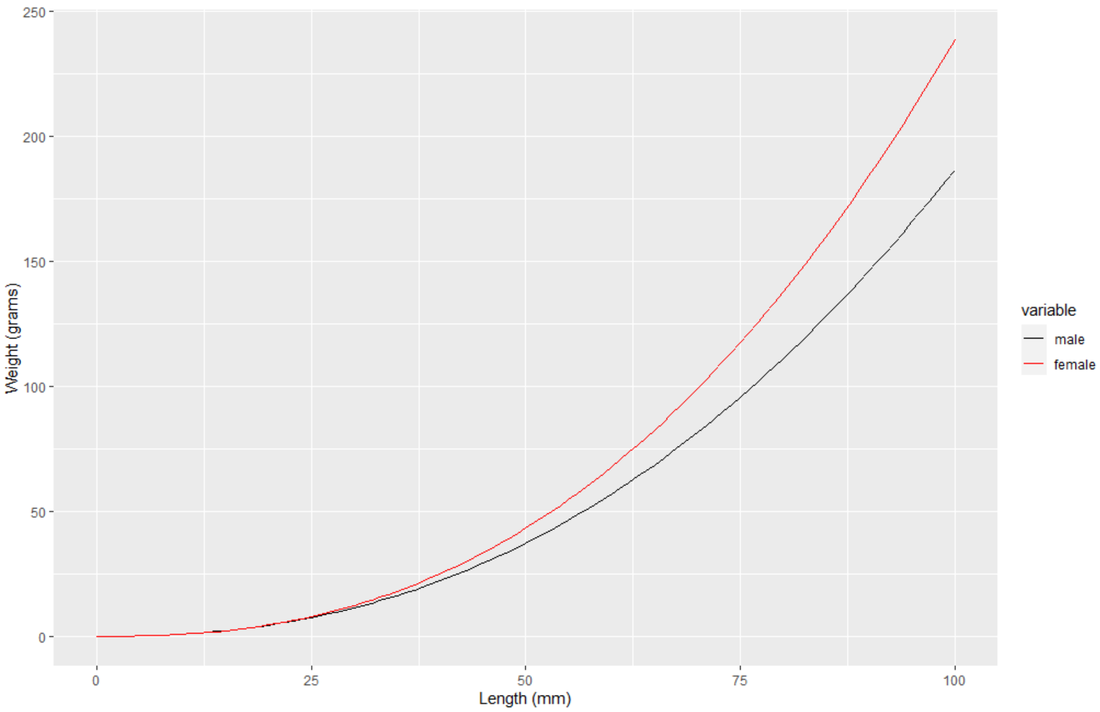


Figure 6.18.1.3. Blue and red shrimp in GSAs 9, 10 and 11. Length weight relationship by sex and GSA as median of a and b parameters provided through DCF for GSA 9.

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

As maturity vector was used the one from GSA9 (as median value by age classes) and natural mortality vector was computed using Chen & Watanabe formula using the same VBGF parameters reported above (Tables 6.18.1.2 and 6.18.1.3).

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

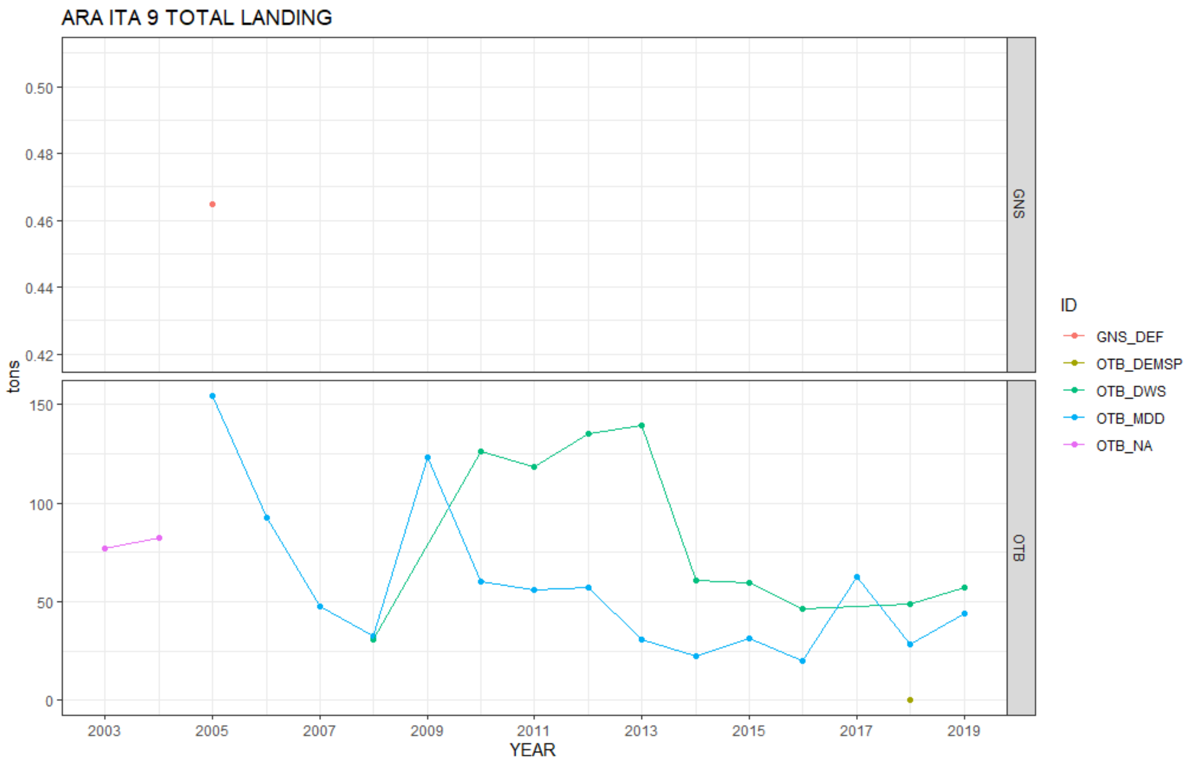
6.18.2 DATA

6.18.2.1 CATCH (LANDINGS AND DISCARDS)

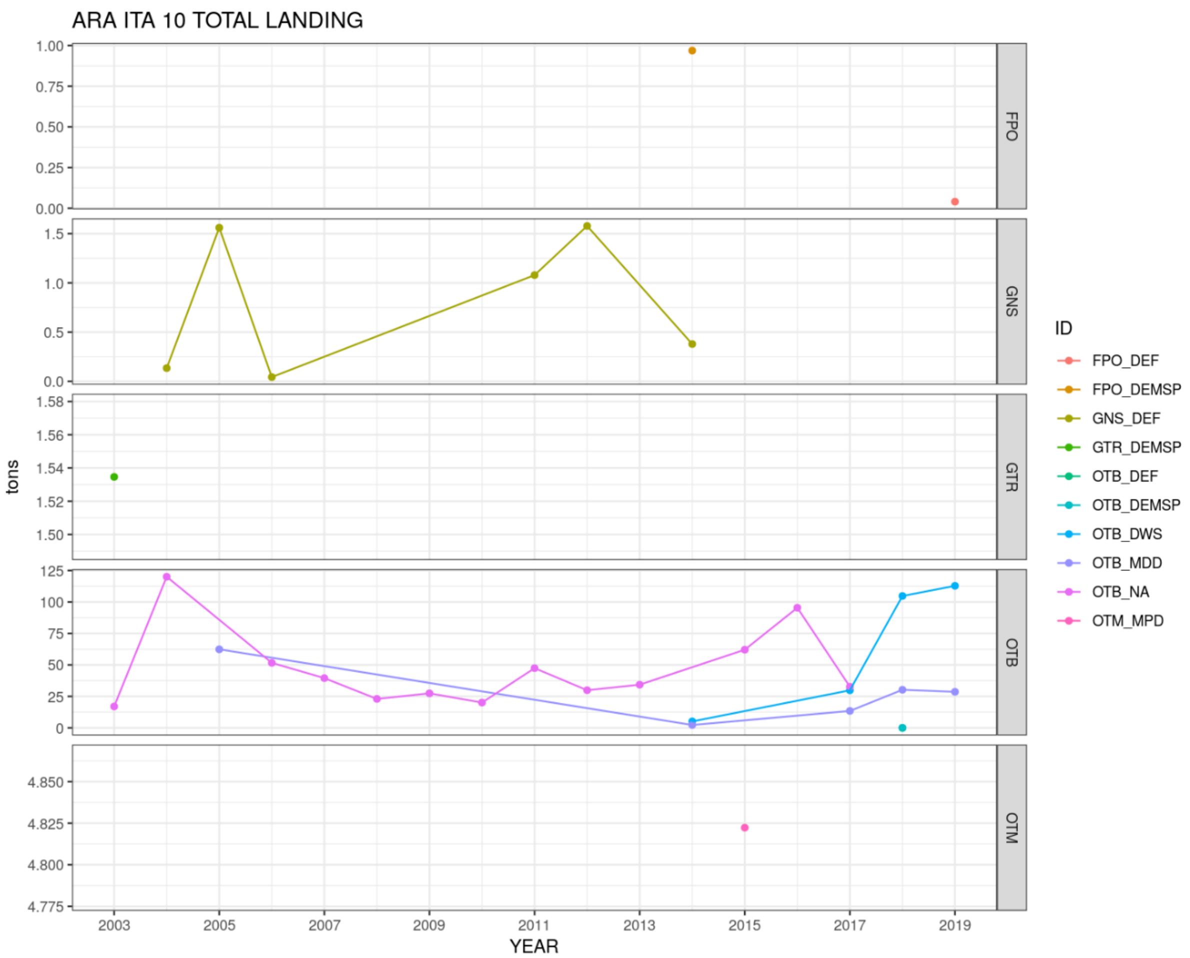
The blue and red shrimp is one of the most important target species of the fishery carried out on the muddy bottoms of the upper and middle slope. The species is almost exclusively exploited by otter bottom trawling. In the past, in particular in the GSA10 there was a Gillnet fleet (GNS) targeting ARA 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 20-09 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.



ARA ITA 9 TOTAL LANDING
tons
0.50
0.48
0.46
0.44
0.42
150
100
50
0
GNS
OTB
2003
2005
2007
2009
2011
2013
2015
2017
2019
YEAR
ID
GNS_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA



ARA ITA 10 TOTAL LANDING
tons
1.00
0.75
0.50
0.25
0.00
1.5
1.0
0.5
0.0
1.58
1.56
1.54
1.52
1.50
125
100
75
50
25
0
4.850
4.825
4.800
4.775
FPO
GNS
GTR
OTB
OTM
2003
2005
2007
2009
2011
2013
2015
2017
2019
YEAR
ID
FPO_DEF
FPO_DEMSP
GNS_DEF
GTR_DEMSP
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTB_NA
OTM_MPD

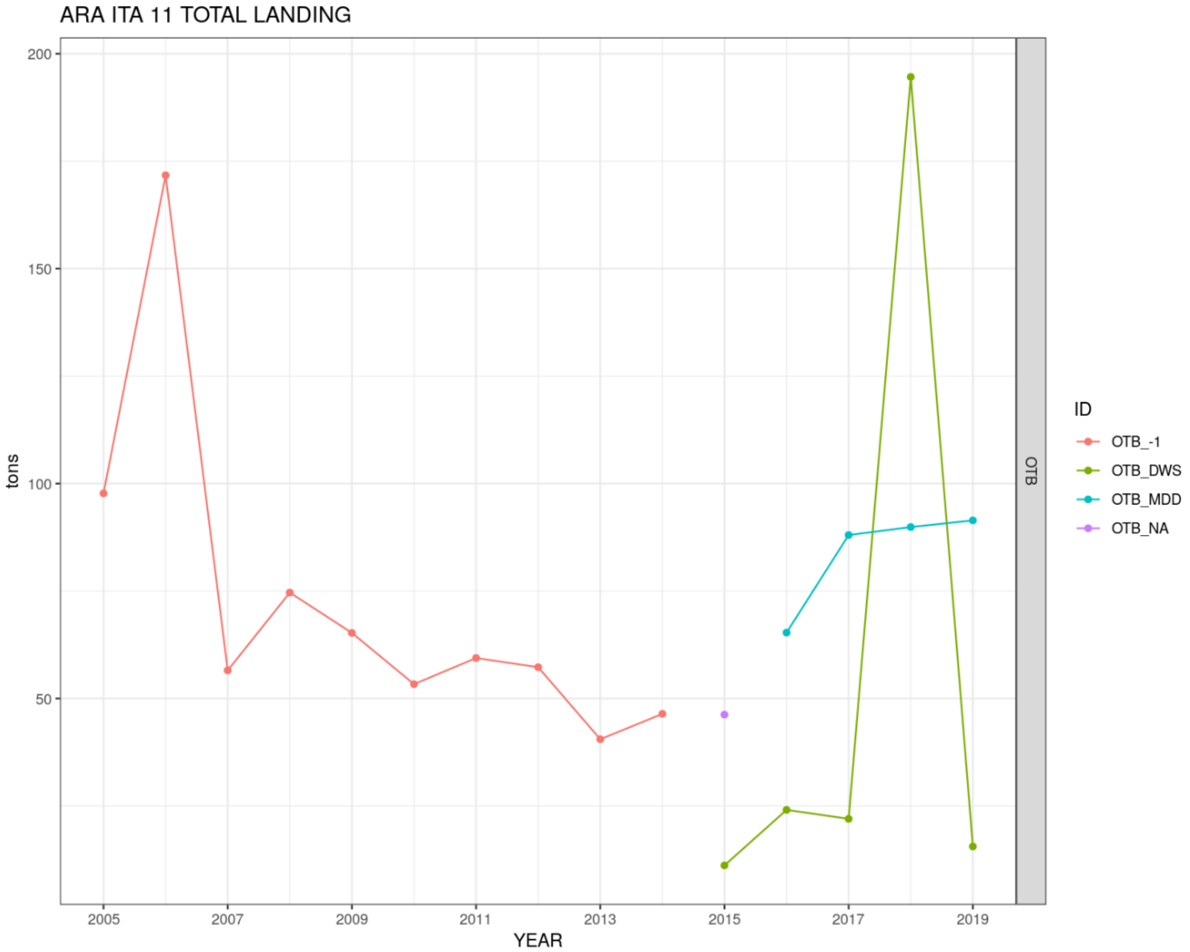
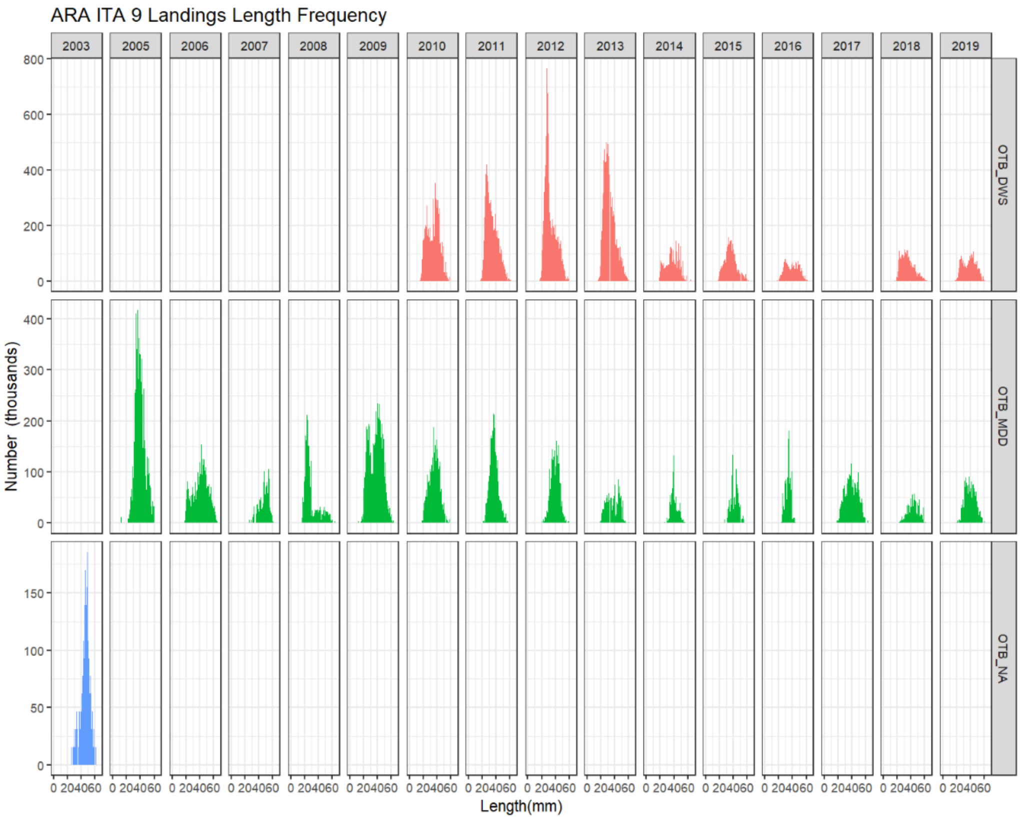


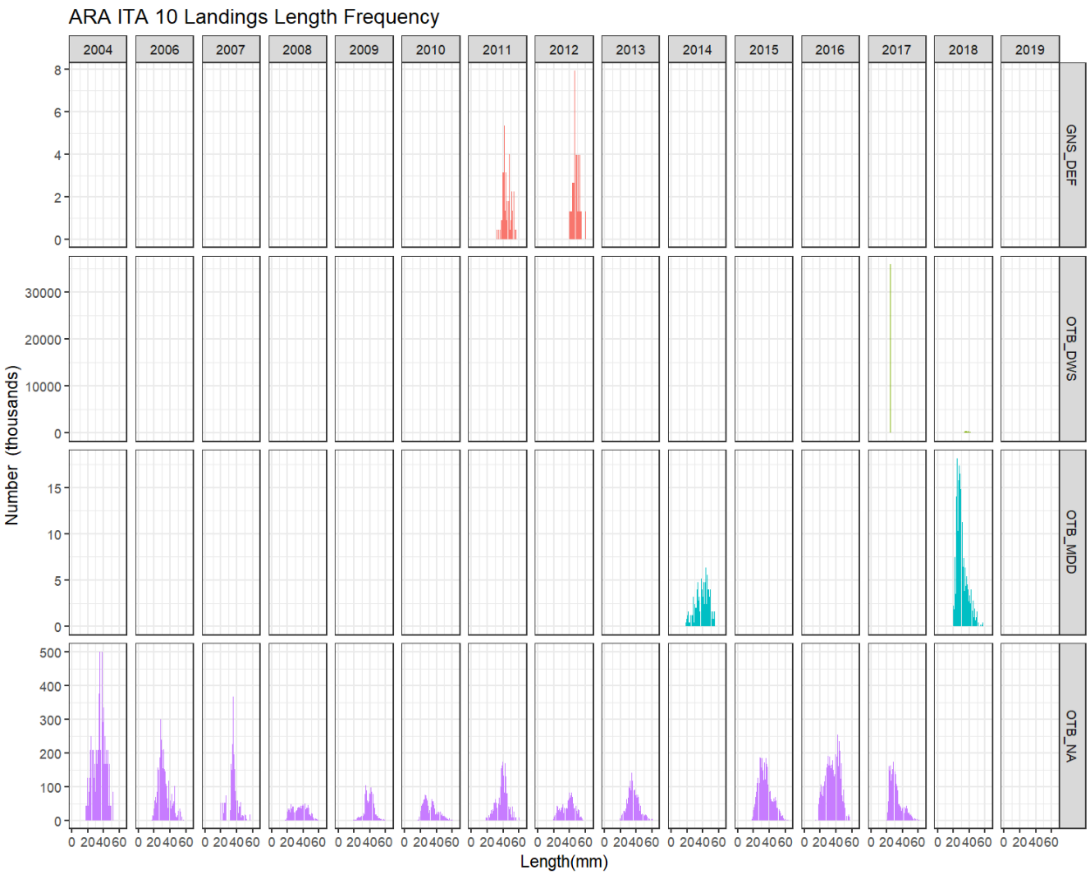
Figure 6.18.2.1.1. Blue and red shrimp in GSAs 9, 10 and 11. Landings data in tons by year and fleet.

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
2006	92.7	51.7	171.7	316.1
2007	47.4	39.5	56.5	143.4
2008	63.5	23.0	74.6	161.1
2009	123.5	27.4	65.3	216.2
2010	186.4	20.1	53.3	259.8
2011	174.7	48.5	59.4	282.6
2012	192.6	31.5	57.3	281.4
2013	170.4	34.3	40.5	245.2
2014	83.6	8.7	46.4	138.7
2015	90.7	66.9	57.4	215.0
2016	66.6	95.4	89.4	251.4
2017	62.4	76.0	110.0	248.4
2018	77.2	135.0	284.5	496.7
2019	101.0	141.5	107.0	349.5

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
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
OTB_DWS
OTB_MDD
OTB_NA
Number (thousands)
Length(mm)


ARA ITA 10 Landings Length Frequency
2004
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
GNS_DEF
OTB_DWS
OTB_MDD
OTB_NA
Number (thousands)
Length(mm)

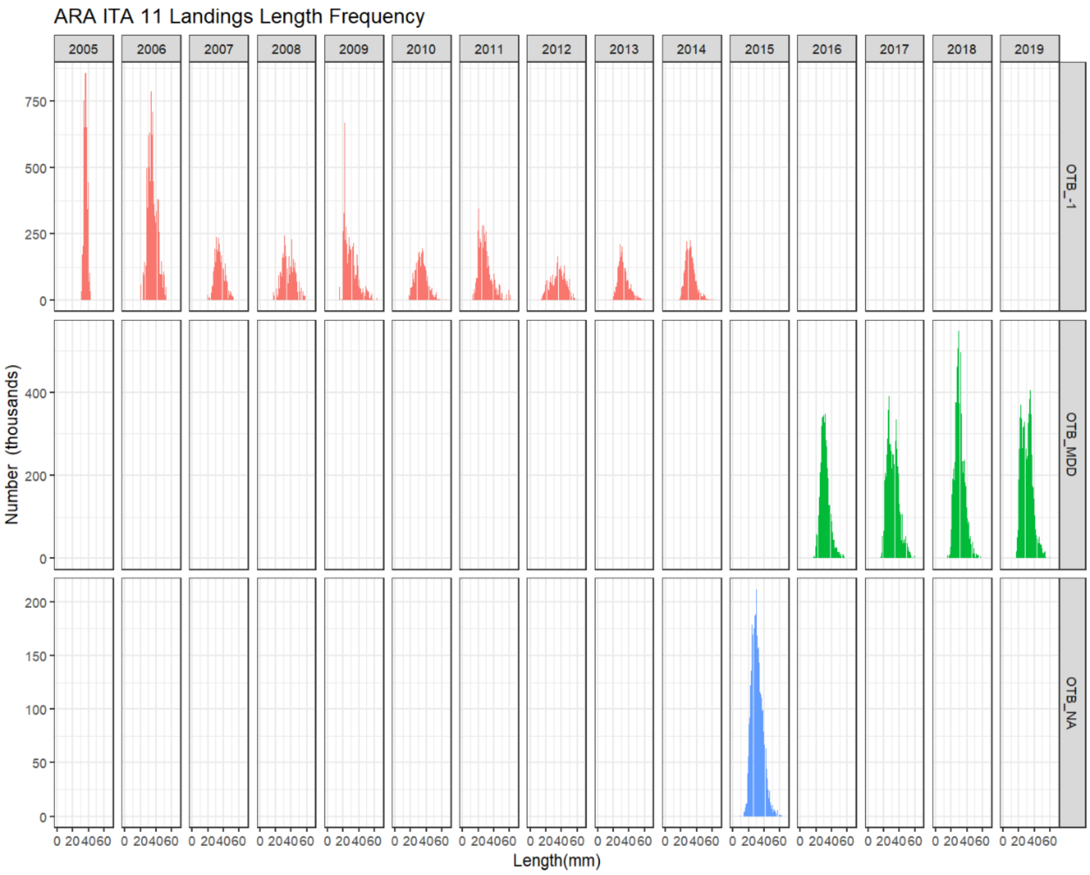


Figure 6.18.2.1.2. Blue and red shrimp in GSAs 9, 10 and 11. Length frequency distribution of the landings by year and fleet.

