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Scientific, Technical and Economic Committee for Fisheries (STECF) - Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-19-10)

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Joint Research Centre

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EWG-19-10 report:

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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 19-10: 2019 stock assessments of demersal stocks in the western Mediterranean Sea from the meeting in Arona Italy from 9^{th} to 15^{rd} September 2019. 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, one full category 3 evaluation and brief re-evaluations and validations of the 2018 results for the final three stocks for which two year's advice was given in 2018. The report also contains the STECF observations and conclusions on the assessment report. These conclusions come from the STECF Plenary meeting November 2019.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Stock Assessments: demersal stocks in the western Mediterranean Sea (STECF-19-10)

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 in Arona, Italy, from 9 to 15 September 2019. The meeting was attended by 16 experts in total, including three STECF members and two JRC experts. One DG MARE representative and one observer also attended the meeting.

The objective of the EWG 19-10 was to carry out demersal stock assessments in the western Mediterranean as defined in the EWG ToRs.

STECF comments

STECF considers that the EWG addressed adequately all the ToRs. STECF notes that the EWG carefully reviewed the quality of the assessments produced. Some analyses were considered to be suitable for short term forecasts, others were only considered sufficiently reliable to estimate F-status, and for these no forecast was produced.

A total of 19 area/species combinations were evaluated (Tables 5.1.1 and 5.1.2). The EWG has carried out short term forecasts for 15 age-based assessments. Catch advice for four stocks was based on biomass index methods. The main results are summarized in the bullet point list below and in Table 5.1.2. Overall, the assessments indicate that all stocks but two are being significantly overfished, and that biomass is stable at low level or decreasing for the majority of the stocks:

- Hake in GSA 1_5_6_7: the biomass is low/stable. Catches should be reduced by at least 63% to reach F_{MSY} in 2020.
- Deep-water rose shrimp in GSA 1_5_6_7: the biomass is increasing. Catches should be reduced by at least 55% to reach F_{MSY} in 2020.
- Red Mullet in GSA 1: the biomass is declining. Catches should be reduced by at least 69% to reach F_{MSY} in 2020.
- Striped Red Mullet in GSA 5: the biomass is increasing. Catches should be reduced by at least 21% to reach F_{MSY} in 2020.
- Red Mullet in GSA 6: the biomass is low/stable. Catches should be reduced by at least 69% to reach F_{MSY} in 2020.
- Red Mullet in GSA 7: the biomass is stable. Catches may be increased by no more than 31% to reach F_{MSY} in 2020.
- Norway lobster in GSA 5: the biomass is fluctuating. Catches should be reduced by at least 47% to reach F_{MSY} in 2020.
- Norway lobster in GSA 6: the biomass is low/stable. Catches should be reduced by at least 71% to reach F_{MSY} in 2020.
- Hake in GSA 9_10_11: the biomass is declining. Catches should be reduced by at least 63% to reach F_{MSY} in 2020.
- Deep-water rose shrimp in GSA 9_10_11: the biomass is high/stable. Catches should be reduced by at least 9% to reach F_{MSY} in 2020.
- Red Mullet in GSA 9: the biomass has been increasing, though declining in the last year. Catches should be reduced by at least 63% to reach F_{MSY} in 2020.
- Red Mullet in GSA 10: the biomass is increasing. Catches should be reduced by at least 23% to reach F_{MSY} in 2020.

- Norway lobster in GSA 9: the biomass is increasing. Catches should be reduced by at least 34% to reach F_{MSY} in 2020.
- Norway lobster in GSA 11: the biomass is declining. Catches should be reduced by at least 55% to reach F_{MSY} in 2020.
- Blue and red shrimp in GSA 1: the biomass is stable. Catches should be reduced by at least 23% to reach F_{MSY} in 2020.
- Blue and red shrimp in GSA 5: the biomass is fluctuating. Catches should be reduced by at least 40% to reach F_{MSY} in 2020.
- Blue and red shrimp in GSA 6_7: the biomass is fluctuating. Catches should be reduced by at least 65% to reach F_{MSY} in 2020.
- Blue and red shrimp in GSA 9_10_11: the biomass is declining. Catches should be reduced by at least 81% to reach F_{MSY} in 2020.
- Giant red shrimp in GSA 9_10_11: the biomass is declining. Catches should be reduced by at least 71% to reach F_{MSY} in 2020.

STECF considers that for all of 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 2019. STECF notes that the assessments are based on short data series and some degree of uncertainty therefore remain, 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 2020. 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. The values for F_{upper} are indicative only; they have not been evaluated as precautionary and should not be used to give catch advice without further evaluation.

For all the stocks with advice based on abundance index, a precautionary buffer of a -20% catch reduction has been applied. STECF notes that this approach is consistent with the procedures applied in the North East Atlantic (ICES stocks). For three of these stocks catch advice for 2020 was already provided in 2018 and is unchanged.

STECF notes that F_{MSY} values for red mullet stocks cover a large range (between 0.31 and 0.62) in the different GSAs. These differences come partly from the F_{bar} range which differs across the stocks, but could also be linked to differences in selection parameters, i.e. catch at age structure (particularly for GSA 7), as well as differences in the growth parameters and natural mortality across the different GSAs evaluated. Sensitivity analysis could be performed to fully understand the effect of using different growth parameters on the assessment results.

Norway lobster in GSA 9 is a new assessment with different growth and data treatment from last year. Catch data were improved and extended back to 1994 (against 2003 in previous assessment) in the RECFISH project, and this longer series stabilised the assessment. Catch reporting errors from last year were corrected. This stock has a consistent catch matrix, though the survey is showing poor fit. The estimation of historical exploitation appears more robust than in the most recent years of the assessment.

In contrast, the assessment of Norway lobster in GSA 5 in 2018 looked unstable, and a 2-years advice based on survey index was given.

STECF notes that for deep-water rose shrimp in GSA 1_5_6_7 the MEDITS biomass indices as well as catch are increasing at different rates in the four GSAs; the general trend is mostly driven by GSAs 5 and 6, though the species is showing a sharp increase in biomass also in GSAs 1 and 7, especially in the last year.

Following ToR 3, EWG 19-10 analysed effort data related to demersal fisheries in Western Mediterranean. Issues identified in previous years in the effort data were largely solved, and tables of effort by gear covering majority of fishery were provided. It was also pointed out that fishing effort data analysed at fishing gear level are related to multiple fisheries and multispecies aspects, and not just to the one single species considered in a certain assessment.

STECF notes that data quality deficiencies have been comprehensively addressed by the EWG for each stock in the report. STECF notes that biological and effort data deficiencies have been also reported in the DTMT (Data Transmission Monitoring Tool) and should be addressed and corrected before the next submission.

Table 5.1.1. Summary of work was attempted and basis for any advice. a4a is an age based assessment methods STF is a standard short term projection with assumptions of status quo F and historic recruitment. Index refers to the ICES Category 3 approach to advice for stocks without analytic assessments.

Area	Species	Previous Analysis (2018)	Attempted analyses and basis of advice
1_5_6_7	Hake	a4a	a4a STF
1_5_6_7	Deep-water rose shrimp	Survey Index	Survey Index
1	Red Mullet	a4a	a4a STF
5	Striped Red Mullet	-	a4a STF
6	Red Mullet	a4a	a4a STF
7	Red Mullet	a4a	a4a STF
5	Norway lobster	a4a	Survey Index
6	Norway lobster	a4a	a4a STF
9_10_11	Hake	a4a	a4a STF
9_10_11	Deep-water rose shrimp	a4a	a4a STF
9	Red Mullet	a4a	a4a STF
10	Red Mullet	a4a	a4a STF
9	Norway lobster	Survey Index	a4a STF
11	Norway lobster	Survey Index	Survey Index
1	Blue and red shrimp	a4a	a4a STF
5	Blue and red shrimp	Survey Index	Survey Index
6_7	Blue and red shrimp	a4a (GSA 6 only)	a4a STF
9_10_11	Blue and red shrimp	-	a4a STF
9_10_11	Giant red shrimp	a4a	a4a STF

Table 5.1.2. Summary of advice from EWG 19-10 by area and species. F 2018 is estimated F in the assessment, and used in the short term forecast for 2019. Change in F is the difference (as a fraction) between target F (F_{MSY}) in 2020 and the estimated F for 2018. Change in catch is from catch 2018 to catch 2020. Biomass and catch 2016-2018 are 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	F_{bar} range	Biomass 2016-2018	Catch 2016-2018	F 2018	F 2020	Change in F	Catch 2018*	Catch 2020	Change in catch
1_5_6_7	Hake	a4a	1-3	low/stable	Stable	1.84	0.38	-79%	3444	1268	-63%
1_5_6_7	Deep-water rose shrimp	Survey Index		increasing	Increasing				1407	638	-55%
1	Red Mullet	a4a	1-3	declining	declining	2.1	0.54	-74%	169	53	-68%
5	Striped Red Mullet	a4a	1-2	increasing	increasing	0.39	0.42	8%	140	110	-21%
6	Red Mullet	a4a	1-3	low/stable	Increasing	1.46	0.31	-79%	1598	488	-69%
7	Red Mullet	a4a		stable	Declining	0.82	0.62	-23%	278	364	31%
5	Norway lobster	Survey Index		fluctuating	Increasing				83	44	-47%
6	Norway lobster	a4a	3-6	low/stable	Stable	0.71	0.11	-85%	265	77	-71%
9_10_11	Hake	a4a	1-3	declining	Slightly declining	0.74	0.22	-70%	2086	772	-63%
9_10_11	Deep-water rose shrimp	a4a	1-2	high/stable	Increasing	0.88	0.97	10%	1422	1301	-9%
9	Red Mullet	a4a	1-3	declining	stable	1.58	0.58	-63%	1393	512	-63%
10	Red Mullet	a4a	1-3	increasing	Stable	0.48	0.41	-16%	403	309	-23%
9	Norway lobster	a4a	2-6	increasing	Increasing	0.31	0.2	-55%	216	142	-34%
11	Norway lobster	Survey Index		declining	Increasing				38	17	-55%
1	Blue and red shrimp	a4a	1-2	stable	Stable	1.13	0.56	-50%	124	96	-23%
5	Blue and red shrimp	Survey Index		fluctuating	Stable				250	150	-40%
6_7	Blue and red shrimp	a4a	0-2	fluctuating	Stable	1.26	0.33	-74%	644	226	-65%
9_10_11	Blue and red shrimp	a4a	2-5	declining	Increasing	1.45	0.39	-73%	387	72	-81%
9_10_11	Giant red shrimp	a4a	1-3	declining	Increasing	1.37	0.45	-67%	681	199	-71%

*Estimated

STECF notes that the Western Mediterranean MAP has 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 European hake and red shrimps, 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 MAP does 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 achieve F_{MSY} by 2025, it may be helpful to give advice in relationship to such a transition. The Commission may consider if they need transition advice and if so, what transition is to be followed.

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. As an illustration, this approach is updated for transition from 2020 to 2025, and is shown below:

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

whereas for the following years:

$F_{MSY\text{-}transition}$ (2021) = {0.667 x F_{2019} + 0.333 x F_{MSY} (2020)}

$F_{MSY\text{-}transition}$ (2022) = {0.500 x F_{2019} + 0.500 x F_{MSY} (2021)}

$F_{MSY\text{-}transition}$ (2023) = {0.333 x F_{2019} + 0.667 x F_{MSY} (2022)}

$F_{MSY\text{-}transition}$ (2024) = {0.166 x F_{2019} + 0.833 x F_{MSY} (2023)}

$F_{MSY\text{-}transition}$ (2025) = {0.000 x F_{2019} + 1.000 x F_{MSY} (2024)}

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

STECF conclusions

STECF concludes that the EWG addressed all the ToRs appropriately.

STECF endorses the assessments and evaluation of stock status produced by the EWG. STECF concludes that the results of the assessments accepted by EWG 19-10 provide reliable information on the status of the stocks and the trends in stock biomass and fishing mortality. One assessment was refused due to inconsistencies between catch and survey data leading to lack of robustness of the assessment. For this stock, advice was given using survey index trend. Survey trends were also used as the basis for advice for other three stocks, consistently with what was done last year.

STECF concludes that the errors reported in the DTMT should be addressed and corrected before the next data submission.

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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-19-10)

Arona, Italy, 9-15 September 2019

1 INTRODUCTION

1.1 Approach to the work

The working group was held in Arona, Italy, from 9th to 15th Sept 2019. The meeting was attended by 16 experts in total, including three STECF members and two JRC experts. The EWG had one observer who attended part time.

The objective of the Mediterranean Methodology EWG 19-10 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 in small groups based on expertise. An ftp repository was created ad-hoc to share documents, data and scripts and prepare the report. The stocks were evaluated by the GSA groups identified in the ToRs.

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 last day.

1.2 Terms of Reference for EWG-19-10

DG MARE focal persons: Amanda Perez Perera

Chair: John Simmonds

GENERAL GUIDELINES: unless the data used and information provided comes from the official DCF data calls, the experts are requested to indicate the data source from where certain information has been taken (e.g. L-W relationships, prices) or if it is an experts' reasoned guess.

Data collected outside the DCF shall be used as well and merged with DCF data whenever necessary and following quality check. Due account shall also be given to data used and assessments carried out within the FAO regional projects co-funded by the European Commission and EU-Member States in particular when using data collected through the DCF/DCR and EU funded research projects, studies and other types of EU funding.

The raw data used to generate the input data, assessment scripts as well as input files should be made available to the JRC for reproducibility of the assessments and compilation of the STECF stock assessment database (https://stecf.jrc.ec.europa.eu/dd/medbs/ram).

STECF 17-07[1] defined methodological guidelines to ensure standardized practices for the preparation of stock assessment input data. EWG 18-12 should adhere to these recommendations referring to the need of: (i) coherence of all growth parameters used in the assessments; (ii) improvement in documenting and defining the growth models and age slicing; (iii) test where possible age slicing by sex;(iv) t0 should be truncated to values between 0 and -0.2; and (v) review the raw age length data, where necessary refitting growth models (section 2.2 in the EWG 17-07 report).

1 Scientific, Technical and Economic Committee for Fisheries (STECF) – Methodology for the Stock Assessments in the Mediterranean Sea (STECF-17-07). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-67479-2, doi:10.2760/106023, JRC107583.

For the stocks given in the table below, the EWG 19-10 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 2018, including length frequency distribution over time.

ToR 3. To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2018. This should be described in terms of fishing days, days at sea, GT*days and nominal effort by Member State, GSA and fishing gear.

ToR 4. To compile and provide indices of abundances and biomass by year and size/age structure for the longest time series available up to and including 2018. Where possible, the EWG should take into account the results of the EU-funded project RECFISH[2].

ToR 5. 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 6. To estimate the F_{MSY} point value, range of F_{MSY} (i.e. MSY F_{LOWER} and MSY F_{UPPER}) and the conservation reference points (i.e. B_{PA} and B_{LIM}), or proxy. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.

ToR 7. 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 F_{LOWER} and MSY F_{UPPER}) or other appropriate proxy by 2020 and 2025.

ToR 8. 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 9. 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 10. 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.

[2] Framework Contract for the provision of scientific advice for the Mediterranean and Black Seas (EASME/EMFF/2016/032). Specific contract N° 1: Recovery of fisheries historical time series for Mediterranean and Black Sea stock assessment (RECFISH).

Table 1.1– List of suggested stocks to be assessed by the EWG 19-10.

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 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*

(*) Explore the possibility to merge blue and red shrimp in GSAs 5-6-7.

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 2019. Fourteen of these were for the same stocks as last year, and one was a stock for which index advice had previously been given. Of the 4 remaining stocks index evaluations with catch advice are provided, three are taken from last year's report, for these stocks 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 11 Blue and red shrimp GSA 5, and Deep Water Rose Shrimp GSA 1, 5, 6 & 7) the results are considered fully acceptable. Last year the EWG evaluated four Nephrops stocks and considered that two could be assessed with an age based assessment and two could not, of these four two follow the same outcome (Nephrops 6 and Nephrops 11) For the other two; Nephrops in GSA 5 STECF accepted the assessment in 2018 but the instability in the assessment found this year suggested it would be preferable to give index advice. For Nephrops in 9 there was an extensive revision and extension of the data and the revised data gave good coherence in the cohorts in the catch, and it's proposed that the assessment should now be accepted.

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 2018 to 2020 are provided in Table 2.2.

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

Area	Common Species name	2018 STECF	2019 Assess
1_5_6_7	Hake	a4a	a4a STF
1_5_6_7	Deep-water rose shrimp	Index	2018 Index
1	Red Mullet	a4a	a4a STF
5	Striped Red Mullet		a4a STF
6	Red Mullet	a4a	a4a STF
7	Red Mullet	a4a	a4a STF
5	Norway lobster	a4a	Index (2019)
6	Norway lobster	a4a	a4a STF
9_10_11	Hake	a4a	a4a STF
9_10_11	Deep-water rose shrimp	a4a	a4a STF
9	Red Mullet	a4a	a4a STF
10	Red Mullet	a4a	a4a STF
9	Norway lobster	Index	a4a STF
11	Norway lobster	Index	2018 Index
1	Blue and red shrimp	a4a	a4a STF
5	Blue and red shrimp	Index	2018 Index
6_7	Blue and red shrimp	a4a (6 only)	a4a STF
9_10	Blue and red shrimp		a4a STF
9_10_11	Giant red shrimp	a4a	a4a STF

Table 2.2 Summary of advice from EWG 19-10 by area and species. F 2018 is estimated F in the assessment, and used in the short term forecast for 2019. Change in F is the difference (as a fraction) between target F in 2020 and the estimated F for 2018. Change in catch is from catch 2018 to catch 2020. 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	Fbar	F 2018	F 2020	Change in F	Catch 2018*	Catch 2020	Change in catch	Biomass (status)
1_5_6_7	Hake	a4a	1-3	1.84	0.38	-79%	3444	1268	-63%	low/stable
1_5_6_7	Deep-water rose shrimp	Index 2018					1407	638	-55%	increasing
1	Red Mullet	a4a	1-3	2.1	0.54	-74%	169	53	-68%	declining
5	Striped Red Mullet	a4a	1-2	0.39	0.42	8%	140	110	-21%	increasing
6	Red Mullet	a4a	1-3	1.46	0.31	-79%	1598	488	-69%	low/stable
7	Red Mullet	a4a		0.82	0.62	-23%	278	364	31%	stable
5	Norway lobster	Index 2018					83	44	-47%	fluctuating
6	Norway lobster	a4a	3-6	0.71	0.11	-85%	265	77	-71%	low/stable
9_10_11	Hake	a4a	1-3	0.74	0.22	-70%	2086	772	-63%	declining
9_10_11	Deep-water rose shrimp	a4a	1-2	0.88	0.97	10%	1422	1301	-9%	high/stable
9	Red Mullet	a4a	1-3	1.58	0.58	-63%	1393	512	-63%	declining
10	Red Mullet	a4a	1-3	0.48	0.41	-16%	403	309	-23%	increasing
9	Norway lobster	a4a	2-6	0.31	0.2		216	142	-34%	increasing
11	Norway lobster	Index 2018					38	17	-55%	declining

1	Blue and red shrimp	a4a	1-2	1.13	0.56	-50%	124	96	-23%	stable
5	Blue and red shrimp	Index 2018					250	150	-40%	fluctuating
6_7	Blue and red shrimp	a4a	0-2	1.26	0.33	-74%	644	226	-65%	fluctuating
9_10_11	Blue and red shrimp	a4a	2-5	1.45	0.39	-73%	387	72	-81%	declining
9_10_11	Giant red shrimp	a4a	1-3	1.37	0.45	-67%	681	199	-71%	declining

*Estimated

2.2 Quality of the assessments

Hake:

For hake in GSA 9-11 the same model was used as last year, with smoothing parameter changed to account for an additional year of data. There were no major issues and a relatively simple model fitted well with comparable results between years. For hake in GAS 1-5-6&7 the information on catches indicated changes in the early part of the time series. The catchability model from last year gave unstable outcomes and was replaced by a logistic function. As with last year all simple model fits to this data gave considerable instability so as with last year model complexity was increased, and some smoothing introduced. The resulting model is considered adequate, but is more uncertain (due to complexity) than for the other hake area, estimated of F are similar though the reduction in terminal F last year is not seen this year. Both assessments were considered suitable for STF advice.

Red Mullet:

For GSA 1 the model was rather unstable and revised data has resulted in a different perception of stock with F closer to F_{MSY}. The assessment is considered suitable for STF but it is noted that there are some concerns and this is a marginal assessment.
For GSA 6 the assessment was relatively stable, with different data treatment but with very similar perception of the state of the stock compared to last year.
GSA 7 was very similar to last year's assessment the only difference was use of a different Fbar which now excludes age 0 which had no catch following the revision of data treatment.
GSA 9 was more stable assessment than last year revised data treatment with very similar perception of exploitation rate.
For GSA 10 some catches were revised and assessment is more stable than previously, for this stock growth are consistent with mid-year spawning and with same data treatment as last year F is still considered below F_{MSY}.

Striped Red Mullet in GSA 5.

This is a new assessment. The historic part of the assessment appears relatively stable with increasing SSB and decreasing F in recent years. While the data supports increases in stock and catch, the extent of the decline in F is less certain. It was noted that MEDITS contained a very high uncertain value in 2017 and the model was parameterised to using variance weighting to reduce the influence of that point. Overall while the historic part of the model is stable the conclusion on reducing F in last years is not seen in XSA assessments. The age based assessment presented is consistent with SPICT assessment from RECFISH.

Nephrops

Nephrops 5 data treatment, model was uncertain last year but this year appears very unstable. While there are some minor data issues, these were largely resolved. Different F and Q models were tested and including with and without smoothing. It was judged that the model was not suitable for advice and advice was based on ICES category 3 approach using the MEDITs survey index.
Nephrops in 6 gave a relatively stable assessment. The same model as last year with revised data treatment. Reference points were largely unchanged though F is higher, due to change of age range.

Nephrops 9 is a new assessment with different growth and data treatment, this stock has a consistent catch matrix though the survey is noisy with correlated residuals therefore with a potential for consistent errors of consecutive years. It was concluded that stock status appear robust along the series, though uncertain in the end of the assessment, and in conclusion exploitation historically appear robust, and is estimated to be recently below F_{MSY} but above again in 2018.

Nephrops 11 The survey and catch data inspected advice from last year is considered applicable.

Deepwater Rose Shrimp

GSA 1,5,6,7 The survey and catch data inspected advice from last year is considered applicable.

GSA 9, 10, 11 some differences were observed from last year, the assessment it was necessary to introduce smoothing at older ages 2 and 3 in fishery. The assessment may be more unstable but is considered more realistic accounting better for growth. The stock is now considered close to F_{MSY}, and is more in line with assessments from earlier years than the one in 2018.

Red Blue Shrimp.

GSA 1 Different data treatment was used this year but this did not influence the conclusion of the assessment relative to reference. The time-series is short and there are issues with retrospective suggesting an unstable assessment overall. The current assessment is in line with 2018 assessment with age range on F modified to deal with observed age range better.

GSA 6-7 this is a new assessment. There was uncertainty with choice of growth function. The data treatment last year resulted in anomalous appearance of 0 group in MEDITS and in catches. Several data treatments and assessments tested. Some differences in estimated and reported catch were noted. More exploration is needed to determine the most appropriate growth functions. All models indicate that the stock is overexploited, with similar F/ F_{MSY} for treatments. So the influences of the different options on F advice are more minor.

GSA 9, 10, 11 the growth parameters for this area do not result in anomalous age zero values and models were applied directly. A new assessment with relatively simple model different models parameterisations was tested but conclusions were robust to alternative setting and final chosen on statistical criteria.

Giant Red shrimp GSA 9_10_11

This was an update assessment with minor changes to growth model. Catches were split by sex as in 2018 but new sex ratio data for GSA 11 allowed each GSA to be split separately. The conclusions of the assessment are in line with last year. Catches show good internal consistency, with more noise in the survey. Overall the assessment appears stable.

2.3 Effort data. (ToR 3)

ToR 3. *To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2018. This should be described in terms of fishing days, days at sea, GT*days and nominal effort by Member State, GSA and fishing gear.*

In accordance with ToR 3, EWG1910 analysed effort data (file: effort.csv) related to demersal fisheries in Wester Mediterranean (GSAs: 1, 5, 6, 7, 9, 10 and 11). Following suggestion of Commission representative, EWG1910 allocated the most of time to analyse effort data related to Fishing days as principal effort index.

Effort data in DCF database (data file: effort.csv) related to Western Mediterranean (GSAs 1, 5, 6, 7, 9, 10 and 11), as available to EWG1910, consisted of 15,320 records in total, in period 2002-2018. These data were submitted by four EU Member states (ESP, FRA, ITA and MLT), indicating fishing effort performed by 23 different gear types, as well as by unknown gear (Non available data: gear code -1).

Among total number of effort data records (15,320), approximately 13% of effort data (1940 records) are related to unknown gear type (Fig 2.3.1). These records without gear data were reported by Spain (335 records in 2002-2008 period), France (145 records in 2015-2018 period) and Italy (1460 records in 2002-2018 period).

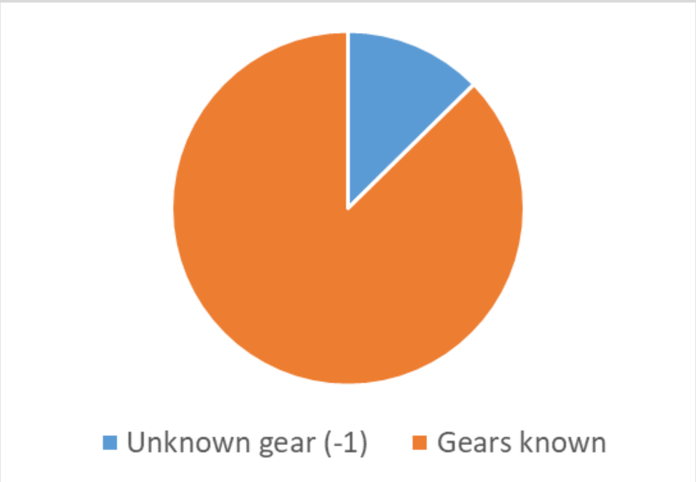


Figure 2.3.1. Amounts of available effort data records with and without information on the gear.

Consequently, 13,380 out of 15,320 records of effort data, related to 23 different gears, were used in further effort data analyses., After examining the catches gear by species by GSA the EWG decided to take into account following gears for species concerned covering the high 90%s of the catch.

It has been realized that effort data are not species specific, but refers to different GSAs, gears, fisheries, countries, etc. With aim to associate effort data with particular stock assessments, based on local expert knowledge, EWG1910 made a selection of gear types in different GSAs (Table 2.3.1). The principal gear included in all fisheries was Bottom otter trawl (OTB).

Table 2.3.1. Gears types as related to different assessments.

Assessment / GEAR types	GNS	GTR	LLS	OTB
Blue & red shrimp (GSA 1)				
Blue & red shrimp (GSA 5)				
Blue & red shrimp (GSA 6-7)				
Blue & red shrimp (GSA 9-10-11)				
Giant red shrimp (GSA 9-10-11)	*			
Deep-water rose shrimp (GSA 1-5-6-7)				
Deep-water rose shrimp (GSA 9-10-11)				
Hake (GSA 1-5-6-7)				
Hake (GSA 9-10-11)				
Red mullet (GSA 1)				
Red mullet (GSA 6)				
Red mullet (GSA 7)				
Red mullet (GSA 9)				
Red mullet (GSA 10)				
Striped red mullet (GSA 5)				
Norway lobster (GSA 5)				
Norway lobster (GSA 6)				
Norway lobster (GSA 9)				
Norway lobster (GSA 11)				

Note: * - GNS considered in GSA 10 only

However, EWG19-10 also highlights that these 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 ToR is analysed on fishing gear level, are related to multiple fisheries and multispecies aspects, and not just to the one single species considered in the assessments.

Despite instructions given in Annex 1 of 2019 Med & BS Data call, all countries report Area code as SA instead GSA. Fishery codes DEMF and FIN, reported by FRA (25 records in 2015, 2016 and 2017 data) are not currently in use also. All countries report area as SA and not GSA as indicated in Annex 1 of 2019 Med & BS Data call. EWG19-10 also noted small difference in area reporting between MLT and ITA, namely for GSA 11 MLT reports SA 11.1 or 11.2, while ITA reports SA 11. These findings had no any effect on data use by EWG19-10, and therefore are not considered as data issues.

However, lack of effort data from France (FRA) for the period before 2015 has been considered as a very serious issue, preventing EWG19-10 to make complete estimation of fishing effort in the areas where fishing fleet from France is operating. EWG19-10 realized that lack of FRA effort data for the period before 2015 were noted before (see DTMT record Id 3290) and missing data was already requested from France (see DTMT), but these data are still not submitted and thus not available to EWG19-10. Member state (FRA) replied to this data issue, but following DTF assessment (record no. 3290) STECF find that answer provided by MS is unsatisfactory. No comment/action on that issue is given from DG-MARE.

EWG19-10 also investigated previous data issue concerning biased effort data in GSA 9 and 10 (Id 3268). This data issue was about biased/unreliable effort data in which number of reported fishing days exceeded the maximum number of days in one quarter (i.e. >90 days/quarter). Member state (ITA) replied to this data issue, but following DTF assessment (DTMT record no. 3268) STECF find that answer provided by MS is unsatisfactory. No comment/action on that issue is given from DG-MARE. However, EWG19-10 noted that most of biased data from ITA have been corrected, and just 13 records from 2004, concerning demersal fisheries, still remained uncorrected in GSA 9 and 10 (Table 2.3.2).

Table 2.3.2. A few remained uncorrected data records in GSA 9 and 10 from 2004.

id_effor	id	country	year	quarter	vessel_	gear	mesh_s	fishery	area	specon	nominal_	gt_days_	no_ves	days_at	fishing_	upload_	TEST
88312	ITA20041(	ITA	2004	1	VL1218	GNS	16D20	DEMSP	SA 9	-1	289893	29625	1	1668	1684	1416	1684
88607	ITA20043(	ITA	2004	3	VL1218	GNS	16D20	DEMSP	SA 9	-1	271869	27526	1	1610	1626	1416	1626
88324	ITA20041(	ITA	2004	1	VL1218	GTR	16D20	DEMSP	SA 10	-1	40198	3446	1	1451	1466	1416	1466
88461	ITA20042(	ITA	2004	2	VL1218	GNS	16D20	DEMSP	SA 9	-1	252603	26176	1	1450	1464	1416	1464
88615	ITA20043(	ITA	2004	3	VL1218	GTR	16D20	DEMSP	SA 9	-1	49288	6321	1	512	517	1416	517
88668	ITA20043(	ITA	2004	3	VL1824	OTB	40D50	DWS	SA 9	-1	40824	9828	1	369	378	1416	378
88475	ITA20042(	ITA	2004	2	VL1218	GTR	16D20	DEMSP	SA 10	-1	26326	1784	3	946	955	1416	318
88473	ITA20042(	ITA	2004	2	VL1218	GTR	16D20	DEMSP	SA 9	-1	31351	3815	1	302	305	1416	305
88322	ITA20041(	ITA	2004	1	VL1218	GTR	16D20	DEMSP	SA 9	-1	16910	2503	1	206	208	1416	208
88646	ITA20043L	ITA	2004	3	VL1218	LLS	-1	DEF	SA 10	-1	85147	9463	8	1601	1617	1416	202
88506	ITA20042L	ITA	2004	2	VL1218	LLS	-1	DEF	SA 10	-1	75568	8272	6	1049	1060	1416	177
88761	ITA20044(	ITA	2004	4	VL1218	GTR	16D20	DEMSP	SA 10	-1	59958	3647	3	499	504	1416	168
88437	ITA20041-	ITA	2004	1	VL1218	-1	-1	DEMSP	SA 9	SB-SV	52971	6268	5	630	636	1416	127

During analyses of records related to demersal fisheries in area GSA 5 (Balearic Islands) it had been expected to have information on fishing efforts from Spanish (ESP) vessels only. However, France (FRA) and Malta (MLT) also reported their fishing activities in area GSA 5 (Table 2.3.3.).

Table 2.3.3. Fishing effort data in GSA 5 as reported by France and Malta.

id_effo	id	country	year	quarter	vessel_	gear	mesh_s	fishery	area	specon	nomina	gt_days	no_ves	days_at	fishing_	upload_
40438	169	FRA	2015	1	VL2440	-1	-1	-1	SA 5	-1	3690	864	1	3	3	211
40477	175	FRA	2015	2	VL1824	-1	-1	-1	SA 5	-1	2528	959.76	1	8	8	211
40490	177	FRA	2015	2	VL2440	-1	-1	-1	SA 5	-1	50814	15255	11	66	66	211
40504	180	FRA	2015	2	VL40XX	-1	-1	-1	SA 5	-1	36674.85	11358.52	6	36.99172	36.99172	211
40551	187	FRA	2015	3	VL40XX	-1	-1	-1	SA 5	-1	22825.46	6111.45	1	17.61224	17.61224	211
40607	195	FRA	2015	4	VL40XX	-1	-1	-1	SA 5	-1	10657.44	2853.5	1	8.223331	8.223331	211
66779	180	FRA	2016	2	VL1218	-1	-1	-1	SA 5	-1	1323.85	137.81	3	7.91619	7.91619	649
66797	53	FRA	2016	2	VL1218	LLD	-1	BFTE	SA 5	-1	284	38.22	1	2	1	649
66803	186	FRA	2016	2	VL1824	-1	-1	-1	SA 5	-1	1119.86	425.16	1	3.543853	3.543853	649
66805	188	FRA	2016	2	VL1824	OTB	-1	DEMF	SA 5	-1	2355.97	894.45	1	7.455587	7.455587	649
66815	190	FRA	2016	2	VL2440	-1	-1	-1	SA 5	-1	12874.76	3942.9	12	20.63375	20.63375	649
66826	63	FRA	2016	2	VL2440	OTT	40D50	DEMF	SA 5	-1	3476	1650	1	11	11	649
66829	199	FRA	2016	2	VL2440	PS	-1	BFTE	SA 5	-1	39975.04	12442.18	6	46.28337	46.28337	649
66831	201	FRA	2016	2	VL2440	PS	100D400	BFTE	SA 5	-1	4174.14	1634.06	1	8.089417	8.089417	649
66832	202	FRA	2016	2	VL2440	PS	14D16	BFTE	SA 5	-1	2697.48	1564.54	1	5.994407	5.994407	649
66836	204	FRA	2016	2	VL2440	PS	50D100	BFTE	SA 5	-1	15563.43	4469.01	2	15.9949	15.9949	649
66840	208	FRA	2016	2	VL40XX	-1	-1	-1	SA 5	-1	13357.78	3799.38	6	13.84715	13.84715	649
66844	212	FRA	2016	2	VL40XX	PS	-1	BFTE	SA 5	-1	32746.96	10191.4	6	32.24185	32.24185	649
66889	236	FRA	2016	3	VL40XX	-1	-1	-1	SA 5	-1	491.82	131.68	1	0.379487	0.379487	649
66893	240	FRA	2016	3	VL40XX	PS	-1	BFTE	SA 5	-1	10540.08	2822.07	1	8.13278	8.13278	649
66942	261	FRA	2016	4	VL2440	PS	-1	BFTE	SA 5	-1	84000	36435	1	105	105	649
66944	262	FRA	2016	4	VL40XX	PS	-1	BFTE	SA 5	-1	15080.73	4037.82	1	11.63636	11.63636	649
72140	FRA_2018	FRA	2018	2	VL1218	-1	-1	-1	SA 5	-1	2444.03	328.91	1	17.21145	17.21145	1291
72168	FRA_2018	FRA	2018	2	VL1824	OTT	40D50	DEF	SA 5	-1	3013.39	1144.04	1	9.536034	9.536034	1291
72185	FRA_2018	FRA	2018	2	VL2440	OTT	40D50	DEF	SA 5	-1	4163.61	1976.4	1	13.17597	13.17597	1291
72282	FRA_2018	FRA	2018	3	VL1218	-1	-1	-1	SA 5	-1	107.92	14.52	1	0.76	0.76	1291

id_effort	id	country	year	quarter	vessel_length	gear	mesh_size	fishery	area	specon	nominal_effort	gt_days_at_sea	no_vessels	days_at_sea	fishing_days	upload_id
69174	NA	MLT	2017	2	VL1824	LLS	-1	DEMF	SA 5	-1	537.12	156	1	3	1	987

EWG19-10 observed unexpected pattern of fishing effort data from Spain (ESP) related to trammel nets fishing activities in Balearic Islands (GSA 5), indicating significant decrease in 2007 and 2008 years. It is suspected that 2007 and 2008 data might be biased, and it will be advisable that MS concerned check these data records (Table 2.3.4).

Generally, in most of GSAs analysed, fishing effort in terms of fishing days has decreasing trend. However, EWG19-10 also observed an unexpected strong increase in number of fishing days in 2018 related to bottom otter trawls (OTB) fleet operating in area GSA 11 (Sardinia) in comparison to previous years. Results of following more detailed analyses indicated that the reason for that is large increase in reported number of fishing vessels that used OTB fishing gear in GSA 11.

EWG19-10 emphasizes the fact that from effort dataset it is not possible to derive exact information on number of fishing vessels. So, the analyses made included the sum of no. vessels reported in all quarters (1,2,3 and 4), as well as analyses of maximum number of vessels reported by quarter and by vessel sizes within 2004-2018 period (Fig 2.3.2 and Fig 2.3.3), are intended to be used just as indications. EWG suggests further analyses of real number of fishing vessels using bottom otter trawls (OTB) in Sardinia (GSA 11) to be performed by STECF.

Table 2.3.4. Effort data records in GSA 5 (gear type: GTR) to be checked by Spain.

id_effo	id	country	year	quarter	vessel_	gear	mesh_s	fishery	area	specon	nomina	gt_days	no_ves	days_at	fishing_	upload_
48530	ESP20071\	ESP	2007	1	VL0006	GTR	16D20	-1	SA 5	-1	475	23.54	1	22	22	368
48535	ESP20071\	ESP	2007	1	VL0612	GTR	16D20	-1	SA 5	-1	26144	1391	28	377	377	368
48551	ESP20072\	ESP	2007	2	VL0006	GTR	16D20	-1	SA 5	-1	1502	51.88	4	53	53	368
48556	ESP20072\	ESP	2007	2	VL0612	GTR	16D20	-1	SA 5	-1	60755	2975.71	34	841	841	368
48574	ESP20073\	ESP	2007	3	VL0006	GTR	16D20	-1	SA 5	-1	1442	54.57	4	58	58	368
48579	ESP20073\	ESP	2007	3	VL0612	GTR	16D20	-1	SA 5	-1	51319	2496.01	32	679	679	368
48604	ESP20074\	ESP	2007	4	VL0612	GTR	16D20	-1	SA 5	-1	14652	855.86	21	250	250	368
48620	ESP20081\	ESP	2008	1	VL0006	GTR	16D20	-1	SA 5	-1	222	7.15	2	7	7	368
48625	ESP20081\	ESP	2008	1	VL0612	GTR	16D20	-1	SA 5	-1	24066	1319.68	25	386	386	368
48642	ESP20082\	ESP	2008	2	VL0006	GTR	16D20	-1	SA 5	-1	1738	65.61	4	68	68	368
48647	ESP20082\	ESP	2008	2	VL0612	GTR	16D20	-1	SA 5	-1	67516	3191.66	38	927	927	368
48664	ESP20083\	ESP	2008	3	VL0006	GTR	16D20	-1	SA 5	-1	1254	58.47	4	66	66	368
48670	ESP20083\	ESP	2008	3	VL0612	GTR	16D20	-1	SA 5	-1	61972	2942.08	35	841	841	368
48689	ESP20084\	ESP	2008	4	VL0006	GTR	16D20	-1	SA 5	-1	125	4.3	1	5	5	368
48693	ESP20084\	ESP	2008	4	VL0612	GTR	16D20	-1	SA 5	-1	14811	804.2	23	258	258	368

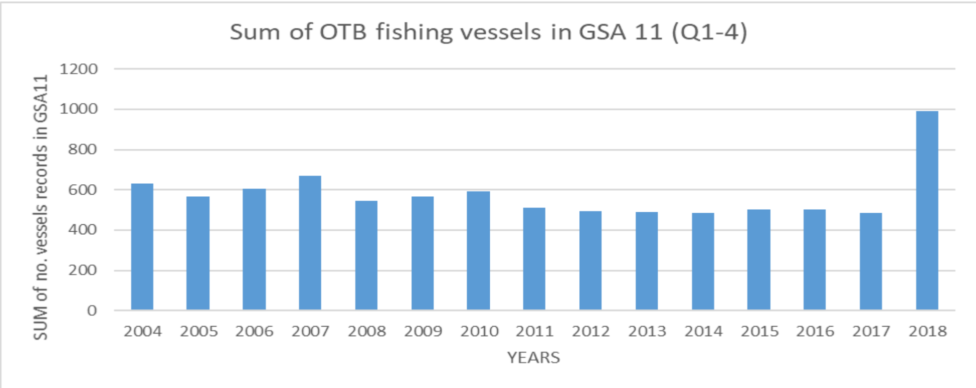


Figure 2.3.2. Sum of no. vessels using OTB gear in GSA 11 as reported in all quarters (1, 2, 3 and 4).

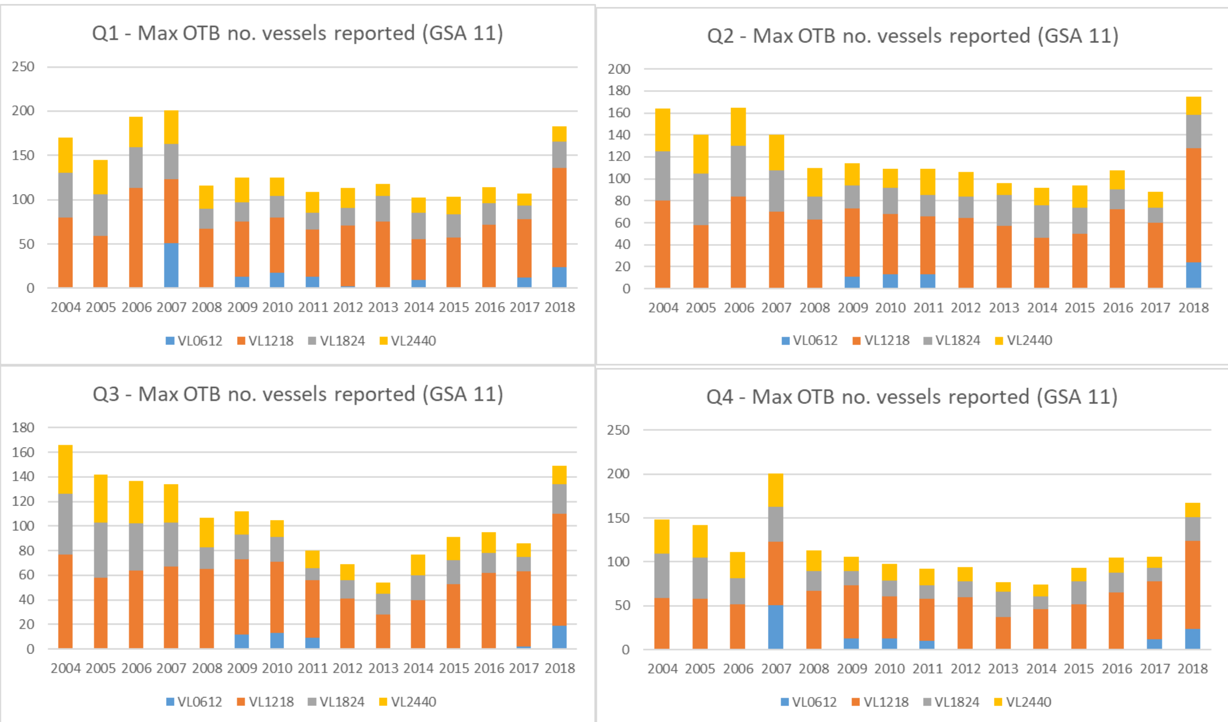


Figure 2.3.3. Maximum no. vessels using OTB gear in GSA 11 as reported by quarter and by vessel sizes.

Finally, in order to better link effort to fisheries, EWG19-10 began to evaluate the relations species vs. gear & fishery data more in detail in landing data table, and some odd records were noted. For example, in 24 data records hake (HKE) appears as a catch obtained by drifting longline gear (LLD) used in large pelagic fishery (LPF) in GSA 10, that are considered as inconsistent data records. Also, some inconsistencies in few records in terms of gear vs. fishery data entries were noticed, as use of bottom otter trawl (OTB) in small pelagic fishery (SPF) or use of drifting longlines (LLD) in demersal fishery (DEMF). These inconsistent data records are shown in Table 2.3.5. Due to these issues the metier / fishery link was not explored further.

Table 2.3.5. Inconsistent data records related to hake (HKE) from landing.csv dataset.

From landing data:												
id_landing	id	country	year	quarter	vessel_len	gear	mesh_size	fishery	area	specon	species	landings
410867	ITA20161L	ITA	2016	1	-1	LLD	-1	LPF	SA 10	-1	HKE	8.9208
411073	ITA20162L	ITA	2016	2	-1	LLD	-1	LPF	SA 10	-1	HKE	4.31981
411249	ITA20163L	ITA	2016	3	-1	LLD	-1	LPF	SA 10	-1	HKE	3.69919
411406	ITA20164L	ITA	2016	4	-1	LLD	-1	LPF	SA 10	-1	HKE	2.20013
419041	ITA2005-1	ITA	2005	-1	-1	LLD	-1	LPF	SA 10	-1	HKE	0.51846
419532	ITA2008-1	ITA	2008	-1	-1	LLD	-1	LPF	SA 10	-1	HKE	1.53623
419730	ITA2009-1	ITA	2009	-1	-1	LLD	-1	LPF	SA 10	-1	HKE	2.85826
419925	ITA2010-1	ITA	2010	-1	-1	LLD	-1	LPF	SA 10	-1	HKE	36.14098
420118	ITA2011-1	ITA	2011	-1	-1	LLD	-1	LPF	SA 10	-1	HKE	72.62722
420332	ITA2012-1	ITA	2012	-1	-1	LLD	-1	LPF	SA 10	-1	HKE	14.26549
457291	ITA20171L	ITA	2017	1	-1	LLD	-1	LPF	SA 10	-1	HKE	7.63113
457292	ITA20172L	ITA	2017	2	-1	LLD	-1	LPF	SA 10	-1	HKE	2.94855
516808	ITA20182L	ITA	2018	2	VL0612	LLD	-1	LPF	SA 10	-1	HKE	0.0775
516809	ITA20182L	ITA	2018	2	VL1218	LLD	-1	LPF	SA 10	-1	HKE	4.7119
516810	ITA20182L	ITA	2018	2	VL1824	LLD	-1	LPF	SA 10	-1	HKE	0.0035
516831	ITA20183L	ITA	2018	3	VL0612	LLD	-1	LPF	SA 10	-1	HKE	0.0806
516832	ITA20183L	ITA	2018	3	VL1218	LLD	-1	LPF	SA 10	-1	HKE	5.005
516850	ITA20184L	ITA	2018	4	VL0612	LLD	-1	LPF	SA 10	-1	HKE	0.1765
516851	ITA20184L	ITA	2018	4	VL1218	LLD	-1	LPF	SA 10	-1	HKE	5.8342
516852	ITA20184L	ITA	2018	4	VL1824	LLD	-1	LPF	SA 10	-1	HKE	0.011
id_landing	id	country	year	quarter	vessel_len	gear	mesh_size	fishery	area	specon	species	landings
187787	FRA2013-1	FRA	2013	-1	VL1218	LLD	-1	DEMF	SA 7	-1	HKE	0.63
188318	FRA2015-1	FRA	2015	-1	VL0612	LLD	-1	DEMF	SA 7	-1	HKE	0.037
407423	1	FRA	2016	3	VL1218	LLD	-1	LPF	SA 7	-1	HKE	0.07
id_landing	id	country	year	quarter	vessel_len	gear	mesh_size	fishery	area	specon	species	landings
498308	MLT20184	MLT	2018	4	VL1824	LLD	-1	LPF	SA 5	-1	HKE	0.005
id_landing	id	country	year	quarter	vessel_len	gear	mesh_size	fishery	area	specon	species	landings
512530	FRA_2018_	FRA	2018	1	VL2440	OTB	40D50	SPF	SA 7	-1	HKE	0.057

In addition to analyses of effort data (fishing days) of particular gear types related to different stock assessments, EWG19-10 also provides in Report the most complete sets of annual data on fishing effort for the longest time series available. Tables describing fishing days, days at sea, GT*days and nominal effort by Member states, GSAs and fishing gear are given in Annex B. It is noted that for some areas and some countries ‘Days at Sea’ data and ‘Fishing Days’ data are numerically equal.

3 FOLLOW UP ITEMS

3.1 Length slicing for populations with mid-year spawning.

In last year's report attention was drawn to the issue of correctly assigning length to age through length slicing routines such as L2A. It was noted that it was important that the size at which the age transition occurs needs to be checked, so that numbers at length caught are mapped appropriately to age with the age changing 1st of January consistent with calendar year assessments used to give calendar year advice. Often growth curves are developed to give size at age from the nominal birth date of the individuals. When spawning occurs in winter there is a coincidence of birth date and calendar year and it should be expected that growth is referred to 1st January. However, if spawning is mid-year, 1st July, then growth may be defined from 1st July or may still be on a calendar year basis depending on how the data and methods used to give growth curves. All of the stocks except hake in this assessment WG are considered to have a summer spawning peak, and the spawning biomass is calculated for 1st of July. In order to check the veracity of the functions used for slicing length to age the growth points defined by the selected growth curves at 6 months, 1 year and 18 months were compared with MEDITS surveys modes and expected presence or absence of 0 group individuals, given that generally 0 group should only be observed in significant numbers in the Autumn. In January through May-June 0 group should be rare. In many cases the 12 month point on selected growth curves was found to coincide with sizes expected at spawning time. In the case of summer spawning stocks and calendar year assessment it is necessary that age 1 individuals are those from month 7 to month 18, and age 2 from month 19 to 30 etc. In using L2A the required shift (from 12/24/36 month to 6/18/30 months) is easily obtained by shifting t0 by 0.5 just for the L2A slicing.

The growth parameters are used not only for length to age slicing, but also to obtain estimates of natural mortality. A brief examination of the natural mortality methods used in the group showed that it's important to use the true t0 value in the equations for natural mortality as this influences M in the first year in a more complex way. Changing t0 changes the natural mortality incorrectly. However, the values of M derived then relate to a full years mortality at each age whereas the 0 group are subject to only 6 months mortality but the magnitude of the mortality should be higher, suitable for only the smallest sizes. The consequences of this are twofold. Recruitment is artificially elevated to replace the numbers lost through the excess mortality; this is a minor technical issue which is not thought to be of major significance. However, the value of M particularly at age 0 but to some extent at age 1 is sensitive to the parameterisation. In some stocks this appears to have little impact (Giant red shrimp in GSA 9_10_11) but on others (Blue and red shrimp in GSA 1 and DWRS in GSA 9_10_11) the effect on $F_{0.1}$ is more important. For species such has herring or mackerel with summer or autumn spawning, assessed by ICES using annual calendar year models it is normal practice to use annual mortality. It's currently unclear what is the correct way to deal with this issue. More work is required to check the best way to parameterise M in an annual model with mid-year spawning. One solution if the data is available is to consider a model with 6 month or quarterly time steps. However, the quality of the data required to parameterise such model is lacking in some cases, and quarterly data was not available at the meeting. The group concluded it was advisable to follow ICES practice and keep annualised mortality for age 0.

For most assessments (red and blue shrimp in GSA 1 and DPS in GSA 9, 10 and 11) the effect of advice was negligible. For others the issues were more complex. The assessment of blue and red shrimp in GSAs 6 & 7 showed some discrepancies related to the method of slicing LFD data. Length slicing has been a topic of considerable uncertainty and debate for many years The STECF EWG suggest that in future the possible methods of slicing LFD data (of fishes and invertebrates), as well as growth information they are using, are thoroughly reviewed, taking into consideration the seasonality of growth, reproduction and moulting processes, in order to define and ably the best practice in cohort slicing for stock assessment. This is particularly the case for the red and blue shrimps and red mullet where different growth is used and length slicing can give different results.

3.2 Hake Benchmark

GFCM is proposing a benchmark for hake in the Mediterranean Sea (excluding Adriatic) December 2019. The EWG briefly considered the work required and made the following notes, these related to hake in GSAs 1, 5, 6, 7, 9, 10 and 11.

The choice of stock boundaries by GSA will need examination; there are four concepts for consideration in this approach, available knowledge on spatial separation of spawning/stock; Differences in dynamics across areas; improvement/deterioration of estimation by joining/separating areas; utility of management information across areas. Taking account also of data availability for types of models.

Availability of data for main parameterisation, availability of age length relationships, use of otolith directly or to inform growth equations. Ensuring coherence of mean weight and fraction mature with growth. Separation by sex for both growth and maturation, and assembling data to examine this. Selection of best time assignment for spawning time (January?) and appropriate stock weights for this spawning time.

If there is to be a continued use of deterministic length slicing and spawning is concentrated substantially in one period of the year then improvements might be possible by slicing quarterly catch data and surveys explicitly based on their temporal placement (i.e. setting age slicing boundaries at the growth points 6 months before and after survey and 6 months before and after the centre of the quarterly data.

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) **Used for 1 stock this year and for 3 from last year**.
7) Valid length analysis: statement of stock status, indication of direction of change required.
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
  - 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

5 SUMMARY SHEETS BY STOCK

ToR 10. *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 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.38 and corresponding catches in 2020 should be no more than 1269 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. The assessment shows a decreasing trend in the number of recruits in the time series, with the minimum value reached in 2014. Fbar (1-3) shows a sharp increasing to 2010 with a slight upward trend through to 2018 when estimated F is 1.84 as mean of last three years .

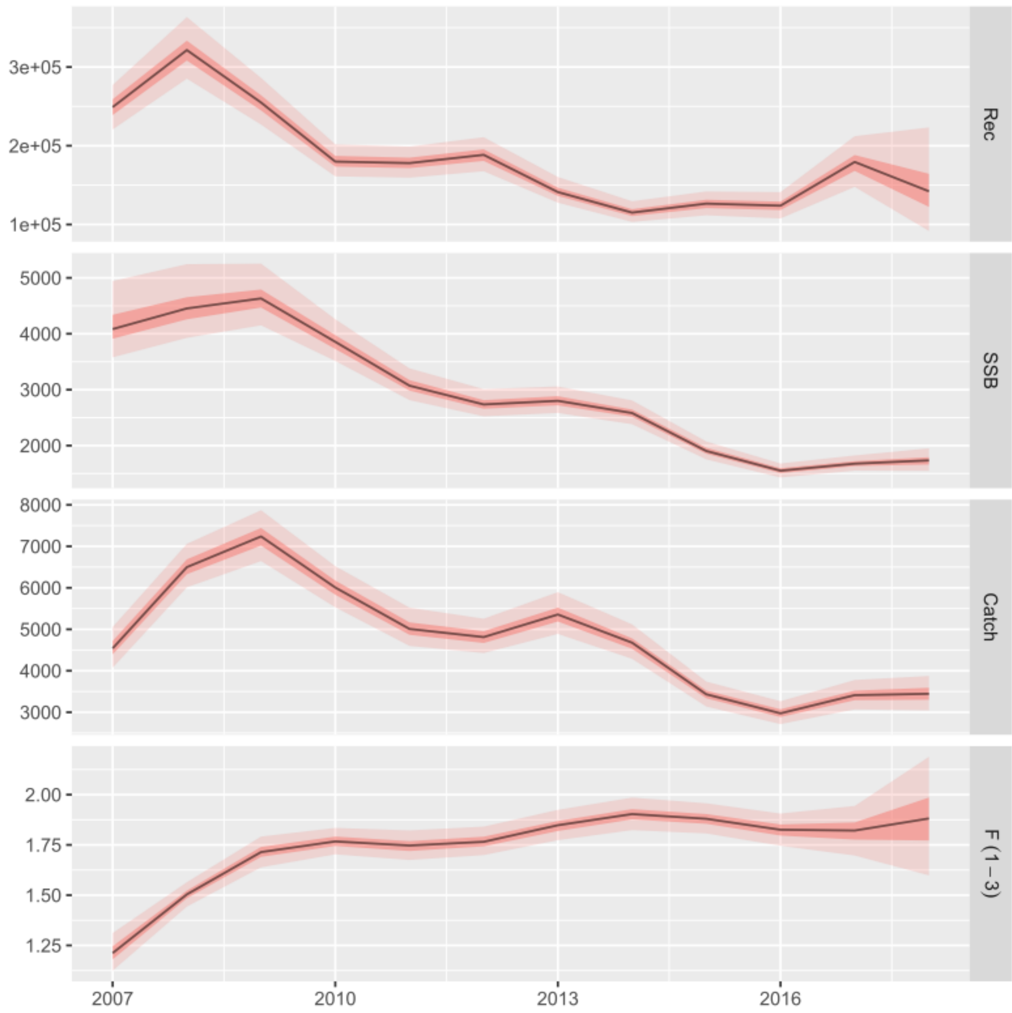


Figure 5.1.1 European hake in GSAs 1, 5, 6 and 7: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (1.84) is 4.8 times above the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.38).

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

Status	2016	2017	2018
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
$F_{ages\ 1\text{-}3}$ (2019)	1.84	mean F 2016-18 used to give F status quo for 2019
SSB (2019)	2045	Stock assessment 1 January 2019
R_{age0} (2019,2020)	150432	Geometric mean of the last 9 years
Total catch (2019)	3659	Assuming F status quo for 2019

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* (2020)	F_{total}# (ages 1-3) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	1269	0.38	6566	221	-63.17
$F_{MSY\ lower}$	894	0.26	7381	261	-74.05
$F_{MSY\ upper}$**	1640	0.52	5773	182	-52.38
Other scenarios					
Zero catch	0.00	0.00	9372	358	-100
Status quo	3640	1.84	1932	-5.49	5.69

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

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, although assessment model was modified to get an improved fit, this change did not change the historical estimation of F. The retrospective analysis showed a strong change in the estimation of F from the previous year, but the F estimated for 2017 is consistent with the F estimated by last year assessment. Also the estimation of recruitment is consistent with the ones obtained from last year assessment. All the diagnostics were considered acceptable.

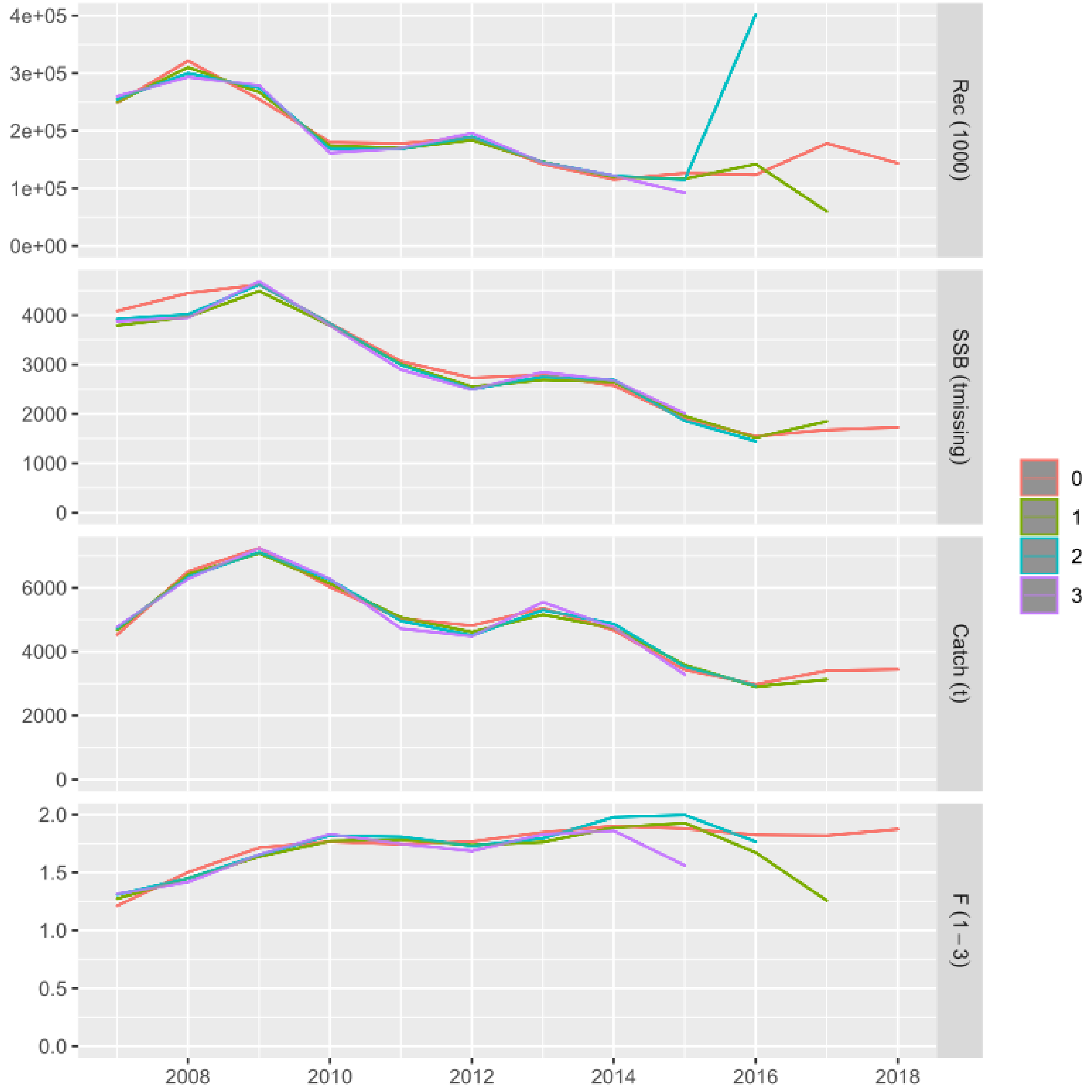


Figure 5.1.2 European hake in GSAs 1, 5, 6 and 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.38	$F_{0.1}$ 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}	0.38	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.26	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.52	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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 19-10

*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 landings	STECF discards
2019	F = F_{MSY}		3659		
2020	F = F_{MSY}		1269		

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.

2018		Wanted catch				Discards
Catch (t)	4077	Otter trawl 94.8%	Gillnets 3.27%	Trammel nets 0.86%	Other 0.02%	247 t
Effort	181794	49296	16721	113760		
		Fishing Days				

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

Year	SPAIN GSA1	SPAIN GSA5	SPAIN GSA6	SPAIN GSA7	FRANCE GSA7	Total landings	Total Effort (Fishing Days)
2002	496	95	2835	369	2343	6138	
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	1774	5466	**190897**
2011	683	85	3182	134	1196	5279	**181572**
2012	463	61	2641	180	933	4278	**175275**
2013	375	109	2950	216	1482	5131	**171356**
2014	283	118	2489	224	1671	4786	**176312**
2015	183	102	1726	126	991	3129	**216479**
2016	176	67	1810	120	911	3083	**205775**
2017	299	72	1728	95	751	2946	**200855**
2018	410	97	2443	87	794	3831	**181794**

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 2-6	High	Low
2007	248685			4086			4529	1.21		
2008	321513			4446			6509	1.5		
2009	254835			4618			7239	1.71		
2010	180131			3836			6023	1.77		
2011	178084			3066			5028	1.74		
2012	188230			2730			4816	1.77		
2013	141960			2791			5360	1.85		
2014	115253			2573			4667	1.9		
2015	126301			1900			3433	1.88		
2016	123527			1546			2976	1.82		
2017	178090			1676			3403	1.82		
2018	143728			1729			3444	1.87		

Sources and references

STECF EWG 19-10

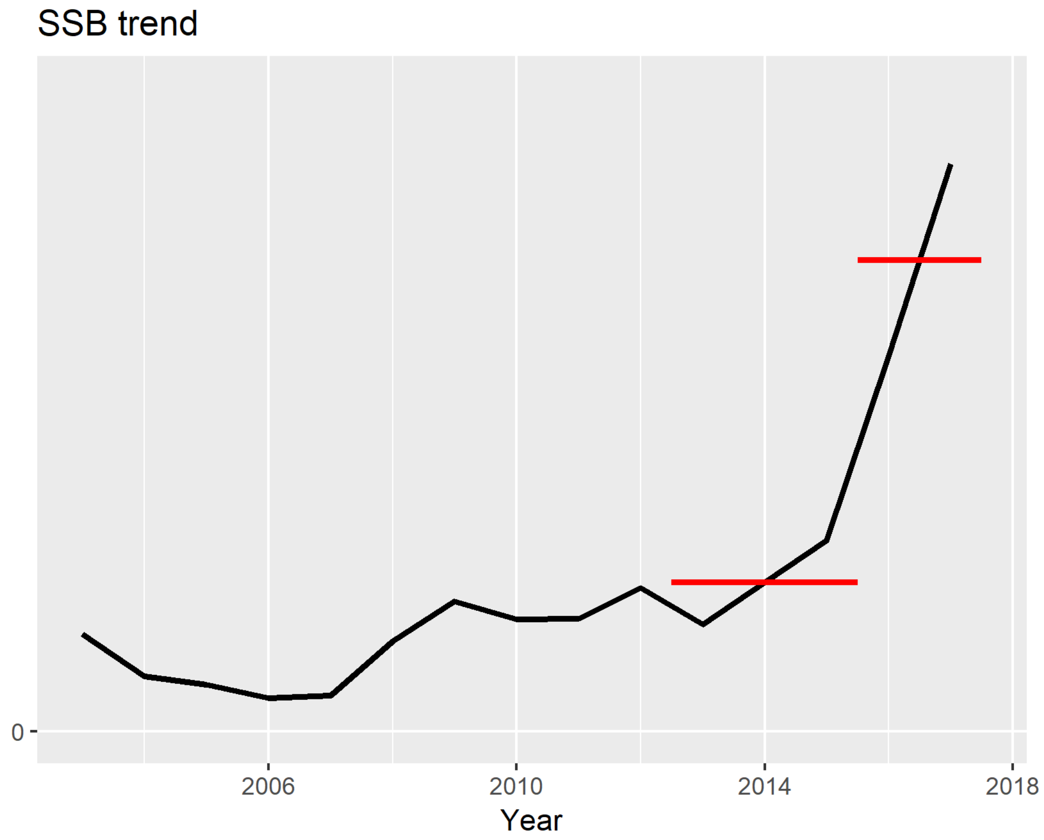
5.2 Summary sheet for deep-water rose shrimp in GSA 1, 5, 6 & 7

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 18-12 advises to decrease the total catch to 96% of the average 2015-2017 catches equivalent to catches of no more than 638.4 tons in each of 2019 and 2020 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 2003 to 2014. In the last 3 years the stock has increased rapidly. Based on the index value in the last two years relative to the previous three years the increase in SSB is estimated to be 3.2 times.



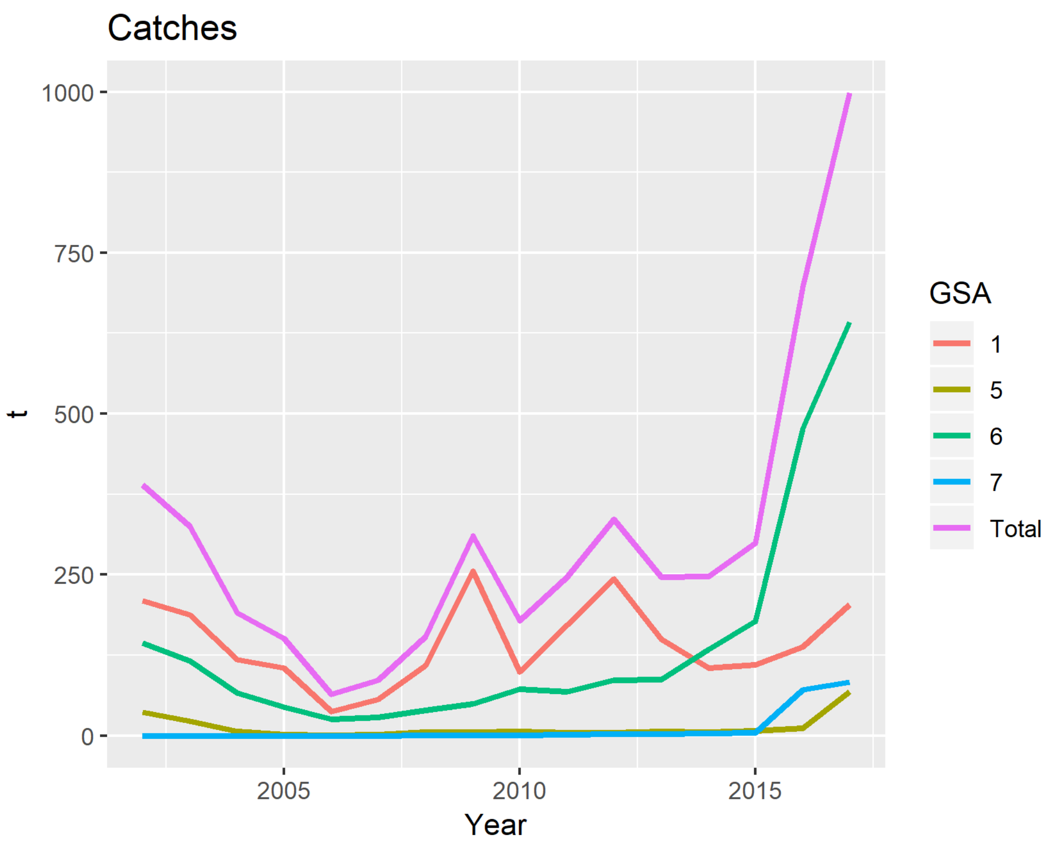


Figure 5.2.1 Deep water rose shrimp in GSA 1, 5, 6&7: Summary of the MEDITS stock indicator and catch by year.

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 over the last 2 to 3 years.

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 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 applied because the precautionary status of the stock is not known.

Table 5.2.2 Deep water rose shrimp in GSA 1, 5, 6&7: Assumptions made for the interim year and in the forecast. *

Index A (2016–2017)		440
Index B (2013–2015)		139
Index ratio (A/B)		3.2
-20% Uncertainty cap	Applied/not applied	Applied
Average catch (2015–2017)		665
Discard rate (2015–2017)		
-20% Precautionary buffer	Applied/not	Applied

	applied	
Catch advice **	638.4	
Landings advice ***		
% advice change ^	%	

* 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)
*** catch advice × (1 – discard rate)
^ Advice value 2019 relative to advice value 2018.

Basis of the advice

Table 5.2.3 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 18-12 concluded that the output of these model were 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 5.2.4 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 5.2.5 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 18-12

Information from stakeholders

Not applicable

History of the advice, catch, and management

Table 5.2.6 Deep water rose shrimp in GSA 1, 5, 6&7: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted catch corresp. to advice	Official landings in (areas)	STECF landings	STECF discards	STECF catch
2019	Reduction of 4% of catch	638.4				
2020	Reduction of 4% of catch	638.4				

History of the catch and landings

Table 5.2.7 Deep water rose shrimp in GSA 1, 5, 6&7: Catch distribution by fleet in YEAR as estimated by STECF.

Catch (2017)	Landings			Discards
998.2 t	100 % trawl	% set nets	% others	10.56 t
	t			

Table 5.2.8 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	SPAIN GSA7	FRANCE GSA7	Discards	Total
2002	209.8	36.2	144.1	0.0	0	0.0	390.0
2003	187.2	22.1	116.0	0.0	0	0.0	325.3
2004	118.1	6.5	66.2	0.0	0	0.0	190.9
2005	103.0	1.6	44.7	0.0	0	1.7	151.0
2006	37.6	1.0	25.2	0.0	0	0.0	63.8
2007	56.2	1.4	28.8	0.0	0	0.0	86.4
2008	108.9	5.2	39.0	0.1	0	0.6	153.7
2009	253.9	5.1	49.1	0.1	0	1.7	310.0
2010	97.6	6.3	71.9	0.4	0	2.1	178.2
2011	171.6	4.5	66.3	1.2	0	2.8	246.4
2012	241.5	4.2	85.6	2.0	0	3.1	336.4
2013	149.1	6.2	86.8	2.3	0	2.3	246.7
2014	100.4	5.6	131.3	3.4	0	6.6	247.2
2015	108.6	7.6	174.6	4.7	0	4.0	299.5
2016	136.8	9.1	471.3	27.1	44.2	8.9	697.4
2017	201.8	68.0	634.7	36.3	46.9	10.6	998.2

Summary of the assessment

Table 5.2.10 Deep water rose shrimp in GSA 1, 5, 6&7: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2003	0.65	325.3	0.0	325.3
2004	0.37	190.9	0.0	190.9
2005	0.31	149.3	1.7	151.0
2006	0.22	63.8	0.0	63.8
2007	0.24	86.4	0.0	86.4
2008	0.60	153.2	0.6	153.7
2009	0.87	308.3	1.7	310.0
2010	0.75	176.1	2.1	178.2
2011	0.75	243.5	2.8	246.4
2012	0.96	333.3	3.1	336.4
2013	0.71	244.4	2.3	246.7
2014	1.00	240.7	6.6	247.2
2015	1.28	295.5	4.0	299.5
2016	2.51	688.5	8.9	697.4
2017	3.80	987.7	10.6	998.2

Sources and references

Reproduced from STECF EWG 18-12 for use in 2019 EWG 19-10. For original data supporting this summary sheet see STECF report of Mediterranean Assessment EWG 18-12

5.3 Summary sheet for red mullet in GSA 1

STECF advice on fishing opportunities

STECF EWG 19-10 advises that, when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.54 and corresponding catches in 2020 should not exceed 53.5 tonnes.

Stock development over time

The SSB shows a decline during the past three years with a mean value of 247 tonnes, having the reached a maximum in 2016. The recruitment also shows a sharp declining pattern since the maximum 2016. Catch shows a fluctuating pattern until 2015. In 2014 – 2017 shows an increasing pattern which falls in the last year, close to long term mean.

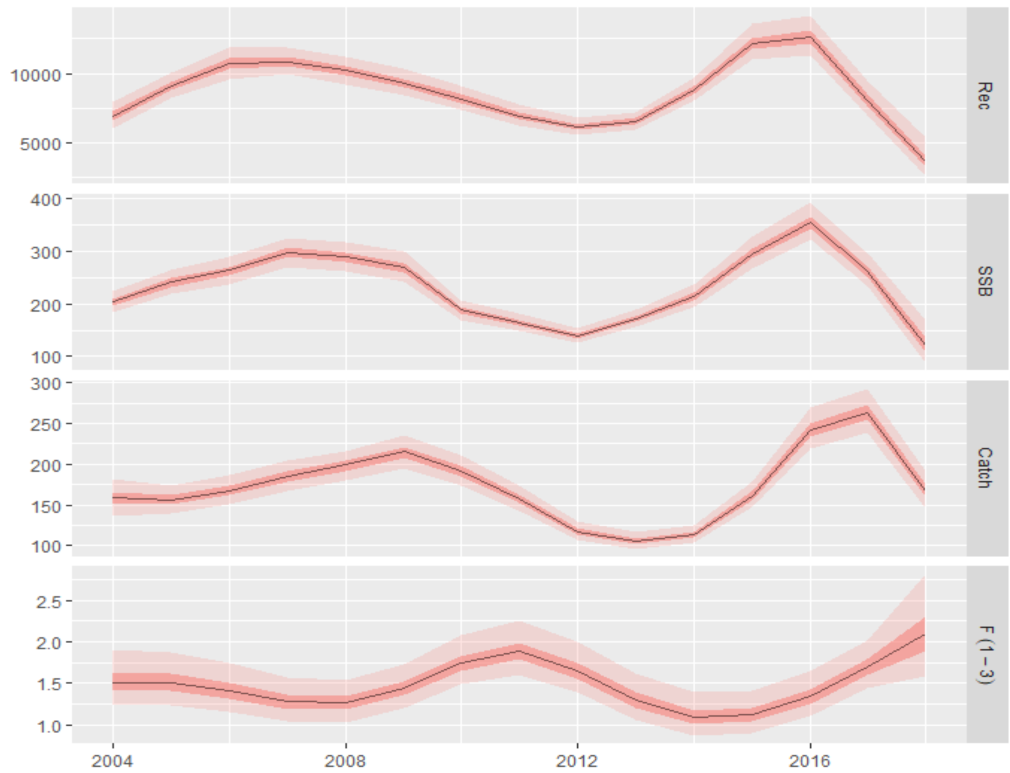


Figure 5.3.1 Red mullet in GSA 1. Summary of assessment results. Trends in recruitment (in 1000), spawning stock biomass (tonnes), catch (tonnes) and fishing mortality for ages 1 – 3.

Stock and exploitation status

The current level of fishing mortality F_{curr} (=2.10) is larger than the reference point $F_{0.1}$ used as proxy of F_{MSY} (=0.54), indicating over exploitation of Red mullet in GSA 1.

Table 5.3.2 Red mullet in GSA 1**.** State of the stock and fishery relative to reference points.

Method	2016	2017	2018

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

Catch scenarios

Table 5.3.3 Red mullet in GSA 1: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2019)	2.10	F status quo = F2018
SSB (2019)	122 t	SSB assuming Status quo F in 2019
R_1 (2019)	8335	Geometric mean of all the time series
Total catch (2019)	99 t	Catch assuming status quo F in 2019

Table 5.3.4 Red mullet in GSA 1: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2020)	F_{total}# (ages 1-3) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	53.5	0.54	271.0	32.51	-68.33
$F_{MSY\ lower}$	38.1	0.36	300.4	41.63	-77.44
$F_{MSY\ upper}$	68.0	0.74	245.5	24.70	-59.74
Other scenarios					
Zero catch	0	0	383.4	67.73	-100
Status quo	130.5	2.10	156.7	0.96	-22.75
0.2	43.4	0.42	290.1	38.41	-74.32
0.4	74.7	0.84	234.4	21.38	-55.78
0.6	98.1	1.26	198.8	11.20	-41.94
0.8	116.1	1.68	174.4	4.93	-31.26

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

*** % change in SSB 2021 to 2019

^Total catch in 2019 relative to Catch in 2018.

Basis of the advice

Table 5.3.5 Red mullet in GSA 1: Stock The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The retrospective of the assessment shows it is quite stable and the stock status is unaffected by the addition of new data, F is estimated to be well above F_{MSY} in all years.

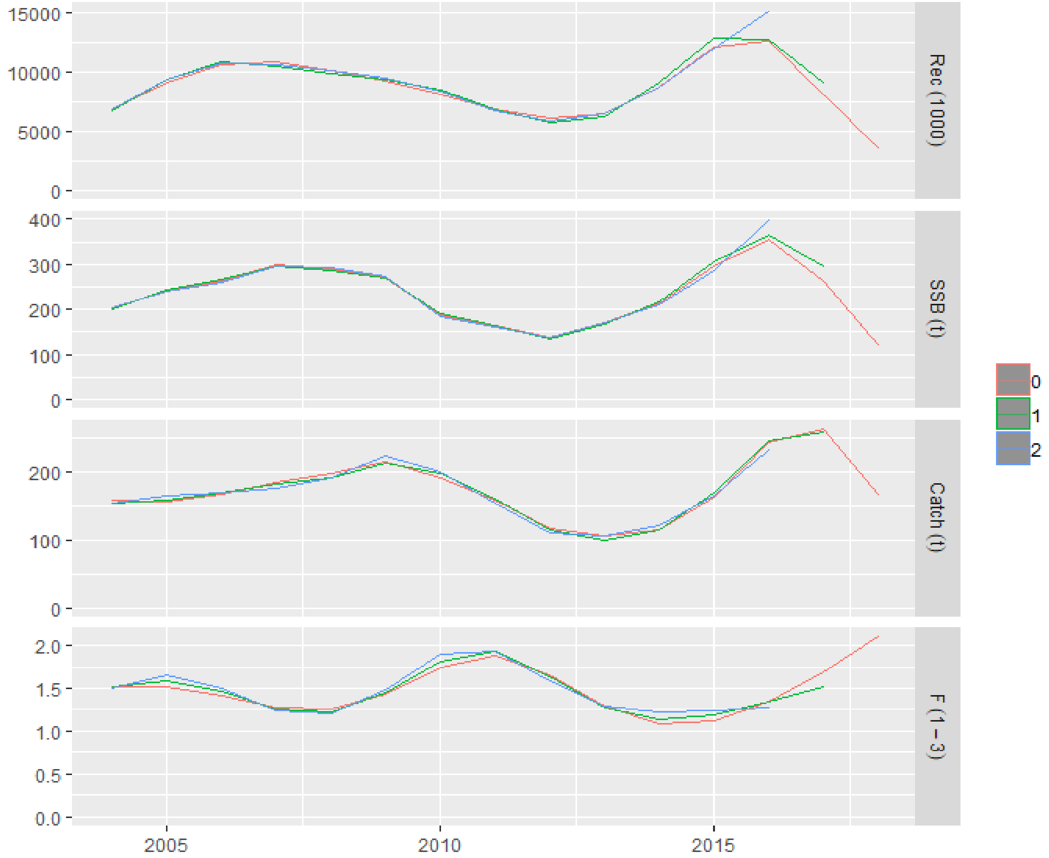


Figure 5.3.2 Red mullet in GSA 1: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Incorrect length frequency distribution were supplied for the landings data in 2012 these were corrected and used in the assessment. The year 2011 was missing, and 2006 length frequency was misreported, from MEDITS survey. Age slicing method was modified this year to account for mid-year spawning.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.3.6 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}	0.54	$F_{0.1}$ used as a proxy of 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}	0.54	$F_{0.1}$ used as a proxy of F_{MSY}	
	target range F_{lower}	0.36	Based on regression calculation (see section 2)	
	target range F_{upper}	0.74	Based on regression calculation but not tested and presumed not precautionary	

Basis of the assessment

Table 5.3.7 Red mullet in GSA 1: Basis of the assessment and advice.

Assessment type	Statistical Catch – at – Age (A4a)
Input data	Commercial catches (2004-2018) and one tuning index, MEDITS bottom trawl survey (CPUE, kg/km2, 2004-2018)
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	EWG 19 - 10

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.3.8 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 landings	STECF discards
2019	$F = F_{MSY}$	99	99			
2020	$F = F_{MSY}$	53.5	53.5			

History of the catch and landings

Table 5.3.9 Red mullet in GSA 1: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

(current year-1)		Wanted catch				Discards
Catch (t)		Beam trawl 0%	Gillnets 0%	Trammel nets 13%	Other 87%	Negligible
		169 tonnes				
Effort	30057			8424	21633	
		Fishing Days				

Table 5.3.10 Red mullet in GSA 1**:** History of commercial landings; official reported values are presented by country and GSA,. All weights are in tonnes. Effort in Fishing Days.

Year	Spain GSA 1	Total landings	Total BMS landings	STECF total landings	Total Effort
2004	154.07	154.07		158	40760
2005	140.21	140.21		156	37895
2006	164.54	164.54		168	37380
2007	194.01	194.01		186	35391
2008	193.65	193.65		199	32165
2009	228.37	228.37		215	36472

2010	201.65	201.65		192	37515
2011	201.18	201.18		158	38558
2012	107.31	107.31		118	36023
2013	131.63	131.63		106	36757
2014	123.87	123.87		115	36058
2015	135.9	135.9		162	31397
2016	260.49	260.49		244	31534
2017	274.67	274.67		265	33123
2018	170.23	170.23		169	30057

Summary of the assessment

Table 5.3.11 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	6939			203			158	1.52		
2005	9132			241			156	1.51		
2006	10702			263			168	1.41		
2007	10875			298			186	1.28		
2008	10197			289			199	1.26		
2009	9309			268			215	1.44		
2010	8206			187			192	1.74		
2011	6945			164			158	1.88		
2012	6146			139			118	1.66		
2013	6566			172			106	1.30		
2014	8793			215			115	1.09		
2015	12197			296			162	1.12		
2016	12646			355			244	1.34		

2017	8110			263			265	1.69		
2018	3673			122			169	2.10		

Sources and references

STECF EWG 19-10

5.4 Summary sheet for striped red mullet in GSA 5

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.42 and corresponding catches in 2020 should be no more than 110.2 tons.

Stock development over time

Catches and SSB of striped red mullet showed an increasing trend for the last year. Recruitment showed the minimum value for the time series in the last year, after a maximum in the previous year. F_{BAR1-2} showed a clear decreasing trend in last two years.

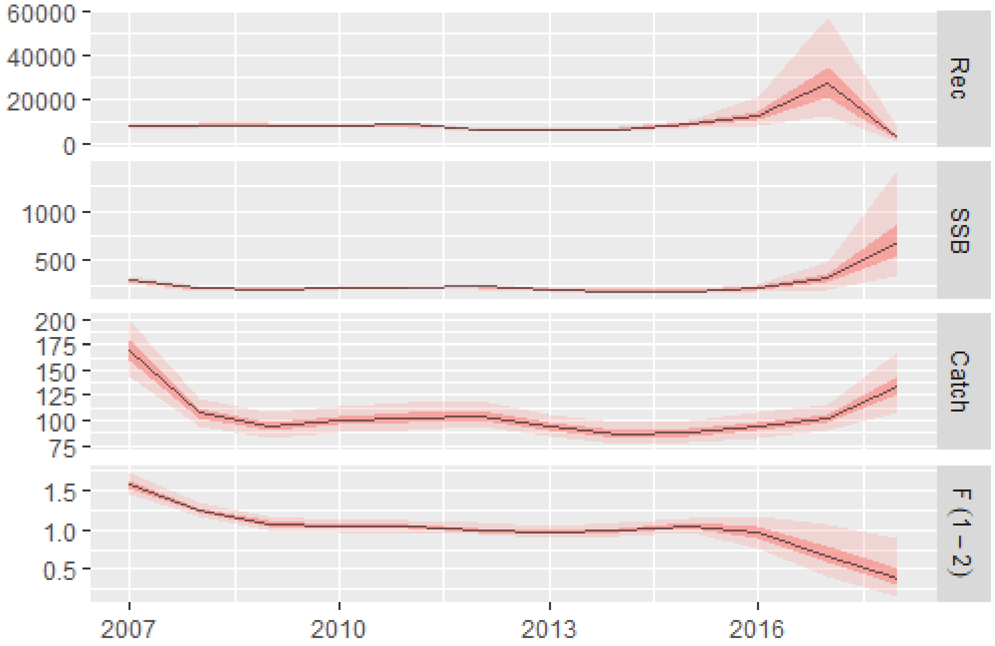


Figure 5.4.1 Striped red mullet in GSA 5: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.42).

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

Status	2016	2017	2018
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
$F_{ages\ 1\text{-}2}$ (2019)	0.39	F2018 used to give F status quo for 2018
SSB (2019)	468	Stock assessment 1 January 2019
R_{age0} (2019,2020)	8081	Geometric mean of the entire data series (12 years)
Total catch (2019)	133	Assuming F status quo for 2019

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* (2020)	F_{total}# (ages 0-2) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	110.2	0.42	368.2	-21.3	-21.1
$F_{MSY\ lower}$	78.6	0.28	402.2	-14	-43.8
$F_{MSY\ upper}$**	140.6	0.57	336.2	-28.1	0.6
Other scenarios					
Zero catch	0	0	488.3	4.4	-100
Status quo	104	0.39	374.9	-19.9	-25.6
0.6	67.2	0.23	414.5	-11.4	-51.9
0.8	86.3	0.31	393.9	-15.8	-38.3
1.2	120.4	0.46	357.5	-23.6	-13.9
1.4	135.6	0.54	341.5	-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 2021 to 2019

^Total catch in 2020 relative to Catch in 2018.

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

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.

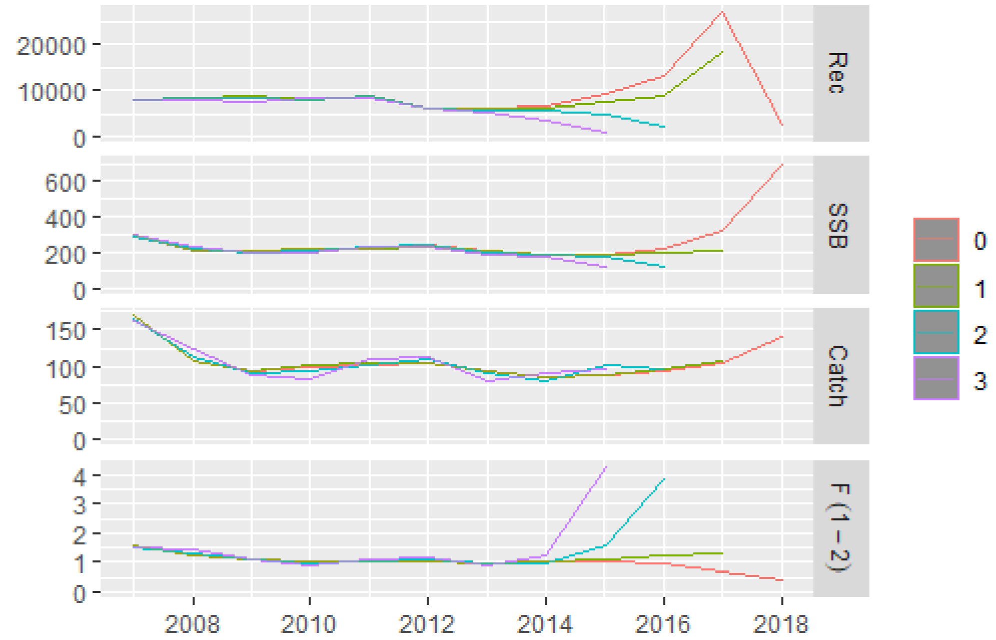


Figure 5.4.2 Striped red mullet in GSA 5: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional issues

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}	0.42	$F_{0.1}$ 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}	0.42	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.28	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.57	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

Basis of the assessment

Table 5.4.6 Striped 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 negligible
Indicators	
Other information	
Working group	STECF EWG 19-10

*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 landings	STECF discards
2019	$F = F_{MSY}$		133		
2020	$F = F_{MSY}$		110		

History of the catch and landings

Table 5.4.8 Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2018		Wanted catch				Discards
Catch (t)		Bottom trawl 92%	Gillnets 0%	Trammel nets 8%	Other 0%	0 t
		132.4 tonnes				
Effort		46%		54%		
		17158 Fishing days				

Table 5.4.9 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	STECF total estimated catch	Total Effort
2004	131.7	131.7		24948
2005	101.6	101.6		26035
2006	153.0	153.0		24075
2007	148.5	148.5	169.0	14187
2008	152.9	152.9	107.0	14784
2009	170.1	170.1	93.9	22438
2010	139.2	139.2	99.9	22508
2011	73.0	73.0	102.9	20759

2012	93.2	93.2	104.6	20509
2013	107.4	107.4	93.4	21081
2014	100.4	100.4	85.9	23844
2015	87.9	87.9	88.0	22957
2016	95.4	95.4	94.6	20926
2017	96.6	96.6	103.3	21539
2018	106.5	106.5	139.7	17158

Summary of the assessment

Table 5.4.10 Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2007	7727.9	6695.9	8759.9	297.1	266.4	327.8	169.0	1.58		
2008	8296.3	7250.3	9342.3	215.0	194.6	235.4	107.0	1.24		
2009	8546.3	7453.3	9639.3	207.3	188.8	225.8	93.9	1.08		
2010	8011.4	6992.4	9030.4	223.1	203.9	242.3	99.9	1.04		
2011	8636.7	7619.7	9653.7	226.0	205.7	246.3	102.9	1.03		
2012	6314.2	5483.2	7145.2	239.0	219.0	259.0	104.6	1.00		
2013	6073.5	5291.5	6855.5	208.9	191.8	226.0	93.4	0.97		
2014	6763.8	5879.8	7647.8	192.1	176.7	207.5	85.9	1.00		
2015	9081.6	7563.6	10599.6	193.6	175.6	211.6	88.0	1.05		
2016	12990.0	8437.0	17543.0	227.0	194.1	259.9	94.6	0.96		
2017	27231.4	11881.4	42581.4	318.8	221.2	416.4	103.3	0.67		
2018	2409.1	516.1	4302.1	710.2	319.0	1101.4	139.7	0.39		

Sources and references

STECF EWG 19-10

5.5 Summary sheet for red mullet in GSA 6

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.31 and corresponding catches in 2020 should be no more than 448 tons.

Stock development over time

Catches of red mullet show an increasing trend in the last years and SSB and recruitment reached a maximum in 2016, decreasing in 2017 and 2018. F has been high and stable from 2010, slightly increasing in 2018.

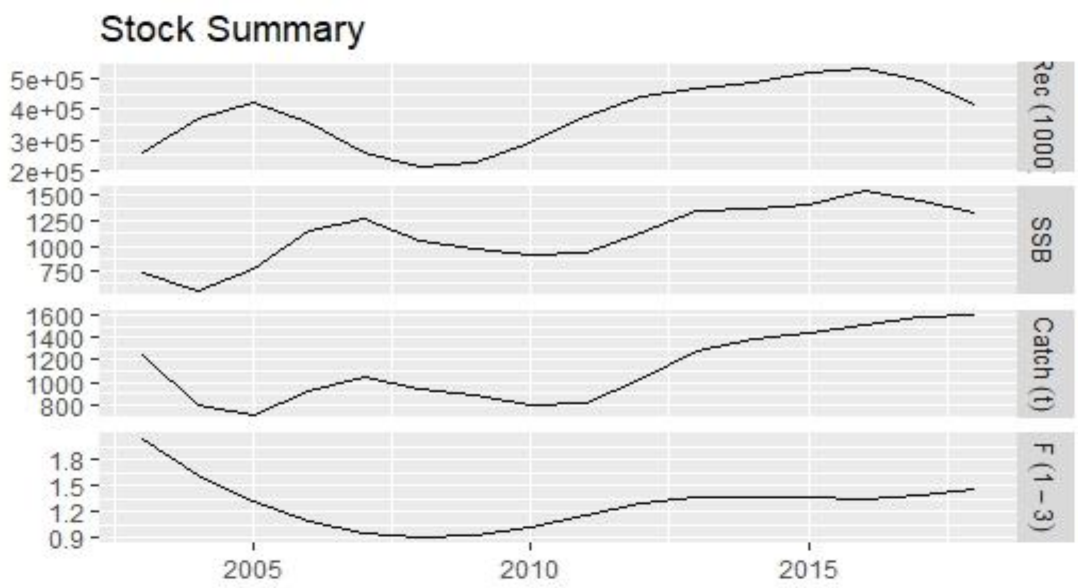


Figure 5.5.1 Red mullet GSA 6: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.31).

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

Status	2016	2017	2018
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
$F_{ages\ 1\text{-}3}$ (2019)	1.462	F2018 used to give F status quo for 2018
SSB (2019)	1335.9	Stock assessment 1 January 2019
R_{age0} (2019,2020)	484531.7	Geometric mean of the last 6 years
Total catch (2019)	1438	Assuming F status quo for 2019

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* (2020)	F_{total}# (ages 1-3) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	448	0.313	822	46	-72
$F_{MSY\ lower}$	315	0.210	2978	54	-80
$F_{MSY\ upper}$**	584	0.430	2456	38	-63
Other scenarios					
Zero catch	0	0	3659	75	-100
Status quo	1343	1.462	1300	3	-16
Factor 0.5	874	0.731	1959	23	-45
Factor 1.5	1632	2.193	985	-4	2

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

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 is not update of the EWG18-12 a4b assessment of red mullet in GSA 6, but a new assessment. The growth curve was corrected for a calendar year assessment (t0 +0.5). All the diagnostics were considered acceptable.

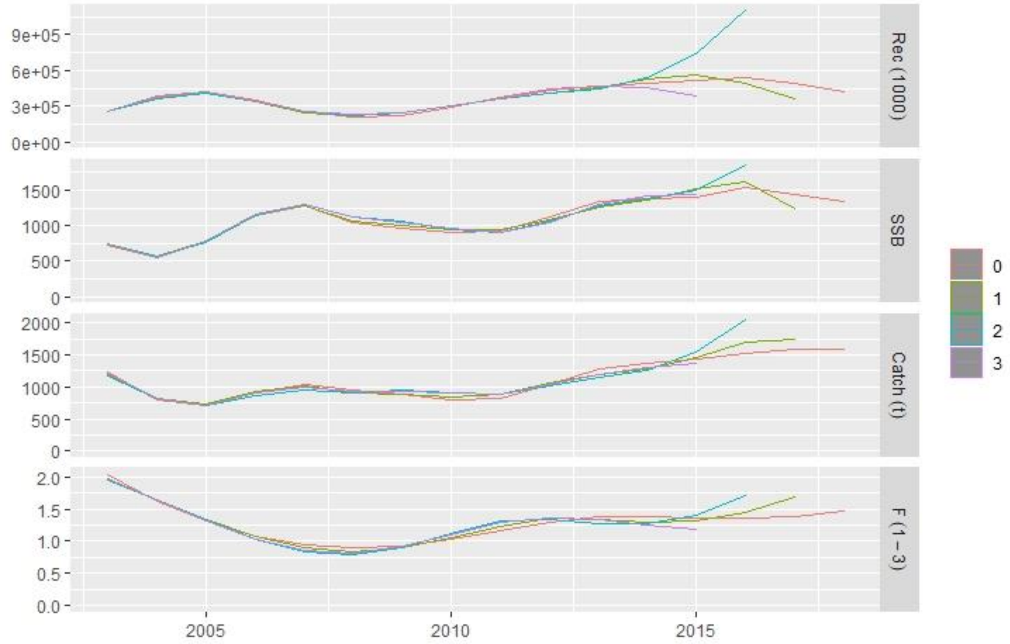


Figure 5.5.2 Red mullet GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	
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}	0.313	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.210	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.430	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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 19-10

*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 landings	STECF discards
2019	$F = F_{MSY}$				
2020	$F = F_{MSY}$		448		

History of the catch and landings

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

<table>
<tr><td>2018</td><td></td><td colspan="4">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Catch
(t)</td><td></td><td>Otter trawl
94%</td><td></td><td>Trammel nets
6%</td><td></td><td>t</td></tr>
<tr><td>1598</td><td></td><td></td><td></td><td></td><td>43.9</td></tr>
<tr><td rowspan="2">Effort</td><td></td><td>74820</td><td></td><td>31071</td><td></td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">Fishing days</td></tr>
</table>

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

Year	GSA6	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	514.1	132612
2011	1063.1	130739
2012	1069.9	125529
2013	1248.0	126112
2014	1309.2	132837
2015	1518.7	123658
2016	1673.9	125006
2017	1449.3	118121
2018	1280.7	105891

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 2-6	High	Low
2003	259285			725.9			1238.0	2.035		
2004	371204			556.2			793.4	1.624		
2005	421640			776.6			715.4	1.307		
2006	353499			1148.5			920.1	1.080		
2007	257710			1275.4			1041.9	0.942		
2008	211926			1050.6			942.1	0.892		
2009	226005			972.8			879.9	0.924		
2010	291302			903.4			808.0	1.026		
2011	378647			926.6			813.5	1.169		
2012	439939			1125.5			1037.7	1.299		
2013	464825			1340.7			1274.9	1.371		
2014	486290			1372.4			1378.5	1.376		
2015	519961			1409.1			1443.1	1.354		
2016	535441			1538.6			1515.8	1.352		
2017	494659			1448.9			1583.0	1.390		
2018	415681			1335.9			1597.5	1.462		

Sources and references

STECF EWG 19-10

5.6 Summary sheet for red mullet in GSA 7

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.62 and corresponding catches in 2020 should not exceed 364 tonnes.

Stock development over time

Red mullet in GSA 7 shows an increasing trend in catches from 2010 to 2016 and a small decrease in the last year (2017-2018). Recruitment and Spawning stock biomass show a similar trend with increases in the last over several years (2010-2018), and F varying along the series and showing a decrease in the last two years.

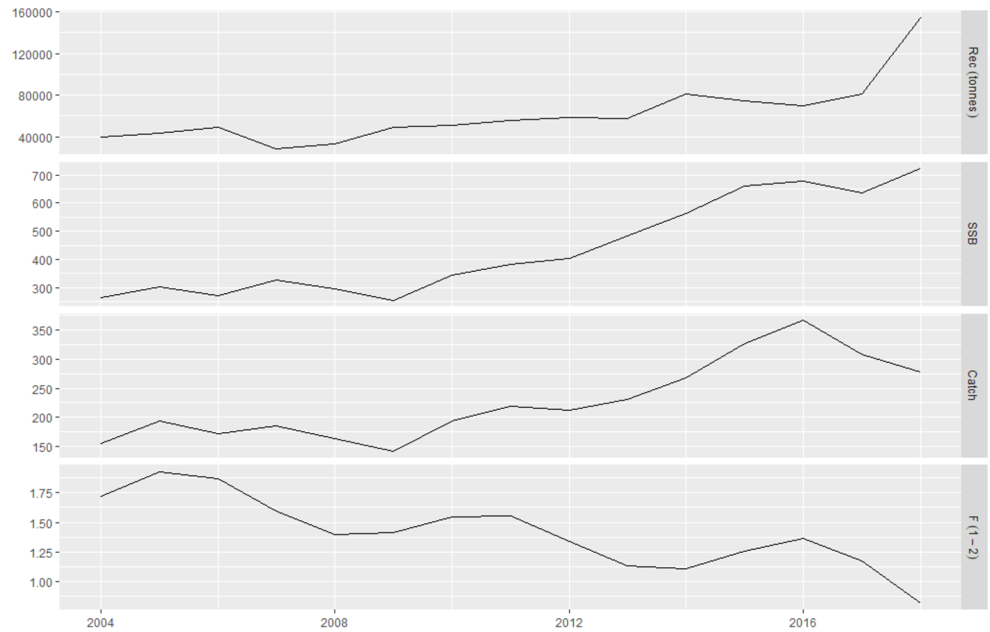


Figure 5.6.1 Red mullet in GSA 7. Stock summary of the assessment results. SSB and catch in tonnes, recruitment in number of individuals (thousand).

Stock and exploitation status

The F current computed as the geometric mean of the last three years of the time series ($F_{bar\ 0\text{-}2}$) is larger than $F_{0.1}$. This indicates that Red mullet in GSA 7 is over exploited.

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

Status	2016	2017	2018
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
$F_{ages\ 1\text{-}2}$ (2019)	0.82	F status quo = F 2018
SSB (2019)	971.5	Projected SSB assuming F = $F_{status\ quo}$
R_{age0} (year)	61763	Mean of R 2004-2017
Total catch (2019)	461.7	Projected catch assuming F = Fstatus quo

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

Basis	Total catch* (2020)	F_{total}#(ages 1-2) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	364	0.62	888	-23	58
$F_{MSY\ lower}$	265	0.41	777.38	-24.2	62.2
$F_{MSY\ upper}$**	452	0.85	1016.59	-0.9	-4.8
Other scenarios					
Zero catch	0	0	1377	34	-100
Status quo	441	0.82	790	-23	58
Factor 0.5	262	0.41	1020	-0.5	-5.7
Factor 1.5	565	1.23	640	-37	103

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

*** % change in SSB 2021 to 2019

^Total catch in 2020 relative to Catch in 2018.

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This is an update of the EWG18-12 a4a assessment of red mullet in GSA 7, However a new F_{BAR} range (1-2) was used in the analysis.

Current assessment results and survey indices have a similar trend. Residuals don't show anomalous values. Retrospective analyses are variable due to short time series, but consistently show $F>F_{MSY}$ in all years

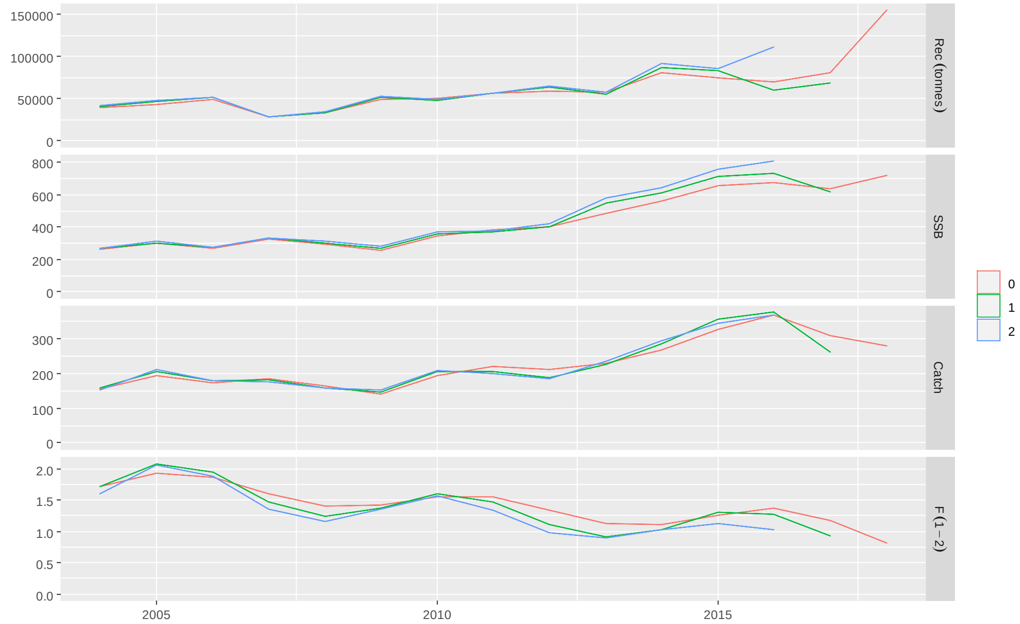


Figure 5.6.2 Red mullet in GSA 7. Retrospective analysis plots up 3 years back for recruitment, SSB, Catch and F.

Issues relevant for the advice

No particular issues

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}	0.62	$F_{0.1}$ as proxy of 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}	0.62	$F_{0.1}$ as proxy of F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.41	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.85	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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 catch data (landing and discard) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards <10% not included in the assessment
Indicators	
Other information	
Working group	STECF EWG 19-10

*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 landing	STECF discards
2019	F= F_{MSY}		191 t		
2020	F= F_{MSY} = 0.62		364 t		

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.

2018		Wanted catch				Discards
Catch (t)		Otter trawl 100%		Trammel nets		t
		322				9.7
Effort		13261		60775	64088	
		fishing days				

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	FRANCE GSA7	SPAIN GSA7	Total landings	Discard (OTB)	Total Catch	Total Effort
2002	111	11	122		123	
2003	164	12	176		176	
2004	152	26	177		177	**4007**
2005	148	27	176		176	**3911**
2006	183	31	215		215	**3758**
2007	172	36	208		208	**3732**
2008	110	21	131	0.2	131	**3851**
2009	123	26	149		149	**3012**
2010	218	28	246		246	**3309**
2011	199	28	227	0.2	227	**3605**
2012	135	29	164	15	179	**3036**
2013	246	38	283	16.3	299	**2850**
2014	318	41	360	2.6	363	**3031**
2015	281	33	314	12.7	327	**56152***
2016	393	43	436	2.2	438	**53728***
2017	241	31	272	6	278	**52145***
2018	298.4	23.8	322.2	9.7	331.9	**41608***

*Until 2015, fishing days only reported for Spain. Effort in these years includes French effort not supplied for earlier years

Summary of the assessment

Table 5.6.10 Red mullet in GSA 7: 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 0-2	High	Low
2004	39712	45341	34083	263.87	296.97	230.77	154.36	1.7	1.9	1.6
2005	43373	49681	37065	301.86	335.06	268.66	194.02	1.9	2.1	1.8
2006	49184	56156	42212	270.14	298.74	241.54	171.52	1.9	2	1.7
2007	28835	32693	24977	325.32	361.32	289.32	184.96	1.6	1.7	1.5
2008	32826	37155	28497	294.35	324.05	264.65	163.51	1.4	1.5	1.3
2009	48831	55799	41863	255.68	282.28	229.08	140.51	1.4	1.6	1.3
2010	50588	58335	42841	343.42	381.82	305.02	192.97	1.5	1.7	1.4
2011	55876	63004	48748	383.12	426.52	339.72	219.34	1.6	1.7	1.4
2012	58289	66760	49818	401.81	444.01	359.61	212.33	1.3	1.5	1.2
2013	57935	65953	49917	483.98	540.88	427.08	230.49	1.1	1.3	1
2014	81282	92241	70323	562.62	626.12	499.12	267.93	1.1	1.2	1
2015	74194	84378	64010	658.59	734.19	582.99	327.32	1.3	1.4	1.1
2016	70053	81016	59090	676.97	757.67	596.27	366.87	1.4	1.5	1.2
2017	80662	103823	57501	636.49	727.99	544.99	308.14	1.2	1.4	1
2018	154809	234836	74782	721.49	916.39	526.59	278.42	0.8	1.1	0.5

Sources and references

STECF EWG 19-10

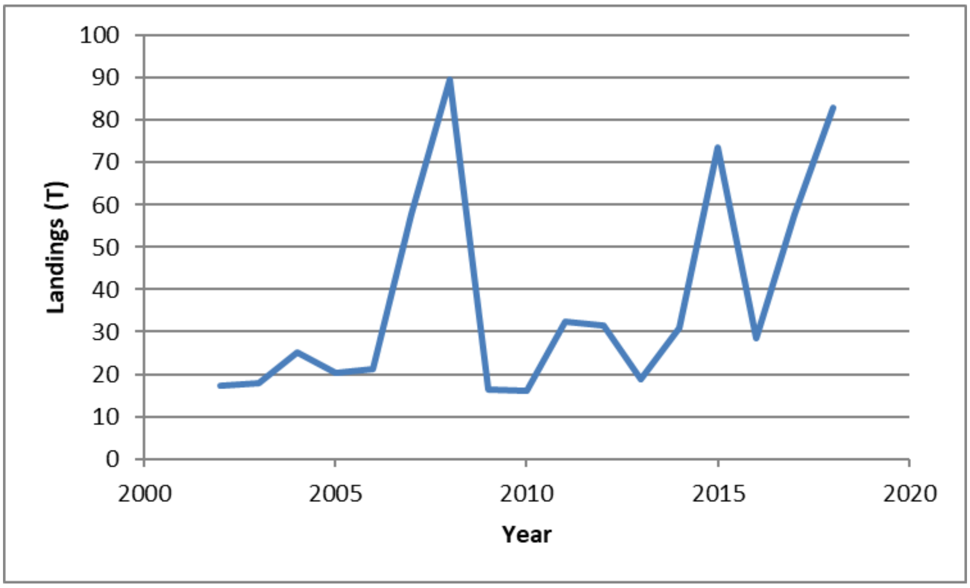
5.7 Summary sheet for Norway lobster in GSA 5

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.



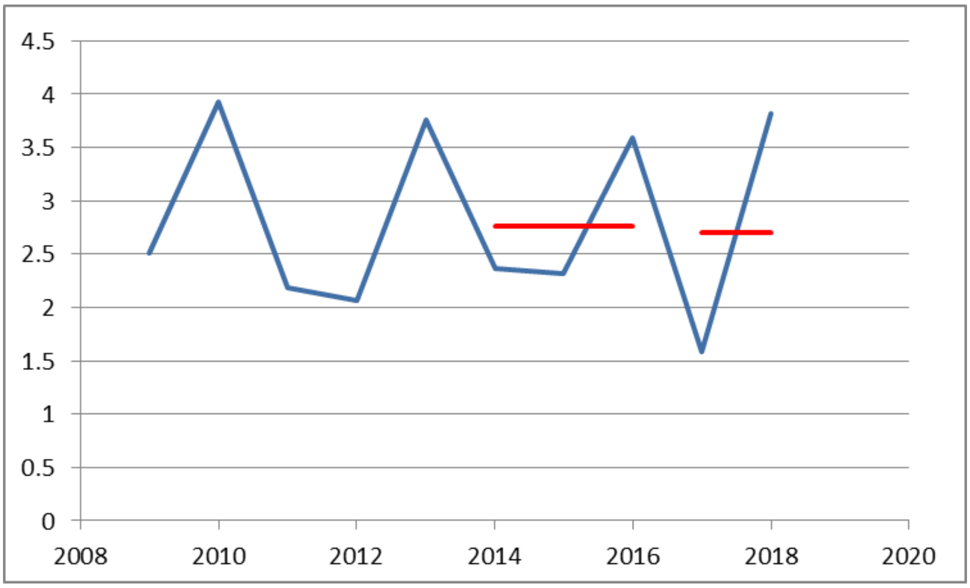


Figure 5.7.1 Norway lobster in GSA 5: Landing (t) from 2002 to 2018. MEDITS estimated biomass in the last ten years (blue) and recent changes (red) showing mean of last

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 reduce catch	56.3				

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

STECF EWG 19-10

5.8 Summary sheet for Norway lobster in GSA 6

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.11 and corresponding catches in 2020 should be no more than 77 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.

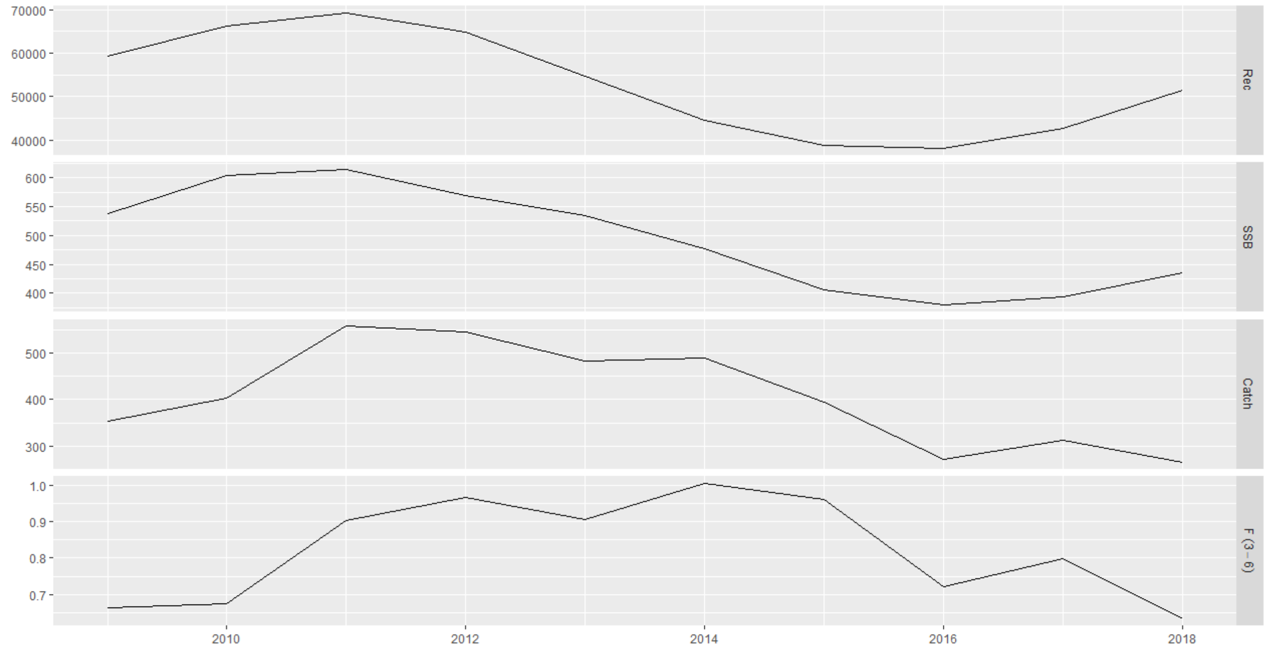


Figure 5.8.1 Norway lobster in GSA 6: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is 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	2016	2017	2018
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
$F_{ages\ 3\text{-}6}$ (2019)	0.71	mean F 2016-18 used to give F status quo for 2019
SSB (2019)	494.24	Stock assessment 1 January 2019
R_{age2} (2019,2020)	51813.89	Geometric mean of the last 10 years
Total catch (2019)	347.12	Assuming F status quo for 2019

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* (2020)	F_{bar}# (ages 3-6) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	77.49	0.11	1070.15	116.52	-71%
$F_{MSY\ lower}$	54.10	0.08	1117.54	126.11	-80%
$F_{MSY\ upper}$**	107.50	0.16	1010.63	104.48	-59%
Other scenarios					
Zero catch	0	0	1230.49	148.97	-100%
Status quo	376.07	0.71	546.89	10.65	42%
$F=F_{2018}*0.8$	319.55	0.57	633.73	28.22	20%
$F=F_{2018}*0.6$	255.05	0.43	740.03	49.73	-5%
$F=F_{2018}*0.4$	181.31	0.29	870.61	76.15	-32%
$F=F_{2018}*0.2$	96.87	0.14	1031.55	108.71	-64%

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at $F>F_{MSY}$
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

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 showed good internal consistency. The retrospective analysis run on the a4a model indicates quite moderate stability for the model but do not change estimation of stock status over the last three years. All the diagnostics were considered acceptable.

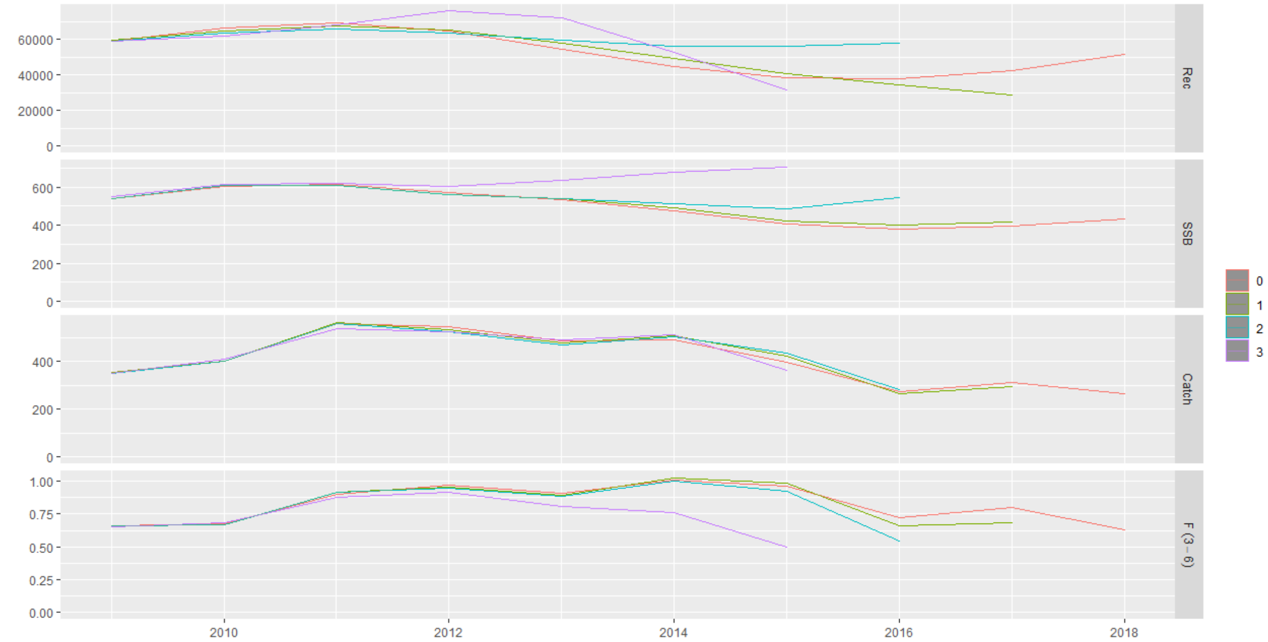


Figure 5.8.2 Norway lobster in GSA 6: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.8.5 Norway lobster in GSA 6: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.11	$F_{0.1}$ 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}	0.11	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.08	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.16	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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 <10% (included in the assessment)
Indicators	
Other information	
Working group	STECF EWG 19-10

*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 landings	STECF discards
2019	$F = F_{MSY}$		125		
2020	$F = F_{MSY}$		77		

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

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
2007										
2008										
2009	59235			538.25			353.99	0.66178		
2010	66282			604.8			402.21	0.6754		
2011	69339			614.53			557.62	0.90309		
2012	64787			569.55			546.06	0.96674		
2013	54660			534.66			483.36	0.90606		
2014	44642			477.43			488.82	1.00618		
2015	38720			406.12			394.83	0.96223		
2016	38087			378.77			271.63	0.72216		
2017	42656			393.33			313.08	0.79931		
2018	51513			435.2			265.23	0.63222		

Sources and references

STECF EWG 19-10

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

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.22 and corresponding catches in 2020 should be no more than 772 tons.

Stock development over time

Catches and SSB of European hake show a decreasing trend in the whole time series. The assessment shows a decreasing trend in the number of recruits with the minimum value reached in 2017. Fbar (1-3) shows a fluctuating pattern with a quite stable trend in the time series.

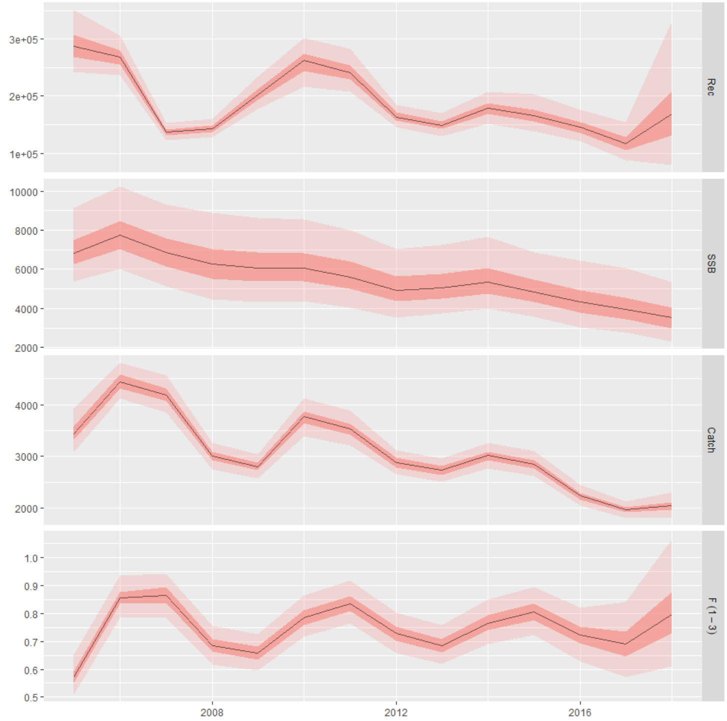


Figure 5.9.1 European hake in GSAs 9, 10 and 11: Trends in catch, recruitment, fishing mortality resulting from the a4a model.

Stock and exploitation status

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

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

Status	2016	2017	2018

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

Catalog scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2019)	0.74	Mean F of the last 3 years
SSB (2019)	3411	From assessment of stock 1 January 2018
R_{age0} (2019,2020)	180785	Geometric mean of the time series 2005 to 2018
Total catch (2019)	2001	Assuming F = Fstatus quo

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

Basis	Total catch* (2020)	F_{total}# (ages 1-3) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	772	0.22	4931	45	-63
$F_{MSY\ lower}$	535	0.15	5211	53	-74
$F_{MSY\ upper}$**	1036	0.31	4624	36	-50
Other scenarios					
Zero catch	0	0	5850	72	-100.00
Status quo	2144	0.74	3372	-1.13	2.78

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy

*** % change in SSB 2020 to 2019

^Total catch in 2020 relative to catch in 2018.

Basis of the advice

Table 5.9.4 European hake 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. 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.

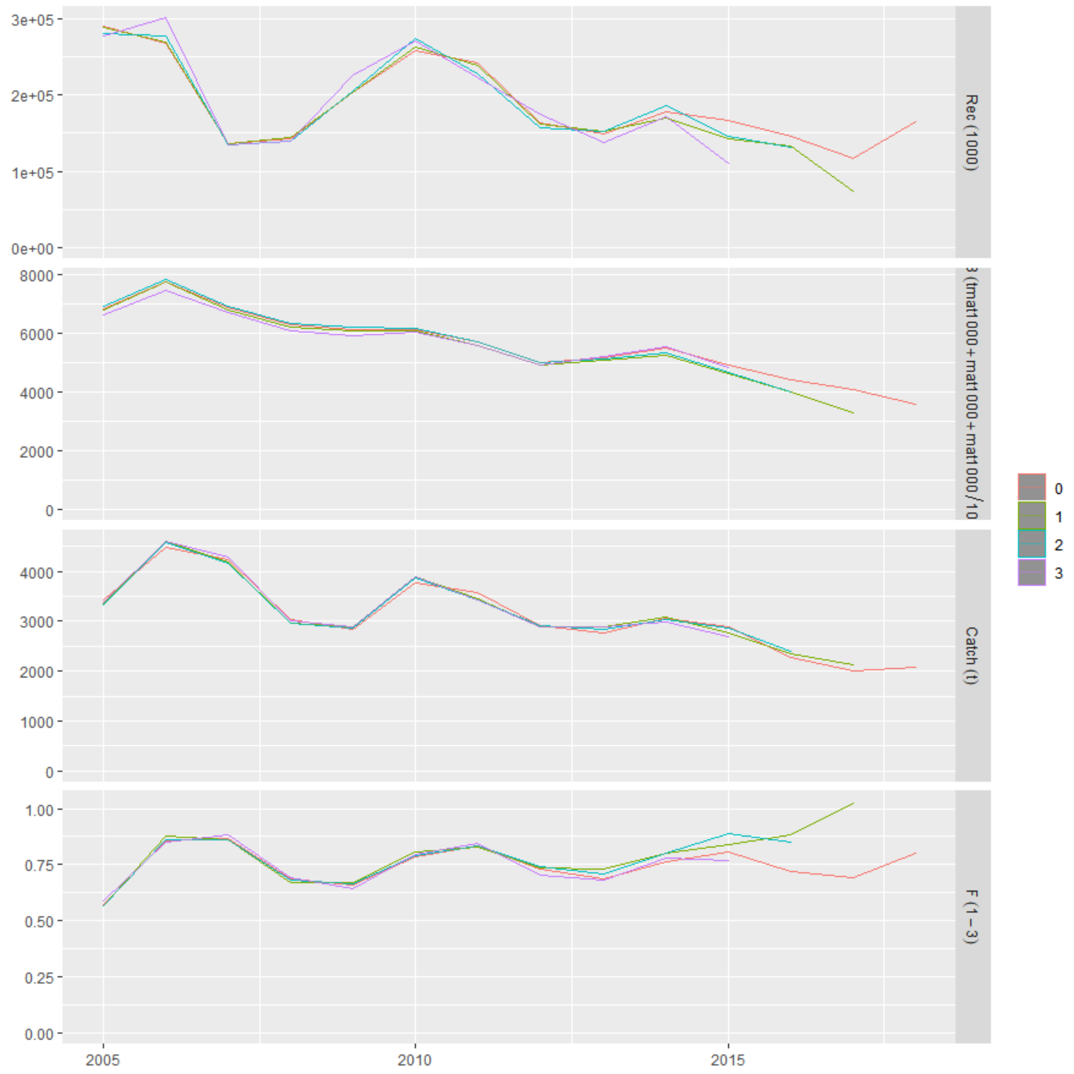


Figure 5.9.2 European hake in GSAs 9, 10 and 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.9.5 European hake 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}	0.22	$F_{0.1}$ 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}	0.22	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.15	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.31	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

Basis of the assessment

Table 5.9.6 European hake 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
Indicators	
Other information	
Working group	STECF EWG 19-10

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.9.7 European hake 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 landings	STECF discards
2019	F = F_{MSY}		494			
2020	F = F_{MSY}		772			

History of the catch and landings

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

2018		Wanted catch				Discards
Catch (t)		Beam trawl 68%	Gillnets 19%	Trammel nets 6%	Other 7%	t
		902	254	82	97	281
Effort		99251	113558	27445		
		24025 Fishing Days				

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

Year	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total landings	Total Effort
2005	1860	1485	397	3742	**416327**
2006	2176	1544	341	4062	**346354**
2007	1733	1269	170	3171	**368252**
2008	1321	1123	139	2583	**293803**
2009	1308	1091	261	2660	**318854**
2010	1467	1329	176	2972	**290646**
2011	1352	1279	277	2908	**311486**
2012	1012	1107	176	2295	**288138**
2013	1342	1052	196	2590	**244008**
2014	1265	1271	45	2581	**293756**
2015	1048	1043	220	2311	**254829**
2016	782	1052	265	2099	**271629**
2017	572	871	304	1748	**247531**
2018	605	821	337	1763	**240254**

Summary of the assessment

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

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2005	289472			6849.2			3417.4	0.57		
2006	268393			7746.3			4470.6	0.86		
2007	136459			6890			4244.1	0.86		
2008	142985			6295.6			3038	0.68		
2009	203143			6122.2			2830	0.66		
2010	258532			6130.8			3772	0.79		
2011	241954			5711			3567.5	0.84		
2012	164141			5014.3			2921.4	0.73		
2013	149453			5175.9			2762	0.68		
2014	178624			5485.9			3050.7	0.77		
2015	167371			4934.5			2887.1	0.80		
2016	145673			4417.7			2269.1	0.72		
2017	117106			4074			2010.2	0.69		
2018	165298			3575.6			2086.1	0.80		

Sources and references

STECF EWG 19-10

5.10 Summary sheet for deep-water rose shrimp in GSA 9, 10 and 11

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more 0.97, and corresponding catches in 2020 should be no more than 1301 tonnes.

Stock development over time

Recruitment

Recruitment (age 0) is characterised by an increasing trend with a peak in 2016 (3,672,862 thousands individuals) and a strong fall in the last two years.

Spawning stock biomass (SSB)

The spawning stock biomass shows an increasing trend reaching the maximum value in 2018 (2336 tons).

Catch

After the minimum value in 2009 (750 tons), the catches have shown a constant increase over the years, until reaching the maximum value in 2018, corresponding to 1476 tons.

Fishing mortality (F)

The lowest value of fishing mortality (0.67) is observed at the beginning of the data series (2009). F consistently increases reaching the maximum value of 1.05 in 2014. In the following three years F decreased and in 2018 was 0.92, showing a slightly increase in respect to the previous year.

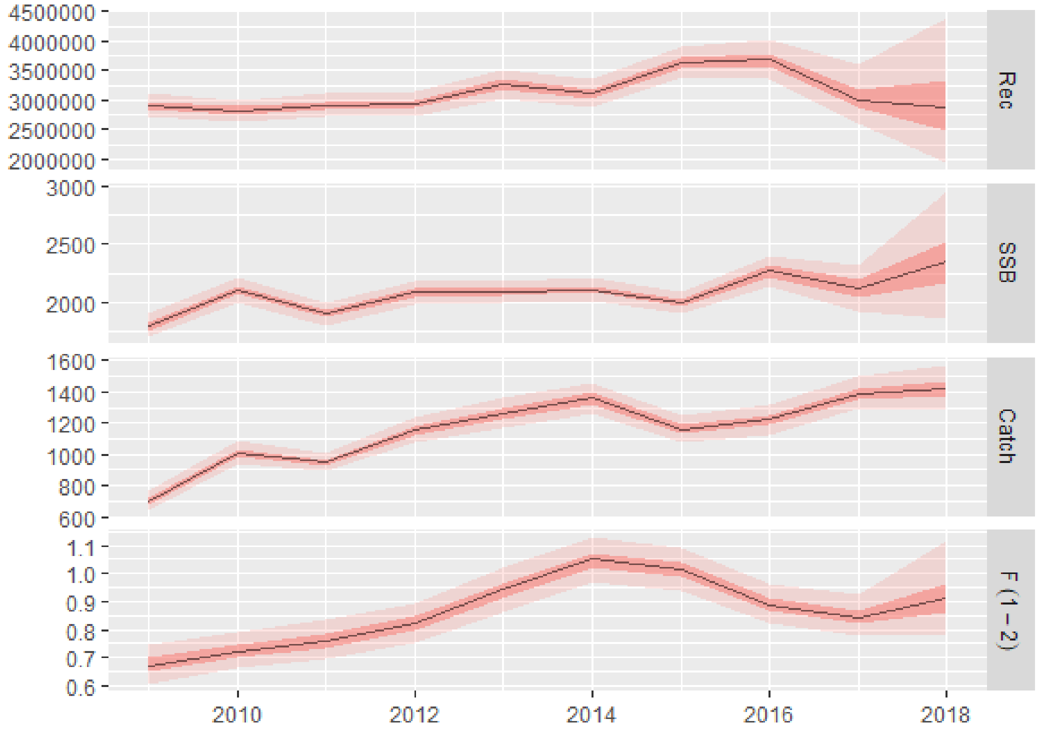


Figure 5.10.1 Deep-water rose shrimp in GSAs 9, 10 & 11. Outputs of the a4a assessment.

Stock and exploitation status

Current F (0.88), estimated as the mean F_{bar1-2} in the last three years of the time series (2018), is lower than $F_{0.1}$ (0.97), which is a proxy of F_{MSY} 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.

Status	2016	2017	2018
F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-2}$ (2019)	0.88	mean F 2016-2018 used to give F status quo for 2019
SSB (2019)	2055 t	Stock assessment 1 January 2019
R_{age0} (2019, 2020)	3101709	Geometric mean of the time series years 2009-2018
Total catch (2019)	1185 t	Assuming F status quo for 2019

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

Basis	Total catch* (2020)	F_{total}# (ages 1-2) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	1301	0.97	2035	-1.0	-8.5
$F_{MSY\ lower}$	971	0.64	2358	14.8	-31.7
$F_{MSY\ upper}$**	1570	1.32	1797	-12.6	10.5
Other scenarios					
Zero catch	0.0	0.0	3523	71.5	-100.0
Status quo	1221	0.88	2110	2.7	-14.1

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}*** % change in SSB 2021 to 2019

^Total catch in 2020 relative to Catch in 2018.

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.

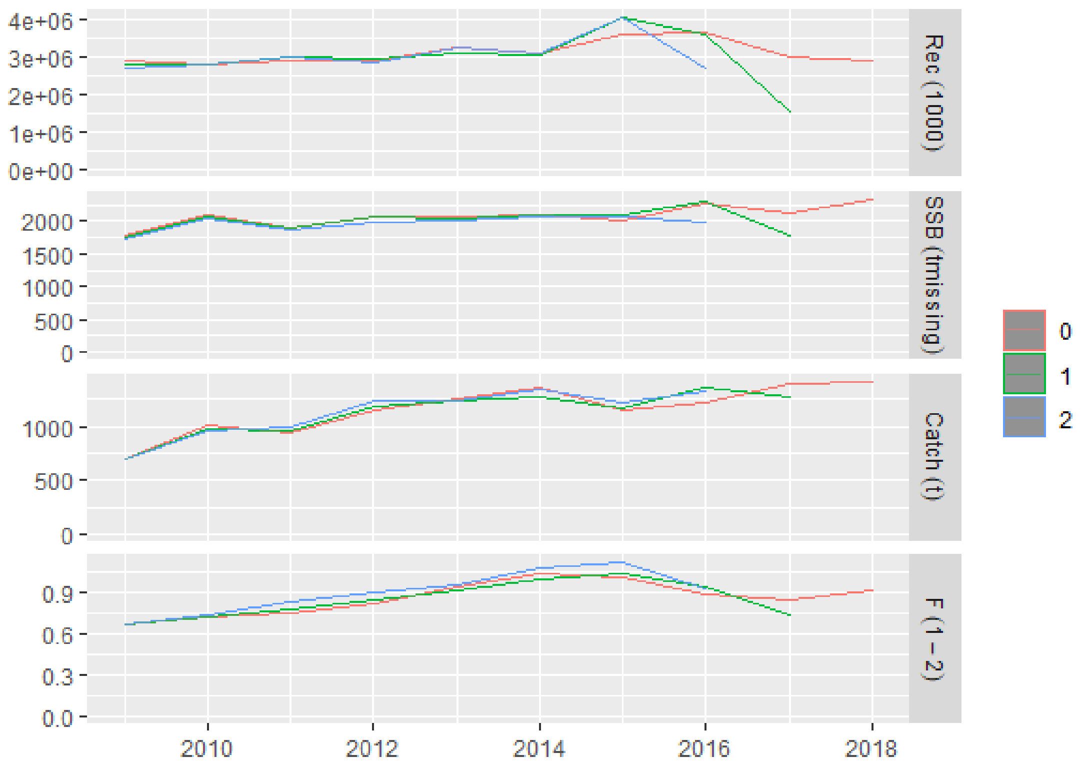


Figure 5.10.2 Deep-water rose shrimp in GSAs 9, 10 & 11 Results of the retrospective analysis (a4a).

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 so the assessment could only be run with the shortest time series 2009 to 2018.

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. With regard to GSA11, there are no data on this fraction of the catch. Missing discard data were not reconstructed.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

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

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.97	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
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}	0.97	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	1.32	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.64	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

Basis of the assessment

Table 5.10.6 Basis of the assessment and advice.

Assessment type	Statistical catch-at-age (a4a)
Input data	Landings at length to landings at age (age slicing)
Discards, BMS landings*, and bycatch	Discards included
Indicators	MEDITS in GSAs 9, 10 & 11
Other information	
Working group	STECF EWG 19-10

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.10.7 STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

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

History of the catch and landings

Table 5.10.8 Catch and effort distribution by fleet in 2018 as estimated by and reported to STECF.

(2018)		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets %	Trammel nets %	Other %	t
	1577	tonnes				50
Effort	99251	100%				
		fishing days				

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

Year	GSA9 ITA	GSA10 ITA	GSA11 ITA	Total landings	Discards	STECF total catches	Total Effort
2009	303	379	22	704	45	749	110223
2010	473	370	23	866	30	896	103749
2011	551	405	53	1010	66	1076	101190
2012	621	459	34	1114	13	1127	94577
2013	576	597	21	1194	39	1233	105927
2014	561	509	16	1086	48	1134	111288
2015	791	547	26	1365	102	1467	98969
2016	836	542	18	1396	41	1437	103845
2017	857	496	29	1382	45	1427	100037
2018	904	555	68	1527	50	1577	99251

Summary of the assessment

Table 5.10.10 Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2009	2900812			1787			749	0.674		
2010	2816533			2099			896	0.723		
2011	2913603			1902			1076	0.760		
2012	2925754			2084			1127	0.820		
2013	3264092			2083			1233	0.940		
2014	3111065			2113			1134	1.048		
2015	3629217			2001			1467	1.012		
2016	3672862			2266			1437	0.889		
2017	3028039			2116			1427	0.845		
2018	2887070			2336			1577	0.921		

Sources and references

STECF EWG 19-10

5.11 Summary sheet for red mullet in GSA 9

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.58 and corresponding catches in 2020 should be no more than 512 tons.

Stock development over time

Catches and SSB of Red mullet show that after an increase since 2012, the past two years show a reduction, more pronounced for SSB and less for catches, and a corresponding increase in F.

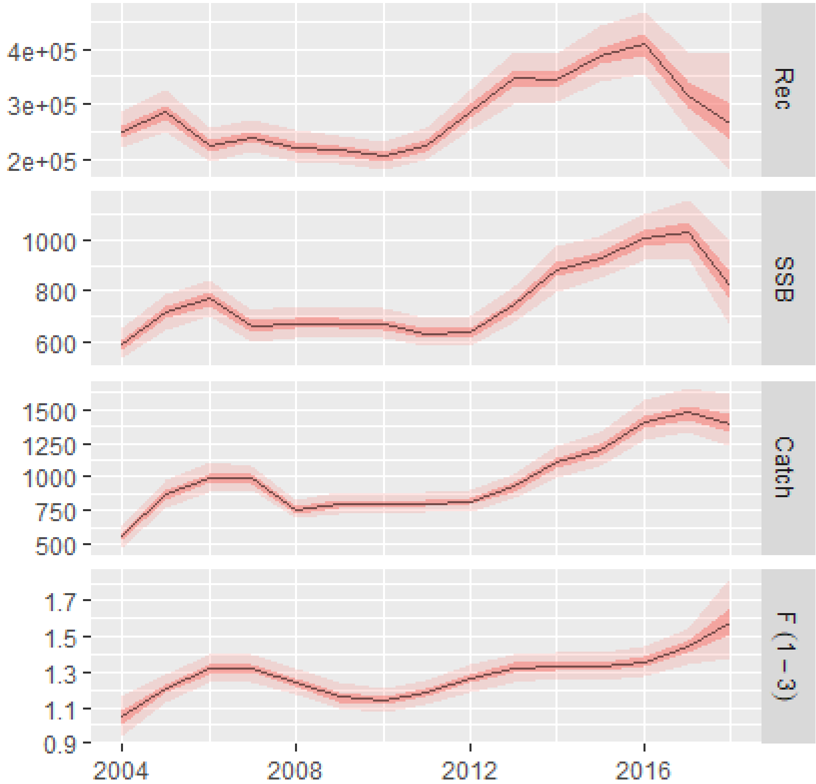


Figure 5.11.1 Red mullet in GSA 9: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.58).

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

Status	2016	2017	2018
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
$F_{ages\ 1-3}$ (2019)	1.58	F2018 used to give F status quo for 2019
SSB (2019)	641	Stock assessment 1 January 2019
R_{age0} (2019,2020)	275835	Geometric mean of the last 15 years
Total catch (2019)	1100	Assuming F status quo for 2019

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* (2020)	F_{total}# (ages 1-3) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	512	0.58	1226	86	-63
$F_{MSY\ lower}$	364	0.39	364	1432	-74
$F_{MSY\ upper}$**	652	0.79	652	1048	-53
Other scenarios					
Zero catch	0	0	2014	206	-100
Status quo	1038	1.58	641	-3	-26
0.1	162	0.16	1742	164	-88
0.2	305	0.32	1517	130	-78
0.3	434	0.47	1332	102	-69
0.4	549	0.63	1177	79	-61
0.5	652	0.79	1048	59	-53
0.6	745	0.95	939	43	-47
0.7	829	1.11	846	29	-40
0.8	906	1.27	768	17	-35
0.9	975	1.42	700	6	-30

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	0.58

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.

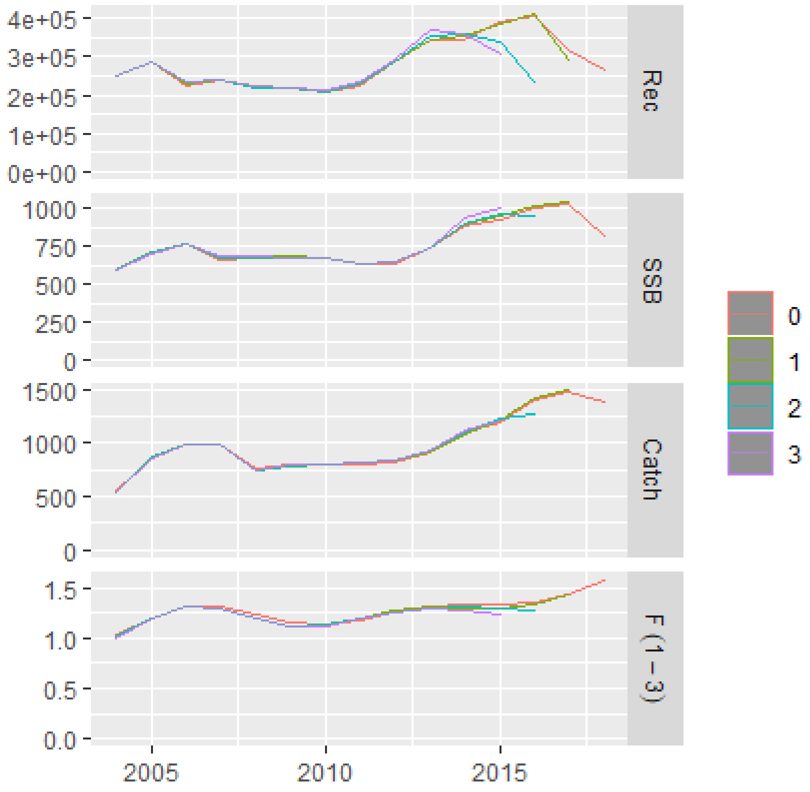


Figure 5.11.2 Red mullet in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.58	$F_{0.1}$ 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}	0.58	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.39	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.79	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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	Attempted to include GRUND survey as tuning index but considered not informative
Working group	STECF EWG 19-10

*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 landings	STECF discards
2019	F = F_{MSY}		812		
2020	F = F_{MSY}		512		

History of the catch and landings

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

2018		Wanted catch				Discards
Catch (t)		Otter trawl 95%	Gillnets 1%	Trammel nets 4%		t
		1151	11	43		127
Effort		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
2003	1057	1057	**327265**
2004	581	581	**320969**
2005	708	708	**230645**
2006	1050	1050	**217493**
2007	1096	1096	**209531**
2008	727	727	**204518**
2009	728	728	**153414**
2010	748	748	**179299**
2011	805	805	**162036**
2012	693	693	**193843**
2013	693	693	**159700**
2014	1181	1181	**168711**
2015	1183	1183	**169043**
2016	1222	1222	**186578**
2017	1461	1461	**166226**
2018	1205	1205	**148962**

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 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2004	252072	121601	382543	591	311	871	552	1.04	0.78	1.31
2005	286258	155787	416729	716	435	996	867	1.21	0.94	1.47
2006	224716	94245	355187	770	490	1051	990	1.32	1.05	1.58
2007	241236	110765	371707	660	380	940	984	1.32	1.06	1.58
2008	222320	91849	352791	672	391	952	756	1.24	0.98	1.50
2009	216486	86015	346957	672	392	952	801	1.16	0.90	1.42
2010	205963	75492	336434	668	388	948	795	1.14	0.88	1.40
2011	225949	95478	356420	634	354	914	804	1.18	0.92	1.45
2012	288639	158168	419110	638	358	918	816	1.26	1.00	1.53
2013	345889	215418	476360	744	464	1024	924	1.32	1.06	1.59
2014	345765	215294	476236	883	602	1163	1101	1.34	1.07	1.60
2015	388439	257968	518910	925	645	1205	1200	1.33	1.07	1.59
2016	408237	277766	538708	1005	725	1285	1409	1.36	1.09	1.62
2017	317679	187208	448150	1032	752	1312	1477	1.44	1.18	1.70
2018	267222	136751	397693	816	536	1097	1393	1.58	1.32	1.84

Sources and references

STECF EWG 19-10

5.12 Summary sheet for red mullet in GSA 10

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.41 and corresponding catches in 2020 should be no more than 309 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.

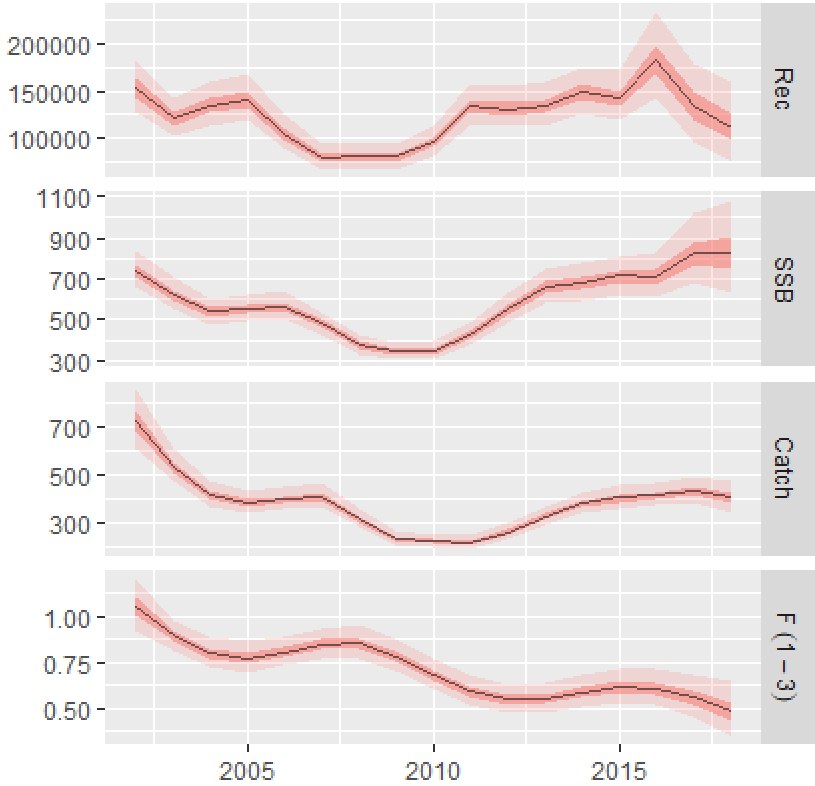


Figure 5.12.1 Red mullet in GSA 10: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.41).

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

Status	2016	2017	2018
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
$F_{ages\ 1-3}$ (2019)	0.48	F2018 used to give F status quo for 2019
SSB (2019)	740	Stock assessment 1 January 2019
R_{age0} (2019,2020)	120898	Geometric mean of the last 15 years
Total catch (2019)	369	Assuming F status quo for 2019

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* (2020)	F_{total}# (ages 1-3) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	309	0.41	780	86	-23
$F_{MSY\ lower}$	397	0.56	669	-12.03	-1.45
$F_{MSY\ upper}$**	219	0.27	903	18.78	-45.52
Other scenarios					
Zero catch	0	0.00	1239	62.97	-100.00
Status quo	350	0.48	728	-4.25	-13.22
0.1	43	0.05	1170	53.91	-89.45
0.2	83	0.10	1106	45.48	-79.38
0.3	122	0.14	1046	37.63	-69.76
0.4	159	0.19	991	30.33	-60.57
0.5	194	0.24	939	23.52	-51.78
0.6	228	0.29	891	17.17	-43.38
0.7	260	0.33	846	11.25	-35.34
0.8	291	0.38	804	5.72	-27.65
0.9	321	0.43	764	0.57	-20.28

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

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 in allocation of length to age which leads to some instability in the assessment relative to last year.

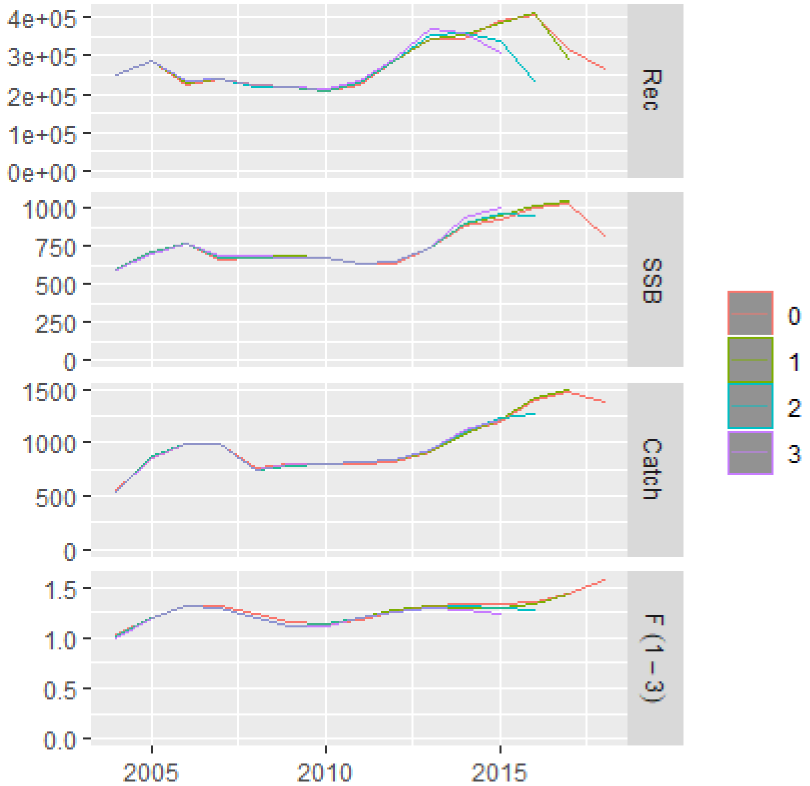


Figure 5.12.2 Red mullet in GSA 10: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.41	$F_{0.1}$ 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}	0.41	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.27	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.56	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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	Attempted to include GRUND survey as tuning index but considered not informative
Working group	STECF EWG 19-10

*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 landings	STECF discards
2019	F = F_{MSY}		1056		
2020	F = F_{MSY}		309		

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.

2018		Wanted catch				Discards
Catch (t)		Otter trawl 79%	Gillnets 7%	Trammel nets 14%		t
		420	37	74		44
Effort		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**

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 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2002	153260	94152	212368	740	420	1061	715	1.05	0.80	1.31
2003	120618	61510	179726	619	298	940	530	0.89	0.64	1.14
2004	134856	75748	193964	538	218	859	414	0.80	0.54	1.05
2005	141093	81985	200201	551	230	871	382	0.77	0.52	1.02
2006	105411	46303	164519	564	243	885	396	0.80	0.55	1.06
2007	78952	19844	138060	479	158	800	408	0.85	0.60	1.10
2008	81516	22408	140624	374	53	695	314	0.85	0.60	1.10
2009	80375	21267	139483	345	24	666	236	0.78	0.53	1.04
2010	96466	37358	155574	345	25	666	220	0.68	0.43	0.93
2011	134667	75559	193775	423	102	743	218	0.59	0.34	0.84
2012	131414	72306	190522	550	229	871	261	0.55	0.29	0.80
2013	134563	75455	193671	663	342	984	326	0.55	0.30	0.80
2014	148763	89655	207871	679	358	1000	379	0.58	0.33	0.84
2015	142380	83272	201488	711	390	1031	402	0.62	0.36	0.87
2016	183410	124302	242518	709	388	1030	412	0.61	0.36	0.86
2017	132753	73645	191861	826	505	1147	434	0.55	0.30	0.80
2018	110830	51722	169938	822	501	1143	403	0.48	0.22	0.73

Sources and references

STECF EWG 19-10

5.13 Summary sheet for Norway lobster in GSA 9

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.20 and corresponding to catches of no more than 142 tons in 2020 implemented either through catch restrictions or effort reduction for the relevant fleets.

Stock development over time

Catches of Norway lobster in GSA 9 show a fluctuating pattern, with a peak in 1996-1997 After 2000 a decreasing trend is seen, with an increase in the last two years.
Recruitment (age 1) was higher in the first part of the time series. It remained at low values from 2002 to 2012, and then showed a slight increase, followed by a decrease.
SSB show a slight decreasing pattern until 2008, then is increasing in the last period of the time series.
Fishing mortality shows a fluctuating pattern, following the trend in the catches. F is low in the last period (below the reference point), then increasing again in the last two years.

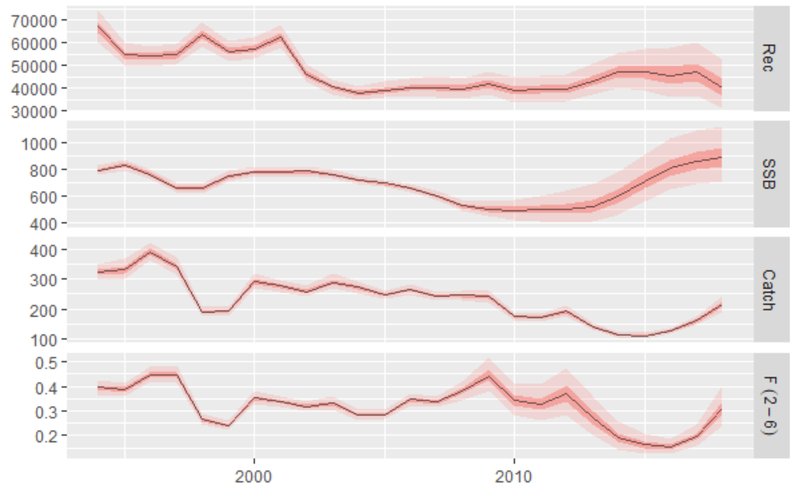


Figure 5.13.1 Norway lobster in GSA 9: Outputs of the assessment.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (= 0.20). However, F was below the reference point in 2016 and at F_{MSY} in 2017.

Status	2016	2017	2018
F / F_{MSY}	F < F_{MSY}	F at F_{MSY}	F > F_{MSY}

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

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1-3}$ (2019)	0.31	F 2018 used for F status quo 2019
SSB (2019; middle year)	860.4 t	Stock assessment 1 January 2019
R_0 (2019, 2020)	41917.9 thousands	Geometric mean of the period 2003-2018
Total catch (2019)	220.7 t	Assuming F status quo for 2019

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 tons.

Basis	Total catch* (2020)	F_{total}# (ages 2-6) (2020)	SSB (2021; middle year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	142.1	0.20	869.9	1.1	-34.3
$F_{MSY\ lower}$	99.2	0.13	936.5	8.8	-12.2
$F_{MSY\ upper}$**	189.8	0.28	798.6	-7.2	-54.1
Other scenarios					
Zero catch	0.0	0.0	1098.9	27.7	-100.0
Status quo	207.6	0.31	772.8	-10.2	-4.0

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

Basis of the advice

Table 5.13.4 Norway lobster in GSA 9The 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 very good internal consistency, while the MEDITS survey showed poor internal consistency. The retrospective analysis run on the a4a model showed consistent results in terms of stock status. All the diagnostics were considered acceptable.
Reported landings in 2017 were considered unreliable, as very high. Despite the fact that official data were not revised, the national experts provided a new estimation of landings to STECF 19-10which was used.

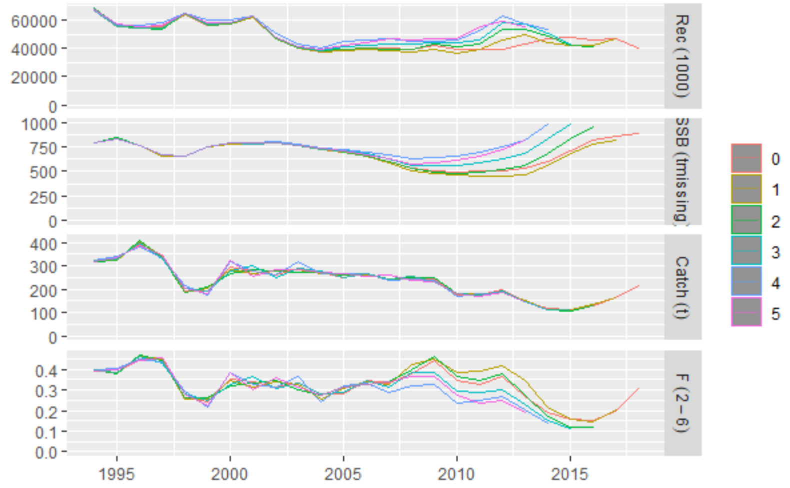


Figure 5.13.2 Norway lobster in GSA 9: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

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

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not defined	
	F_{MSY}	0.20	$F_{0.1}$ 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}	0.20	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.13	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.28	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	Age based
Input data	Landings at length to landings at age (age slicing)
Discards, BMS landings*, and bycatch	Discards included
Indicators	MEDITS in GSAs 9, 10, 11
Other information	
Working group	STECF EWG 19-10

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

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

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice		STECF landings	STECF discards
2019	Precautionary considerations	90	90			
2020	F = F_{MSY}	142.1	142.1			

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.

(2018)		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets %	Trammel nets %	Other %	t
	223.9	tons				0.7
Effort	80027	100%				
		Fishing Days				

Table 5.13.9 Norway lobster 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 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	273.8	13.0	286.8	89025
2018	223.2	0.7	223.9	80027

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 (age 1, '000)	SSB (t)	Catch (t)	$F_{bar\ 2\text{-}6}$
1994	66913	793.3	321.1	0.39
1995	54842	835.0	331.4	0.39
1996	53973	766.0	391.6	0.45
1997	54804	667.2	340.7	0.45
1998	63665	659.4	191.4	0.27
1999	56167	749.7	192.8	0.24
2000	57476	785.0	294.4	0.35
2001	62708	779.1	277.0	0.34
2002	46380	788.9	259.7	0.32
2003	40509	764.5	291.0	0.33
2004	37614	723.1	273.3	0.28
2005	39138	697.6	247.1	0.28
2006	40178	659.5	265.9	0.35
2007	40412	603.0	242.3	0.34
2008	39626	531.5	246.0	0.38
2009	42003	505.3	241.3	0.44
2010	39017	497.2	176.0	0.34
2011	39432	500.9	173.3	0.33
2012	39565	508.4	195.8	0.37
2013	43328	526.9	144.4	0.27
2014	47065	599.3	116.0	0.19
2015	47271	711.9	113.5	0.16
2016	45569	810.2	128.3	0.15
2017	47044	857.6	162.6	0.20
2018	40509	887.2	216.2	0.31

Sources and references

STECF EWG 19-10

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 18-12 advises to decrease the total catch to 77% of the average 2015-2017 catches equivalent to catches of no more than 17.1 tons in each of 2019 and 2020 implemented either through catch restrictions or effort reduction for the relevant fleets.

Stock development over time

In the period 1994 – 2010 MEDITS indices (Figure 5.14.1 a - b) 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). On the contrary, during the latest 7 years density and biomass values show a more stable behaviour, oscillating respectively in the range 1.8 – 2.7 (average value 2.1) in terms of biomass and 37.7 – 58.6 (average value 47.3) in terms of density. Biomass and density average values along the whole time series were respectively 2.75 kg/Km^2 and 67.18 n/Km^2.
The annual landings (Figure 5.14.1 c) does not show a clear temporal pattern; the minimum value (6.3 tons) is recorded in the first year of the time series while an abrupt increase in landings is observed in 2006 (42.3 tons). Landing values in the period 2006 – 2012 ranged between 30 and 50 tons except in 2010 when landing falls below 25 tons. Finally, in the period 2013 – 2016 landings values are quite low, ranging between 15.8 and 20.6 while in the last year an increase in landings (28.3) is recorded.
LPUE values (Figure 5.14.1 d) when compared to the MEDITS biomass (slope) show a good agreement in terms of temporal pattern except in 2011 and 2017 the last year of the time series.

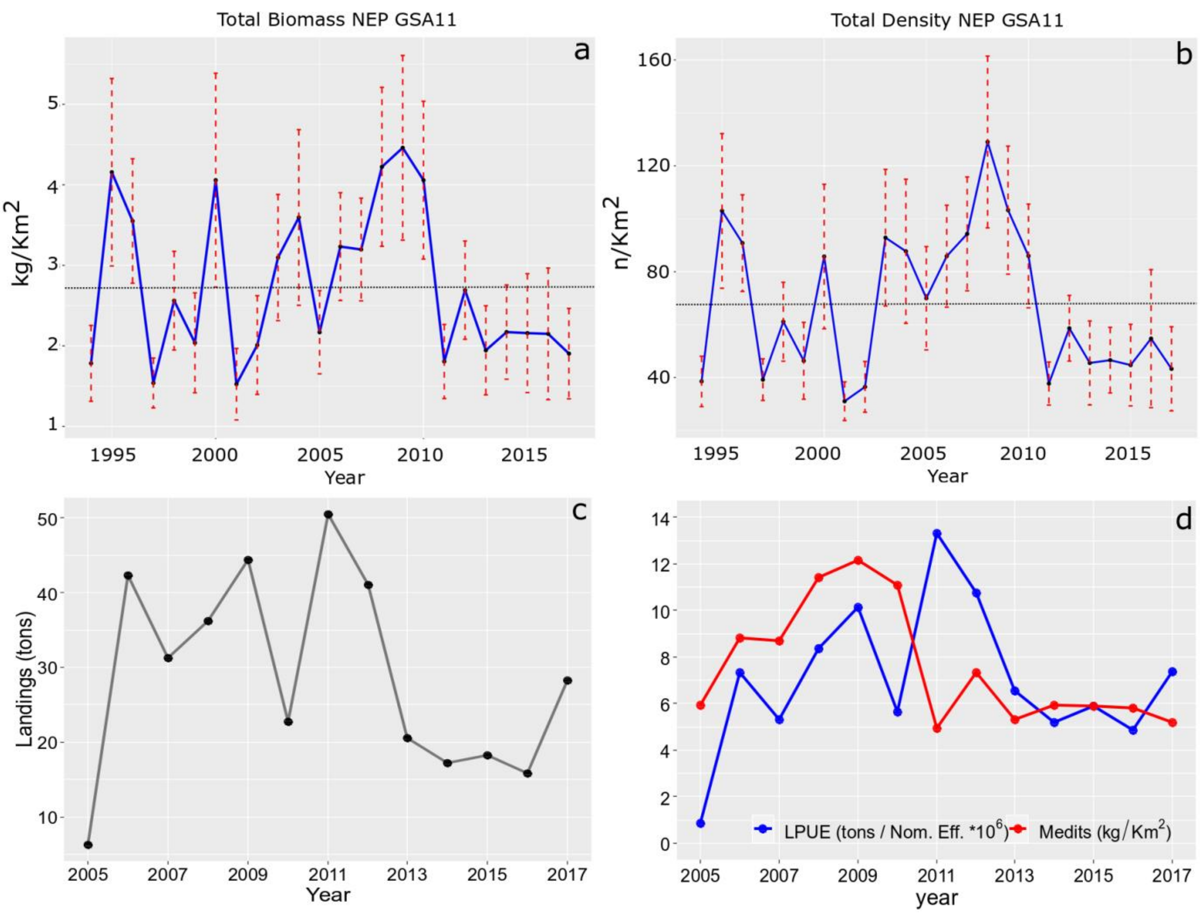


Figure 5.14.1 Norway lobster in GSA 11: MEDITS indices (total biomass a; total density b), landings (c), number of vessels (c) and MEDITS biomass (slope) vs Landings Per Unit Effort (d)

Stock and exploitation status

The stock status both 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 (see table 5.14.1). The precautionary buffer of -20% is applied because the precautionary status of the stock is not known.

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

Index A (2016–2017)		2.02
Index B (2013–2015)		2.09
Index ratio (A/B)		0.97
-20% Uncertainty cap	Applied/not applied	Not applied
Average catch (2015–2017)		22.1
Discard rate (2015–2017)		0 (negligible)
-20% Precautionary buffer	Applied/not applied	Applied
Catch advice **		17.1
Landings advice ***		17.1
% advice change ^		%

* 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)
*** catch advice × (1 – discard rate)
^ Advice value 2019 relative to advice value 2018.

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

XSA and a4a results were considered as not acceptable 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.

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

Assessment type	Index based assessment
Input data	Landings (2005 - 2017)
Discards and bycatch	
Indicators	MEDITS indices
Other information	
Working group	EWG 18 - 12

History of the advice, catch, and management

Table 5.14.5 Norway lobster in GSA 11: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted catch corresp. to advice	Official landings in (areas)	STECF landings	STECF discards	STECF catch
2019	precautionary advice reduce catch	17.1				
2020	precautionary advice reduce catch	17.1				

History of the catch and landings

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

Catch (Current year-1)	Landings			Discards
28.3 t	100 % trawl	% set nets	% others	0 t
	T			

Table 5.14.7 Norway lobster in GSA 10: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

Year	ITALY GSA11	Country 2	Country 3	Country 4	Country 5	Total landings	Total BMS landings	STECF total landings	Total Effort (Nom. Eff. 10^6)
2005	6.3					6.3			7.32
2006	42.3					42.3			5.75
2007	31.3					31.3			5.87
2008	36.2					36.2			4.33
2009	44.4					44.4			4.37
2010	22.8					22.8			4.04
2011	50.5					50.5			3.79
2012	41.1					41.1			3.82
2013	20.6					20.6			3.14
2014	17.2					17.2			3.30
2015	18.2					18.2			3.09
2016	15.8					15.8			3.25
2017	28.3					28.3			3.83

Summary of the assessment

Table 5.14.8 Norway lobster in GSA 11: Assessment summary (weights in tonnes).

Year	Biomass Index (MEDITS tons/Km^2)	Landings tonnes	Discards tonnes	Total catch
2005	2.17E-03	6.3	0	6.3
2006	3.23E-03	42.3	0	42.3
2007	3.20E-03	31.3	0	31.3
2008	4.22E-03	36.2	0	36.2
2009	4.46E-03	44.4	0	44.4
2010	4.06E-03	22.8	0	22.8
2011	1.81E-03	50.5	0	50.5
2012	2.69E-03	41.1	0	41.1
2013	1.94E-03	20.6	0	20.6
2014	2.17E-03	17.2	0	17.2
2015	2.16E-03	18.2	0	18.2
2016	2.15E-03	15.8	0	15.8
2017	1.90E-03	28.3	0	28.3

Sources and references

Reproduced from STECF EWG 18-12 for use in 2019 EWG 19-10. For original data supporting this summary sheet see STECF report of Mediterranean Assessment EWG 18-12

5.15 Summary sheet for blue and red shrimp in GSA 1

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.56 and corresponding catches of blue and red shrimp in 2020 should not exceed 96 tonnes.

Stock development over time

The Spawing stock biomass (SSB) shows a clear decreasing trend since 2012 but appear rather stable in the last three years. Recruitment shows similar declining pattern since 2005 (highest value in the time series). The recruitment in 2018 was 250,000 individuals, near the mean of the time series. Catches have declined from around 250 t in 2002-2004 to around 100 t in 2018, with a clear declining trend since 2014. Fishing mortality(F) has been exceeding F0.1 since 2003. It declined in the early part of the time-series but has fluctuated around 1.0 until 2017 but has increased again in the last year to 1.14.

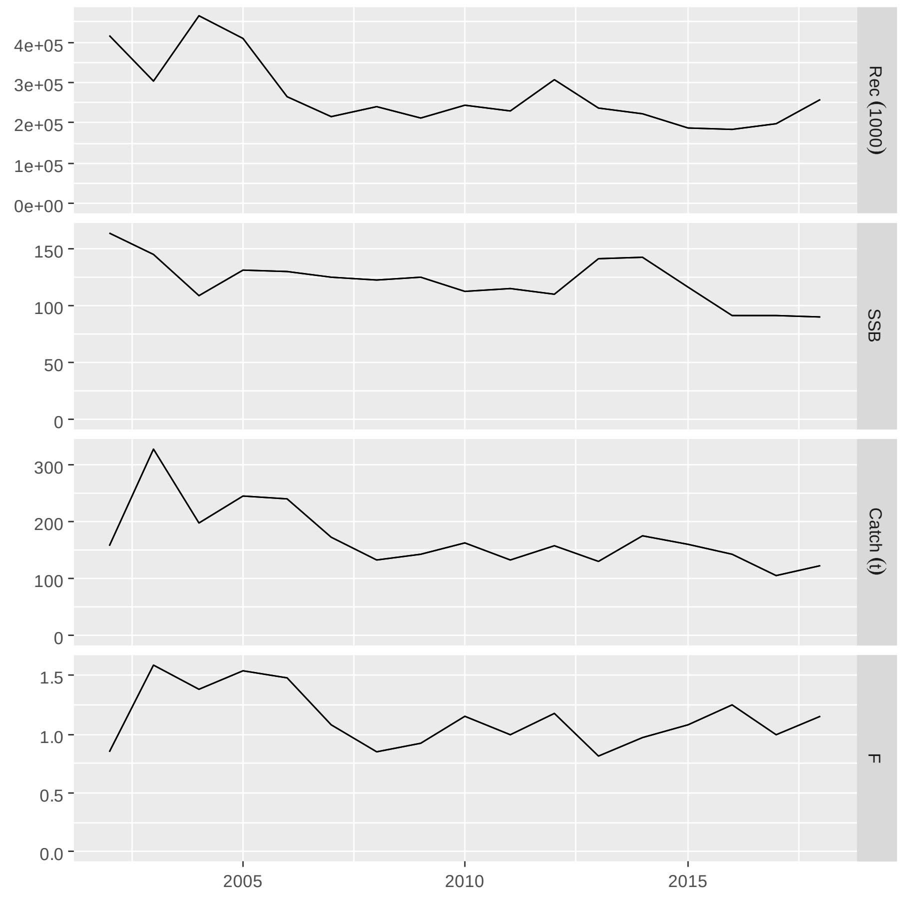


Figure 5.15.1. Blue and red shrimp in GSA 1. Stock summary of the assessment (a4a) results. SSB and catch are in tonnes, recruitment in number of individuals.

Stock and exploitation status

The current F (=1.15) computed as the mean of the last three years, 2015-2017) was larger than $F_{0.1}$ (0.56), 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	2016	2017	2018
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

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
$F_{ages\ 1\text{–}2}$ (2019)	1.13	F status quo based on Mean of F 2016 to 2018
SSB (2019)	106.3	SSB from assessment
R_0 (2019-2021)	279960	Mean R 17 years 2002-2018
Total catch (2019)	139.6	Catch at status quo F

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

Basis	Total catch* (2019)	F_{total}# (ages 0-2) (2019)	SSB (2020)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	96.03	0.56	189.50	78%	-22%
$F_{MSY\ lower}$	69.27	0.37	229.75	116%	-44%
$F_{MSY\ upper}$ **	120.56	0.76	156.68	47%	-3%
Other scenarios					
Zero catch	0.00	0.00	355.41	234%	-100%
Status quo	156.18	1.13	156.97	48%	26%
0.3	64.27	0.34	237.80	124%	-48%
0.4	81.52	0.45	210.75	98%	-34%
0.6	111.22	0.68	168.72	59%	-10%
0.8	135.73	0.91	138.32	30%	10%

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

Basis of the advice

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

Advice basis	MSY approach.
Management plan	

Quality of the assessment

The recruitment and SSB estimates shown for the last years are uncertain due to variation in MEDITS index. The retrospective performance is considered adequate as this does not change the status of the stock (F>Fmsy for recent period), however due to short time series more years of restrspective could not be run indicating some instability in the assessment.

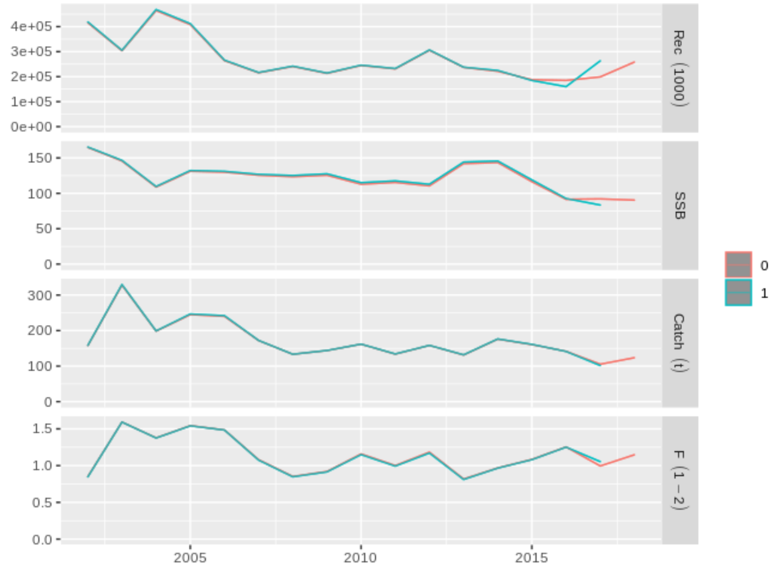


Figure 5.15.2 Blue and red shrimp in GSA 1. Results of the retrospective analysis (a4a).

Data treatment was revised in 2019, to deal with potential miss age allocation. This results in fewer age 0 in catch and survey. The Fbar is revised and rescaled, although the value of Fbar and Fmsy are revised the ratio is unaltered.

Issues relevant for the advice

There are no additional issues for the advice.e

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}	0.56	F0.1 used as proxy for Fmsy	EWG 19-10
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}	0.56	F0.1 used as proxy for Fmsy	EWG 19-10
	MAP target range F_{lower}	0.37	Based on regression calculation (see section 2)	EWG 19-10
	MAP target range F_{upper}	0.76	Based on regression calculation but not tested and presumed not precautionary	EWG 19-10

Basis of the assessment

The stock of blue and red shrimp in GSA 1 was assessed using the statistical catch-at-age method (a4a) that were applied to catch data for the period 2002-2018, tuned with fishery independent survey abundance indices (MEDITS in GSA 1).

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 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 (2002-2017) from one fleet (OTB) and one tuning index, MEDITS bottom trawl survey (CPUE, kg/km^2, 2002-2017). 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 2018.
Working group	EWG 19-10

History of the advice, catch, and management

Table 5.15.7 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 landings	STECF discards
2015	F0.1=0.40. Catch for 2016 should not exceed 96 t.	96	96		138	-
2018	Fmsy=0.42. Catch for 2019 should not exceed 98 t.	98	98	-	124	-
2019	Fmsy=0.56. Catch for 2020 should not exceed 96 t.	96	96			

History of the catch and landings

Table 5.15.8 Blue and red shrimp in GSA 1. Catch and effort distribution by fleet in 2017 as estimated by and reported to STECF.

<table>
<tr><td>Catch (2018)</td><td colspan="4">Landings</td><td>Discards</td></tr>
<tr><td rowspan="2">124(t)</td><td>OTB
100 %</td><td>Gillnets
0 %</td><td>Trammel nets
0 %</td><td>Other
0 %</td><td>Negligible</td></tr>
<tr><td colspan="4">99 (t)</td><td></td></tr>
<tr><td rowspan="2">Effort</td><td>100%</td><td>-</td><td>-</td><td>-</td><td rowspan="2"></td></tr>
<tr><td colspan="4">21633 fishing days</td></tr>
</table>

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	STECF total landings	Total Effort fishing days
2002	157	157	157	28002
2003	336	336	336	32892
2004	225	225	225	34951
2005	233	233	233	32295
2006	289	289	289	31443
2007	178	178	178	29917
2008	133	133	133	26201
2009	145	145	145	27017
2010	152	152	152	28476
2011	132	132	132	28170
2012	149	149	149	25851
2013	125	125	125	24334
2014	184	184	184	22395
2015	170	170	170	21587
2016	138	138	138	21345
2017	99	99	99	22537
2018	124	124	124	21633

Summary of the assessment

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

Year	Recruitment age 1 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 0-2	High	Low
2002	415694			164.882			157.72	0.85033		
2003	303739			145.676			328.2	1.59233		
2004	464287			108.89			198.59	1.37763		
2005	408243			131.144			244.93	1.54393		
2006	263960			129.975			240.09	1.48459		
2007	215496			125.528			172	1.08044		
2008	240670			123.525			133.36	0.85306		
2009	213130			125.549			143.84	0.92001		
2010	244678			112.861			161.78	1.15885		
2011	231094			115.416			133.86	1.00101		
2012	305428			110.538			158.23	1.1832		
2013	237014			141.963			131.35	0.81806		
2014	221565			143.546			175.98	0.96866		
2015	187840			116.45			160.58	1.08483		
2016	184881			91.59			141.65	1.25404		
2017	198947			92.13			105.43	0.99504		
2018	258398			90.448			123.7	1.14778		

Sources and references

5.16 Summary sheet for blue and red shrimp in GSA 5

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 18-12 advises to decrease the total catch to 88% of the average 2015-2017 catches equivalent to catches of no more than 150 tons in each of 2019 and 2020 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 5.16.1).

Figure 5.16.1 Blue and red shrimp in GSA5. A) Summary of the MEDITS stock indicator showing mean value 2013 to 2015 = 2.44, mean 2016-2017 = 4.67 and b) Landings by year.

Stock and exploitation status

The stock status both 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. The change is estimated from the two most recent values relative to the three preceding values (see table 5.16.1). The precautionary buffer of -20% is applied because the precautionary status of the stock is not known.

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

Index A (2016–2017)		4.27
Index B (2013–2015)		2.44
Index ratio (A/B)		1.75
-20% Uncertainty cap	Applied/not applied	Applied
Average catch (2015–2017)		156.5
Discard rate (2015–2017)	Assumed negligible	0

-20% Precautionary buffer	Applied/not applied	Applied
Catch advice **		150
Landings advice ***		150
% advice change ^		12.3%

* 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)
*** catch advice × (1 – discard rate)
^ Advice value 2019 relative to advice value 2018.

Basis of the advice

Table 5.16.3 Blue and red shrimp in GSA 5. The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

Both models showed oscillations along the data series, both for recruitment and SSB. However, a4a showed an increase of both parameters for the last years. F values were higher for a4a than for XSA, but this was considered as the most unstable parameter. The assessments were not accepted for advice. Biomass and abundance indices from the MEDITS survey showed oscillations along the years, without a clear trend, but appear to be acceptable for index advice

Issues relevant for the advice

Reference points

Table 5.16.4 Blue and red shrimp in GSA 5: 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 5.16.5 Blue and red shrimp in GSA 5: 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 5
Other information	
Working group	EWG 18-12

History of the advice, catch, and management

Table 5.16.6 Blue and red shrimp in GSA 5. STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted catch corresp. to advice	Official landings in (areas)	STECF landings	STECF discards	STECF catch
2019	Reduction of 12% in catch	150				
2020	Reduction of 12% in catch	150				

History of the catch and landings

Table 5.16.7 Blue and red shrimp in GSA 5. Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

(current year-1)		Wanted catch				Discards
Catch (t)	171	Bottom trawl 100%	Gillnets %	Trammel nets %	Other %	0 t
		tonnes				
Effort		100%				
	4808	Fishing days				

Table 5.16.8 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 in Fishing Days.

Year	SPAIN GSA5	Total landings	STECF total landings	Total Effort
2002	141.45	141.45	141.45	
2003	122.01	122.01	122.01	
2004	193.58	193.58	193.58	
2005	191.48	191.48	191.48	
2006	213.89	213.89	213.89	
2007	239.12	239.12	239.12	
2008	232.85	232.85	232.85	
2009	126.16	126.16	126.16	5933
2010	153.24	153.24	153.24	6138
2011	111.24	111.24	111.24	5529
2012	201.14	201.14	201.14	5428
2013	188.6	188.6	188.6	5068
2014	141.28	141.28	141.28	5144
2015	160.15	160.15	160.15	5522
2016	138.1	138.1	138.1	4262
2017	171.35	171.35	171.35	4808

Summary of the assessment

Table 5.16.9 Blue and red shrimp in GSA 5: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2002		141.45		141.45
2003		122.01		122.01
2004		193.58		193.58
2005		191.48		191.48
2006		213.89		213.89
2007	2.40	239.12		239.12
2008	3.61	232.85		232.85
2009	3.42	126.16		126.16
2010	2.30	153.24		153.24
2011	1.79	111.24		111.24
2012	3.73	201.14		201.14
2013	3.29	188.6		188.6
2014	1.94	141.28		141.28
2015	2.09	160.15		160.15
2016	5.86	138.1		138.1
2017	2.68	171.35		171.35

Sources and references

Reproduced from STECF EWG 18-12 for use in 2019 EWG 19-10. For original data supporting this summary sheet see STECF report of Mediterranean Assessment EWG 18-12

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

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.33 and corresponding catches of blue and red shrimp in 2020 should not exceed 226 tonnes.

Stock development over time

The SSB shows some increase after 2015, but decreased again after 2017. Catch is estimated to be decreasing consistently from 2011 onwards. Fishing mortality is seen to slightly increase after 2015.

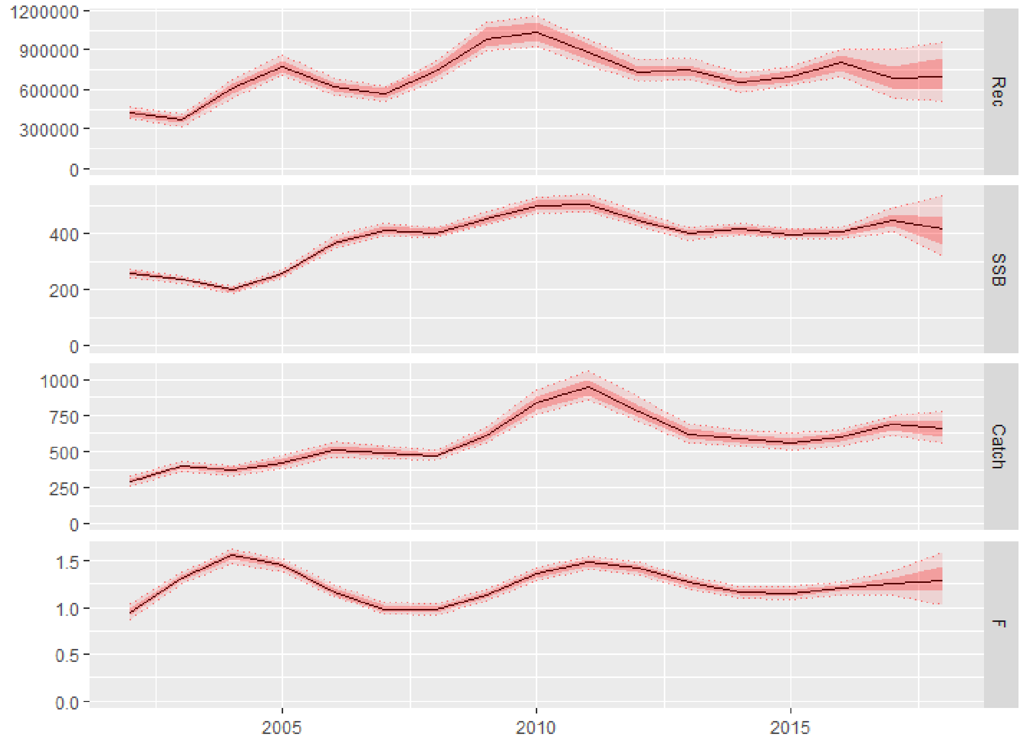


Figure 5.17.1 Blue and red shrimp (ARA) in GSAs 6 & 7. Outputs of the a4a assessment. SSB and catch are in tonnes, recruitment in number of individuals.

Stock and exploitation status

The current F (=1.26) computed as the mean of the last three years, 2015-2017) was larger than $F_{0.1}$ (0.33), 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 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	2016	2017	2018
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
$F_{ages\ 1-2}$ (2019)	1.26	F2019 status quo is mean F bar 2016-2018
SSB (2019)	392	SSB from assessment
R_{age0} (2019)	387906	Geometric mean of R from time series years 2012 to 2018
Total catch (2019)	600 t	Catch at F status quo in 2019

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

Basis	Total catch* (2020)	F_{total}# (ages 1-2) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	226	0.33	948	142	-65
$F_{MSY\ lower}$	158	0.22	1066	172	-75
$F_{MSY\ upper}$**	295	0.45	833	113	-54
Other scenarios					
Zero catch	0.0	0.0	1370	250	-100
Status quo	644	1.26	404	3	-4.5

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

*** % change in SSB 2021 to 2019

^Total catch in 2020 relative to Catch in 2018.

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

Two assessments were run with input data from two alternative approaches of slicing LFD data, (the two assessments are presented in Ch. 6.17). The assessment with input data acounting for summer spawning of the stock was prefered and is presented in the stock summary, the results of the assessment give slightly higher F and similar MSY reference point. The conclusions that F> F_{MSY} is robust to all options

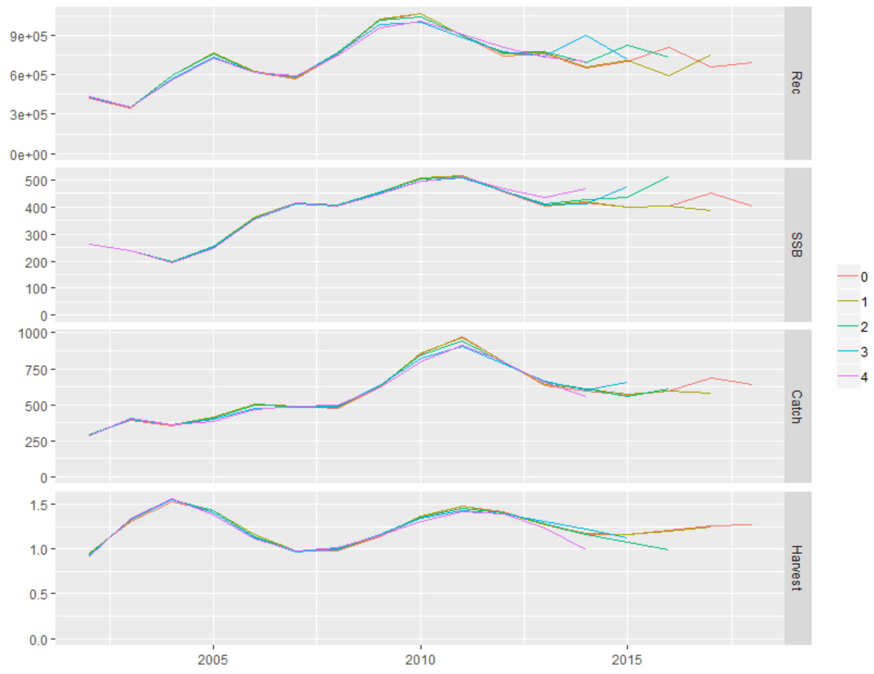


Figure 5.17.2 Blue and red shrimp in GSAs 6 & 7: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.33	$F_{0.1}$ 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}	0.33	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.22	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.45	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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 19 -10

*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 landings	STECF discards
2019	F= F_{MSY}	223	223			
2020	F= F_{MSY}	226	226			

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.

(2018)		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	t
		643 tonnes				Negligible
Effort		100%	0%	0%	0%	
		84370 effort (fishing days)				

Table 5.17.9 Blue and red shrimp in GSAs 6 & 7: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	SPAIN 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	92142
2016	650	650	93455
2017	588	588	88662
2018	656	656	84180

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' the credible intervals (Median Absolute Deviance).

Year	Recruitment age 0 (thousands)	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-2	High	Low
2002	424467			261.05			296.03	0.96	1.30	0.63
2003	367160			237.75			396.47	1.32	1.79	0.88
2004	603594			200.55			368.99	1.56	2.11	1.03
2005	772884			256.77			424.73	1.46	1.97	0.97
2006	626070			361.45			513.84	1.18	1.61	0.78
2007	576232			411.93			494.60	0.99	1.35	0.66
2008	735412			402.98			475.97	0.98	1.33	0.65
2009	975437			452.19			610.89	1.13	1.53	0.75
2010	1014080			497.78			821.79	1.34	1.82	0.89
2011	868761			505.41			928.22	1.46	1.97	0.96
2012	732509			450.95			772.28	1.40	1.89	0.92
2013	750698			403.01			623.49	1.26	1.70	0.83
2014	658474			416.36			595.64	1.17	1.58	0.77
2015	708929			398.79			569.74	1.17	1.58	0.77
2016	799592			404.35			603.05	1.22	1.66	0.81
2017	671041			445.08			683.63	1.27	1.72	0.84
2018	697470			402.57			643.50	1.29	1.75	0.85

Sources and references

STECF EWG 19-10

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

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2019 should be no more than 0.39 and corresponding catches in 2020 should be no more than 72 tons.

Stock development over time

SSB of Blue and red shrimp show a fluctuating pattern reaching the lowest value in 2018 (353 tonnes). Recruitment fluctuates similarly also with a minimum in 2018 (21035). Fbar (2-5) shows a fluctuating pattern with a steep increase in the last years (Fbar 2018 = 1.45).

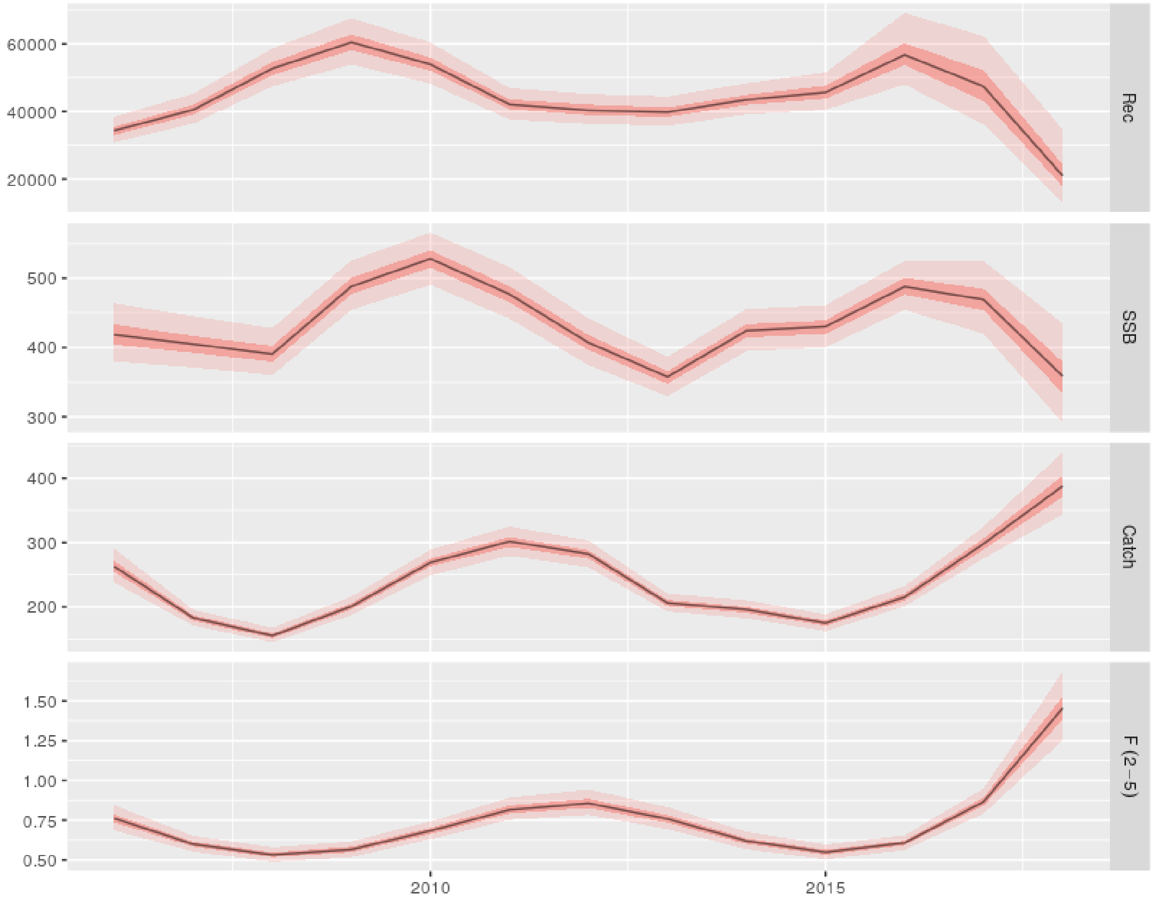


Figure 5.18.1 Blue and red shrimp in GSAs 9, 10 and 11: Trends in catch, recruitment, fishing mortality resulting from the a4a model.

Stock and exploitation status

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

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	2016	2017	2018
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
$F_{ages\ 2\text{-}5}$ (2019)	1.45	Last year value
SSB (2019)	221	At mid 2019
R_{age1} (2019,2020)	43233	Geometric mean of the time series
Total catch (2019)	227	Assuming F = Fstatus quo

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* (2020)	F_{total}# (ages 2-5) (2020)	SSB (2021)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	72	0.39	431	95	-81
$F_{MSY\ lower}$	50	0.26	465	111	-87
$F_{MSY\ upper}$**	94	0.53	398	80	-76
Other scenarios					
Zero catch	0	0	548	148	-100
Status quo	202	1.45	264	20	-48

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

*** % change in SSB 2021 to 2019

^Total catch in 2020 relative to Catch in 2018.

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.

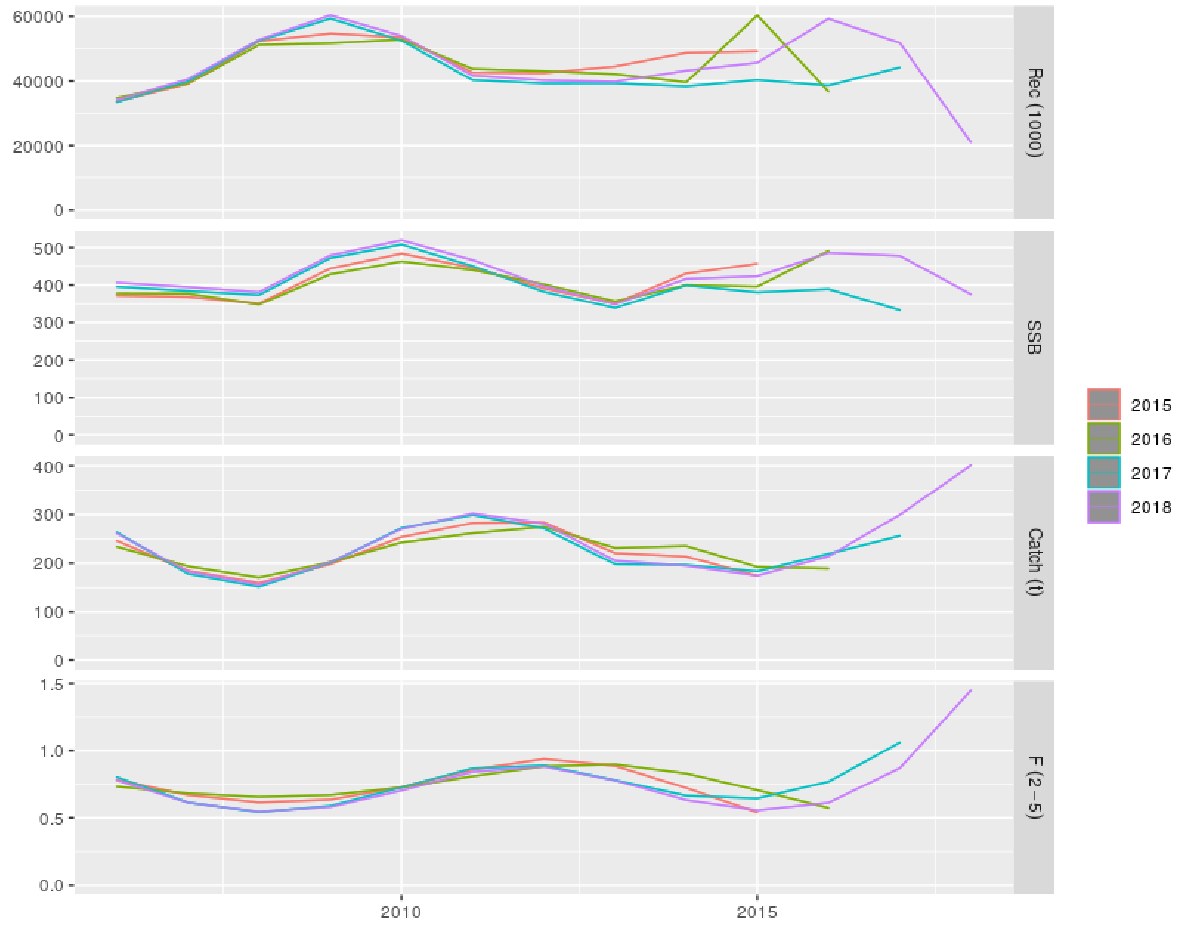


Figure 5.18.2 Blue and red shrimp in GSAs 9, 10 and 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.39	$F_{0.1}$ 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 19-10
	target range F_{lower}	0.26	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.53	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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
Indicators	
Other information	
Working group	STECF EWG 19-10

*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 landings	STECF discards
2020	F = F_{MSY}		72			

History of the catch anjd 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.

