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Scientific, Technical and Economic Committee for Fisheries (STECF) - Stock Assessments: demersal stocks in Adriatic, Ionian and Aegean Seas and straits of Sicily (STECF-22-16)

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ABSTRACT

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report documents the outcomes of STECF Expert Working Group 22-16: 2022 stock assessments of demersal stocks in the Adtiatic, Ionian and Aegean Seas from the meeting held in Rome from 17th to 23th October 2022. A total of 16 fish stocks were considered and 15 were fully evaluated. The EWG reports age based assessments, target Fs, with short term forecasts for 9 stocks of the remaining 6 stocks, four of these do not have short term forecasts as he assessments are not suitable, and one is given ICES category 3 advice. The content of the report gives the STECF terms of reference; the basis of the evaluations; assessments, summaries of state of stock and advised catch or F based on either the MSY approach for assessed stocks and category 3 based advice for those without assessments. The report contains the full stock assessment reports for the 14 assessments, the exploration of assessments and category 3 evaluations for the remaining stock. The report also contains the STECF observations and conclusions on the assessment report. These conclusions come from the STECF Plenary meeting November 2022.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - STOCK ASSESSMENTS: DEMERSAL STOCKS IN ADRIATIC, IONIAN AND AEGEAN SEAS AND STRAITS OF SICILY (STECF-22-16)

REQUEST TO THE STECF

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

STECF COMMENTS.

EWG 22-16 met in Rome, from 17th to 23rd October 2022. The meeting was attended by 19 experts in total with two attending virtually. This included one STECF member and one JRC expert. Two observers also attended the meeting remotely for part of the meeting. The objective of EWG 22-16 was to carry out demersal stock assessments and provide short-term forecast advice for stocks in the Adriatic, Ionian and Aegean Seas as defined in the EWG ToRs.

STECF acknowledges that the EWG has addressed adequately all ToRs except for one low priority stock (Red mullet in GSA 20) for which time and resource constraints meant the assessment was not completed.

STECF notes that the EWG has carefully reviewed the quality of the assessments produced. From the overall stock list of 16 stocks, a total of 15 area/species combinations were evaluated this year (Table.1). For one of these (Red mullet in GSA 17-18), an assessment model could not be found to provide acceptable results and a biomass index-based advice is given. The EWG carried out short term forecasts for ten of the accepted analytical assessments. The remaining five assessed stocks were new assessments, and they were deemed inherently unsuitable for catch advice (i.e., CMSY for Striped venus clam) or insufficiently stable in the last years to give target catch advice.

STECF notes that the assessments completed for four area/species combinations for the Adriatic stocks (GSA 17-18) by EWG 22-16 can be used to provide advice on stock status in terms of F relative to F_{MSY} and whether these stocks are behind/ahead of transition to MSY in 2026. This applies to stocks under the GFCM 2019 MAP.

STECF notes that for hake in GSA 17-18, the retrospective analysis shows a strong pattern of overestimation of SSB and underestimation of F in each new assessment year. This highlights the need to look again at a new benchmark for this stock.

STECF acknowledges that for sole in GSA 17, the assessment carried out is an update of the 2021 benchmark assessment from GFCM with a survey index correction for 2020 and 2021 to account for incomplete survey implementation. The potential influence of these adjustments on the stock estimates are not considered to affect the quality of the advice.

STECF notes that addressing the ToRs for sole regarding F-based short-term forecasts using the benchmark ensemble approach was not a trivial task. The procedure is approximate in that the EGW opted to provide median values emphasising the most likely estimates of current and future F from the ensemble models for the combined fishing mortality. This would benefit from a more thorough review.

STECF concludes that diagnostics of the Norway lobster (GSA 17-18) assessment improved a lot through the use of the SPiCT package (Pedersen and Berg, 2017; https://github.com/DTUAqua/spict (version 1.3.7 2002-09-06))

STECF recalls that even if stock status for Norway lobster in GSA17-18 is improving thanks to the implementation of the Pomo Pit area closures, management, local biomass and exploitation rates still vary greatly across Norway lobster subareas (Ancona, Kvarner, Pomo/Jabuka Pit and GSA 18).

This suggests that additional protective measures may need to be considered around especially on the Ancona ground and in GSA 18.

STECF notes that the stock assessment for Striped venus clam, for the nine market districts where assessments are available, show stocks exploited at or below an appropriate level. There is insufficient data for assessing the remaining districts. This species is known to be sensitive to short timescale variability due to environmental factors, and the assessments give little information on F year by year. Under these circumstances it seems unlikely that catch forecasts two years ahead will be of practical use, and that local area management, reactive to short term variations in local catch trends, would be preferable to any broad scale control.

STECF notes that the assessments completed for four area/species combinations for the Southern Adriatic and Ionian seas (GSA 18-19-20) stocks by EWG 22-16 can be used to provide catch advice in terms of F relative to F_{MSY}.

STECF notes that the benchmarked Hake stock (GSA 19) has considerable retrospective problems supporting, as in the case of Hake in GSA 17-18, the need for planning a revision of the benchmark.

STECF notes that ToR 4 requested information on the transition to FMSY by 2030 of Giant red shrimp and blue and red shrimps in GSA 18. This stock spans multiple GSAs. STECF acknowledges that it is not possible to provide such advice when there is no management controlling F in the other parts of the stock. In addition, the allocation of catches to a specific GSA is by the landings port rather than the capture location. Therefore, STECF agrees with the EWG that a response in relation to this ToR is not possible.

STECF notes that both Hake stocks in GSA 20 and GSA 22 benefited of the inclusions of small-scale fishery data which improved the quality of assessments especially for Hake GSA22.

STECF notes that an evaluation and comparison of effort data in terms of vessel number and days at sea was carried out on FDI and MED&BS data calls. Although, last 3 years of effort data are only included in the FDI data call, there is still an overlapping period of several years. The comparison for some countries and fleets resulted in inconsistencies between the two data sets.

STECF notes that problems were encountered in assessing two low priority stocks. For Red mullet in GSA20, no work was attempted and red mullet in GSA 19, which was added very late to the ToRs, and for which there was no time to assemble the data prior to the EWG. In contrast, stocks such as Norway lobster and Striped red mullet both in GSA 15-16 benefited from an ad hoc contract that prepared the data. STECF observes that early identification of data issues is critical for an efficient use of EWG resources and time.

Table 1 Summary of the work attempted and basis for advice in 2021 and 2022 assessments. a4a: an age-based assessment method; Index refers to the ICES Category 3 approach to advice for stocks without analytical assessment.

Area	Species	Method	Basis
		2021	2022
GSA 17-18	Hake	SS3	**SS3 STF**
GSA 17	Sole	STF 2021	**SS3 STF**
GSA 17-18	Red mullet	a4a	**Index**
GSA 17-18	Norway lobster	SPiCT	**SPICT+subarea STF**
GSA 17-18-19	Deep-water rose shrimp	a4a	**a4a STF**
GSA 19	Hake	a4a	**a4a STF**
GSA 19	Red mullet	-	XSA **a4a**
GSA 18-19-20	Giant red shrimp	*	**a4a STF**
GSA 18-19-20	Blue and red shrimp	*	**a4a**
GSA7-18	Venus Clam	*	**CMSY (by area)** **No STF**
GSA 15-16	Norway lobster	**	**a4a STF**
GSA 15-16	Striped red mullet	**	**a4a**
GSA 20	Hake	a4a 2020	**a4a STF**
GSA 22	Hake	Index 2020	**a4a STF**
GSA 20	Red mullet	-	-
GSA 22	Red mullet	a4a 2020	**a4a**

* Data evaluated in EWG 22-03

** Data prepared in an ad hoc contract.

- Previous STECF assessment not available and no data preparation prior to meeting

The main results are summarized in the bullet point list below and in Table 2. Overall, the assessments indicate that 5 out of the 15 stocks are being significantly overfished, 8 are being fished close or at F_{MSY} and 2 are under-exploited. In addition, in 2021, out of the 5 overfished stocks, two are behind transition to F_{MSY} in 2026 the other three are not currently in a MAP (Table 3).

<u>Stocks under Adriatic MAP with transition to F_{MSY} in 2026</u>

- Hake in GSA17-18: the biomass is increasing. Catches should be reduced by at least 25% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2026 is behind transition.
- Sole in GSA17: the biomass is increasing. Catches may be increased by no more than 26% to reach F_{MSY} in 2023. F is already below F_{MSY}.
- Red Mullet in GSA17-18: the biomass is increasing. Catches should be reduced by at least 21%.

- Norway lobster in GSA17-18: the biomass is increasing. Catches may be increased by no more than 199% to reach F_{MSY} in 2023. F is already below F_{MSY}.
- Deep-water rose shrimp in GSA17-18-19: the biomass is increasing. Catches should be reduced by at least 53% to reach F_{MSY} in 2023. F_{2021} is > F_{MSY} Transition so progress to F_{MSY} in 2026 is behind transition.

Stocks in Ionian Sea with transition proposals to F_{MSY} in 2030

- Hake in GSA19: the biomass is increasing. Catches should be reduced by at least 10% to reach F_{MSY} in 2023. F is already below F_{MSY}.
- Red mullet in GSA19: the biomass is increasing. No catches forecast is provided
- Giant red shrimp in GSA18-19-20: the biomass is fluctuating. Catches should be reduced by at least 28% to reach F_{MSY} in 2023. F should be changed by -7% to transition to F_{MSY} in 2030
- Blue and red shrimp in GSA18-19-20: the biomass is declining. Catches should be reduced by at least 17% to give status quo F in 2023. F can be reduced by 10% in 2023 to transition to F_{MSY} in 2030

Stocks without transition objectives

- No catch advice is provided for striped venus clam, local market district assessments are provided with assessments that give stock status for recent years but given the known dynamics of the stocks catch advice (two years ahead, in 2023) is not provided.
- Norway lobster in GSA15-16: the biomass is declining. Catches should be reduced by at least 65% to reach F_{MSY} in 2023.
- Striped red mullet in GSA15-16: the biomass is increasing. No catches forecast is provided.
- Hake in GSA20: the biomass is increasing. Catches should be reduced by at least 40% to reach F_{MSY} in 2023.
- Hake in GSA22: the biomass is stable. Catches should be reduced by at least 74% to reach F_{MSY} in 2023
- Red mullet in GSA22: the biomass is increasing. No catches forecast is provided.

Table 2 Summary of advice and stock status from EWG 22-09 by area and species based on **F_{MSY} target for F2023**. Stocks with light grey shading do not have assessments capable of providing catch options at F_{MSY}, and the line is based on F status quo. Stock status is provided as change in Biomass and F from 2019 to 2021. Fishing mortality (F) 2021 is estimated F in the assessment. Catch in 2023 is based on F_{MSY} (or light grey Fstatus quo). Change in F is the difference (%) between target F in 2023 and the estimated F for 2021. Change in catch is the difference (%) between catch 2021 and catch 2023. Biomass and catch 2019-2021 are given as an indication of trends over the last 3 years for stocks with time series analytical assessments or biomass indices. Dark shaded cells are for stocks without assessment and ICES cat 3 index based advice. Pale grey shaded stocks have unstable assessments, suitable for general stock status by not specific F advice. For these 4 stocks status quo F advice is given.

Area	Species	Method / Basis	Age Fbar	Biomass 2019-2021	Catch 2019-2021	F 2021	F_{MSY}	Change in F**	Catch 2021*	Catch 2023 Based on F_{MSY} or at $F_{status\ quo}$	Change in catch**
GSA17-18	Hake	**SS3 STF**	1-4	increasing	declining	0.39	0.23	-41%	4845	3612	-25%
GSA17	Sole	**SS3 STF**	1-4	increasing	fluctuating	0.18	0.24	32%	1583	2000	26%
GSA17-18	Red mullet	**Index**		increasing	decreasing				3861	3043	-21%
GSA17-18	Norway lobster	**SPICT+subarea STF**		increasing	fluctuating	0.11	0.27	149%	878	2626	199%
GSA17-18-19	Deep-water rose shrimp	**a4a STF**	0-2	increasing	stable	2.41	0.75	-69%	5015	2352	-53%
GSA19	Hake	**a4a STF**	0-4	increasing	fluctuating	0.34	0.21	-37%	522	468	-10%
GSA19	Red mullet	**a4a**	1-3	increasing	stable	0.31	0.51	65%	219	214	-2%
GSA18-19-20	Giant red shrimp	**a4a STF**	1-3	fluctuating	declining	0.83	0.37	-55%	292	210	-28%
GSA18-19-20	Blue and red shrimp	**a4a**	1-3	declining	declining	0.91	0.21	-77%	233	195	-17%
GSA17-18	Venus Clam	**CMSY (by area) No STF**									
GSA 15-16	Norway lobster	**a4a STF**	2-8	declining	declining	0.20	0.10	-50%	148	51	-65%
GSA15-16	Striped red mullet	**a4a**	1-4	increasing	declining	0.34	0.27	-20%	478	651	36%
GSA20	Hake	**a4a STF**	1-3	increasing	fluctuating	0.51	0.24	-53%	881	528	-40%
GSA22	Hake	**a4a STF**	1-3	stable	declining	0.51	0.11	-79%	4214	1094	-74%
GSA22	Red mullet	**a4a**	1-3	increasing	declining	0.21	0.31	42%	1888	2107	12%

Table 5.7.3a Summary of stock and fishery status by area and species, **based on $F_{MSY\ Transition}$ either to 2026 or 2030 (5.7.3b)**. Recent change gives general change in F and catch over the last three years. F_{2019} and F_{2021} are both estimated F in the 2022 assessment. F 2022 is status quo F from 2021. F_{2026} or F_{2030} are F_{MSY} the target for the end of transition, F_{2019} of F_{2022} are the starting point of the plans. For Adriatic stocks (Table 2.3a) the estimate of progress so far is shown as the F change % 2019 to 2021 and the F status relative to transition with $F_{MSY\ Transition}$ 2021. **Advice for 2023** is based on the $F_{MSY\ Transition}$ for the next advice year (2023) which is set at a level to reach F_{MSY} in 2026 or 2030, the change in F and implied by the MAP is the difference (as a fraction) between $F_{MSY\ Transition}$ in 2023 and the F in 2019 or F in 2021. Change in catch is from catch 2021 to catch 2023. Shaded cells in 5.7.3a are index based.

Area	Species	F change	Catch Change	F	F	F_{MSY} Transition	F_{MSY} Transition	Target F 2026	F Change %	F Status 2021	F Change %	F Change %	Catch	Catch 2023	Catch Change
		2018-2020	2018-2020	2019	2021	2021	2023	F_{MSY}	2019-2021	Rel to F_{MSY} transition 2021	2019-2023	2021-2023	2021	F_{MSY} Transition	2021-2023
GSA17-18	Hake	Declining	declining	0.55	0.39	0.46	0.37	0.23	-29%	behind transition	-33%	-6%	4845	4690	-3%
GSA17	Sole	Declining	fluctuating	0.30	0.18	0.28	0.27	0.24	-40%	F below F_{MSY}	-12%	47%	1583	2125	34%
GSA17-18	Red mullet		decreasing							Not known			3861		
GSA17-18	Norway lobster	Declining	fluctuating	0.22	0.11	0.24	0.25	0.27	-50%	F below F_{MSY}	14%	128%	878	2437	178%
GSA17-18-19	Deep-water rose shrimp	increasing	stable	1.87	2.41	1.55	1.23	0.75	29%	behind transition	-34%	-49%	5015	3201	-36%

Table 3.b (shaded entries are for stocks with preliminary assessments and are indicative of magnitude only)

Area	Species	F change 2018-2020	Catch Change 2018-2020	F 2022	F 2021	F_{MSY} Transition 2023	Target F 2030 F $_{MSY}$	F Change % 2021-2023	Catch 2021	Catch 2023 F_{MSY} Transition	Catch Change 2021-2023
GSA19	Hake	declining	fluctuating	0.34	0.34	0.25	0.21	-5%	522	678	30%
GSA19	Red mullet	declining	stable	0.31	0.31	F already below F_{MSY}	0.51				
GSA18-19-20	Giant red shrimp	declining	declining	0.83	0.83	0.52	0.37	-7%	292	367	26%
GSA18-19-20	Red and blue shrimp	increasing	declining	0.91	0.91	0.44	0.21	-10%			

STECF CONCLUSIONS

STECF concludes that the EWG adequately addressed all the ToRs.

STECF endorses the assessments and evaluations of stock status produced by the EWG.

STECF concludes that assessment models for hake stocks in GSA 17-18 and GSA 19 (benchmarked by GFCM in 2019) are deteriorating, showing strong retrospective patterns. STECF suggests that a benchmark of both assessments should be considered before the EWG next year.

STECF concludes that for Sole in GSA 17 benchmark assessment there are still some issues to be solved and/or improved (see Section 3 of the EWG22-16 report). Moreover, STECF agrees that to run a short-term forecast (STF) on an ensemble model according to the STECF procedures (F basis) is complex and requires additional work outside the scope of the EWG. STECF suggests an ad-hoc contract to provide methods and tools to extract data and implement the forecast required by DGMARE.

STECF concludes that diagnostics of the Norway lobster (GSA 17-18) assessment improved a lot through the use of the SPiCT package. STECF also notes that one of the main issues detected in the past (observed value higher than the estimated carrying capacity) is now solved. STECF concludes the assessment is now acceptable for advice.

STECF concludes that the Norway lobster stock is now estimated to be above B_{MSY} and F below F_{MSY}. However, the sub-area evaluations indicate that while Pomo/Jabuka Pit has recovered quickly following the area closure, the Ancona and GSA 18 sub areas are estimated to be at historic low biomasses and should be considered for reduced exploitation to avoid local depletion.

STECF concludes that for Striped venus clam, local area management, reactive to short term local population trends, would be preferable to any broad scale control.

STECF concludes that to best perform the tasks that the EWG is requested to carry out under the ToRs, the process in planning the meeting needs to be streamed to have ToRs and stock list concluded by the Summer Plenary. If this is not possible, the stock list should be finalised at that time.

STECF REFERENCES

Pedersen, M. W. and Berg, C. W. (2017), A stochastic surplus production model in continuous time. Fish and Fisheries, 18(2): 226-243. doi:10.1111/faf.12174

SPiCT package v. 1.3.7 - GitHub - DTUAqua/spict: Surplus Production model in Continuous Time

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REPORT TO THE STECF

EXPERT WORKING GROUP ON Stock Assessment in the Adriatic, Ionian, Strait of Sicily and Aegean Sea (EWG-22-16)

Meeting Rome, 17-23 October 2022

1 INTRODUCTION

1.1 ORGANISATION OF THE MEETING

The working group was held in mostly in person in Rome, Italy, from 17th to 23th Oct 2022. The meeting was attended by 19 experts in total, including one STECF member and one JRC expert along with three observers who attended part time. Two experts and the observers attended remotely.

The objective of the EWG 22-16 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:15 on the first day. The ToRs were discussed and examined in detail. Stocks were allocated to participants based on expertise. An ad-hoc ftp repository was created to share documents, data and scripts and prepare the report. The stock assessments were evaluated by all participants.

Over the week plenary sessions were held each day to monitor progress and share results. The overall conclusions for each stock were discussed and finalized during the EWG. A review of the assessment quality was completed on Saturday and the meeting closed at 13:30 on Sunday. On Saturday, one participant tested positive to Covid19, and the meeting move to an online process. Participants organised there online participation from more isolated environments including hotel rooms.

1.2 ORGANISATION OF THE REPORT

Section 1 provides a meeting overview and ToRs, Section 2 gives a summary of the report containing all the main conclusions, stock status relative to MSY, MSY Transition and where available biomass reference points. Also presented are headline fishing mortality and catch values for MSY, and MSY Transition. In the case of MSY Transition two regimes were applied, 2019 to 2026 for those stocks in the Adriatic MAP, and 2022 to 2030 for some stocks in the Ionian Sea with full assessments.

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

Section 5 gives the summaries by stock relating to stock specific aspects of all of the ToRs. These summaries are based on the template developed in EWG 18-12. Additional advice regarding partial Fishing mortalities by area or by fleet requested in ToR 5 is included by stock within the summaries. Section 6 documents the data, assessments and short term forecasts from ToRs 1-5, with Section 6.17 reporting the effort data for GSA 17-18. Section 7 summarises data deficiencies for ToR 6.

1.3 TERMS OF REFERENCE FOR EWG 22-16

EWG 22-16 was requested to address the following Terms of References:

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 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. STECF 21-02 implemented data quality checks and cleaning to stabilize the time series. EWG 21-15 should adhere to these recommendations from STECF 17-07 and used data prepared in STECF 22-03, where possible.*

For the stocks given in Annex I, the EWG 22-16 is requested to:

ToR 1. Data preparation for the stock assessments:

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.

2. To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2021 while also considering/comparing the results of STECF 21-02 and 22-03. This should be presented by fishing gear as well as by size/age structure.

3. For GSA 17&18 to compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2021, based on the FDI database for the recent part and from prior Mediterranean & Black Sea Data calls for the older part. This should be described in terms of number of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size (linear and/or GT), engine power kW, etc.) by Member State/Country, vessel length and fishing gear. Data shall be the most detailed possible to support the implementation of a fishing effort management regime.

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 2020 by GSA and Country.

ToR 2. 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. Where a benchmark has been performed by GFCM (Hake GSA 17-18, Hake GSA 19) and the stock object is available, the benchmark should be considered for the updated assessment. In absence of the stock object and for robustness testing, other statistical catch at age models may be fitted.

ToR 3. For the stocks listed in Annex I address the specific points as follows:

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[1] https://stecf.jrc.ec.europa.eu/documents/43805/1691180/STECF+17-07+-+Methods+for+stock+assessments+in+MED.pdf

1. For the stock of Norway lobster in the Adriatic Sea, as in prior EWGs, update the SPICT assessment to give overall stock assessment which will reflect total and overall exploitation. In second priority, in line with Tor 3 of EWG 21-15, update the analysis of local trends with the MEDITS biomass indices in 4 areas to evaluate local trends.

2. To further work on the assessment of red mullet in GSA 17-18 in view of contributing to the GFCM benchmark of this stock.

3. Address outstanding issues in the Sole assessment in GSA 17 as identified in EWG 21-15.

ToR 4.

1. For all stocks in Annex I, using the report structure of 2021 (EWG 21-12), 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 FMSY value, conservation and biomass reference points and effort levels.

2. For stocks under the GFCM demersal MAP (GFCM/43/2019/5) and marked by (^) in Annex I, provide a summary table showing the progress made in the transition towards MSY as well as the catch advice for 2023-24 and F to reach Fmsy by 2026. Account should also be taken of a linear reduction of fishing effort of 7%[#] for OTB and 3% TBB in 2022.

3. For the other stocks in Annex I provide a short-term forecast for 2023-24 on the basis of a linear reduction of F that will allow reaching Fmsy in 2028[#].

ToR 5. Additional, stock-specific analyses are requested as follows:

1. Quantify the partial fishing mortality stemming from longlines (LLS) and, if possible, within the current model, from other gears (GNS, GTR and TBB) catching Mediterranean hake in GSA 17-18.

2. Quantify the partial fishing mortality stemming from GNS, GTR, DRB and OTB gear catching common sole in GSA 17.

3. For Giant red shrimp, Blue and Red shrimp stocks in GSA 18-19-20:

   - quantify the catch share by stock for GSA 18,
   - quantify the partial F for catches in GSA 18,
   - advise on an catch limit for GSA 18 under a linear transition to reach Fmsy in 2028.

ToR 6. 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.

Amendment to ToR 4 was received by Email 14 October. In ToR 4 the % change in OTB was modified from 7% to 5.2% for hake and sole. The transition for the remaining stocks was modified from a linear F regime from 2022 to 2028 to a transition from 2022 to 2030

with an initial 3% reduction in TAC per year for 5 years followed by a linear reduction in F for the remaining five years to reach F_{MSY} by 2030.

ANNEX I

Table I – List of suggested stocks to be assessed by the EWG 22-16.

	Area	**Common name**	**Scientific name**
1	GSA 17-18* (improve benchmark and include TBB and GNS/GTR)	Hake^	***Merluccius merluccius***
2	GSA 17-18 (improve on benchmark models)	Red mullet^	***Mullus barbatus***
3	GSA 17-18 (update current SPICT)	Norway lobster^	***Nephrops norvegicus***
4	GSA 17-18-19	Deep-water rose shrimp^	***Parapenaeus longirostris***
5	GSA 17* (update catch and identify possible improvements for benchmark assessment model)	Sole^	***Solea vulgaris***
6	GSA 18-19-20	Giant red shrimp	***Aristaeomorpha foliacea***
7	GSA 18-19-20	Blue and Red shrimp	***Aristeus antennatus***
8	GSA 19 **	Hake	***Merluccius merluccius***
9	GSA 19 (update GFCM stock object) **	Red mullet	***Mullus barbatus***
10	GSA 17-18 (development of CPUE and standardized length composition, preliminary assessment)	Venus clam	***Chamelea galina***
11	GSA 20/22 **	Hake	***Merluccius merluccius***
12	GSA 20/22 **	Red mullet	***Mullus barbatus***

13	GSA 15-16 (ad-hoc)	Norway lobster	***Nephrops norvegicus***
14	GSA 15-16 (ad-hoc)	Striped red mullet	***Mullus surmuletus***

^ key demersal stock in Recommendation GFCM/43/2019/5

* Stock with a GFCM benchmark

** Second priority

2 SUMMARY OF MAIN OUTCOMES

2.1 STOCK SPECIFIC FINDINGS AND 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.

There were sufficient resources to evaluate all but one of the stocks, red mullet in GSA 20. This stock was selected for lower priority based previous experience where different sources of data gave conflicting signals, thus the most likely unproductive analysis. One stock (red mullet in GSA 17-18) has advice based on biomass indices following ICES category 3 procedures as no assessment is available. The remaining 15 of the 16 assessments have been considered suitable for providing guidance of stock status and 10 of these have short term forecasts using the standard STF projection with assumptions of status quo F and historic recruitment. For the five stocks without STF, four are not suitable due to instability in the final years of the assessment. As these stocks are not under active management the assessments are provided as illustrative of stock status, but F_{MSY} forecasts are not available. In these cases a status quo F forecast is provided to give a general indication of change, the assumptions for this are less demanding than for a specified F change, and the catches are not advised. For the final stock, striped Venus clam, preliminary results by sub area give indications of recent stock status, in this cases the models do not capture the short term dynamics well but a general indication of status is possible using local size data.

The results in terms of F and catch based primarily on F_{MSY} targets and relative changes from 2019 to 2021 are provided in Table 2.2. Where short term forecasts could not be provided due to instability in the final year of the assessment status quo catches are provided as an indication of current trajectory. For several stocks in the Adriatic a MAP has been adopted which aims to bring exploitation levels to F_{MSY} by 2026. In 2019 STECF suggested that as a guide to progress towards F_{MSY} in 2026 STECF would provide advice for F and catch based on a 7 year linear change in F from 2019 to 2026 (Table 2.3a). This year several stocks in the Ionian Sea are expected to have a similar objective but with a different time line. The transition is from 2022 to 2030 (amendedfrom 2028 just prior to the EWG), but the initial changes are by 3% per year change in TAC. It is not possible to predict progress to an F target via a fixed percentage TAC change, so the same linear transition approach is provided (Table 2.3b) just to illustrate the catches that would be implied by this linear transition for each stock. The details of this approach are laid out in Section 4.4.1. Tables 2.3a provides a summary by stock of progress to 2021 for those Adriatic stocks with a start date of 2019, based on F2021 in the most recent assessment, which includes the effect of any changes implemented before and during 2021. The future F and catch options for 2023 based on the two linear transitions are provided in Table 2.3a for Adriatic and 2.3b for Ionian Sea stocks.

Table 2.1 Summary of the work attempted and basis for advice in 2020 and 2021 assessments. a4a: an age-based assessment method; Index refers to the ICES Category 3 approach to advice for stocks without analytic assessment[2]. Selected method in Bold

Area	Species	Method 2021	Basis 2022
GSA 17-18	Hake	SS3	**SS3 STF**
GSA 17	Sole	STF 2021	**SS3 STF**
GSA 17-18	Red mullet	a4a	**Index**
GSA 17-18	Norway lobster	SPiCT	**SPICT+subarea STF**
GSA 17-18-19	Deep-water rose shrimp	a4a	**a4a STF**
GSA 19	Hake	a4a	**a4a STF**
GSA 19	Red mullet	-	XSA **a4a**
GSA 18-19-20	Giant red shrimp	*	**a4a STF**
GSA 18-19-20	Blue and red shrimp	*	**a4a**
GSA7-18	Venus Clam	*	**CMSY (by area) No STF**
GSA 15-16	Norway lobster	**	**a4a STF**
GSA 15-16	Striped red mullet	**	**a4a**
GSA 20	Hake	a4a 2020	**a4a STF**
GSA 22	Hake	Index 2020	**a4a STF**
GSA 20	Red mullet	-	-
GSA 22	Red mullet	a4a 2020	**a4a**

* Data evaluated in EWG 22-03, ** data prepared in Ad Hoc contract.

- previous STECF assessment not available

Table 2.2 Summary of advice and stock status from EWG 22-09 by area and species based on **F_{MSY} target for F2023**. Stocks with light grey shading do not have assessments capable of providing catch options at F_{MSY}, and the line is based on F status quo. Stock status is provided as change in Biomass and F from 2019 to 2021. Fishing mortality (F) 2021 is estimated F in the assessment. Catch in 2023 is based on F_{MSY} (or light grey Fstatus quo). Change in F is the difference (%) between target F in 2023 and the estimated F for 2021. Change in catch is the difference (%) between catch 2021 and catch 2023. Biomass and catch 2019-2021 are given as an indication of trends over the last 3 years for stocks with time series analytical assessments or biomass indices. Dark shaded cells are for a stock without assessment and ICES cat 3 index based advice. Pale grey shaded stocks have unstable assessments, suitable for general stock status by not specific F advice. For these 4 stocks status quo F illustrative catch is given.

Area	Species	Method / Basis	Age Fbar	Biomass 2019-2021	Catch 2019-2021	F 2021	F MSY	Change in F**	Catch 2021*	Catch 2023 Based on F_{MSY} or Or catch at F $_{status\ quo}$	Change in catch**
GSA 17-18	Hake	**SS3 STF**	1-4	increasing	declining	0.39	0.23	-41%	4845	3612	-25%
GSA 17	Sole	**SS3 STF**	1-4	increasing	fluctuating	0.18	0.24	32%	1583	2000	26%
GSA 17-18	Red mullet	**Index**		increasing	decreasing				3861	3043	-21%
GSA 17-18	Norway lobster	**SPICT+subarea STF**		increasing	fluctuating	0.11	0.27	149%	878	2626	199%
GSA 17-18-19	Deep-water rose shrimp	**a4a STF**	0-2	increasing	stable	2.41	0.75	-69%	5015	2352	-53%
GSA 19	Hake	**a4a STF**	0-4	increasing	fluctuating	0.34	0.21	-37%	522	468	-10%
GSA 19	Red mullet	**a4a**	1-3	increasing	stable	0.31	0.51	65%	219	214	-2%
GSA 18-19-20	Giant red shrimp	**a4a STF**	1-3	fluctuating	declining	0.83	0.37	-55%	292	210	-28%
GSA 18-19-20	Blue and red shrimp	**a4a**	1-3	declining	declining	0.91	0.21	-77%	233	195	-17%
GSA7-18	Venus Clam	**CMSY (by area) No STF**									
GSA 15-16	Norway lobster	**a4a STF**	2-8	declining	declining	0.20	0.10	-50%	148	51	-65%
GSA 15-16	Striped red mullet	**a4a**	1-4	increasing	declining	0.34	0.27	-20%	478	651	36%
GSA 20	Hake	**a4a STF**	1-3	increasing	fluctuating	0.51	0.24	-53%	881	528	-40%
GSA 22	Hake	**a4a STF**	1-3	stable	Declining	0.51	0.11	-79%	4214	1094	-74%
GSA 22	Red mullet	**a4a**	1-3	increasing	declining	0.21	0.31	42%	1888	2107	12%

Table 2.3 Summary of stock and fishery status by area and species, **based on $F_{MSY\ Transition}$ either to 2026 (Table 2.3a) or 2030 (2.3b)**. Recent change gives general change in F and catch over the last three years. F_{2019} and F_{2021} are both estimated F in the 2022 assessment. F 2022 is status quo F from 2021. F $_{2026}$ or F_{2030} are F_{MSY} the target for the end of transition, F_{2019} of F_{2022} are the starting point of the plans. For Adriatic stocks (Table 2.3a) the estimate of progress so far is shown as the F change % 2019 to 2021 and the F status relative to transition with $F_{MSY\ Transition}$ 2021. **Advice for 2023** is based on the $F_{MSY\ Transition}$ for the next advice year (2023) which is set at a level to reach F_{MSY} in 2026 or 2030, the change in F and implied by the MAP is the difference (as a fraction) between $F_{MSY\ Transition}$ in 2023 and the F in 2019 and the most recent year for which we has estimates, F in 2021. Change in catch is from catch 2021 to catch 2023. Shaded cells are index based.

Area GSA	Species	F change 2018-2020	Catch Change 2018-2020	F 2019	F 2021	FMSY Transition 2021	FMSY Transition 2023	Target F 2026 F MSY	F Change % 2019-2021	F Status 2021 Rel to F_{MSY} transition 2021	F Change % 2019-2023	F Change % 2021-2023	Catch 2021	Catch 2023 F_{MSY} Transition	Catch Change 2021-2023
17-18	Hake	declining	declining	0.55	0.39	0.46	0.37	0.23	-29%	Ahead of transition	-33%	-6%	4845	4690	-3%
17	Sole	declining	fluctuating	0.30	0.18	0.28	0.27	0.24	-40%	F below F_{MSY}	-12%	47%	1583	2125	34%
17-18	Red mullet		decreasing							Not known			3861		
17-18	Norway lobster	declining	fluctuating	0.22	0.11	0.24	0.25	0.27	-50%	F below F_{MSY}	14%	128%	878	2437	178%
17-18-19	Deep-water rose shrimp	increasing	stable	1.87	2.41	1.55	1.23	0.75	29%	behind transition	-34%	-49%	5015	3201	-36%

Table 2.3.b (pale shaded entries are for stocks with preliminary assessments and are indicative of magnitude only)

Area GSA	Species	F change 2018-2020	Catch Change 2018-2020	F 2022	F 2021		FMSY Transition 2023	Target F 2030 F MSY				F Change % 2021-2023	Catch 2021	Catch 2023 F_{MSY} Transition	Catch Change 2021-2023
19	Hake	declining	fluctuating	0.34	0.34		0.25	0.21				-5%	522	678	30%
19	Red mullet	declining	stable	0.31	0.31		0.44	0.51		F below F_{MSY}		8%			
18-19-20	Giant red shrimp	declining	declining	0.83	0.83		0.52	0.37				-7%	292	367	26%
18-19-20	Red and blue shrimp	increasing	declining	0.91	0.91		0.44	0.21				-10%			

2.2 QUALITY OF THE ASSESSMENTS

There have been some issues with timing of MEDITS survey leading to revision of advice. It has not proved possible to identify if a delayed survey is still informative for a particular species or not until some years after. This has led to issues with hake in GSA 19 for this EWG requiring revision of the benchmark, and for some other stocks some uncertainty remains. The EWG would like to reiterate the statement from EWG 22-09 that it essential that surveys are carried out according to a planned timing if resources are not to be wasted. The quality and particular issues with assessments are noted below by species.

2.2.1 HAKE

Hake in GSA 17-18 Settings used for the SS3 assessment model were modified a little from those from the January 2019 GFCM benchmark, there were minor changes noted in 2020 to survey use and fitting process, but additionally errors were found last year within way the age data were loaded into the assessment file and this was corrected this year. The model updated with 2021 data shows similar stock slightly revised SSB, and F as previous 2021 assessment mostly due to the changes in the age data. The retrospective analysis shows stronger tendency to overestimate SSB and underestimate F, highlighting as noted last year the need to look again at a new benchmark. Some data revisions have been submitted by Italy particularly gear codes these revisions have not been included, but are expected to have very minor influence. Official catch was used from Albania and Montenegro, and length data from Albania was available. ToR 5 requesting a STF to give information on TBB, GTR, GNT and LSS was addressed through catch proportions. The influence of these fleets can be estimated to be very small though they are not included in the assessment. It would be good practice to include these catches so the fishery and survey data are both related to a complete stock unit, but they do not influence the model results. Overall given Italian data revisions, missing catch and continuation of the use of age errors and the clear retrospective pattern a revision of the benchmark should be considered urgent.

Hake in GSA 19. The Benchmarked assessment was observed to have considerable retrospective problems, and was inspected for the underlying reasons; the problem had been observed in 2021 but was more extreme this year. There were two causes identified. First the 2017 MEDITS survey carried out very late in the year was distorting the fit to the survey time series and resulted in about half of the retrospective revision. Checks on the catchability of survey model parameters in the assessment identified that the survey was then fitting consistently. Secondly it was observed that F at age was shifting in magnitude and by age. Examination of the catch data shows that there is a shift of fleet catches between otter trawlers and set nets. This shift requires more flexibility than that provided in the current separable model. Various approaches were tested and the best results were obtained with a breakpoint in the fishery in 2015. In the future it is likely that similar though slightly different flexibility will be required depending on whether or not this shift continues or changes. It may not be possible to specify sufficient flexibility that can be fitted dependably it is suggested that this stock is in need of a benchmark, but this should address likely future changes in fleet proportions. The current model is considered as an interim model use for advice this year, as it has dealt with the issue this year. It’s expected that either the model will need to be modify year by year or a more flexible approach could be applied, but there is a tradeoff between flexibility and stability of model that needs some careful consideration.

Hake in GSA 20. The data on Greek small scale fisheries was extensively reconstructed it is now considered that the input data is much improved from before. The missing years of data still influence this assessment though the recent run of data years is much improving the prospects for better advice. The retrospective shows some instability with a pattern of consistent SSB overestimation, attempts were made to fix this, but these changes did not succeed fully. In terms of stock status all the outcomes indicate over exploitation, so the assessment is considered suitable for the recognition of this status, but catch advice is somewhat uncertain. This should be considered a marginal assessment.

Hake in GSA 22. The data issues are similar to hake in 20, but with very slightly better data from the small scale fishery, with some length data available to assist with the reconstruction. Discards from the Greek fleet and official landings from the Turkish fleet for GSA 22 were also included in the assessment. This is a much more stable assessment compared with earlier work. It is used for stock status and catch advice.

2.2.2 SOLE

Sole in GSA 17

The assessment used is the benchmark assessment from GFCM; however adjustments for the SoleMon survey were necessary due to an incomplete survey grid being available for 2020 and 2021 (different areas omitted in each of the years. Two different methods were applied to correct the index (a spatial-temporal modelling approach described in Coro et al., 2022) and an orthogonal model for 2021 based on statistical properties for each event. The impact of the choice of method on the biomass index is small so not thought to affect the assessment results. However, the impact of the survey changes on the associated length distributions is unknown.

Addressing the ToRs for sole regarding F-based short-term forecasts from the benchmark ensemble is not a trivial task. The EWG opted to provide median values (emphasizing the most likely estimates of current and future F) from the ensemble for the combined fishing mortality. For partial F by fleet median values were extracted from the 18 models, not the entire ensemble, because currently the covariance structure of fleet F and populations numbers-at-age is not implemented in SS3diags package and there was insufficient time at the EWG to redevelop the package. Consequently, the STF and the partial F's are not necessarily consistent. However, given that the sum of the partials is quite close to the total this is unlikely to have a major impact on management advice given the overall uncertainty.

2.2.3 RED MULLET AND STRIPED RED MULLET

Striped red mullet in GSAs 15 and 16 (Strait of Sicily and Maltese Islands). The assessment is a new assessment. Data preparations were carried out quite successfully considering the issues spotted in the data in particular in the commercial ones. Because the first available year of the Malta MEDITS survey was 2005 the time series used selected as 2005 to 2021. All the models tested showed a similar set of residuals pattern with values varying but all in the acceptable range but always a bad fit in particular with the survey data. This bad fit is thought to be mainly due to the fact that the MEDITS it is not designed properly to take signals for this species which is very coastal and usually associated with the rocky bottom. Huge instability in the retrospective pattern in the assessment has been observed. To try to reduce this a flat selectivity has been imposed both in the catch and in the surveys, this assumption was considered plausible for this species. The final assessment has been considered as really preliminary and not robust enough in providing catch advice for the next two years. Catch advice for a specific F is not provided.

Red Mullet in GAS 17-18

The advice is based on a combination of change in abundance, and the size at first capture in relation to an F_{MSY} proxy (length at F=M), suggesting an overall decrease in catch advice due to the latter constraint.

However, the survey data provides convincing evidence that not only the index is increasing, but that also the age-structure is expanding. Therefore this advice may be more precautionary than necessary forgoing some sustainable yield which cannot be recovered in future years due to the high natural mortality rate of the species. Hopefully an agree GFCM assessment may be able to give more appropriate results

In any case, the main reason for advising a reduction in catches is because of the size of first capture and there is no guarantee that a reduction in catches is likely to provide a useful measure / the right incentives to increase the size at first exploitation particularly for this species where the market value per recruit is not monotonically increasing. It may still serve to increase biomass further in the short-term, but the current size of the population as evidenced by the increasing survey does not appear to be the limiting factor.

Red Mullet in GSA 19. No data preparation was carried out prior to the meeting due to the late addition of this stock to the ToRs. A preliminary assessment has been developed, which gives indicative results in terms of the general stock trajectory over the recent past. The model is unstable and the model is not suitable for a final assessment and has been considered as really preliminary and not robust enough in providing catch advice for the next two years. Catch advice for a specific F is not provided.

Red Mullet in GSA 22. The reported catches in recent years have remained relatively constant; in contrast the survey index shows a substantial increase in recent years. The assessment model is very uncertain with high sensitivity to choice of recruitment assumptions. Versions that best fit the data give what are considered unrealistic increase in biomass and resulting very low F. These changes do not fit with observations of the fishery. This leads to great uncertainly in the magnitude and scale of both fishing mortality and SSB. Nevertheless the conclusion on the status of F is clear F<Fmsy. It is hoped that more data over the next few years may help to resolve the uncertainties and give more reliable assessment. Catch advice for a specific F is not provided.

2.2.4 NORWAY LOBSTER

Norway Lobster in GAS 15 & 16. Data was assembled with an ad hoc contract prior to the EWG. Based on reduced coverage MEDITS 2014 was removed. There was no length frequency data in 2018. The assessment is considered relatively stable using a sex separated model. The model may require further exploration with regard to the plus group. While the results are not likely sensitive in terms of F and SSB, as the index is fitted with flat selection, there may be some differences with $F_{0.1}$ resulting from choice of plus group. Overall the assessment is considered acceptable for sate of stock and STF advice.

Norway Lobster in GSA 17-18 Data was updated with 2021 catch. A new more stable version of SPiCT is now available. This allowed more flexible fitting options, as the model now converges with only the MEDITS survey as a tuning index. The possibilities for different priors and survey combinations were tested. In previous assessment the early surveys had stabilized the model but provided little increased information on the detail of the stock in these periods. The final assessment had several improvements, it passed all diagnostics tests, and the carrying capacity is increased so that the single catch observation that was previously above carrying capacity is now within range. The perception of precision of the assessment is improved, and the retrospective is now much more stable and well within any limiting criteria. There is one small reduction in performance which is increased uncertainty in the first few years of the assessment. Overall the assessment is considered much improved and fully acceptable. The same area based biomass split used in 2021 is provided to give catch by area information for all catch options. It is noted that locally the stock is in very different states, with Ancona and GS18 at relatively low biomass and Pomo/Jabuka recovering to historic levels.

Deep water rose shrimp in GSA 17, 18 & 19. There were some issues with reported landing data from Albania with reported data excluded some smaller lengths that were present in earlier reports. For the purposes of the assessment it was assumed that Albanian OTB fishery had a similar Length composition to Italian OTB. This assumption had been made often in the past. GSA 18-19 have a full data series while GSA 17 is a part series, it is thought this reflects the development of the stock and the fishery in GSA 17. There is missing info by sex in GSA 17; earlier sensitivity analyses indicate separation by sex results only in minor differences. The assessment is fully in line with last year but with increased uncertainty in terminal F which is seen to increase.

2.2.5 GIANT RED AND BLUE AND RED SHRIMPS

Partial F transition for GSA 18. The assessment is discussed below. The ToR 4 request information to transition these stocks to MSY by 2030 in GSA 18 is considered here. It should be noted that while it is possible to advise catches year by year for any transition, in the correct proportion for GSA 18, it is not possible to control F in GSA 18 without controlling catches in the other parts of the stock in other GSAs. The EWG is therefore unable to provide transition for a part of a stock while leaving the other parts uncontrolled. This is especially true for GSA 18 and 19 where catch reporting to GSA is considered uncertain due to practices such as reporting by port rather than fishing location which may explain some variability among GSA catches. If transition to MSY is to be considered for this area, the plan needs to consider changes at region linked to stock area.

Blue and Red Shrimp GSA 18 19 & 20. Following the EWG 22-03 it was decided to use only GSA 19 Length Frequency because GSA 18 data presence and quality varies considerably. There is an additional potential issue with GSA 18 catch as it seems that this is possibly reported inconsistently by GSA, possibly due assignment by port rather than fishing area. While this is not a problem for a joint GSA assessment it may makes estimates of partial F by GSA flawed. Sex separated age slicing was used in the assessment. Two attempts were made to stabilize the assessment: one due to poor consistency of survey index and secondly for catch the 1st 5 years were removed. This helped but did not solve the stability problems. It was noted that age zero is negligible in the catch and index. This was also removed as it allowed smoothing of selection at age with removing an issue of bias in the age 0. After these changes the retrospective performance was still found to be unstable in F and SSB so not suitable for catch advice linked to a target F. The model is considered good for assessing the general level of exploitation but not for catch advice. It is noted that GSA 20 has little impact on the stock, as reported catches are low and the index does influence the assessment much. The evaluation of partial F is entirely dependent on the fraction of the catch in GSA 18 which is variable and of uncertain validity.

Giant Red Shrimp in GSA 18 19 20. Similar data issues to those reported for blue and red shrimp were observed for this stock; missing Greek data from GSA 20 for both catch and survey and late submission of some 2021 data. Slightly more data is reported from GSA 18 for this species and while still sparse it was considered suitable for use. The fishery is thought to be complex with possible area miss reporting which does not impact in the assessment but makes for added complexity to the dynamics. Some important area misreporting implies fraction of F from GSA 18 is uncertain. Survey issues similar to those for blue and red shrimp. Overall this assessment is better and more stable than the assessment for blue and red shrimp, and advice is provided.

2.2.6 VENUS CLAM

Venus Clams 17 & 18. The evaluation concentrates on data from GSA 17. The data is limited in time but has a useful spatial component. With a few minor exceptions the area based survey estimates are limited to the last five or six years. The longer term catch data is available aggregated to GSA but by subarea for recent years. A CMSY model is fitted by sub area while it does not capture the short term variability it does indicate that a general status can be obtained by this method. The information on current status is predominantly being obtained from the combination of long term reduction in average catch over the longer term combined with length indicators in the last year. However the contrast in the length indicators is small and so far it is unclear how good they are at determining MSY status. Nevertheless it is possible to draw some general conclusions from the evaluations. The overall perception for the 9 stocks with assessments, is of exploitation rates that have declined over the long time series of catch. However, it's hard to know what has happened in individual areas as partitioning of historic catch is based only on recent data. Three districts have insufficient data to carry out evaluations. No catch advice is provided as this requires more detail in the last years than these models can produce. It seems that local area management sensitive to local catch trends would be preferable to any broad scale control. Though setting data and exploitation target standards to be implemented locally may be a good approach.

3 FUTURE DEVELOPMENTS

There have been a number of issues with survey timing, and the late timing of MEDITS in GSA 19 has raised issues with the assessment. Generally the point that MEDITS need to be conducted at the agreed time needs to be strongly emphasised.

There are four stocks which previously the group has not provided assessment. Some progress has been made with these, blue and red shrimp in GSA 18, 19 & 20, red mullet in GSA 19, red mullet in GSA 22 and striped red mullet in GSA 15 & 16. All these assessments suffer from very variable retrospectives, u=indicating instability in the assessments due to a combination of issues, short time series, noisy or intermittent data and general variability in the fisheries. In all these case further development of the assessments is require before MSY catch advice can be given

Three stocks require some further development of assessments. For hake in GSA 19 a more adaptive model is required. For the other two (red mullet in GSA 17 & 18 and sole in GSA 17) some modelling issues are discussed below.

Red mullet in GSA 17 &18

There is currently no benchmarked assessment for this species and previous efforts to develop a new proposal have focused on a series of progressively complex models to reduce the retrospective inconsistencies and to allow the model to reconstruct the dynamic of the stocks along the year (e.g. quarterly configuration) and in the different sub-areas (e.g. area configuration). The approach the ad hoc contract (report?) and the EWG2216 took to the problem was to dig into the available information sources to determine what information they contained individually and 2nd substantially reduce the complexity of the model to account only for the dynamics / contrast for which there was actual information on.

The latest model developed during the EWG (with the MEDITS biomass index all together, with selectivity parameters all free, OTB17 dome-shaped, ALB and MNE selectivity mirroring HRV and block on MEDITS selectivity in 2012) indicated some improvements with regards to stability and fitting the survey trend but still did not provide very convincing evidence of accurately tracking the cohorts. Also the estimation of recruitment deviates suggests that historical recruitment (prior to the compositional data) was substantially higher than expected compared to the later period. This will need to be resolved either through different specification of the SR relationship or potentially as described below. However the model is sufficiently robust and consistent with the data that one can now develop further hypothesis testing with regards to improving specific characteristics of the model.

These include:

- a better understanding of the impact of variability in size-at-age prior in the model. While the last model does show some improvements in the inter-annual contrast in recruitment estimates (an indication of improved cohort tracking) there appears to be more contrast in the survey length frequency data that is being interpreted as residuals by the model. Some preliminary examination suggests that the penalty for not having individuals of an older age is too low.
- a greater understanding of the impact of the cv externally estimated from the survey data and provided to the model as well as an external review of the method of estimating the design based variance as there appears to be a strong link in the mean to cv estimate, i.e. the data appear to be substantially over dispersed which may be inappropriate for this species.
- Conditional age-at-length residuals from the model suggest some highly systematic patterns, but a lot of these are obscured by some very large residuals at the youngest age. Removal of these relatively rare individuals in the catches may provide an improved assessment or at least allow for better interpretation of the patterns at older ages / larger lengths to help specify growth differently.

Based on the results of the above exercise it may be necessary to explore a sex specific model, but it is too early to suggest this as a recommendation.

Sole in GSA 17

The EWG points to the report by EWG 21-15 reviewing the GFCM benchmark model for sole. EWG 22-16 prioritised updating the benchmark model and providing means of converting the catch-based advice to F-based advice while respecting the properties of the ensemble as noted in the previously mentioned report. Unfortunately, there was relatively additional time at the EWG to make progress on other issues, but a number of things were discussed as potential areas of improvement for future developments towards the next benchmark.

Previous meetings of the EWG had noticed and described the cohort consistency in the SoleMon survey when length sliced (EWG 21-15 and EWG 20-15), ICES WGBEAM report). Using the biomass index and the length frequency distributions within the SS3 assessment there appears to be much less cohort tracking within the benchmark assessment. The reason for this effect remains unclear three possible reasons could be investigated:

- Is the difference in the interpretation of the data due to conflict in the data sources, i.e. are the growth functions / uncertainty in growth different for the length sliced index and the VB-growth used in the model.
- Can use of a different growth function provide better cohort tracking in the index,
- or is it possible to provide the assessment with more information on cohort strength through the use of conditional ALKs at least for the younger ages (+group = 4) which do not suffer from the biased reading errors.
- What is the effect of changing the juvenile and adult uncertainty on size-at-and how does this compare to the observed variation on size-at-age?

The transition from catch only data in the assessment to catch plus compositional data is a critical point in the time series of this assessment since this represents the time series lowest SSB in all 18 runs of the ensemble. There is conflict in the transition between these two periods. There is no information or substantive information of a population collapse in the catch data to support the modelled population changes, which are unique in the time series in terms of SSB.

- This could be investigated through exploring a short timeseries model (i.e. only using the data rich period) to see if the dynamics are substantially different from the long-timseries model and comparing the expected population numbers at this time.
- Detail the differences during this time period between the secondary biomass model (JARA) and the benchmark catch-at-age model.

4 METHODS

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

4.1 DATA QUALITY

4.1.1 JRC SCRIPT ON QUALITY CHECKS

4.1.1.1 GENERAL INTRODUCTION

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

Listed below the R scripts used during the EWG2102

1) Check_landings.R

2) Check_discards.R

3) Cumulative.R

4) Quality checks.R

5) Landings_LFgaps_metier.R

6) Discards_LFgaps_metier.R

7) Relative weights.R

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

4.2 DATA PREPARATION

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

4.2.1 FILL-IN PROCEDURES

All stratified sampling programs can result in fleets or metiers that are missed or severely under-sampled[3]. These strata are most often a very small part of the total catch however; they require the allocation of size/age as part of the stock assessment. This allocation of LFDs can be done within some assessment packages that operate by fleet/metier and handle patchy data on length frequency distributions (LFDs) and fit the missing data as part of the assessment model process. Other packages that operate by combining catch data to the total catch require a procedure that either leaves a year without an LFD, or alternatively fill-ins the small proportion of the catch with a suitable LFD. The modelling methods that work by fleet/metier and fit the missing observation often require more complex modelling but also the strong additional assumption that the catch is a true census (including discards) in order to estimate the missing LFDs. When a combined catch assessment is used with a minor fill-in the assumption that allows some error in catch estimation is then possible. For the purposes of estimating stock status (F and SSB) and giving catch advice the differences between the approaches are usually small, for example hake in GSA 17-18 (REF STECF 2020 report).   The procedures used in this EWG for filling in landings and discard LFDs are documented below.

4.2.1.1 FILL IN FOR LENGTH FREQUENCY DISTRIBUTIONS FOR LANDINGS

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

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

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

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

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

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

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

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

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

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

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

4.2.1.2 FILL-IN FOR DISCARDS DATA

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

Quantities of discards by years:

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

Missing LFDs:

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

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

4.2.2 LENGTH SLICING

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

4.3 BASIS OF THE CATCH AND FISHING MORTALITY ADVICE

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

Full assessment and full MSY reference points or with surplus production model with F and biomass relative to F_{MSY} proxy and B_{MSY}: Catch advice at MSY based on short term forecast. F and catch advice reduced if SSB is forecast to be below B_{pa} at the start of the advice year. **Used for three stocks for this year**

Full assessment without full evaluation MSY reference points due to short time historic series: Catch advice based on MSY proxy of $F_{0.1}$ based on short term forecast. Used for 3 stocks for this year. **Used for eight stocks this year and four stocks without STF.**

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 or status quo F. **Not used.**

For sparse data with insufficient years for VPA type analysis, but with catch at length or age for most of the fishery: advice is based on pseudo cohort analysis at equilibrium, with estimate of current F relative to $F_{0.1}$. **Not used.**

Trend based indicator with exploitation and stock status know to be OK: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend without precautionary buffer, giving 2 years advice. **Not used.**

Trend based indictor: Catch / Effort advice under MSY considerations based on ICES smoothed index of trend **Used for one stocks this year**.

Valid length analysis: statement of stock status, indication of direction of change required. **Not used**

No valid analysis: no advice. **One stock not evaluated**

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

4.4 MSY REFERENCE POINTS FOR STOCKS IN THIS REPORT

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

4.4.1 MSY RANGES

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

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

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

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

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

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

4.4.2 VALUES OF F_{MSY} 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.

4.5 BASIS OF SHORT TERM FORECASTS

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

Biological conditions are assumed to be recent biological conditions

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

Recruitment **-** Most probable recruitment

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

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

Fishery is assumed to be the same as the recent fishery

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

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

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

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

4.5.1 MSY TRANSITION

4.5.1.1 TRANSITION TO MSY BY 2026

The EWG continues to provide the main catch option presented in section 5 based on the target of F_{MSY} in 2023 (modified if necessary if B at the beginning of the advice year is forecast to be below B_{pa}. This MSY option remains the primary advice. However, in Plenary November 2019 The STECF considered if it would be possible to give an additional advice option or options associated with the Adriatic MAP. The MAPs have the objective of achieving F_{MSY} either by at latest 2026. For a few stocks F is already close to F_{MSY}, but for many stocks such as hake F is substantially higher than F_{MSY} and it seems likely that these stocks will be considered under the objective for reaching F_{MSY} by 2026. For such stocks the plans do not specify how it is expected that F should change over the 7 years from 2020 to 2026. Currently STECF reports the F_{MSY} and expected catch in the advice year based on EWG assessment and short term forecasts. However, if the approach is to attempt a reduction in F to F_{MSY} by 2026 it may be helpful to give advice in relationship to such a transition, and the EWG has included an additional 'F_{MSY} Transition' option for the

STF Table (Section 5 and 6). In 2010 and the following years ICES provided advice following an MSY transition approach with a linear change in F from 2010 to achieve F_{MSY} in 2015. This approach is updated below for transition from 2020 to 2026.

$F_{MSY\ Transition}$ (2023) = {7/8 • F_{2022} (2022) + 1/8 • F_{MSY}(2022)}

whereas for the following years:

$F_{MSY\text{-}Ttransition}$ (2021) = {5/7• F (2019) + 2/7• F_{MSY}(2020)}

$F_{MSY\text{-}Transition}$ (2022) = {4/7• F (2019) + 5/7• F_{MSY}(2021)}

$F_{MSY\text{-}Transition}$ (2023) = {3/7• F (2019) + 0.4/7• F_{MSY}(2022)}

$F_{MSY\text{-}Transition}$ (2024) = {2/7• F (2019) + 5/7• F_{MSY}(2023)}

$F_{MSY\text{-}Transition}$ (2026) = {1/7 • F (2019) + 6/7 • F_{MSY}(2024)}

$F_{MSY\text{-}Transition}$ (2026) = F_{MSY}(2025)

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

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

4.5.1.2 TRANSITION TO MSY BY 2030

For other stocks in the Ionian Sea a different approach to reaching MSY has been proposed and a transition to 2030 has been agreed. Currently the transition is expected to use TAC constraints with a limit of -3% per year for the first three years followed by linear transition. It is not possible to provide a trajectory to follow using % TAC constraints to reach an F target; the TACs need to be set in the context of a catch to achieve a choice of F by year to reach the F target. However, in order to indicate the simplest trajectory an 8 year linear transition is provided. It is hoped that the values of Catch based on a linear F transition will be helpful to indicate the likely progress of any TAC change. Showing if the TAC proposed gives F above or below the transition.

$F_{MSY\ Transition}$ (2023) = {7/8 • F_{2019} (2022) + 1/8 • F_{MSY}(2022)}

whereas for the following years:

$F_{MSY\text{-}Ttransition}$ (2024) = {6/8• F_{2019} (2023) + 2/8• F_{MSY}(2023)}

$F_{MSY\text{-}Transition}$ (2025) = {5/8• F_{2019} (2024)+ 3/8• F_{MSY}(2024)}

$F_{MSY\text{-}Transition}$ (2026) = {4/8• F_{2019} (2025)+ 4/8• F_{MSY}(2025)}

$F_{MSY\text{-}Transition}$ (2027) = {3/8• F_{2019} (2026)+ 5/8• F_{MSY}(2026)}

$F_{MSY\text{-}Transition}$ (2028) = {2/8 • F_{2019} (2027)+ 6/8 • F_{MSY}(2027)}

$F_{MSY\text{-}Transition}$ (2029) = {1/8 • F_{2019} (2028)+ 7/8 • F_{MSY}(2028)}

$F_{MSY\text{-}Transition}$ (2030) = F_{MSY}(2029)

4.6 INDEX BASED METHOD USED FOR STOCK WITHOUT ASSESSMENTS

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

Currently the STECF assessment EWG utilised two of the options:

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

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

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

- **r** : biomass ratio (survey trend)
- **f** : fishing proxy (length data, target)
- **b** : biomass safeguard

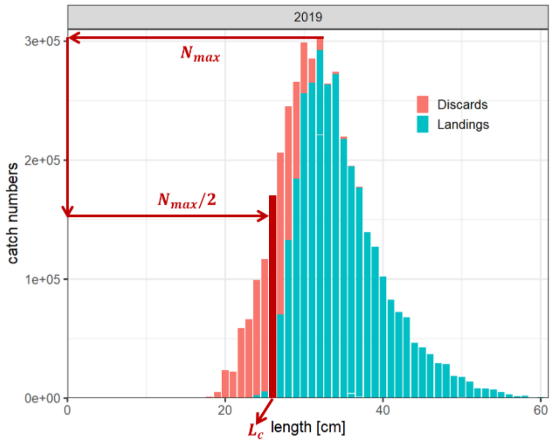
This HCR improves on the "2-over-3" rule (ICES, 2012a) with the addition of multipliers based on a stock's life history characteristics, its status in terms of relative biomass, and its status relative to a target reference length (ICES, 2018c, 2019a).

The rfb catch rule is defined as:

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

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

Table 4.6.1 Data requirements of the rfb rule.

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

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

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

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

The HCR is defined as:

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

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

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

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

The notation of these rules is for in-year advice where the advised catch for the current year is based on last year's advised catch adjusted by the trend in the most recent abundance index, I_y, relative to the average of the index value in the previous two years.

An uncertainty cap is applied to limit the change in the index trend, the I_y component of the HCR, to ±80%, which allows the current years advised catch to increase or decrease up to 80% relative to the previous years advised catch.

Note that $\frac{I_y}{\sum_{y-1}^{y-2} I_y/2}$ should be replaced by $\frac{I_{y+1}}{\sum_{y}^{y-1} I_y/2}$ in the formula above if the index is available at the beginning of the management year *y+1*, instead of being available at the end of the interim (management) year *y*.

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

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

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

5 STOCK SUMMARIES

ToR 4.

1. *For all stocks in Annex I, using the report structure of 2021 (EWG 21-12), 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 FMSY value, conservation and biomass reference points and effort levels.*
2. *For stocks under the GFCM demersal MAP (GFCM/43/2019/5) and marked by (^) in Annex I, provide a summary table showing the progress made in the transition towards MSY as well as the catch advice for 2023-24 and F to reach Fmsy by 2026.*
3. *Account should also be taken of a linear reduction of fishing effort of 7% for OTB and 3% TBB in 2022.*
4. *For the other stocks in Annex I provide a short-term forecast for 2023-24 on the basis of a linear reduction of F that will allow reaching Fmsy in 2028.*

ToR 5. Additional, stock-specific analyses are requested as follows:

1. *Quantify the partial fishing mortality stemming from longlines (LLS) and, if possible, within the current model, from other gears (GNS, GTR and TBB) catching Mediterranean hake in GSA 17-18.*
2. *Quantify the partial fishing mortality stemming from GNS, GTR, DRB and OTB gear catching common sole in GSA 17.*
3. *For Giant red shrimp, Blue and Red shrimp stocks in GSA 18-19-20: quantify the catch share by stock for GSA 18, quantify the partial F for catches in GSA 18, advise on an catch limit for GSA 18 under a linear transition to reach Fmsy in 2028.*

Stock summaries provided in this section are based on the assessment, short term forecast and reference points reported in Section 6 below. The results of the additional requests from ToR 5 are included in the advice summary sheets, where necessary supporting analyses are given in Section 6 by stock.

5.1 SUMMARY SHEET FOR EUROPEAN HAKE IN GSAS 17 AND 18

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.232 and corresponding catches in 2023 should be no more than 3612 tons.

Stock development over time

Catches have been around 6000 tons in the last six years with a decrease in the last three years to around 5000 tons. Female SSB of European hake is relatively stable until 2006, then decreased considerably until 2014 (1344 tons) to then rise to the highest value of the time-series in 2022 (4017 tons). $F_{bar(1-4)}$ shows a decreasing trend in the last six years, declining from around $F_{bar(1-4)}$ = 0.7 in 2016 to the lowest value in the most recent year ($F_{bar(1-4)}$ in 2021 = 0.39). Recruitment shows a decreasing trend in the last six years with the exception of 2019. Recruitment in the last five years is below average.

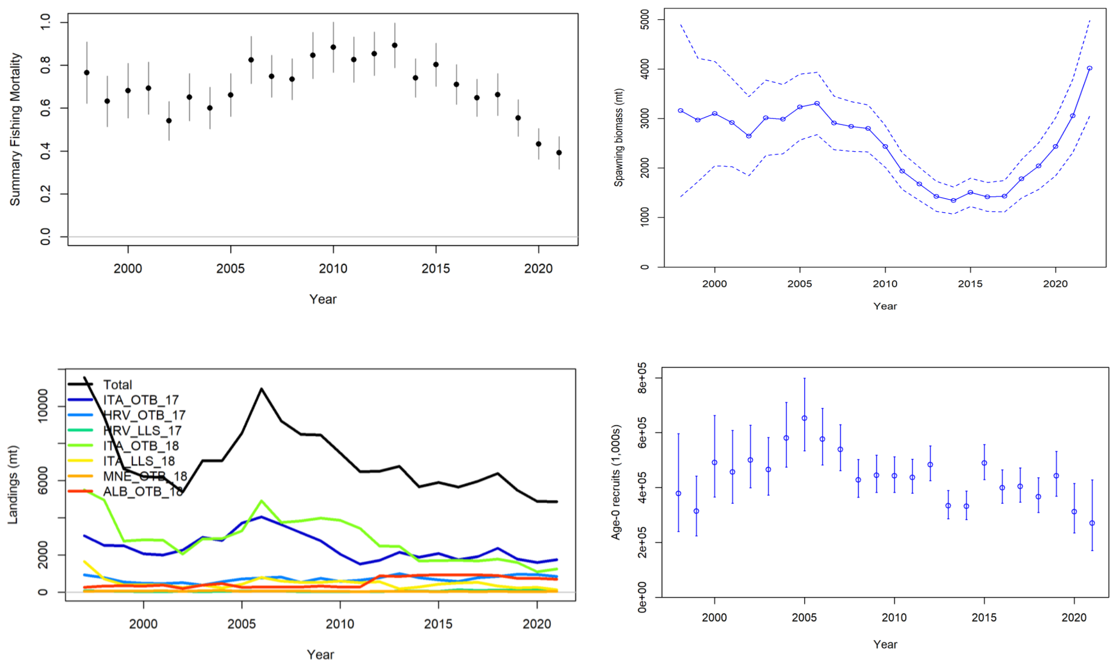


Figure 5.1.1 European hake in GSAs 17 and 18: Trends in catch, recruitment, fishing mortality and **female** SSB resulting from the SS3 model.

Stock and exploitation status

The current level of fishing mortality (0.39) is above the reference point F_{MSY} (0.232) and has been since 1998.

Table 5.1.1 European hake in GSAs 17 and 18: State of the stock and fishery relative to reference points.

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

Catch scenarios

The short-term forecast was performed for standard options for 2023 and an additional option for a forecast for 2024. The assumptions for 2022 are given in Table 5.1.2a, and results are given in Table 5.1.3a.

Table 5.1.2 European hake in GSAs 17 and 18: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		Mean weights at age, maturity at age, natural mortality at age and selection at age, based on the average of 2019-2021
$F_{ages\ 1\text{-}4}$ (2022)	0.37	F_{2021} used to give F status quo for 2022 plus a reduction of 5.2% for the OTB fleets
Female SSB (2022)	4017 t	Stock assessment 1 January 2022
R_{age0} (2022,2023,2024)	348,562	Mean of the last 3 years
Total catch (2022)	4719 t	Assuming F status quo for 2022

Table 5.1.3a European hake in GSAs 17 and 18: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	**Female** SSB (2024)	% **Female** SSB change**	% Catch change***
STECF advice basis					
F_{MSY} / MAP	3612	0.232	6037	50.3	-25.5
$F_{MSY\ Transition}$ ^^	4690	0.37	5238	30.4	-3.2
$F_{MSY\ lower}$	2670	0.16	6528	62.5	-44.9
$F_{MSY\ upper*}$	4153	0.32	5510	37.1	-14.3
Other scenarios					
Zero catch	0	0	7675	91	-100.0
Status quo	4919	0.39	5123	27.5	1.5
60% of status quo	3162	0.23	6017	49.8	-34.7
80% of status quo	4072	0.31	5551	38.2	-16.0
7% reduction OTB fleets^	4658	0.37	5251	30.7	-3.9

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

** % change in SSB 2024 to 2022

***Total catch in 2023 relative to catch in 2021.

^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026

^7% reduction in partial F_{2023} for all OTB fleets, and $F_{2023} = F_{2021}$ for all LLS fleets

Table 5.1.3b European hake in GSAs 17 and 18: Annual catch scenarios by area and gear assuming same catch proportions as 2021

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	GSA 17 OTB	GSA 17 LLS	GSA 18 OTB	GSA 18 LLS
STECF advice basis						
F_{MSY}	3612	0.232	1922	101	1489	101
$F_{MSY\ Transition}$	4690	0.37	2495	131	1933	131
$F_{MSY\ lower}$	2670	0.16	1421	74	1101	74
$F_{MSY\ upper}$**	4153	0.32	2210	116	1712	116
Other scenarios						
Zero catch	0	0	0	0	0	0
Status quo	4919	0.39	2617	137	2027	137
60% of status quo	3162	0.23	1682	88	1303	88
80% of status quo	4072	0.31	2166	113	1678	113
7% reduction OTB fleets**	4658	0.37	2478	130	1920	130

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

** 5.2% reduction in partial F_{2022} for all OTB fleets, and $F_{2022} = F_{2021}$ for all LLS fleets

The TBB is not included in the GFCM assessment, on the basis that there is no directed fishery and catches are negligible, so the TBB has no influence on the results. Indeed, LLS are relevant, since they account for ~ 20% of the total fishing mortality in 2021 (with higher values in the less recent years).

Basis of the advice

Table 5.1.4 European hake in GSAs 17 and 18: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The retrospective analysis run on the SS3 model showed a steady year on year upward revision of F by about 0.1 over 3 years, and a substantial overestimation of female SSB which is being revised downward annually. It is suggested to review this model in a new benchmark.

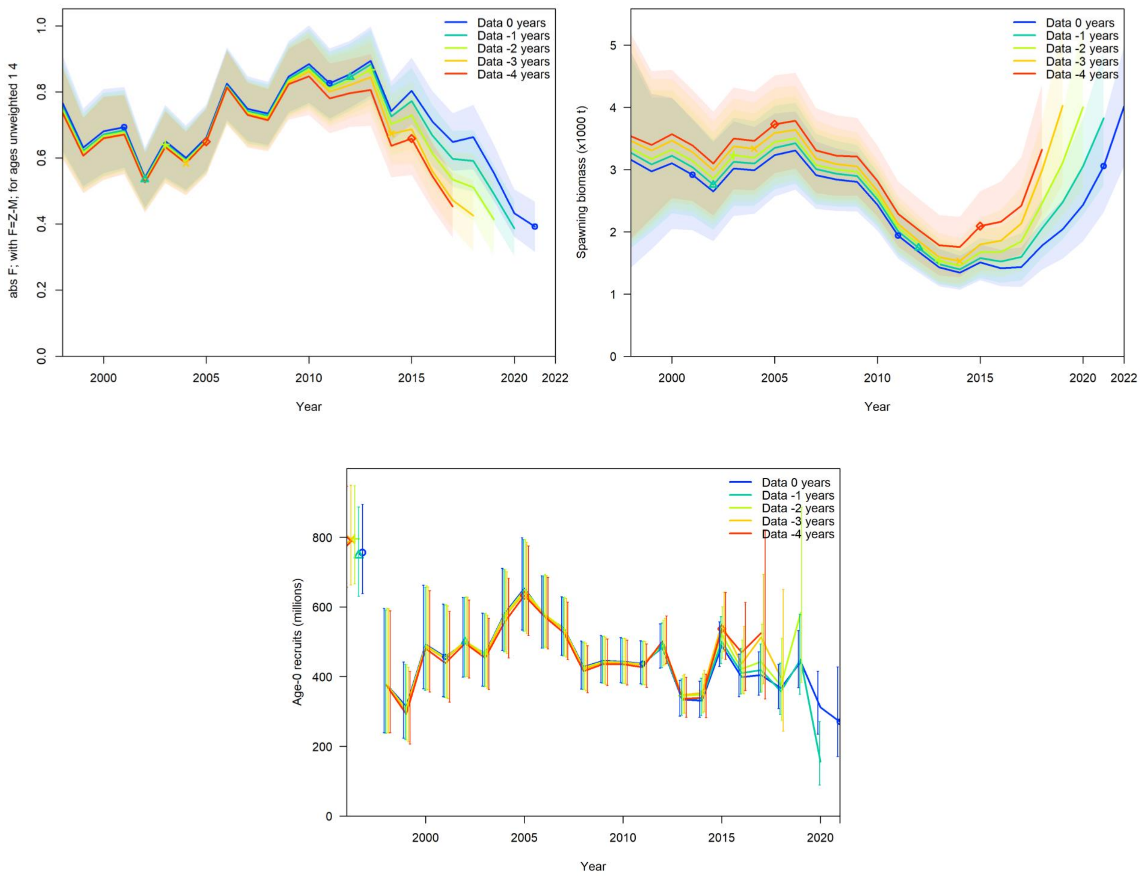


Figure 5.1.2 European hake in GSAs 17 and 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

This stock is taken in a mixed fishery with Red Mullet, Mantis Shrimp and Sole. Management of these stocks should be considered together.

The assessment is carried out with only two gears (OTB and LLS) included in the data set; GTR TBB and GNS are not included, so information on the partial mortality by these gears is not included in the assessment. Table 5.1.8b. below gives historic proportions of catch by gears OTB, LLS, GTR and GNS. The fishery is dominated by OTB with a lesser but still important contribution from LLS at about 9% of catch. GNS contributes around 2% to landings and GTR about 0.1%.

Reference points

Table 5.1.5 European hake in GSAs 17 and 18: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.232	F_{MSY} from SS3 model	STECF EWG 22-16
Precautionary approach	B_{lim}	1344	B_{loss}	STECF EWG 22-16
	B_{pa}	1881	$B_{lim} \cdot exp^{(1.645 \cdot \sigma)}$	STECF EWG 22-16
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.232	F_{MSY}	STECF EWG 22-16
	MAP target range $F_{MSY\ lower}$	0.12	Based on regression calculation (see section 2)	STECF EWG 19-16
	MAP target range $F_{MSY\ upper}$	0.25	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-16

Basis of the assessment

Table 5.1.6 European hake in GSAs 17 and 18: Basis of the assessment and advice.

Assessment type	SS3
Input data	DCF commercial data (landings and discards), plus commercial data provided by Albania and Montenegro from GFCM framework, age-length keys, and scientific survey (MEDITS) data.
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.1.7 European hake in GSAs 17 and 18: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted catch corresponding to advice	STECF catch	STECF landings	STECF discards
2019	$F = F_{MSY}$	2694	53551	5100	265
2020	$F = F_{MSY}$	2563	4841	4736	105
2021	$F = F_{MSY}$	2789	4845	4743	102
2022	$F = F_{MSY}$	2920			
2023	$F = F_{MSY}$	3612			

Values of catch in this table relate to the assessed fleets included in the hake assessment, they do not correspond to the total catch.

History of the catch and landings

Table 5.1.8a European hake in GSAs 17 and 18: Catch and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021	Landings			Discards
Catch (t)	Otter trawl* 90%	Longlines 6%	Other** 4%	t
	4450	293	200	128
Effort***	135086	18664		
	Fishing days			

*Otter trawl contains all the official landings from the different countries
** Other fleets not included in the assessment are GNS, GTR and TBB
***Effort only for member states

Table 5.1.8b European hake in GSAs 17 and 18: DCF landings by year and gear at totals and percentage.

	Landings by gear				% landing by gear			
Year	**GNS**	**GTR**	**LLS**	**OTB**	**GNS**	**GTR**	**LLS**	**OTB**
2002*	26	0	0	2006	1.3%	0.0%	0.0%	98.7%
2003*	199	0	0	2899	6.4%	0.0%	0.0%	93.6%
2004*	19	21	233	2932	0.6%	0.7%	7.3%	91.5%
2005**	38	18	452	3277	1.0%	0.5%	11.9%	86.6%
2006^	31	26	836	8595	0.3%	0.3%	8.8%	90.6%
2007^	20	18	620	6937	0.3%	0.2%	8.2%	91.3%
2008^	15	42	551	6678	0.2%	0.6%	7.6%	91.7%
2009^	8	20	534	6247	0.1%	0.3%	7.8%	91.7%
2010^	0	19	601	5341	0.0%	0.3%	10.1%	89.6%
2011^	0	18	519	4881	0.0%	0.3%	9.6%	90.1%
2012^^	71	24	601	5278	1.2%	0.4%	10.1%	88.3%
2013^^	46	3	253	5606	0.8%	0.1%	4.3%	94.9%
2014^^	60	3	341	4207	1.3%	0.1%	7.4%	91.2%
2015^^	62	3	483	4381	1.3%	0.1%	9.8%	88.9%
2016^^	46	2	642	4158	0.9%	0.0%	13.2%	85.8%
2017^^	82	6	605	4452	1.6%	0.1%	11.8%	86.5%
2018^^	72	4	451	4726	1.4%	0.1%	8.6%	90.0%
2019^^	86	4	378	4245	1.8%	0.1%	8.0%	90.1%
2020^^	92	6	443	3617	2.2%	0.1%	10.7%	87.0%
2021^^	87	4	294	3830	2.1%	0.1%	7.0%	90.9%

*data for ITA 18 only; ** data for ITA 18 and SVN 17; ^data for ITA 18, ITA 17 and SVN 17; ^^all fleet in the DCF database

Table 5.1.9 European hake in GSAs 17 and 18: History of commercial landings; the official reported values are presented by country. All weights are in tonnes. Effort in fishing days.

Year	ITALY OTB GSA 18	ITALY LLS GSA 18*	ITALY OTB GSA 17**	SLOVENIA OTB GSA 17***	CROATIA OTB GSA 17^	CROATIA LLS GSA 17^	MONTENEGRO OTB GSA 18^^	ALBANIA OTB GSA 18^^	Total landings	Total Effort Fishing days¤
2002	2006	258	2308	2	521	41	42	200	5378	209953
2003	2899	385	3062	5	384	30	80	384	7229	196309
2004	2932	233	2894	1	566	45	99	473	7243	227810
2005	3275	452	3833	2	726	57	55	267	8667	218240
2006	4613	836	3980	2	768	61	59	280	10599	209408
2007	3497	620	3435	5	818	65	58	275	8773	183203
2008	3640	551	3037	1	532	33	63	275	8132	170137
2009	3545	534	2549	1	734	37	56	336	7792	192878
2010	3400	601	1863	0	572	40	49	280	6805	172034
2011	3312	519	1460	0	653	37	40	286	6307	164032
2012	2520	566	1777	0	796	34	42	899	6634	197438
2013	2379	188	2192	1	1014	65	43	851	6733	183574
2014	1584	279	1789	1	774	61	44	902	5434	165539
2015	1614	427	2011	1	655	56	38	914	5716	161955
2016	1672	518	1731	0	586	124	42	948	5621	163014
2017	1682	515	1836	0	784	90	37	940	5884	174027
2018	1650	335	1853	2	815	116	48	872	5690	182846
2019	1481	235	1556	4	944	116	37	731	5100	164423
2020	1086	265	1488	1	927	178	37	751	4736	145475
2021	1229	159	1637	3	836	134	42	703	4743	152593

*Values in 2002-2003 are catches. **Values in 2002-2005 are catches.
***Values in 2002-2004 are catches. ^Values in 2002-2011 are catches.
^^Values from GFCM
¤Effort only from member states and OTB and LLS.

Summary of the assessment

Table 5.1.10 European hake in GSAs 17 and 18: Assessment summary. Weights are in tonnes. 'High' and 'Low' represent approximately 95% confidence intervals.

Year	Recruitment age 0 thousands	High	Low	**Female** SSB Tonnes*	High	Low	Catch tonnes	F ages 1-4	High	Low
1998	377949	552544	203354	3159	4894	1423	9441	0.77	0.91	0.62
1999	314041	422115	205967	2970	4219	1722	6666	0.63	0.75	0.51
2000	491860	639299	344421	3100	4153	2046	6268	0.68	0.81	0.55
2001	456429	588331	324527	2917	3807	2026	6206	0.69	0.81	0.57
2002	500071	613678	386464	2646	3445	1848	5442	0.54	0.63	0.45
2003	466046	570499	361593	3016	3776	2256	7322	0.65	0.76	0.54
2004	580616	698399	462833	2988	3688	2289	7336	0.60	0.70	0.50
2005	653281	784918	521644	3233	3899	2568	8772	0.66	0.76	0.56
2006	576703	679675	473731	3305	3934	2677	10832	0.83	0.94	0.71
2007	538905	622531	455279	2911	3452	2370	8959	0.75	0.85	0.65
2008	427866	496569	359163	2839	3342	2336	8312	0.74	0.83	0.64
2009	445250	512840	377660	2801	3276	2327	7998	0.85	0.95	0.74
2010	442583	507153	378013	2435	2856	2015	6923	0.88	1.00	0.77
2011	437259	498930	375588	1936	2305	1568	6416	0.83	0.93	0.72
2012	483923	547332	420514	1679	2016	1342	6818	0.85	0.95	0.75
2013	334048	385401	282695	1427	1730	1124	6753	0.89	1.00	0.79
2014	331292	382816	279769	1344	1617	1071	5493	0.74	0.83	0.65
2015	489151	553047	425255	1510	1797	1223	5817	0.80	0.90	0.70
2016	399050	460118	337982	1415	1707	1123	5764	0.71	0.80	0.62
2017	404425	466747	342103	1432	1751	1113	6033	0.65	0.74	0.56
2018	366616	429815	303417	1781	2168	1393	6091	0.66	0.76	0.57
2019	442777	524227	361327	2040	2512	1568	5355	0.55	0.64	0.47
2020	312207	401788	222626	2434	3020	1847	4819	0.43	0.50	0.36
2021	270053	396036	144070	3054	3792	2315	4845	0.39	0.47	0.32
2022				4017	4978	3056				

*SS3 model provides estimates of SSB only for females.

Sources and references

EWG 22-16

5.2 SUMMARY SHEET FOR SOLE IN GSA 17

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.24 and corresponding catches in 2023 should be no more than 2000 tons.

Stock development over time

Catches have been around 2000 tons in the last five years before Covid-19 pandemic when an almost 25% decrease in landings took place between 2019 and 2020 (1468 tons). A slight increase occurred in 2021 (1580 tons). The assessment shows a female spawning biomass of common sole follows a steady biomass to 2000 and a decreasing to 2010. In the recent years, SSB followed an increasing trend reflecting its recovering status. The last estimate of SSB in 2020 is 3440 tons. Fishing mortality is defined as the average F of age classes 1 to 4. Fishing mortality to 2000 was low and fluctuating, increasing up to 2010, then following a decreasing trend until 2021, reaching the value of 0.18. Data informing recruits estimates are only available since 2005 (first year of SoleMon survey LFD). Since 2005, recruitment has shown an increasing trend; in the last year estimate recruits are 86378 (x 1000s).

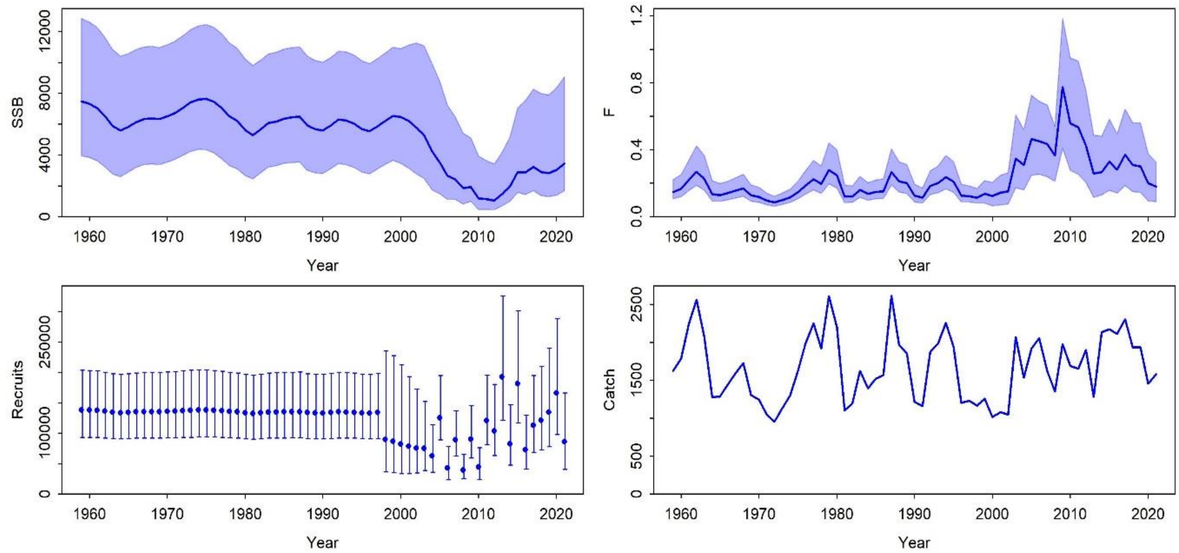


Figure 5.2.1 Common sole in GSAs 17: Trends in catch, recruitment, fishing mortality and female SSB resulting from the SS3 model.

Stock and exploitation status

The current level of fishing mortality (0.180) is below the reference point F_{MSY*} (0.24). The current assessment also estimates F_{2020} to have been below the reference point and below or equal to $F_{Transition}$ for the period 2020-2021.

Table 5.2.1 Common sole in GSAs 17: State of the stock and fishery relative to reference points.

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

* F_{40} as proxy of F_{MSY}

Catch scenarios

The short-term forecast was performed up to 2023. The assumptions are given in Table 5.2.2, and results are given in Table 5.2.2b. Annual catch scenarios by gear are reported in Table 5.2.3.

Table 5.2.2 Common sole in GSAs 17: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		Maturity, natural mortality and selectivity, based on the average of 2019-2021
$F_{ages\ 1\text{-}4}$ (2022)	0.198	Average last 3-yr (2019-2020-2021) in apical F by fleet + 3% reduction for ITA TBB fleet and 5.2% for ITA OTB
SSB (2022)	4315 t	Stock assessment 1 January 2022
R_{age0} (2022,2023)	128,456	Mean of the last 10 years (2012-2021)
Total catch (2022)	1769 t	Predicted catch from ensemble model

Table 5.2.2b Common sole in GSAs 17: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	SSB (2023)	% SSB change**	% Catch change***
STECF advice basis					
F_{MSY} / MAP	2000	0.238	4344	-3.35	+20.87
$F_{MSY\ Transition}$^^	2125	0.258	4093	-5.40	+25.49
$F_{MSY\ lower}$*	1451	0.158	4529	4.74	-9.11
$F_{MSY\ upper}$*	2560	0.336	3782	-14.07	+38.16
Other scenarios					
Status quo^	1741	0.198	4344	0.67	+9.06
F 80% of status quo	1451	0.158	4529	4.74	-9.11
F 90% of status quo	1599	0.178	4435	2.72	+1
F 110% of status quo	1876	0.218	4259	-1.31	+15.64
F 120% of status quo	2000	0.238	4175	-3.35	+20.87
F 130% of status quo	2125	0.258	4093	-5.40	+25.49

* F_{MSY} ranges were derived using the formula provided by STECF 15-09: $F_{MSY\ upper}$ is assumed not to be precautionary. STECF does not advise fishing at $F>F_{MSY}$
** % change in SSB 2023 to 2022
***Total catch in 2023 relative to catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026
^ assumes a 3% reduction for ITA TBB fleet and 5.2% for ITA OTB

Table 5.2.3 Common sole in GSAs 17: Annual catch scenarios by gear

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	ITA GNS	ITA TBB	ITA OTB	HRV GTR	HRV DRB
STECF advice basis							
F_{MSY} / MAP	2000	0.238	263	1093	381	198	66
$F_{MSY\ Transition}$^^	2125	0.258	280	1161	404	210	70
$F_{MSY\ lower}$*	1451	0.158	191	793	276	144	48
$F_{MSY\ upper}$*	2560	0.336	337	1399	487	253	84
Other scenarios							
Status quo^	1741	0.198	229	951	331	172	57
F 80% of status quo	1451	0.158	191	793	276	144	48
F 90% of status quo	1599	0.178	211	874	304	158	53
F 110% of status quo	1876	0.218	247	1026	357	186	62
F 120% of status quo	2000	0.238	263	1093	381	198	66
F 130% of status quo	2125	0.258	280	1161	404	210	70

* F_{MSY} ranges were derived using the formula provided by STECF 15-09: $F_{MSY\ upper}$ is assumed not to be precautionary. STECF does not advise fishing at $F>F_{MSY}$
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026
^ 3% reduction for ITA TBB fleet and 5.2% for ITA OTB

Basis of the advice

Table 5.2.4 Common sole in GSAs 17: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The assessment performed during the meeting is an update from the one benchmarked in GFCM in 2020 (FAO-GFCM, 2021). Results in terms of main output value are stable and consistent with the benchmark and with the update of 2021.

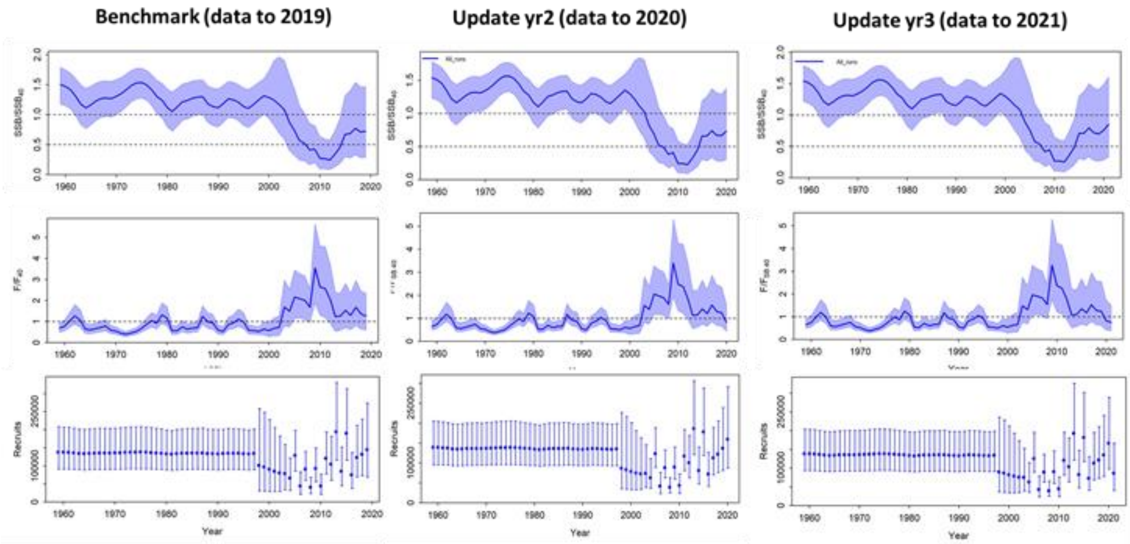


Figure 5.2.2 Common sole in GSAs 17: Assessment main outputs from benchmark, update 2021 and update 2022.

The interconnected diagnostic tests were considered acceptable and diagnostics scores were used as weighting factor during ensemble procedure. However, overall diagnostics for the CS (Cubic Spline) set (run 9 to 18) continue to deteriorate slightly compared to the benchmark model leading to heavier emphasis in the ensemble of models assuming dome-shaped selection for all fleets. This may represent a small increase in the risk of an assessment with a cryptic biomass. Moreover, the approach taken to weight the individual runs within the ensemble should be considered further as the science and experience around ensemble modelling develops in international community.

Forecasts were performed on the ensemble using the median estimate from the delta approximation (delta-MVLN) results for catch and SSB. Catches by fleet however could not technically be estimated in this way yet and were taken as the median of only the 18 forecast runs. Therefore fleet catches may not sum to the total catches.

All 18 runs appear to be sensitive to the specification of growth and its uncertainty as is usual for length based models with fixed growth functions.

Issues relevant for the advice

This stock is taken in a mixed fishery with Cuttlefish, Mantis Shrimp. Management of these stocks should be considered simultaneously.

Both the ITA TBB and HRV DRB use identical fishing techniques but are differently classified by member states. The effort reductions of 3% in F for the TBB fleet based on the effort reduction by management in 2022 (the interim year) was only applied to the ITA TBB fleet in line with the literal interpretation of the ToRs.

Partial F by fleet has been provided as a proportion of F by fleet (Table 5.2.11). The catches are dominated by Italian TBB and OTB, constituting 74% of the fishing mortality in the last three years (2019-2021)

Reference points

Table 5.2.5 Common sole in GSAs 17: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY B_{target} *	4022	$B_{40\%}$	STECF EWG 22-16
	F_{MSY}*	0.238	F at B40% from SS3 ensemble model	STECF EWG 22-16
Precautionary approach	B_{lim}*	2011	$B_{20\%}$	STECF EWG 22-16
	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. 238	F at B40% from SS3 ensemble model	STECF EWG 22-16
	MAP target range $F_{MSY\ lower}$	0.161	Based on regression calculation (see section 2)	
	MAP target range $F_{MSY\ upper}$	0.332	Based on regression calculation but not tested and presumed not precautionary	

*The reference points are expressed in relative terms as 40% of B0 (B_{target}) and the F that brings the stock to B_{target}. Moreover, both reference points are the median of the model ensemble and therefore the absolute value could slightly change when updating the model.

Basis of the assessment

Table 5.2.6 Common sole in GSAs 17: Basis of the assessment and advice.

Assessment type	Ensemble of SS3 models
Input data	DCF commercial data (catch), plus historical data from Fortibuoni e t al. 2017, LFDs, and scientific survey (SOLEMON) data.
Discards, BMS landings*, and bycatch	Discards not included, discards negligible
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.2.7 Common sole in GSAs 17: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted catch corresponding to advice	STECF catch	STECF landings	STECF discards
2021	Reduction of 1% of catch	1960	1588.6	1588.6	
2022	Reduction of 1% of catch	1960			
2023	$F = F_{MSY}$	2000			

*STECF provides advice on catches where ever possible; discards are negligible for this stock and are not included in this assessment

History of the catch and landings

Table 5.2.8 Common sole in GSAs 17: Catch and effort distribution by fleet in 2021 reported to STECF.

2020	Landings						Discards
Catch (t)	ITA TBB 60%	ITA OTB 18%	ITA Nets 13%	HRV GTR 6%	HRV DRB 3%	Other* <1%	t
	952	290	209	90	43	5	negligible
Effort	7753	60159	64001	33198	2879	5147	
	Fishing days						

* Slovenian (SVN) fleets not included in the assessment

Table 5.2.9 Common sole in GSAs 17: History of commercial landing. All weights are in tonnes. Effort in fishing days.

Year	ITA Nets *,**,^,°	ITA TBB *,**,^,°	ITA OTB *,**,^,°	HRV GTR ***,^^,°°	HRV DRB ***,^^	SVN GNS ^^^	SVN GTR ^^^	SVN OTB ^^^	Total landings	Total effort
1953	298.3	427.3	178.1	128.0	-	-	-	-	1031.7	-
1954	457.6	655.4	273.2	196.2	-	-	-	-	1582.3	-
1955	417.8	598.4	249.4	179.2	-	-	-	-	1444.9	-
1956	499.4	715.2	298.1	214.2	-	-	-	-	1726.9	-
1957	445.3	637.8	265.9	191.0	-	-	-	-	1540.0	-
1958	438.7	628.3	261.9	188.1	-	-	-	-	1516.9	-
1959	470.2	673.5	280.7	201.7	-	-	-	-	1626.2	-
1960	516.6	739.9	308.4	221.6	-	-	-	-	1786.4	-
1961	648.7	929.0	387.2	278.2	-	-	-	-	2243.1	-
1962	740.2	1060.1	441.9	317.5	-	-	-	-	2559.7	-
1963	601.1	860.9	358.9	257.8	-	-	-	-	2078.7	-
1964	369.0	528.5	220.3	158.3	-	-	-	-	1276.0	-
1965	371.5	532.1	221.8	159.3	-	-	-	-	1284.7	-
1966	416.5	596.5	248.6	178.6	-	-	-	-	1440.3	-
1967	461.9	661.5	275.7	198.1	-	-	-	-	1597.2	-
1968	499.0	714.7	297.9	214.0	-	-	-	-	1725.6	-
1969	377.8	541.1	225.5	162.0	-	-	-	-	1306.4	-
1970	359.4	514.8	214.6	154.1	-	-	-	-	1242.9	-
1971	303.0	434.0	180.9	129.9	-	-	-	-	1047.8	-
1972	275.9	395.1	164.7	118.3	-	-	-	-	954.1	-
1973	326.2	467.1	194.7	139.9	-	-	-	-	1127.9	-
1974	376.4	539.0	224.7	161.4	-	-	-	-	1301.5	-
1975	468.4	670.9	279.6	200.9	-	-	-	-	1619.9	-
1976	574.1	822.2	342.7	246.2	-	-	-	-	1985.2	-
1977	650.7	931.9	388.4	279.1	-	-	-	-	2250.1	-
1978	554.9	794.8	331.3	238.0	-	-	-	-	1919.0	-
1979	754.6	1080.8	450.5	323.7	-	-	-	-	2609.7	-
1980	636.1	911.1	379.8	272.7	-	-	-	-	2199.7	-
1981	319.6	457.7	190.8	137.2	-	-	-	-	1105.2	-
1982	345.3	494.6	206.1	147.8	-	-	-	-	1193.8	-
1983	470.1	673.3	280.6	201.8	-	-	-	-	1625.8	-
1984	403.1	577.3	240.6	172.6	-	-	-	-	1393.6	-
1985	440.4	630.7	262.9	188.6	-	-	-	-	1522.6	-
1986	452.9	648.7	270.4	194.8	-	-	-	-	1566.8	-
1987	755.0	1081.3	450.7	324.0	-	-	-	-	2611.0	-
1988	567.8	813.2	339.0	243.5	-	-	-	-	1963.5	-
1989	537.8	770.2	321.0	231.1	-	-	-	-	1860.1	-
1990	351.6	503.5	209.9	150.5	-	-	-	-	1215.5	-

1991	335.1	479.9	200.0	143.4	-	-	-	-	1158.4	-
1992	540.7	774.5	322.8	231.9	-	-	-	-	1869.9	-
1993	572.8	820.3	341.9	246.1	-	-	-	-	1981.1	-
1994	652.3	934.3	389.4	279.7	-	-	-	-	2255.7	-
1995	560.9	803.3	334.8	240.8	-	-	-	-	1939.8	-
1996	347.3	497.4	207.3	148.7	-	-	-	-	1200.7	-
1997	355.9	509.7	212.4	152.3	-	-	-	-	1230.3	-
1998	336.7	482.3	201.0	144.3	-	-	-	-	1164.3	-
1999	363.8	521.0	217.2	155.8	-	-	-	-	1257.8	-
2000	286.5	410.4	171.1	148.7	-	-	-	-	1016.7	-
2001	296.4	424.6	177.0	182.4	-	-	-	-	1080.4	-
2002	276.3	395.7	165.0	210.7	-	-	-	-	1047.7	-
2003	587.6	841.6	350.8	289.5	-	-	-	-	2069.5	-
2004	463.1	398.7	453.7	217.8	-	-	-	-	1533.3	257308
2005	700.2	373.1	558.8	287.7	-	0.9	5.1	0.2	1926.0	280102
2006	769.1	863.1	248.0	176.2	-	1.3	3.9	0.2	2061.8	249146
2007	520.5	691.6	226.1	185.0	-	1.9	6.4	0.2	1631.7	229672
2008	454.9	576.1	199.3	123.9	-	1.3	5.2	0.3	1361.0	207307
2009	573.7	849.5	284.1	266.5	-	1.0	9.0	0.2	1984.0	233961
2010	577.2	664.6	236.2	210.7	-	0.7	7.1	0.2	1696.5	221595
2011	732.4	414.1	224.3	281.5	-	0.6	12.0	0.3	1665.1	234506
2012	857.3	639.8	266.3	127.1	9.6	0.7	7.3	0.1	1908.3	247606
2013	291.2	545.2	241.8	182.6	21.5	1.6	12.2	0.5	1296.6	196468
2014	642.2	1059.9	283.3	121.6	29.9	1.1	12.4	0.4	2150.7	207119
2015	479.1	1177.5	293.4	171.2	49.2	1.3	11.2	0.0	2183.0	188817
2016	429.5	1026.5	503.9	105.8	44.7	1.3	9.4	0.1	2121.1	193818
2017	496.3	1273.6	337.6	152.8	44.9	2.1	10.8	0.1	2318.1	183528
2018	270.6	1094.0	392.8	139.8	38.3	0.8	8.9	0.2	1945.3	204200
2019	291.8	1093.4	381.2	124.7	41.9	0.7	10.4	0.3	1944.4	194145
2020	191.5	795.1	276.8	144.0	47.8	0.3	7.5	0.7	1463.7	167339
2021	208.7	951.6	290.0	89.8	43.3	0.2	4.8	0.2	1588.6	173137

*Values from 1953-1979 are catches obtained from ISTAT-IREPA revised by Fortibuoni et al., 2017. **Values from 1980-2003 are catches from FAO FishStatJ. ***Values from 1980-2011 are catches from FAO FishStatJ. ^Values in 2004-2021 are official catches from ITA DCF. ^^Values in 2012-2021 are official catches in Zone A from HRV DCF. ^^^Values in 2005-2021 are official catches from SVN DCF. ° Partition by fleet from 1953 to 2003 applying to the proportion (average ratio along the years) observed in DCF data (2004-2019). °° Reconstruction from 1953 to 1980 applying a ratio between ITA and HRV in the first 10 years of FishtatJ data.

Summary of the assessment

Table 5.2.10 Common sole in GSAs 17: Assessment summary. Weights are in tonnes. 'High' and 'Low' represent 95% confidence intervals.

Year	SSB Tonnes	High	Low	F ages 1-4	High	Low	Recruitment age 0 thousands	High	Low
1961	7049	3640	12269	0.220	0.157	0.337	137496	92994	202424
1962	6536	3250	11636	0.269	0.188	0.424	136352	92373	200430
1963	5886	2767	10841	0.227	0.157	0.367	134649	91379	197788
1964	5585	2602	10401	0.135	0.095	0.215	133698	90803	196666
1965	5826	2886	10564	0.129	0.092	0.198	134336	91293	198026
1966	6129	3194	10828	0.141	0.101	0.212	135075	91840	199364
1967	6320	3376	11003	0.156	0.112	0.233	135510	92167	200105
1968	6376	3423	11041	0.170	0.122	0.254	135605	92269	200256
1969	6325	3374	10969	0.128	0.092	0.190	135449	92219	200006
1970	6503	3531	11143	0.118	0.086	0.174	135868	92477	200702
1971	6729	3717	11378	0.097	0.071	0.141	136347	92776	201503
1972	7052	3975	11730	0.086	0.063	0.123	137039	93152	202630
1973	7402	4240	12121	0.100	0.074	0.142	137746	93518	203689
1974	7602	4359	12369	0.115	0.085	0.164	138121	93719	204156
1975	7642	4339	12448	0.146	0.108	0.211	138212	93756	204147
1976	7456	4131	12281	0.187	0.136	0.274	137887	93588	203454
1977	7043	3754	11855	0.223	0.160	0.337	137077	93162	202003
1978	6499	3306	11266	0.197	0.140	0.303	135869	92504	200003
1979	6209	3109	10918	0.280	0.196	0.441	135139	92089	199002
1980	5613	2658	10232	0.247	0.170	0.399	133484	91042	196539
1981	5296	2461	9813	0.119	0.083	0.189	132465	90348	195295
1982	5665	2848	10154	0.120	0.086	0.183	133576	91131	197431
1983	6061	3222	10553	0.160	0.115	0.240	134661	91831	199172
1984	6171	3313	10666	0.137	0.098	0.203	134928	92021	199544
1985	6356	3463	10863	0.148	0.107	0.219	135359	92303	200245
1986	6443	3524	10966	0.152	0.110	0.225	135567	92428	200526
1987	6479	3535	11015	0.267	0.190	0.404	135643	92490	200613
1988	5901	3016	10399	0.211	0.148	0.328	134161	91607	198170
1989	5682	2851	10134	0.200	0.140	0.312	133521	91208	197345
1990	5598	2810	10008	0.126	0.089	0.194	133257	91035	197099
1991	5916	3115	10323	0.114	0.082	0.171	134144	91615	198649
1992	6293	3447	10728	0.183	0.132	0.273	135125	92213	200155
1993	6225	3365	10677	0.201	0.143	0.302	134965	92127	199750
1994	6032	3183	10477	0.238	0.168	0.366	134455	91834	198922
1995	5686	2886	10095	0.209	0.146	0.327	133478	91234	197462
1996	5543	2785	9916	0.125	0.089	0.193	133052	90948	196909
1997	5863	3090	10241	0.122	0.087	0.183	133954	91531	198485

1998	6205	3390	10611	0.114	0.082	0.168	90007	36701	235230
1999	6541	3664	10982	0.137	0.083	0.215	86967	35292	227925
2000	6457	3470	10886	0.124	0.065	0.206	82347	33872	212670
2001	6208	3153	11115	0.144	0.072	0.248	78366	33416	193530
2002	5779	2784	11250	0.152	0.075	0.263	75812	34521	172703
2003	5295	2471	11074	0.348	0.173	0.609	75223	38781	152036
2004	4221	1748	9914	0.310	0.160	0.520	63114	36217	114586
2005	3525	1491	8763	0.464	0.247	0.726	125175	89210	194885
2006	2664	1128	7227	0.451	0.254	0.688	42849	23521	78584
2007	2400	1125	6452	0.435	0.239	0.667	89198	63000	137089
2008	1860	824	5402	0.367	0.211	0.538	39566	25233	64971
2009	1913	1014	5105	0.774	0.408	1.183	90614	59344	146119
2010	1181	472	3923	0.558	0.278	0.948	44592	24305	76402
2011	1145	484	3620	0.535	0.254	0.929	120754	81374	195563
2012	1060	446	3434	0.424	0.202	0.752	103894	63180	180176
2013	1467	698	4169	0.258	0.117	0.487	192444	121293	325761
2014	1977	1014	5185	0.266	0.132	0.481	82603	47626	147293
2015	2900	1590	7043	0.327	0.159	0.583	181789	117518	301412
2016	2873	1451	7523	0.282	0.141	0.495	72611	40944	130160
2017	3232	1686	8271	0.371	0.186	0.642	112998	68816	195184
2018	2887	1379	7985	0.309	0.150	0.560	121095	73027	210196
2019	2820	1313	7899	0.301	0.145	0.559	135008	78323	239851
2020	3025	1404	8355	0.200	0.095	0.377	166243	98121	288552
2021	3440	1686	9060	0.180	0.091	0.326	86379	40613	166466

Table 5.2.11 Common sole in GSAs 17: Partial F (% of total F) from 2005 when more detail on catch is available.

Year	ITA Nets	ITA TBB	HRV GTR	ITA OTB	HRV DRB
2005	34.8%	18.7%	16.0%	30.4%	0.0%
2006	32.9%	41.0%	12.5%	13.6%	0.0%
2007	29.4%	41.1%	14.3%	15.1%	0.0%
2008	30.5%	41.3%	12.3%	15.9%	0.0%
2009	28.0%	41.9%	15.0%	15.1%	0.0%
2010	26.0%	34.1%	24.4%	15.6%	0.0%
2011	34.4%	21.2%	30.0%	14.4%	0.0%
2012	36.2%	31.4%	15.3%	16.3%	0.9%
2013	16.6%	35.4%	26.4%	19.1%	2.4%
2014	24.4%	46.8%	11.7%	14.9%	2.2%
2015	20.4%	53.0%	10.1%	13.9%	2.6%
2016	17.4%	46.1%	7.5%	26.0%	2.9%
2017	20.4%	54.5%	7.8%	15.1%	2.2%
2018	12.4%	53.3%	9.7%	22.0%	2.6%
2019	13.3%	53.9%	9.0%	20.9%	2.8%
2020	11.0%	49.9%	14.6%	20.0%	4.4%
2021	11.4%	57.4%	8.4%	19.4%	3.5%

Since partial F is not directly available from the ensemble model, the median from the 18 runs was used for the calculation. This approximation leads to a small discrepancy between the sum of the partial F and the F_{bar} coming from the ensemble (runs weighted differently according to the diagnostic scores). For this reason, the group agreed to report partial F as a ratio and not as an absolute F value.

Sources and references

EWG 22-16

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5.3 Summary Sheet for red mullet in GSA 17 and 18

STECF advice on fishing opportunities

Based on MSY considerations, STECF EWG 22-16 advises to decrease the total catch by 20.5% relative to the average catches in 2019-2021 equivalent to catches of no more than 3043 tons in 2023.

Stock development over time

The MEDITS biomass index was used to provide an index for change (Figure 5.3.1). The stock shows a marked increase in recent years, especially from 2008. From 2008 the stock has increased rapidly reaching its maximum in 2021 (well above the reference point $I_{trigger}$). Based on the index value in the last two years relative to the previous three years the increase in biomass in recent years is estimated to be 1.26 times.

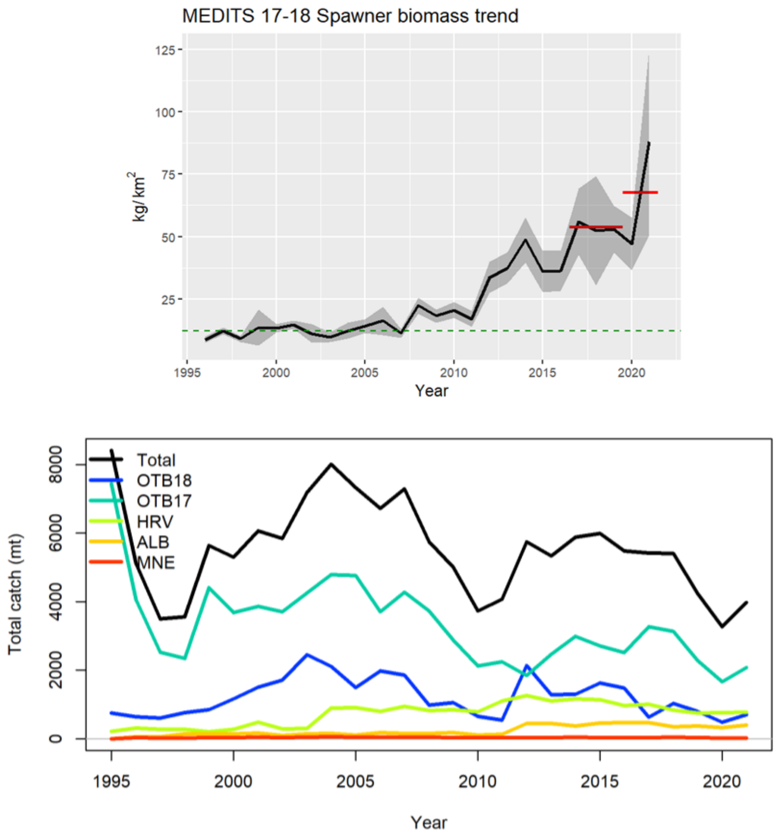

Figure 5.3.1 Red mullet in GSAs 17 and 18: (top panel) MEDITS in GSAs 17-18 spawning biomass index. The green dashed line represents Itrigger. The two red segments represent the mean index of 2020-2021 and of 2017-2019. (bottom panel) Catch by year and fleet.

Stock and exploitation status

The fishing pressure proxy on the stock is higher than F_{MSY} proxy (Figure 5.3.2), and the stock size index is above MSY $B_{trigger}$ proxy ($I_{trigger}$) (Figure 5.3.1).

Table 5.3.1 Red mullet in GSAs 17 and 18: State of the stock and fishery relative to reference points.

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

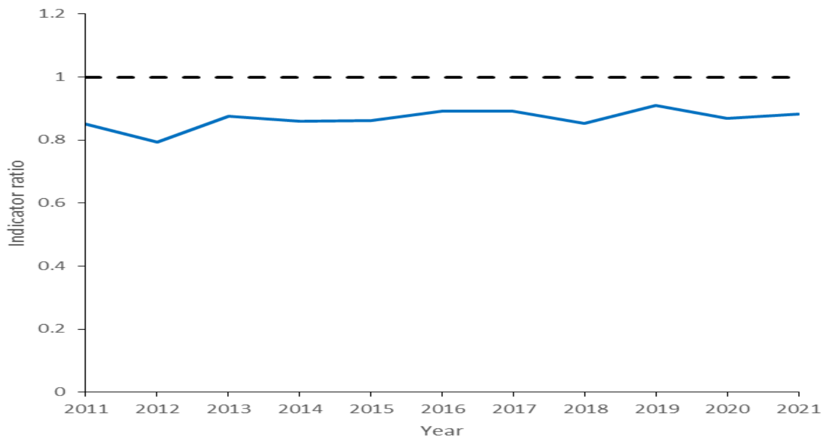

Figure 5.3.2 Red mullet in GSAs 17 and 18: Length indicator (mean length of fish in the catch divided by MSY proxy reference length). The exploitation status is below F_{MSY} proxy when the indicator ratio value is higher than 1 (shown by the dashed line).

Catch scenarios

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

Table 5.3.2 Red mullet in GSAs 17 and 18: Basis for the catch scenarios. The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the tables.

Last year catch C_{y-1} (average catch in 2019-2021)	3830 tonnes	
Stock biomass trend		
Index A (2020, 2021)	67.6 kg / km²	
Index B (2017, 2018, 2019)	53.7 kg / km²	
r: Index ratio (A/B)	1.26	
Fishing pressure proxy		
Mean catch length ($\bar{L}_{y-1}=L_{2021}$)	11.83	
MSY proxy length ($L_{F=M}$)	13.41	
f: multiplier for relative mean length in catches ($\bar{L}_{y-1}/L_{F=M\ 2021}$)	0.88	
Biomass safeguard		
Last index value (I_{2021})	88 kg / km²	
Index trigger value ($I_{trigger}=1.4*I_{loss}$)	12.21 kg / km²	
b: index relative to trigger value, min{$I_{2021}/I_{trigger}$, 1}	1	
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability		
m: multiplier (generic multiplier based on life history)	0.9	
rfb calculation*		
Uncertainty cap (+20%/-30% compared to C_{y-1}, only considered if b≥1)	Not applied	
Discard rate	34%	
Catch advice for 2023	3043 tonnes	
% advice change**	-20.5%	

* $C_{(y+1)} = C_y \times r \times f \times b \times m$ limited by stability clause if applicable.
** Advice value for 2023 relative to the catch in 2019-2021 (3830 tonnes).

Basis of the advice

Table 5.3.4 Red mullet in GSAs 17 and 18: The basis of the advice.

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

Quality of the assessment

Despite the exploration carried out during EWG 22-16 no run was considered suitable to provide advice at this stage. The ICES category 3 Method 2.1 was applied. This involves two reference points, a biomass MSY Btrigger proxy and F_{MSY} proxy. The biomass proxy available from the MEDITS series shown above is considered robust (only spawners considered), with good indication of sustainable exploitation in recent years. The F_{MSY} proxy defining optimal exploitation rate is not considered particularly good for this stock as length contrast is very limited (see Figure 5.3.2 above) and comparison of length and F indicators (EWG 16-13) suggest the Length indicators are poor at informing F levels, though they can sometimes be used to infer F change. For short living stocks, length indicators tend to respond to recruitment more than exploitation rate.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.3.5 Red mullet in GSAs 17 and 18: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$ proxy	12.21	Biomass index trigger value ($I_{trigger}$), defined as $I_{trigger} = I_{loss} \times 1.4$, where I_{loss} is the lowest observed historical spawning biomass index value from 1996 MEDITS in GSAs 17-18. In kg / km^2.	STECF EWG 22-16
	$F_{MSY\ proxy}$	0.88	$L_{mean}/L_{F=M}$; Mean catch length divided by MSY proxy reference length ($L_{F=M}$).	STECF EWG 22-16
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	SSB_{mgt}		Not Defined	
	F_{mgt}		Not Defined	

Basis of the assessment

Table 5.3.6 Red mullet in GSAs 17 and 18: Basis of the assessment and advice.

Assessment type	Survey biomass trend applying the rfb rule for advice (ICES, 2022)
Input data	DCF commercial data (catch) and scientific survey (MEDITS) data
Discards and bycatch	Discards included.
Indicators	Length-based indicator
Other information	
Working group	STECF EWG 22-16

History of the advice, catch, and management

Table 5.3.7 Red mullet in GSAs 17 and 18: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	$F = F_{MSY}$		5083	4381	
2020	$F = F_{MSY}$		6078	3250	
2021	$F = F_{MSY}$		3285	3861	
2022	$F = F_{MSY}$		4279		
2023	MSY approach (ICES category 3 method 2.1)		3043		

History of the catch and landings

Table 5.3.8 Red mullet in GSAs 17 and 18: Catch and effort distribution by fleet in 2021 as estimated by and reported to STECF (DCF data, Albania and Montenegro included only for catches).

2021		Wanted catch				Discards
Catch (t)		Otter trawl 97%	Gillnets 1.5%	GTR 0%	Other 1.4%	t
	3506	3397	54.8	1.8	52	46
Effort (Fishing days)		135 086	161 333	85 588		
		Fishing days				

Table 5.3.9 Red mullet in GSAs 17 and 18: History of commercial landings; the official reported values are presented by country. All weights are in tonnes. OTB Effort in fishing days (OTB currently catches 97%).

Year	ITA 17+SVN	HRV	ITA 18	ALB	MTN	Total	OTB Effort (fishing days)
2006	3101	805	1934	185	47	6072	189181
2007	3298	950	1802	154	48	6252	165677
2008	3158	826	961	162	42	5149	157594
2009	2433	844	1031	187	40	4535	178099
2010	1796	792	646	113	38	3386	157246
2011	1890	1102	532	132	35	3691	149019
2012	1525	1262	2096	450	39	5372	169736
2013	1979	1102	1250	448	35	4814	172071
2014	2399	1168	1272	380	45	5265	153144
2015	2220	1144	1587	466	40	5457	148737
2016	2042	972	1448	475	41	4978	150419
2017	2672	1001	620	470	36	4799	161943
2018	2517	842	1004	347	43	4753	170204
2019	1733	748	775	373	40	3668	288445
2020	1261	762	466	333	26	2849	128052
2021	1582	773	679	399	28	3460	135086

Summary of the assessment

Table 5.3.10 Red mullet in GSAs 17 and 18: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Biomass Index			Length indicator	Catch
	Low	Value	High		tonnes
1996	6	9	11		
1997	9	12	15		
1998	7	9	11		
1999	0	14	28		
2000	10	13	16		
2001	11	15	18		
2002	4	11	19		
2003	6	10	13		
2004	6	12	19		
2005	9	14	20		
2006	5	16	27		
2007	8	11	15		
2008	16	22	29		
2009	13	18	23		
2010	14	21	27		
2011	11	17	23	13	4581
2012	21	34	46	11	6167
2013	25	37	50	12	5146
2014	31	49	67	12	5874
2015	19	36	53	12	6211
2016	20	36	52	13	5566
2017	29	56	83	13	5887
2018	9	52	96	11	6353
2019	34	53	72	12	4381
2020	26	47	68	13	3250
2021	13	88	163	12	3861

Sources and references

STECF EWG 22-16

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

5.4 SUMMARY SHEET FOR NORWAY LOBSTER IN GSAS 17 AND 18

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.275 and corresponding catches in 2023 should be no more than 2626 tons.

Stock development over time

The SPICT model accepted to assess Norway lobster in GSA 17-18 uses the most complete data set fitted to the longest time series available covering also periods with high biomass and low F, some stock declines and recoveries. The assessment shows a reduction in B/Bmsy since 60s, with values consistently below 1 since mid-90s with an increase in the last years. In terms of F/Fmsy the assessment indicates an increase since the early '90s with values over 1 since mid-2000, and after 2010 shows a decrease, with F in 2021 below F_{MSY}.

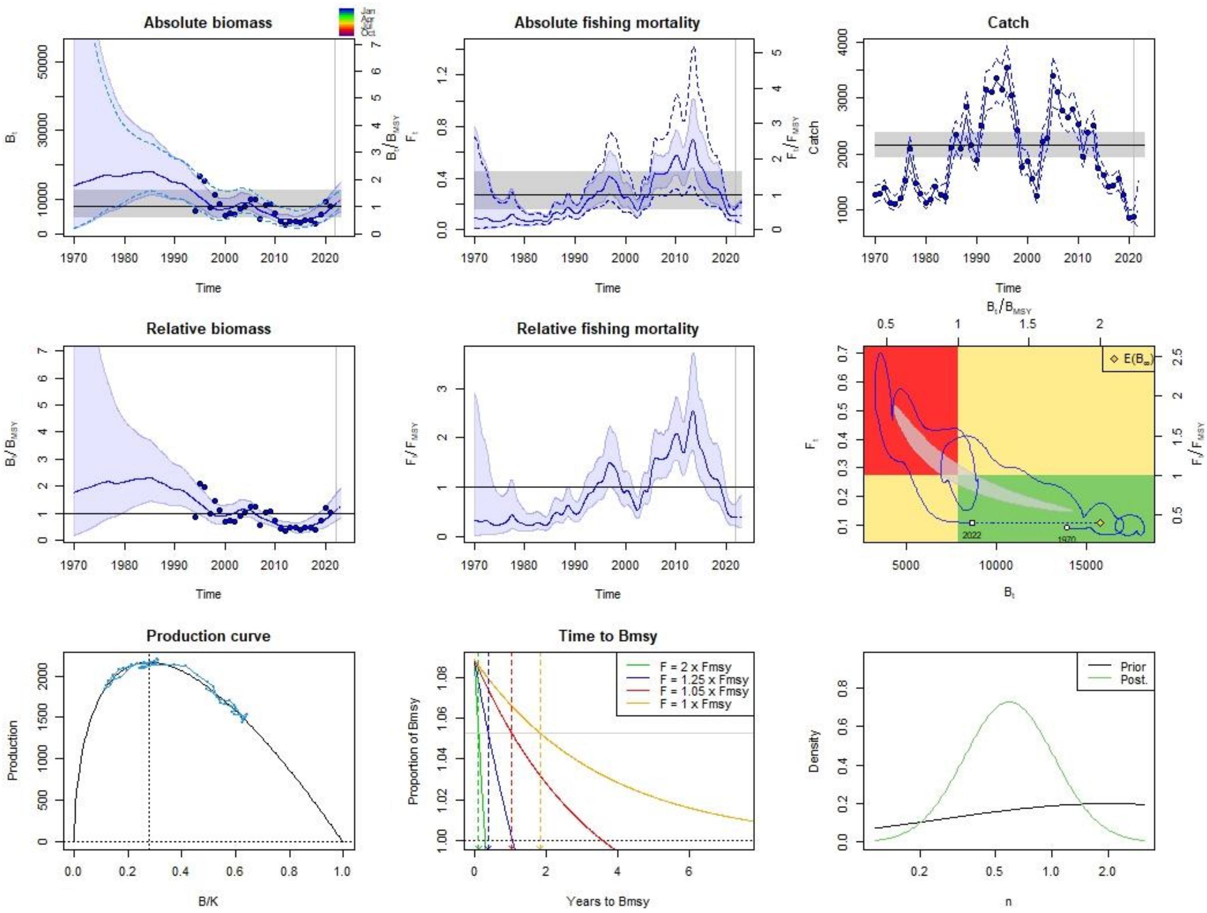

Figure 5.4.1 Norway lobster in GSA 17 and 18. SPICT model main outputs.

Stock and exploitation status

The status of the stock in 2021 using mean value by year, referred to the reference points B is above B_{MSY} = 7874 and F is below F_{MSY} = 0.275 implying that F is also below $F_{MSY\ Transition}$.

Table 5.4.1 Norway lobster in GSA 17 and 18. State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.4.2 Norway lobster in GSA 17 and 18. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ all}$ (2022)	0.109	Harvest rate 2021 from surplus production model (SPICT)
Catch (2022)	998.5 t	
Biomass 2022	9202	Biomass assuming F status quo in 2022

Table 5.4.3a Norway lobster in GSA 17 and 18: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{msy} (2023)	SSB (2024)	% SSB change***	% Catch change#
STECF advice basis					
FMSY	2626	0.275	9129	-1%	+67%
F (HR) Transition ^^	2437	0.253	9381	2%	+64%
$F_{MSY\ lower}$	1833	0.184	10201	11%	+52%
$F_{MSY\ upper}$	3460	0.379	8048	-13%	+75%
Other scenarios					
Zero catch	0	0	12827	39%	-100%
Status quo	998.5	0.109	11204	22%	+14

*** % change in SSB 2024 to 2022

#Catch in 2023 relative to Catch in 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026

Table 5.4.3 b Norway lobster in GSA 17 and 18: Annual catch scenarios by gears and GSA. All weights are in tonnes.

Basis	Total catch* (2023)	F_{msy}** (all) (2023)	Catch 2023 GSA 17		Catch 2023 GSA 18
STECF advice basis			OTB	FPO	OTB
F_{MSY}	2626	0.275			
$F_{MSY\ lower}$	1833	0.184			
$F_{MSY\ upper}$	3460	0.379			

In addition to the main catch advice for Norway lobster, further analysis based on splitting the whole area into sub-areas and allocating catch based on the same exploitation rate across all sub areas gives the following catch allocation for exploitation at F_{MSY} and FMST Transition.

Table 5.4.3 c Norway lobster in GSA 17 and 18: Annual catch scenarios by areas. All weights are in tonnes. GSA 17 is split into three areas, Pomo/Jabuka Pit (Depth greater than 100m in GSA 17, and the remaining area split East and West as Kvarner and Ancona respectively.

	Total GSA 17-18	Ancona	GSA 18	Kvarner	Pomo/ Jabuka Pit
B 2021	7976	251	404	1134	6187
Fmsy from SPiCT Model (HR)	0.28	0.28	0.28	0.28	0.28
F (HR) Transition 2023 from F 2019 to F_{MSY} 2026	0.26	0.26	0.26	0.26	0.26
Catch 2023 at F= F_{MSY}	2626	70	113	318	1732
Catch at F transition	2437	64	103	290	1582

Basis of the advice

Table 5.4.4 Norway lobster in GSA 17 and 18. The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

All the diagnostics were considered acceptable.

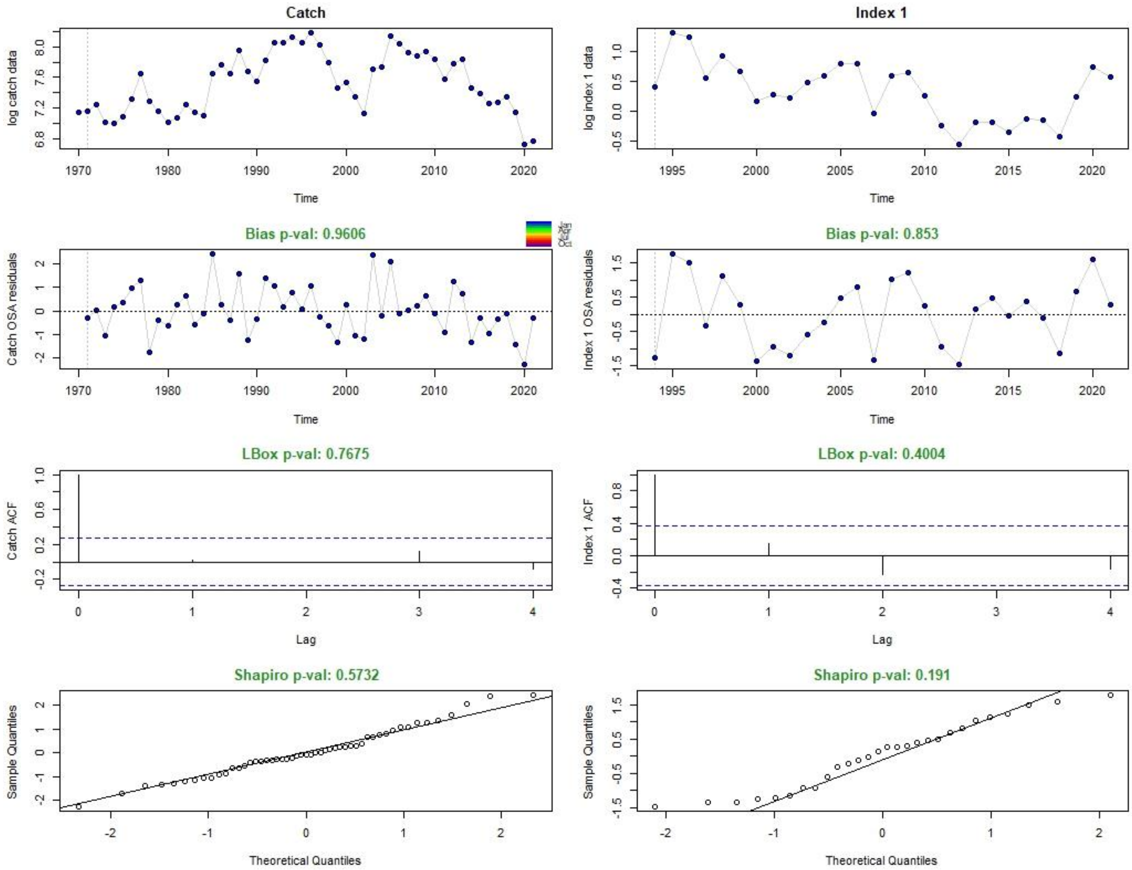

Figure 5.4.2 Norway lobster in GSA 17 and 18. SPICT model diagnostics

The retrospective analysis run on the SPiCT model showed consistent results in terms of F/F_{MSY} and B/B_{MSY}, though not in terms of absolute values of F and biomass which as can be seen in the figure are more difficult to estimate that the relative values. The revised model shows less retrospective revision than last year's assessment; with upward revision of biomass and downward revision in F, the revisions are well within accepted limits. Catches in 2021 are similar to 2020. It is common for stock assessments to show more retrospective changes during periods of management change. The reduced confidence intervals with respect to the previous assessment reflect less uncertainties of this model and the improved retrospective suggests better stability.

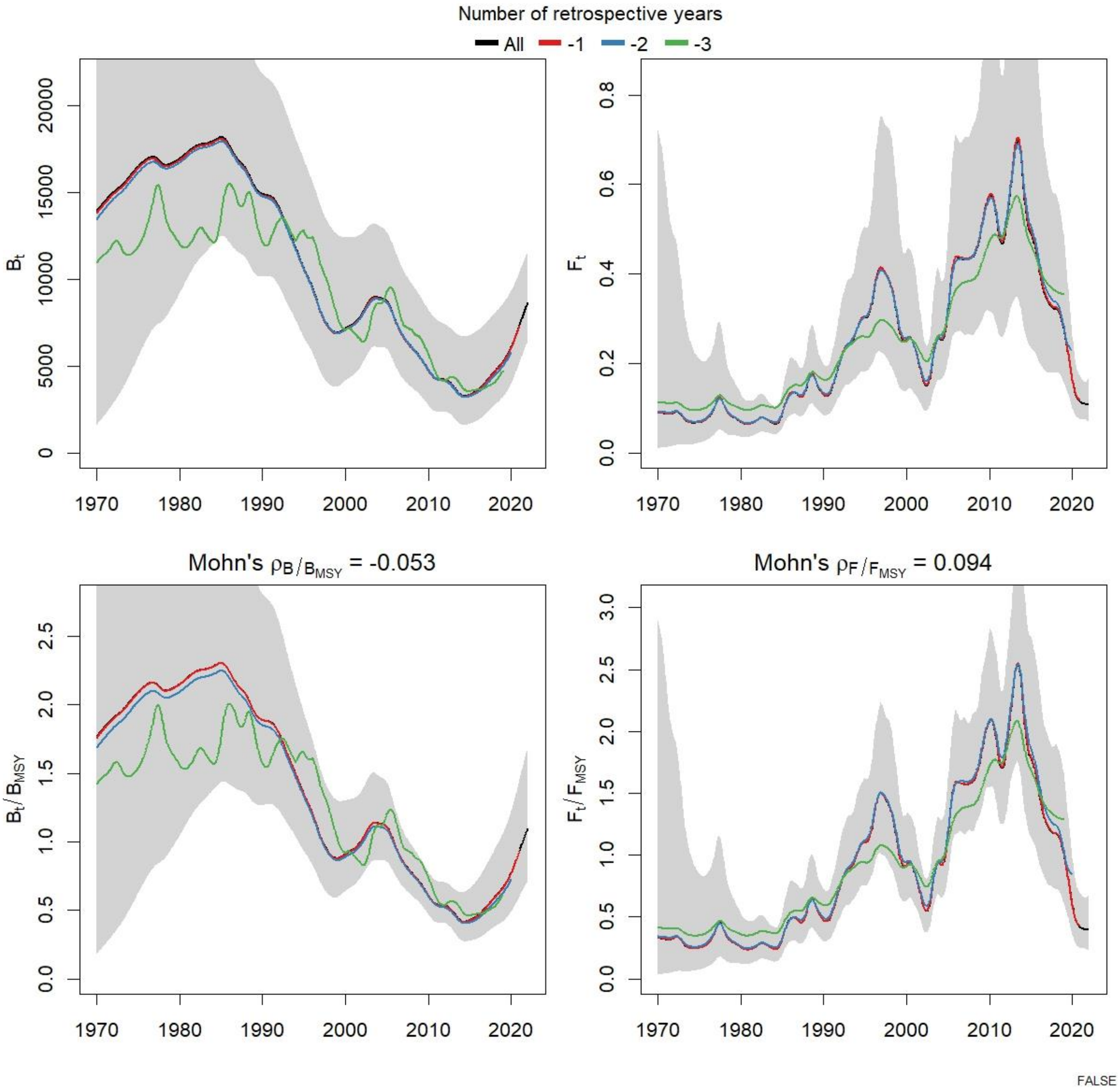

Figure 5.4.3 Norway lobster in GSA 17 and 18. Historical assessment results. (Retrospective graph)

Issues relevant for the advice

The Norway lobster sub-area shows biomass indices strongly suggest that Ancona and GSA 18 are still at a relatively poor state (Figure 5.4.4) with historically lower biomasses in recent years (0.31 and 0.34 respectively; Table 5.4.5). In contrast the situation for biomass in Kvarner and Pomo/Jakuba Pit is likely to be within acceptable limits (0.70 and 2.12 respectively; Table 5.4.5). Given this information on the state of the biomass it would be prudent to keep exploitation rates in line with local biomass, and in the case Ancona and GSA 18 consider additional protective measures.

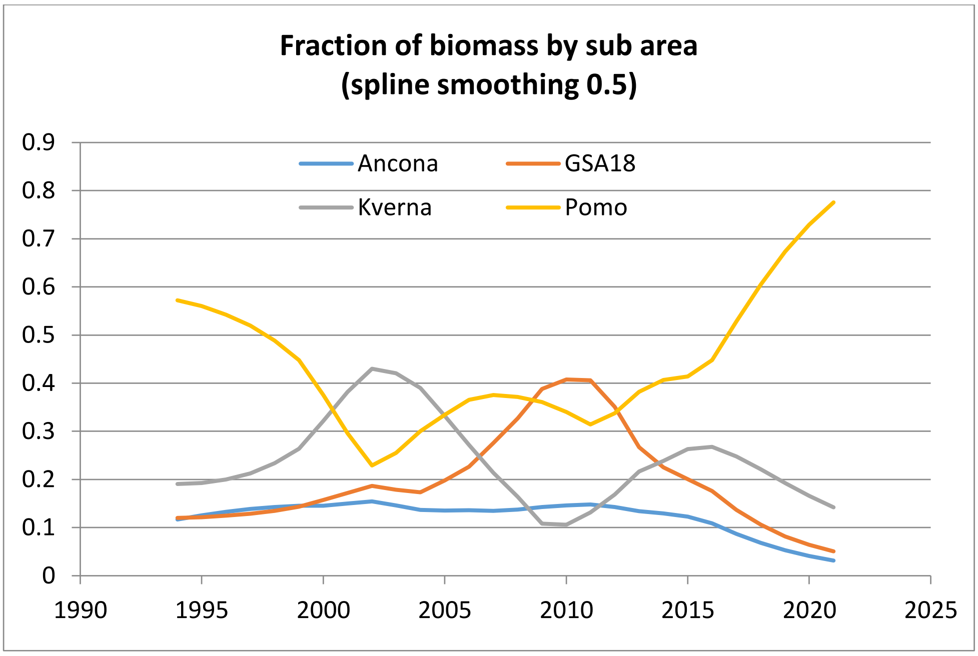

Figure 5.4.4 Norway lobster in GSA 17 and 18. Relative Biomass 1994-2021 by sub-area from smoothed MEDITS biomass data. Biomass in Ancona and GSA 18 are at historic lows for the period, Biomass in Kvarner is below average, Biomass in Pomo/Jabuka Pit is above average.

Table 5.4.5 Norway lobster in GSA 17-18 biomass by sub area.

	Total GSA 17-18	Ancona	GSA 18	Kvarner	Pomo/Jabuka Pit
Average biomass 94-2021	6530	806	1187	1624	2912
B 2021	7976	251	404	1134	6187
B2021/B1994-2021	1.22	0.31	0.34	0.70	2.12

Reference points

Table 5.4.5 Norway lobster in GSA 17 and 18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	4409.24	MSY Btrigger = B_{pa} = B_{lim}*1.4	STECF EWG 22-16
	F_{MSY}	0.275	F target (MSY reduced)	STECF EWG 22-16
Precautionary approach	B_{lim}	3149.46	B_{lim} = 40% Bmsy	
	B_{pa}	4409.2	B_{pa} = B_{lim} *1.4	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY Btrigger		MSY Btrigger = B_{pa} = B_{lim} *1.4	STECF EWG 22-16
	MAP B_{lim}		B_{lim} = 40% Bmsy	STECF EWG 22-16
	MAP F_{MSY}		F target (MSY reduced)	STECF EWG 22-16
	MAP target range F_{lower}	0.184		STECF EWG 22-16
	MAP target range F_{upper}	0.379		STECF EWG 22-16

Basis of the assessment

Table 5.4.6 Norway lobster in GSA 17 and 18. Basis of the assessment and advice.

Assessment type	Production model (SPICT)
Input data	DCF commercial data (landings), historical landings (FAO-GFCM and ISTAT), scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	From DCF data
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.4.7 Norway lobster in GSA 17 and 18. 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} (reduced B< B_{pa})		745	1247	
2020	F = F_{MSY} (reduced B< B_{pa})		785	834	
2021	F = F_{MSY} (reduced B< B_{pa})		1218	867	
2022	F = F_{MSY}		1986		
2023	F = F_{MSY}		2626		

History of the catch and landings

Table 5.4.8 Norway lobster in GSA 17 and 18. Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch		Discards
Catch (t)		OTB 0.89%	FPO 0.11%	t
		587.5	74.3	0
Nominal Effort		130313.4	453.2	
		(Days at sea GSA17-18)		

Table 5.4.9 Norway lobster in GSA 17 and 18. History of commercial landings; both the official reported values are presented by country, official reported BMS landings, STECF estimated landings and the TAC are presented. All weights are in tonnes. Effort in days at sea.

Year	ITALY GSA17-18	CROATIA GSA 17	ALBANIA GSA 18	Total landings	Total Effort
1970	1270			1270	
1971	1283			1283	
1972	1397			1397	
1973	1113			1113	
1974	1098			1098	
1975	1197			1197	
1976	1520			1520	
1977	2104			2104	
1978	1469			1469	
1979	1288			1288	
1980	1116			1116	
1981	1185			1185	
1982	1407			1407	
1983	1270			1270	
1984	1219			1219	
1985	2109			2109	
1986	2350			2350	
1987	2087			2087	
1988	2836			2836	
1989	2159			2159	
1990	1890			1890	
1991	2507			2507	
1992	3151			3151	
1993	3122			3122	
1994	3366			3366	
1995	3148			3148	
1996	3558			3558	
1997	3058			3058	
1998	2426			2426	
1999	1753			1753	
2000	1864			1864	
2001	1559			1559	
2002	1252			1252	
2003	2219			2219	
2004	2279			2279	256292.2
2005	3394			3394	238583.3
2006	3107			3107	223146.0
2007	2775	344		2775	189204.1
2008	2654	408		2654	178527.1
2009	2800	303		2800	209530.5

2010	2523	731		2523	178268.9
2011	1956	237		1956	166983.9
2012	1520	370	435	1955	198885.0
2013	1441	278	398	2117	227575.3
2014	981	343	400	1724	192153.6
2015	900	303	405	1608	182556.1
2016	757	237	411	1405	185499.1
2017	844	200	389	1433	196024.0
2018	1036	231	257	1524	218413.1
2019	769	265	213	1247	203901.5
2020	404	236	194	834	177132.9
2021	406	250	211	867	130313.4

*** No landings in Slovenia. We report the effort for HRV from 2012 to 2021 only.**

Summary of the assessment

Table 5.4.10 **Norway lobster in GSA 17 and 11:** Assessment summary. Weights are in tonnes. ‘High’ and ‘Low’ are 2 standard errors (approximately 95% confidence intervals).

Year	Biomass tonnes	High	Low	Catch tonnes	F ages all	High	Low
1970	14196			1267	0.09		
1971	14746			1296	0.09		
1972	15187			1362	0.09		
1973	15628			1134	0.07		
1974	16199			1102	0.07		
1975	16696			1207	0.07		
1976	16990			1540	0.09		
1977	16823			1994	0.12		
1978	16583			1506	0.09		
1979	16778			1280	0.08		
1980	17118			1132	0.07		
1981	17509			1196	0.07		
1982	17734			1379	0.08		
1983	17840			1272	0.07		
1984	18056			1275	0.07		
1985	17998			2038	0.11		
1986	17273			2313	0.13		
1987	16631			2169	0.13		
1988	15890			2703	0.17		
1989	15066			2188	0.15		
1990	14815			1943	0.13		

1991	14504	2494	0.17
1992	13587	3096	0.23
1993	12404	3151	0.25
1994	11242	3300	0.29
1995	10126	3201	0.32
1996	8920	3498	0.39
1997	7706	3069	0.4
1998	7043	2422	0.34
1999	7027	1825	0.26
2000	7314	1840	0.25
2001	7679	1553	0.2
2002	8406	1335	0.16
2003	8939	2105	0.24
2004	8863	2365	0.27
2005	8303	3257	0.39
2006	7183	3122	0.43
2007	6395	2771	0.43
2008	5829	2675	0.46
2009	5189	2793	0.54
2010	4505	2514	0.56
2011	4230	2031	0.48
2012	4076	2354	0.58
2013	3559	2425	0.68
2014	3300	1781	0.54
2015	3485	1601	0.46
2016	3865	1434	0.37
2017	4412	1446	0.33
2018	4958	1523	0.31
2019	5617	1246	0.22
2020	6678	873	0.13
2021	7976	878	0.11

Sources and references

EWG 22-16

5.5 SUMMARY SHEET FOR EUROPEAN HAKE IN GSA 19

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.211 and corresponding catches of hake in 2022 should not exceed 468 tonnes.

Stock development over time

The SSB is increasing after 2016 while fishing mortality is decreasing.

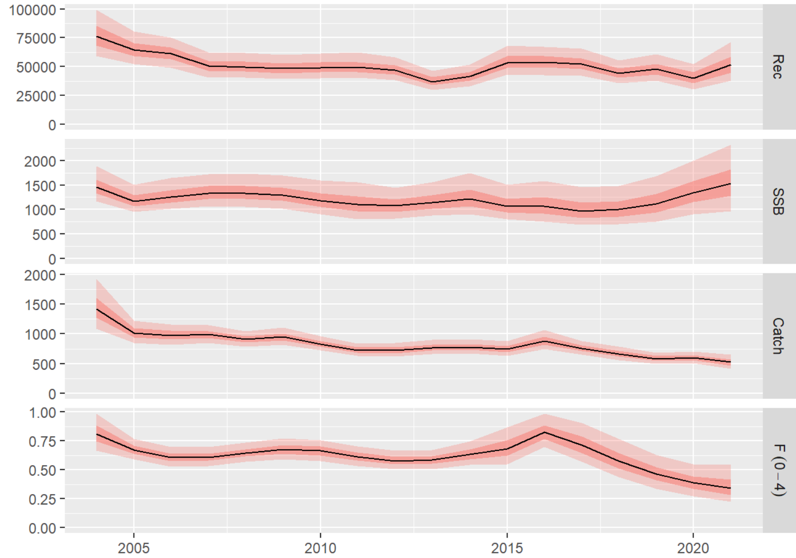

Figure 5.5.1 Hake (HKE) in GSA 19. Outputs of the a4a assessment. SSB and catch are in tonnes, recruitment in number (‘000) of individuals.

Stock and exploitation status

Current Fbar= 0.335 is higher than $F_{0.1}$ (0.211), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields. This indicates that hake stock in GSAs 19 is over-exploited.

Table 5.5.1 Hake in GSA 19. State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.5.2 Hake in GSA 19: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 0\text{-}4}$ (2022)	0.335	F status quo (in the interim year 2022) is assumed F_{bar} in the last assessment year (2021)
SSB (2022)	1924	SSB projection based on stock assessment
R_{age0} (2022, 2023)	50367	Geometric mean of the whole time series
Total catch (2022)	649	Catch at F status quo in 2022

Table 5.5.3 Hake in GSA 19: Annual catch scenarios. All weights are in tons.

Basis	Total catch (2023)	F_{total} (ages 0-4) (2023)	SSB (2024)	% SSB change**	% Catch change^
STECF advice basis					
F_{MSY} / MAP	468	0.211	2904	51	-10
$F_{MSY\ Transition}$^^	678	0.320	2652	38	30
$F_{MSY\ upper}$*	627	0.292	2713	41	20
$F_{MSY\ lower}$	325	0.142	3078	60	-38
Other scenarios					
Zero catch	0	0	3479	81	-100
Status quo	706	0.335	2618	36	35

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

** % change in SSB 2024 to 2022

^Total catch in 2023 relative to Catch in 2021.

^^F_{MSY} Transition is based on a linear change in F from 2022 to F_{MSY} in 2030

Basis of the advice

Table 5.5.4 Hake in GSA 19: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This stock was assessed using a4a at the hake benchmark meeting of GFCM in 2019 (GFCM 2019), by STECF EWG 20-15 in 2020, by STECF EWG 21-15 in 2021 and by STECF EWG 22-16 in 2022, on the basis of reconstructed data. Problems with retrospective performance were encountered initially last year and to a greater extent this year. This a4a assessment uses a different model settings than the one used by EWG 20-15 and EWG 21-15 and has an improved stability compared to the last year updated assessment. The conclusion that F>Fmsy is maintained by the present assessment (Table 5.5.1).

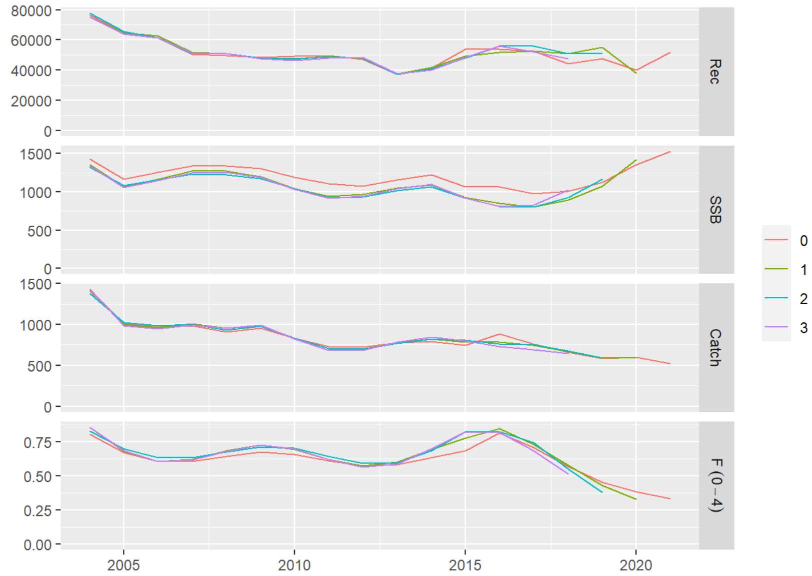

Figure 5.5.2 Hake in GSA 19: Historical assessment results (final-year recruitment estimates included). Retrospective graph.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.5.5 Hake in GSA 19: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	-	Not Defined	
	F_{MSY}	0.211	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 2022-16
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}	0.211	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 2022-16
	MAP target range F_{lower}	0.142	Based on regression calculation (see section 2)	STECF EWG 2022-16
	MAP target range F_{upper}	0.292	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 2022-16

Basis of the assessment

Table 5.5.6 Hake in GSA 19: 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 GSA 19
Other information	-
Working group	STECF EWG 2022-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.5.7 Hake in GSA 19: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tons.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	$F = F_{MSY}$		379	522	
2022	$F = F_{MSY}$		420		
2023	$F = F_{MSY}$		468		

History of the catch and landings

Table 5.5.8 Hake in GSA 19: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2022		Wanted catch				Discards
Catch (t)	621	Bottom trawl 64%	Gillnets 6 %	Trammel nets 10 %	Longlines 20 %	9
		Tons				
Effort		30094	36496	61748	11101	
		Fishing days				

Table 5.5.9 Hake in GSA 19: History of commercial landings. All weights are in tonnes. Effort is expressed in fishing days.

Year	Italy GSA 19	Total landings	Total Effort
2004	1299	1299	229455
2005	1271	1271	166921
2006	1629	1629	176066
2007	882	882	151657
2008	932	932	161885
2009	999	999	187026
2010	839	839	194831
2011	810	810	205963
2012	675	675	184899
2013	760	760	286251
2014	740	740	251228
2015	807	807	231839
2016	707	707	246118
2017	714	714	172937
2018	660	660	184900
2019	669	669	162061
2020	614	614	134108
2021	621	621	139439

Summary of the assessment

Table 5.5.10 Hake in GSA 19: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 times the standard deviation (approximately 95% confidence intervals).

Year	Recruitment age 0 '000	SSB (t)	Fbar 0-4	Catch (t)
2004	76443	1426	0.804	1409
2005	64670	1164	0.670	1018
2006	61241	1256	0.604	977
2007	50532	1336	0.604	988
2008	49805	1338	0.643	911
2009	48535	1301	0.673	952
2010	49289	1188	0.658	834
2011	49563	1105	0.611	731
2012	47037	1076	0.575	726
2013	37138	1152	0.582	775
2014	41341	1222	0.632	790
2015	53883	1067	0.683	748
2016	53923	1068	0.815	886
2017	52464	975	0.707	760
2018	44380	1007	0.567	665
2019	47756	1122	0.456	586
2020	40029	1356	0.383	601
2021	51566	1527	0.335	522

Sources and references

STECF EWG 22-16

5.6 Summary Sheet for red mullet in GSA 19

STECF advice on fishing opportunities

While the assessment gives some indication of stock status, STECF EWG 22-16 is unable to provide F_{MSY} advice due to instability in the assessment. However, fishing at status quo F corresponds to catches in 2023, of 214 tonnes.

Stock development over time

Catches recruitment and SSB of red mullet show a decreasing in the first few years. Subsequently recruitment has remained relatively consistent over time, catches have fallen slightly and SSB risen to midrange value in 2021. F has fluctuated but with a general decline over the assessment, reaching a lowest value in 2021.

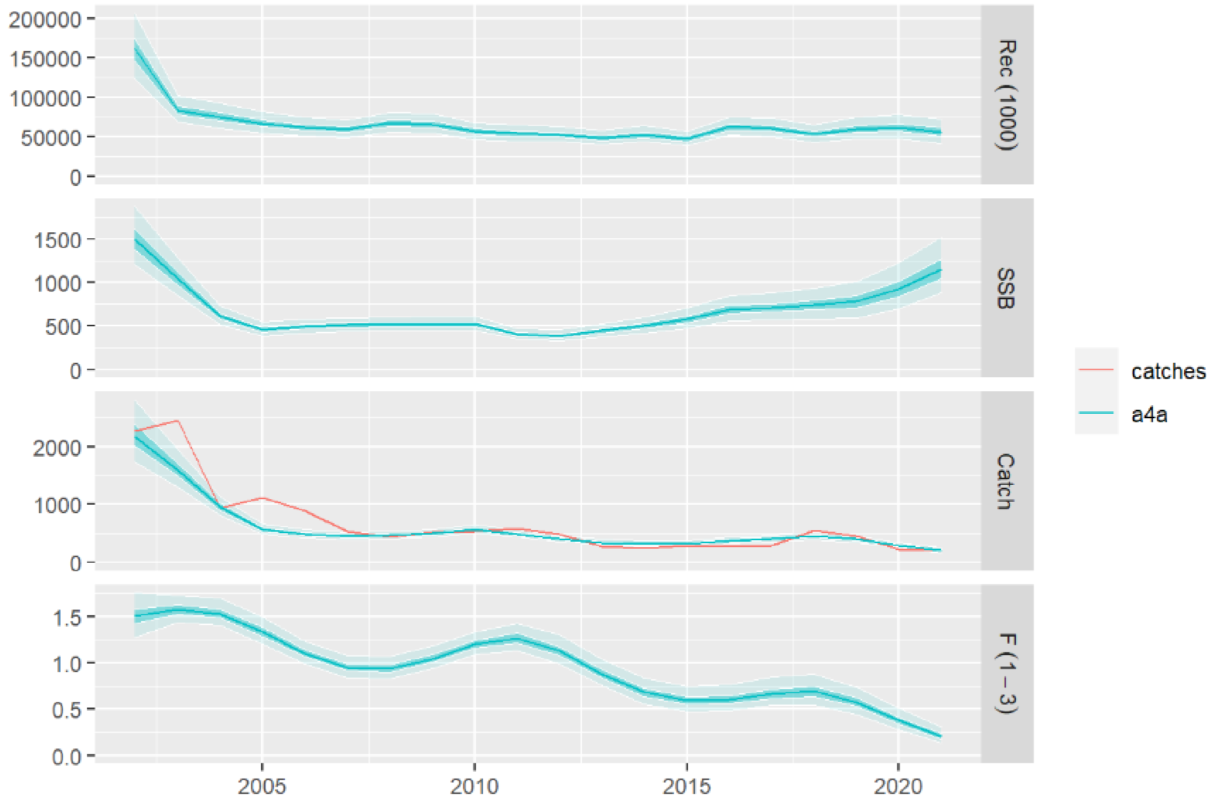

Figure 5.6.1 Red mullet in GSA 19: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.31) is below the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.51).

Table 5.6.1 Red mullet in GSA 19: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.6.2 Red mullet in GSA 19: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2022)	0.31	F 2021 used to give F status quo for 2022
SSB (2022)	785.77	Stock assessment 1 January 2022
R_{age0} (2022,2023)	44200.51	Mean of 2012 to 2021
Total catch (2022)	215.24	Assuming F status quo for 2022

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

Table 5.6.3 Red mullet in GSA 19: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
20% reduction	175.73	0.25	1020.1	29.82	-17.22
10% reduction	195.24	0.28	990.11	26.01	-8.26
Status quo	214.26	0.31	961.27	22.34	+0.68
10% increasing	232.81	0.34	933.55	18.61	+9.4
20% increasing	250.9	0.37	906.57	15.40	+17.9
Other scenarios					
Zero catch	0	0			

*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.

Basis of the advice

Table 5.6.4 Red mullet in GSA 19: The basis of the advice.

Advice basis	F Status Quo
Management plan	

Quality of the assessment

Two assessment models have been tested, XSA and a4a, giving broadly consistent results the period of the assessment. The models give a consistent view of a stock with declining F and SSB and R that has been steady for a number of years. However, the model is unstable in the last few years making the estimate of F and SSB in the last years particularly uncertain. The assessment is not considered suitable for advice on specific target values but use of status quo F give an indication of changes.

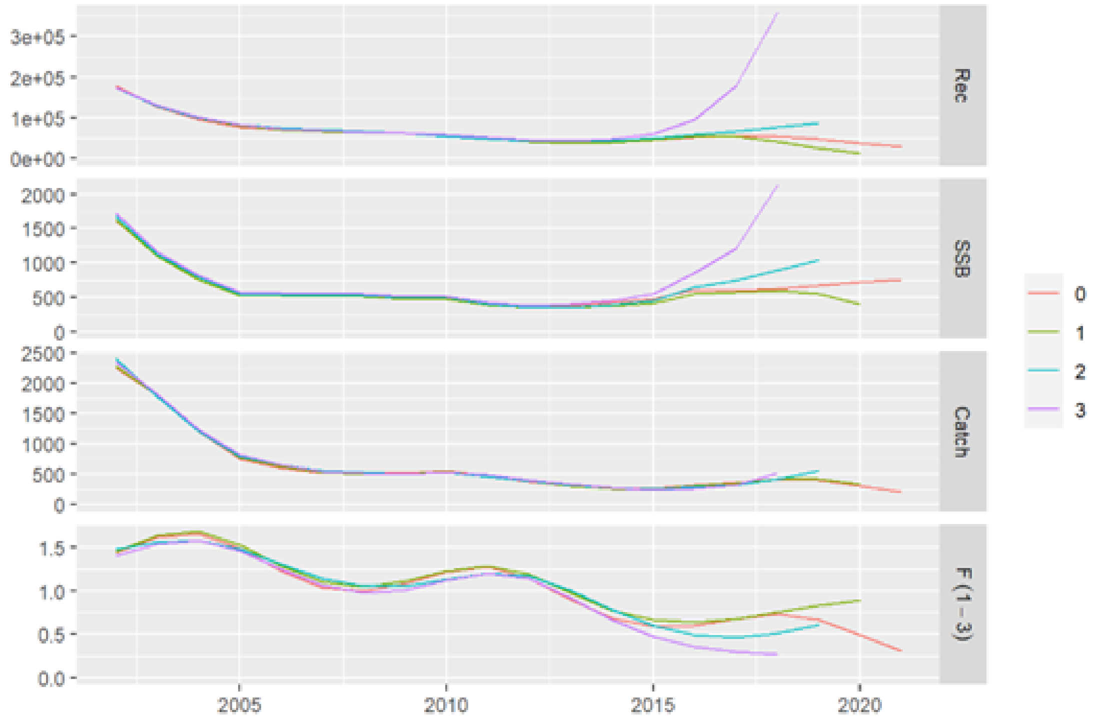

Figure 5.6.2 Red mullet in GSA 19: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

Due to the instability on the retrospective and the bad fit with the survey the assessment has been considered provisional and according to the precautionary approach able to provide catch advice only in term of current fishing mortality level.

Reference points

Table 5.6.5 Red mullet in GSA 19: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.51	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.51	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range F_{lower}	0.34	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range F_{upper}	0.70	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

Basis of the assessment

Table 5.6.6 Red mullet in GSA 19: Basis of the assessment and advice.

Assessment type	Statistical catch at age a4a
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.6.7 Red mullet in GSA 19: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021				…	
2022					
2023	No Advice				

History of the catch and landings

Table 5.6.8 Red mullet in GSA 19: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)	219	Otter trawl	Gillnets	Trammel nets	Other	0.05t
		69%	13%	18%		
Effort	139439	30094	36496	61748	11101	
		Fishing days				

Table 5.6.9 Red mullet in GSA 19: History of commercial landings; official reported values are presented by gear. Only GNS, GTR and OTB contribute to the current fishery. All weights are in tonnes.

Year	Otter Trawl	Gillnets	Trammel Nets	other	Total landings	Total Effort * (Fishing Days**)
2002	781.75		242.79	1248.13	2272.67	265099
2003	427.07		1152.26	872.43	2451.76	286466
2004	363.75	52.05	534.97	0.21	950.98	178370
2005	297.53	42.79	760.27	13.11	1113.7	147840
2006	566	64.69	240.93	15.75	887.37	161239
2007	287.76	54.73	189.52	9.12	541.13	134258
2008	348.32	68.53	29.26	1.7	447.81	144338
2009	389.81	114.08	16.13	9.49	529.51	169055
2010	283.53	220.02	13.13	21.44	538.12	180857
2011	371.51	172.9	25.01	18.93	588.35	185477
2012	309.32	145.86	20.77	7.32	483.27	163302
2013	110.49	119.17	41.28	3.5	274.44	213835
2014	102.65	122.85	23.7	1.83	251.03	226227
2015	189.43	65.02	28.94	20.22	303.61	209185
2016	165.54	95.17	17.15	0	277.86	227143
2017	197.42	57.52	39.99	0	294.93	157235
2018	285.44	113.5	152.05	0	550.99	173677
2019	212.06	93.32	154.84	0.41	460.63	152675
2020	140.07	39.64	55.41	0.02	235.14	126191
2021	151.19	28.48	39.26	0	218.93	128370

Summary of the assessment

Table 5.6.10 Red mullet in GSA 19: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2002	179067			1611.52			2261.66	1.44356		
2003	127131			1119.16			1810.67	1.61886		
2004	94984			755.77			1219.57	1.65798		
2005	77876			518.79			757.55	1.48772		
2006	70613			520.17			595.84	1.22772		
2007	68512			530.27			514.81	1.04021		
2008	67264			542.61			518.79	0.9936		
2009	63627			510.08			523.66	1.07942		
2010	57009			493.57			563.76	1.22415		
2011	49474			390.91			478.12	1.28049		
2012	43647			355.28			383.95	1.14395		
2013	41072			375.57			306.02	0.89541		
2014	42132			423.17			269.49	0.68896		
2015	46305			469.25			266.24	0.59306		
2016	51836			607.33			326.45	0.60322		
2017	55508			599.96			370.53	0.68083		
2018	54148			627.74			417.84	0.73709		
2019	47364			675.38			401.29	0.66805		
2020	37939			714.49			311.74	0.48825		
2021	29069			762.1			212.81	0.31178		

Sources and references

STECF EWG 22-16,

5.7 SUMMARY SHEET FOR DEEP WATER ROSE SHRIMP IN GSAS 17, 18 AND 19

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.75 and corresponding catches in 2023 should be no more than 2352 tons.

Stock development over time

The Deep-water rose shrimp stocks in GSAs 17-19 shows increasing catch from 2014 to 2019, that slightly decrease in 2020-2021 and looks stable in the previous years. Recruitment and SSB initially fluctuating then steeply increasing from 2014 to 2019, and then both slightly decrease again. Fbar (0-2) increasing along most of the time series with a more rapid increase in the last 3 years, and reach a maximum of 2.41 in 2021.

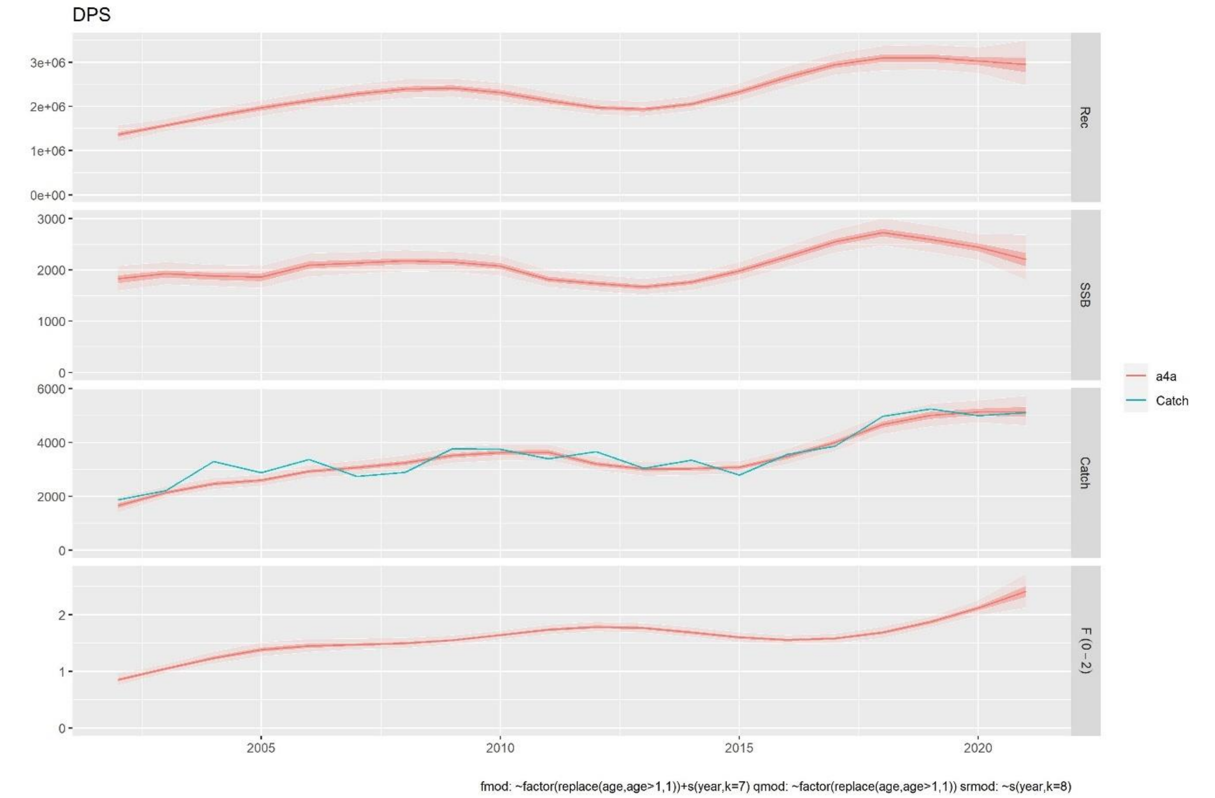

Figure 5.7.1 Deep-water rose shrimp stocks in GSAs 17-19: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (2.41) is more than 3 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.746). F in 2020 is also higher than $F_{MSY\ Transition}$ indicating progress to F_{MSY} in 2026 is behind transition.

Table 5.7.1 Deep-water rose shrimp stocks in GSAs 17-19: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.7.2 Deep-water rose shrimp stocks in GSAs 17-19: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 0\text{-}2}$ (2022)	2.41	F 2021 used to give F status quo for 2022
SSB (2022)	2188	Stock assessment 1 January 2022
R_{age0} (2022,2023)	3022529	Mean of the last 3 years
Total catch (2022)	5015	Assuming F status quo for 2022

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

Table 5.7.3 Deep-water rose shrimp stocks in GSAs 17-19: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 0-2) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	2352	0.75	4073	86.12	-54.33
$F_{MSY\ Transition}$ ^^	3355.9	1.23	3201	46.27	-34.83
$F_{MSY\ lower}$	1701	0.49	5248	254.14	-56.91
$F_{MSY\ upper}$**	2943	1.01	3993	169.46	-22.49
Other scenarios					
Zero catch	0	0.00	7066	222.85	-100.00
Status quo	5073	2.41	2197	0.40	-1.49
Intermediate Options					
F=F2019 * 0.8	4460	1.93	2493	13.93	-13.40
F=F2019 * 0.6	3736	1.45	2929	33.84	-27.44
F=F2019 * 0.4	2842	0.97	3619	65.34	-44.81
F=F2019 * 0.2	1665	0.48	4807	119.62	-67.66

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

*** % change in SSB 2024 to 2022

^Total catch in 2023 relative to Catch in 2021.

^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026

Basis of the advice

Table 5.7.4 Deep-water rose shrimp stocks in GSAs 17-19: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Both commercial catches and MEDITS survey index showed poor internal cohort consistency except for age 0-1 in MEDITS. The historic assessment is stable, and the assessment model was not modified. The retrospective analysis run on the a4a model showed some instability in SSB and F, but only after 4 years removed, due to varying survey signals and survey timing in recent years, however, all years in all retrospective runs confirm F> F_{MSY} and that the F in 2021 is high. All the diagnostics were considered acceptable.

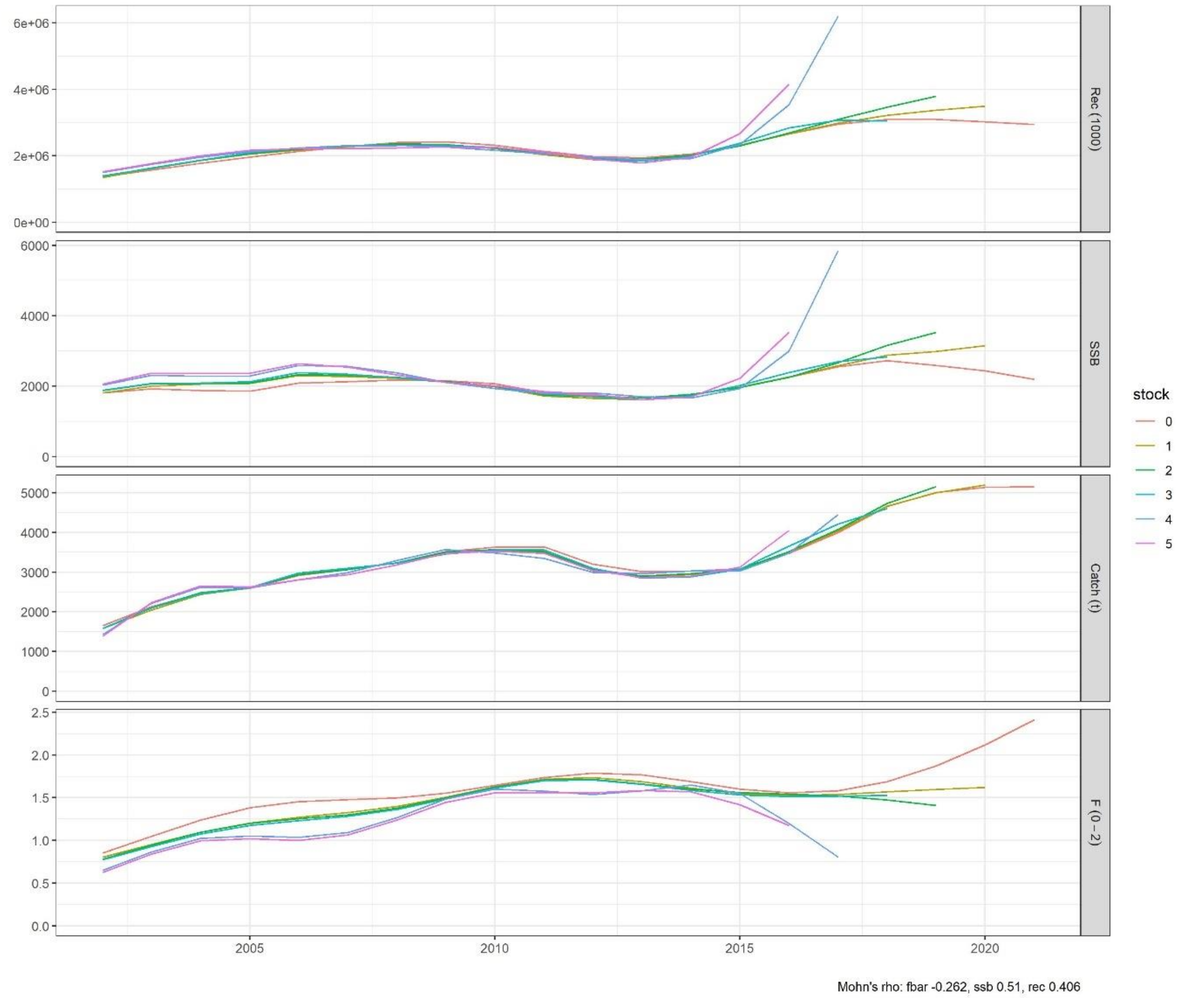

Figure 5.7.2 Deep-water rose shrimp stocks in GSAs 17-19: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.7.5 Deep-water rose shrimp stocks in GSAs 17-19: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.746	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
Precautionary approach	B_{lim}			
	B_{pa}			
	B_{MSY}			
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.746	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range F_{lower}	0.50	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range F_{upper}	1.01	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

Basis of the assessment

Table 5.7.6 Deep-water rose shrimp stocks in GSAs 17-19: 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	MEDITS survey
Other information	
Working group	STECF EWG 21-15

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.7.7 Deep-water rose shrimp stocks in GSAs 17-19: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2019	F = F_{MSY}			5086	
2020	F = F_{MSY}		5215	4029	
2021	F = F_{MSY}		5227	4446	
2022	F = F_{MSY}		3092		
2023	F = F_{MSY}		2352		

History of the catch and landings

Table 5.7.8 Deep-water rose shrimp stocks in GSAs 17-19: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch				Discards
Catch (t)	5108	Bottom trawl 100%				
Effort	165180*					
		Fishing days				

***ONLY FOR ITALY**

Table 5.7.9 Deep-water rose shrimp stocks in GSAs 17-19: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

	Catch							Effort (fishing days)					
country	ALB	HRV	ITA	ITA	ITA	MNE	Total	HRV	ITA	ITA	ITA	SVN	Total
GSA	18	17	17	18	19		17,18,19	17	17	18	19	17	17,18,19
2002		140	62	921	755		1877	0	220915	138899	131590	0	491404
2003		176	95	1278	661		2210	0	223216	107183	153810	0	484209
2004		153	62	1884	1197		3296	0	242276	87211	106719	0	436206
2005		169	230	1205	1271		2875	0	203974	79638	56199	831	339811
2006		315	316	1480	1264		3374	0	169108	85122	82371	963	336601
2007	198	370	678	880	621		2748	0	138377	70774	76509	1202	285660
2008	187	535	593	779	803		2897	0	130131	70654	76484	1254	277269
2009	262	657	1063	970	822		3774	0	137929	85892	88055	1205	311876
2010	236	845	1009	906	752		3747	0	136949	73021	90514	1263	300484
2011	209	920	784	875	606		3395	0	138540	68754	78239	1178	285533
2012	1170	719	742	530	496		3657	50835	116850	63411	60017	917	291113
2013	1210	670	62	746	355		3042	52973	97982	79244	45588	766	275787
2014	1430	744	95	645	430		3345	54650	97868	54851	48040	680	255409
2015	1290	140	62	665	634		2792	55076	85984	54774	51394	696	247228
2016	1460	176	230	1017	673		3556	33715	89376	60876	49784	812	233751
2017	1473	153	316	1152	738	33	3864	35649	96415	57053	52214	697	241331
2018	1275	169	678	2014	784	47	4967	56844	79551	62311	46672	692	245378
2019	962	315	593	2283	1046	44	5243	30997	65911	50169	32875	769	179952
2020	1026	370	1063	1841	683	16	4999	31916	56549	39509	25186	879	154039
2021	1034	535	1009	1684	847		5108	32400	60159	41734	30094	793	165180

*Effort data is reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.7.10 Deep-water rose shrimp stocks in GSAs 17-19: 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	1369483			1814			756	0.85		
2003	1571592			1924			911	1.05		
2004	1776032			1878			1254	1.24		
2005	1962427			1857			1134	1.38		
2006	2129810			2093			1788	1.45		
2007	2282465			2132			783	1.48		
2008	2397240			2173			867	1.5		
2009	2419753			2156			1361	1.55		
2010	2316978			2074			1315	1.64		
2011	2134871			1822			1851	1.74		
2012	1977507			1739			723	1.79		
2013	1936632			1667			1395	1.77		
2014	2055282			1763			1566	1.69		
2015	2321873			1975			2462	1.6		
2016	2660476			2255			3123	1.56		
2017	2947837			2550			3813	1.58		
2018	3092065			2730			4932	1.69		
2019	3097166			2595			5086	1.87		
2020	3028801			2440			4029	2.12		
2021	2941620			2199			4446	2.41		

Sources and references

STECF EWG 22-16

5.8 Summary Sheet for giant red shrimp in GSA s 18, 19 and 20

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.37 and corresponding catches in 2023 should be no more than 210 tons.

Stock development over time

According to the age slicing, catches of Giant red shrimp includes a large portion of not fully mature specimens, therefore the SSB represents just around one third of the stock biomass. SSB of Giant red shrimp show an increasing trend from 2012 to 2017 then declining to just under 400 tonnes in 2021. Catches increase to 2017 and have declined steadily until 2021. The assessment shows a general increase in the number of recruits to 2015, especially after 2012, declining to 2018 with recent years indicating a slight increasing. Fbar (1-3) shows a slight general increase until 2018 declining until 2021 where it reached a value of F of 0.828.

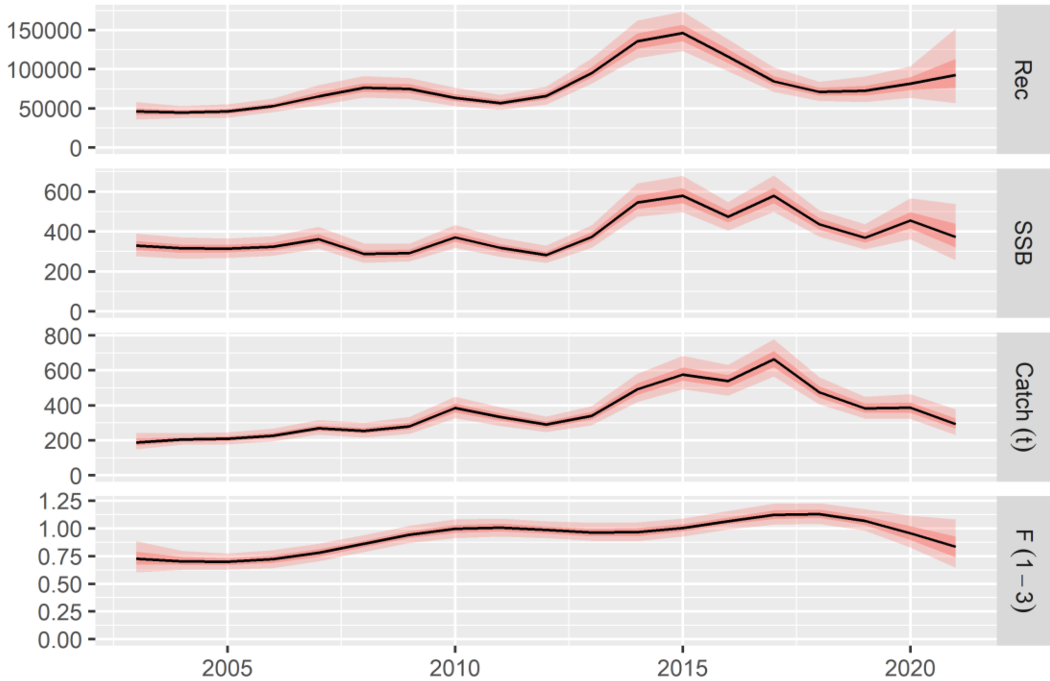

Figure 5.1.1 Giant red shrimp in GSA 18, 19 and 20: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.828) is 2 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.371). .

Table 5.1.1 Giant red shrimp in GSA 18, 19 and 20: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.1.2 Giant red shrimp in GSA 18, 19 and 20: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	0.828	F 2021 used to give F status quo for 2022
SSB (2022)	487	Stock assessment 1 January 2022
R_{age0} (2022,2023)	78755	Mean of the last 4 years
Total catch (2022)	392	Assuming F status quo for 2022

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

Table 5.1.3 Giant red shrimp in GSA 18, 19 and 20: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	210	0.37	635.60	30.64	-28.24
$F_{MSY\ Transition}$ ^^	367	0.77	470.14	-3.37	25.76
$F_{MSY\ lower}$	149	0.25	710.31	45.99	-49.15
$F_{MSY\ upper}$**	270	0.51	567.67	16.67	-7.55
Other scenarios					
Zero catch	0	0.00	918.58	88.80	-100.00
Status quo	386	0.83	453.03	-6.89	32.14
	191	0.33	658.24	35.29	-34.76
	265	0.50	573.00	17.77	-9.24
	330	0.66	506.32	4.06	12.84
	359	0.75	478.25	-1.70	22.80

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

*** % change in SSB 2024 relative to 2022

^Total catch in 2023 relative to Catch in 2021.