Discards

Blue and red shrimp is very rarely discarded. Some data were reported to STECF EWG 20-09 through the DCF for GSA9 in 2011 (0.40 tonnes) and included in the stock assessment. 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**
2006	-	-	-	**-**
2007	-	-	-	**-**
2008	-	-	-	**-**
2009	-	-	-	**-**
2010	-	-	-	**-**
2011	0.40	-	-	**0.40**
2012	-	-	-	**-**
2013	-	-	-	**-**
2014	-	-	-	**-**
2015	-	-	-	**-**
2016	-	-	-	**-**
2017	-	-	-	**-**
2018	-	-	-	**-**
2019	-	-	-	**-**

Length and age frequency distributions of the discards are shown in Figure 6.18.2.1.3.

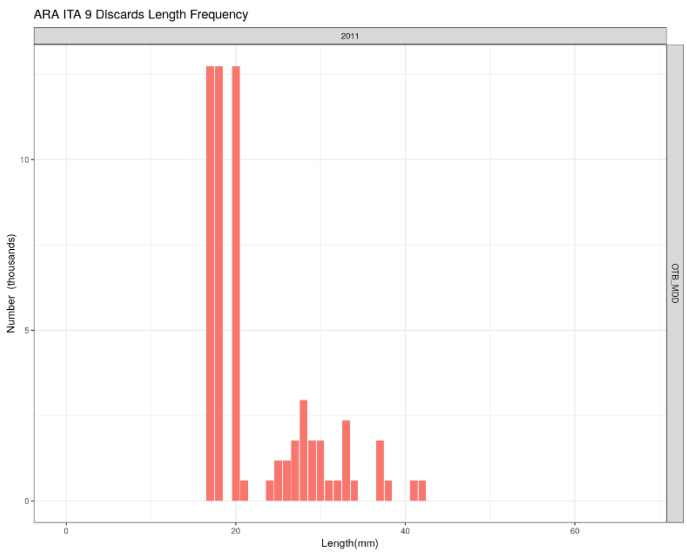


Figure 6.18.2.1.3. Blue and red shrimp in GSAs 9, 10 and 11. Length frequency distribution of the discards by year and fleet in GSA

6.18.2.2 Effort

Fishing effort data were reported to STECF EWG 20-09 through DCF (Table 6.18.2.2.1 and 6.18.2.2.2).

Table 6.18.2.2.1. Blue and red shrimp in GSAs 9, 10 and 11. Fishing effort in days at sea by year and fishing gear.

	GSA9_OTB	GSA10_OTB	GSA11_OTB
2004	67828	32555	24827
2005	67714	50056	28645
2006	62517	38364	22836
2007	64161	38151	22321
2008	49759	38109	19435
2009	53330	36749	20128
2010	52606	31741	19321
2011	50737	33256	17018
2012	47851	31223	15472
2013	51715	38270	15872
2014	51286	42227	17583
2015	52900	30709	15278
2016	51257	35479	16926
2017	47457	36271	16285
2018	44296	33570	21190

Table 6.18.2.2.2. Blue and red shrimp in GSAs 9, 10 and 11. Nominal effort by year and fishing gear.

	GSA9_OTB	GSA10_OTB	GSA11_OTB
2002	14583556	7344089	3679604
2003	14671042	7231486	4652647
2004	14820339	8070376	7706431
2005	14700599	8029362	7324728
2006	12404787	7500584	5752588
2007	12782144	7287211	5867826
2008	11083521	7017668	4498889
2009	12190003	6921061	4390811
2010	11403131	5934581	4124461
2011	10687896	5609667	3814899
2012	9949155	6036034	3784372
2013	10725751	6162546	3138792
2014	10989815	8354825	3299652
2015	11054468	5476707	3108641
2016	10546689	6202964	3219773
2017	10594055	6526582	3827523
2018	9443736	6099176	5144513

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.

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 indexes were calculated using the script provided by JRC (Figures 6.18.2.3.1 and 6.18.2.3.2).

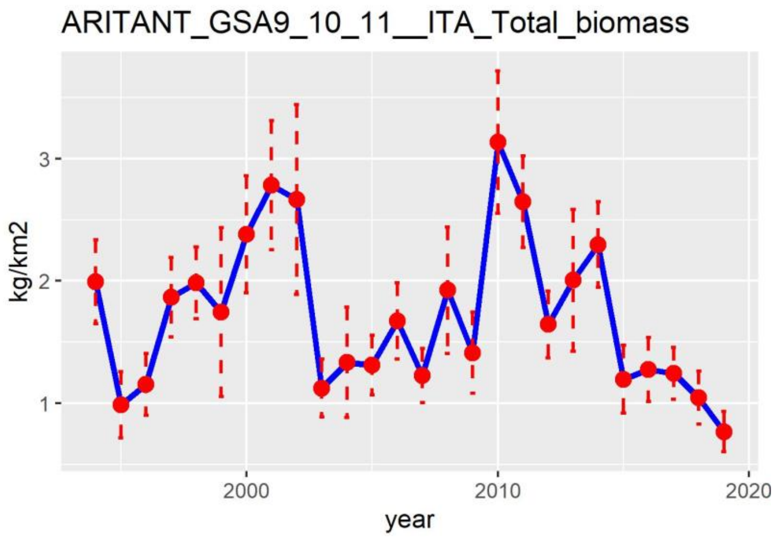


Figure 6.18.2.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

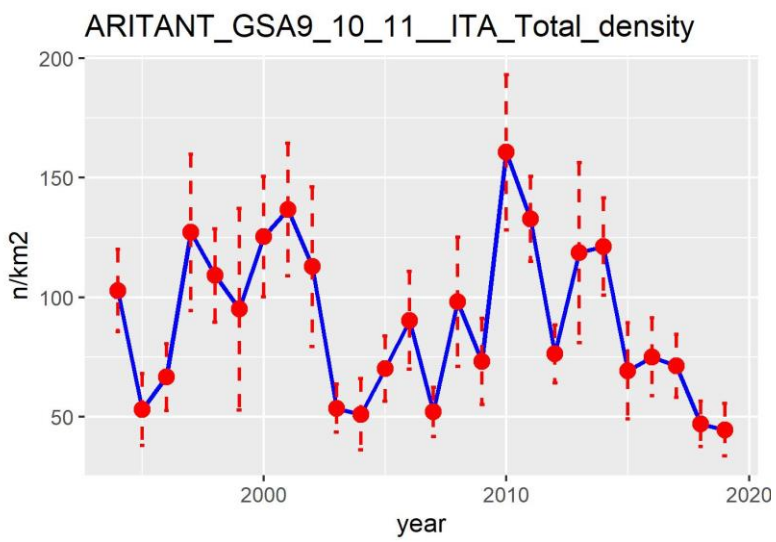
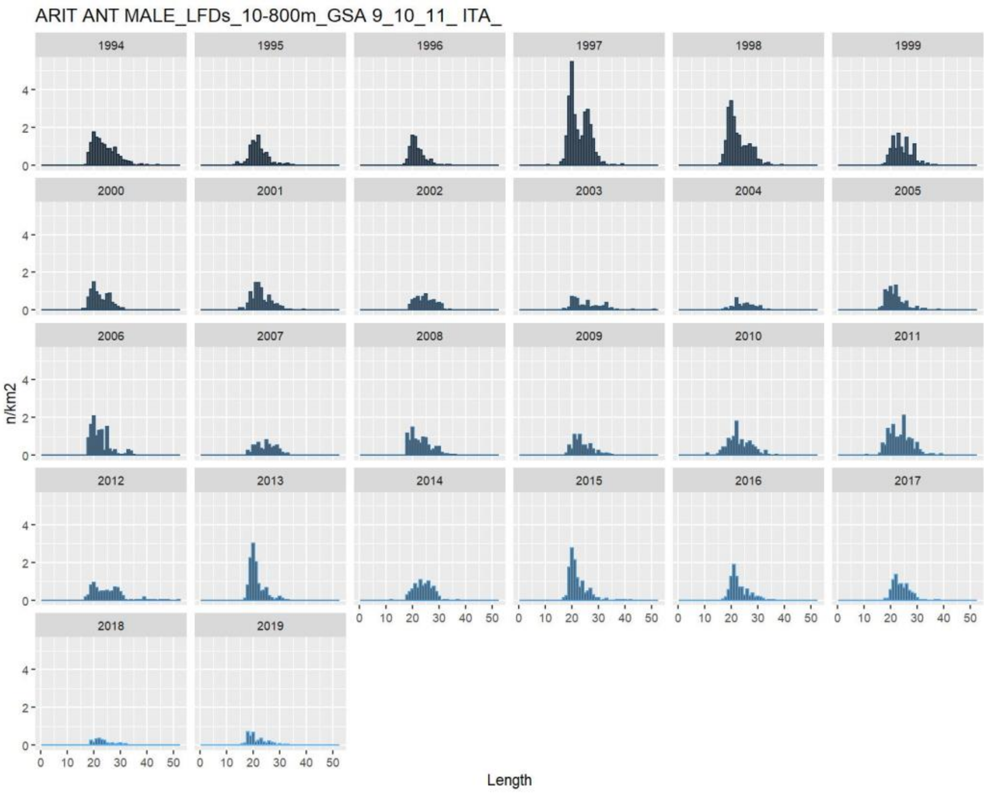
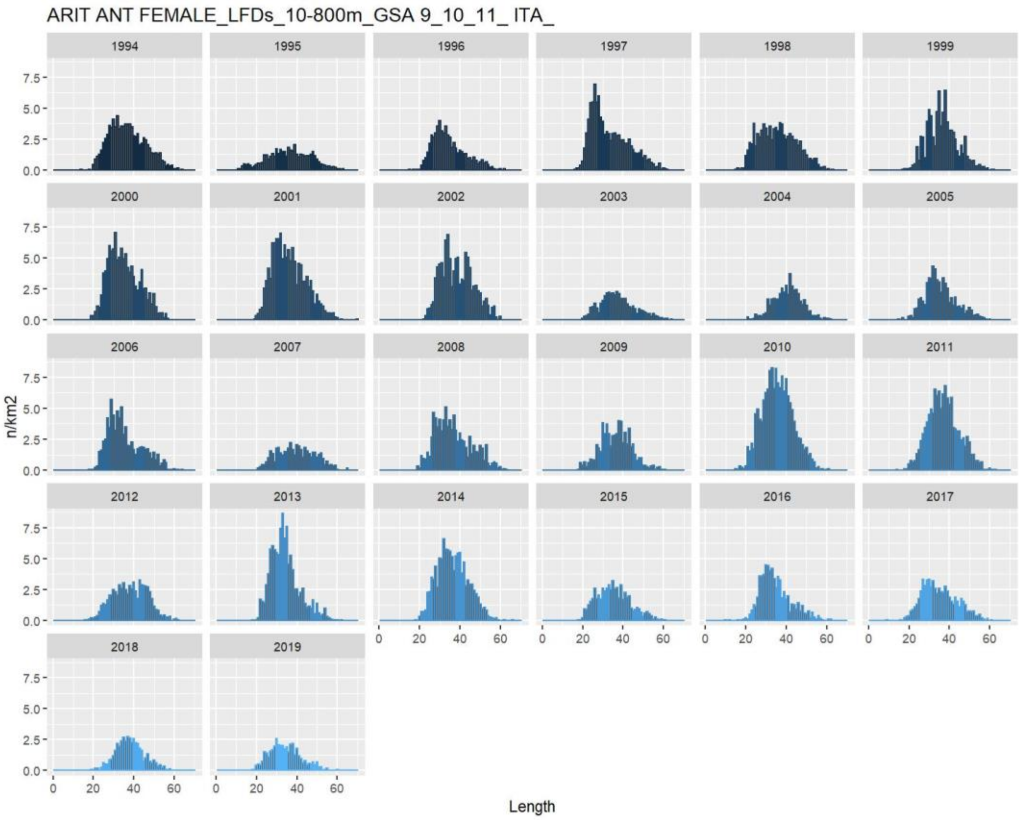


Figure 6.18.2.3.2. Blue and red shrimp in GSAs 9, 10 and 11. Estimated density indices from the MEDITS survey (n/km^2).

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.





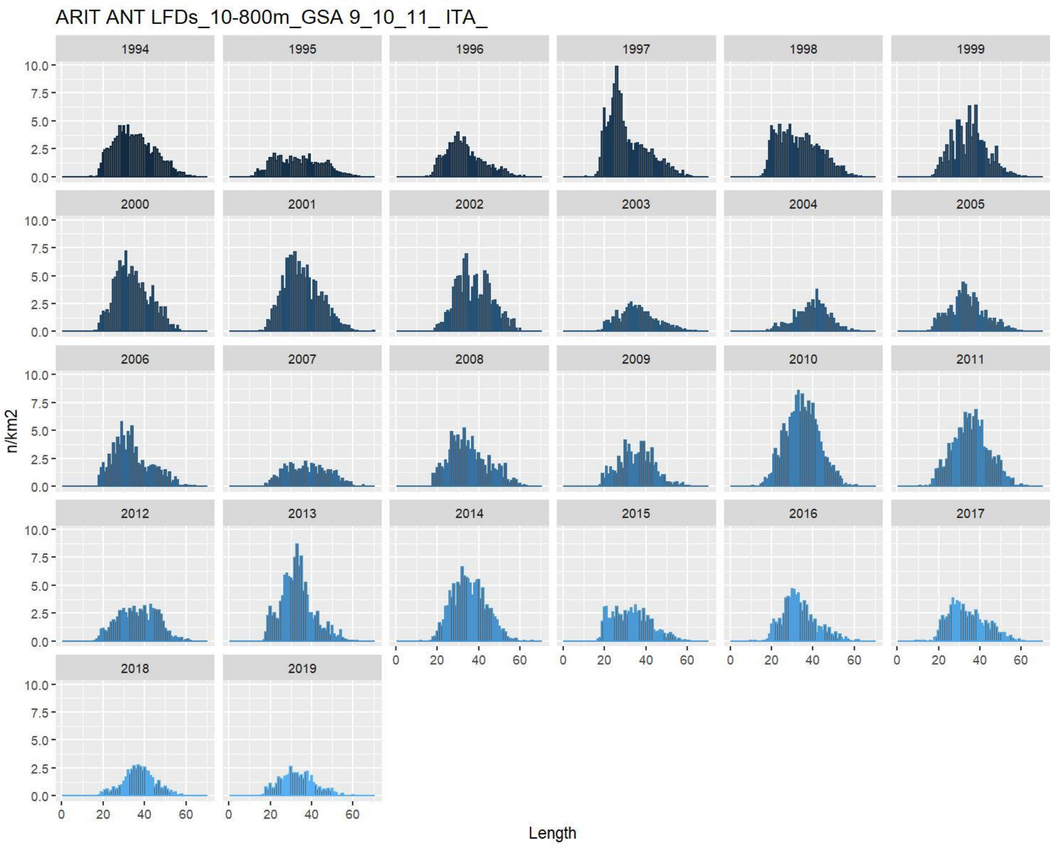


Figure 6.18.2.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Length frequency distribution by year and sex of MEDITS survey.

6.18.3 STOCK ASSESSMENT

A statistical catch-at-age assessment was carried out for this stock, using the Assessment for All Initiative (a4a) method (Jardim et al. 2015). The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike XSA, model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error.

The assessment was carried out using the period 2006-2019 for catch data and tuning file for which data were fully available in the three GSAs. In 2005 distribution from GSA11 was clearly affected by under sampling procedures (abundance ranged across few length classes) and so it was decided to exclude this year. The LFDs of 2018 and 2019 in GSA 10 were reconstructed based on the 2015-2016 for 2018 and 2016-2017 for 2019, to reduce the SOP correction factor.

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. SOP correction was applied to catch numbers at age (Table 6.18.3.1). High SOP correction values in 2018 in GSA11 are due to no sampling data for OTB_DWS in GSA11 for which, even though not selected in the ranking system, landings reported were substantial. Thus SoP for 2018 in GSA11 reflects data late and missing reporting and not errors in the data.

Table 6.18.3.1. Blue and red shrimp in GSAs 9, 10 and 11. SOP correction vector.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
GSA 9	0.96	0.91	1.91	0.97	0.98	0.98	0.98	0.98	0.97	0.98	0.98	0.98	1.01	0.98
GSA 10	0.97	0.97	0.97	0.96	1.00	0.91	0.92	0.92	1.08	1.02	0.96	1.65	1.63	1.94
GSA 11	0.93	0.92	0.93	0.96	0.95	0.96	0.93	0.95	0.95	1.19	1.32	1.20	3.05	1.13

Tables 6.18.3.2 lists the input data for the a4a model, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age and the tuning series at age. Fishing and natural mortality before spawning were set as 0.5.

Table 6.18.3.2. Blue and red shrimp in GSAs 9, 10 and 11. Input data for the a4a model.

Catches (t)

2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
316	143	161	216	260	283	261	245	139	215	222	251	497	350

Table 6.18.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Catch numbers at age (thousands)

Year/Age	1	2	3	4	5	6
2006	764.48	5918.27	4580.65	2075.46	930.15	485.91
2007	232.52	2085.6	2246.36	789.01	494.48	209.7
2008	1404.49	2559.66	2539.55	1457.54	541.46	293.59
2009	1739.58	2908.86	3540.44	1831.88	694.47	365.17
2010	1317.32	3713.53	4792.74	2196.46	749.34	440.05
2011	2121.81	4895.29	4868.14	2383.59	905.65	570.78
2012	1224.61	3889.49	4295.55	3128.25	1071.47	430.49
2013	1298.24	4869.88	3658.34	2260.38	1003.05	463.92
2014	557.16	2217.04	2129.08	1061.81	495.21	210.26
2015	1139.55	3853.27	3538.39	1624.77	597.28	339.39
2016	1198.97	5822.05	3532.27	1985.21	739.18	305.93
2017	2094.1	5143.23	3931.76	2016.59	706.71	277.43
2018	3701.35	13181.93	7703.06	3582.55	1170.1	417.32
2019	2496.51	6644.1	5383.9	3001.02	959.51	361.15

Table 6.18.3.4. Blue and red shrimp in GSAs 9, 10 and 11. Weights at age (Kg)

Year/Age	1	2	3	4	5	6
2006	0.007247	0.013781	0.022621	0.029195	0.038819	0.059045
2007	0.007487	0.014721	0.022861	0.031638	0.044416	0.060409
2008	0.006728	0.011834	0.018522	0.026161	0.037764	0.053516
2009	0.006366	0.012357	0.020259	0.029569	0.039592	0.043122
2010	0.006797	0.013037	0.021609	0.027829	0.034053	0.027792
2011	0.006573	0.01259	0.020823	0.025321	0.030715	0.031306
2012	0.006997	0.012714	0.021434	0.026576	0.03266	0.030517
2013	0.007268	0.013317	0.020143	0.024381	0.028781	0.02863
2014	0.007021	0.013493	0.021881	0.030182	0.039222	0.032408
2015	0.006929	0.01323	0.021356	0.028306	0.036682	0.037314
2016	0.007182	0.013259	0.021579	0.026869	0.034092	0.035395
2017	0.007102	0.0129	0.019268	0.025876	0.037458	0.045896
2018	0.00701	0.012848	0.0205	0.024476	0.032218	0.043365
2019	0.006754	0.01299	0.020405	0.028394	0.037645	0.041911

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
2006-2018	0	0.204	0.787	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
2006-2018	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/km^2)

Year/Age	**0**	**1**	**2**	**3**	**4**	**5**
2006	0.02	8.67	43.72	20.54	10.25	4.56
2007	0.02	3.03	14.21	15.86	10.66	5.69
2008	0.02	8.77	40.67	26.14	11.63	7.89
2009	0.02	5.09	25.54	27.51	9.34	2.01
2010	0.02	18.17	61.49	55.07	18.32	6.45
2011	0.04	8.35	48.77	46.99	18.87	7.59
2012	0.02	5.73	23.96	22.44	17.54	4.33
2013	0.02	11.62	66.63	28.25	7.25	4.19
2014	0.02	10.76	46.28	40.04	18.33	4.66
2015	0.02	9.27	28.56	20.95	6.72	2.78

2016	0.07	6.09	37.98	19.51	7.59	2.85
2017	0.10	9.10	27.82	20.00	9.98	3.16
2018	0.02	2.08	15.13	19.97	6.41	2.75
2019	0.02	6.43	19.74	12.58	3.94	1.53

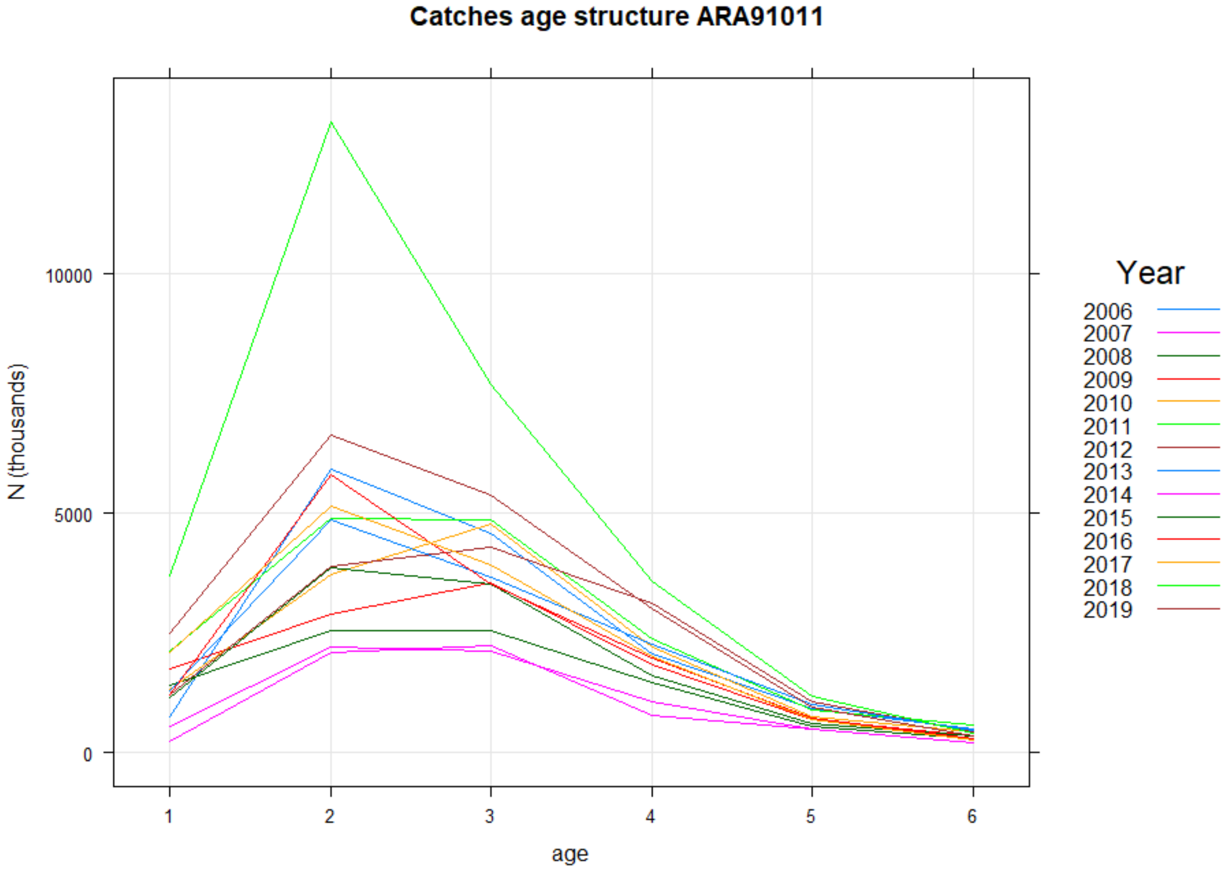


Figure 6.18.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Catch at age input data.