2018		Wanted catch				Discards
Catch (t)	387	Otter bottom trawl (OTB) 100%				t
		387				0
Effort		99251				
		Fishing Days				

Table 5.18.9 Blue and red shrimp in GSAs 9, 10 and 11: History of commercial landings; official reported values are presented by country and GSA,. All weights are in tonnes. Effort in Fishing Days.

Year	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total catches	Total Effort (Fishing Days)
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	161.4	107345
2009	123.5	24.4	65.3	213.2	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	57.6	215.2	98969
2016	66.6	66.1	89.4	222.1	103845
2017	62.4	79.1	110.0	251.5	100037
2018	77.2	135.0	284.7	496.9	99251

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	Fages 2-5	High	Low
2006	34317	-	-	417	-	-	262	0.76	-	-
2007	40615	-	-	403	-	-	183	0.60	-	-
2008	52721	-	-	389	-	-	156	0.53	-	-
2009	60523	-	-	486	-	-	201	0.57	-	-
2010	54070	-	-	526	-	-	268	0.68	-	-
2011	42066	-	-	475	-	-	301	0.82	-	-
2012	40464	-	-	405	-	-	282	0.86	-	-
2013	39812	-	-	356	-	-	206	0.76	-	-
2014	43462	-	-	422	-	-	196	0.62	-	-
2015	45727	-	-	428	-	-	175	0.55	-	-
2016	57117	-	-	486	-	-	215	0.61	-	-
2017	47378	-	-	466	-	-	298	0.87	-	-
2018	21035	-	-	353	-	-	387	1.45	-	-

Sources and references

STECF EWG 19-10

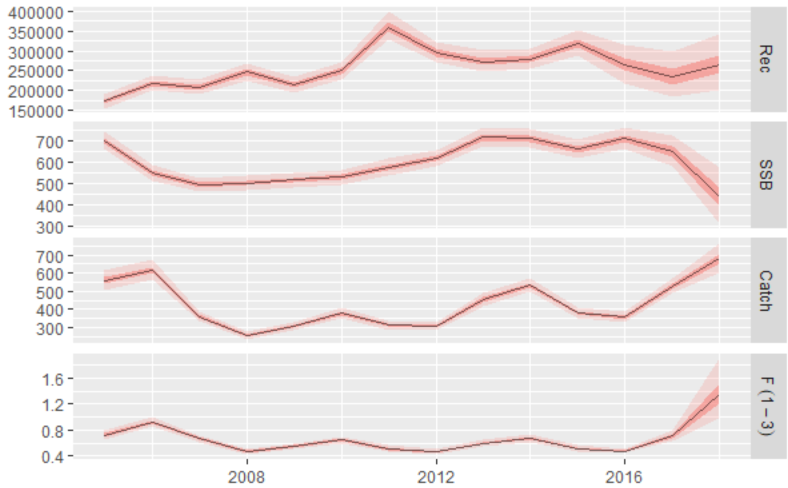
5.19 Summary sheet for giant red shrimp in GSA 9, 10 & 11

STECF advice on fishing opportunities

STECF EWG 19-10 advises that when MSY considerations are applied the fishing mortality in 2020 should be no more than 0.44 and corresponding to catches of no more than 199 tons in 2020 implemented either through catch restrictions or effort reduction for the relevant fleets.

Stock development over time

Catches of giant red shrimp in GSAs 9, 10, 11 shows a fluctuating pattern, with peaks in 2006 and 2014, then increasing again in the last two years. Recruitment and SSB peaked in 2011 and 2013, respectively; after that, they showed a decreasing trend. Fishing mortality showed a rather constant pattern between 0.5 and 0.8, with a sharp increase in the last two years due to the increase in catches.



Catches of giant red shrimp in GSAs 9, 10, 11 shows a fluctuating pattern, with peaks in 2006 and 2014, then increasing again in the last two years. Recruitment and SSB peaked in 2011 and 2013, respectively; after that, they showed a decreasing trend. Fishing mortality showed a rather constant pattern between 0.5 and 0.8, with a sharp increase in the last two year due to the increase in catches.

Figure 5.18.1 Giant red shrimp in GSAs 9, 10, 11: Output of the assessment.

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} (= 0.45). However, F has been very close to or at F_{MSY} in 2016 and previous years.

Status	2016	2017	2018
F / F_{MSY}	F at 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
$F_{ages\ 1-3}$ (2019)	1.37	F current in the last year
SSB (2019; middle of the year)	343.6 t	Stock assessment 1 January 2019
R_0 (2019,2020,2021)	252911.7 thousands	Geometric mean of the whole time series (2005-2018)
Total catch (2019)	467.7 t	Assuming F status quo for 2019

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

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

Basis	Total catch* (2020)	F_{total}# (ages 1-3) (2020)	SSB (2021 middle of the year)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	199.3	0.45	596.6	73.6	-70.8
$F_{MSY\ lower}$	140.2	0.30	670.2	95.1	-79.4
$F_{MSY\ upper}$**	257.7	0.62	529.9	54.2	-62.2
Other scenarios					
Zero catch	0.0	0.0	872.2	153.9	-100.0
Status quo	458.3	1.37	341.5	-0.6	-32.8

** Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F> F_{MSY}
*** % change in SSB 2021 to 2019
^Total catch in 2020 relative to Catch in 2018.

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	

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.

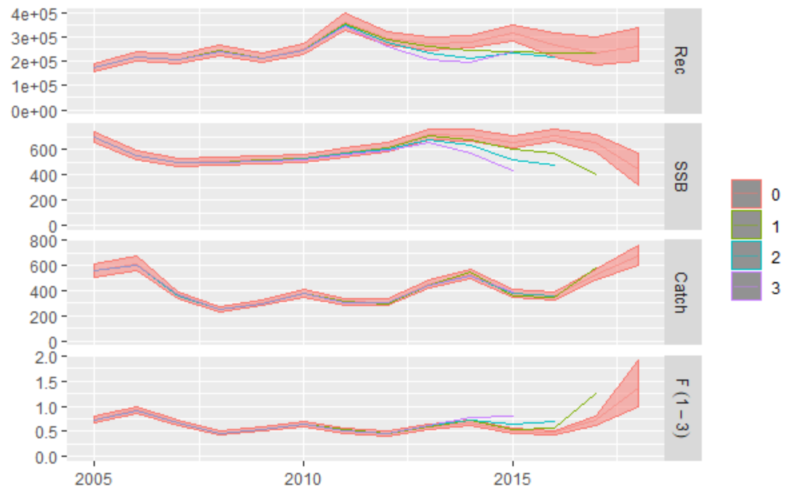


Figure 5.19.2 Giant red shrimp in GSA 9, 10, 11: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

At STECF 18-12, no sex ratio (and maturity vector) at length was available for GSA 11, thus the vectors available for GSA 10 were used to split the LFDs of GSA 11 in LFDs by sex. This information was made available to STECF 19-10, and then used to prepare the stock object.
Information on landings for quarter III in 2017 and quarter I in 2018 for GSA 10 was missing. The information was requested to the Italian National Correspondent and made available to the EWG in due time. In GSA 11, landings data for OTB_DWS were missing from 2015 to 2018. Landings data were recovered from the FDI data; this required rerunning the assessment after the EWG.
MEDITS contained some missing values ("pfrac" and "pechan" (TC) of hauls 29 and 67 of GSA10 in 2017) these were corrected but resubmission is required.

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}	0.45	$F_{0.1}$ 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}	0.45	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 19-10
	target range F_{lower}	0.30	Based on regression calculation (see section 2)	STECF EWG 19-10
	target range F_{upper}	0.62	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-10

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	Landings at length to landings at age (age slicing)
Discards, BMS landings*, and bycatch	Discards included
Indicators	MEDITS in GSAs 9, 10, 11
Other information	
Working group	STECF EWG 19-10

*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 landings	STECF discards
2019	$F = F_{MSY}$	171.2	171.2			
2020	$F = F_{MSY}$	199.3	199.3			

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.

<table>
<tr><td>(2018)</td><td></td><td colspan="4">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Catch
(t)</td><td></td><td>Bottom trawl 100%</td><td>Gillnets %</td><td>Trammel nets %</td><td>Other %</td><td>t</td></tr>
<tr><td>640.9</td><td colspan="4">tons</td><td>0.0</td></tr>
<tr><td rowspan="2">Effort</td><td>142091</td><td>100%</td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">Fishing Days</td></tr>
</table>

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 Fishing Days.

Year	ITALY GSA9	ITALY GSA10	ITALY GSA11	Total landings	Discards	STECF total catches	Effort Fishing days
2005	77.4	505.1	55.2	637.7	0.0	637.7	251918
2006	62.6	419.6	98.1	580.3	0.0	580.3	198695
2007	36.7	300.3	42.0	379.0	0.0	379.0	180757
2008	33.8	120.1	38.6	192.5	0.0	192.5	170207
2009	34.3	211.7	117.4	363.4	0.0	363.4	167934
2010	54.6	190.2	98.6	343.4	0.0	343.4	167480
2011	68.4	140.9	94.7	304.0	0.1	304.1	170808
2012	62.0	159.8	72.7	294.5	0.9	295.4	175096
2013	23.1	399.4	63.3	485.8	0.0	485.8	170068
2014	16.8	454.1	61.1	532.0	0.0	532.0	182371
2015	44.2	232.1	97.8	374.1	0.0	374.1	150232
2016	35.8	179.1	127.6	342.5	0.0	342.5	167117
2017	33.6	325.9	249.2	608.7	1.0	608.7	154607
2018	36.4	416.2	188.4	640.9	0.0	640.9	142901

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 thousands	SSB tonnes	Catch tonnes	F ages 1-3
2005	172512	697.9	557.0	0.72
2006	218771	551.0	615.3	0.92
2007	208398	496.2	358.9	0.67
2008	245651	503.3	252.9	0.47
2009	214309	516.4	306.4	0.54
2010	249321	530.5	378.1	0.64
2011	361483	577.4	311.0	0.51
2012	295227	617.5	307.6	0.46
2013	273184	714.7	453.0	0.60
2014	279055	708.3	532.2	0.67
2015	318607	658.9	378.9	0.52
2016	264308	709.0	355.5	0.47
2017	234439	648.8	525.2	0.71
2018	264215	435.9	681.8	1.37

Sources and references

STECF EWG 19-10

6 STOCK ASSESSMENTS

ToR 1. *To compile and provide the most updated information on stock identification and boundaries, length and age composition, growth, maturity, feeding, essential fish habitats 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 2018, including length frequency distribution over time.*

ToR 3. *To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2018. This should be described in terms of fishing days, days at sea, GT*days and nominal effort by Member State, GSA and fishing gear.*

ToR 4. *To compile and provide indices of abundances and biomass by year and size/age structure for the longest time series available up to and including 2018. Where possible, the EWG should take into account the results of the EU-funded project RECFISH*

ToR 5. *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 6. *To estimate the F_{MSY} point value, range of F_{MSY} (i.e. MSY F_{LOWER} and MSY F_{UPPER}) and the conservation reference points (i.e. B_{PA} and B_{LIM}), or proxy. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.*

ToR 7. *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 F_{LOWER} and MSY F_{UPPER}) or other appropriate proxy by 2020 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 19-10 considered the stock shared by GSAs 1, 5, 6 and 7.

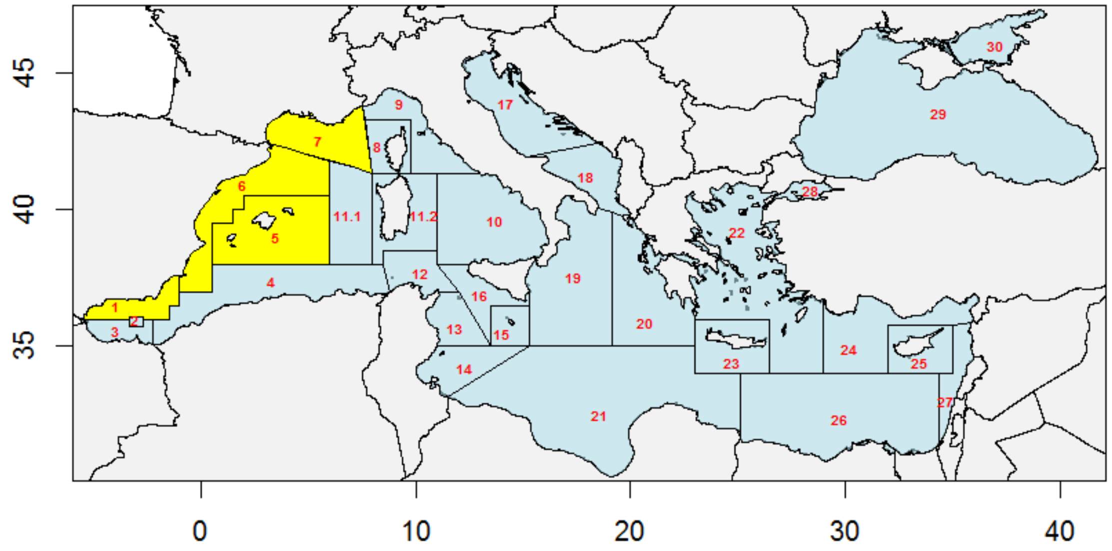


Figure 6.1.1.1 Geographical location of GSAs 1, 5, 6 and 7.

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 as in the previous assessment for hake in this area, carried out during the STECF EWG 18-12.

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	0.00677	3.0351

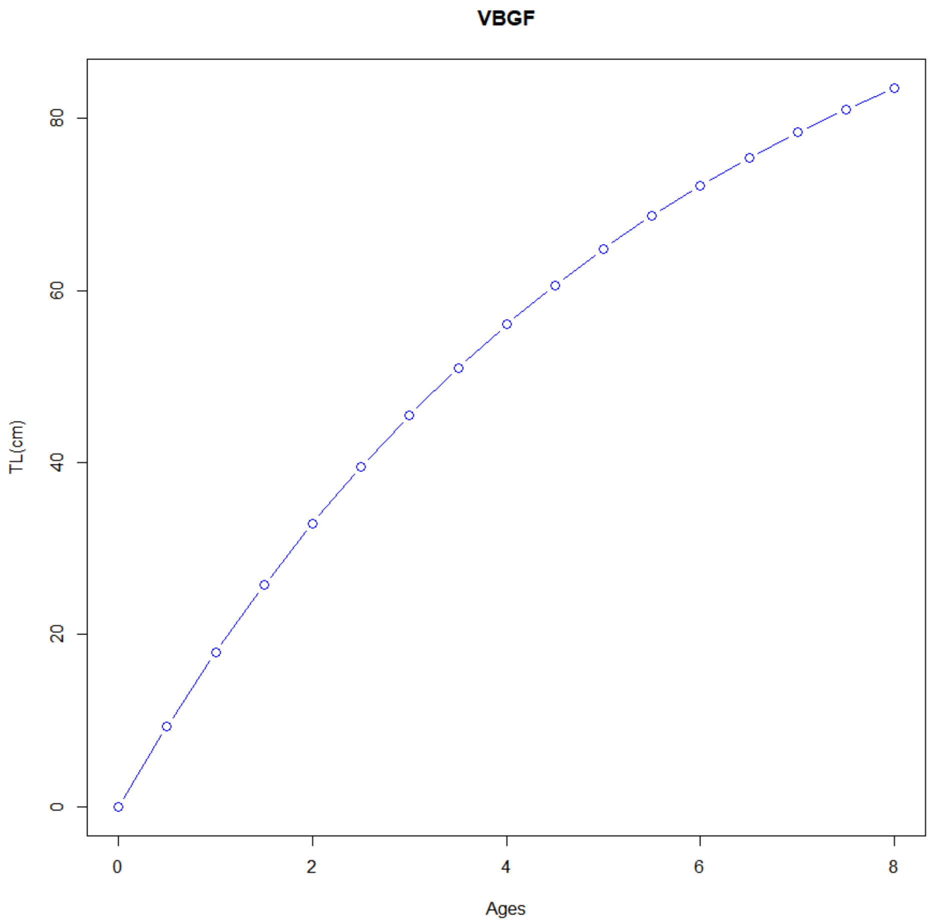


Figure 6.1.1.2. European hake in GSAs 1, 5, 6 and 7. Von Bertalanffy growth curve.

The maturity vector was taken from García-Rodríguez and Esteban (1995); the natural mortality vector was estimated using PRODBIOM (Abella et al, 1997) (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	1.24
1	0.15	0.58
2	0.82	0.45
3	0.98	0.4
4	1	0.37
5+	1	0.35

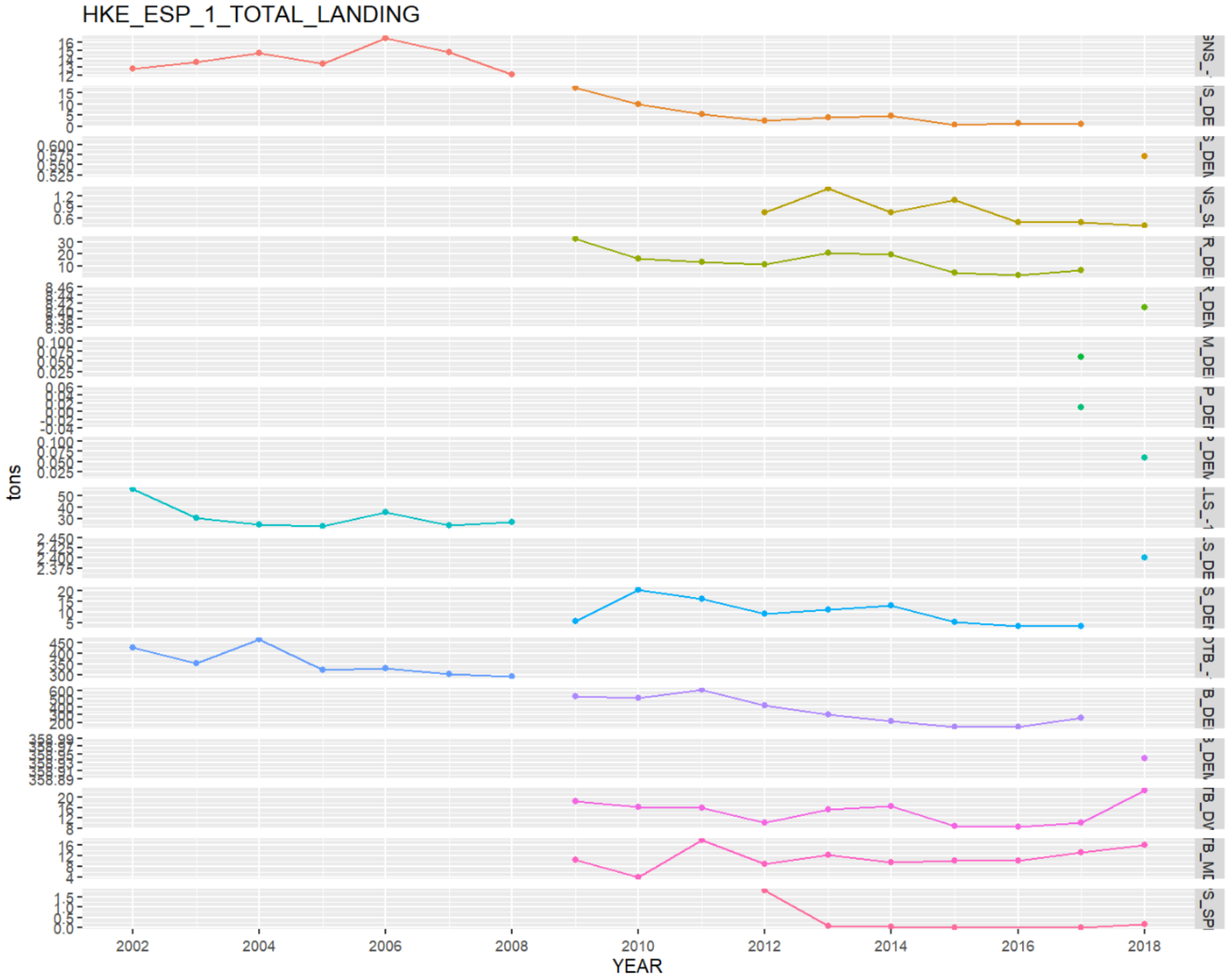
6.1.2 DATA

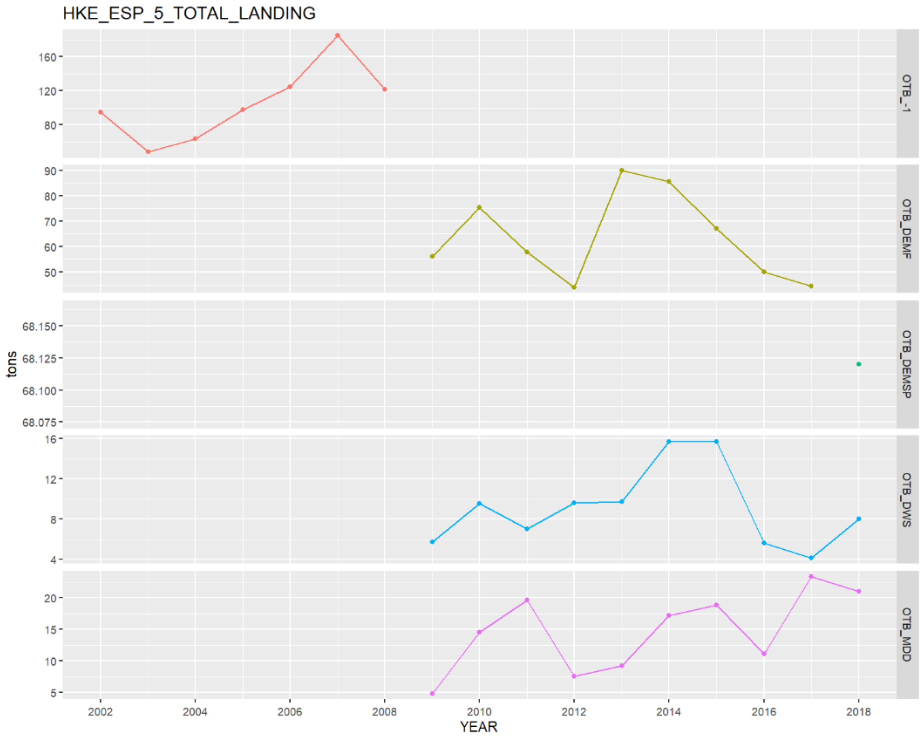
6.1.2.1 CATCH (LANDINGS AND DISCARDS)

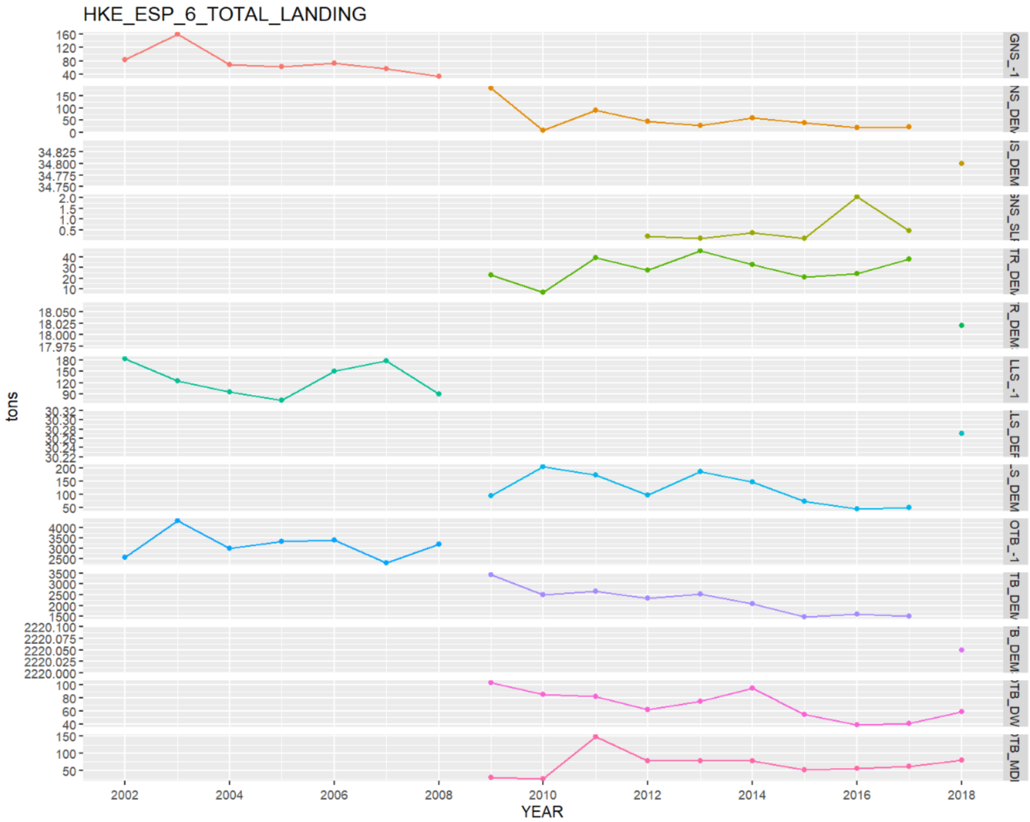
European hake is largely exploited in GSAs 1 and 6, mainly by trawlers on the shelf and slope, but also by small-scale fisheries using long lines, gill nets and trammel nets. In GSA 5, hake catches come exclusively from bottom trawlers. They show important variation along the data series, between 50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

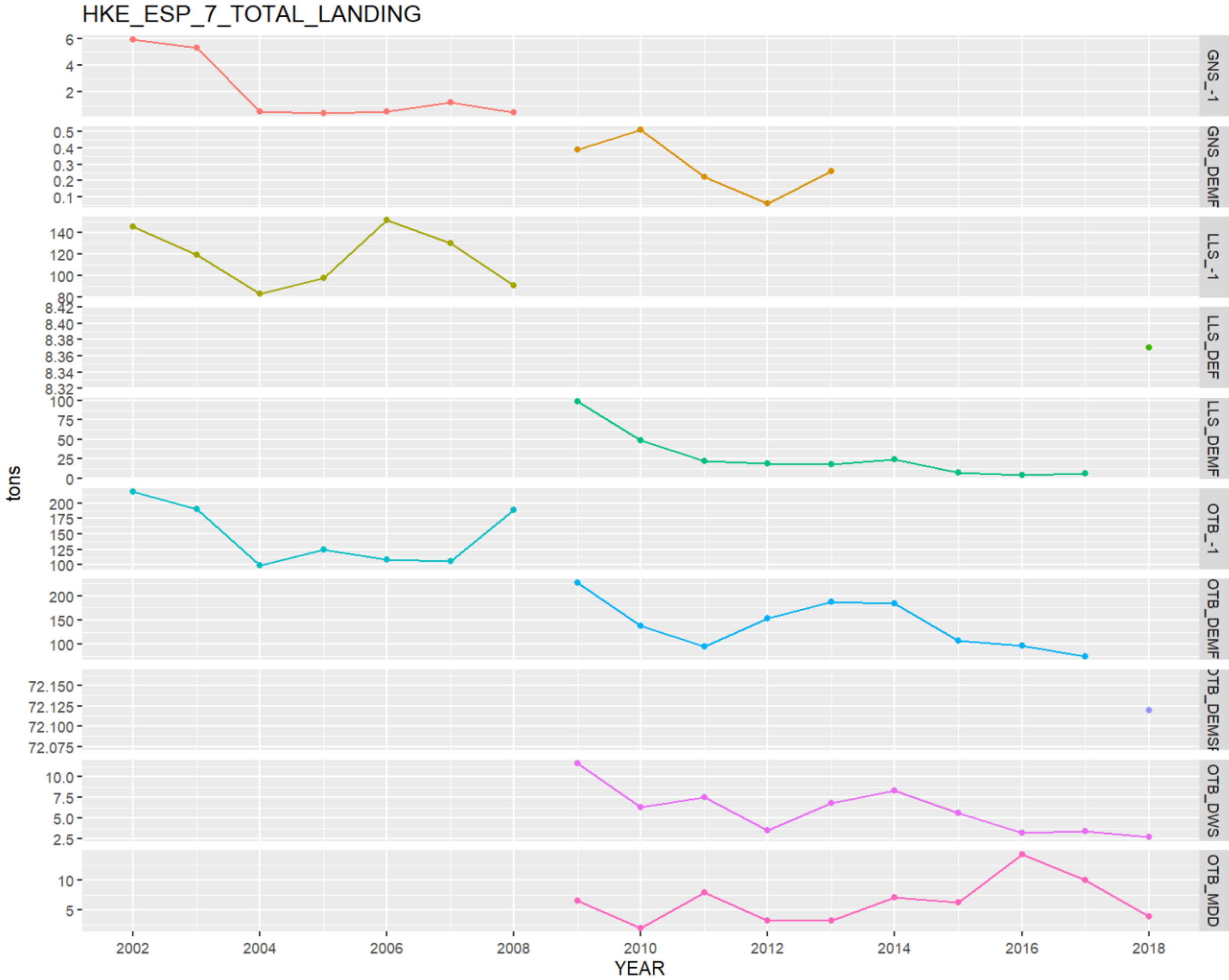
Landings

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
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_DWS
OTB_MDD


HKE_ESP_6_TOTAL_LANDING
tons
YEAR


HKE_ESP_7_TOTAL_LANDING
tons
YEAR
GNS_-1
GNS_DEMF
LLS_-1
LLS_DEF
LLS_DEMF
OTB_-1
OTB_DEMF
OTB_DEMSF
OTB_DWS
OTB_MDD
2002
2004
2006
2008
2010
2012
2014
2016
2018

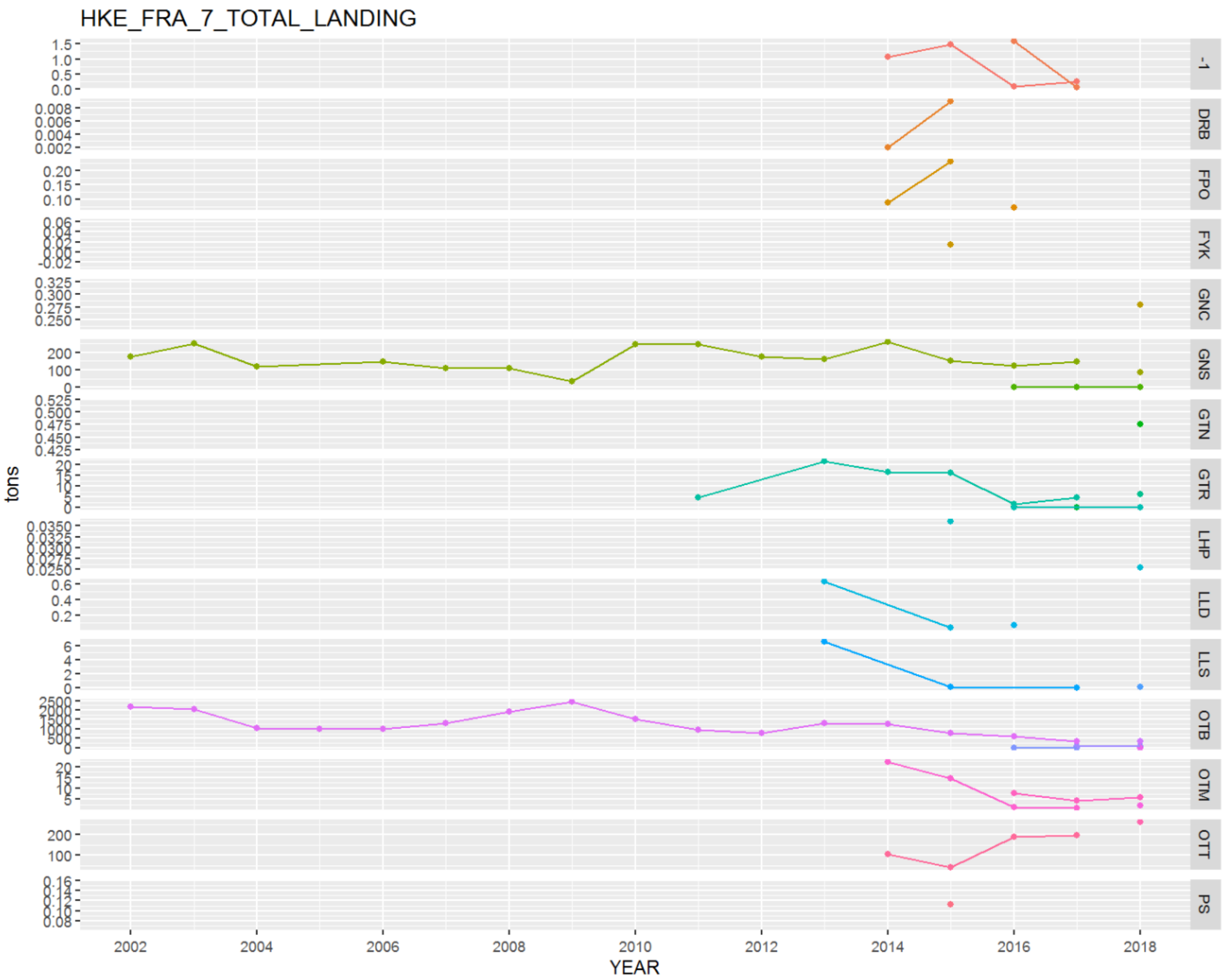
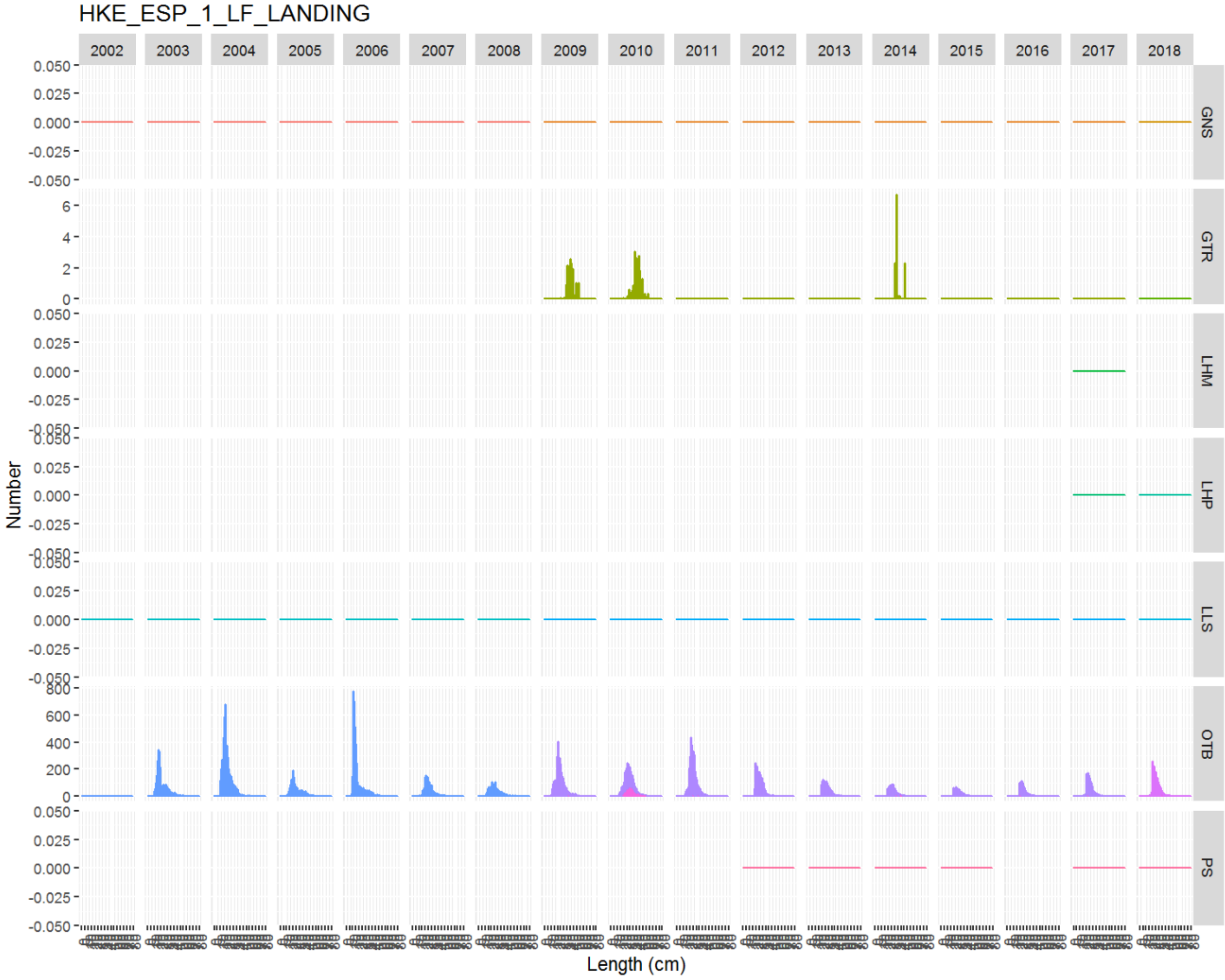


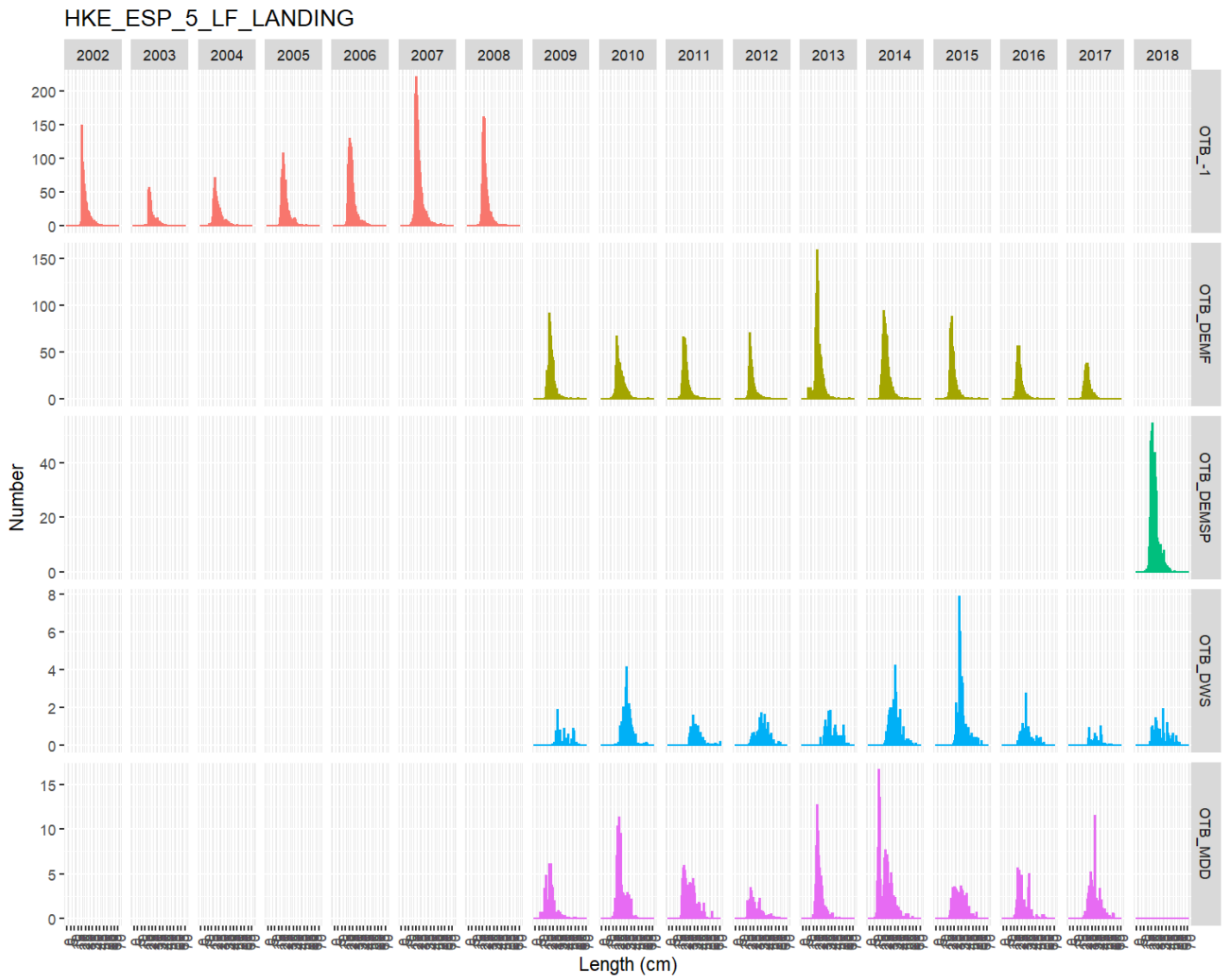
Figure 6.1.2.1.1. European hake in GSAs 1, 5, 6 and 7. Landings data in tons by year GSA country and fleet (for France in GSA 7 landings data are shown by year and gear for visualization reasons). From 2015 onwards there can be two points in the same year due to the increase in "fishery classes" for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

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

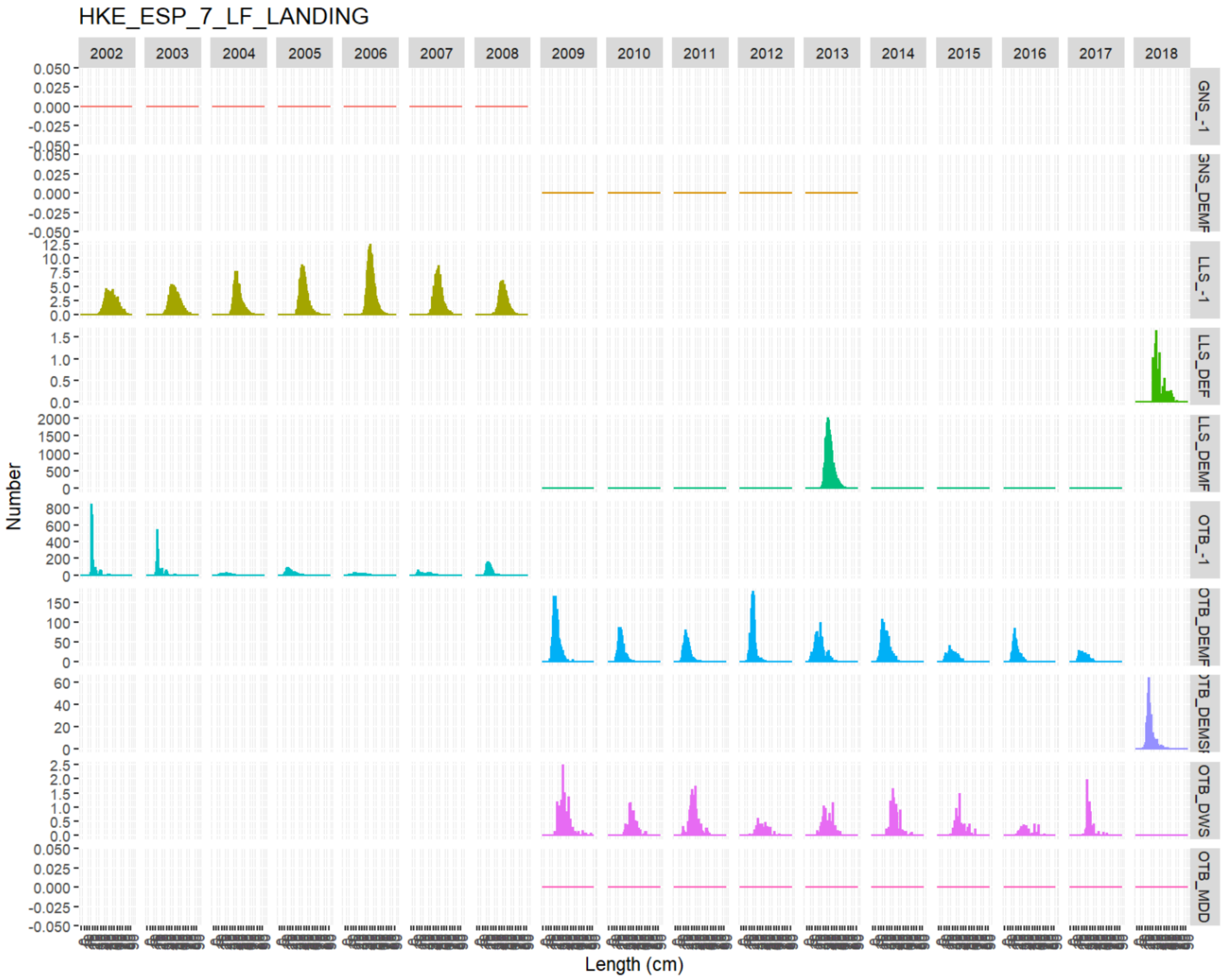
	Total Landing (tons)
2002	6138
2003	7666
2004	5039
2005	5156
2006	5558
2007	4697
2008	6082
2009	7362
2010	5466
2011	5279
2012	4278
2013	5131
2014	4786
2015	3129
2016	3083
2017	2946
2018	3831

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


HKE_ESP_1_LF_LANDING
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
GNS
GTR
LHM
LHP
LLS
OTB
PS
Number
Length (cm)


HKE_ESP_5_LF_LANDING
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
OTB_-1
OTB_DEMF
OTB_DEMSP
OTB_DWS
OTB_MDD
Number
Length (cm)


HKE_ESP_6_LF_LANDING
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Number
Length (cm)
GNS_-1
OTB_-1
LLS_-1


HKE_ESP_7_LF_LANDING
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
GNS_-1
GNS_DEMF
LLS_-1
LLS_DEF
LLS_DEMF
OTB_-1
OTB_DEMF
OTB_DEMSI
OTB_DWS
OTB_MDD
Number
Length (cm)

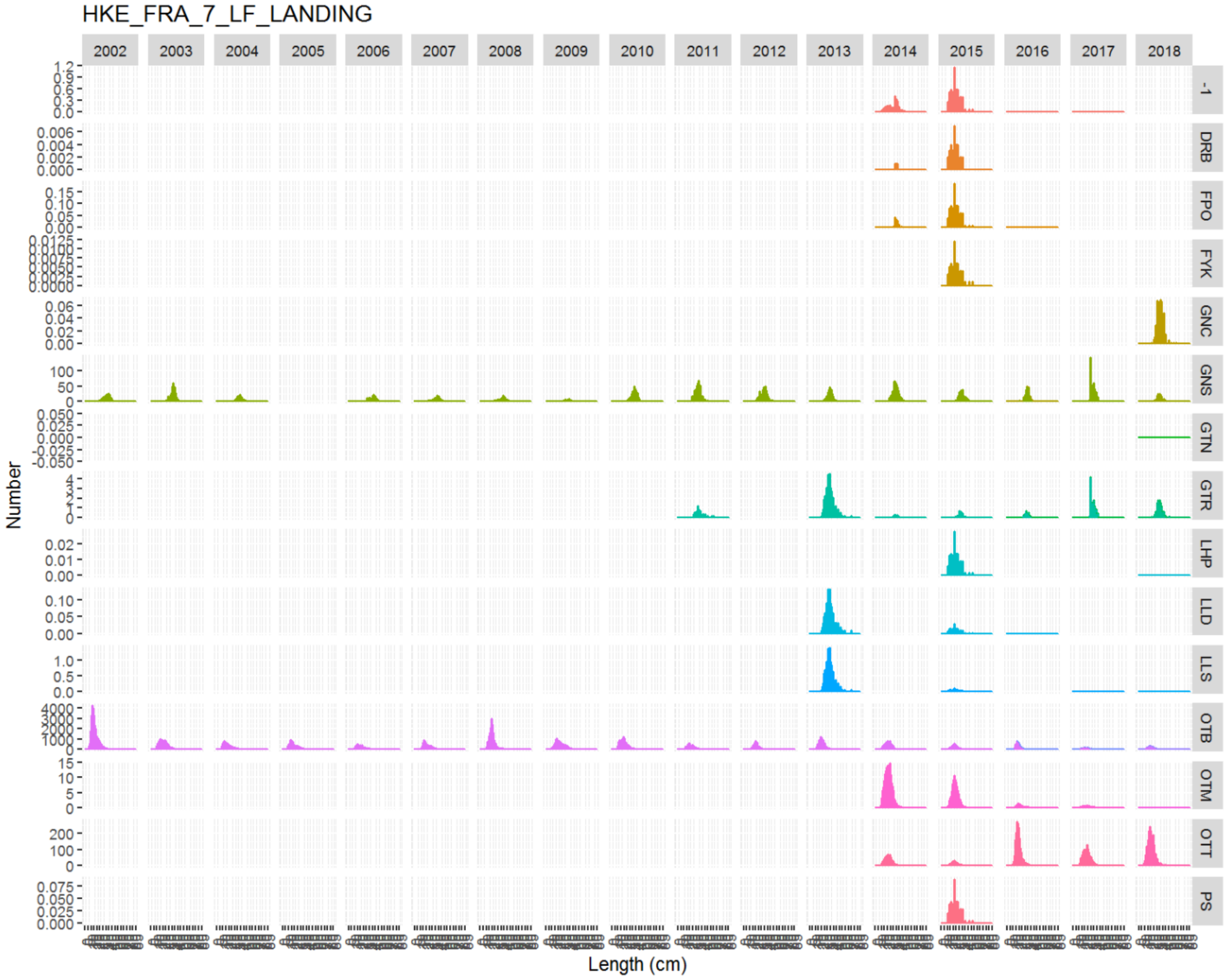


Figure 6.1.2.1.2. European hake in GSAs 1, 5, 6 and 7. Length frequency distribution of the landings by year and gear or fleet.

Discards

Discards data were reported to STECF EWG 19-10 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**
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
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
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
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	4.8	33.4
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**

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.

6.1.2.2 EFFORT

Fishing effort data were reported to STECF EWG 19-10 through DCF (Table 6.1.2.2.1 and 6.1.2.2.2).

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).

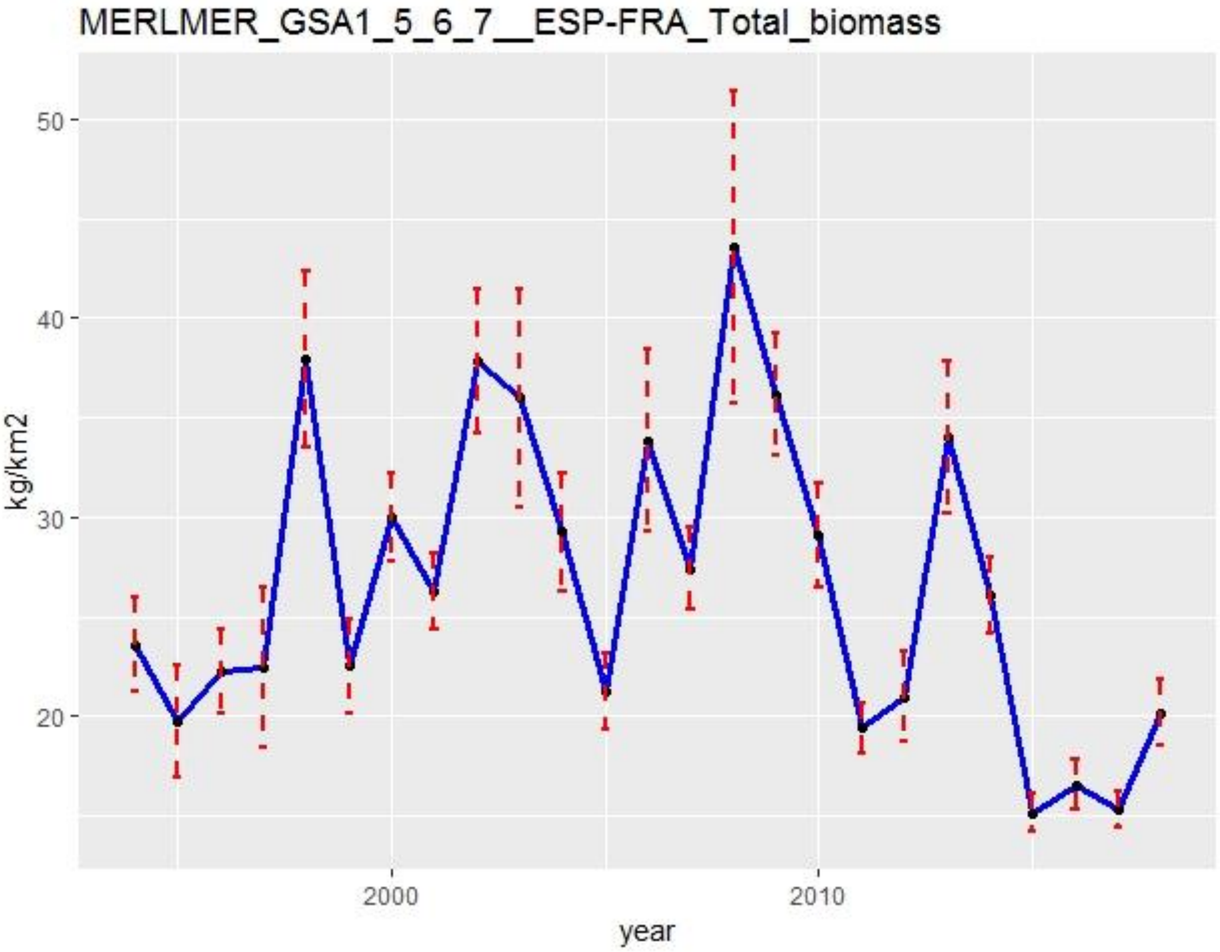


Figure 6.1.2.3.1. European hake in GSAs 1, 5, 6 and 7. Estimated biomass indices from the MEDITS survey (kg/km^2).

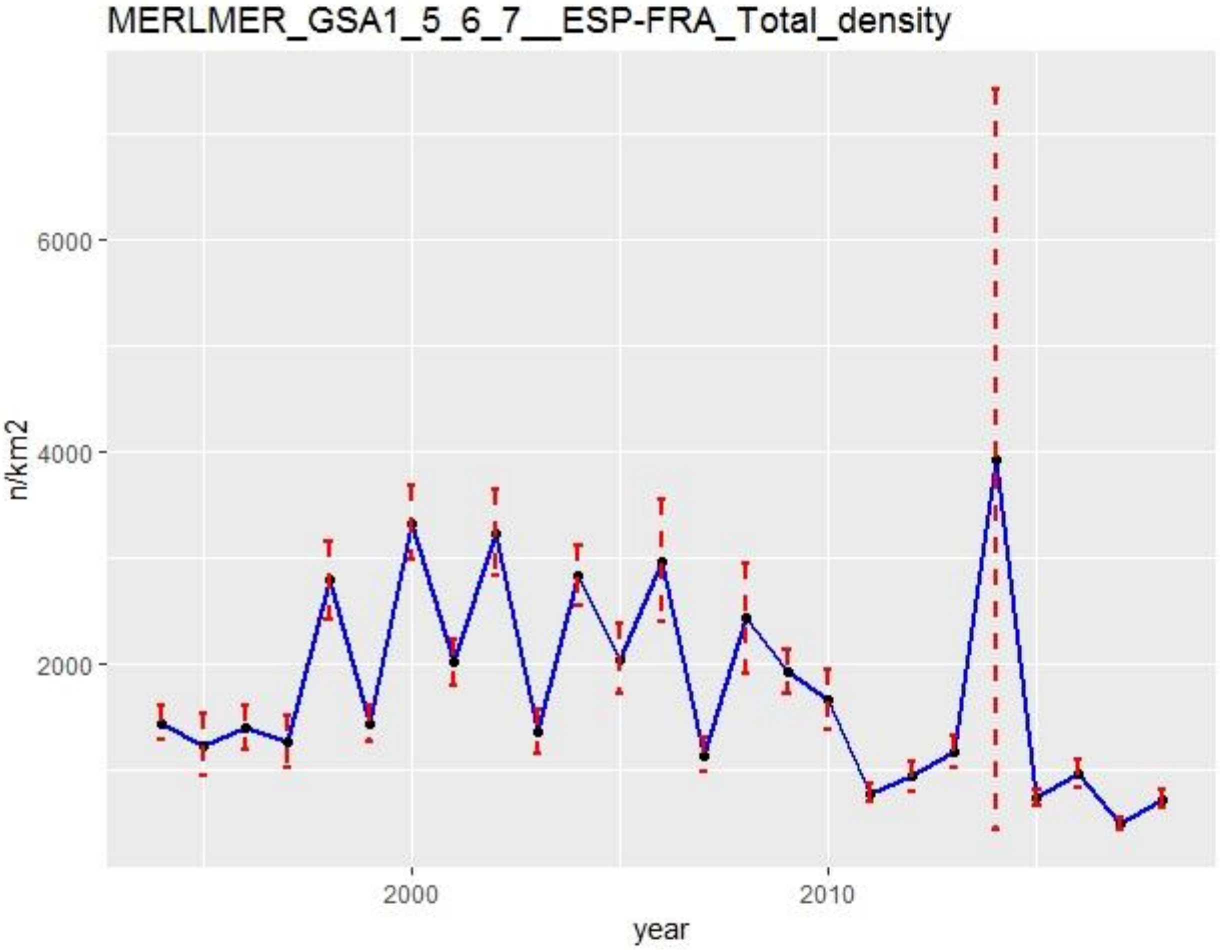


Figure 6.1.2.3.2. European hake in GSAs 1, 5, 6 and 7. Estimated density indices from the MEDITS survey (n/km^2).

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

Size structure indices are shown in Figure 6.1.2.3.3.

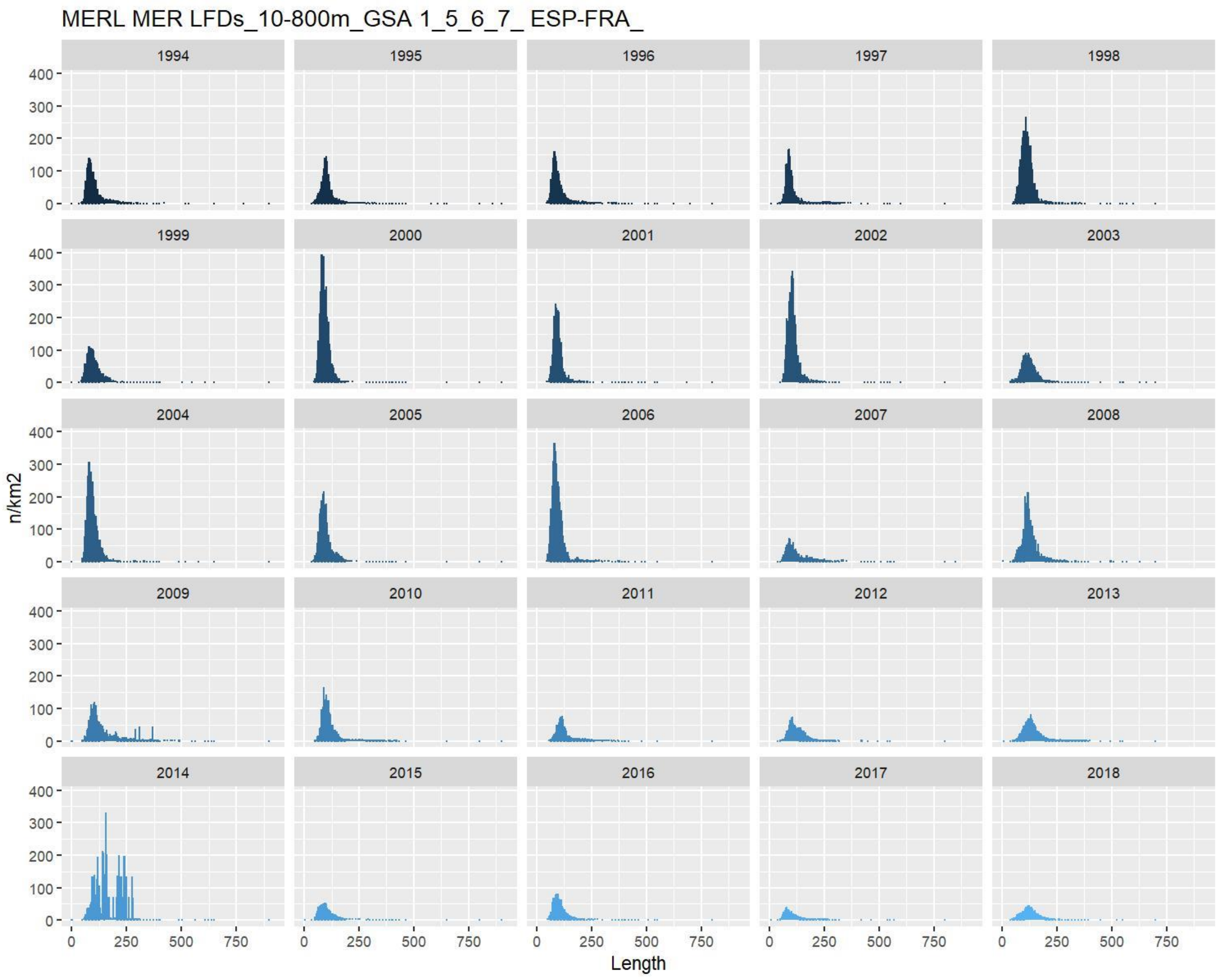


Figure 6.1.2.3.3. European hake in GSAs 1, 5, 6 and 7. Length frequency distribution by year of MEDITS survey.

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 2007-2018 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
SOP	1.05	1.10	1.01	0.92	1.05	1.14	1.12	1.12	1.11	1.16	1.10	1.02

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
4814.5	6288.8	7409.2	5502.2	5436.3	4510.3	5338.6	5018	3208.7	3209.2	3045.1	4077.3

Catch numbers at age (thousands)

	0	1	2	3	4	5+
2007	42048.58	18325.41	3528.93	525.86	96.14	23.66
2008	70082.19	38842.29	2855.38	299.18	102.96	18.10
2009	71066.10	32161.29	5396.14	528.76	125.60	13.56
2010	15980.27	26182.47	4767.19	374.10	91.19	10.36
2011	9228.88	28730.84	4527.02	348.89	64.12	9.21
2012	11167.71	29624.35	2970.79	248.99	44.38	3.80
2013	12600.23	33062.28	3514.35	324.34	37.77	5.97
2014	14220.58	25491.95	4066.91	257.69	28.14	4.83
2015	7916.29	17277.83	2473.69	187.57	27.49	2.37
2016	14929.19	22093.15	1880.76	113.95	20.97	1.72
2017	10174.79	18059.08	2274.76	121.04	17.68	4.19
2018	15280.85	40337.49	2097.47	176.92	12.43	1.41

Weights at age (Kg)

	0	1	2	3	4	5+
2007	0.018	0.105	0.404	0.945	1.599	2.764
2008	0.017	0.088	0.398	0.955	1.615	2.665
2009	0.020	0.095	0.409	0.946	1.516	2.792
2010	0.018	0.106	0.402	0.933	1.627	2.419
2011	0.024	0.104	0.390	0.923	1.628	2.507
2012	0.024	0.093	0.394	0.906	1.622	2.451
2013	0.024	0.100	0.386	0.916	1.606	2.721
2014	0.020	0.112	0.388	0.919	1.562	2.616
2015	0.019	0.109	0.387	0.914	1.580	2.695
2016	0.023	0.091	0.378	0.942	1.578	2.631
2017	0.019	0.103	0.370	0.922	1.529	2.741
2018	0.020	0.067	0.388	0.917	1.589	2.465

Maturity and Natural Mortality vectors

	0	1	2	3	4	5+
Maturity	0	0.15	0.82	0.98	1	1
Natural Mortality	1.24	0.58	0.45	0.40	0.37	0.35

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

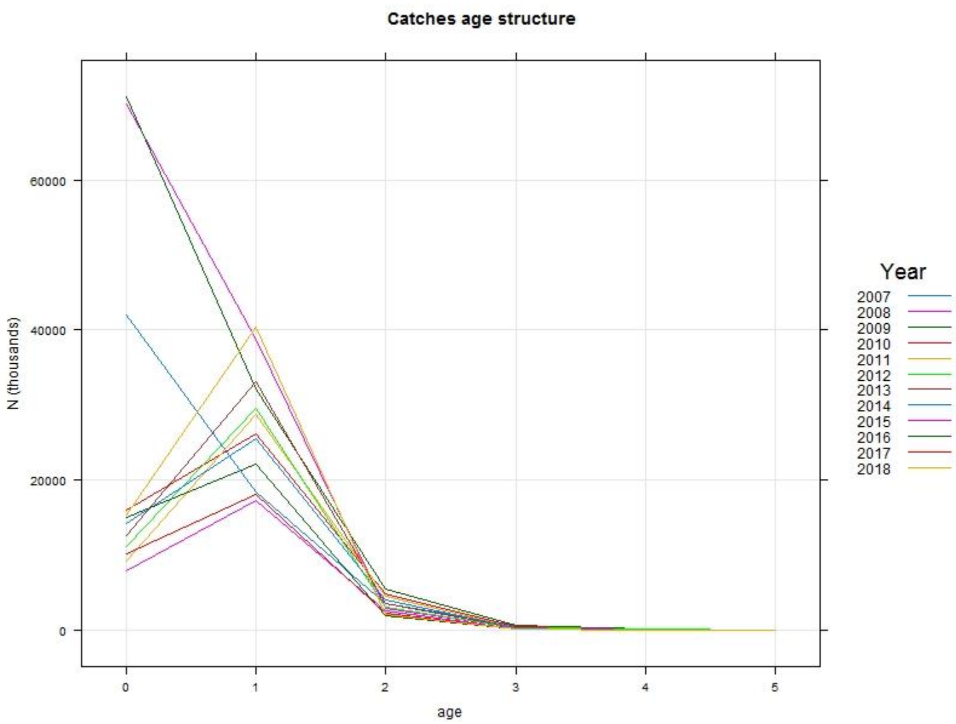


Figure 6.1.3.1. European hake in GSAs 1, 5, 6 and 7. Catch at age input data.

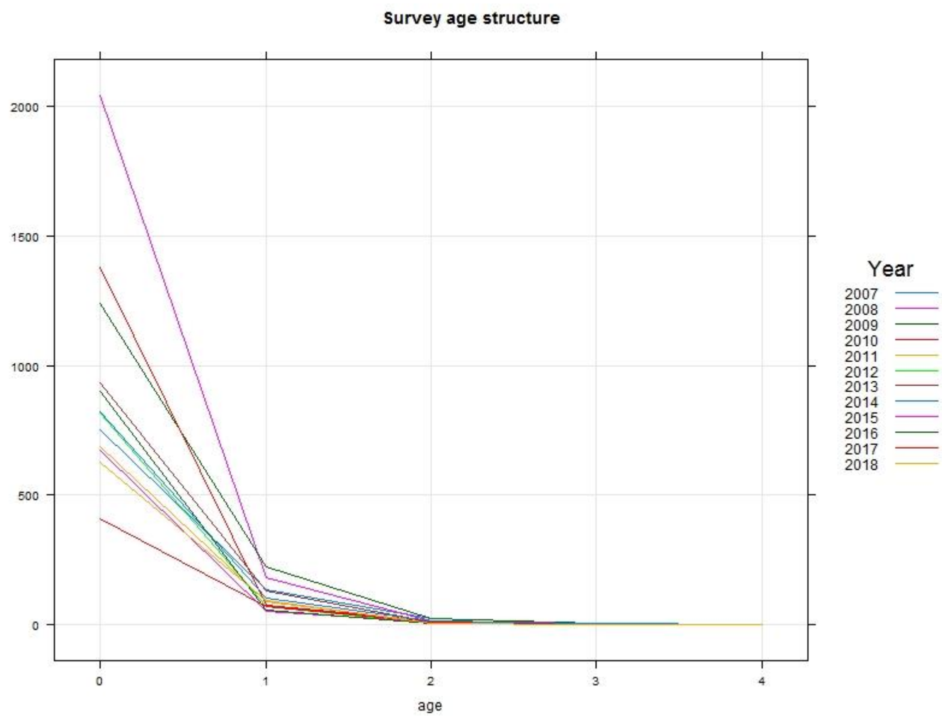


Figure 6.1.3.2. European hake in GSAs 1, 5, 6 and 7. Age structure of the index.

Assessment results

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

q ~ I(1/(1+exp(-age)))

The use of additional parameters on age 0 an age 4 in the fishery model were included to allow the model to fit better to the first few years of the data which show higher catches particularly at age 0. These extra terms also improved the retrospective performance, suggesting the early years are indeed different from the recent year's fishery.

Results are shown in Figures 6.1.3.3 – 6.1.3.9

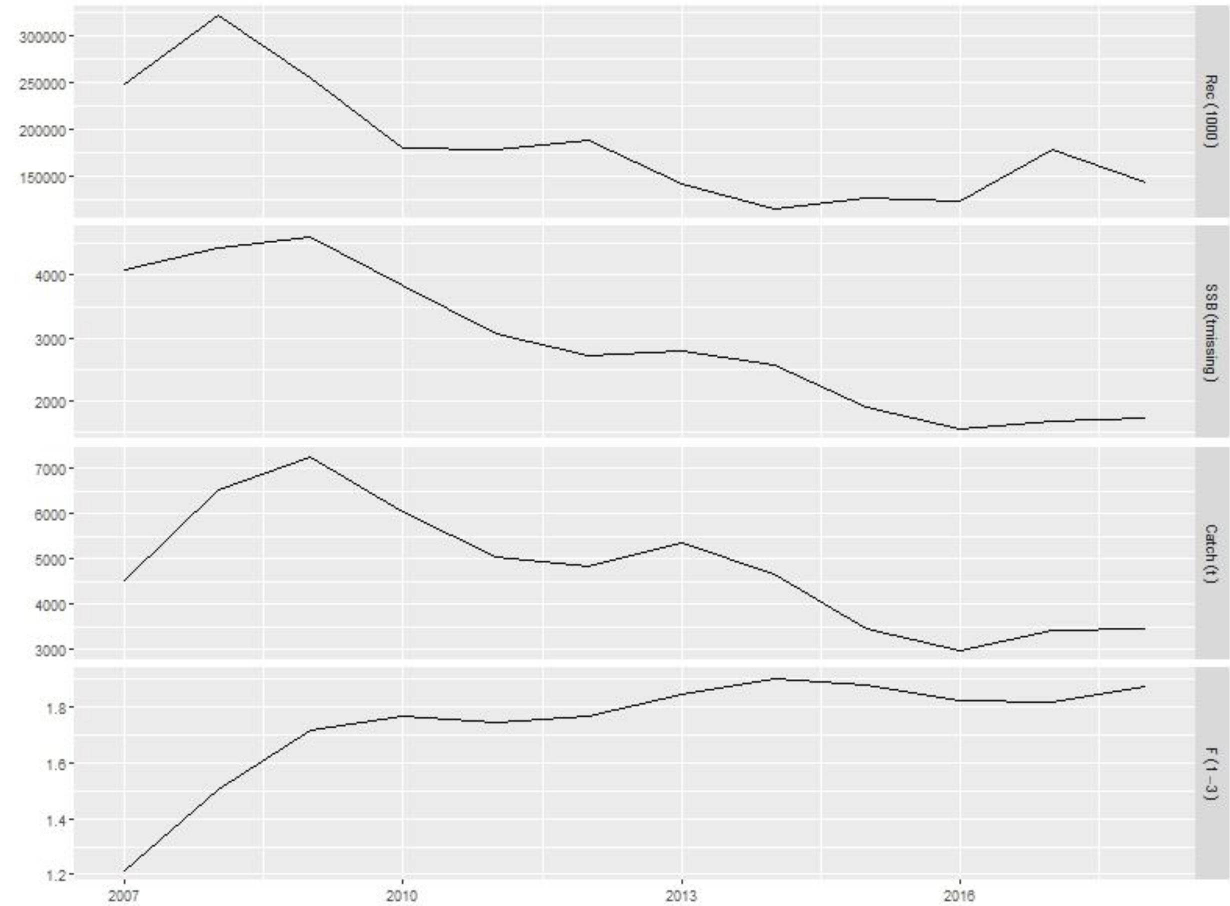
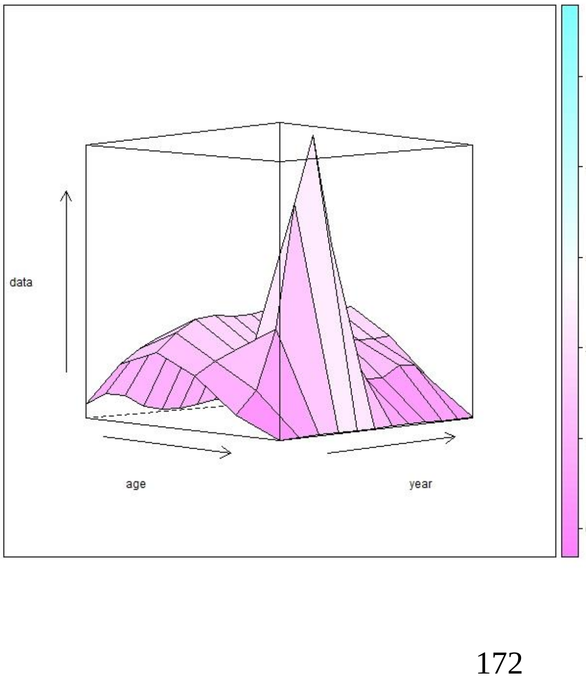


Figure 6.1.3.3. European hake in GSAs 1, 5, 6 and 7. Stock summary from the final a4a model.



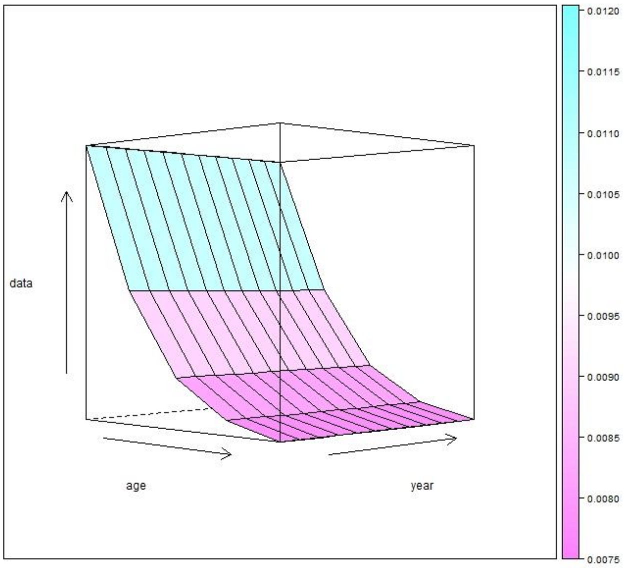
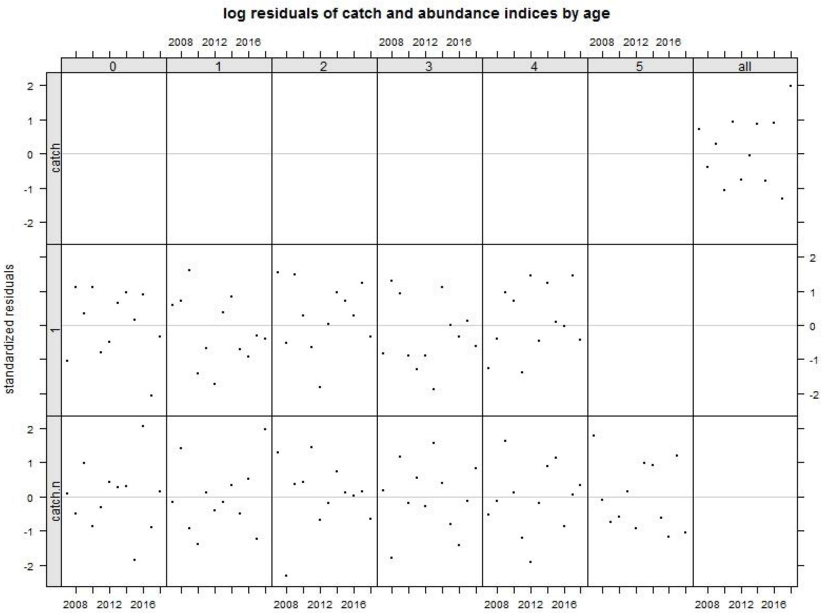


Figure 6.1.3.4. European hake in GSAs 1, 5, 6 and 7. 3D contour plot of estimated fishing mortality (top) and 3D contour plot of estimated survey catchability (bottom) at age and year.



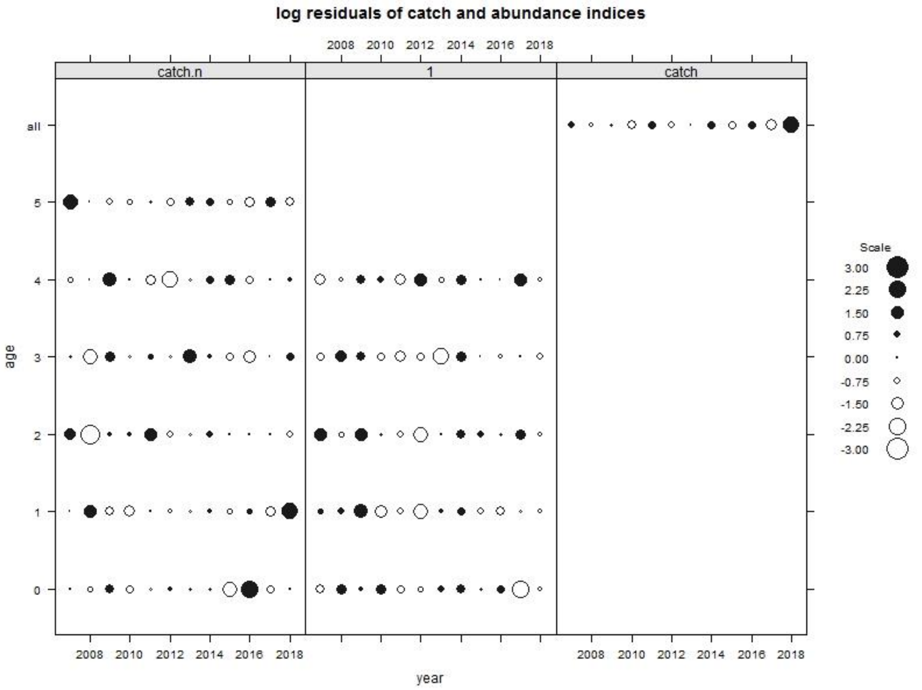


Figure 6.1.3.5. European hake in GSAs 1, 5, 6 and 7. Standardized residuals for abundance indices and for catch numbers.

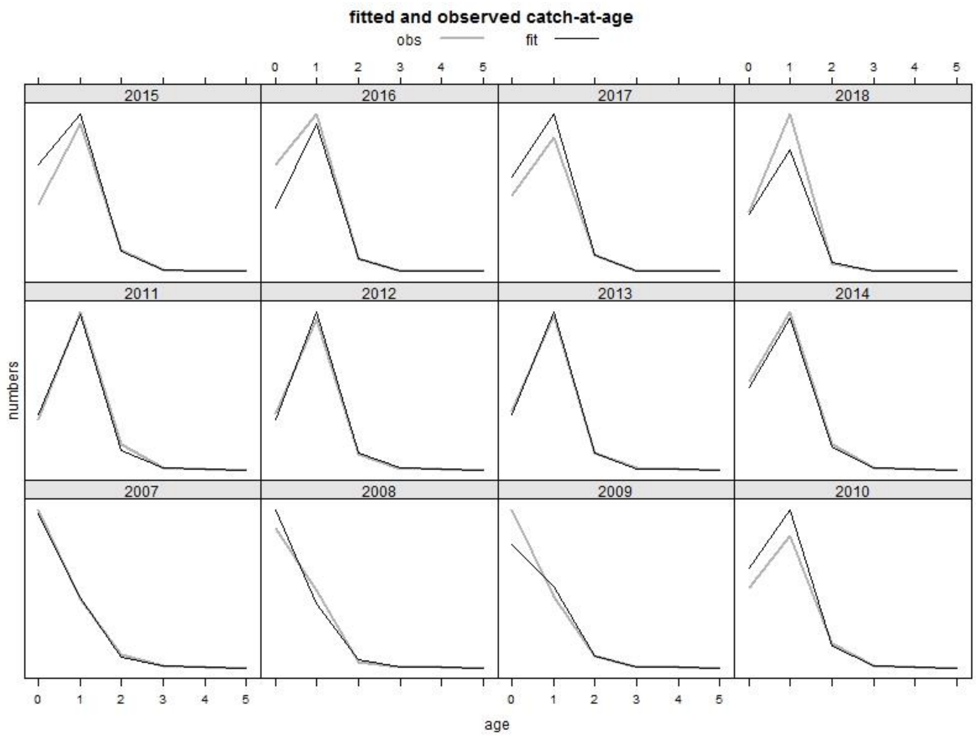


Figure 6.1.3.6. European hake in GSAs 1, 5, 6 and 7. Fitted and observed catch at age.

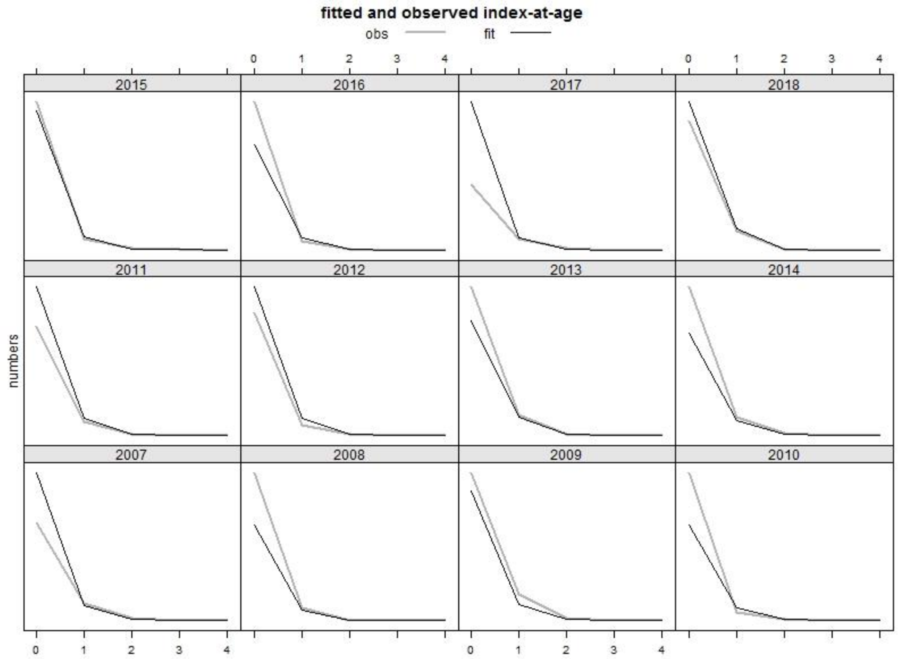


Figure 6.1.3.7. European hake in GSAs 1, 5, 6 and 7. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up only to 3 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.

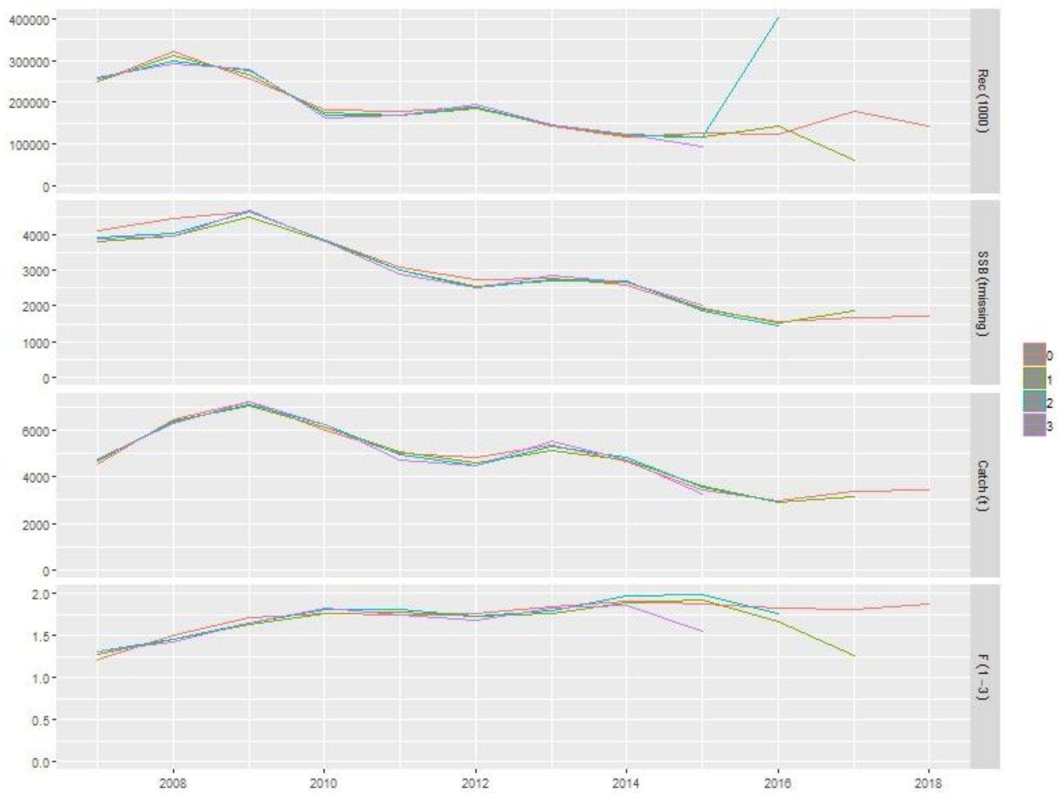
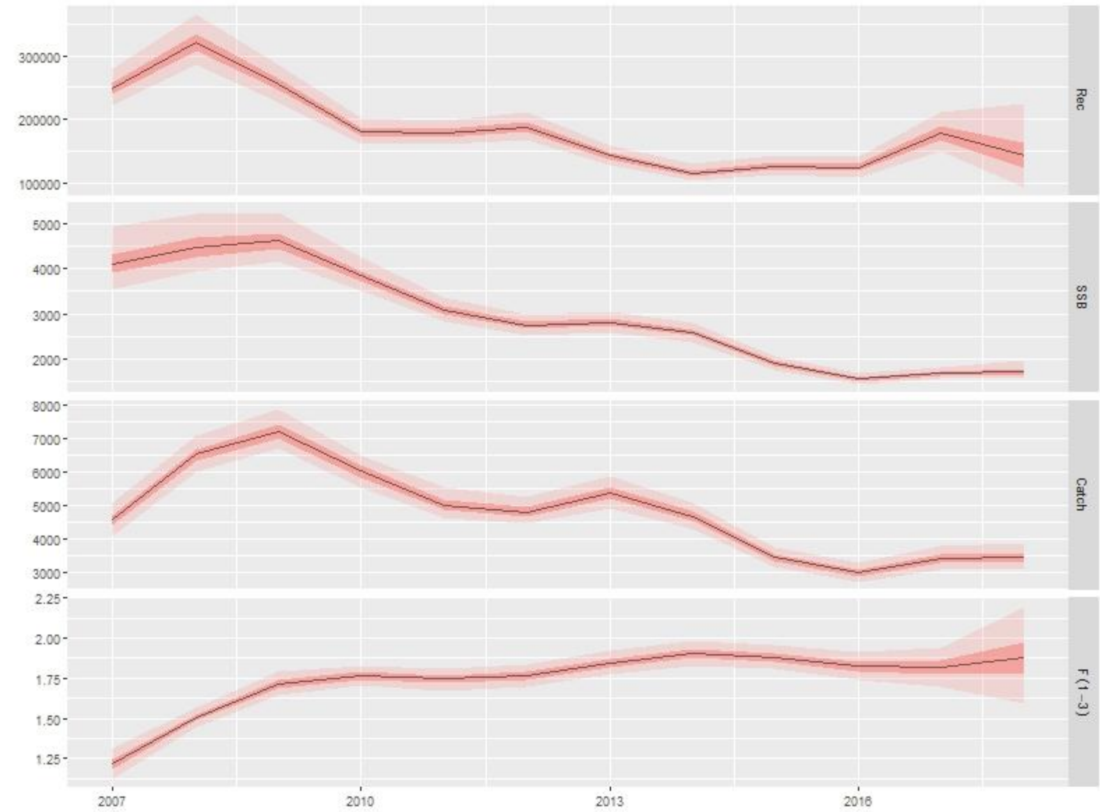


Figure 6.1.3.8. European hake in GSAs 1, 5, 6 and 7. Retrospective analysis.

Figure 6.1.3.9. European hake in GSAs 1, 5, 6 and 7. **Simulations**



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	248684.8	33774.91	4443.257	925.048	367.867	231.511
2008	321512.5	51903.49	5854.973	679.756	219.544	321.797
2009	254834.9	55043.51	6800.122	636.968	125.896	277.593
2010	180131.2	46948.67	5877.785	576.741	98.429	193.269
2011	178083.7	42335.18	4765.87	468.713	85.214	126.196
2012	188230.1	46553.06	4388.207	389.83	70.546	82.039
2013	141960.3	49466.88	4721.33	349.535	57.551	54.706
2014	115253.1	35207.09	4646.376	342.536	48.213	44.115
2015	126300.7	26835.36	3132.747	315.602	45.036	42.293
2016	123527.1	30320.05	2443.091	218.801	42.344	40.195
2017	178090.5	31301.11	2910.005	181.963	30.762	35.654
2018	143727.9	45207.04	3020.439	218.169	25.705	30.232

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	1.21	248685	4086	11896	4529
2008	1.50	321513	4446	14394	6509
2009	1.71	254835	4618	14689	7239
2010	1.77	180131	3836	11816	6023
2011	1.74	178084	3066	11496	5028
2012	1.77	188230	2730	11252	4816
2013	1.85	141960	2791	10783	5360
2014	1.90	115253	2573	8530	4667
2015	1.88	126301	1900	7046	3433
2016	1.82	123527	1546	6895	2976
2017	1.82	178091	1676	7997	3403
2018	1.87	143728	1729	7332	3444

	F at age					
	0	1	2	3	4	5+
2007	0.33	1.17	1.43	1.04	0.41	0.06
2008	0.52	1.45	1.77	1.29	0.82	0.07
2009	0.45	1.66	2.02	1.47	1.89	0.08
2010	0.21	1.71	2.08	1.51	4.14	0.08
2011	0.10	1.69	2.05	1.49	5.41	0.08
2012	0.10	1.71	2.08	1.51	3.42	0.08
2013	0.15	1.79	2.17	1.58	1.50	0.09
2014	0.22	1.84	2.24	1.63	0.87	0.09
2015	0.19	1.82	2.21	1.61	0.88	0.09
2016	0.13	1.76	2.15	1.56	1.10	0.09
2017	0.13	1.76	2.14	1.56	1.08	0.09
2018	0.19	1.81	2.21	1.60	0.76	0.09

Based on the a4a results, the European hake SSB shows a decreasing trend from 2009 to 2016 (from 4618 to 1546 tons), with a slight increase in the last two years (1728 tons in 2018). The assessment shows a decreasing trend in the number of recruits in the time series. The recruitment (age 0) reached a minimum of 115253 thousands individuals in 2014, there has been an increase up to 2017 (178090 thousands). F_{bar} (1-3) shows a slight upward trend in the time series since 2010 increasing from a value of 1.71 to a value of 1.87 in 2018. A maximum peak of 1.90 was reached in 2014.

6.1.4 Reference Points

The time series is too short to fit a stock recruitment relationship, 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 (1.84, estimated as the average of the F_{bar1-3} in the last three years of the time series) is much higher than $F_{0.1}$ (0.38), 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 2019 to 2021 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age, while the F_{bar} =1.84 (average of the last three years' F from the a4a assessment) was used for F in 2019, as F is rising (See section 4.3). Recruitment is observed to decline over the period of the assessment (Figure 6.1.3.9), but becomes stable from 2010, so the last 9 years are used as an estimate of recruits in 2019 to 2020. Recruitment (age 0) was estimated from the population results as the geometric mean of the last 9 years (150432).

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 2016-2018
$F_{ages\ 1\text{-}3}$ (2019)	1.84	Mean F 2016-2018 was used to give F status quo for 2019
SSB (2019)	2045	Stock assessment 1 January 2019
R_{age0} (2019,2020)	150432	Geometric mean of the last XX years
Total catch (2019)	3659	Assuming F status quo for 2019

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

Rationale	Ffactor	Fbar	Catch2018	Catch2019	Catch2020	Catch2021	SSB2019	SSB2021	Change_SSB 2019-2021(%)	Change_Catch 2018-2020(%)
Zero catch	0	0.00	3444	3659	0	0	2045	9372	358	-100
High long term yield (F0.1)	0.21	0.38	3444	3659	1269	2877	2045	6566	221	-63
Status quo	1	1.84	3444	3659	3640	3694	2045	1932	-5	6
F upper	0.28	0.52	3444	3659	1640	3362	2045	5773	182	-52
F lower	0.14	0.26	3444	3659	894	2228	2045	7381	261	-74
Different Scenarios	0.1	0.18	3444	3659	665	1749	2045	7886	286	-81
	0.2	0.37	3444	3659	1229	2816	2045	6652	225	-64
	0.3	0.55	3444	3659	1710	3437	2045	5625	175	-50
	0.4	0.74	3444	3659	2121	3770	2045	4771	133	-38
	0.5	0.92	3444	3659	2474	3922	2045	4061	99	-28
	0.6	1.10	3444	3659	2778	3961	2045	3468	70	-19
	0.7	1.29	3444	3659	3040	3933	2045	2975	46	-12
	0.8	1.47	3444	3659	3268	3868	2045	2563	25	-5
	0.9	1.65	3444	3659	3467	3784	2045	2220	9	1
	1.1	2.02	3444	3659	3794	3605	2045	1692	-17	10
	1.2	2.21	3444	3659	3929	3520	2045	1491	-27	14
	1.3	2.39	3444	3659	4049	3441	2045	1322	-35	18
	1.4	2.57	3444	3659	4157	3370	2045	1180	-42	21
	1.5	2.76	3444	3659	4254	3307	2045	1061	-48	24
	1.6	2.94	3444	3659	4341	3250	2045	960	-53	26
	1.7	3.13	3444	3659	4421	3201	2045	875	-57	28
	1.8	3.31	3444	3659	4493	3157	2045	803	-61	30
	1.9	3.49	3444	3659	4560	3118	2045	742	-64	32
	2	3.68	3444	3659	4622	3084	2045	690	-66	34

6.1.6 DATA DEFICIENCIES

The same data deficiencies encountered in EWG 18-12 were found in last year (2018) data and within the whole time series.

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.

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.

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

6.2.1 Stock Identity and Biology

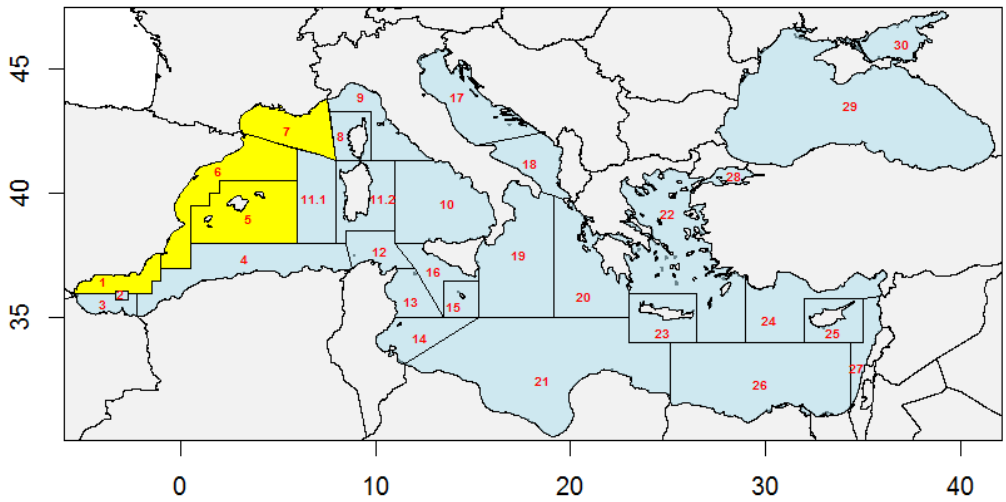


Figure 6.2.1.1. Geographical location of GSAs 1-5-6-7.

An advice on DPS in GSAs 1-5-6-7 based on SSB and MEDITS trends was already given in 2018 for 2020 and can be taken directly from STECF EWG 18-12 report. STECF EWG 19-10 was asked to perform a short evaluation of survey data to determine if new data (2019) is different and could help with an assessment.
Growth parameters and length-weight relationship parameters were estimated within the DCF 2019 for sexes combined and carapace length expressed in mm.

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	2018	47	0.689	-0.12	0.004	2.347
ESP	GSA 5	2018	47	0.76	0	0.002	2.567
ESP	GSA 6	2018	47	0.764	0	0.002	2.591

The von Bertalanffy did not change significantly from the previous single GSA assessments done during the previous STECF EWG.

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 01. 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 19-10 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 (Table 6.2.2.1.1).

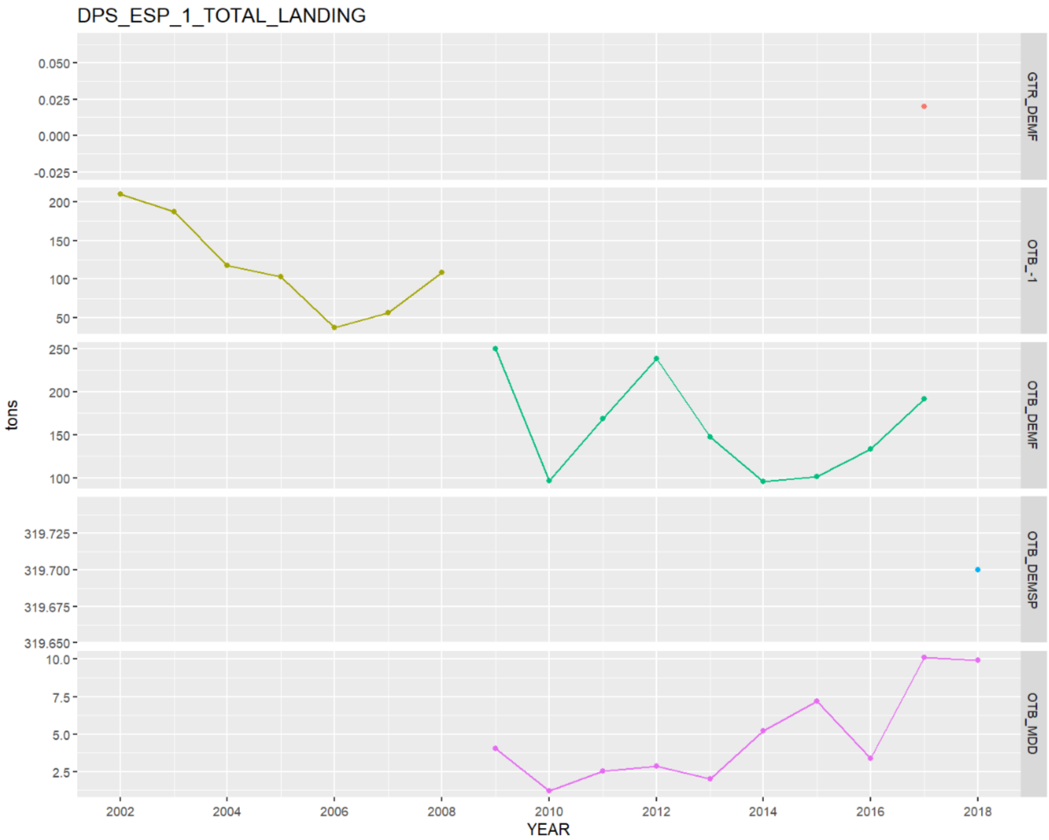
Table 6.2.2.1.1. Deep-water rose shrimp GSAs 1-5-6-7. Landings data in tonnes by fleet.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ ESP_GTR																0.02	
GSA1_ ESP_OTB	209.8	187.2	118.1	103	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
GSA5_ ESP_OTB	36.2	22.1	6.5	1.6	1	1.4	5.2	5.1	6.3	4.5	4.2	6.2	5.6	7.6	9.1	68	101.2
GSA6_ ESP_OTB	144.1	116	66.2	44.7	25.2	28.8	39	49.1	71.9	66.3	85.6	86.8	131.3	174.6	471.3	634.7	914.6
GSA7_ ESP_-1	0	0	0	0	0	0											
GSA7_ ESP_OTB							0.1	0.1	0.4	1.2	2	2.3	3.4	4.7	27.1	36.3	17.9
GSA7_ FRA_-1																0.2	
GSA7_ FRA_OTB															34.4	21.2	16.6
GSA7_ FRA_OTM															0.2	0.2	0.1
GSA7_ FRA_OTT															9.7	25.3	21.7

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	176.1	243.5
2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**			
333.3	244.4	240.7	295.5	688.5	987.7	1401.6			



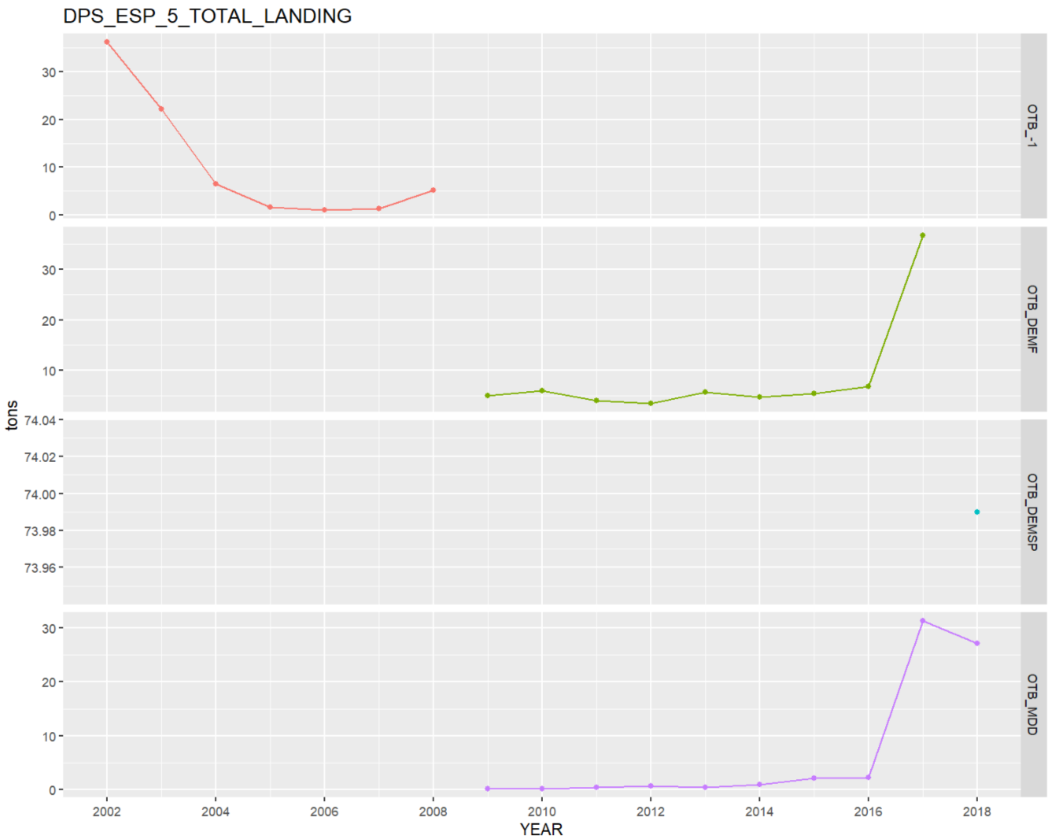


Figure 6.2.2.1.1. Deep-water rose shrimp GSAs 1 and 5. Landings data in tonnes by year and fleet.

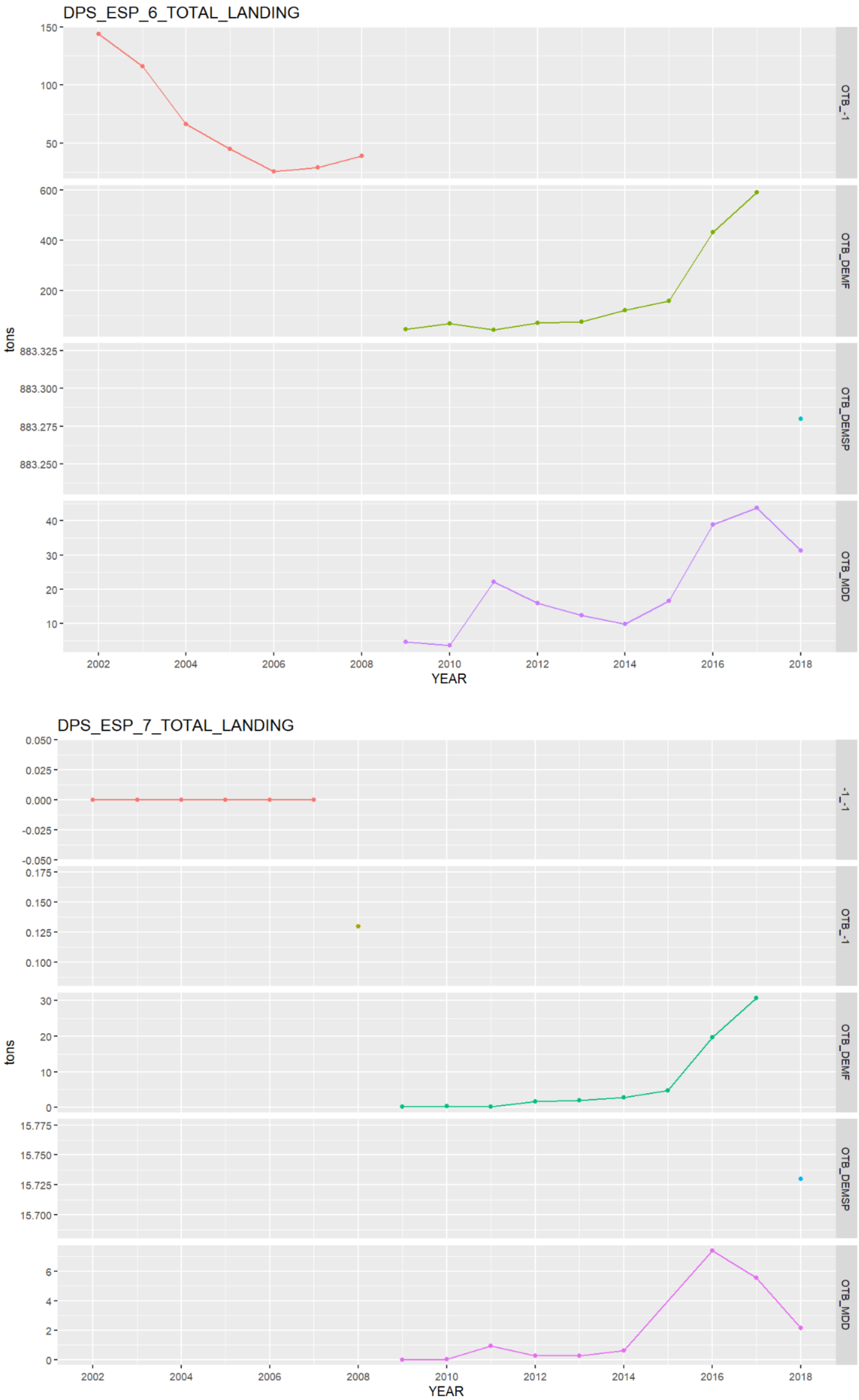


Figure 6.2.2.1.2. Deep-water rose shrimp GSAs 6 and 7 (Spain). Landings data in tonnes by year and fleet.

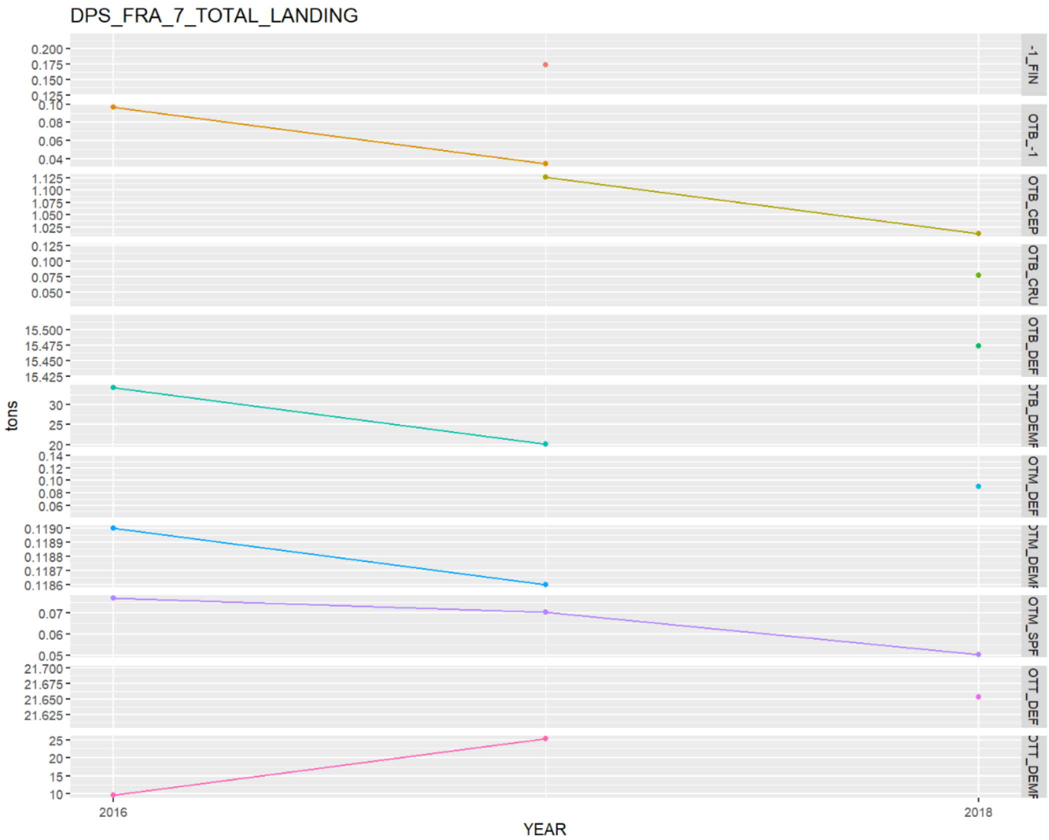


Figure 6.2.2.1.3. Deep-water rose shrimp GSA 7 (France). Landings data in tonnes by year and fleet.

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

In GSA 1, length frequency distributions were not available for 2002 and for all years of OTB-MDDWSP.

In GSA 5, length frequency distributions were not available for 2016. For OTB-MDDWSP data were lacking for the years 2009 and 2018.

In GSA 6, length frequency distributions were not available for all years of OTB-MDDWSP. The length frequency distribution in 2015 had an error.

In GSA 7, only the length frequency distributions for Spanish OTB were available.

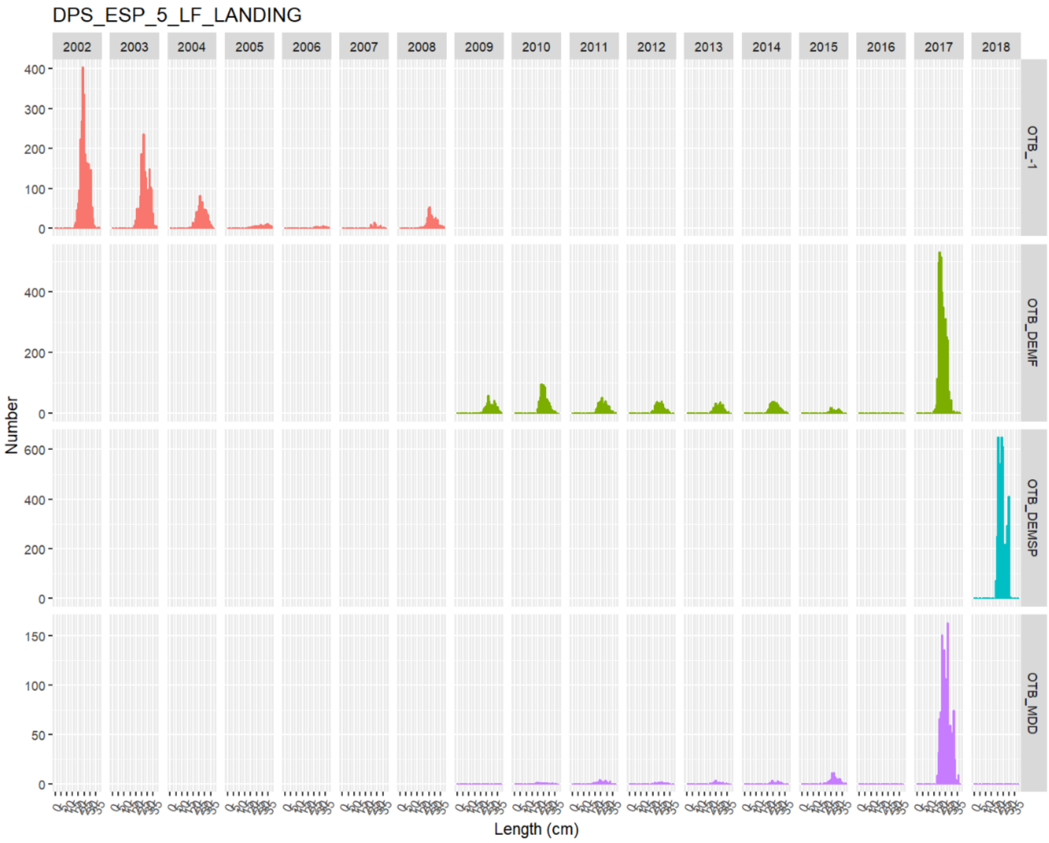
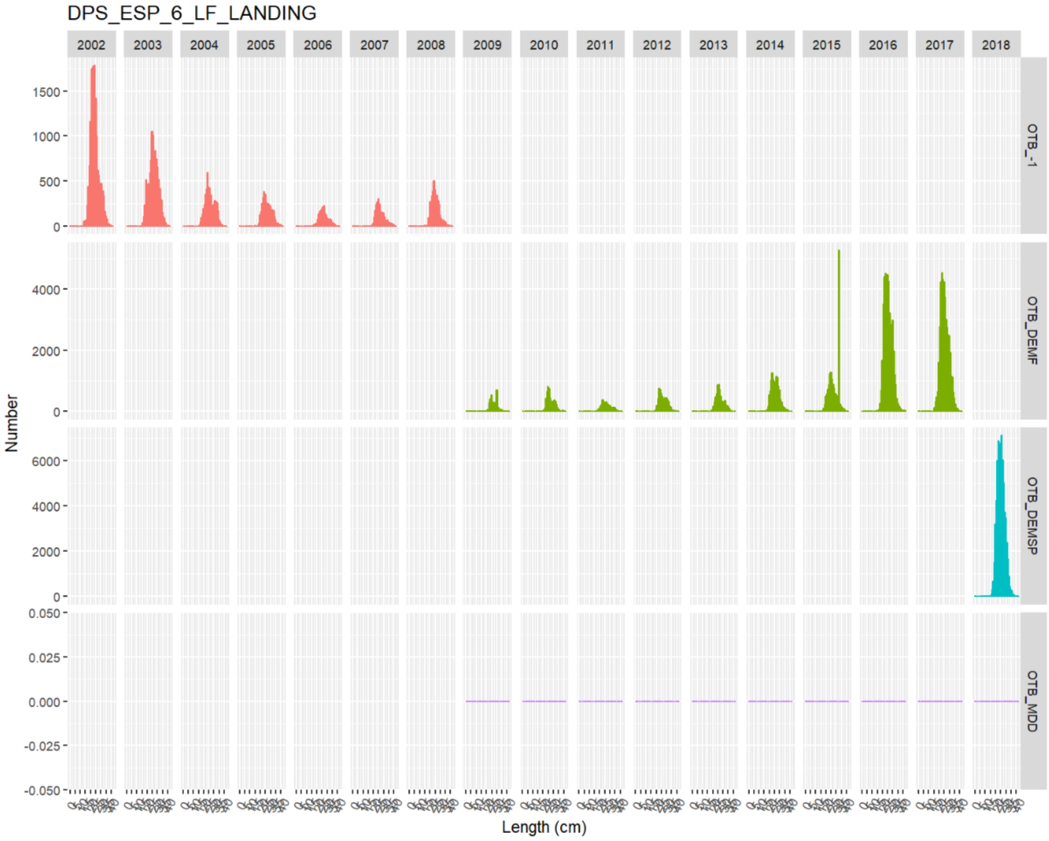


Figure 6.2.2.1.4. Deep-water rose shrimp GSAs 1 and 5. Length frequency distribution of the landings by year and fleet.



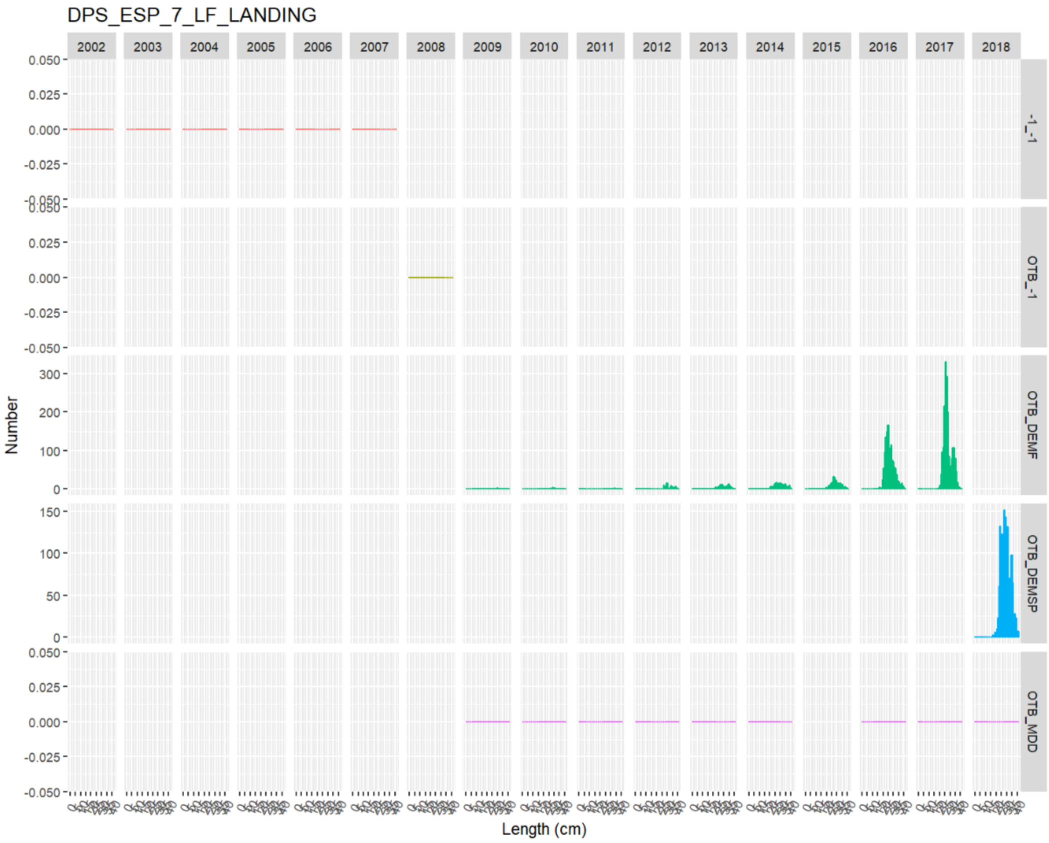


Figure 6.2.2.1.5. Deep-water rose shrimp GSAs 6 and 7 (Spain). Length frequency distribution of the landings by year and fleet.

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.

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

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ESP_OTB	1.71			0.55	1.74	1.81	0.38	1.65	0.87	4.25	1.17	0.88	1.71	0.66
GSA5_ESP_OTB	0			0	0	0	0.13	0.41	0.32	0.01	0.01	1.98	0.6	0.00
GSA6_ESP_OTB	0.01			0	0	0.28	2.26	0.74	0.82	2.26	2.8	5.96	8.02	2.45
GSA7_ESP_OTB				0.01	0	0	0.07	0.3	0.29	0.03	0.03	0.1	0.23	0.04
GSA7_FRA_-1													0	0
GSA7_FRA_OTB													0	0
GSA7_FRA_OTM													0	0
GSA7_FRA_OTT													0	0
Total	**1.72**			**0.56**	**1.74**	**2.09**	**2.84**	**3.1**	**2.3**	**6.55**	**4.01**	**8.92**	**10.56**	**3.15**

Missing discards data were not reconstructed.

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

6.2.2.2 EFFORT

Fishing effort data were reported to STECF EWG 19-10 through DCF. Only effort from OTB is reported.

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									
Total			168753	158375	155508	145015	148988	142964	138250

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					9657	8724	7292	7003
Total	132624	125972	122776	124825	124443	123760	120357	113760

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									
Total			9557032	9157386	9060096	8570525	8918841	8546535	8189138

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					949262	830898	662204	641292
Total	7777756	7404322	7206494	7314162	7676698	7588379	7287215	6866976

Table 6.2.2.2.3. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in kW*Days at sea (in thousands) by year and fishing gear.

GSA	2002	2003	2004	2005	2006	2007	2008	2009	2010
GSA1_ESP_OTB	4975	5915	6396	5940	5654	5427	4884	5096	5269
GSA5_ESP_OTB			2912	2695	2509	2939	3036	2784	2928
GSA6_ESP_OTB			33561	31447	31080	27966	29957	28339	26306
GSA7_ESP_OTB			1798	1692	1646	1657	1695	1624	1456
GSA7_FRA_OTB									
Total			44667	41773	40890	37990	39571	37843	35959

GSA	2011	2012	2013	2014	2015	2016	2017	2018
GSA1_ESP_OTB	5079	4675	4372	3954	3780	3808	3987	3853
GSA5_ESP_OTB	2694	2676	2746	2829	2821	2273	2330	2054
GSA6_ESP_OTB	24806	23554	22822	23423	20513	21352	20593	19752
GSA7_ESP_OTB	1630	1392	1303	1386	1431	1506	1366	1066
GSA7_FRA_OTB					3119	2802	2323	2237
Total	34210	32296	31242	31591	31664	31741	30599	28962

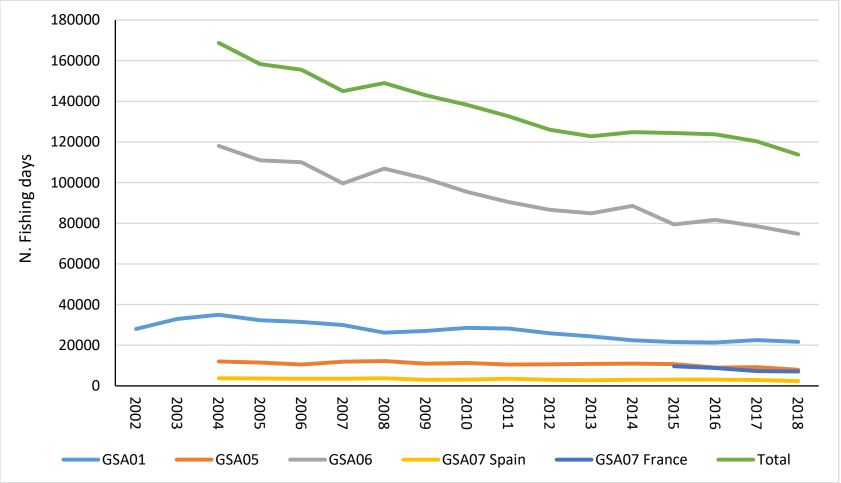


Figure 6.2.2.2.1. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in Days at sea by year and fishing gear.

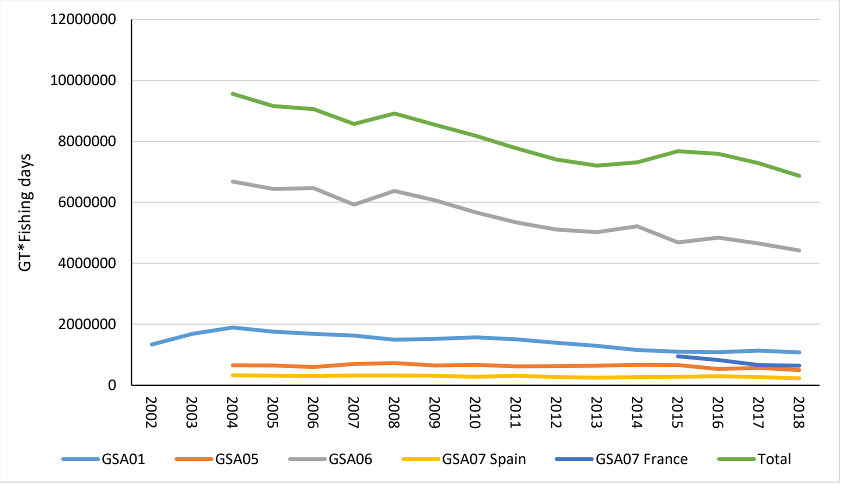


Figure 6.2.2.2.2. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in GT*Days at sea by year and fishing gear.

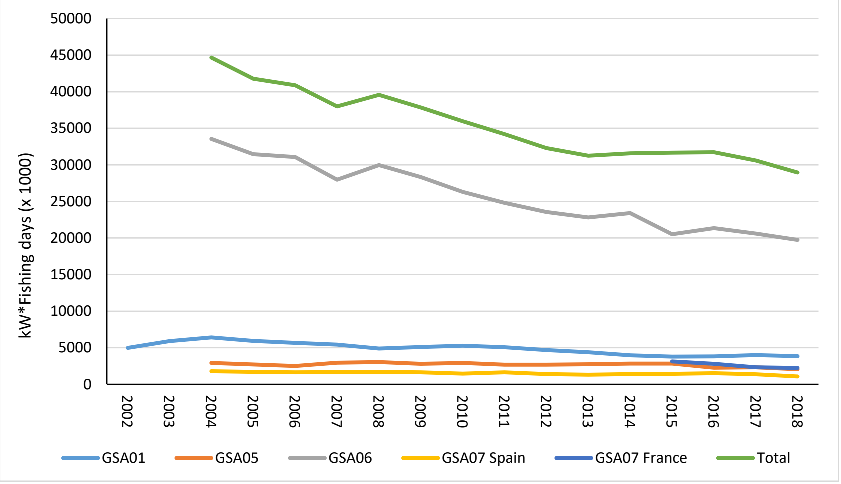


Figure 6.2.2.2.3. Deep-water rose shrimp GSAs 1-5-6-7. Fishing effort in kW*Days at sea by year and fishing gear.

6.2.2.3 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out each year during the spring season. The MEDITS in GSA 5 has been carried out consistently only from 2007. 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 = $Yst \pm t(\text{student distribution}) * V(Yst) / n$

It was noted that while this is a standard approach, the calculation 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 and 6, 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. In GSA 7, a sharp increase was observed in 2015 and 2016, while in 2018 both density and biomass showed a reduction in respect to the previous years.

Considering the whole area (GSAs 1-5-6-7) the density and biomass indices showed a sharp increase in the last three years (2016-2018), reaching the maximum values in the last year of the data series.

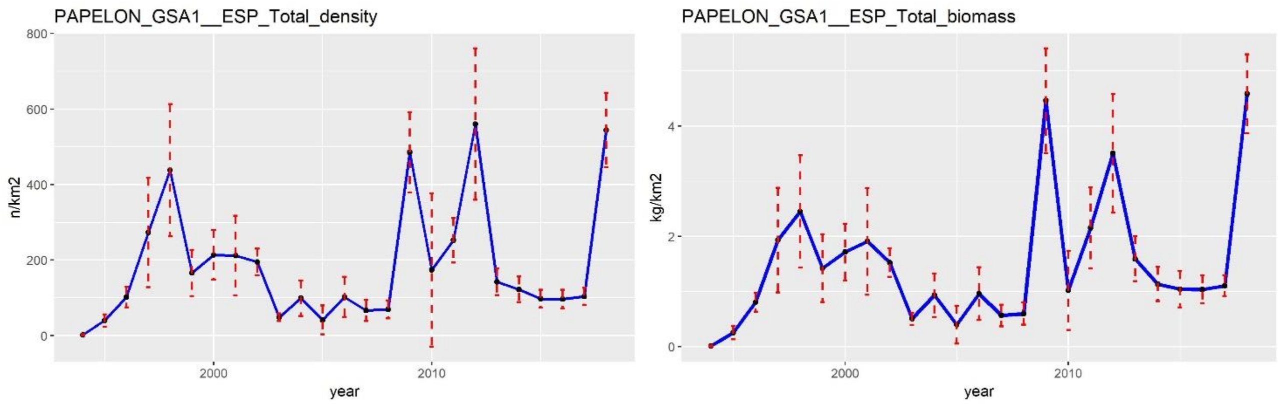


Figure 6.2.2.3.1. Deep-water rose shrimp GSA 1. Estimated density (N/km^2) and biomass (kg/km^2) indices.

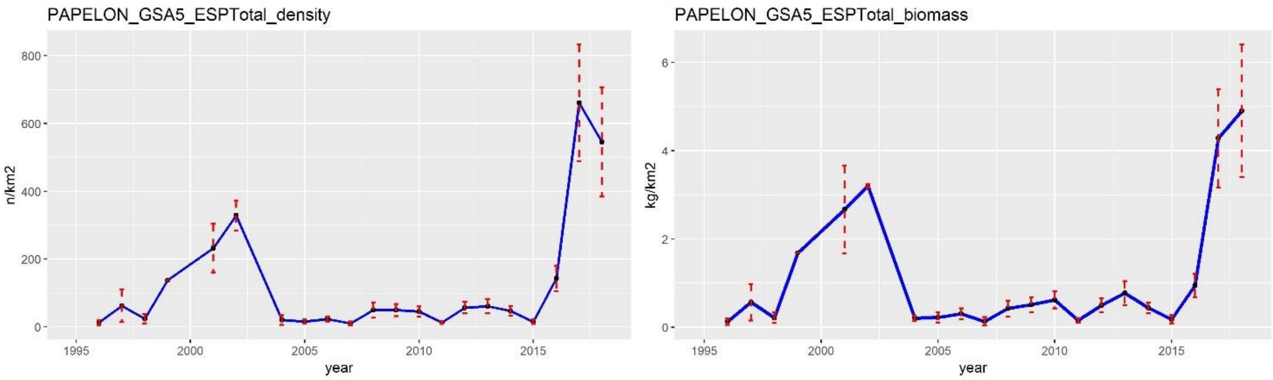


Figure 6.2.2.3.2. Deep-water rose shrimp GSA 5. Estimated density (N/km^2) and biomass (kg/km^2) indices.

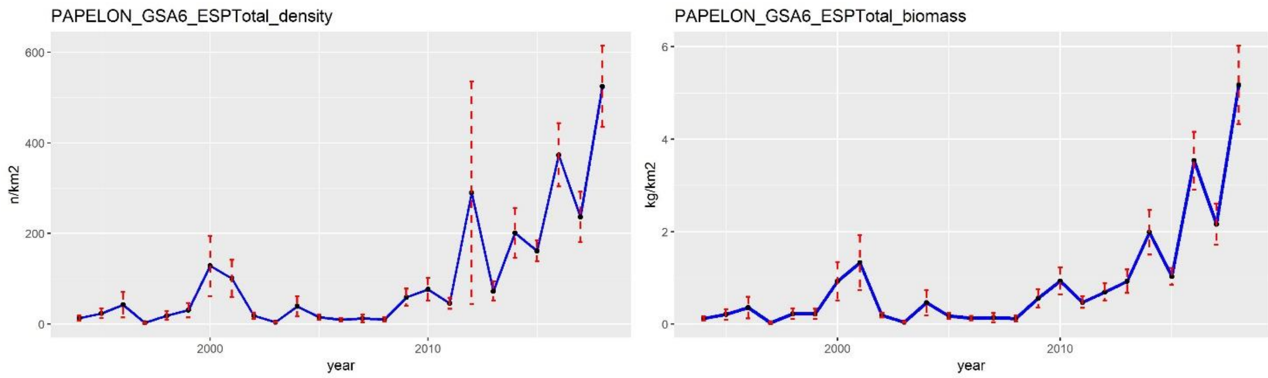


Figure 6.2.2.3.3. Deep-water rose shrimp GSA 6. Estimated density (N/km^2) and biomass (kg/km^2) indices.

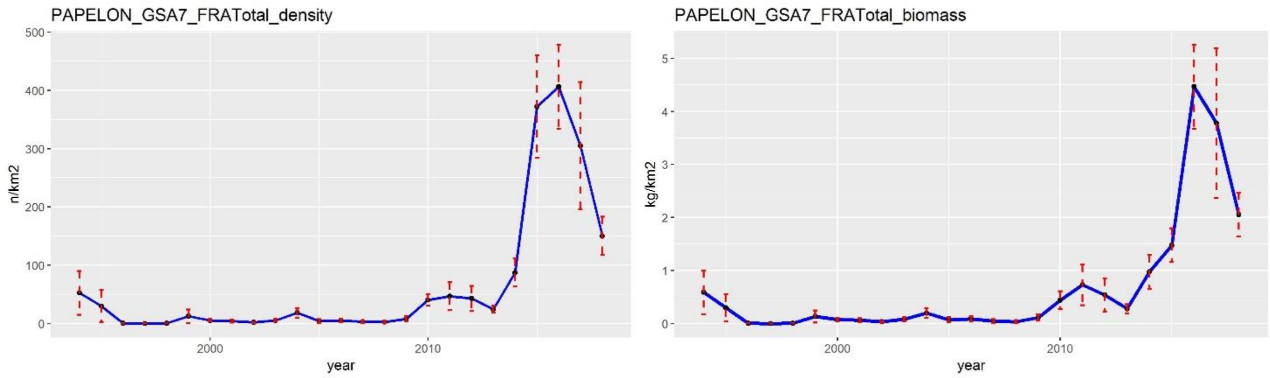


Figure 6.2.2.3.4. Deep-water rose shrimp GSA 7. Estimated density (N/km^2) and biomass (kg/km^2) indices.

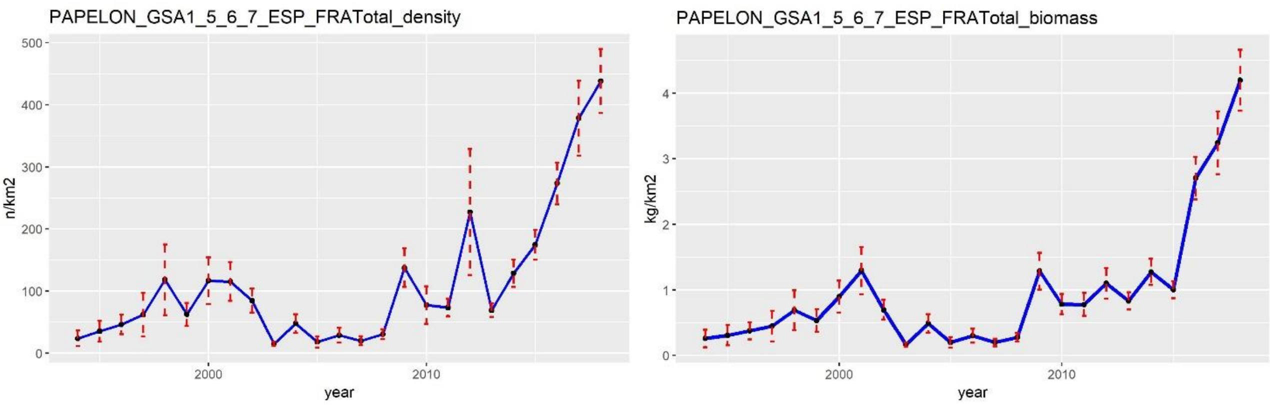


Figure 6.2.2.3.5. Deep-water rose shrimp GSAs 1-5-6-7. Estimated density (N/km^2) and biomass (kg/km^2) combined MEDITS indices.

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

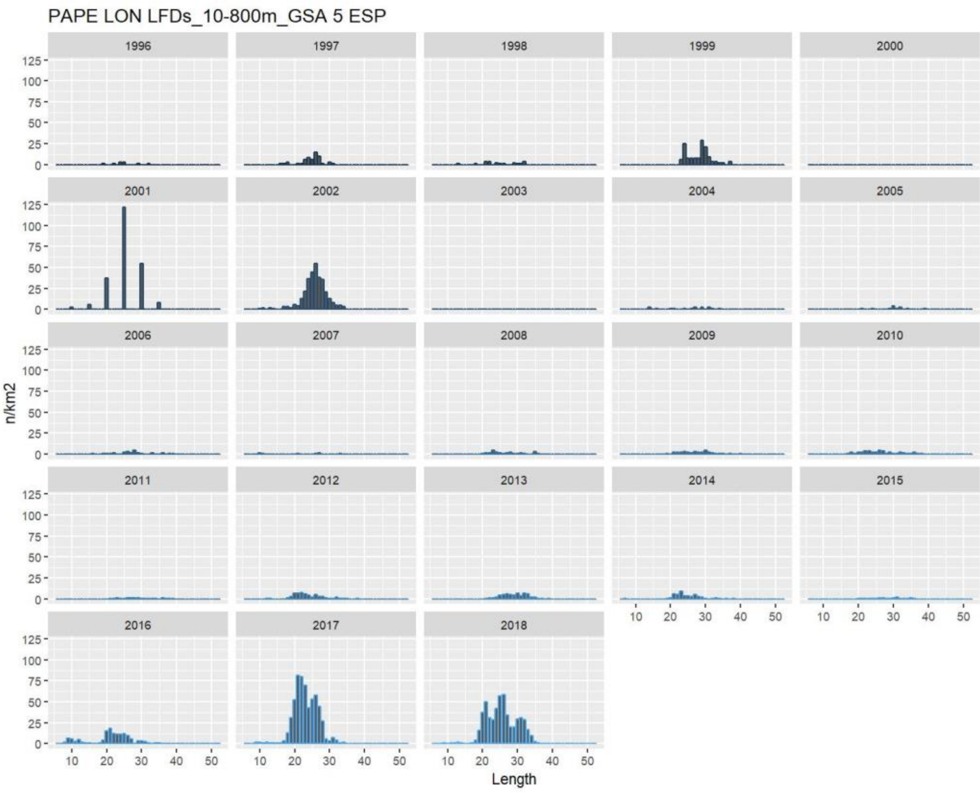


Figure 6.2.2.3.7. Deep-water rose shrimp GSA 5. Length frequency distribution by year of MEDITS.

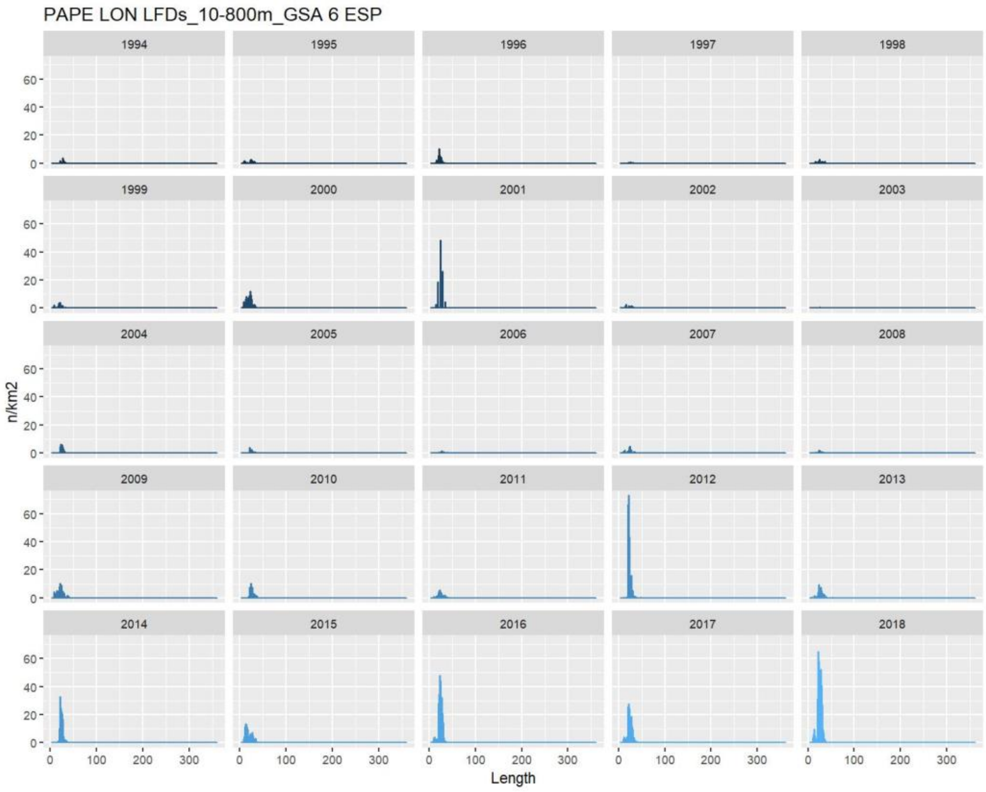


Figure 6.2.2.3.8. Deep-water rose shrimp GSA 6. Length frequency distribution by year of MEDITS.

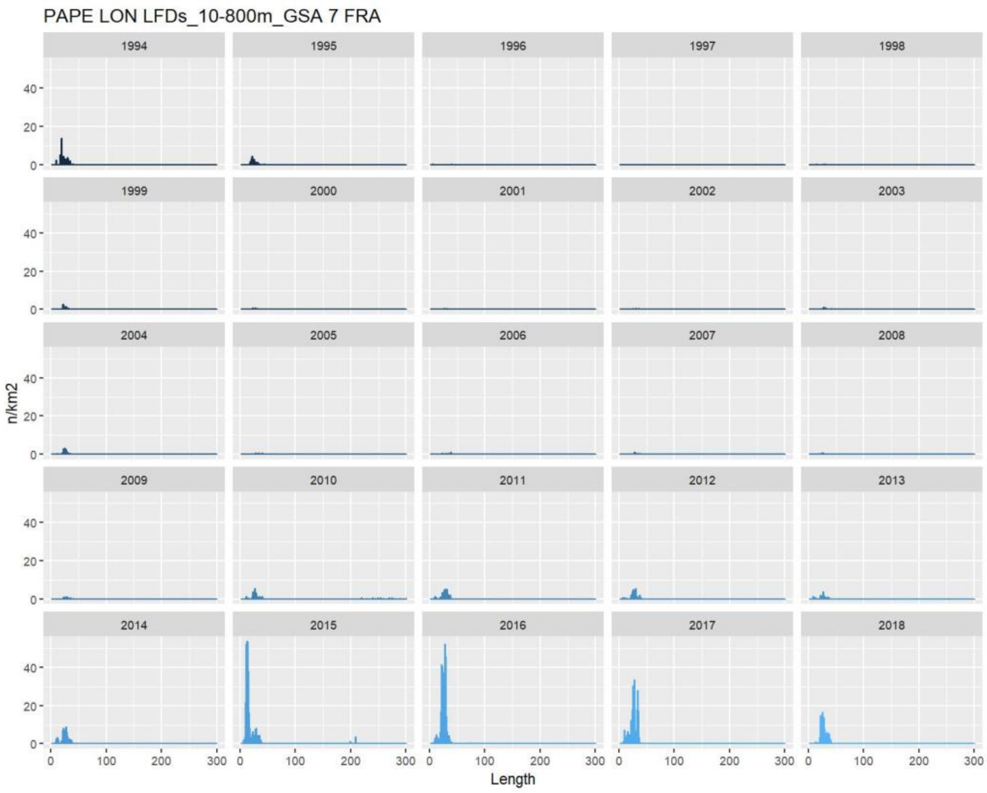


Figure 6.2.2.3.9. Deep-water rose shrimp GSA 7. Length frequency distribution by year of MEDITS.

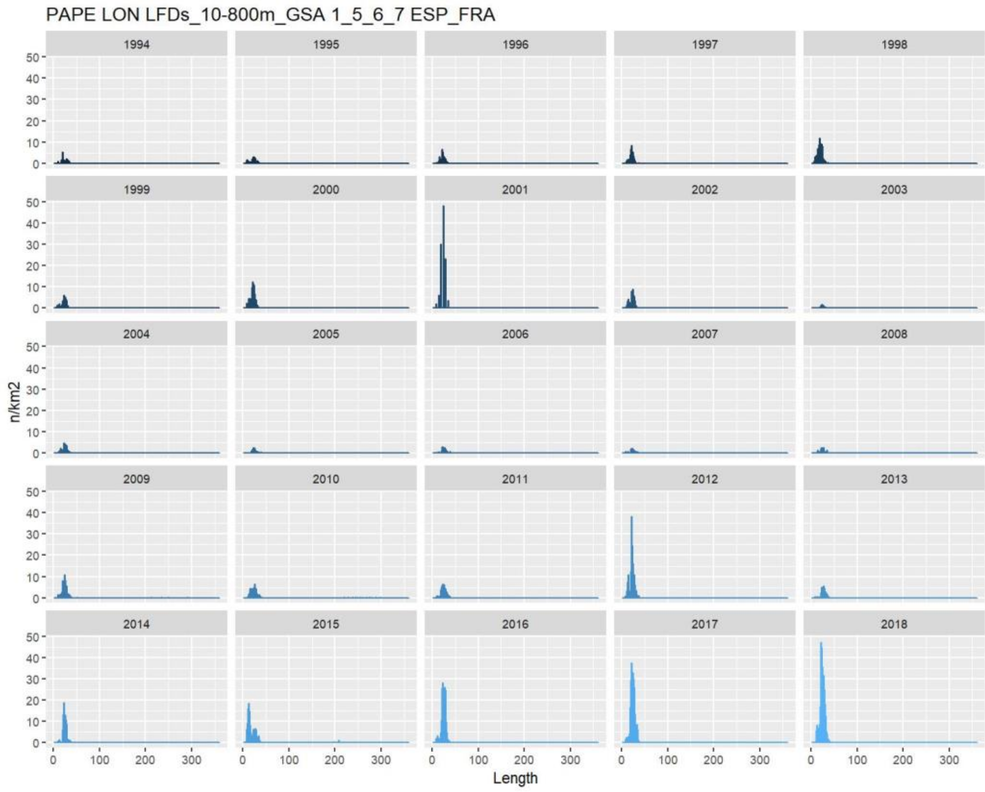


Figure 6.2.2.3.10. Deep-water rose shrimp GSAs 1-5-6-7. Length frequency distribution by year of MEDITS.

The following maps show the abundance (in biomass) per haul of the MEDITS survey standardized to square kilometre. It is evident as in the first years the abundance of Deep-water rose shrimp was low in all the GSAs.

Since end of ‘90s, the abundance of the species increased in the southern part (GSA 1). In the following years, the species showed an expansion of the distribution area towards the north. In the last four years, the species resulted abundant in all the GSAs.

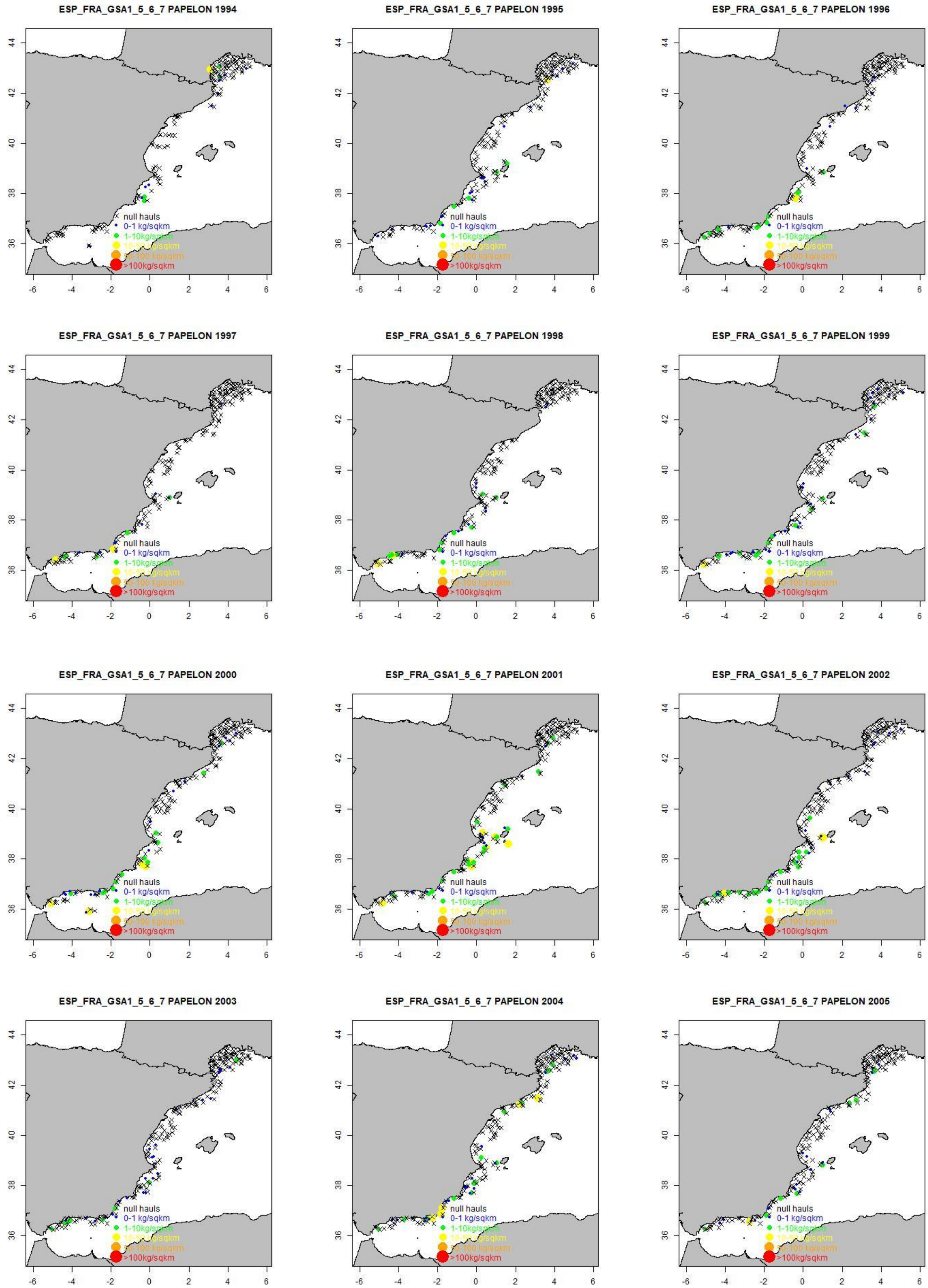


Figure 6.2.2.3.11 Deep-water rose shrimp GSAs 1-5-6-7. Distribution pattern in the period 1994-2005 (MEDITS survey).

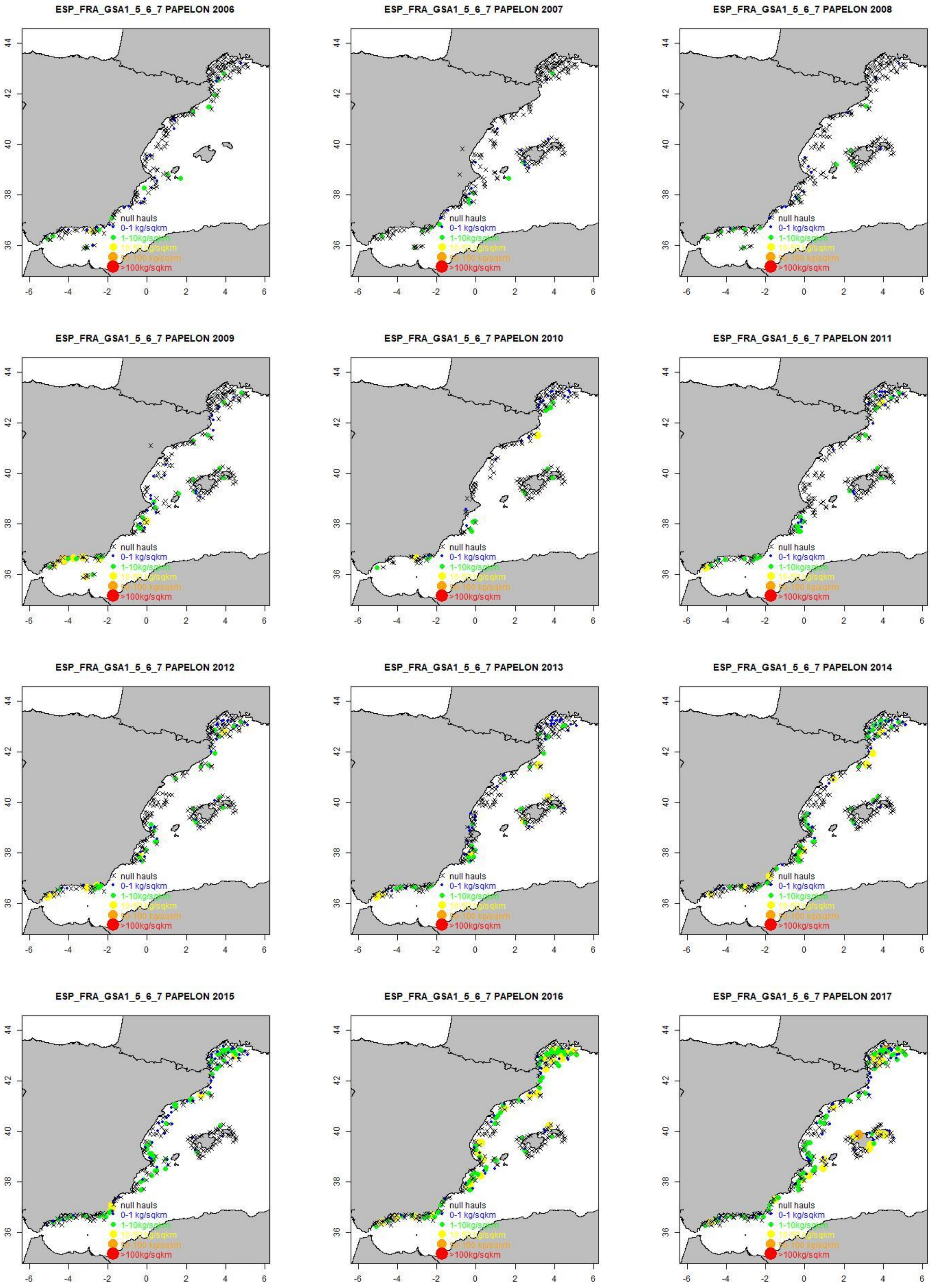


Figure 6.2.2.3.12 Deep-water rose shrimp GSAs 1-5-6-7. Distribution pattern in the period 2006-2017 (MEDITS survey).

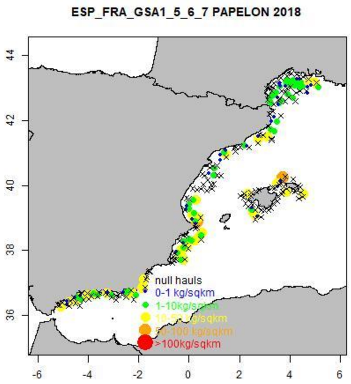


Figure 6.2.2.3.13 Deep-water rose shrimp GSAs 1-5-6-7. Distribution pattern in 2018 (MEDITS survey).

6.2.3 Stock assessment

The EWG 18-12 concluded that the outputs of the XSA and a4a model were not suitable to provide the basis of the current status of the stock but could be used as indicative of a trend. On this basis, advice was given for the years 2019 and 2020.

EWG 19-10 was required to do a short evaluation of survey and landing trends to determine if new data is different and could help with an assessment. As no substantive change in survey and landing signals was observed, a new assessment has not been performed and the advice done in EWG 18-12 has been confirmed.

6.2.4 Reference Points

As the assessment carried out during EWG 18-12 was not accepted for advice, reference points were not calculated.

6.2.5 Short term Forecast and Catch Options

No new short term forecast has been carried out as advice given last year is valid fpor 2020. Details of the 2018 assessment are avaiable in STECF EWG 18-12 report.

6.2.6 Data Deficiencies

Data from DCF 2018 as submitted through the Official data call in 2019 were used.

In GSA 1, no length frequency distributions of landing were available for 2002 and for all years of OTB-MDDWSP.

In GSA 5, no length frequency distributions of landing were available for 2016 and for 2009 of OTB-MDDWSP.

In GSA 6, no length frequency distributions were available for all years of OTB-MDDWSP. The length frequency distribution in 2015 had an extremely high number of individuals in the length class 33.

In GSA 7, only the length frequency distributions of landing for Spanish OTB were available. They cover the period 2009-2018. No length frequency distributions of landing were available for OTB-MDDWSP.

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

Issues with the MEDITS data in GSA 1 were pointed out. The TC in 2013 contains two hauls (16 and 38) with wrong values in “pfrac”. The correct values (854 and 261 g, respectively) were recovered from "pechan". The numbers of individuals were also corrected in TB, finding them from TC.

In the MEDITS data of GSAs 1, 6 and 7 there are animals of lengths higher than 50 mm carapax length, which were considered wrong.

The MEDITS length frequency distributions in GSA 5 for 2001 should be checked thoroughly because are considered to be wrong.

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

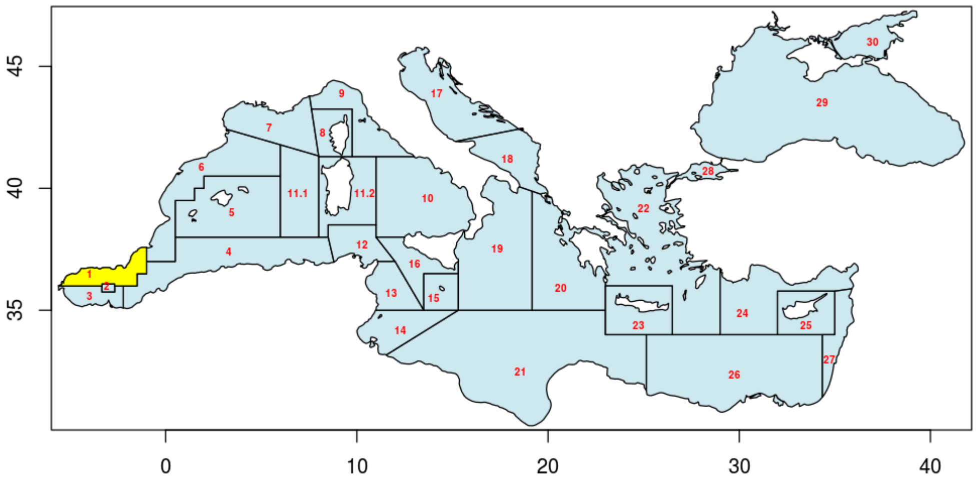


Figure 6.3.1.1 Geographical location of GSA 1

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 (L_{inf}=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 19 – 10.

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**	
	123.87	135.9	260.49	274.67	170.23	

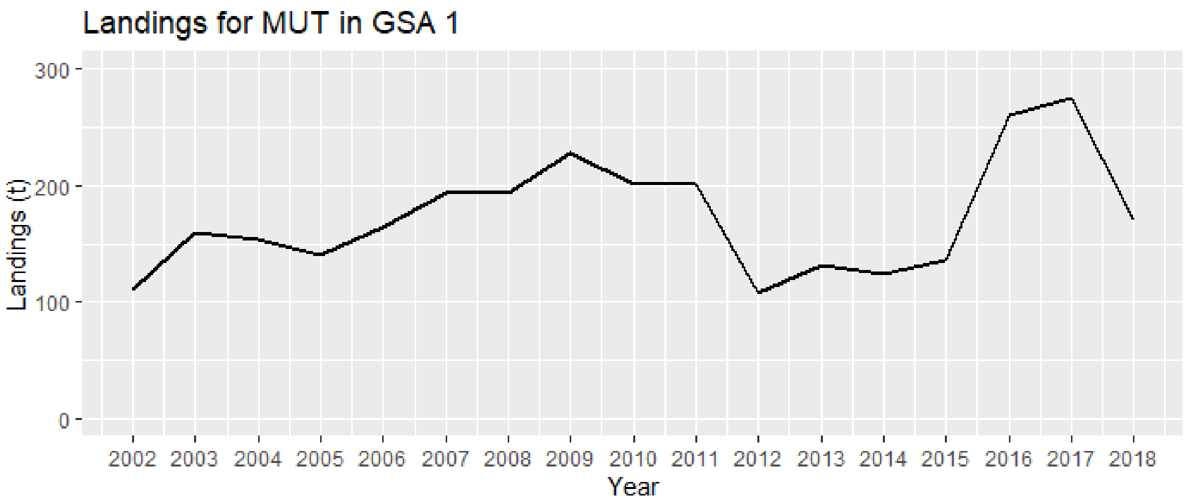


Figure 6.3.2.1.1 Total landings by year for Red mullet in GSA 1

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 132 tonnes. Catches in 2018 are close to long term mean (2002-2018)

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

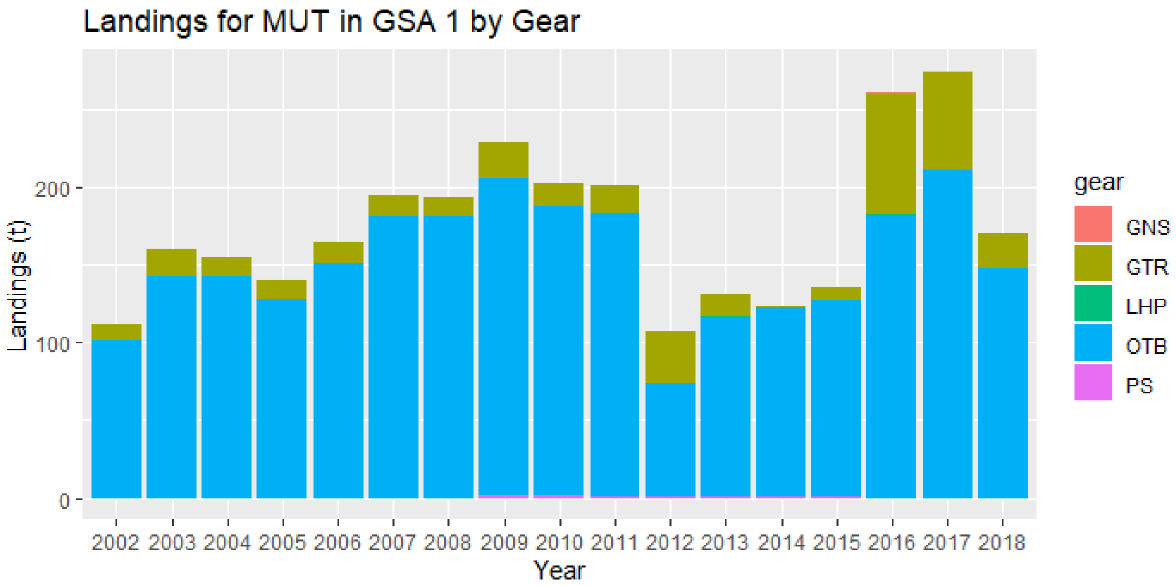


Figure 6.3.2.1.2 Total landings by year and gear for Red mullet in GSA 1.

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

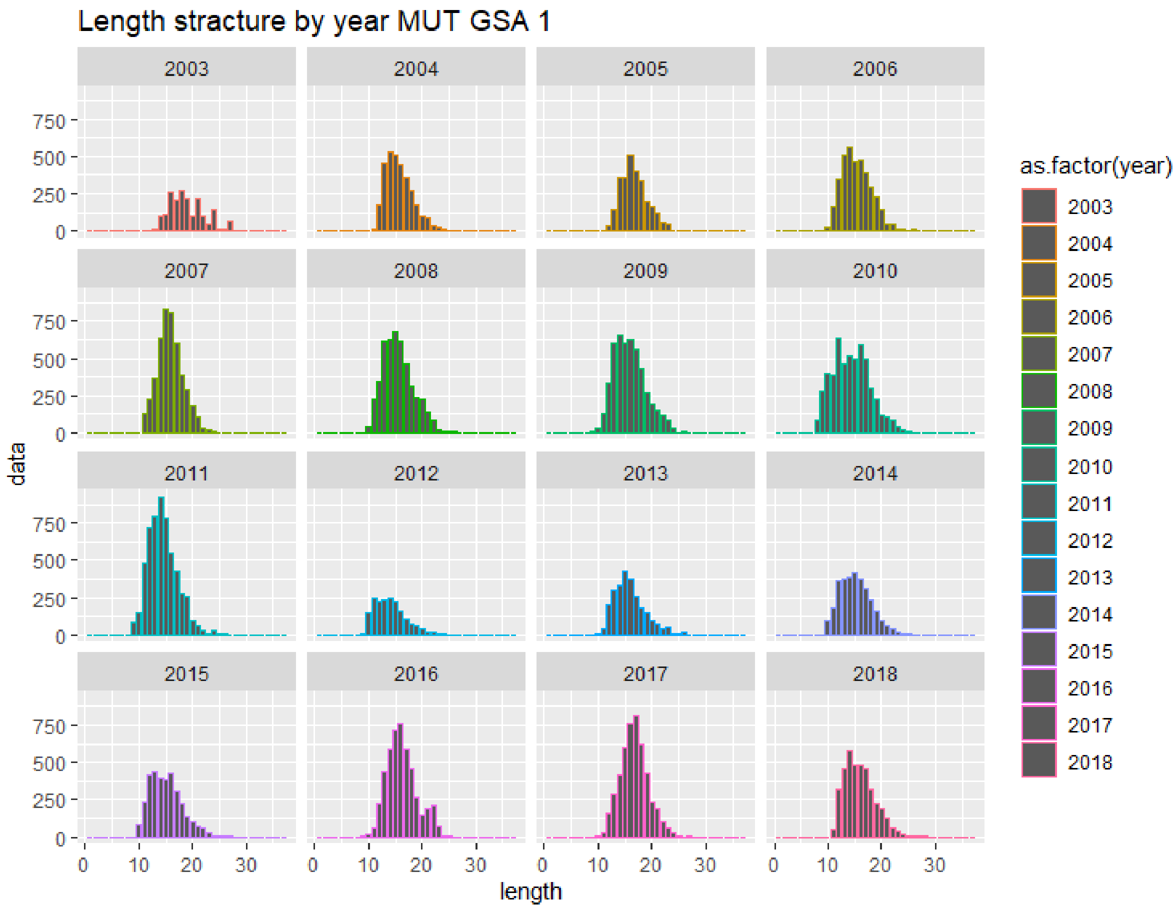


Figure 6.3.2.1.3 Length frequency distribution of Red mullet landings in GSA 1.

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.

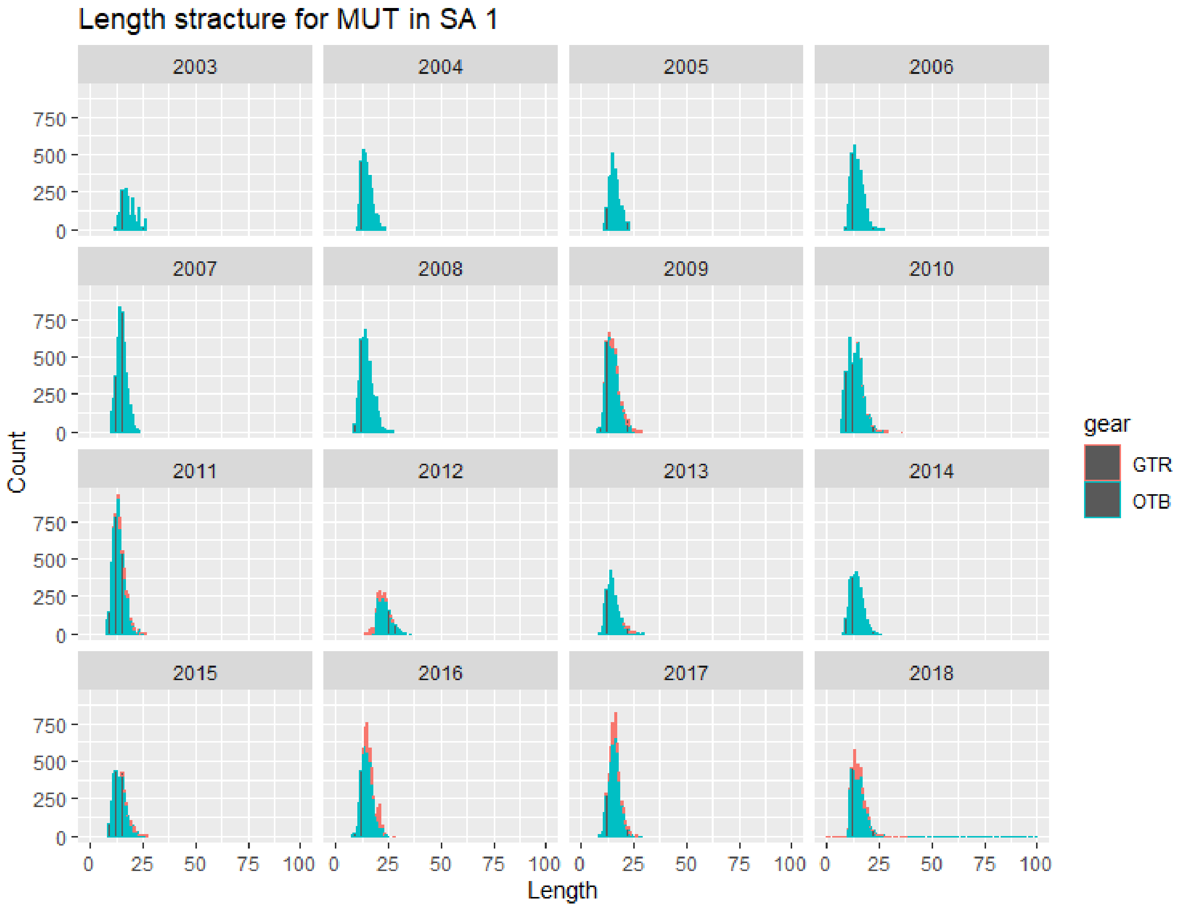


Figure 6.3.2.1.4 Length frequency distribution of Red mullet landings by year and gear in GSA 1.

DISCARDS

Discards of Red mullet in GSA 1 provided by the Spanish DCF. Discards for Red mullet in GSA 1 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 with a 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

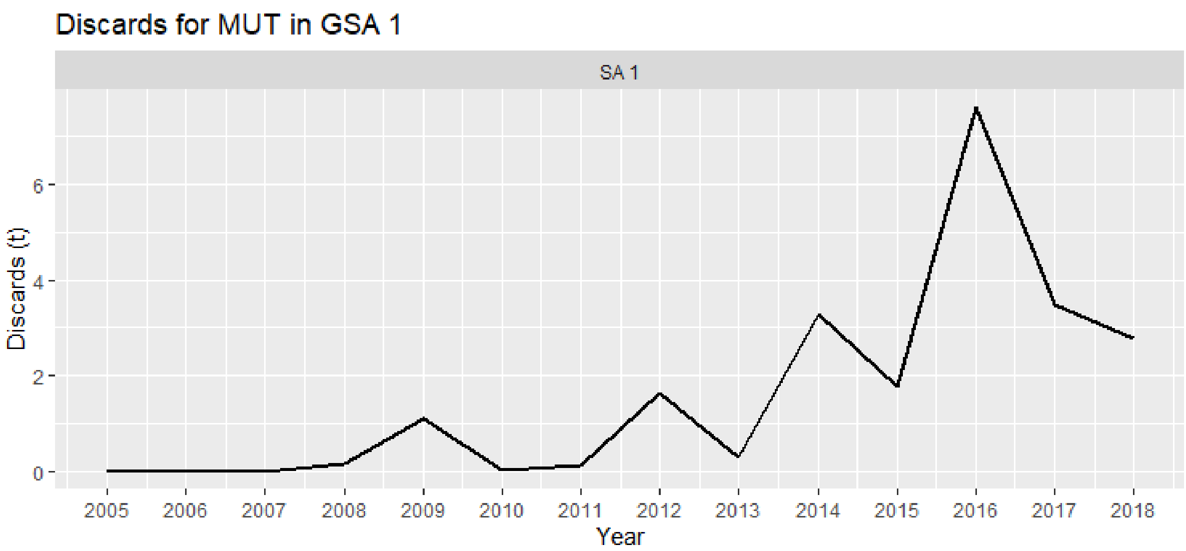


Figure 6.3.2.1.5 Red mullet in GSA 1. Discards by year.

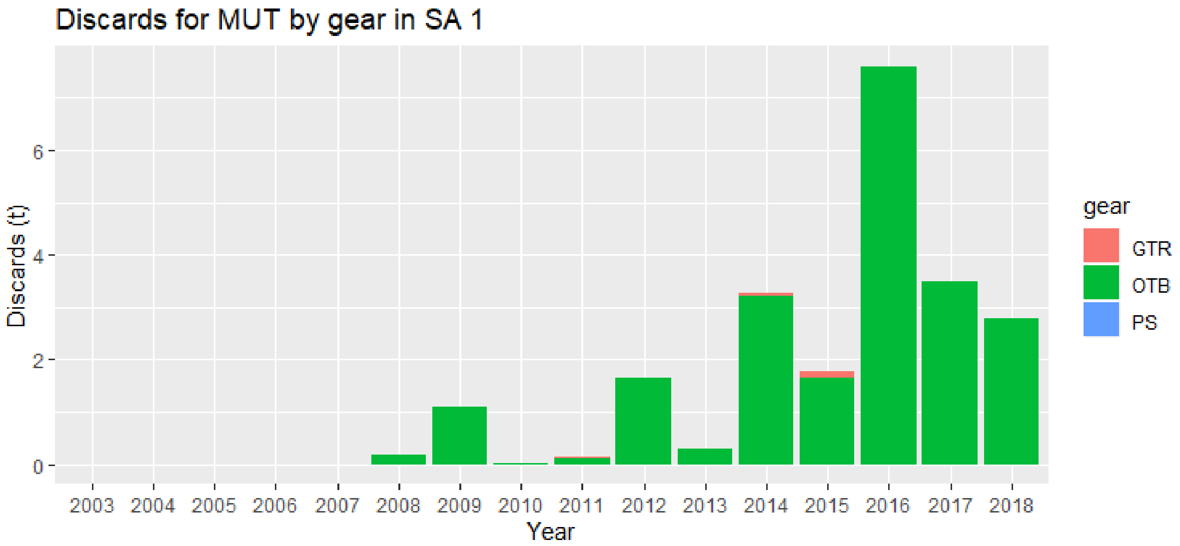


Figure 6.3.2.1.6 Red mullet in GSA 1. Discards by year and gear.

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

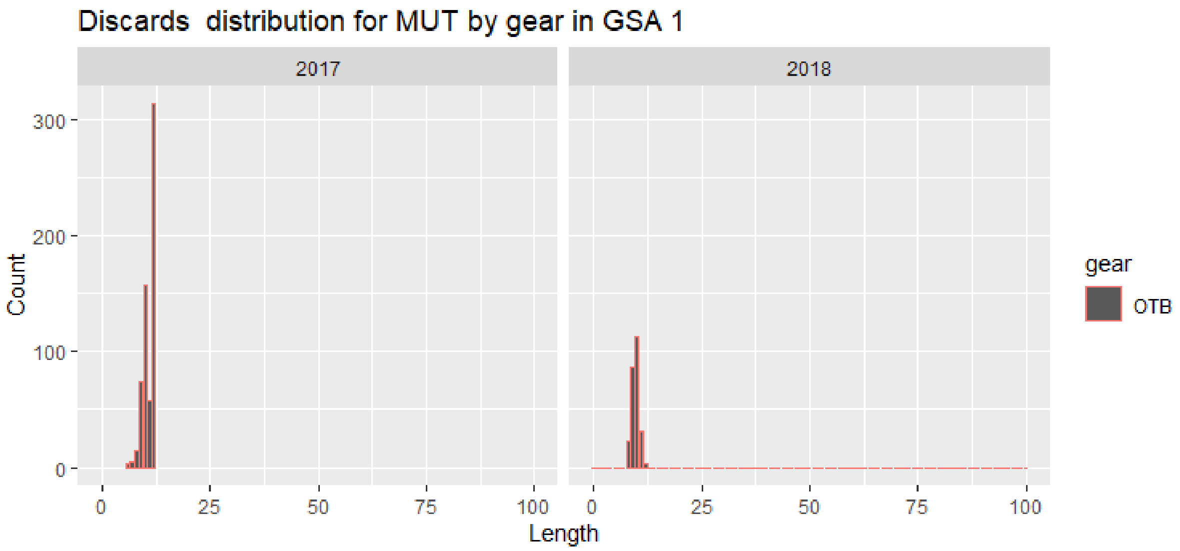


Figure 6.3.2.1.7 Red mullet in GSA 1. Discards length frequency distribution by year and gear.

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 metiers. 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

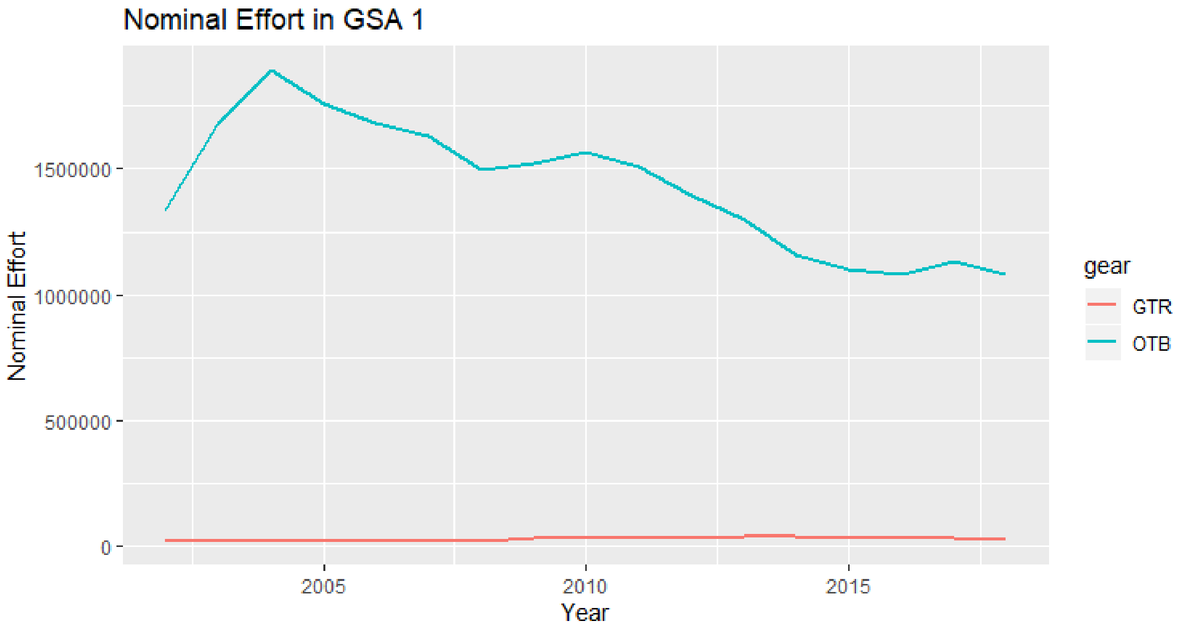


Figure 6.3.2.2.1 Nominal effort for GSA 1 for trawlers and trammel nets.

6.3.2.3 SURVEY DATA

Since 1994, MEDITS trawl surveys has 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.

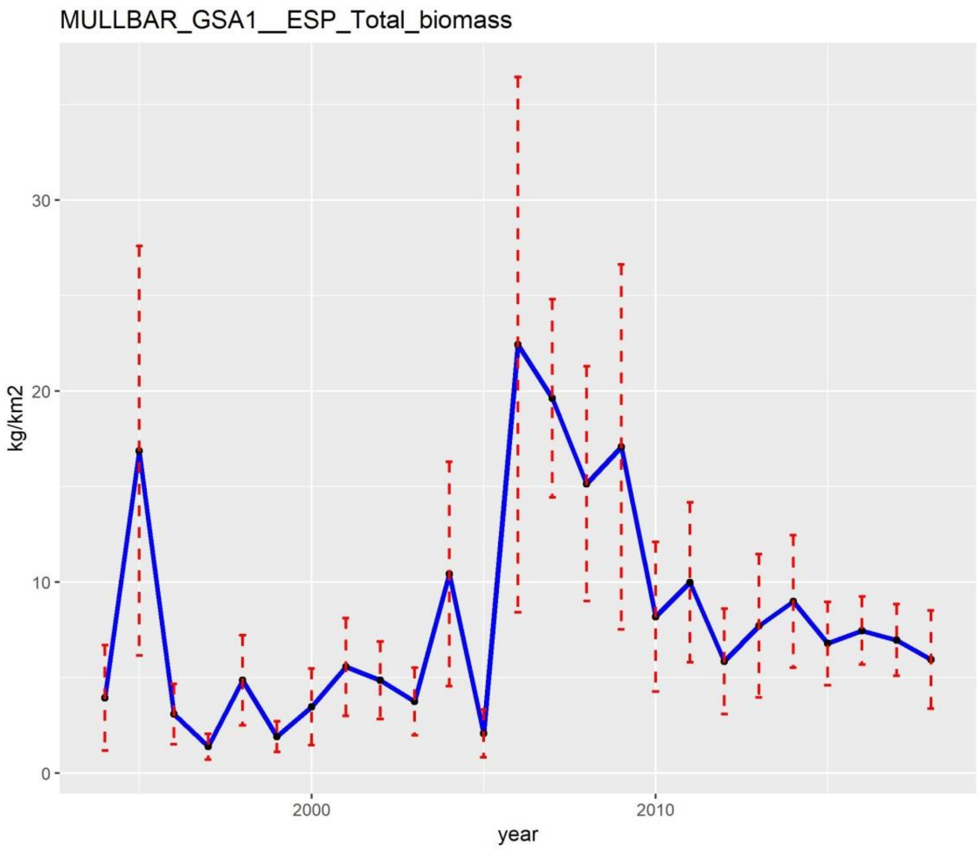


Figure 6.3.2.3.1. Red mullet in GSA 1. Estimated biomass index.

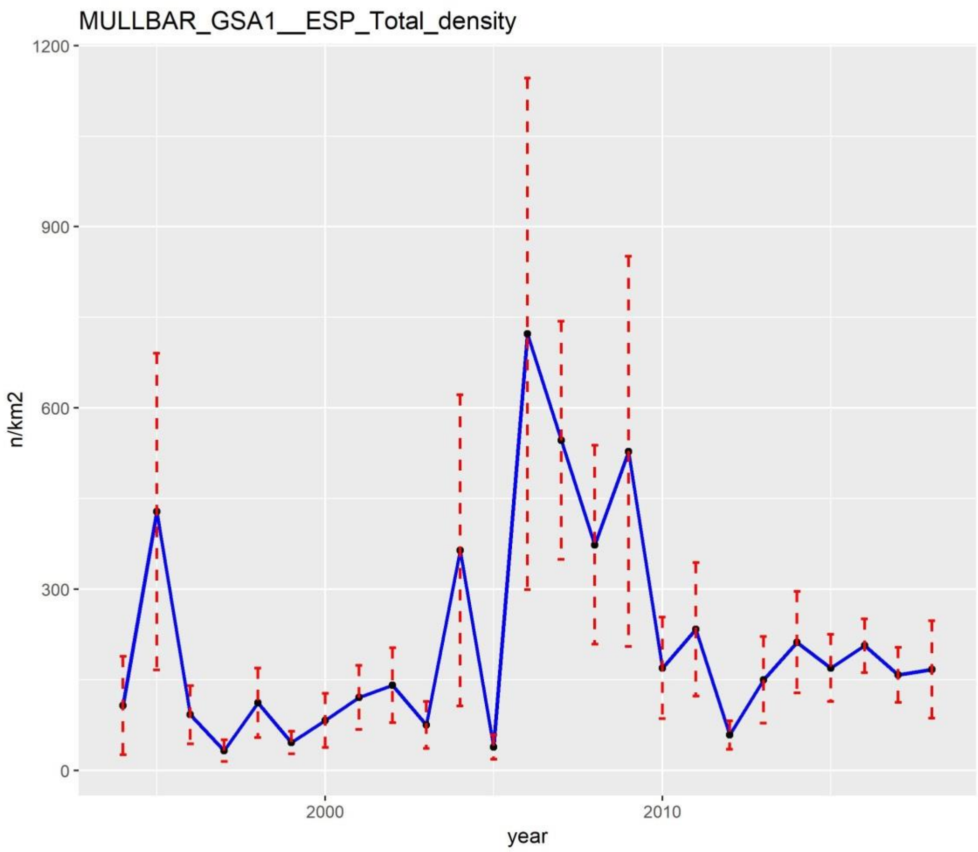


Figure 6.3.2.3.2. Red mullet in GSA 1. Estimated abundance index.

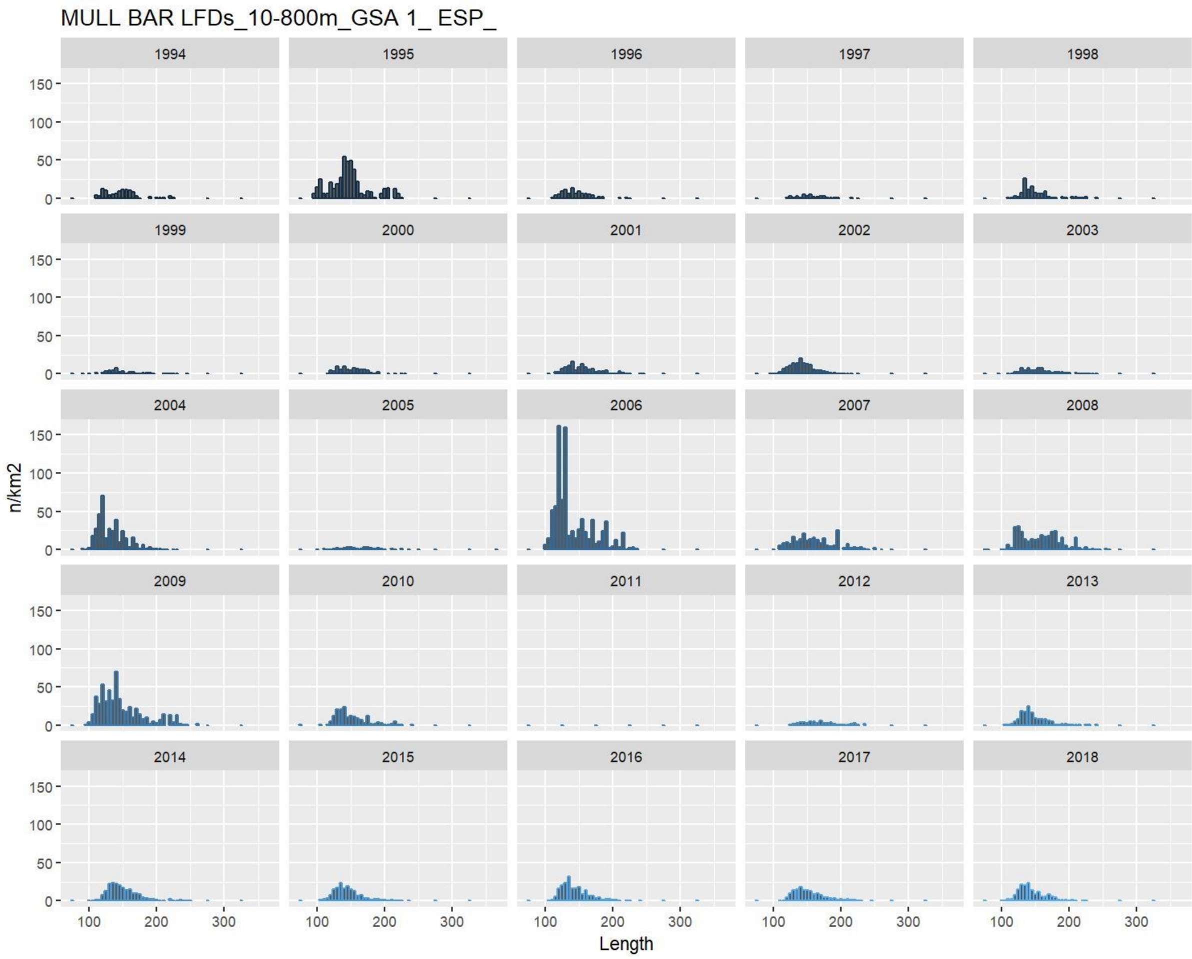


Figure 6.3.2.3.3. Red mullet in GSA 1. Length frequency distribution for the MEDITS index for the years 1994 – 2018.

6.3.3 STOCK ASSESSMENT

STECF EWG 19-10 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 2018 due to misreported length frequency distribution of catch in 2003. For the tuning fleet, MEDITS survey was used for the years 2004 – 2018.

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**		
SoP	0.96	1.05	1.03	0.90		

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**	
	123.87	135.9	260.49	274.67	170.23	

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

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

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 – 2018 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

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

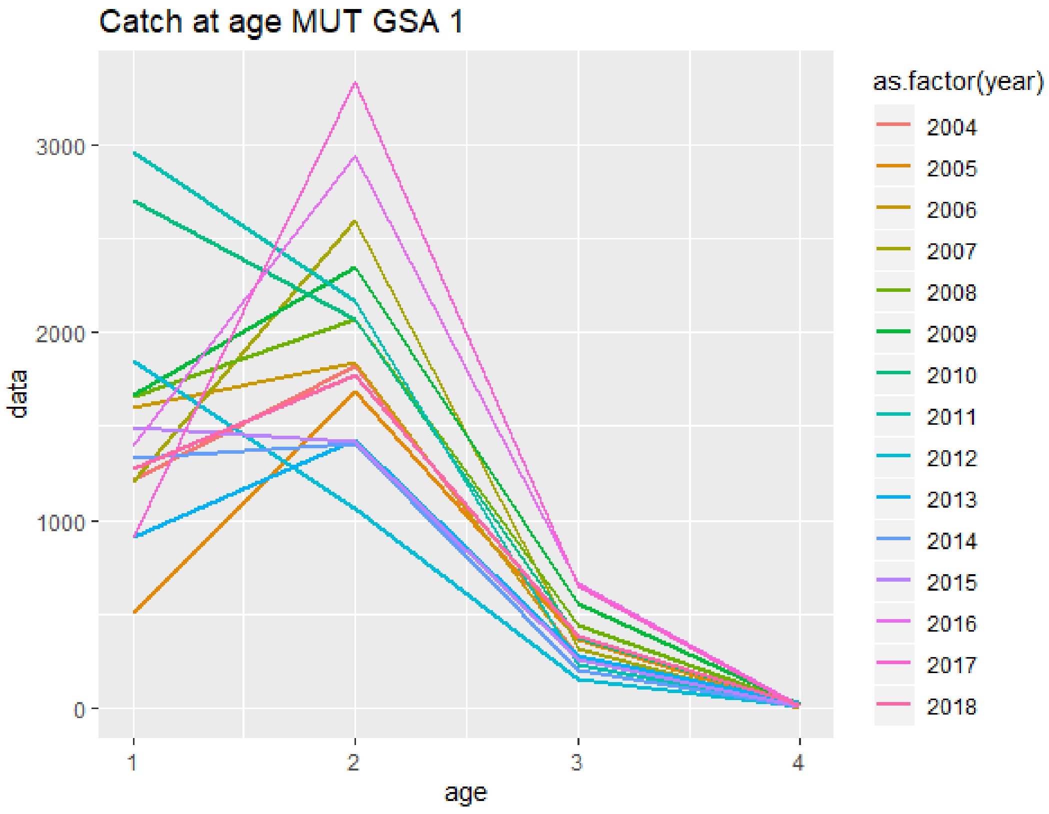


Figure 6.3.3.1. Red mullet in GSA 1. Catch number at age for the years 2004 – 2018.

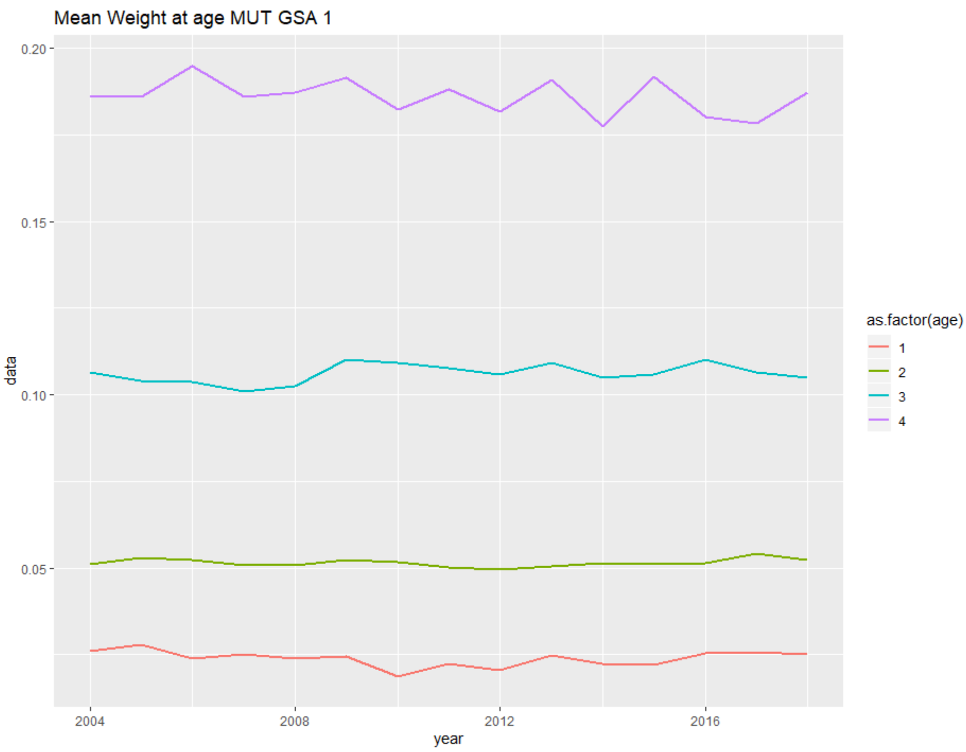


Figure 6.3.3.3. Red mullet in GSA 1. Mean weight for each year and age.