^^$F_{MSY\ Transition}$ is based on a linear change in F from 2022 to F_{MSY} in 2030

Basis of the advice

Table 5.1.4 Giant red shrimp in GSA 18, 19 and 20: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Data quality and biological parameters exploration were carried out in STECF 22-03 (STECF, 2022). Commercial catches showed better internal consistency than MEDITS survey index. The quality of the cohort consistency in the MEDITS survey index might have been impaired by the missing years in GSA 20, which is an area where high density is observed. Data gaps in LFDs data for the catches, between 2003 and 2008, did not permit to closely track the stock depletion by age classes, causing a smooth trend in Recruitment and SSB for the first part of the time series. The retrospective analysis showed consistency in the estimation of F. All the diagnostics were considered acceptable although survey data residuals had a trend potentially caused by data quality. Catch reporting by GSA might not reflect accurately the exploitation by GSA, especially due to the fleet displacement among GSAs (D'Onghia *et al.*, 2005). This should not have affected the quality of the assessment, because vessels are likely to remained within the boundaries of the GSAs 18, 19 and 20 area, but impaired the calculation of the partial F (see section below).

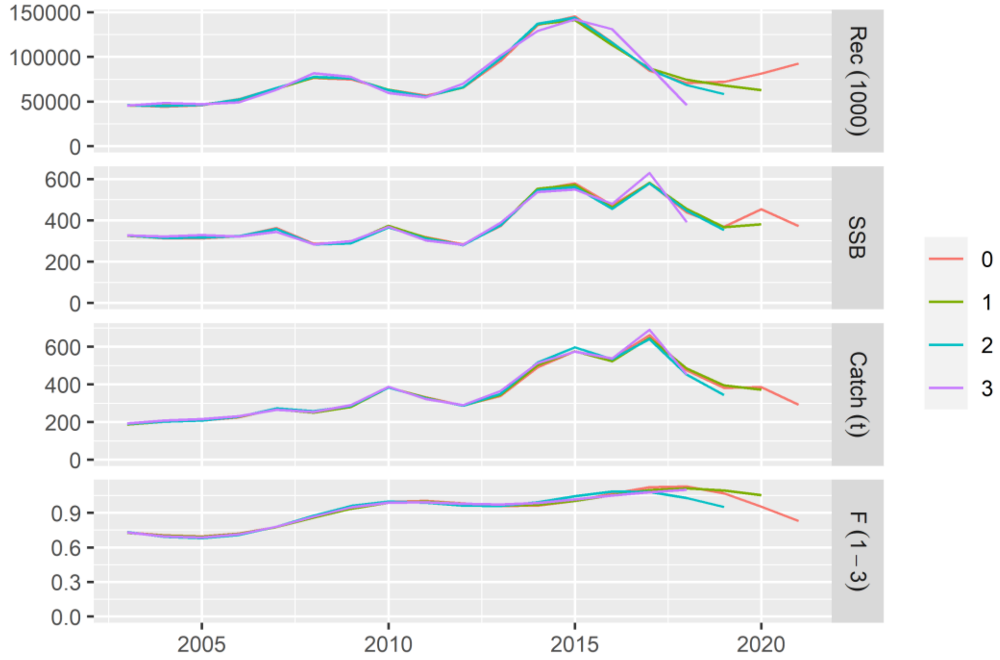

Figure 5.1.2 Giant red shrimp in GSA 18, 19 and 20: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

Vessels targeting deep water shrimps may move around several GSAs, it is not therefore realistic to estimate an accurate catch share solely basing on reported commercial data. As a consequence, the estimated partial F provided in Table 5.1.10, where large oscillations are observed, it is considered unreliable. In addition, controlling the exploitation level for one single fleet over the entire assessed area might not result in improvement of the overall stock status.

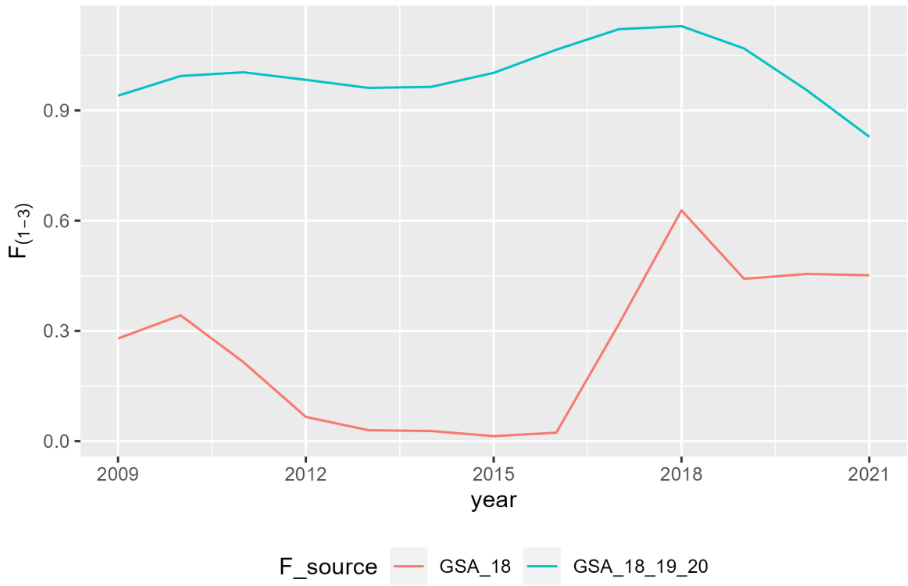

Figure 5.1.3 Giant red shrimp in GSA 18, 19 and 20: partial F for GSA 18 compared to the F for GSAs 18, 19 and 20.

Reference points

Table 5.1.5 Giant red shrimp in GSA 18, 19 and 20: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.37	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
Precautionary approach	B_{lim}			
	B_{pa}			
	B_{MSY}			
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.37	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range F_{lower}	0.25	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range F_{upper}	0.51	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

Basis of the assessment

Table 5.1.6 Giant red shrimp in GSA 18, 19 and 20: 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 considered negligible.
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.1.7 Giant red shrimp in GSA 18, 19 and 20: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	No advice			292	
2022	No advice				
2023	$F = F_{MSY}$		210		

History of the catch and landings

Table 5.1.8 Giant red shrimp in GSA 18, 19 and 20: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021	Wanted catch			Discards
Catch (t)	292	Otter trawl 99.6%	Other 0.4%	Negligible
Effort	4698			
		Fishing days*		

* fishing days relates exclusively to the metier "DWS"

Table 5.1.9 Giant red shrimp in GSA 18, 19 and 20: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	ITALY GSA18	ITALY GSA19	GREECE GSA20	MALTA GSA20	MALTA GSA19	Total landings	Total Effort * (Fishing Days**)
2003	198	4	0	0	0	202	
2004	89	63	0	0	0	152	
2005	72	55	0	0	0	127	
2006	169	236	0	0	0	405	
2007	115	199	0	0	0	313	
2008	97	133	0	0	0	229	
2009	88	226	0	0	0	314	
2010	127	301	0	0	0	429	
2011	75	347	0	0	0	422	
2012	15	262	0	0	0	277	
2013	15	349	0	0	0	363	11283
2014	8	320	18	0	0	346	13376
2015	9	646	7	0	0	662	14647
2016	14	690	27	0	0	731	21242
2017	141	509	27	2	0	680	10820
2018	176	162	33	1	3	374	13554
2019	106	157	37	8	3	310	10695
2020	133	218	35	1	3	390	7995
2021	110	155	24	0	3	292	4698

*Effort data is reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward.

** fishing days relates exclusively from metier "DWS"

Summary of the assessment

Table 5.1.10 Giant red shrimp in GSA 18, 19 and 20: Assessment summary. Weights are in tonnes.

Year	Recruitment age 1 thousands	SSB tonnes	Catch tonnes	F ages 1-3	Partial F GSA 18*
2003	45830	326.71	187.09	0.73	
2004	44494	313.14	202.98	0.70	
2005	45957	313.14	207.55	0.70	
2006	52848	323.04	226.26	0.72	
2007	65362	362.79	269.19	0.78	
2008	76416	287.01	253.19	0.86	
2009	74822	291.68	279.91	0.94	0.28
2010	63377	370.43	382.67	0.99	0.34
2011	56872	317.75	331.23	1.00	0.22
2012	65721	282.68	288.82	0.98	0.07
2013	95499	372.46	337.83	0.96	0.03
2014	135525	546.89	490.73	0.96	0.03
2015	145625	578.47	576.54	1.00	0.01
2016	115994	473.07	536.49	1.07	0.02
2017	84628	579.54	660.87	1.12	0.32
2018	70941	437.14	475.12	1.13	0.63
2019	72171	368.37	381.00	1.07	0.44
2020	81201	453.83	385.25	0.96	0.45
2021	92534	372.27	292.09	0.83	0.45

* start from 2009 because of LFD availability

Sources and references

D'Onghia, G., Capezzuto, F., Mytilineou, C., Maiorano, P., Kapiris, K., Carlucci, R., Sion, L., *et al.* 2005. Comparison of the population structure and dynamics of Aristeus antennatus (Risso, 1816) between exploited and unexploited areas in the Mediterranean Sea. Fisheries Research, 76: 22–38. Elsevier. https://linkinghub.elsevier.com/retrieve/pii/S0165783605001463 (Accessed 6 April 2022).

STECF. 2022. Scientific , Technical and Economic Committee for Fisheries (STECF) Quality checking of MED & BS data and reference points (STECF-22-03). EUR 28359 EN, Publications Office of the European Union, Luxembourg, 2022.

5.9 SUMMARY SHEET FOR BLUE AND RED SHRIMP IN GSA S 18, 19 AND 20

STECF advice on fishing opportunities

While the assessment gives some indication of stock status, STECF EWG 22-16 is unable to provide F_{MSY} advice due to instability in the assessment. However, fishing at status quo F corresponds to catches in 2023, of 194 tonnes.

Stock development over time

Recruitment of blue and red shrimp shows an overall oscillating pattern and a declining trend since 2018. Spawning Stock Biomass (SSB) has also oscillated with an overall decreasing trend and is in decline since 2018. Catch has been fluctuating between 100 and 400 tonnes with an overall increasing trend, while fishing mortality (Fbar (1-3)) has been rising since 2018. It should be noted that the model hasn't been able to adequately capture (fit) the observed catch, either for the whole time series (2003-2021) or the reduced one (final assessment, 2008-2021).

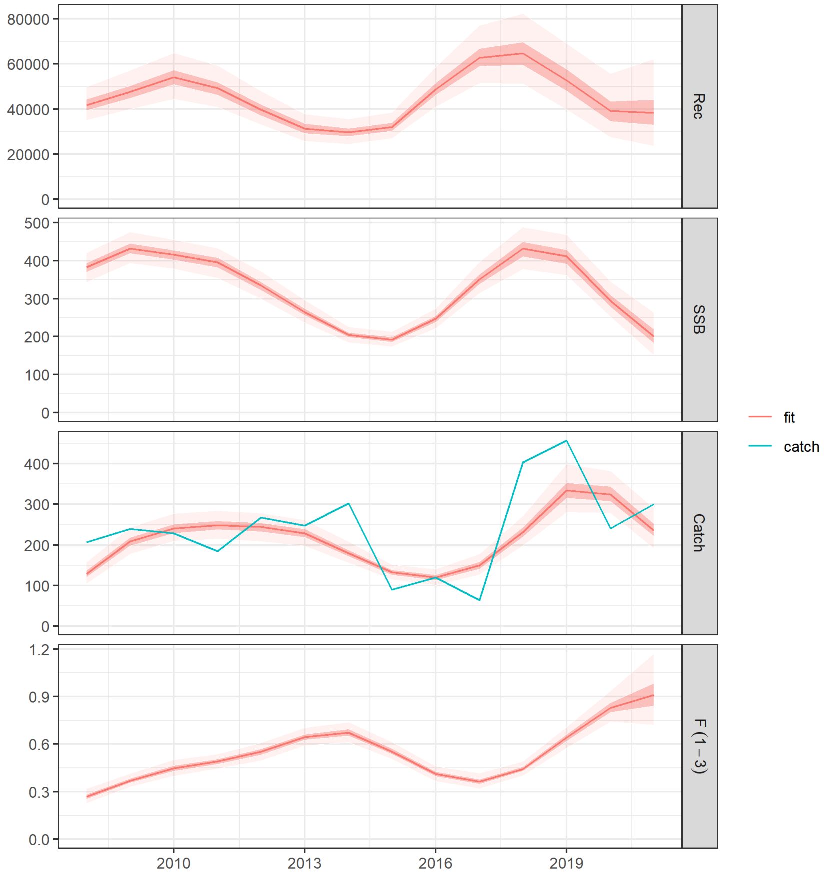

Figure 5.5.1 Blue and red shrimp in GSAs 18, 19 & 20: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.914) is well above the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.206).

Table 5.5.1 Blue and red shrimp in GSAs 18, 19 & 20: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.5.2 Blue and red shrimp in GSAs 18, 19 & 20: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	0.914	F 2021 used to give F status quo for 2022
SSB (2022)	180.5	Stock assessment 1 January 2022
R_{age0} (2022,2023)	43882.7	Geometric mean of series (2008 to 2021)
Total catch (2022)	196.1	Assuming F status quo for 2022

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

Table 5.5.3 Blue and red shrimp in GSAs 18, 19 & 20: Annual catch scenarios. All weights are in tonnes. Catch advice is based on status quo fishing mortality ($F_{ages\ 1\text{-}3}$ (2022)) and corresponding increase or decrease of the status quo fishing mortality by 10% and 20% respectively.

Basis	Total catch (2023)	F_{total} (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
20% reduction	166.76	0.731	217.06	20.28	-28.45
10% reduction	181.18	0.823	200.33	11.01	-22.26
Status quo	194.61	0.914	185.50	2.79	-16.50
10% increasing	207.13	1.006	172.29	-4.52	-11.12
20% increasing	218.81	1.097	160.51	-11.05	-6.11
Other scenarios					
Zero catch	0	0	470.75	160.87	-100

*** % change in SSB 2024 to 2022

^Total catch in 2023 relative to Catch in 2021.

Basis of the advice

Table 5.5.4 Blue and red shrimp in GSAs 18, 19 & 20: The basis of the advice.

Advice basis	$F_{status\ quo}$
Management plan	

Quality of the assessment

Commercial catches and MEDITS survey index distributions showed poor internal consistency, which was slightly improved when the first years of the time series (2003-2007) were removed. The assessment could not capture the distribution of age0 of the index, while residual patterns were slightly improved when age0 was removed from both index and catch distributions. Overall, the model could not adequately capture the trends of the observed catch time series. The retrospective analysis showed significant uncertainty in fishing mortality, hence the estimated $F_{0.1}$ (F_{MSY} proxy) is not considered reliable basis for advice. By contrast, all fits showed consistent stock status in term of $F/F_{0.1}$ (F/F_{MSY} proxy) indicating overexploitation of the stock.

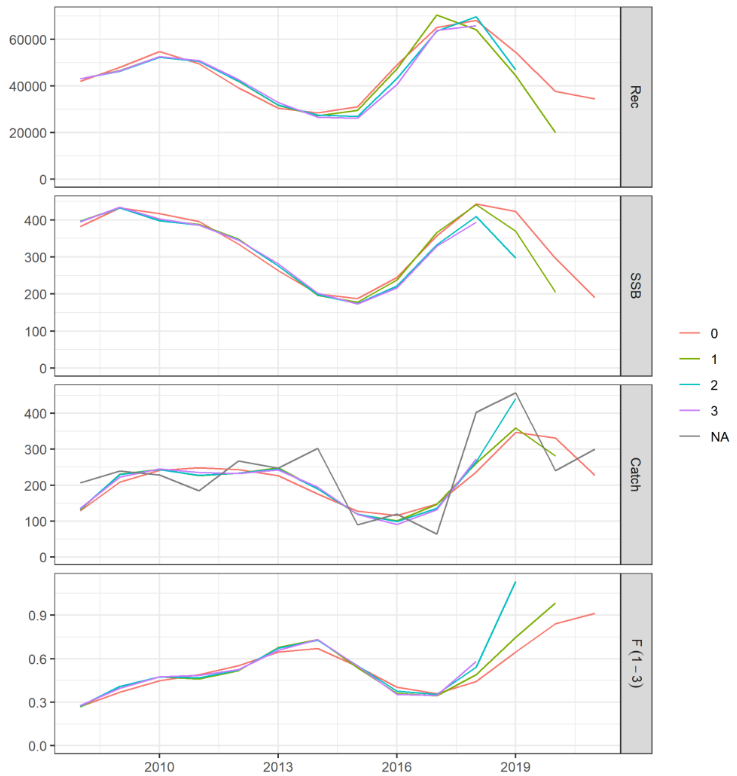

Figure 5.5.2 Blue and red shrimp in GSAs 18, 19 & 20: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.5.5 Blue and red shrimp in GSAs 18, 19 & 20: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.206	$F_{0.1}$	STECF EWG 22-16
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}		Not Defined	
	target range F_{lower}		Not Defined	
	target range F_{upper}		Not Defined	

Basis of the assessment

Table 5.5.6 Blue and red shrimp in GSAs 18, 19 & 20: 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 not included in the total catch (less than 0.3%)
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.5.7 Blue and red shrimp in GSAs 18, 19 & 20: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catches	STECF discards
2021				233.05	
2022					
2023	F = F status quo		194.61		

History of the catch and landings

Table 5.5.8 Blue and red shrimp in GSAs 18, 19 & 20: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch	Discards
Catch (t)	300.52	Otter trawl 100%	Otter trawl 100%
		300.52	0.44
Effort	77436	Fishing days	

Table 5.5.9 Blue and red shrimp in GSAs 18, 19 & 20: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort of OTB in Fishing Days.

Year	ITA GSA18	ITA GSA19	GRC GSA20	Total landings	Total Effort * (Fishing Days)
2003	-	132.67	-	132.67	-
2004	4.81	41.19	-	46.00	-
2005	8.18	120.55	-	128.73	-
2006	21.75	437.57	-	459.32	-
2007	14.17	359.65	-	373.82	-
2008	4.63	201.85	-	206.48	-
2009	14.07	225.08	-	239.15	-
2010	21.59	206.53	-	228.12	-
2011	24.84	159.99	-	184.82	-
2012	4.33	263.39	-	267.71	-
2013	4.41	242.60	-	247.01	112436
2014	2.70	299.46	-	302.16	92405
2015	10.47	78.97	-	89.44	95295
2016	16.76	103.02	-	119.78	98369
2017	36.31	27.63	-	63.94	95311
2018	67.94	335.59	-	403.53	99959
2019	51.95	405.93	-	457.88	88474
2020	36.22	204.55	-	240.77	70337
2021	37.58	252.84	10.10	300.52	77436

* Effort time series refer to FDI

Summary of the assessment

Table 5.5.10 Blue and red shrimp in GSAs 18, 19 & 20: Assessment summary. Weights are in tonnes.

Year	Recruitment age 1 thousands	SSB tonnes	Catch tonnes	F ages 1-3
2008	41906.73	380.61	128.09	0.269
2009	47717.61	431.18	206.85	0.369
2010	54043.17	414.41	239.54	0.446
2011	49172.29	393.47	246.85	0.489
2012	39648.12	333.73	242.00	0.550
2013	31255.16	264.87	227.33	0.644
2014	29637.35	204.43	179.03	0.671
2015	32031.74	191.94	131.47	0.555
2016	48887.45	246.44	118.83	0.411
2017	62858.22	351.72	148.90	0.363
2018	64925.32	429.51	230.60	0.443
2019	52631.75	408.63	332.45	0.638
2020	38973.09	292.26	322.67	0.831
2021	38382.60	197.40	233.06	0.914

Sources and references

STCEF EWG 22-16: Stock assessments in the Adriatic, Ionian and Aegean seas

5.10 Summary Sheet for striped Venus clam in GSAs 17-18

STECF advice on fishing opportunities

STECF EWG 22-16 does not have sufficient information to provide catch advice regarding the Striped Venus Clam in GSA 17 and 18 for 2023.

Stock development over time

Striped Venus clam has been evaluated by district located along the Italian coast (Figure 5.10.1). Catches of the Striped Venus Clam (SVE) show a decreasing trend since the start of the fishery (Figure 5.10.2). The fishery independent Biomass Index (BI) from survey data, used as the biomass of individuals with a total length greater than 25mm per metre square, was only partially correlated to landings data (Figure 5.10.2). In fact, BI shows strong variability and inconsistent trends over short periods. However, BI values for the past 4 years are in line with historical survey data for most of the Italian maritime districts. However, both landings and BI of the Striped Venus Clam are low in the maritime districts of Monfalcone, Manfredonia and Barletta likely as a result of significant disturbance events and coastal anthropization. Nine of the maritime districts have been assessed and F/F_{MSY} is shown in Figure 5.10.3, most show that recent exploitation is lower than historic exploitation, except for AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto and OR = Ortona.

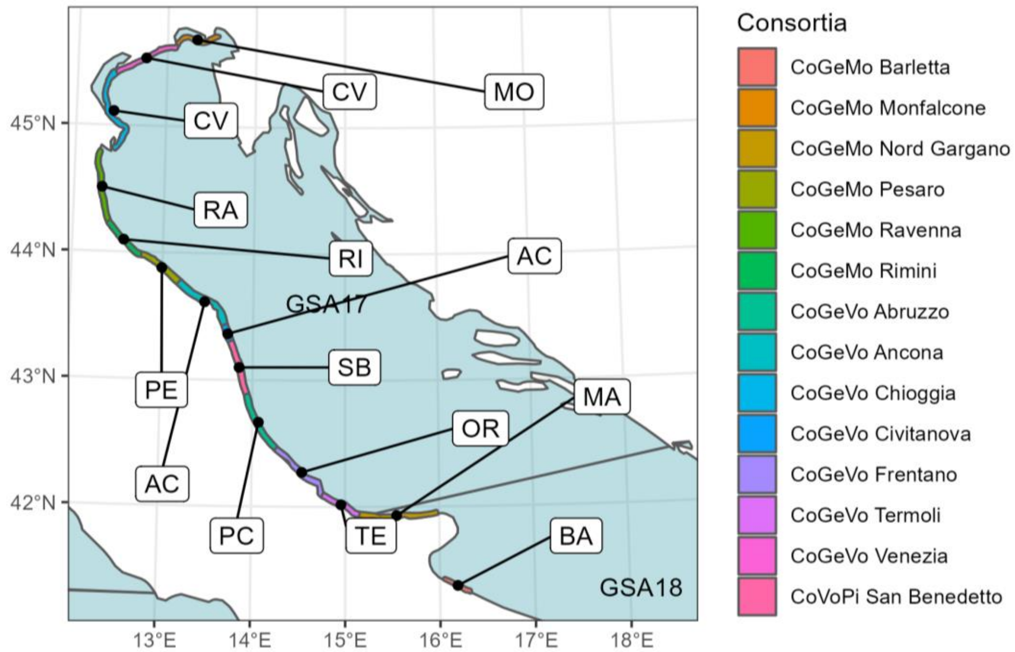

Figure 5.10.1. Striped Venus Clam in GSA 17 & 18: Geographical location of the Italian Consortia through GSA 17 and 18.

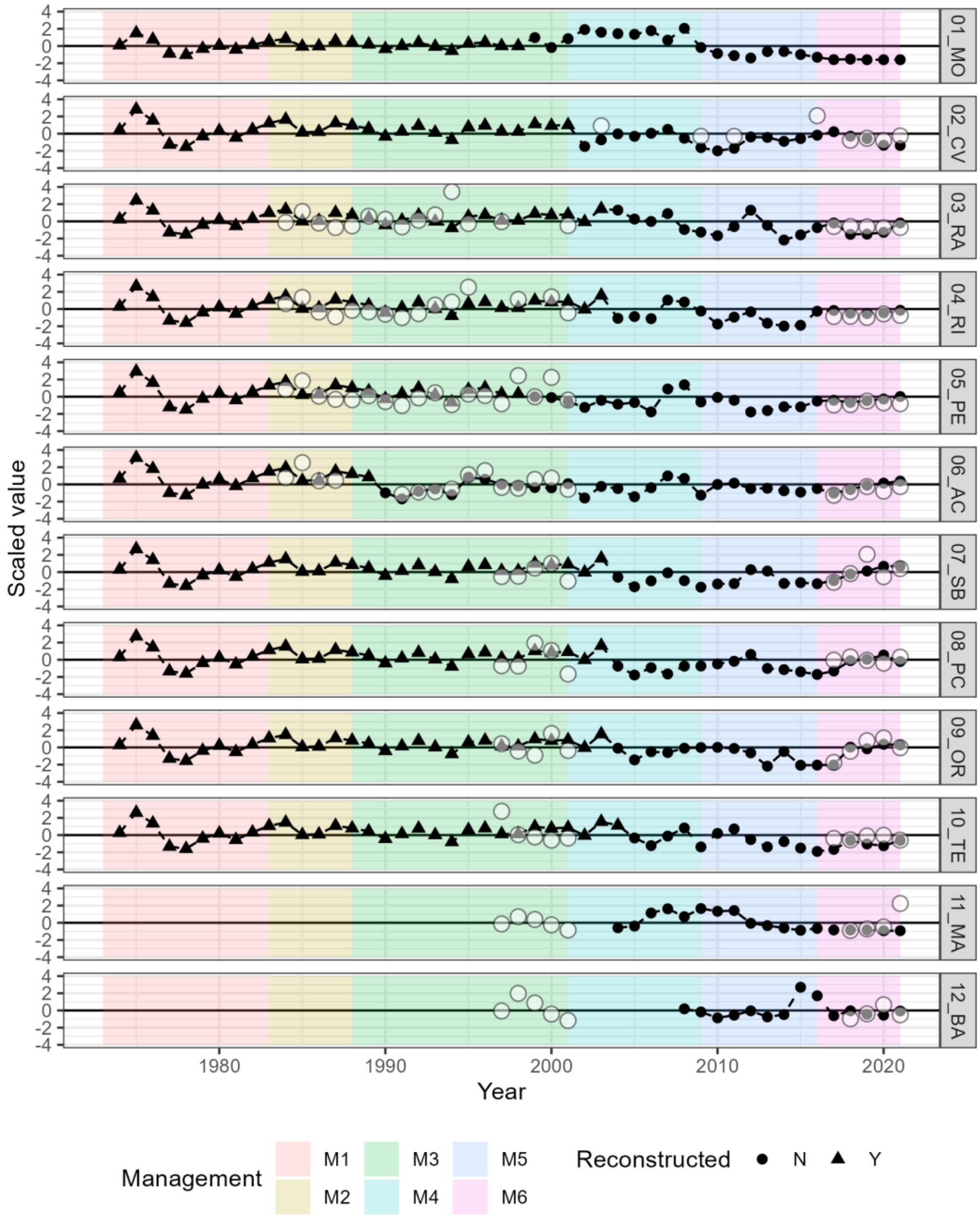

Figure 5.10.2 Striped Venus Clam in GSA 17 & 18: Trends in landings and biomass index (g of clams greater than 25mm per metre square). Values are scaled around the mean for each of the twelve maritime districts, from north to south, in which the striped Venus calm is targeted by hydraulic dredges (GSA17: MO = Monfalcone, CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli; GSA18: MA = Manfredonia, BA = Barletta). Different background colours indicate changes in national management and changes in daily quota per vessel per day. White dots indicate reconstructed landings, white squares are observed landings and black dots refer to the Biomass Iindex (BI).

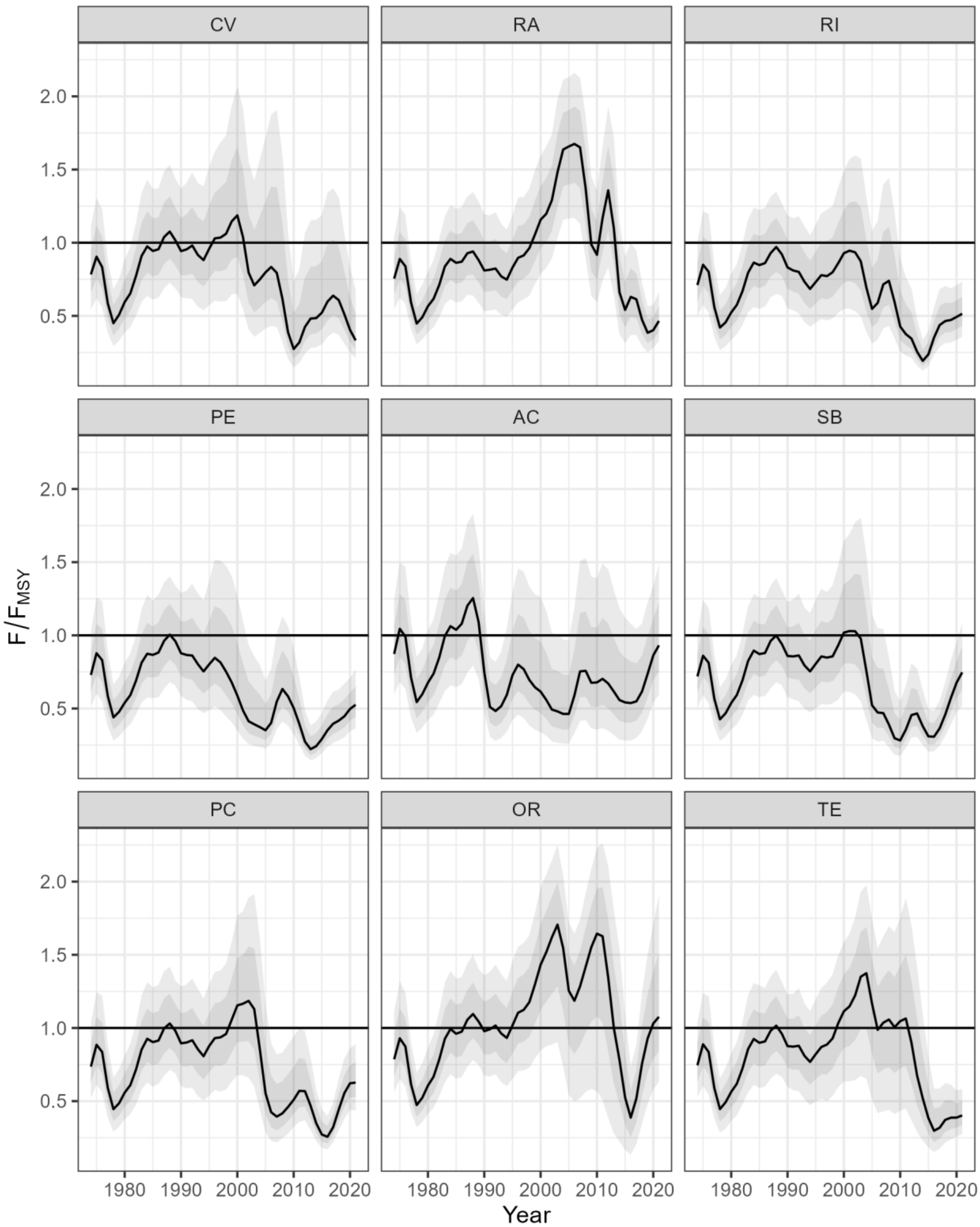

Figure 5.10.3. Striped Venus Clam in GSA 17 & 18: Stock summary F/F_{MSY} for each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli).

Stock and exploitation status

F over the past three years (2019-2021) of the nine maritime districts analysed is below or close to MSY (Table 5.10.1), except for Ancona and Civitanova Marche, for which F was constantly over F_{MSY} in the past three years. The recent F and catch, over the last three years (2019-2021), are lower or close to the estimated reference points (Table 5.10.2).

Table 5.10.1 Striped Venus Clam in GSA 17: State fishery relative to F_{MSY} for each of the nine maritime districts assessed

Maritime District	Status	2019	2020	2021
Chioggia and Venezia	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
Ravenna	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
Rimini	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
Pesaro	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
Ancona and Civitanova Marche	F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
San Benedetto del Tronto	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
Pescara	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
Ortona	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
Termoli	F / F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$

Table 5.10.2. Striped Venus Clam in GSA 17: Exploitation rate and fishing mortality relative to reference points for each of the nine maritime districts assessed. Recent average = 2019-2021

Stock	F_{RECENT}/F_{MSY}	C_{RECENT}/C_{MSY}
Chioggia and Venezia	0.416	0.538
Ravenna	0.418	0.531
Rimini	0.493	0.724
Pesaro	0.49	0.721
Ancona and Civitanova Marche	0.844	0.927
San Benedetto del Tronto	0.665	0.99
Pescara	0.601	0.897
Ortona	1.012	0.985
Termoli	0.392	0.558

Catch scenarios

Given the limited amount of information regarding landings and biomass indices, And the known short term volatility of stock numbers due to environmental influences, it is not possible to give 2 year ahead catch predictions (for 2023), so no catch scenarios were considered.

Basis of the advice

Table 5.10.2 Striped Venus Clam in GSA 17 & 18: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

12 Maritime districts have been evaluated assuming recent catch proportions provide a guide to historic catch proportions. Three districts were not evaluated fully. Monfalcone maritime districts were not evaluated due to the lack of catches in the last 4-5 years, likely resulting from significant disturbance events and coastal anthropization. Manfredonia and Barletta's maritime districts were not evaluated over the full time period because FishstatJ FAO dataset used to reconstruct the data in the old period is only available for GSA 17 and not for GSA 18.

The retrospective analysis showed consistency in the estimation of fishing mortality relative to F_{MSY} (Figure 5.10.2). However, survey data is scant, with short time series intersperse among periods with no information, which given the high stochastic variability in stock biomass, hampers the model fitting and inferences concerning stock biomass. These trends are correlated to changes in Italian management of the fishery, which has reduced the daily quota from 2.5 tons per day per vessel to 0.4 tons per day per vessel over the years. Alongside daily quota reduction, also the number of vessels, fishing days and fishing grounds were reduced. Therefore, the present model outputs have to be taken with caution and are indicative of the exploitation levels in each maritime district where the analysis was conducted.

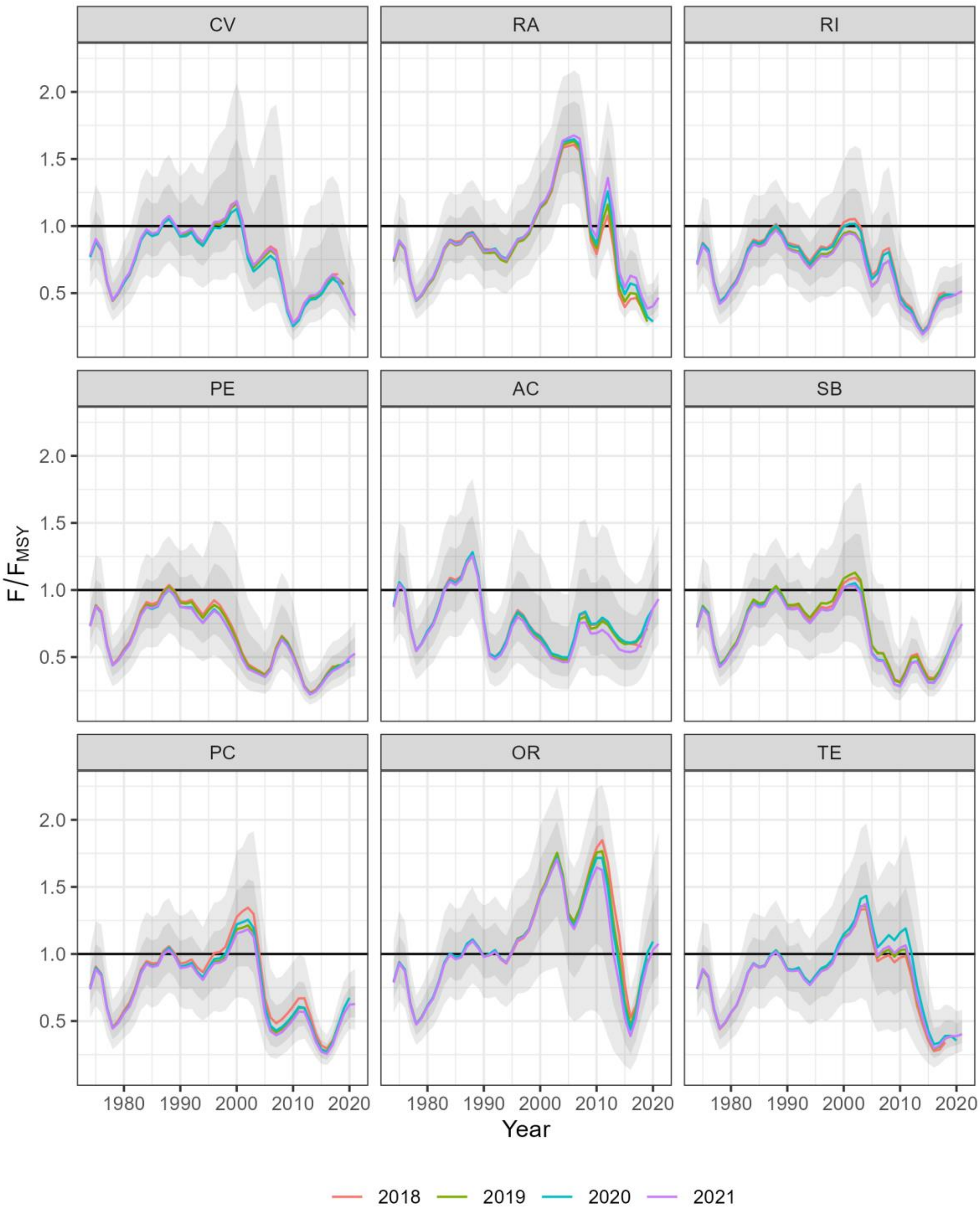

Figure 5.10.3 Striped Venus Clam in GSA 17: Historical assessment results of Fishing mortality relative to MSY (Retrospective graph) for each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli).

Issues relevant for the advice

SVE, Chamelea gallina (Linnaeus, 1758), is an infaunal filter-feeder clam of the Veneridae family (Bivalvia: Lamellibranchiata: Veneridae) that inhabits the fine well-sorted sand (Péres and Picard 1964). It is widespread in the Mediterranean and Black Seas and along the eastern Atlantic coast at depths ranging from 0 to 12 m. Within the Adriatic Sea (GSA17 and GSA18), the resource is distributed along a narrow strip (max 2NMI from the coast) with densities decreasing as a function of sediment grain size characteristics and is particularly abundant in the central western Adriatic Sea, where the massive Po River outflow and the currents flowing along the Italian coast provide abundant resources (Orban et al., 2007).

Given its habitat, the Striped Venus Calm is subject to important stochastic fluctuation due to environmental and anthropogenic disturbance. These events have frequency and intensity that greatly vary along the Eastern Italian coast, thus creating different outcomes by maritime district that should be considered individually. Environmental characteristics and hydrodynamic regimes along the Western Adriatic Sea are not uniform and striped Venus clam stocks can have different population dynamics over time and space. In particular, both landings and survey data show larger populations characterising the central Adriatic Sea with generally low reported landings and densities of clams in the north and south (Figure 5.10.4).

The first hydraulic dredgers in Italy entered service in the Adriatic Sea in the early 70s and a few years exceeded the traditional dredges operated by hand because the catches and economic returns were much higher. In 1974, the Italian vessels targeting SVE amounted to 383 boats. This fleet reached around 50 thousand tons in those years in 1975. Ten years later dredges had increased to 607 in the same area, peaking at 778 in 1993. Then, the fleet started decreasing as a consequence of European, National and Regional management plans, which led to a reduction of fishing capacity from 665 Adriatic vessels in 1998 to 585 ships in 2002 (plus 65 boats authorised to catch and sell Callista chione only). In 2021 the number of vessels allowed to fish SVE remains nearly unchanged. Alongside vessel reduction, the daily quota per vessel and the maximum number of days per week lowered over the years from 2500 kg in 1986 to 600 kg in 1989 and to 400 kg in 2017 (DM 27/12/2016, transposing EU Regulation 2376/2016).

Since 1995, the Italian management of the fishery is entrusted by the MIPAAF to the Bivalve Molluscs Management Consortia, established under Ministerial Decree (MD) 44/1995 and 515/1998 and recognised by the Ministry of Agriculture, Food and Forestry. The operational procedures and the prerogatives of the Consortia are defined by the Ministerial Decree of 22 December 2000 that amends DM 21/7/1998, which regulates the fishing of bivalve molluscs based upon the principle that, given the heterogeneity of environmental realities along the Italian coast, Consortia are better suited to locally manage the effort and other conservation strategies for achieving National and European targets by adopting ad hoc management strategies and imposing more restrictive measures as a function of stock size and resilience (Lucchetti et al., 2022).

Reference points

Fishing mortality from the nine districts with CMSY models are expressed relative to F_{MSY} and there therefore directly related to F_{MSY} reference points by district

Basis of the assessment

Table 5.10.6 Striped Venus Calm in GSA 17 & 18: Basis of the assessment and advice.

Assessment type	Surplus production model (CMSY/BSM)
Input data	DRESS data plus observed (consortia's official landings records) and estimated landings (fishstat landings)
Discards, BMS landings*, and bycatch	Discards not available, BMS are returned at sea with more than 90% survival rate
Indicators	g of individuals above 25mm in length per metre square
Other information	No advice is given
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Catch advice is not provided.

History of the catch and landings

Table 5.10.8 Striped Venus Clam in GSA 17 & 18: Catch and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021		Wanted catch	Discards
Catch (t)	21082	DRB 100%	0
Effort	56749		
		Fishing days	

Table 5.10.9 Striped Venus Clam in GSA 17 & 18: History of commercial landings for each of the twelve Italian maritime districts in which the striped Venus calm is targeted by hydraulic dredges (GSA17: MO = Monfalcone, CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli; GSA18: MA = Manfredonia, BA = Barletta), and Croatia (HRV); official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days. <> indicates values obtained from total landings by the use of recent catch shares.

Year	GSA17 ITA										GSA18 ITA		GSA17 HRV	Total landings	Total Effort * (Fishing Days)
	MO	CV	RA	RI	PE	AC	SB	PC	OR	TE	MA	BA	HRV		
1974	<362>	<5295>	<941>	<2540>	<4345>	<5317>	<2694>	<4055>	<833>	<313>				26695	
1975	<663>	<9715>	<1727>	<4660>	<7972>	<9754>	<4942>	<7439>	<1528>	<574>				48973.01	
1976	<503>	<7373>	<1311>	<3537>	<6050>	<7402>	<3750>	<5646>	<1159>	<436>				37166.98	
1977	<155>	<2266>	<403>	<1087>	<1860>	<2275>	<1153>	<1735>	<356>	<134>				11424	
1978	<122>	<1781>	<317>	<854>	<1461>	<1788>	<906>	<1364>	<280>	<105>				8976.02	
1979	<276>	<4043>	<719>	<1939>	<3318>	<4059>	<2057>	<3096>	<636>	<239>				20381	
1980	<353>	<5166>	<918>	<2478>	<4239>	<5186>	<2628>	<3956>	<812>	<305>				26041.02	
1981	<256>	<3751>	<667>	<1799>	<3078>	<3766>	<1908>	<2873>	<590>	<222>				18910.01	
1982	<369>	<5402>	<960>	<2591>	<4433>	<5423>	<2748>	<4137>	<849>	<319>				27231	
1983	<465>	<6804>	<1210>	<3264>	<5583>	<6831>	<3461>	<5210>	<1070>	<402>				34300.01	
1984	<516>	<7563>	<1345>	<3628>	<6206>	<7593>	<3847>	<5792>	<1189>	<447>				38126	
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1988	<430>	<6298>	<1120>	<3021>	<5168>	<6324>	<3204>	<4823>	<990>	<372>				31751.01	
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1990	<272>	<3979>	<707>	<1909>	<3265>	2289	<2024>	<3047>	<626>	<235>				18586.87	
1991	<344>	<5042>	<896>	<2418>	<4137>	995	<2565>	<3861>	<793>	<298>				21644.31	
1992	<426>	<6235>	<1109>	<2991>	<5117>	2618	<3172>	<4775>	<981>	<368>				28156.88	
1993	<328>	<4808>	<855>	<2306>	<3946>	3100	<2446>	<3682>	<756>	<284>				22792.89	
1994	<224>	<3279>	<583>	<1573>	<2690>	1871	<1668>	<2511>	<516>	<194>				15298.96	
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1996	<430>	<6302>	<1120>	<3023>	<5171>	5175	<3206>	<4826>	<991>	<372>				30986.51	
1997	<344>	<5031>	<894>	<2413>	<4129>	4090	<2559>	<3853>	<791>	<297>				24696.1	
1998	<343>	<5027>	<894>	<2412>	<4125>	3753	<2557>	<3850>	<791>	<297>				24343.29	
1999	550	<6616>	<1176>	<3173>	3638	3417	<3365>	<5066>	<1040>	<391>				29190.11	
2000	303	<6265>	<1114>	<3005>	3489	3346	<3187>	<4798>	<985>	<370>				27579.95	
2001	524	<6410>	<1140>	<3075>	2790	4224	<3261>	<4909>	<1008>	<379>				28451.37	
2002	750	1855	<834>	<2251>	1805	1181	<2386>	<3593>	<738>	<277>				16400.27	
2003	684	3259	<1372>	<3703>	3021	3648	<3927>	<5912>	<1214>	<456>				28398.19	
2004	650	4514	1319	1303	2353	3195	1850	2552	719	<408>	272			19674.38	
2005	632	4001	950	1491	2650	1454	800	1103	311	245	428			14290.01	
2006	724	4646	852	1266	1035	3367	1445	2298	594	146	1628			18275.15	
2007	487	5474	1177	3212	4963	5880	2331	1279	567	270	2015			28075.42	
2008	781	3586	517	3008	5682	5334	1469	2554	719	375	1293	268		25587.08	
2009	304	1607	409	2058	2734	1787	758	2576	743	129	2041	189		15334.93	
2010	155	931	262	700	3521	4067	1109	2919	749	305	1789	40		16547.48	
2011	102	1451	640	1430	3030	4340	1148	3353	710	363	1855	108		18529	
2012	42	3866	1317	1980	1018	3177	2677	4478	555	224	689	218	0.005	20241.01	
2013	202	3774	691	793	1262	3261	2524	2184	88	129	472	65	0.002	15445	47510
2014	205	2938	81	484	1911	2720	1168	1991	603	198	255	123		12677	56660
2015	130	3521	295	572	1888	2422	1254	1632	122	114	38	812		12800	48992
2016	63	4237	595	2045	2887	3194	1138	1196	127	71	210	598		16361	63771
2017	3	4970	787	2129	3023	2210	1472	1759	132	97	71	94		16747	43810
2018	15	4027	317	1835	2666	2978	2193	3454	757	213	68	218		18741	48016
2019	0	3508	327	1802	2957	3890	2527	3673	699	167	64	129	0.006	19743.01	52004
2020	0	2110	400	1888	3245	4343	3049	4372	858	144	0	109		20518	56636
2021	0	2069	788	2147	3666	4776	3063	3314	833	213	0	213		21082	56749

*Effort data is taken from STECF EWG 22-16. For some fleets effort reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to FDI from 2014 onward.

Summary of the assessment

Table 5.10.10 Striped Venus Clam in GSA 17: Assessment summary for each of the nine maritime districts assessed in GSA17:

Year	GSA17-ITA								
	Chioggia and Venezia			Ravenna			Rimini		
	F/F_{MSY}	lcl	ucl	F/F_{MSY}	lcl	ucl	F/F_{MSY}	lcl	ucl
1974	0.783	0.545	1.11	0.755	0.548	1.037	0.711	0.498	1.002
1975	0.904	0.621	1.308	0.889	0.624	1.241	0.849	0.577	1.214
1976	0.833	0.559	1.224	0.839	0.584	1.189	0.801	0.522	1.194
1977	0.585	0.385	0.88	0.591	0.409	0.863	0.561	0.358	0.848
1978	0.45	0.295	0.683	0.448	0.306	0.647	0.42	0.265	0.643
1979	0.507	0.331	0.752	0.491	0.34	0.712	0.456	0.293	0.69
1980	0.595	0.387	0.885	0.566	0.389	0.802	0.523	0.338	0.787
1981	0.654	0.425	0.971	0.617	0.422	0.879	0.575	0.375	0.853
1982	0.772	0.501	1.133	0.711	0.489	1.023	0.669	0.44	0.989
1983	0.91	0.597	1.339	0.838	0.582	1.179	0.795	0.525	1.158
1984	0.975	0.637	1.43	0.889	0.615	1.255	0.864	0.561	1.238
1985	0.944	0.612	1.368	0.863	0.593	1.233	0.847	0.549	1.225
1986	0.955	0.626	1.369	0.87	0.6	1.244	0.86	0.565	1.239
1987	1.039	0.69	1.486	0.928	0.645	1.317	0.929	0.628	1.314
1988	1.076	0.726	1.532	0.94	0.64	1.344	0.971	0.649	1.348
1989	1.016	0.689	1.436	0.881	0.591	1.28	0.92	0.638	1.268
1990	0.943	0.629	1.37	0.81	0.532	1.192	0.831	0.554	1.187
1991	0.955	0.62	1.409	0.815	0.538	1.186	0.81	0.538	1.167
1992	0.981	0.616	1.479	0.823	0.544	1.208	0.801	0.519	1.18
1993	0.916	0.564	1.407	0.77	0.509	1.128	0.733	0.458	1.112
1994	0.881	0.54	1.385	0.748	0.497	1.087	0.684	0.427	1.049
1995	0.959	0.572	1.518	0.83	0.542	1.187	0.732	0.454	1.125
1996	1.03	0.605	1.622	0.897	0.592	1.308	0.778	0.48	1.201
1997	1.035	0.598	1.684	0.913	0.614	1.312	0.772	0.469	1.225
1998	1.061	0.6	1.734	0.963	0.638	1.368	0.798	0.483	1.25
1999	1.146	0.649	1.936	1.056	0.718	1.493	0.86	0.521	1.377
2000	1.187	0.651	2.067	1.157	0.79	1.592	0.928	0.548	1.49
2001	1.038	0.551	1.917	1.197	0.828	1.659	0.946	0.551	1.572
2002	0.796	0.409	1.554	1.291	0.894	1.739	0.934	0.532	1.596
2003	0.709	0.359	1.424	1.482	1.034	1.976	0.873	0.498	1.575
2004	0.75	0.384	1.567	1.636	1.158	2.113	0.693	0.39	1.307
2005	0.797	0.414	1.718	1.657	1.165	2.131	0.548	0.312	1.078
2006	0.834	0.432	1.874	1.675	1.17	2.16	0.588	0.338	1.148
2007	0.794	0.425	1.907	1.652	1.129	2.126	0.715	0.414	1.396
2008	0.617	0.323	1.598	1.369	0.894	1.86	0.74	0.433	1.442
2009	0.387	0.206	1.064	0.988	0.636	1.451	0.594	0.348	1.203
2010	0.274	0.149	0.738	0.917	0.595	1.357	0.427	0.255	0.895
2011	0.319	0.179	0.817	1.169	0.74	1.651	0.375	0.229	0.763
2012	0.425	0.242	1.064	1.358	0.836	1.929	0.345	0.214	0.687
2013	0.481	0.281	1.152	1.098	0.642	1.72	0.255	0.161	0.478
2014	0.485	0.286	1.156	0.661	0.375	1.133	0.192	0.124	0.336
2015	0.522	0.306	1.189	0.541	0.315	0.901	0.237	0.156	0.399
2016	0.597	0.355	1.342	0.63	0.37	1.001	0.351	0.234	0.559
2017	0.638	0.387	1.371	0.613	0.37	0.946	0.437	0.288	0.683
2018	0.608	0.371	1.309	0.474	0.295	0.723	0.465	0.316	0.704
2019	0.511	0.311	1.062	0.385	0.25	0.564	0.472	0.317	0.689
2020	0.404	0.251	0.827	0.403	0.282	0.575	0.493	0.337	0.708
2021	0.333	0.211	0.677	0.466	0.329	0.663	0.514	0.356	0.733

Year	GSA17-ITA								
	Pesaro			Ancona and Civitanova Marche			San Benedetto del Tronto		
	F/F_{MSY}	lcl	ucl	F/F_{MSY}	lcl	ucl	F/F_{MSY}	lcl	ucl
1974	0.729	0.511	1.024	0.873	0.599	1.241	0.719	0.505	1.004
1975	0.878	0.604	1.258	1.045	0.681	1.499	0.861	0.592	1.239
1976	0.83	0.547	1.235	0.991	0.634	1.468	0.812	0.538	1.186
1977	0.586	0.378	0.887	0.711	0.44	1.092	0.568	0.376	0.862
1978	0.439	0.282	0.663	0.544	0.334	0.852	0.426	0.28	0.645
1979	0.477	0.309	0.714	0.598	0.371	0.908	0.467	0.31	0.699
1980	0.539	0.357	0.812	0.677	0.423	1.036	0.538	0.359	0.796
1981	0.591	0.393	0.876	0.738	0.459	1.106	0.593	0.392	0.864
1982	0.689	0.46	0.994	0.848	0.538	1.278	0.693	0.458	1.007
1983	0.813	0.542	1.175	0.995	0.619	1.464	0.825	0.556	1.198
1984	0.874	0.575	1.276	1.063	0.66	1.563	0.896	0.594	1.281
1985	0.866	0.571	1.237	1.038	0.646	1.544	0.872	0.578	1.261
1986	0.883	0.577	1.276	1.079	0.667	1.592	0.879	0.587	1.252
1987	0.963	0.638	1.361	1.203	0.746	1.767	0.962	0.638	1.339
1988	1.005	0.681	1.403	1.255	0.796	1.828	0.999	0.681	1.391
1989	0.96	0.657	1.338	1.089	0.703	1.603	0.94	0.659	1.306
1990	0.877	0.587	1.291	0.748	0.478	1.175	0.859	0.578	1.228
1991	0.866	0.56	1.306	0.511	0.307	0.846	0.856	0.564	1.246
1992	0.862	0.549	1.352	0.483	0.28	0.818	0.862	0.55	1.283
1993	0.803	0.497	1.286	0.516	0.299	0.887	0.795	0.5	1.188
1994	0.753	0.469	1.238	0.593	0.343	1.047	0.753	0.473	1.151
1995	0.802	0.489	1.37	0.727	0.42	1.292	0.805	0.499	1.245
1996	0.847	0.517	1.516	0.8	0.459	1.457	0.856	0.531	1.317
1997	0.815	0.491	1.51	0.769	0.434	1.434	0.848	0.526	1.296
1998	0.752	0.446	1.474	0.695	0.385	1.332	0.856	0.535	1.342
1999	0.678	0.406	1.405	0.645	0.355	1.278	0.932	0.561	1.476
2000	0.588	0.35	1.27	0.615	0.338	1.264	1.018	0.617	1.645
2001	0.487	0.296	1.095	0.559	0.315	1.166	1.029	0.613	1.692
2002	0.413	0.257	0.932	0.493	0.276	1.016	1.028	0.597	1.774
2003	0.392	0.244	0.857	0.48	0.266	1.006	0.978	0.551	1.803
2004	0.373	0.236	0.796	0.463	0.261	0.97	0.755	0.424	1.546
2005	0.351	0.226	0.691	0.463	0.259	0.967	0.522	0.297	1.141
2006	0.402	0.262	0.771	0.589	0.334	1.185	0.473	0.273	1.05
2007	0.548	0.359	1.012	0.754	0.416	1.507	0.469	0.282	1.043
2008	0.633	0.412	1.131	0.757	0.422	1.528	0.39	0.234	0.847
2009	0.583	0.383	1.06	0.676	0.365	1.399	0.297	0.185	0.618
2010	0.503	0.326	0.909	0.678	0.357	1.392	0.282	0.178	0.55
2011	0.395	0.253	0.712	0.703	0.367	1.491	0.356	0.233	0.653
2012	0.274	0.178	0.486	0.671	0.349	1.451	0.455	0.302	0.809
2013	0.222	0.146	0.386	0.616	0.319	1.306	0.466	0.307	0.772
2014	0.243	0.162	0.411	0.558	0.289	1.186	0.379	0.251	0.625
2015	0.292	0.195	0.469	0.542	0.28	1.12	0.31	0.206	0.497
2016	0.351	0.238	0.555	0.537	0.282	1.078	0.307	0.208	0.483
2017	0.396	0.266	0.614	0.549	0.3	1.042	0.364	0.248	0.553
2018	0.417	0.283	0.63	0.616	0.345	1.081	0.459	0.312	0.679
2019	0.447	0.303	0.668	0.737	0.432	1.223	0.572	0.393	0.829
2020	0.497	0.347	0.709	0.863	0.542	1.336	0.676	0.476	0.952
2021	0.526	0.363	0.765	0.932	0.594	1.484	0.747	0.52	1.082

Year	GSA17-ITA								
	Pescara			Ortona			Termoli		
	F/F_{MSY}	lcl	ucl	F/F_{MSY}	lcl	ucl	F/F_{MSY}	lcl	ucl
1974	0.736	0.522	1.03	0.786	0.562	1.107	0.745	0.531	1.032
1975	0.885	0.614	1.244	0.929	0.653	1.319	0.888	0.603	1.238
1976	0.836	0.56	1.221	0.873	0.6	1.241	0.836	0.548	1.219
1977	0.591	0.388	0.886	0.615	0.424	0.897	0.59	0.382	0.864
1978	0.445	0.291	0.66	0.473	0.322	0.692	0.445	0.286	0.656
1979	0.485	0.326	0.719	0.523	0.358	0.76	0.492	0.313	0.726
1980	0.558	0.378	0.809	0.606	0.414	0.865	0.563	0.365	0.823
1981	0.609	0.411	0.892	0.667	0.456	0.954	0.619	0.404	0.905
1982	0.715	0.476	1.023	0.784	0.533	1.113	0.724	0.478	1.038
1983	0.852	0.581	1.221	0.926	0.63	1.31	0.856	0.562	1.223
1984	0.926	0.629	1.313	0.993	0.685	1.387	0.925	0.612	1.307
1985	0.903	0.599	1.277	0.961	0.654	1.337	0.899	0.591	1.29
1986	0.914	0.619	1.293	0.975	0.664	1.347	0.908	0.6	1.273
1987	0.997	0.675	1.387	1.056	0.736	1.44	0.981	0.655	1.351
1988	1.031	0.715	1.417	1.096	0.783	1.5	1.015	0.688	1.399
1989	0.98	0.69	1.323	1.044	0.747	1.402	0.96	0.665	1.31
1990	0.895	0.604	1.283	0.978	0.674	1.361	0.876	0.598	1.229
1991	0.901	0.588	1.297	0.991	0.669	1.383	0.872	0.576	1.233
1992	0.916	0.592	1.336	1.016	0.684	1.431	0.878	0.568	1.272
1993	0.854	0.534	1.265	0.963	0.631	1.366	0.81	0.514	1.167
1994	0.807	0.505	1.2	0.932	0.604	1.32	0.768	0.473	1.114
1995	0.877	0.537	1.298	1.017	0.651	1.456	0.821	0.497	1.196
1996	0.931	0.576	1.382	1.104	0.706	1.554	0.87	0.517	1.273
1997	0.936	0.566	1.393	1.124	0.71	1.58	0.887	0.501	1.309
1998	0.959	0.578	1.439	1.176	0.729	1.634	0.929	0.537	1.364
1999	1.056	0.634	1.589	1.298	0.793	1.786	1.033	0.596	1.493
2000	1.154	0.678	1.768	1.432	0.848	1.957	1.114	0.636	1.588
2001	1.166	0.675	1.796	1.517	0.875	2.049	1.147	0.636	1.644
2002	1.185	0.66	1.892	1.619	0.887	2.144	1.222	0.644	1.754
2003	1.129	0.602	1.913	1.706	0.904	2.25	1.351	0.673	1.931
2004	0.853	0.444	1.607	1.547	0.74	2.04	1.374	0.652	1.974
2005	0.554	0.287	1.159	1.254	0.544	1.722	1.166	0.511	1.745
2006	0.424	0.229	0.893	1.186	0.497	1.644	0.987	0.418	1.543
2007	0.394	0.218	0.818	1.284	0.522	1.738	1.036	0.432	1.624
2008	0.417	0.247	0.832	1.418	0.565	1.92	1.058	0.44	1.695
2009	0.46	0.278	0.887	1.552	0.584	2.087	1.005	0.413	1.653
2010	0.509	0.325	0.94	1.645	0.568	2.231	1.047	0.435	1.756
2011	0.57	0.358	0.999	1.627	0.509	2.261	1.064	0.451	1.888
2012	0.568	0.37	0.977	1.344	0.386	2.103	0.899	0.369	1.699
2013	0.469	0.303	0.796	0.999	0.28	1.801	0.674	0.29	1.413
2014	0.349	0.229	0.575	0.781	0.225	1.538	0.52	0.23	1.093
2015	0.272	0.182	0.442	0.525	0.168	1.088	0.385	0.184	0.801
2016	0.256	0.171	0.398	0.387	0.135	0.736	0.298	0.152	0.586
2017	0.322	0.219	0.488	0.519	0.21	0.881	0.318	0.176	0.585
2018	0.442	0.301	0.652	0.756	0.348	1.237	0.372	0.218	0.624
2019	0.555	0.381	0.792	0.928	0.484	1.499	0.387	0.24	0.612
2020	0.622	0.441	0.861	1.031	0.579	1.709	0.388	0.258	0.572
2021	0.627	0.436	0.889	1.076	0.631	1.91	0.402	0.275	0.583

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STECF EWG 22-16

5.11 SUMMARY SHEET FOR NORWAY LOBSTER IN GSAS 15 AND 16

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.10 and corresponding catches in 2023 should be no more than 51 tons.

Stock development over time

Catches of Norway lobster show a decreasing trend from 2007 to 2015 followed by a slight increase up to 2018 and a decrease after that. The Norway lobster recruitment at age 2 shows a decreasing trend from the beginning of the time series with a slight increase in 2021. SSB follows the same pattern but is declining also in 2021. F has been fluctuating throughout the time series, reached a maximum in 2019 and has been slightly decreasing after.

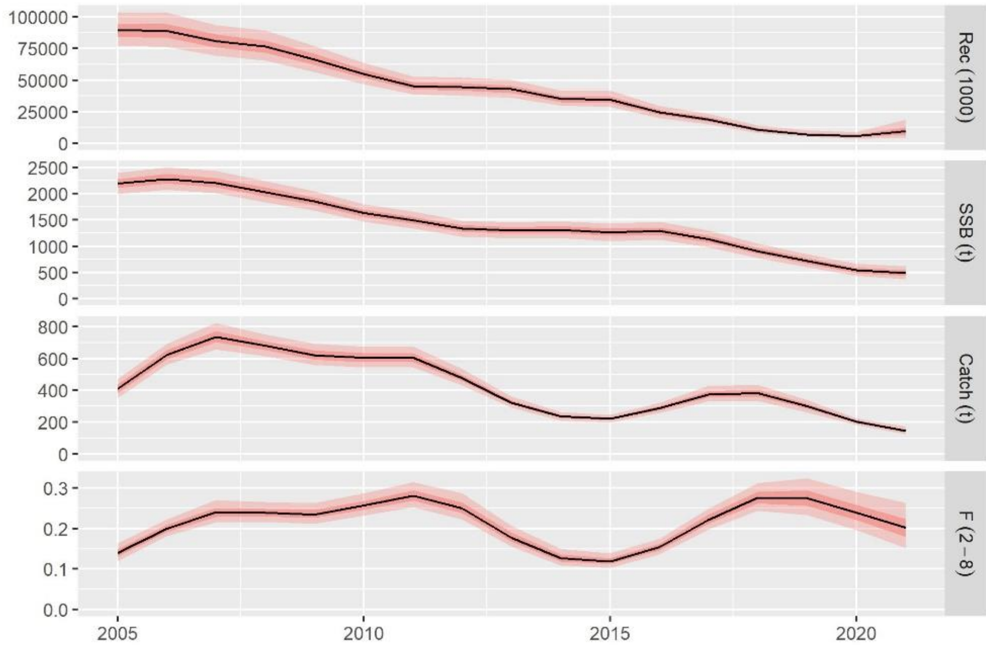


Figure 5.11.1 Norway lobster in GSAs 15 and 16: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.20) is 2 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.10).

Table 5.11.1 Norway lobster in GSAs 15 and 16: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.11.2 Norway lobster in GSAs 15 and 16: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 2\text{-}8}$ (2022)	0.20	The F estimated in 2021 was used to give F status quo for 2022.
SSB (2022)	385	SSB intermediate year from STF output.
R_{age2} (2022,2023)	7955	Geometric mean of the last 4 years.
Total catch (2022)	115	Assuming F status quo for 2022.

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

Table 5.11.3 Norway lobster in GSAs 15 and 16: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (ages 2-8) (2023)	SSB* (2024)	% SSB change**	% Catch change***
STECF advice basis					
F_{MSY}	51	0.10	347	-9.8	-65
$F_{MSY\ lower}$	71	0.143	322	-16.5	-52
$F_{MSY\ upper}$^	36	0.069	368	-4.5	-76
Other scenarios					
Zero catch	0	0	418	8.6	-100
Status quo	96	0.20	290	-24.6	-35
Different scenarios	32	0.06	374	-2.9	-79
	61	0.12	335	-13	-59
	120	0.26	261	-32.1	-19
	142	0.32	236	-38.7	-4
	168	0.40	207	-46.3	14

* SSB at the middle of the year.
** % change in SSB 2024 to 2022.
*** Total catch in 2023 relative to Catch in 2021.
^ $F_{MSY\ upper}$ is not tested and is assumed not to be precautionary STECF does not advise fishing at F > F_{MSY}.

Basis of the advice

Table 5.11.4 Norway lobster in GSAs 15 and 16: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The retrospective analysis shows that the model results are quite stable and show a slight tendency to overestimate SSB (Mohn's rho 0.02) and F (Mohn's rho 0.09). All the diagnostics were considered acceptable. MEDITS survey in 2014 has been excluded from the assessment due to partial spatial coverage. Catch numbers for 2018 were excluded from the assessment due to no length frequency distribution available in the dataset; catches in tonnes for 2018 were included.

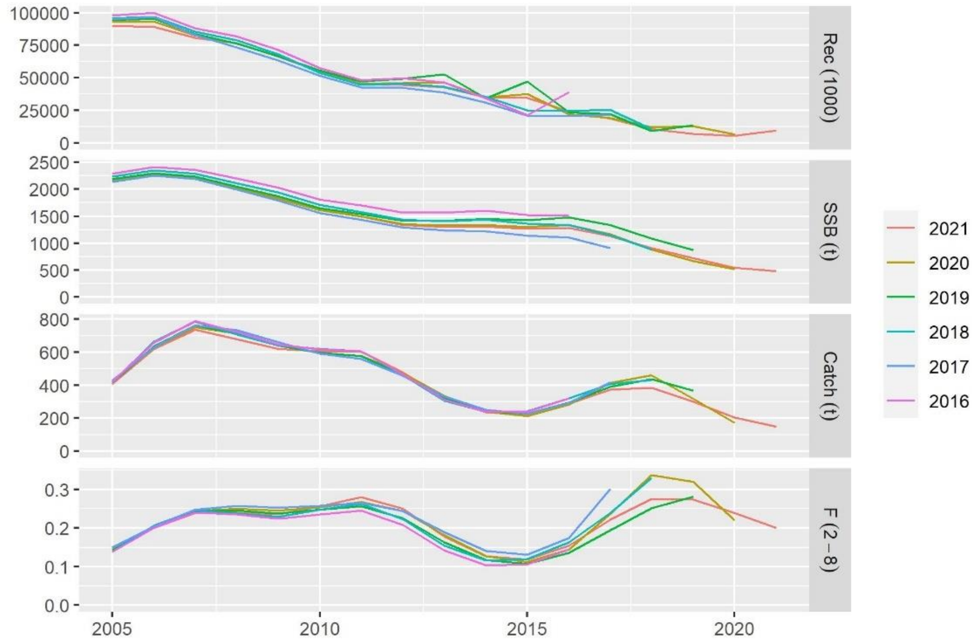


Figure 5.11.2 Norway lobster in GSAs 15 and 16: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.11.5 Norway lobster in GSAs 15 and 16: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.10	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.10	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range F_{lower}	0.069	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range F_{upper}	0.143	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

Basis of the assessment

Table 5.11.6 Norway lobster in GSAs 15 and 16: Basis of the assessment and advice.

Assessment type	Statistical catch at age a4a
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.11.7 Norway lobster in GSAs 15 and 16: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	No advice			148	
2022	No advice				
2023	F = F_{MSY}		51		

History of the catch and landings

Table 5.11.8 Norway lobster in GSAs 15 and 16: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2021		Wanted catch	Discards
Catch (t)	189	Otter trawl 100%	0 t
		189 t	
Effort	49117	49117	
		Fishing days	

Table 5.11.9 Norway lobster in GSAs 15 and 16: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	Malta GSA 15	Malta GSA 16	Italy GSA 16	Total landings	Total Effort * (Fishing Days)
2002			516	516	87300
2003			647	647	76233
2004			428	428	90123
2005			490	490	83686
2006			673	673	84115
2007			797	797	80798
2008			673	673	77579
2009	1.49**		636	636	80543
2010	1.68**		616	616	80910
2011	1.09**		627	627	72685
2012	0.66**		479	479	66399
2013			293	293	64057
2014	1.70**		249	249	56444
2015	1.44		229	230	59299
2016	1.12		275	276	60436
2017	0.99		371	372	65427
2018	1.06	0.17	332	333	56012
2019	0.91	0.04	337	338	57199
2020	0.40	0.08	147	147	49618
2021	0.27	0.19	189	189	49117

* Effort data is reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2013 and to FDI from 2013 onward. From 2002 to 2005 the effort includes only Italy.
** Data excluded from the final landings dataset due to high uncertainty in the reporting.

Summary of the assessment

Table 5.11.10 Norway lobster in GSAs 15 and 16: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 2 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 2-8	High	Low
2005	89745			2187			408	0.14		
2006	88986			2278			621	0.20		
2007	80741			2203			735	0.24		
2008	76529			2029			680	0.24		
2009	66388			1850			621	0.23		
2010	54908			1629			605	0.26		
2011	45409			1493			603	0.28		
2012	44469			1334			478	0.25		
2013	42692			1298			323	0.18		
2014	35164			1309			235	0.13		
2015	34612			1264			221	0.12		
2016	24442			1286			287	0.15		
2017	18849			1134			374	0.22		
2018	10688			909			383	0.27		
2019	7063			720			301	0.27		
2020	5595			541			204	0.24		
2021	9484			485			148	0.20		

Sources and references

STECF EWG 22-16

5.12 Summary Sheet for striped red mullet in GSAs 15 and 16

STECF advice on fishing opportunities

While the assessment gives some indication of stock status, STECF EWG 22-16 is unable to provide F_{MSY} advice due to instability in the assessment. However, fishing at status quo F corresponds to catches in 2023, of 651 tonnes.

Stock development over time

SSB and Recruitment show a fluctuating trend in the period with an increase in the last three years. Catches are decreasing in the same last three years. F shows a waving pattern with a steep decrease in the last years. It should be noted as the model hasn't been able to cope properly with the observed catches reported at the beginning of the time series.

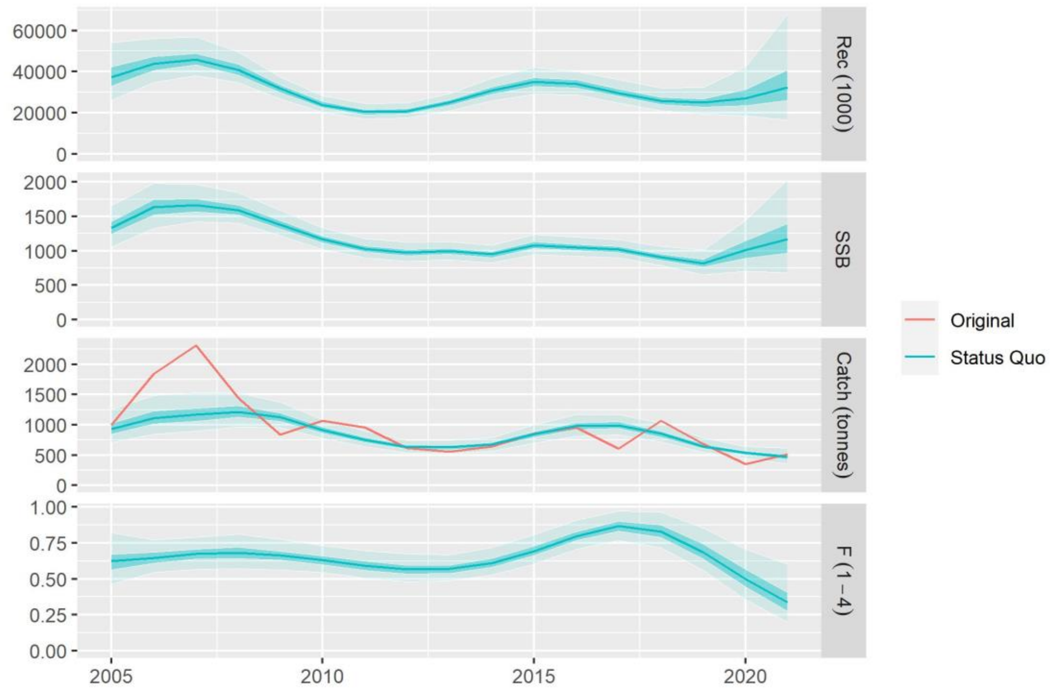


Figure 5.12.1 Striped red mullet in GSAs 15 and 16: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. Original catches are also shown.

Stock and exploitation status

The current level of fishing mortality is 25% above the estimated reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.272).

Table 5.12.1 Striped red mullet in GSAs 15 and 16: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.12.2 Striped red mullet in GSAs 15 and 16: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Fages 1-4 (2022)	0.341	Fsq = F in the last year
SSB (2022)	1426.98	SSB intermediate year from STF output
Rage1 (2022,2023)	27147.895	Recruitment will be set as geometric mean of the last 12 years
Total Catch (2022)	611.605	Catch intermediate year from STF output

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

Table 5.12.3 Striped red mullet in GSAs 15 and 16: Annual catch scenarios. All weights are in tonnes. Catch advice are based on status quo fishing mortality level and corresponding increase and decrease level of 10% and 20% respectively of the status quo fishing mortality

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
20% reduction	540.39	0.272	1700.5	19.16	13.03
10% reduction	596.83	0.307	1630.3	14.24	24.84
Status quo	651.12	0.341	1564.0	9.60	36.19
10% increasing	703.37	0.375	1501.5	5.22	47.12
20% increasing	753.64	0.409	1442.5	1.09	57.64
Other scenarios					
Zero catch	0	0	2439.1	70.93	-100

*** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.

Basis of the advice

Table 5.12.4 Striped red mullet in GSAs 15 and 16: The basis of the advice.

Advice basis	F Status Quo
Management plan	

Quality of the assessment

The assessment of striped red mullet in GSAs 15 and 16 (Strait of Sicily and Maltese Islands) is a new assessment. Data preparations were carried out quite successfully extensive issues spotted in the commercial data. Because the first available year of the Malta MEDITS survey was 2005 the time series used has been restricted to 2005 to 2021. All potential models showed a similar residuals pattern with the values varying in the acceptable range always associated to a bad fit with the survey data. This bad fit may be because the MEDITS it is not designed properly to take signals for this species which is very coastal and usually associated with the rocky bottom. Considerable instability in the retrospective has been observed, particularly in the F. To stabilise the model a flat selectivity has been imposed both in the catch and in the surveys which was considered plausible for this species. The assessment has been considered preliminary and not robust enough in providing catch advice for the next years in term of FMSY proxy (F0.1). Only catch projections based on the fishing mortality at current level of exploitation has been provided.

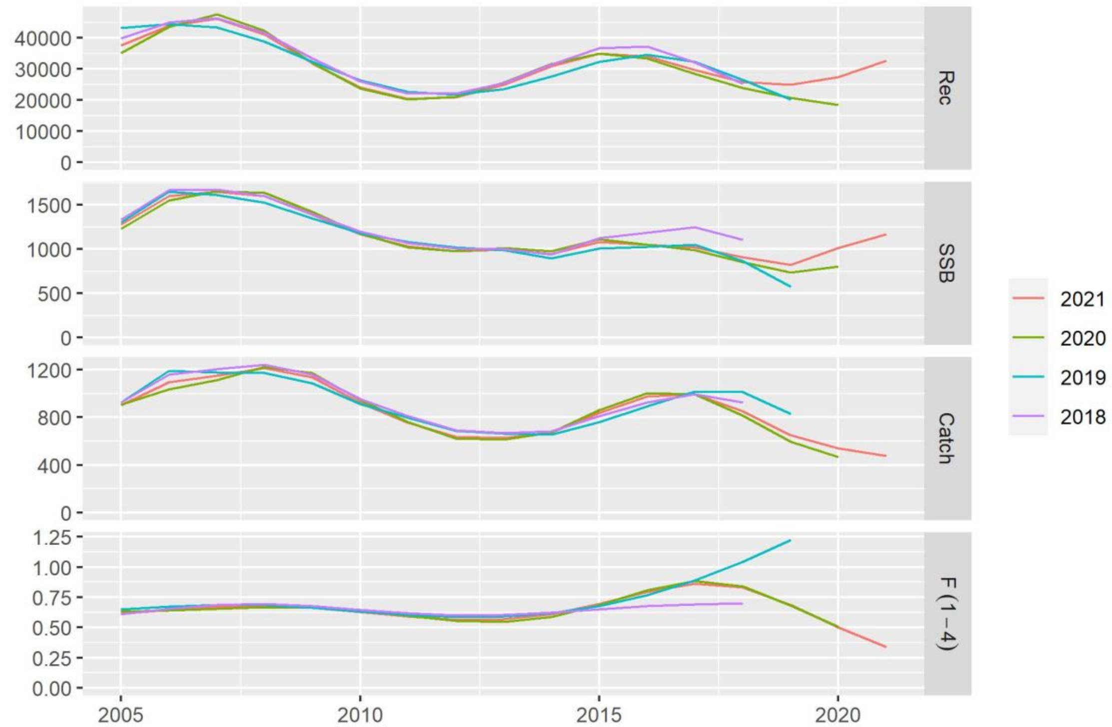


Figure 5.12.2 Striped red mullet in GSAs 15 and 16: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

Due to the instability on the retrospective and the bad fit with the survey the assessment has been considered provisional and according to the precautionary approach able to provide catch advice only in term of current fishing mortality level.

Reference points

Table 5.12.5 Striped red mullet in GSAs 15 and 16: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}		0.272	EWG 22-16
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}		Not Defined	
	target range F_{lower}		Not Defined	
	target range F_{upper}		Not Defined	

Basis of the assessment

Table 5.12.6 Striped red mullet in GSAs 15 and 16: 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 in weight included.
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.12.7 Striped red mullet in GSAs 15 and 16: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catches	STECF discards
2021				478.07	
2022					
2023	F = Fstatus quo		651.12		

History of the catch and landings

Table 5.12.8 Striped red mullet in GSAs 15 and 16: Catch in 2021 and effort distribution by fleet in 2021 as reported to STECF.

2021	Wanted catch			Discards
Catch (t)	Bottom Otter Trawl (OTB) 73%	Trammel net (GTR) 24%	Others gears 3%	Bottom Otter Trawl (OTB) 100%
	374.76	123.21	35.94	Less than 0.1%
Effort (2021)	49117	52373	21479	
	Fishing Days			

Table 5.12.9 Striped red mullet in GSAs 15 and 16: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort data source FDI 2013 -2021.

Year	ITA (GSA16)	MLT (GSA15)	Total landings	Total effort (Fishing days)
2002	2107.782	NA	2107.782	NA
2003	1744.967	NA	1744.967	NA
2004	2080	NA	2080	NA
2005	1001.423	NA	1001.423	NA
2006	1842.806	NA	1842.806	NA
2007	2313.8	NA	2313.8	NA
2008	1440.64	NA	1440.64	NA
2009	833.347	NA	833.347	NA
2010	1064.744	NA	1064.744	NA
2011	940.871	NA	940.871	NA
2012	610.457	NA	610.457	NA
2013	522.717	NA	522.717	139520
2014	576.011	45.259	621.27	107628
2015	816.153	38.326	854.479	126158
2016	863.661	43.17	906.831	141782
2017	572.466	31.296	603.763	133176
2018	1034.25	30.263	1064.513	114950
2019	651.74	28.072	679.796	109834
2020	341.53	16.96	358.491	88516
2021	487.624	25.751	513.376	101490

Summary of the assessment

Table 5.12.10 Striped red mullet in GSAs 15 and 16: Assessment summary. Weights are in tonnes.

Year	Recruitment age 1 ('000)	SSB (t)	Catch (t)	F_{bar} ages 1-4
2005	37505.825	1281.146	902.9112	0.615185
2006	43869.646	1602.643	1093.697	0.645833
2007	46222.311	1652.148	1149.219	0.669408
2008	41099.390	1598.515	1212.285	0.676619
2009	31763.444	1390.344	1136.401	0.662194
2010	24010.289	1169.952	918.7311	0.629589
2011	20365.143	1030.492	757.3571	0.591617
2012	20857.199	977.0032	634.5145	0.565839
2013	24931.687	993.529	626.4092	0.568562
2014	30914.777	942.9379	671.2345	0.610961
2015	35002.748	1082.692	839.8255	0.694124
2016	34090.998	1051.042	974.6559	0.796816
2017	29735.477	1022.458	995.1016	0.864095
2018	25878.938	911.0353	852.7108	0.831233
2019	24896.187	821.9153	651.3152	0.688809
2020	27334.077	1013.624	541.3561	0.501812
2021	32626.829	1165.461	478.0739	0.341226

Sources and references

EWG 22-16: Stock assessments in the Adriatic, Ionian and Aegean seas

5.13 Summary sheet for European hake in GSA 20

STECF advice on fishing opportunities

STECF EWG 22-16 advices that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.238 and corresponding catches in 2022 should be no more than 528 tonnes.

Stock development over time

Recruitment has declined to almost one third times since the beginning of the time series and since 2013 has been fluctuating around 10.000 (‘000). SSB follows an increasing trend since 2016 and F is declining since 2009 reaching its lowest values at the end of the time series.

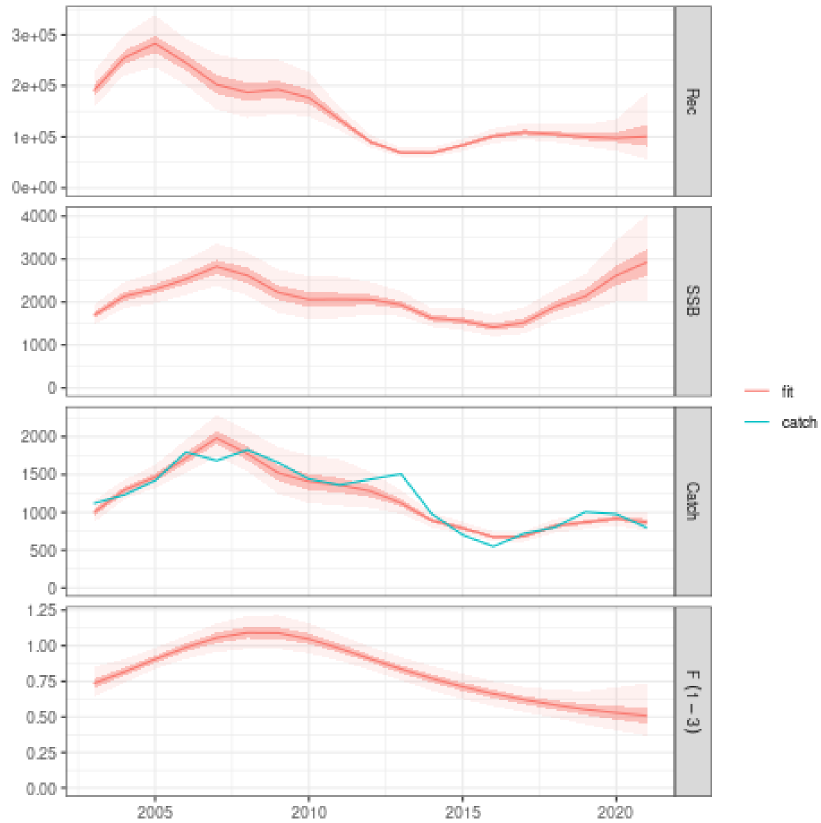


Figure 5.13.1 Hake in GSA 20. Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

Current Fbar= 0.507 is higher than $F_{0.1}$ (0.238), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields. This indicates that hake stock in GSAs 20 is over-exploited.

Table 5.13.1 Hake in GSA 20. State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.13.2 Hake in GSA 20: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	0.507	F status quo (in the interim year 2022) is assumed Fbar in the last assessment year (2021)
SSB (2022)	2909 t	SSB projection based on stock assessment
R_{age0} (2022)	91642	Geometric mean of the last ten years
Total catch (2022)	962 t	Catch at F status quo in 2022

Table 5.13.3 Hake in GSA 20: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (ages 1-3) (2023)	SSB (2024)	% SSB change**	% Catch change^
STECF advice basis					
F_{MSY}	528	0.238	4026	27	-40
$F_{MSY\ upper}$*	701	0.329	3775	19	-20
$F_{MSY\ lower}$	368	0.160	4260	34	-58
1.2 x F_{sq}	1152	0.609	3134	-1	31
0.8 x F_{sq}	836	0.406	3580	13	-5
Other scenarios					
Zero catch	0	0.000	4809	51	-100.00
Status quo	1001	0.507	3346	5	14

* F_{upper} is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy
** % change in SSB 2024 to 2022
^Total catch in 2023 relative to Catch in 2021.

Basis of the advice

Table 5.13.4 Hake in GSA 20: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Revised data were provided through DCF for this stock for length frequency distributions. The assessment was accepted from the STECF EWG 22 – 16 with some considerations regarding the heavy retrospective patterns especially in SSB. These patterns mainly come from the missing years both in LFDs and tuning index for the year 2017.

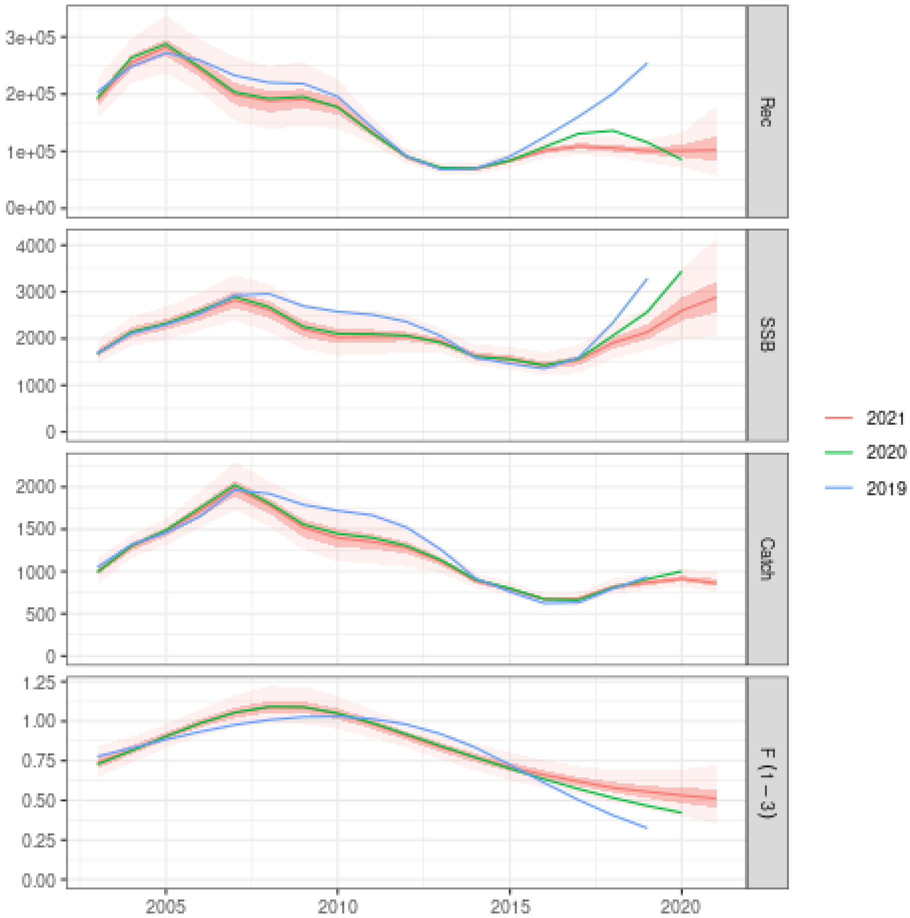


Figure 5.13.2 Hake in GSA 20: Historical assessment results (final-year recruitment estimates included). Retrospective graph.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.13.5 Hake in GSA 20: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	-	Not Defined	
	F_{MSY}	0.238	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}	-	Not Defined	
	B_{pa}	-	Not Defined	
	F_{lim}	-	Not Defined	
	F_{pa}	-	Not Defined	
Management plan	MAP MSY $B_{trigger}$	-	Not Defined	
	MAP B_{lim}	-	Not Defined	
	MAP F_{MSY}	0.238	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 2022-16
	MAP target range F_{lower}	0.160	Based on regression calculation (see section 2)	STECF EWG 2022-16
	MAP target range F_{upper}	0.329	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 2022-16

Basis of the assessment

Table 5.13.6 Hake in GSA 20: 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 GSA 20
Other information	-
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.13.7 Hake in GSA 20: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	No advice			882	
2022	No advice				
2023	F = F_{MSY}		528		

History of the catch and landings

Table 5.13.8 Hake in GSA 20: Catch and effort distribution by fleet in 2021 as estimated by HELSTAT and reported to STECF.

<table>
<tr><td>2021</td><td></td><td colspan="2">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Catch (t)</td><td>614</td><td>Bottom trawl 37%</td><td>Gillnets, Trammel nets & Longlines 63 %</td><td>13.8 t</td></tr>
<tr><td></td><td colspan="2">Tones</td><td></td></tr>
<tr><td rowspan="2">Effort</td><td></td><td>2%</td><td>98%</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="2"></td></tr>
</table>

Table 5.13.9 Hake in GSA 20: History of commercial landings. All weights are in tonnes. Effort is expressed in fishing days.

Years	Greece GSA 20	Total landings	Total discards	Effort
2003	1117	1058	59	
2004	1231	1187	43	
2005	1421	1338	83	
2006	1797	1716	81	
2007	1683	1610	72	
2008	1827	1748	79	
2009	1658	1584	74	
2010	1441	1378	63	
2011	1361	1306	55	
2012	1437	1379	59	
2013	1508	1462	47	
2014	979	964	14	455173
2015	702	649	53	165390
2016	548	528	20	542418
2017	720	693	27	
2018	802	748	53	544287
2019	1006	986	20	499371
2020	977	959	18	462617
2021	795	782	13	363630

Summary of the assessment

Table 5.13.10 Hake in GSA 20: Assessment summary. Weights are in tonnes.

Years	Recruitment (1000)	Total biomass	SSB	$Fbar_{1-3}$	Catch (t)
2003	189646	3710	1676	0.73	986
2004	256814	4698	2137	0.81	1296
2005	282251	5186	2300	0.90	1468
2006	244691	5317	2539	0.98	1721
2007	200949	5522	2829	1.05	1992
2008	187055	5078	2614	1.09	1785
2009	191553	4522	2195	1.08	1523
2010	178124	4291	2037	1.04	1398
2011	133693	3943	2044	0.98	1354
2012	90128	3453	2052	0.91	1280
2013	69013	3012	1938	0.83	1129
2014	68861	2539	1631	0.77	897
2015	83279	2644	1568	0.71	797
2016	101259	2622	1421	0.66	677
2017	109140	2846	1526	0.62	682
2018	105583	3338	1896	0.58	820
2019	100123	3493	2149	0.55	876
2020	98909	3958	2634	0.53	926
2021	101361	4299	2910	0.51	881

Sources and references

STECF EWG 22-16

5.14 Summary Sheet for red mullet in GSA 20

No analysis was carried out and no advice is given

5.15 Summary Sheet for European hake in GSA 22

STECF advice on fishing opportunities

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.106 and corresponding catches in 2023 should be no more than 1094 tons.

Stock development over time

The combined Greek and Turkey catches of European hake in GSA 22 show a decreasing trend from 2009 to 2022, with some oscillations in time series. The landings of both countries present similar trends. The assessment shows a general long term declining trend in the number of recruits whereas SSB is increasing since 2011, following a declining trend between 2005 and 2010. Fbar (1-3) shows an increase until 2007 and a declining trend thereafter with slightly upward values between 2016 and 2018

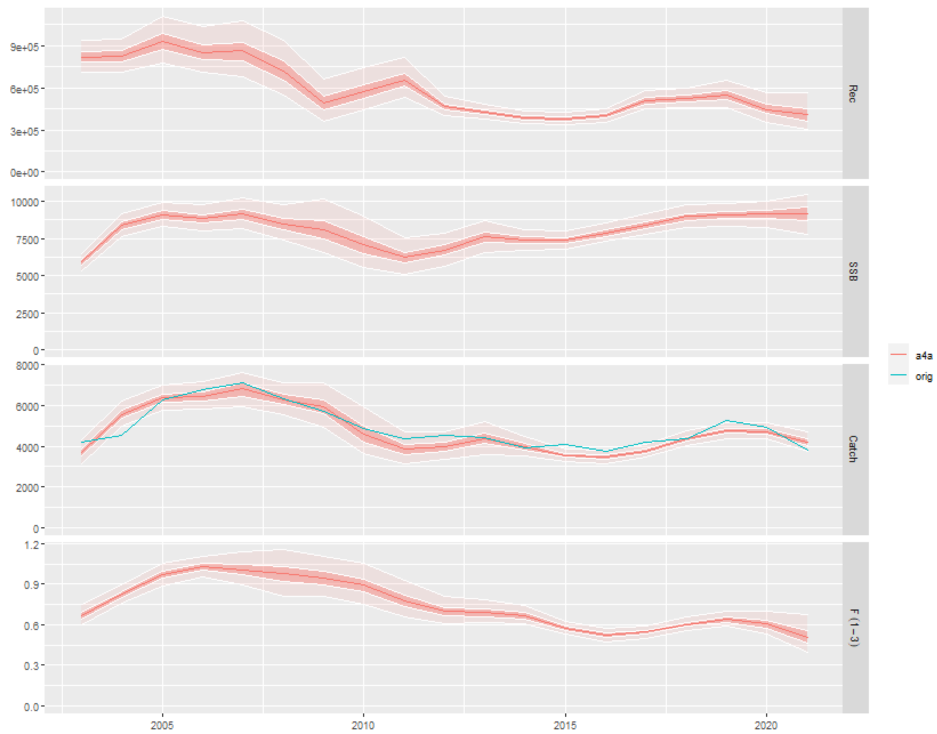


Figure 5.15.1 Hake in GSA 22: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality (0.506) is 4.76 times the reference point $F_{0.1}$, used as a proxy of F_{MSY} (=0.106)

Table 5.15.1 Hake in GSA 22: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.15.2 Hake in GSA 22: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	0.506	F 2021 used to give F status quo for 2023
SSB (2022)	9326	Stock assessment 1 January 2023
R_{age0} (2022,2023)	564218	Mean of the entire time series (19 years)
Total catch (2022)	4134	Assuming F status quo for 2023

Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of the last three (3) years.

Table 5.15.3 Hake in GSA 22: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	1094	0.106	15043	61.30	-74.04
$F_{MSY\ lower}$	766	0.073	15550	66.73	-81.83
$F_{MSY\ upper}$**	1521	0.151	14386	54.26	-63.89
Other scenarios					
Zero catch	0	0	16736	79.46	-100
Status quo	4287	0.506	10208	9.45	1.75
F(1-3)=0.1	536	0.051	15905	70.55	-87.28
F(1-3)=0.3	1526	0.152	14379	54.18	-63.78
F(1-3)=0.5	2419	0.253	13016	39.56	-42.60
F(1-3)=0.7	3224	0.354	11797	26.50	-23.49
F(1-3)=0.9	3951	0.455	10708	14.82	-6.24
F(1-3)=1.1	4608	0.556	9734	4.37	9.35
F(1-3)=1.3	5203	0.657	8861	-4.98	23.47
F(1-3)=1.5	5742	0.758	8079	-13.37	36.27
F(1-3)=1.7	6231	0.860	7378	-20.89	47.89
F(1-3)=1.9	6676	0.961	6749	-27.63	58.45

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

*** % change in SSB 2024 to 2022

^Total catch in 2023 relative to Catch in 2021.

Basis of the advice

Table 5.15.4 Hake in GSA 22: The basis of the advice.

Advice basis	F_{MSY}
Management plan	-

Quality of the assessment

Unlike to previous assessments, the EWG 22-16 assessment included the catch of the small-scale fisheries Greek fleet and the landings of the Turkish fleet. Commercial catches and the MEDITS survey index showed improved internal consistency compared to previous assessments because the quality of the dataset was improved. The historic assessment is stable for recruitment, SSB and catch, and the assessment model was not modified. The retrospective analysis showed consistency in the estimation of F in the assessment of 2022, especially considering the fluctuations in discards and the instability in catch and effort of the covid years. All the diagnostics were considered acceptable with the exception of age 7 that was set as the plus group.

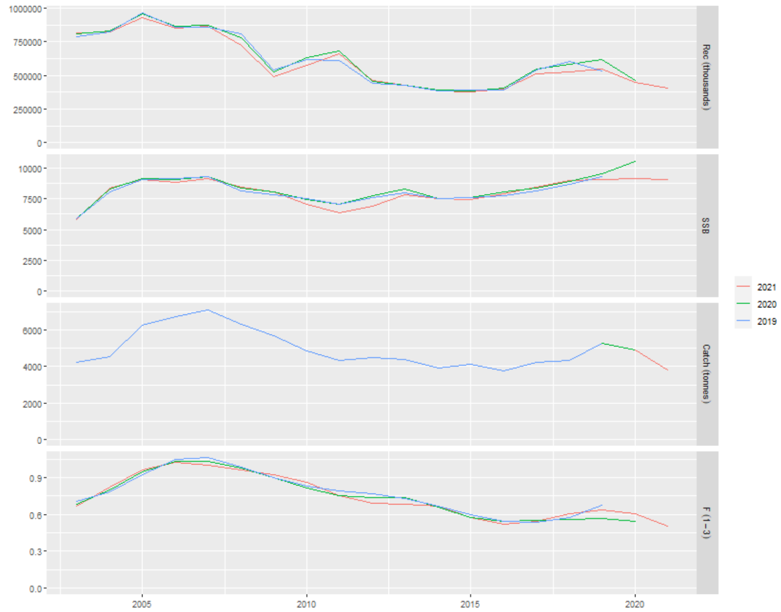


Figure 5.15.2 Hake in GSA 22: Historical assessment results (final-year recruitment estimates included). (Retrospective graph).

Issues relevant for the advice

The current assessment is more coherent, with small scale fisheries and Turkish catches included. This inclusion has significantly increased the proportion of the small-scale fleet to the total landings of the Greek part of GSA 22 and cannot be overlooked for management or sampling purposes.

Reference points

Table 5.15.5 Hake in GSA 22: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.106	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
Precautionary approach	B_{lim}			
	B_{pa}			
	B_{MSY}			
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.106	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range F_{lower}	0.073	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range F_{upper}	0.151	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

Basis of the assessment

Table 5.15.6 Hake in GSA 22: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	Hellenic Statistical (HellStat) and Turkish Statistical (TurkStat) commercial data for landings and DCF discards (only for the Greek fleet) and scientific survey (MEDITS) data. Because of the addition of the landings of an extra fleet (Tsikliras et al. 2020, Marine Policy 117:103886) the Greek landings were corrected for 2003-2015.
Discards, BMS landings*, and bycatch	Discards (only of the Greek fleet based on DCF data) included in the total catch
Indicators	-
Other information	-
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.15.7 Species in Hake in GSA 22: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	No Advice			4214	496
2022	No advice				
2023	F = F_{MSY}		1094		

History of the catch and landings

Table 5.15.8 Hake in GSA 22: Catch and effort distribution by fleet in 2021 as estimated by and reported to STECF.

2021		Wanted catch			Discards
Catch (t)	3830	Otter trawl (OTB) GR	SSF (GTR, GNS, LLS) GR	All gears combined TR	All gears combined GR
		1644	1005	685	496
Effort	967788				
		Fishing days			

Table 5.15.9 Hake in GSA 22: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort that includes only the Greek fleet, in Fishing Days.

Year	GREECE	TURKEY	Total landings	Total Effort * (Fishing Days)
2002	2806	941	3747	-
2003	3118	672	3790	-
2004	3585	392	3977	-
2005	3600	1880	5480	-
2006	4363	1849	6212	-
2007	4977	2142	7119	-
2008	5002	546	5548	-
2009	5054	644	5698	-
2010	4405	447	4852	-
2011	4067	2845	4351	-
2012	3899	607	4506	-
2013	3950	454	4404	38792 (only OTB)
2014	3360	444	3805	1147288
2015	3498	599	4097	368669 (only one quarter)
2016	3067	637	3704	1190332
2017	3159	890	4048	39185 (only OTB)
2018	3179	900	4080	1219620
2019	3342	1143	4485	1113556
2020	3240	1015	4255	982973
2021	2649	685	3334	967788

*Effort data is reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2014 and to FDI from 2014 onward

Summary of the assessment

Table 5.15.10 Hake in GSA 22: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 1	High	Low	SSB	High	Low	Catch tonnes	F	High	Low
2003	817992			5857			3644	0.665		
2004	822643			8371			5547	0.823		
2005	931254			9088			6364	0.967		
2006	852895			8838			6430	1.027		
2007	861812			9123			6730	1.005		
2008	720802			8469			6288	0.964		
2009	489587			8091			5848	0.924		
2010	573563			7051			4486	0.860		
2011	657020			6347			3788	0.756		
2012	464775			6900			4014	0.689		
2013	426058			7799			4434	0.687		
2014	385530			7539			4024	0.667		
2015	377189			7474			3576	0.572		
2016	402021			7917			3468	0.521		
2017	510389			8445			3773	0.543		
2018	522931			8963			4380	0.602		
2019	548089			9066			4755	0.638		
2020	447207			9127			4730	0.605		
2021	408386			9090			4214	0.506		

Sources and references

STECF EWG 22-16

5.16 Summary Sheet for red mullet in GSA 22

STECF advice on fishing opportunities

While the assessment gives some indication of stock status, STECF EWG 22-16 is unable to provide F_{MSY} advice due to instability in the assessment. However, fishing at status quo F corresponds to catches in 2023, of 2107 tonnes.

Stock development over time

The stock shows signs of being exploited in a sustainable way. Fishing mortality is declining since 2008 and SSB is increasing since 2016. However, STECF EWG 22-16 decided that it was not possible to quantify the exact level of current fishing exploitation and biomass status of the stock due to the uncertainty on the estimation of their value. This uncertainty possibly stems from contrasting trends between the tuning index (derived from MEDITS survey) with catch and recruitment during the last years. Due to this discrepancy, the model seems to be highly sensitive on the applied recruitment model; different recruitment models provide a wide range of possible model outcomes. However, since in all possible model combinations the value on fbar/ $F_{0.1}$ for 2021 is below 1, STECF EWG 22-16 decided to provide relative trends for stock outcomes based on the most reliable applied model In figure 5.14.1, the relative trends in SSB, recruitment, Fbar/f0.1 and the catch values are provided based on the most reasonable model applied.

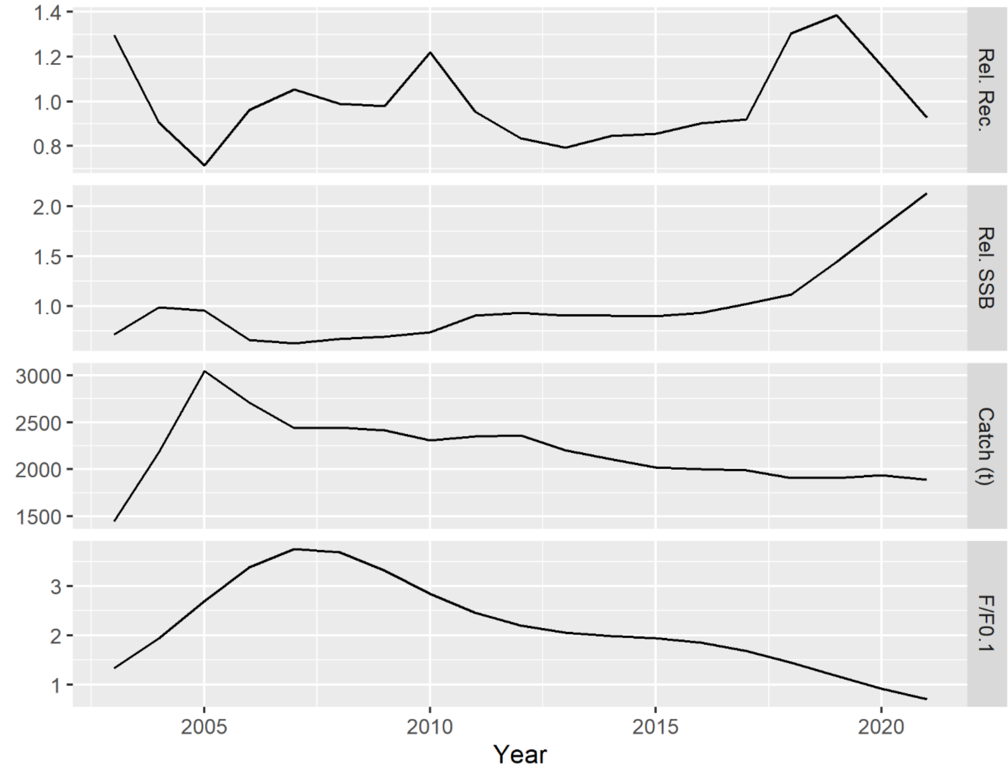


Figure 5.16.1 MUT in GSA 22: Trends in catch, relative recruitment, fishing mortality$F_{0.1}$ and relative SSB resulting from the a4a model.

Stock and exploitation status

The stock status in terms of exploitation rate (F) is provided based on the selected model.

Table 5.16.1 Species in MUT in GSA 22: State of the stock and fishery relative to reference points.

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

Catch scenarios

Catch scenarios are not provided for illustrative purposes, based on the uncertainty in the assessment in the most recent years it is not possible to provide catch advice for a specific F and no other F options are provided, apart from status quo catch which is provided for illustrative purposes.

Table 5.16.2 Species in MUT in GSA 22: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	0.2149	Fsq = F in the last year
SSB (2022)	8580	SSB intermediate year from STF output
R_{age0} (2022,2023)	404214	Recruitment will be set as geometric mean of the last 6 years
Total catch (2022)	2063.56	Catch intermediate year from STF output

Table 5.16.3 MUT in GSA 22: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
Other scenarios					
Zero catch	0	0			-100
Status quo	2106.62	0.215			11.55

Basis of the advice

Table 5.16.4 MUT in GSA 22: The basis of the advice.

Advice basis	No Advice
Management plan	-

Quality of the assessment

Commercial catches showed better internal consistency than MEDITS survey index. The retrospective analysis showed consistency in the estimation of catches and Fbar. The diagnostics revealed a pattern on the fitting of the index-at-age model in the last years (from 2016 to 2021); the fitted values of the model were consistently lower than the observed ones in the majority of the applied models. The only possible combination of models that was able to provide a good fitting of the index-at-age model with the observed values included the application of a year dependent stock recruitment model. However, this fitting was achieved only through the estimation of unrealistically high values on the recruitment and SSB. The absolute level of F and SSB are uncertain.

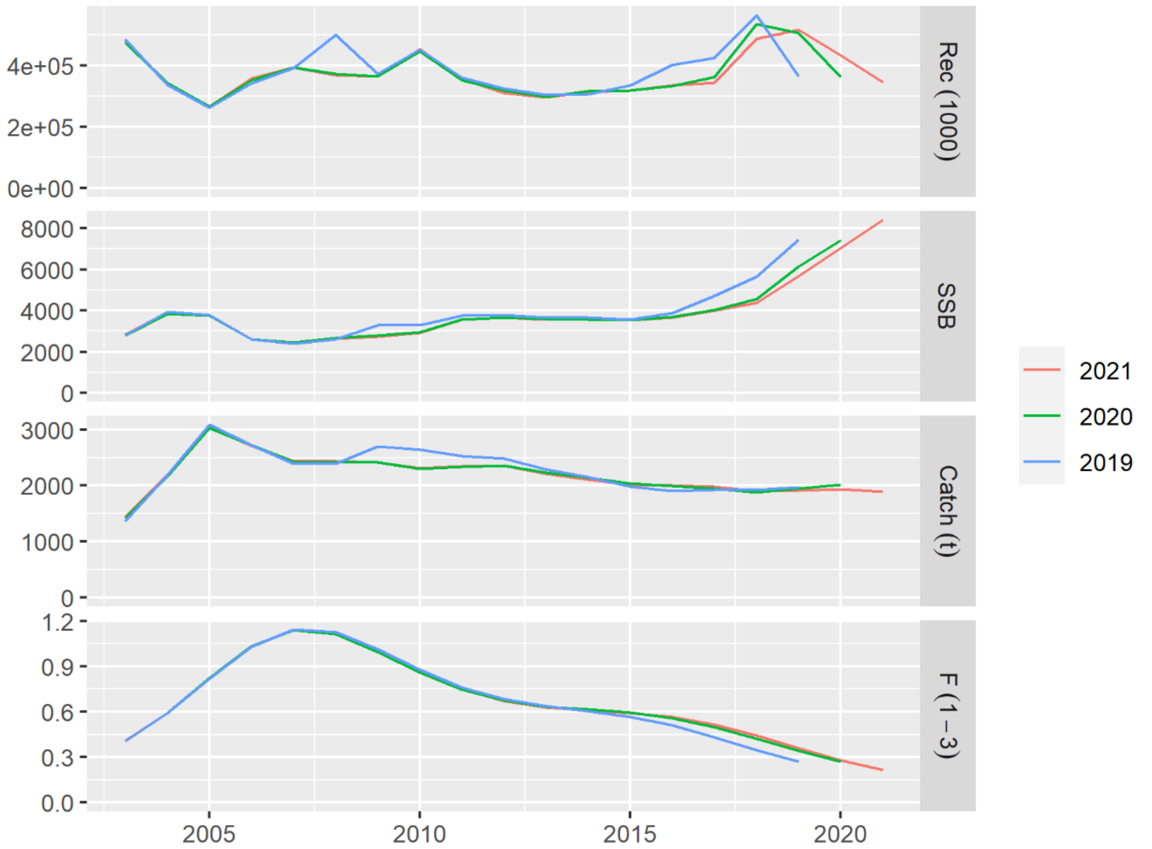


Figure 5.16.2 MUT in GSA 22: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.16.5 MUT in GSA 22: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.305	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
Precautionary approach	B_{lim}			
	B_{pa}			
	B_{MSY}			
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.305	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range F_{lower}	-	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range F_{upper}	-	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

Basis of the assessment

Table 5.16.6 MUT in GSA 22: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	
Other information	
Working group	STECF EWG 22-16

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.16.7 MUT in GSA 22: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	No Advice		-	-	
2022	No Advice		-		
2023	F = F status quo		2107		

History of the catch and landings

Table 5.16.8 MUT in GSA 22: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF. Total catch is Greece + turkey, effort is only Greece

2021		Wanted catch				Discards
Catch (t)	1870	Otter trawl 67.16%	Gillnets 24.5%	Trammel nets 8.27%	Other 0.07%	14.9t
Effort	1054066	3.49%	24.6%	46.46%	25.45%	
		Fishing days				

Table 5.16.9 MUT in GSA 22: History of commercial landings; official reported values are presented by country and GSA. All weights are in tonnes. Effort in Fishing Days.

Year	GREECE GSA22	TURKEY GSA22	Total landings	Total Effort * (Fishing Days)
2003	1338	345	1683	
2004	1563	456	2019	
2005	1843	762	2605	
2006	2263	757	3020	
2007	2209	460	2669	
2008	2038	475	2513	
2009	2074	687	2761	
2010	2188	578	2766	
2011	1940	417	2357	
2012	1566	444	2010	
2013	1831	446	2277	-
2014	1890	332	2222	1272606
2015	1763	329	2092	-
2016	1331	412	1743	1274356
2017	1467	443	1910	-
2018	1487	415	1902	1327124
2019	1538	538	2076	1218192
2020	1527	498	2025	1068793
2021	1457	413	1870	1054066

*Effort data correspond only to the Greek fleet.

Summary of the assessment

Table 5.16.10 MUT in GSA 22: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Relative recruitment	Relative SSB	Catch tonnes	F ages 1-3/ $F_{0.1}$
2003	1.30	0.71	1446.64	1.34
2004	0.90	0.99	2182.96	1.94
2005	0.71	0.95	3047.67	2.69
2006	0.96	0.66	2709.81	3.38
2007	1.05	0.62	2442.28	3.75
2008	0.99	0.67	2443.52	3.69
2009	0.98	0.69	2417.16	3.31
2010	1.22	0.74	2311.28	2.85
2011	0.95	0.90	2351.48	2.46
2012	0.83	0.93	2360.16	2.20
2013	0.79	0.90	2206.06	2.06
2014	0.84	0.90	2105.98	1.99
2015	0.86	0.90	2021.30	1.94
2016	0.90	0.93	2002.08	1.85
2017	0.92	1.02	1987.58	1.69
2018	1.30	1.11	1908.03	1.45
2019	1.39	1.44	1909.48	1.18
2020	1.16	1.79	1938.15	0.92
2021	0.93	2.13	1888.47	0.70

Sources and references

STECF EWG 22-16

6 STOCK ASSESSMENTS

ToR 1. Data preparation for the stock assessments:

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.*
2. *To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2021 while also considering/comparing the results of STECF 21-02 and 22-03. This should be presented by fishing gear as well as by size/age structure.*
3. *For GSA 17&18 to compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2021, based on the FDI database for the recent part and from prior Mediterranean & Black Sea Data calls for the older part. This should be described in terms of number of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size (linear and/or GT), engine power kW, etc.) by Member State/Country, vessel length and fishing gear. Data shall be the most detailed possible to support the implementation of a fishing effort management regime.*
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 2020 by GSA and Country.*

ToR 2. 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. Where a benchmark has been performed by GFCM (Hake GSA 17-18, Hake GSA 19) and the stock object is available, the benchmark should be considered for the updated assessment. In absence of the stock object and for robustness testing, other statistical catch at age models may be fitted.

The assembled data, stock assessments, reference point calculations and short term forecast are given below by stock following the stock units of the ToRs.

Advice based on an ICES category 3 method was applied and given for one stock (red mullet in GSA 17-18. An analysis by sub area is provided but no catch advise is given for Venus clam in GSA 17-18.

6.1 EUROPEAN HAKE IN GSAS 17 AND 18

6.1.1 STOCK IDENTITY AND BIOLOGY

The stock of European hake was assumed to be constrained within the boundaries of the whole Adriatic Sea (GSAs 17-18) (Figure 6.1.1.1), as suggested by the genetic results of the MAREA Stock Med project that shows a common sub-population of hake throughout the Adriatic Sea. However, that project identifies two distinct stock units in the Adriatic Sea, uncorrelated with the GSA units (Fiorentino et al., 2014). For this analysis the two stocks are assumed combined.

The species depth distribution (Figure 6.1.1.2) ranges between a few meters in the coastal area down to 800 m in the South Adriatic Pit (Kirinčić and Lepetić, 1955; Ungaro et al., 1993), though it is most abundant at depths between 100 and 200 m, where the catches are mainly composed of juveniles (Bello et al., 1986; Vrgoč, 2000). In the northern and central part of the Adriatic Sea adults are mainly caught at depths of 100 to 150 m (Vrgoč et al., 2004); whereas in the south Adriatic the largest individuals are caught in waters deeper than 200 m and medium-sized fish appear in waters not deeper than 100 m (Ungaro et al., 1993).

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data and geostatistical methods. This species presents the greatest abundance in the central Adriatic Sea in water deeper than 100 meters, whereas the greatest biomass is found in the eastern part of the Adriatic Sea, where the biggest sizes individuals are concentrated (Piccinetti et al., 2012). Nursery areas are located in the central Adriatic Sea, off Gargano promontory and in the southern part of Albanian coasts (Frattini and Paolini, 1995; Lembo et al., 2000; Carlucci et al., 2009) (Figure 6.1.1.3), whereas the spawning grounds are located among the Croatian channels (Figure 6.1.1.4).

European hake can grow to 107 cm (Grubišić, 1959) total length. The observed maximum lengths of European hake in the Adriatic were 93.5 cm for females and 66.5 cm for males both registered during MEDITS samplings. In the commercial sampling also a female of 93.5 cm length was observed in 2009. However, its usual length in trawl catches is from 10 to 60 cm. This is a long-lived species; it can live more than 20 years. In the Adriatic, however, the exploited stock by number is mainly composed of 0, 1 and 2 year-old individuals.

Females attain larger size than males, which grow more slowly after maturation at the age of three or four years. Consequently, the proportion of males in the population is higher in the lower length classes and proportion of females is higher for greater lengths. In the central and northern Adriatic, females already start dominating the population at lengths of about 30 to 33 cm. In trawl catches at lengths over 38 to 40 cm, almost all the specimens are females (Vrgoč, 2000). The growth parameters assumed for this study are showed in Table 6.1.1.1 and they are obtained from the data collected within the DCF in 2018 in GSA 18 (L_{inf}, k and t_0) and GSA 17 (a and b – length weight parameters)

In the Adriatic Sea, European hake spawn throughout the year, but with different intensities. The spawning peaks are in the summer and winter periods (Karlovac, 1965; Županović, 1968; Županović and Jardas, 1986, Županović and Jardas, 1989; Jukić and Piccinetti, 1981; Ungaro et al., 1993). Hake is a partial spawner. Females spawn usually four or five times without ovarian rests. In females in the pre-spawning stage, fish 70 cm long can contain more than 400,000 oocytes (Sarano, 1986). The earliest spawning in the Pomo/Jabuka Pit occurs in winter in deeper water (up to 200 m). As the season progresses into the spring-summer period, spawning occurs in more shallow waters. The recruitment of young individuals into the breeding stock has two different maxima. The first one is in the spring and the second one in the autumn.

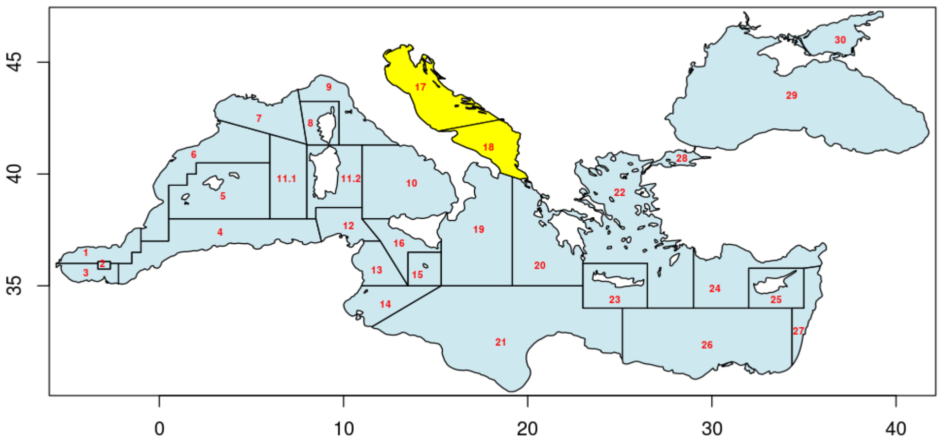


Figure 6.1.1.1 European hake in GSAs 17 and 18. Geographical location of GSAs 17-18

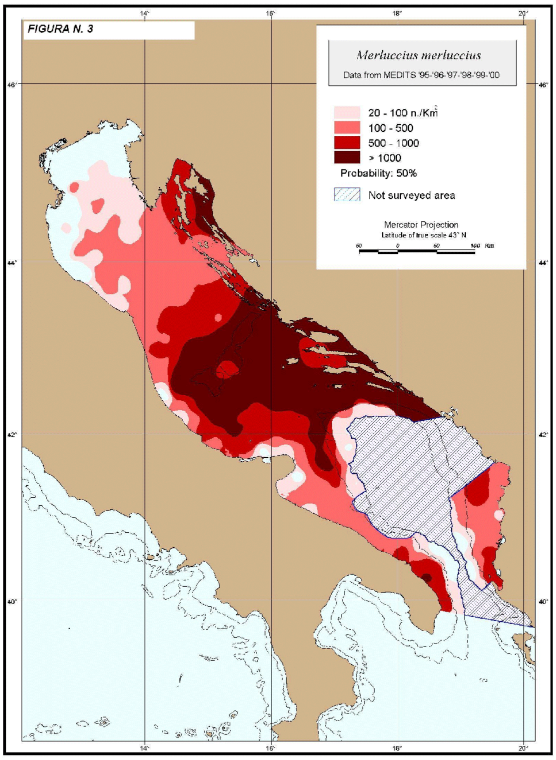


Figure 6.1.1.2 European hake in GSAs 17 and 18. Distribution map in the Adriatic Sea from MEDITS Programme (Sabatella and Piccinetti, 2005)

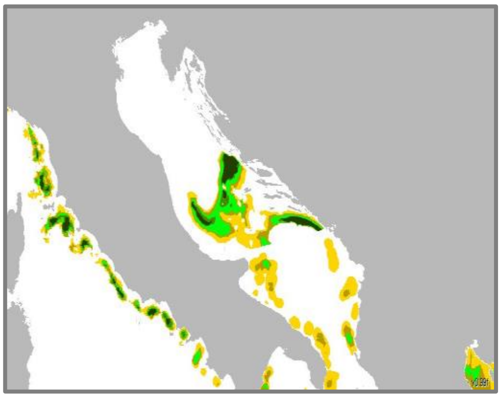


Figure 6.1.1.3 European hake in GSAs 17 and 18. Position of persistent nursery in GSAs 17 and 18 from MEDISEH project.

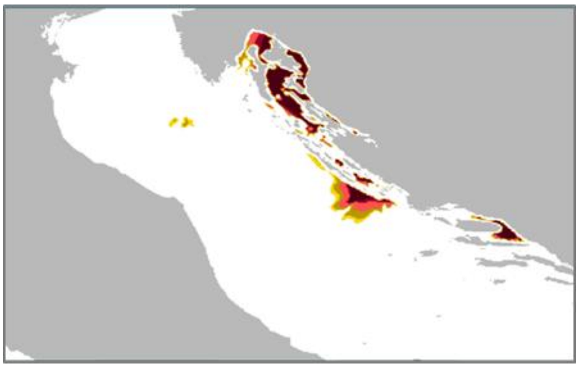


Figure 6.1.1.4 European hake in GSAs 17 and 18. Position of persistent spawning area in GSAs 17 and 18 from MEDISEH project.

Table 6.1.1.1 European hake in GSAs 17 and 18: Growth and length/weight relationship parameters

Sex	L_{inf}	k	t_0	a	b
M	73 cm	0.15	-0.741	0.0057	3.081
F	111 cm	0.10	-0.717	0.0094	2.937

Table 6.1.1.2 European hake in GSAs 17 and 18. Proportion of mature specimens at age (maturity) estimated from maturity at length in a4a model (see section 6.1.3.2) and natural mortality vector divided by age and sex used within the SS3 model (see section 6.1.3.1) agreed in GFCM benchmark.

Age	0	1	2	3	4	5	6	7+
M	1.34	0.657	0.454	0.364	0.315	0.283	0.257	0.243
Time of spawning	1st of January							

Sex	Age 0	Age 1	Age 5	Age 20
F	1.31	0.61	0.26	0.17
M	1.37	0.70	0.30	0.22

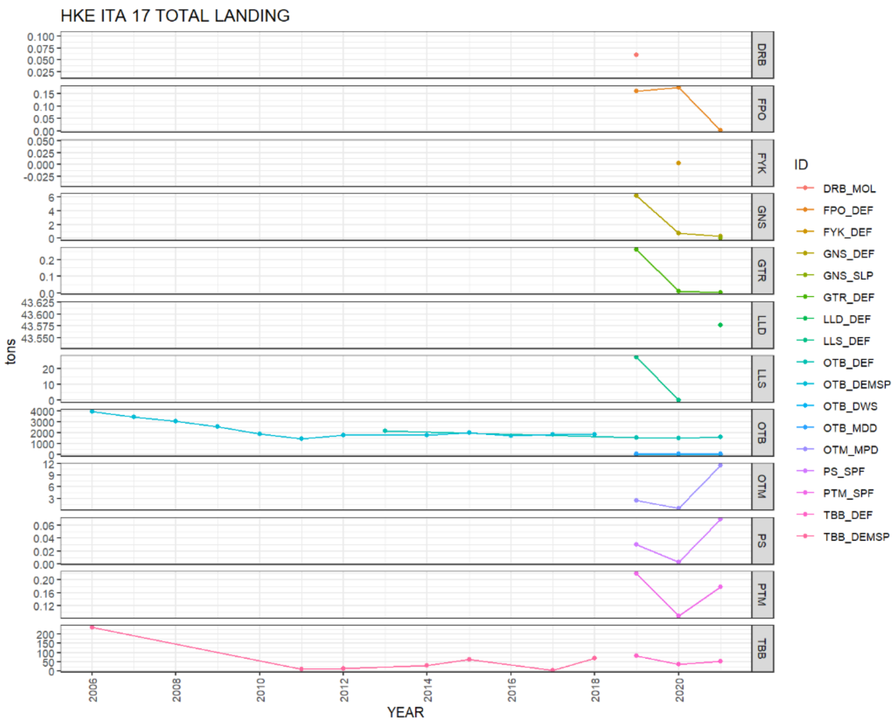
6.1.2 DATA

6.1.2.1 CATCH (LANDINGS AND DISCARDS)

The following table (Tables 6.1.2.1.1-4) and the following plots (Figures 6.1.2.1.1-8) summarise the catch data (landings plus discards) included in the DCF database. Most of the landings come from the bottom trawler, followed by longlines and to a lesser extent gillnet fishery and rapido trawls (only Italy GSA 17). Catches from gears with less than 1 t in every year of the time series are not shown in the tables but only in the figures.

Table 6.1.2.1.1 European hake in GSAs 17 and 18. Catch (landings and discards) data included in the DCF database for Italy in GSA 17.

	Landings						Discards
Year	**OTB**	**OTM**	**TBB**	**GNS**	**LLD**	**LLS**	**OTB**
2006	3980		237				0
2007	3435						0
2008	3037						0
2009	2549						0
2010	1863						0
2011	1460		12				9
2012	1777		15				6
2013	2192						3
2014	1789		30				11
2015	2011		62				13
2016	1731						61
2017	1836		6				116
2018	1853		71	6			346
2019	1556	3	82			27	155
2020	1498		38				84
2021	1637	11	53		44		100


HKE ITA 17 TOTAL LANDING
DRB
FPO
FYK
GNS
GTR
LLD
LLS
OTB
OTM
PS
PTM
TBB
tons
YEAR
ID
DRB_MOL
FPO_DEF
FYK_DEF
GNS_DEF
GNS_SLP
GTR_DEF
LLD_DEF
LLS_DEF
OTB_DEF
OTB_DEMSP
OTB_DWS
OTB_MDD
OTM_MPD
PS_SPF
PTM_SPF
TBB_DEF
TBB_DEMSP

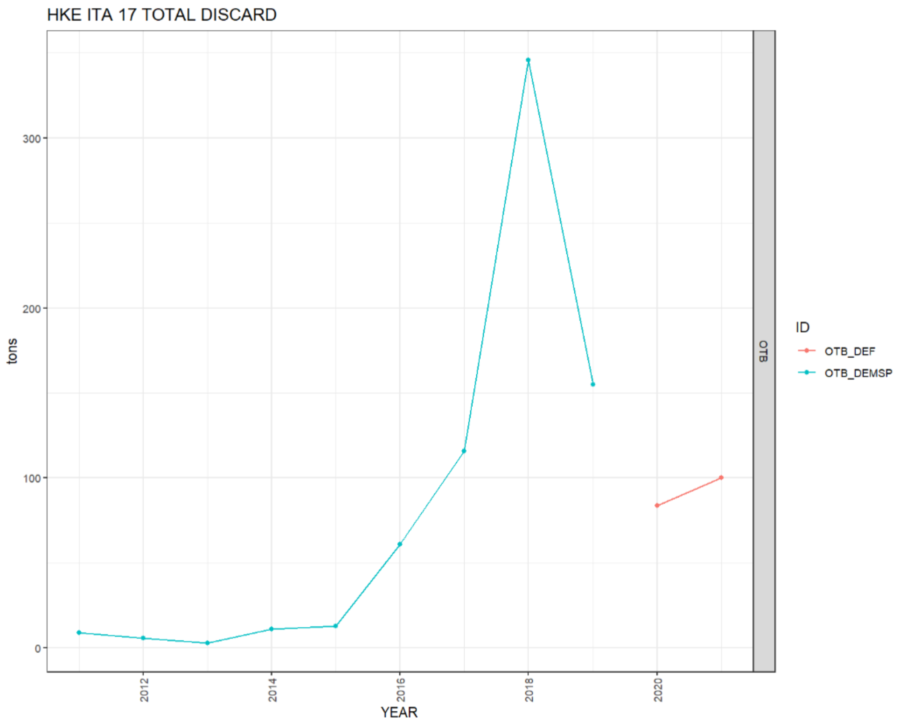
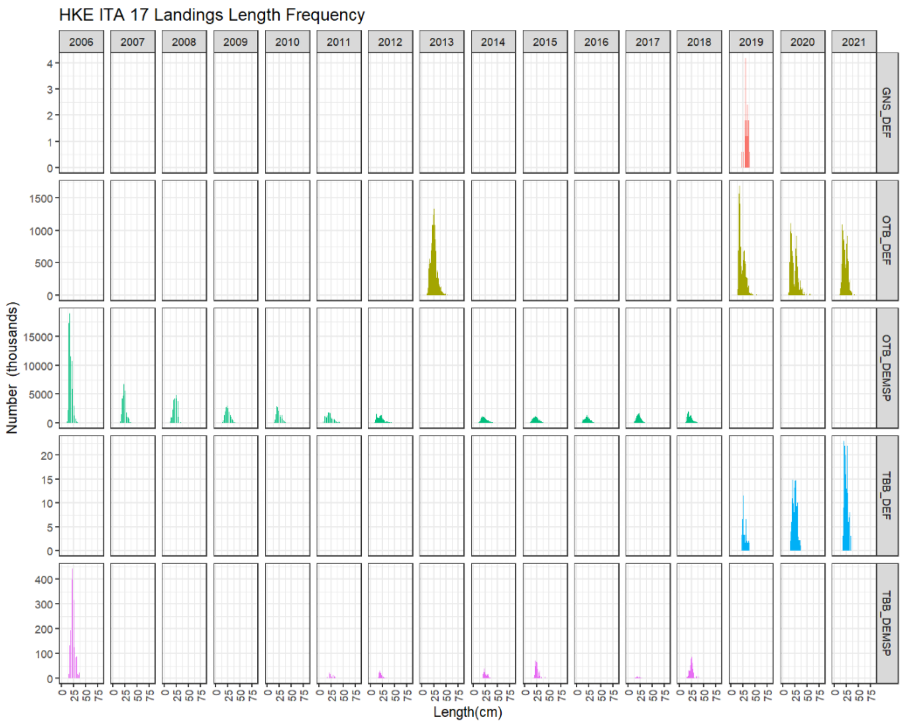


Figure 6.1.2.1.1 European hake in GSAs 17 and 18. Catch (landings and discards) data included in the DCF database for Italy in GSA 17.



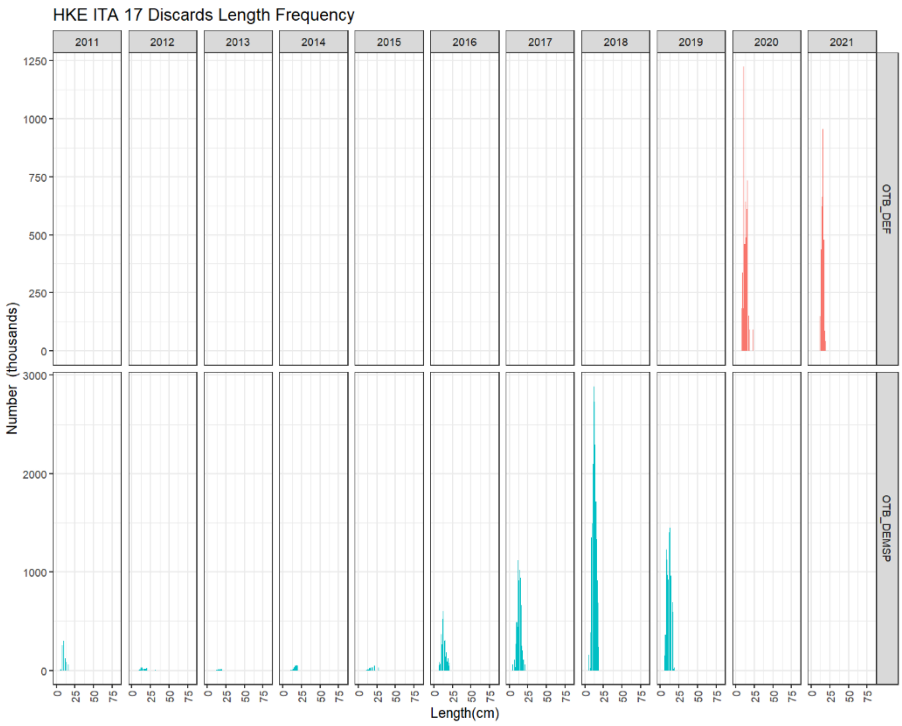


Figure 6.1.2.1.2 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database for Italy in GSA 17.

Table 6.1.2.1.2 European hake in GSAs 17 and 18. Catch data included in the DCF database for Italy in GSA 18.

	Landings					**Discards**				
Year	**NA**	**GNS**	**GTR**	**LLS**	**OTB**	**NA**	**GNS**	**GTR**	**LLS**	**OTB**
2002	277	26			2006	0	0			0
2003	1353	199			2899	0	0			0
2004		19	21	233	2932		0	0		0
2005	1	38	18	452	3275	0	0	0		0
2006	1	30	26	836	4613	0	0	0		0
2007	0.2	19	18	620	3497	0	0	0		0
2008		15	42	551	3640		0	0		0
2009		8	20	534	3545		0	0		152
2010			19	601	3400			0		78
2011			18	519	3312			0		100
2012			20	566	2520			0	0.3	177
2013				188	2379					15
2014			0.03	279	1584			0	1	46
2015				427	1614					86
2016		5		518	1672		0			107
2017		31	3	515	1682		0	0		31
2018		15	0.2	335	1650		0	0		56
2019	0.1	5	0.6	235	1481	0	0	0		102
2020		0.8	1	265	1086		0	0		19
2021		1.08		159	1229					23

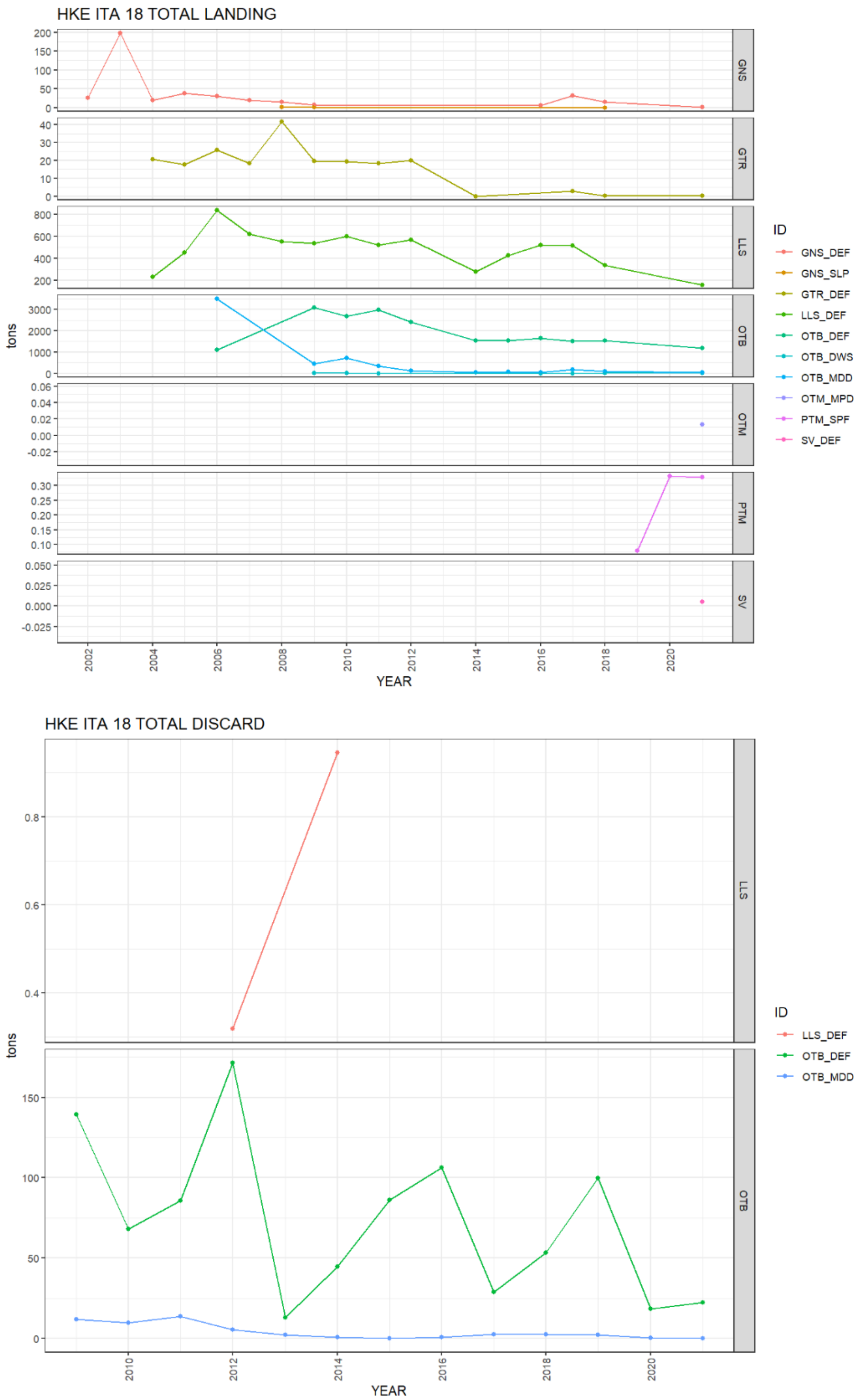


Figure 6.1.2.1.3 European hake in GSAs 17 and 18. Catch (landings and discards) data included in the DCF database for Italy in GSA 18.

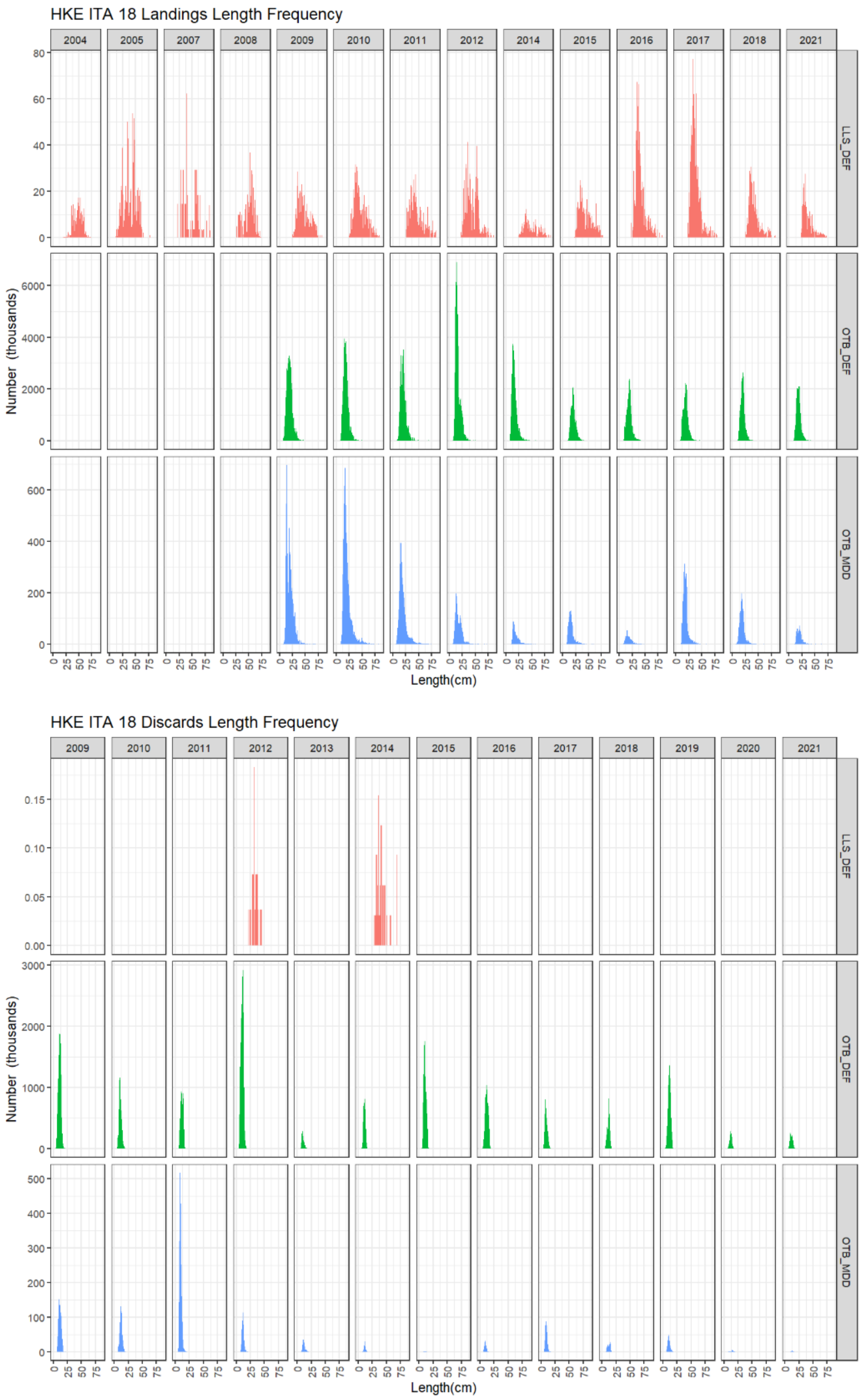


Figure 6.1.2.1.4 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database for Italy in GSA 18.

Table 6.1.2.1.3 European hake in GSAs 17 and 18. Catch data included in the DCF database Croatia and Slovenia in GSA 17.

		Landings				Discard			
Year	**Country**	**GNS**	**GTR**	**OTB**	**LLS**	**GNS**	**GTR**	**OTB**	**LLS**
2005	SVN	0.1	0.04	2		0	0	0	
2006	SVN	1	0.1	2	0.01	0	0	0	0
2007	SVN	1	0.1	5		0	0	0	
2008	SVN	0.3	0.04	1		0	0	0	
2009	SVN	0.4	0.1	1	0.004	0	0	0	0
2010	SVN	0.01	0.01	0.1		0	0	0	
2011	SVN	0.1	0.01	0.2		0	0	0	
2012	SVN	0.2	0.01	0.2		0	0	0	
2013	SVN	0.2	0.004	1		0	0	0	
2014	SVN	0.2	0.01	1		0	0	0	
2015	SVN	1	0.04	1		0	0	0	
2016	SVN	0.1	0.001	0.2		0	0	0	
2017	SVN	0.1	0.002	0.4		0	0	0.002	
2018	SVN	0.4	0.01	2		0	0	0.01	
2019	SVN	1	0.04	4		0	0	0.02	
2020	SVN	0.3	0.01	1		0	0	0.004	
2021	SVN	0.1		3		0	0	0.02	
2012	HRV	67	4	796	34	4	0.12	2	0.2
2013	HRV	44	3	1014	65	2	0.09	2	0.1
2014	HRV	57	3	774	61	3	0.06	2	0.2
2015	HRV	58	3	655	56	3	0.04	1	0.1
2016	HRV	39	2	586	124	2	0.17	1	0.1
2017	HRV	49	3	784	90	2	0.09	3	0.2
2018	HRV	55	4	815	116	2	0.12	4	0.3
2019	HRV	77	3	944	116	3	0.07	3	0.2
2020	HRV	88	5	927	178	3	0.08	2	0.4
2021	HRV	84	4	836	134	2		2	0.5

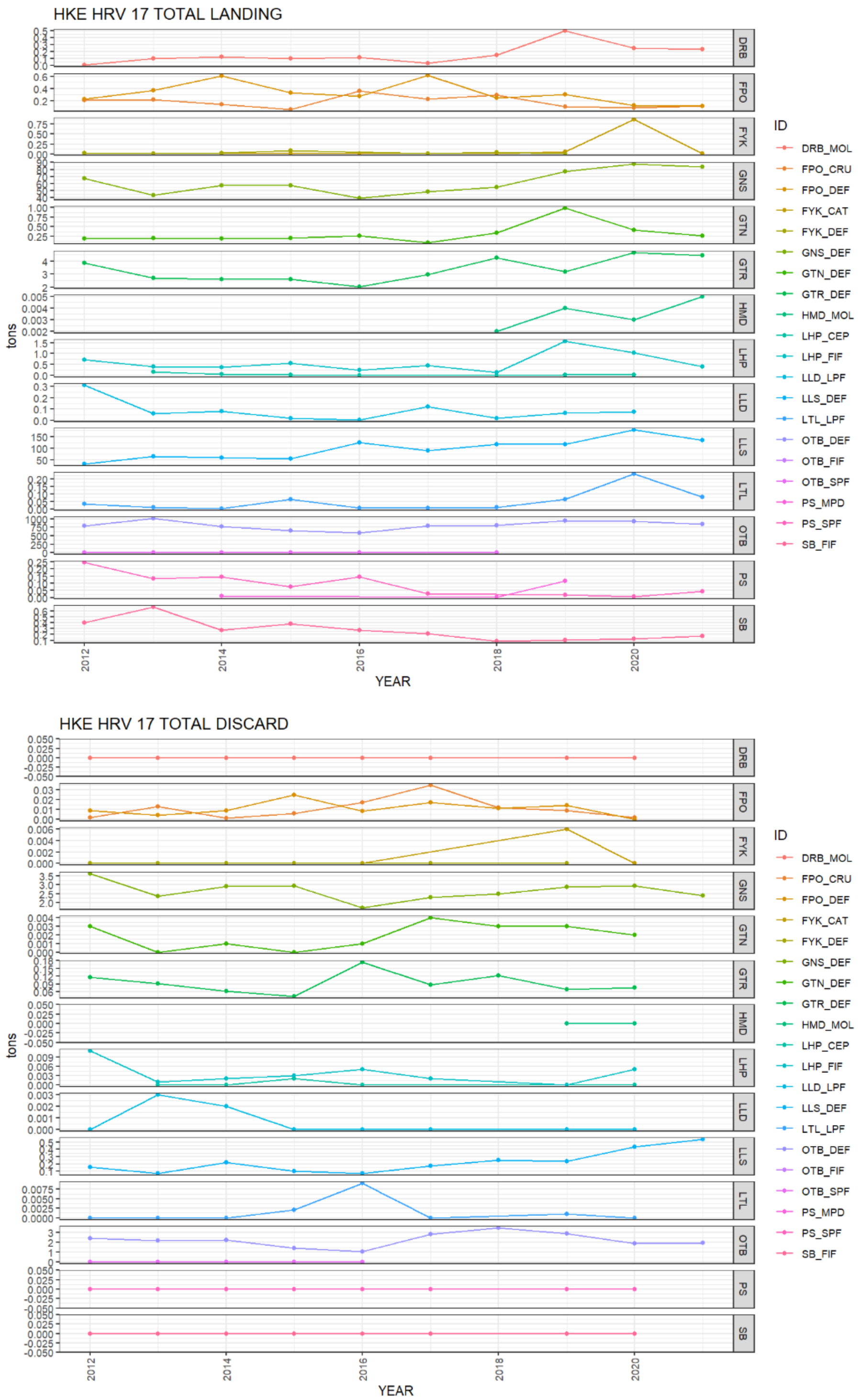


Figure 6.1.2.1.5 European hake in GSAs 17 and 18. Catch data included in the DCF database Croatia in GSA 17.

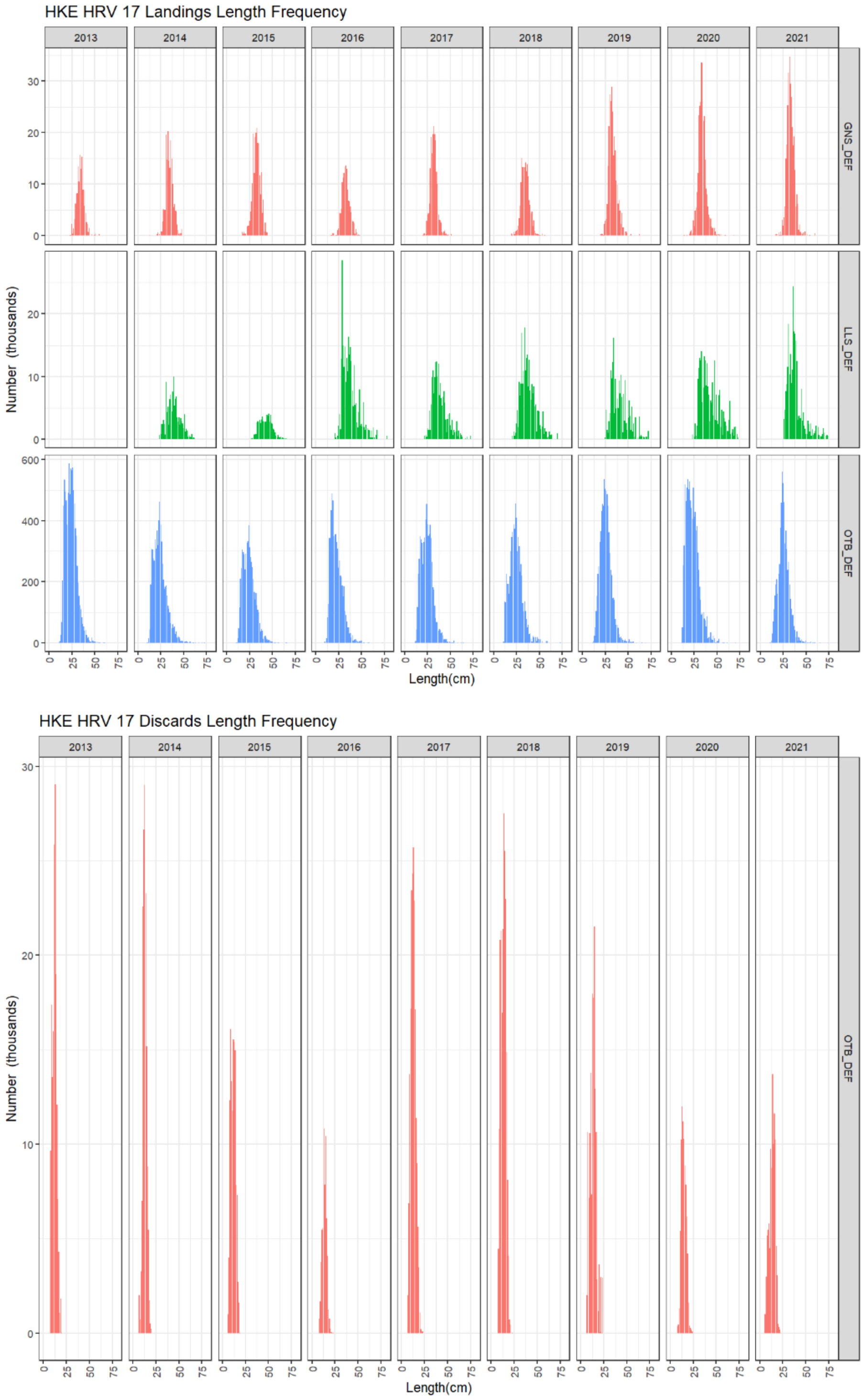


Figure 6.1.2.1.6 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database Croatia in GSA 17.

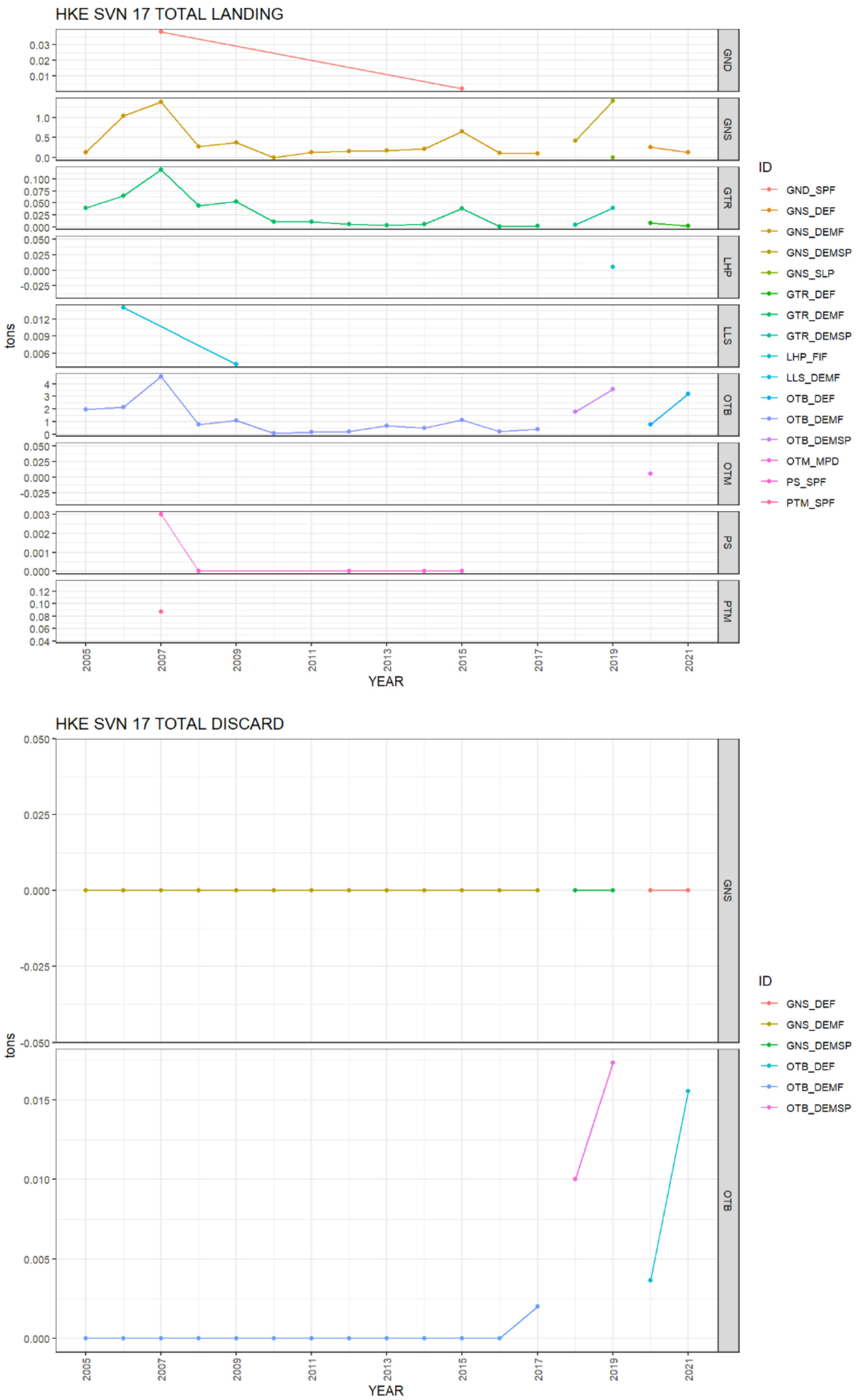


Figure 6.1.2.1.7 European hake in GSAs 17 and 18. Catch data included in the DCF database Slovenia in GSA 17.

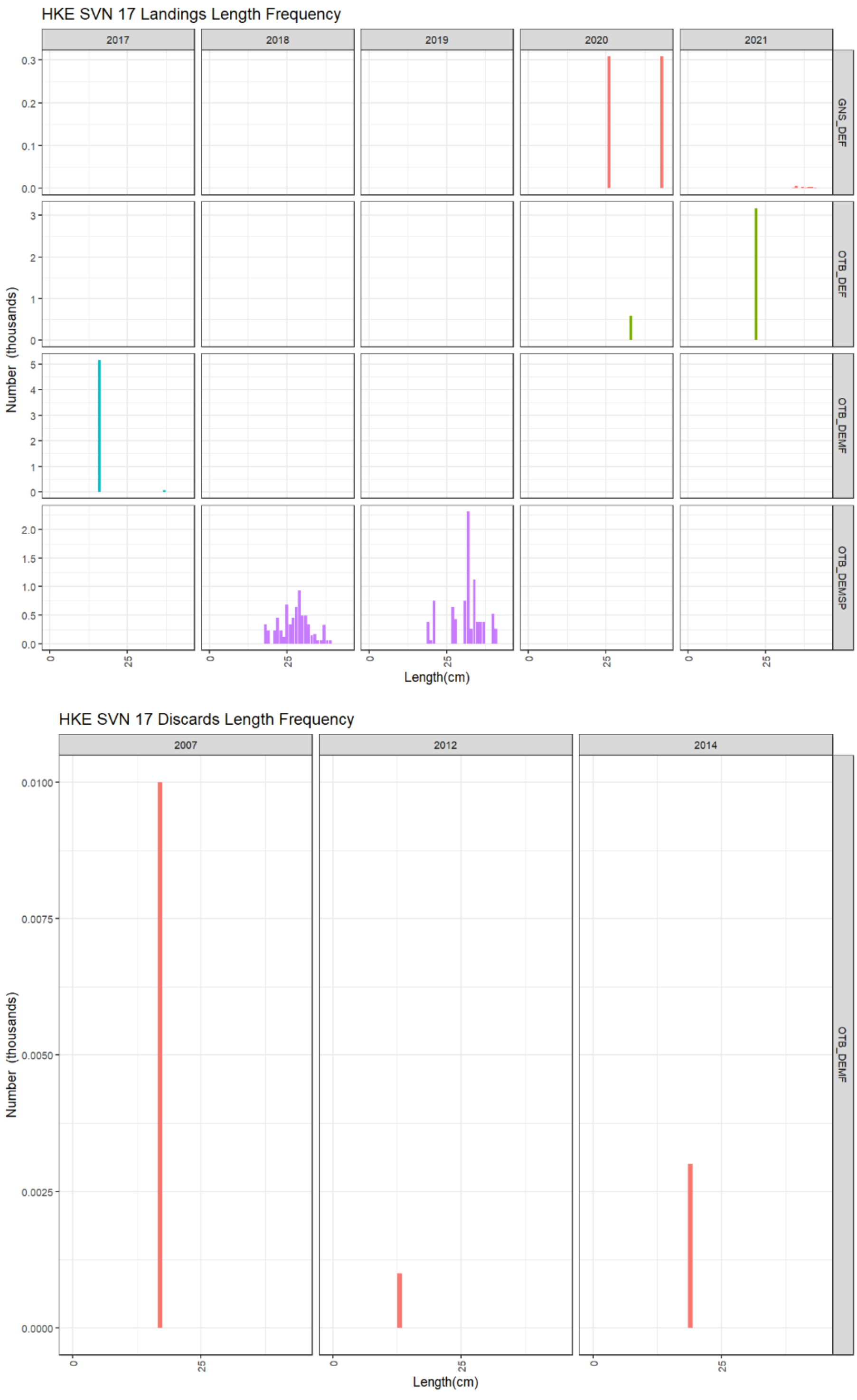


Figure 6.1.2.1.8 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database Slovenia in GSA 17.

Bottom trawl and longlines catch data (landings plus discards) are included in the stock assessments models. Also, the Albanian and Montenegrin data included in the GFCM database were included in the assessment input data; these two countries transmitted also 2021 catch data to the EWG 2216. For the SS3 model, catch data were included from 1998; the source of this data is FishStatJ (FAO-GFCM, 2020). Table 6.1.2.1.4 summarises the catch data included in the SS3 assessment split by fleet.

Table 6.1.2.1.4 European hake in GSAs 17 and 18. Catch data included in the SS3 assessment.

Year	ITA_OTB_17*	HRV_OTB_17	HRV_LLS_17	ITA_OTB_18	ITA_LLS_18	MNE_OTB_18	ALB_OTB_18	Total
1998	2524	781	62	4953	710	71	340	9441
1999	2516	543	43	2757	395	71	341	6666
2000	2094	487	38	2843	407	69	330	6268
2001	2022	465	37	2819	404	79	380	6206
2002	2310	521	41	2070	258	42	200	5442
2003	3067	384	30	2992	385	80	384	7322
2004	2895	566	45	3025	233	99	473	7336
2005	3835	726	57	3380	452	55	267	8772
2006	4068	768	61	4760	836	59	280	10832
2007	3514	818	65	3609	620	58	275	8959
2008	3102	532	33	3756	551	63	275	8312
2009	2605	734	37	3696	534	56	336	7998
2010	1903	572	40	3478	601	49	280	6923
2011	1469	653	37	3412	519	40	286	6416
2012	1784	796	34	2697	566	42	899	6818
2013	2196	1015	65	2395	188	43	851	6753
2014	1801	776	61	1630	279	44	902	5493
2015	2026	656	56	1700	427	38	914	5817
2016	1792	587	124	1779	492	42	948	5764
2017	1953	786	90	1713	514	37	940	6033
2018	2200	818	116	1706	331	48	872	6091
2019	1710	946	113	1584	232	37	731	5355
2020	1573	929	178	1086	265	37	751	4819
2021	1740	838	135	1252	135	42	703	4845

* Slovenian catches are included in the Italian OTB GSA 17 in the SS3 model

LFDs from landings of Italy in GSA 17 are available only for OTB and TBB and for GNS only for 2019. LFDs from landings of TBB of Italy in GSA 17 are missing for 2007-2010, 2013, 2015 and 2016. LFDs from discards of Italy in GSA 17 are available only for OTB from 2011 to 2021 (TBB is not included in the assessment).

LFDs from landings of Italy in GSA 18 are available only for OTB and LLS. LFDs from landings of LLS of Italy in GSA 18 are missing for 2002-2003 and 2006. LFDs from landings of OTB of Italy in GSA 18 are missing for 2006. LFDs from discards of Italy in GSA 18 are available only for OTB and LLS from 2009 to 2021. LFDs from discards of LLS of Italy in GSA 18 are missing for 2009-2011, 2013 and 2015-2021.

LFDs from landings of Croatia in GSA 17 are available only for OTB, LLS and GNS from 2013 to 2020. LFDs from landings of LLS of Croatia in GSA 17 are missing for 2013. LFDs from discards of Croatia in GSA 17 are available only for OTB from 2013 to 2021. (GNS is not included in the assessment)

LFDs from landings and discards of Slovenia in GSA 17 needs to be thoroughly checked because they are deemed not reliable however, the numbers are small and do not influence the assessment.

6.1.2.2 Effort

Hake is a primary species for the Adriatic fishing fleet; specifically it is a target species for the bottom trawl fishery and to a lesser extent for the longline and gill net fisheries. Longlines target mainly bigger individuals, however their activity, together with the gill net activity, are minor compared to the bottom trawl fishery activity. Tables 6.1.2.2.1-4 report the fishing days by country, year, gear and vessel length.

Table 6.1.2.2.1. Effort in term as fishing days for Croatia (HRV) in GSA17 for longlines (LLS) and otter trawl (OTB) by vessel length (VL).

Sum of fishing days – HRV LLS					
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**Grand Total**
2012	2085	7041	104		9230
2013	2466	7127	52		9645
2014	2283	6940	52	9	9284
2015	2216	6895	79	10	9200
2016	1786	6393	29		8208
2017	1867	6977	10		8854
2018	2580	7307	15	1	9903
2019	4538	7755	107		12400
2020	4927	8197	170		13294
2021	4718	8287	217		13222

Sum of fishing days – HRV OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2012	24	10846	17617	4694	4840	35572
2013	25	10260	16885	5321	5992	35483
2014	15	11246	16841	5316	2928	36346
2015	4	10909	16672	4337	3019	34941
2016	63	10488	16277	4887	2253	33968
2017	16	11862	17218	4586	2067	35749
2018		9961	17230	4176	1737	33104
2019		9075	15579	4612	1731	30997
2020		10170	16075	4151	1520	31916
2021		10144	15646	4859	1751	32400

Table 6.1.2.2.2. Effort in term as fishing days for Italy (ITA) in GSA17 for longlines (LLS) and otter trawl (OTB) by vessel length (VL).

Sum of fishing days - ITA17 LLS						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2006		21				21
2007		41				41
2008						0
2009						0
2010						0
2011						0
2012						0
2013						0
2014						0
2015						0
2016		439				439
2017		361				361
2018		877	8	149		1035
2019		545	277			822
2020		208	6			214
2021	18	48	286			352

Sum of fishing days - ITA17 OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2004		35665	52605	34338	10422	133030
2005		10053	62455	36578	12588	121674
2006	61	8067	46604	29437	9888	104056
2007		6724	47688	30438	8945	93795
2008		5525	44720	27977	8480	86701
2009		7635	47220	28571	7618	91044
2010		5952	41995	27106	7909	82962
2011		5999	40792	26424	6971	80187
2012		6048	34301	25466	4788	70603
2013		6351	33282	22579	4081	66293
2014		6220	33052	21194	6027	66492
2015		2271	29582	25022	4422	61297
2016		2758	29701	24561	4844	61865
2017		6339	30074	30350	5616	72379
2018		4951	34671	30788	5524	75934
2019		3281	31403	24641	6585	65911
2020		1332	27162	22482	5651	56627
2021		1039	29153	24024	5943	60159

Table 6.1.2.2.3. Effort in term as fishing days for Italy (ITA) in GSA18 for longlines (LLS) and otter trawl (OTB) by vessel length (VL).

Sum of fishing days ITA18 LLS						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2004		5138	2717			7855
2005		15328	3198			18526
2006	6924	9769	3532			20226
2007	6841	6892	3792			17526
2008	5320	4017	3206			12543
2009	6532	5278	2969			14779
2010	6112	4969	3707			14788
2011	6231	5055	3727			15013
2012	9029	6873	2571			18472
2013		477	1645			2122
2014			3067			3067
2015			3845			3845
2016			4168			4168
2017		36	3094			3130
2018		72	2997	40	7	3115
2019		1825	2299	50		4175
2020		1865	1433	38		3336
2021		3598	1337	143		5078

Sum of fishing days ITA18 OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2004		9008	51197	20024	6697	86925
2005		4803	47330	16897	8179	77209
2006		5550	52174	22181	4259	84163
2007		3470	43555	19836	3819	70680
2008		4743	45641	14282	4972	69639
2009		5760	59695	14984	5410	85850
2010		5197	48372	15105	4347	73021
2011		3818	47116	13130	3589	67654
2012		4583	44403	11501	2156	62644
2013		5514	49028	12511	2241	69294
2014		4060	33736	10182	1708	49685
2015		4015	35442	10341	2204	52002
2016		3650	37510	10889	1978	54028
2017		4239	36248	10623	2108	53218
2018		3343	42089	12670	1996	60098
2019		1828	35764	10735	1844	50171
2020		608	28042	9241	1618	39509
2021		2032	29721	8587	1394	41734

Table 6.1.2.2.3. Effort in term as fishing days for Slovenia (SVN) in GSA17 for otter trawl (OTB) by vessel length (VL).

Sum of fishing days SVN17 OTB						
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440	Grand Total
2005	4	358	469			831
2006		356	607			963
2007		343	858		1	1202
2008		316	937		1	1254
2009		229	976			1205
2010		305	958			1263
2011		270	908			1178
2012		124	793			917
2013		183	554			737
2014		183	482			665
2015		171	499			670
2016		265	512			777
2017		194	503			697
2018		201	491			692
2019		205	564			769
2021		200	593			793

6.1.2.3 SURVEY DATA

MEDITS survey data are available from the official 2022 Data Call for GSA 17 and for GSA 18 from 1994. All the Countries are covered by the survey data, with some differences among the years. For the present assessment the data from 1998 to 2021 were used. Data were analysed using the JRC script.

The MEDITS survey in GSAs 17 and 18 is performed in three units: Italy (and Slovenia) GSA 17, Croatia GSA 17 and Italy GSA 18. The information collected by three surveys were combined and used together, since there were no specific reasons supporting the use of three separated surveys.

Figure 6.1.2.3.1 European hake in GSAs 17 and 18. MEDITS survey period over 1994-2021.

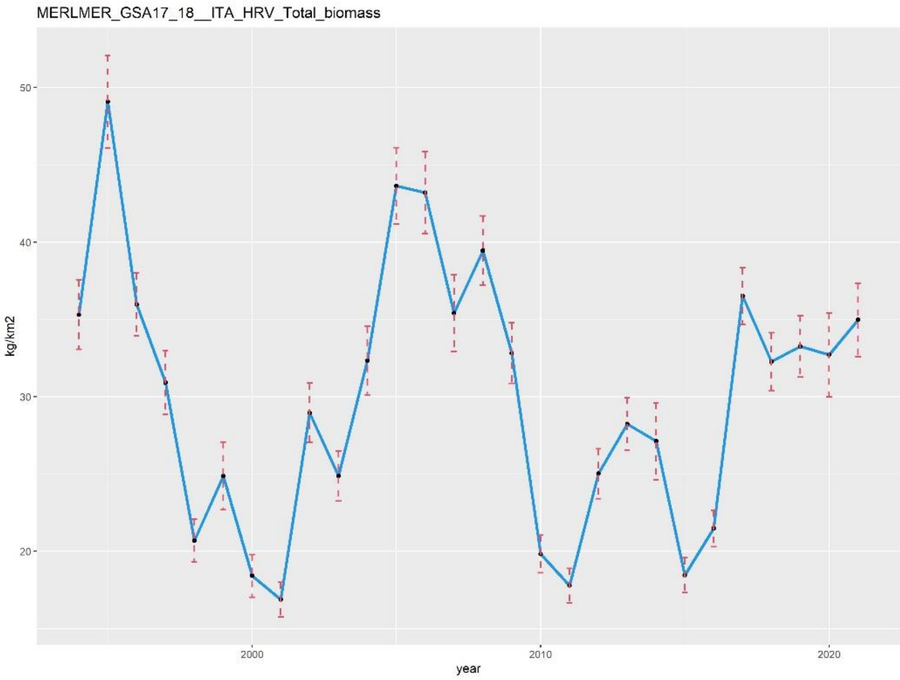


Figure 6.1.2.3.2 European hake in GSAs 17 and 18. MEDITS biomass (kg/km^2) over 1994-2020.

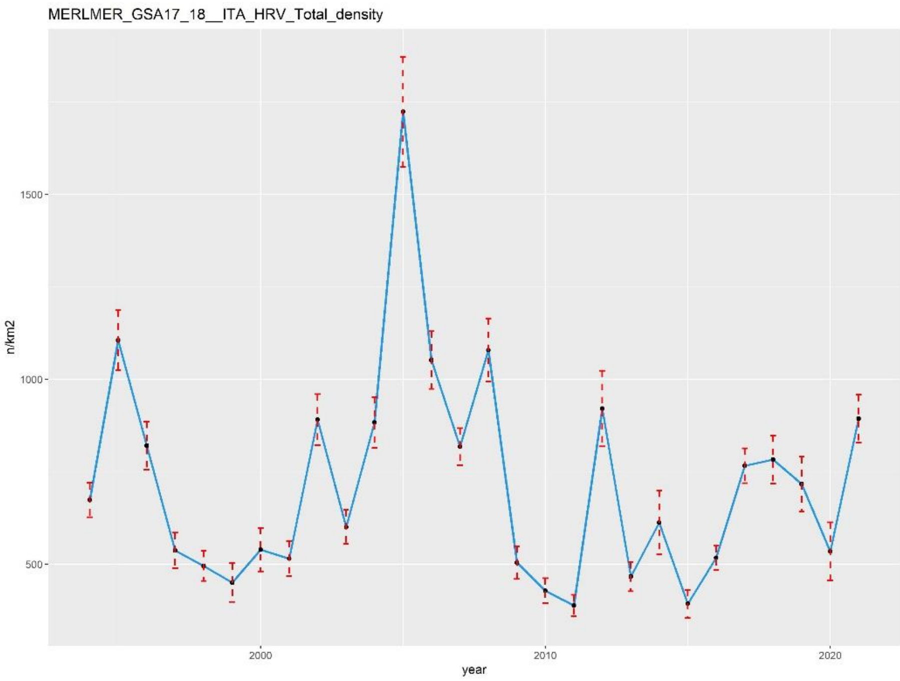


Figure 6.1.2.3.3 European hake in GSAs 17 and 18. MEDITS abundance (n/km^2) over 1994-2021.

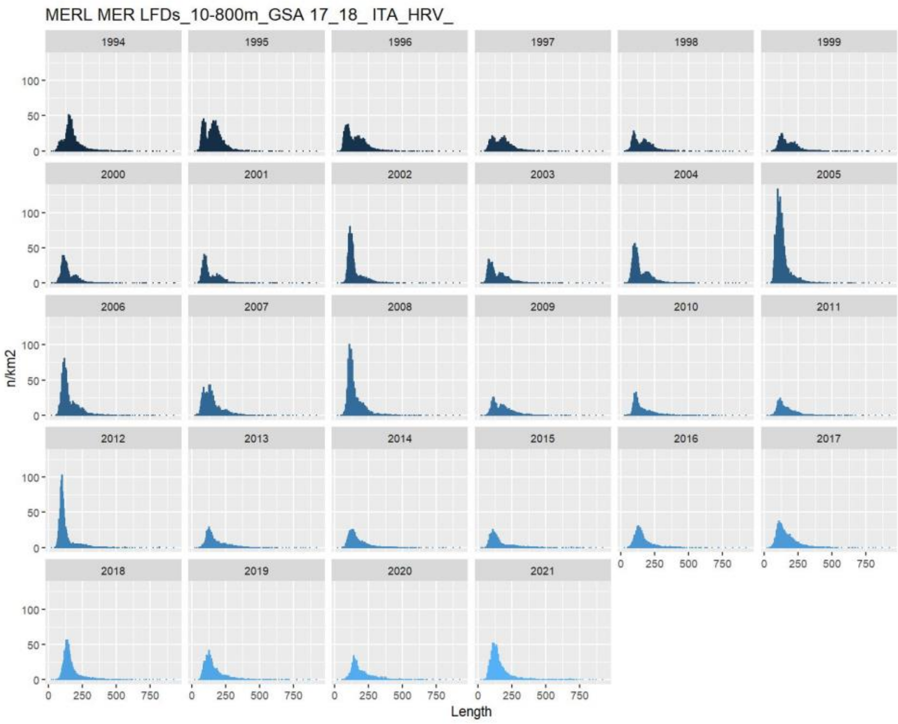


Figure 6.1.2.3.4 European hake in GSAs 17 and 18. MEDITS Length frequency distribution (TL mm; n/km^2).

6.1.3 STOCK ASSESSMENT

The management advice is given using the SS3 model since it was the model chosen during the GFCM benchmark in 2019.

Stock Synthesis (SS3)

Stock Synthesis 3 (SS3; Methot and Wetzel, 2013) provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. It is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analysed. It uses forward projection of population as in the "statistical catch-at-age" (SCAA) approach. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Some SS3 features include ageing error, growth estimation, spawner-recruitment relationship, movement between areas. The ADMB C++ software in which SS is written searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian methods

The SS model of European hake in GSAs 17-18 was benchmarked in 2019 (GFCM, 2019). It is a one-area yearly model where the population is comprised of 20+ age-classes with two sexes (males and females are considered as separated). The model is a length-based model where the numbers at length in the fisheries and survey data are converted into ages using the von Bertalanffy growth function. SS3 assumes multinomial likelihoods for the proportions-at-length in catches and survey data. The last age-class (i.e. 20+) represents a "plus group" in which mortality and other characteristics are assumed to be constant.

The model starts in 1998 and the initial population age structure was assumed not to be in an unexploited equilibrium state, so that the initial fishing mortality was estimated for all fleets in the model. Initial catches were assumed as the average of the 3 previous years (1995–1997; FishStatJ FAO-GFCM, 2020). Differently from the benchmark, fishing mortality was modelled using the Baranov's continuous F, with each F as a model parameter, instead of the hybrid method, as it is preferred when F is high because hybrid F has high gradients that limit pace of convergence when F is high. Option 5 was selected for the F report basis. This option represents the last development of SS and corresponds to the fishing mortality requested by the ICES, GFCM and STECF frameworks (i.e. simple average of F of the age classes chosen to represent Fbar). Selectivity by fleet has been generated as length-specific. Fbar was calculated considering ages from 1 to 4.

The SS3 analysis has been carried out considering the following 8 fleets: 7 fishing fleets and 1 survey. The MEDITS survey is performed by 3 different units (Croatia GSA 17, Italy GSA 17 and GSA 18). However, considering the standardised procedure, it was preferred to use this information as unique, thus combined the indices by lengths using the ad-hoc script.

Fishing fleet

1) Italian bottom trawl GSA 17, including also Slovenian data (catch and LFDs)
2) Croatian bottom trawl (catch and LFDs)
3) Croatian longlines (catch and LFDs)
4) Italian bottom trawl GSA 18 (catch and LFDs)
5) Italian longlines GSA 18 (catch and LFDs)
6) Montenegrin bottom trawl and nets (catch and LFDs)
7) Albania bottom trawls (catch and LFD; LFD only for 2017-2021)

Survey

1) MEDITS survey (index Kg/Km^2 and LFDs)

The MEDITS survey in the benchmark model was miss-specified (the density index used in the model as a biomass index; the report stated a biomass index was the selected approach) so it was corrected during STECF EWG 19-16 by substituting with the correct biomass MEDITS index.

For the Italian longlines GSA 18 fishing fleet, ALKs have been also considered for the time series from 2002 to 2021 (except for the years 2003, 2004 and 2006). During the EWG 21-15 and EWG 2216 it was noticed that the ALKs included during the benchmark were miss-specified, therefore these were corrected this year.

This model includes only catches from OTB and LLS. All the catches from other gears are not included in the assessment. In a future benchmark the catches from other gears should be considered as possible other information to be included in the model.

Input data and fitting of the model

Figure 6.1.3.1.1 summarises the data included in the SS3 model. Specifically, the catch data (Fig. 6.1.3.1.2) goes from 1998 to 2021. The last official assessment from GFCM (GFCM, 2022) was updated with data from 2021. Albania and Montenegro made available information from 2021.LFDs from Montenegro were missing for 2021 so are not included in the model.

SS3 allows different selectivity by gear (Fig. 6.1.3.1.3.) Specification of selectivity model has been left unchanged compared to the benchmark.

Growth parameters were estimated within the model for both sexes using the von Bertalanffy growth curve informed by the annual ALKs derived from the catches of the Italian part of GSA 18 (6.1.3.1.4). The ALKs used in this assessment are the corrected ones (see below). L_{inf} parameters for both sexes were also assumed to have a prior distribution (assuming a beta distribution) equal to the values estimated externally using otolith reading (GSA 18 – DCF, 2017).

Length-based maturity ogives were derived by data collected from commercial and survey samples in the western side of GSA 18. The maturity ogives based on macroscopic inspection of the gonads of both sexes indicates that the onset of maturation (L50%) occurs at about 32 cm for females and 17 cm for males for the entire time series (6.1.3.1.4). L50% of females only is included in the SS model.

Figure 6.1.3.1.5 summarises the observed length frequency distribution (LFD) by fleet, also showing the fitting of the model. While figure 6.1.3.1.6 summarises the Pearson residuals for the LFDs by fleet and year.

Figure 6.1.3.1.7 shows the biomass index by year from the MEDITS survey with the model fitting; residuals are also reported (Fig. 6.1.3.1.8).