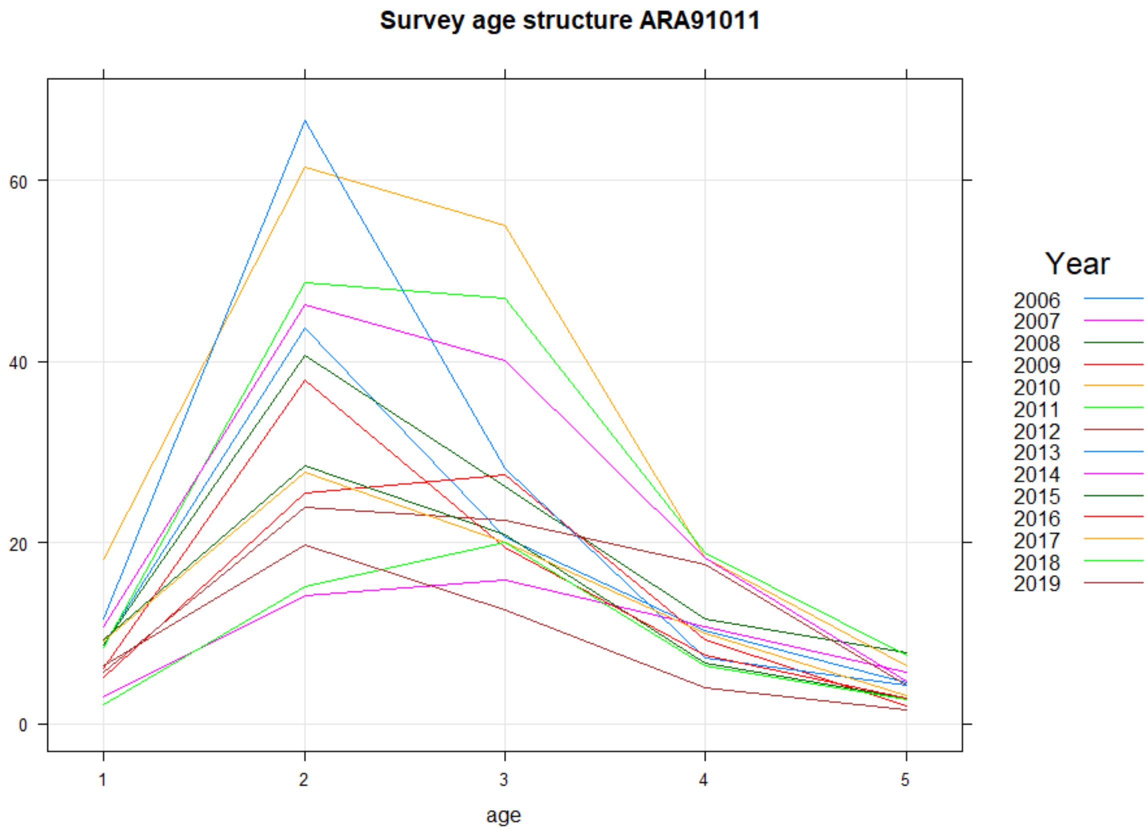


Figure 6.18.3.2. Blue and red shrimp in GSAs 9, 10 and 11. Age structure of the index.

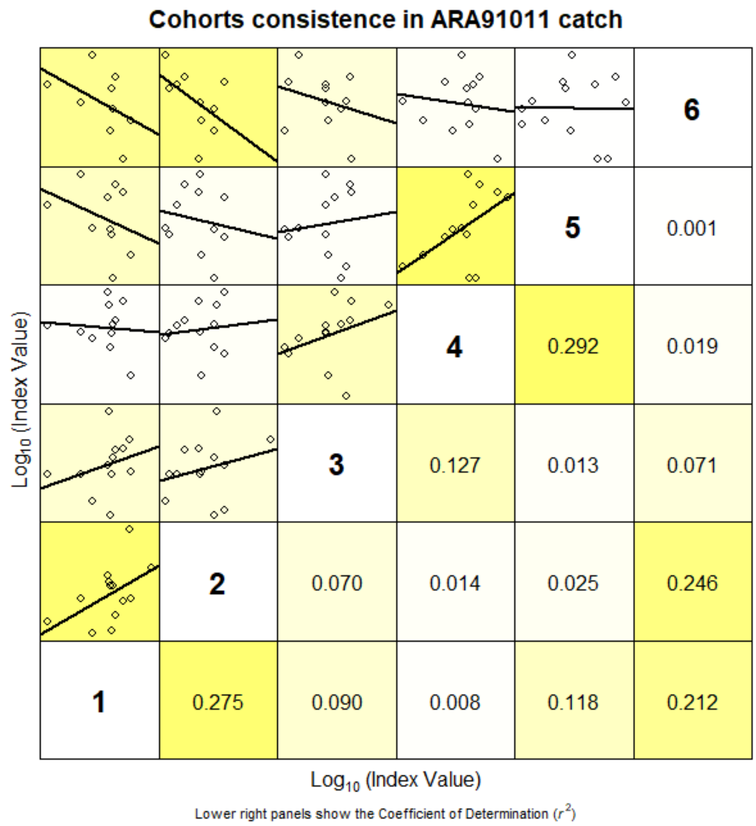


Figure 6.18.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Catch at age cohort consistency

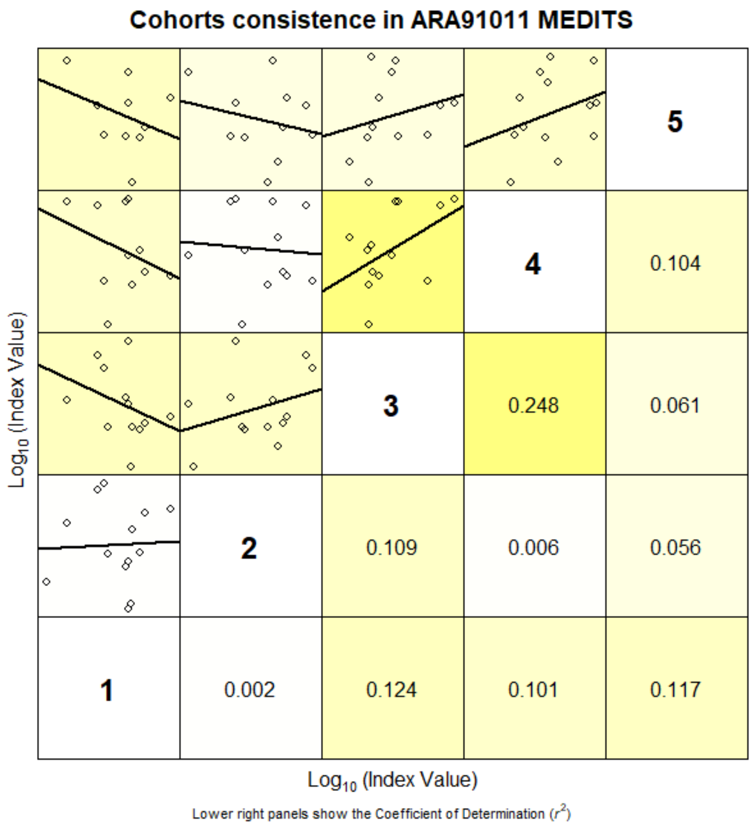


Figure 6.18.3.4. Blue and red shrimp in GSAs 9, 10 and 11. Index at age cohort consistency

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 = 5) + s(year, k = 5)***
- ***srmodel: ~factor(year)***
- ***n1model: ~s(age, k = 3)***
- ***qmodel:***
- ***IND: ~factor(replace(age, age > 4, 4))***
- ***vmodel:***
- ***catch: ~s(age, k = 3)***
- ***IND: ~1***

Results are shown in Figures 6.18.3.5 – 6.18.3.11.

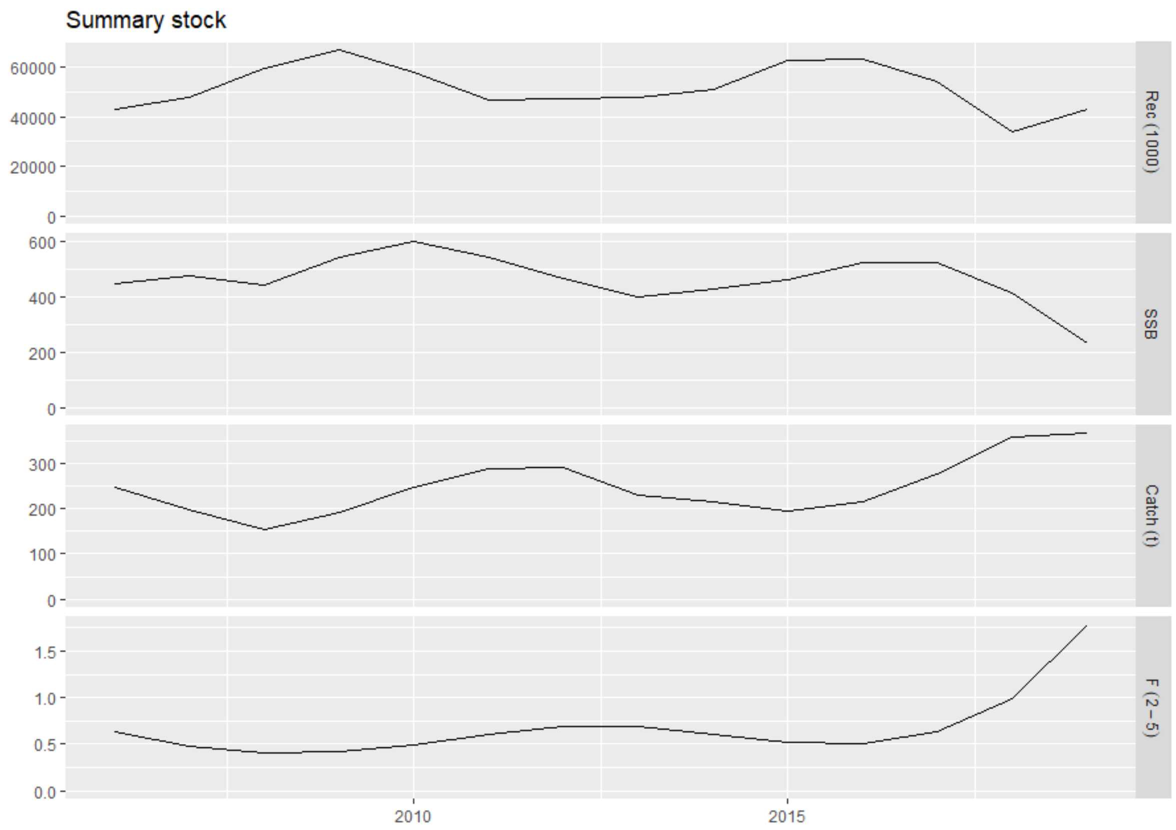
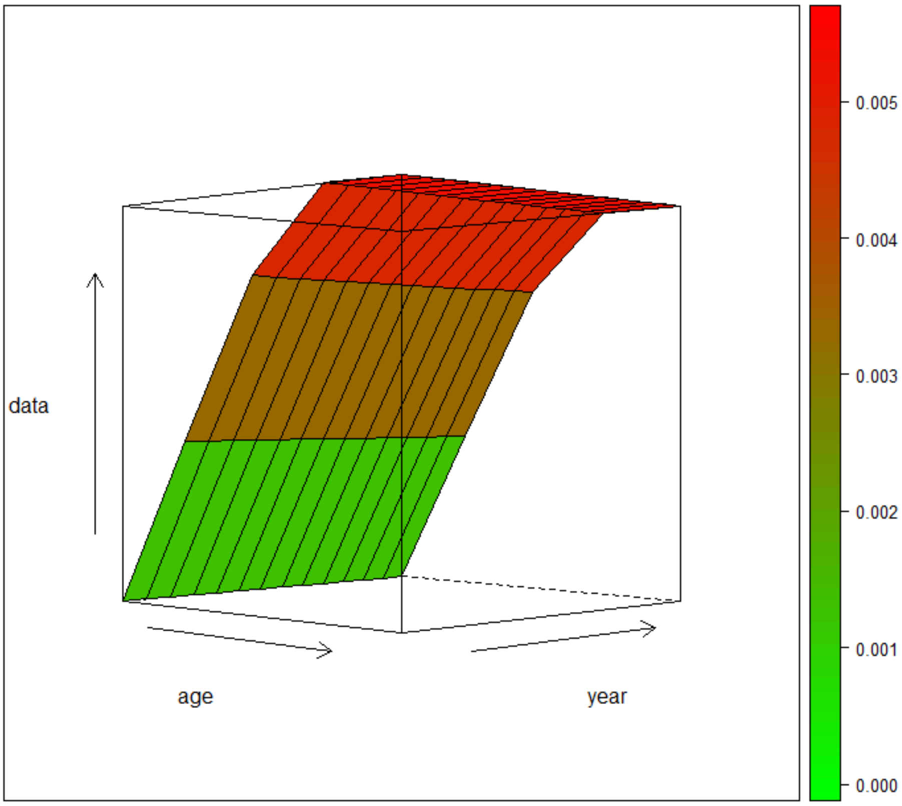
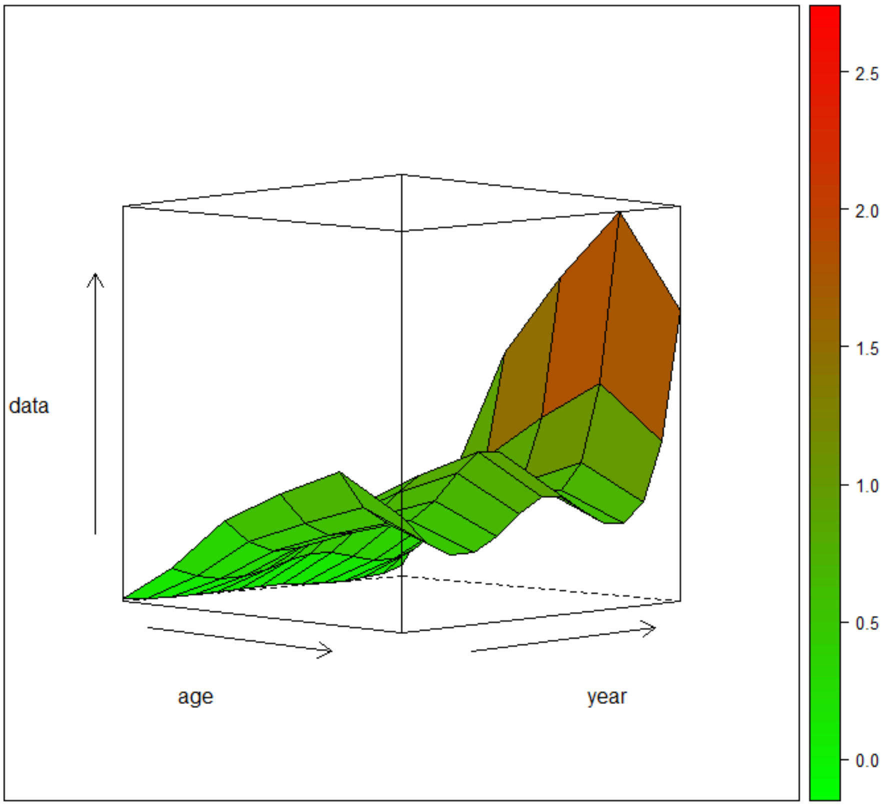


Figure 6.18.3.5. Blue and red shrimp in GSAs 9, 10 and 11. Stock summary from the final a4a model.



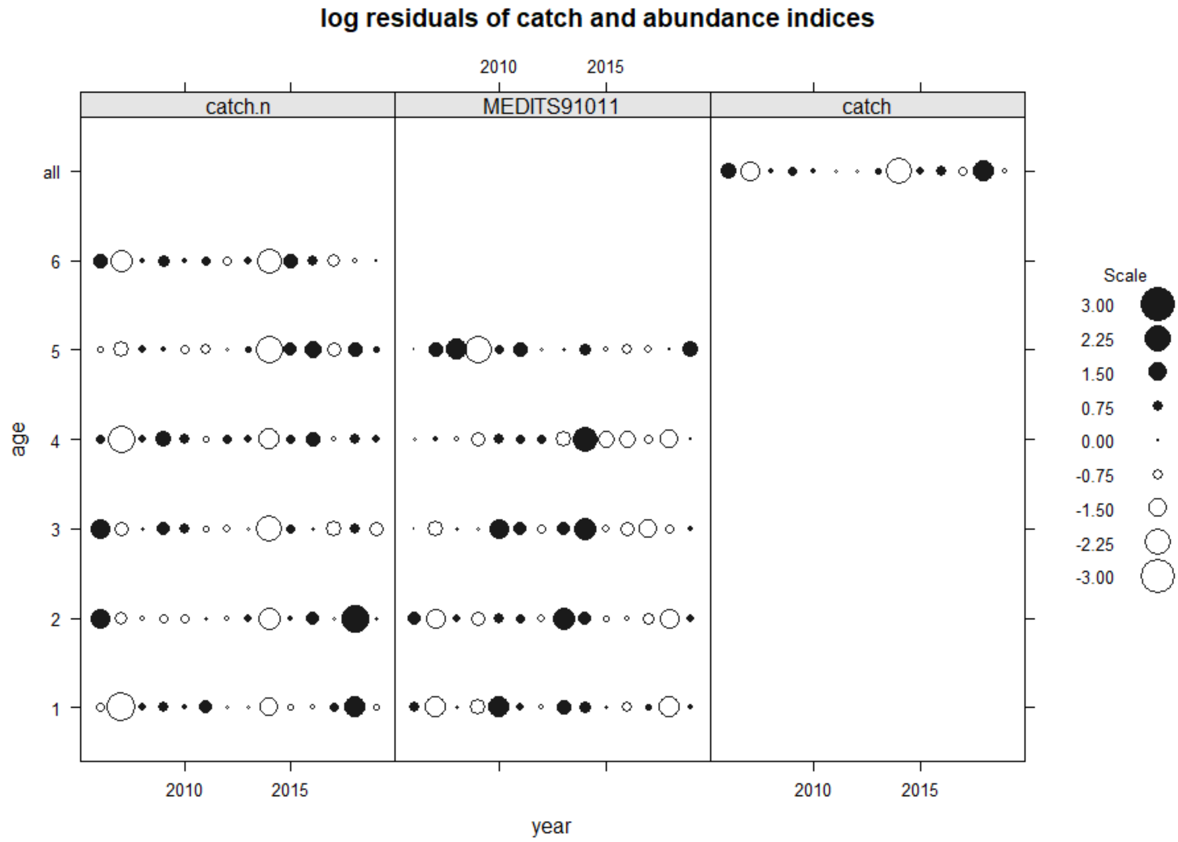
data
age
year
0.005
0.004
0.003
0.002
0.001
0.000



data
age
year
2.5
2.0
1.5
1.0
0.5
0.0

Figure

6.18.3.6. Blue and red shrimp in GSAs 9, 10 and 11. 3D contour plot of estimated catchability (top) and 3D contour plot of estimated fishing mortality (bottom) at age and year.



Figure

6.18.3.7. Blue and red shrimp in GSAs 9, 10 and 11. Standardized residuals for abundance indices and for catch numbers.

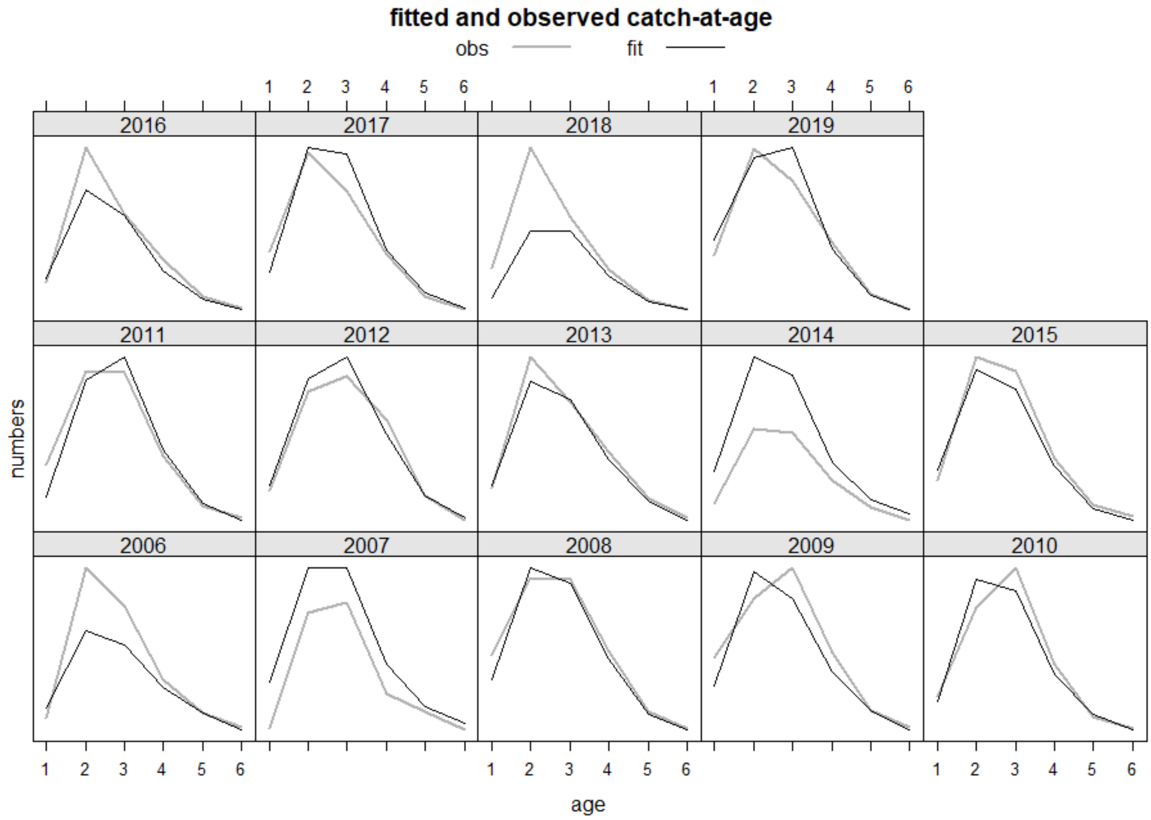


Figure 6.18.3.8. Blue and red shrimp in GSAs 9, 10 and 11. Fitted and observed catch at age.