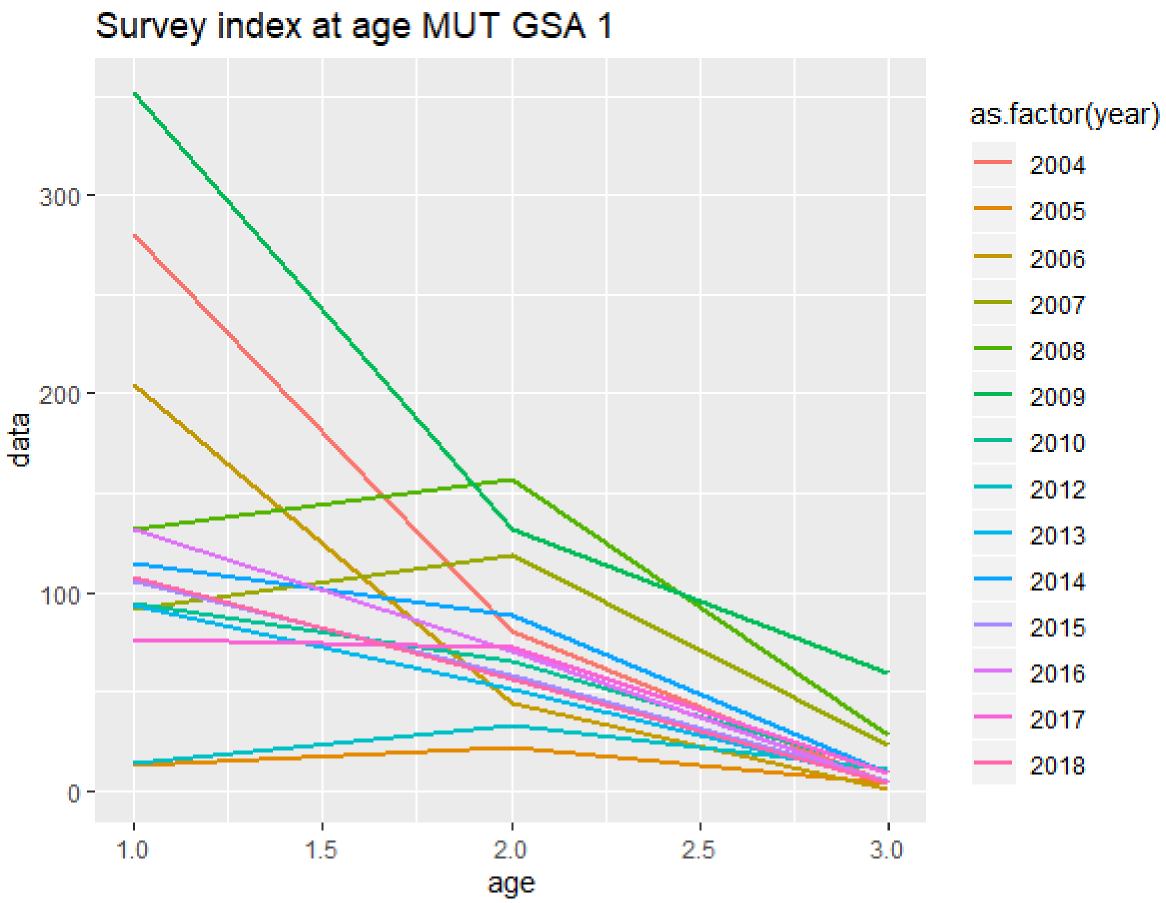


Figure 6.3.3.4. Red mullet in GSA 1. Survey index at age for the years 2004 -2018

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.

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 <- ~ s(age, k =3) + s(year, k =7)
srmod <- ~ s(year,k=7)
```

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.

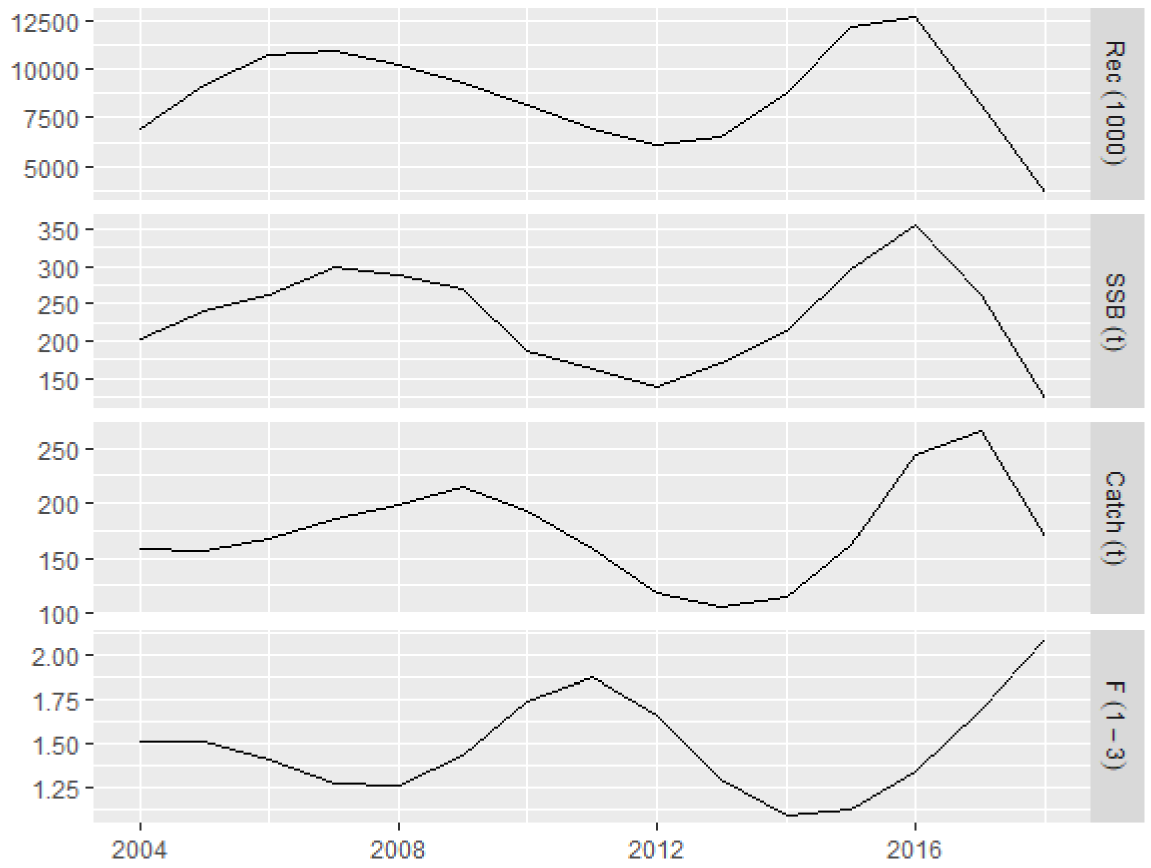


Figure 6.3.3.5. Red mullet in GSA 1. Stock summary from the a4a model for Red mullet in GSA 20, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

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

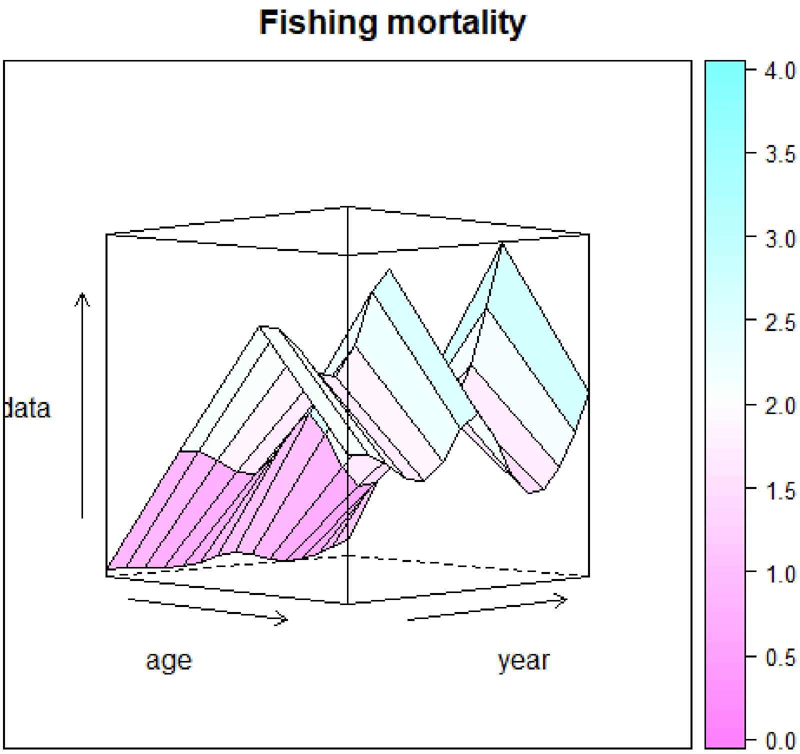


Figure 6.3.3.6. Red mullet in GSA 1. 3D contour plot of estimated fishing mortality by age and year.

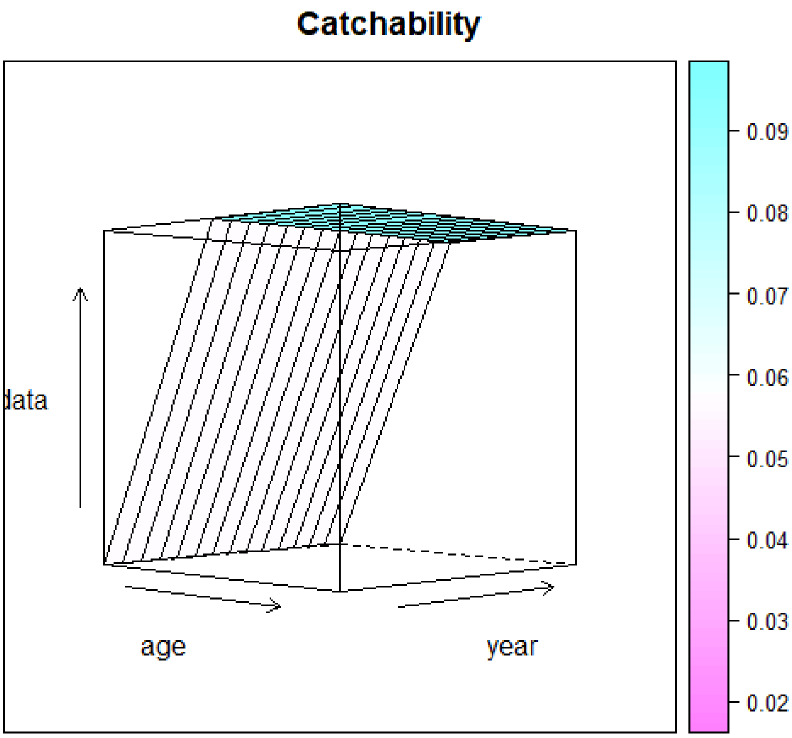


Figure 6.3.3.7. Red mullet in GSA 1. 3D contour plot of catchability by age and year.

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 19 -10 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.

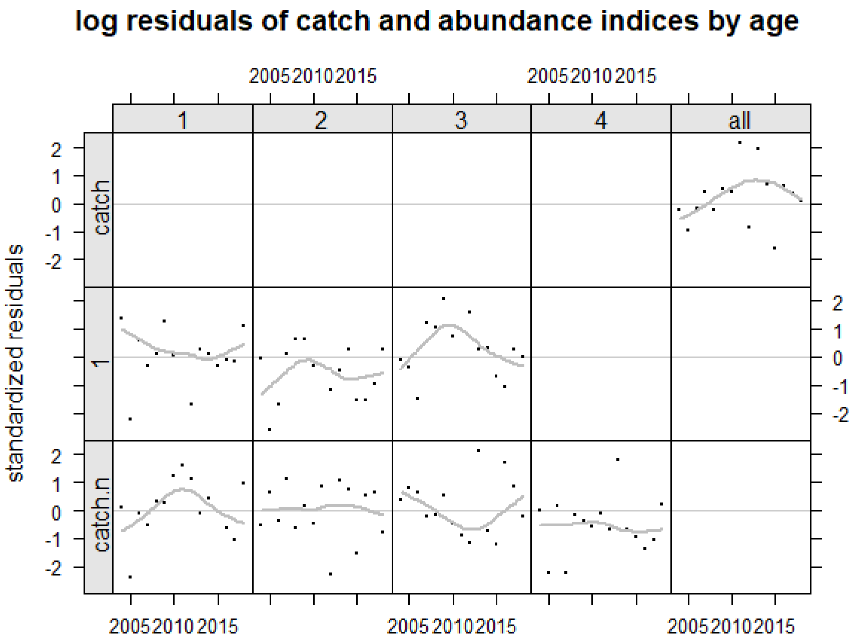


Figure 6.3.3.8. Red mullet in GSA 1. Standardized residuals for catch, abundance indices and for catch numbers.

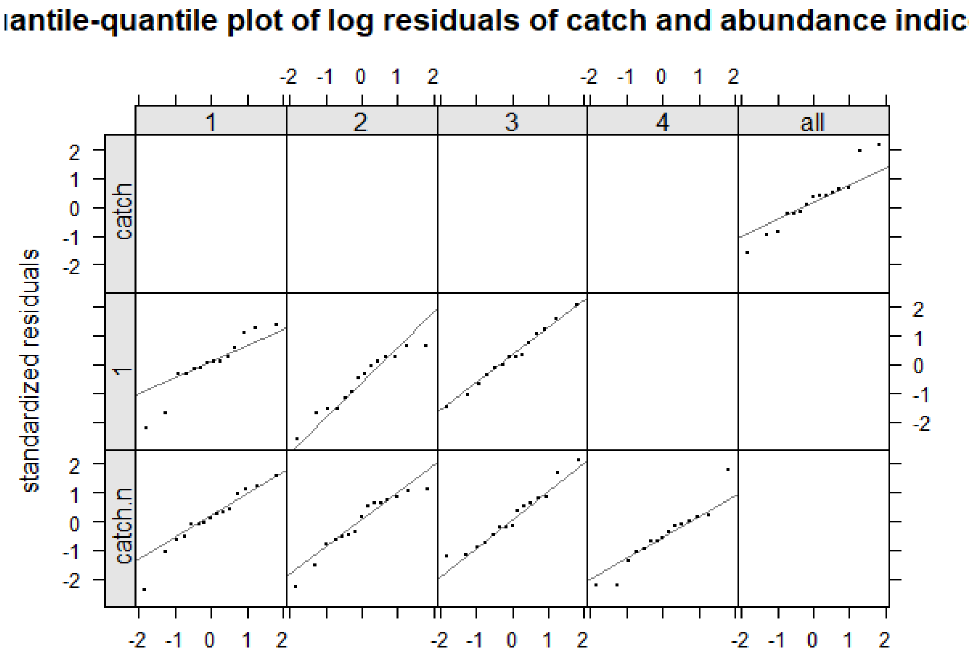


Figure 6.3.3.9. Red mullet in GSA 1. Quantile-quantile plot of standardized residuals for catch, abundance indices and for catch numbers.

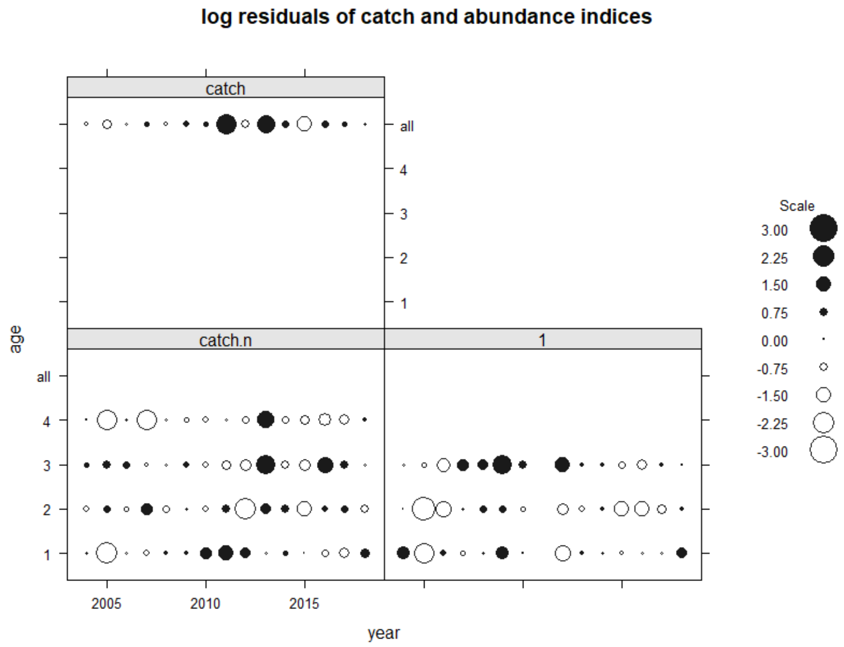


Figure 6.3.3.10. Red mullet in GSA 1. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

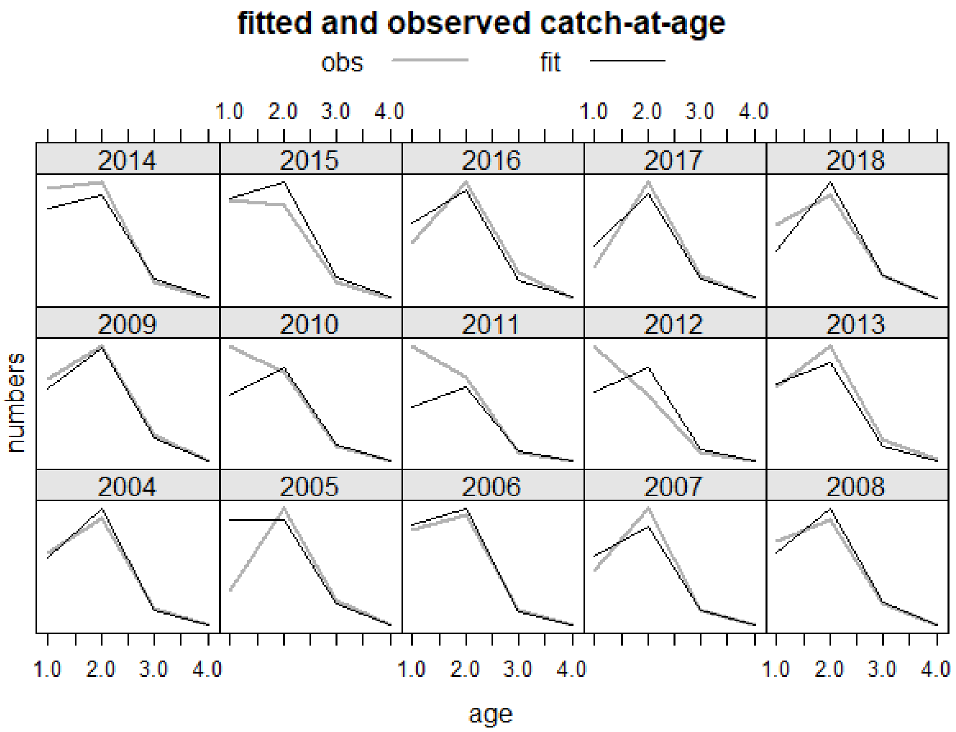


Figure 6.3.3.11. Red mullet in GSA 1. Fitted and observed catch at age.

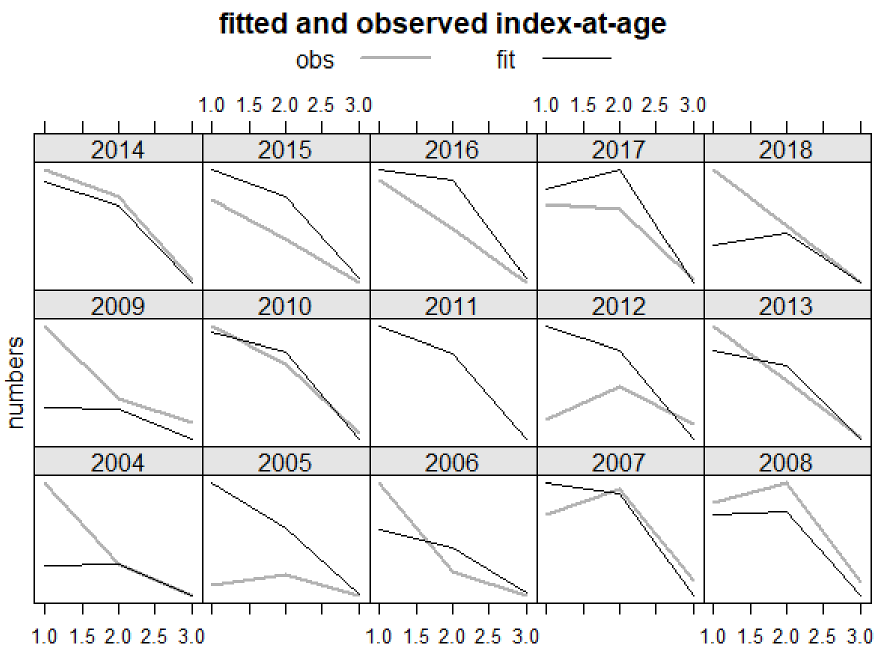


Figure 6.3.3.12. Red mullet in GSA 1. Fitted and observed index at age

RETROSPECTIVE

The retrospective analysis was applied only up to 2 years back due to the short time series. Models results were considered stable.

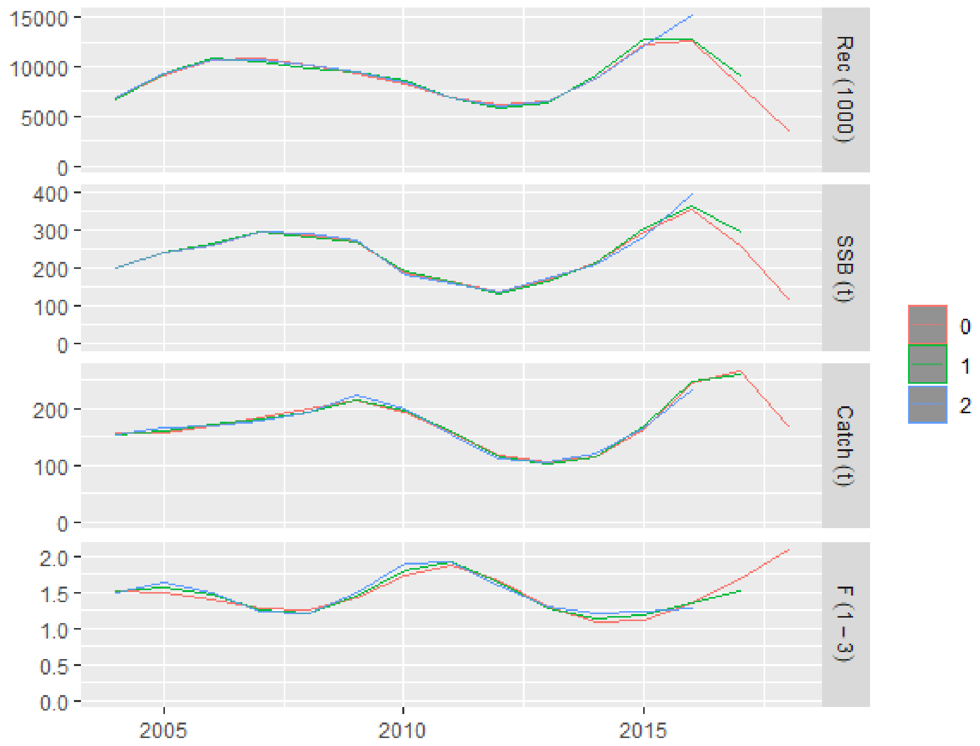


Figure 6.3.3.13. Red mullet in GSA 1. Retrospective analysis for the a4a model.

SIMULATIONS

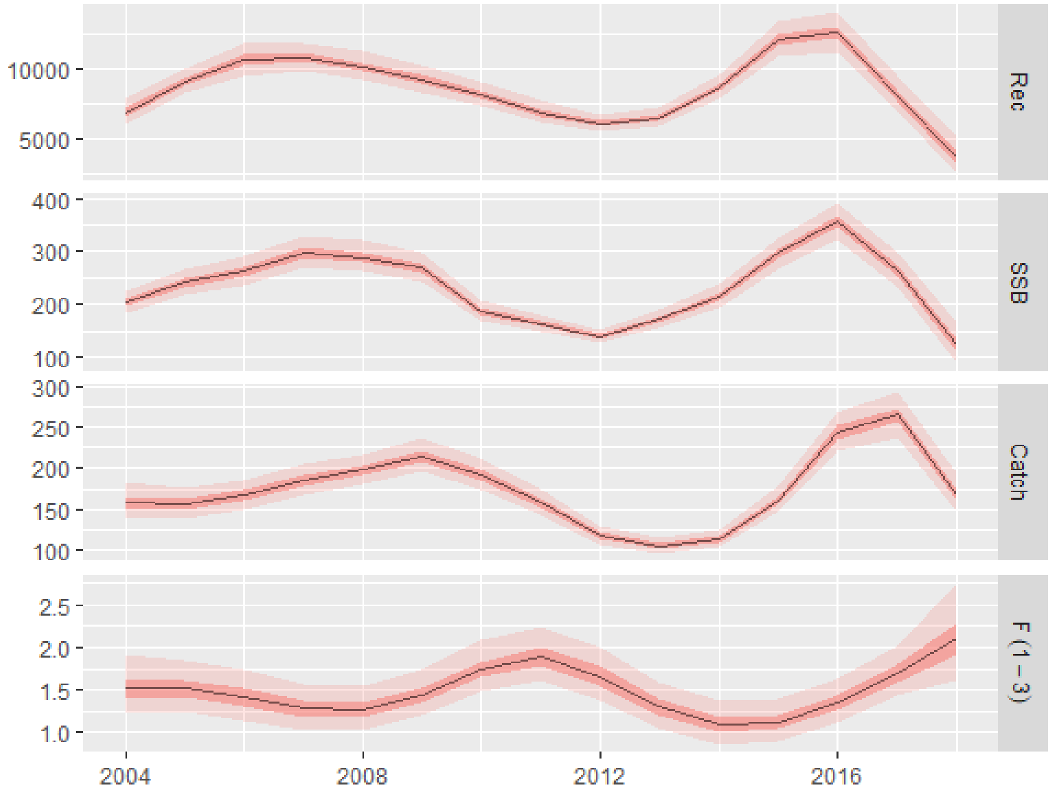


Figure 6.3.3.14. Red mullet in GSA 20. Stock summary of the simulated and fitted data for the a4a model.

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

Table 6.3.3.7 Red mullet in GSA 1. Summary results of Recruitment, Spawning stock biomass, Catch and Fbar (ages 1 – 3).

	Recruitment	SSB	Catch	Fbar ages 1 - 3
2004	6939	203	158	1.52
2005	9132	241	156	1.51
2006	10702	263	168	1.41
2007	10875	298	186	1.28
2008	10197	289	199	1.26
2009	9309	268	215	1.44
2010	8206	187	192	1.74
2011	6945	164	158	1.88
2012	6146	139	118	1.66
2013	6566	172	106	1.30
2014	8793	215	115	1.09
2015	12197	296	162	1.12
2016	12646	355	244	1.34
2017	8110	263	265	1.69
2018	3673	122	169	2.10

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, $F_{0.1}$ has been considered as the best proxy of F_{MSY} reference point. $F_{0.1}$ 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 $F_{0.1}$ was calculated equal to 0.54.

6.3.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2020 to 2021 was performed using the FLR routines provided by JRC and based on the results of the a4a stock assessments performed during EWG 19-10.

The input parameters for the STF were taken following the procedure in Section 4.3 Table 6.1.5.1. The input parameters for selection, mean weights, maturity and natural mortality were means of the last three years from the a4a stock assessment and its results. F status quo for

F_{2019} is equal to F_{2018}, equal to 2.10 and corresponding to a $catch_{2019}$ of 99t. Recruitment was estimated to be 8335 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*F2018

Table 6.1.5.1 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)	2.10	F2018
SSB (2019)	122 t	Stock assessment 1 January 2019
R_{age0} (2019,2020)	8335	Geometric mean of time series, years 2004-2018
Total catch (2019)	99	Assuming F status quo for 2019

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

	Ffactor	Fbar	Catch2020	Catch2021	SSB* 2020	SSB* 2021	SSB_change_2019-2021(%)	Catch_change_2018-2020(%)
zero catch	0.00	0.00	0	0	229	383	68	-100
$F_{0.1}$	0.26	0.54	53	102	205	271	33	-68
$f_{status\ quo}$	1.00	2.10	130	137	155	157	1	-23
f_{upper}	0.35	0.74	68	116	197	245	25	-60
f_{lower}	0.17	0.36	38	82	212	300	42	-77
Different Scenarios	0.10	0.21	24	57	219	330	51	-86
	0.20	0.42	43	90	210	290	38	-74
	0.30	0.63	60	109	201	259	29	-64
	0.40	0.84	75	121	193	234	21	-56
	0.50	1.05	87	128	186	215	16	-48
	0.60	1.26	98	132	179	199	11	-42
	0.70	1.47	108	134	172	186	8	-36
	0.80	1.68	116	136	166	174	5	-31
	0.90	1.89	124	137	161	165	3	-27
	1.10	2.31	137	137	150	150	0	-19
	1.20	2.52	142	138	146	143	-2	-16
	1.30	2.72	147	138	141	138	-3	-13
	1.40	2.93	152	138	137	132	-3	-10
	1.50	3.14	157	138	133	128	-4	-7
	1.60	3.35	161	137	129	124	-4	-5
	1.70	3.56	165	137	126	120	-5	-3
	1.80	3.77	168	137	122	116	-5	0
	1.90	3.98	172	137	119	113	-5	2
	2.00	4.19	175	137	116	110	-5	4

*SSB at mid-year

6.3.6 DATA DEFICIENCIES

EWG 19-10 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 EWG18-12 also summarized and concisely described catch and effort data deficiencies, in terms of coverage and quality.

6.4 Striped Red Mullet in GSA 5

6.4.1 Stock Identity and Biology

GSA 5 (Figure 6.4.1.1) has been pointed as an individualized area for assessment and management purposes in the western Mediterranean (Quetglas *et al.*, 2012) due to its main specificities. These include: 1) Geomorphologically, the Balearic Islands (GSA 5) are clearly separated from the Iberian Peninsula (GSA 6) by depths between 800 and 2000 m, which would constitute a natural barrier to the interchange of adult stages of demersal resources; 2) Physical geographically-related characteristics, such as the lack of terrigenous inputs from rivers and submarine canyons in GSA 5 compared to GSA 6, give rise to differences in the structure and composition of the trawling grounds and hence in the benthic assemblages; 3) Owing to these physical differences, the faunistic assemblages exploited by trawl fisheries differ between GSA 5 and GSA 6, resulting in large differences in the relative importance of the main commercial species; 4) There are no important or general interactions between the demersal fishing fleets in the two areas, with only local cases of vessels targeting red shrimp in GSA 5 but landing their catches in GSA 6; 5) Trawl fishing exploitation in GSA 5 is much lower than in GSA 6; the density of trawlers around the Balearic Islands is one order of magnitude lower than in adjacent waters; and 6) Due to this lower fishing exploitation, the demersal resources and ecosystems in GSA 5 are in a healthier state than in GSA 6, which is reflected in the population structure of the main commercial species (populations from the Balearic Islands have larger modal sizes and lower percentages of small-sized individuals), and in the higher abundance and diversity of elasmobranch assemblages.

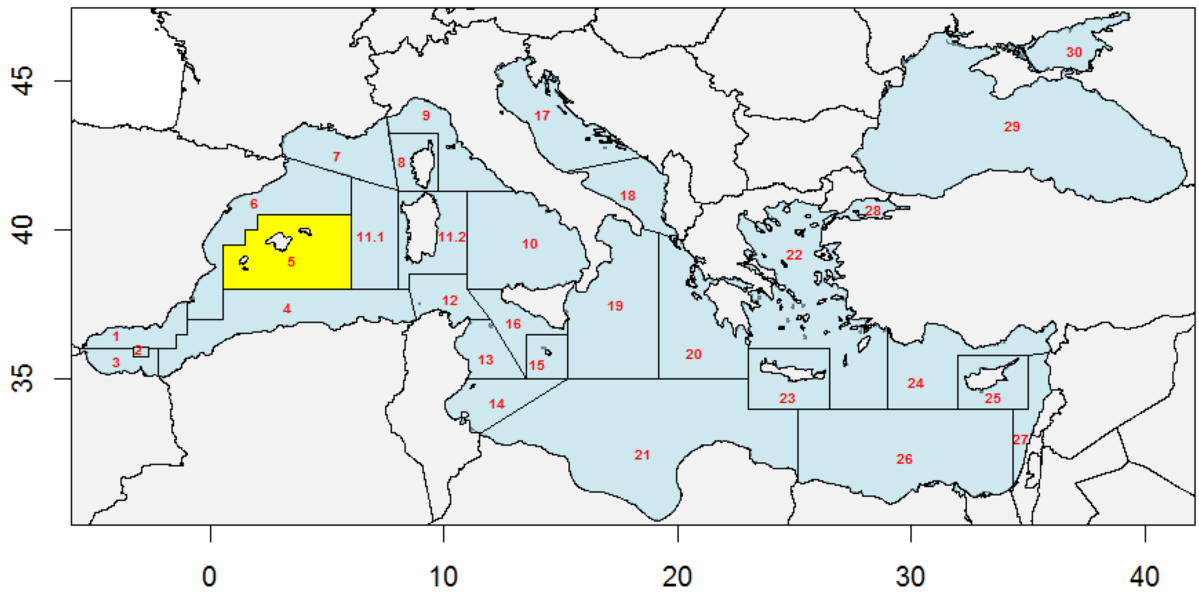


Figure 6.4.1.1. Geographical localization of GSA 5.

The biological parameters, natural mortality vector and maturity ogive used for the assessment of *M. surmuletus* were those shown in the following tables. Growth parameters (Table 6.4.1.1) 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
t_0	0.43
k	-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, since 2013 an increase in bottom trawl catches is observed (Figure 6.4.2.1).

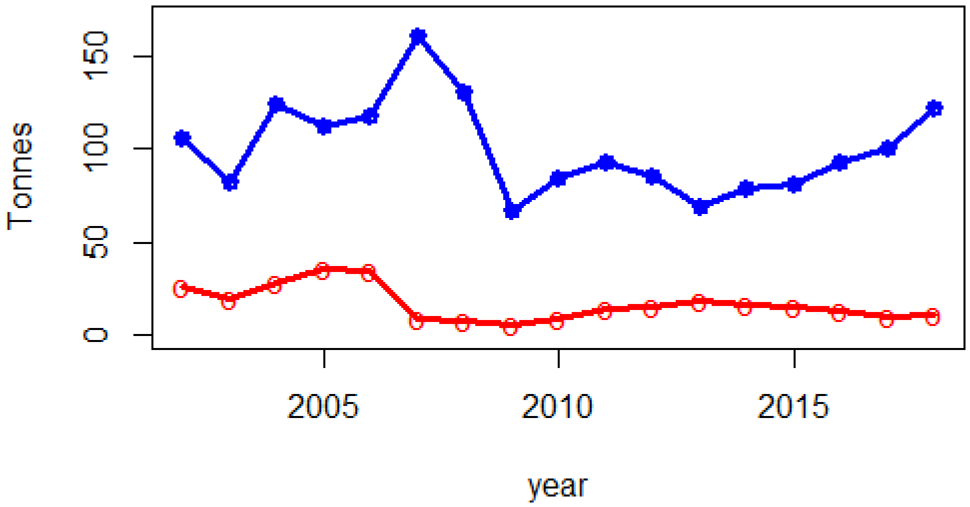


Figure 6.4.2.1. *Mullus surmuletus* in GSA 5. Reported Landings from the DCF Data call by gear.

Discards for this stock can be considered as neliglible and catches are assumed to be equal to landings.

Length frequency distribution for the striped red mullet in GSA 5 shows differences between métiers, with trammelnets targetting larger individuals than bottom trawlers (Figure 6.4.2.2). Age composition is mainly formed by age 1 individuals, although age 0 and age 2 are also frequent in the catches (Figure 6.4.2.3). Cohorts showed a good consistency, especially for the youngest classes (figure 6.4.2.4).

Figure 6.4.2.2. Striped red mullet in GSA5. Catch length frequency distribution, by year and métier (TL cm).

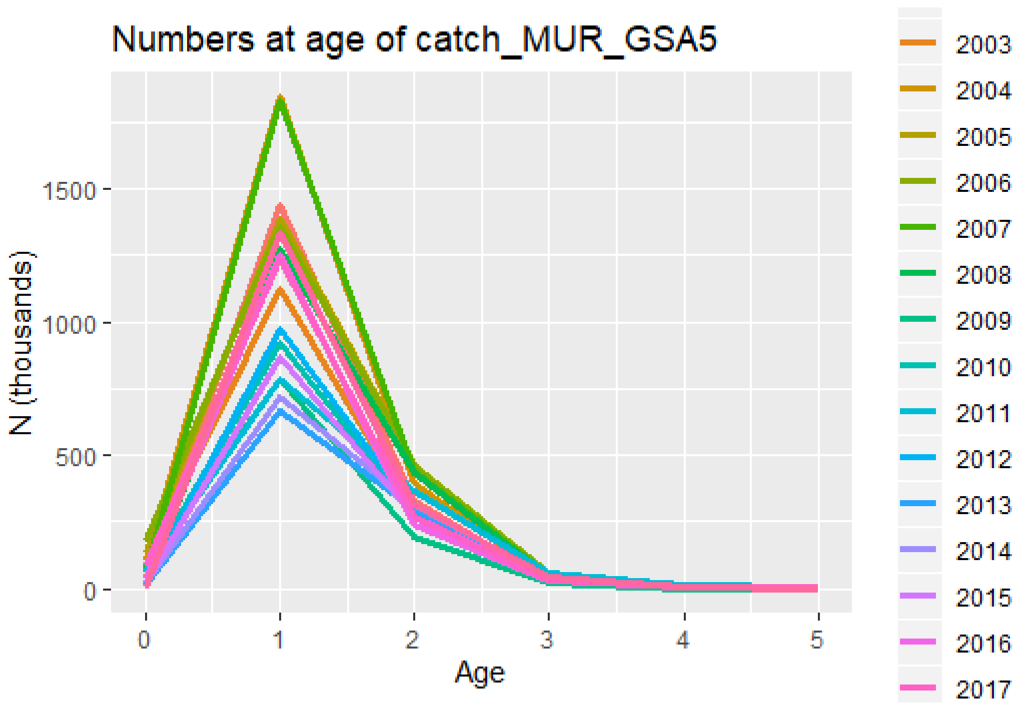


Figure 6.4.2.3. Striped red mullet in GSA 5. Catch-at-age.

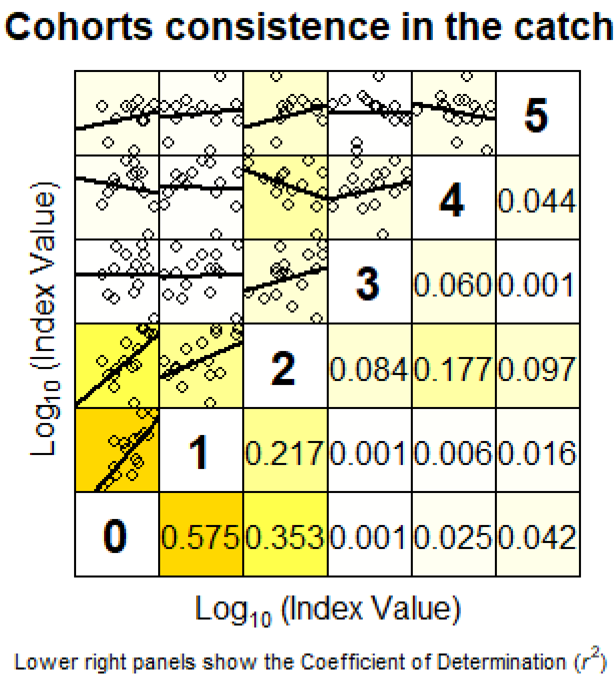


Figure 6.4.2.4. Striped red mullet in GSA 5. Cohort consistency for the commercial catches.

6.4.2.2 Effort

Fishing effort, as days at sea, by fishing gear (OTB and GTR) is shown in Figure 6.4.2.5 and Table 6.4.2.1. 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 considerably lower than the rest of the data series and thus this should be checked (see Quality section). There are some French landings reports assigned to this GSA which may be an error than should be reviewed.

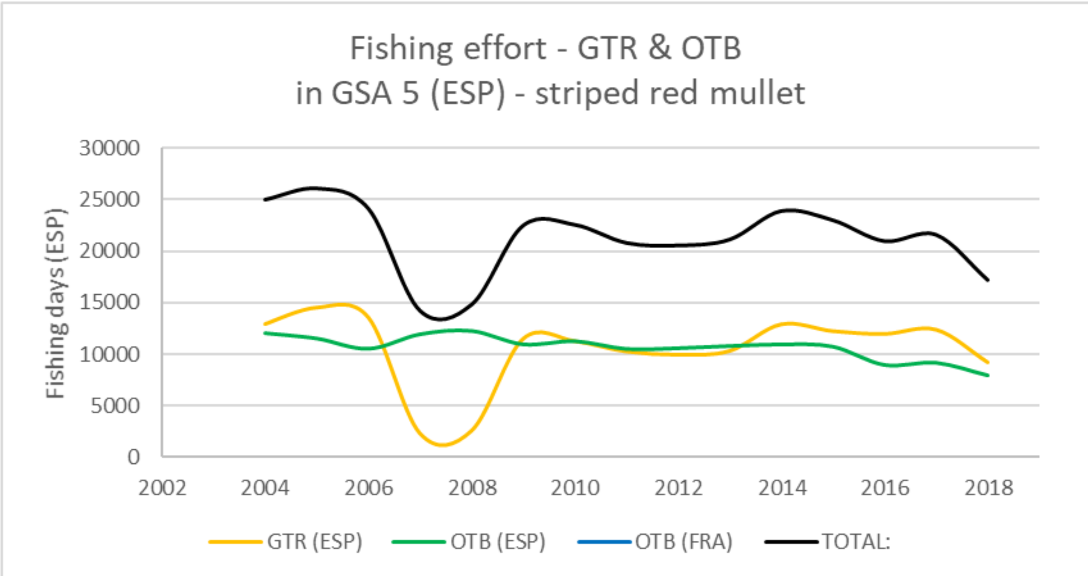


Figure 6.4.2.5. Fishing effort (in fishing days) for the fleet operating in GSA 5: trawlers (OTB) and trammel net (GTR).

Table 6.4.2.1. Fishing effort (in fishing days) for the fleet operating in GSA 5: trawlers (OTB) and trammel net (GTR).

YEAR	GTR (ESP)	OTB (ESP)	OTB (FRA)	**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	7	**20926**
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 has been computed using the methodology described by Grosslein and Laurec (1982).

Density and biomass indices showed variations along the data series, with high values for 2007 and 2017 (Figure 6.4.2.6). Due to the large variability found in the indices for some of the years, their variance were included in the assessment in order to weight the data. Length frequency distributions are shown in Figure 6.4.2.7 and table 6.4.2.2. 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 6.4.2.8). Cohorts showed no consistency (Figure 6.4.2.9).

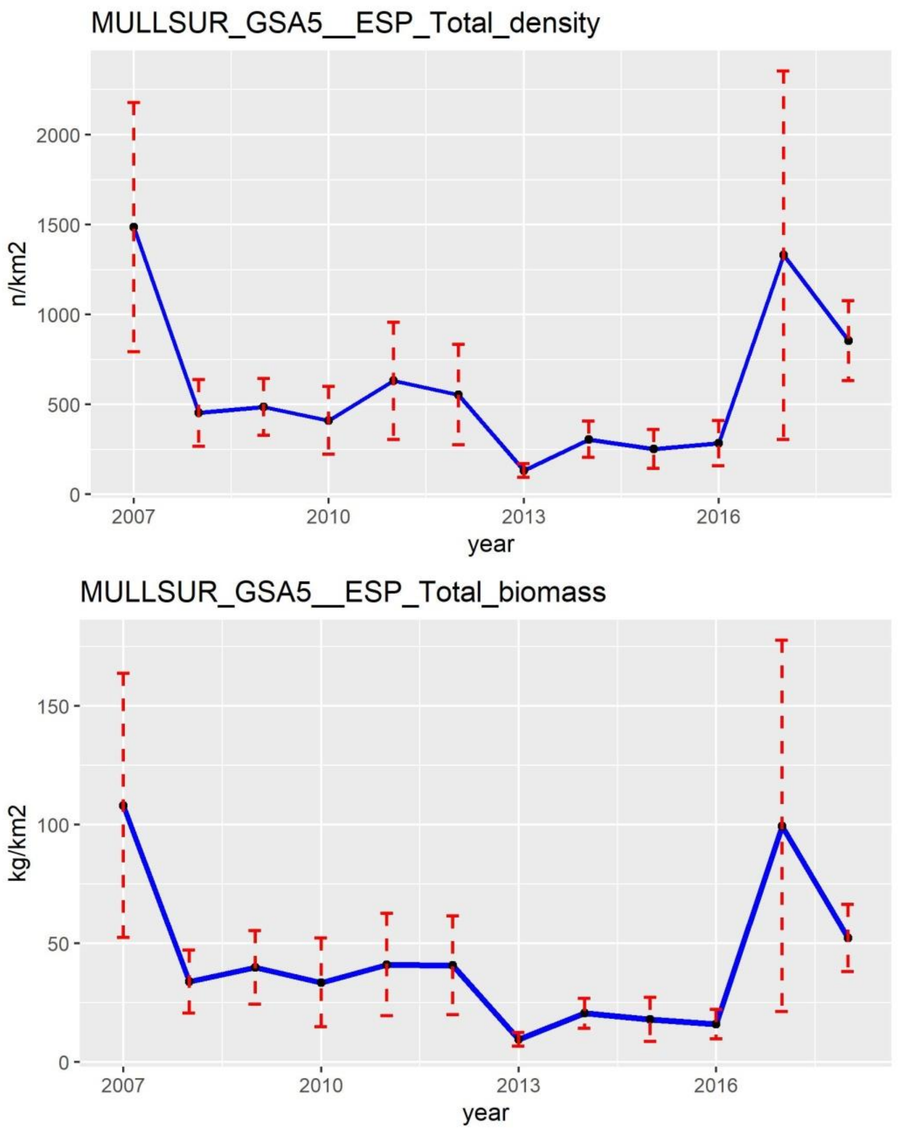


Figure 6.4.2.6. Striped red mullet in GSA 5. MEDITS abundance (n/km^2) and biomass (kg/km^2) indices over 2007-2018.

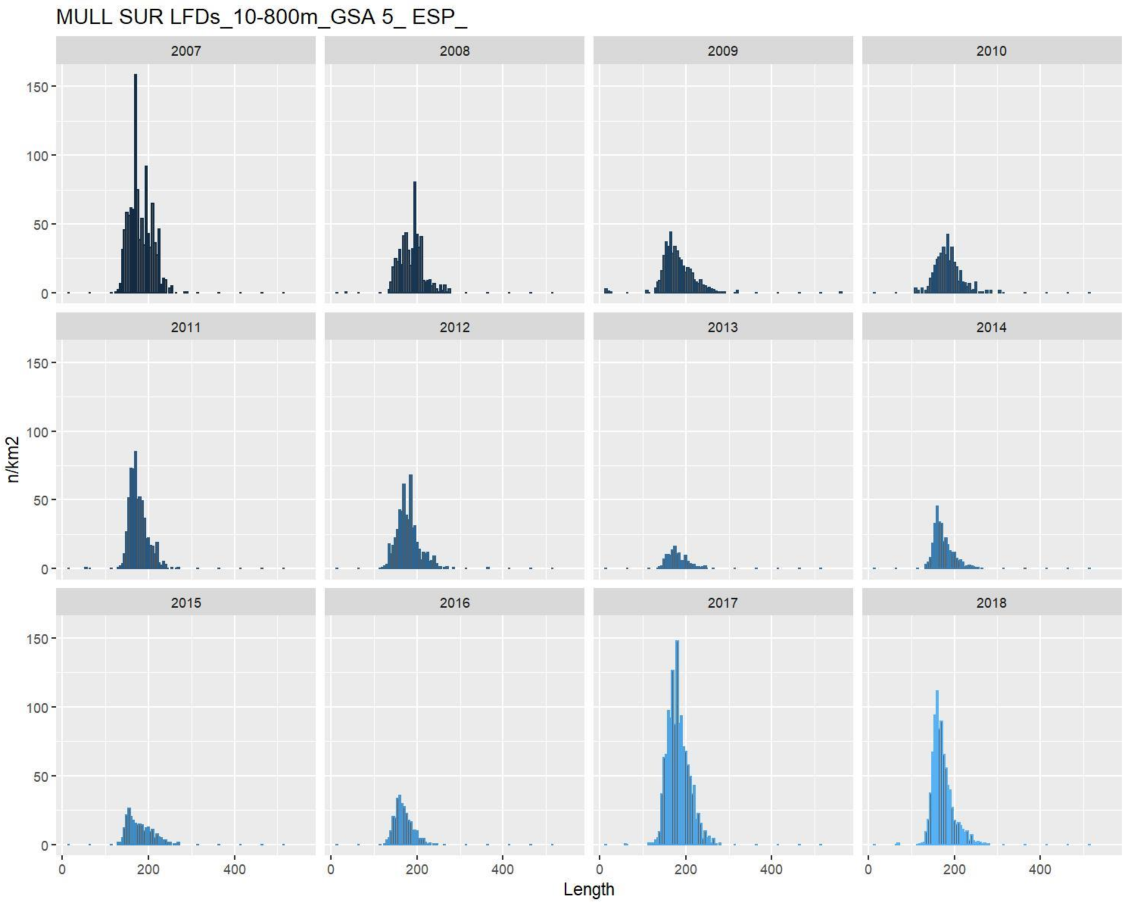


Figure 6.4.2.7. Striped red mullet in GSA 6. MEDITS length frequency distribution (n/km^2).

Table 6.4.2.2. 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.

Year/age	0	1	2	3	4	5+
2007	0.4	757.4	290.2	12	0.9	0.3
2008	0.001	358.7	177.5	19.1	1.2	0.001
2009	1.6	331	108.6	17.5	1.7	1.9
2010	7.3	281.7	100.2	11.3	2.4	1.8
2011	0.001	525.1	106.8	2.4	0.2	0.001
2012	1.5	438.3	100.1	9	1	0.5
2013	0.001	100.9	29.6	1.6	0.001	0.001
2014	0.001	257	45.5	3.2	0.001	0.001
2015	0.001	181.4	64.3	5.6	0.6	0.001
2016	0.2	255.5	28.7	0.4	0.001	0.001
2017	1.9	962.8	341.8	21.3	0.9	0.001
2018	0.8	731.8	108.4	10.7	0.9	0.001

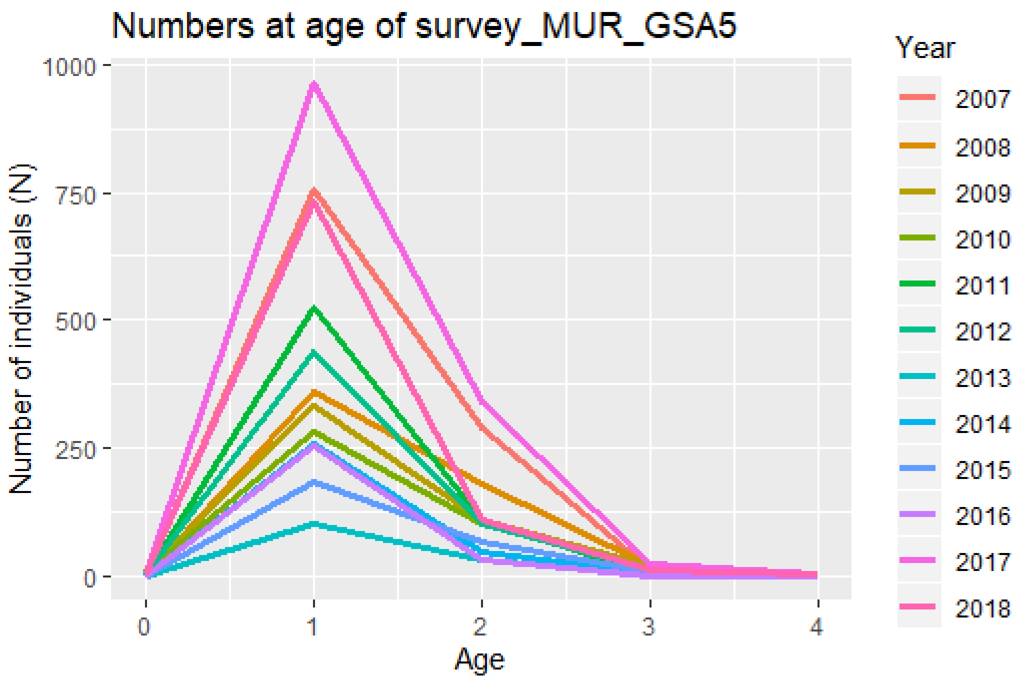


Figure 6.4.2.8. Striped red mullet in GSA 6. Age composition of MEDITS estimated by length slicing from length frequency distribution n/km^2).

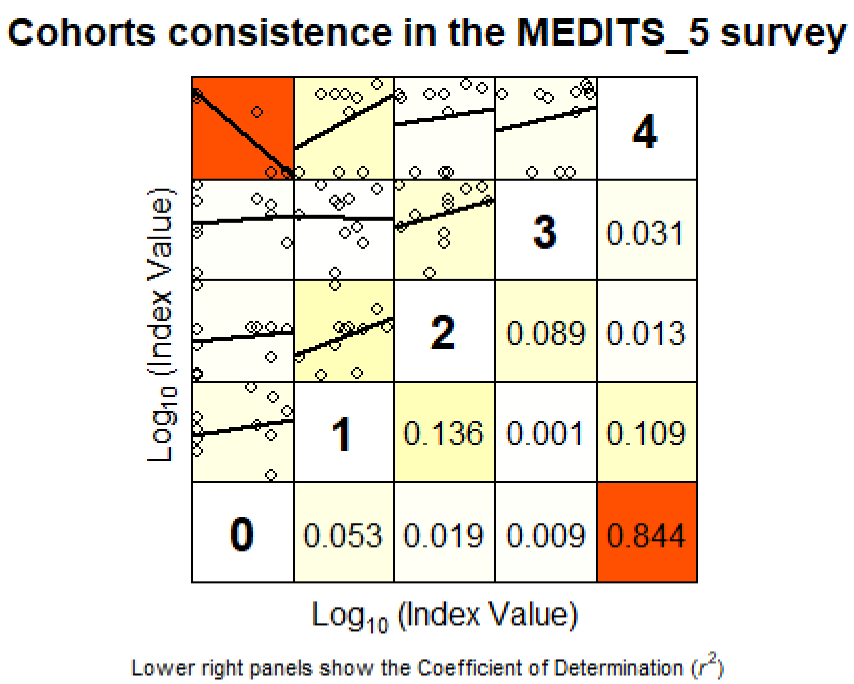


Figure 6.4.2.9. Striped red mullet in GSA 5. Cohort consistency for the MEDITS data.

6.4.3 Stock assessment

Striped red mullet in GSA 5 was assessed with XSA (Method 1) and a4a (Method 2). Advice and short term forecast are given based on a4a.

Method 1: XSA

Input data come from the DCF. Striped red mullet 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 shrinkage (Figure 6.4.3.1). The final settings considered were the following:

fse	Rage	qage	shk.n	shk.f	shk.yrs	shk.ages
1.5	0	3	TRUE	TRUE	3	2

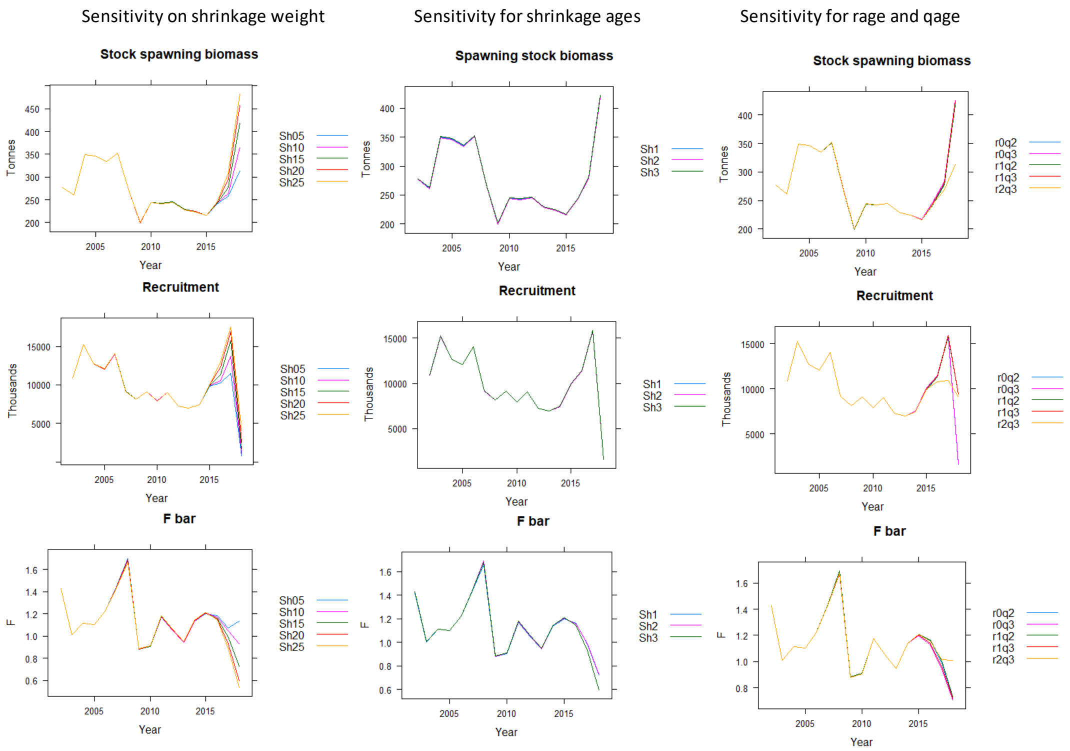


Figure 6.4.3.1. Striped red mullet in GSA 5. XSA sensitivity analyses consdering different combinations for shrinkage.

Residuals showed high values for age 4 but not a significant trend for any of the ages, and low values for the rest of the ages (Figure 6.4.3.2). Retrospective analysis did not show any trend (Figure 6.4.3.3).

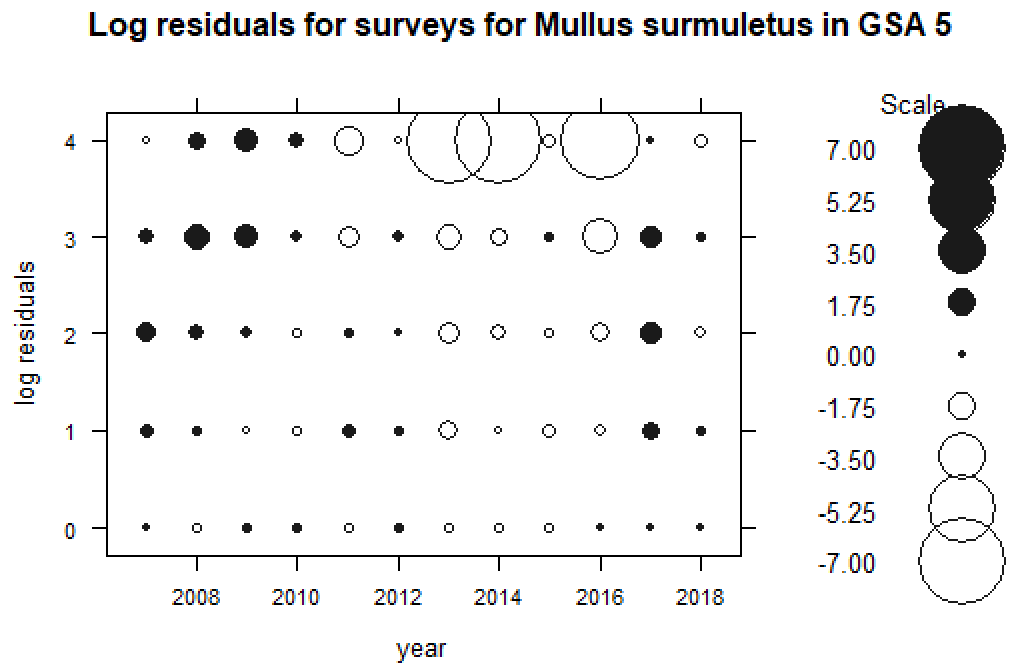


Figure 6.4.3.2 Striped red mullet in GSA 5. Residuals pattern of MEDITS survey residuals at age 4+ in 2014,2015 and 2016 are from dummy values set arbitrarely to 0.001.

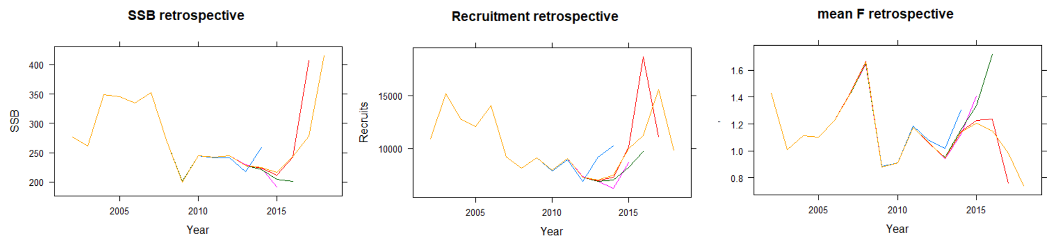


Figure 6.4.3.3 Striped red mullet in GSA5. XSA retrospective analysis.

XSA results for striped red mullet in GSA5 showed a clear decreasing tren for the last years and an increasing trend in recruitment and SSB (Figure 6.4.3.4, Table 6.4.3.1).

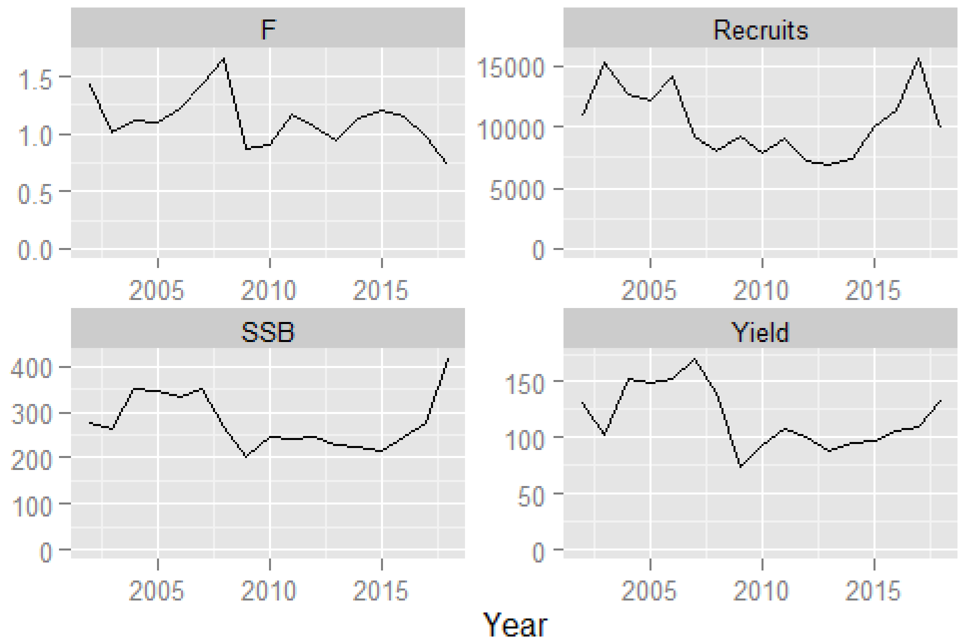


Figure 6.4.3.4. Striped red mullet in GSA 5. XSA assessment summary results.

Table 6.4.3.1. Striped red mullet in GSA 5. XSA assessment summary results. Biomass, catch and SSB in tonnes, recruits in thousands, F_{bar} ages 1-2.

	Biomass	Catch	SSB	Recruits	Fbar
2002	494.5	131.7	276.8	10884.7	1.43
2003	519.8	101.6	261.1	15217.4	1.01
2004	603.8	152.9	349.4	12719.6	1.11
2005	575.7	148.5	346.0	12085.9	1.10
2006	559.6	152.9	334.4	14078.2	1.22
2007	526.5	170.1	352.4	9161.4	1.43
2008	431.0	139.2	268.4	8130	1.66
2009	364.7	73	200.4	9130	0.88
2010	394.8	93.2	244.7	7904.3	0.91
2011	404.9	107.4	242.2	9038.1	1.18
2012	390.4	100.4	244.8	7277.5	1.06
2013	374.8	87.9	228.5	6963.8	0.95
2014	373.3	95.3	224.3	7453.5	1.14
2015	395.4	96.6	216.0	9961.5	1.21
2016	446.6	106.5	244.0	11259.2	1.15
2017	574.1	109.9	277.5	15610.6	0.98
2018	621.6	132.4	414.8	9844	0.74

From XSA results, $F_{ref,1-2}$ in the last years (2016-2018) = 0.96; and $F_{0.1}$= 0.42 (from YpR). According to these values, F/ $F_{0.1}$= 2.3, thus, the stock is considered overexploited.

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 survey and 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.

```
qmod <- list(~ factor(replace(age,age>2,2)))
fmod <- ~ s(replace(age,age>2,2), k=3) + s(year,k=6)
srmod <- ~factor(year)
```

Figure 6.4.3.5 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 in the last two years. Recruitment showed the highest values in 2017 and the lowest in 2018. SSB showed an increasing trend in the last year.

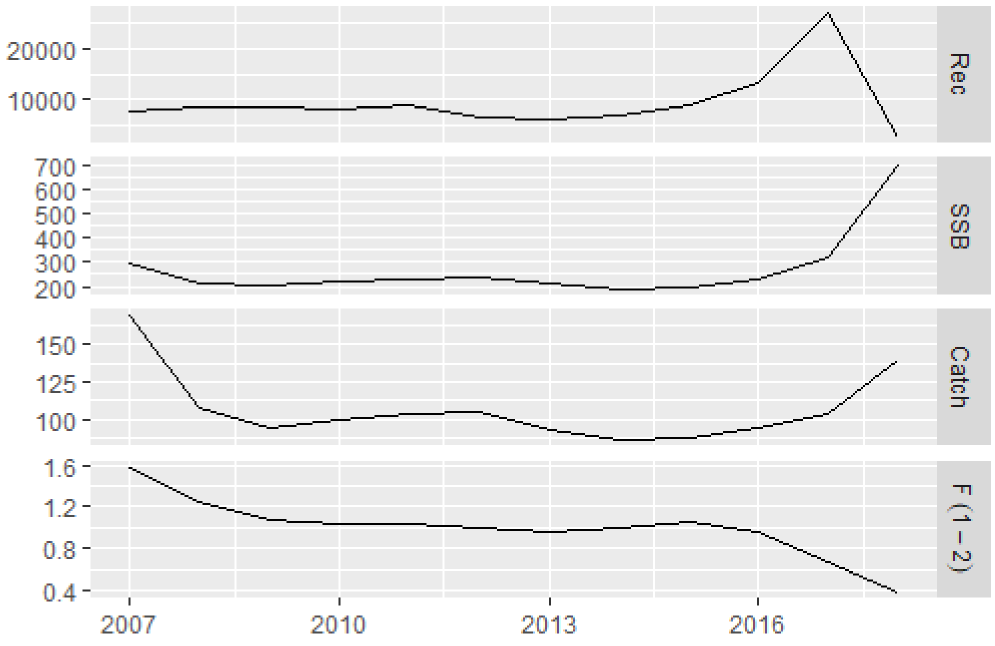


Figure 6.4.3.5. Striped red mullet in GSA 5. Stock summary from the a4a model: recruitmend (thousands), SSB (Stock Spawning Biomass, tonnes), catch (tonnes) and fishing mortality for ages 1 to 2).

Figure 6.4.3.6 and 6.4.3.7 show the estimated fishing mortality by age and year and estimated catchability by age and year, respectively.

Table 6.4.3.2. Striped red mullet 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 1-2.

	Biomass	Catch	SSB	Recruits	Fbar
2007	442.6	169.0	295.8	7727.0	1.58
2008	380.3	107.0	214.2	8303.4	1.24
2009	361.1	93.9	207.7	8524.3	1.08
2010	374.7	99.9	222.0	8037.2	1.04
2011	382.2	102.9	225.8	8690.8	1.03
2012	364.6	104.6	238.7	6295.9	1.00
2013	336.6	93.4	209.0	6078.9	0.97
2014	326.3	85.9	191.3	6750.8	1.00
2015	355.7	88.0	193.2	9024.3	1.05
2016	460.9	94.6	226.1	13040.2	0.96
2017	835.3	103.3	317.9	27229.8	0.67
2018	752.6	139.7	701.1	2452.2	0.39

Table 6.4.3.3. Striped red mullet in GSA 5. Estimation of N at age from the a4a assessment model.

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	7727.0	8303.4	8524.3	8037.2	8690.8	6295.9	6078.9	6750.8	9024.3	13040.0	27230.0	2452.2
1	3587.3	2445.7	2634.0	2707.0	2552.9	2760.6	2000.3	1931.8	2144.8	2866.2	4144.3	8670.1
2	598.3	475.5	414.9	505.0	533.6	505.2	560.4	415.0	391.4	418.6	599.0	1068.5
3	95.6	42.9	52.1	56.1	71.7	76.2	75.4	86.8	61.7	54.6	65.7	134.8
4	14.4	7.5	5.1	7.7	8.7	11.2	12.5	12.8	14.1	9.4	9.4	16.2
5	2.1	1.4	1.1	1.0	1.4	1.7	2.2	2.6	2.7	2.7	2.2	3.0

Table 6.4.3.4. Striped red mullet in GSA 5. Estimation of F at age from the a4a assessment model.

age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
1	1.16	0.91	0.79	0.76	0.76	0.73	0.71	0.74	0.77	0.71	0.50	0.29
2	1.99	1.57	1.36	1.31	1.31	1.26	1.22	1.27	1.33	1.21	0.85	0.49
3	1.99	1.57	1.36	1.31	1.31	1.26	1.22	1.27	1.33	1.21	0.85	0.49
4	1.99	1.57	1.36	1.31	1.31	1.26	1.22	1.27	1.33	1.21	0.85	0.49
5	1.99	1.57	1.36	1.31	1.31	1.26	1.22	1.27	1.33	1.21	0.85	0.49

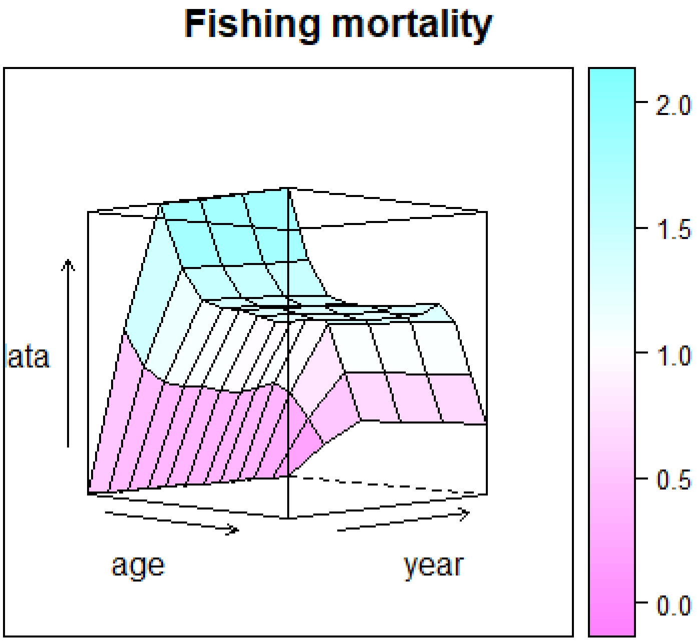


Figure 6.4.3.6. Striped red mullet in GSA 5. 3D contour plot of estimated fishing mortality by age and year.

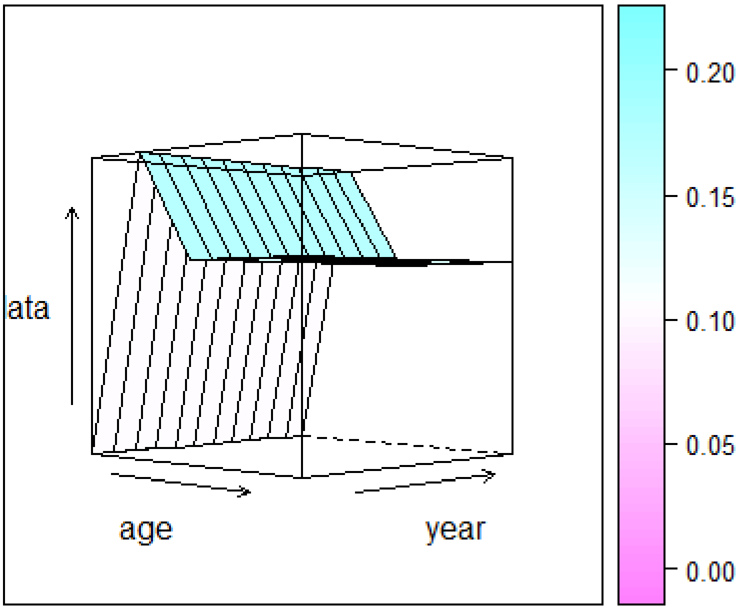


Figure 6.4.3.7 Striped red mullet in GSA 5. 3D contour plot of catchability by age and year.

Diagnostics

Figures 6.4.3.8, 6.4.3.9, 6.4.3.10 and 6.4.3.11 show several diagnostic plots for the goodness of fit of the selected model for the assessment of striped red mullet in GSA 5.

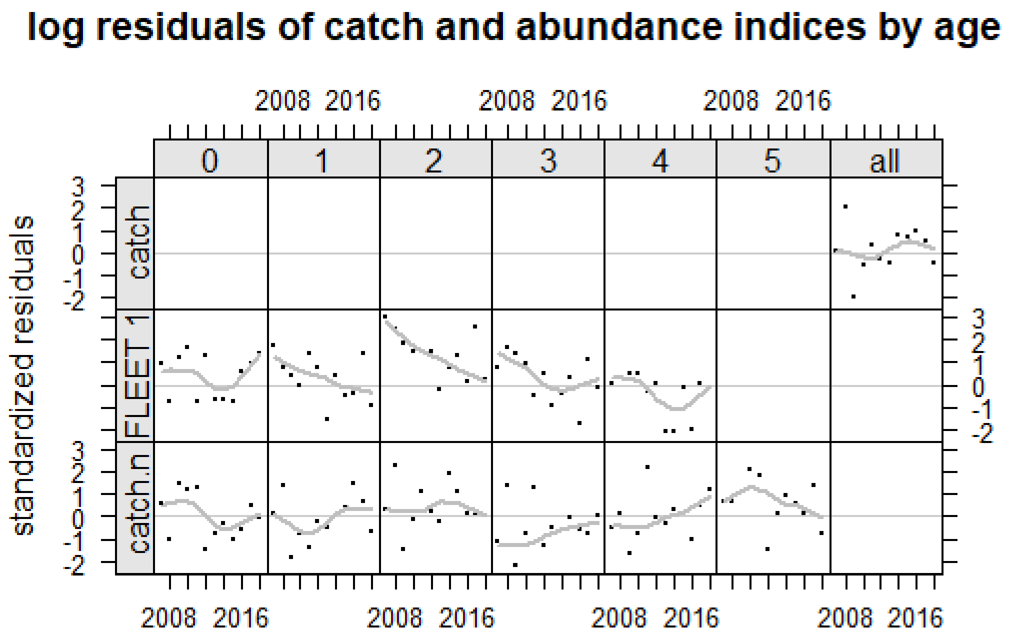


Figure 6.4.3.8. Striped red mullet in GSA 5. Standardized residuals for catch, abundance indices and for catch numbers.

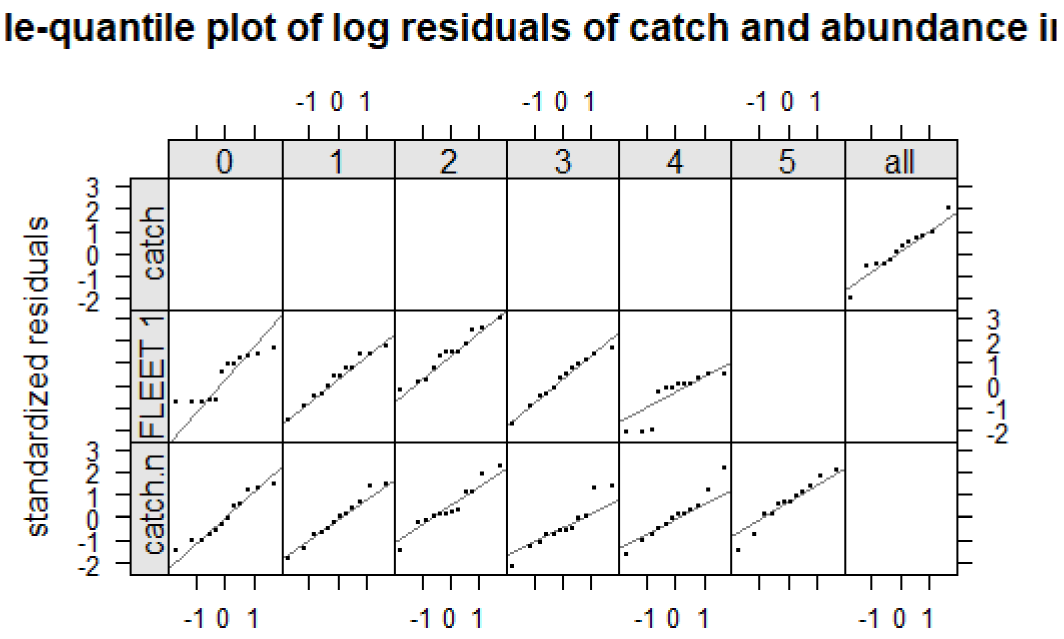


Figure 6.4.3.9. Striped red mullet in GSA 5. Quantile-quantile plot of standardized residuals for catch, abundance indices and for catch numbers.

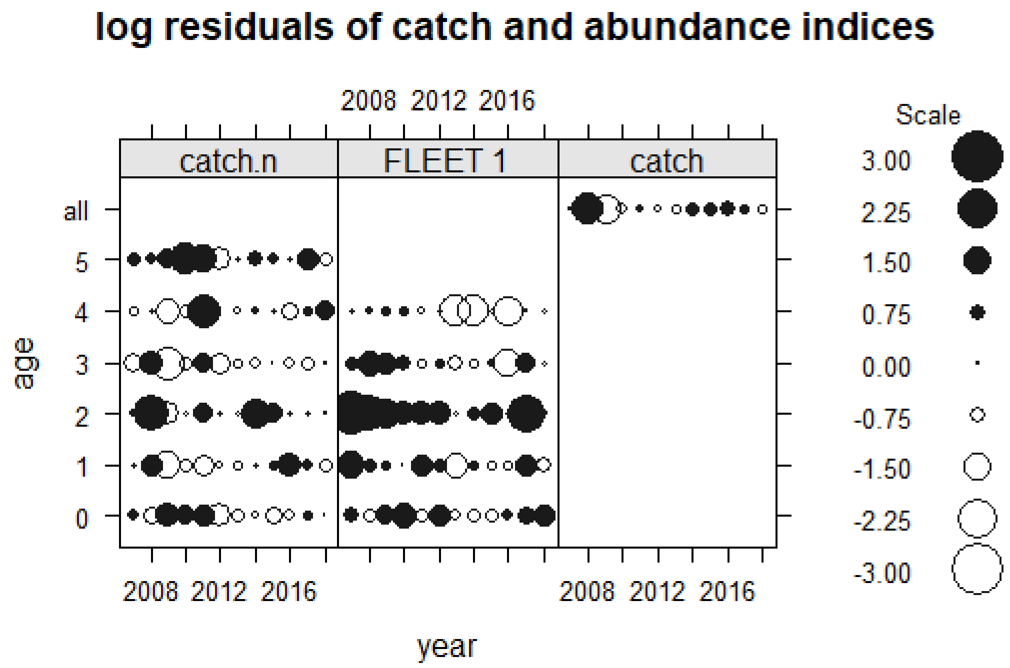


Figure 6.4.3.10. Striped red mullet in GSA 5. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

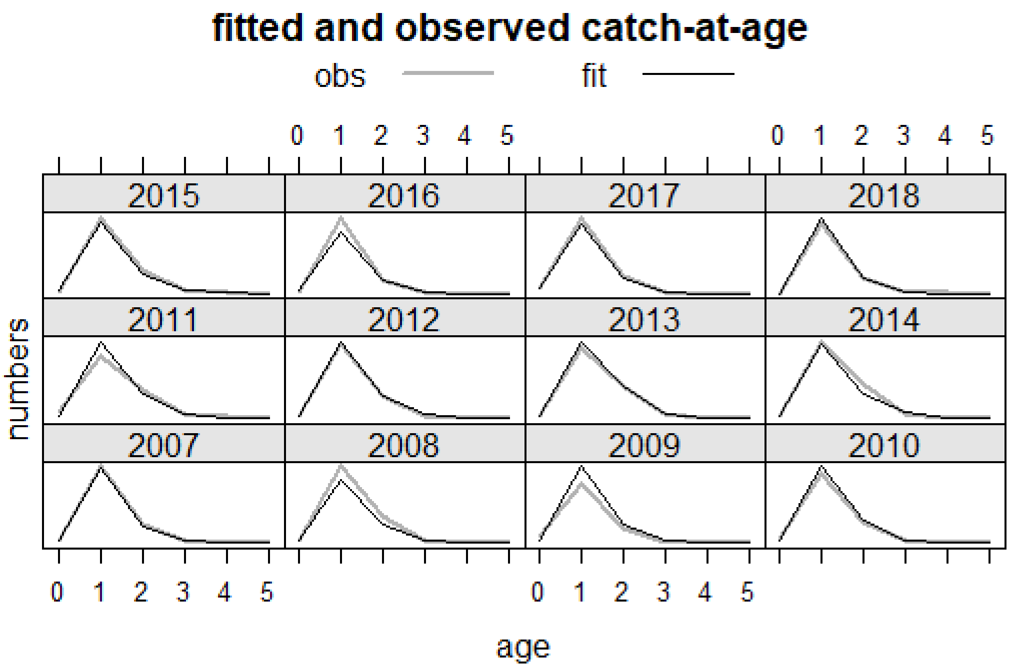


Figure 6.4.3.11. Striped red mullet in GSA 5. Fitted and observed catch at age.

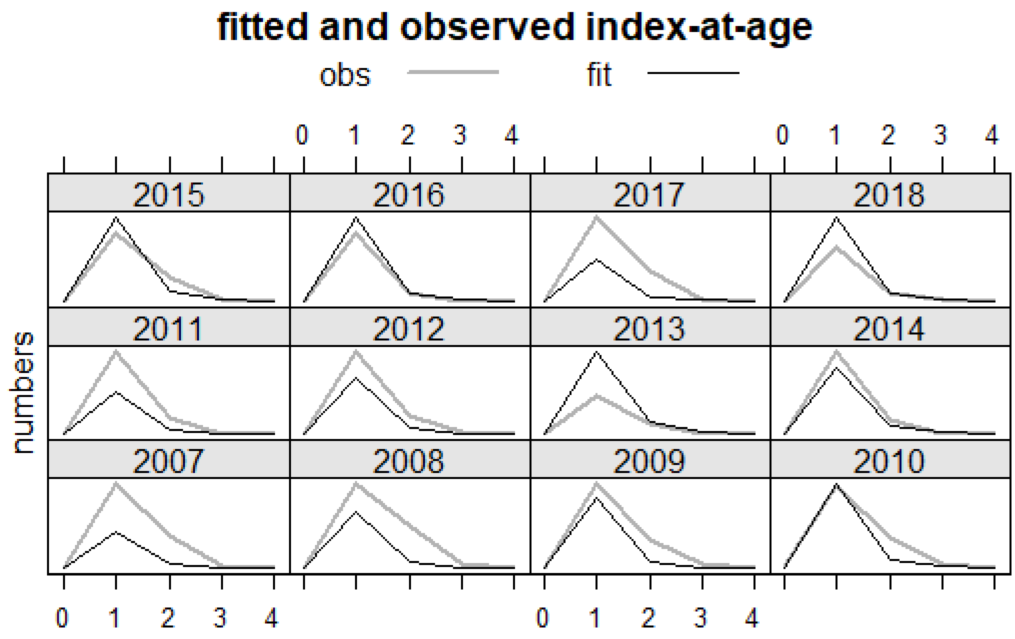


Figure 6.4.3.11. Striped red mullet in GSA 6. Fitted and observed index at age

RETROSPECTIVE

The retrospective analysis was applied up to 3 years back (Figure 6.4.3.12). They shown an underestimation trend for recruitment and SSB and an overestimation for F, probably due to the short data series available.

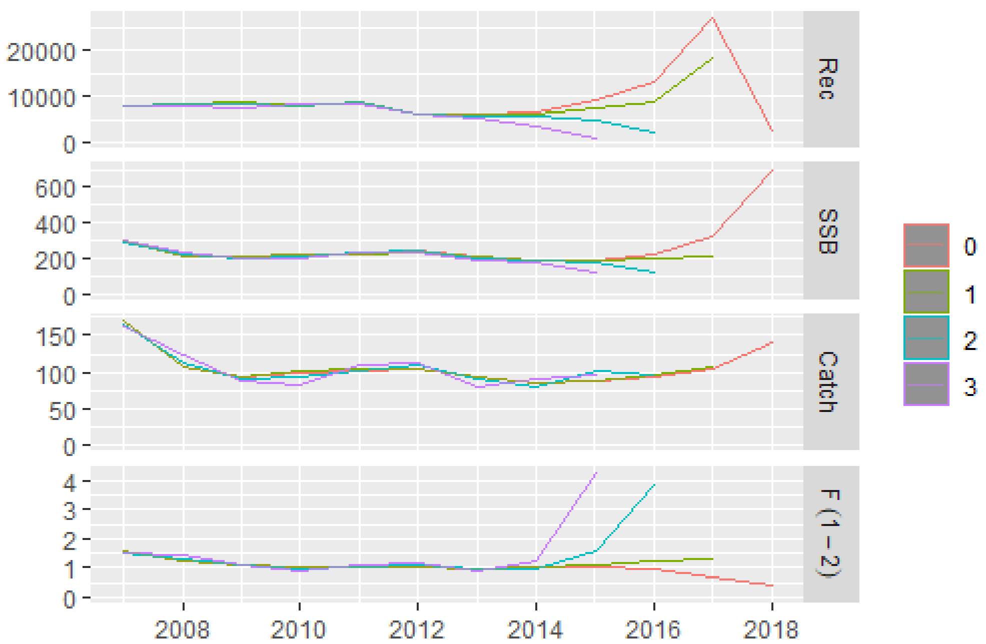


Figure 6.4.3.12. Striped red mullet in GSA 5. Retrospective analysis for the a4a model.

SIMULATIONS

Figure 6.4.3.13 shows the simulations carried out for striped red mullet in GSA 5.

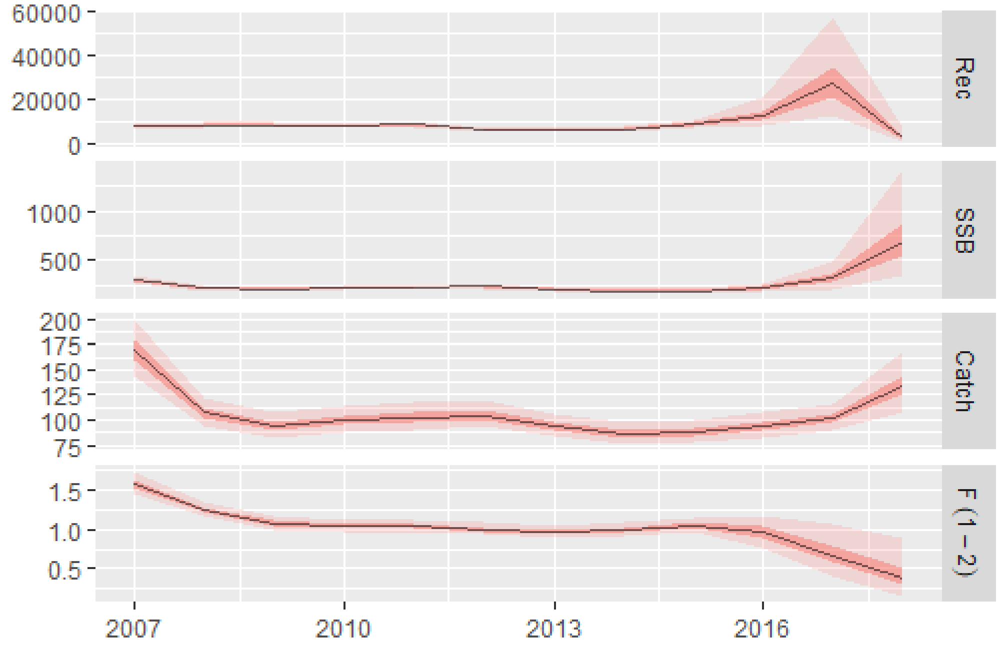


Figure 6.4.3.13. Striped red mullet in GSA 5. Stock summary of the simulated and fitted data for the a4a model.

Comparison between XSA and a4a

Figure 6.4.3.14 show the results for XSA and a4a models. They showed very similar valules in all cases, except for recruitment in the last two years, SSB in the last year and F in the last 4 years, in which a4a showed lower values than XSA. The a4a model assumes that F is separable and consistent over age in recent years, in contrast XSA assumes F at age varies and F is maintained closer to the long term mean. These differences give the different conclusions in the last two years. While it is not possible to be certain which approach is correct, the retrospective in a4a does not suggest repeated underestimation of F, rather the opposite. Overall it was decided to use the a4a model. Overall it must be considered that the terminal F is uncertain.

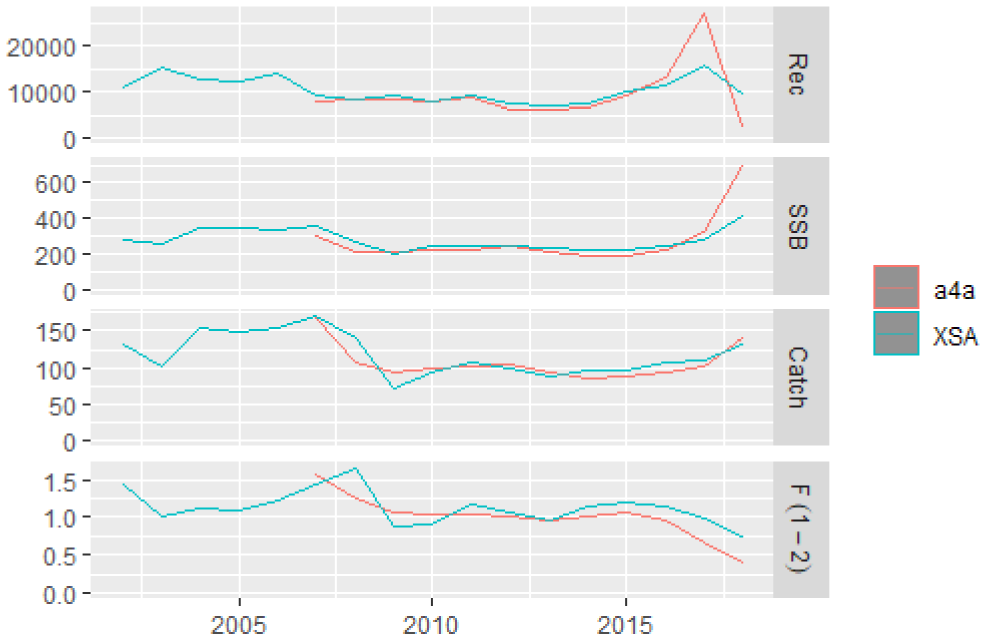


Figure 6.4.3.14. Striped red mullet in GSA 5. Results for the XSA and a4a models: recruitmend (thousands), SSB (Stock Spawning Biomass, tonnes), catch (tonnes) and fishing mortality for ages 1 to 2).

6.4.4 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. $F_{0.1}$ had been calculated using the FLBRP package of the FLR library on the assessment results, with a value of 0.39. FLBRP allows Yield per Recruit analysis and the estimation of f-based reference points. Using the assessment the value of $F_{0.1}$ was calculated equal to 0.42.

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. 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 2018 and 2019 was estimated as the geometric mean of the timeseries. Table 6.4.5.1 summarizes the results of the short term forecast.

Table 6.1.5.1 Striped red mullet GSAs 5: 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
$F_{ages\ 1-2}$ (2019)	0.39	F2018 used to give F status quo for 2019
SSB (2019)	468	Stock assessment 1 January 2019
R_{age0} (2019,2020)	8081	Geometric mean of the time series years
Total catch (2019)	133	Assuming F status quo for 2019

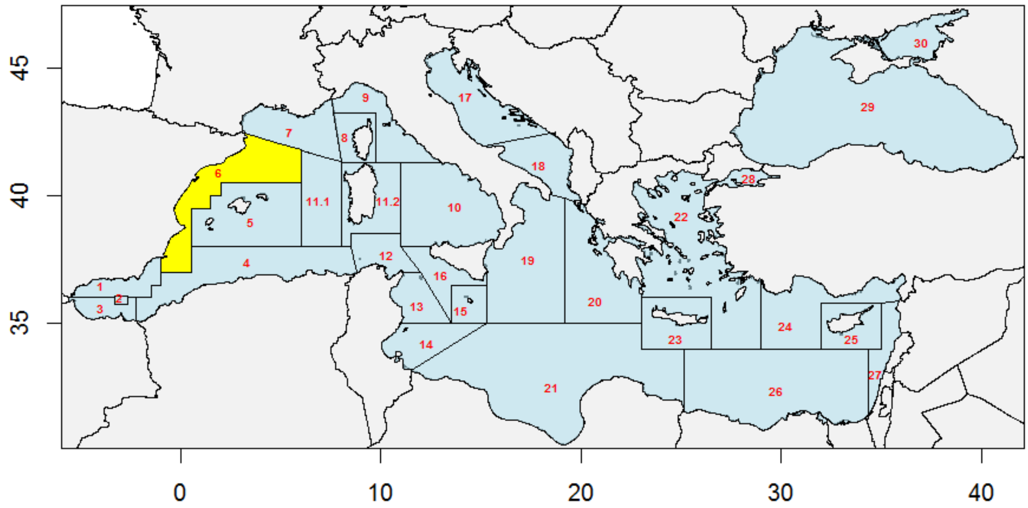
Table 6.4.5.1. Striped red mullet GSA 5. Short term forecasts showing catch options for different fishing mortalities.

*SSB at mid year

	Ffactor	Fbar	Catch 2020	Catch 2021	SSB* 2020	SSB* 2021	SSB change 2019-2021(%)	Catch change 2018-2020(%)
Zero Catch	0	0.00	0.0	0.0	406.5	488.3	4.4	-100.0
$F_{0.1}$	1.07	0.42	110.2	97.6	406.5	368.2	-21.3	-21.1
$f_{status\ quo}$	1	0.39	104.0	94.1	406.5	374.9	-19.9	-25.6
f_{upper}	1.47	0.57	140.6	111.6	406.5	336.2	-28.1	0.6
f_{lower}	0.72	0.28	78.6	77.3	406.5	402.2	-14.0	-43.8
Different f senarios	0.1	0.04	12.3	14.8	406.5	474.6	1.4	-91.2
	0.2	0.08	24.2	28.1	406.5	461.5	-1.4	-82.7
	0.3	0.12	35.6	40.0	406.5	449.0	-4.0	-74.5
	0.4	0.15	46.5	50.6	406.5	437.0	-6.6	-66.7
	0.5	0.19	57.1	60.1	406.5	425.6	-9.0	-59.2
	0.6	0.23	67.2	68.6	406.5	414.5	-11.4	-51.9
	0.7	0.27	76.9	76.1	406.5	404.0	-13.7	-45.0
	0.8	0.31	86.3	82.8	406.5	393.9	-15.8	-38.3
	0.9	0.35	95.3	88.8	406.5	384.2	-17.9	-31.8
	1.1	0.43	112.3	98.7	406.5	366.0	-21.8	-19.6
	1.2	0.46	120.4	102.8	406.5	357.5	-23.6	-13.9
	1.3	0.50	128.1	106.4	406.5	349.3	-25.3	-8.3
	1.4	0.54	135.6	109.6	406.5	341.5	-27.0	-3.0
	1.5	0.58	142.7	112.4	406.5	334.0	-28.6	2.1
	1.6	0.62	149.6	114.7	406.5	326.8	-30.2	7.1
	1.7	0.66	156.3	116.8	406.5	319.9	-31.6	11.9
	1.8	0.70	162.7	118.6	406.5	313.2	-33.1	16.5
	1.9	0.74	168.9	120.1	406.5	306.9	-34.4	20.9
	2	0.77	174.9	121.4	406.5	300.8	-35.7	25.2

6.5 Red mullet in GSA 6

6.5.1 Stock Identity and Biology



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.
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).

<u>Maturity</u>
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.

<u>Growth</u>

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 EWG18-12 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	0.80	0.57	0.48	0.43

6.5.2 DATA

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.

6.5.1.1 Catch (landings and discards)

Table 6.5.2.1.1 Red mullet in GSA 6. Landings by fishing gear over 2002-2017 (tonnes; FPO=pots and traps; GNS=gillnet; GTR=trammel net; LLS=longline; 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	1.5	137.0	0.6	923.1	1063.1
2012	0.6	0.1	76.1	0.4	992.7	1069.9
2013	1.5		98.6	1.2	1146.7	1248.0
2014		0.3	122.4	0.3	1186.2	1309.2
2015	0.9	0.8	129.7	0.8	1386.5	1518.7
2016	0.6		92.2	0.2	1580.9	1673.9
2017	0.6		109.8	0.5	1338.4	1449.3
2018			80.0		1200.7	1280.7

Table 6.5.2.1.2 Red mullet in GSA 6. Discards by fishing gear (left) and total catch (right) over 2002-2017 (tonnes; GNS=gillnet; GTR=trammel net; OTB=otter bottom trawl).

	GNS	GTR	OTB	DISCARDS
2005			0.0	0.0
2007		0.0		0.0
2008			0.1	0.1
2009		0.0	0.0	0.0
2010		0.0	0.4	0.4
2011	0.0	0.0	5.4	5.4
2012	0.0	0.0	21.9	21.9
2013		0.0	14.2	14.2
2014	0.0	0.0	3.3	3.3
2015	0.0	0.0	51.5	51.5
2016		0.0	30.2	30.2
2017			14.7	14.7
2018			43.9	43.9

	CATCH
2002	305.4
2003	1400.0
2004	919.5
2005	995.0
2006	1387.8
2007	1183.6
2008	872.2
2009	520.9
2010	514.5
2011	1068.5
2012	1091.8
2013	1262.2
2014	1312.5
2015	1570.1
2016	1704.1
2017	1464.0
2018	1324.9

Table 6.5.2.1.3 Red mullet in GSA 6. Landings: size structure by gear (TL cm; GTR=trammel net, 2009-2017; OTB=otter bottom trawl, 2002-2017).

	2009 GTR	2010 GTR	2011 GTR	2012 GTR	2013 GTR	2014 GTR	2015 GTR	2016 GTR	2017 GTR	2018 GTR
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	4.1	0	0	1.3	0	0	0	0
10	0	0	9.0	0	0.3	1.3	2.9	0	2.3	0.2
11	0.1	0	0	0.1	0	1.9	5.6	0	2.5	2.5
12	0.1	0	8.2	0	0	6.6	11.7	5.4	2.2	4.4
13	1.9	2.4	58.8	1.9	38.79	31.5	81.0	40.5	17.6	43.8
14	8.3	8.9	337.1	26.5	190.3	104.7	196.8	121.1	66.9	158.9
15	25.1	32.8	652.4	106.7	350.8	259.2	337.0	271.5	170.2	294.6
16	29.0	56.0	391.7	194.2	413	298.2	451.6	265.8	224.1	298.3
17	28.2	65.3	214.3	177.5	381.6	319.6	386.6	281.0	219.2	217.2
18	22.0	34.9	210.0	148.9	180.6	320.1	290.9	141.0	207.2	171.8
19	13.9	31.4	231.1	92.0	114.7	223.4	184.1	119.5	169.9	120.5
20	8.1	20.0	124.5	70.2	38.86	133.0	80.9	88.0	102.6	51.1
21	8.1	11.3	51.9	68.6	15.04	72.2	36.7	54.3	97.3	30.2
22	5.3	7.9	27.7	40.7	9.574	28.7	21.8	29.4	56.1	18.4
23	3.8	5.6	17.0	22.6	4.132	11.7	18.9	10.4	48.7	10.6
24	2.3	2.3	8.7	17.2	3.935	3.9	5.8	6.7	25.5	3.0
25	1.8	1.7	3.0	5.9	1.019	3.5	5.2	2.5	10.4	0.9
26	1.1	0.4	2.9	4.7	1.503	0.8	4.5	0.4	2.5	0.4
27	0.1	0.1	1.0	3.1	0.138	0	2.7	0	0.5	0
28	0.4	0	0	0.7	0.994	0	0.8	0	0	0
29	0	0	0	0.1	0	0	0.4	0	0	0
30	0	0	0	0	0	0	0	0	0	0

Table 6.5.2.1.3 cont.

	2002 OTB	2003 OTB	2004 OTB	2005 OTB	2006 OTB	2007 OTB	2008 OTB	2009 OTB	2010 OTB	2011 OTB
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	20.7	0	0	0	0	0	0	0	0	0
5	1139.9	0	15.3	0	4.3	0	28.1	0	0.7	0
6	1099.4	23.5	107.5	271.6	20.9	0	1742.5	0	0.7	0
7	1401.7	342.0	859.3	624.3	150.0	0	1911.2	20.3	0	14.0
8	2689.1	1428.6	2656.8	838.0	984.1	88.6	590.2	30.4	13.2	6.2
9	2712.5	3082.3	3963.3	2655.0	1988.6	851.8	309.5	129.8	113.5	399.3
10	1766.8	4576.2	3200.0	4077.2	4691.7	2369.6	26.1	423.5	219.3	778.8
11	1111.5	4778.0	3896.6	4635.1	5083.4	3779.6	1295.4	845.7	320.2	1100.2
12	848.6	3834.4	3129.2	3182.5	5122.7	4559.6	2696.9	1391.6	552.3	1167.9
13	1002.5	3741.1	3313.2	2991.5	5942.1	4410.7	3270.8	1646.6	783.9	1878.8
14	963.4	4251.0	2843.1	2747.4	5861.7	4465.3	3509.2	1194.4	1148.5	2777.4
15	958.7	3419.9	2404.1	3085.8	5169.9	4560.5	3414.6	1037.2	1573.5	2795.8
16	583.4	2958.6	2474.3	2668.8	3592.1	3268.6	2452.1	958.6	1668.7	2569.1
17	400.7	2906.8	2323.8	2390.8	2533.9	2990.8	1719.9	1059.7	952.6	1380.0
18	215.1	2258.0	1195.6	1219.6	1253.6	1540.9	1051.3	611.2	800.8	769.1
19	109.0	1593.4	482.4	488.1	722.6	788.1	599.5	633.8	771.7	696.6
20	77.1	605.4	195.4	308.1	355.1	147.2	392.0	435.2	557.3	569.6
21	43.6	313.8	97.7	170.2	153.5	66.3	180.6	287.1	374.4	288.3
22	29.6	166.5	35.5	99.5	89.4	24.9	129.3	170.2	268.4	150.9
23	15.5	76.2	16.9	48.4	22.5	25.0	41.5	72.5	184.0	136.9
24	10.3	65.0	10.1	7.6	16.8	10.0	15.4	11.0	41.8	87.0
25	2.9	11.6	2.6	17.6	7.5	5.9	5.5	11.9	1.0	23.5
26	0.5	11.4	0.2	1.5	4.8	3.2	1.2	1.0	5.6	8.9
27	0	0	0	2.5	0.4	0.8	0	1.4	6.5	4.7
28	0	0	0	0	0.9	1.2	0	0	14.1	4.7
29	0	0	0	0	0	0	0	0	10.8	0
30	0	0	0	0	0	0	0	0	0	0

	2012 OTB	2013 OTB	2014 OTB	2015 OTB	2016 OTB	2017 OTB	2018 OTB
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	1.0	0	0	0	0	0.2
5	0	0	0	0	0	2.2	1.2
6	0	0	0	0.0	5.6	2.2	2.4
7	0	10.9	5.7	6.7	19.1	2.7	7.9
8	2.4	10.9	30.9	52.8	84.3	56.1	18.8
9	92.7	55.5	205.9	363.9	309.1	476.8	101.5
10	276.1	146.3	775.7	1166.5	1145.5	1702.8	982.0
11	820.1	701.5	1349.5	2033.5	2291.8	2839.3	2208.1
12	1192.8	1341.0	1712.9	2383.2	3910.5	3137.6	3056.4
13	1308.7	1830.7	2441.2	2772.9	4968.7	3401.6	3333.5
14	1878.8	2680.6	3382.1	3330.4	5658.1	3597.5	3342.2
15	2456.1	3583.2	3640.8	3500.2	4725.9	3698.2	3608.8
16	3338.0	3189.7	3092.1	3141.7	4056.5	3260.4	3577.1
17	2459.9	2592.8	2382.2	2463.9	2820.2	2440.7	3027.0
18	1596.4	2310.4	1814.5	2257.9	2274.6	1834.7	2097.9
19	1252.8	1183.5	1331.3	1801.1	1331.9	1391.1	1238.7
20	778.0	682.5	894.5	1205.4	1030.6	893.7	804.1
21	373.3	448.8	518.6	658.2	590.0	522.3	444.5
22	190.5	246.5	281.7	366.8	281.5	322.9	304.3
23	103.9	160.4	143.2	210.8	164.2	201.8	159.4
24	32.5	78.3	60.3	83.5	52.9	81.7	84.3
25	25.5	56.5	17.7	42.2	18.8	39.1	42.4
26	72.4	23.8	10.4	20.2	6.7	12.2	20.0
27	0	7.5	0.7	3.5	0.9	8.7	5.7
28	0	0	0	0	2.2	2.5	2.5
29	0	1.0	0	0	0	0.5	0.8
30	0	2.0	0	0	0	0	0.0

Table 6.5.2.1.4 Red mullet in GSA 6. Discards: size structure by gear (TL cm; OTB=otter bottom trawl). Data are available for 2017-2018.

	2017 OTB	2018 OTB
0	0	0
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	13.0	0
7	233.6	75.5
8	317.2	446.0
9	397.1	895.0
10	285.0	1392.5
11	134.8	366.4
12	49.5	170.8
13	46.1	112.0
14	0	34.7
15	9.4	52.0
16	40.8	5.0
17	0	7.1
18	0	0.0
19	0	8.0
20	0.4	0
21	0.8	0
22	0.0	0
23	0.4	0
24	0	0
25	0	0
26	0	0
27	0	0
28	0	0
29	0	0
30	0	0

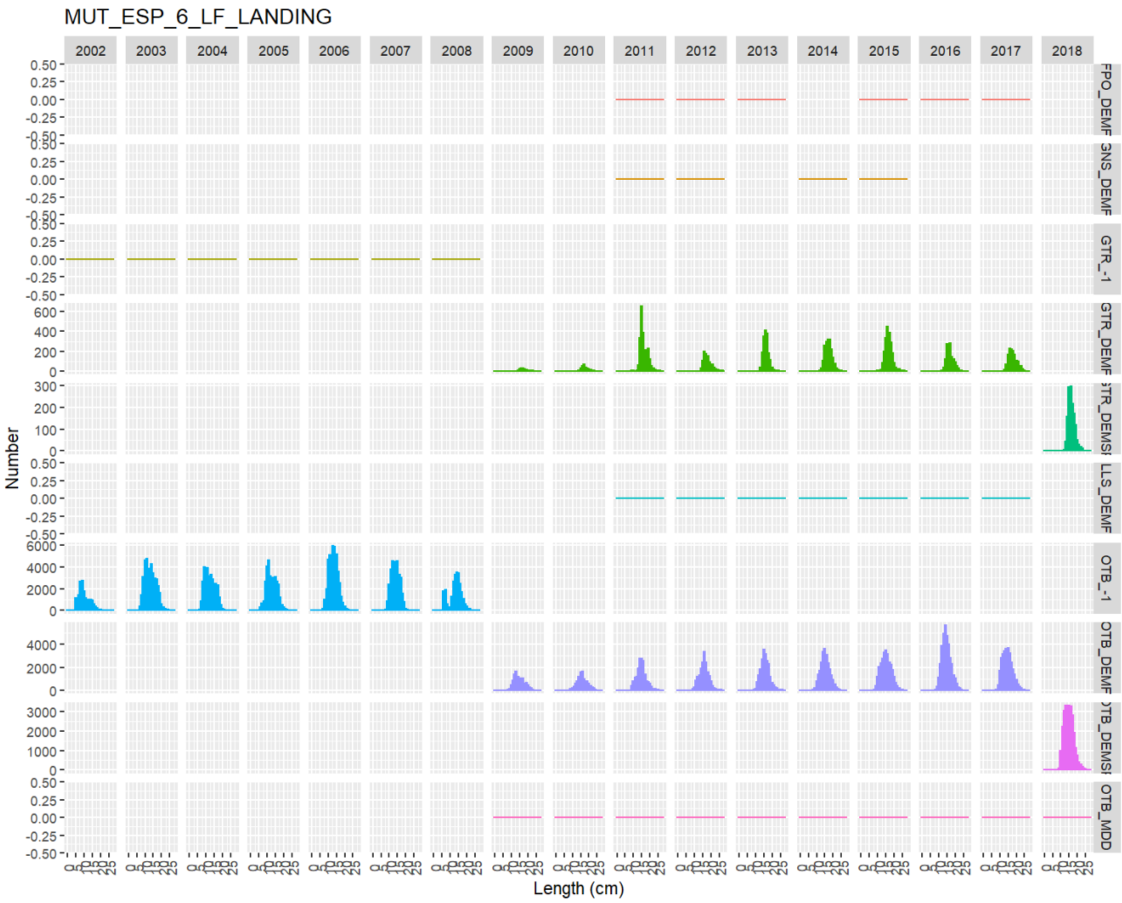


Figure 6.5.2.1.1 Red mullet in GSA 6. Catch length frequency distribution, by year and gear (TL cm).

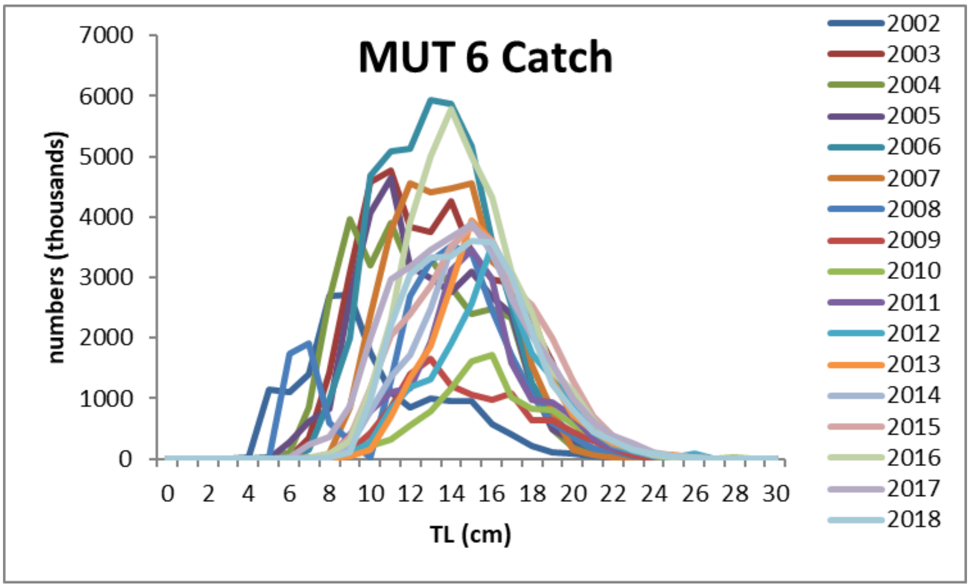


Figure 6.5.2.1.2 Red mullet in GSA 6. Catch length frequency distribution (TL cm).

Catches are combined landings and discards. SOP correction Table 6.5.2.1.5 was applied in the preparation of the input data for the a4a assessment this varied a little but was about +15% on average.

Table 6.5.2.1.5 Red mullet in GSA 6. SoP correction.

2002	1.13
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

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

age	2002	2003	2004	2005	2006	2007
0	2546.5	26.8	137.9	307.4	28.7	0.0
1	16626.0	29798.0	26935.0	24919.0	33915.0	23068.0
2	2554.2	15023.0	9972.6	11149.0	15080.0	14778.0
3	186.9	1328.8	388.0	708.6	705.0	296.2
4	15.4	100.6	14.6	33.0	34.4	23.7
age	2008	2009	2010	2011	2012	2013
0	1991.1	0.0	1.3	0.0	0.0	1.2
1	17295.0	6627.7	3062.4	11226.0	6721.5	8308.0
2	10388.0	5144.6	5796.3	13027.0	14190.0	16954.0
3	836.0	1152.9	1383.3	1796.6	1977.7	1903.9
4	24.9	36.1	81.8	189.8	194.5	209.4
age	2014	2015	2016	2017	2018	
0	0.0	0.0	6.6	20.3	4.3	
1	11753.0	15026.0	22054.0	19594.0	18566.0	
2	15998.0	17941.0	19355.0	15951.0	15283.0	
3	2436.4	3147.8	2671.9	2622.9	1921.2	
4	113.9	204.3	108.3	214.3	174.7	

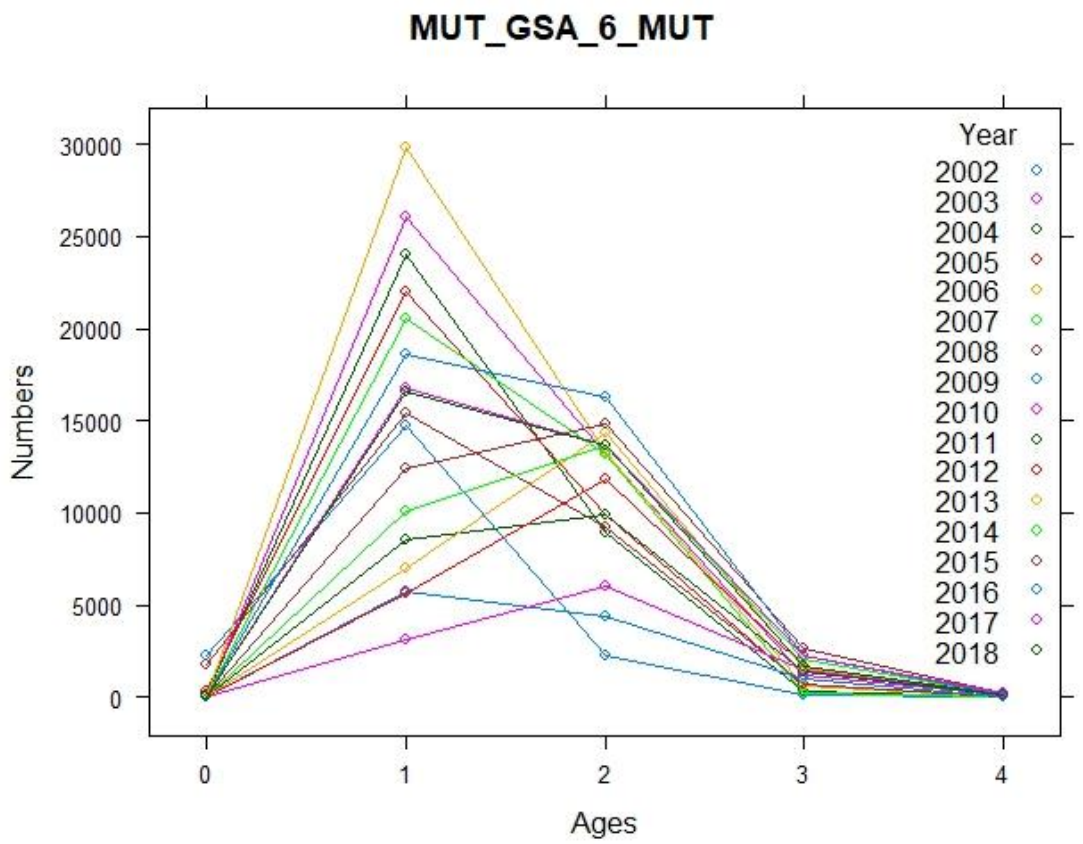


Figure 6.5.2.1.3 Red mullet in GSA 6. Catch at age, input to a4a.

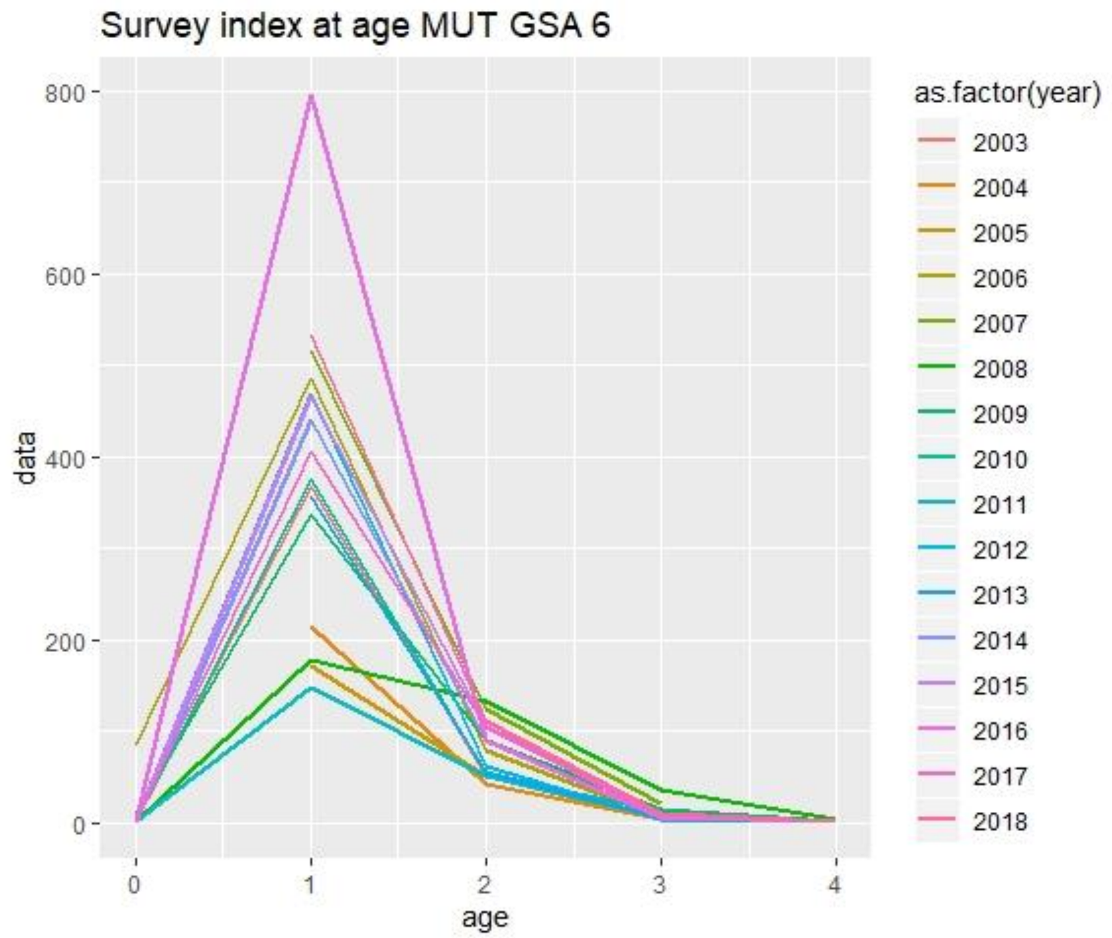


Figure 6.5.2.1.4 Red mullet in GSA 6. MEDITS survey index at age, input to a4a.

6.5.1.2 ffort

Table 6.5.2.2.1 Fishing effort in GSA 6, expressed in number of days at sea, for the 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**

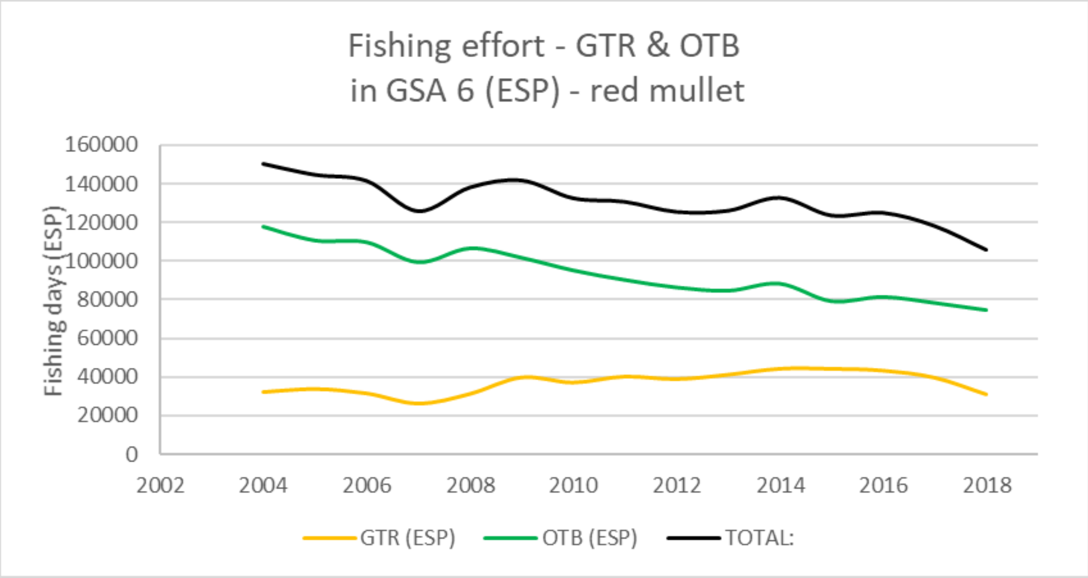


Figure 6.5.2.2.1 Fishing effort in GSA 6, expressed in number of days at sea, for the trammel net (GTR) and bottom trawl (OTB), the fishing gears that target red mullet.

6.5.1.3 Survey data

Survey indices used in this assessment originate from the MEDITS bottom trawl survey. This survey was carried out regularly in late spring, in May-June, over the period 1994-2018 (Fig. 6.5.2.3.1).

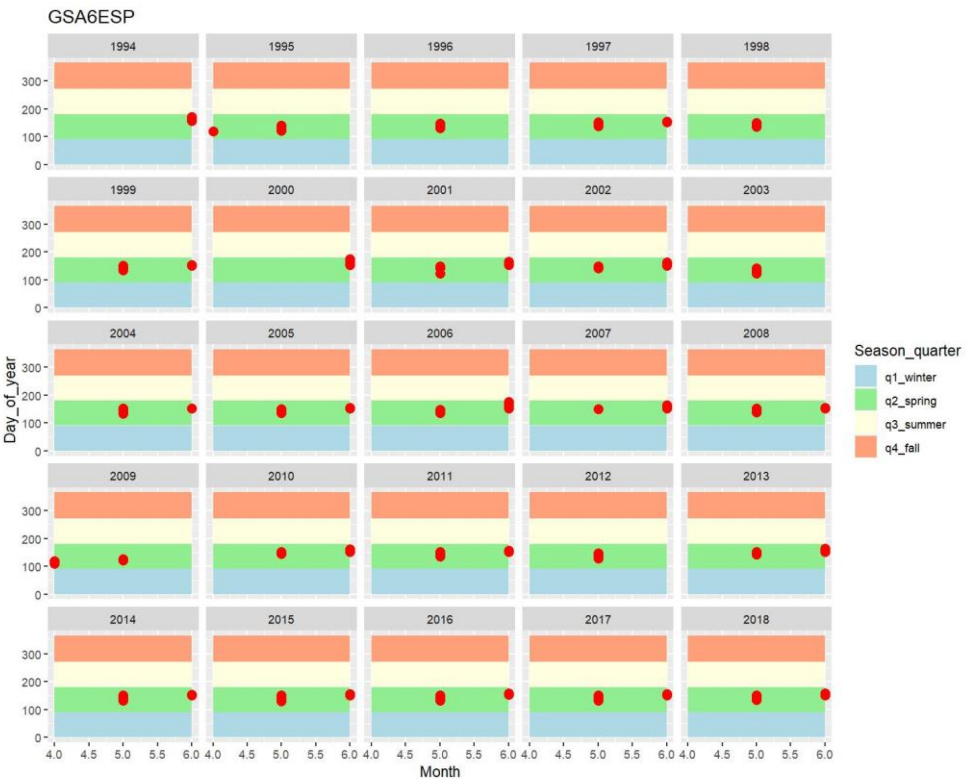


Figure 6.5.2.3.1 MEDITS survey periods in GSA 6.

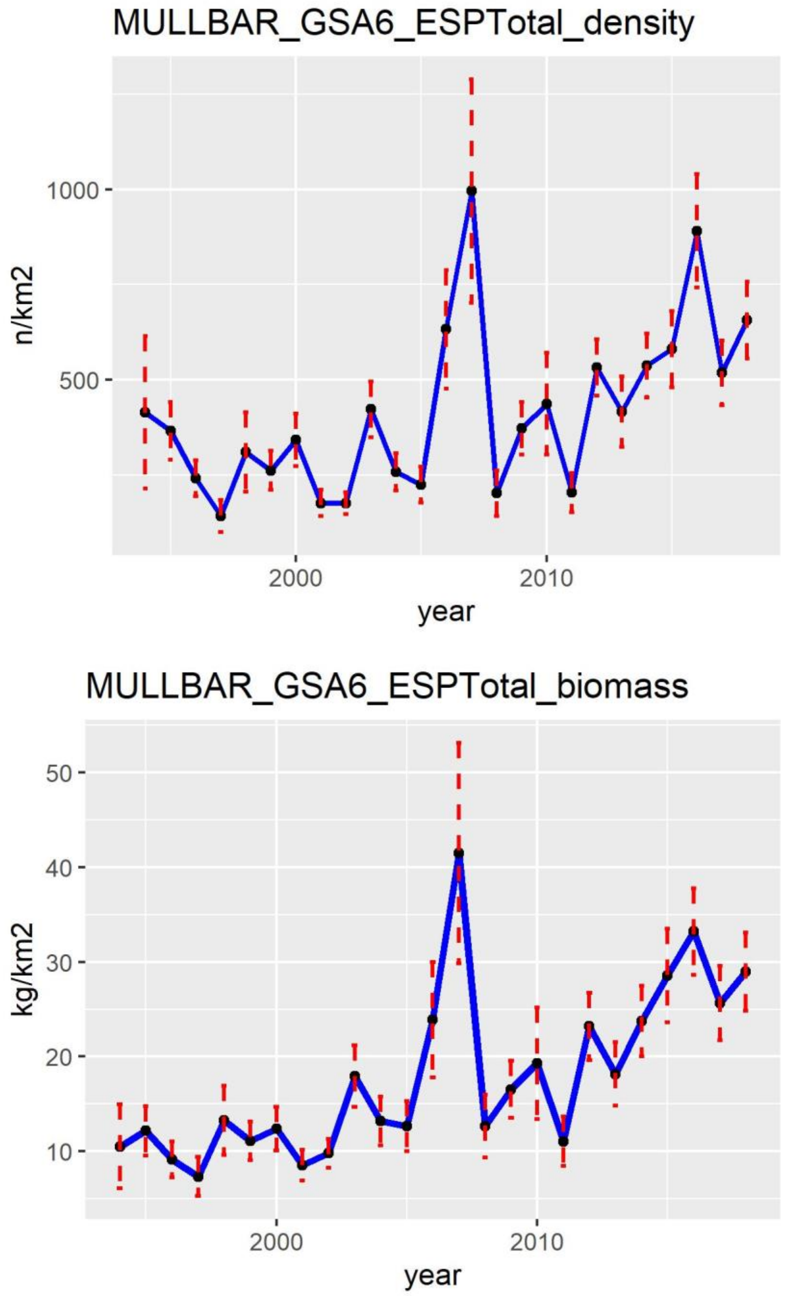


Figure 6.5.2.3.2 Red mullet in GSA 6. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2018.

Table 6.5.2.3.1 Red mullet in GSA 6. MEDITS Length frequency distribution (TL cm; n/km²)

	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	3.3	0	0	0	0
6	0	0	0	0	16.6	0	0	0	0
7	0	0	0	0	23.3	0	0	2.3	0
8	0	0.3	0	0	29.9	0	0	2.1	0
9	0	0.2	0	0	11.6	0	0.3	4.5	0.4
10	0	4.0	2.2	0	26.5	6.3	0	20.2	2.2
11	0	38.7	16.3	2.8	27.2	46.8	0.3	49.5	17.9
12	7.2	62.9	42.5	17.4	82.6	96.4	1.0	42.9	58.8
13	20.6	72.9	37.7	32.1	113.6	98.7	21.8	46.8	79.4
14	25.7	58.6	29.6	34.4	77.1	89.5	31.9	45.2	82.5
15	29.0	52.8	31.2	33.9	64.5	59.5	47.9	45.0	46.4
16	22.5	45.5	29.7	27.3	55.4	74.4	39.4	42.1	55.1
17	17.9	32.4	23.8	22.7	37.2	43.2	34.3	44.5	32.0
18	15.9	24.8	15.0	18.9	21.6	38.9	31.7	32.9	17.8
19	11.1	12.9	10.1	13.6	21.9	50.5	16.2	21.5	12.4
20	9.1	4.7	8.8	9.7	17.5	18.8	42.3	16.3	7.3
21	4.9	5.7	5.1	4.3	10.5	12.0	15.6	12.1	7.7
22	2.3	3.0	2.5	3.3	8.0	4.1	26.4	5.7	6.9
23	2.1	2.7	1.0	2.7	3.1	12.9	15.0	5.0	8.2
24	0.9	0.2	1.4	0.9	2.2	4.5	6.6	4.6	1.7
25	0.4	0.6	0.2	0	1.0	2.9	11.9	3.7	1.3
26	0	0.2	0.5	0.7	0	0	2.5	1.7	0.4
27	0	0	0.2	0	0	0	0	1.7	0
28	0	0	0	0.3	0	0	2.8	0	0
29	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0.4	0
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
0	0	0	0	0	0	0	0	0	
1	0	0	0	0.2	0.2	0	0	0	
2	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0.2	0	
7	0	0	0	0	0	0	0	0	
8	0.2	0	0	0.2	0	0	0	0	
9	0.9	0.2	0	0.4	0.2	0.4	0	0	
10	2.6	5.7	2.2	6.2	3.7	11.3	0.6	7.1	
11	4.3	30.9	19.7	28.9	14.3	69.9	2.6	38.0	

12	13.1	104.0	50.1	81.5	51.7	202.6	25.3	90.6
13	22.3	109.0	70.1	90.5	85.9	196.1	68.9	115.3
14	24.3	80.9	68.5	76.0	87.7	124.5	94.4	88.8
15	28.8	55.0	51.9	57.6	97.7	79.5	95.4	77.0
16	28.1	46.1	54.2	58.4	67.4	64.0	64.9	65.5
17	24.1	35.4	39.1	41.2	57.4	47.7	53.7	51.0
18	16.8	24.2	20.1	26.9	36.0	34.1	41.5	35.5
19	10.4	16.4	15.6	24.6	25.5	21.4	26.7	27.7
20	10.3	12.7	8.6	17.6	18.5	14.2	14.3	18.2
21	7.5	4.7	6.3	13.8	14.5	11.5	12.5	15.3
22	5.5	3.4	3.5	7.6	9.0	7.6	9.5	14.4
23	3.0	2.2	2.2	3.5	6.2	3.3	4.6	4.5
24	1.9	0.7	2.3	1.6	2.2	1.6	2.0	3.0
25	1.1	0.9	1.4	0.9	1.5	0.8	0.7	1.4
26	0.2	0.5	0	0	0.1	0	0.3	0.3
27	0	0.2	0.2	0	0	0.4	0	0.2
28	0	0.5	0	0	0	0	0	0.2
29	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0

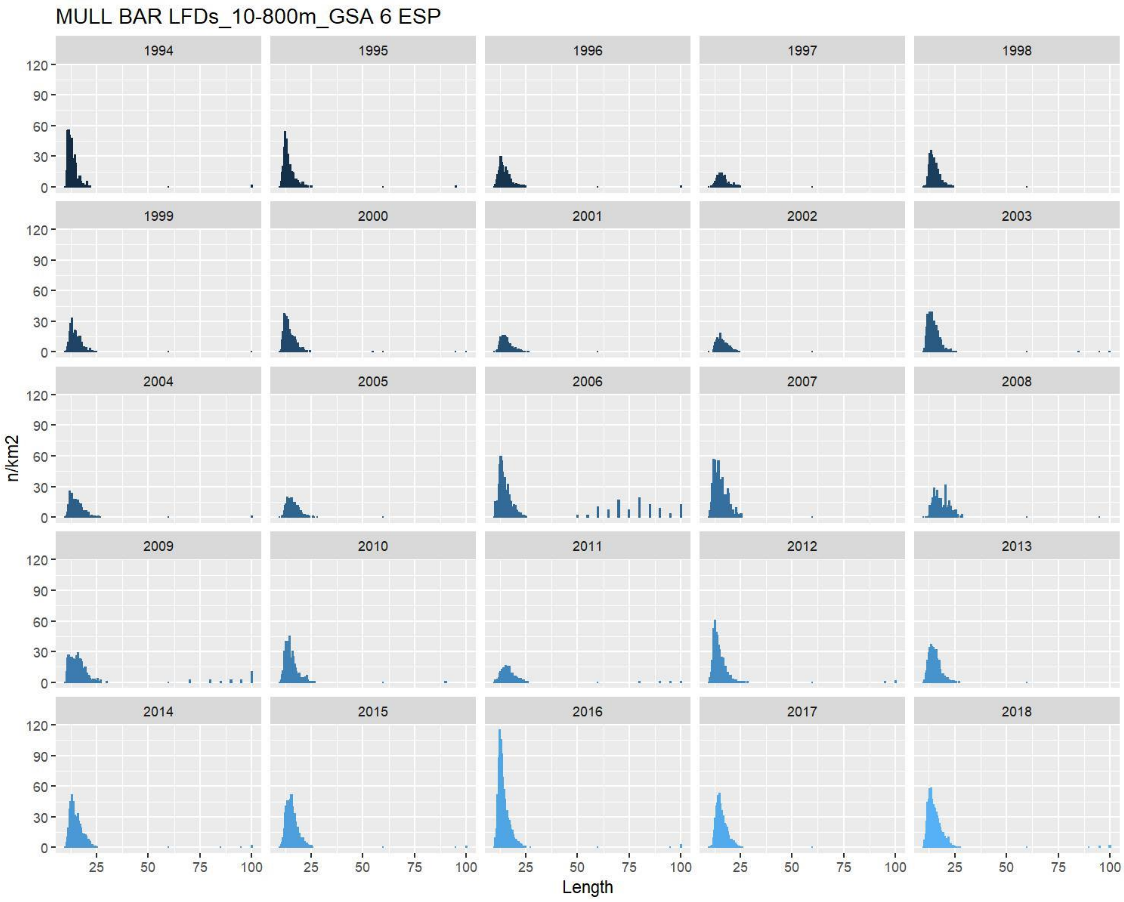


Figure 6.5.2.3.3 Red mullet in GSA 6. MEDITS length frequency distribution n/km^2).

Table 6.5.2.3.1 Red mullet in GSA 6. MEDITS catch at age index used in a4a assessment, 2003-2018.

age	2003	2004	2005	2006	2007	2008	2009	2010
0	0.5	0.0	0.0	84.8	0.0	0.3	8.9	0.4
1	367.7	213.1	170.6	484.0	514.6	176.6	336.3	374.4
2	51.0	41.5	49.8	79.4	124.5	132.2	88.6	52.2
3	3.7	3.1	4.3	6.3	20.3	36.1	14.9	11.6
4	0.0	0.2	0.3	0.0	0.0	2.8	2.1	0.0
age	2011	2012	2013	2014	2015	2016	2017	2018
0	1.2	0.2	0.0	0.8	0.5	0.4	0.2	0.0
1	147.5	467.0	355.8	440.3	466.0	795.6	405.8	533.3
2	50.5	61.5	54.1	90.4	103.5	88.9	104.5	111.1
3	6.3	4.3	5.9	6.0	10.0	5.7	7.7	9.2
4	0.0	0.7	0.2	0.0	0.0	0.4	0.0	0.3

6.5.3 STOCK ASSESSMENT

Assessment for All Initiative (a4a) (Jardim et al., 2015) is a statistical catch–at– age method that utilize catch at age data to derive estimates of historical population size and fishing mortality was used to assess this stock. 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 F(1-3).

Table 6.5.3.1 Input data. Catch and stock weight at age (kg)

age	2002	2003	2004	2005	2006	2007
0	0.002	0.002	0.002	0.002	0.002	0.000
1	0.010	0.017	0.015	0.016	0.018	0.020
2	0.045	0.051	0.048	0.047	0.046	0.047
3	0.100	0.097	0.096	0.099	0.096	0.097
4	0.156	0.159	0.156	0.170	0.166	0.170
age	2008	2009	2010	2011	2012	2013
0	0.002	0.000	0.002	0.000	0.000	0.001
1	0.017	0.021	0.022	0.022	0.022	0.023
2	0.047	0.051	0.050	0.047	0.050	0.050
3	0.098	0.099	0.102	0.099	0.098	0.100
4	0.158	0.167	0.189	0.163	0.176	0.169
age	2014	2015	2016	2017	2018	
0	0.000	0.000	0.002	0.002	0.002	
1	0.022	0.021	0.022	0.019	0.019	
2	0.050	0.051	0.049	0.050	0.049	
3	0.098	0.099	0.098	0.100	0.100	
4	0.160	0.165	0.161	0.164	0.166	

Assessment Model Settings

Different a4a models were performed (combination of different f, q and sr). The following model 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)))

Assessment Results

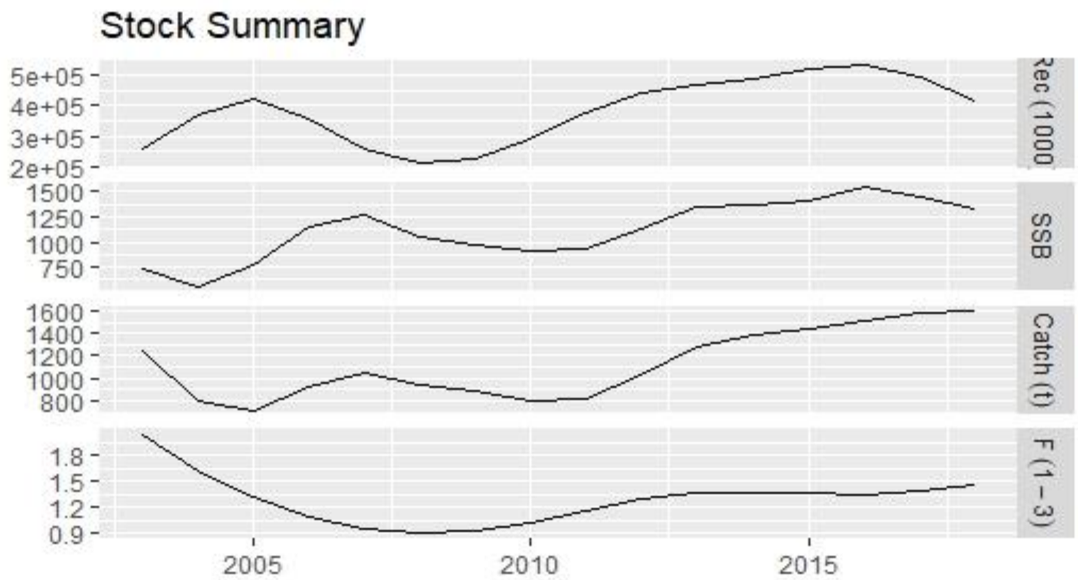


Figure 6.5.3.1 Red mullet in GSA 6. Stock summary from the a4a model for Red mullet in GSA 6, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

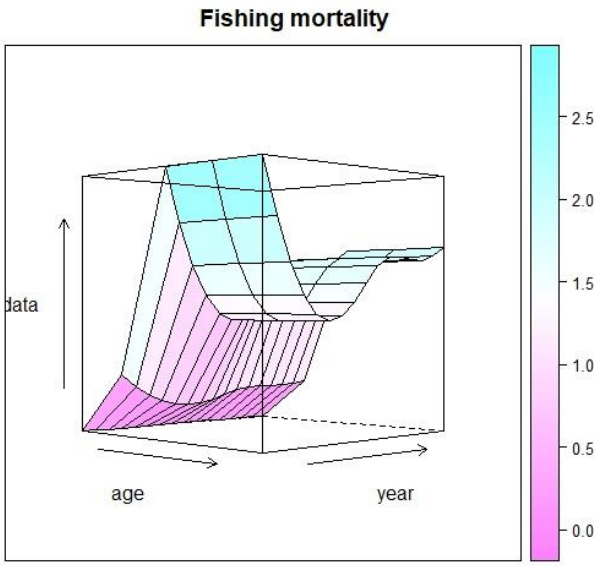


Figure 6.5.3.2 Red mullet in GSA 6. 3D contour plot of estimated fishing mortality by age and year.

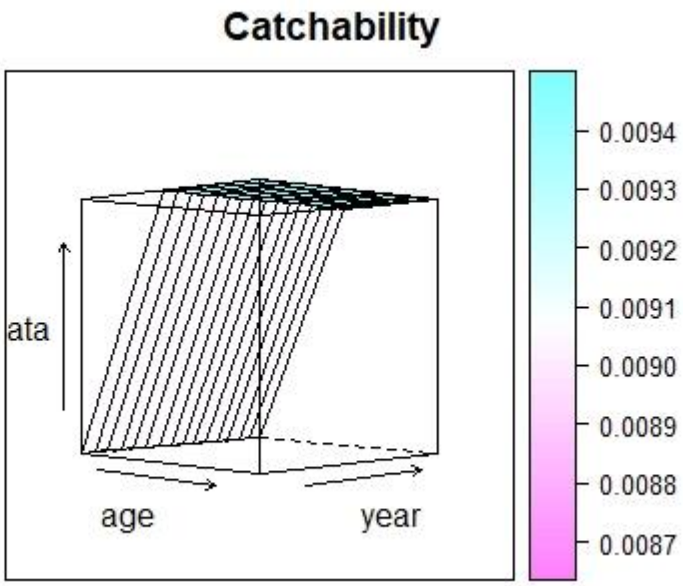


Figure 6.5.3.3 Red mullet in GSA 6. 3D contour plot of estimated fishing mortality by age and year.

Diagnostics

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

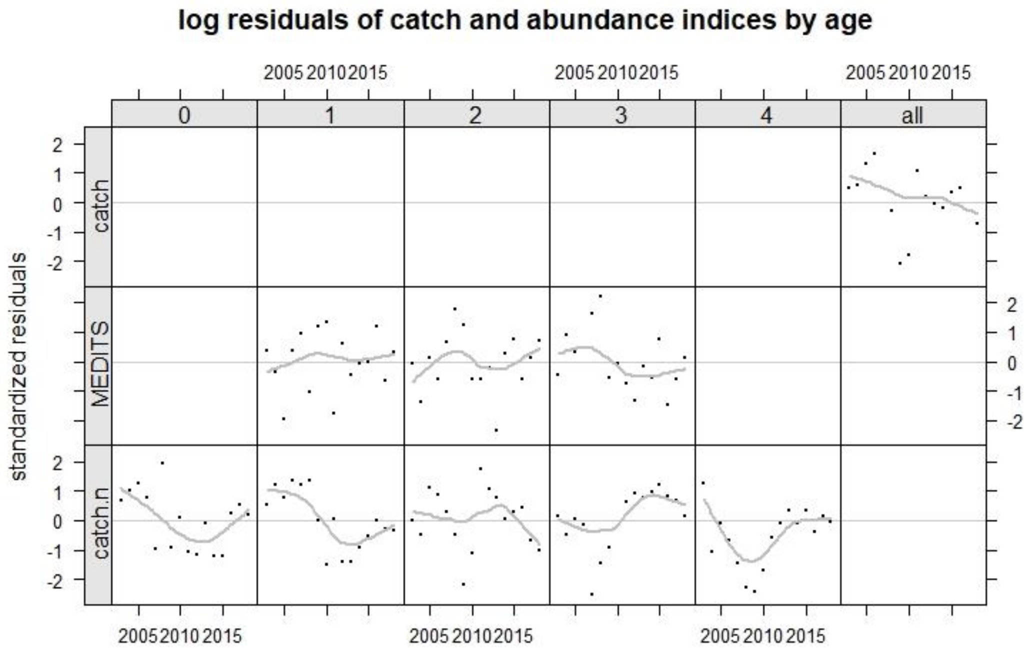


Figure 6.5.3.4 Red mullet in GSA 6. Standardized residuals for catch, abundance indices and for catch numbers.

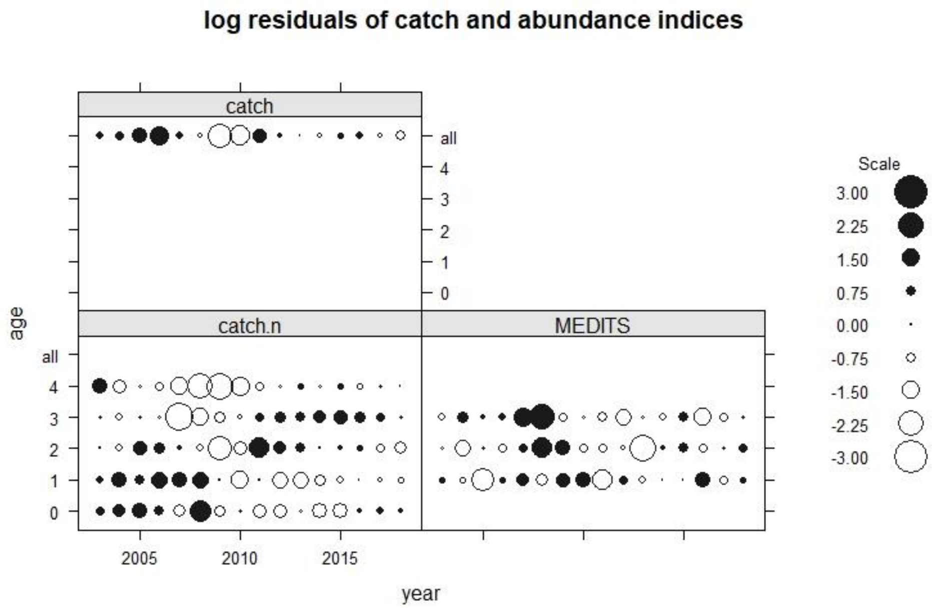


Figure 6.5.3.5 Red mullet in GSA 6. Bubble plot of standardized residuals for catch, abundance indices and for catch numbers.

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

	2003	2004	2005	2006	2007	2008	2009	2010
0	0.668	1.022	1.231	0.760	-0.979	1.923	-0.936	0.089
1	0.546	1.220	0.791	1.360	1.211	1.337	0.019	-1.520
2	0.003	-0.493	1.116	0.852	0.265	-0.489	-2.179	-1.105
3	0.143	-0.461	0.068	-0.143	-2.511	-1.472	-0.913	-0.200
4	1.264	-1.082	-0.116	-0.672	-1.468	-2.256	-2.393	-1.671
	2011	2012	2013	2014	2015	2016	2017	2018
0	-1.084	-1.165	-0.116	-1.208	-1.212	0.265	0.540	0.204
1	0.028	-1.406	-1.377	-0.899	-0.544	-0.016	-0.300	-0.326
2	1.747	1.057	0.792	0.041	0.313	0.412	-0.681	-1.002
3	0.621	0.936	0.794	0.975	1.191	0.818	0.688	0.161
4	-0.575	-0.089	0.340	-0.106	0.354	-0.366	0.167	-0.045

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

	2003	2004	2005	2006	2007	2008	2009	2010
1	0.342	-0.344	-1.971	0.366	0.949	-1.048	1.170	1.315
2	-0.068	-1.394	0.128	-0.582	0.640	1.771	1.208	-0.620
3	-0.443	0.892	0.311	0.483	1.631	2.212	-0.573	-0.066
	2011	2012	2013	2014	2015	2016	2017	2018
1	-1.758	0.623	-0.465	-0.048	-0.024	1.206	-0.630	0.319
2	-0.580	-0.222	-2.329	0.285	0.764	-0.624	0.140	0.682
3	-0.767	-1.318	-0.182	-0.563	0.750	-1.485	-0.588	0.120

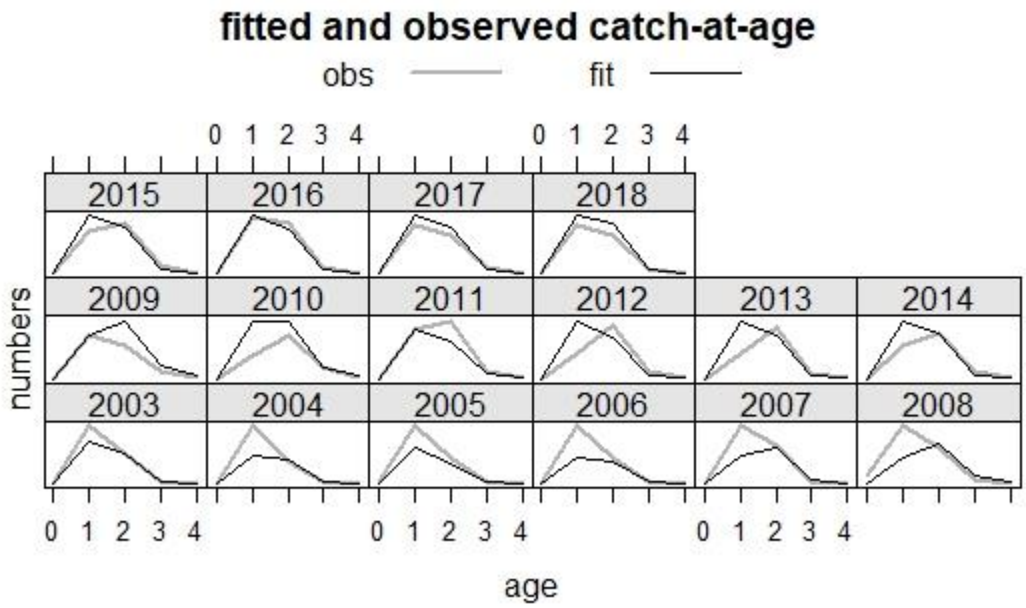


Figure 6.5.3.6 Red mullet in GSA 6. Fitted and observed catch at age.

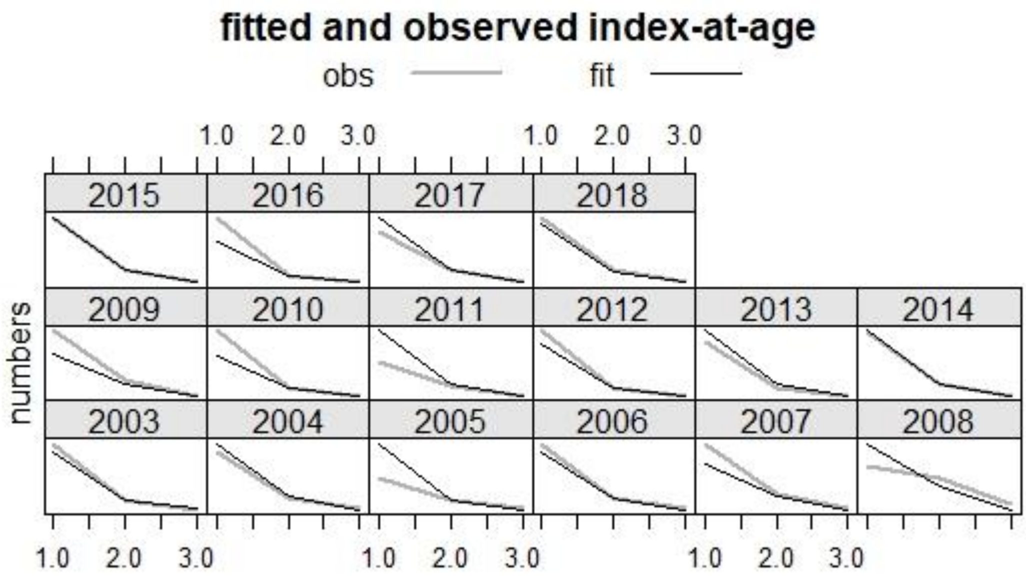


Figure 6.5.3.7 Red mullet in GSA 6. Fitted and observed index at age

RETROSPECTIVE

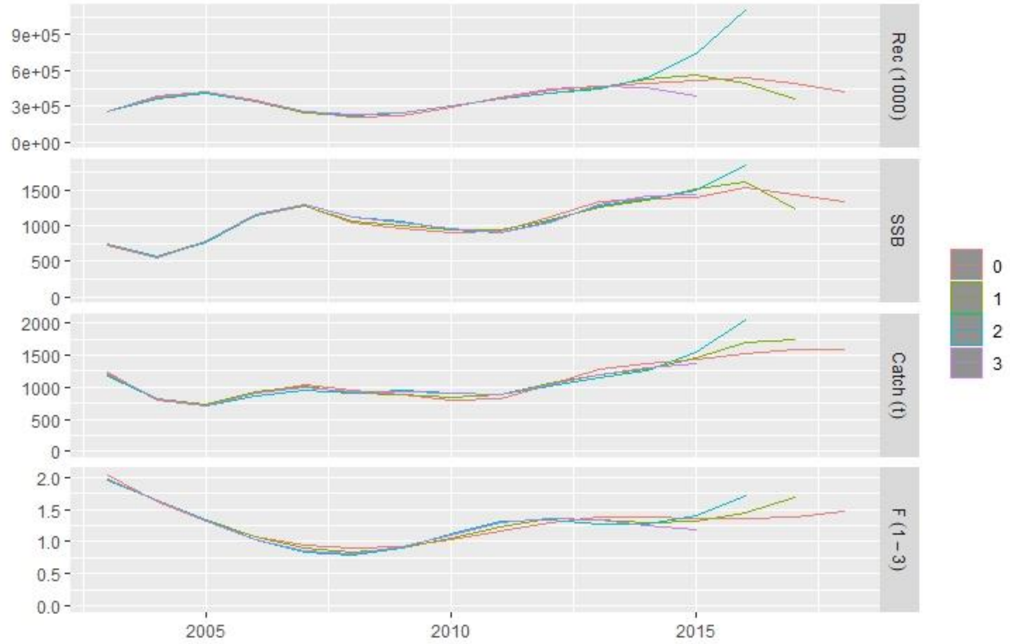


Figure 6.5.3.8 Red mullet in GSA 6. Retrospective analysis for the a4a model.

SIMULATIONS

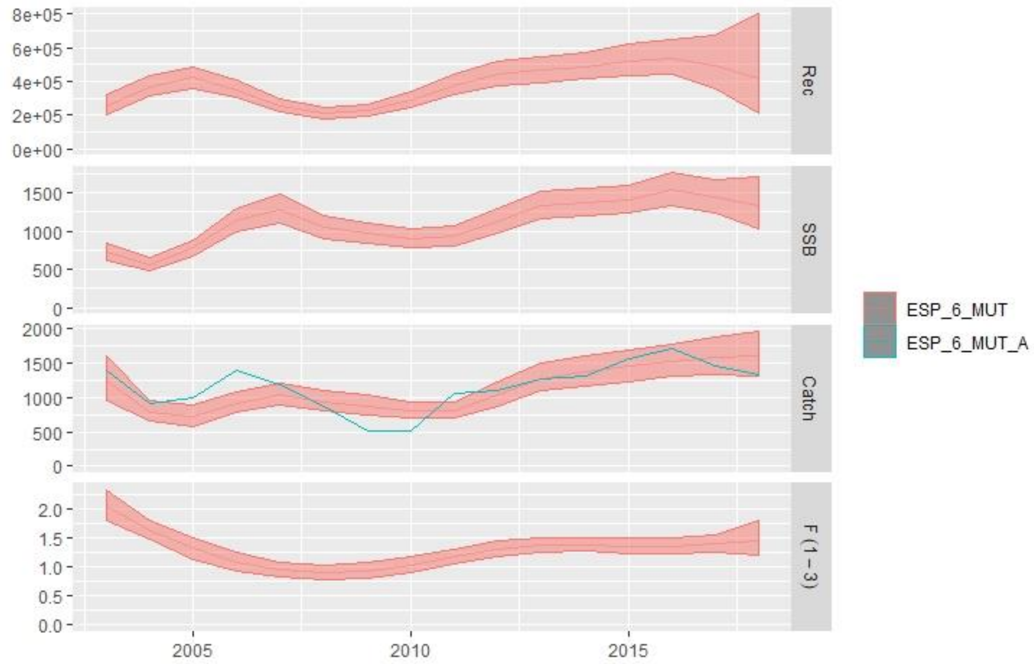


Figure 6.5.3.9 Red mullet in GSA 20. Stock summary of the simulated and fitted data for the a4a model.

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

	2003	2004	2005	2006	2007	2008	2009	2010
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.634	0.506	0.407	0.337	0.294	0.278	0.288	0.320
2	2.735	2.184	1.757	1.452	1.267	1.199	1.242	1.379
3	2.735	2.184	1.757	1.452	1.267	1.199	1.242	1.379
4	2.735	2.184	1.757	1.452	1.267	1.199	1.242	1.379
	2011	2012	2013	2014	2015	2016	2017	2018
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.364	0.405	0.427	0.429	0.422	0.421	0.433	0.456
2	1.571	1.747	1.842	1.850	1.820	1.817	1.869	1.965
3	1.571	1.747	1.842	1.850	1.820	1.817	1.869	1.965
4	1.571	1.747	1.842	1.850	1.820	1.817	1.869	1.965

Table 6.5.3.5 Red mullet in GSA 6. Stock numbers at age from a4a assessment (thousands).

age	2003	2004	2005	2006	2007	2008	2009	2010
0	259285.1	371204.4	421639.8	353499.1	257709.9	211926.1	226005.0	291302.1
1	63541.4	45570.3	65240.5	74104.7	62129.3	45293.7	37247.0	39721.4
2	18852.5	15210.0	12396.6	19592.5	23888.7	20906.1	15481.5	12604.7
3	1480.8	689.1	965.1	1205.0	2585.0	3792.4	3550.7	2518.6
4	30.8	60.8	52.5	109.1	191.5	486.4	803.8	786.4
age	2011	2012	2013	2014	2015	2016	2017	2018
0	378646.9	439939.2	464825.3	486289.6	519960.6	535441.5	494658.9	415681.1
1	51197.8	66549.1	77321.4	81694.8	85467.7	91385.3	94105.6	86937.9
2	13020.7	16054.3	20033.8	22765.5	24012.6	25293.4	27067.5	27538.0
3	1787.5	1524.9	1576.9	1788.1	2017.1	2191.1	2316.4	2352.8
4	521.7	300.9	198.9	175.3	192.2	222.7	244.2	246.0

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	259285	725.9	1238.0	2.035
2004	371204	556.2	793.4	1.624
2005	421640	776.6	715.4	1.307
2006	353499	1148.5	920.1	1.080
2007	257710	1275.4	1041.9	0.942
2008	211926	1050.6	942.1	0.892
2009	226005	972.8	879.9	0.924
2010	291302	903.4	808.0	1.026
2011	378647	926.6	813.5	1.169
2012	439939	1125.5	1037.7	1.299
2013	464825	1340.7	1274.9	1.371
2014	486290	1372.4	1378.5	1.376
2015	519961	1409.1	1443.1	1.354
2016	535441	1538.6	1515.8	1.352
2017	494659	1448.9	1583.0	1.390
2018	415681	1335.9	1597.5	1.462

Overall the assessment provides consistent if not very precise perception of the stock. The residuals are variable with some minor cohort effects. The restrospectives are relatively stable and the conclusions on stock status are similar across years. F is consistemntly estimated to be 3 to 4 times F_{MSY} (see section 6.5.4) Catches are estimated to be significantly higher in 2009 and 2010 and lower in 2005 and 2006, but in recent years catch estimates are within intervals (Figure 6.5.3.9). In recent years catches, recruit, SSB but also F are found to be high (Figure 6.5.3.9).

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. $F_{0.1}$ ages 1-3 is estimated to be 0.313

6.5.5 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 basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} =1.46 terminal F (2018) from the a4a assessment was used for F in 2019. Recruitment is observed to be higher in the later part of the timeperiod of the assessment (Figure 6.5.3.1) so only recent recruitment is used as an estimate of recruits in 2019 and 2020. Recruitment (age 0) for 2019 to 2021 has been estimated from the population results as the geometric mean of the last 6 years (484531.7).

Table 6.5.5.1 Red mullet GSA 6: 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)	1.46	F2018 used to give F status quo for 2019
SSB (2019)	1335.9	Stock assessment 1 January 2019
R_{age0} (2019,2020)	484532	Geometric mean of the last 6 years (2013-2018)
Total catch (2019)	1438	Assuming F status quo for 2019

Table 6.5.5.1 Red mullet GSA 6. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB* 2020	SSB* 2021	SSB change 2019-2021(%)	Catch change 2018-2020(%)
Zero Catch	0.00	0.000	1597	1438	0	0	2091	3659	75	-100
$F_{0.1}$	0.21	0.313	1597	1438	448	822	1856	2713	46	-72
$f_{status\ quo}$	1.00	1.462	1597	1438	1343	1440	1262	1300	3	-16
f_{upper}	0.29	0.430	1597	1438	584	996	1778	2456	38	-63
f_{lower}	0.14	0.210	1597	1438	315	618	1929	2978	54	-80
Different f scenarios	0.10	0.146	1597	1438	226	464	1976	3162	60	-86
	0.20	0.292	1597	1438	422	785	1870	2763	48	-74
	0.30	0.439	1597	1438	593	1007	1772	2440	38	-63
	0.40	0.585	1597	1438	742	1159	1682	2176	29	-54
	0.50	0.731	1597	1438	874	1263	1598	1959	23	-45
	0.60	0.877	1597	1438	990	1333	1521	1779	17	-38
	0.70	1.023	1597	1438	1093	1380	1449	1628	12	-32
	0.80	1.169	1597	1438	1185	1410	1382	1501	9	-26
	0.90	1.316	1597	1438	1268	1429	1320	1393	6	-21
	1.10	1.608	1597	1438	1412	1446	1208	1220	1	-12
	1.20	1.754	1597	1438	1474	1447	1158	1150	-1	-8
	1.30	1.900	1597	1438	1531	1447	1111	1088	-2	-4
	1.40	2.047	1597	1438	1584	1445	1067	1034	-3	-1
	1.50	2.193	1597	1438	1632	1442	1026	985	-4	2
	1.60	2.339	1597	1438	1677	1438	987	941	-5	5
	1.70	2.485	1597	1438	1720	1434	951	902	-5	8
	1.80	2.631	1597	1438	1759	1429	917	866	-6	10
	1.90	2.777	1597	1438	1796	1425	885	834	-6	12

	2.00	2.924	1597	1438	1831	1421	854	804	-6	15

*SSB at mid year

6.5.6 DATA DEFICIENCIES

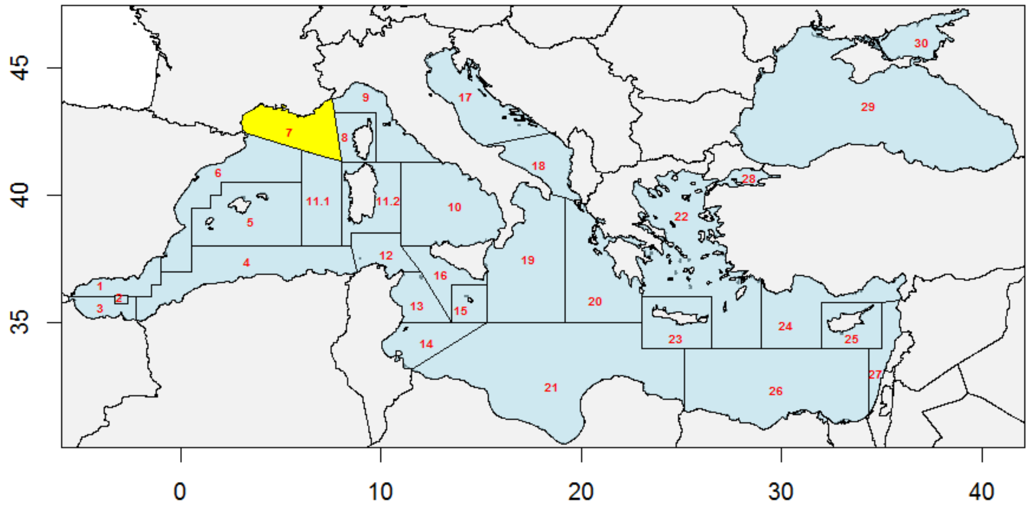
A change in the coding of the métiers was observed in 2010 and 2018.

MEDITS length frequencies distributions should be checked for sizes 10 and 60. The value in these sizes is systematically 0, over the whole period 1994-2018, even in cases when sizes > 60 are recorded.

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.



The growth parameters used in the present assessment are fast growth parameters sex combined from Demestre et al. (1997) and used in the recent assessment (GFCM, 2017), STECF 18-12. Lenght-weight relation ship is also the used in the

recent assessment (GFCM, 2017), STECF 18-12 (Table 6.6.1.1).

Table 6.6.1.1 Red mullet in GSA7. Von Bertalanffy growth paramenters and length-weight relationship.

Von Bertalanffy	**Sex Combined**	**Length-weight relation ship**	
Linf (cm)	34.5	a	0.0064
k (years-1)	0.34	b	3.18
t_0	-0.14		

Maturity (table 6.6.1.2) was calculated assuming that spawning red mullet season is very short (May-June) and young individuals reach maturity when arrive to Age 1 on 1st of January. For ages >1 all individuals are considered adults.

Natural mortality (table 6.6.1.2) was obtained from Rscript provided during the meeting and it is based on Chen Watanabe formula.

Table 6.6.1.2 Red mullet in GSA7. Maturity and M (natural mortality) vectors

Age	0	1	2	3+
Maturity	0	1	1	1
M	1.74	0.80	0.57	0.48

6.6.2 DATA

Available catch, landing and discards data are from DCF. EWG 19-10 received French and Spanish data for GSA 7 by fishing gears. French data are provided since 2002 to 2017 and Spanish data are provided since 2004 to 2017. Data used in EWG 18-12 are for the period from 2004 to 2017.

6.6.2.1 CATCH (LANDINGS AND DISCARDS)

Total catch by year is reported in table 6.6.2.1.1 (in term of landing and discard) and figure 6.6.2.1.1. Catches include the discards of OTB gear, given that discard is not present in artisanal gears. Catches are calculated as sum of landings ab=nd reported discards.

Table 6.6.2.1.1 Red mullet in GSA7. Total landings and discards by country and year.

Year	FRA-landings	ESP-landings	Total landings	discards	Total catch
2004	151.6	25.8	177.5	0	177.5
2005	148.1	27.5	175.6	0	175.6
2006	183.5	31.4	214.9	0	214.9
2007	171.5	36.2	207.7	0	207.7
2008	110.5	20.7	131.2	0.2	131.4
2009	122.6	26.1	148.7	0	148.7
2010	218.0	28.2	246.3	0	246.3
2011	198.7	28.1	226.8	0.2	227.0
2012	135.3	29.2	164.5	15.0	179.4
2013	245.6	37.5	283.1	16.3	299.4
2014	318.4	41.2	359.6	2.6	362.2
2015	281.1	33.1	314.2	12.7	326.9
2016	393.1	43.3	436.4	2.2	438.6
2017	240.6	31.1	271.7	6.0	277.7
2018	298.4	23.8	322.2	9.7	331.9

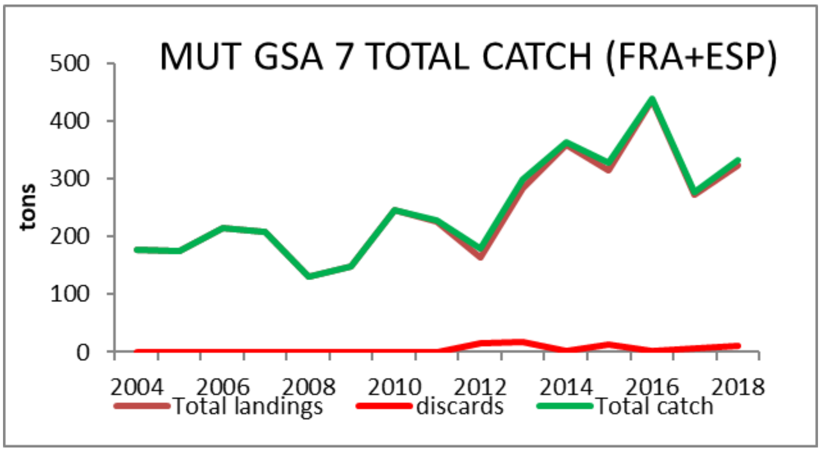


Figure 6.6.2.1.1 Red mullet in GSA7. Total catch all gears included (tons).

Landings

EWG 19-20 received French and Spanish landings data for GSA 7 by fishing gears, which are listed in table 6.6.2.1.2 and figure 6.6.2.1.2.

Table 6.6.2.1.2 Red mullet in GSA7. Annual landings (t) by gear type, 2004-2018.

	ESP-GTR	ESP-OTB	FRA -1	FRA-DRB	FRA-FPO	FRA-FYK	FRA-GNS	FRA-GTR	FRA-LLS	FRA-OTB	FRA-OTM	FRA-OTT	FRA-PS	FRA-SB	FRA-TBB
2002		11.1								111.4					
2003		11.9								164.1					
2004		25.8								151.6					
2005		27.5								148.1					
2006		31.4								183.5					
2007		36.2								171.5					
2008		20.7								110.5					
2009	0.1	26.0								122.6					
2010	0.2	28.1								218.0					
2011	0.1	28.1					30.0			168.7					
2012		29.2								135.3					
2013		37.5					13.7	19.5		210.5			1.2		0.8
2014		41.2	1.2	2.3			19.1	13.1		254.2	3.0	25.0	0.3	0.3	
2015		33.1	0.2	0.0	0.02	0.01	0.7	0.5	0.0	262.7	1.7	15.4	0.0	0.01	
2016		43.3	0.01			0.2	31.9	16.0		244.4	1.8	98.9			
2017		31.1					3.8			139.5	0.5	96.8			
2018		23.8								180.1	0.1	118.2			

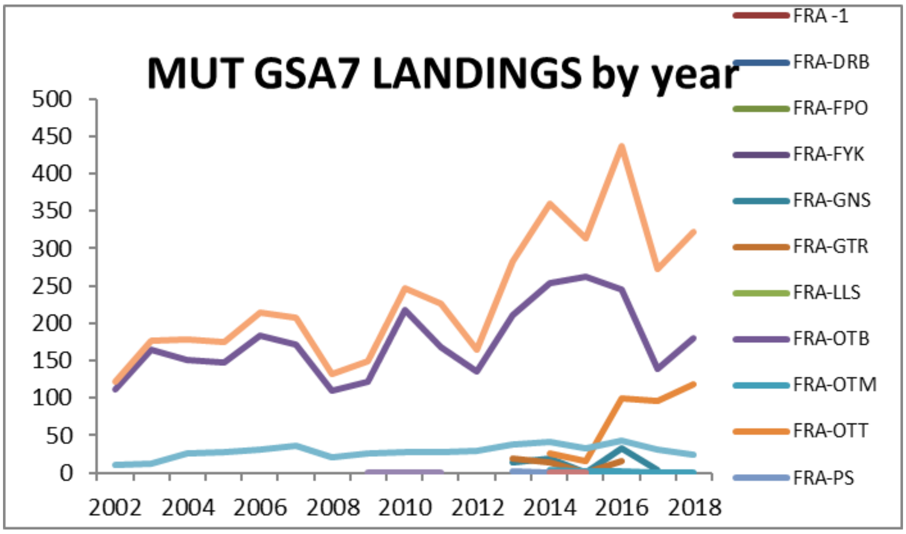


Figure 6.6.2.1.2 Red mullet in GSA7. Landings by gear and total landings.

Landings in recent years vary around 300 tons with the maximum in 2016 and the minimum in 2002. The majority of the landings of red mullet are distributed between trawlers (>85%) and the other part are mainly nets (GNS and GTR). Landings of gears other than OTB, GNS and GTR are on average less than 1%).

Length distribution of landings is reported for the Spanish and French OTB fleet from 2004 to 2018 and for the other French gears from 2013 to 2018. Since 2014 to 2018 LFD of the French Trawl fleet are separated by OTB, OTM and OTT trawlers, the majority of catches belonging to OTB but OTT belongs important on the last three years 2016, 2017 and 2018. LFD of this trawl fleets are similar.

For the analyses the LFD of all gears are considered (figure 6.6.2.1.3).

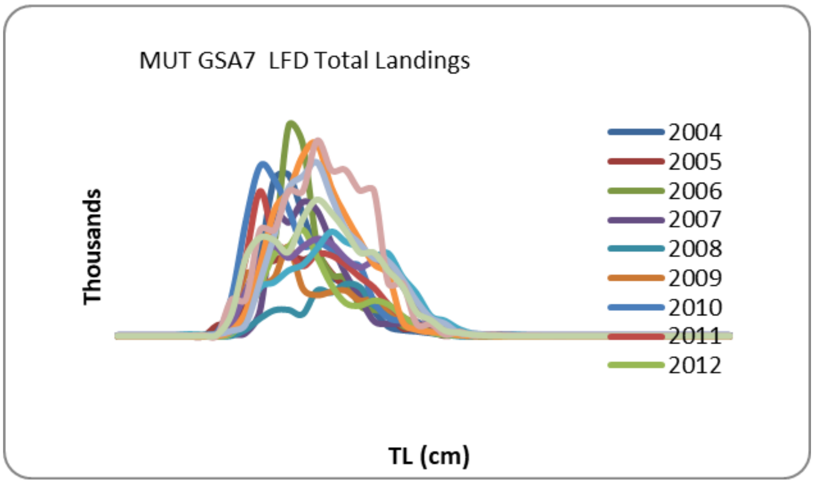


Figure 6.6.2.1.3 Red mullet in GSA7. Landing length distribution from 2004-2018.

Discards

Discards of red mullet in the GSA 7 are reported for OTB fleets from 2008 to 2018. In 2004-2007 and 2009-2010 the discarded catches were not available. The volume of discards is rather variable among years, around a 3% as a mean, with some values between 5-8% (2012-2013). Volume of discard is reported in table 6.6.2.1.4 and in figure 6.6.2.1.4. There are length frequencies distribution of discards from 2012 to 2018 and are reported in figure 6.6.2.1.5.

Table 6.6.2.1.4 Red mullet in GSA 7. Annual discard (t) reported in the period 2004-2017.

	OTB
2004	
2005	
2006	
2007	
2008	0.2
2009	
2010	
2011	0.2
2012	15.0
2013	16.3
2014	2.6
2015	12.7
2016	2.2
2017	6.0
2018	9.7

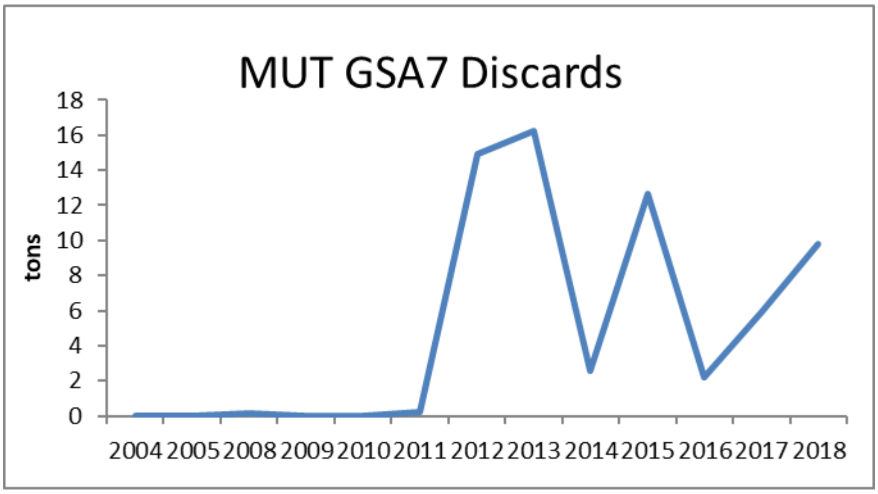


Figure 6.6.2.1.4 Red mullet in GSA 7. OTB discards.

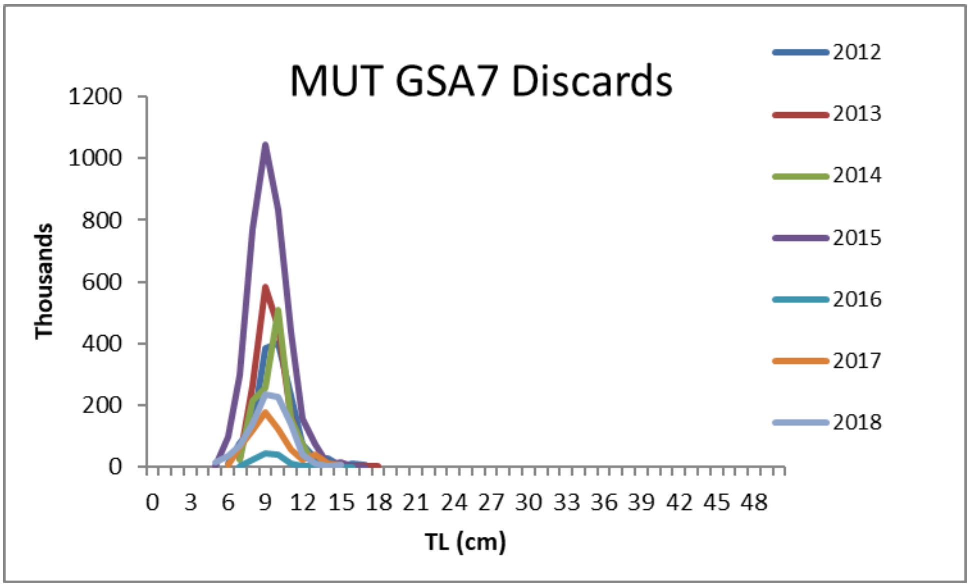


Figure 6.6.2.1.5 Red mullet in GSA 7. Discards landing length distribution from 2012-2018.

Catch at age

For the present assessment, age distribution of red mullet (catches) in GSA 7 has been obtained as sum of landing and discard age distribution estimated using the knife-edge slicing method from the R-script provided during the meeting.

Age data from DCF obtained with a different set of parameters have not been used.

Age distribution by year of the red mullet in GSA 7 is reported in table 6.6.2.1.5 and in figure 6.6.2.1.6.

Table 6.6.2.1.5 Red mullet in GSA 7. Catch at age (thousands) by year.

	0	**1**	**2**	**3+**
2004	969.9	4664	357.9	27.4
2005	976.7	3365.8	656.6	61.2
2006	598.5	4897.5	500.6	38
2007	294.4	4952.2	447	49.3
2008	187.9	1753.5	727.7	25.4
2009	891.1	2372.5	692.2	37.1
2010	2397.9	4659.8	684.5	59.9
2011	1709.9	3389.6	723.6	47.9
2012	537.9	3132.8	725.7	37.1
2013	891.8	3766.4	1376.6	103.8
2014	437.3	2915.5	1531.5	173.2
2015	587.9	4966.5	928.1	37.5
2016	295.1	3236.8	962	69.2
2017	366.2	1354.6	594.9	43.1
2018	482.3	1913.7	693.2	43.7

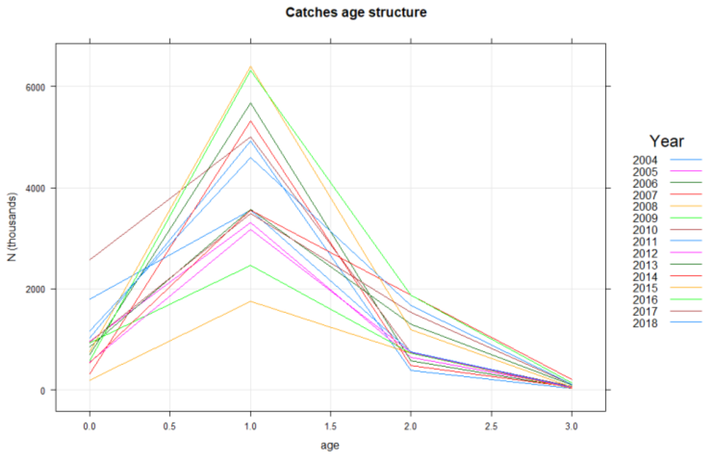


Figure 6.6.2.1.6 Red mullet in GSA 7. Catch at age (thousands) by year.

6.6.2.2 EFFORT

The trends in fishing effort by fleet and major gear type targeting red mullet in GSA 7 (OTB, OTM, OTT, GNS and GTR) are listed in tables 6.6.2.2.1 and 6.6.2.2.2 and shown in figures 6.6.2.2.1 and 6.6.2.2.2. Spanish effort values are available from 2004-2017. French effort values are only available from 2015-2017, earlier French data is missing from data call and tables and figures below.

Table 6.6.2.2.1 Red mullet in GSA 7. Trend in number of vessels by fleet level from 2004-2017, DCF data.

	ESP-GNS	ESP-GTR	ESP-OTB	FRA-GNS	FRA-GTR	FRA-OTB	FRA-OTM	FRA-OTT
2004	8	4	33					
2005	5	9	32					
2006	4	7	19					
2007	7	5	25					
2008	8	7	25					
2009		1	38					
2010	18	8	49					
2011	7	3	45					
2012	9	4	38					
2013	11	3	31					
2014	4	3	32					
2015	3	6	37	5	13	60	12	5
2016	2	5	43	6	19	62	15	13
2017	4	3	34	4	5	85	14	29
2018	5	7	29	-	-	110	14	34

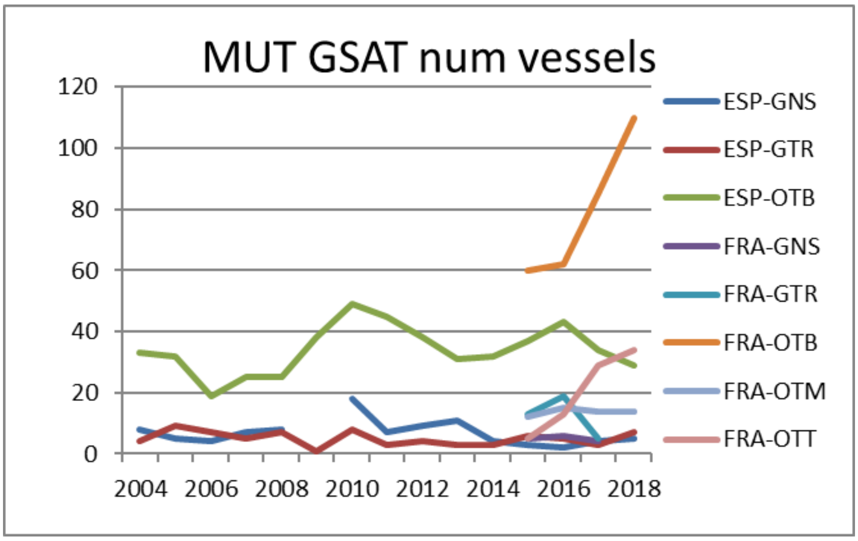


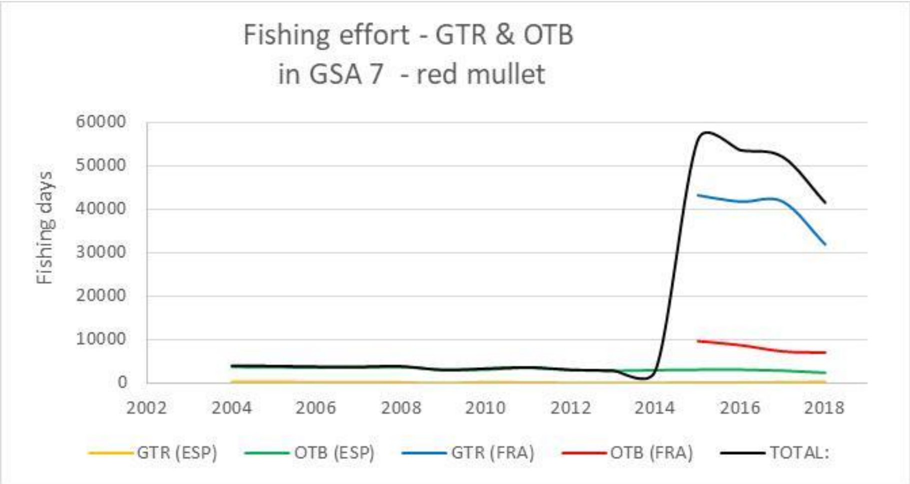
Figure 6.6.2.2.1 Red mullet in GSA 7. Trend in number of vessels for the pulled fleet, from 2004 to 2018.

Table 6.6.2.2.2 Red mullet in GSA 7. Trend in nominal fishing effort (kW*days) by fleet level from 2004-2018, DCF data.

	ESP-GTR	ESP-OTB	FRA-GNS	FRA-GTR	FRA-OTB	FRA-OTM	FRA-OTT
2004	10367	1798337					
2005	10227	1691888					
2006	9225	1645823					
2007	8673	1657076					
2008	9788	1695033					
2009	64	1623651					
2010	12017	1456054					
2011	5040	1630298					
2012	3137	1392365					
2013	2299	1302803					
2014	2704	1386059					
2015	6977	1431042	10853132	12762037	3118530	122118	231965
2016	4056	1506128	9253938	11966169	2801864	146388	599486
2017	16099	1365818	2577029	3165900	2322626	116432	1087629
2018	20017	1066495	2499832	2540676	2236550	137595	1139094

Table 6.6.2.2.3 Red mullet in GSA 7. Trend in fishing effort (fishing days) by fleet level from 2004-2018, DCF data.

Fishing days (ESP)	GTR (ESP)	OTB (ESP)	GTR (FRA)	OTB (FRA)	**TOTAL:**
2004	293	3714			**4007**
2005	285	3626			**3911**
2006	208	3550			**3758**
2007	179	3553			**3732**
2008	157	3694			**3851**
2009	4	3008			**3012**
2010	212	3097			**3309**
2011	119	3486			**3605**
2012	70	2966			**3036**
2013	59	2791			**2850**
2014	65	2966			**3031**
2015	143	3064	43288	9657	**56152**
2016	88	3090	41834	8716	**53728**
2017	176	2840	41837	7292	**52145**
2018	287	2357	31962	7003	**41608**



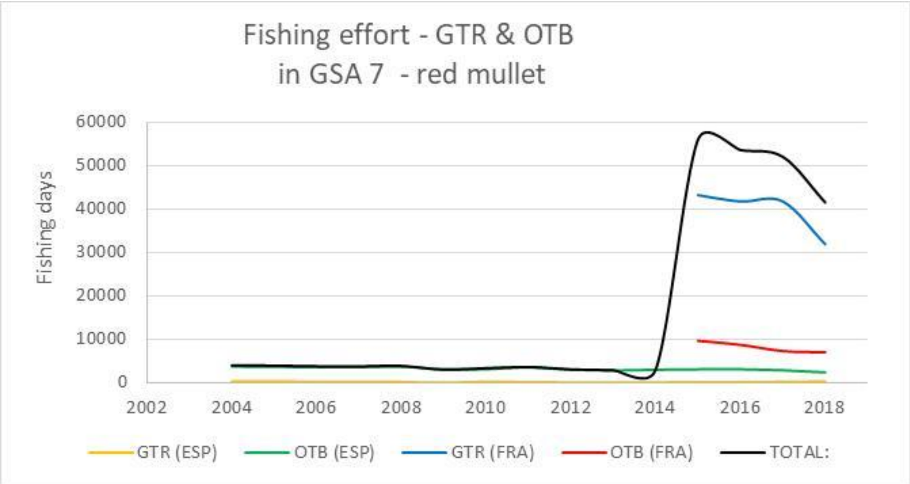


Figure 6.6.2.2.2 Red mullet in GSA 7. Trend in fishing days fishing effort for the GTR and OTB fleets, from 2004 to 2017 the increase in 2015 is not a real increase but shows the French data prior to 2015 French data is missing.

6.6.2.3 SURVEY DATA

Methods

According to the MEDITS protocol (Bertrand et al. 2002), trawl surveys were yearly carried out, the majority of them centred in 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. All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method. The period when MEDITS survey has been done in GSA 7 is reported in figure 6.6.2.3.1

Figure 6.6.2.3.1 MEDITS sampling period in GSA 7.

The number of hauls per MEDITS stratum is shown in Table 6.6.2.3.1.

Table 6.6.2.3.1 Number of hauls per depth stratum in MEDITS trawl survey in GSA 7, A (10-50 m), B (50-100 m), C (100-200 m), D (200-500), E (500-800 m), 1994-2017.

Year	A	B	C	D	E	Total
1994	12	32	11	6	8	69
1995	12	32	10	7	7	68
1996	12	32	10	6	4	64
1997	14	35	10	7	5	71
1998	12	39	10	6	4	71
1999	12	32	10	6	4	64
2000	12	31	11	6	6	66
2001	12	32	10	7	5	66
2002	12	31	10	5	4	62
2003	13	38	11	6	5	73
2004	12	32	13	6	5	68
2005	12	30	12	6	5	65
2006	12	33	11	6	5	67
2007	14	31	11	6	5	67
2008	11	24	8	5	5	53
2009	11	29	11	6	5	62
2010	12	29	9	3	5	58
2011	12	31	11	6	5	65
2012	12	32	11	5	5	65
2013	12	30	11	7	4	64
2014	12	31	11	5	6	65
2015	12	30	12	5	5	64
2016	12	31	11	5	4	63
2017	12	32	10	6	5	65
2018	12	30	12	6	5	65

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). The density and biomass indices of red mullet in GSA 7 were estimated on the depth strata to 10-800 m and standardized to km^2.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in the 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 +/- standard deviation.

It was noted that while this is a standard approach, the calculation may be biased due to a number of different factors including the change in the number of hauls over time, and change of the survey time over the years. Precision may also be affected by the choice of parametric distribution, 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 (e.g. O'Brien et al. 2004).

Length distributions represented an aggregation (sum) of standardized length frequencies distribution raise to standardized haul abundance per square km over the stations of each stratum.

Geographical distribution

The geographical distribution pattern of red mullet has been studied in the area using trawl-survey data and applying geostatistical methods. Abundance and biomass of red mullet in GSA 7 for the year 2017 have shown in the Figure 6.6.2.3.2.

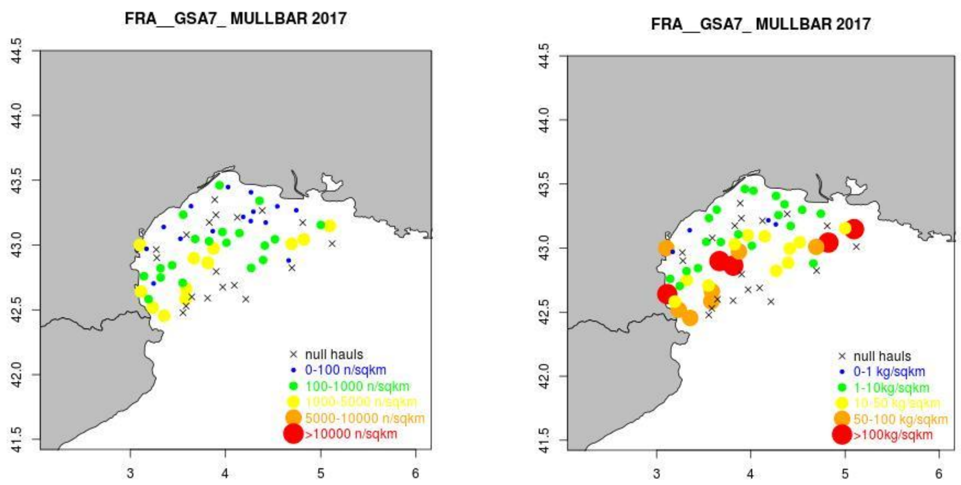


Figure 6.6.2.3.2 Red mullet in GSA 7. 2017 abundance of red mullet in n/sqkm on left and biomass of red mullet in kg/sqkm at right.

Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 7 was derived from the MEDITS survey. Figure 6.6.2.3.3 displays the estimated trend of red mullet abundance and biomass indices standardized to the surface unit in the GSA 7. Indices from MEDITS trawl-surveys show an increasing trend along the series from 2007 to 2016.

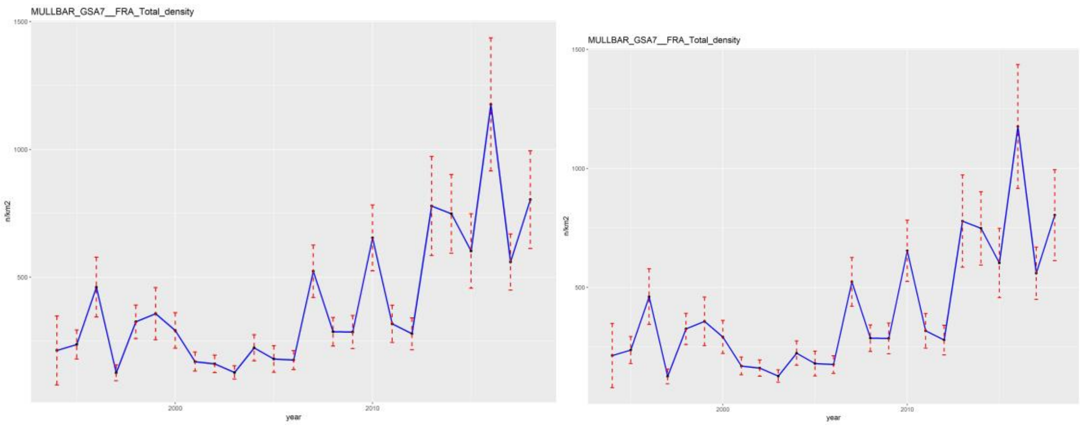


Figure 6.6.2.3.3 Red mullet in GSA 7. Abundance (n/sqkm) on left and biomass (kg/sqkm) at right, time series of derived from MEDITS (dotted lines indicate standard deviation).

Table 6.6.2.3.2 Red mullet in GSA 7. Stratified abundance indices (N/km^2 and kg/km^2) by year, 1994-2017.

year	N/km^2	stdev	CV (%)	Kg/km^2	stdev	CV (%)
1994	213	135	63	7.6	3.9	52
1995	236	57	24	8.4	2.2	26
1996	461	117	25	13.8	3.7	27
1997	126	31	24	4.9	1.2	24
1998	325	65	20	10.7	1.9	18
1999	357	102	29	12.0	3.4	29
2000	291	70	24	10.2	2.2	22
2001	169	37	22	6.8	1.4	20
2002	161	34	21	6.8	1.4	21
2003	127	26	20	5.4	1.1	21
2004	223	51	23	7.8	1.5	19
2005	180	52	29	6.9	1.9	28
2006	175	37	21	5.6	1.2	21
2007	523	103	20	17.9	3.5	20
2008	286	56	20	11.4	2.1	19
2009	285	64	23	13.9	3.2	23
2010	653	129	20	18.1	4.0	22
2011	317	73	23	12.2	2.9	24
2012	278	62	22	14.3	3.6	25
2013	778	194	25	24.0	5.6	23
2014	748	154	21	27.0	4.9	18
2015	602	146	24	27.6	6.3	23
2016	1176	260	22	34.9	7.3	21
2017	559	110	20	26.5	4.9	18
2018	803.34	191.3	21	29.63	7	22

Trends in abundance by length

The stratified abundance indices of red mullet in GSA 7 from 1994-2018 are given in Figure 6.6.2.3.4. It can be observed some modal peaks in the LFDs in the 2010 and 2016.

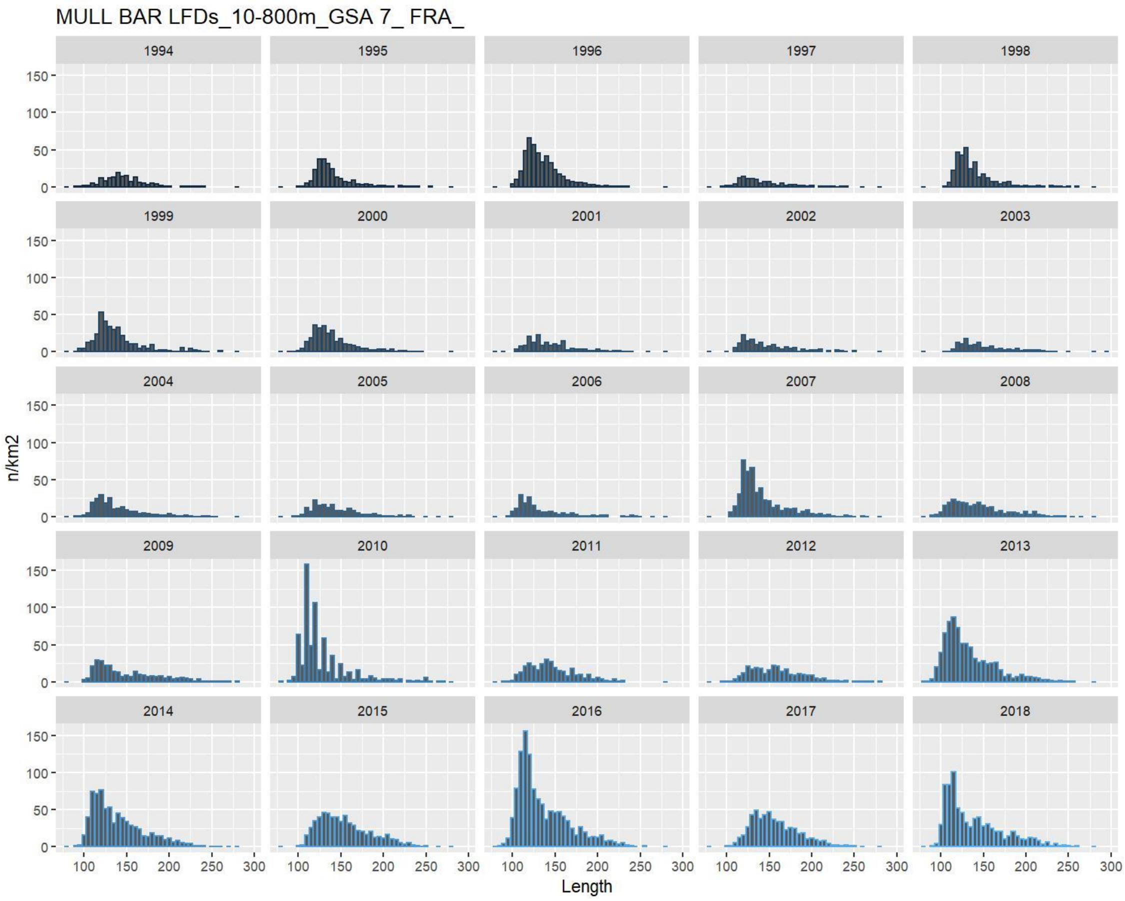


Figure 6.6.2.3.4 Red mullet in GSA 7. Stratified abundance indices by size, 1994-2018.

6.6.3 STOCK ASSESSMENT

XSA

An assessment has been conducted using XSA method.

The Extended Survivors Analysis (XSA – Darby and Flatman, 1994) has been performed using the same parameters than have been used in the last assessment (GFCM, 2018) in order to compare reference points obtained. XSA has been used with an age range from 0 to +3 and an Fbar 1-2. Discards was included in the analysis so catches are sum of landings and discards. SoP correction was applied.

Input data

For the assessment of red mullet in GSA 7 the DCF data on the length structure has been used:SOP correction has been applied.. The age distribution has been estimated using the knife-edge slicing method with the fast growth parameters used in the previous assessment. A sex-combined analysis was carried out.

The survey indices from MEDITS data from 2004 to 2018 have been used for the tuning.

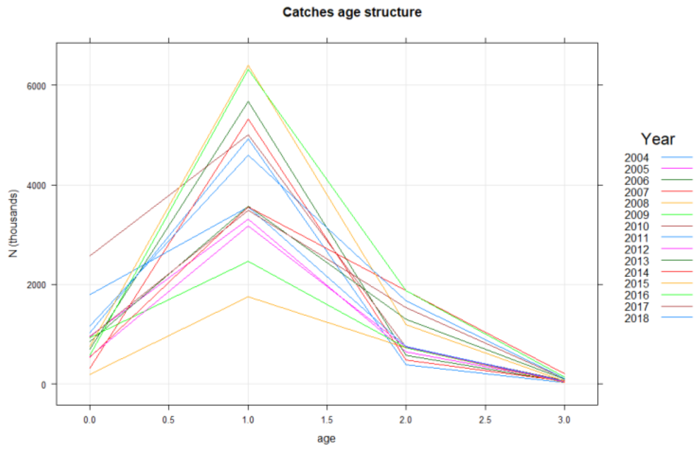


Figure 6.6.3.1 Red mullet in GSA 7. Catch (landings + discards) in numbers (thousands) by age and year used in the XSA.

Table 6.6.3.1 Red mullet in GSA 7. Catch (including discard) in numbers (thousands) by age and year used in the XSA.

Year	0	1	2	3+
2004	969.9	4664	357.9	27.4
2005	976.7	3365.8	656.6	61.2
2006	598.5	4897.5	500.6	38
2007	294.4	4952.2	447	49.3
2008	187.9	1753.5	727.7	25.4
2009	891.1	2372.5	692.2	37.1
2010	2397.9	4659.8	684.5	59.9
2011	1709.9	3389.6	723.6	47.9
2012	537.9	3132.8	725.7	37.1
2013	891.8	3766.4	1376.6	103.8
2014	437.3	2915.5	1531.5	173.2
2015	587.9	4966.5	928.1	37.5
2016	295.1	3236.8	962	69.2
2017	366.2	1354.6	594.9	43.1
2018	482.3	1913.7	693.2	43.7

Table 6.6.3.2 Red mullet in GSA 7. Abundance indices (N/km^2) by age and year from MEDITS survey used in the XSA.

Year	0	1	2	3+
2004	1.8	187.4	27.3	6.1
2005	0.6	149.7	24.4	5.3
2006	0.7	151.8	17.8	4.6
2007	0.9	404	65.8	9.6
2008	4.6	222.2	52.1	7.3
2009	0.4	202	64.3	18.6
2010	9	573.1	50.4	14.5
2011	1.2	244.7	66	5.8
2012	0.3	182.8	85.8	9.6
2013	22.9	660.6	76.3	11.4
2014	3.4	611.5	118.6	13.9
2015	0.1	428	154.7	19.5
2016	16.3	981.3	157.1	21
2017	0.8	389	156.2	13.5
2018	5.6	639.9	135.2	22.3

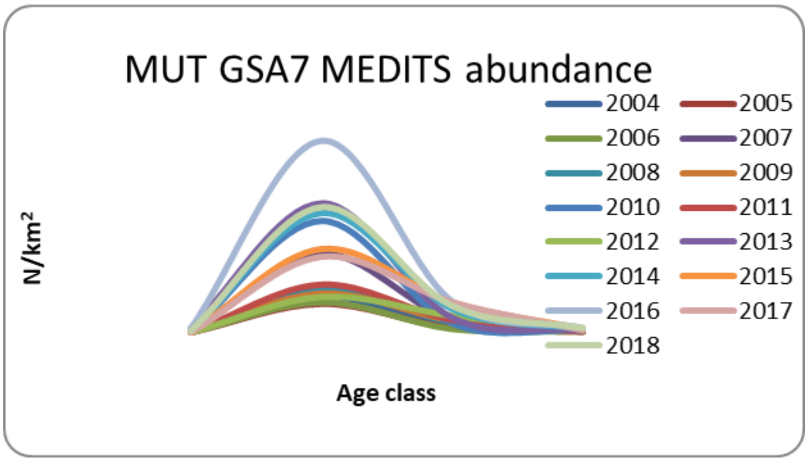


Figure 6.6.3.2 Red mullet in GSA 7. Abundance indices (N/km^2) by age and year from MEDITS survey used in the XSA.

Table 6.6.3.3 Red mullet in GSA 7. Weights at age (kg) used in the XSA.

	0	1	2	3+
2004	0.011	0.027	0.076	0.154
2005	0.01	0.031	0.08	0.159
2006	0.011	0.027	0.081	0.149
2007	0.012	0.029	0.087	0.145
2008	0.011	0.037	0.084	0.141
2009	0.01	0.03	0.083	0.144
2010	0.01	0.03	0.082	0.15
2011	0.01	0.031	0.08	0.147
2012	0.011	0.029	0.082	0.149
2013	0.01	0.032	0.084	0.148
2014	0.01	0.035	0.086	0.149
2015	0.011	0.032	0.077	0.148
2016	0.011	0.032	0.085	0.148
2017	0.01	0.034	0.079	0.151
2018	0.01	0.034	0.083	0.148

Results

Several runs of XSA have been performed with the following settings:

Shk.n= TRUE, shk.f=TRUE, shk.yrs=4, shk.ages=3, rage=-1, qage=2

Sensitivity analyses have been performed varying the following settings:

Shrinkage of the mean (fse) = 0.5, 1, 1.5, 2 and 2.5

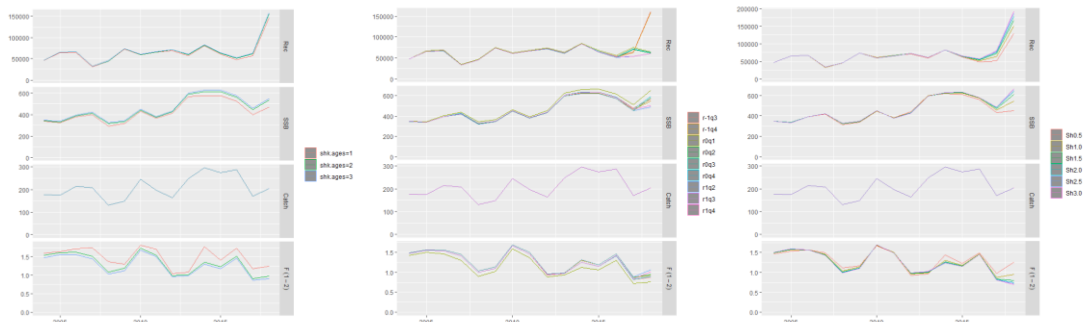


Figure 6.6.3.3 Red mullet in GSA 7. Plot of the stock parameters estimated in the sensitivity analyses.

The run with catchability (rage) independent on stock size for all ages = -1, the catchability (qage) independent of age for ages >2 and shrinkage of the mean (fse) = 1.5 has been chosen on the basis of the residuals and of the retrospective analysis.

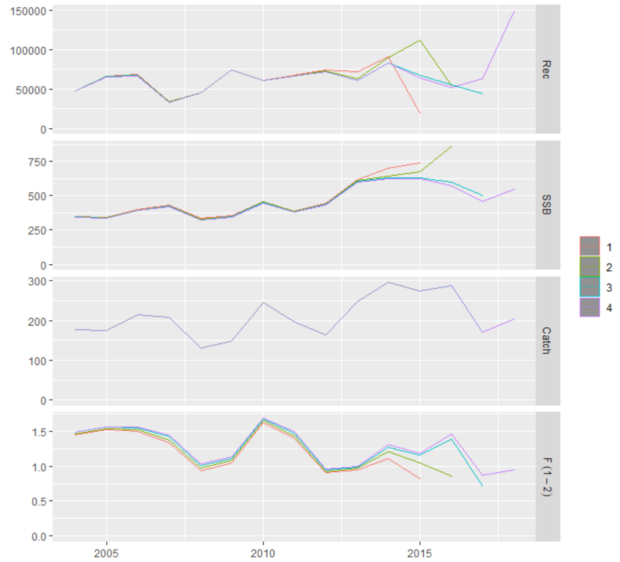


Figure 6.6.3.4 Red mullet in GSA 7. Retrospective analysis (2015-2018).

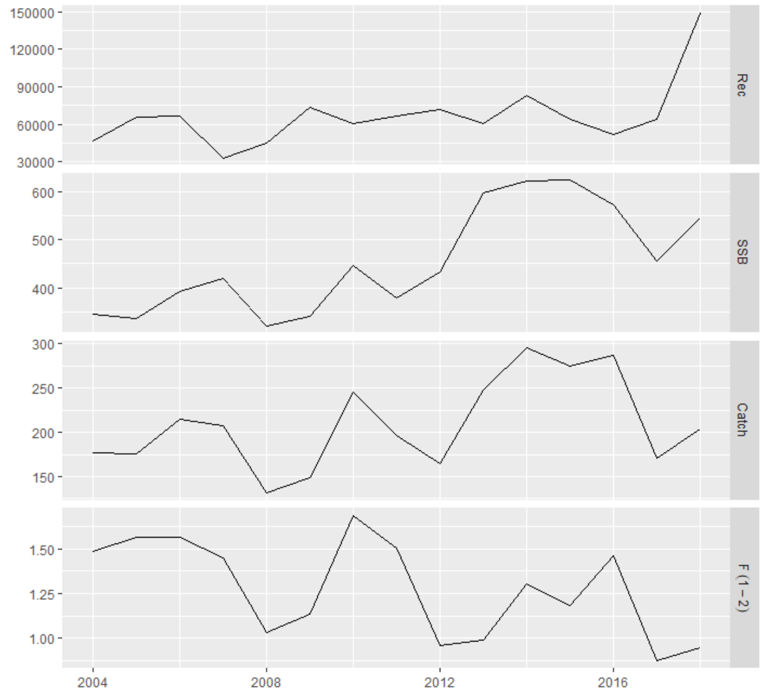


Figure 6.6.3.5 Red mullet in GSA 7. XSA results in terms of recruitment, SSB, Catches and fishing mortality.

The Fbar along the time series is on average 0.96, with a minimum of 0.73 in 2008 and 2017 and a maximum of 1.17 in 2010 and 2016 (Table 6.6.3.4). The recruitment show a stable trend until 2014-2017 period and then increase in 2018.

Table 6.6.3.4 Red mullet in GSA 7. Fishing mortality at age by year, Fbar(0-2), spawning stock biomass (SSB, t) and Recruitment (R, thousands) estimated with XSA.

Year	F age 0	F age 1	F age 2	F age 3	Fbar (1-2)	SSB (t)	Recreuitment (thousands)
2004	0.06	1.47	1.54	0.75	1.5	317	42721
2005	0.04	1.2	2.06	1.16	1.62	319	60564
2006	0.03	1.76	1.65	1.35	1.7	365	62870
2007	0.02	1.34	1.67	1.03	1.5	395	31019
2008	0.01	0.67	1.45	0.47	1.06	314	35777
2009	0.04	0.9	1.55	0.34	1.22	311	59749
2010	0.12	1.34	1.99	0.73	1.66	420	52759
2011	0.07	1.05	1.91	1.05	1.48	363	60142
2012	0.02	0.66	1.41	0.52	1.03	40	67915
2013	0.03	0.61	1.43	0.98	1.02	597	59146
2014	0.01	0.75	2.04	1.79	1.39	646	91721
2015	0.02	0.92	1.39	0.33	1.15	704	87585
2016	0.02	0.98	2.12	0.82	1.54	769	64585
2017	0.03	0.63	1.64	0.89	1.13	617	85179
2018	0.02	0.64	1.82	0.63	1.23	757	118933

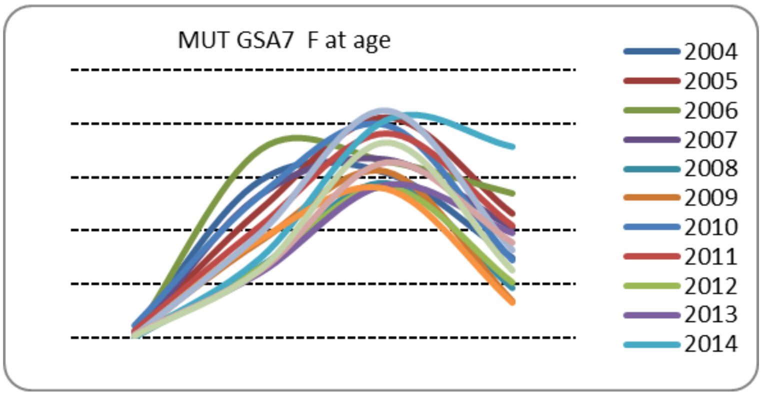


Figure 6.6.3.6 Red mullet in GSA 7. Fishing mortality at age by year estimated with XSA.

Method: a4a

A second assessment has been conducted using a4a method, based on linear modelling techniques, all fleets combined, using the same input data as the XSA model.

Input data

The catch at age matrices, survey MEDITS data and individual weights at age for the stock and for the catch were the same as used on the above XSA assessment and reported in paragraph 6.6.3. The natural mortality vector and the maturity at age are the same reported in paragraph 6.6.1. The a4a model settings were as follows:

fmod <- ~ s(age, k = 4) + s(year, k = 7) qmod <- list(~factor(replace(age,age>2,2)))

srmodel: ~factor(year)

Results

The F time series estimated by a4a is shown summarised in Table 6.6.3.7, and as F at age and n at age in Tables 6.6.3.8 and 6.6.3.9. Fishery selection, F at age is shown in Figure 6.6.3.7.

Table 6.6.3.7 Red mullet in GSA 7. Results of the final a4a run: Summary, Recruits, SSB, estimated catch and Fbar (1-2).

year	Recruits thousands	SSB tonnes	catch tonnes	Fbar age 1-2
2004	39712	264	154.36	1.72
2005	43373	302	194.02	1.92
2006	49184	270	171.52	1.87
2007	28835	325	184.96	1.6
2008	32826	294	163.51	1.4
2009	48831	256	140.51	1.41
2010	50588	343	192.97	1.55
2011	55876	383	219.34	1.55
2012	58289	402	212.33	1.34
2013	57935	484	230.49	1.13
2014	81282	563	267.93	1.11
2015	74194	659	327.32	1.26
2016	70053	677	366.87	1.37
2017	80662	636	308.14	1.18
2018	154809	721	278.42	0.82

Table 6.6.3.8 Red mullet in GSA 7. Results of the final a4a run: F by age.

Year	F age 0	F age 1	F age 2	F age 3+
2004	0.04	1.21	2.23	0.98
2005	0.04	1.35	2.5	1.09
2006	0.04	1.31	2.43	1.06
2007	0.03	1.12	2.07	0.91
2008	0.03	0.98	1.82	0.79
2009	0.03	0.99	1.84	0.8
2010	0.03	1.08	2.01	0.88
2011	0.03	1.09	2.02	0.88
2012	0.03	0.94	1.75	0.76
2013	0.02	0.79	1.47	0.64
2014	0.02	0.78	1.44	0.63
2015	0.03	0.88	1.63	0.71
2016	0.03	0.96	1.78	0.78

2017	0.02	0.82	1.53	0.67
2018	0.02	0.57	1.06	0.46

Table 6.6.3.9 Red mullet in GSA 7. Results of the final a4a run: N by age.

	0	1	2	3
2004	39711.95	7732.58	564.562	78.778
2005	43372.86	6722.959	1041.024	52.524
2006	49184.42	7311.197	784.18	59.187
2007	28835.5	8300.363	886.062	51.717
2008	32825.87	4894.443	1219.541	75.994
2009	48831.35	5594.867	825.592	133.372
2010	50587.57	8320.046	933.218	111.309
2011	55876.05	8595.093	1263.557	99.214
2012	58288.76	9492.406	1299.81	120.267
2013	57934.92	9946.272	1664.009	163.043
2014	81281.69	9929.676	2020.548	268.972
2015	74193.89	13938.83	2054.948	360.195
2016	70052.75	12683.24	2595.529	336.09
2017	80661.62	11947.44	2185.467	343.88
2018	154809.2	13812.18	2353.904	377.065

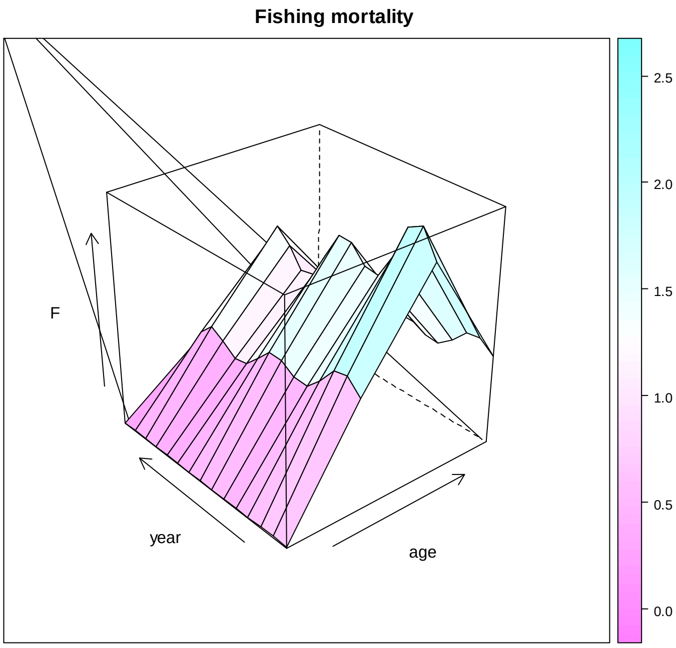


Figure 6.6.3.7 Red mullet in GSA 7. Fishing mortality by year and age.

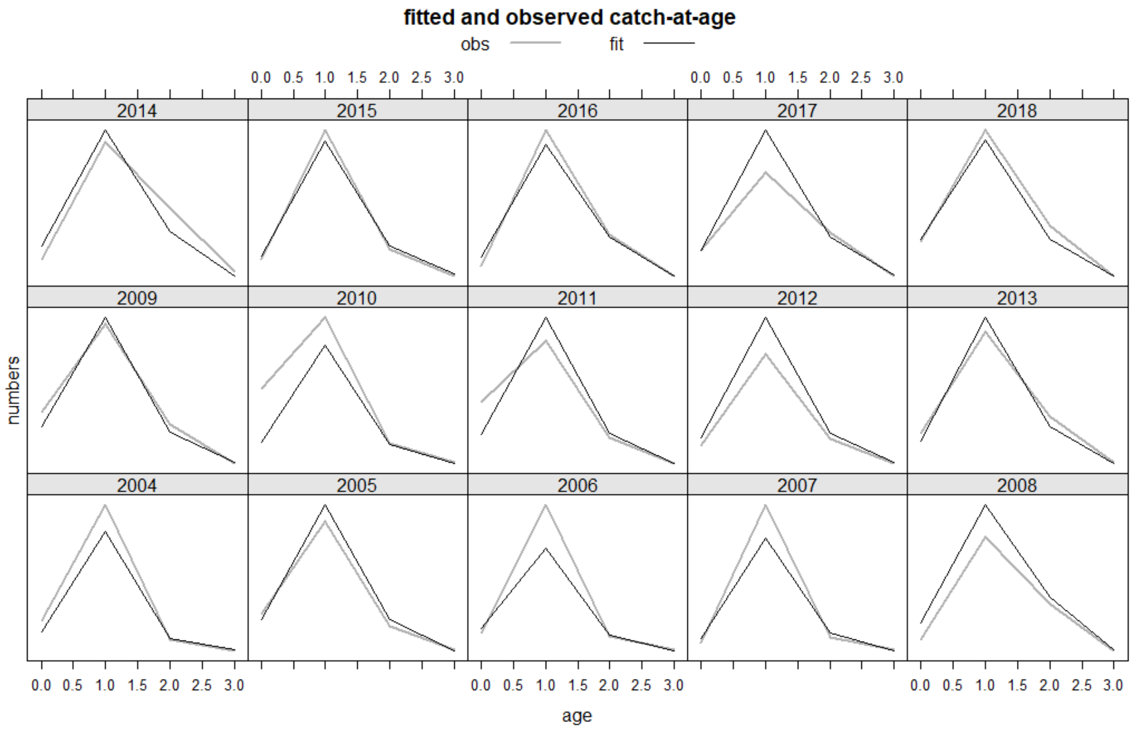


Figure 6.6.3.8 Red mullet in GSA 7. Comparison between observed and fitted catch at age.

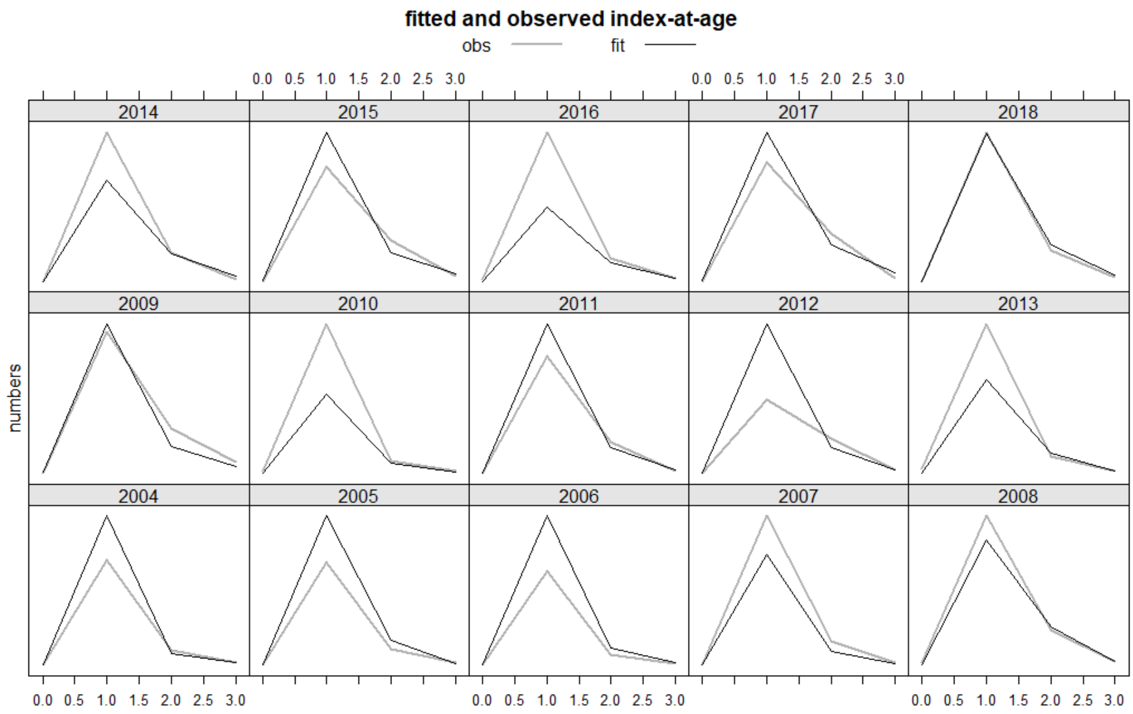


Figure 6.6.3.9 Red mullet in GSA 7. Comparison between observed and fitted index at age.

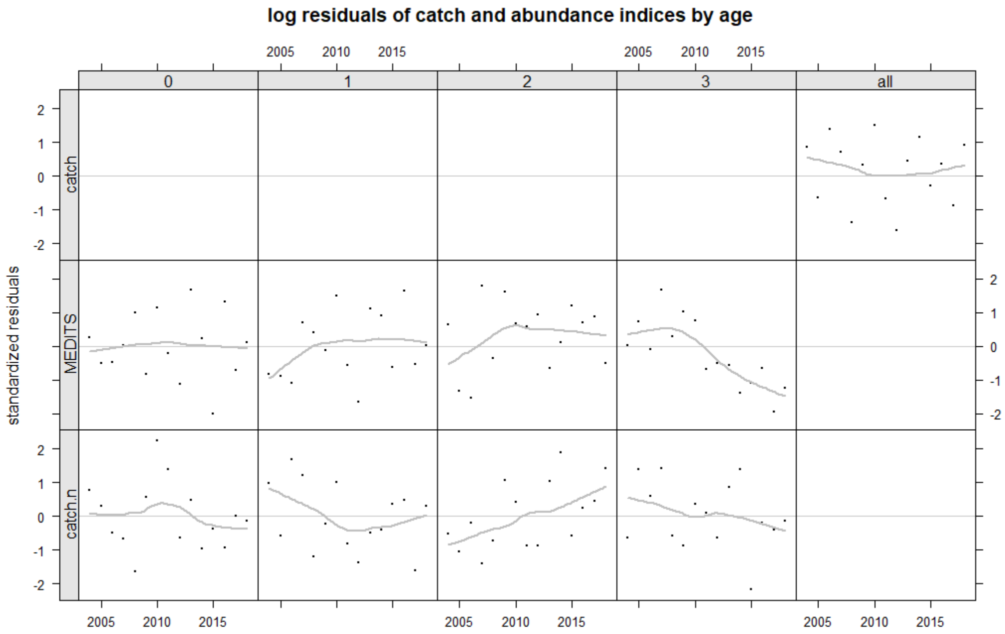


Figure 6.6.3.10 Red mullet in GSA 7. Log-residuals of catch and abundance indices by age.

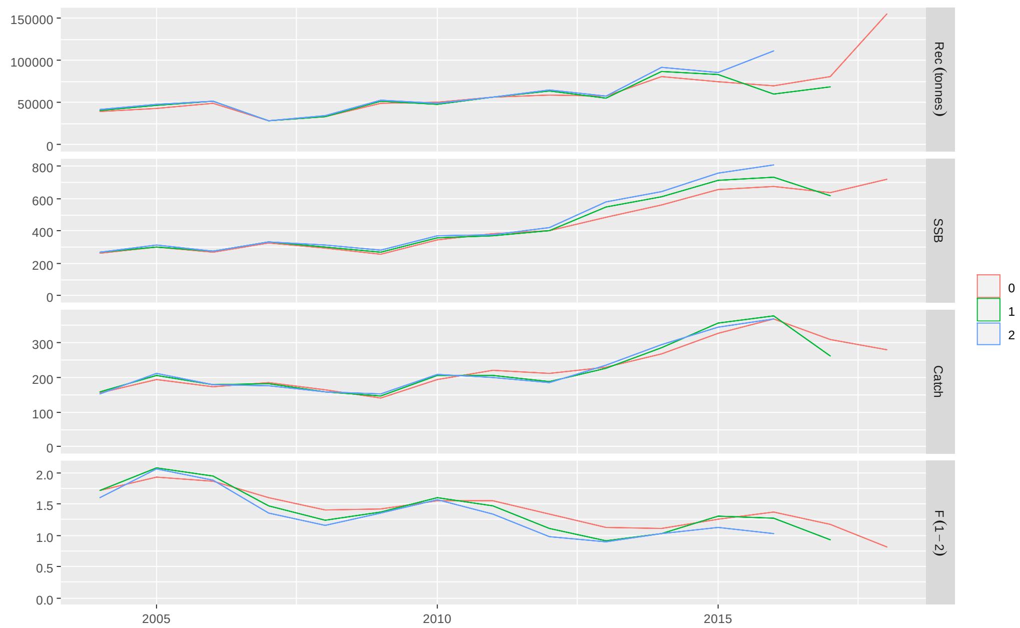


Figure 6.6.3.11 Red mullet in GSA 7. Retrospective analysis plots up 3 years back for recruitment, SSB, Catch and F.

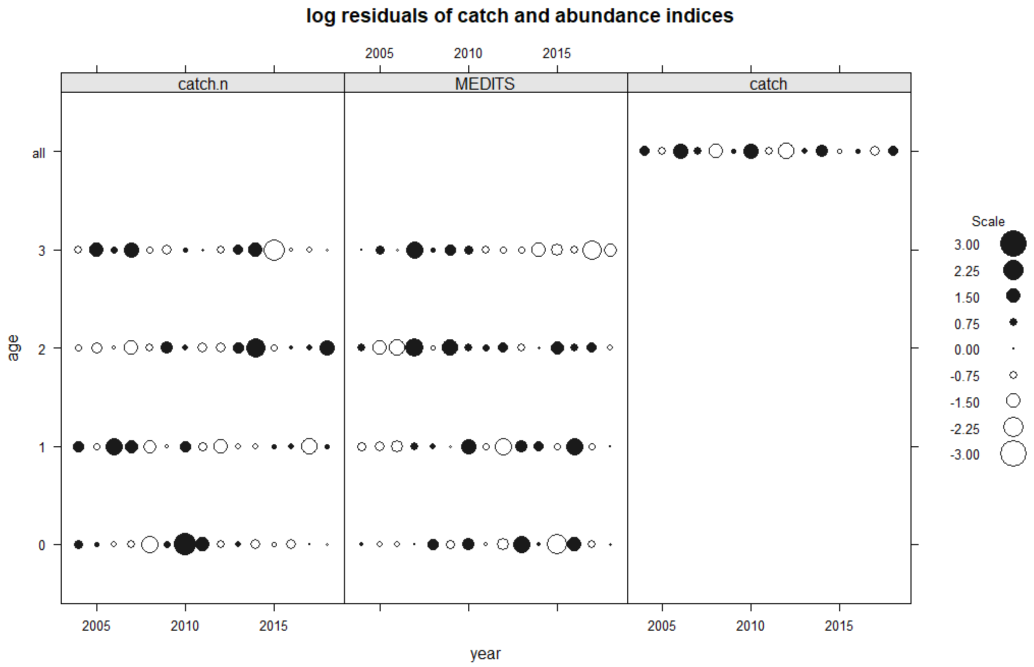


Figure 6.6.3.12 Red mullet in GSA 7. Bubble plot of residuals.

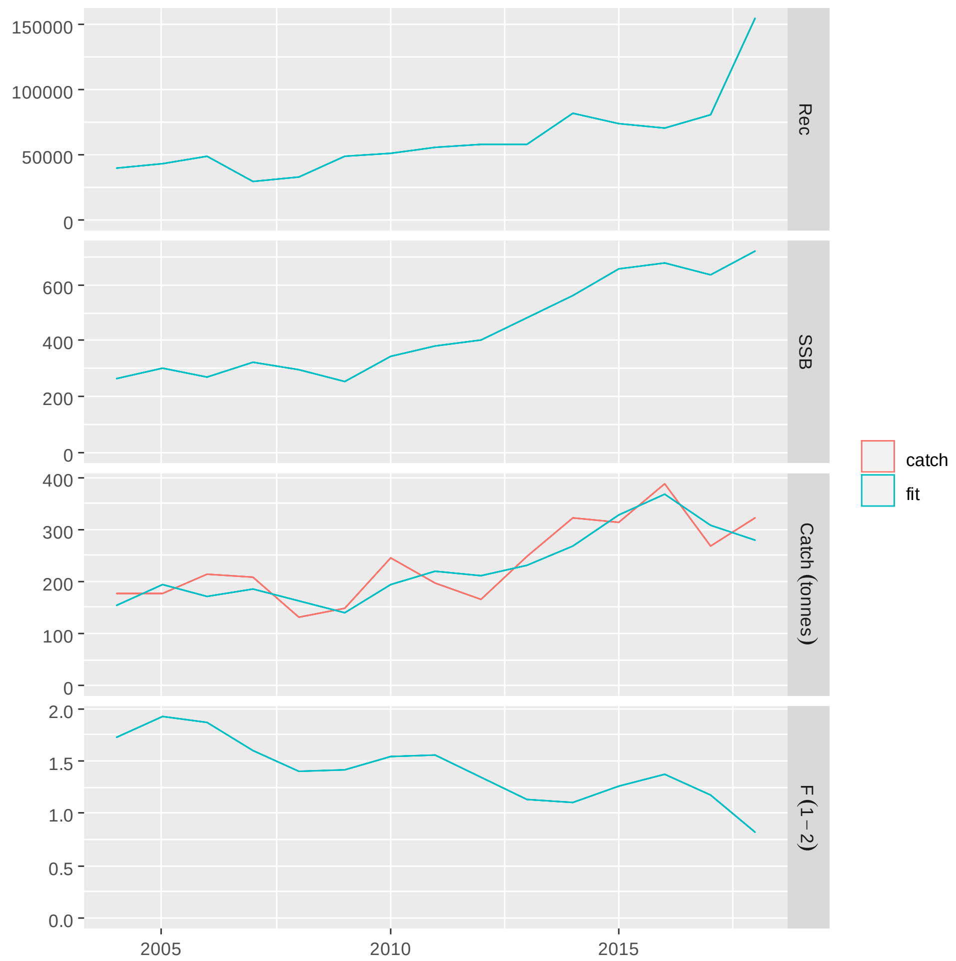


Figure 6.6.3.13 Red mullet in GSA 7. Stock results summary. SSB and catches are in tonnes, recruitment in number of individuals (thousand)

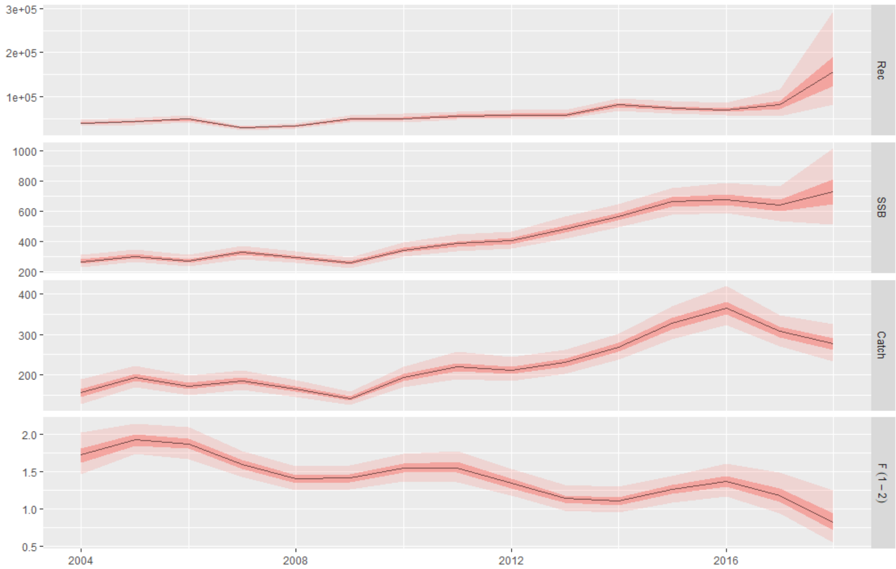


Figure 6.6.3.14 Red mullet in GSA 7. Stock results with uncertainty.

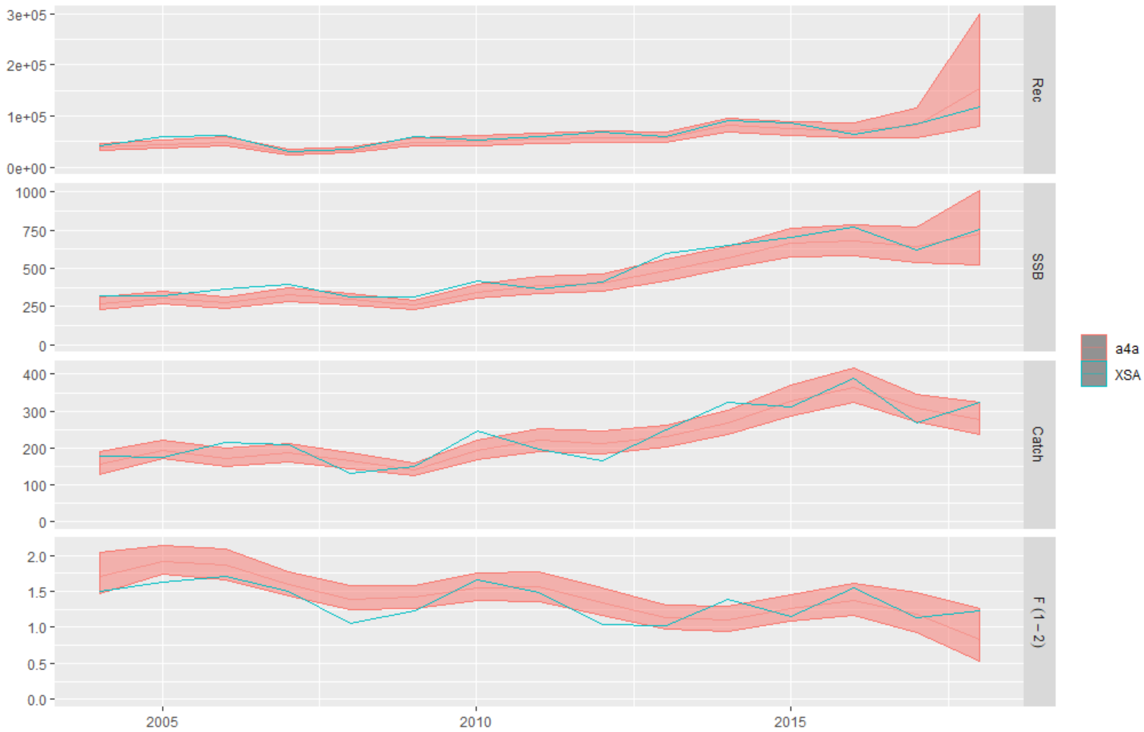


Figure 6.6.3.1.5 Red mullet in GSA 7. Stock results a4a vs XSA models.

The a4a asesement is chosen to provide the state of the stock and input stock status for STF below. The a4a assessment has better retrospective performance of F and SSB. The terminal F in XSA is heavily shrunk to the mean giving little information on the last years. A4a also provides explicit uncertainty analysis. The conclusions are different in detail but both methods conclude F is greater that F_{MSY}.

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.

Input data

As input the same population parameters used for the XSA and a4a and its output of the exploitation pattern for last three years of the assessment.

Results

The reference points calculated with FLBRP package are shown in table 6.6.4.1.

Table 6.6.4.1 Red mullet in GSA 7. Reference points estimated on the $F_{bar(-2)}$ using XSA and a4a and for the last assessments (GFCM, 2017, STECF 14-17, 2014). The exploitation status (F/ $F_{0.1}$) is similar for XSA or a4a.

	$F_{0.1}$	**Fcurrent***	**F/$F_{0.1}$**
a4a	0.62	0.82	1.32
XSA	0.52	1.2	2.3
GFCM 2018	0.31	0.78	2.52
STECF 18-12 - a4a	0.64	1.30	2.03
STECF 18-12 - XSA	0.40	0.87	2.18

*For the present analysis Fcurrent was determined as the FBAR1-2 value for the last year (2018).

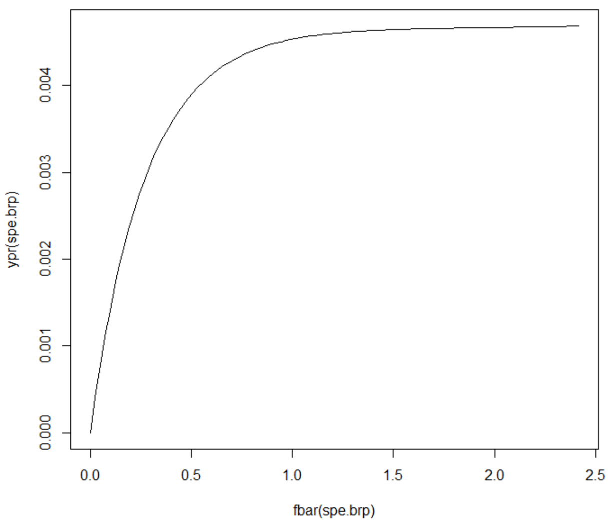


Figure 6.6.4.1 Red mullet in GSA 7. Yield per Recruitment, XSA.

6.6.5 SHORT TERM FORECAST AND CATCH OPTIONS

a4a

Folloing the procedure described in Section 4.3 input parameters used in the XSA and a4a analysis were used for the STF. Different scenarios of constant harvest strategy with F_{bar} calculated as the average of ages 1 to 2 and F status quo (F_{stq} = 0.82 based on F in 2018) were performed. Recuitment (class 0) has been estimated from the population results from the geometric mean of the whole series (2004-2018) (61763 thousand) estimated using a4a. The EWG has chosen to use the a4a assessment as this is considered to be more explicitly consistent in its treatment of the data.

Table 6.3.5.2 Red mullet GSA 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
$F_{ages\ 1\text{-}2}$ (2019)	0.82	F2018 (terminal F (2018) used to give F status quo for 2019
SSB (2019)	971.5	Stock assessment 1 January 2019
R_{age0} (2019,2020)	61763	Geometric mean of the time series years 2004-2018
Total catch (2019)	461.7	Assuming F status quo for 2019

Table 6.3.5.3 Red mullet in GSA 7. Short term forecast in different F scenarios computed for red mullet in GSA 7. Basis: F(2019) = mean F_{bar1-2} (2018) = 0.82; R (2019) = geometric mean of the recruitment of the time series = 61763 (thousands); SSB (2019) = 971.5 t, Catch (2019) = 461.7 t.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB* 2020	SSB* 2021	SSB change 2019-2021(%)	Catch change 2018-2020(%)
Zero Catch	0	0	278.42	461.74	0	0	1025.36	1377.2	34.3	-100
$F_{0.1}$	0.76	0.62	278.42	461.74	363.99	266.67	1025.36	887.9	-13.4	30.7
$f_{status\ quo}$	1	0.82	278.42	461.74	441.09	291.61	1025.36	790.51	-22.9	58.4
f_{upper}	1.03	0.85	278.42	461.74	451.67	294.2	1025.36	777.38	-24.2	62.2
f_{lower}	0.505	0.41	278.42	461.74	265.15	218.65	1025.36	1016.59	-0.9	-4.8
Different f scenarios	0.1	0.08	278.42	461.74	61.24	62.03	1025.36	1292.3	26	-78
	0.2	0.16	278.42	461.74	117.72	113.14	1025.36	1214.78	18.5	-57.7
	0.3	0.25	278.42	461.74	169.85	155.08	1025.36	1143.95	11.6	-39
	0.4	0.33	278.42	461.74	218.03	189.34	1025.36	1079.2	5.3	-21.7
	0.5	0.41	278.42	461.74	262.59	217.16	1025.36	1019.97	-0.5	-5.7
	0.6	0.49	278.42	461.74	303.84	239.61	1025.36	965.76	-5.8	9.1
	0.7	0.57	278.42	461.74	342.07	257.59	1025.36	916.1	-10.7	22.9
	0.8	0.66	278.42	461.74	377.54	271.84	1025.36	870.58	-15.1	35.6
	0.9	0.74	278.42	461.74	410.48	283	1025.36	828.83	-19.2	47.4
	1.1	0.9	278.42	461.74	469.58	298.13	1025.36	755.31	-26.3	68.7
	1.2	0.98	278.42	461.74	496.12	302.92	1025.36	722.95	-29.5	78.2
	1.3	1.06	278.42	461.74	520.88	306.31	1025.36	693.19	-32.4	87.1
	1.4	1.15	278.42	461.74	543.98	308.56	1025.36	665.79	-35.1	95.4
	1.5	1.23	278.42	461.74	565.58	309.89	1025.36	640.55	-37.5	103.1
	1.6	1.31	278.42	461.74	585.78	310.5	1025.36	617.28	-39.8	110.4
	1.7	1.39	278.42	461.74	604.7	310.52	1025.36	595.8	-41.9	117.2
	1.8	1.47	278.42	461.74	622.44	310.1	1025.36	575.97	-43.8	123.6
	1.9	1.56	278.42	461.74	639.1	309.33	1025.36	557.64	-45.6	129.5
	2	1.64	278.42	461.74	654.74	308.3	1025.36	540.68	-47.3	135.2

*SSB at mid year

Fishing at $F_{0.1}$ (0.62) generates an increase of the catch of 30.7% from 2018-2020 and a decrease of the spawning stock biomass of -13.4% from 2018-2020. F_{low} and F_{upp} values are calculated for $F_{0.1}$, being F_{low}= 0.5 and F_{upp}=1.03

6.6.6 DATA DEFICIENCIES

Red mullet GSA 7 Effort data

French effort values are only available for the last four years (2015-2018).

6.7 NORWAY LOBSTER IN GSA 5

6.7.1 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 5 boundaries (Figure 6.9.1.1). Generally managing Norway Lobster is considered to be a local small scale management, as ited to suitable benthic conditions, and occupy specific areas only.

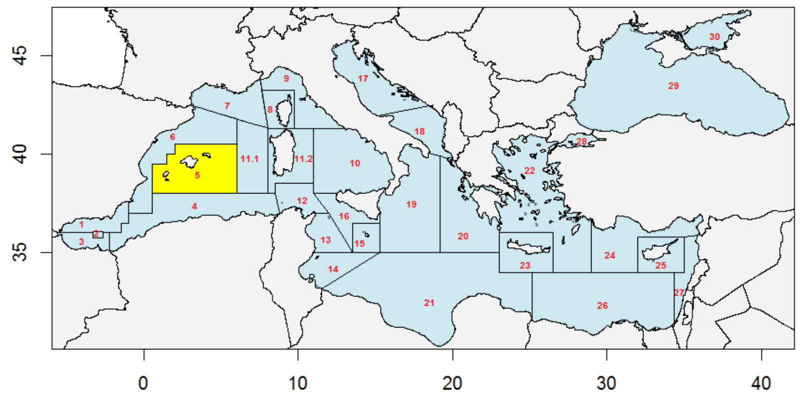


Figure 6.7.1.1. Geographical location of GSA 5.

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 by sex of *N. norvegicus* in GSA 5. So although the sex ratio in the catches was available in the DCF, growth parameters for both sexes combined were taken used from DCF (see Table 6.8.1.1), there were no previous assessments to compare with practice.

Table 6.8.1.1 parameters used for growth and weight at length taken from DCF data.

Growth Equation	$L\infty$	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 and a constant of 0.5 was added to t0.

Maturity is taken from DCF data and given in Table 6.8.1.2

Natural mortality is based on growth parameters given above using Chen and Watanabe and given in Table 6.8.1.2.

Table 6.7.1.2 Nephrops in GSA 5: Maturity and Natural mortality parameters used in the assessment

Age	1	2	3	4	5	6	7	8	9
Maturity	0.1	0.25	0.8	1	1	1	1	1	1

Natural mortality	0.732	0.466	0.353	0.291	0.252	0.226	0.206	0.191	0.180

6.7.2 Data

6.7.2.1 Catch (landings and discards)

Catch data are available from Spain, for 2002 to 2018, but catch at length is only available from 2009 onwards (Figure 6.9.2.1).

Figure 6.7.2.1 Nephrops in GSA 5: Catch at length by year reported by Spain.

Reported discards at length are low relative to landings and only available since 2009 (table 6.7.2.1, figure 6.7.2.2) . Discards have not been included in the total catches because considered negligible.

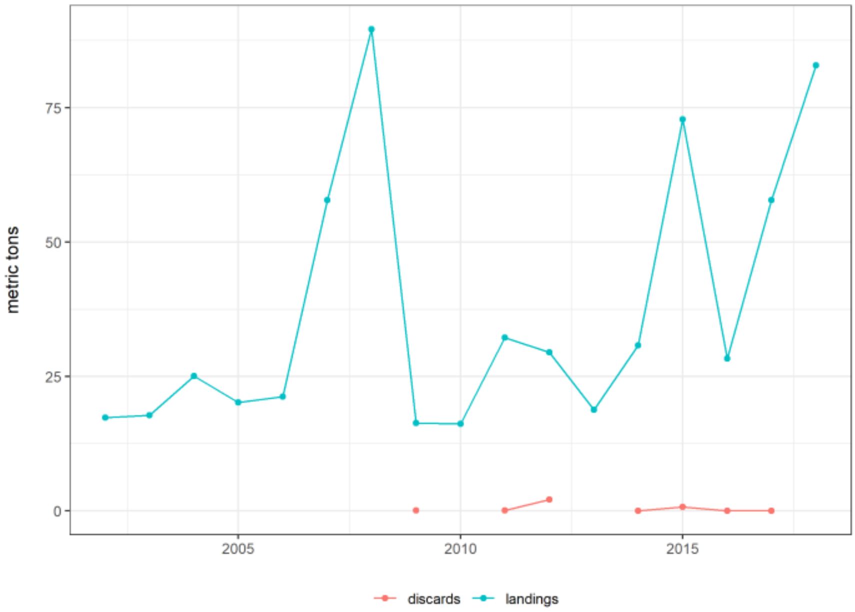


Figure 6.7.2.2 Nephrops in GSA 5: Catch and landings by year reported by Spain.

Table 6.7.2.1 Nephrops in GSA 5: Total landing discards and total catch by year reported by Spain.

year	landings	discards	total
2002	17.32	0	17.32
2003	17.77	0	17.77
2004	25.09	0	25.09
2005	20.17	0	20.17
2006	21.27	0	21.27
2007	57.78	0	57.78
2008	89.63	0	89.63
2009	16.34	0.05	16.39
2010	16.19	0	16.19
2011	32.26	0.07	32.33
2012	29.5	2.11	31.61
2013	18.82	0	18.82
2014	30.8	0.03	30.83
2015	72.87	0.74	73.61
2016	28.33	0.02	28.35

year	landings	discards	total
2017	57.82	0.02	57.84
2018	82.91	0	82.91

Reported catches at length were raised to the total by using the sum of products correction. SOP corrections were high, similar in all years but higher than expected between 1.65 in 2018 compared to 1.11 in 2017 (Figure 6.7.2.3).

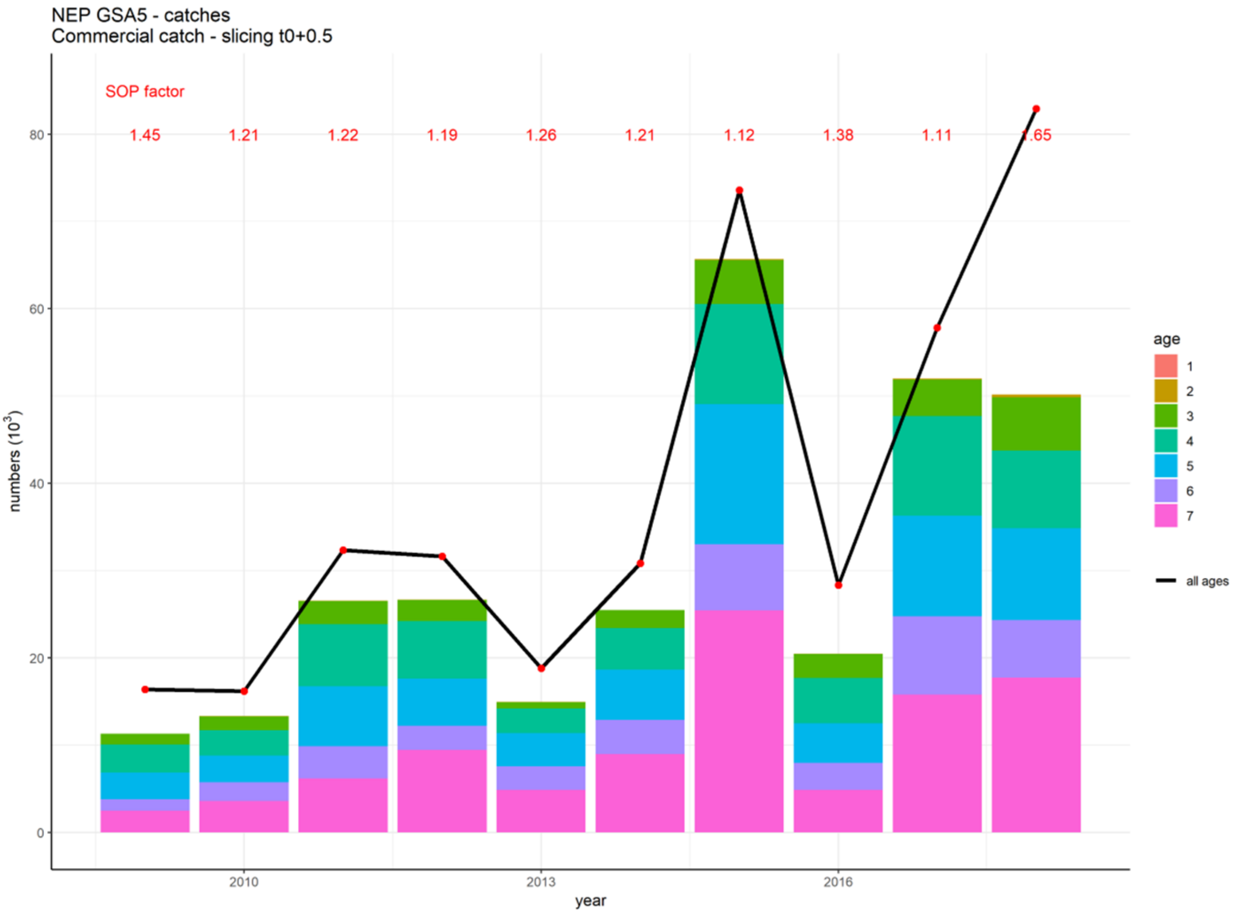


Figure 6.7.2.3 Nephrops in GSA 5: Total landing by year reported by Spain and factor needs for SOP correction.

Table 6.7.2.2 Nephrops in GSA 5: SOP corrections for years applied to raised catch at length/age used in the assessment.

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1.45	1.21	1.22	1.19	1.26	1.21	1.12	1.38	1.11	1.65

Catch at length was deterministically length sliced to numbers and mean weights at age for the assessment using the growth parameters and weight length relationship given in Table 6.9.1.1. but 0.5 was added to t0 due to the spawing season of the species that occur in the middle of the year. The original parameters were taken from the DCF data call and considered reasonable.

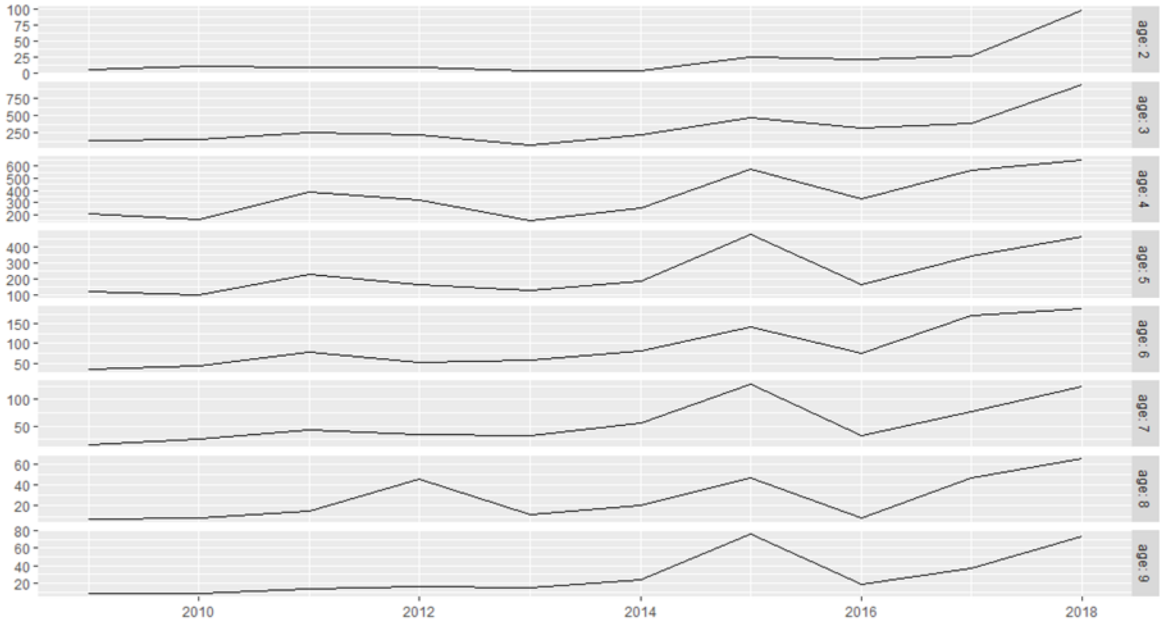


Figure 6.7.2.2 Nephrops in GSA 5: Catch at age by year from length sliced catch at length.

In conclusion catch at age is available from 2009 to 2017, in addition total catch is available for earlier years 2002 to 2008, but without length or age data.

6.7.2.2 EFFORT

In GSA 5 catches Norway lobster are only reported by trawl vessels (OTB).

Available information about OTB effort in GSA 5 shows a decreasing trend in the last 10 years (Figure 6.7.2.2.1).

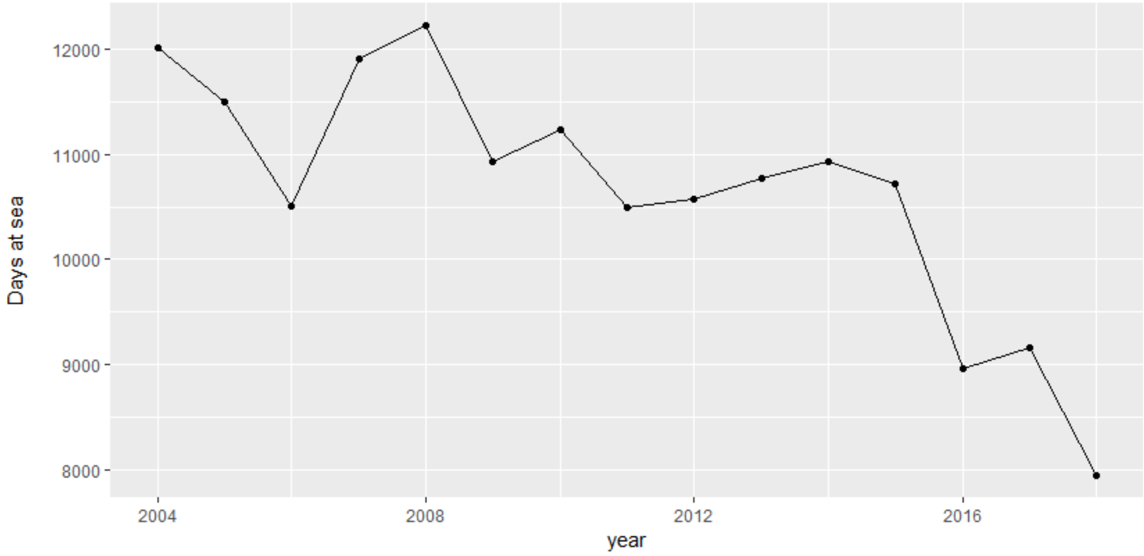
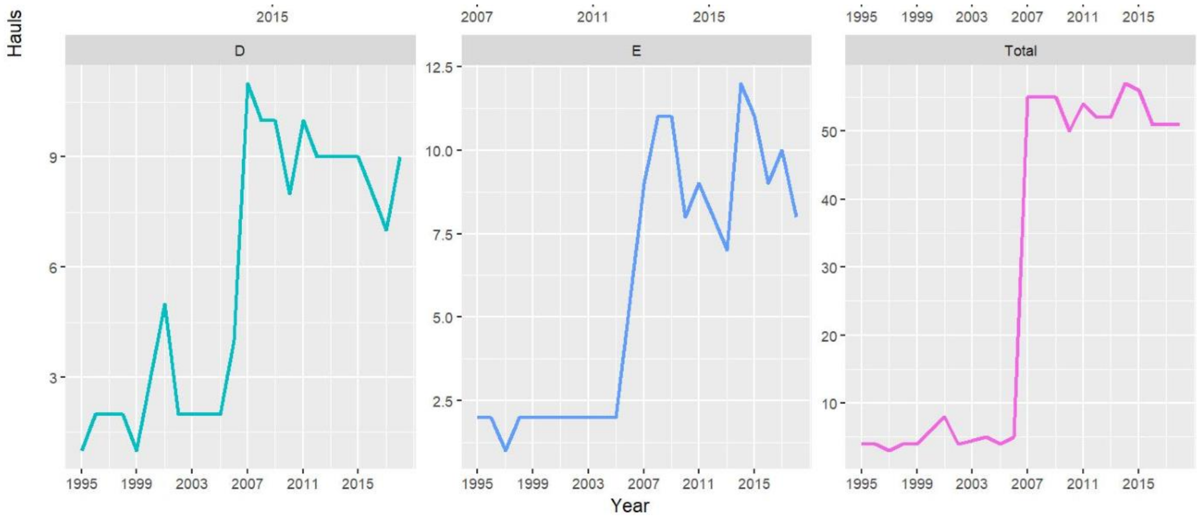


Figure 6.7.2.2.1 Nephrops in GSA 5: Days at sea by OTB fleet and by year.

6.7.2.3 SURVEY DATA

The MEDITS survey was conducted in a restricted way from 1995 to 2006. In, in 2007 the number of stations was increased greatly (Figure 6.9.2.3) and MEDITS was conducted consistently from 2007 to the present. The early data with very few hails per year was not considered suitable for a tuning index, given also that during most of that period only total catch would be available.

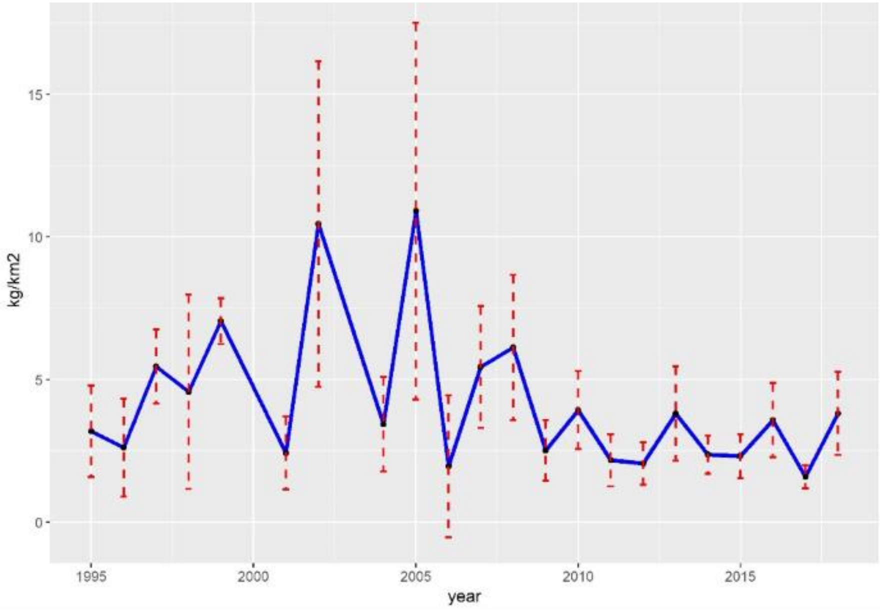
The mean depth of occurrence of the specie is 492 ± 152 m, and the species occur below



Hauls_time_series

Figure 6.7.2.3, number of MEDITS hauls per year 1995 to 2017, (increase in 2007).

Observed abundance and biomass indices of Norway lobster and the length frequency distributions are given in the figures below for GSA5. Both estimated abundance and biomass indices show a similar high variable pattern throughout the time series trends, with a sharp increase of density in the last year (Figure 6.7.2.3).



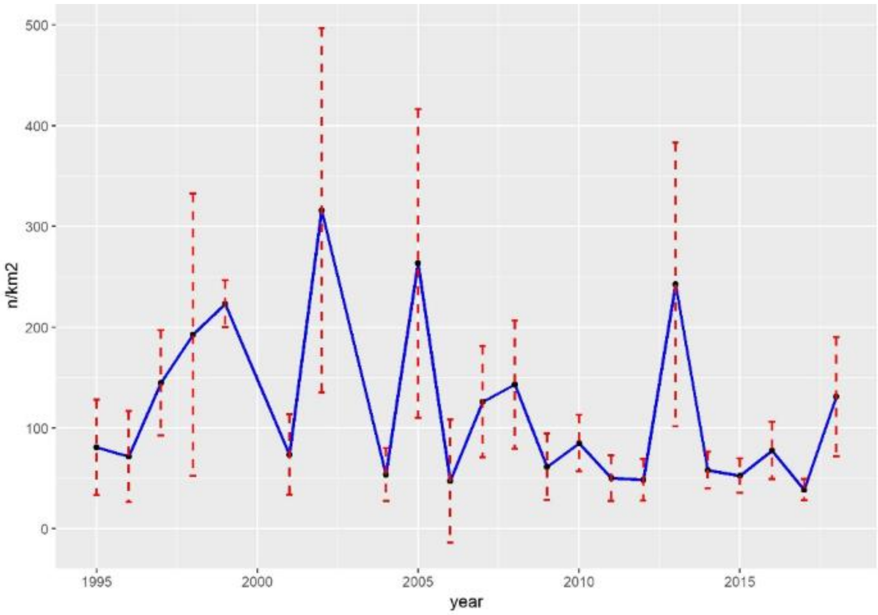


Figure 6.7.2.3. Norway lobster GSA 5. Estimated biomass indices (kg/km^2) and abundance indices (N/km^2) in whole time series.

In the last ten years the pattern is less variable with a greater uncertainity during the peaks (Figure 6.7.2.4).

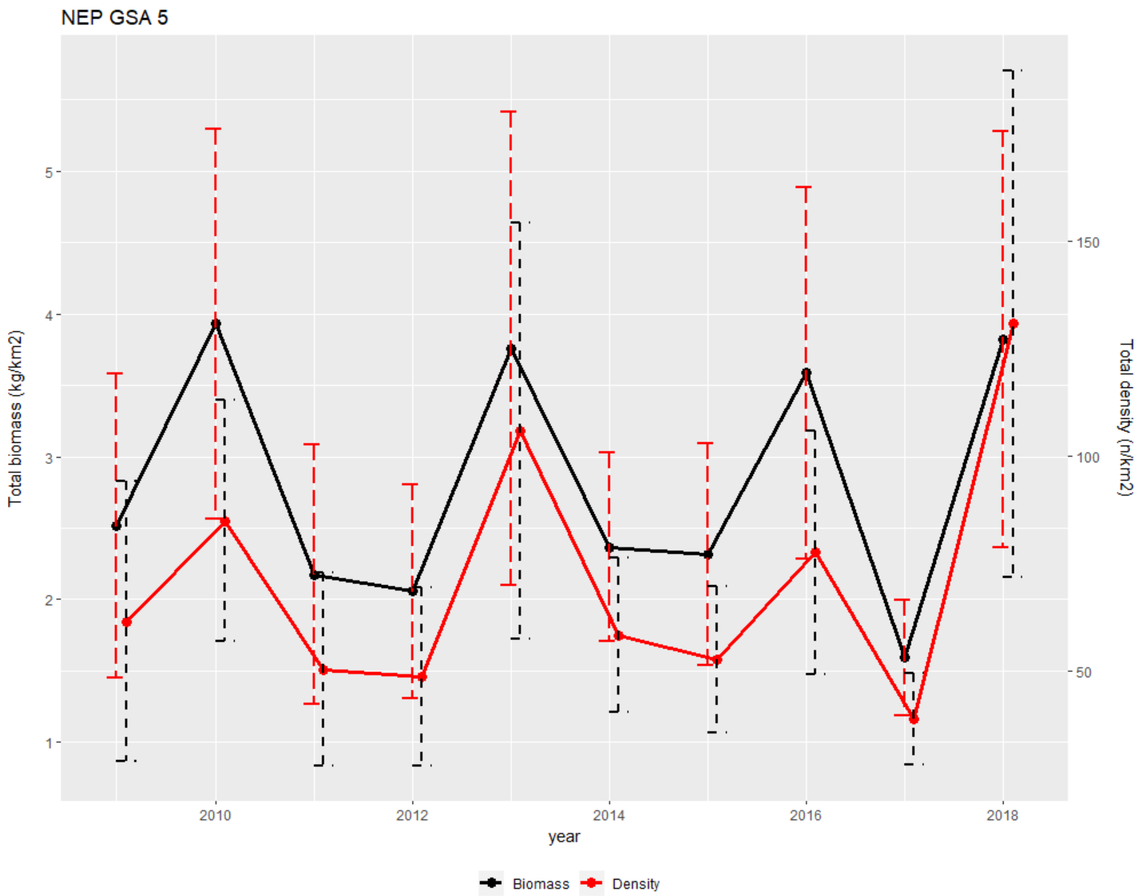


Figure 6.7.2.4. Norway lobster GSA 5. Comparison of biomass indices (kg/km^2) and abundance indices (N/km^2) in the last 10 years (density are shifted slightly on year axis to avoid overlapping).

Standardized MEDITS catch at length data (Figure 6.7.2.5) was length sliced to give catch at age Figure (6.7.2.6) using the same growth and length parameters as the catch (Table 6.7.1.1).

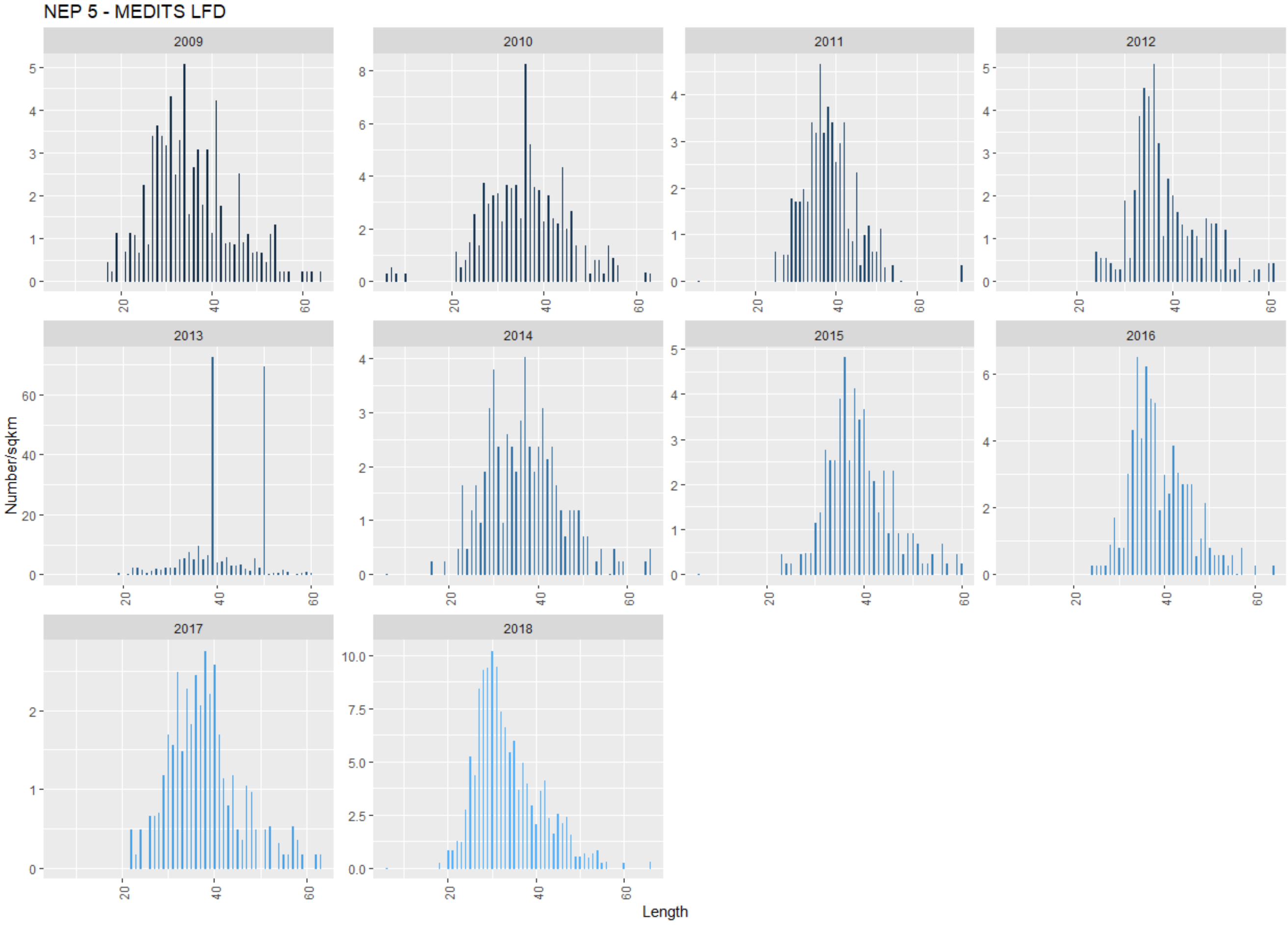


Figure 6.7.2.4. Nephrops in GSA 5: MEDITS catch at length by year

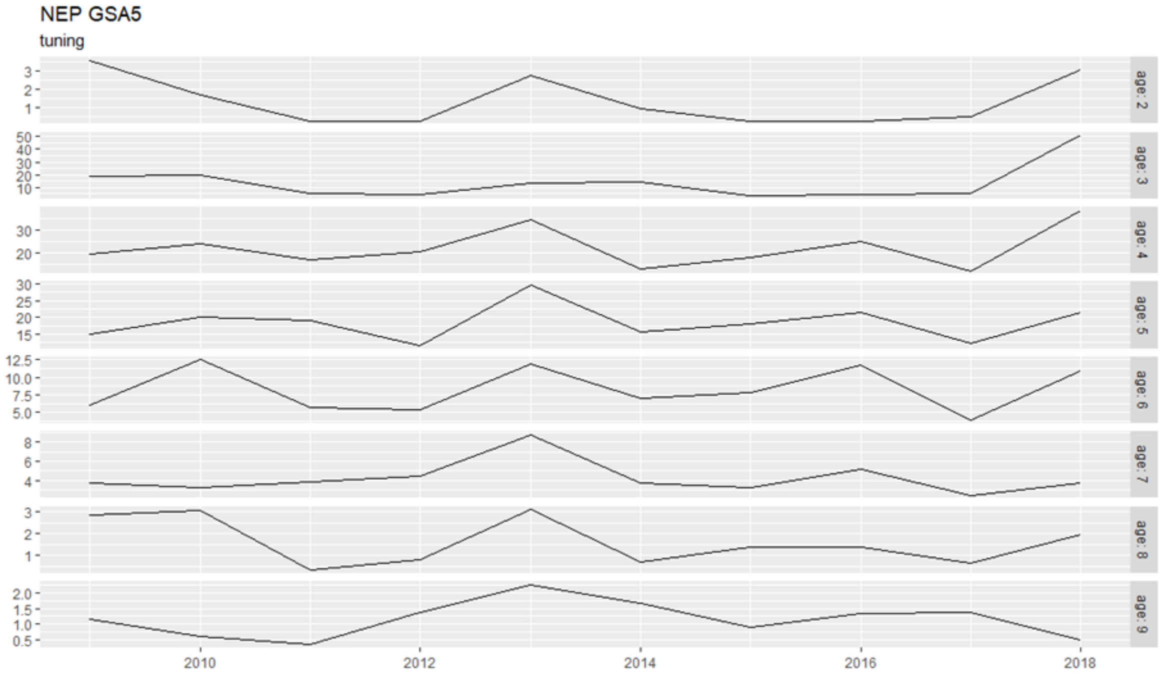


Figure 6.7.2.5. Nephrops in GSA 5: MEDITS mean catch/rate at age by year derived from length by slicing.

The conclusion to the data investigation, is that only age disaggregated data is available from 2007 for the survey and 2009 for the catch, the best option for the assessment is when both catch and index are available age disaggregated. So the assessment is run based on catches from 2009 to 2018. The addition of just two extra years 2007 and 2008 with no age data for catch was considered to increase model complexity without any real benefits in information.

6.7.3 STOCK ASSESSMENT

Stock assessment input data is given in Tables 6.7.3.1 to 6.7.3.4

Table 6.7.3.1 Nephrops in GSA 5: Total Catch by year in tonnes

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
All	16.34	16.19	32.26	29.50	18.82	30.80	72.87	28.35	57.82	82.91

Table 6.7.3.2 Nephrops in GSA 5: Total Catch by age and year in tonnes

Age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	5.341	9.624	9.348	8.998	3.612	3.717	24.126	20.702	27.087	97.853
3	142.658	153.295	259.822	224.977	69.052	212.775	470.184	322.808	381.946	942.145
4	207.539	161.967	390.815	324.729	157.109	257.919	571.863	328.056	570.421	653.806
5	117.254	97.885	222.241	161.436	126.934	182.635	474.703	164.949	336.567	463.451
6	33.795	44.163	76.583	52.562	58.394	81.115	142.746	74.391	171.816	186.657
7	15.949	25.85	42.148	33.734	33.198	54.913	128.79	31.893	77.143	123.665
8	7.402	8.819	15.238	46.05	11.362	20.815	46.366	8.729	46.309	64.978
9	8.478	7.725	13.732	15.464	14.047	24.393	76.636	19.008	37.5	73.12

Table 6.7.3.3 Nephrops in GSA 5: Stock and catch weights at age

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
3	0.012	0.013	0.012	0.012	0.013	0.012	0.012	0.012	0.012	0.011
4	0.022	0.022	0.022	0.022	0.023	0.022	0.022	0.022	0.022	0.022
5	0.038	0.038	0.038	0.037	0.038	0.038	0.038	0.038	0.038	0.038
6	0.057	0.059	0.059	0.058	0.058	0.059	0.059	0.058	0.058	0.058
7	0.084	0.083	0.083	0.082	0.083	0.085	0.081	0.082	0.082	0.083
8	0.113	0.111	0.113	0.111	0.108	0.11	0.109	0.107	0.111	0.112
9	0.166	0.164	0.166	0.165	0.152	0.159	0.166	0.167	0.161	0.161

Table 6.7.3.4 Nephrops in GSA 5: Maturity and Natural mortality at age

Age	2	3	4	5	6	7	8	9+
Maturity	0.25	0.80	1	1	1	1	1	1
Natural Mortality	0.466	0.353	0.291	0.252	0.225	0.206	0.192	0.180

Average spawning time set 0.5 (Ist July)

Catch 2009 to 2018

age range 2 to 9+

Fbar set 2 to 6

Table 6.7.3.5 Nephrops in GSA 5: MEDITS tuning index of abundance by age and by year.

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	3.589	1.660	0.241	0.241	2.777	0.945	0.241	0.241	0.481	3.071
3	18.408	19.320	5.215	4.575	13.170	14.634	3.433	4.443	5.515	50.789
4	19.344	23.705	16.584	20.469	34.282	12.970	17.866	24.895	12.056	38.440
5	15.033	20.141	19.192	11.638	29.570	15.795	18.078	21.486	12.427	21.544
6	6.054	12.499	5.625	5.347	11.879	7.068	7.789	11.695	3.825	10.894
7	3.747	3.197	3.866	4.455	8.780	3.769	3.200	5.146	2.444	3.685
8	2.868	3.053	0.346	0.798	3.099	0.707	1.370	1.403	0.654	1.986
9	1.139	0.594	0.346	1.356	2.260	1.649	0.915	1.337	1.381	0.512

The stock assessment was explore for two final models. In particular two separable f models were used:

```
fmodel0 <- ~factor(age) + factor(year)
fmodel1 <- ~factor(replace(age,age>6,6)) + s(year,k=4)
```

while the same catchability and stock recruitment models were considered

```
qmodel1 <- ~factor(replace(age,age>5,5))
srmodel0 <- ~factor(year)
```

Assessment results of Nephrops in GSA 5 are given in tables 6.7.3.6 to 6.7.3.8 and figure 6.7.3.1.

Table 6.7.3.6 Nephrops in GSA 5: Stock number by age and by year in thousands in the two models tested

Fit n.	age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	2	3110	3138	2670	3639	4267	4063	4208	3678	6263	14914
1	3	1503	1945	1963	1668	2276	2672	2542	2624	2301	3909
1	4	751	942	1237	1161	1035	1479	1692	1403	1661	1316
1	5	364	421	547	597	634	635	850	685	805	736
1	6	166	194	236	241	309	381	351	298	378	317
1	7	71	97	118	118	137	199	230	145	179	172
1	8	29	40	57	55	64	87	115	84	84	74
1	9	11	21	34	37	45	65	81	60	77	55

Fit n.	age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	2	2946	2929	2607	3020	3689	3612	4035	3780	6805	16535
2	3	1536	1843	1832	1630	1888	2307	2259	2523	2362	4246
2	4	732	967	1146	1128	1002	1164	1424	1384	1506	1339
2	5	349	414	529	612	599	536	626	750	682	650
2	6	166	188	213	264	303	300	270	307	338	258
2	7	78	91	99	109	134	155	155	135	141	130
2	8	37	44	49	52	56	70	82	79	64	55
2	9	17	31	41	48	52	58	68	78	75	56

Table 6.7.3.7 Nephrops in GSA 5: Fishing Mortality by age and by year in the two models tested

fit	age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	2	0	0	0	0	0	0	0.01	0	0.01	0.01
1	3	0.11	0.1	0.17	0.12	0.08	0.1	0.24	0.1	0.21	0.36
1	4	0.29	0.25	0.44	0.31	0.2	0.26	0.61	0.26	0.52	0.91
1	5	0.38	0.33	0.57	0.41	0.26	0.34	0.8	0.34	0.68	1.19
1	6	0.31	0.27	0.47	0.34	0.21	0.28	0.66	0.28	0.56	0.98
1	7	0.37	0.33	0.57	0.41	0.26	0.34	0.79	0.34	0.68	1.19
1	8	0.36	0.31	0.54	0.39	0.25	0.33	0.76	0.33	0.65	1.14
1	9	0.68	0.59	1.03	0.74	0.46	0.62	1.44	0.62	1.23	2.15

fit	age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	2	0	0	0	0	0	0	0	0	0.01	0.01
2	3	0.11	0.12	0.13	0.13	0.13	0.13	0.14	0.16	0.21	0.3
2	4	0.28	0.31	0.34	0.34	0.33	0.33	0.35	0.42	0.55	0.77
2	5	0.37	0.41	0.44	0.45	0.44	0.43	0.46	0.55	0.72	1.01
2	6	0.37	0.41	0.45	0.45	0.44	0.44	0.46	0.55	0.73	1.02
2	7	0.37	0.41	0.45	0.45	0.44	0.44	0.46	0.55	0.73	1.02
2	8	0.37	0.41	0.45	0.45	0.44	0.44	0.46	0.55	0.73	1.02
2	9	0.37	0.41	0.45	0.45	0.44	0.44	0.46	0.55	0.73	1.02

Table 6.7.3.8 Nephrops in GSA 5: Stock assessment summary table by year in the two models, Fishing morality, Recruitment (thousands) Spawing stock biomass (tonnes) and catch (tonnes)

Fit	year	Fbar	Recruitment	SSB	TB	Catch
1	2009	0.22	3110	52	83	15
1	2010	0.19	3138	67	102	17
1	2011	0.33	2670	74	120	34
1	2012	0.24	3639	77	121	26
1	2013	0.15	4267	94	142	20
1	2014	0.2	4063	111	168	32
1	2015	0.46	4208	104	187	71
1	2016	0.2	3678	102	154	29
1	2017	0.39	6263	103	185	59
1	2018	0.69	14914	92	223	77

fit	year	Fbar	Recruitment	SSB	TB	Catch
2	2009	0.23	2946	54	84	15
2	2010	0.25	2929	65	101	21
2	2011	0.27	2607	73	113	26
2	2012	0.28	3020	77	119	28
2	2013	0.27	3689	83	132	29
2	2014	0.27	3612	89	139	31
2	2015	0.28	4035	95	152	35
2	2016	0.34	3780	97	157	43
2	2017	0.44	6805	93	172	53
2	2018	0.62	16535	95	223	63

Cohorts consistence was checked for both landings and survey index (Figure 6.7.3.1). Consistence among cohorts was poor both in survey index and catches.

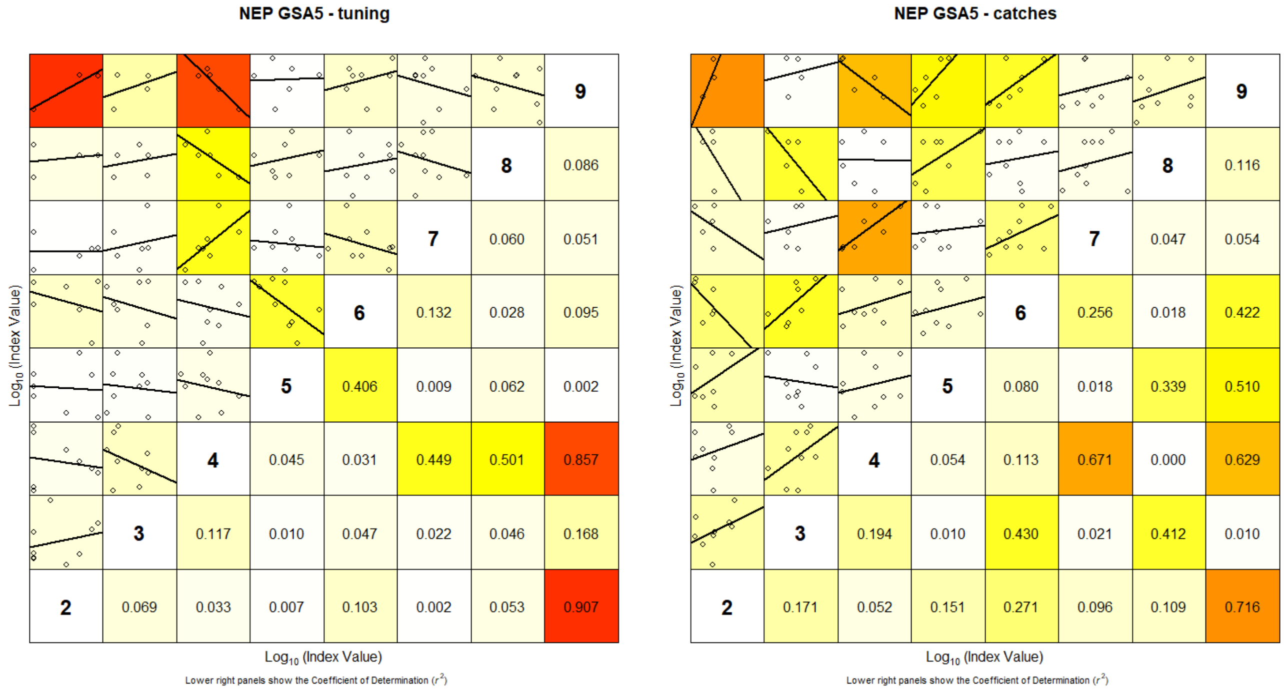


Figure 6.7.3.1. Norway lobster GSA5; cohorts consistence in catch (right panel) and tuning index (left panel).

The assessment models diagnostics are shown in Figures 6.7.3.1, 6.7.3.2 and 6.7.3.3. Generally the residuals are moderate, with some year effects visible in both catch and survey indices, particularly in Fit 2. Catch and index observations and estimates given in Figures 6.7.3.2 and 6.7.3.3 are similar without major outliers in both data sets.

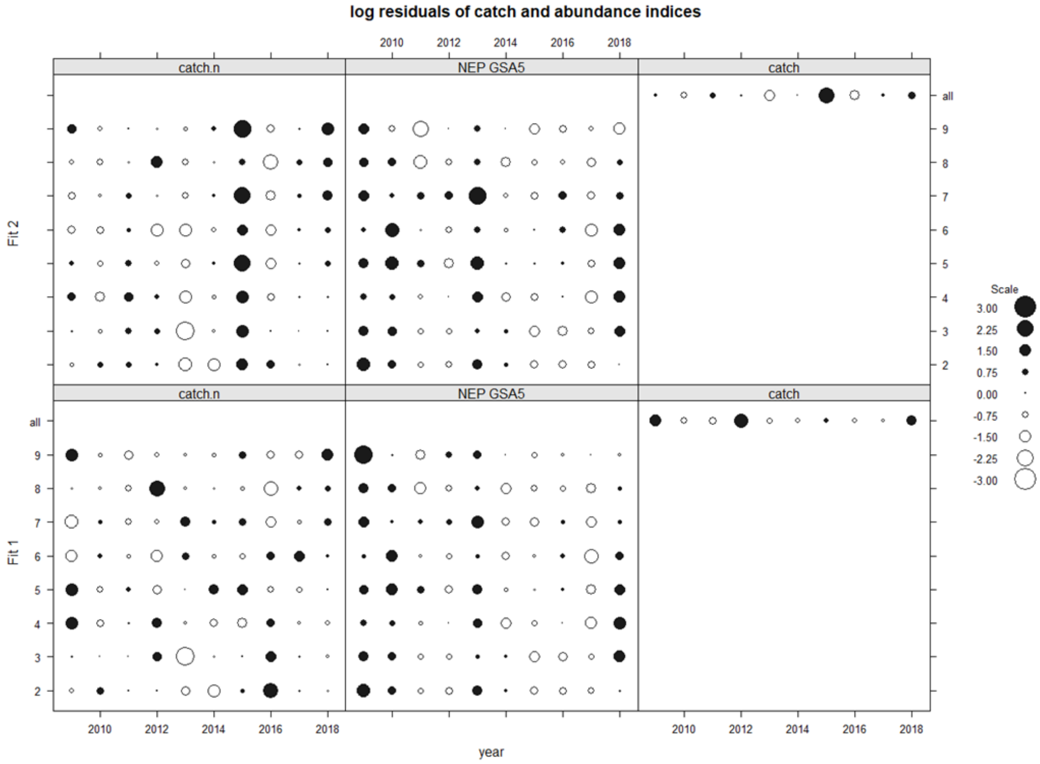
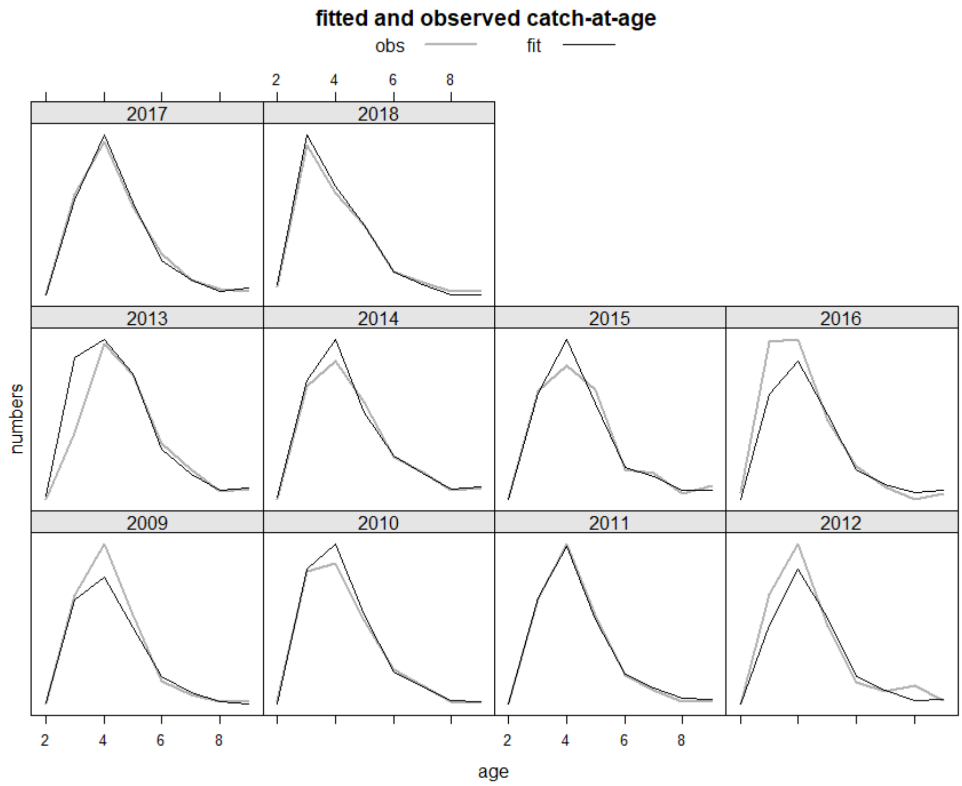
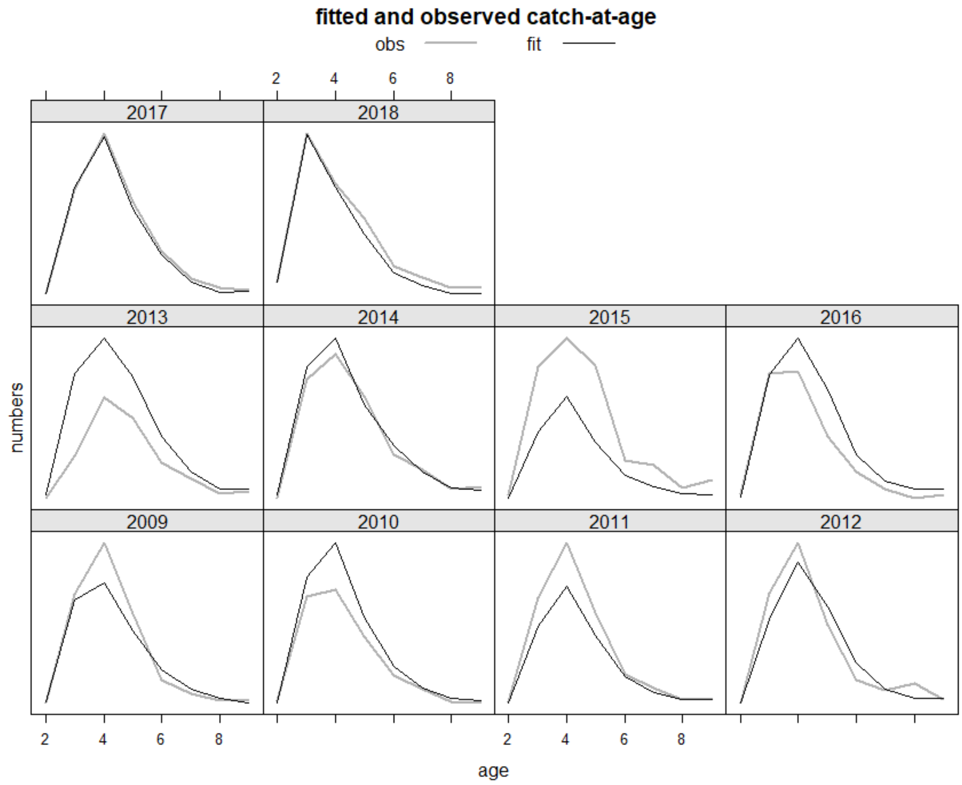


Figure 6.7.3.1 Nephrops in GSA 5: Normalised log residuals for catch and abundance indices in the two models.

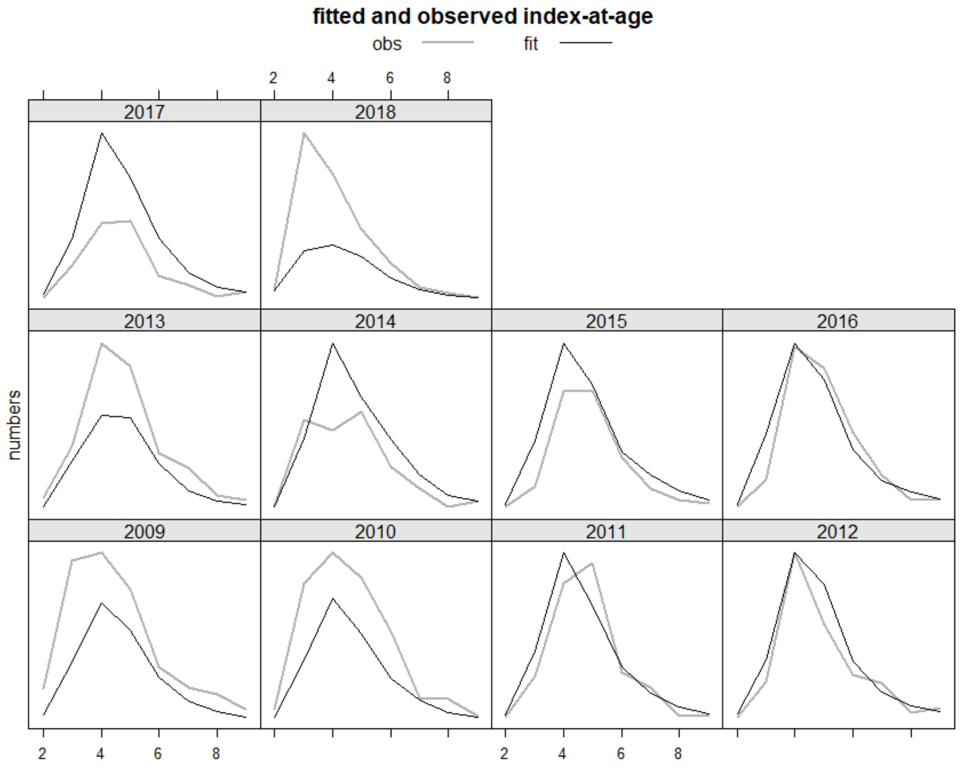


A

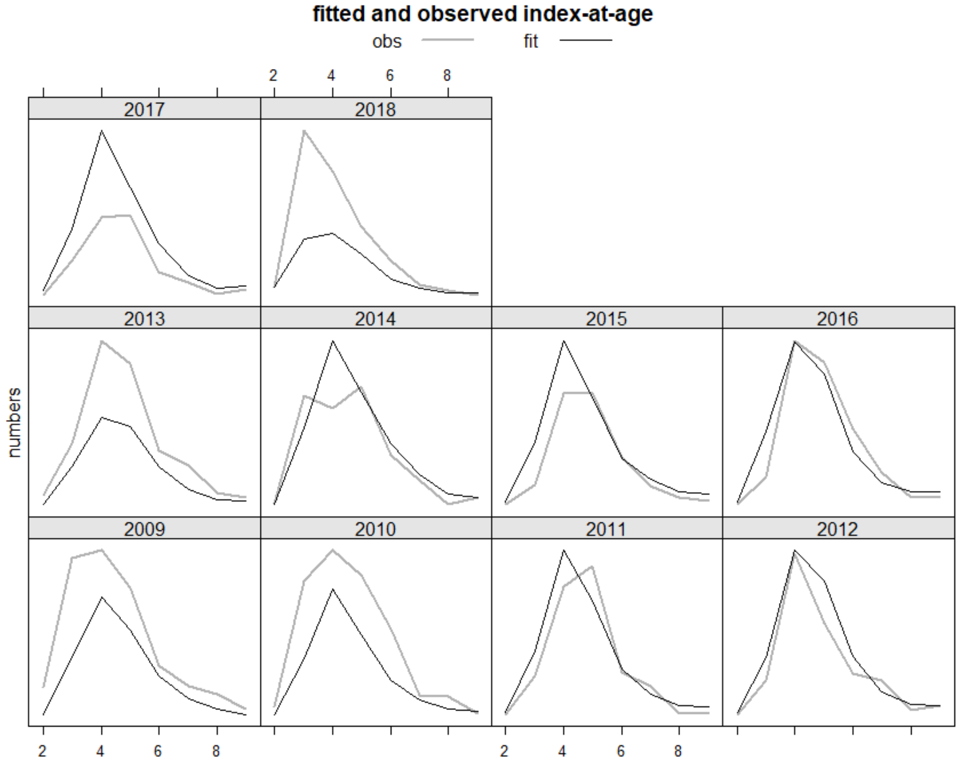


B

Figure 6.7.3.2 Nephrops in GSA 5: Observations and estimated catch at age and year in the two model (A=Fit1, B=Fit2).



A



B

Figure 6.7.3.3 Nephrops in GSA 5: Observations and estimated MEDITS index at age and year in the two model (A=Fit1, B=Fit2).

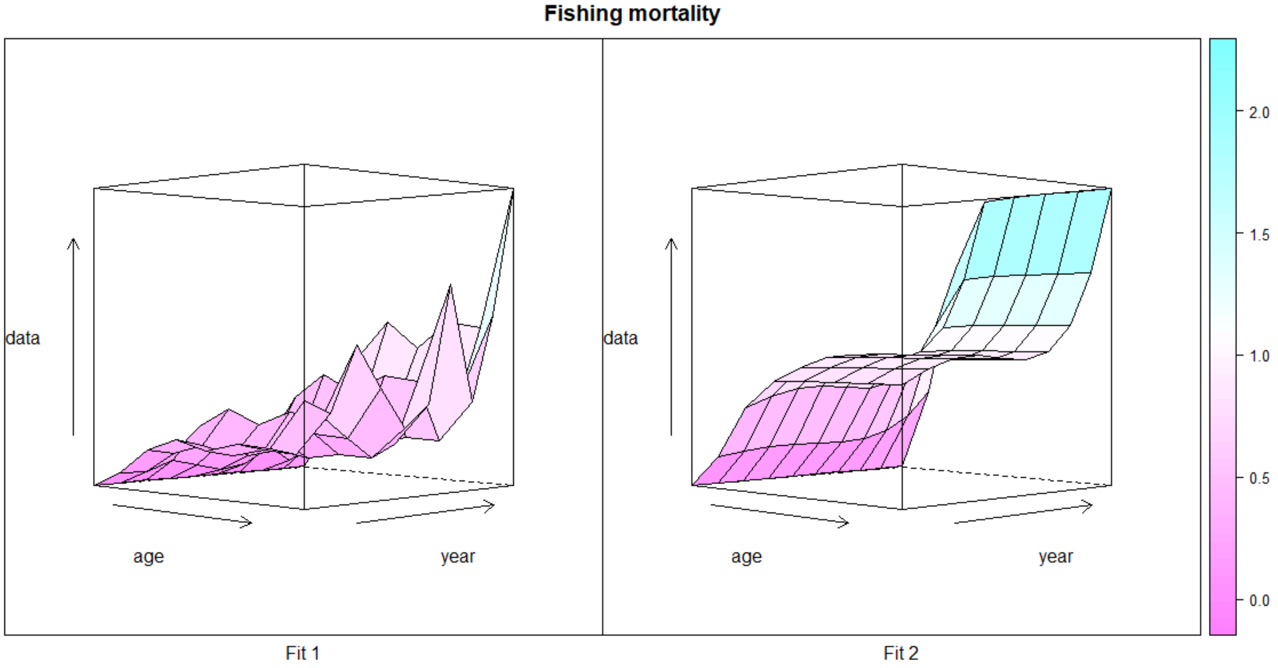


Figure 6.7.3.4 Nephrops in GSA 5: Fishing mortality at age and year in the two models.

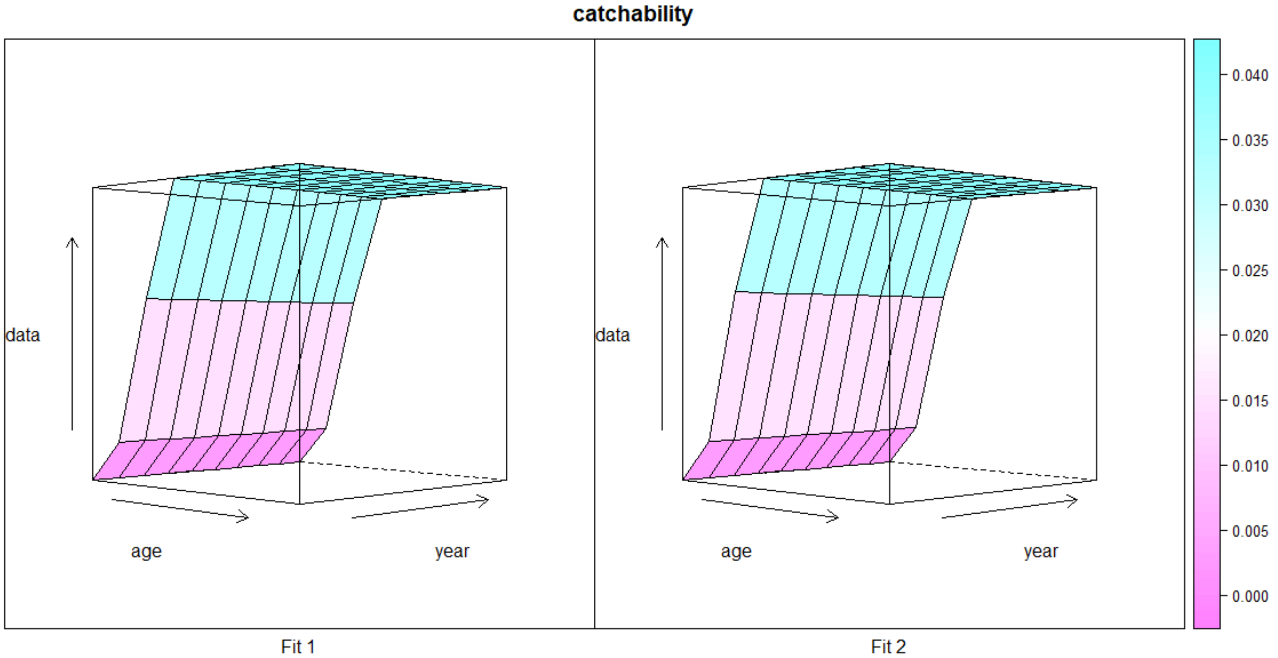


Figure 6.7.3.5 Nephrops in GSA 5: Selection pattern for MEDITS index at age and year (flat age 5 and above) in the two models.

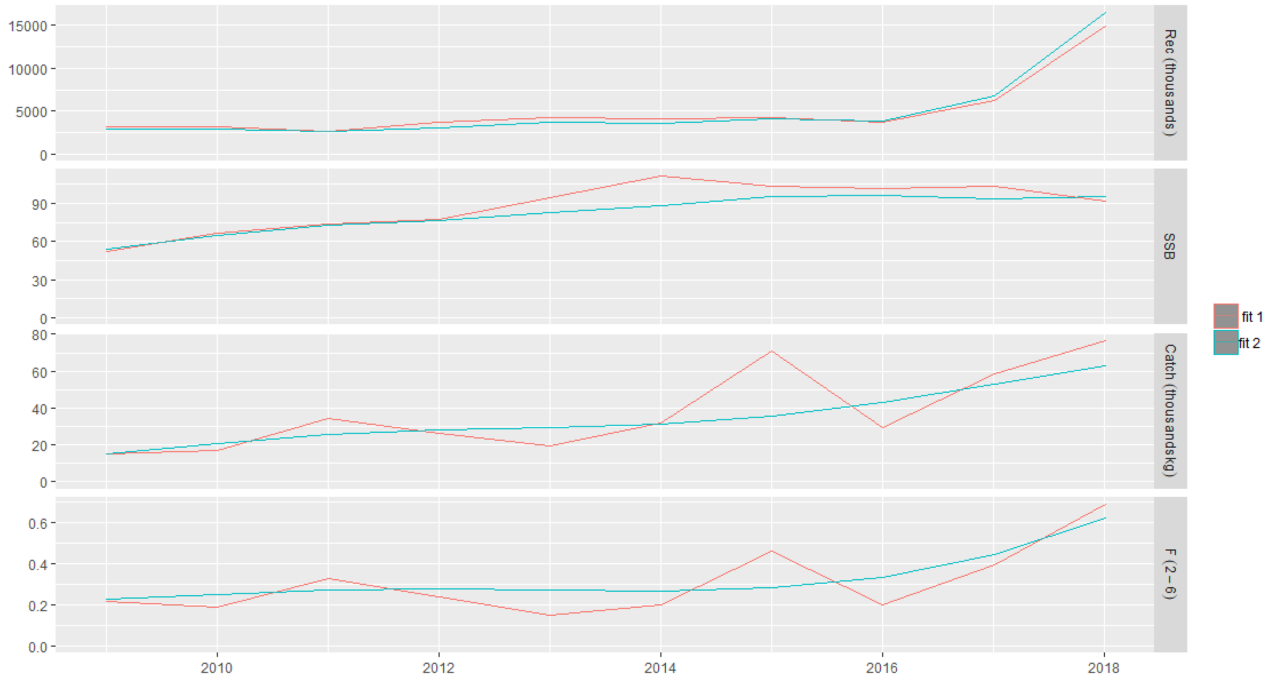
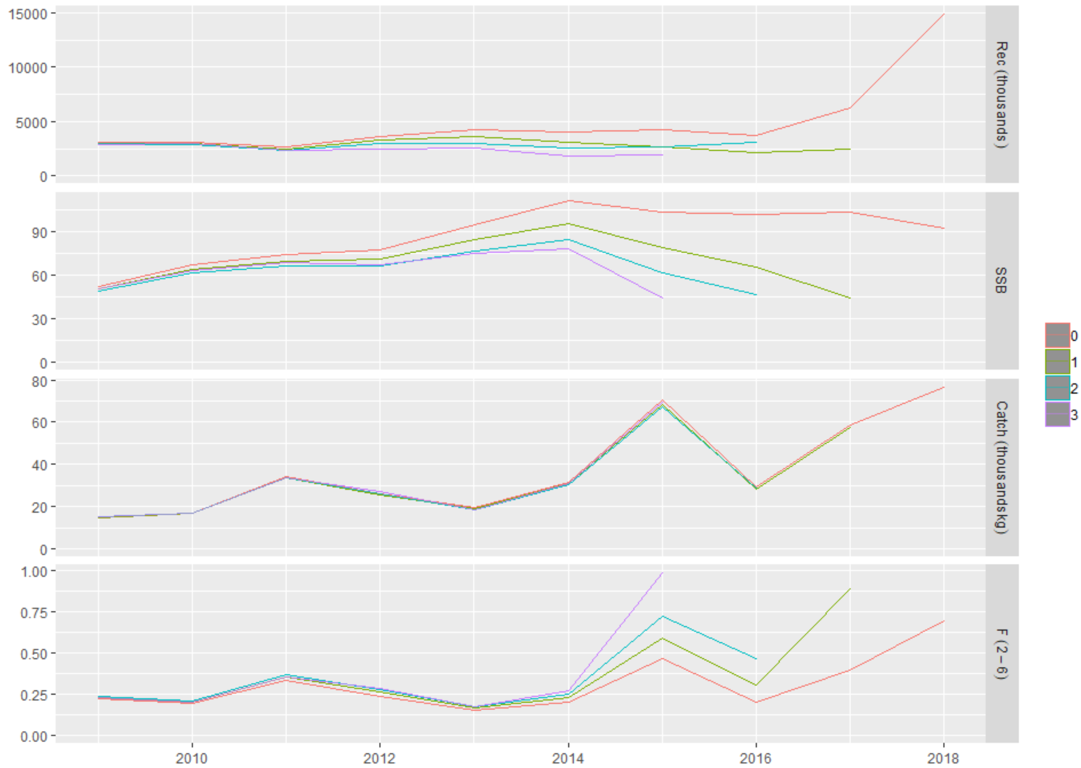


Figure 6.7.3.6 Nephrops in GSA 5: Stock summary 2009 to 2017, Recruitment, SSB, catch and Fishing mortality in the two models.



A

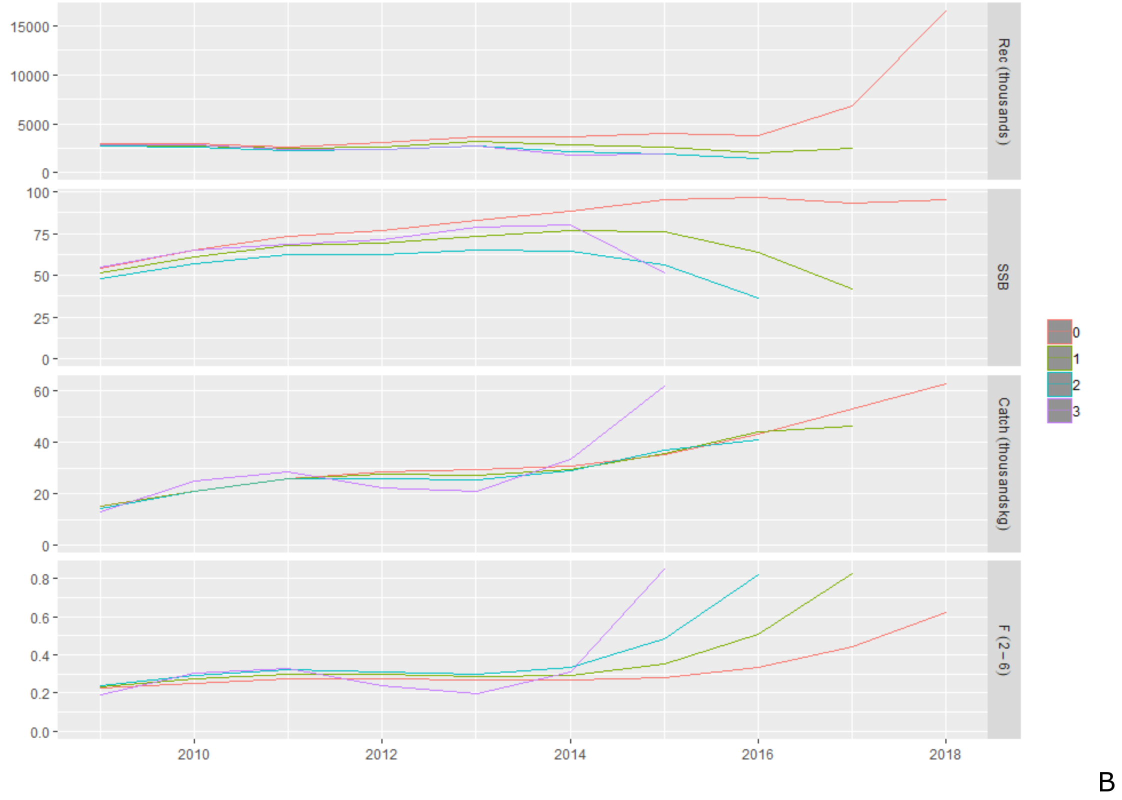


Figure 6.7.3.7 Nephrops in GSA 5: Analytical retrospective 2009 to 2017, in the two model (A=Fit1, B=Fit2), Recruitment, SSB, catch and Fishing mortality.

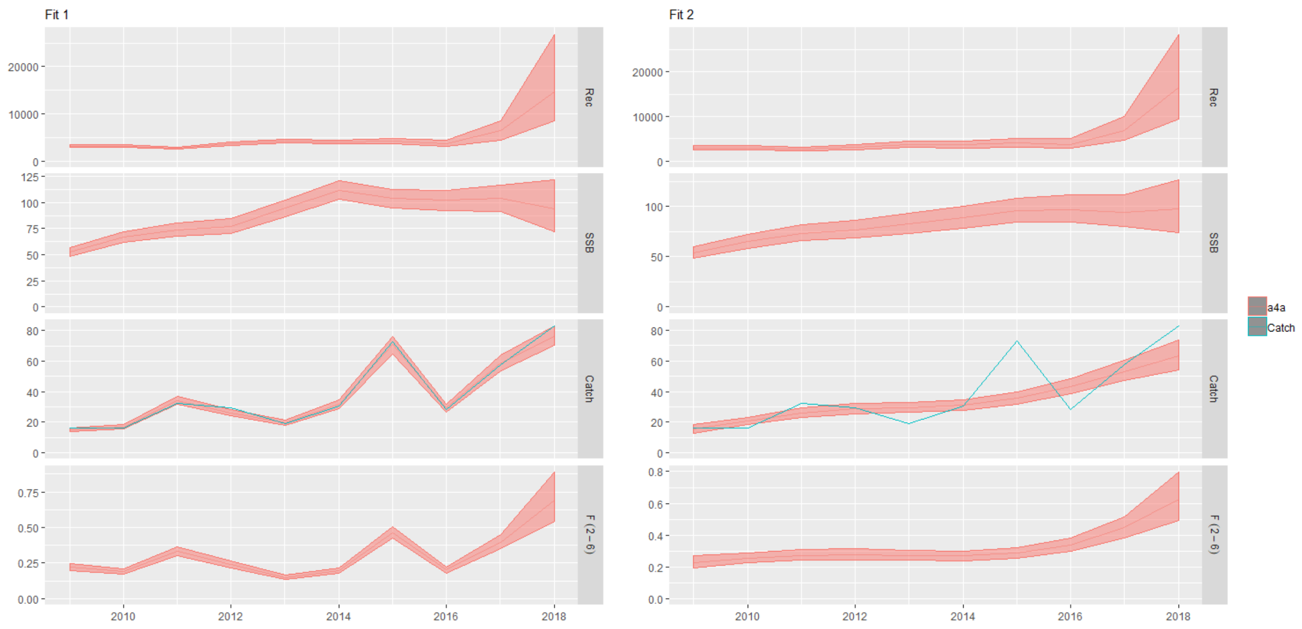


Figure 6.7.3.8 Nephrops in GSA 5: Stock summary and 90% intervals 2009 to 2018 in the two models (Recruitment, SSB, catch and Fishing mortality).

Conclusions to the assessment

Some aspects of the assessment look good, for example the log residuals for catch and abundance indices, but neither Fit1 nor Fit2 show a stable retrospective performance. Both catch and tuning data are lacking of coherent information comparing cohorts across years.

EWG 19-10 concluded that the output of the a4a models were both not suitable to provide the basis of the current status of the stock but could be used as indicative of a trend. The survey index appears reasonably coherent so the use of that index is considered likely to give an indications of the state of the stock. Based on this, advice was given using the ICES category 3 index method see Section 6.9.5 below.

6.7.4 Reference Points

As the assessment was not accepted for advice, reference points are not calculated.

6.7.5 Short term Forecast and Catch Options

Biomass Index refers to the ICES data limited approach using a stock status indicator (ICES 2012). In the last years biomass of norway lobster in GSA 5 has displayed a stable/sligthly decreasing trend (figure 6.9.5.1). The change in biomass over the last five years was used to provide an index for change (0.98). As the biomass index change is lower than 1.2 and greater than 0.8, following the ICES approach, STECF EWG 19-10 used the index of change and a precautionary buffer value of 0.80 to multiply the catch (mean catch over 2016-2018). The catch advice, which is applicable for two years (2019 and 2020) is 44.1 tonnes (Table 6.9.5.1).

Table 6.7.5.1: 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)		56.35
Discard rate (2016–2018)		0 (negligible)
-20% Precautionary buffer		Applied
Catch advice **		44.1
Landings advice ***		44.1
% advice change ^		-47%

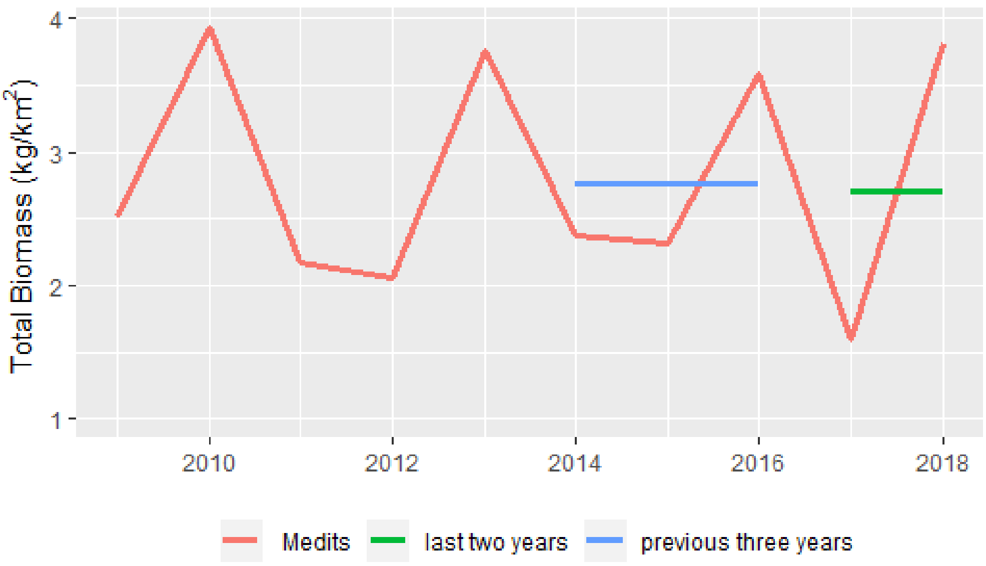


Figure 6.7.5.1 Norway lobster GSA 5. Biomass index (kg/km2) estimated from MEDITS survey. In green the mean of the last two years (2.70) compared to the previous three years in blue (2.75).

6.7.6 Data Deficiencies

The analysis of MEDITS data, showed a problem in the size distribution of Nep in 2013 with two anomalous peaks. A deeper check of row data showed wrong nbtot reported number (350) for the haul coded 150.

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.

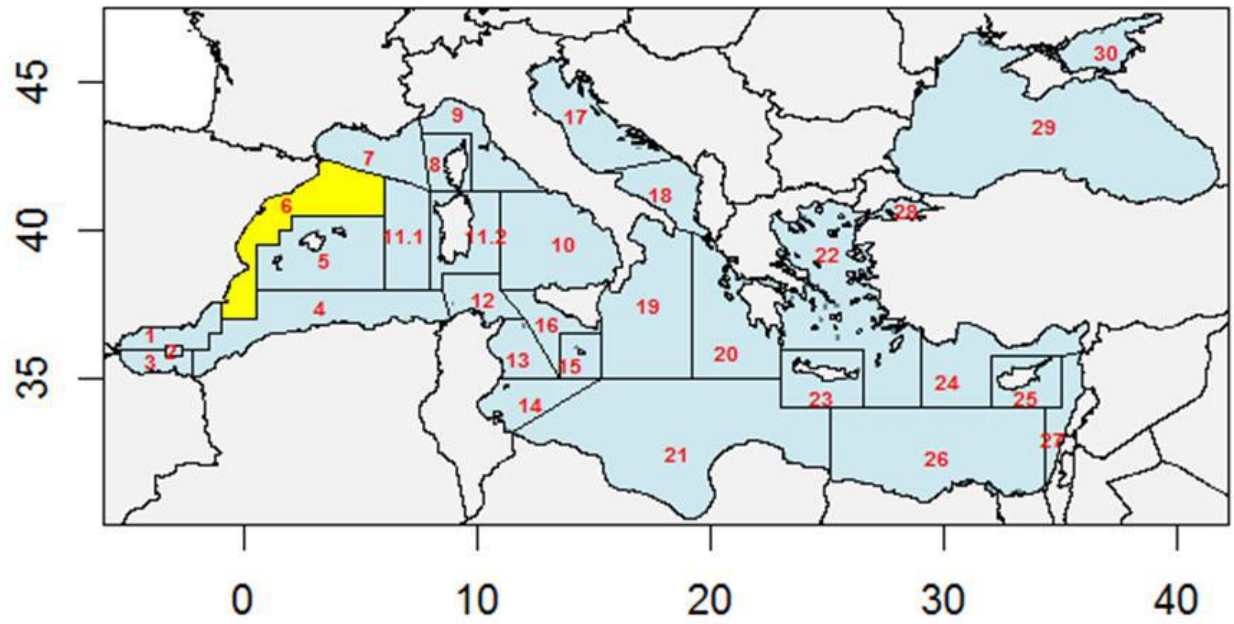


Figure 6.8.1.1. Geographical location of GSA 6.

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 EWG19-10, length data from catches and MEDITS survey were age sliced using the standard length slicing software (L2a) by adding 0.5 to t_0 for internal consistency in the stock assessment model.

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).

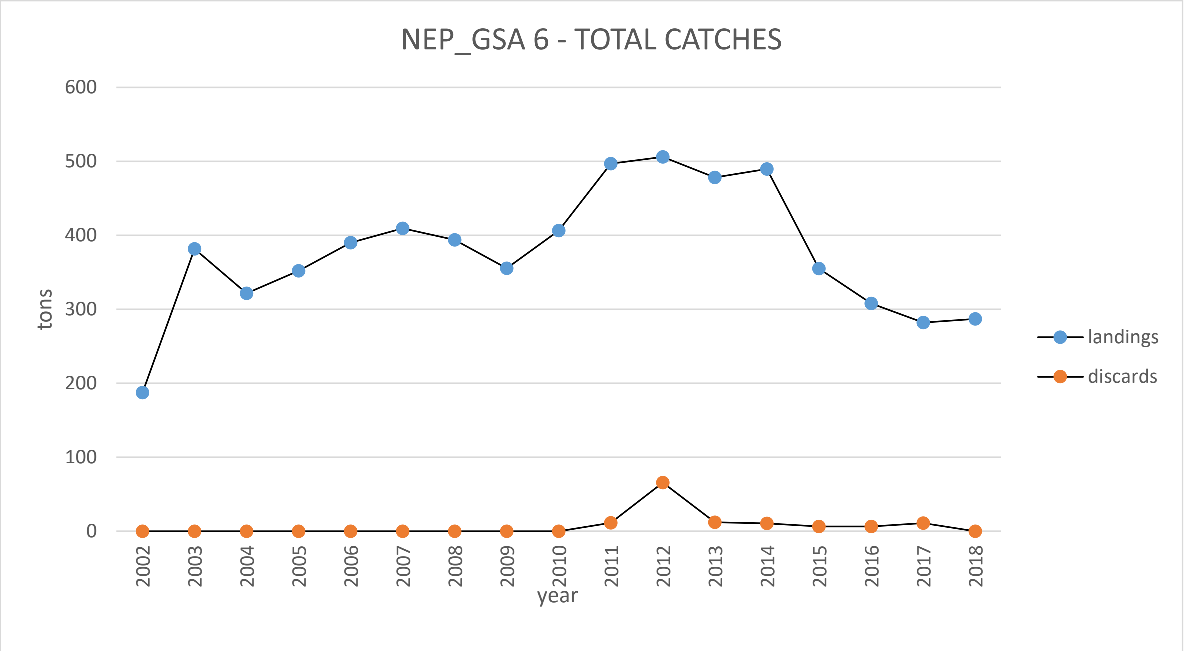


Figure 6.8.2.1. Norway lobster in GSA 6: Total landing discards and total catch by year reported by Spain.

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

Information at length is available from 2009 onwards (Figure 6.8.2.2).

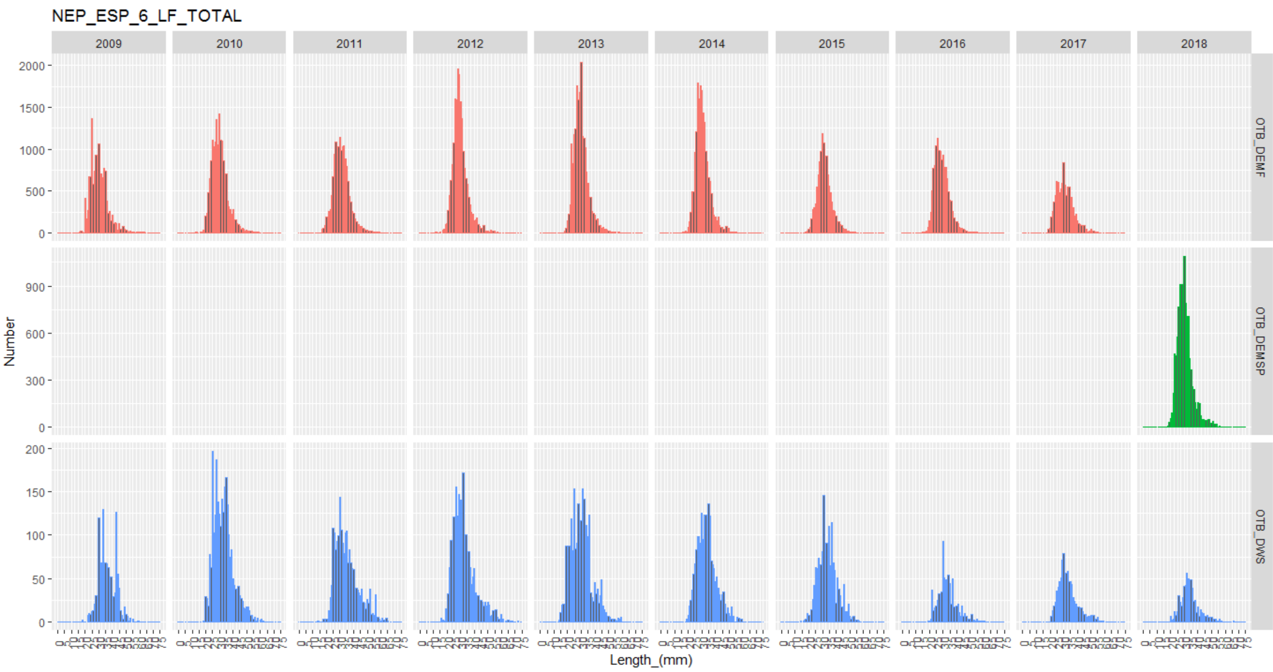


Figure 6.8.2.2. Norway lobster in GSA 6: Total catch by lengths and year reported by Spain for GSA 6.

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
SOP	1.34	1.21	1.52	1.63	1.40	1.40	1.39	1.47	1.51	1.39

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

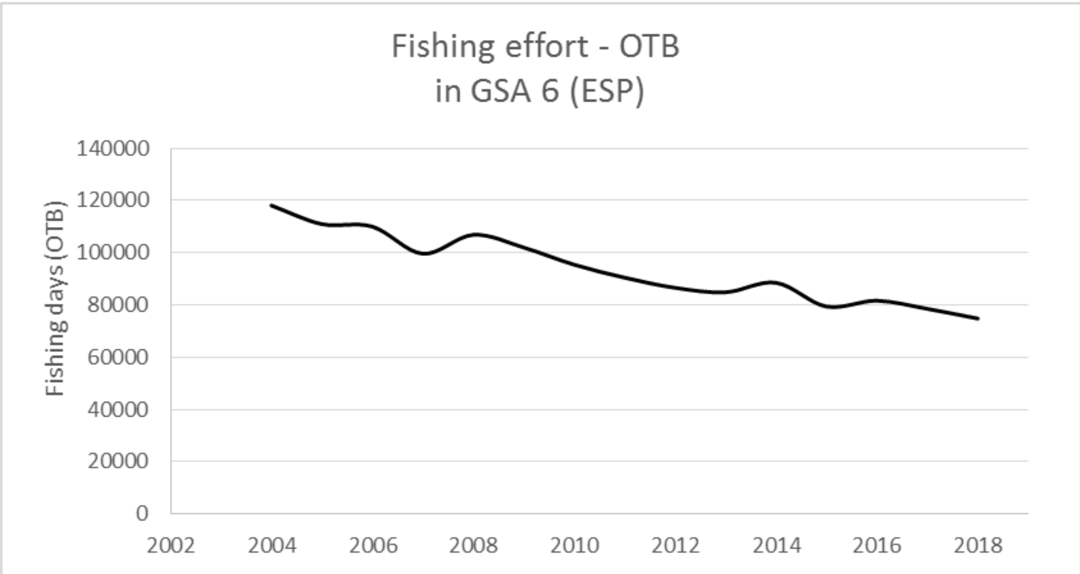


Figure 6.8.2.2.1 Norway lobster in GSA 6: Fishing days by OTB and year.

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 has 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 (1994-2018) 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).

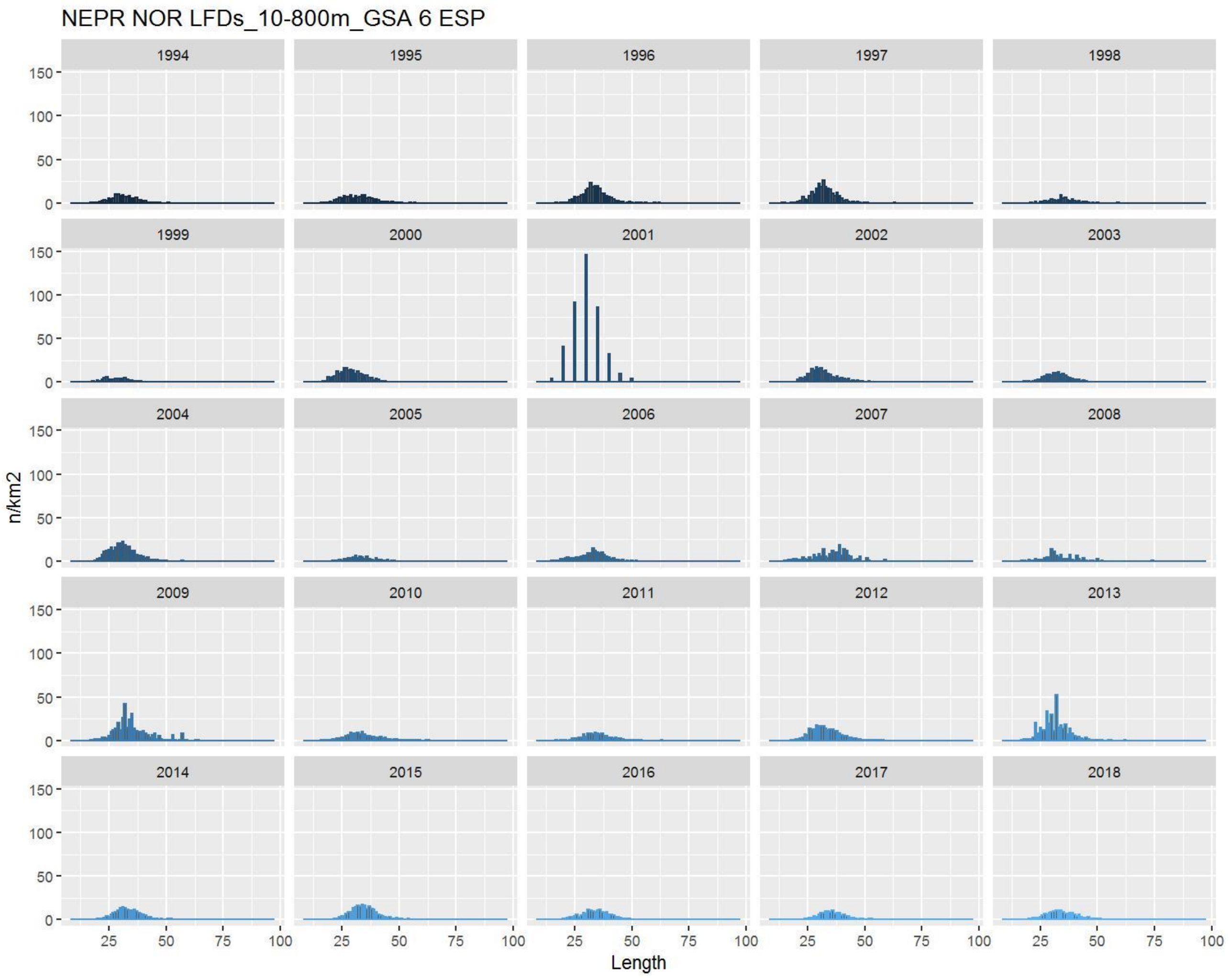


Figure 6.8.2.3.2. Norway lobster in GSA 6: length frequency distribution by year of MEDITS. (sampling in 2006 was by 5mm giving fewer higher values, and at 1mm in all other years)

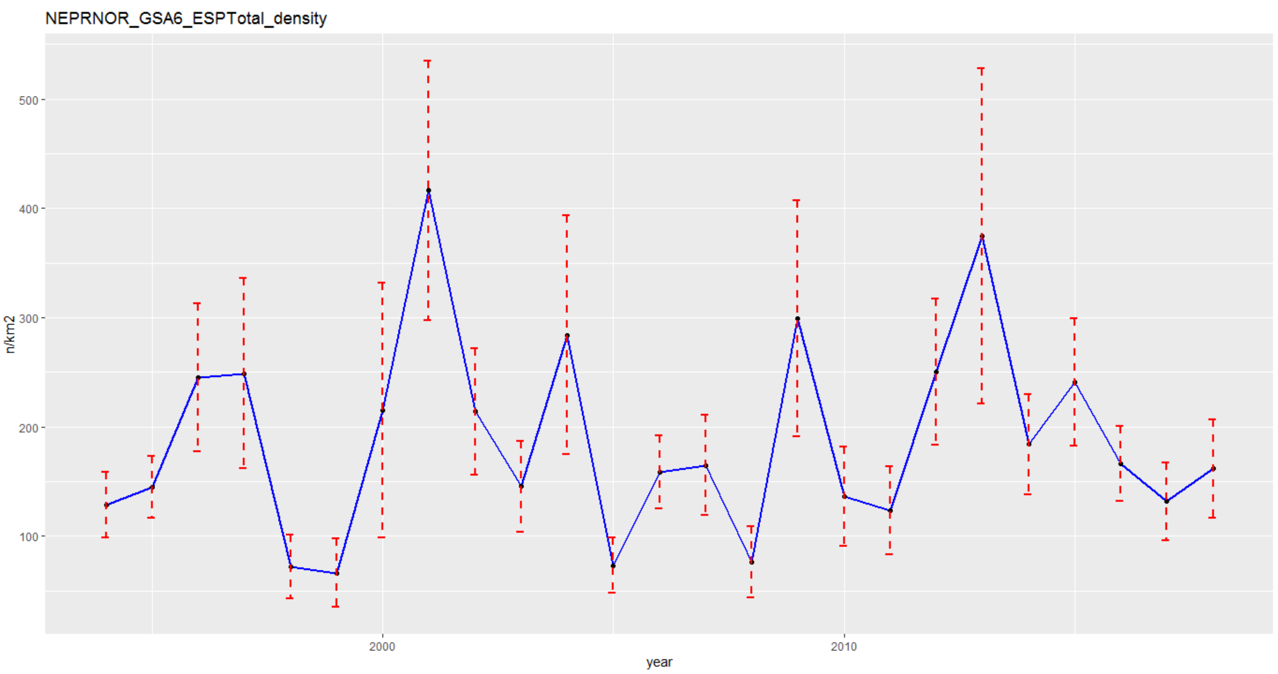


Figure 6.8.2.3.3. Norway lobster in GSA 6: estimated abundance indices (n/km^2).

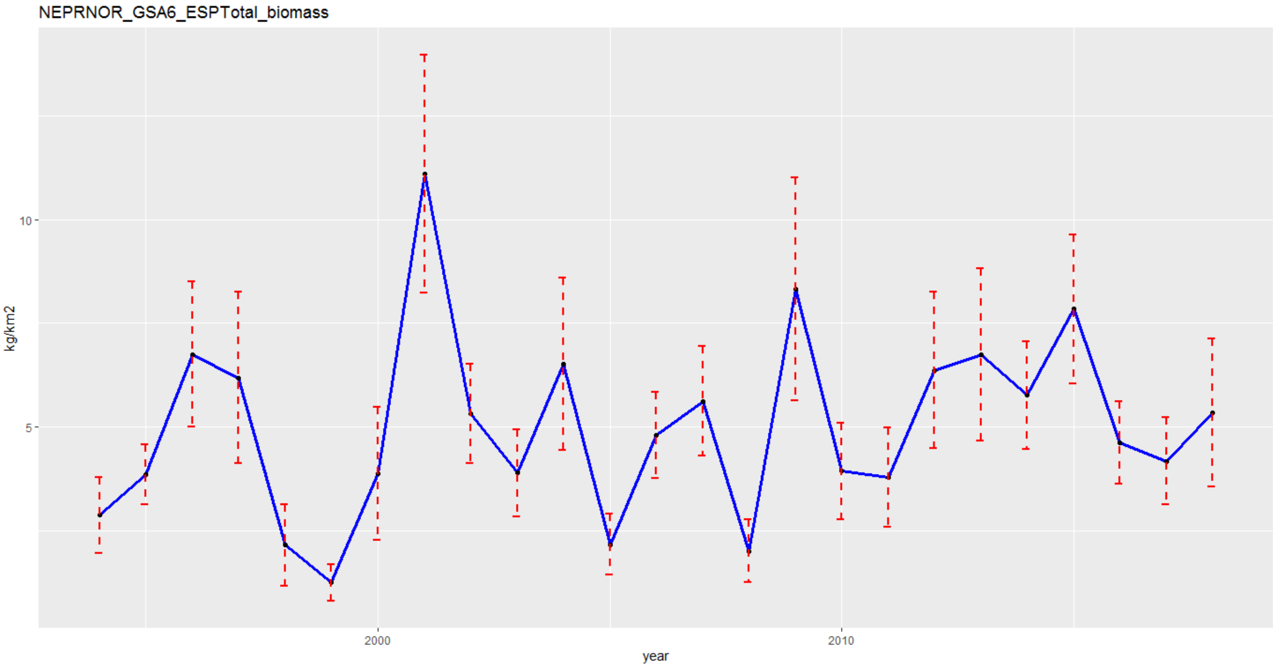


Figure 6.8.2.3.4. Norway lobster in GSA 6: estimated biomass indices (kg/km^2).

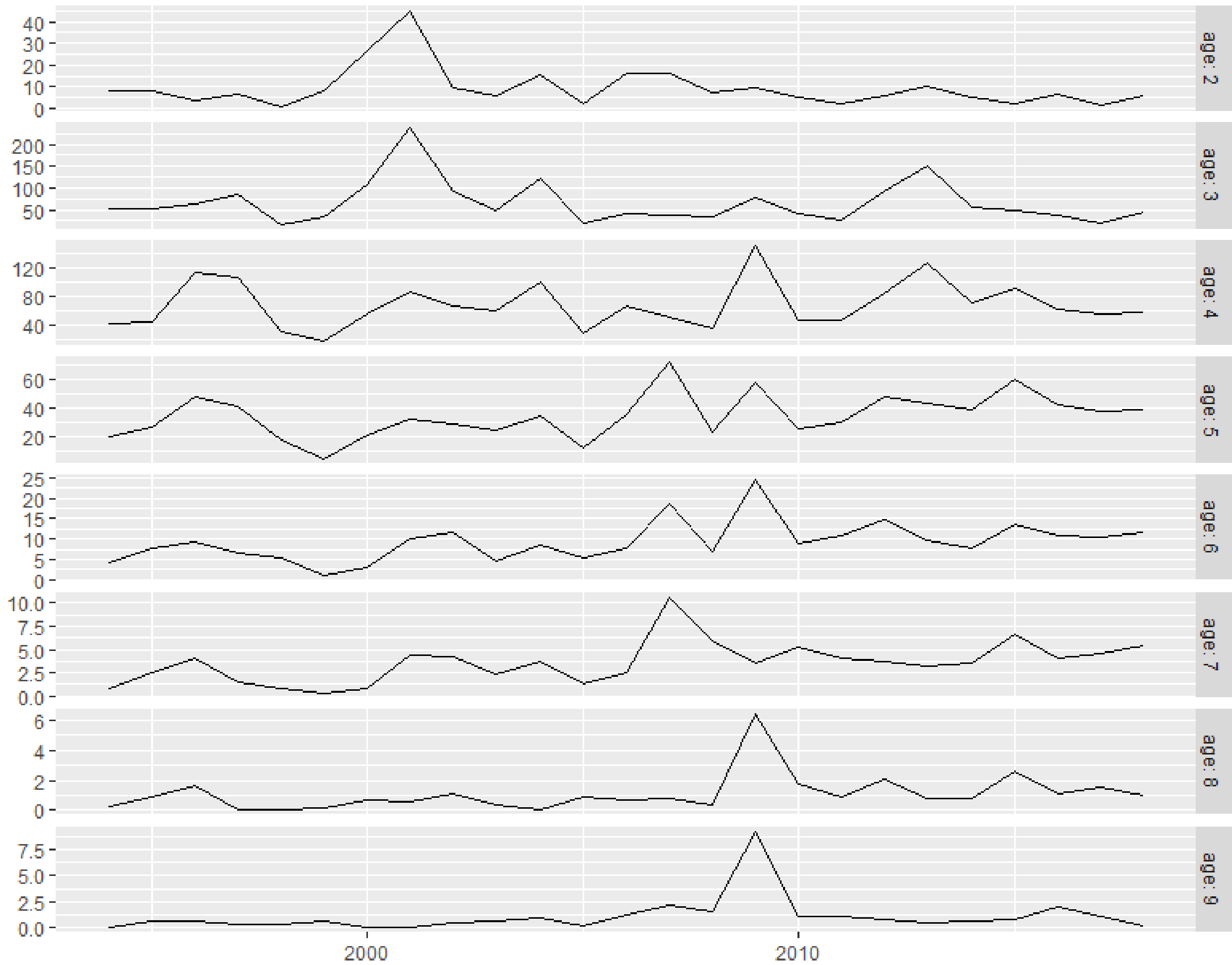
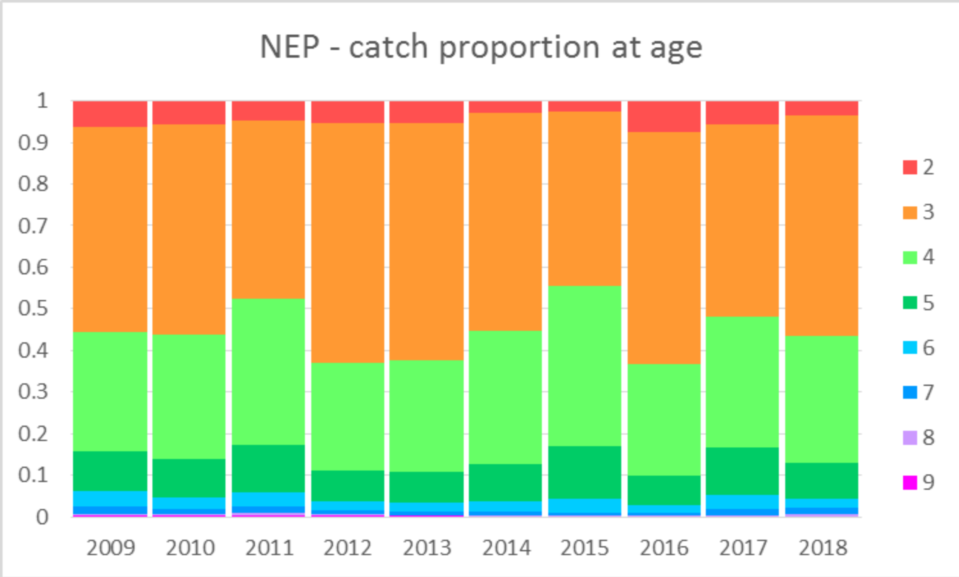


Figure 6.8.2.3.5. Norway lobster in GSA 6: Medits catch at age by year derived by age slicing.

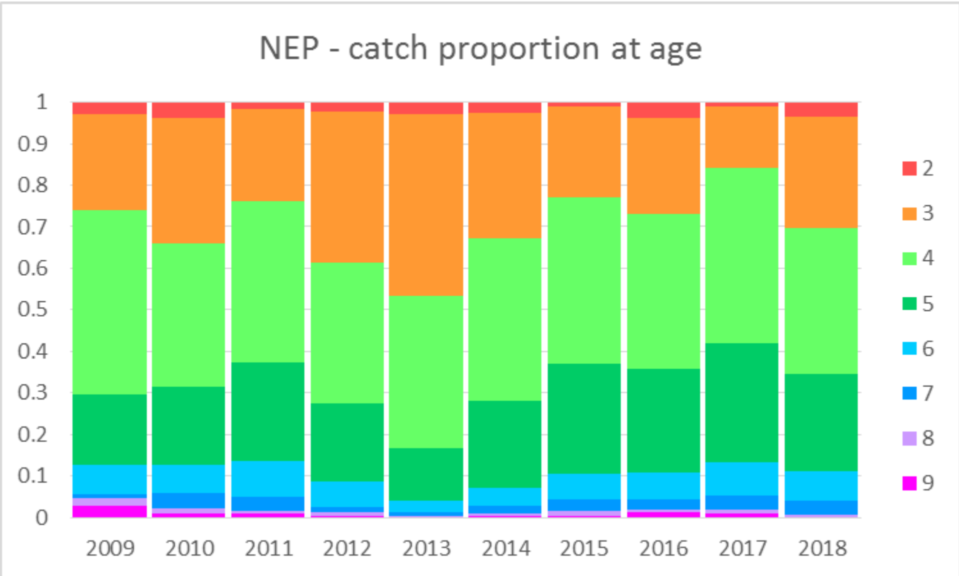
6.8.3 Stock assessment

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).

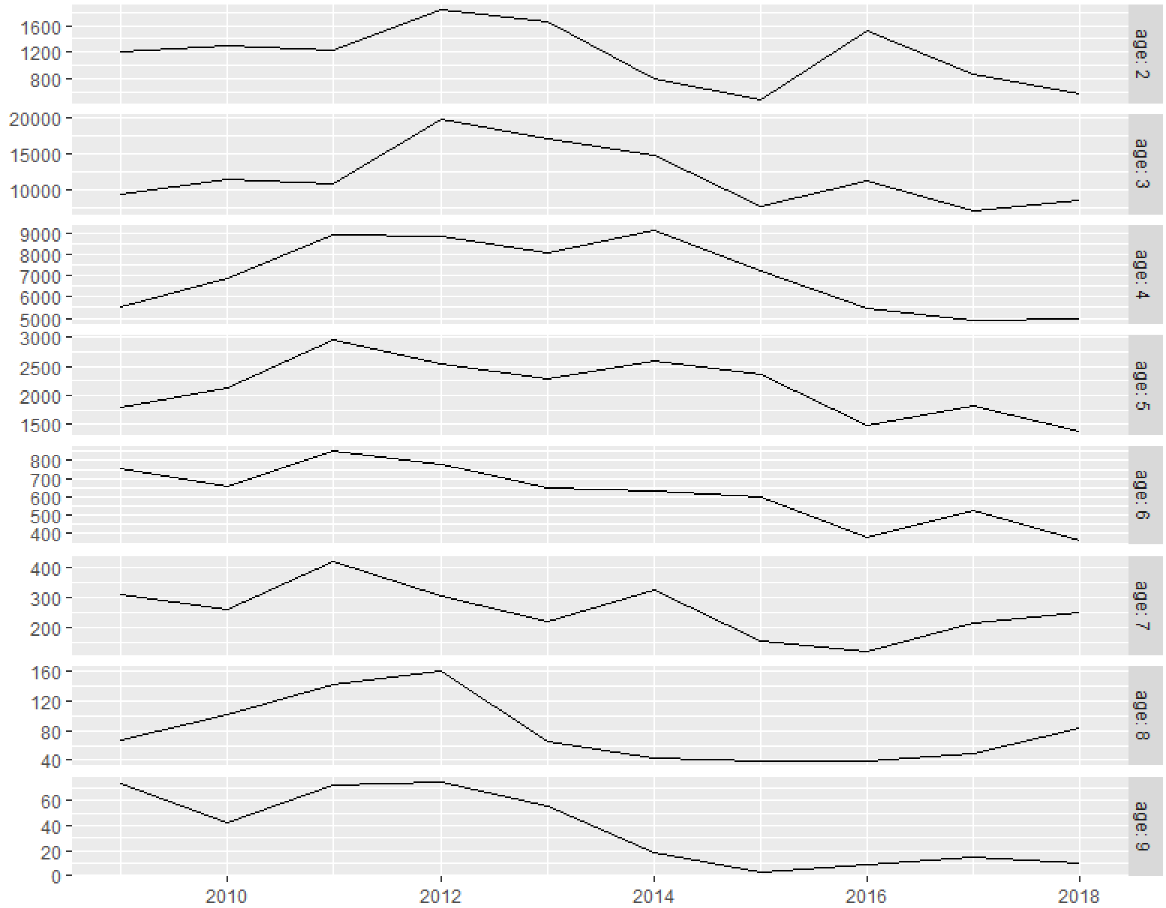


Figure 6.8.3.2. Norway lobster in GSA 6: Catch at age by year from length sliced catch at length.

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
355.61	406.51	508.21	571.89	490.7	500.79	361.58	314.47	293.24	287.03

Table 6.8.3.2. Norway lobster in GSA 6: Catch in numbers by age and by year.

age	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	1196.7	1296.0	1230.2	1844.1	1658.5	788.7	477.8	1526.4	861.8	580.6
3	9411.1	11597.0	10982.0	19775.0	17147.0	14902.0	7852.9	11396.0	7253.3	8593.5
4	5534.9	6840.8	8941.5	8818.6	8054.6	9126.1	7186.7	5460.8	4884.2	4937.9
5	1781.5	2123.5	2945.7	2536.0	2291.5	2590.5	2371.5	1467.7	1811.0	1380.6
6	754.2	653.0	852.0	777.7	650.2	628.0	601.1	379.4	522.7	360.0
7	308.0	263.0	421.3	307.6	219.4	325.0	158.1	122.8	218.0	253.2
8	67.2	100.9	142.1	160.6	65.3	43.3	37.8	39.4	49.2	82.7
9	73.5	42.6	72.0	75.3	55.4	17.9	2.7	9.1	14.9	10.1

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
2	0.004	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005
3	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.010	0.010	0.011
4	0.021	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.021	0.020
5	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
6	0.051	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.052	0.054
7	0.073	0.075	0.076	0.076	0.074	0.074	0.073	0.076	0.077	0.075
8	0.098	0.099	0.102	0.101	0.098	0.099	0.097	0.098	0.099	0.098
9	0.141	0.133	0.142	0.140	0.123	0.123	0.119	0.124	0.131	0.131

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
2	9.54	5.25	2.03	5.71	10.13	4.95	2.02	6.49	1.16	5.89
3	79.31	41.00	27.40	90.75	150.38	55.35	49.96	39.14	19.69	43.61
4	152.04	47.35	47.79	84.97	126.93	72.34	91.09	63.05	55.73	56.97
5	57.59	25.73	29.43	47.40	43.69	38.68	60.07	42.68	37.40	38.25
6	24.58	9.05	10.74	14.93	9.65	7.82	13.69	11.01	10.57	11.57
7	3.47	5.22	4.00	3.66	3.14	3.50	6.66	4.08	4.49	5.46
8	6.39	1.71	0.93	2.06	0.74	0.81	2.64	1.12	1.51	1.04

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.

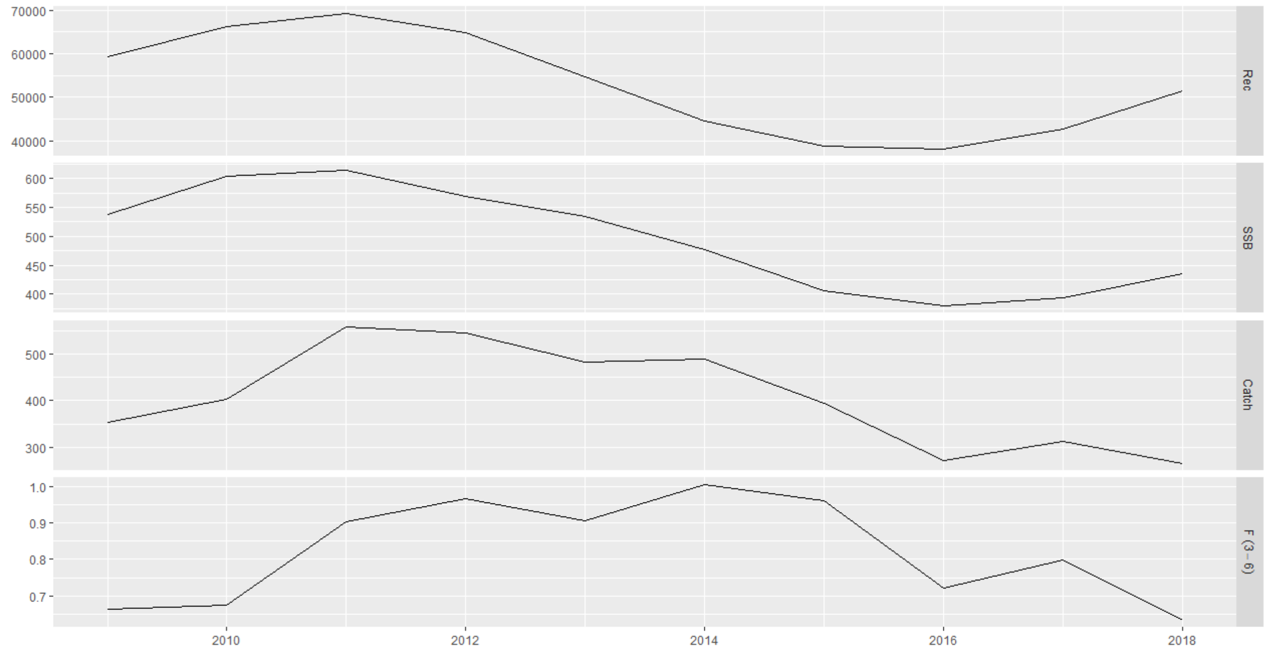


Figure 6.8.3.3. Results of the best a4a model for norway lobster in GSA 6.

Table 6.8.3.6. Norway lobster in GSA 6: Stock summary from the assessment

Year	Fbar	Recruitment	SSB	TB	Catch
2009	0.66	59235	538	1104	354
2010	0.68	66282	605	1261	402
2011	0.90	69339	615	1385	558
2012	0.97	64787	570	1327	546
2013	0.91	54660	535	1196	483
2014	1.01	44642	477	1105	489
2015	0.96	38720	406	926	395
2016	0.72	38087	379	793	272
2017	0.80	42656	393	858	313
2018	0.63	51513	435	908	265

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
2	59235	66282	69339	64787	54660	44642	38720	38087	42656	51513
3	31444	36388	40699	42270	39415	33318	27125	23559	23352	26089
4	11376	14088	16152	15477	15394	14959	11813	9909	10131	9529
5	4125	4029	4914	4358	3886	4139	3593	2981	3279	3073
6	1502	1485	1427	1336	1100	1053	998	911	1000	1006
7	550	607	591	450	394	346	298	296	346	351
8	202	189	205	149	104	99	76	70	94	100
9	74	94	94	73	50	38	29	24	29	35

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

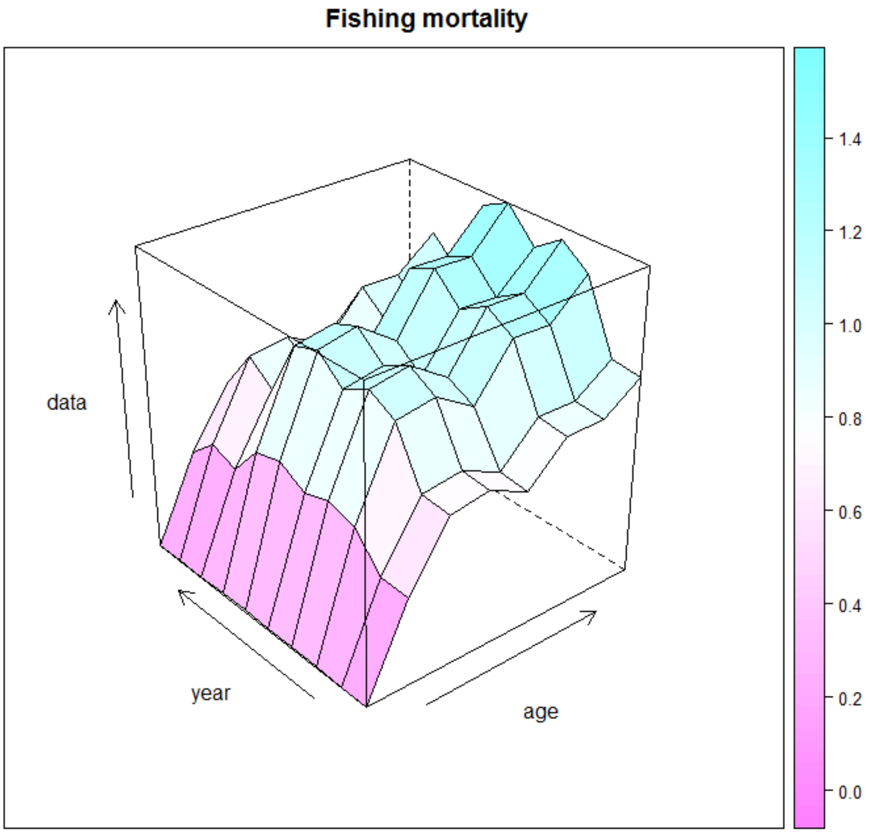


Figure 6.8.3.4. Norway lobster in GSA 6. 3D contour plot of estimated fishing mortality at age and year

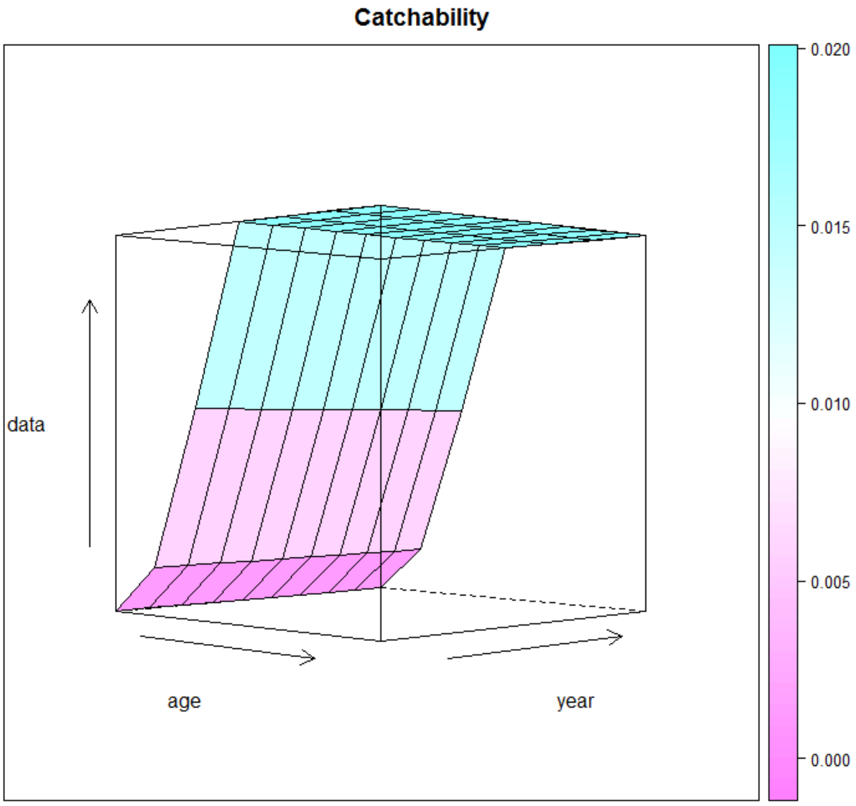


Figure 6.8.3.5. Norway lobster in GSA 6. 3D contour plot of estimated catchability at age and year.

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

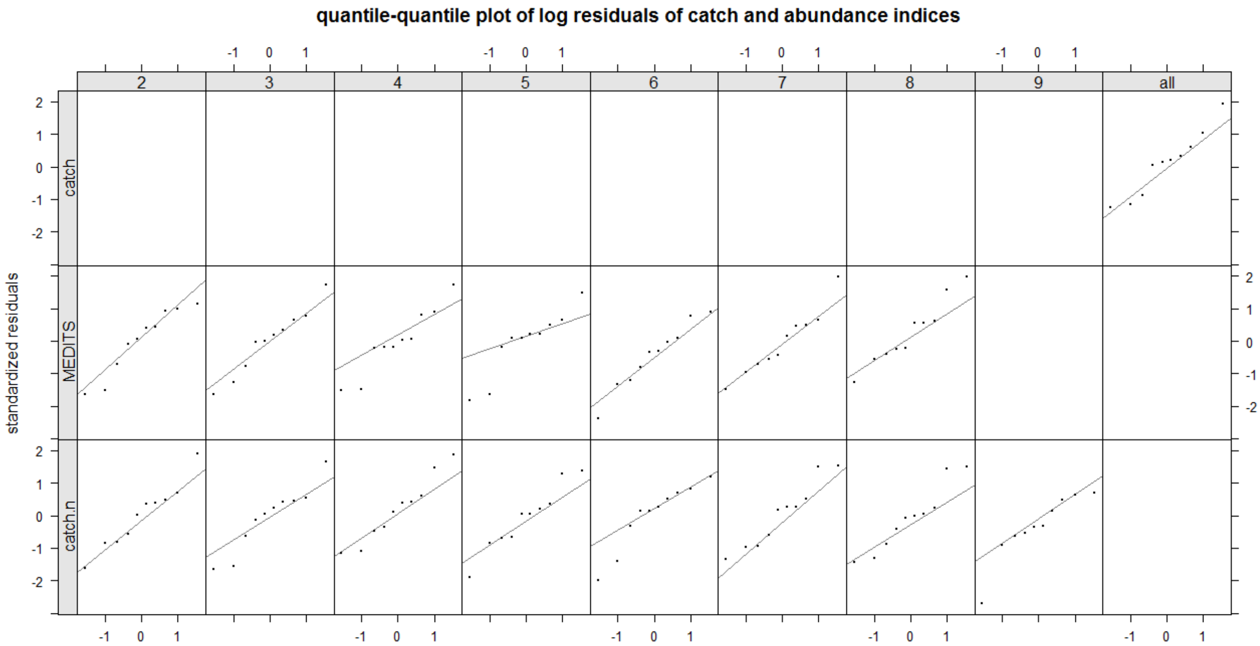


Figure 6.8.3.7. Norway lobster in GSA 6. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

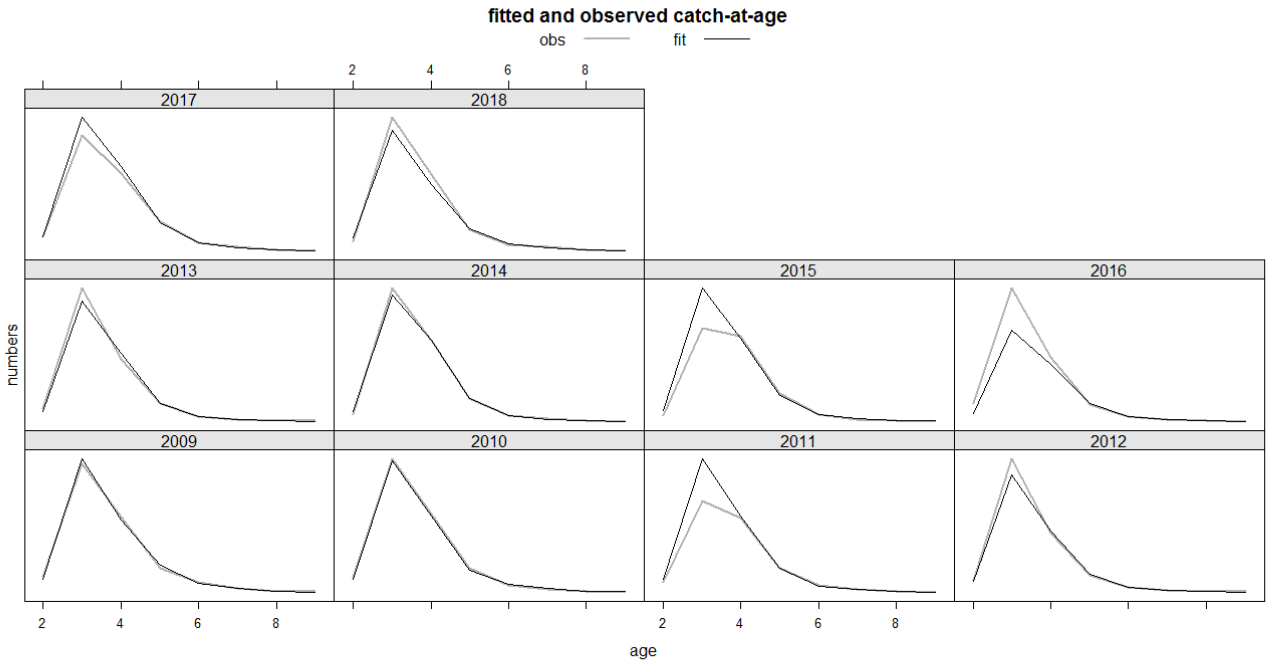


Figure 6.8.3.8. Norway lobster in GSA 6. Fitted and observed catch at age.

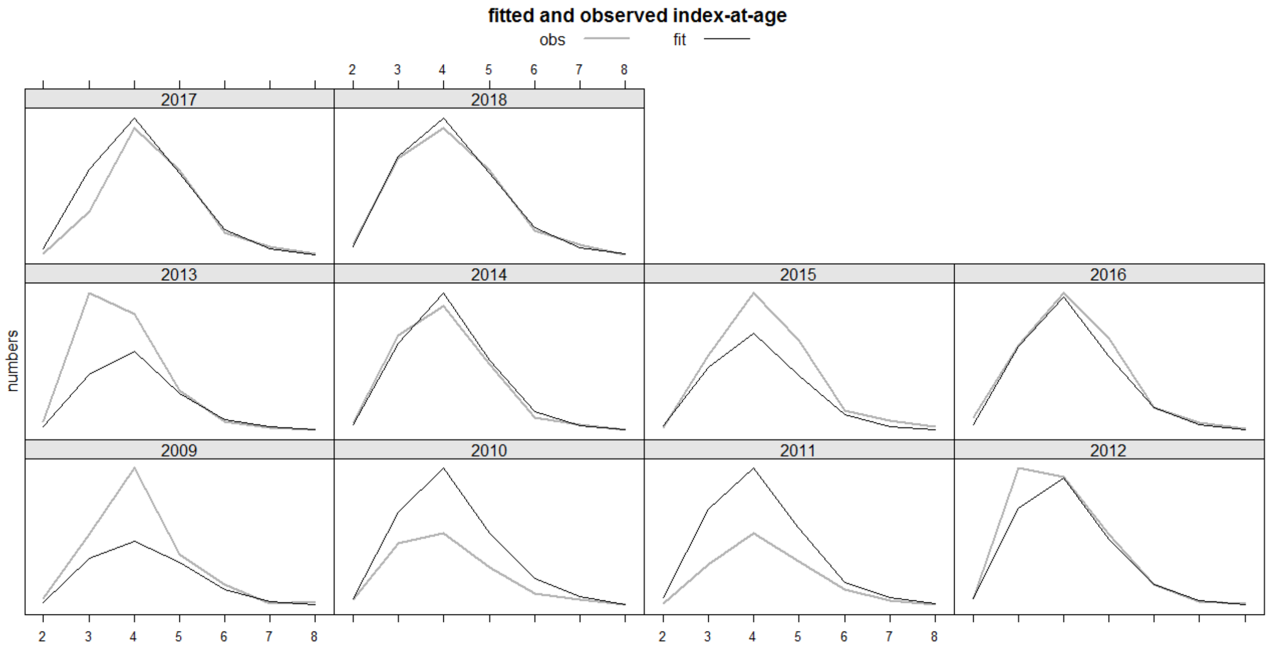


Figure 6.8.3.9. Norway lobster in GSA 6. Fitted and observed index at age.

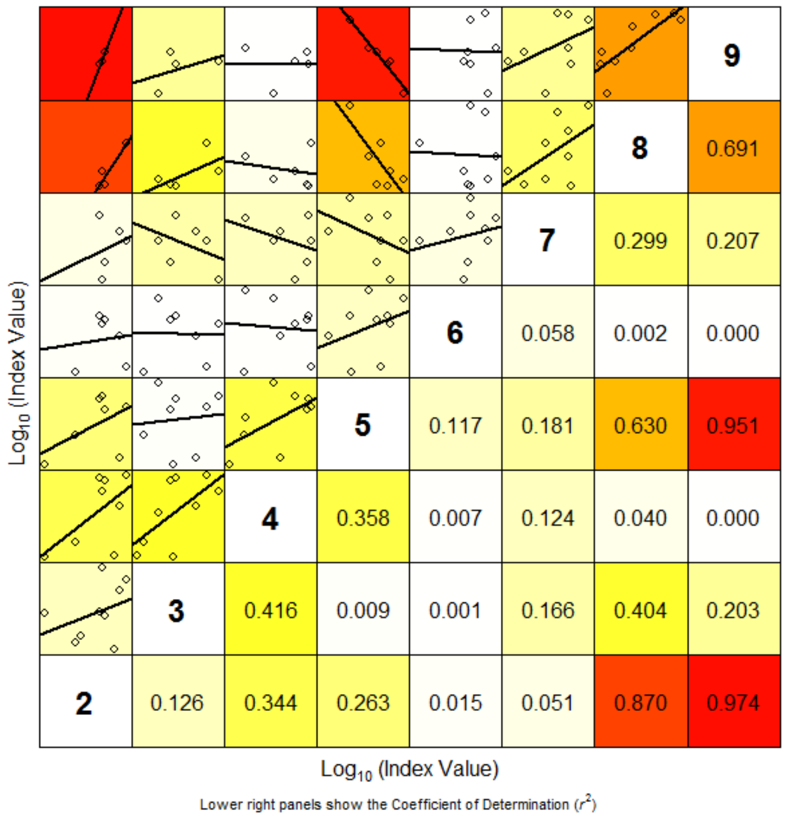


Figure 6.8.3.10. Norway lobster in GSA 6. Internal consistency of the catch at age data

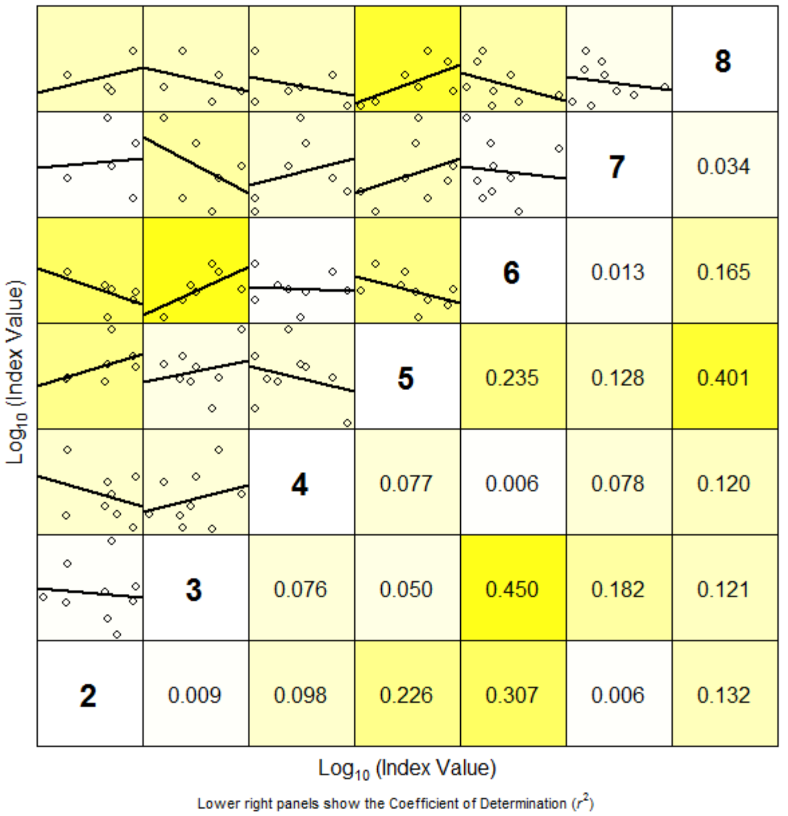


Figure 6.8.3.11. Norway lobster in GSA 6. Internal consistency of the MEDITS index at age data

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.

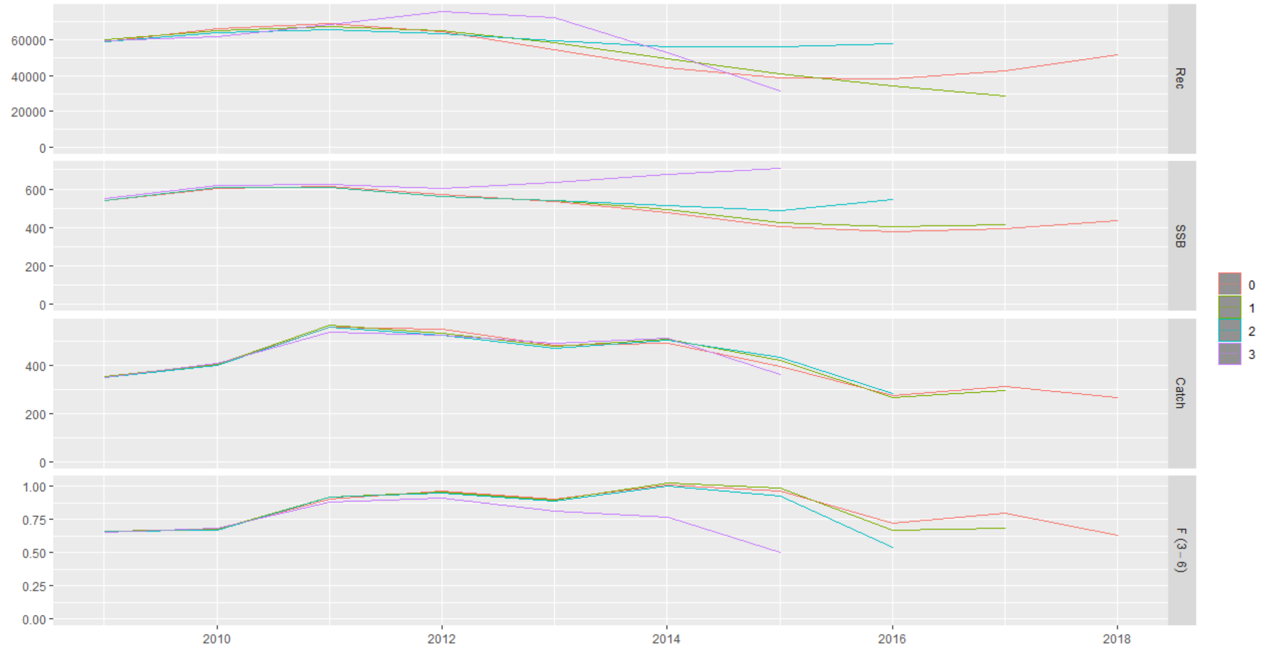


Figure 6.8.3.12. Norway lobster in GSA 6: Analytical retrospective 2009 to 2018, Recruitment, SSB, catch and Fishing mortality.

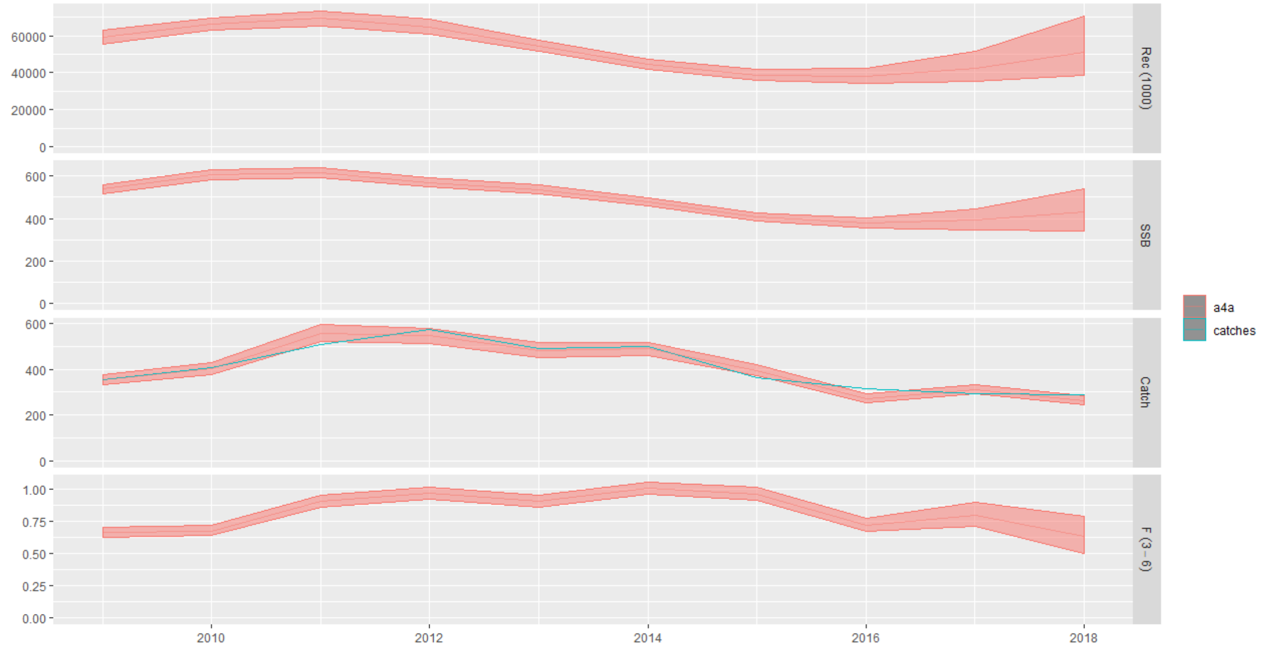


Figure 6.8.3.13. Norway lobster in GSA 6: Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals 2009 to 2018.

Conclusions to the assessment

This assessment is considered acceptable, the age sliced catch data has coherence from year to year and the assessment provides a coherent explanation of the trend in catches. Retrospective performance is moderate and confirms stock explitation status at F well above F_{MSY} throughout.

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. Fbar (3-6) fluctuated and shows a decreasing trend in the last years down to a value of 0.63 in 2018.

In conclusion, the biomass status for the Norway lobster in GSA 6 appears low and stable.

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	0.000	0	1	0.1617	0.166
msy	0.198	0.010	1	0.0431	0.047
crash	1030.000	0.005	1	0.00000000008	0.000
$F_{0.1}$	0.113	0.0096	1	0.0672	0.071
fmax	0.198	0.010	1	0.0431	0.047
spr.30	0.173	0.010	1	0.0486	0.052

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 2016-2018
$F_{ages\ 3\text{-}6}$ (2019)	0.71	mean F 2016-18 used to give F status quo for 2019
SSB (2019)	494.24	Stock assessment 1 January 2019
R_{age0} (2019,2020)	51813.89	Geometric mean of the last 10 years
Total catch (2019)	347.12	Assuming F status quo for 2019

Table 6.8.5.2 Norway lobster in GSA 6: Catch options.

Rationale	Ffactor	Fbar	Catch_2018	Catch_2020	SSB_2019	SSB_2021	Change_SSB 2019-2021(%)	Change_Catch 2018-2020(%)
High long term yield (F0.1)	0.2	0.11	265.23	77.49	494.24	1070.15	116.52	-70.78
F upper	0.22	0.16	265.23	107.50	494.24	1010.63	104.48	-59.47
F lower	0.11	0.08	265.23	54.10	494.24	1117.54	126.11	-79.60
Zero catch	0	0	265.23	0.00	494.24	1230.49	148.97	-100.00
Status quo	1	0.71	265.23	376.07	494.24	546.89	10.65	41.79
ifferent Scenari	0.1	0.07	265.23	50.10	494.24	1125.72	127.77	-81.11
	0.2	0.14	265.23	96.87	494.24	1031.55	108.71	-63.48
	0.3	0.21	265.23	140.53	494.24	946.85	91.58	-47.01
	0.4	0.29	265.23	181.31	494.24	870.61	76.15	-31.64
	0.5	0.36	265.23	219.42	494.24	801.94	62.26	-17.27
	0.6	0.43	265.23	255.05	494.24	740.03	49.73	-3.84
	0.7	0.50	265.23	288.37	494.24	684.17	38.43	8.73
	0.8	0.57	265.23	319.55	494.24	633.73	28.22	20.48
	0.9	0.64	265.23	348.73	494.24	588.14	19.00	31.49
	1.1	0.79	265.23	401.67	494.24	509.54	3.10	51.45
	1.2	0.86	265.23	425.68	494.24	475.68	-3.75	60.50
	1.3	0.93	265.23	448.19	494.24	444.96	-9.97	68.99
	1.4	1.00	265.23	469.31	494.24	417.05	-15.62	76.95
	1.5	1.07	265.23	489.14	494.24	391.67	-20.75	84.43
	1.6	1.14	265.23	507.77	494.24	368.56	-25.43	91.45
	1.7	1.21	265.23	525.27	494.24	347.49	-29.69	98.05
	1.8	1.29	265.23	541.73	494.24	328.26	-33.58	104.25
	1.9	1.36	265.23	557.21	494.24	310.69	-37.14	110.09
	2	1.43	265.23	571.78	494.24	294.61	-40.39	115.58

*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 9, 10 and 11

6.9.1 Stock Identity and Biology

The assessment of European hake carried out during the STECF EWG 19-10 considered the stock shared by the GSAs 9, 10 and 11.

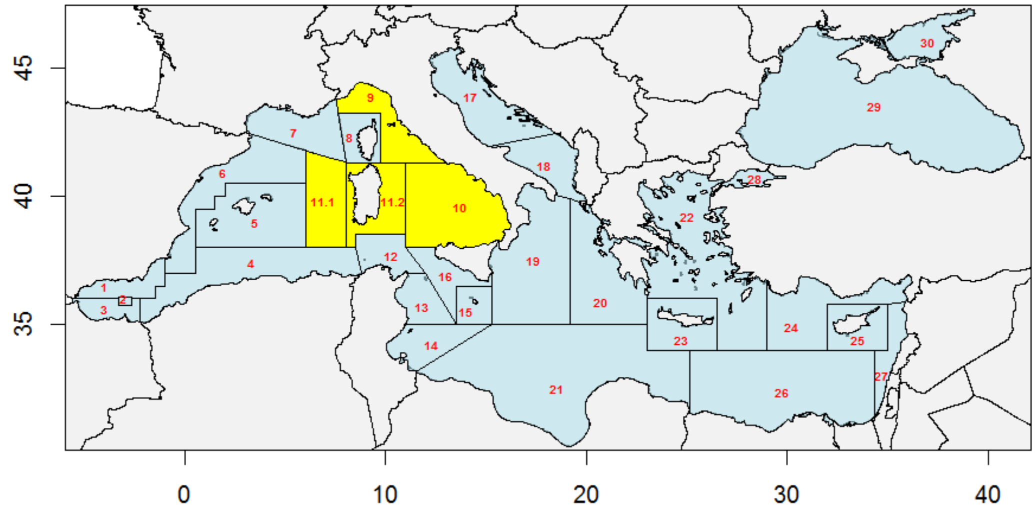


Figure 6.9.1.1. Geographical location of GSAs 9, 10 and 11.

Growth parameters and length-weight parameters were those used for the previous assessment (STECF EWG 18-12), as provided through the DCF data calls by each GSA. In GSAs 9 and 10, VBGF curves by sex were available from the beginning of the time series, while in GSA 11 a sex-combined growth curve was provided for the whole time series. The von Bertalanffy growth curves did not change significantly among the three sets of parameters available (Figure 6.9.1.2). To obtain sex specific growth in GSA 11, the parameters of GSA 9 were applied to the data from GSA 11. The VBGF and LW relationship parameters used are summarized in the following table (Tab. 6.9.1.1).

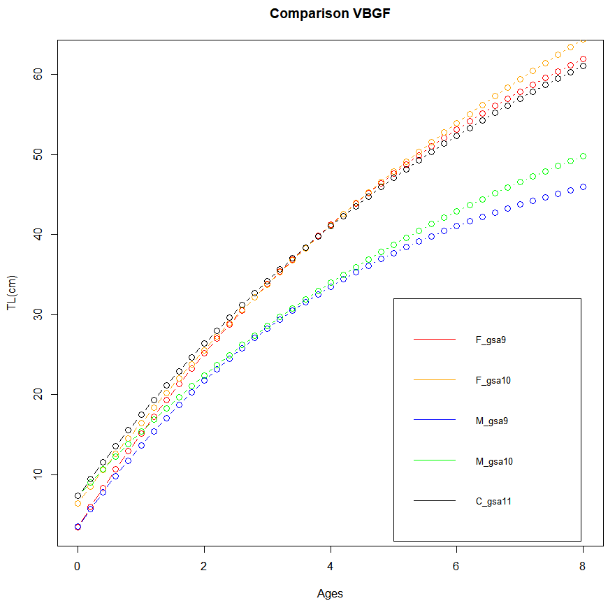


Figure 6.9.1.2. European hake in GSAs 9, 10 and 11. Von Bertalanffy growth curves provided within the DCF; red line for females in GSA 9, blue line for males in GSA 9, orange line for females in GSA 10, green line for males in GSA 10, black line for sex combined in GSA 11.

Table 6.9.1.1. European hake 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	M	54.78	0.22	-0.3	0.007	3.027
	F	87.18	0.15	-0.27	0.006	3.066
10	M	73	0.13	-0.82	0.004	3.166
	F	111	0.1	-0.59	0.004	3.191
11	M	54.78	0.22	-0.3	0.007	3.027
	F	87.18	0.15	-0.27	0.006	3.066

The maturity and natural mortality vector used were the same as in the previous assessment (Tables 6.9.1.2 and 6.9.1.3).

Table 6.9.1.2. European hake in GSAs 9, 10 and 11. Maturity vectors used in the assessment.

Maturity	0	1	2	3	4	5	6+
GSA 9	0.01	0.11	0.58	0.94	1	1	1
GSA 10	0.00	0.03	0.34	0.92	0.99	1	1
GSA 11	0.00	0.00	0.19	0.85	1	1	1

Table 6.9.1.3. European hake in GSAs 9, 10 and 11. Natural mortality vectors used in the assessment.

M	0	1	2	3	4	5	6+
GSA 9	1.36673	0.659174	0.462119	0.360575	0.30619	0.274312	0.241628
GSA 10	0.891796	0.516922	0.374765	0.301561	0.255597	0.224196	0.1991
GSA 11	1.369526	0.657342	0.463955	0.367764	0.307594	0.278025	0.258118

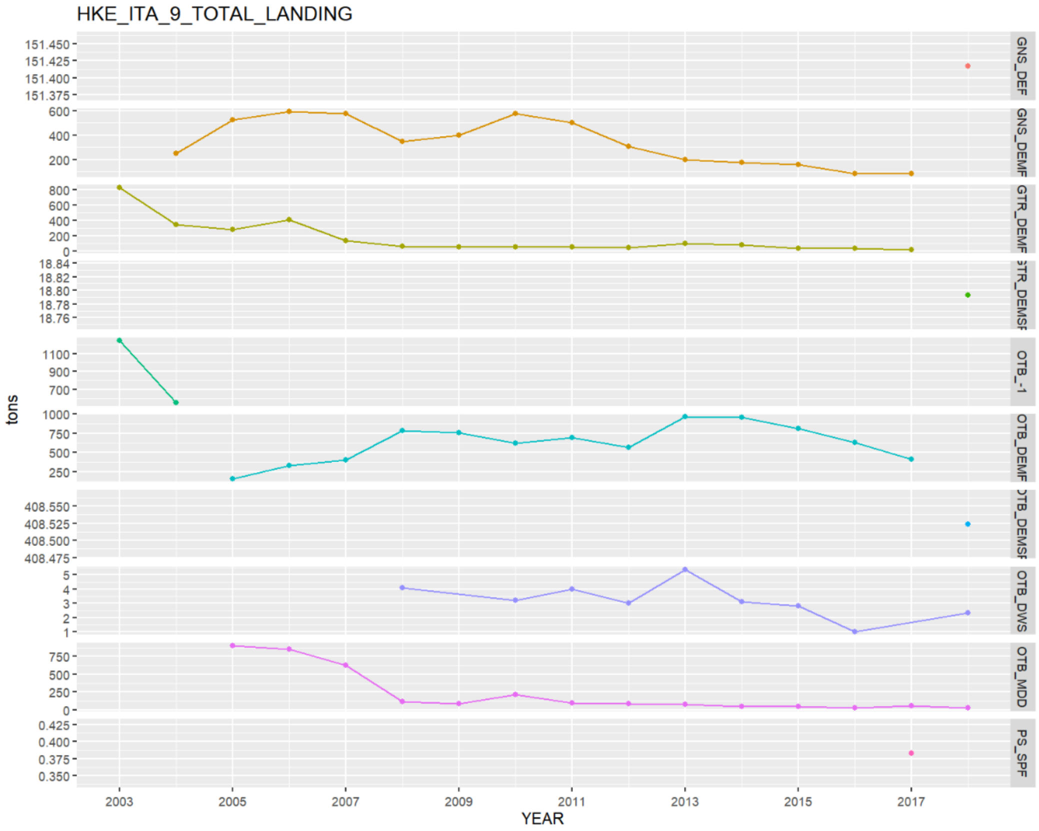
6.9.2 DATA

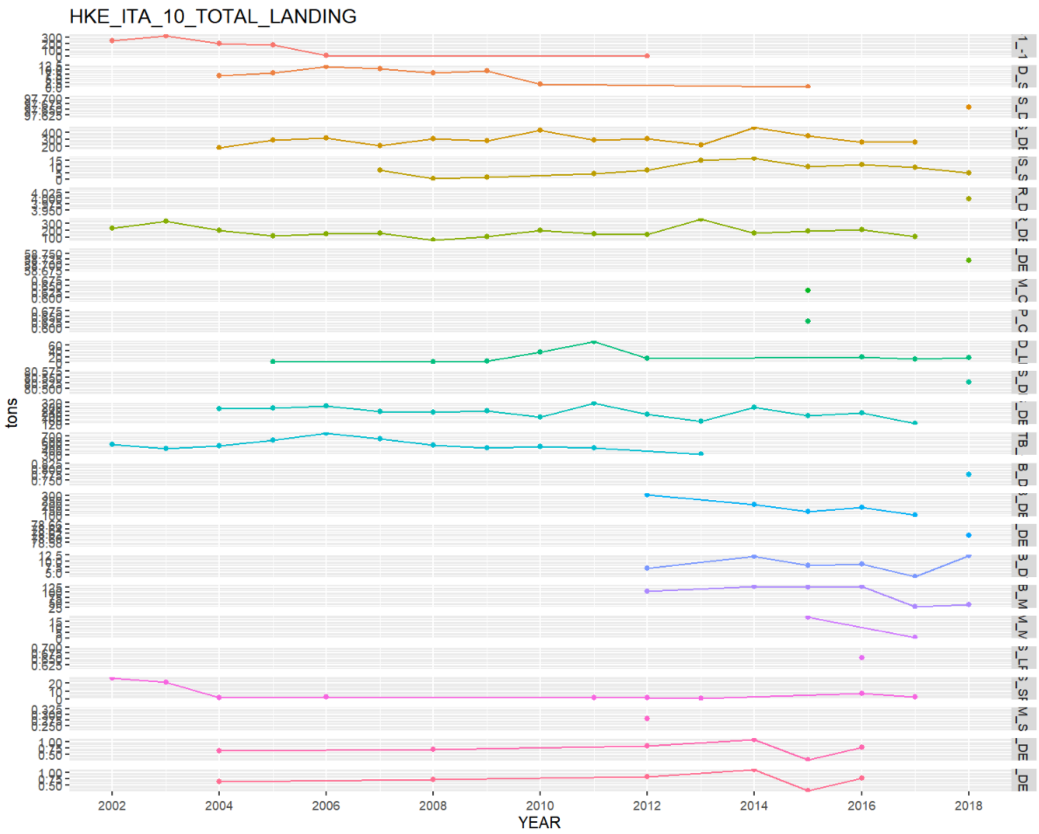
6.9.2.1 CATCH (LANDINGS AND DISCARDS)

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.

Landings

Landings data were reported to STECF EWG 19-10 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. Landings data by year and fleet are presented in Figure 6.9.2.1.1, total landings by year are presented in Table 6.9.2.1.1.





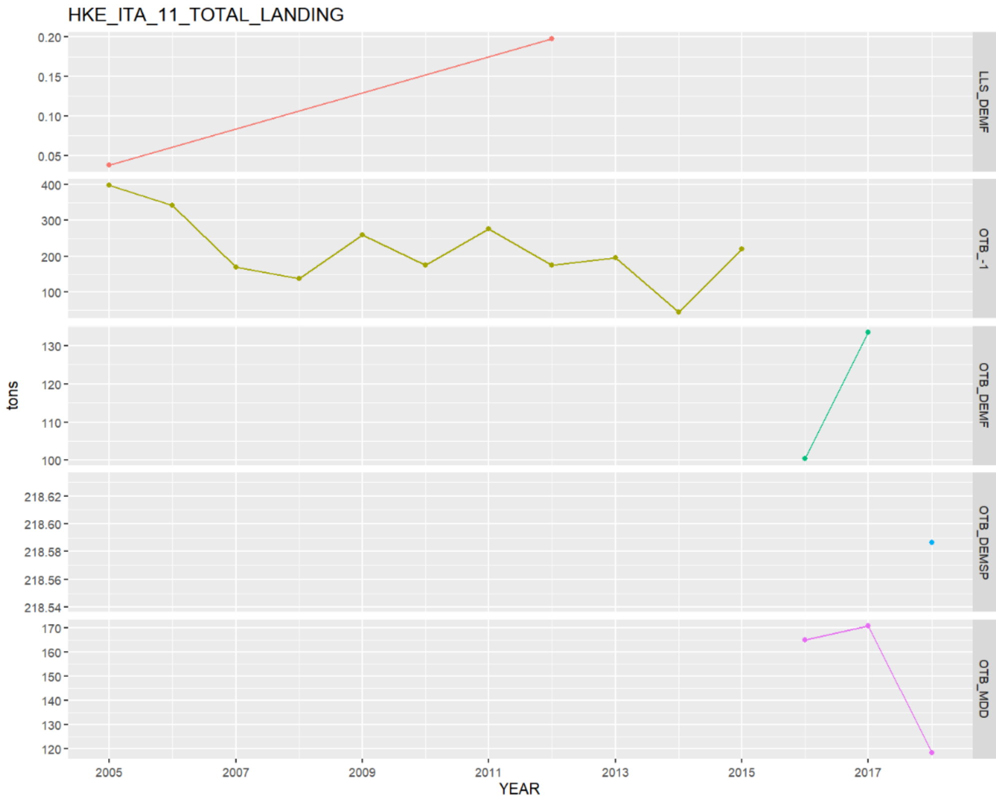
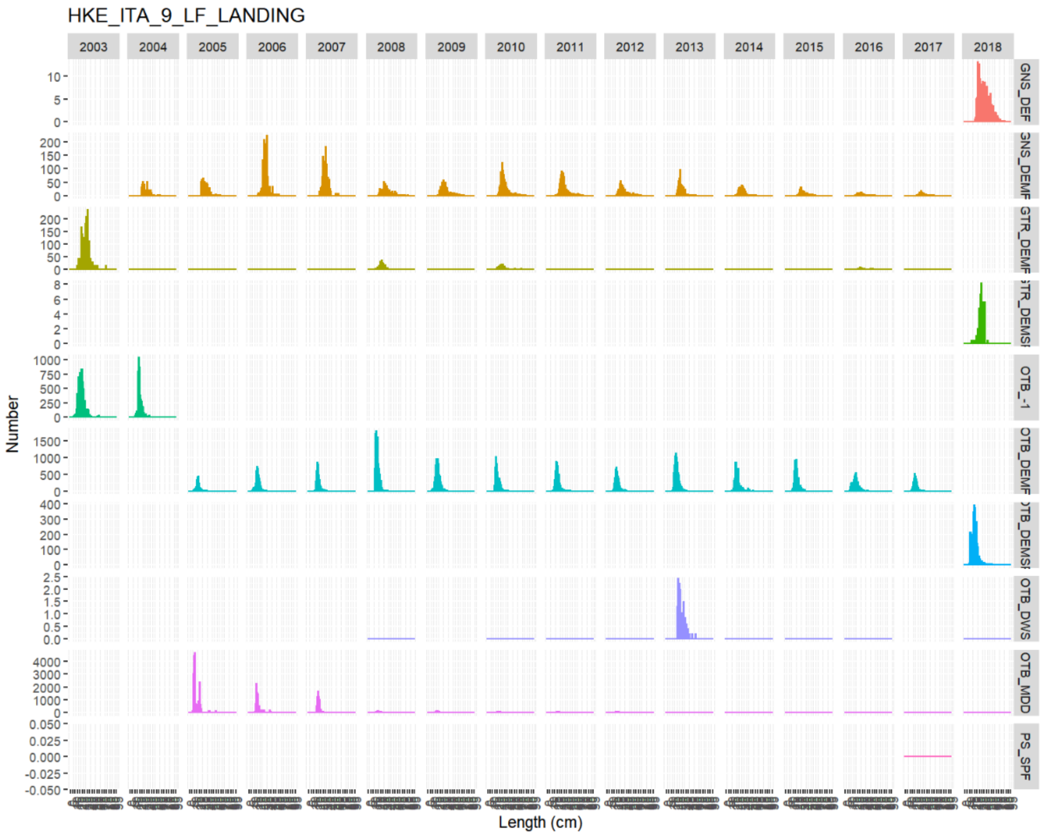


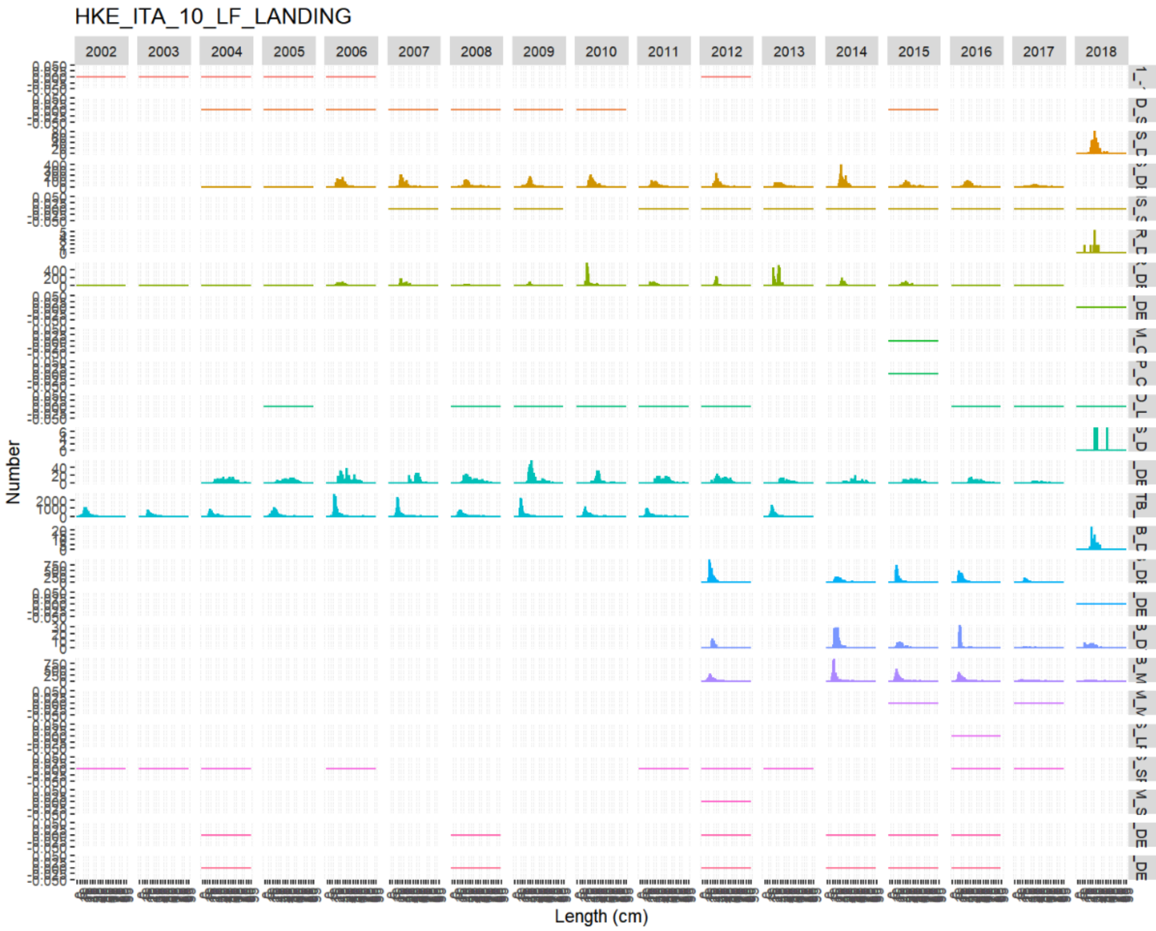
Figure 6.9.2.1.1. European hake in GSAs 9, 10 and 11. Landings data in tons by year and fleet.

Table 6.9.2.1.1. European hake in GSAs 9, 10 and 11. Landings data in tons by year and GSA.

	Total Landing (tons)			
	GSA 9	**GSA 10**	**GSA 11**	**Total**
2005	1860	1485	397	**3742**
2006	2176	1544	341	**4062**
2007	1733	1269	170	**3171**
2008	1321	1123	139	**2583**
2009	1308	1091	261	**2660**
2010	1467	1329	176	**2972**
2011	1352	1279	277	**2908**
2012	1012	1107	176	**2295**
2013	1342	1052	196	**2590**
2014	1265	1271	45	**2581**
2015	1048	1043	220	**2311**
2016	782	1052	265	**2099**
2017	572	871	304	**1748**
2018	605	821	337	**1763**

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.9.2.1.2.


HKE_ITA_9_LF_LANDING
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
GNS_DEF
GNS_DEMF
GTR_DEMF
OTB_-1
OTB_DEMF
OTB_DWS
OTB_MDD
PS_SPF
Number
Length (cm)


HKE_ITA_10_LF_LANDING
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Number
Length (cm)

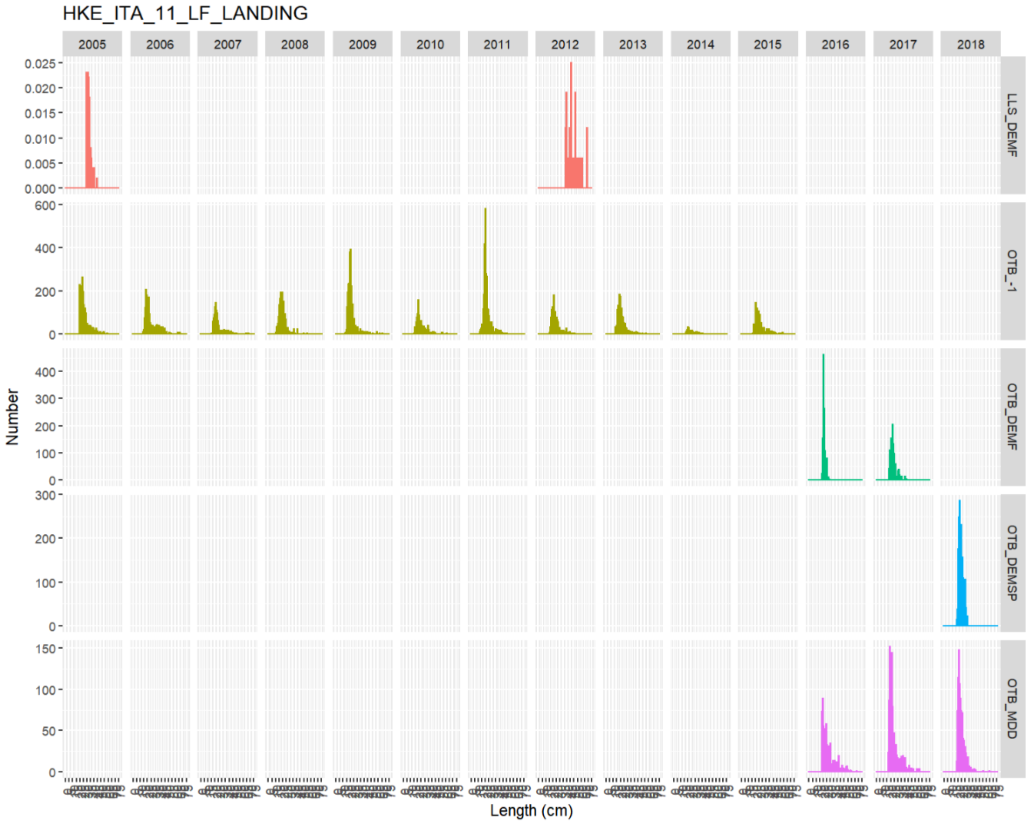


Figure 6.9.2.1.2. European hake in GSAs 9, 10 and 11. Length frequency distribution of the landings by year and fleet.

Discards

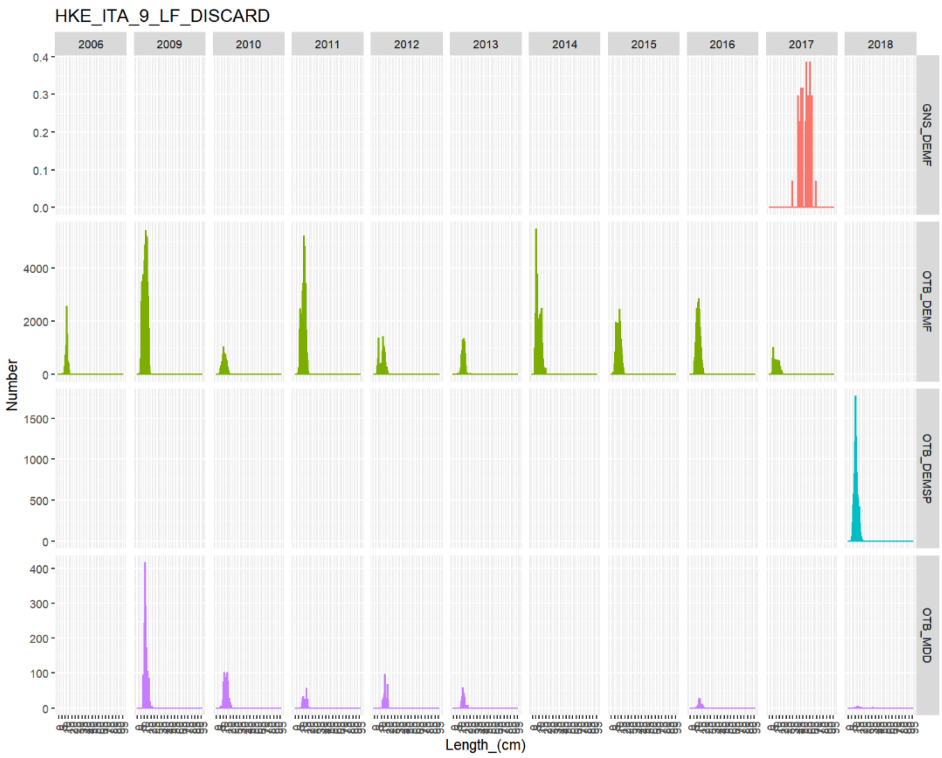
Discards data were reported to STECF EWG 19-10 through the DCF, and they were included in the stock assessment. For the years in which discards data were missing, they were estimated on the basis of the discard ratio (discard/landing) of the available years and the landing time series.

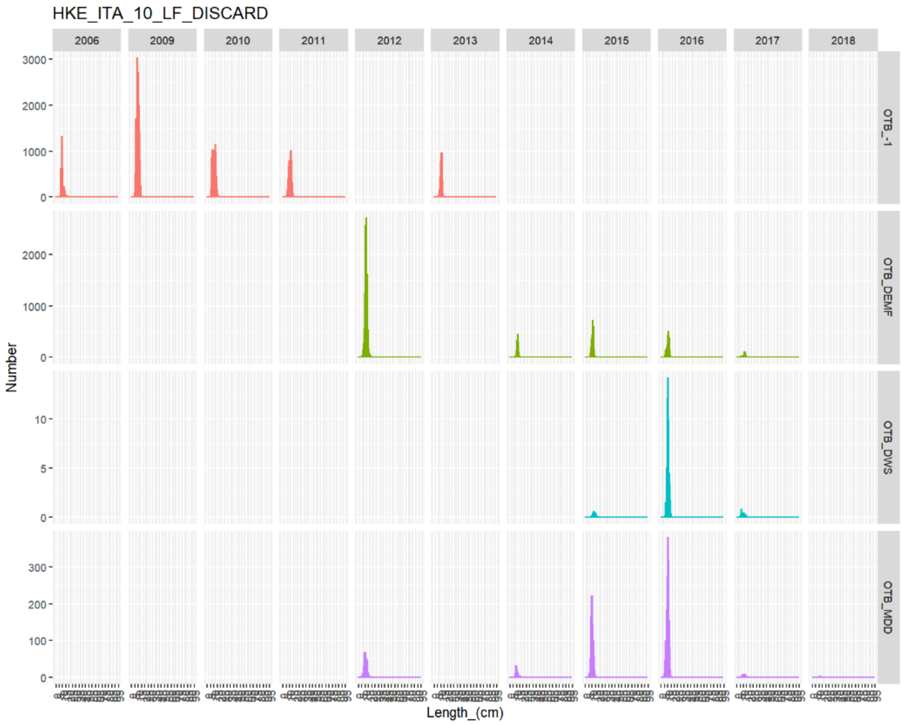
The highest discard rate were represented by the bottom trawl fishery; for the other gears the discards were negligible. Total discard by year for the bottom trawl fishery is presented in Table 6.9.2.1.2.

ble 6.9.2.1.2. European hake in GSAs 9, 10 and 11. OTB discards data in tons by GSA.

	Total Discard (tons)			
	GSA 9	**GSA10**	**GSA11**	**Total**
2005	441.32	61.9	160.02	**663.3**
2006	105.2	26.57	595.48	**727.3**
2007	411.2	52.89	105.15	**569.2**
2008	313.47	46.81	86.04	**446.3**
2009	697.27	99.78	106.87	**903.9**
2010	116.41	68.06	164.79	**349.3**
2011	527.79	54.93	268.67	**851.4**
2012	174.23	117.9	16.72	**308.9**
2013	242.43	35.63	32.27	**310.3**
2014	285.84	17	24.51	**327.4**
2015	231.04	29.71	102.85	**363.6**
2016	305.13	28.38	102.29	**435.8**
2017	75.68	3.18	212.34	**291.2**
2018	114.35	0.175	166.7	**281.2**

Length and age frequency distributions of the discards are shown in Figure 6.9.2.1.3.





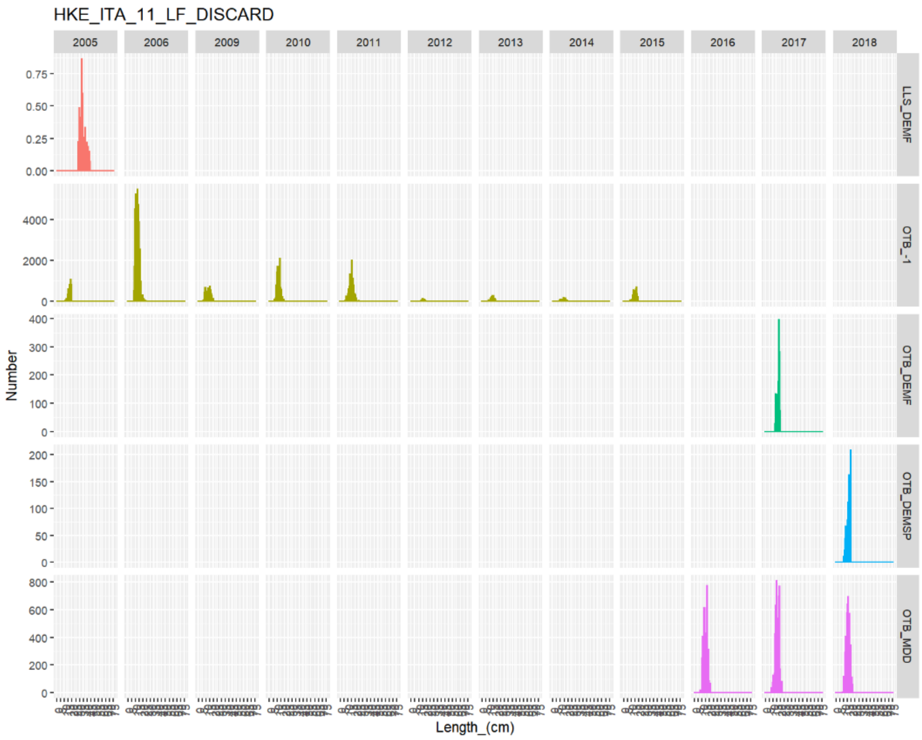


Figure 6.9.2.1.3. European hake in GSAs 9, 10 and 11. Length frequency distribution of the discards by year and fleet.

6.9.2.2 EFFORT

Fishing effort data were reported to STECF EWG 19-10 through DCF (Table 6.9.2.2.1 GT days 6.9.2.2.2 kWdays and 6.9.2.2.3 Days at sea).

Table 6.9.2.2.1. European hake in GSAs 9, 10 and 11. Fishing effort in GT*Days at sea by year and fishing gear.

	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	1879470	969054	760006
2016	1810294	1149217	829858
2017	1890758	1110902	864739
2018	1673855	1164354	1221171

	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	115584	113065	33606
2016	94490	148369	59837
2017	133845	159071	47616
2018	95419	92917	59601

	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	206746	169198	187799
2016	180231	179494	134018
2017	124705	202825	169094
2018	120872	214251	122729

	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	5531	104388	23528
2016	7613	103283	19117
2017	15023	116162	24146
2018	20718	72511	11155

Table 6.9.2.2.2. European hake 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

	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	1946625.68	1511278	481406.65
2016	1668387.23	1980063	890097.26
2017	2150649.2	2219366	671953.95

2018	1532938.43	1189583	880222.89

	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	3597446.46	2285913.64	2907172.97
2016	3241336.12	2295862.06	2020539.87
2017	1799467.05	3016437.59	2423966.99
2018	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	78693.28	1291327.08	363011.67
2016	98224.17	1287431.84	296066.97
2017	230496.05	1516092.62	335202.07
2018	313448.6	843182.28	151553.2

Table 6.9.2.2.3. European hake in GSAs 9, 10 and 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	52900	30709	15278
2016	51257	35479	16926
2017	47457	36271	16285
2018	44296	33570	21190

	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	43630	49189	19003
2016	37026	58865	25768
2017	41019	53789	15862
2018	34219	40737	31629

	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	86418	106350	58899
2016	74174	99466	51698
2017	59024	103390	56620
2018	62728	129714	38286

	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	2269	28118	5049
2016	1768	29336	3318
2017	3288	25357	6362
2018	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 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).

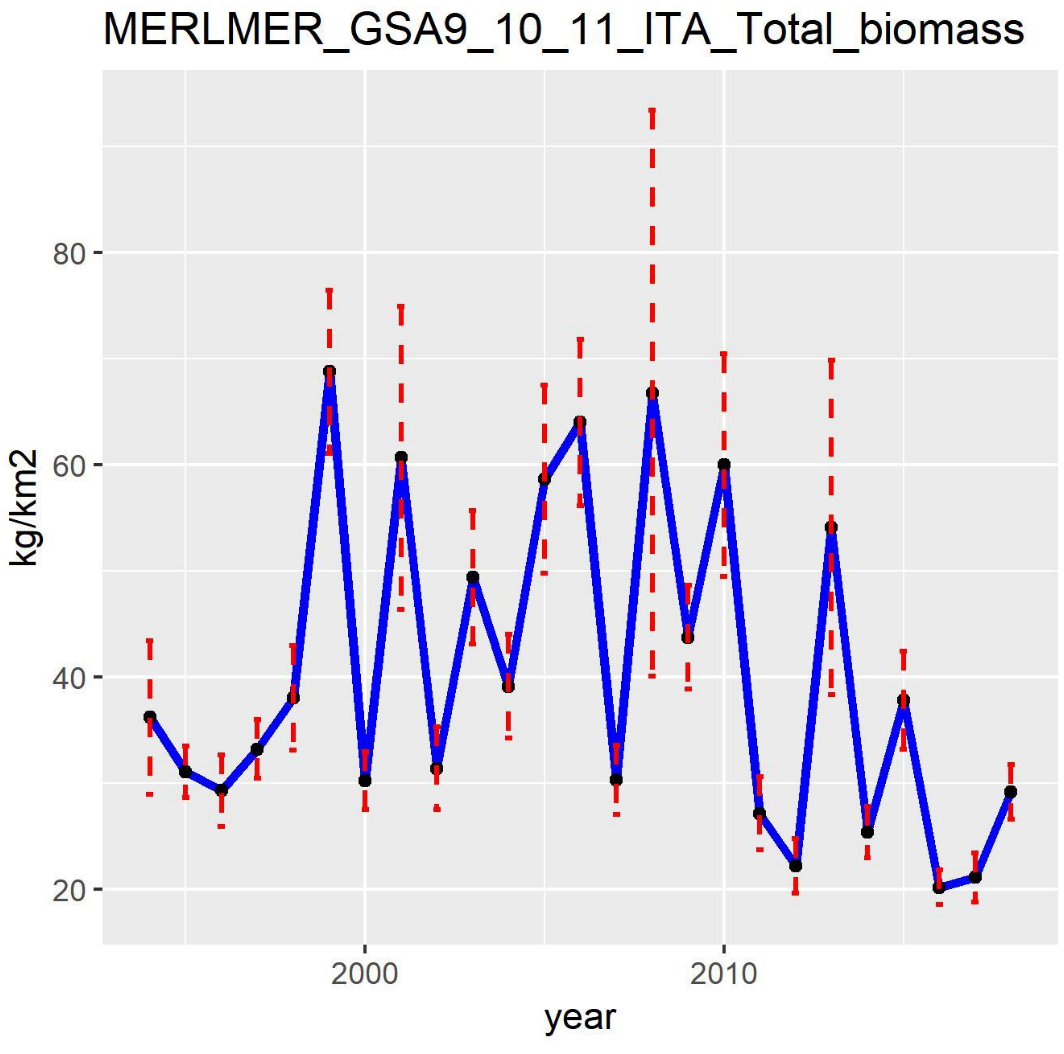


Figure 6.9.2.3.1. European hake in GSAs 9, 10 and 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

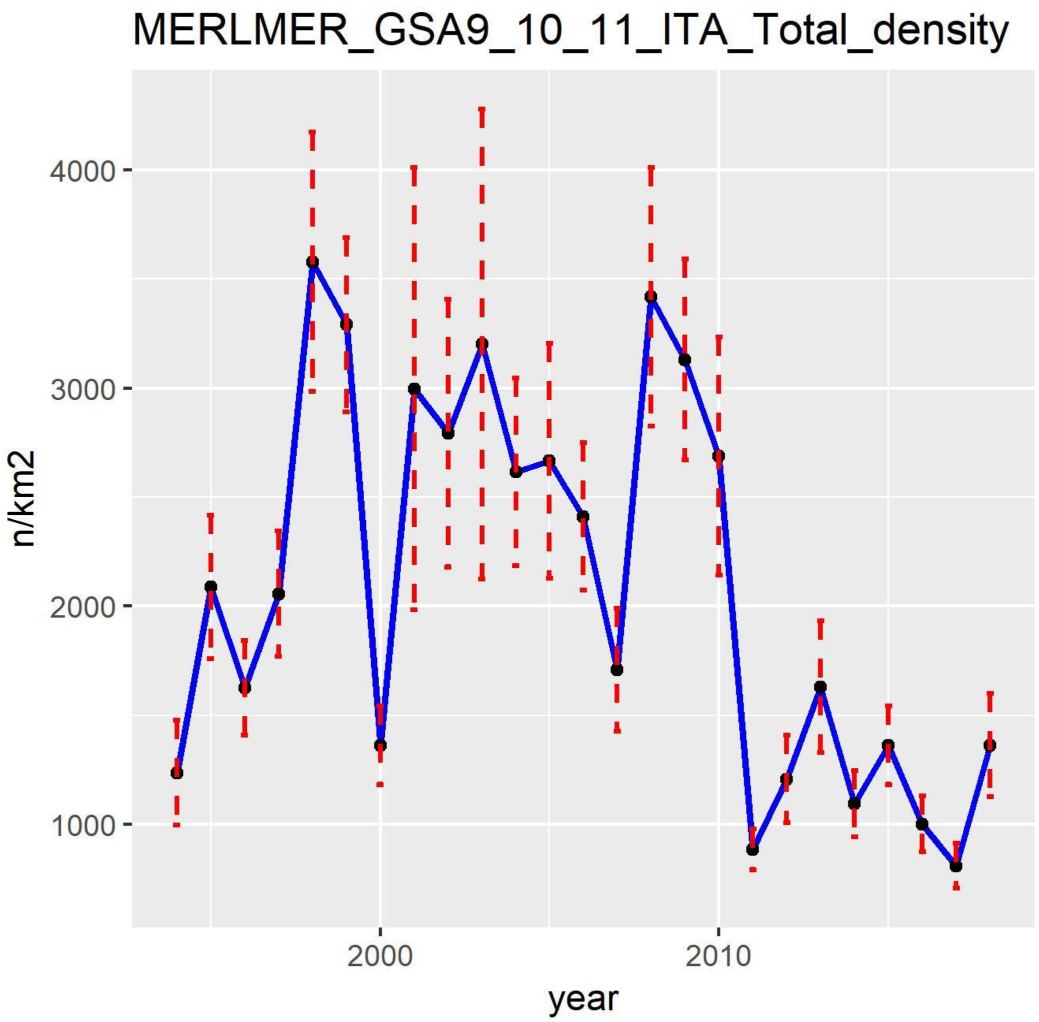


Figure 6.9.2.3.2. European hake in GSAs 9, 10 and 11. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series.
Size structure indices are shown in Figure 6.9.2.3.3.

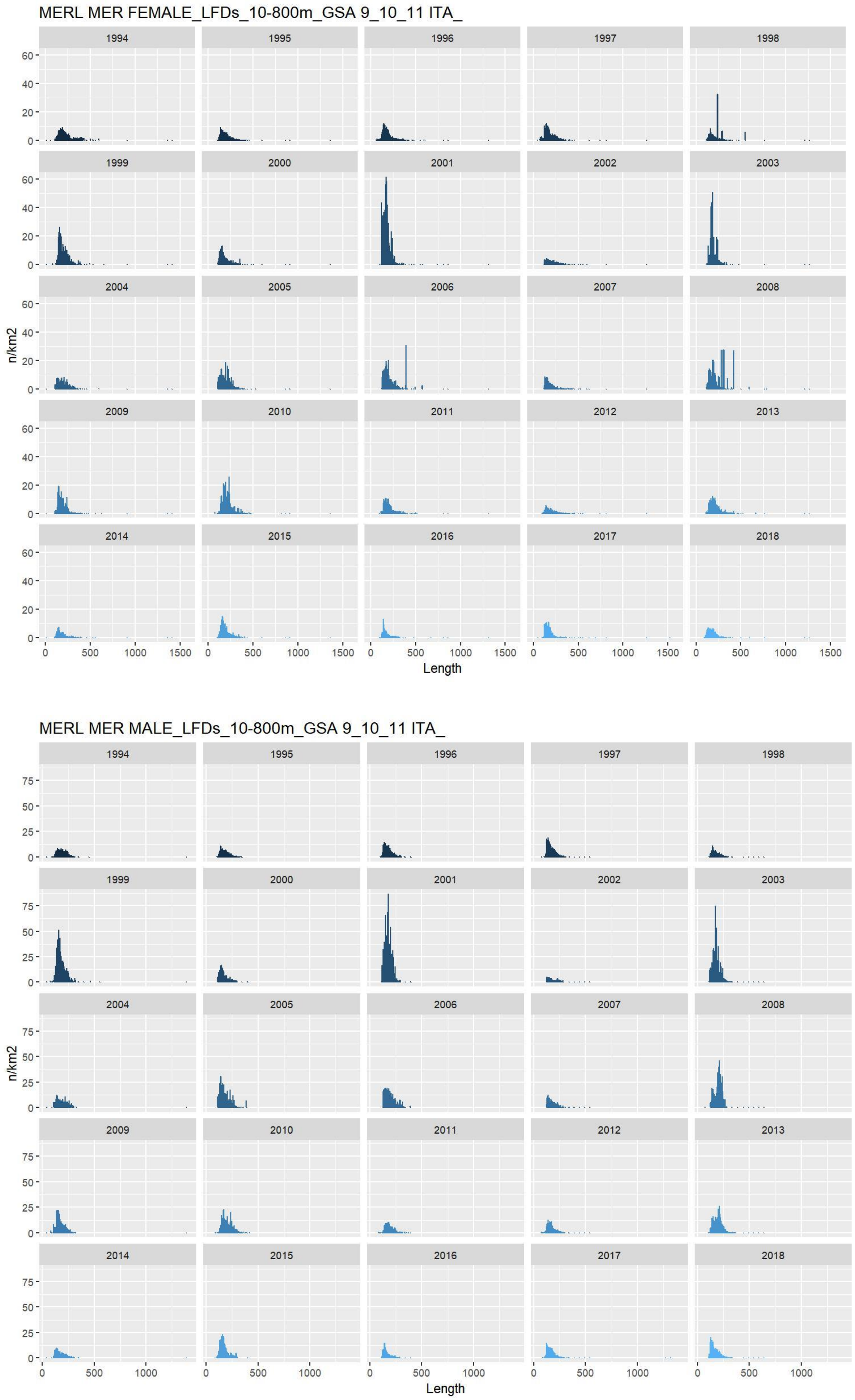


Figure 6.9.2.3.3. European hake in GSAs 9, 10 and 11. Length frequency distribution by year and sex of MEDITS survey.

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 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 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 6+. Concerning the Fbar, the age range used was 1-3 age groups.

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. SOP correction was applied to catch numbers at age (Table 6.9.3.1).

Table 6.9.3.1. European hake in GSAs 9, 10 and 11. SOP correction vector by GSA.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
GSA 9	1.85	1.30	1.43	1.32	1.10	1.07	1.11	1.12	1.14	1.13	1.06	1.04	1.16	1.08
GSA 10	1.88	1.10	1.14	1.12	1.09	1.07	1.13	1.06	1.08	1.00	1.08	1.33	1.49	1.10
GSA 11	1.04	1.03	1.70	1.68	1.02	1.03	1.02	1.03	1.04	1.04	1.06	1.03	1.02	1.01

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**
4405	4789	3741	3029	3563	3322	3759	2604	2900	2908	2675	2535	2039	2045

Catch numbers at age (thousands)

	0	**1**	**2**	**3**	**4**	**5**	**6+**
2005	32387	32470	6783	1267	761	191	520
2006	46567	39885	5314	2559	1017	284	291
2007	6044	26327	5844	2089	809	188	219
2008	3536	21433	5493	1257	476	212	284
2009	70274	28514	5544	1587	341	120	231
2010	25078	18298	5344	1743	675	213	280
2011	41058	28450	5013	1722	572	276	297
2012	22062	14635	5006	1350	431	169	186
2013	12785	21846	6380	1491	364	118	136
2014	35142	12605	5774	1850	540	186	184
2015	25701	13923	4394	1498	525	168	230
2016	27067	16009	3940	1324	380	121	205

2017	8219	12219	2660	754	404	165	159
2018	11859	12279	3666	1203	372	100	157

Weights at age (Kg)

	0	**1**	**2**	**3**	**4**	**5**	**6+**
2005	0.009	0.051	0.120	0.290	0.515	0.772	1.383
2006	0.012	0.037	0.149	0.297	0.521	0.840	1.462
2007	0.017	0.051	0.131	0.312	0.511	0.707	1.492
2008	0.016	0.046	0.131	0.290	0.529	0.850	1.679
2009	0.009	0.039	0.139	0.273	0.498	0.779	1.721
2010	0.010	0.045	0.139	0.296	0.522	0.725	1.722
2011	0.010	0.039	0.137	0.288	0.515	0.883	1.696
2012	0.010	0.046	0.134	0.280	0.524	0.839	1.544
2013	0.013	0.044	0.135	0.269	0.516	0.842	1.609
2014	0.007	0.045	0.140	0.294	0.492	0.829	1.753
2015	0.009	0.045	0.138	0.294	0.515	0.786	1.577
2016	0.010	0.044	0.136	0.290	0.495	0.833	1.734
2017	0.008	0.047	0.123	0.319	0.544	0.820	1.608
2018	0.010	0.045	0.136	0.309	0.507	0.832	1.491

Maturity vector

	0	**1**	**2**	**3**	**4**	**5**	**6+**
2005	0.02	0.10	0.54	0.93	1.00	1	1
2006	0.01	0.09	0.53	0.95	1.00	1	1
2007	0.00	0.12	0.64	0.96	1.00	1	1
2008	0.00	0.13	0.59	0.95	1.00	1	1
2009	0.01	0.13	0.57	0.95	1.00	1	1
2010	0.01	0.09	0.57	0.95	1.00	1	1
2011	0.02	0.10	0.57	0.95	1.00	1	1
2012	0.01	0.11	0.54	0.94	1.00	1	1
2013	0.01	0.13	0.61	0.95	1.00	1	1
2014	0.02	0.13	0.60	0.95	1.00	1	1
2015	0.02	0.11	0.64	0.94	1.00	1	1
2016	0.02	0.10	0.55	0.94	1.00	1	1
2017	0.02	0.07	0.54	0.93	1.00	1	1
2018	0.01	0.05	0.35	0.91	0.99	1	1

Natural Mortality vector

	0	1	2	3	4	5	6+
2005	1.31	0.61	0.43	0.34	0.29	0.26	0.23
2006	1.25	0.63	0.42	0.34	0.30	0.25	0.23
2007	0.90	0.61	0.44	0.34	0.29	0.25	0.22
2008	0.97	0.63	0.43	0.33	0.28	0.25	0.22
2009	1.19	0.65	0.43	0.33	0.29	0.26	0.22
2010	1.16	0.61	0.42	0.33	0.28	0.25	0.23
2011	1.26	0.64	0.43	0.33	0.29	0.24	0.22
2012	1.05	0.61	0.42	0.33	0.28	0.25	0.23
2013	1.04	0.63	0.43	0.34	0.29	0.24	0.22
2014	1.29	0.63	0.42	0.33	0.29	0.24	0.22
2015	1.22	0.63	0.44	0.33	0.28	0.25	0.22
2016	1.22	0.62	0.43	0.33	0.28	0.24	0.22
2017	1.31	0.64	0.45	0.34	0.27	0.24	0.22
2018	1.37	0.66	0.45	0.33	0.28	0.26	0.23

MEDITS numbers at age (n/km^2)

	0	1	2	3	4	5	6+
2005	1823.7	690.8	122.0	9.6	2.1	7.7	0.4
2006	1507.4	684.7	130.0	67.8	2.9	3.6	3.1
2007	1426.7	219.2	40.2	8.1	3.9	1.4	1.0
2008	2575.6	546.5	266.0	11.8	29.1	0.7	2.1
2009	2596.4	380.6	64.7	5.0	0.5	0.3	0.6
2010	1828.4	725.9	146.7	25.3	4.3	0.8	0.9
2011	557.0	251.0	53.2	10.7	2.7	1.7	0.3
2012	906.7	204.4	35.8	5.2	1.2	0.3	0.5
2013	941.8	513.0	126.0	12.1	4.3	0.5	0.5
2014	836.7	185.5	47.0	9.6	2.0	0.4	0.5
2015	762.6	476.5	63.7	19.6	1.6	0.8	0.5
2016	789.8	152.1	31.9	5.4	1.6	0.6	0.6
2017	488.9	259.3	26.5	6.0	1.1	0.5	1.3
2018	951.6	285.3	44.2	10.2	2.5	0.6	0.7

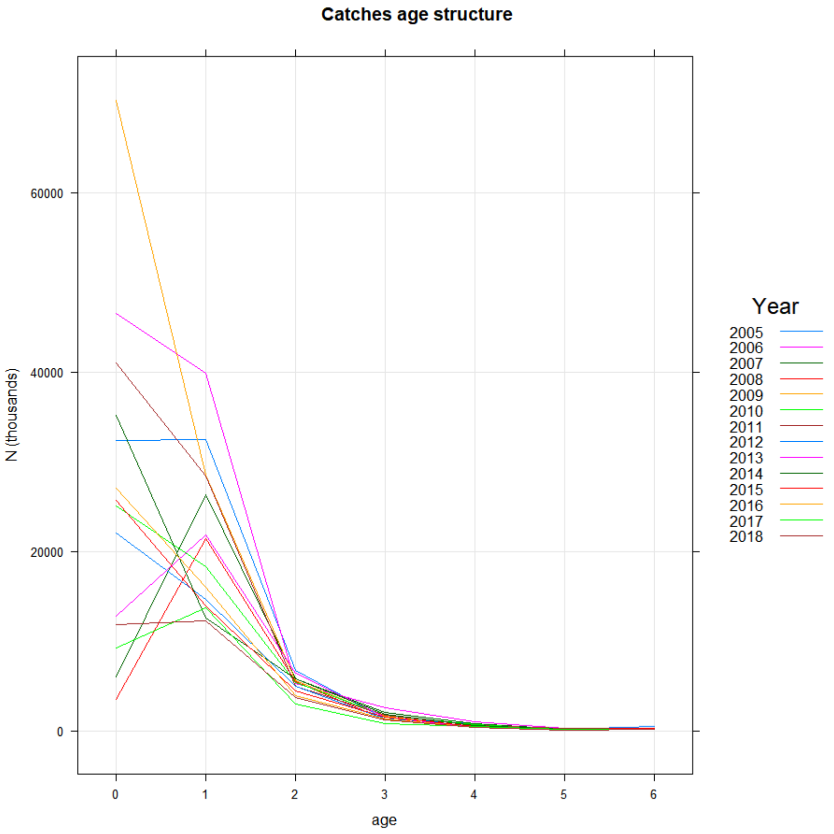


Figure 6.9.3.1. European hake in GSAs 9, 10 and 11. Catch at age input data.

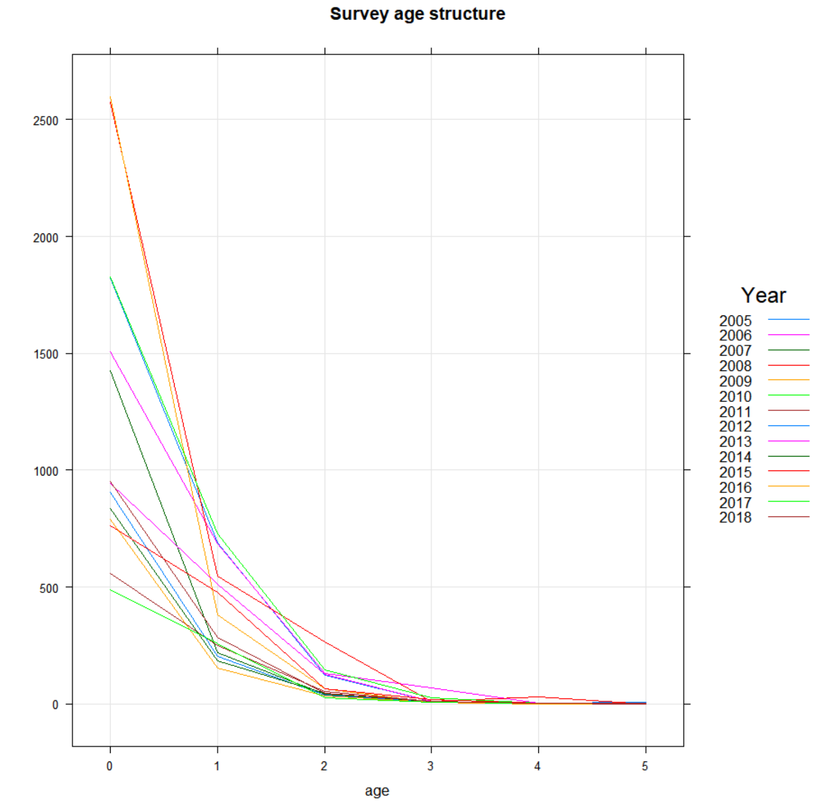


Figure 6.9.3.2. European hake in GSAs 9, 10 and 11. Age structure of the index.

Assessment results

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

f ~ s(age, k=3)+s(year, k=8) + s(year, k=8, by=as.numeric(age==0))

q ~ list(~ factor(age))

Results are shown in Figures 6.9.3.3 – 6.9.3.9.

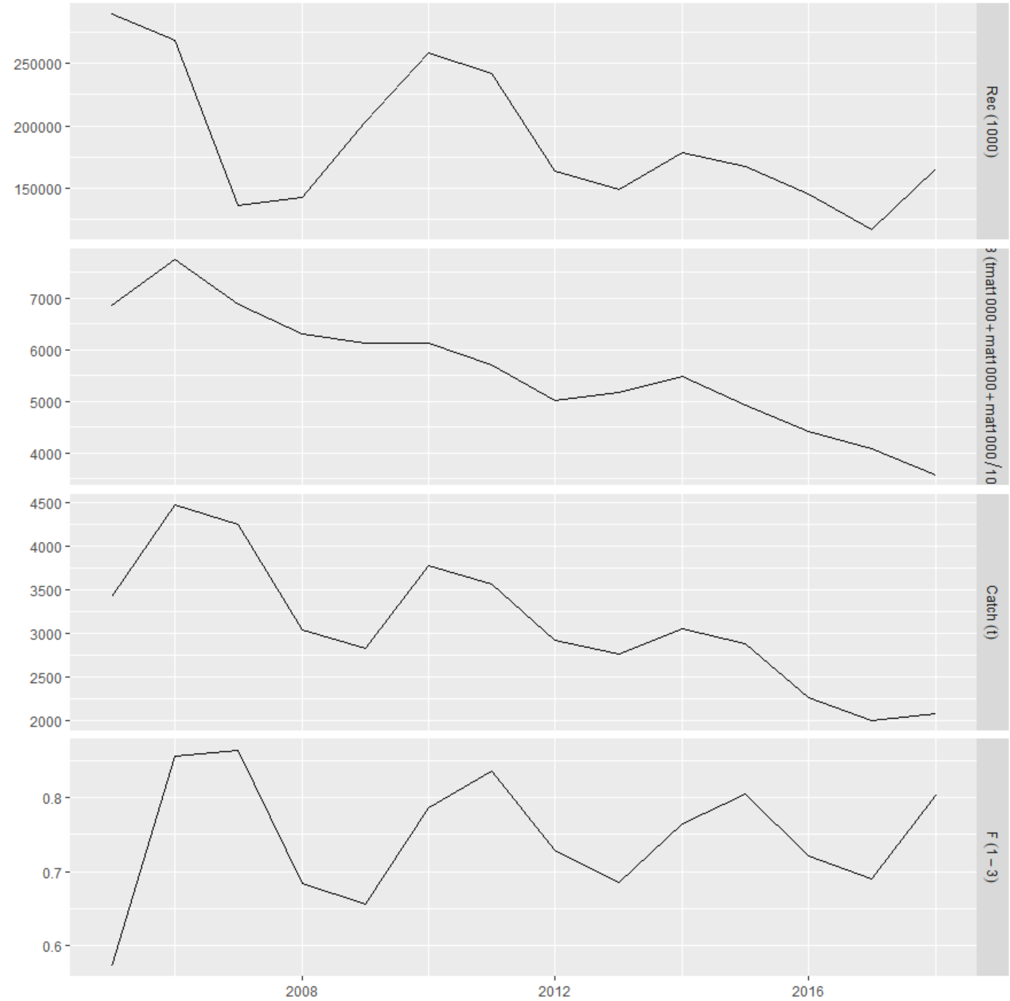


Figure 6.9.3.3. European hake in GSAs 9, 10 and 11. Stock summary from the final a4a model.

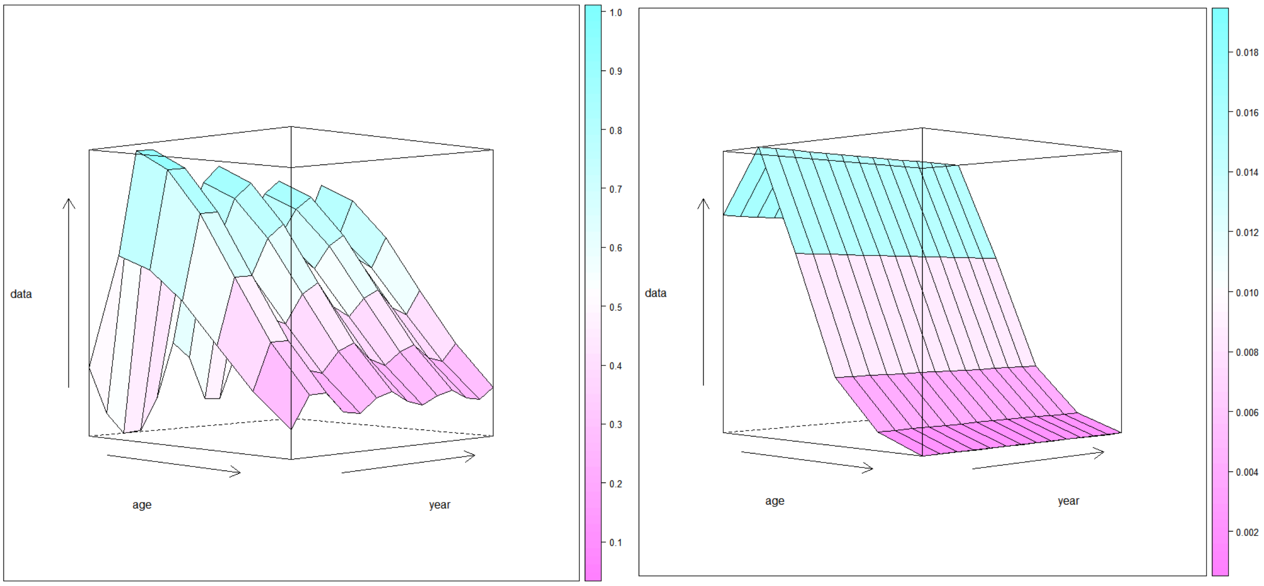


Figure 6.9.3.4. European hake in GSAs 9, 10 and 11. 3D contour plot of estimated fishing mortality (left) and 3D contour plot of estimated catchability (right) at age and year.

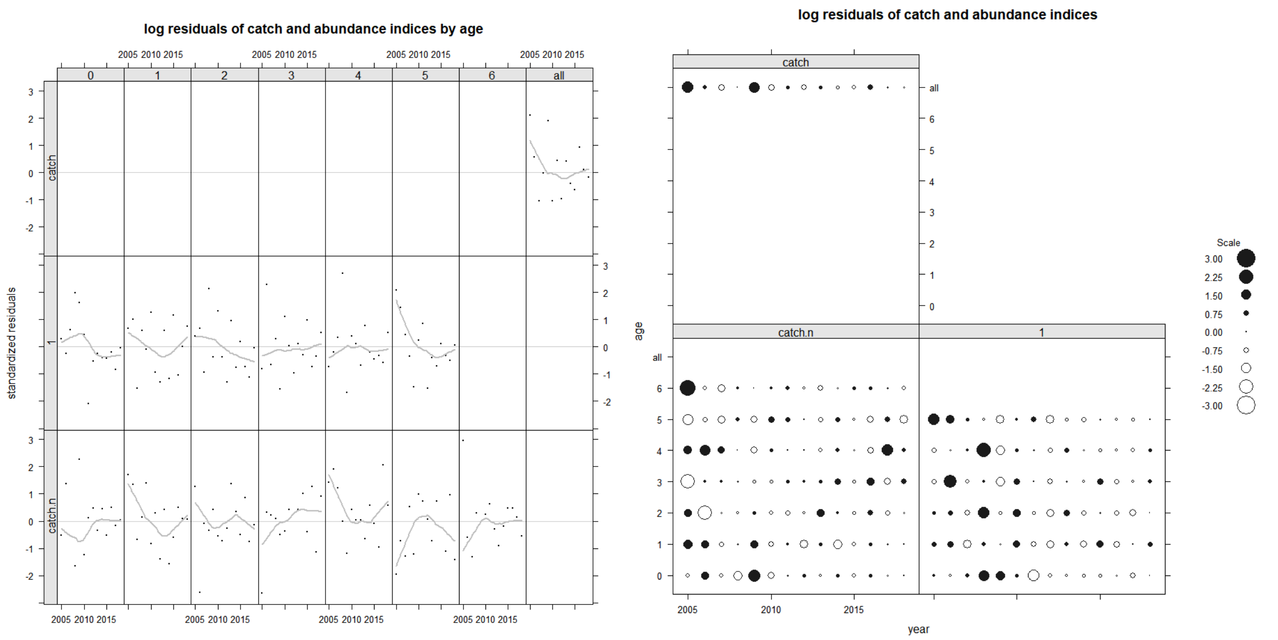


Figure 6.9.3.5. European hake in GSAs 9, 10 and 11. Standardized residuals for abundance indices and for catch numbers.

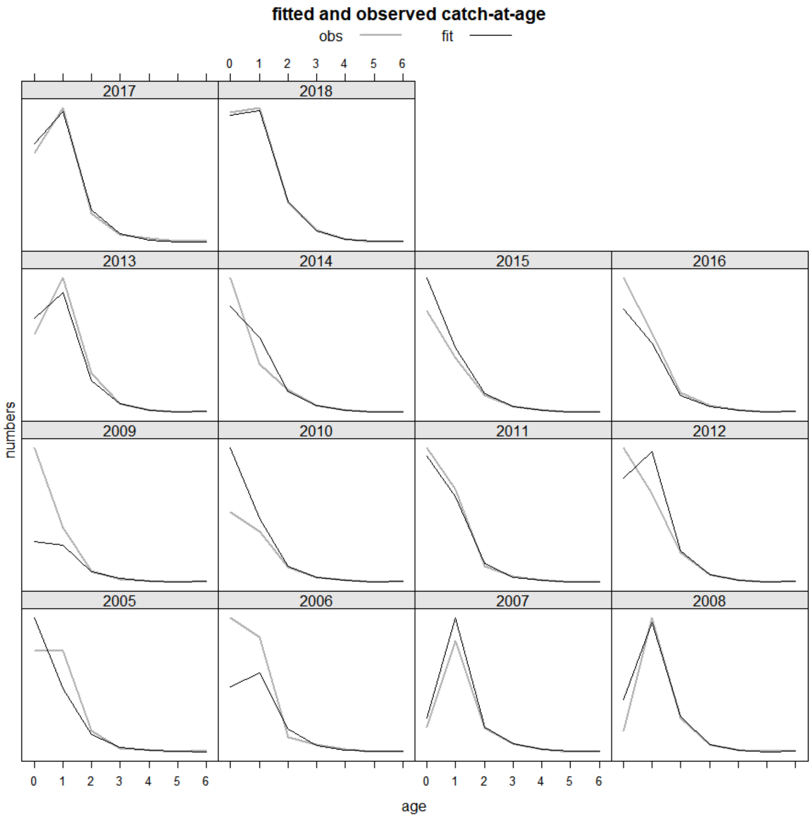


Figure 6.9.3.6. European hake in GSAs 9, 10 and 11. Fitted and observed catch at age.

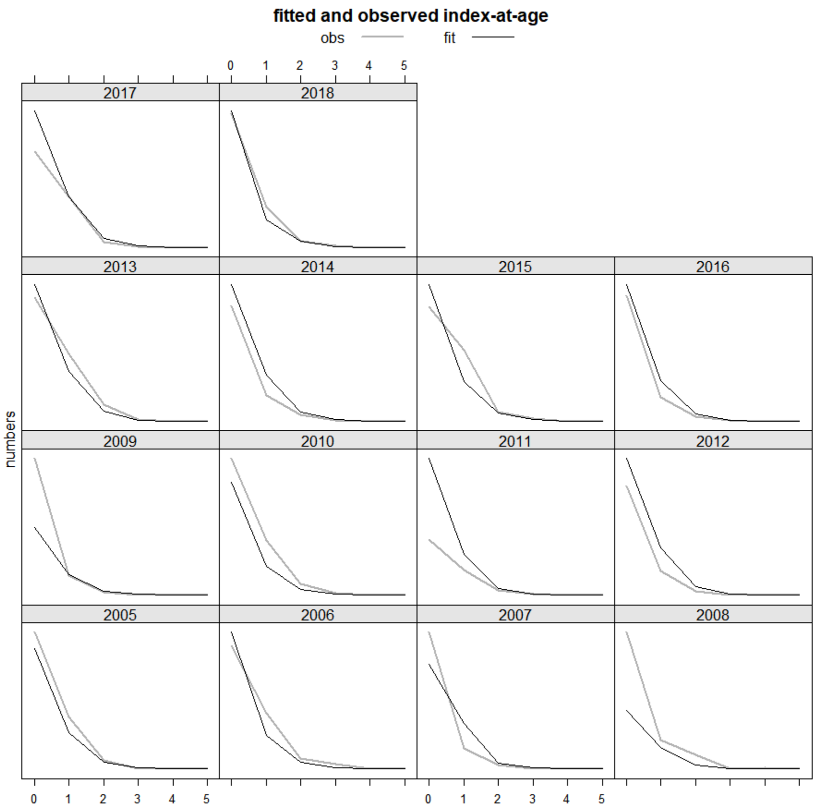


Figure 6.9.3.7. European hake in GSAs 9, 10 and 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 2 years back. Models results were quite stable (Figure 6.9.3.8).

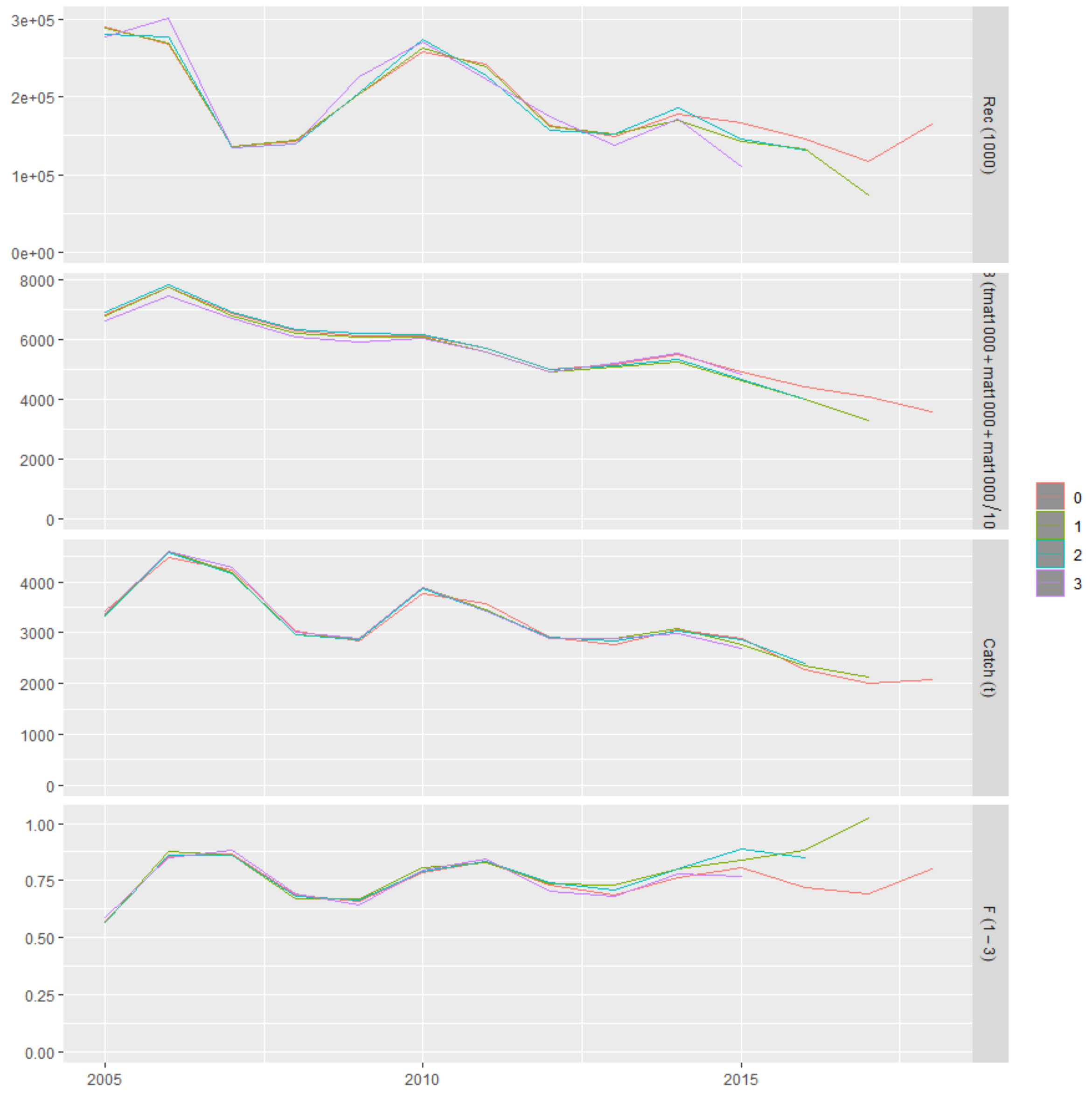


Figure 6.9.3.8. European hake in GSAs 9, 10 and 11. Retrospective analysis.

Simulations

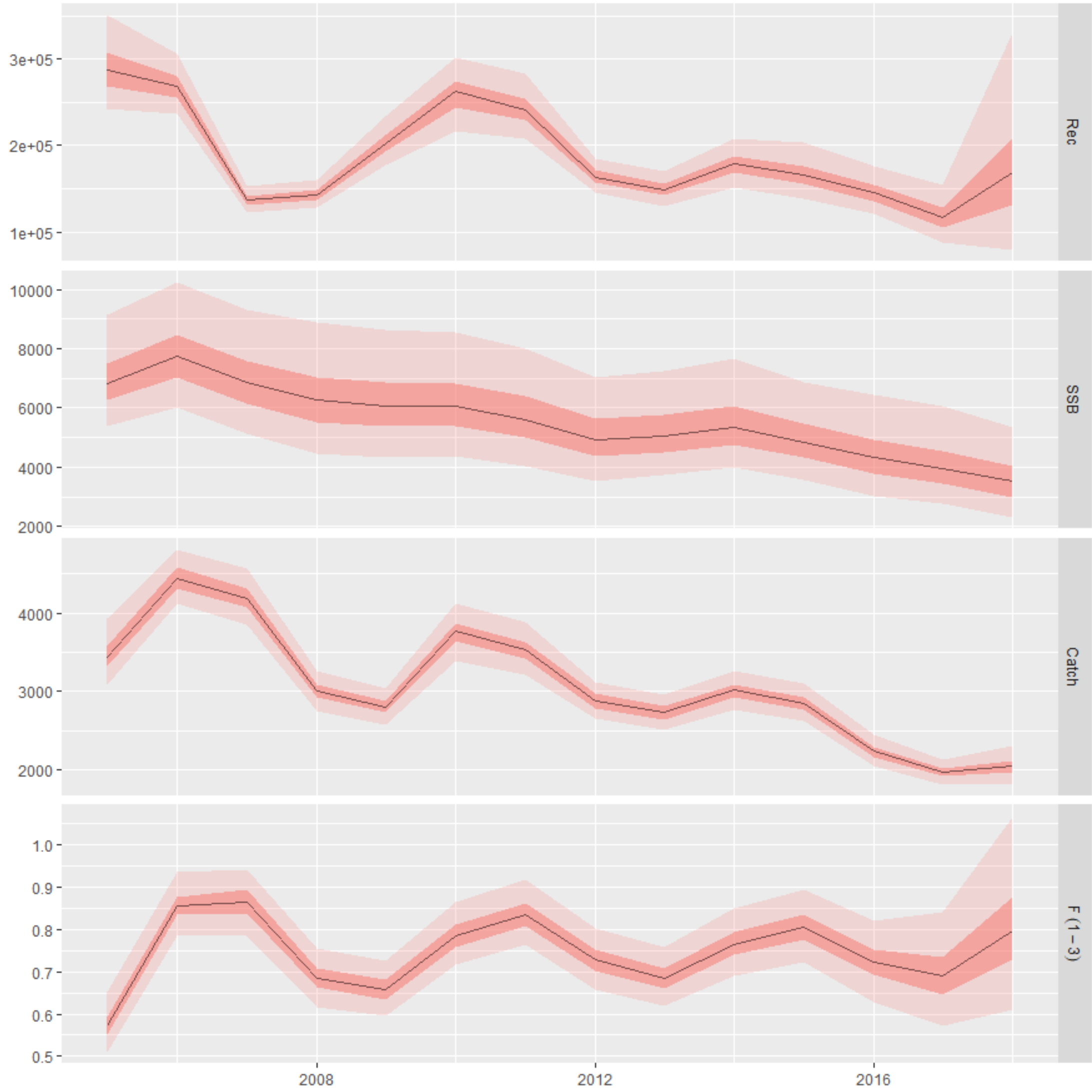


Figure 6.9.3.9. European hake in GSAs 9, 10 and 11. Stock summary of the simulated and fitted data for the a4a model.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.9.3.3. European hake in GSAs 9, 10 and 11. Stock numbers at age (thousands) as estimated by a4a.

	0	1	2	3	4	5	6+
2005	289472	56317	15056	4979	2336	1555	1280
2006	268393	58031	16276	5432	2141	1193	1787
2007	136459	65828	12070	4458	1837	904	1723
2008	142985	50710	13818	3205	1492	773	1539
2009	203143	49364	12705	4442	1268	714	1451
2010	258532	50892	12562	4222	1799	615	1364
2011	241954	56439	11678	3676	1525	808	1191
2012	164141	50271	11841	3222	1271	660	1178
2013	149453	47680	12213	3678	1227	593	1127
2014	178624	44229	11996	3930	1446	586	1073
2015	167371	35953	10139	3576	1457	654	1009
2016	145673	32862	7896	2861	1273	647	992
2017	117106	32649	7972	2445	1097	595	1006
2018	165298	26767	8042	2507	955	528	999

Table 6.9.3.4. European hake in GSAs 9, 10 and 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	0.57	289472	6849.2	12935	3417.4
2006	0.86	268393	7746.3	14134	4470.6
2007	0.86	136459	6890	12863	4244.1
2008	0.68	142985	6295.6	11308	3038
2009	0.66	203143	6122.2	10298	2830
2010	0.79	258532	6130.8	11684	3772
2011	0.84	241954	5711	10866	3567.5
2012	0.73	164141	5014.3	9518.4	2921.4
2013	0.68	149453	5175.9	9596.2	2762
2014	0.77	178624	5485.9	9150.3	3050.7
2015	0.80	167371	4934.5	8469.6	2887.1
2016	0.72	145673	4417.7	7682.3	2269.1
2017	0.69	117106	4074	6943.3	2010.2
2018	0.80	165298	3575.6	7137.1	2086.1

Table 6.9.3.5. European hake in GSAs 9, 10 and 11. Fishing mortality at age as estimated by a4a.

	0	**1**	**2**	**3**	**4**	**5**	**6+**
2005	0.30	0.63	0.59	0.50	0.38	0.26	0.17
2006	0.16	0.94	0.88	0.75	0.57	0.39	0.26
2007	0.09	0.95	0.89	0.75	0.57	0.39	0.26
2008	0.10	0.75	0.70	0.60	0.45	0.31	0.20
2009	0.19	0.72	0.67	0.57	0.43	0.30	0.20
2010	0.36	0.87	0.81	0.68	0.52	0.36	0.23
2011	0.32	0.92	0.86	0.73	0.55	0.38	0.25
2012	0.18	0.80	0.75	0.63	0.48	0.33	0.22
2013	0.18	0.75	0.70	0.60	0.45	0.31	0.20
2014	0.31	0.84	0.79	0.67	0.51	0.35	0.23
2015	0.41	0.89	0.83	0.70	0.53	0.37	0.24
2016	0.28	0.79	0.74	0.63	0.48	0.33	0.22
2017	0.16	0.76	0.71	0.60	0.46	0.31	0.21
2018	0.14	0.88	0.83	0.70	0.53	0.37	0.24

Based on the a4a results, the European hake SSB shows a decreasing trend from the beginning of the time series, from a maximum of 7746 tons in 2006 to minimum of 3576 tons in 2018. The assessment shows a decreasing trend in the number of recruits in the time series. The recruitment (age 0) reached a minimum of 117106 thousands individuals in 2017, followed by a slight increase up to 165298 thousands individuals in 2018. F_{bar} (1-3) shows a fluctuating pattern with a slightly increasing trend in the time series, with a value of 0.80 reached in 2018. 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 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 (0.80, estimated as the F_{bar1-3} in the last year of the time series, 2018) is higher than $F_{0.1}$ (0.22), 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 9, 10 and 11 is over-exploited.

6.9.5 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 choice of parameter values used followed the procedure described in Section 4.3. An average of the last three years has been used for weight at age, maturity at age and F_{bar}.

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 last whole time series years (180785 thousands).

Table 6.9.5.1 European hake in GSAs 9, 10 and 11: Assumptions made for the interim year and in the forecast.

<table>
<tr><th>Variable</th><th>Value</th><th>Notes

Table 6.9.5.1 European hake in GSAs 9, 10 and 11. Short term forecast in different F scenarios.
<table>
<tr><th>Rationale</th><th>Ffactor</th><th>Fbar</th><th>Catch 2018</th><th>Catch 2019</th><th>Catch 2020</th><th>Catch 2021</th></tr>
<tr><td>High long term yield ($F_{0.1}$)</td><td>0.30</td><td>0.22</td><td>2086</td><td>2001</td><td>772</td><td>1145</td></tr>
</table>
</th></tr>
<tr><td>Biological Parameters</td><td></td><td>mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2016-2018</td></tr>
<tr><td>$F_{ages\ 1\text{-}3}$ (2019)</td><td>0.74</td><td>mean F 2016-2018 used to give F status quo for 2019</td></tr>
<tr><td>SSB (2019)</td><td>3411</td><td>Stock assessment 1 January 2019</td></tr>
<tr><td>R_{age0} (2019,2020)</td><td>180785</td><td>Geometric mean of the time series, years 2005-2018</td></tr>
<tr><td>Total catch (2019)</td><td>2001</td><td>Assuming F status quo for 2019</td></tr>
</table>

Table 6.9.5.1 European hake in GSAs 9, 10 and 11. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB 2019	SSB 2021	Change_SSB 2019-2021(%)	Change_Catc 2018-2020(%)
High long term yield ($F_{0.1}$)	0.30	0.22	2086	2001	772	1145	3411	4931	45	-63
F upper	0.41	0.31	2086	2001	1036	1446	3411	4624	36	-50
F lower	0.20	0.15	2086	2001	535	835	3411	5211	53	-74
Zero catch	0.00	0	2086	2001	0	0	3411	5850	72	-100
Status quo	1.00	0.74	2086	2001	2144	2250	3411	3372	-1	3
Different Scenarios	0.10	0.07	2086	2001	273	451	3411	5522	62	-87
	0.20	0.15	2086	2001	531	830	3411	5215	53	-75
	0.30	0.22	2086	2001	775	1148	3411	4928	44	-63
	0.40	0.29	2086	2001	1004	1412	3411	4660	37	-52
	0.50	0.37	2086	2001	1222	1632	3411	4409	29	-41
	0.60	0.44	2086	2001	1427	1812	3411	4174	22	-32
	0.70	0.52	2086	2001	1621	1960	3411	3953	16	-22
	0.80	0.59	2086	2001	1805	2079	3411	3747	10	-13
	0.90	0.66	2086	2001	1979	2175	3411	3554	4	-5
	1.10	0.81	2086	2001	2301	2308	3411	3202	-6	10
	1.20	0.88	2086	2001	2449	2351	3411	3043	-11	17
	1.30	0.96	2086	2001	2590	2382	3411	2893	-15	24
	1.40	1.03	2086	2001	2724	2403	3411	2752	-19	31
	1.50	1.11	2086	2001	2852	2415	3411	2619	-23	37
	1.60	1.18	2086	2001	2973	2420	3411	2495	-27	43
	1.70	1.25	2086	2001	3089	2419	3411	2378	-30	48
	1.80	1.33	2086	2001	3199	2412	3411	2268	-34	53
	1.90	1.40	2086	2001	3304	2402	3411	2164	-37	58
	2.00	1.47	2086	2001	3404	2388	3411	2066	-39	63

6.9.6 DATA DEFICIENCIES

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. LFDs in 2018 are reported with a 2 cm step. No discard data are available for 2018. Very low discard values in 2017, compared to the previous years time series.

MEDITS data provided for hake in GSA11 present some issues in the TC file, maybe due to uncorrect raising procedures. In 2006, for example, haul 71 presents a raising factor of 885 only for size 395; in 2008, haul 30 presents a raising factor of 391 for lengths 280, 300, 310 and 420. This results in biased LFD patterns.

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.

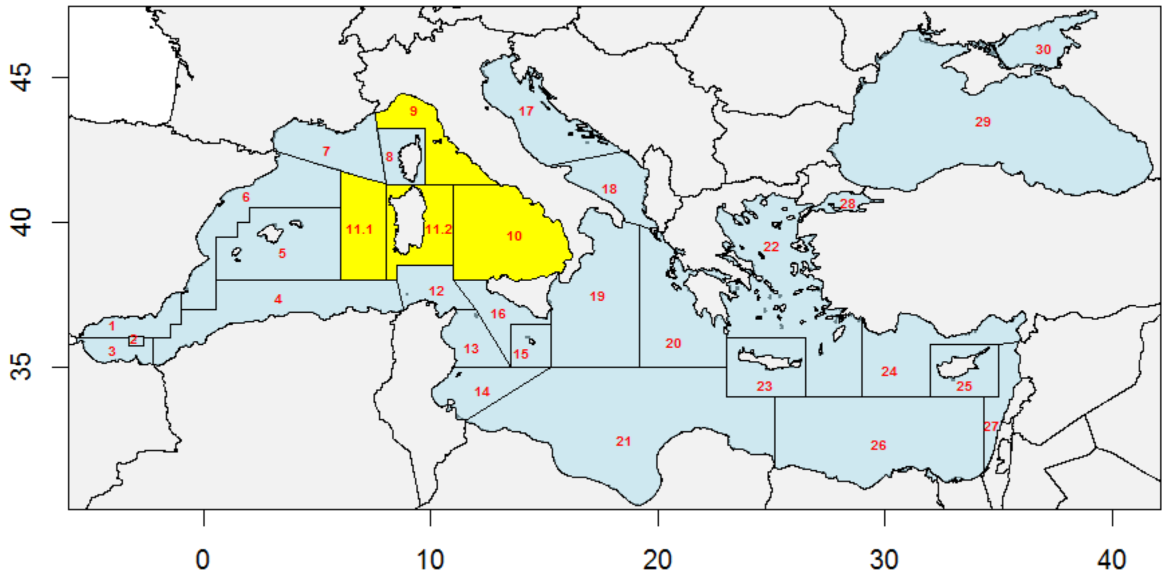


Figure 6.10.1.1 Deep-water rose shrimp in GSAs 09, 10 & 11.Geographical location of the GSAs.

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 (Lembo *et al.*, 2000a).

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 (e.g. Spedicato *et al*,. 2003) 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.

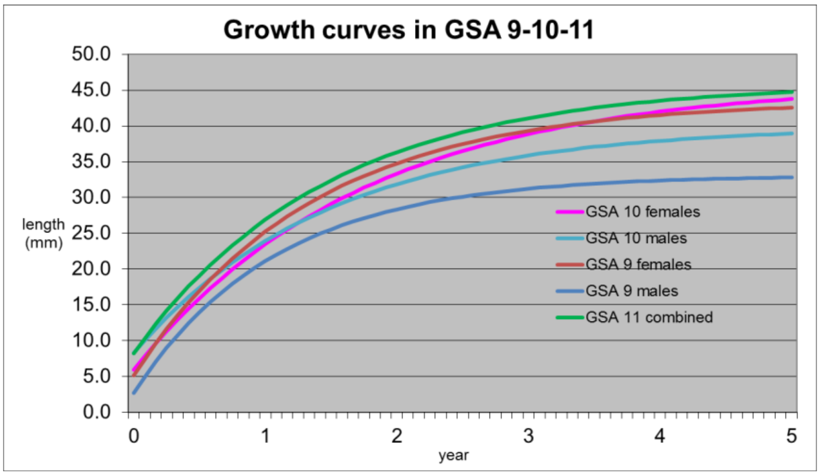


Figure 6.10.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Von Bertalanffy curves.

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
0	0.48	0.48	0.50	0.45	0.46	0.47	0.48	0.46	0.49	0.54	0.48	0.48	0.50	0.45	0.46
1	0.94	0.93	0.94	0.94	0.93	0.94	0.94	0.93	0.93	0.92	0.94	0.93	0.94	0.94	0.93
2	0.98	0.98	0.95	0.99	0.99	0.97	0.99	0.99	0.99	0.99	0.98	0.98	0.95	0.99	0.99
3	0.95	1.00	0.99	0.99	1.00	1.00	0.99	1.00	1.00	1.00	0.95	1.00	0.99	0.99	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

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 2018 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: 2003-2018 for GSA09, 2002-2018 for GSA10 and 2009-2018 for GSA11.

The landings coming from GSA11 are 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 2018. 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 11% 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 for GSA11. Missing discard data were not reconstructed.

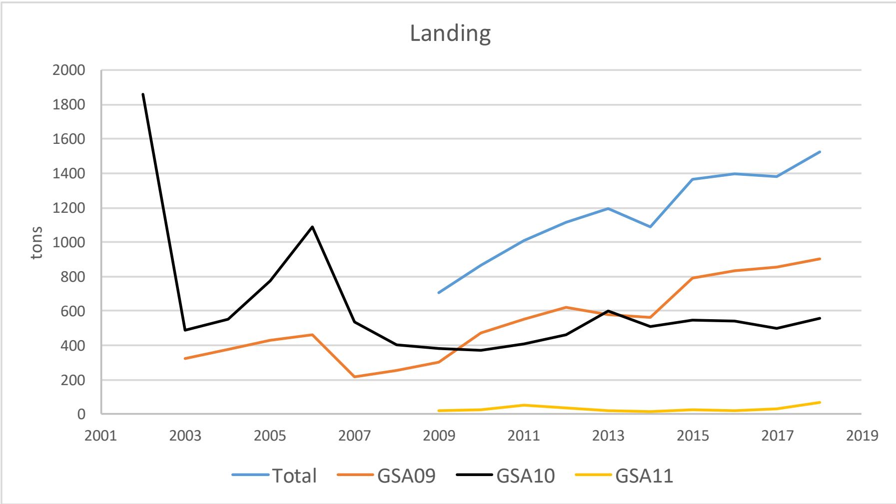


Figure 6.10.2.1.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings from 2002 to 2018 by single and combined GSAs.

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
GSA 09	OTB	Landing	NA	317	367	430	462	215	253	303	473	551	621	576	561	791	836	857	904
GSA 09	GNS		NA	0	4	0	0	2	1	0	0	0	0	0	0	0	0	0	0
GSA 09	GTR		NA	6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
GSA 10	OTB		1452	416	544	743	1088	534	400	379	370	402	455	597	509	525	542	389	555
GSA 10	GNS		0	0	3	6	0	0	0	0	0	3	4	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
Total	ALL		1452	739	922	1180	1550	751	654	704	866	1009	1114	1194	1086	1342	1396	1275	1426
GSA 09	OTB	Discard	NA	NA	NA	NA	NA	NA	NA	38	27	63	8	30	45	89	35	41	50
GSA 10	OTB		NA	NA	NA	NA	4	NA	NA	7	3	3	5	9	3	13	6	4	0
GSA 11	OTB		NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0
Total	OTB		0	0	0	0	4	0	0	45	30	66	13	39	48	102	41	45	50
TOTAL	ALL	Catch	1452	739	922	1180	1554	751	654	749	896	1075	1127	1233	1134	1444	1437	1320	1476

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.

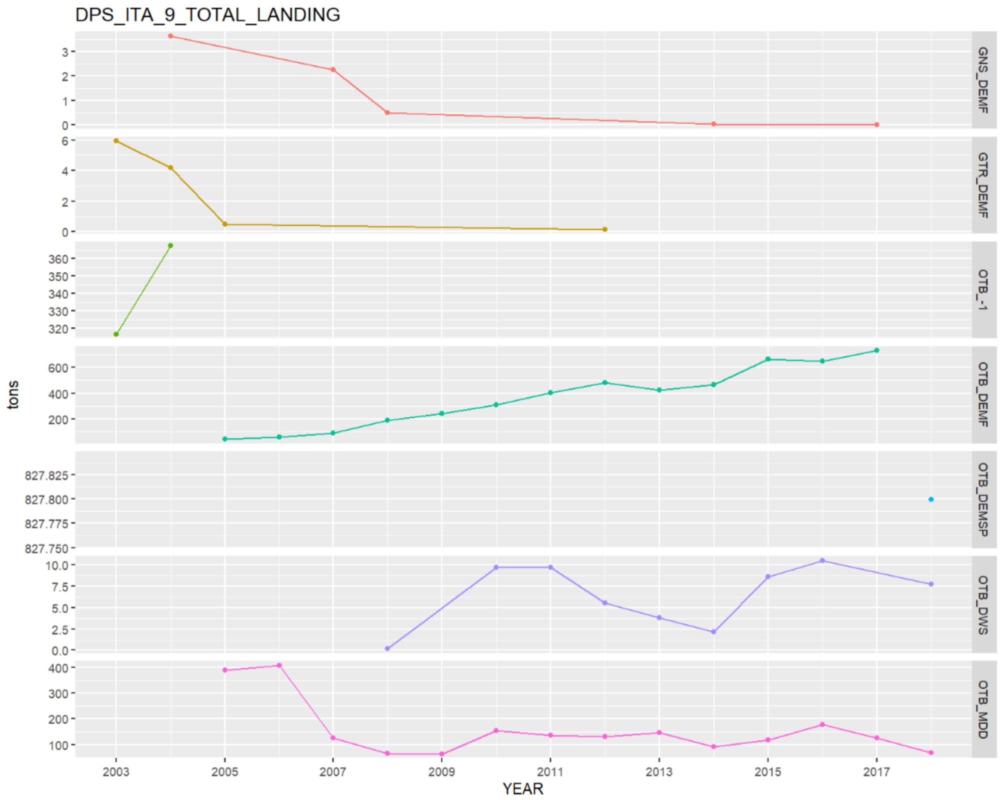


Figure 6.10.2.1.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA09.

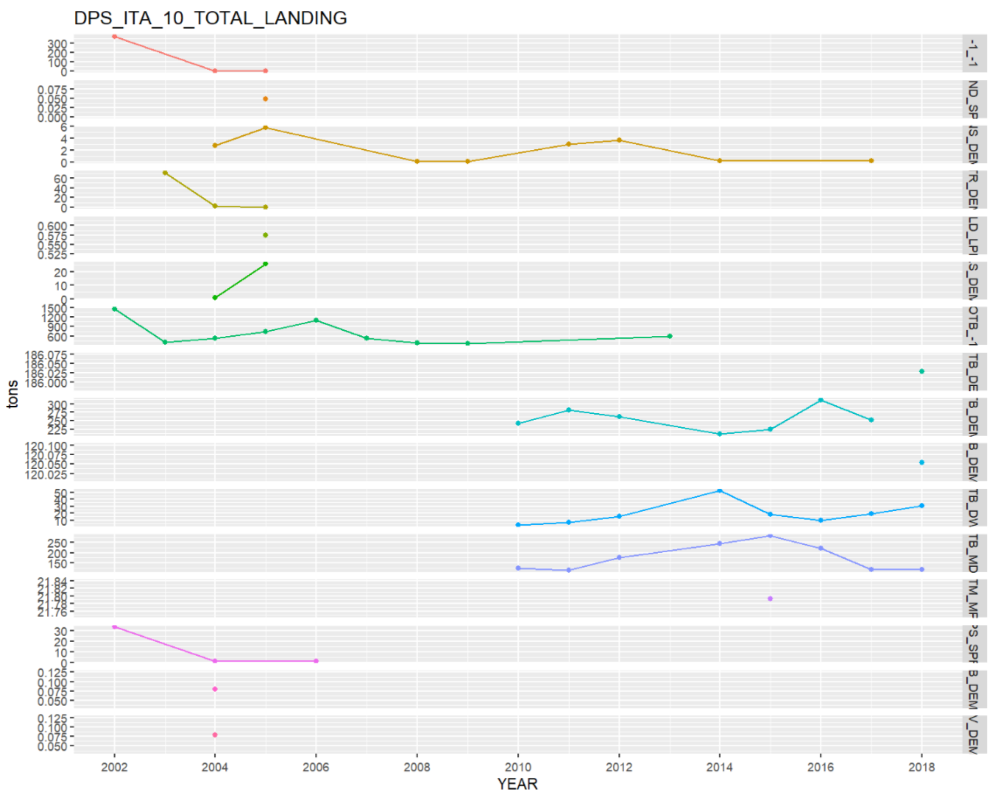


Figure 6.10.2.1.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA10.

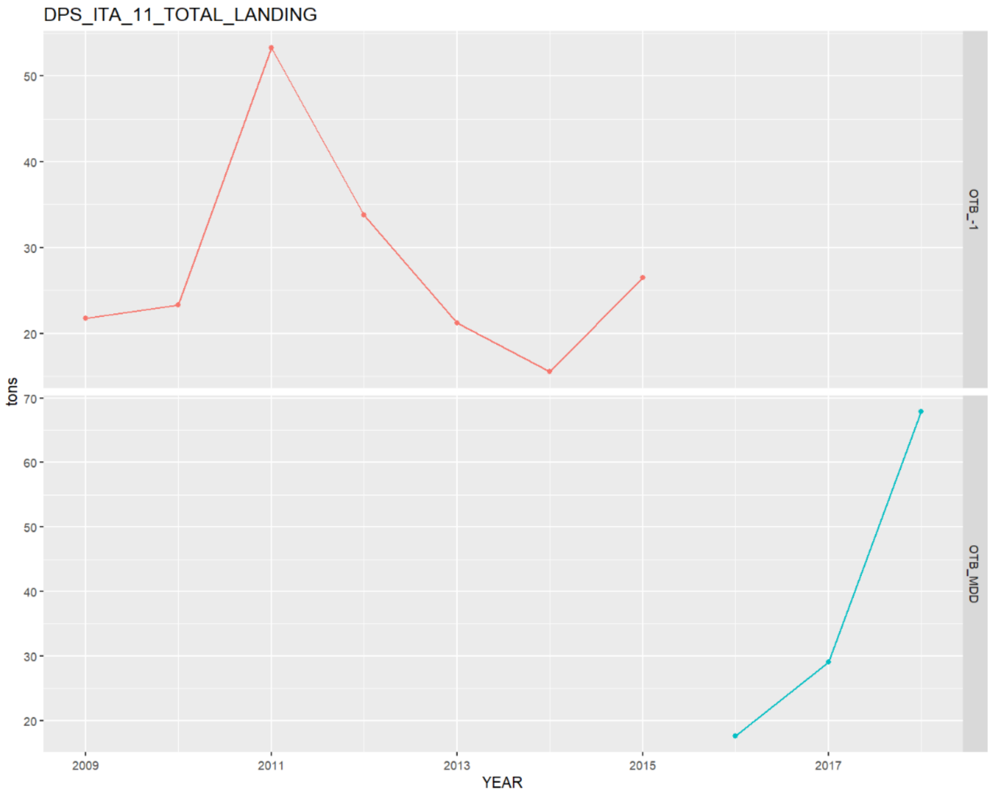


Figure 6.10.2.1.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual landings in tonnes by year and fleet for GSA11.

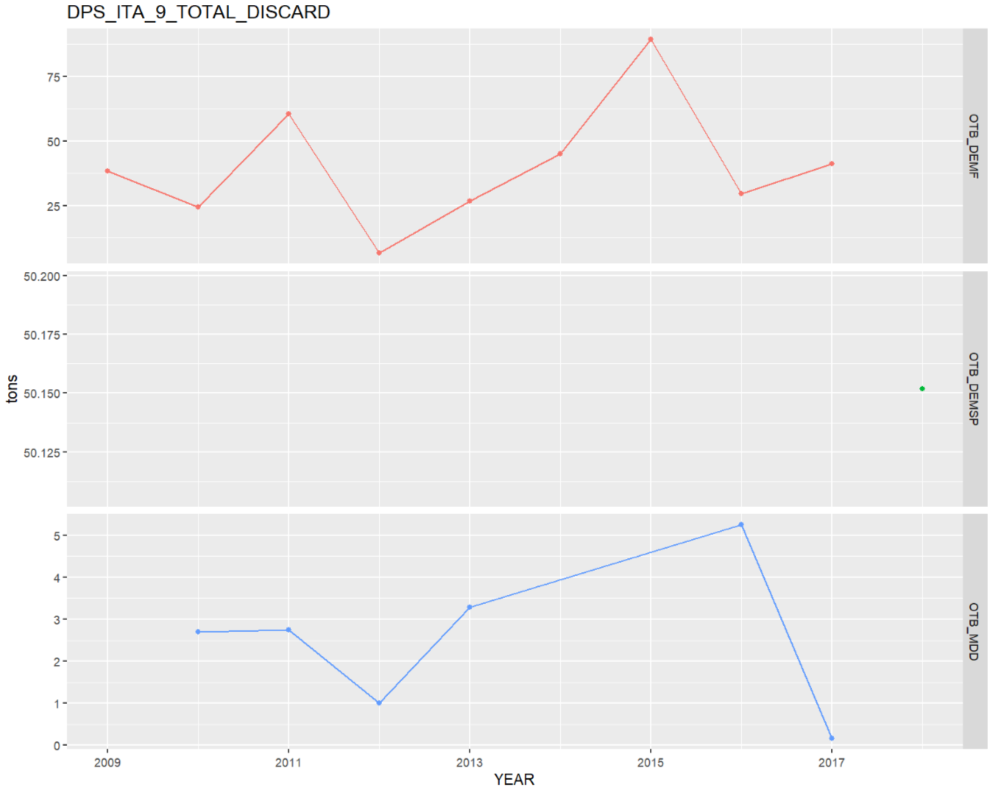


Figure 6.10.2.1.5 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA09.

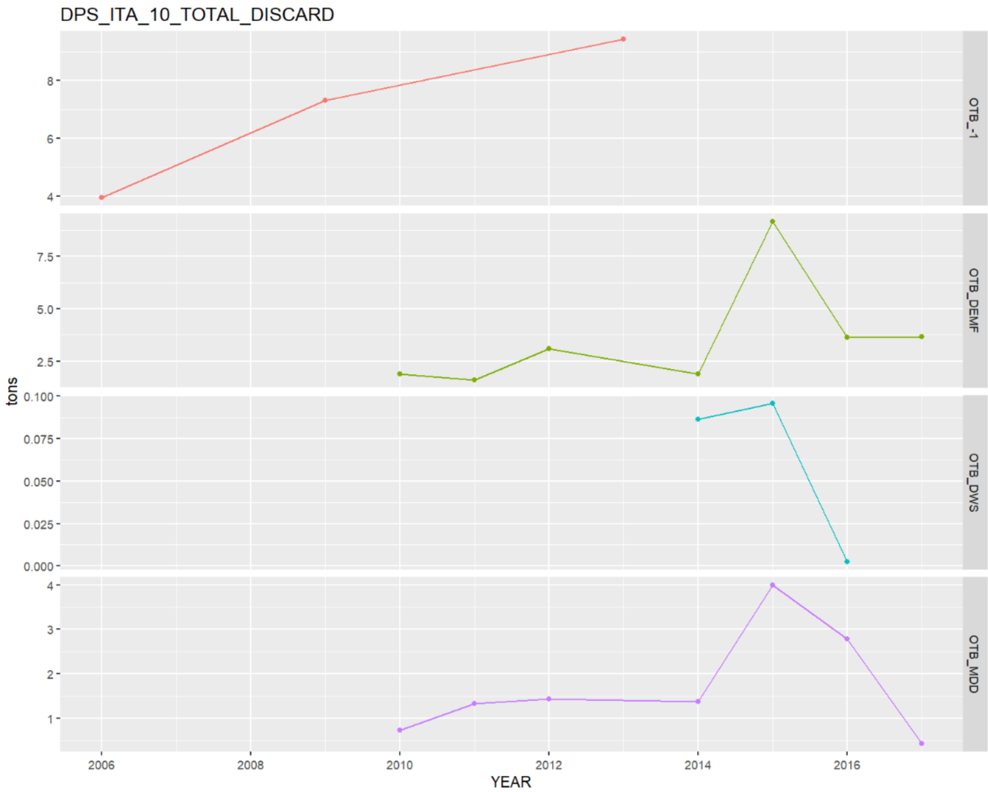
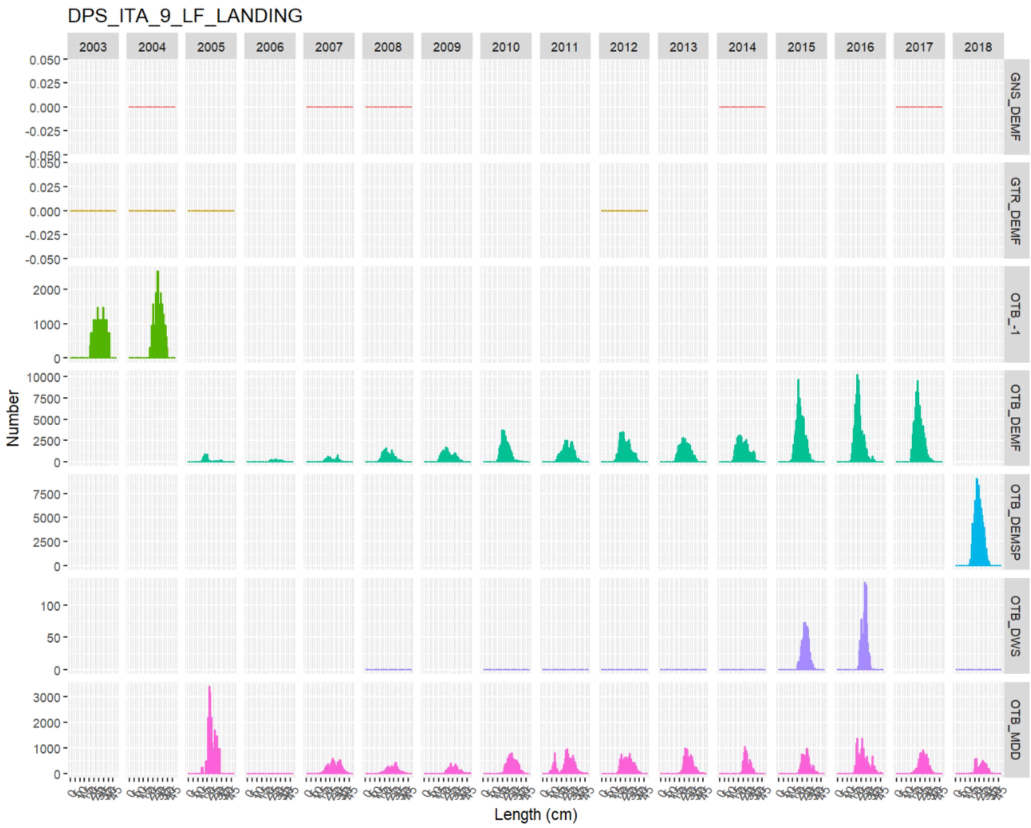


Figure 6.10.2.1.6 Deep-water rose shrimp in GSAs 09, 10 & 11. Annual discards in tonnes by year and fleet for GSA10.

Length frequency distributions of the commercial and discard fractions are displayed in Figs. 6.10.2.1.7-9.



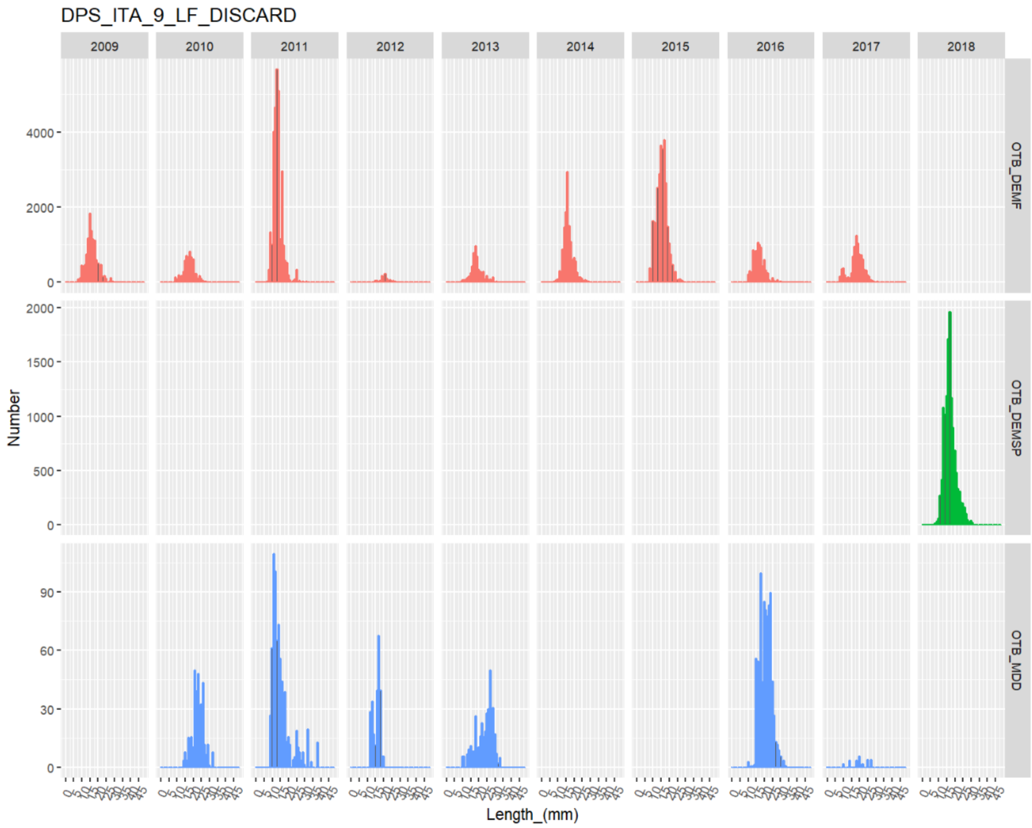
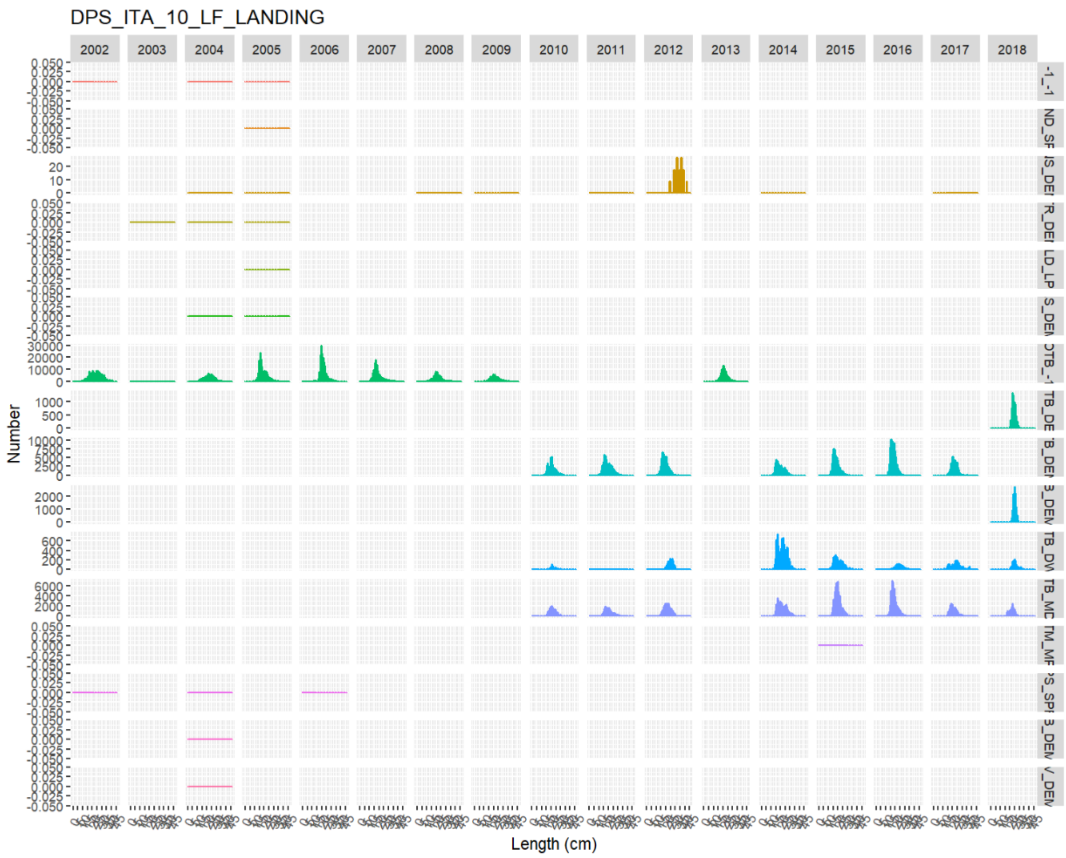


Figure 6.10.2.1.7 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing (above) and discard (below) in GSA09.



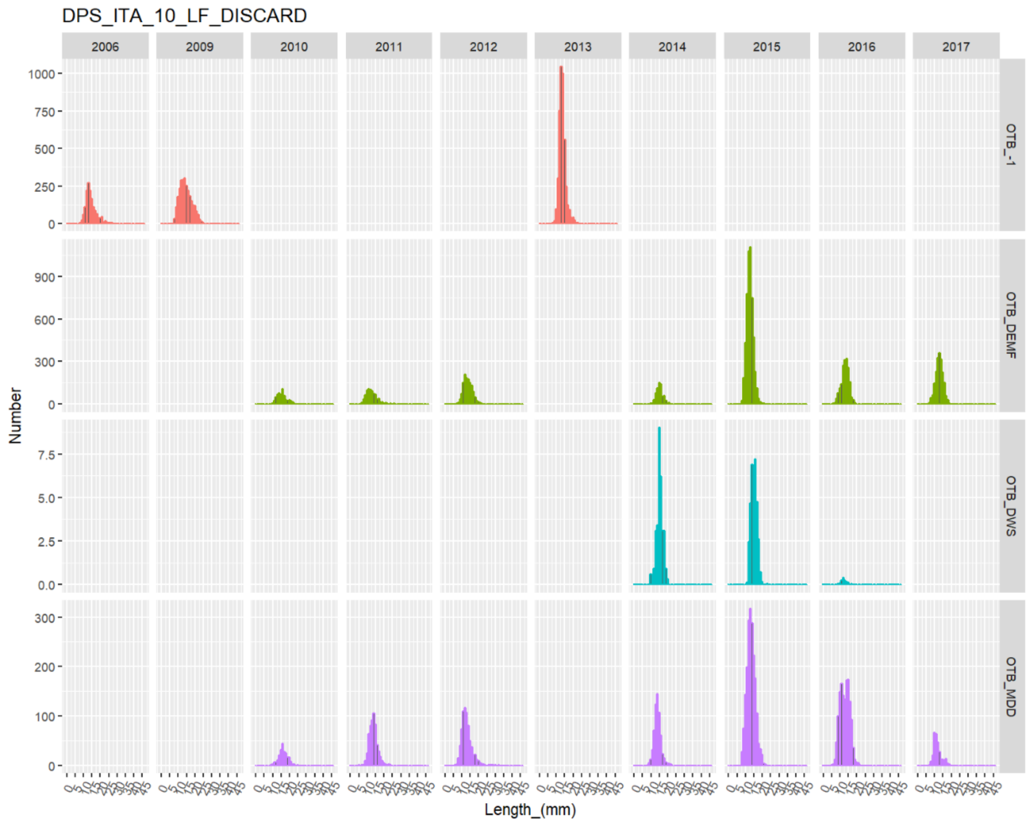


Figure 6.10.2.1.8 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing (above) and discard (below) in GSA10.

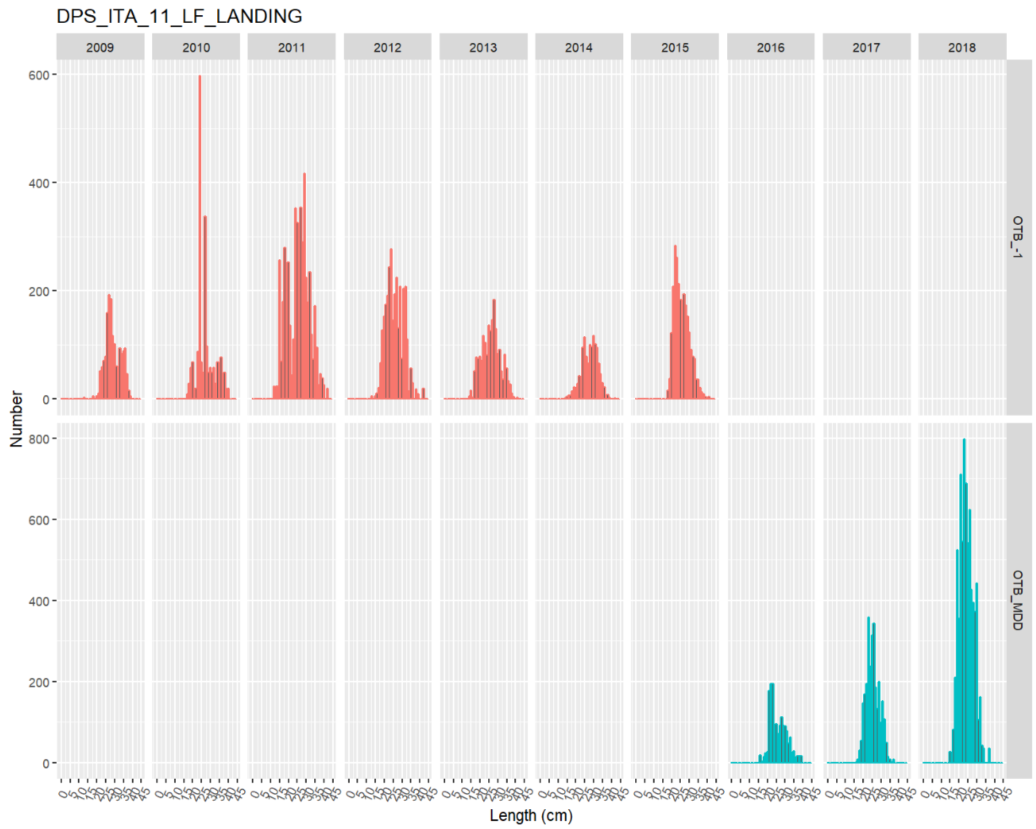


Figure 6.10.2.1.9 Deep-water rose shrimp in GSAs 09, 10 & 11. Size frequency distributions of landing in GSA11.

In GSA09, demographic structure of the landing is available for OTB in 2003 and 2004 and by metier from 2005 to 2018 (OTB_DEMF, 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 2004-2018. Data by metier are available for the periods 2010-2012 and 2014-2018. 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.

In GSA11, length frequency distributions are present in the DCR-DCF database only for landing in the period 2009-2018.

6.10.2.2 Effort

Fishing effort data were reported through DCR-DCF database.

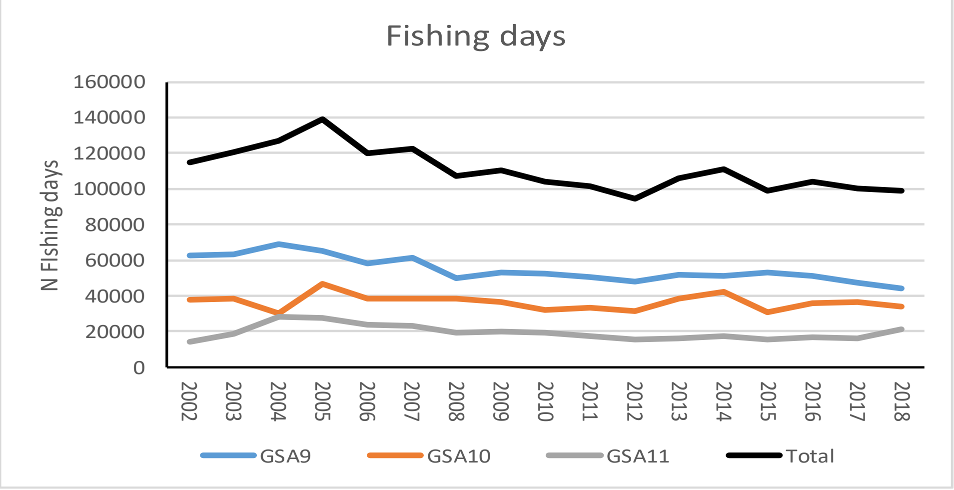
All the indicators related to the fishing effort showed a decreasing trend along the time series, more evident in the period 2004-2008. A similar trend is observed comparing the three GSAs.

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*.



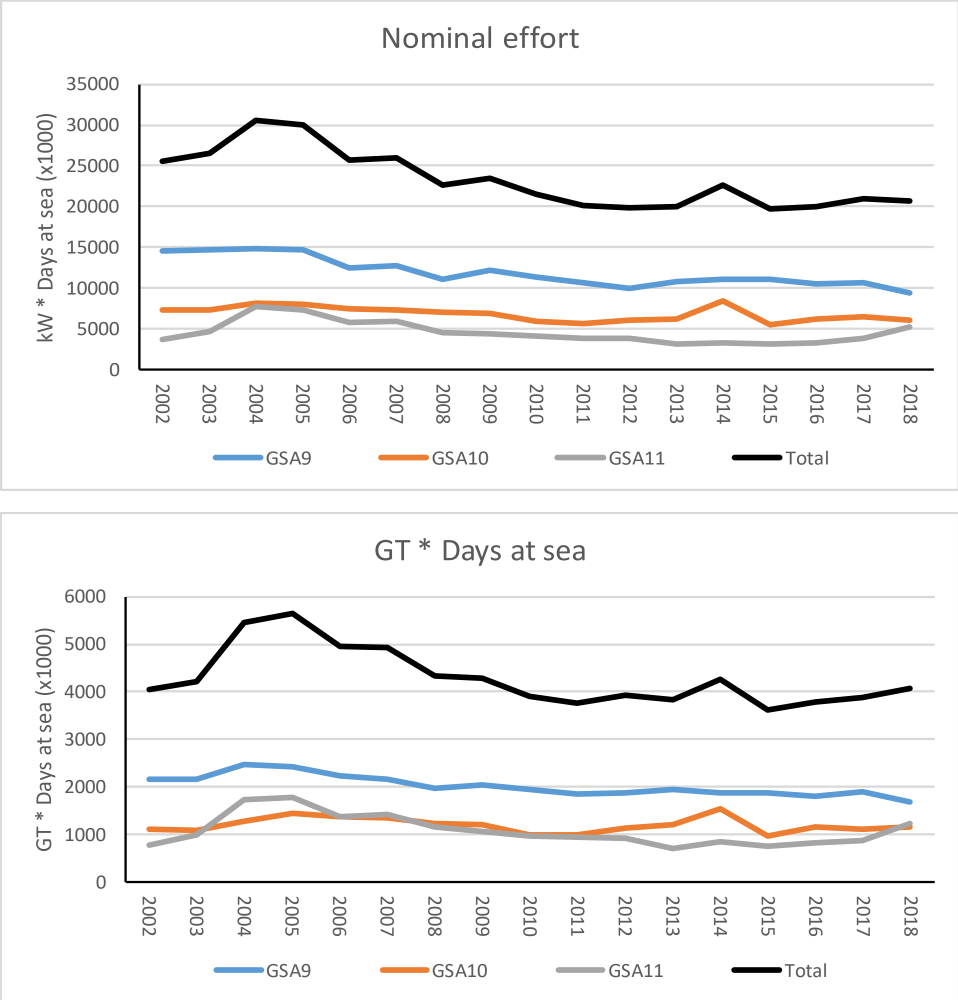


Figure 6.10.2.2.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Trends of fishing days, nominal effort and effort expressed in GT*days at sea for the three GSAs and for the whole area.

6.10.2.3 Survey data

Survey #1 (MEDITS)

Since 1994 MEDITS trawl surveys has 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 1994-2018.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
10-50	21	20	20	20	21	20	20	20	15	15	15	16
50-100	21	21	20	22	20	21	22	22	17	17	17	16
100-200	38	39	40	38	39	39	38	38	30	30	30	31
200-500	40	40	40	41	40	41	42	42	33	31	34	34
500-800	33	33	33	32	33	32	31	31	25	27	24	23
Total	153	153	153	153	153	153	153	153	120	120	120	120

STRATUM	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
10-50	15	15	16	16	15	15	15	16	15	14	14	14	15
50-100	18	18	16	16	19	18	17	17	19	19	18	20	18
100-200	29	29	31	31	29	30	31	30	29	30	31	29	30
200-500	35	35	34	34	34	33	35	35	36	35	36	36	36
500-800	23	23	23	23	23	24	22	22	21	22	21	21	21
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 1994-2018.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
10-50	7	8	8	8	8	8	8	8	7	7	7	7
50-100	10	10	10	10	10	10	10	10	8	8	8	8
100-200	17	17	17	17	17	17	17	17	14	14	14	14
200-500	22	23	22	22	22	22	22	24	18	18	18	18
500-800	28	27	28	28	28	27	28	26	23	23	23	23
Total	84	85	85	85	85	84	85	85	70	70	70	70

STRATUM	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
10-50	7	7	7	7	7	7	7	7	7	7	7	7	7
50-100	8	8	8	8	8	8	8	7	8	8	8	8	8
100-200	14	14	14	14	14	14	14	14	14	14	14	14	14
200-500	18	18	19	18	18	18	18	18	18	18	18	18	18
500-800	23	23	22	23	23	23	23	23	23	23	23	23	23
Total	70	70	70	70	70	70	70	69	70	70	70	70	70

Table 6.10.2.3.1.3 Number of hauls per year and depth stratum in GSA11, period 1994-2018.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
10-50	16	19	22	21	21	20	19	17	20	18	18	17
50-100	25	20	22	23	22	22	22	24	19	19	17	22
100-200	20	23	30	31	30	30	31	30	24	24	24	24
200-500	32	28	29	26	25	27	24	25	20	24	21	20
500-800	23	17	22	25	25	24	27	26	16	14	15	14
Total	116	107	125	126	123	123	123	122	99	99	95	97

STRATUM	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
10-50	19	20	19	18	20	20	20	20	21	18	18	21	19
50-100	19	19	18	20	18	19	19	19	19	19	19	19	18
100-200	24	24	21	24	24	24	24	24	24	24	24	24	24
200-500	20	20	21	19	20	21	21	21	21	21	21	21	21
500-800	16	17	16	16	17	17	17	17	17	17	17	17	17
Total	98	100	95	97	99	101	101	101	102	99	99	102	99

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 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.

6.10.2.3.2 Geographical distribution

The following maps show the abundance (in biomass) per haul of the MEDITS survey standardized to square kilometre. It is evident as in the first years the abundance of Deep-water rose shrimp was low in particular in the northern part of GSA09. Since 1998 the abundance of the species increased in the north-central Tyrrhenian Sea and along the south-western coasts of Sardinia. Since 2015, very high indices were observed for GSA09 including the northern part.

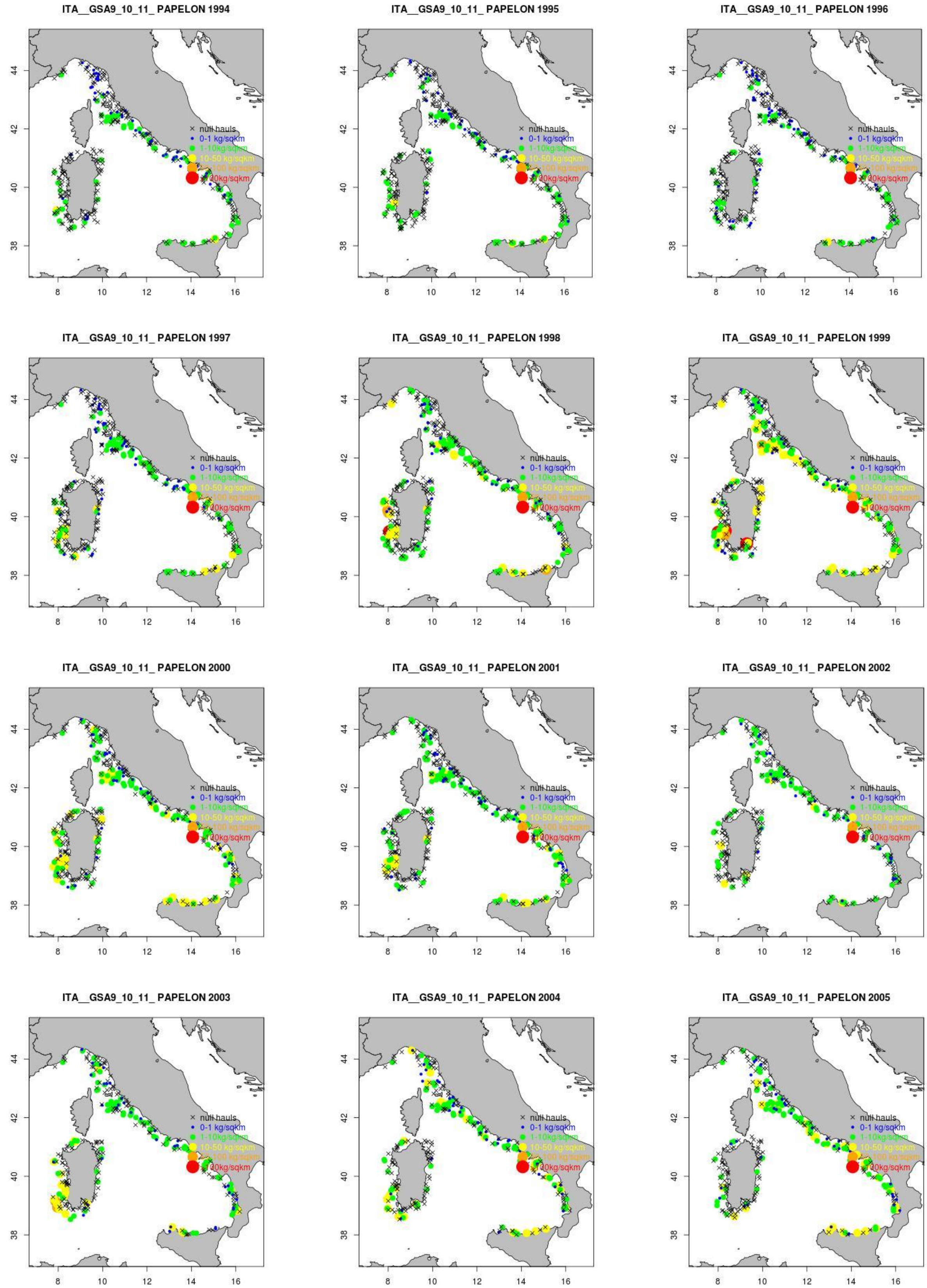


Figure 6.10.2.3.2.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Distribution pattern in the period 1994-2005 (MEDITS survey).

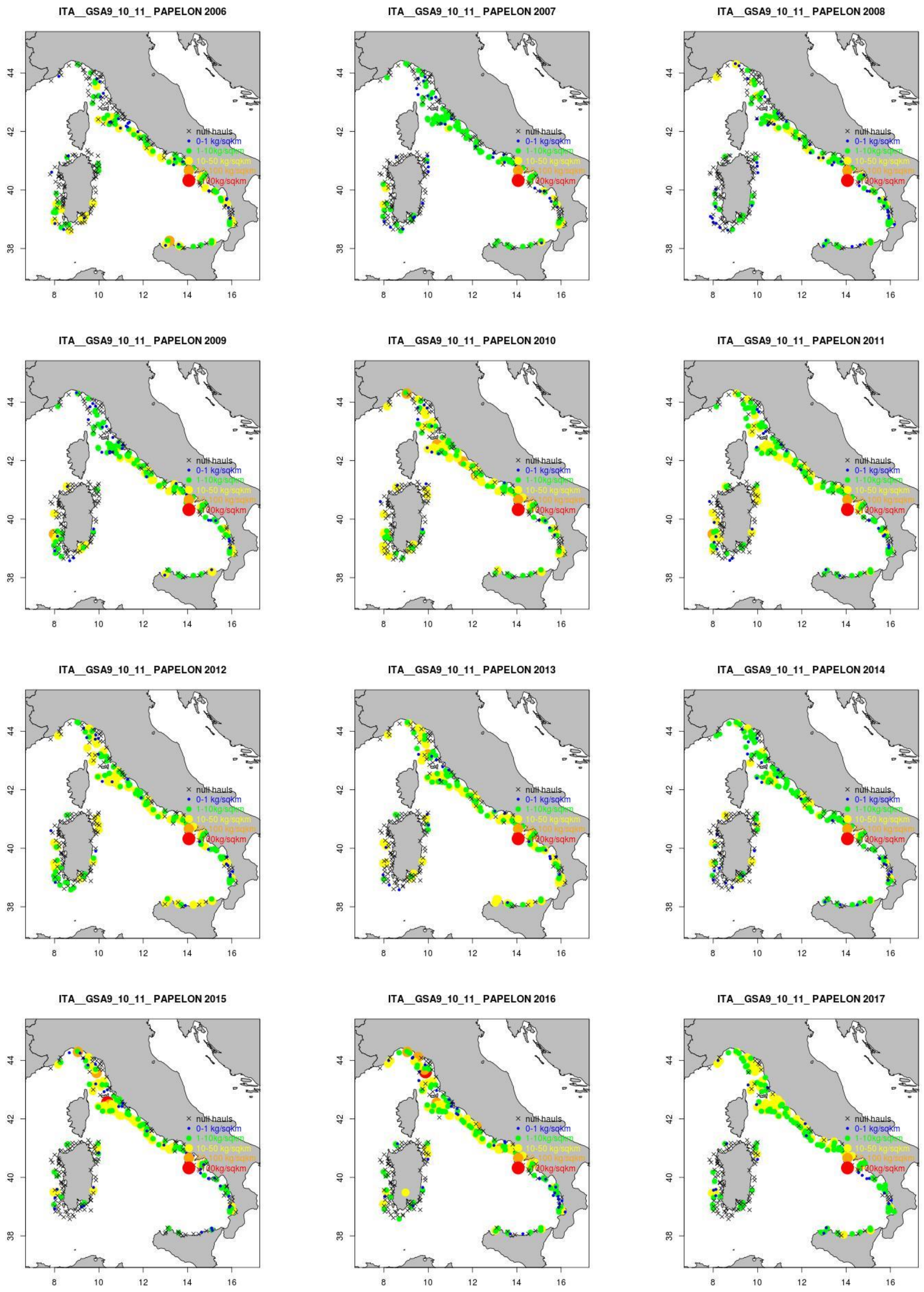


Figure 6.10.2.3.2.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Distribution pattern in the period 2006-2017 (MEDITS survey).

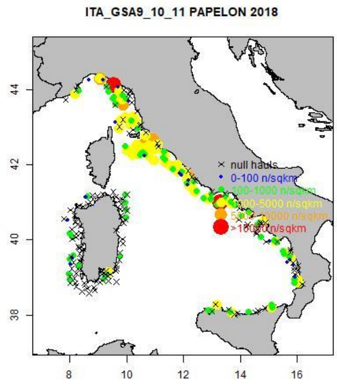


Figure 6.10.2.3.2.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Distribution pattern in the period 1994-2018 (MEDITS survey).

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 2015-2018.

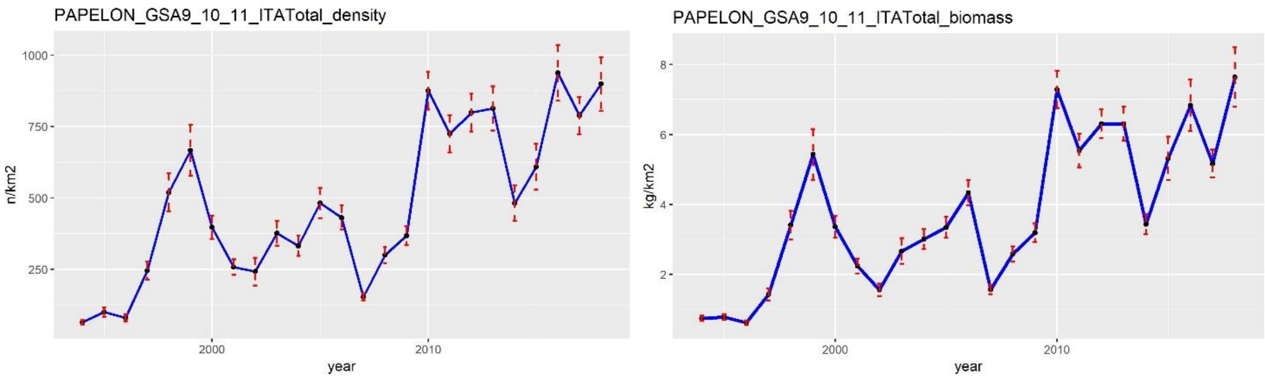


Figure 6.10.2.3.3.1 Deep-water rose shrimp in GSAs 09, 10 & 11. MEDITS standardized abundance and biomass indices (10-800 m).

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 2018.

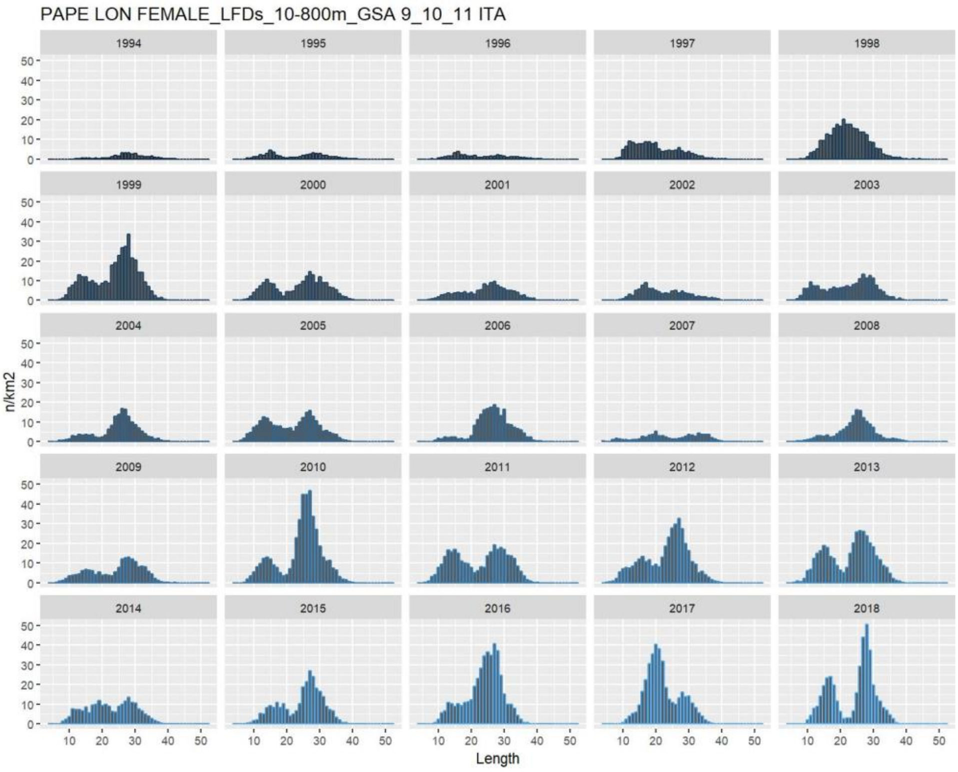


Figure 6.10.2.3.4.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for females, period 1994-2018.

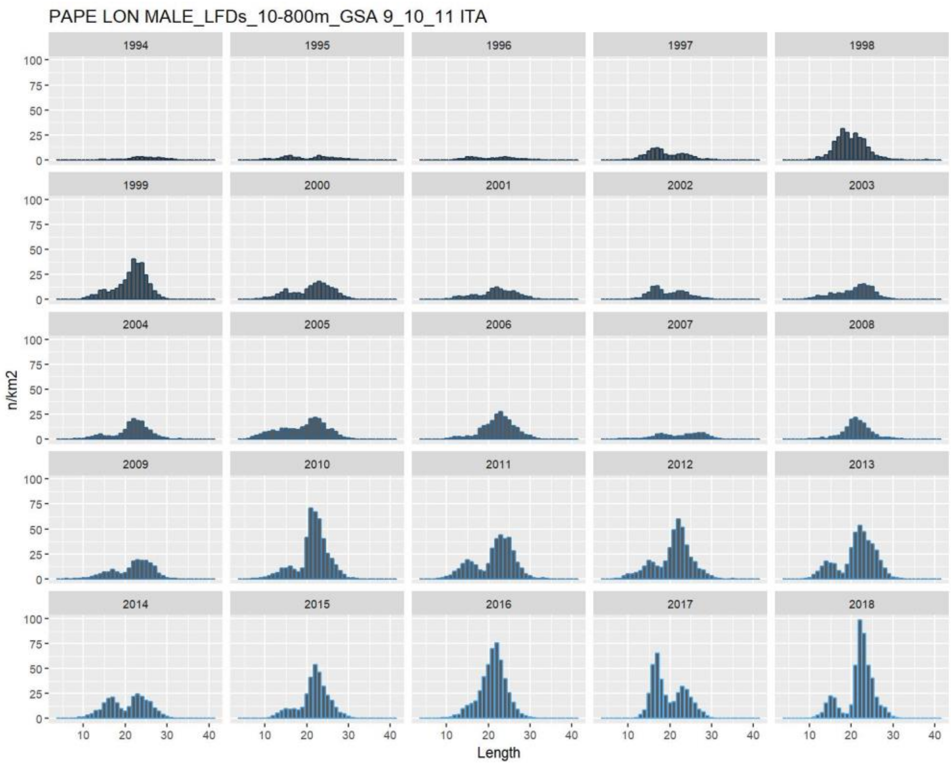


Figure 6.10.2.3.4.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for males, period 1994-2018.

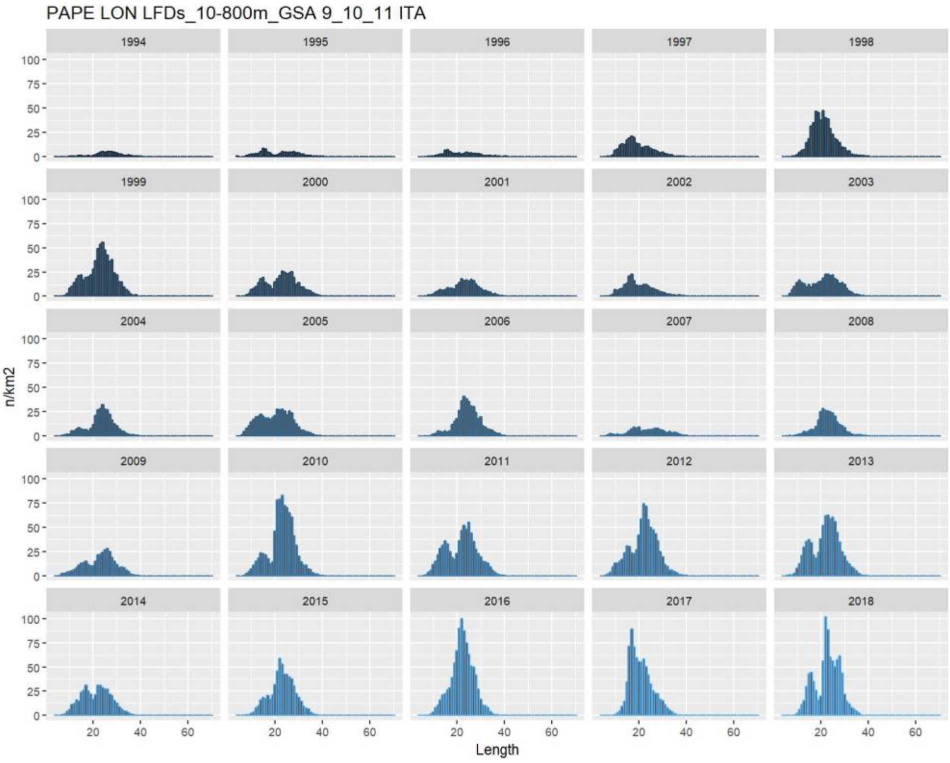


Figure 6.10.2.3.4.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Stratified abundance indices by size for the total population, period 1994-2018.

6.10.3 STOCK ASSESSMENT

A Statistical Catch-at-age (a4a) assessment was carried out during STECF EWG 19-10 using catch data collected under DCR-DCF from 2009 to 2018 and calibrated with survey data (MEDITS 2009-2018). 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 increased by 0.5 because the origin of growth is assumed to be at the peak of reproduction for this species which mainly occurs in summer, and the assessment year is from Jan to Dec. Plus group was set at age 4. 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 2009-2018 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}.

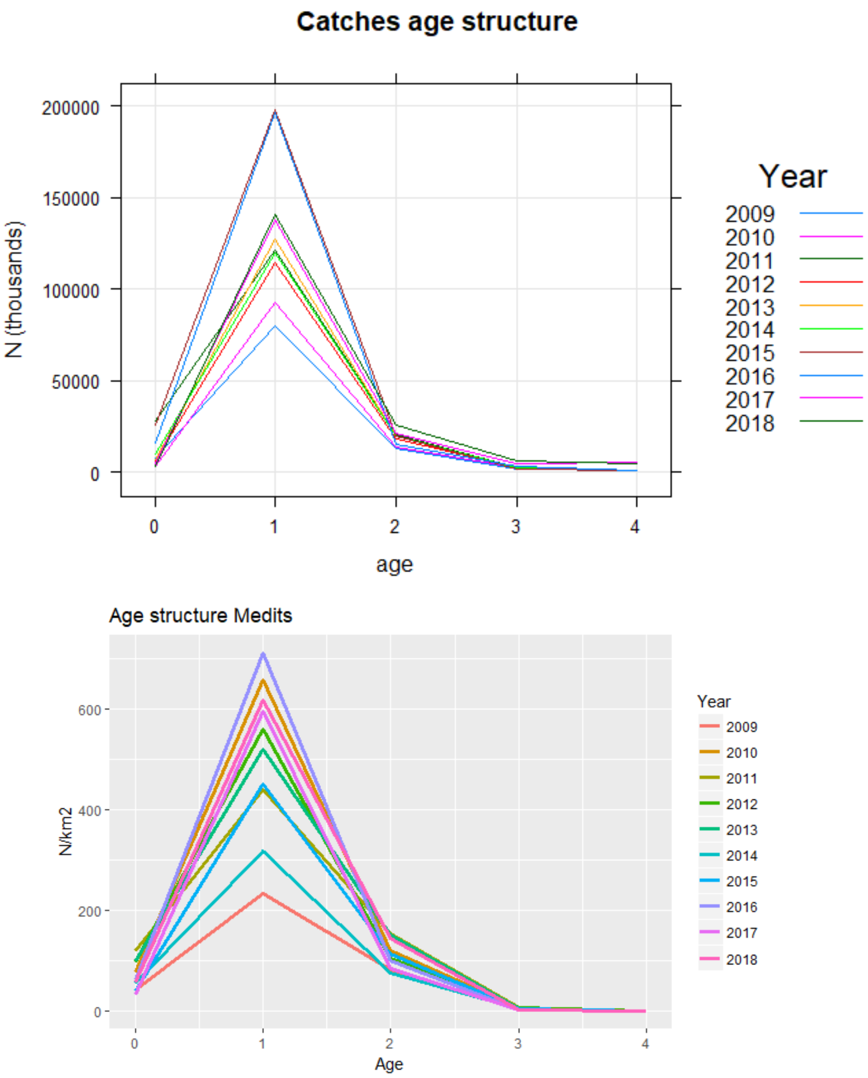


Figure 6.10.3.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Age frequency distributions of the total commercial catches (above) and of the MEDITS catches (below) by year.

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	9981.76	119446.44	19668.69	2265.64	1095.22
2010	25925.01	198246.50	20108.02	2012.60	667.17
2011	16029.13	196700.43	15558.51	3170.55	883.64
2012	4686.77	137512.41	21555.49	5054.81	5728.51
2013	2922.22	140459.04	25530.80	6161.82	4563.10
2014	7705.85	79631.47	12764.91	1537.94	808.95
2015	2948.18	92714.35	13809.98	2134.81	823.83
2016	27734.59	121076.84	20420.58	2618.74	1344.86
2017	5952.46	114481.38	18634.24	2658.01	1298.29
2018	6656.01	127177.71	19768.10	2590.23	1240.33

	Catches (in tons)
2009	749.6
2010	895.97
2011	1075.82
2012	1125.67
2013	1233.01
2014	1134.45
2015	1467.25
2016	1436.99
2017	1320.79
2018	1476.18

Mean weight at age (Catches)	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	0.002	0.006	0.016	0.023	0.023
2010	0.002	0.005	0.015	0.020	0.021
2011	0.002	0.005	0.015	0.025	0.026
2012	0.002	0.007	0.013	0.017	0.022
2013	0.002	0.007	0.013	0.016	0.021
2014	0.002	0.006	0.016	0.025	0.023
2015	0.002	0.006	0.015	0.024	0.027
2016	0.002	0.005	0.016	0.023	0.023
2017	0.002	0.006	0.017	0.023	0.024
2018	0.002	0.006	0.016	0.023	0.023

Mean weight at age (Stock)	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	0.002	0.006	0.016	0.023	0.023
2010	0.002	0.005	0.015	0.020	0.021
2011	0.002	0.005	0.015	0.025	0.026
2012	0.002	0.007	0.013	0.017	0.022
2013	0.002	0.007	0.013	0.016	0.021
2014	0.002	0.006	0.016	0.025	0.023
2015	0.002	0.006	0.015	0.024	0.027
2016	0.002	0.005	0.016	0.023	0.023
2017	0.002	0.006	0.017	0.023	0.024
2018	0.002	0.006	0.016	0.023	0.023

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

Proportion of mature	Age 0	Age 1	Age 2	Age 3	Age 4+
2009	0.47	0.94	0.97	1.00	1.00
2010	0.48	0.94	0.99	0.99	1.00
2011	0.46	0.93	0.99	1.00	1.00
2012	0.49	0.93	0.99	1.00	1.00
2013	0.54	0.92	0.99	1.00	1.00
2014	0.48	0.94	0.98	0.95	1.00
2015	0.48	0.93	0.98	1.00	1.00
2016	0.50	0.94	0.95	0.99	1.00
2017	0.45	0.94	0.99	0.99	1.00
2018	0.46	0.93	0.99	1.00	1.00

Tuning MEDITS index	Age 0	Age 1	Age 2	Age 3
2009	43.6	234.3	83.7	4.1
2010	78.7	656.6	120.2	6.6
2011	121.4	439.8	154.4	7.2
2012	98.8	559.3	104.6	6.6
2013	101.1	518.7	151.1	4.8
2014	56.6	317.6	75.2	4.2
2015	40.9	450.1	113.4	4.7
2016	63.9	711.1	100.0	2.8
2017	34.9	595.9	84.3	2.3
2018	58.2	617.4	143.9	3.5

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=6) + 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))