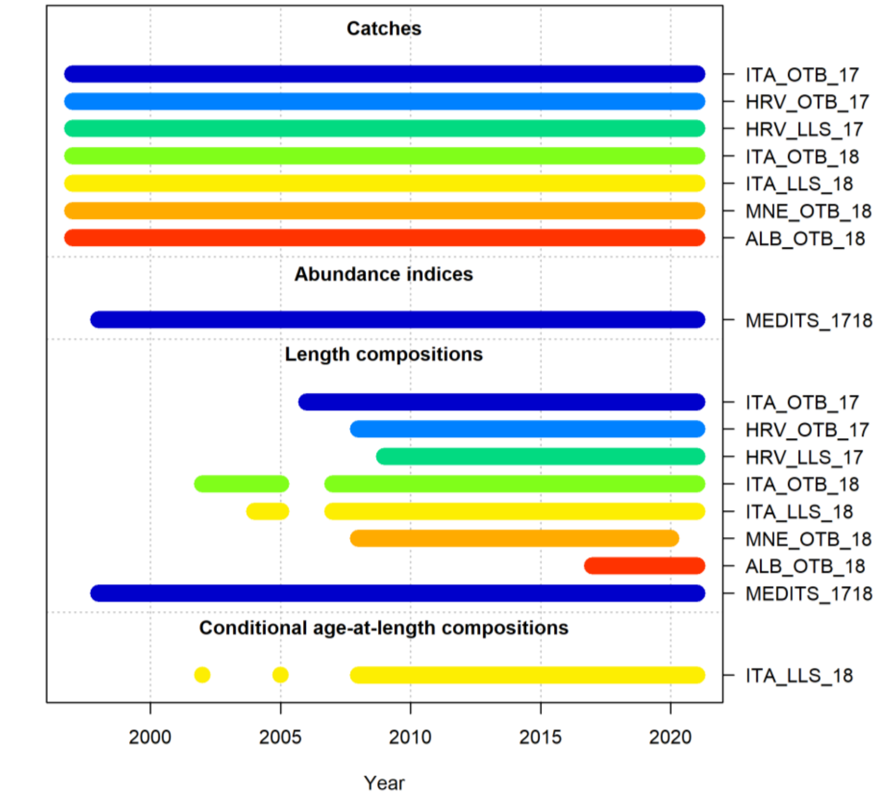


Figure 6.1.3.1.1 European hake in GSAs 17 and 18: Summary of the input included in the SS3 model.

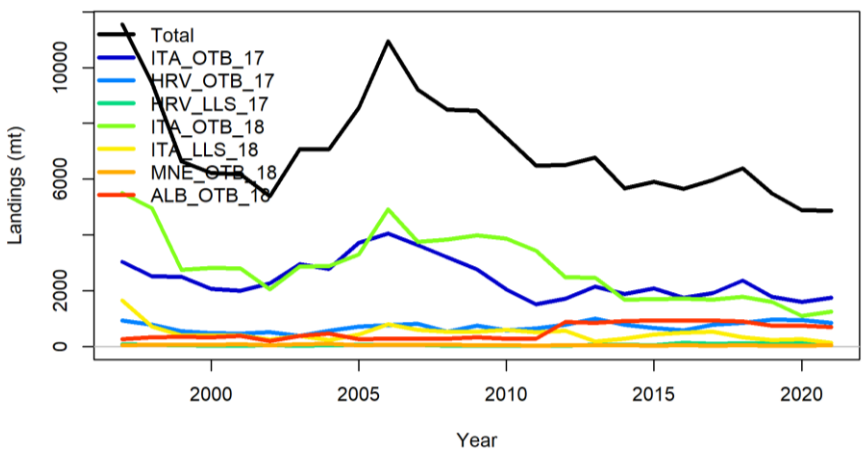


Figure 6.1.3.1.2 European hake in GSAs 17 and 18: Catch data by country, gear and year.

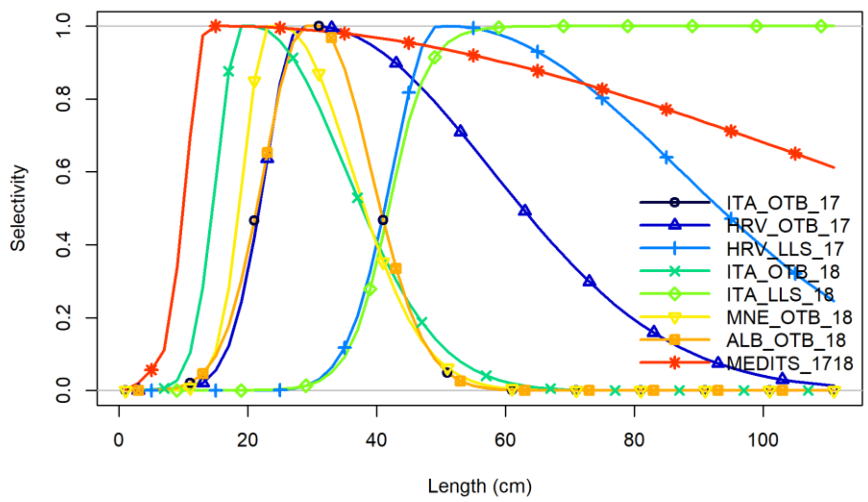


Figure 6.1.3.1.3 European hake in GSAs 17 and 18: Selectivity by fleet in 2021.

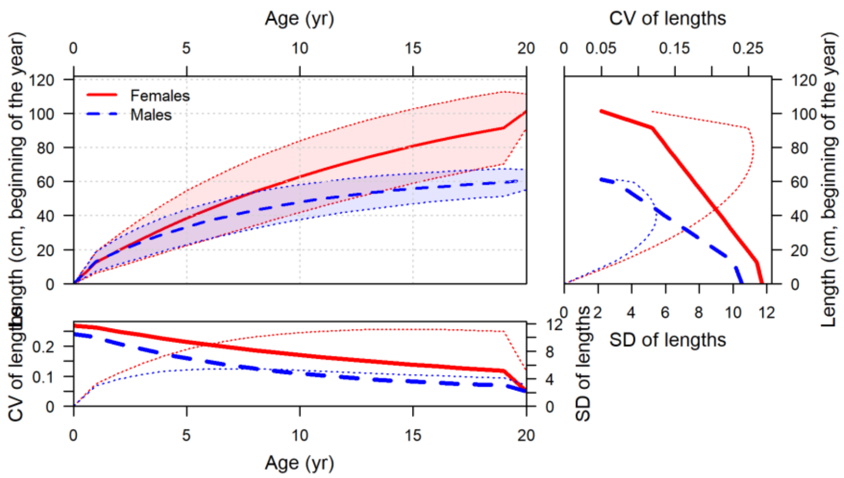


Figure 6.1.3.1.4 European hake in GSAs 17 and 18: Length at age (top-left panel) with weight (thick line) and maturity (thin line) shown in top-right and lower-left panels.

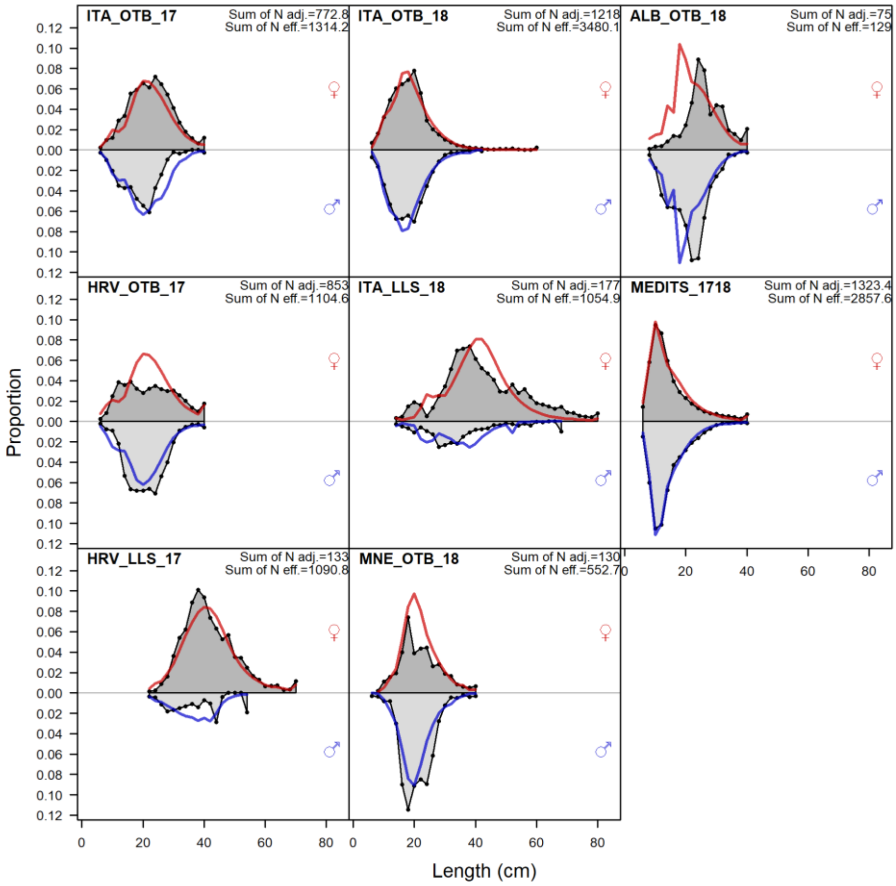


Figure 6.1.3.1.5 European hake in GSAs 17 and 18: Catch at length by fleet input data. fitted males and females

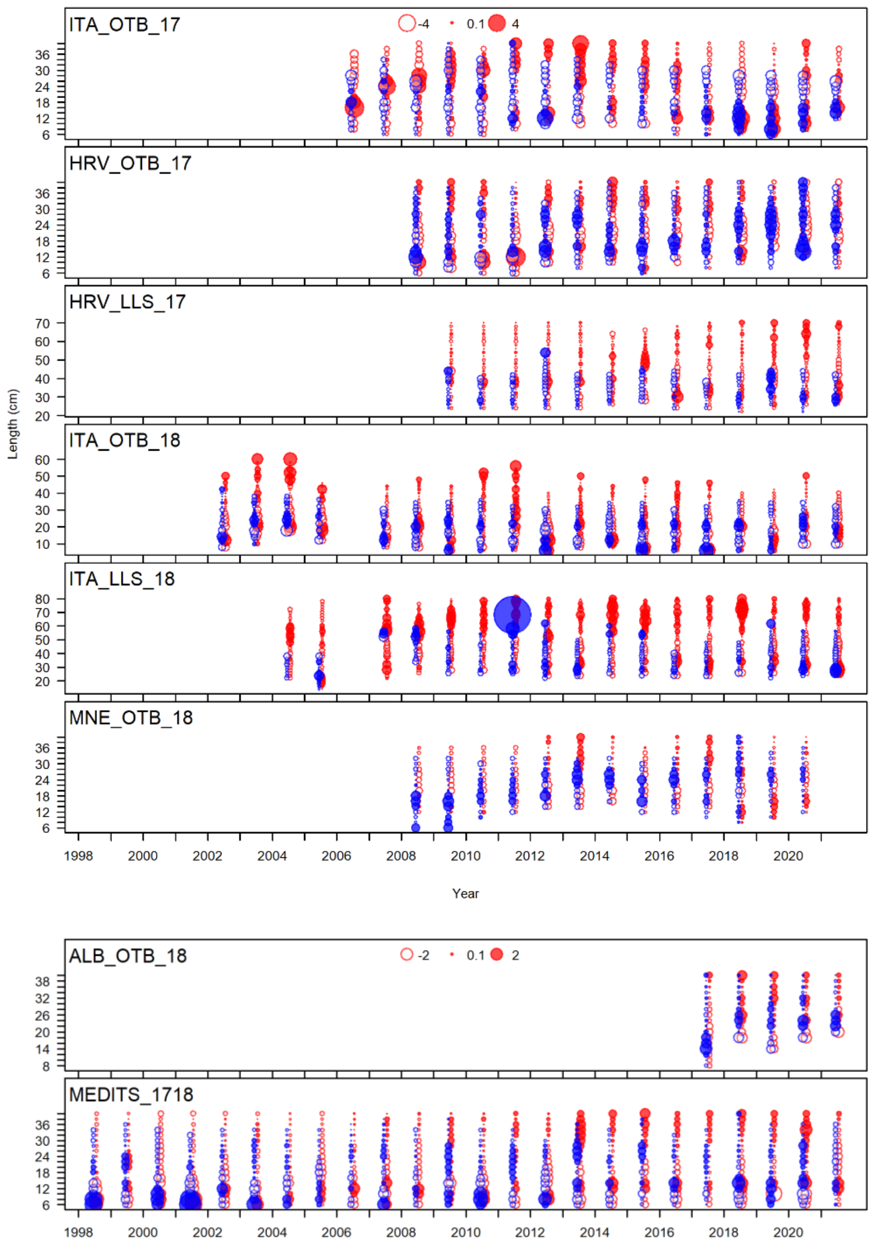


Figure 6.1.3.1.6 European hake in GSAs 17 and 18: Summary of the Pearson residuals for the LFDs by fleet and year. Closed bubbles are positive residuals (observed > expected), and open bubbles are negative residuals (observed < expected). Blue bubbles are used for males, red for females.

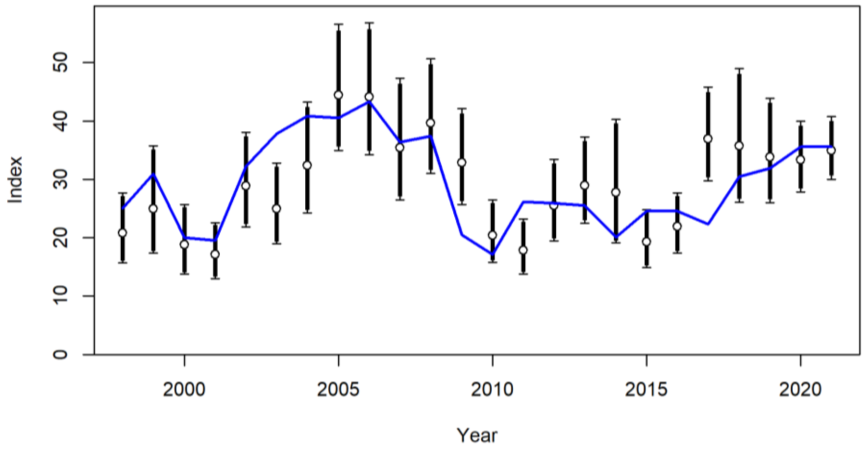


Figure 6.1.3.1.7 European hake in GSAs 17 and 18: Biomass index (Kg/Km^2) and fitting of the model (blue line) for the MEDITS survey.

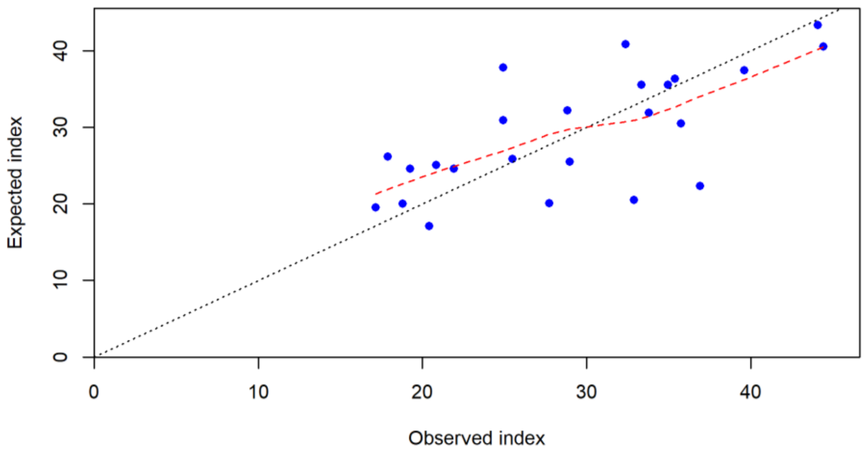
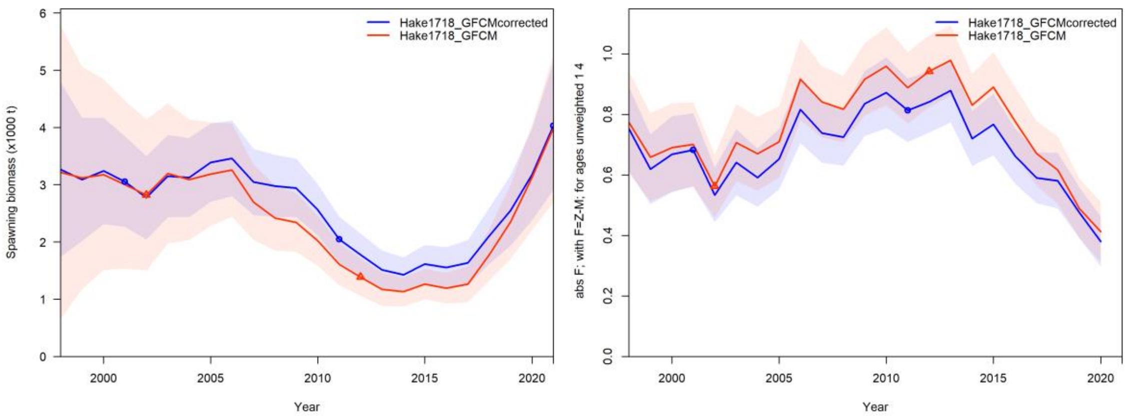


Figure 6.1.3.1.8 European hake in GSAs 17 and 18: Residuals by year for the MEDITS survey.

The setup of the final model was in line with the updated run of STECF EWG 20-15 and the run performed during the GFCM 2022 with the addition of 2021 DCF data and data from Montenegro and Albania. Specifically:

- 2021 catches for Montenegro were added;
- 2021 catches and LFD for Albania were added;
- New SS3 bias adjustment and weighting included as part of the fitting process.
- Correction to ALK data, which was previously put in with some ages misaligned.

All the modifications are considered minor or to be model technicalities and do not represent a deviation from the updated run of STECF EWG 20-15 or GFCM benchmark. Figure 6.1.3.1.9 reports also the comparison between the last stock assessment accepted by the GFCM and a new run including the corrected ALKs. The two assessment present very similar values, specifically in the most recent years, with some revision the SSB in the middle years of the assessment. Even though these are small changes and may not imply new long term dynamics and the changes seen in the final assessment are not so large new reference points have been estimated (see section 6.1.4) to ensure the changes that have occurred are taken into account. The effect of the realigned ALKs should be investigated in a future benchmark, considering this modification from the previous assessments.



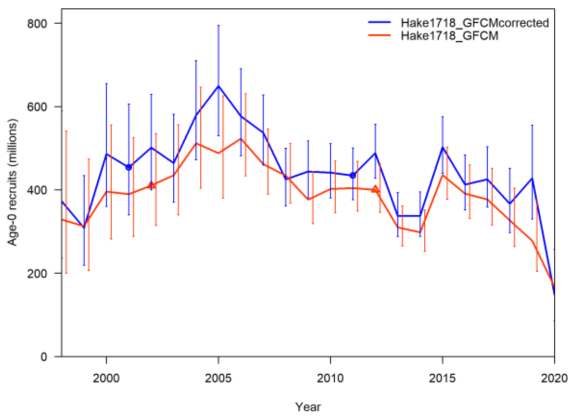


Figure 6.1.3.1.9 European hake in GSAs 17 and 18: Comparison between the last official GFCM stock assessment (red line – Hake1718_GFCM2022; GFCM, 2022) and a new run including the corrected ALKs (blue line – Hake1718_GFCMcorrected).

Results

In the results below SSB has been evaluated as Female SSB taken directly from the model. Female SSB of European hake is relatively stable until 2006, then decreased considerably until 2014 (1344 tons) to then rise to the highest value of the time-series in 2022 (4017 tons).

$F_{bar(1-4)}$ shows a decreasing trend in the last six years, accounting for the lowest value in the most recent year ($F_{bar(1-4)}$ in 2021 equal at 0.39). Bottom trawlers are the fleets accounting for the highest values of fishing mortality, specifically ITA OTB 17 and ITA OTB 18. However, exploitation from longlines is not negligible (Table 6.1.3.1.2); they accounted for ~ 25% of total Fishing mortality along the time series with peak of ~ 45% in 2016 and 2017. A substantially higher proportion total F comes from LLS than the proportion of catch, which is about 8% overall years and 13% in 2016. The reason for this is that LLS dominate catches of older individuals over 40cm, and covers a larger age range than the OTB fleet, but these bigger individuals contribute little to the F_{bar} (ages 1-4) because compared to OTB few individuals are caught by LLS at ages 4 and below.

Recruitment shows a decreasing trend in the last six years with the exception of 2019. Recruitment in the last five years is below average.

Results are summarised in tables (Tables 6.1.3.1.1, 6.1.3.1.2, 6.1.3.1.3 and 6.1.3.1.4) and figures (Figs. 6.1.3.1.10, 6.1.3.1.11, 6.1.3.1.12 and 6.1.3.1.13).

Table 6.1.3.1.1 European hake in GSAs 17 and 18: Female spawning stock biomass (SSB, in tonnes), Fishing mortality, and recruitment (in thousands) resulting from the SS3 model. 'High' and 'Low' represent approximately 95% confidence intervals.

Year	Recruitment age 0 thousands	High	Low	**Female** SSB Tonnes*	High	Low	Catch tonnes	F ages 1-4	High	Low
1998	377949	552544	203354	3159	4894	1423	9441	0.77	0.91	0.62
1999	314041	422115	205967	2970	4219	1722	6666	0.63	0.75	0.51
2000	491860	639299	344421	3100	4153	2046	6268	0.68	0.81	0.55
2001	456429	588331	324527	2917	3807	2026	6206	0.69	0.81	0.57
2002	500071	613678	386464	2646	3445	1848	5442	0.54	0.63	0.45
2003	466046	570499	361593	3016	3776	2256	7322	0.65	0.76	0.54
2004	580616	698399	462833	2988	3688	2289	7336	0.60	0.70	0.50
2005	653281	784918	521644	3233	3899	2568	8772	0.66	0.76	0.56
2006	576703	679675	473731	3305	3934	2677	10832	0.83	0.94	0.71
2007	538905	622531	455279	2911	3452	2370	8959	0.75	0.85	0.65
2008	427866	496569	359163	2839	3342	2336	8312	0.74	0.83	0.64
2009	445250	512840	377660	2801	3276	2327	7998	0.85	0.95	0.74
2010	442583	507153	378013	2435	2856	2015	6923	0.88	1.00	0.77
2011	437259	498930	375588	1936	2305	1568	6416	0.83	0.93	0.72
2012	483923	547332	420514	1679	2016	1342	6818	0.85	0.95	0.75
2013	334048	385401	282695	1427	1730	1124	6753	0.89	1.00	0.79
2014	331292	382816	279769	1344	1617	1071	5493	0.74	0.83	0.65
2015	489151	553047	425255	1510	1797	1223	5817	0.80	0.90	0.70
2016	399050	460118	337982	1415	1707	1123	5764	0.71	0.80	0.62
2017	404425	466747	342103	1432	1751	1113	6033	0.65	0.74	0.56
2018	366616	429815	303417	1781	2168	1393	6091	0.66	0.76	0.57
2019	442777	524227	361327	2040	2512	1568	5355	0.55	0.64	0.47
2020	312207	401788	222626	2434	3020	1847	4819	0.43	0.50	0.36
2021	270053	396036	144070	3054	3792	2315	4845	0.39	0.47	0.32
2022				4017	4978	3056				

*SS3 model provides estimates of SSB only for females.

Table 6.1.3.1.2 European hake in GSAs 17 and 18: F by fleet by year estimated by the model.

Year	ITA OTB 17	HRV OTB 17	HRV LLS 17	ITA OTB 18	ITA LLS 18	MNE OTB 18	ALB OTB 18
1998	0.193	0.039	0.016	0.290	0.198	0.005	0.026
1999	0.230	0.033	0.012	0.203	0.116	0.006	0.031
2000	0.228	0.035	0.011	0.248	0.117	0.007	0.036
2001	0.239	0.033	0.011	0.239	0.118	0.008	0.045
2002	0.240	0.034	0.012	0.153	0.077	0.004	0.021
2003	0.256	0.021	0.008	0.224	0.102	0.006	0.033
2004	0.226	0.029	0.012	0.224	0.065	0.007	0.038
2005	0.274	0.034	0.015	0.198	0.118	0.004	0.020
2006	0.285	0.035	0.016	0.254	0.213	0.004	0.020
2007	0.276	0.040	0.019	0.210	0.179	0.004	0.021
2008	0.264	0.029	0.010	0.236	0.169	0.005	0.023
2009	0.271	0.048	0.012	0.298	0.180	0.005	0.033
2010	0.237	0.044	0.015	0.324	0.229	0.005	0.033
2011	0.187	0.050	0.016	0.296	0.236	0.004	0.036
2012	0.192	0.066	0.016	0.192	0.285	0.004	0.099
2013	0.274	0.118	0.044	0.213	0.132	0.005	0.108
2014	0.205	0.078	0.038	0.134	0.183	0.004	0.100
2015	0.221	0.062	0.031	0.132	0.256	0.004	0.098
2016	0.151	0.046	0.062	0.100	0.268	0.003	0.081
2017	0.136	0.053	0.042	0.087	0.263	0.002	0.066
2018	0.193	0.062	0.053	0.110	0.169	0.004	0.073
2019	0.155	0.075	0.046	0.108	0.103	0.003	0.065
2020	0.118	0.060	0.052	0.062	0.084	0.002	0.056
2021	0.133	0.053	0.034	0.079	0.037	0.003	0.053

Table 6.1.3.1.3 European hake in GSAs 17 and 18: Stock numbers at age estimated by SS3.

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1998	377948	131796	57147	12550	4121	1676	637	272	75	24	10
1999	314042	93890	42079	14332	3200	1223	598	248	113	33	16
2000	491860	79103	33756	12272	4186	1084	505	274	123	60	27
2001	456428	123289	27202	9273	3399	1362	437	229	137	65	49
2002	500070	114471	42470	7400	2520	1084	540	197	114	73	65
2003	466046	125229	43060	13701	2415	950	497	275	109	67	86
2004	580616	120456	52058	12741	3614	714	348	210	132	57	89
2005	653280	150092	51622	16374	3558	1123	274	155	106	73	90
2006	576702	167847	58353	14805	4402	1089	424	118	74	55	93
2007	538906	144230	54442	13947	3420	1173	355	155	47	32	69
2008	427866	134451	48613	14154	3539	997	416	140	67	22	51
2009	445250	106728	45090	12730	3671	1066	368	172	64	32	39
2010	442584	109846	32830	10407	2916	993	361	142	74	29	37
2011	437258	108856	32592	7264	2301	758	318	129	55	31	30
2012	483924	107612	33175	7692	1737	639	253	115	50	23	27
2013	334048	120998	35499	7901	1706	426	183	78	38	17	18
2014	331292	83738	40285	8120	1619	398	125	62	30	16	17
2015	489152	83900	30693	10934	2008	440	128	44	23	12	14
2016	399050	123549	29955	7883	2512	498	126	39	14	8	10
2017	404426	101274	46415	8586	2050	677	145	37	11	4	5
2018	366616	103025	39450	14224	2408	593	210	45	11	4	3
2019	442778	93239	39415	11658	3883	712	202	76	17	4	3
2020	312208	113076	37278	12902	3650	1337	285	87	35	8	4
2021	270054	80372	48722	13924	4679	1434	595	133	42	17	6

Table 6.1.3.1.4 European hake in GSAs 17 and 18: Fishing mortality (F) at age estimated by SS3.

	Age									
Year	0	1	2	3	4	5	6	7	8	9	Mean Age 10 - 20
1998	0.05	0.49	0.83	0.91	0.86	0.77	0.69	0.62	0.58	0.54	0.47
1999	0.04	0.37	0.67	0.77	0.73	0.63	0.54	0.46	0.40	0.36	0.28
2000	0.04	0.42	0.73	0.83	0.77	0.66	0.56	0.47	0.41	0.36	0.27
2001	0.04	0.41	0.74	0.84	0.79	0.68	0.57	0.48	0.41	0.37	0.28
2002	0.05	0.33	0.57	0.66	0.62	0.53	0.44	0.36	0.31	0.27	0.20
2003	0.01	0.23	0.66	0.87	0.86	0.76	0.64	0.54	0.45	0.39	0.27
2004	0.01	0.19	0.60	0.81	0.81	0.71	0.60	0.49	0.41	0.34	0.21
2005	0.02	0.29	0.69	0.85	0.83	0.73	0.62	0.53	0.46	0.41	0.31
2006	0.05	0.47	0.87	1.00	0.96	0.87	0.77	0.69	0.63	0.59	0.51
2007	0.05	0.44	0.79	0.91	0.87	0.78	0.69	0.62	0.56	0.52	0.44
2008	0.05	0.44	0.78	0.89	0.84	0.74	0.64	0.57	0.51	0.47	0.39
2009	0.06	0.53	0.91	1.02	0.95	0.84	0.72	0.63	0.56	0.51	0.42
2010	0.06	0.56	0.95	1.05	0.99	0.89	0.79	0.71	0.66	0.62	0.53
2011	0.06	0.54	0.89	0.97	0.92	0.84	0.77	0.71	0.67	0.64	0.56
2012	0.05	0.46	0.88	1.05	1.05	0.99	0.93	0.88	0.85	0.82	0.75
2013	0.04	0.45	0.92	1.13	1.10	0.99	0.86	0.75	0.66	0.60	0.45
2014	0.03	0.35	0.74	0.94	0.94	0.88	0.81	0.74	0.69	0.65	0.56
2015	0.04	0.38	0.80	1.01	1.03	0.99	0.93	0.88	0.85	0.82	0.74
2016	0.03	0.33	0.69	0.88	0.94	0.96	0.96	0.97	0.98	0.98	0.93
2017	0.03	0.29	0.62	0.81	0.87	0.89	0.91	0.92	0.93	0.93	0.90
2018	0.03	0.31	0.66	0.84	0.85	0.81	0.76	0.71	0.68	0.65	0.57
2019	0.03	0.26	0.56	0.70	0.70	0.65	0.59	0.54	0.50	0.46	0.38
2020	0.02	0.19	0.43	0.55	0.57	0.54	0.50	0.47	0.44	0.42	0.35
2021	0.02	0.19	0.40	0.50	0.49	0.44	0.38	0.33	0.28	0.25	0.18

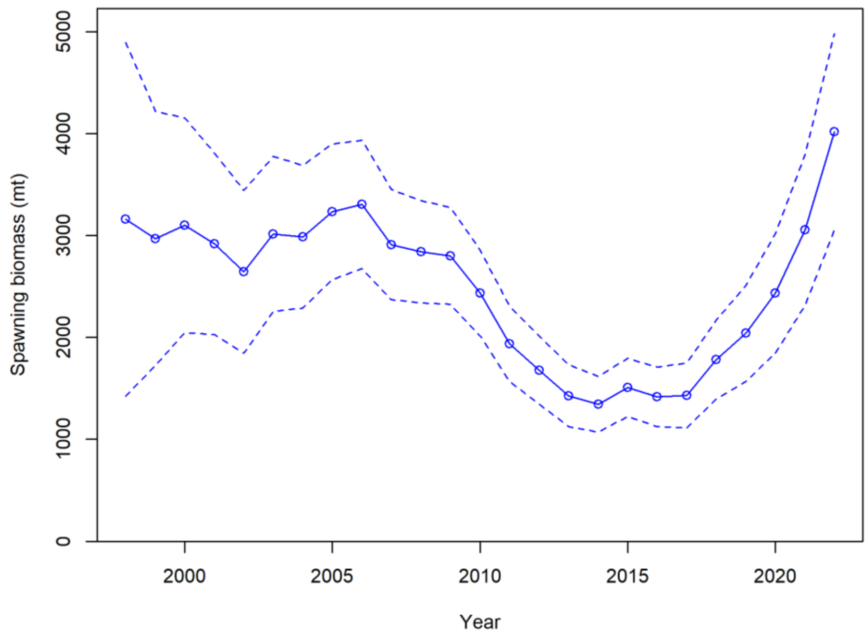


Figure 6.1.3.1.10 European hake in GSAs 17 and 18: Female spawning stock biomass by year estimated by the SS3 model.

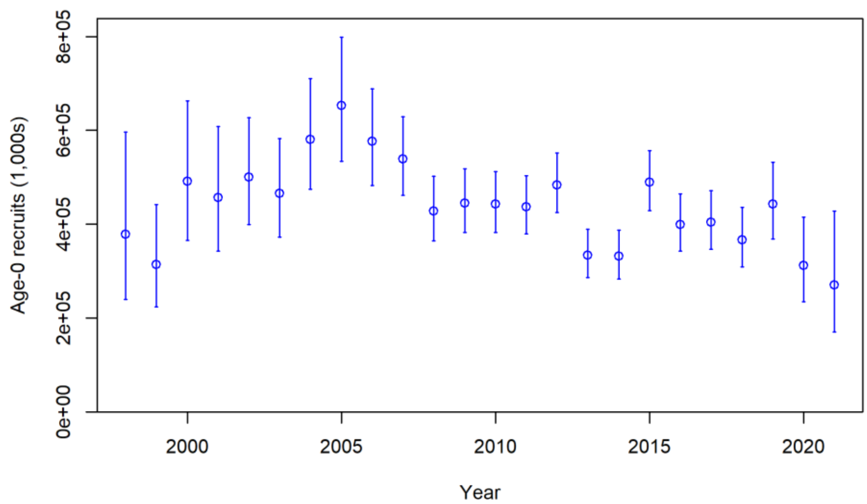


Figure 6.1.3.1.11 European hake in GSAs 17 and 18: Recruitment by year estimated by the SS3 model.

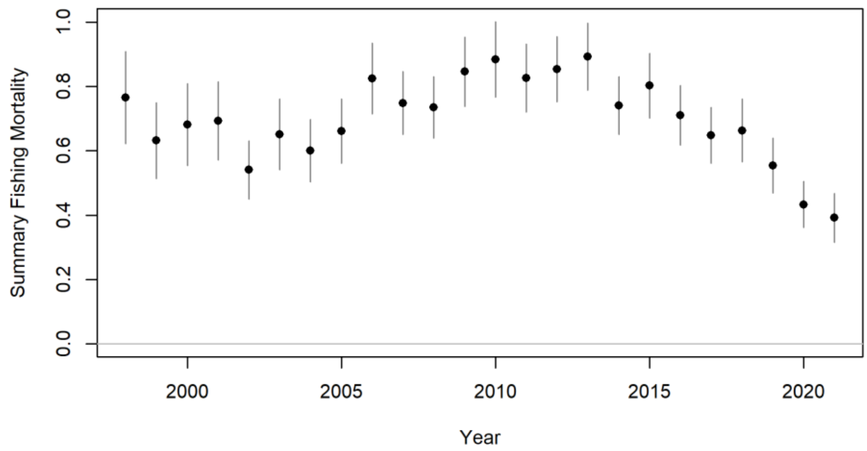


Figure 6.1.3.1.12 European hake in GSAs 17 and 18: Fishing mortality by year estimated by the SS3 model.

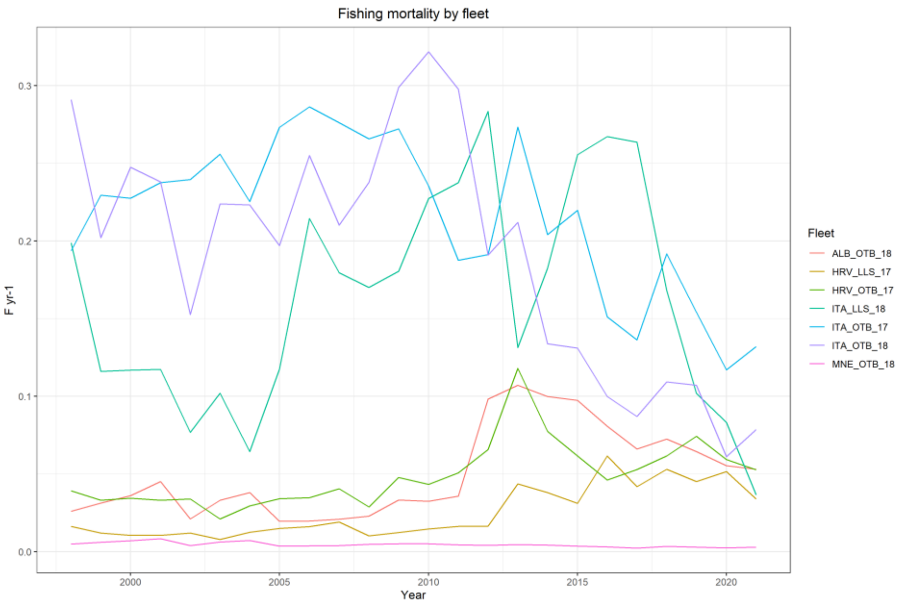


Figure 6.1.3.1.13 European hake in GSAs 17 and 18: Fishing mortality by year and fleet estimated by the SS3 model.

Retrospectives

Figures 6.1.3.1.14, 6.1.3.1.15 and 6.1.3.1.15 show the retrospectives obtained by running the SS3 model. The retrospective analysis run on the SS3 model showed a slight underestimation of F but a substantial overestimation of female SSB. It is suggested to review this model in a new benchmark.

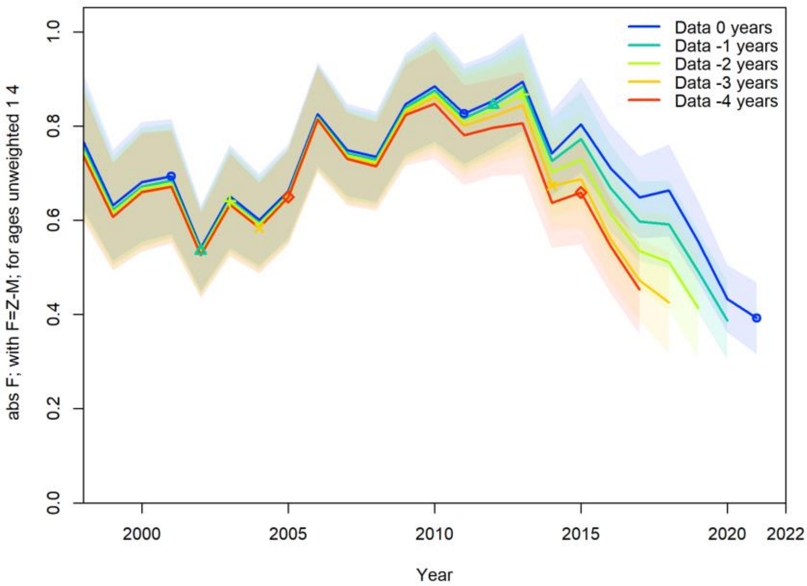


Figure 6.1.3.1.14 European hake in GSAs 17 and 18: Retrospectives – Fishing mortality from SS3.

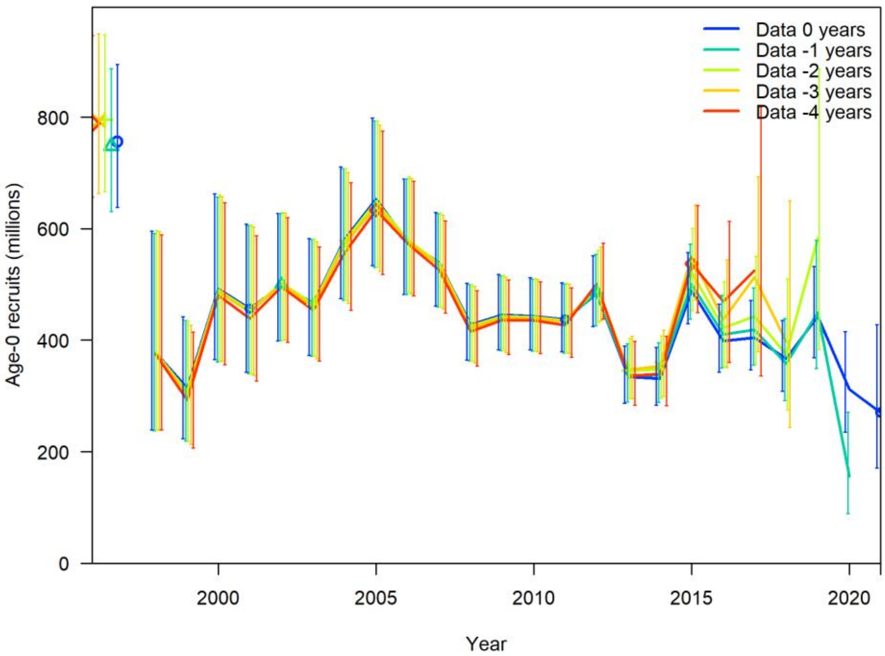


Figure 6.1.3.1.15 European hake in GSAs 17 and 18: Retrospectives – Recruitment from SS3.

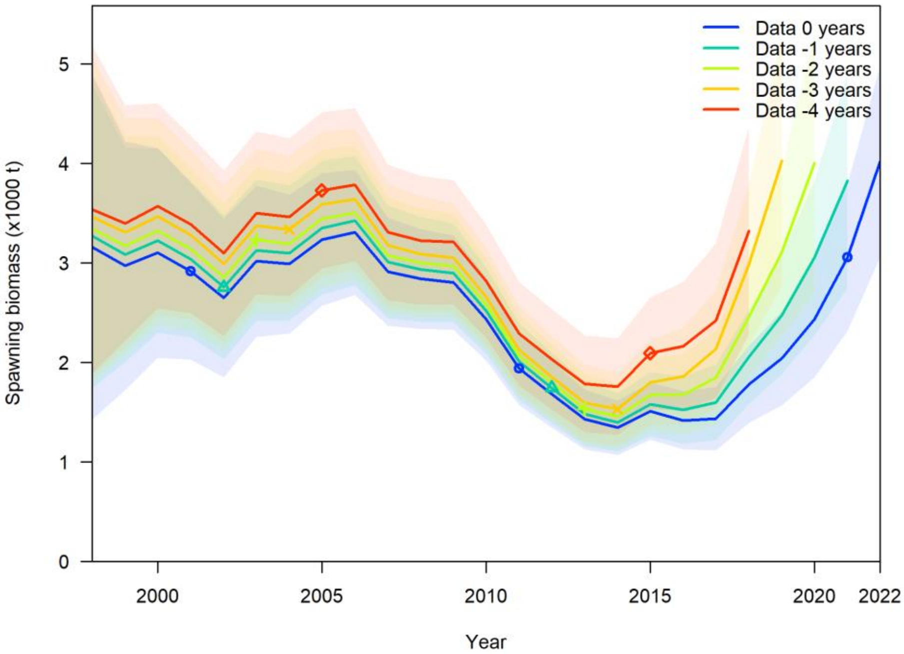


Figure 6.1.3.1.16 European hake in GSAs 17 and 18: Retrospectives – **Female** spawning stock biomass from SS3.

6.1.4 Reference points

During the data preparation for this stock assessment, experts noticed the use of improper ALKs; this information has been corrected during the EWG 2216. Considering this change, new reference points were derived by the present SS3 assessment and the estimated values are presented in table 6.1.4.1.

Table 6.1.4.1 European hake in GSAs 17 and 18: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.232	F_{MSY} from SS3 model	STECF EWG 22-16
Precautionary approach	B_{lim}	1344	B_{loss}	STECF EWG 22-16
	B_{pa}	1881	$B_{lim} \cdot exp^{(1.645 \cdot \sigma)}$	STECF EWG 22-16
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.232	F_{MSY}	STECF EWG 22-16
	MAP target range $F_{MSY\ lower}$	0.12	Based on regression calculation (see section 2)	STECF EWG 19-16
	MAP target range $F_{MSY\ upper}$	0.25	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 19-16

6.1.5 Short term Forecast and Catch Options

The short-term forecast was performed using SS for standard options for 2023 and an additional option for a forecast for 2024 requested in ToR 6.1. The assumptions for 2022 are based on the GFCM decision and are given in Table 6.1.5.1, and results are given in Table 6.1.5.3.

The TBB is not included in the GFCM assessment, on the basis that there is no directed fishery and catches are negligible, so the TBB has no influence on the results. Indeed, LLS are relevant, since they account for ~ 20% of the total fishing mortality in 2022 (with higher values in the less recent years; see figure 6.1.3.1.13).

There are a number of other aspects that need to be considered in interpreting the results. The analysis carried out assumes a direct relationship between effort and F which may not hold over time. F estimated in the assessment has already declined from 0.43 in 2020 to 0.39 in 2021, however retrospective analysis (Figure 6.1.3.1.14) shows that F is being revised upwards by about 0.1 over a 2-3 year period, suggesting underestimation of F in the last year, so the absolute values of F may not be as low as indicated in the assessment, though the it seems likely a substantial reduction has occurred.

Table 6.1.5.1 European hake in GSAs 17 and 18: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		Mean weights at age, maturity at age, natural mortality at age and selection at age, based on the average of 2019-2021
$F_{ages\ 1-4}$ (2022)	0.37	F_{2021} used to give F status quo for 2022 plus a reduction of 5.2% for the OTB fleets
Female SSB (2022)	4017 t	Stock assessment 1 January 2022
R_{age0} (2022,2023,2024)	348,562	Mean of the last 3 years
Total catch (2022)	4719 t	Assuming F status quo for 2022

Table 6.1.5.2 European hake in GSAs 17 and 18: Assumptions made for 2023/2024 to give the $F_{MSY\ Transition}$ forecast for 2023.

Variable	Value	Notes
Biological Parameters		Mean weights at age, maturity at age, natural mortality at age and selection at age, based on the average of 2018-2020
$F_{ages\ 1-4}$ (2023)	0.24	7% reduction in partial F_{2022} for all OTB fleets, F_{2020} for all LLS fleets in 2022
R_{age0} (2024)	348,562	Mean of the last 3 years
Female SSB (2023)	4795	Short term forecast 1 January 2023
Total catch (2023)	3162	Assuming F option above

Table 6.1.5.3 European hake in GSAs 17 and 18: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	**Female** SSB (2024)	% **Female** SSB change**	% Catch change***
STECF advice basis					
F_{MSY} / MAP	3612	0.232	6037	50.3	-25.5
$F_{MSY\ Transition}$	4690	0.37	5238	30.4	-3.2
$F_{MSY\ lower}$	2670	0.16	6528	62.5	-44.9
$F_{MSY\ upper*}$	4153	0.32	5510	37.1	-14.3
Other scenarios					
Zero catch	0	0	7675	91	-100.0
Status quo	4919	0.39	5123	27.5	1.5
60% of status quo	3162	0.23	6017	49.8	-34.7
80% of status quo	4072	0.31	5551	38.2	-16.0
7% reduction OTB fleets^	4658	0.37	5251	30.7	-3.9

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

** % change in SSB 2024 to 2022

***Total catch in 2023 relative to catch in 2021.

^7% reduction in partial F_{2022} for all OTB fleets, and $F_{2022} = F_{2020}$ for all LLS fleets

Table 6.1.5.4 European hake in GSAs 17 and 18: Annual catch scenarios by area and gear assuming same catch proportions as 2021.

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	GSA 17 OTB	GSA 17 LLS	GSA 18 OTB	GSA 18 LLS
STECF advice basis						
F_{MSY}	3612	0.232	1922	101	1489	101
F_{MSY} transition	4690	0.37	2495	131	1933	131
$F_{MSY\ lower}$	2670	0.16	1421	74	1101	74
$F_{MSY\ upper}$**	4153	0.32	2210	116	1712	116
Other scenarios						
Zero catch	0	0	0	0	0	0
Status quo	4919	0.39	2617	137	2027	137
60% of status quo	3162	0.23	1682	88	1303	88
80% of status quo	4072	0.31	2166	113	1678	113
7% reduction OTB fleets**	4658	0.37	2478	130	1920	130

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

** 7% reduction in partial F_{2023} for all OTB fleets, and $F_{2023} = F_{2021}$ for all LLS fleets

A probabilistic forecast was also run to estimate the probabilities of the stock to fall below B_{lim} and $B_{trigger}$ in 2023 and 2024. The results are shown in Table 6.1.5.5 and Figure 6.1.5.1.

Table 6.1.5.5 European hake in GSAs 17 and 18: Kobe matrix: probabilistic forecast with the associated probability at different level of F for the stock to be below B_{lim} and below $B_{trigger}$.

Scenario	Probability SSB<B_{lim} 2023	Probability SSB<B_{lim} 2024	Probability SSB<$B_{trigger}$ 2023	Probability SSB<$B_{trigger}$ 2024
F_{upper}	0	0	0	0
F_{lower}	0	0	0	0
F_{MSY}	0	0	0	0
$F_{MSY\ transition}$	0	0	0	0
Status quo	0	0	0	0
80% of status quo	0	0	0	0
60% of status quo	0	0	0	0
Zero catches	0	0	0	0
7% reduction OTB fleets*	0	0	0	0

* 7% reduction in partial F_{2023} for all OTB fleets, and F_{2023} = F_{2021} for all LLS fleets

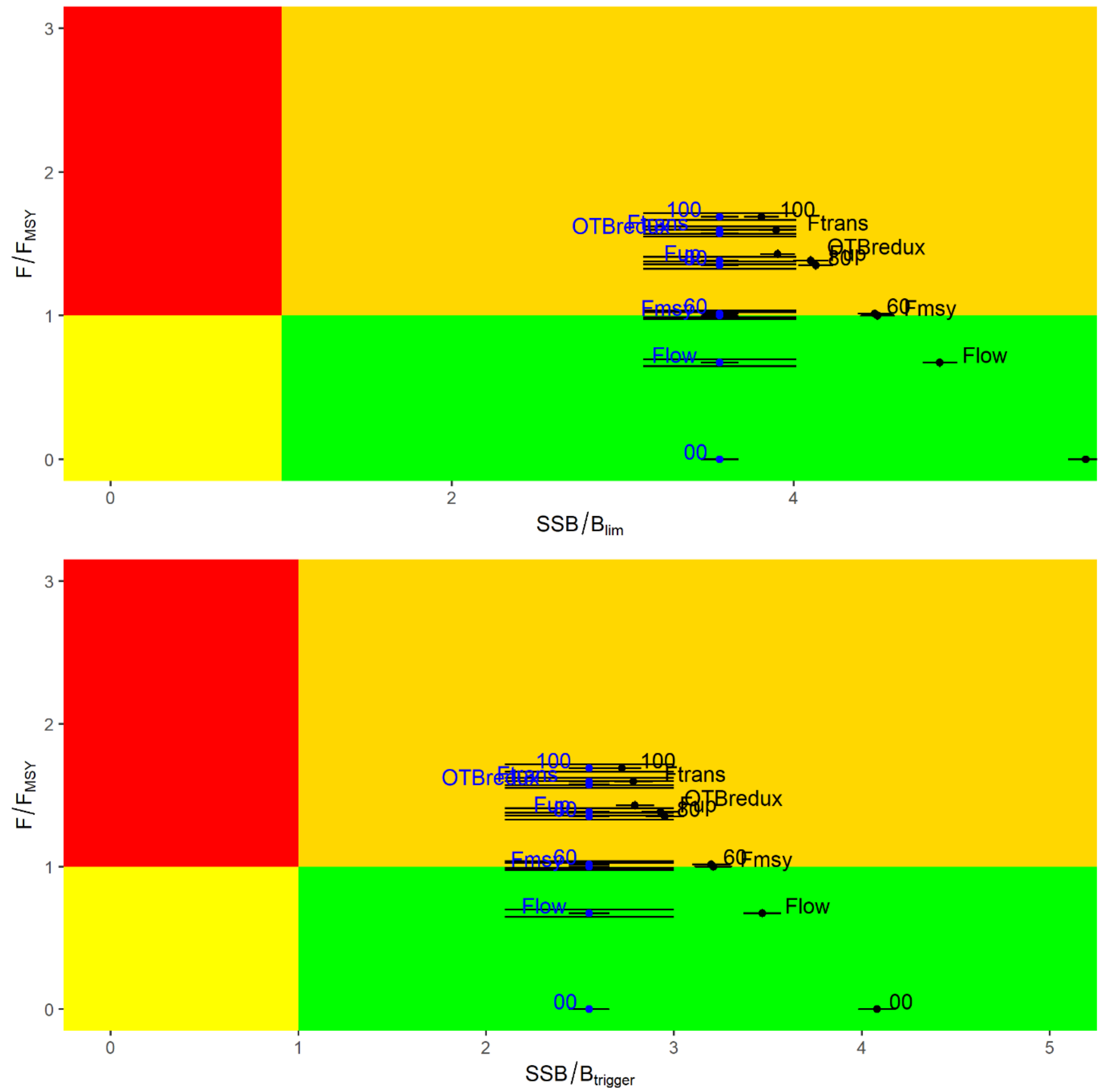


Figure 6.1.5.1 European hake in GSAs 17 and 18: Kobe plots for B_{lim} and $B_{trigger}$.

6.1.6 Data Deficiencies

The data from the last EU DCF official Data Call (2022) was scrutinized for issues.

LFDs from landings of Italy in GSA 17 are available only for OTB and TBB and only for 2019 for GNS. LFDs from landings of TBB of Italy in GSA 17 are missing for 2007-2010, 2013 and 2016. LFDs from discards of Italy in GSA 17 are available only for OTB from 2011 to 2021.

LFDs from landings of Italy in GSA 18 are available only for OTB and LLS from 2002 to 2021. LFDs from landings of LLS of Italy in GSA 18 are missing for 2002-2003 and 2006.

LFDs from landings of OTB of Italy in GSA 18 are missing from 2004 to 2008. LFDs from discards of Italy in GSA 18 are available only for OTB and LLS from 2009 to 2021. LFDs from discards of LLS of Italy in GSA 18 are missing for 2009-2011, 2013 and 2015-2021. There is no LFDs data in 2019 and 2020 in the last EU DCF official Data Call (2022); however, this is due to some misreporting since the data has been collected and available in the previous data call.

LFDs from landings of Croatia in GSA 17 are available only for OTB, LLS and GNS from 2013 to 2021. LFDs from landings of LLS of Croatia in GSA 17 are missing for 2013. LFDs from discards of Croatia in GSA 17 are available only for OTB from 2013 to 2021.

LFDs from landings and discards of Slovenia in GSA 17 needs to be thoroughly checked because they are deemed not reliable.

6.2 SOLE IN GSA 17

6.2.1 STOCK IDENTITY AND BIOLOGY

The common sole (*Solea solea*, Linnaeus, 1758; Figure 6.2.1.1) is a demersal species, particularly abundant on relatively low depth (< 150 meters) sandy and muddy bottoms in the Mediterranean Sea and north-eastern Atlantic (Quéro et al., 1986). Sole feed primarily during night period, remaining buried in the seabed during the day. Juveniles feed preferably on small polychaetes, amphipods, and bivalves, while adult large on bigger polychaetes and holoturians (Beyst et al., 1999; Grati et al., 2013).

Tagging experiments using the traditional mark-and-recapture procedure showed that all of the soles caught inside the northern Adriatic Sea were recaptured in the sub-basin (Pagotto et al., 1979). However, based on the mitochondrial DNA variation, Guarniero et al. (2002) and Sabatini et al. (2018) concluded that in the Adriatic Sea two near-panmictic populations of common sole exist. The first inhabits the northern-central Adriatic Sea and the western part of the southern Adriatic Sea, while the second population is located along the Albanian coasts (eastern part of the southern Adriatic Sea). The hydro-geographical features of this semi-enclosed basin might support the overall pattern of differentiation of the Adriatic common soles. The northern Adriatic Sea has a high geographical homogeneity, with a wide continental shelf and eutrophic shallow-waters. The southern Adriatic in contrast, is characterized by narrow continental shelves and a marked, steep continental slope (1200 m deep). Significant geographical barrier such as local currents, eddies and canyons (Artegiani et al., 1997), may prevent a high rate of exchange of adult spawners and the mixing of planktonic larval stages from nursery areas of adjacent basins (Magoulas et al., 1996). The official assessment of common sole has historically been carried out using only the GSA17 (Northern Adriatic Sea) as management unit since the landings of common sole in the western part of the southern Adriatic (GSA18) are negligible (Sabatini et al., 2018).

Reproduction period in the central and northern Adriatic Sea takes place in coastal areas between November and March (Piccinetti and Giovanardi, 1984) when the species reaches a size of 25 cm (L50%= 25.8 cm; MEDISEH, 2013). Hatching occurs after eight days and the larva measures 3 to 4 mm TL (Tortonese, 1975; Wagemans and Vandewalle, 2001). Eye migration starts at 7 mm TL and ends at 10-11 mm TL. Benthic life begins after seven or eight weeks (15 mm) in coastal areas, estuaries, lagoon systems and brackish waters along the Italian coast of the central and northern Adriatic Sea. The entire life cycle of sole seems to follow the general Adriatic circulation and the cyclonic gyres which in autumn, in correspondence to the spawning season of this species, occur in the northern and central Adriatic (Russo and Artegiani, 1996). In confirmation of this, data on the spatial distribution reveals distribution is a function of age with a progressive spawners migration from coastal waters, which is a shallow water area characterized by a high concentration of nutrients, to deeper ones outside the western coast of Istria (Scarcella et al., 2014).

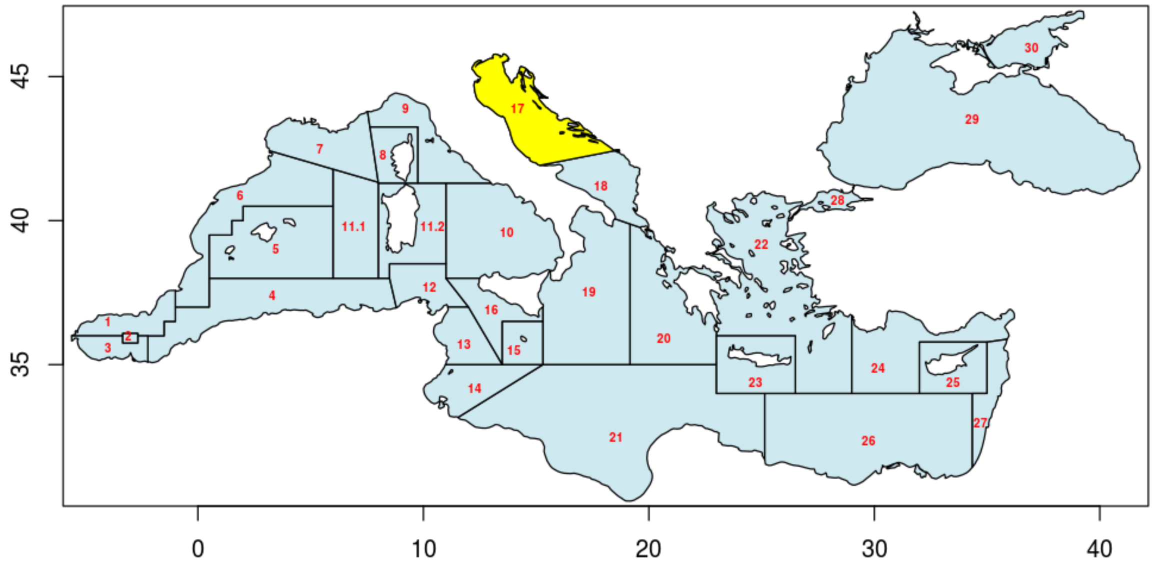


Figure 6.2.1.1 Common sole in GSA 17. Geographical location of GSA 17

Different studies revealed a great variability in the growth rate: some specimens had grown 2 cm in one month, while others, of the same age group, needed a whole year (Piccinetti and Giovanardi, 1984).

Von Bertalanffy growth equation parameters have been calculated using various methods. In 2009, within the framework of SoleMon project, growth parameters of sole were estimated through the length-frequency distributions obtained from surveys (Fabi et. al 2009). Subsequently, with the availability of the otoliths reading, new age-based studies were conducted both on commercial and survey data and catch at age data series were provided by official statistics within Data Collection Framework. However, in 2018, catch at age data were no longer considered reliable by the EWG 18-16 (STECF 2018) due to internal inconsistencies and communications from Italian and Croatian experts that otoliths reading are being recalibrated. Due to these problems related to otoliths reading, 2018 WGSAD stock assessment of common sole in GSA 17 was not performed. To overcome the problems in the age data, the stock assessment experts planned the move toward a length based instead of age based approach. This approach needed a good estimation of the von Bertalanffy parameters in general and overall a good estimation of the L∞. In this context, the new FAO "Handbook on fish age determination" (Carbonara & Follesa 2019) recommends, for bigger specimens of sole (greater than TL 28-30 cm) and for all samples for which the age determination is doubtful, a more suitable and precise otoliths reading method consisting in the sectioning of the transverse section of the otolith (Arneri, Colella and Giannetti 2001; Easey and Miller 2008; Mahè et al. 2012). Within AdriaMed - FAO regional project, a Study Group on intercalibration of fish otolith reading (SG-OTH-SOLEA) was established. After a process began in 2019, consisting in several otolith exchange (whole otolith exchange, thin section exchange), a set of agreed modal age data were available to derive a Von Bertalanffy growth curve to be used in this assessment. In particular, if the modal age of the same otolith was different for the two preparation methods (whole vs thin section), the thin section reading was used. Further data, coming from back-calculation process and from SOLEMON survey age data (group 0 and > 4 year) were used to complete the set.

The Von Bertalanffy growth parameters (Table 6.2.1.1; Figure 6.2.1.2) were estimated applying the non-linear least square algorithm on the age readings collected in GSA 17 above described.

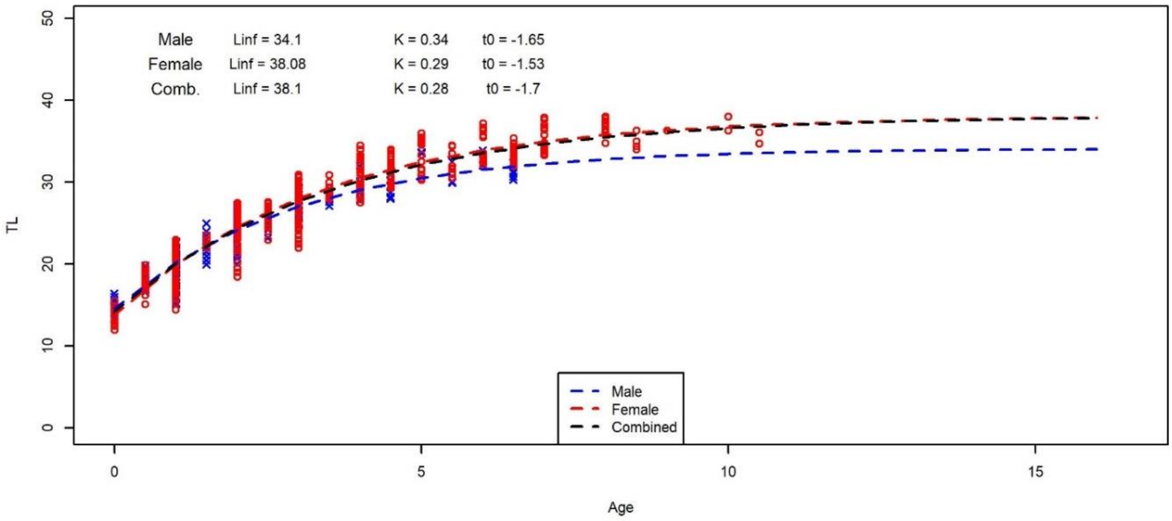


Figure 6.2.1.2. Common sole in GSA 17: Von Bertalanffy growth curve (by sex and combined) coming from AdriaMed SG-OTH-SOLEA and related growth parameters.

Table 6.2.1.1 Common sole in GSA 17: Growth parameters estimated from otolith readings in GSA 17.

	Males	**Females**	**Combine**
L_∞	34.1	38.08	38.1
k	0.34	0.29	0.28
t_0	-1.65	-1.53	-1.7

Information on the length-weight relationships used in GFCM benchmark assessment (FAO-GFCM 2021) session are available from 2005 onward from survey data (Table 6.2.1.2).

Table 6.2.1.2. Common sole in GSA 17: Length-weight relationship parameters.

Source	**Area**	**Time range**	**a**	**b**	**Sample size**	**Size range**
SoleMon	GSA 17	2005–2020	0.0046	3.110	18 860	10–39 cm

The male-female ratio is approximately 1:1 (Piccinetti and Giovanardi, 1984; Fabi *et al*., 2009). Length at first maturity (L50%) is 25.8 cm (MEDISEH, 2013); this value has been estimated using data from the SoleMon project. Females weighing 300 g have about 150 000 eggs, while those weighting 400 g have about 250 000 eggs (Piccinetti and Giovanardi, 1984).

The natural mortality rate (M) of fish populations is one of the most important parameters for population dynamics and stock assessment models. Unfortunately, it is also one of the most difficult parameters to estimate. For this reason, a pool of methodologies has been considered. The Barefoot Ecologist's Toolbox (*http://barefootecologist.com.au/shiny_m*) has been used to derive different values of M (single M value or vector by age). This Toolbox, developed by Jason Cope, provides a straightforward method for obtaining the estimated value of M from a range of life-history based methods. In Table 6.2.1.3 and Figure 6.2.1.3 a summary of the input and output of all methods considered in the Toolbox divided by different input requirements (Input Categories). The VB parameters were taken from analyses above reported in table 6.2.1.1.

Table 6.2.1.3. Common sole in GSA 17: Natural mortality from a range of life-history based methods.

	Methods	**Input Categories**	**Value**	**Reference**
Vector by age	Gislason	Linf, k, length	see Figure 2.6.5.1.	*Gislason et al., 2010*
	Chen-Wat	Age, k, t0	see Figure 2.6.5.1.	*Chen and Watanabe, 1989*
Single M value	Then_nls	maximum age	0.41	*Then et al., 2015*
	Then_lm	maximum age	0.36	*Then et al., 2015*
	Hamel_Amax	maximum age	0.36	*Hamel (in press)*
	Then_VBGF	Linf, k	0.51	*Then et al., 2015*
	Jensen_VBGF 1	k	0.45	*Jensen, 1997*
	Jensen_VBGF 2	k	0.48	*Jensen, 1997*
	Roff	k, age at maturity	1.10	*Roff, 1984*
	Jensen_Amat	age at maturity	0.83	*Jensen, 1996*
	Ri_Ef_Amat	age at maturity	0.76	*Rikhter and Efanov, 1976*
	Lorenzen	wet weight	0.47	*Lorenzen, 1996*

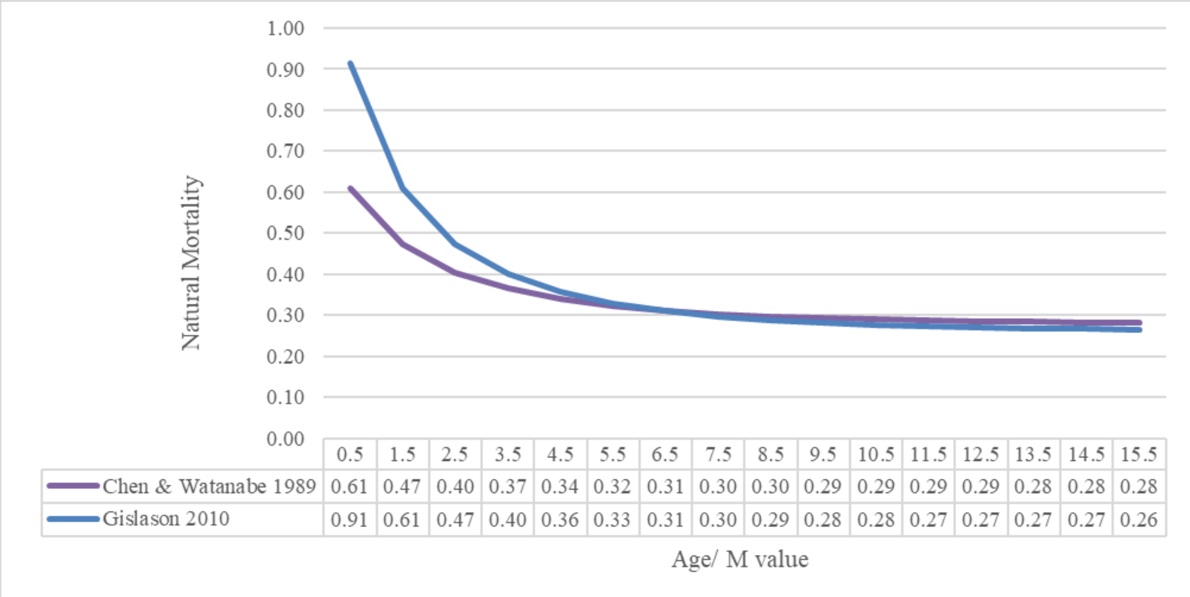


Figure 6.2.1.3. Common sole in GSA 17: Natural mortality vectors by age.

6.2.2 DATA

6.2.2.1 CATCH (LANDINGS AND DISCARDS)

The common sole is a very important commercial species in the central and northern Adriatic Sea (Vallisneri et al., 2000; Grati et al., 2013), where the stock is shared among Italy, Slovenia and Croatia, representing about 2000 tons and more than 20 million of euros in terms of landing value (FAO-GFCM, 2021). Sole has been included in the European Commission Data Collection Framework in the GSA 17 since 2004 (DCF; EU Regulation 2017/1004). Common sole official landings data updated to 2021 from the framework of Croatian, Italian and Slovenian Official Data Collection are showed in Table 6.2.2.1.1. Catch from Slovenia are negligible, therefore Slovenian netters are not counted in the SS3 assessment. Italian rapido trawl fleets (TBB) has become dominant in the Italian catches since 2014, while Italian gill netters (GNS) has been decreasing total catches since the same period and Italian otter trawlers (OTB) catches are increasing slightly since 2015. Croatian total catches for trammel netters (GTR) are reported only since 2012 and are stable across years while rampon fishery (DRB) started as new fishery in recent years (~ 2012) and it is constantly increasing. In 2021, 60% of the catches is provided by Italian TBB, 19% from the Italian, Slovenian and Croatian netters (GNS and GTR) operating mostly within 3 nautical miles from the coast, 18% from the Italian OTB, and the remaining 3% from the Croatian DRB.

Table 6.2.2.1.1 Common sole in GSA 17: Catch data included in the DCF database.

Year	ITA Nets	ITA TBB	ITA OTB	HRV GTR	HRV DRB	SVN GNS*	SVN GTR*	SVN OTB*
2004	463.1	398.7	453.7	-	-	-	-	-
2005	700.2	373.1	558.8	-	-	0.9	5.1	0.2
2006	769.1	863.1	248.0	-	-	1.3	3.9	0.2
2007	520.5	691.6	226.1	-	-	1.9	6.4	0.2
2008	454.9	576.1	199.3	-	-	1.3	5.2	0.3
2009	573.7	849.5	284.1	-	-	1.0	9.0	0.2
2010	577.2	664.6	236.2	-	-	0.7	7.1	0.2
2011	732.4	414.1	224.3	-	-	0.6	12.0	0.3
2012	857.3	639.8	266.3	127.1	9.6	0.7	7.3	0.1
2013	291.2	545.2	241.8	182.6	21.5	1.6	12.2	0.5
2014	642.2	1059.9	283.3	121.6	29.9	1.1	12.4	0.4
2015	479.1	1177.5	293.4	171.2	49.2	1.3	11.2	0.0
2016	429.5	1026.5	503.9	105.8	44.7	1.3	9.4	0.1
2017	496.3	1273.6	337.6	152.8	44.9	2.1	10.8	0.1
2018	270.6	1094.0	392.8	139.8	38.3	0.8	8.9	0.2
2019	291.8	1093.4	381.2	124.7	41.9	0.7	10.4	0.3
2020	191.5	795.1	276.8	144.0	47.8	0.3	7.5	0.7
2021	208.7	951.6	290.0	89.8	43.3	0.2	4.8	0.2

* Slovenian (SVN) fleets not included in the assessment

Moreover, the inclusion of historical information in stock assessments can revealed larger declines compared to those detected with short-term observations alone (Rosenberg et al., 2005; Fortibuoni et al., 2017). In the context of complex statistical age-structured models, historical data are fundamental in the calculation of reference points as they provide quantitative information used by the model to better estimate the initial exploitation condition of the stock (e.g. initial catch used to estimate initial fishing mortality). For this reason, the further historical data goes back in time to provide the general picture of what the conditions of the stock were like at the beginning of the evolution/expansion of fisheries in the study area, the more robust the assessment and the consequent scientific advice will be. In Italy, centralized reporting on landings of marine fisheries started in 1947 by the Italian National Institute of Statistics (ISTAT). However, it is only since 1953 that landings are reported at the species level (Fortibuoni et al., 2017).

A complete overlook on landings data used in SS3 assessment for common sole are presented in Figure 6.2.2.1.1 with the relative sources and time line of relevant management events for sole fishery. Relevant events are shown to provides the context to better understand the evolution of catches in conjunction with the evolution and implementation of the management regulations that led to the nowadays situation.

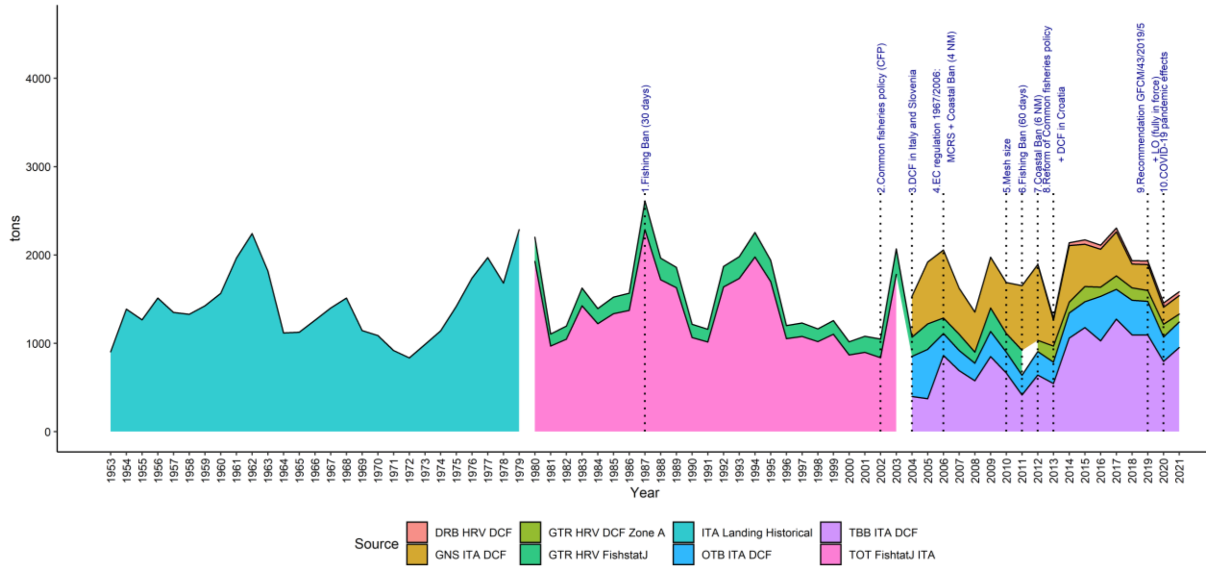


Figure 6.2.2.1.1 common sole in GSA 17: Time series of landings with relevant management events. OTB: bottom otter trawl, GNS: gillnets, GTR: trammel nets; TBB: modified beam trawl (rapido trawl); DRB: modified beam trawl for shellfish (rampon).

Below is a detailed description of the management event timeline shown in the plot.

1. 1987 - Fishing Ban (30 days): start of the summer fishing ban for trawlers, with a duration of 30 days;

2. 2002 - CFP + 8 weeks of technical measures: Council Regulation (EC) No 2371/2002 (4) established a revised Community system for the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy (CFP). This law implies the introduction of technical measures such as reduction of fishing days during the first 8 weeks after the summer fishing ban;

3. 2004 - ITA_SVN_DCF start: Italian and Slovenian fishery dependent data collected according to the European schema, potentially affecting the coherence with the methodology in use prior to this year. European Commission Data Collection Framework (DCF; EU Regulation 2017/1004);

4. 2006 - MCRS + Coastal Ban (4 NM): (1) Minimum landing sizes (MCRS) adopted: Codend mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a codend with 40 mm (stretched) square meshes or a codend with 50 mm (stretched) diamond meshes, in addition Set net minimum mesh size: 16 mm stretched and Set net maximum length x vessel x day: 5,000 m; (2) Coastal Ban (4NM): in the period following the fishing ban are adopted further technical measures, for a duration of ten weeks, indicating that trawlers may not fish within 4 nautical miles from the coast;

5. 2010 - Mesh size: enforcement of regulations (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts;

6. 2011 - Fishing Ban (60 days): summer fishing ban for trawlers extended to 60 days. National regulations based on EC 2006;

7. 2012 - Coastal Ban (6 NM) + 10 weeks of technical measures + fishing ban reduced to 45 days: in the period following the fishing ban are adopted further technical measures, for a duration of ten weeks, indicating that trawlers may not fish within 6 nautical miles from the coast. National regulations based on EC 2006;

8. 2013 - Reform of CFP + HRV_DCF start: (1) The current CFP is adopted in December 2013, becoming applicable as of 1 January 2014. It focuses on the management of fisheries (whereas earlier CFP regulations focused only on stock conservation), and it includes aquaculture. Achieving maximum sustainable yield (MSY) by 2015 where possible, and at the latest by 2020, and having healthy fish stocks form the guiding principles of the 2013 CFP. Based on scientific advice, fishing must be adjusted to bring exploitation to the levels that maximize yields within the boundaries of sustainability; (2) Croatian fishery dependent data collected according to the European schema starts;

9. 2019 - GFCM/43/2019/5 + LO: (1) GFCM/43/2019/5: A five-year fishing effort regime shall be established for 2022–2026: each year, on the basis of SAC advice, the GFCM shall establish yearly effort quotas, thus contributing to reaching F_{MSY} and staying within safe biological limits. In 2020 and 2021, a transitional fishing effort regime shall be established: at least 12% reduction for OTB and 16 % for TBB with respect to the annual effort exerted in 2015 or to the three-year average within the 2015–2018 period. The provisions shall not apply to national fleets operating with OTB and fishing for less than 1 000 days during the reference period; (2) Landing Obligation (LO). Enforcement of the EU law limiting the discards at sea of target species.

10. 2020 - COVID-19 pandemic effects (data from Scarcella et al., 2022): effort reduction imposed by pandemic-related restrictions added up to the effort regime by the GFCM/43/2019/5 management plan. Rapido trawlers was the most affected gear, showing reduced amount of activity over the entire year: hours at sea -23.5 %, fishing hours -18.7%, fishing days -25.4% compare to 2019.

To derive the landings by gear in the past useful for stock assessment, Italian total landings from 1953 to 2003 (from Fortibuoni et al., 2017 and FAO-FishStatJ source) have been divided into fleet thanks to the proportion (average ratio along the years) observed in DCF data before COVID-19 pandemic effects (2004-2019). This was the procedure:

Starting data: ITA DCF official landings data (2004 – 2019)

OTB reconstruction: $\frac{OTB}{TOT\ ITA}$ calculated between 2004-2019 (~ 0.19) and applied backward

TBB reconstruction: $\frac{TBB}{TOT\ ITA}$ calculated between 2004-2019 (~ 0.47) and applied backward

GNS reconstruction: $\frac{GNS}{TOT\ ITA}$ calculated between 2004-2019 (~ 0.33) and applied backward

There is some evidence in Chioggia fish market database that *rapido* fishery started in the ’70s and not in the ‘50s (UNIPD, 2020). Nevertheless, before ’70s common sole was fished with a specific gear called *sfogliara*, considered by the experts of the area to be a very similar and comparable fishing method to modern *rapido* fishery.

In Croatia *S. solea* is usually caught only in some area, but in national statistics it is declared together with all other flat fishes. The main area of *S. solea* distribution is the Zone A (Northern Adriatic - western Istrian coast). In other parts of Adriatic there is some amount of the catch, but mostly it refers to other *Solea* species (*S. kleini* or *S. lascaris*). To solve this discrepancy also in historical data coming from FishtatJ, a ratio between Zone A catch and total DCF HRV catch has been used as follow:

Starting data: HRV DCF official landings data (2012 – 2019) + HRV Zone A landings data

Zone A reconstruction: $\frac{GTR\ Zone\ A}{TOT\ HRV\ Solea\ spp}$ calculated between 2012-2019 (~ 0.88) and applied backward to FistatJ HRV data

The information on total landings of *Solea* spp. is available through the FAO database since 1980. However, data prior to 1980 are lacking. During the benchmark session in 2021, a historical time series of Croatian catches reconstructed by Matić-Skoko et al. 2014 were considered, but these were not used due to probable overestimate and large discrepancy with official national statistics (78% higher). The group also debated on the use of a fixed landing amount for the period from 1953 to 1980 (150 tons), but this was also considered as inappropriate. In the end, assuming the proportionality between Italian and Croatian catches due to the exploitation of the same stock, it was agreed to use reconstructed landings by calculating a ratio between ITA and HRV in the first 10 years of FishtatJ data (~ 0.14) and applied backwards up to 1953. In conclusion, Figure 6.2.2.1.2 and Table 6.2.2.1.2 show the final time series from 1953 to 2021 used in the assessments (landing by fleet for integrated model).

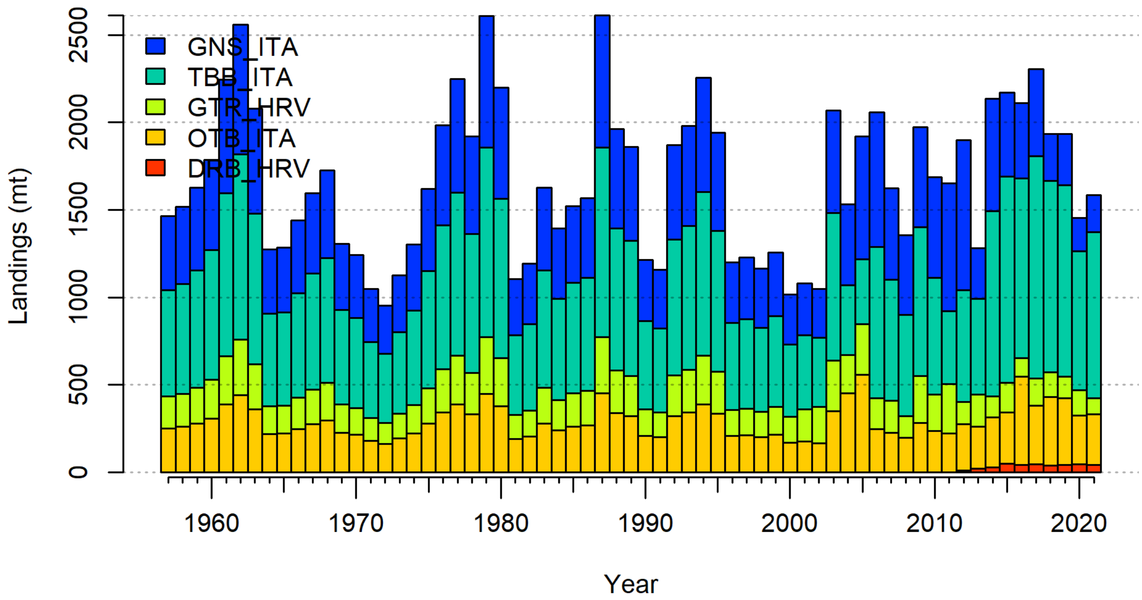


Figure 6.2.2.1.2. Common sole in GSA 17: Landings reconstruction by gear and country used as input data in the assessment models.

Table 6.2.2.1.2 Common sole in GSA 17: Landings reconstruction by gear and country used as input data in the assessment models.

Year	ITA Nets	ITA TBB	ITA OTB	HRV GTR	HRV DRB
1953	298.3	427.3	178.1	128.0	-
1954	457.6	655.4	273.2	196.2	-
1955	417.8	598.4	249.4	179.2	-
1956	499.4	715.2	298.1	214.2	-
1957	445.3	637.8	265.9	191.0	-
1958	438.7	628.3	261.9	188.1	-
1959	470.2	673.5	280.7	201.7	-
1960	516.6	739.9	308.4	221.6	-
1961	648.7	929.0	387.2	278.2	-
1962	740.2	1060.1	441.9	317.5	-
1963	601.1	860.9	358.9	257.8	-
1964	369.0	528.5	220.3	158.3	-
1965	371.5	532.1	221.8	159.3	-
1966	416.5	596.5	248.6	178.6	-
1967	461.9	661.5	275.7	198.1	-
1968	499.0	714.7	297.9	214.0	-
1969	377.8	541.1	225.5	162.0	-
1970	359.4	514.8	214.6	154.1	-
1971	303.0	434.0	180.9	129.9	-
1972	275.9	395.1	164.7	118.3	-
1973	326.2	467.1	194.7	139.9	-
1974	376.4	539.0	224.7	161.4	-
1975	468.4	670.9	279.6	200.9	-
1976	574.1	822.2	342.7	246.2	-
1977	650.7	931.9	388.4	279.1	-
1978	554.9	794.8	331.3	238.0	-
1979	754.6	1080.8	450.5	323.7	-
1980	636.1	911.1	379.8	272.7	-
1981	319.6	457.7	190.8	137.2	-
1982	345.3	494.6	206.1	147.8	-
1983	470.1	673.3	280.6	201.8	-
1984	403.1	577.3	240.6	172.6	-
1985	440.4	630.7	262.9	188.6	-
1986	452.9	648.7	270.4	194.8	-
1987	755.0	1081.3	450.7	324.0	-
1988	567.8	813.2	339.0	243.5	-
1989	537.8	770.2	321.0	231.1	-
1990	351.6	503.5	209.9	150.5	-
1991	335.1	479.9	200.0	143.4	-
1992	540.7	774.5	322.8	231.9	-
1993	572.8	820.3	341.9	246.1	-

1994	652.3	934.3	389.4	279.7	-
1995	560.9	803.3	334.8	240.8	-
1996	347.3	497.4	207.3	148.7	-
1997	355.9	509.7	212.4	152.3	-
1998	336.7	482.3	201.0	144.3	-
1999	363.8	521.0	217.2	155.8	-
2000	286.5	410.4	171.1	148.7	-
2001	296.4	424.6	177.0	182.4	-
2002	276.3	395.7	165.0	210.7	-
2003	587.6	841.6	350.8	289.5	-
2004	463.1	398.7	453.7	217.8	-
2005	700.2	373.1	558.8	287.7	-
2006	769.1	863.1	248.0	176.2	-
2007	520.5	691.6	226.1	185.0	-
2008	454.9	576.1	199.3	123.9	-
2009	573.7	849.5	284.1	266.5	-
2010	577.2	664.6	236.2	210.7	-
2011	732.4	414.1	224.3	281.5	-
2012	857.3	639.8	266.3	127.1	9.6
2013	291.2	545.2	241.8	182.6	21.5
2014	642.2	1059.9	283.3	121.6	29.9
2015	479.1	1177.5	293.4	171.2	49.2
2016	429.5	1026.5	503.9	105.8	44.7
2017	496.3	1273.6	337.6	152.8	44.9
2018	270.6	1094.0	392.8	139.8	38.3
2019	291.8	1093.4	381.2	124.7	41.9
2020	191.5	795.1	276.8	144.0	47.8
2021	208.7	951.6	290.0	89.8	43.3

Italian catches are dominated by smaller individuals mainly caught by TBB and OTB, a smaller proportion of individuals is caught by GNS. On the contrary Croatian catches are dominated by bigger individuals caught by GTR (Figure 6.2.2.1.3). This agrees with the spatial distribution of common sole in the Adriatic Sea which is characterized by a migration of part of the adults from the west coast (nursery areas) to the east coast (spawning areas) (Fabi et al., 2009; Scarcella et al., 2014).

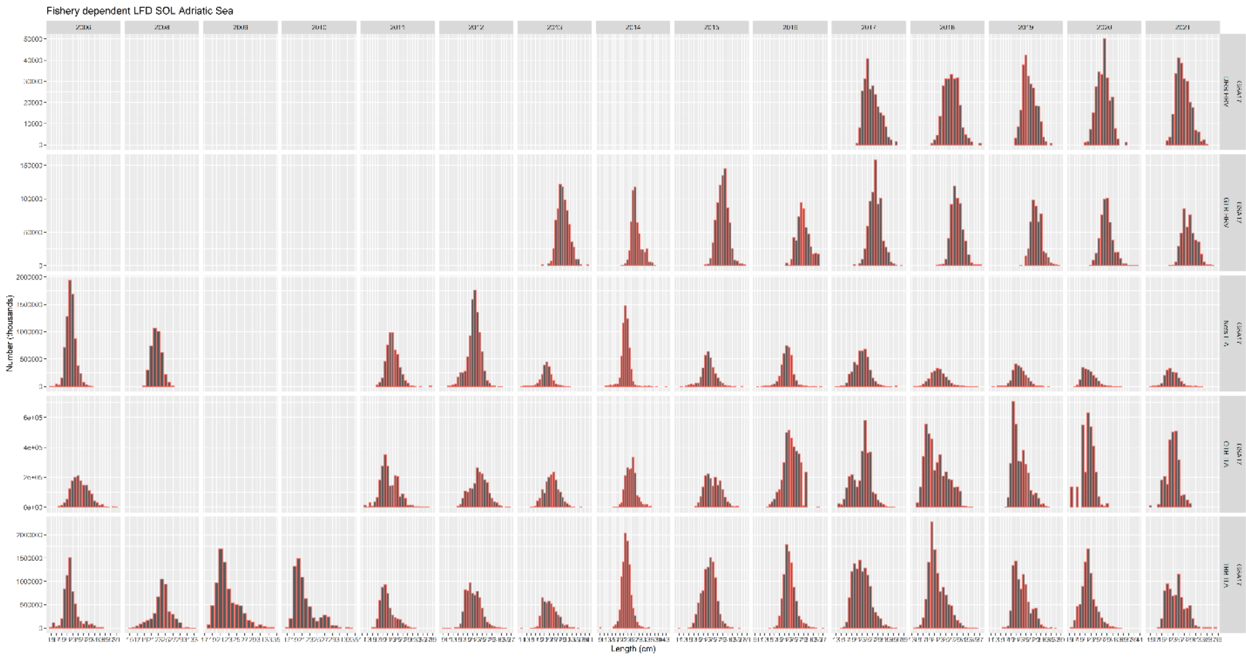


Figure 6.2.2.1.3. Common sole in GSA 17: Length Frequency Distribution of catches from 2006 to 2021.

6.2.2.2 EFFORT

Common sole is one of the main species for the Adriatic fishing fleet. Specifically, it is a target species for the *rapido* beam trawl fishery and to a lesser extent for the bottom trawl and net fisheries. Tables 6.2.2.2.1-3 report the fishing days by country, year, gear and vessel length.

Table 6.2.2.2.1. Common sole in GSA 17: Effort in term as fishing days for Italy (ITA) in GSA17 for *rapido* trawl (TBB), otter trawl (OTB) and nets (GTR & GNS) by vessel length (VL).

Sum of fishing days - ITA17 TBB						
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440	Total
2004			2693	9715	2894	15302.1
2005			1293	8136	2288	11717.3
2006		95	1911	10267	3151	15423.8
2007			4080	12611	3585	20275.8
2008			2460	5420	5514	13393.7
2009		429	3201	4869	5150	13649.4
2010		382	2769	4400	4840	12391.5
2011		437	920	3927	3475	8759.2
2012			2043	4626	3631	10300.7
2013			1761	4299	1912	7972.0
2014			2365	6041	2407	10814.2

2015		296	1822	6170	1650	9937.2
2016			1986	5122	1897	9004.4
2017		328	1297	5653	2074	9351.8
2018		668	2600	4118	4463	11848.3
2019		123	2183	3761	4921	10988.8
2020		321	1508	2869	2904	7602.0
2021		220	907	3188	3438	7753.0
Sum of fishing days - ITA17 OTB						
2004		35665	52605	34338	10422	133029.9
2005		10053	62455	36578	12588	121674.2
2006	61	8067	56604	29437	9888	104055.5
2007		6724	47688	30438	8945	93794.9
2008		5525	44720	27977	8480	86701.1
2009		7635	47220	28571	7618	91043.8
2010		5952	41995	27106	7909	82962.5
2011		5999	40792	26424	6971	80186.8
2012		6048	34301	25466	4788	70603.1
2013		6351	33282	22579	4081	66293.0
2014		6220	33052	21194	6027	66492.4
2015		2271	29582	25022	4422	61296.9
2016		2758	29701	24561	4844	61864.8
2017		6339	30074	30350	5616	72378.5
2018		4951	34671	30788	5524	75933.7
2019		3281	31403	24641	6585	65911.3
2020		1332	27162	22414	5641	56549.0
2021		1039	29153	24024	5943	60159.0
Sum of fishing days - ITA17 GTR						
2004		22993	274			23267.75
2005		20019	569			20587.62
2006	1216	17271				18486.61
2007	620	21221				21841.46
2008	430	15476				15906.07
2009	2042	17780	29			19850.54
2010	1305	20076				21380.71
2011	3991	17623	360			21973.77
2012	2836	20768				23603.96
2013	2145	17195	464			19804
2014	4420	9249				13669.66
2015	4824	14435				19258.68
2016	5269	18918				24187.65
2017	6325	15077	1235			22637.47
2018	14906	20089	1635	2		36632.06

2019	11407	19449	2141			32996.54
2020	10264	13004	1061	73		24402
2021	10830	13625	757			25212
Sum of fishing days - ITA17 GNS						
2004		85160	549			85708.55
2005		121935	341		97	122372.8
2006	51493	55879	118			107490.1
2007	41839	46982				88820.38
2008	37164	48680				85843.91
2009	55998	47019	989			104006.5
2010	53083	44624	1558			99264.74
2011	56574	59096	1856			117525.7
2012	42848	64212	68			107128.7
2013	26448	36178	640			63266
2014	34244	42777	978			77999.65
2015	18735	37279	1243			57256.62
2016	16576	44919	490			61986.01
2017	16260	26599	816			43674.47
2018	14659	27137	1173	110	2	43081.34
2019	14217	29320	2022	72		45630.9
2020	12352	22362	986			35700
2021	14943	22784	971	91		38789

Table 6.2.2.2.2. Common sole in GSA 17: Effort in term as fishing days for Croatia (HRV) in GSA17 for gill net (GTR) and *rampon* trawl (DRB) by vessel length (VL).

Sum of fishing days - HRV17 GTR						
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440	Total
2012	5873	20483	995		12.4	27363
2013	5492	20937	742	4		27175
2014	5218	18933	587			24738
2015	4784	20389	874			26047
2016	4551	17911	541			23003
2017	4314	18056	777			23147
2018	5510	19913	850			26273
2019	6918	21441	990			29349
2020	7510	25464	1220			34194
2021	8649	23715	834			33198
Sum of fishing days - HRV17 DRB						
2012		962	920	2		1883

2013	1	1197	1498	158	3	2857
2014	1	1497	2154	174	1	3827
2015	1	1735	3340	152		5228
2016		1605	3268	154	50	5077
2017		1351	2970	119	22	4462
2018		1423	2189	12		3624
2019		1163	1676		95	2934
2020		1059	1704		15	2778
2021		1109	1770			2879

Table 6.2.2.2.3. Common sole in GSA 17: Effort in term as fishing days for Slovenia (SVN) in GSA17 for nets (GNS & GTR) and otter trawl (OTB) by vessel length (VL).

			Sum of fishing days - SVN17 OTB			
2005	4	358	469			831
2006		356	607			963
2007		343	858		1	1202
2008		316	937		1	1254
2009		229	976			1205
2010		305	958			1263
2011		270	908			1178
2012		124	793			917
2013		183	554			737
2014		183	482			665
2015		171	499			670
2016		265	512			777
2017		194	503			697
2018		201	491			692
2019		205	564			769
2020		293	586			879
2021		200	593			793
			Sum of fishing days - SVN17 GTR			
2005	636	641	36			1313
2006	674	589				1263
2007	764	1099	106			1969
2008	844	1276	64			2184
2009	868	1440	24			2332
2010	888	1428	72			2388
2011	1035	2028	17			3080
2012	1462	1533	30			3025
2013	2126	2245	511			4882
2014	2360	2949	37			5346

2015	2311	2824	95	5230
2016	1423	2568	67	4058
2017	1318	2117	18	3453
2018	1056	1986	4	3046
2019	989	1970	13	2972
2020	1079	1611	178	2868
2021	732	1282	164	2178
Sum of fishing days - SVN17 GNS				
2005	895	708	3	1606
2006	581	868	15	1464
2007	832	791	146	1769
2008	849	1092	84	2025
2009	871	979	24	1874
2010	691	1227	27	1945
2011	668	1079	56	1803
2012	1164	1521	96	2781
2013	1669	1777	36	3482
2014	1674	1870	24	3568
2015	1869	1980	44	3893
2016	1919	1914	28	3861
2017	1446	2236	45	3727
2018	1306	1713	51	3070
2019	1292	1226	76	2594
2020	1294	1058	15	2367
2021	1363	787	26	2176

6.2.2.3 SURVEY DATA

The SoleMon surveys collect distribution, relative abundance and biological data on commercial marine species in GSA 17 for use in stock assessment and fishery management. Up to now, annual rapido trawl fishing surveys were carried out in GSA 17 from 2005 to 2021: two systematic “pre-surveys” carried out with the chartered fishing vessels (years 2005 and 2006), followed by a sequence of fall surveys from 2007 to 2021 performed with CNR R/V Dallaporta (Figure 6.2.2.3.1). The surveys have a random stratified design with three depth strata (0-30 m, 30-50 m, 50-100m). Hauls were carried out during the day using 2-4 rapido trawls simultaneously; stretched codend mesh size = 40.2 ± 0.83). The following number of hauls was reported per depth stratum (Table 6.2.2.3.1). Hauls inside Croatian national waters are present in 2005 and 2006 but have been fully implemented only in 2016 and were totally performed only in some year due to different issues (mainly time coverage issue). For this reason, the 7 Croatian national waters hauls are not counted for the calculation of the abundance and biomass indices and LFDs to be used in the assessment models. In the future it is recommended to increase the coverage of survey sampling stations in the eastern part of GSA 17.

Table 6.2.2.3.1. **Common sole in GSA 17:** Number of hauls per year and depth stratum in GSA 17, 2005-2021.

Depth strata	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0-30	30	35	32	39	39	39	39	35	37	39	39	39	38	41	41	37	35
30-50	12	20	19	18	18	18	18	18	18	18	18	18	16	15	15	12	15
50-100	15	8	11	10	10	10	10	10	10	10	10	10	10	12	12	9	8
HRV	5	4	0	0	0	0	0	0	0	0	0	7	6	0	0	0	3
Total	62	67	62	67	67	67	67	63	65	67	67	74	70	68	68	58	61

Abundance and biomass indexes from rapido trawl surveys were computed using TruST software (https://www.kosmosambiente.it). The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran et al., 1954; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval:

Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, and hence makes assumptions over the distribution of data. The arithmetic mean is an unbiased estimator of the mean, but may be sensitive to changing configurations of stations in the early years and the most recent years when stations have been omitted (see below). A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modeled using the idea of conditionality and the negative binomial. Thus while the mean is unbiased the precision based on a normal distribution may not be representative. Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA.

Figure 6.2.2.3.1. **Common sole in GSA 17**. SOLEMON survey period over 2005-2021.

Survey Index reconstruction (2020-2021)

In 2020 and 2021 surveys, 10 stations in the north-east of the basin and 9 in the southern part had to be dropped respectively due to overlap issues such as COVID-19 restriction (only 5 scientific members on board), bad weather conditions and limited ship-time.

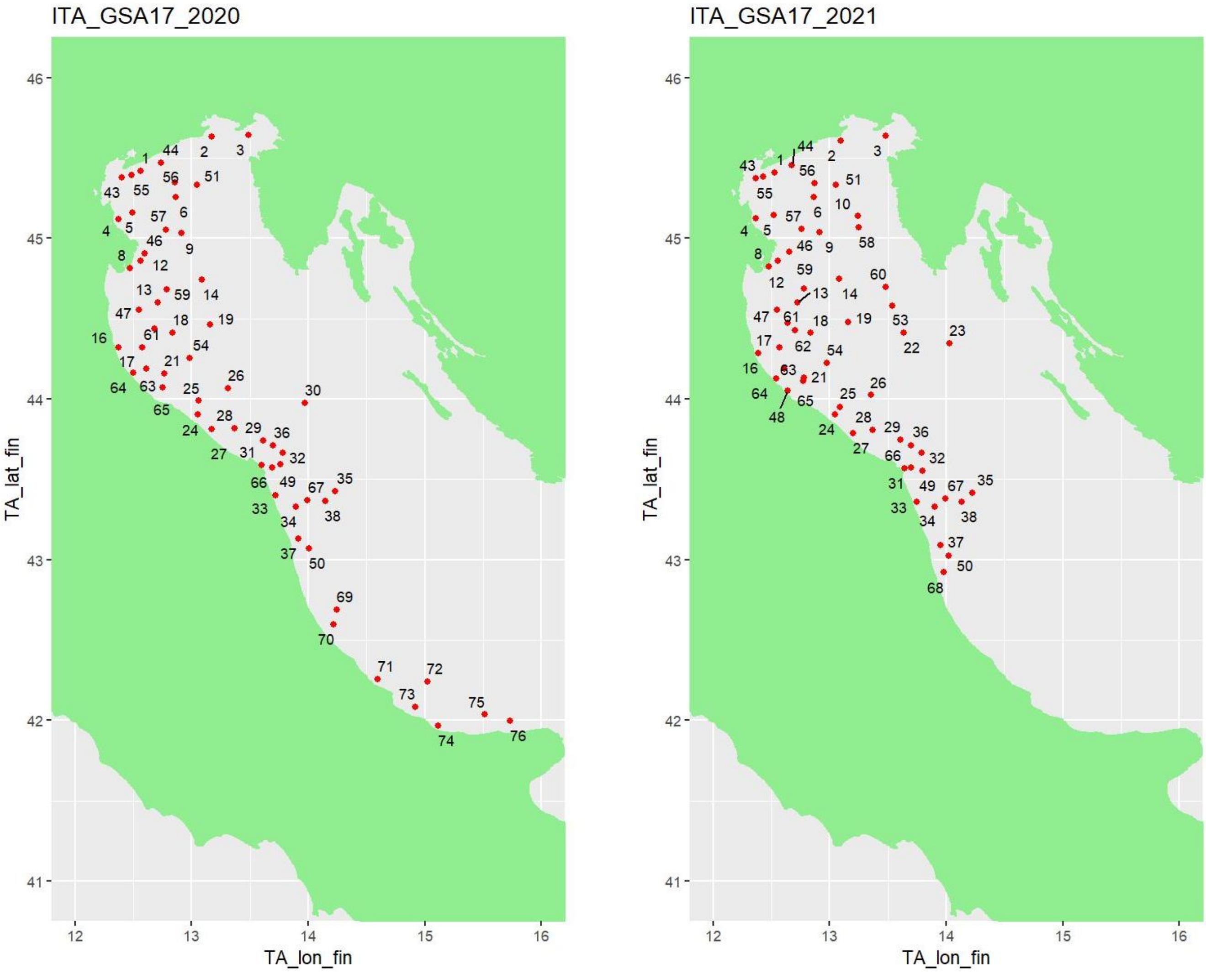
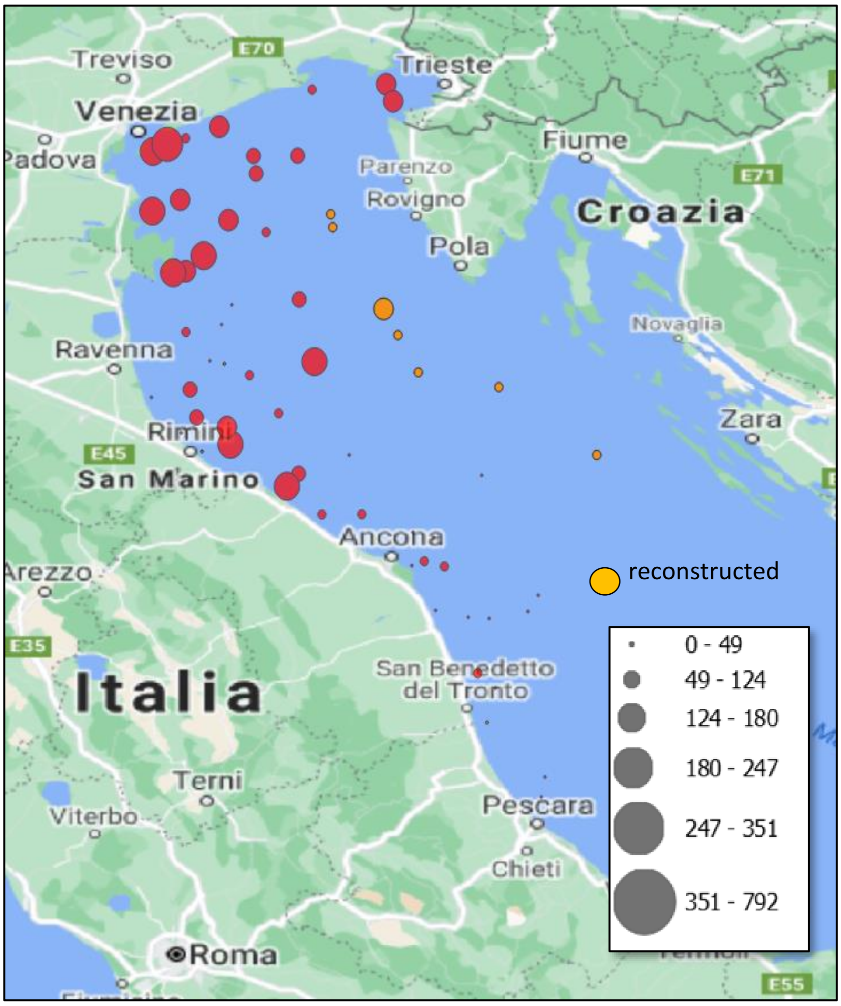


Figure 6.2.2.3.2. Common sole in GSA 17: SoleMon map of hauls positions in 2020 and 2021 survey.

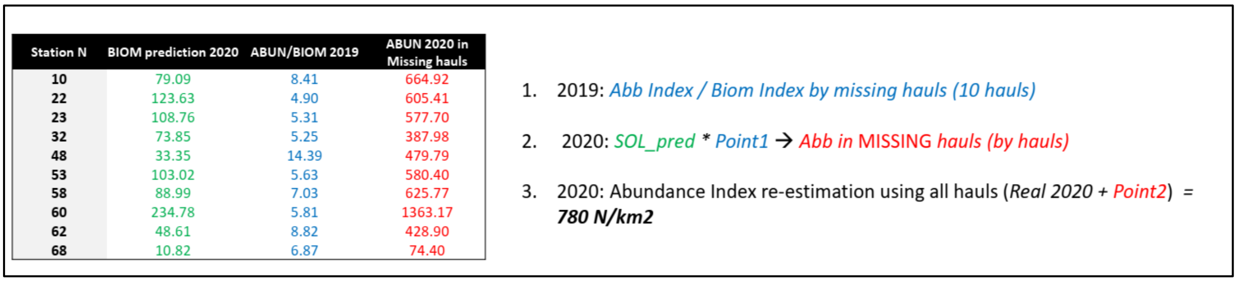
Considering that adults usually concentrate in the offshore area where in 2020 there are missing hauls (deepest waters in at South West from Istria, Figure 6.2.2.3.2. on the left), spatial coverage effect on the survey indices have to be expected for that year. In the framework of EcoScope project (https://ecoscopium.eu/), researchers from ISTI and

IRBIM CNR have developed a spatio-temporal ecological model to predict biomass in missing survey hauls (Coro et al., 2022). This model has been applied to SoleMon survey to reconstruct biomass index for target species such as Sepia officinalis, Squilla mantis, Pecten jacobeus and Solea solea (Fig. 6.2.2.3.3). During simulation testing, accuracy on known hauls over the four species ranged between 80% and 100% and true total biomass index was always included in the confidence intervals during 2019-year tests. Moreover, the model achieved higher performance than individual sub-component models (spatial, temporal, and ecological models per se) and a widely used equiproportional reconstruction (e.g. equiproportional; ICES, 2021a).

Figure 6.2.2.3.3. Common sole in GSA 17: SOLEMON 2020 biomass index with reconstructed hauls.



In particular, with the aim of obtaining an abundance index to be included in the assessment model, the missing hauls biomass index has been converted to numbers assuming the same proportion of 2019 survey (point 1,2 of Figure 6.2.2.3.4). Then, 2020 overall abundance index were re-computed as usual through stratified means (Cochran et al., 1954; Saville, 1977) using TruST software with the inclusion of the missing hauls reconstructed values (point 3 of Figure 6.2.2.3.4).



Station N	BIOM prediction 2020	ABUN/BIOM 2019	ABUN 2020 in Missing hauls
10	79.09	8.41	664.92
22	123.63	4.90	605.41
23	108.76	5.31	577.70
32	73.85	5.25	387.98
48	33.35	14.39	479.79
53	103.02	5.63	580.40
58	88.99	7.03	625.77
60	234.78	5.81	1363.17
62	48.61	8.82	428.90
68	10.82	6.87	74.40

1. 2019: *Abb Index / Biom Index by missing hauls (10 hauls)*
2. 2020: *SOL_pred* * *Point1* → *Abb in* MISSING *hauls (by hauls)*
3. 2020: Abundance Index re-estimation using all hauls (*Real 2020* + *Point2*) = ***780 N/km2***

Figure 6.2.2.3.4. Common sole in GSA 17: SOLEMON 2020 abundance index reconstruction process.

In contrast, considering that common sole has a very low presence in the southern part of the GSA17, EWG 22-16 agreed that a less time-consuming bias-adjustment approach was the most feasible option to be apply for the reconstruction of 2021 SoleMon index.

Specifically, the log-error has been calculated in for each year of the time series as follow:

$Log\text{-}error_{(y)}$ <- $\log(IndT_{(y)})$ - $\log(Ind\_cut_{(y)})$

where *IndT* is the index produce using the TruST software considering 2021 missing data hauls; *Ind_cut* is the index produce using the TruST software subtracting the 2021 missing data hauls and corresponding stratum area for each year (*y*) of the survey time series.

Finally, since $Log\text{-}error_{(y)}$ trend is stable along the whole time series (Figure 6.2.2.3.5), the exponential of the mean (0.88) was used as a correction factor to adjust the 2021 value (Figure 6.2.2.3.6 & Table 6.2.2.3.2).

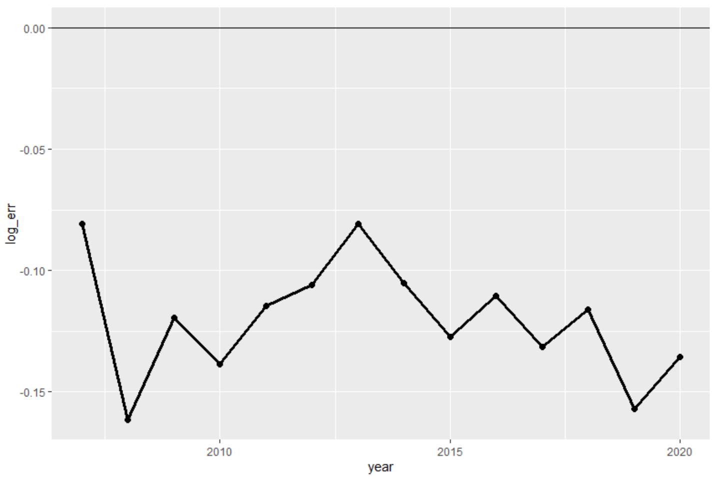


Figure 6.2.2.3.5. Common sole in GSA 17. SOLEMON log-error time series.

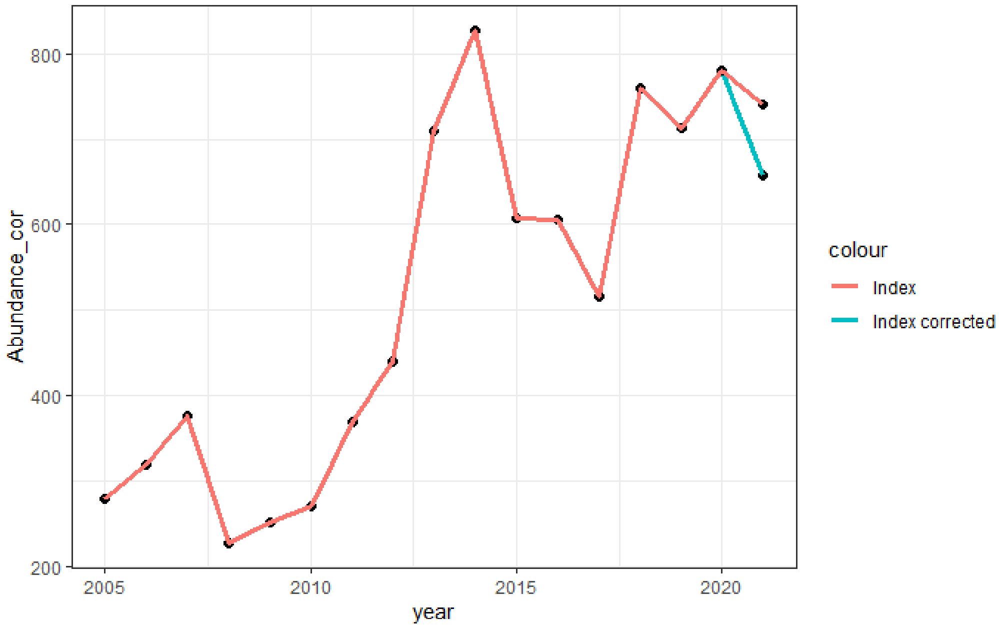


Figure 6.2.2.3.6. Common sole in GSA 17. SOLEMON abundance (n/km^2) over 2005-2021.

Table 6.2.2.3.2. Common sole in GSA 17. SOLEMON survey abundance and biomass results, 2005-2021.

Year	AbunIndex (N/km2)	AbunStDev	AbunCV
2005	279.690	52.064	18.615
2006	318.273	70.138	22.037
2007	375.709	83.197	22.144
2008	227.629	41.155	18.080
2009	251.053	65.630	26.142
2010	269.536	49.490	18.361
2011	368.667	86.260	23.398
2012	439.591	73.752	16.778
2013	709.202	117.123	16.515
2014	827.245	188.386	22.773
2015	607.379	129.269	21.283
2016	605.569	70.380	11.622
2017	515.403	75.618	14.672
2018	760.500	117.654	15.471
2019	712.534	153.911	21.601
2020	780	-	-
2021	658	-	-

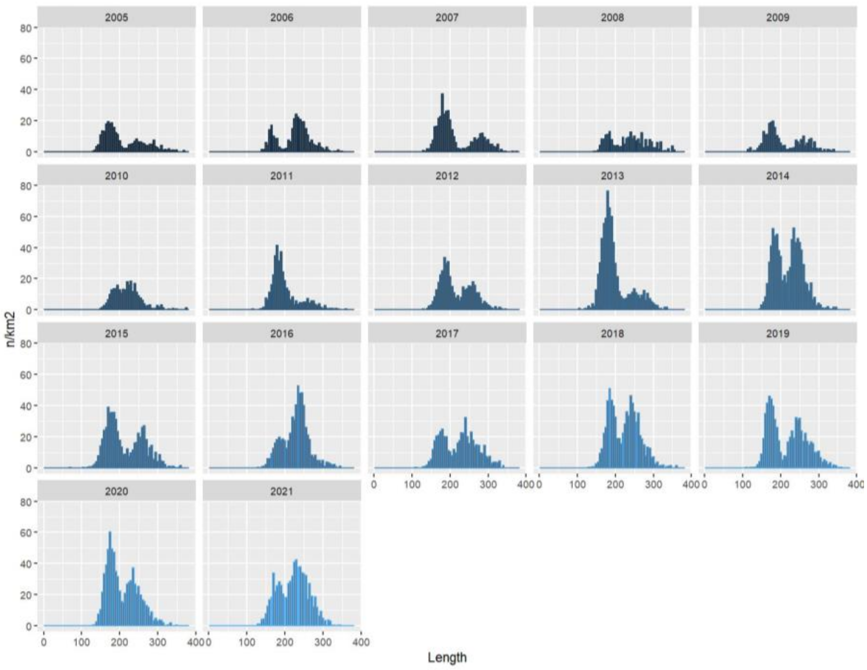


Figure 6.2.2.3.7. Common sole in GSA 17. SOLEMON Length frequency distribution (mm; n/km^2).

6.2.3 STOCK ASSESSMENT

The management advice is given using an ensemble of SS3 models since it was the approach chosen during the GFCM benchmark session of April 2021 (FAO-GFCM, 2021). All the modifications are considered minor or to be model technicalities and do not represent a deviation from the updated run of 2022 or GFCM benchmark.

Stock Synthesis (SS3)

The assessment of common sole in the Norther Adriatic Sea (GSA 17) was conducted using the Stock Synthesis (SS) model (Methot & Wetzel, 2013). Stock Synthesis is programmed in the ADMB C++ software and searches for the set of parameter values that maximizes the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian and MCMC methods. Stock Synthesis 3.3 provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. The model is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analysed. It uses forward projection of population in the "statistical catch-at-age" (SCAA) approach. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity. The total likelihood of SS model is composed of a number of components, including the fit to the survey and CPUE indices, tag recovery data (when tagging data are used), fishery length frequency data, age compositions and catch data. There are also contributions to the total likelihood from the recruitment deviates and priors on the individual model parameters (if any). SS model is configured to fit the catch almost exactly so the catch component of the likelihood is very small. In this assessment, fishing mortality was modelled using the hybrid method, which estimates the harvest rate using the Pope's approximation and then converts it to an approximation of the corresponding F (Methot & Wetzel, 2013). Option 5 was selected for the F report units. This option represents the last development of SS and corresponds to the fishing mortality requested by the ICES and GFCM framework (i.e. simple average of F of the age classes chosen to represent Fbar). Details of the formulation of the individual components of the likelihood are provided in Methot & Wetzel, 2013).

Why use an ensemble model?

Stock assessment models require a number of highly influential, yet difficult to estimate parameters, many of which are commonly fixed in age-structured assessments. In reality, the actual value of these parameters is often uncertain. Therefore, assuming a specific fixed value results in making strong assumptions about stock's resilience, productivity and associated biological reference points (Maunder et al., 2021; Winker et al., 2020). This means that stock assessors are often faced with a range of model formulations which should be scrutinized before decisions are made (Mannini et al, 2021). In this context, when discussing which could be the best model used in assessing stocks, Hilborn and Walters (1992) recalled an adage that "the truth often lies at the intersection of competing lies". This uncertainty in 'what is the best model?' necessitates a comparison of a range of alternative models. Instead of comparing multiple model outputs and selecting a single final one, an ensemble modelling approach (Dietterich, 2000) was used to present results with a quantitative criterion for weighting several model predictions. An ensemble approach better encapsulates the variability and uncertainty of model predictions because instead of choosing a single set of fixed parameter values, can explore a contrasting but plausible range of values (Dietterich, 2000; Tebaldi & Knutti, 2009). Ensemble models have been proven to be more accurate and less biased than the choice of an individual model, as they can effectively tease apart the conditions under which various model assumptions result in the most accurate predictions. This a promising approach when decisions have to be made despite the presence of multiple and potentially conflicting estimates of stock status (Anderson et al. 2017).

The objective when using an ensemble model is therefore to quantify the total uncertainty across all plausible models, where the structural uncertainty is likely to be much greater than the within model uncertainty. For example, ensembles are often helpful because modellers need not decide on dome versus asymptotic fisheries selectivity (e.g. Sampson & Scott, 2012), or whether to fix or estimate natural mortality (e.g. Johnson et al., 2015).

Input data and Parameters

Ensemble approach is capable of representing all the possible "states of nature" of the stock under analysis based on a number of sources of natural and fisheries uncertainty. For common sole in GSA17, major uncertainly was linked to alternative hypothesis of selectivity which has a large influence on the assessment. Other alternative hypothesis are based on different levels of natural mortality (M) and steepness (h). The final model grid for the ensemble included all combinations of alternative values for these three nested parameters, as listed in Table 6.2.3.1.1. A schematic graphical representation of the assessment workflow is provided in Figure 6.2.3.1.1. Its inclusion is designed to provide a guideline via which the process of ensemble model grid construction can be followed as well as the steps taken prior to its implementation.

Table 6.2.3.1.1. Parameter and levels employed in the final ensemble grid SS3 assessment.

Parameter	**Levels**	**Progressive number of runs**	**Values**
Selectivity (survey)	2	2	double normal (DN); cubic splines (CS)
Natural Mortality (*M*)	3	6	Average of Gislason & ChenWatanabe; Average of Then_nls,Then_lm,Hamel_Amax; Average of Then_VBGF, Jensen_VBGF 1, Jensen_VBGF 2
Steepness of the stock-recruitment relationship (*h*)	3	18	0.7; 0.8; 0.9

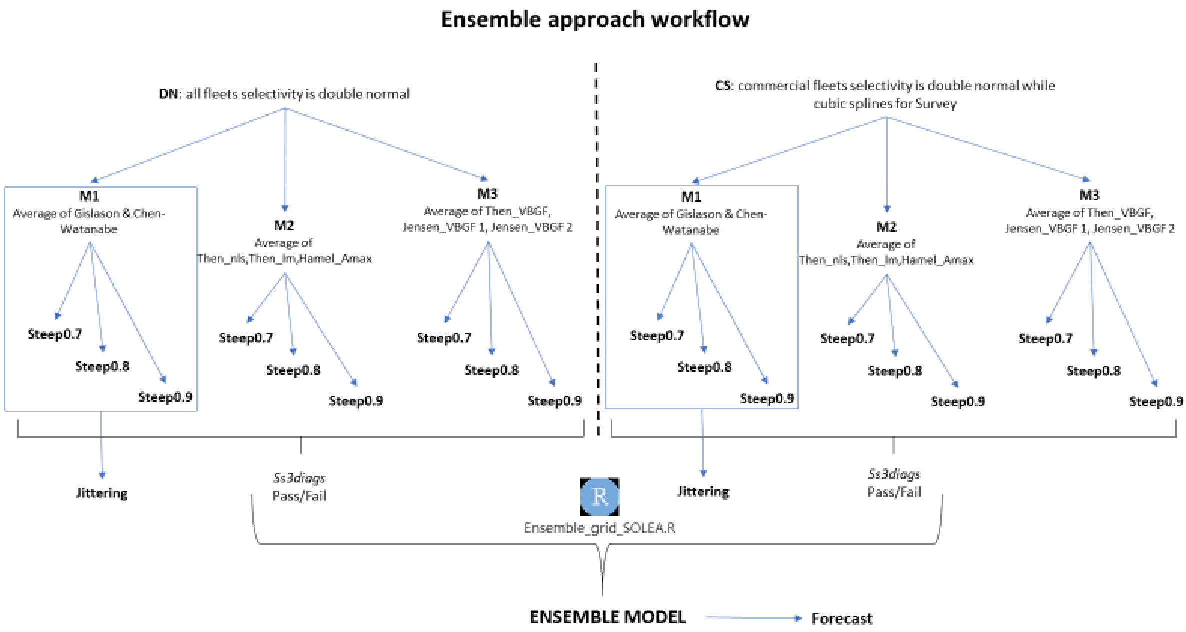


Figure 6.2.3.1.1 Common sole in GSA 17: Schematic graphical representation of the assessment workflow during common sole benchmark assessment in GSA17.

The baseline configuration of all SS model runs for Common Sole in GSA 17 are one-area yearly models where the population is comprised of 15+ age-classes with sexes combined (males and females are considered together). The final selected runs here presented are length-based models where the numbers at length in the fisheries and survey data are converted into ages using von Bertalanffy growth parameters presented in 3.6.2 chapter. The last age-class (i.e. 15+) represents a "plus group" in which mortality and other characteristics are assumed to be constant.

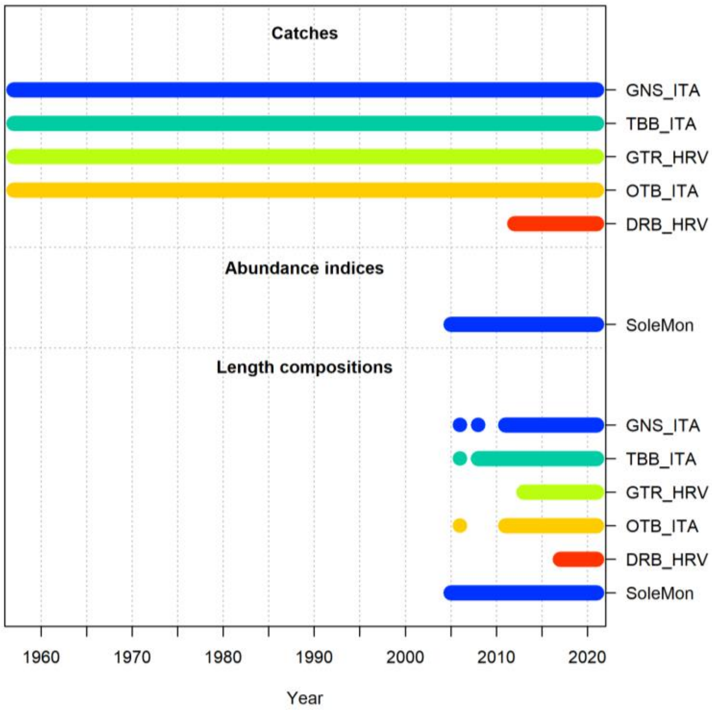
All models start in 1958 and the initial population age structure was assumed not to be in an unexploited equilibrium state, so that the initial fishing mortality was estimated for all fleets in the model. Initial catches were assumed as the average of the previous years (1953–1957; Fortibuoni e t al. 2017).

The SS3 analysis has been carried out considering the following five fleets and (Figure 6.2.3.1.2):

1. Italian netters (GNS ITA);
2. Italian rapido trawler (TBB ITA);
3. Croatian set netters (GTR HRV);
4. Italian otter trawler (OTB ITA);
5. Croatian rampon fishery (DRB HRV)

All Stock Synthesis models used in the final grid are size structure data model based on the separate fleet LFD from 2006 to 2021. Sizes are then converted to age inside the model using von Bertalanffy growth equation. Tuning data were provided by SoleMon surveys, carried out in fall for the years 2005-2021.

Figure 6.2.3.1.2. Common sole in GSA 17: Data presence by year for each fleet and data type.

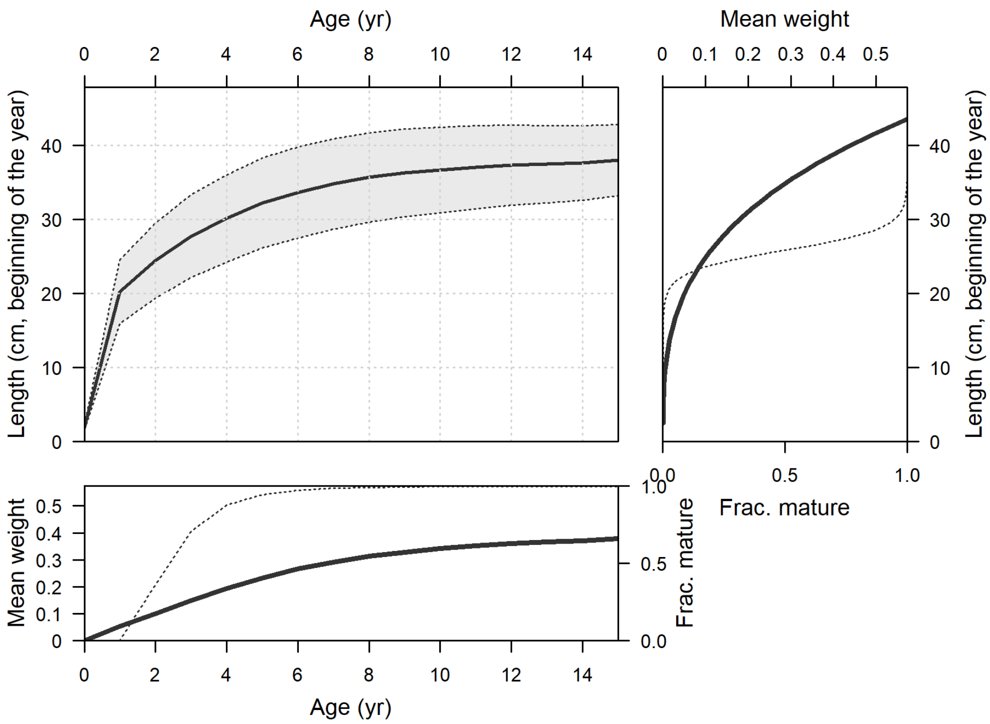


For the commercial fleets, the coefficient of variation (CV) of the catches was set to 0.1 for the historical part of the time series (until 1980), then 0.05. The CV of the initial catches of the commercial fleets was also set to 0.1. The choice for a higher CV for the historical part of the time series is due to the different sources of landings that may be affected by the underlying monitoring programs, and lead to higher catch-derived uncertainty in the past. The annual sample size associated with the LFD data is reported as the number of trips sampled for commercial catches (as reported from national sources) and the number of hauls for the surveys. CV in 2020 and 2021 reconstructed survey index has been set by default to 0.15. No weighting of the LFDs was used in the model.

Growth and maturation

The sex combined von Bertalanffy growth parameters seen in Table 6.2.1.1 has been used as input parameters in the SS3 model. The very fast growth in the first year of age does not allow to have a good estimate of *t0* using these data. True age 0 data are not available. Given the ecology of sole in the Adriatic, juveniles are widespread in coastal shallow water, lagoons or brackish waters, making impossible to capture these specimens both with commercial fishing gear or SoleMon survey. Even the smallest specimens captured during the survey are still to be considered at least 5-6 months old. This problem can be bypassed thank to the SS3 modeling platform because the SS growth model does not directly depend on *t0*. More precisely, when fish recruit at the real age of 0.0 at settlement, they have body size equal to the lower edge of the first population size bin. The fish then grow linearly until they reach a real age equal to the input value *growth-at-age for L1* and have a size equal to the parameter value for L1 (the minimum length parameter). As they age further, they grow according the selected growth equation. The SS3 deverived growth curve is showned in Figure 6.2.3.1.3. Reference length value for *growth-at-age for L1* equal to 0.5 (recruits at the half of the year) has been estimated by using a random walk for the period 2005-2021 around the average value of SoleMon age 0 data (17.5 cm). The variance in length-at-age was fixed for older and younger individuals (Table 6.2.3.1.3) allowing the fitting for bigger specimens present in the commercial catches LFDs. Length-weight relationship and L50% values comes from survey data (Figure 4.5.2.3.1).

Figure 6.2.3.1.3. Common sole in GSA 17: Growth and maturation: length at age (top-left panel) with weight (thick line) and maturity (thin line) shown in the top-right panel and in the lower-left panel.



Selectivity patterns

In all the grid runs, fishery selectivity is assumed to be length-specific and time-invariant. Selectivity represents the probability that a fish of a particular length or age will be caught by the fishery. This is a combination of gear selection (e.g., the size of the hook or the width of mesh in a net) and availability (are fish of that age in the area being fished). In SS these components are not separate and instead modeled as a single probability. The selected proportions at age generally increase from young ages to older ages, but may also decline at the oldest ages. This is referred to as dome shaped selectivity and may occur because older fish move out of the fishing area and become less available to the fishery, older fish may be able to avoid or escape the fishing gear, etc. This type of selectivity can affect biomass estimation by producing a kind of cryptic biomass phenomenon.

Some evidence in the spatial distribution of the fishing fleet and of the species (Figure 6.2.3.1.4) suggests dome shape selectivity for all the fleets present in GSA17. In particular, the offshore area southward of Istria peninsula, an important spawning area for sole, is poorly exploited by trawlers (both otter and *rapido*) mainly due to the high concentrations of debris and benthic communities that are dominated by holothurians (Despalatović et al., 2009; Santelli et al., 2017). Moreover, survey age data coming from otoliths sectioning show older specimen (already from age 4) gathering in this central area of the Adriatic Sea, with a greater chance of escaping fishing activities. Link to that, Adriatic sole stock shows higher resilience argued to be linked to high exploitation of juveniles but lower adult mortality because of these offshore spawning refuges (Scarcella et al. 2014). These considerations are important to justify the population selectivity curves used in the SS3 model but the scale of this phenomenon is not yet completely clear and it is difficult to understand how much it can affect the final selectivity shape.

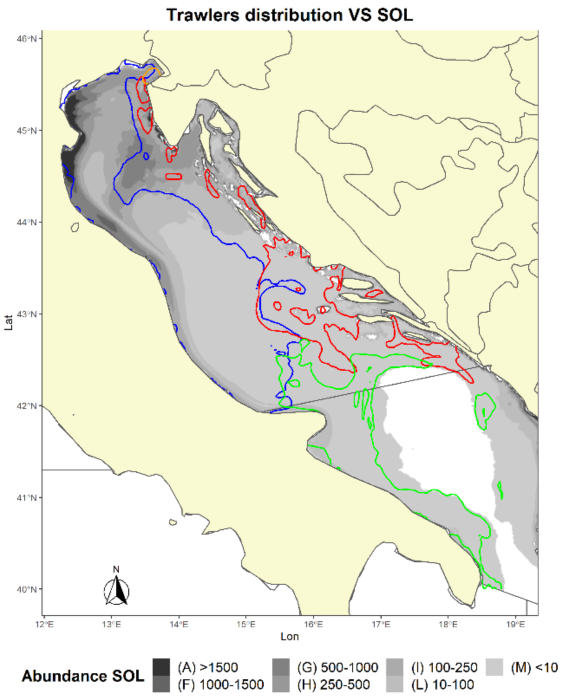


Figure 6.2.3.1.4. Common sole in GSA 17: Spatial distribution of fishing fleet (transit of fishing boat, referred to the year 2017) on abundance (n individuals/km2) of Solea solea predicted with SoleMon data (2009-2017) (left side); Spatial distribution of common sole specimens by age from SoleMon data (2014-2018) (right side).

Several alternative assumptions for selectivity were discussed and examined during benchmark session in 2021 but discarded after extensive diagnostics (FAO-GFCM, 2021). Finally, following a precautionary approach, ensemble modeling approaches were used to stitch two parallel configurations for selectivity that reflected two plausible scales of the phenomenon:

- DN) full double normal selectivity for all fleet (commercial and survey). For all the fleets, the selectivity was estimated by the model using a double normal function which estimates the peak, the ascending and the descending values of the selection curve. Figure 6.2.3.1.5.a represent length-based selectivity and derived age-based selectivity by the baseline DN model with steepness equal to 0.9 and M1, the parameters values of the other DN runs can be found in the summary Table 6.2.3.1.3;
- CS) cubic spline for survey selectivity. This specific selectivity pattern allows a better fitting to the bimodal distribution of survey LFDs (first mode juveniles, second mode adults). Figure 6.2.3.1.5.b represent length-based selectivity and derived age-based selectivity by the baseline CS model with steepness equal to 0.9 and M1, the parameters values of the other CS runs can be found in the summary Table (Table 6.2.3.1.3). Note that changing the survey selectivity also has an effect on the shape of the other fleet normal double selectivity parameters which are left free to be estimated by the model.

Final derived age-based selectivities show that the biggest difference in the two selectivity patterns is the probability of fishing older specimens (approximately from age 4-5 onwards) for TBB ITA, GTR HRV and the survey.

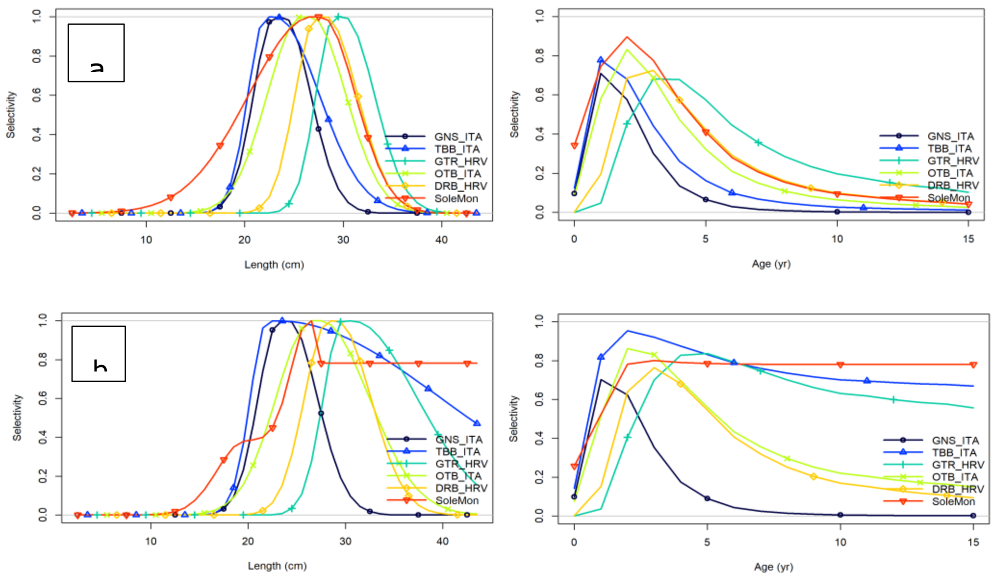


Figure 6.2.3.1.5. Common sole in GSA 17: *a)* Baseline DN model: length-based selectivity by fleet estimated by the model (left side); age-based selectivity by fleet derived by the model (right side). b) Baseline CS model: length-based selectivity by fleet estimated by the model (left side); age-based selectivity by fleet derived by the model (right side).

Natural mortality

As previously mentioned, alternative hypotheses are reasonable given that M is considered one of the most difficult to estimate, yet most influential parameters in stock assessment (Mannini et al, 2021). Three final more plausible set of *M*'s has been selected from methods exposed in Table 6.2.1.3 to represent structural uncertainty around natural mortality based on different life-history input requirement (Table 6.2.3.1.2):

- M1 configuration is based on average values of Gislason & ChenWatanabe vectors by age:
- M2 configuration is based on average values of Then_nls, Then_lm, Hamel_Amax;
- M3 configuration is based on average values of Then_VBGF, Jensen_VBGF 1, Jensen_VBGF 2.

M2 and M3 values are taken as value at maximum age (Age 15) and scaled by the body size-at-age of the fish with Lorenzen option within SS3.

Table 6.2.3.1.2. Common sole in GSA 17: Age-specific natural mortality value assumed for the three different model configurations: M1,M2, M3.

Age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
M1	0.76	0.65	0.49	0.42	0.39	0.35	0.33	0.32	0.31	0.30	0.29	0.28	0.28	0.28	0.27	0.27
M2	0.70	0.57	0.50	0.46	0.44	0.42	0.40	0.39	0.39	0.38	0.38	0.38	0.37	0.37	0.37	0.37
M3	0.91	0.74	0.65	0.60	0.56	0.54	0.52	0.51	0.50	0.50	0.49	0.49	0.49	0.48	0.48	0.48

Recruitment

Recruitment (i.e. settlement) presents one peak in fall. It was assumed that recruitment event occurs at the beginning of the year. Spawning biomass was estimated at the beginning of the year. Recruitment was derived from a standard Beverton and Holt stock recruitment relationship (SRR) and the variation in recruitment was estimated as deviations from the SRR. Recruitment deviations were estimated for 2005 to 2021 (17 annual deviations). Recruitment deviations were assumed to have a standard deviation (σR) of 0.5.

Steepness (h) is a parameter noting the percentage of unfished equilibrium recruitment (R_0) that occurs when the female spawning biomass is 20% of unfished equilibrium female spawning biomass. Steepness is typically fixed because accurate estimation requires long time series of data informative of recruitment at low biomass levels and variability in recruitment often reduces the information content. Initial reference model assumed a level of steepness (h) of 0.9. This value is in line with literary knowledge, in particular flatfishes are suspected to demonstrate high steepness (h > 0.8 for Iles 1994, Myers et al. 1999; close to 1 for Maunder 2012). However, additional lower values comparable to the life history have been examined and added to the grid to explore different effect on production function. Final h values tested are: 0.7, 0.8 and 0.9 (Table 6.2.3.1.3).

Table 6.2.3.1.3. Common sole in GSA 17: Configurations and settings of SS3 models. The table columns show: initial value, the intervals allowed for the parameters and the estimation phase. Parameters in bold are set and not estimated by the models.

Parameter	Initial value	Bounds (low,high)	Phase
Natural mortality (age classes 0-15)	***M1*; *M2*; *M3***		
Stock and recruitment			
$Ln(R_0)$	12.7	(3, 30)	1
Steepness (h)	**0.7; 0.8; 0.9**		
Recruitment variability (σR)	**0.5**		
Recruitment autocorrelation	**0**		
Growth			
Linf (cm)	**38.1**		
k	**0.28**		
L at minimum age t0	**17.5**		
CV of young individuals	**0.11**		
CV of old individuals	**0.065**		
Weight (kg) at length (cm)			
a	**0.0000046**		
b	**3.11**		
Maturity			
Length (cm) at 50% mature	**25.8**		
Slope of the length at maturity ogive	**-0.7**		
Initial fishing mortality			
ITA GNS	0.1	(0, 1.5)	1
ITA TBB	0.1	(0, 1.5)	1
HRV GTR	0.1	(0, 1.5)	1
ITA OTB	0.1	(0, 1.5)	1
Selectivity DN (double normal)			
ITA GNS			
Peak	21	(6, 41)	3
Asc-width	2.3	(-4, 12)	4

Desc-width	2.8	(-2, 6)	4
ITA TBB			
Peak	21	(6, 41)	3
Asc-width	1.3	(-10, 12)	4
Desc-width	2.8	(-2, 12)	4
HRV GTR			
Peak	29	(6, 41)	3
Asc-width	1.3	(-4, 12)	4
Desc-width	1.8	(-2, 6)	4
ITA OTB			
Peak	23.5	(6, 41)	3
Asc-width	3.3	(-10, 12)	4
Desc-width	2.8	(-2, 6)	4
HRV DRB			
Peak	21.5	(6, 41)	3
Asc-width	1.3	(-4, 12)	4
Desc-width	2.8	(-2, 6)	4
SOLEMON Survey			
Peak	21	(6, 41)	3
Asc-width	3.3	(-10, 12)	4
Desc-width	2.8	(-2, 6)	4
Selectivity CS (cubic splines)			
SOLEMON Survey			
Gradient at first node	**0.77**		
Gradient at last node	-0.78	(-1, 0.001)	3
Node 1	**13**		
Node 2	**18.5**		
Node 3	**22.5**		
Node 4	**26.5**		
Sel Node 1	**0.35**		
Sel Node 2	2.95	(-15, 7)	4

Sel Node 3	3.2	(-15, 7)	4
Sel Node 4	4	(-15, 7)	4
Catchability			
Solomen Survey			
Ln(Q) – catchability	**-2.81 (floated)**		

Model Diagnostics

Diagnostic tests are important in determining the robustness of estimates for management advice in integrated stock assessment models. There is little guidance and few objective criteria to determine how to best summarize the results of integrated assessment models, determine if the model fits the data adequately and if the model is well specified (Carvalho et al., 2017). Moreover, it is very difficult to easily evaluate convergence or identify problematic areas given the large number of estimable parameters in these assessments. However, selection of diagnostics (i.e., a diagnostic toolbox) is recommended to increase the ability to detect model misspecification while acknowledging that the use of multiple diagnostics may increase the probability that a diagnostic test results in a false positive. In this context, the recent "Cookbook" by Carvalho et al. 2021 provides a conceptual flow chart that lays out a generic process of model development and selection using model diagnostics. The cookbook, propose a series of interconnected diagnostic tests that should be carried out to establish a base model (Carvalho et al., 2017) or an ensemble of candidate models (Maunder et al., 2020). The procedure is based on the following four properties as objective criteria for evaluating the plausibility of a model: model convergence and stability, fit to the data, model consistency and prediction skill. The R package *ss3diags* (github.com/JABBAmodel/ss3diags) has been used to produce all the diagnostic analysis for this assessment.

Model weighting

The need to weight models based on information in the available data is recognized, but it is difficult to do so in a context in which the complexity of fisheries stocks assessment models prevents strict adherence with statistical rigor. In this context, the selected 18 grid runs represent the alternative states of nature of the stock and must be weighted in the final ensemble model. This is a necessary step because assigning the same weight (reliability) to all hypotheses could introduce biases into the management advice if some models are, in fact, highly unlikely or miss-specified (model specification is the difference between the model and reality). To assign weights to the various models and hypotheses, it is preferable to establish a system of discrete weight categories. In this assessment we decided to use diagnostic scores (*W(Diagnostics)*) as weighting metrics (Maunder et al., 2020) to judge the plausibility of each candidate model based on each model's fit. In fact, when all diagnostic tests are considered together, the power to detect model misspecification improves without a substantial increase in the probability of incorrectly rejecting a correctly specified model (Carvalho et al., 2017). In this context, the *W(Diagnostics)* component is calculated based on a series of interconnected diagnostic tests as discussed by Carvalho et al., 2021 as:

$$W(Diagnostics)\text{:}\ \frac{W(\text{Diags 1}) +\ W(\text{Diags 2}) +\ W(\text{Diags 3}) \ldots\ +\ W(\text{Diags N})}{\text{Num of } W(\text{Diags})}$$

where to each *W* component a value of 1 is assigned when the run passed the diagnostic test and 0 when fail. The *W(Diagnostics)* values are used as a scaling factor for the number of simulations used by the ensemble estimator when estimating the posterior distributions of the derived quantities (i.e. 5000 simulations when the *W(Diagnostics)* value is 100% and less according to the assign weight such that a value of 50% would have 2500 simulations).

A summary of all main diagnostics for the 18 model runs is provided is Table 6.2.3.1.4. Based on these results, different weights were used to stitch together the different runs in the final ensemble model. In order to make the reading as effective as possible, diagnostic analyses for each of the 18 runs of the ensemble grid are not showed here in the report but stored in a stand-alone shiny app at the link https://framasnadi.shinyapps.io/AppSOL2022/.

Table 6.2.3.1.4. Common sole in GSA 17: Summary table of the diagnostics used in the weighting procedure. Green colour refers to "Passed" score, red one to "Failed". *W(Diagnostic)* represents the weighting vector use in the ensemble procedure.

Run	run1	run2	run3	run4	run5	run6	run7	run8	run9	run10	run11	run12	run13	run14	run15	run16	run17	run18
Runs_test_SURVEY	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Runs_test_lenGNS_ITA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Runs_test_lenTBB_ITA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Runs_test_lenGTR_HRV	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Runs_test_lenOTB_ITA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Runs_test_lenSoleMon	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
RMSE_SURVEY	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
RMSE_LEN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Retro_Rho_SSB	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1
Forecast_Rho_SSB	1	1	1	1	1	1	0	1	1	0	1	0	0	1	0	1	1	1
Retro_Rho_F	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	1	1
Forecast_Rho_F	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	1	0
MASE_SURVEY	1	1	1	1	1	1	0	1	1	0	0	0	1	0	0	1	1	1
MASE_lenSURVEY	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MASE_COMfleet	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W(Diagnostics)	1.00	1.00	1.00	1.00	1.00	1.00	0.80	1.00	0.93	0.73	0.93	0.80	0.80	0.87	0.73	0.93	1.00	0.93

Running the ensemble model

Once all plausible models have been run and have been assigned weights, a delta-Multivariate log-Normal estimator (delta-MVLN; Walter and Winker, 2019; Winker et al., 2019) was used to run the ensemble model. During this, the delta-MVLN generates and stitches together the joint posterior distributions of the target derived quantities (e.g. SSB/SSBtarget and F/Ftarget) coming from all the alternative runs of the ensemble grid. These quantities are derived by using the delta-method to calculate asymptotic variance estimates from the inverted Hessian matrix of the Stock Synthesis model (i.e. the quantities are calculated from each of the three model runs). The delta-MVLN is used to run the ensemble because it can infer within model uncertainty from maximum likelihood estimates (MLEs), standard errors (SEs) and the correlation of the untransformed quantities. Another commonly used approach to do so include the use of Markov Chain Monte Carlo methods (MCMC). However, in integrated age-structured stock assessment models such as SS3, this MCMC method is computationally intense and time consuming as it requires first inverting the Hessian matrix and then running sufficiently long MCMC chains (several hours to days; Magnusson et al., 2013; Maunder et al., 2006). This renders it as challenging task to complete during typically time-constrained stock assessment meetings. Therefore, the delta-MVLN estimator has been used here because is quite fast (take only few minutes to obtain final result from 18 runs grid) and has demonstrated the ability to mimic the MCMC and processes fairly closely (Winker et al., 2019).

Results

To recap, to capture structural uncertainties, a range of alternative models were selected through diagnostics (interconnected diagnostic tests) and were stitched together in an ensemble using the delta-Multivariate log-Normal estimator (delta-MVLN). The run specifications and final weighting factors used in the ensemble procedure are reported below. The final outputs from the ensemble model are based on the weighted-median value of the 18 runs.

Name	**Selectivity**	**M**	**h**	**Weighting**
run1	DN	M1	0.9	1.00
run2	DN	M1	0.7	1.00
run3	DN	M1	0.8	1.00
run4	DN	M2	0.9	1.00
run5	DN	M2	0.7	1.00
run6	DN	M2	0.8	1.00
run7	DN	M3	0.9	0.80
run8	DN	M3	0.7	1.00
run9	DN	M3	0.8	0.93
run10	CS	M1	0.9	0.73
run11	CS	M1	0.7	0.93
run12	CS	M1	0.8	0.80
run13	CS	M2	0.9	0.80
run14	CS	M2	0.7	0.87
run15	CS	M2	0.8	0.73
run16	CS	M3	0.9	0.93
run17	CS	M3	0.7	1.00
run18	CS	M3	0.8	0.93

Figures 6.2.3.1.5. and Table 6.2.3.1.5 present the main outputs from the final ensemble model. Spawning biomass of common sole follows a decreasing trend in the whole time series up to 2010. In the recent years, SSB followed an increasing trend reflecting its recovering status. The last estimate of SSB in 2021 is 3440 tons. Fishing mortality is defined as the average F of age

classes 1 to 4. Fishing mortality increased up to 2010 to follow then a continuous decreasing trend until 2021, reaching the value of 0.18. Data informing recruits estimates are only available since 2005 (first year of SoleMon survey LFD). Since 2005, recruitment has shown an increasing trend; in the last year estimate recruits are 86378 (1000s).

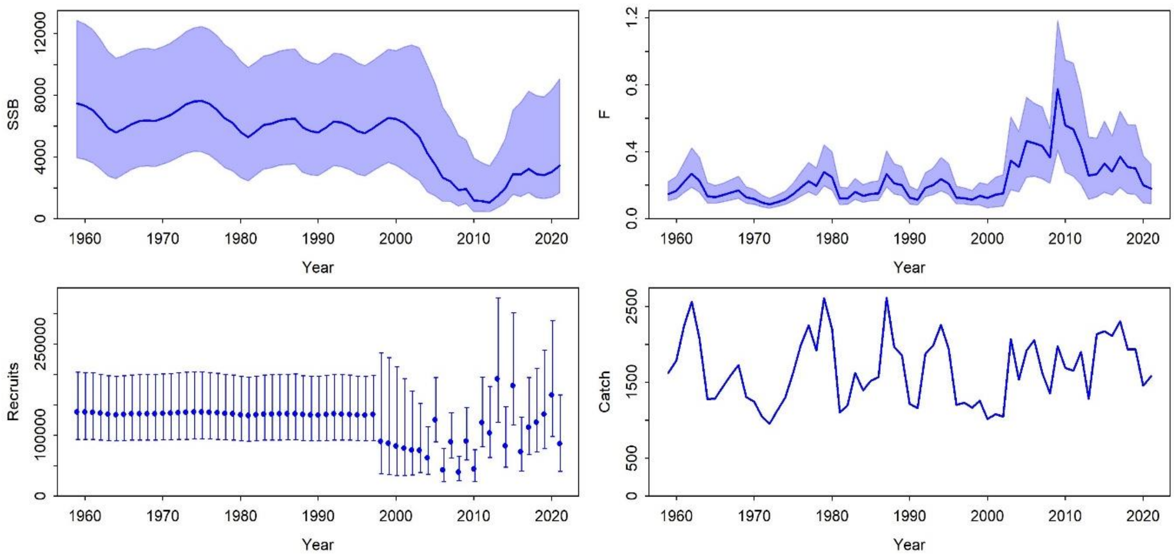


Figure 6.2.3.1.5. Common sole in GSAs 17: Trends in catch, recruitment, fishing mortality and SSB resulting from the ensemble model.

Table 6.2.3.1.5. Common sole in GSAs 17: Assessment summary. Weights are in tonnes. 'High' and 'Low' represent 95% confidence intervals.

Year	SSB Tonnes	High	Low	F ages 1-4	High	Low	Recruitment age 0 thousands	High	Low
1961	7049	3640	12269	0.220	0.157	0.337	137496	92994	202424
1962	6536	3250	11636	0.269	0.188	0.424	136352	92373	200430
1963	5886	2767	10841	0.227	0.157	0.367	134649	91379	197788
1964	5585	2602	10401	0.135	0.095	0.215	133698	90803	196666
1965	5826	2886	10564	0.129	0.092	0.198	134336	91293	198026
1966	6129	3194	10828	0.141	0.101	0.212	135075	91840	199364
1967	6320	3376	11003	0.156	0.112	0.233	135510	92167	200105
1968	6376	3423	11041	0.170	0.122	0.254	135605	92269	200256
1969	6325	3374	10969	0.128	0.092	0.190	135449	92219	200006
1970	6503	3531	11143	0.118	0.086	0.174	135868	92477	200702
1971	6729	3717	11378	0.097	0.071	0.141	136347	92776	201503
1972	7052	3975	11730	0.086	0.063	0.123	137039	93152	202630
1973	7402	4240	12121	0.100	0.074	0.142	137746	93518	203689
1974	7602	4359	12369	0.115	0.085	0.164	138121	93719	204156
1975	7642	4339	12448	0.146	0.108	0.211	138212	93756	204147
1976	7456	4131	12281	0.187	0.136	0.274	137887	93588	203454
1977	7043	3754	11855	0.223	0.160	0.337	137077	93162	202003
1978	6499	3306	11266	0.197	0.140	0.303	135869	92504	200003
1979	6209	3109	10918	0.280	0.196	0.441	135139	92089	199002
1980	5613	2658	10232	0.247	0.170	0.399	133484	91042	196539
1981	5296	2461	9813	0.119	0.083	0.189	132465	90348	195295

1982	5665	2848	10154	0.120	0.086	0.183	133576	91131	197431
1983	6061	3222	10553	0.160	0.115	0.240	134661	91831	199172
1984	6171	3313	10666	0.137	0.098	0.203	134928	92021	199544
1985	6356	3463	10863	0.148	0.107	0.219	135359	92303	200245
1986	6443	3524	10966	0.152	0.110	0.225	135567	92428	200526
1987	6479	3535	11015	0.267	0.190	0.404	135643	92490	200613
1988	5901	3016	10399	0.211	0.148	0.328	134161	91607	198170
1989	5682	2851	10134	0.200	0.140	0.312	133521	91208	197345
1990	5598	2810	10008	0.126	0.089	0.194	133257	91035	197099
1991	5916	3115	10323	0.114	0.082	0.171	134144	91615	198649
1992	6293	3447	10728	0.183	0.132	0.273	135125	92213	200155
1993	6225	3365	10677	0.201	0.143	0.302	134965	92127	199750
1994	6032	3183	10477	0.238	0.168	0.366	134455	91834	198922
1995	5686	2886	10095	0.209	0.146	0.327	133478	91234	197462
1996	5543	2785	9916	0.125	0.089	0.193	133052	90948	196909
1997	5863	3090	10241	0.122	0.087	0.183	133954	91531	198485
1998	6205	3390	10611	0.114	0.082	0.168	90007	36701	235230
1999	6541	3664	10982	0.137	0.083	0.215	86967	35292	227925
2000	6457	3470	10886	0.124	0.065	0.206	82347	33872	212670
2001	6208	3153	11115	0.144	0.072	0.248	78366	33416	193530
2002	5779	2784	11250	0.152	0.075	0.263	75812	34521	172703
2003	5295	2471	11074	0.348	0.173	0.609	75223	38781	152036
2004	4221	1748	9914	0.310	0.160	0.520	63114	36217	114586
2005	3525	1491	8763	0.464	0.247	0.726	125175	89210	194885
2006	2664	1128	7227	0.451	0.254	0.688	42849	23521	78584
2007	2400	1125	6452	0.435	0.239	0.667	89198	63000	137089
2008	1860	824	5402	0.367	0.211	0.538	39566	25233	64971
2009	1913	1014	5105	0.774	0.408	1.183	90614	59344	146119
2010	1181	472	3923	0.558	0.278	0.948	44592	24305	76402
2011	1145	484	3620	0.535	0.254	0.929	120754	81374	195563
2012	1060	446	3434	0.424	0.202	0.752	103894	63180	180176
2013	1467	698	4169	0.258	0.117	0.487	192444	121293	325761
2014	1977	1014	5185	0.266	0.132	0.481	82603	47626	147293
2015	2900	1590	7043	0.327	0.159	0.583	181789	117518	301412
2016	2873	1451	7523	0.282	0.141	0.495	72611	40944	130160
2017	3232	1686	8271	0.371	0.186	0.642	112998	68816	195184
2018	2887	1379	7985	0.309	0.150	0.560	121095	73027	210196
2019	2820	1313	7899	0.301	0.145	0.559	135008	78323	239851
2020	3025	1404	8355	0.200	0.095	0.377	166243	98121	288552
2021	3440	1686	9060	0.180	0.091	0.326	86379	40613	166466

Table 6.2.3.1.6. Common sole in GSAs 17: F by fleet (% on total F) by year as median of the 18 runs.

Year	ITA Nets	ITA TBB	HRV GTR	ITA OTB	HRV DRB
1958	28.6%	40.0%	13.1%	18.4%	0.0%
1959	28.7%	40.0%	12.9%	18.3%	0.0%
1960	28.7%	39.9%	13.0%	18.4%	0.0%
1961	28.5%	39.9%	13.2%	18.5%	0.0%
1962	28.1%	39.8%	13.5%	18.6%	0.0%
1963	27.6%	39.5%	14.2%	18.7%	0.0%
1964	27.4%	39.4%	14.6%	18.7%	0.0%
1965	27.6%	39.6%	14.4%	18.5%	0.0%
1966	27.9%	39.8%	14.0%	18.4%	0.0%
1967	28.1%	39.9%	13.7%	18.4%	0.0%
1968	28.1%	39.9%	13.6%	18.4%	0.0%
1969	28.0%	39.8%	13.7%	18.4%	0.0%
1970	28.1%	39.9%	13.6%	18.3%	0.0%
1971	28.2%	40.0%	13.5%	18.3%	0.0%
1972	28.5%	40.0%	13.3%	18.2%	0.0%
1973	28.7%	40.1%	13.0%	18.2%	0.0%
1974	28.9%	40.0%	12.9%	18.2%	0.0%
1975	28.9%	39.9%	12.9%	18.3%	0.0%
1976	28.8%	39.8%	13.0%	18.4%	0.0%
1977	28.5%	39.8%	13.3%	18.5%	0.0%
1978	28.1%	39.7%	13.7%	18.6%	0.0%
1979	27.8%	39.7%	13.9%	18.6%	0.0%
1980	27.5%	39.4%	14.4%	18.7%	0.0%
1981	27.2%	39.3%	14.9%	18.7%	0.0%
1982	27.5%	39.6%	14.5%	18.5%	0.0%
1983	27.9%	39.8%	14.0%	18.3%	0.0%
1984	28.0%	39.9%	13.8%	18.4%	0.0%
1985	28.1%	39.9%	13.7%	18.3%	0.0%
1986	28.1%	39.9%	13.6%	18.3%	0.0%
1987	28.2%	39.9%	13.5%	18.4%	0.0%
1988	27.8%	39.6%	14.0%	18.6%	0.0%
1989	27.6%	39.5%	14.4%	18.6%	0.0%
1990	27.5%	39.5%	14.5%	18.5%	0.0%
1991	27.7%	39.7%	14.2%	18.4%	0.0%
1992	28.0%	39.9%	13.7%	18.3%	0.0%
1993	28.1%	39.8%	13.7%	18.4%	0.0%
1994	28.0%	39.7%	13.9%	18.5%	0.0%
1995	27.7%	39.5%	14.3%	18.5%	0.0%
1996	27.5%	39.5%	14.5%	18.5%	0.0%
1997	27.7%	39.7%	14.2%	18.4%	0.0%
1998	28.2%	39.9%	13.7%	18.3%	0.0%
1999	30.0%	39.5%	12.5%	18.0%	0.0%

2000	29.0%	39.6%	14.0%	17.4%	0.0%
2001	28.1%	38.9%	15.6%	17.4%	0.0%
2002	26.6%	37.2%	19.5%	16.8%	0.0%
2003	28.2%	40.0%	13.8%	18.0%	0.0%
2004	28.8%	25.4%	14.7%	31.1%	0.0%
2005	34.8%	18.7%	16.0%	30.4%	0.0%
2006	32.9%	41.0%	12.5%	13.6%	0.0%
2007	29.4%	41.1%	14.3%	15.1%	0.0%
2008	30.5%	41.3%	12.3%	15.9%	0.0%
2009	28.0%	41.9%	15.0%	15.1%	0.0%
2010	26.0%	34.1%	24.4%	15.6%	0.0%
2011	34.4%	21.2%	30.0%	14.4%	0.0%
2012	36.2%	31.4%	15.3%	16.3%	0.9%
2013	16.6%	35.4%	26.4%	19.1%	2.4%
2014	24.4%	46.8%	11.7%	14.9%	2.2%
2015	20.4%	53.0%	10.1%	13.9%	2.6%
2016	17.4%	46.1%	7.5%	26.0%	2.9%
2017	20.4%	54.5%	7.8%	15.1%	2.2%
2018	12.4%	53.3%	9.7%	22.0%	2.6%
2019	13.3%	53.9%	9.0%	20.9%	2.8%
2020	11.0%	49.9%	14.6%	20.0%	4.4%
2021	11.4%	57.4%	8.4%	19.4%	3.5%

Since partial F is not directly available from the ensemble model, the median from the 18 runs was used for the calculation. This approximation leads to a small discrepancy between the sum of the partial F and the F_{bar} coming from the ensemble (runs weighted differently according to the diagnostic scores). For this reason, the group agreed to report partial F as a ratio and not as an absolute F value.

Quality of the assessment

The assessment performed during the meeting is an update from the one benchmarked in GFCM (FAO-GFCM, 2021). Results in terms of main output value are stable and consistent with the benchmark and with the update of 2021.

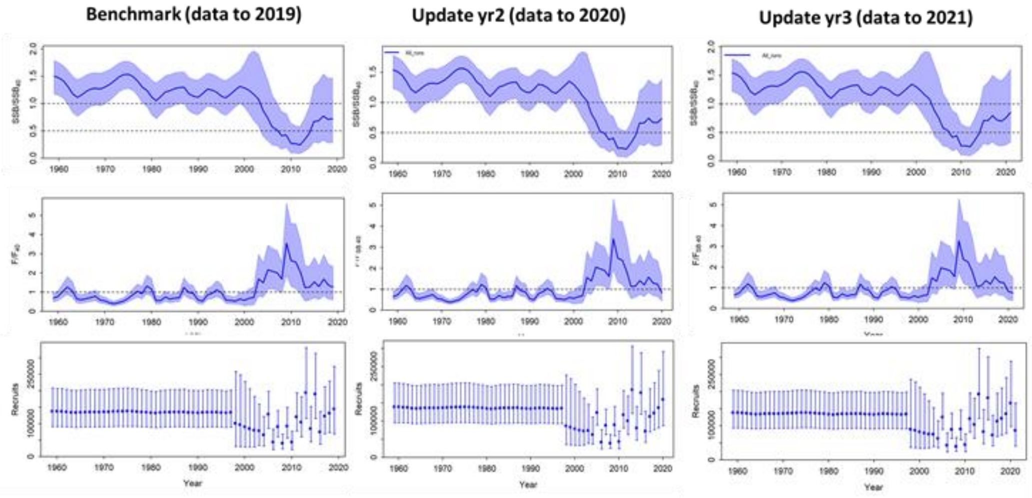


Figure 6.2.3.1.6. Common sole in GSAs 17: Assessment main outputs from benchmark, update 2021 and update 2022.

The interconnected diagnostic tests were considered acceptable and diagnostics scores were used as weighting factor during ensemble procedure. However, overall diagnostics for the CS (Cubic Spline) set (run 9 to 18) continue to deteriorate slightly compared to the benchmark model leading to heavier emphasis in the ensemble of models assuming dome-shaped selection for all fleets. This may represent a small increase in the risk of an assessment with a cryptic biomass. Moreover, the approach taken to weight the individual runs within the ensemble should be considered further as the science and experience around ensemble modelling develops in international community.

All 18 runs appear to be sensitive to the specification of growth and its uncertainty as is usual for length-based models with fixed growth functions.

6.2.4 Reference points

The reference points derived from the SS3 ensemble assessment are presented in table 6.2.4.1. Biomass reference points are considered as SSB and not total biomass. Horbowy and Luzenzzyk (2012) and Punt et al. (2013) showed that fishing mortality corresponding to a biomass at 40% B0 as a proxy for BMSY leads to high yield and safe biomass levels irrespective of the steepness value of the stock recruitment function. Following this generic but more precautionary rule, SSB40 (biomass equal to 40% of unfished biomass) and F40 (fishing mortality level at SSB40) has been chosen as proxies for MSY. Moreover, SS B_{lim}, defined as the level of spawning biomass below which recruitment is considered to be impaired, is set as 20% of unfished biomass B0 (SSB20) based on biological principles and international best practice (type 2; ICES, 2022).

Table 6.2.4.1 Common sole in GSA 17: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY B_{target} *	4022	$B_{40\%}$	STECF EWG 22-16
	F_{MSY}*	0.240	F at B40% from SS3 ensemble model	STECF EWG 22-16
Precautionary approach	B_{lim}*	2011	$B_{20\%}$	STECF EWG 22-16
	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. 240	F at B40% from SS3 ensemble model	STECF EWG 22-16
	MAP target range $F_{MSY\ lower}$	0.161	Based on regression calculation (see section 2)	
	MAP target range $F_{MSY\ upper}$	0.332	Based on regression calculation but not tested and presumed not precautionary	

*The reference points are expressed in relative terms as 40% of B0 (B_{target}) and the F that brings the stock to B_{target}. Moreover, both reference points are the median of the model ensemble and therefore the absolute value could slightly change when updating the model.

Figure 6.2.4.1.1 represent the Kobe plot for the ensemble model. Kobe plot represents the time series of pressure (F/Ftarget) on the Y-axis and of state of the Biomass (SSB/SSBtarget) on the X-axis. The orange area indicates healthy stock sizes that are about to be depleted by overfishing. The red area indicates ongoing overfishing while the stock is too small to produce maximum sustainable yields. The yellow area indicates reduced fishing pressure on stocks recovering from still too small biomass. The green area is the target area for management, indicating sustainable fishing pressure and healthy stock size capable of producing high yields close to the reference point chosen (MSY or proxies).

For common sole the stock trajectory begun in 1958 in the green quadrant, when the biomass was quite higher than the SSB40. Starting from 2000s, the F level registered an increasing trend that resulted in a progressive erosion of the stock size which led the stock trajectory towards the red quadrant. From 2010 onwards, the F has returned to decrease, falling under the reference point in the final year. In 2021 there is about 29% probability that the stock is in the red quadrant of the Kobe plot (i.e. SSB < SSB40 and F > F40) with probabilities of about 35% to be in the yellow (i.e. SSB < SSB40 and F < F40) and 36% to be in the green (SSB > SSB40 and F < F40). In conclusion, the trajectory of the stock from 2010 onwards reflects its recovering status.

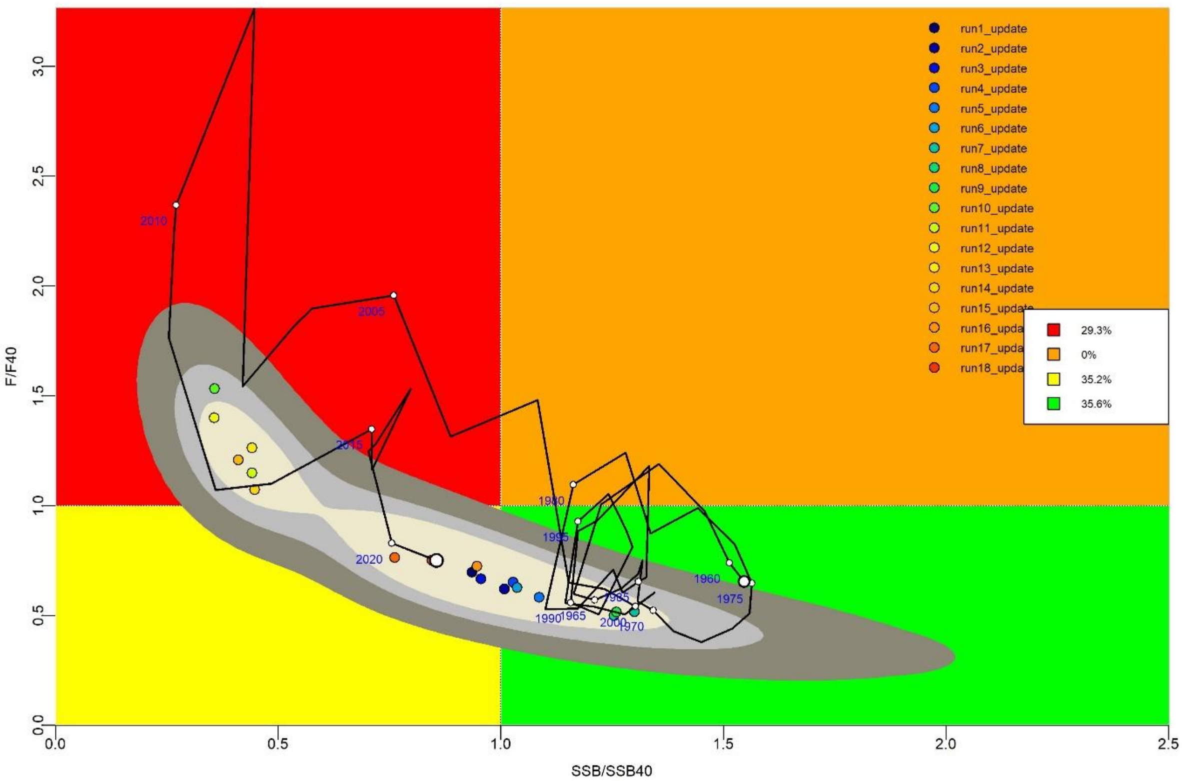


Figure 6.2.4.1.1. Common sole in GSAs 17: Kobe plot showing the trajectory of relative stock size (SSB/SSB40) over relative exploitation (F/F40) based on SS3 final ensemble model (white dot: weighted-median value of 18 runs). Gray shading indicates CI of 50%, 80% and 95% from delta-MVNL of the final assessment year (2021). The legend indicates the estimated probability of the stock status being in each of the Kobe quadrant.

6.2.5 SHORT TERM FORECAST AND CATCH OPTIONS

The short-term projections are made with Stock Synthesis using the ensemble model for 2022 and 2023 following a linear transition in F from the F in 2019 to F_{MSY} in 2026. Recruitment in the forecast period was decided to be set to the average of the last 10 years for which recruitment deviations are estimated in the ensemble model.

Forecasts were performed on the ensemble using the median estimate from the delta approximation (delta-MVLN) results for catch and SSB. Catches by fleet however could not technically be estimated in this way yet and were taken as the median of only the 18 forecast runs. Therefore, fleet catches may not sum to the total catches.

The assumptions made for the forecast and are given in Table 6.2.5.1, and results are given in Table 6.2.5.2. Annual catch scenarios by gear are reported in Table 6.2.5.3.

Table 6.2.5.1. Common sole in GSAs 17: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters		Maturity, natural mortality and selectivity, based on the average of 2019-2021
$F_{ages\ 1\text{-}4}$ (2022)	0.198	Average last 3-yr (2019-2020-2021) in apical F by fleet + 3% reduction for ITA TBB fleet and 5.2% for ITA OTB
SSB (2022)	4315 t	Stock assessment 1 January 2022
R_{age0} (2022,2023)	128,456	Mean of the last 10 years (2012-2021)
Total catch (2022)	1769 t	Predicted catch from ensemble model

Table 6.2.5.2. Common sole in GSAs 17: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	SSB (2023)	% SSB change**	% Catch change***
STECF advice basis					
F_{MSY} / MAP	2000	0.238	4344	-3.35	+20.87
$F_{MSY\ Transition}$^^	2125	0.258	4093	-5.40	+25.49
$F_{MSY\ lower}$	1451	0.158	4529	4.74	-9.11
$F_{MSY\ upper}$*	2560	0.336	3782	-14.07	+38.16
Other scenarios					
Status quo^	1741	0.198	4344	0.67	+9.06
F 80% of status quo	1451	0.158	4529	4.74	-9.11
F 90% of status quo	1599	0.178	4435	2.72	+1
F 110% of status quo	1876	0.218	4259	-1.31	+15.64
F 120% of status quo	2000	0.238	4175	-3.35	+20.87
F 130% of status quo	2125	0.258	4093	-5.40	+25.49

* F_{MSY} ranges were derived using the formula provided by STECF 15-09: $F_{MSY\ upper}$ is assumed not to be precautionary. STECF does not advise fishing at $F>F_{MSY}$
** % change in SSB 2023 to 2022
***Total catch in 2023 relative to catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026
^3% reduction for ITA TBB fleet and 5.2% for ITA OTB

Table 6.2.5.3. Common sole in GSAs 17: Annual catch scenarios by gear

Basis	Total catch (2023)	F_{total} (ages 1-4) (2023)	ITA GNS	ITA TBB	ITA OTB	HRV GTR	HRV DRB
STECF advice basis							
F_{MSY} / MAP	2000	0.238	263	1093	381	198	66
$F_{MSY\ Transition}$^^	2125	0.258	280	1161	404	210	70
$F_{MSY\ lower}$	1451	0.158	191	793	276	144	48
$F_{MSY\ upper}$*	2560	0.336	337	1399	487	253	84
Other scenarios							
Status quo^	1741	0.198	229	951	331	172	57
F 80% of status quo	1451	0.158	191	793	276	144	48
F 90% of status quo	1599	0.178	211	874	304	158	53
F 110% of status quo	1876	0.218	247	1026	357	186	62
F 120% of status quo	2000	0.238	263	1093	381	198	66
F 130% of status quo	2125	0.258	280	1161	404	210	70

* F_{MSY} ranges were derived using the formula provided by STECF 15-09: $F_{MSY\ upper}$ is assumed not to be precautionary. STECF does not advise fishing at $F>F_{MSY}$
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026
^ 3% reduction for ITA TBB fleet and 5.2% for ITA OTB

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.240 (F at $B_{40\%}$ as proxy of F_{MSY}) and corresponding catches in 2023 should be no more than 2000 tons.

Nevertheless, the stock is taken in a mixed fishery with Cuttlefish, Mantis Shrimp. Management of these stocks should be considered simultaneously.

Moreover, both the ITA TBB and HRV DRB use identical fishing techniques but are differently classified by member states. The effort reductions of 3% in F for the TBB fleet based on the effort reduction by management in 2022 (the interim year) was only applied to the ITA TBB fleet in line with the literal interpretation of the ToRs.

6.2.6 Data Deficiencies

The data used in the sole in GSA 17 stock assessment was reviewed by GFCM and did not use the data from the MED-BS data call under the DFC directly so no data quality information is provided for the DTMT. General issues with data are provided in the GFCM report (GFCM 2022)

EWG 2216 discussed the interpolation of the survey data for 2020 and 2021 for the SOLEMON survey which was not carried out in its entirety in these years. Two different methods were applied to the two years although overall this had relatively little impact on the survey index so it is not expected that the assessment is sensitive to the uncertainty in methods.

6.3 RED MULLET IN GSA 17 AND 18

6.3.1 STOCK IDENTITY AND BIOLOGY

Red mullet in GSA 17 and 18 was assessed as a unique unit after previous analyses from STECF 18-16 on the basis of the analysis of the survey indices, showing a very similar increasing trend in both areas in the recent years, and considering that the Western side of both GSAs was characterized by a decrease in effort from 2004 to 2016. Nevertheless, during the GFCM SAD working group 2019 and 2020 was raised the need to further explore the suitability of the combination of the two areas for the stock assessment and to have a benchmark assessment as soon as possible.

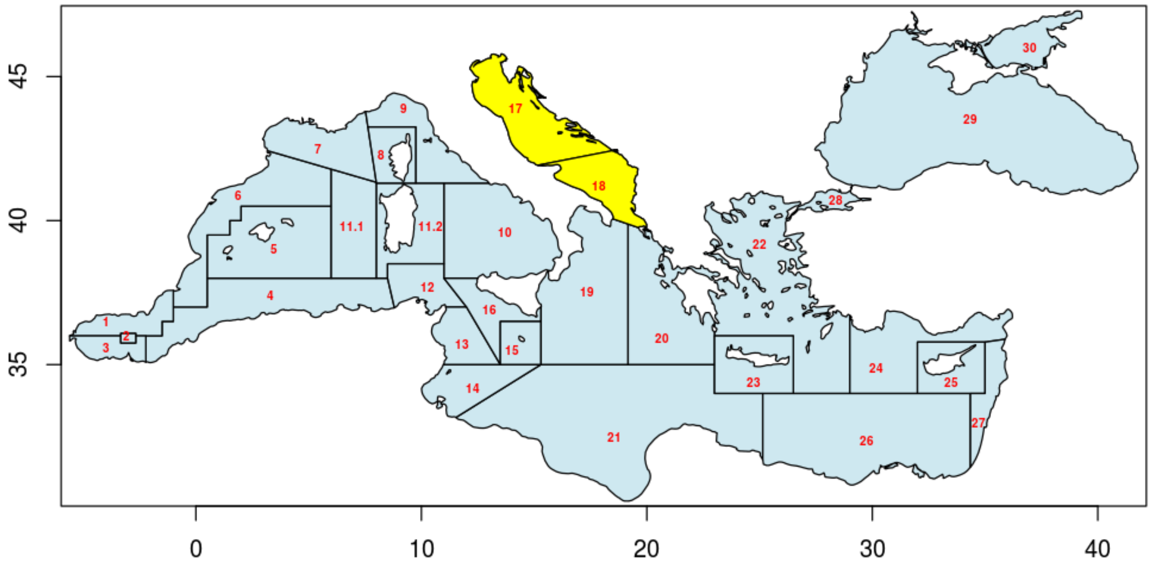


Figure 6.3.1.1.1 Geographical location of GSAs 17 and 18.

Growth

The growth of red mullet has been studied through validation of age reading by Carbonara et al., (2018), providing parameters for the von Bertalanffy growth curve for GSA 18 for males, females and combined sexes. For an exploration of the hypothesis of t0 correction, see the STECF 20-15 report. For a further exploration to compare the parameters of GSA 17 from DCF age-length data with the one from Carbonara et al., 2018, see the same report. According to the abovementioned exploration, the parameters reported in table 6.3.1.1.1 are used for the whole area. The a and b parameters of the length-weight relationship are the same used in the last EWG meeting (DCF data) and have been applied to both GSAs. These are reported in table 6.3.1.1.1, and were used for the assessment.

Table 6.3.1.1.1. Growth parameters used for GSA 17-18

Sex	L_{inf}	K	t_0	a	b
Female	29.185	0.247	−0.768	0.00895	3.100137
Male	22.725	0.328	−0.816	0.00868125	3.103919

Maturity

The vector of proportion of mature individuals by was the one reported in Table 6.3.1.1.2.

Table 6.3.1.1.2. Maturity vector at age used for GSA 17-18.

Age	Maturity
0	0
1	1
2	1
3	1
4	1

Natural mortality

Following the last GFCM benchmark meeting held in March 2022, the natural mortality vector was estimated, with uncertainty, firstly as an average using six scalar methods using the Jason Cope approach implemented in the barefoot ecologist's toolbox for the estimation of M. The six methods were based on the growth parameters listed in Table 6.3.1.1.1. The average scalar M was then split by age on the basis of an average of seven different natural mortality methods by age. The agreed vector is reported in Table 6.3.1.1.3.

Table 6.3.1.1.3. Natural Mortality vector at age agreed for red mullet in GSA 17-18.