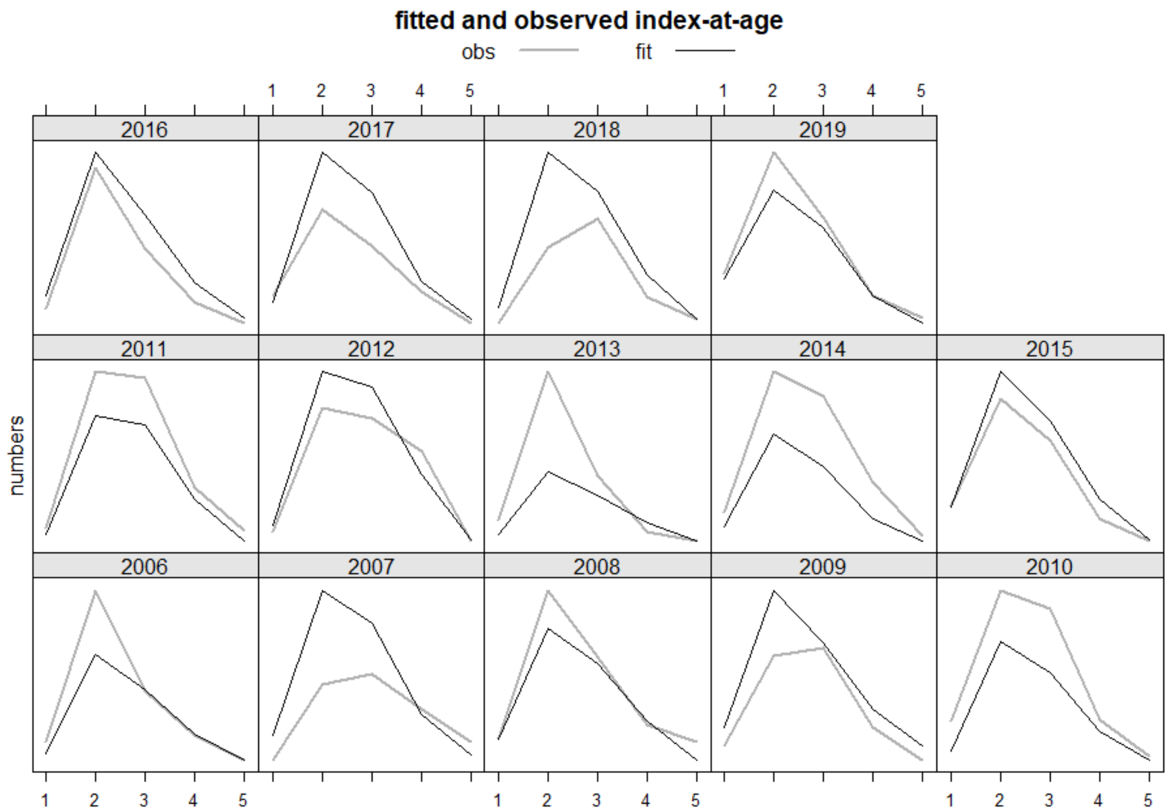


Figure 6.18.3.9. Blue and red shrimp in GSAs 9, 10 and 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 3 years back. Models results were quite stable with respect to SSB, catch and F (Figure 6.18.3.10).

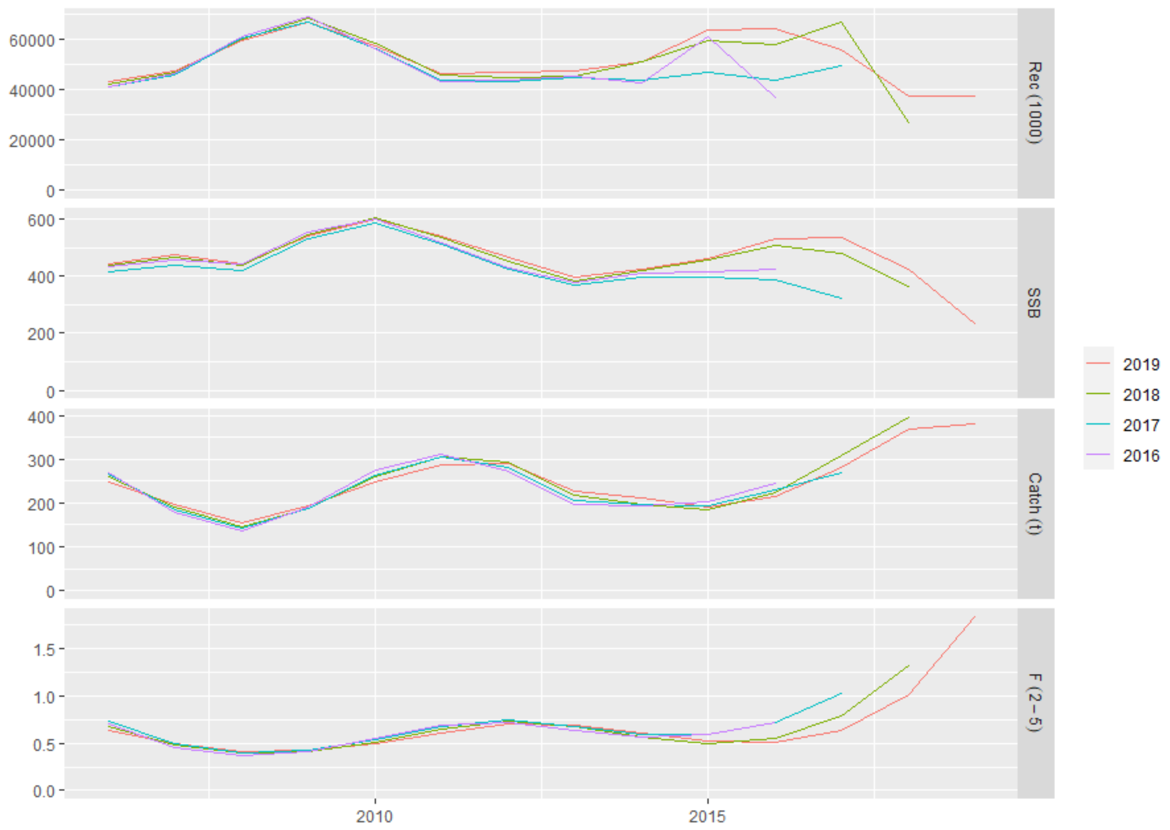


Figure 6.18.3.10. Blue and red shrimp in GSAs 9, 10 and 11. Retrospective analysis.

Simulations

In the following figures and tables, the population estimates obtained by the a4a model are provided.

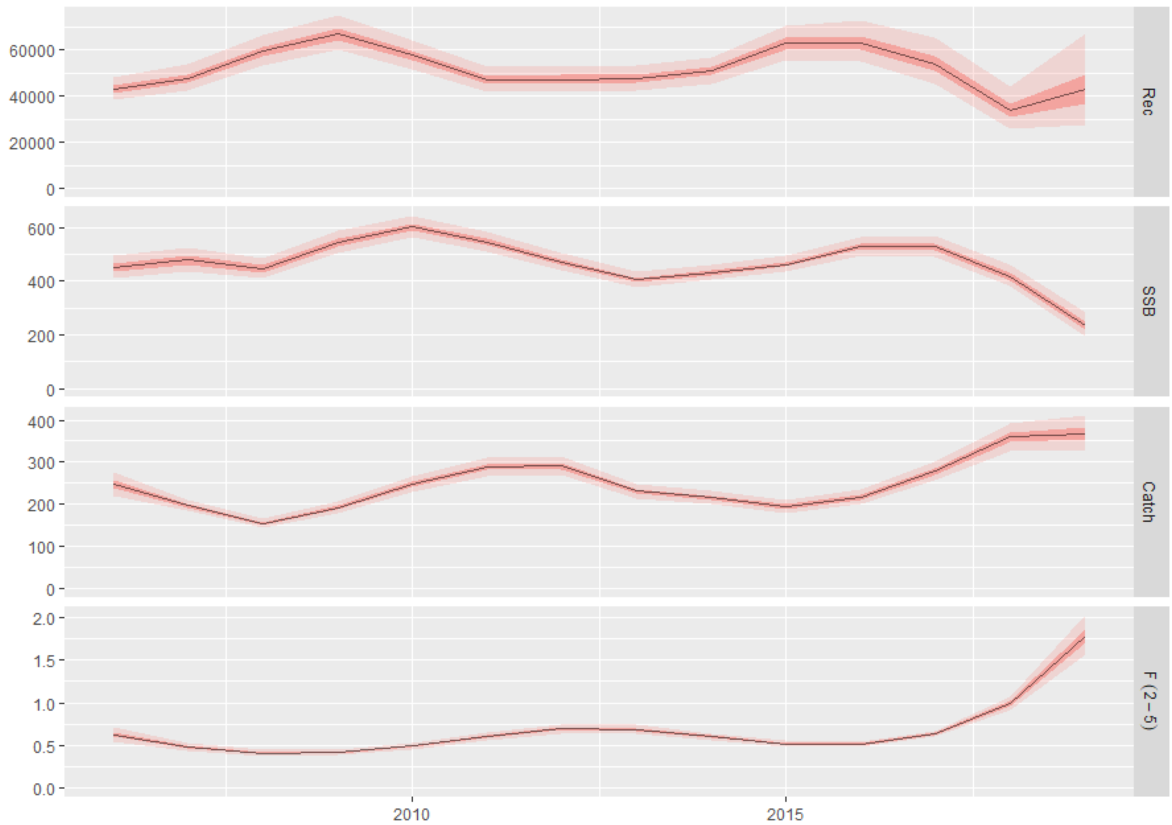


Figure 6.18.3.11. Blue and red shrimp in GSAs 9, 10 and 11. Stock summary of the simulated and fitted data for the a4a model.

Table 6.18.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Stock numbers at age (thousands) as estimated by a4a.

Year/Age	1	2	3	4	5	6
2006	42952	20146	8821	3964	1847	883
2007	47743	19174	9257	3289	1314	890
2008	59475	21502	9373	3953	1301	883
2009	66719	26900	10830	4274	1703	958
2010	57625	30166	13516	4912	1829	1149
2011	46897	25938	14691	5724	1922	1175
2012	47232	20963	12033	5593	1950	1055
2013	47549	21001	9370	4222	1713	907
2014	51005	21151	9413	3308	1303	797
2015	62832	22805	9829	3597	1132	719
2016	63112	28233	10971	4052	1359	705
2017	54283	28373	13630	4559	1547	786
2018	33840	24224	13006	5055	1501	757
2019	43108	14778	9546	3462	1080	463

Table 6.18.3.4. Blue and red shrimps in GSAs 9, 10 and 11. a4a summary results Fbar age 2-5, recruitment (thousands), catches, SSB and total biomass (tonnes).

	Fbar (2-5)	Recruitment (age1)	SSB	Total Biomass	Catch
2006	0.63	42952	448	1028	247
2007	0.484	47743	477	1067	197
2008	0.413	59475	444	1028	154
2009	0.419	66719	543	1212	192
2010	0.493	57625	600	1308	248
2011	0.608	46897	543	1182	288
2012	0.696	47232	470	1099	290
2013	0.689	47549	403	992	231
2014	0.604	51005	430	1026	216
2015	0.522	62832	461	1117	194
2016	0.513	63112	528	1245	216
2017	0.636	54283	526	1226	278
2018	0.993	33840	415	1020	359
2019	1.778	43108	232	836	366

Table 6.18.3.4. Blue and red shrimps in GSAs 9, 10 and 11. a4a results F at age.

F at age	1	2	3	4	5	6
2006	0.038	0.267	0.585	0.762	0.908	0.670
2007	0.029	0.205	0.449	0.585	0.697	0.515
2008	0.025	0.175	0.383	0.499	0.595	0.440
2009	0.025	0.177	0.389	0.506	0.603	0.446
2010	0.030	0.208	0.457	0.596	0.710	0.524
2011	0.037	0.257	0.564	0.734	0.875	0.646
2012	0.042	0.294	0.645	0.841	1.002	0.740
2013	0.042	0.291	0.639	0.833	0.992	0.733
2014	0.036	0.255	0.560	0.729	0.869	0.642
2015	0.032	0.221	0.484	0.631	0.751	0.555
2016	0.031	0.217	0.476	0.620	0.739	0.546
2017	0.038	0.269	0.590	0.768	0.916	0.676
2018	0.060	0.420	0.922	1.201	1.431	1.057
2019	0.107	0.752	1.650	2.149	2.561	1.891

Based on the a4a results, the Blue and red shrimp SSB shows a fluctuating pattern and a constant declining trend during the last five years reaching the lowest value in 2019 (232 tonnes). The number of recruits a fluctuating pattern until a minimum value reached in 2018 (33840) but increased again in 2019 to 43108. Fbar (2-5) shows a fluctuating pattern with a steep increase in the last years (Fbar 2019 = 1.78).

6.18.4 Reference Points

The time series is too short to give stock recruitment relationship, so reference points are based on equilibrium methods. The STECF EWG 20-09 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

Current F (1.78, estimated as the F_{bar2-5} in the last year of the time series, 2019) is higher than $F_{0.1}$ (0.33), 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 9, 10 and 11 is highly overfishing.

In Figures 6.18.4.1 Blue and red shrimps in GSAs 9, 10 and 11. Yield per Recruit model and histogram of the probabilities of $F_{0.1}$, Fbar and F/ F_{MSY} according to 300 simulations are reported

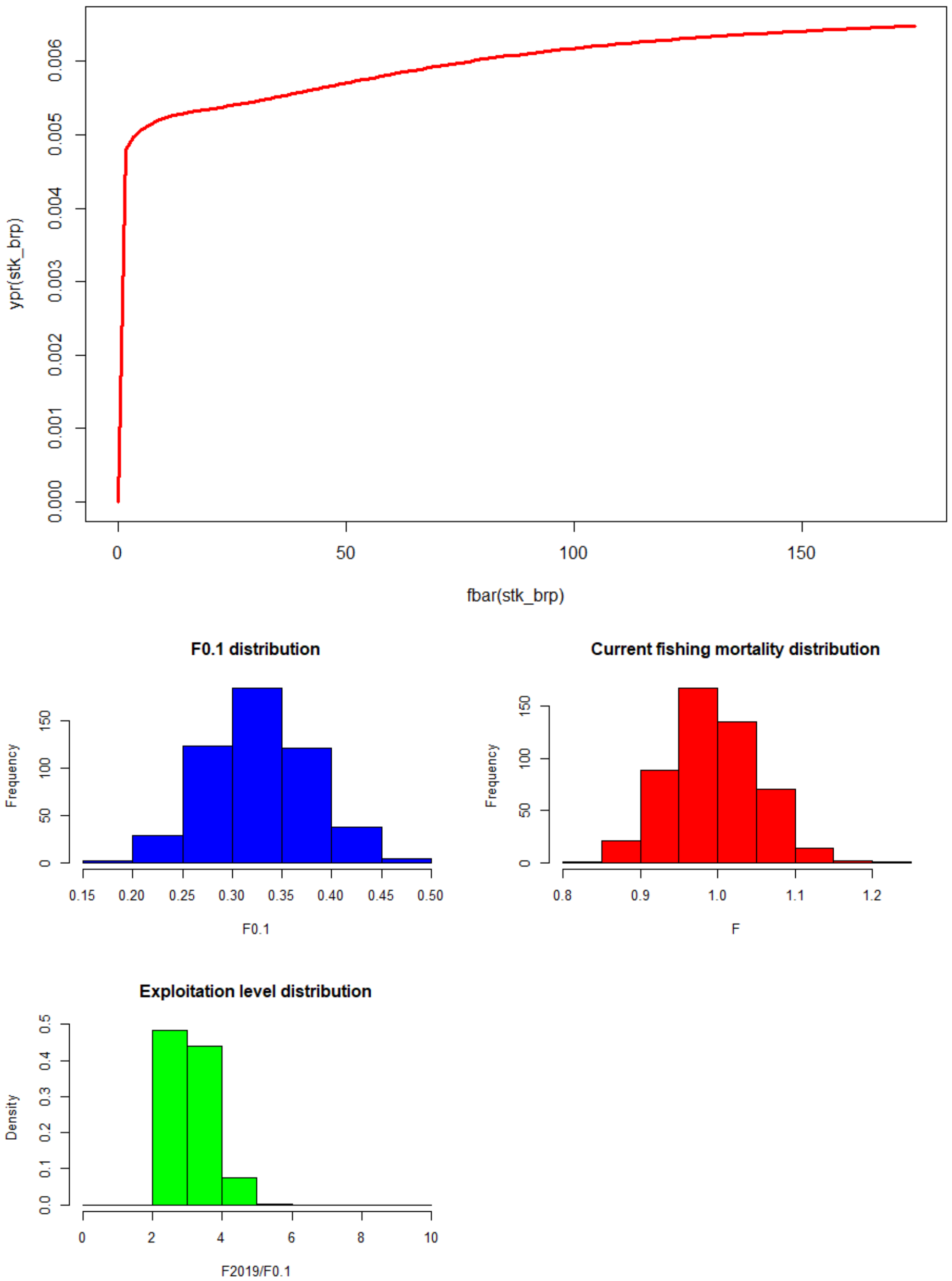


Figure 6.18.4.1. Blue and red shrimp in GSAs 9, 10 and 11. Yield per Recruit model (up) and histogram of probability/density for $F_{0.1}$, Fcurr and level of exploitation values (iter=300)

6.18.5 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 choice of parameter values used followed the procedure described in Section 4.3. An average of the last three years has been used for biological parameters. F status quo was set equal to the last year (2019) Fbar value (1.78)

Recruitment shows a fluctuating pattern over the period of the assessment, so it has been estimated from the population results as the geometric mean of the whole time series years

(51741 individuals). The assumptions are summarized in Table 6.18.5.1, and the results of the short term forecast are given in Table 6.18.5.2

Table 6.18.5.1 Blue and red shrimp in GSA 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, based average of 2016-2018
$F_{ages\ 2\text{-}5}$ (2020)	1.78	F2019 used to give F status quo for 2020
SSB (2020)	187	Stock assessment 1 January 2019
R_{age0} (2020,2021)	51741 individuals	Mean of the time series years 2006 - 2019
Total catch (2020)	221	Assuming F status quo for 2019

Table 6.18.5.2 Blue and red shrimp in GSAs 9, 10 and 11. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2021	SSB* 2020	SSB* 2022	Change_SSB 2020-2022(%)	Change_Catch 2019-2021(%)
High long term yield ($F_{0.1}$)	0.18	0.33	366	61	187	431	130.45	-83.33
F upper	0.25	0.45	366	81	187	400	113.71	-77.9
F lower	0.12	0.22	366	42	187	463	147.11	-88.49
FMSY transition	0.73	1.29	366	187	187	258	38.07	-48.84
Zero catch	0	0	366	0	187	537	187.1	-100
Status quo	1	1.78	366	231	187	212	13.36	-36.9
Different Scenarios	0.1	0.18	366	35	187	475	154.04	-90.56
	0.2	0.36	366	66	187	424	126.53	-82.08
	0.3	0.53	366	94	187	381	103.48	-74.43
	0.4	0.71	366	119	187	344	84.03	-67.51
	0.5	0.89	366	142	187	314	67.5	-61.21
	0.6	1.07	366	163	187	287	53.37	-55.48
	0.7	1.24	366	182	187	264	41.19	-50.23
	0.8	1.42	366	200	187	245	30.64	-45.42
	0.9	1.6	366	216	187	227	21.44	-40.99
	1.1	1.96	366	245	187	199	6.23	-33.11
	1.2	2.13	366	258	187	187	-0.1	-29.6
	1.3	2.31	366	270	187	176	-5.75	-26.32
	1.4	2.49	366	281	187	167	-10.82	-23.27
	1.5	2.67	366	292	187	158	-15.39	-20.41
	1.6	2.84	366	301	187	151	-19.52	-17.73
	1.7	3.02	366	311	187	144	-23.28	-15.21
	1.8	3.2	227	288	221	183	-17	-26
	1.9	3.38	227	296	221	176	-20	-24
	2	3.56	227	304	221	170	-23	-22

* SSB at mid-year

6.19 GIANT RED SHRIMP IN GSA 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).

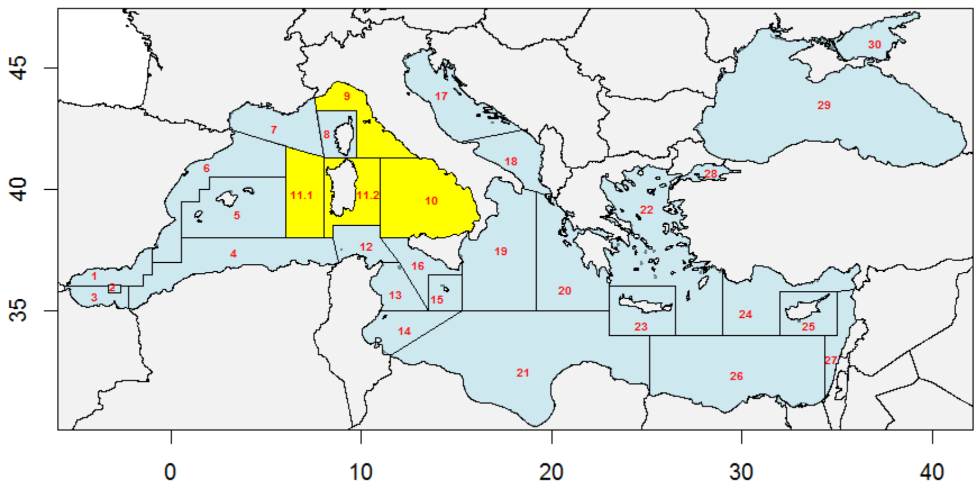


Figure 6.19.1.1 Limit of Geographical Sub-Areas (GSAs) 9, 10, 11.

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 to slice the size frequency

distributions by sex in the three GSAs. As the previous year, 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 GSAs 9, 10 and 11. 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	$years^{-1}$	0.435	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 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**

6.19.1 DATA

6.19.1.1 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 resulted lower along the time series in comparison with 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. Between 2017 and 2019, landings show an increase due to a sharp increase in GSA10 (and GSA 11 in 2017). The time series of landings by GSA and gear are shown in Figures 6.19.2.1.2-6.19.2.1.4.

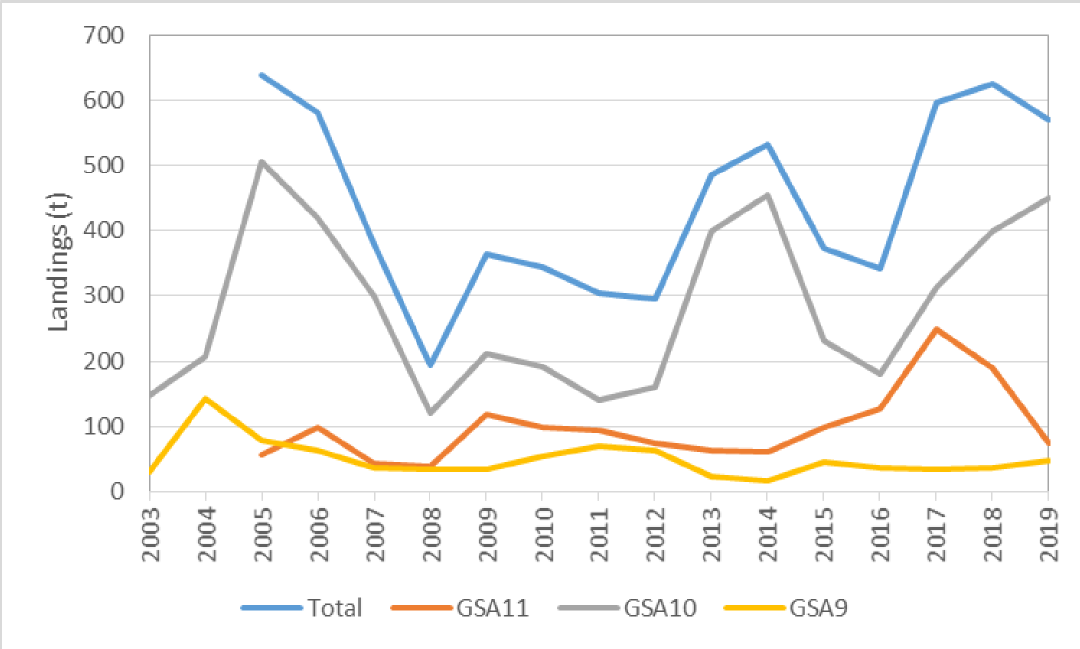


Figure 6.19.2.1.1 Giant red shrimp in GSAs 9, 10, 11: landings by GSA and total landings.