```
Model <- a4aSCA(stock = stk, indices = idx, fmodel, qmodel)
```

The assessment results are shown in Figs. 6.10.3.2-12 and Tabs. 6.10.3.2-4.

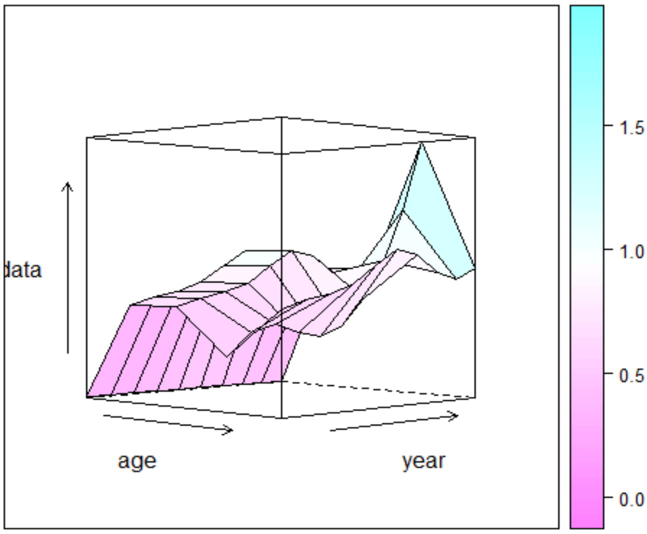


Figure 6.10.3.2 Deep-water rose shrimp in GSAs 09, 10 & 11. Fishing mortality by age and year obtained from the a4a model (2009-2018).

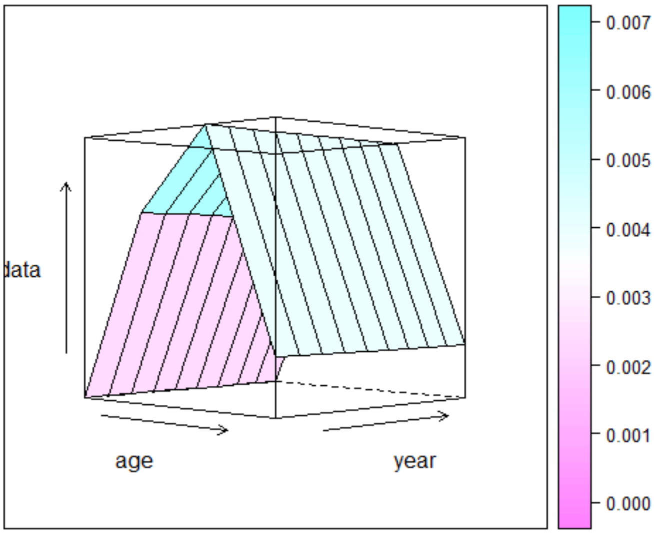


Figure 6.10.3.3 Deep-water rose shrimp in GSAs 09, 10 & 11. Catchability by age and year obtained from the a4a model (2009-2018).

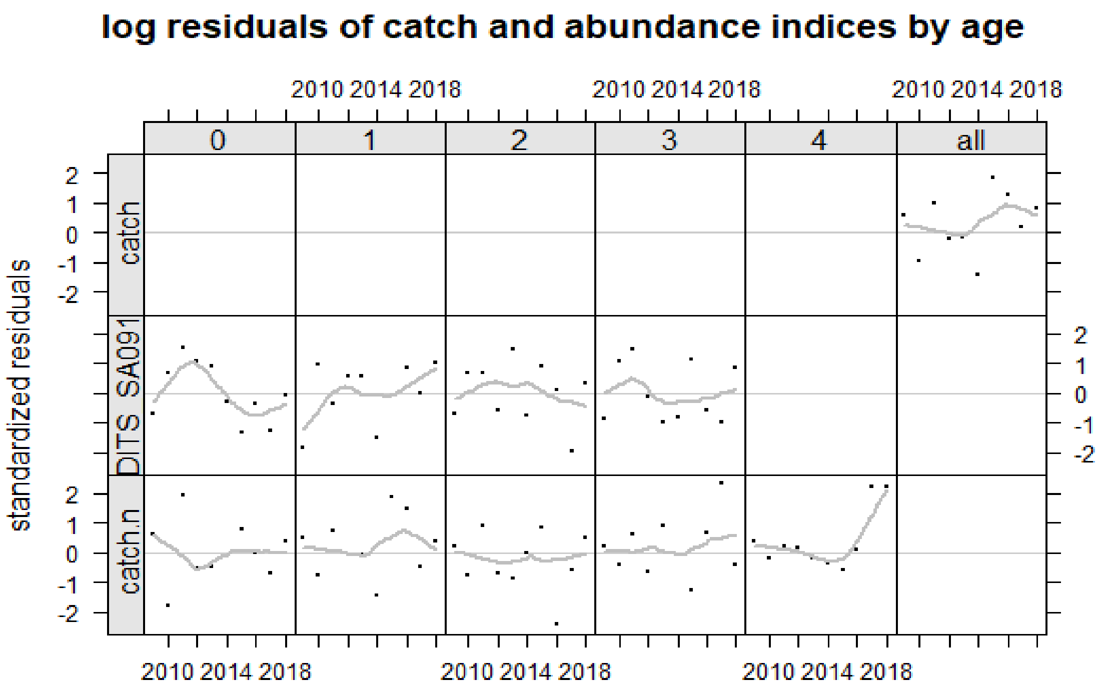


Figure 6.10.3.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Log residuals of the fishery and the survey data by age, and of the total catches.

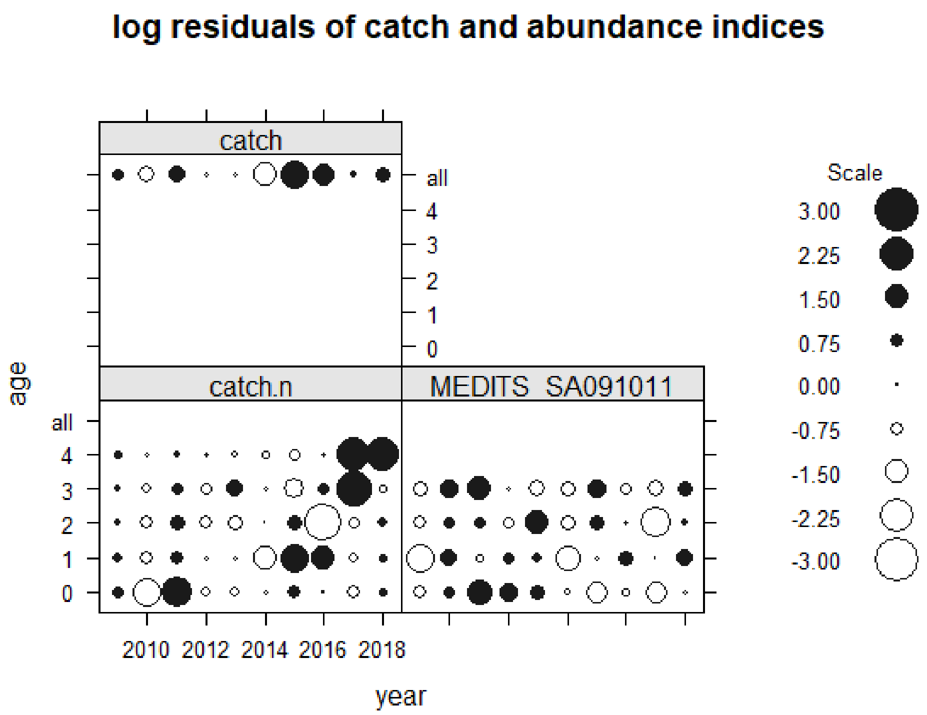


Figure 6.10.3.5 Deep-water rose shrimp in GSAs 09, 10 & 11. Bubble plot of the log residuals of the fishery and the survey data by age, and of the total catches.

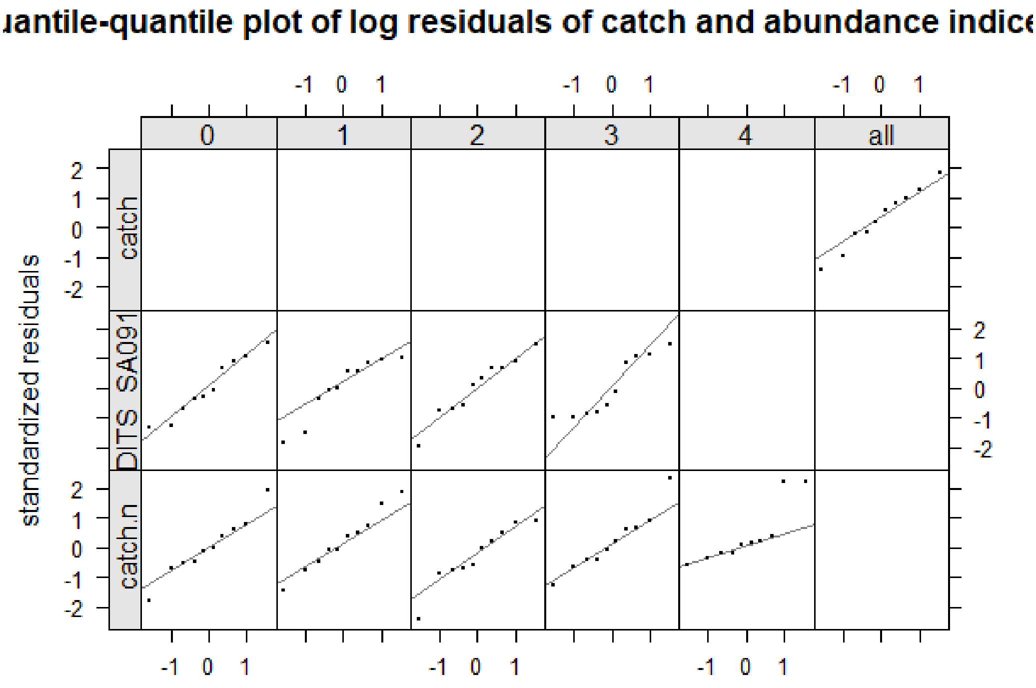


Figure 6.10.3.6 Deep-water rose shrimp in GSAs 09, 10 & 11. QQ-plot of the log residuals of the fishery and the survey data by age, and of the total catches.

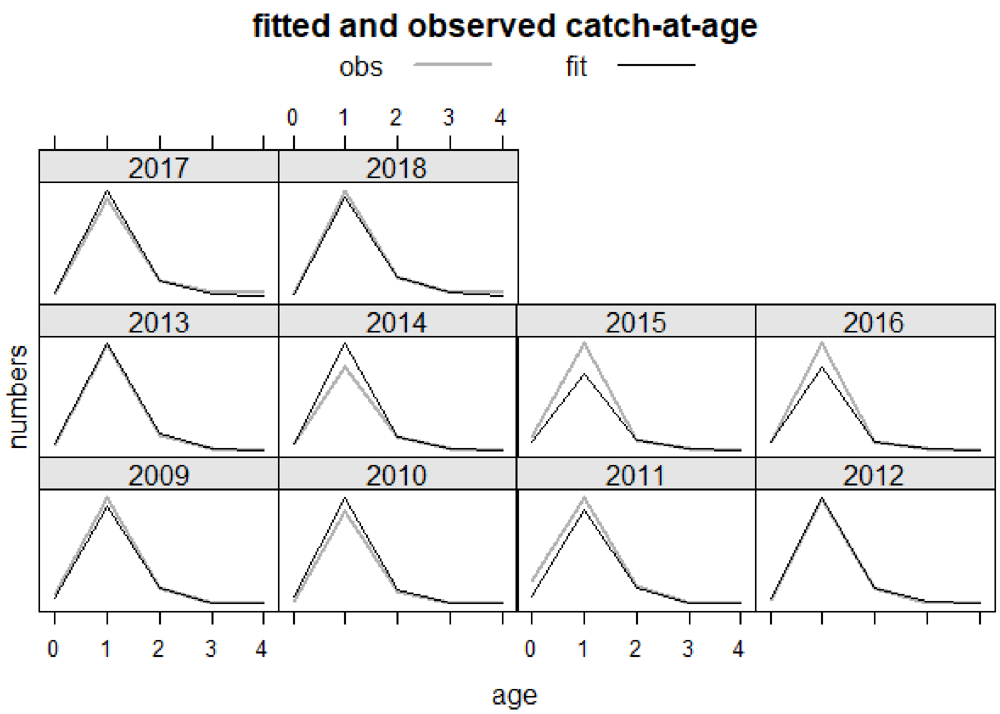


Figure 6.10.3.7 Deep-water rose shrimp in GSAs 09, 10 & 11. Fitted and observed catches at age by year.

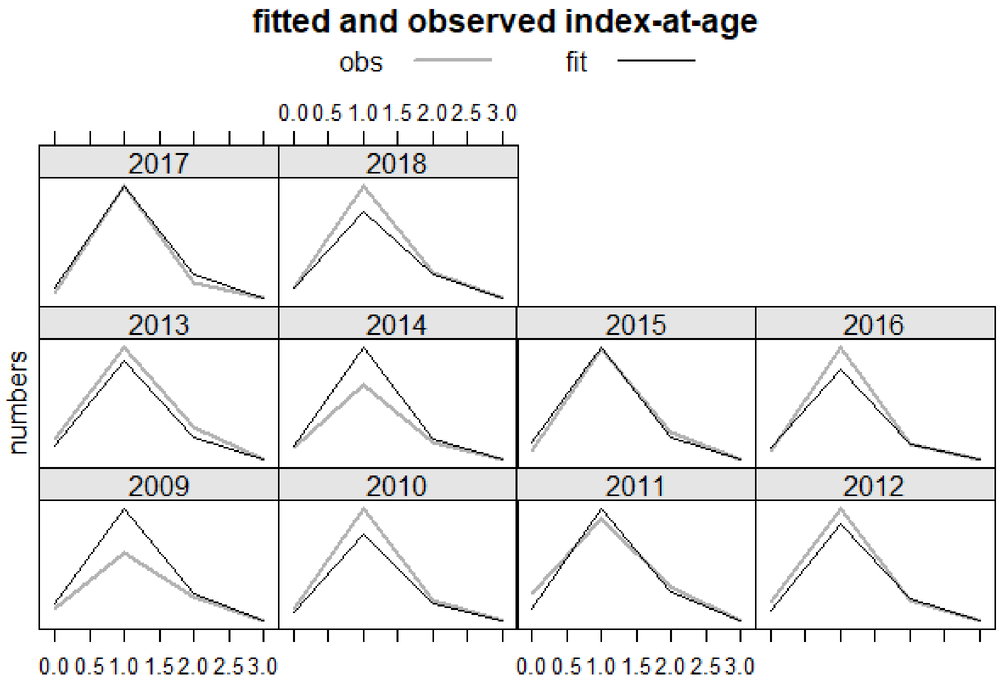


Figure 6.10.3.8 Deep-water rose shrimp in GSAs 09, 10 & 11. Fitted and observed MEDITS index at age by year.

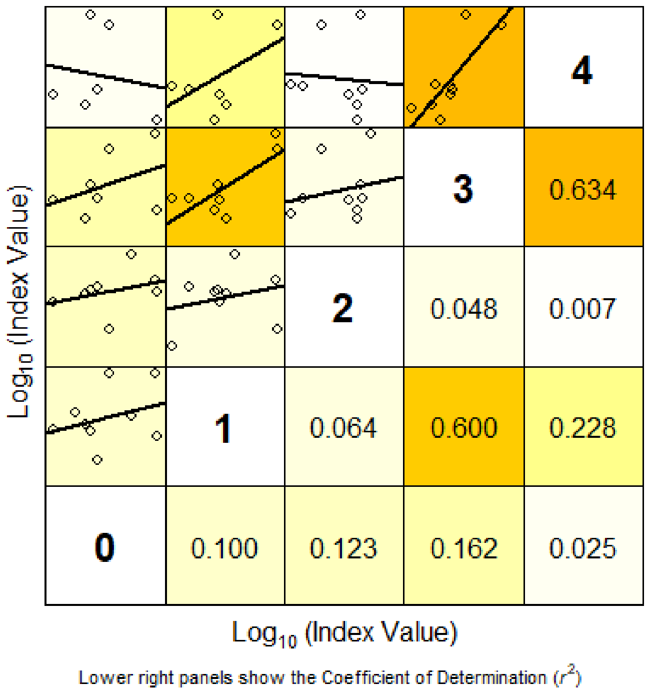


Figure 6.10.3.9 Deep-water rose shrimp in GSAs 09, 10 & 11. Internal consistency of the catch at age data.

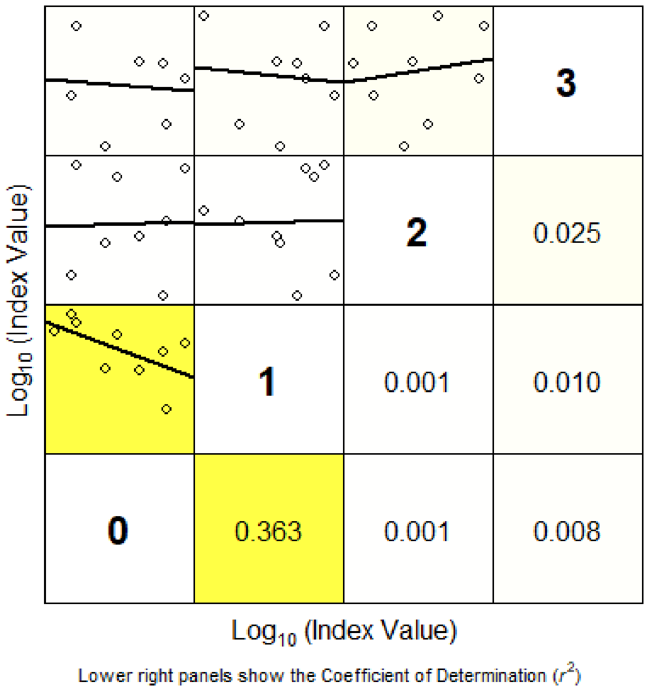


Figure 6.10.3.10 Deep-water rose shrimp in GSAs 09, 10 & 11. Internal consistency of the MEDITS index at age data.

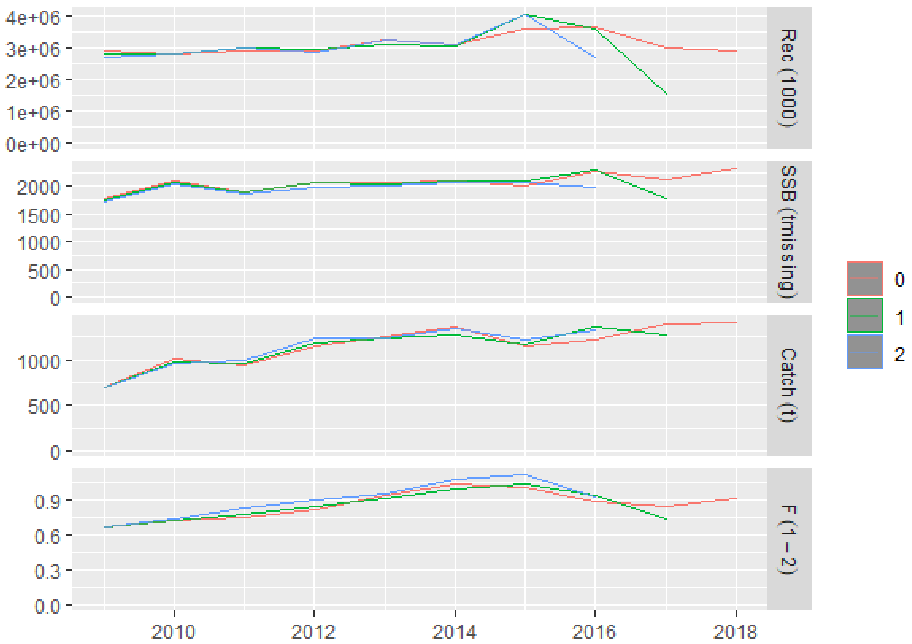


Figure 6.10.3.11 Deep-water rose shrimp in GSAs 09, 10 & 11. Retrospective analysis.

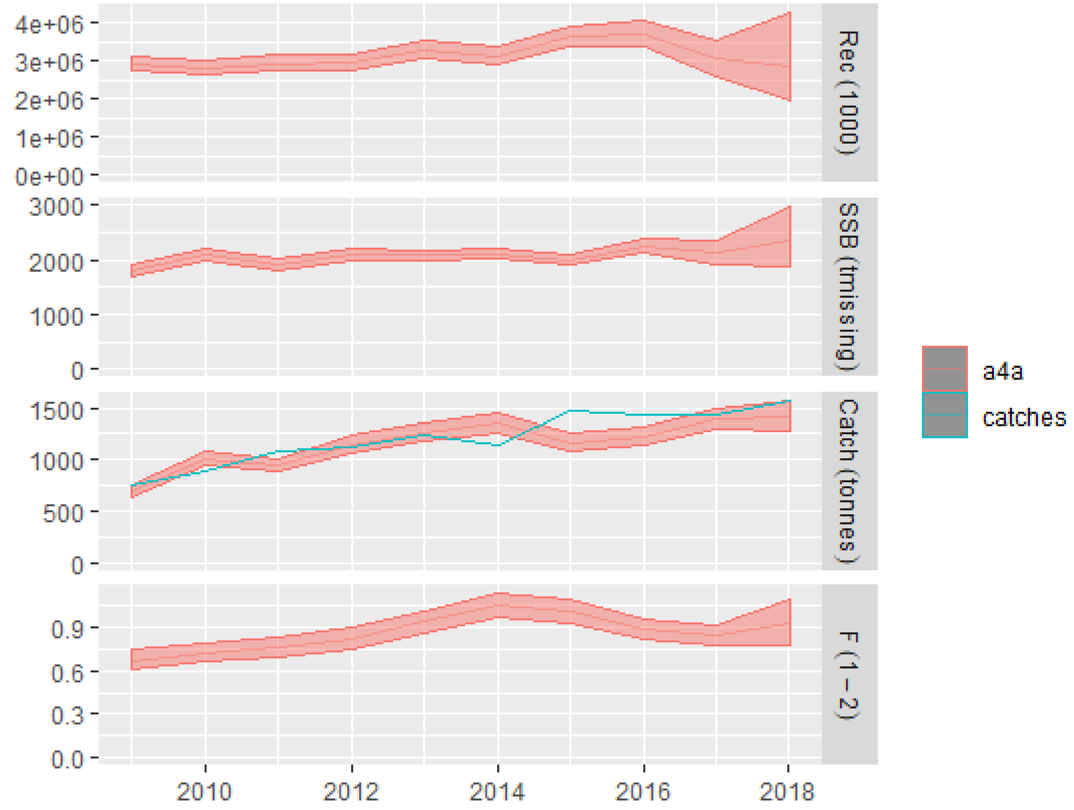


Figure 6.10.3.12 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment model with uncertainty. Green line represents the catches observed.

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	2900812	228839	36850	6989	1562
2010	2816533	316726	39612	7869	2579
2011	2913603	306736	52177	8051	2738
2012	2925755	317061	48703	10220	2697
2013	3264092	318764	47411	8985	3388
2014	3111066	355729	42275	7757	3193
2015	3629217	338390	42351	6209	2596
2016	3672862	393530	41750	6446	1825
2017	3028039	398569	54922	7188	1445
2018	2887070	330282	58118	9880	1137

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	0.005	0.674	0.674	0.363	0.674
2010	0.007	0.723	0.723	0.506	0.723
2011	0.008	0.760	0.760	0.555	0.760
2012	0.007	0.820	0.820	0.493	0.820
2013	0.007	0.940	0.940	0.460	0.940
2014	0.009	1.048	1.048	0.530	1.048
2015	0.012	1.012	1.012	0.711	1.012
2016	0.011	0.889	0.889	0.984	0.889
2017	0.006	0.845	0.845	1.348	0.845
2018	0.002	0.921	0.921	1.851	0.921

Tab. 6.10.3.4 Deep-water rose shrimp in GSAs 09, 10 & 11. Outputs of the a4a stock assessment.

	$F_{bar\ 1\text{-}2}$	Recruitment (thousands	SSB (t)	Total Biomass (t)
2009	0.674	2900812	1786.5	7702.4
2010	0.723	2816533	2099.1	8766.9
2011	0.760	2913603	1902.1	7776.0
2012	0.820	2925754	2084.1	8927.9
2013	0.940	3264092	2082.5	9349.8
2014	1.048	3111065	2113.0	9822.1
2015	1.012	3629217	2000.9	9540.7
2016	0.889	3672862	2266.0	10761.3
2017	0.845	3028039	2116.3	8538.6
2018	0.921	2887070	2336.3	9761.8

Based on a4a results, the Deep-water rose shrimp SSB showed an increasing trend, reaching the maximum value in 2018 (2336 tons). The recruitment (age 0) showed a similar trend of SSB, with a peak in 2016 (3,672,862 thousands individuals) and a decreasing in the last two years. The lowest value of fishing mortality (Fbar = 0.67) is observed in 2009. After that, a constant increase of F was showed reaching the maximum value of 1.05 in 2014. In the following three years, Fbar decreased. In 2018, Fbar was 0.92.

6.10.4 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.

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 (0.92), estimated as the F_{bar1-2} in the last year of the time series (2018), is lower than $F_{0.1}$ (0.97), which indicates that Deep-water rose shrimp stock in GSAs 9, 10 and 11 is exploited sustainability.

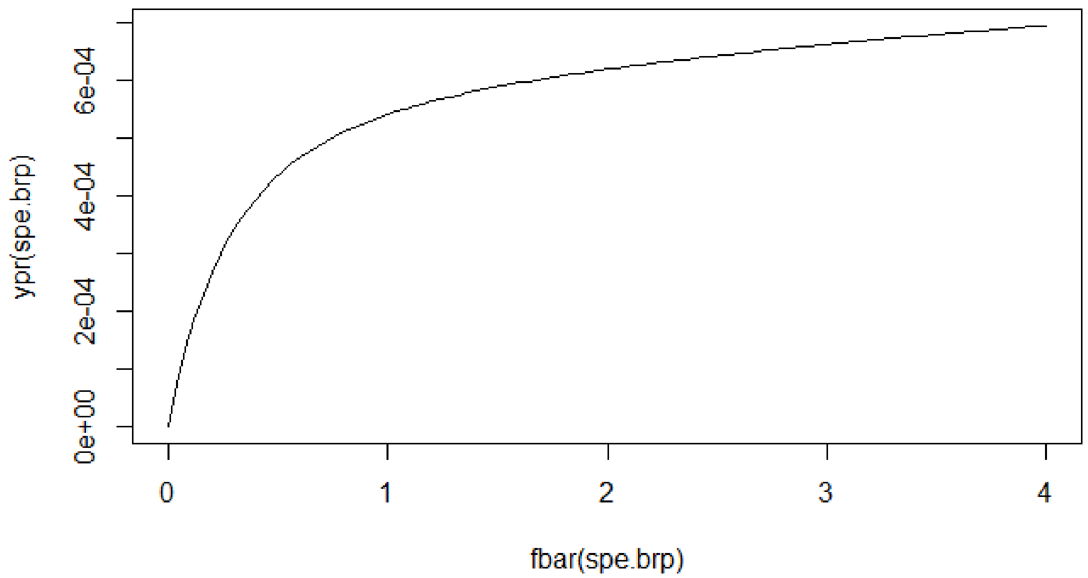


Figure 6.10.4.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Yield per Recruit curve.

6.10.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 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 for the period 2017 to 2019 were the same used for the a4a stock assessment and its results Table 6.10.5.1. An average of the last three years has been used for weight at age, maturity at age, and F_{bar}.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the whole data series (3101709 thousand individuals).

A short-term projection of the trawl fleet (Tab. 6.10.5.2) fishing at the status quo (F=0.88) generates a decrease of the catch of 14.1% from 2018 to 2020 along with an approximately stable spawning stock biomass (change +2.7%) from 2019 to 2021. Fishing at $F_{0.1}$ (0.97) generates a decrease of the catch of 8.5% from 2018 to 2020, while the spawning stock biomass remains quite stable from 2019 to 2021 (-1.0%).

Table 6.10.5.1 Deep-water rose shrimp in GSAs 9, 10 and 11: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2016-2018
$F_{ages\ 1\text{-}2}$ (2019)	0.88	mean F 2016-2018 used to give F status quo for 2019
SSB (2019)	2055 t	Stock assessment 1 January 2019
R_{age0} (2019,2020)	3101709	Geometric mean of the time series years 2009-2018
Total catch (2019)	1185	Assuming F status quo for 2019

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.

$F_{0.1}$	1.1	0.97	1422	1185	1301	1284	2047	2035	-1.0	-8.5
	1.5	1.32	1422	1185	1570	1424	1877	1797	-12.6	10.5
	0.7	0.64	1422	1185	971	1065	2237	2358	14.8	-31.7
	0.0	0.00	1422	1185	0	0	2722	3523	71.5	-100.0
	1.0	0.88	1422	1185	1221	1237	2094	2110	2.7	-14.1
	0.1	0.09	1422	1185	167	234	2645	3301	60.6	-88.3
	0.2	0.18	1422	1185	321	430	2572	3103	51.0	-77.4
	0.3	0.27	1422	1185	464	596	2502	2927	42.4	-67.3
	0.4	0.35	1422	1185	597	736	2436	2769	34.8	-58.0
	0.5	0.44	1422	1185	721	855	2372	2628	27.9	-49.3
	0.6	0.53	1422	1185	836	957	2311	2502	21.7	-41.2
	0.7	0.62	1422	1185	943	1043	2253	2388	16.2	-33.7
	0.8	0.71	1422	1185	1042	1117	2198	2286	11.2	-26.7
	0.9	0.80	1422	1185	1135	1181	2145	2193	6.7	-20.2
	1.1	0.97	1422	1185	1302	1285	2046	2034	-1.0	-8.4
	1.2	1.06	1422	1185	1378	1327	2000	1965	-4.4	-3.1
	1.3	1.15	1422	1185	1448	1364	1956	1902	-7.5	1.9
	1.4	1.24	1422	1185	1514	1397	1914	1844	-10.3	6.5
	1.5	1.33	1422	1185	1576	1426	1873	1792	-12.8	10.9
	1.6	1.42	1422	1185	1634	1453	1835	1743	-15.2	15.0
	1.7	1.50	1422	1185	1689	1477	1798	1699	-17.3	18.8
	1.8	1.59	1422	1185	1740	1498	1763	1658	-19.3	22.4
	1.9	1.68	1422	1185	1788	1518	1730	1620	-21.2	25.8

*SSB at mid-year

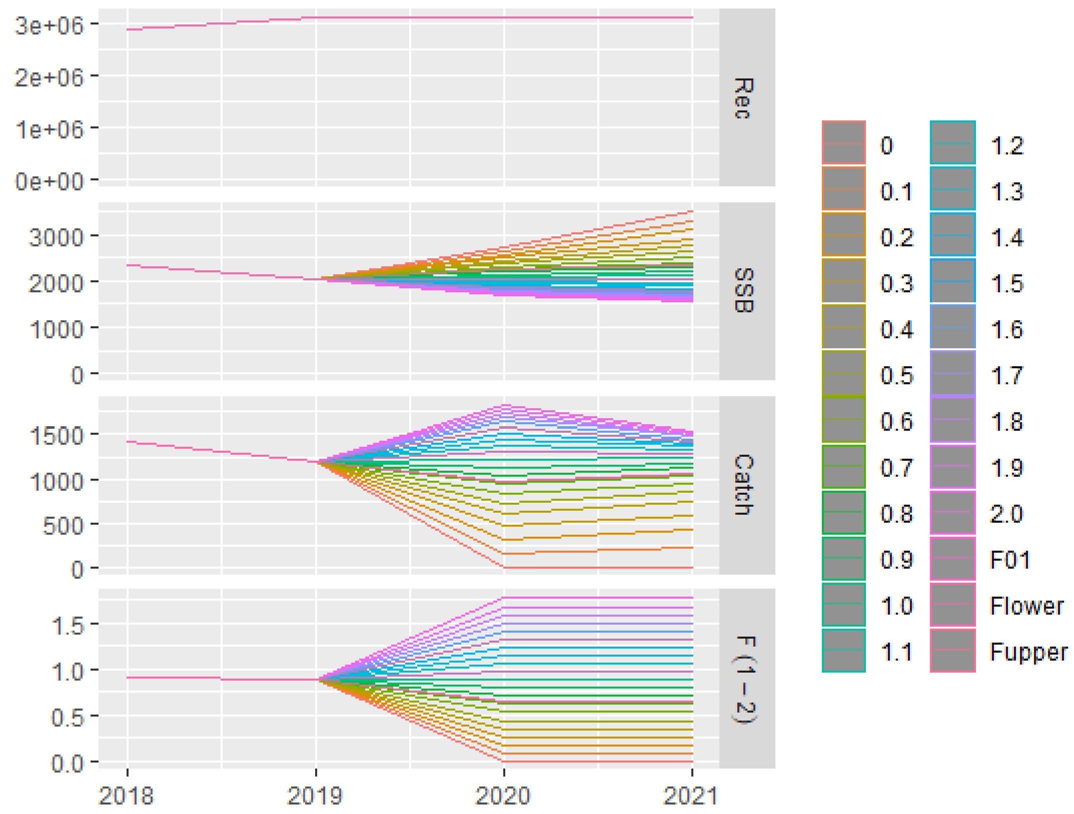


Fig. 6.10.5.1 Deep-water rose shrimp in GSAs 09, 10 & 11. Short-term forecast in different F scenarios.

6.10.6 Data Deficiencies

Data from DCR-DCF database as submitted through the Official data call in 2019 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: 2003-2018 for GSA09, 2002-2018 for GSA10 and 2009-2018 for GSA11.

The length frequency distributions of the landing for GSA09 are available for the period 2003-2018 (year 2002 is missing). For GSA10, data are not available for 2003. The historical data series for GSA11 includes the period 2009-2018 (the years 2002-2008 are missing). In GSA10, length frequency distributions and relative landings are missing for the third quarter of 2017 and for the first quarter of 2018. 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. Concerning the lack of quarters in GSA10 in the last two years, a sop correction was necessary.

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 for GSA10 had a low impact on the assessment as, on average, discard in GSA10 represents about 2% of the total catch. With regard to GSA11, there are no data on this fraction of the catch. Due to the low catches of DPS in GSA11 the discard of this species could be considered negligible in the area. It should be emphasized that the Italian national data collection program did not provide for the collection of discard before 2006 and in the years 2007-2008.

6.11 Red Mullet in GSA 9

6.11.1. Stock Identity and Biology

Red mullet (*Mullus barbatus*) is distributed in GSA 9 (Figure 6.11.1.1) along the shelf at depths up to 200m, but mainly concentrated in the depth range 0-100 m. EU project STOCKMED outcomes suggest a single stock unit in the GSA 9 and the rest of Western Mediterranean (see: https://ec.europa.eu/fisheries/documentation/studies/stockmed_en). Available spatial information from MEDITS show continuous distribution of the red mullets along western Italian coast (i.e. connectivity of GSA9 with GSA 10) (Figure 6.11.1.2).

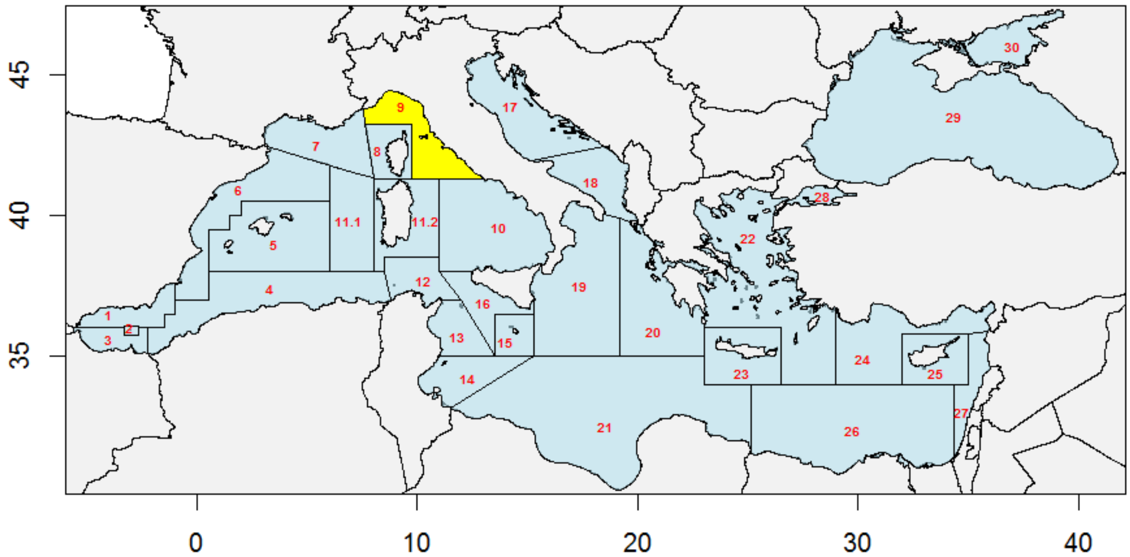


Figure 6.11.1.1 Location of GSA 9 in the Mediterranean Sea.

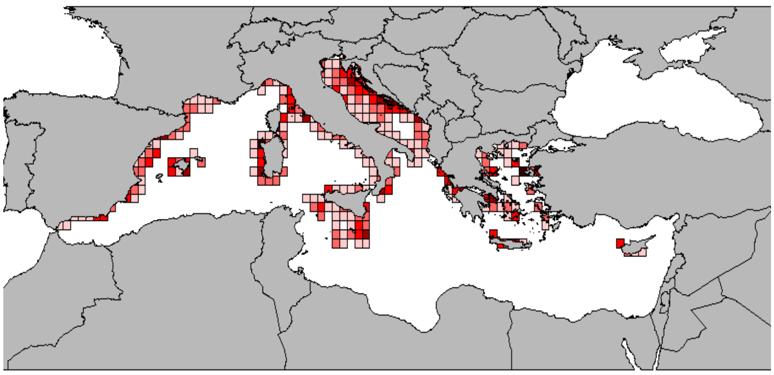


Figure 6.11.1.2 Geographical distribution of red mullet in the Mediterranean basin (kg/km^2, average 2004-2014 by GFCM rectangle), STOCKMED Project.

However, in line with ToR given, EWG19-10 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 2018 (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).

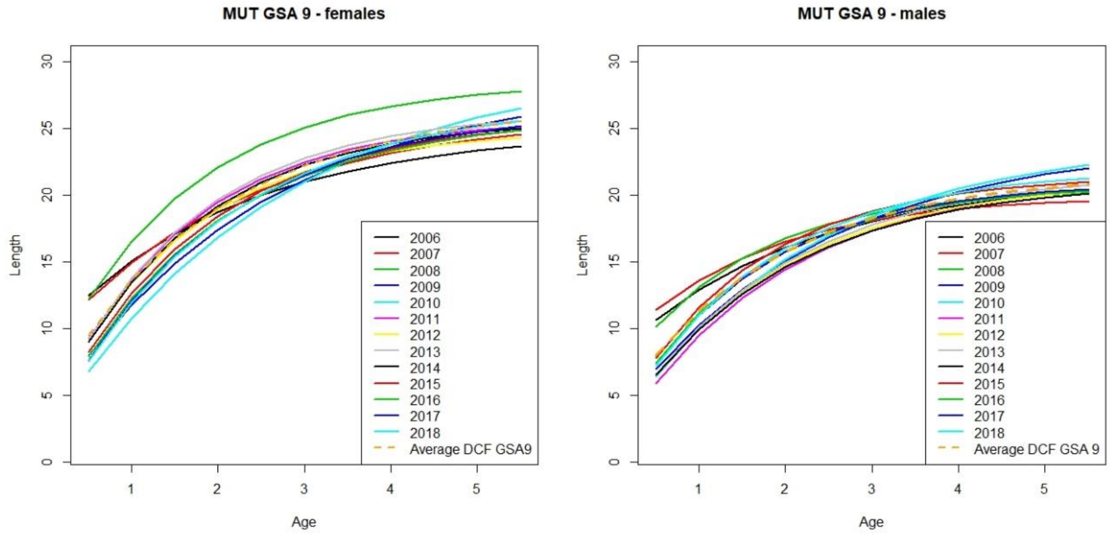


Figure 6.11.1.3. Estimated growth curves of red mullet in GSA9.

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 EWG19-10 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: 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 2018 in the DCF data. The vector of matures by year and age showed a wide uncertainty especially on maturity at age 0 and 1 (Figure 6.11.1.4), that seems inconsistent with the growth curve and the spawning season of the species. For this reason the EWG 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 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

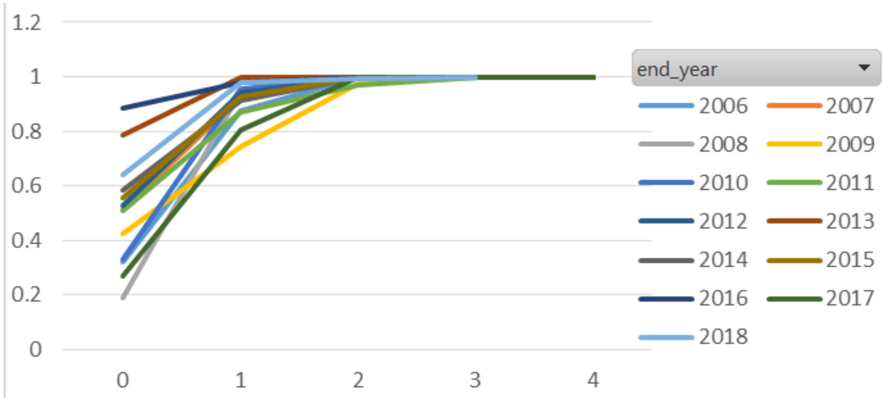


Figure 6.11.1.4. Maturity ogives by age and by years for red mullet in GSA 9.

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 2018 are shown in Figures 6.11.2.1.1 - 6.11.2.1.3 for landings, discards and catches respectively.

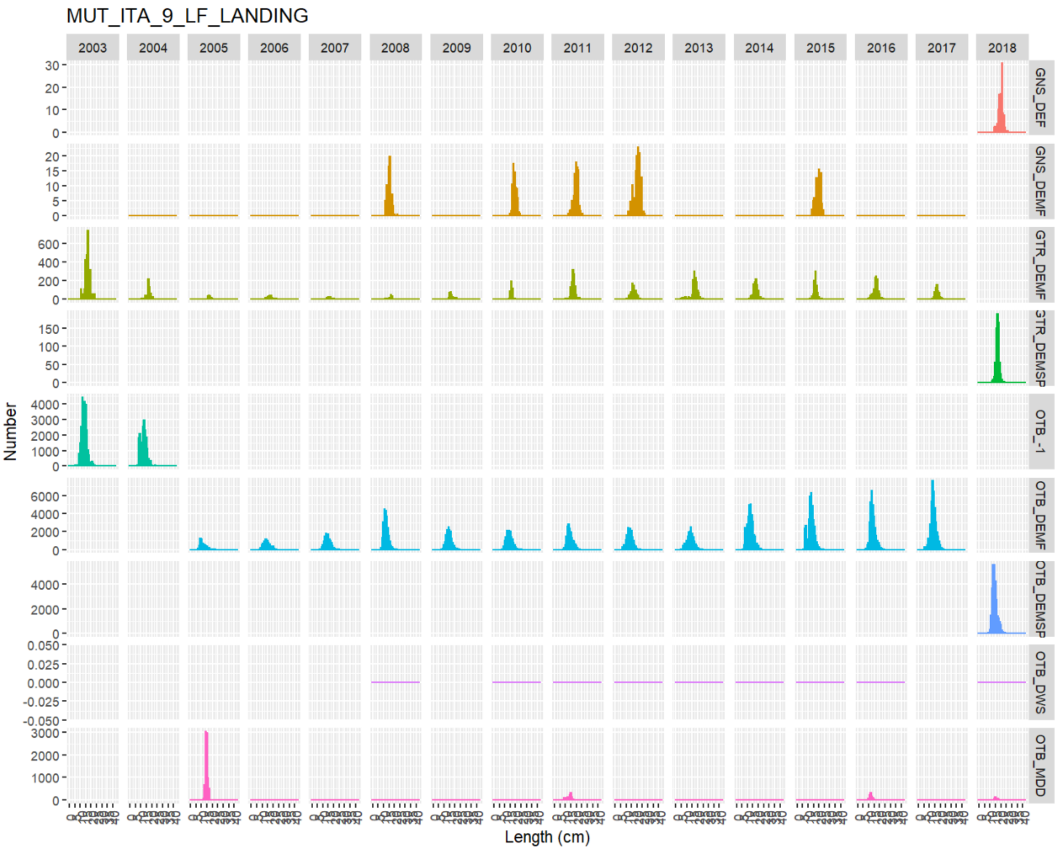


Figure 6.11.2.1.1. Length structure of red mullet landed in GSA 9 in the period from 2003 to 2018 by fishing gear and fishery.

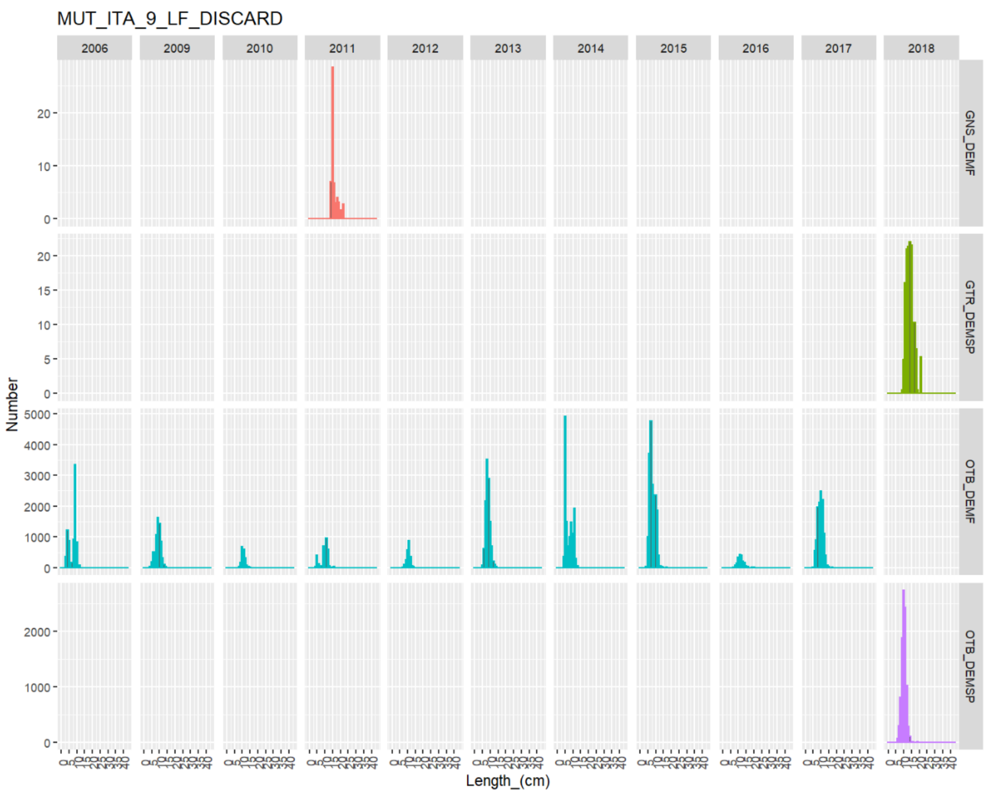


Figure 6.11.2.1.2. Length structure of red mullet catch discarded in GSA 9 in the period from 2006 to 2018 by fishing gear and fishery.

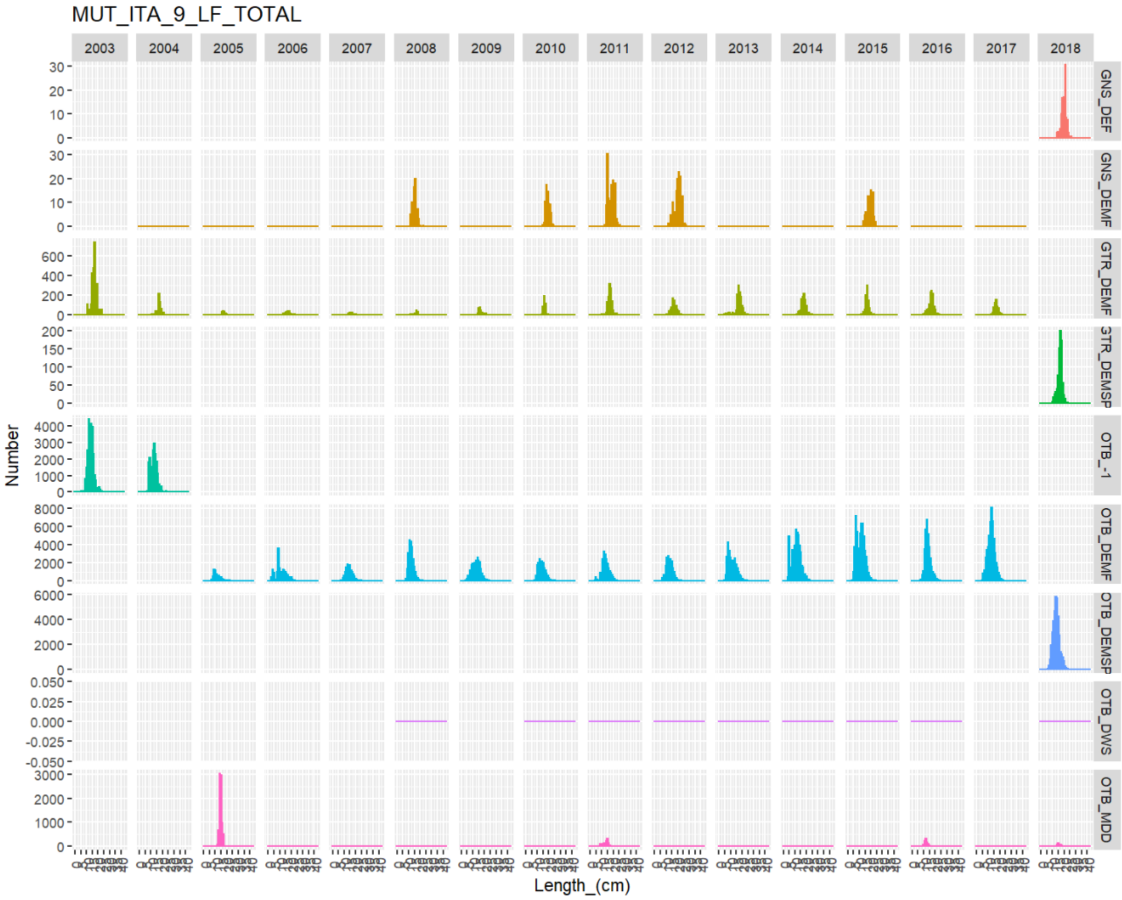


Figure 6.11.2.1.3. Length structure of red mullet total catch (landing plus discard) in GSA 9 in the period from 2003 to 2018 by fishing gear and fishery.

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, EWG19-10 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, EWG19-10 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 ToR 3 is analysed on fishing gear level, are related to multifisheries and multispecies aspects, and not just to one single species considered in the assessments.

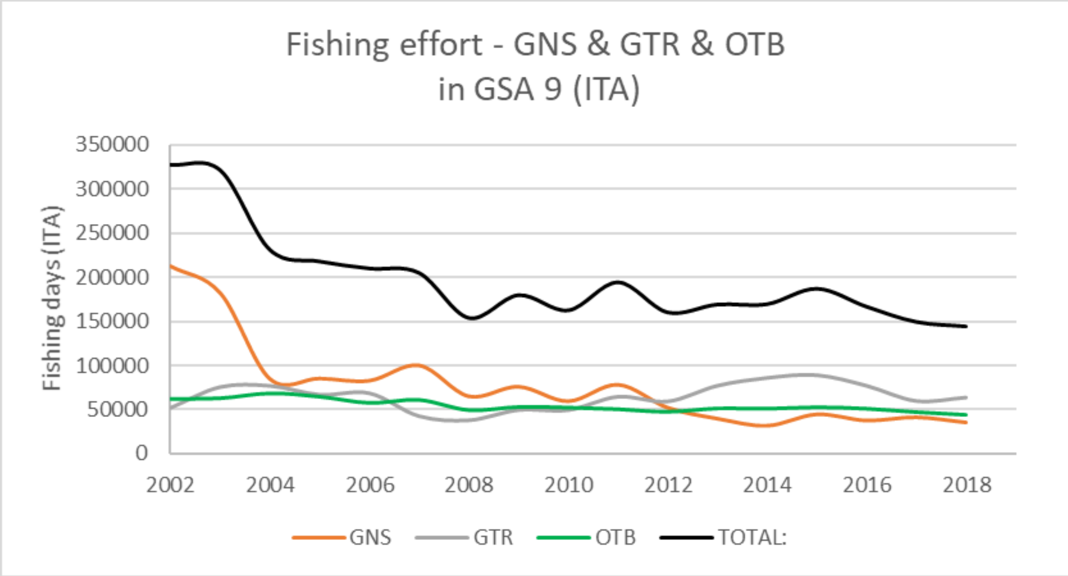


Figure 6.11.2.2.1. Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 9 in the period 2002-2018.

Table 6.11.2.2.1. 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. 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). EWG19-10 considered this fact during interpretation of available survey indices in the assessment excluding age 0 in the tuning index, because not intercepted every year. In addition, the EWG19-10 attempted to include the Italian GRUND survey (1994-2008, and until 2006 in GSA 9) in the analysis, in order to use the information collected by RECFISH project and to increase the model performance. This attempt was also done because the GRUND survey generally was carried out in autumn and, thus, it was possible that the recruits were detected more regularly than with the MEDITS. However, the analyses revealed that the GRUND survey was not informative for the model, and it was not included in the final model run.

Figure 6.11.2.3.1 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 index (abundance and biomass) can be noticed from 2014 onward, with peaks in 2014 and 2017.

However, in relation to MEDITS data available, EWG19-10 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.

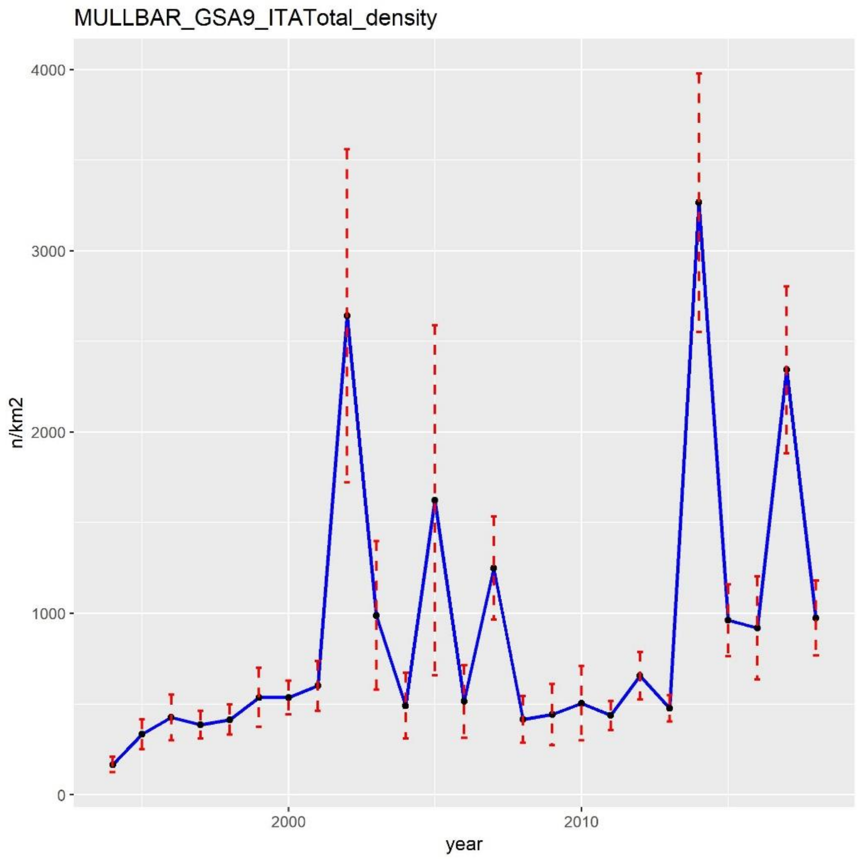


Figure 6.11.2.3.2. Abundance indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2018).

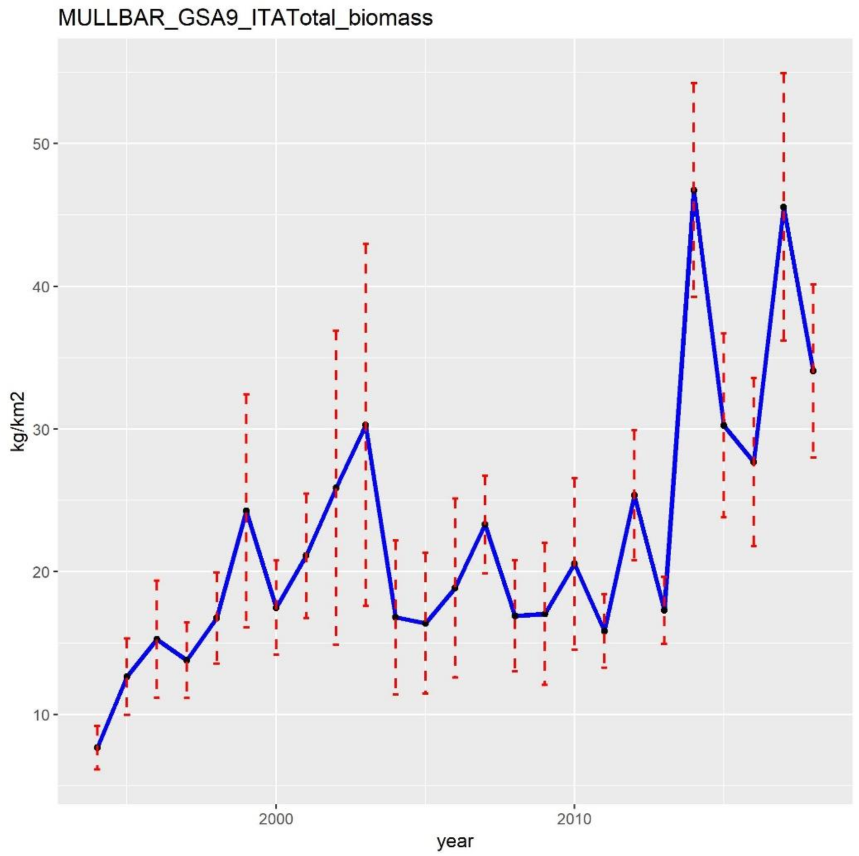


Figure 6.11.2.3.3 Biomass indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2018).

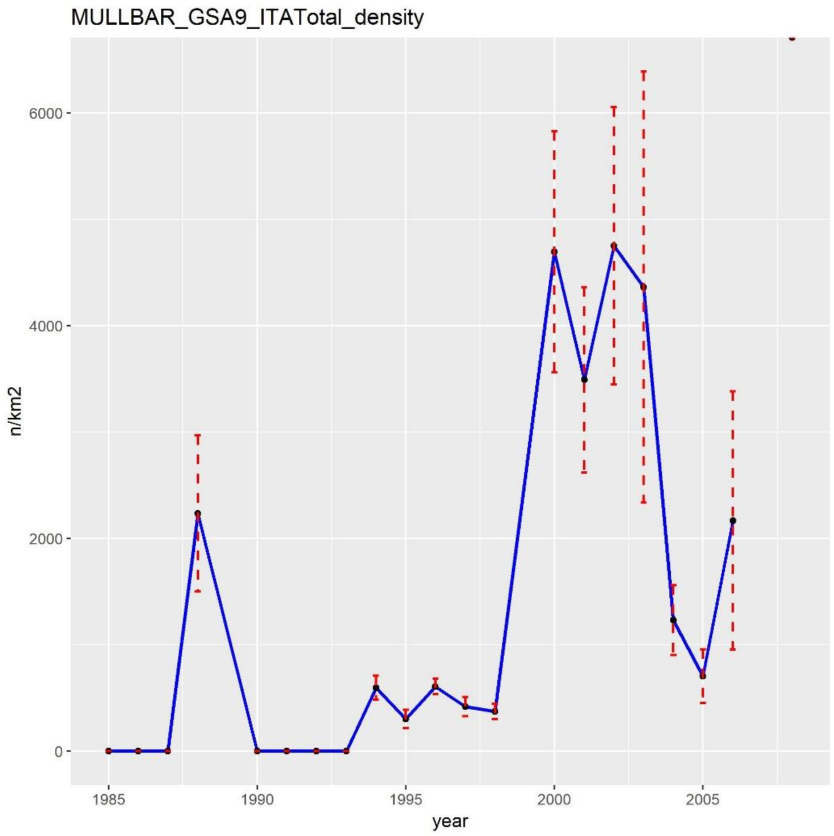


Figure 6.11.2.3.4 Abundance indices of red mullet in GSA 9 as derived from trawl surveys (GRUND, 1994-2006).

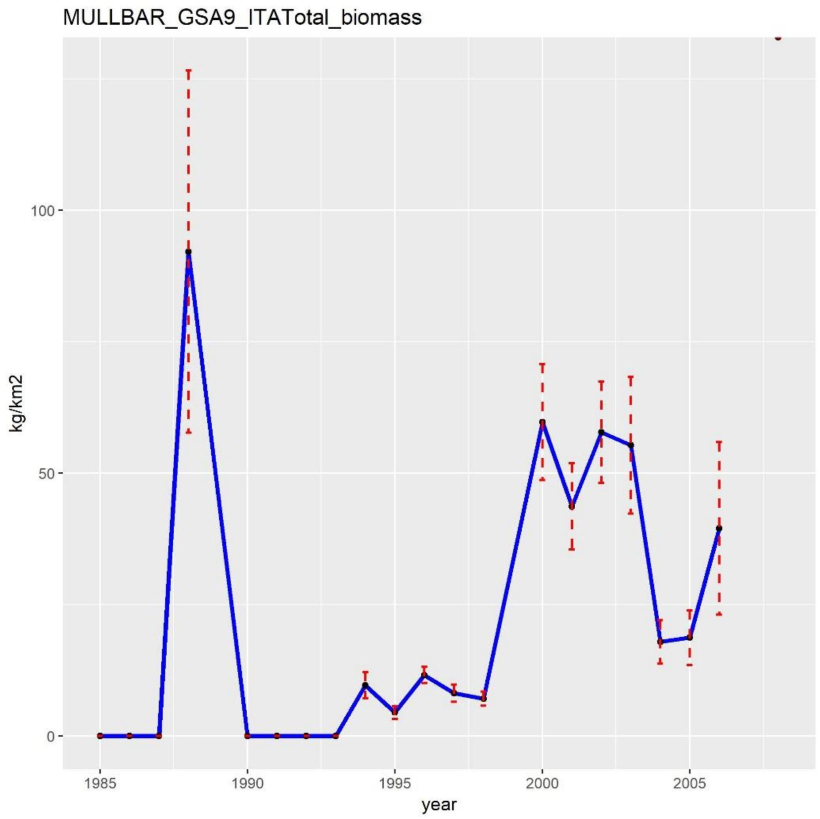


Figure 6.11.2.3.5 Biomass indices of red mullet in GSA 9 as derived from trawl surveys (GRUND, 1994-2006).

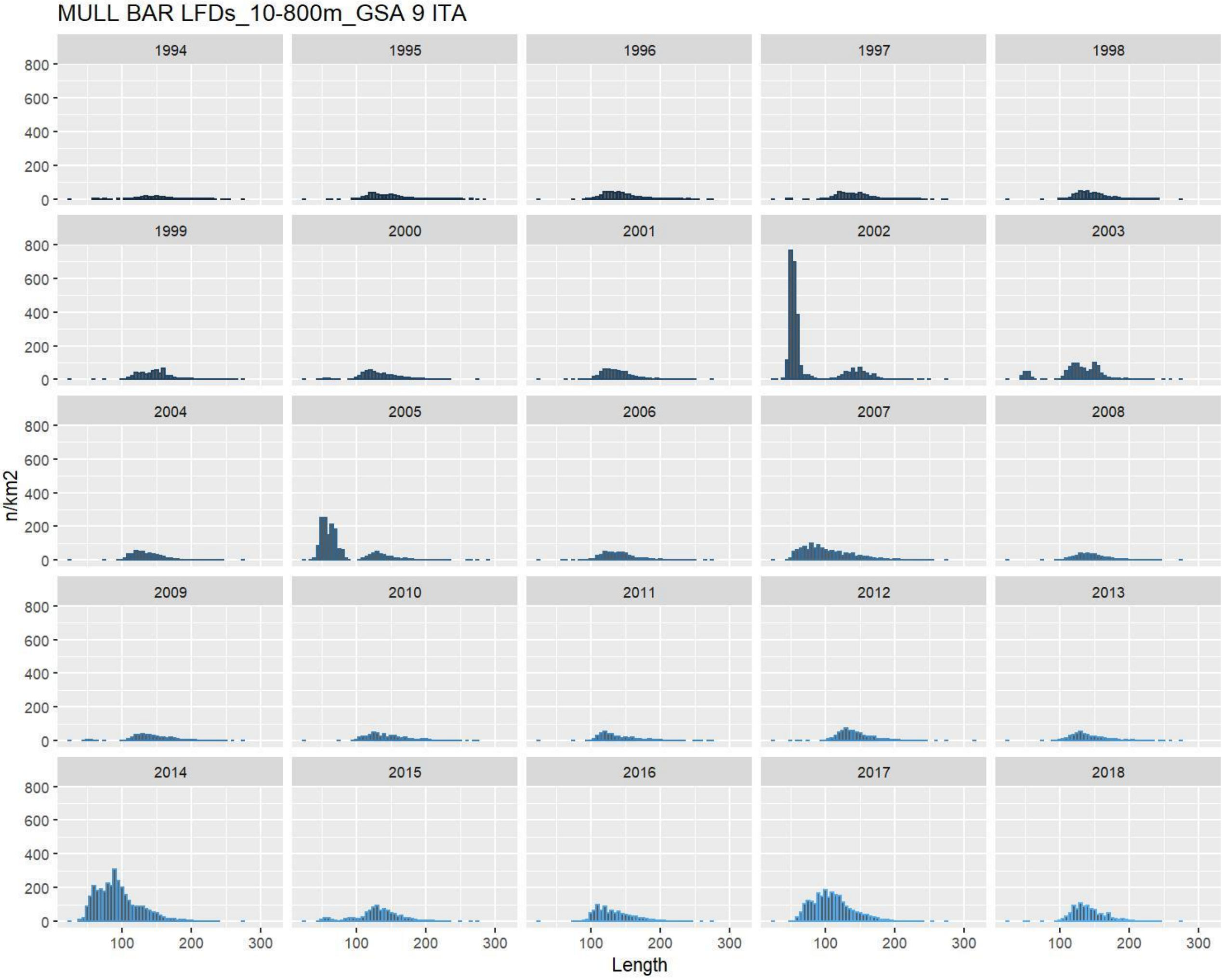


Figure 6.11.2.3.6. Size structure indices of red mullet in GSA 9 as derived from trawl surveys (MEDITS, 1994-2018).

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 2003-2018. Despite availability of commercial fishery data since 2003, the assessment was carried out from 2004 in accordance with EWG 18-12, 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. The final catch at age data are shown in the figure 6.11.3.1. In comparison with EWG18-12, the catches at age resulted more abundant in age class 1 due to the shift in the growth curve.

Table 6.11.3.1. Values of catch at age per year used in the assessment.

	Age				
	0	1	2	3	4
2004	1840.014	15919.84	3898.417	299.6835	114.9868
2005	1284.906	15917.53	6434.742	312.9313	9.2499
2006	12550.16	24630.14	7679.563	1052.19	212.7909
2007	462.0453	19942.78	9747.116	1163.664	268.1637
2008	884.3763	28135.42	4166.442	333.0357	42.5874
2009	2895.147	16746.99	6102.122	706.742	161.9533
2010	327.4221	15609.01	6089.146	741.9921	181.9033
2011	1208.465	16652.9	6721.578	848.1701	130.0963
2012	875.3793	16710.3	5358.594	600.1565	114.4071
2013	7132.219	19261.88	5544.7	689.5421	110.5943
2014	12511.39	34420.2	8079.818	755.6867	179.6723
2015	15681.64	34531.72	7828.267	756.1708	95.9254
2016	413.425	28095.26	9165.384	917.4324	175.435
2017	4752.889	39268.81	11126.75	1037.18	164.097
2018	1550.17	29340.21	10098.26	960.0504	146.3814

Table 6.11.3.2. Values of mean weight at age per year used in the assessment.

	Age				
age	0	1	2	3	4
2004	0.01	0.02	0.05	0.08	0.12
2005	0.01	0.02	0.05	0.08	0.12
2006	0.01	0.02	0.05	0.08	0.12
2007	0.01	0.02	0.05	0.08	0.12
2008	0.01	0.02	0.05	0.08	0.12
2009	0.01	0.02	0.05	0.08	0.12
2010	0.01	0.02	0.05	0.08	0.12
2011	0.01	0.02	0.05	0.08	0.12
2012	0.01	0.02	0.05	0.08	0.12
2013	0.01	0.02	0.05	0.08	0.12
2014	0.01	0.02	0.05	0.08	0.12
2015	0.01	0.02	0.05	0.08	0.12
2016	0.01	0.02	0.05	0.08	0.12
2017	0.01	0.02	0.05	0.08	0.12
2018	0.01	0.02	0.05	0.08	0.12

Table 6.11.3.3. Survey index (MEDITS) values at age per year used in the assessment.

	Age				
	0	1	2	3	4
2004	0	407.6871	71.68427	9.08343	1.72698
2005	1242.878	308.4707	60.4201	7.33023	3.1905
2006	1.47802	410.719	89.13618	9.45807	3.47212
2007	435.3922	668.5617	124.0129	17.81806	3.21573
2008	0	261.1319	132.3238	19.6488	1.03481
2009	23.2173	266.7056	127.1257	21.14521	3.23562
2010	0	347.6557	127.959	23.67642	5.25607
2011	0	311.7225	106.0815	16.53179	2.2217
2012	6.86029	429.0408	199.011	17.97754	3.05387
2013	0	318.7595	126.9984	15.83693	1.49818
2014	1398.302	1632.84	213.5123	18.81477	0.93642
2015	93.9532	602.695	240.4376	22.88879	1.3427
2016	4.62213	687.692	209.4566	16.22128	1.87458
2017	497.7433	1620.552	188.0202	13.2654	1.9224
2018	1.33622	666.136	287.7801	18.51678	0.85125

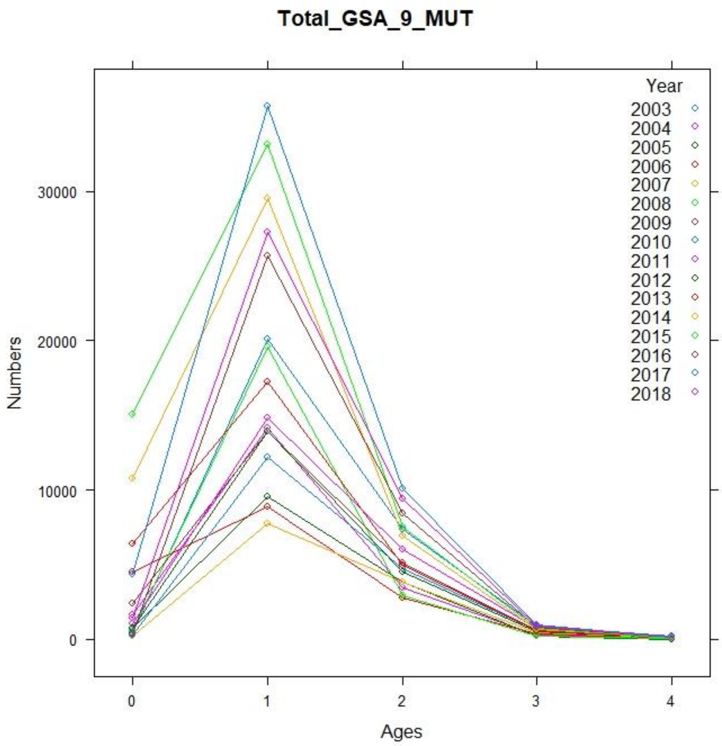


Figure 6.11.3.1. Catch-at-age data of red mullet in GSA9 used in assessment.

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.

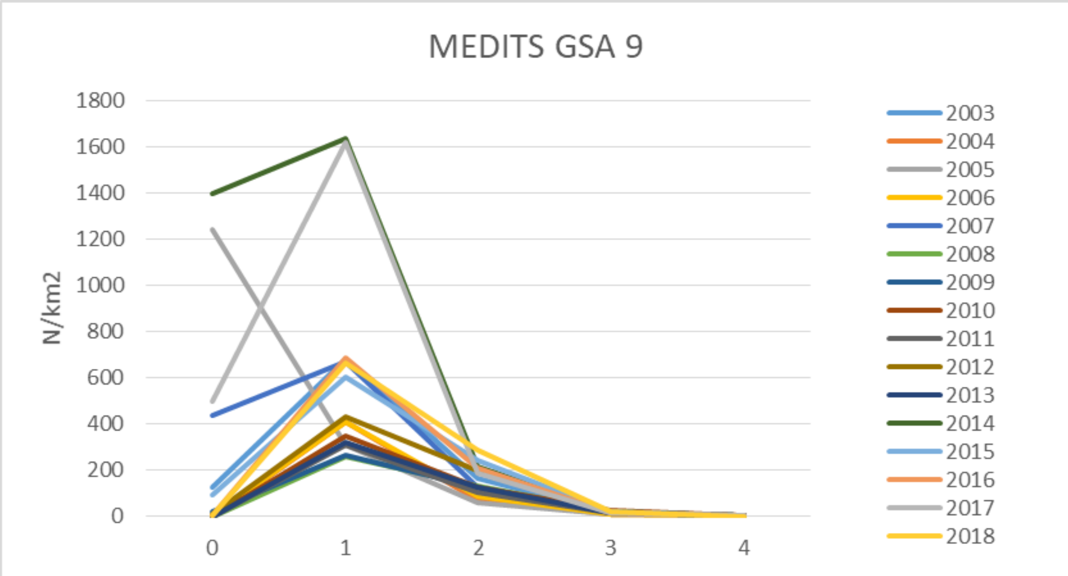


Figure 6.11.3.2 MEDITS indices describing density by age of red mullet in GSA9 by year.

For the assessment purposes, different F, q and sr bub-model were explored. Among them, the ones retunring the most consisten tresults in terms of residuals and retrospective are:

Fmodels

- fmod1 <- ~ s(replace(age, age > 2, 2), k = 3) + s(year, k = 6)
- fmod2<- ~s(replace(age, age > 2, 2), k = 3) + s(year, k = 6) + te(age, year,k=c(3,7))

qmodels

- qmod1<- list(~factor(replace(age,age>2,2)))
- qmod2<- list(~1)

SRmodels

- srmod1 <- ~factor(year)
- srmod2 <- ~s(year,k=4)
- srmod3 <- ~ geomean(CV=0.3)

All the combinations of the 7 sub-models were tested, compared and evaluated according to the quality of residuals and retrospective analysis.

The best fit was obtained:

- fmodel: ~s(age, k = 3) + s(year, k = 3) + te(age, year),
- srmodel: ~s(year, k = 4)
- qmodel: ~1.

Results are shown below (Figure 6.7.5.3).

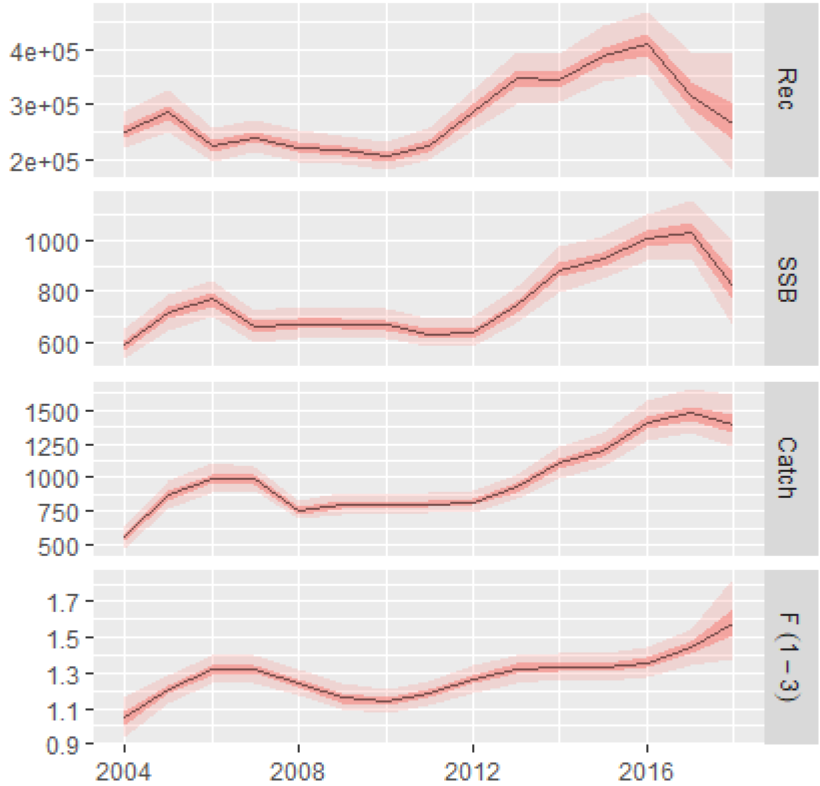


Figure 6.11.3.3 Results of the best a4a model for red mullet in GSA9.

The results of the retrospective analysis are shown in Figure 6.11.3.4.

Log residuals of the catch and abundance indices related to outcomes of the best run do not show any particular trend and they are shown in Figure 6.11.3.5.

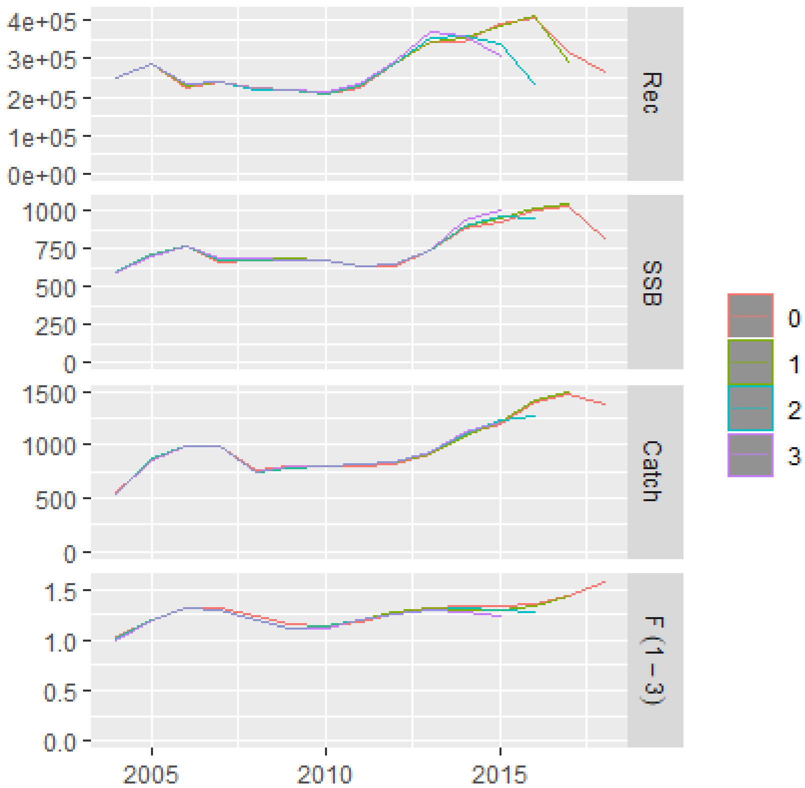


Figure 6.11.3.4 Retrospective analysis of the selected a4a model for red mullet in GSA9.

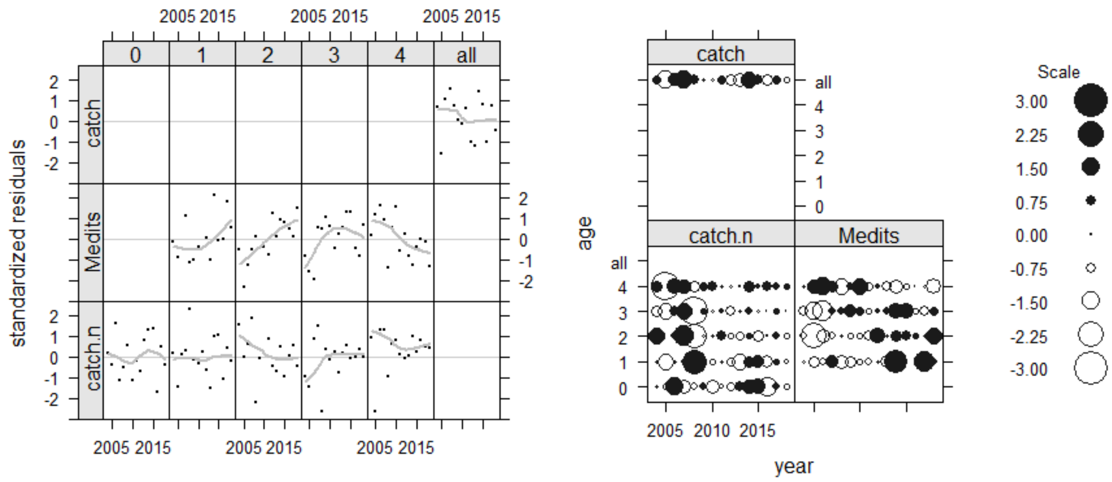


Figure 6.11.3.5. Log residuals of catch and abundance indices for red mullet in GSA9.

Final assessment outcomes are given in Table 6.11.3.4.

Table 6.11.3.4 Final results of the red mullet assessment in GSA9.

Year	Recruitment age 0 thousands	SSB tonnes	Catch tonnes	F ages 1-2
2004	252072	591	552	1.04
2005	286258	716	867	1.21
2006	224716	770	990	1.32
2007	241236	660	984	1.32
2008	222320	672	756	1.24
2009	216486	672	801	1.16
2010	205963	668	795	1.14
2011	225949	634	804	1.18
2012	288639	638	816	1.26
2013	345889	744	924	1.32
2014	345765	883	1101	1.34
2015	388439	925	1200	1.33
2016	408237	1005	1409	1.36
2017	317679	1032	1477	1.44
2018	267222	816	1393	1.58

Table 6.11.3.5. Stock number at age for red mullet in GSA 9.

	Age				
	0	1	2	3	4
2004	252072.3	48140.32	5702.975	716.123	95.316
2005	286258	55566.2	10828.27	811.308	124.19
2006	224716.1	62985.78	11342.62	1267.388	117.869
2007	241235.7	49382.01	12027.79	1161.038	152.356
2008	222319.8	53010.21	9412.898	1226.684	144.1
2009	216485.9	48897.79	10595.09	1056.002	165.367
2010	205962.7	47658.2	10253.74	1309.047	162.462
2011	225948.6	45352.72	10125.58	1300.685	200.761
2012	288639	49727.88	9377.547	1216.174	194.138
2013	345889.1	63468.28	9808.069	1024.348	165.869
2014	345764.8	76004.83	12077.74	996.946	130.267
2015	388438.7	75965.27	14341.09	1206.864	121.17
2016	408237.4	85346.37	14382.8	1442.931	143.607
2017	317678.7	89671.27	15922.09	1404.8	166.538
2018	267221.8	69711.71	15888.6	1402.078	148.797

Table 6.11.3.6. Fishing mortality at age for red mullet in GSA 9.

	Age				
	0	1	2	3	4
2004	0.011842	0.623188	1.25284	1.25284	1.25284
2005	0.013686	0.720238	1.44794	1.44794	1.44794
2006	0.014953	0.786919	1.58199	1.58199	1.58199
2007	0.014988	0.788735	1.58565	1.58565	1.58565
2008	0.014087	0.741324	1.49033	1.49033	1.49033
2009	0.013175	0.693322	1.39383	1.39383	1.39383
2010	0.012926	0.68022	1.36749	1.36749	1.36749
2011	0.013442	0.707382	1.4221	1.4221	1.4221
2012	0.014339	0.75459	1.517	1.517	1.517
2013	0.015019	0.790405	1.589	1.589	1.589
2014	0.015181	0.798899	1.60608	1.60608	1.60608
2015	0.015116	0.795473	1.59919	1.59919	1.59919
2016	0.015396	0.81024	1.62888	1.62888	1.62888
2017	0.016376	0.86178	1.73249	1.73249	1.73249
2018	0.017965	0.945439	1.90068	1.90068	1.90068

6.11.4 Reference Points

The time series is too short to produce meaningful stock recruitment rationship, so reference points are based on equilibrium methods. The STECF EWG recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the 6.11.3 assessment.

Values of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 0.58. Current F values (2018), as calculated by model a4a, is 1.58 indicating that the stock is being overfished.

6.11.5 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 stock assessment.

The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} =1.58 terminal F (2018) from the a4a assessment was used for F in 2019. Recruitment is observed to be fluctutating over the period of the assessment (Figure 6.11.3.3) so the average across the whole time series is used as an estimate of recruits from 2019. Recruitment (age 0) for 2019 to 2021 has been estimated from the population results as the geometric mean of the whole time series of 15 years (275835).

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 2016-2018	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1-3}$ (2019)	1.58	F 2018 used to give F status quo for 2019
SSB (2019)	641	Stock assessment 1 January 2019
R_{age0} (2019,2021)	275835	Geometric mean of the time series last 15 years
Total catch (2019)	1100	Assuming F status quo for 2019

The short term forecast was carried out estimating a catch for 2018-2020 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 2019 equal to 1100 and 641 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.58) would increase biomass of 86% from 2019 to 2021, while decreasing the catch of the 63% from 2018 to 2020.

Table 6.11.5.2 – Short term forecast table for red mullet in GSA 9.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2020	SSB* 2019	SSB* 2021	Change SSB 2019-2021 (%)	Change Catch 2018-2020 (%)
High long term yield ($F_{0.1}$)	0.4	0.58	1393	512	937	1226	86	-63
F upper	0.5	0.79	1393	652	864	1048	59	-53
F lower	0.2	0.39	1393	364	1011	1432	117	-74
Zero catch	0	0.00	1393	0	1178	2014	206	-100
Status quo	1	1.58	1393	1038	641	641	-3	-26
Different Scenarios	0.1	0.16	1393	162	1106	1742	164	-88
	0.2	0.32	1393	305	1039	1517	130	-78
	0.3	0.47	1393	434	977	1332	102	-69
	0.4	0.63	1393	549	918	1177	79	-61
	0.5	0.79	1393	652	864	1048	59	-53
	0.6	0.95	1393	745	813	939	43	-47
	0.7	1.11	1393	829	766	846	29	-40
	0.8	1.27	1393	906	721	768	17	-35
	0.9	1.42	1393	975	680	700	6	-30
	1.1	1.74	1393	1095	604	590	-10	-21
	1.2	1.90	1393	1148	570	545	-17	-18
	1.3	2.06	1393	1196	538	505	-23	-14
	1.4	2.22	1393	1241	508	470	-29	-11
	1.5	2.37	1393	1282	480	438	-33	-8
	1.6	2.53	1393	1320	454	410	-38	-5
	1.7	2.69	1393	1355	429	384	-42	-3
	1.8	2.85	1393	1387	406	361	-45	0
	1.9	3.01	1393	1417	384	340	-48	2
	2	3.16	1393	1446	363	320	-51	4

*SSB at mid year

EWG advises that when the MSY approach is applied, catches in 2020 should be no more than 512 tonnes.

6.11.6 Data Deficiencies

The EWG19-10 did not find any particular data deficiency for this stock, in terms of data quality.

6.12 Red mullet in GSA 10

6.12.1 Stock Identity and Biology

Red mullet (*Mullus barbatus*) is distributed in GSA 10 along the shelf at depths up to 200m, but mainly concentrated in the depth range 0-100 m. The area of GSA 10 extends in the South and Central Tyrrhenian Sea, that features one of the most complex structures in the seas around the Italian peninsula, due to its morphological and geophysical characteristics and water mass dynamics (Cataudella and Spagnolo, 2011). In line with the given ToR, it is assumed in the present assessment that inside the GSA 10 boundaries inhabits a single, homogeneous red mullet stock that behaves as a single well-mixed and self-perpetuating population.

However, the EWG19-10 noticed that EU project STOCKMED outcomes suggest a single stock unit in Western Mediterranean

(see: https://ec.europa.eu/fisheries/documentation/studies/stockmed_en). In addition, available spatial information from MEDITS show continuous distribution of the red mullets along western Italian coast (i.e. continuity in spatial distribution in GSA10 and GSA9).

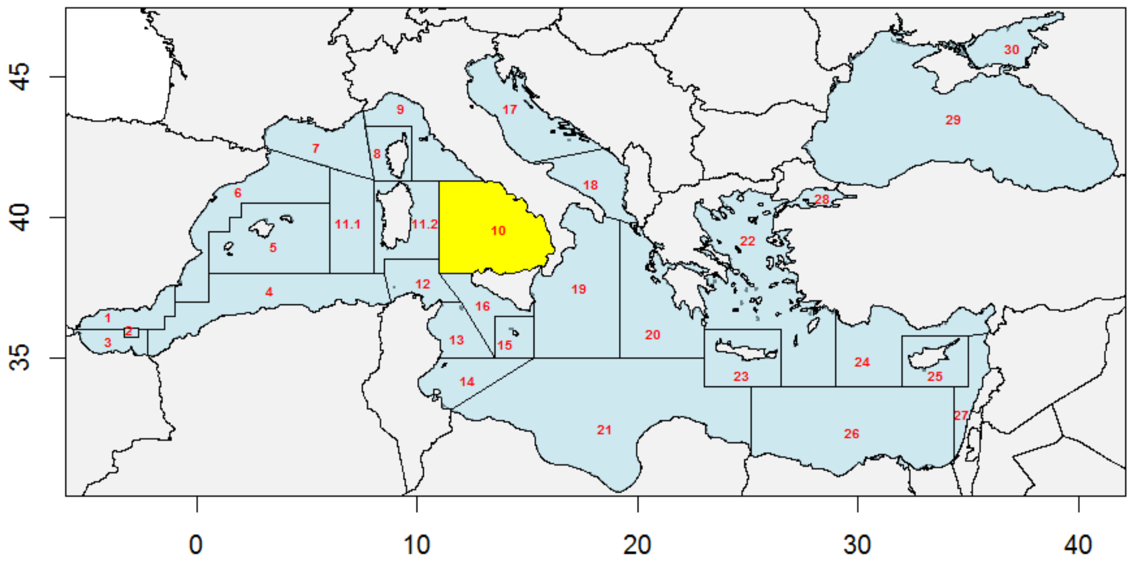


Figure 6.12.1.1. Map of GSA 10.

Growth

The information on the age-length key (ALK) and on the growth von Bertalanffy parameters was available from 2002 and appeared consistent with the recent study of Carbonara et al. (2018) on age validation of red mullet in Adriatic Sea.

Growth parameters reported in DCF are: females: Linf=30, k=0.243, t0=-0.62; males: Linf=26, k=0.237, t0=-0.9.

In contrast with the previous EWG, the EWG19-10 agreed that no adjustment of t0 was needed to parameterize the stock assessment model (a4a) to work with calendar year, being the mean length at age derived by the DCF von Bertalanffy growth curve already in line with the mean length expected at the end of the year.

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 2002 to 2018 by sex. Data until 2017 are quite consistent with the maturity vector agreed within the EWG 18-12, while data in 2018 show an incosistent pattern (Figure 6.12.1.2). The EWG19-10 applied the vector used in previous years. Mortality and maturity parameters used in assessment are shown in Table 6.12.1.1.

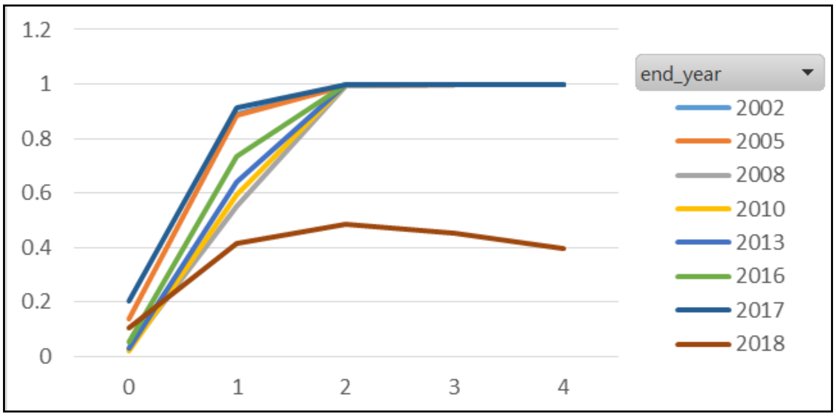


Figure 6.12.1.2. Maturity at age for *Mullus barbatus* in GSA 10.

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

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 2018 are shown in Figures 6.12.2.1.1 and 6.12.2.1.2 for landing and discards, respectively, and in 6.12.2.1.3 for combined landing plus discards.

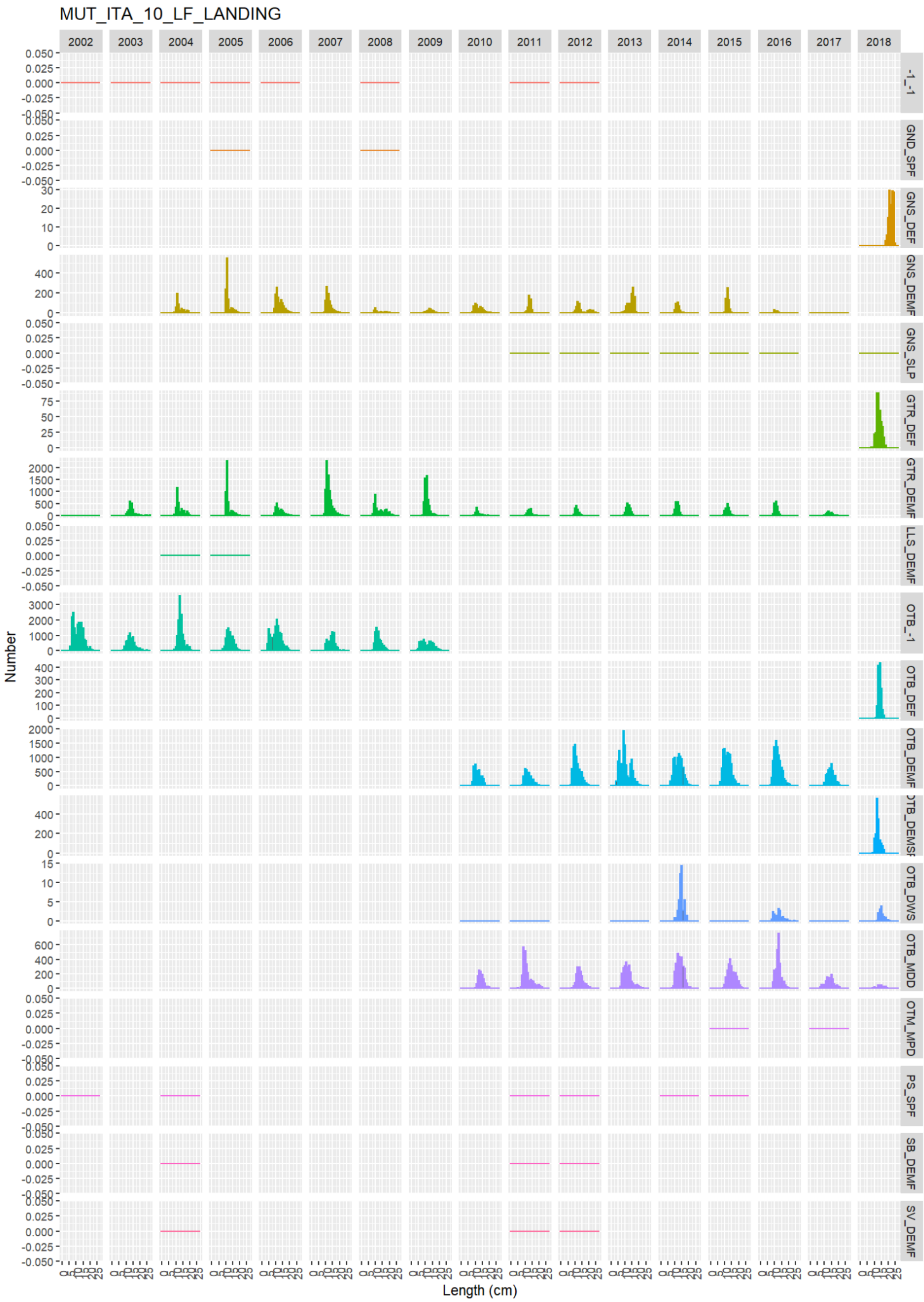


Figure 6.12.2.1.1. Length structure of red mullet landed in GSA 10 in the period from 2002 to 2018 by fishing gear and fishery.

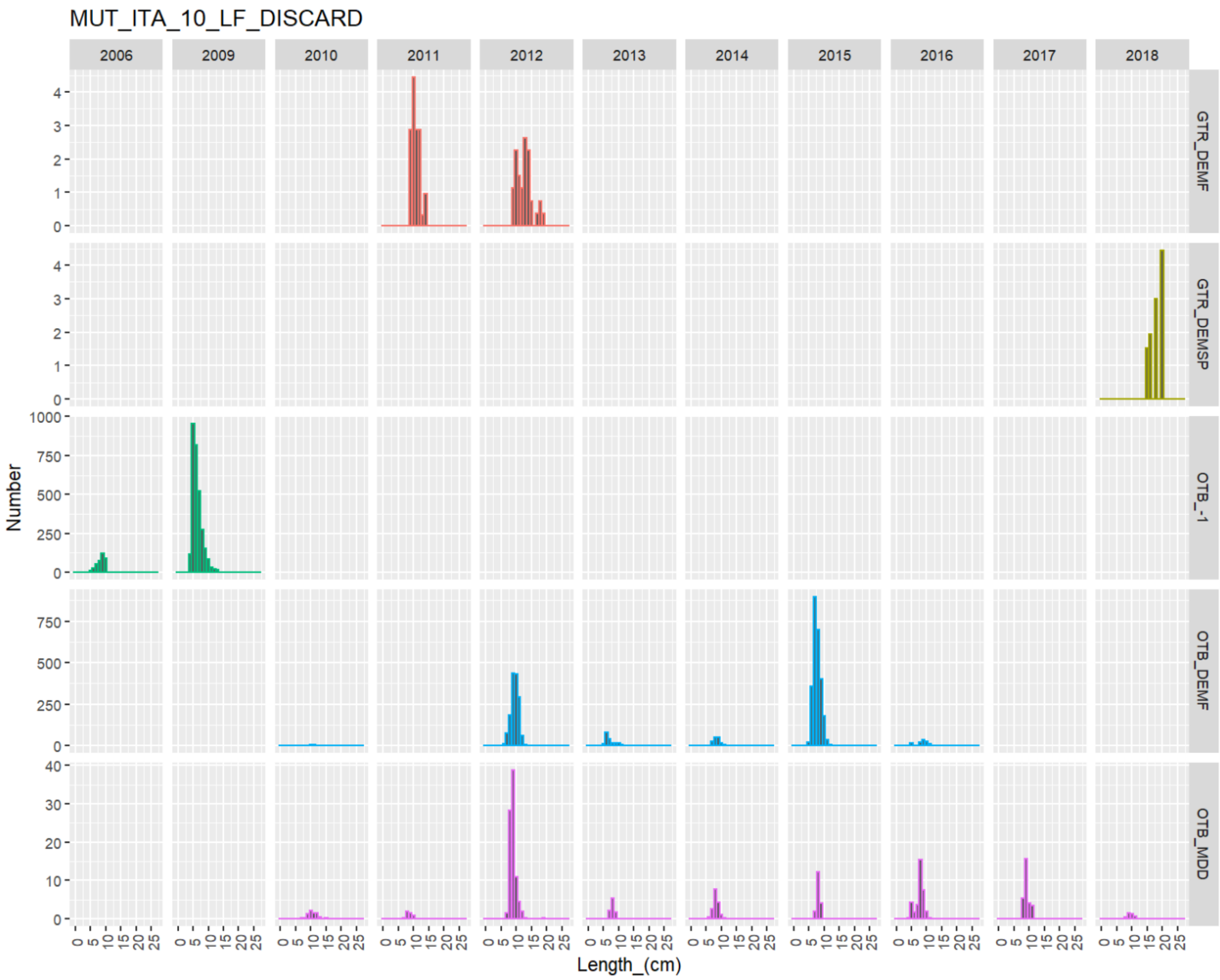


Figure 6.12.2.1.2. Length structure of discarded catch of red mullet in GSA 10 in the period from 2006 to 2018 by fishing gear and fishery.

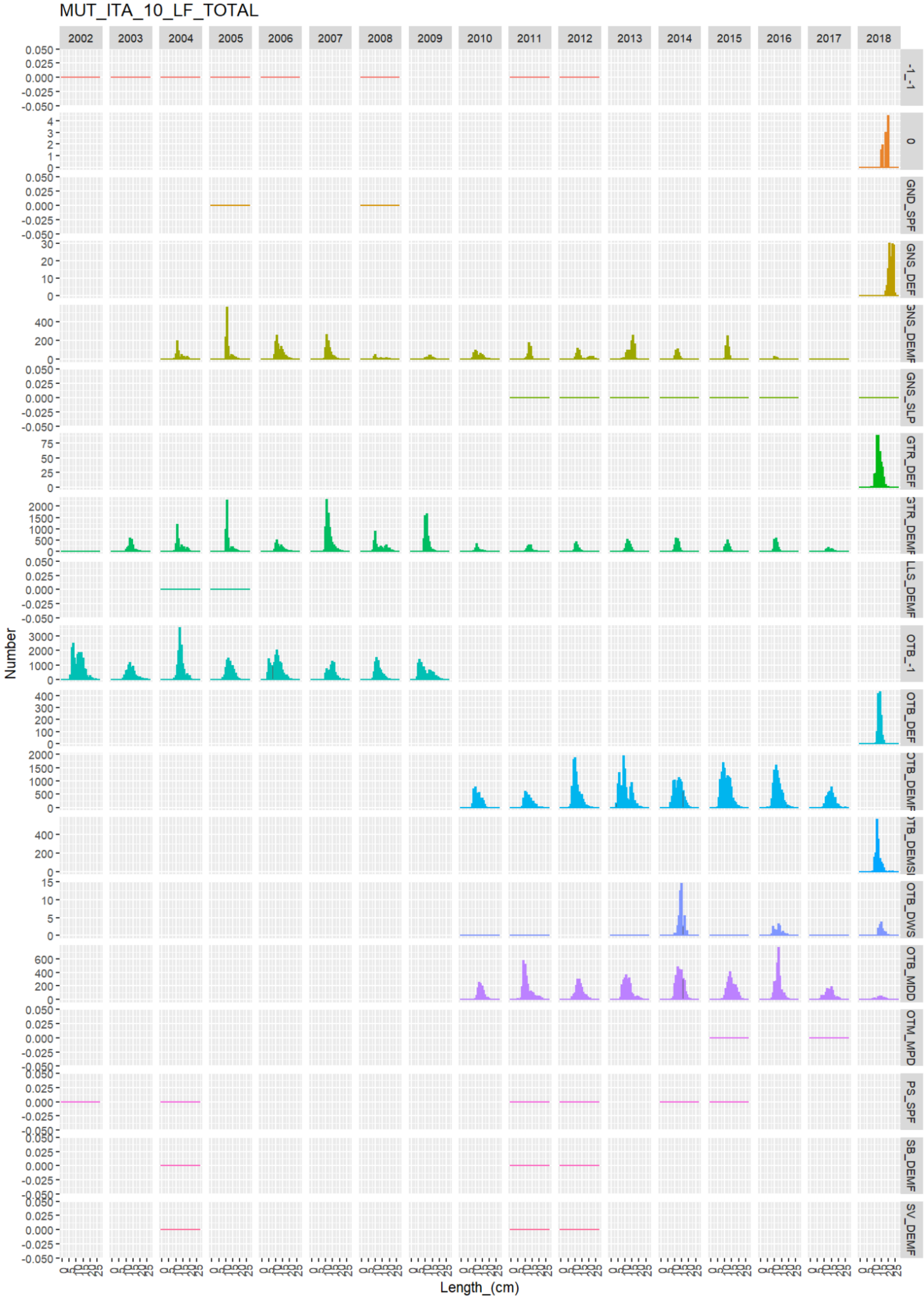


Figure 6.12.2.1.3. Length structure of catches (landing+discarded catch) of red mullet in GSA 10 in the period from 2006 to 2018 by fishing gear and fishery.

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.

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, EWG19-10 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, EWG19-10 also highlights that gears indicated in the table are used in framework of different fisheries where multispecies catches are obtained.

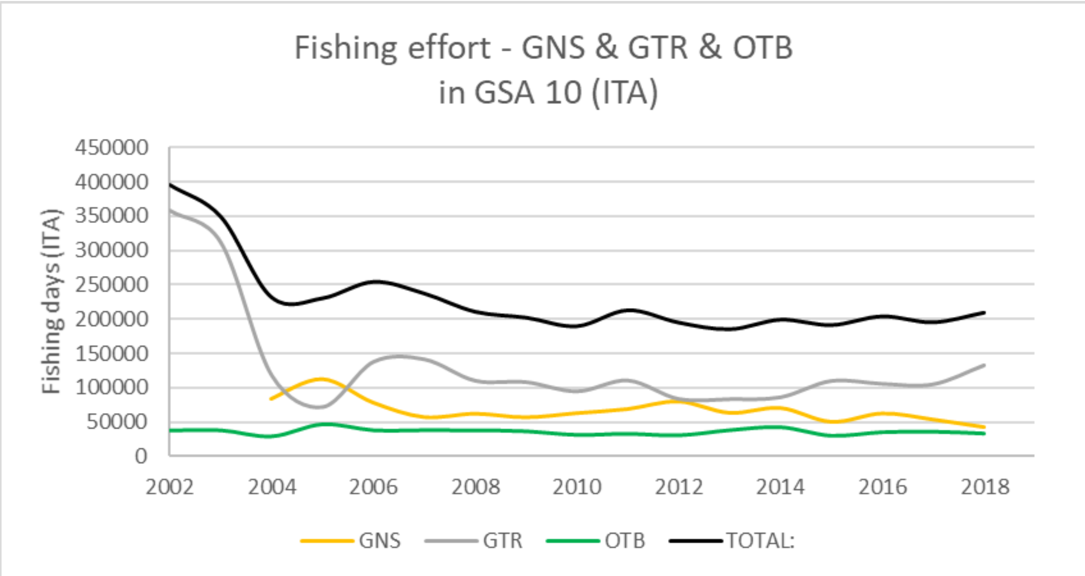


Figure 6.12.2.2.1. Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 10 in the period from 2002 to 2018 by fishing gear.

Table 6.12.2.2.1. Nominal effort (fishing days) associated to *Mullus barbatus* in GSA 10 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). EWG19-10 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). In addition, the EWG19-10 attempted to include the Italian GRUND survey (1994-2008) in the analysis, using the information collected by RECFISH project, in the attempt of increasing the model performance. Indeed, GRUND survey was generally carried out in autumn, thus the detecction more frequent of the recruitment, could improve the estimation of the recruitment also in the model. However, the analyses revealed that the GRUND survey was not informative for the model, and it was therefore not included in the final model run.

Figure 6.12.2.3.1. Survey periods (MEDITS, 1994-2018) in GSA 10.

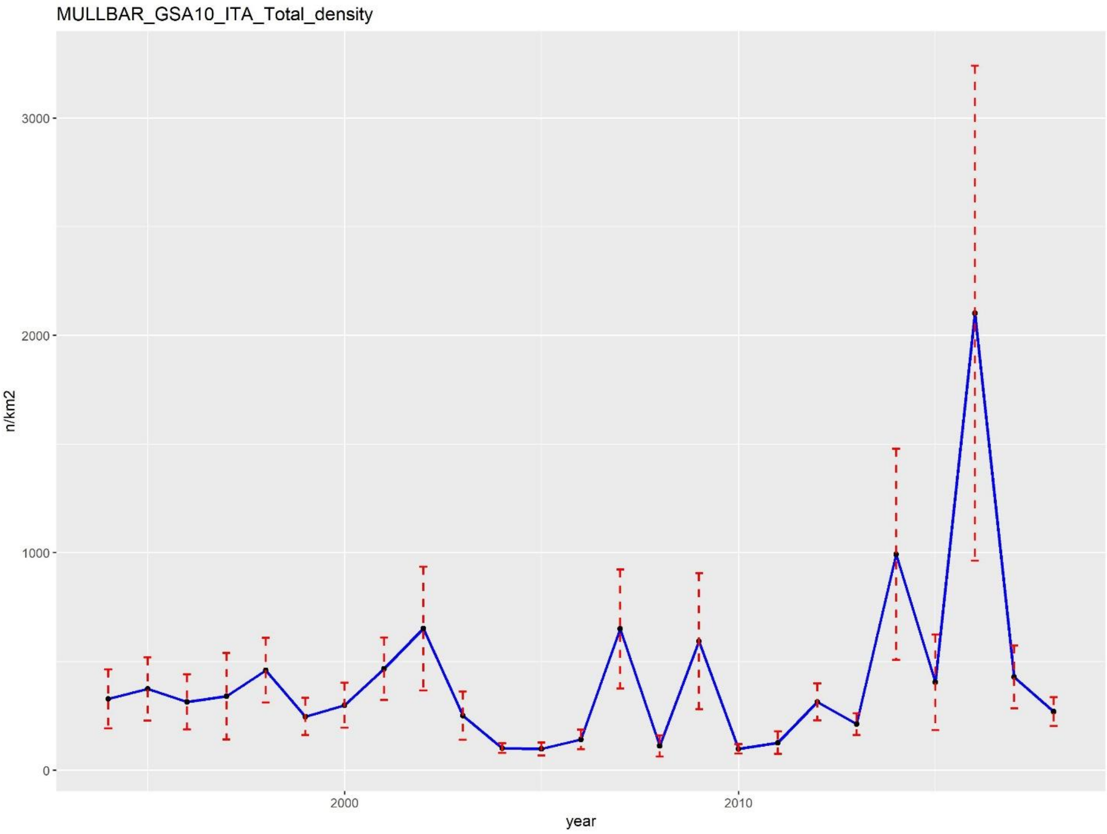


Figure 6.12.2.3.2. Abundance indices (N/km^2) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2018).

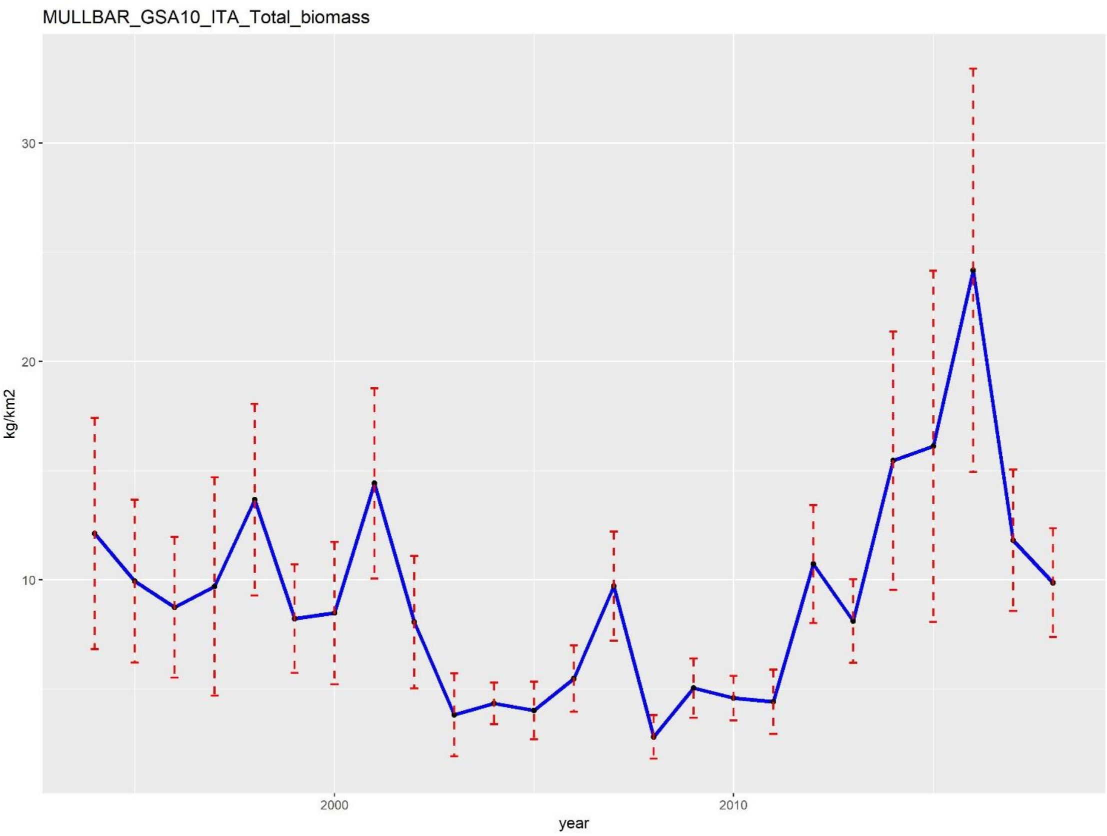


Figure 6.12.2.3.3. Biomass indices (kg/km^2)) of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2018).

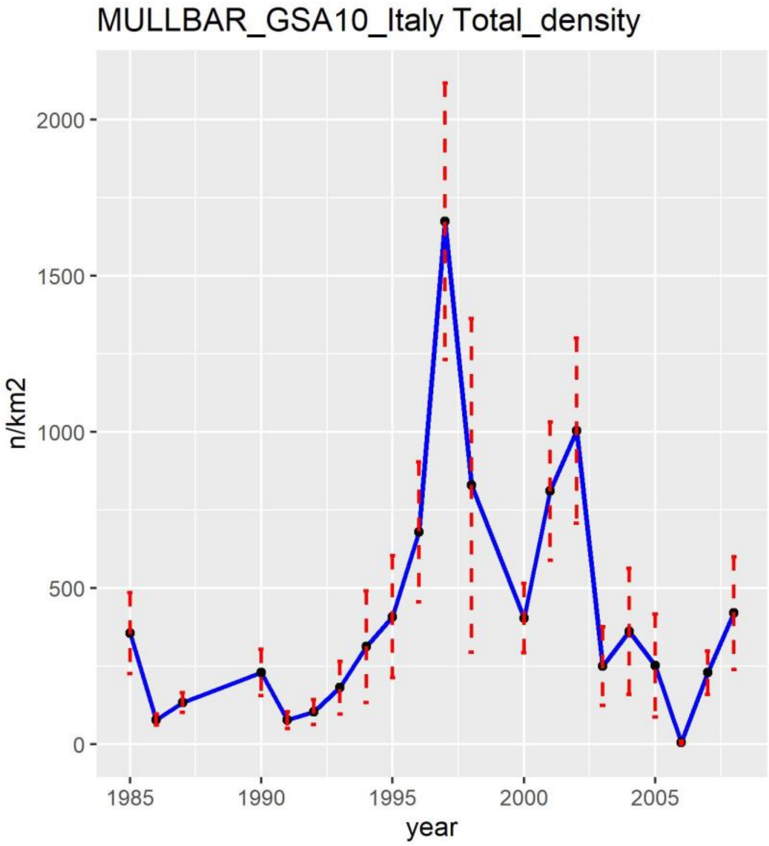


Figure 6.12.2.3.4. Abundance indices (N/km^2) of red mullet in GSA 10 as derived from trawl surveys (GRUND, 1985-2008).

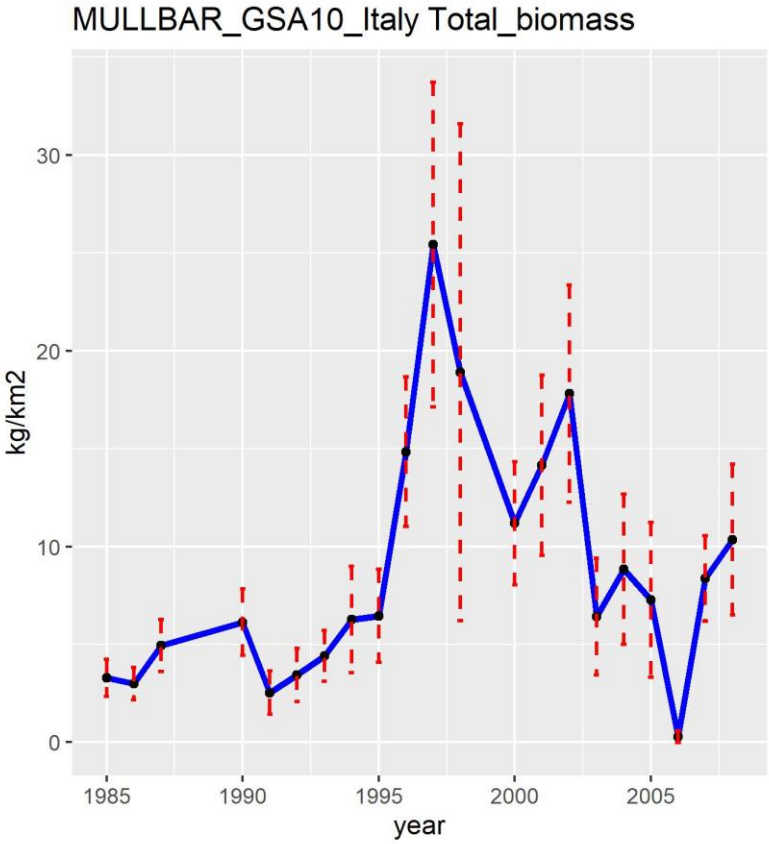


Figure 6.12.2.3.5. Biomass indices (kg/km^2)) of red mullet in GSA 10 as derived from trawl surveys (GRUND, 1985-2008).

Size structure indices of red mullet in GSA 10, as derived from trawl surveys (MEDITS, 1994-2018), 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.

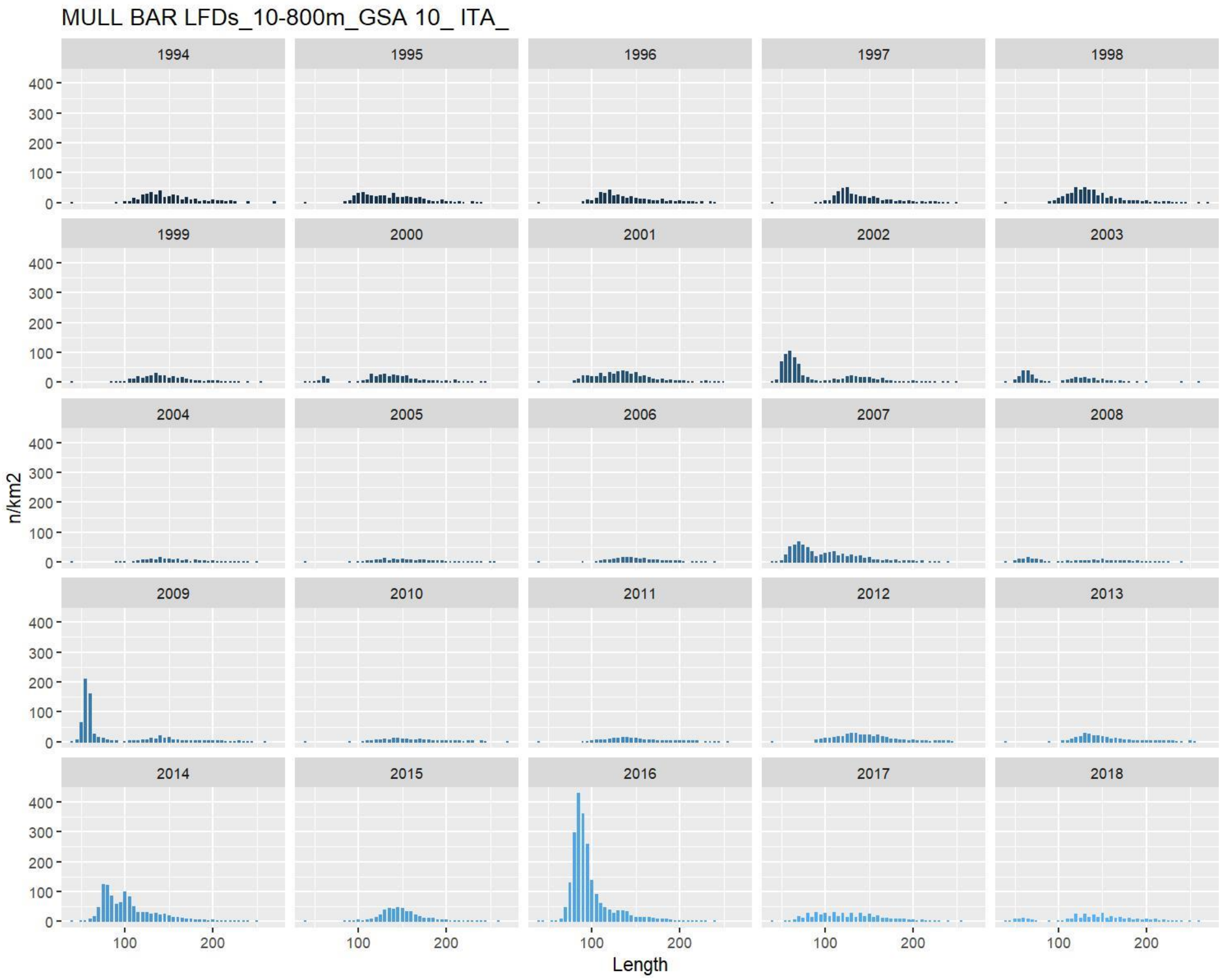


Figure 6.12.2.3.6. Size structure indices of red mullet in GSA 10 as derived from trawl surveys (MEDITS, 1994-2018).

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. While in previous years the assessment was performed since 2004, EWG19-10 included 2002 and 2003 data in the assessment, not occuring the same convergence problems of the last years.

Table 6.12.3.1. Values of catch at age per year used in the assessment.

	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

Table 6.12.3.2. 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

Table 6.12.3.3. 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

Age slicing of the length frequency distributions of landing, discard and survey has been done by sex (in combination with sex ratio at length) using a4aGr model and then data were combined. The final catch at age data are shown in the Figure 6.12.3.1 and Table 6.12.3.1. The corresponding mean weights at age ate shown in Table 6.12.3.2.

The 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.

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.

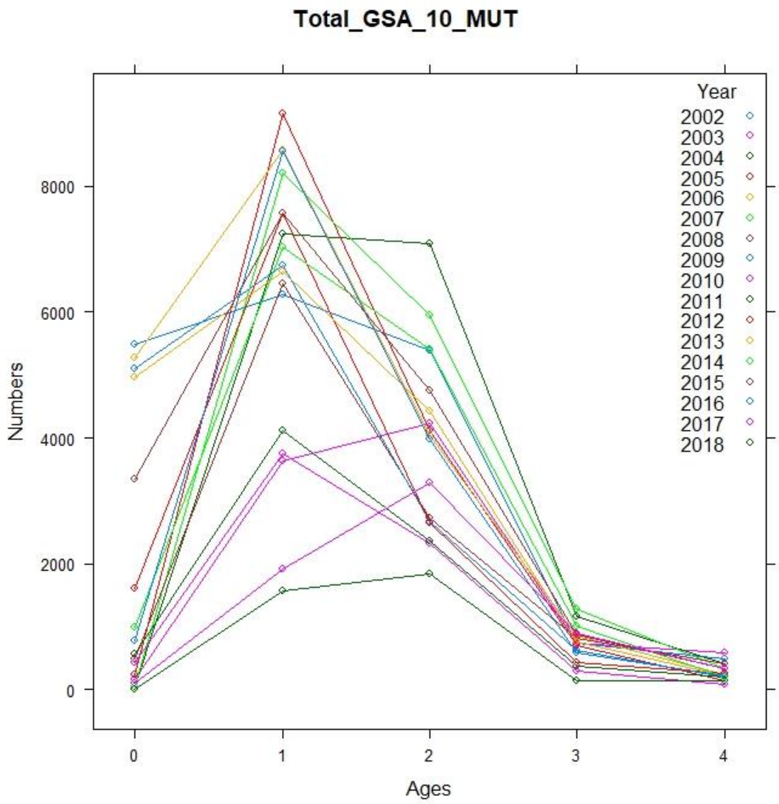


Figure 6.12.3.1. Catch-at-age data of red mullet in GSA10.

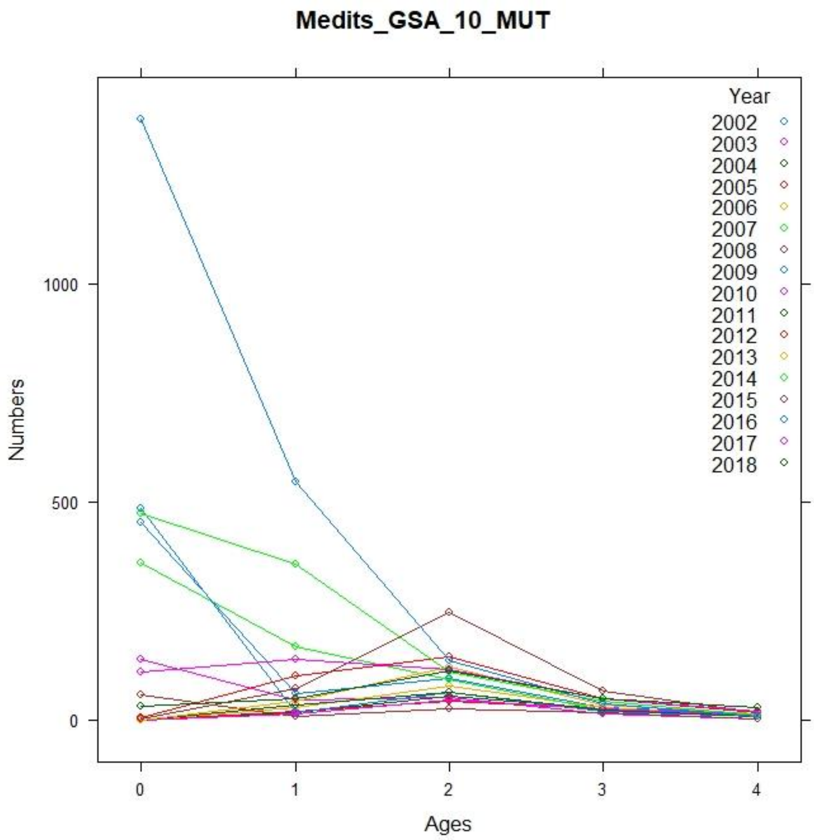


Figure 6.12.3.2. MEDITS indices describing density by age of red mullet in GSA10 by years.

For the assessment purposes, different F, q and sr sub-model were explored. 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, 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)

Results are shown below (Figure 6.12.3.4).

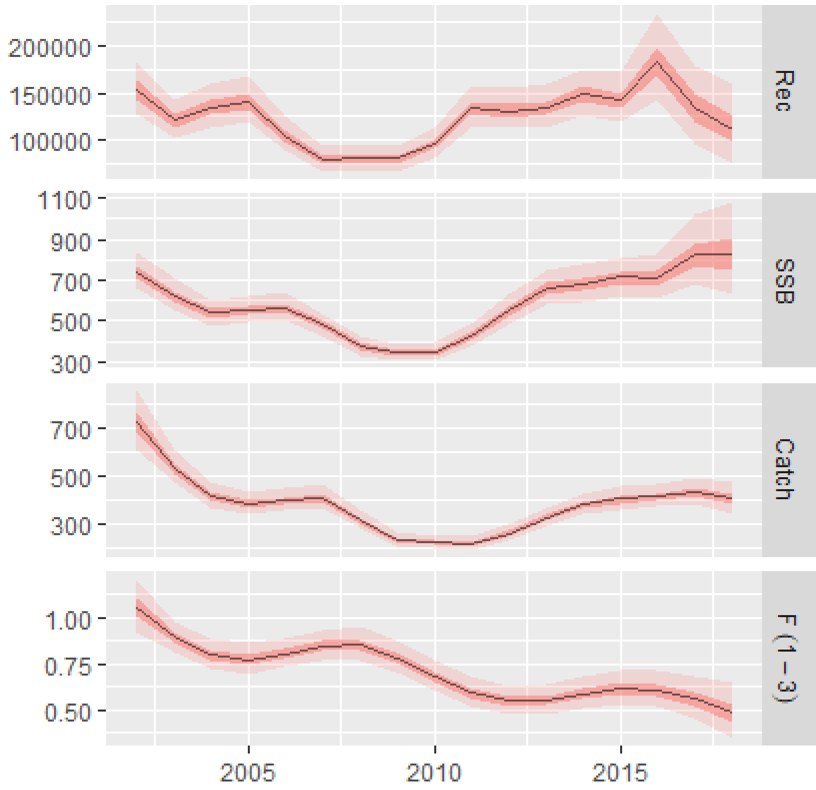


Figure 6.12.3.4. Results of the best a4a model outcomes for red mullet in GSA10.

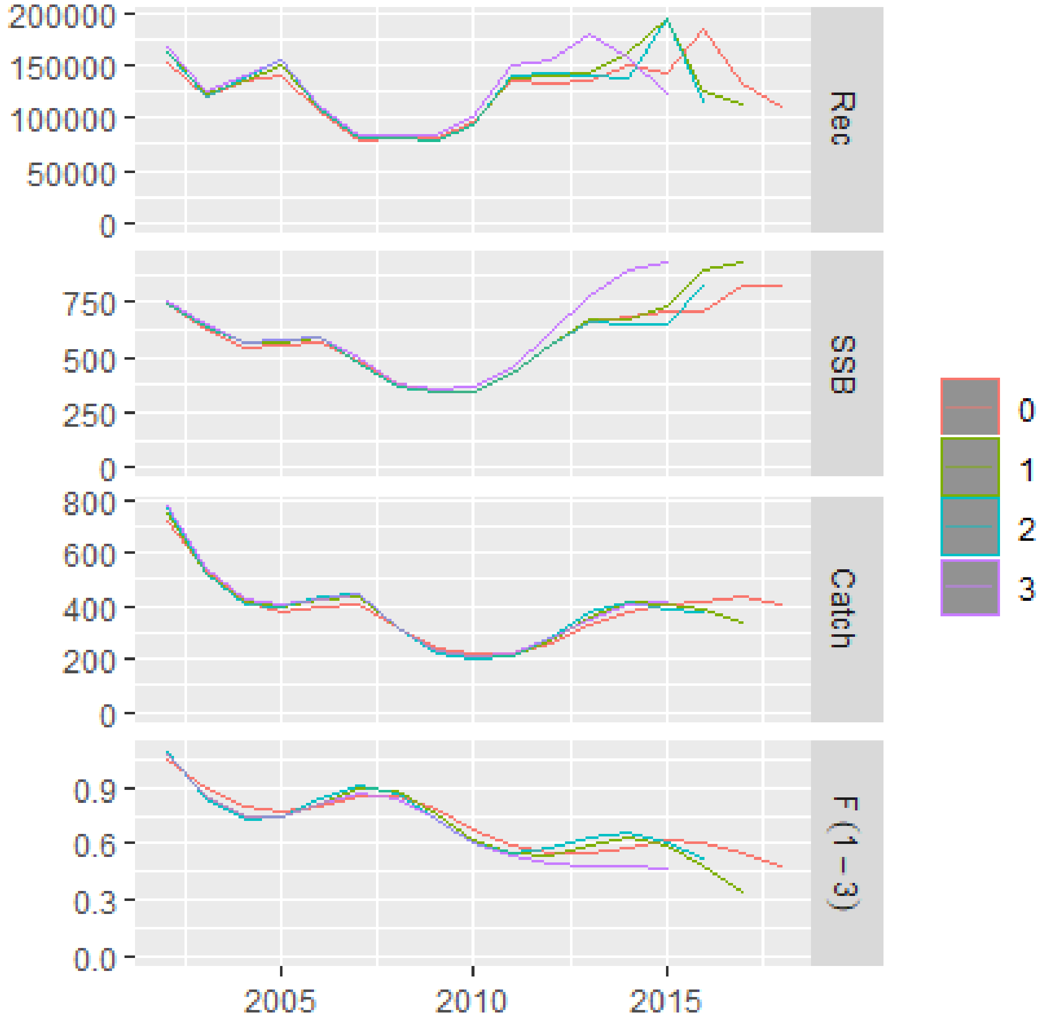


Figure 6.12.3.5. Retrospectve analysis of the best a4a model outcomes for red mullet in GSA10.

Log residuals of the catch and MEDITS abundance indices related to the best run do not show any particular trends over time with the possible exception of catch at ages 1 and 3 (Figure 6.12.3.6), however the fit to overall catch and to survey showed no trend. This choice is supported by the reasonable retrospective performance. The final assessment outcomes are given in summary in Table 6.12.3.4 and as N and F at age in Tables6.12.3.5 and 6.12.3.6 respectively.

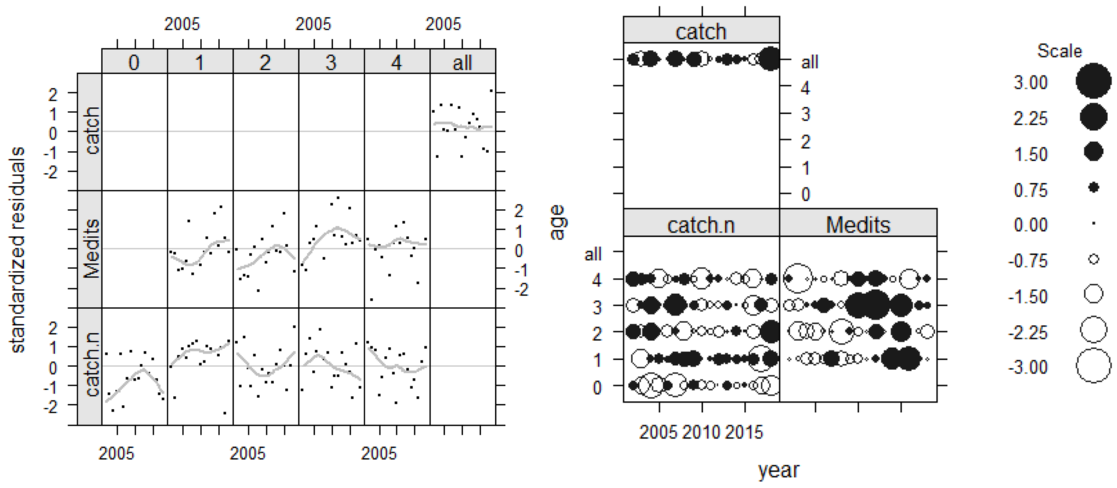


Figure 6.12.3.6 Log residuals of catch and MEDITS abundance indices.

Table 6.12.3.4. Final results of the red mullet assessment in GSA10.

Year	Recruitment age 0 (housands)	SSB tonnes	Catch tonnes	F ages 1-3
2002	153260	740	715	1.05
2003	120618	619	530	0.89
2004	134856	538	414	0.80
2005	141093	551	382	0.77
2006	105411	564	396	0.80
2007	78952	479	408	0.85
2008	81516	374	314	0.85
2009	80375	345	236	0.78
2010	96466	345	220	0.68
2011	134667	423	218	0.59
2012	131414	550	261	0.55
2013	134563	663	326	0.55
2014	148763	679	379	0.58
2015	142380	711	402	0.62
2016	183410	709	412	0.61
2017	132753	826	434	0.55
2018	110830	822	403	0.48

Table 6.12.3.5. Stock number at age for red mullet in GSA10.

	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

Table 6.12.3.6. Fishing mortality at age for red mullet in GSA10.

	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

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 6.12.3 assessment.

The value of $F_{0.1}$ calculated by FLBRP package on the a4a assessment results is equal to 0.41. The F value estimated for 2018, 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, as confirmed by the decline in recruitment.

6.12.5 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 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 (2018) from the a4a assessment was used for F in 2019. 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 2019. Recruitment (age 0) for 2019 to 2021 has been estimated from the population results as the geometric mean of the whole time series of 17 years (120897.6).

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 2016-2018	mean weights at age, maturation at age, natural mortality at age and selection at age
$F_{ages\ 1\text{-}3}$ (2019)	0.48	F 2018 used to give F status quo for 2019
SSB (2019)	740	Stock assessment 1 January 2019
R_{age0} (2019,2020)	120898	Geometric mean of the time series 17 years 2002-2018
Total catch (2019)	369	Assuming F status quo for 2019

These assumptions resulted in a catch and a SSB in 2019 equal to 369 and 740 tons, respectively.

The analysis, carried out with stf.r FLR script made available to the EWG, shows that fishing at a level equal to $F_{0.1}$ (=0.41) would increase the SSB of the 3% from 2019 to 2021, while decreasing the catch by the 23% from 2018 to 2020.

Table 6.12.5.2 – Short term forecast table for red mullet in GSA 10.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2020	SSB* 2019	SSB* 2021	Change SSB 2019-2021 (%)	Change Catch 2018-2020 (%)
High long term yield ($F_{0.1}$)	0.9	0.41	403	309	763	780	2.58	-23.18
F upper	1.2	0.56	403	397	711	669	-12.03	-1.45
F lower	0.6	0.27	403	219	814	903	18.78	-45.52
Zero catch	0	0.00	403	0	929	1239	62.97	-100.00
Status quo	1	0.48	403	350	740	728	-4.25	-13.22
Different Scenarios	0.1	0.05	403	43	908	1170	53.91	-89.45
	0.2	0.10	403	83	887	1106	45.48	-79.38
	0.3	0.14	403	122	867	1046	37.63	-69.76
	0.4	0.19	403	159	847	991	30.33	-60.57
	0.5	0.24	403	194	828	939	23.52	-51.78
	0.6	0.29	403	228	810	891	17.17	-43.38
	0.7	0.33	403	260	791	846	11.25	-35.34
	0.8	0.38	403	291	774	804	5.72	-27.65
	0.9	0.43	403	321	757	764	0.57	-20.28
	1.1	0.52	403	377	723	694	-8.76	-6.46