Age	Mval.50%	Mval.5%	Mval.95%
0.5	1.71	1.31	2.09
1.5	0.85	0.65	1.03
2.5	0.63	0.48	0.77
3.5	0.52	0.40	0.63
4.5	0.45	0.35	0.55
5.5	0.42	0.32	0.51
6.5	0.40	0.31	0.49
7.5	0.38	0.29	0.47
8.5	0.37	0.28	0.45
9.5	0.35	0.27	0.43

6.3.2 DATA

6.3.2.1 CATCH (LANDINGS AND DISCARDS)

Red mullet landings in the whole area come predominantly from OTB (about 97% of the landing in tons in 2021); a small amount is reported for small-scale fishing gears (gillnet and trammel net), slightly more important for GSA 18 Italy (about 12%).

Landing data in weight and the related length and age distributions are reported in the official Data call for the GSA 17 Italy from 2006 to 2021, for GSA 17 Croatia from 2013 to 2021 and for GSA 17 Slovenia from 2005 to 2021. For GSA 18 Italy from 2002 to 2020 were available in the STECF 21-15, but from the last Data call the years 2013, 2019, and 2020 were missing. Thus for those years the data available during the EWG 21-15 were used.

The discard was available for GSA 17 Italy from 2010 to 2021, for GSA 17 Croatia from 2013 to 2021, for GSA 17 Slovenia from 2005 to 2021 and for GSA 18 Italy from 2009 to 2021. In the missing years the discard was estimated on the basis of the discard ratio (discard/landing) of the first available years of the landing time series.

Landing data and corresponding LFDs for Montenegro and Albania were agreed during the benchmark session and were here were updated to 2021 using the data provided by national authorities. No discard data were available for Albania and Montenegro.

Table 6.3.2.1.1 Red mullet in GSAs 17 and 18. Landings in GSA 17 by fishing gear and country over 2006-20201 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; TBB=beam trawl; OTB=otter bottom trawl).

country	year	GNS	GTR	OTB	TBB	Total
HRV	2012	4.535	2.246	1244.008		1250.789
	2013	3.752	1.148	1087.082		1091.982
	2014	5.215	1.61	1153.032		1159.857
	2015	4.8	0.844	1128.542		1134.186
	2016	7.908	2.456	953.498		963.862
	2017	3.572	0.902	987.712		992.186
	2018	6.576	0.557	825.68		832.813
	2019	8.878	0.76	731.117		740.755
	2020	9.375	0.813	745.526		755.714
	2021	8.581	1.644	750.346		760.571
ITA	2006			3101		3101
	2007			3298		3298
	2008			3158		3158
	2009			2433		2433
	2010			1796		1796
	2011	31		1823	36	1890
	2012	18		1464	43	1525
	2013			1946	31	1977
	2014	8		2324	64	2396
	2015	16		2143	61	2220
	2016	5		2037		2042
	2017	9		2659	4	2672
	2018	6		2471	40	2517
	2019	10	0	1673	44	1727
	2020	2.253	0.108	1245.368	25.746	1273.475
	2021	19.746	0.148	1562.71	32.826	1615.43
SVN	2005		0.002	4.362		4.364
	2006	0.002		1.932		1.934
	2007	0.002	0.005	6.403		6.41
	2008	0.003	0.011	2.006		2.02
	2009	0.001	0	2.668		2.669
	2010	0.005	0.003	1.268		1.276
	2011	0.002	0.003	6.054		6.059
	2012	0.012	0	3.572		3.584
	2013	0.002	0	2.431		2.433
	2014	0.042	0.001	3.27		3.313
	2015	0.008	0.002	3.375		3.385
	2016	0	0	2.324		2.324
	2017	0.001	0	3.35		3.351
	2018	0.014	0.001	6.012		6.027
	2019	0.0079	0.0008	3.61997		3.62867
	2020	0.0171		4.5036		4.5207
	2021	0.0025	0.0002	5.2853		5.288

Table 6.3.2.1.2 Red mullet in GSAs 17 and 18. Landings in GSA 18 by fishing gear and country over 2002-2021 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; OTB=otter bottom trawl).

country	year	GNS	GTR	OTB	Total
ITA	2002	89.60081		3114.21	3203.81
	2003	311.9539		1749.802	2061.756
	2004	82.49578		1981.129	2063.625
	2005	99.33683		1349.999	1449.336
	2006	123.4987	6.26977	1803.474	1933.242
	2007	119.771	2.73862	1679.597	1802.106
	2008	41.91888	4.70392	914.195	960.8178
	2009	75.87371	0.81381	954.6023	1031.29
	2010	43.97281	1.43019	600.7786	646.1816
	2011	37.11939	0.39839	494.2273	531.7451
	2012	7.1176	0.55257	2088.61	2096.281
	2013	47.0261		1202.783	1249.809
	2014	4.53201	18.11179	1249.565	1272.209
	2015	15.2754		1572.097	1587.372
	2016	50.48169		1397.565	1448.047
	2017	0.18156	66.34732	552.9773	619.5062
	2018	78.73549	13.14884	911.9695	1003.854
	2019	54.85634	8.3594	711.3328	774.5486
	2020	56.10239	2.22705	408.0947	466.4241
	2021	26.4627	0.048	652.1205	678.6312

Table 6.3.2.1.3 Red mullet in GSAs 17 and 18. Discards by GSA, fishing gear (OTB) and country as reported in the DCF (tonnes).

country	year	GSA 17	GSA 18	Total
HRV	2013	3.06		3.06
	2014	2.25		2.25
	2015	0.92		0.92
	2016	1.06		1.06
	2017	3.59		3.59
	2018	3.22		3.22
	2019	2.91		2.91
	2020	1.02		1.02
	2021	2.234		2.234
ITA	2009		14.73	14.73
	2010	183.00	35.01	218.01
	2011	796.00	13.92	809.92
	2012	325.00	434.05	759.05
	2013	291.00	18.05	309.05
	2014	446.00	119.62	565.62
	2015	910.00	89.37	999.37
	2016	499.00	87.41	586.41
	2017	1069.00	13.17	1082.17
	2018	2038.00	182.87	2220.87
	2019	597.00	198.04	795.04
	2020	129.60	21	150.60
	2021	25	19.51998	44.52
SVN	2005	0.08		0.08
	2006	0.02		0.02
	2007	0.17		0.17
	2008	0.03		0.03
	2009	0.04		0.04
	2010	0.01		0.01
	2011	0.14		0.14
	2012	0.07		0.07
	2013	0.05		0.05
	2014	0.07		0.07
	2015	0.07		0.07
	2016	0.05		0.05
	2017	0.14		0.14
	2018	0.15		0.15
	2019	0.19		0.19
	2020	0.29		0.29
	2021	0.34209		0.34209

Table 6.3.2.1.4 Red mullet in GSAs 17 and 18. Total landing (tonnes).

Year	Albania	Montenegro
2006	185	47
2007	154	48
2008	162	42
2009	187	40
2010	113	38
2011	132	35
2012	450	39
2013	448	35
2014	380	45
2015	466	40
2016	475	41
2017	470	36
2018	347	43
2019	373	40
2020	333	26
2021	399	28

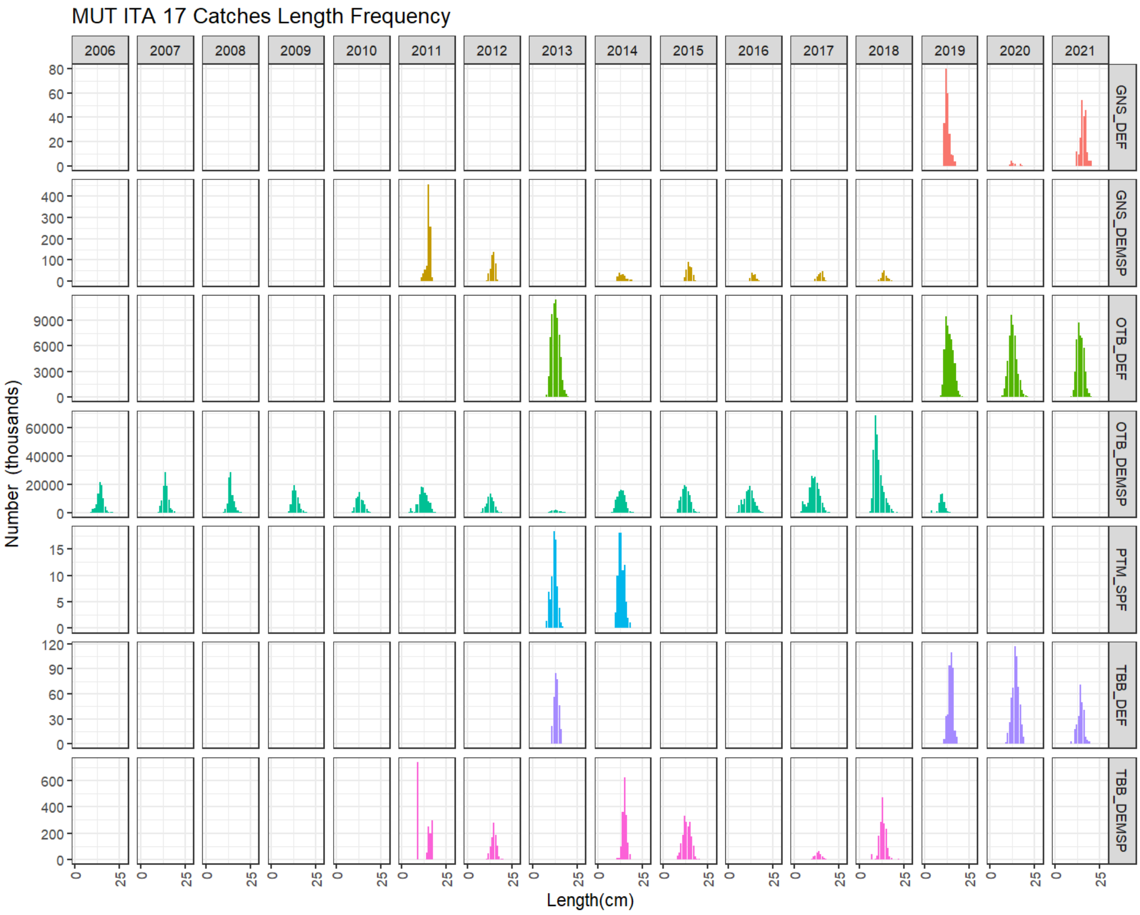


Figure 6.3.2.1.1 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Italy

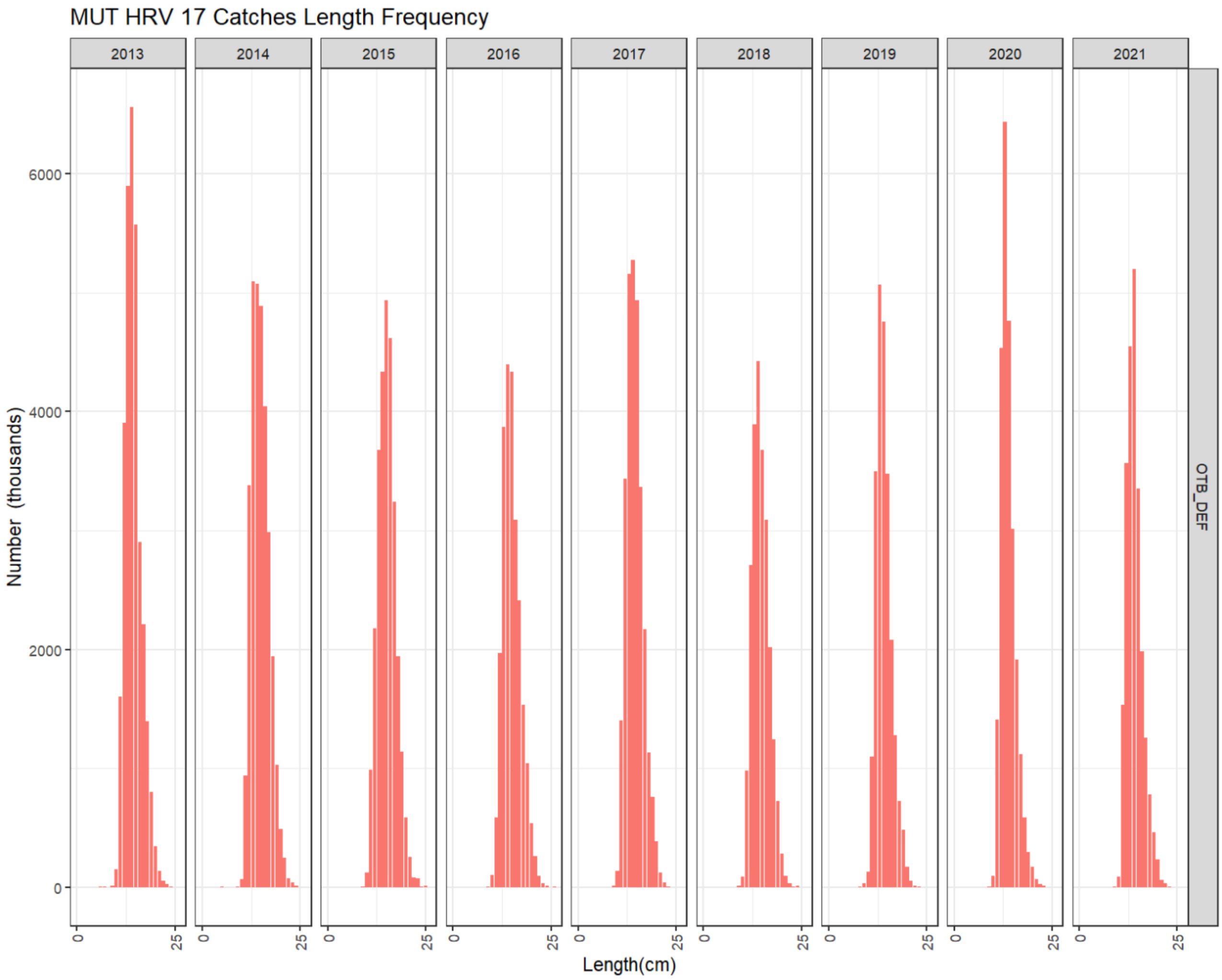


Figure 6.3.2.1.2 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Croatia.

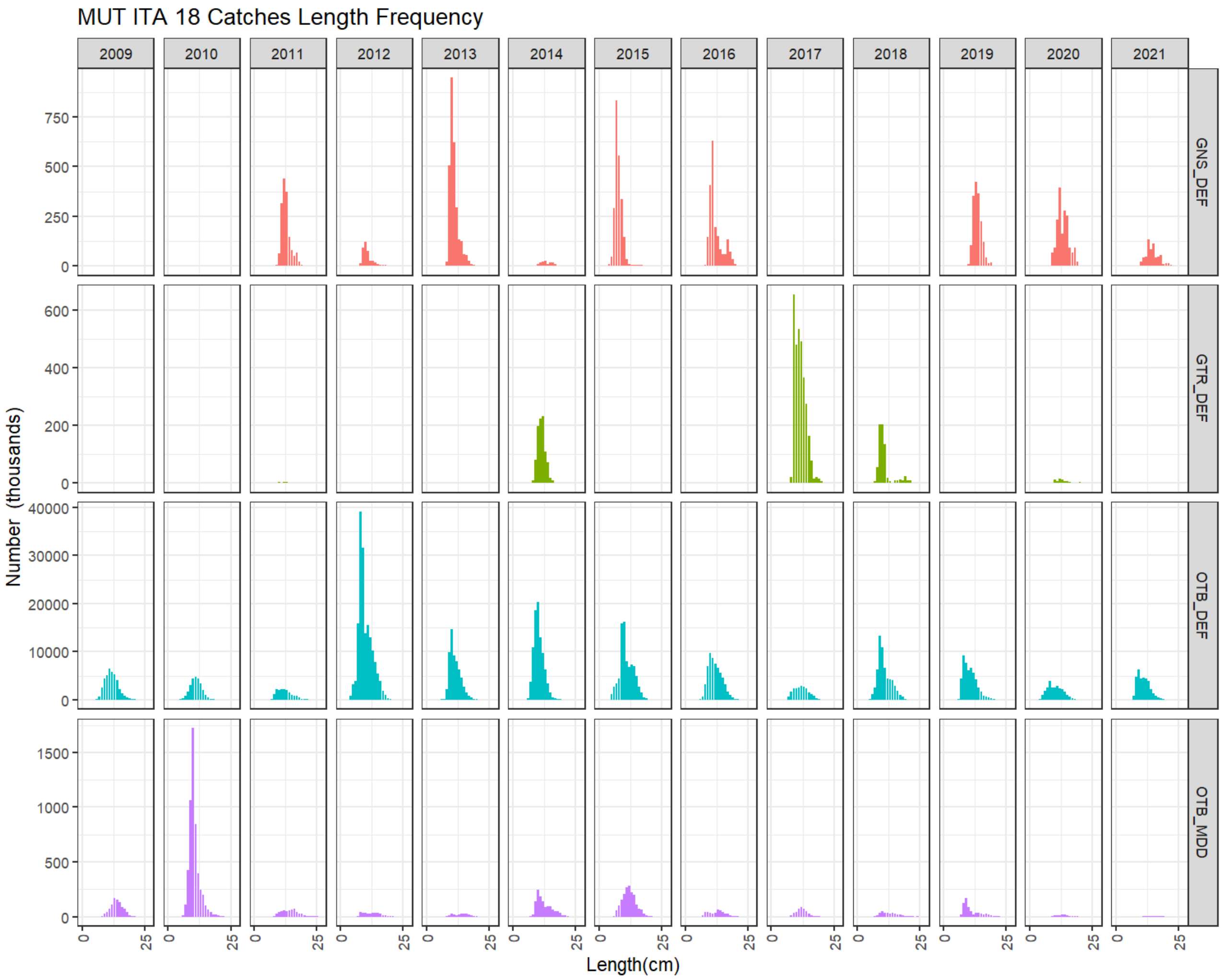


Figure 6.3.2.1.3 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 18, Italy

6.3.2.2 EFFORT

Red mullet in GSA 17 and 18 is exploited mostly by demersal trawlers, and to a lesser extent by gillnets and trammel nets. The effort data are available for GSA17 (Italy, Slovenia and Croatia) and 18 (Italy). Effort data for the Italian trawl fleet (OTB) in GSA17 and 18 since 2004 is available by fishery. Nominal effort data of Croatian trawlers cover the period 2012-2020 (Table 6.3.2.2.1). The temporal trend shows an increasing values in 2017 and 2018 which follows a reduction in the fishing days in 2019 and 2020 of the Italian trawl fleet and an increase in 2021 both in GSA 17 and GSA 18. The Croatian fleet effort was globally decreasing from 2014 with an increase in 2017, followed by a decrease until 2019 and a slight increase in 2020 and 2021. Effort data for Italy GSA 17 and 18 are reported in Table 6.3.2.2.2 and Table 6.3.2.2.3 respectively. Effort data for Slovenia GSA 17 is reported in Table 6.3.2.2.4.

Table 6.3.2.2.1 Red mullet GSA 17 and 18. Fishing days for Croatian OTB fishery by LOA.

Sum of fishing_days					
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2012	24	10846	17167	4694	2840
2013	25	10260	16885	5321	2992
2014	15	11246	16841	5316	2928
2015	4	10909	16672	4337	3019
2016	63	10488	16277	4887	2253
2017	16	11862	17218	4586	2067
2018		9961	17230	4176	1737
2019		9075	15579	4612	1731
2020		10170	16075	4151	1520
2021		10144	15646	4859	1751

Table 6.3.2.2.2 Red mullet GSA 17 and 18. Fishing days for Italian fleets in GSA 17 OTB by LOA.

Sum of fishing_days					
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2004		35665	52605	34338	10422
2005		10053	62455	36578	12588
2006	61	8067	56604	29437	9888
2007		6724	47688	30438	8945
2008		5525	44720	27977	8480
2009		7635	47220	28571	7618
2010		5952	41995	27106	7909
2011		5999	40792	26424	6971
2012		6048	34301	25466	4788
2013		6351	33282	22579	4081
2014		6220	33052	21194	6027
2015		2271	29582	25022	4422
2016		2758	29701	24561	4844
2017		6339	30074	30350	5616
2018		4951	34671	30788	5524
2019		3281	31403	24641	6585
2020		1332	27162	22414	5641
2021		1039	29153	24024	5943

Table 6.3.2.2.3 Red mullet GSA 17 and 18. Fishing days for Italian fleets in GSA 18 for OTB, GNS and GTR per LOA.

OTB Sum of fishing_days					
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2004		9008	51197	20024	6697
2005		4803	47330	16897	8179
2006		5550	52174	22181	4259
2007		3470	43555	19836	3819
2008		4743	45641	14282	4972
2009		5760	59695	14984	5410
2010		5197	48372	15105	4347
2011		3818	47116	13130	3589
2012		4583	44403	11501	2156
2013		5514	49028	12511	2241
2014		4060	33736	10182	1708
2015		4015	35442	10341	2204
2016		3650	37510	10889	1978
2017		4239	36248	10623	2108
2018		3343	42089	12670	1996
2019		1828	35764	10735	1844
2020		608	28042	9241	1618
2021		2032	29721	8587	1394
GNS Sum of fishing_days					
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2004		36337			
2005		39701			
2006	9225	34770	219		
2007	7976	24729			
2008	4645	22187			
2009	9680	32637			
2010	7610	22286			
2011	7351	19143			
2012	5684	11297			
2013	26097	33749			
2014	14048	7748			
2015	17567	26678			
2016	16503	25170			
2017	12013	5217	73		
2018	12917	21370	233		6
2019	10266	19843	157		
2020	4423	24873	97		
2021	9482	22001	153		

Table 6.3.2.2.4 Red mullet GSA 17 and 18. Fishing days for Slovenian OTB fleet in GSA 17 per LOA.

Fishing days					
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2005	4	358	469		
2006		356	607		
2007		343	858		1
2008		316	937		1
2009		229	976		
2010		305	958		
2011		270	908		
2012		124	793		
2013		183	554		
2014		183	482		
2015		171	499		
2016		265	512		
2017		194	503		
2018		201	491		
2019		205	564		
2020		293	586		
2021		200	593		

6.3.2.3 SURVEY DATA

MEDITS survey data are available from the official Data call for GSA 17 and for GSA 18 from 1994. All the Countries are covered by the survey data. From 2017 to 2019 the hauls in territorial waters of Albania and Montenegro were not carried out under the DCF, but under AdriaMed umbrella. In 2020 and 2021 they have not carried out. However, during the meeting the hauls carried out in territorial waters were used for the estimation of the indices, because the Countries made the data available in the previous meetings. Moreover, Croatia provided the MEDITS data from 1996 to 2001, which were not in the JRC database.

The long duration and the shift in the survey time in some years (Italy) may be critical for species such as red mullet, with a short spawning period, in late spring, and recruitment in autumn. Thus, in the years when the survey ends in summer, recruits will be absent or their presence very low, while when the survey ends in autumn recruits will be present (see Fig. 6.3.2.3.1).

All the surveys explored reveal a strong increase in the density and in the biomass indices (Figure 6.3.2.3.2) from 2012 onwards, with the 2020 quite stable and 2021 markedly increasing respect to 2019.

Figure 6.3.2.3.1 Red mullet in GSAs 17 and 18. MEDITS survey period over 1994-2021.

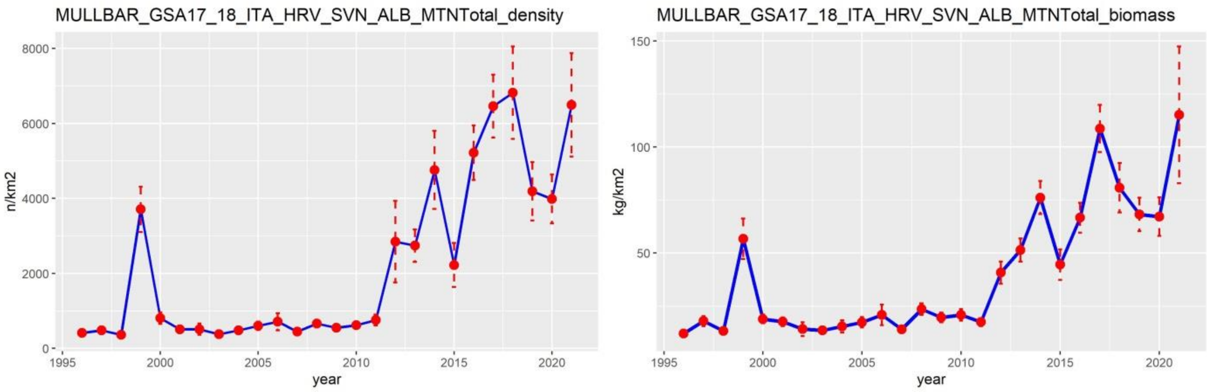


Figure 6.3.2.3.2 Red mullet in GSAs 17 and 18. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2021.

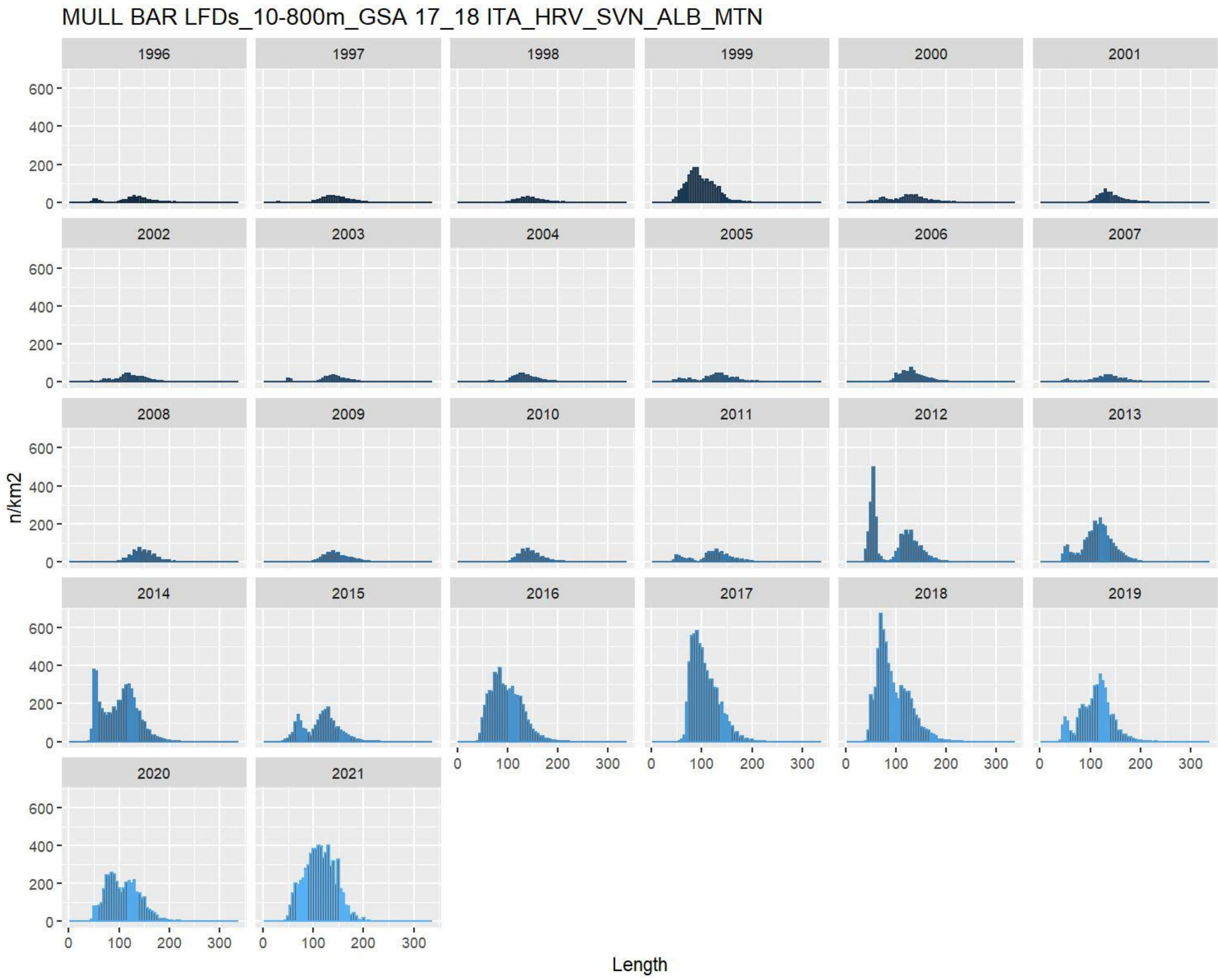


Figure 6.3.2.3.3 Red mullet in GSAs 17 and 18. MEDITS Length frequency distribution (TL mm; n/km2).

6.3.3 STOCK ASSESSMENT

It was not possible to achieve an agreed assessment at the EWG; the following section describes the issues found so far in the assessment.

Methods: SS3 (Stock Synthesis)

Following the work carried out during the GFCM benchmark session and according to what required in ToR 3 (further work on the assessment of red mullet in GSA 17-18, the Stock Synthesis (SS) model (Methot and Wetzel, 2013) was explored in view of contributing to the GFCM benchmark of this stock.

Stock Synthesis is programmed in the ADMB C++ software and searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian and MCMC methods. The assessment was conducted using the 3.30.20 version of the Stock Synthesis software under the Windows platform.

Base case model and improvement before the meeting

The runs carried out during the meeting built on the work performed under the ad hoc contract 2258. The hoc contract updated the dataset agreed during the GFCM benchmark session (https://gfcmsitestorage.blob.core.windows.net/website/5.Data/SAFs/DemersalSpecies/2020/SAF_MUT_GSA17-18_RefY2020.pdf) to 2021 and explored different model configurations, working on the base case model (developed during the benchmark). The main characteristics of the base case model are:

- one area, length-based with a population of 10+ age classes (with age 10 representing a plus group), modelled as sex combined.
- Annual time step, starting from 1972.
- Six commercial fleets with landings and discards separated: ITA OTB GSA 18, ITA NETS GSA 18, ITA OTB GSA 17 + SVN OTB GSA 17, HRV OTB GSA 17, ALB OTB GSA 18, MNE OTB GSA 18. Discards observation present only for ITA OTB GSA 17, ITA OTB GSA 18 and HRV OTB GSA 17, without discard reconstruction.
- One standardised biomass survey (MEDITS), with LFDs unstandardized.
- Fishing mortality modelled using a fleet-specific method. Option 5 was selected for the F report basis; this option corresponds to the simple unweighted average of the F of the age classes chosen to represent the Fbar (age 1-3).
- Spawning stock biomass estimated at the beginning of the year and considered proportional to fecundity. Recruitment assumed to be a single event at the beginning of the year, derived from a Beverton and Holt stock recruitment relationship with a steepness 0.7361 (using Myer's priors).
- Recruitment deviations estimated for 1996-2020 as main recruitment deviations and for the six preceding years as early recruitment deviations. Recruitment deviations were assumed to have a standard deviation (σR) of 1.2.
- Growth and natural mortality fixed as described in chapter 6.3.1.
- Fishery selectivity assumed to be length specific and time variant for the years in which LFDs for the specific fleets are available. The three fleets with discards available also have a retention time varying selectivity for discards. All commercial fleets' selectivity modelled as logistic with the exception of the NETS ITA GSA 18 which is modelled using a double normal selectivity.
- MEDITS selectivity time invariant and logistic.
- Age length keys included in the model and associated with ITA OTB GSA 18.
- Both LFDs and ALKs are weighted using the Francis method.

The base model results revealed several issues probably due to conflicts between different data sources as well as model misspecification in the case of some parameters. Specifically:

- In the runs when the model was left free to estimate the von Bertalanffy parameters, using ALK information, in some case the Linf estimated was lower than the value from Carbonara et. al (2018). The basis for Linf in SS3 is as the asymptote around which a distribution of lengths is expected, the basis from observed data may tend to relate to largest observed individuals. The underlying data need to be evaluated with respect to the relationship of Carbonara and appropriate priors included.

- A massive drop in SSB around the mid-1990s is present, revealing an issue in the model fitting in those years; this is due to the lack of LFD information, of any source, before 1996. The length distribution provided to the model are so different from the estimated ones before 1996, on the basis of the only catch, that the model assumes a sudden drop in the SSB with consequent extreme increase in F and a recruitment failure in order to reconcile the two sources of information. This could be evaluated by carrying out the assessment only for time period with LFD data to determine of the effect is supported by the first LFDs, or due to the model configuation. If this does not occur further constraints in the model could be considered.

- The fit of the MEDITS selectivity in the base case is questionable compared to all the other commercial fleets showing for MEDITS the full selections only around 30 cm.

The LFDs of the MEDITS survey are not fitted satisfactorily by the model due to the issue of the timing of the survey.

Despite passing the retrospective diagnostic, the predictive power of the base model was poor as shown by the MASE of the MEDITS and the forecast Mohn's Rho.

The ad hoc contract applied several modification to the base case model:

- o Settlement month set as 8 (August), according to the biology of the species;
- o Recruitment deviations were assumed to have a standard deviation (σR) of 0.9;
- o Von Bertalanffy parameters not fixed;
- o Selectivity logistic for NETS GSA 18, not being the LFDs of NETS very different from the one of OTB.

In the ad hoc it was attempted to split the information of the MEDITS survey into two surveys: MEDITS as biomass index for all the years when the survey was carried out within the protocol period and MEDITS2 as density index (because expected to inform the model about recruitment) in the other years (1999, 2002, 2014, 2016, 2017, 2018, 2019, 2020, 2021). The MEDITS LFDs were split accordingly. Moreover, it was attempted to fix the selectivity plateau of the two surveys, in order to facilitate the convergence. Some trials were made using the complete time series (from 1972) and the short one (from 1996), as during the benchmark. Finally NETS GSA 18 were aggregated to OTB18 to further simplify the model.

Despite some aspects were improved (e.g. reasonable fleets selectivity, more gradual drop in SSB, no recruitment failures, discard amount well estimated, acceptable composite LFDs fit), several outstanding issues still remained, as evident retrospective pattern, need to improve index fits (residual analysis shows trend in MEDITS mean length residuals and high residuals in age-length composition).

Work carried out during EWG 22-16

During EWG 22-16 additional modifications to the best model of the ad hoc contract were made:

- The MEDITS was unified and used as a biomass index;
- The selectivity of Albania and Montenegro was mirrored on the basis of Croatia;
- The time variant selectivity and retention were deleted;
- It was attempted to put a block in 2012 or 2015 (when the enforcement of controls in coastal areas are expected due to regulations).

The temporal coverage of the dataset used during the meeting is showed in Figure 6.3.3.1.

In Table 6.3.3.1 the runs carried out during the meeting were listed; all runs had the growth parameters free. Some runs explored a dome-shaped selectivity for OTB GSA 17 (Italy), on the basis of the higher concentration of smallest individuals in the catches and in the MEDITS, and time blocks for OTB 18 and OTB 17. However, when the time block on selectiviy was set, the model returned a shift backword of the length at first capture. This was not considered reliable, because, with the hypothesized enforcement of the controls on the coastal areas (that should protect juveniles), it is expected a shift forward at higher lengths.

A block on Log(R_0) (run 7) and on regime (run 8) were also explored, but the model shows an unreasonable increase in SSB and index, completely out of scale.

A block on MEDITS survey was finally attempted in 2012, assuming a different availability of the resource from 2012 (run 9). This run shows a better fitting of the index (Figure 6.3.3.6), acceptable LFDs fit and a more gradual decrease in SSB in 1990ies. The model seems to have still some problems in following the cohorts, showing some high residuals in the age-length composition at the smallest lengths (Figure 6.3.3.2).

The model estimates a size at first capture for the MEDITS of 13 cm before 2012 and of 6 cm from 2012, indicating a higher amount of recruits in the survey in recent years as observed. The selectivity of the fleets seem quite consistent with what is expected on the basis of observed LFDs. The results on the F show an increase in F respect to the historical part with a very high peak in 1994 (Figure 6.3.3.5). In the recent years the SSB is increasing and the F is decreasing.

Despite passing the retrospective diagnostic, the predictive power of the run 9 was still poor as shown by the MASE of the MEDITS and the forecast Mohn's Rho.

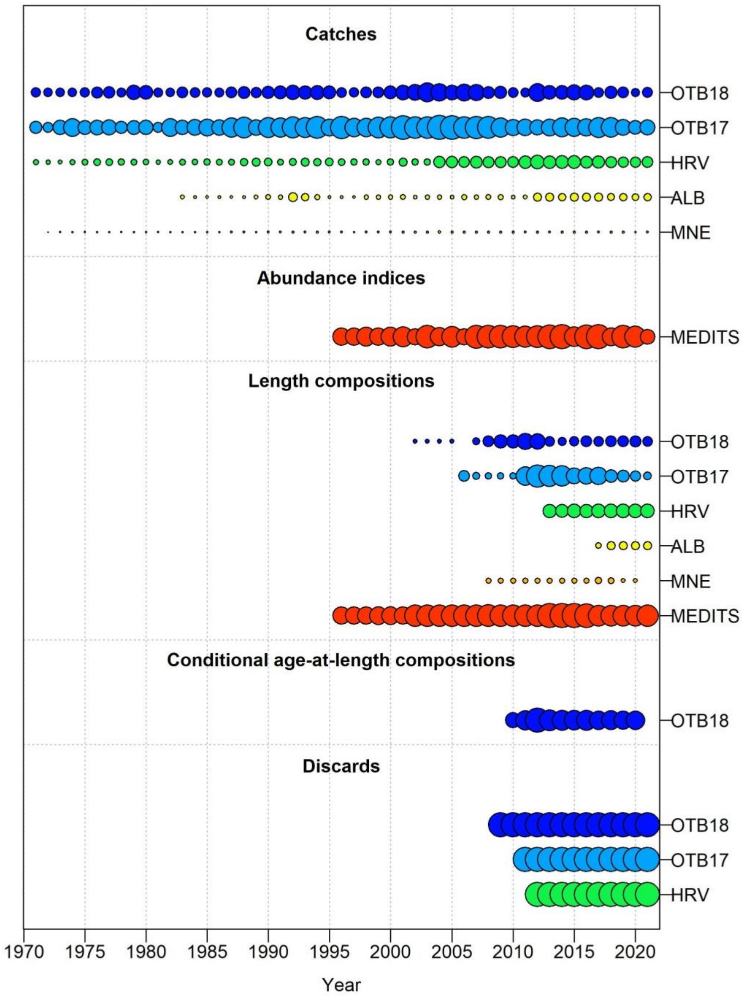


Figure 6.3.3.1 Coverage of the dataset used in EWG 22-16 for SS3 runs.

Table 6.3.3.1 SS3 runs carried out during the EWG 22-16.

Run	Growth	Selectivity	SRR	Outcome	Comment
1	free	all fleet free	all fixed except SR_LN(R_0)	unreasonable increase of SSB and index in last year; discard not well estimated; Linf=26	
2	free	block from 2015 on OTB18	all fixed except SR_LN(R_0)	unreasonable increase of SSB and index in last year; discard better estimated; Linf=22; shift back of the selectivity	based on run1
3	free	block from 2015 on OTB18 and OTB17	all fixed except SR_LN(R_0)	unreasonable increase of SSB;index in last year; discard not well estimated; Linf=26	based on run2
4	free	block from 2015 on OTB18; OTB17 dome-shaped with no block	all fixed except SR_LN(R_0)	unreasonable increase of SSB;index in last year; discard not well estimated; Linf=24; shift back of the selectivity	based on run2
5	free	block from 2012 on OTB18 and OTB17; OTB17 dome-shaped	all fixed except SR_LN(R_0)	unreasonable increase of SSB;index in last year; discard not well estimated; Linf=27; shift back of the selectivity	based on run3
6	free	all fleet free; OTB17 dome-shaped	all fixed except SR_LN(R_0)	catch penalty	based on run1
7	free	all fleet free; OTB17 dome-shaped	block in 2012 on SR_LN(R_0)	high gradient in all params. Different ln(R_0)) estimated in the blocks; Linf=30.5	based on run6
8	free	all fleet free; OTB17 dome-shaped	block in 2012 on SR_regime	unreasonable increase of SSB and index in last year; different sr_regime estimated in the blocks; Linf=23	based on run6
9	free	all fleet free; OTB17 dome-shaped; block on MEDITS selectivity in 2012	all fixed except SR_LN(R_0)	index better; SSB gradually increase in recent years. LFDs better. Linf=23.	based on run1

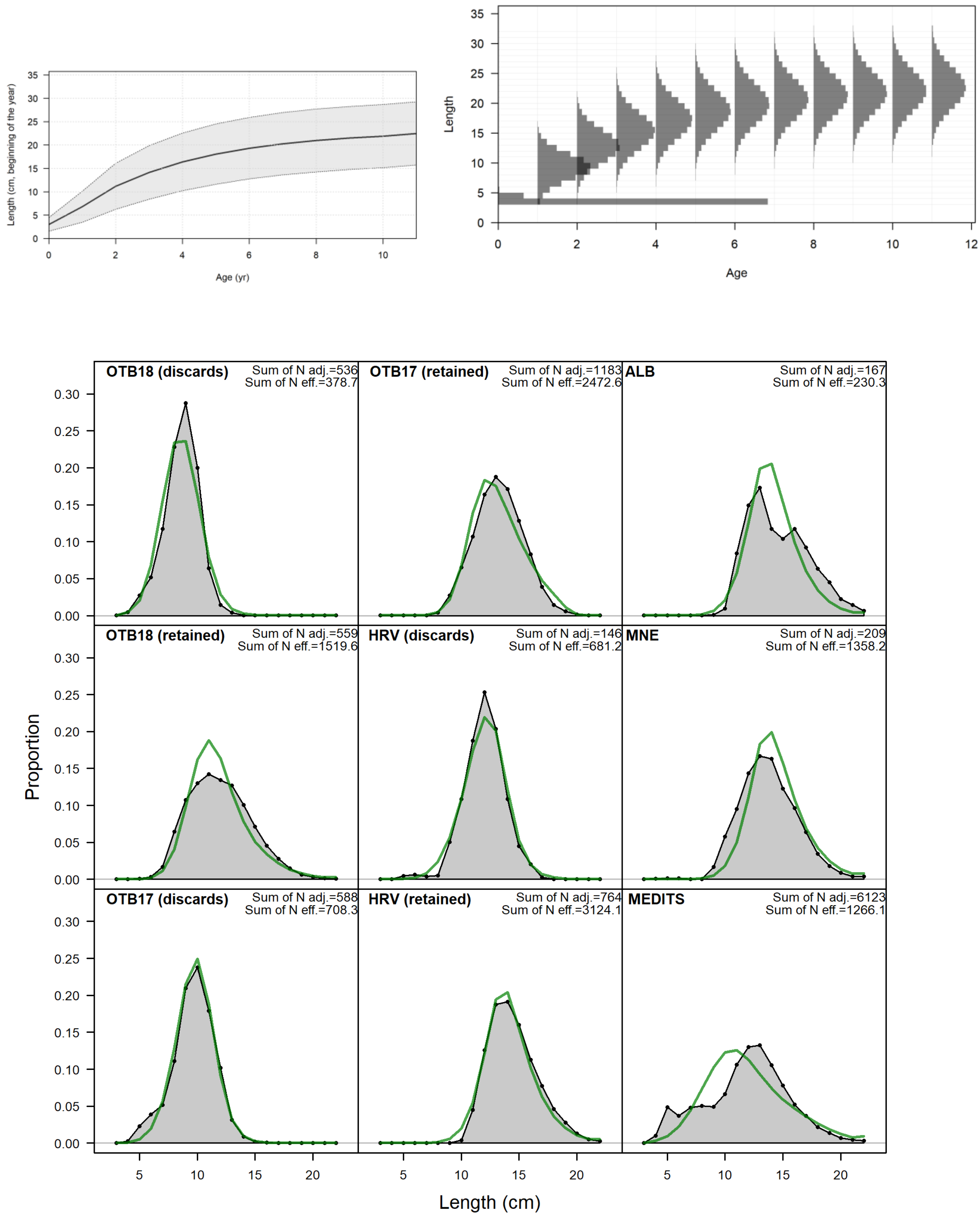


Figure 6.3.3.2 Growth curve, LFDs by age and LFDs fit by fleet in SS3 run 9.

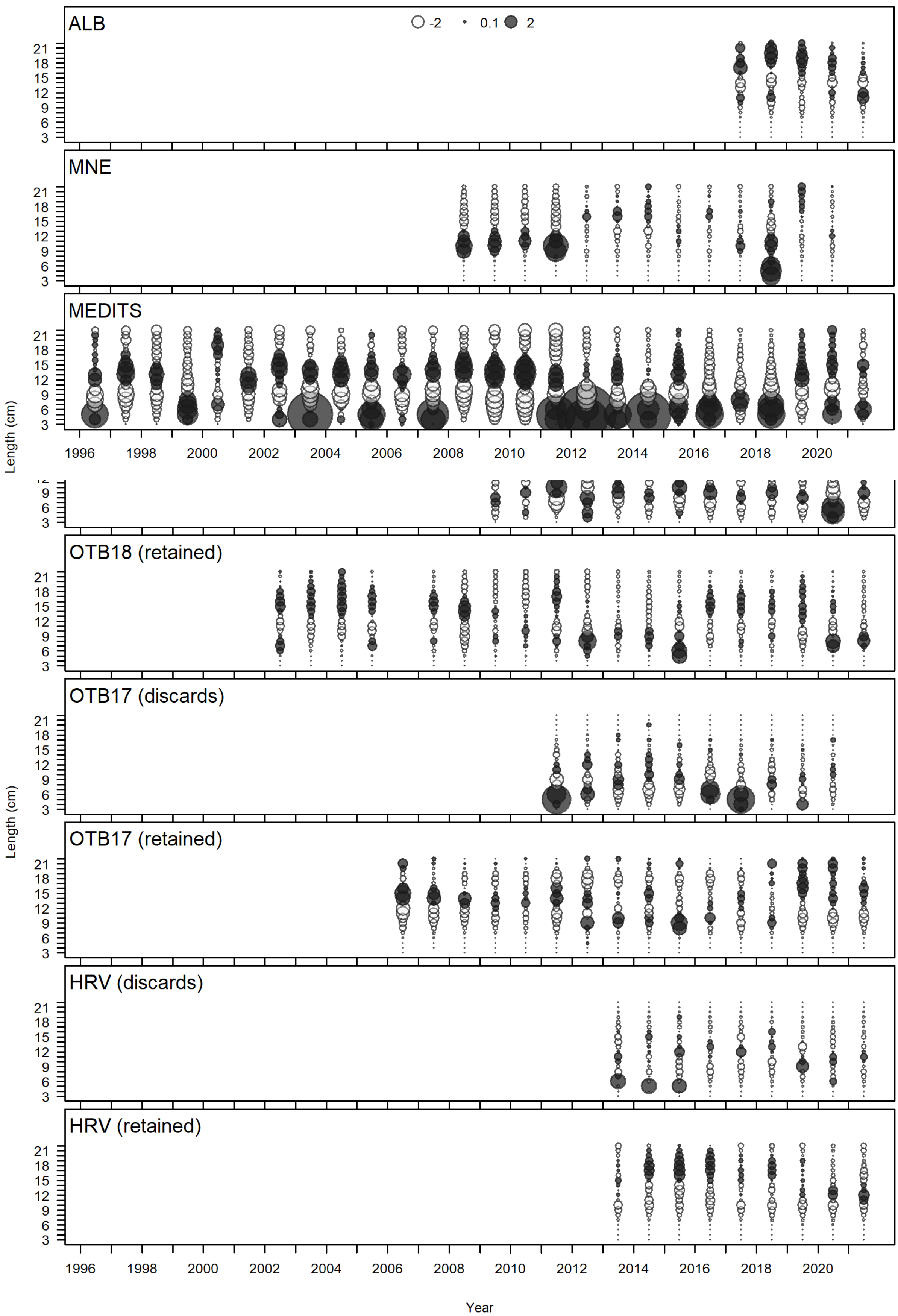


Figure 6.3.3.3 Residuals on LFDS by fleet in SS3 run 9.

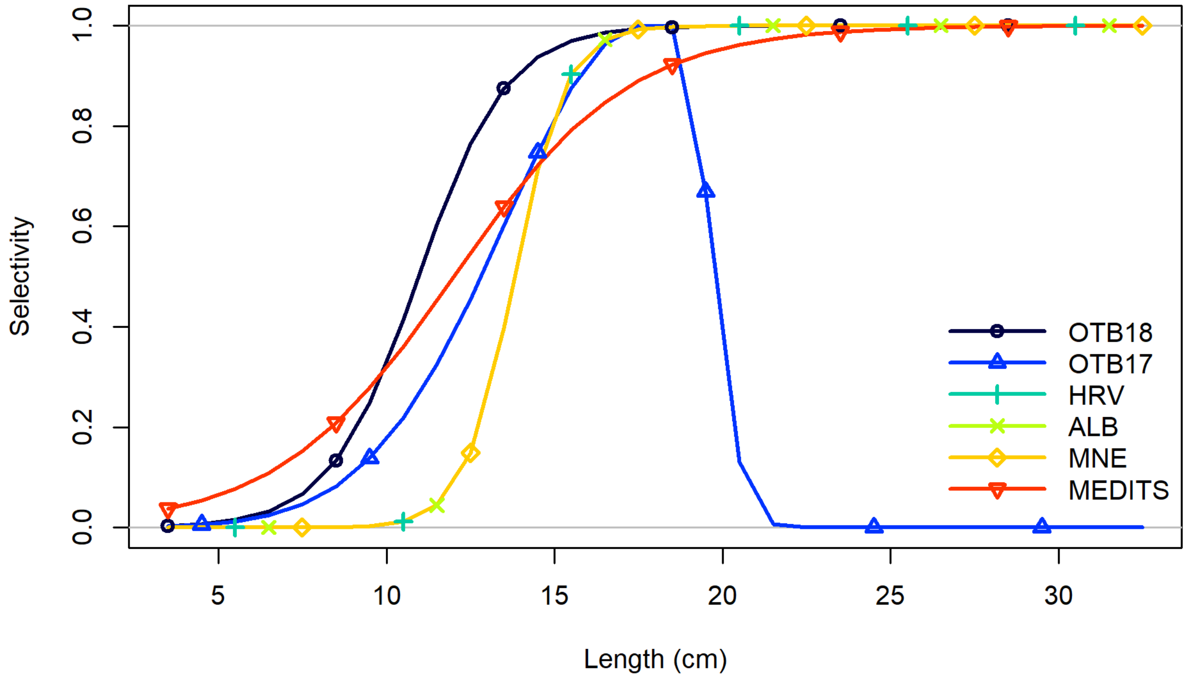
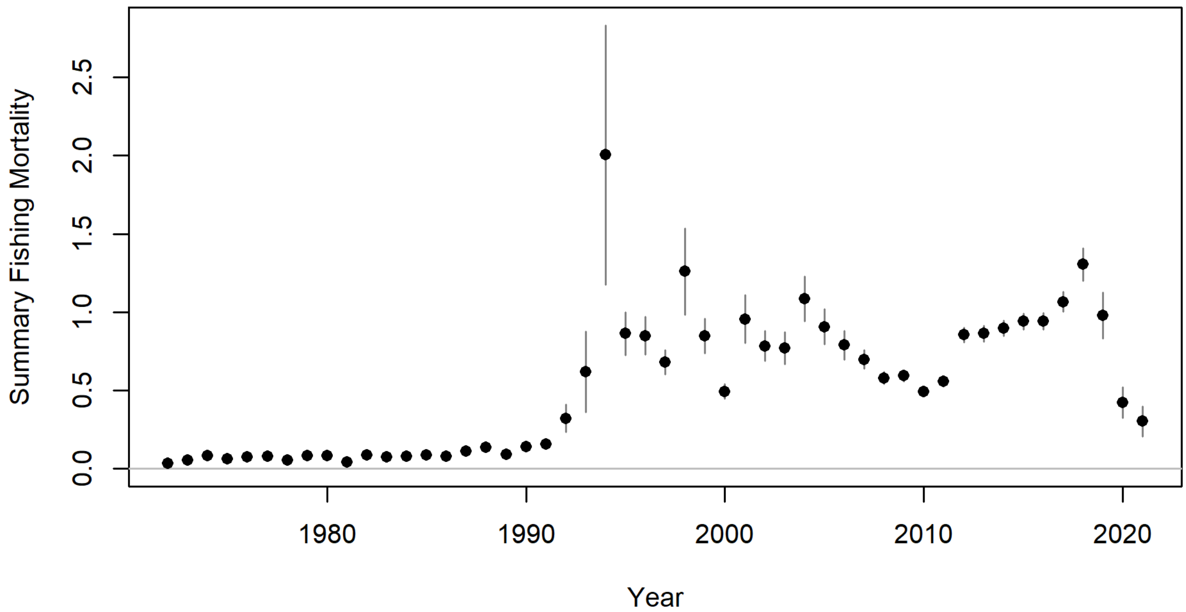


Figure 6.3.3.4 Selectivity by fleet in SS3 run 9. MEDITS selectivity if referred to the years until 2012.



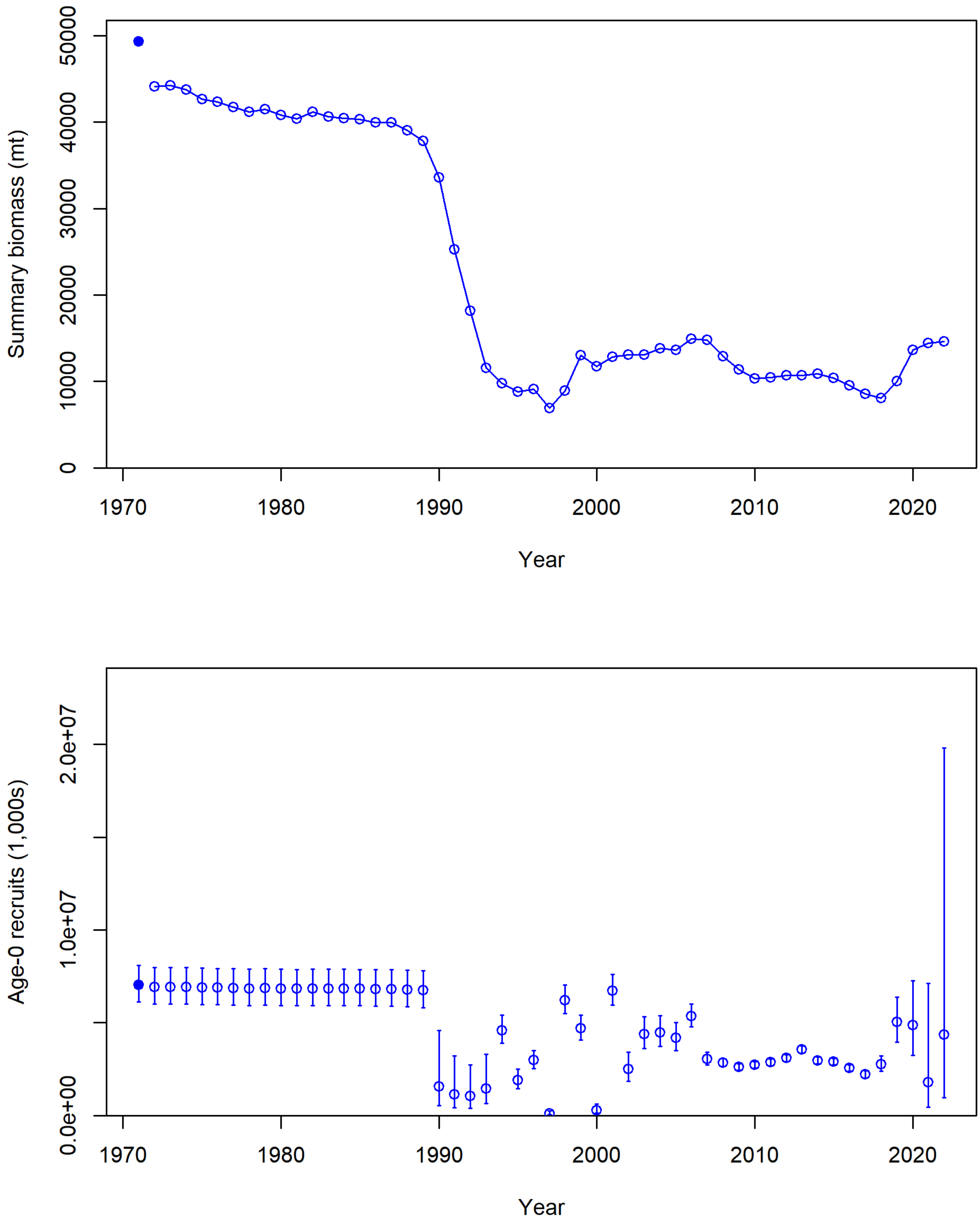


Figure 6.3.3.5 Time series of F, SSB and recruitment as estimated by run 9 of SS3.

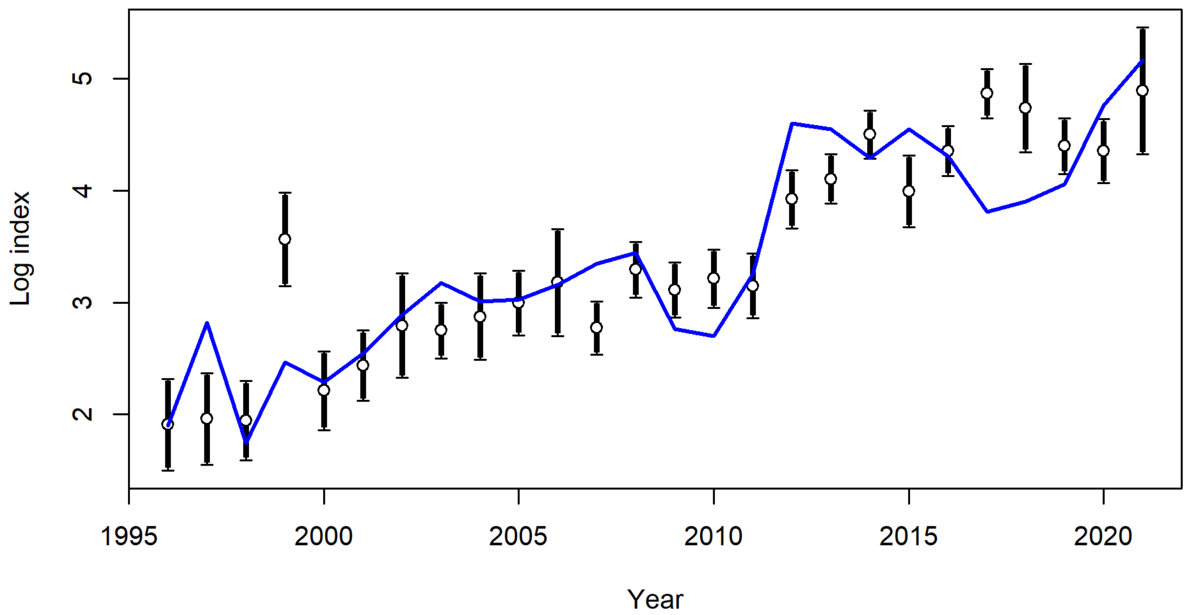


Figure 6.3.3.6 Fitting of the MEDITS biomass index in logarithmic scale (SS3 run 9).

Outstanding issues

Despite the block set in 2012 improves the fitting of the MEDITS biomass index, very high residuals are still present in the MEDTIS LFDs.

Some very low values in recruitment time series is still present, showing some issues in explaing the population dynamic in the years before DCF, that is the more data-rich period.

The period immediatey prior to first LFD data does not apear to have a good basis for the high F observed in 1994 (just before the first survey year), this is an important part of the dynamics that appears to be spurious.

The model seems to have still some problems in following the cohorts, showing some high residuals in the age-length composition at the smallest lengths.

Despite passing the retrospective diagnostic, the predictive power of the model is still poor especially when trying to fit index from MEDITS. However, this is to be expected if the survey fit is poor, and may reflect situsation where the model is much more dependent on catch than survey.

Further improvements to the model could be provided integrating the MEDITS standardized index and LFDs and, possibly, the historical information from Grund survey in GSA 17, as planned by the benchmarch roadmap.

6.3.4 Reference Points

No reference points have been estimated.

6.3.5 Short term Forecast and Catch Options

ICES framework for category 3 stocks was applied (rfb rule, method 2.1, ICES, 2022). A survey spawning biomass (TL>=12 cm) index was used as an indicator of stock development. The advice is based on the recent catches (from 2011, first more complete year in terms of discard), multiplied by the ratio of the mean of the last two index values (index A) and the mean of the three preceding values (index B), a ratio of observed mean length in the catch relative to the target mean length, a biomass safeguard, and a precautionary multiplier. The stability clause was considered but not applied since the change in catch is within the uncertainty cap.

Following the decision tree provided in the ICES technical guidance, given the availability of an index of abundance, of length data and a von Bertalanffy *k* between 0.2 and 0.3, the *rfb* rule is chosen to provide advice.

The *rfb* formula contains different factors to determine the catch in the advice year:

$$A_{y+1} = A_y \times r \times f \times b \times m$$

where the advised catch (*A*) for next year *y*+1 is based on the most recent year's advised catch A_y adjusted by the components in table 6.3.5.1. According to the guidelines, being the most recent realized catch (catch in 2021 = 3860 tonnes) very similar to the average of the last three years (3830 tonnes); the latter was used as A_y as the *rfb* rule is meant to adjust realised catches influencing the stock.

Table 6.3.5.1. Red mullet in GSAs 17 and 18. Components of the *rfb* rule.

Component	Definition	Description and use
A_{y+1}	$A_y \times r \times f \times b \times m$	The advised catch for next year *y*+1.
A_y		The most recent catch (average catch in 2019-2021).
r	$\frac{\sum_{i=y-2}^{y-1}(I_i/2)}{\sum_{i=y-5}^{y-3}(I_i/3)}$	The rate of change in the biomass index (I), based on the average of the two most recent years of data (*y*−2 to *y*−1) relative to the average of the three years prior to the most recent two (*y*−3 to *y*−5), and termed the "2-over-3" rule; *y* = 2022.
f	$\frac{\bar{L}_{y-1}}{L_{F=M}}$	The fishing proxy is the mean length in the observed catch ($\bar{L}_{y-1}$) relative to an MSY proxy length ($L_{F=M}$) and is meant to move the stock towards MSY. Only lengths above the length of first capture (L_c) are considered for $\bar{L}_{y-1}$. The target reference length is $L_{F=M} = 0.75L_c + 0.25L_\infty$, where L_c is defined as length at 50% of modal abundance (ICES, 2012, 2018). The reference length follows Beverton and Holt (1957), derived by Jardim et al. (2015), and assumes *M*/*k* = 1.5.
b	$\min\left\{1, \frac{I_{y-1}}{I_{\text{trigger}}}\right\}$	Biomass safeguard. Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{\text{trigger}} = 1.4I_{\text{loss}}$ such that b is set equal to $I_{y-1}/I_{\text{trigger}}$. When the most recent index data I_{y-1} is greater than I_{trigger}, $\boldsymbol{b}$ is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock. I_{trigger} may need to be adapted if the stock has been exploited only heavily or lightly in the past.
m	[0,1]	A tuning parameter to ensure that the rfb rule is precautionary (that risk does not exceed 5%). It does not decrease advice continuously but can be considered as adjusting the target in component *f*.

Component	Definition	Description and use
		m is linked to von Bertalanffy ***k*** and based on generic MSE simulations. May range from 0 to 1.0. Since ***k*** is between 0.2 and 0.3 ***m*** is 0.9
Stability clause	$min\{max(0.7A_y, A_{y+1}), 1.2A_y\}$	Asymmetric conditional uncertainty cap. Limits the amount the advised catch (A_{y+1}) can change upwards or downwards relative to the previous catch advice (A_y). The recommended values are +20% and −30%; i.e. the catch would be limited to a maximum 20% increase or a maximum 30% decrease relative to the previous year's advised catch. The stability clause does not apply when **b** < 1.

To obtain the *f* component of the *rfb* rule:

- First parameter, calculation of the length at first capture (L_c) by year, which is defined as the first length class where abundance is more than or equal to half of the maximum abundance. Length data from 2011 onwards was used, because the first more complete historical data in terms of landing + discard. L_c per year is shown in the table below.

year	Lc
2011	10
2012	8
2013	9
2014	9
2015	9
2016	9
2017	9
2018	8
2019	8
2020	10
2021	8

- Second parameter, the target reference length $L_{F=M} = 0.75L_c + 0.25L_{inf}$ is calculated per year and shown in the table below. We used as L_{inf} the female L_{inf} as reported in Table 6.3.1.1.

Year	$L_{F=M}$ (mm)
2011	14.9125
2012	13.4125
2013	14.1625
2014	14.1625
2015	14.1625
2016	14.1625
2017	14.1625
2018	13.4125
2019	13.4125
2020	14.9125
2021	13.4125

- Third parameter, the <u>mean length above L_c</u> is calculated.

Year	$L_{mean} > L_c$ (mm)
2011	12.67971322
2012	10.64627885
2013	12.39428072
2014	12.16775496
2015	12.19681403
2016	12.61401786
2017	12.62227164
2018	11.45517662
2019	12.20366359
2020	12.95234241
2021	11.83724892

- Fourth parameter, the quantity *f* is calculated as the ratio of the mean length above L_c and $L_{F=M}$. Calculations were done with unrounded values. For all years the fishing pressure proxy relative to the MSY proxy indicator ratio L_{mean} / $L_{F = M}$ (*f*) was smaller than 1 (figure 6.3.5.1).

Year	L_{mean} / $L_{F = M}$
2011	0.850274147
2012	0.793757976
2013	0.8751478
2014	0.859153042
2015	0.861204874
2016	0.89066322
2017	0.891246011
2018	0.854067222
2019	0.909872402
2020	0.868556071
2021	0.882553508

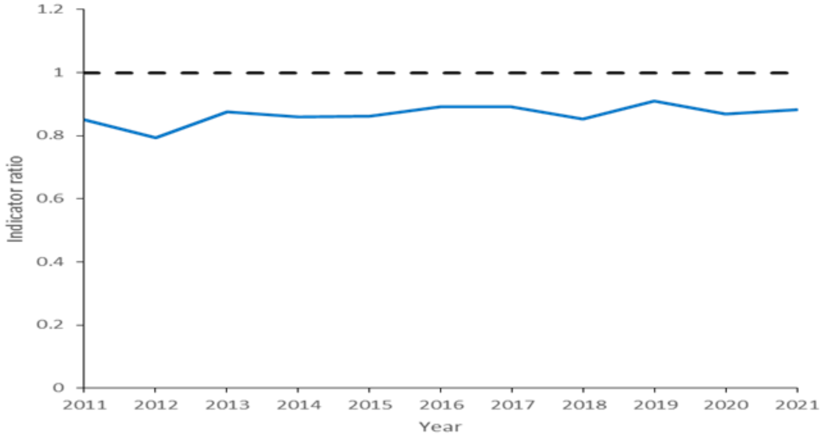


Figure 6.3.5.1. Red mullet in GSAs 17 and 18. Length indicator (mean length of fish in the catch divided by MSY proxy reference length). The exploitation status is above $F_{MSY\ proxy}$ when the indicator ratio value is lower than 1 (shown by the dashed line).

To obtain the *b* component of the *rfb* rule we defined the biomass index trigger value ($I_{trigger}$), defined as $I_{trigger} = I_{loss} \times 1.4$, where I_{loss} is the lowest observed historical biomass index value from 1996 MEDITS in GSAs 17 and 18 (Figure 6.3.5.2).

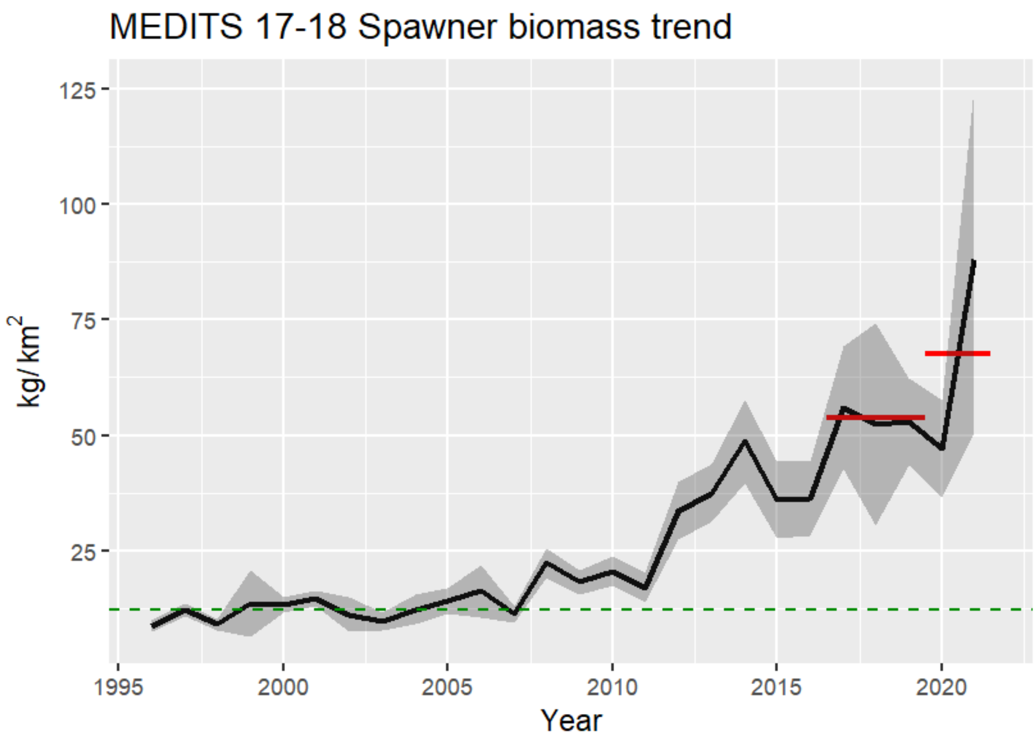


Figure 6.3.5.2. Red mullet in GSAs 17 and 18. MEDITS in GSAs 17-18 spawning biomass index. The green dashed line represents Itrigger. The two red segments represent the mean index of 2020-2021 and of 2017-2019.

The advice for 2023 was set using the *rfb* as outlined in the table below.

Table 6.3.5.2. Red mullet in GSAs 17 and 18. Basis for the catch scenarios. The figures in the table are rounded. Calculations were done with unrounded inputs, and computed values may not match exactly when calculated using the rounded figures in the table.

Last year catch C_{y-1} (average catch in 2019-2021)	3830 tonnes
Stock biomass trend	
Index A (2020, 2021)	67.6 kg / km^2
Index B (2017, 2018, 2019)	53.7 kg / km^2
r: Index ratio (A/B)	1.26
Fishing pressure proxy	
Mean catch length ($\bar{L}_{y-1}$=L_{2021})	11.83
MSY proxy length ($L_{F=M}$)	13.41
f: multiplier for relative mean length in catches ($\bar{L}_{y-1}$/ $L_{F=M\ 2021}$)	0.88
Biomass safeguard	
Last index value (I_{2021})	88 kg / km^2
Index trigger value ($I_{trigger}$=1.4*I_{loss})	12.21 kg / km^2
b: index relative to trigger value, min{I_{2021}/$I_{trigger}$, 1}	1
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability	
m: multiplier (generic multiplier based on life history)	0.9
rfb calculation*	
Uncertainty cap (+20%/-30% compared to C_{y-1}, only considered if b≥1)	Not applied
Discard rate	34%
Catch advice for 2023	3043 tonnes
% advice change**	-20.5%

* $C_{(y+1)}$ = C_y × r × f × b × m limited by stability clause if applicable.
** Advice value for 2023 relative to the catch in 2019-2021 (3830 tonnes).

Based on MSY considerations, STECF EWG 22-16 advises to decrease the total catch by 20.5% relative to the average catches in 2019-2021 equivalent to catches of no more than 3043 tons in 2023.

6.3.6 Data Deficiencies

The landings and LFDs of GSA 18 in 2013, 2019 and 2020 was not reported in the last Data call, while in the catch table the age distribution for 2021 was not available. Discards from Italy in GSA 17 from 2018 was reported by quarter, differently from the other years for which it was reported annually. The discard amount in all the quarters of 2018 and 2019 seems anomalously high, especially in the first and fourth quarter, when a high amount of red mullet discard is not expected, considering that the species recruits in the third quarter. In 2021 the Italian data for GSA 17 was reported only for the 4th quarter.

6.4 NORWAY LOBSTER IN GSAS 17 AND 18

Evaluations of Norway lobster in GSA 17 and 18 have been carried out at regional and sub area levels. The regional analysis is given in Section 6.4.3 where a SPiCT assessment is given with new data added. In response to concerns that the regional evaluation might be missing excess depletion in some areas, (Canu *et al* 2021) a four sub-area analysis of survey data was used to determine differences in local biomass and exploitation rates from 1994 to 2021. The analysis of sub-area survey biomass is given in Section 6.4.3.2. The overall results of these analyses are summarized in Section 6.4..3.3, and additional information for management is given in Sections 6.4.5 and summarized in Section 5.5 along with the regional catch advice.

6.4.1 STOCK IDENTITY AND BIOLOGY

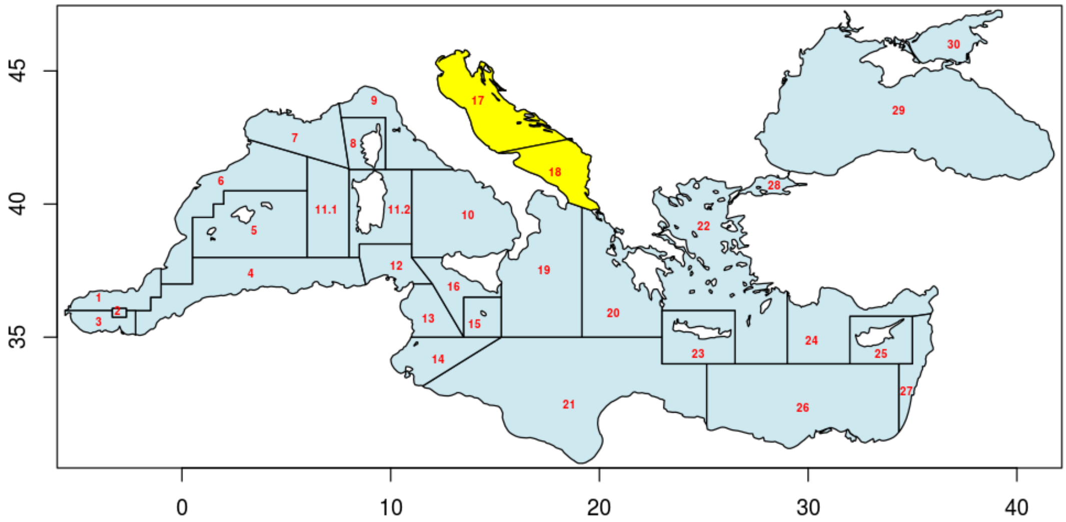


Figure 6.4.1.1 Norway lobster in GSA 17 and 18. Geographical location of GSAs 17-18.

The main biological traits of the species in the Adriatic have been discussed during the EWG 15-16, EWG 18-16, EWG 19-16, and revised during EWG 20-15 and EWG 21-15. We update the assessment using a different production model (SPICT) using MEDITS index only. The model converged, passed all the check sensitivity tests, and has presented a better stability without the two indices (Froglia and Pomo) used in the previous EWGs. The new SPiCT version 1.3.7 presents relevant improvements and more stability respect to previous versions.

In GSA 18 the stock is basically distributed on the continental slope, deeper than 200m depth, both on the eastern (Montenegro, Albania) and western side (Italy, Puglia) of the GSA. The distribution of nursery grounds and spawning areas has been analyzed during the EU project MEDISEH (MAREA tender project). In GSA 17 denser and persistent patches of small specimens occur in the Pomo Pit area (MEDISEH project report, 2013). Aggregations of adults were identified in GSA 17 offshore the SW coasts, in the Pomo Pit, and in north and south Croatian waters (Figure 6.4.1.2). In GSA 18 the more persistently abundant adult aggregations occur on the SE and SW edges of the South Adriatic Pit (Figure 6.4.1.3).

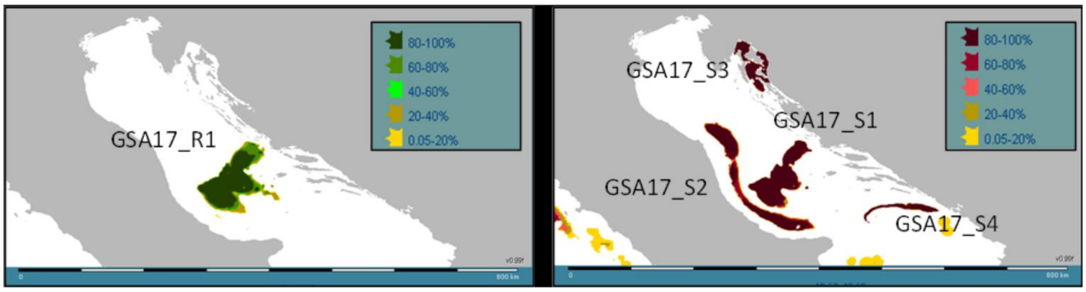


Figure 6.4.1.2 Norway lobster in GSA 17 and 18. Position of persistent nursery (left) and spawning areas (right) in GSA 17 as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

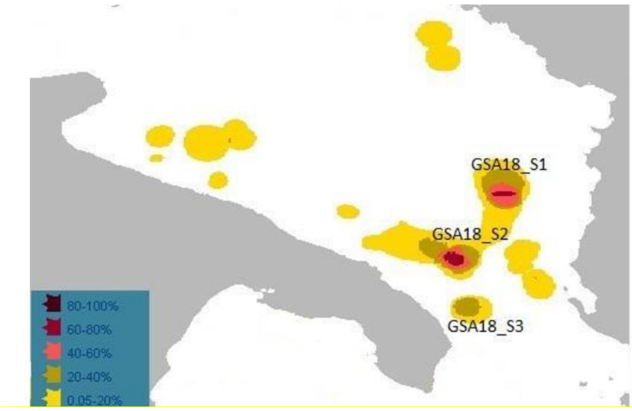


Figure 6.4.1.3 Norway lobster in GSA 17 and 18 Position of persistent spawning areas in GSA 18 of as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

6.4.2 Data

6.4.2.1 Catch (landings and discards)

No data were available for Slovenia because Norway lobster it isn't caught in Slovenian fishery grounds. In the following sections Croatian, Italian and Albania data in term of landings and discards in weight are reported. For Croatia and Italy available size distributions by gear are reported.

Landings

Landings in weight

Landings data by gear for Croatia were available for the period 2013-2021.

Table 6.4.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2021.

Gear	2013	2014	2015	2016	2017	2018	2019	2020	2021
FPO	0	18	33.8	33.6	40.7	48.2	50.7	48.2	74.34
OTB	278.167	325	269	203	159	183	214	188	175.41
Total	278.167	343	302.8	236.6	199.7	231.2	264.7	236.2	249.75

Table 6.4.2.1.2 Norway lobster in GSA 17 and 18. Proportion of Croatian landings data by gear for the period 2013-2021.

Gear	2013	2014	2015	2016	2017	2018	2019	2020	2021
FPO	0.00	0.05	0.11	0.14	0.20	0.20	0.19	0.20	0.30
OTB	1.00	0.95	0.89	0.86	0.80	0.80	0.81	0.80	0.70

Otter trawler (OTB) represents the most important gear in catching Norway Lobster, by Croatia though the relative importance of traps and pots (FPO) increase in time.

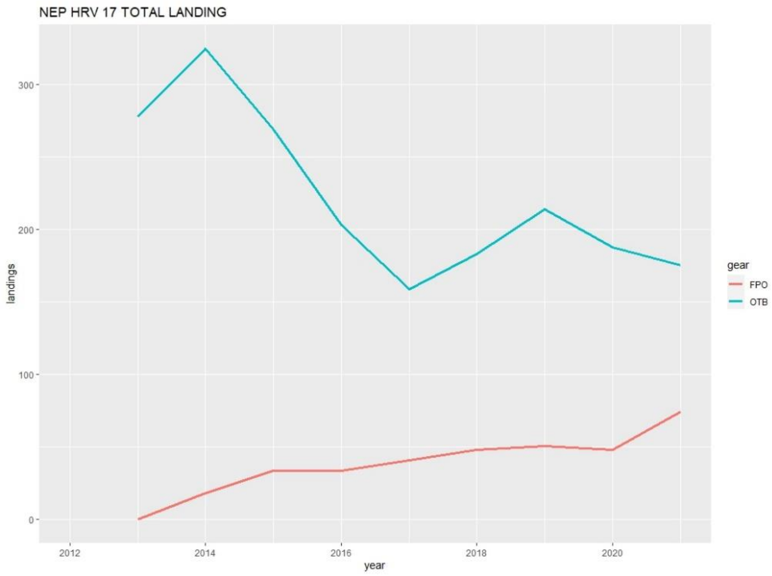


Figure 6.4.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2021 for GSA 17.

Landings data by gear for Italy (GSA17) were available for the period 2006-2021.

Table 6.4.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2021.

Total landings in weight (tonnes)	
Year	OTB
2006	1462
2007	1259
2008	1270
2009	1379
2010	1216
2011	937
2012	802
2013	607
2014	536
2015	457
2016	362
2017	288
2018	388
2019	393
2020	244
2021	285

Otter trawler (OTB) is the only gear catching Norway Lobster in the GSA17 Italian side. There is a clear decreasing trend in the landings from almost 1500 tonnes in 2006 to just below 300 tonnes in 2021.

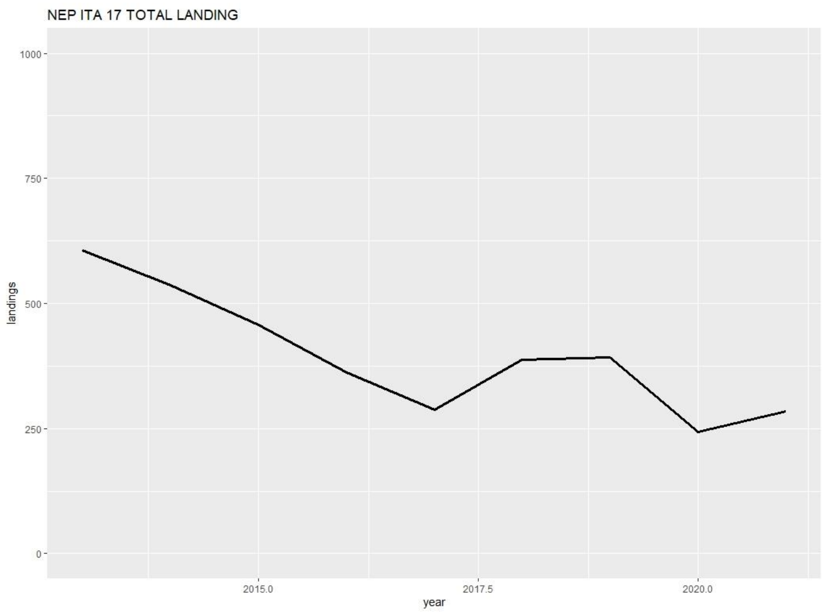


Figure 6.4.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2021.

Table 6.4.2.1.4 Norway lobster in GSA 17 and 18. Italian (GSA18) landings (t) by gear for the period 2002-2021.

Year	-1	GNS	OTB	Total
2002	36.317		442.156	478
2003	141.766	5.528	1039.255	1187
2004			1218.43	1218
2005		2.274	1196.402	1199
2006	0.477	9.551	1436.62	1447
2007		14.743	1299.891	1315
2008		9.836	1003	1013
2009			1093	1093
2010			1023	1023
2011			759	759
2012			459	459
2013			834	834
2014			445	445
2015			443	443
2016			395	395
2017			556	556
2018			648	648
2019			376	376
2020			160	160
2021			121	121

Table 6.4.2.1.5 Norway lobster in GSA 17 and 18. Proportion of Italian (GSA18) landings data by gear 2002-2021.

Year	-1	GNS	OTB
2002	0.076	0.000	0.924
2003	0.119	0.005	0.876
2004	0.000	0.000	1.000
2005	0.000	0.002	0.998
2006	0.000	0.007	0.993
2007	0.000	0.011	0.989
2008	0.000	0.010	0.990
2009	0.000	0.000	1.000
2010	0.000	0.000	1.000
2011	0.000	0.000	1.000
2012	0.000	0.000	1.000
2013	0.000	0.000	1.000
2014	0.000	0.000	1.000
2015	0.000	0.000	1.000
2016	0.000	0.000	1.000
2017	0.000	0.000	1.000
2018	0.000	0.000	1.000
2019	0.000	0.000	1.000
2020	0.000	0.000	1.000
2021	0.000	0.000	1.000

For Italy the most important gear is OTB with lowest proportion of 87%) Very few catches derived from gillnet (GNS) in 2003, 2005, 2006, 2007 and 2008 and from an undefined gear in 2002-2003.

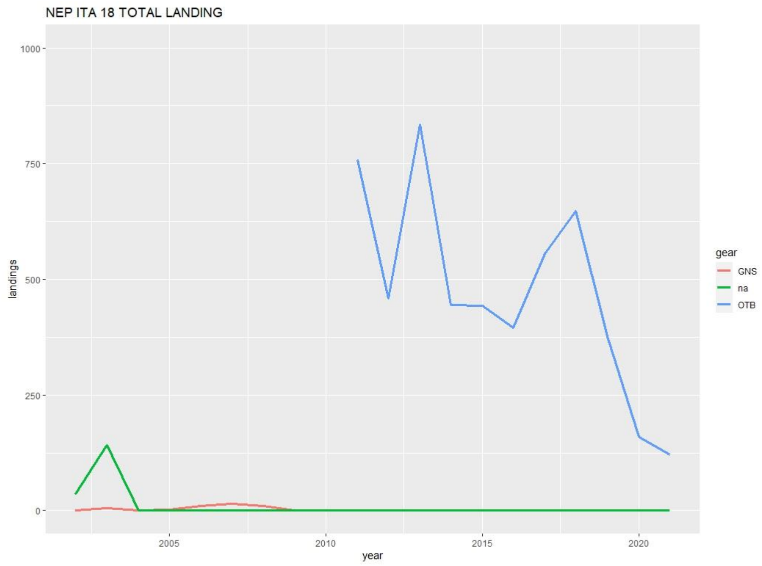


Figure 6.4.2.1.4 Norway lobster in GSA 17 and 18. Italian (GSA18) landings data by gear for the period 2002-2021.

For Albania landings were available from 2012-2021.

Table 6.4.2.1.6 Norway lobster in GSA 17 and 18. Albanian (GSA18) landings data for the period 2012-2021.

Albania_GSA18_NEP_Landings

Year	Tonnes
2012	435
2013	398
2014	400
2015	405
2016	411
2017	389
2018	257
2019	213
2020	194
2021	211

Size distributions of the landings

The size distribution is given in Figures 6.4.2.1.4-6

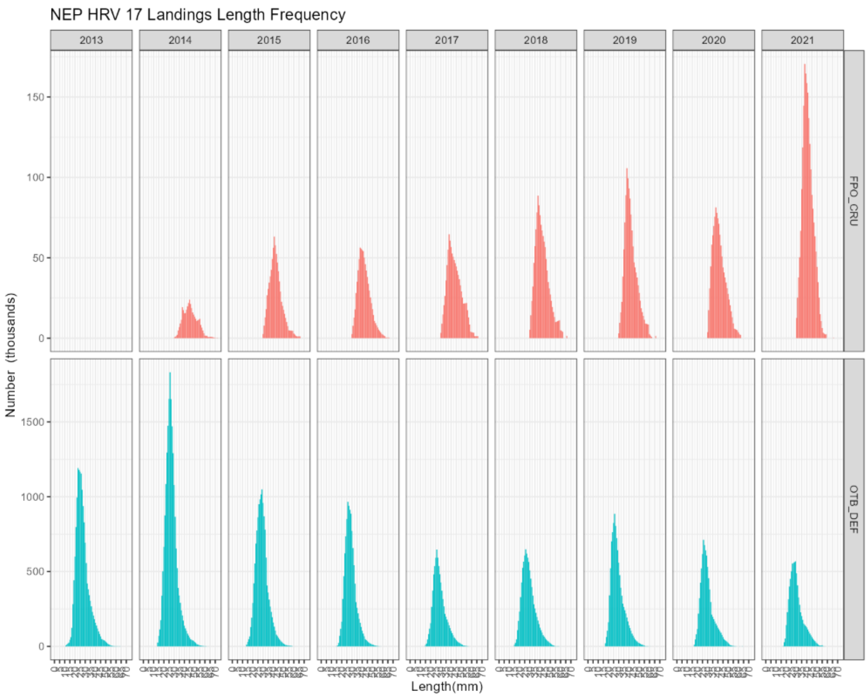


Figure 6.4.2.1.5 Norway lobster in GSA 17 and 18. Length frequency distributions of the Croatian landings by gear in the period 2013-2021.

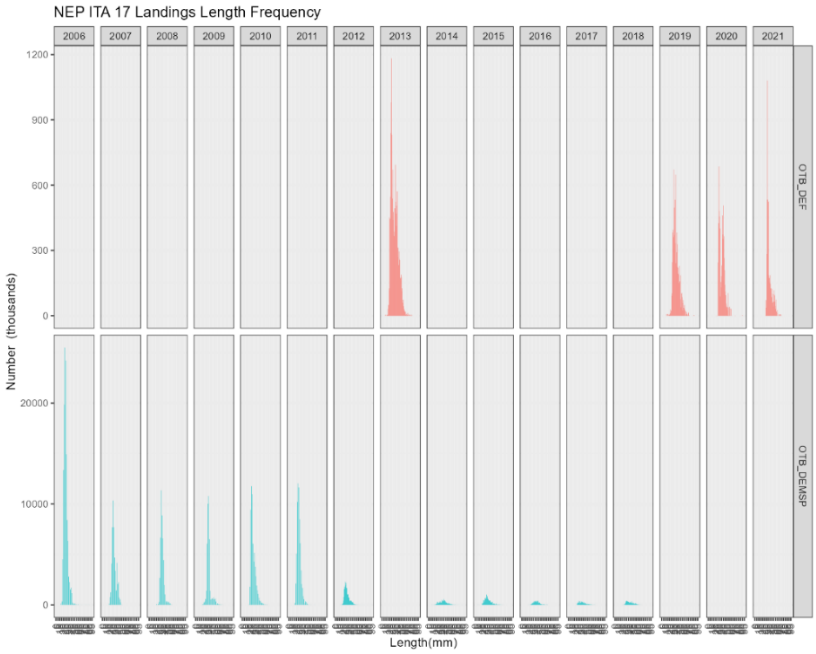


Figure 6.4.2.1.6 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA17) landings by gear in the period 2006-2021

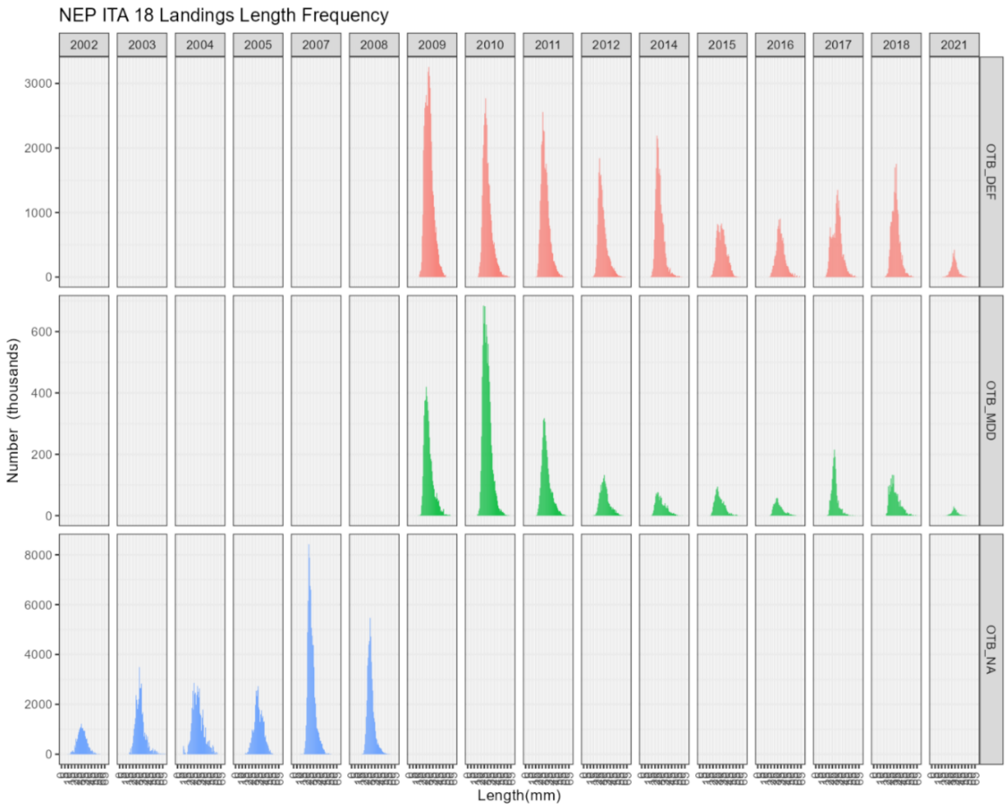


Figure 6.4.2.1.7 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA18) landings by gear in the period 2002-2021.

DISCARDS

This species is rarely discarded. OTB is the only gear in which discards was observed in all the areas.

Discards in weight

Discards data by gear for Croatia were available for the period 2013-2021.

Table 6.4.2.1.7 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2013-2021.

Total discards in weight (tonnes)

Gear	2013	2014	2015	2016	2017	2018	2019	2020	2021
OTB	0.275	0.145	0.171	0.047	0.164	0.582	1.94	0.281	0.74

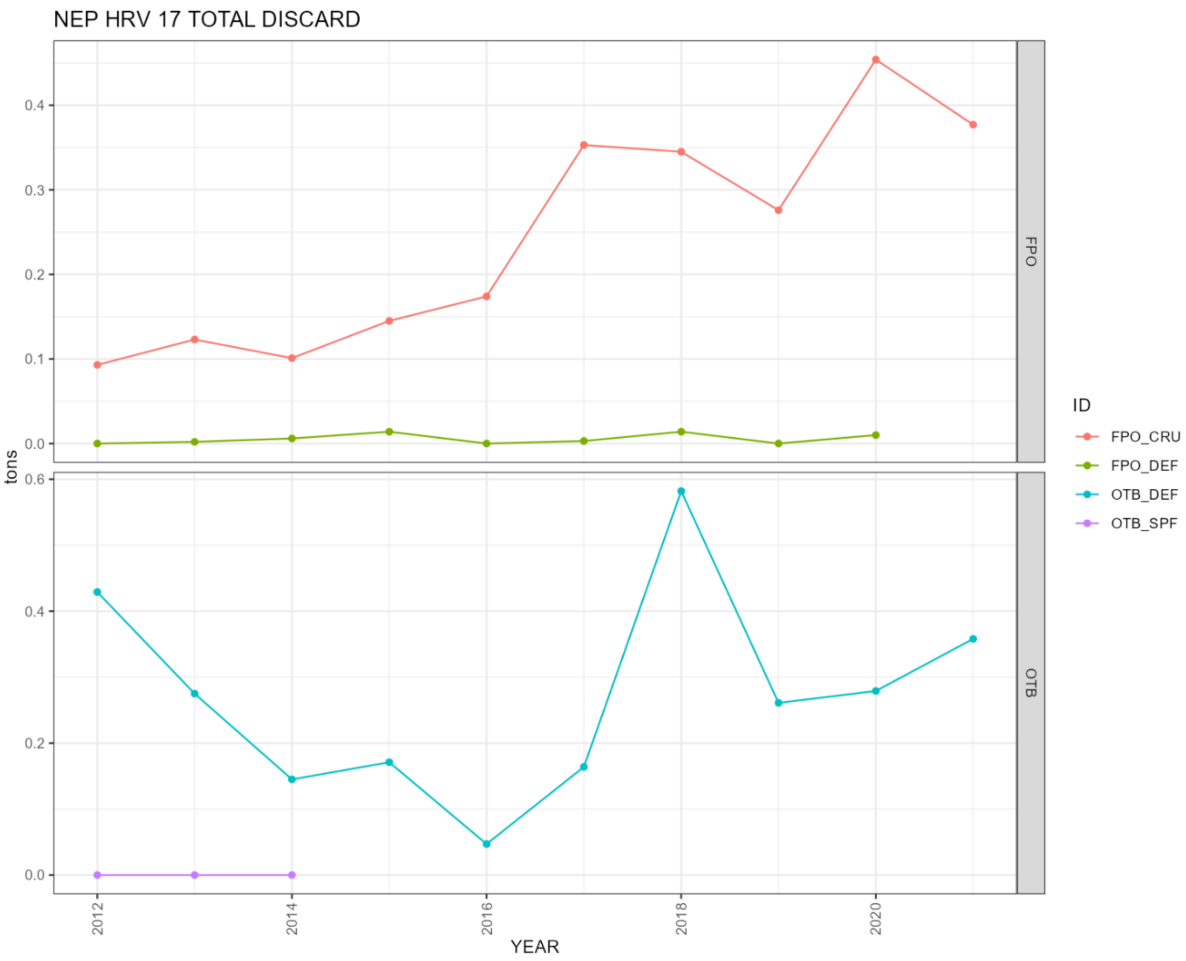


Figure 6.4.2.1.8 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2012-2021.

In Italy (GSA17) discarding was observed only in 2011 (4.92 tonnes OTB) and 2018 (61 tonnes).

Table 6.4.2.1.8 Norway lobster in GSA 17 and 18. Italian (GSA18) discards data by gear for the period 2009-2021.

Total discards in weight (tonnes)

Year	OTB
2009	66.77
2010	6.23
2011	0.83
2012	3.99
2013	2.27
2014	2.51
2015	2.27
2016	3.28
2017	0.05
2018	27.2
2019	11.3
2020	6.33
2021	0

Discards values were always very low aside in the 2009 (66 tonnes).

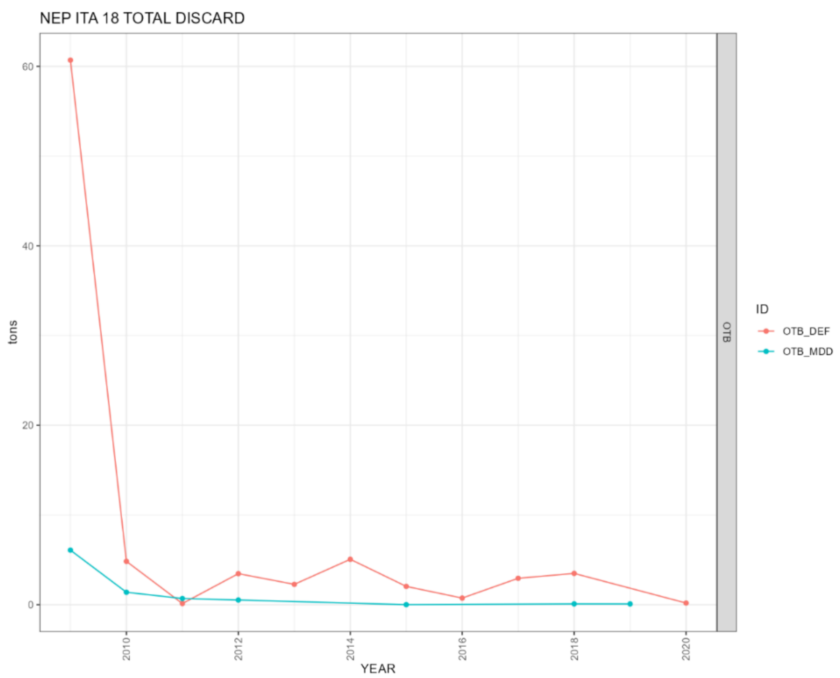


Figure 6.4.2.1.9 Norway lobster in GSA 17 and 18. Italian (GSA18) discards data by gear for the period 2009-2020.

Size distributions of the discards

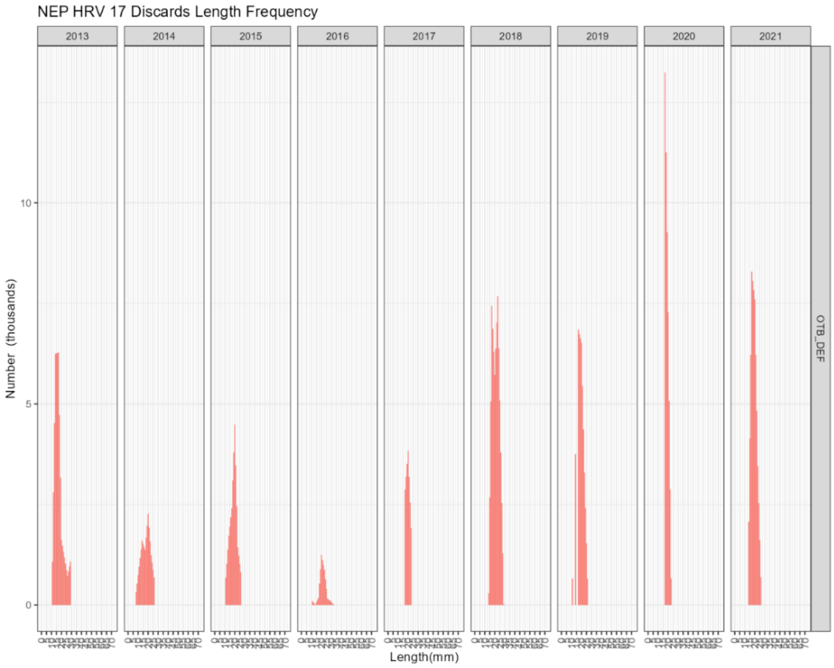


Figure 6.4.2.1.10 Norway lobster in GSA 17 and 18. Length frequency distribution of the Croatian discards by gear in the period 2013-2021.

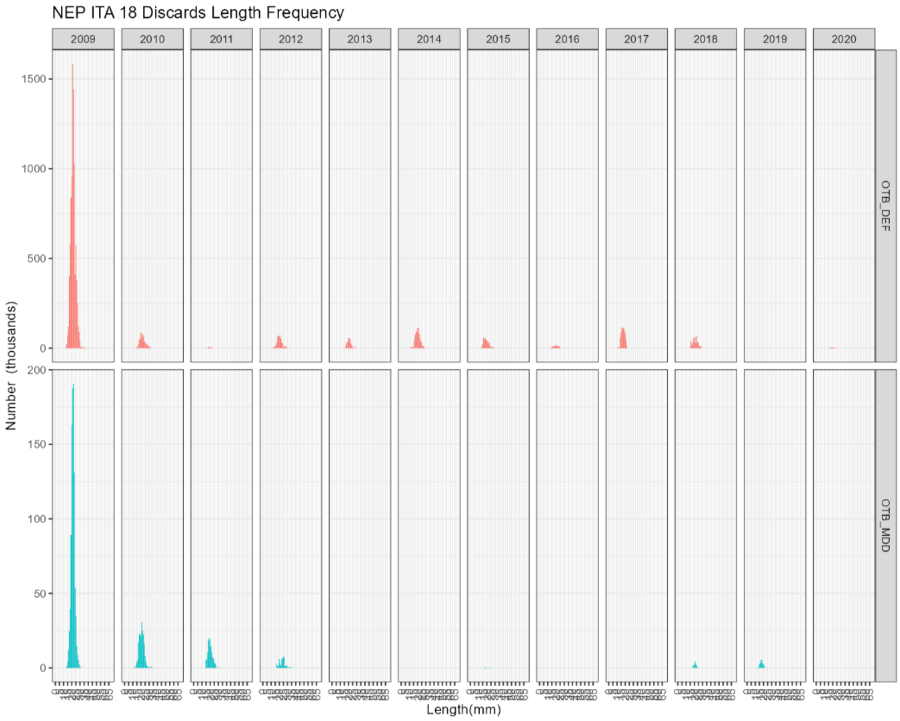


Figure 6.4.2.1.11 Norway lobster in GSA 17 and 18. Length frequency distribution of the Italian (GSA18) discards by gear in the period 2009-2020.

In the production model (SPICT) landings series was updated according to revised Albanian landings (2012-2021) and to Italian and Croatian DCF landings (2006-2021).

In the analytical assessment both data in landings and discards available from 2006 onward were used. Catches data were computed according to both (Table 6.4.2.1.9 and Figure 6.4.2.1.11).

Table 6.4.2.1.9 Norway lobster in GSAs 17 and 18. Landings and discards data by GSA for the period 2006-2021.

	ITA17		HRV17		ITA18		ALB18	GSA17_18			
year	landings	discards	landings	discards	landings	discards	landings	**Total landings**	**Total discards**	**Total catches**	%discards
2006	1462	0	223	0	1447	0	0.00	**3132**	**0.00**	**3132**	0
2007	1259	0	198	0	1315	0	0.00	**2772**	**0.00**	**2772**	0
2008	1270	0	201	0	1013	0	0.00	**2484**	**0.00**	**2484**	0
2009	1379	0	371	0	1093	**67**	0.00	**2843**	**67**	**2909**	2.30
2010	1216	0	328	0	1023	6	0.00	**2567**	**6**	**2574**	0.24
2011	937	5	284	0	759	1	0.00	**1980**	**6**	**1986**	0.29
2012	802	0	260	0	459	4	435	**1955**	**4**	**1959**	0.20
2013	607	0	278	0	834	2	398	**2117**	**2**	**2117**	0.12
2014	536	3	344	0	445	d5	400	**1725**	**8**	**1738**	0.30
2015	457	2	303	0	443	2	405	**1608**	**4**	**1618**	0
2016	362	3	237	0	395	1	411	**1405**	**4**	**1417**	0
2017	288	0	201	1	556	3	389	**1434**	**4**	**1438**	0
2018	388	27	232	1	651	4	257	**1528**	**32**	**1559**	0.02
2019	393	11	266	1	376	0	213	**1248**	**12**	**1269**	0.01
2020	244	6	238	1	161	9	194	**837**	**16**	**843**	0.02
2021	285	0	250	0.74	130	0	211	**876**	**0.74**	**877**	0

In red are reported Croatian landings data extracted from FishStatJ FAO database.

6.4.2.2 Effort

Norway lobster in GSAs 17 and GSA 18 is exploited mostly by bottom trawlers. A small amount of catch is produced by small-scale vessels using traps in the northern-eastern Adriatic channels as well as by gillnetters in GSA 18. For this fleet Norway lobster is a minor by-catch of boats targeting hake on the continental slope. Effort data for the Italian trawl fleet (OTB) in GSA18 is available since 2002, in GSA17 since 2004 whereas nominal effort data of Croatian trawlers cover the period 2012-2021 (Table 6.4.2.2.1-3, Figure 6.4.2.2.1). The temporal trend shows an increasing value in 2018 which follows a relevant reduction in the nominal effort (KW*fishing days) of the Italian trawl fleet both in GSA 17 and GSA 18. The Croatian fleet effort was quite stable in the last three years. Effort data until 2014 are consistent with previous assessment; from 2015 to 2021 the data have been updated from FDI database.

Table 6.4.2.2.1 Norway lobster in GSA 17 and 18. Nominal effort in fishing days for Croatian (GSA17) FPO and OTB fleets.

Year	FPO	OTB
2012	18770	35572
2013	18923	35492
2014	16856	37229
2015	17271	36375
2016	18565	33803
2017	18011	34772
2018	21410	32656
2019	27094	30516
2020	24965	31269
2021	32873	32400

Table 6.4.2.2.2 Norway lobster in GSA 17 and 18. Nominal effort in fishing days for Italian (GSA17) OTB fleet.

Year	OTB
2004	133030
2005	121674
2006	104056
2007	93795
2008	86701
2009	91044
2010	82962
2011	80187
2012	70603
2013	66522
2014	66076
2015	61257
2016	61714
2017	72332
2018	76097
2019	70231
2020	55901
2021	60159x

Table 6.4.2.2.3 Norway lobster in GSA 17 and 18. Nominal effort in fishing days for Italian (GSA18) OTB fleet.

Year	OTB
2004	86925
2005	77209
2006	84163
2007	70680
2008	69639
2009	85850
2010	73021
2011	67654
2012	62644
2013	69292
2014	49549
2015	52003
2016	54028
2017	53217
2018	60215
2019	51818
2020	39490
2021	41734

6.4.2.3 SURVEY DATA

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were carried out yearly (May - July), 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 (Figure 6.4.2.3.1). 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 used throughout the time series. 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 and weight per surface unit) were standardized to square kilometre, using the swept area method. Abundance and biomass indices were recalculated, based on the DCF data call.

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Only hauls noted as valid were used, including stations with no catches (zero catches are included). Data were analysed using the JRC script (Mannini, 2020)

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 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

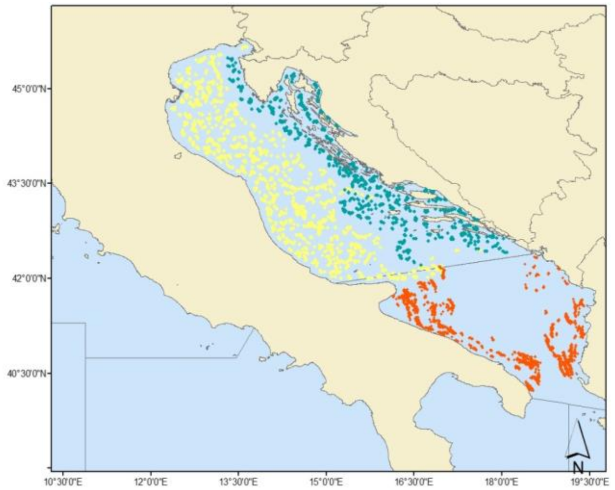


Figure 6.4.2.3.1 Norway lobster in GSA 17 and 18. MEDITS trawl survey, distribution of the hauls carried out in the area.

Trends in abundance and biomass

Abundance and biomass indices of MEDITS display a decreasing temporal trend in GSA 17 and 18 with abundance decreasing of about 10 times since '90s in the Italian side (Figure 6.4.2.3.2). The pattern is slightly different in Croatian waters the early decline is also seen but where the indices show a modest increase since 2012 (Figure 6.4.2.3.3).

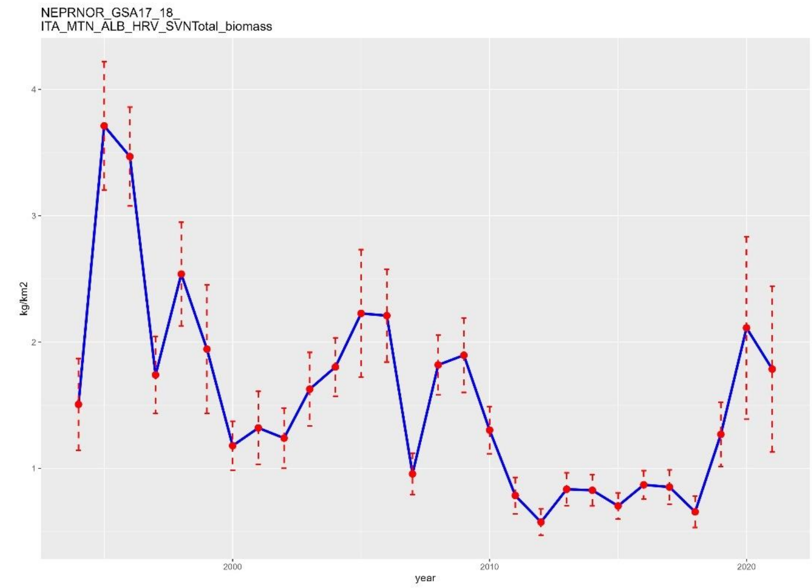


Figure 6.4.2.3.2 Norway lobster in GSA 17 and 18. Abundance indices from the MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro of GSA 17 and 18 during 1994–2021.

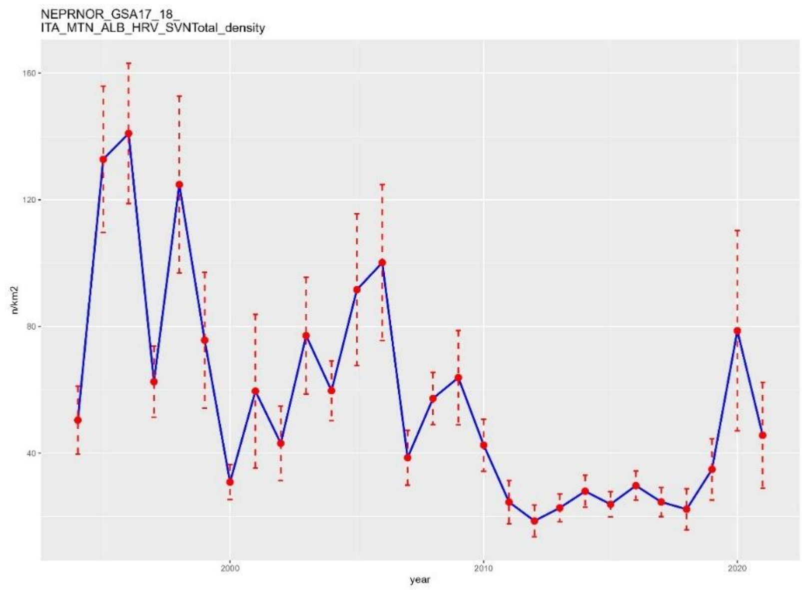


Figure 6.4.2.3.3 Norway lobster in GSA 17 and 18. Biomass indices from the MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro of GSA 17 and 18 during 1994 – 2021.

Length frequency distributions of the MEDITS surveys are showed in Figures 6.4.2.3.4-6. In GSA 17 and 18 a recruitment peak appears in 2006 as observed in the catch data. Since then MEDITS did not register any abundant new year class and this can explain the observed decreasing trend.

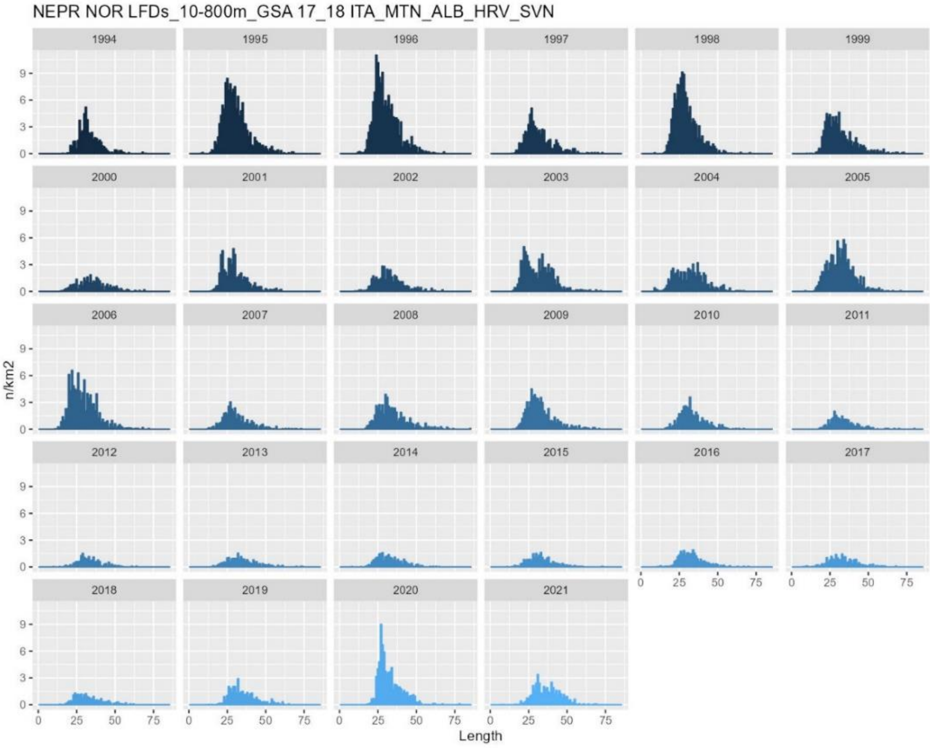


Figure 6.4.2.3.4. Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2021.

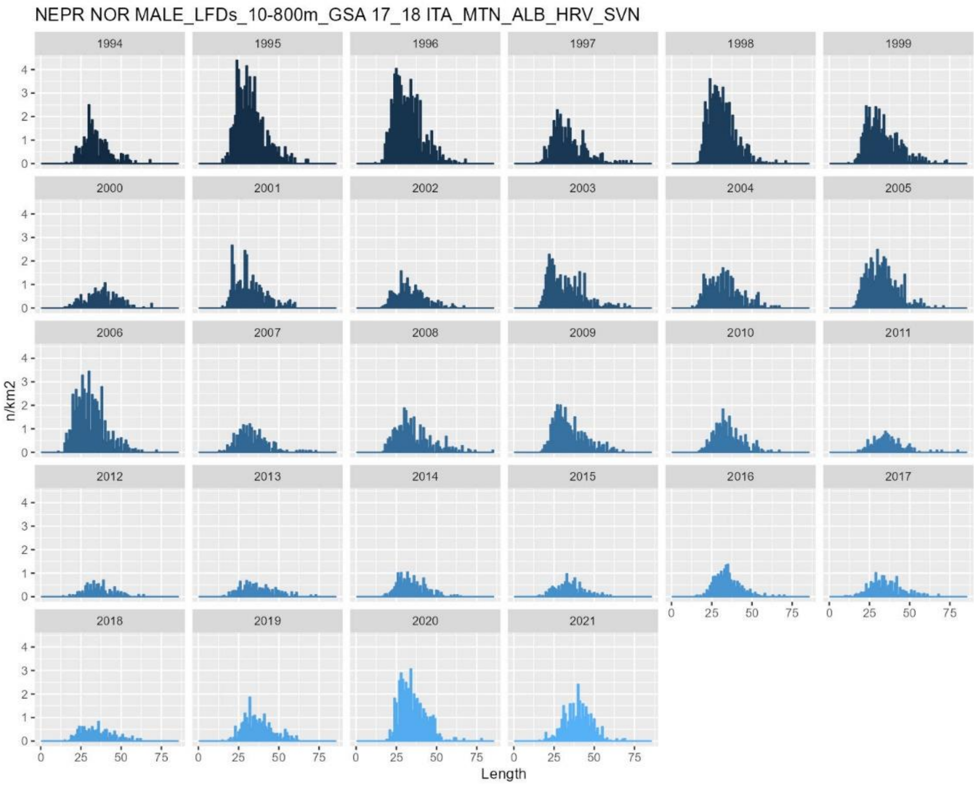


Figure 6.4.2.3.5 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (Male) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2021.

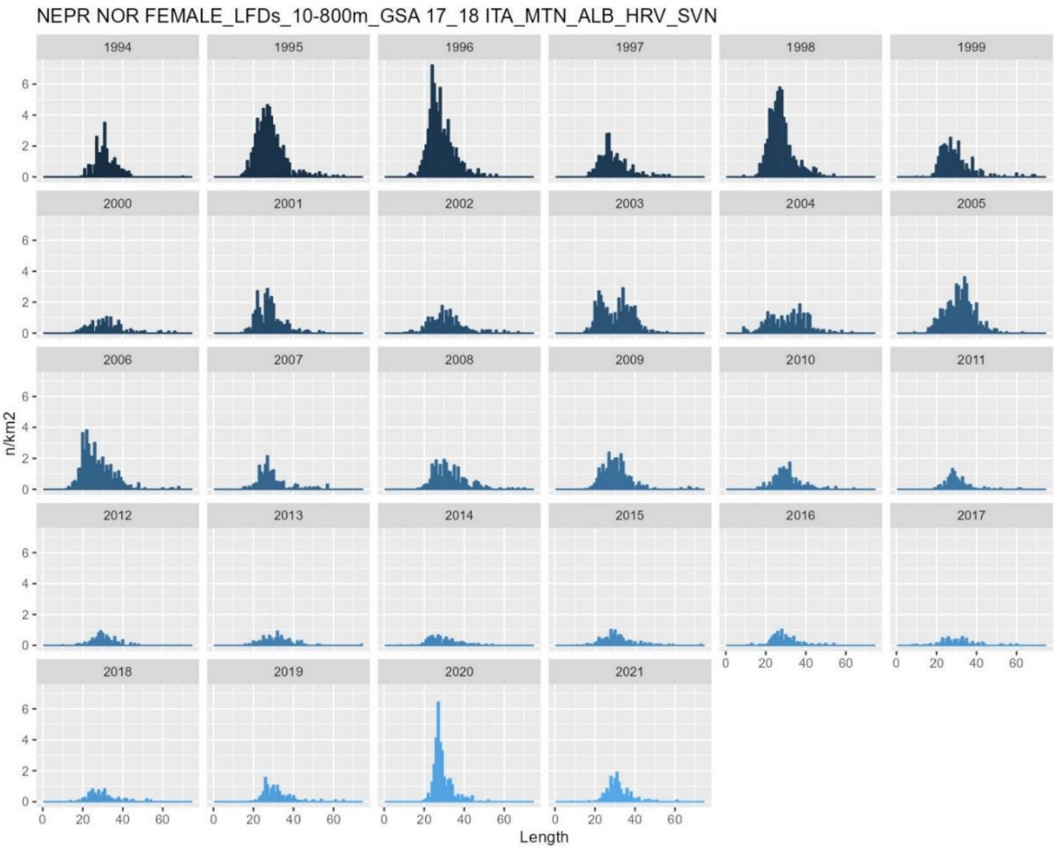


Figure 6.4.2.3.6 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (Female) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2021.

Spatial distribution

According to MEDITS data the highest relative biomass (yellow bubble) occur in GSA17 around the Pomo Pit area while in GSA 18 the stock appears more abundant along both the east and west slope of the south sector of the GSA (Fig. 6.4.2.3.7).

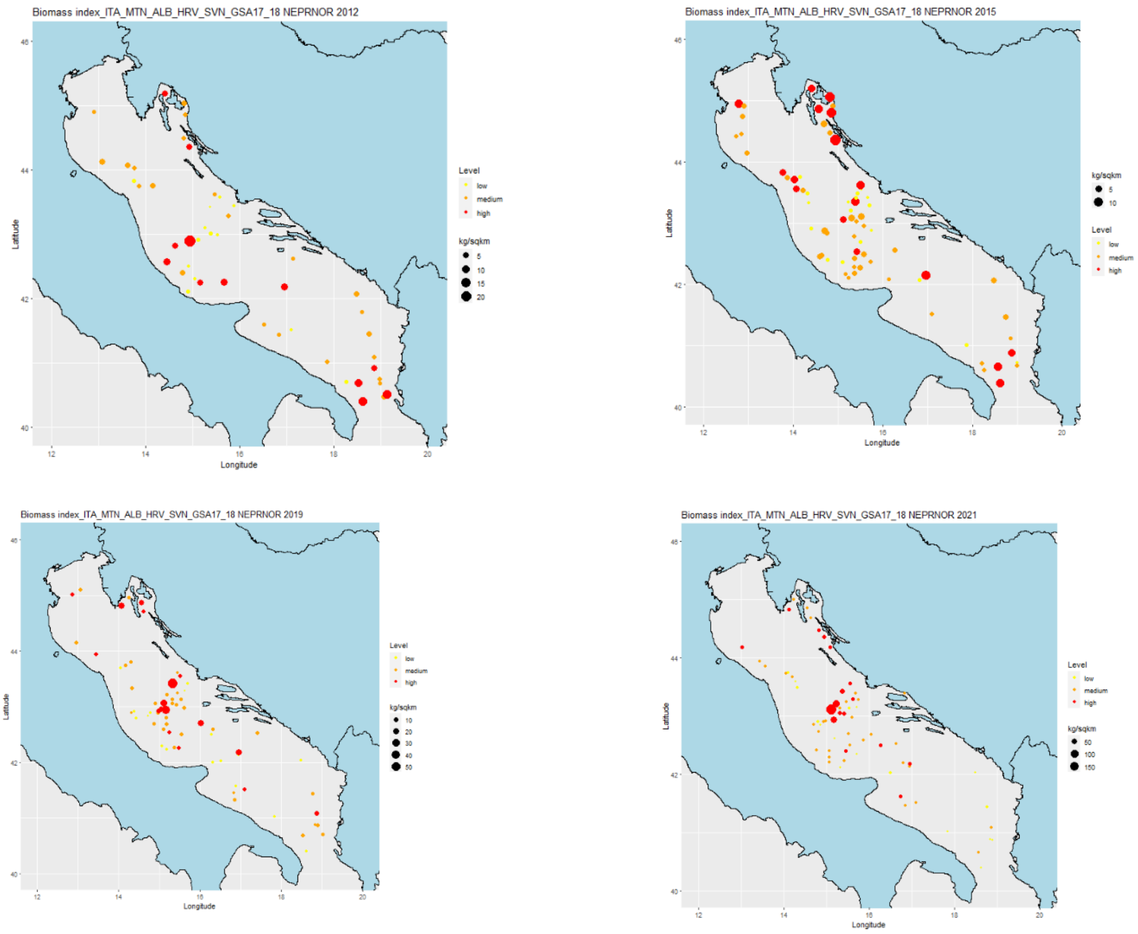


Fig. 6.4.2.3.7 Norway lobster in GSA 17 and 18. Spatial distribution of relative biomass (kg km^{-2}) during MEDITS from 2012 to 2021.

6.4.3 Stock assessment

The choice of stock assessment method to use for this stock was based on careful consideration discussed during the previous EWG 18-16, EWG 19-16, EWG 20-15 and EWG 21-15 The different sources of data and their short comings discussed above were considered together. The type of model was selected based on the following arguments: Ageing of Decapoda like *Nephrops norvegicus* is difficult and relies on indirect methods. With the specific uncertainties for this stock identified and explained in sections above on growth; the uncertainties on the proportion of the stock that lives in and outside Pomo, the potential mixing of landings between Norway lobster from GSA 17 and 18 (STECF EWG 18-16, EWG 19-16, EWG 20-15 and EWG 21-15), the EWG deemed that the only viable approach assessment to provide scientific advice is to use a production model on the combined GSA 17-18 as requested by the TORs. As STECF (PLEN 03) recommended the use of SPiCT, this was the model of choice for the surplus production assessment.

Surplus Production model in Continuous Time - SPiCT

The Surplus Production in Continuous time (SPiCT) assessment method is briefly described here; Pedersen and Berg (2016) contains a comprehensive description of the model

The SPiCT assessment method is a state-space version of the Pella-Tomlinson surplus production model (Pella and Tomlinson 1969). The dynamics of fisheries (F_t) and exploitable biomass (B_t) are modelled as latent processes:

$$dB_t = rB_t\left(1-\left(\frac{B_t}{K}\right)^{n-1}\right)dt - F_tB_tdt + \sigma_B B_t dW_t$$

$$dlog(F_t) = f(t, \sigma_F)$$

Where W_t is Brownian motion and f represents a random walk process if yearly data are provided and a seasonal model for F if subannual data are available. The time series of catch and biomass index are used as observations with e_t and ϵ_t their corresponding error terms:

$$log(I_t) = log(qB_t) + e_t, e_t \sim N(0, [\alpha\sigma_B]^2)$$

$$log(C_t) = log\left(\int_t^{t+\Delta} F_sB_sds\right) + \epsilon_t, \epsilon_t \sim N(0, [\beta\sigma_F]^2)$$

The following list summarises the model parameters:

B_t: Exploitable biomass

F_t: Fishing mortality

r: Intrinsic growth rate (growth, recruitment, natural mortality)

K: Carrying capacity

n: Production curve shape parameter

q: Catchability

σ_B: Standard deviation of B_t

σ_F: Standard deviation of F_t

α: Ratio of standard deviation of I_t to σ_B

β: Ratio of standard deviation of C_t to σ_F

SPiCT allows the inclusion of prior distributions for parameters that are difficult to estimate. By default, there are wide uninformative priors on n, α, and β; these can be removed.

The continuous time formulation of the model allows for arbitrary and irregular data sampling without a need for catch and index observations to match temporally.

The version of SPiCT used (2022) was an updated version which provided better stability of fit and improved diagnostics.

Main assumptions

SPiCT shares many assumptions with other surplus production models:

No emigration/immigration, changes in biomass occur through growth (r and K) and fishing.

No lagged effects in the biomass dynamics

Constant catchability i.e. no change in technology of fishing technique that changes q.

Gear selectivity is not modelled

No knowledge of natural mortality is required

Data requirements - Expected outputs

SPiCT requires a time series of landings or catches and one or more time series of commercial or survey CPUE indices. The expected output includes all parameter estimates and the most interesting derived quantities, F/F_{msy} and B/B_{msy} , that quantify the stock status. The results are presented using SPiCT's extensive plotting capabilities.

Forecasting and management

SPiCT is able to use the estimated underlying process model to make forecast of biomass, fishing mortality, catch and stock status (F/F_{msy} and B/B_{msy}). A forecasting period and a fishing scenario are set before fitting the model. The fishing scenario is a multiplication factor that is applied to the current fishing mortality.

Availability

SPiCT is available as an R (R Core Team 2015) package in the github online repository: https://github.com/mawp/spict. For fast and efficient estimation, SPiCT uses the Template Model Builder package (TMB, Kristensen et al., 2016, Pedersen, Martin W., and Casper W. Berg. *Fish and Fisheries* 18.2 (2017):

INPUT Data

The same input data were available as previous years however, the inputs used were different of the previous assessment (STECF 21-15). Catches and MEDITS where updated until 2021. Two additional surveys, Froglia e Pomo indices were removed and as the model without these surveys were seen to perform better:

Retrospective was less variable,

The precision of the assessment was improved especially in the most recent years,

carrying capacity was more plausible (previously one observed catch was outside the limit of the carrying capacity, now all observations lie within range.

All diagnostics were passed (previously one minor diagnostic indicated correlation that was undesirable.

So the improved option selected used commercial catch and MEDITS survey only. The general perception of the stock is unchanged; rising biomass above B_{MSY} F less than F_{MSY}

LANDINGS data were updated according to revised Albania data and 2021 DCF landings.

Input data described in data section are reported below in the following R list. This forms the input data basis to run SPICT model on Norway lobster GSA 17-18 combined

Table 6.4.3.1 Norway lobster in GSA 17 and 11: Assessment input data.

$obsC (COMBINED Catches GSA 17 + 18)

 [1] 1269.9950 1283.4810 1397.0000 1113.0000 1098.0000 1197.0000 1520.0000 2104.0000 1469.0000

[10] 1288.0000 1116.0000 1185.0000 1407.0000 1270.0000 1219.0000 2109.0000 2350.0000 2087.0000

[19] 2836.0000 2159.0000 1890.0000 2507.0000 3151.0000 3122.0000 3366.0000 3148.0000 3558.0000

[28] 3058.0000 2426.0000 1753.0000 1864.0000 1558.7367 1252.4735 2218.5499 2279.4303 3393.6758

[37] 3107.0166 2775.0568 2654.2410 2799.6820 2523.3727 1955.7586 2390.2312 2514.5424 1738.3813

[46] 1617.4878 1417.3120 1438.2062 1559.3179 1268.6368 843.3556 873.9744

$timeC (COMBINED Catches GSA 17 + 18)

 [1] 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988

[20] 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

[39] 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

$timeI

$timeI[[1]] (MEDITS)

 [1] 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012

[20] 2013 2014 2015 2016 2017 2018 2019 2020 2021

$obsI

$obsI[[1]] (MEDITS)

 [1] 1.5070003 3.7113814 3.4686277 1.7402263 2.5383215 1.9438871 1.1795964 1.3204727 1.2397093

[10] 1.6274549 1.8030879 2.2267225 2.2092643 0.9568275 1.8191969 1.8961276 1.3031724 0.7852298

[19] 0.5751616 0.8351504 0.8270706 0.7028787 0.8704190 0.8525636 0.6563420 1.2695230 2.1123751

[28] 1.7860921

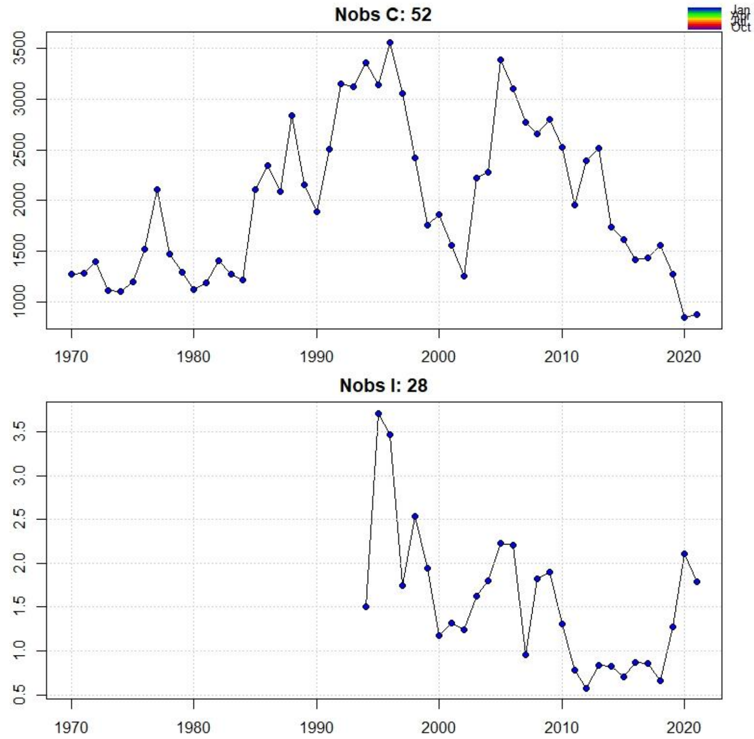


Figure 6.4.3.1.1 Norway lobster in GSA 17 and 18. Input Data from Norway lobster GSA 17-18. Index = MEDITS.

SPiCT was run with the default prior settings and no informative priors for initial parameter estimates. The model converged and the diagnostic results (Residuals, Auto correlation and Shapiro p-values) are good for both catches and the tuning index (Figures 6.4.3.1.2-3).

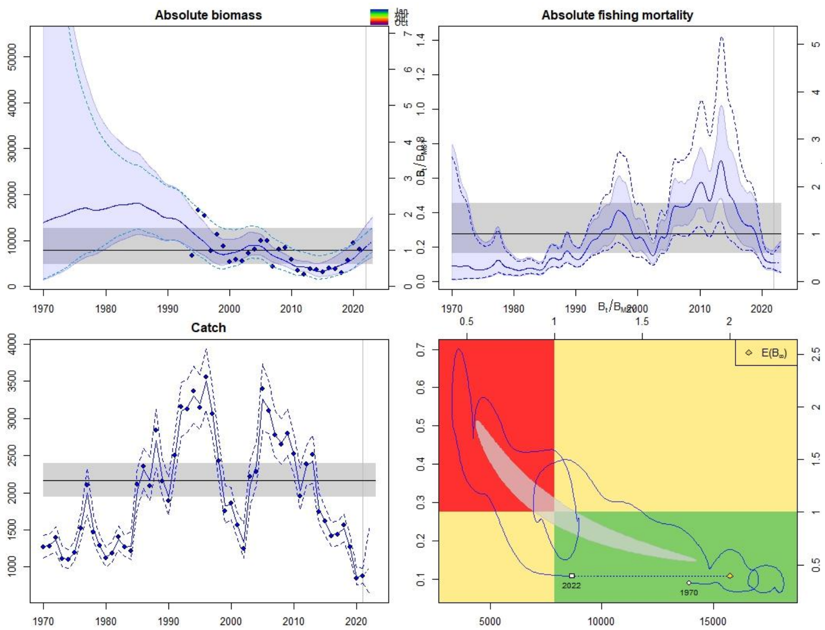


Figure 6.4.3.1.2 Norway lobster in GSA 17 and 18. SPiCT model fit with full time series and one CPUE index.

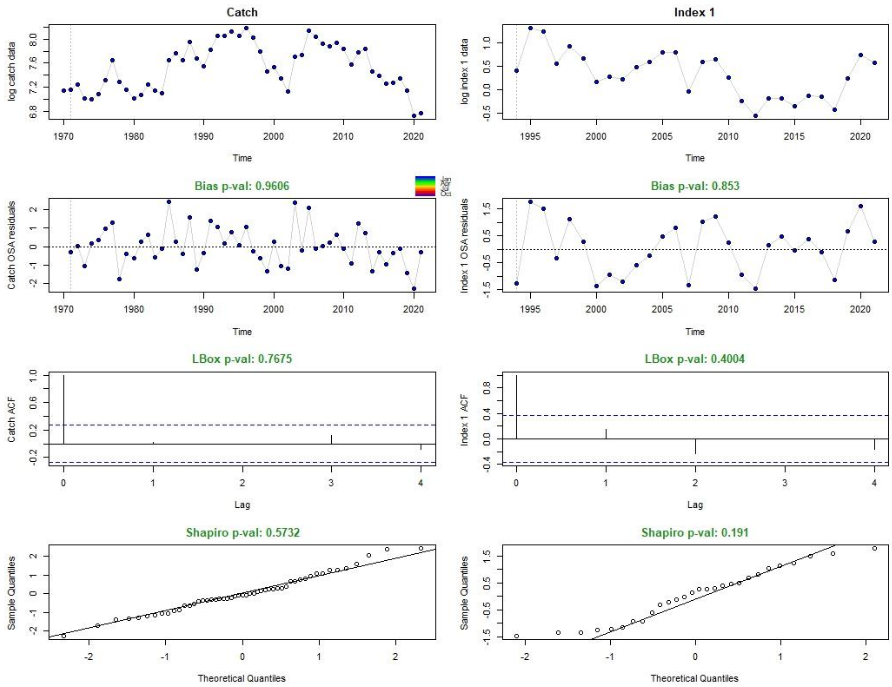


Figure 6.4.3.1.3 Norway lobster in GSA 17 and 18. Diagnostics for SPICT model of Norway lobster GSA 17-18. Index = MEDITS.

A retrospective was run with 3 retro years. For production models, the most reliable estimates are in terms of F/ F_{MSY} and B/ B_{MSY}. The retrospective patterns are consistent across years in terms of B/ B_{MSY} with biomass estimated well below B_{MSY}. F/ F_{MSY} is estimated to be greater than 1 in all runs for all years after 2005. The coherence of the results indicates the retrospective performance is acceptable (Figure 6.4.3.1.4).

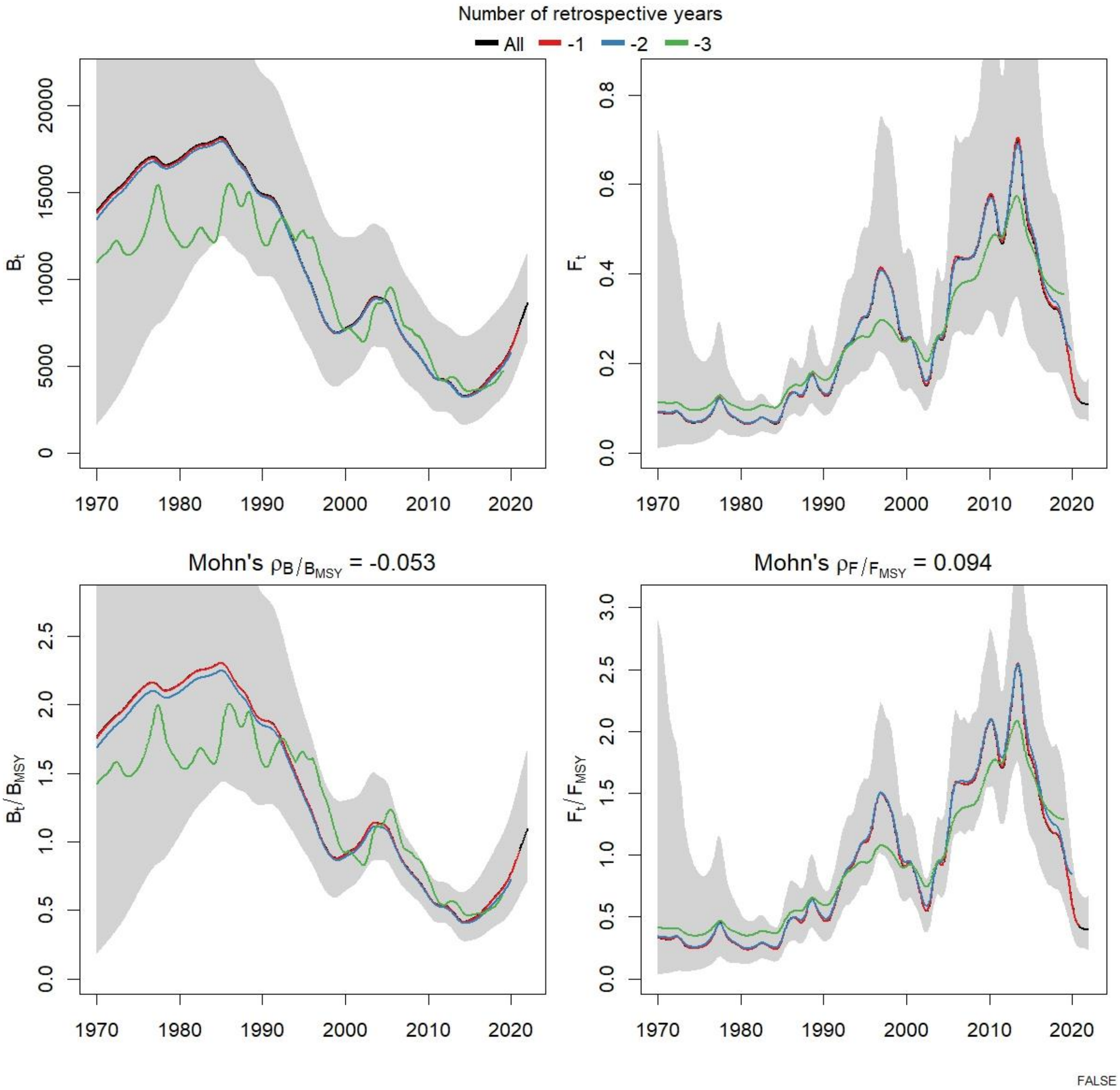


Figure 6.4.3.1.4 Norway lobster in GSA 17 and 18. Retrospective analysis for Norway lobster in GSA 17-18.

Table 6.4.3.2 Norway lobster in GSA 17 and 11: Model estimates, reference points and summaries are reported below:

Convergence: 0 MSG: relative convergence (4)

Objective function at optimum: 17.1871709

Euler time step (years): 1/16 or 0.0625

Nobs C: 52, Nobs I1: 28

Priors

logn ~ dnorm[log(2), 2^2]

logalpha ~ dnorm[log(1), 2^2]

logbeta ~ dnorm[log(1), 2^2]

Model parameter estimates w 95% CI

```
            estimate         cilow         ciupp     log.est
alpha     10.8712655     1.1646079   101.4800049  2.3861231
beta       0.2328684     0.0598128     0.9066240 -1.4572816
r          0.1642436     0.0593378     0.4546169 -1.8064043
rc         0.5494768     0.3330977     0.9064150 -0.5987887
rold       0.4083817     0.0321671     5.1846590 -0.8955531
m       2165.0027963  1959.8300730  2391.6548544  7.6801769
K      28319.5263930 15909.1829016 50410.8589415 10.2513068
q          0.0002245     0.0001363     0.0003698 -8.4016544
n          0.5978183     0.2044975     1.7476331 -0.5144685
sdb        0.0290849     0.0032181     0.2628703 -3.5375349
sdf        0.2672198     0.1945389     0.3670547 -1.3196837
sdi        0.3161901     0.2412036     0.4144886 -1.1514118
sdc        0.0622271     0.0200546     0.1930830 -2.7769653
 Deterministic reference points (Drp)
          estimate        cilow         ciupp   log.est
 Bmsyd 7880.2332968 4900.7217934 12671.2103704  8.972113
 Fmsyd    0.2747384    0.1665489     0.4532075 -1.291936
 MSYd  2165.0027963 1959.8300730  2391.6548544  7.680177
Stochastic reference points (Srp)
          estimate        cilow         ciupp   log.est  rel.diff.Drp
 Bmsys 7873.6517823 4898.6631332 12655.3695780  8.971277 -0.0008358910
 Fmsys    0.2748213    0.1666084     0.4533191 -1.291634  0.0003016004
 MSYs  2163.8478560 1958.2243546  2391.0628693  7.679643 -0.0005337438
States w 95% CI (inp$msytype: s)
                  estimate        cilow         ciupp    log.est
 B_2021.94      8573.1607518 6377.1268065 11525.4232048  9.0563918
 F_2021.94         0.1085120    0.0705197     0.1669724 -2.2208946
 B_2021.94/Bmsy    1.0888417    0.7058540     1.6796340  0.0851145
 F_2021.94/Fmsy    0.3948456    0.2303192     0.6769001 -0.9292604
Predictions w 95% CI (inp$msytype: s)
                prediction        cilow         ciupp    log.est
 B_2023.00       9799.4068953 7511.8654060 12783.5591174  9.1900771
 F_2023.00          0.1085122    0.0543845     0.2165119 -2.2208930
 B_2023.00/Bmsy     1.2445822    0.8126121     1.9061800  0.2187999
 F_2023.00/Fmsy     0.3948463    0.1841236     0.8467334 -0.9292588
 Catch_2022.00    998.5058335  655.1225400  1521.8739071  6.9062600
```

E(B_inf)	15746.2080574	NA	NA	9.6643549

Table 6.4.3.3 Norway lobster in GSA 17 and 18: Assessment summary. Weights are in tonnes.

year	Biomass (Tonnes)	Catch (Tonnes)	F all ages
1970	14196	1267	0.09
1971	14746	1296	0.09
1972	15187	1362	0.09
1973	15628	1134	0.07
1974	16199	1102	0.07
1975	16696	1207	0.07
1976	16990	1540	0.09
1977	16823	1994	0.12
1978	16583	1506	0.09
1979	16778	1280	0.08
1980	17118	1132	0.07
1981	17509	1196	0.07
1982	17734	1379	0.08
1983	17840	1272	0.07
1984	18056	1275	0.07
1985	17998	2038	0.11
1986	17273	2313	0.13
1987	16631	2169	0.13
1988	15890	2703	0.17
1989	15066	2188	0.15
1990	14815	1943	0.13
1991	14504	2494	0.17
1992	13587	3096	0.23
1993	12404	3151	0.25
1994	11242	3300	0.29
1995	10126	3201	0.32
1996	8920	3498	0.39
1997	7706	3069	0.40
1998	7043	2422	0.34
1999	7027	1825	0.26
2000	7314	1840	0.25
2001	7679	1553	0.20
2002	8406	1335	0.16
2003	8939	2105	0.24
2004	8863	2365	0.27
2005	8303	3257	0.39
2006	7183	3122	0.43
2007	6395	2771	0.43
2008	5829	2675	0.46
2009	5189	2793	0.54

2010	4505	2514	0.56
2011	4230	2031	0.48
2012	4076	2354	0.58
2013	3559	2425	0.68
2014	3300	1781	0.54
2015	3485	1601	0.46
2016	3865	1434	0.37
2017	4412	1446	0.33
2018	4958	1523	0.31
2019	5617	1246	0.22
2020	6678	873	0.13
2021	7976	878	0.11

The SPiCT assessment this year is quite stable with some considerable retrospective bias in the third removed year. This is thought to be the result of two possible separated / compounded reasons. Exploitation has changes, with catch of smaller individuals from the Pomo/Jabuka Pit reduced due to closures of fisheries in recent years (2017), such a change in exploitation may result in some revisions to earlier estimates. Secondly the overall exploitation rate has decreased considerably in 2021 from 0.22 in 2019, to 0.13 in 2020 and 0.11 in 2021, possibly influenced by this closure but also by other effort measures. Changes in retrospective performance are common where rapid changes in the size of individuals in catch occurs. The wide confidence intervals seen in this assessment reflect the considerable uncertainty in the assessment.

Area based biomass indices for Norway lobster GSA 17-18.

Tor 3.2 For Norway lobster GSA 17-18 Explore local trends with the MEDITS biomass indices in 4 areas: Pomo/Jabuka/Jabuka Pit, Ancona , Kvarner and GAS 18. Evaluate if trends are different in different areas.

Introduction

Pomo/Jabuka pit is a deep area in Adriatic Sea, considered as a valuable spawning ground for Norway lobster as well as for European Hake. After repeated unsuccessful attempts to establish a Fisheries Restricted Area (FRA) in the region, in 2018, based on the GFCM/41/2017/3 recommendation, an FRA was finally established and fishing in the area is now regulated. More specifically, Zone A of the FRA (figure 6.4.3.2.1) is permanently closed (Prohibition to use bottom-set nets, bottom trawls, set longlines and traps) while temporal closures were set on zones B and C (Prohibition to use bottom-set nets, bottom trawls, set longlines and traps from 01/09 to 31/10 each year, fishing is allowed if the vessel or its master is in possession of a specific authorization and if historical fishing activities in zone B or C are demonstrated. Bottom trawls are entitled to fish only on specific days and hours.). For Norway lobster, it has been pointed out in the past that the sub-unit of the Adriatic population living in the Pomo-Jabuka pit area features significant differences in their biology (e.g. growth and maturity) in comparison with specimens distributed on the continental shelf of the GSA 17 (Froglia and Gramitto, 1988). Additionally, the continental shelf area could be also divided to two regions: the Ancona area, mainly exploited by the Italian bottom otter trawl fleet, and the Kvarner Gulf area which is fished by the Croatian bottom otter trawl and fishing pots fleet as well.

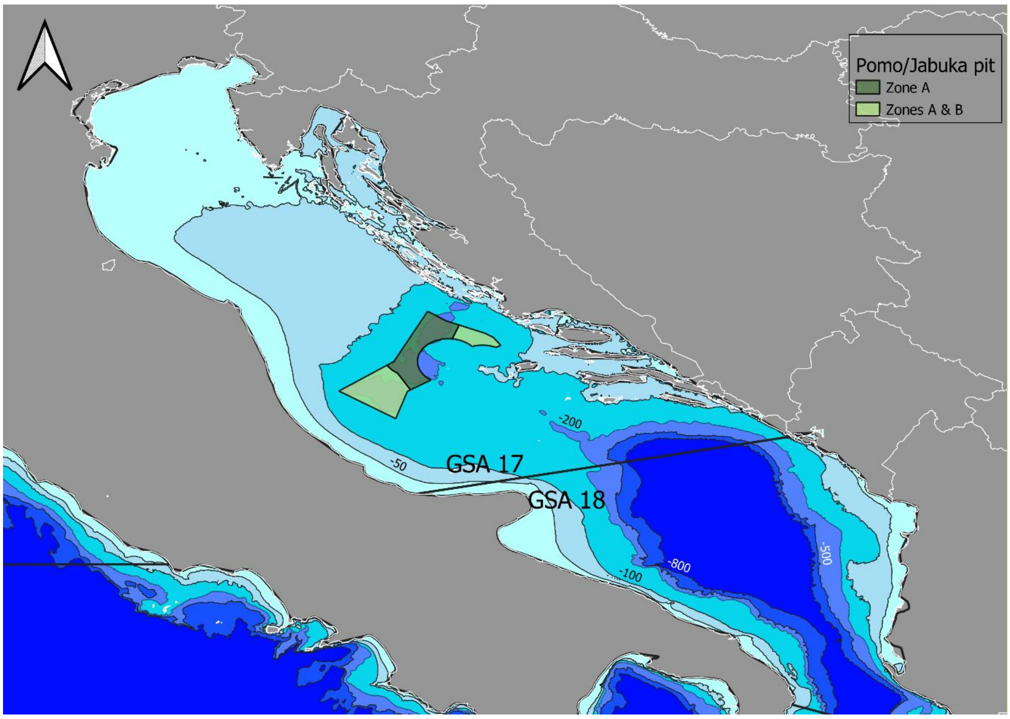


Figure 6.4.3.2.1 The Pomo/Jabuka Pit closure regulation areas within the Adriatic Sea. Contoured areas are depth ranges: 0, 50, 100, 200, 500 and 800 meters.

The EWG was requested to evaluated four sub areas designated as Ancona, Kvarner, Pomo/Jabuka and GSA 18 (ToR 3.3). Based on the above and to explore the possibility of providing area-based management advice, as suggested by Canu *et al* (2021) the application of area specific assessments using length/age data from MEDITS survey was examined.

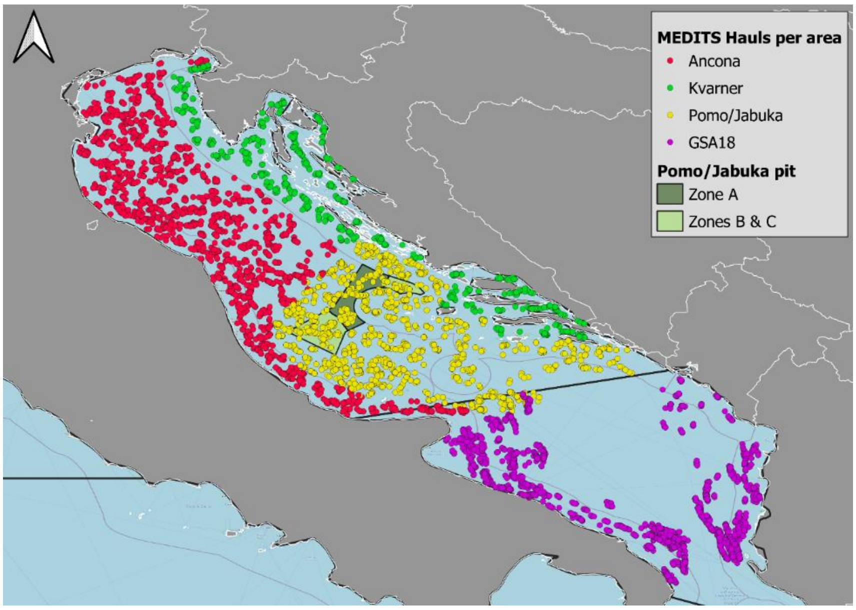
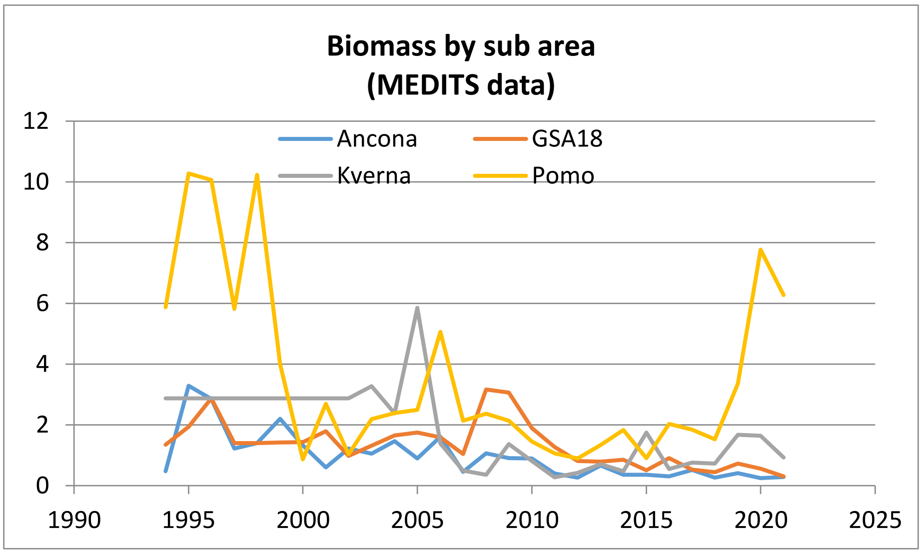


Figure 6.4.3.2.2 Distribution of MEDITS hauls in the four GSA17-GSA18 sub-areas.

MEDITS indices by area are derived for 4 sub-areas, GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit. The basis of these areas is given in Section 6.4.3.2. The estimated biomass indices by area are given in Figure 6.4.3.2.3. Use of these values directly gives annually fluctuating values due to the variability in the survey data. For Kvarner the survey data is not available for the years 1994 to 1999; to fill in these values the mean of the following 6 years is used. The stock biomass from the SPiCT assessment (Table 6.4.3.3) shows a relatively smooth continuous trajectory over time, the assessment is effectively a smoothed version of the MEDITS biomass index. By smoothing the separate sub-area indices, the rapid fluctuations seen in figure 6.4.3.2.13 can be removed (Figure 6.4.3.2.4). A good match between the combined sub area indices and the SPICT biomass (Figure 6.4.3.2.5) is then obtained by choosing the smoothing having the best fit to the SPiCT assessment stock biomass. This gives a smoothed subarea fraction of biomass that is specifically matched to the variability observed in the assessment output. The values are then used to split the SPiCT output and provide sub-area estimates of biomass from 1994 to 2020. The four sub area biomass indices are given in Figure 6.4.3.2.6 and Table 6.4.3.2.1.



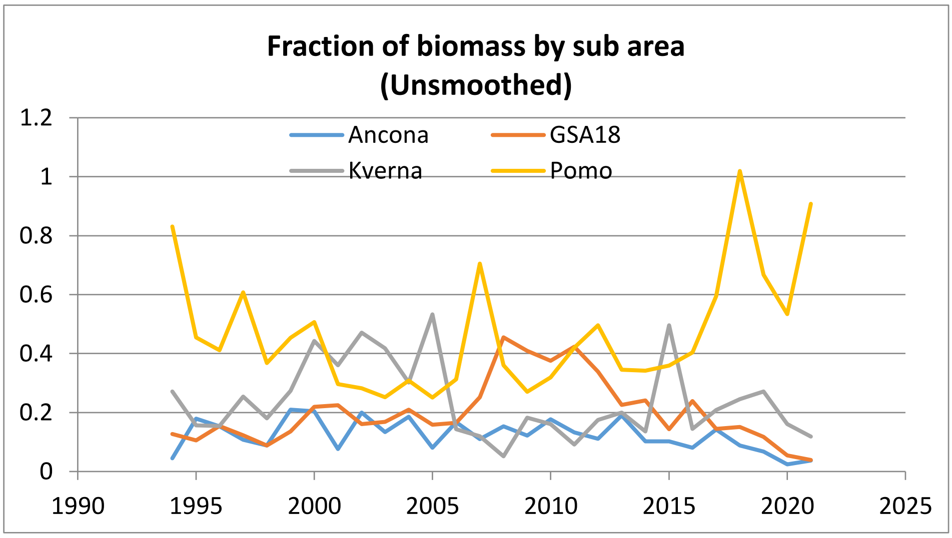


Figure 6.4.3.2.3 MEDITS sub area indices for the four sub areas GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit (Top) 1994 to 2021, and fraction of total biomass calculated from the indices (Bottom)

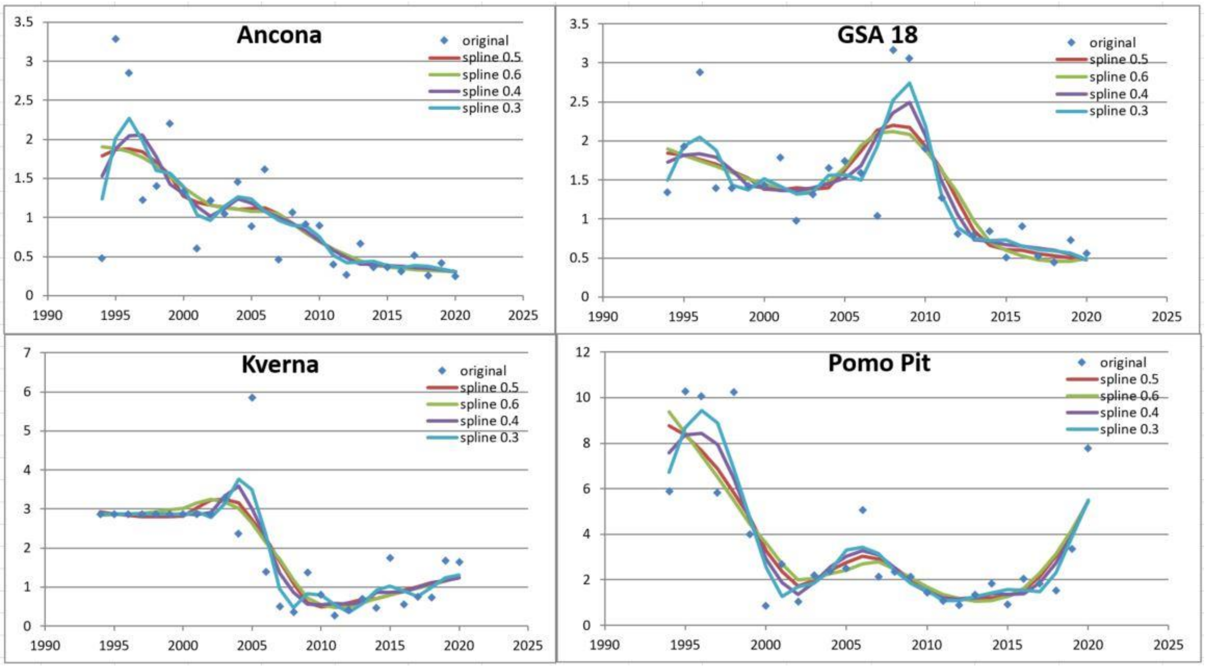
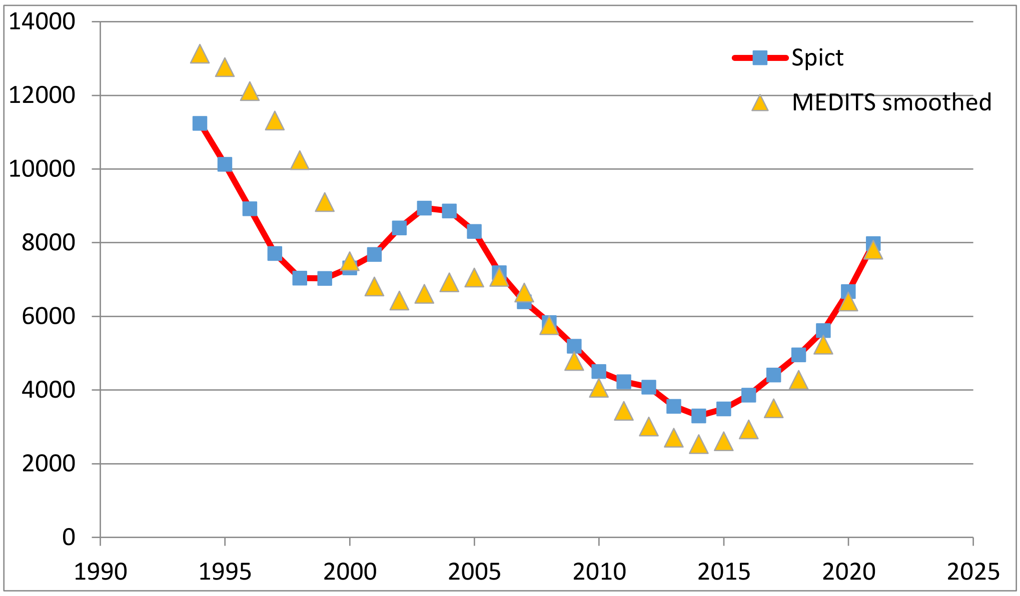


Figure 6.4.3.2.4 MEDITS sub area indices for the four sub areas GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit with original data (points) and a range of smoothing options.



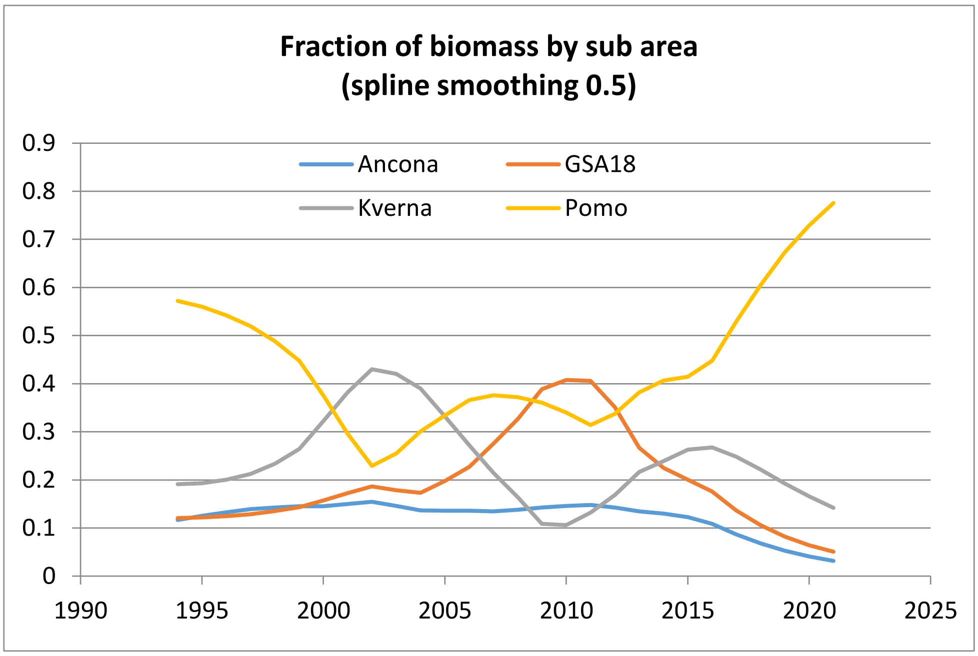


Figure 6.4.3.2.5 Combined smoothed MEDITS index with best fit to assessment compared with SPiCT assessment biomass (Top) (MEDITS indices are rescaled to the mean of the assessment); and the resulting smoothed fraction of biomass for the four sub areas GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit (Bottom) 1994 to 2021.

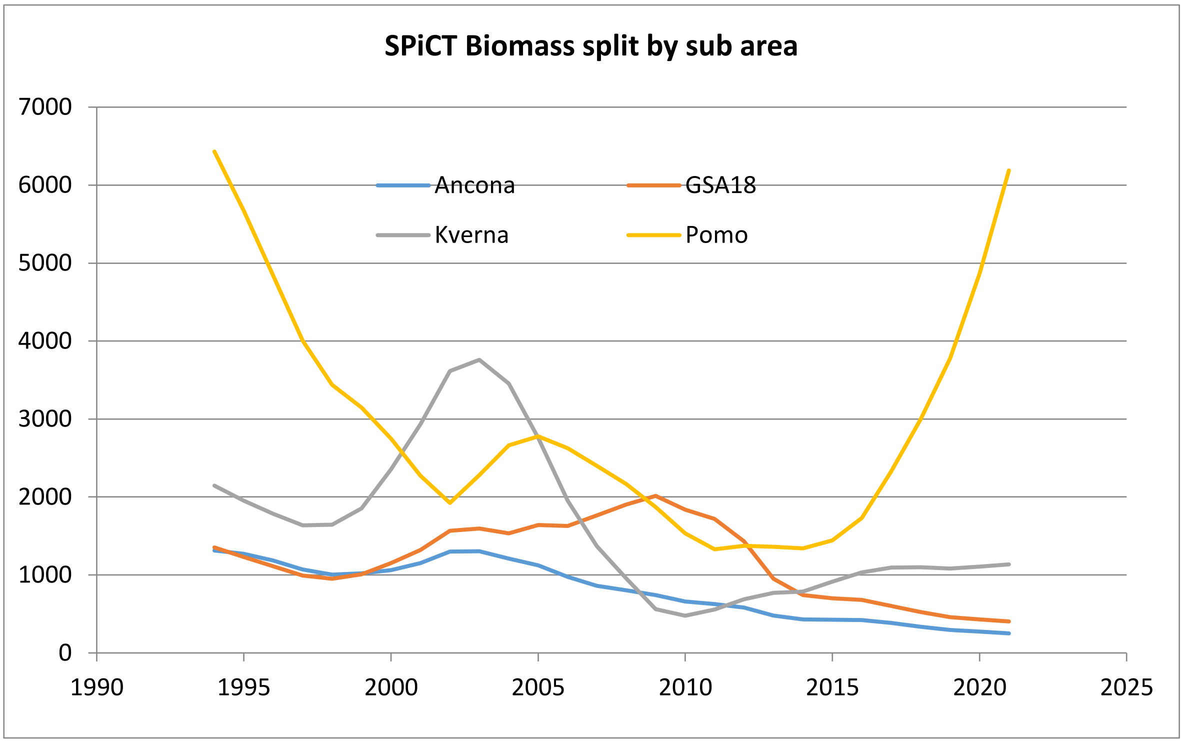


Figure 6.4.3.2.6 SPiCT biomass split using smoothed MEDITS for the four sub areas GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit (left) 1994 to 2020.

Table 6.4.3.2.1 Norway lobster in GSA 17-18 biomass indices by sub area; GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit 1994 to 2021.

year	Ancona	GSA18	Kverna	Pomo	SPiCT
1994	1314	1352	2145	6431	11242
1995	1271	1232	1952	5670	10126
1996	1185	1112	1786	4837	8920
1997	1072	993	1637	4004	7706
1998	1006	951	1646	3440	7043
1999	1020	1008	1854	3145	7027
2000	1062	1151	2353	2747	7314
2001	1153	1322	2932	2272	7679
2002	1298	1568	3615	1926	8406
2003	1304	1595	3760	2280	8939
2004	1211	1534	3455	2663	8863
2005	1126	1643	2759	2776	8303
2006	976	1628	1953	2626	7183
2007	861	1763	1369	2402	6395
2008	803	1905	955	2166	5829
2009	741	2014	562	1872	5189
2010	658	1836	477	1533	4505
2011	626	1718	557	1329	4230
2012	582	1431	688	1376	4076

2013	478	951	771	1360	3559
2014	428	743	787	1341	3300
2015	427	699	916	1443	3485
2016	421	679	1035	1730	3865
2017	383	602	1094	2332	4412
2018	337	526	1098	2998	4958
2019	296	460	1081	3781	5617
2020	273	429	1107	4869	6678
2021	251	404	1134	6187	7976

Conclusions to area based evaluation

The methods use rescaling by the mean biomass from MEDITS for the whole period to match to the assessed stock biomass from SPiCT. The smoothed MEDITS biomass indices which are matched not just on average biomass but also variability with the SPiCT model give an acceptable perception of relative trend, but do not use the size/age data. For the catch allocation for management purposes, the smoothed indices give a more stable allocation key, and used in to give values for catch allocation across areas for the target exploitation rates for Norway lobster in GSA 17-18 in Section 6.4.5.2.

For general stock biomass considerations, the overall estimated biomass in 2021 from the SPiCT assessment is B= 7976.05 = 1.01 B_{MSY} , which is almost equal to the average biomass for the survey period 1994 to 2020 where B = 7543.79. The 2021 biomass in the four sub areas is shown in Table 6.4.3.2.1. The average biomass B $_{94\text{-}2020}$ is in Table 6.4.3.3.1, along with the ratio of B_{2020} to the average B $_{94\text{-}2020}$ while relative B in the Pomo/Jabuka Pit is at 1.6, 2021 relative biomass in Ancona and GSA 18 are much lower at 0.31 and 0.34 average biomass, and relative biomass in Kvarner is in a much better state at 0.70. This suggests that Norway lobster in sub-areas Ancona and GSA 18 should be considered for greater protection and lower catches, than those suggested by applying F_{MSY} equally across the area. It's not possible to give explicit stock status for these sub areas, however, given that the mean for the period evaluated is 100% BMSY, the values of at 0.31 and 0.34 relative to average biomass suggest that Ancona sub area is low enough to require additional measures. In contrast the state of Pomo/Jabuka Pit sub area suggests the biomass in this area is currently in a good state following the sharp increase from 3866 to 7976 (MEDITS Biomass index) from 2016 to 2021 (see Figure 6.4.3.3.4 and Table 6.4.3.2.1.).

Table 6.4.3.3.1 Norway lobster in GSA 17-18 biomass by sub area.

	Total GSA 17-18	**Ancona**	**GSA 18**	**Kvarner**	**Pomo/ Jabuka Pit**
Average biomass 94-2020	6530	806	1187	1624	2912
B2021/B1994-2020	1.22	0.31	0.34	0.70	2.12

Information on exploitation rates for the whole stock is available from the SPiCT assessment, and indicates that exploitation rates were above MSY in the past but are estimated to have decreased below F_{MSY} in the last two years.

In conclusion, the biomass indices show that GSA 18 and Ancona are at a relatively poorer state with historically lower biomasses in recent years. In contrast the situation for biomass in Kvarner and Pomo/Jakuba Pit is likely to be within acceptable limit. Given this information on the state of the biomass and the supporting exploitation rate information it would be prudent to keep exploitation rates in line with local biomass, and in the case Ancona and GSA 18 consider additional protective measures.

6.4.4 REFERENCE POINTS

The SPiCT model provides output set directly in the context of MSY, and the results are more are estimated by the model, however, these are less precise than the F/ F_{MSY} and B/ B_{MSY} results. Based on model F_{MSY} from stochastic reference points is F_{MSYs} 0.28 y^{-1} and B_{MSYs} = 7873.7 t. Based on agreed procedure for estimating B_{lim} in the absence of a S/R relationship B_{lim} is estimated as B_{MSY}*0.40. Based on these results STECF-EWG 22-16 considers the stock sustainably exploited (F< F_{MSY}) in recent years.

Table 6.4.4.1 Norway lobster in GSA 17 and 18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
Precautionary approach	B_{lim}	3149.46	B_{lim} = 40% B_{MSY}	STECF EWG 22-16
	B_{pa}	4409.244	B_{pa} = B_{lim} *1.4	STECF EWG 22-16
	F_{lim}		Not defined	
	F_{pa}		Not defined	
MSY Approach	MSY $B_{trigger}$	4409.244	MSY Btrigger = B_{pa} = B_{lim} *1.4	STECF EWG 22-16
	F_{MSY}	0.275	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16

6.4.5 SHORT TERM FORECAST AND CATCH OPTIONS

STF catch estimates for the total area.

The SPiCT model was used to carry out a short term forecast with the following conditions:

SPiCT timeline:

```
     Observations          Intermediate          Management
   1970.00 - 2022.00     2022.00 - 2023.00     2023.00 - 2024.00
 |-----------------------| ----------------------| ----------------------|
```

Management evaluation: 2024.00

Predicted catch for management period and states at management evaluation time:

Full time series of forecasts are outlined in Table 6.4.5.1 and Figure 6.4.5.1

Table 6.4.5.1 Norway lobster in GSA 17-18. Short term forecasts of status quo and different fishing mortalities options

	Year	Catch	F	SSB
Keep_current_F	2022	999	0.109	9202
Keep_current_F	2023	1115	0.109	10278
Keep_current_F	2024	1216	0.109	11204
Fishing_at_F_{MSY}	2022	999	0.109	9202
Fishing_at_ F_{MSY}	2023	2626	0.275	9557
Fishing_at_ F_{MSY}	2024	2509	0.275	9129
No_fishing	2022	999	0.109	9202
No_fishing	2023	1	0.000	10790
No_fishing	2024	1	0.000	12827
Reduce F - 25%	2022	999	0.109	9202
Reduce F - 25%	2023	847	0.081	10403
Reduce F - 25%	2024	943	0.081	11588
Increase + F25%	2022	999	0.109	9202
Increase + F25%	2023	1378	0.136	10156
Increase + F25%	2024	1469	0.136	10834
Fishing at Transisition F	2022	999	0.109	9202
Fishing at Transisition F	2023	2437	0.253	9649
Fishing at Transisition F	2024	2369	0.253	9381
Fishing at F_{lower}	2022	999	0.109	9202
Fishing at F_{lower}	2023	1833	0.184	9940
Fishing at F_{lower}	2024	1881	0.184	10201
Fishing at F_{upper}	2022	999	0.109	9202
Fishing at F_{upper}	2023	3460	0.379	9141
Fishing at F_{upper}	2024	3046	0.379	8048

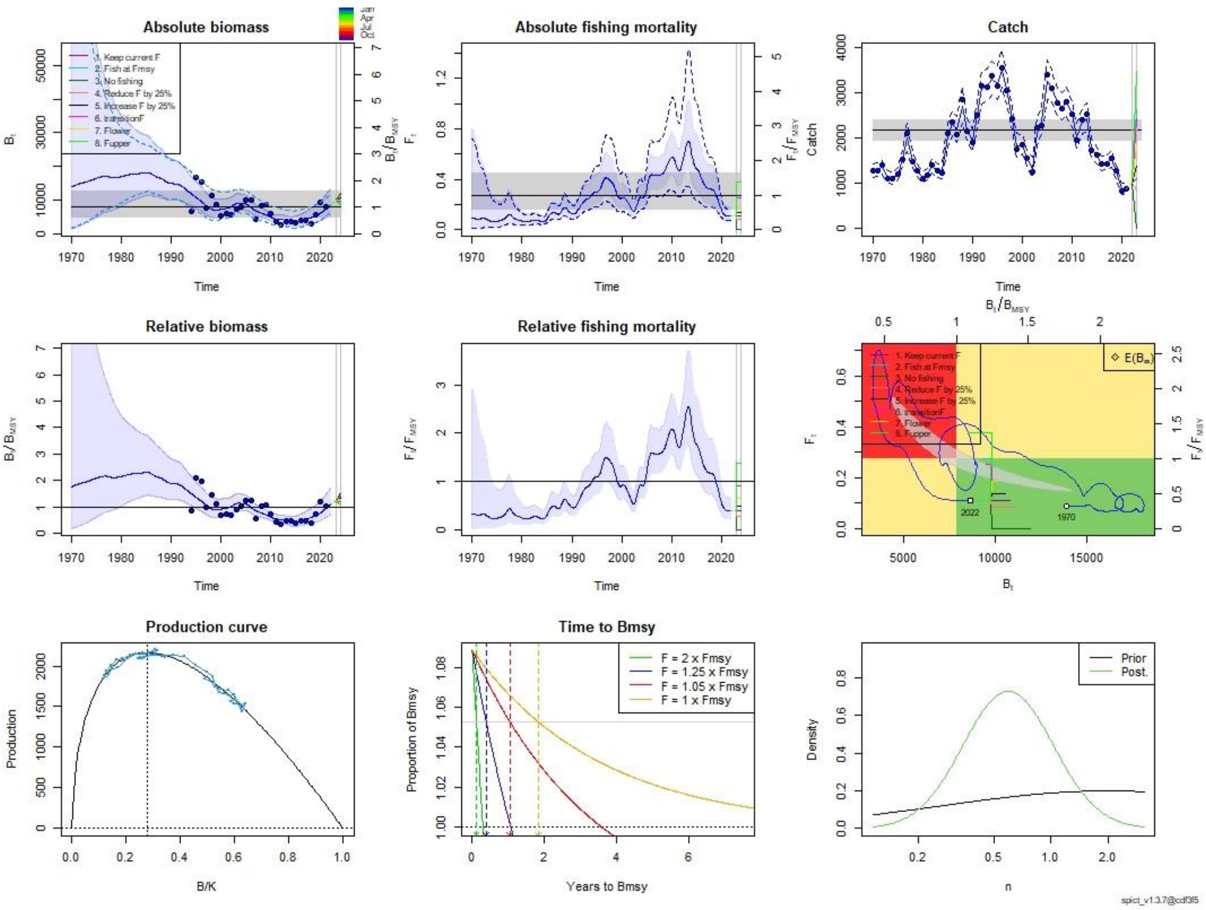


Figure 6.4.5.1 Norway lobster in GSA 17 and 18. Short term forecast for the period 2022-2024 according to different scenarios: Keep_current_F, Fishing_at_Fmsy, No_fishing, Reduce_F25%, Increase_F25%, Fishing at F transition, F $_{lower}$ and F $_{upper}$.