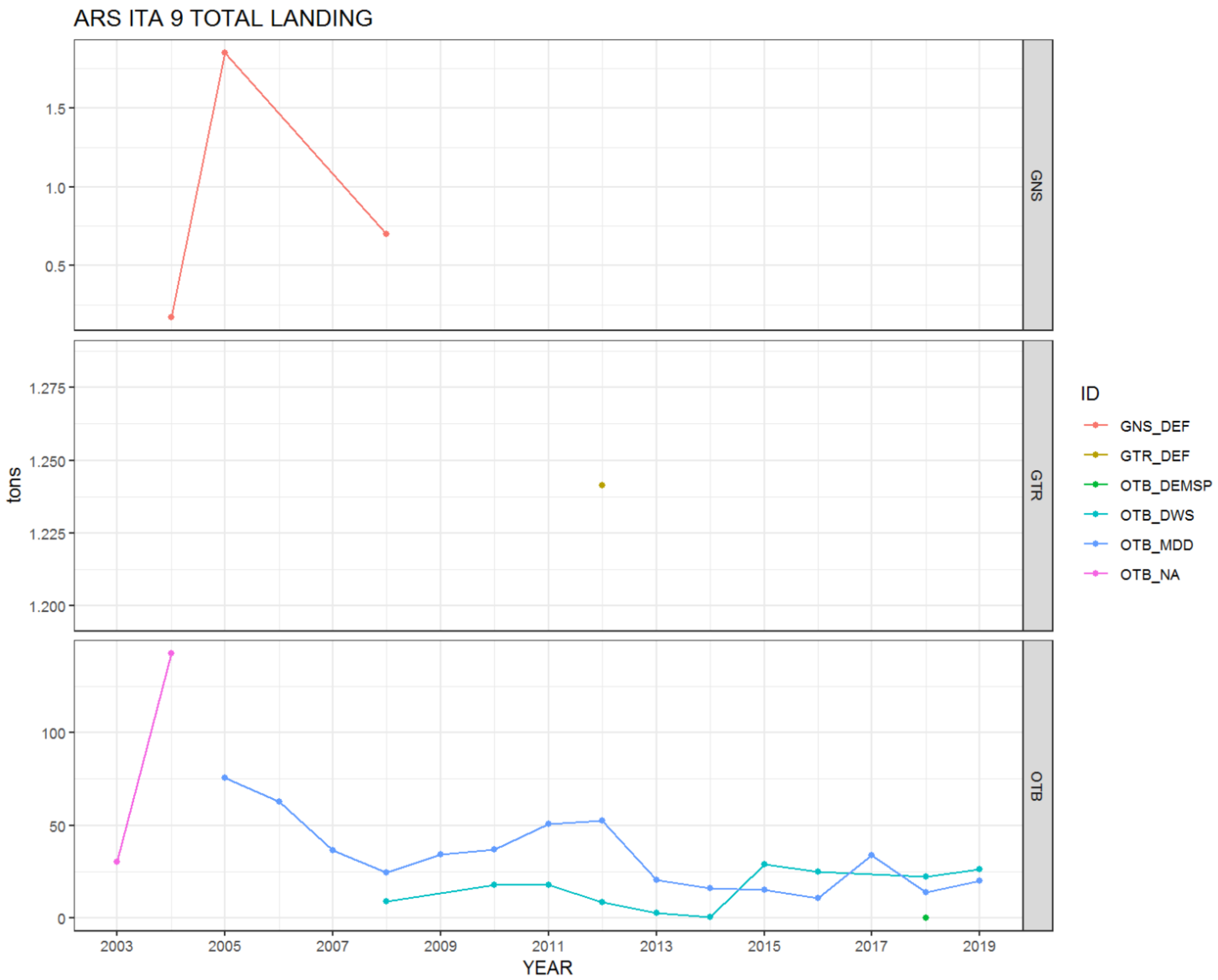


Figure 6.19.2.1.2. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 9.

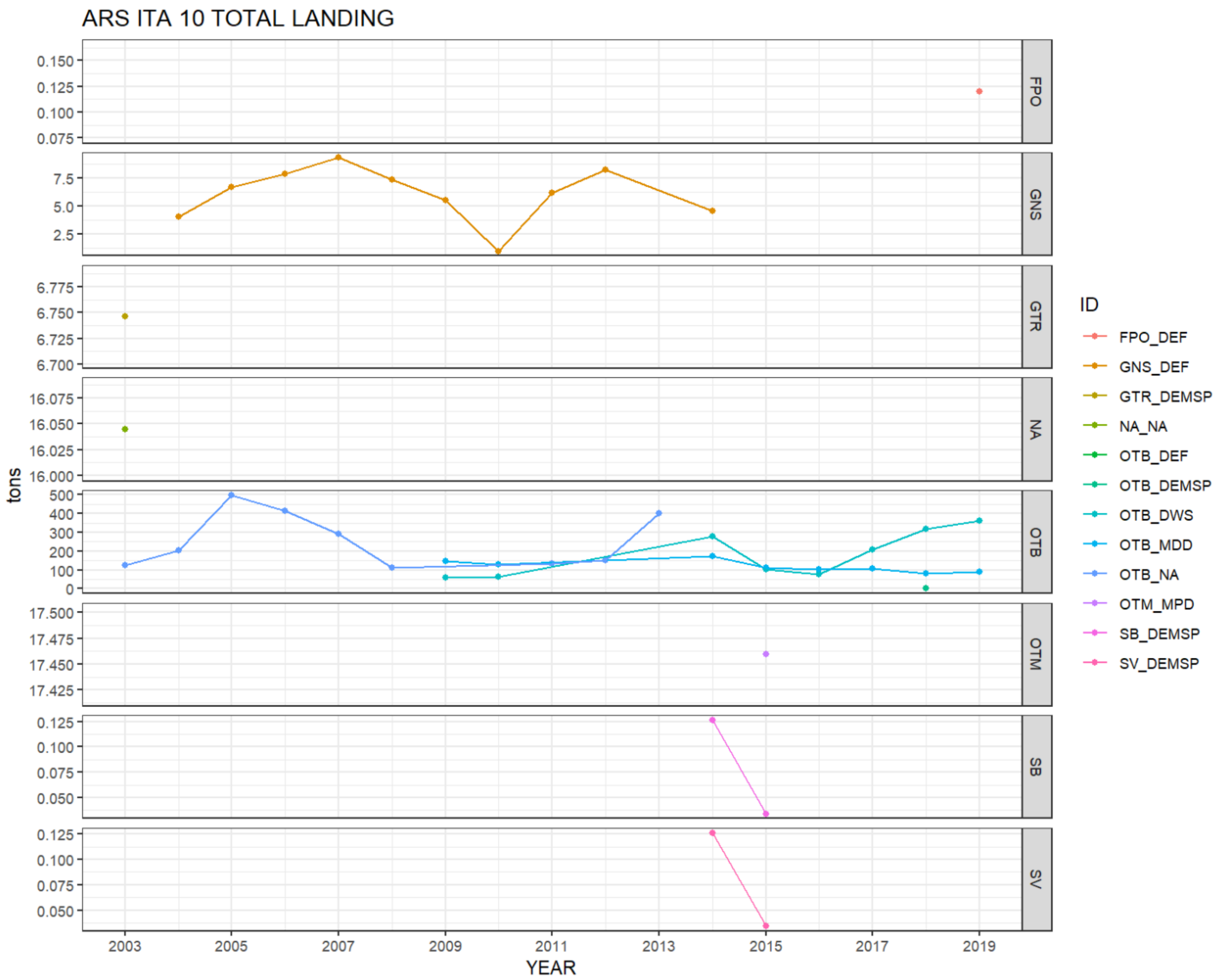


Figure 6.19.2.1.3. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 10.

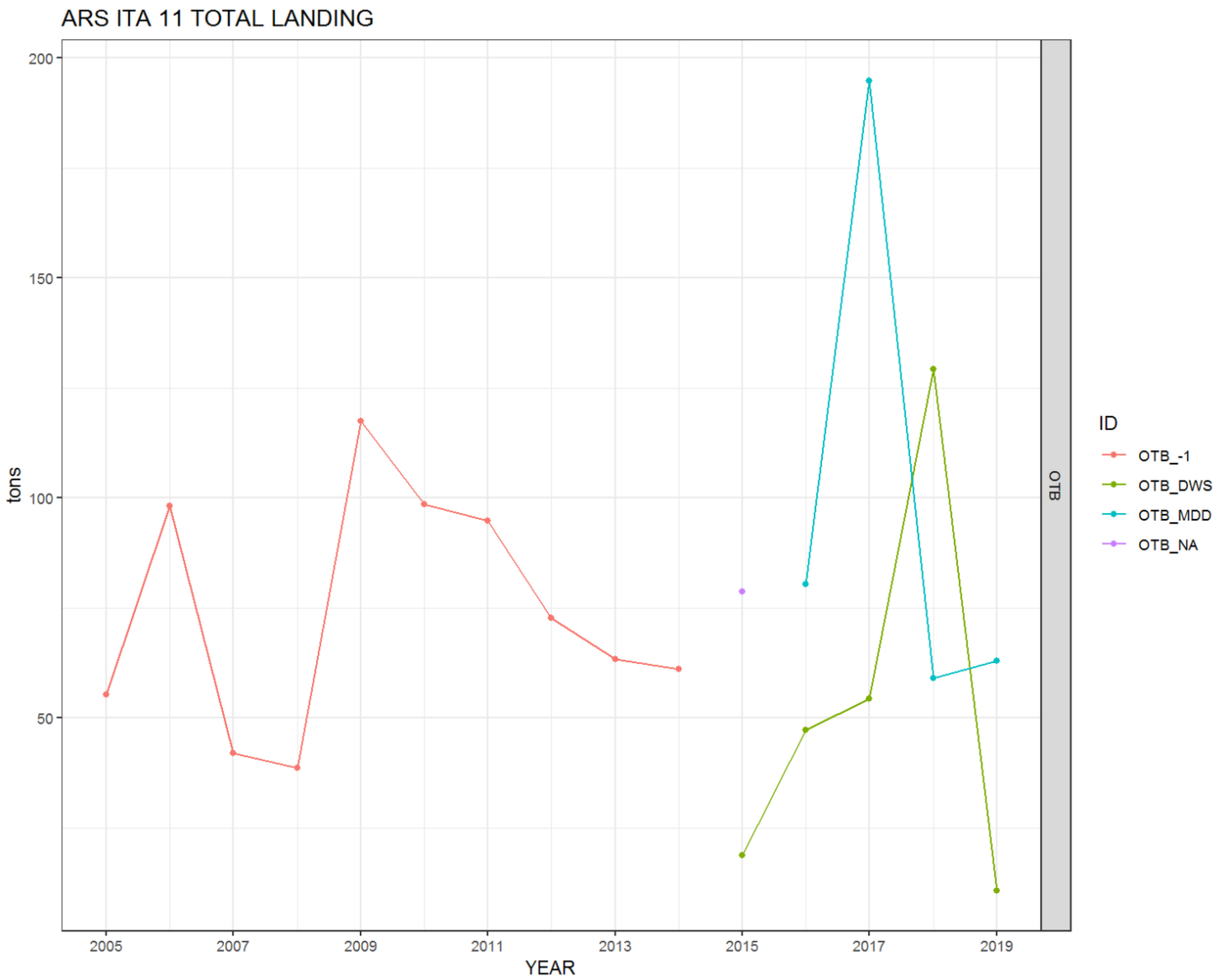


Figure 6.19.2.1.4. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 11.

Although the bulk of the production in GSA 10 is coming from the trawl fisheries (mostly 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 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	411.7	7.9	62.6	
2007	42.0	291.0	9.3	36.7	
2008	38.6	112.8	7.3	33.1	0.7
2009	117.4	206.3	5.4	34.3	
2010	98.6	189.2	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	97.8	214.6	17.5	44.2	
2016	127.6	179.1		35.8	
2017	249.2	325.9		33.6	
2018	188.4	416.2		36.4	
2019	73.6	450.1	0.1	46.2	0.0

Due to the low values of LFDs for GSA 10 in 2019, the group decided to substitute this LFD with the one relative to 2019 for both 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.

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.

LFDs of discards of giant red shrimp included in the assessment are shown in Figures 6.19.2.1.8 - 6.19.2.1.9.

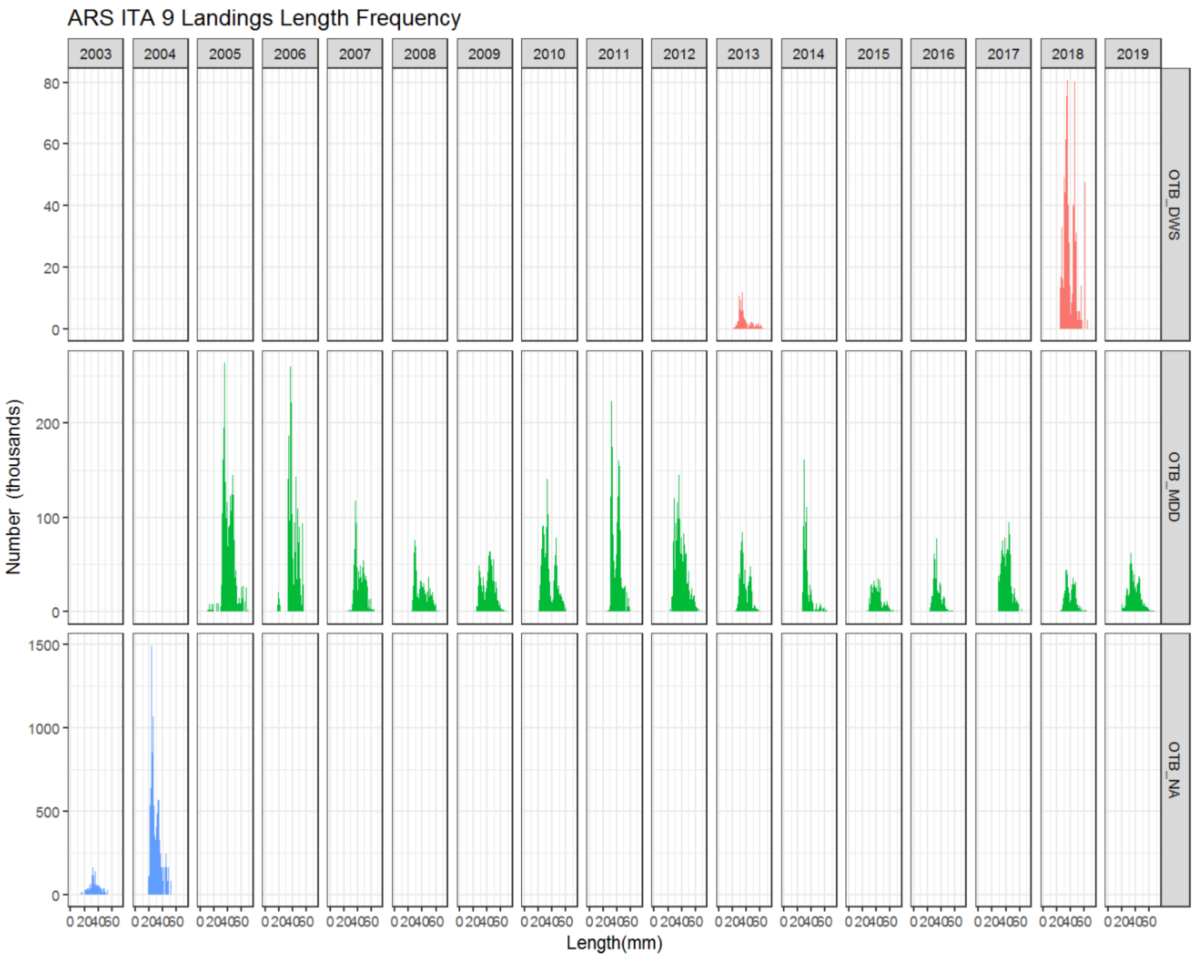


Figure 6.19.2.1.5. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 9.

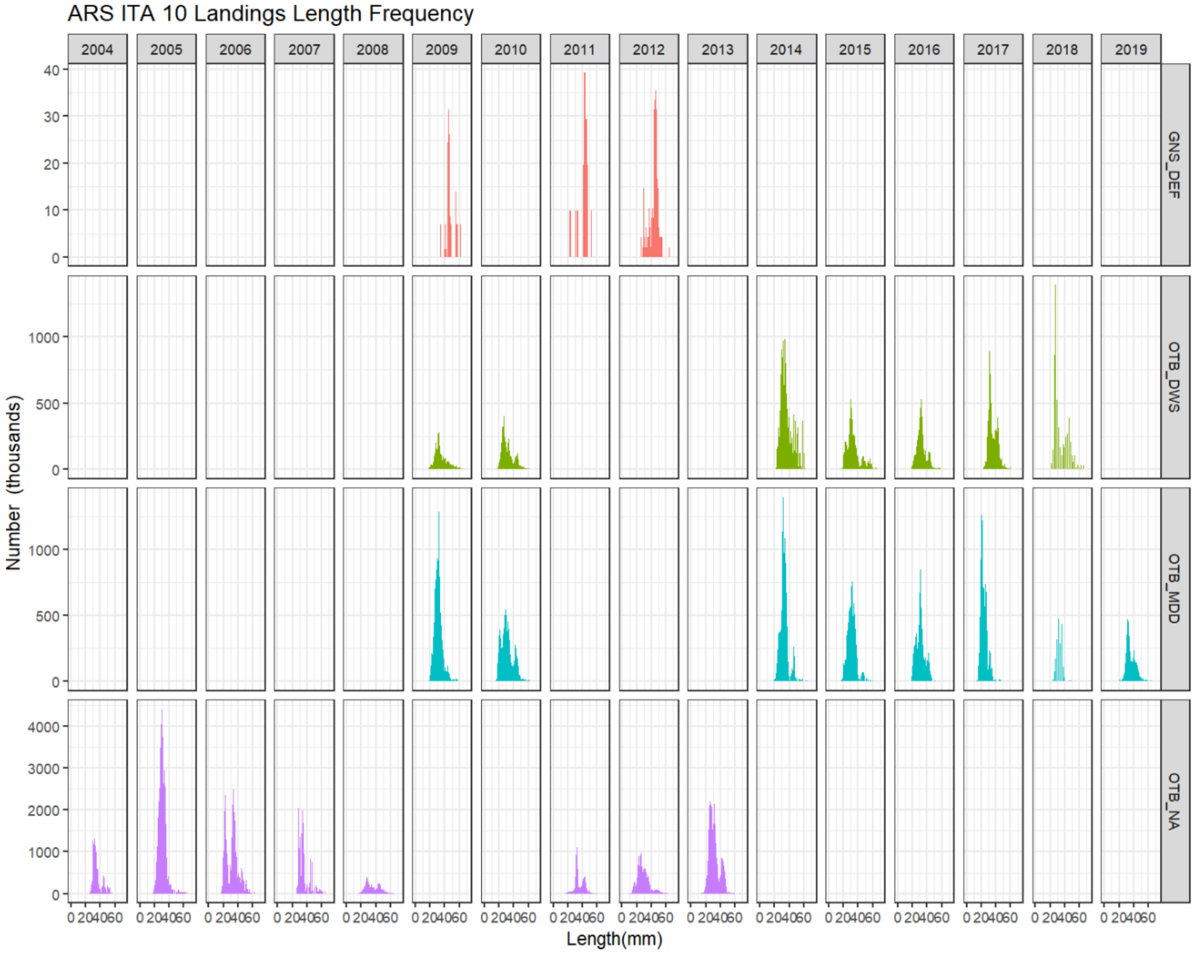


Figure 6.19.2.1.6. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 10.

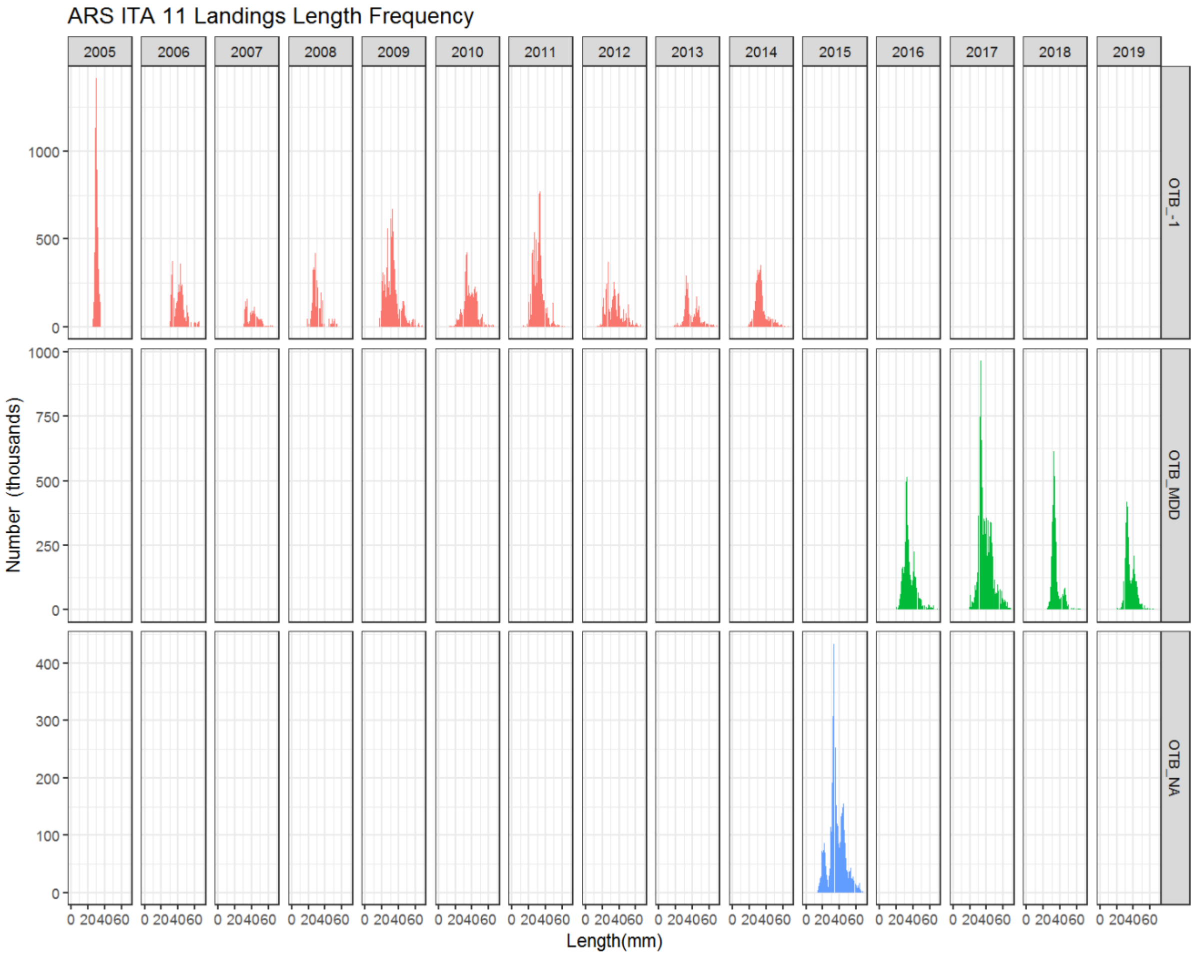


Figure 6.19.2.1.7. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 11.

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

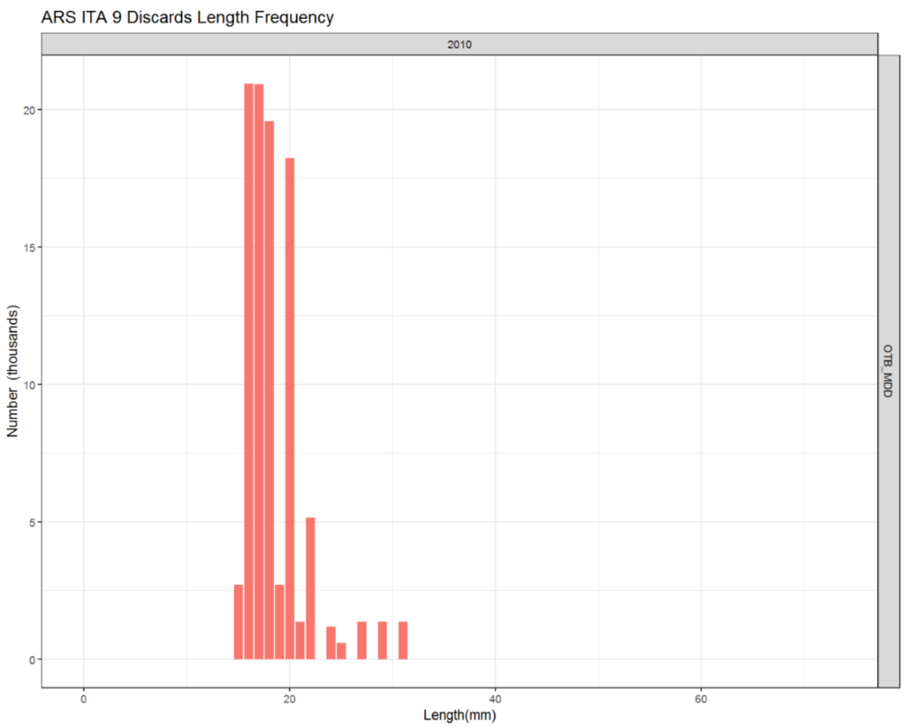


Figure 6.19.2.1.8. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 9.