	1.2	0.57	403	403	707	662	-12.97	0.02
	1.3	0.62	403	428	692	632	-16.92	6.23
	1.4	0.67	403	452	677	603	-20.61	12.20
	1.5	0.72	403	475	662	577	-24.07	17.92
	1.6	0.76	403	497	648	552	-27.32	23.42
	1.7	0.81	403	518	634	529	-30.36	28.70
	1.8	0.86	403	539	620	508	-33.22	33.77
	1.9	0.91	403	559	607	487	-35.91	38.65
	2	0.95	403	578	594	468	-38.43	43.35

*SSB at mid year

EWG advises that when the management strategy is applied, catches in 2020 should be no more than 309 tonnes.

6.12.6 Data Deficiencies

EWG19-10 has noted that landing and discard data of the 3rd quarter of 2017 were missing for all gears and fisheries, as well as the landing and discard of the first quarter 2018. The missing landing data were requested to the Member State and received in the due time to carry out the assessment. Being available the landing data of the third quarter in 2017, the discard of the third quarter was estimated.

Despite these deficiencies, addressed on time for the analyses, an uncommon length structure (between 15 and 20 cm) associated to the discard of the GTR with vessel length VL0006 in 2018 was noticed in quarter 4. 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.

The EWG19-10 reported on line via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt.

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).

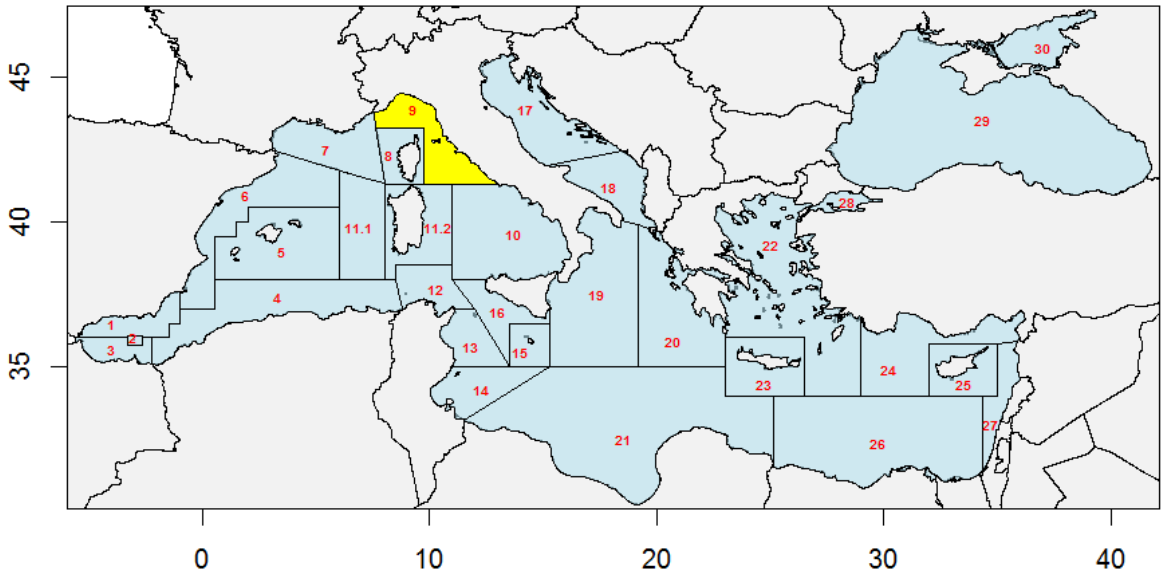


Figure 6.13.1.1 Limit of Geographical Sub-Area (GSA) 9.

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 6.18.1.2.

Table 6.13.1.2 Norway lobster in GSA 9: natural mortality and proportion of mature vectors by age.

Age	Natural mortality	Proportion of matures
1	0.75	0.40
2	0.50	0.75
3	0.39	1.00
4	0.33	1.00
5	0.29	1.00
6	0.26	1.00
7	0.24	1.00
8	0.23	1.00
9+	0.23	1.00

6.13.2 DATA

6.13.2.1 CATCH (LANDINGS AND DISCARDS)

The annual total landings of Norway lobster available in the DCF database are reported in Table 6.13.2.1.1 and Figure 6.13.2.1.1. In general, landings are showing a decreasing pattern along the time series, 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).

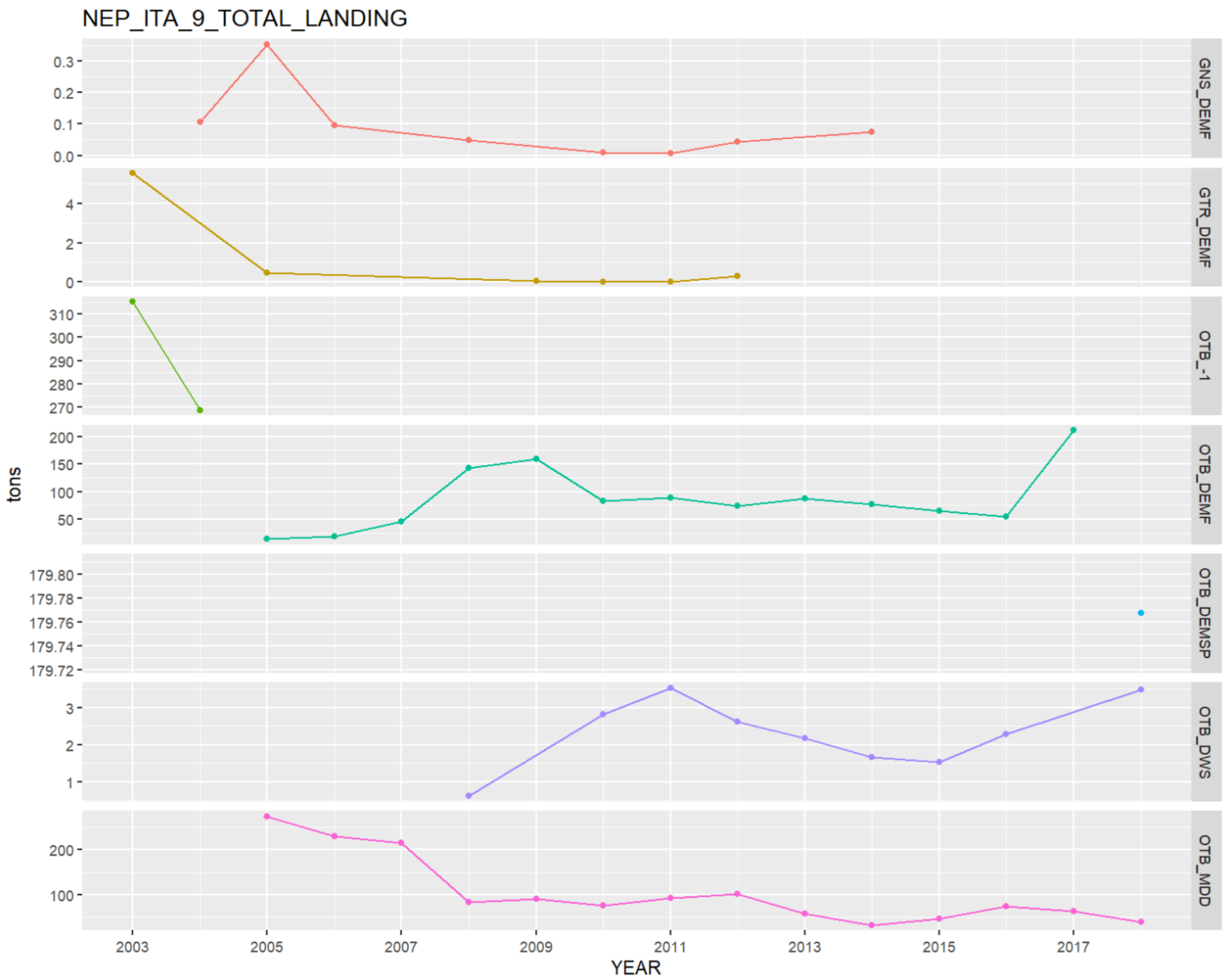


Figure 6.13.2.1.2. Norway lobster in GSA 9: landings trend by gear in GSA 9.

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 6.13.2.1.3. 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	273.8	0.00
2018	223.2	0.00

Table 6.13.2.1.4. 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 6.18.2.1.5-6.18.2.1.7.

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.

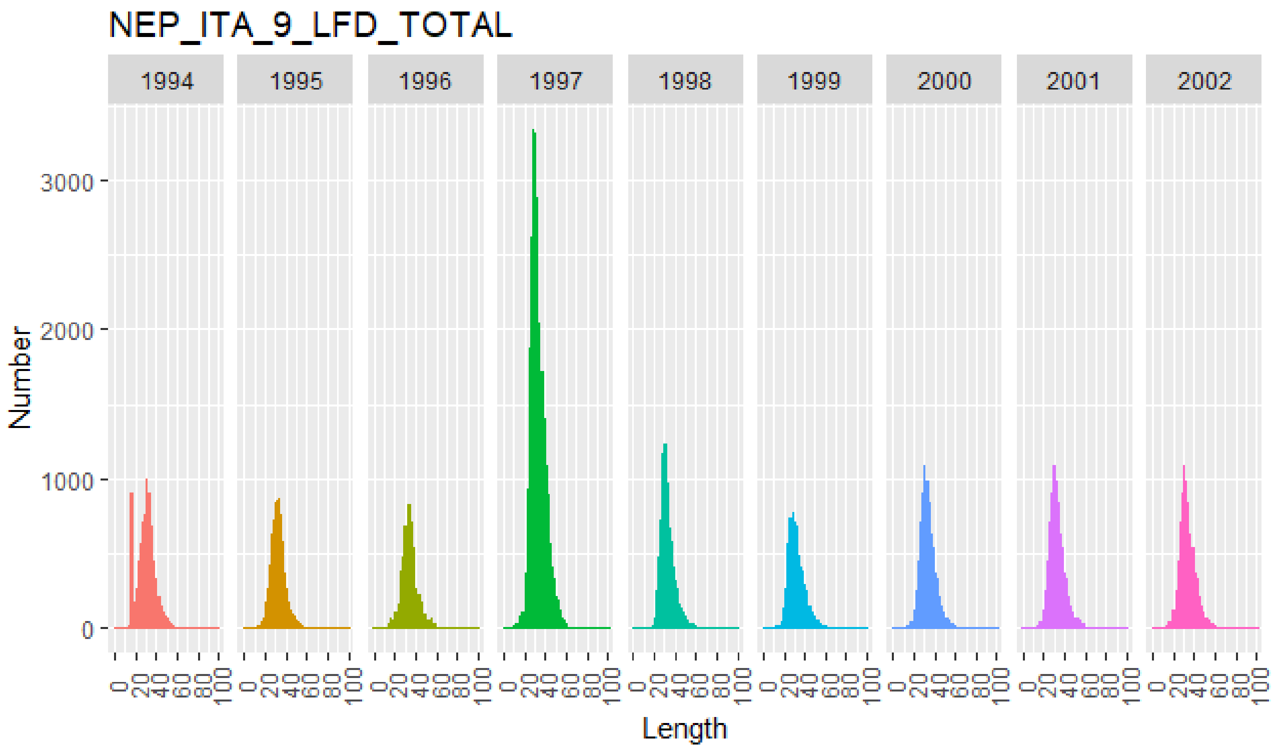


Figure 6.13.2.1.3. Norway lobster in GSA 9: LFDs of landings by year provided by the RECFISH project.

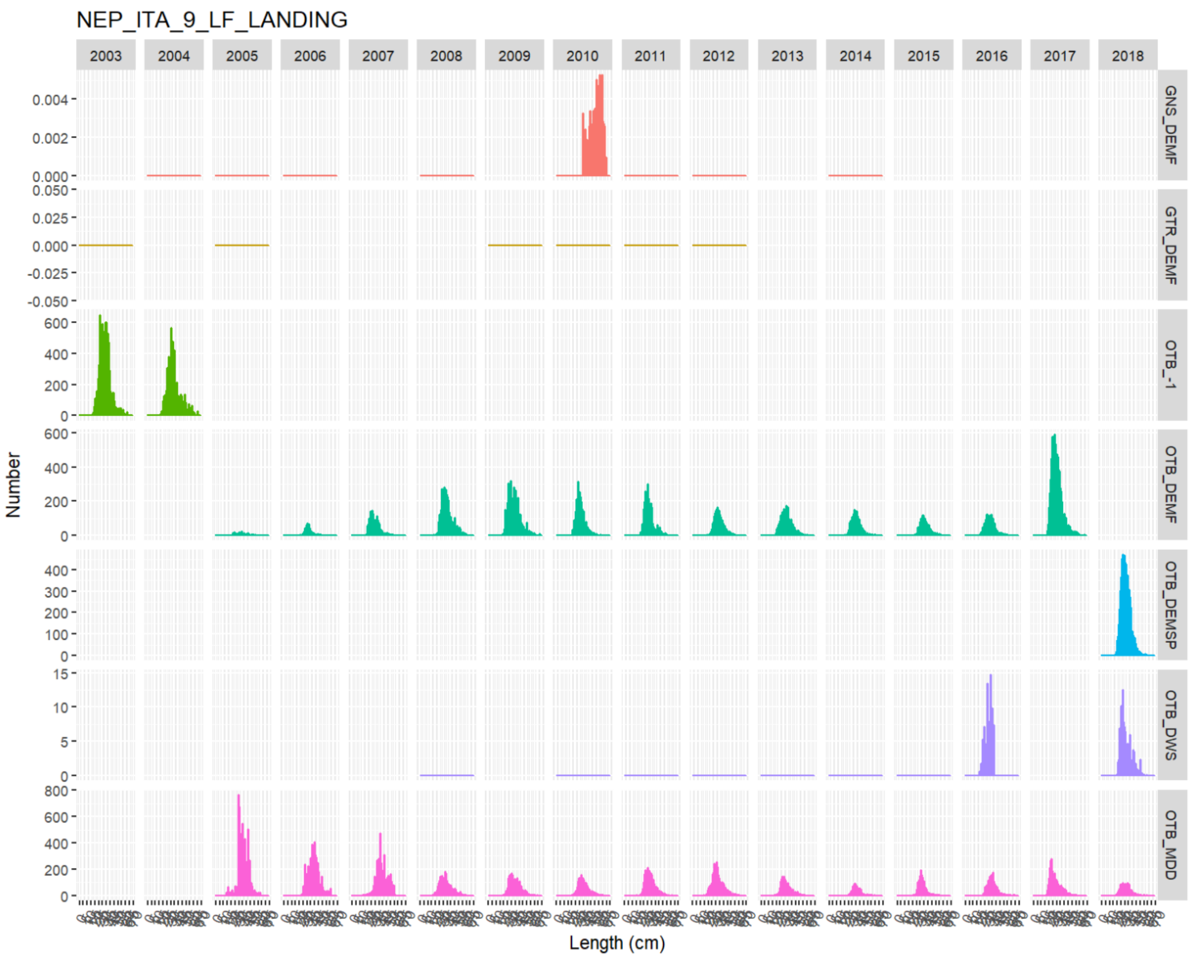


Figure 6.13.2.1.4. Norway lobster in GSA 9: LFDs of landings by year and gear of Norway lobster in GSA 9.

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 6.18.2.1.2. 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 6.18.2.1.8.

Table 6.13.2.1.5. 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	13.0
2018	0.7

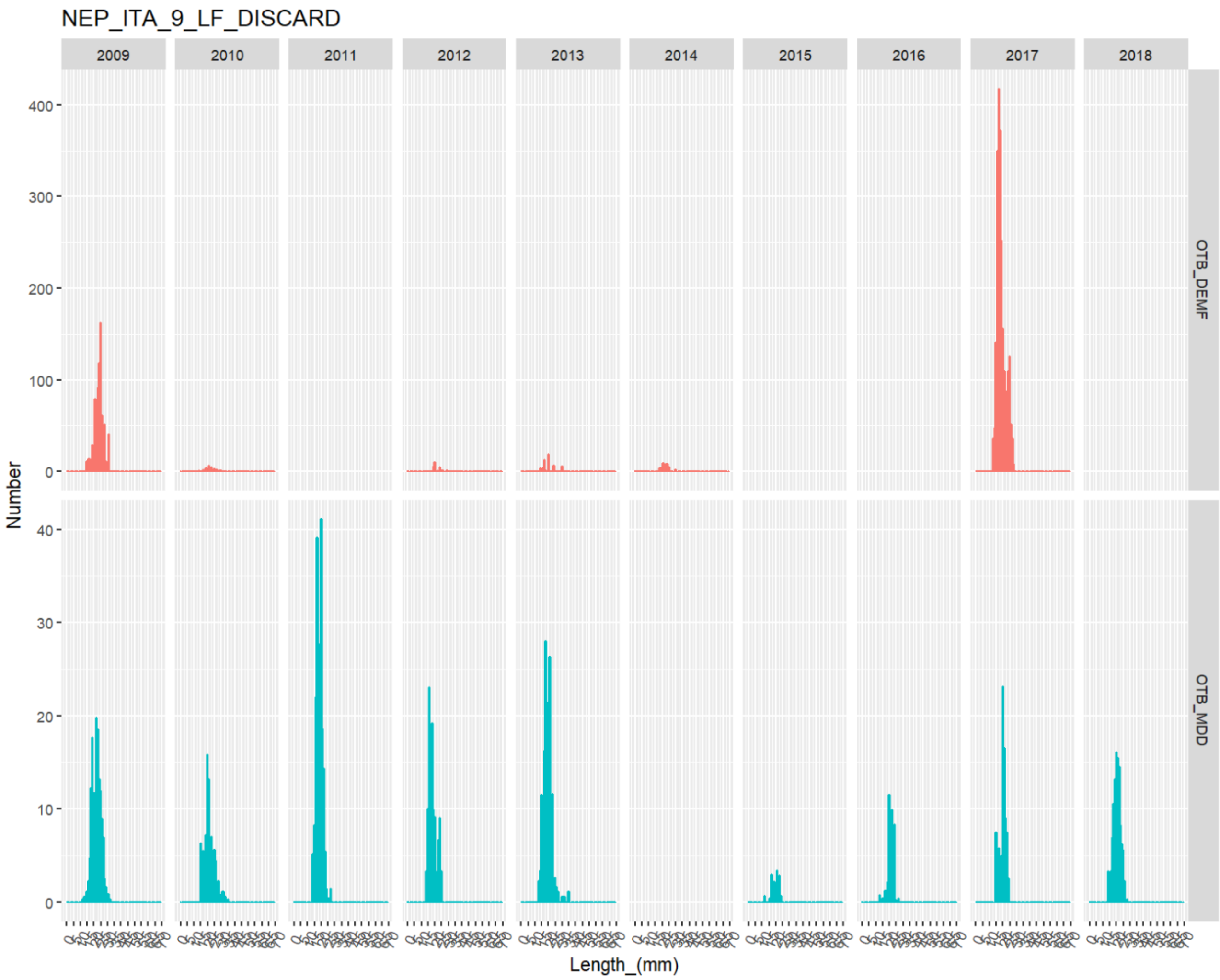


Figure 6.18.2.1.5. Norway lobster in GSA 9: LFDs of discards of Norway lobster in GSA 9.

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 6.18.2.2.1 and Figure 6.18.2.2.1, nominal effort is reported in '000 kW*fishing days, in Table 6.18.2.2.2 and Figure 6.18.2.2.2, 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

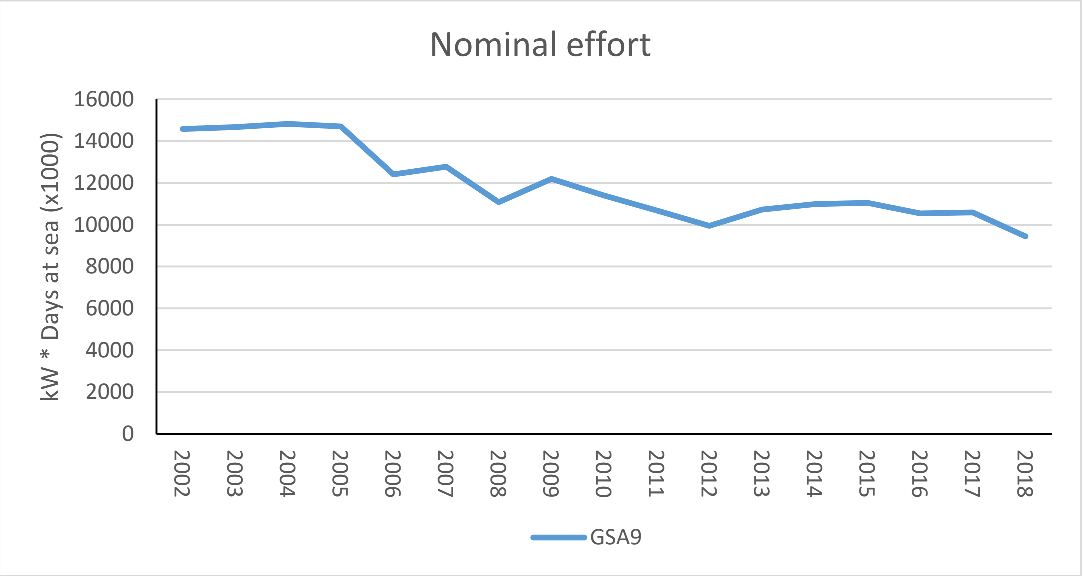


Figure 6.13.2.2.1. Norway lobster in GSA 9: Trend of OTB nominal effort (‘000 kW*fishing days) in GSA 9.

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

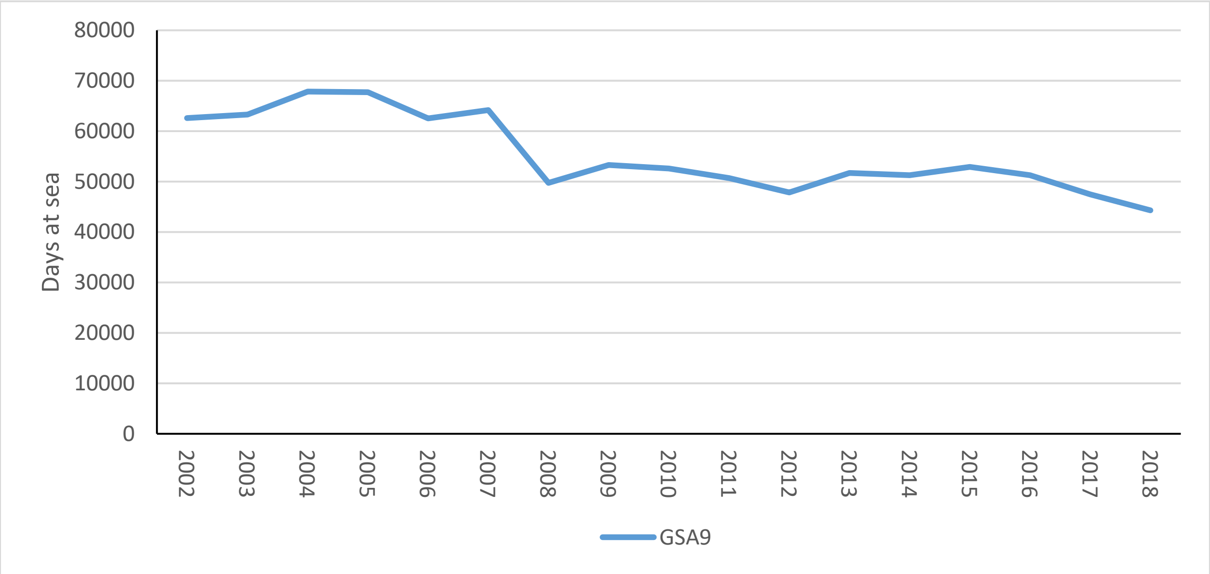


Figure 6.13.2.2.2. Norway lobster in GSA 9: Trend of OTB effort (Days at sea) in GSA 9.

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 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).

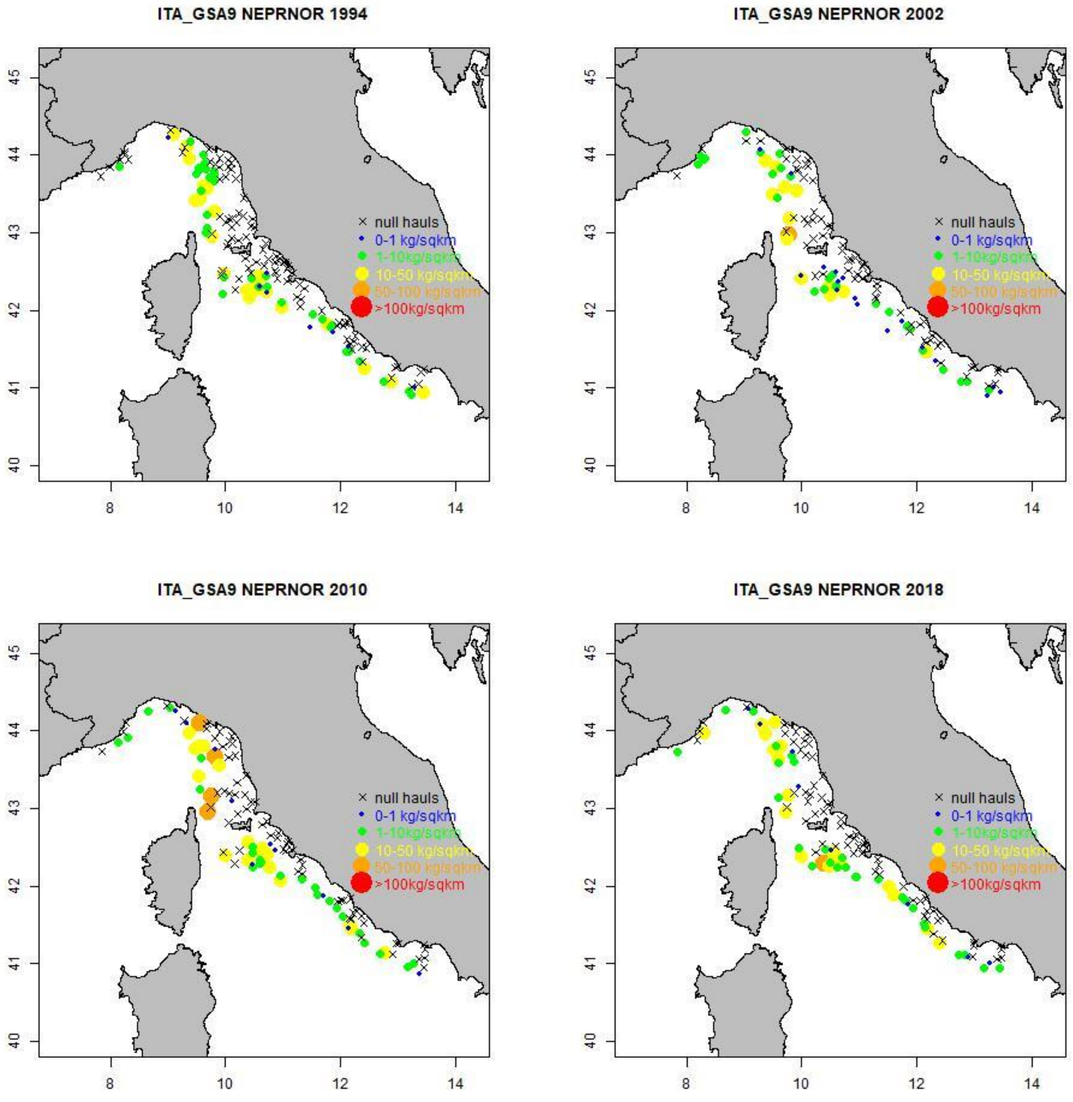
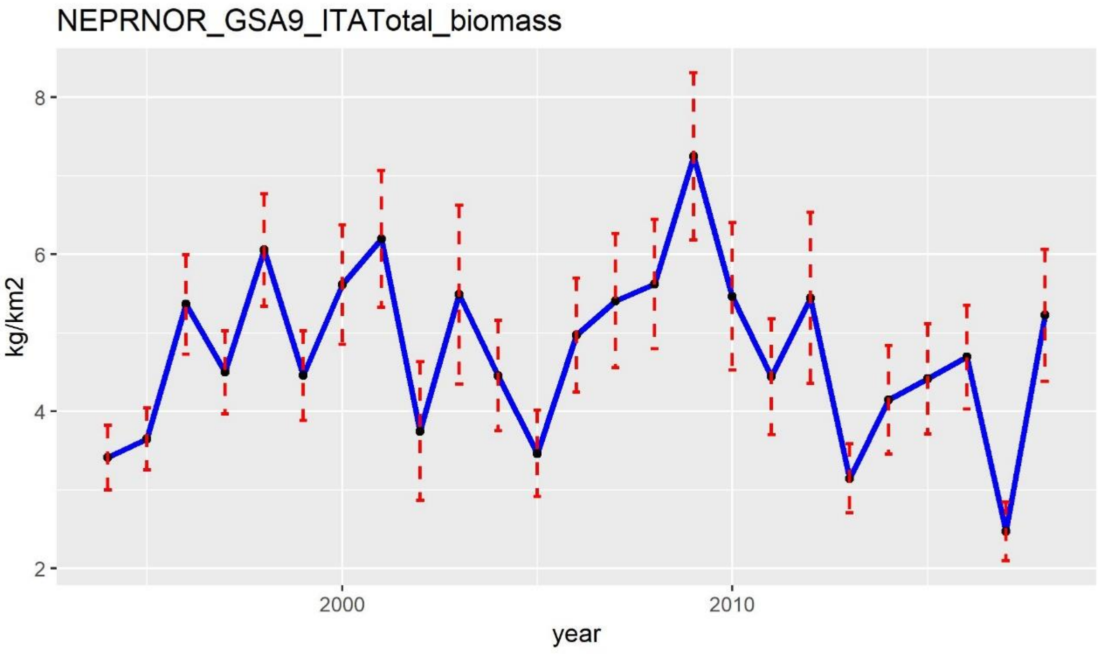


Figure 6.13.2.3.1 Norway lobster in GSA 9: distribution pattern in the period 1994-2018 (MEDITS survey). Maps for the years 1994, 2002, 2010 and 2018 are shown.

Trends in abundance and biomass

The trends of the MEDITS indices (biomass and density) computed on the three GSAs combined are shown in Figure 6.18.2.3.2.

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.



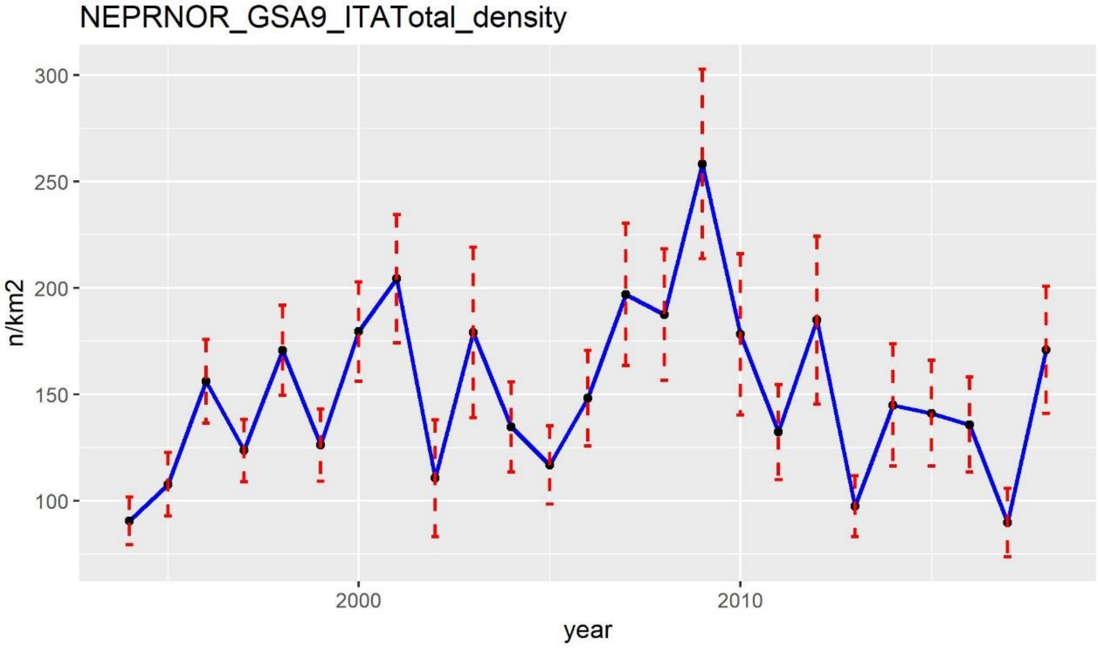


Figure 6.13.2.3.2. Norway lobster in GSA 9: MEDITS standardized biomass and density indices (10-800 m).

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 6.18.2.3.3-6.18.2.3.5. 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.

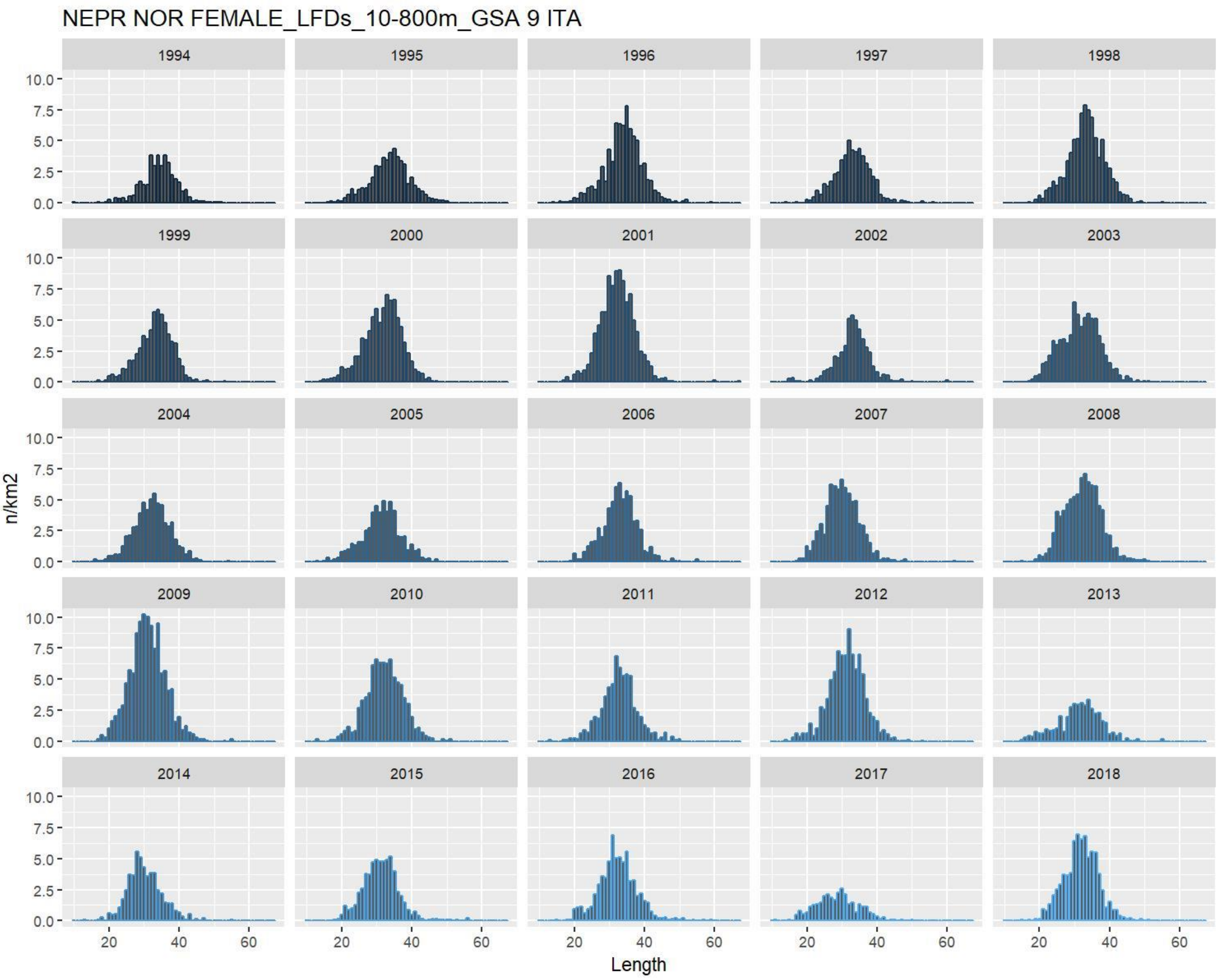


Figure 6.13.2.3.3. Norway lobster in GSA 9: stratified abundance indices by size for females, 1994-2018.

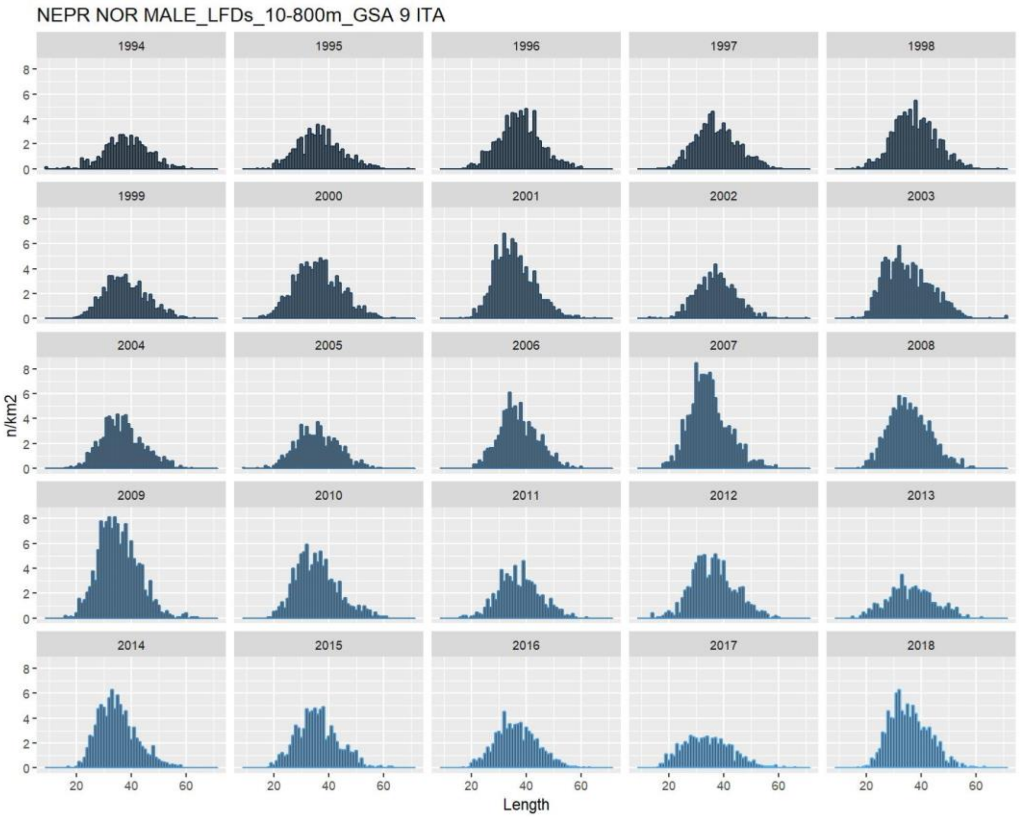


Figure 6.13.2.3.4. Norway lobster in GSA 9: stratified abundance indices by size for males, 1994-2018.

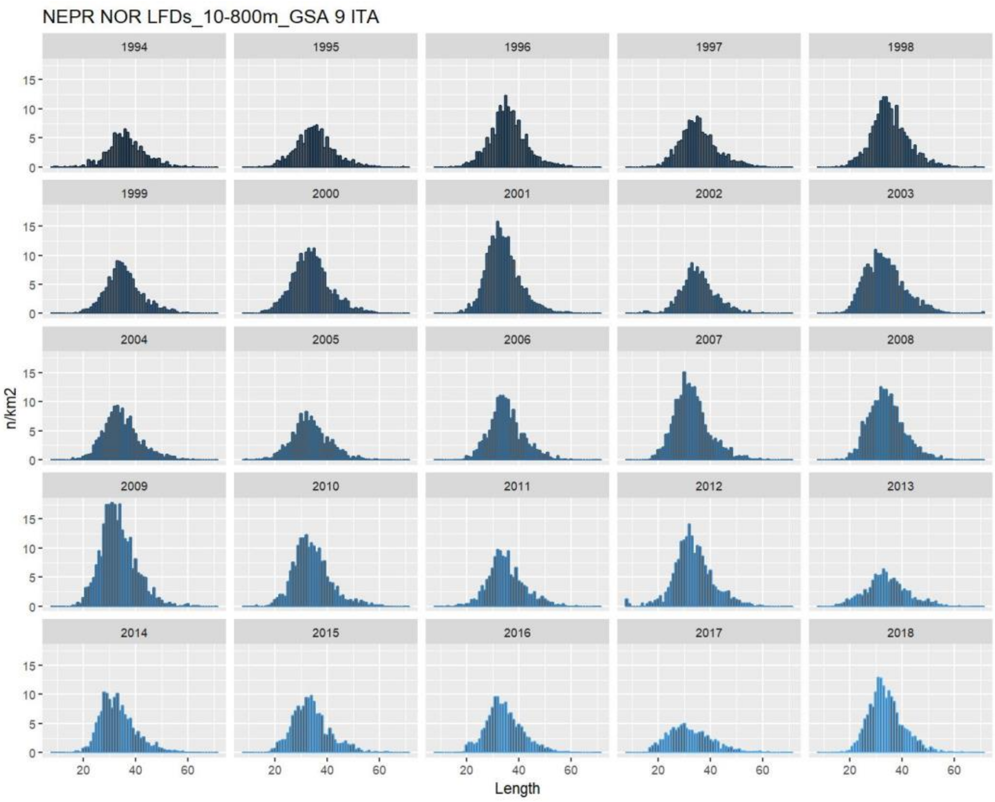


Figure 6.13.2.3.5 Norway lobster in GSA 9: total stratified abundance indices by size, 1994-2018.

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 1994-2018 for the catch data and 1994-2018 for the tuning file (MEDITS indices). This is a considerable extention to the series tried 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 6.18.1.1. 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 account for spawning at middle year.

Landings in 1997 (reported in the Italian official statistics) 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 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.

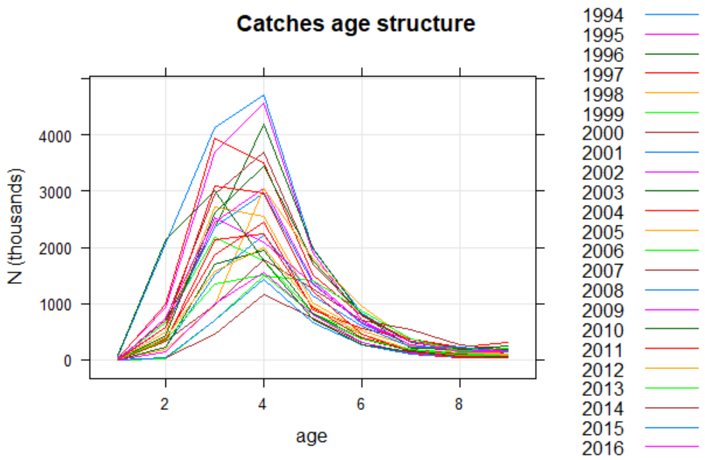


Figure 6.13.3.1. Norway lobster in GSA 9: catch-at-age distribution by year of the catches (1994-2018).

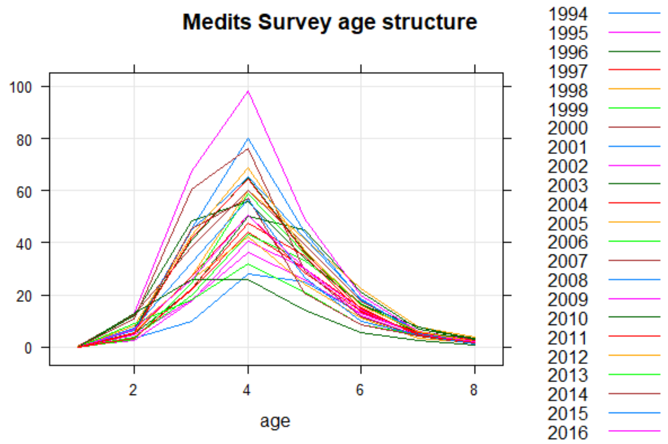


Figure 6.13.3.2. Norway lobster in GSA 9: catch-at-age distribution by year of the MEDITS survey (1994-2018).

Table 6.13.3.1. Norway lobster in GSA 9: catch-at-age matrix (thousands).

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	52.95	44.04	15.87	28.96	0.02	28.52	22.56	18.15	18.64	0.02	0.02	29.66	0.02
2	2068.10	940.40	697.83	997.69	496.42	657.78	710.43	571.64	587.18	434.60	382.37	192.73	16.69
3	4130.60	3693.40	2349.20	3947.90	2722.80	2174.60	2947.60	2371.70	2436.20	2620.60	1864.60	967.75	702.52
4	4706.40	4563.80	4187.20	3494.10	2553.20	1771.00	3687.90	2967.40	3048.10	3433.10	2437.40	3043.60	1496.60
5	1973.50	1903.00	1986.70	1506.00	1020.70	820.93	1698.80	1366.90	1404.10	1760.80	890.20	1804.20	1402.40
6	818.65	707.86	780.78	791.73	510.77	462.32	807.52	649.75	667.42	811.33	553.90	946.61	876.36
7	315.25	266.57	312.32	340.16	250.85	179.66	328.55	264.36	271.55	214.78	368.55	340.41	371.26
8	175.67	147.23	194.77	223.05	147.60	130.76	204.54	164.58	169.05	188.10	220.04	158.83	168.06
9+	95.38	85.85	245.60	110.10	73.73	62.79	170.19	136.94	140.67	193.16	316.53	92.35	197.08
Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
1	6.07	0.02	4.94	2.89	7.88	7.34	13.37	0.02	0.70	0.94	84.19	3.41	
2	335.97	229.16	737.92	236.77	337.78	394.08	360.66	43.89	36.95	149.96	2133.10	575.96	
3	968.53	1519.80	2539.80	1709.10	2134.80	1578.90	1338.80	458.35	708.16	990.63	3000.30	3088.80	
4	1786.30	2219.00	2097.10	1942.90	2237.00	1992.20	1523.30	1168.80	1420.50	1555.60	1769.90	2960.60	
5	1270.60	1131.10	1350.60	836.48	940.49	951.33	810.06	753.40	656.60	817.10	718.94	1221.80	
6	696.87	590.84	672.54	363.55	398.46	451.81	368.85	311.06	269.80	311.86	273.49	445.15	
7	532.22	233.97	324.62	162.19	177.71	189.65	177.05	108.16	109.92	119.04	136.07	134.91	
8	276.72	218.80	141.91	77.72	94.87	91.35	88.92	48.21	54.87	61.68	60.02	60.84	
9+	161.23	133.98	155.83	56.99	50.45	66.81	53.59	58.25	50.90	44.25	71.00	47.25	

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	
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	
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	
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	
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	
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	
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	
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	
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	

Table 6.13.3.3. Catch (tons; discards are included).

1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
376.4	345.4	359.4	327.0	225.5	178.6	335.0	269.5	276.9	320.9	268.7	288.5	247.5
2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
260.6	227.7	259.5	162.6	185.0	179.0	149.0	112.0	113.7	131.3	170.0	223.9	

Table 6.13.3.4. 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	
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	
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	
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	
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	
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	
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	
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	
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	
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	

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(3,17))+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)

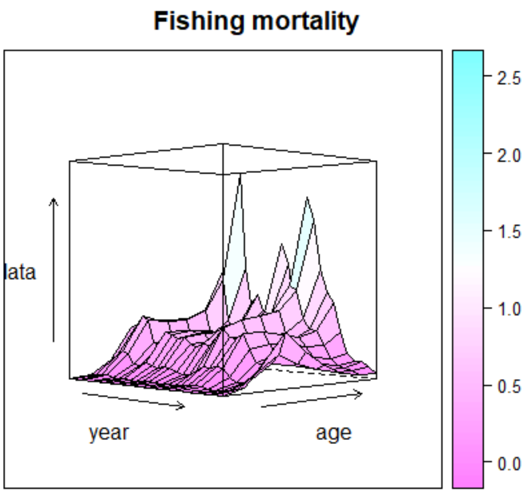


Figure 6.13.3.3. Norway lobster in GSA 9: fishing mortality by age and year obtained from the a4a model (1994-2018).

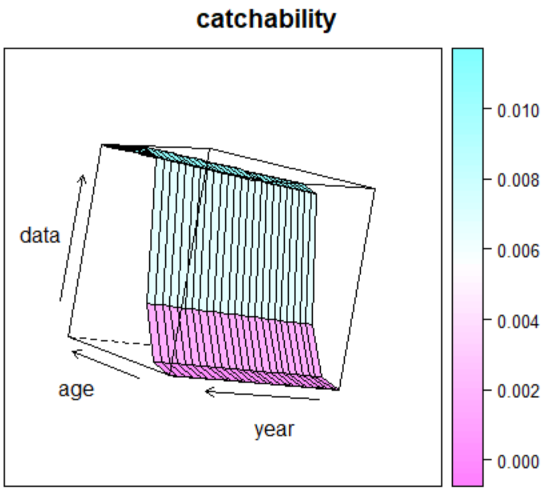


Figure 6.13.3.4. Norway lobster in GSA 9: catchability of the survey by age and year obtained from the a4a model.

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.

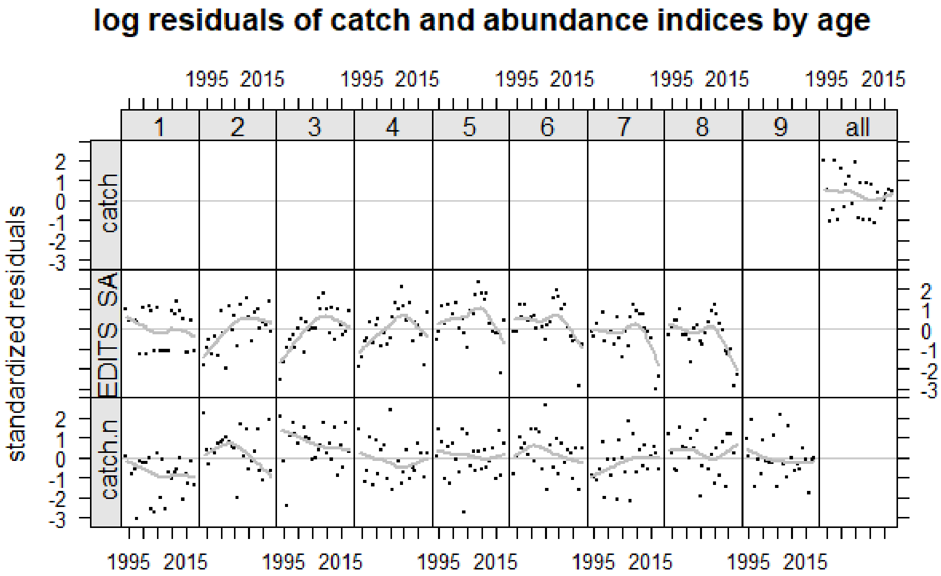


Figure 6.13.3.5. Norway lobster in GSA 9: log residuals for the catch-at-age data of the fishery and the survey, and the catches.

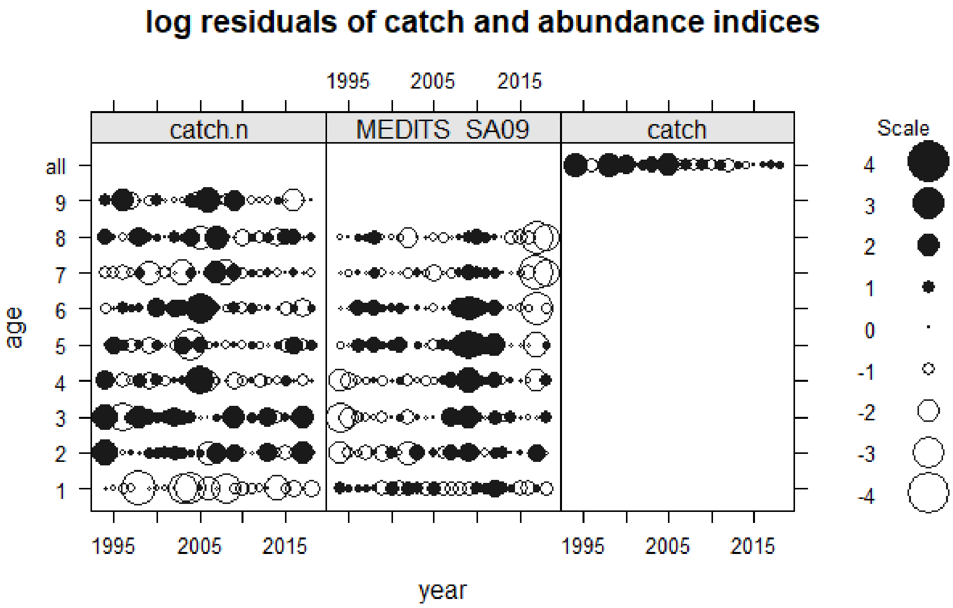


Figure 6.13.3.6. Norway lobster in GSA 9: bubble plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

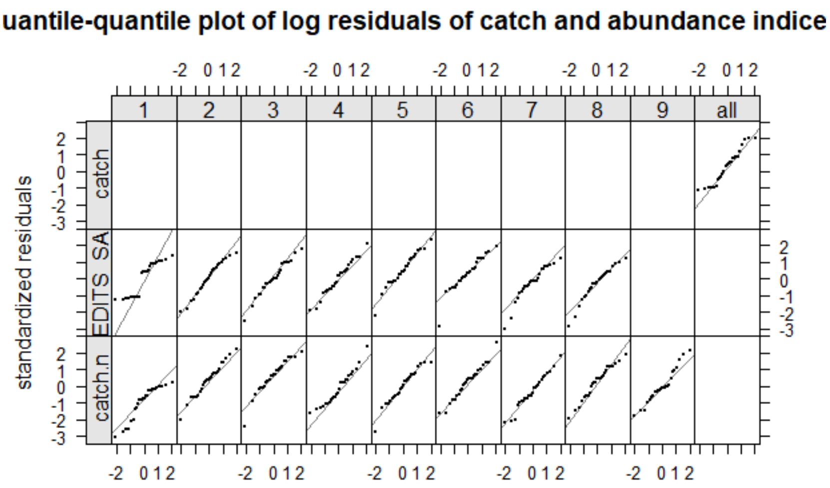


Figure 6.13.3.7. Norway lobster in GSA 9: QQ-plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

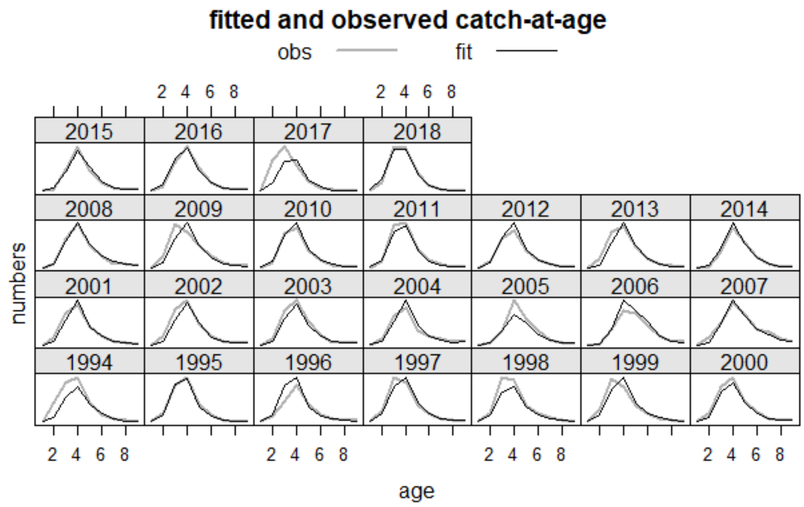


Figure 6.13.3.8. Norway lobster in GSA 9: fitted vs observed values by age and year for the catches.

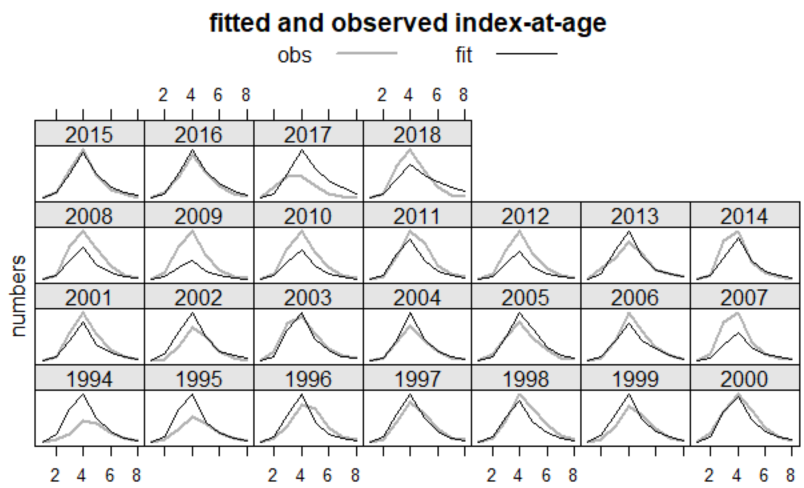


Figure 6.13.3.9. Norway lobster in GSA 9: fitted vs observed values by age and year for the survey.

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.

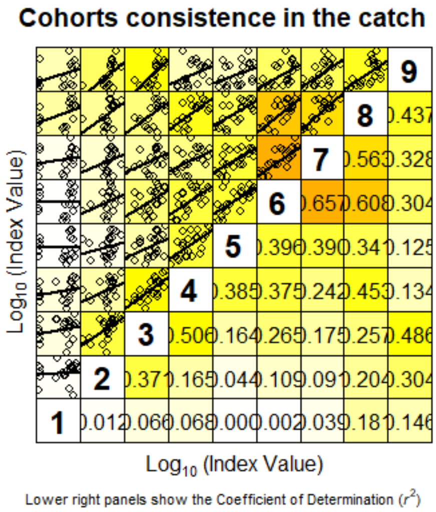


Figure 6.13.3.10. Norway lobster in GSA 9: internal consistency of the catch-at-age data.

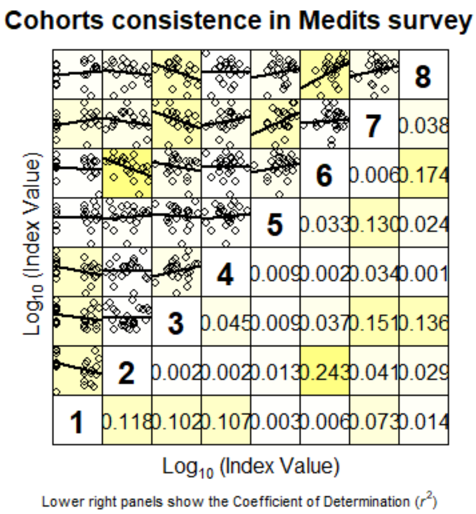


Figure 6.13.3.11. Norway lobster in GSA 9: internal consistency of the catch-at-age data of the MEDITS survey.

The effect of cryptic biomass was investigated, and did not show any relevant issue, as the biomass of the plus group (age 9+) is always below 5% of the total SSB, increasing to 13% in the last year.

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> F_{MSY} is robust to all years in the retrospective. The assessment is considered acceptable for advice.

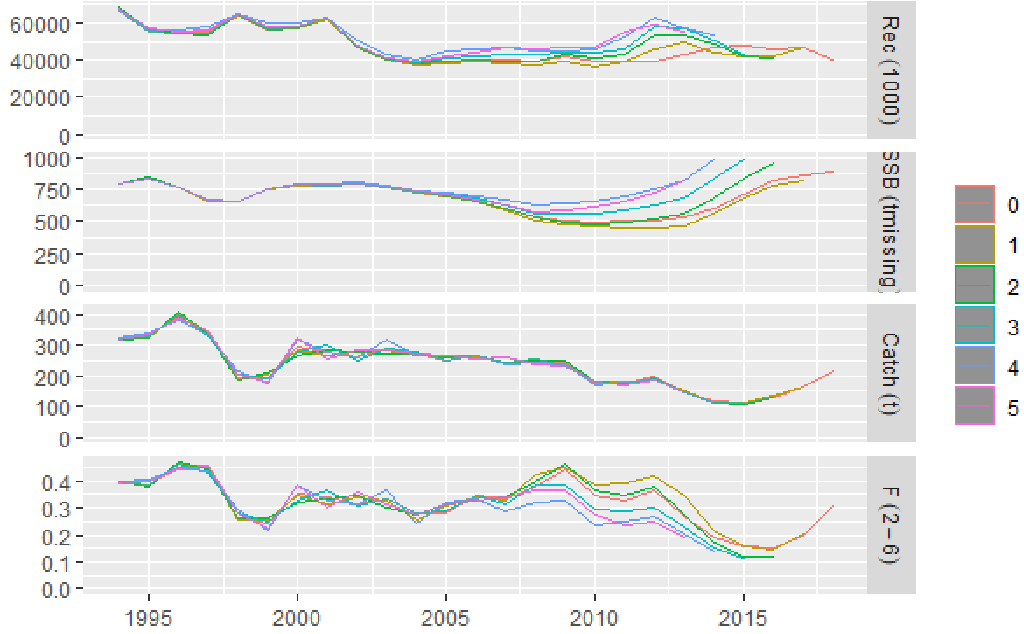


Figure 6.13.3.12. Norway lobster in GSA 9: retrospective analysis.

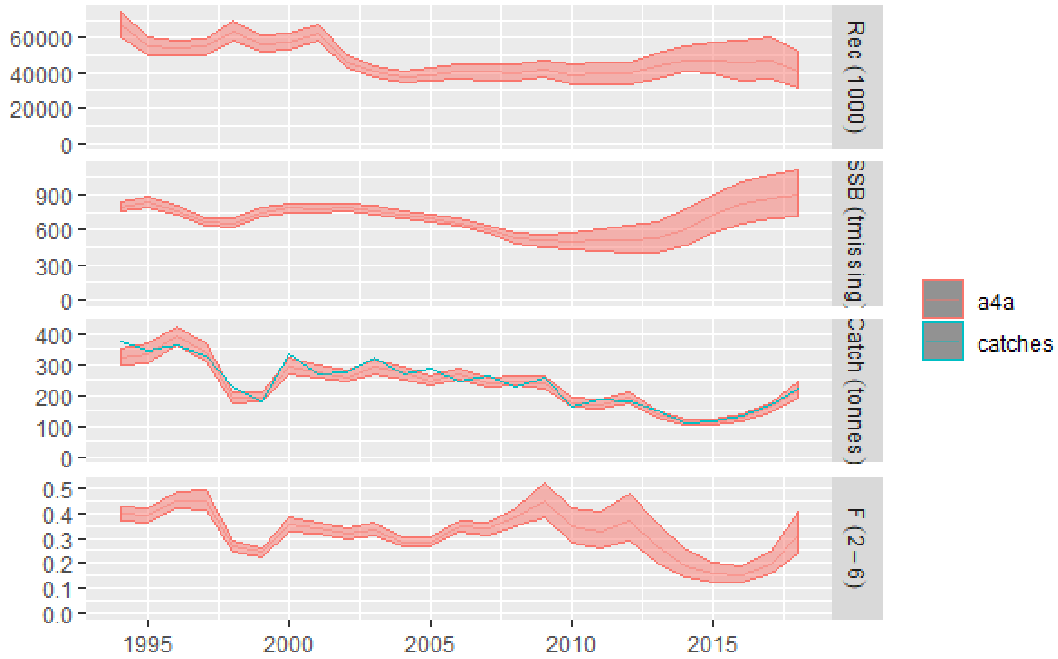


Figure 6.13.3.13. Norway lobster in GSA 9: outputs of the a4a stock assessment model, with uncertainty; input catch data (blue line) are plotted against the estimated catches.

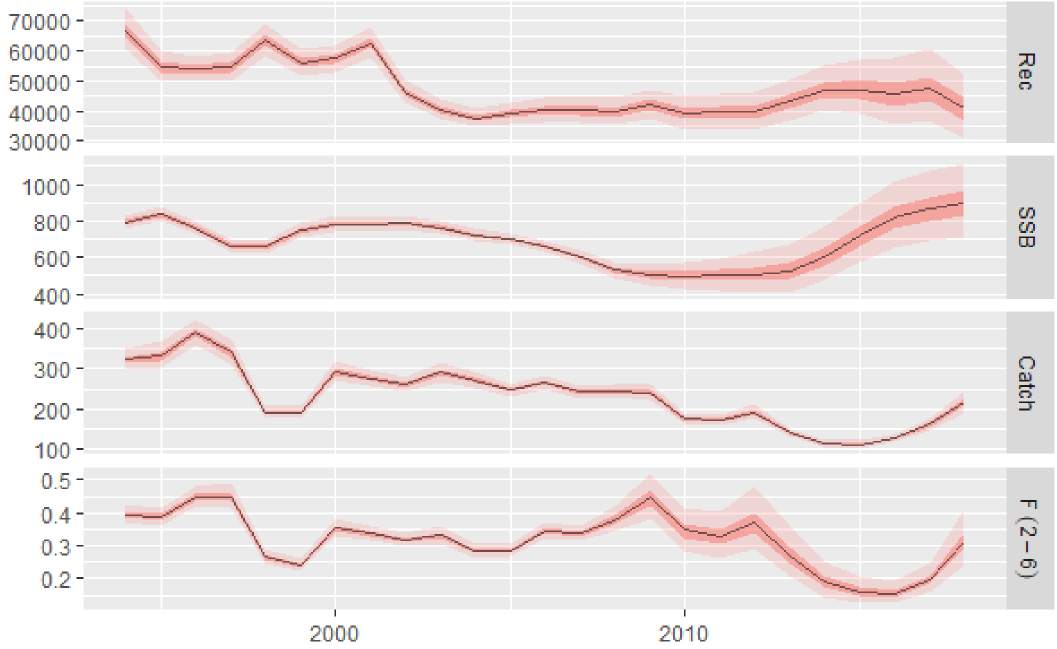


Figure 6.13.3.14. Norway lobster in GSA 9: outputs of the a4a stock assessment model (with uncertainty).

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	66913	54842	53973	54804	63665	56167	57476	62708	46380	40509	37614	39138	40178
2	36880	31581	25849	25399	25801	30022	26499	27116	29597	21895	19119	17745	18477
3	19690	22017	18593	15006	14811	15321	17904	15757	16201	17733	13088	11392	10654
4	10133	11258	11760	9287	7692	8557	9033	10095	9117	9562	10331	7646	6905
5	4860	4216	4450	4226	3460	3744	4289	3854	4439	4161	4293	4991	3794
6	2130	1969	1807	1797	1698	1779	1972	1889	1708	2012	1866	2129	2407
7	853	877	910	781	731	895	975	916	885	814	933	928	1010
8	319	361	425	397	295	378	499	474	459	454	393	445	430
9+	115	147	205	190	116	154	247	304	348	378	324	203	218
Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
1	40412	39626	42003	39017	39432	39565	43328	47065	47271	45569	47044	40509	
2	18976	19084	18703	19819	18400	18588	18664	20458	22228	22325	21503	22139	
3	11154	11426	11410	11125	11744	10868	11033	11218	12356	13419	13357	12591	
4	6637	6830	6656	6354	6214	6491	6040	6700	7134	7862	8175	7429	
5	3315	3172	3003	2606	2750	2713	2680	2966	3725	4072	4391	4135	
6	1578	1438	1328	1140	1181	1295	1168	1298	1612	2141	2458	2594	
7	968	653	575	499	536	590	596	593	736	981	1391	1616	
8	435	397	243	210	236	274	288	325	363	483	674	977	
9+	261	211	130	87	106	140	175	242	354	482	656	940	

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
1	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
2	0.02	0.03	0.04	0.04	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.00
3	0.17	0.24	0.30	0.28	0.16	0.14	0.18	0.16	0.14	0.15	0.15	0.11	0.08
4	0.55	0.60	0.69	0.66	0.39	0.36	0.52	0.49	0.45	0.47	0.40	0.37	0.40
5	0.61	0.56	0.62	0.62	0.38	0.35	0.53	0.52	0.50	0.51	0.41	0.44	0.59
6	0.63	0.51	0.58	0.64	0.38	0.34	0.51	0.50	0.48	0.51	0.44	0.49	0.65
7	0.62	0.48	0.59	0.73	0.42	0.34	0.48	0.45	0.43	0.49	0.50	0.53	0.60
8	0.74	0.58	0.78	1.11	0.61	0.44	0.56	0.49	0.45	0.57	0.73	0.70	0.61
9+	1.24	0.98	1.52	2.49	1.28	0.81	0.92	0.73	0.65	0.92	1.57	1.32	0.83

Age	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.01	0.02	0.02	0.03	0.02	0.01	0.00	0.00	0.01	0.04	0.05
3	0.10	0.15	0.20	0.19	0.20	0.20	0.11	0.06	0.06	0.11	0.20	0.32
4	0.41	0.49	0.61	0.51	0.50	0.55	0.38	0.26	0.23	0.25	0.35	0.59
5	0.55	0.58	0.68	0.50	0.46	0.55	0.43	0.32	0.26	0.21	0.24	0.37
6	0.62	0.66	0.72	0.49	0.43	0.52	0.42	0.31	0.24	0.17	0.16	0.20
7	0.65	0.75	0.76	0.51	0.43	0.48	0.37	0.25	0.18	0.14	0.11	0.11
8	0.79	1.06	1.00	0.66	0.54	0.54	0.37	0.22	0.16	0.13	0.10	0.07
9+	1.33	2.13	1.86	1.25	0.99	0.85	0.51	0.27	0.18	0.18	0.13	0.06

Table 6.13.3.7. Norway lobster in GSA 9: summary results of the a4a assessment.

Year	Recruitment (age 1, '000)	High	Low	SSB (t)	High	Low	Catch (t)	F_{bar} 2-6	High	Low
1994	66913	72683	61143	793.3	819.4	767.2	321.1	0.39	0.42	0.37
1995	54842	58805	50879	835.0	866.1	803.9	331.4	0.39	0.41	0.37
1996	53973	57413	50533	766.0	795.6	736.4	391.6	0.45	0.47	0.42
1997	54804	58534	51074	667.2	693.7	640.7	340.7	0.45	0.48	0.42
1998	63665	67839	59491	659.4	686.4	632.4	191.4	0.27	0.28	0.25
1999	56167	59806	52528	749.7	779.3	720.1	192.8	0.24	0.26	0.23
2000	57476	61179	53773	785.0	813.7	756.3	294.4	0.35	0.37	0.33
2001	62708	66841	58575	779.1	805.6	752.6	277.0	0.34	0.35	0.32
2002	46380	49461	43299	788.9	815.8	762.0	259.7	0.32	0.33	0.30
2003	40509	43019	37999	764.5	790.8	738.2	291.0	0.33	0.35	0.31
2004	37614	40148	35080	723.1	748.0	698.2	273.3	0.28	0.30	0.27
2005	39138	41905	36371	697.6	720.6	674.6	247.1	0.28	0.30	0.27
2006	40178	43484	36872	659.5	684.3	634.7	265.9	0.35	0.37	0.33
2007	40412	44211	36613	603.0	630.5	575.5	242.3	0.34	0.36	0.32
2008	39626	43423	35829	531.5	567.5	495.5	246.0	0.38	0.41	0.35
2009	42003	46029	37977	505.3	552.6	458.0	241.3	0.44	0.50	0.39
2010	39017	43348	34686	497.2	557.5	436.9	176.0	0.34	0.40	0.29
2011	39432	44216	34648	500.9	575.7	426.1	173.3	0.33	0.38	0.27
2012	39565	44410	34720	508.4	601.4	415.4	195.8	0.37	0.44	0.30
2013	43328	48613	38043	526.9	637.5	416.3	144.4	0.27	0.33	0.21
2014	47065	53092	41038	599.3	719.9	478.7	116.0	0.19	0.23	0.15
2015	47271	54329	40213	711.9	845.4	578.4	113.5	0.16	0.19	0.13
2016	45569	53596	37542	810.2	950.2	670.2	128.3	0.15	0.18	0.13
2017	47044	56122	37966	857.6	1008.5	706.7	162.6	0.20	0.23	0.16
2018	40509	48636	32382	887.2	1041.2	733.2	216.2	0.31	0.37	0.24

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 (0.31), estimated as the F_{bar1-3} in the last year of the time series, 2018) is higher than $F_{0.1}$ (0.20), 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 over-exploited.

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 (2018) from the a4a assessment was used.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the 2002-2018 (41917.9 thousand individuals), 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
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2016-2018
$F_{ages\ 1-3}$ (2019)	0.31	F current in the last year
SSB (2019; middle year)	860.4 t	Stock assessment 1 January 2019
R_0 (2019, 2020,2021)	41917.9 thousands	Geometric mean of the period 2003-2018
Total catch (2019)	220.7 t	Assuming F status quo for 2019

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	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB* 2020	SSB* 2021	Change SSB 2019-2021 (%)	Change Catch 2018-2020 (%)
High long term yield ($F_{0.1}$)	0.65	0.20	216.2	220.7	142.1	146.6	852.2	869.9	1.1	-34.3
F_{upper}	0.90	0.28	216.2	220.7	189.8	183.2	825.7	798.6	-7.2	-12.2
F_{lower}	0.44	0.13	216.2	220.7	99.2	108.4	875.3	936.5	8.8	-54.1
Zero catch	0.00	0.00	216.2	220.7	0.0	0.0	926.1	1098.9	27.7	-100.0
Status quo	1.00	0.31	216.2	220.7	207.6	195.2	815.6	772.8	-10.2	-4.0
Different Scenarios	0.10	0.03	216.2	220.7	23.9	28.8	914.1	1058.6	23.0	-88.9
	0.20	0.06	216.2	220.7	47.1	55.0	902.4	1020.3	18.6	-78.2
	0.30	0.09	216.2	220.7	69.5	78.9	890.9	983.9	14.3	-67.9
	0.40	0.12	216.2	220.7	91.1	100.6	879.6	949.2	10.3	-57.9
	0.50	0.15	216.2	220.7	112.1	120.4	868.4	916.2	6.5	-48.2
	0.60	0.18	216.2	220.7	132.4	138.4	857.5	884.7	2.8	-38.8
	0.70	0.22	216.2	220.7	152.1	154.7	846.7	854.7	-0.7	-29.7
	0.80	0.25	216.2	220.7	171.2	169.6	836.2	826.1	-4.0	-20.8
	0.90	0.28	216.2	220.7	189.7	183.1	825.8	798.9	-7.2	-12.3
	1.10	0.34	216.2	220.7	224.9	206.3	805.5	748.0	-13.1	4.0
	1.20	0.37	216.2	220.7	241.8	216.3	795.7	724.3	-15.8	11.8
	1.30	0.40	216.2	220.7	258.2	225.2	786.0	701.6	-18.5	19.4
	1.40	0.43	216.2	220.7	274.0	233.3	776.4	679.9	-21.0	26.7
	1.50	0.46	216.2	220.7	289.4	240.6	767.1	659.1	-23.4	33.8
	1.60	0.49	216.2	220.7	304.4	247.1	757.8	639.3	-25.7	40.8
	1.70	0.52	216.2	220.7	318.9	253.0	748.8	620.3	-27.9	47.5
	1.80	0.55	216.2	220.7	333.0	258.2	739.8	602.1	-30.0	54.0
	1.90	0.58	216.2	220.7	346.7	262.8	731.1	584.7	-32.0	60.3
	2.00	0.62	216.2	220.7	360.1	266.9	722.4	568.0	-34.0	66.5

*SSB at mid year

6.13.6 DATA DEFICIENCIES

Landings in 2017 were considered unreliable, as very high. Despite official data were not revised, the experts informed that a new estimation of landings was produced, and was provided to STECF 19-10.

The impact on the assessment was then low.

6.14 Norway lobster in GSA 11

6.14.1. Stock identity and biology

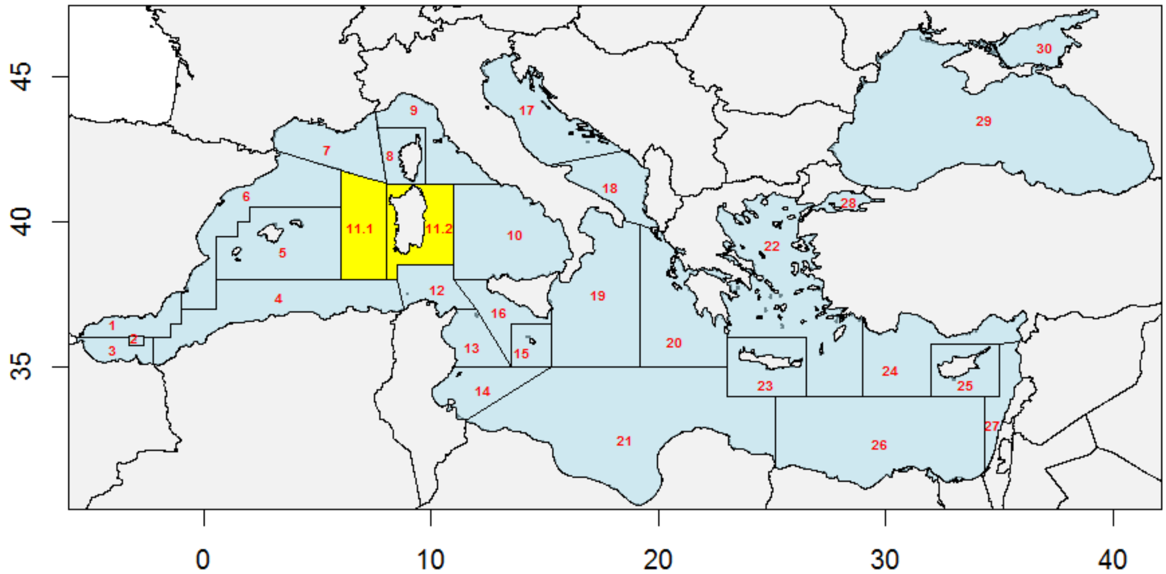


Figure 6.14.1.1. Geographical location of GSA 11

An advice on NEP in GSA 11 based on MEDITS indices trends was already given in 2018 for 2020 and can be taken directly from STECF EWG 18-12 report. STECF EWG 19-10 was asked to perform a short evaluation of survey data to determine if new data is different and could help with an assessment.

No substantial differences were found in the biological parameters.

6.14.2. Data

6.14.2.1. Catch (landings and discards)

Landings data were reported to STECF EWG 19-10 through the DCF. Landings data are available for GSA 11 in the period 2005-2018 and were related to OTB (Table 6.14.2.1.1, Figure 6.14.2.1.1). No discards were reported.

Length frequency distribution of the landings by year and fleet from the DCF database are presented in figure 6.14.2.1.2.

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
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

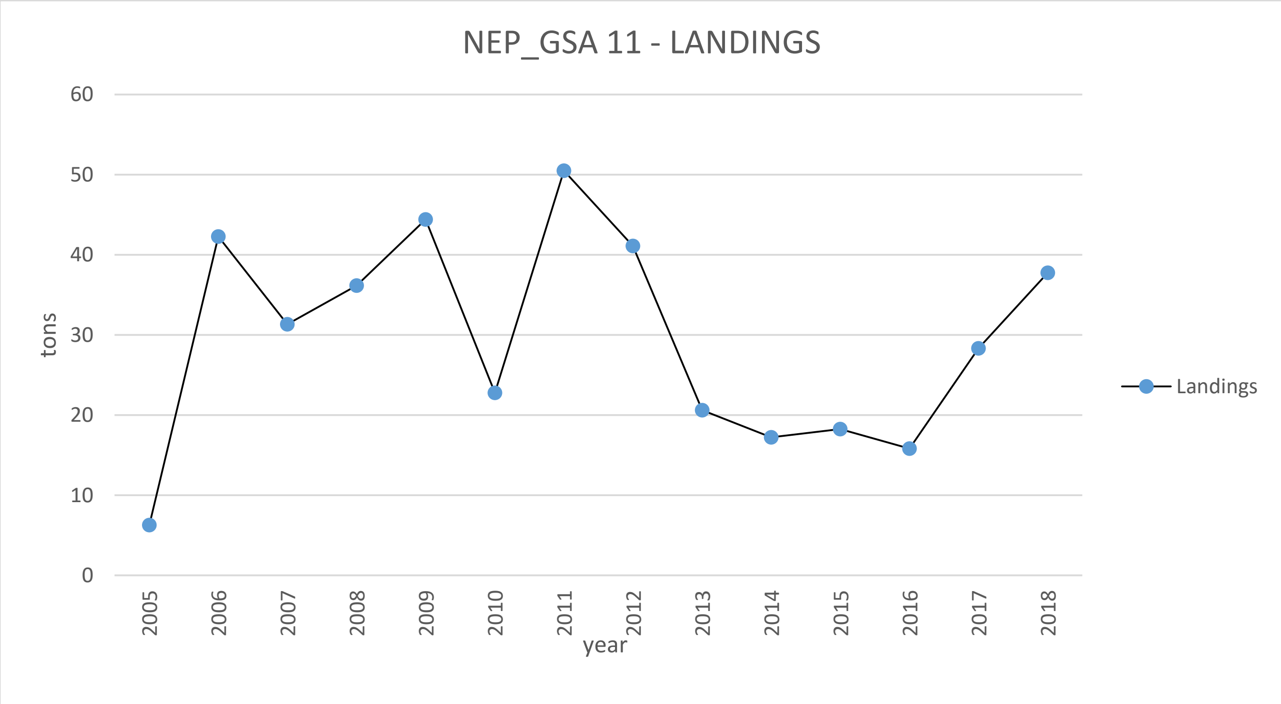


Figure 6.14.2.1.1. Norway lobster landing data (in tons) in GSA 11

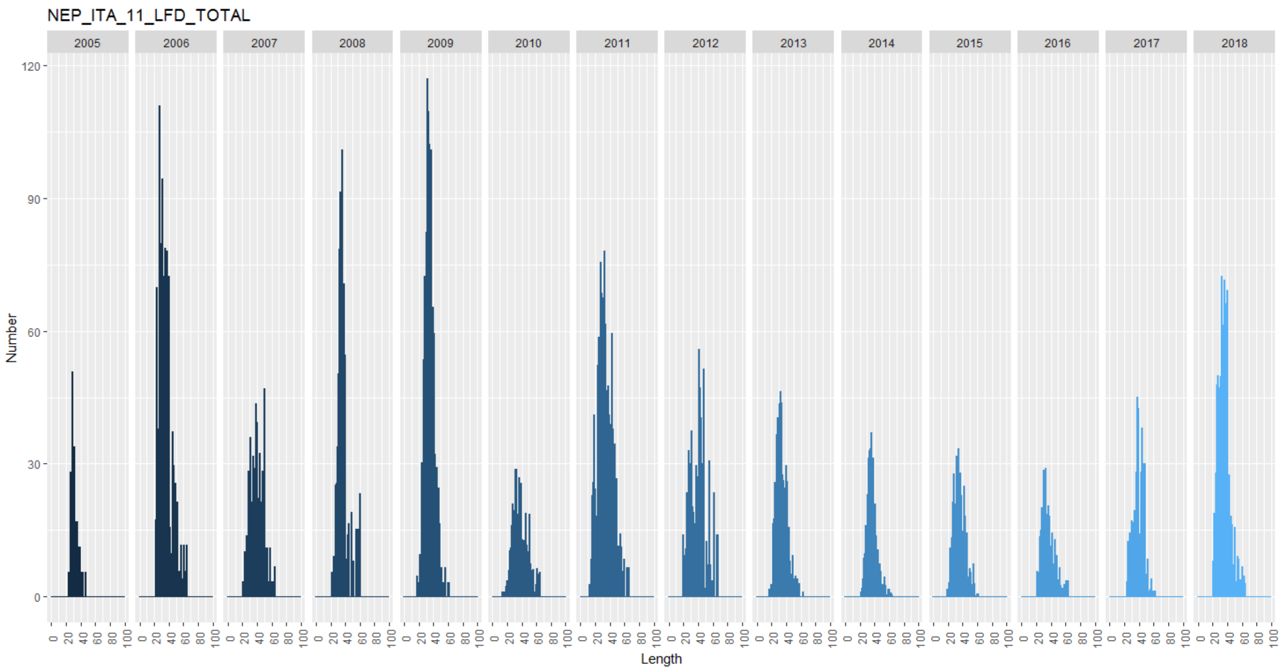


Figure 6.14.2.1.2. Norway lobster in GSA 11. Length frequency distribution of the landings by year in GSA 11.

6.14.2.2. Effort

Fishing effort data were reported to STECF EWG 19-10 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

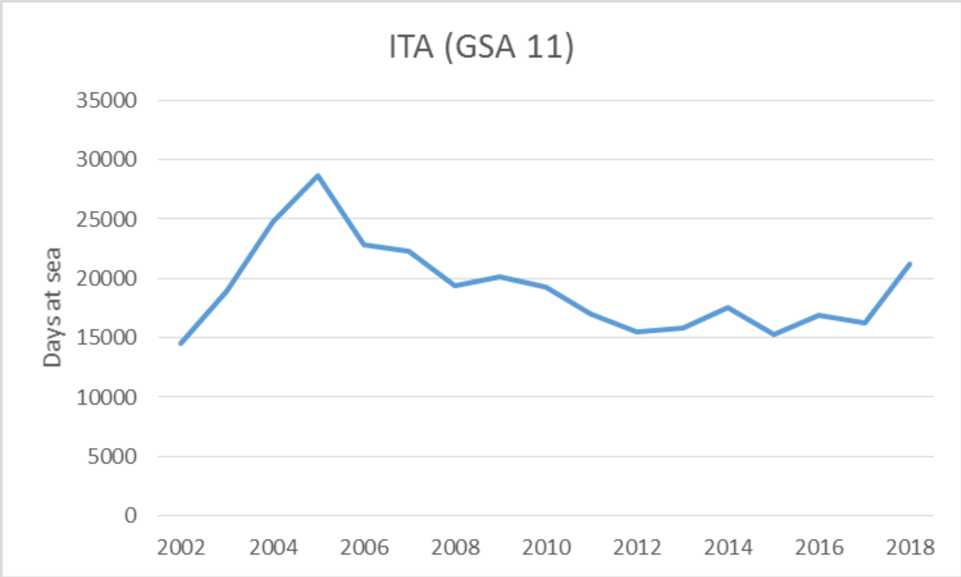


Figure 6.14.2.2.1. Norway lobster in GSA 11. Fishing effort in Days at sea by year and fishing gear.

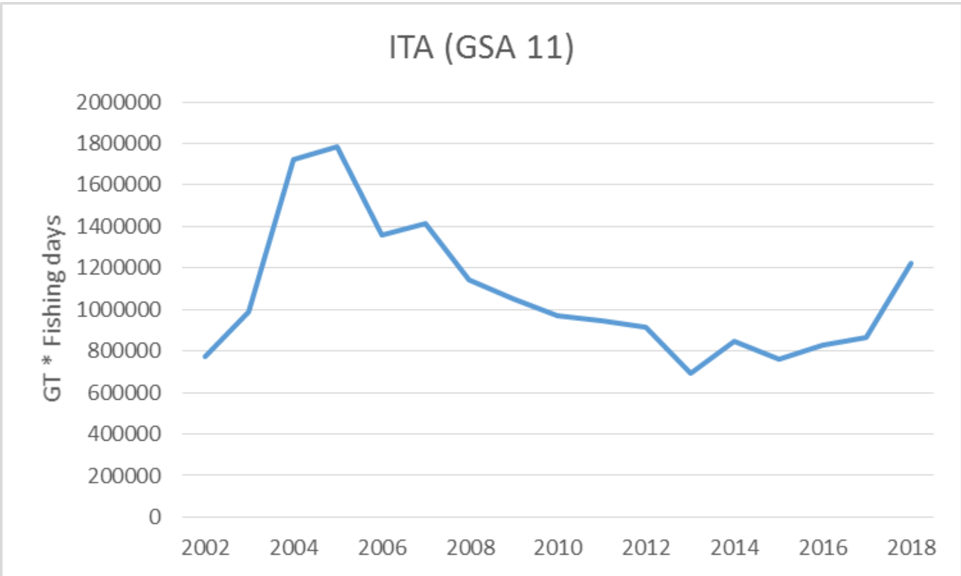


Figure 6.14.2.2.2. Norway lobster in GSA 11. Fishing effort in GT*Days at sea by year and fishing gear.

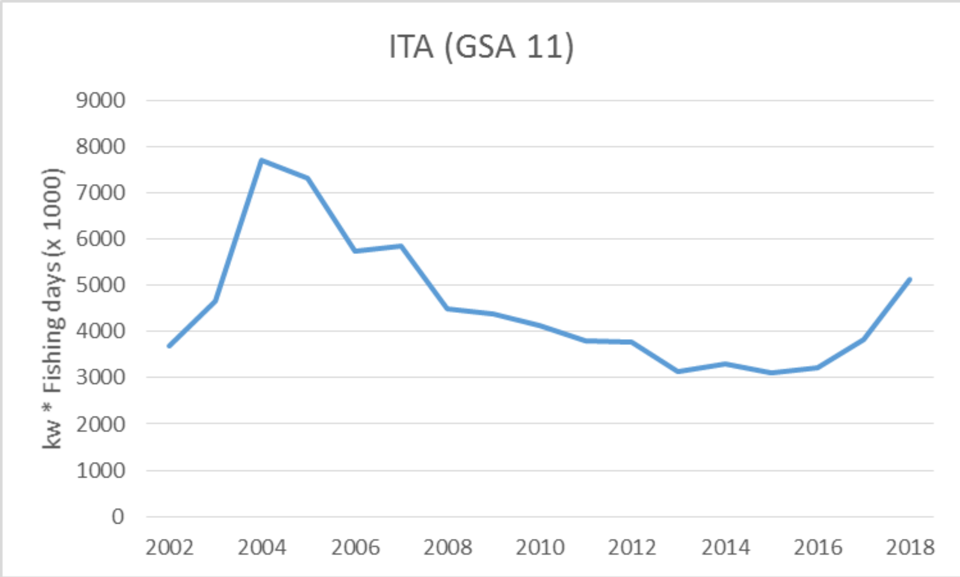


Figure 6.14.2.2.3. Norway lobster in GSA 11. Fishing effort in kW*Days at sea by year and fishing gear.

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 31.07 (2001) and 129.01 (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. On the contrary, during the latest 8 years, density and biomass values show a more stable behaviour, oscillating respectively in the range 1.32 (2018) – 2.69 (2012) (average value 2.02) in terms of biomass and 31.53 (2018) – 58.64 (2012) (average value 45.35) in terms of density. Biomass and density average values along the whole time series was respectively 2.70 kg/Km^2 and 65.76 n/Km^2.

Observed length frequency distribution for MEDITS data are reported in Figure 6.14.2.3.2 and 6.14.2.3.3.

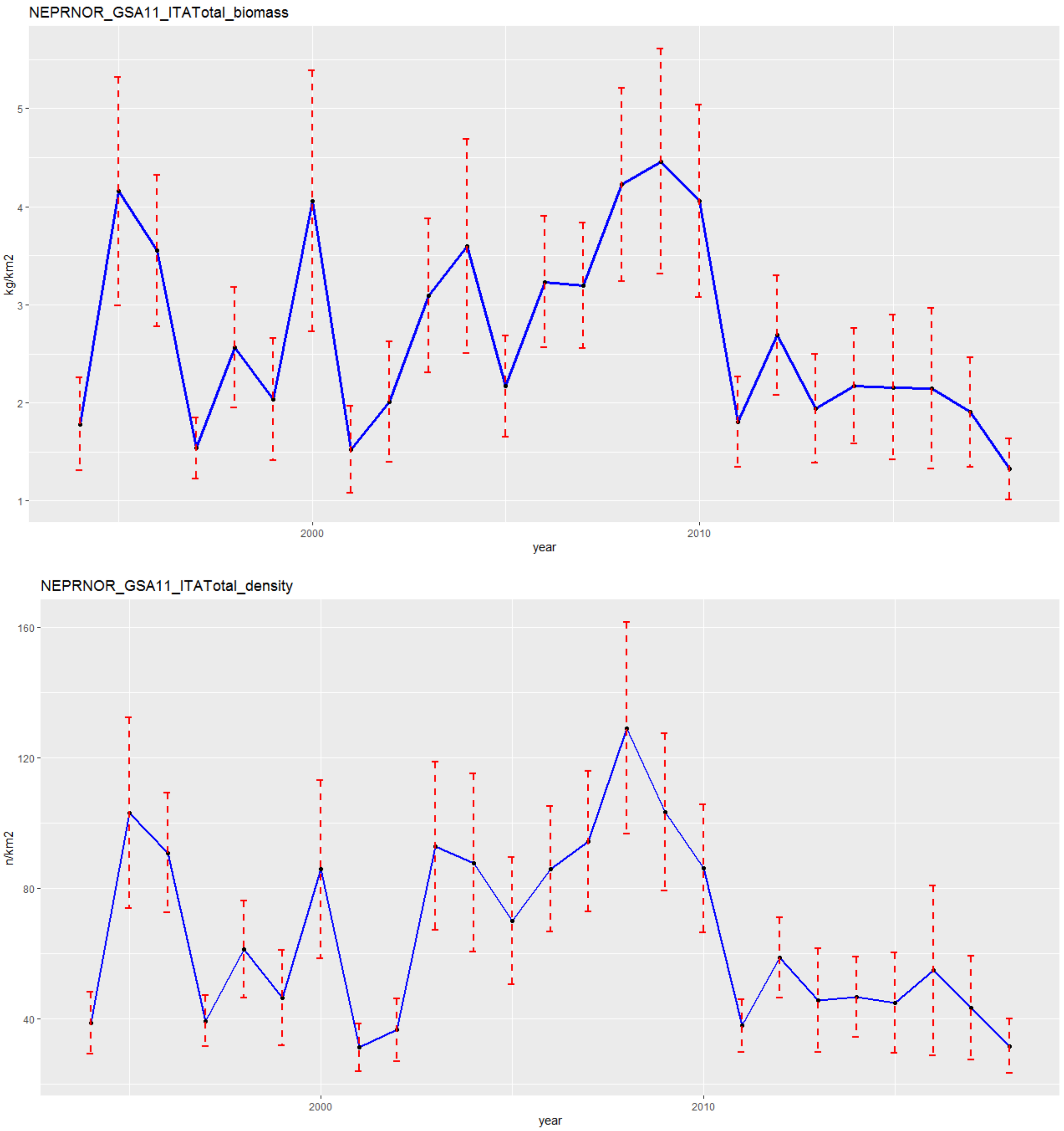


Figure 6.14.2.3.1. MEDITS indices for the period 1994-2018: relative biomass (kg km^2) and density (n km^2).

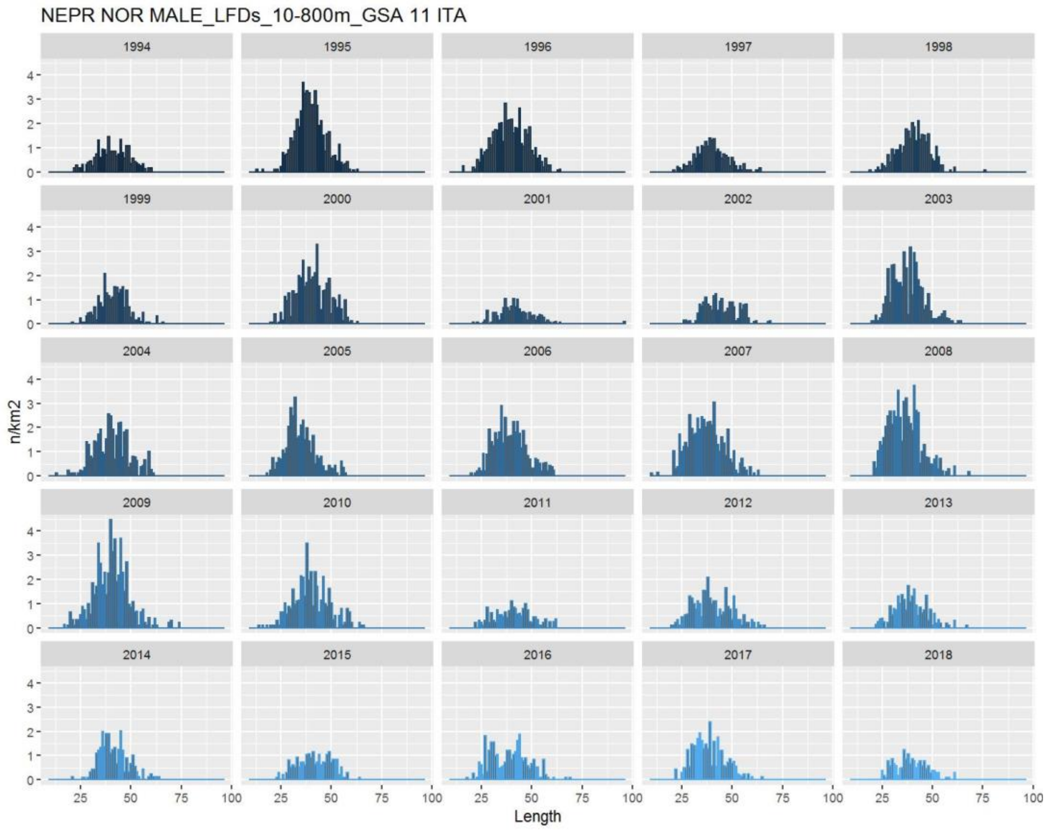


Figure 6.14.2.3.2. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for males.

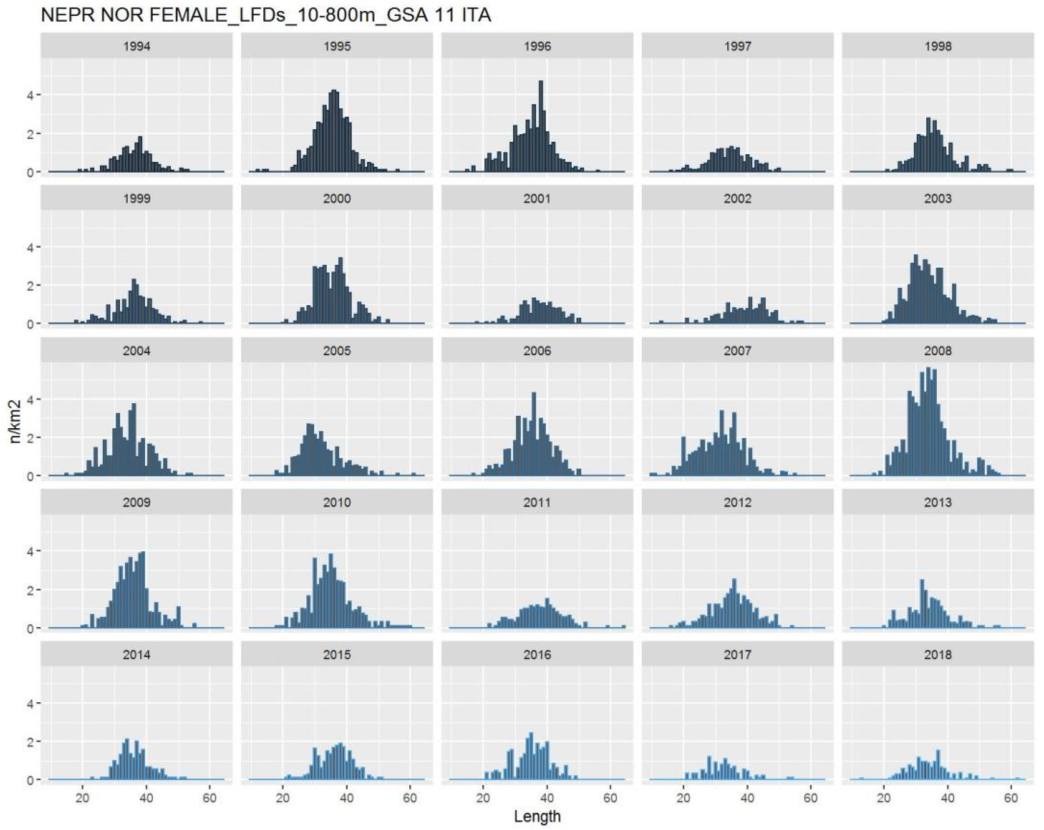


Figure 6.14.2.3.3. Norway lobster in GSA 11. Observed Length-frequency distributions (MEDITS data) for females.

6.14.3. STOCK ASSESSMENT

The EWG 18-12 concluded that XSA and a4a results were considered as not acceptable 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 is different and could help with an assessment. As no substantive change in survey and landing signals was observed, a new assessment has not been performed and the advice done in EWG 18-12 has been confirmed.

However, the unexpected increase in the fishing effort in the last years, could have affected the landings values of the same year, increase not detected in the survey data.

6.14.4. REFERENCE POINTS

As the assessment carried out during EWG 18-12 was not accepted for advice, reference points were not calculated.

6.14.5. SHORT TERM FORECAST AND CATCH OPTIONS

The advice on catch options for 2019 and 2020 (17.1 ton, EWG 18-12) are based on the observed catch adjusted to the change in the stock size index for the two most recent values relative to the three preceding values following the approach adopted for ICES category 3 stocks.

The analyses performed during EWG 19-10 on the biomass and density indices of the MEDITS survey confirm the decreasing trend of this resource also in 2018 in the GSA 11.

Therefore, EWG 19-10 confirms the advice given by EWG 18-12 not to exceed the catches of 17.1 tonnes for the years 2019 and 2020.

6.14.6. DATA DEFICIENCIES

Growth parameters previous to 2015 were available only for males, as well as length weight relationship coefficients. However, growth parameters for both sexes have been submitted since 2016.

6.15 BLUE AND RED SHRIMP IN GSA 1

6.15.1 STOCK IDENTITY AND BIOLOGY

This stock was assessed last year in 2018 (STECF EWG 18-12) 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).

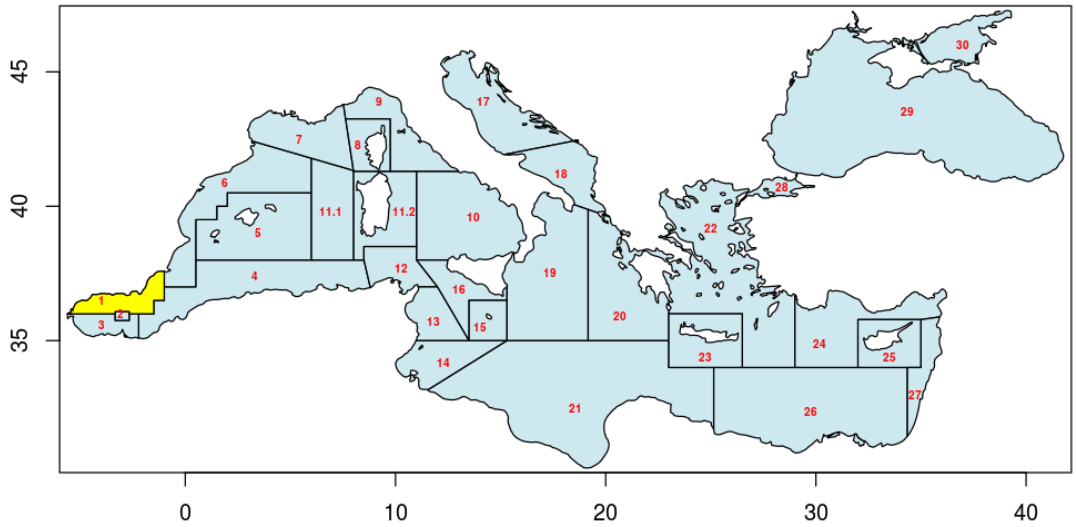


Figure 6.15.1.1. Geographical location of GSA 1.

There are some differences from 2018. 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. The starting point for the growth curve is assumed to be mid year (1st July) for length slicing of length to age. In 2018 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 is very small differences in the assessment. This year the length slicing for assessment was run with 0.532 value of t_0 in order to provide correct length transitions for 1st of January to coincide with Jan-Dec assessment year. It should be noted that he 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 thje 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 (2002-2018) 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 (2002-2018). 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	
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

The proportion of mature individuals at age was not available from the DCF data for blue and red shrimp in GSA 1 and in 2018 was taken from the 2015 assessment that was based on the DCF data this was applied in the 2018 assessment (Table 6.15.1.2) It noted incorrectly in the 2018 report with a one year shift, but the correct value was used in the assessment. 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.

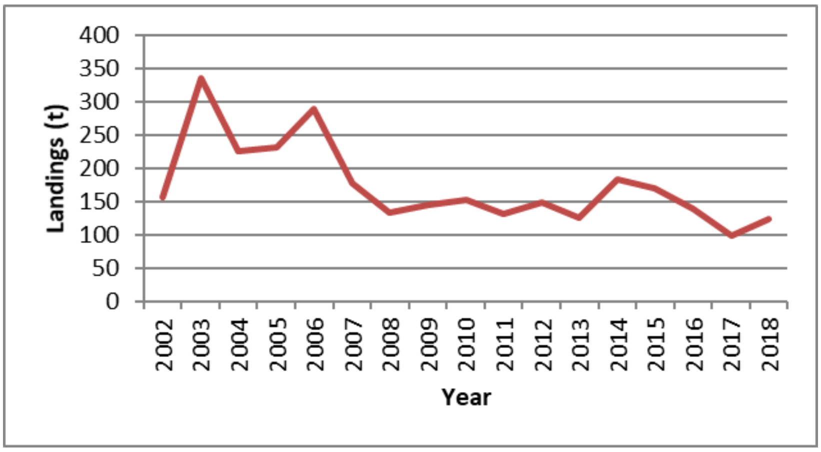


Figure 6.15.2.1.1. Blue and red shrimp in GSA 1. Blue and red shrimp DCF landings (t), in GSA 1.

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
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

The total OTB landings and discards per year, as reported by DCF, are shown below.

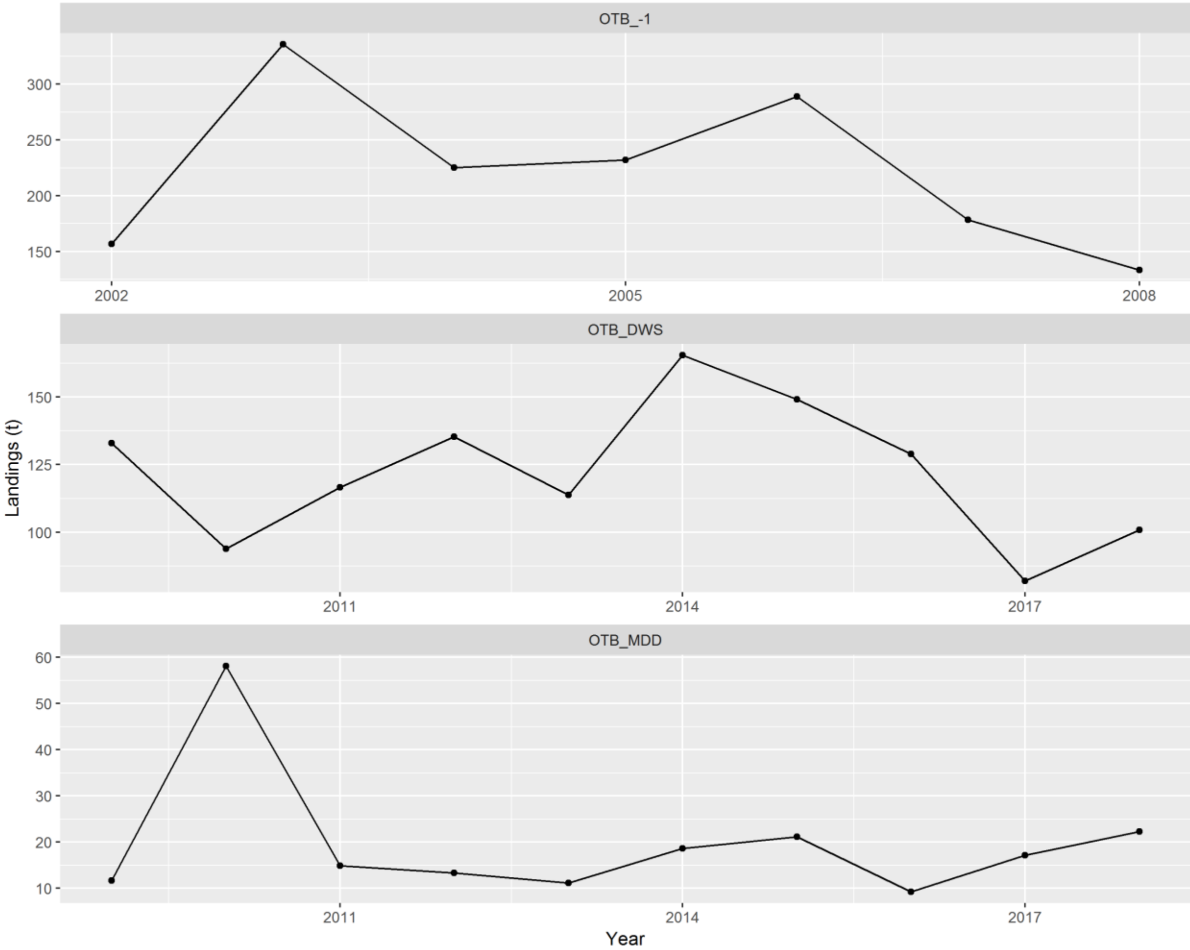


Figure 6.15.2.1.2. Blue and red shrimp in GSA 1. Blue and red shrimp DCF landings (t) in GSA 1 per gear (2002-2008) and metier (2009-2018).

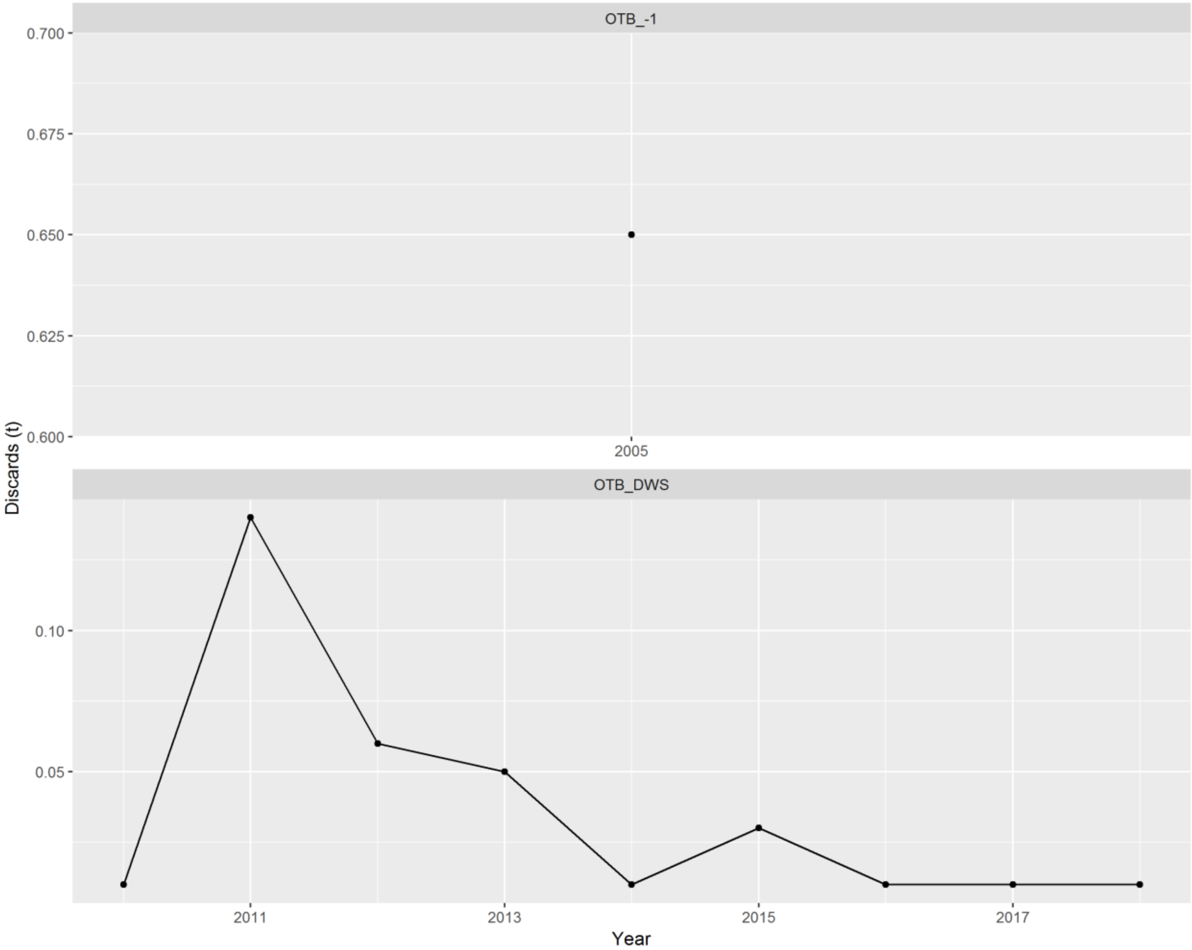


Figure 6.15.2.1.3. Blue and red shrimp in GSA 1. Blue and red shrimp DCF discards (t) in GSA 1 per gear (2002-2008) and metier (2009-2018).

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.

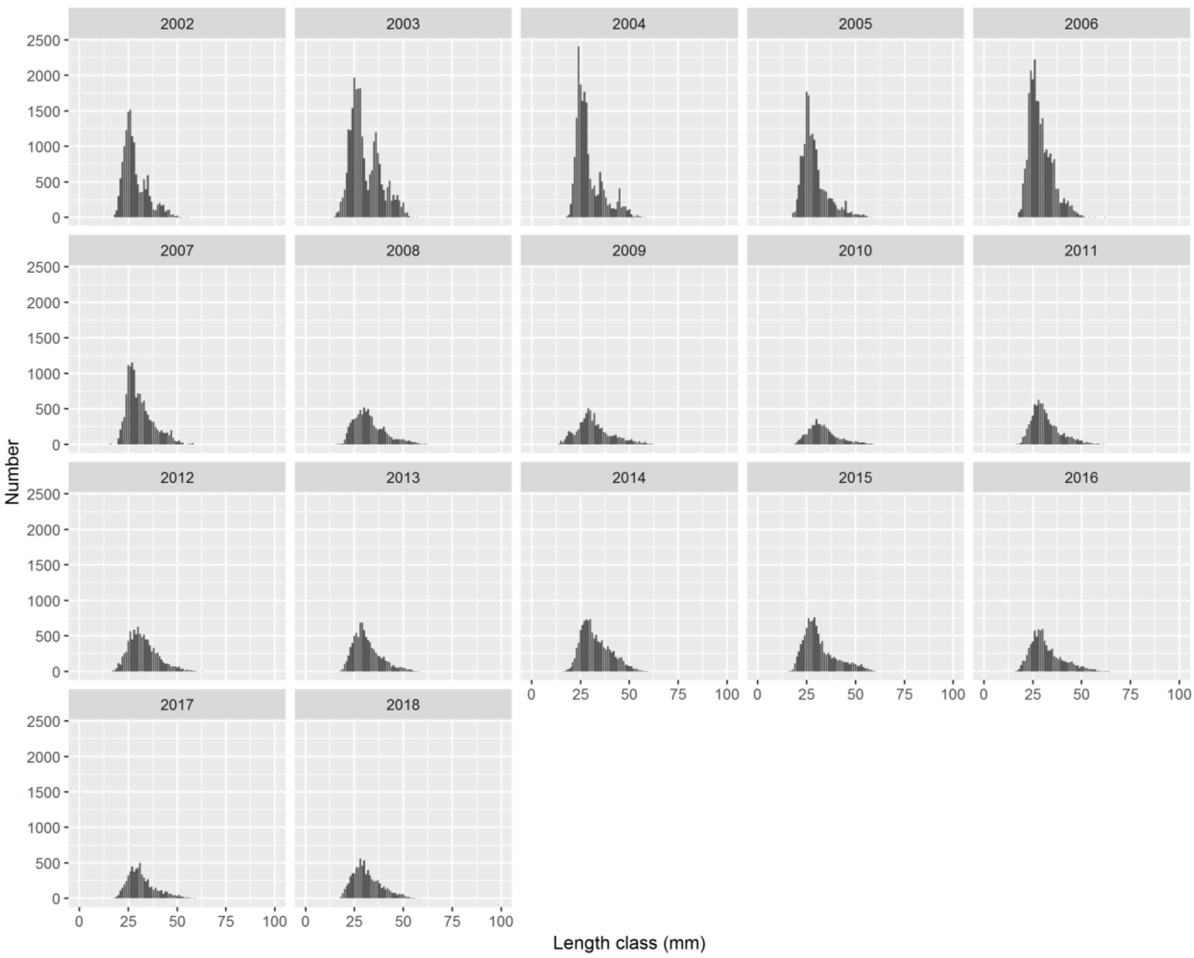


Figure 6.15.2.1.4. Blue and red shrimp in GSA 1. Blue and red shrimp length frequency distribution of catch (landings only) by year in GSA 1.

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.

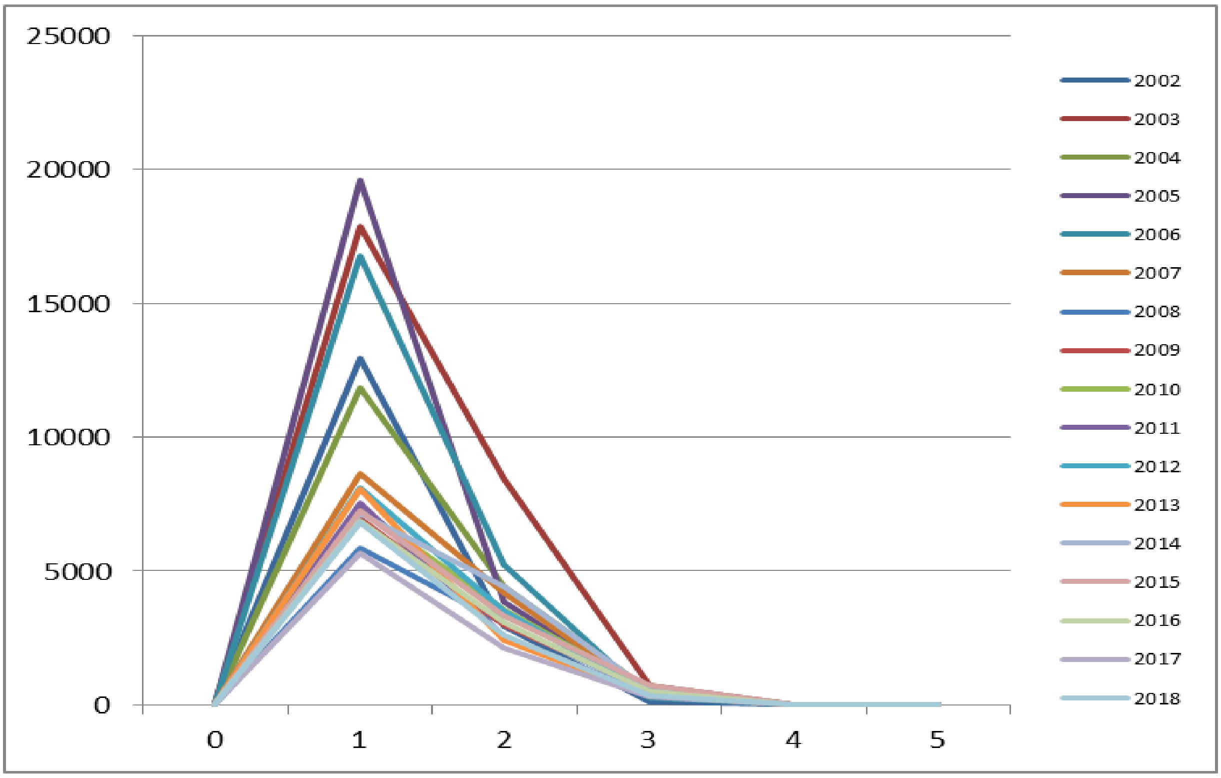


Figure 6.15.2.1.6. Blue and red shrimp in GSA 1. Blue and red shrimp number of individuals (N, thousands) at age of the catch in GSA 1 (2002-2018). Data from DCF.

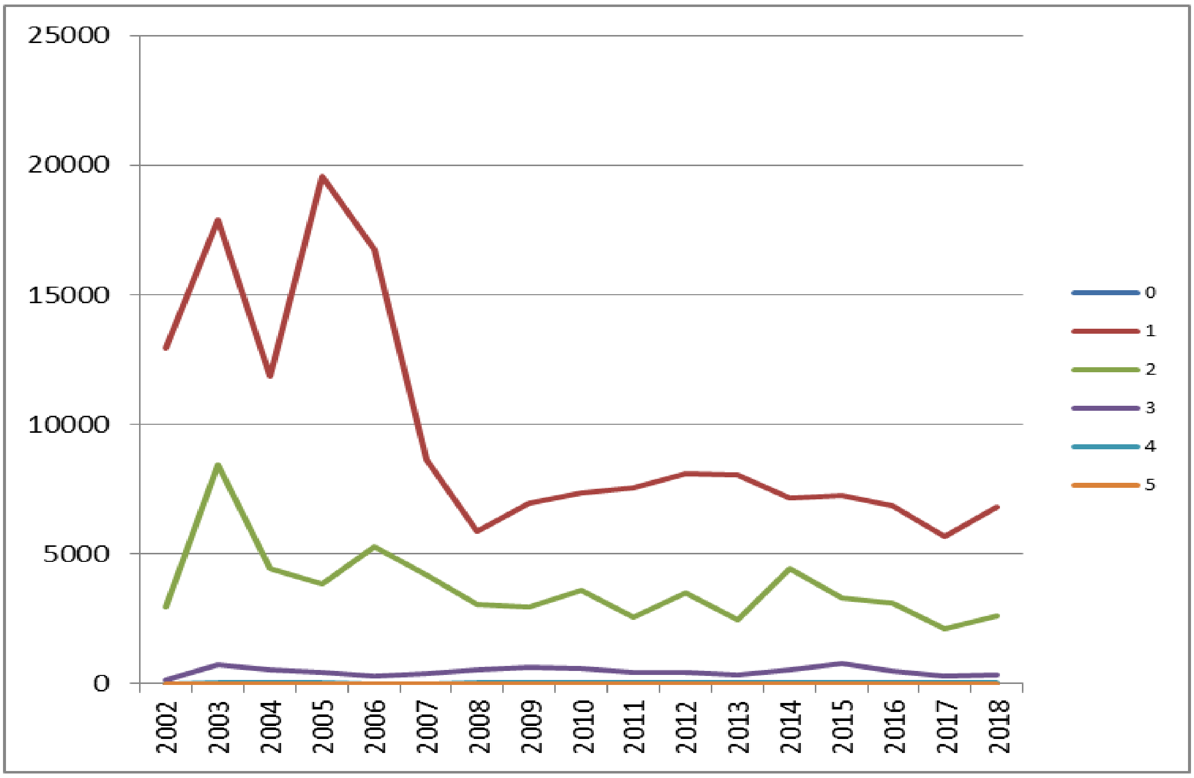


Figure 6.15.2.1.7. Blue and red shrimp in GSA 1. Blue and red shrimp number of individuals (N, thousands) per year by age group of the catch in GSA 1 (2002-2018). Data from DCF.

Table 6.15.2.1.XX. 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 (2002-2018). Length sliced from data from DCF.

Year/age	0	1	2	3	4	5
2002	0.29793	12958	2964.5	107.19	0.15034	1.22E-05
2003	0.40765	17894	8442.8	726.06	7.2576	0.008773
2004	0.5391	11854	4432.3	526.46	9.4492	0.17621
2005	0.53125	19582	3857.6	407.18	11.398	0.4257
2006	0.33029	16772	5251.4	266.07	6.1777	0.56163
2007	0.19624	8638.4	4163.7	357.98	3.4795	0.38618
2008	0.17304	5870.1	3032.8	515.53	8.6233	0.27819
2009	0.16527	6960.3	2967.2	606.25	21.941	0.4836
2010	0.23899	7348.6	3580.3	570.28	26.996	1.2428
2011	0.19497	7555.6	2549.2	413.48	13.401	1.3776
2012	0.30459	8090.7	3498.7	421.59	15.663	1.5242
2013	0.16342	8044.7	2434.1	352.07	7.8952	0.99531
2014	0.18089	7135.7	4417.8	535.78	17.01	1.0513
2015	0.17175	7273.1	3315.6	752.14	20.243	1.3376
2016	0.19541	6859.7	3091	478.24	24.983	1.6892
2017	0.16685	5682.9	2113.6	300.84	9.1995	1.4344
2018	0.24998	6811.1	2615.7	349.58	11.253	1.3829

The calculated annual individual weight at age (kg) for the entire period (2002-2018) is presented in Figure 6.15.2.1.8 and the internal cohort consistency of the catch in Figure 6.15.2.1.9.

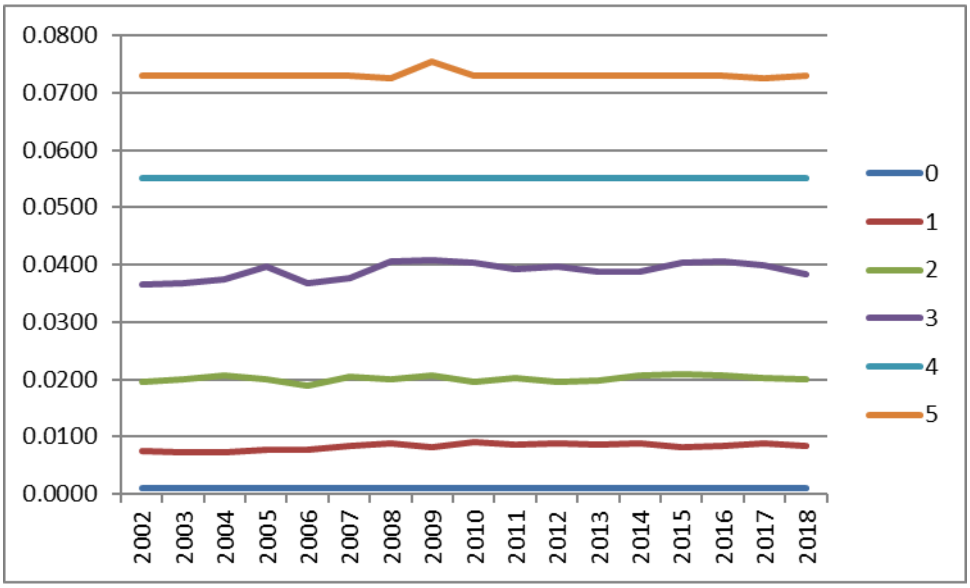


Figure 6.15.2.1.8. Blue and red shrimp in GSA 1. Blue and red shrimp mean weight (kg) at age of catches per year in GSA 1 (2002-2018). Data from DCF.

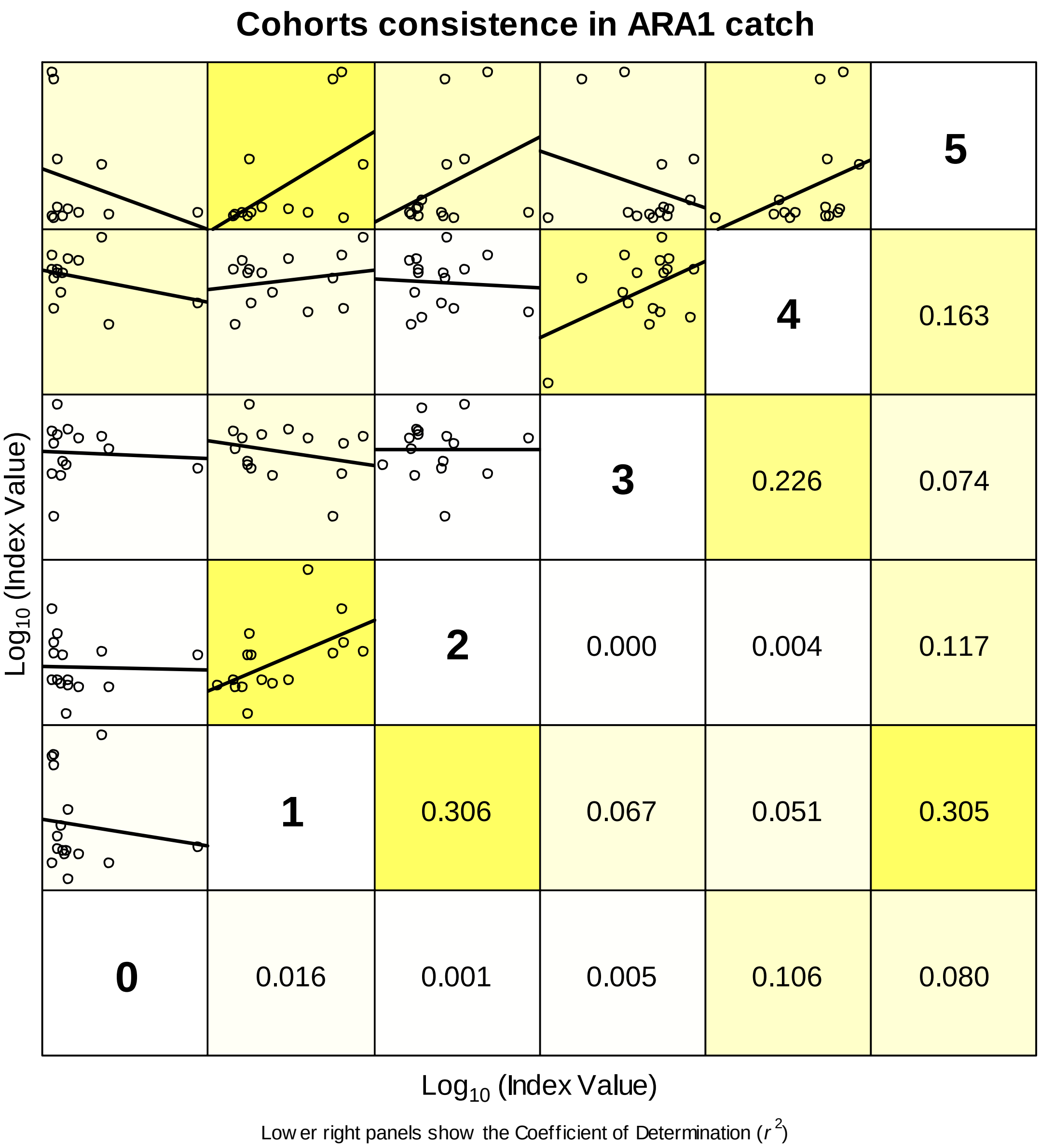


Figure 6.15.2.1.9. Blue and red shrimp in GSA 1. Cohorts consistency in the catch.

6.15.2.2 EFFORT

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 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

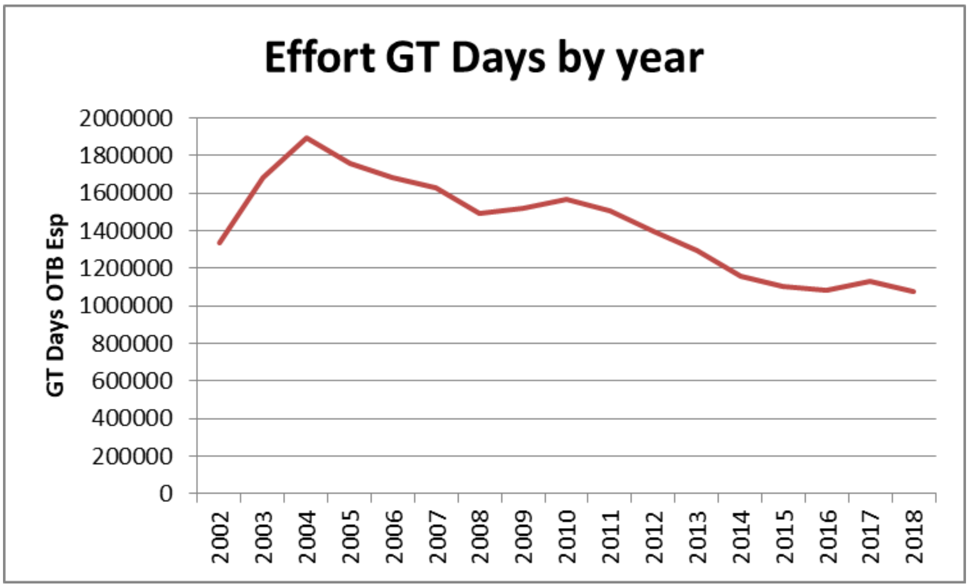


Figure 6.15.2.2.1. Blue and red shrimp in GSA 1. Effort (GT Days) of vessels operating with OTB in GSA 1 (DCF).

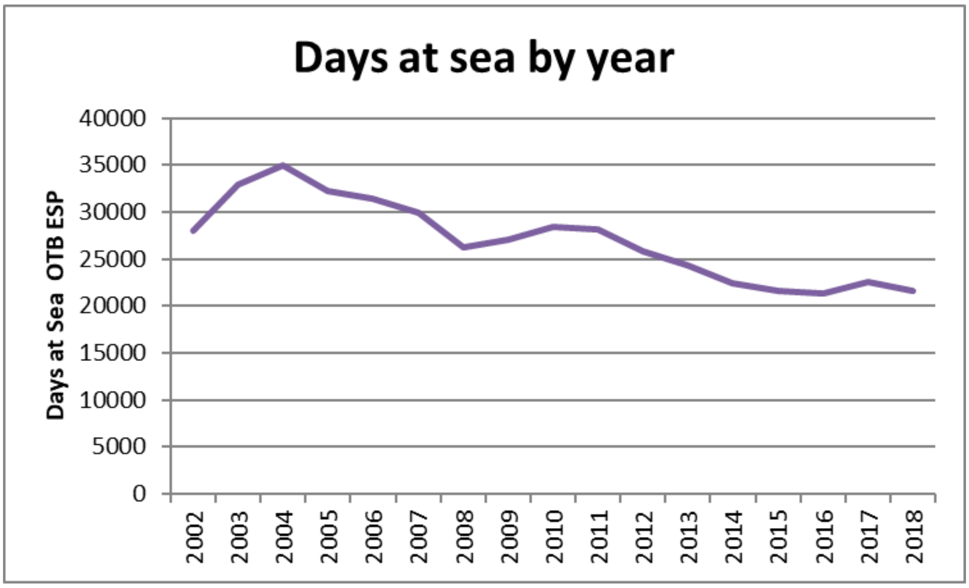


Figure 6.15.2.2.2. Blue and red shrimp in GSA 1. Effort (days at sea) of vessels operating with OTB

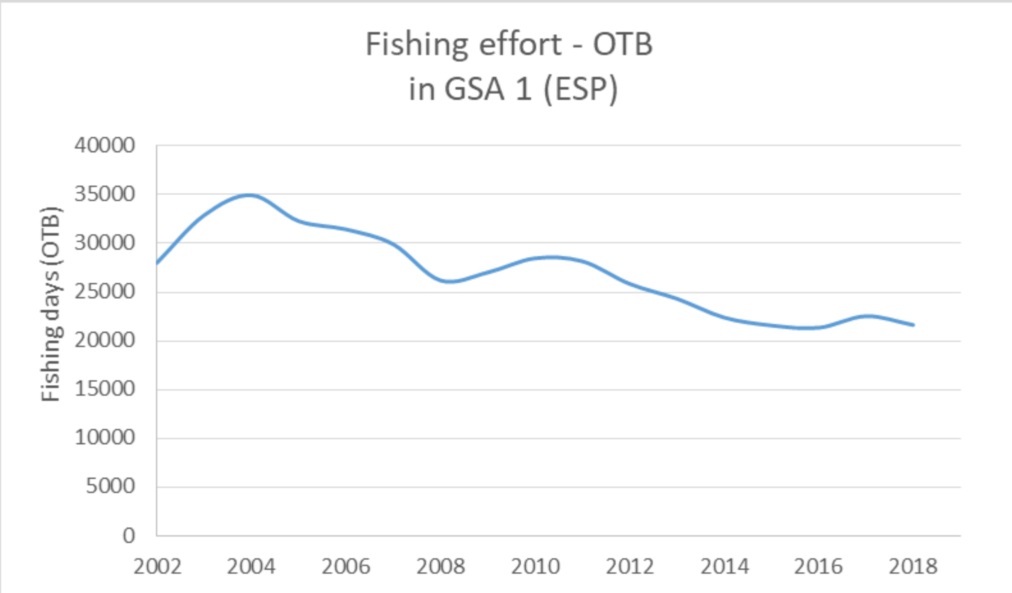


Figure 6.15.2.2.3. Blue and red shrimp in GSA 1. Effort (fishing days) of vessels operating with OTB (2002-2008) and OTB metiers (2009-2014) in GSA 1 (DCF). Dashed line is the cumulative of metiers.

6.15.2.3 SURVEY DATA

6.15.2.3.1.Description and timing

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 obvious data errors (e.g. typos, duplicated records) had been noted on the dataset (mainly regarding length frequency distributions of 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.

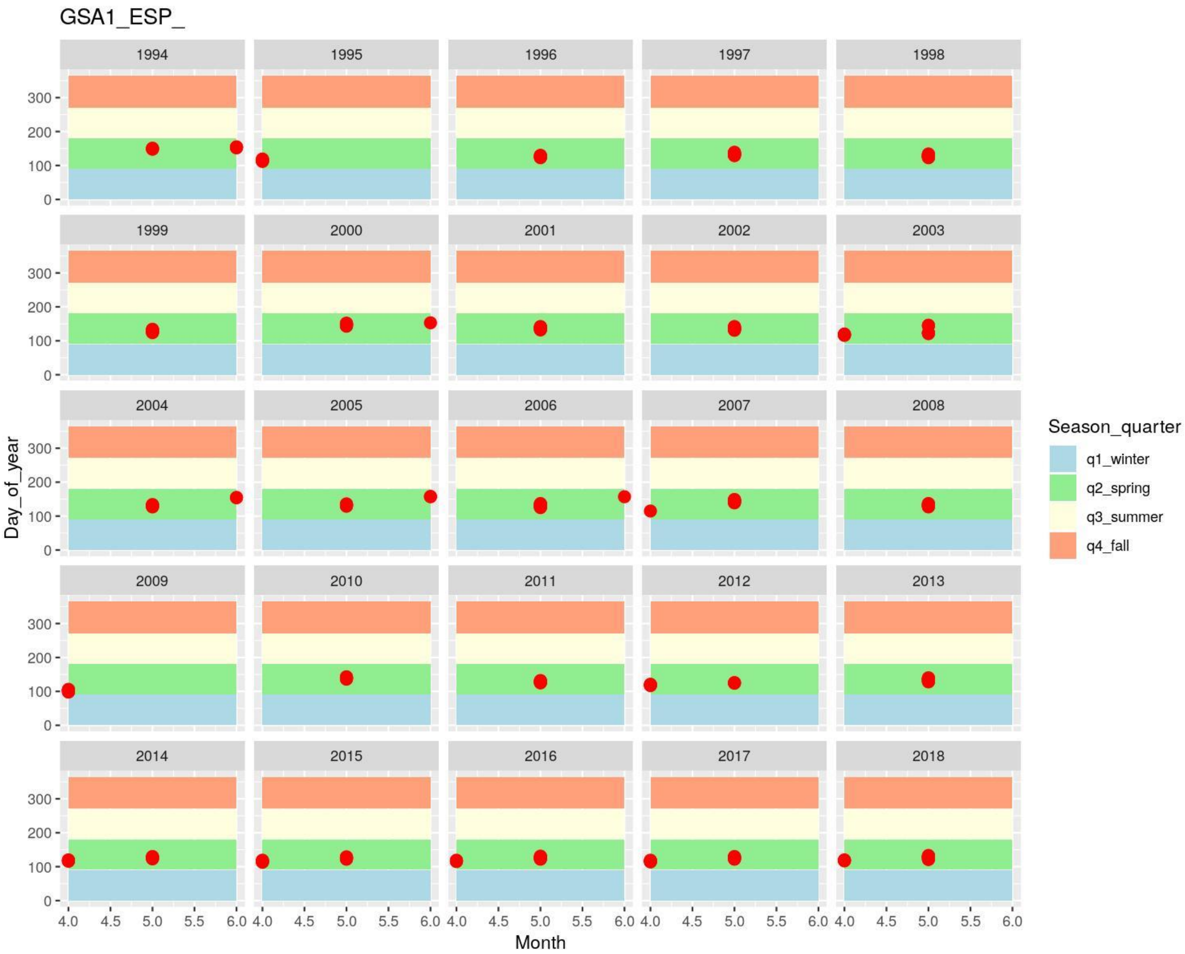


Figure 16.15.2.3.1. Month of the year when the hauls of MEDITS survey are being conducted in GSA 1.

6.15.2.3.2. Geographical distribution

The blue and red shrimp are mainly concentrated at the eastern part of the north Alboran Sea and deep waters. The geographical distribution of the stock since 2002 is shown in Figure 6.15.2.3.2.

Figure 6.15.2.3.2 Geographical distribution of blue and red shrimp in GSA 1 based on the biomass index of MEDITS survey (2002-2018).

6.15.2.3.3 Trends in abundance and biomass

The time series of abundance and biomass indices of blue and red shrimp from MEDITS bottom trawl survey in GSA 1 are shown in the following figures (Figure 6.15.2.3.3 and 6.15.2.3.4) 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 2007-2018. In two 2018 the value is similar to the mean of the later period.
Please note the very low (near zero) total biomass and density in years 2011 and 2013 were excluded from the analysis. Only four individual blue and red shrimps were caught in 2011 and 2013 probably because the hauls where the main biomass of the species is usually caught were not conducted during those years. Consequently the number of individuals at age for 2011 and

2013 from MEDITS were not used in the age based assessment, this was the same as previous years.

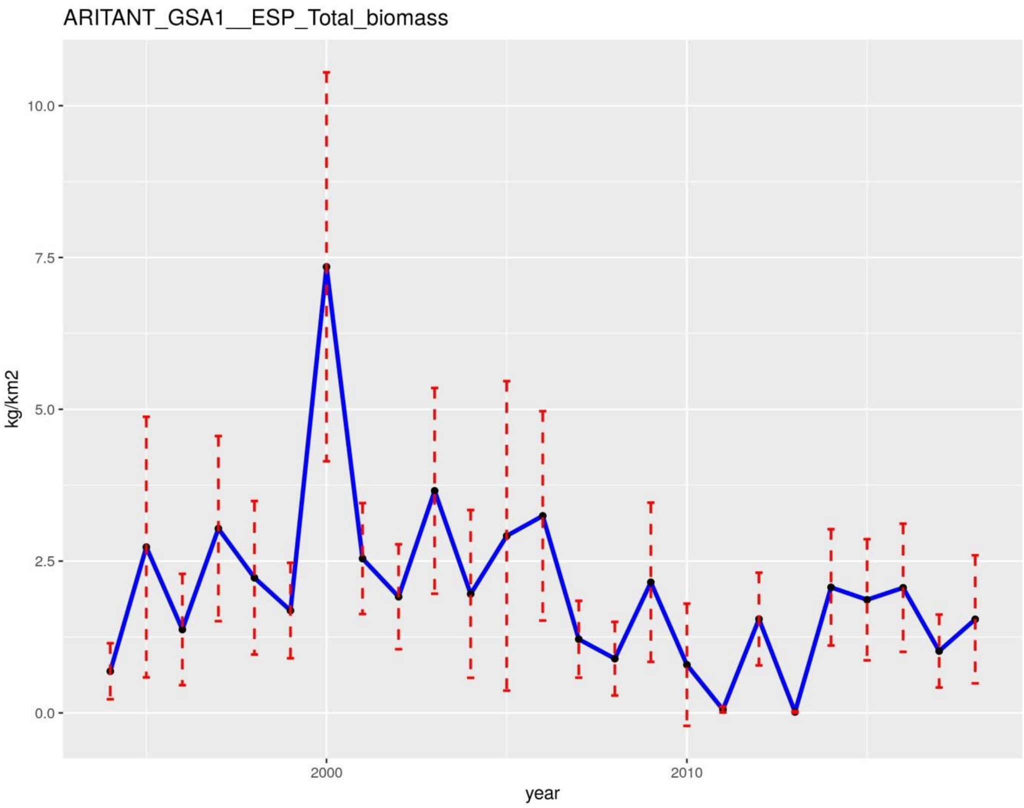


Figure 6.15.4.3. Blue and red shrimp in GSA 1. MEDITS survey biomass index (kg/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

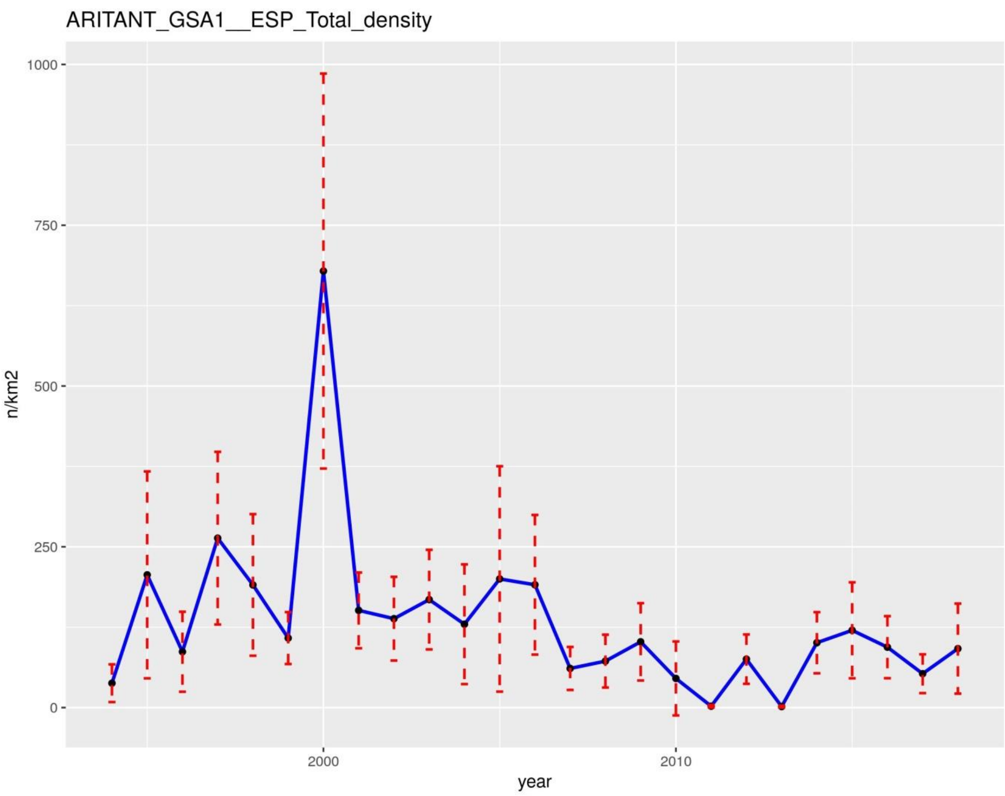


Figure 6.15.2.3.4. Blue and red shrimp in GSA 1. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

Table 6.15.2.3.1. 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
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	1.213
2008	0.893
2009	2.151
2010	0.793
2011	0.054
2012	1.545
2013	0.014
2014	2.067
2015	1.863
2016	2.060
2017	1.019
2018	1.541

Trends in abundance by length (Figure 6.15.2.3.5), the cohorts consistency in MEDITS index (Figure 6.15.2.3.6), number of individuals per year by age (Figure 6.15.2.3.7), number of individuals per age by year (Figure 6.15.2.3.8) are shown below.

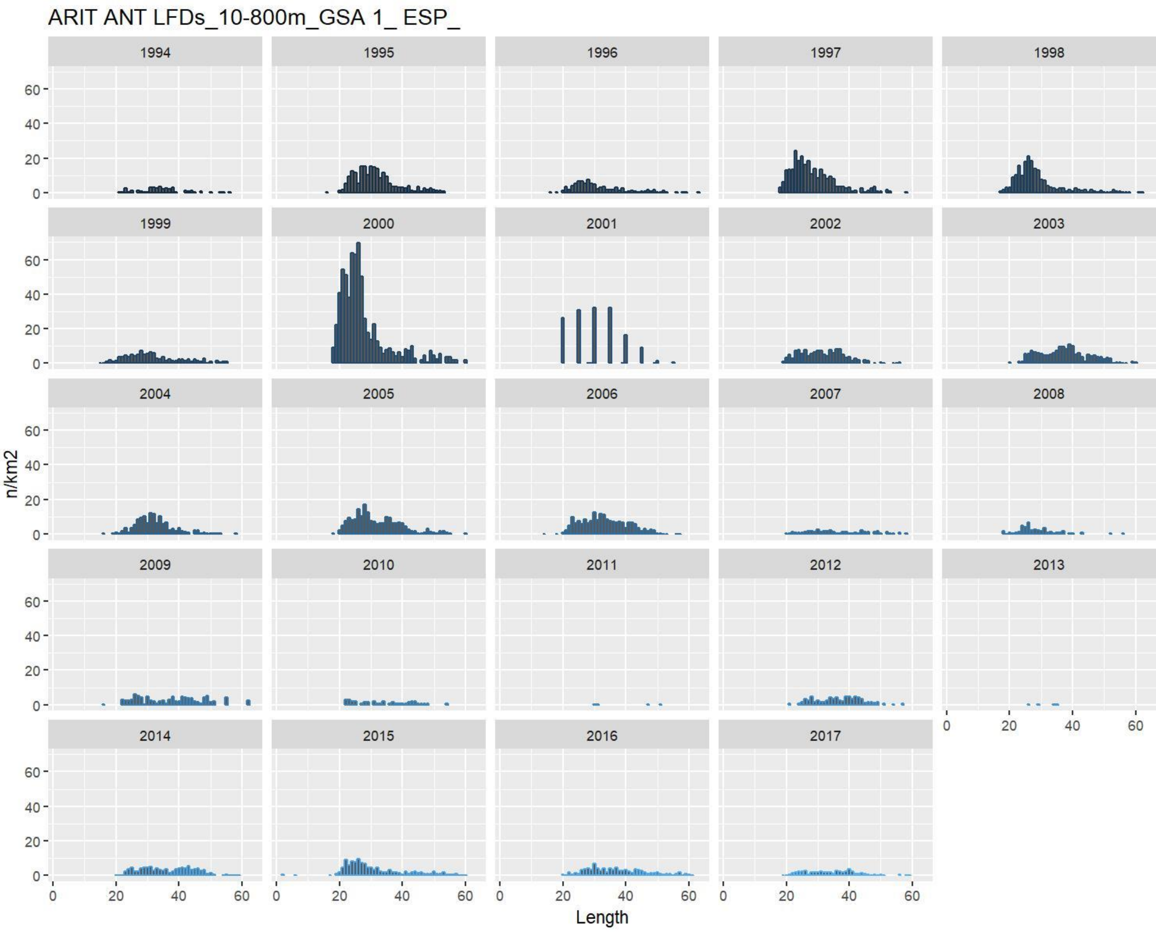


Figure 6.15.2.3.5. Blue and red shrimp in GSA 1. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June.

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 1-4) according to MEDITS surveys. Years 2011 and 2013 were excluded from the analysis, due to shortage of hauls in some strata in these years.

	1	2	3	4
2002	82.06426	53.61917	2.6045	
2003	54.75935	93.12369	18.36242	1.6395
2004	82.62845	43.54377	3.40254	0.29897
2005	124.1028	65.31726	10.20582	0.40823
2006	105.0441	78.69487	7.20384	
2007	19.64706	14.57685	7.9222	0.31689
2008	75.69246	8.15924	0.85887	
2009	46.20399	55.54309	59.47535	2.45766
2010	23.40023	20.38085	1.50969	
2011				
2012	24.32503	47.13194	4.45291	
2013				
2014	42.69805	49.7059	7.96956	0.48391
2015	82.73878	24.46131	11.18995	0.88183
2016	38.92225	40.65035	12.08044	2.26103
2017	25.62647	24.62326	1.98513	0.44618
2018	50.49887	37.31798	3.71039	0.24736

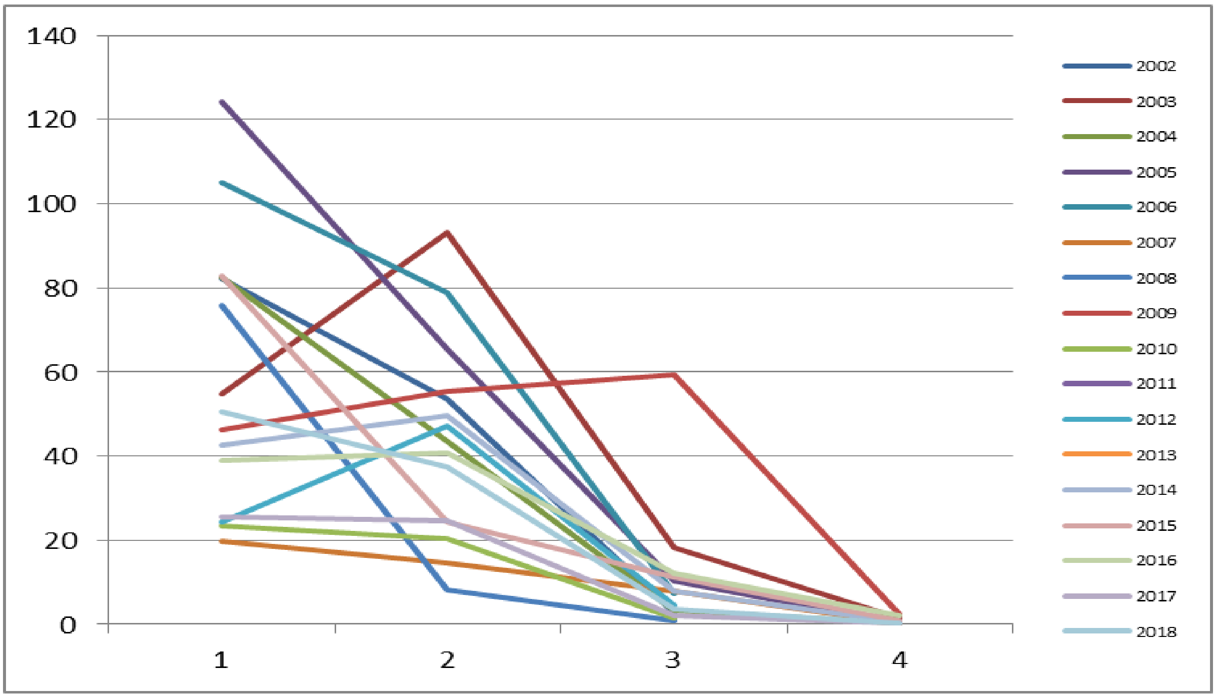


Figure 6.15.2.3.6. Blue and red shrimp in GSA 1. Age frequency distribution of the MEDITS survey of blue and red shrimp in GSA 1 as reported by DCF. The survey is carried out from April to June. Note that 2011 and 2013 were excluded from the analysis (see maintext for details).

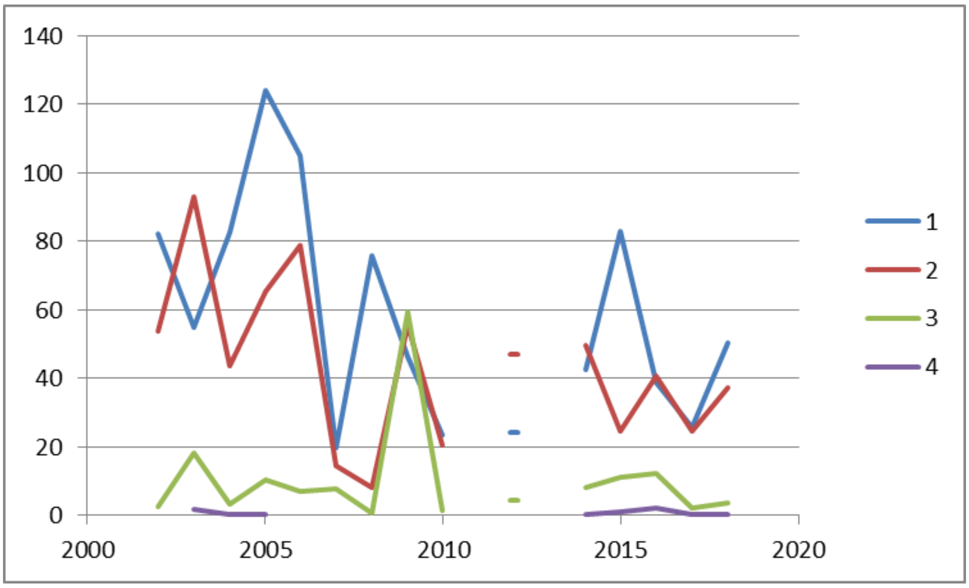


Figure 6.15.2.3.7. Blue and red shrimp in GSA 1. Number of individuals per year by age group (ages 1-4) according to MEDITS surveys. Years 2011 and 2013 were excluded from the analysis.

6.15.3 STOCK ASSESSMENT

This stock was assessed for the in 2018 (STECF EWG 18-12) using a4a and XSA, prior to that in 2015using 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 was used this year with the addition of 2018 catch and survey data. However different treatment of length to age that better aligns the the birthday to 1st of January for stocks with summer spawing. This 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 y and were kept identical as in the previous assessment but 0.5 was added to t_0 for purpose of aligning sizes appropriately with 1st of January for length slicing.

The spawning of blue and red shrimp peaks during the summer, although continuous spawning throughout the year has been reported from some areas of the Mediterranean.

The proportion of mature individuals at age was not available for blue and red shrimp in GSA 1 and was taken from the previous assessment that was based on the DCF data (Table 6.15.1.2). 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 origonal 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 1.6.7 of FLa4a, together with version 2.6.13 of the FLR library (FLCore) in FLR environment. The 3.5.1 (64-bit) version of R was used.

Settings

The analysis was carried out for the ages 0 to 4 age class (age group 4 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 0-2 age groups that form the vast majority of the catch.

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