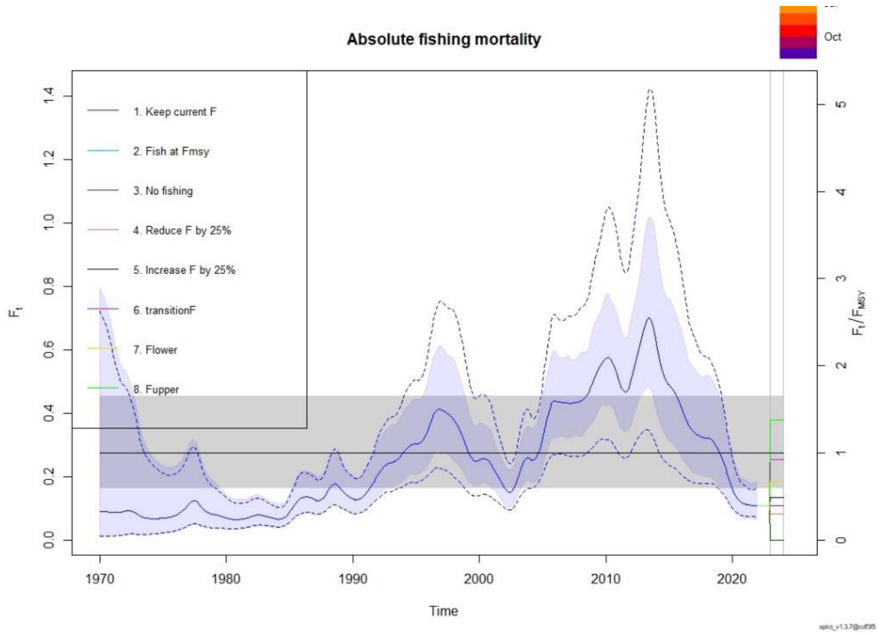


Figure 6.4.5.2 Norway lobster in GSA 17 and 18. Absolute fishing mortality of the short term forecast for the period 2022-2023 according to different scenarios:

An implemented SPiCT version 1.3.7 forecast scenarios have been for this assessment. In addition, recruitment to the stock (or growth in the stock) has been observed to increase in recent years and SSB, is now above B_{pa}, the growth implied by the SPiCT forecast is mean growth for the time series. The Analysis by sub area shows that some parts of the stock are depleted (Section 6.4.3.5). This forecast which is shown in Table 6.4.5.2 is used for the catch options in Section 5.5.

Catch Allocations by sub area.

The STF from the SPiCT assessment provides a set of catch options for the whole area from the STF (Table 6.4.4.2) Using the same exploitation rates for all areas the catch options by sub area are provided n Table 6.4.4.2.2. It should be noted that the biomass in sub-areas Ancona and GSA 18 show important reductions in comparison to the mean (B/B average = 0.31 and 0.34 respectively Table 6.4.3.5.1). Exploitation indices are in general agreement with the biomass indices showing that GSA 18 and Ancona have seen less reduction in exploitation over recent years. In contrast the situation for biomass in Kvarner and Pomo/Jakuba Pit is more likely to be within acceptable limits (B/B average = 0.70 and 2.12 respectively). Given this information on the state of the biomass and the supporting exploitation rate information as a minimum it would be prudent to keep exploitation rates in line with local biomass, and in the case of Ancona and GSA 18 consideration should be given to additional protective measures to restore biomass, i.e.. catches below the levels given in Table 6.4.5.2.1.

Table 6.4.5.2.1 Norway lobster in GSA 17-18 catch options by sub area.

	Total GSA 17-18	Ancona	GSA 18	Kvarner	Pomo/ Jabuka Pit
Catch 2021	878	27.66	44.49	124.87	681.28
B 2021	7976	251	404	1134	6187
F_{MSY} from SPiCT Model (HR)	0.275	0.275	0.275	0.275	0.275
F (HR) Transition from F current and F_{MSY}	0.26	0.26	0.26	0.26	0.26
Catch 2022/2023 at F= F_{MSY}	2626	70	113	318	1732
Catch at F transition	2437	64	103	290	1582

6.4.6 Data Deficiencies

No data deficiencies reported

6.5 EUROPEAN HAKE IN GSA 19

The stock of European hake (*Merluccius merluccius*) in GSA 19 was assessed using a4a model at benchmark working group of GFCM in 2019 (GFCM 2019) based on reconstructed data and updated by STECF EWG 20-15 in 2020, by STECF EWG 21-15 in 2021 and by STECF EWG 22-16 in 2022.

6.5.1 STOCK IDENTITY AND BIOLOGY

According to the main outcomes of the EU StockMed project carried out in MAREA framework, the hake in the GSA 19 seems to belong to a wider stock unit distributed on the Central Mediterranean Sea. However, for the purposes of this assessment it is assumed a single, homogeneous stock living confined in GSA 19 (Figure 6.5.1.1).

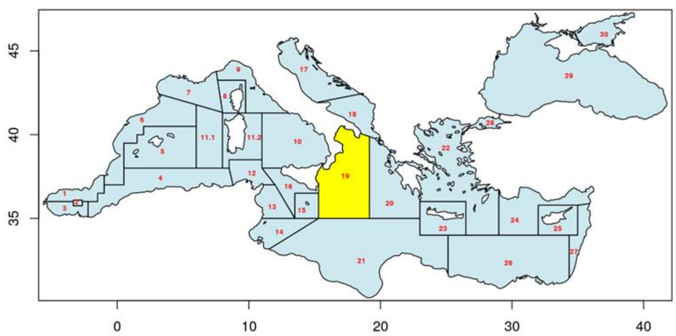


Figure 6.5.1.1. Hake in GSA 19. Geographical location of GSA 19.

M. merluccius represents one of the most important demersal species in terms of landing and income in GSA 19, especially for longlines (20% of the hake landing), gillnets and trammel nets (20% of the hake landing), as well as for the trawlers (60%).

The GSA 19 covers a surface of about 16500 km^2 in the depth range between 10-800 m along a coastline of about 1000 km (Italian regions of Apulia, east Lucania, east Calabria and east Sicily). The Northern Ionian Sea is geo-morphologically divided in two sectors by the Taranto Valley, which is exceeding 2200 m in depth. The former is located between the Taranto Valley and the Apulia region and is represented by a broad continental shelf. Along Calabria and Sicily instead, the shelf is generally very limited with the shelf break located at a depth varying between 30 and 100 m.

According to MEDITS and GRUND surveys, data *M. merluccius* has been caught at depth ranging from 14 to 800 m in the GSA 19. Adult specimens of European hake are mainly found on the slope, while recruits and pre-adult are mainly distributed on the shelf and shelf-break upper slope.

European hake is considered fully recruited at 10 cm TL (from SAMED, 2002). The length structures from trawl surveys are generally dominated by juveniles, while large size individuals are rare. This pattern might be also due to the different vulnerability of older fish (Abella and Serena, 1998) beside the effect of high exploitation rates. Shelter for adults of this species can be represented by many submarine canyons located along the coasts of GSA 19. The few large European hakes caught during trawl surveys are generally females and inhabit deeper waters.

Biological information on growth such as von Bertalanffy growth parameters, length-weight relationship (Table 6.5.1.1), maturity and natural mortality at age (Table 6.5.1.2) were obtained as determined at the hake benchmark meeting (GFCM 2019) and are applied to the entire catch time series (2004-2021).

Table 6.5.1.1 Hake in GSA 19. Von Bertalanffy growth (VBGF) parameters and length-weight relationship coefficient.

Sex	VBGF			Length/weight	
	L∞	k	t0	a	b
Females	111	0.1	-0.6	0.0055	3.1
Males	73	0.15	-0.73	0.005	3.04

Table 6.5.1.2. Hake in GSA 19. Proportion of mature specimens at age (Maturity) and natural mortality (M) vector divided by age and sex agreed in GFCM benchmark (GFCM 2019).

Age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
Maturity	0.03	0.33	0.57	0.92	0.99	0.98	1.00	1.00
M	1.27	0.69	0.45	0.34	0.28	0.24	0.22	0.20
Time of spawning	1st of January							

6.5.2 DATA

The time series of landings for Hake in the area used in the assessment were from the DCF since 2002 but being the first two years quite different from the rest of the time series, and lacking the longlines in the same years, the assessment was carried out from 2004.

6.5.2.1 CATCH (LANDINGS AND DISCARDS)

On average on landings from 2004 to 2021, the catch from longlines (LLS) represent about the 23% of the total hake landing, the gillnets and trammel nets (GTR, GNS) around the 13% (together), while the trawlers (OTB) are about the 64%. In 2021 these proportions are 79% bottom trawl, 6% gillnets and trammel nets, and 15% longlines.

The overall catches, as landings and discards are listed used for the assessment are reported in Table 6.5.2.1.1 and Figure 6.5.2.1.1.

While the landings are included for all years, discards are missing in 2004-2005 and 2007-2008, as collection of discard data was not foreseen by DCF. Discard data were subsequently reconstructed for the missing years during the benchmark session in 2019 (GFCM 2019) and the same dataset was used during EWG 22-16, plus 2021.

As shown on Figure 6.5.2.1.1, catches after a peak in 2006 and a decrease until 2012, the landings time series show a trend quite stable until 2018. Current level of landing is around 631 tons compared with 1630 tons in 2006.

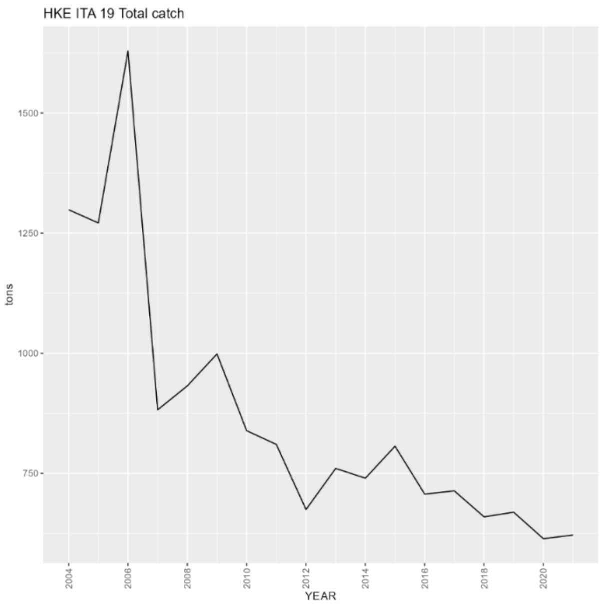


Figure 6.5.2.1.1. Hake in GSA 19. Hake DCF total catch (t), in GSA 19 (2004-2021). Data from DCF.

Table 6.5.2.1.1. Hake in GSA 19. Hake DCF landings (t), discards (t) in GSA 19 and values of SoP and SoP correction.

Year	Landings (t)	Discards (t)	Catch (t)	SOP	Catch/SOP
2004	1299	56	1355	1361	1.00
2005	1271	58	1329	1254	1.06
2006	1629	34	1663	1564	1.06
2007	882	31	913	892	1.02
2008	932	37	969	935	1.04
2009	999	53	1052	1057	1.00
2010	839	11	855	861	0.99
2011	810	9	819	821	1.00
2012	675	11	686	686	1.00
2013	760	11	773	776	1.00
2014	740	4	744	749	0.99
2015	807	5	812	736	1.10
2016	707	18	725	614	1.18
2017	714	5	719	536	1.34
2018	660	12	672	545	1.23
2019	669	40	710	707	1.00
2020	614	0.5	615	559	1.10
2021	622	9	631	574	1.10

With regards of the catch composition by gear (Figure 6.5.2.1.2) the bulk of catches are taken by bottom OTB and LLS for the landed fraction and by OTB for the discard component (Figure 6.5.2.1.3). OTB has increased in 2021 both for catches and discard, while LLS have decreased for catches.

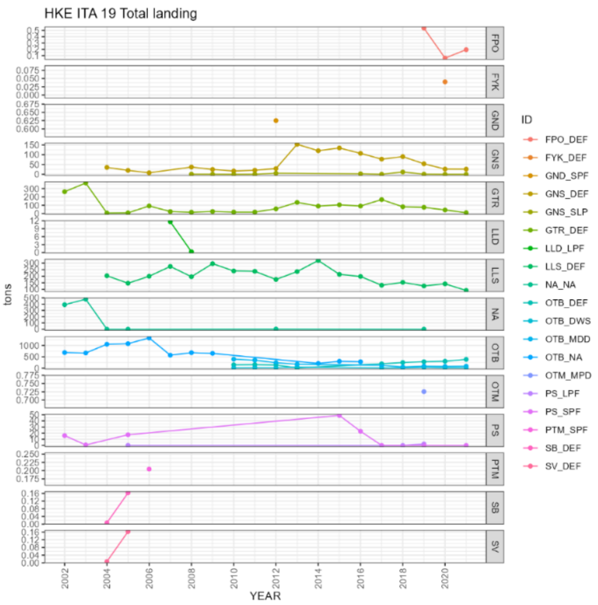


Figure 6.5.2.1.2. Hake in GSA 19. Hake total landing by metier in GSA 19 (2004-2021). Data from DCF.

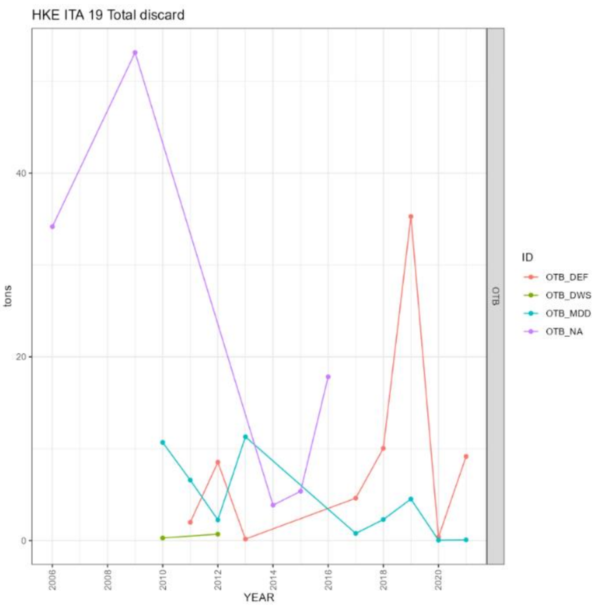


Figure 6.5.2.1.3. Hake in GSA 19. Hake total discards by bottom OTB in GSA 19 (2004-2021). Data from DCF.

Figure 6.5.2.1.4 reports the length frequency distributions of the catches (landings and discards). These distributions are generally dominated by individuals up to 30 cm total length. As seen on Figure 6.5.2.4. different gears have different size selectivity for hake.

Missing discard data have been reconstructed (GFCM 2019) and are considered in this assessment. The landings and discards at length for 2021 were then split into ages by applying the L2a routine as implemented in a4a package.

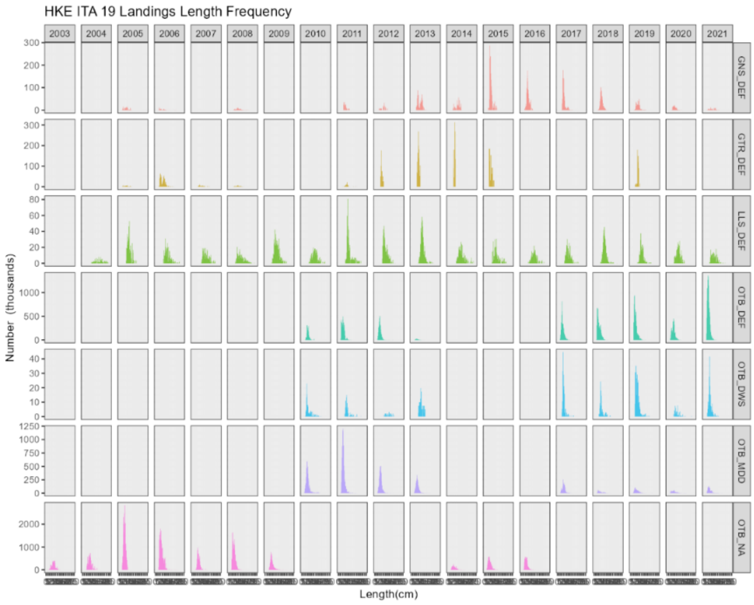


Figure 6.5.2.1.4. Hake in GSA 19. Length frequency distribution of catch by metier in GSA 19 (2004-2021). Data from DCF.

6.5.2.2 Effort

Fishing effort data were not reported to STECF EWG 22-16 and Effort data for missing years are now assembled from the FDI data call and reported in Table 6.5.2.2.1 and in Figure 6.5.2.2.1. For 2021 there is an increase in effort for OTB, LLS and GNS, while GTR continue to have a negative trend like in recent years. In general, there is a change in the fishing effort trend after 2014. Over the medium term, effort has been changing with a decline in OTB and LLS to with a relative increase in use of set nets (GNS and GTR) up to 2013 although these too decline in recent years. Overall there is a change in effort from the early part of the series to the later part.

Table 6.5.2.2.1. Hake GSA 19. Fishing effort in Fishing days by year and fleets targeting hake from 2004 to 2021.

Year	OTB	LLS	GTR	GNS
2004	45177	51085	96734	36458
2005	25416	19081	75301	47123
2006	39530	14827	44200	77509
2007	33397	17398	29759	71103
2008	39447	17547	47607	57284
2009	43744	17972	61891	63420
2010	42935	13982	64386	73527
2011	45238	20486	71419	68819
2012	38322	21596	59894	65086
2013	36679	29269	120837	99466
2014	36663	25000	89127	100437
2015	37454	22697	96065	75622
2016	38967	19033	107875	80243
2017	35995	15716	86649	34578
2018	34136	11245	91781	47738
2019	32877	9450	83327	36437

2020	25186	7953	67390	33579
2021	30094	11101	61748	36496

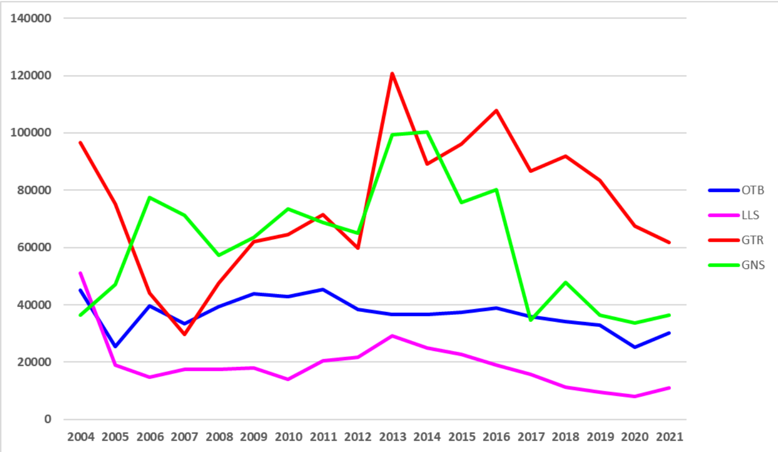


Figure 6.5.2.2.1. Hake GSA 19. Fishing effort in Fishing days by year and fleets targeting hake in GSA 19 (2004-2021). Data from DCF and FDI data call.

6.5.2.3 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out yearly during the spring season (May-July Figure 6.5.2.3.1). In 2014 and 2021 the survey was carried out in September, in 2017 – in November-December, and in 2020 – in October. According to the MEDITS protocol (Bertrand *et al*., 2002) a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m) was applied.

Figure 6.5.2.3.1. Hake GSA 19. MEDITS survey period over 1994-2021.

Each haul position was 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 utilized. Considering the small mesh size, a complete retention was assumed.

All the abundance data (number of fish per surface unit) were standardized to square kilometres, using the swept area method. Data for 2021 were analysed using the JRC script (Mannini, 2020).

MEDITS survey data are available from the official 2022 Data Call for GSA 19 since 1994. For the present assessment, data from 2004 to 2021 were used. It should be noted that the survey timing does change in some years; in particular 2017 survey was unusually late in the year.

Geographical distribution

The hake is mainly concentrated along the shelf. The distribution did not show substantial variation across time Figure 6.5.2.3.2.

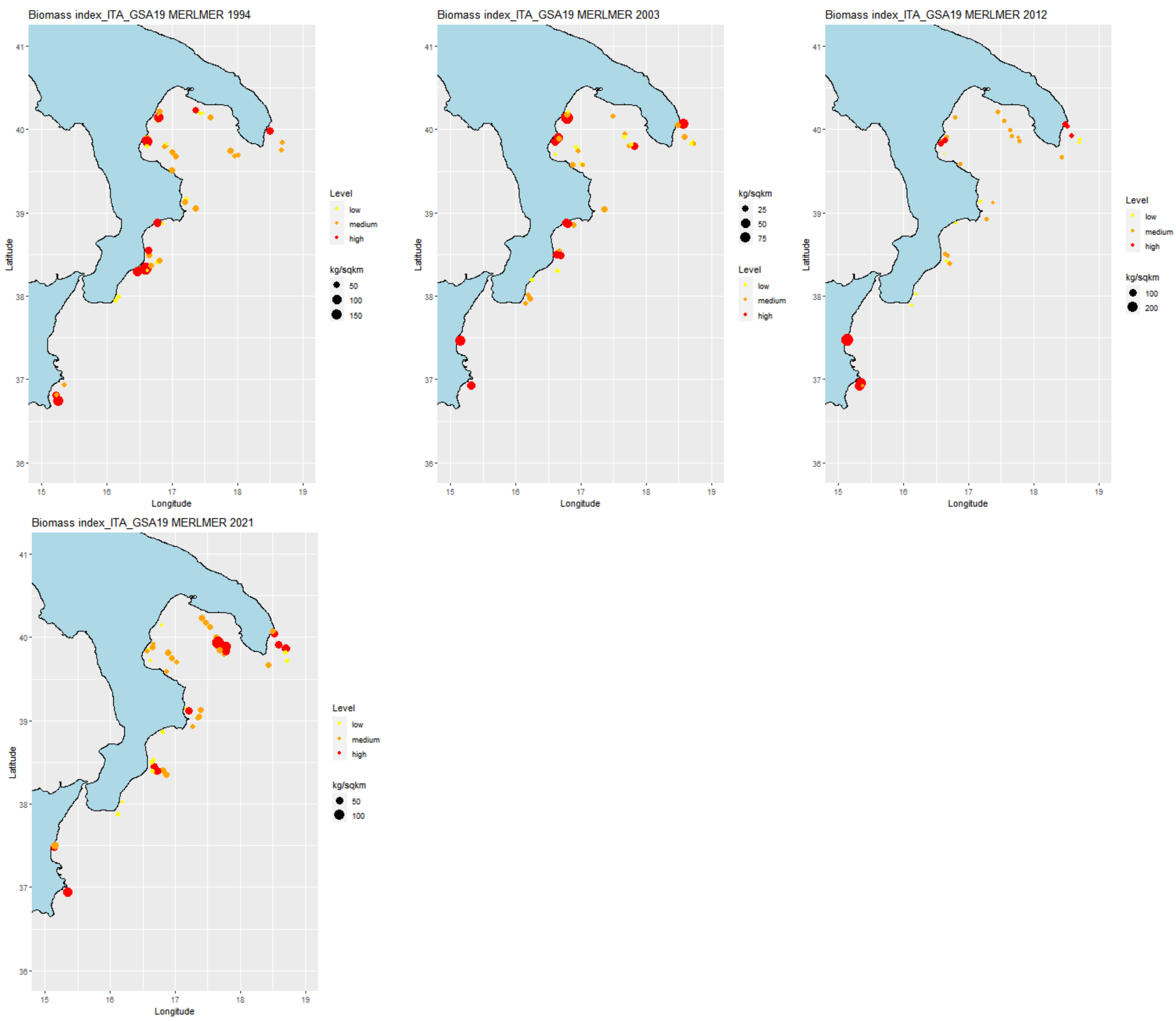
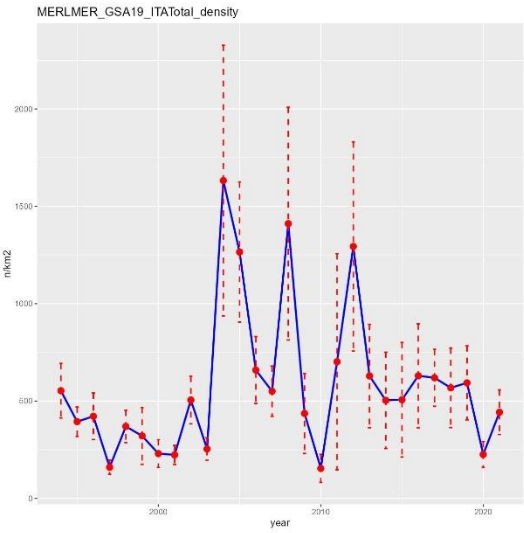


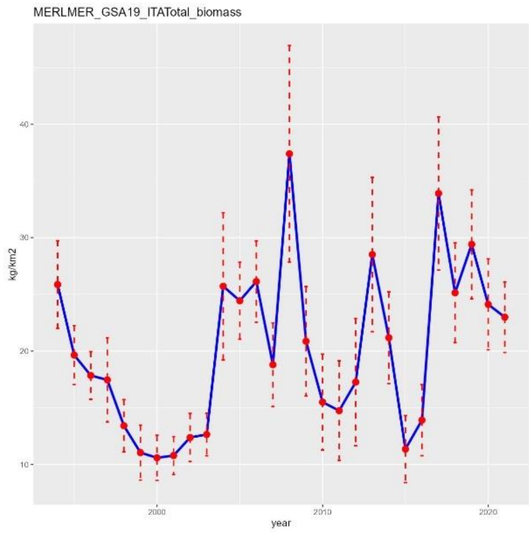
Figure 6.5.2.3.2. Hake GSA 19. Geographical distribution of hake in GSA 19 based on the biomass index of MEDITS survey in 1994, 2003, 2012 and 2021.

Trends in abundance and biomass

Based on the DCF data call input, abundance and biomass indices were calculated for 2021. Observed abundance and biomass indices of hake and the length frequency distributions are given on the figures below (Figure 6.5.2.3.3, Figure 6.5.2.3.4). Both abundance and biomass indices show increase between 2005 and 2013 with a drop around 2010. In 2021 the density goes up after a drop in 2020 while the biomass shows a decreasing trend as in 2020 (Figure 6.5.2.3.3).



A.



B.

Figure 6.5.2.3.3. Hake in GSA 19. Estimated A. abundance (N/km^2), and B. biomass (kg/km^2) indices and from the MEDITS survey. Data from DCF.

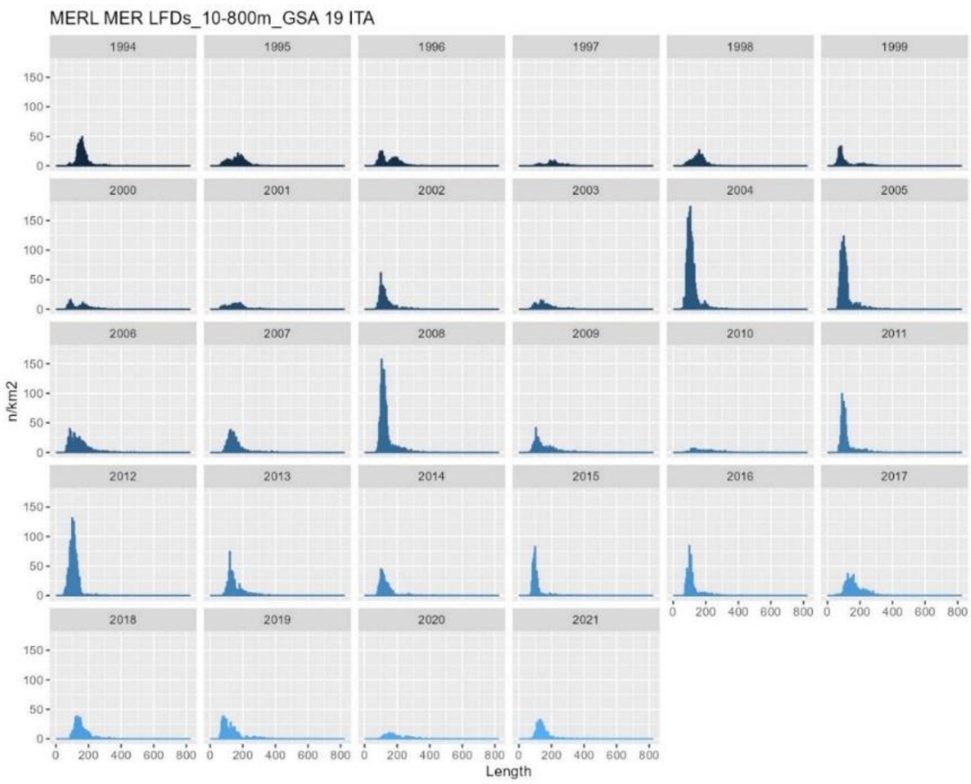


Figure 6.5.2.3.4. Hake in GSA 19. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of hake in GSA 19. Data from DCF.

6.5.3 STOCK ASSESSMENT

The management advice is given using the a4a statistical catch-at-age modelling framework - Assessment for all (a4a, Jardim et al., 2014), using R script from FLR package (http://www.flr-project.org/), since it was the model chosen during the GFCM benchmark in 2019.
The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality. 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.

6.5.3.1. Input data

Input data for the last year 2021 as extracted and sliced from DCF data were added to the stock object from the hake benchmark from last year (EWG 21-15). There were minor differences in numbers at age when recalculating the years prior to 2021, though these were thought to be derived from the process of discard reconstruction and weight at age calculation.

Considerable effort was spent trying to track down the reason for the differences but given the limited time and prior information accessible at the EWG 22-16 we could not find the causes of these discrepancies. Therefore, the EWG 22-16 decided to simply add 2021 to the time series, without recalculating the years prior to 2021.

Input data in terms of catch numbers and mean weight at age, and tuning data in terms of catch numbers from the MEDITS survey are shown from Figure 6.5.3.3.3. to Figure 6.5.3.3.7 and from Table 6.5.3.3.4 to 6.5.3.3.6.

No such discrepancies were found following the length to age procedures from the previous assessment when analysing the MEDITS data.
Proportion of mature and M at age are shown in Table 6.5.1.2. The plus group in the catch data was set to age 7, and ages 0-4 in MEDITS survey data were used to tune the assessment model. The age range of F_{bar} was set to age 0-4 as most of the catches were represented within these age classes.

Catch data were SOP corrected using the ratio between total catch and SOPs at year are reported in Table 6.5.2.1.

Relatively good consistency is observed between cohorts in the catch and survey data (Figure 6.5.3.3.8).

6.5.3.3 Stock assessment models and results

The a4a model used in EWG 21-15 was tested with the new data added in 2021. The EWG found that the original Fmodel used for the previous assessment resulted in high instability of the assessment over time, especially looking at the retrospective analysis (Figure 6.5.3.3.1). Also, the analysis of residuals coming from MEDITS index showed a strong inconsistency for 2017 (Figure 6.5.3.3.2). For this reason, the Fishing mortality model was examined for modification and sensitivity to 2017 data in MEDITS index was removed.

Survey catchability (Figure 6.5.3.3.9) and Stock-recruit sub-models remain the same as the one used for the previous assessment (EWG 21-15).

First, was decided to remove the 2017 from MEDITS index (Figure 6.5.3.3.7) because checking the survey timing in Figure 6.5.2.3.1, we noticed that for 2017 was carried out in November-December, in a very different period compared to the time series and this may be the reason for the strong trend in 2017 looking at the residuals plot (Figure 6.5.3.3.2). Following removal of 2017 data the retrospective performance improve reducing the effect to about half the original level. However, this still left poor retrospective performance.

Second, was noticed a change in gear catchability for effort and catches (Figure 6.5.2.2.1, Figure 6.5.2.1.2) since 2014. To understand how this could affect the retrospective analysis, we conducted an analysis on the proportion of F obtained by the retrospective and on catchability of the survey, using the original sub-models of the previous assessment (EWG 21-15) without MEDITS index for 2017 (Table 6.5.3.3.1, 6.5.3.3.2, 6.5.3.3.3).The analysis highlighted that the F of last 5 years was very changing as years of data were removed and consequently this gave instability to the model. In contrast, with 2017 removed the catchability of the survey was very stable.

For all these reasons, EWG 22-16 agreed that to continue with the benchmark setting was not providing good advice, so the following changes were adopted: to use a model without 2017 for MEDITS index; and with a breakpoint for 2015 in Fmodel, in order to account for the change in effort and catches. With this replacement the assessment has greater stability (Figure 6.5.3.3.12.). These modifications were considered to greatly improve the advice for this year, however, it may be that further modifications will be required if the shift in fishery among the gears continues. It is suggested that either the model be adapted year by year to cope with these changes, or a further benchmark is carried out.

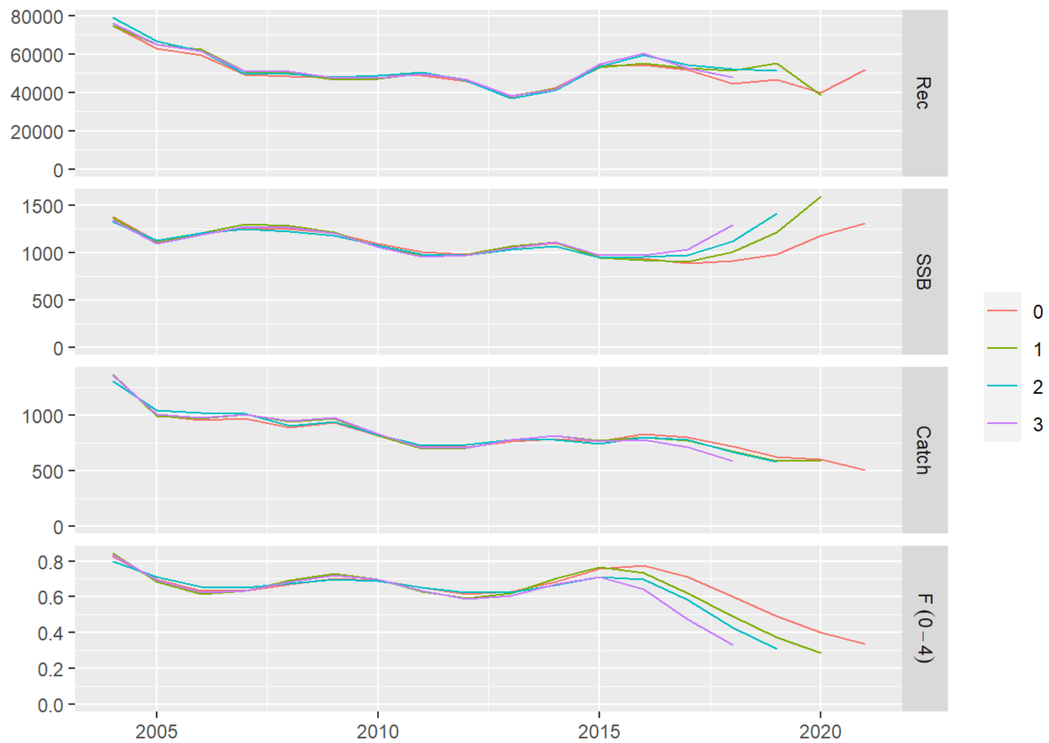


Figure 6.5.3.3.1. Hake in GSA 19. Retrospective analysis output of last model used in EWG 21-15 with the new data added in 2021.

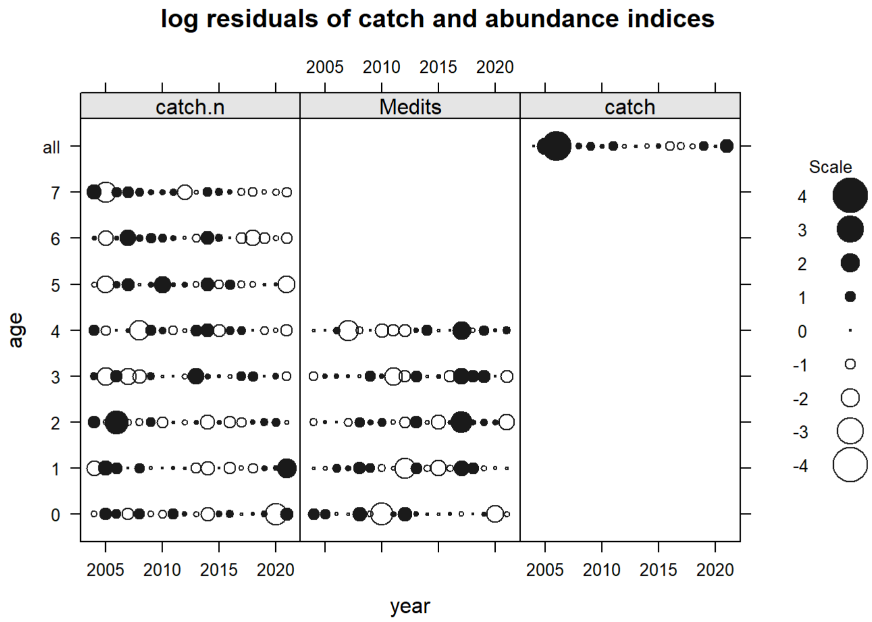


Figure 6.5.3.3.2. Hake in GSA 19. Standardized residuals for abundance indices (MEDITS) and catch at age data model used in EWG 21-15 with the new data added in 2021. Each panel present residuals by age and year.

Table 6.5.3.3.1. Hake in GSA 19. Proportion of F mortality coming from retrospective PIL analysis until 2020.

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	-0.081	0.096	0.140	0.017	-0.110	-0.113	0.017	0.166	0.142	-0.046	-0.191	-0.164	0.052	0.278	0.125	-0.340	-0.680
1	0.011	-0.042	-0.053	-0.018	0.028	0.033	-0.010	-0.058	-0.065	-0.027	0.017	0.008	-0.063	-0.147	-0.195	-0.204	-0.211
2	0.031	-0.024	-0.035	0.001	0.048	0.053	0.009	-0.040	-0.047	-0.008	0.036	0.027	-0.045	-0.131	-0.180	-0.189	-0.196
3	0.038	-0.017	-0.028	0.008	0.055	0.061	0.016	-0.033	-0.041	-0.001	0.044	0.035	-0.038	-0.124	-0.174	-0.183	-0.190
4	0.036	-0.019	-0.031	0.006	0.052	0.058	0.014	-0.035	-0.043	-0.004	0.041	0.032	-0.041	-0.127	-0.176	-0.185	-0.192
5	0.051	-0.005	-0.016	0.021	0.068	0.074	0.029	-0.021	-0.029	0.011	0.057	0.048	-0.026	-0.114	-0.164	-0.173	-0.180
6	0.118	0.059	0.046	0.086	0.136	0.142	0.094	0.041	0.033	0.075	0.123	0.114	0.035	-0.057	-0.111	-0.121	-0.128
7	0.238	0.173	0.159	0.203	0.259	0.265	0.213	0.154	0.144	0.192	0.245	0.234	0.147	0.044	-0.015	-0.026	-0.034

Table 6.5.3.3.2. Hake in GSA 19. Proportion of F mortality coming from retrospective PIL analysis until 2019.

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	-0.026	-0.011	0.016	0.049	0.065	0.044	0.000	-0.033	-0.027	0.014	0.047	0.024	-0.052	-0.107	-0.037	0.304
1	-0.057	0.001	0.027	0.012	-0.020	-0.036	-0.025	-0.005	-0.001	-0.022	-0.052	-0.074	-0.096	-0.151	-0.267	-0.422
2	-0.045	0.013	0.040	0.024	-0.008	-0.024	-0.014	0.007	0.011	-0.010	-0.041	-0.063	-0.085	-0.141	-0.258	-0.415
3	-0.022	0.037	0.065	0.049	0.016	-0.001	0.010	0.031	0.035	0.014	-0.018	-0.041	-0.063	-0.121	-0.240	-0.401
4	-0.020	0.040	0.067	0.051	0.018	0.001	0.012	0.033	0.037	0.016	-0.016	-0.039	-0.061	-0.119	-0.239	-0.399
5	-0.005	0.056	0.084	0.068	0.034	0.017	0.028	0.050	0.054	0.032	0.000	-0.023	-0.046	-0.105	-0.227	-0.390
6	0.104	0.172	0.203	0.185	0.147	0.129	0.141	0.165	0.170	0.145	0.110	0.084	0.059	-0.006	-0.142	-0.323
7	0.345	0.427	0.465	0.443	0.397	0.375	0.389	0.418	0.424	0.394	0.351	0.320	0.289	0.210	0.045	-0.175

Table 6.5.3.3.3. Hake in GSA 19. Differences in catchability of the MEDITS survey.

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
2	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
3	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
4	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001

<u>a4a submodels</u>:

Fishing mortality:
Fmodel <- ~s(age, k=5, by=breakpts(year, 2015)) + s(year, k=7) + s(year,k=7, by=as.numeric(age==0))

Survey catchability:
Qmodel <- list(~factor(replace(age,age>2,2)))

Stock-recruit:
Rmodel=~geomean(CV=0.2)

Summary results and diagnostics from the a4a model are presented in Figure 6.5.3.3.10. to Figure 6.5.3.3.14.

The results and the diagnostics of the fitted model are quite similar to those obtained during last assessment (EWG 21-15), except for the recruitment that is increasing instead of decreasing like in 2020. Following the F model modification and removal of delayed survey (MEDIT 2017) the retrospective analysed no longer show consistent pattern of under- or overestimation of Recruits, SSB and F_{bar}, in the last years.
The estimated catch follows the trend of the input catch data (except for 2006). The stock summary with simulated confidence intervals is presented at Figure 6.5.3.3.14. The SSB is increasing after 2016 while fishing mortality is decreasing. Estimated stock numbers and fishing mortality at age, as well as stock summary are presented from Tables 6.5.3.3.6 to 6.5.3.3.8.

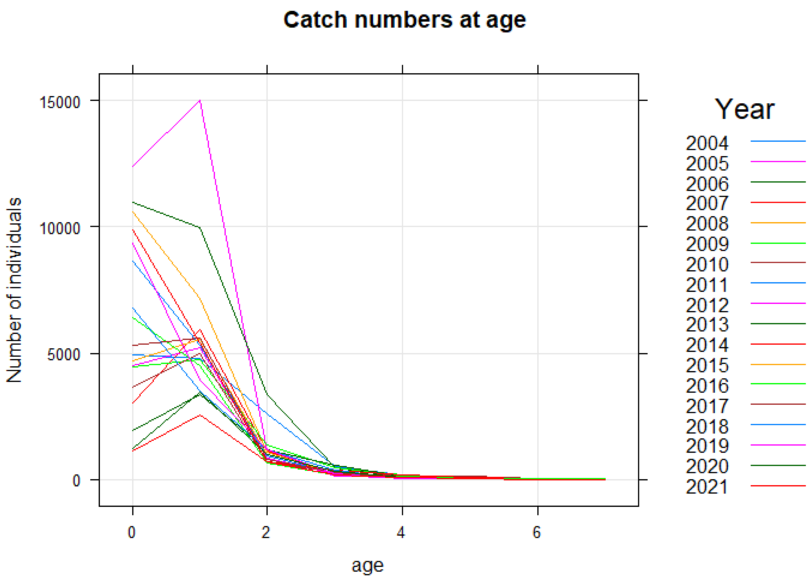


Figure 6.5.3.3.3. Hake in GSA 19. Hake number of individuals (thousands) at age of the catch in GSA 19 (2004-2021). Data from DCF.

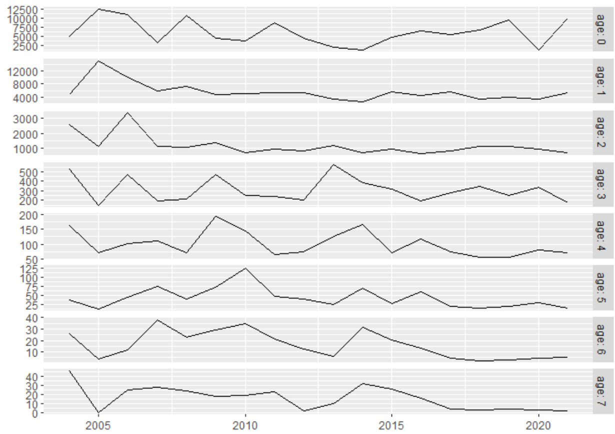


Figure 6.5.3.3.4. Hake in GSA 19. Hake number of individuals per year by age group (0-7) of the catch in GSA 19 (2004-2021). Data from DCF.

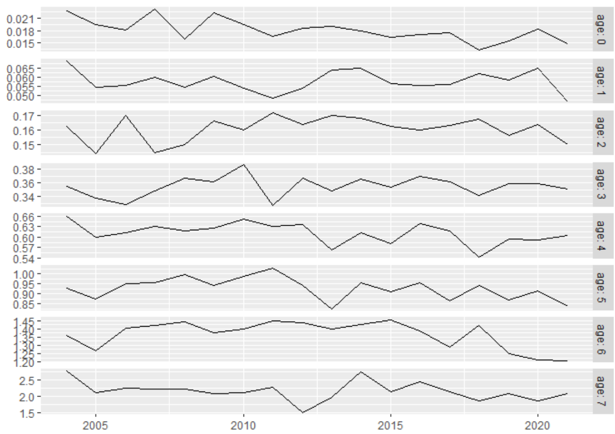


Figure 6.5.3.3.5. Hake in GSA 19. Hake means weight (kg) at age (0-7) of catches per year in GSA 19 (2004-2021). Data from DCF.

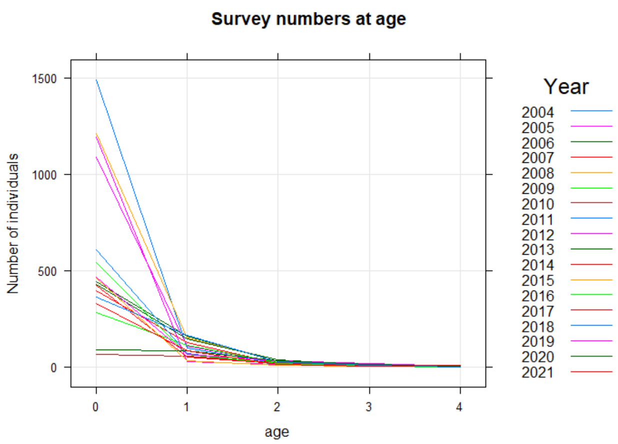


Figure 6.5.3.3.6. Hake in GSA 19. Age composition of the MEDITS survey of hake in GSA 19 (2004-2021). Data from DCF.

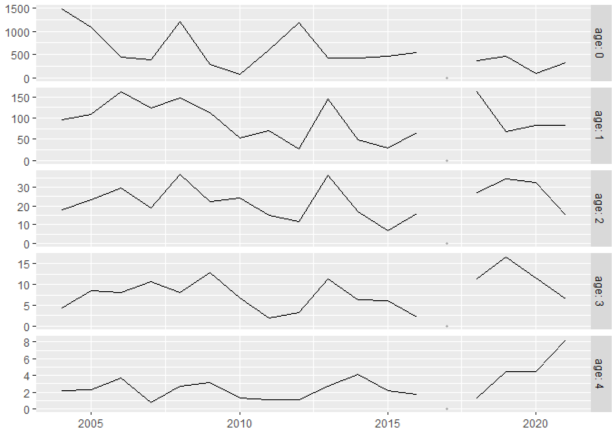
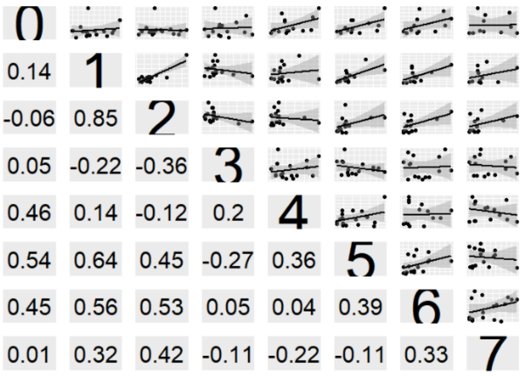


Figure 6.5.3.3.7. Hake in GSA 19. Number of individuals per year by age group (ages 0-4) according to MEDITS surveys (2004-2021) without 2017.

A.



B.

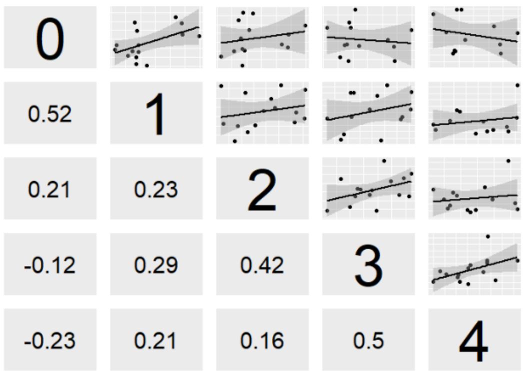
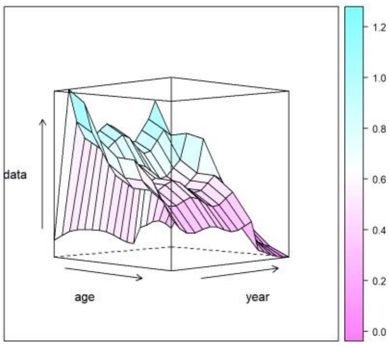


Figure 6.5.3.3.8. Hake in GSA 19. A. Cohorts consistency in the catches, and B. in MEDITS survey.

A.



B.

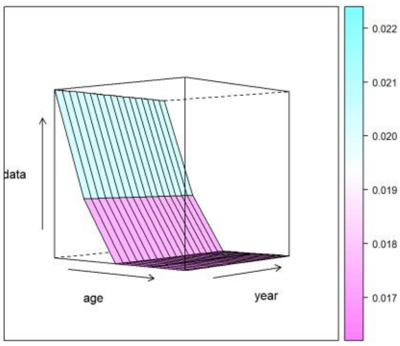
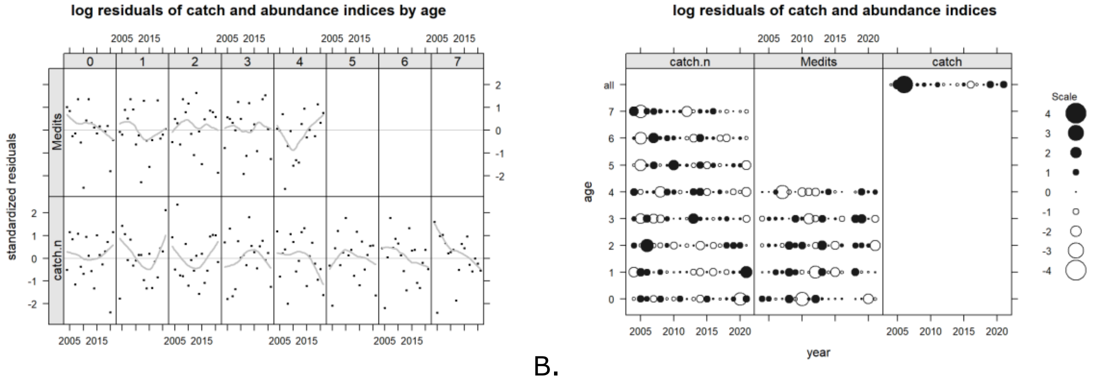
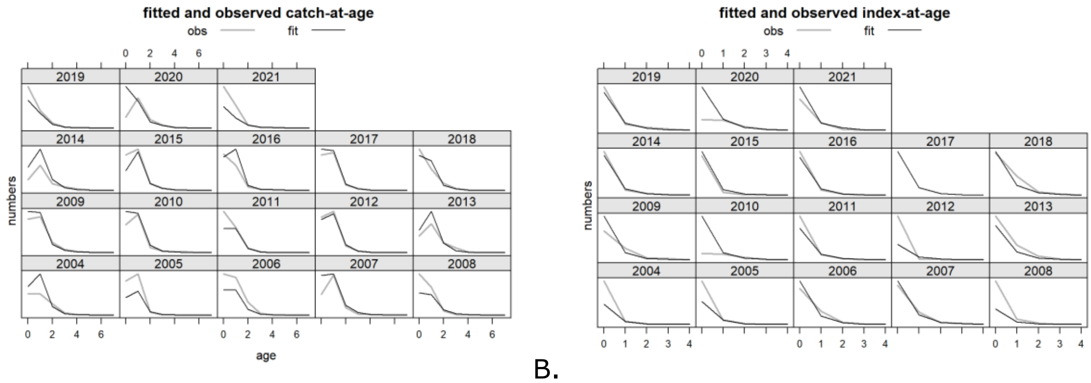


Figure 6.5.3.3.9. Hake in GSA 19. 3D plots of fishing mortality (A), and survey catchability (B) at age and year.



A. B.

Figure 6.5.3.3.10. Hake in GSA 19. Standardized residuals for abundance indices (MEDITS) and catch at age data. Each panel present residuals by age and year.



A. B.

Figure 6.5.3.3.11. Hake in GSA 19. Fitted and observed catch (A.) and survey index (B) numbers at age.

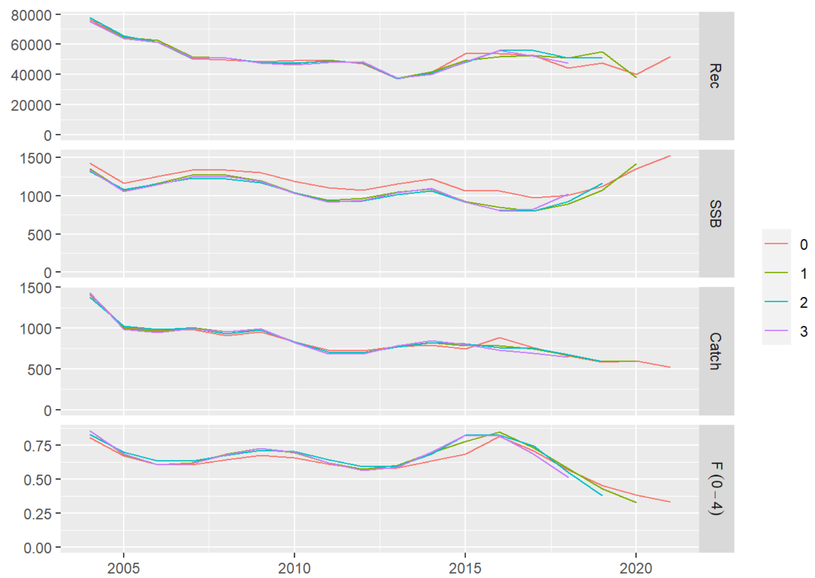


Figure 6.5.3.3.12. Hake in GSA 19. Retrospective analysis output.

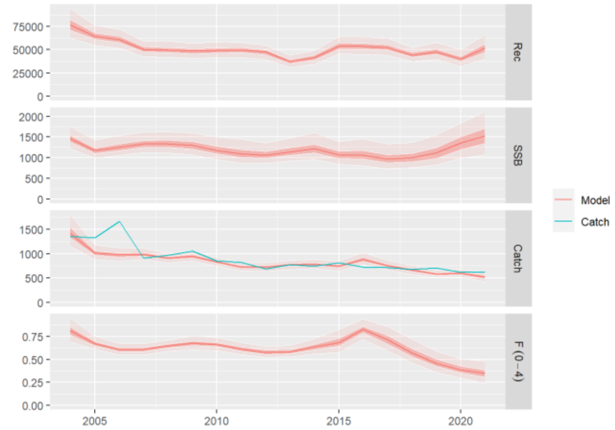


Figure 6.5.3.3.13. Hake in GSA 19. Stock summary for hake in GSA 19, recruits (‘000), SSB (t), catch (t) and F_{bar} (age 0-4). Estimated catch is compared to recorded catch.

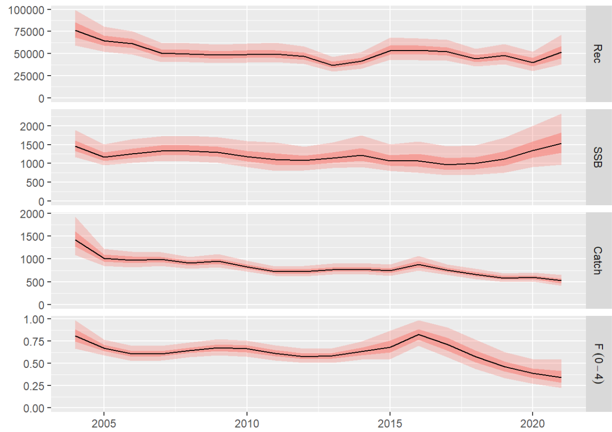


Figure 6.5.3.3.14. Hake in GSA 19. Stock summary of the simulated and fitted model from a4a. Stock summary for hake in GSA 19, recruits (‘000), SSB (t), catch (t) and F_{bar} (age 0-4).

Table 6.5.3.3.4. Hake in GSA 19. Number of individuals per year by age group (ages 0-7) in the catch from 2004 to 2021. Data from DCF.

Year/Age	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
0	4912	12375	10986	3049	10582	4442	3643	8630	4486	1949	1119	4709	6408	5293	6772	9375	1237	9860
1	4790	14998	9973	5924	7166	4726	4962	5320	5217	3386	2574	5535	4488	5602	3499	3941	3478	5397
2	2587	1106	3384	1121	1076	1363	696	952	862	1167	685	964	653	808	1158	1162	977	712
3	524	147	473	191	212	473	251	239	203	577	381	317	190	284	346	249	333	170
4	165	72	103	110	71	195	144	64	73	128	166	71	118	74	56	56	81	72
5	38	13	45	74	39	73	126	47	39	24	71	27	60	19	14	20	31	15
6	26	4	12	38	23	29	35	21	13	6	32	20	13	5	2	3	5	5
7+	46	1	25	29	24	18	19	24	2	10	32	27	17	5	3	4	3	2

Table 6.5.3.3.5. Hake in GSA 19. Weight of individuals at age (0-7) in the catch from 2004 to 2021. Data from DCF.

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0.023	0.019	0.018	0.023	0.016	0.022	0.020	0.017	0.019	0.019	0.018	0.016	0.017	0.018	0.013	0.016	0.018	0.015
1	0.069	0.055	0.056	0.060	0.055	0.061	0.054	0.049	0.054	0.064	0.065	0.057	0.056	0.056	0.062	0.058	0.065	0.047
2	0.163	0.144	0.170	0.145	0.150	0.166	0.160	0.172	0.164	0.170	0.168	0.162	0.160	0.163	0.167	0.156	0.164	0.150
3	0.355	0.338	0.329	0.349	0.367	0.362	0.387	0.327	0.366	0.348	0.365	0.354	0.370	0.362	0.342	0.360	0.359	0.351
4	0.661	0.599	0.614	0.632	0.619	0.625	0.653	0.632	0.637	0.563	0.613	0.582	0.639	0.619	0.542	0.594	0.591	0.605
5	0.930	0.872	0.952	0.958	0.999	0.941	0.987	1.030	0.941	0.826	0.957	0.913	0.956	0.864	0.942	0.868	0.913	0.840
6	1.360	1.266	1.407	1.423	1.445	1.379	1.400	1.449	1.438	1.399	1.427	1.456	1.390	1.290	1.418	1.251	1.212	1.208
7+	2.767	2.097	2.247	2.209	2.212	2.087	2.122	2.273	1.511	1.967	2.745	2.146	2.440	2.133	1.854	2.080	1.873	2.087

Table 6.5.3.3.6. Hake in GSA 19. Number of individuals per year by age group (ages 0-4) according to MEDITS surveys from 2004 to 2021. Data from DCF.

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	1487	1089	442	395	1212	281	64	606	1193	430	422	459	541	NA	363	466	89	329
1	96	109	162	125	148	114	54	70	27	146	49	31	65	NA	163	67	83	84
2	18	23	30	19	37	22	24	15	12	36	17	7	16	NA	27	34	33	15
3	4	8	8	11	8	13	7	2	3	11	6	6	2	NA	11	17	11	7
4	2	2	4	1	3	3	1	1	1	3	4	2	2	NA	1	4	4	8

Table 6.5.3.3.7. Hake in GSA 19. Number of individuals at age in the stock (2004-2021).

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	76443	64670	61241	50532	49805	48535	49289	49563	47037	37138	41341	53883	53923	52464	44380	47756	40029	51566
1	17442	18280	15029	13905	11357	11206	10979	11233	11461	11168	9115	10442	13837	12273	11750	9707	10391	8935
2	3433	2640	3438	3155	2928	2251	2116	2116	2320	2483	2368	1773	1866	2150	2258	2691	2637	3126
3	785	731	686	988	909	798	587	563	599	686	720	635	440	481	631	785	1068	1133
4	235	241	262	265	383	337	286	214	215	237	267	264	219	125	156	243	346	510
5	97	86	101	117	118	165	141	121	94	98	106	114	107	69	45	66	117	179
6	52	38	38	47	55	54	73	63	56	45	46	48	49	47	33	24	38	71
7+	33	42	45	48	55	63	65	77	81	82	76	70	66	78	88	89	85	94

Table 6.5.3.3.8. Hake in GSA 19. Hake fishing mortality (F) at age (2004-2021).

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
0	0.161	0.189	0.213	0.223	0.222	0.216	0.209	0.194	0.168	0.135	0.106	0.089	0.210	0.226	0.250	0.255	0.230	0.190
1	1.198	0.981	0.871	0.868	0.928	0.977	0.956	0.887	0.840	0.861	0.947	1.032	1.172	1.003	0.784	0.613	0.511	0.451
2	1.096	0.897	0.797	0.794	0.849	0.894	0.875	0.812	0.768	0.788	0.866	0.944	0.906	0.776	0.606	0.474	0.395	0.349
3	0.841	0.688	0.611	0.609	0.651	0.685	0.671	0.623	0.589	0.604	0.664	0.724	0.916	0.785	0.613	0.480	0.400	0.353
4	0.727	0.595	0.528	0.527	0.563	0.593	0.580	0.538	0.509	0.522	0.574	0.626	0.871	0.746	0.583	0.456	0.380	0.335
5	0.708	0.580	0.515	0.513	0.549	0.577	0.565	0.524	0.496	0.509	0.560	0.610	0.584	0.500	0.391	0.306	0.255	0.225
6	0.579	0.474	0.421	0.419	0.448	0.472	0.462	0.429	0.406	0.416	0.457	0.498	0.275	0.236	0.184	0.144	0.120	0.106
7+	0.355	0.290	0.258	0.257	0.275	0.289	0.283	0.263	0.249	0.255	0.280	0.306	0.109	0.094	0.073	0.057	0.048	0.042

Table 6.5.3.3.9. Stock summary: number of recruits, SSB, F_{bar} 0-4**,** estimated catch

Year	Recruitment age 0 in thousands	SSB (t)	Fbar 0-4	Catch (t)
2004	76443	1426	0.804	1409
2005	64670	1164	0.670	1018
2006	61241	1256	0.604	977
2007	50532	1336	0.604	988
2008	49805	1338	0.643	911
2009	48535	1301	0.673	952
2010	49289	1188	0.658	834
2011	49563	1105	0.611	731
2012	47037	1076	0.575	726
2013	37138	1152	0.582	775
2014	41341	1222	0.632	790
2015	53883	1067	0.683	748
2016	53923	1068	0.815	886
2017	52464	975	0.707	760
2018	44380	1007	0.567	665
2019	47756	1122	0.456	586
2020	40029	1356	0.383	601
2021	51566	1527	0.335	522

6.5.4 Reference Points

The STECF EWG 22-16 recommended to use $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object. Current F_{bar}= 0.335 is higher than $F_{0.1}$ (0.211), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that hake stock in GSAs 19 is over-exploited.

6.5.5 Short term Forecast and Catch Options

Method

A deterministic short-term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts and based on the results of the a4a stock assessment (Chapter 6.5.3.2).

Table 6.5.5.1. Hake in GSA 19: Assumptions made for the interim year (2022) and in the STF forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, mean weight, etc. were averaged
F_{ages} 0-4 (2022)	0.335	F_{sq} = F in the last year. Base year fishing mortality from current assessment for the calculation of F_{MSY} transition to reach F_{MSY} in 2030
SSB (2022)	1924	SSB intermediate year from STF output
R Age0 (2022,2023)	50367	Recruitment will be set as geometric mean of the last 18 years
Total Catch (2022)	649	Catch intermediate year from STF output
a and b values	a=0.875 and b=0.125	Regression parameters from $T_{ransition}$ regression line

Results
The results of the short-term forecasts for hake (GSA 19) are shown in Table 6.5.5.2.1.

The F_{sq} = 0.335 (assumed F_{bar} in the last assessment year 2020) is larger than $F_{0.1}$ (0.211), which is a proxy of F_{MSY} and is used as the exploitation reference point consistent with high long-term yields. This indicates that hake in GSA 19 is over exploited. The catch of hake in 2022, consistent with $F_{0.1}$ (0.211), should not exceed 468 tonnes, 27.9 % less than the current estimated catch (649 t).

Table 6.5.5.2.1. Hake (HKE) in GSA 19 short term forecast. Annual catch scenarios and predictions of catch and SSB. Catch and SSB are in tonnes.

Rationale	F_{factor}	F_{bar}	Catch2023	SSB2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long-term yield ($F_{0.1}$)	0.628	0.211	468	2904	51	-10
F_{upper}	0.871	0.292	627	2713	41	20
F_{lower}	0.424	0.142	325	3078	60	-38
$F_{MSY\ Transition}$	0.954	0.320	678	2652	38	30
Zero catch	0.0	0.000	0	3479	81	-100
Status quo	1.0	0.335	706	2618	36	35
Different Scenarios	0.1	0.034	81	3379	76	-85
	0.2	0.067	159	3282	71	-70
	0.3	0.101	235	3189	66	-55
	0.4	0.134	308	3099	61	-41
	0.5	0.168	380	3012	57	-27
	0.6	0.201	449	2928	52	-14
	0.7	0.235	516	2846	48	-1
	0.8	0.268	581	2768	44	11
	0.9	0.302	645	2691	40	24
	1.1	0.369	766	2547	32	47
	1.2	0.403	824	2478	29	58
	1.3	0.436	880	2412	25	69
	1.4	0.470	935	2347	22	79
	1.5	0.503	988	2285	19	89
	1.6	0.537	1039	2225	16	99
	1.7	0.570	1090	2167	13	109
	1.8	0.604	1138	2110	10	118
	1.9	0.637	1186	2056	7	127
	2.0	0.671	1232	2003	4	136

6.5.6 DATA DEFICIENCIES

No issues

6.6 RED MULLET IN GSA 19

6.6.1 STOCK IDENTITY AND BIOLOGY

Stock of red mullet (*Mullus barbatus*) was assumed in the boundaries of the GSA 19. Red mullet is with hake, deep-water rose shrimp, anchovy and sardine a key species of fishing assemblages in the Ionian Sea (GSA 19) (Figure 6.6.1.1).

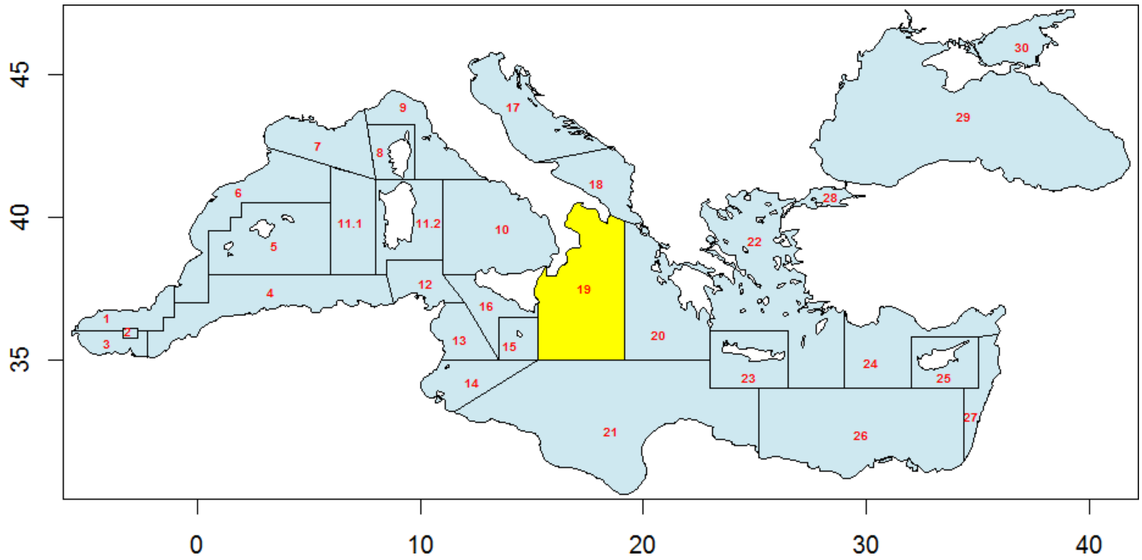


Figure 6.6.1. Geographical location of GSA 19.

Growth

Growth parameters were estimated following the age reading procedure described in Carbonara et al. (2018) and are consistent with those estimated in GSA 18 in the same paper and in DCF. The length-to-weight ratio is from DCF and the vector of natural mortality by age was calculated using the method of Chen and Watanabe. The proportion of mature males and females was calculated following Carbonara et al. (2015) as agreed upon during the benchmark meeting for the red mullet assessment in GSAs 17 and 18.

Table 6.6.1.1 6.6 Red mullet in GSA 19. Growth parameters used in the present assessments.

	males	females	Units	Data source	Years
L_∞	26	30	cm	DCF	2003-2020
K	0.253	0.234	cm	DCF	2003-2020
t_0	-0.8	-0.66	cm	DCF	2003-2020
a	0.0075	0.0076	cm/gr	DCF	2003-2020
b	3.15	3.15	cm/gr	DCF	2003-2020

Natural mortality

Table 6.6.1.2 Red mullet in GSA 19: M vector by age (sex combined)

Age class	M Chen and Watanabe
0	0.62
1	0.52
2	0.48
3	0.46
4	0.45

Maturity

The vector of proportion of mature individuals by was the one reported in Table 6.6.1.3.

Table 6.6.1.3 Red mullet in GSA 19. Maturity proportion at age adopted in the present assessments.

Age	Maturity
0	0
1	1
2	1
3	1
4	1

6.6.2 DATA

Data on catch (landings + discards) weight and length frequencies are provided by official DCF data only for period 2002 - 2021. Red mullet is mostly targeted by trawlers (about 55% of the total catch in average of last five years), but also with small scale fisheries using mostly gillnet and trammel net. The sum of these three gears (OTB+GNS+GTR) represents almost 100% of the total catch. Significant amount of catch was recorded at beginning of time series by NA gears.

6.6.2.1 CATCH (LANDINGS AND DISCARDS)

Landings fluctuate around 220 and 2500 tons with the maximum in 2002 and the minimum in 2021. Landings of gears other than OTB, GNS and GTR can be considered negligible or misreporting.

The volume of landings by gear is reported in table 6.6.2.1.1 and figure 6.6.2.1.1.

Table 6.6.2.1.1 Red mullet in GSA 19. Landings by year and metier.

Year	FPO	GNS	GTR	LLD	LLS	NA	OTB	OTM	PS	PTM	SB	SV	Total
2002			242.79			1242.26	781.75		5.87				2272.67
2003			1152.26			870.13	427.07		2.30				2451.77
2004		52.05	534.97		0.08	0.09	363.75				0.02	0.02	950.97
2005		42.79	760.27			0.01	297.53		0.68		6.21	6.21	1113.69
2006		64.69	240.93				566.00			0.35	7.70	7.70	887.38
2007		54.73	189.52			0.98	287.76				4.07	4.07	541.13
2008		68.53	29.26	0.39	0.58	0.55	348.32				0.09	0.09	447.81
2009		114.08	16.13		0.06	1.45	389.81				3.99	3.99	529.50
2010		220.02	13.13			5.64	283.53				7.90	7.90	538.12
2011		172.90	25.01			3.01	371.51				7.96	7.96	588.36
2012		145.86	20.77			0.08	309.32				3.62	3.62	483.27
2013		119.17	41.28			0.72	110.49				1.39	1.39	274.44
2014		122.85	23.70			0.45	102.65				0.69	0.69	251.03
2015		65.02	28.94	0.55			189.43		19.67				303.60
2016		95.17	17.15				165.54						277.86
2017		57.52	39.99				197.42						294.94
2018		113.50	152.05				285.44						550.99
2019		93.32	154.84		0.14	0.17	212.06	0.10					460.63
2020	0.02	39.64	55.41				140.07						235.14
2021	0.00	28.48	39.26		0.00		151.19						218.93

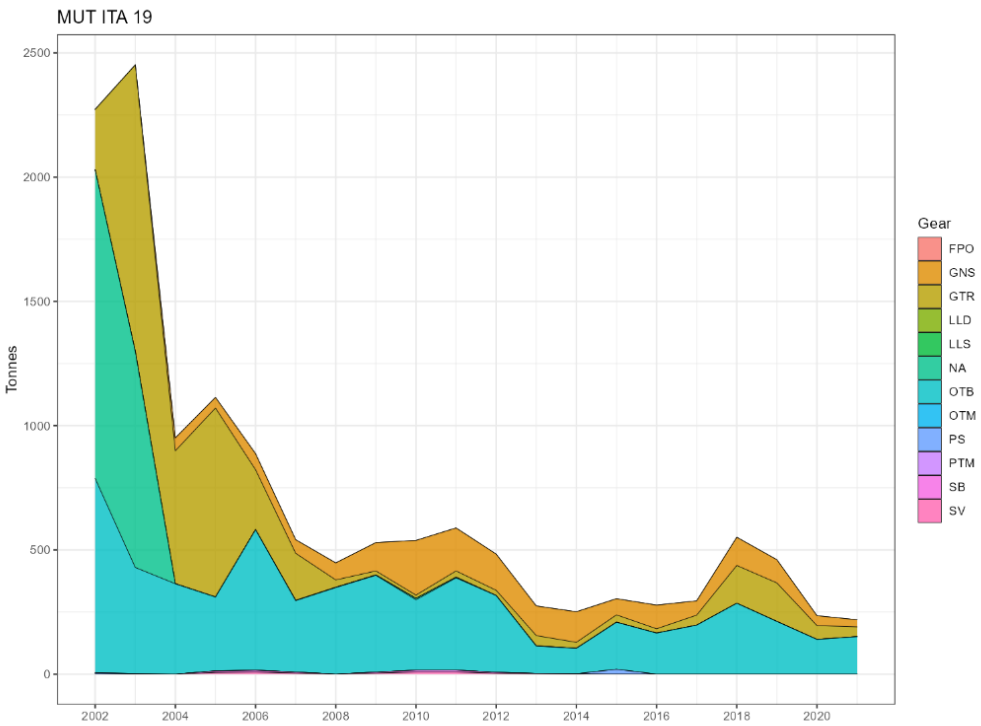


Figure 6.6.2.1.1 Red mullet in GSA 19. Landings by gears (tons).

Discards of red mullet in the GSA 19 are reported for 2009, 2011-2021. The volume of discards is rather variable among years, but anyway discards no greater than 1% of the total catch. The weight of discard by gear is reported only for OTB and shown in table 6.6.2.1.2 and figure 6.6.2.1.2.

Table 6.6.2.1.2 Red mullet in GSA 19. Discards by fishing gear (OTB)

Year	Discards
2009	9.96
2011	0.06
2012	3.29
2013	0.02
2014	1.45
2015	0.08
2016	0.12
2017	3.88
2018	1.12
2019	1.47
2020	0.08
2021	0.05

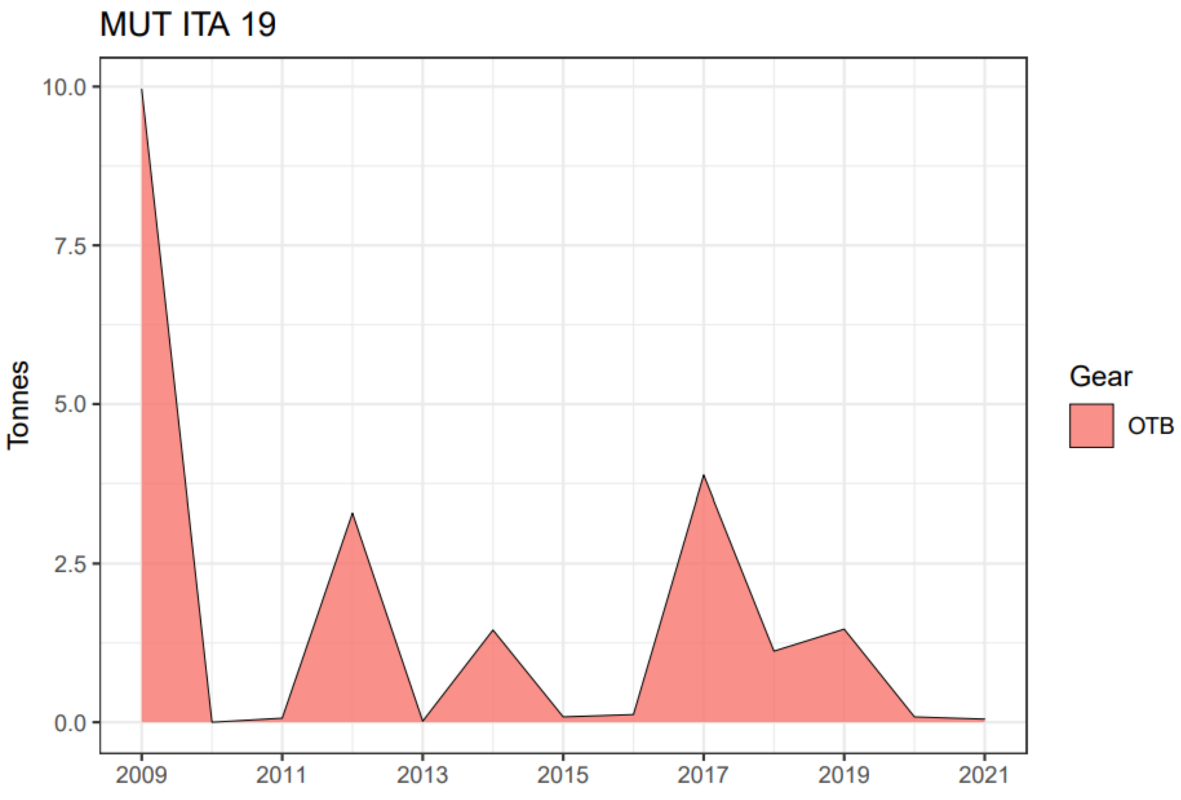


Figure 6.6.2.1.2 Red mullet in GSA 19. Discard by gears - OTB (tons).

Length frequency distribution

Length distribution of landings is reported by main gears in DCF from 2002-2021 and it is shown in figure 6.6.2.1.3

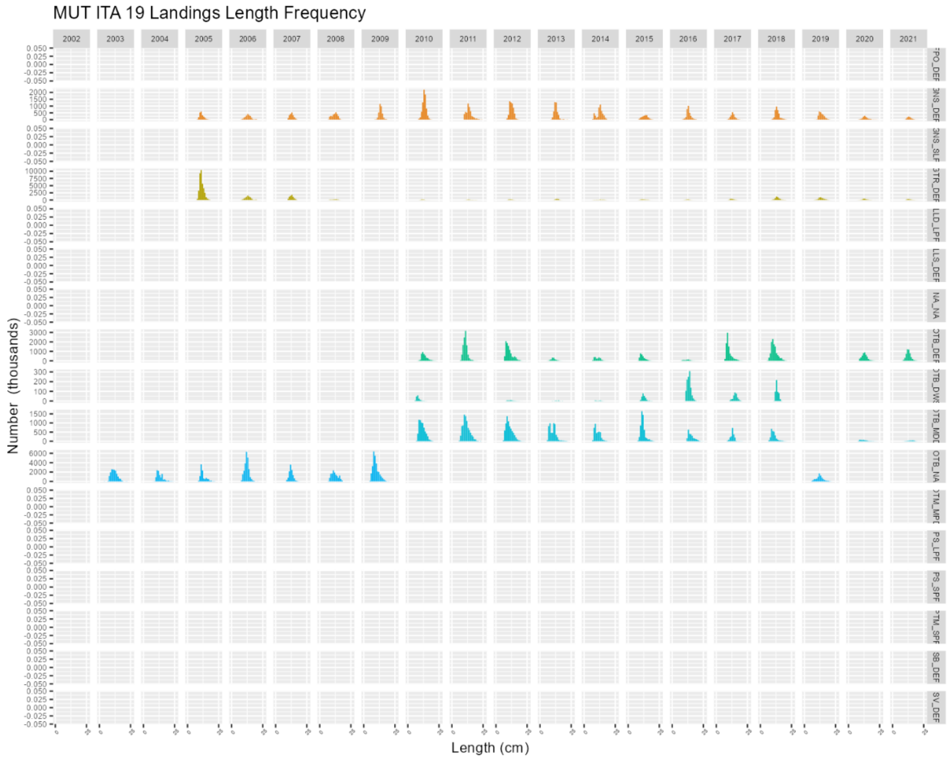


Figure 6.6.2.1.3 Red mullet in GSA 19. Landing length frequencies distribution by gears.

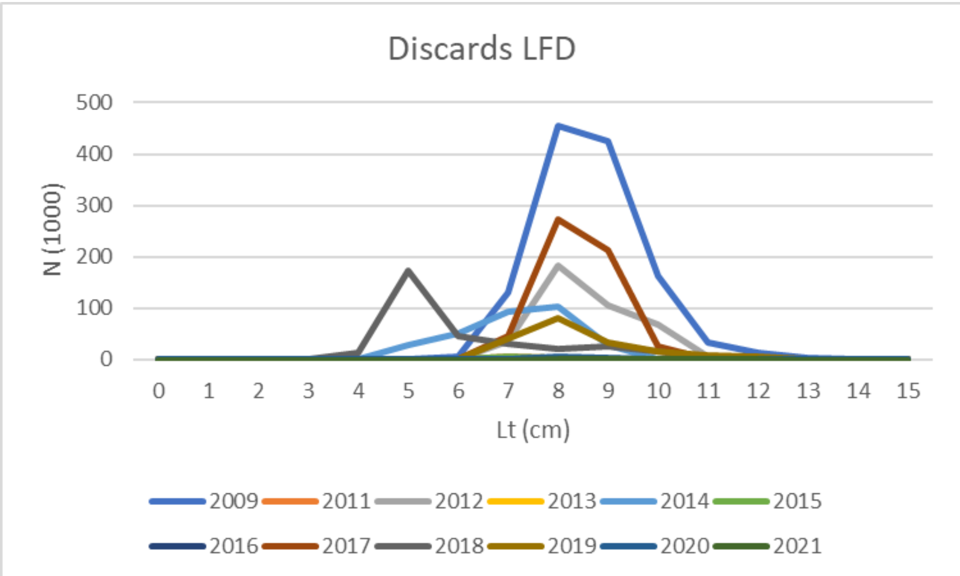


Figure 6.6.2.1.4 Red mullet in GSA 19. Discards length frequencies distribution by OTB gear.

Landings and discard data reconstruction

The quality check routine was performed according to the methodology accepted during EWG 21-01 on available DCF data in order to reconstruct missing LFD data by years/métiers.

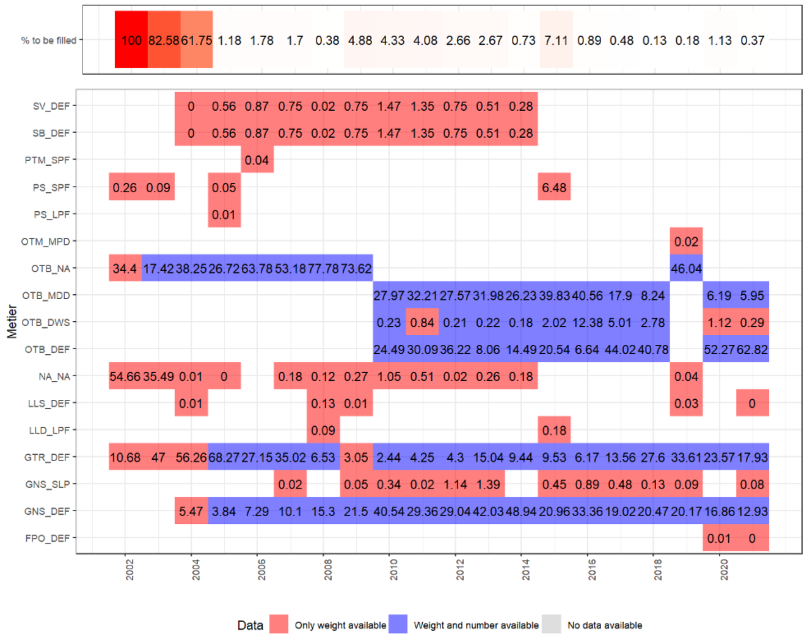


Figure 6.6.2.1.5 Red mullet in GSA 19. Missing length data to be filled in landings

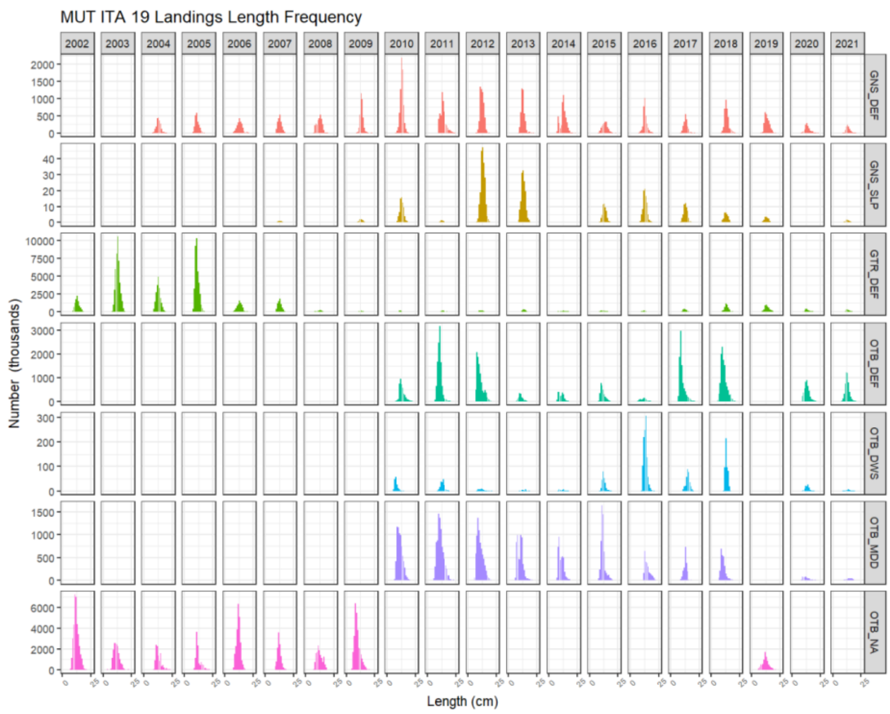


Figure 6.6.2.1.6 Red mullet in GSA 19. Final landings length frequency data

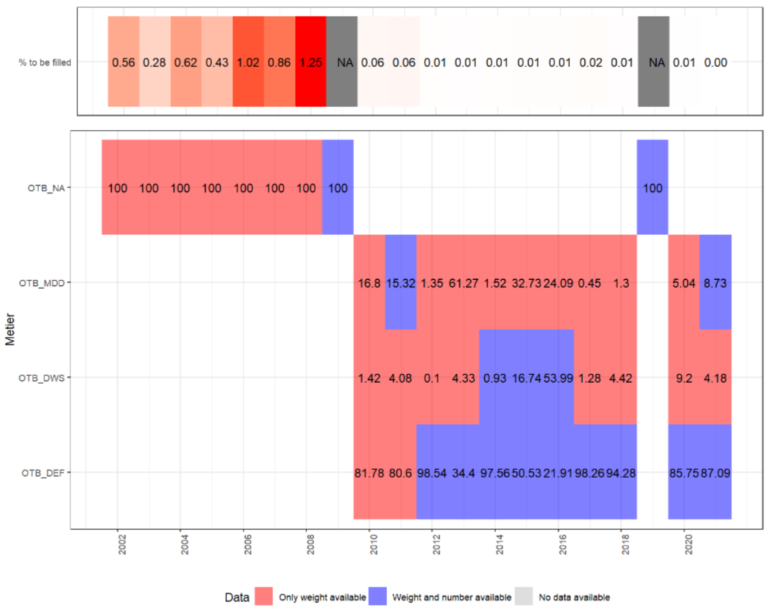


Figure 6.6.2.1.7 Red mullet in GSA 19. Missing length data to be filled in discards

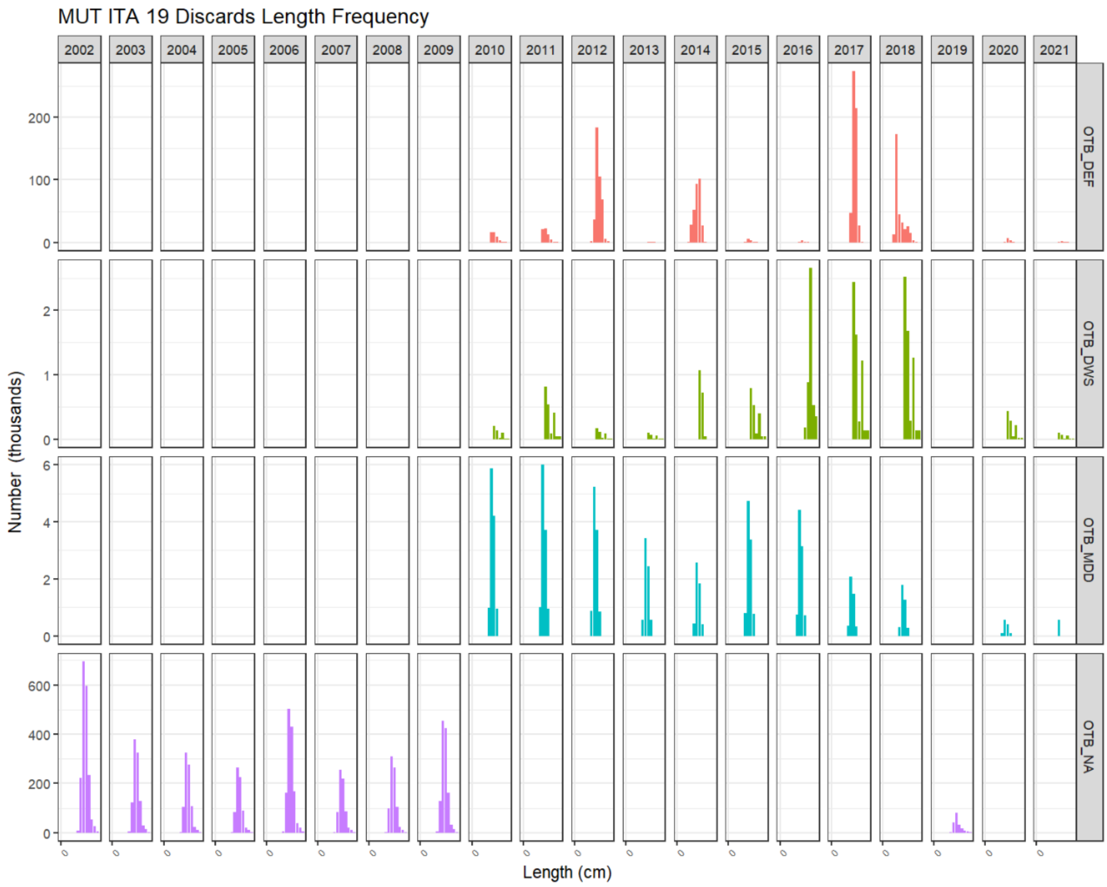


Figure 6.6.2.1.8 Red mullet in GSA 19. Final landings length frequency data

6.6.2.2 Effort

Red mullet in GSA 19 is exploited mostly by demersal trawlers, and to a lesser extent by gillnets and trammel nets. The effort data are available for period 2013 to 2021 from FDI data call. The temporal trend shows a reduction in the fishing days starting from 2016. The trends in fishing effort by major gear type targeting red mullet in GSA 19 are listed in table 6.6.2.2.1.

Table 6.6.2.2.1 Red mullet in GSA 19. Fishing days by fleet level from 2013-2021, DCF - FDI data.

Year	GNS	GTR	LLS	OTB	Total
2013	81753	95399	26074	36683	239909
2014	100437.1	89127.36	25038.24	36662.92	251265.6
2015	75622.44	96065.22	22697.36	37454.2	231839.2
2016	80243.24	107874.7	19033.37	38966.66	246118
2017	34578.07	86648.51	15715.59	35994.64	172936.8
2018	47738.02	91780.72	11244.97	34135.83	184899.5
2019	36437.3	83326.57	9450.123	32877.46	162091.5
2020	33579	67390	7953	25186	134108
2021	36496	61748	11101	30094	139439

6.6.2.3 Survey Data

Methods

According to the MEDITS protocol, trawl surveys were conducted annually, most of them in May-July, with randomly stratified samples by depth (5 strata with depth limits at 50, 100, 200, 500, and 800 m). Allocation of hauls was proportional to the area of the stratum. In recent years, a significant shift in the survey period has been noted (surveys in late summer, autumn up to winter)

MEDITS data are available through the official Data call for GSA 19 from 1994 - 2021. The shift in survey period in some years can greatly affect the interpretation of density data, especially for species such as red mullet that have a short spawning season in late spring and recruitment in the autumn.

Figure 6.6.2.3.1 Red mullet in GSA 19. MEDITS sampling period in GSA 19.

Although the trends of the indices show fluctuations from year to year, an increase in density and biomass indices has been observed in recent years. Indices show important recruitment peaks in 2007, 2014 and 2017 due to the displacement of survey in later period (August, September, December) that it is the recruitment period for red mullet.

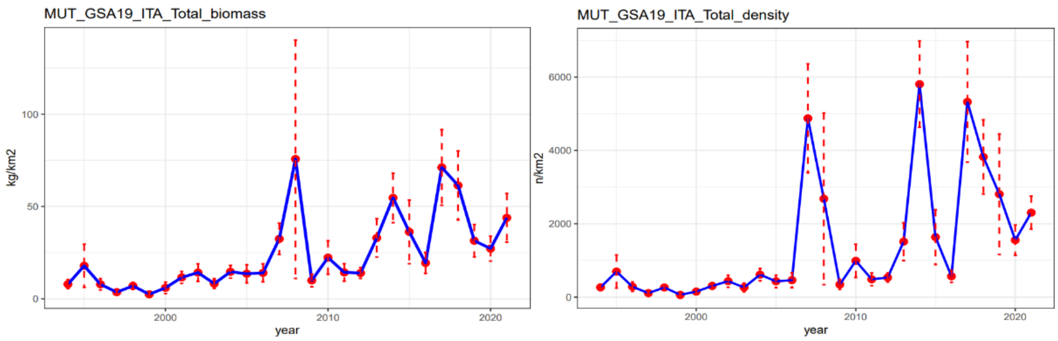


Figure 6.6.2.3.2 Red mullet in GSA 19. Biomass and abundance time series of derived from MEDITS (dotted lines indicated standard deviation).

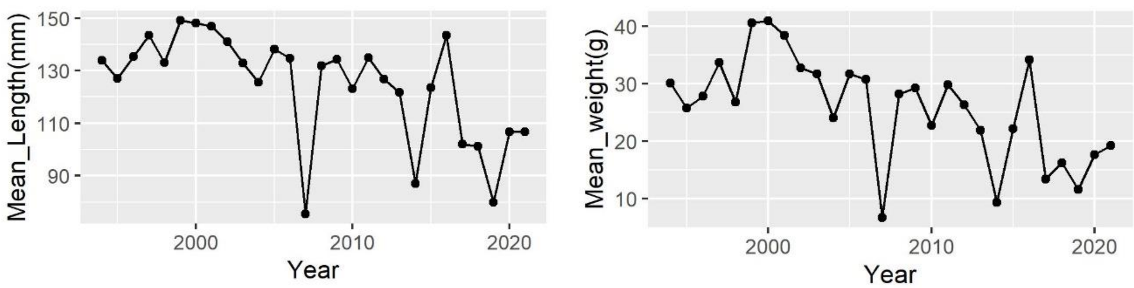


Figure 6.6.2.3.3 Red mullet in GSA 19. Mean length and weight of individuals derived from MEDITS survey 1994-2021.

Trends in abundance by length

The following figure display the stratified abundance indices of red mullet in GSA 19 in1994-2021.

Figure 6.6.2.3.4 Red mullet in GSA 19. Stratified abundance indices by size, 1994- 2021.

The LFDs shows that the recruitment is not always detected by the survey, because of the shift of the survey time. For this reason, the age 0 was not included in the tuning in the assessment.

Geographical distribution

The geographical distribution pattern of red mullet has been studied in the area usingtrawl-survey data and applying geostatistical methods.

In the STOCKMED project (MAREA Framework; Fiorentino et al., 2015) biomass trends (average of the last 10 years) have been estimated (Figure 6.6.2.3.5).

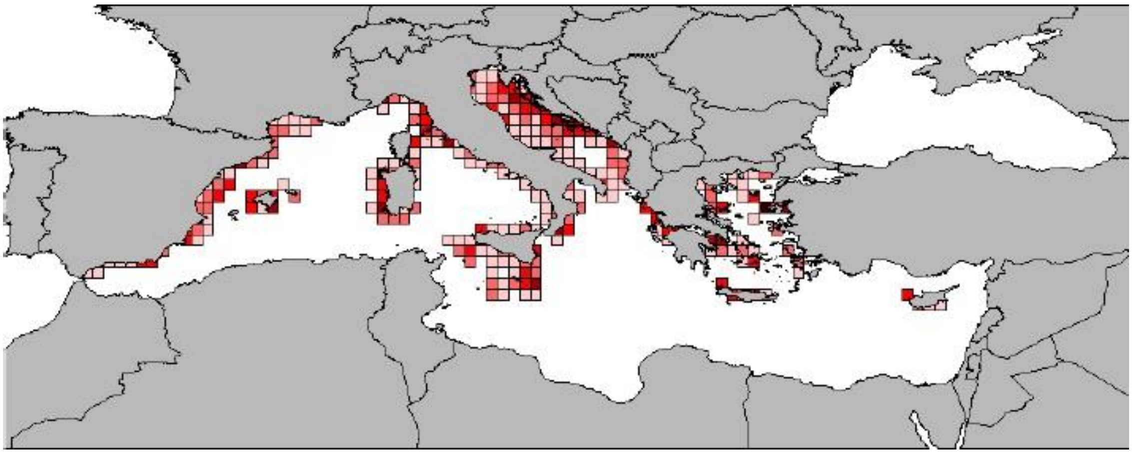


Figure 6.6.2.3.5 Geographical distribution of red mullet in the Mediterranean basin (kg/km2), STOCKMED Project.

If spawners are considered, the higher concentration in the GSA 19 was localized in the southern side. Recent estimations (MEDISEH Project, MAREA Framework; Giannoulaki et al., 2013) have confirmed the presence of spawning areas with persistence along time inthe southern part of the GSA (figure 6.6.2.3.6).

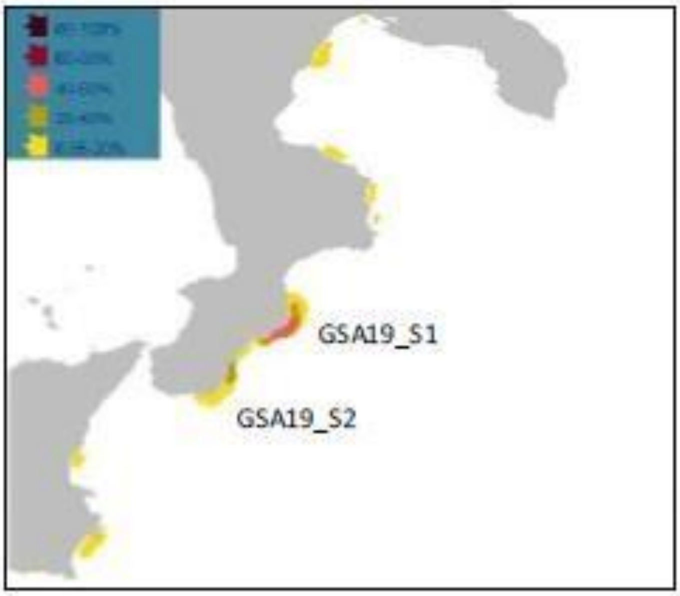


Figure 6.6.2.3.6 Red mullet in GSA 19. Spawning areas with the persistence along time, MEDISEH Project.

6.6.3 Stock Assessment

Stock assessments were performed applying an Extended Survivor Analysis (XSA) and an Assessment for All (a4a) methods calibrated with fishery independent survey abundance indices (MEDITS). The differences between methods are minor and do not change the perception of the state of stock or fishery. Both methods were based on the size composition of landings and discards and were taken from DCF. Von Bertalanffy growth parameters, length-weight relationship and natural mortality vector, were taken from parameters used for red mullet in GSA 19 in the previous assessment (GFCM WGSAD 2021) based on the results of GFCM WGSAD benchmark session for the assessment of red mullet in GSAs 12–16 and 19 (2018).

Method 1: XSA

The Extended Survivors Analysis (XSA – Darby and Flatman, 1994) has been performed using aforementioned parameters. XSA has been used with an age range from 0 to 4+ and an Fbar 1-3. Discard was included in the analysis.

Input data

For the assessment of red mullet in GSA 19 the DCF data on the length structure has been used: no SOP correction has been applied as differences were far less than 1%. The age distribution has been estimated using the knife-edge slicing method with sex separated parameters and then, summed up. The growth parameters were defined by benchmark session.

The survey indices from MEDITS data from 2002 to 2021 have been used for the tuning not including age 0.

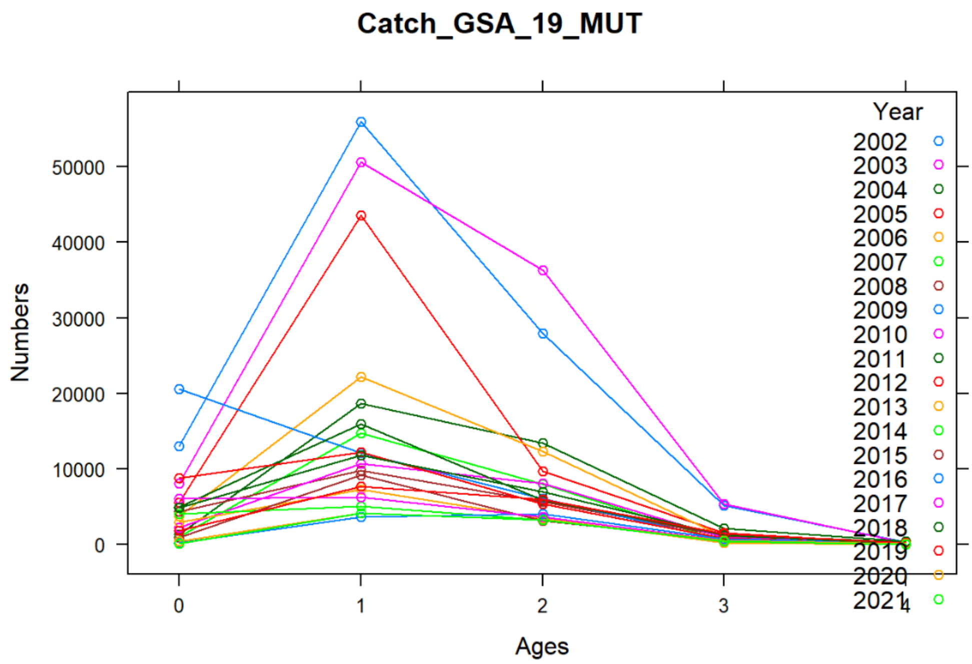


Figure 6.6.3.1 Red mullet in GSA 19. Catch (including discard) in numbers (thousands) by age and year used in the XSA.

Table 6.6.3.1 Red mullet in GSA 19. Catch (including discard) in numbers (thousands)by age and year used in the XSA.

Year	0	1	2	3	4 +
2002	13009.87	55987.52	27901.14	5148.687	371.4046
2003	8126.406	50600.9	36316.26	5342.99	243.3967
2004	1342.322	18659.48	13426.33	2122.187	447.6509
2005	5550.111	43582.3	9691.842	1533.207	156.6671
2006	3735.58	22247.29	12316.92	1082.98	212.2966
2007	1025.145	14775.83	7964.393	411.9423	6.4475
2008	4322.2	9820.493	5696.633	1096.515	43.6017
2009	20570.08	12099.2	6042.75	659.6329	61.0741
2010	2224.68	10727.88	8117.992	955.2031	125.6962
2011	5014.598	15991.06	5850.714	1335.185	324.2081
2012	8800.989	12270.3	5352.826	823.6599	112.0742
2013	2909.57	7261.187	3433.935	269.4807	78.5707
2014	4022.403	5062.511	3263.412	466.1236	36.2275
2015	917.4955	9219.467	3135.278	652.4319	63.837
2016	265.3468	3618.468	4078.305	773.5995	215.878
2017	6039.645	6329.299	3706.279	493.0029	54.354
2018	4864.074	11786.35	6998.921	1274.666	179.4138
2019	1839.519	7665.198	5999.905	1470.195	204.3804
2020	463.7965	4194.273	3277.91	538.7693	138.8543
2021	170.9559	4192.849	3281.807	445.5874	67.3491

Table 6.6.3.2 Red mullet in GSA 19. Abundance indices (N/km^2) by age and year from MEDITS survey used in the XSA. (Age 0 not used in the assessment)

Year	0	1	2	3	4 +
2002	4.160	181.265	163.056	74.285	9.256
2003	0.170	148.199	91.163	11.798	10.978
2004	0.585	448.104	122.107	25.056	14.640
2005	3.018	187.362	199.939	27.651	10.428
2006	0.341	246.260	165.021	33.268	14.631
2007	4185.452	522.590	97.210	40.871	30.235
2008	0.170	1426.465	1197.331	35.955	19.575
2009	0.170	203.747	106.458	19.477	11.132
2010	15.349	749.197	179.249	29.600	13.702
2011	1.399	269.656	154.025	40.565	17.910
2012	3.949	346.255	150.065	21.411	9.501
2013	11.370	1171.787	262.165	51.729	13.966
2014	4144.623	1240.595	331.409	72.839	18.873
2015	26.973	1158.077	381.657	48.504	18.868
2016	0.170	213.301	243.127	72.478	34.973
2017	1901.298	2963.948	329.959	108.350	22.290
2018	2081.448	994.439	494.004	168.690	84.098
2019	1858.850	491.749	342.797	78.371	34.587
2020	627.168	620.611	221.997	54.226	28.802
2021	1189.660	493.125	420.355	131.952	67.686

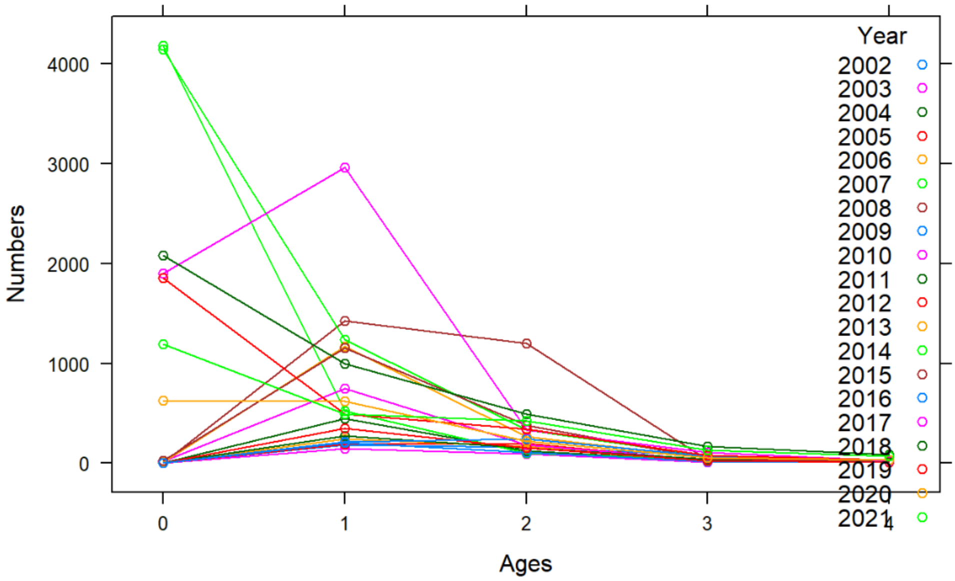


Figure 6.6.3.2 Red mullet in GSA 19. Abundance indices (N/km^2) by age and year from MEDITS survey used in the XSA.

Table 6.6.3.3 Red mullet in GSA 19. Weights at age (kg) used in the XSA

Year	0	1	2	3	4 +
2002	0.00693	0.01658	0.03316	0.05925	0.09818
2003	0.00681	0.01740	0.03268	0.05846	0.09792
2004	0.00736	0.01751	0.03316	0.05945	0.10898
2005	0.00735	0.01502	0.03232	0.06099	0.10477
2006	0.00724	0.01759	0.03184	0.06045	0.09623
2007	0.00753	0.01790	0.03139	0.05606	0.08120
2008	0.00673	0.01619	0.03481	0.05696	0.10672
2009	0.00534	0.01557	0.03260	0.05843	0.09406
2010	0.00685	0.01758	0.03245	0.06103	0.10203
2011	0.00646	0.01534	0.03294	0.06285	0.10647
2012	0.00605	0.01569	0.03324	0.06226	0.10384
2013	0.00519	0.01731	0.03143	0.06440	0.10749
2014	0.00631	0.01771	0.03253	0.05892	0.10598
2015	0.00742	0.01584	0.03348	0.06095	0.09608
2016	0.00676	0.01968	0.03263	0.06355	0.10557
2017	0.00660	0.01636	0.03248	0.06054	0.09718
2018	0.00663	0.01635	0.03287	0.06257	0.09732
2019	0.00558	0.01814	0.03349	0.06271	0.09612
2020	0.00731	0.01797	0.03277	0.06236	0.11140
2021	0.00723	0.01843	0.03237	0.06101	0.10509

XSA Results

The XSA run was performed according to the benchmark setting:

- qage=3
- rage=1
- shrinkage=2
- nb of years for shrinkage =3
- nb of ages for shrinkage=2.

Figure 6.6.3.3 Red mullet in GSA 19. Diagnostics and retrospective analysis (2018-2021)

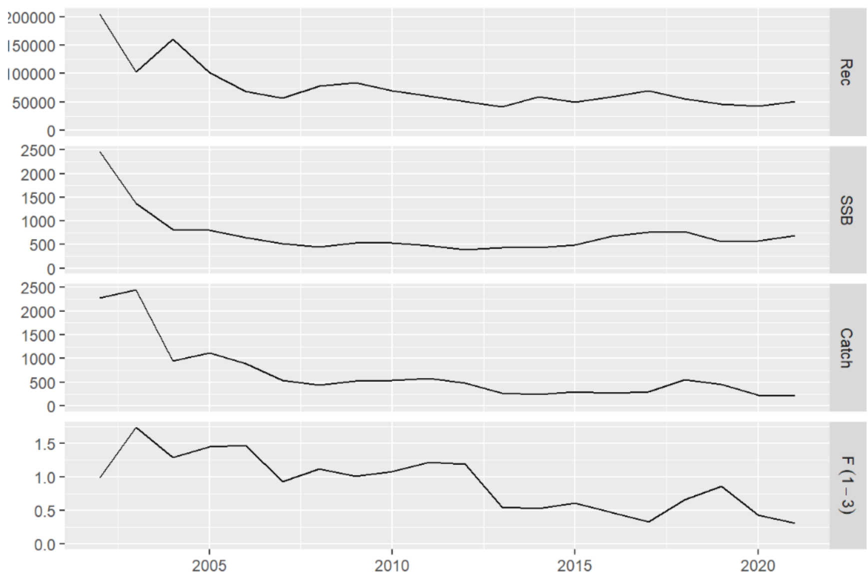


Figure 6.6.3.4 Red mullet in GSA 19. XSA results in terms of recruitment, SSB, Catches and fishing mortality.

Method2: a4a

A second assessment was conducted using the a4a method, which is based on linear modelling techniques, is non-fleet based, and uses the same input data as the XSA model. The method was developed as part of FLR.

Input data

The catch-at-age matrices, survey MEDITS data, natural mortality vector, maturity-at-age, and individual weights-at-age for the stock and catch were the same as those used in the previous XSA assessment. The final model chosen for analysis was the same as that used in XSA.

Model setup

Several submodels were tested based on different scenarios for catchability, mortality, and recruitment. The best submodel runs were performed with the following settings:

qmod1<- list(~factor(replace(age, age > 2, 2)))

fmod1 <- ~ factor(age)+factor(year) - (not converging)

fmodel_b=~s(age, k = 3) + s(year, k = 7) – (best fitting)

Fit1: srmod2= ~ geomean(CV = 0.2)

Fit2: srmod_b <- ~s(year, k=7) – (best fitting)

Results

The recruitment series shows a decline since the beginning of the time series with stable values in recent years. The SSB shows a decline over time, but in recent years there has been a steady increase. The F time series estimated by a4a shows a general decline over time.

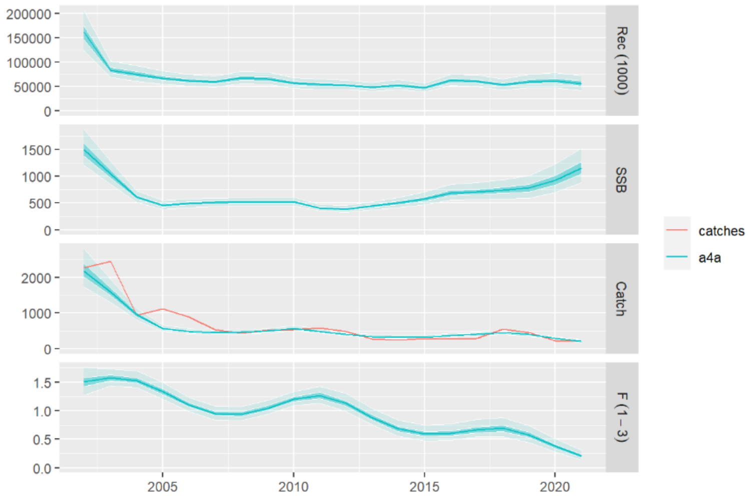


Figure 6.6.3.5 Red mullet in GSA 19. A4A results in terms of recruitment, SSB, Catches and fishing mortality.

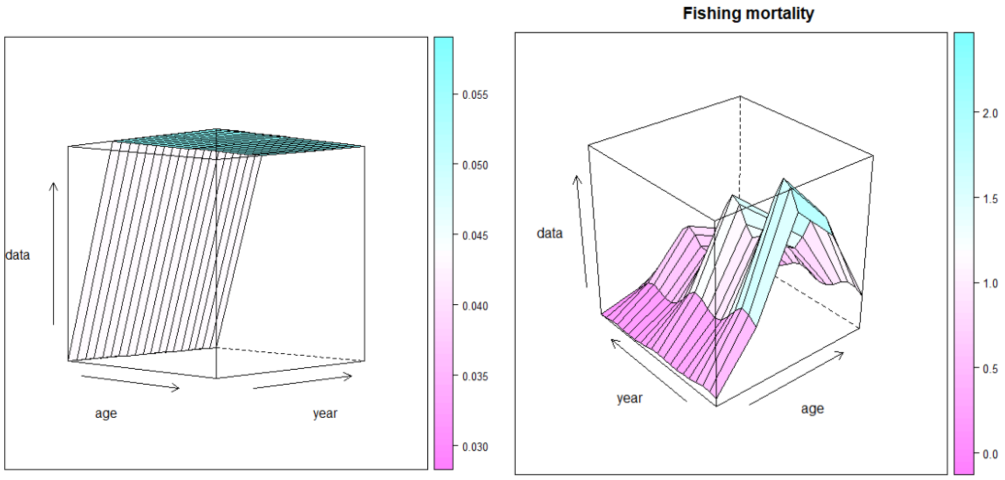


Figure 6.6.3.6 Red mullet in GSA 19. Fishing catchability and mortality.

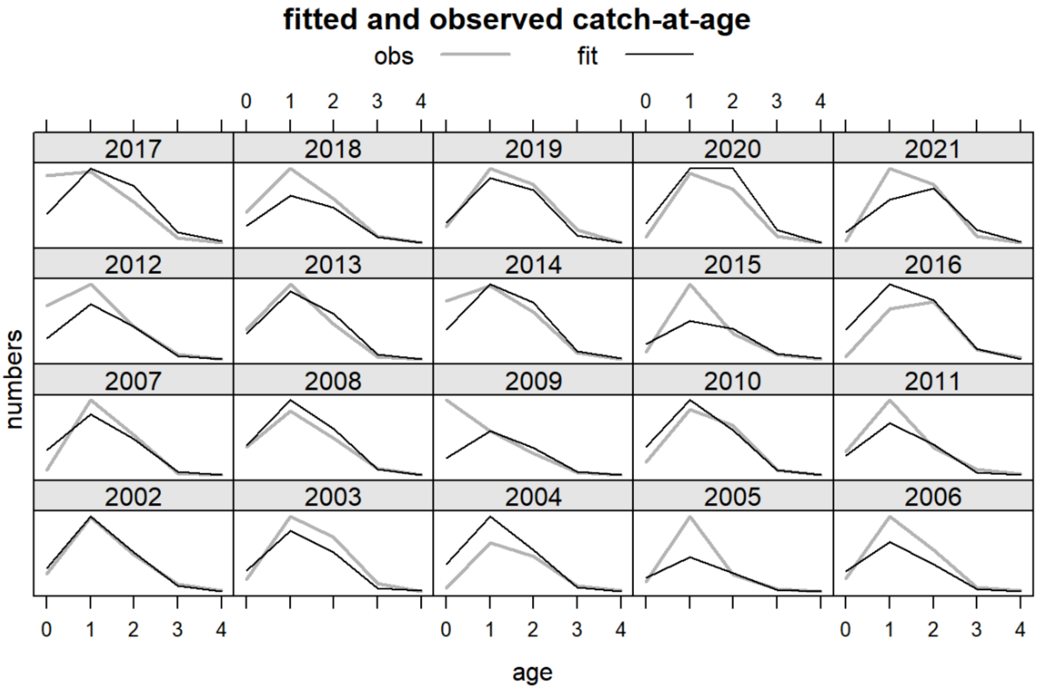


Figure 6.6.3.7 Red mullet in GSA 19. Comparison between observed and fitted catch at age.

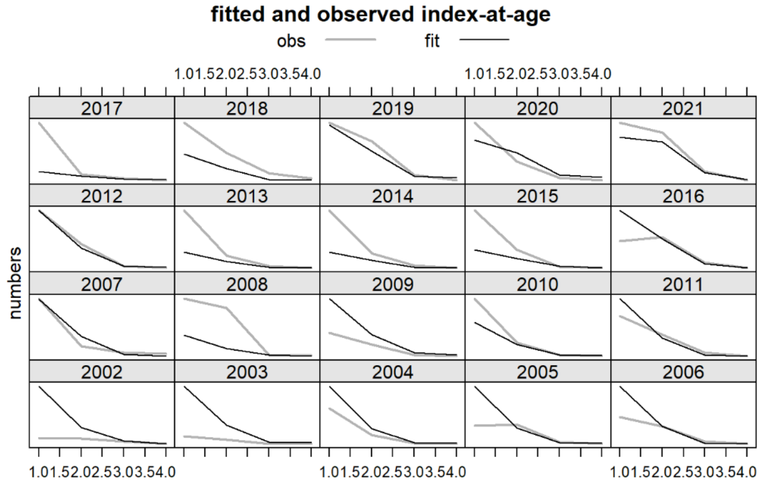
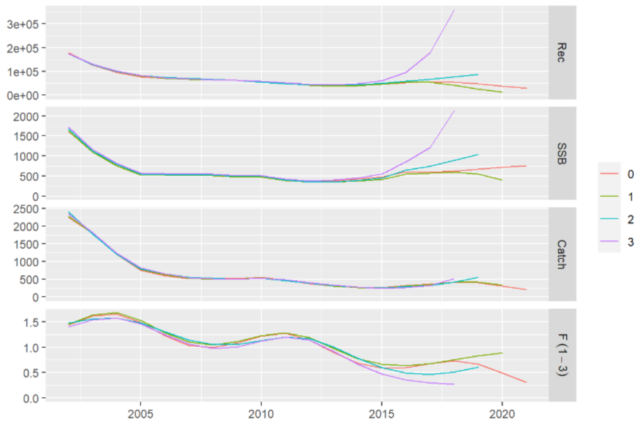


Figure 6.6.3.8 Red mullet in GSA 19. Comparison between observed and fitted index at age.



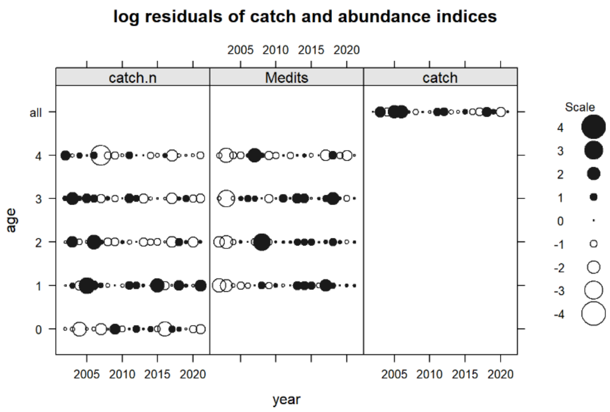


Figure 6.6.3.9 Red mullet in GSA 19. Retrospective analysis and bubble plot of residuals of catch and abundance indicesby age.

The inputs and final outputs were also tested using the ad hoc package a4adiags, which performs tests to evaluate the stability and suitability of the model (e.g., hindcasting, MASE value, etc.)

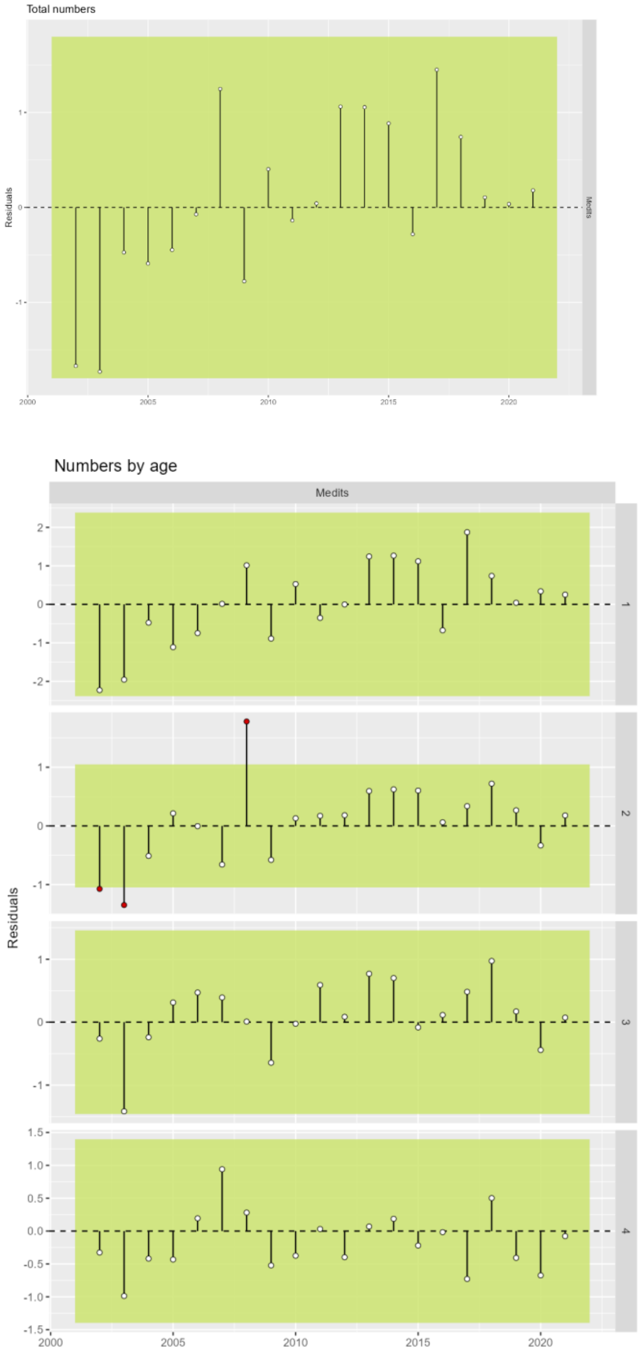


Figure 6.6.3.10 Red mullet in GSA 19. Runtest results from the a4adigs package.

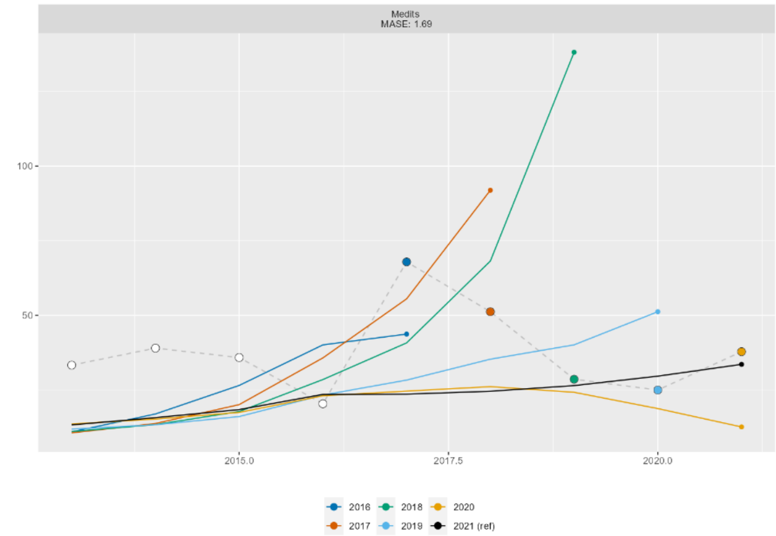


Figure 6.6.3.11 Red mullet in GSA 19. Hindcasting and MASE value results from the a4adiags package.

Comparison of the models

The two models run: XSA and a4a, agree on SSB and catch time series. In terms of recruitment, XSA shows an increase in the last year, while a4a shows a decreasing trend. Fbar shows a decreasing trend for both.

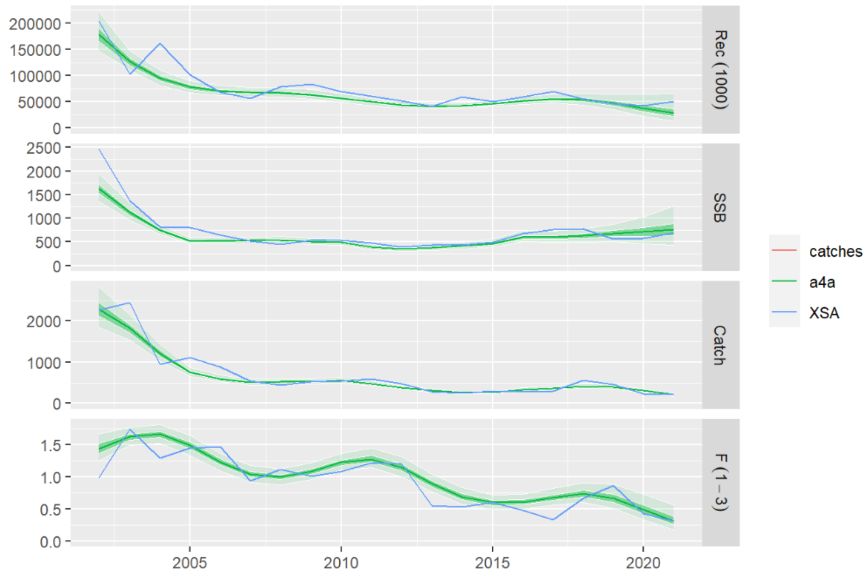


Figure 6.6.3.12 Red mullet in GSA 19. Comparison of the results of two model runs; A4A and XSA

Table 6.6.3.4 Red mullet in GSA 19. Stock summary Table , R age 0, SSB, Catch Tonnes and F ages 1-3.

Year	R	SSB	Catch	F 1-3
2002	179067	1611.52	2261.66	1.44356
2003	127131	1119.16	1810.67	1.61886
2004	94984	755.77	1219.57	1.65798
2005	77876	518.79	757.55	1.48772
2006	70613	520.17	595.84	1.22772
2007	68512	530.27	514.81	1.04021
2008	67264	542.61	518.79	0.9936
2009	63627	510.08	523.66	1.07942
2010	57009	493.57	563.76	1.22415
2011	49474	390.91	478.12	1.28049
2012	43647	355.28	383.95	1.14395
2013	41072	375.57	306.02	0.89541
2014	42132	423.17	269.49	0.68896
2015	46305	469.25	266.24	0.59306
2016	51836	607.33	326.45	0.60322
2017	55508	599.96	370.53	0.68083
2018	54148	627.74	417.84	0.73709
2019	47364	675.38	401.29	0.66805
2020	37939	714.49	311.74	0.48825
2021	29069	762.1	212.81	0.31178

Table 6.6.3.5 Red mullet in GSA 19. Assessment results N at age

age	0	1	2	3	4
2002	179066.7	126822.4	39313.4	5769.51	400.86
2003	127131.1	83908.06	33708.88	3261.21	956.29
2004	94983.89	58581.52	20225.18	2190.77	728.1
2005	77875.84	43604.76	13815.82	1244.8	506.97
2006	70612.75	36337.79	11308.02	1077.75	359.87
2007	68512.09	33778.25	10893.83	1266.8	338.69
2008	67263.5	33366.24	11242.74	1584.39	419.95
2009	63626.6	32904.41	11398.06	1744.74	543.42
2010	57008.93	30870.91	10715.02	1569.66	594.74
2011	49473.87	27279.96	9273.4	1206.36	524.3
2012	43647.19	23547.12	7941.19	965.29	414.97
2013	41072.16	21046.81	7396.86	999.65	362.77
2014	42132.36	20281.64	7594.4	1316.04	417.12
2015	46305.45	21219.88	8211.22	1801.04	613.48
2016	51835.98	23536.41	9063.03	2225.42	929.75
2017	55507.93	26321.98	9995.66	2421.78	1228.7
2018	54147.53	27978.15	10705.16	2397.5	1369.74
2019	47363.8	27146	11027.27	2374.25	1378.04
2020	37938.98	23902.3	11119.26	2692.39	1443.58
2021	29068.61	19478.09	10823.25	3486.95	1797.76

Table 6.6.3.6 Red mullet in GSA 19. Assessment results F at age

age	0	1	2	3	4
2002	0.138036	0.805027	2.00947	1.51618	0.489632
2003	0.154799	0.902792	2.2535	1.7003	0.549094
2004	0.15854	0.924605	2.30795	1.74139	0.562362
2005	0.142259	0.829655	2.07094	1.56256	0.504611
2006	0.117397	0.684662	1.70902	1.28948	0.416424
2007	0.099467	0.580092	1.448	1.09254	0.352823
2008	0.09501	0.554101	1.38312	1.04359	0.337014
2009	0.103217	0.60196	1.50258	1.13372	0.366123
2010	0.117055	0.682667	1.70404	1.28573	0.415211
2011	0.122443	0.714089	1.78247	1.3449	0.434322
2012	0.109387	0.637947	1.59241	1.2015	0.388011
2013	0.085621	0.49934	1.24643	0.94045	0.303708
2014	0.065879	0.38421	0.959046	0.723615	0.233684
2015	0.05671	0.330732	0.825557	0.622896	0.201157
2016	0.057681	0.336398	0.8397	0.633567	0.204603
2017	0.065102	0.379676	0.947728	0.715076	0.230926
2018	0.070482	0.411051	1.02605	0.774168	0.250009
2019	0.063881	0.372553	0.929947	0.70166	0.226593
2020	0.046687	0.272281	0.679654	0.51281	0.165606
2021	0.029813	0.173869	0.434003	0.327462	0.10575

6.6.4 REFERENCE POINTS

Of the two models used for the assessment, an A4A model was considered more stable and consistent based on the results of retrospectives and residuals, and was therefore selected to generate stock recommendations.

The FLBRP library available in FLR was used to estimate $F_{0.1}$ based on the stock object resulting from the assessment results. The value of $F_{0.1}$ (Fbar 1-3) calculated by the FLBRP package using the a4a assessment results equals 0.510. The current F values (2021) calculated by the a4a model are 0.31, indicating that the stock is underfished (Fcurr/ $F_{0.1}$= 0.608). These results should be viewed with caution due to the instability of the retrospectives.

6.6.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the stock assessment.

An average of the last three years has been used for weight at age, maturity at age, natural mortality at age and selectivity at age. Recruitment is in a clear increasing phase over the period of the assessment (Figure 6.11.3.5) so the geometric mean across the last 10 years has been used as an estimate of recruits from 2022 (Table 6.5.5.1). The results of short term forecast for 2022 and 2023 are in Table 6.5.5.2

Table 6.5.5.1 Red mullet in GSA 19: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2022)	0.31	F 2021 used to give F status quo for 2022
SSB (2022)	785.77	Stock assessment 1 January 2022
R_{age0} (2022,2023)	44200.51	Mean of 2012 to 2021
Total catch (2022)	215.24	Assuming F status quo for 2022

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

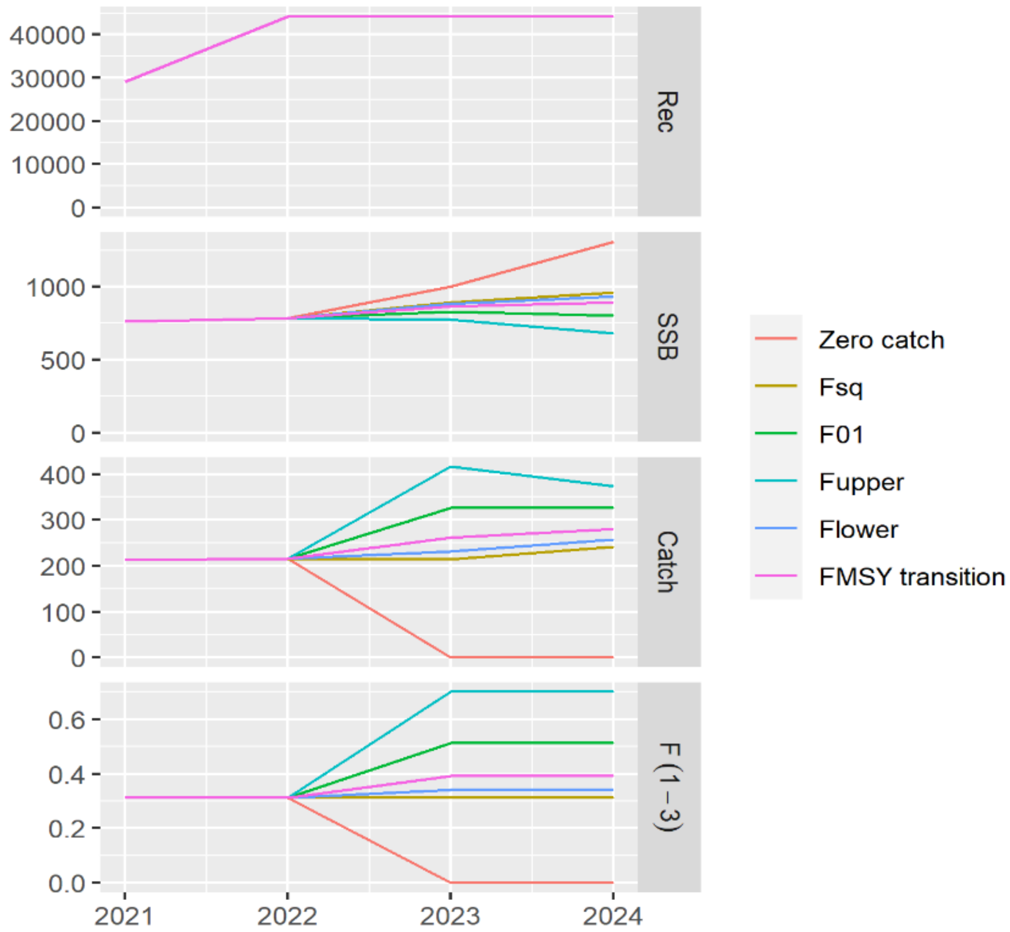


Figure 6.6.5.1 Red mullet in GSA 19. Short term forecast in different F scenarios computed for red mullet in GSA 19.

Table 6.6.5.2 Red mullet in GSA 19. Short term forecast in different F scenarios computed for red mullet in GSA 19.

Rationale	Ffactor	Fbar	Recruitment 2022	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB change 2022-2024 (%)	Catch change 2021-2023 (%)
High long term yield (F0.1)	1.646	0.51	44200.51	0.31	212.81	215.24	326.35	785.77	799.62	1.76	53.35
F upper	2.246	0.7	44200.51	0.31	212.81	215.24	416	785.77	680.7	-13.37	95.48
F lower	1.096	0.34	44200.51	0.31	212.81	215.24	232.09	785.77	934.61	18.94	9.06
FMSY transition	1.258	0.39	44200.51	0.31	212.81	215.24	261.24	785.77	891.78	13.49	22.76
Zero catch	0	0	44200.51	0.31	212.81	215.24	0	785.77	1308.75	66.56	-100
Status quo	1	0.31	44200.51	0.31	212.81	215.24	214.26	785.77	961.27	22.34	0.68
Different Scenarios	0.1	0.03	44200.51	0.31	212.81	215.24	24.05	785.77	1267.31	61.28	-88.7
	0.2	0.06	44200.51	0.31	212.81	215.24	47.47	785.77	1227.54	56.22	-77.69
	0.3	0.09	44200.51	0.31	212.81	215.24	70.27	785.77	1189.38	51.37	-66.98
	0.4	0.12	44200.51	0.31	212.81	215.24	92.47	785.77	1152.74	46.7	-56.55
	0.5	0.16	44200.51	0.31	212.81	215.24	114.11	785.77	1117.56	42.22	-46.38
	0.6	0.19	44200.51	0.31	212.81	215.24	135.18	785.77	1083.76	37.92	-36.48
	0.7	0.22	44200.51	0.31	212.81	215.24	155.71	785.77	1051.3	33.79	-26.83
	0.8	0.25	44200.51	0.31	212.81	215.24	175.73	785.77	1020.1	29.82	-17.42
	0.9	0.28	44200.51	0.31	212.81	215.24	195.24	785.77	990.11	26.01	-8.26
	1.1	0.34	44200.51	0.31	212.81	215.24	232.81	785.77	933.55	18.81	9.4
	1.2	0.37	44200.51	0.31	212.81	215.24	250.9	785.77	906.87	15.41	17.9
	1.3	0.41	44200.51	0.31	212.81	215.24	268.54	785.77	881.2	12.15	26.19
	1.4	0.44	44200.51	0.31	212.81	215.24	285.76	785.77	856.5	9	34.28
	1.5	0.47	44200.51	0.31	212.81	215.24	302.57	785.77	832.72	5.98	42.18
	1.6	0.5	44200.51	0.31	212.81	215.24	318.96	785.77	809.82	3.06	49.88
	1.7	0.53	44200.51	0.31	212.81	215.24	334.97	785.77	787.76	0.25	57.41
	1.8	0.56	44200.51	0.31	212.81	215.24	350.61	785.77	766.51	-2.45	64.75
	1.9	0.59	44200.51	0.31	212.81	215.24	365.87	785.77	746.03	-5.06	71.93
	2	0.62	44200.51	0.31	212.81	215.24	380.78	785.77	726.29	-7.57	78.93

6.6.6 DATA DEFICIENCIES

Survey sampling period (MEDITS) has been done in different year periods. The displacement of MEDITS survey to August (2007), September (2014), December 2017 and October 2020 that it is the recruitment period for red mullet, difficult the tuning of the VPA.

6.7 DEEP WATER ROSE SHRIMP IN GSAS 18 ,19 AND 20

6.7.1 STOCK IDENTITY AND BIOLOGY

STECF EWG 21-15 was asked to assess the state of Deep-water rose shrimp stocks in the Adriatic and Ionian Sea by GSAs combined.

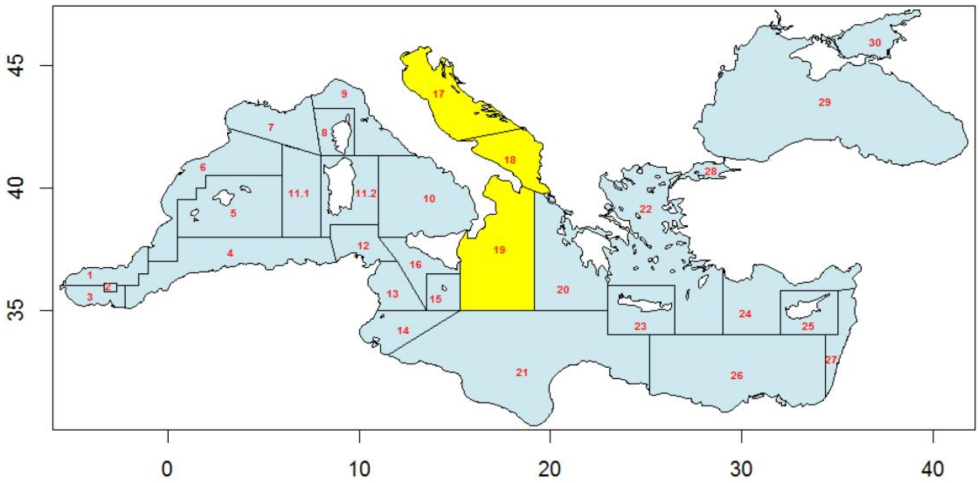


Figure 6.7.1.1. Deep water rose shrimp in GSA 17-19. Geographical location of GSAs 17,18 and 19.

Age and growth

For *P. longirostris*, males and females are known to have different growth profiles, with males growing slower and reaching smaller size than females. The DCF data include information on the growth parameters by sex of in GSA 18 and 19, but not in GSA 17 but, since the sex ratio in the catches was not available in the DCF, was not possible to use it for the purposes of the DPS assessment. Moreover EWG 19-16 ran an exercize for GSA 19 only on the previous assessment to check whether or not the use of different growth parameter by sex rather than the combinated improve the consistency of cohorts evolution. The exercise did not shows consistent differences because males and females grow in a similar way when they are small and few males are found at larger sizes, so female growth provides a good model to cover the full range of sizes observed. For the purposes of the assessment EWG 21-15 then decided to age slicing the commercial catches and the survey index by using the sex combined parameters as was done in the previous meeting.

Growth parameter and length-weight relationship parameters for sex combined used are the same used in the previous assessments and comes from DCF (see Table 6.7.1.1).

Table 6.7.1.1 Deep water rose shrimp in GSA 17-19. parameters used for growth and weight at length taken from DCF data.

Growth Equation	$L\infty$	k	T_0
$L(t) = L_\infty *[1 - \exp(-K*(t-t_0))]$	45.0	0.6	-0.2
Weight at Length	a	b	
aL^b	0.0024	2.5372	

Natural mortality

The same vector of natural mortality used last year was considered. It was estimated by the Chen and Watanabe (1989) function using growth and length-weight relationship parameters for sex combined (Table 6.7.1.2) and used again this year.

Maturity

Studies carried out in the Mediterranean indicate a variable reproductive strategy for this species. Some authors found that in the South Ionian the spawning of the deepwater rose shrimp females' is carried out during summer and that it is more protracted in Montenegrin waters compared to Ionian waters (K. Kapiris et al., 2013). From other authors spawning is considered to occur through the year (D' Onghia et al., 1998). Then for the purposes of this assessment the spawning time was set at the mid-point of the year with 50% F and M occurring before spawning.

Following this assumption, the proportion of mature individual of age 0 was set as 0.4 corresponding to 5/12, that is the number of months during which the individuals born in January would be mature, and thus also the proportion of those born throughout the year would reach maturity before the end of the year, when they then increment their age from 0 to 1. It also follows that all individuals from the previous year will spawn at some time during the following year, so Maturity is 1 at all other ages. This is unchanged from last year.

Natural mortality was estimated applying Chen & Watanabe model. A single M vector was by considering as growth parameters (k and t0) input those reported in Tab. 6.7.1.1. The natural mortality vector by age is reported below in Tab. 6.7.1.2.

Table 6.7.1.2. **Deep-water rose shrimp stocks in GSAs 17-19:** Maturity and Natural mortality parameters used in the assessment.

Age	0	1	2	3+
Maturity	0.4	1	1	1
Natural mortality	1.75	0.938	0.748	0.673

General description of Fisheries

Deep-water rose shrimp is targeted mainly by bottom trawlers in these areas. Deep-water rose shrimp is commercially important in the Adriatic Sea: it is targeted by trawlers (Italy, Croatia, Albania and Montenegro). The Southern Adriatic Sea makes a substantial contribution to the Italian Deep-water rose shrimp national fishery production, with an input comparable to that of the Strait of Sicily, accounting for about 13% of total production (Cataudella and Spagnolo, 2011).

In the northwestern Ionian Sea, fishing occurs from coastal waters to 700–750 m. The most important demersal resources in the northwestern Ionian Sea are represented by the red mullet (*Mullus barbatus*) on the continental shelf, hake (*Merluccius merluccius*), deep-water rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*) over a wide bathymetric range and the deep- water red shrimps (*Aristeus antennatus and Aristaeomorpha foliacea*) on the slope.

Management regulations

In Italy management regulations are based on technical measures, a restricted number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban, that in southern Adriatic has been mandatory since the late eighties. In the GSA 19 the fishing ban has not been mandatory at all times, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it has been mandatory. Regarding small scale fishery management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) along the mainland, offshore Bari (180 km2, between about 100 and 180 m depth), and in the vicinity of Tremiti Islands (115 km2 along the bathymetry of 100 m) on the northern border of the GSA where a marine protected area (MPA) had been established in 1989. In the former only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30th, while in the latter the trawling fishery is allowed from November 1st to March 31 and the small scale fishery all year round. A recreational fishery using no more than 5 hooks is allowed in both the areas. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

In Montenegro, management regulations are based on technical regulations, such as mesh size (Official Gazette of Montenegro, 8/2011), including the minimum landing sizes (Official Gazette of Montenegro, 8/2011), and a regulated number of fishing licenses and area limitation (no–fishing zone up to 3 NM from the coastline or 8 NM for trawlers of >24 m LOA). Currently there are no MPAs or fishing bans in Montenegrin waters.

In Albania, a new law "On fishery" has now been approved, repealing the Law n. 7908. The new law is based on the main principles of the CFP, it reflects Reg. 1224/2009 CE; Reg.1005/2008 CE; Reg. 2371/2002 CE; Reg. 1198/2006 CE; Reg. 1967/2006 CE; Reg. 104/2000; Reg. 1543/2000 as well as the GFCM recommendations. The legal regime governing access to marine resources is being regulated by a licensing system. Also concerning conservation and management measures, minimum legal sizes and minimum mesh sizes are those proposed by EU Regulations. Albania has already an operational vessel register system. It is forbidden to trawl at less than 3 nautical miles (nm) from the coast or inside the 50m isobath when this distance is reached at a smaller distance from the shore.

Since the accession of Croatia to the EU the 1st of July 2013, the same regulations as in the Italy are implemented. Furthermore the following regulations are applied:Bottom trawl fisheries is closed one and half NM from the coast and island in inner sea, 2 NM around island on the open sea, and 3 NM about several island in the central Adriatic. For vessel smaller than 15 meters, according derogation in sea deeper than 50 meters bottom trawl fisheries is forbidden till 1NM of the coast. Bottom trawl fishery is closed also in the majority of channel area and bays. About 1/3 of the territorial waters is closed for bottom trawl fisheries over whole year and additionally 10% is closed from 100-300 days per years. Minimum mesh size on the bottom trawl net was 20 mm ("knot to knot") in the open sea, and 24 mm ("knot to knot") in the inner sea. Recently, mesh site regulation is according EC 1967/2006 (ie. 40 mm square or 50 mm diamond). In 2015 the no-take zone was established in Jabuka Pit. The establishment of Marine managed area (MMA) was based on long- time assessment of biological resources and analysis carried out by working group through FAO AdriaMed project that showed a decline in biomass of these commercial species. The proposed MMA covers the waters closed to trawling through a bilateral agreement between Republic of Italy and Republic of Croatia. The Pit was re-opened to trawling in 2016. Recently, following the growing support for a MMA in the Jabuka/Pomo Pit, Croatia and Italy agreed to reintroduce a fishing closure from the 1st of September 2017 to 31st of August 2020. Other interventional fisheries regulation measures were introduced in Croatia such as temporal ban of trawl fisheries in open part of central Adriatic and in channel area of northern Adriatic. The aim of those measures were protection of commercially important species (e.g. European hake and Norway lobster) in critical period (spawning or recruitment period).

6.7.2 DATA

6.7.2.1 CATCH (LANDINGS AND DISCARDS)

Catch data were reported to STECF EWG 22-16 through the DCF since 2002. In GSAs 17, 18, and 19, most of the catches come from otter trawls (Table 6.7.2.1.1, Figure 6.7.2.1.1), while other gears were considered sampled inconsistently and thus not included in the stock assessment. In 2002 and 2003 gear not assigned (gear=NA) were considered belonging to OTB.

In the rest of the report, we will refer to and present only data for otter trawl.

OTB landings and discards by year are presented in figure 6.7.2.1.2 and table 6.7.2.1.1.

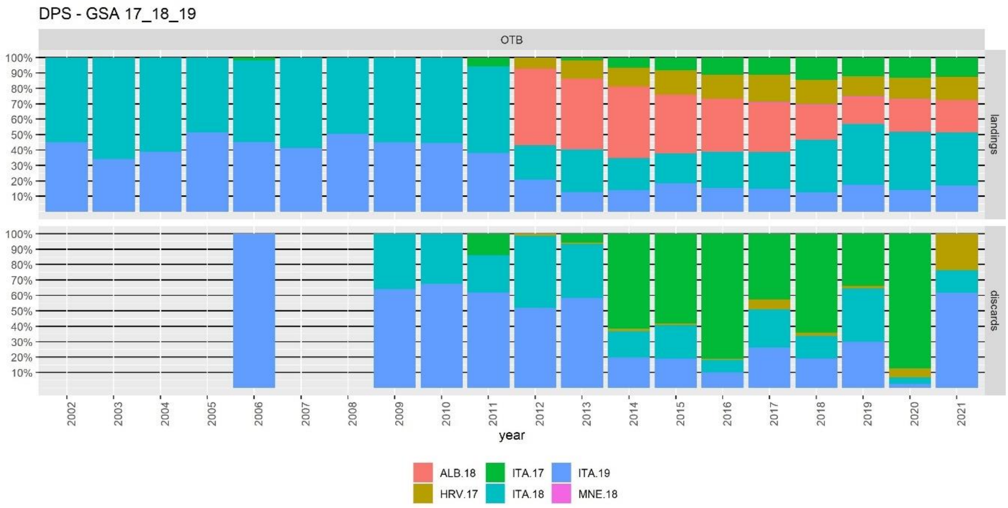


Figure 6.7.2.1.1. Deep-water rose shrimp stocks in GSAs 17-19: OTB landings and discards percentage composition by main fleet from DCF 2021.

Table 6.7.2.1.1. Deep-water rose shrimp stocks in GSAs 17-19: Catch data (landings and discards) in tonnes by OTB as reported by DCF 2021.

OTB	landings					discards			
country	HRV	ITA	ITA	ITA	ALB	HRV	ITA	ITA	ITA
gsa	17	17	18	19	18	17	17	18	19
2002	0	0	902.9	738.5		0	0	0	0
2003	0	0	1253	646.4		0	0	0	0
2004	0	0	1847.7	1170.1		0	0	0	0
2005	0	0	1181.5	1243.1		0	0	0	0
2006	0	54	1464.6	1244.6		0	0	0	19
2007	0	0	863.1	607.5		0	0	0	0
2008	0	0	766.2	785		0	0	0	0
2009	0	0	939.4	767.3		0	0	30.8	54.6
2010	0	0	888.1	715.6		0	0	17.5	36.1
2011	0	92	869.6	592.8		0	3	5.3	13.5
2012	168.5	0	522.8	487.6	1170	0.2	0	7.2	8
2013	314.5	47.9	733.7	334.5	1210	0.3	2	12.3	20.4
2014	369.6	202	637.7	421.5	1430	0.7	28	7.7	8.9
2015	534.3	279	651.3	622.4	1290	0.7	37	13.9	12
2016	654.8	471	996.4	647.4	1460	1.9	207	20.8	25.5
2017	833.9	520	1109.4	692.8	1473	11.1	73	42.3	44.7
2018	912.5	835	1962	716.3	1275	7.6	228	52	67.7
2019	714.6	677.5	2187	963.9	962	4.5	92	94.1	81.7
2020	660.7	644.4	1833.8	678.4	1026	9.2	138.5	6.5	4.2
2021	737	609.6	1679	829.3	1034	6.6	0	4.1	17.2

Landings data for GSA 17 were incomplete. Italian landings were present just for 2006, 2011, and from 2013 to 2020. Croatian landings were present just from 2012 to 2020 in the DCF database because previously there was no obligation to monitor that species. Landings data for GSA 18 were complete for the full time series (2002-2021) for Italy, and since 2012 for Albania. Landings data for GSA 19 were complete (2002-2021). Data from Albania exactly match with latest FAO Fishery and Aquaculture Statistics.

Discards were reported trhough DCF for GSA 18 and GSA 19 since 2009, for GSA 17 in 2011 and 2013-2017 for Italy and since 2016 for Croatia; no information was available neither for Albania nor for Montenegro (Table 6.7.2.1.2, figure 6.7.2.1.3).

For the puproses of the assessment EWG 22-16 total landing for Albania, Montenegro and Cratia were updatated in some years with the fishieries statistics from FAO. The years updated were respectively 2002-2011, 2009-2011 and the last 4 years for Montenegro (Table 6.7.2.1.3, Figure 6.7.2.1.4).

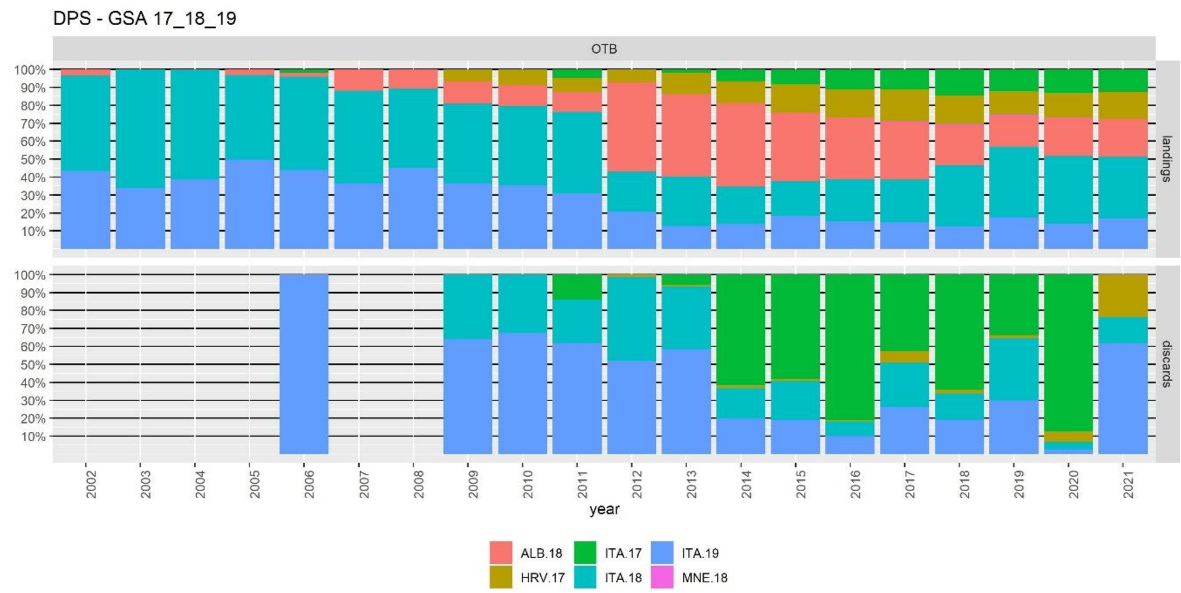


Figure 6.7.2.1.3. **Deep-water rose shrimp stocks in GSAs 17-19**: OTB Landings and discards data as updated by EWG22-16.

Table 6.7.2.1.2. **Deep-water rose shrimp stocks in GSAs 17-19**: OTB landings and OTB discards by year and fleet as updated by EWG22-16.

OTB	landings						discards			
country	**HRV**	**ITA**	**ITA**	**ITA**	**ALB**	**MNE**	**HRV**	**ITA**	**ITA**	**ITA**
gsa	**17**	**17**	**18**	**19**	**18**	**18**	**17**	**17**	**18**	**19**
2002	0	0	902.9	738.5	57	0	0	0	0	0
2003	0	0	1253	646.4	1	0	0	0	0	0
2004	0	0	1847.7	1170.1	8	0	0	0	0	0
2005	0	0	1181.5	1243.1	78	0	0	0	0	0
2006	0	54	1464.6	1244.6	65	0	0	0	0	19
2007	0	0	863.1	607.5	198	0	0	0	0	0
2008	0	0	766.2	785	187	0	0	0	0	0
2009	139	0	939.4	767.3	262	0	0	0	30.8	54.6
2010	175	0	888.1	715.6	235.5	0	0	0	17.5	36.1
2011	152	92	869.6	592.8	209	0	0	3	5.3	13.5
2012	168.5	0	522.8	487.6	1170	0	0.2	0	7.2	8
2013	314.5	47.9	733.7	334.5	1210	0	0.3	2	12.3	20.4
2014	369.6	202	637.7	421.5	1430	0	0.7	28	7.7	8.9
2015	534.3	279	651.3	622.4	1290	0	0.7	37	13.9	12
2016	654.8	471	996.4	647.4	1460	0	1.9	207	20.8	25.5
2017	833.9	520	1109.4	692.8	1473	33	11.1	73	42.3	44.7
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2020	660.7	644.4	1833.8	678.4	1026	15.9	9.2	138.5	6.5	4.2
2021	737	609.6	1679	829.3	1034	0	6.6	0	4.1	17.2

Information on landings at length is available for the whole time series (2002-2021) for Italy in GSA 19 and for most years in GSA 18 (2006 and 2008 excuded). For GSA 17 landings at length are only available in 2006, 2011 and 2013-2021 for Italy and from 2014 onwards in Croatia (Figure 6.7.2.1.8). For Albania in GSA 18 information is available since 2017, but minimum lenghts starts from 19 cm thus suggesting that youngers specimens are not properly reported.

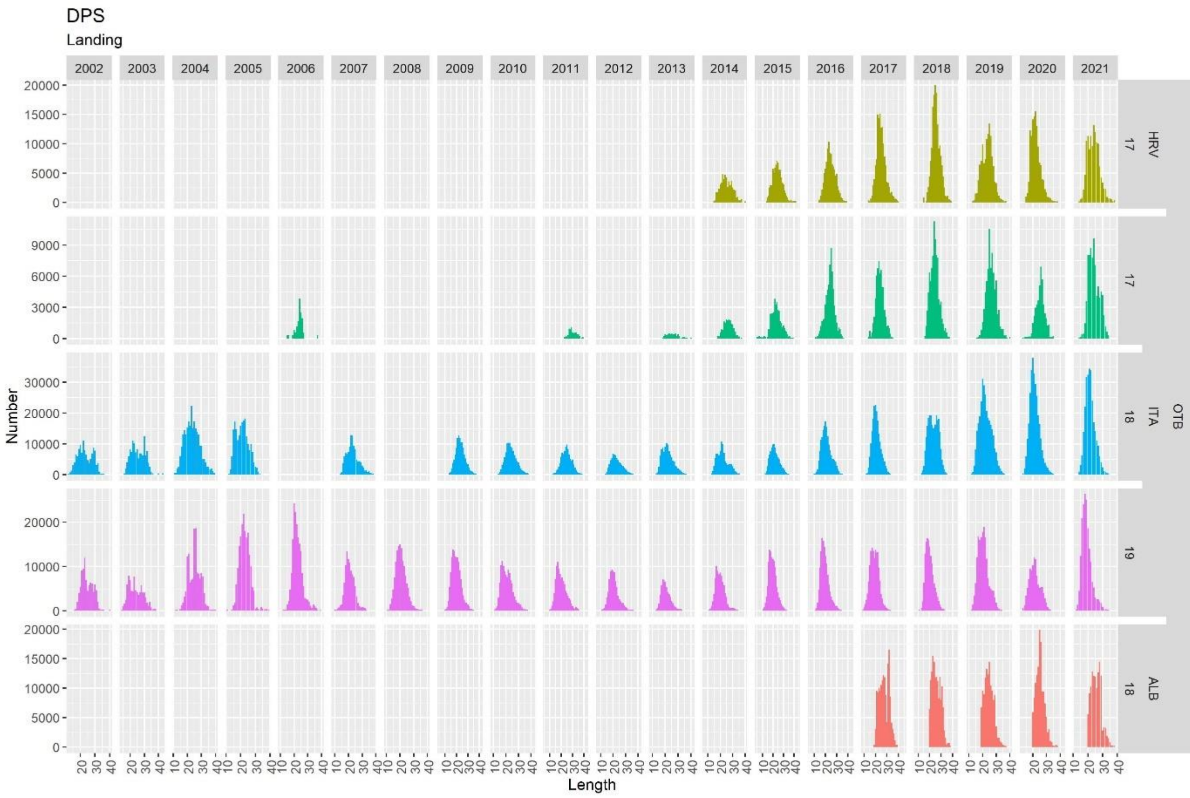


Figure 6.7.2.1.8. **Deep-water rose shrimp stocks in GSAs 17-19**: Length frequency distribution of the landings by year and fleet.

Information on discards at length is available since 2009 for Italy in GSA 19 and GSA18. For GSA 19 length are present also for 2006. For GSA 17 data at length are available in 2011 and from 2013 onwards for Italy and from 2015 onwards for Croatia (Figure 6.7.2.1.9)

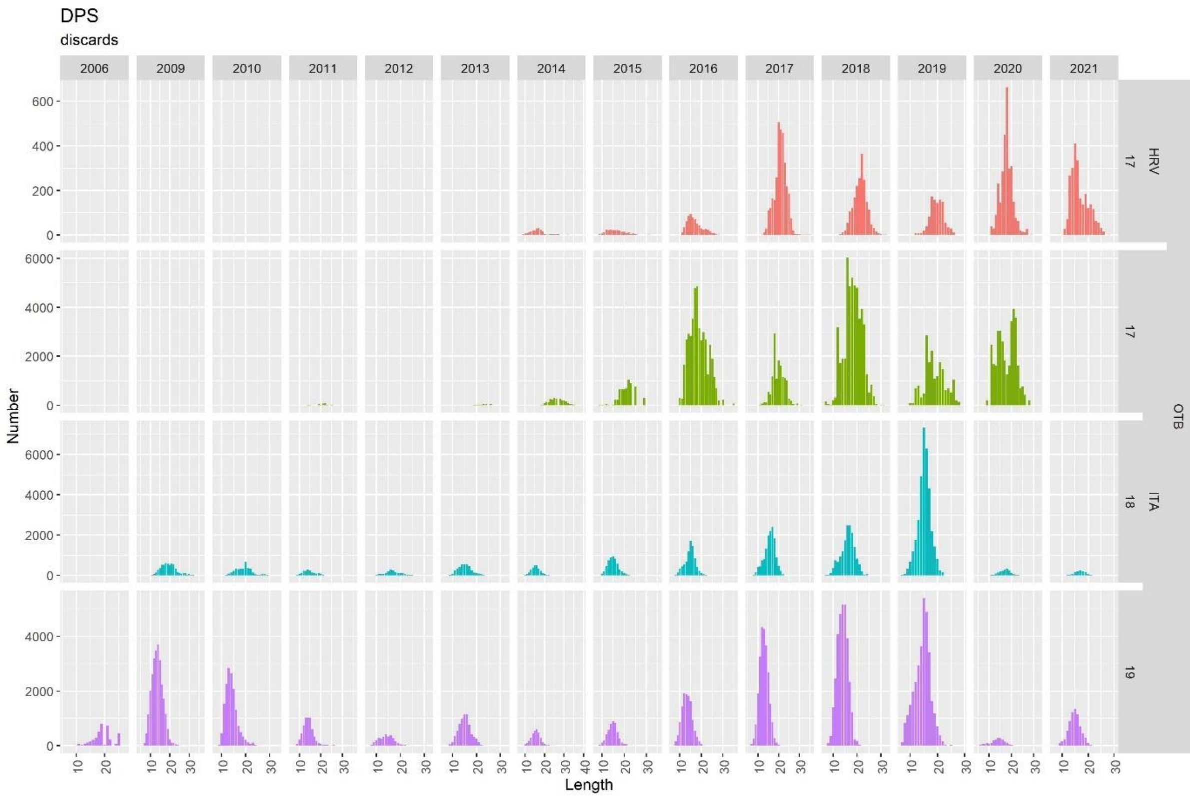
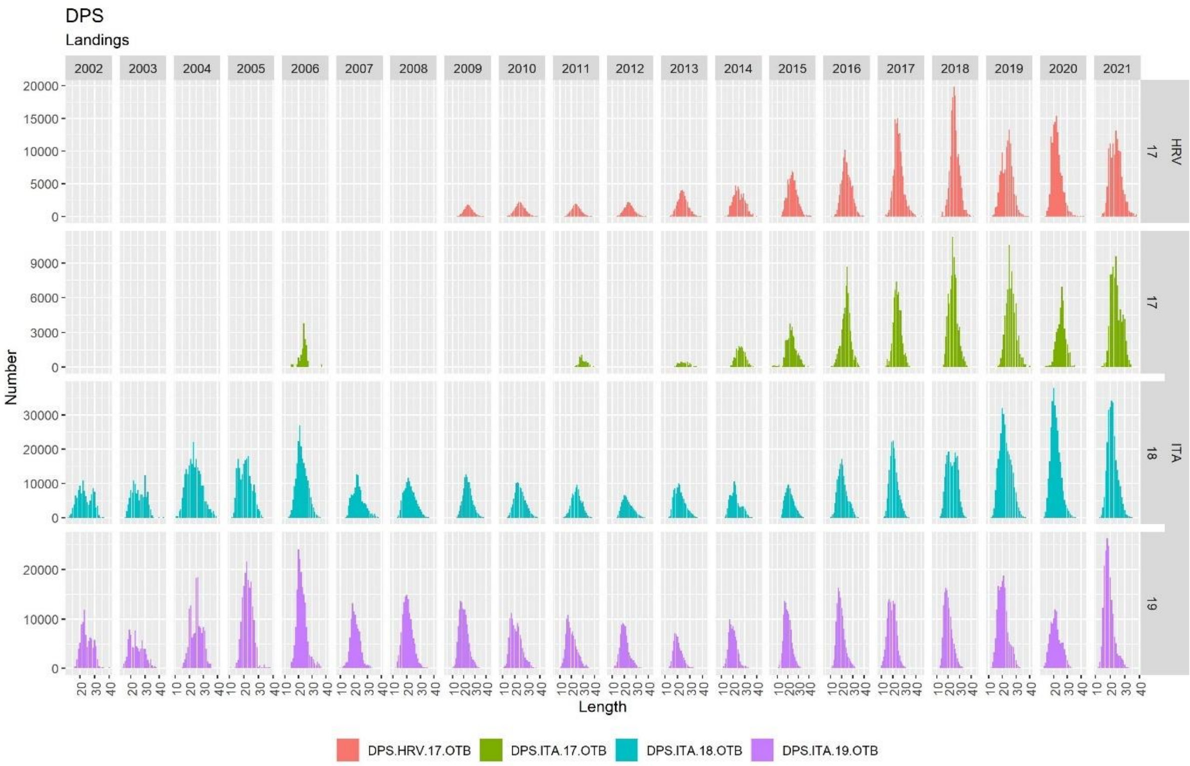
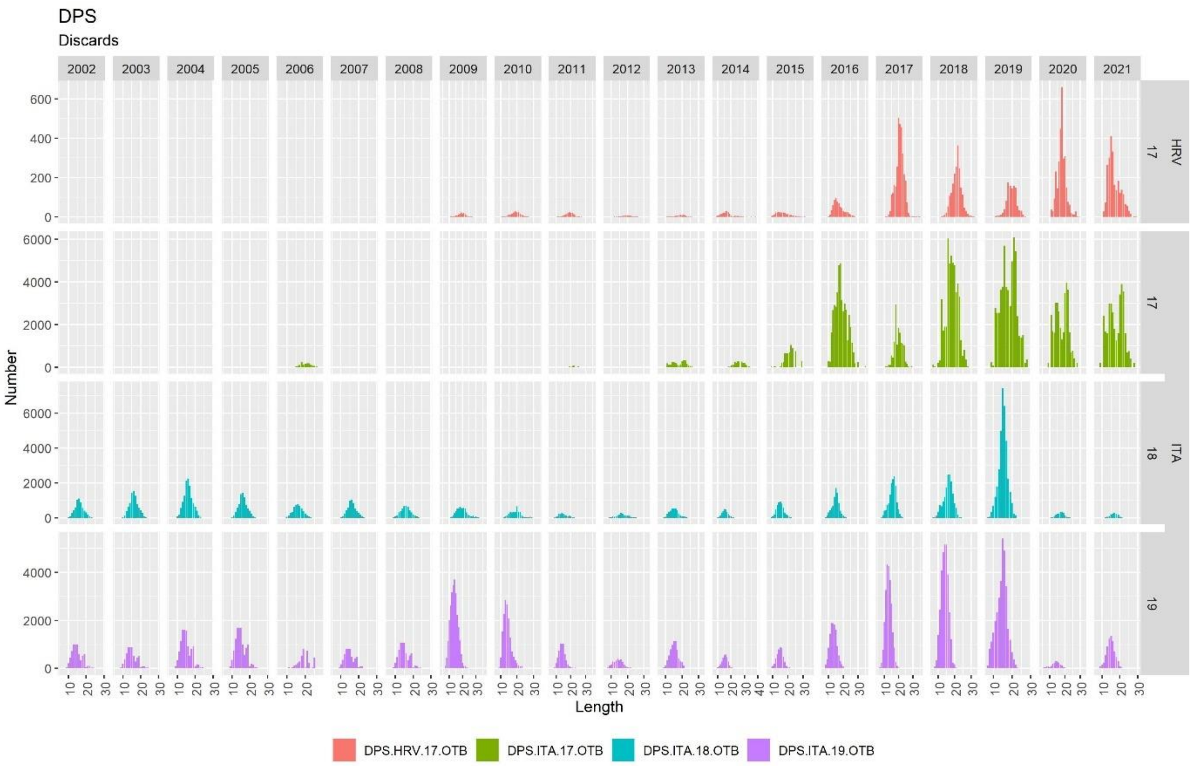


Figure 6.7.2.1.9. **Deep-water rose shrimp stocks in GSAs 17-19**: Length frequency distribution of the discards by year and fleet.

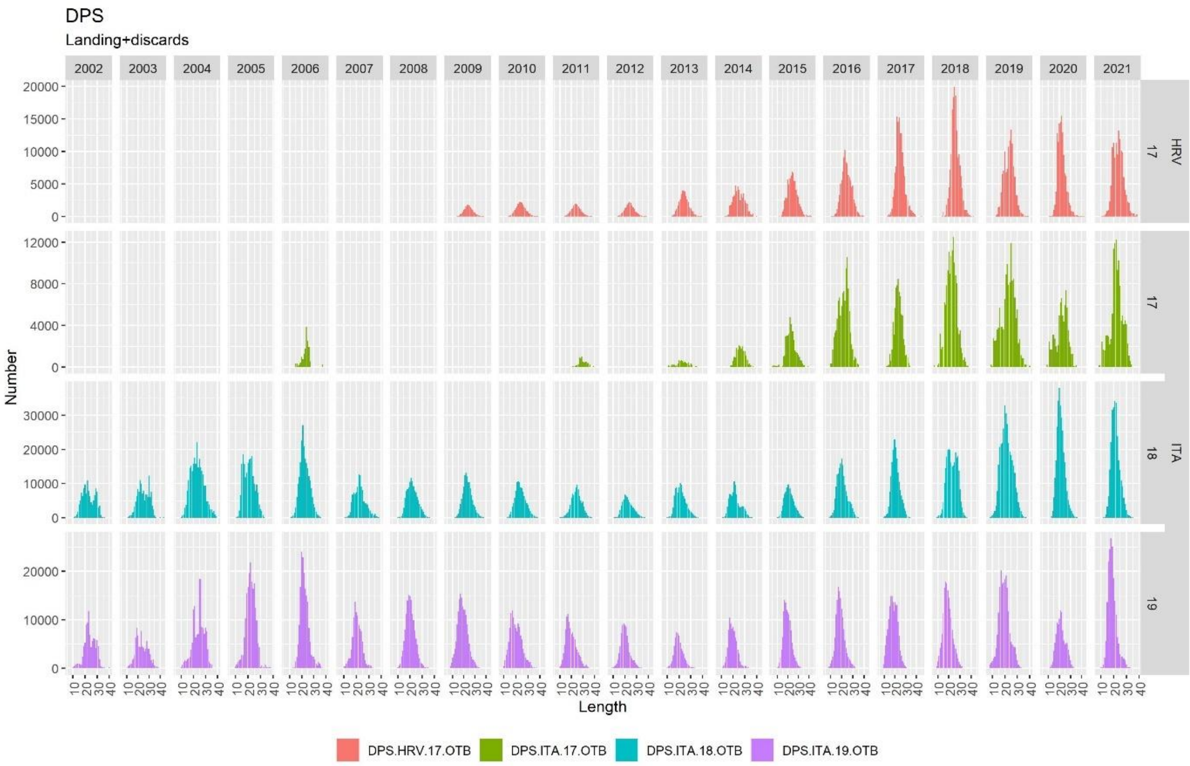
Landings and discards at length information derived from DCF where filled for missing years applying the procedures described in section 4.2 by using the script developed in EWG 21-02 (Landings_LFgaps_metier and the Discards_LFgaps_metier). The filling procedure was applied using the mean LF distribution of all available years and results are showed in figure 6.7.2.1.10 (A,B,C).


DPS
Landings
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
HRV 17
ITA 17
ITA 18
ITA 19
Number
Length
DPS.HRV.17.OTB
DPS.ITA.17.OTB
DPS.ITA.18.OTB
DPS.ITA.19.OTB

A


DPS
Discards
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
HRV 17
ITA 17
ITA 18
ITA 19
Number
Length
DPS.HRV.17.OTB
DPS.ITA.17.OTB
DPS.ITA.18.OTB
DPS.ITA.19.OTB

B



C

Figure 6.7.2.1.10. **Deep-water rose shrimp stocks in GSAs 17-19**: Length frequency distribution of landing (A) and discards (B) and both (C) by year and fleet reconstructed for missing years.

6.7.2.2 EFFORT

Fishing effort data were reported to STECF EWG 22-16 through DCF. In all the GSAs considered, the fishing effort related to fleets that report catches of some DPS is almost exclusively from bottom trawl gears. The effort data are available for GSA17 (Italy, Slovenia and Croatia), GSA18 (Italy) and GSA19 (Italy). For Italy effort data are available since 2004, for Croatia since 2005 and for Croatia since 2012.

Table 6.7.2.2.1 and Figure 6.7.2.2.1 shows a decreasing trend of effort in fishing days for OTB by country and gsa.

Table 6.7.2.2.1. Deep-water rose shrimp stocks in GSAs 17-19: Fishing effort in in fishing days for OTB by country and gsa.

effort		fishing_days			
country	HRV	ITA	ITA	ITA	SVN
gsa	17	17	18	19	17
2002	0	220915	138899	131590	0
2003	0	223216	107183	153810	0
2004	0	242276	87211	106719	0
2005	0	203974	79638	56199	831
2006	0	169108	85122	82371	963
2007	0	138377	70774	76509	1202
2008	0	130131	70654	76484	1254
2009	0	137929	85892	88055	1205
2010	0	136949	73021	90514	1263
2011	0	138540	68754	78239	1178
2012	50835	116850	63411	60017	917
2013	52973	97982	79244	45588	766
2014	54650	97868	54851	48040	680
2015	55076	85984	54774	51394	696
2016	33715	89376	60876	49784	812
2017	35649	96415	57053	52214	697
2018	56844	79551	62311	46672	692
2019	30997	65911	50169	32875	769
2020		56627	39509	25186	
2021					

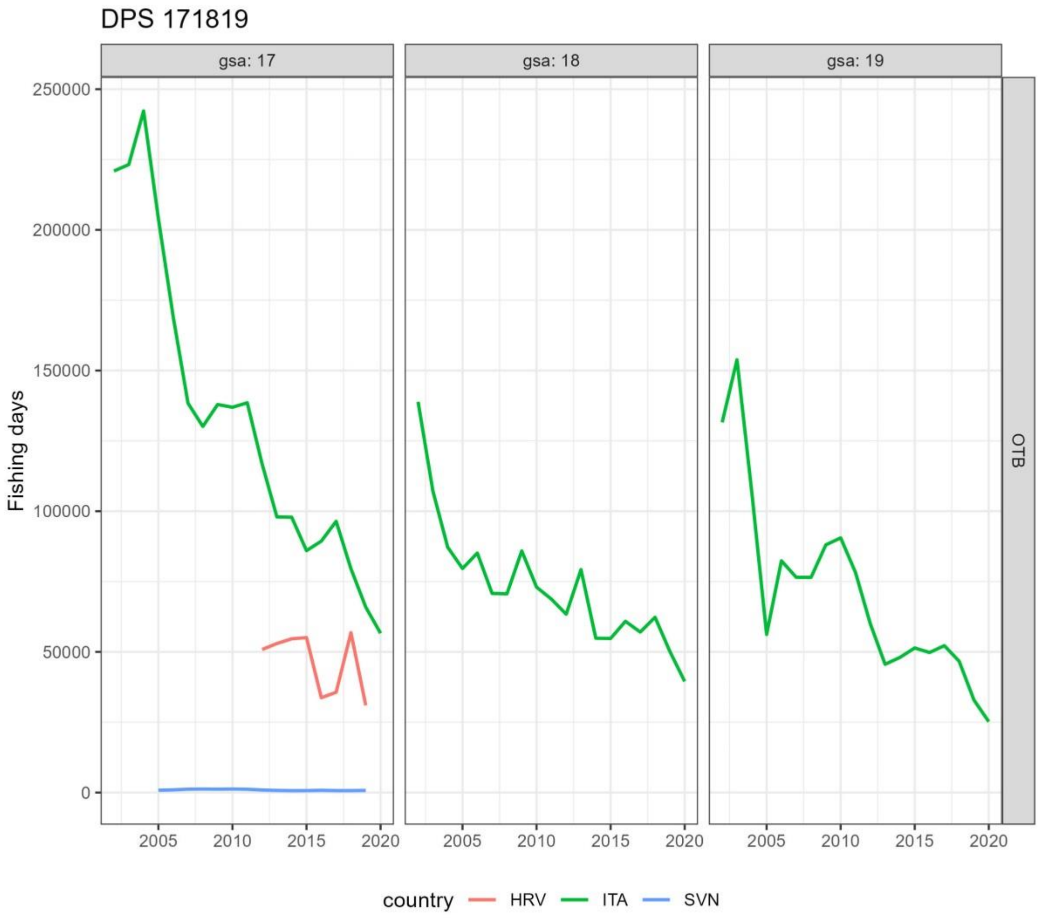


Figure 6.7.2.2.1. **Deep-water rose shrimp stocks in GSAs 17-19**: trend of effort in fishing days.

6.7.2.3 SURVEY DATA

Since 1994, MEDITS trawl surveys has been regularly carried out each year during the spring season in GSAs 17-19 (Figure 6.7.2.3.1) and MEDITS was conducted consistently from 2007 to the present.