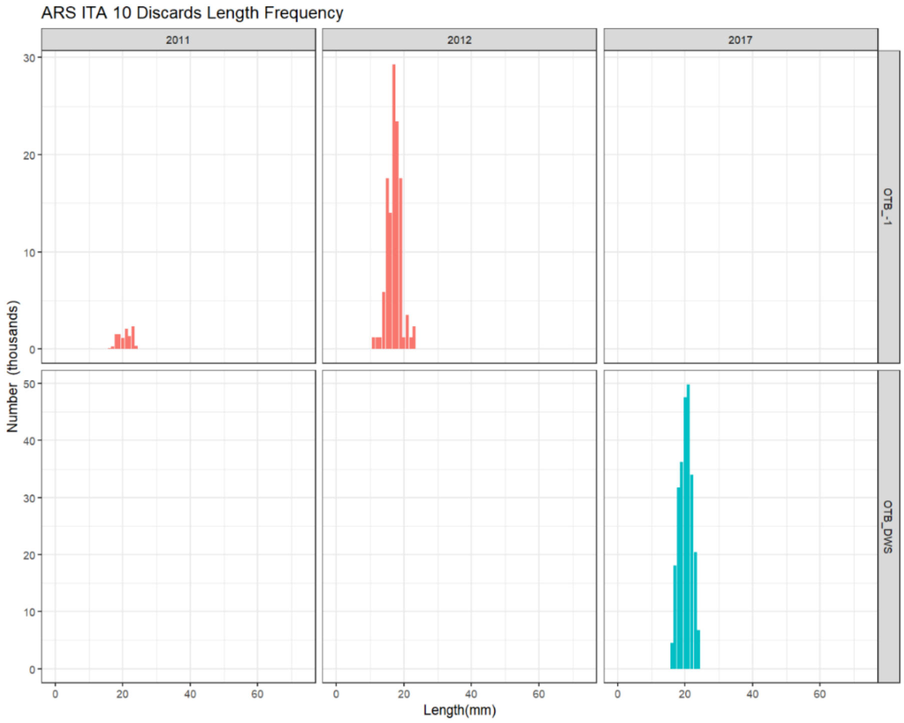


Figure 6.19.2.1.9. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 10.

6.19.1.2 EFFORT

The total effort of the trawl fleets operating in the three GSAs (9, 10, 11), expressed as Days at sea, has shown a progressive decrease in the period 2005-2018 (Table 6.19.2.2.1 and Figure 6.19.2.2.1). It varied from about 146,000 in 2005 to around 99,000 in 2018, with a minimum in 2012 (94,000). There is no information on the specific effort directed to giant red shrimp.

Table 6.19.2.2.1. Giant red shrimp in GSAs 9, 10, 11: Summary of the OTB effort (Days at sea) by year and GSA (and total for the three GSAs).

Year	GSA 9	GSA 10	GSA 11	Total
2005	67714	50056	28645	146415
2006	62517	38364	22836	123716
2007	64161	38151	22321	124633
2008	49759	38109	19435	107303
2009	53330	36749	20128	110207
2010	52606	31741	19321	103668
2011	50737	33256	17018	101011
2012	47851	31223	15472	94547
2013	51715	38270	15872	105858
2014	51286	42227	17583	111096
2015	52900	30709	15278	98887
2016	51257	35479	16926	103661
2017	47457	36271	16285	100013
2018	44296	33570	21190	99056

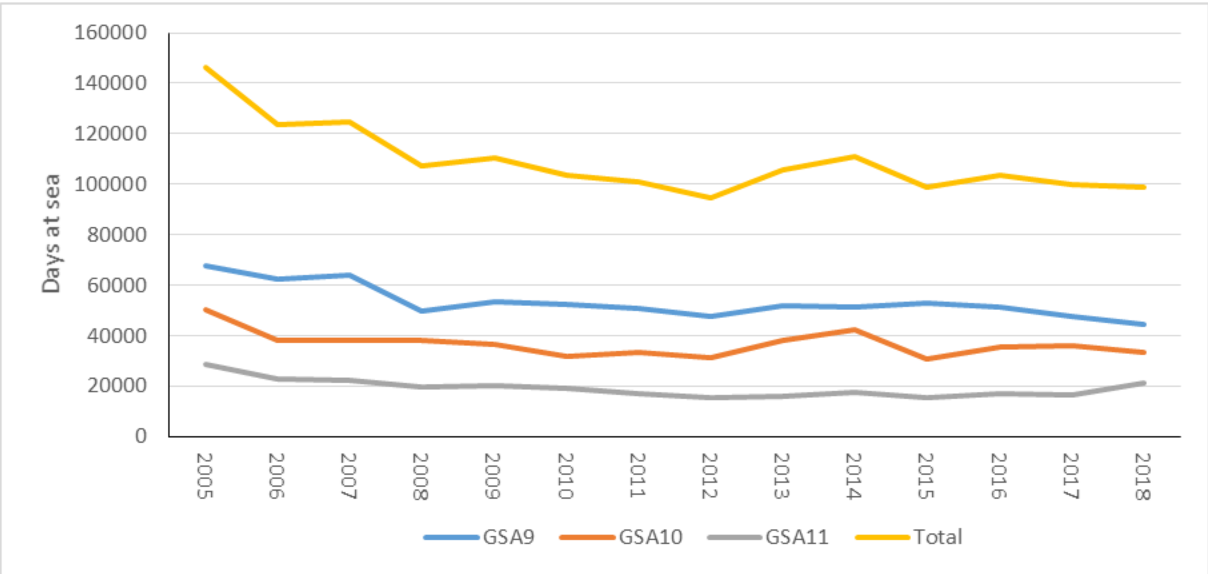


Figure 6.19.2.2.1. Giant red shrimp in GSAs 9, 10, 11: Trend of OTB effort (Days at sea) by GSA and total (GSAs 9, 10, 11).

6.19.1.3 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 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).

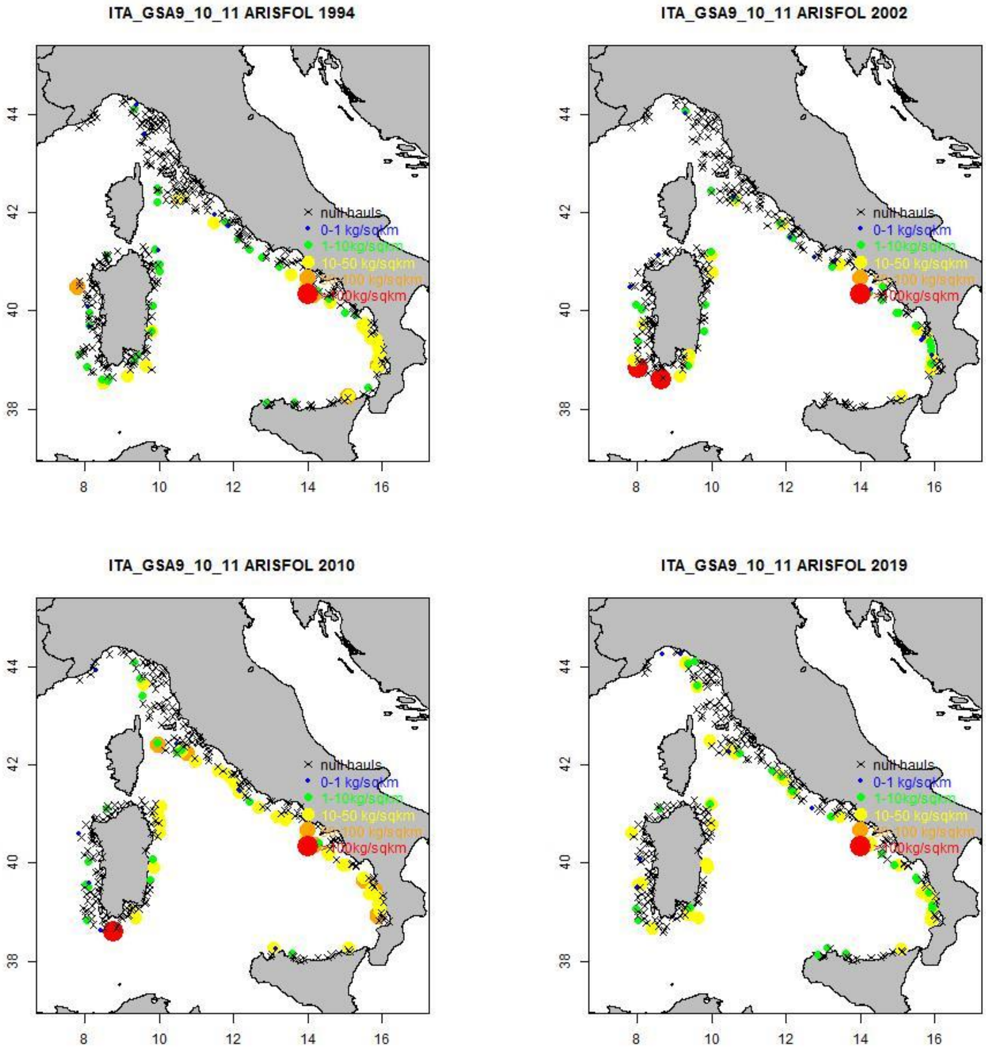
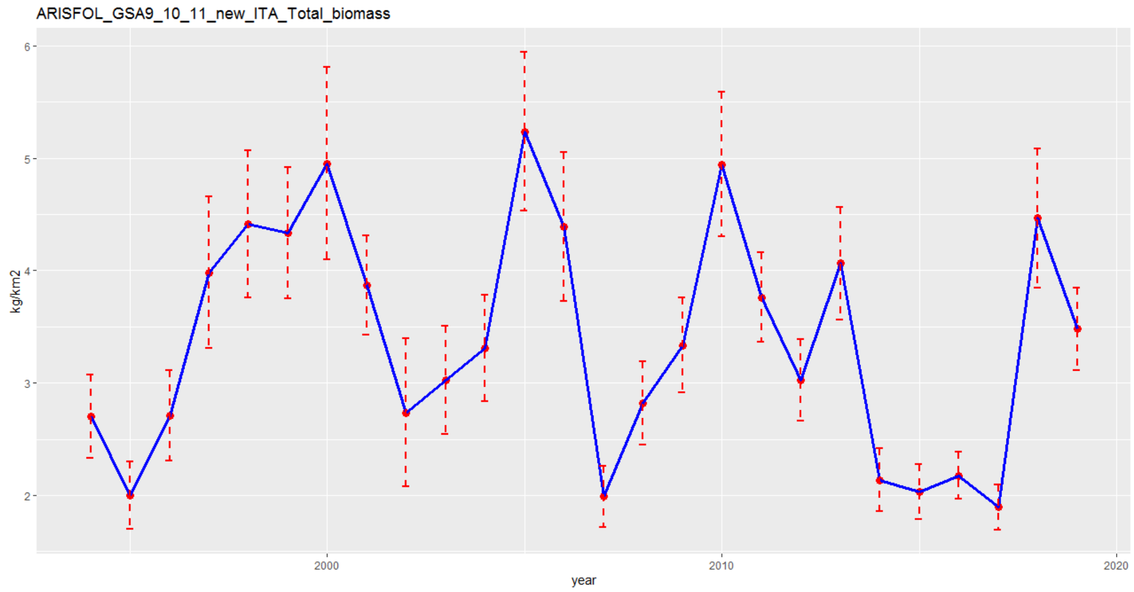


Figure 6.19.2.3.1 Giant red shrimp in GSAs 9, 10, 11: distribution pattern in the period 1994-2019 (MEDITS survey). Maps for the years 1994, 2002, 2010 and 2019 are shown.

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.



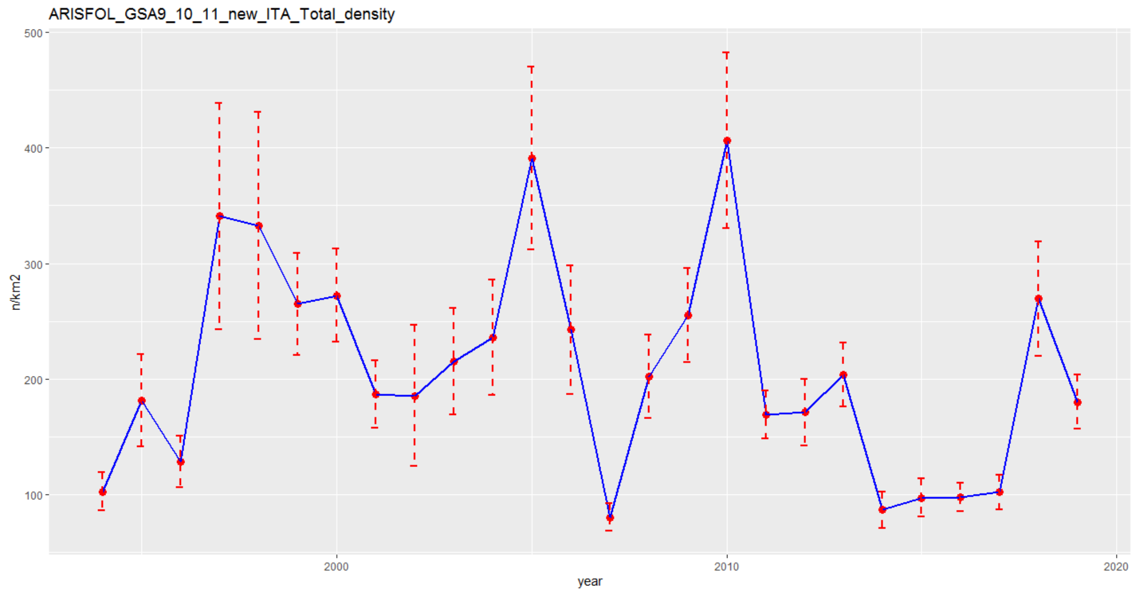


Figure 6.19.2.3.2. Giant red shrimp in GSAs 9, 10 and 11: MEDITS standardized biomass and density indices (10-800 m).

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 2019 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, 1994-2019.

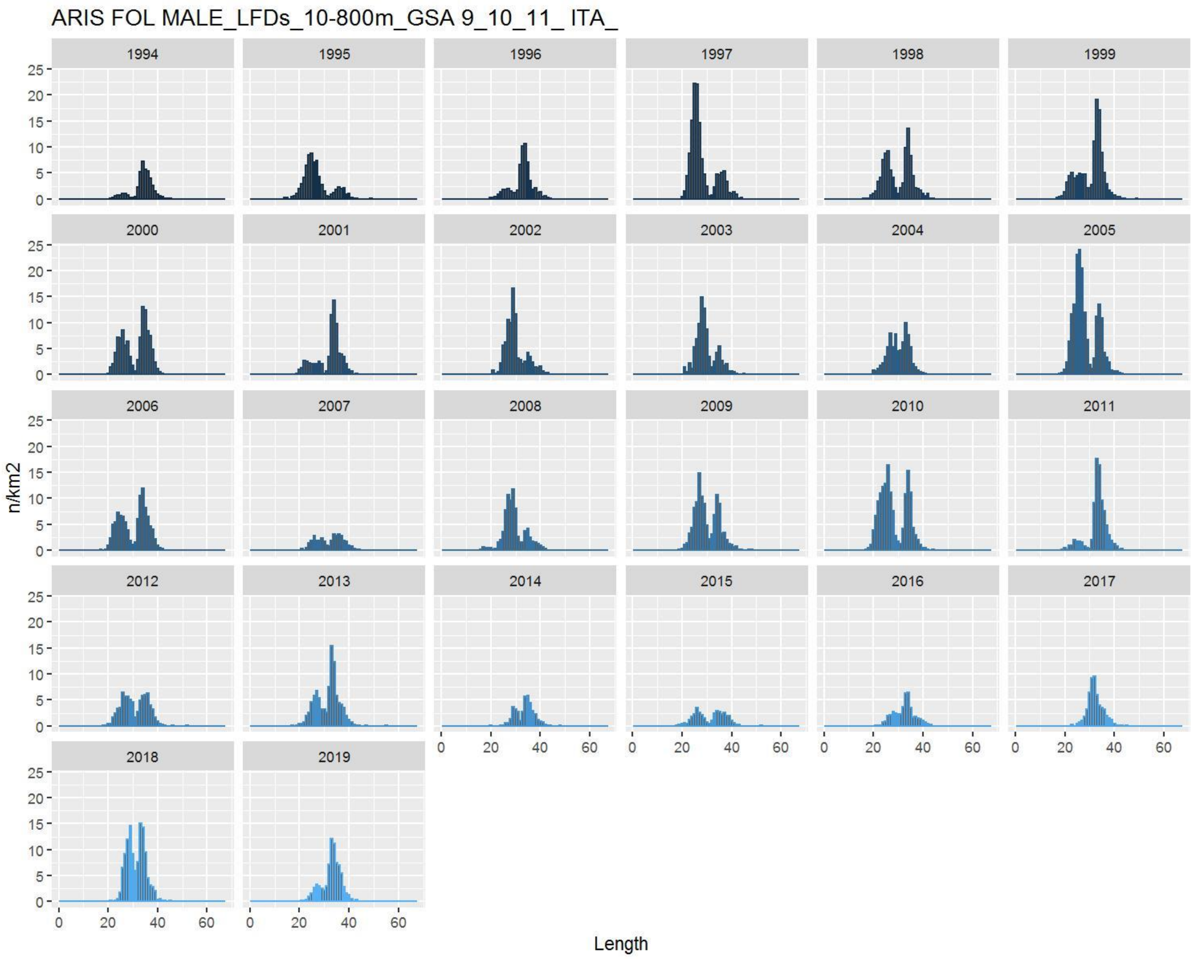


Figure 6.19.2.3.4. Giant red shrimp in GSAs 9, 10 and 11: stratified abundance indices by size for males, 1994-2019.

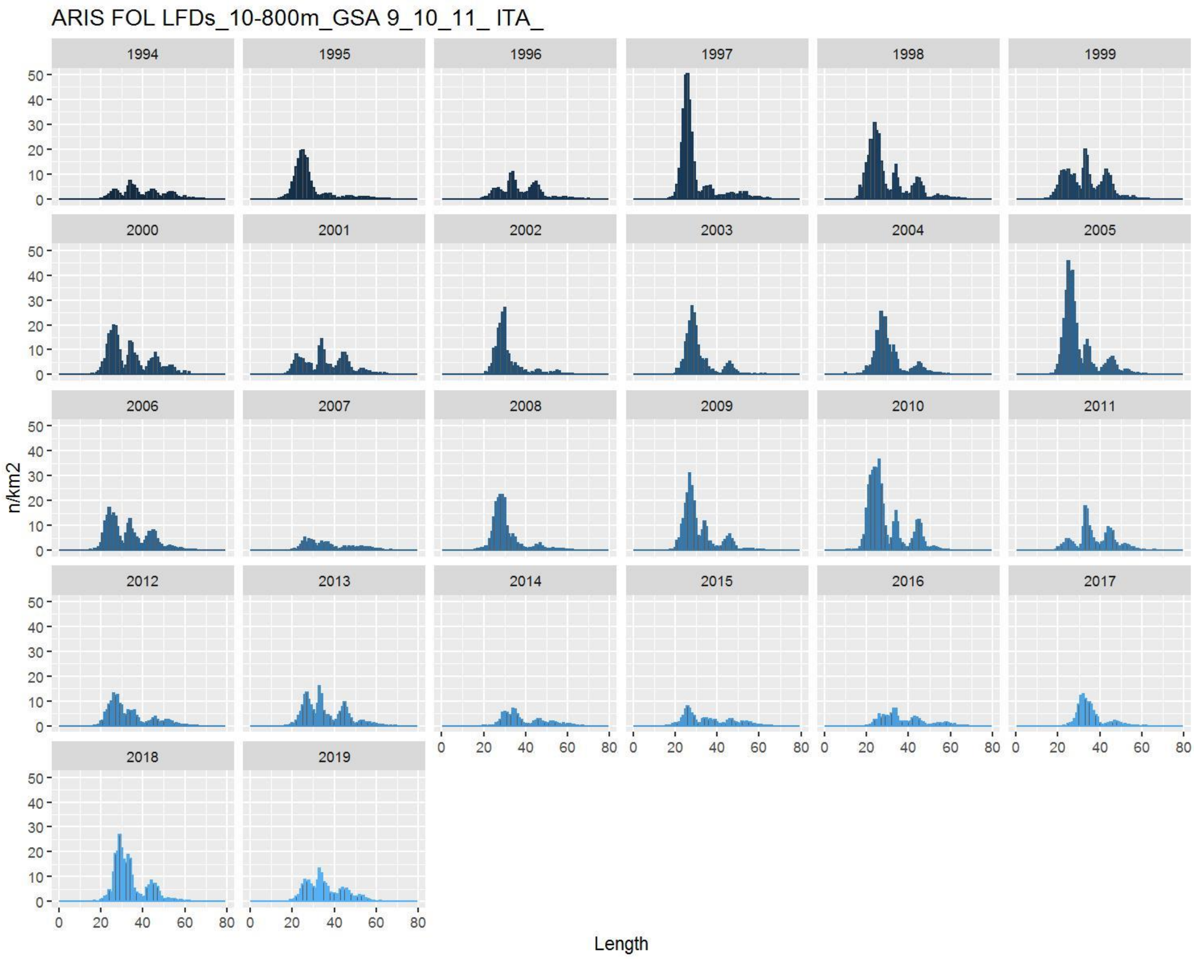


Figure 6.19.2.3.5 Giant red shrimp in GSAs 9, 10 and 11: total stratified abundance indices by size, 1994-2019.

6.19.2 STOCK ASSESSMENT

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 2005-2019 for the catch data and 2005-2019 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 was SOP corrected [SOP = Landings / Σa (total catch numbers at age a x catch weight-at-age a)]. However, the correction factor that resulted was low.

In both catches and survey, a plus group at age 4 was set. The plus group in the survey was estimated separately and not estimated using the a4a routine.

F_{bar} range was fixed at 1-3.

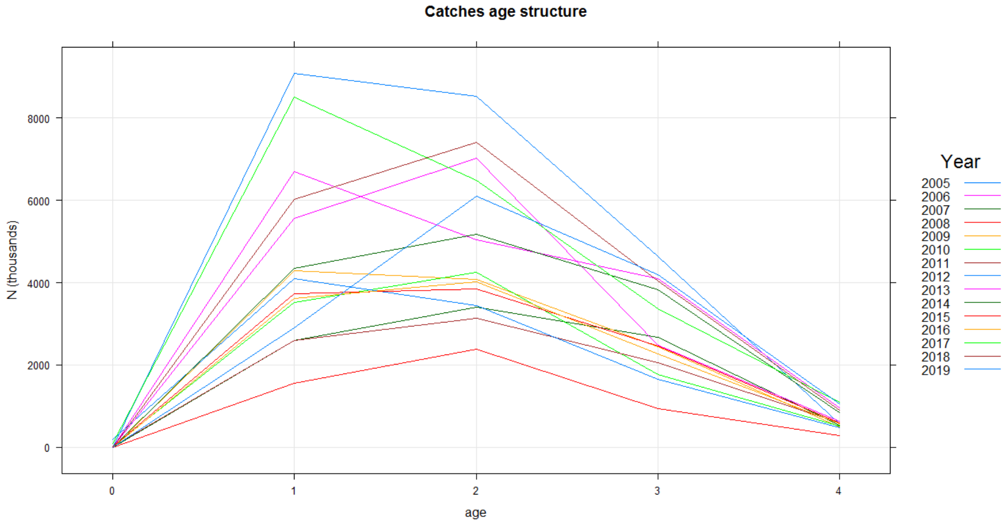


Figure 6.19.3.1. Giant red shrimp in GSAs 9, 10 and 11: catch-at-age distribution by year of the catches (2005-2019).