```
fmodel <- ~ factor(age) + factor(year)
qmodel <- list(~ s(replace(age,age>2,2), k=3))
sr: srmodel <- ~s(year)
```

This was the similar formulation as last year.

All diagnostic tests and retrospective analysis were applied.

Results

The stock summary (Table 6.15.3.1, Figure 6.15.3.5) 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 6.15.3.6), the residuals of catch and abundance indices by age (Figure 6.15.3.7), the quantile-quantile plot of residuals (log) of catch and abundance indices (Figure 6.15.3.8), the fitted and observed catch at age (Figure 6.15.3.9) and index at age (Figure 6.15.3.10), the residuals of catch and abundance index (Figure 6.15.3.11) as well as the retrospective analysis (Figure 6.15.3.12) and the stock summary of the simulated and fitted data (Figure 6.15.3.13).

Historical stock trends

Spawning stock biomass (SSB)

The SSB shows a clear decreasing trend since 2012 but appear rather stable in the last three years. The average SSB in the last 5 years of the dataset (2014-2018) is 106 t, which is considerably lower compared to the average SSB in the beginning of the time series (2002-2006) that was 136 t (Figure 6.15.3.5).

Recruitment

Recruitment shows similar declining pattern since 2005 (highest value in the time series). The recruitment in 2018 was 250,000 individuals, near the mean of the time series(Figure 6.15.3.5). The overall average recruitment that was used in the STF was 270298 recruits.

Catch

Catch declined from around 250 t in 2002-2004 to around 100 t in 2018, with a clear declining trend since 2014. It appeared rather stable from 2008 to 2014.

Fishing mortality (F)

F has been exceeding $F_{0.1}$ since 2003. It declined in the early part of the time-series but has fluctuated around 1.0 until 2017 but has increased again in the last year to 1.14.

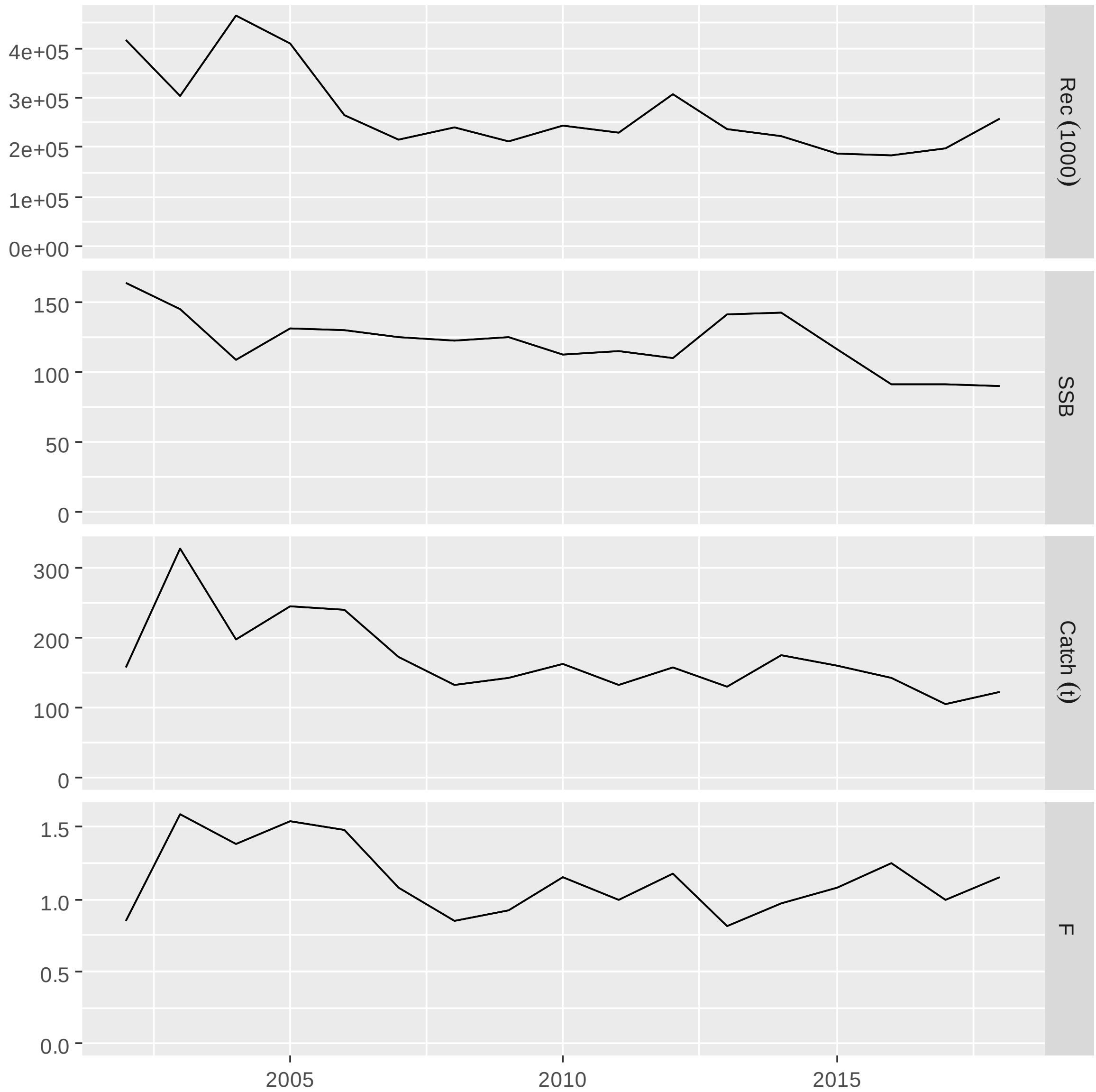


Figure 6.15.3.5. Blue and red shrimp in GSA 1. Stock summary for blue and red shrimp in GSA 1, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality).

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	415694	164.882	157.72	0.85033
2003	303739	145.676	328.2	1.59233
2004	464287	108.89	198.59	1.37763
2005	408243	131.144	244.93	1.54393
2006	263960	129.975	240.09	1.48459
2007	215496	125.528	172	1.08044
2008	240670	123.525	133.36	0.85306
2009	213130	125.549	143.84	0.92001
2010	244678	112.861	161.78	1.15885
2011	231094	115.416	133.86	1.00101
2012	305428	110.538	158.23	1.1832
2013	237014	141.963	131.35	0.81806
2014	221565	143.546	175.98	0.96866
2015	187840	116.45	160.58	1.08483
2016	184881	91.59	141.65	1.25404
2017	198947	92.13	105.43	0.99504
2018	258398	90.448	123.7	1.14778

Table 6.15.3.2 Stock Summary blue and red shrimp in GSA 1 N at age from a4a assessment including survivors ist of January 2019 (Geometric mean recruitment).

year/age	0	1	2	3	4	5
2002	415690	46538	5405.3	166.65	0.79191	0.000999
2003	303740	40563	11472	892.49	22.568	0.38439
2004	464290	29639	6365.9	674.6	33.006	8.9086
2005	408240	45305	5300.7	504.66	36.32	19.23
2006	263960	39836	7322.5	333.4	20.312	26.371
2007	215500	25757	6675.4	500.22	14.887	24.833
2008	240670	21028	5519.7	800.21	45.294	22.615
2009	213130	23484	5175	907.91	107.85	36.472
2010	244680	20797	5548.8	775.5	108.84	74.556
2011	231090	23875	4249.1	596.4	61.219	95.556
2012	305430	22550	5369.9	568.88	62.053	89.577
2013	237010	29803	4539.5	557.94	43.035	84.348
2014	221570	23128	7492.6	783.94	79.947	75.337
2015	187840	21620	5305.1	1049.3	86.313	85.671
2016	184880	18329	4620.8	632.07	94.286	93.719
2017	198950	18041	3534.1	435.05	42.243	100.09
2018	258400	19413	4072.3	477.1	45.74	83.755
2019	259960	25214	3993.1	444.5	38.4	73.762

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	0.51748	1.1832	1.4875	0.26685	0.015168
2003	0.96904	2.2156	2.7855	0.4997	0.028404
2004	0.83838	1.9169	2.4099	0.43232	0.024574
2005	0.93959	2.1483	2.7008	0.48451	0.02754
2006	0.90348	2.0657	2.597	0.46589	0.026482
2007	0.65752	1.5033	1.89	0.33906	0.019273
2008	0.51915	1.187	1.4923	0.2677	0.015217
2009	0.55989	1.2801	1.6094	0.28871	0.016411
2010	0.70524	1.6125	2.0272	0.36367	0.020671
2011	0.60918	1.3928	1.7511	0.31413	0.017856
2012	0.72006	1.6463	2.0698	0.37131	0.021106
2013	0.49785	1.1383	1.431	0.25672	0.014592
2014	0.5895	1.3478	1.6945	0.30398	0.017279
2015	0.66019	1.5095	1.8977	0.34044	0.019351
2016	0.76317	1.7449	2.1937	0.39354	0.02237
2017	0.60555	1.3845	1.7406	0.31226	0.017749
2018	0.69851	1.5971	2.0078	0.36019	0.020474

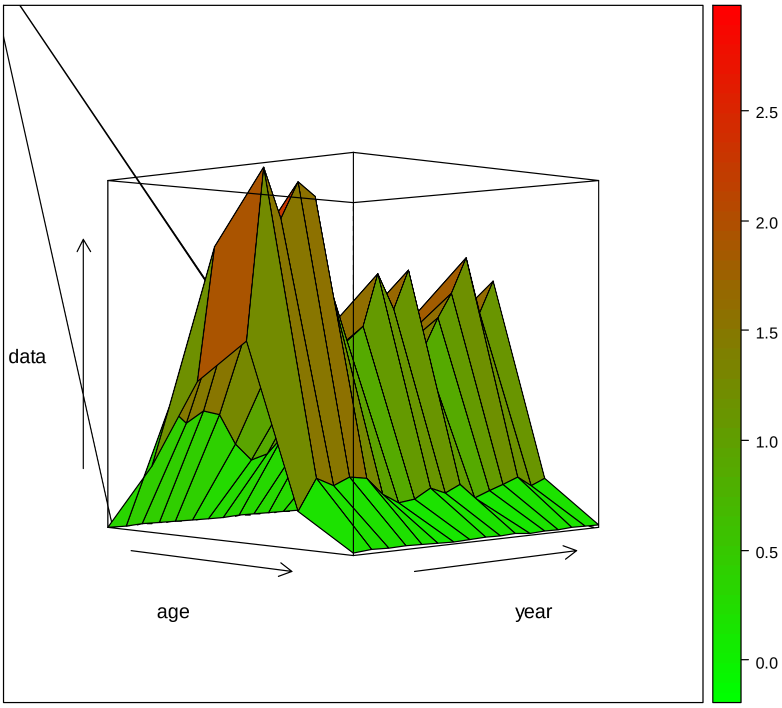


Figure 6.15.3.6. Blue and red shrimp in GSA 1. 3D contour plot of estimated fishing mortality at age and year.

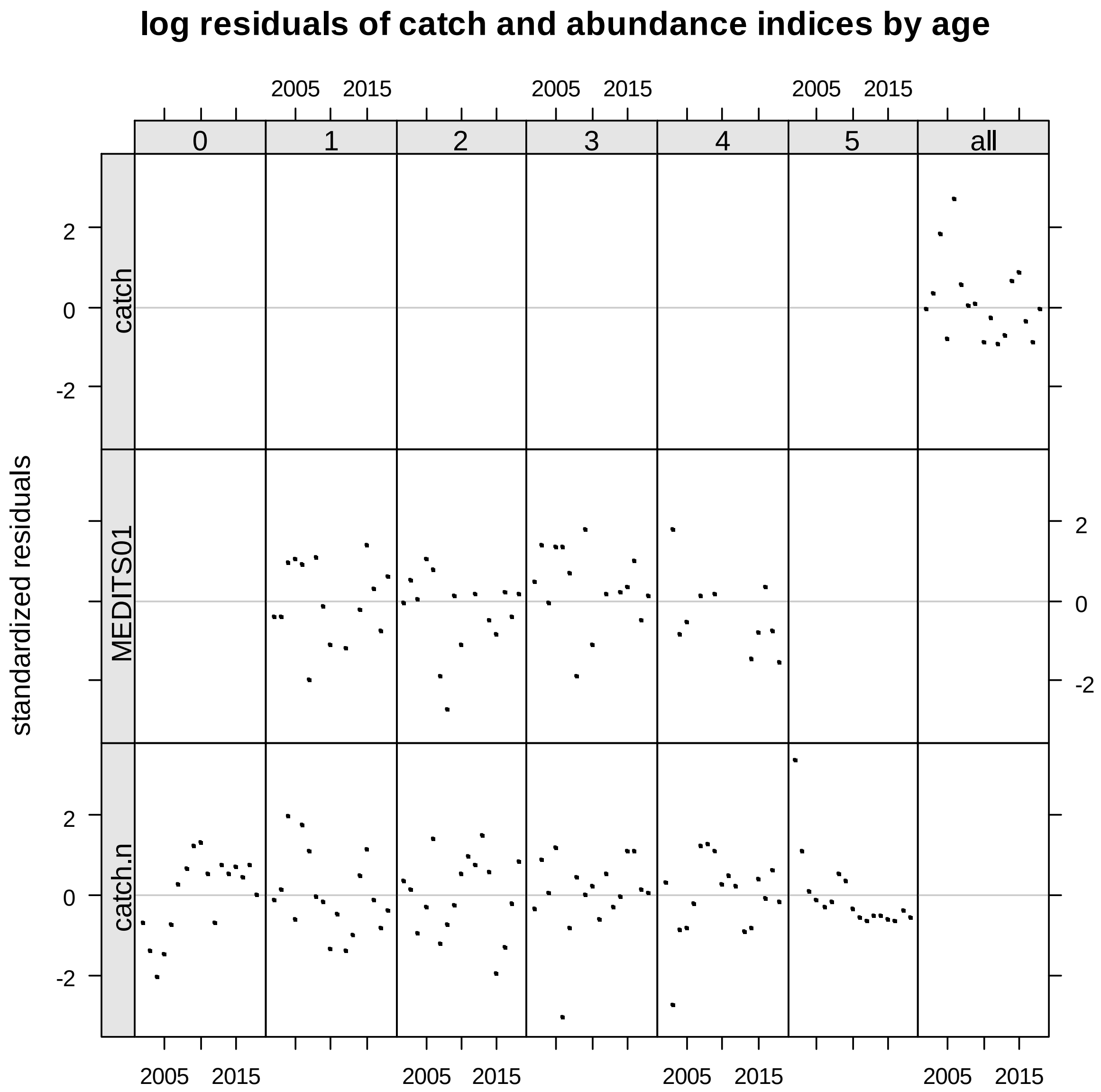


Figure 6.15.3.7. Blue and red shrimp in GSA 1. Standardized residuals for abundance indices (MEDITS) and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

Figure 6.15.3.8. Blue and red shrimp in GSA 1. Quantile-quantile plot of 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 the normal distribution quantiles.

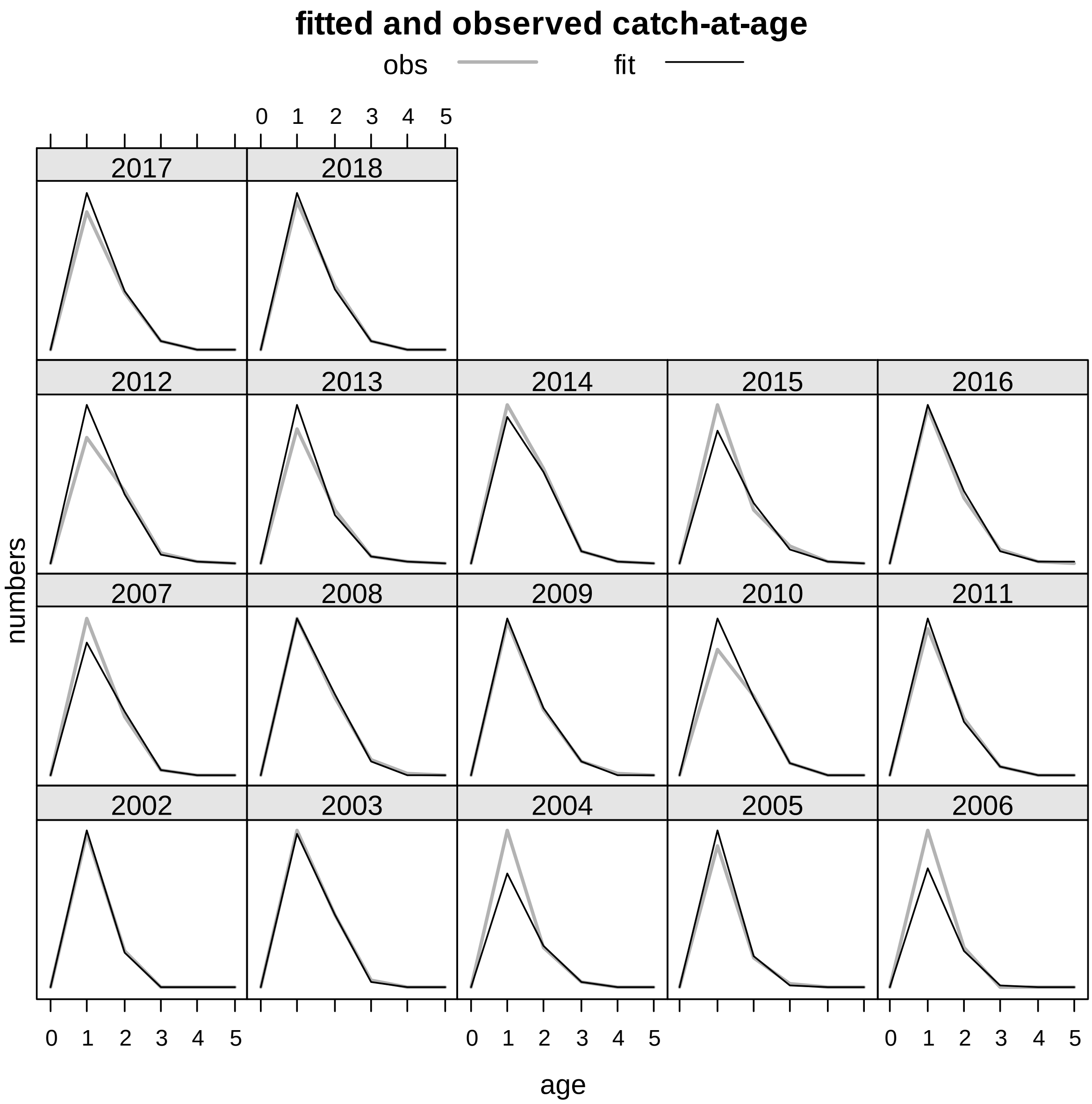


Figure 6.15.3.9. Blue and red shrimp in GSA 1. Fitted and observed catch at age.

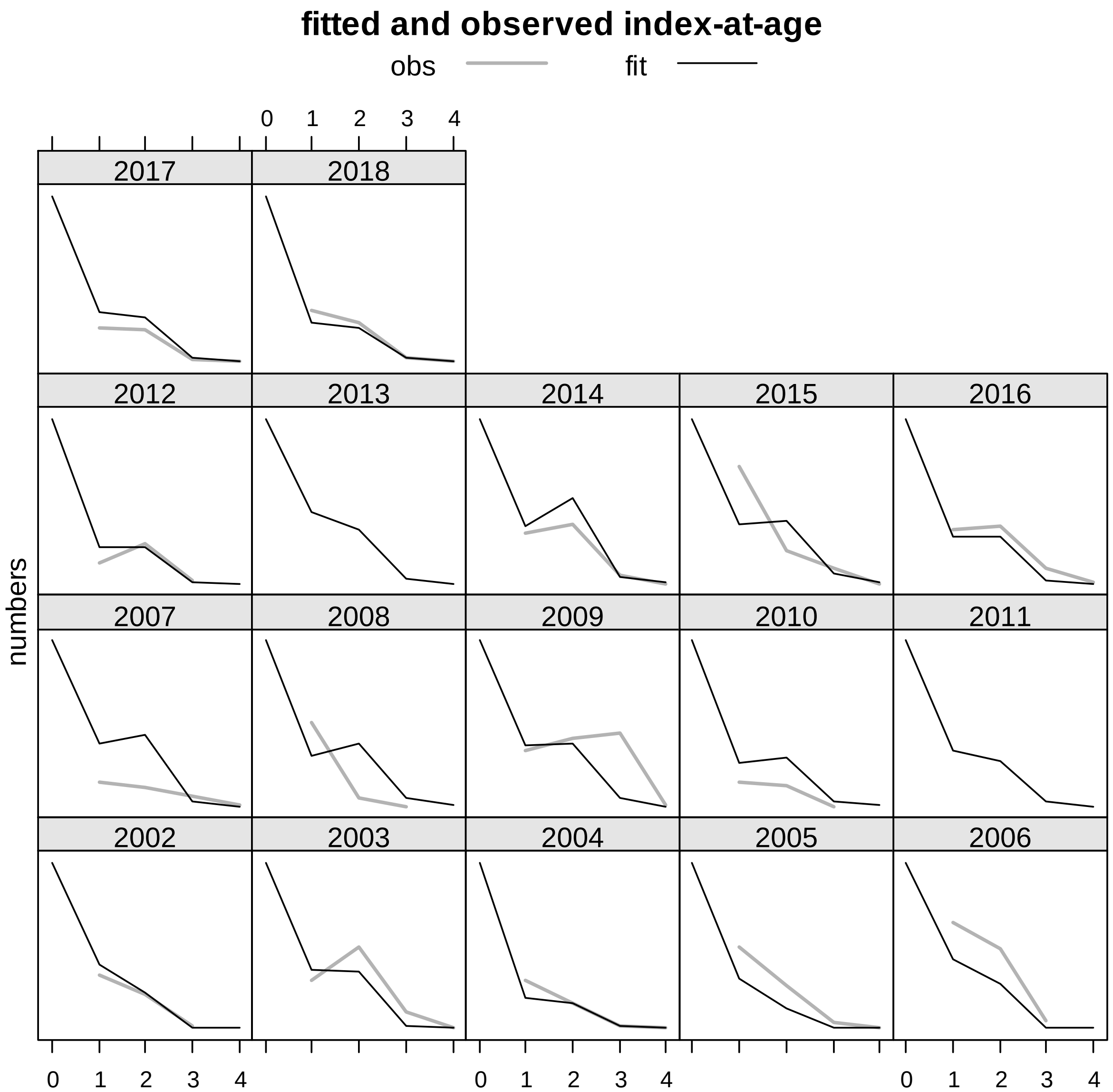


Figure 6.15.3.10. Blue and red shrimp in GSA 1. Fitted and observed index at age.

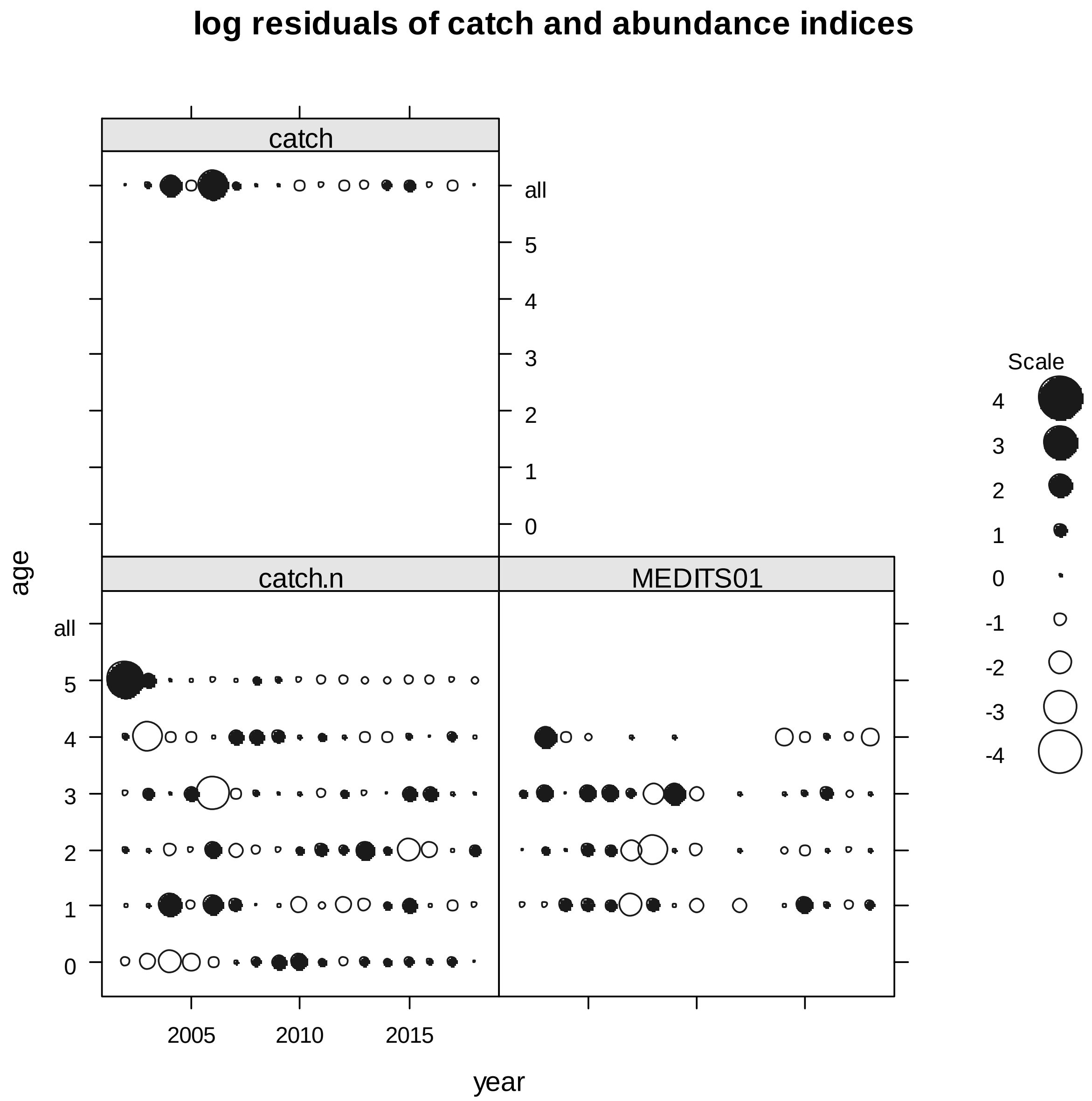


Figure 6.15.3.11. Blue and red shrimp in GSA 1. Residuals of catch and abundance index (a4a).

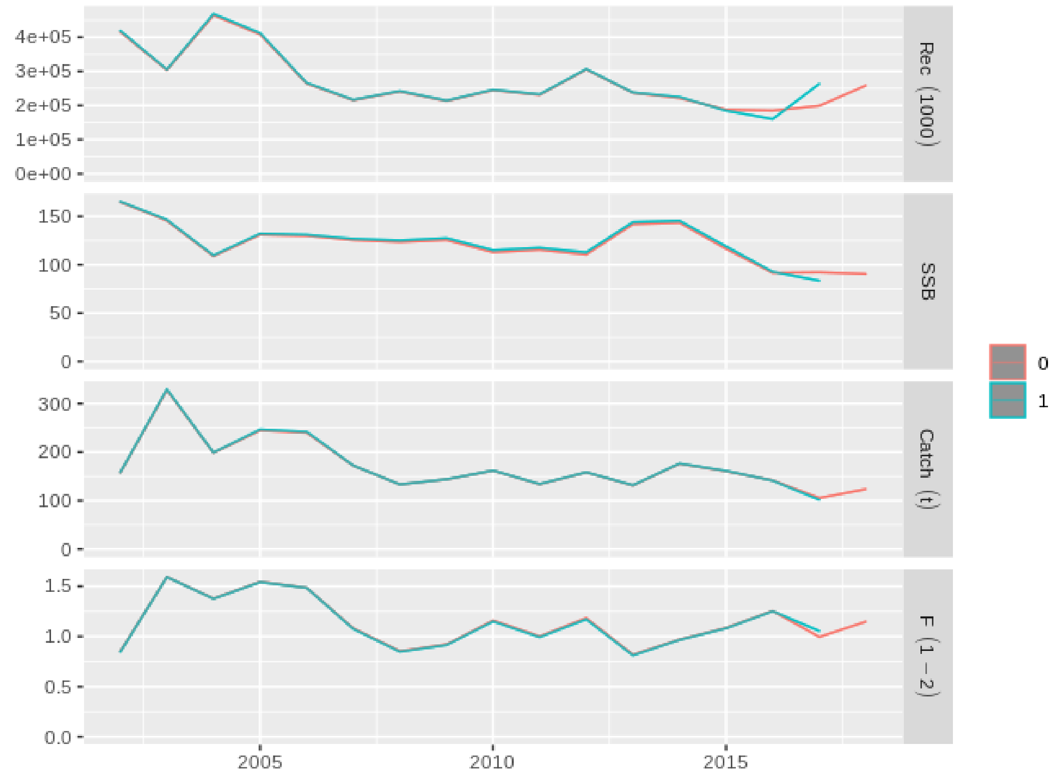


Figure 6.15.3.12. Blue and red shrimp in GSA 1. Retrospective analysis output from a4a.

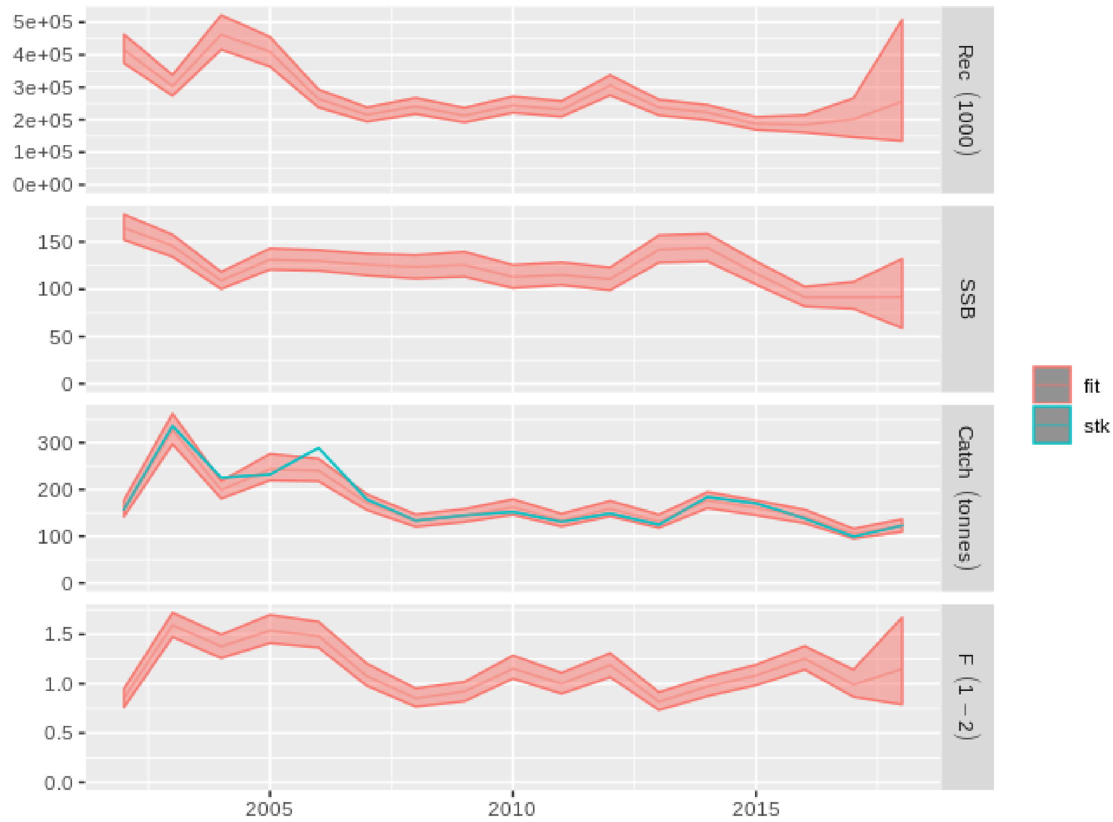


Figure 6.15.3.13. Blue and red shrimp in GSA 1. Stock summary of the simulated and fitted data from a4a.

The assessment this year is different from last year in two ways, the data has been treated differently in the length slicing in order to obtain good alignment with the perception of intividal growth at the time of the survey, and size at 1st of January. In order to slice the catch and survey at length the positioning of the length at 1st of January takes into account the growth at to best optimes this with: the spawing period of mid year the size at maturity (~24mm) and a calendar year for the assessment. In order to test if this change was having an important difference in the perception of the state of the stock, last years assessment, this years assessment and an asessment carried out with this years data sliced using the parameters of last year are compared below. It can be seen that F/F_{MSY} in 2017 and 2018 are highly comparable across data treatments. As the new method has greater biological realism this is the method chosen and reported in detail above.

Method	**F01**	**Fbar 2017**	**F01/ Fbar2017**	**Fbar 2018**	**F/F_{MSY} 2018**
a4a 2019 assessment **2018 and 2017 F bar ages 1-2**	0.56	0.99	1.77	1.15	2.06
a4a 2018 (previous) assessment **2017 F bar ages 0,2**	0.42	0.73	1.74		
Assessment run on 2019 data and using 2018 age-length method **2018 and 2017 F ages 1-2**	0.53	0.94	1.76	1.16	2.17

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 2002-2018 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 0.56 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 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-11.

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 mean for last three years F = 1.13 as F is seen to fluctuate. No trend in recruitment is observed so R 2019 is taken as geometric mean of time series.

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		mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2016-2018
$F_{ages\ 1\text{-}2}$ (2019)	1.13	mean F 2016-2018 is used to give F status quo for 2019
SSB (2019)	106.3	Stock assessment 1 January 2019
R_{age0} (2019,2020)	259960	Geometric mean of the last 17 years (full time series)
Total catch (2019)	139.6	Assuming F status quo for 2019

Table 6.15.5.2. Results of STF

The results of the short term forecasts for blue and red shrimp (GSA 1) are shown in table 6.15.5.1.

Ffactor	Fbar	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB 2020	SSB 2021	SSB_change 2019-21(%)	Catch_change 2018-2020(%)
0.49	0.56	123.7	139.6	96.0	132.6	148.5	189.5	78.3	-22.4
0.67	0.76	123.7	139.6	120.6	148.0	135.2	156.7	47.5	-2.5
0.33	0.37	123.7	139.6	69.3	108.2	162.2	229.7	116.2	-44.0
0.00	0.00	123.7	139.6	0.0	0.0	194.2	355.4	234.5	-100.0
0.10	0.11	123.7	139.6	23.8	45.2	183.7	308.8	190.6	-80.8
0.20	0.23	123.7	139.6	45.1	78.4	173.8	270.1	154.2	-63.5
0.30	0.34	123.7	139.6	64.3	102.7	164.6	237.8	123.8	-48.0
0.40	0.45	123.7	139.6	81.5	120.5	156.0	210.8	98.3	-34.1
0.50	0.57	123.7	139.6	97.1	133.4	147.9	188.0	76.9	-21.5
0.60	0.68	123.7	139.6	111.2	142.8	140.4	168.7	58.8	-10.1
0.70	0.79	123.7	139.6	124.0	149.7	133.3	152.3	43.4	0.3
0.80	0.91	123.7	139.6	135.7	154.6	126.6	138.3	30.2	9.7
0.90	1.02	123.7	139.6	146.4	158.1	120.4	126.3	18.8	18.4
1.00	1.13	123.7	139.6	156.2	160.6	114.5	115.9	9.1	26.3
1.10	1.25	123.7	139.6	165.2	162.3	109.0	106.8	0.5	33.5
1.20	1.36	123.7	139.6	173.4	163.5	103.8	98.9	-6.9	40.2
1.30	1.47	123.7	139.6	181.0	164.4	98.9	92.0	-13.4	46.3
1.40	1.59	123.7	139.6	188.1	164.9	94.3	85.9	-19.2	52.0
1.50	1.70	123.7	139.6	194.6	165.3	89.9	80.5	-24.3	57.3
1.60	1.81	123.7	139.6	200.7	165.6	85.8	75.6	-28.8	62.2
1.70	1.92	123.7	139.6	206.3	165.7	82.0	71.3	-32.9	66.8
1.80	2.04	123.7	139.6	211.5	165.9	78.3	67.4	-36.6	71.0
1.90	2.15	123.7	139.6	216.5	166.0	74.9	63.8	-39.9	75.0
2.00	2.26	123.7	139.6	221.0	166.1	71.6	60.6	-43.0	78.7

*SSB at mid year

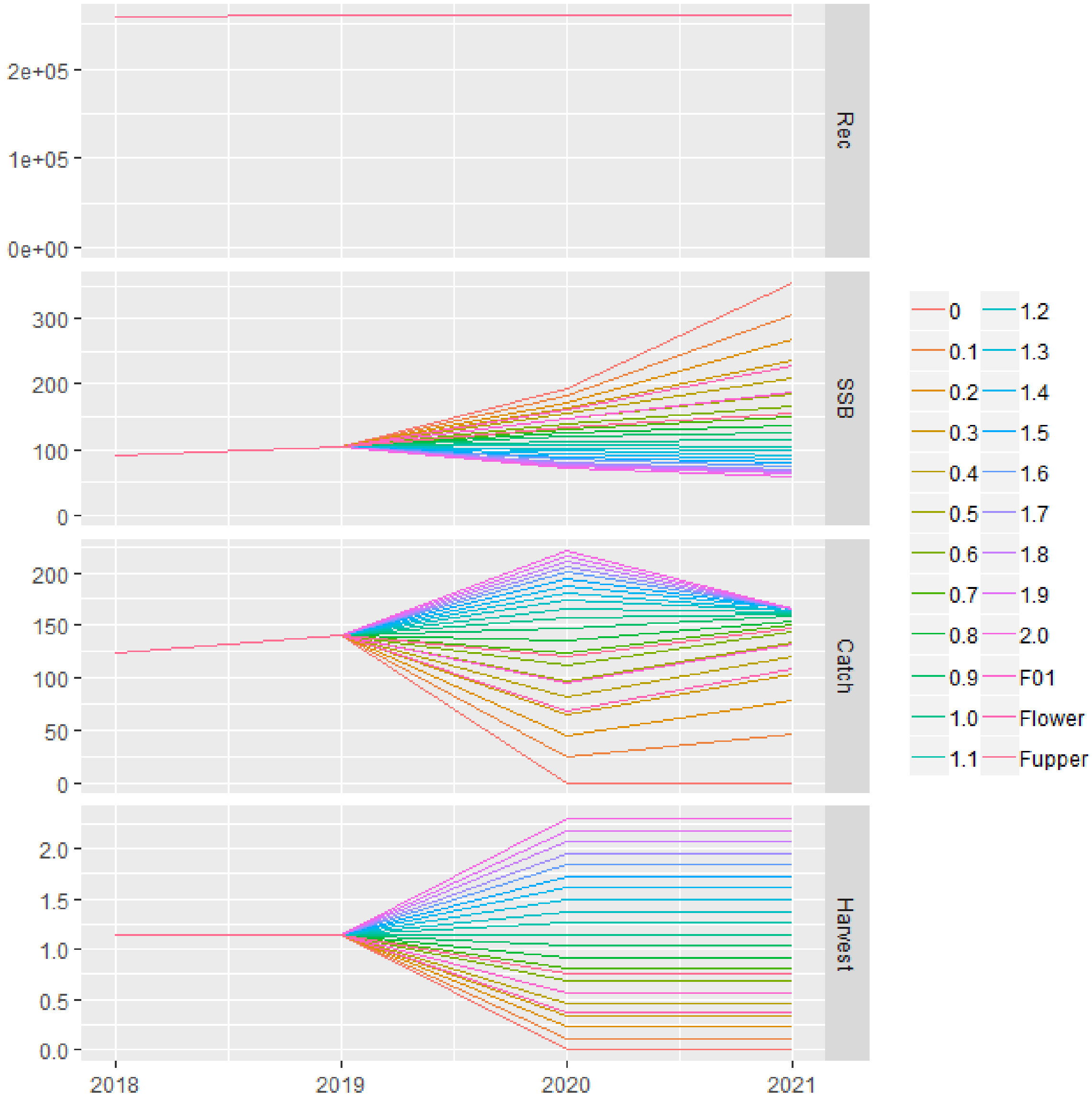


Figure 6.15.5.1. Blue and red shrimp in GSA 1. Annual catch scenarios and predictions of catch and SSB for blue and red shrimp (GSA 1).

Table 6.15.5.3. Blue and red shrimp (ARA) in GSA 1 short term forecast. For Section 5. Annual catch scenarios and predictions of catch and SSB. All weights are in tonnes. Basis: F(status quo) = geometric mean(Fbar1-2 2016-2018) = 1.15; R = geometric mean of the recruitment of the full timeseries 17 years; R = 259960; SSB(2019) = 118.5 t, Catch (2019) = 140.8 t.

Basis	Total catch* (2020)	F_{total}# (ages 0-2) (2020)	SSB (2021)	% SSB change***	% Catch change^^
STECF advice basis					
F_{MSY}	96.03	0.56	189.50	78%	-22%
$F_{MSY\ lower}$	69.27	0.37	229.75	116%	-44%
$F_{MSY\ upper}$	120.56	0.76	156.68	47%	-3%
Other scenarios					
Zero catch	0.00	0.00	355.41	234%	-100%
Status quo	156.18	1.13	156.97	48%	26%
0.3	64.27	0.34	237.80	124%	-48%
0.4	81.52	0.45	210.75	98%	-34%
0.5	97.10	0.57	187.99	77%	-22%
0.6	111.22	0.68	168.72	59%	-10%
0.7	124.05	0.79	152.33	43%	0%
0.8	135.73	0.91	138.32	30%	10%
0.9	146.40	1.02	126.28	19%	18%
1.0	156.18	1.13	115.88	9%	26%

6.15.6 DATA DEFICIENCIES

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.

6.16 BLUE AND RED SHRIMP IN GSA 5

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; 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 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.

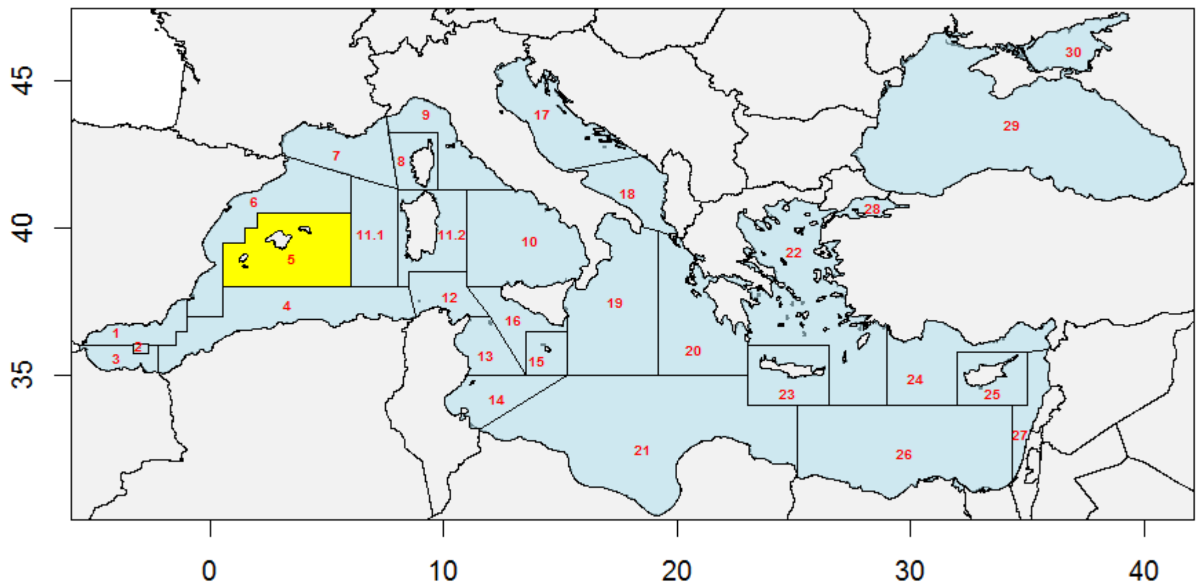


Figure 6.16.1 Geographical location of GSA 5.

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).

6.16.2 DATA

General description of the fisheries

In the Balearic Islands, commercial trawlers develop up to four different fishing tactics, which are associated with the shallow shelf (SS), deep shelf (DS), upper slope (US) and middle slope (MS) (Guijarro and Massutí 2006; Ordines et al. 2006), mainly targeted to: (i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the SS (50-80 m); (ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the DS (80-250 m); (iii) *Nephrops norvegicus*, but with an important by-catch of big *M. merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the US (350-600 m) and (iv) *Aristeus antennatus* on the MS (600-750 m). The MS fishing tactics coincides with the metier OTB_DWSP; OTB_DEMSP corresponds to those days in one of the other fishing tactics is present (SS, DS and/or US) and OTB_MDDWSP corresponds to those days in which one haul in MS and at least one of the other fishing tactics is performed.

6.16.2.1 CATCH (LANDINGS AND DISCARDS)

Landings

Landings data were reported to STECF EWG 19-10 through the Data call. They come exclusively from bottom trawl, both from OTB_DWSP and OTB_MDDWSP (Figure 6.16.2.1). From the period in which information by metier was available (2009-2017), the relative importance of OTB_DWSP oscillates between 30 and 73%.

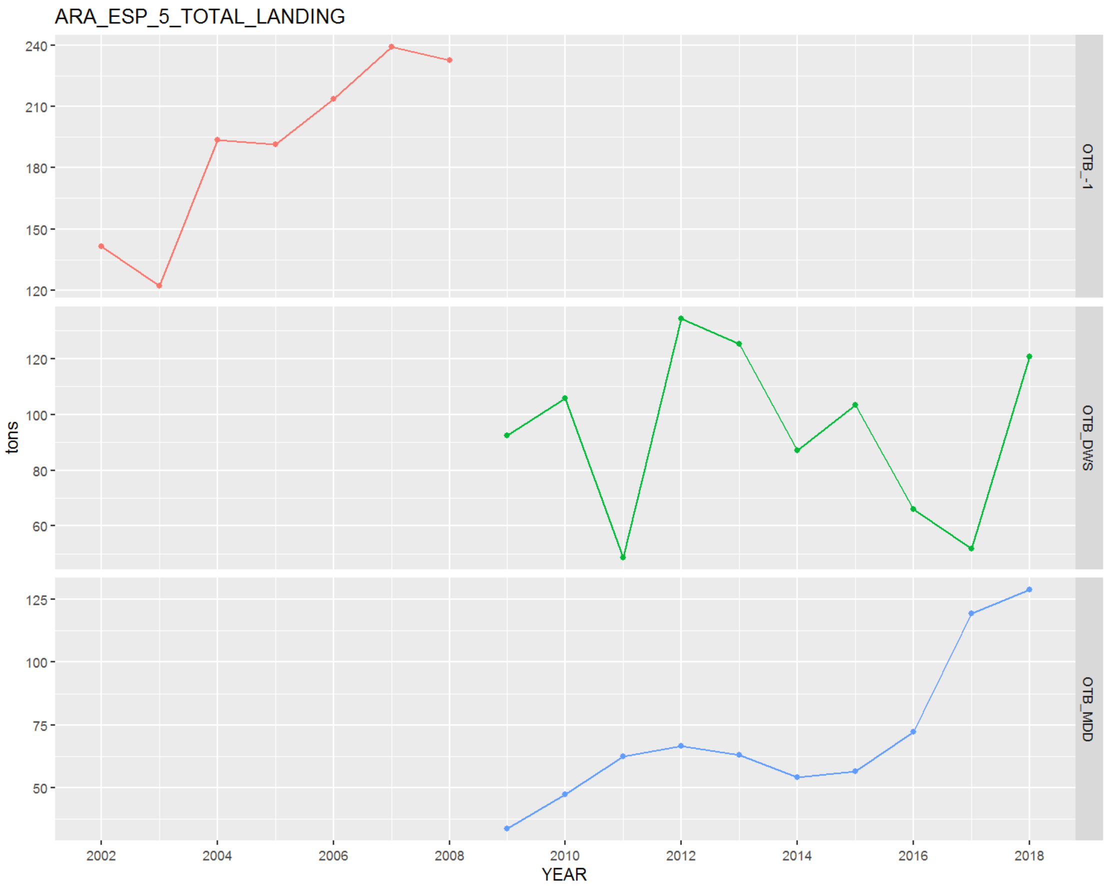


Figure 6.16.2.1 Blue and red shrimp in GSA 5. Blue and red shrimp DCF landings (t) in GSA 5 by gear (2002-2008)

Table 6.16.2.1 Blue and red shrimp in GSA 5. Blue and red shrimp DCF landings (t) in GSA 5 by gear (2002-2008)

Year	OTB-1	OTB_MOD	OTB_DWS	Total
2002				141.45
2003				122.01
2004				193.58
2005				191.48
2006				213.89
2007				239.12
2008				232.85
2009				126.16
2010				153.24
2011				111.24
2012				201.14
2013				188.6
2014				141.28
2015				160.15
2016				138.1
2017				171.35
2018				249.68

Discards

Landings data were reported to STECF EWG 19-10 through the Data call. The percentage of the catch discarded for the blue and red shrimp in GSA 5 is very low, generally lower than 1% and thus they can be considered as nil and were not included in the assessment.

6.16.2.2 EFFORT

Effort data were reported to STECF EWG 19-10 through the Data call. The parameters showed a clear decreasing trend for the period analysed.

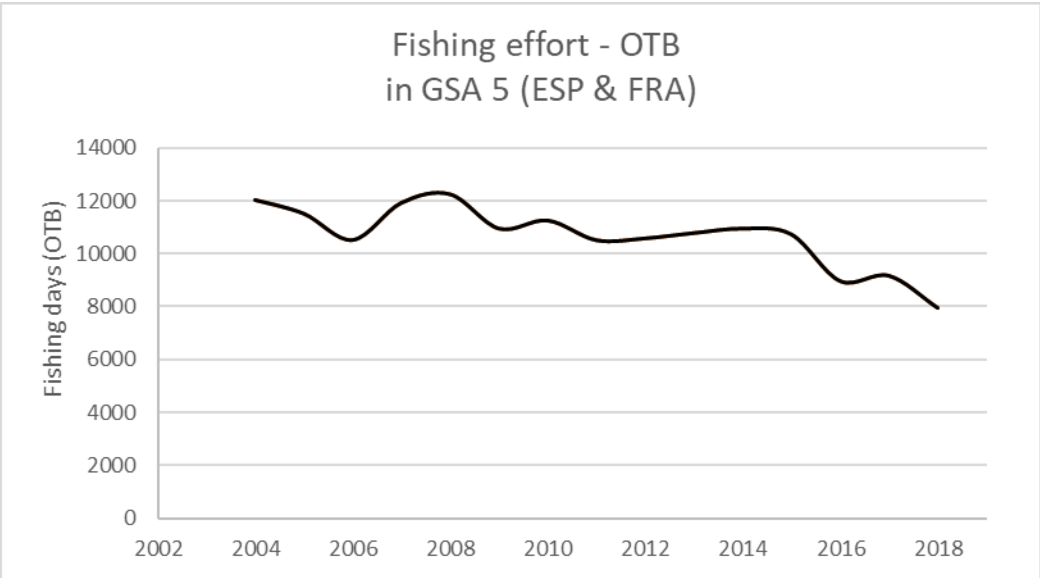


Figure 6.16.2.2 Blue and red shrimp in GSA 5. Effort data (days at sea) of OTB in GSA 5 as reported by DCF.

Table 6.16.2.1 Blue and red shrimp in GSA 5. Effort data (days at sea) of OTB in GSA 5 as reported by DCF.

YEAR	OTB (ESP)	OTB (FRA)	TOTAL:
2004	12012		12012
2005	11497		11497
2006	10507		10507
2007	11907		11907
2008	12226		12226
2009	10934		10934
2010	11239		11239
2011	10498		10498
2012	10568		10568
2013	10769		10769
2014	10936		10936
2015	10714		10714
2016	8952	7	8959
2017	9158		9158
2018	7947		7947

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 Balearic Islands were only 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, only the information collected from 2007 on, when the sampling was extended, should be considered in stock assessment (Figure 6.16.2.3 and Table 6.16.2.2).

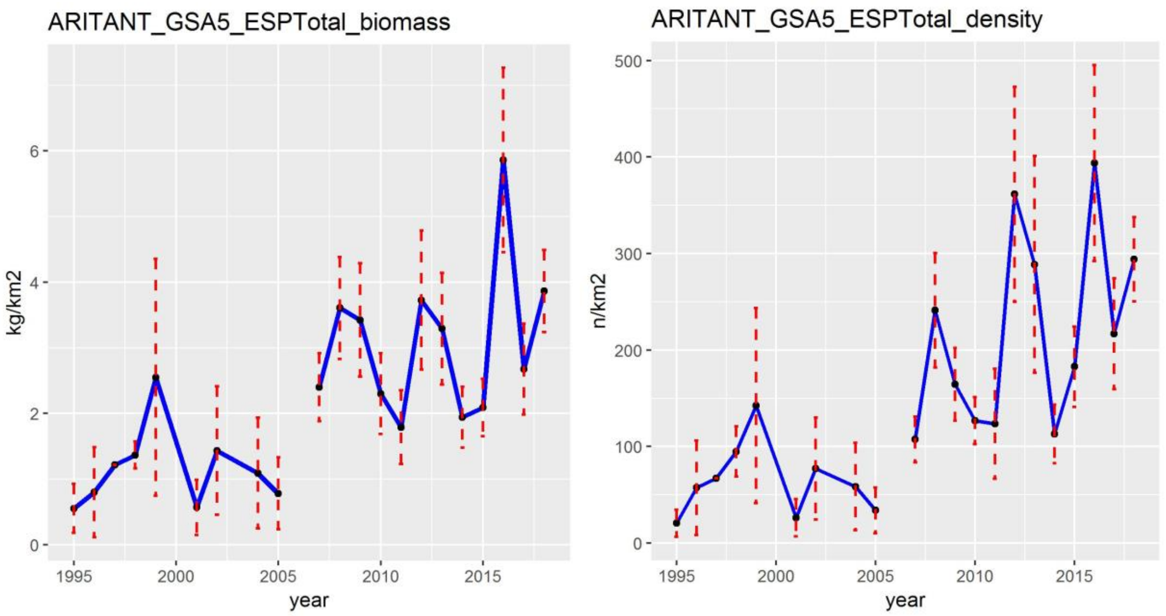


Figure 6.16.2.3 Blue and red shrimp – GSA 5. Biomass (kg/km^2) and density (n/km^2) indices from the MEDITS survey.

Table 6.16.2.2 Blue and red shrimp – GSA 5; biomass and density indices from MEDITS survey Blue and red shrimp – GSA 5

Year	Biomass Index	Density index
2007	2.40	107.39
2008	3.61	241.17
2009	3.42	164.47
2010	2.30	126.78
2011	1.79	123.66
2012	3.73	361.43
2013	3.29	288.69
2014	1.94	113.00
2015	2.09	182.84
2016	5.86	393.64
2017	2.68	216.74
2010	3.86	293.94

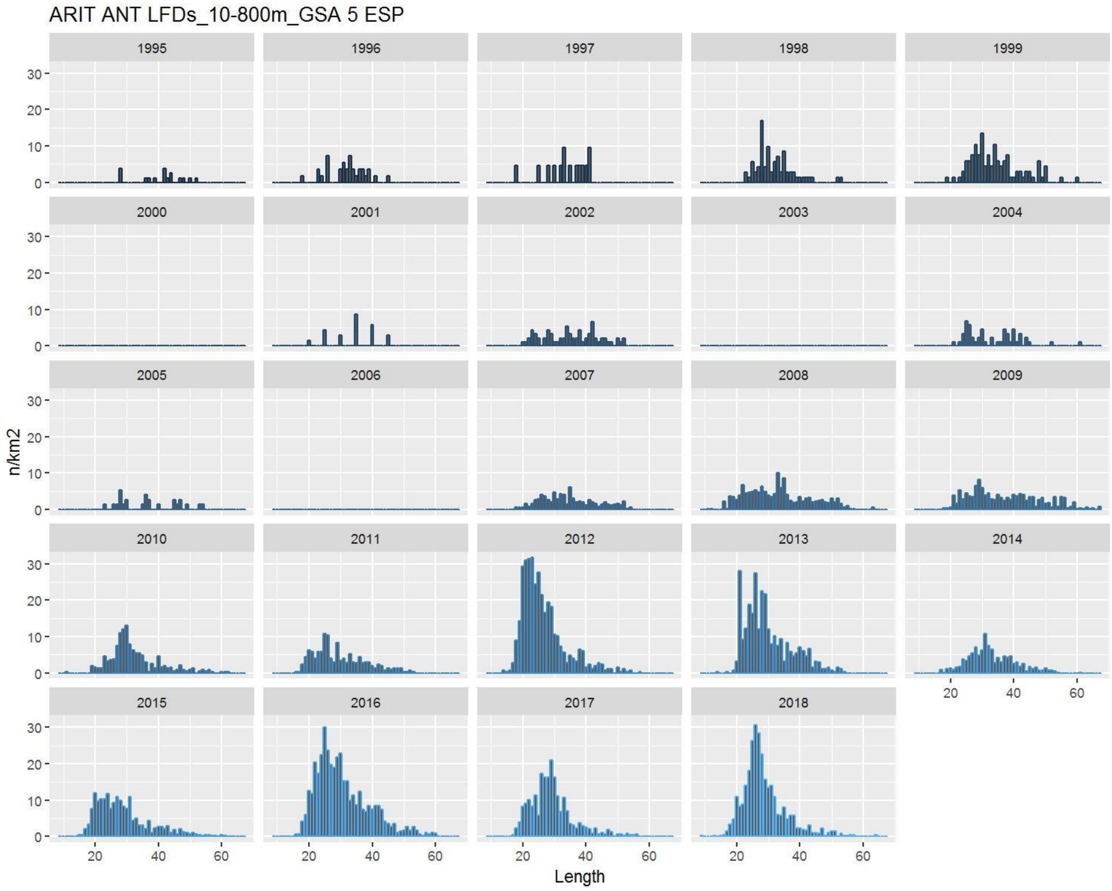


Figure 6.16.2.4 Blue and red shrimp – GSA 5. Length frequency distribution (nkm^2) from the MEDITS survey.

6.16.3 Stock assessment

The EWG 18-12 concluded both neither the XSA nor a4a assessment provided stable models suitable for advice. In the absence of an assessment the 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 is different and could help with an assessment. As no substantive change in survey and landing data in 2018 was observed, a new assessment has not been performed and the advice done in EWG 18-12 has been confirmed by the EWG 19-10.

6.16.4 Reference Points

The assessment carried out by the EWG 18-12 has not been accepted, therefore reference points were not calculated.

6.16.5 Short term Forecast and Catch Options

The advice on catch option for 2019 (150 tonnes, EWG 18-12) was based on the observed catch adjusted to the change in the stock size index for the two most recent values relative to the three preceding values following the approach adopted for ICES category 3 stocks.

The review of the biomass and density indices of the MEDITS survey by the EWG 19-10, confirms the observed trend, and therefore the EWG 19-10 reiterrates the advice from the previous year, to not exceed the catches of 150 tonnes for the years 2019 and 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 2018 (STECF EWG 18-12) using XSA and 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).

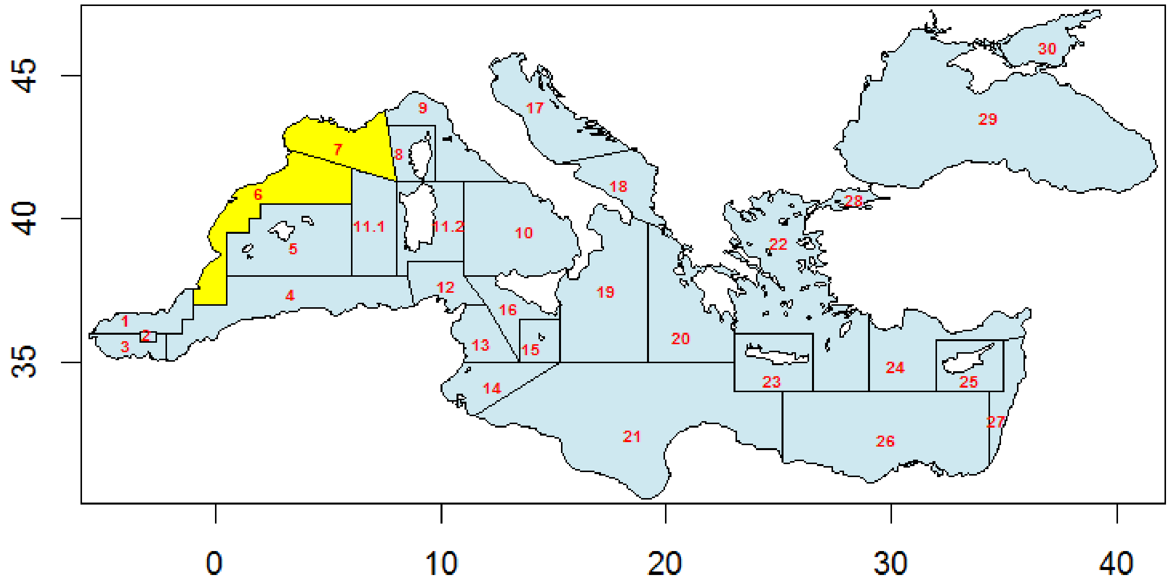


Figure 6.17.1.1. Geographical location of GSA 6&7.

The growth parameters used were taken from Garcia-Rodriguez (2003), just as in the previous assessment (STECF EWG 18-12); 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 18-12).

The proportion of mature individuals at length was available from the DCF for blue and red shrimp in GSA 6&7 (Table 6.17.1.2).

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 6.17.1.3).

Table 6.17.1.2. Blue and red shrimp in GSA 6&7. Natural mortality (M) at age.

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, specially 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.

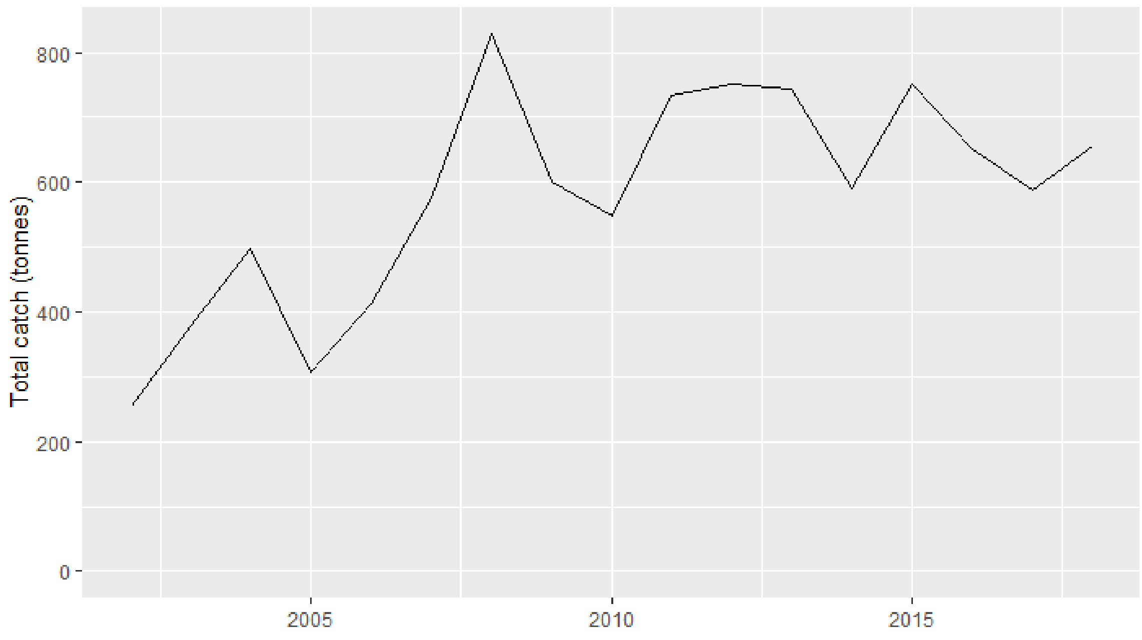
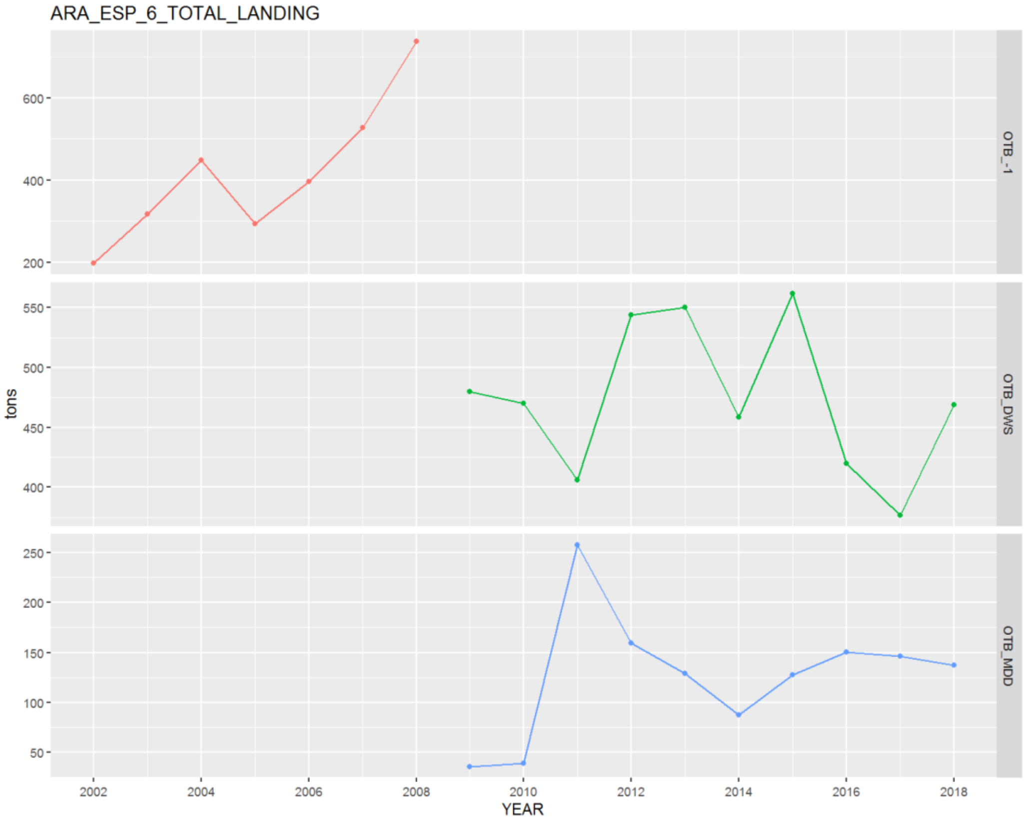


Figure 6.17.2.1. Blue and red shrimp in GSA 6&7. Blue and red shrimp DCF total catch (t), in GSA 6&7.

Table 6.17.2.1. Blue and red shrimp in GSA 6&7. Blue and red shrimp DCF landings (t) and discards (t) by OTB (all metiers) in GSA 6&7.

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

A.



B.

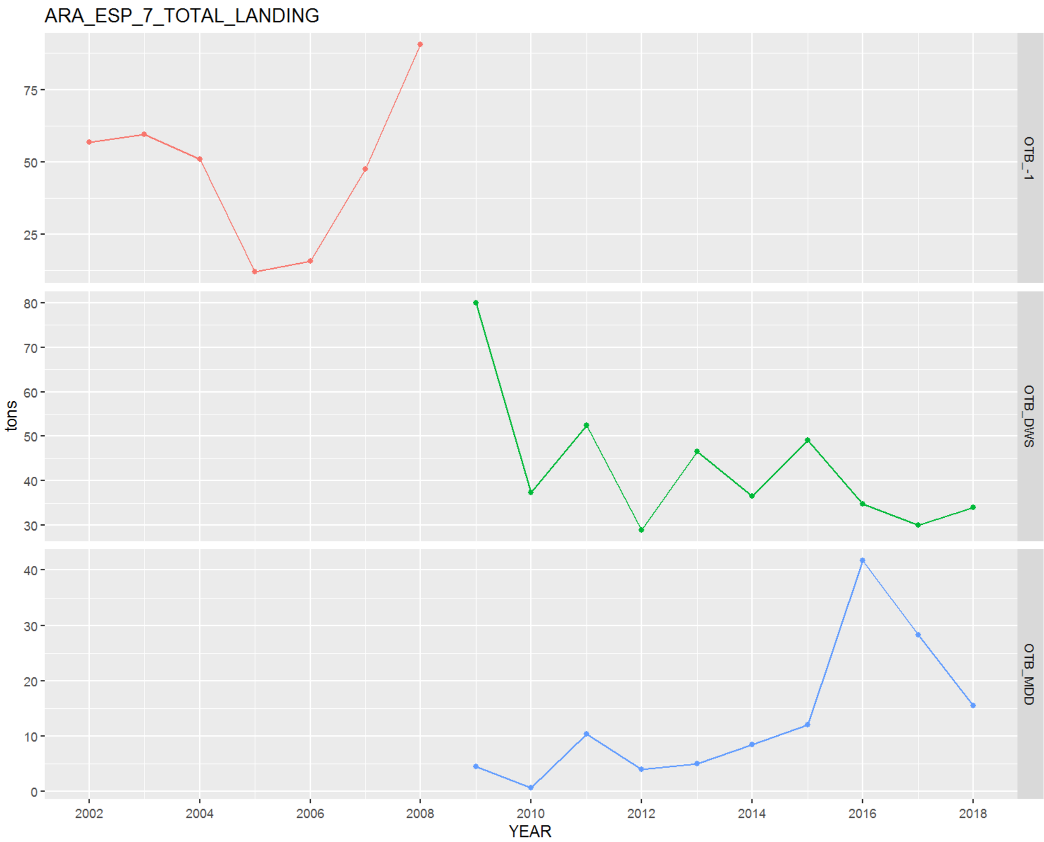
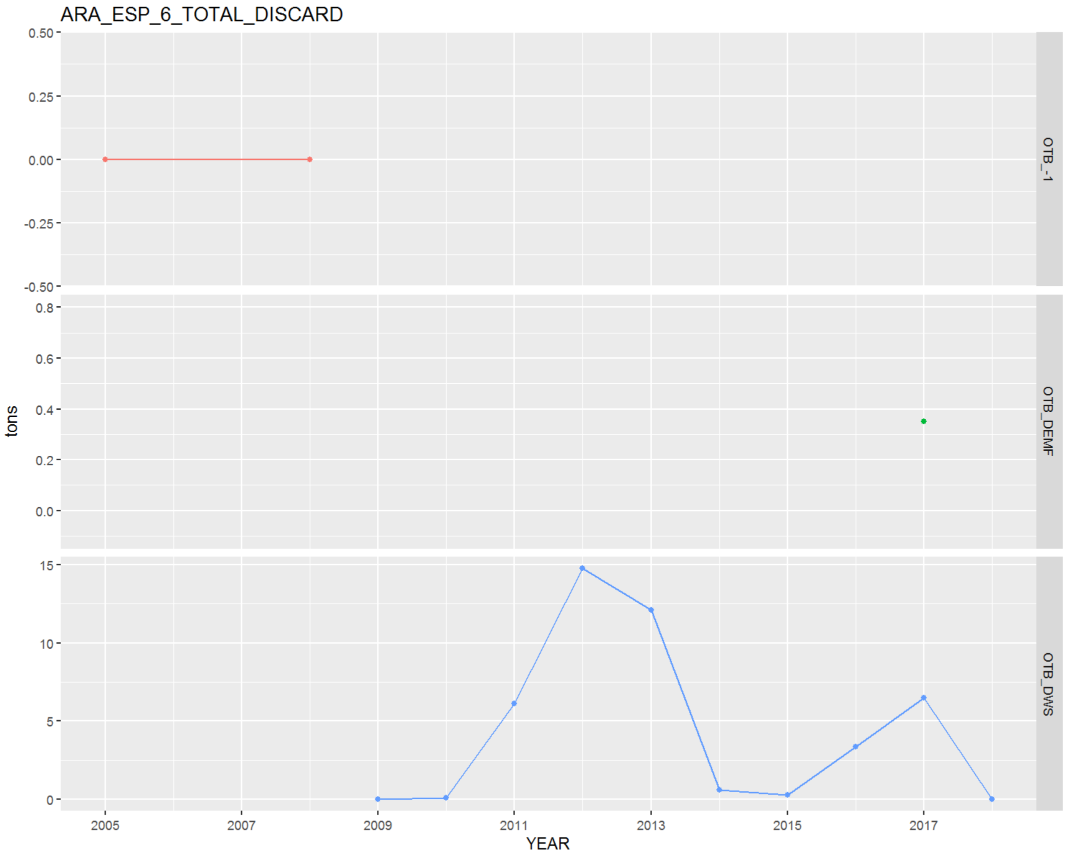


Figure 6.17.2.2. Blue and red shrimp in GSA 6&7. Blue and red shrimp DCF landings (t) in GSA 6 per gear (2002-2008) and metier (2009-2018): A. GSA 6, B. GSA 7.

A.



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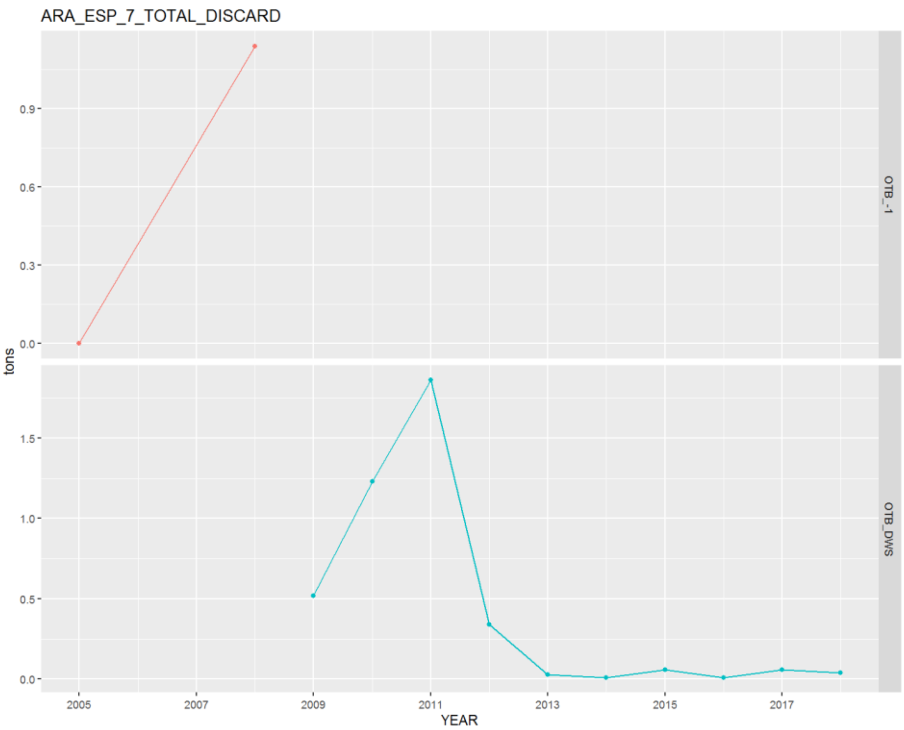
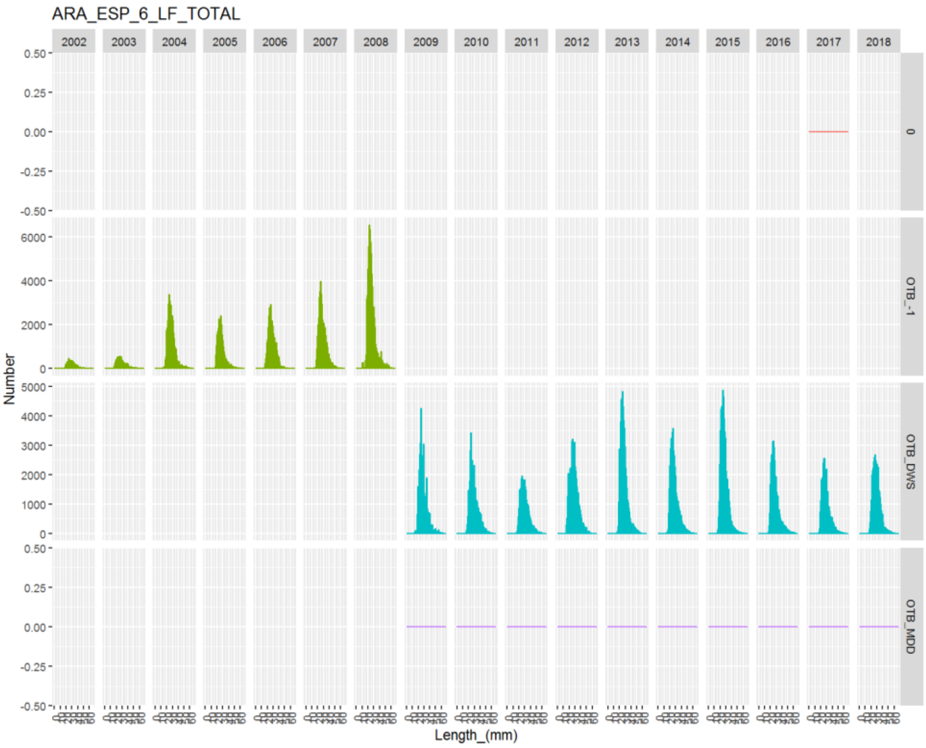


Figure 6.17.2.3. Blue and red shrimp in GSA 6&7. Blue and red shrimp DCF discards (t) in GSA 6&7 per gear (2002-2008) and metier (2009-2018): A. GSA 6, B. GSA 7.

A.



B.

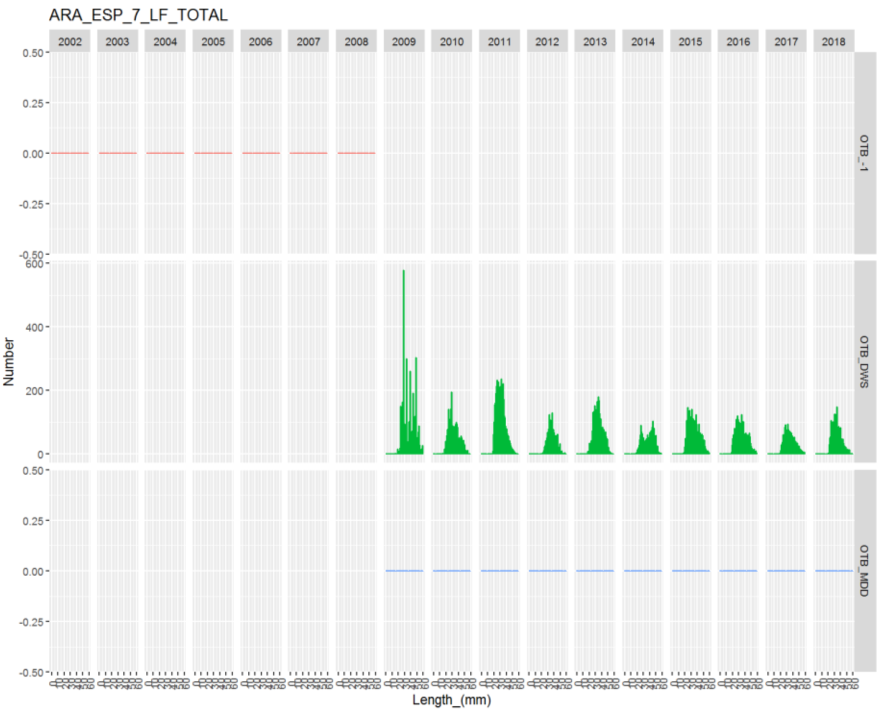


Figure 6.17.2.4. Blue and red shrimp in GSA 6&7. Blue and red shrimp length frequency distribution of catch in GSA 6&7 per gear (2002-2008) and metier (2009-2018): A. GSA 6, B. GSA 7.

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 and France was requested to provide missing data, but these data was not submitted and thus not available to EWG19-10.

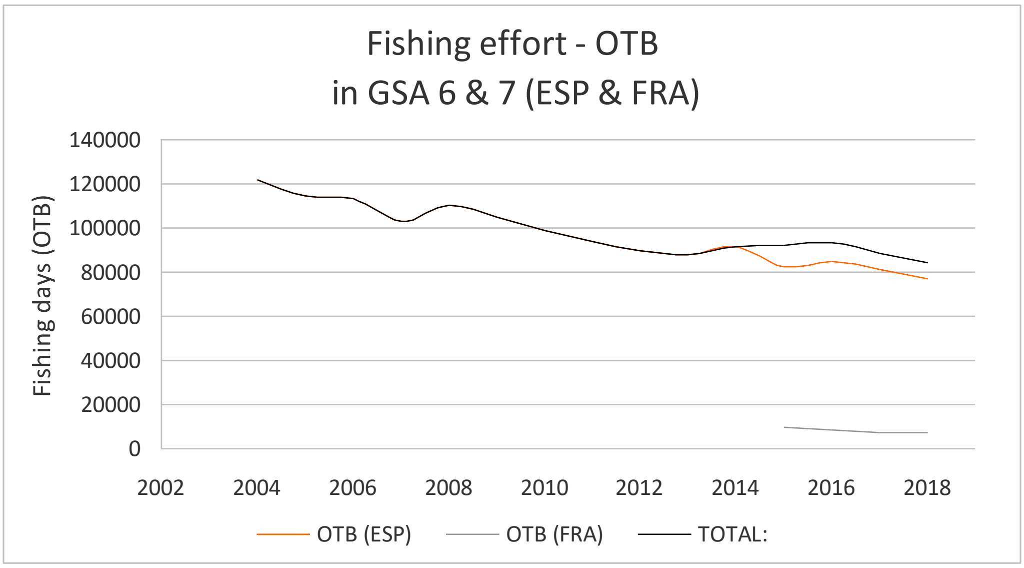


Figure 6.17.2.2.1. Blue and red shrimp in GSA 6&7 effrt data (days at sea) of OTB in GSA 6&7 as reported by DCF.

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 effrt data (days at sea) of OTB in GSA 6&7 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.

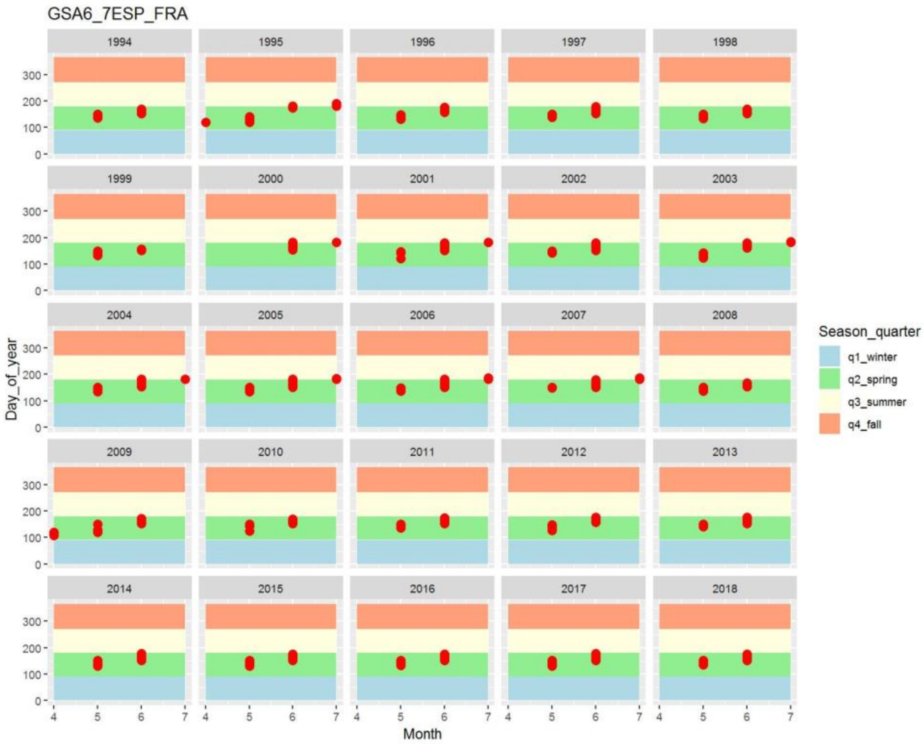


Figure 16.17.2.3.1. Month of the year when the hauls of MEDITS survey are being conducted in GSA 6&7.

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 not present 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).

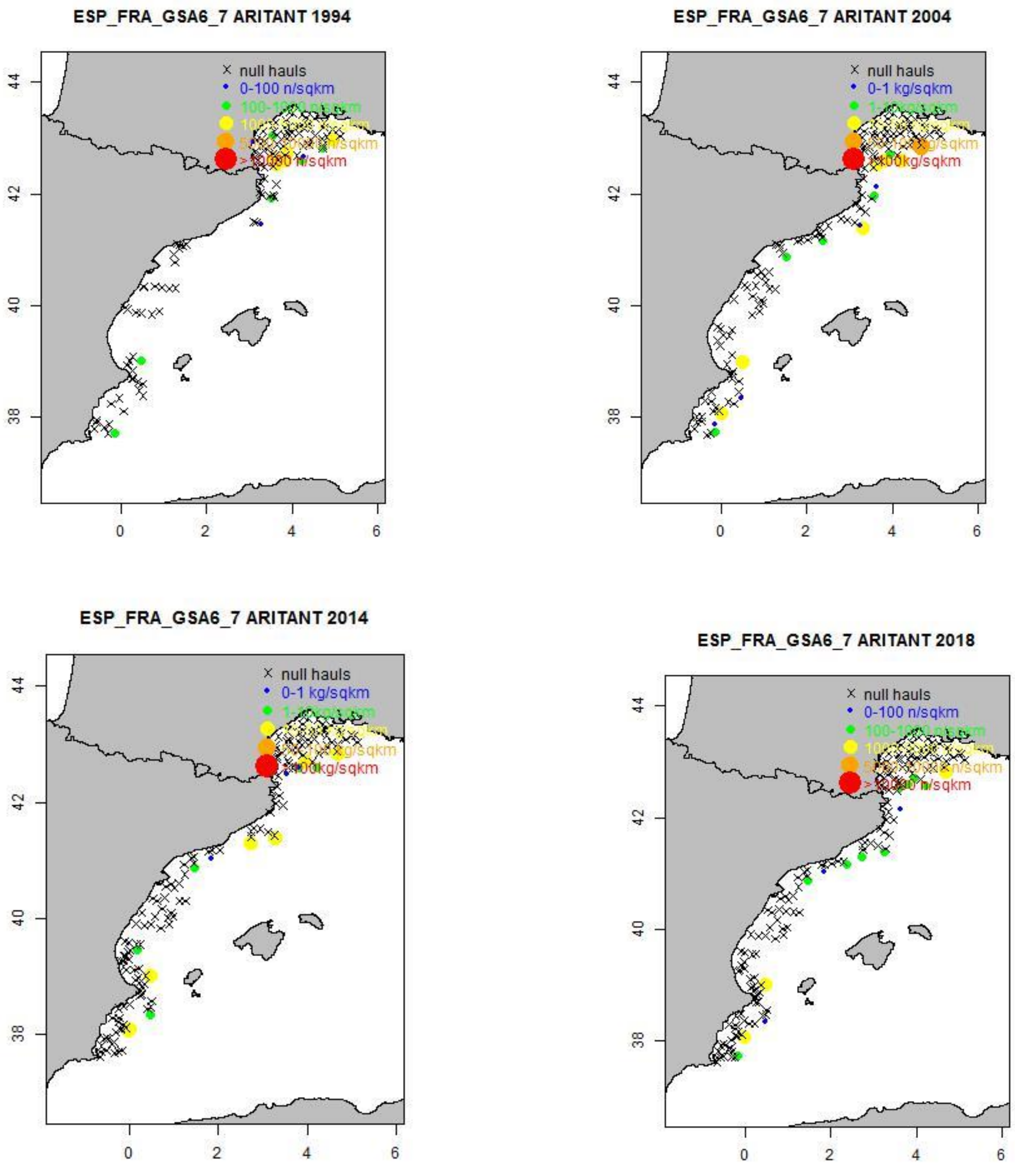


Figure 6.17.2.3.2. Geographical distribution of blue and red shrimp in GSA 6&7 based on the biomass index of MEDITS survey every 10 years and in 2018.

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.

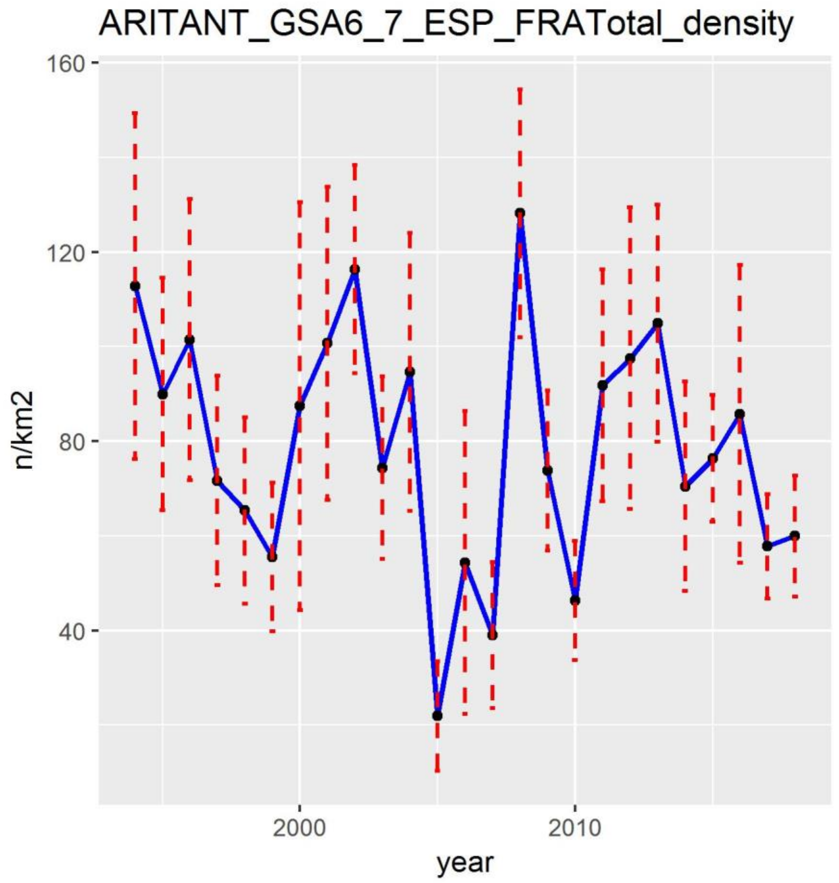


Figure 6.17.2.3.3.1 Blue and red shrimp in GSA 6&7. MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 6&7 as reported by DCF.

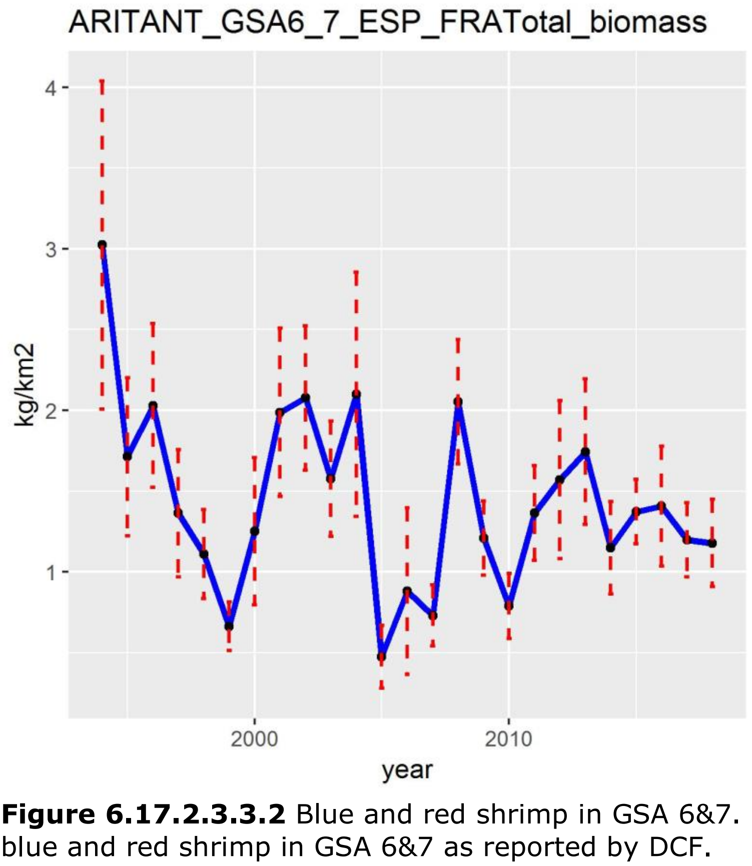


Figure 6.17.2.3.3.2 Blue and red shrimp in GSA 6&7. MEDITS survey biomass index (kg/km^2) of blue and red shrimp in GSA 6&7 as reported by DCF.

Table 6.17.2.3.3 Blue and red shrimp in GSA 6&7. MEDITS survey biomass index (kg/km^2) of blue and red shrimp in GSA 6&7 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

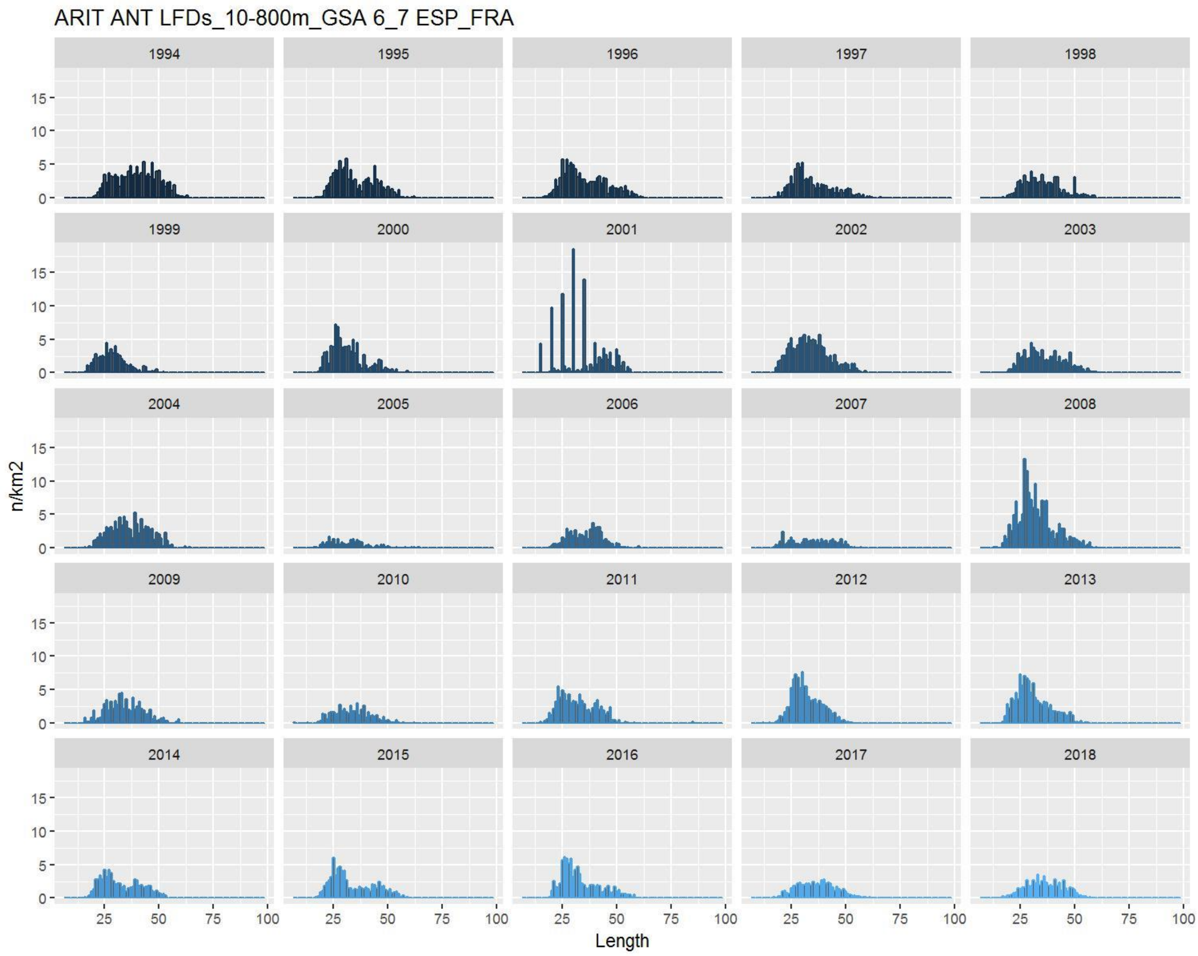


Figure 6.17.2.3.3.3 Blue and red shrimp in GSA 6&7. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of blue and red shrimp in GSA 6&7 as reported by DCF.

6.17.3 STOCK ASSESSMENT

This stock was assessed for the last time in 2018 (STECF EWG 18-12) using XSA and 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 o 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, the two aproaches were applied to length to age slicing both catch and survey data: with/without adding 0.5 years to t_o (see Section 6.17.3.2 and section 6.17.3.3, to be called from now on "t_0", and "t_0+0.5" approaches, respectively). This was necessary because without 0.5 there were large numbers of age 0 in both catch and particularly survey which are not expected and some unusual patterns in catch errors emerging when using the "t_0+ 0.5" approach. Further on, two data sets, and respectively two sets of results were considered by the group.

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.

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 landings were considered as equal to catches because discards were negligible as they are usually less than 1% of the reported catch (Table 6.17.2.1). The MEDITS bottom trawl survey data (Table 6.17.2.3.3) were used for tunning of the a4a models.

6.17.3.2 Stock assessment using data processed according the "t0 approach"

Inbut 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 6.17.3.2.1 to Figure 6.17.3.2.5. It can be noted that there are considerable numbers of age 0 (young of the year) individuals especialy in the catches obtained when the standard parameters of the VBGF are used for slicing of the LFD data (so called "t0 approach").

The cohort consistency in the catch and survey data are shown on Fig. 6.17.3.2.6 . Quite low consistency between cohorts is observed in survey data.

The plus group in the catch data was set to age 4, and ages 0-3 were used to tune the assessement model. The age range of Fbar was set to 0-2 as the majority of the catches were represented within these age classes.

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=6) + factor(replace(age,age>3,3))

Survey catchability: qmodel <- list(~s(replace(age,age>2,2), k=3,by=breakpts(year,c(2004))))

Stock-recruit: srmodel <- ~ geomean(CV=0.2)

Variance model: vmodel <- list(~s(age,k=3),~s(age, k=3))

Summary results and diagnostics from the a4a model are presented in Figure 6.17.3.2.8 to Figure 6.17.3.2.12.

The residuals show some more pronounced year effects in 2008 when the estimated catch is lower that the observed (Figs. 6.17.3.2.8, 6.17.3.2.9, 6.17.3.2.11). The fit to the catch numbers looks much better than the fit to survey data (Fig. 6.17.3.2.9). The retrospective analysis shows moderate tendency to underestimate the fishing mortality and overestimate SSB (Figure 6.17.3.2.10). The estimated catch follows closely the main pattern in observed catches except for 2008 (Figure 6.17.3.2.11).

The stock summary with simulated confidence intervals is presented at Figure 6.17.3.2.12. The recrutment has an increasing trend until 2014, then decreased. Similarly the SSB decreased and Fbar increased after 2015.

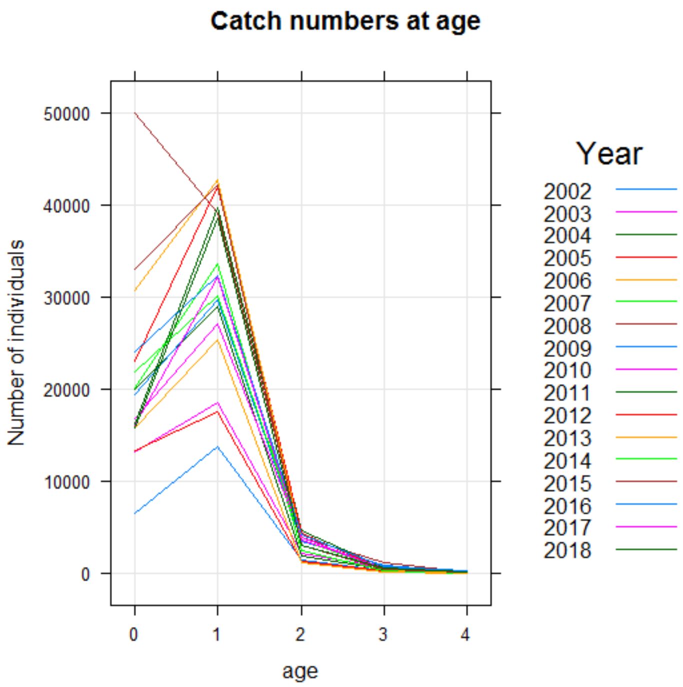


Figure 6.17.3.2.1 Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals at age of the catch in GSA 6&7 (2002-2018). Data from DCF.

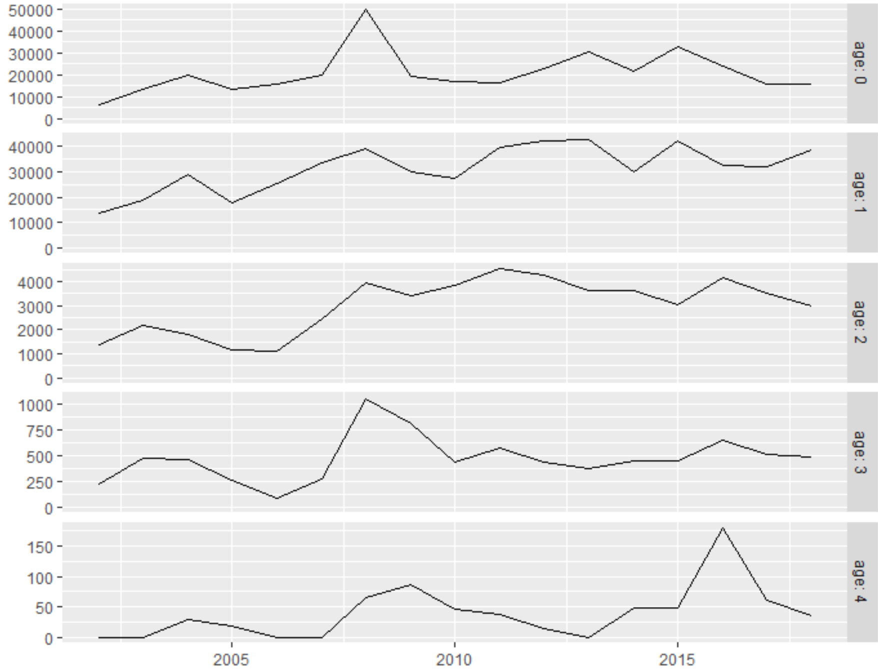


Figure 6.17.3.2.2 Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals per year by age group of the catch in GSA 6&7 (2002-2018). Data from DCF.

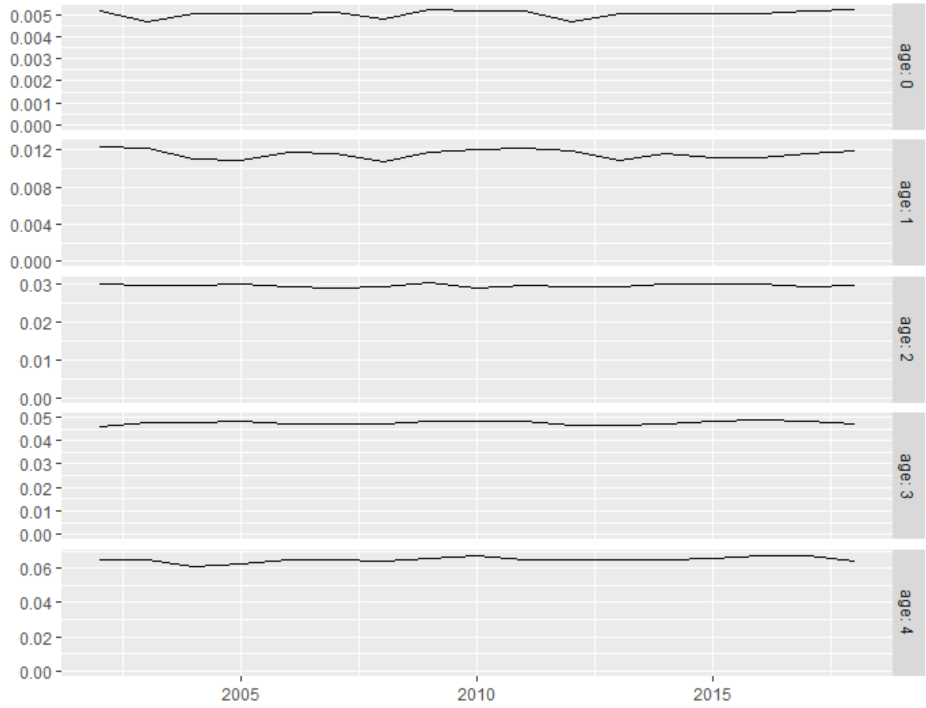


Figure 6.17.3.2.3. Blue and red shrimp in GSA 6&7. Blue and red shrimp mean weight (kg) at age of catches per year in GSA 6&7 (2002-2018). Data from DCF.

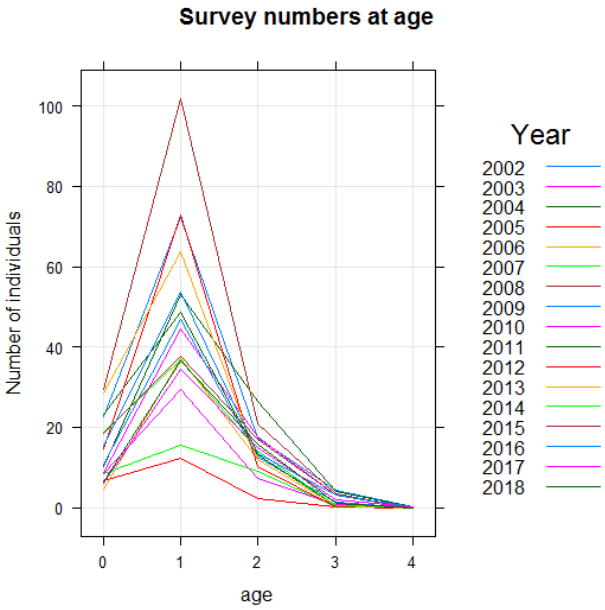


Figure 6.17.3.2.4 Blue and red shrimp in GSA 6&7. Number of individuals per year by age group (ages 0-4) according to MEDITS surveys.

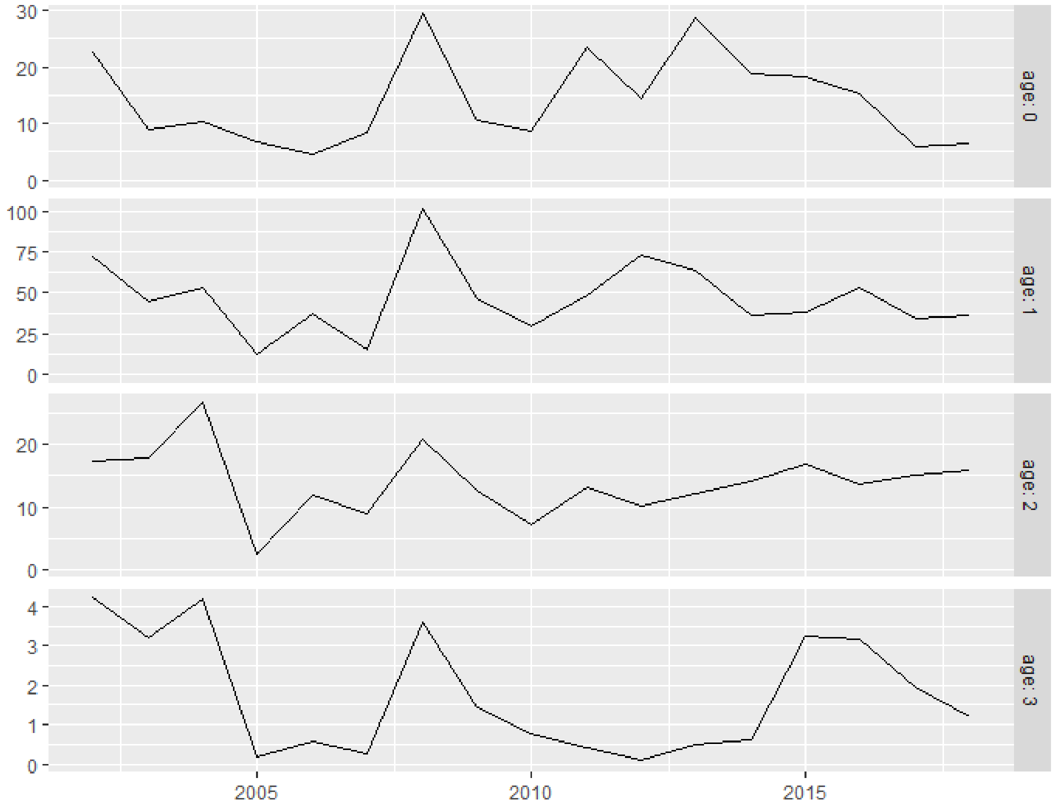
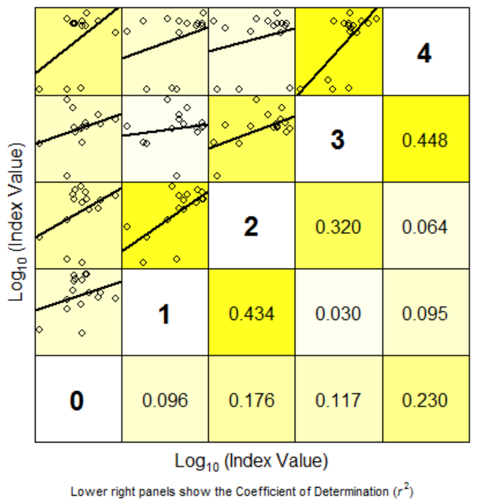


Figure 6.17.3.2.5 Blue and red shrimp in GSA 6&7. Number of individuals per year by age group (ages 0-3) according to MEDITS surveys.

A.



B.

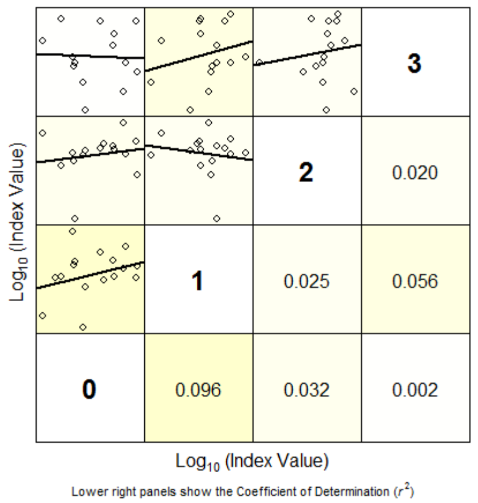


Figure 6.17.3.2.6 Blue and red shrimp in GSA 6&7. A.Cohorts consistency in the catch, and B. in MEDITS GSA 6&7 survey.

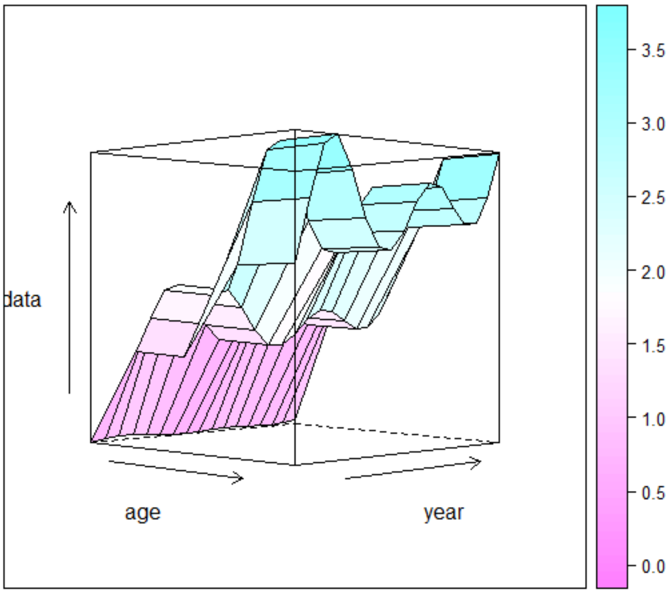
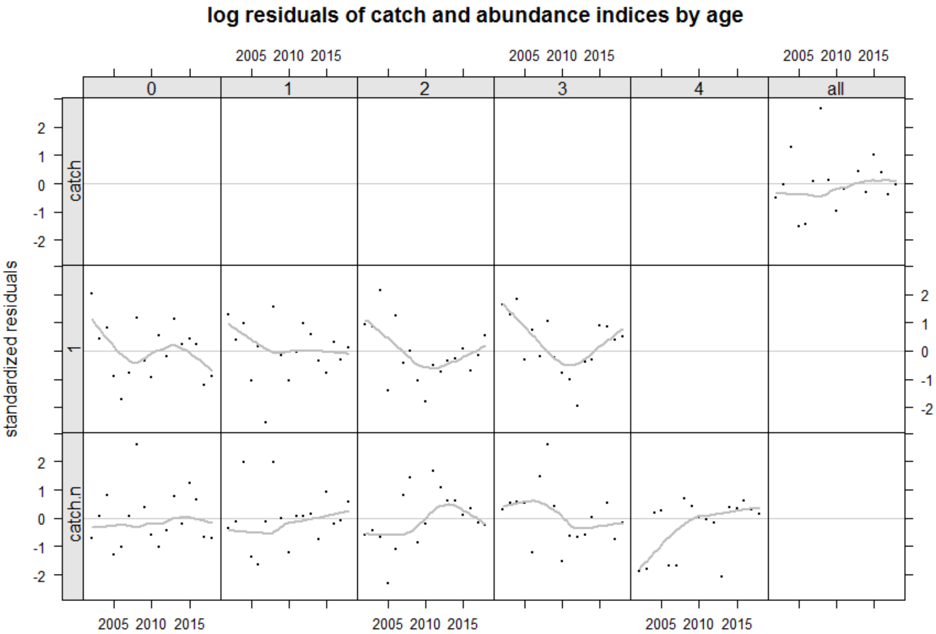


Figure 6.17.3.2.7 Blue and red shrimp in GSA 6&7. 3D plot of estimated fishing mortality at age and year.

A.



B.

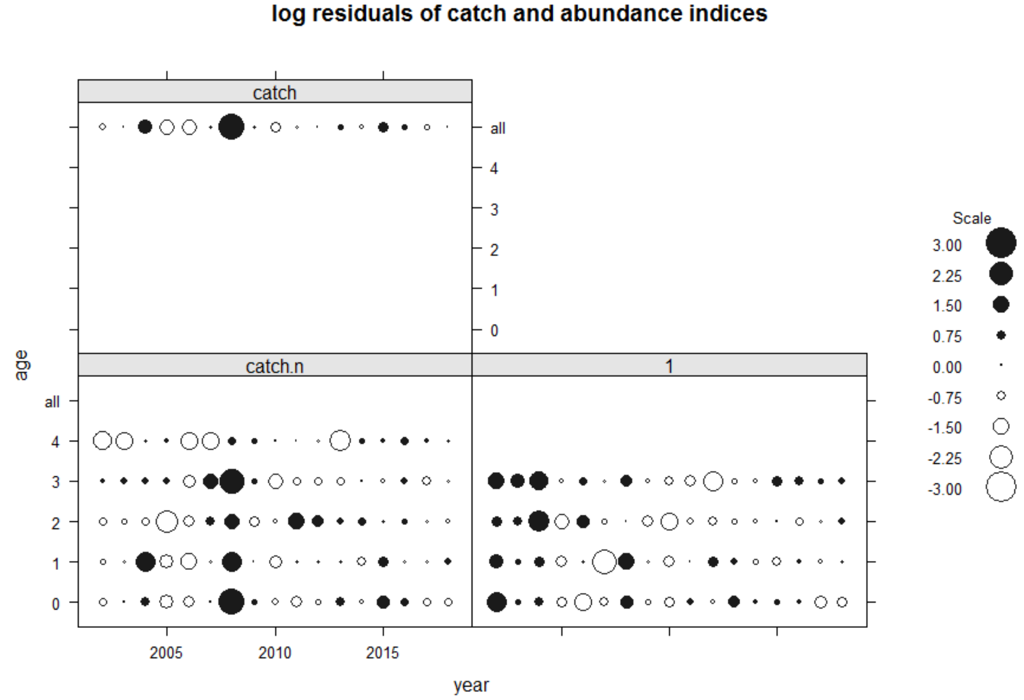
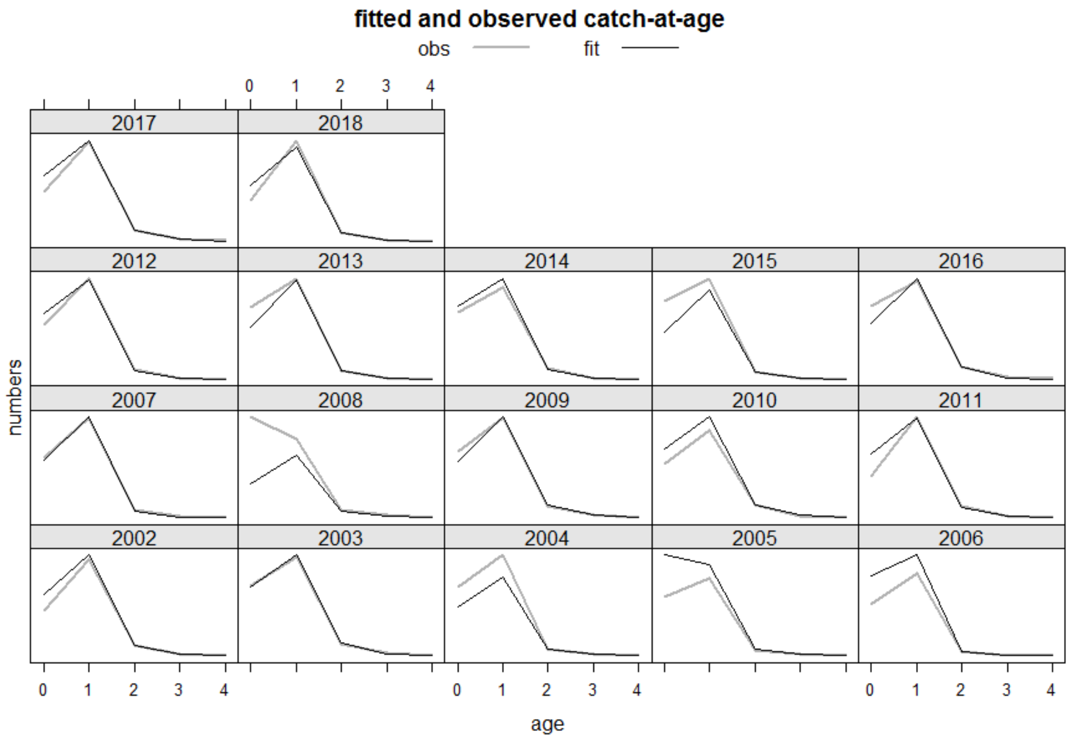


Figure 6.17.3.2.8 Blue and red shrimp in GSA 6&7. Standardized residuals for abundance indices (MEDITS) and catch at age data. Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

A.



B.

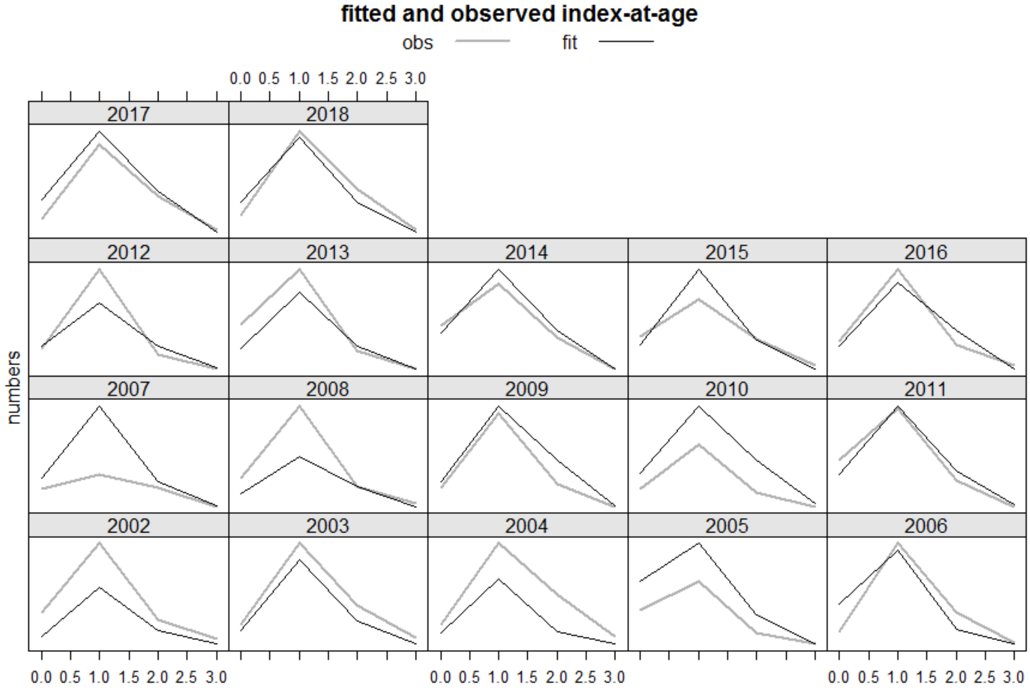


Figure 6.17.3.2.9 Blue and red shrimp in GSA 6&7. Fitted and observed catch (A.) and survey (B) numbers at age.

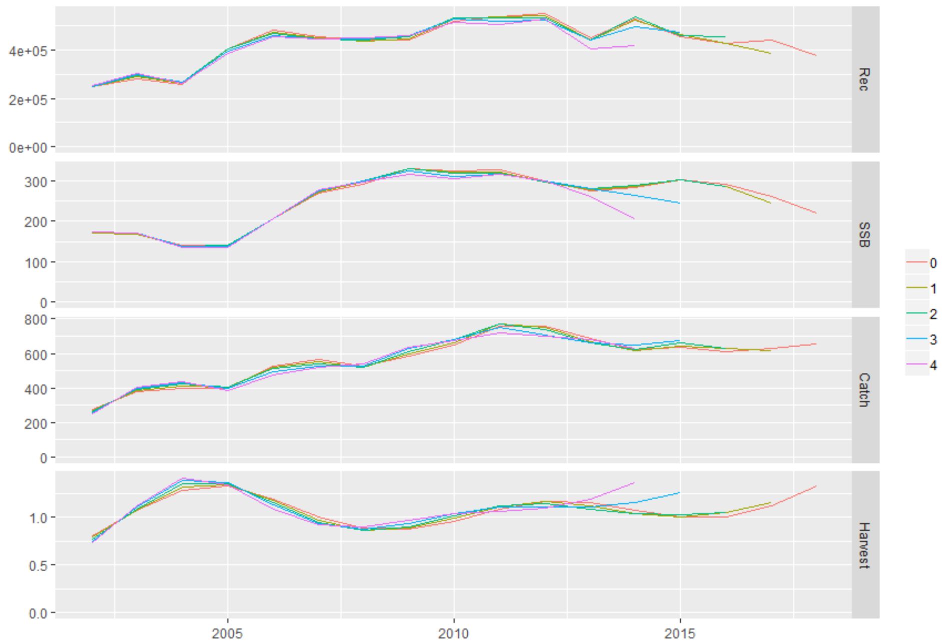


Figure 6.17.3.2.10 Blue and red shrimp in GSA 6&7. Retrospective analysis output.

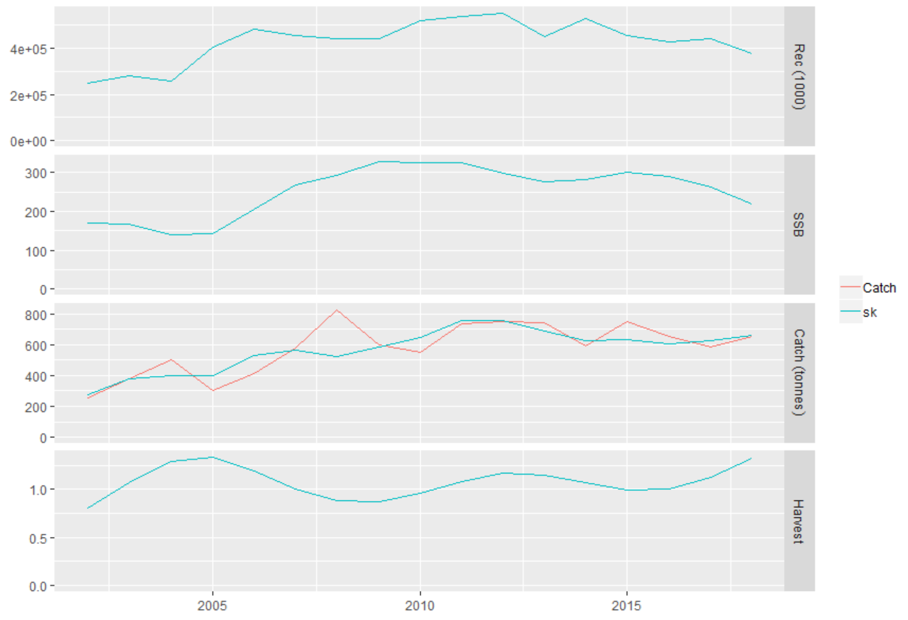


Figure 6.17.3.2.11 Blue and red shrimp in GSA 6&7. Stock summary for blue and red shrimp in GSA 6&7, recruits, SSB (Stock Spawning Biomass), catch (t) and harvest (fishing mortality).

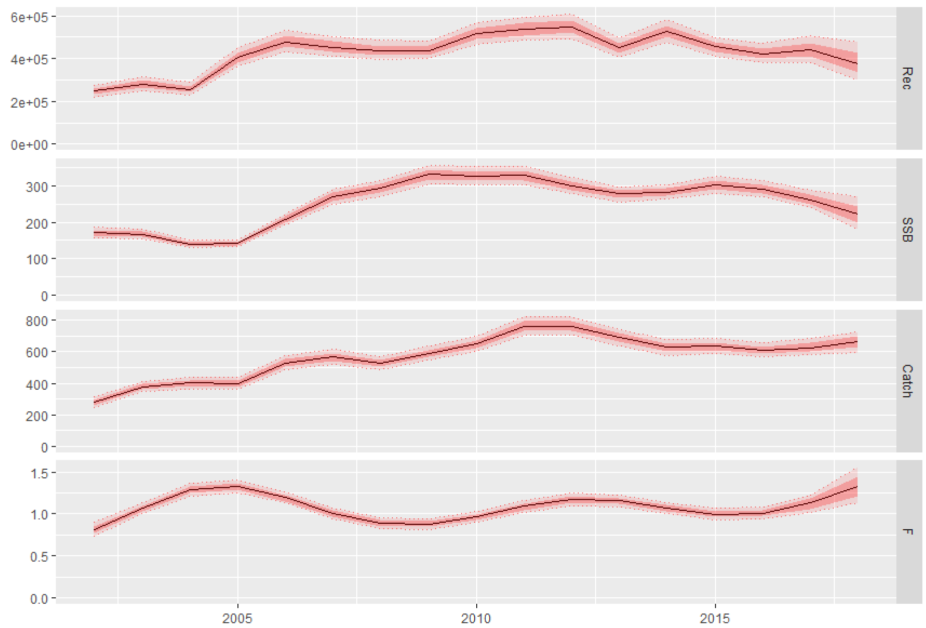


Figure 6.17.3.2.12 Blue and red shrimp in GSA 6&7. Stock summary of the simulated and fitted model from a4a.

Table **6.17.3.2.1** Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals at age of the catch in GSA 6&7 (2002-2018). Data from DCF.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2
0	6446	13189	19914	13358	15772	20136	49901	19424	16715	16153	22996	30670	21898	32979	24052	15
1	13667	18564	28987	17513	25284	33585	39067	29673	27100	39593	41920	42680	30067	42107	32276	32
2	1379	2182	1788	1190	1102	2471	3934	3397	3828	4542	4271	3607	3634	3056	4149	3
3	227	477	462	263	95	276	1056	816	445	578	434	379	448	454	653	
4	0	0	29	18	0	0	65	86	47	38	15	0	48	48	180	

Table **6.17.3.2.1** Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals at age of the catch in GSA 6&7 (2002-2018). Data from DCF.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1	0.012	0.012	0.011	0.011	0.012	0.012	0.011	0.012	0.012	0.012	0.012	0.011	0.012	0.011	0.011	0.012
2	0.030	0.030	0.030	0.030	0.029	0.029	0.029	0.031	0.029	0.030	0.029	0.030	0.030	0.030	0.030	0.029
3	0.046	0.047	0.048	0.048	0.047	0.047	0.047	0.048	0.048	0.048	0.047	0.046	0.047	0.048	0.049	0.048
4	0.065	0.065	0.061	0.063	0.065	0.065	0.064	0.066	0.067	0.065	0.065	0.065	0.065	0.065	0.067	0.067

Table **6.17.3.2.3** Blue and red shrimp in GSA 6&7. Number of individuals per year by age group (ages 0-4) according to MEDITS surveys.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	23	9	10	7	5	8	29	11	9	23	15	29	19	18	15	6	6
2	72	44	53	12	37	16	102	47	30	49	73	64	37	38	54	35	36
3	17	18	27	2	12	9	21	12	7	13	10	12	14	17	13	15	16
4	4	3	4	0	1	0	4	1	1	0	0	1	1	3	3	2	1

Table **6.17.3.2.4** Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals at age in the stock in GSA 6&7 (2002-2018)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	201
0	246855	281323	257229	404496	479583	454626	437691	438768	517590	536503	549890	448060	525697	45522
1	28074	31799	35299	31564	49418	59426	57415	55943	56145	65671	67198	68289	55741	6597
2	2738	3649	2825	2271	1906	3662	5799	6666	6603	5860	5687	5142	5360	496
3	269	469	432	245	185	189	475	890	1040	914	677	583	540	63
4	27	21	17	9	4	5	8	27	53	51	32	19	17	1

Table **6.17.3.2.5** Blue and red shrimp in GSA 6&7. Blue and red shrimp fishing mortality at age (2002-2018)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
0	0.08	0.11	0.13	0.14	0.12	0.10	0.09	0.09	0.10	0.11	0.12	0.12	0.11	0.10	0.10	0.11	0.13
1	1.19	1.57	1.90	1.96	1.75	1.48	1.31	1.29	1.41	1.60	1.72	1.70	1.57	1.47	1.48	1.65	1.95
2	1.15	1.52	1.84	1.90	1.70	1.43	1.26	1.25	1.37	1.55	1.67	1.64	1.52	1.42	1.44	1.60	1.89
3	2.16	2.85	3.43	3.55	3.18	2.68	2.36	2.33	2.56	2.89	3.12	3.07	2.84	2.66	2.69	2.99	3.54
4	2.16	2.85	3.43	3.55	3.18	2.68	2.36	2.33	2.56	2.89	3.12	3.07	2.84	2.66	2.69	2.99	3.54

Table **6.17.3.2.6** Stock summary: number of recruits, SSB, Fbar 1-2**,** estimated catch

	Recruitment	SSB, tonnes	Fbar 1-2	Catch, tonnes
2002	246855	170.17	0.81	277.13
2003	281323	167.36	1.07	378.41
2004	257229	139.75	1.29	400.18
2005	404496	141.52	1.33	397.15
2006	479583	206.58	1.19	528.15
2007	454626	269.20	1.00	565.60
2008	437691	292.14	0.89	525.49
2009	438768	329.38	0.88	587.38
2010	517590	325.26	0.96	645.28
2011	536503	326.85	1.09	758.93
2012	549890	299.42	1.17	759.78
2013	448060	276.04	1.15	689.86
2014	525697	281.78	1.07	625.16
2015	455221	301.10	1.00	633.19
2016	423819	290.05	1.01	608.04
2017	439940	261.71	1.12	627.31
2018	376644	219.77	1.33	657.82

6.17.3.3 Stock assessment using data processed according the “t0 +0.5 approach”

Inbut 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. Unlike the previous assessment (Section. 6.17.3.2), it is to note the lack of age 0 (young of the year) individuals in the catches and survey due to the application of the “t0+0.5 approach”).

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 were used to tune the assessement model. The age range of Fbar was set to 1-2 as the majority of the catches were represented within these age classes.

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=7) + factor(replace(age,age>2,2))

Survey catchability: qmodel <- list(~s(replace(age,age>3,3), k=3, by=breakpts(year,c(2004))))

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 plot of fishing mortality at age (Fig. 6.17.3.3.7) reflects the assumption of constant F after age 2. The residuals show major year effects in 2008 and 2011 when the estimated catch (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 moderate tendency to underestimate the fishing mortality and overestimate SSB (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. Similarly the SSB increased until 2010 then decreased. Fbar decreased from 2011 to 2015, then slightly increased. Therefore, the trends in abundance, biomass and fishing mortality in this assessment show some differences from the assessment following the "to approach".

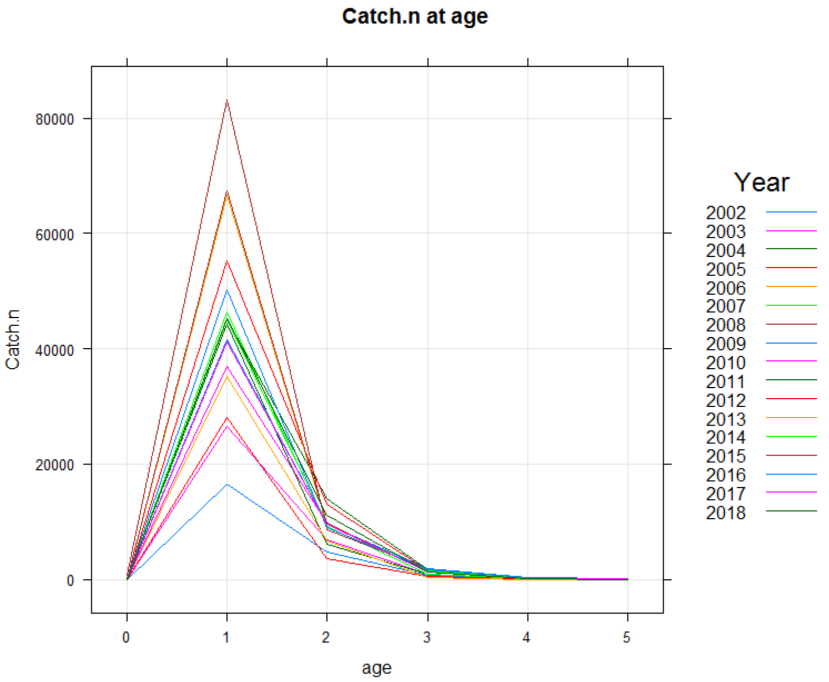


Figure 6.17.3.3.1 Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals (thousands) at age of the catch in GSA 6&7 (2002-2017). Data from DCF.

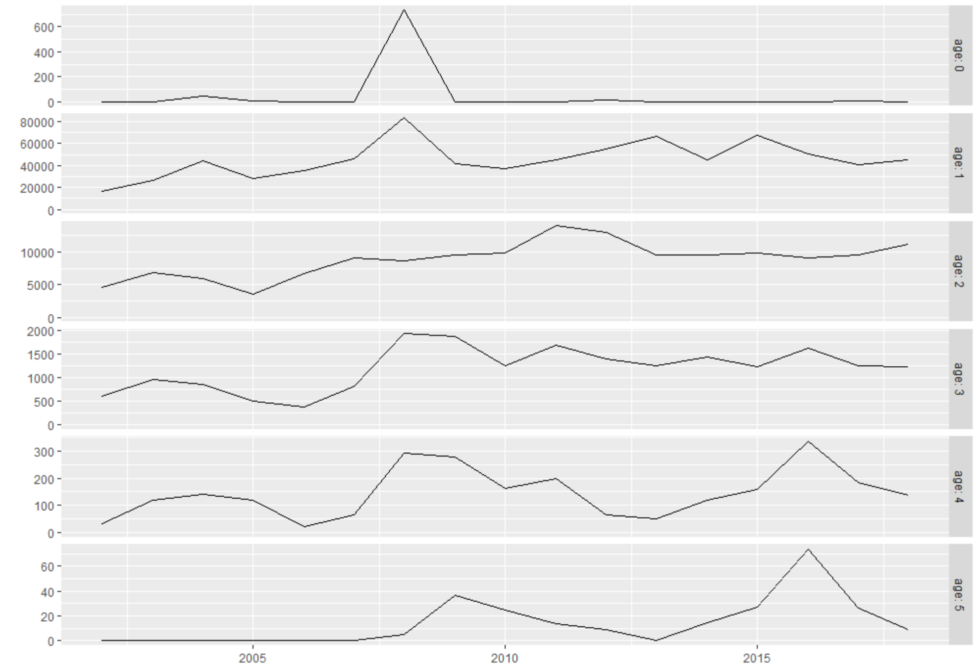


Figure 6.17.3.3.2 Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals per year by age group of the catch in GSA 6&7 (2002-2018). Data from DCF.

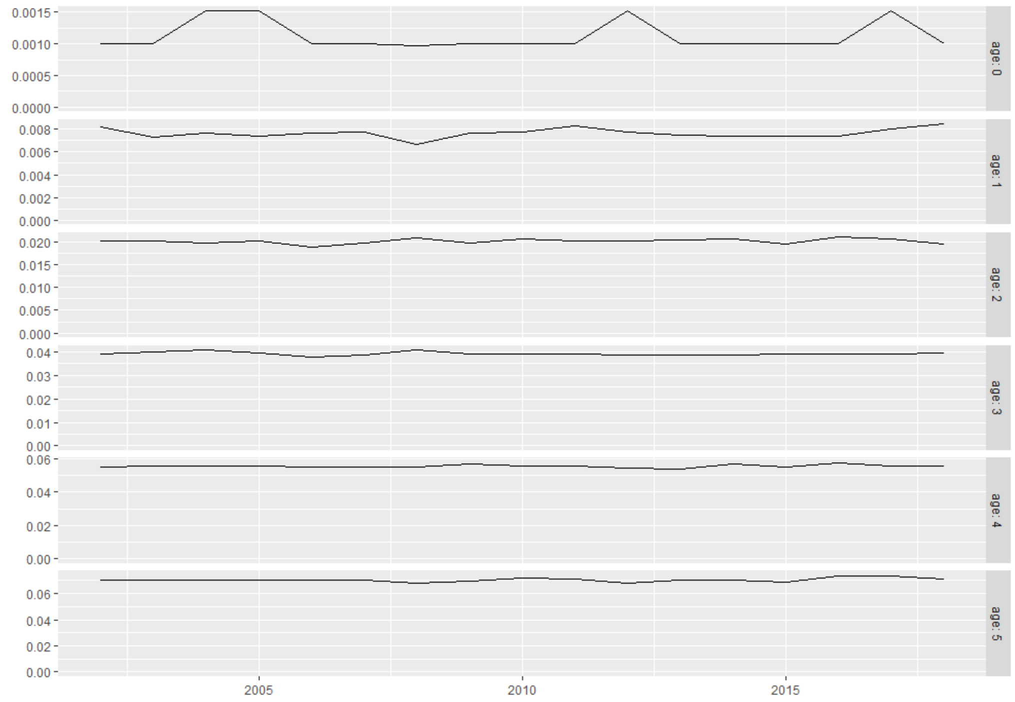


Figure 6.17.3.3.3. Blue and red shrimp in GSA 6&7. Blue and red shrimp mean weight (kg) at age of catches per year in GSA 6&7 (2002-2018). Data from DCF.

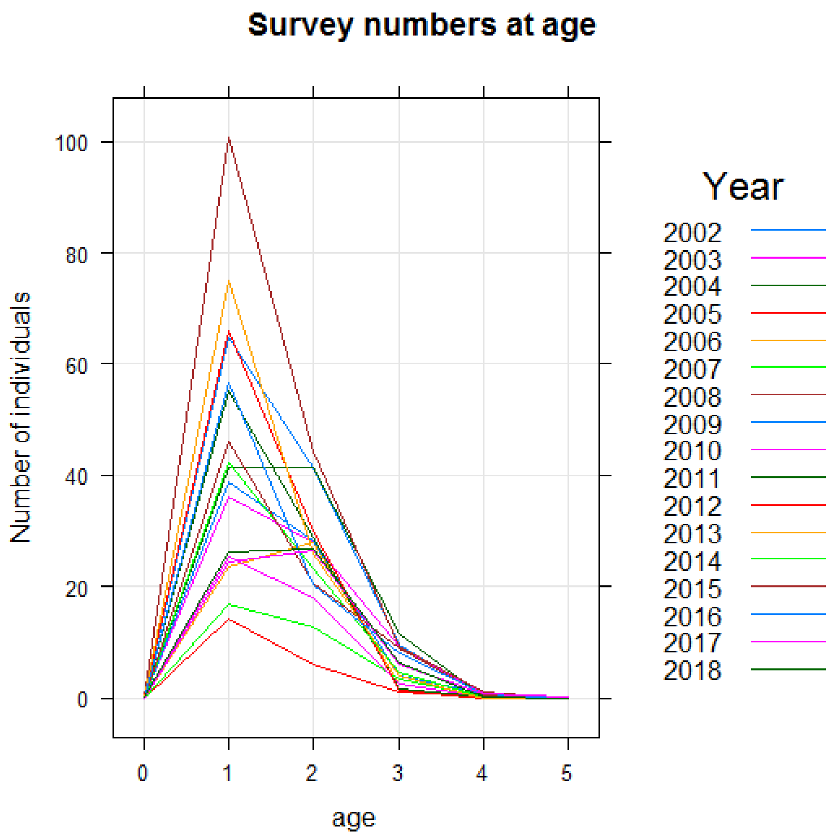


Figure 6.17.3.3.4 Blue and red shrimp in GSA 6&7. Age frequency distribution of the MEDITS survey of blue and red shrimp in GSA 6&7 as reported by DCF.

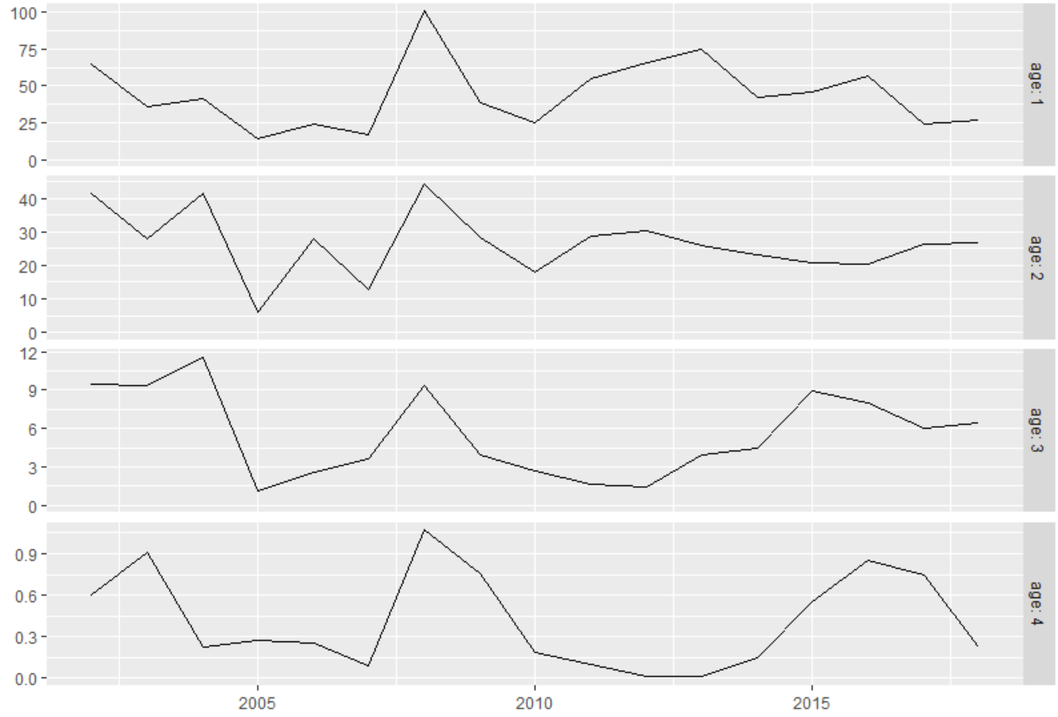
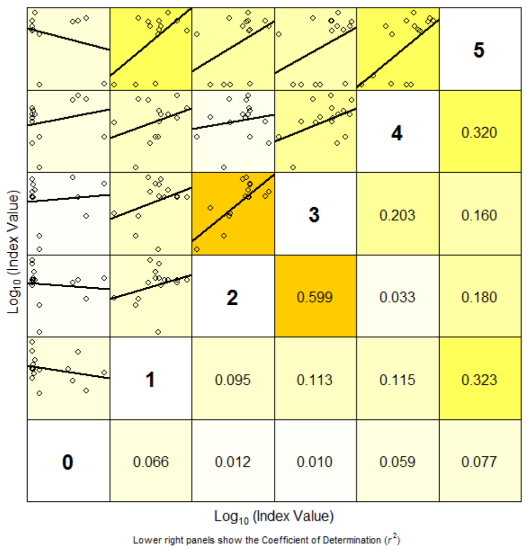


Figure 6.17.3.3.5 Blue and red shrimp in GSA 6&7. Number of individuals per year by age group (ages 1-4) according to MEDITS surveys.

A.



B.

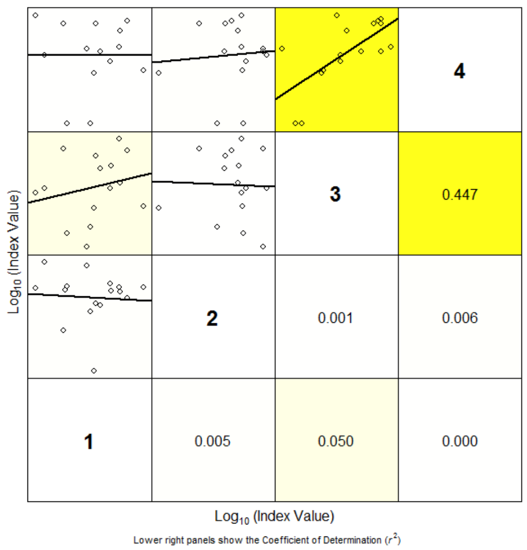


Figure 6.17.3.3.6 Blue and red shrimp in GSA 6&7. A.Cohorts consistency in the catch, and B. in MEDITS GSA 6&7 survey.

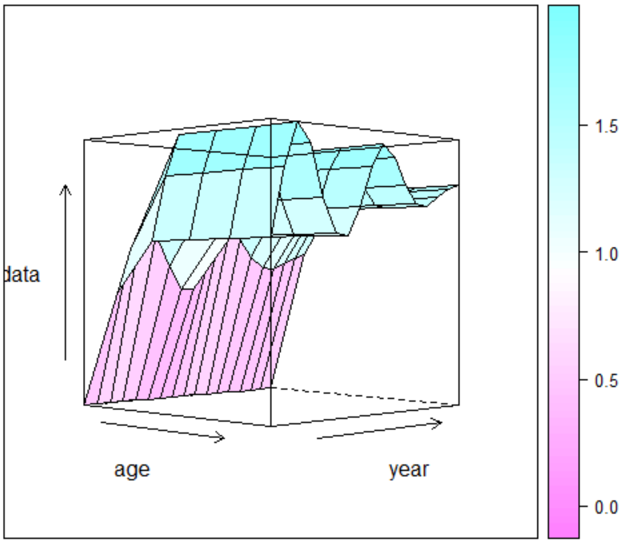
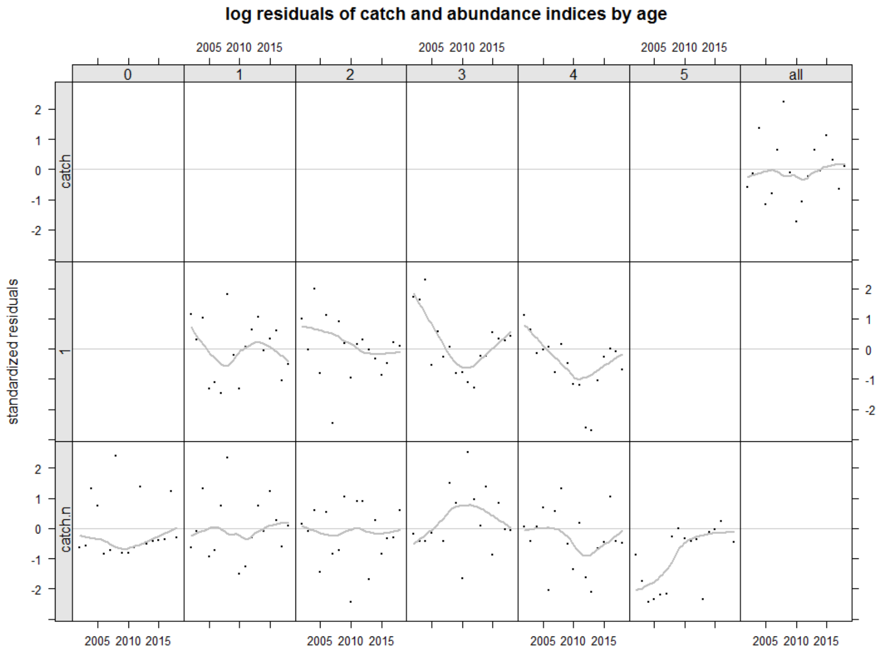


Figure 6.17.3.3.7 Blue and red shrimp in GSA 6&7. 3D plot of estimated fishing mortality at age and year.

A.



B.

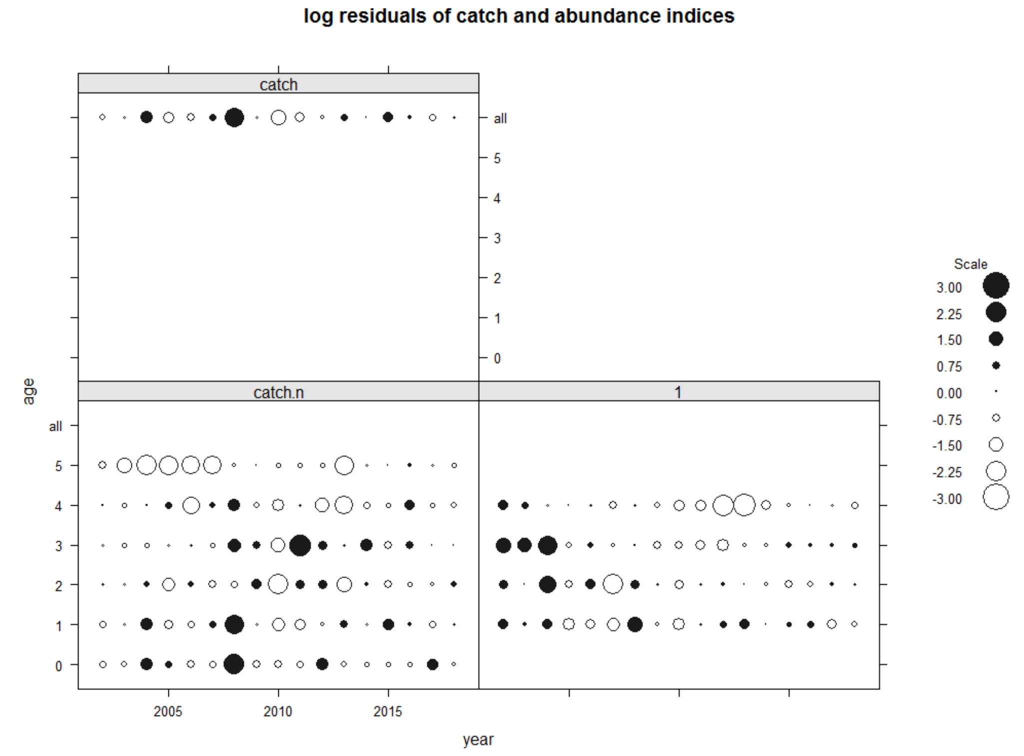
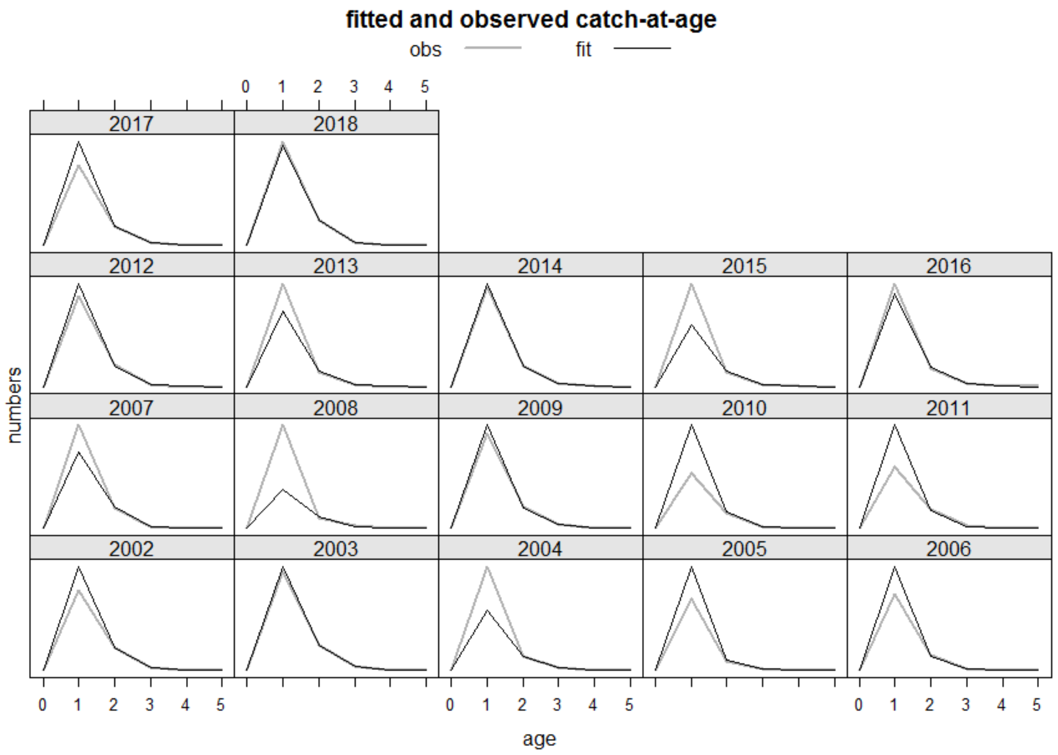


Figure 6.17.3.3.8 Blue and red shrimp in GSA 6&7. Standardized residuals for abundance indices (MEDITS) and catch at age data. Each panel is coded by age class, dots represent standardized residuals and lines a simple smoother.

A.



B.

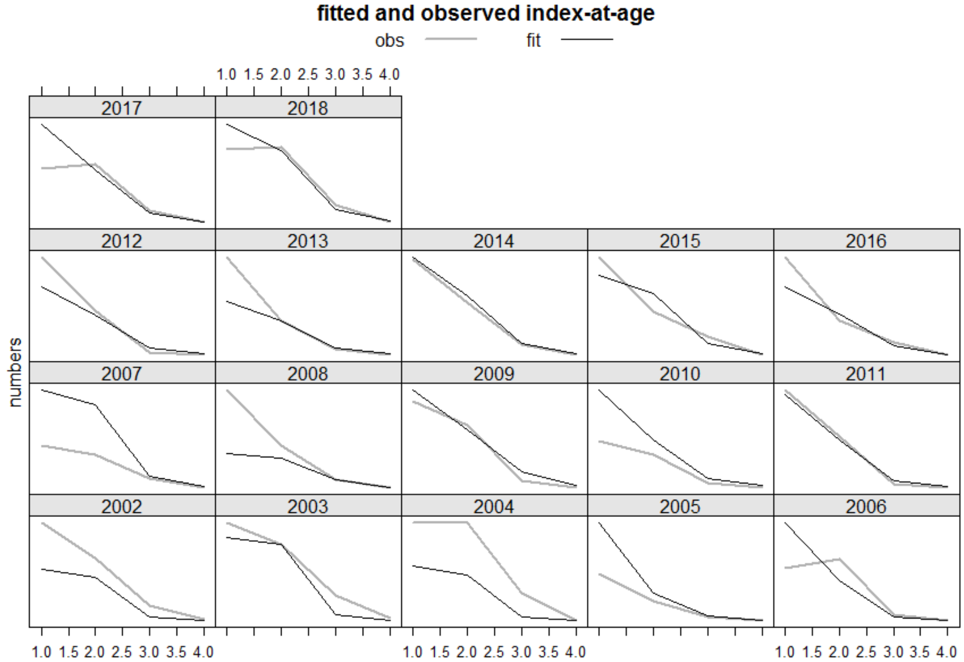


Figure 6.17.3.3.9 Blue and red shrimp in GSA 6&7. Fitted and observed catch (A.) and survey (B) numbers at age.

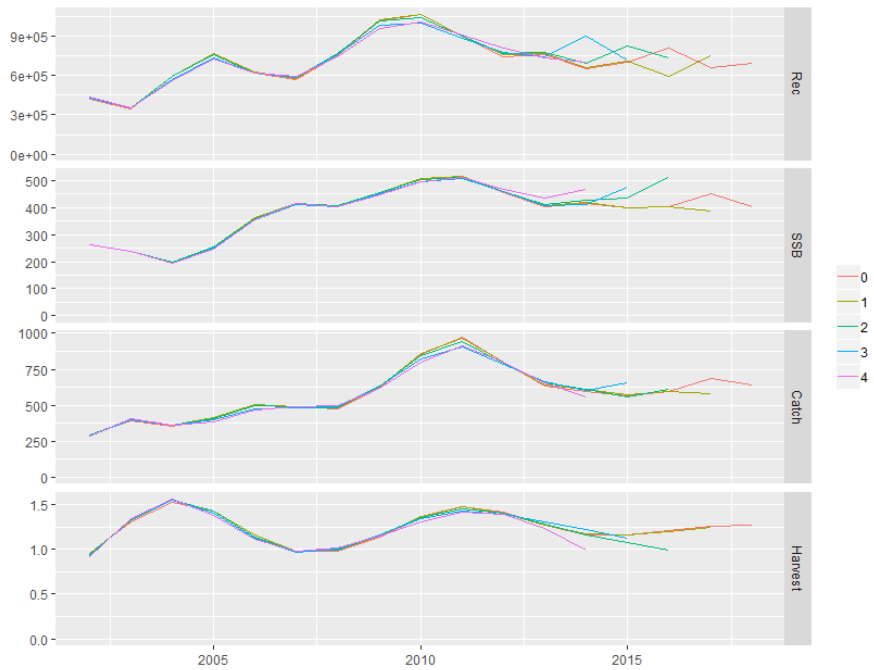


Figure 6.17.3.3.10 Blue and red shrimp in GSA 6&7. Retrospective analysis output.

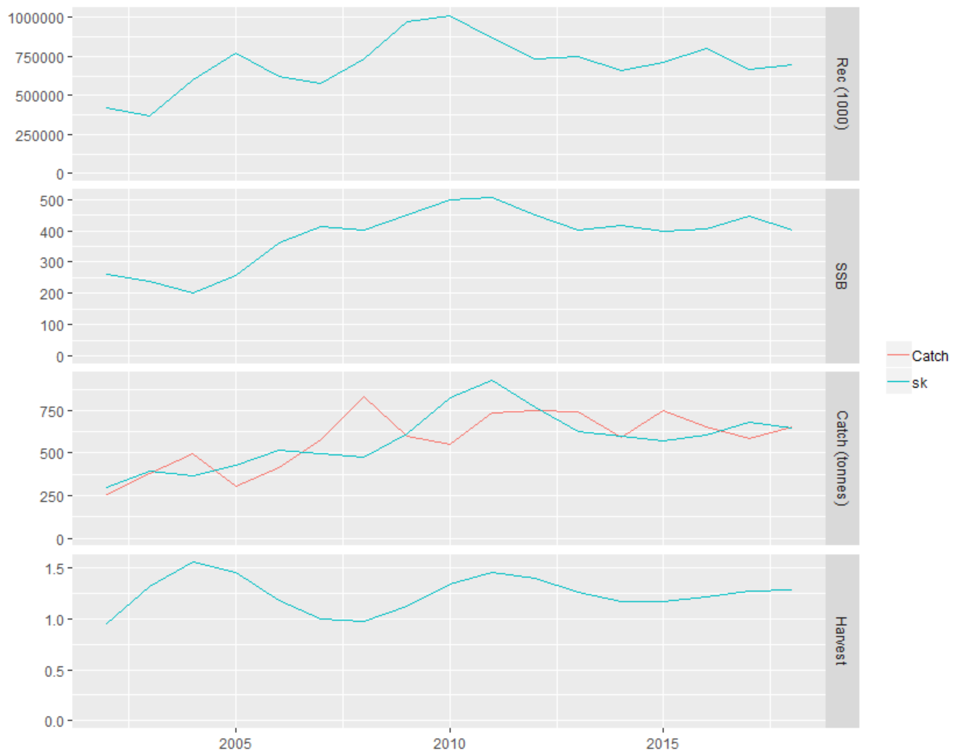


Figure 6.17.3.3.11 Blue and red shrimp in GSA 6&7. Stock summary for blue and red shrimp in GSA 6&7, recruits, SSB (Stock Spawning Biomass), catch (t) and harvest (fishing mortality).

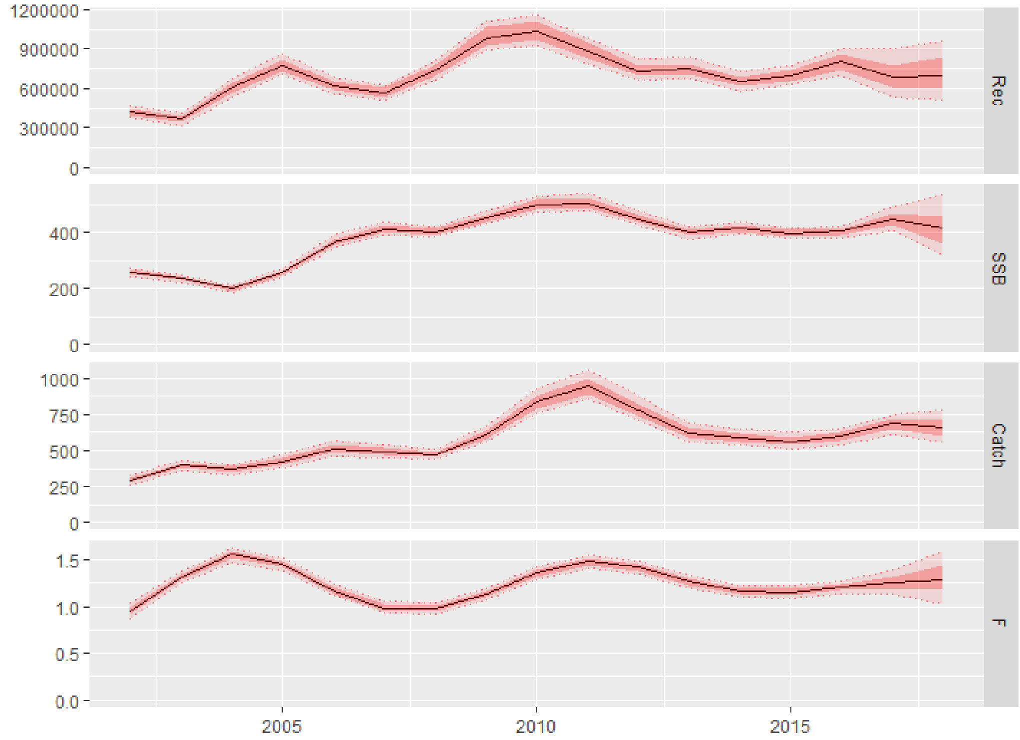


Figure 6.17.3.3.12 Blue and red shrimp in GSA 6&7. Stock summary of the simulated and fitted model from a4a.

Table **6.17.3.3.1** Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals at age of the catch in GSA 6&7 (2002-2018). Data from DCF.

Year Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	20
0	0	0	45	6	0	0	733	0	0	0	13	0	0	0	0	
1	16417	26528	44180	28105	35178	46466	83130	41656	36867	45003	55167	66535	44983	67411	50238	410
2	4655	6807	6002	3604	6681	9127	8591	9570	9839	14004	12994	9499	9542	9830	9040	96
3	614	957	849	514	373	807	1926	1859	1242	1683	1397	1249	1435	1219	1625	12
4	33	119	142	119	21	68	290	275	162	200	67	53	121	157	334	1
5	0	0	0	0	0	0	5	37	24	14	9	0	15	27	74	

Table **6.17.3.3.2** Blue and red shrimp in GSA 6&7. Number of individuals per year by age group (ages 0-4) according to MEDITS surveys.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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
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
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
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
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
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

Table **6.17.3.3.3** Blue and red shrimp in GSA 6&7. Number of individuals per year by age group (ages 0-4) according to MEDITS surveys.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	65	36	41	14	24	17	101	39	25	55	66	75	42	46	57	24
2	41	28	41	6	28	13	44	28	18	29	30	26	23	21	20	27
3	9	9	12	1	3	4	9	4	3	2	1	4	4	9	8	6
4	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1

Table **6.17.3.3.4** Blue and red shrimp in GSA 6&7. Blue and red shrimp number of individuals at age in the stock in GSA 6&7 (2002-2018)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	20
0	421206	363051	597561	767679	623683	574810	730625	967021	1005408	862509	728900	746413	654460	7042
1	54780	58917	50782	83584	107380	87238	80402	102197	135263	140633	120644	101955	104405	915
2	8924	10729	8599	6139	10937	17516	16587	15453	17443	19434	18399	16570	15657	172
3	1060	1561	1226	748	599	1468	2936	2824	2215	1949	1896	1926	2038	21
4	81	204	197	118	80	89	271	551	447	273	210	219	261	3
5	4	17	29	23	16	15	20	58	102	71	39	30	36	

Table **6.17.3.3.5** Blue and red shrimp in GSA 6&7. Blue and red shrimp fishing mortality at age (2002-2018)

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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
1	0.78	1.08	1.26	1.19	0.97	0.81	0.80	0.92	1.09	1.19	1.14	1.03	0.95	0.95	0.99	1.04
2	1.13	1.56	1.83	1.72	1.40	1.18	1.16	1.33	1.58	1.72	1.65	1.49	1.38	1.38	1.44	1.50
3	1.13	1.56	1.83	1.72	1.40	1.18	1.16	1.33	1.58	1.72	1.65	1.49	1.38	1.38	1.44	1.50
4	1.13	1.56	1.83	1.72	1.40	1.18	1.16	1.33	1.58	1.72	1.65	1.49	1.38	1.38	1.44	1.50
5	1.13	1.56	1.83	1.72	1.40	1.18	1.16	1.33	1.58	1.72	1.65	1.49	1.38	1.38	1.44	1.50

Table **6.17.3.3.6** Stock summary: number of recruits, SSB, Fbar 1-2**,** estimated catch

	Recruitment	SSB, tonnes	Fbar 0-2	Catch, tonnes
2002	424467	261.05	0.96	296.03
2003	367160	237.75	1.32	396.47
2004	603594	200.55	1.56	368.99
2005	772884	256.77	1.46	424.73
2006	626070	361.45	1.18	513.84
2007	576232	411.93	0.99	494.60
2008	735412	402.98	0.98	475.97
2009	975437	452.19	1.13	610.89

2010	1014080	497.78	1.34	821.79
2011	868761	505.41	1.46	928.22
2012	732509	450.95	1.40	772.28
2013	750698	403.01	1.26	623.49
2014	658474	416.36	1.17	595.64
2015	708929	398.79	1.17	569.74
2016	799592	404.35	1.22	603.05
2017	671041	445.08	1.27	683.63
2018	697470	402.57	1.29	643.50

Summary of the two assessments

The pros and cons of the two approaches of slicing LFD data, and respective assessment are summarised bellow:

The "to approach" pros: more regular fit to catch data, cons: large amount of age 0 individuals in the catches

The "to +0.5 approach" pros: no age 0 individuals in the catches, cons: larger missmach between estimated and observed catch (seems out of phase).

Finally, the EWG prefered the second assessment (Ch. 6.17.3.2 "to +0.5 approach"), because it is in line with the conceptual model of slicing LFD of summer spawning fishes described in Section. 3.2. The following estimation of reference points and short term forecasts, are carried out using output of second assessment (according to the "to +0.5 approach"). The EWG catch advice is given in section 5.17 is based on the second assessment with length slicing with 0.5 added.

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 resulting from the outputs of the a4a assessment according to the "to +0.5 approach" (Section. 6.17.3.3). Current F (1.26, estimated as the Fbar 1-2 in the last year of the time series, 2017) 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 6 is 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 according to the "to +0.5 approach" (Ch. 6.17.3.2).

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 2016-2018
$F_{ages\ 1-2}$ (2019)	1.26	F2019 status quo is mean Fbar 2016-2018
SSB (2019)	392	SSB from assessment
R_{age0} (2019)	387906	Geometric mean of R from time series years 2012 to 2018
Total catch (2019)	600 t	Catch at F status quo in 2019

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 (1.26), which corresponds to average Fbar over 2016-2018, is larger than $F_{0.1}$ (0.33), 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 2020, consistent with $F_{0.1}$ (0.33), should not exceed 226 tonnes, 65% less than the current estimated catch (644 t).

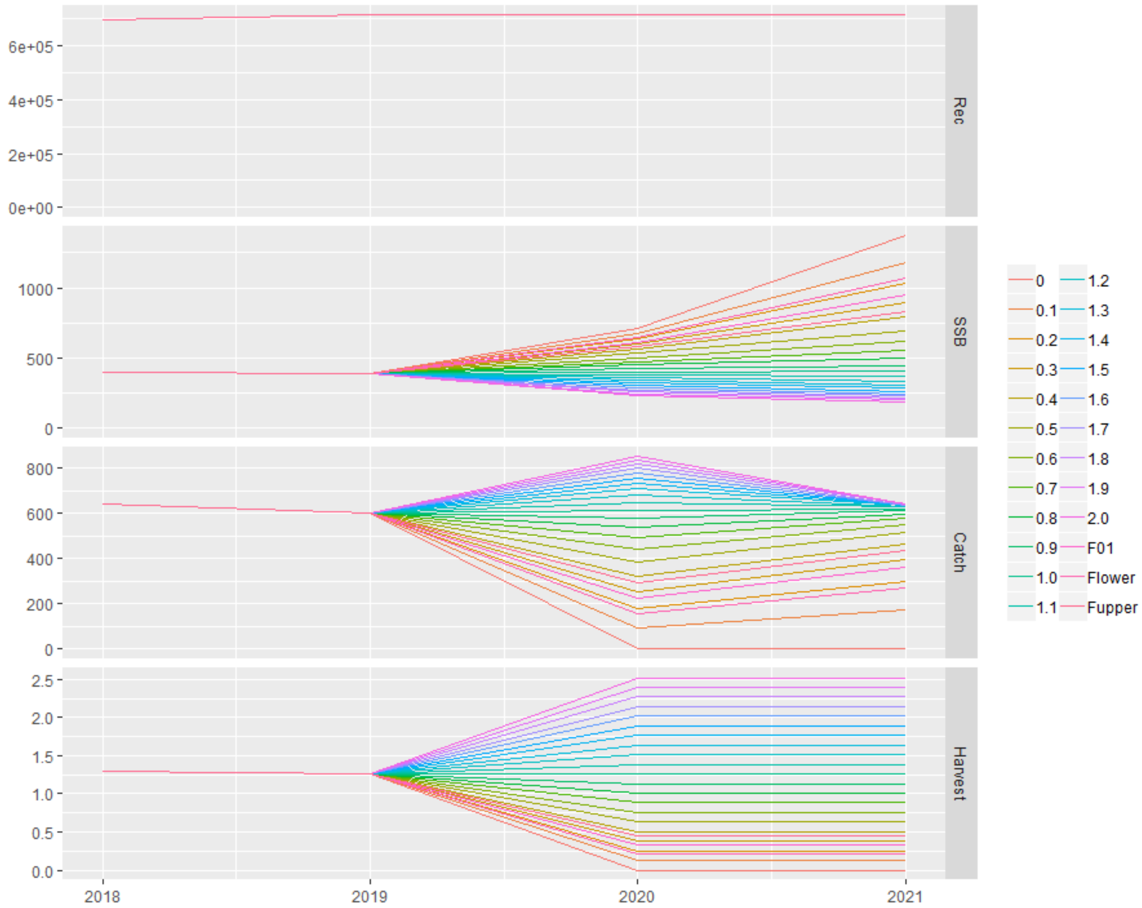


Figure 6.17.5.1 Annual catch scenarios and predictions of catch and SSB for blue and red shrimp (GSA 6&7).

Table 6.17.5.1 Blue and red shrimp (ARA) in GSA 6&7 short term forecast. Annual catch scenarios and predictions of catch and SSB. All weights are in tonnes. Basis: F(status quo) = geometric mean of F 2016-F 2018 = 1.26, Catch (2019) = 600 t, Recruitement= geometric mean of Recruits 2012-F 2018.

Rationale	Ffactor	Fbar	Catch 2018	Catch 2019	Catch 2020	Catch 2021	SSB 2019	SSB 2021	SSB change 2019-2021 (%)	Catch change 2018-2020 (%)
Zero catch	0	0	643.50	600.02	0.00	0.00	391.95	1369.69	249.46	-100
High long term yield ($F_{0.1}$)	0.26	0.33	643.50	600.02	225.57	360.69	391.95	947.50	141.74	-64.95
F_{upper}	0.36	0.45	643.50	600.02	294.96	437.63	391.95	833.15	112.57	-54.16
F_{lower}	0.17	0.22	643.50	600.02	157.81	270.66	391.95	1066.29	172.05	-75.48
Status quo	1	1.26	643.50	600.02	614.40	620.81	391.95	404.35	3.16	-4.52
Scenarios	0.1	0.13	643.50	600.02	94.01	171.77	391.95	1184.49	202.21	-85.39
	0.2	0.25	643.50	600.02	178.42	299.65	391.95	1029.41	162.64	-72.27
	0.3	0.38	643.50	600.02	254.33	394.40	391.95	899.21	129.42	-60.48
	0.4	0.50	643.50	600.02	322.66	464.22	391.95	789.59	101.45	-49.86
	0.5	0.63	643.50	600.02	384.27	515.33	391.95	697.02	77.83	-40.29