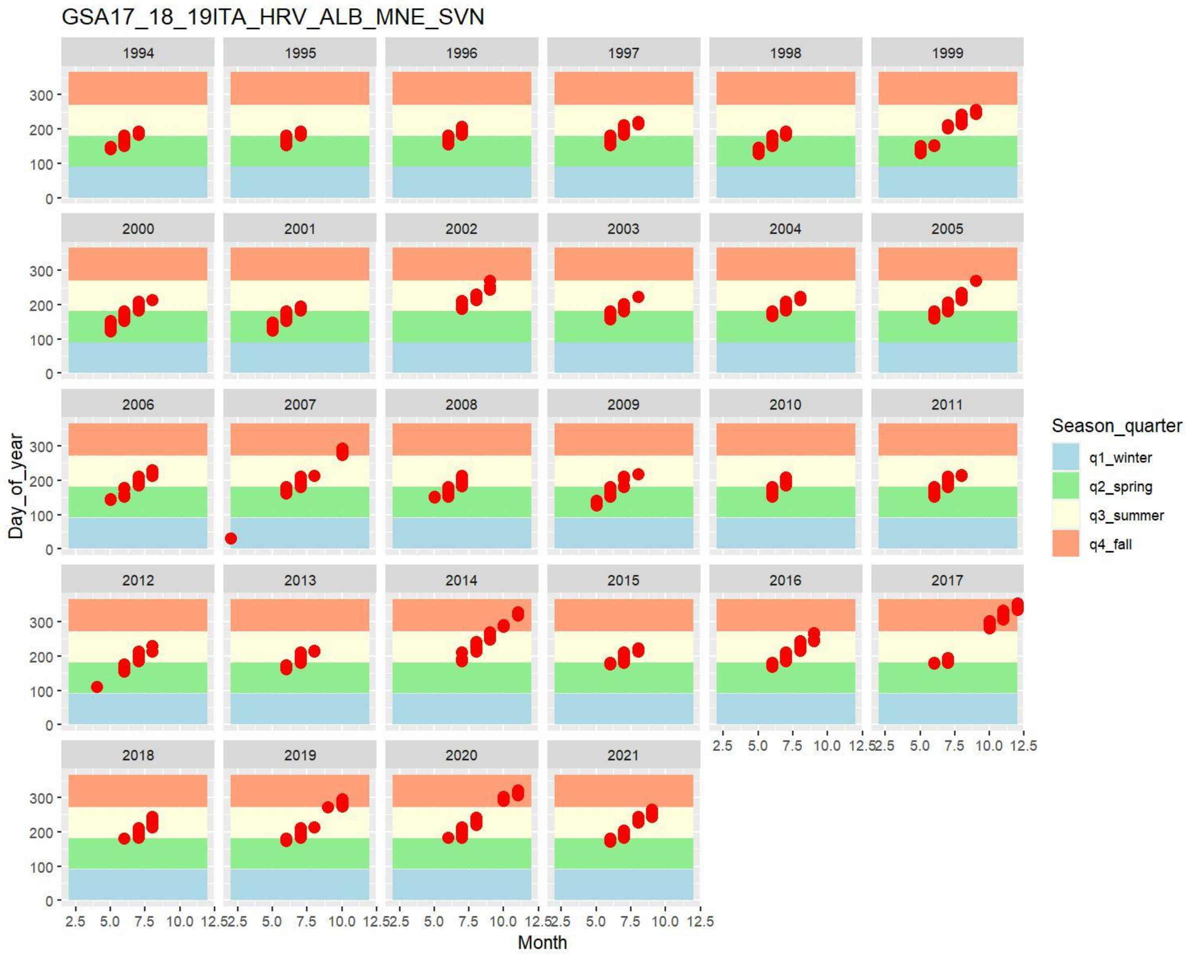


Figure 6.7.2.3.1. Period of MEDITS survey in GSAs 17, 18, 19.

Table 6.7.2.3.1. Total number of MEDITS hauls per year and country.

country	ALB	HRV	ITA	ITA	ITA	MTN
area	18	17	17	18	19	18
1994	0	0	86	72	73	0
1995	0	0	86	72	74	0
1996	40	0	85	72	74	0
1997	40	0	86	72	74	0
1998	40	0	86	72	74	0
1999	40	0	84	72	74	0
2000	40	0	86	72	74	0
2001	40	0	86	72	74	0
2002	32	59	119	58	70	0
2003	32	59	120	58	70	0
2004	32	61	118	58	70	0
2005	32	59	121	58	70	0
2006	32	59	120	58	70	0
2007	32	60	120	58	70	0
2008	27	59	121	53	70	10
2009	32	60	121	58	70	0
2010	27	60	120	53	70	10
2011	27	60	120	53	70	10
2012	27	60	120	53	70	10
2013	27	59	180	53	70	10
2014	27	56	180	53	70	10
2015	27	65	180	53	70	10
2016	27	56	180	53	70	10
2017	22	61	122	53	70	10
2018	27	63	120	53	70	9
2019	27	61	120	53	70	10
2020	12	58	122	53	70	5
2021	12	79	120	53	70	5

Observed abundance and biomass indices of Deep-water rose shrimp stocks from Medist are given in the figure 6.7.2.3.3 and 6.7.2.3.4).

For the whole area both estimated abundance and biomass indices show similar trends, with a peak in 2017 (figure 6.7.2.3.3).

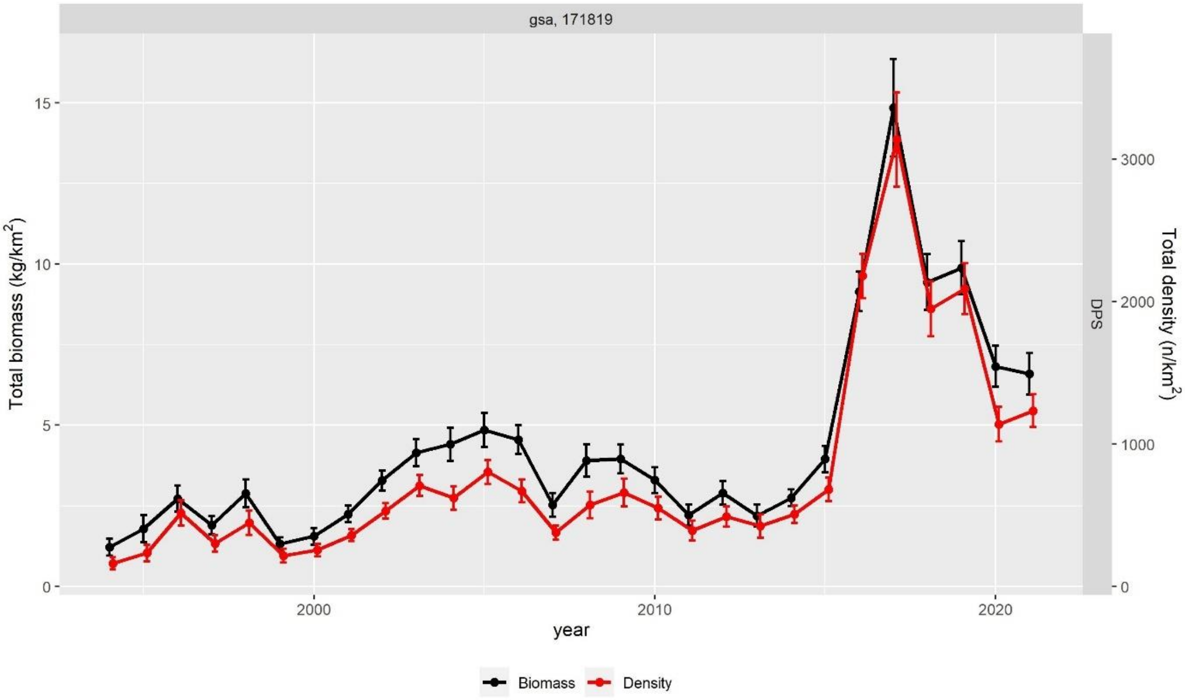


Figure 6.7.2.3.3. Deep-water rose shrimp stocks in GSAs 17-19: Estimated biomass (kg/km^2) and density indices (N/km^2) for the whole area and all countries (ALB. HRV, MTN, ITA).

Anlysing the abundance and biomass indices by gsa and countries some differences in trends are showed (figure 6.7.2.3.4).

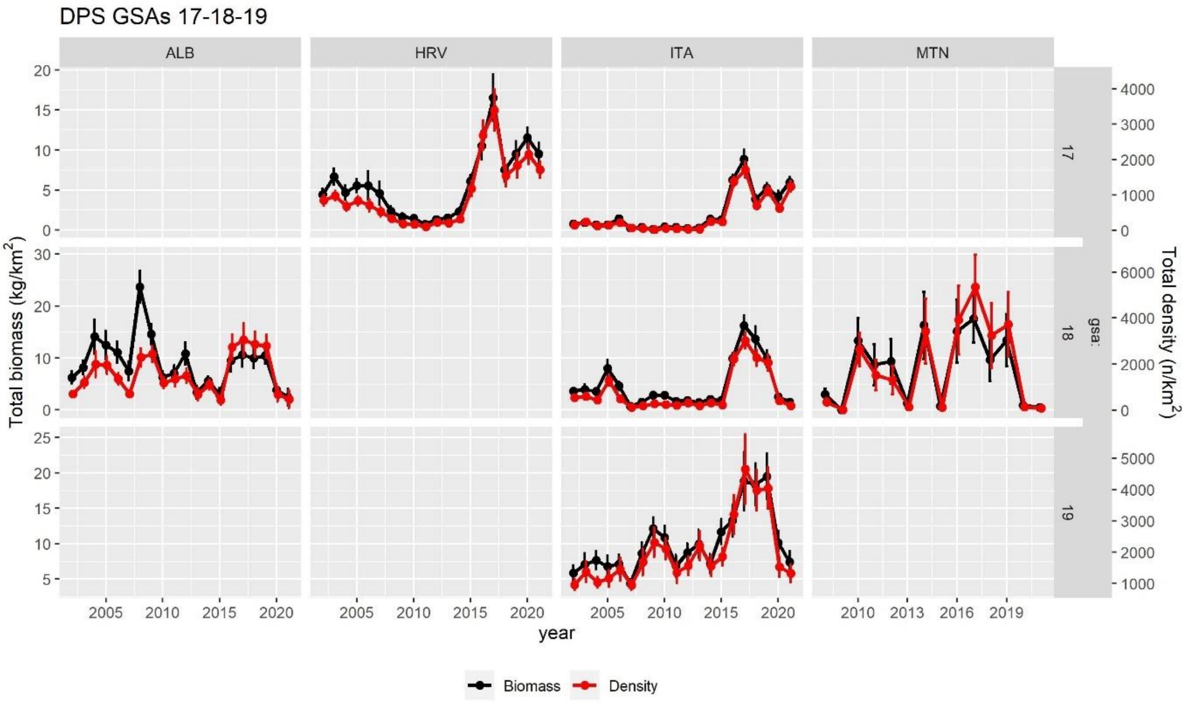


Figure 6.7.2.3.4. Deep-water rose shrimp stocks in GSAs 17-19: Estimated biomass (kg/km^2) and density indices (N/km^2) by area and countries.

Length frequency distribution of Deep-water rose shrimp stocks from Medist are given in the figure below for the whole area (Figure 6.7.2.3.5) and by gsa and country (Figure 6.7.2.3.6).

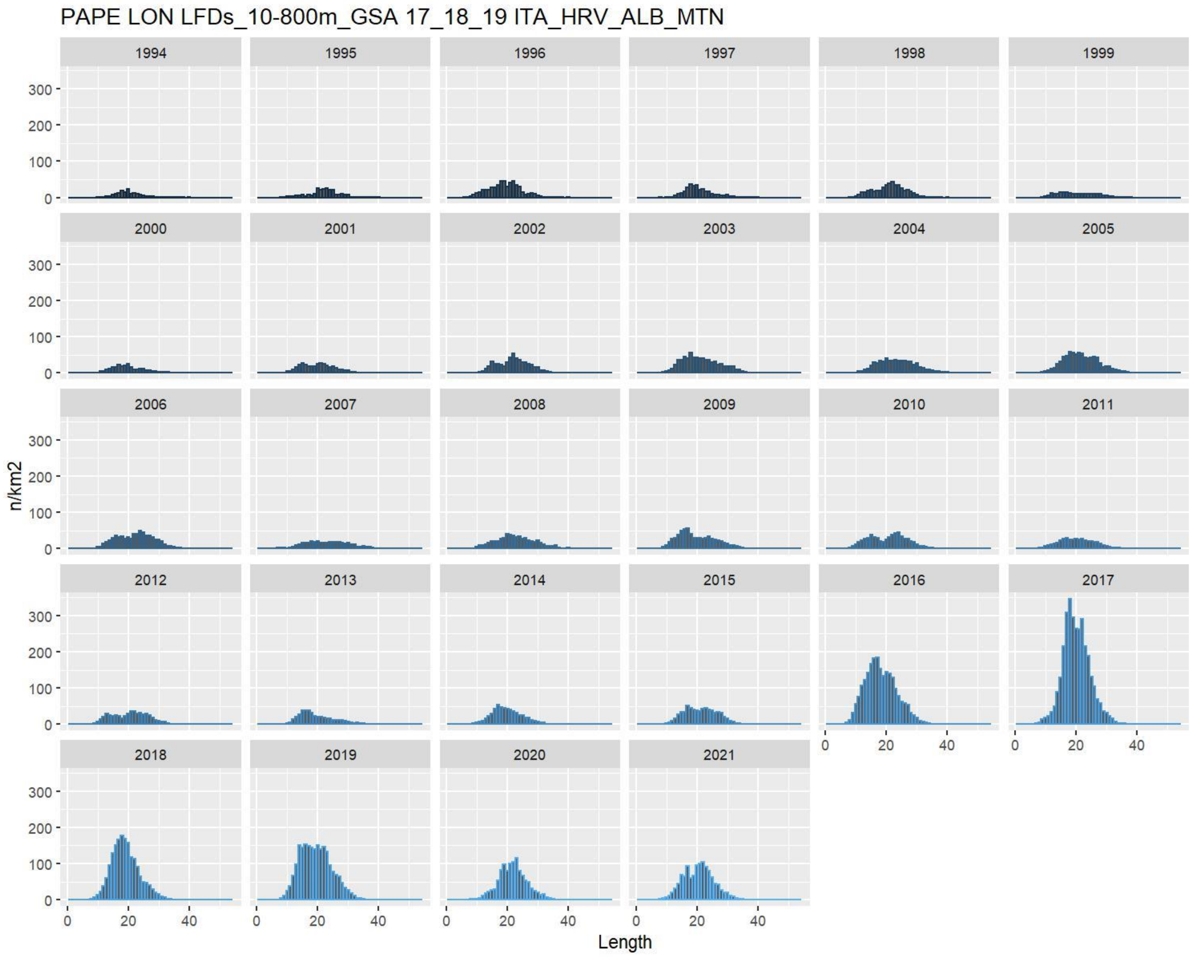


Figure 6.7.2.3.5. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution by year of MEDITS.

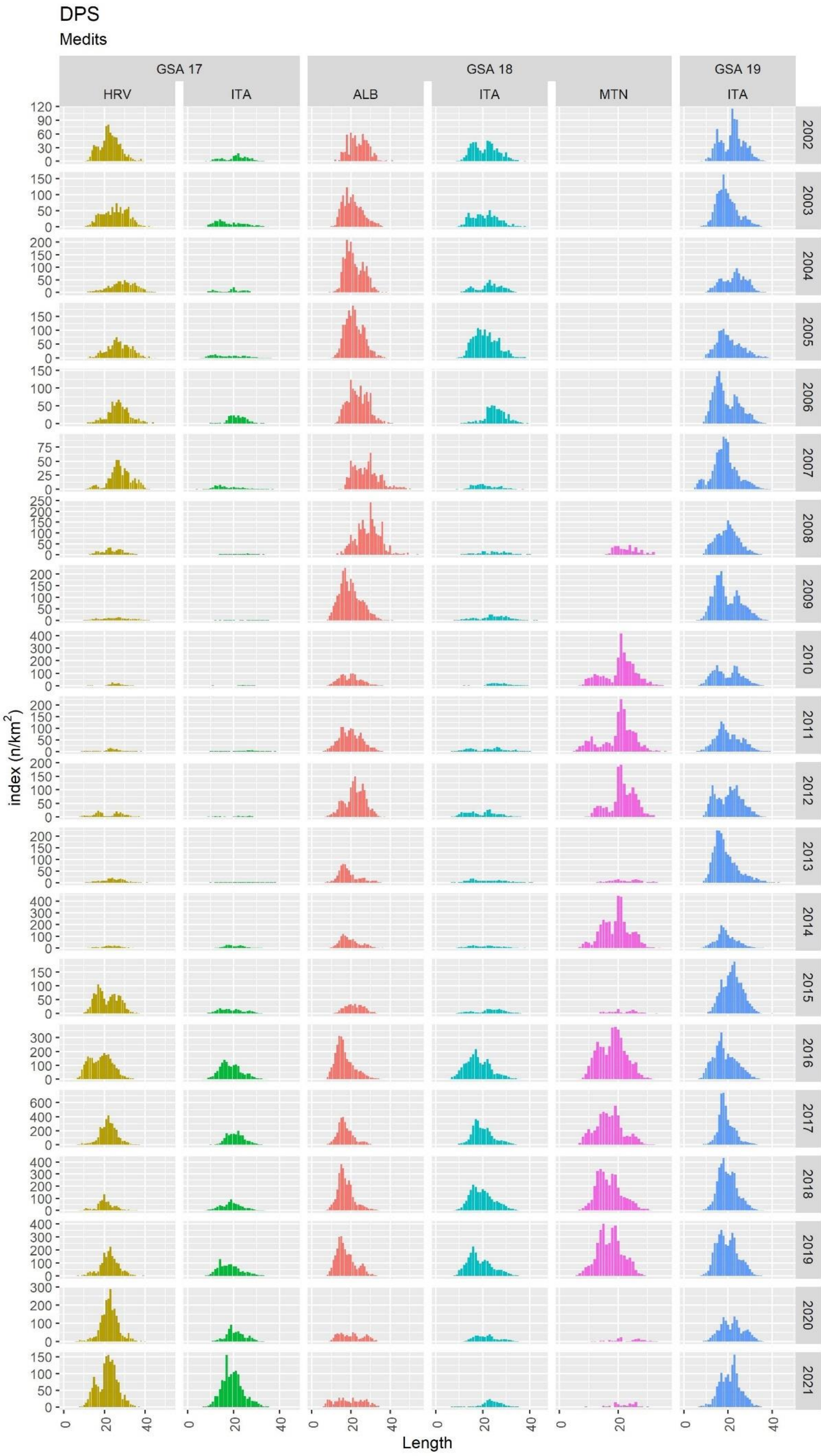


Figure 6.7.2.3.6. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution by year, country and gsa of MEDITS.

6.7.3 STOCK ASSESSMENT

The conclusion to the data investigation is that only age disaggregated data is available from 2002 for the catch, so the assessment is run based on catches from 2002 to 2020. In addition data on discards at length are availble only from 2009 with some gaps in some GSA when was not mandatory to collect/provide discards data. For this years data were reconstructed by using the "discards LFgaps metier" routine, which estimates discards weight values as mean of the available years and then use the same procedure of "landings LFgaps metier" routine to reconstruct the missing length distribution.

The statistical catch-at-age method Assessment for All (a4a) (Jardim et al., 2015) was used to estimate historical population size and fishing mortality.

An extensive sensitivity analysis of possible model configuration was carried out.

The l2a routine in FLR was used to deterministically length slicing catch at length and MEDITS abundaces to numbers and mean weights at age for the assessment. The growth parameters and weight length relationship used for the slicing are given in Table 6.7.1.1 for all the GSAs. These parameters do not change from the last working group (EWG 21-15).

Input data

Stock assessment input data for the a4a model are given in this section below.

Data used in the last EWG 21-15 were revised and uptaded using the raw data from 2021 DCF data call. The catch at age matrix, the catch at weight matrix and the catch matrix were derived for each country and gsa from DCF and then SOP corrected.

The catch age matrix from the slicing of MEDITS catch rate at length data is reported below in Table 6.7.3.1.1 and Figure 6.7.3.1.1.

Table 6.7.3.1.1. Deep-water rose shrimp stocks in GSAs 17-19: MEDITS tuning index of abundance by age and by year.

MEDITS

Year/Age	0	1	2	3
2002	284.3	224.6	9.3	1.4
2003	424.1	250.4	29.2	4.1
2004	289.3	283	37.4	11.1
2005	467.1	302.3	30.1	4.6
2006	320.3	318.8	27.1	4.1
2007	181.2	157.6	27.4	7.2
2008	291.3	236.7	35.8	8.3
2009	434.2	205.9	18	2
2010	316.6	214.3	13.5	1.8
2011	251.8	132.3	7.5	0.5
2012	296	185.8	7.6	0.6
2013	306.7	105.6	11.3	0.7
2014	337.5	139.7	5.7	0.7
2015	392.3	279.2	9.8	0.5
2016	1737.2	434.1	10.5	0.4
2017	2242.7	874.3	20.4	1.1
2018	1361.2	370.7	9.3	0.5
2019	1499.7	575.2	15.2	1.8
2020	644.5	477.6	15.6	1.1
2021	784.3	414.1	10.6	0

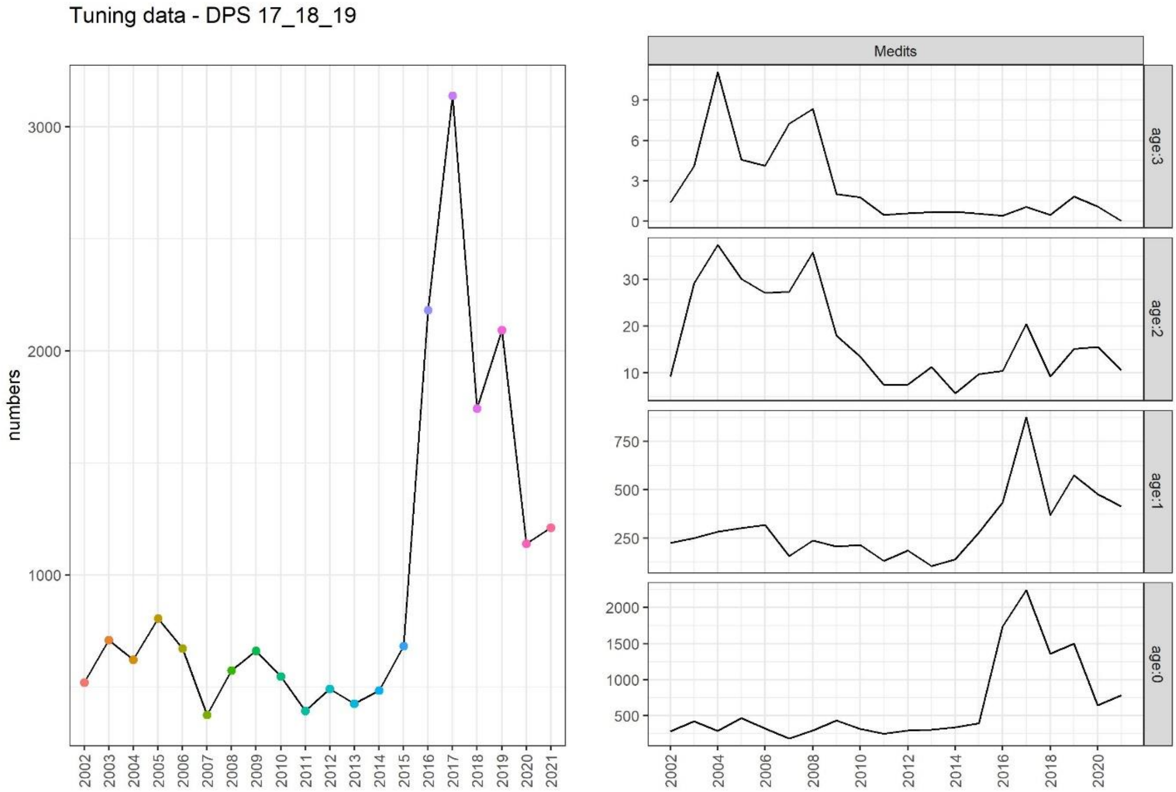


Figure 6.7.3.1.1. **Deep-water rose shrimp stocks in GSAs 17-19**: MEDITS mean catch/rate at age by year and numbers at age derived from length by slicing.

Input data in terms of total catch, catch numbers and mean weight at age were obtained for each country and gsa using in all the same procedure and the same growth parameter (Table 6.7.1.1) to deterministically slice the length frequency distributions as reconstructed by EWG 22-16.

The catch, catch at age and catch weight at age data by country and gsa are shonw in Figure 6.7.3.1.2.

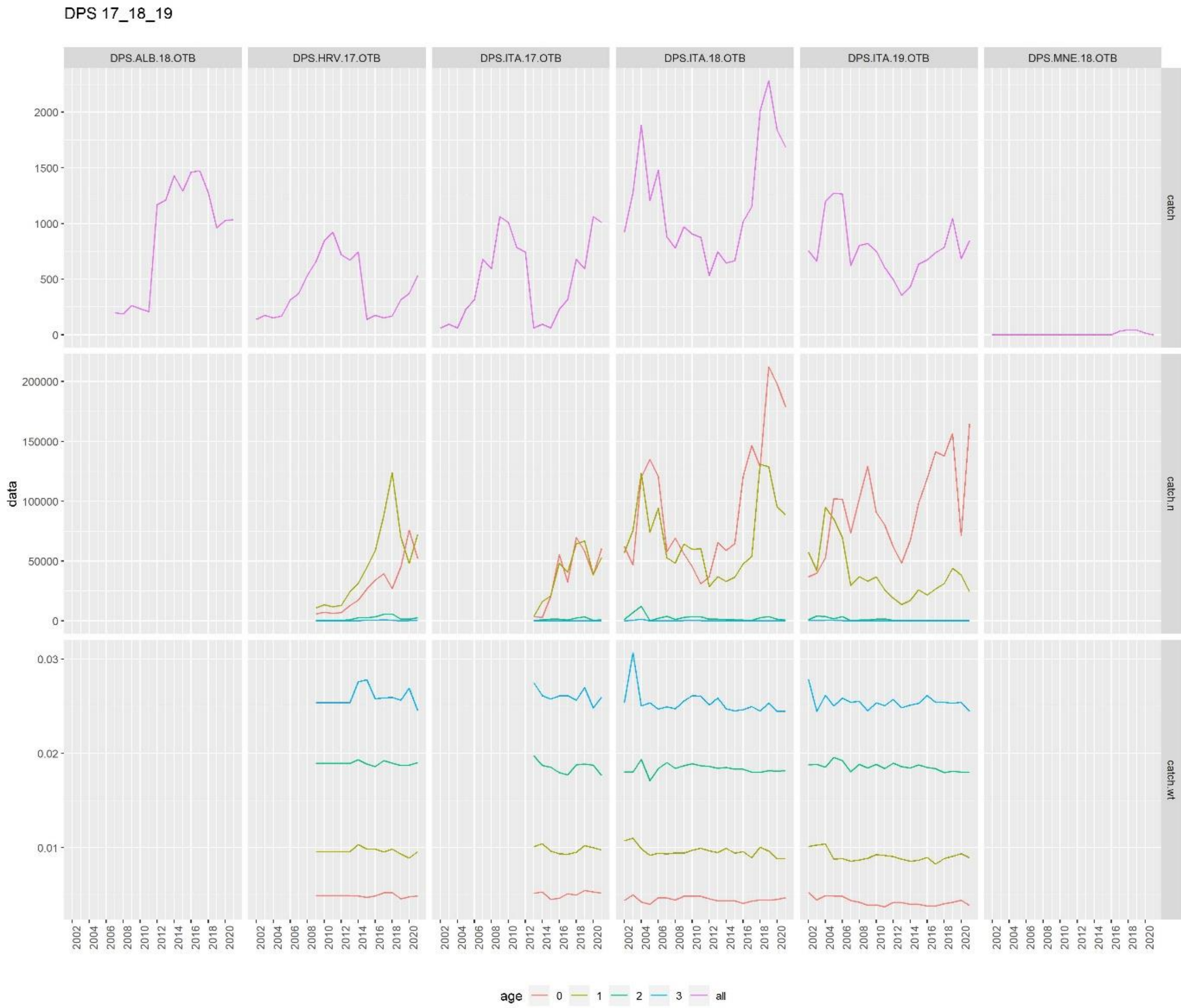


Figure 6.7.3.1.2. **Deep-water rose shrimp stocks in GSAs 17-19**: catch, catch at age and catch weight data by country and gsa used to derive the stock object for the whole area.

The catch and catch at age matrices by country and gsa were sum and then SoP corrected raising catches at age to total catches. The catch at weight matrix was derived averaging the data by country and gsa.

The final stock object used for the assessment is reported below (Table 6.7.3.1.3-5 and Figure 6.7.3.1.3).

Table 6.7.3.1.3. Deep-water rose shrimp stocks in GSAs 17-19: The final catch at age matrix.

Year/Age	0	1	2	3
2002	108349.66	125212.03	2547.4	228.02
2003	101275.3	138109.76	13062.92	879.35
2004	170254.17	215152.69	15575.33	1823.7
2005	270923.58	181974.16	2061.69	416.01
2006	278023.15	213836.22	7296.34	302.46
2007	257258.1	160498.2	7770.21	354.96
2008	320318.52	159206.06	3783.1	105.71
2009	370506.29	209424.28	7624.19	398.44
2010	296266.15	227520.34	11580.94	700.5
2011	231915.34	202283.81	13449.19	824.55
2012	349971.37	201317.65	8498.53	416.68
2013	281083.94	169410.09	6667.81	414.79
2014	283388.71	188599.6	9537.84	221.89
2015	262543.85	159997.52	6389.65	958.23
2016	366010.84	195499.9	6473.13	419.13
2017	376986.28	219518	7040.24	952.24
2018	343158.16	330813.94	10454.56	571.76
2019	464793.59	304703.45	8784.97	304.2
2020	488517.43	280888.88	4382.74	301.93
2021	528103.21	276328.39	5270.57	377.54

Table 6.7.3.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Total Catch by year in tonnes

year	catches
2002	1877.1
2003	2209.7
2004	3295.9
2005	2874.8
2006	3373.8
2007	2747.7
2008	2896.8
2009	3773.9
2010	3746.8
2011	3394.6
2012	3656.9
2013	3042.2
2014	3344.5
2015	2791.6
2016	3555.9
2017	3863.8
2018	4966.9
2019	5242.5
2020	4999.1
2021	5108.1

Table 6.7.3.1.5. Deep-water rose shrimp stocks in GSAs 17-19: Catch at weight matrix.

year	0	1	2	3
2002	0.0048	0.0104	0.0184	0.0266
2003	0.0047	0.0106	0.0184	0.0276
2004	0.0046	0.0101	0.0189	0.0256
2005	0.0044	0.009	0.0183	0.0252
2006	0.0048	0.0088	0.0201	0.0255
2007	0.0045	0.0089	0.0185	0.0252
2008	0.0043	0.0091	0.0186	0.0251
2009	0.0045	0.0093	0.0187	0.0251
2010	0.0046	0.0095	0.0189	0.0256
2011	0.0046	0.0101	0.0187	0.0256
2012	0.0045	0.0094	0.0188	0.0254
2013	0.0046	0.0095	0.0189	0.0259
2014	0.0046	0.0098	0.0187	0.0259
2015	0.0044	0.0094	0.0186	0.0258
2016	0.0043	0.0094	0.0183	0.0257
2017	0.0046	0.009	0.0183	0.0256
2018	0.0047	0.0096	0.0184	0.0254
2019	0.0046	0.0096	0.0185	0.0258
2020	0.0047	0.0093	0.0184	0.0254
2021	0.0046	0.0092	0.0182	0.0249

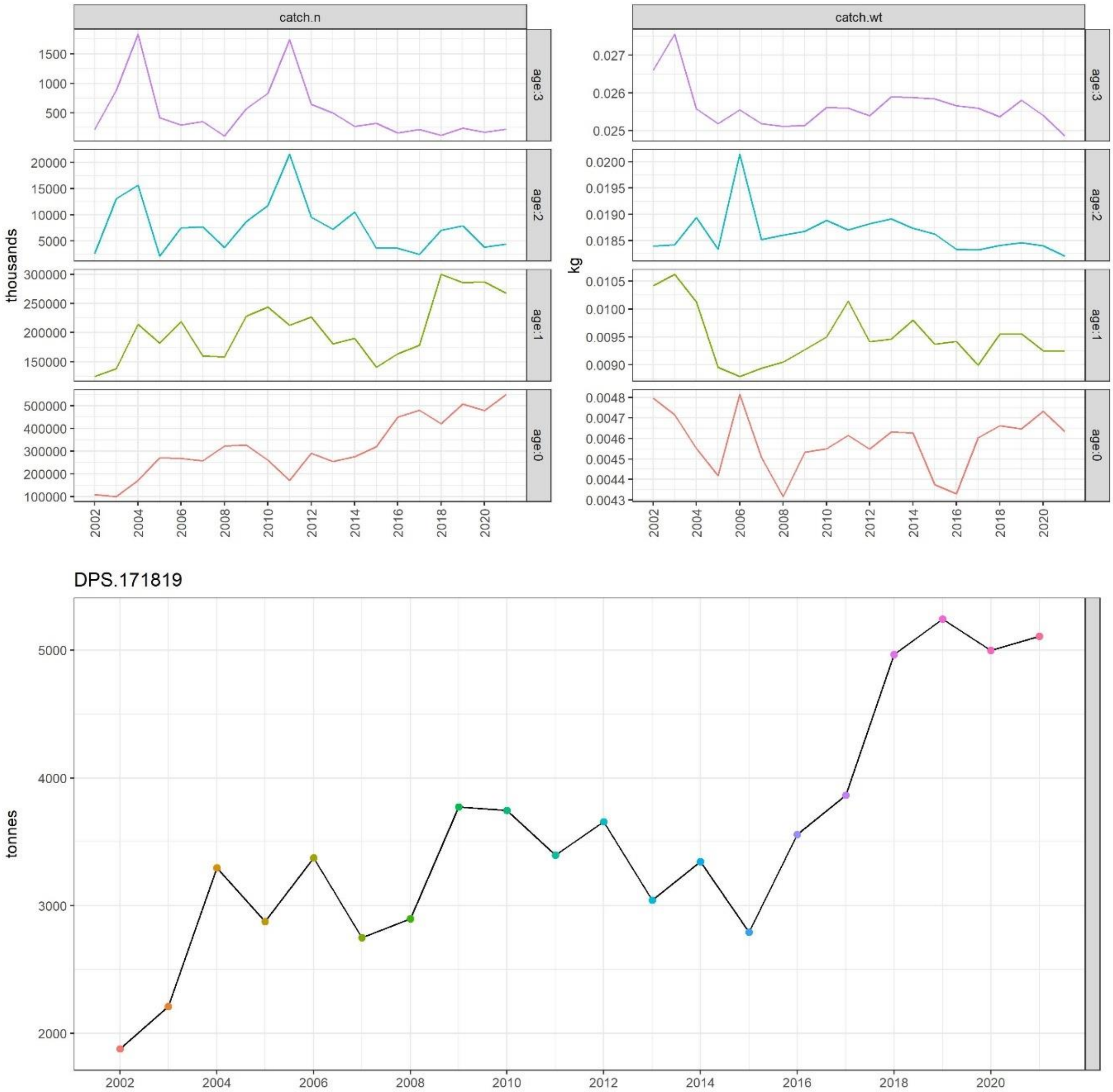


Figure 6.7.3.1.3. Deep-water rose shrimp stocks in GSAs 17-19: Trends of total catch in tonnes, and catch at age and catch weigth used as input in the assessment.

Input data on maturity and natural Mortality derived by the Chan-Watanabe method are reported on table 6.7.3.1.6.

Table 6.7.3.1.6. Deep-water rose shrimp stocks in GSAs 17-19: Maturity and Natural mortality and catch weights at age.

Age	0	1	2	3
Maturity	0.4	0.1	1.0	1.0
Natural Mortality	1.75	0.94	0.75	0.67

Results

For the assessment catch were used from 2002 to 2021 and the average spawning time was set 0.5 (1st July) according to the biology of the species.

The age range used in the assessment was 0 to 3+ and Fbar was set from 0 to 2.

The stock assessment was based on the following submodels:

fmodel: ~factor(replace(age, age > 1, 1)) + s(year, k = 7)

srmodel: ~s(year, k = 8)

n1model: ~s(age, k = 3)

qmodel: ~factor(replace(age, age > 1, 1))

vmodel: catch: ~s(age, k = 3)

IND: ~MEDITS (One index)

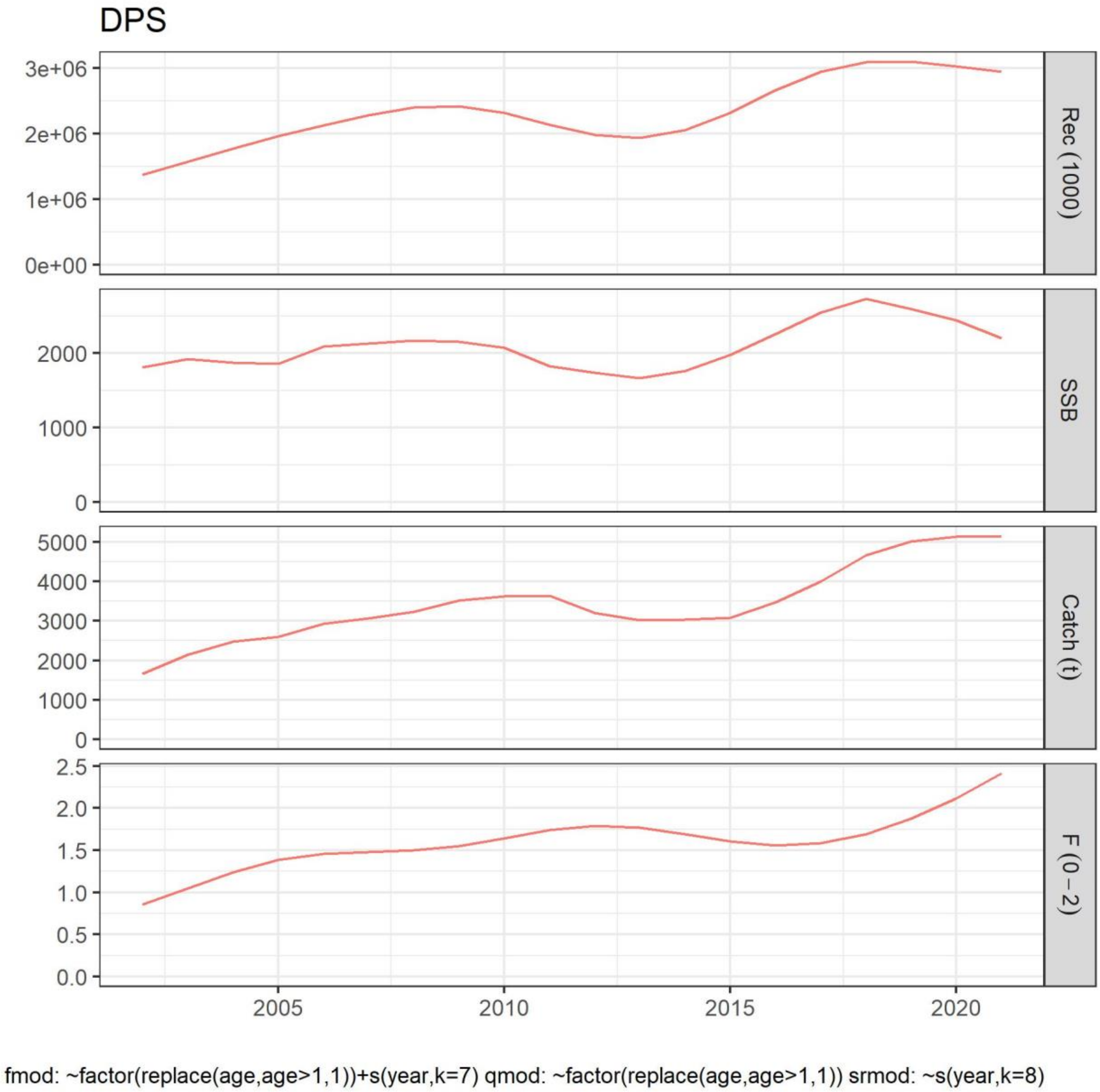


Figure 6.7.3.5. Deep-water rose shrimp stocks in GSAs 17-19: Stock summary from the a4a model for recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality).

Table 6.7.3.7. **Deep-water rose shrimp stocks in GSAs 17-19**: Stock summary from the assessment.

year	Fbar	Recruitment	SSB	TB	Catch
2002	0.85	1369483	1814	8840	756
2003	1.05	1571592	1924	10027	911
2004	1.24	1776032	1878	10532	1254
2005	1.38	1962427	1857	11077	1134
2006	1.45	2129810	2093	12882	1788
2007	1.48	2282465	2132	13159	783
2008	1.5	2397240	2173	13429	867
2009	1.55	2419753	2156	13459	1361
2010	1.64	2316978	2074	13243	1315
2011	1.74	2134871	1822	11900	1851
2012	1.79	1977507	1739	11604	723
2013	1.77	1936632	1667	11099	1395
2014	1.69	2055282	1763	11531	1566
2015	1.6	2321873	1975	12670	2462
2016	1.56	2660476	2255	14258	3123
2017	1.58	2947837	2550	16230	3813
2018	1.69	3092065	2730	17808	4932
2019	1.87	3097166	2595	17731	5086
2020	2.12	3028801	2440	17726	4029
2021	2.41	2941620	2199	17020	4446

Table 6.7.3.8. Deep-water rose shrimp stocks in GSAs 17-19: Stock number by age and by year in thousands.

Year/Age	0	1	2	3
2002	1369483	216888.8	5825.28	497.91
2003	1571592	202522.2	25535.09	906.05
2004	1776032	224070.2	18179.91	2878.83
2005	1962427	244123.3	15332.43	1761.64
2006	2129810	262505.5	13651.02	1165.55
2007	2282465	281118.9	13294.82	913.28
2008	2397240	300029.8	13808.68	848.45
2009	2419753	313866	14308.59	849.37
2010	2316978	313539.7	13858.64	813.15
2011	2134871	295116.2	12188.67	692.91
2012	1977507	267078.3	10040.64	532.37
2013	1936632	245005.2	8455.94	406.52
2014	2055282	240919.8	7994.67	351.07
2015	2321873	259502.3	8776.84	368.99
2016	2660476	298005.7	10676.54	456.6
2017	2947837	344427.9	13072.07	592.63
2018	3092065	379802.2	14579.73	702.07
2019	3097166	390437	13844.08	676.23
2020	3028801	377759.5	11004.28	496.84
2021	2941620	352588.3	7532.1	278.33

Table 6.7.3.9. Deep-water rose shrimp stocks in GSAs 17-19: Fishing Mortality by age and by year

Year/Age	0	1	2	3
2002	0.16	1.2	1.2	1.2
2003	0.2	1.47	1.47	1.47
2004	0.23	1.74	1.74	1.74
2005	0.26	1.95	1.95	1.95
2006	0.28	2.04	2.04	2.04
2007	0.28	2.08	2.08	2.08
2008	0.28	2.1	2.1	2.1
2009	0.29	2.18	2.18	2.18
2010	0.31	2.31	2.31	2.31
2011	0.33	2.44	2.44	2.44
2012	0.34	2.51	2.51	2.51
2013	0.33	2.48	2.48	2.48
2014	0.32	2.37	2.37	2.37
2015	0.3	2.25	2.25	2.25
2016	0.29	2.19	2.19	2.19
2017	0.3	2.22	2.22	2.22
2018	0.32	2.37	2.37	2.37
2019	0.35	2.63	2.63	2.63
2020	0.4	2.98	2.98	2.98
2021	0.46	3.39	3.39	3.39

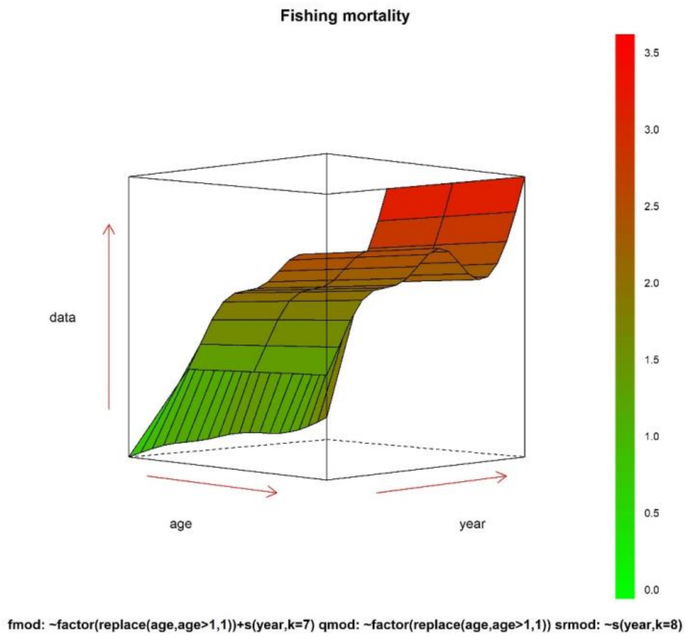


Figure 6.7.3.6. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated fishing mortality at age and year.

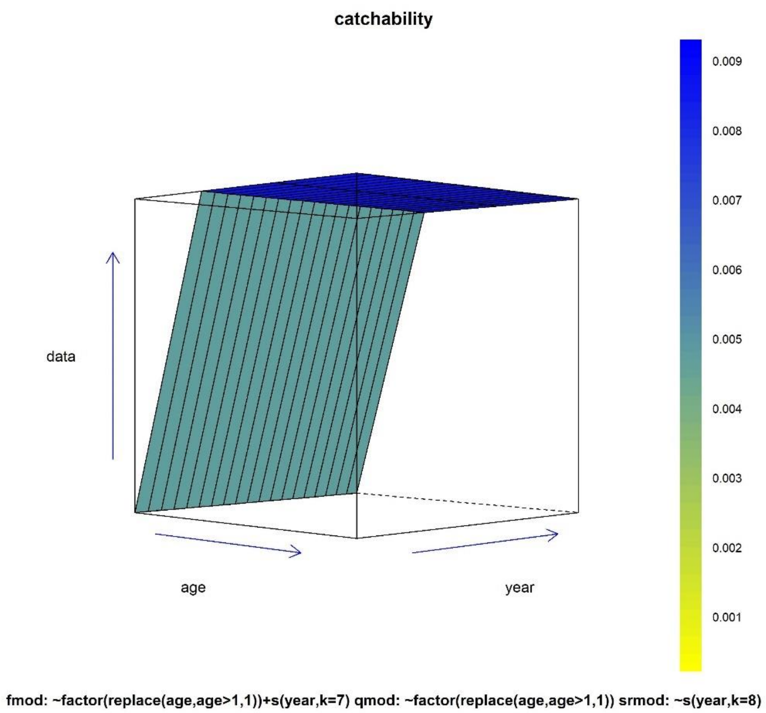


Figure 6.7.3.7. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated catchability at age and year.

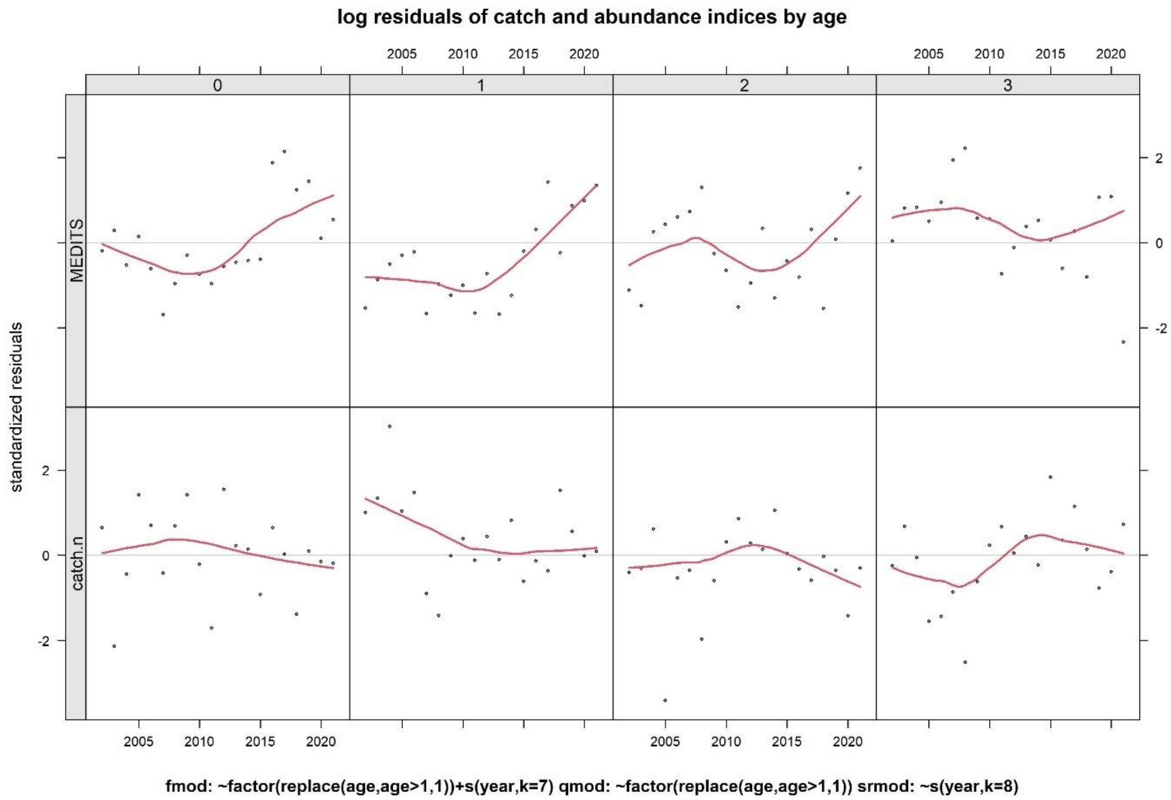


Figure 6.7.3.8. Deep-water rose shrimp stocks in GSAs 17-19. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and red lines a simple smoother.

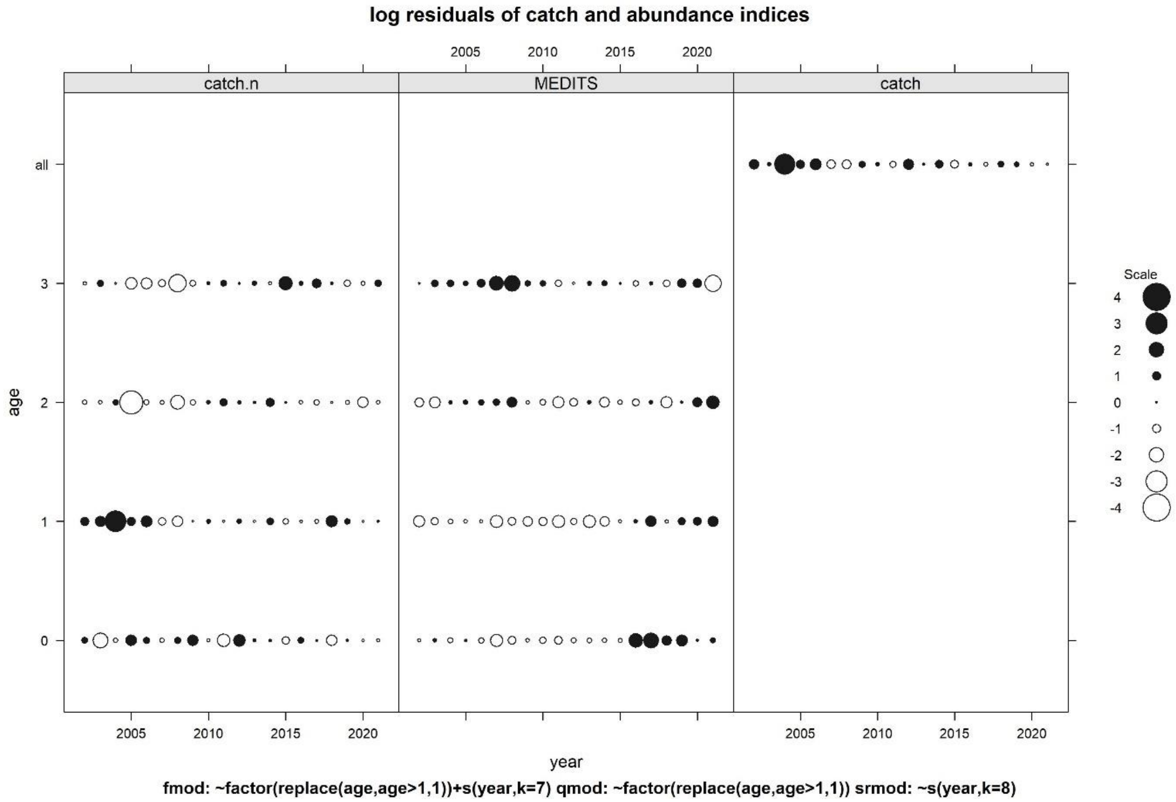


Figure 6.7.3.9. Deep-water rose shrimp stocks in GSAs 17-19. Residuals of residuals for abundance indices and catch by age.

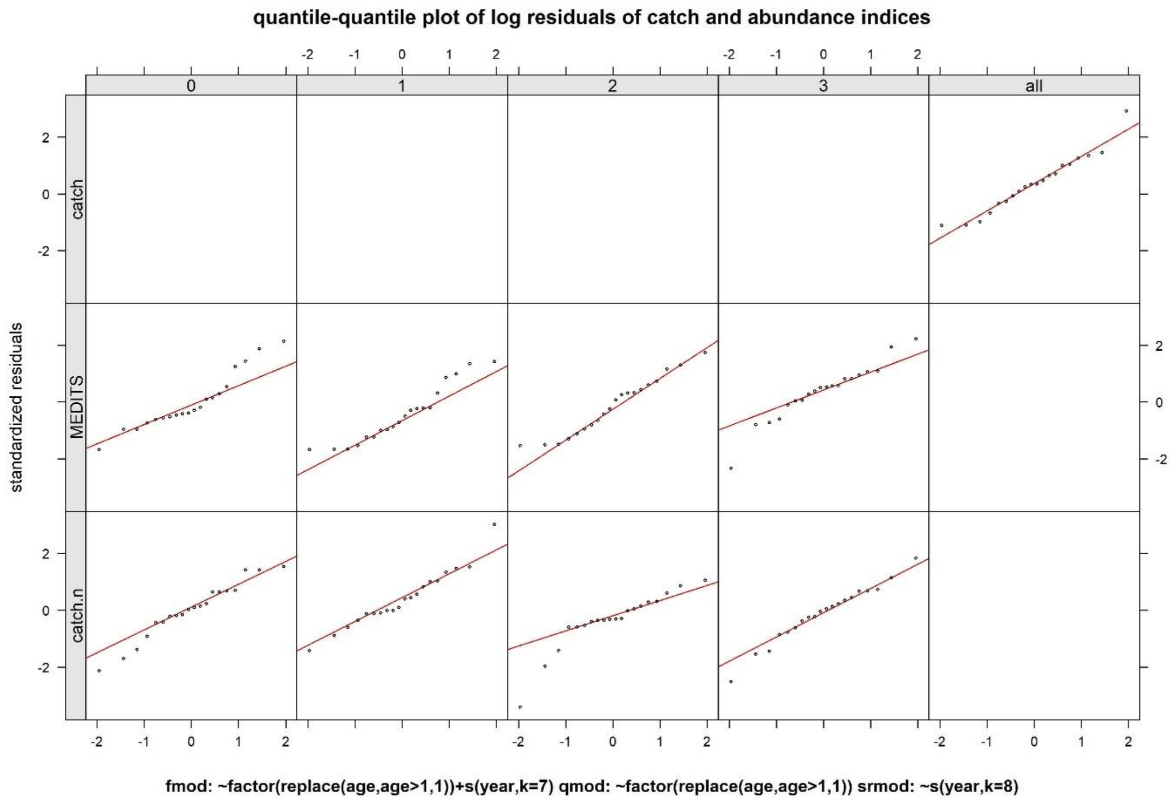


Figure 6.7.3.10. Deep-water rose shrimp stocks in GSAs 17-19. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and red lines the normal distribution quantiles.

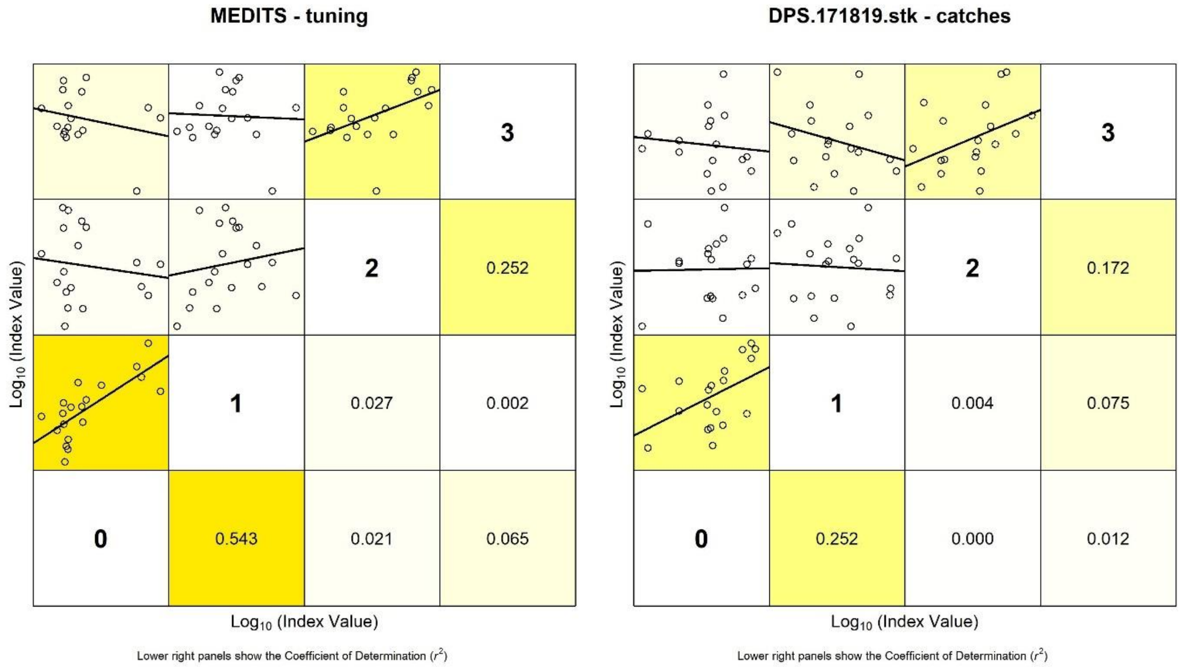


Figure 6.7.3.11. Deep-water rose shrimp stocks in GSAs 17-19. Internal consistency in tuning index and catches.

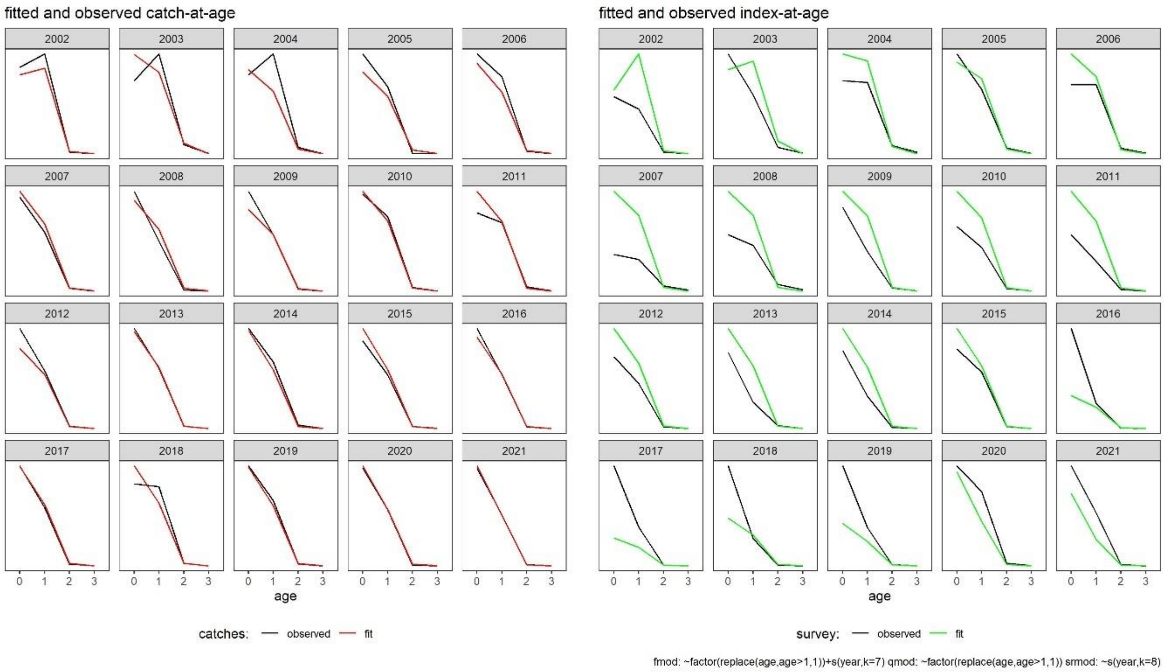


Figure 6.7.3.12. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed catch at age(left panel) and index at age (right panel).

Retrospective

The retrospective analysis applied up to 3 years back shows quite moderate stability for the models (Figure 6.7.3.14).

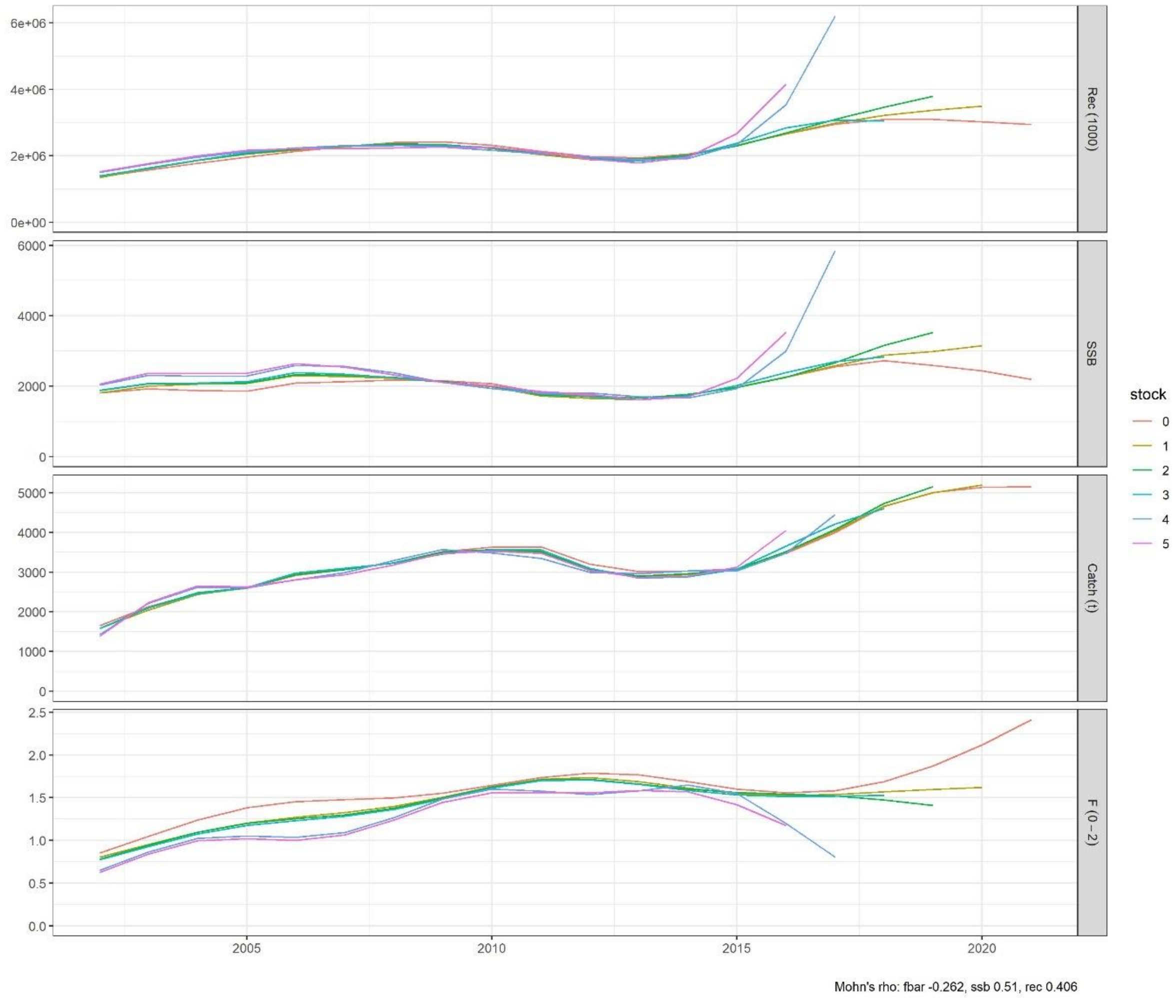


Figure 6.7.3.14. **Deep-water rose shrimp stocks in GSAs 17-19**: retrospective analysis.

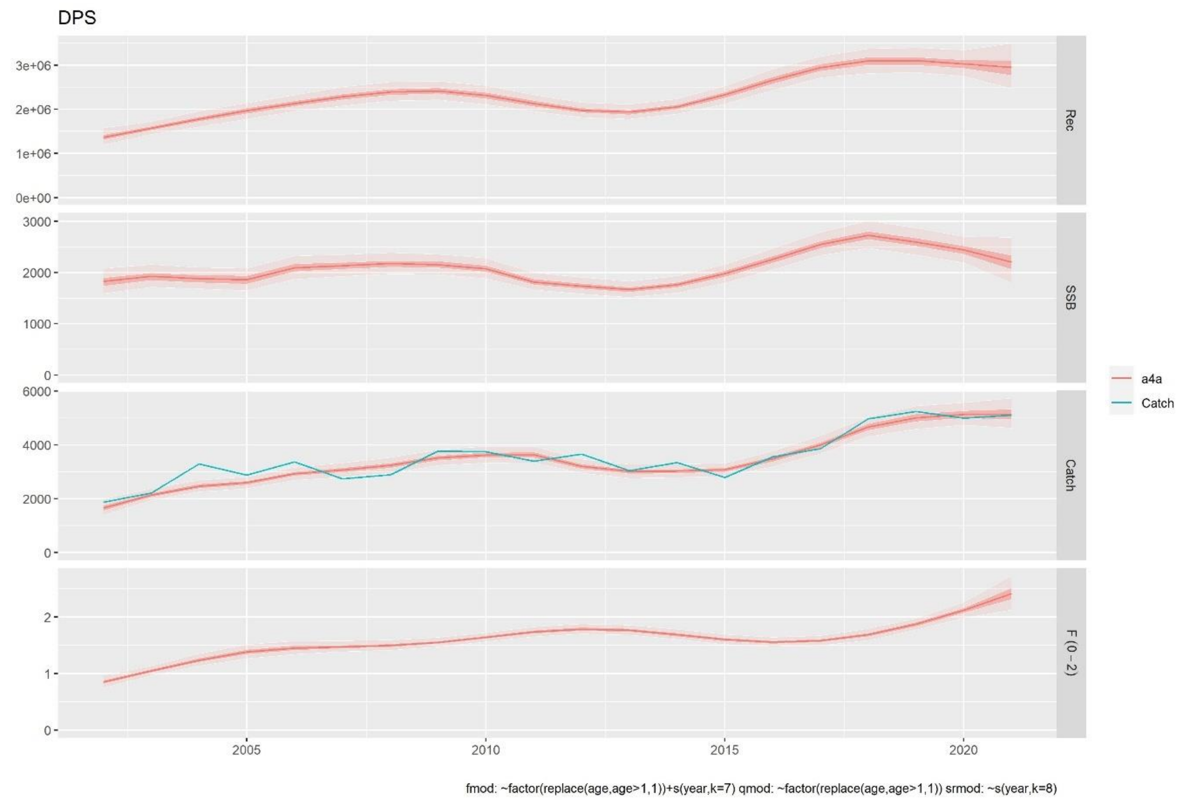


Figure 6.7.3.15. **Deep-water rose shrimp stocks in GSAs 17-19**: Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals.

Conclusions to the assessment

After an extensive sensitivity analysis of possible model configuration, small changes to the previous EWG 21-15 model have been used again this year.

Based on the assessment results, the Deep-water rose shrimp stocks in GSAs 17-19 shows SSB high fluctuated around a mean value of 2092 tons and, after an increasing trend in the number of recruits from 2014 to 2019, a sligthly decreasing pattern to a value of 2941620 thousands individuals in 2021. Fbar (0-2) fluctuated and shows a increasing trend, with a steep increase in the last two years (2.41 in 2021).

This assessment is considered acceptable. Retrospective performance is sensitive to the index data over the last few years, the variability in survey timing and survey results has resulted in greater uncertainty in terminal F than would be desirable, however, given the short timesries and only 4 ages the variability is expected. The results confirm stock exploitation status throughout as being highwith $F>F_{MSY}$ in all retrospective runs in all years. The assessmemt also shows most recent recruitment is sligthly declining from the recent very high level.

6.7.4 Reference Points

Reference points are based on equilibrium methods. The STECF EWG 21-15 confirmed the reccomendations to use $F_{0.1}$ as proxy of F_{MSY}. Reference points were estimated using the FLBRP package and given in Table 6.7.4.1

Considering the F current of 2.52 estimated for 2021, the fishing mortlity level estimated by a4a is well above the reference point $F_{0.1}$ of 0.746, and the stock resulted being overexploited.

Table 6.7.4.1 Deep-water rose shrimp stocks in GSAs 17-19: reference points.

refpt	harvest	yield	rec	ssb	biomass
$F_{0.1}$	0.746	0. 000112	1	0.00143	0. 00250

6.7.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts, and based on the results of the A4A stock assessment.

The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age. F_{bar} =2.41 as the F of last year from the a4a assessment was used for F in 2022. Recruitment (age 0) for 2022 to 2023 has been estimated from the population results as the geometric mean of the last 3 years (3022529).

Fishing at $F_{0.1}$ in 2022 leads to reduce catch of about 54.3% (Table 6.7.5.2).

Table 6.7.5.1. Deep-water rose shrimp stocks in GSAs 17-19: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological Parameters	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 0-2 (2021)	2.41	Fsq = F in the last year
SSB (2022)	2188.68	SSB intermediate year from STF output
Rage0 (2022,2023)	3022529	Recruitment will be set as geometric mean of the last 3 years
Total catch (2021)	5015.06	Catch intermediate year from STF output
Fbar (2019)	1.87	MAP base year fishing mortality from current assessment
a and b values	a=0.42, b=0.57	Regression parameters from Transition regression line

Table 6.7.5.2. Deep-water rose shrimp stocks in GSAs 17-19: Catch options.

Rationale	Ffactor	Fbar	Recruitment 2022	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB 2022	SSB 2024	SSB_change 2022-2024(%)	Catch_change 2021-2023(%)
High long term yield ($F_{0.1}$)	0.3091	0.75	3022529.0	2.41	5149.7	5015.1	2351.8	2188.7	4073.7	86.1	-54.3
F_{upper}	0.4203	1.01	3022529.0	2.41	5149.7	5015.1	2943.5	2188.7	3531.7	61.4	-42.8
F_{lower}	0.2053	0.50	3022529.0	2.41	5149.7	5015.1	1701.7	2188.7	4765.1	117.7	-67.0
F_{MSY} Transition	0.5090	1.23	3022529.0	2.41	5149.7	5015.1	3355.8	2188.7	3201.4	46.3	-34.8
Zero catch	0	0.00	3022529.0	2.41	5149.7	5015.1	0.0	2188.7	7066.1	222.8	-100.0
Status quo	1	2.41	3022529.0	2.41	5149.7	5015.1	5072.8	2188.7	2197.4	0.4	-1.5
Different Scenarios	0.1	0.24	3022529.0	2.41	5149.7	5015.1	912.3	2188.7	5743.4	162.4	-82.3
	0.2	0.48	3022529.0	2.41	5149.7	5015.1	1665.4	2188.7	4806.7	119.6	-67.7
	0.3	0.72	3022529.0	2.41	5149.7	5015.1	2299.0	2188.7	4126.0	88.5	-55.4
	0.4	0.97	3022529.0	2.41	5149.7	5015.1	2842.1	2188.7	3618.8	65.3	-44.8
	0.5	1.21	3022529.0	2.41	5149.7	5015.1	3316.1	2188.7	3231.6	47.7	-35.6
	0.6	1.45	3022529.0	2.41	5149.7	5015.1	3736.5	2188.7	2929.4	33.8	-27.4
	0.7	1.69	3022529.0	2.41	5149.7	5015.1	4114.8	2188.7	2688.7	22.8	-20.1
	0.8	1.93	3022529.0	2.41	5149.7	5015.1	4459.6	2188.7	2493.5	13.9	-13.4
	0.9	2.17	3022529.0	2.41	5149.7	5015.1	4777.4	2188.7	2332.4	6.6	-7.2
	1.1	2.66	3022529.0	2.41	5149.7	5015.1	5349.6	2188.7	2082.8	-4.8	3.9
	1.2	2.90	3022529.0	2.41	5149.7	5015.1	5610.6	2188.7	1984.2	-9.3	8.9
	1.3	3.14	3022529.0	2.41	5149.7	5015.1	5857.9	2188.7	1898.3	-13.3	13.8
	1.4	3.38	3022529.0	2.41	5149.7	5015.1	6093.1	2188.7	1822.5	-16.7	18.3
	1.5	3.62	3022529.0	2.41	5149.7	5015.1	6317.8	2188.7	1755.0	-19.8	22.7
	1.6	3.86	3022529.0	2.41	5149.7	5015.1	6532.8	2188.7	1694.3	-22.6	26.9
	1.7	4.10	3022529.0	2.41	5149.7	5015.1	6739.1	2188.7	1639.0	-25.1	30.9
	1.8	4.34	3022529.0	2.41	5149.7	5015.1	6937.5	2188.7	1588.4	-27.4	34.7
	1.9	4.59	3022529.0	2.41	5149.7	5015.1	7128.5	2188.7	1541.5	-29.6	38.4
	2	4.83	3022529.0	2.41	5149.7	5015.1	7312.6	2188.7	1497.8	-31.6	42.0

6.7.6 DATA DEFICIENCIES

The data used for the analyses come from the last EU DCF official Data Call (2021). The update of data related to non-EU countries was provided during the meeting. For Albania five years (from 2017 to 2021) of length data was available, but seems to be cutted at length size of 19 mm ant then missing for younger specimens. For Montenegro no catch data were provided to EWG 22-16. Landings LFDs from GSA19 and GSA18 (Italy) were available from 2002. In GSA18 LFDs were missing in 2006 and 2008 for italy and in most of the years for non-EU countries. Regarding GSA17, LFDs from Italy were available continuously from from 2013 for Italy and from 2014 for Croatia. For Italy (both GSA17 and 18), the time period of the survey has changed in some last years.

As regards the catch information, from different sources are not equal. In particulary in the database "catches.csv" no data on DPS are available for Italy in GSA 17, while they are present in both landings.csv and discard.csv database. Moreover total landing in some years also differ from quantities reported in FDI.

6.8 GIANT RED SHRIMP IN GSA S 18 ,19 AND 20

6.8.1 STOCK IDENTITY AND BIOLOGY

STECF EWG 22-16 was asked to assess the state of giant red shrimp *Aristaeomorpha foliacea* (Risso, 1827) in the GSAs 18, 19 and 20. A preparatory work aimed to explore data quality and biological parameters was done by STECF EWG 22-03 (STECF, 2022).

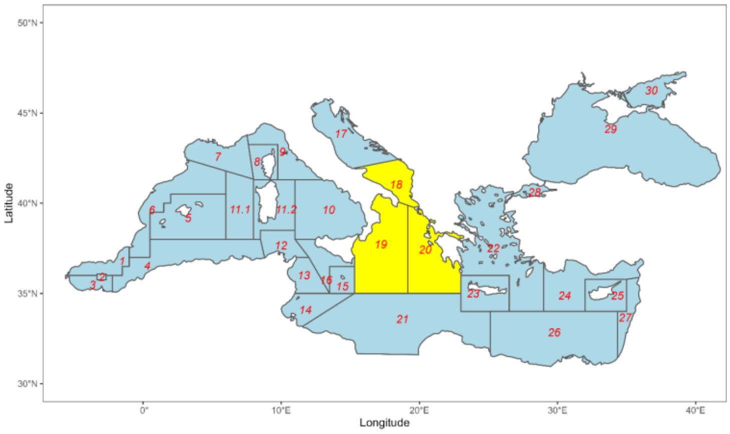


Figure 6.8.1.1. Geographical location of the GSA 18, GSA 19 and GSA 20

The Giant red shrimp *Aristaeomorpha foliacea* (Risso, 1827) is mainly found in the epibathyal and mesobathyal waters of the Mediterranean. *Aristeomorpha foliacea* is a large-sized decapod crustacean with a scarlet red coloured, firm though flexible and light exoskeleton and black eyes. In mature females the dorsal part of the abdomen is darker due to the black colour of the mature ovaries. Adult females are larger and have a longer rostrum, which extends far beyond the antennal scale. In males the rostrum is short and does not exceed the tip of the antennular peduncle. The giant red shrimp *Aristaeomorpha foliacea* has a wide geographic distribution. In the Mediterranean Sea the distribution of giant red shrimp is patchy in nature, with the highest abundances found in the central-eastern basins (Politou *et al.*, 2004). The assessment on giant red shrimp carried out during the STECF EWG 22-16 considered the stock confined within the boundaries of GSAs 18, 19 and 20 (Figure 6.8.1.1). Growth and length-weight parameters used in EWG 22-16 were ones explored and agreed on EWG 22-03: the growth parameters for the Giant red shrimp were provided through the DCF and they were common for GSAs 18 and 19. For GSA 20 no growth parameters were provided and the EWG decided to use the ones from GSA 18 and 19. The growth parameters were provided by sex and it was noted that these species exhibit a strong sexual dimorphism. Giant red shrimp spawns during the summer (June – July), thus it was decided to add a correction of 0.5 to the t_0. Note that table 6.8.1.1 reports t_0 before the correction, thus values used in length slicing for the assessment was 0.4. The value used for natural mortality calculations is in the table below

Table 6.8.1.1 Giant red shrimp in GSA 18-20. Growth parameters from DCF data

Source	Sex	L_{inf}	k	t_0 *	a	b
STECF 22-03	M	53	0.36	-0.1	0.00089	2.78
	F	74	0.438	-0.1	0.0013	2.63

* Before the t_0 correction

Regarding maturity, the young of the year recruiting in spring are immature, with only a few individuals reproducing during their first year. Gonadic development begins in winter and individuals become sexually mature in the second summer (Bianchini, 1999; Politou *et al.*, 2004). Once they have reached maturity male giant red shrimp have a protracted reproductive capacity and are ready to mate throughout the year, whilst females mature seasonally (Bianchini, 1999; Perdichizzi *et al.*, 2012). *A. foliacea* gather in shoals during the mating and spawning season (Bianchini, 1999), however only very limited information on the location of such spawning areas is available. From literature is known that the mature population rise out of the canyons to spawn on the upper slope. After the mating peak, the population goes back to the deeper grounds (D'Onghia *et al.*, 1998). Maturity vector were available for GSAs 18 (table 6.8.1.2) and 19 (table 6.8.1.3) as sex separated, suggesting most of the specimens were mature after second year of life. The natural mortality vectors by sex, computed using Chen & Watanabe formula based on the same VBGP reported above, are presented in Tables 6.8.1.4.

Table 6.8.1.2. Giant red shrimp in GSA 18-20. Maturity at age vectors from GSA 18 used in the assessment.

Maturity	**0**	**1**	**2**	**3**	**4**	**5**
Males	0.00	0.60	1.00	1.00	1	1
Females	0.00	0.09	0.90	1.00	1	1

Table 6.8.1.3. Giant red shrimp in GSA 18-20. Maturity at age vectors from GSA 19 used in the assessment.

Maturity	**0**	**1**	**2**	**3**	**4**	**5**
Males	0	0.35	0.97	1	1	1
Females	0	0.14	0.83	1	1	1

Table 6.8.1.4. Giant red shrimp in GSA 18-20. Natural mortality at age vectors from used in the assessment.

Natural Mortality	**0**	**1**	**2**	**3**	**4**	**5**
Males	1.85	0.82	0.59	0.50	0.44	0.42
Females	1.90	0.87	0.64	0.55	0.51	0.48

6.8.2 Data

6.8.2.1 Catch (landings and discards)

Catch data explored during EWG 22-03 were compared to data reported to STECF EWG 22-16 through the DCF. Only some small differences were noted from GSA 20. GSA 20 catches, which are not big amount in relationship with other areas, was updated assuming DCF updated values and SOP was applied effectively applying LFD from 18/19 to the small additional landings from GSA 20.

In GSAs 18, 19 and 20 the main fleet targeting the Giant red shrimp is the bottom otter trawl (OTB). A few tons were coming from the Maltese fleet. A negligible amount of landings (< 0.5% in 2021) were coming from other gears, mostly nets.

Landings

Landings data by year, GSA, country and fleet are presented in Figures 6.8.2.1.1-3, total landings by year, country and GSA are presented in Table 6.8.2.1. In all GSAs most of the landings come from otter trawls. The metiér level was not homogeneously filled: although it is expected that metier targeting Giant red shrimp is DWS, data were sporadically assigned to this metier. This issue made the calculation of fishing days potentially inaccurate. DCF data coming from other gear were considered inaccurate or sampled inconsistently; anyway, their catches were included in the stock assessment due to the low amounts.

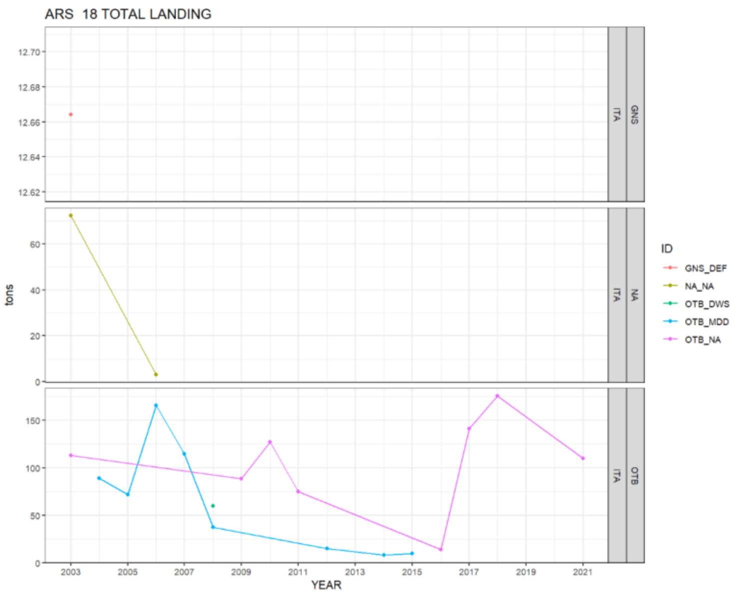


Figure 6.8.2.1.1. Giant red shrimp in GSA 18-20. Landings data in tonnes by year, area country and fleet for in GSA 18.

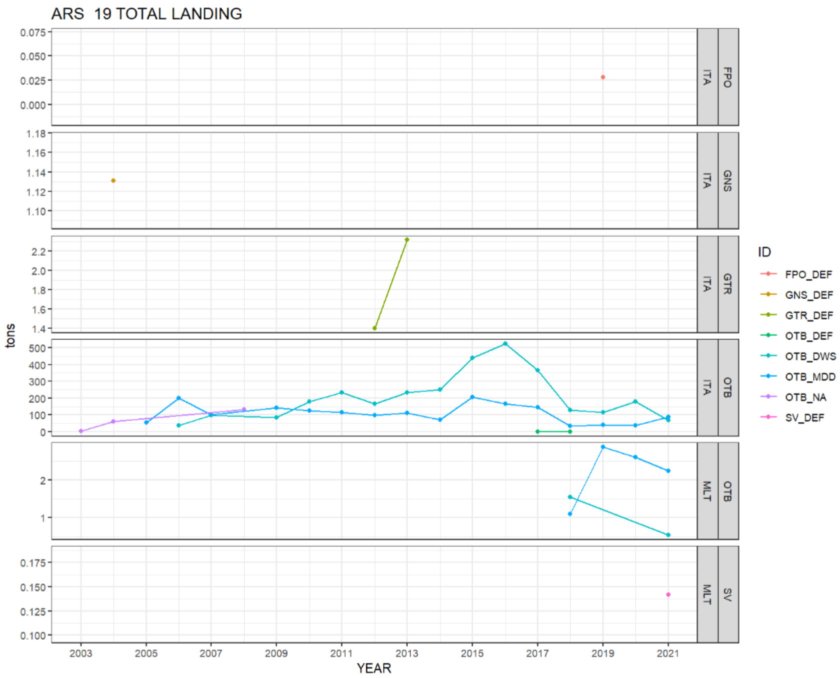


Figure 6.8.2.1.2. Giant red shrimp in GSA 18-20. Landings data in tonnes by year, area country and fleet for in GSA 19.

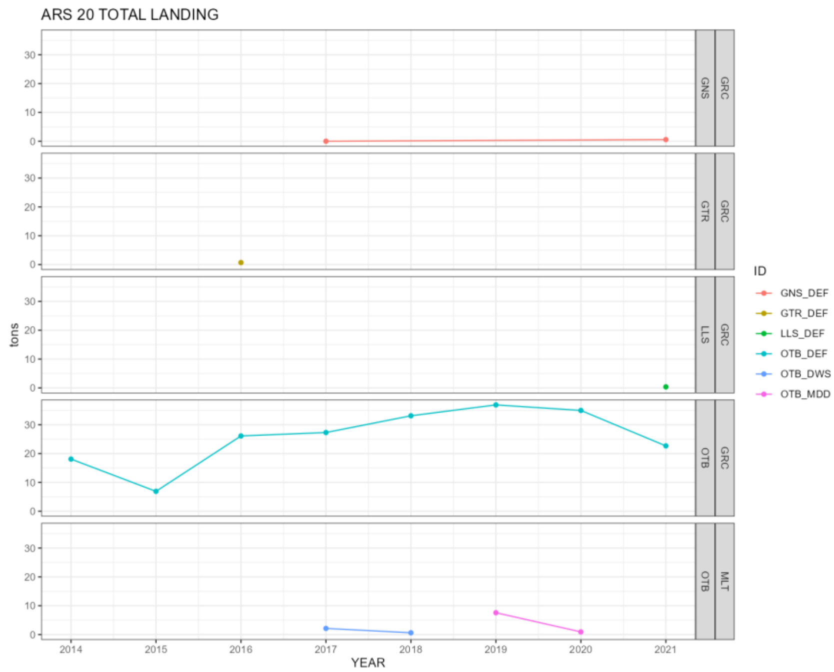


Figure 6.8.2.1.3. Giant red shrimp in GSA 18-20. Landings data in tonnes by year, area country and fleet for in GSA 20.

Table 6.8.2.1. Giant red shrimp in GSA 18-20. Landings by country and GSA.

Year	ITALY GSA18	ITALY GSA19	GREECE GSA20	MALTA GSA20	MALTA GSA19	Total landings
2003	198	4	0	0	0	202
2004	89	63	0	0	0	152
2005	72	55	0	0	0	127
2006	169	236	0	0	0	405
2007	115	199	0	0	0	313
2008	97	133	0	0	0	229
2009	88	226	0	0	0	314
2010	127	301	0	0	0	429
2011	75	347	0	0	0	422
2012	15	262	0	0	0	277
2013	15	349	0	0	0	363
2014	8	320	18	0	0	346
2015	9	646	7	0	0	662
2016	14	690	27	0	0	731
2017	141	509	27	2	0	680
2018	176	162	33	1	3	374
2019	106	157	37	8	3	310
2020	133	218	35	1	3	390
2021	110	155	24	0	3	292

Length frequency distributions of the landings were available only from Italian fleet. For GSA 18, in EWG 22-03 the missing years were from 2003 to 2008, for GSA 19 from 2005 – 2007 and there was no information for length frequency distribution for GSA 20. For the needs of stock assessment, it was decided to use the LFD from GSA 19 for the years 2003, 2004 and 2008 for all the areas, while for the common missing years 2005 – 2007, no reconstruction was decided (Figures 5.12.4.4 – 5.12.4.6). In EWG 22-16 LFDs for GSA 18 were also not available for the years 2013, 2019 and 2020, which were retrieved from EWG 22-03 (data not shown in this report). Length frequency distribution of landings by year, GSA and fleet from the DCF database provided to EWG 22-16 are presented in Figures 6.8.2.1.4-5.

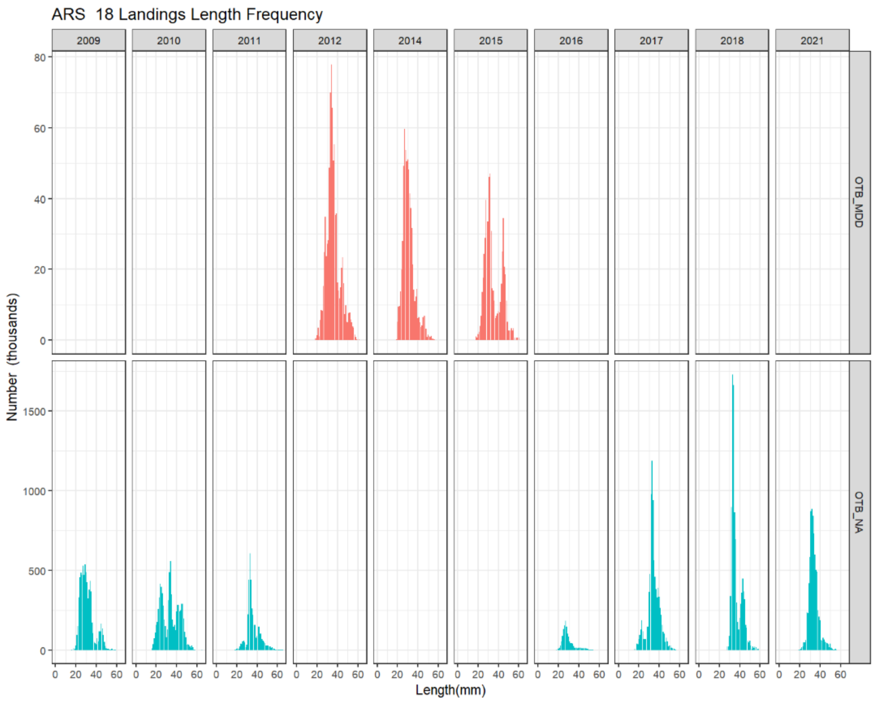


Figure 6.8.2.1.4. Giant red shrimp in GSA 18-20. Length frequency distribution of the landings by year and fleet for Italy in GSA 18.

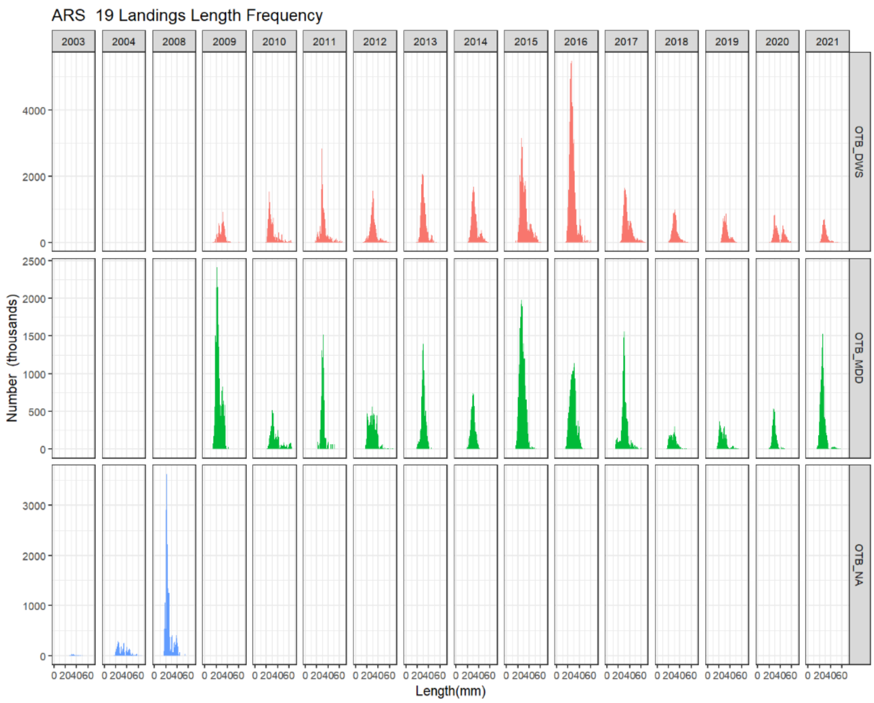


Figure 6.8.2.1.5. Giant red shrimp in GSA 18-20. Length frequency distribution of the landings by year and fleet for Italy in GSA 19.

Discards

Very few and sparse information on discards was available from DCF. As from EWG 22-03, EWG 22-16 decided that the discards for this species can be considered negligible and will not be used for the purposes of an assessment.

Catch share by GSA

Catch share of GSA 18 was quantified by dividing the total catches by the amount reported for GSA 18. From the Figure 6.8.2.1.6 emerges that the share of GSA 18 was oscillating along the years, moving from near 0% to almost 50% from 2016 to 2018. EWG 22-16 argued that a potential issue of misreporting was on-going. In particular, it was supposed that vessels where not reporting landings by GSA homogeneously along the time series. This may be due to reporting catches to port rather than area of catch. Considering that in this area it is known that vessels may move among different GSAs, EWG 22-16 considered the catch share estimation not reliable. It should be noted that if area misreporting is occurring then this does not influence a combined area assessment such as the one documented below.

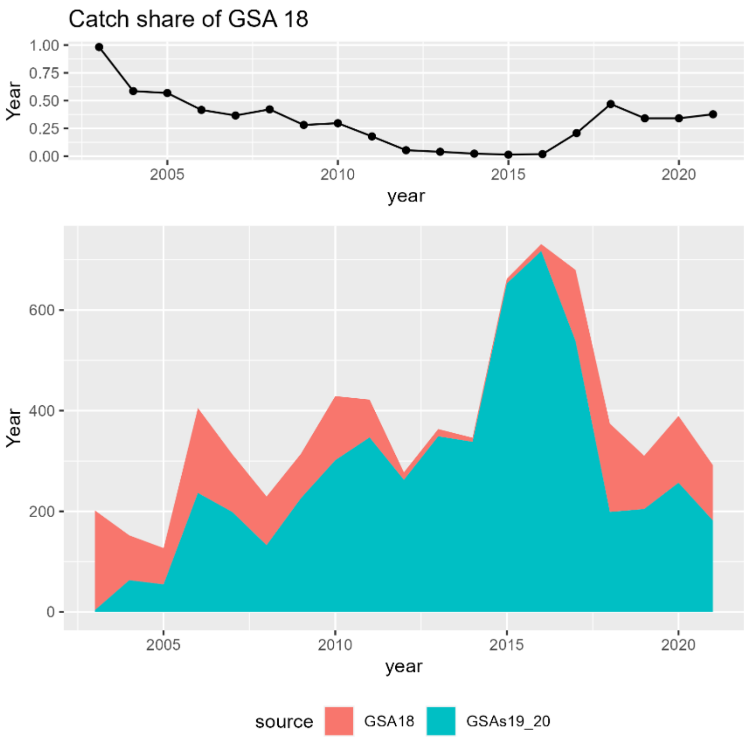


Figure 6.8.2.1.6. Giant red shrimp in GSA 18-20. Catch share by GSA 18.

6.8.2.2 Effort

The effort analysis was carried out by STECF EWG 22-16. The fleet targeting ARS is supposed to be the "Deep Water Shrimp", DWS, which is represented by a limited number of vessels. Considering that the numbers of the other bottom trawlers fleets are not representative of the effort targeting deep water shrimps, in the table 6.8.2.2.1 only DWS fishing days are reported. Data for the Greek fleet are absent and the time series is restricted to a limited number of years, suggesting caution when using these data to attempt calculating catches per unit of effort.

Table 6.8.2.2.1. Giant red shrimp in GSA 18-20. Effort in Fishing Days for Italian and Maltese OTB, metier DWS, by GSA.

Year	Italy GSA18	Italy GSA19	Malta GSA19	Malta GSA20	Total
2013		11283			11283
2014		13376			13376
2015		14622	25		14647
2016	65	21177			21242
2017	331	10443	10	36	10820
2018	2842	10699	10	3	13554
2019	1188	9507			10695
2020	1494	6501			7995
2021	590	4100	8		4698

6.8.2.3 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 place 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. The same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end, is used throughout GSAs and years. The timing of the survey is shown in Figure 6.8.2.3.1. According to the MEDITS handbook procedures and what it is stated in MS EU-MAPs the period in which the survey should be carried out was not always respected: in 2014 the survey was carried out in September and in 2017 and 2020 in November-December. The survey coverage was heterogeneous along the time series, since in GSA 20 the survey was missing in the years 2007, 2009 – 2013, 2015 and 2017. The lack of coverage for GSA 20 was considered a relevant issue since in this area are located hauls where high abundance is usually found (6.8.2.3.2). EWG 22-03 addressed the issue of the heterogeneous coverage, comparing the index calculated on GSAs 18 and 19 with the one covering GSAs 18-20 (6.8.2.3.3), and highlighting that including GSA 20 was determining a general increase of the survey index. EWG 22-16 continued to explore the possible bias introduced by the lack of coverage by checking sensitivity of the stock assessment model considering two separate indices: one for GSAs 18 and 19 combined and one for GSA 20. The alternate index approach did not cause a significant difference in the model fitting probably due to the few data points provided by the GSA 20 index on its own. As a result, EWG 22-16 agreed on using a combined index for GSAs 18-20, including all countries (Albania, Montenegro, Italy and Greece). Data were analysed using the JRC script.

Figure 6.8.2.3.1. Giant red shrimp in GSA 18-20. survey periods for GSA 18-19

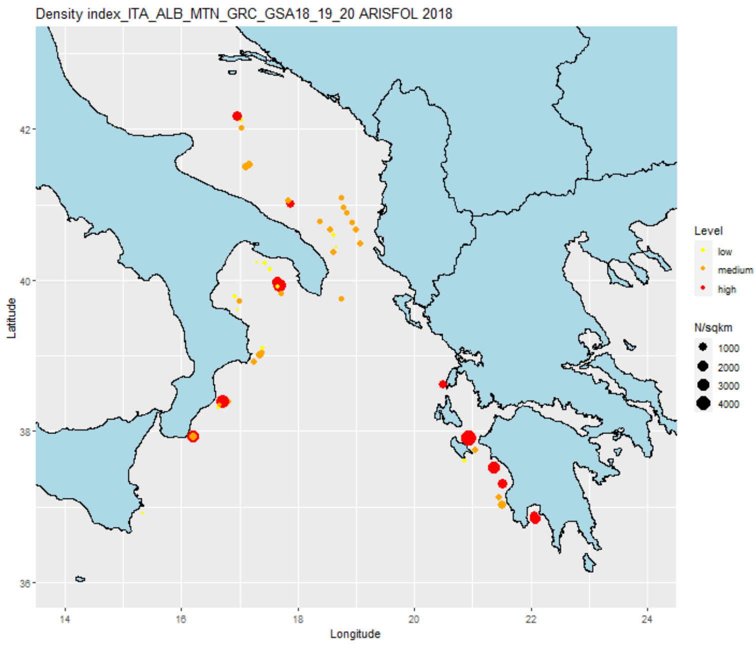


Figure 6.8.2.3.2. Giant red shrimp in GSA 18-20. Density index by haul in a year when the coverage was complete. Note the high values observed in GSA 20.

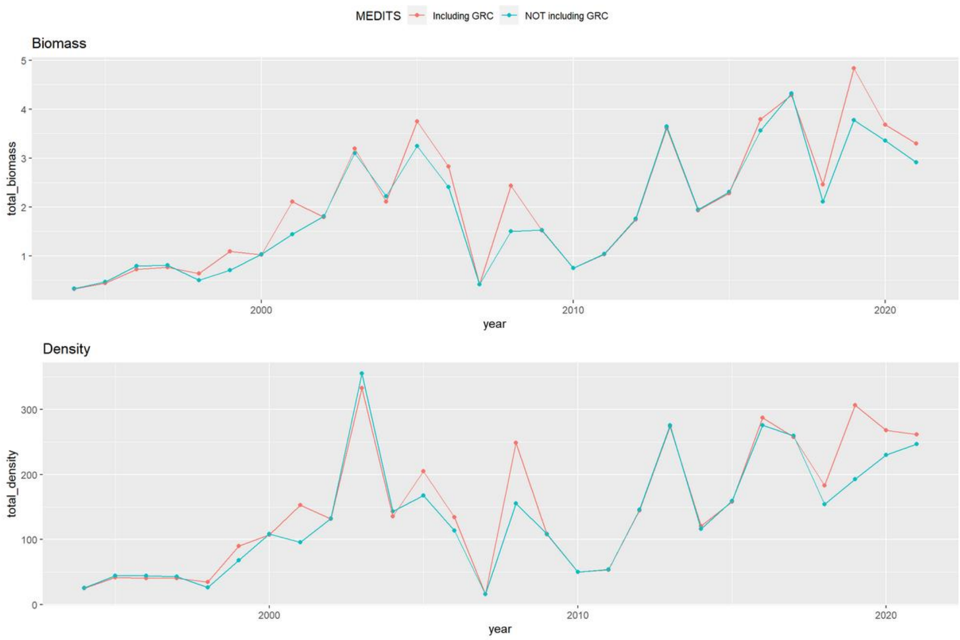


Figure 6.8.2.3.3. Giant red shrimp in GSA 18-20. Density and biomass index when including (Including GRC) and excluding (NOT including GRC) GSA 20 from the Index computation.

Both biomass and density index (Figures 6.8.2.3.4-5) were suggesting a generally increasing trend, while oscillating between high and low peaks, with low values especially found in the years 2007 and 2010-2011. The year 2007 was considered not representative of the stock and was excluded by the present stock assessment. Length frequency distributions for male, female and sex combined are shown in Figures 6.8.2.3.6-8.

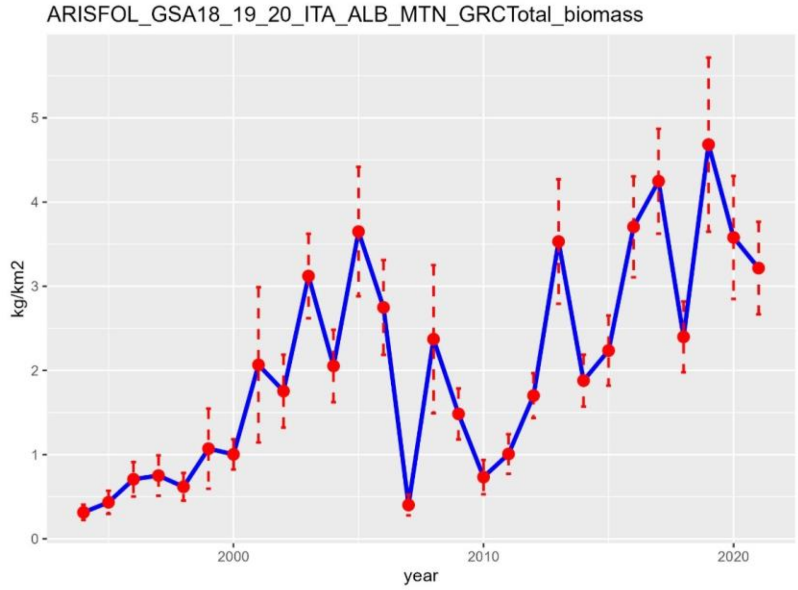


Figure 6.8.2.3.4. Giant red shrimp in GSA 18-20. Estimated biomass indices from the MEDITS survey (kg/km^2).

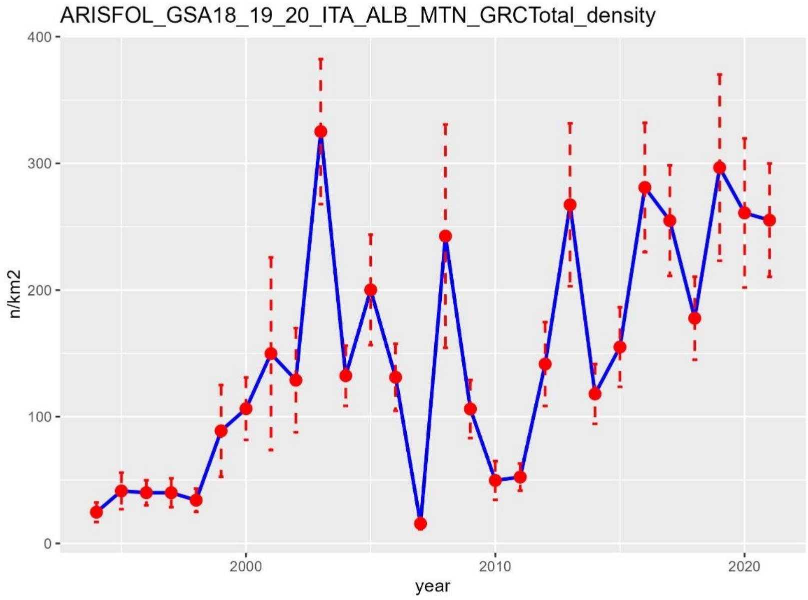


Figure 6.8.2.3.5. Giant red shrimp in GSA 18-20. Estimated density indices from the MEDITS survey (kg/km^2).

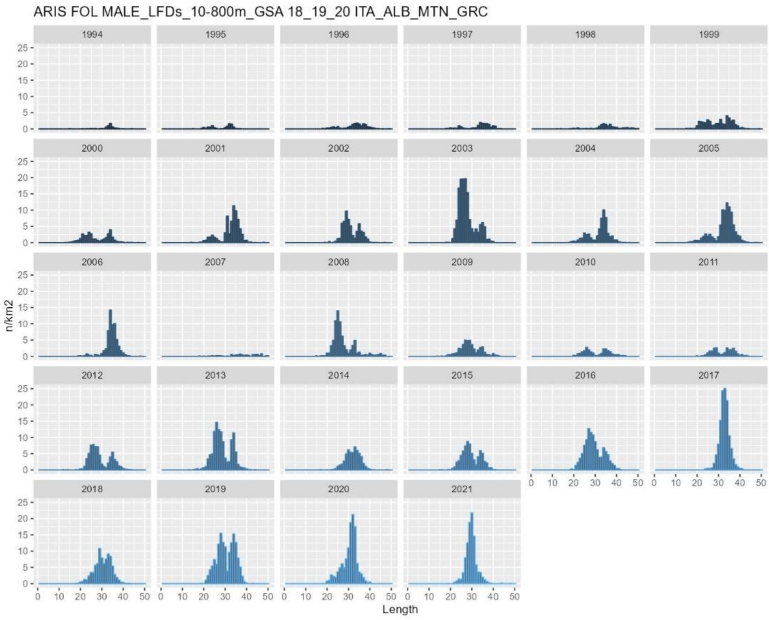


Figure 6.8.2.3.6. Giant red shrimp in GSA 18-20. Length frequency distribution by year for males of MEDITS survey.

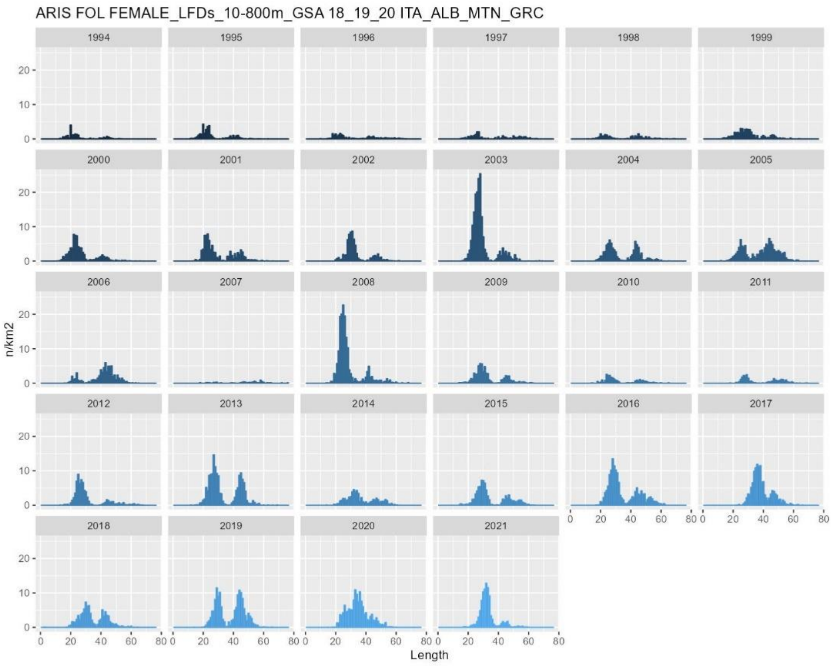


Figure 6.8.2.3.7. Giant red shrimp in GSA 18-20. Length frequency distribution by year for females of MEDITS survey.

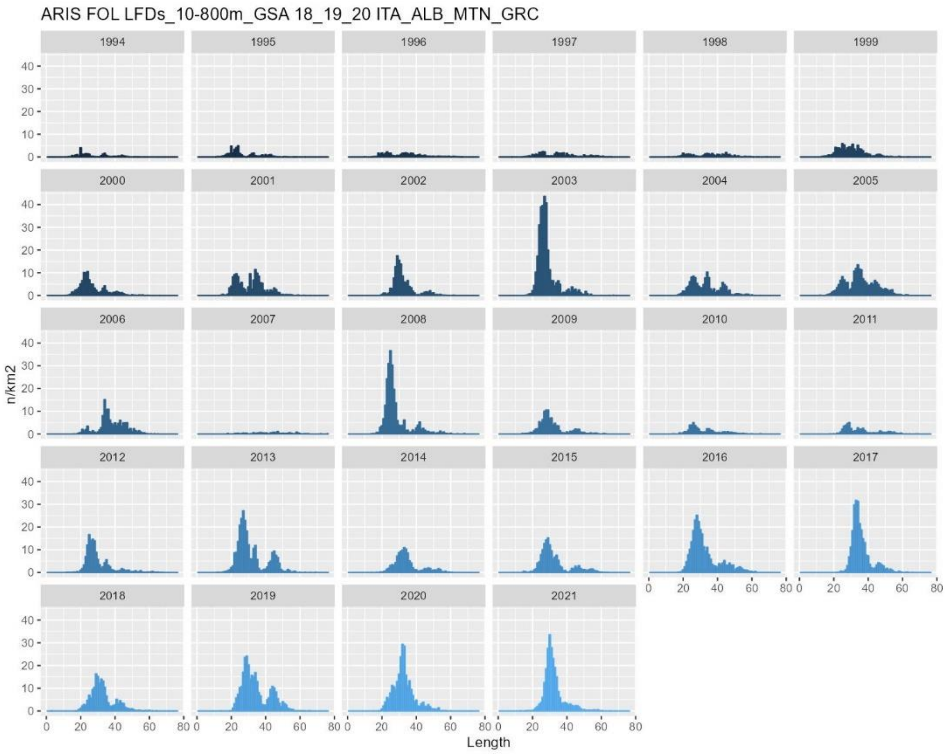


Figure 6.8.2.3.8. Giant red shrimp in GSA 18-20. Length frequency distribution by year for sex combined of MEDITS survey.

6.8.3 STOCK ASSESSMENT

The stock in GSA 18, 19 & 20 was previously assessed by EWG 21-15 (STECF, 2021) based on survey indicators. A statistical catch-at-age assessment was carried out for this stock by EWG 22-16, using the Assessment for All Initiative (a4a) method (Jardim *et al.*, 2014). The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike XSA, model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error.

The model was fitted using as input data the period 2003-2021 for the catch data (landings) and the tuning index.

Both catch numbers at length and index number at length were sliced by sex and GSA using the a4a age slicing routine in FLR, using for each GSA the same sex-specific growth parameters. Catch at age by sex was obtained by splitting commercial total length distribution according to a sex-ratio vector model obtained from DCF available sex ratio vectors in the respective areas. The analyses were carried out for the ages 1 to 5+. Concerning the Fbar, the age range used was 1-3.

Input data

The growth parameters used for VBGF are reported in table 6.8.1.1.

Total catches and catch numbers at age were used as input data. Catch numbers for 2007 for the MEDITS survey were removed from the input data due to the unrealistic low values of the LFDs for that year. SOP correction + raising were applied to catch numbers at age. Table 6.8.3.1-2 presents the SOP correction + raising vector applied for GSAs 18, 19. Table 6.8.3.1-2 presents the SOP correction + when adding GSA 20 landings. The high values from 2003 to 2008 in GSA 18 and 2005 to 2007 in GSA 19 are due to the raising applied because of missing length frequency distributions in the catches of those years.

Table 6.8.3.1. Giant red shrimp in GSA 18-20. SOP correction + raising vector in GSA 18.

Year	SOP
2003	71.59
2004	32.23
2005	26.06
2006	61.00
2007	41.53
2008	34.95
2009	0.96
2010	1.00
2011	1.05
2012	1.02
2013	1.04
2014	1.01
2015	0.96
2016	0.97
2017	1.01
2018	1.00
2019	1.05
2020	0.97
2021	0.93

Table 6.8.3.2. Giant red shrimp in GSA 18-20. SOP correction + raising vector in GSA 19.

Year	SOP
2003	0.99
2004	1.05
2005	32.37
2006	139.86
2007	117.46
2008	1.01
2009	0.95
2010	1.06
2011	1.06
2012	0.99
2013	1.02

2014	1.05
2015	0.98
2016	1.04
2017	1.02
2018	1.03
2019	1.05
2020	1.01
2021	1.04

Table 6.8.3.3. Giant red shrimp in GSA 18-20. SOP correction + raising vector when adding GSA 20 data.

Year	SOP
2003	1.00
2004	1.00
2005	1.00
2006	1.00
2007	1.00
2008	1.00
2009	1.00
2010	1.00
2011	1.00
2012	1.00
2013	1.00
2014	1.06
2015	1.01
2016	1.04
2017	1.05
2018	1.10
2019	1.17
2020	1.10
2021	1.09

Table 6.8.3.4 lists the input data for the a4a model, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age, Proportion of M and F before spawning, and the tuning series at age. Data suggested that most of the specimens were of age 1 or 2 with an increased presence of age 4 in some of the years. The mean weight of the ages varied slightly over the years.

Table 6.8.3.4. Giant red shrimp in GSA 18-20. Input data for the a4a model.

Catch numbers-at-age matrix (thousands)

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	4279.2	3450.7	3336.5	11402.4	9009.4	15121.9	20116.7	10395.5	12672.6	10135.3
2	5256.8	4105.2	2889.6	8739.9	6635.7	7538.8	10336.6	12064.9	10059.7	7799.0
3	3008.0	1840.5	1994.0	6487.8	5048.6	1852.9	3453.0	3723.6	5686.0	3093.1
4	416.3	306.2	232.2	706.9	537.9	405.7	153.5	924.2	483.9	334.5
5	58.7	44.8	35.1	109.9	84.4	30.4	24.7	382.1	138.5	43.5

age	2013	2014	2015	2016	2017	2018	2019	2020	2021	
1	12931.1	11029.3	25444.1	38544.6	14971.5	9273.5	8707.9	7833.4	12287.0	
2	11253.5	10391.7	22826.6	30084.5	15143.7	8289.0	8407.2	10833.5	10516.9	
3	4022.6	3803.1	6184.6	5233.4	8960.9	6347.1	3705.0	4689.0	3558.1	
4	261.9	173.0	473.8	607.1	1360.3	511.9	303.1	447.9	295.5	
5	20.5	23.7	56.3	43.8	238.9	105.7	77.6	53.8	20.5	

Weights-at-age (kg)

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.010	0.010	0.009	0.009	0.009	0.006	0.007	0.009	0.011	0.009
2	0.017	0.017	0.018	0.018	0.018	0.013	0.011	0.016	0.015	0.014
3	0.018	0.020	0.018	0.018	0.018	0.018	0.016	0.022	0.019	0.020
4	0.025	0.030	0.028	0.029	0.029	0.024	0.029	0.041	0.035	0.031
5	0.054	0.054	0.057	0.058	0.058	0.053	0.033	0.067	0.063	0.063

age	2013	2014	2015	2016	2017	2018	2019	2020	2021	
1	0.011	0.011	0.009	0.008	0.011	0.011	0.009	0.011	0.008	
2	0.014	0.015	0.013	0.011	0.018	0.018	0.017	0.018	0.011	
3	0.016	0.019	0.021	0.018	0.019	0.017	0.020	0.021	0.018	
4	0.024	0.024	0.028	0.031	0.035	0.027	0.027	0.029	0.025	
5	0.034	0.033	0.039	0.037	0.062	0.037	0.033	0.037	0.033	

Maturity

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.60	0.49	0.46	0.43	0.42	0.38	0.38	0.41	0.37	0.35
2	1.00	0.99	0.99	0.98	0.98	0.98	0.98	0.98	0.97	0.97
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2013	2014	2015	2016	2017	2018	2019	2020	2021	
1	0.35	0.35	0.35	0.35	0.39	0.42	0.40	0.44	0.40	
2	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Natural mortality

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.87	0.87	0.86	0.86	0.86	0.86	0.86	0.87	0.87	0.87
2	0.62	0.62	0.62	0.62	0.62	0.61	0.60	0.61	0.61	0.61
3	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.50	0.50

4	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.47	0.46	0.46
5	0.45	0.45	0.45	0.45	0.45	0.45	0.42	0.47	0.46	0.46
age	2013	2014	2015	2016	2017	2018	2019	2020	2021	
1	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	
2	0.61	0.61	0.61	0.60	0.62	0.62	0.62	0.62	0.60	
3	0.50	0.50	0.51	0.50	0.50	0.50	0.50	0.51	0.50	
4	0.45	0.45	0.45	0.46	0.46	0.45	0.45	0.45	0.45	
5	0.42	0.42	0.43	0.42	0.46	0.42	0.42	0.42	0.42	

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
age	2013	2014	2015	2016	2017	2018	2019	2020	2021	
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	

Proportion of M and F before spawning vectors

MEDITS number (n/km^2) at age

age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	159.65	45.73	46.63	15.49	NA	144.53	47.53	17.74	13.98	59.52
2	134.51	43.01	69.77	50.02	NA	74.96	41.82	17.55	16.87	54.04
3	28.64	38.50	72.43	58.37	NA	16.03	13.38	11.12	16.98	21.58
4	1.95	4.88	10.02	6.90	NA	3.37	2.77	2.63	4.09	4.61
5	0.22	0.23	0.64	0.32	NA	2.75	0.11	0.51	0.46	0.85
age	2013	2014	2015	2016	2017	2018	2019	2020	2021	
1	100.22	37.45	56.33	100.13	55.09	58.43	70.21	96.57	90.99	
2	126.85	40.45	63.59	110.50	94.64	77.08	145.76	103.98	116.82	
3	36.59	37.42	31.02	40.50	98.72	38.16	76.81	58.03	35.46	
4	2.05	2.46	2.82	6.54	4.44	2.87	3.57	1.84	3.33	
5	0.40	0.10	0.11	0.04	0.28	0.13	0.19	0.02	0.30	

Figures 6.13.3.1-5 show the age structure of the catches, of the index, the weight at age matrix and the catch at age and MEDITS cohort consistency. Mean weight at age was inspected because of large oscillation in age 5, and it was concluded that it was the effect of sporadic catches of large individuals in the plus group. Cohort consistency was good in the younger ages in the catches while it was poor in the MEDITS survey.

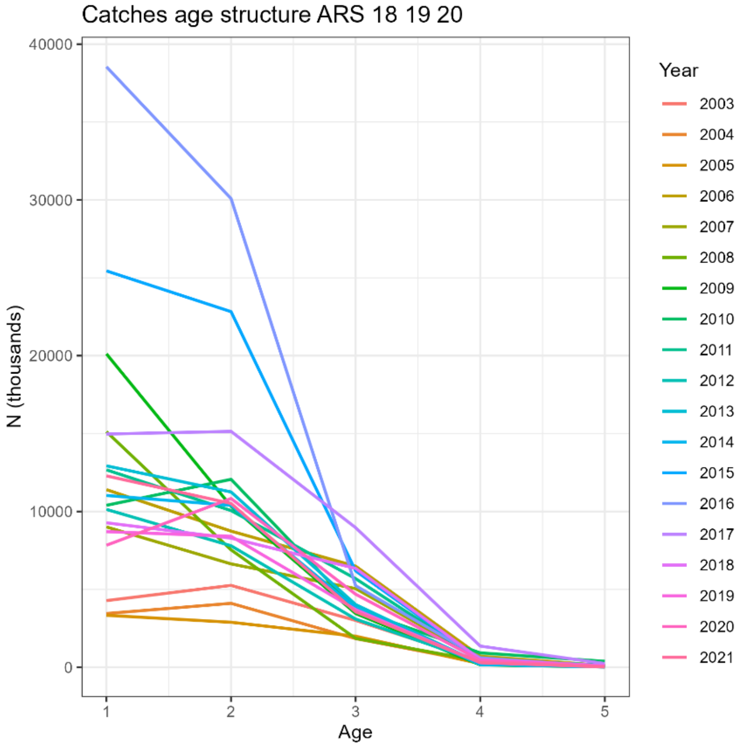


Figure 6.8.3.1. Giant red shrimp in GSA 18-20. Catch numbers for stock

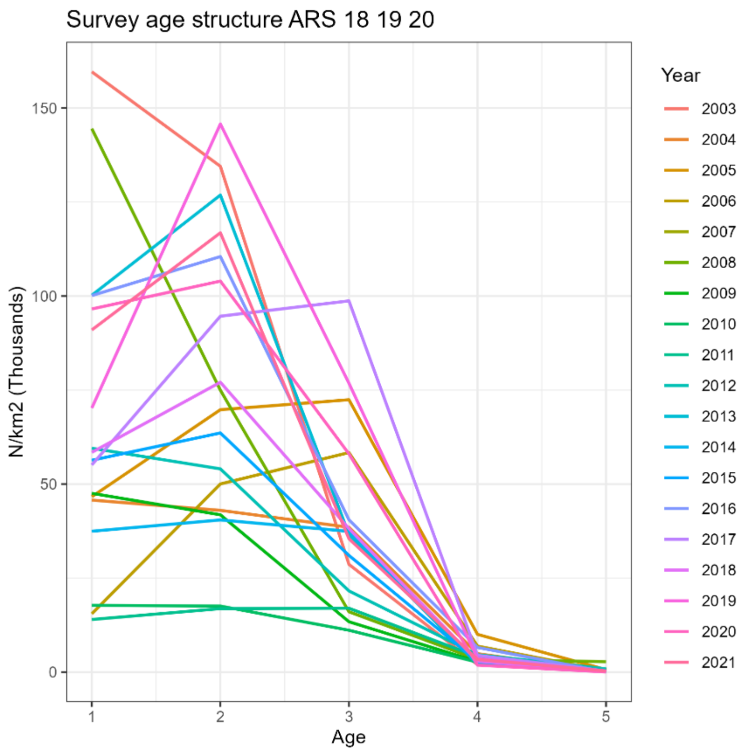


Figure 6.8.3.2. Giant red shrimp in GSA 18-20. Catch numbers for index

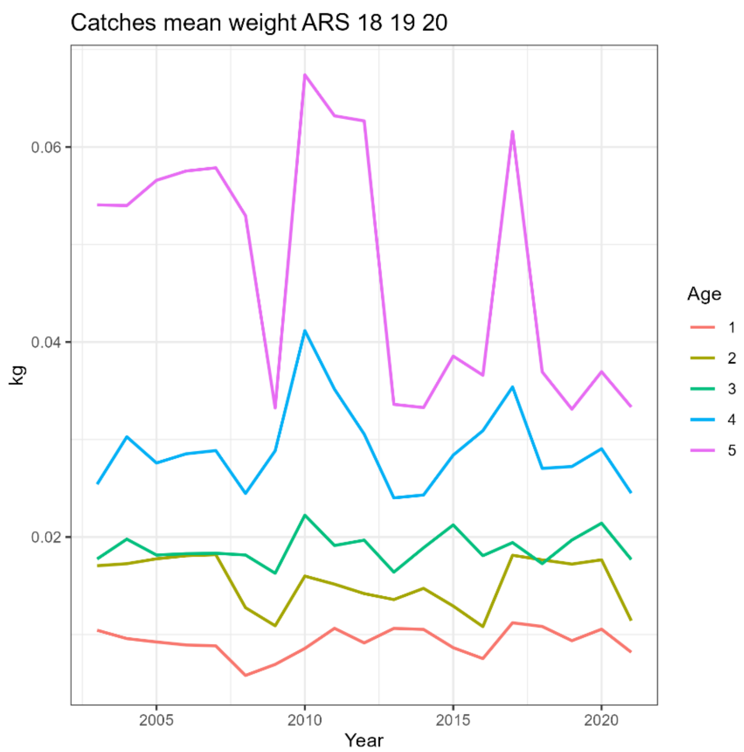


Figure 6.8.3.3. Giant red shrimp in GSA 18-20. Weight at age for stock

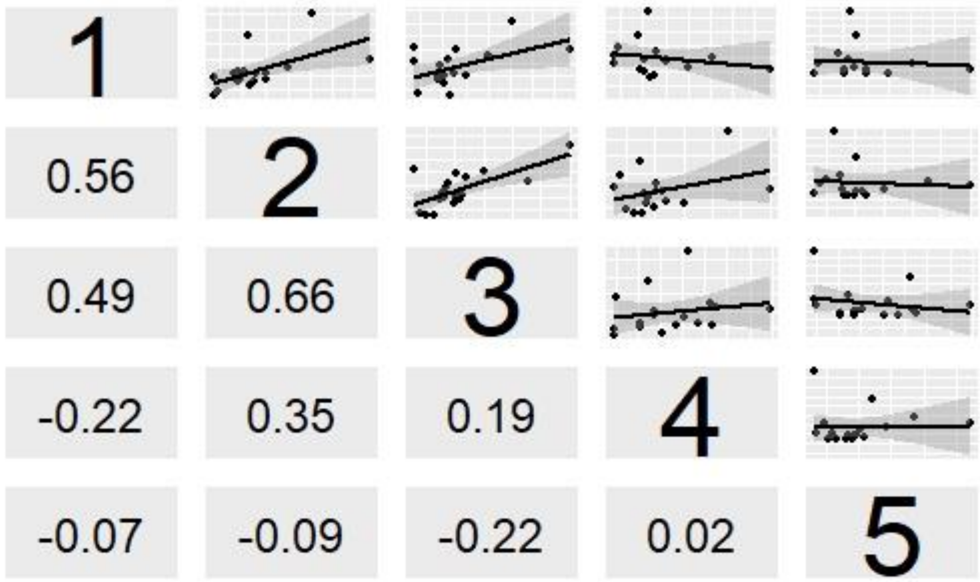


Figure 6.8.3.4. Giant red shrimp in GSA 18-20. Catch internal consistency plot

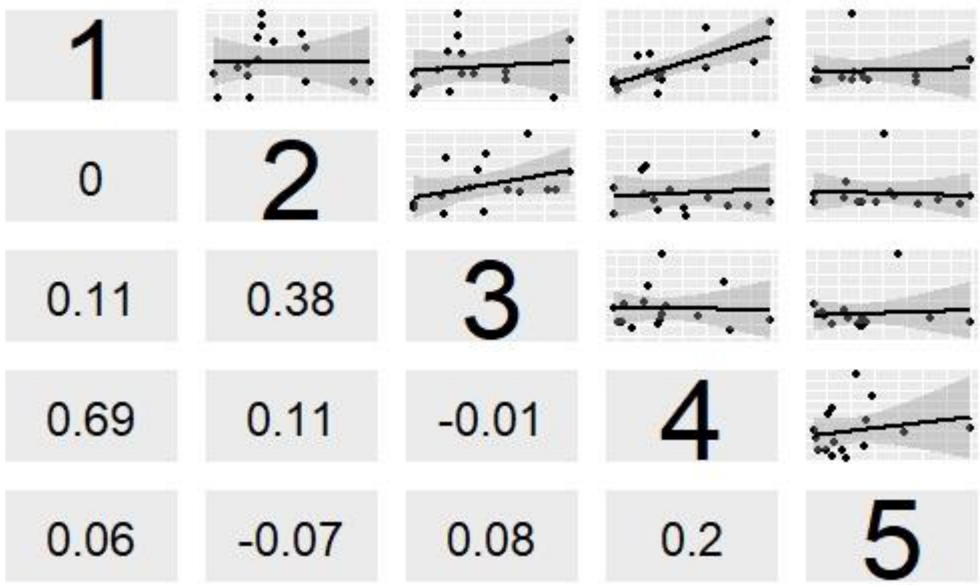


Figure 6.8.3.5. Giant red shrimp in GSA 18-20. MEDITS Index internal consistency table

Assessment results

Different a4a models were examined (a combination of different f and q models), including an exploration of dividing the MEDITS index in GSAs 18-19 and GSA 20. The best model (according to residuals and retrospective) was based on a single index for the target area and included:

Submodels:

fmodel: ~factor(replace(age, age > 2, 3))+s(year,k=6)

srmodel: ~s(year, k =9)

qmodel: MEDITS: ~factor(replace(age, age > 3, 4))

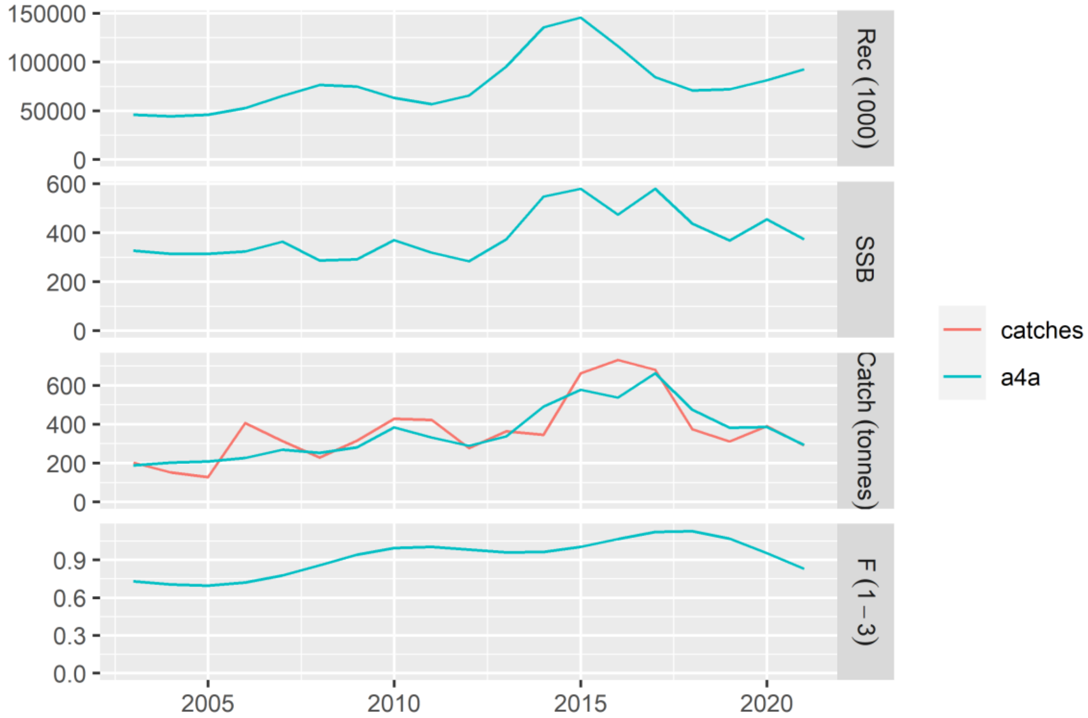


Figure 6.8.3.6. Giant red shrimp in GSA 18-20. Results of the a4a model

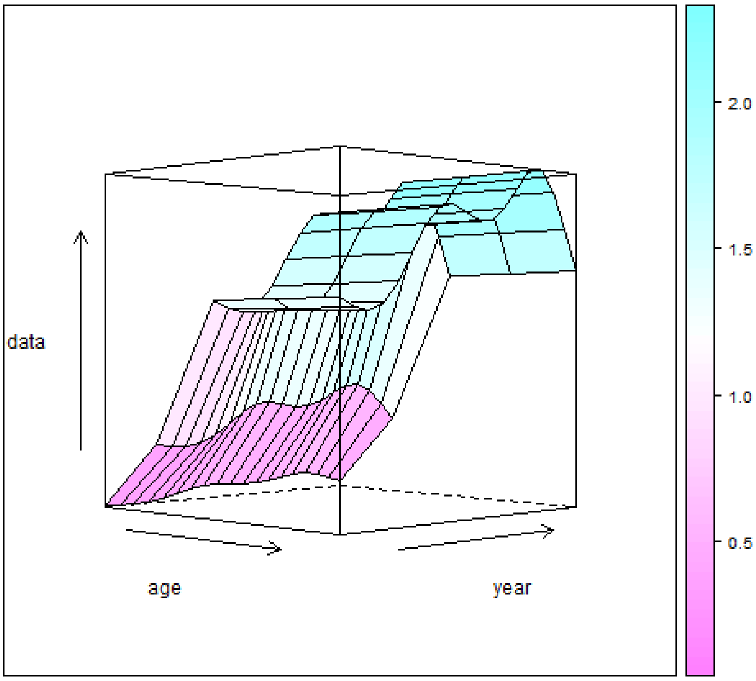


Figure 6.8.3.7. Giant red shrimp in GSA 18-20. 3D contour plot of estimated fishing mortality at age and year.

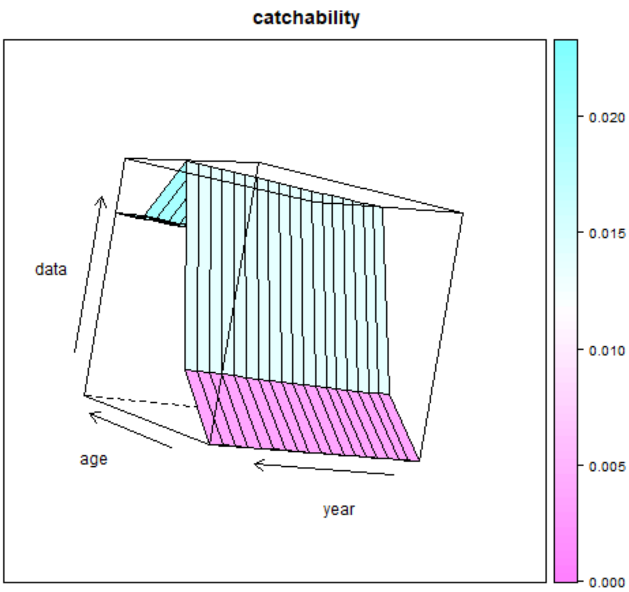


Figure 6.8.3.8. Giant red shrimp in GSA 18-20. 3D contour plot of estimated catchability at age and year.

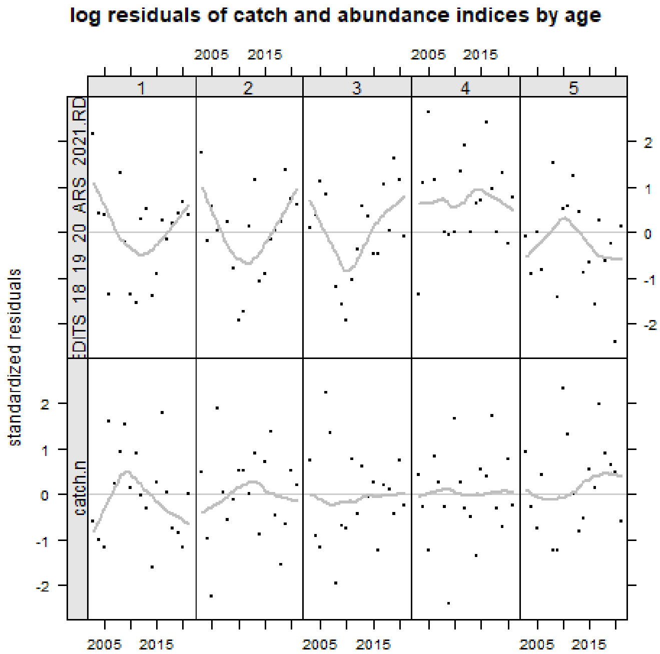


Figure 6.8.3.9. Giant red shrimp in GSA 18-20. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines simple smoothers.

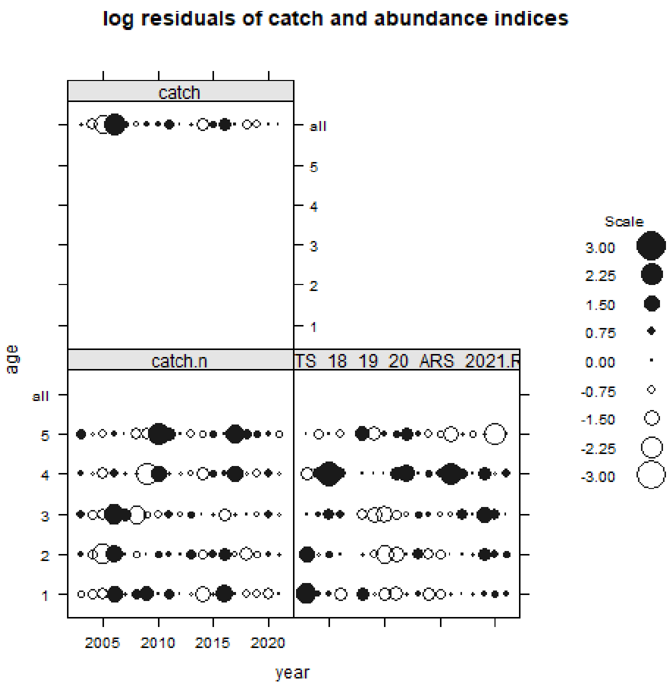


Figure 6.8.3.10. Giant red shrimp in GSA 18-20. Standardized residuals for abundance indices, catch and catch numbers.

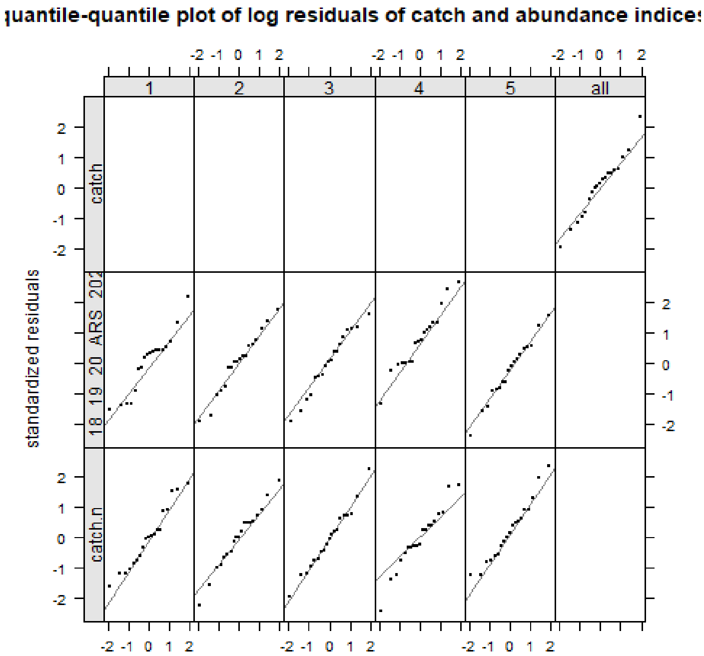


Figure 6.8.3.11. Giant red shrimp in GSA 18-20. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles.

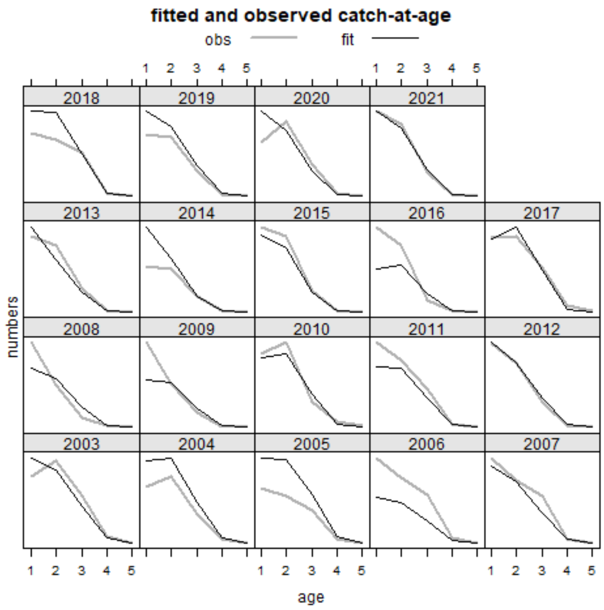


Figure 6.8.3.12. Giant red shrimp in GSA 18-20. Fitted and observed catch at age.

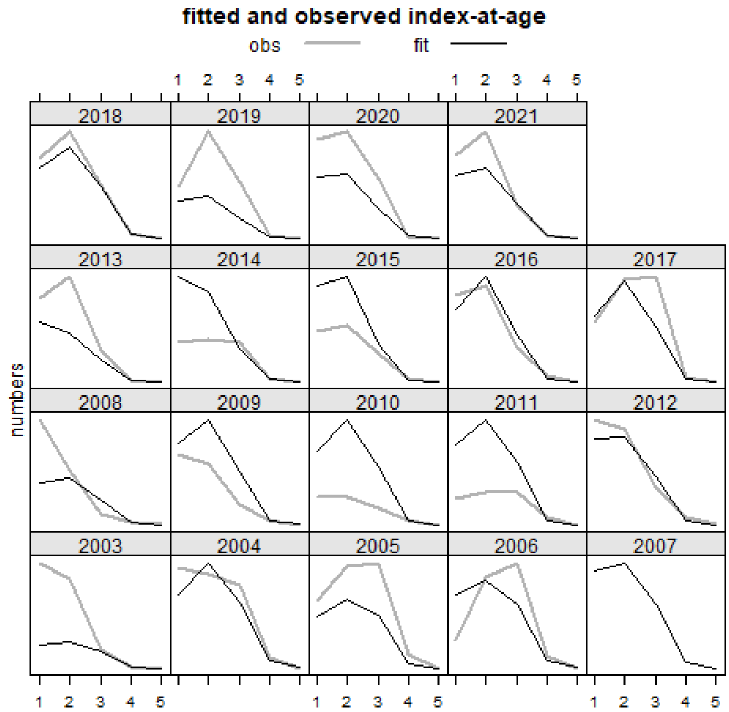


Figure 6.8.3.13. Giant red shrimp in GSA 18-20. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 3 years back. Model results are quite stable (Figure 6.8.3.14) and show a slight tendency to underestimate SSB (Mohn's rho -0.1) and F (Mohn's rho -0.01).

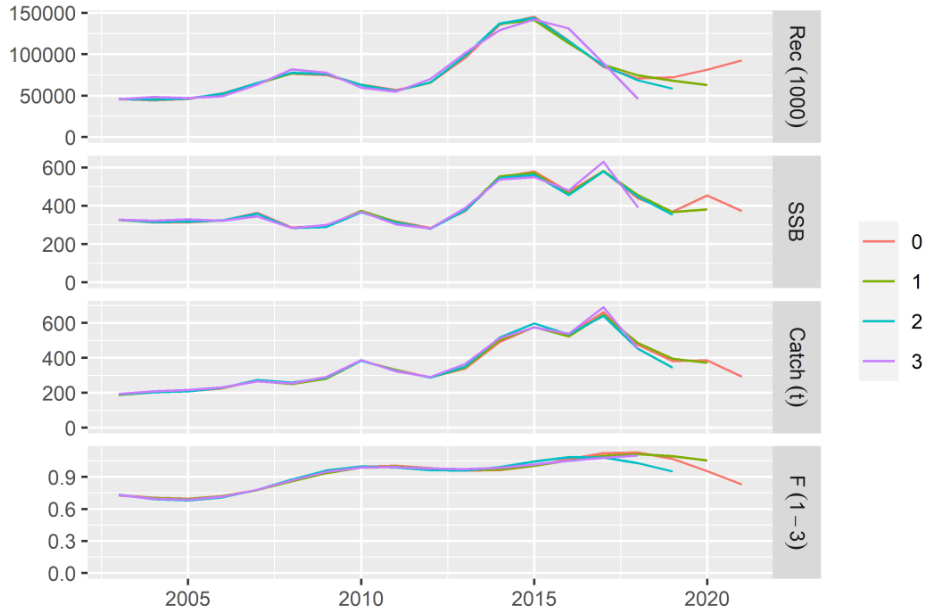


Figure 6.8.3.14. Giant red shrimp in GSA 18-20. Retrospective analysis

Simulations

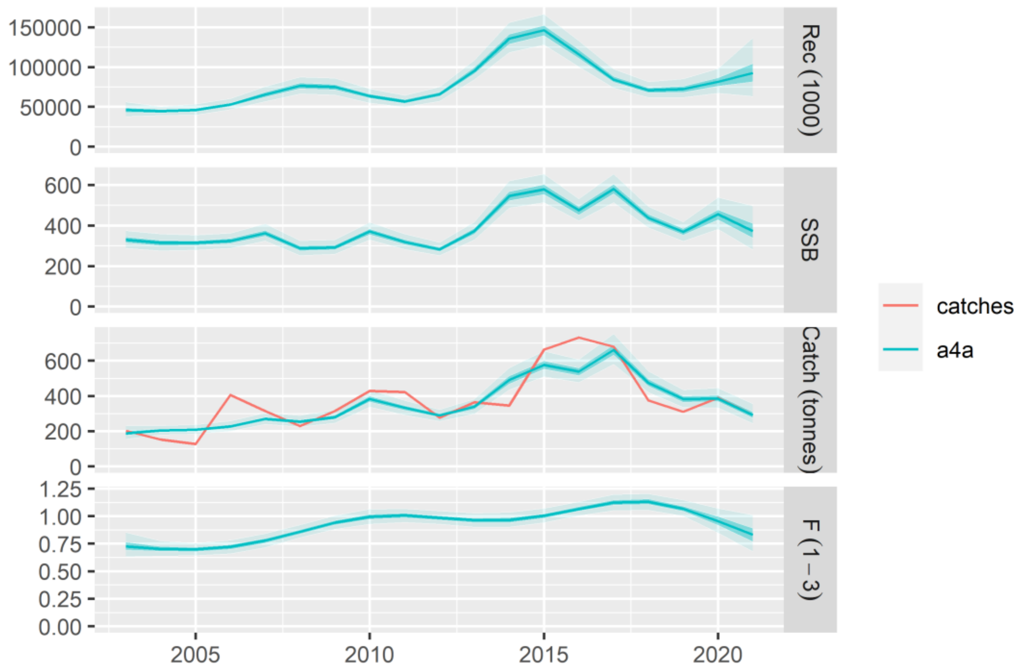


Figure 6.8.3.15. Giant red shrimp in GSA 18-20. Simulations over summary results.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.8.3.5. Giant red shrimp in GSA 18-20. Stock numbers at age (thousands) as estimated by a4a.

Year	1	2	3	4	5+
2003	5404.2	4624.9	2335.9	346.0	26.8
2004	5081.4	5251.7	2528.2	344.7	57.1
2005	5204.0	5091.8	2992.8	396.3	65.0
2006	6169.1	5421.0	2990.9	487.6	77.6
2007	8187.4	6575.6	3165.0	475.9	92.8
2008	10500.3	8677.3	3625.5	455.5	84.4
2009	11154.0	10670.4	4366.4	441.1	68.9
2010	9906.7	10537.2	4820.0	443.6	53.6
2011	8967.5	8836.5	4375.0	431.2	45.6
2012	10181.7	7785.7	3596.2	381.2	42.7
2013	14479.1	8936.3	3243.0	326.9	40.1
2014	20601.2	13031.5	3856.5	312.1	37.0
2015	22938.4	19000.5	5669.6	372.2	35.4
2016	19301.6	21159.4	8011.3	509.9	38.5
2017	14716.2	17047.6	8312.2	635.6	45.0
2018	12417.8	12289.0	6132.6	584.3	49.6
2019	12039.0	9921.1	4283.4	416.2	45.1
2020	12242.8	9517.2	3609.2	318.0	36.0
2021	12277.6	9978.3	3862.8	327.7	33.8

Table 6.8.3.6. Giant red shrimp in GSA 18-20. a4a summary results.

Year	F ages 1-3	Recruitment age 1 Thousands	SSB Tonnes	TB Tonnes	Catches Tonnes
2003	0.73	45830	326.71	792.74	187.09
2004	0.7	44494	313.14	803.6	202.98
2005	0.7	45957	313.14	812.83	207.55
2006	0.72	52848	323.04	880.73	226.26
2007	0.78	65362	362.79	1032.63	269.19
2008	0.86	76416	287.01	850.95	253.19
2009	0.94	74822	291.68	922.6	279.91
2010	0.99	63377	370.43	1117.54	382.67
2011	1	56872	317.75	1056.42	331.23
2012	0.98	65721	282.68	979.7	288.82
2013	0.96	95499	372.46	1392.94	337.83
2014	0.96	135525	546.89	2000	490.73
2015	1	145625	578.47	2013.46	576.54
2016	1.07	115994	473.07	1601.33	536.49
2017	1.12	84628	579.54	1864.84	660.87
2018	1.13	70941	437.14	1398.37	475.12
2019	1.07	72171	368.37	1188.7	381
2020	0.96	81201	453.83	1385.57	385.25
2021	0.83	92534	372.27	1176.17	292.09

Table 6.8.3.7. Giant red shrimp in GSA 18-20. a4a results F at age.

Year	1	2	3	4	5
2003	0.19	0.58	1.41	1.41	1.41
2004	0.18	0.56	1.36	1.36	1.36
2005	0.18	0.56	1.35	1.35	1.35
2006	0.19	0.58	1.39	1.39	1.39
2007	0.20	0.62	1.50	1.50	1.50
2008	0.23	0.69	1.66	1.66	1.66
2009	0.25	0.75	1.82	1.82	1.82
2010	0.26	0.80	1.92	1.92	1.92
2011	0.26	0.80	1.94	1.94	1.94
2012	0.26	0.79	1.90	1.90	1.90
2013	0.25	0.77	1.86	1.86	1.86
2014	0.25	0.77	1.87	1.87	1.87
2015	0.26	0.80	1.94	1.94	1.94
2016	0.28	0.85	2.06	2.06	2.06
2017	0.29	0.90	2.17	2.17	2.17
2018	0.30	0.90	2.19	2.19	2.19
2019	0.28	0.86	2.07	2.07	2.07
2020	0.25	0.77	1.85	1.85	1.85
2021	0.22	0.66	1.60	1.60	1.60

According to the age slicing, catches of Giant red shrimp include a large portion of not fully mature specimens, therefore the SSB represents just around one-third of the stock biomass. SSB of Giant red shrimp show an increasing trend from 2003 to 2017. Then catches started to decline steadily until 2021, while SSB was declining until 2019 and then it stabilized at around 400 tons. The assessment shows a general fluctuating but increasing trend in the number of recruits, especially after 2012,. Fbar (1-3) shows a slight increase until 2017 when it starts declining until 2021 when it reached a value of F of 0.828.

Based on the retrospective analysis the assessment appears to be stable and the results are consistent between different models. The patterns in the residuals in the MEDITS survey were mostly attributable to the low values observed in the middle of the time series, causing a systematic overestimation from 2008 to 2012. Considering that the catches at age did not show clear patterns in the residuals and that the fit of this data source was generally good, it was considered that the model was estimating the age structure from the catches, giving precision to the model, while the index was mostly informing on the biomass scale. Considering the heterogeneity in the MEDITS coverage, lacking an area of high density for the population, a better fitting of the model to the MEDITS data is not expected. A decrease in maximum age for this stock could be explored given the low number of catches in age 5.

Partial F for GSA 18

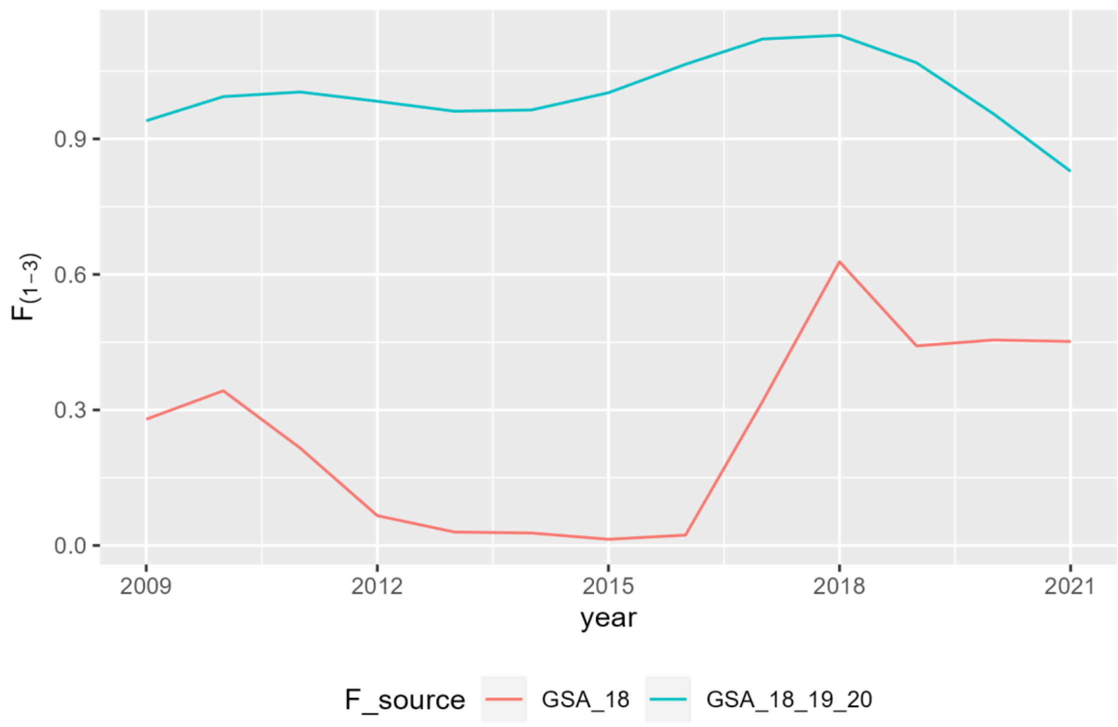
STECF EWG 22-16 was required to quantify the partial F for catches in GSA 18 and to advise on a catch limit for GSA 18 under a linear transition to reach F_{MSY} in 2030. As emerged from catch share estimation (Figure 6.8.2.1.5), the catch share of GSA 18 was oscillating between near 0% and almost 50%. The partial F estimation was based on the proportion of catch at age observed in GSA 18 and GSA 19. Namely, the proportion of catches at age of GSA 18 was derived from the stock objects of single GSAs (18 and 19) by dividing the catch at age and year numbers of GSA 18 + 19 by the values observed for GSA 18. The proportion obtained was applied to the Fbar at age and year, deriving the Fbar proportion assigned to GSA 18. Fbar for ages 1-3 was then calculated from the proportion of Fbar at age assigned to GSA 18. GSA 20 was excluded because no Length Frequencies data were available and because of the low number of landings. As a result, the partial F closely followed the catch share values and oscillated between almost 0% and more than 50%. The estimated partial F provided in table 6.8.3.8, and Figure 6.8.35.16 where a large fluctuation is observed, and the values are considered unrepresentative of the fishery. The EWG 22-16 considered inappropriate to advise on a catch limit for GSA 18 based on these data. Vessels targeting deep water shrimps may move around several GSAs, it is therefore not realistic to estimate an accurate catch share solely based on reported commercial data. Controlling only part of a fishery cannot guarantee to achieve MSY status for that part of a larger area, as the exploitation will depend on the other fisheries through the stock area and the stock mixing within the area. Thus a control regime in GSA 18 cannot assure that exploitation in GSA 18 will reach MSY by 2030 even if it is followed properly.

Table 6.8.3.8. Giant red shrimp in GSA 18-20. F at age and partial F age 1-3 for GSA 18.

Year	F ages 1-3	Partial F GSA 18*
2003	0.73	
2004	0.70	
2005	0.70	
2006	0.72	
2007	0.78	
2008	0.86	
2009	0.94	0.28
2010	0.99	0.34
2011	1.00	0.22
2012	0.98	0.07
2013	0.96	0.03
2014	0.96	0.03
2015	1.00	0.01
2016	1.07	0.02
2017	1.12	0.32
2018	1.13	0.63
2019	1.07	0.44
2020	0.96	0.45
2021	0.83	0.45

* start from 2009 because of LFD availability

Figure 6.8.3.16. Giant red shrimp in GSA 18-20. Fbar (1-3) and partial Fbar (1-3) for GSA 18.



6.8.4 Reference points

The STECF EWG 22-16 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. $F_{0.1}$ (0.371) chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields. F current = 0.83 which indicates that giant red shrimp stock in GSAs 18, 19 & 20 is over-exploited.

Table 6.8.4.1 summarises all known reference points for Giant red shrimp in GSAs 18, 19 and 20 and their technical basis.

Table 6.8.4.1 Giant red shrimp in GSA 18-20. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.37	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	B_{MSY}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MSY $B_{trigger}$		Not Defined	
	B_{lim}		Not Defined	
	F_{MSY}	0.37	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range F_{lower}	0.25	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range F_{upper}	0.51	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

6.8.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short-term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, 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_{2021} =0.828 (the last year's F estimated by the assessment model) was used for F in 2022, as F shows a decreasing trend (See section 4.3). As for this stock the recruitment has been oscillating along the time series, and a spike was observed in 2015, the geometric mean of the recruitment of the last four years was used for the short-term projections as an estimate of recruits in 2022 to 2023.

Table 6.8.7.1 Giant Red Shrimp in GSAs 18-20. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3 years	Mean weights at age, maturation at age, natural mortality at age and selection at age, are based average of years 2019-2021
$F_{ages\ 2\text{-}8}$ (2022)	0.828	The F estimated in 2021 was used to give F status quo for 2022
SSB (2022)	487	SSB intermediate year from STF output.
R_{age2} (2022,2023)	78755	Geometric mean of the last 4 years
Total Catch (2022)	392	Assuming F status quo for 2022

Table 6.11.5.2. Giant Red Shrimp in GSAs 18-20. Short term forecast in different F scenarios.

Rationale	F factor	Fbar 2023	Catch 2023	SSB* 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield ($F_{0.1}$)	0.448	0.37	210	636	30.64	-28.24
F_{upper}	0.614	0.51	270	568	16.67	-7.55
F_{lower}	0.300	0.25	149	710	45.99	-49.15
$F_{MSY\ transition}$	0.931	0.77	367	470	-3.37	25.76
Zero catch	0	0.00	0	919	88.80	-100.00
Status quo	1	0.83	386	453	-6.89	32.14
Different Scenarios	0.1	0.08	54	839	72.34	-81.54
	0.2	0.17	103	770	58.19	-64.63
	0.3	0.25	149	710	45.94	-49.09
	0.4	0.33	191	658	35.29	-34.76
	0.5	0.41	229	613	25.97	-21.52
	0.6	0.50	265	573	17.77	-9.24
	0.7	0.58	298	538	10.52	2.18
	0.8	0.66	330	506	4.06	12.84
	0.9	0.75	359	478	-1.70	22.80
	1.1	0.91	412	430	-11.57	40.92
	1.2	0.99	436	410	-15.81	49.19
	1.3	1.08	459	391	-19.68	57.00
	1.4	1.16	480	374	-23.21	64.39
	1.5	1.24	501	358	-26.46	71.39
	1.6	1.33	520	343	-29.45	78.05
	1.7	1.41	539	330	-32.22	84.38
	1.8	1.49	556	317	-34.78	90.41
	1.9	1.57	573	306	-37.17	96.17
	2	1.66	589	295	-39.39	101.68

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.371 and corresponding catches in 2023 should be no more than 210 tons.

6.8.6 DATA DEFICIENCIES

MEDITS TC file for GSA 20 was not provided to DCF and was provided to EWG 22-16.

6.9 BLUE AND RED SHRIMP IN GSA S 18, 19 AND 20

The stock of blue and red shrimp (*Aristeous antennatus*) in GSAs 18, 19 & 20 is assessed by STECF EWG 22-16 for the first time. The assessment is based on recommendations and data prepared in EWG 22-03 (STECF, 2022). Previous assessment of the stock in GSAs 18 & 19 was performed during the GFCM working group, session on the assessment of deep-water red shrimp (FAO, 2022).

6.9.1 STOCK IDENTITY AND BIOLOGY

Distribution and abundance

Blue and red shrimp (*Aristeous antennatus*) is distributed in the Eastern-Central Atlantic (from the Iberian Peninsula to Angola), the Mediterranean and the Western Indian Ocean (Kapiris *et al.*, 2022; Palomares & Pauly, 2022). It occurs at depths ranging from 80 to 3,300 m in muddy bottoms in deep waters off the continental shelf, especially near submarine trenches and canyons along the continental slope (Kapiris *et al*., 2022; Palomares & Pauly, 2022). In the Mediterranean, genetic studies indicated that it consists of two genetic stocks: the Western and the Eastern Mediterranean stocks, while the Strait of Sicily may be serving as a barrier for the migration of individuals and gene flow between the two basins (Fernández *et al.*, 2011). Individuals move from depths of 200 m during the night to 800 m during the day, and change locations within the year. They feed on small benthic invertebrates mainly crustaceans and polychaetes and also carrion (Palomares & Pauly, 2022)

The average relative density of the species is much greater in the Western Ionian Sea (GSA 19), reaching ~450 N/km2, while in GSAs 18 (South Adriatic) and 20 (Eastern Ionian) it does not exceed ~ 100 N/km2 in most years (DCF data call 2022, MEDITS survey). In GSA 20, areas of higher juvenile blue and red shrimp aggregations are the Kyparissiakos Gulf (~ 200 N/km2), Othonoi Islands and Messiniakos Gulf (~ 100 N/km2). The highest spawning aggregations of female individuals are found SW of Corfu Island (~ 1,000 N/km2) in late July. Other hotspot areas (500-1,000 N/km2) are the Kyparissiakos Gulf, W of Corfu Island, S-SW of Kefallinia Island and SE of Zakynthos Island (Kapiris *et al.*, 2022).

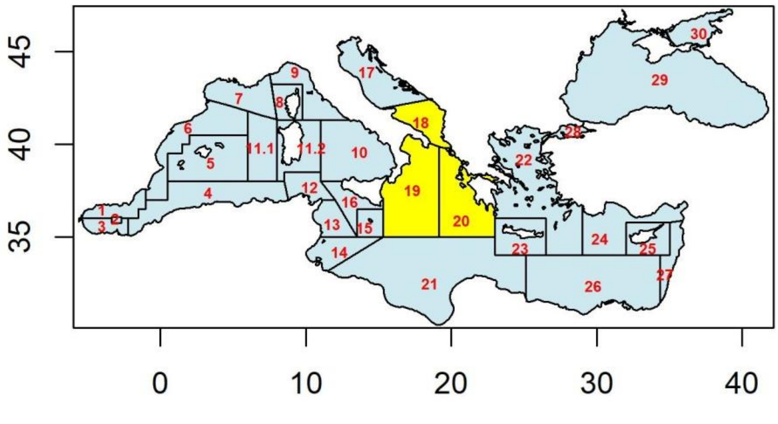


Figure 6.9.1.1 Geographical location of GSAs 18, 19 and 20. Countries fishing in the area are Italy, Greece, Albania and Montenegro.

Growth

Blue and red shrimp shows sexual dimorphism, with females growing faster and reaching greater sizes than males. The species is thought to live up to ~6 years of age (Palomares & Pauly, 2022). The Von Bertalanffy (VBGF) parameters and length-weight function for males and females were taken from DCF 2022 data call from GSA 19 (ITA). These are contained in Tables 6.6.1.1 and 6.6.1.2. The VBGFs were used to age slice both the catch and index data that were used in the assessment. The length-weight relationships were used to estimate weights by length per sex, which were then transformed to weight by age through the VBGFs.

Table 6.9.1.1 Blue and red shrimp in GSAs 18, 19 & 20: Von Bertalanffy growth parameters by sex in GSA 19 (ITA) (source: DCF data call 2022).

sex	linf	k	t0
Female	66.44	0.24	-0.20
Male	44.40	0.36	-0.33

Table 6.9.1.2 Blue and red shrimp in GSAs 18, 19 & 20: Parameters of the length weight relationship by sex in GSA 19 (ITA) (source: DCF data call 2022).

sex	a	b
Female	0.0027	2.45
Male	0.003	2.42

Maturity

Red and blue shrimp spawning takes place each year during late spring to summer (Cartes *et al.*, 2018). Recruitment takes place about three to five months after spawning (Kapiris *et al.*, 2022). Blue and red shrimp is already sexually active from its first year of life. In Eastern Ionian Sea (GSA 20), the smallest mature female was found to be 18 cm carapace length and the length at first maturity of females is estimated at 26 mm CL, hence juvenile individuals are those with CL< 25 mm (Kapiris *et al.*, 2022) .

For the assessment in GSAs 18, 19 and 20 combined, the maturity at age were adopted from DCF data call 2022, from GSA 19 (ITA), which is the GSA with the majority of landings (>85%). The vector of maturity at age (for female individuals) is presented in Table 6.9.1.3.

Table 6.9.1.3 Blue and red shrimp in GSAs 18, 19 & 20: Maturity by age in GSA 19 (ITA) for females (source: DCF data call 2022).

age	0	1	2	3	4	5	6	7+
maturity	0	0.49	0.97	1	1	1	1	1

Natural Mortality

The natural mortality has been estimated by the Chen Watanabe relationship using the growth parameters of Table 6.9.1.1 and is presented in Table 6.9.1.4. The natural mortality was estimated first by sex and then for sexes combined by taking the average natural mortality of females and males by age, weighted by the total number of females and males at this age.

Table 6.9.1.4 Blue and red shrimp in GSAs 18, 19 & 20: Natural mortality by age (of sexes combined) estimated from Chen Watanabe relationship on the basis of the growth parameters of Table 6.9.1.1.

age	0	1	2	3	4	5	6	7+
mortality	1.44	0.73	0.51	0.41	0.36	0.32	0.3	0.29

Sex ratio

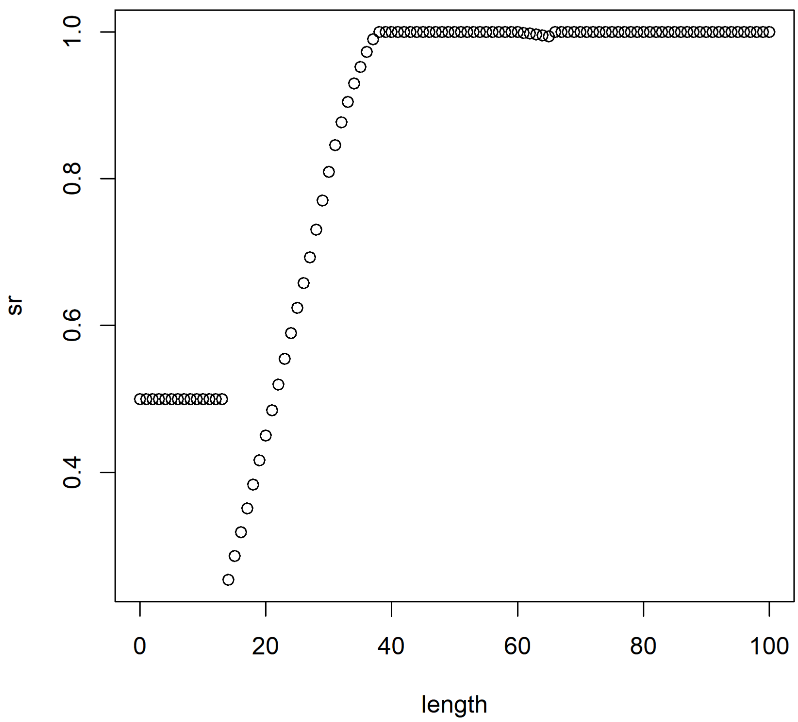


Figure 6.9.1.2 Blue and red shrimp in GSAs 18, 19 & 20: Predicted sex ratio (Fem/(Fem + Male)) for GSA 19 used to split total LFDs by sex (source DCF data call 2022).Small length with no data (<16mm) are conventionally assigned 50% by sex but are not involved in any calculations.

Fishery

Blue and red shrimp is among the main target species for the demersal deep-water fishery in the Western and Central Mediterranean and of great economic interest (Kapiris *et al.*, 2022). The stock has been exploited commercially since the 1930s in the Western Mediterranean basin (Bas, 2006). It is harvested by bottom trawlers on the slope, commonly at depths ranging from 400 to 800 m. Over the last decades, the red shrimp fishing fleets have expanded their operations to various areas of the E. Mediterranean (Mitilineou, 2007, Vitale *et al.*, 2018). The blue and red shrimp, although less abundant in the Eastern Mediterranean, is an important commercially targeted species (Kapiris *et al.*, 2022).

According to the latest published GFCM stock assessments (FAO, 2022a), the stocks of blue and red shrimp in GSA 01 (Northern Alboran), GSA 02 (Alboran Island), GSA 05 (Baleares Islands), GSA 06 (Northern Spain) and GSAs 09-10-11 (Ligurian Sea, Tyrrhenian Sea - Sardinia), were overexploited and the management advice was to reduce fishing mortality (FAO, 2022 a). For GSAs 18-19 (Southern Adriatic and Western Ionian Sea) the stock was found to be in overexploitation with relatively low biomass (FAO, 2022).

The catches of blue and red shrimp have increased in recent years with an increasing exploitation ratio at Mediterranean level (FAO, 2020). In the Central Mediterranean, the red shrimp fishery has been traditionally conducted by Italian trawlers. However, the decrease in the catch in the Strait of Sicily and the absence of deep trawling in the Eastern Mediterranean drove some fishing vessels to new fishing grounds since 2004 (Kapiris *et al.*, 2022). It is likely that unreported catches are significant, since the Automatic Identification System (AIS) data show increasing fishing activity of the red shrimp fleets in the Mediterranean. Available information indicates a future offshore expansion of the deep-water red shrimp fishing grounds in the Eastern Mediterranean (Kapiris *et al.*, 2022).

At present, a recommendation establishing multiannual management plan for sustainable trawl fisheries targeting deep-water red shrimp species in the Ionian Sea (GSAs 19-20) has been established *(Recommendation GFCM/44/2021/8 on a multiannual management plan for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp in the Ionian Sea (geographical subareas 19 to 21*) (FAO, 2020).

In the present assessment, combined data coming from the Ionian (GSAs 19 and 20) and South Adriatic Sea (GSA 18) have been used. These include fisheries data from Italy (ITA) in GSA18 and GSA19 and Greece (GRC) in GSA20. Montenegro and Albania are also fishing in GSA 19 but no data for blue and red shrimp were available from these countries. The main bulk of catches (>85%) in this combined area comes from the western Ionian Sea (GSA 19) and Italian fishing fleets.

6.9.2 DATA

6.9.2.1 CATCH (LANDINGS AND DISCARDS)

Landings

Landings data for blue and red shrimp in GSAs 18, 19 and 20 were retrieved from the DCF 2022 data call for year 2021, while data before 2021 were retrieved from 2021 data call. The quality of the data has been checked for this stock in STECF 22-03 (STECF, 2022). Main issues detected were the missing length frequency distributions (LFDs) from GSA 18 in years 2002-2007 and 2019, and the reporting of same VBGF growth parameters for both males and females in both GSAs 18 and 19. Since STECF 22-03, the growth parameters have been updated and the VBGF parameters reported differ by sex, allowing a sex separated age slicing. However, landings were still missing for some years for GSA 18, however a different set of years than those reported in STECF 22-03 (see "Data deficiencies" section 6.7.9). Both LFDs and total landings by gear in the period 2003-2020 were the same as in STECF 22-03 for GSAs 18 and 19, for the years where available. In GSA 20, the species is not fished by the Greek fleets hence there are no historical records of landings, except for year 2021 when landings of 10.10 tonnes were reported. It should be noted that the main bulk of landings (>85%) come from GSA 19 (ITA) (Figure 6.9.2.1.2). Landings data from Montenegrin and Albanian fleets (fishing in GSA 19) were not included, as these were not made available in the former case, while there were no records of landings for this species in the latter.

Landings' length frequency distributions (LFDs) were reconstructed using the ad-hoc scripts supplied by JRC. In GSA18, landings data by length from Italy (ITA) are scarce, and in most years landings are few. Following STECF 22-03 recommendation, and to use best available consistent annual length frequency data, only LFDs from GSA 19 were used to inform the assessment (STECF, 2022). In effect, landings data from GSA 18 (ITA) and GSA 20 (GRC) were added to the total catch and scaled using the LFDs during the SoP (sum of products) correction (see section 6.9.3.1).

Table 6.9.2.1.1 and Figure 6.9.2.1.1 present total landings data by country and GSA. The majority of landings (>85% in most years) come from the Italian fleet from GSA 19, with the exception of year 2017, when landings from GSA 18 comprised 57% of total (Figure 6.9.2.1.2). This is coincident with very low reported landings from GSA 19 in this year, which raised concerns for area misreporting. Landings show an overall increasing trend, with significant fluctuation (ranging between approx. 50-500 tonnes) and two peaks in 2006 and 2018. Landings come almost exclusively from OTB, with very low occasional landings from GNS and FPO. The reconstructed length frequency distributions of landings by gear and year for GSAs 18 and 19 are presented in Figures 6.9.2.1.3 and 6.9.2.1.4 respectively. Figure 6.9.2.1.5 shows the length frequency distribution of landings by year for GSA 19. The distributions were split to females and males on the basis of the sex ratio of Figure 6.9.1.2 to obtain the LFDs by sex that were used in the assessment (Figures 6.9.2.1.5 - 6).

Landings' shares by age (between GSAs) were not estimated due to the scarcity of data from GSA 18 and no data from GSA 20. In the performed assessment, the landings' shares by age follow the pattern of the total landings' shares (i.e. same fractions as of Figure 6.9.2.1.2), as only GSA19 data are used to inform age distributions.

Table 6.9.2.1.1 Blue and red shrimp in GSAs 18, 19 & 20: Landings data in tonnes by GSA and country as well as total landings.

	GSA 18	GSA 19		GSA 20	Total
	ITA	ITA	ITA Total	GRC Total	
2003	-	132.67	132.67	-	132.67
2004	4.81	41.19	46.00	-	46.00
2005	8.18	120.55	128.73	-	128.73
2006	21.75	437.57	459.32	-	459.32
2007	14.17	359.65	373.82	-	373.82
2008	4.63	201.85	206.48	-	206.48
2009	14.07	225.08	239.15	-	239.15
2010	21.59	206.53	228.12	-	228.12
2011	24.84	159.99	184.82	-	184.82
2012	4.33	263.39	267.71	-	267.71
2013	4.41	242.60	247.01	-	247.01
2014	2.70	299.46	302.16	-	302.16
2015	10.47	78.97	89.44	-	89.44
2016	16.76	103.02	119.78	-	119.78
2017	36.31	27.63	63.94	-	63.94
2018	67.94	335.59	403.53	-	403.53
2019	51.95	405.93	457.88	-	457.88
2020	36.22	204.55	240.77	-	240.77
2021	37.58	252.84	290.42	10.10	300.52

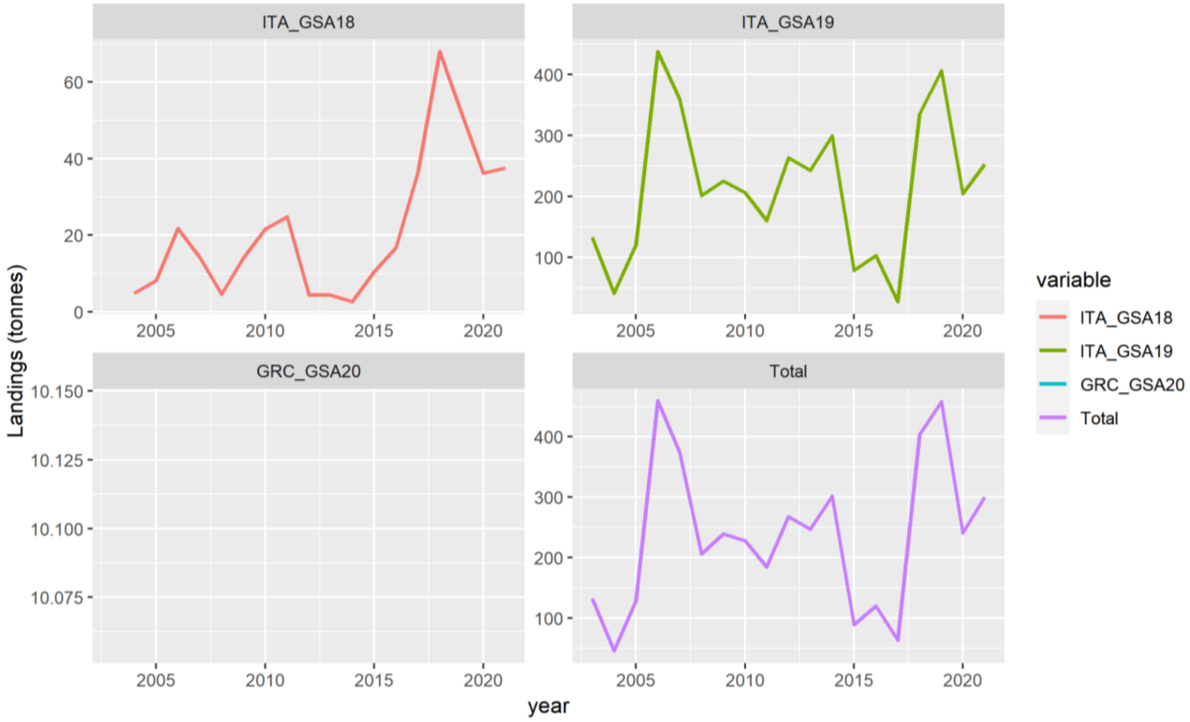


Figure 6.9.2.1.1 Blue and red shrimp in GSAs 18, 19 & 20: Landings' trends in tonnes by GSA and country from 2003 to 2021.

Figure 6.9.2.1.2 Blue and red shrimp in GSAs 18, 19 & 20: Landings shares between GSAs 18, 19 and 20 from 2004 to 2021. Note that in 2003, GSA 18 did not report any landings for this stock; hence catch share for this year is not shown.

Table 6.9.2.1.2 Blue and red shrimp in GSAs 18, 19 & 20: Landings in tonnes by country and gear. Also showing fleets with occasional landings (FPO and GNS).

Year	GSA 18		GSA 19			GSA 20
	ITA		ITA			GRC
	NA	OTB	FPO	GNS	OTB	OTB
2003					132.67	
2004		4.81		1.18	40.01	
2005		8.18			120.55	
2006	0.42	21.33			437.57	
2007		14.17			359.65	
2008		4.63			201.85	
2009		14.07			225.08	
2010		21.59			206.53	
2011		24.84			159.99	
2012		4.33			263.39	
2013		4.41			242.60	
2014		2.70			299.46	
2015		10.47			78.97	
2016		16.76			103.02	
2017		36.31			27.63	
2018		67.94			335.59	
2019		51.95	0.1		405.83	
2020		36.22			204.55	
2021		37.58			252.84	10.10

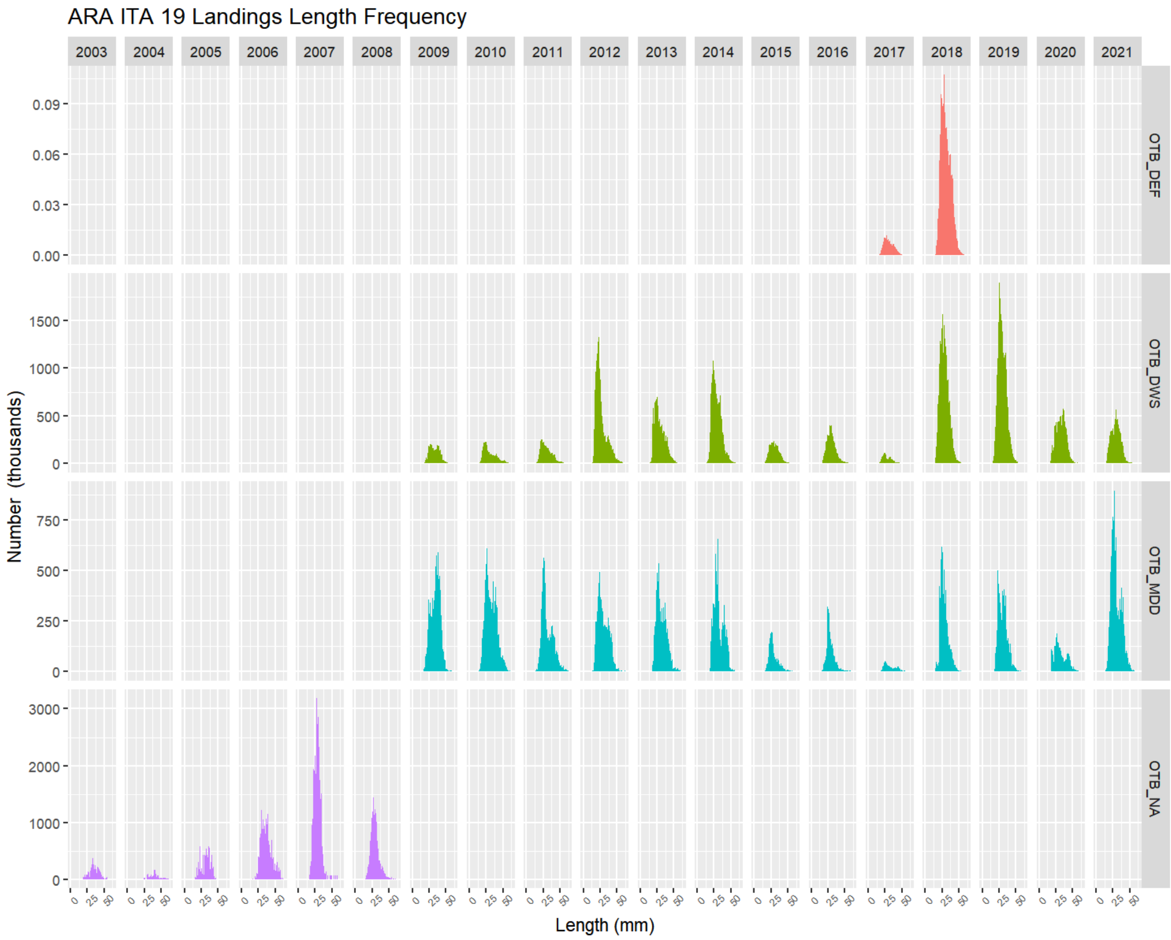


Figure 6.9.2.1.3 Blue and red shrimp in GSAs 18, 19 & 20: Reconstructed length structure for landings by year and gear in GSA 19 (ITA).