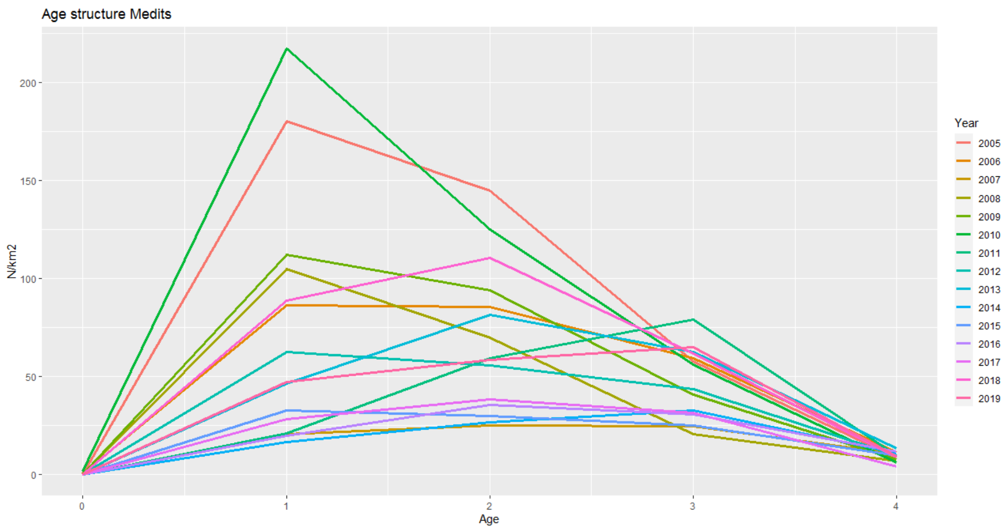


Figure 6.19.3.2. Giant red shrimp in GSAs 9, 10 and 11: catch-at-age distribution by year of the MEDITS survey (2005-2019).

Table 6.19.3.1. Giant red shrimp in GSAs 9, 10 and 11: catch-at-age matrix (thousands).

Age	2005	2006	2007	2008	2009
0	4.53	0.03	0.03	0.04	0.27
1	9079.80	6689.60	2603.10	1559.00	4280.50
2	8527.20	5031.50	3406.00	2382.50	4078.10
3	4629.70	4092.00	2673.00	936.83	2440.80
4+	573.75	957.48	532.24	279.59	493.57
Age	2010	2011	2012	2013	2014
0	18.34	6.09	193.90	3.86	0.03
1	3528.90	2587.40	4100.60	5568.90	4352.40
2	4252.00	3134.40	3443.80	7022.70	5170.60
3	1770.40	2064.80	1653.40	2471.10	3826.90
4+	510.04	588.62	472.97	627.57	852.77
Age	2015	2016	2017	2018	2019
0	15.95	1.14	93.87	0.27	0.09
1	3729.40	3618.80	8510.50	6019.70	2901.20
2	3855.40	4015.30	6493.80	7411.10	6102.70
3	2469.00	2264.00	3366.80	4034.10	4192.60
4+	595.47	578.90	1093.10	894.92	1048.40

Table 6.19.3.2. Giant red shrimp in GSAs 9, 10 and 11: tuning data (MEDITS survey, n/km^2).

Age	2005	2006	2007	2008	2009
0	0.16	0.36	0.00	0.03	0.08
1	180.14	86.31	20.44	105.05	112.06
2	144.64	85.38	24.92	69.67	94.01
3	57.54	59.14	24.57	20.66	40.58
4+	8.39	11.39	10.62	6.86	7.75
Age	2010	2011	2012	2013	2014
0	1.46	0.11	0.02	0.04	0.00
1	217.42	20.79	62.43	46.48	16.62
2	125.25	59.49	55.50	81.54	26.74
3	56.14	79.14	43.59	62.43	32.86
4+	6.07	9.59	9.73	13.41	10.75
Age	2015	2016	2017	2018	2019
0	0.08	0.00	0.00	0.08	0.09
1	32.86	19.85	28.26	88.59	47.19
2	29.71	35.61	38.44	110.50	58.54
3	24.86	30.73	31.36	61.57	64.76
4+	9.56	11.67	4.11	8.84	9.13

Table 6.19.3.3. Giant red shrimp in GSAs 9, 10 and 11: Catch (tons; discards are included, though negligible).

2005	2006	2007	2008	2009
637.7	580.3	378.9	192.6	363.4
2010	2011	2012	2013	2014
343.8	304.1	294.8	485.8	532.0
2015	2016	2017	2018	2019
374.1	342.5	608.8	640.9	570.0

Table 6.19.3.4. Giant red shrimp in GSAs 9, 10 and 11: Weight-at-age matrix (kg).

Age	2005	2006	2007	2008	2009
0	0.003	0.000	0.000	0.000	0.004
1	0.022	0.018	0.026	0.019	0.020
2	0.027	0.043	0.042	0.037	0.034
3	0.037	0.045	0.047	0.057	0.042
4+	0.076	0.063	0.081	0.071	0.074
Age	2010	2011	2012	2013	2014
0	0.004	0.003	0.004	0.004	0.000
1	0.018	0.022	0.016	0.019	0.024
2	0.039	0.042	0.033	0.035	0.037
3	0.045	0.039	0.049	0.038	0.043
4+	0.068	0.060	0.071	0.066	0.079
Age	2015	2016	2017	2018	2019
0	0.004	0.004	0.004	0.002	0.000
1	0.021	0.022	0.016	0.023	0.025
2	0.036	0.036	0.039	0.036	0.043
3	0.046	0.036	0.043	0.041	0.040
4+	0.074	0.066	0.071	0.075	0.063

The assessment was performed by sex combined. Given that the landings 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=9)

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)

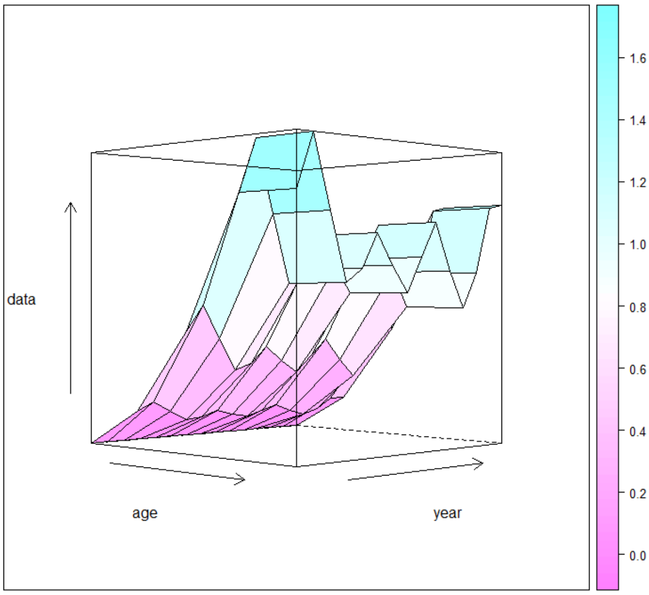


Figure 6.19.3.3. Giant red shrimp in GSAs 9, 10 and 11: fishing mortality by age and year obtained from the a4a model (2005-2019).

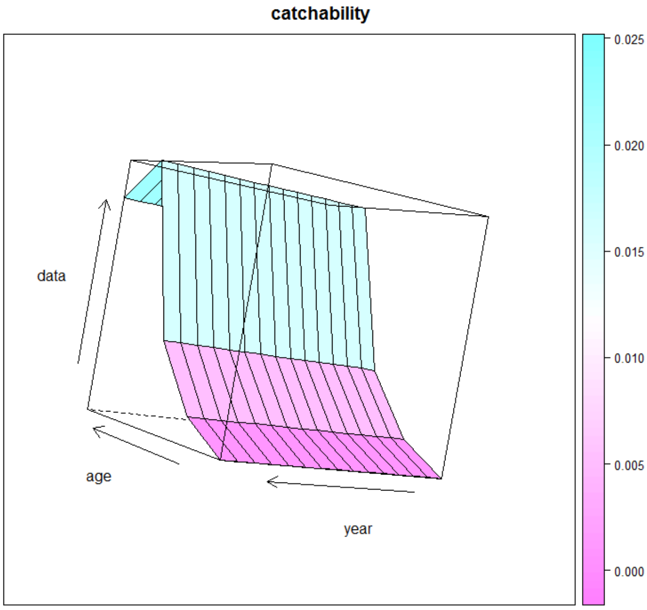


Figure 6.19.3.4. Giant red shrimp in GSAs 9, 10 and 11: catchability of the survey by age and year obtained from the a4a model (2005-2019).

The log residuals for both the catches and the survey do not show any particular trend or issue. Indices show positive residuals at age 2 and negative residuals at age 3 (Figures 6.19.3.5 and 6.19.3.6). 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.

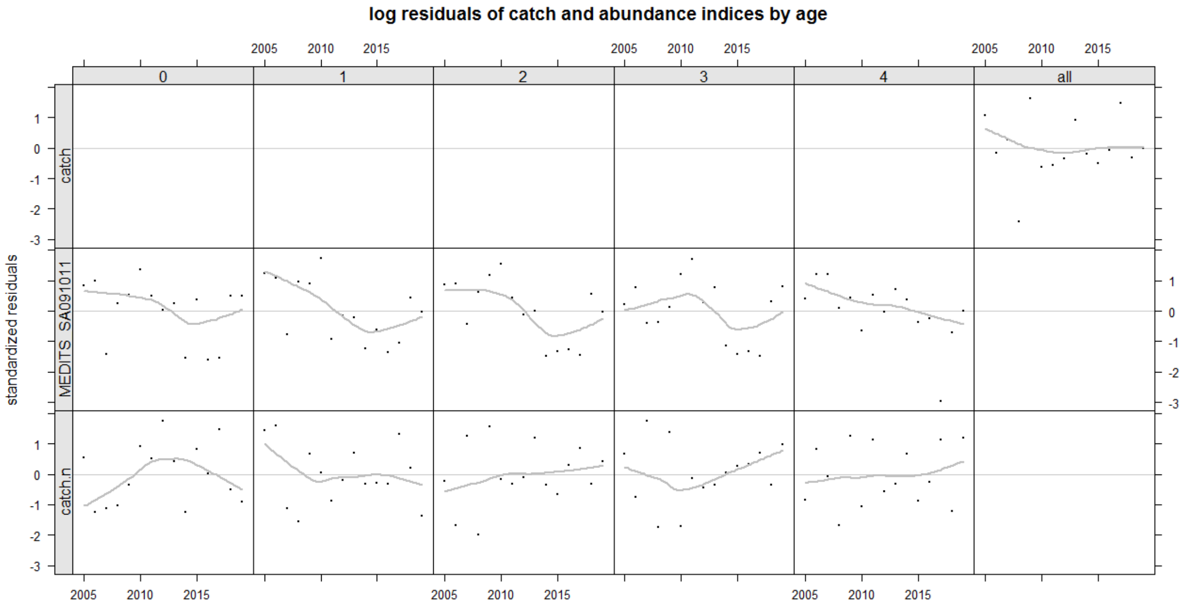


Figure 6.19.3.5. Giant red shrimp in GSAs 9, 10 and 11: log residuals for the catch-at-age data of the fishery and the survey, and the catches.

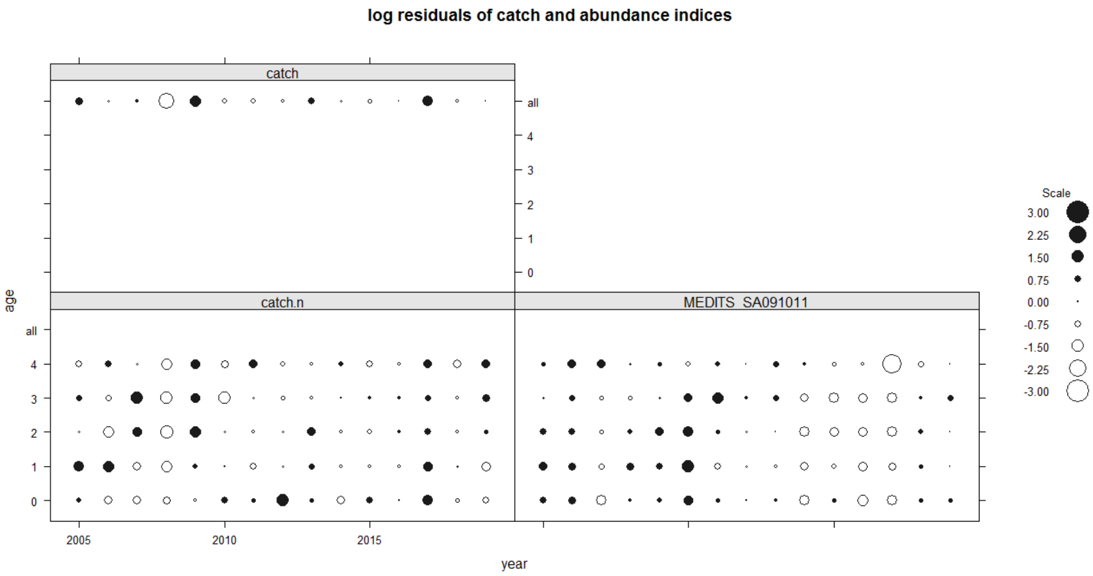


Figure 6.19.3.6. Giant red shrimp in GSAs 9, 10 and 11: bubble plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

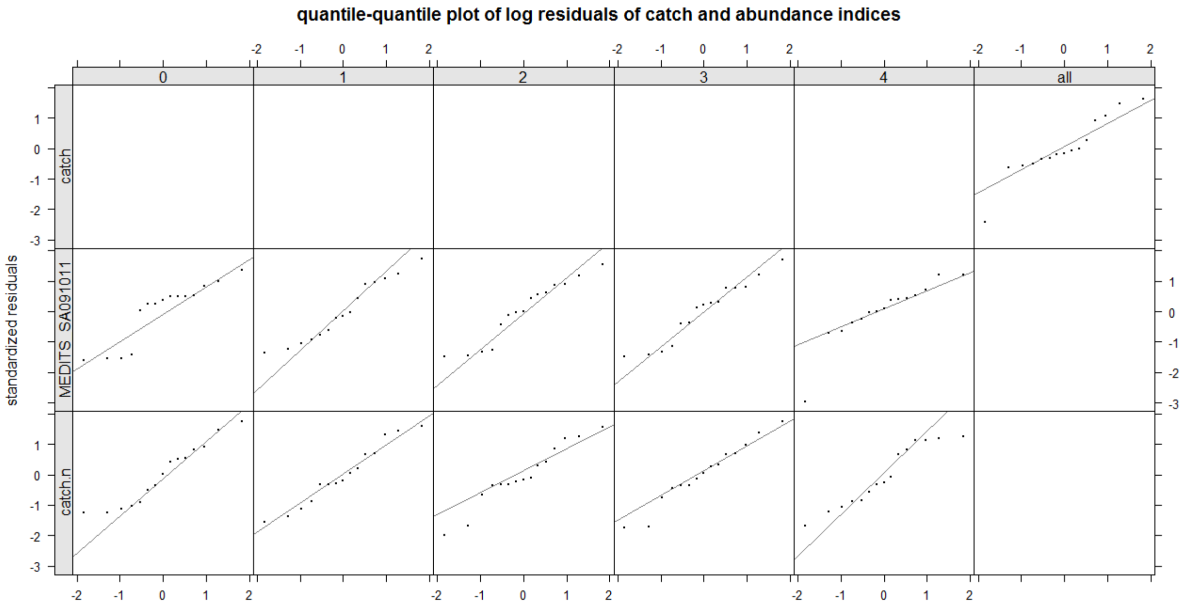


Figure 6.19.3.7. Giant red shrimp in GSAs 9, 10 and 11: QQ-plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

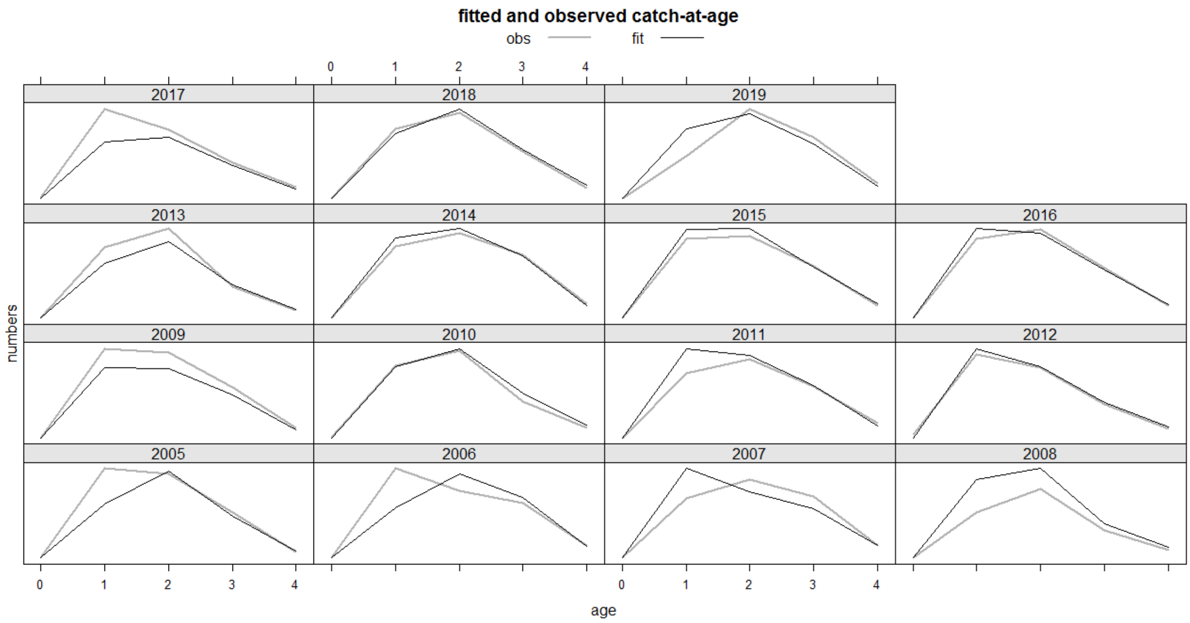


Figure 6.19.3.8. Giant red shrimp in GSAs 9, 10 and 11: fitted vs observed values by age and year for the catches.

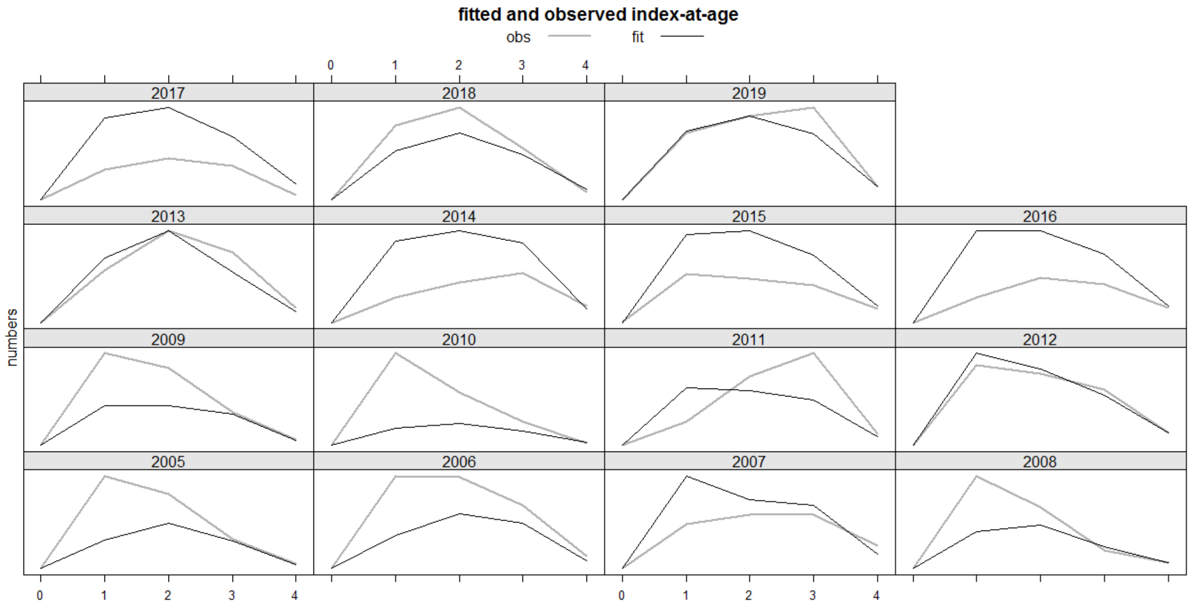


Figure 6.19.3.9. Giant red shrimp in GSAs 9, 10 and 11: fitted vs observed values by age and year for the survey.

The internal consistency of both the catches and the survey indices is acceptable.

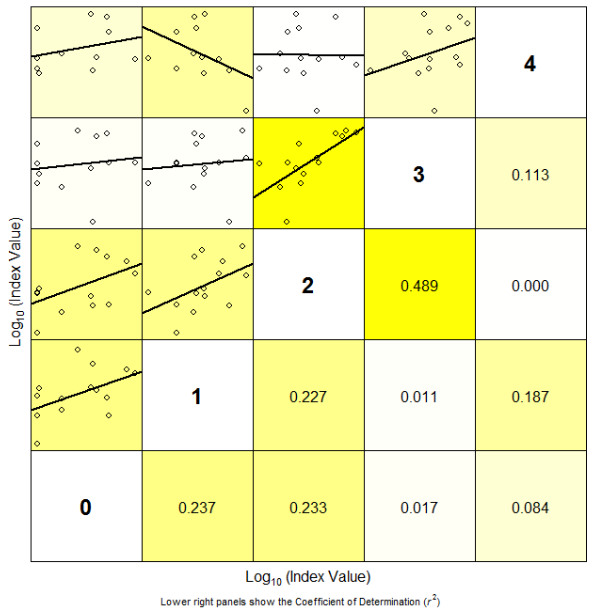


Figure 6.19.3.10. Giant red shrimp in GSAs 9, 10 and 11: internal consistency of the catch-at-age data.

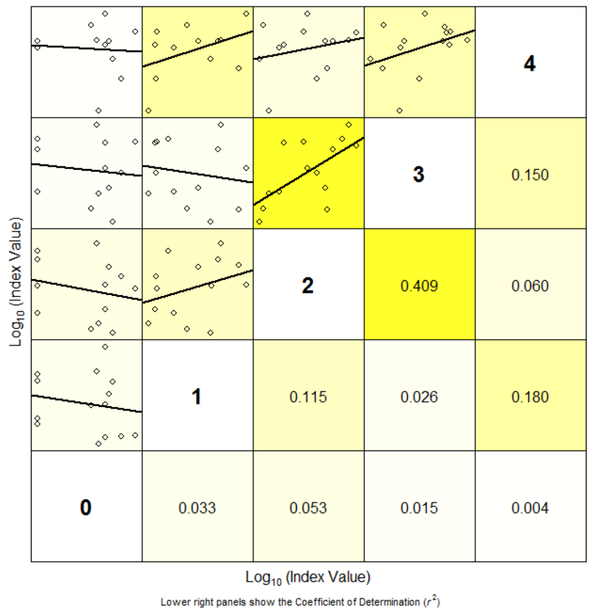


Figure 6.19.3.11. Giant red shrimp in GSAs 9, 10 and 11: internal consistency of the catch-at-age data of the MEDITS survey.