	0.6	0.76	643.50	600.02	439.88	552.46	391.95	618.59	57.82	-31.64
	0.7	0.88	643.50	600.02	490.16	579.18	391.95	551.91	40.81	-23.83
	0.8	1.01	643.50	600.02	535.67	598.20	391.95	495.02	26.30	-16.76
	0.9	1.13	643.50	600.02	576.93	611.56	391.95	446.28	13.86	-10.34
	1	1.26	643.50	600.02	614.40	620.81	391.95	404.35	3.16	-4.52
	1.1	1.39	643.50	600.02	648.46	627.10	391.95	368.13	-6.08	0.77
	1.2	1.51	643.50	600.02	679.48	631.29	391.95	336.69	-14.10	5.59
	1.3	1.64	643.50	600.02	707.77	634.03	391.95	309.28	-21.09	9.99
	1.4	1.76	643.50	600.02	733.61	635.79	391.95	285.27	-27.22	14.00
	1.5	1.89	643.50	600.02	757.25	636.91	391.95	264.14	-32.61	17.68
	1.6	2.02	643.50	600.02	778.91	637.66	391.95	245.45	-37.38	21.04
	1.7	2.14	643.50	600.02	798.79	638.20	391.95	228.84	-41.62	24.13
	1.8	2.27	643.50	600.02	817.06	638.66	391.95	214.00	-45.40	26.97
	1.9	2.39	643.50	600.02	833.89	639.13	391.95	200.69	-48.80	29.59
	2	2.52	643.50	600.02	849.40	639.68	391.95	188.70	-51.86	32.00

*SSB at mid year

6.17.6 DATA DEFICIENCIES

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.

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 19-10 considered the stock shared by the GSAs 9, 10 and 11.

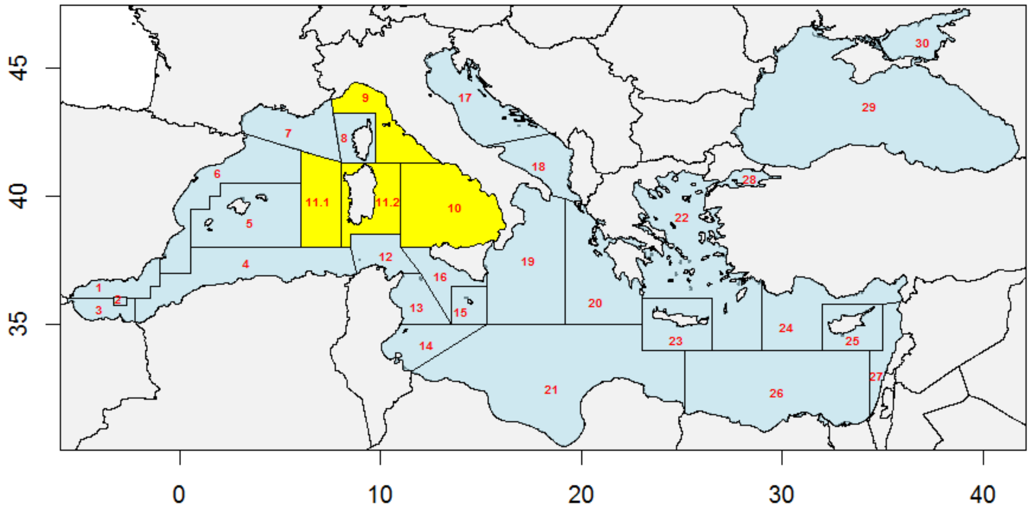


Figure 6.18.1.1. Geographical location of GSAs 9, 10 and 11.

The growth of A. antennatus has been studied both in the southern part than in the northern part of the 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 M. et al., 2000, 2004) provided the basis for an interpretation of growth in which the possible life span of A. antennatus was of 8-10 years. The following sets of Von Bertalanffy growth parameters were estimated:
Females: $L\infty$= 76.9, K=0.21, t0=-0.02 and
Males: $L\infty$= 46, K=0.21, t0=-0.02 (Orsi Relini and Relini, 1998).
More recently this interpretation of growth has been confirmed (Orsi Relini and Mannini, 2011; Orsi Relini et al., 2013).
STECF EWG 19-10 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 very similar. As input for the assessment the median values of a and b from GSA9 (Figure 6.18.1.3) were used.
The VBGF and LW relationship parameters used are summarized in the following Table (Tab. 6.18.1.1). The reproduction period, although with some differences between the various geographic areas of the Mediterranean, 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

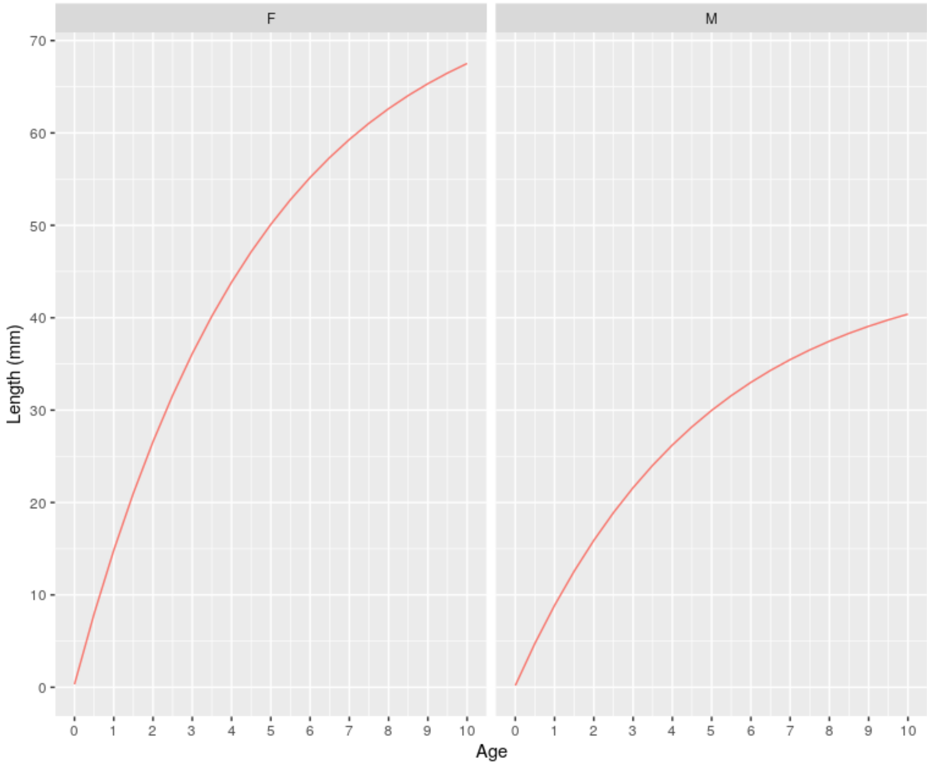


Figure 6.18.1.2. Blue and red shrimp in GSAs 9, 10 and 11. Von Bertalanffy growth curves by sex used in the assessment (Orsi Relini and Relini, 1998).

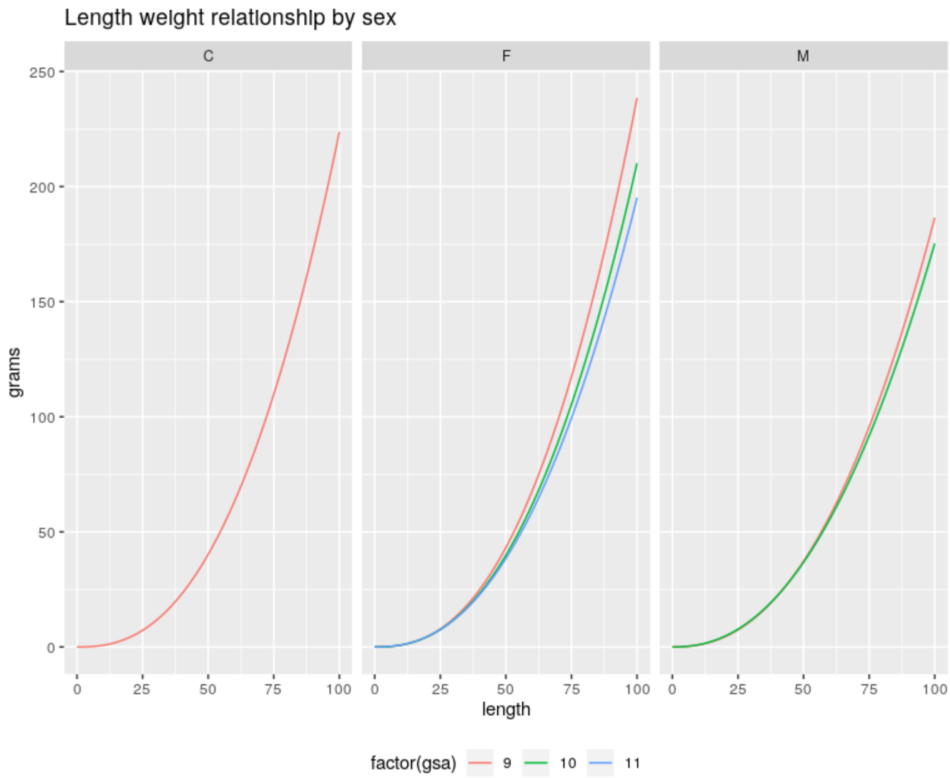


Figure 6.18.1.3. Blue and red shrimp in GSAs 9, 10 and 11. Length weight relationship by sex and GSA as median of a and b parameters provided through DCF.

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	1	2	3	4	5	6+
GSA 9_10_11	0.20408	0.78658	0.98333	0.99967	1.00000	1.00000

Table 6.18.1.3. Blue and red shrimp in GSAs 9, 10 and 11. Natural mortality vectors used in the assessment.

M	1	2	3	4	5	6+
GSA 9_10_11	0.76847	0.51104	0.40191	0.34261	0.30601	0.28162

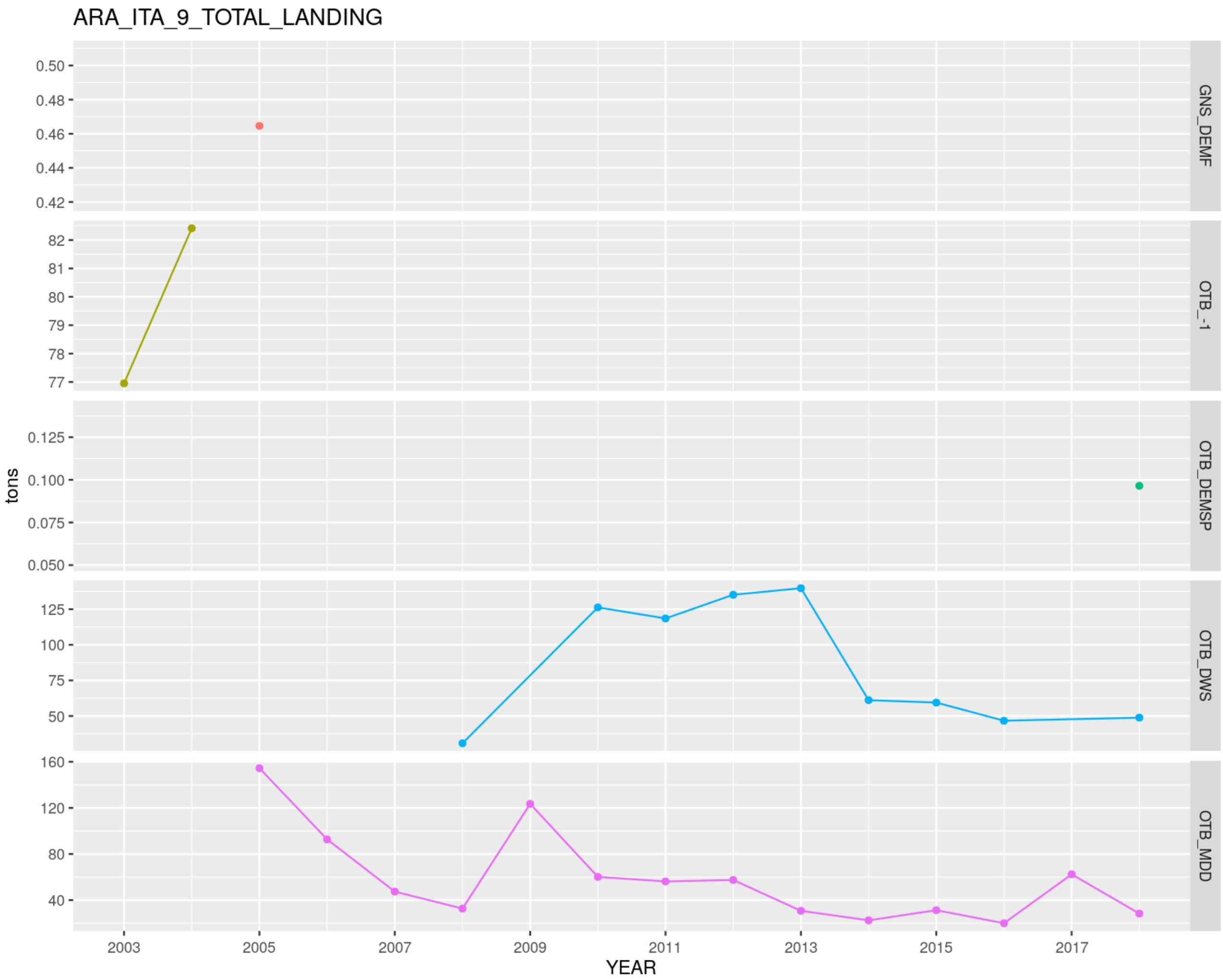
6.18.2 Data

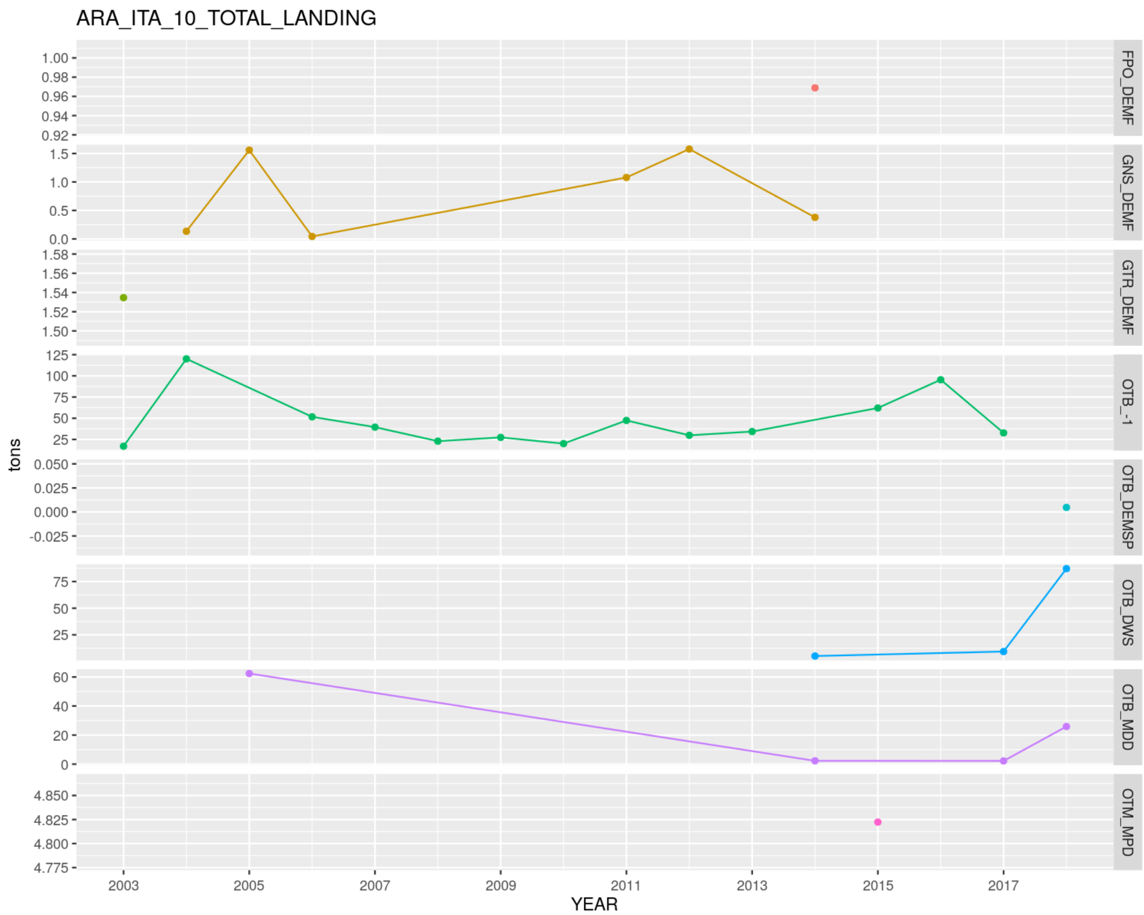
6.18.2.1 Catch (landings and discards)

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 with 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 19-10 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. Landings for GSA10 and 11 were revised according FDI data.


ARA_ITA_9_TOTAL_LANDING
tons
YEAR
GNS_DEMF
OTB_-1
OTB_DEMSP
OTB_DWS
OTB_MDD


ARA_ITA_10_TOTAL_LANDING
tons
YEAR
FPO_DEMF
GNS_DEMF
GTR_DEMF
OTB_-1
OTB_DEMSP
OTB_DWS
OTB_MDD
OTM_MPD

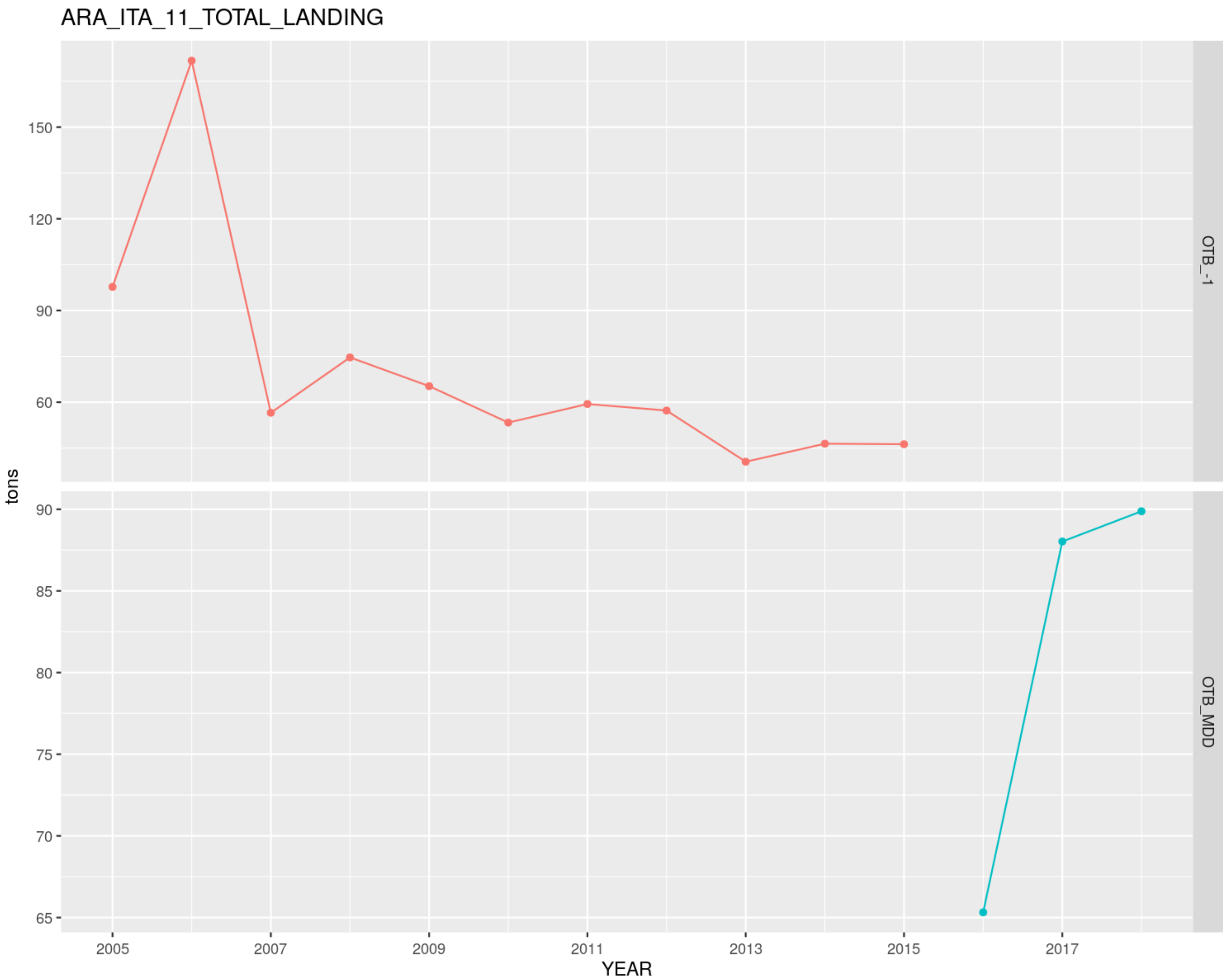


Figure 6.18.2.1.1. Blue and red shrimp in GSAs 9, 10 and 11. Landings data in tons by year and fleet.

Table 6.18.2.1.1. Blue and red shrimp in GSAs 9, 10 and 11. Landings data in tons by year and GSA.

	Total Landing (t)			
Year	**GSA 9**	**GSA 10**	**GSA 11**	**Total**
2003	77.0	18.5	-	95.5
2004	82.4	120.2	-	202.6
2005	154.9	63.9	97.7	316.5
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	161.4
2009	123.5	24.4	65.3	213.2
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*	57.6*	215.2
2016	66.6	66.1*	89.4*	222.1
2017	62.4	79.1*	110.0*	251.5
2018	77.2	135.0*	284.7*	496.9

*Revised according FDI data

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.18.2.1.2.

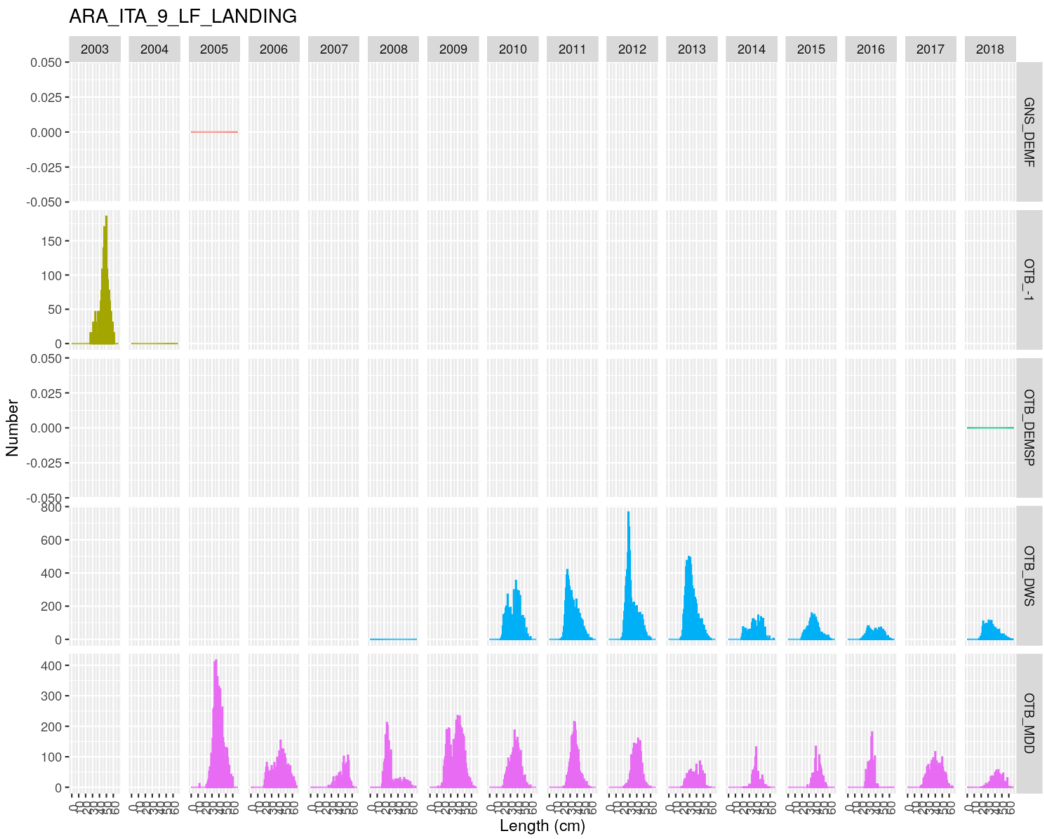

ARA_ITA_9_LF_LANDING
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
GNS_DEMF
OTB_-1
OTB_DEMSP
OTB_DWS
OTB_MDD
Number
Length (cm)

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. Anyway some data were reported to STECF EWG 19-10 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	-	-	-	**-**

Length and age frequency distributions of the discards are shown in Figure 6.18.2.1.3.

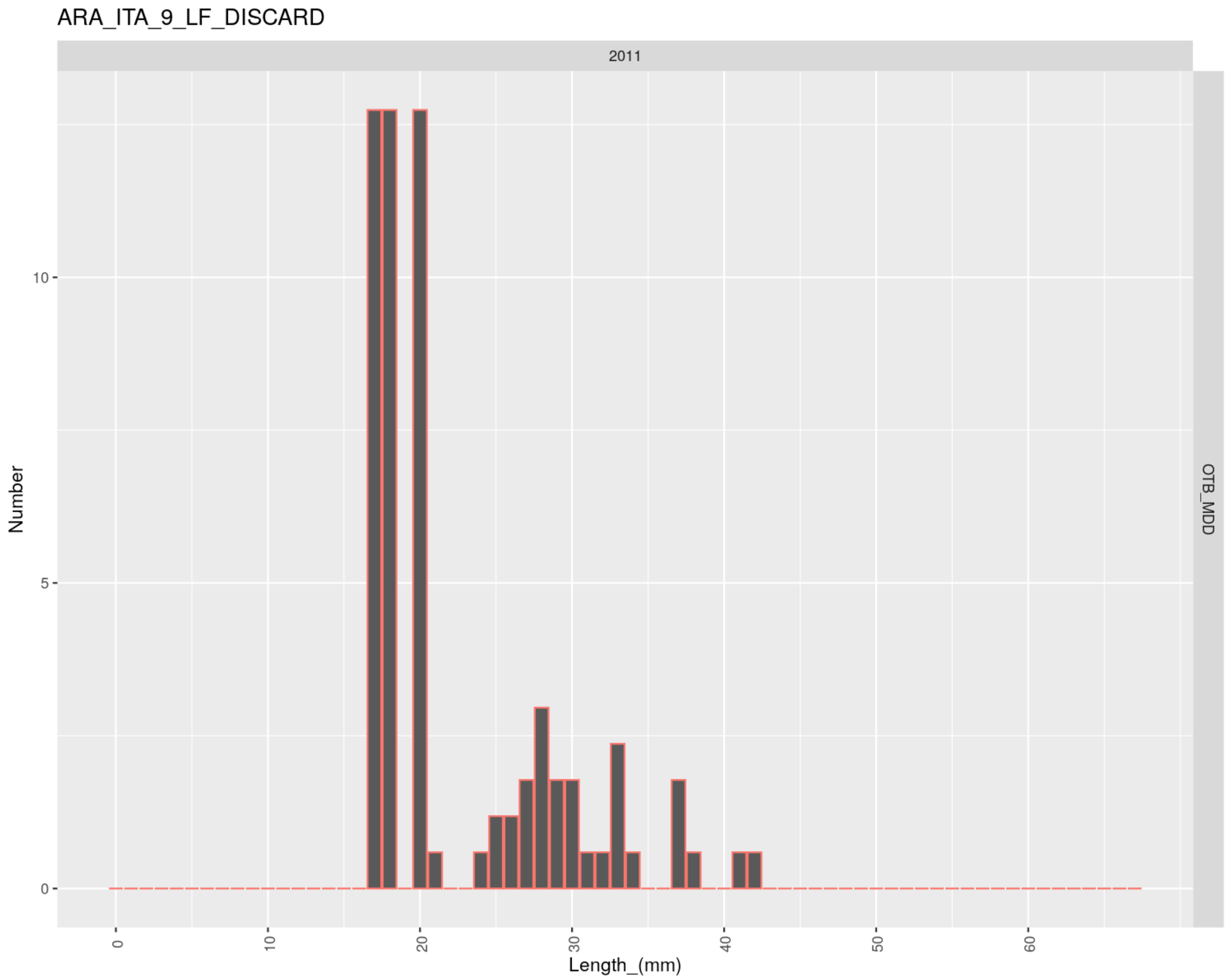


Figure 6.18.2.1.3. Blue and red shrimp in GSAs 9, 10 and 11. Length frequency distribution of the discards by year and fleet in GSA 9.

6.18.2.2 Effort

Fishing effort data were reported to STECF EWG 19-10 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).

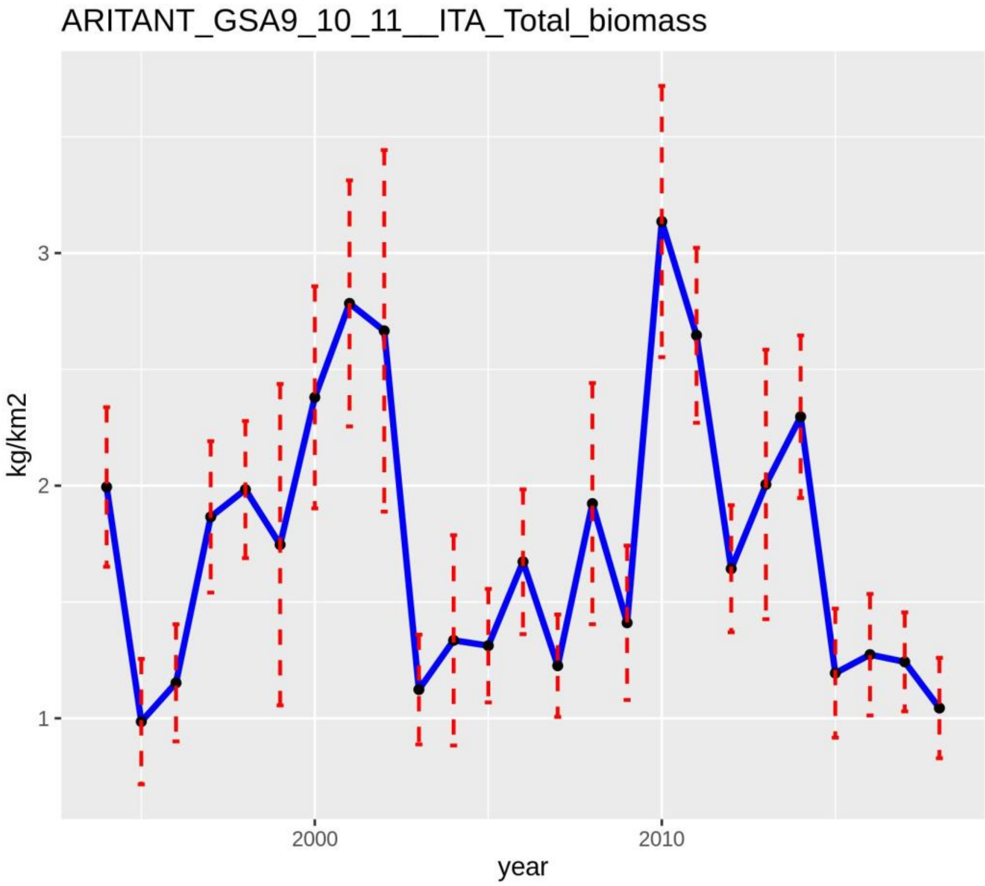


Figure 6.18.2.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Estimated biomass indices from the MEDITS survey (kg/km^2).

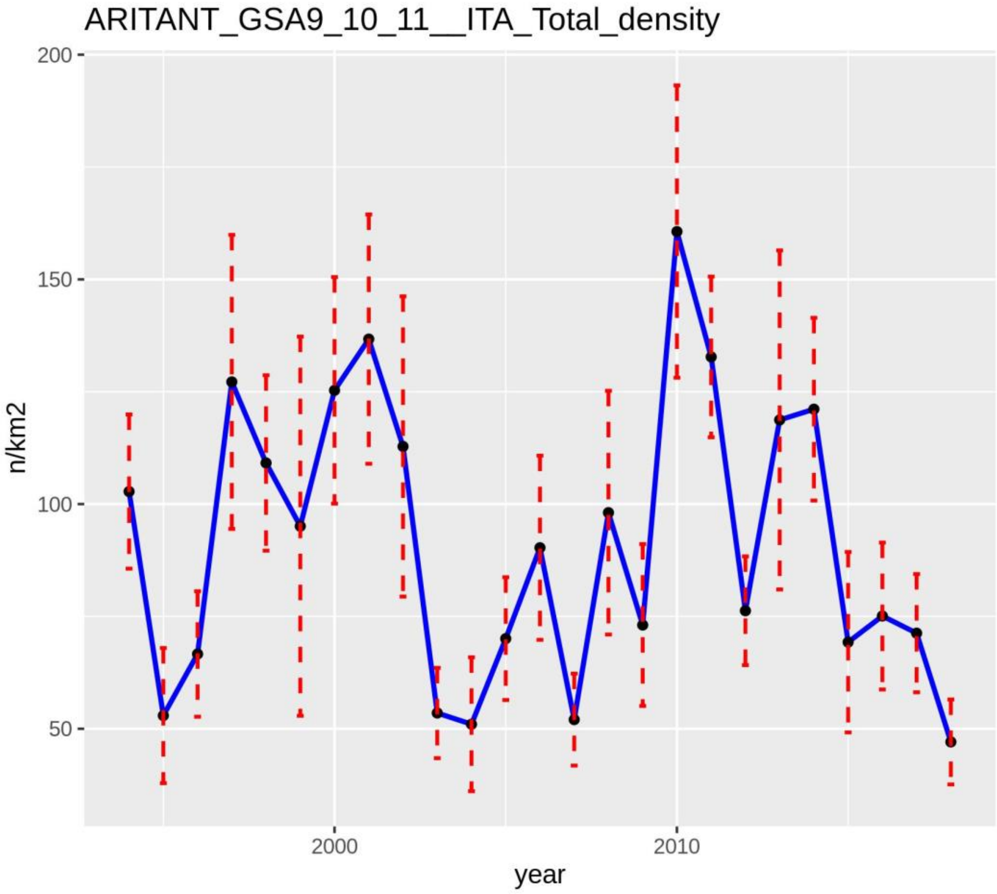


Figure 6.18.2.3.2. Blue and red shrimp in GSAs 9, 10 and 11. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with strong fluctuations throughout the time series.
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 2006-2018 for catch data and tuning file for which data were fully available in the three GSA (2005 distribution from GSA11 was clearly affected by under sampling procedures (abundance ranged across few length classes) and so was decided to skip this year). 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 the last year in GSA10 and GSA11 are due to missing reporting abundance data by quarter (GSA10) and no sampling data for DWS (GSA11) for which, even though not selected in the ranking system, landings reported were substantial. Thus SoP for those years 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
GSA 9	0.96	0.95	1.9	0.97	0.97	0.98	0.98	0.98	0.97	0.98	0.98	0.98	1.00
GSA 10	1.03	1.03	1.03	1.03	1.06	0.97	0.99	0.98	1.15	1.08	0.71	1.86	2.39
GSA 11	0.66	0.66	0.65	0.68	0.66	0.69	0.65	0.67	0.67	0.85	0.93	0.84	2.17

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**
316	143	161	216	260	283	261	245	139	215	222	251	497

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	670.803	4749.977	3743.231	1862.909	874.32	450.846
2007	190.783	1686.908	2041.201	749.834	500.833	220.993
2008	1312.064	2364.241	2218.112	1179.137	458.336	246.654
2009	1147.759	2688.463	3419.193	1693.443	604.353	223.362
2010	1185.631	3753.735	4653.864	1989.96	598.148	143.191
2011	1619.71	5081.244	4847.551	2108.07	680.08	208.784
2012	1144.474	4361.156	4131.076	2661.355	791.548	158.696
2013	1279.727	5172.732	3591.948	1941.041	717.734	175.899
2014	407.518	1844.981	2011.506	993.068	457.627	89.741
2015	842.249	3551.969	3425.93	1565.628	568.544	196.018
2016	796.526	4552.218	2867	1603.249	616.244	166.835
2017	1468.306	4567.517	3487.443	1958.856	699.502	226.198
2018	2139.366	8990.244	9197.511	2489.959	936.281	310.064

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	0.008	0.017	0.028	0.033	0.042	0.058
2007	0.008	0.018	0.025	0.035	0.046	0.052
2008	0.007	0.013	0.021	0.032	0.044	0.063
2009	0.008	0.014	0.022	0.032	0.045	0.062
2010	0.007	0.014	0.023	0.030	0.040	0.050
2011	0.008	0.014	0.022	0.028	0.037	0.060
2012	0.008	0.013	0.023	0.030	0.041	0.055
2013	0.008	0.014	0.021	0.027	0.036	0.049

2014	0.009	0.017	0.024	0.032	0.042	0.054
2015	0.008	0.015	0.023	0.029	0.038	0.052
2016	0.009	0.016	0.024	0.027	0.036	0.049
2017	0.008	0.015	0.022	0.027	0.039	0.053
2018	0.010	0.017	0.023	0.026	0.032	0.050

Table 6.18.3.5. Blue and red shrimp in GSAs 9, 10 and 11.Maturity vector Natural Mortality vector

Year/Age	1	2	3	4	5	6
2006=2018	0.204	0.787	0.983	1.000	1.000	1.000
2006-2018	0.768	0.511	0.402	0.343	0.306	0.282

Table 6.18.3.6. Blue and red shrimp in GSAs 9, 10 and 11.MEDITS numbers at age (n/km^2)

Year/Age	**1**	**2**	**3**	**4**	**5**
2006	8.660	43.721	20.522	10.252	4.565
2007	3.013	14.213	15.860	10.659	5.688
2008	8.751	40.673	26.137	11.629	7.889
2009	5.080	25.539	27.511	9.337	2.008
2010	18.167	61.445	55.068	18.275	6.453
2011	8.352	48.773	46.990	18.866	7.594
2012	5.692	23.964	22.438	17.518	4.327
2013	11.565	66.609	28.232	7.234	4.193
2014	10.700	46.242	40.017	18.328	4.657
2015	9.256	28.559	20.953	6.716	2.779
2016	6.042	37.965	19.484	7.592	2.855
2017	9.035	27.819	20.000	9.976	3.165
2018	2.050	15.115	19.973	6.410	2.753

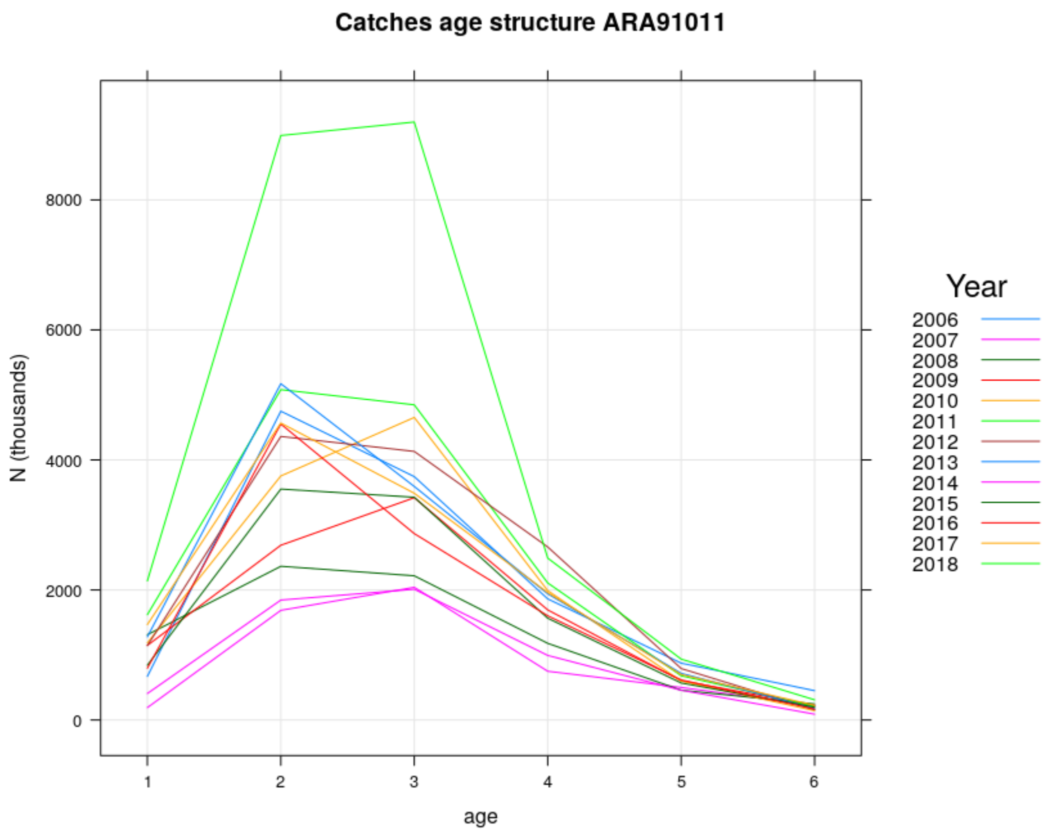


Figure 6.18.3.1. Blue and red shrimp in GSAs 9, 10 and 11. Catch at age input data.

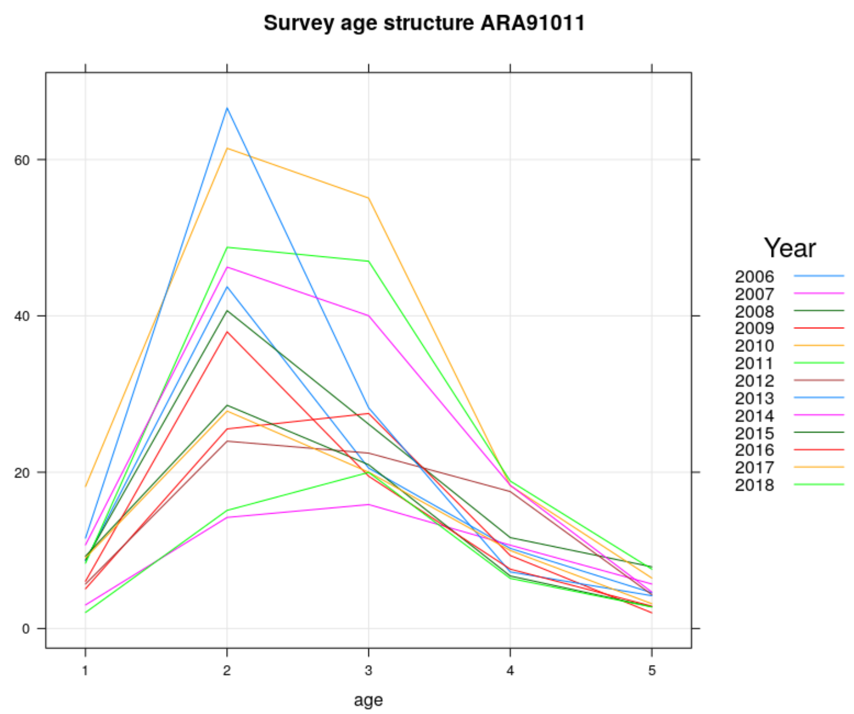


Figure 6.18.3.2. Blue and red shrimp in GSAs 9, 10 and 11. Age structure of the index.

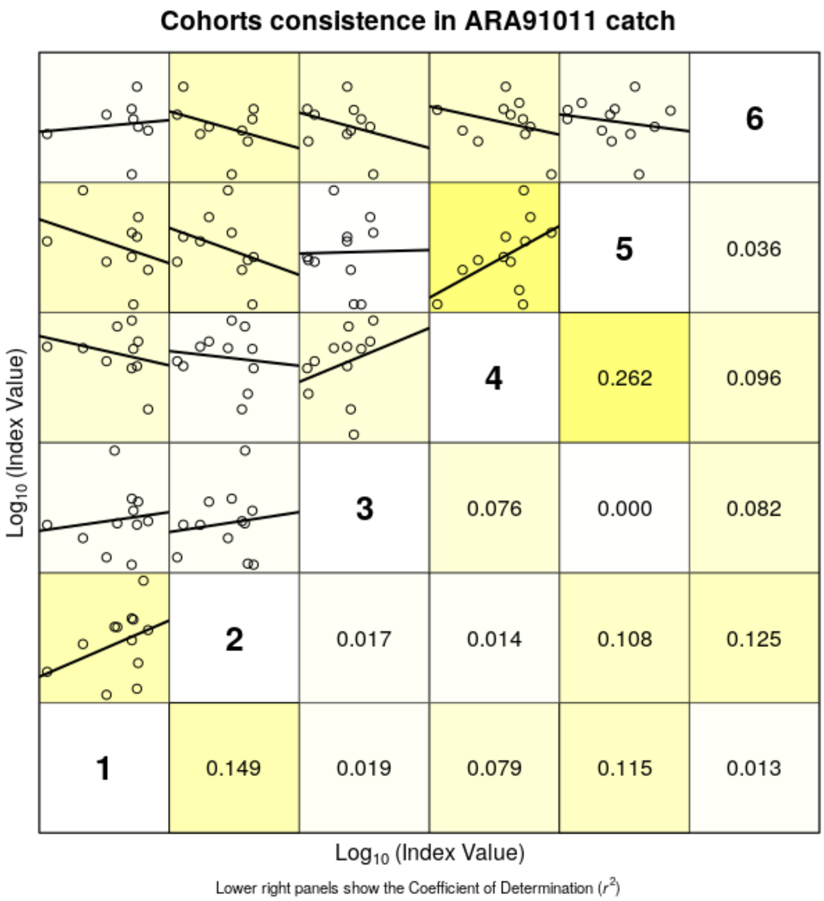


Figure 6.18.3.3. Blue and red shrimp in GSAs 9, 10 and 11. Catch at age cohort consistency

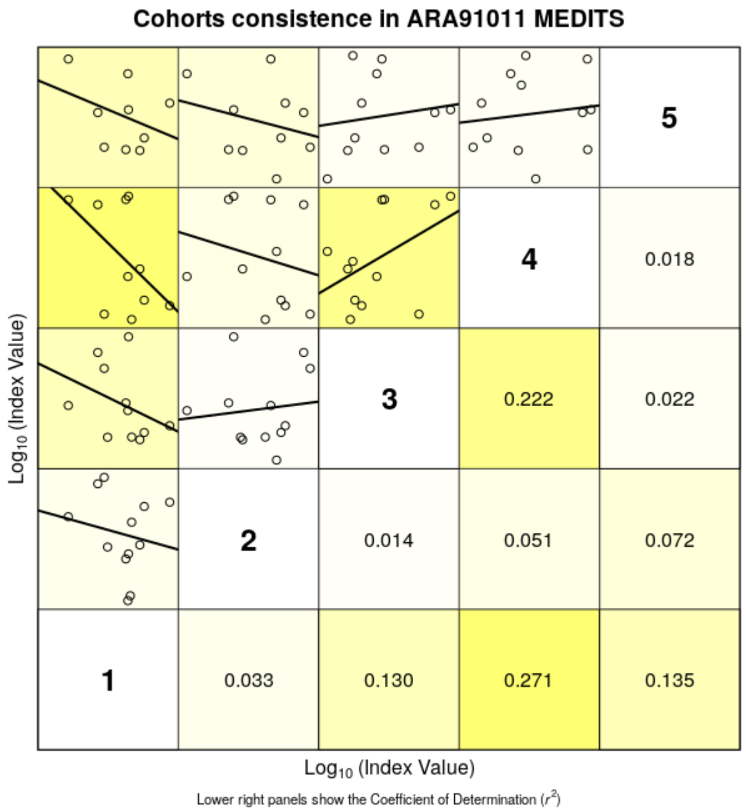


Figure 6.18.3.4. Blue and red shrimp in GSAs 9, 10 and 11. Index at age cohort consistency

Assessment results

Different a4a models were performed (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.

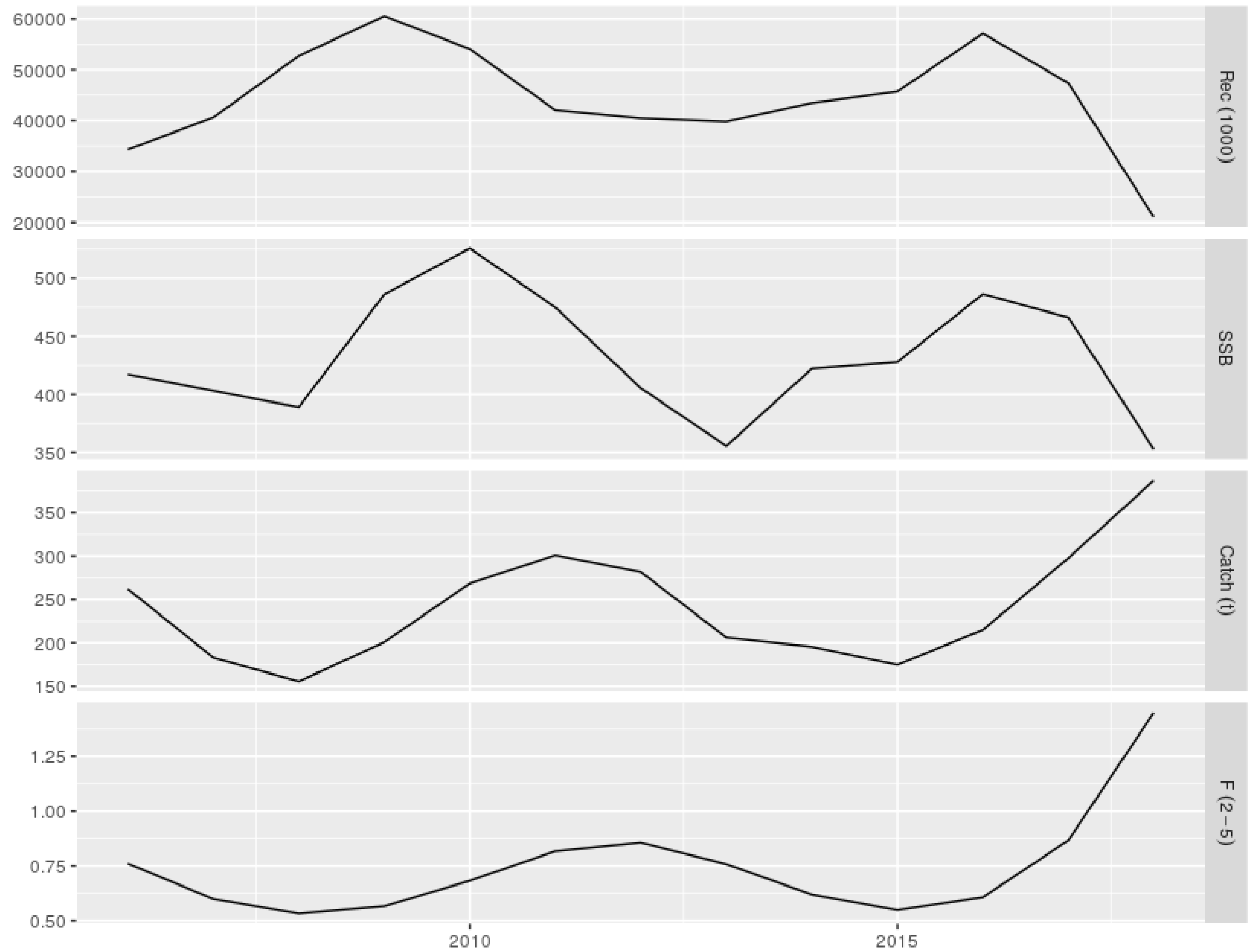
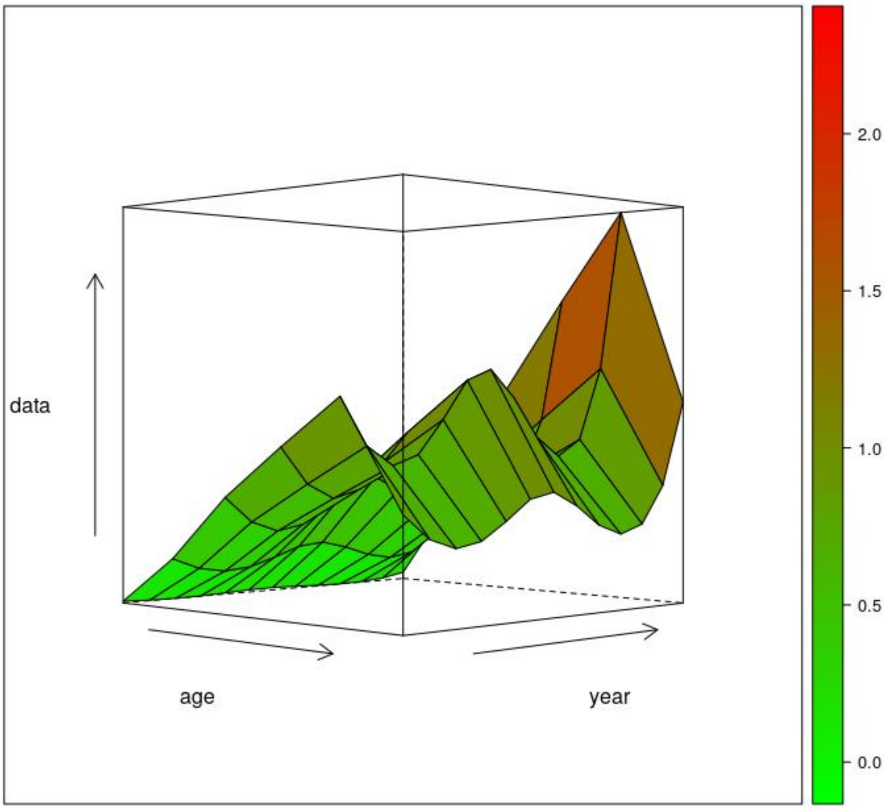


Figure 6.18.3.5. Blue and red shrimp in GSAs 9, 10 and 11. Stock summary from the final a4a model.



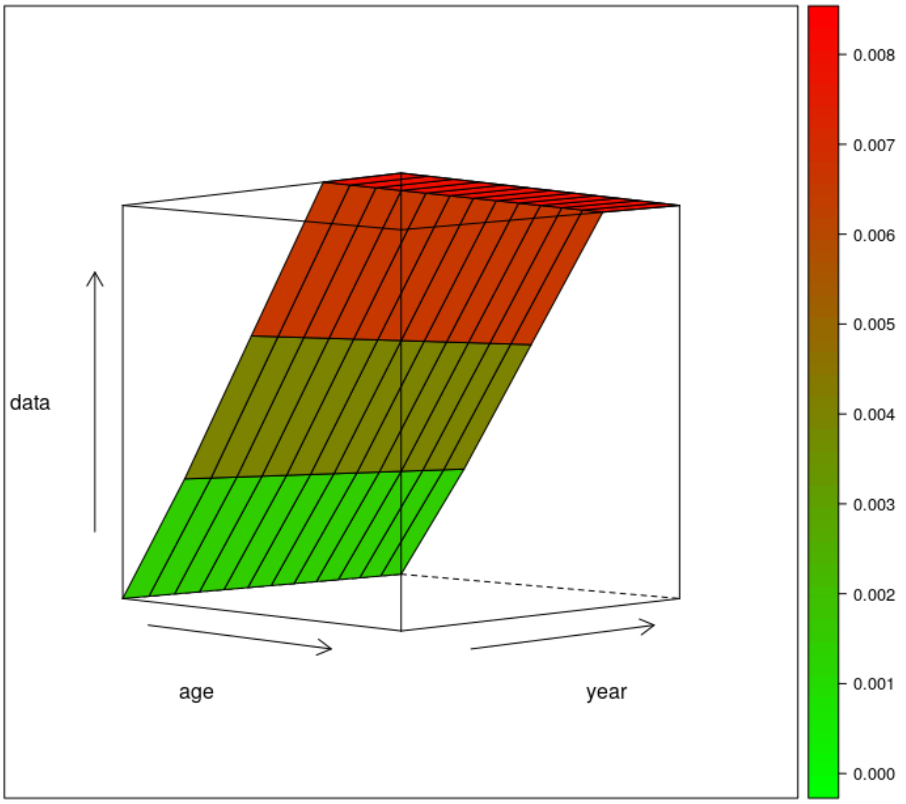


Figure 6.18.3.6. Blue and red shrimp in GSAs 9, 10 and 11. 3D contour plot of estimated fishing mortality (up) and 3D contour plot of estimated catchability (low) at age and year.

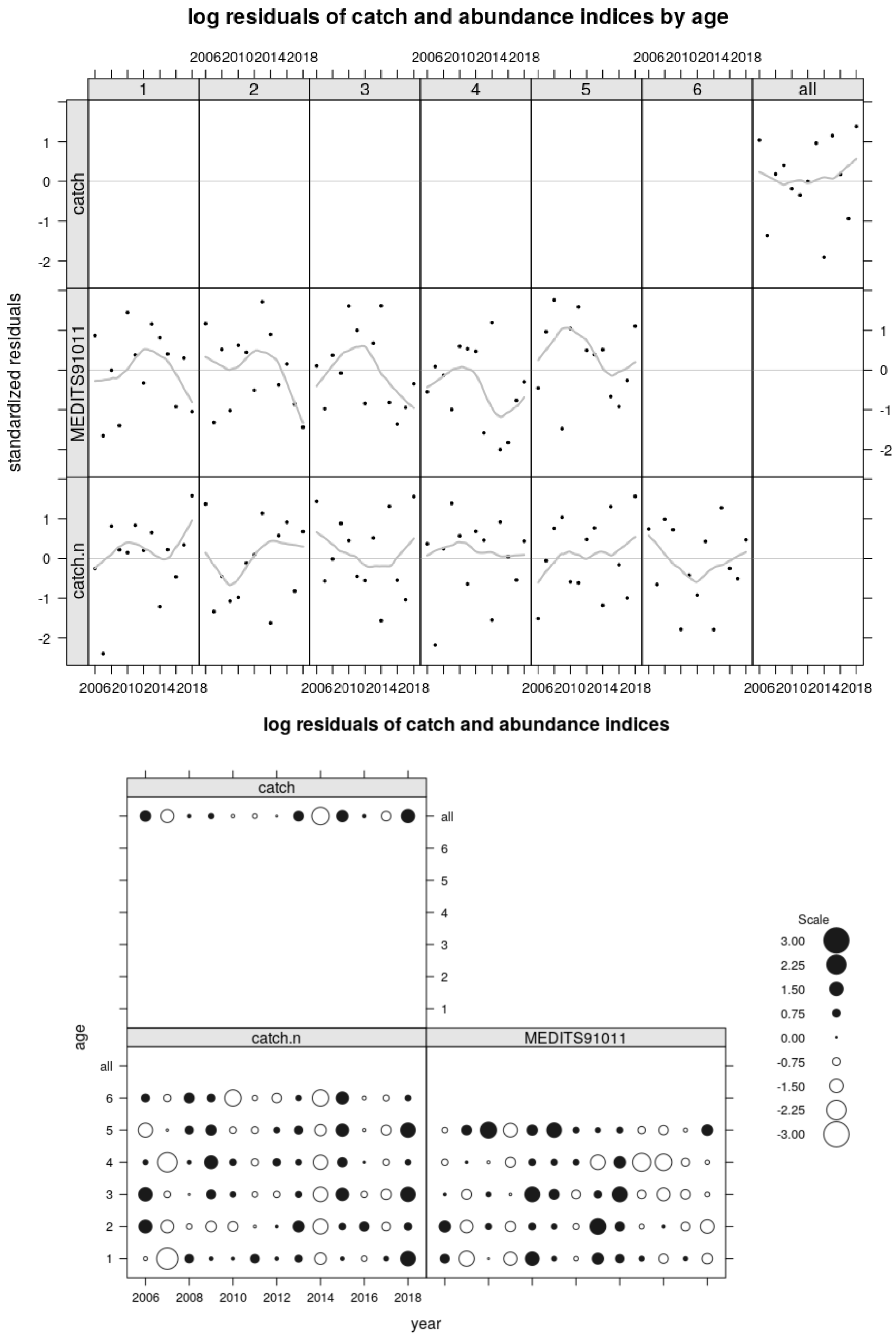


Figure 6.18.3.7. Blue and red shrimp in GSAs 9, 10 and 11. Standardized residuals for abundance indices and for catch numbers.

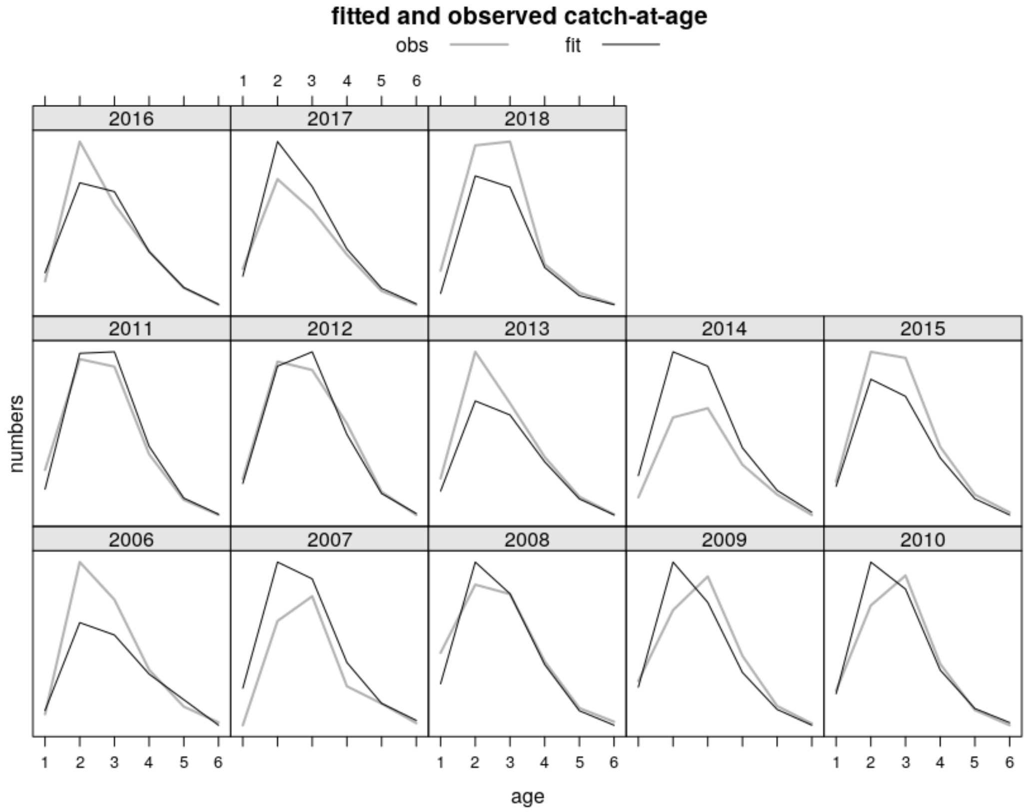


Figure 6.18.3.8. Blue and red shrimp in GSAs 9, 10 and 11. Fitted and observed catch at age.

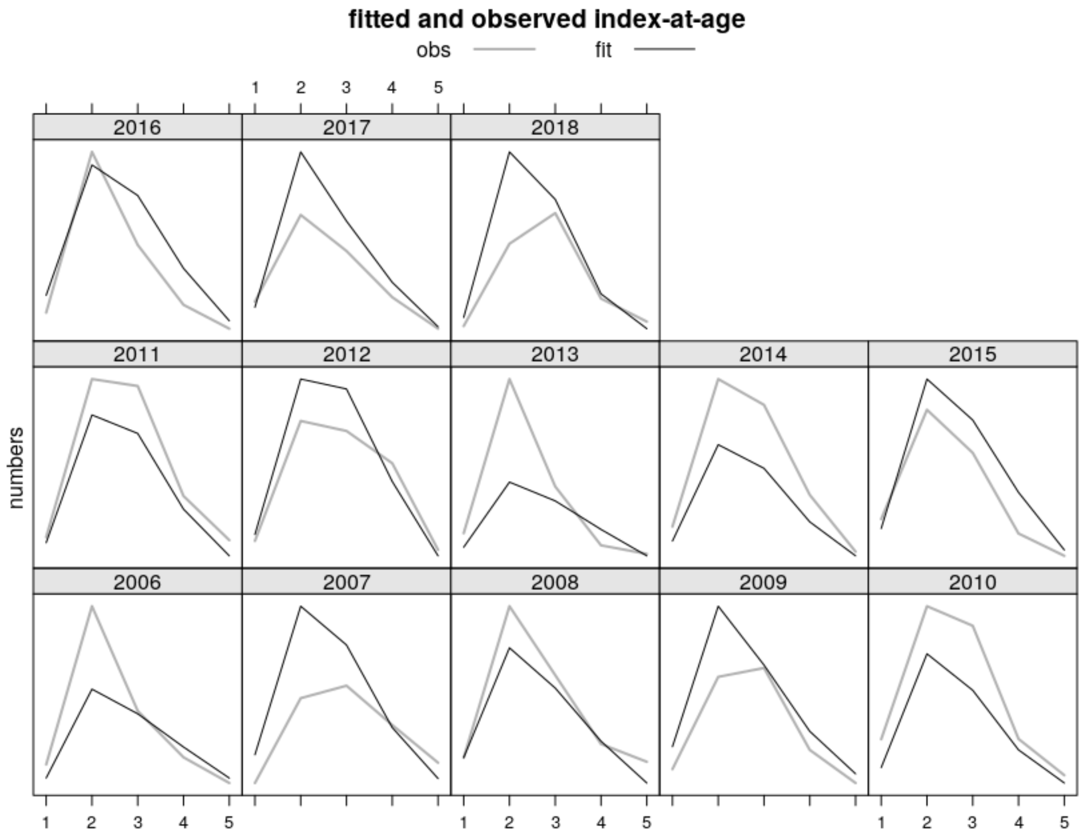


Figure 6.18.3.9. Blue and red shrimp in GSAs 9, 10 and 11. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 2 years back. Models results were quite stable (Figure 6.18.3.10).

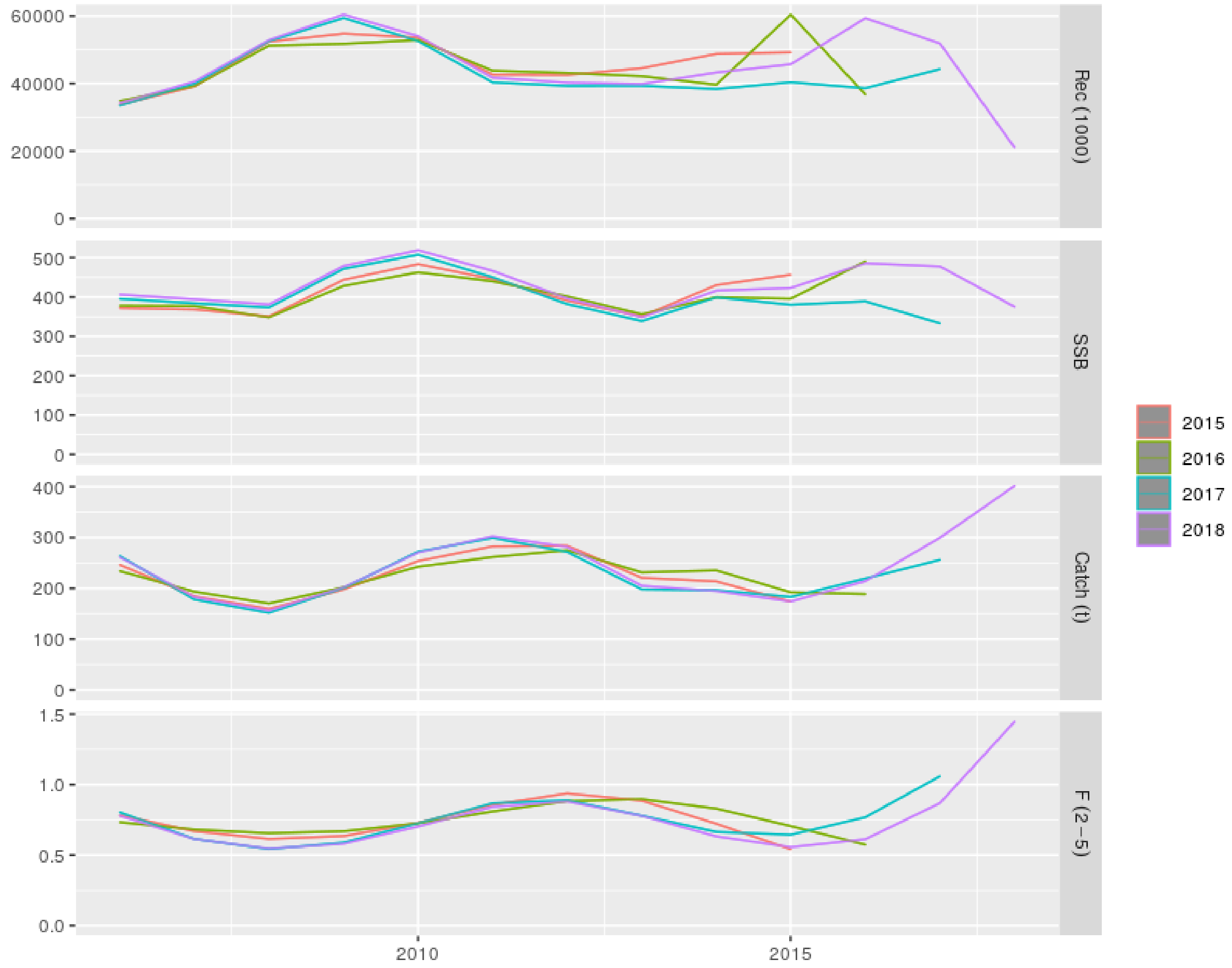


Figure 6.18.3.10. Blue and red shrimp in GSAs 9, 10 and 11. Retrospective analysis.

Simulations

In the following figures and tables, the population estimates obtained by the a4a model are provided.

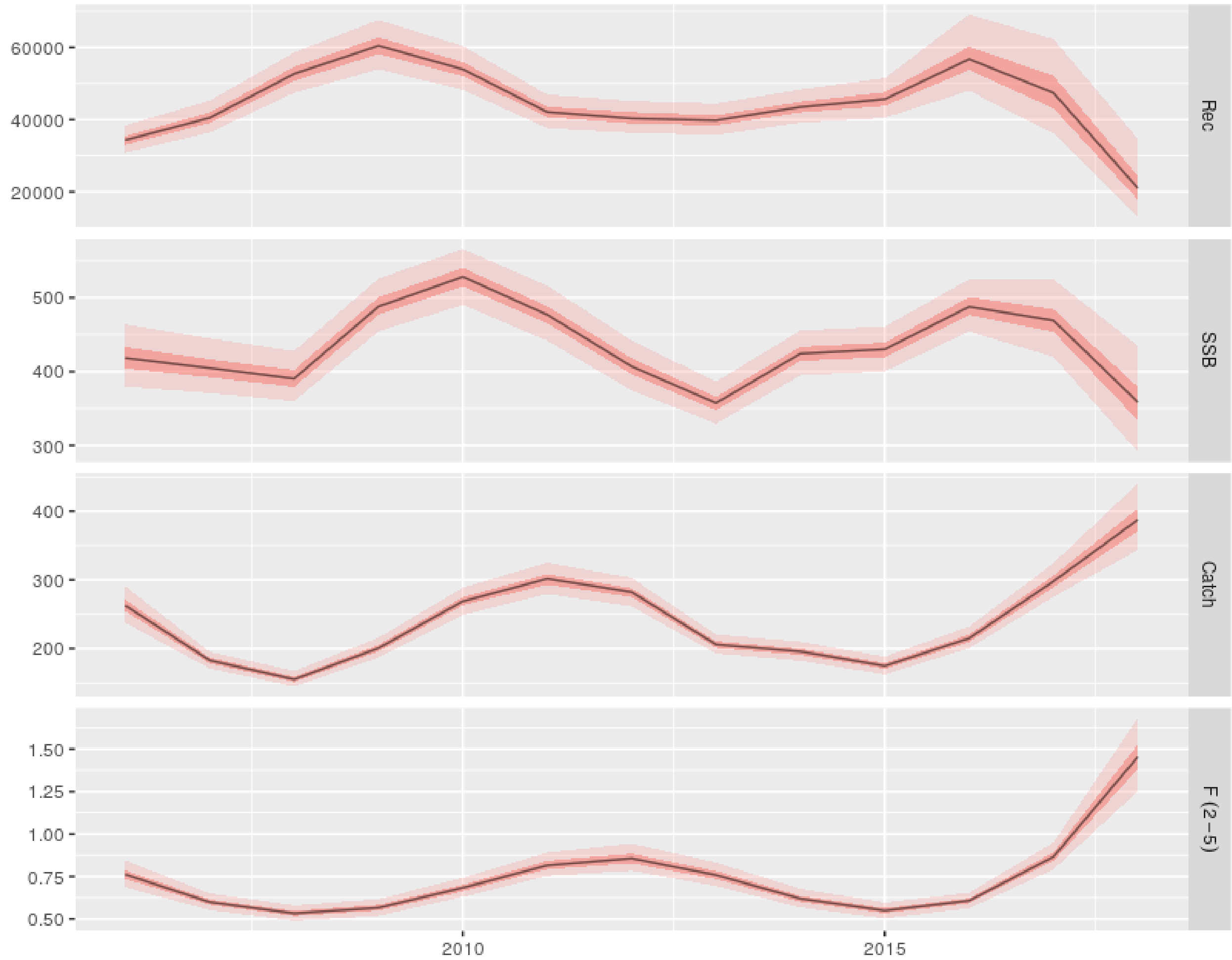


Figure 6.18.3.11. Blue and red shrimp in GSAs 9, 10 and 11. Stock summary of the simulated and fitted data for the a4a model.

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	34317	15387	6983	3342	1724	938
2007	40615	15401	6864	2449	945	776
2008	52721	18355	7318	2762	842	639
2009	60523	23895	8951	3116	1030	587
2010	54070	27391	11501	3704	1116	598
2011	42066	24348	12598	4310	1152	547
2012	40464	18833	10627	4212	1139	454
2013	39812	18086	8097	3438	1062	396
2014	43462	17870	8078	2846	976	405
2015	45727	19625	8424	3195	956	462
2016	57117	20710	9510	3539	1168	526
2017	47378	25804	9811	3801	1206	581
2018	21035	21167	11048	3145	946	451

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	0.76	34317	417.3	965.3	262.1
2007	0.60	40615	403.1	948.9	183.1
2008	0.53	52721	389.1	944.0	155.7
2009	0.57	60523	486.0	1211.1	200.8
2010	0.68	54070	525.7	1238.8	268.5
2011	0.82	42066	474.9	1135.8	300.9
2012	0.86	40464	405.4	997.8	281.6
2013	0.76	39812	355.6	882.7	206.1
2014	0.62	43462	422.2	1018.2	195.5
2015	0.55	45727	427.8	1020.7	174.9
2016	0.61	57117	486.2	1230.7	214.9
2017	0.87	47378	466.2	1187.9	297.6
2018	1.45	21035	352.8	953.1	386.9

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	0.03	0.30	0.65	0.92	1.18	0.61
2007	0.03	0.23	0.51	0.72	0.93	0.48
2008	0.02	0.21	0.45	0.64	0.83	0.42
2009	0.02	0.22	0.48	0.68	0.88	0.45
2010	0.03	0.27	0.58	0.83	1.06	0.54
2011	0.04	0.32	0.69	0.99	1.27	0.65
2012	0.04	0.33	0.73	1.04	1.33	0.68
2013	0.03	0.29	0.64	0.92	1.18	0.60
2014	0.03	0.24	0.53	0.75	0.96	0.49
2015	0.02	0.21	0.47	0.66	0.85	0.44
2016	0.03	0.24	0.52	0.73	0.94	0.48
2017	0.04	0.34	0.74	1.05	1.34	0.69
2018	0.06	0.56	1.23	1.75	2.25	1.15

Based on the a4a results, the Blue and red shrimp SSB shows a fluctuating pattern reaching the lowest value in 2018 (353 tonnes). The number of recruits a fluctuating pattern until a minimum value reached in 2018 (21035). Fbar (2-5) shows a fluctuating pattern with a steep increase in the last years (Fbar 2019 = 1.45).

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 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 (1.45, estimated as the F_{bar2-5} in the last year of the time series, 2018) is higher than $F_{0.1}$ (0.39), 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 high overfishing.

In Figures 6.18.4.1 Yield per Recruit model and histogram of the probabilities of $F_{0.1}$, Fbar and F/ F_{MSY} according to 500 simulations are reported

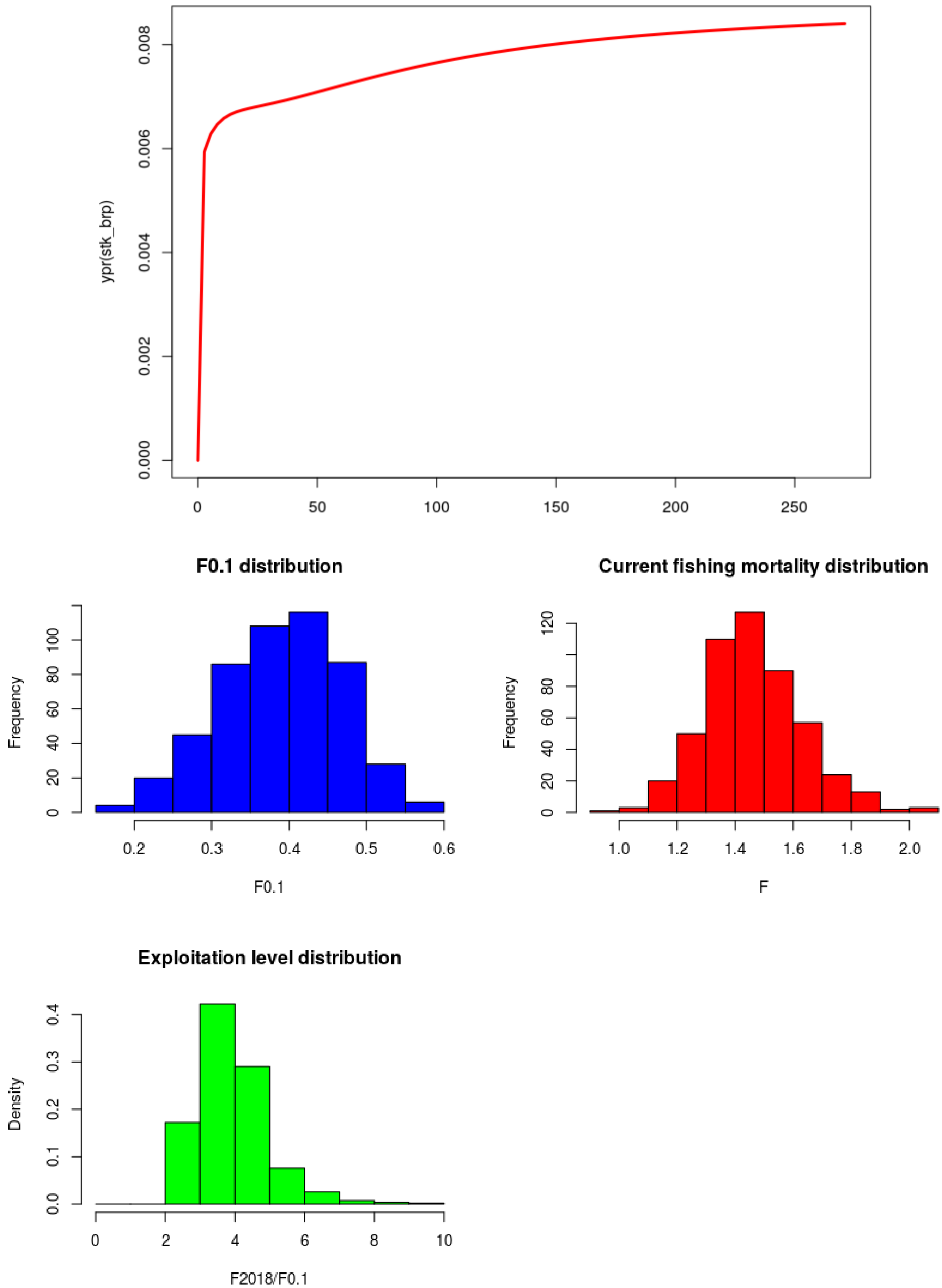


Figure 6.18.4.1. Blue and red shrimp in GSAs 9, 10 and 11. Yield per Recruit model (up) and histogram of probability/density for $F_{0.1}$, Fcurr and level of exploitation values (iter=500)

6.18.5 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 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 Fbar value (1.45)

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 (43233 thousands). 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
$F_{ages\ 2\text{-}5}$ (2019)	1.45	F2018 used to give F status quo for 2019
SSB (2019)	220.7	Stock assessment 1 January 2019
R_{age0} (2019,2020)	43233 thousands	Geometric mean of the time series years 2006 - 2018
Total catch (2019)	277.4	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 2018	Catch 2019	Catch 2020	Catch 2021	SSB* 2019	SSB* 2021	Change_SSB 2019-2021(%)	Change_Catch 2018-2020(%)
High long term yield ($F_{0.1}$)	0.27	0.39	387	227	72	116	221	431	95	-81
F upper	0.37	0.53	387	227	94	143	221	398	80	-76
F lower	0.18	0.26	387	227	50	85	221	465	111	-87
Zero catch	0.00	0.00	387	227	0	0	221	548	148	-100
Status quo	1	1.45	387	227	202	229	221	264	20	-48
Different Scenarios	0.1	0.15	387	227	29	52	221	499	126	-93
	0.2	0.29	387	227	55	93	221	457	107	-86
	0.3	0.44	387	227	79	125	221	420	90	-80
	0.4	0.58	387	227	101	150	221	389	76	-74
	0.5	0.73	387	227	121	171	221	361	64	-69
	0.6	0.87	387	227	140	188	221	337	53	-64
	0.7	1.02	387	227	157	201	221	315	43	-59
	0.8	1.16	387	227	173	212	221	296	34	-55
	0.9	1.31	387	227	188	221	221	279	26	-51
	1.1	1.60	387	227	215	235	221	250	13	-44
	1.2	1.74	387	227	228	241	221	238	8	-41
	1.3	1.89	387	227	239	245	221	226	3	-38
	1.4	2.03	387	227	250	249	221	216	-2	-35
	1.5	2.18	387	227	260	252	221	207	-6	-33
	1.6	2.32	387	227	270	255	221	198	-10	-30
	1.7	2.47	387	227	279	258	221	190	-14	-28
	1.8	2.61	387	227	288	260	221	183	-17	-26
	1.9	2.76	387	227	296	262	221	176	-20	-24
	2	2.90	387	227	304	263	221	170	-23	-22

* SSB at mid-year

6.18.6 Data Deficiencies

GSA_10 in year 2018 abundance per length classes is reported by 2mm step while in the Data Call Annex 2 was requested by 1mm step.

During EWG 1912 landings data from the Mediterranean data call and the FDI data call were compared. As discrepancies were found for ARA in GSA 10 and 11 (more than 50% for this GSA in the last two years), the stock assessment data for ARA in GSA 9, 10 and 11 was revised with the updated total landings.

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 shimp 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).

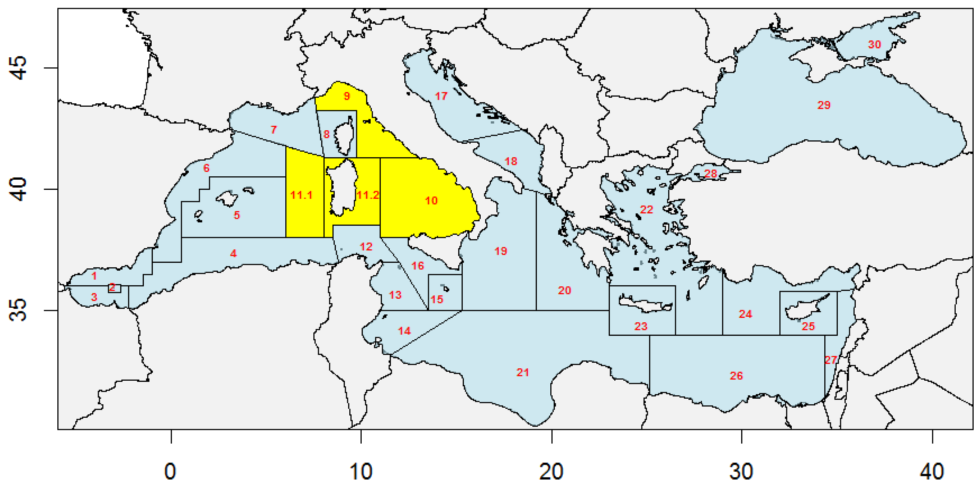


Figure 6.18.1.1 Limit of Geographical Sub-Areas (GSAs) 9, 10, 11.

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.

Also for the Length-Weight relationship, several sets of paramentes by sex are provided for GSAs 9 and 10. In GSA11, LW relationship parameters were reported for female only. The average of LW parameters (a and b) was computed and used 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 6.18.1.1).

Table 6.18.1.1 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 computed as a weighed average of the vectors available from the DCF database in GSAs 9 and 10. No vector of proportion of mature by age was provided for GSA11.

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 giant red shrimp in GSAs 9, 10, 11 are shown in Table 6.18.1.2.

Table 6.18.1.2 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 6.18.2.1.1 and Figure 6.18.2.1.1. 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 and 2014. In 2017 and 2018, 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 6.18.2.1.2-6.18.2.1.4.

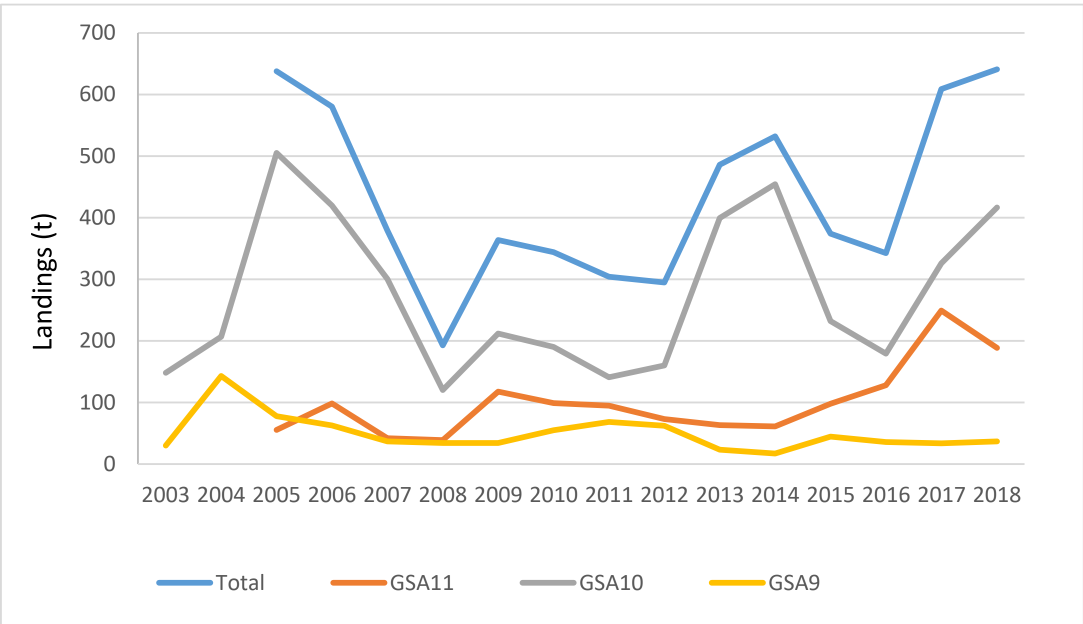


Figure 6.18.2.1.1 Giant red shrimp in GSAs 9, 10, 11: landings by GSA and total landings.

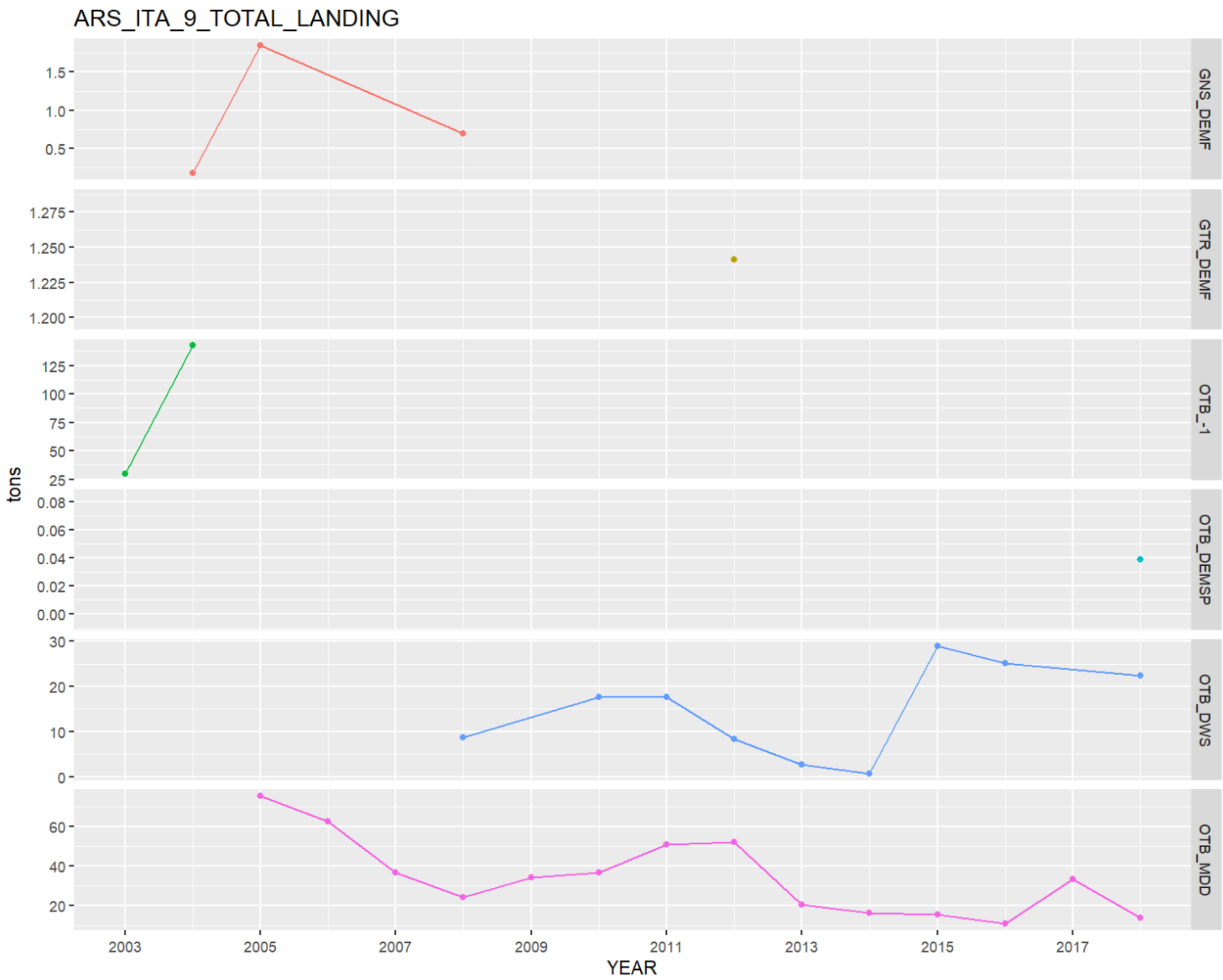


Figure 6.18.2.1.2. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 9.

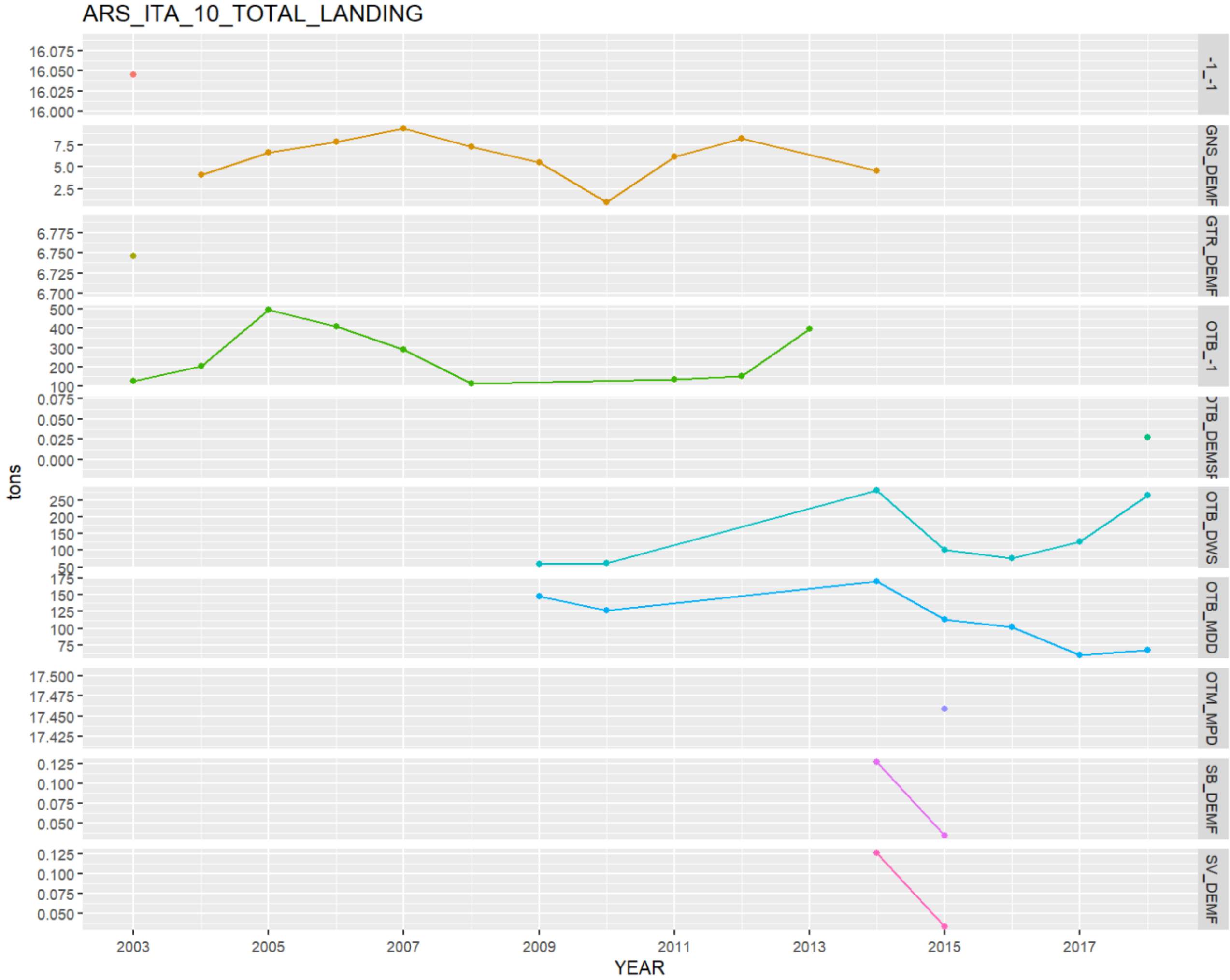


Figure 6.18.2.1.3. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 10.

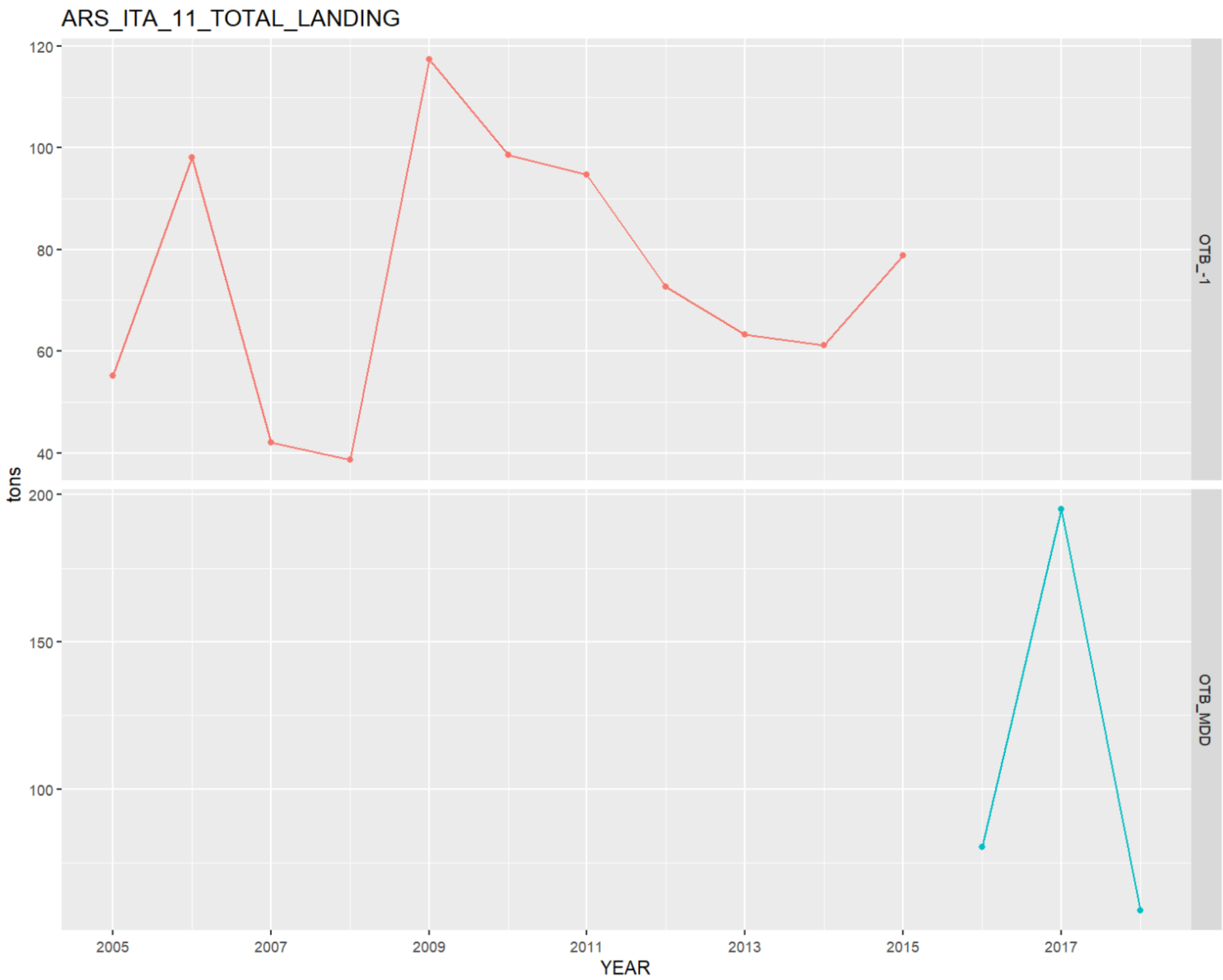


Figure 6.18.2.1.4. Giant red shrimp in GSAs 9, 10, 11: landings trend by gear in GSA 11.

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 6.18.2.1.1. 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	

The size structure by year, area and gear is shown in Figures 6.18.2.1.5-6.18.2.1.7.

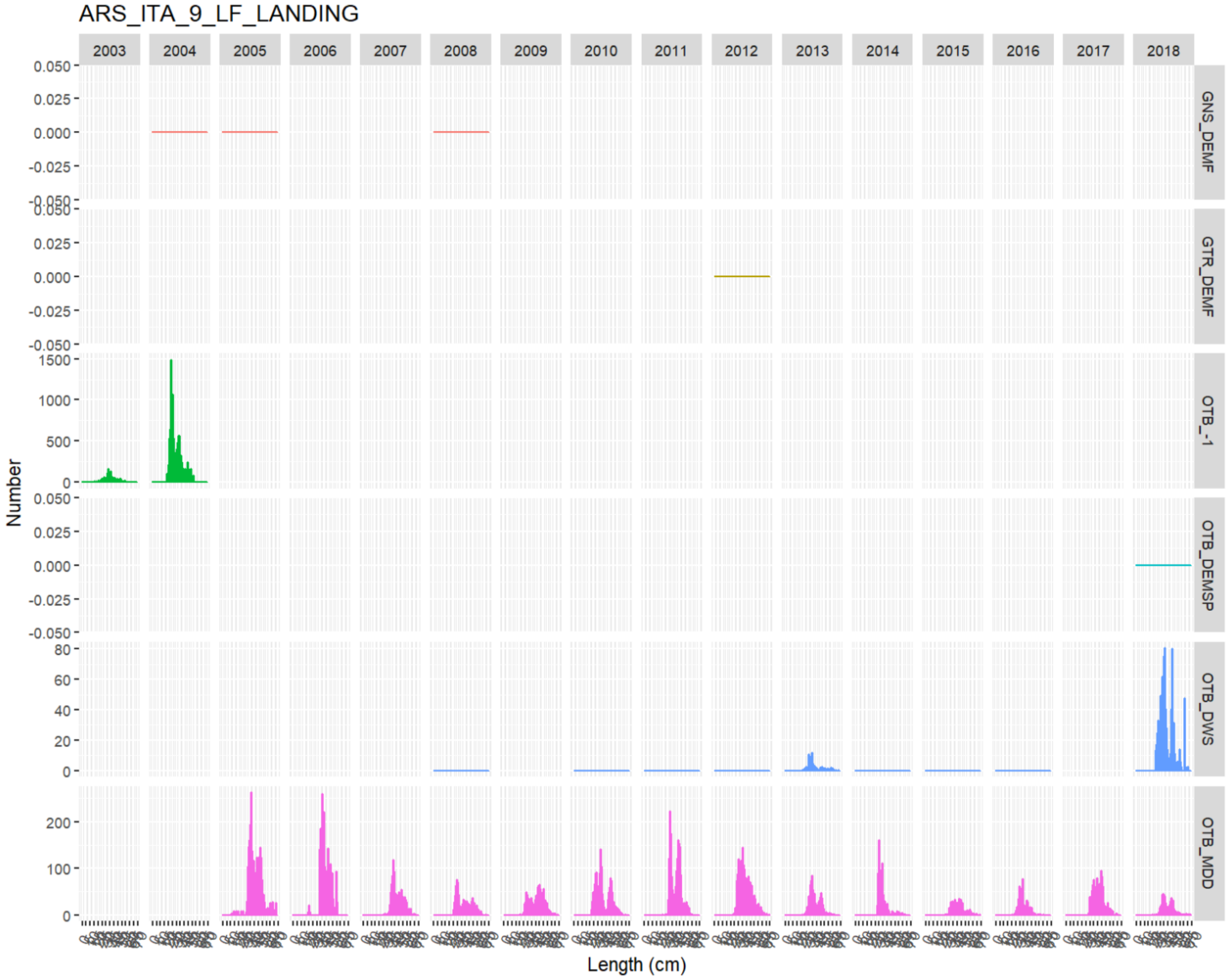


Figure 6.18.2.1.5. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 9.

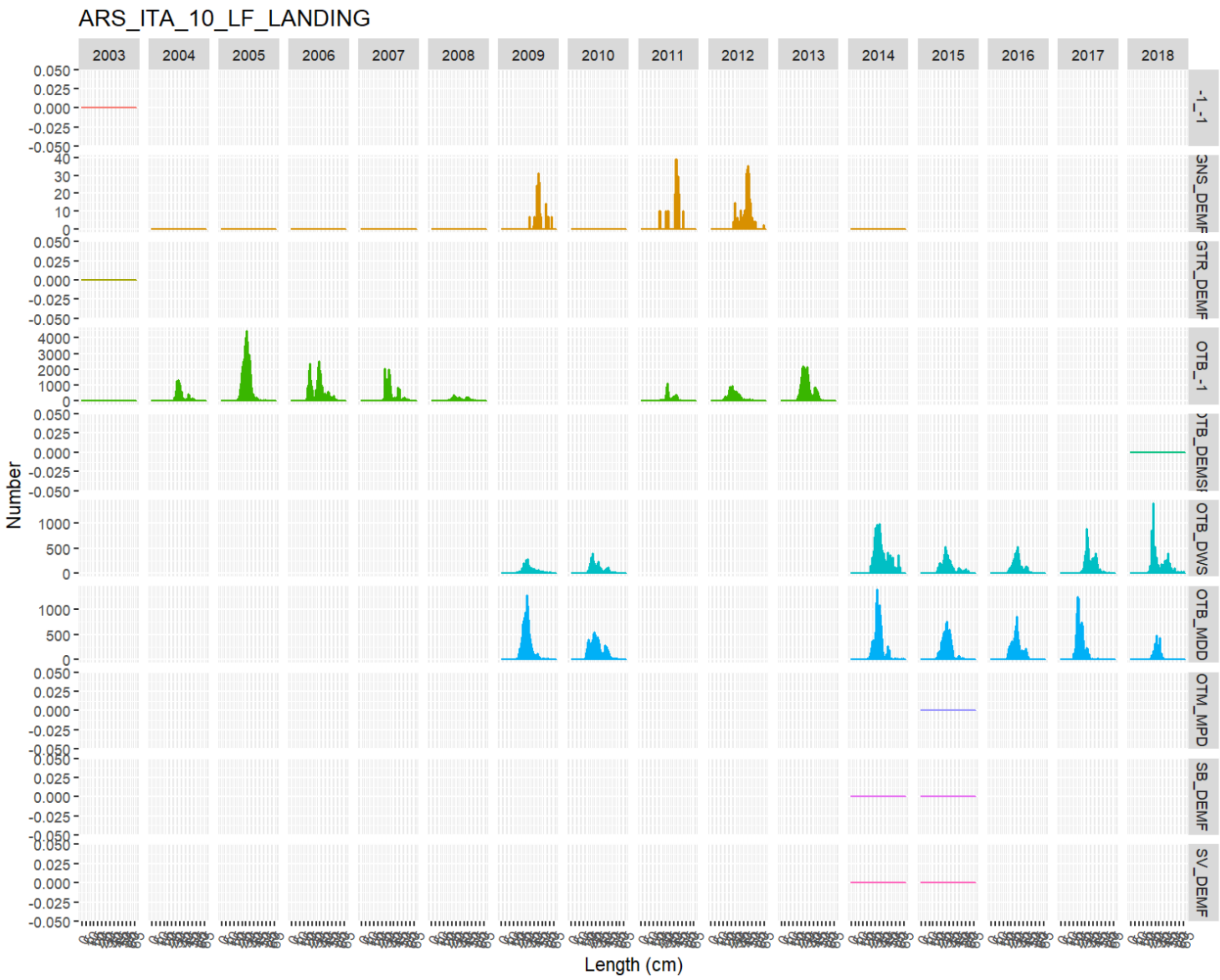


Figure 6.18.2.1.6. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 10.

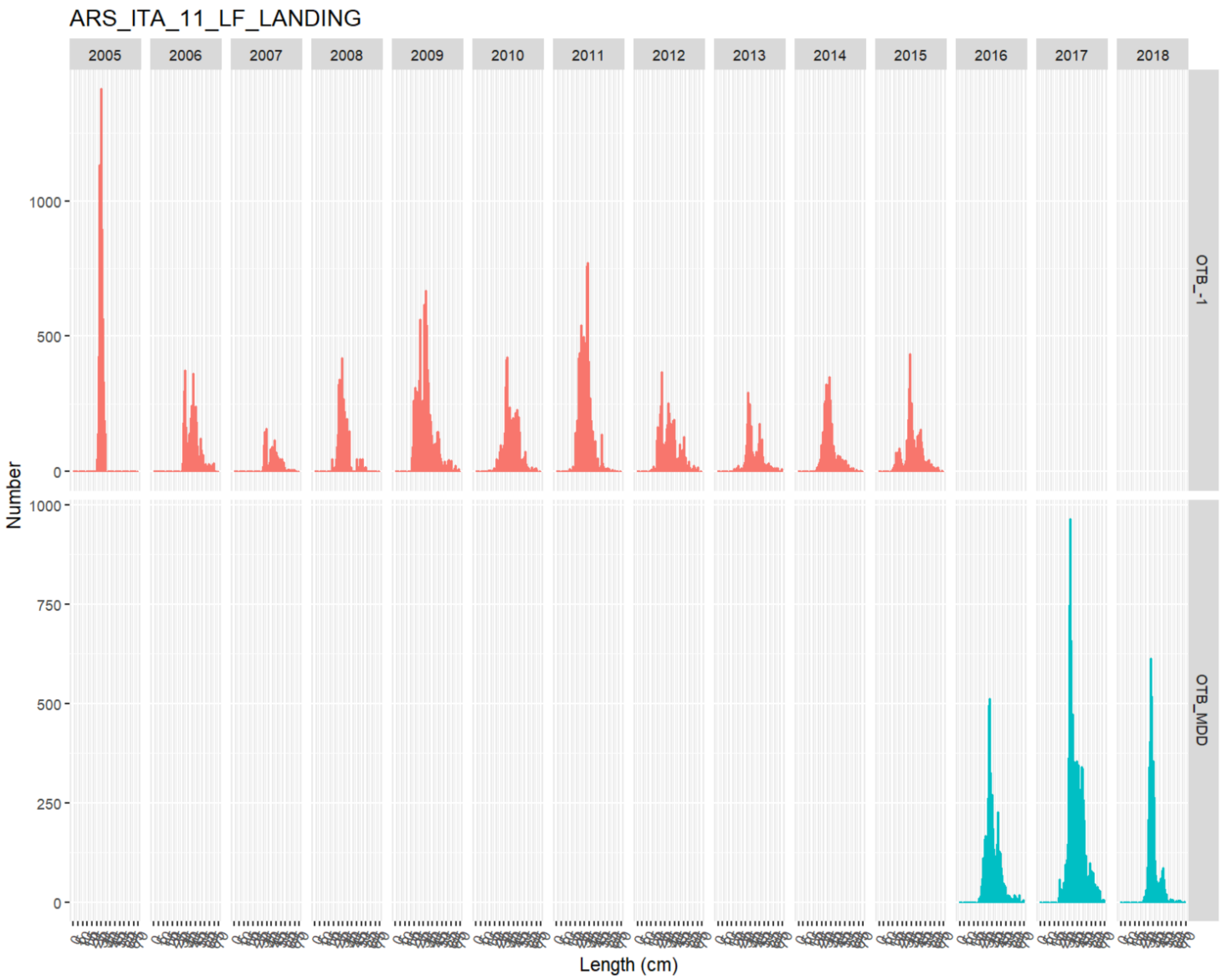


Figure 6.18.2.1.7. Giant red shrimp in GSAs 9, 10, 11: LFDs of landings by year and gear of giant red shrimp in GSA 11.

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 6.18.2.1.2. Despite the low values of discards, LFDs are available, and the data were included into the stock assessment. LFDs of discards of giant red shrimp are shown in Figures 6.18.2.1.8 and 6.18.2.1.9.

Table 6.18.2.1.2. 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

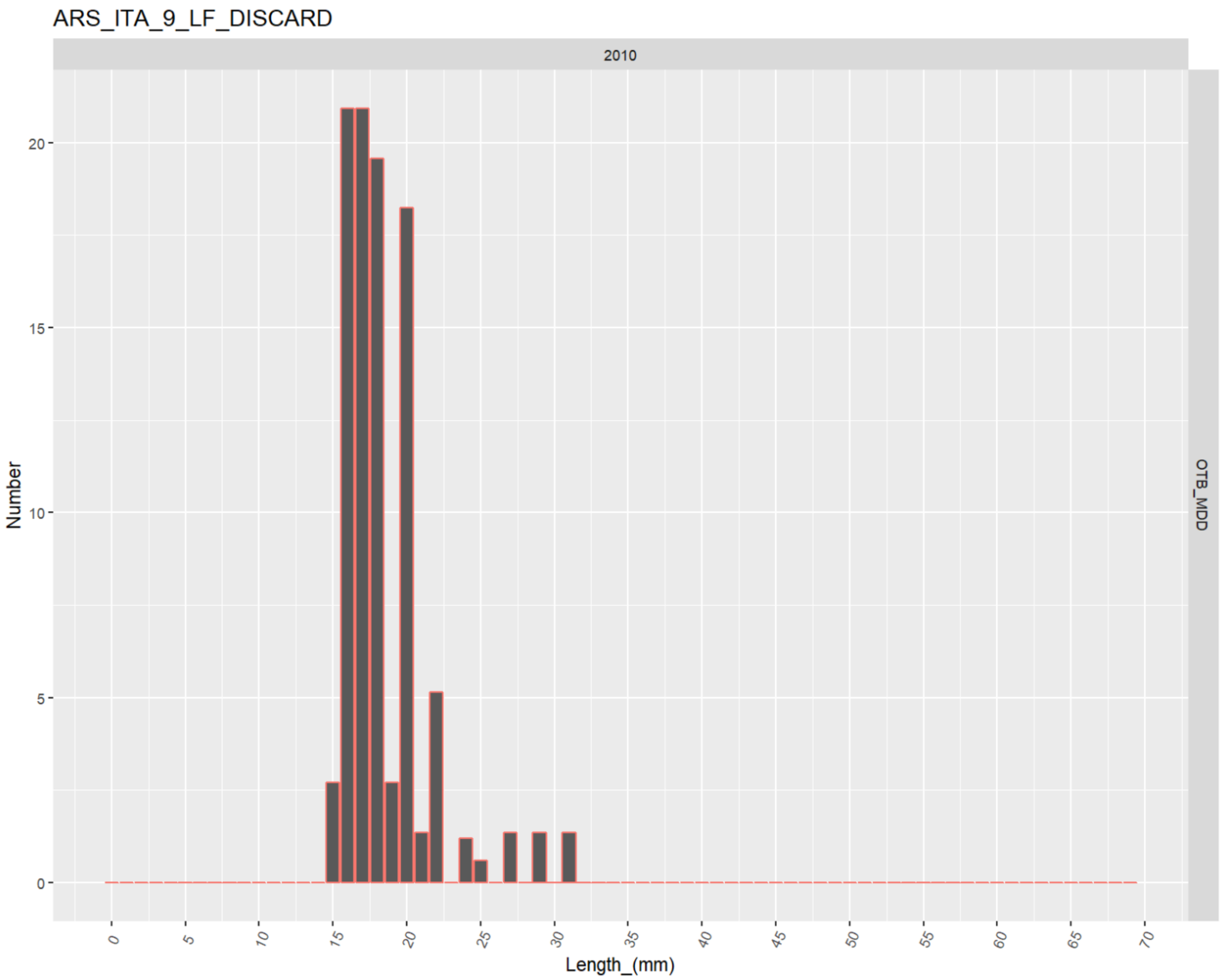


Figure 6.18.2.1.8. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 9.

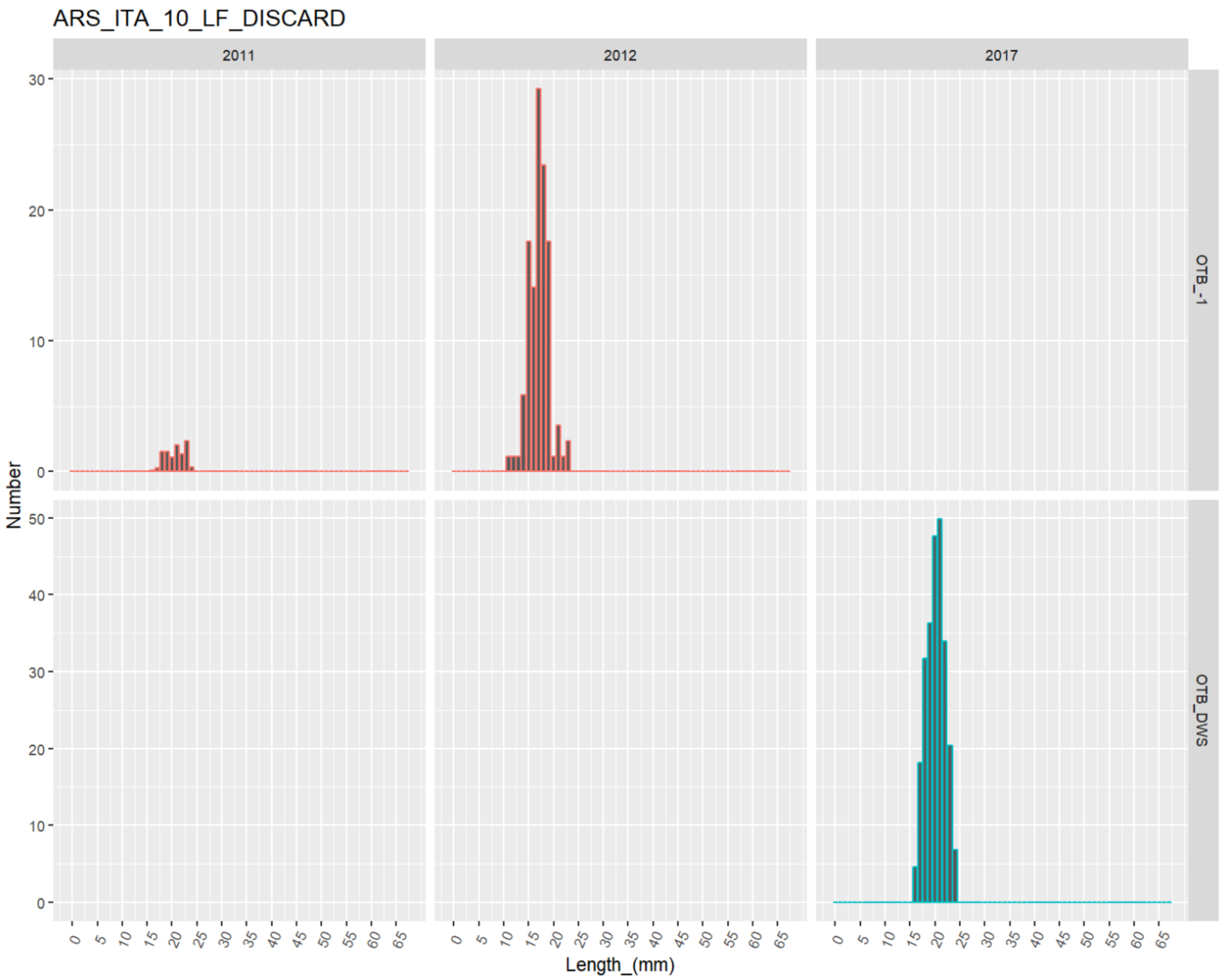


Figure 6.18.2.1.9. Giant red shrimp in GSAs 9, 10, 11: LFDs of discards of giant red shrimp in GSA 10.

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 6.18.2.2.1 and Figure 6.18.2.2.1). 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 6.18.2.2.1. 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

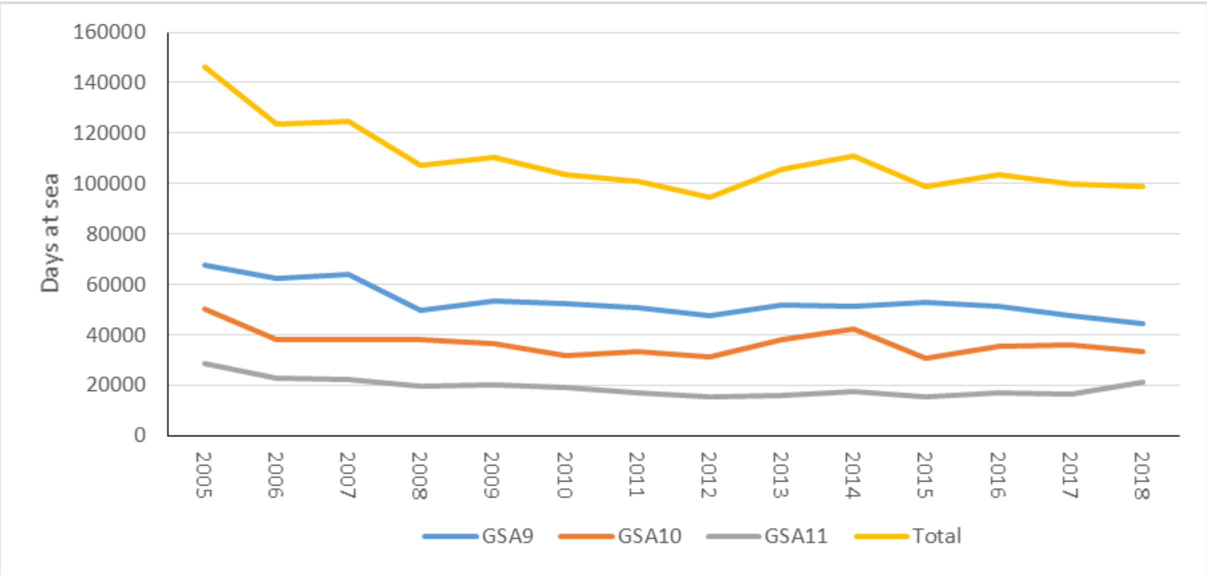


Figure 6.18.2.2.1. Giant red shrimp in GSAs 9, 10, 11: Trend of OTB effort (Days at sea) by GSA and total (GSAs 9, 10, 11).

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).

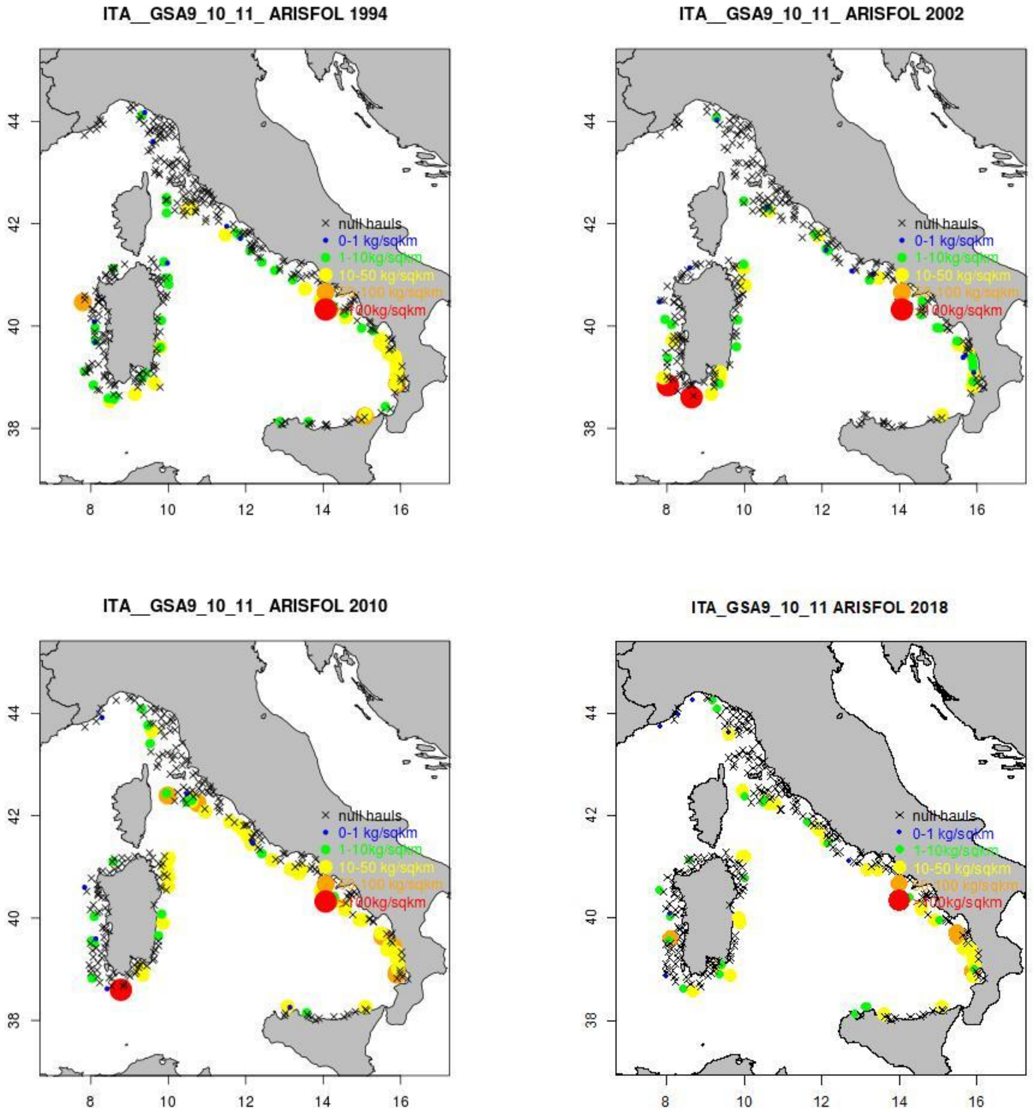


Figure 6.18.2.3.1 Giant red shrimp in GSAs 9, 10, 11: distribution pattern in the period 1994-2018 (MEDITS survey). Maps for the years 1994, 2002, 2010 and 2018 are shown.

Trends in abundance and biomass

The trends of the MEDITS indices (biomass and density) computed on the three GSAs combined are shown in Figure 6.18.2.3.2.

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.

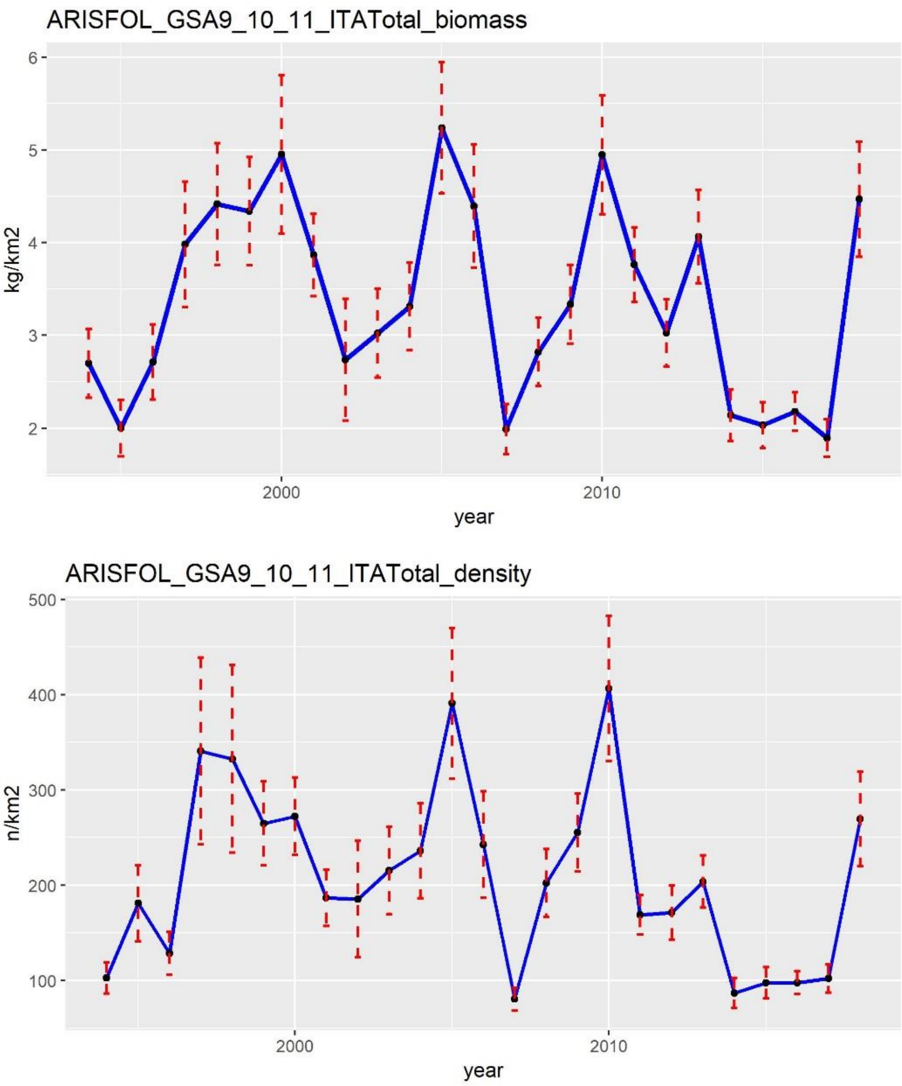


Figure 6.18.2.3.2. Giant red shrimp in GSAs 9, 10 and 11: MEDITS standardized biomass and density indices (10-800 m).

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 2018 are shown in Figures 6.18.2.3.3-6.18.2.3.5. 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.

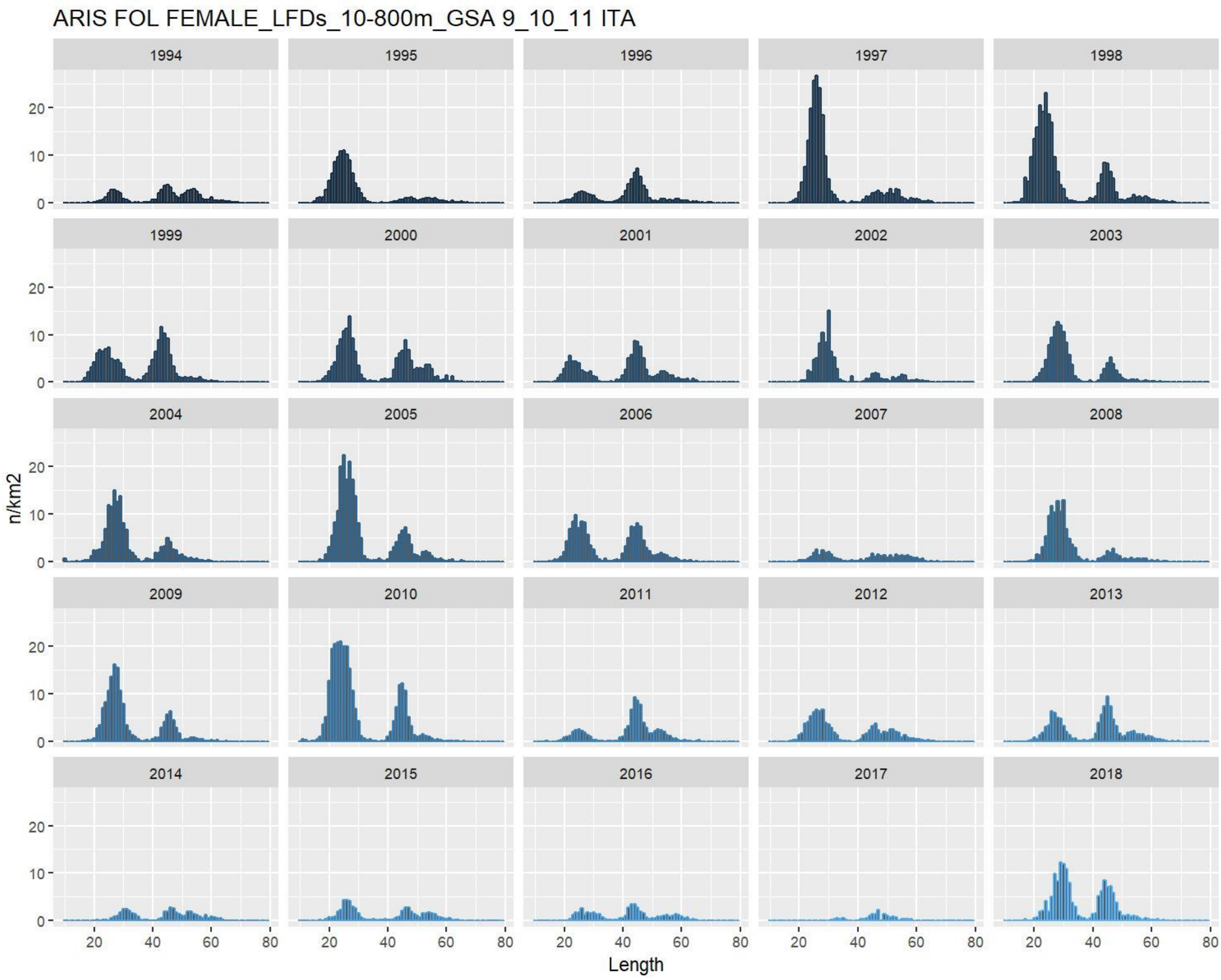


Figure 6.18.2.3.3. Giant red shrimp in GSAs 9, 10 and 11: stratified abundance indices by size for females, 1994-2018.

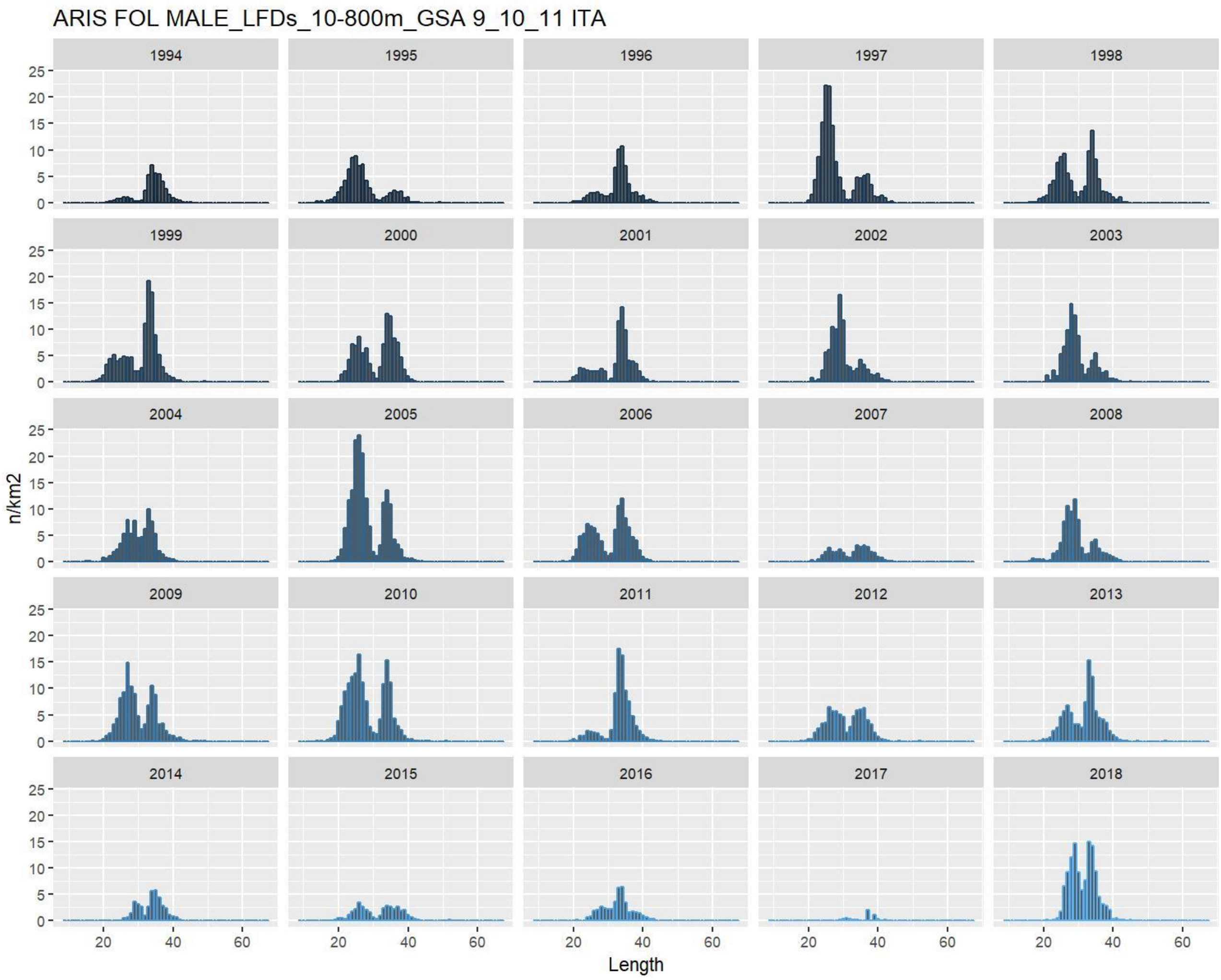


Figure 6.18.2.3.4. Giant red shrimp in GSAs 9, 10 and 11: stratified abundance indices by size for males, 1994-2018.

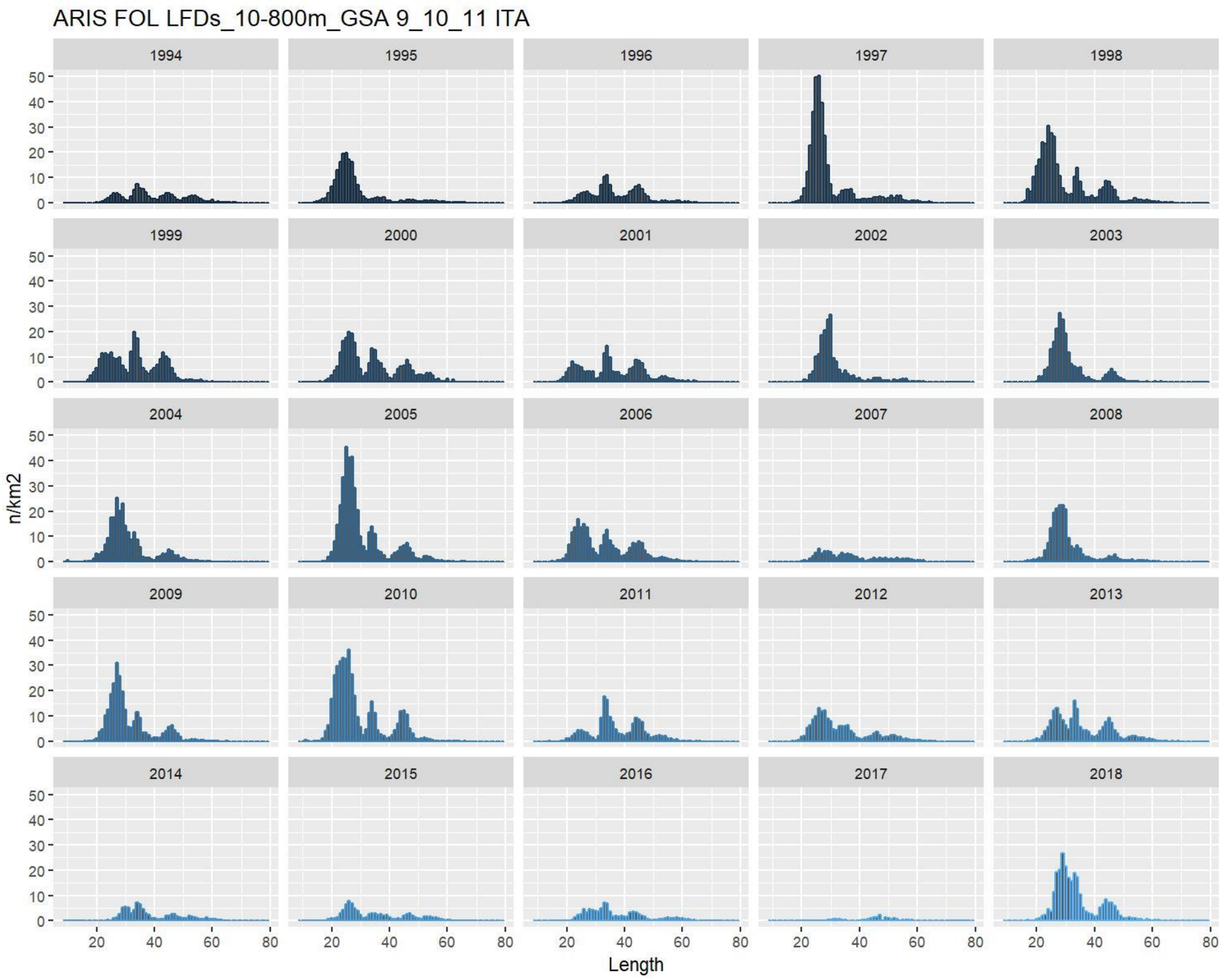


Figure 6.18.2.3.5 Giant red shrimp in GSAs 9, 10 and 11: total stratified abundance indices by size, 1994-2018.

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 2005-2018 for the catch data and 2005-2018 for the tuning file (MEDITS indices).

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 6.18.1.1. 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.

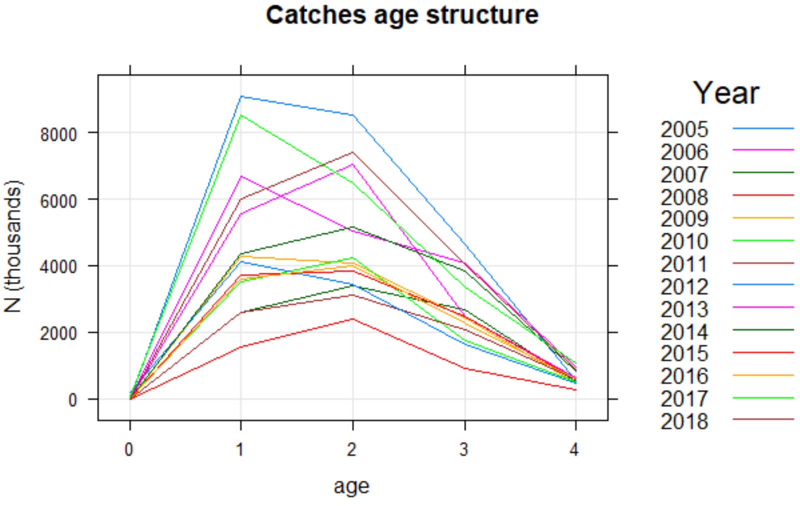


Figure 6.18.3.1. Giant red shrimp in GSAs 9, 10 and 11: catch-at-age distribution by year of the catches (2005-2018).

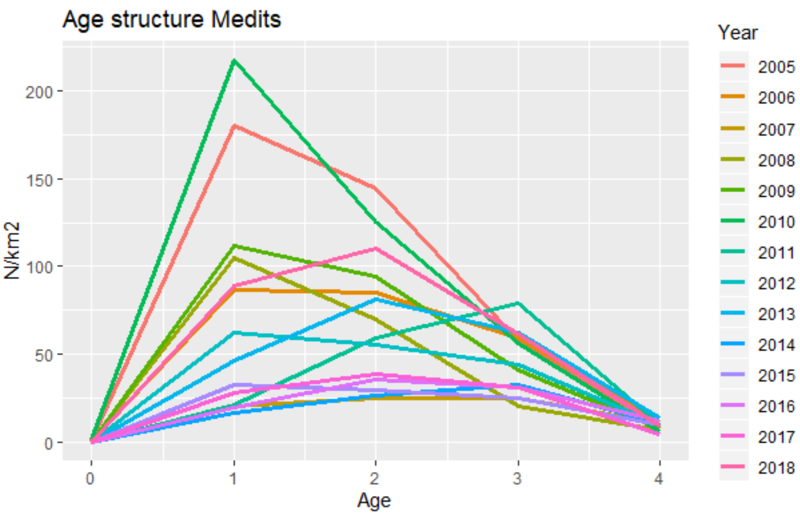


Figure 6.18.3.2. Giant red shrimp in GSAs 9, 10 and 11: catch-at-age distribution by year of the MEDITS survey (2005-2018).

Table 6.18.3.1. Giant red shrimp in GSAs 9, 10 and 11: catch-at-age matrix (thousands).

Age	2005	2006	2007	2008	2009	2010	2011
0	4.53	0.03	0.03	0.04	0.27	18.34	6.09
1	9079.80	6689.60	2603.10	1559.00	4280.50	3528.90	2587.40
2	8527.20	5031.50	3406.00	2382.50	4078.10	4252.00	3134.40
3	4629.70	4092.00	2673.00	936.83	2440.80	1770.40	2064.80
4+	573.75	957.48	532.24	279.59	493.57	510.04	588.62
Age	2012	2013	2014	2015	2016	2017	2018
0	193.90	3.86	0.03	15.95	1.14	93.87	0.27
1	4100.60	5568.90	4352.40	3729.40	3618.80	8510.50	6019.70
2	3443.80	7022.70	5170.60	3855.40	4015.30	6493.80	7411.10
3	1653.40	2471.10	3826.90	2469.00	2264.00	3366.80	4034.10
4+	472.97	627.57	852.77	595.47	578.90	1093.10	894.92

Table 6.18.3.2. Giant red shrimp in GSAs 9, 10 and 11: tuning data (MEDITS survey, n/km^2).

Age	2005	2006	2007	2008	2009	2010	2011
0	0.16	0.36	0.00	0.03	0.08	1.46	0.11
1	180.14	86.31	20.44	105.05	112.06	217.42	20.79
2	144.64	85.38	24.92	69.67	94.01	125.25	59.49
3	57.54	59.14	24.57	20.66	40.58	56.14	79.14
4+	8.39	11.39	10.62	6.86	7.75	6.07	9.59
Age	2012	2013	2014	2015	2016	2017	2018
0	0.02	0.04	0.00	0.08	0.00	0.00	0.08
1	62.43	46.48	16.62	32.86	19.85	28.26	88.59
2	55.50	81.54	26.74	29.71	35.61	38.44	110.50
3	43.59	62.43	32.86	24.86	30.73	31.36	61.57
4+	9.73	13.41	10.75	9.56	11.67	4.11	8.84

Table 6.18.3.3. Catch (tons; discards are included, though negligible).

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
637.7	580.3	378.9	192.6	363.4	343.8	304.1	294.8	485.8	532.0	374.1	342.5	608.8	640.9

Table 6.18.3.4. Weight-at-age matrix (kg).

Age	2005	2006	2007	2008	2009	2010	2011
0	0.003	0.000	0.000	0.000	0.004	0.004	0.003
1	0.022	0.018	0.026	0.019	0.020	0.018	0.022
2	0.027	0.043	0.042	0.037	0.034	0.039	0.042
3	0.037	0.045	0.047	0.057	0.042	0.045	0.039
4+	0.076	0.063	0.081	0.071	0.074	0.068	0.060
Age	2012	2013	2014	2015	2016	2017	2018
0	0.004	0.004	0.000	0.004	0.004	0.004	0.002
1	0.016	0.019	0.024	0.021	0.022	0.016	0.023
2	0.033	0.035	0.037	0.036	0.036	0.039	0.036
3	0.049	0.038	0.043	0.046	0.036	0.043	0.041
4+	0.071	0.066	0.079	0.074	0.066	0.071	0.075

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)

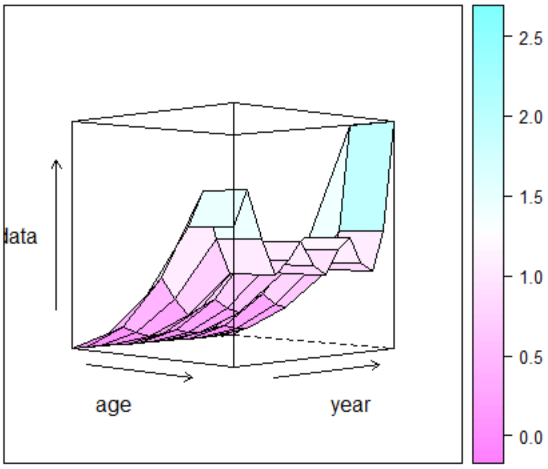


Figure 6.18.3.3. Giant red shrimp in GSAs 9, 10 and 11: fishing mortality by age and year obtained from the a4a model (2005-2018).

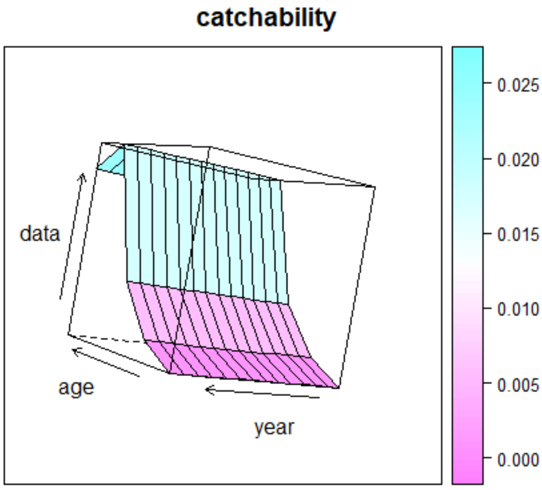


Figure 6.18.3.4. Giant red shrimp in GSAs 9, 10 and 11: catchability of the survey by age and year obtained from the a4a model.

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 6.18.3.5 and 6.18.3.6). The fitting of the survey shows some problems (Figures 6.18.3.9), 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.

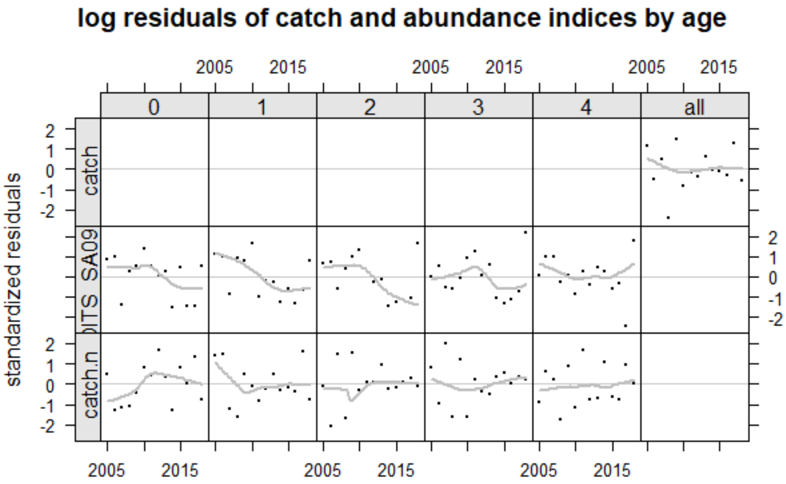


Figure 6.18.3.5. Giant red shrimp in GSAs 9, 10 and 11: log residuals for the catch-at-age data of the fishery and the survey, and the catches.

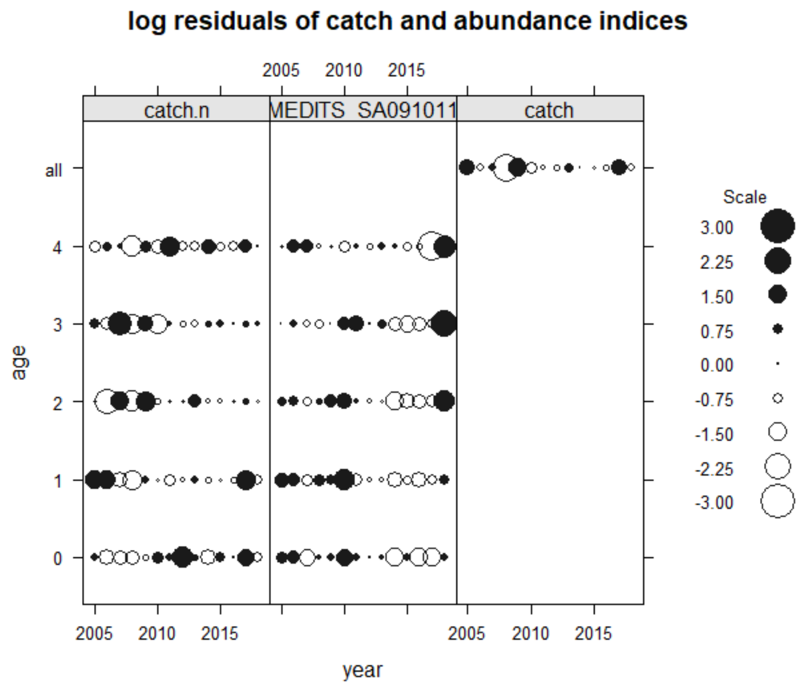


Figure 6.18.3.6. Giant red shrimp in GSAs 9, 10 and 11: bubble plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

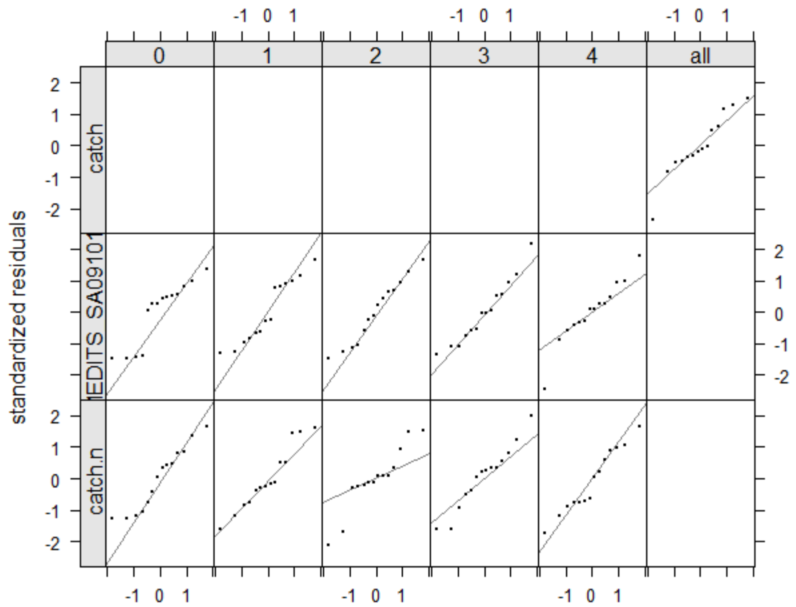


Figure 6.18.3.7. Giant red shrimp in GSAs 9, 10 and 11: QQ-plot of the log residuals for the catch-at-age data of the fishery and the survey, and the catches.

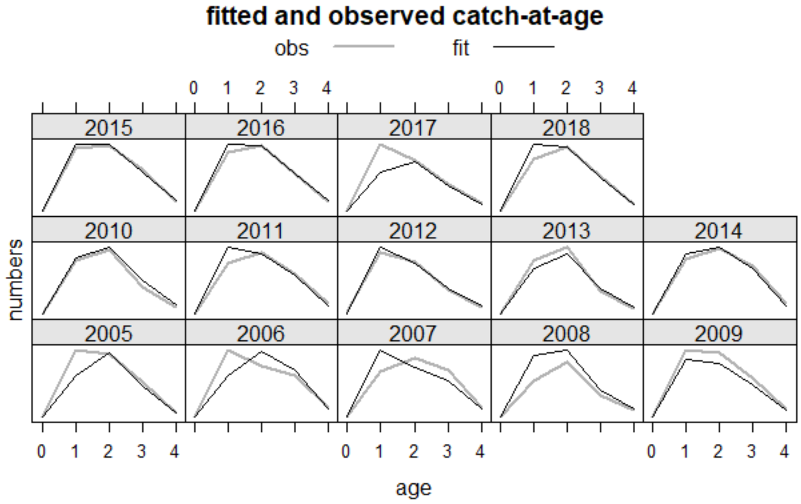


Figure 6.18.3.8. Giant red shrimp in GSAs 9, 10 and 11: fitted vs observed values by age and year for the catches.

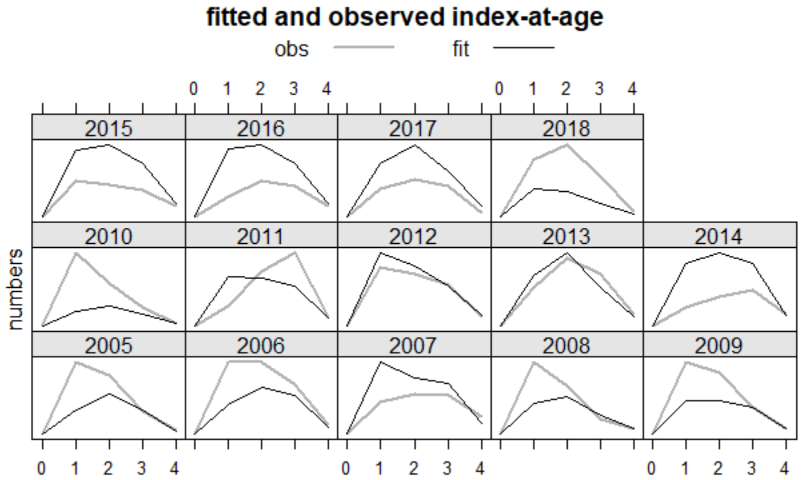


Figure 6.18.3.9. Giant red shrimp in GSAs 9, 10 and 11: fitted vs observed values by age and year for the survey.

The internal consistency of both the catches and the survey indices is acceptable.

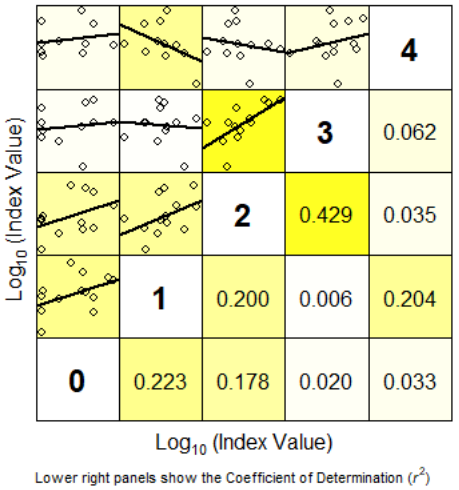


Figure 6.18.3.10. Giant red shrimp in GSAs 9, 10 and 11: internal consistency of the catch-at-age data.

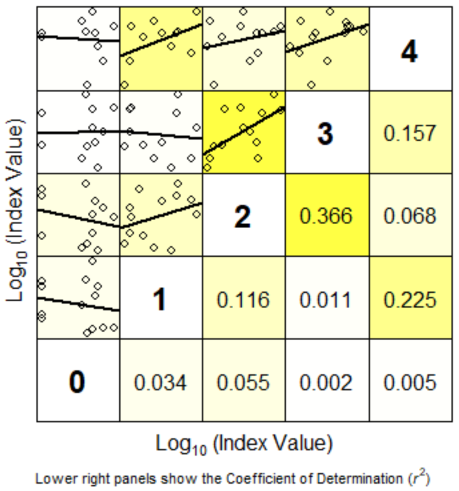


Figure 6.18.3.11. Giant red shrimp in GSAs 9, 10 and 11: internal consistency of the catch-at-age data of the MEDITS survey.

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 5% 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 possitive residuals in survey data in last 4 years. The instability does not affect the conclusion $F>F_{MSY}$ with F_{MSY} = 0.45 (Section 6.19.4)

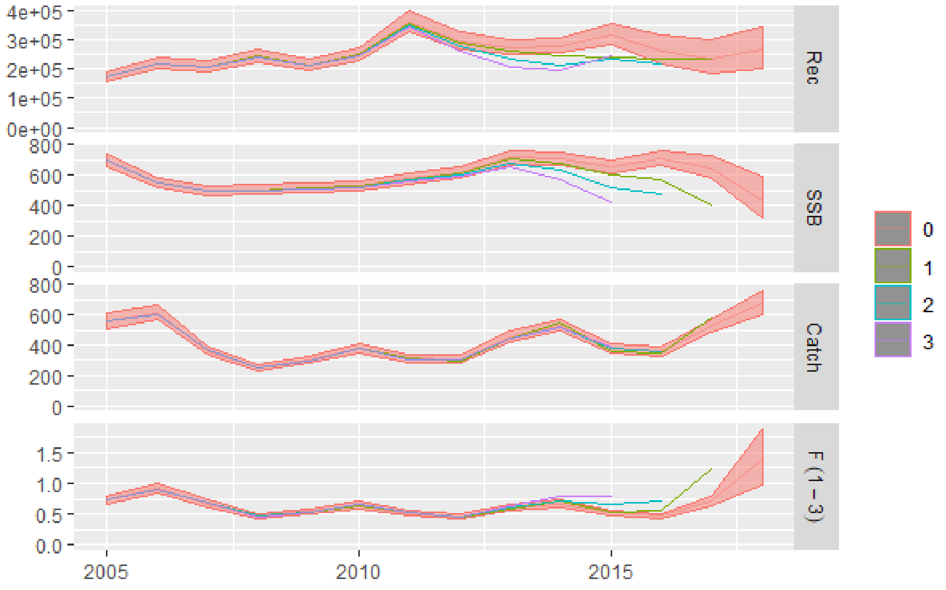


Figure 6.18.3.12. Giant red shrimp in GSAs 9, 10 and 11: retrospective analysis.

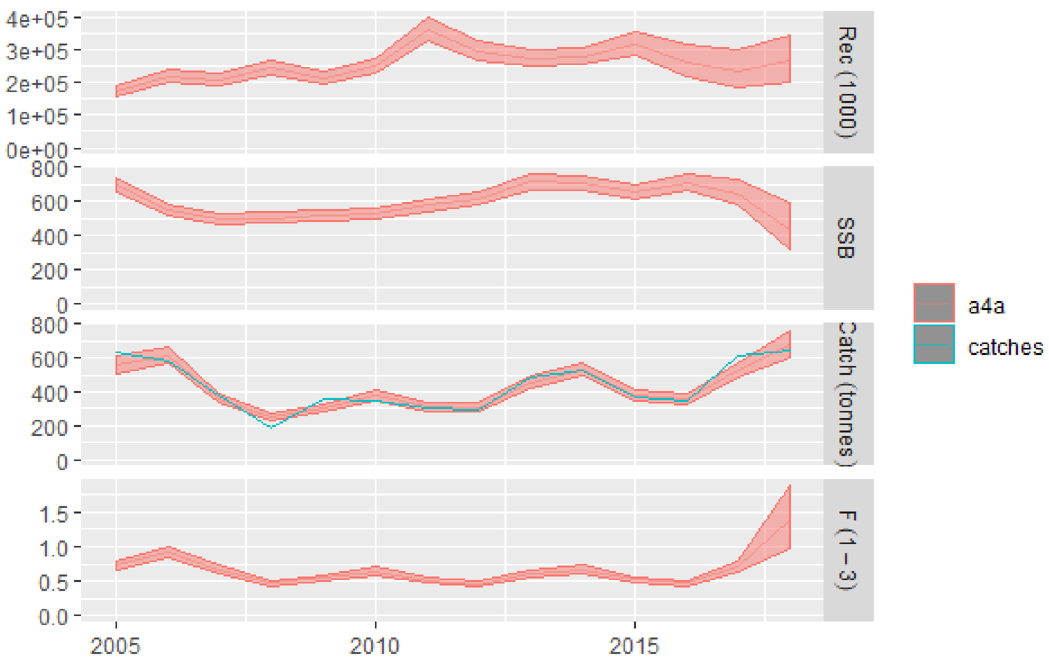


Figure 6.18.3.13. Giant red shrimp in GSAs 9, 10 and 11: outputs of the a4a stock assessment model, with uncertainty; input catch data (blue line) are plotted against the estimated catches.

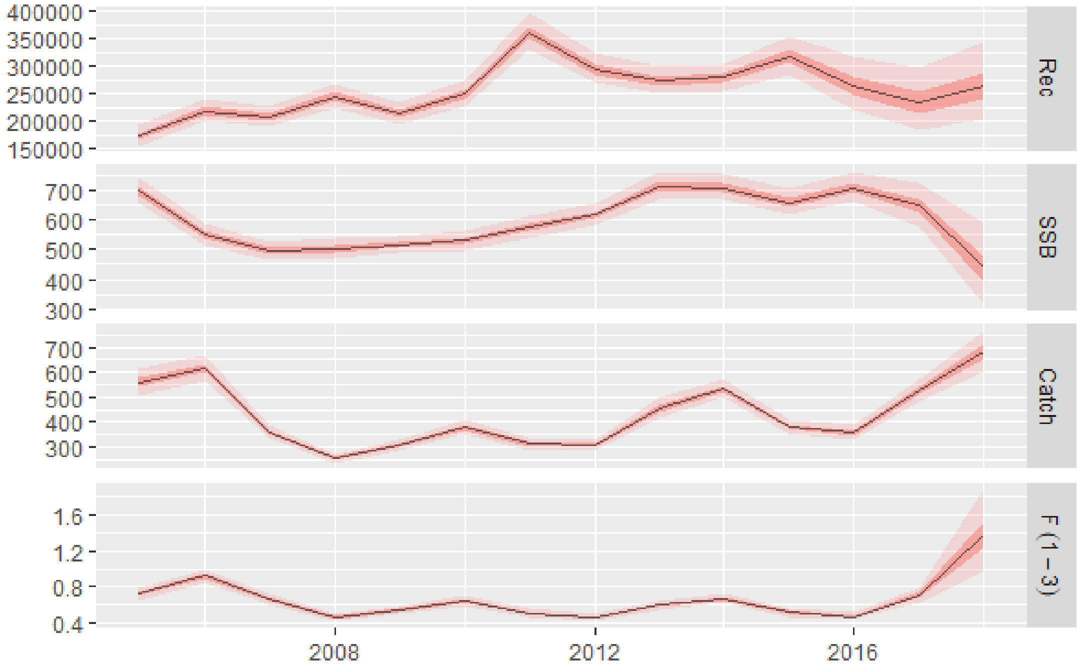


Figure 6.18.3.14. Giant red shrimp in GSAs 9, 10 and 11: outputs of the a4a stock assessment model (with uncertainty).

Table 6.18.3.5. Giant red shrimp in GSAs 9, 10 and 11: Stock numbers-at-age (thousands).

Age	2005	2006	2007	2008	2009	2010	2011
0	172512.0	218771.0	208398.4	245650.6	214308.8	249321.2	361483.1
1	44654.7	25926.7	33216.8	31642.1	37298.3	32242.8	37468.6
2	23923.1	15245.8	8401.6	11522.2	11632.5	13416.0	11287.1
3	6915.5	6793.2	3586.0	2485.7	4070.1	3843.2	4048.6
4+	1078.6	1256.7	878.7	780.6	821.9	1068.2	896.1
Age	2012	2013	2014	2015	2016	2017	2018
0	295226.8	273183.8	279055.3	318607.2	264308.5	234439.2	264214.8
1	54326.6	44366.7	41057.2	42370.1	47881.8	39741.4	35231.5
2	13588.7	20075.3	15717.1	14227.2	15359.1	17559.2	13674.2
3	3807.9	4847.8	6328.5	4640.2	4801.0	5385.2	4986.9
4+	1147.7	1272.1	1218.4	1307.5	1365.1	1539.7	1116.8

Table 6.18.3.6. Giant red shrimp in GSAs 9, 10 and 11: Fishing mortality-at-age.

Age	2005	2006	2007	2008	2009	2010	2011
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.21	0.26	0.19	0.13	0.16	0.18	0.15
2	0.64	0.81	0.58	0.41	0.48	0.57	0.45
3	1.33	1.69	1.22	0.86	1.00	1.18	0.94
4+	1.33	1.69	1.22	0.86	1.00	1.18	0.94
Age	2012	2013	2014	2015	2016	2017	2018
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.13	0.17	0.19	0.15	0.14	0.20	0.39
2	0.40	0.52	0.59	0.46	0.42	0.62	1.20
3	0.84	1.10	1.23	0.95	0.87	1.31	2.51
4+	0.84	1.10	1.23	0.95	0.87	1.31	2.51

Table 6.18.3.7. 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	172512	186006	159018	697.9	731.6	664.2	557.0	0.72	0.79	0.65
2006	218771	234817	202725	551.0	579.8	522.2	615.3	0.92	0.98	0.84
2007	208398	222835	193961	496.2	520.7	471.7	358.9	0.67	0.74	0.60
2008	245651	262871	228431	503.3	529.2	477.4	252.9	0.47	0.53	0.41
2009	214309	230971	197647	516.4	541.4	491.4	306.4	0.54	0.59	0.49
2010	249321	267297	231345	530.5	557.5	503.5	378.1	0.64	0.69	0.59
2011	361483	388065	334901	577.4	605.7	549.1	311.0	0.51	0.56	0.46
2012	295227	317620	272834	617.5	646.8	588.2	307.6	0.46	0.52	0.40
2013	273184	292460	253908	714.7	750.5	678.9	453.0	0.60	0.67	0.53
2014	279055	299319	258791	708.3	742.3	674.3	532.2	0.67	0.72	0.61
2015	318607	343158	294056	658.9	691.5	626.3	378.9	0.52	0.57	0.47
2016	264308	300702	227914	709.0	748.1	669.9	355.5	0.47	0.53	0.41
2017	234439	278590	190288	648.8	705.1	592.5	525.2	0.71	0.97	0.45
2018	264215	318090	210340	435.9	539.5	332.3	681.8	1.37	1.71	1.02

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 (1.37), estimated as the F_{bar1-3} in the last year of the time series, 2018) is higher than $F_{0.1}$ (0.45), 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 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 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 6.18.5.1 Giant red shrimp in GSAs 9, 10, 11: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2016-2018
$F_{ages\ 1-3}$ (2019)	1.37	F current in the last year
SSB (2019; middle of the year)	343.6 t	Stock assessment 1 January 2019
R_0 (2019, 2020, 2021)	252911.7 thousands	Geometric mean of the whole time series (2005-2018)
Total catch (2019)	467.7 t	Assuming F status quo for 2019

Table 6.18.5.1 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 2018	Catch 2019	Catch 2020	Catch 2021	SSB 2020	SSB 2021	Change SSB 2019-2021 (%)	Change Catch 2018-2020 (%)
High long term yield ($F_{0.1}$)	0.3	0.45	681.8	467.7	199.3	279.4	474.5	596.6	73.6	-70.8
F_{upper}	0.5	0.62	681.8	467.7	257.6	332.5	447.4	530.0	54.3	-62.2
F_{lower}	0.2	0.30	681.8	467.7	140.2	214.0	501.1	670.3	95.1	-79.4
Zero catch	0.0	0.00	681.8	467.7	0.0	0.0	560.8	872.2	153.9	-100.0
Status quo	1.0	1.37	681.8	467.7	458.3	452.7	347.6	341.5	-0.6	-32.8
Different Scenarios	0.1	0.14	681.8	467.7	67.8	115.0	532.5	769.6	124.0	-90.1
	0.2	0.27	681.8	467.7	128.7	199.8	506.2	685.3	99.4	-81.1
	0.3	0.41	681.8	467.7	183.8	263.5	481.6	615.2	79.1	-73.0
	0.4	0.55	681.8	467.7	233.9	312.1	458.5	556.4	61.9	-65.7
	0.5	0.68	681.8	467.7	279.5	349.9	437.0	506.4	47.4	-59.0
	0.6	0.82	681.8	467.7	321.3	379.8	416.8	463.7	34.9	-52.9
	0.7	0.96	681.8	467.7	359.7	403.7	397.9	426.7	24.2	-47.2
	0.8	1.09	681.8	467.7	395.1	423.2	380.1	394.6	14.8	-42.0
	0.9	1.23	681.8	467.7	427.9	439.3	363.3	366.4	6.6	-37.2
	1.1	1.50	681.8	467.7	486.7	464.0	332.8	319.3	-7.1	-28.6
	1.2	1.64	681.8	467.7	513.1	473.7	318.9	299.6	-12.8	-24.7
	1.3	1.78	681.8	467.7	537.9	482.0	305.7	281.8	-18.0	-21.1
	1.4	1.91	681.8	467.7	561.1	489.2	293.3	265.9	-22.6	-17.7
	1.5	2.05	681.8	467.7	582.9	495.6	281.5	251.4	-26.8	-14.5
	1.6	2.19	681.8	467.7	603.4	501.1	270.4	238.2	-30.7	-11.5
	1.7	2.33	681.8	467.7	622.8	506.1	259.9	226.3	-34.1	-8.7
	1.8	2.46	681.8	467.7	641.2	510.6	249.9	215.3	-37.3	-6.0
	1.9	2.60	681.8	467.7	658.5	514.7	240.5	205.3	-40.3	-3.4
	2.0	2.74	681.8	467.7	675.0	518.3	231.6	196.0	-42.9	-1.0

6.19.5 DATA DEFICIENCIES

At STECF 18-12, no sex ratio (and maturity vector) at length was available for GSA 11, thus the vectors available for GSA 10 were used to split the LFDs of GSA 11 in LFDs by sex. This information was made available to STECF 19-10, then used to prepare the stock object.

In terms of coverage, information on landings for quarter III in 2017 and quarter I in 2018 for GSA 10 was missing. The information was requested to the Italian National Correspondent and made available to the EWG in due time.

In GSA 11, landings data for OTB_DWS were missing from 2015 to 2018. Landings data were recovered from the FDI data. This required the assessment to be re-run after the EWG.

As concerns MEDITS survey data, missing values in "pfrac" and "pechan" (TC) of hauls 29 and 67 of GSA10 in 2017 were pointed out. The correct values were recovered from TB: 2877 g and 2342 g in haul 29 and 67, respectively.

The impact on the assessment was then low.

7 Data Quality

ToR 8. *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 9. *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 European hake in GSA 1, 5, 6 & 7

The same data deficiencies encountered in EWG 18-12 were found in last year (2018) data and within the whole time series.

France 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 reflects itself in TB data too.

Spain 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 reflects itself in TB data too.

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

Data from DCF 2018 as submitted through the Official data call in 2019 were used.

In GSA 1, no length frequency distributions of landing were available for 2002 and for all years of OTB-MDDWSP.

In GSA 5, no length frequency distributions of landing were available for 2016 and for 2009 of OTB-MDDWSP.

In GSA 6, no length frequency distributions were available for all years of OTB-MDDWSP. The length frequency distribution in 2015 had an extremely high number of individuals in the length class 33.

In GSA 7, only the length frequency distributions of landing for Spanish OTB were available. They cover the period 2009-2018. No length frequency distributions of landing were available for OTB-MDDWSP.

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

Issues with the MEDITS data in GSA 1 were pointed out. The TC in 2013 contains two hauls (16 and 38) with wrong values in “pfrac”. The correct values (854 and 261 g, respectively) were recovered from “pechan”. The number of individuals were also corrected in TB, gathering them from TC.

In the MEDITS data of GSAs 1, 6 and 7 there are animals of lengths higher than 50 mm carapax length, which were considered wrong.

The MEDITS length frequency distributions in GSA 5 for 2001 should be checked thoroughly because are considered to be wrong.

7.3 Red mullet in GSA 1

EWG 19-10 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 EWG18-12 also summarized and concisely described catch and effort data deficiencies, in terms of coverage and quality.

7.4 Red mullet in GSA 6

A change in the coding of the métiers was observed in 2010 and 2018.

MEDITS length frequencies distributions should be checked for sizes 50 to 100 (probably change of unit).

7.5 Red mullet in GSA 7

The analysis of MEDITS data, showed a problem in the size distribution of Nep in 2013 with two anomalous peak. A deeper check of row data showed wrong nbtot reported number (350) for the haul coded 150

7.6 Norway lobster 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.

7.7 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. LFDs in 2018 are reported with a 2 cm step. No discard data are available for 2018. Very low discard values in 2017, compared to the previous year’s time series.

MEDITS data provided for hake in GSA11 present some issues in the TC file, maybe due to incorrect raising procedures. In 2006, for example, haul 71 presents a raising factor of 885 only for size 395; in 2008, haul 30 presents a raising factor of 391 for lengths 280, 300, 310 and 420. This results in biased LFD patterns.

7.8 DEEP-WATER ROSE SHRIMP IN GSA 9, 10 AND 11

Data from DCR-DCF database as submitted through the Official data call in 2019 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: 2003-2018 for GSA09, 2002-2018 for GSA10 and 2009-2018 for GSA11.

The length frequency distributions of the landing for GSA09 are available for the period 2003-2018 (year 2002 is missing). For GSA10, data are not available for 2003. The historical data series for GSA11 includes the period 2009-2018 (the years 2002-2008 are missing). In GSA10, length frequency distributions and relative landings are missing for the third quarter of 2017 and for the first quarter of 2018. 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. Concerning the lack of quarters in GSA10 in the last two years, a sop correction was necessary.

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 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.

7.9 RED MULLET IN GSA 9

The EWG19-10 did not find any particular data deficiency for this stock, in terms of data quality.

7.10 RED MULLET IN GSA 10

EWG19-10 has noted that landing and discard data of the 3rd quarter of 2017 were missing for all gears and fisheries, as well as the landing and discard of the first quarter 2018. The missing landing data were requested to the Member State and received in the due time to carry out the assessment. Being available the landing data of the third quarter in 2017, the discard of the third quarter was estimated.

Despite these deficiencies, addressed on time for the analyses, an uncommon length structure (between 15 and 20 cm) associated to the discard of the GTR with vessel length VL0006 in 2018 was noticed in quarter 4. 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.

The EWG19-10 reported on line via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt.

7.11 NORWAY LOBSTER IN GSA 9

Landings in 2017 were considered unreliable, as very high. Despite official data were not revised, the experts informed that a new estimation of landings was produced, and was provided to STECF 19-10.

The impact on the assessment was then low.

7.12 NORWAY LOBSTER IN GSA 11

Growth parameters previous to 2015 were available only for males, as well as length weight relationship coefficients. However, growth parameters for both sexes have been submitted since 2016.

7.13 BLUE AND RED SHRIMP IN GSA 1

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.

7.14 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.

The assessment of blue and red shrimp in GSAs 6 & 7 showed some discrepancies related to the method of slicing LFD data. The STECF EWG suggest that in future the possible methods of slicing LFD data (of fishes and invertebrates), as well as growth information they are using, are thoroughly reviewed, checked and tested, taking into consideration the seasonality of growth, reproduction and moulting processes, in order to define and ably the best practice in cohort slicing for stock assessment.

7.15 BLUE AND RED SHRIMP IN GSA 9, 10 AND 11

GSA_10 in year 2018 abundance per length classes is reported by 2mm step while in the Data Call Annex 2 was requested by 1mm step.

7.16 GIANT RED SHRIMP IN GSA 9, 10 AND 11

At STECF 18-12, no sex ratio (and maturity vector) at length was available for GSA 11, thus the vectors available for GSA 10 were used to split the LFDs of GSA 11 in LFDs by sex. This information was made available to STECF 19-10, then used to prepare the stock object.

In terms of coverage, information on landings for quarter III in 2017 and quarter I in 2018 for GSA 10 was missing. The information was requested to the Italian National Correspondent and made available to the EWG in due time.

In GSA 11, landings data for OTB_DWS were missing from 2015 to 2018. Landings data were recovered from the FDI data. This required the assessment to be re-run after the EWG.

As concerns MEDITS survey data, missing values in "pfrac" and "pechan" (TC) of hauls 29 and 67 of GSA10 in 2017 were pointed out. The correct values were recovered from TB: 2877 g and 2342 g in haul 29 and 67, respectively.

The impact on the assessment was then low.

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10 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/ewg1910

List of electronic annexes documents:

EWG-19-10 – Annex 1 – Quality checks MEDBS datacall.docx

EWG-19-10 – Annex 2 – Effort tables.pdf

11 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
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List of background documents:

EWG-19-10 – Declarations of invited and JRC experts (see also section 8 of this report – List of participants)

EWG-19-10 – ToRs_STECF_EWG1910.pdf

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