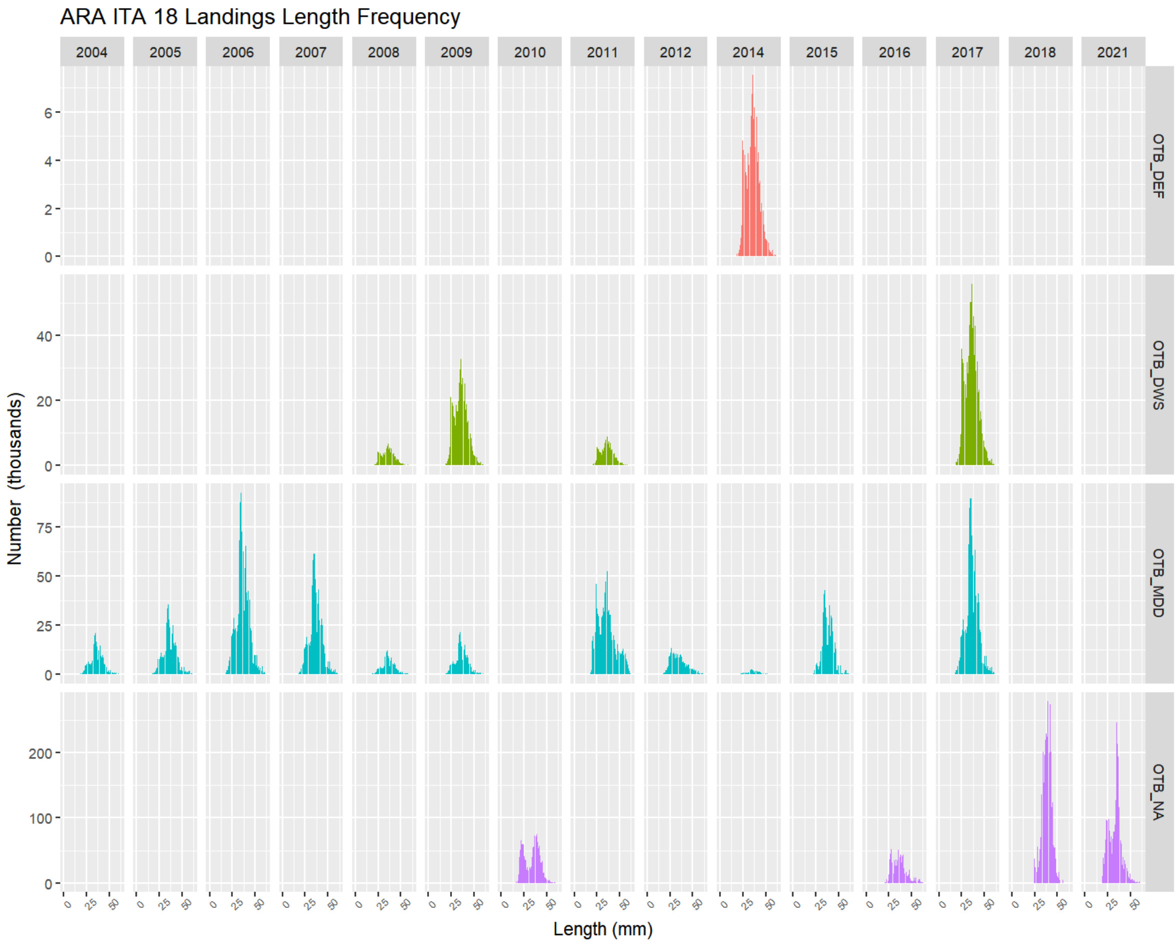


Figure 6.9.2.1.4 Blue and red shrimp in GSA 18, 19 & 20: Reconstructed length structure of landings by year and gear for GSA 18 (ITA).

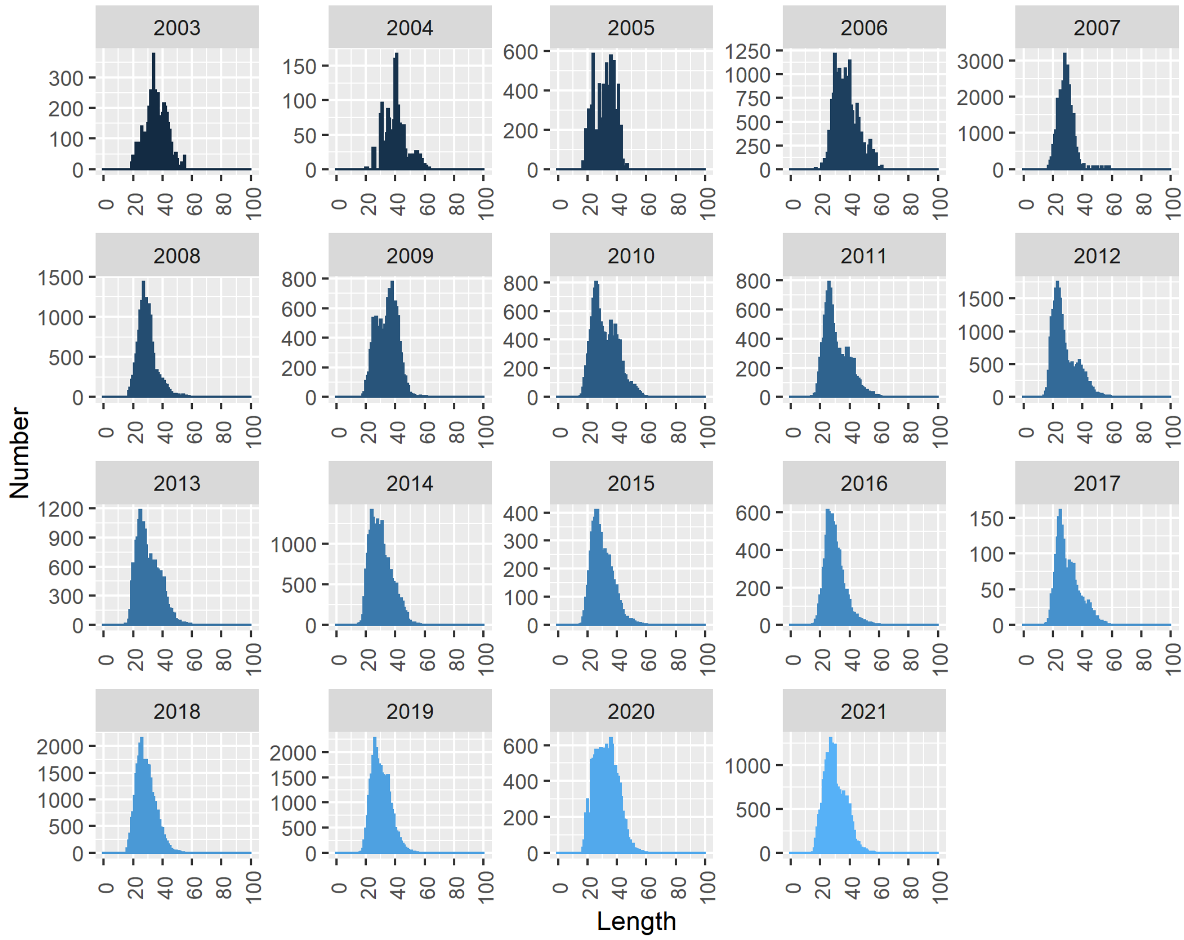


Figure 6.9.2.1.5 Blue and red shrimp in GSA 18, 19 & 20: Length structure of landings by year in GSA19.

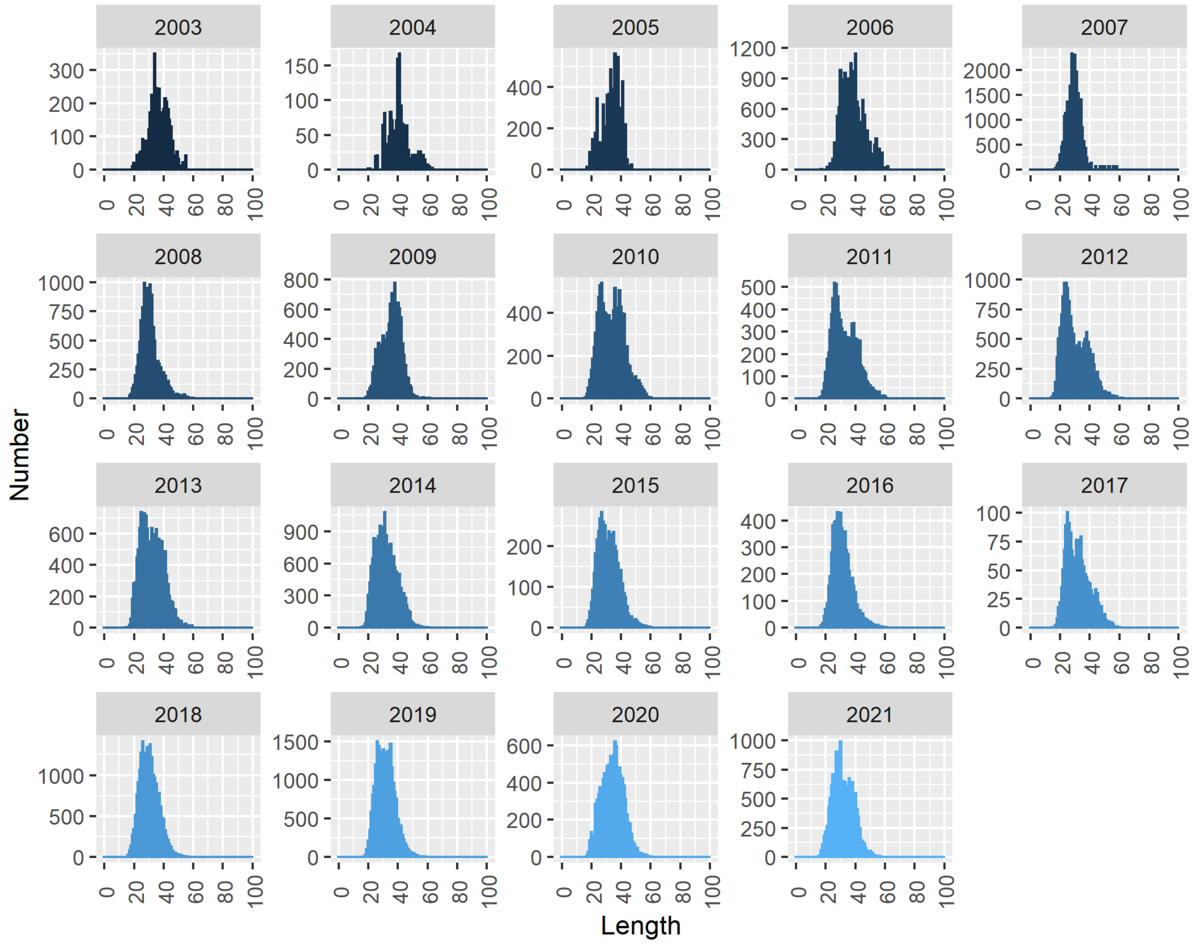


Figure 6.9.2.1.6 Blue and red shrimp in GSA 18, 19 & 20: Length structure of landings by year for females in GSA19 (used in the assessment).

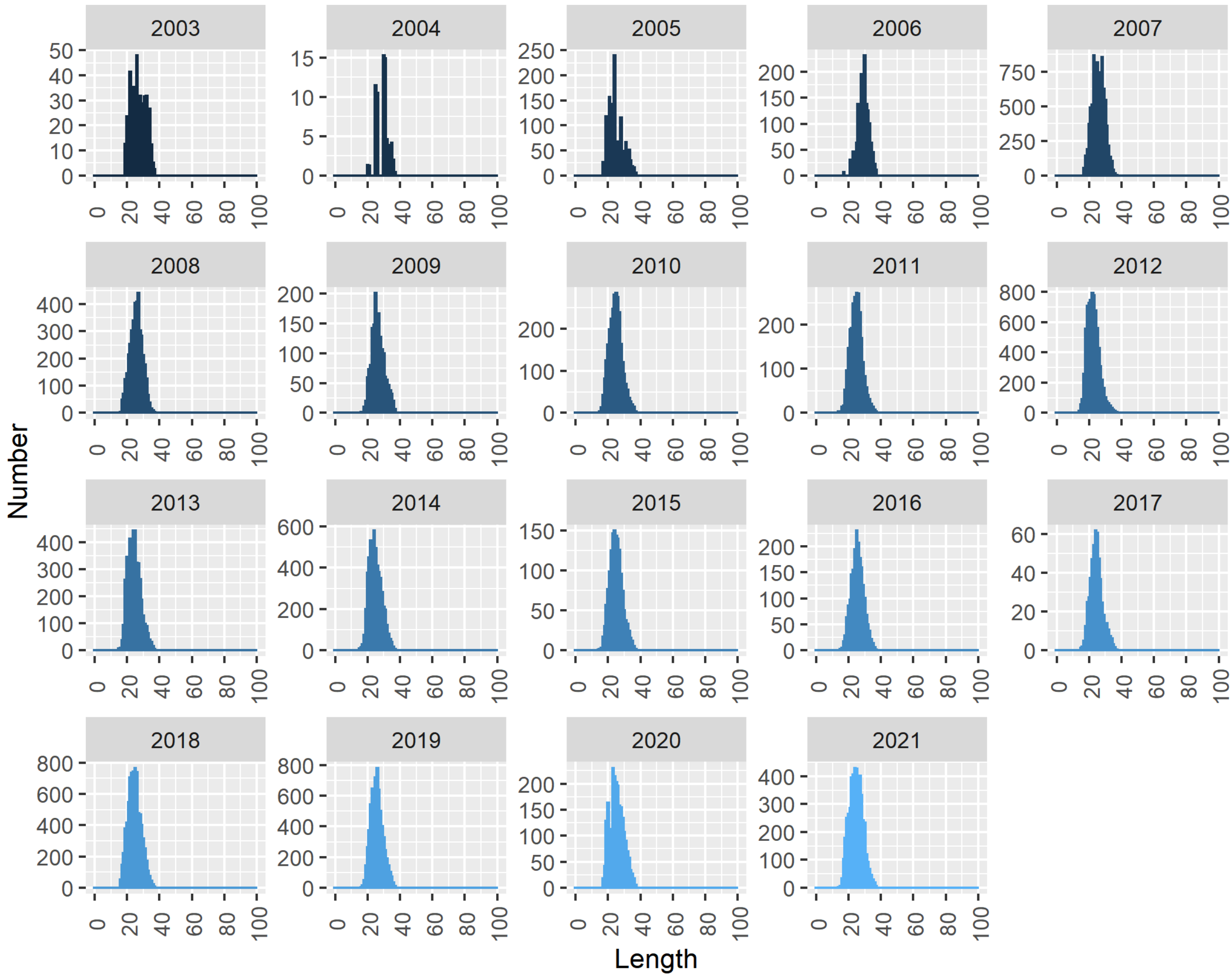


Figure 6.9.2.1.7 Blue and red shrimp in GSA 18, 19 & 20: Length structure of landings by year for males in GSA19 (used in the assessment).

Discards

Discards for this stock are negligible. Very few individuals are discarded as this species is very valuable (attains high prices), while there is no Minimum Landing Size (MLS) for the stock (STECF, 2022). Landings will be called catch hereafter.

6.9.2.2 EFFORT

Table 6.9.2.2.1. Effort in fishing days by country and GSA for the OTB fishing fleet (fishing blue and red shrimp almost exclusively). Effort from Italy (ITA) regards both GSAs 18 and 19, while effort in GSA 20 refers to the Greek fleet, which however is not reporting catches of this stock (except 2021). Data from FDI.

year	OTB			
	ITA	ITA	GRC	Total
	GSA 19	GSA 18	GSA 20	
2013	69294	36683	6459	112436
2014	49685	36663	6057	92405
2015	52002	37454	5839	95295
2016	54028	38967	5375	98369
2017	53218	35995	6098	95311
2018	60098	34136	5726	99959
2019	50171	32877	5425	88474
2020	39509	25186	5642	70337
2021	41734	30094	5608	77436

6.9.2.3 SURVEY DATA

MEDITS survey

For the assessment of blue and red shrimp the length frequency distributions from the MEDITS survey of GSAs 18, 19 and 20 combined was estimated from DCF 2022 data call using the ad-hoc JRC script (Mannini, 2020). The LFDs for males and females from the combined area were age sliced and then added to obtain the final index-at-age distributions used in the assessment.

MEDITS survey is carried out in GSAs 18, 19 and 20 since 1994. In GSA 20 the survey did not take place in 2002, 2007, 2009-2013, 2015 and 2017 hence data are missing for these years. In addition, blue and red shrimp has not been caught in years 1994-1997, 2000, 2001 and 2004 hence the biomass is zero in those years. In GSA 18, zero biomass (species not found) is reported in 1994, 1995, 2004 and 2006. In GSA 19 the reported biomass (kg/km²) is much greater than in GSAs 18 and 20 with the species being continuously present since 1994. Figure 6.9.2.3.1 shows the relative total biomass and density reported in GSAs 18, 19 and 20, while the total biomass and density in the combined area are shown in Figures 6.9.2.3.2-3. The resulting LFDs for females and males are shown in Figures 6.9.2.3.4-5 respectively.

Figure 6.9.2.3.1 Blue and red shrimp in GSAs 18, 19 & 20: MEDITS relative biomass and relative density in GSAs 18, 19 and 20. For GSA 20 zero values indicate missing surveys in - 2002, 2007, 2009-2013, 2015 and 2017, while zero biomass (species not found) in 1994-1997, 2000, 2001 and 2004.

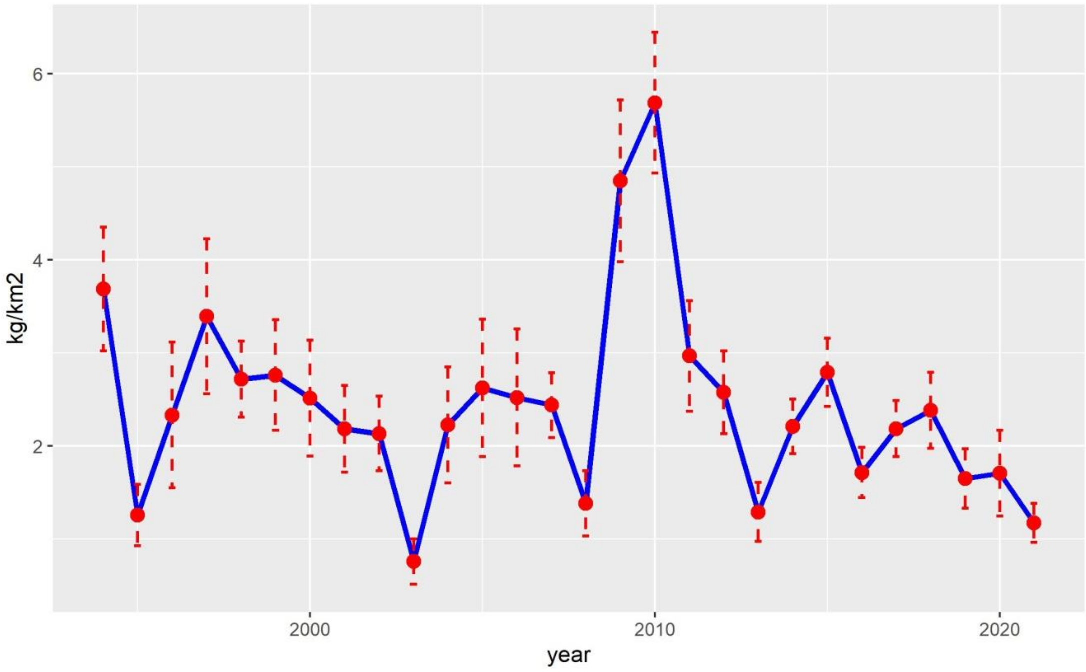


Figure 6.9.2.3.2 Blue and red shrimp in GSAs 18, 19 & 20: MEDITS relative biomass in GSAs 18, 19 and 20 combined.

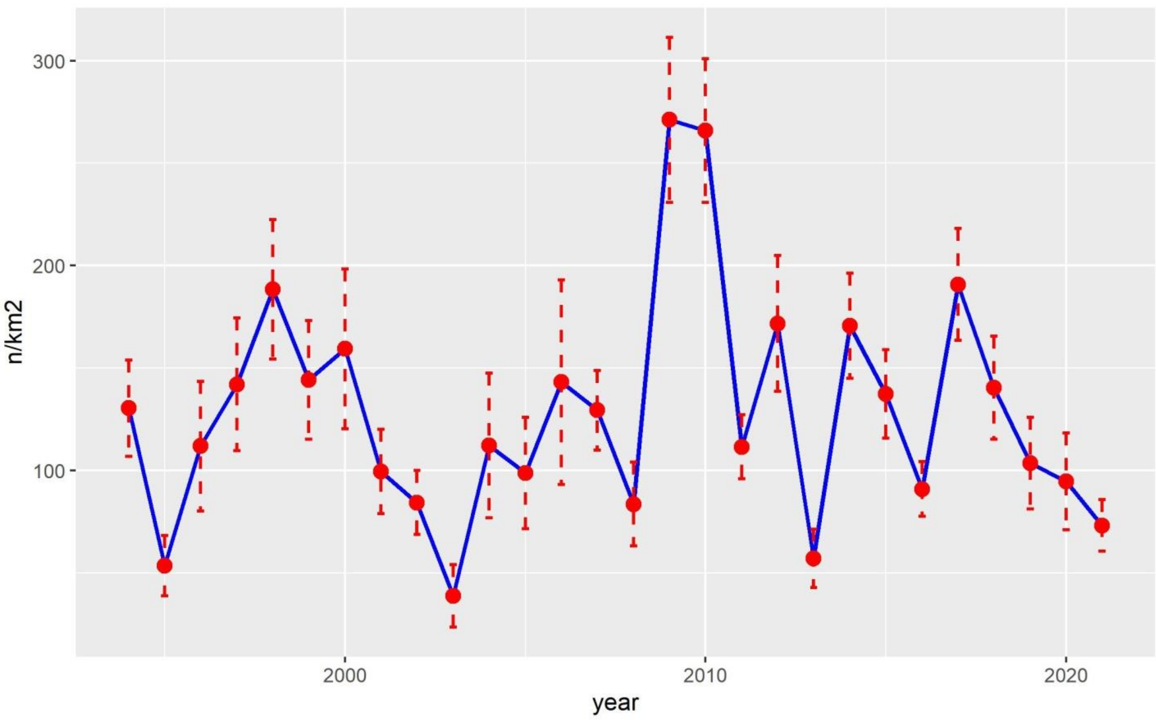


Figure 6.9.2.3.3 Blue and red shrimp in GSAs 18, 19 & 20: MEDITS relative density in GSAs 18, 19 and 20 combined.

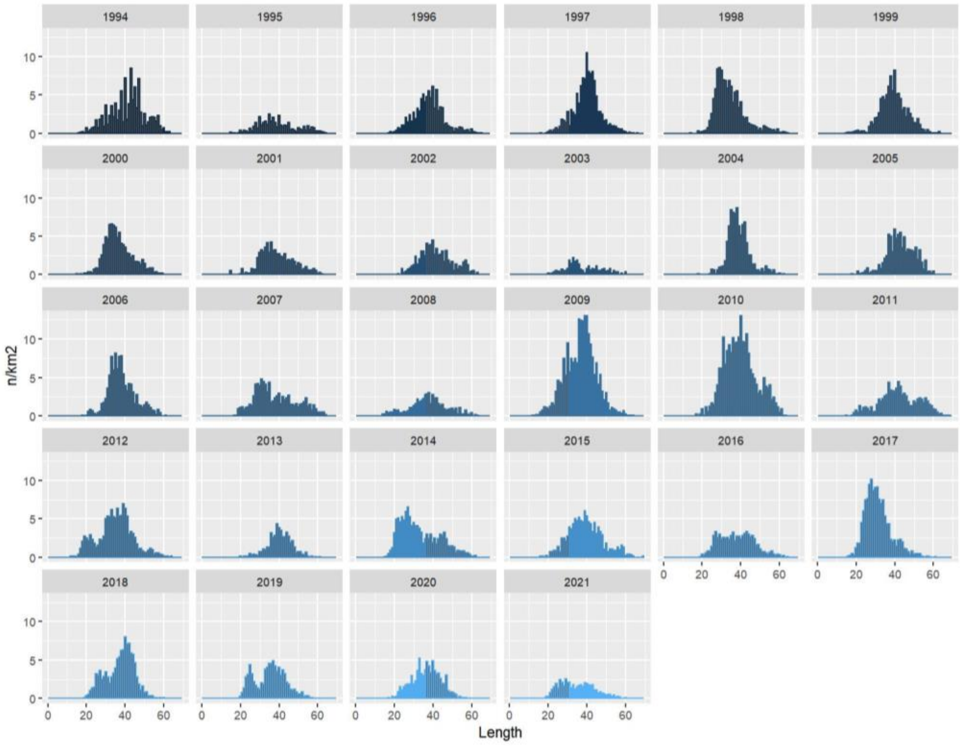


Figure 6.9.2.3.4 Blue and red shrimp in GSA 18, 19 & 20: MEDITS length frequency distributions for females in GSAs 18, 19 and 20 combined.

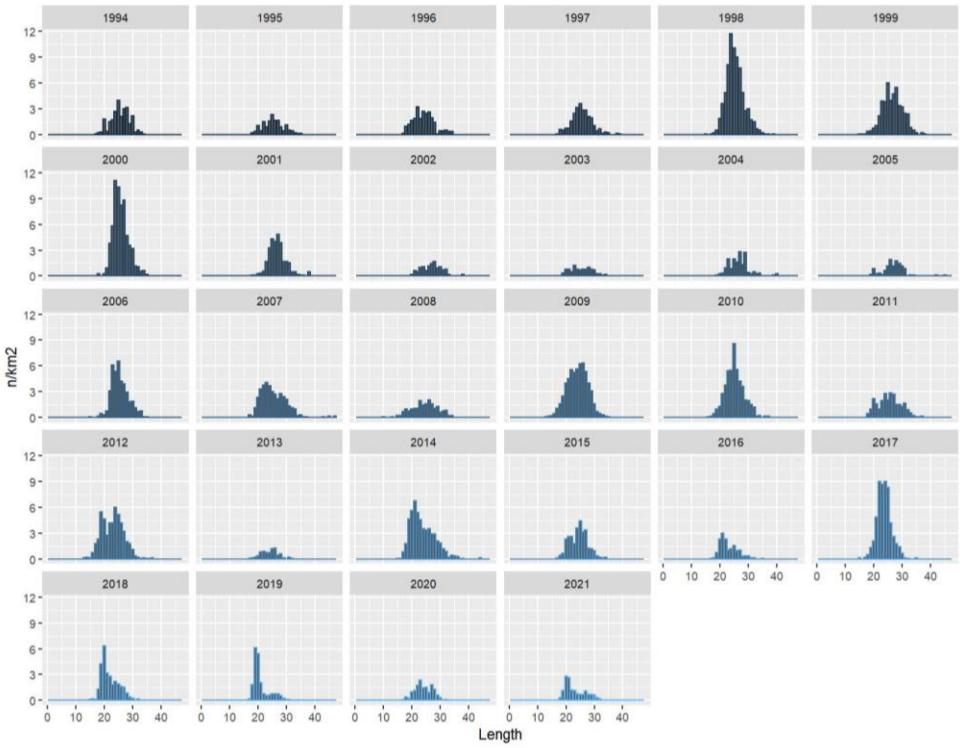


Figure 6.9.2.3.5 Blue and red shrimp in GSA 18, 19 & 20: MEDITS length frequency distributions for males in GSAs 18, 19 and 20 combined.

6.9.3 STOCK ASSESSMENT

The EWG 22-16 decided to perform an age-structured stock assessment of blue and red shrimp in GSAs 18, 19 and 20 combined. Following suggestion of STECF 22-03 the assessment used length frequency distribution data from GSA 19, while survey information was used from all areas combined (STECF, 2022). Accordingly, Von Bertallanfy (VBGF) growth parameters, length-weight relationships, and maturity at age were retrieved from GSA 19 (ITA). Natural mortality was estimated from Chen Watanabe relationship on the basis of the above parameters.

Since STECF 22-03, the VBGF parameters for ITA GSA 19 have been provided by sex allowing a sex separated age slicing.

The assessment was performed over the period 2008-2021. Although data exists since 2003, the group considered the reduced time series in an attempt to capture the observed catch trends, which the model was unable to fit for the full time series.

a4a assessment input

Assessment method: The assessment was performed with a4a statistical catch at age framework developed by the Joint Research Centre (Jardim *et al.*, 2015).

Total catch: The total catch was obtained by adding the catch from all GSAs were available (GSA 18 and GSA 19 (ITA) and GSA 20 (GRC)). Note that the majority of the catch (>85%) comes from GSA 19, while in GSA 20 the species is not fished by the Greek fleets, with reported catch only existing in 2021 (see section 6.9.2.1).

Catch-at-age: The length distributions of catch form GSA 19 (assumed to be identical to landings, due to minimal discards) were split by sex using information for sex ratio (DCF data, GSA 19 (ITA)). The resulting catch distributions by sex were translated to age distributions using the corresponding VBGF relationship of Table 6.9.1.1. Numbers at age by sex were combined to form the total catch by age. Finally, these catch-at-age distributions were re-scaled to sum up to the total catch using SoP correction (Table 6.9.3.1.1). Table 6.9.3.1.1 presents the SoP correction factor applied by year. Few individuals were present at age 0 for both males and females, which were thought to correspond to true age zero individuals and hence a t0 correction was not applied. The age plus group was set to 7. The fishing mortality, Fbar, was estimated as the average fishing mortality of ages 1-3, as the catches are composed mainly of individuals of ages between 1 and 3 years. In the end, in an effort to improve the fit to the MEDITS index, age0 was removed from both catch and index and a second SoP was applied (SoP2 - Table 6.9.3.1.1).

Weight-at-age: The mean weight-at-length was estimated by sex using the length-weight relationships of Table 6.9.1.2. The total weights-at-length of females and males by year were translated to age by performing age slicing. Then, the mean weight-at-age by sex and year was estimated by dividing the total weight of each age class by the total number of individuals of the class. Finally, an average weight-at-age of individuals (sex combined) by year was found as an average of the weights-at-age of females and males, weighted by the total catch numbers-at-age of females and males of that year.

Index-at-age: The MEDITS trawl survey of GSAs 18, 19 and 20 combined was used as tuning index of abundance in the assessment. As with the catch this was sliced by age using 0-7+ age classes and combined afterwards. No t0 correction was used for the index. In the final assessment age0 was removed from the index object. It should be noted that MEDITS data were missing for GSA 20 in years 2004, 2007, 2009-2013, 2015 and 2017. The effect of the missing years on the final distributions of the index at-age was checked and found to be minimal.

All of the above were performed with the ad-hoc scripts provided from JRC.

Tables 6.9.3.1.2 to 6.9.3.1.5 contain input data of the assessment of blue and red shrimp: total catch, catch at age, mean weight at age, maturity and natural mortality vectors and MEDITS index catch numbers at age. Figures 6.9.3.1.1 and 6.9.3.1.2 show the age distributions of the catch and the MEDITS index by year. The mean weight by age of the catch by year is shown in Figure 6.9.3.1.3. Consistency of catch and index at age distributions are shown in Figures 6.9.3.1.4-5. Both index and catch consistency is poor.

Table 6.9.3.1.1 Blue and red shrimp in GSAs 18, 19 & 20: Vector of Sum of Products correction (SoP) applied to the catch distributions in two steps prior to assessment. Initially for years 2003 to 2021 (SoP1) and then for years 2008 to 2021 (SoP2) after removing years 2003-2007 and age 0 from the initial catch-at-age object (stk0).

year	SoP1	SoP2
2003	1.65379	-
2004	1.15202	-
2005	1.08861	-
2006	1.10047	-
2007	1.08938	-
2008	1.08045	1.000088
2009	1.11526	1.000020
2010	1.12783	1.000292
2011	1.17636	1.000388
2012	1.04654	1.002109
2013	1.02351	1.000250
2014	1.01992	1.000287
2015	1.14746	1.000215
2016	1.17646	1.000239
2017	2.32044	1.000353
2018	1.23227	1.000587
2019	1.17682	1.000031
2020	1.21403	1.000011
2021	1.20153	1.000554

Table 6.9.3.1.2 Blue and red shrimp in GSAs 18, 19 & 20: Total catch in tonnes.

year	2008	2009	2010	2011	2012	2013	2014
data	206.48	239.15	228.12	184.82	267.71	247.01	302.16
year	2015	2016	2017	2018	2019	2020	2021
data	89.44	119.78	63.94	403.53	457.88	240.77	300.52

Table 6.9.3.1.3 Blue and red shrimp in GSAs 18, 19 & 20: Catch numbers at age in thousands, informed from GSA 19 data.

age	2008	2009	2010	2011	2012	2013	2014
1	4946.49	1997.25	4278.21	4094.48	12670.71	6229.02	7500.13
2	9754.93	5211.60	5447.46	5043.64	6528.25	7386.32	10192.19
3	2059.34	4710.08	3185.25	2225.60	3149.34	3503.22	3843.37
4	639.42	1826.48	1380.88	1095.61	1355.03	1234.70	1558.69
5	145.02	362.75	464.31	370.05	372.48	355.15	435.03
6	103.35	63.85	331.80	190.30	191.48	133.10	96.53
7+	38.38	37.74	138.89	141.52	111.86	80.29	49.39
age	2015	2016	2017	2018	2019	2020	2021
1	2862.12	1754.79	13144.51	9863.64	3402.52	7329.65	2862.12
2	5097.72	1929.85	16821.96	18574.33	6247.63	10544.18	5097.72
3	1334.02	679.51	4951.31	6258.47	3971.18	4497.56	1334.02
4	350.30	341.64	1103.32	1593.56	1629.19	1256.15	350.30
5	130.16	137.75	203.55	326.26	385.71	279.52	130.16
6	62.81	51.05	74.89	116.94	135.84	106.67	62.81
7+	39.05	26.49	17.20	24.70	45.60	31.08	39.05

Table 6.9.3.1.4 Blue and red shrimp in GSAs 18, 19 & 20: Catch mean weight at age in kg, informed from GSA19 data.

age	2008	2009	2010	2011	2012	2013	2014
1	0.0061	0.0063	0.0059	0.0060	0.0053	0.0058	0.0058
2	0.0111	0.0121	0.0113	0.0110	0.0110	0.0114	0.0115
3	0.0189	0.0203	0.0202	0.0202	0.0201	0.0200	0.0197
4	0.0276	0.0275	0.0277	0.0279	0.0278	0.0277	0.0280
5	0.0363	0.0356	0.0364	0.0360	0.0359	0.0358	0.0356
6	0.0445	0.0436	0.0440	0.0439	0.0440	0.0437	0.0436
7+	0.0543	0.0570	0.0531	0.0547	0.0551	0.0537	0.0533
age	2015	2016	2017	2018	2019	2020	2021
1	0.0059	0.0061	0.0059	0.0058	0.0062	0.0059	0.0057
2	0.0114	0.0113	0.0114	0.0113	0.0116	0.0119	0.0113
3	0.0196	0.0192	0.0195	0.0191	0.0192	0.0199	0.0199
4	0.0272	0.0275	0.0283	0.0270	0.0270	0.0277	0.0273
5	0.0363	0.0362	0.0361	0.0361	0.0359	0.0358	0.0362
6	0.0436	0.0439	0.0440	0.0432	0.0432	0.0434	0.0432
7+	0.0553	0.0546	0.0531	0.0540	0.0540	0.0530	0.0529

Table 6.9.3.1.5 Blue and red shrimp in GSAs 18, 19 & 20: Maturity, natural mortality, proportion of m and f before spawning, informed from GSA 19 data.

age	1	2	3	4	5	6	7+
Natural mortality	0.726	0.517	0.423	0.359	0.322	0.301	0.285
Maturity	0.49	0.97	1.00	1.00	1.00	1.00	1.00
Harvest before spawn	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Maturity before spawn	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table 6.9.3.1.6 Blue and red shrimp in GSAs 18, 19 & 20: MEDITS numbers per km^2 at age (from GSA 18, 19 and 20 combined).

age	2008	2009	2010	2011	2012	2013	2014
1	14.67	50.64	28.40	18.12	51.86	5.34	69.77
2	22.20	87.60	88.55	25.41	57.08	10.67	54.05
3	17.56	75.78	65.35	24.04	36.65	20.53	17.81
4	7.88	33.48	40.21	16.86	14.02	13.22	13.96
5	3.60	13.85	15.28	6.48	3.69	4.83	6.87
6	3.22	4.50	15.12	8.40	3.72	2.14	3.77
7+	2.46	3.44	13.08	12.22	2.78	0.44	3.75
age	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	19.91	18.30	67.31	33.11	33.67	16.13	20.11
2	46.09	28.95	93.00	34.13	26.13	32.72	21.05
3	31.42	16.34	17.06	38.58	24.49	24.91	11.44
4	19.18	15.14	8.86	26.22	12.31	13.09	6.42
5	9.06	6.74	2.30	5.49	3.88	5.89	2.70
6	3.82	2.40	1.64	1.94	2.17	1.66	1.81
7+	7.85	3.16	0.44	0.60	0.66	0.33	0.97

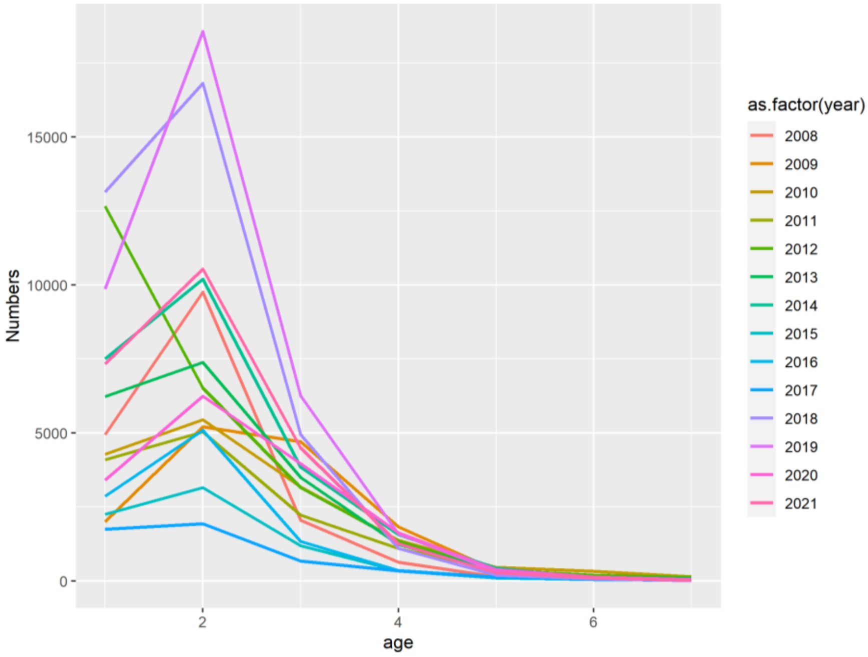


Figure 6.9.3.1.1 Blue and red shrimp in GSAs 18, 19 & 20: Catch numbers in thousands at age (informed from GSA 19 data and raised to the total catch of GSA 18, 19 and 20 with SoP).

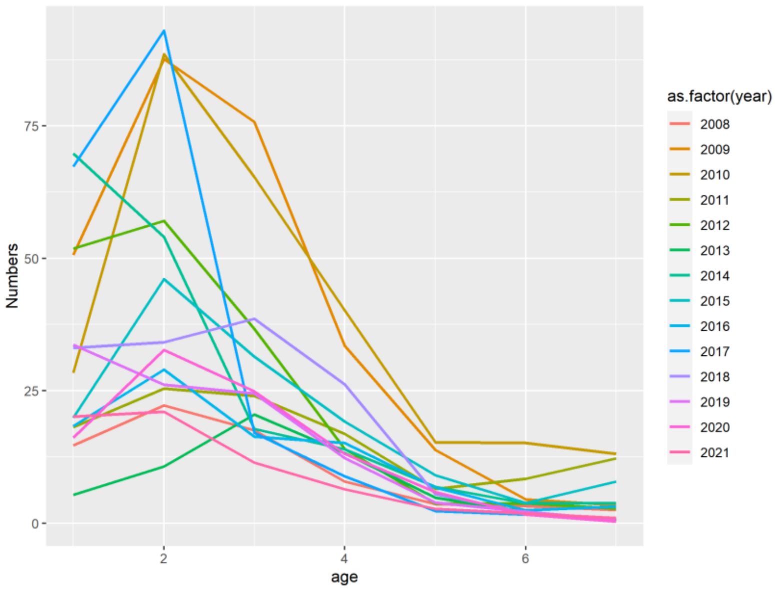


Figure 6.9.3.1.2 Blue and red shrimp in GSAs 18, 19 & 20: MEDITS tuning index numbers at age (GSA 18, 19 and 20 combined).

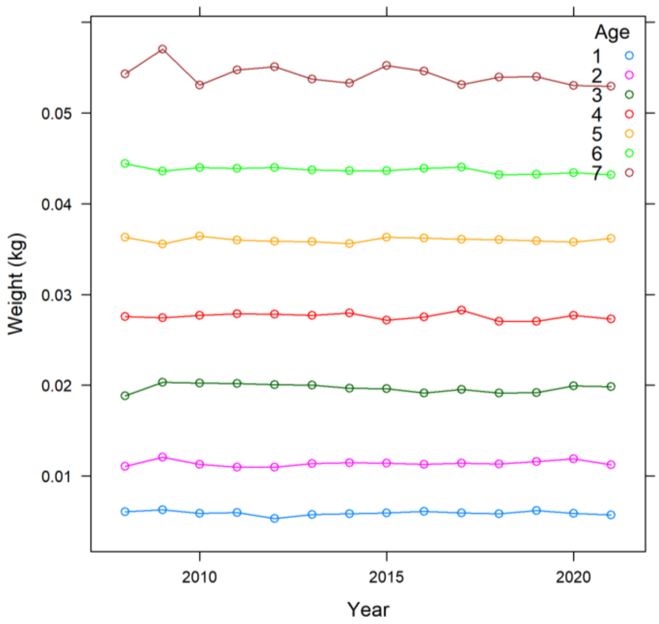


Figure 6.9.3.1.3 Blue and red shrimp in GSAs 18, 19 & 20: Mean weight at age for sexes combined.

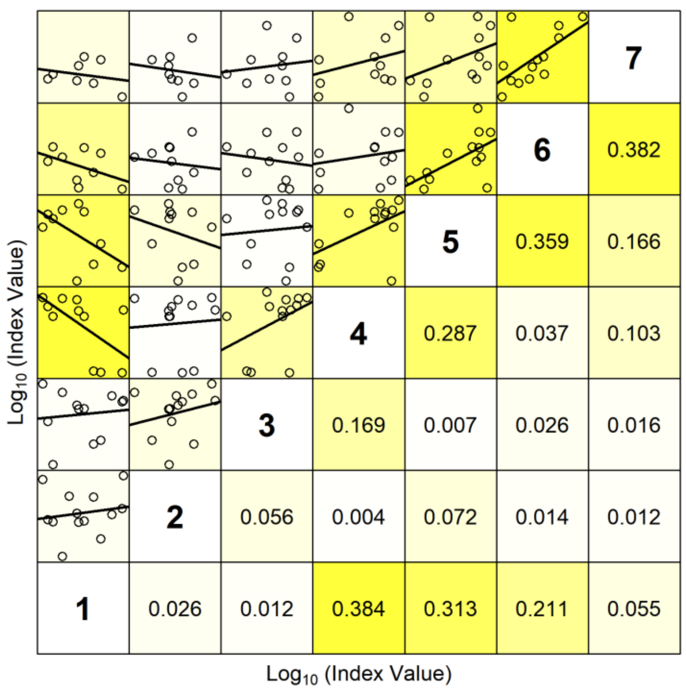


Figure 6.9.3.1.4 Blue and red shrimp in GSAs 18, 19 & 20: Consistency of catch-at-age distributions.

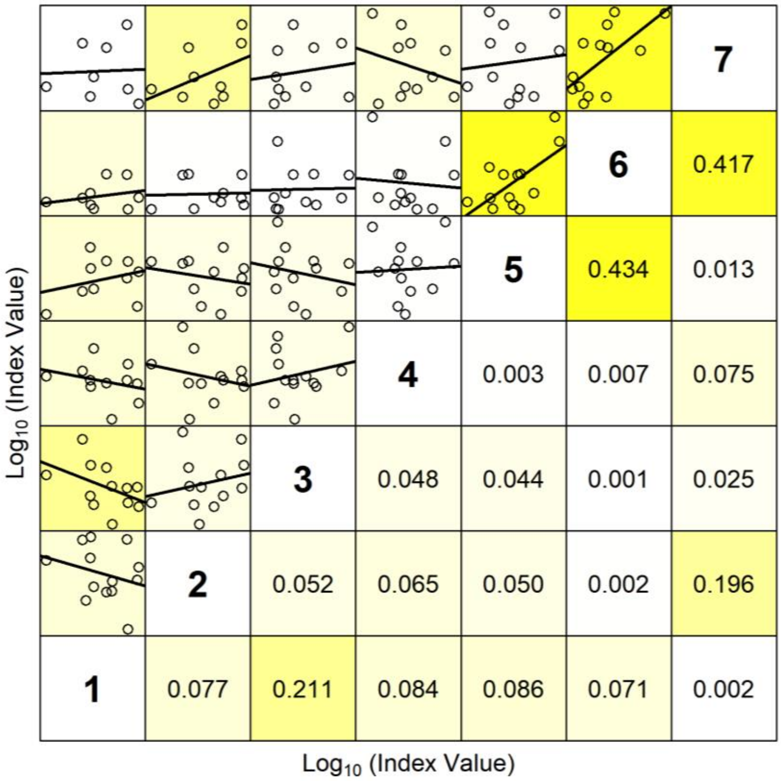


Figure 6.9.3.1.5 Blue and red shrimp in GSAs 18, 19 & 20: Consistency of index-at-age distributions.

Assessment results

Several different model settings were tested. In the final a4a model setting adopted, the fishing mortality was assumed to be a 4th order spline of age and a 7th order spline of year. Catchability was assumed to be a factor of age (constant after age 5) and stock recruitment a geometric mean with CV=0.6. In particular,

```
fmodel  <-  ~ s(age, k=4)) + s(year, k=7)
qmodel  <-  list(~ factor(replace(age, age>5,5)))
srmodel <-  geomean(CV=0.6)
```

The results of the assessment are presented in Figures 6.9.3.2.1 to 6.9.3.2.3. Estimated recruits, spawning stock biomass, catch and harvest rates for ages 1 - 3 are shown in Figure 6.9.3.2.1. Fishing mortality by age and year and catchability of the gear of the MEDITS survey tuning index by age and year are shown in Figures 6.9.3.2.2 and 6.9.3.2.3 respectively.

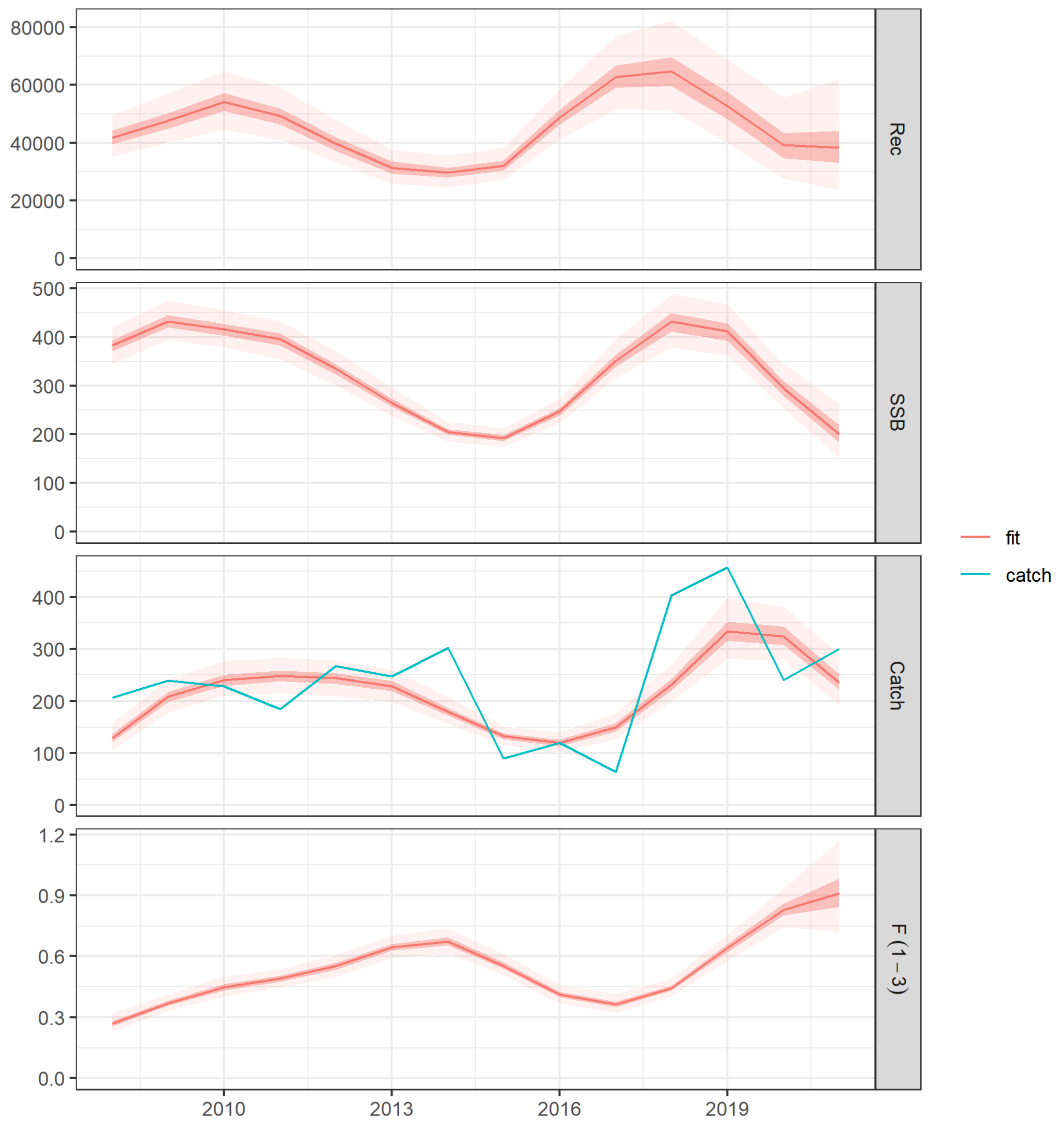


Figure 6.9.3.2.1 Blue and red shrimp in GSAs 18, 19 & 20: Stock summary of the final a4a model. Evolution of recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3) in the period 2008 to 2021. The light blue line in the catch panel is the observed total catch.

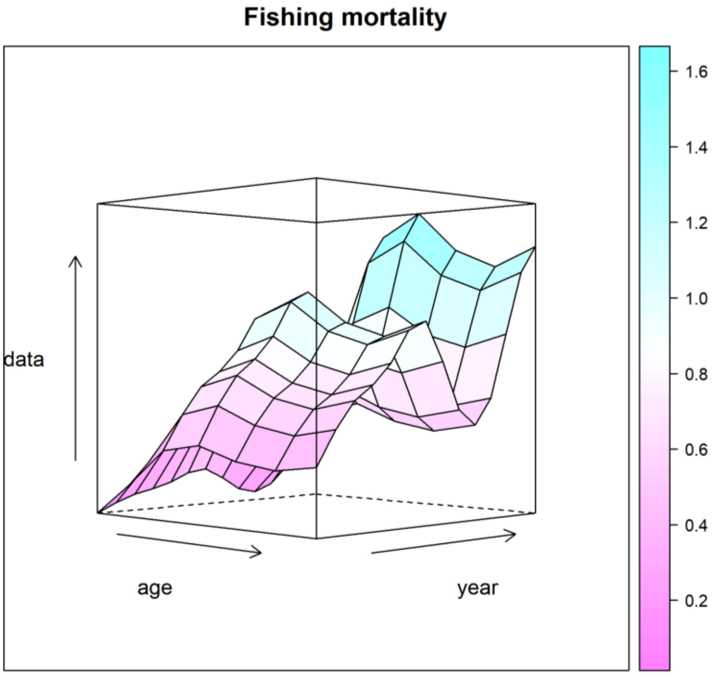


Figure 6.9.3.2.2 Blue and red shrimp in GSAs 18, 19 & 20: 3D contour plot of estimated fishing mortality by age and year.

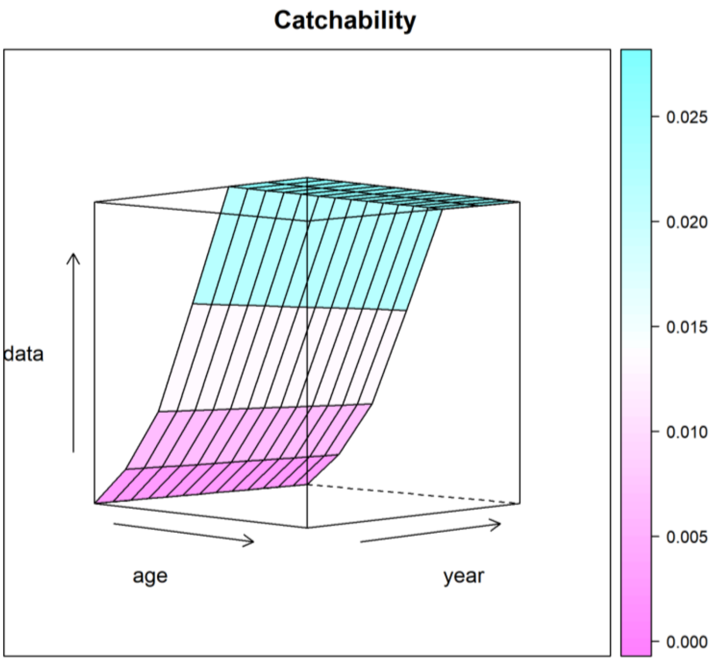


Figure 6.9.3.2.3 Blue and red shrimp in GSAs 18, 19 & 20: 3D contour plot of estimated catchability of the MEDITS tuning index by age and year.

Diagnostics

Diagnostic plots for the goodness of fit of the selected model for the assessment of Blue and red shrimp stock are presented in Figures 6.9.3.2.4 - 6.9.3.2.7. Residuals at age in the catch show consistent over or underestimation in ages 1, 2, and 7. Residuals for the survey index are better with underestimation in age 5 (Figures 6.9.3.2.4 and 6.9.3.2.5). Fitted versus observed catch at age and MEDITS index at age show poor fit especially in ages 1, 2 and 3 (Figure 6.6.3.2.6 and 6.6.3.2.7).

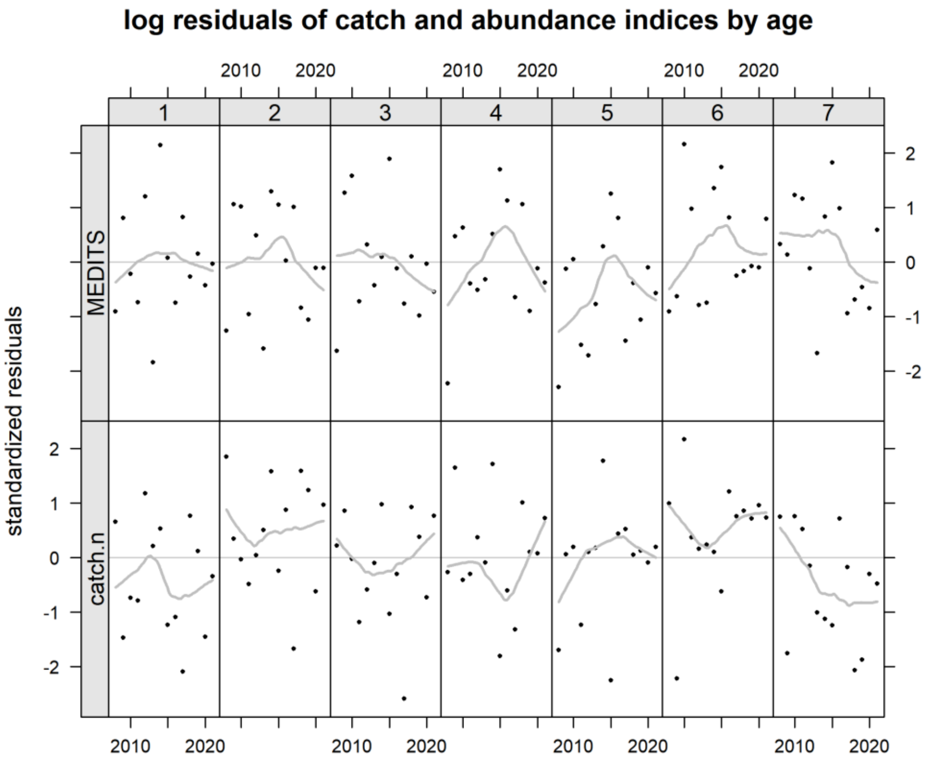


Figure 6.9.3.2.4 Blue and red shrimp in GSAs 18, 19 & 20: Standardized log residuals for the fitted model for catch numbers at age and index abundances.

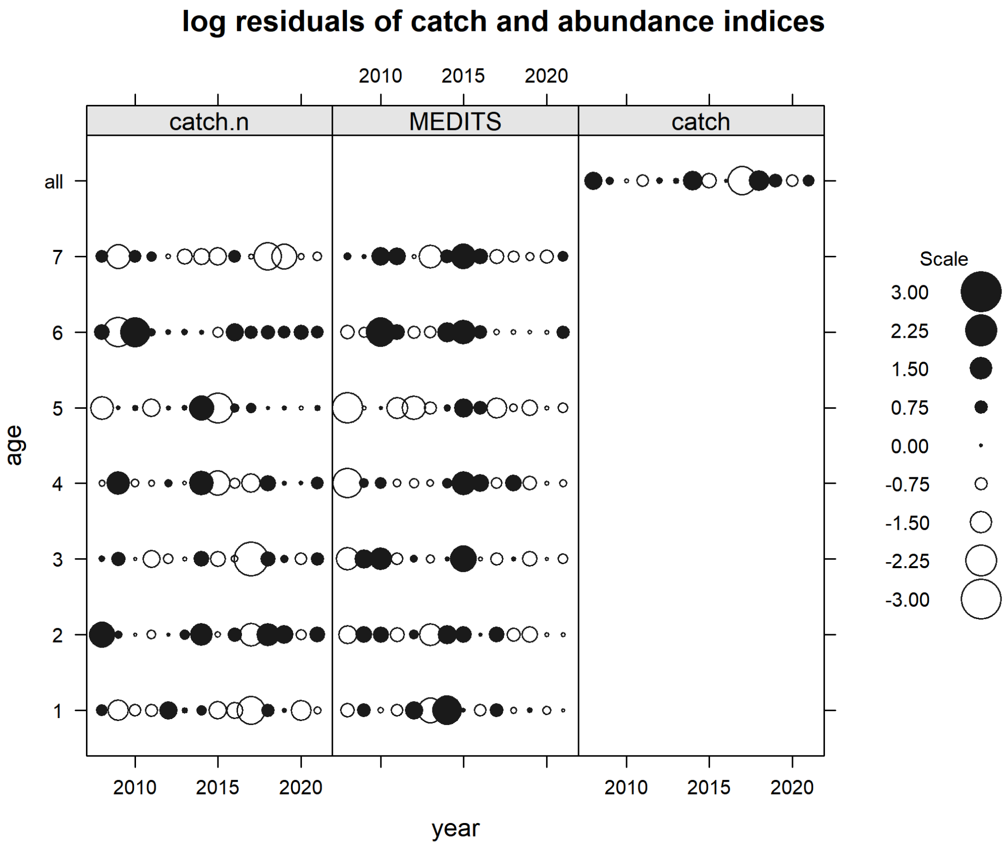


Figure 6.9.3.2.5 Blue and red shrimp in GSAs 18, 19 & 20: Standardized log residuals for the fitted model for catch numbers at age, index abundances and total catch presented in a bubble plot.

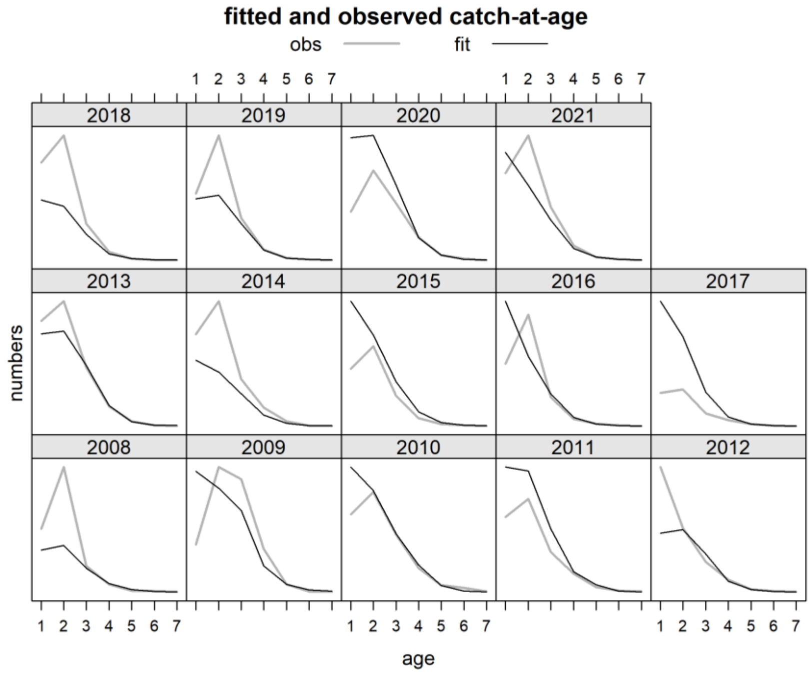


Figure 6.9.3.2.6 Blue and red shrimp in GSAs 18, 19 & 20: Estimated versus observed catch at age.

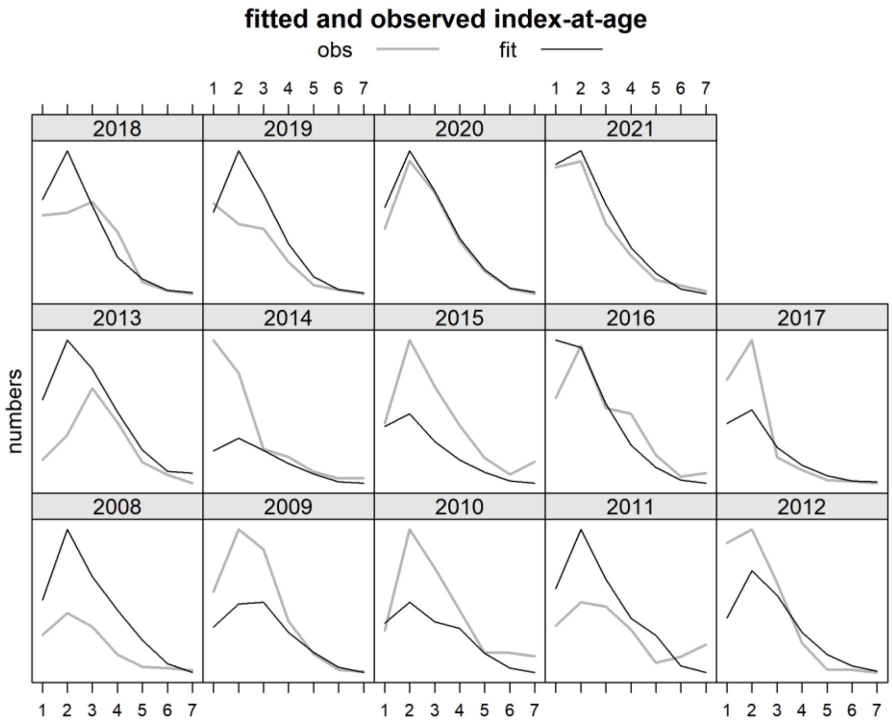


Figure 6.9.3.2.7 Blue and red shrimp in GSA 18, 19 & 20: Estimated versus observed index at age.

Retrospective

The retrospective analysis showed significant uncertainty and pattern especially in fishing mortality and SSB, hence the estimated $F_{0.1}$ (F_{MSY} proxy) was not considered reliable basis for advice. However, fishing mortality is consistently above $F_{0.1}$ reference point for all years in all retrospective runs. In addition, the stock status in term of F/ $F_{0.1}$ (F/F_{MSY} proxy) was fairly consistent among all different model settings tested, indicating overexploitation of the stock.

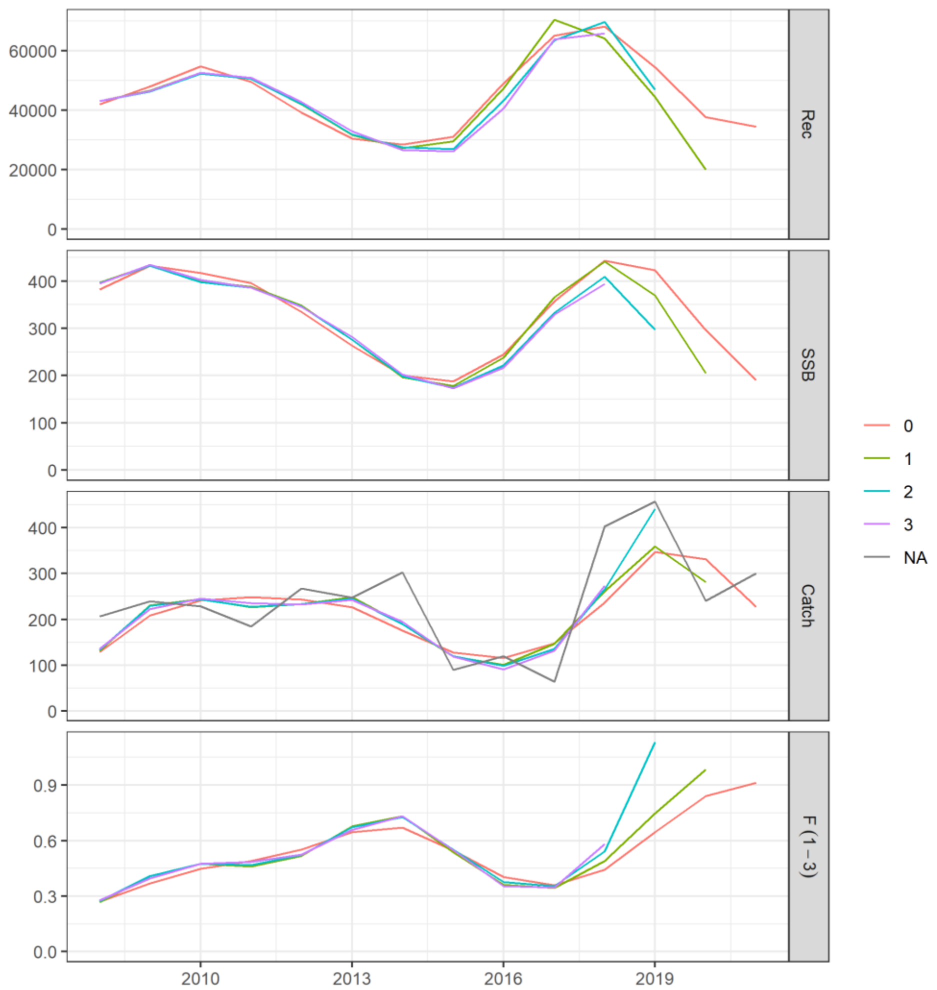


Figure 6.9.3.2.8 Blue and red shrimp in GSAs 18, 19 & 20: Retrospective plots for recruitment, SSB (Spawning Stock Biomass), Catch and Harvest rate (ages 1-3). The different trajectories are obtained by removing 0 to 3 final years of data and re-running the assessment, hence the red curve corresponds to final assessment. The black line in the catch panel is the observed total catch.

Stock Summary

Table 6.9.3.2.1 presents a summary of the a4a stock assessment for blue and red shrimp, showing average values of recruitment, ssb, catch, fishing mortality and total biomass per year. Tables 6.9.3.2.2 and 6.9.3.2.3 contain fishing mortality-at-age and catch-at-age per year. The assessment results show decrease of recruitment, spawning stock biomass and catch in recent years. Estimated catch is fluctuating around 100 and 400 tonnes. The average fishing mortality, Fbar, is increasing in recent years and is estimated to 0.914 in 2021. The model could not adequately capture the observed catch historical trend, while the fishing mortality shows a significant retrospective pattern. For the above reasons, EWG 22-16 concluded that the a4a model was suitable to give a general guide for the exploitation rate over much of the period of the assessment but was not suitable to provide the basis of the current status of the stock in 2021 or to give catch options at specified Fishing Mortalities (E.g. $F_{0.1}$).

Table 6.9.3.2.1 Blue and red shrimp in GSAs 18, 19 & 20: Stock summary results for a4a model. Recruitment (age1), spawning stock biomass (ssb), catch, mean fishing mortality of ages 1-3 (fbar) and total biomass.

year	**recruitment (numbers)**	**ssb (tonnes)**	**catch (tonnes)**	**fbar (1-3)**	**total biomass (tonnes)**
2008	41906.73	380.61	128.09	0.269	706.75
2009	47717.61	431.18	206.85	0.369	844.02
2010	54043.17	414.41	239.54	0.446	854.8
2011	49172.29	393.47	246.85	0.489	823.21
2012	39648.12	333.73	242	0.55	702.1
2013	31255.16	264.87	227.33	0.644	590.1
2014	29637.35	204.43	179.03	0.671	475.75
2015	32031.74	191.94	131.47	0.555	434.73
2016	48887.45	246.44	118.83	0.411	553.48
2017	62858.22	351.72	148.9	0.363	750.17
2018	64925.32	429.51	230.6	0.443	908.13
2019	52631.75	408.63	332.45	0.638	925.9
2020	38973.09	292.26	322.67	0.831	724.79
2021	38382.6	197.4	233.06	0.914	532.67

Table 6.9.3.2.2 Blue and red shrimp in GSA 18, 19 & 20: Fishing mortality at age by year.

age	2008	2009	2010	2011	2012	2013	2014
1	0.116	0.159	0.192	0.211	0.237	0.277	0.289
2	0.262	0.360	0.436	0.478	0.537	0.628	0.655
3	0.428	0.588	0.711	0.779	0.877	1.025	1.069
4	0.460	0.631	0.764	0.837	0.942	1.101	1.148
5	0.402	0.552	0.668	0.732	0.823	0.963	1.004
6	0.376	0.516	0.624	0.684	0.769	0.900	0.938
7+	0.401	0.550	0.666	0.730	0.821	0.960	1.001
age	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	0.177	0.157	0.191	0.275	0.358	0.394	0.177
2	0.401	0.355	0.433	0.623	0.811	0.893	0.401
3	0.655	0.579	0.706	1.016	1.324	1.457	0.655
4	0.703	0.622	0.758	1.092	1.422	1.565	0.703
5	0.615	0.544	0.663	0.955	1.244	1.368	0.615
6	0.575	0.508	0.619	0.892	1.162	1.278	0.575
7+	0.613	0.542	0.661	0.951	1.239	1.364	0.613

Table 6.9.3.2.3 Blue and red shrimp in GSA 18, 19 & 20: Estimated Catch numbers at age by year.

age	2008	2009	2010	2011	2012	2013	2014
1	3280.09	5033.68	6797.15	6727.29	6026.71	5466.94	5379.59
2	3657.19	4334.85	5536.82	6517.50	6385.77	5643.90	4417.55
3	1896.03	3420.94	3217.16	3457.75	3918.27	3635.28	2672.35
4	691.78	1125.16	1556.70	1196.38	1214.23	1268.32	940.90
5	218.72	357.46	442.63	499.72	363.44	340.56	282.89
6	75.02	130.55	165.02	168.77	181.73	123.51	93.47
7+	29.26	71.05	105.85	117.34	118.00	115.62	74.14
age	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1	4908.15	5701.80	6536.00	8110.92	9142.33	8514.91	9090.20
2	3582.83	3201.83	4690.98	7257.28	9639.47	8696.99	6303.23
3	1754.79	1494.05	1784.30	3509.83	5427.17	5212.65	3386.00
4	574.82	418.94	504.04	819.75	1547.52	1591.81	1014.57
5	173.18	117.08	121.44	201.26	316.11	394.82	266.74
6	64.11	42.52	40.02	56.85	92.80	99.80	84.37
7+	43.29	30.16	28.26	36.18	48.49	50.78	36.92

6.9.4 REFERENCE POINTS

The FLBRP package allowed a Yield per recruit analysis and an estimate of F-based Reference Point $F_{0.1}$ (Kell & Scott, 2020). Yield per Recruit computation was made using R project software and the FLR libraries (R Core Team, 2020; Kell *et al.*, 2007). The fishing mortality rate corresponding to $F_{0.1}$ in the yield per recruit curve is considered here as a proxy of F_{MSY}. The FLBRP package was supplied with input and output parameters of the a4a assessment. The resulting reference point for the end year of the assessment based on the separable model for the whole assessment was estimated to $F_{0.1}$=0.206.

6.9.5 SHORT TERM FORECAST AND CATCH OPTIONS

Due to significant retrospective pattern in F and inability of the model to fit the observed catch, STECF 22-16 decided that advice for this stock should not be given on an $F_{0.1}$ (proxy of F_{MSY}) basis. Instead, a fishing mortality status quo has been applied to derive corresponding catches in 2023. A deterministic short term prediction for the period 2021 to 2023 was performed using the FLR routines provided by JRC. F status quo was set equal to the fishing mortality of the end year of the assessment (2021), corresponding to a catch of 233.06 tonnes. Recruitment 2021 and 2022 was set to 43882.7 thousands (equal to the geometric mean recruitment of all the years in the assessment, 2008-2021). Biological parameters (maturity, natural mortality, mean weights) and fishery selection were set to the mean of the last three assessment years. Table 6.9.5.1 includes information on the conditioning of the short term forecast. Table 6.9.5.2 contains the forecast results, namely the expected catch and spawning stock biomass under a range of different fishing mortality scenarios. The STF table is provided for illustrative reasons only. The EWG does not consider that the catch options at a specified F are reliable. F status quo gives an indication of catch at current exploitation levels.

Table 6.9.5.1 Blue and red shrimp in GSAs 18, 19 & 20: Assumptions made for the interim year and the forecast.

Variable	Value	Notes
Biological parameters		maturity, natural mortality, mean weights and fishery selection taken as mean of last three years 2019-2021
$F_{ages\ 1\text{-}3}$ (2022)	0.914	F 2021 used to give F status quo for 2022
SSB (2022)	180.5	Stock assessment 1 January 2022
R_{age0} (2022,2023)	43882.7	Geometric mean of series (2008 to 2021)
Total catch (2022)	196.1	Assuming F status quo for 2022

Table 6.9.5.2 Blue and red shrimp in GSAs 18, 19 & 20: Short term forecasts showing catch options and ssb (spawning stock biomass) for different fishing mortality scenarios. The table below is provided for illustrative reasons only; the EWG does not consider that the catch options at a specified F are reliable. F status quo gives an indication of catch at current exploitation levels.

Rationale	Ffactor	Fbar (1-3)	F 2022	Catch 2023	SSB 2022	SSB 2024	SSB 2022-2024 (%change)	Catch 2021-2023 (%change)
High long-term yield ($F_{0.1}$)	0.225	0.206	0.914	58.56	180.46	368.92	104.44	-74.87
F_{upper}	0.313	0.286	0.914	78.38	180.46	337.58	87.07	-66.37
F_{lower}	0.152	0.139	0.914	40.74	180.46	398.45	120.80	-82.52
F_{MSY} transition	0.903	0.826	0.914	181.63	180.46	199.83	10.74	-22.07
Zero catch	0	0.000	0.914	0.00	180.46	470.75	160.87	-100.00
Status quo	1	0.914	0.914	194.61	180.46	185.50	2.79	-16.50
Different Scenarios	0.1	0.091	0.914	27.38	180.46	421.42	133.53	-88.25
	0.2	0.183	0.914	52.49	180.46	378.83	109.93	-77.48
	0.3	0.274	0.914	75.56	180.46	341.94	89.49	-67.58
	0.4	0.366	0.914	96.80	180.46	309.88	71.72	-58.47
	0.5	0.457	0.914	116.38	180.46	281.92	56.23	-50.06
	0.6	0.549	0.914	134.48	180.46	257.46	42.67	-42.30
	0.7	0.640	0.914	151.22	180.46	235.98	30.77	-35.11
	0.8	0.731	0.914	166.76	180.46	217.06	20.28	-28.45
	0.9	0.823	0.914	181.18	180.46	200.33	11.01	-22.26
	1.1	1.006	0.914	207.13	180.46	172.29	-4.52	-11.13
	1.2	1.097	0.914	218.81	180.46	160.51	-11.05	-6.11
	1.3	1.189	0.914	229.74	180.46	149.95	-16.90	-1.42
	1.4	1.280	0.914	239.98	180.46	140.47	-22.16	2.97
	1.5	1.372	0.914	249.58	180.46	131.92	-26.90	7.09
	1.6	1.463	0.914	258.61	180.46	124.19	-31.18	10.96
	1.7	1.554	0.914	267.10	180.46	117.18	-35.06	14.61
	1.8	1.646	0.914	275.10	180.46	110.81	-38.59	18.04
	1.9	1.737	0.914	282.65	180.46	105.00	-41.81	21.28
	2	1.829	0.914	289.78	180.46	99.69	-44.76	24.34

Discussion

The assessment of blue and red shrimp in GSAs 18, 19 & and 20 has been attempted for the first time in STECF 22-16. Following the recommendations of data quality checking STECF 22-03 (STECF, 2022) an a4a assessment utilizing catch length distributions from GSA 19 and MEDITS data from GSAs 18, 19 and 20 combined was attempted. In addition, Von Bertalanffy growth parameters, length-weight relationship, maturity and mortality by age were also taken from GSA 19 (ITA) (DCF data call 2022). The same growth parameters were also used to age-slice the MEDITS survey index. The assessment was informed with data from DCF 2022 data call, which showed no significant differences to the data analysed during STECF 22-03, except from updated VBGF parameters from ITA (GSA 19), which differed by sex, allowing a sex separated age slicing.

The input age distributions to the assessment showed poor consistency both for the catch and the index. The final a4a assessment was not able to capture the observed catch time series. In addition, significant patters and uncertainty was detected by the retrospective analysis especially for fishing mortality. For these reasons, the assessment was considered provisional and no advice on the basis of F_{MSY} is given.

Table 6.9.6.1 Blue and red shrimp in GSAs 18, 19 & 20: F and F/ $F_{0.1}$ for last year of assessment, for the update assessment of EWG 21-15 and the previous assessment of (EWG 20-15).

Year	Fbar	F/ $F_{0.1}$
EWG 22-16 (ref year 2019)	0.638	3.14
EWG 22-16 (ref year 2020)	0.831	3.88
EWG 22-16 (ref year 2021)	0.914	4.03

6.9.6 DATA DEFICIENCIES

Data deficiencies were described in STECF 22-03. Main issues detected were:

The same VBGF parameters have been provided for both sexes for both GSA 19 and GSA 18 (ITA). This issue has been dealt with. Since STECF 22-03, Italy provided revised growth parameters separate by sex for both GSAs 19 and 18.

No landings data were reported from 2002 to 2007 and 2019 for GSA 18 (ITA). This was not the case with data provided to STECF 22-16, were landings were missing for years 2002, 2003, 2013, 2019 and 2020 (see below).

No landings data were reported for 2002 for GSA 19 (ITA). This was still the case with data provided to STECF 22-16.

During STECF 22-16 additional data issues detected were:

No landings data reported in years 2002, 2003, 2013, 2019 and 2020 for GSA 18 (ITA) in the provided data. These were retrieved from 2021 DCF data call.

NA in gear in GSA 18 for year 2006.

NA in gear in GSA 19 for year 2003.

6.10 STRIPED VENUS CLAM IN GSAS 17 & 18

6.10.1 STOCK IDENTITY AND BIOLOGY

STECF EWG 22-16 was asked to assess the state of Striped Venus Clam (SVE) in the GSAs 17 and 18 (Figure 6.10.1.1). The GSAs 17 and 18 (North and South Adriatic Sea) are neighbouring GSAs, with the first reporting landings of around 19.9 thousand tons of SVE, while GSA 18 reported around 200 tons as the average of the last three years.

In 2021, SVE is targeted by a fleet of 501and 76 Italian vessels using hydraulic dredges (DRB)in GSA 17 and 18 respectively, . The current maximum effort is set to a maximum of 4 days per week with a maximum daily landing per vessel of 0.4 tons of calms with total length greater than 22mm. These numbers, however, have gone through significant changes since the start of the fishery (1974). In 1974 there were 240 boats using traditional small dredges equipped with water pumps and 143 vessels using the large fishing iron cage still in use nowadays. In 1975 annual landings overreached 50 thousand tons, but landings quickly diminished. Ten years later dredges had increased to 607 in the same area and peaked at 778 in 1993. After 1993, the fleet started decreasing likely in response to European, National and Regional management plans which led to a reduction of fishing capacity from 665 Adriatic vessels in 1998 to 585 ships in 2002 (plus 65 boats authorised to catch and sell *Callista chione* only) and these numbers have remained substantively the same until now. Alongside vessel reduction, the daily quota per vessel and number of fishing days per week was lowered over the years; from 2500 kg in 1986 to 600 kg in 1989 and to 400 kg in 2017 (DM 27/12/2016, transposing EU Regulation 2376/2016).

Since 1995, the Italian management of the fishery is entrusted by the MIPAAF to the Bivalve Molluscs Management Consortia, established under Ministerial Decree (MD) 44/1995 and 515/1998 and recognised by the Ministry of Agriculture, Food and Forestry. The operational procedures and the prerogatives of the Consortia are defined by the Ministerial Decree of 22 December 2000 that amends DM 21/7/1998, which regulates the fishing of bivalve molluscs based upon the principle that, given the heterogeneity of environmental realities along the Italian coasts, Consortia are better suited to locally manage the effort and other conservation strategies for achieving National and European targets by adopting *ad hoc* management strategies by imposing more restrictive measures as a function of stock size and resilience.

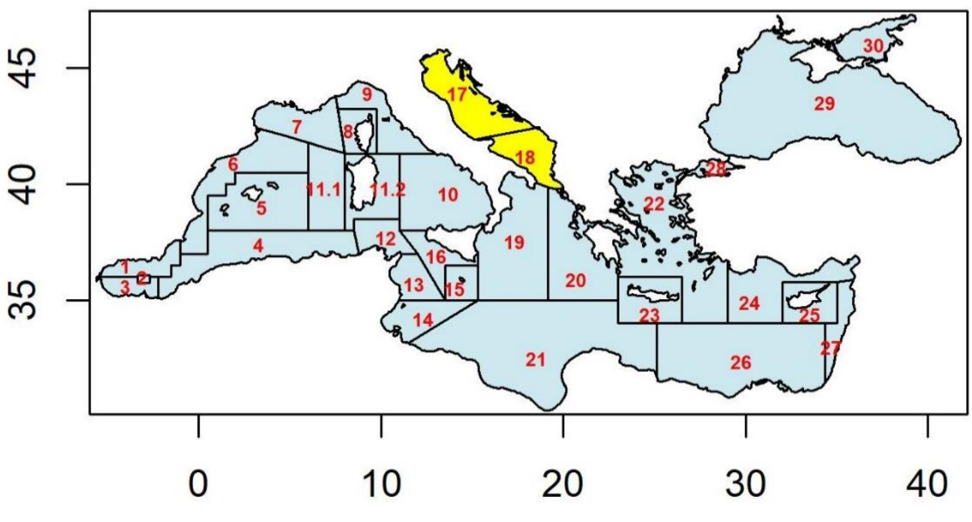


Figure 6.10.1.1. Striped Venus Clam in GSA 17 & 18. Geographical location of GSAs 17-18.

SVE, *Chamelea gallina* (Linnaeus, 1758), is an infaunal filter-feeder clam of the Veneridae family (Bivalvia: Lamellibranchiata: Veneridae).The species occurs in sediments characterised by well-sorted fine sand (Péres and Picard 1964). It is widespread in the Mediterranean and Black Seas and along the eastern Atlantic coast at depths ranging from 0 to 12 m. Within the Adriatic Sea (GSA17 and GSA18), the resource is distributed along a narrow strip (max 2NM from the coast) with densities decreasing as a function of sediment grain size characteristics , depth and river outflow. In particular, SVE reach very high densities along the coast of the central western Adriatic Sea, where the Po River outflow and the currents flowing along the Italian coast provide abundant resources (Orban et al., 2007).

The von Bertalanffy growth parameters (VBGP) of SVE in GSA 17 have been estimated in a recent paper concerning the population inhabiting the Central-Western Adriatic Sea (Bargione et al, 2020), while the a and b parameters of the length-weight relationship of SVE in GSA 17 and 18 were estimated from the DRESS Survey data (Table 6.10.1.1.). Individuals' growth rates and length-weight relationships are assumed to differ between and within areas. However, information for depicting changes on a small spatial scale is currently limited and does not provide enough evidence for this assumption.

Table 6.10.1.1. Striped Venus Clam in GSA 17 & 18. Growth and length-weight relationship parameters.

GSA	Year	L_{inf}	k	t_0	A	b
17	2017				-7.688	2.807
17	2018				-7.334	2.713
18	2018				-8.229	2.982
17	2019	43.9	0.26	-0.84	-7.684	2.84
18	2019				-7.602	2.78
17	2020				-8.247	3.015
18	2020				-7.92	2.864
17	2021				-7.844	2.895

SVE is a partial spawner that undergoes multiple emissions from March to September (Bargione et al, 2021a). A total of 504 additional individuals (227 females, 243 males) collected during the reproductive season of 2019 were analysed to assess TL_{50} in both sexes. The smallest females and males with well-developed gametes measured 9.6mm and 9.9mm TL, respectively. TL_{50} was estimated at around 11.0 for females and 11.5mm for males, whereas the TL_{50} of the entire sample was ~11.2mm.

6.10.2 DATA

6.10.2.1 CATCH (LANDINGS AND DISCARDS)

Landings data have been obtained from the Italian Ministry of Agricultural, Food and Forestry Policies (MIPAAF) data call. Where data was not available, information was derived from FishstatJ FAO database (see: https://www.fao.org/fishery/en/topic/166235?lang=en) for the period 1974 until the early 2000s, depending on the availability of official landings. For years in common among the observation and the FishstatJ datasets, the ratio between the two was on average 1.09 with a standard deviation equal to 0.17 (6.10.2.1.1). FishstatJ FAO data were available only for GSA 17, thus for the two maritime districts located in GSA 18 (Barletta and Manfredonia) was not possible to reconstruct the time series since the beginning of the exploitation (1974).

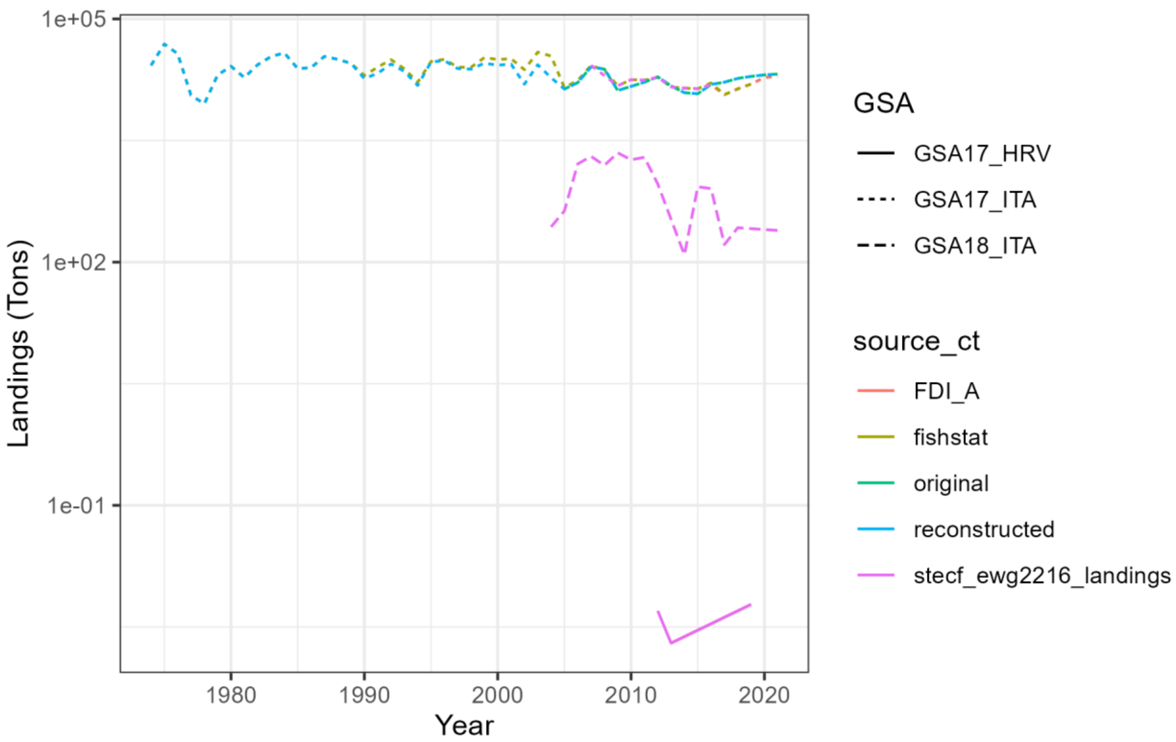


Figure 6.10.2.1.1 Striped Venus Clam in GSA 17 & 18: Available SVE landings data for GSA 17 and 18.

Croatian landings for DRB in GSA 17 were negligible and available only for 2012, 2013 and 2019. Thus, they were not used in the assessment.

For GSA17, Italy reports landings from the 10 maritime districts operating in the sector. However, in Monfalcone District there is no exploitation of SVE as a result of a sudden collapse of the stock shortly after 2010 from which is struggling to recover.

Given the high heterogeneity in landings within each Italian maritime district, which reflect stock size, market demand and different management strategies, it was deemed appropriate to assess SVE separately for each of the nine remaining Italian districts (Figure 6.10.2.1.2).

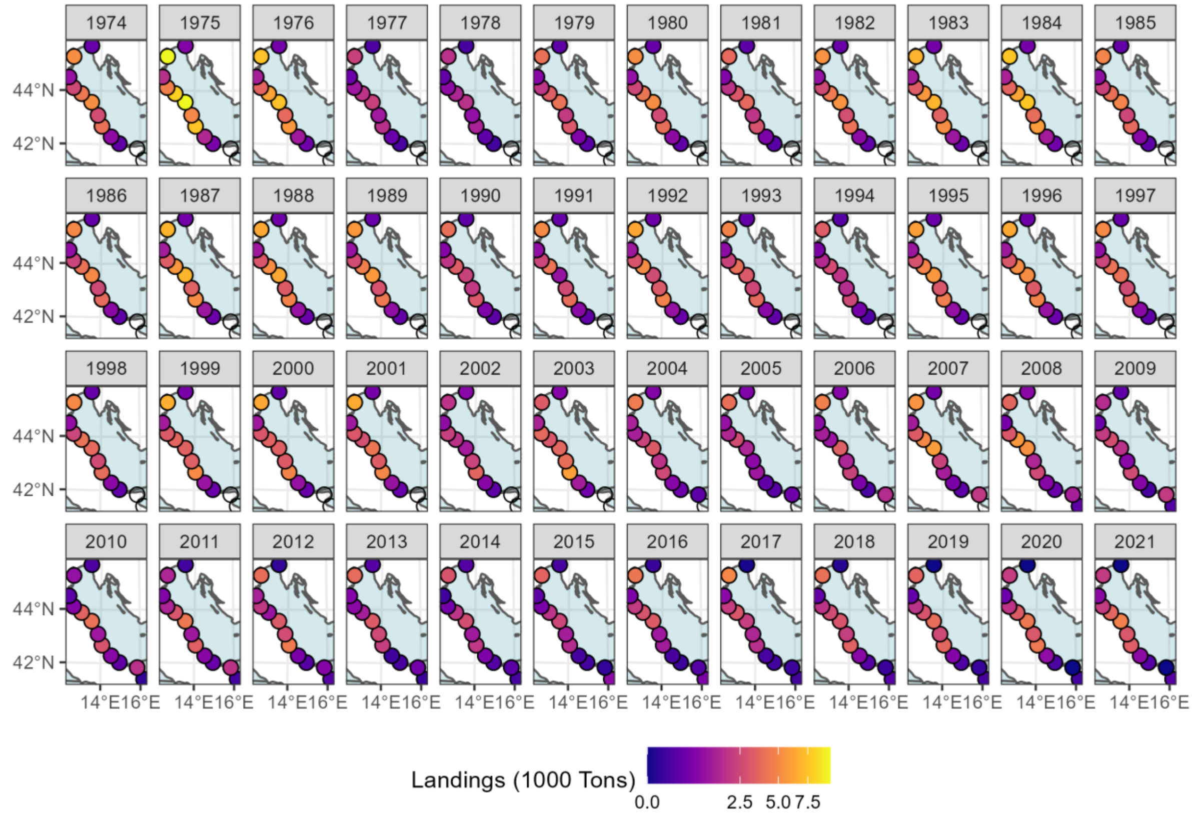


Figure 6.10.2.1.2 Striped Venus Clam in GSA 17 & 18: Trends in landings for each of the twelve maritime districts used for the assessments in which the striped Venus calm is targeted by hydraulic dredges (GSA17: MO = Monfalcone, CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli; GSA18: MA = Manfredonia, BA = Barletta).

Discards are not available and discarded portions of the catches are returned at sea with more than 90% survival rate (Bargione et al, 2021b).

6.10.2.2 SURVEY DATA

The DRESS (Dredgers Mollusc Survey) survey is an extensive survey aiming at collecting information concerning the state of three main mollusc targets (SVE, KLK and EQI) along Italian coasts. Sampling operations for SVE use a rectangular cage 3 m wide, weighing 0.6 T, mounted upon two sledge runners. The cage is connected to a hose, which serves to eject water under pressure from the nozzles at the mouth of the dredge and inside the dredge cage. Within each of the twelve Italian maritime districts in the Adriatic Sea (GSA 17 and GSA18), at least ten regularly spaced transect perpendicular to the coast (around 2 NM each other) are sampled with along transect spacing of 0.25 NM from the coast until the resource reach negligible abundance and is then assumed to be absent. The catch of SVE is automatically conveyed to a mechanical vibrating sieve, composed of a sieving plane (19 mm hole diameter). All clams retained by the sieve are weighed. For each sample, the length frequency distribution of clams is measured. As juveniles are returned at sea, a sampling net is mounted within the metal cage. The whole sample collected by the net is then weighted on board and subsampled for laboratory analyses (length-weight and age-length relationship, sex and fecundity stage determination, and for assessing the length frequency distribution).

In the current assessment, DRESS data from 2017 onwards were used. Given the short time series covered by the DRESS survey, historical survey data were collected also from different sources (Froglia et al, 1989, 1990, 1994, 2007, 2008; Paolini et al, 1998a,b; Carlucci et al, 2013). To allow for comparison between DRESS and previous data (biomass of commercial (25mm) individuals per metre square), DRESS survey data were filtered and used to estimate the biomass of individuals with a total length greater than 25mm per metre square (Figure 6.10.2.2.1).

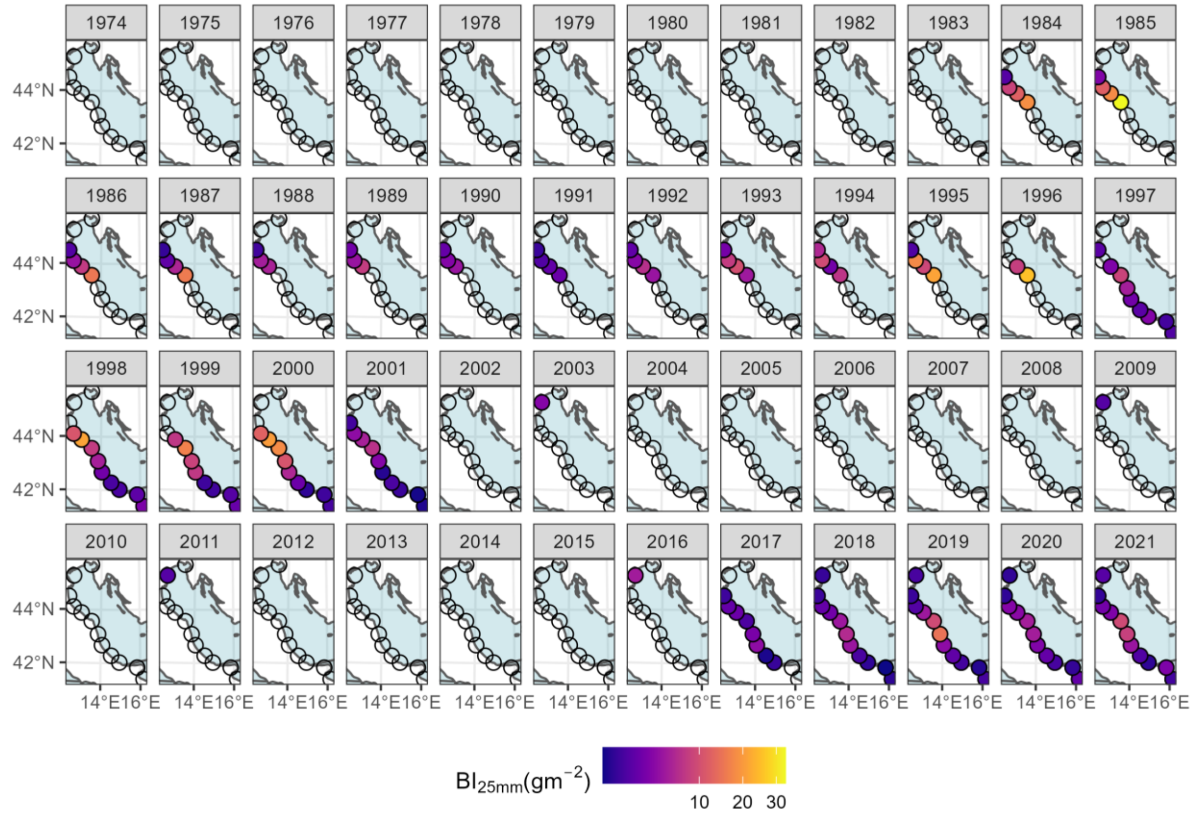


Figure 6.10.2.2.1. Striped Venus Clam in GSA 17 & 18: Survey data (biomass index: g of clams greater than 25mm per metre square) used for the assessments. Open circles indicate no survey data for that year in that district.

6.10.3 STOCK ASSESSMENT

SVE is subject to important stochastic fluctuation due to environmental and anthropogenic disturbances. These events have frequency and intensity that greatly vary along the Eastern Italian coast, thus creating different outcomes that should be considered individually. Given this information and the long history of local independent management of individual maritime districts, stock assessments have been conducted for 9 of the 12 Italian maritime districts (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli). The district of Monfalcone was not evaluated due to the lack of catches in the last 4-5 years, likely resulting from significant disturbance events and coastal anthropization. Manfredonia and Barletta maritime districts were not evaluated because FishStatJ FAO dataset used to reconstruct the data in the old period is only available for GSA 17 and not for GSA 18. The status of Venus clam was assessed in each maritime district using a Bayesian surplus production model (CMSY/BSM, Froese et al., 2017). This model is an advanced state-space Bayesian method for stock assessment and estimates fisheries reference points (MSY, F_{MSY}, B_{MSY}) as well as status or relative stock size (B/Bmsy) and fishing pressure or exploitation (F/F_{MSY}) from catch and biomass data. A prior for resilience or productivity (r), and broad priors for the ratio of biomass to unfished biomass (B/k) at the beginning, an intermediate year, and the end of the time series (Froese et al, 2017) can be applied to improve model out in case of lack of sufficient data.

The model was fitted using as input data the period 1974-2021 for the catch data, and surveys-derived biomass of clams with TL greater than 25mm per square metre (Table 6.11.3.1).

The intrinsic growth rate prior (*r*) ranges were derived from SeaLifeBase.org for all stocks (0.325-0.763) but Chioggia/Venezia (CV), for which 0.2-0.6 was deemed more appropriate as there are reasons to believe that resilience is lower. This assumption is based on the biology of the species, which have a significant pelagic dispersal phase, and the main water circulation characterising the North Adriatic Sea, which move downward along the Italian coast. Hence, the combination of this two factors is likely responsible for transporting south most of the larvae.

Starting stock biomass prior was set to 0.75-1 assuming that Stock was nearly pristine at the start of the fishery (1974).

Input data

Table 6.11.3.1. Striped Venus Clam in GSA 17 & 18: Catch (Tons), and biomass index (BI:biomass of clams, g, with TL greater than 25mm per square metre), used for the assessment of SVE in each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli). year

	AC		CV		OR		PC		PE		RA		RI		SB		TE	
year	Catch	BI	Catch	BI	Catch	BI	Catch	BI	Catch	BI	Catch	BI	Catch	BI	Catch	BI	Catch	BI
1974	5317		5295		833		4055		4345		941		2540		2694		313	
1975	9754		9715		1528		7439		7972		1727		4660		4942		574	
1976	7402		7373		1159		5646		6050		1311		3537		3750		436	
1977	2275		2266		356		1735		1860		403		1087		1153		134	
1978	1788		1781		280		1364		1461		317		854		906		105	
1979	4059		4043		636		3096		3318		719		1939		2057		239	
1980	5186		5166		812		3956		4239		918		2478		2628		305	
1981	3766		3751		590		2873		3078		667		1799		1908		222	
1982	5423		5402		849		4137		4433		960		2591		2748		319	
1983	6831		6804		1070		5210		5583		1210		3264		3461		402	
1984	7593	18.48	7563		1189		5792		6206	12.23	1345	1.18	3628	8.65	3847		447	
1985	4863	33.17	4843		762		3709		3974	17.94	861	2.83	2323	12.04	2464		286	
1986	4986	15.26	4966		781		3803		4075	7.77	883	1.08	2382	4.07	2526		293	
1987	6860	15.7	6833		1074		5232		5607	5.61	1215	0.42	3278	1.46	3476		404	
1988	6324		6298		990		4823		5168	5.36	1120	0.65	3021	4.95	3204		372	
1989	5635		5613		883		4298		4606	8.03	998	2.11	2692	4.14	2855		332	
1990	2289		3979		626		3047		3265	4.16	707	1.64	1909	2.9	2024		235	
1991	995	1.81	5042		793		3861		4137	1.55	896	0.52	2418	1.02	2565		298	
1992	2618	4.1	6235		981		4775		5117	6.63	1109	1.5	2991	3.12	3172		368	
1993	3100	4.53	4808		756		3682		3946	10.03	855	2.32	2306	7.81	2446		284	
1994	1871	7.15	3279		516		2511		2690	2.17	583	5.82	1573	9.51	1668		194	
1995	5607	21.31	5919		931		4533		4858	9.12	1052	1.01	2840	17.61	3011		350	
1996	5175	25.25	6302		991		4826		5171	8.16	1120		3023		3206		372	

1997	4090	8.7	5031		791	1.28	3853	2.17	4129	2.71	894	1.3	2413		2559	4.95	297	2.94
1998	3753	7.84	5027		791	0.82	3850	2.11	4125	21.37	894		2412	10.94	2557	5.09	297	0.82
1999	3417	16.58	6616		1040	0.58	5066	7.51	3638	7.35	1176		3173		3365	8.65	391	0.62
2000	3346	17.92	6265		985	1.9	4798	5.75	3489	20.25	1114		3005	12.33	3187	10.72	370	0.33
2001	4224	6.77	6410		1008	0.86	4909	0.23	2790	5.17	1140	0.69	3075	3.56	3261	2.99	379	0.51
2002	1181		1855		738		3593		1805		834		2251		2386		277	
2003	3648		3259	3	1214		5912		3021		1372		3703		3927		456	
2004	3195		4514		719		2552		2353		1319		1303		1850		408	
2005	1454		4001		311		1103		2650		950		1491		800		245	
2006	3367		4646		594		2298		1035		852		1266		1445		146	
2007	5880		5474		567		1279		4963		1177		3212		2331		270	
2008	5334		3586		719		2554		5682		517		3008		1469		375	
2009	1787		1607	1.13	743		2576		2734		409		2058		758		129	
2010	4067		931		749		2919		3521		262		700		1109		305	
2011	4340		1451	1.13	710		3353		3030		640		1430		1148		363	
2012	3177		3866		555		4478		1018		1317		1980		2677		224	
2013	3261		3774		88		2184		1262		691		793		2524		129	
2014	2720		2938		603		1991		1911		81		484		1168		198	
2015	2422		3521		122		1632		1888		295		572		1254		114	
2016	3194		4237	4.76	127		1196		2887		595		2045		1138		71	
2017	2210	0.92	4970		132	0.13	1759	3.49	3023	1.88	787	0.57	2129	1.6	1472	2.44	97	0.48
2018	2978	4.41	4027	0.45	757	0.81	3454	4.26	2666	2.12	317	0.55	1835	1.66	2193	6.21	213	0.36
2019	3890	9.52	3508	0.79	699	1.46	3673	3.44	2957	4.49	327	0.51	1802	1.07	2527	14.66	167	0.71
2020	4343	4.99	2110	0.37	858	1.63	4372	2.8	3245	3.3	400	0.36	1888	3	3049	4.89	144	0.77
2021	4776	9.54	2069	1.2	833	1.04	3314	4.21	3666	2.73	788	0.41	2147	2.18	3063	8.41	213	0.34

Assessment model setup and results

Different combinations of intermediate and ending stock biomass priors were examined. The best model (according to residuals and retrospective) included the following priors:

- Intermediate stock biomass in the year 1990 was set to 0.4-0.6 for all but Ravenna (RA), for which a smaller prior range was used (0.2-0.4) for 2010 as it was a period of known distress for the stock.
- Ending stock biomass was set in an objectve way using the outputs of Length-based Bayesian Biomass estimator approch (LBB, Froese et al., 2018). LBB works only with length frequency data. It estimates asymptotic length, length at first capture, relative natural mortality, and relative fishing mortality. LBB also provides an indication of the health of the stock. For our scope, the length distribution obtained from DRESS surveys for the period 2017-2021 were used to etimate initial priors for the enging stock biomass, but, as LBB-derived priors were wide, a smaller interval was considered appropriate and was ultimately set as follows:
    - CV: 0.4-0.8
    - RA: 0.6-0.8
    - RI: 0.6-0.8
    - PE: 0.6-0.8
    - AC: 0.4-0.6
    - SB: 0.6-0.8
    - PC: 0.6-0.8
    - OR: 0.2-0.6
    - TE: 0.6-0.8

Based on the model results, the Striped Venus Calm shows increasing catch and fishing mortality relative to MSY. Estimated catches and fishing mortality relative to MSY are low, or close to MSY, and in line with estimated values of about 15 years ago, with recent values, average over the last three years (2019-2021), below MSY (Table 6.11.3.2).

Table 6.11.3.2. Striped Venus Clam in GSA 17: State of the stock and fishery relative to reference points for each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli). Recent = 2019-2021

Stock	F_{RECENT}/F_{MSY}	C_{RECENT}/C_{MSY}
CV	0.416	0.538
RA	0.418	0.531
RI	0.493	0.724
PE	0.49	0.721
AC	0.844	0.927
SB	0.665	0.99
PC	0.601	0.897
OR	1.012	0.985
TE	0.392	0.558

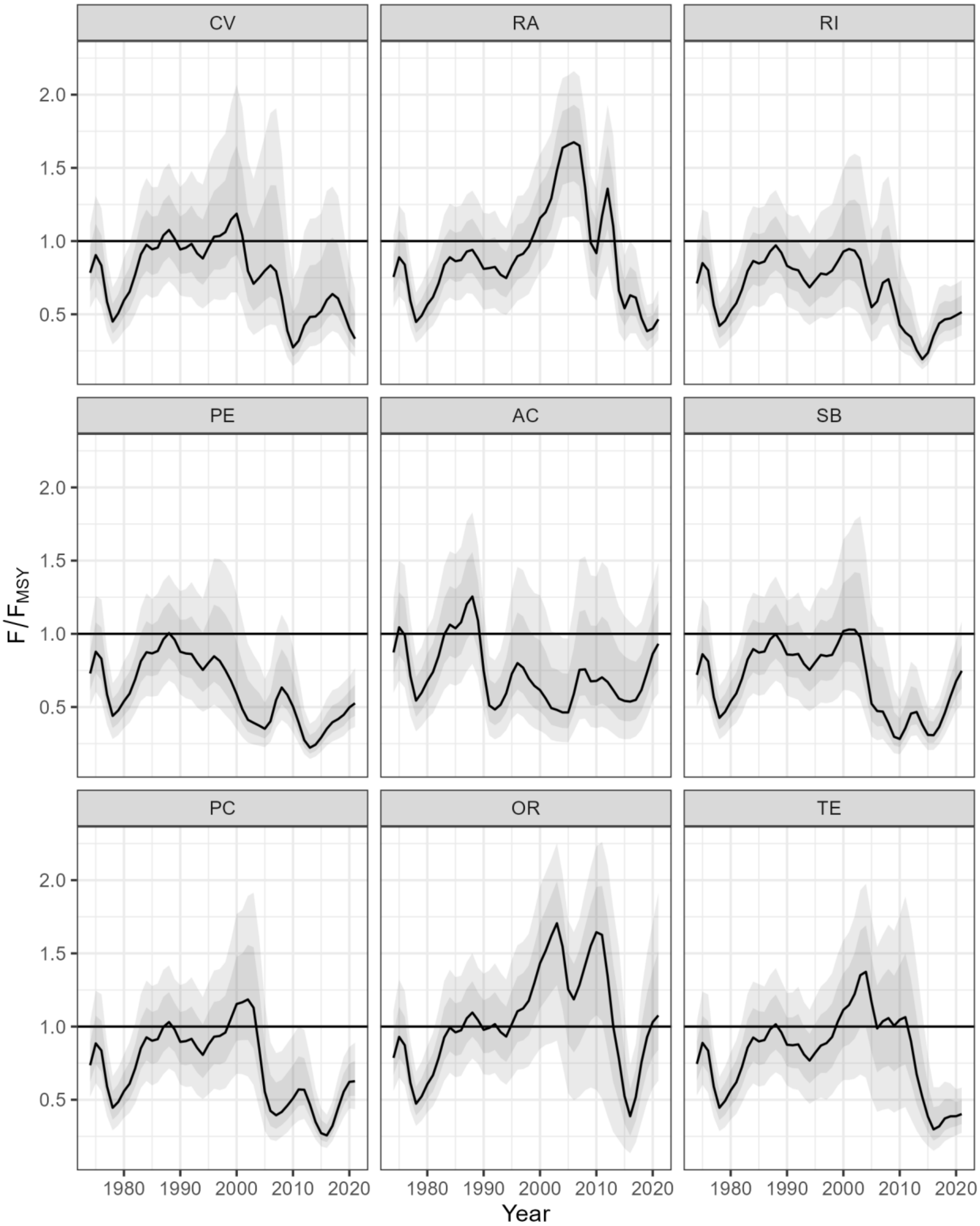


Figure 6.10.3.1. Striped Venus Clam in GSA 17 & 18: Stock summary for the final CMSY++ model. F/F_{MSY} for each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli).

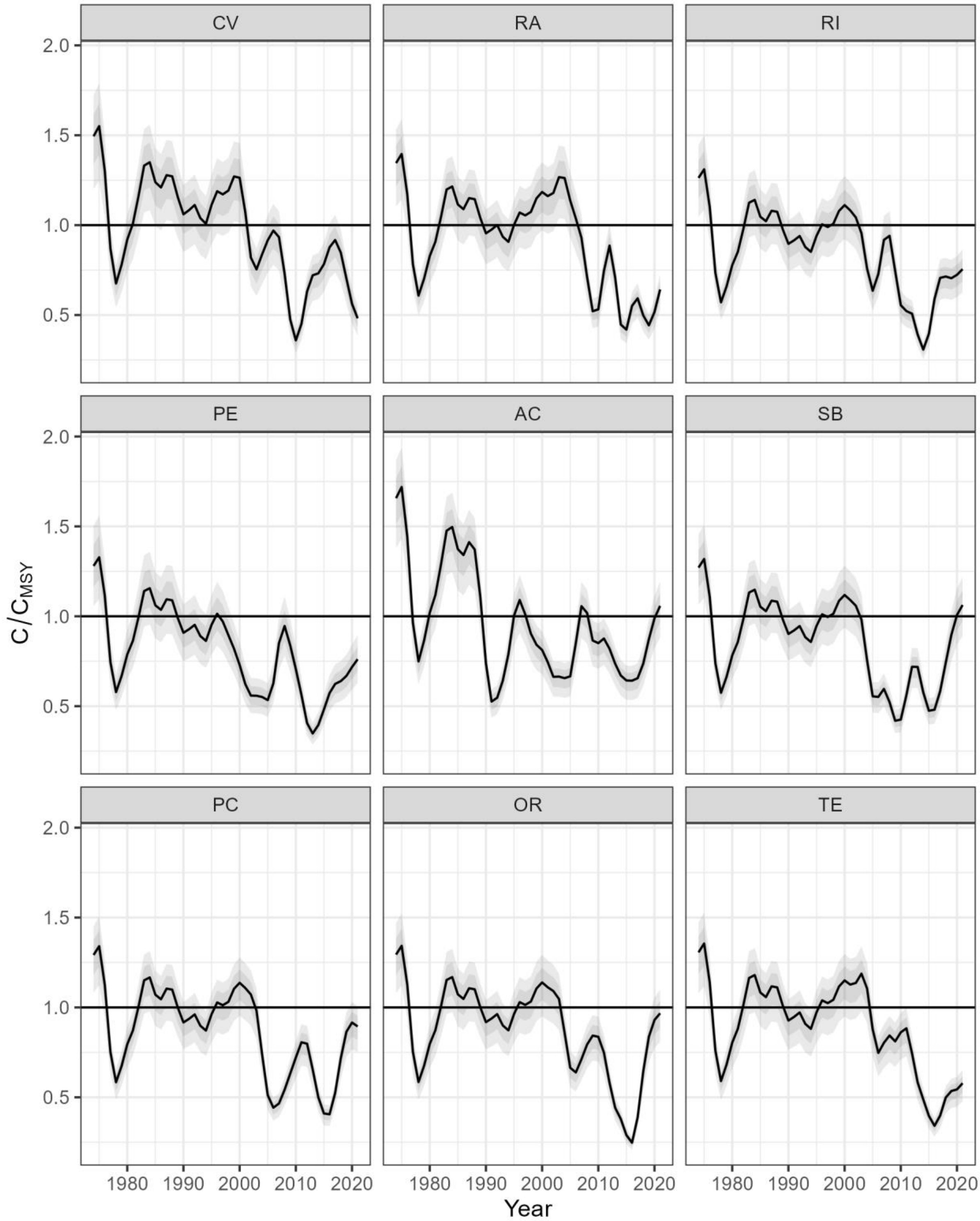


Figure 6.11.3.2. Striped Venus Clam in GSA 17 & 18: Stock summary for the final CMSY++ model. Catch relative to MSY for each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli).

Stock biomass was poorly correlated with the biomass index. These results could be resulting from the high stochastic variability in SVE population size and the high resilience. The ecology and the distribution of the species expose it to possibly high disturbance events, which could severely reduce population size. Following these events, populations can recover quite rapidly given SVE's large reproductive period over around 7 months. Moreover, catchability greatly varies through the year, with higher catchability in summer as the clams tend to stay closer to the interface between water and sediments and differences in the time of the year on which the survey was conducted may add uncertainty to the estimated biomass index. In contrast the CMSY model picks up the longer term trends and does not capture the short timescale fluctuations seen in the survey data which as noted above fits poorly to the CMSY biomass on a short timescale. The model provides a general indication of stock status rather than a specific stock size by year.

Overall, retrospective analysis (applied up to 4 years back) shows relatively good stability for F relative to MSY as shown in Figures 6.10.3.3.

The overall conclusions regarding long term trends are based on the long time series of combined catches split to maritime district based on recent relative catch rates. So while the general conclusions may hold regarding exploitation and biomass status the individual districts may have experienced different biomass and exploitation than this illustrated here.

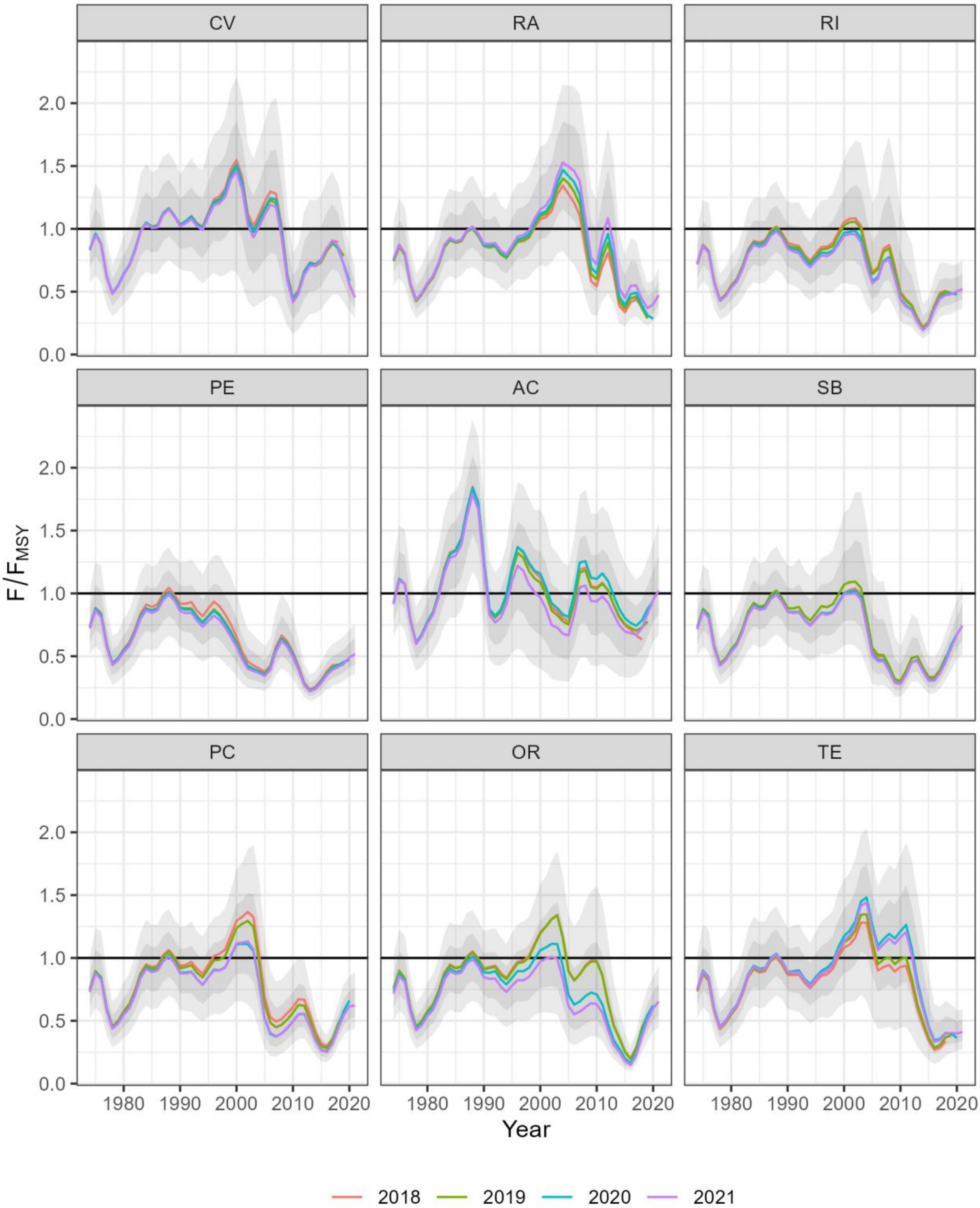


Figure 6.10.3.3. Striped Venus Clam in GSA 17 & 18: Stock summary from the final CMS++ model. F relative to F_{MSY} for each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI = Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli).

6.10.4 Reference Points

Given the quality of the model results, the table below (**Table 6.10.4.1**) report the average value, over the last three years, of catches and fishing mortality relative to MSY.

Table 6.10.4.1. Striped Venus Clam in GSA 17: State of the stock and fishery relative to reference points for each of the nine maritime districts assessed (GSA17: CV = Chioggia and Venezia, RA = Ravenna, RI

= Rimini, PE = Pesaro, AC = Ancona and Civitanova Marche, SB = San Benedetto del Tronto, PC: Pescara, OR = Ortona, TE = Termoli). Recent = 2019-2021

Stock	C_{RECENT}/C_{MSY}	F_{RECENT}/F_{MSY}
CV	0.601	0.620
RA	0.591	0.445
RI	0.805	0.555
PE	0.757	0.519
AC	1.030	1.294
SB	1.093	0.742
PC	0.913	0.613
OR	1.058	0.818
TE	0.564	0.398

6.10.5 SHORT TERM FORECAST AND CATCH OPTIONS

Due to the know high temporal variability of striped Venus clam, and that the model while capturing the general tends in biomass does not give good estimate of potential catch two years ahead (for 2023) no short term forecast and catch option are provided.

It is likely that local management based on in year local survey data used in an overall agreed management approach will provide more timely advice for managing catch options. The models here provide a more medium term view of stock status.

6.10.6 DATA DEFICIENCIES

Data available to STECF EWG 22-16 concerning both landings and survey data were limited to the past 10 years. Other data were made available from other official sources (historical survey data and landings data from the FishStat platform). However, especially for survey data, direct comparisons between data collected in recent and past surveys should be considered with caution due to differences in sampling strategy and standardisation between surveys. To allow for honest comparisons, recent data were standardised to report the biomass of clams with a total length (TL) greater than 25mm in one metre square as in the previous survey. Therefore, a more accurate study could be conducted if the raw data collected during past surveys are made available.

The time of the year in which the DRESS surveys take place sometimes differs between districts. Given the changes in catchability of the species between winter and summer, with the first being lower than the second, biomass information could be biased by this and other environmental factors.

Given the lack of length frequency distributions (LFDs) on the landings, it was not considered appropriate to standardise the landings as only relating to clams with TL greater than 25, because the LFDs derived from the DRESS only reflect the population structure during a small period of the year.

Survey and landing data from GSA 18 were not included in the analyses because inconsistencies were found in the sampling design that required further investigation before the collected data could be used.

Croatian data from GSA 17 are negligible and do not allow for assessing the state of the resource in the North Eastern Adriatic Sea.

6.11 Norway lobster in GSAs 15 and 1

6.11.1 Stock Identity and Biology

STECF EWG 22-16 was asked to assess the state of Norway lobster in the GSAs 15 and 16. An ad-hoc contract was issued to prepare the data for this stock and to provide a preliminary assessment (Annex).

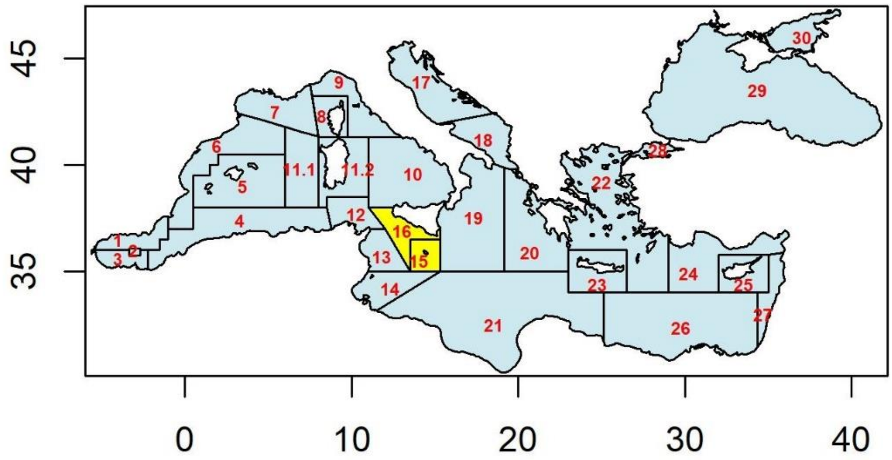


Figure 6.11.1.1. Norway lobster in GSAs 15 and 16. Geographical location of GSAs 15-16.

The GSAs 15-16 (Strait of Sicily and Maltese waters) are neighbouring GSAs which are not under the DCF regulations as belonging to non-EU Member State (e.g., Tunisia) (Figure 6.11.1.1). It is well known that Sicilian fleets exploit resources on international south-western waters belonging to GSAs 12, 13 and 14, so it could be possible that the data available through the DCF are partly related to these fishing grounds making the analyses quite challenging (as data could be assigned to GSA 16 even if collected in other GSAs).

The von Bertalanffy growth parameters and length weight relationships of Norway lobster were both available in the DCF data for several years. Data were available only for GSA 16.

The time series of the von Bertalanffy growth parameters show that values by sex didn't change in time while the length weight parameters show some differences through time.

The following sets of von Bertalanffy growth parameters (VBGP) have been used in the present assessment:

Females: L_∞= 54, K=0.14, t_0=-0.25

Males: L_∞= 63, K=0.13, t_0=-0.25

STECF EWG 22-16 used the above set of growth parameters to convert catch in length into age.

The median values of *a* and *b* by sex from GSA 16 were used for the length weight (LW) relationship.

The VBGP and LW relationship parameters used are summarized in the following Table (Tab. 6.11.1.1).

Table 6.11.1.1. Norway lobster in GSAs 15 and 16. Growth parameters and length-weight relationship parameters used in the assessment.

GSA	Sex	L_{inf}	k	t_0	a	b
15-16	M	63	0.13	-0.25	0.0004	3.164
	F	54	0.14	-0.25	0.0006	3.025

In literature the Norway lobster in the area is reported as mainly summer spawner even if berried females could be observed almost along all the months. Based on this, the proportions of F and M before spawning were set to 0.5 in the assessment model.

DCF data provided maturity ogives both in age and length for many years between 2002 and 2021. Following the ad-hoc contract data provided for 2015 and 2016 were removed from the dataset and remain years data was used to produce the maturity vectors by sex to be used in the assessment. Considering the low amount of catches coming from GSA 15 (see section 6.11.2), and the consequent lower number of biological samples, maturity vectors by sex have been estimated based only on GSA 16 data.

The maturity vectors by sex are presented in Table 6.11.1.2 and the natural mortality vectors by sex, computed using Chen & Watanabe formula based on the same VBGP reported above, are presented in Table 6.11.1.3. Because for older ages (9-10+) the fully maturation level hasn't been observed in the DCF data, in running the assessment maturity values for those ages have been set equal to 1.

Table 6.11.1.2. Norway lobster in GSAs 15 and 16. Maturity vectors by sex.

Maturity	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
Males	0.00	0.05	0.43	0.66	0.84	0.91	0.94	0.96	0.97	1*	1*
Females	0.00	0.28	0.43	0.55	0.53	0.62	0.73	0.80	0.79	1*	1*

* Fixed to 1

Table 6.11.1.3. Norway lobster in GSAs 15 and 16. Natural mortality vectors by sex.

M	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
Males	1.40	0.64	0.43	0.34	0.28	0.25	0.22	0.20	0.19	0.18	0.17
Females	1.40	0.64	0.44	0.34	0.29	0.25	0.23	0.21	0.20	0.19	0.18

6.11.2 DATA

6.11.2.1 CATCH (LANDINGS AND DISCARDS)

Catch data have been prepared based on the ad-hoc contract. The only difference is the inclusion of data from Malta in GSA 16 which are negligible.

In GSA 16 the main fleet targeting the Norway lobster is the bottom otter trawl (OTB). In 2019 less than 75 kg have been reported for OTM (Midwater otter trawl) and PTM (Midwater pair trawl) gears.

In GSA 15 the main gear is still OTB. Negligible landings are reported for LLS in 2018.

Landings

Landings data were reported to STECF EWG 22-16 through the DCF. Landings data by year, GSA, country and fleet are presented in Figures 6.11.2.1.1-3, total landings by year, country and GSA are presented in Table 6.11.2.1.1. In all GSAs most of the landings come from otter trawls. DCF data coming from other gear were considered inaccurate or sampled inconsistently; anyway, their catches were included in the stock assessment due to the low amounts.

The ad-hoc contract found that in GSA 15 reported landings are quite inconsistent when comparing values extracted from catches and landings at length DCF templates. So, only values matching between the two sources of information have been considered. However, these values are absolutely negligible (always less than 2 tons) comparing the ones in GSA 16 (Table 6.11.2.1.1).

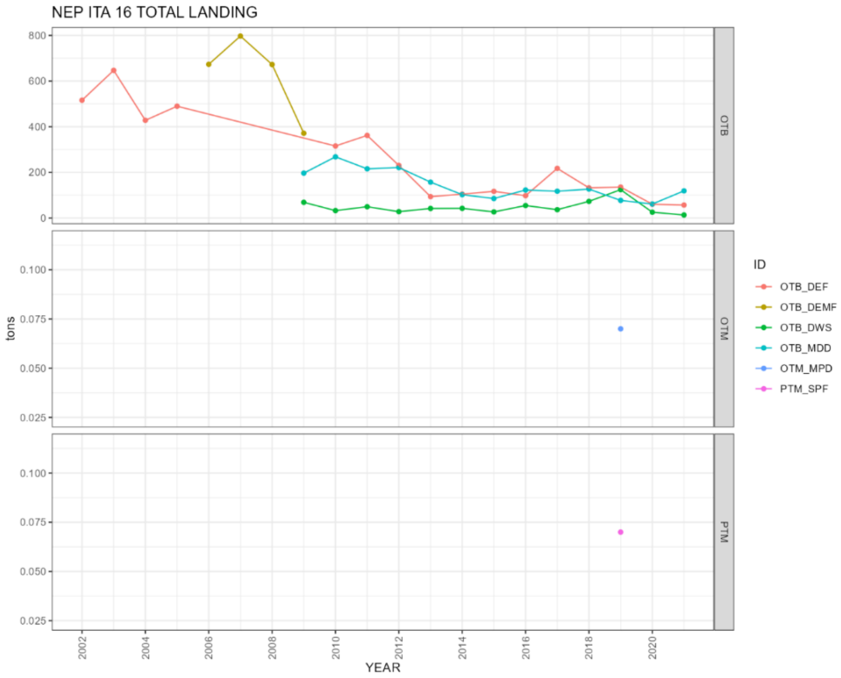


Figure 6.11.2.1.1. Norway lobster in GSAs 15 and 16. Landings data in tonnes by year, area and fleet for Italy in GSA 16.

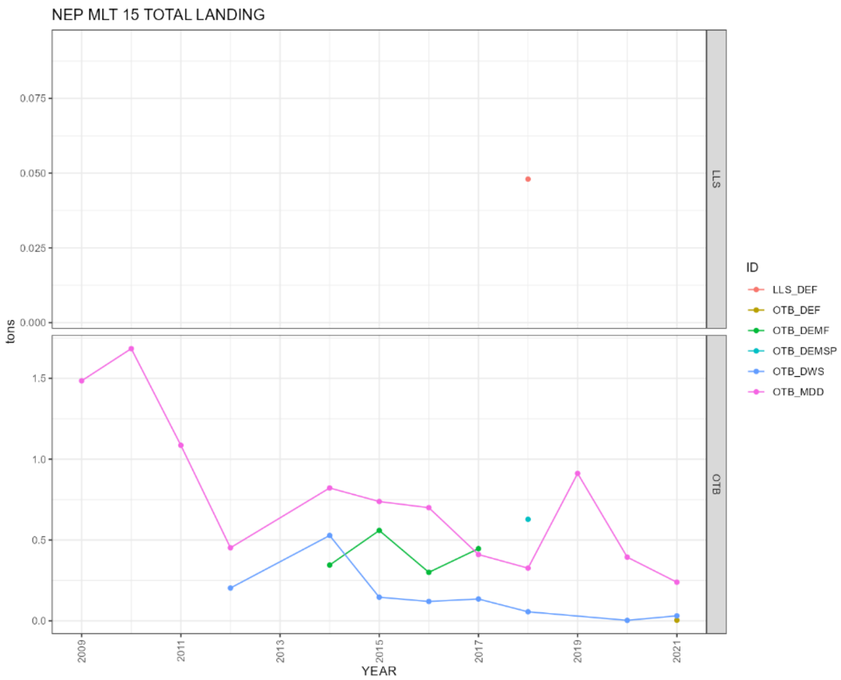


Figure 6.11.2.1.2. Norway lobster in GSAs 15 and 16. Landings data in tonnes by year, area and fleet for Malta in GSA 15. Data from 2009 to 2014 were excluded from the final landings dataset due to high uncertainty in the reporting.

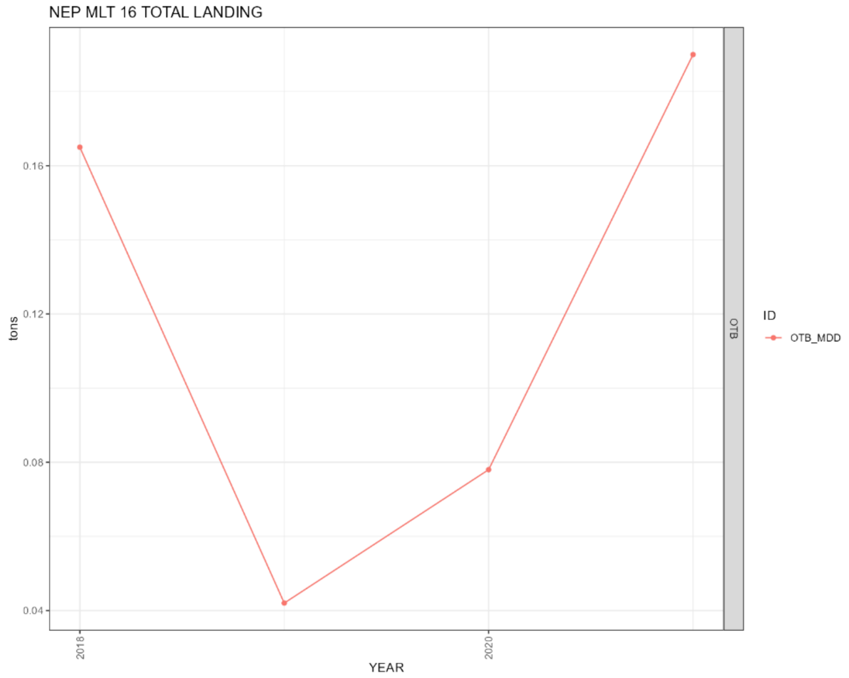


Figure 6.11.2.1.3. Norway lobster in GSAs 15 and 16. Landings data in tonnes by year, area and fleet for Malta in GSA 16.

Table 6.11.2.1.1. Norway lobster in GSAs 15 and 16. Landings data in tonnes by year, country and GSA.

Year	Malta GSA 15	Malta GSA 16	Italy GSA 16	Total landings
2002			516	516
2003			647	647
2004			428	428
2005			490	490
2006			673	673
2007			797	797
2008			673	673
2009	1.49*		636	636
2010	1.68*		616	616
2011	1.09*		627	627
2012	0.66*		479	479
2013			293	293
2014	1.70*		249	249
2015	1.44		229	230
2016	1.12		275	276
2017	0.99		371	372
2018	1.06	0.17	332	333
2019	0.91	0.04	337	338
2020	0.40	0.08	147	147
2021	0.27	0.19	189	189

* Data excluded from the final landings dataset due to high uncertainty in the reporting.

Length frequency distribution of the landings by year, GSA, country and fleet from the DCF database are presented in Figures 6.2.1.2.1.4-5.

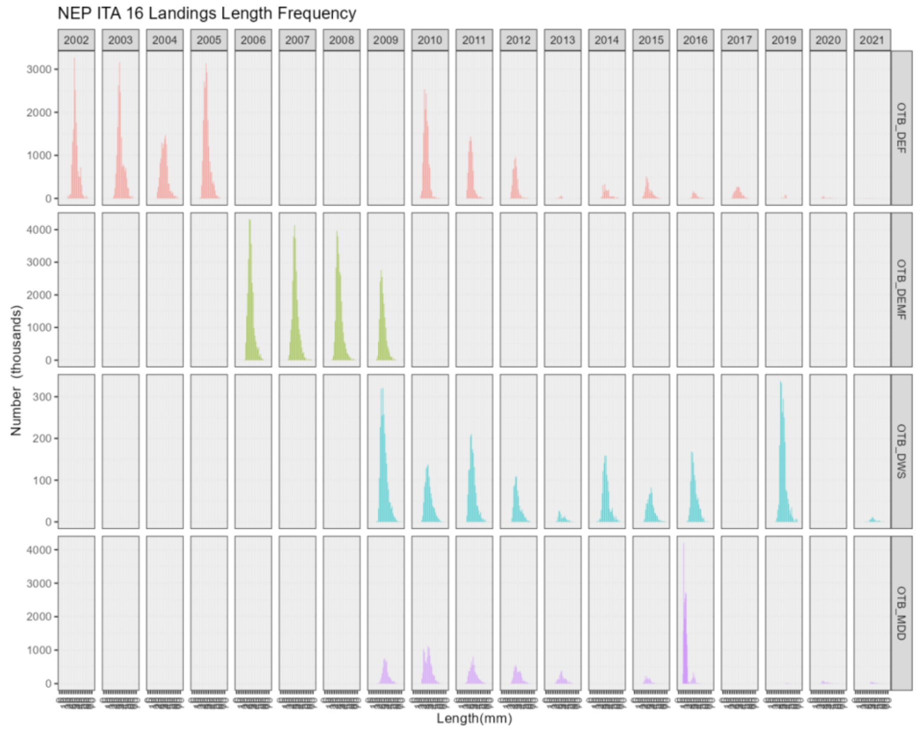


Figure 6.11.2.1.4. Norway lobster in GSAs 15 and 16. Length frequency distribution of the landings by year and fleet for Italy in GSA 16. Note the missing year 2018.

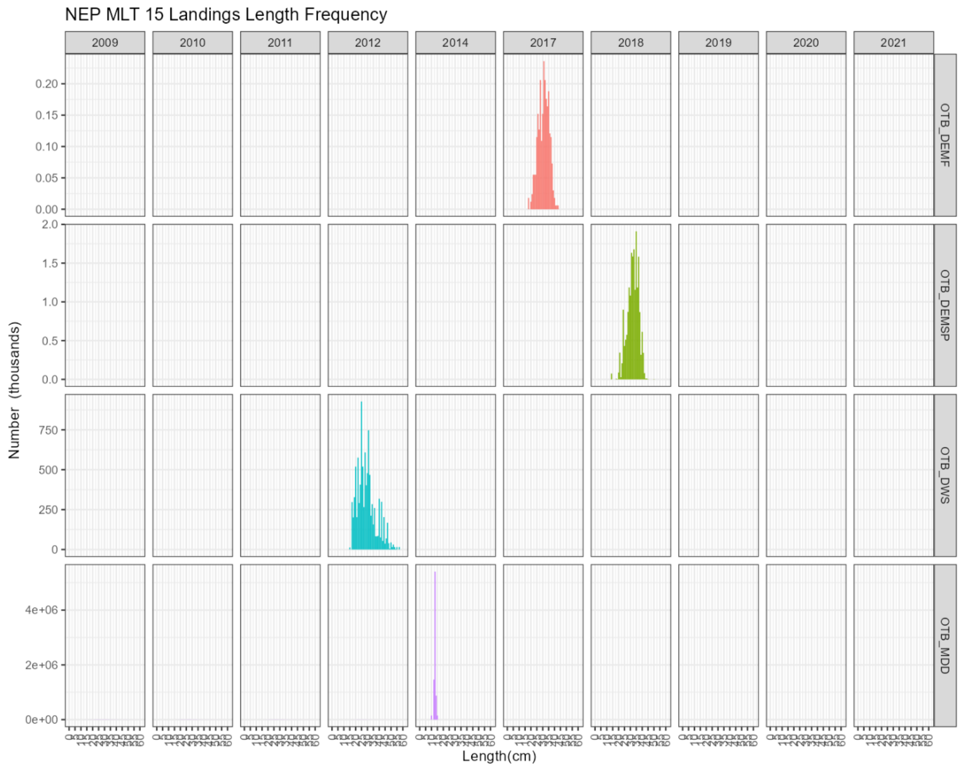


Figure 6.11.2.1.5. Norway lobster in GSAs 15 and 16. Length frequency distribution of the landings by year and fleet for Malta in GSA 15.

The length frequency distributions of the Italian landings in GSA 16 were available since 2002. The main issues spotted by the ad-hoc contract were:

1) Carapace length (CL) is reported by 2-mm step rather than 1-mm step as requested in the DCF Mediterranean and Black Sea data call (MEDBS).

2) No data available for 2018.

3) In 2016 OTB_MDD the lengths are aggregated both at 1- and 2-mm step.

4) Numbers in 2016 quarter 4 VL1218 gear OTB and fishery MDD have been reported as total and not as thousands as requested by the MEDBS data call.

5) The length samples are not covering consistently each quarter during the year and all the metier available in the area.

6) Length distributions are quite poor in the last years.

Only few length frequency distributions were available for Maltese landings in GSA 15. Due to data inconsistencies and due to the very low number of samples in the area these LFD have been excluded from the assessment.

No length frequency distributions were available for Maltese landings in GSA 16.

The group decided to use the scripts developed during STECF EWG 21-02 to fill the missing length frequency distributions for the metiers without any length information for Italy in GSA 16. However, raising of the landings from the metiers with partial length frequency distributions was performed together with the SOP correction. Reconstructed length frequency distribution of the landings by year and fleet and the reconstruction procedure are presented in Figures 6.2.1.2.1.6-11.

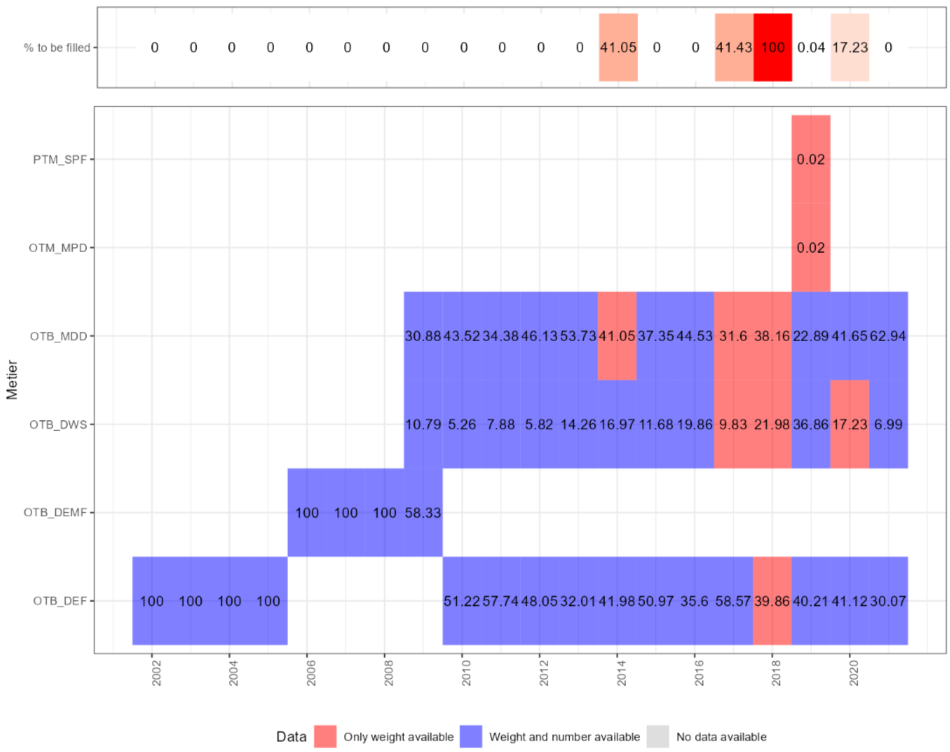


Figure 6.11.2.1.6. Norway lobster in GSAs 15 and 16. Reconstruction of the length frequency distribution of the landings by year and fleet for Italy in GSA 16. The upper panel (single row) shows the total percentage of the weight to be reconstructed over total landings per year. The lower panel shows the percentage of the weight of each metier to be reconstructed over total landings per year.

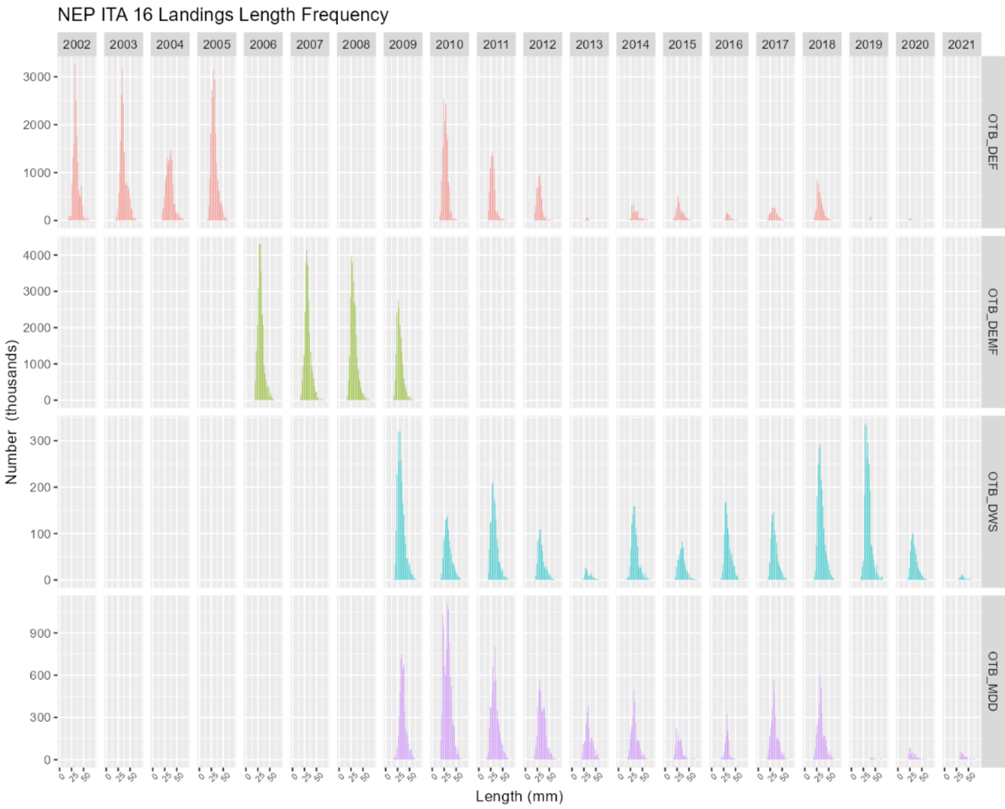


Figure 6.11.2.1.7. Norway lobster in GSAs 15 and 16. Length frequency distribution of the reconstructed landings by year and fleet for Italy in GSA 16.

Discards

Discards data were reported to STECF EWG 22-16 through the DCF. In general, Norway lobster is very rarely discarded. In the study area, very small quantities of Norway lobster are reported sporadically by the different countries in the different GSAs. No discard data are reported by Malta for GSAs 16. Total discard by year and GSA for the bottom trawl fishery is presented in Table 6.11.2.1.2. Due to the negligible amount of discards, no discard reconstruction was performed.

Table 6.11.2.1.2. Norway lobster in GSAs 15 and 16. OTB discards data in tonnes by GSA.

Year	Malta GSA 15	Italy GSA 16	Total discards
2002	-	0	0
2003	-	0	0
2004	-	0	0
2005	-	0	0
2006	-	0	0
2007	-	0	0
2008	-	0	0
2009	0.065	0	0.065
2010	0.008	19.17	19.18
2011	0.042	4.39	4.40
2012	0.004	1.80	1.81
2013	-	0.43	0.43
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	0	2.70	2.70
2018	0	0	0
2019	0	0	0
2020	0	0	0
2021	0	0	0

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

6.11.2.2 EFFORT DATA

The effort analysis was carried out by STECF EWG 21-13, and effort results are available from that meeting. The effort in Fishing Days is reported in Table 6.11.2.2.1.

Table 6.11.2.2.1. Norway lobster in GSAs 15 and 16. Effort in Fishing Days for Italian and Maltese OTB by GSA. Effort data is reported under the Fishery Dependent Information (FDI) data call differs from effort previously reported under the Mediterranean and Black Sea (MEDBS) data call. Effort time series refer to MEDBS before 2013 and to FDI from 2013 onward.

Year	Malta GSA 15	Malta GSA 16	Italy GSA 16
2002			87300
2003			76233
2004			90123
2005			83686
2006	404		83711
2007	727		80071
2008	1147		76432
2009	1200		79343
2010	1116		79794
2011	1138		71547
2012	1624		64775
2013	1092		62965
2014	600		55844
2015	620	7	58672
2016	562	35	59839
2017	616	10	64801
2018	527	21	55464
2019	764	10	56425
2020	499	26	49093
2021	745	56	48316

6.11.2.3 SURVEY DATA

The MEDITS (Mediterranean International Trawl Survey) survey is an extensive trawl survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime, following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintained fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end, is used throughout GSAs and years. The timing of the survey is shown in Figure 6.11.2.3.1. According to the MEDITS handbook procedures and what it is stated in MS EU-MAPs the period in which the survey should be carried out was not always respected. Indeed, in many years a clear delay has been observed in GSA 16 (e.g., 2013, 2017, 2020 and 2021) and in one year in GSA 15 (i.e., 2018).

In the current assessment, combined MEDITS data for GSAs 15 and 16 from 2005 onwards were used, as before 2005 the area covered from MEDITS in the study area was much smaller. The combined MEDITS biomass and density indexes as well as the corresponding length frequency distributions were calculated using the script provided by JRC (Figures 6.11.2.3.2 and 6.11.2.3.3).

Figure 6.11.2.3.1. Norway lobster in GSAs 15 and 16. Timing of the survey.

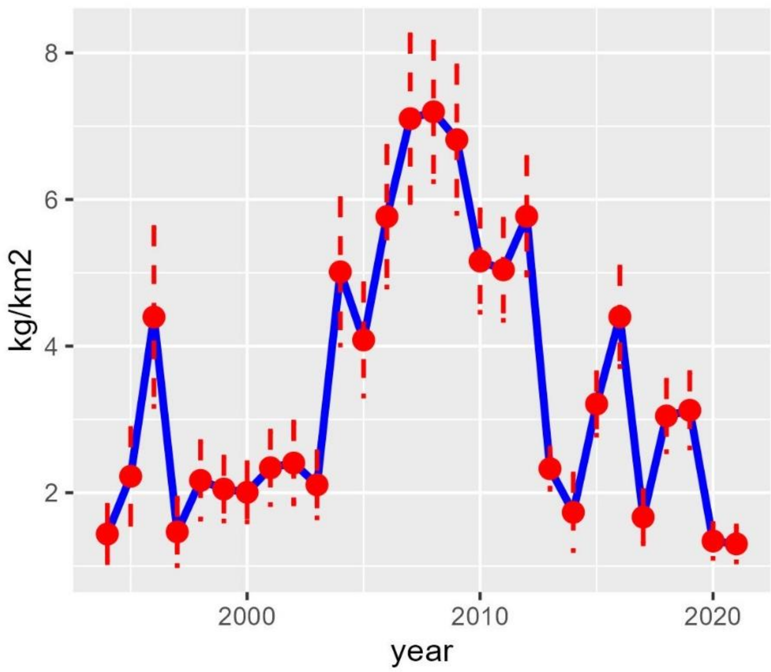


Figure 6.11.2.3.2. Norway lobster in GSAs 15 and 16. Estimated biomass indices from the MEDITS survey (kg/km^2).

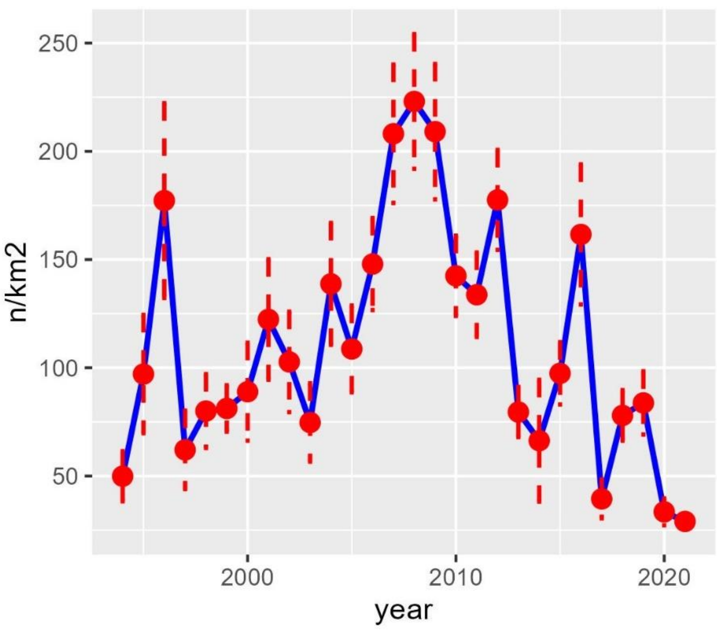


Figure 6.11.2.3.3. Norway lobster in GSAs 15 and 16. Estimated density indices from the MEDITS survey (n/km^2).

Both estimated abundance and biomass indices show similar trends, with a strong increase from the end of the 1990s up to 2008 and a clear declining trend after.

Length frequency distributions for male, female and sex combined are shown in Figures 6.11.2.3.4-6.

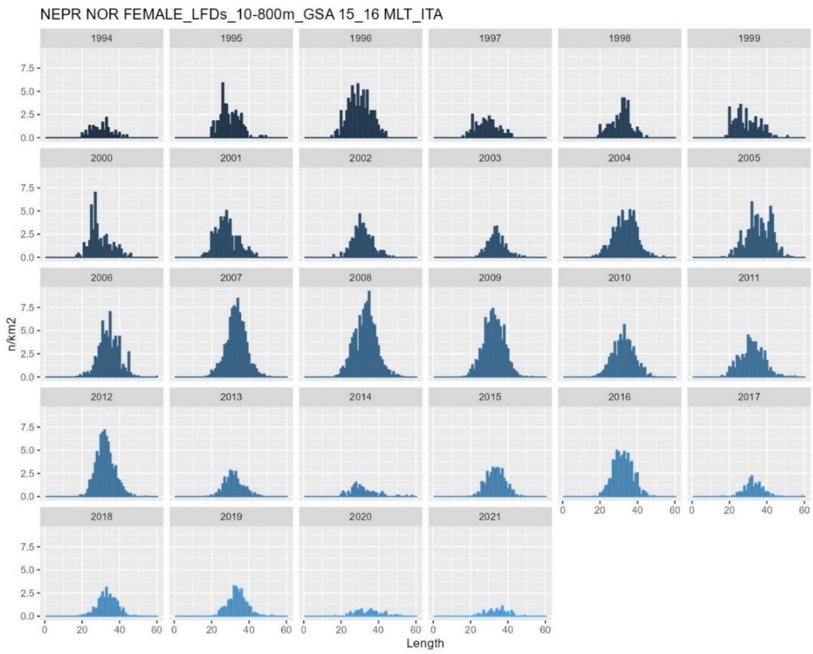


Figure 6.11.2.3.4. Norway lobster in GSAs 15 and 16. Length frequency distribution by year for females of MEDITS survey.

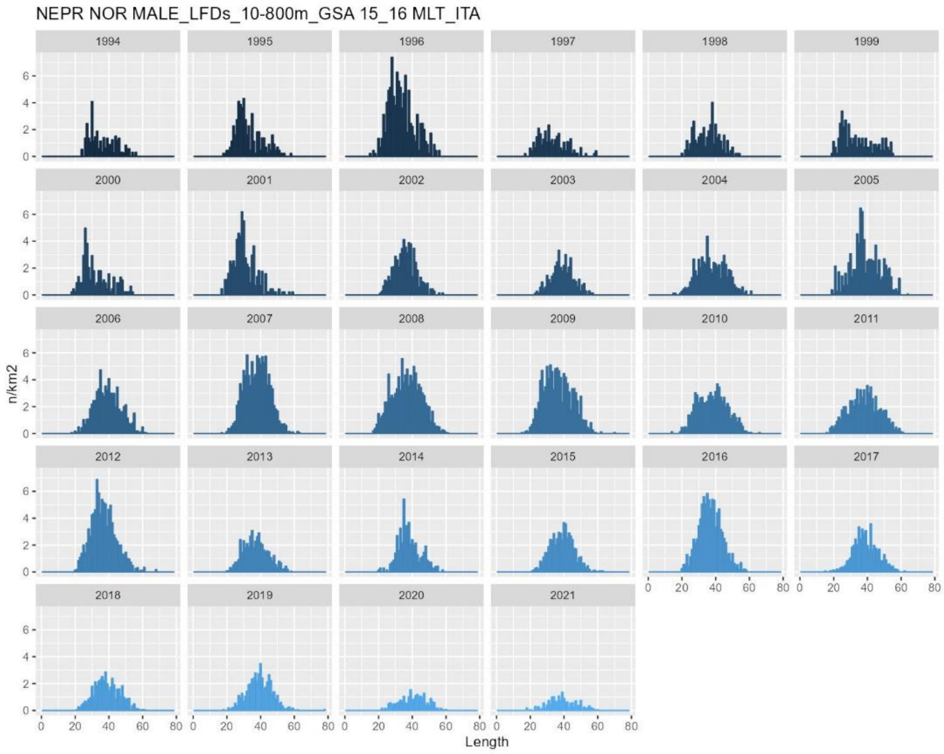


Figure 6.11.2.3.5. Norway lobster in GSAs 15 and 16. Length frequency distribution by year for males of MEDITS survey.

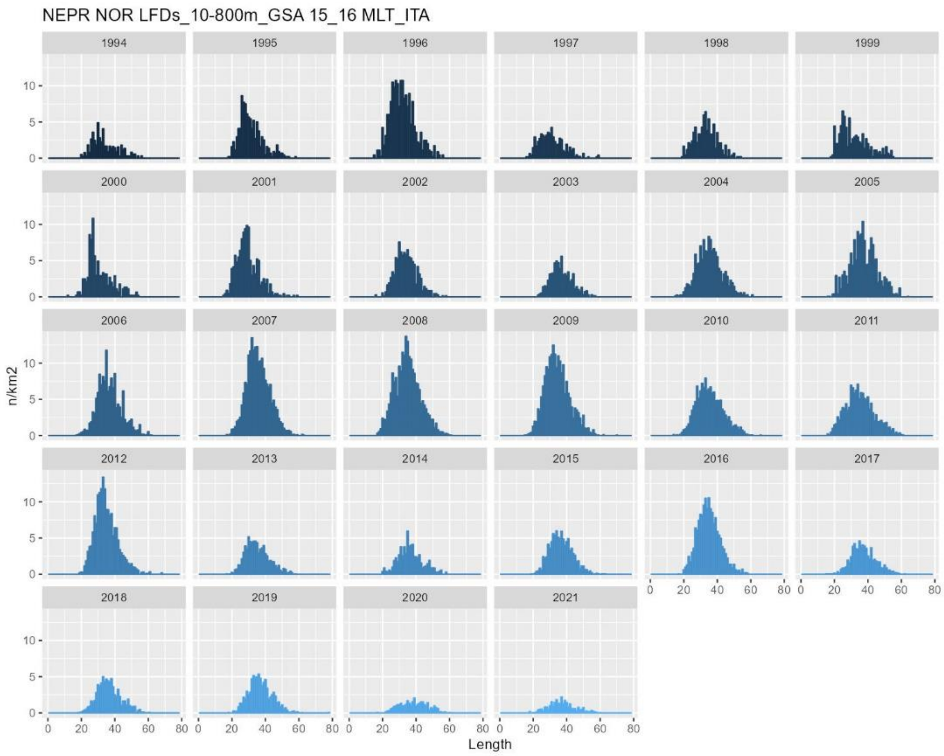


Figure 6.11.2.3.6. Norway lobster in GSAs 15 and 16. Length frequency distribution by year for sexes combined of MEDITS survey.

In 2014 there has been a high reduction in the number of hauls carried out in the deeper strata (D=200-500m, E=500-800m) in which Norway lobster is usually caught. Therefore, the 2014 MEDITS index was excluded from the assessment as done also in the ad-hoc contract.

6.11.3 Stock assessment

A statistical catch-at-age assessment was carried out for this stock, using the Assessment for All Initiative (a4a) method (Jardim et al. 2015). The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike XSA, model parameters estimated using catch-at-age analysis are done so by working forward in time and analyses do not require the assumption that removals from the fishery are known without error.

The model was fitted using as input data the period 2005-2021 for the catch data (landings + discards) and for the tuning index.

Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR, using for each GSA the same sex specific growth parameters. Catch at age by sex were obtained by splitting commercial total length distribution according to a sex-ratio vector model obtained from DCF available sex ratio vectors in the respective areas. The analyses were carried out for the ages 2 to 10+. Concerning the Fbar, the age range used was 2-8.

Input data

The growth parameters used for VBGF were the one reported in table 6.11.1.1.

Total catches and catch numbers at age were used as input data. Catch numbers for 2018 were removed from the input data due to the complete reconstructions of the LFDs for that year. SOP correction + raising were applied to catch numbers at age. Table 6.11.3.1 present the SOP correction + raising vector applied. The high values from 2011 to 2021 are mainly due to the raising applied because of missing length frequency distributions in the catches of those years.

Table 6.11.3.1. Norway lobster in GSAs 15 and 16. SOP correction + raising vector.

Year	SOP
2005	0.95
2006	1.03
2007	1.18
2008	1.04
2009	1.03
2010	1.15
2011	1.61
2012	1.70
2013	3.02
2014	1.22
2015	1.86
2016	2.84
2017	1.81
2018	-
2019	3.66
2020	3.46
2021	8.79

Table 6.11.3.2 lists the input data for the a4a model, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age, Proportion of M and F before spawning, and the tuning series at age.

Table 6.11.3.2. Norway lobster in GSAs 15 and 16. Input data for the a4a model.

Catches (t)

2005	2006	2007	2008	2009	2010	2011	2012	2013
490	673	797	673	637	616	627	479	293
2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
249	230	276	372	333	338	147	189	

Catch numbers-at-age matrix (thousands)

age	2005	2006	2007	2008	2009	2010	2011	2012	2013
2	131.5	206.0	435.6	349.2	382.9	888.0	183.9	125.5	20.2
3	2833.8	4019.4	3364.8	4609.5	4446.1	6953.7	4013.7	2351.0	556.6
4	4897.9	7037.8	6648.5	7335.0	6308.2	7281.6	6278.7	4354.1	1125.3
5	5138.0	7842.1	8780.6	6686.1	5860.4	6424.9	6479.5	4714.8	2054.3
6	2089.6	3105.5	3494.0	2490.0	2478.7	2791.3	2314.8	1762.4	1070.2
7	2242.6	3316.5	4250.4	3506.2	3468.3	3142.3	3044.6	2251.7	1605.4
8	734.9	828.7	1281.2	914.6	1057.8	706.4	837.1	842.4	515.6
9	454.5	594.2	925.7	713.7	688.3	571.6	617.0	556.0	483.1
10+	1337.0	1530.1	1812.6	1547.5	1532.8	1156.8	1640.9	1295.0	1118.2
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
2	20.6	162.9	25.0	46.3	NA	20.9	22.7	4.0	
3	370.7	1562.5	410.1	1035.6	NA	190.2	693.2	61.5	
4	1051.6	2340.4	1345.7	1971.4	NA	1307.3	1159.2	93.9	
5	1882.6	1960.8	2682.8	2940.4	NA	1726.6	1039.9	507.5	
6	1000.1	765.4	1495.7	1562.0	NA	2291.3	445.1	478.7	
7	1396.5	1128.8	1685.9	2133.4	NA	1178.8	719.1	1063.4	
8	380.9	380.0	450.8	600.4	NA	1028.4	245.7	357.1	
9	345.4	264.2	312.0	556.7	NA	587.4	181.3	298.9	
10+	881.5	620.6	726.9	1196.2	NA	1117.1	520.1	910.9	

Weights-at-age (kg)

age	2005	2006	2007	2008	2009	2010	2011	2012	2013
2	0.005	0.005	0.004	0.004	0.004	0.004	0.005	0.005	0.005
3	0.009	0.009	0.009	0.009	0.009	0.008	0.009	0.009	0.009
4	0.014	0.014	0.015	0.013	0.013	0.013	0.014	0.014	0.015
5	0.020	0.019	0.020	0.020	0.020	0.020	0.020	0.019	0.022
6	0.025	0.026	0.025	0.026	0.026	0.026	0.025	0.025	0.026
7	0.033	0.033	0.033	0.033	0.034	0.033	0.033	0.035	0.033
8	0.046	0.045	0.045	0.044	0.044	0.044	0.045	0.046	0.048
9	0.053	0.053	0.054	0.054	0.053	0.052	0.054	0.053	0.055
10+	0.081	0.082	0.085	0.089	0.084	0.083	0.088	0.088	0.083
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
2	0.004	0.004	0.004	0.005	0.005	0.005	0.004	0.004	
3	0.010	0.009	0.010	0.009	0.010	0.009	0.010	0.009	
4	0.015	0.013	0.016	0.014	0.014	0.015	0.013	0.014	
5	0.021	0.019	0.021	0.021	0.020	0.020	0.020	0.025	
6	0.026	0.027	0.026	0.026	0.026	0.027	0.027	0.029	

7	0.035	0.034	0.033	0.034	0.034	0.036	0.035	0.035	
8	0.045	0.045	0.044	0.046	0.045	0.046	0.045	0.045	
9	0.052	0.054	0.054	0.054	0.053	0.048	0.053	0.054	
10+	0.092	0.088	0.085	0.084	0.085	0.091	0.089	0.100	

Maturity.

age	2005	2006	2007	2008	2009	2010	2011	2012	2013
2	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
3	0.63	0.63	0.62	0.63	0.63	0.62	0.63	0.63	0.63
4	0.68	0.71	0.73	0.67	0.67	0.66	0.69	0.70	0.71
5	0.74	0.73	0.74	0.74	0.74	0.74	0.74	0.73	0.80
6	0.79	0.81	0.80	0.81	0.81	0.80	0.80	0.80	0.81
7	0.86	0.85	0.86	0.85	0.86	0.85	0.85	0.87	0.85
8	0.89	0.88	0.88	0.87	0.87	0.86	0.88	0.89	0.91
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
2	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	
3	0.64	0.63	0.63	0.63	0.64	0.61	0.64	0.63	
4	0.74	0.67	0.76	0.71	0.70	0.73	0.66	0.69	
5	0.78	0.72	0.78	0.78	0.76	0.80	0.74	0.88	
6	0.81	0.83	0.80	0.81	0.81	0.83	0.83	0.87	
7	0.87	0.87	0.85	0.86	0.86	0.88	0.87	0.87	
8	0.87	0.88	0.87	0.89	0.88	0.90	0.88	0.87	
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
10+	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Natural mortality.

age	2005	2006	2007	2008	2009	2010	2011	2012	2013
2	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
3	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
4	0.29	0.28	0.28	0.29	0.29	0.29	0.29	0.28	0.28
5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
6	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
7	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
8	0.19	0.19	0.19	0.20	0.20	0.20	0.19	0.19	0.19
9	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
10+	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
2	0.43	0.43	0.43	0.43	0.43	0.43	0.44	0.43	
3	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	
4	0.28	0.29	0.28	0.28	0.29	0.28	0.29	0.29	
5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
6	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.22	
7	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	
8	0.20	0.19	0.20	0.19	0.19	0.19	0.19	0.20	
9	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.18	
10+	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.17	

Proportion of M and F before spawning vectors.

Age	2	3	4	5	6	7	8	9	10+
Prop M	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Prop F	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Norway lobster in GSAs 15 and 16. MEDITS number (n/km^2) at age for GSAs 15 and 16.

age	2005	2006	2007	2008	2009	2010	2011	2012	2013
2	2.73	0.75	0.93	4.50	2.19	1.66	2.75	0.51	0.28
3	6.53	4.35	8.24	16.73	15.67	8.05	11.65	8.11	3.62
4	14.45	10.59	22.60	25.63	27.53	18.88	15.86	22.03	11.93
5	15.73	20.42	32.10	30.90	35.03	19.84	19.37	37.70	14.82
6	28.70	26.10	36.50	33.65	35.56	22.45	19.93	35.49	14.91
7	19.55	25.35	38.01	35.71	28.64	20.31	18.31	27.15	12.02
8	15.73	17.35	27.55	24.06	20.61	15.89	14.06	17.67	7.36
9	11.00	13.13	14.18	14.74	11.60	9.07	8.96	8.49	4.82
10	40.57	22.48	23.31	27.24	23.74	20.56	19.51	17.17	8.33
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
2	NA	0.14	0.86	0.50	0.20	0.30	0.12	0.28	
3	NA	2.26	7.82	1.54	2.97	1.65	1.16	1.15	
4	NA	8.76	19.55	5.21	6.77	7.47	3.10	2.62	
5	NA	15.70	33.44	11.49	12.11	11.00	4.52	4.39	
6	NA	16.19	29.56	14.32	14.84	15.85	3.54	4.17	
7	NA	17.58	26.51	12.18	12.75	16.97	5.26	5.12	
8	NA	14.02	17.69	8.77	9.95	9.39	4.27	3.15	
9	NA	7.57	10.50	4.80	5.09	7.44	2.72	2.01	
10	NA	12.49	13.21	10.98	11.71	12.24	8.48	5.43	

Figures 6.13.3.1-5 show the age structure of the catches, of the index, the weight at age matrix and the catch at age and MEDITS cohort consistency

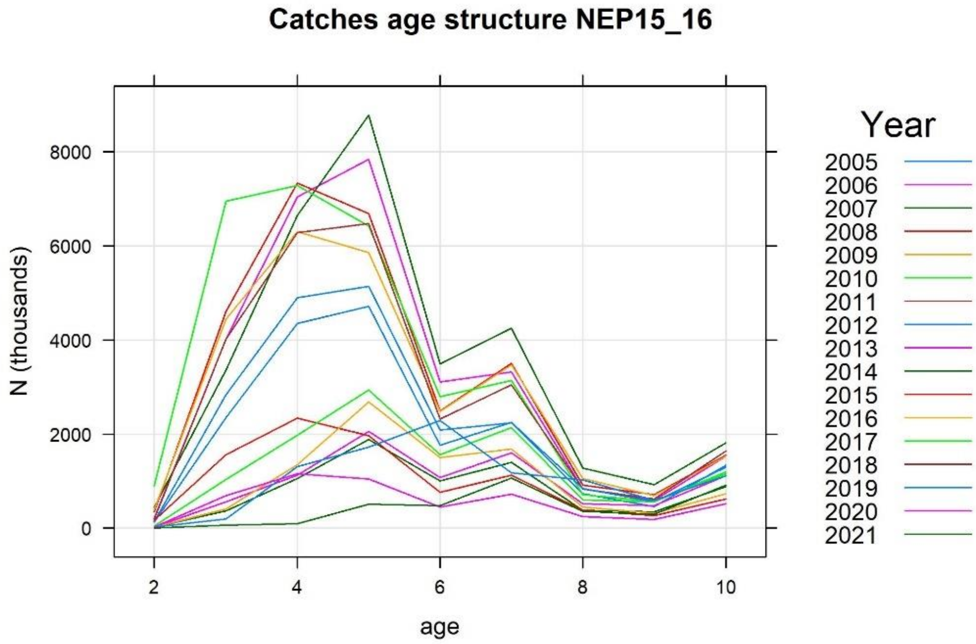


Figure 6.11.3.1. Norway lobster in GSAs 15 and 16. Age structure of the catches.

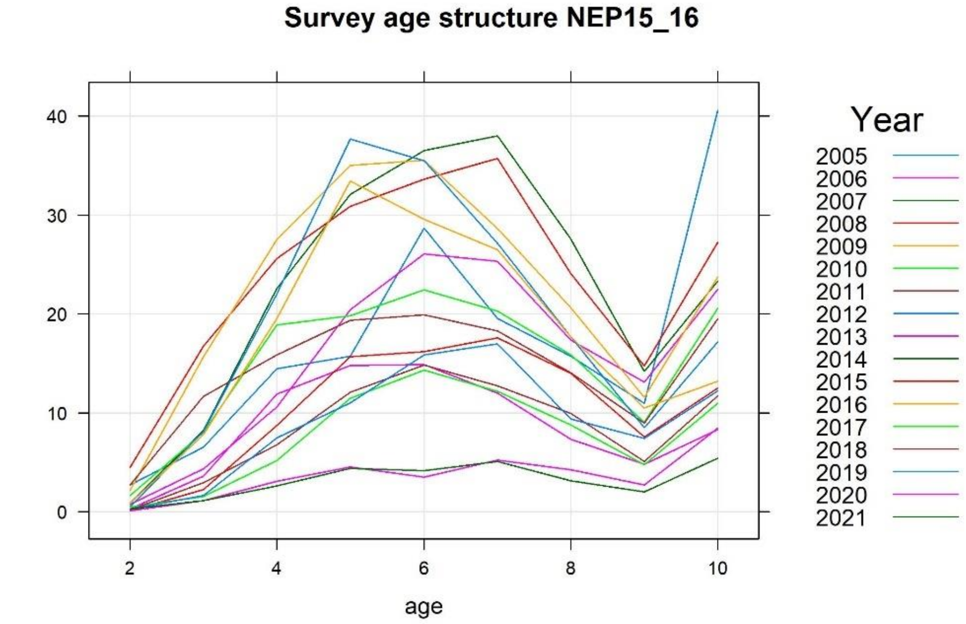


Figure 6.11.3.2. Norway lobster in GSAs 15 and 16. Age structure of the index.

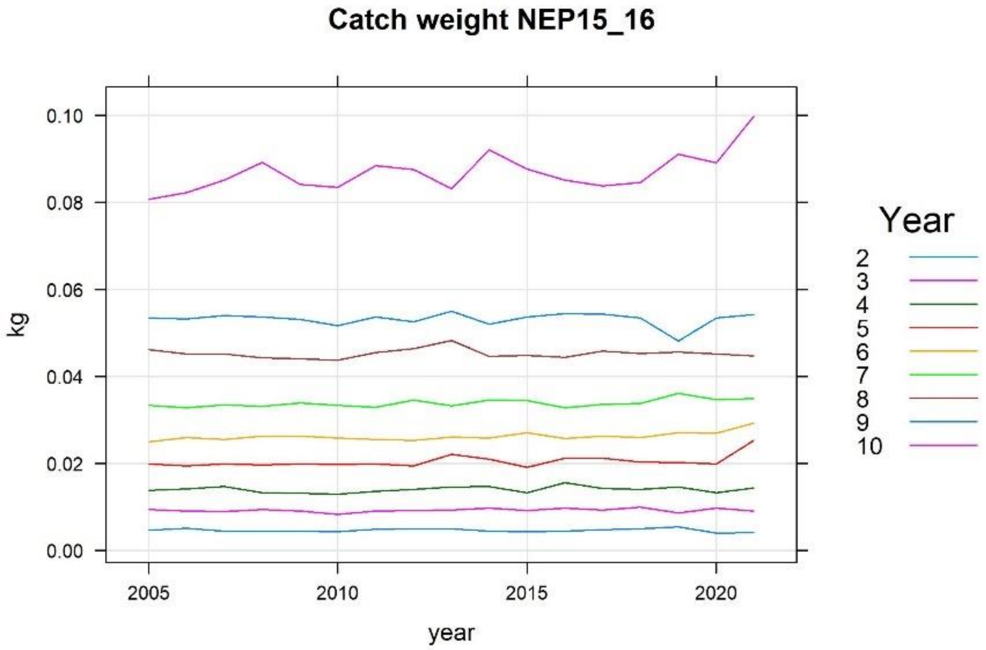


Figure 6.11.3.3. Norway lobster in GSAs 15 and 16. Weight at age matrix.

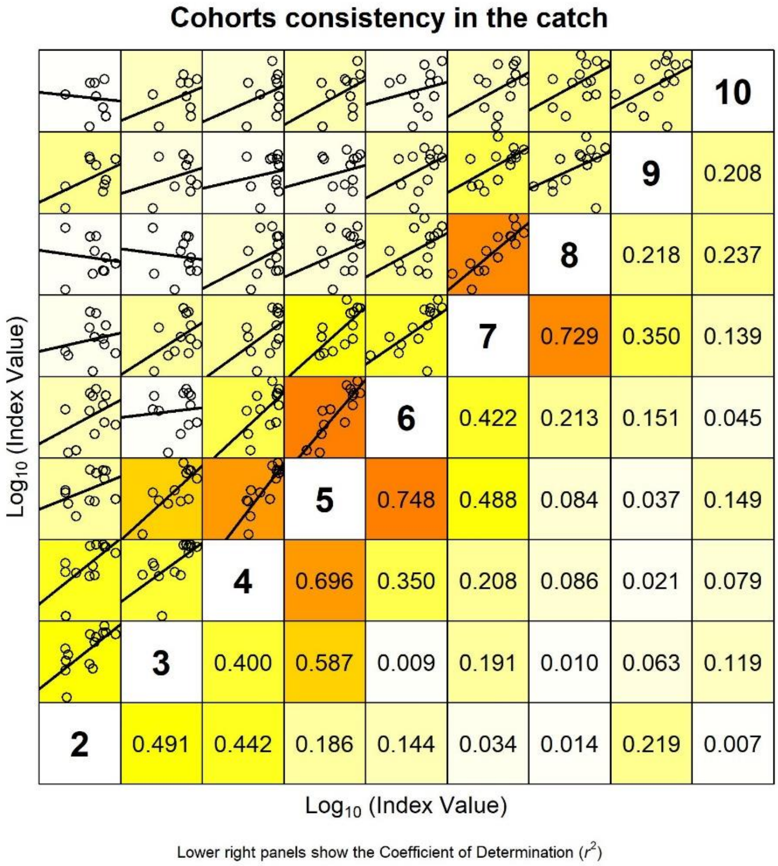


Figure 6.11.3.4. Norway lobster in GSAs 15 and 16. Catch at age cohort consistency.