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.

The retrospective analysis 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 in last 4 years. The instability does not affect the conclusion $F>F_{MSY}$ with F_{MSY} = 0.48 (Section 6.19.4)

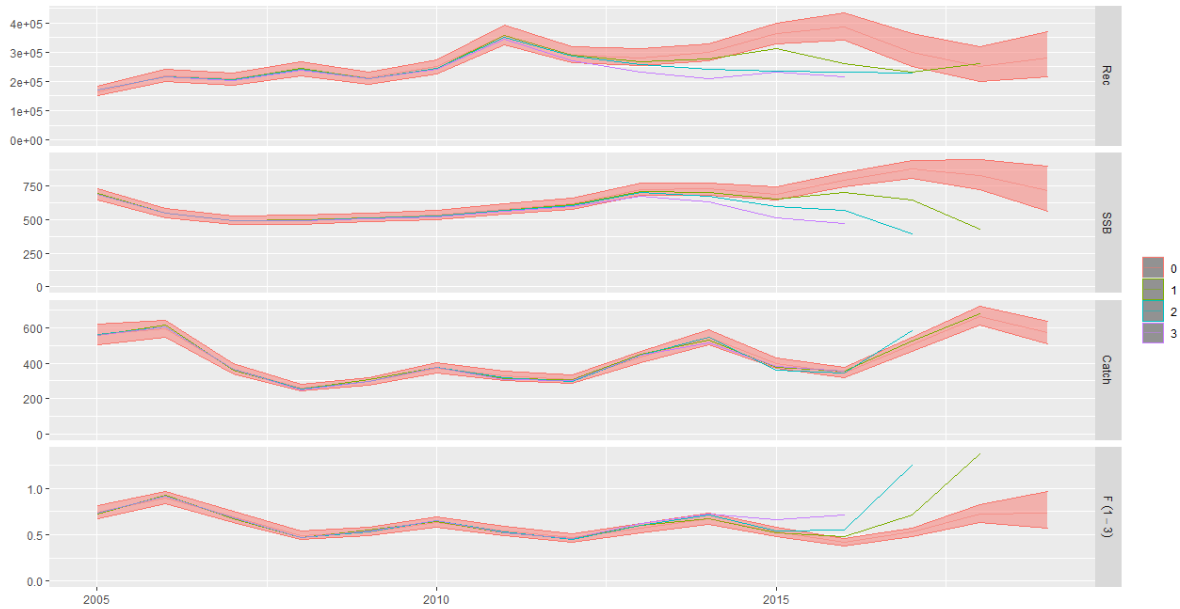


Figure 6.19.3.12. Giant red shrimp in GSAs 9, 10 and 11: retrospective analysis.

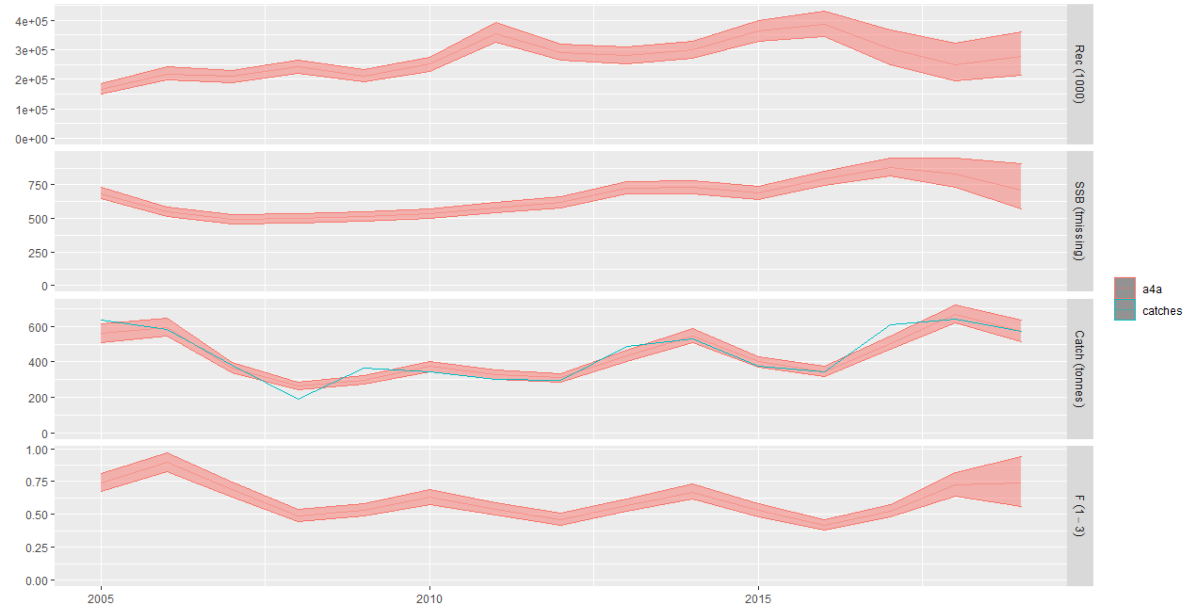


Figure 6.19.3.13. Giant red shrimp in GSAs 9, 10 and 11: outputs of the a4a stock assessment model, with uncertainty; input catch data (blue line) are plotted against the estimated catches.

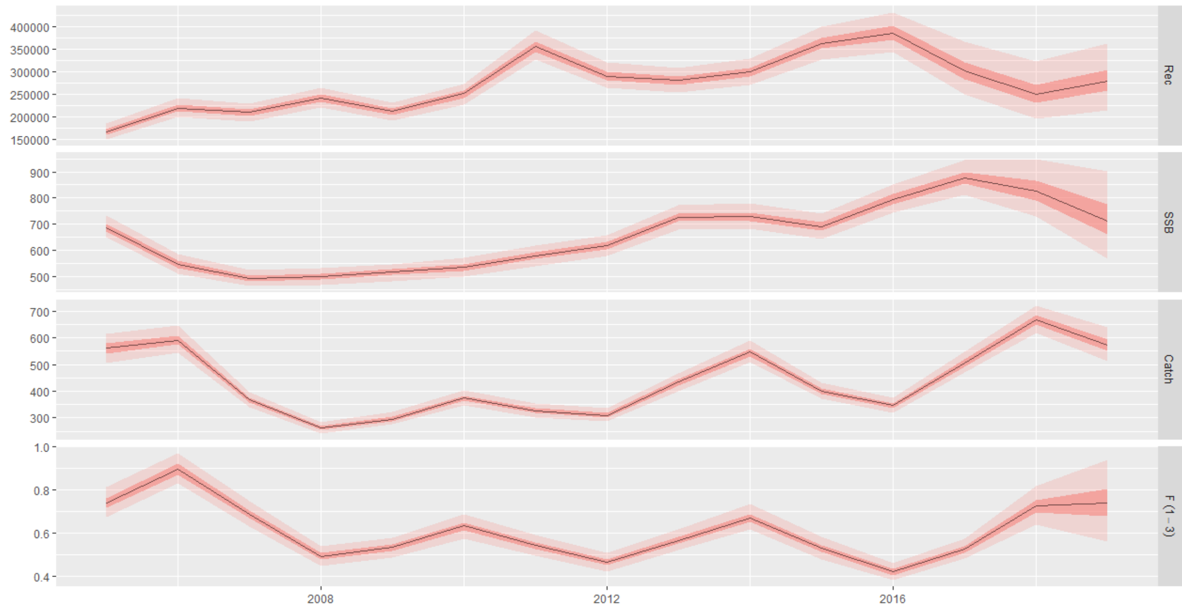


Figure 6.19.3.14. Giant red shrimp in GSAs 9, 10 and 11: outputs of the a4a stock assessment model (with uncertainty).

Table 6.19.3.5. Giant red shrimp in GSAs 9, 10 and 11: Stock numbers-at-age (thousands).

Age	2005	2006	2007	2008	2009
0	166140	218929	209881	241636	211177
1	42972	25098	33073	31707	36504
2	23847	14826	8272	11548	11689
3	6946	6692	3632	2433	4029
4+	1066	1211	899	760	771
Age	2010	2011	2012	2013	2014
0	249403	356254	290658	281048	299053
1	31903	37677	53820	43910	42458
2	13297	11321	13731	20026	15892
3	3924	4111	3782	4915	6534
4+	1075	929	1106	1236	1285
Age	2015	2016	2017	2018	2019
0	362940	386899	300348	252749	279654
1	45178	54829	58449	45373	38183
2	14918	16512	20653	21385	15750
3	4730	5034	6140	7005	6081
4+	1349	1374	1767	1793	1369

Table 6.19.3.6. Giant red shrimp in GSAs 9, 10 and 11: Fishing mortality-at-age.

Age	2005	2006	2007	2008	2009
0	0.00	0.00	0.00	0.00	0.00
1	0.20	0.25	0.19	0.14	0.15
2	0.65	0.79	0.60	0.43	0.47
3	1.36	1.65	1.27	0.90	0.98
4+	1.36	1.65	1.27	0.90	0.98
Age	2010	2011	2012	2013	2014
0	0.00	0.00	0.00	0.00	0.00
1	0.17	0.15	0.13	0.16	0.19
2	0.55	0.48	0.41	0.50	0.59
3	1.16	1.00	0.85	1.04	1.23
4+	1.16	1.00	0.85	1.04	1.23
Age	2015	2016	2017	2018	2019
0	0.00	0.00	0.00	0.00	0.00
1	0.15	0.12	0.15	0.20	0.20
2	0.46	0.37	0.46	0.63	0.64
3	0.97	0.77	0.97	1.33	1.36
4+	0.97	0.77	0.97	1.33	1.36

Table 6.19.3.7. Giant red shrimp in GSAs 9, 10 and 11: summary results of the a4a assessment.

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2005	166140	179938	152342	686.7	719.8	653.6	560	0.74	0.79	0.69
2006	218929	234978	202880	548.1	578.9	517.3	593	0.90	0.95	0.84
2007	209881	225306	194456	492.9	517.2	468.6	367	0.69	0.73	0.64
2008	241636	260050	223222	499.4	526.0	472.8	262	0.49	0.53	0.45
2009	211177	226838	195516	516.1	541.3	490.9	297	0.53	0.57	0.49
2010	249403	268617	230189	535.2	563.9	506.5	373	0.63	0.67	0.59
2011	356254	384861	327647	578.5	609.1	547.9	327	0.54	0.58	0.50
2012	290658	312813	268503	616.4	648.3	584.5	309	0.46	0.50	0.43
2013	281048	302928	259168	725.0	760.3	689.7	433	0.56	0.60	0.53
2014	299053	321339	276767	729.3	769.6	689.0	546	0.67	0.71	0.63
2015	362940	389650	336230	692.5	730.5	654.5	399	0.53	0.57	0.49
2016	386899	422841	350957	796.9	837.7	756.1	345	0.42	0.45	0.39
2017	300348	346403	254293	879.5	931.3	827.7	507	0.52	0.56	0.49
2018	252749	299078	206420	831.2	917.1	745.3	669	0.72	0.80	0.65
2019	279654	335369	223939	716.2	848.3	584.1	571	0.73	0.88	0.58

6.19.3 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 (0.73), estimated as the F_{bar1-3} in the last year of the time series, 2019, is higher than $F_{0.1}$ (0.48), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that giant red shrimp stock in GSAs 9, 10, 11 is over-exploited.

6.19.4 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 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 (2018) from the a4a assessment was used.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the whole time series (252911.7 thousand individuals).

Table 6.19.5.1 Giant red shrimp in GSAs 9, 10, 11: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	average of 2016-2018	mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2016-2018
$F_{ages\ 1-3}$ (2020)	0.73	F current in the last year
SSB (2020)	590.8	Stock assessment 1 January 2020
R_{age0} (2020,2022)	266969.6 thousands	Geometric mean of the whole time series (2005-2019)
Total catch (2020)	464	Assuming F status quo for 2020

Table 6.19.5.1 Giant red shrimp in GSAs 9, 10, 11: short term forecast in different F scenarios. The SSB estimates are computed at the middle of the year.

Rationale	Ffactor	Fbar	Catch 2019	Catch 2021	SSB* 2020	SSB* 2022	Change SSB 2020-2022 (%)	Change Catch 2019-2021 (%)
High long term yield ($F_{0.1}$)	0.65	0.48	571.38	322.85	590.80	706.08	19.51	-43.50
F upper	0.89	0.65	571.38	410.91	590.80	616.26	4.31	-28.09
F lower	0.43	0.32	571.38	230.42	590.80	809.97	37.10	-59.67
F_{MSY} transition (intermediate year)	0.88	0.65	571.38	409.80	590.80	617.34	4.49	-28.28
Zero catch	0.0	0.00	571.38	0.00	590.80	1115.2	88.76	-100.00
Status quo	1.0	0.73	571.38	448.99	590.80	580.05	-1.82	-21.42
Different Scenarios	0.1	0.07	571.38	59.72	590.80	1029.5	74.26	-89.55
	0.2	0.15	571.38	115.28	590.80	953.98	61.47	-79.82
	0.3	0.22	571.38	167.07	590.80	887.15	50.16	-70.76
	0.4	0.29	571.38	215.43	590.80	827.78	40.11	-62.30
	0.5	0.37	571.38	260.68	590.80	774.83	31.15	-54.38
	0.6	0.44	571.38	303.10	590.80	727.43	23.13	-46.95
	0.7	0.51	571.38	342.92	590.80	684.84	15.92	-39.98
	0.8	0.59	571.38	380.38	590.80	646.42	9.41	-33.43
	0.9	0.66	571.38	415.68	590.80	611.64	3.53	-27.25
	1.1	0.81	571.38	480.47	590.80	551.25	-6.69	-15.91
	1.2	0.88	571.38	510.27	590.80	524.92	-11.15	-10.70
	1.3	0.95	571.38	538.53	590.80	500.76	-15.24	-5.75
	1.4	1.03	571.38	565.36	590.80	478.53	-19.00	-1.05
	1.5	1.10	571.38	590.87	590.80	458.02	-22.48	3.41
	1.6	1.17	571.38	615.15	590.80	439.03	-25.69	7.66
	1.7	1.25	571.38	638.30	590.80	421.43	-28.67	11.71

	1.8	1.32	571.38	660.39	590.80	405.05	-31.44	15.58
	1.9	1.39	571.38	681.50	590.80	389.79	-34.02	19.27
	2.0	1.47	571.38	701.70	590.80	375.53	-36.44	22.81

7 DATA ISSUES BY STOCK

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.*

7.1 Mediterranean hake in GSA 1,5,6 and 7

The same data deficiencies encountered in EWG 18-12 were found in the data submitted in 2020.

French data

In some years and for some hauls, hake MEDITS data seem biased due to have applied a very high raising factor. This fact could occur in TB data too.

The same issue is encountered within commercial data.

Spanish data

In some years and for some hauls, hake MEDITS data seem biased due to have applied a very high raising factor. This fact could occur in TB data too. Specifically see haul 168 in GSA 5 in 2014, this issue was detected for the first time in 2018.

Additionally, length measurements (TC file) of 1 and 5 mm were detected in data from GSA 1 and 6. Length measurements should start from 10mm.

In GSA 1-5-6-7 biological parameters for the SRL file were submitted only for 2019 instead of the complete time series as requested by the DCF.

Landings length measurements data for GSA 7 in 2013 are reported in real numbers instead of thousands. This issue was already detected since 2015 onwards.

7.2 Deep-water Rose Shrimp in GSA 1,5,6 and 7

Data from DCF 2019 as submitted through the Official data call in 2020 were used.

No growth parameters were available for this stock in any GSA.

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

In GSA 5, length frequency distributions were not available for 2016. For OTB-MDD data were lacking for the years 2009 and 2018-2019 as it is not a selected metier for sampling in this GSA.

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. The length frequency distribution in 2015 had a recurring error (an extremely high number of individuals in the length class 33) that was corrected during the working group.

In GSA 7, only the length frequency distributions for Spanish OTB were available. This is due to the fact that sampling is not compulory for landings less than 200 tons.

Length frequency distributions of the discards were available in the DCF data only for GSA 6 for Spain in 2019 but were deemed unreliable.

In GSA 1 hauls 16 and 38 in 2013 were removed due to wrong data, the same was done for haul 51 in 2012 in GSA 6. In the MEDITS data of GSAs 1, 6 and 7 there are animals of lengths higher than 80 mm carapax length, which were considered wrong.

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

7.3 Red mullet in GSA 1

EWG 20-09 decided not to include year 2003 in the assessment input due to some inconsistencies reported in the length frequency distribution of landings. Scientists from the corresponding country (Spain) agreed that being the first year of sampling for the DCF, the reported values are incomplete or misreported. Discards data were also incomplete and misreported for several years. Gaps appeared throughout the years 2003 - 2007 and 2010. Length frequency distribution for the discards reported only for 2017 and 2018. Inconsistencies were also apparent in the MEDITS Survey Index for the year 2006 and the year 2011 was missing. Standardized length frequency distribution was recalculated for this year.

According to ToR 9, the EWG19-10 reported on line via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt.

The EWG 18-12 and EWG 19-10 also summarized and concisely described catch and effort data deficiencies, in terms of coverage and quality.

7.4 Striped red mullet in GSA 5

The EWG 20-09 found some relevant data deficiency for this stock in terms of data quality.

Catches for the GTR métiers are important during the period 2002-2008. However, the DCF does not hold length structure for this period. Accordingly, the length structure by year was reconstructed as indicated in this report.

There is high variance for the abundance index estimated in 2007, 2009, 2017 and 2019 that match with issues identified in the TB to TC check. It is highly recommended request fitting the biomass of several hauls holding TB/TC ratios away from 1.

After inspect the hauls for the above-mentioned years, the hauls 134 and 149 in 2009 were removed. Hauls in other years were kept despite they are contributing a high annual variance because were jointly checked with the country expert.

The recruitment peak estimated in 2018 may promote that fishing mortality looks very low after this year. At the same time, recruitment in 2019 is too low regarding the available time series, despite fishing mortality is the lowest as well.

7.5 Red mullet in GSA 6

The EWG 20-09 did not find any particular data deficiency for this stock in terms of data quality that would affect the assessment.

A change in the coding of métiers was observed in 2009 and 2018 in the case of OTB and in 2018 in GRT.

A small amount of landings is assigned to FPO and LLS, which should be checked.

7.6 Red mullet in GSA 7

No specific data issues have been noted

7.7 Norway lobster in GSA 5

Although in GSA 5 only Spanish trawlers operate, some landings for N. norvegicus has been reported from France (OTB_DEF in 2017: 0.00032 t and OTT_DEMF in 2016: 1.98 t). Similarly, some registers in effort has been reported from France (2014: OTB_CRU and 2015-2017: OTB_DEF).

Commercial landings seemed to have increased in last years, without an increase in the effort reported, indicating a huge increase on the catches per unit of effort. This increase is not detected in the survey indices and thus commercial data should be reviewed to confirm its correctness.

Regarding MEDITS data, for the year 2013 an error on the raising in one haul (150) has been detected. As it corresponded to only two individuals, this hauls was removed from the analysis.

7.8 Nephrops in GSA 6

A lack of growth parameters and length weight relationship coefficient has been detected. As previously observed, the length distribution in 2001 is very different from all the other years and reported for greater bins than usual.

7.9 European hake in GSA 9,10 and 11

GSA10: unlikely length measures (total length more than 100 cm) were found for European hake (HKE) in MEDITS data in 2017. Regarding commercial data, LFDs and relative landings are missing for 2017 third quarter and 2018 first one. No discard data are available for 2018. Very low discard values in 2017 and 2019, compared to the previous years' time series.

7.10 Deep-water Rose Shrimp in GSA 9,10 and 11

Data from DCR-DCF database as submitted through the Official data call in 2020 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: 2003-2019 for GSA09, 2002-2019 for GSA10 and 2009-2019 for GSA11.

The length frequency distributions of the landing for GSA09 are available for the period 2003-2019 (year 2002 is missing). For GSA10, data are not available for 2003. The historical data series for GSA11 includes the period 2009-2019 (the years 2002-2008 are missing). In GSA10, the length frequency distributions of the main metiers targeting DPS in 2019 (OTB_DEF and OTB_DEMSP) are missing. In order to reconstruct them, the length frequency distribution of OTB_DEF of 2017 was used after a SOP correction. Although the assessment started from 2009, the lack of data in the previous years in GSA11 has a low impact as the landing in this area are very low if compared to those observed in GSA9 and GSA10.

Discard data. The biomass discarded and the related length frequency distributions of Deep-water rose shrimp in GSA09 are available for the period 2009-2018. In GSA10, the data on discard are available for 2006 and for the years 2009-2017. The lack of data in 2018 and 2019 for GSA10 had a low impact on the assessment as, on average, discard in GSA10 represents about 2% of the total catch. With regard to GSA11, there are no data on this fraction of the catch. Due to the low catches of DPS in GSA11 the discard of this species could be considered negligible in the area. It should be emphasized that the Italian national data collection program did not provide for the collection of discard before 2006 and in the years 2007-2008.

7.11 Red mullet in GSA 9

The EWG 20-09 did not find any particular data deficiency for this stock in terms of data quality.

7.12 Red mullet in GSA 10

EWG20-09 has noted that landing and discard data of the 3rd quarter of 2017 were available in the last submission of the data missing for all gears and fisheries, as well as the landing and discard of the first quarter 2018.

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 SOP correction of 5 was applied to 2019 data, because the available LFDs represented only one fifth of the total production of the stock.

The EWG20-09 reported on line via the Data Transmission Monitoring Tool (DTMT).

7.13 Norway lobster in GSA 9

The EWG 20-09 did not find any particular data deficiency for this stock in terms of data quality.

17.14 Norway Lobster in GSA 11

The Length frequency distribution of the landings, particularly in the time period 2005-2012, shows some deficiencies in the procedure of sampling commercial catches. The distribution are far to be well represented and seem biased by the raising procedures. The bad cohort consistency support this theory.

7.15 Blue and red shrimp in GSA 1

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 2007,2008, 2009 and 2011 and 2013. These data were not included in the assessment. There were issues with the dataset regarding the survey index for 2009 that were identified before the meeting. These issues (reporting of a very large individual with CL=362 mm and duplicate records for some length classes) were resolved before the index was prepared for running the assessment.

7.16 Blue and red shrimp in GSA 5

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.

7.17 Blue and red shrimp in GSA 6 and 7

Considering that blue and red shrimp shows sex dimorphism, females grow more than males, the lack of growth information on both sexes, instead of combined parameters, could potentially bias the slicing procedure. Numbers of individuals in the catch (from the DCF) are consistantly about 50% (on average) less than those estimated from total catch by means of the SOP analysis.

7.18 Blue and red shrimp in GSA 9,10 and 11

A typo that was removed from LFD of OTB_DWS in 2017 from length class 25 mm.

The LFDs of 2018 and 2019 in GSA 10 were reconstructed based on the 2015-2016 for 2018 and 2016-2017 for 2019, to reduce the SOP correction factor.

7.19 Giant red shrimp in GSA 9, 10 and 11

In terms of coverage, information on LFD for 2019 in GSA 10 were present only for quarter I and IV. This required the reconstruction on the LFD by using data from the other two GSAs. The impact on the assessment was then low.

8 CONTACT DETAILS OF EWG-20-09 PARTICIPANTS

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

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9 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/web/stecf/ewg2009

List of electronic annexes documents:
Annex I: analytical assessments final stock objects
Annex II: MEDITS JRC script Tech. Document

10 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg2009

List of background documents:

EWG-20-09 – Doc 1 - Declarations of invited and JRC experts (see also section 8 of this report – List of participants)

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