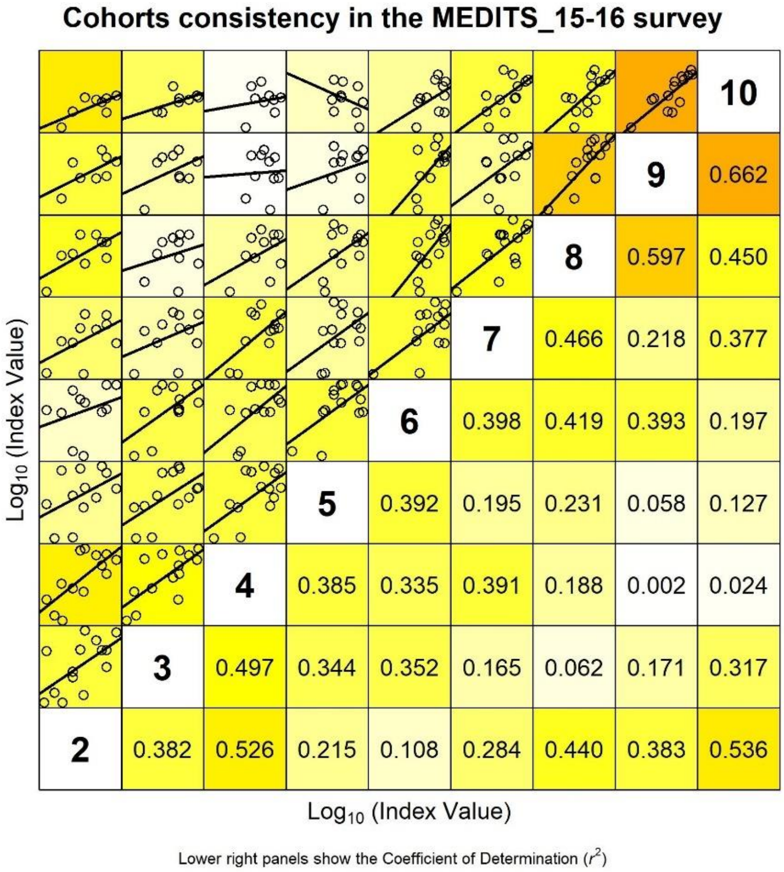


Figure 6.11.3.5. Norway lobster in GSAs 15 and 16. Index at age cohort consistency.

Assessment results

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

Submodels:

fmodel: ~ factor(age) + s(year, k=8)

srmodel: ~factor(year)

qmodel: MEDITS: ~factor(replace(age, age > 7, 7))

Assessment results are shown in Figures 6.11.3.3-6.11.3.9 and Tables 6.11.3.3- 6.11.3.6.

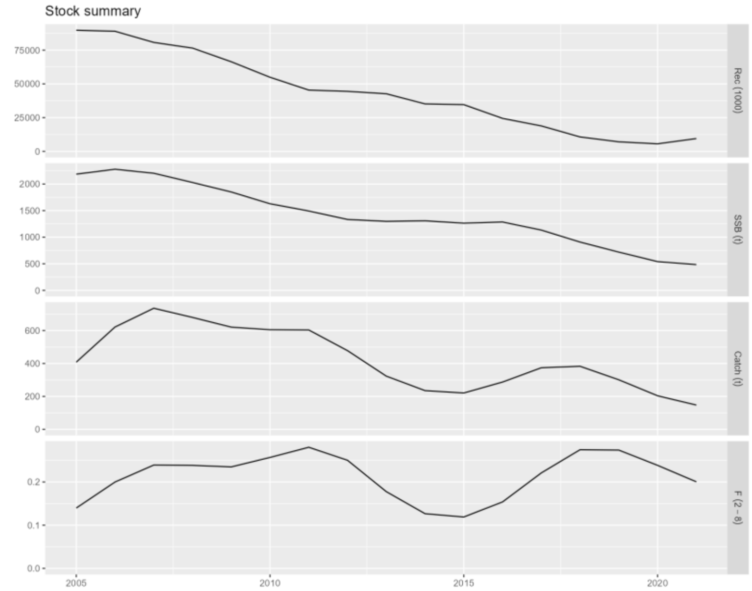


Figure 6.11.3.6. Norway lobster in GSAs 15 and 16. Stock summary from the final a4a model. Recruits (Age 2), SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 2 to 8).

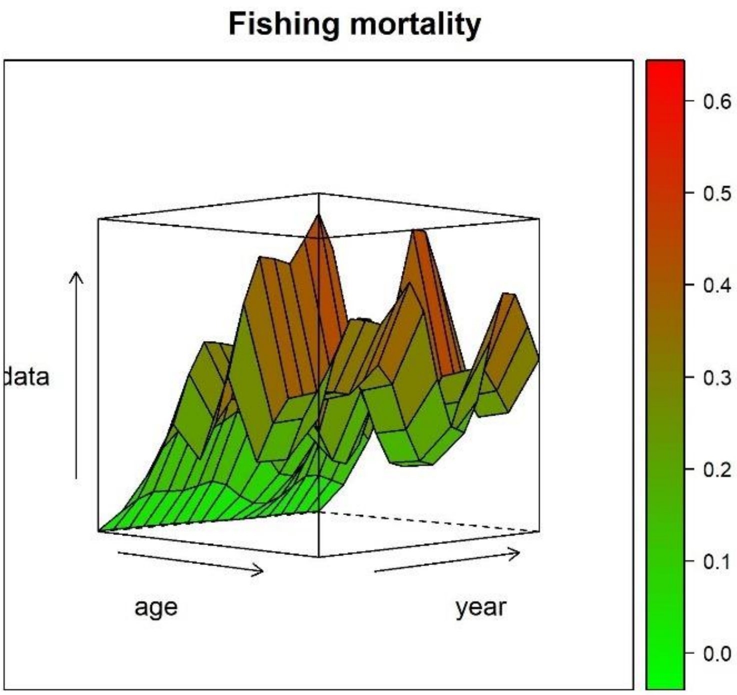


Figure 6.11.3.7. Norway lobster in GSAs 15 and 16. 3D contour plot of estimated fishing mortality at age and year.

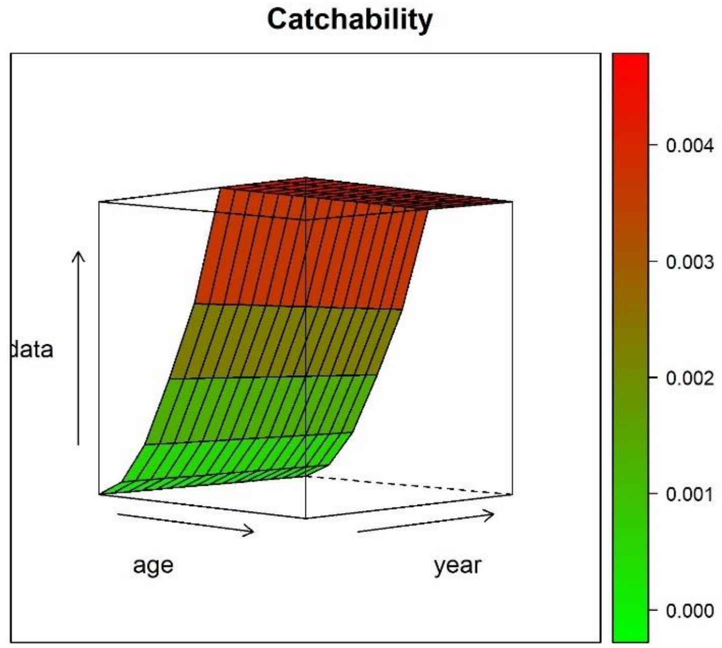


Figure 6.11.3.8. Norway lobster in GSAs 15 and 16. 3D contour plot of estimated catchability at age and year.

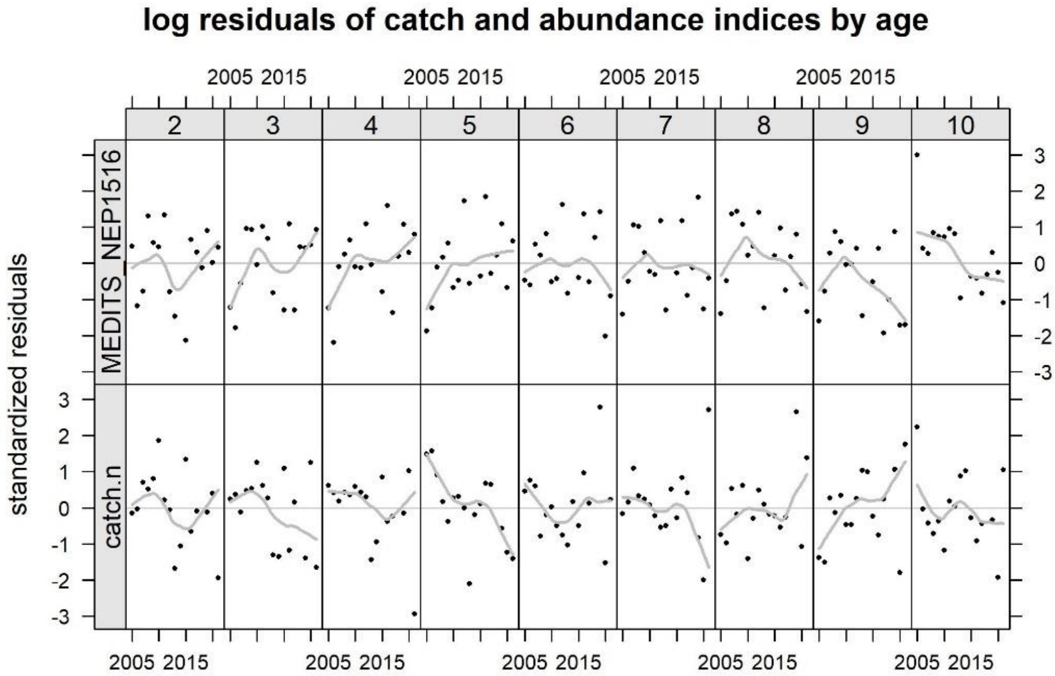


Figure 6.11.3.9. Norway lobster in GSAs 15 and 16. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines simple smoothers.

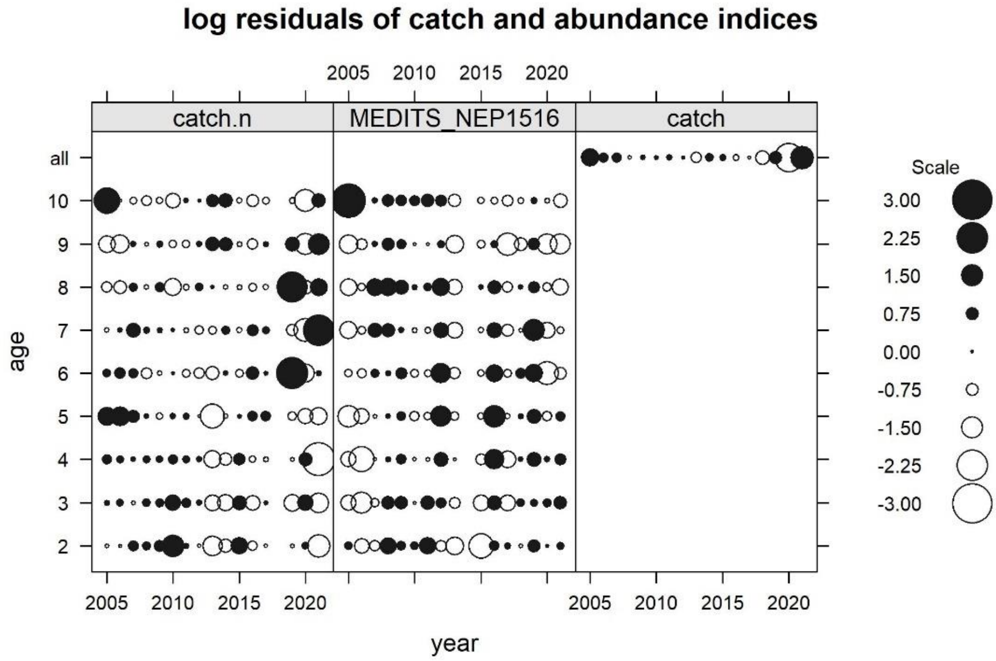


Figure 6.11.3.10. Norway lobster in GSAs 15 and 16. Standardized residuals for abundance indices and for catch numbers.

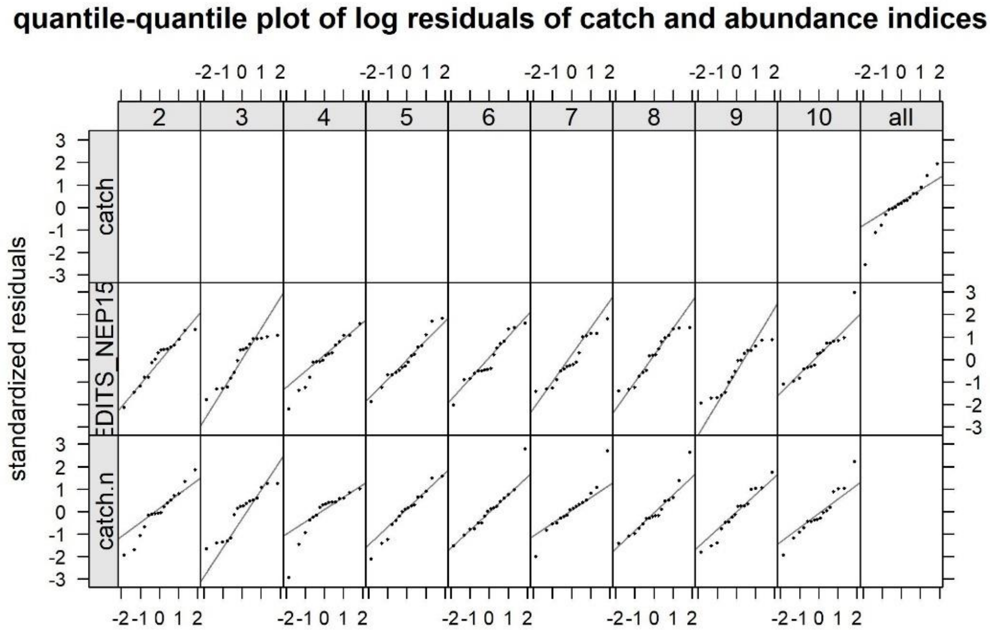


Figure 6.11.3.11. Norway lobster in GSAs 15 and 16. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and line the normal distribution quantiles.

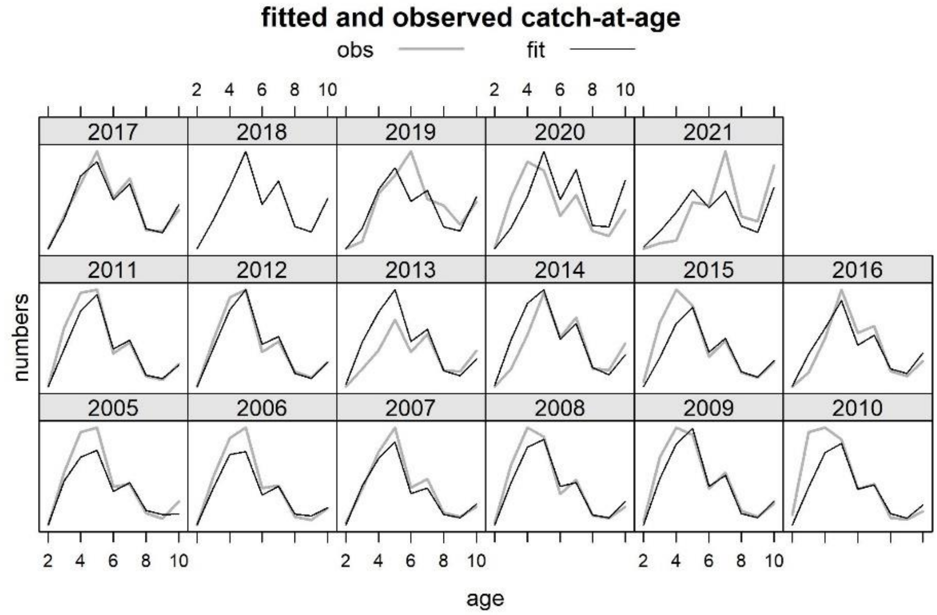


Figure 6.11.3.12. Norway lobster in GSAs 15 and 16. Fitted and observed catch at age.

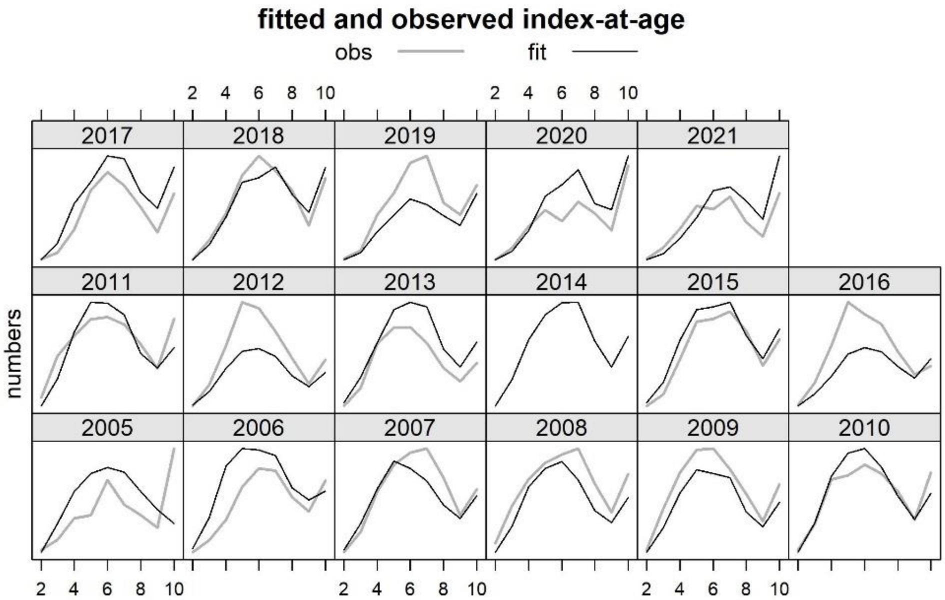


Figure 6.11.3.13. Norway lobster in GSAs 15 and 16. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to 5 years back. Model results are quite stable (Figure 6.11.3.14) and show a slight tendency to overestimate SSB (Mohn's rho 0.02) and F (Mohn's rho 0.09).

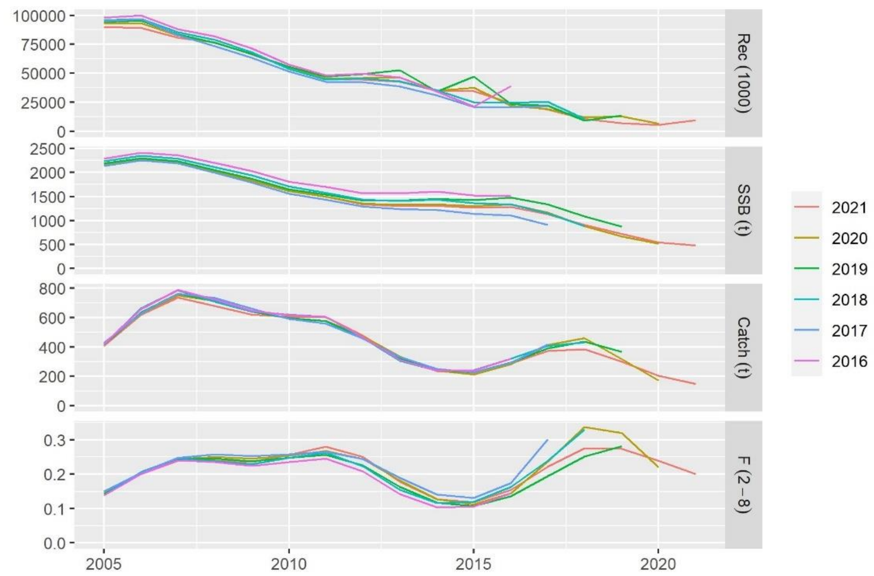


Figure 6.11.3.14. Norway lobster in GSAs 15 and 16. Retrospective analysis.

Simulations

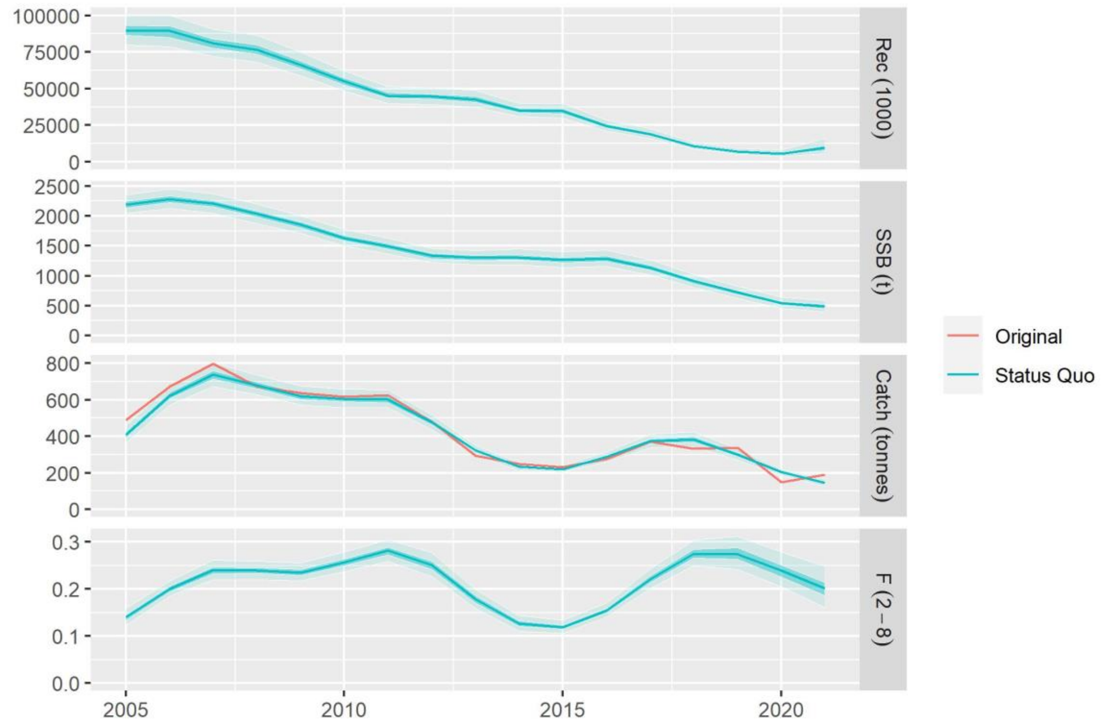


Figure 6.11.3.9. Norway lobster in GSAs 15 and 16. Simulations over summary results.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.11.3.3. Norway lobster in GSAs 15 and 16. Stock numbers at age (thousands) as estimated by a4a.

	2	3	4	5	6	7	8	9	10+
2005	89745	63462	38103	23318	14804	9849	6867	4967	3662
2006	88986	58045	43230	25527	14677	10146	5922	4854	5960
2007	80741	57544	38758	27569	14658	9432	5360	3919	6806
2008	76529	52095	37929	23937	14915	9026	4581	3398	6322
2009	66388	49389	34362	23414	12964	9197	4390	2905	5727
2010	54908	42846	32606	21273	12751	8024	4509	2795	5105
2011	45409	35418	28069	19822	11206	7706	3752	2802	4533
2012	44469	29314	23039	16743	10073	6601	3425	2274	4083
2013	42692	28726	19260	14094	8906	6129	3133	2146	3685
2014	35164	27607	19326	12512	8383	5863	3397	2126	3762
2015	34612	22732	18891	13102	8040	5830	3627	2434	4091
2016	24442	22364	15588	12871	8507	5642	3667	2622	4587
2017	18849	15790	15166	10336	7935	5745	3290	2551	4813
2018	10688	12176	10474	9505	5754	4986	2901	2128	4450
2019	7063	6901	7940	6278	4874	3411	2244	1769	3663
2020	5595	4557	4495	4766	3226	2894	1540	1371	3027
2021	9484	3605	3007	2774	2581	1990	1408	977	2580

Table 6.11.3.4. Norway lobster in GSAs 15 and 16. a4a summary results.

	Fbar(2-8)	Recruitment (Age 2; thousands)	SSB (t)	TB (t)	Input Catch (t)	Estimated Catch (t)
2005	0.14	89745	2187	3582	490	408
2006	0.20	88986	2278	3812	673	621
2007	0.24	80741	2203	3709	797	735
2008	0.24	76529	2029	3446	673	680
2009	0.23	66388	1850	3143	637	621
2010	0.26	54908	1629	2800	616	605
2011	0.28	45409	1493	2577	627	603
2012	0.25	44469	1334	2259	479	478
2013	0.18	42692	1298	2080	293	323
2014	0.13	35164	1309	2001	249	235
2015	0.12	34612	1264	1930	230	221
2016	0.15	24442	1286	1942	276	287
2017	0.22	18849	1134	1767	372	374
2018	0.27	10688	909	1454	333	383
2019	0.27	7063	720	1116	338	301
2020	0.24	5595	541	821	147	204
2021	0.20	9484	485	703	189	148

Table 6.11.3.5. Norway lobster in GSAs 15 and 16. a4a results F at age.

	F at age								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2005	0.002	0.05	0.12	0.21	0.15	0.30	0.15	0.16	0.23
2006	0.003	0.07	0.17	0.30	0.22	0.43	0.22	0.23	0.33
2007	0.004	0.08	0.20	0.36	0.26	0.51	0.26	0.27	0.40
2008	0.004	0.08	0.20	0.36	0.26	0.51	0.26	0.27	0.40
2009	0.003	0.08	0.19	0.36	0.25	0.50	0.26	0.27	0.39
2010	0.004	0.08	0.21	0.39	0.28	0.55	0.28	0.29	0.43
2011	0.004	0.09	0.23	0.43	0.30	0.60	0.31	0.32	0.46
2012	0.004	0.08	0.21	0.38	0.27	0.54	0.27	0.29	0.41
2013	0.003	0.06	0.15	0.27	0.19	0.38	0.19	0.20	0.29
2014	0.002	0.04	0.10	0.19	0.14	0.27	0.14	0.14	0.21
2015	0.002	0.04	0.10	0.18	0.13	0.26	0.13	0.14	0.20
2016	0.002	0.05	0.13	0.23	0.17	0.33	0.17	0.18	0.25
2017	0.003	0.07	0.18	0.34	0.24	0.47	0.24	0.25	0.37
2018	0.004	0.09	0.23	0.42	0.30	0.59	0.30	0.31	0.46
2019	0.004	0.09	0.23	0.42	0.30	0.59	0.30	0.31	0.45
2020	0.004	0.08	0.20	0.36	0.26	0.51	0.26	0.27	0.40
2021	0.003	0.07	0.17	0.30	0.22	0.43	0.22	0.23	0.33

Based on the a4a results, the Norway lobster recruitment shows a decreasing trend from the beginning of the time series with a slight increase in 2021. SSB follows the same pattern but is declining also in 2021. F has been fluctuating throughout the time series, reached a maximum in 2019 and has been slightly decreasing after.

The assessment appears to be stable and the results are consistent between different models and between different approaches used to slice the length data (sex separated or sex combined). However, in future meetings the increase in maximum age for this stock should be explored in order to reduce the numbers in the plus group of both catches and index. This issue does not have a substantial impact on the results of the present assessment because of the catchability submodel used in the a4a assessment that assumes constant catchability for ages above 7.

6.11.4 REFERENCE POINTS

The table below (Table 6.11.4.1) summarises all known reference points for Norway lobster in GSAs 15 and 16 and their technical basis.

Table 6.11.4.1 Norway lobster in GSAs 15 and 16. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.10	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
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}	0.10	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range $F_{MSY\ lower}$	0.069	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range $F_{MSY\ upper}$	0.143	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

6.11.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age, while the F_{2021} =0.20 (the last year's F estimated by the assessment model) was used for F in 2022, as F shows a decreasing trend (See section 4.3). As for this stock the recruitment has been constantly decreasing throughout the time series, the geometric mean of the recruitment of the last four years was used for the short term projections as an estimate of recruits in 2022 to 2023.

Table 6.11.5.1 Norway lobster in GSAs 15 and 16. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3 years	Mean weights at age, maturation at age, natural mortality at age and selection at age, are based average of years 2019-2021
$F_{ages\ 2\text{-}8}$ (2022)	0.20	The F estimated in 2021 was used to give F status quo for 2022
SSB (2022)	385	SSB intermediate year from STF output.
R_{age2} (2022,2023)	7955	Geometric mean of the last 4 years
Total Catch (2022)	115	Assuming F status quo for 2022

Table 6.11.5.2. Norway lobster in GSAs 15 and 16. Short term forecast in different F scenarios.

Rationale	F factor	Fbar 2023	Catch 2023	SSB* 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
High long term yield ($F_{0.1}$)	0.499	0.10	51	347	-9.8	-65
F_{upper}**	0.712	0.143	71	322	-16.5	-52
F_{lower}	0.344	0.069	36	368	-4.5	-76
Zero catch	0	0	0	418	8.6	-100
Status quo	1	0.20	96	290	-24.6	-35
Different Scenarios	0.1	0.02	11	403	4.6	-93
	0.2	0.04	22	388	0.8	-86
	0.3	0.06	32	374	-2.9	-79
	0.4	0.08	42	360	-6.4	-72
	0.5	0.10	51	347	-9.8	-65
	0.6	0.12	61	335	-13	-59
	0.7	0.14	70	323	-16.1	-53
	0.8	0.16	79	312	-19.1	-47
	0.9	0.18	88	301	-21.9	-41
	1.1	0.22	104	280	-27.3	-29
	1.2	0.24	112	271	-29.7	-24
	1.3	0.26	120	261	-32.1	-19
	1.4	0.28	127	253	-34.4	-14
	1.5	0.30	135	244	-36.6	-8.8
	1.6	0.32	142	236	-38.7	-4
	1.7	0.34	149	228	-40.7	0.7
	1.8	0.36	155	221	-42.7	5.2
	1.9	0.38	162	214	-44.5	9.6
	2	0.40	168	207	-46.3	14

* SSB at the middle of the year. ** F_{upper} is not tested and is assumed not to be precautionary STECF does not advise fishing at F > F_{MSY}

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.10 and corresponding catches in 2023 should be no more than 51 tons.

6.11.6 Data Deficiencies

Data from DCF 2021 as submitted through the Official data call in 2022 were used.

In GSA 16, the Italian length frequencies distributions provided have a 2 mm length class step which is not in agreement with the template requested by the Mediterranean and Black Sea Data Call.

In GSA 16, the Italian length frequencies distribution provided in 2016 for the metier OTB MDD have both 2 mm and 1 mm length class step.

In GSA 16, the Italian length frequencies distributions have been not provided in year 2018.

In GSA 16, the Italian length samples are not covering consistently each quarter and metier available in the area.

In GSA 16, the Italian length frequencies distributions in numbers are quite poor in the last years. It is not clear whether due to a not appropriate samplings or a huge reduction of the abundance of the species in the area.

In GSA 16, the numbers for Italy in year 2016, quarter 4, vessel length 1218, gear OTB and fishery MDD seem reported in total numbers not in thousands as requested in the Mediterranean and Black Sea Data Call.

In GSA 16 for Italy, an inconsistent Sum of Product has been spotted in year 2009, quarter -1, gear OTB, fishery DEMSP. Please check total landings and number reported.

In GSA 16 for Italy, an unrealistic maturity at length reported in years 2015 and 2016 for female.

In GSA 16 for Italy, maturity at length has been reported having 2 mm length class step.

In GSA 16 for Italy, length weight parameter a in 2019 for sex combined (C) is likely misreported. Indeed, a is equal to 0.005 while 0.0005 is expected.

In GSA 16 for Italy, in the MEDITS TA file the number of hauls carried out along the time series change a lot. In particular, in years 2014 and in 2020. In the former year the reduction applied doesn’t seem proportional to each stratum ending up with a very few hauls carried out in the deeper stratum.

In GSA 16 for Italy, the MEDITS survey period has not been always respected. In particular in years 2013, 2017, 2020 and 2021.

In GSA 16 for Italy, many inconsistencies in total weight or total number reported by haul in the MEDITS TB and TC files have been spotted.

In GSA 15 for Malta, no landings LFD have been provided from 2005 to 2008 and in 2013.

In GSA 15 for Malta, the mean weight derived as ratio between landings in weight and numbers by length classes for each metier combinations seem quite unrealistic in 2009, 2010, 2011, 2012, 2014 and 2019 in OTB_MDD and in 2017 in OTB_DEMF.

In GSA 15 for Malta, the discards length frequencies distributions for year 2012 seems related just to one measures while the derived mean length as ration between discards weight and numbers by metier seem quite unrealistic. Likely numbers have been reported as absolute numbers and not as thousands as MEDBS data call requested.

In GSA 15 for Malta, the MEDITS TB data for year 2017 are missing.

In GSA 15 for Malta, the MEDITS survey period has not been always respected. In particular in year 2018.

In GSA 15 for Malta, in the MEDITS TB file the total weight in year 2009 hauls 21, 22 and 70 and likely also in haul 11 is misreported.

In GSA 15 for Malta, in the MEDITS TC file the total weight in year 2009 hauls 21, 22 and 70 and likely also in haul 11 is misreported.

6.12 STRIPED RED MULLET IN GSAs 15 AND 16

6.12.1 STOCK IDENTITY AND BIOLOGY

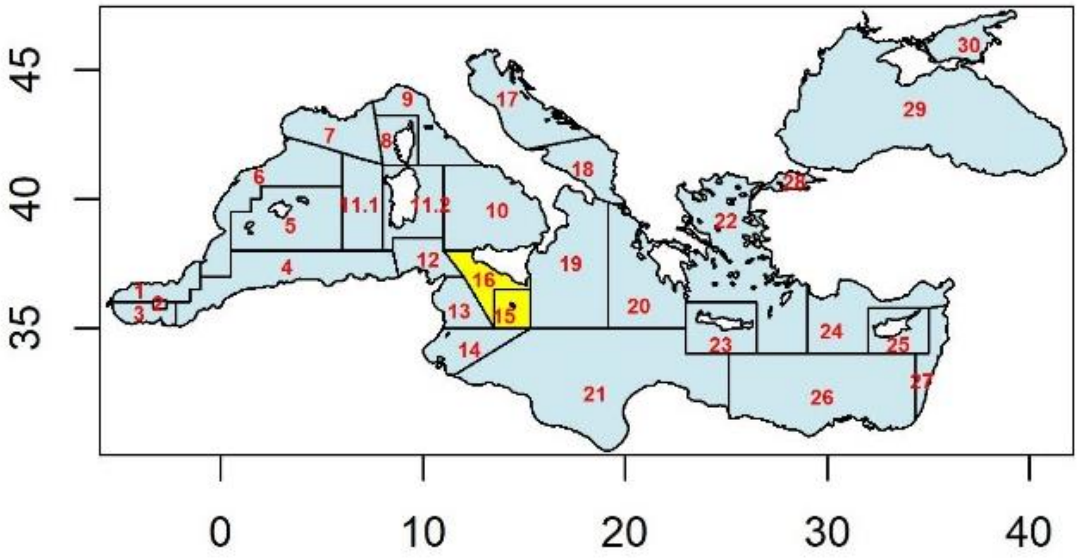


Figure 6.12.1 - Striped red mullet in GSA15_16: Location of the GSA 15 and 16 in the Mediterranean Sea.

The GSA15_16 (Strait of Sicily and Maltese waters) is located next to GSAs which are not under the DCF regulations as not belonging to any EU Member State (e.g. Tunisia and Lybia) (Figure 6.12.1). Because of it, it is well known that, Sicilian fleets exploit resources on international western-southern waters belonging to GSAs 12, 13 and 14, giving the possibility that data available through the DCF could be also related to cacthes derived from these fishing grounds and, conseguentely, making the analysis of GSAs 15 and 16 more difficult (i.e., catches could be assigned to GSA16 even if collected in other areas).

Growth

The GSA16 von Bertalanffy growth parameters and length weight relationships of striped red mullet were both available in the DCF data for many years along 2002 to 2021 period (Figures 6.12.2-7). Data weren’t available for GSA15.

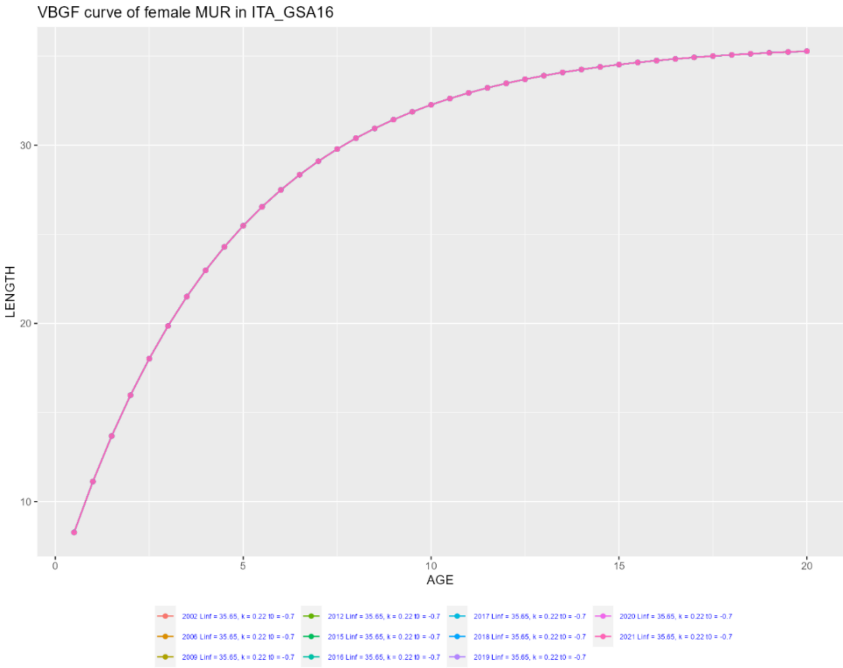


Figure 6.12.2 - Striped red mullet in GSA15_16: von Bertalanffy growth curves by female in GSA16.

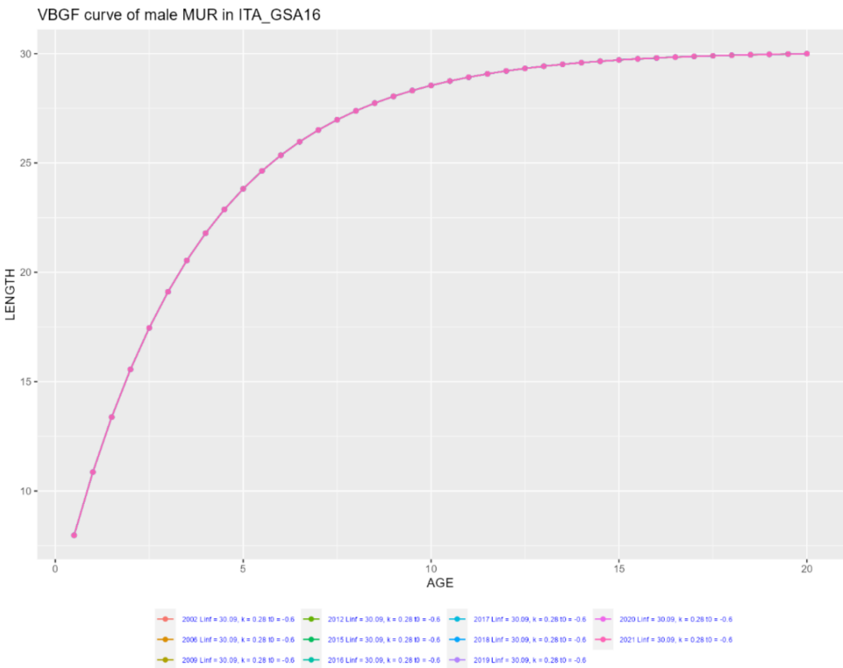


Figure 6.12.3 - Striped red mullet in GSA15_16: von Bertalanffy growth curves by male in GSA16.

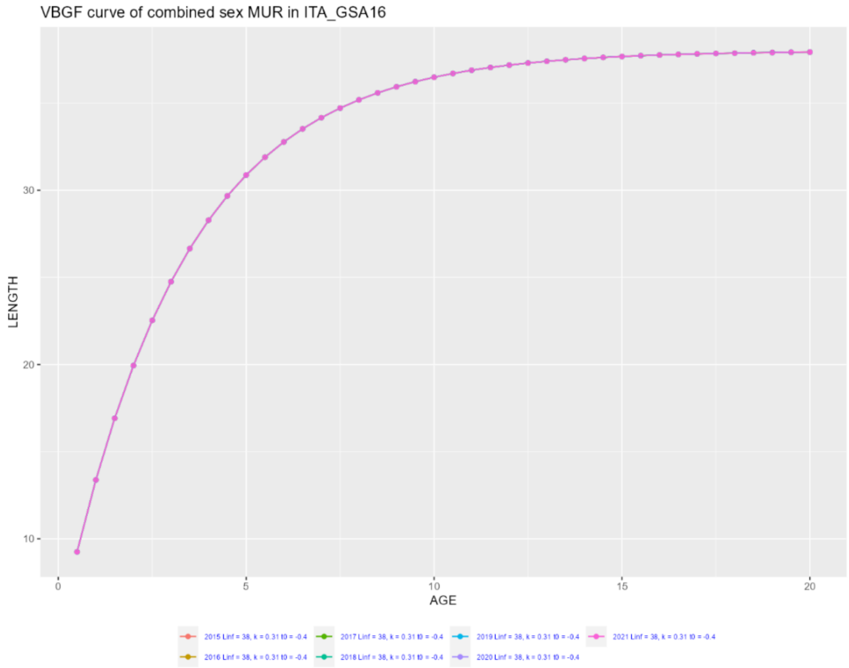


Figure 6.12.4 - Striped red mullet in GSA15_16: von Bertalanffy growth curves by sex combined in GSA16.

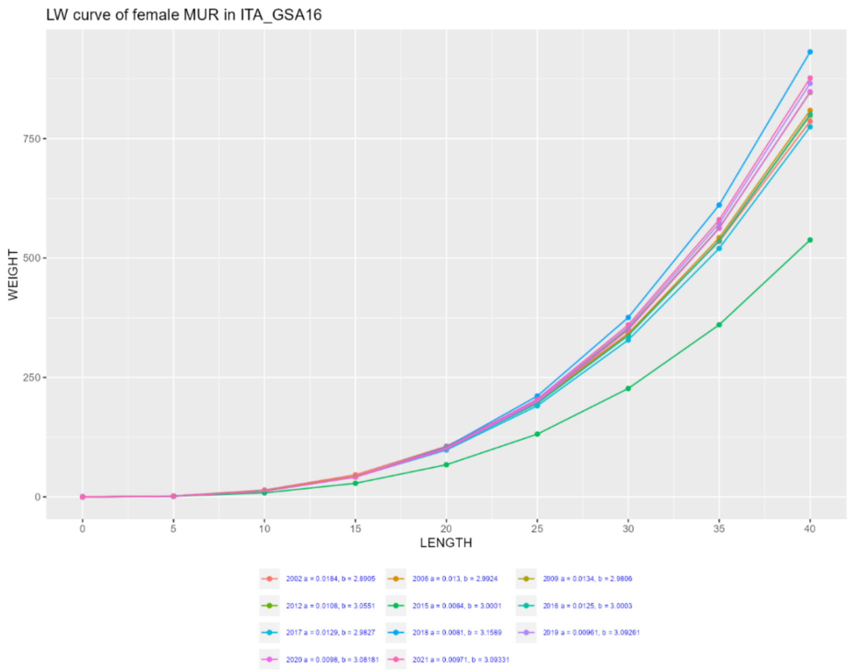


Figure 6.12.5 - Striped red mullet in GSA15_16: length weight relationships by female in GSA16.

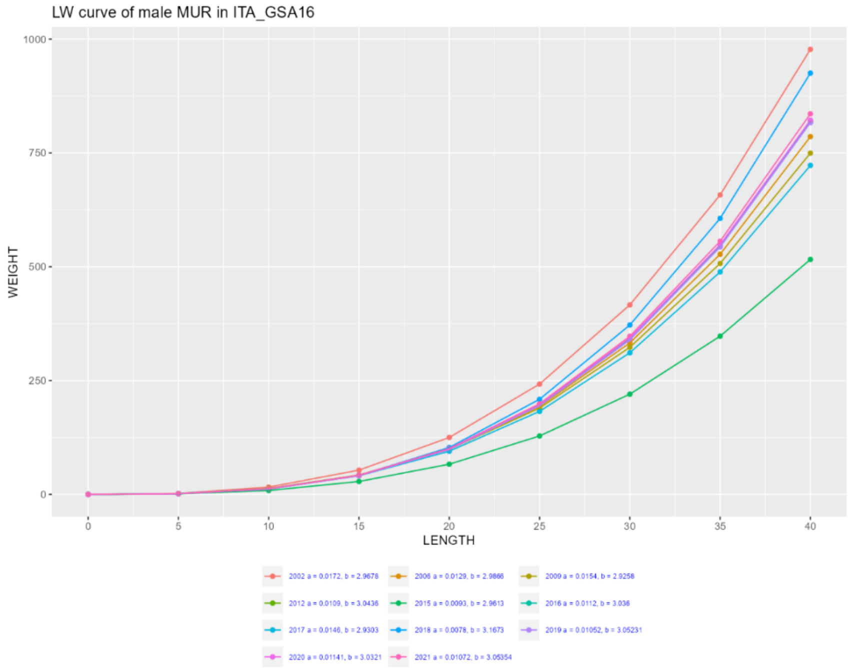


Figure 6.12.6 - Striped red mullet in GSA15_16: length weight relationships by male in GSA16.

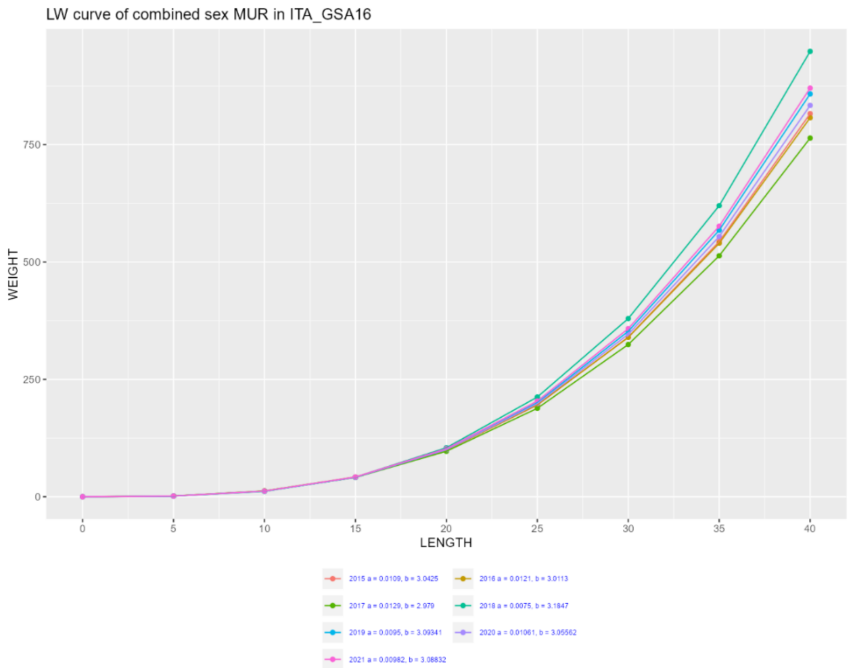


Figure 6.12.7 - Striped red mullet in GSA15_16: length weight relationships by sex combined in GSA16.

The time series of the VBGF parameters show that values by sex are always the same along the years. (Figure 6.12.8).

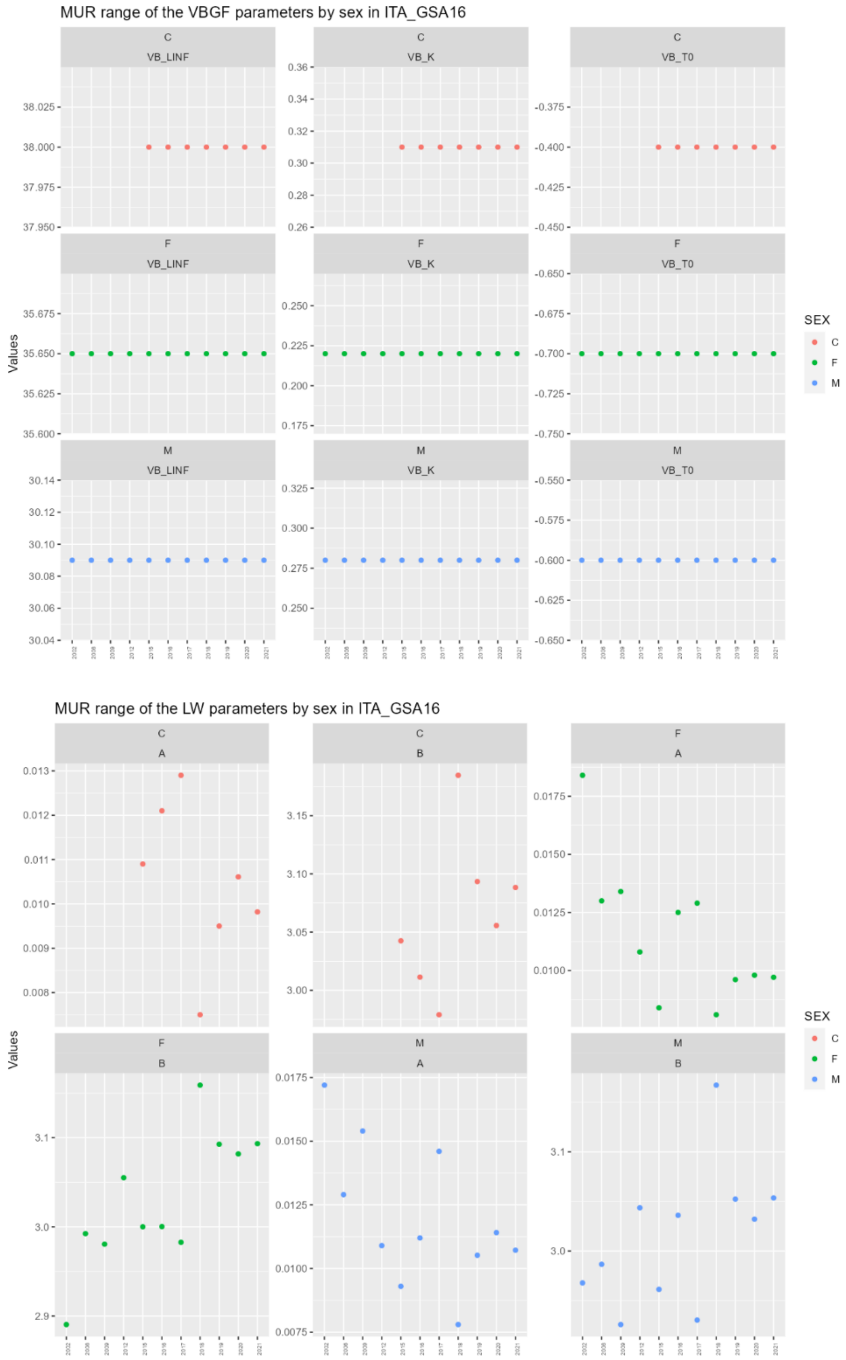


Figure 6.12.8 - Striped red mullet in GSA15_16: GSA16 Time series of the von Bertalanffy growth parameters (upper panel) and length weight relationship ones (lower panel) are showed.

Maturity

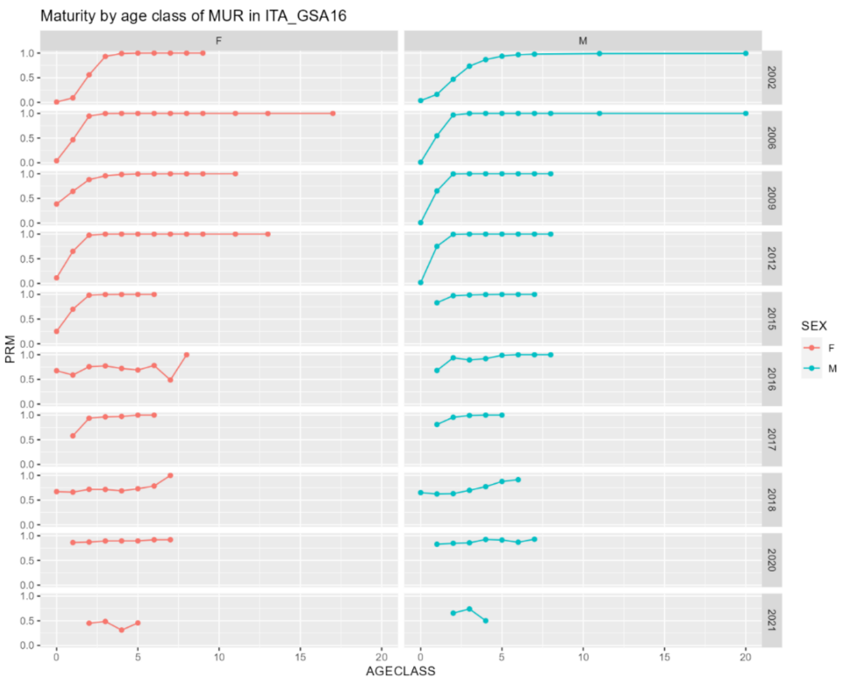
In literature the striped red mullet in the area is reported mainly as a late Spring/Summer spawners (Figure 6.12.9).

SPAWNING PERIOD

Geographic area	Sex	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	References
Mediterranean Sea														
GSA 3 N.W. Morocco	C				X	X	X							El Bakali, Talbaoui and Bendriss (2010)
GSA 3 Morocco	C					X	X	X						Lamrini (2010)
GSA 4 Algerian coast	C					X	X	X						Lalami (1971)
GSA 5 Balearic Sea	C				X	X								Morales-Nin (1992)
	C			X	X	X	X							Reñones, Massuti and Morales-Nin (1995a)
GSA 7 Gulf of Lion	C					X	X	X						Lloret, Lleonart and Solé (2000)
GSAs 12, 13, 14 Tunisia	C				X	X	X							Gharbi and Ktari (1981)
GSA 12 Gulf of Tunis	C					X	X	X						Chérif *et al.* (2007)
GSA 16 Strait of Sicily	C				X	X	X	X	X	X				Ragonese *et al.* (2004a)
GSA 17 Adriatic Sea	C					X	X	X						Jardas (1996)
	C						X	X						Grubišic (1962)
GSA 22 Izmir Bay	C					X	X							Ak and Hossucu (2001)
	C				X	X	X	X	X	X				İlhan *et al.* (2009)
GSA 22 Edremit Bay	C				X	X	X	X	X	X				Üstün, Torcu-Koç and Zerdoğan (2010)
GSA 22 N.E. Aegean Sea	C				X	X	X							Arslan and Ismen (2014)
GSA 26 Egyptian waters	C				X	X	X							Hashem (1973b)
	C				X	X	X							Mehana (2009)
GSA 27 Israel	C			X	X	X	X							Golani (1994)

Figure 6.12.9 – Striped red mullet in GSA15_16: Spawning periods as reported in the Mediterranean areas.

DCF data provided maturity ogives both in age and length for many years between 2002 and 2021 (Figures 6.12.10-11).



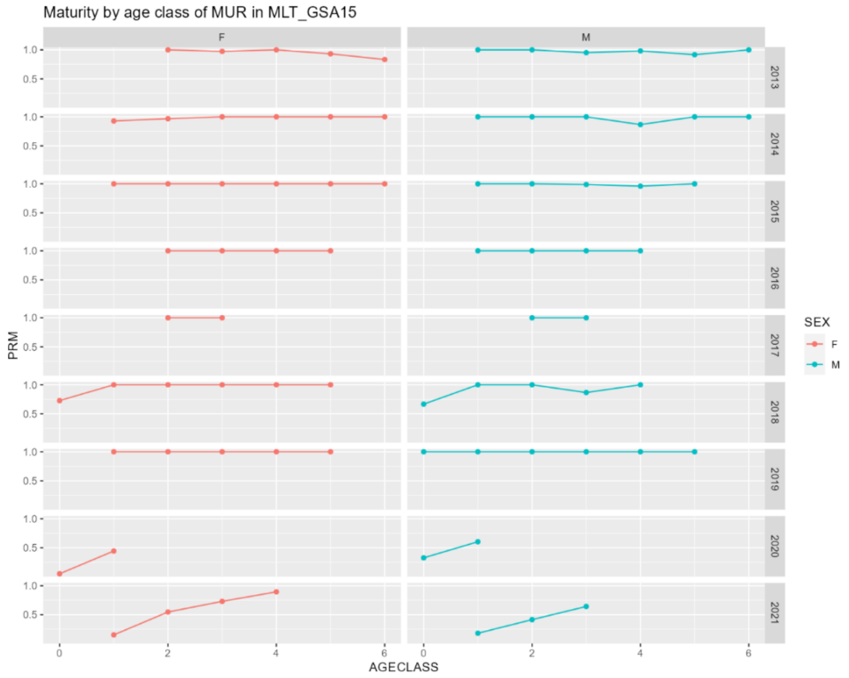
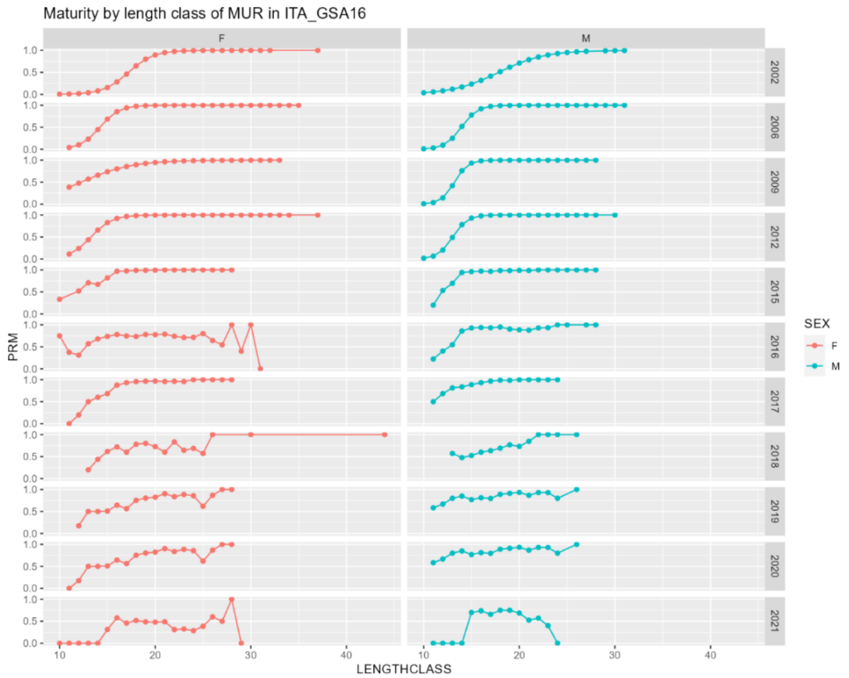


Figure 6.12.10 – Striped red mullet in GSA15_16: Maturity vector by age available through the DCF data in GSA 16 (upper panel) and in GSA15 (lower panel).



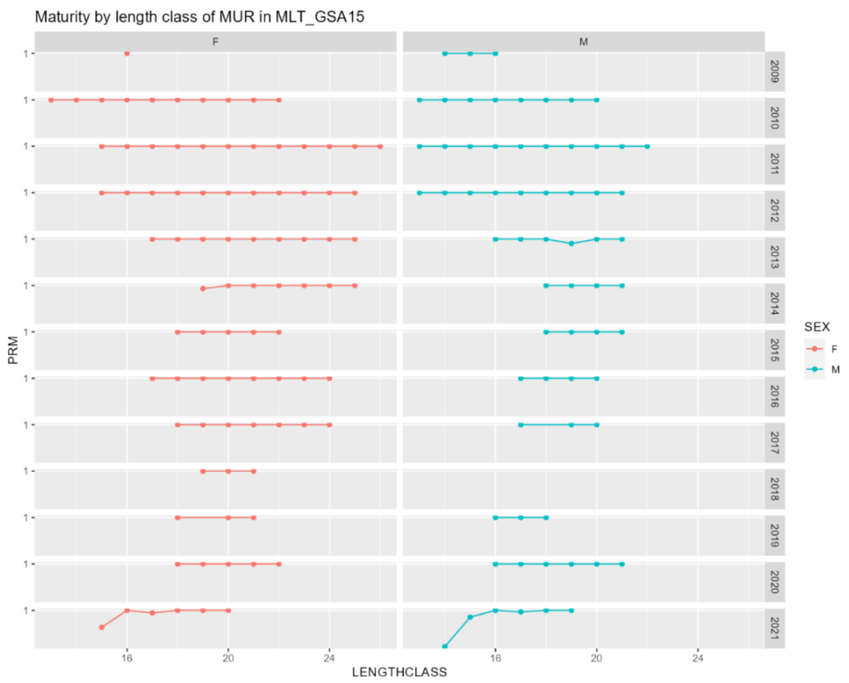


Figure 6.12.11 – Striped red mullet in GSA15_16: Maturity vector by length available through the DCF data in GSA 16 (upper panel) and in GSA15 (lower panel).

Maturity vector by length data provided in GSA16 for females in years 2016 and 2021 seem misreported. In 2021 the same issue is present for males. Basically, maturity values decrease in size. In 2018 a exceptional specimens of more than 44 cm TL has been observed (bigger than all the VBGF length infinite values reported). Considering the low amount of catches coming from GSA15 (see chapter Catch) and consequent lower number of biological samples available the final maturity vector to be used in the assessment has been estimated using only GSA16 data.

6.12.2 Data

6.12.2.1 Catch (landings and discards)

In GSA16 the main fleets targeting the striped red mullet are the bottom otter trawl (OTB) and the trammel nets (GTR).

In GSA15 reported landings values extracted from catches and landings at length DCF templates are inconsistent up to 2014 (Table 6.12.1). So, only values matching between the two sources of information have been accepted. The discards values are usually very low with the exceptions of 2011, 2013, 2014 and 2016 years in GSA16. Based on the EU Mediterranean Regulation, the striped red mullet has a Minimum Conservation Reference Size (MCRS) set at 11 cm TL. This MCRS length size should be the main reason for which some individuals could be discarded in OTB fleet while the discard amounts from the set netters is likely due to individuals which are damaged. In Table 6.12.2 and Figures 6.12.12-13 yearly total landings and discards in weight are presented.

Table 6.12.1 Striped red mullet in GSA15_16: Landings, discards and catches in tonnes of striped red mullet in GSA15 as extracted from the three main data templates. In bold landings data matching

Year	Landings (t) from catches data file	Landings (t) from landings data file	Landings % of variation	Discards (t) from catches data file	Discards (t) from discards data file	Discards % of variation
2005	7.385	NA	NA	0.000	NA	NA
2006	10.007	NA	NA	0.000	NA	NA
2007	14.558	NA	NA	0.000	NA	NA
2008	15.909	NA	NA	0.000	NA	NA
2009	36.923	28.507	22.793	0.000	0.000	0.000
2010	52.973	37.482	29.243	0.000	0.000	0.000
2011	64.258	43.970	31.573	0.000	0.000	0.000
2012	75.219	39.184	47.907	0.007	0.007	0.068
2013	23.125	5.607	75.753	0.000	0.000	0.000
2014	**45.259**	**45.259**	**0.000**	0.000	0.000	0.000
2015	**38.324**	**38.326**	**-0.006**	0.000	0.000	0.000
2016	**43.170**	**43.170**	**0.000**	0.004	0.004	0.000
2017	**31.297**	**31.297**	**0.000**	0.057	0.057	0.000
2018	**30.263**	**30.263**	**0.000**	0.162	0.162	0.000
2019	**28.074**	**28.073**	**0.005**	0.009	0.009	0.000
2020	**16.960**	**16.960**	**0.001**	0.118	0.118	0.000
2021	**25.751**	**25.751**	**0.000**	0.128	0.128	0.000

Table 6.12.2 Striped red mullet in GSA15_16: Landings, discards and catches in tonnes of striped red mullet in GSA15_16.* GSA15 landings and discards in weight only from the years in which data matching between the DCF templates.

Year	Landings GSA16	*Landings GSA15	Discards GSA16	*Discards GSA15	Catches
2002	2107.782	NA	0.000	NA	2107.782
2003	1744.967	NA	0.000	NA	1744.967
2004	2080.000	NA	0.000	NA	2080.000
2005	1001.423	NA	0.000	NA	1001.423
2006	1842.806	NA	0.000	NA	1842.806
2007	2313.800	NA	0.000	NA	2313.800
2008	1440.640	NA	0.000	NA	1440.640
2009	833.347	NA	0.000	0.000	833.347
2010	1064.744	NA	0.860	0.000	1065.604
2011	940.871	NA	13.172	0.000	954.043
2012	610.457	NA	0.729	0.007	611.193
2013	522.717	NA	30.999	0.000	553.716
2014	576.012	45.259	20.530	0.000	641.801
2015	816.152	38.326	2.409	0.000	856.887
2016	863.660	43.170	46.648	0.004	953.482
2017	572.465	31.297	0.000	0.057	603.819
2018	1034.250	30.263	0.000	0.162	1064.675
2019	651.740	28.073	0.000	0.009	679.822
2020	341.530	16.960	0.000	0.118	358.608
2021	487.624	25.751	0.000	0.128	513.503

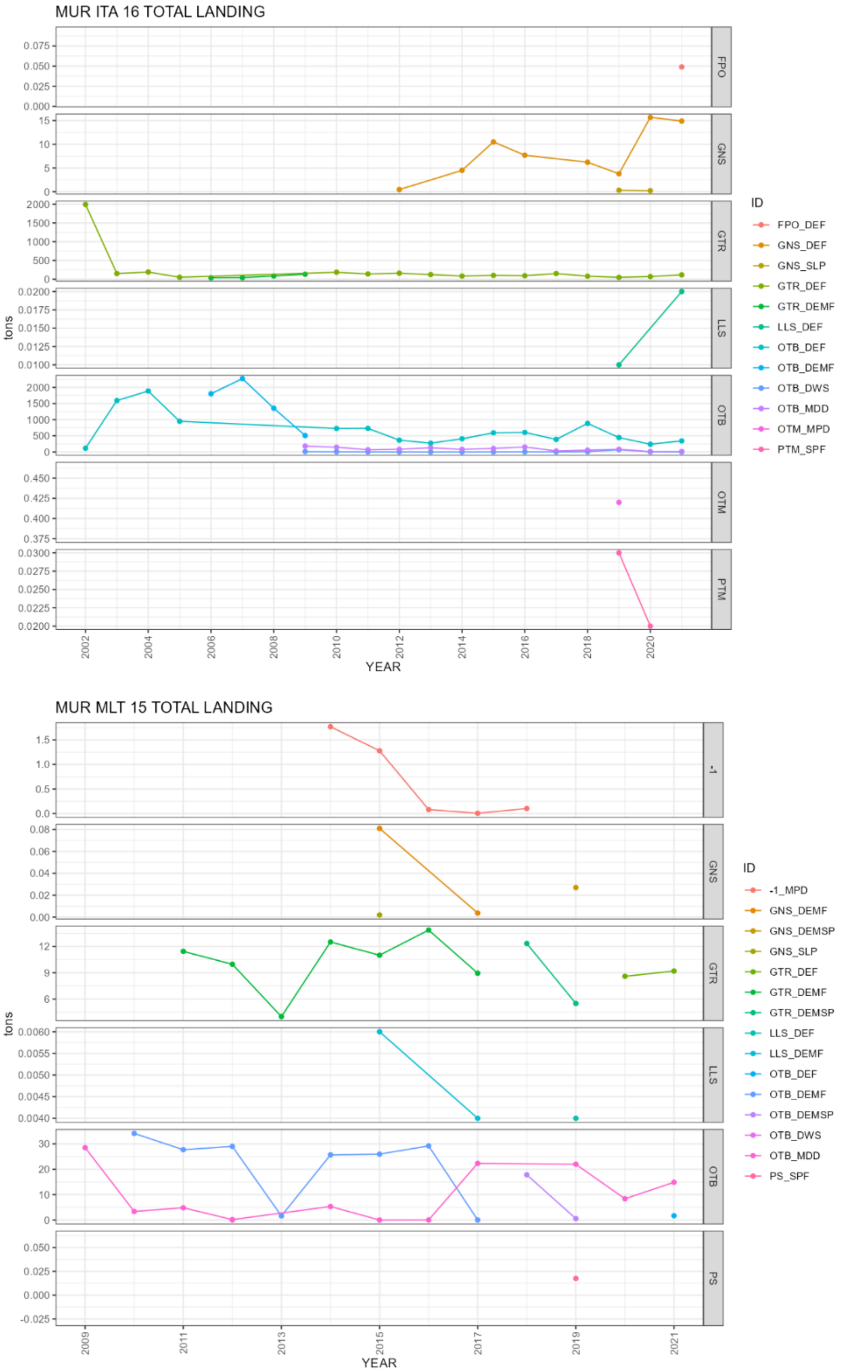
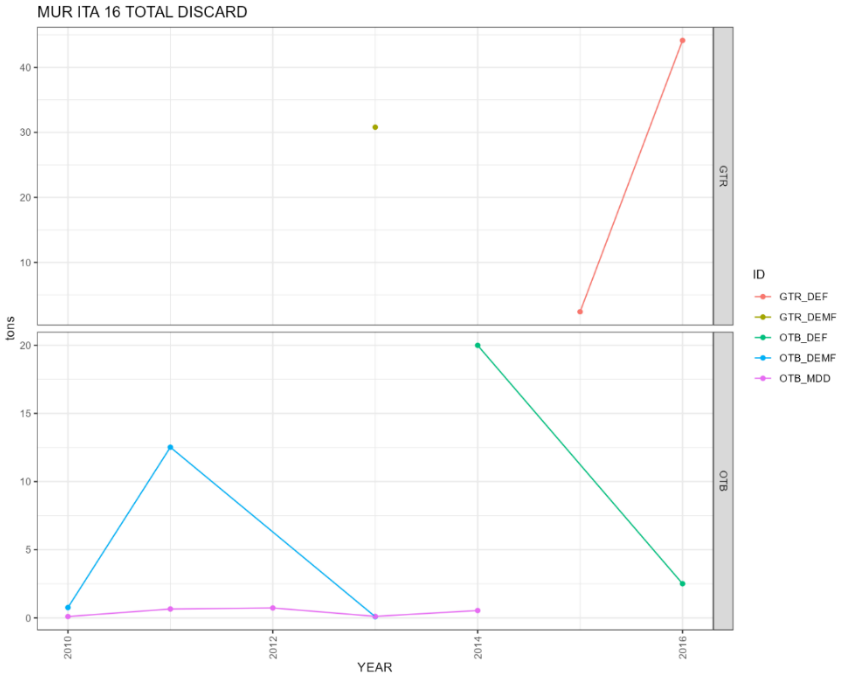


Figure 6.12.12 – Striped red mullet in GSA15_16: yearly landings in weight by main gear and fishery available through the DCF data in GSA16 (upper panel) and GSA15 (lower panel).

In GSA16 value for gear GTR in 2002 seems to be gear misreported considering also that almost zero landing value has been reported for OTB in the same year.



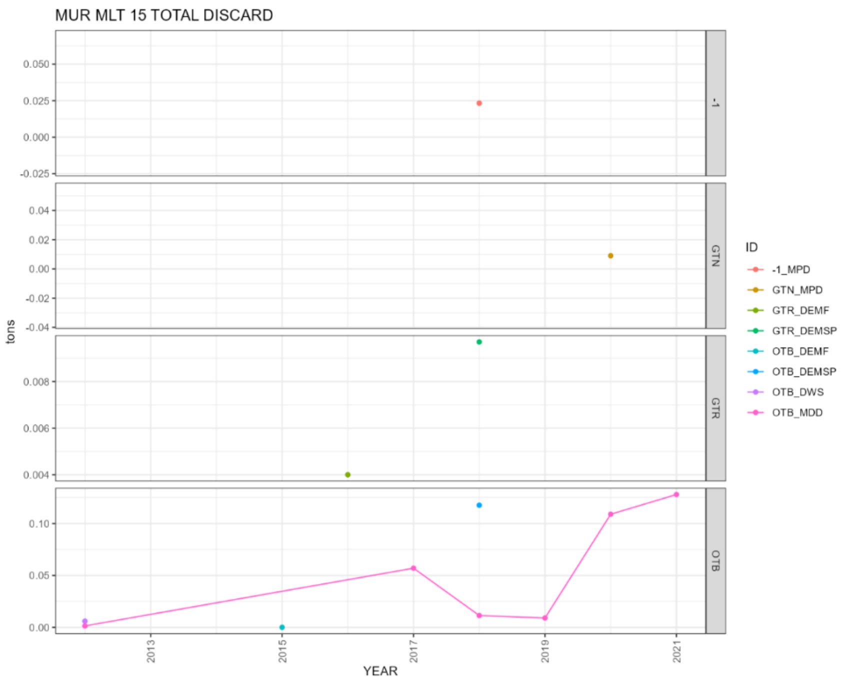
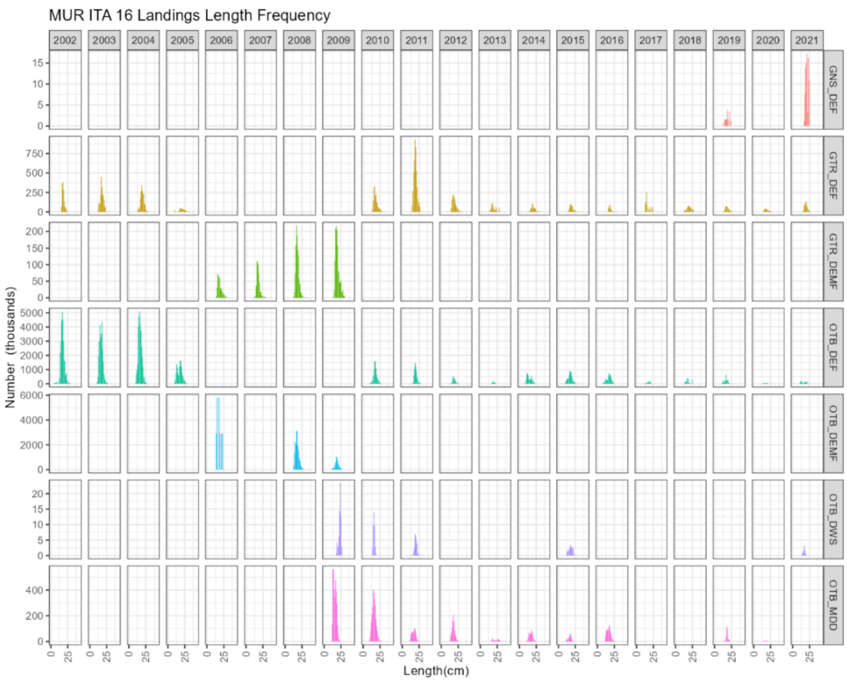


Figure 6.12.13 – Striped red mullet in GSA15_16: yearly discards in weight by main gear and fishery available through the DCF data in GSA16 (upper panel) and GSA15 (lower panel).

The landings length frequencies distributions (LFL) of the striped red mullet available in the DCF dataset in GSA15_16 are shown in Figure 6.12.14. In table 6.12.3 landings and discards by gear and area are reported

Table 6.12.3 – Striped red mullet in GSA15_16: landings and discards in weight by gear and GSA (in bold data resulted uncertain).

	GSA16 landings							GSA16 discards		GSA15 Landings						GSA15 discards			
Year	**FPO**	**GNS**	**GTR**	**LLS**	**OTB**	**OTM**	**PTM**	**GTR**	**OTB**	**-1**	**GNS**	**GTR**	**LLS**	**OTB**	**PS**	**-1**	**GTN**	**GTR**	**OTB**
2002			1992.814		114.968														
2003			152.401		1592.566														
2004			192.600		1887.400														
2005			51.503		949.920														
2006			39.339		1803.467														
2007			42.100		2271.700														
2008			85.830		1354.810														
2009			133.230		700.117									**28.507**					
2010			186.574		878.170				0.860					**37.482**					
2011			140.616		800.255				13.172			**11.440**		**32.530**					
2012		0.450	160.847		449.160				0.729			**9.971**		**29.213**					0.007
2013			123.930		398.787			30.798	0.201			**3.998**		**1.609**					
2014		4.504	83.896		487.611				20.530	1.768		12.513		30.978					
2015		10.497	102.357		703.299			2.409		1.278	0.083	11.001	0.006	25.958					0.000
2016		7.689	94.032		761.940			44.141	2.507	0.080		13.870		29.220				0.004	
2017			151.839		420.627					0.005	0.004	8.949	0.004	22.335					0.057
2018		6.215	80.858		947.177					0.102		12.339		17.822		0.023		0.010	0.129
2019		4.090	49.110	0.010	598.080	0.420	0.030				0.027	5.500	0.004	22.525	0.018				0.009
2020		15.890	70.750		254.870		0.020					8.598		8.363			0.009		0.109
2021	0.049	14.886	116.227	0.020	356.442							9.199		16.553					0.128



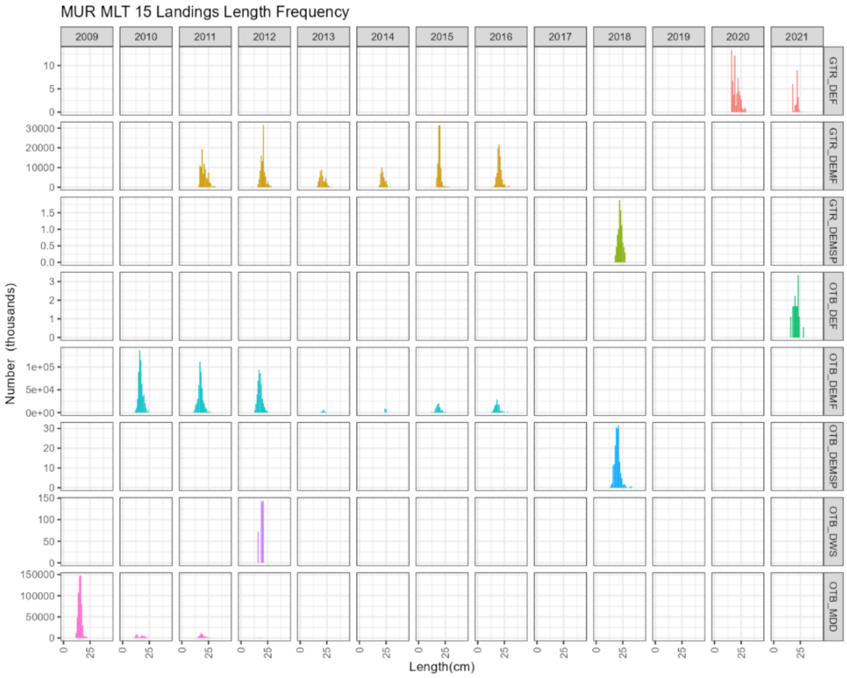


Figure 6.12.14 – Striped red mullet in GSA15_16: landings length structures of the Norway lobster by fishing gear and fishery.

The LFD in GSA16 were available since 2002. The main issues spotted were:

The order of magnitude of the abundance in the first 3 years in OTB_DEF is much higher of the values collected in the time series; moreover the derived mean weights seem not in line with the expected ones for this species

Length distribution in year 2006 for OTB_DEMF seems weird, likely few individuals have been raised to the whole production;

Length distributions in years 2020 and 2021 for GNS_DEF seem weird, likely few individuals have been raised to the whole production;

The order of magnitude of the abundance in year 2011 for GTR_DEF is much higher of the values collected in the time series;

No length distributions available for OTB in 2007

The LFDs in GSA15 were available since 2009. The main issues spotted were:

Abundance in year 2009 for OTB_MDD is weird. Likely numbers have been provided in absolute values not in thousands;

Abundance in years 2010-2012 for OTB_DEMF are weird. Likely numbers have been provided in absolute values not in thousands;

Length distribution in year 2012 for OTB_DWS seems weird. Likely few individuals have been raised to the whole production;

Length distributions in years 2020 and 2021 for GTR_DEF seem weird. Likely few individuals have been raised to the whole production;

Abundance in years 2011-2016 for GTR_DEMF are weird. Likely numbers have been provided in absolute values not in thousands;

Only a few reasonable LFDs seem available in GSA15. Due to the above mentioned data inconsistencies the assessment has been based only on LFLs GSA16 data. Only the values of catches (even if lower compared to the ones in GSA16) have been incorporated with the GSA16 time series to give total catches for GSA 15 and 16 combined.

In figure 6.12.15 the GSA16 data time series available in number and weight with relative percentage of landings which should be reconstructed in term of abundance by length is showed.

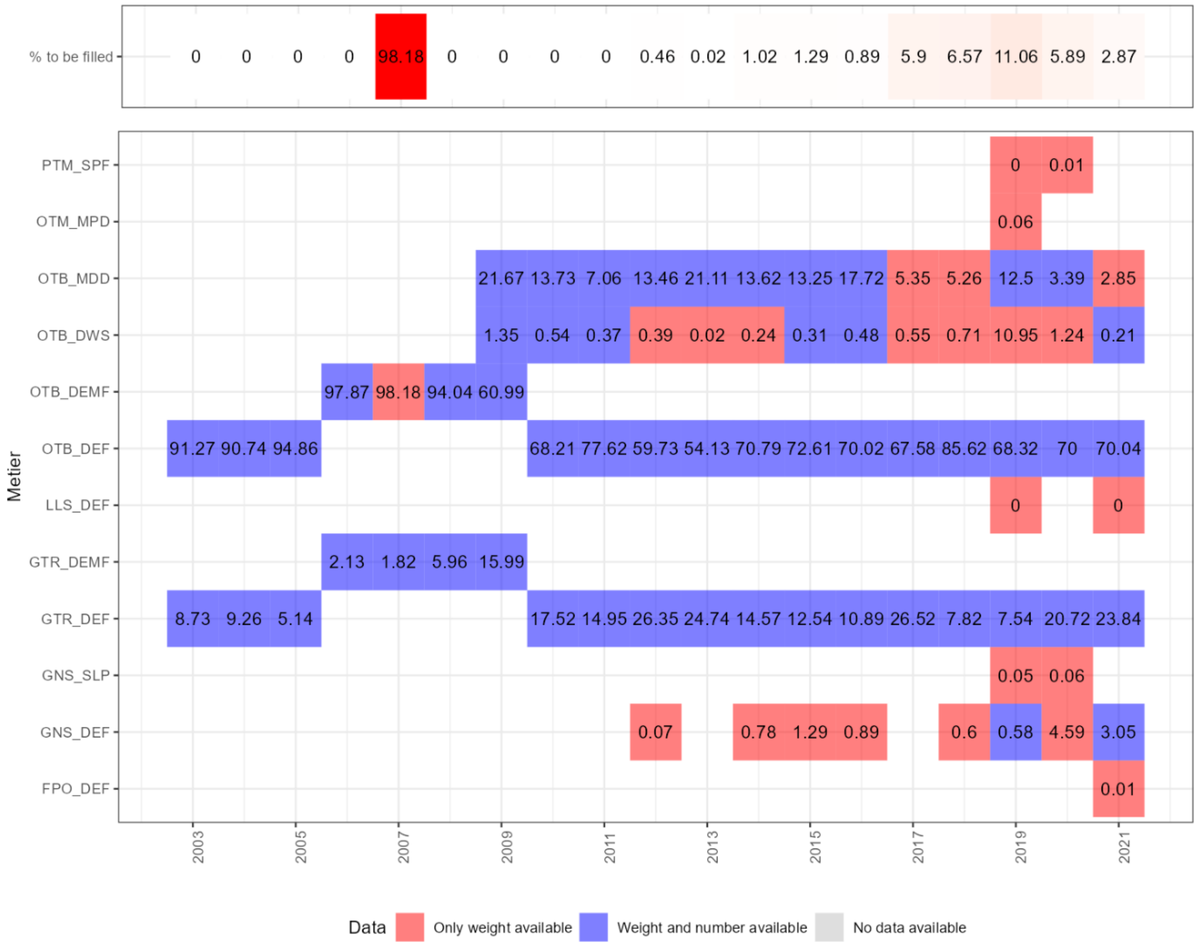
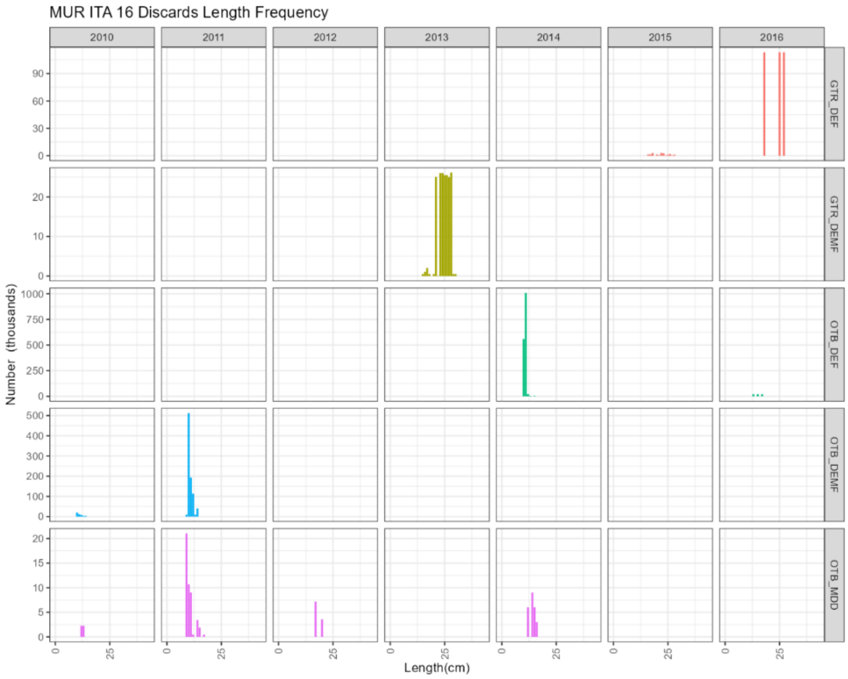


Figure 6.12.15 – Striped red mullet in GSA15_16: landings data available by metier and year in GSA16. Upper panel percentage of landings to be reconstructed in term of number by length.

The discards length frequencies distributions (LFD) of the striped red mullet available in the DCF dataset in GSA15_16 are shown in Figure 6.12.16.



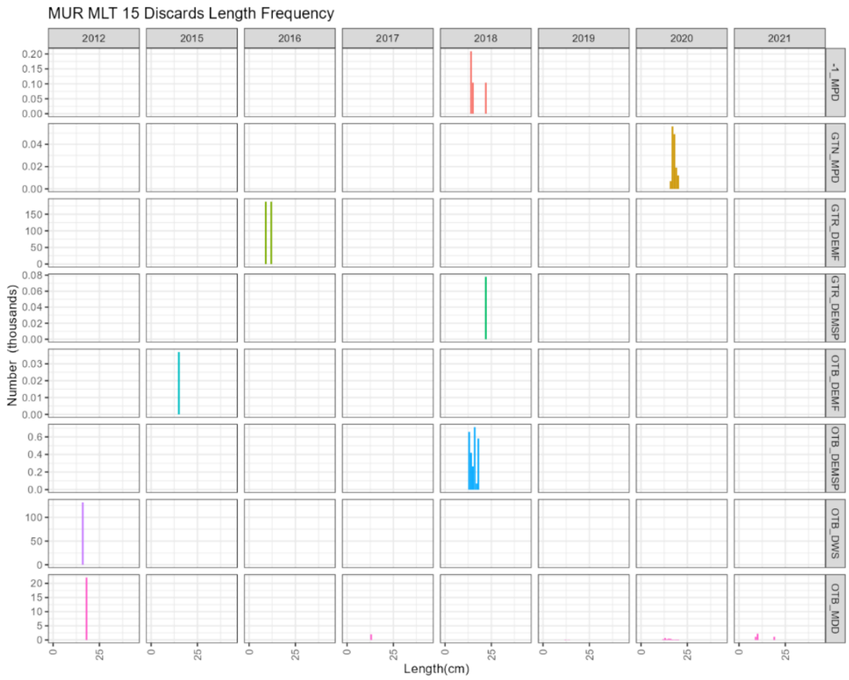


Figure 6.12.16 – Striped red mullet in GSA15_16: discards length structures of the Norway lobster by fishing gear and fishery

Because this species is discarded rarely, good LFD samples are not often available. However, the main gears for which discard is reported are OTB and GTR. In both GSAs discard LFDs seem weird. It seams likely thst the very few measured individuals have been raised to the whole production.

6.12.2.2 Effort

Table 6.12.4 – Striped red mullet in GSA15_16: effort in fishing days in GSA15_16 by country and GSA. Source FDI data.

	GSA15					GSA16				
Year/Country	GNS	GTR	LLS	OTB	GSA15 Total	GNS	GTR	LLS	OTB	GSA16 Total
ITA										
2013							69290	7569	62965	139824
2014						3763	43943	9286	55844	112835
2015						6582	60988	6297	58672	132540
2016						6476	76962	5978	59839	149255
2017						10840	62931	8230	64801	146802
2018						9850	54222	10269	55464	129805
2019						7817	49628	8283	56425	122152
2020						8098	35619	7022	49093	99832
2021						9004	47713	8247	48316	113280
MLT										
2013	1939	6173	4729	1092	13933					
2014	1309	7241	5870	600	15020					
2015	1765	5870	3987	620	12242			23	7	30
2016	1244	4385	4388	562	10579			47	35	82
2017	959	4818	2626	616	9019			12	10	22
2018	713	4716	3297	527	9253			7	21	28
2019	417	3008	2195	764	6384			35	10	45
2020	515	3279	3154	499	7447			38	26	64
2021	1004	4660	3172	745	9581			52	56	108

6.12.2.3 Survey data

The survey indices used as fisheries independent information to tune the commercial catch data have been collected from the MEDITS scientific bottom trawl survey. According to the MEDITS handbook procedures and based on what it is stated in MS EU-MAPs the period in which the survey should be carried out wasn't always respected. Indeed, in many years a clear delay have been observed in GSA16 (e.g. 2013, 2017, 2020 and 2021) and in one year in GSA15 (i.e. 2018) (figure 6.12.17).

Figure 6.12.17 – Striped red mullet in GSA15_16: Survey periods of MEDITS in GSA15_16.

In GSA16 the number of hauls carried out during the surveys have been changed in time. Indeed, a huge increase in the number of hauls has been observed during the period 2005-2007 resulting in the total number of hauls equal to 120 for subsequent years. However, in 2014 and 2020 a lower number of hauls has been reported compared to the expected 120 (Figure 6.12.18a). In GSA15 haul time series is consistent (Figure 6.12.18b). In GSA15 a haul has been reported with wrong geographical position (haul 19 in 2019).

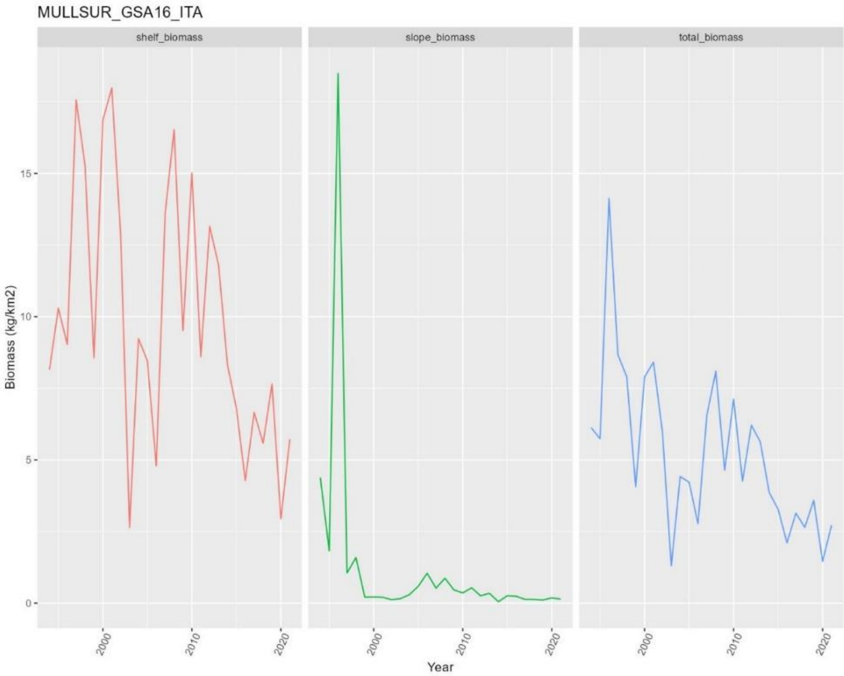
Year	A	B	C	D	E	Total
1994	4	8	4	10	10	36
1995	4	8	4	11	14	41
1996	4	8	4	11	14	41
1997	4	8	4	12	13	41
1998	4	8	5	11	14	42
1999	4	8	5	11	14	42
2000	4	7	6	11	14	42
2001	4	8	5	11	14	42
2002	7	11	10	18	20	66
2003	7	12	9	18	20	66
2004	7	12	9	18	19	65
2005	10	20	18	28	32	108
2006	10	22	19	30	33	114
2007	12	22	21	27	38	120
2008	11	23	21	27	38	120
2009	11	23	21	27	38	120
2010	11	23	21	27	38	120
2011	11	23	21	27	38	120
2012	11	23	21	27	38	120
2013	11	23	21	27	38	120
2014	10	10	16	12	7	55
2015	11	23	21	28	37	120
2016	11	23	21	27	38	120
2017	11	23	21	27	38	120
2018	11	23	21	27	38	120
2019	11	23	21	27	38	120
2020	9	21	15	21	28	94
2021	11	23	21	27	38	120

Figure 6.12.18a – Striped red mullet in GSA15_16: GSA16 time series of hauls conducted by year and strata (A= 10-50m, B=50-100m, C=100-200m, D=200-500m and E= 500-800m).

Year	A	B	C	D	E	Total
2005	1	5	14	9	16	45
2006	1	5	13	10	16	45
2007	0	12	12	4	17	45
2008	0	6	13	9	17	45
2009	0	6	14	10	15	45
2010	0	6	14	10	15	45
2011	0	6	12	12	14	44
2012	0	6	14	11	13	44
2013	0	6	14	10	15	45
2014	0	6	14	10	15	45
2015	0	6	14	10	15	45
2016	0	6	14	9	16	45
2017	0	6	14	9	16	45
2018	0	6	14	9	16	45
2019	0	6	14	10	15	45
2020	0	7	13	9	16	45
2021	0	6	14	9	16	45

Figure 6.12.18b – Striped red mullet in GSA15_16: GSA15 time series of hauls conducted by year and strata (A= 10-50m, B=50-100m, C=100-200m, D=200-500m and E= 500-800m).

In GSA16 the biomass index showed a general decreasing pattern while the density is fluctuating around the average of the period aside some years in which recuitment has been detected (Figure 6.12.19). In GSA15 a clear cycling pattern could be observed having peaks in biomass in years 2009, 2014 and 2019.



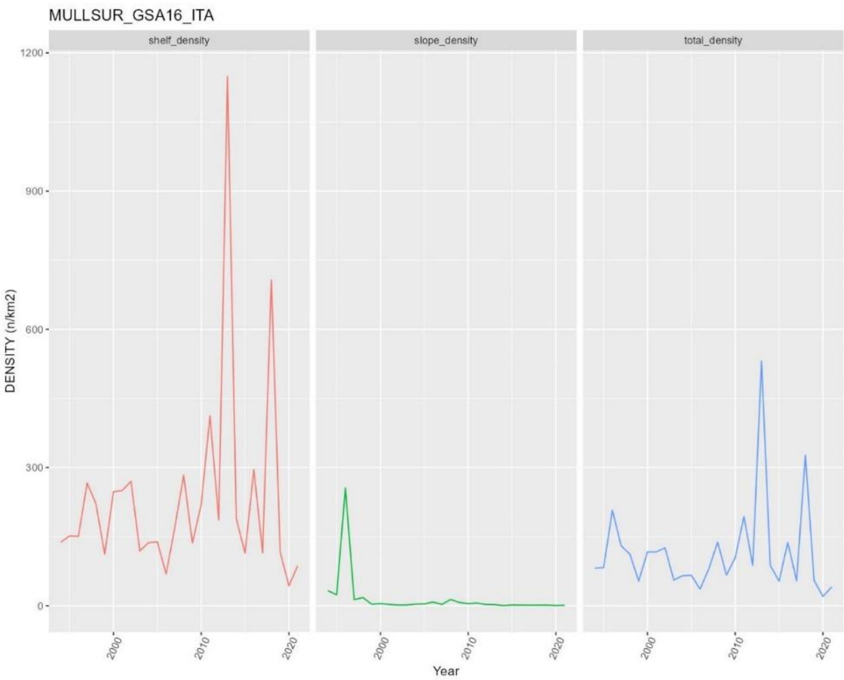
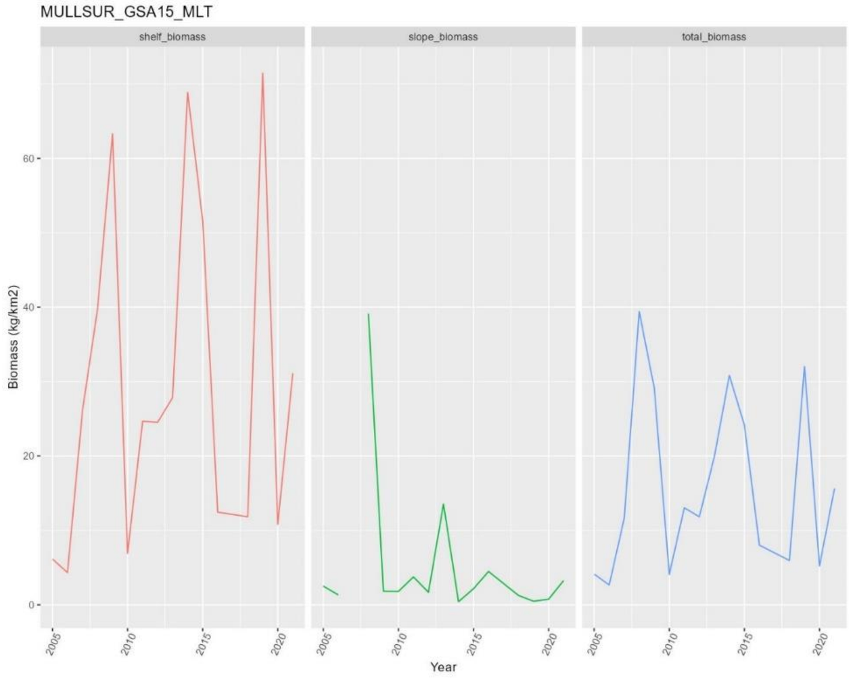


Figure 6.12.19a – Striped red mullet in GSA15_16: GSA16 biomass (kg/km2) (upper panel) and abundance (n/km2) (lower panel) indices as derived from trawl surveys (MEDITS, 1994-2021).

In GSA16 haul 61 carried out during year 2021 have been removed due to inconsistencies in weight values reported in the corresponding TB and TC records.



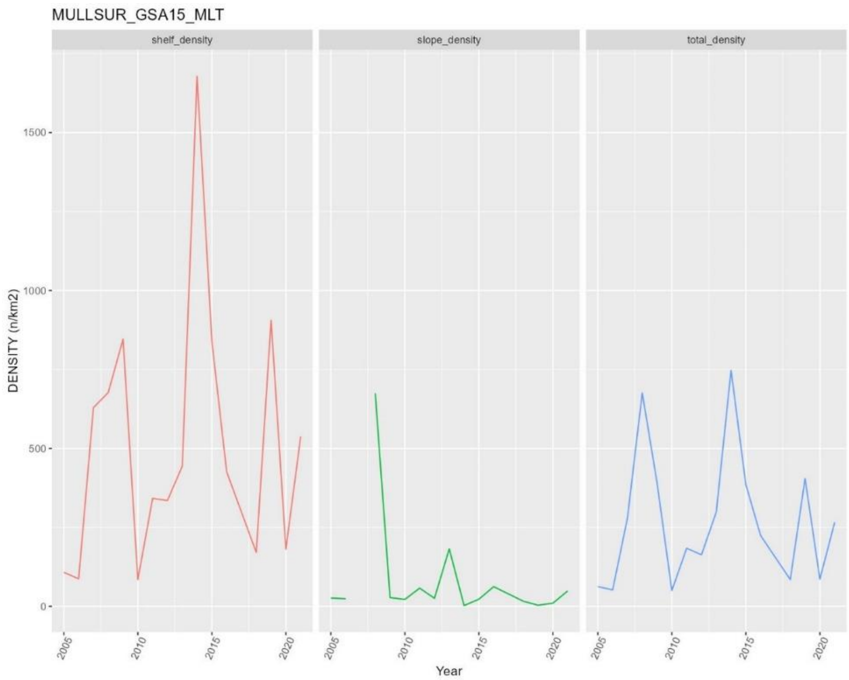
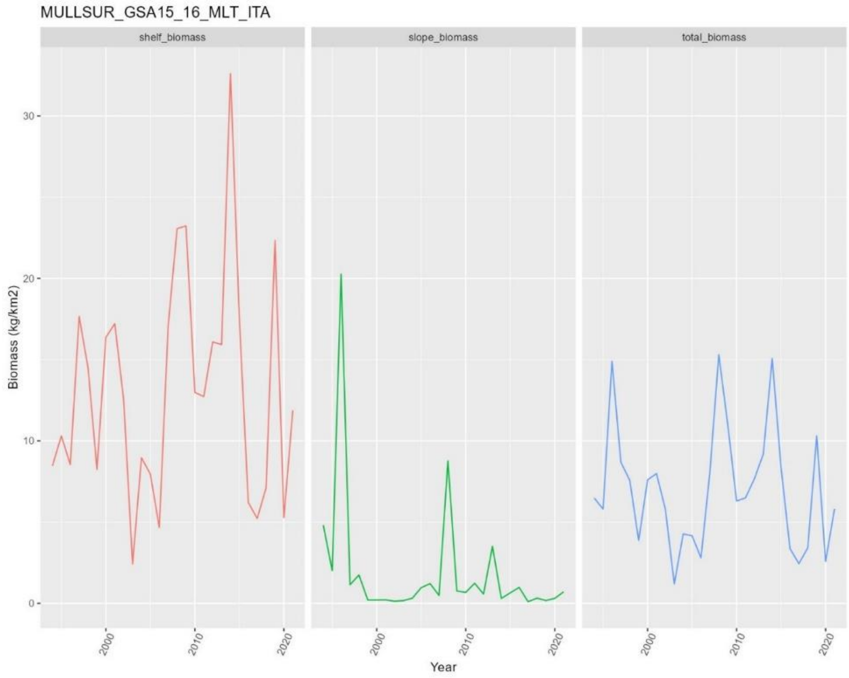


Figure 6.12.19b – Striped red mullet in GSA15_16: GSA15 biomass (kg/km2) (upper panel) and abundance (n/km2) (lower panel) indices as derived from trawl surveys (MEDITS, 2005-2021).

In GSA15 haul 19 carried out during year 2013 have been removed due to inconsistencies in weight values reported in the corresponding TB and TC records. Moroever, the whole 2017 TB dataset was missing.



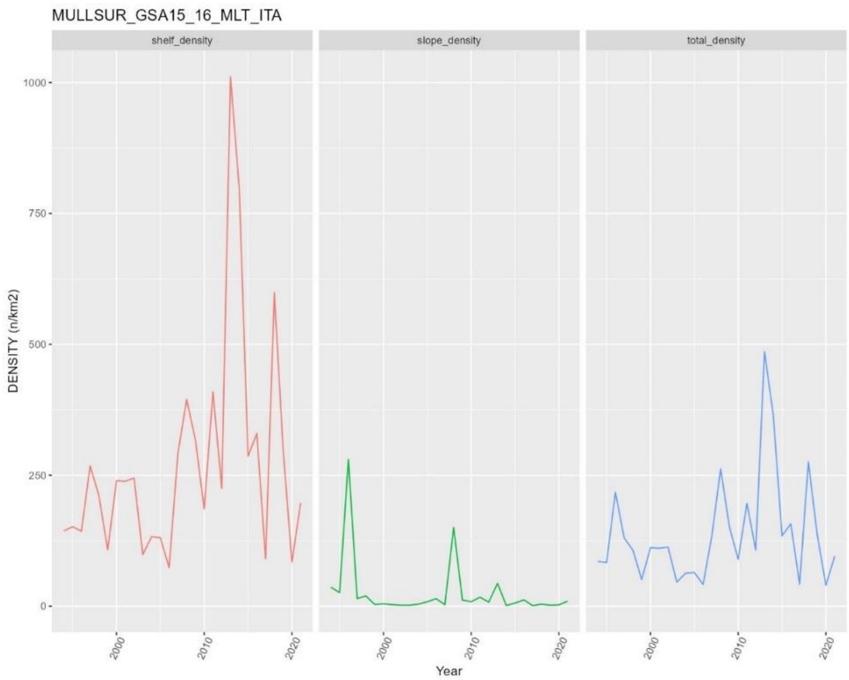


Figure 6.12.19c – Striped red mullet in GSA15_16: GSA15_16 biomass (kg/km2) (upper panel) and abundance (n/km2) (lower panel) indices as derived from trawl surveys (MEDITS, 1994-2021).

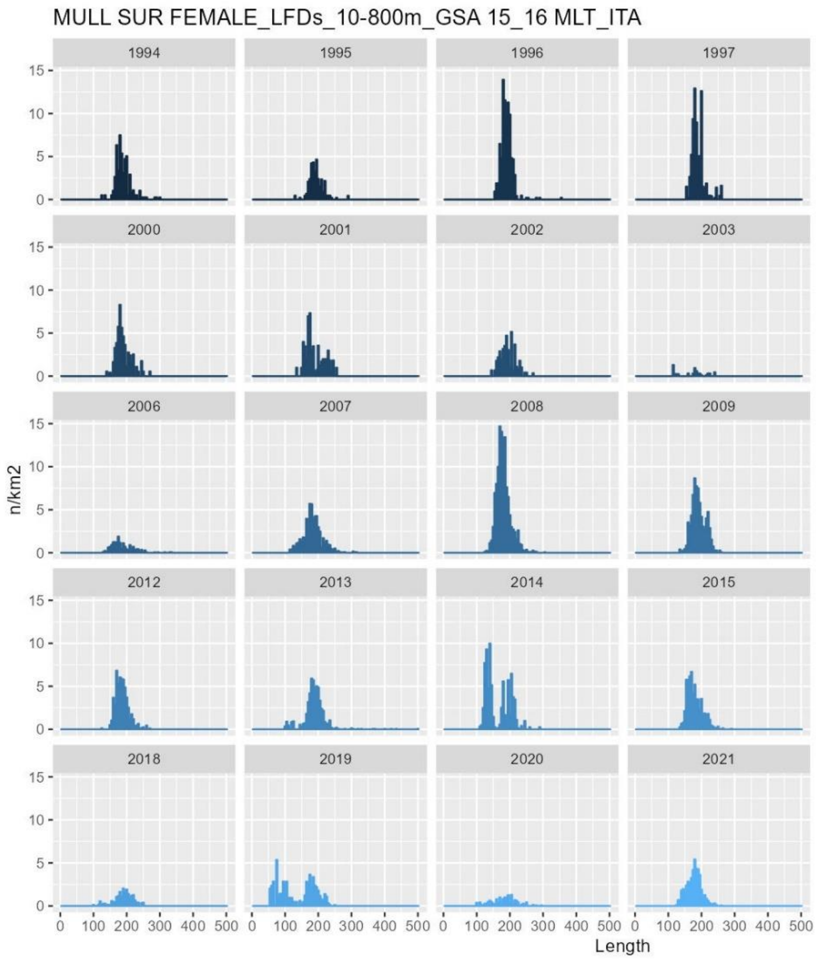


Figure 6.12.20 - Striped red mullet in GSA15_16: GSA15_16 female size structure as derived from trawl surveys (MEDITS, 1994-2021).

Figure 6.12.21 - Striped red mullet in GSA15_16: GSA15_16 male size structure as derived from trawl surveys (MEDITS, 1994-2021).

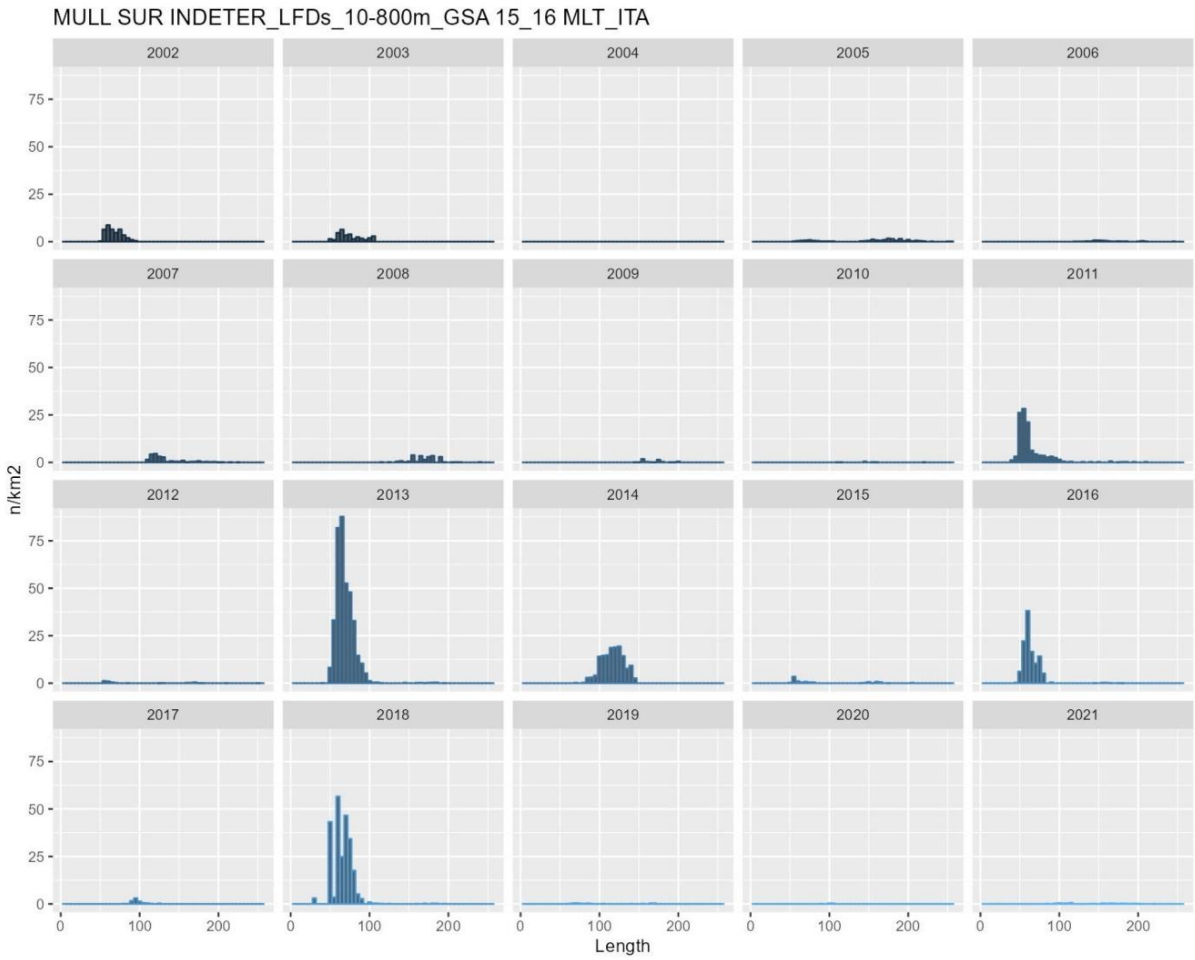


Figure 6.12.22 - Striped red mullet in GSA15_16: GSA15_16 indetermine size structure as derived from trawl surveys (MEDITS, 1994-2021).

In GSA16 a misreported specimen of 199 mm of TL has been removed from the TC file.

In GSA15 a misreported speciment of 945 mm of TL has been removed from the TC. Some very suspicious measures have been removed as well (i.e. males 45 and 20 mm TL in years 2021 and 2019 and females 15 and 25 mm TL in years 2014 and 2013).

Some hauls resulted, in term of numbers, inconsistent between values reported in the catch template (TB) and the corresponding numbers reported in the biological data template (TC). In table 6.12.5 inconsistencies spotted in term of number are showen.

Table 6.12.5 - Striped red mullet in GSA15_16: Hauls for which total numbers reported in TB and TC MEDITS files are inconsistencies.

country	area	year	haul_number	totnbB	totnbC
ITA	16	2005	14	2	4
ITA	16	2005	37	70	83
ITA	16	2005	46	1	2
ITA	16	2005	58	1	2
ITA	16	2005	59	1	2
ITA	16	2005	63	46	25
ITA	16	2005	71	1	3
ITA	16	2005	74	1	2
ITA	16	2005	79	57	12
ITA	16	2005	81	43	10
ITA	16	2005	93	2	3
ITA	16	2006	58	2	1
ITA	16	2006	62	6	5
ITA	16	2006	72	8	7
ITA	16	2007	61	25	23
ITA	16	2008	26	6	5
ITA	16	2009	16	2	1
ITA	16	2009	73	67	57
ITA	16	2010	26	37	35
ITA	16	2012	111	31	29
ITA	16	2014	1	16	15
ITA	16	2018	55	6	5
MLT	15	2019	47	10	3
MLT	15	2021	46	38	28

6.12.3 Stock assessment

In evaluating the status of the striped red mullet in the GSA15_16 a catch at age model based on a4a package has been attempted

A4A

Although the uncertainties in the robustness of the length frequencies distributions (LF) available through the official DCF Med&BS data call 2022 (see section Catch) an attempt in assessing the species with a fully analitycal assessment has been carried out using a4a.

The a4a model is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by gear. The method was developed within FLR framework.

All the input data used were extracted and derived from the data collected through the official DCF Med&BS data call 2022.

None LFD recostruction of missing year/metier LFs have been used. Because of MEDITS survey in GSA15 started only in 2005 the years used in the assessment has been trimmed accordingly. LFD input data for 2006 and 2007 have been reconstructed by the model (see figure 6.12.23). Finally, GSA15 length and biological data have been not included due to the very poor samples available. Only GSA15 catches (from 2014) in weight values have been added to GSA16 time series.

The aggregated length frequencies distributions data have been split by sex according to a sex ratio model derived from the sex ratio by length vector available in the DCF data set. Lengths have been converted in age by a deterministic slicing method (l2a) available in the Fla4a package.

The set used in the slicing procedures are showed in table 6.12.6. Because the spawning season has been set in the middle of the year a check of the transition age (ag0 and age1) at the end of the calendar year has been performed. Results showed there is no need to apply the 0.5 correction of the t0 values to match with the calendar year basis of the assessment (Figure 6.12.23- 6.12.24).

Table 6.12.6 - Striped red mullet in GSA15_16: growth parameters used in the assessment

	Von Bertalanffy Growth parameters			Length Weight parameters	
Sex	Linf	k	t0	a	b
Female	35.65 (cm)	0.22	-0.7	0.0108	3.0030
Male	30.09 (cm)	0.28	-0.6	0.0112	3.0321

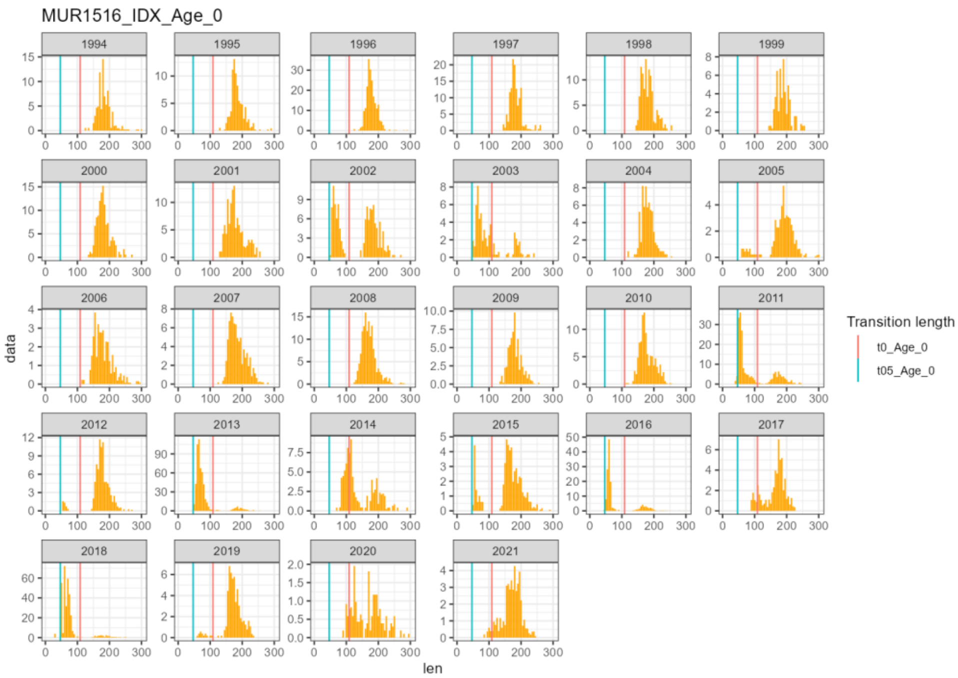


Figure 6.12.23 – Striped red mullet in GSA15_16: Comparison of biological and calendar length at year transition between age0 and age1 on index at age (male growth rate)

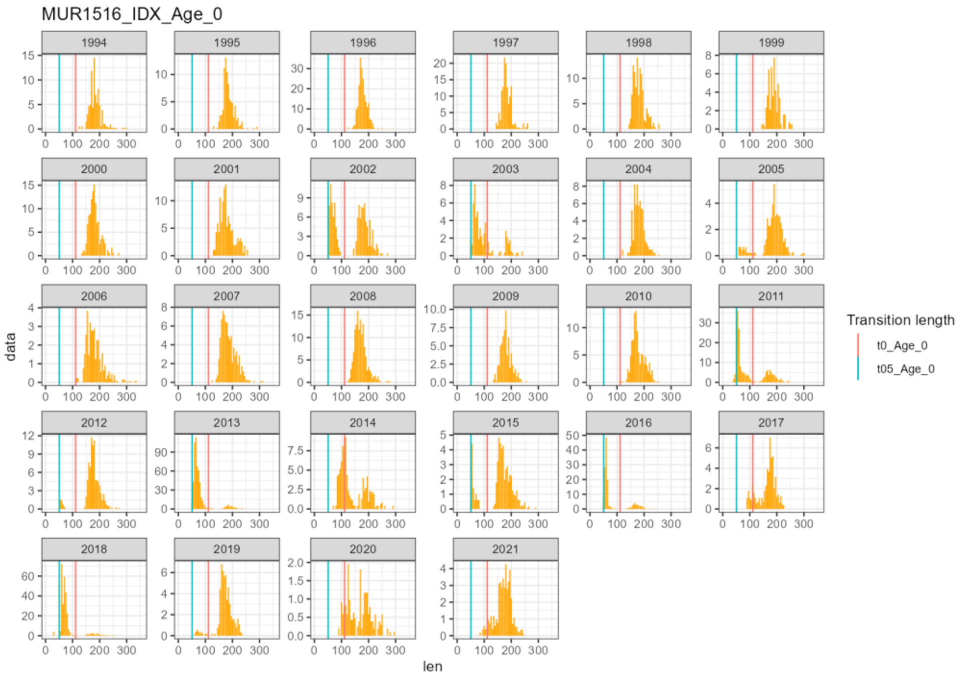


Figure 6.12.24 – Striped red mullet in GSA15_16: Comparison of biological and calendar length at year transition between age0 and age1 on index at age (female growth rate)

Indeed, in both cases appliying respectively male and female growth rates on the standardized length frequenies distributions from MEDITS survey the growth without correction is able to isolate a first length component of quite young specimens which must be the young of the year.

Harvest and natural mortality values before spawning have been set equal to 0.5

In table 6.12.7 natural mortality and maturity vectors by age used in the assessment are reported. Natural mortality vector has been computed according to the Chen Watanabe method. Male and female vectors have been weighted by the number at age by sex to derived the final vector. The maturity vector is obtained as median values of female maturation at age vectors available in the DCF dataset. Because for oldest age (plus group 5+) the fully maturation level hasn't been observed in the DCF data, in running the assessment maturity values for those age has been set equal to 1. At the same time a 30% of age0 individuals resulted already able to spawn. This effect is due to the mismatch between data at provided at calendar year with the biology of the species. There was no need in fixing this value because age 0 has been removed from the assessment.

Table 6.12.7 – Striped red mullet in GSA15_16: natural mortality and maturity vectors used in the assessment

Age	Natural mortality vector (male)	Natural mortality vector (female)	Maturity vector assessment (female)
0	1.056	0.948	0.306
1	0.629	0.573	0.582
2	0.482	0.435	0.808
3	0.410	0.364	0.871
4	0.368	0.322	0.856
5+	0.341	0.295	0.876

A sum of product corrections (SoPs) were needed to raise the catch at age number to final production see vector below (Figure 6.12.25).

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SoP	1.00	NA	NA	1.00	1.00	1.00	1.00	1.00	1.00	1.09	1.05	1.05	1.06	1.03	1.04	1.04	1.05

Figure 6.12.25 – Striped red mullet in GSA15_16: Sum of Product (SoP) applied to the catch at age numbers.

Because data for age 0 are not always detected and considering that the survey is not planned to properly monitoring the recruitment, age0 has been removed from the assessment. Based on the catch at age patterns an Fbar range between age1 and age4 has been set.

In the following tables (Tables 6.12.8-14) all the final input values are listed. In Figures 6.12.26-27 the catch and indexes at age number respectively are shown. Finally in figure 6.12.28 the complete inputs data of the stock object are shown.

Table 6.12.8 – Striped red mullet in GSA15_16: Catch (t) per year used in the assessment.

Year	Catches (t)
2005	1001.423
2006	1842.806
2007	2313.8
2008	1440.64
2009	833.3471
2010	1065.604
2011	954.043
2012	611.186
2013	553.716
2014	641.802
2015	856.8813
2016	953.4784
2017	603.8154
2018	1064.68
2019	679.82
2020	353.61
2021	513.504

Table 6.12.9 – Striped red mullet in GSA15_16: Catch at age number (*1000) per year.

Year/Age	0	1	2	3	4	5+
2005	162.06	4679.50	5020.29	3483.36	862.42	505.15
2006	2.84	9732.60	8805.33	4488.91	3266.34	32.97
2007	155.29	2724.18	22153.87	6290.37	1034.77	781.54
2008	2.82	4388.06	11206.09	4435.23	781.90	402.91
2009	2.84	2425.97	5211.23	2852.57	620.82	388.27
2010	106.60	3028.76	8992.03	3056.14	657.84	263.06
2011	12.55	337.22	4637.24	4827.03	788.21	368.12
2012	4.31	374.71	4392.64	2282.70	427.76	229.33
2013	9.79	156.00	2469.57	1677.59	642.23	642.50
2014	733.87	5644.33	3508.69	1749.38	310.03	147.25
2015	125.39	2838.86	5946.44	2732.07	471.11	245.11
2016	487.66	3710.83	6717.56	3153.90	533.90	139.60
2017	13.69	3316.97	2788.76	2064.07	616.88	54.80
2018	17.52	2556.01	7403.04	3039.07	728.38	561.31
2019	17.30	2456.68	5827.11	2047.48	204.04	74.01
2020	16.56	852.96	2117.50	1279.07	256.28	151.29
2021	25.50	1989.16	2083.68	2353.45	395.72	149.62

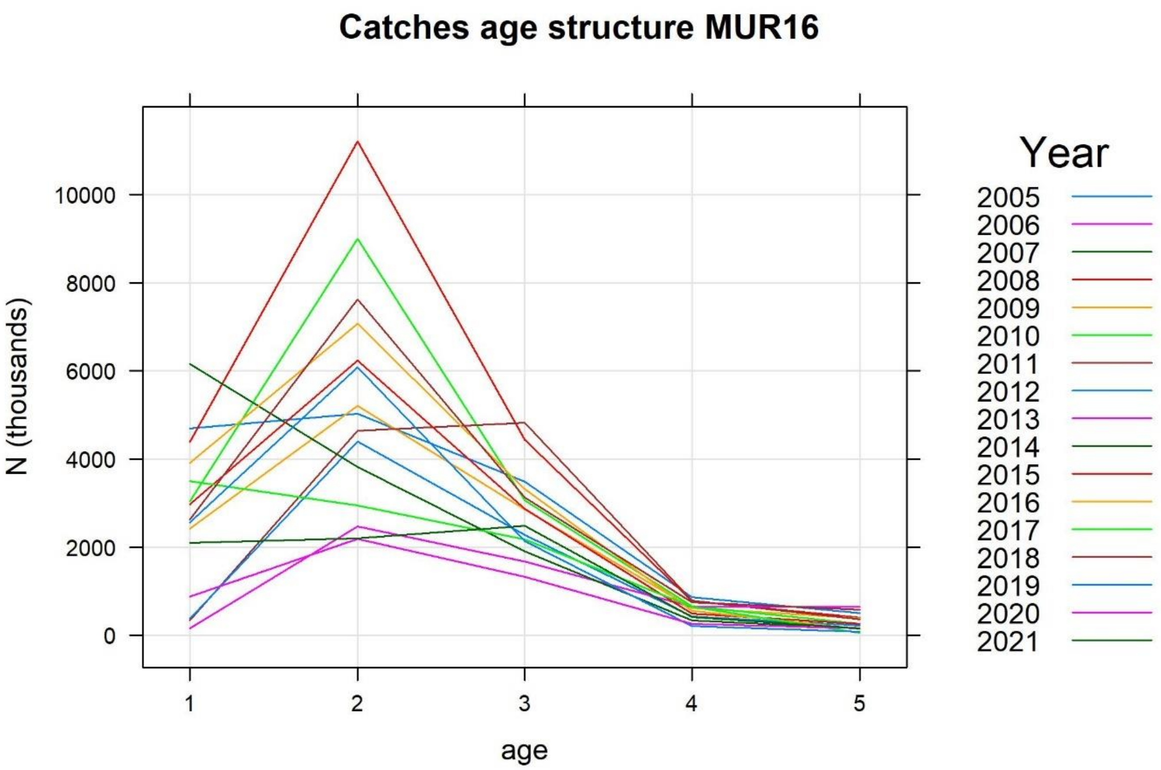


Figure 6.12.26 – Striped red mullet in GSA15_16: Catch at age numbers (*1000) used in the assessment (age 0 removed).

Table 6.12.10 – Striped red mullet in GSA15_16: Mean weight at age number (kg) per year.

Year/Age	0	1	2	3	4	5+
2005	0.012	0.028	0.063	0.096	0.139	0.194
2006	0.011	0.036	0.068	0.099	0.134	0.203
2007	0.011	0.037	0.059	0.095	0.139	0.222
2008	0.011	0.035	0.060	0.096	0.138	0.196
2009	0.011	0.031	0.062	0.096	0.139	0.197
2010	0.011	0.032	0.060	0.096	0.138	0.188
2011	0.011	0.032	0.065	0.096	0.137	0.187
2012	0.011	0.037	0.062	0.096	0.140	0.204
2013	0.011	0.034	0.064	0.095	0.138	0.220
2014	0.011	0.024	0.061	0.095	0.140	0.212
2015	0.011	0.028	0.061	0.095	0.139	0.205
2016	0.009	0.027	0.060	0.096	0.137	0.190
2017	0.011	0.033	0.061	0.096	0.138	0.184
2018	0.011	0.034	0.061	0.095	0.141	0.182
2019	0.012	0.029	0.060	0.094	0.137	0.186
2020	0.011	0.036	0.060	0.095	0.138	0.184
2021	0.012	0.024	0.063	0.097	0.137	0.178

Table 6.12.11 – Striped red mullet in GSA15_16: Maturity at age by year.

Year/Age	0	1	2	3	4	5+
2005	0.306	0.582	0.808	0.872	0.857	1
2006	0.306	0.582	0.808	0.872	0.857	1
2007	0.306	0.582	0.808	0.872	0.857	1
2008	0.306	0.582	0.808	0.872	0.857	1
2009	0.306	0.582	0.808	0.872	0.857	1
2010	0.306	0.582	0.808	0.872	0.857	1
2011	0.306	0.582	0.808	0.872	0.857	1
2012	0.306	0.582	0.808	0.872	0.857	1
2013	0.306	0.582	0.808	0.872	0.857	1
2014	0.306	0.582	0.808	0.872	0.857	1
2015	0.306	0.582	0.808	0.872	0.857	1
2016	0.306	0.582	0.808	0.872	0.857	1
2017	0.306	0.582	0.808	0.872	0.857	1
2018	0.306	0.582	0.808	0.872	0.857	1
2019	0.306	0.582	0.808	0.872	0.857	1
2020	0.306	0.582	0.808	0.872	0.857	1
2021	0.306	0.582	0.808	0.872	0.857	1

Table 6.12.12 – Striped red mullet in GSA15_16: Values of natural mortality at age per year.

Year/Age	0	1	2	3	4	5+
2005	1.009	0.602	0.454	0.383	0.335	0.304
2006	1.009	0.603	0.451	0.382	0.333	0.302
2007	1.009	0.602	0.450	0.385	0.330	0.301
2008	1.009	0.602	0.454	0.384	0.335	0.301
2009	1.009	0.602	0.453	0.382	0.336	0.302
2010	1.009	0.603	0.452	0.382	0.334	0.302
2011	1.008	0.603	0.453	0.383	0.334	0.303
2012	1.008	0.602	0.449	0.381	0.335	0.302
2013	1.009	0.602	0.452	0.382	0.333	0.303
2014	1.009	0.602	0.450	0.383	0.331	0.300
2015	1.007	0.604	0.453	0.381	0.334	0.303
2016	1.008	0.603	0.452	0.383	0.334	0.303
2017	1.005	0.603	0.452	0.383	0.336	0.304
2018	1.009	0.602	0.452	0.382	0.330	0.318
2019	1.009	0.602	0.451	0.387	0.332	0.303
2020	1.009	0.603	0.453	0.383	0.338	0.303
2021	1.009	0.602	0.452	0.383	0.333	0.302

Table 6.12.13 – Striped red mullet in GSA15_16: Values of harvest and natural mortality at age before spawning per.

Year/Age	0	1	2	3	4	5+
2005	0.5	0.5	0.5	0.5	0.5	0.5
2006	0.5	0.5	0.5	0.5	0.5	0.5
2007	0.5	0.5	0.5	0.5	0.5	0.5
2008	0.5	0.5	0.5	0.5	0.5	0.5
2009	0.5	0.5	0.5	0.5	0.5	0.5
2010	0.5	0.5	0.5	0.5	0.5	0.5
2011	0.5	0.5	0.5	0.5	0.5	0.5
2012	0.5	0.5	0.5	0.5	0.5	0.5
2013	0.5	0.5	0.5	0.5	0.5	0.5
2014	0.5	0.5	0.5	0.5	0.5	0.5
2015	0.5	0.5	0.5	0.5	0.5	0.5
2016	0.5	0.5	0.5	0.5	0.5	0.5
2017	0.5	0.5	0.5	0.5	0.5	0.5
2018	0.5	0.5	0.5	0.5	0.5	0.5
2019	0.5	0.5	0.5	0.5	0.5	0.5
2020	0.5	0.5	0.5	0.5	0.5	0.5
2021	0.5	0.5	0.5	0.5	0.5	0.5

Table 6.12.14 – Striped red mullet in GSA15_16: Values of index number at age (n/km2) per year.

Year/Age	0	1	2	3	4	5+
2005	3.070	1.842	11.403	24.891	9.334	1.061
2006	0.112	1.353	23.370	11.329	3.655	1.523
2007	0.112	28.215	53.500	39.104	10.831	2.602
2008	0.112	2.955	157.452	87.864	11.307	1.730
2009	0.112	0.159	58.266	72.011	18.630	0.834
2010	0.112	0.534	46.281	28.431	11.304	0.867
2011	95.920	14.548	33.050	43.271	7.788	0.962
2012	2.989	0.473	42.814	52.397	6.853	1.127
2013	322.116	60.598	31.851	61.130	8.358	1.621
2014	0.374	183.965	91.043	78.994	7.338	2.325
2015	6.796	0.774	78.925	39.542	6.784	1.082
2016	109.725	4.242	22.813	17.678	2.333	0.446
2017	0.132	12.938	16.044	21.503	3.164	0.069
2018	217.779	25.317	9.634	17.720	4.509	0.751
2019	38.684	28.558	29.783	30.130	5.493	0.194
2020	0.112	6.356	14.284	14.676	3.584	0.962
2021	3.887	5.115	46.364	37.568	3.847	0.484

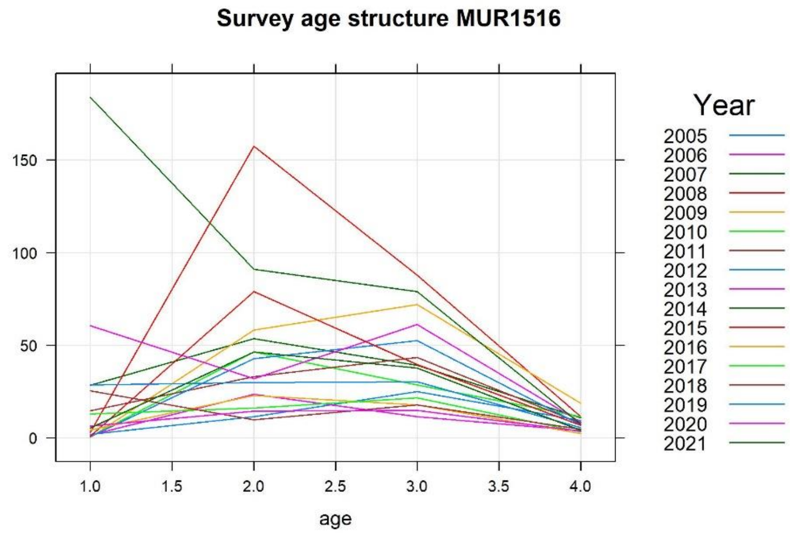


Figure 6.12.27 – Striped red mullet in GSA15_16: Index at age numbers (*1000) used in the assessment (age0 and age5+ removed).

In the assessment age4 has been considered as the last true. As for the catches also in the index at age age0 has been removed.

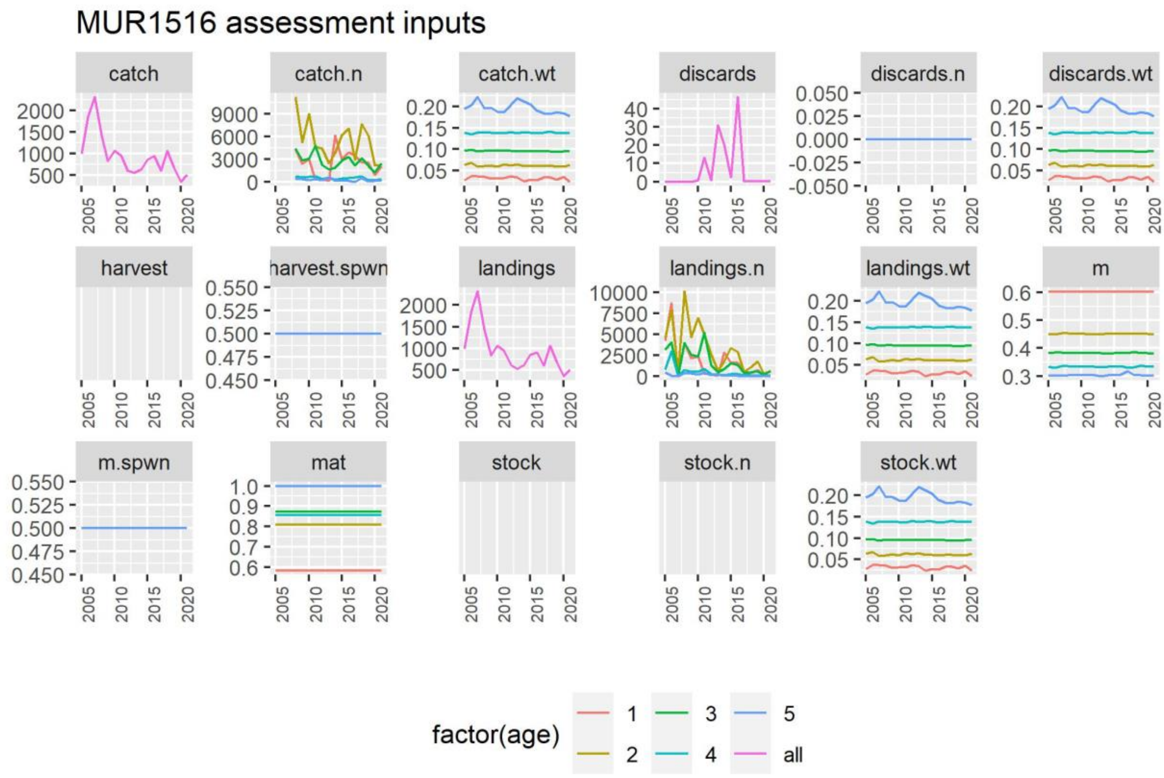


Figure 6.12.28 – Striped red mullet in GSA15_16: the whole stock object inputs.

All the input stock objects have been created using the R scripts developed in the JRC and made available in the EWG2216 ftp. Below the version of R, Rstudio and Rpackages used in running the assessment:

R: 4.2.1

RStudio: 2022.07.0

FLCore: 2.6.19

FLa4a: 1.8.3

Flash: 2.5.11

FLBRP: 2.5.8.9002

In Figures 6.12.29-34 the cohorts' consistency, the number at age trend in time and the log number of the cohort decay derived from the catch and index at age numbers respectively are shown.

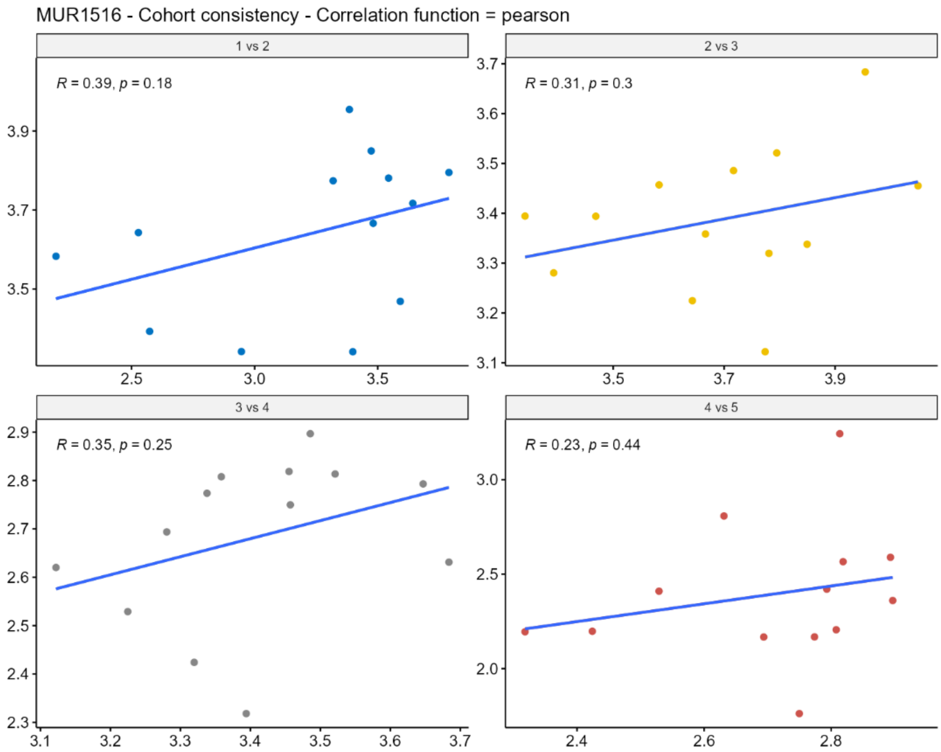


Figure 6.12.29 – Striped red mullet in GSA15_16: Catch at age numbers cohorts' internal consistency.

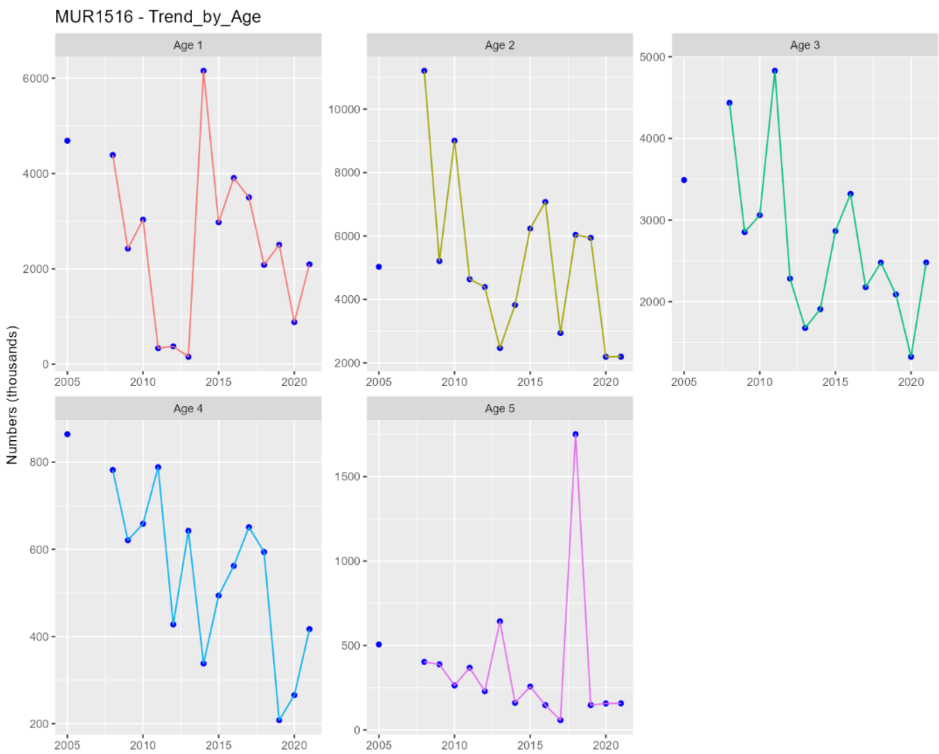


Figure 6.12.30 – Striped red mullet in GSA15_16: Trend in time of catch number at age.

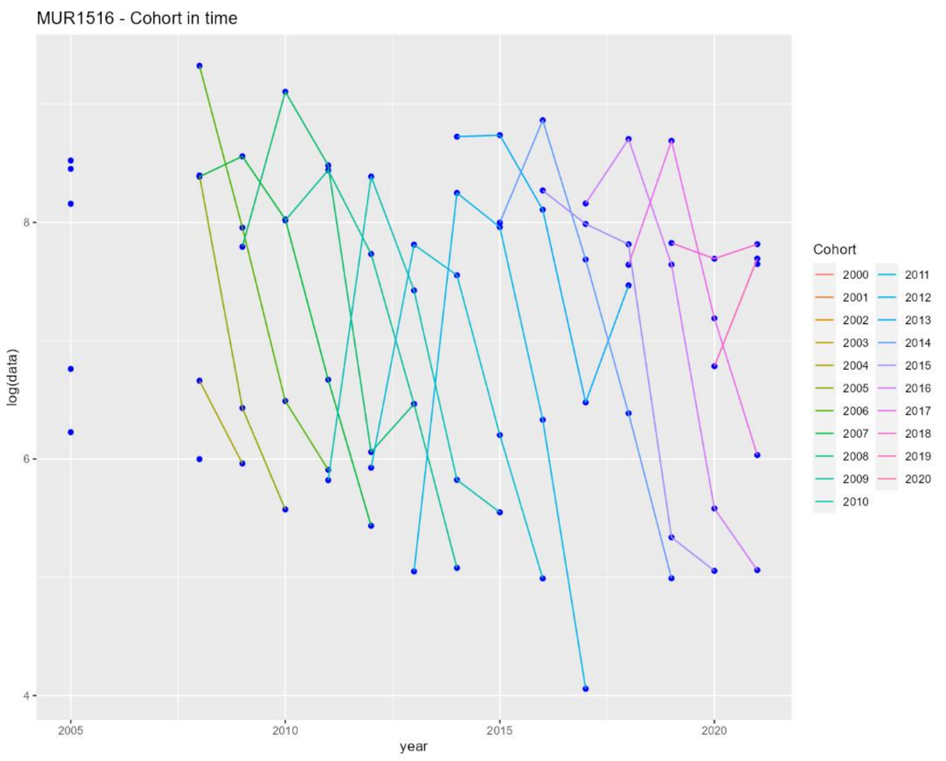


Figure 6.12.31 – Striped red mullet in GSA15_16: Log of the catch cohort number decay.

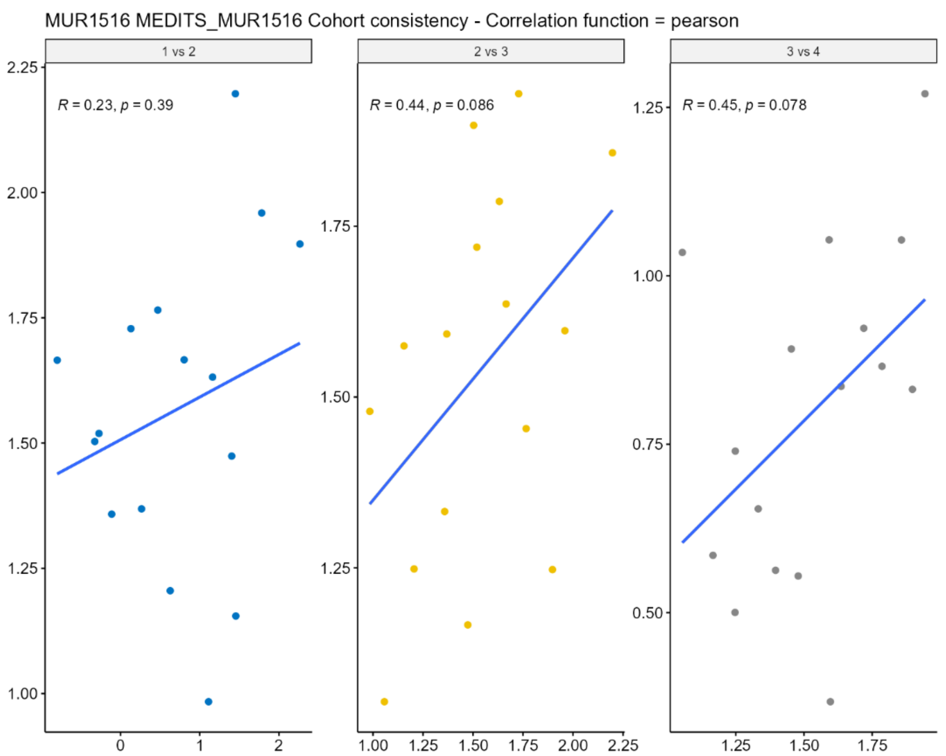


Figure 6.12.32 – Striped red mullet in GSA15_16: Index number at age cohorts' internal consistency.

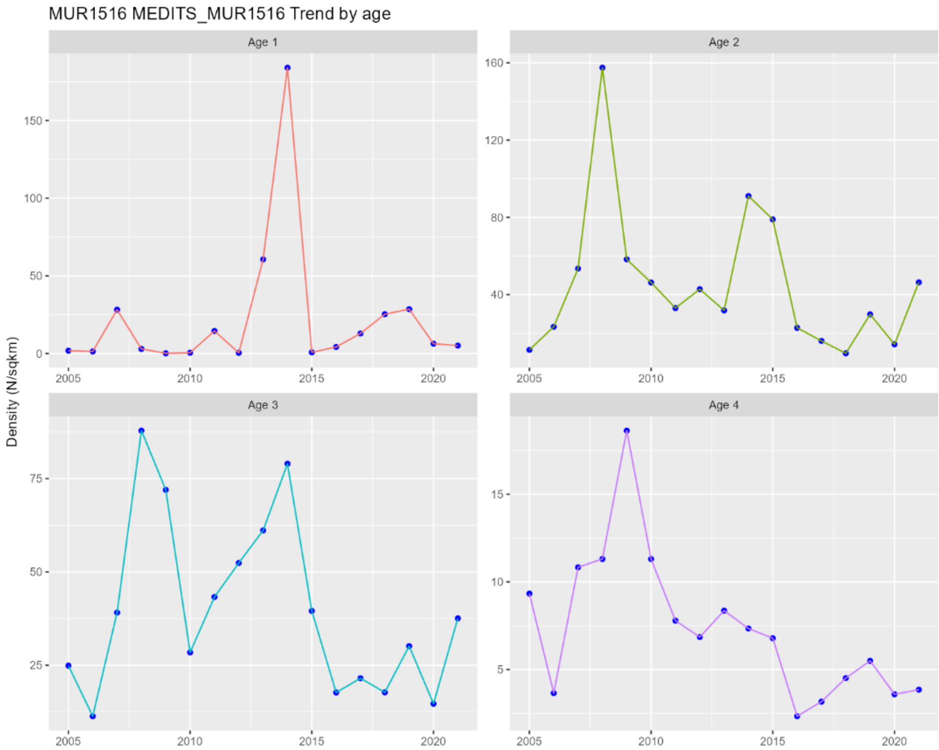


Figure 6.12.33 – Striped red mullet in GSA15_16: Trend in time of index number at age.

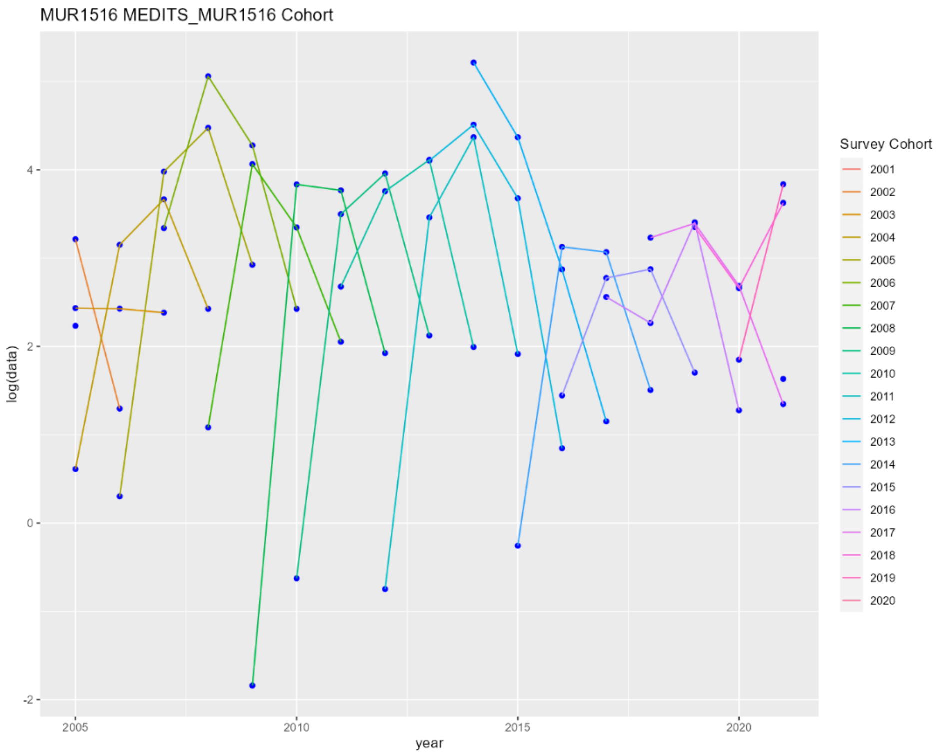


Figure 6.12.34 – Striped red mullet in GSA15_16: Log of the index cohort number decay.

Different models have been tried during the EWG selecting one as the best:

fmodel: ~ factor(replace(age,age>2,2))+s(year,k=6)

qmodel: list(~ factor(replace(age,age>2,2)))

srmodel: ~s(year,k=6)

n1model: ~s(age, k = 3)

vmodel: catch: ~s(age, k = 3) index: ~1

Summary of the model fit using the fitSumm command:

Statistics	Status_Quo
AIC	366.04
BIC	431.22
GCV	0.30
nb_par	22
nb_obs	143
%_param	15.385

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

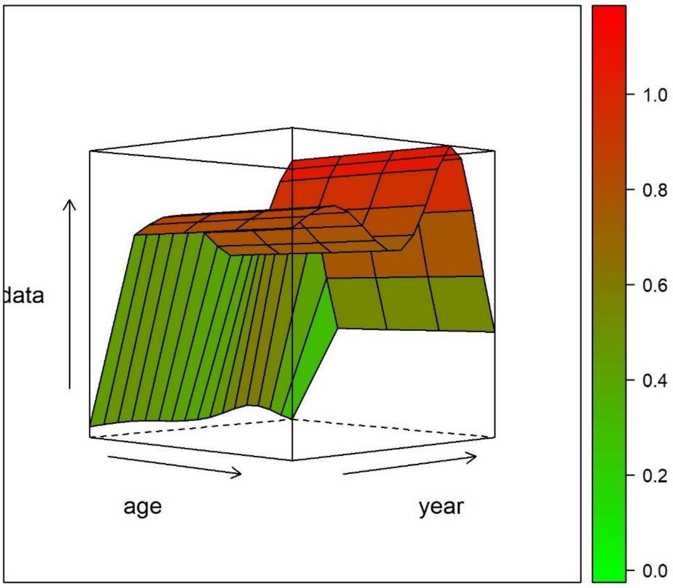


Figure 6.12.35 – Striped red mullet in GSA15_16: Harvest at age wireframe.

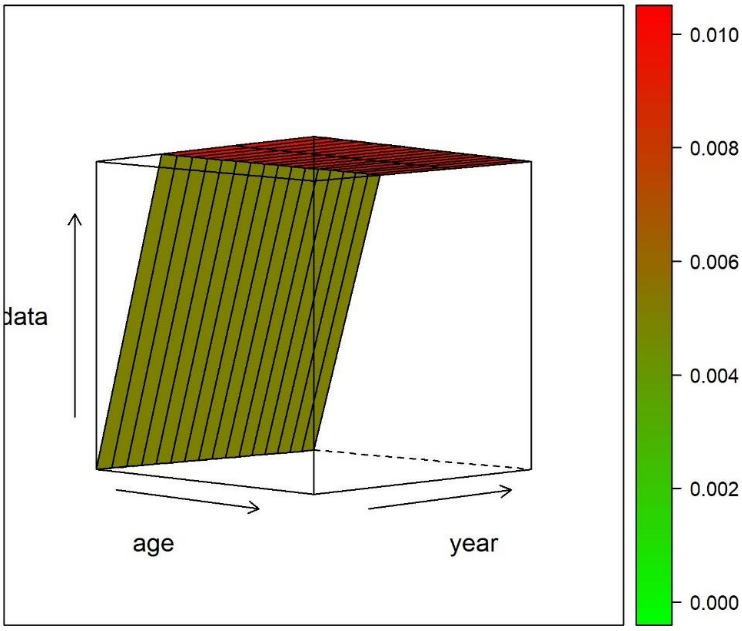


Figure 6.12.36 – Striped red mullet in GSA15_16: Catchability at age wireframe

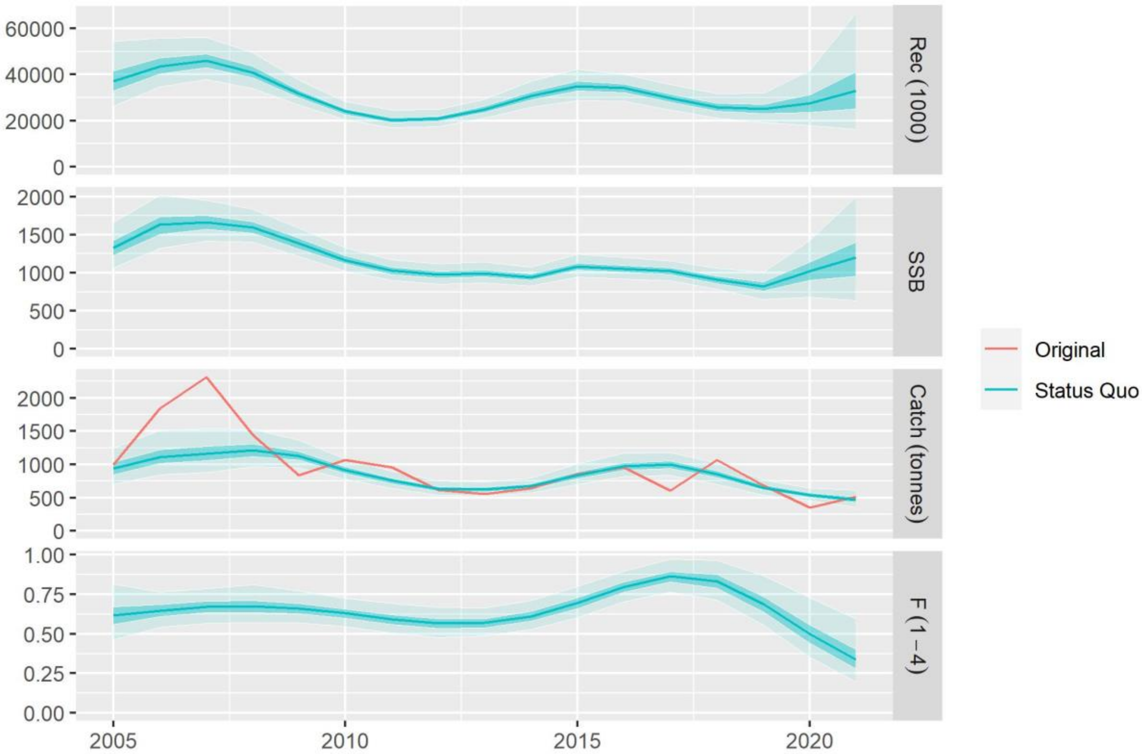


Figure 6.12.37 – Striped red mullet in GSA15_16: Results of the best a4a model. The observed catches are shown by the red line.

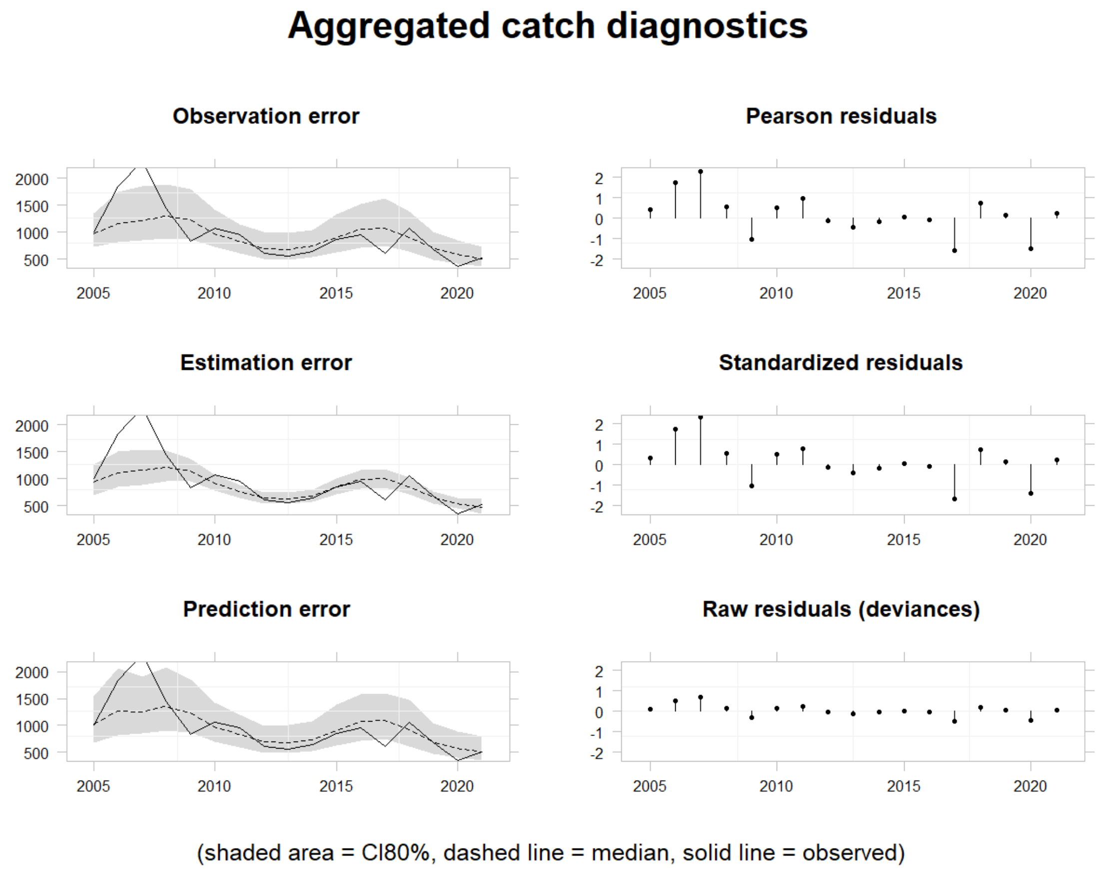


Figure 6.12.38 – Striped red mullet in GSA15_16: Catch diagnostics.

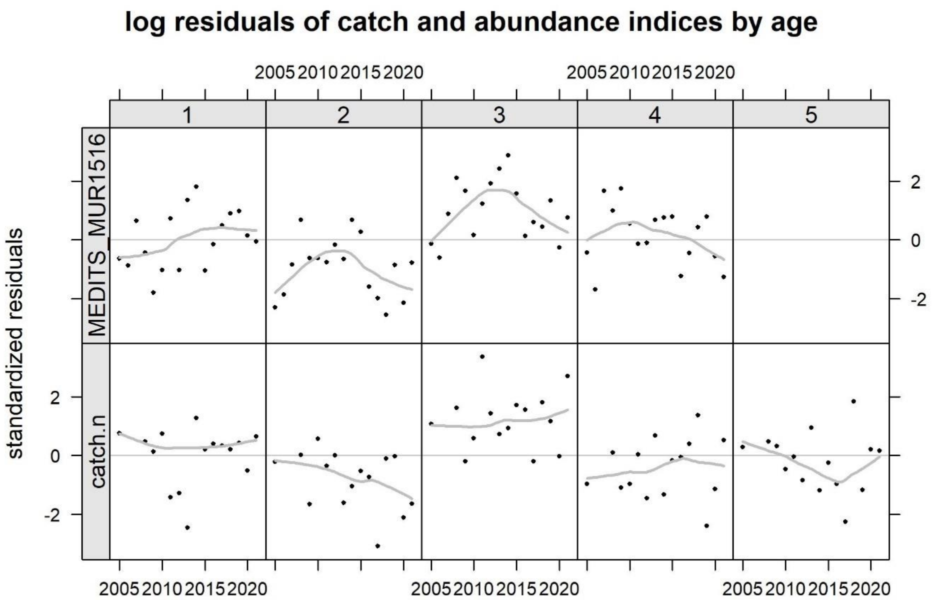


Figure 6.12.39 – Striped red mullet in GSA15_16: Log residuals of catch and abundance indices by age.

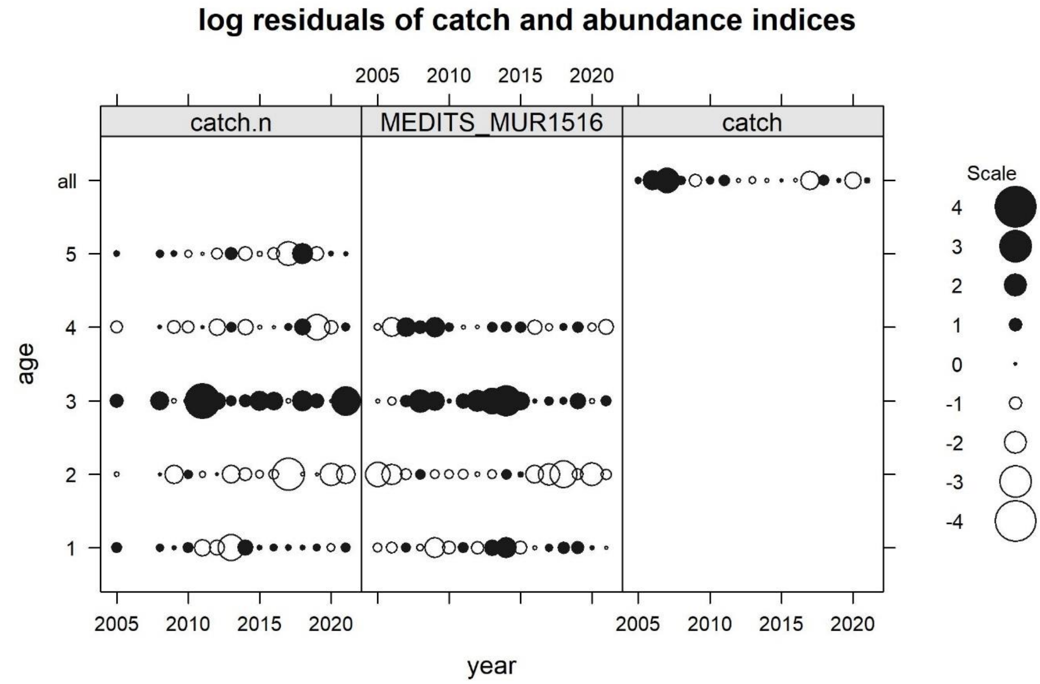


Figure 6.12.40 – Striped red mullet in GSA15_16: Bubble plot of the log residuals of catch and abundance indices by age.

Table 6.12.15 – Striped red mullet in GSA15_16: Range of variation of minimum and maximum residuals values estimated.

Variable	Minimum_residual_value	Maximum_residual_value
Catch	-1.66	2.33
Catch_at_age	-3.09	3.36
Index_at-age	-2.56	2.88

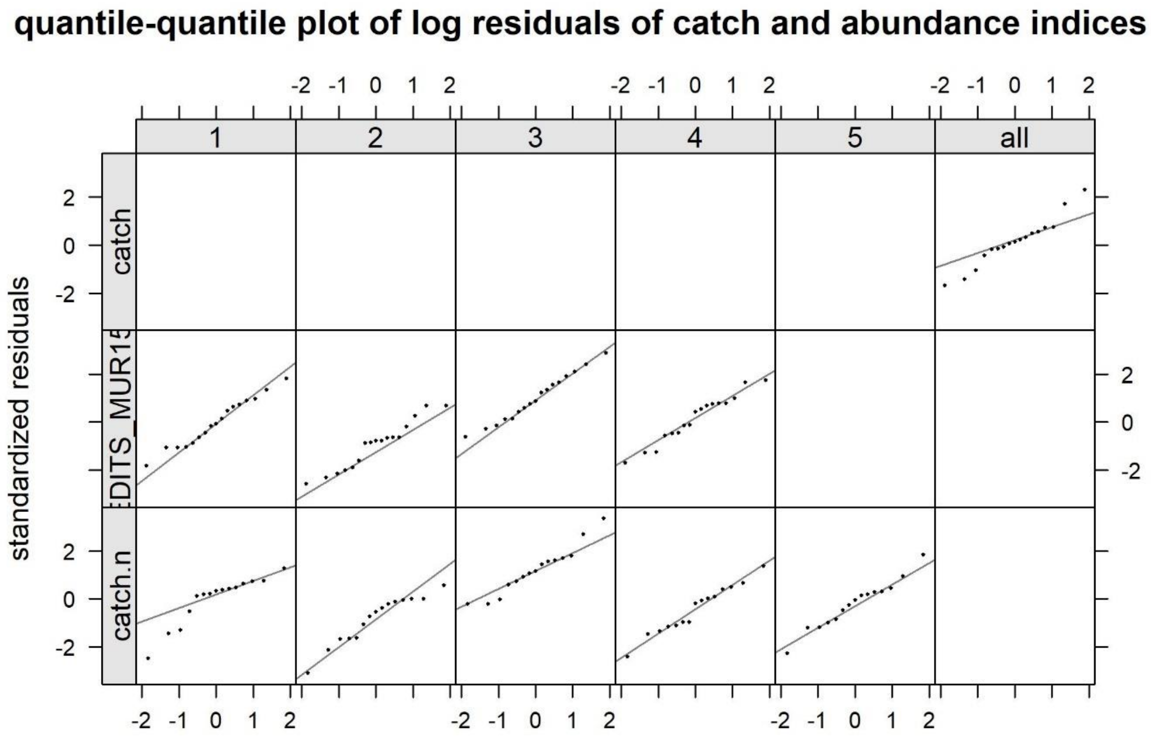


Figure 6.12.41 – Striped red mullet in GSA15_16: QQ-plot of the log residuals of catch and abundance indices by age.

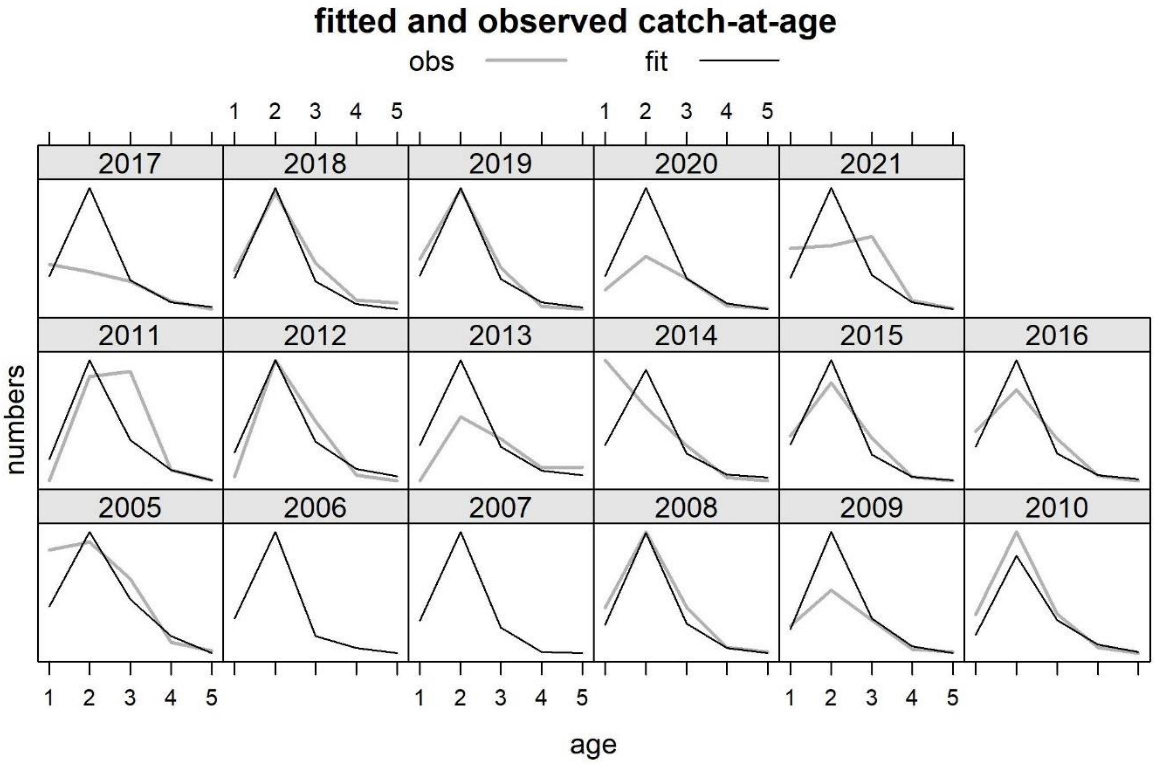


Figure 6.12.42 – Striped red mullet in GSA15_16: Fitting of the catch-at-age data.

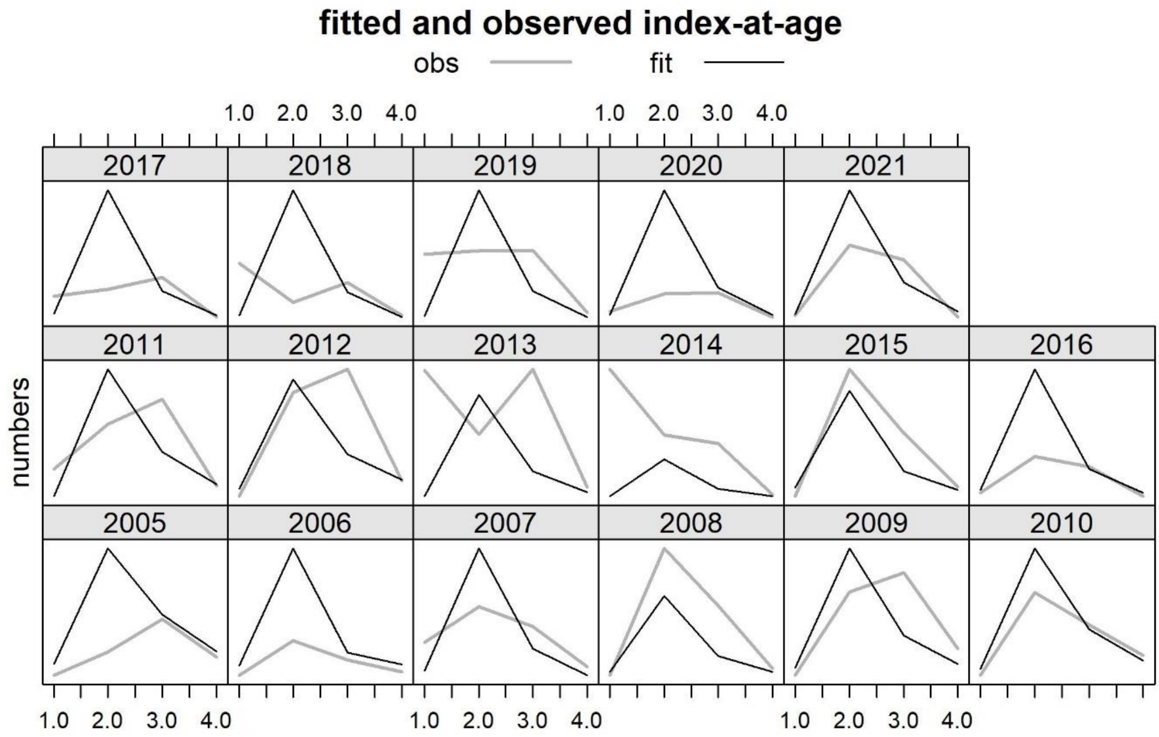


Figure 6.12.43 – Striped red mullet in GSA15_16: Fitting of the index-at-age data.

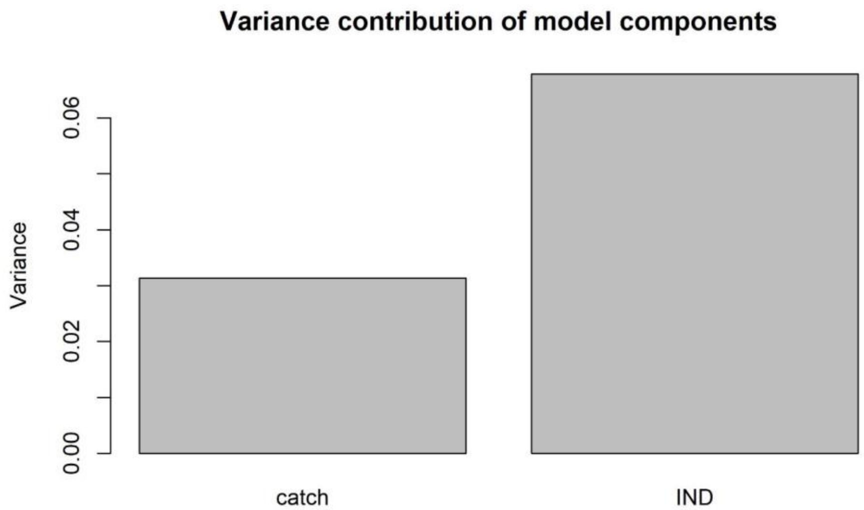


Figure 6.12.44 – Striped red mullet in GSA15_16: Variance contribution of model components: catches and survey.

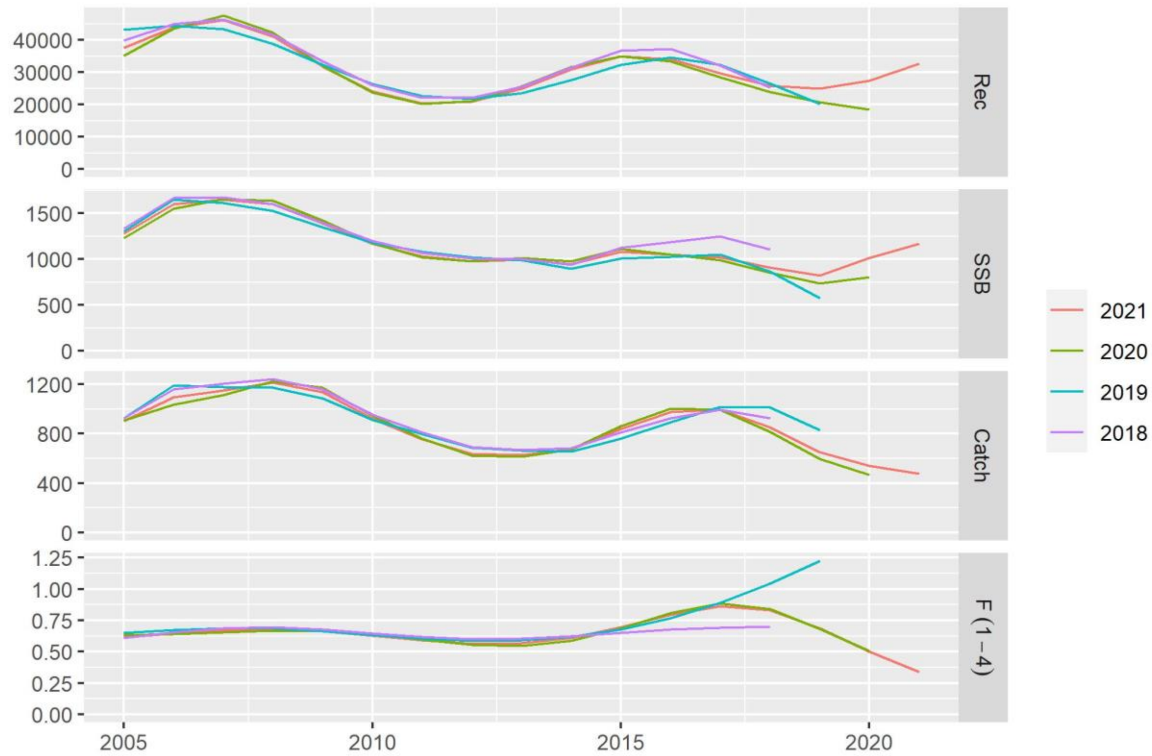


Figure 6.12.45 – Striped red mullet in GSA15_16: Retrospective analysis of the selected a4a model.

SSB	Fcurr	Rec	Catch
-0.09754	0.209236	-0.17875	0.075277

The residuals of the catch and abundance indices related to the outcomes of the best run do not show any particular trend in the only age free to be fitted (age1). The instability on the retrospective led the EWG in accepting the assessment only for providing an indication of historic stock status and trajectory and catch advice on fishing at F status quo.

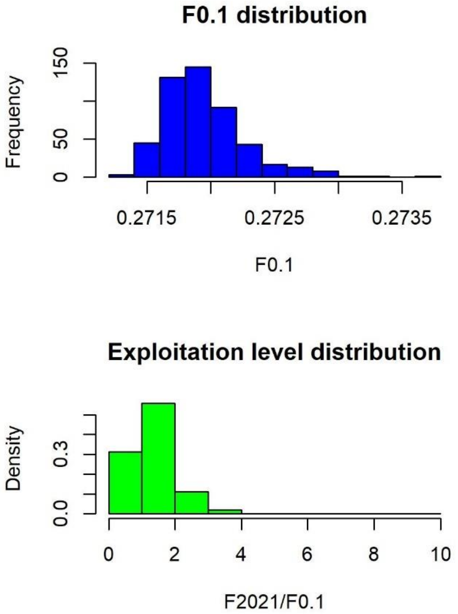


Figure 6.12.46 – Striped red mullet in GSA15_16: Histograms of probability for $F_{0.1}$, Fcurr and level of exploitation (Fcurr/F01 ratio) values.

A sensitivity analysis was performed on the number of knots applied to the smoother in year in the F sub-model.

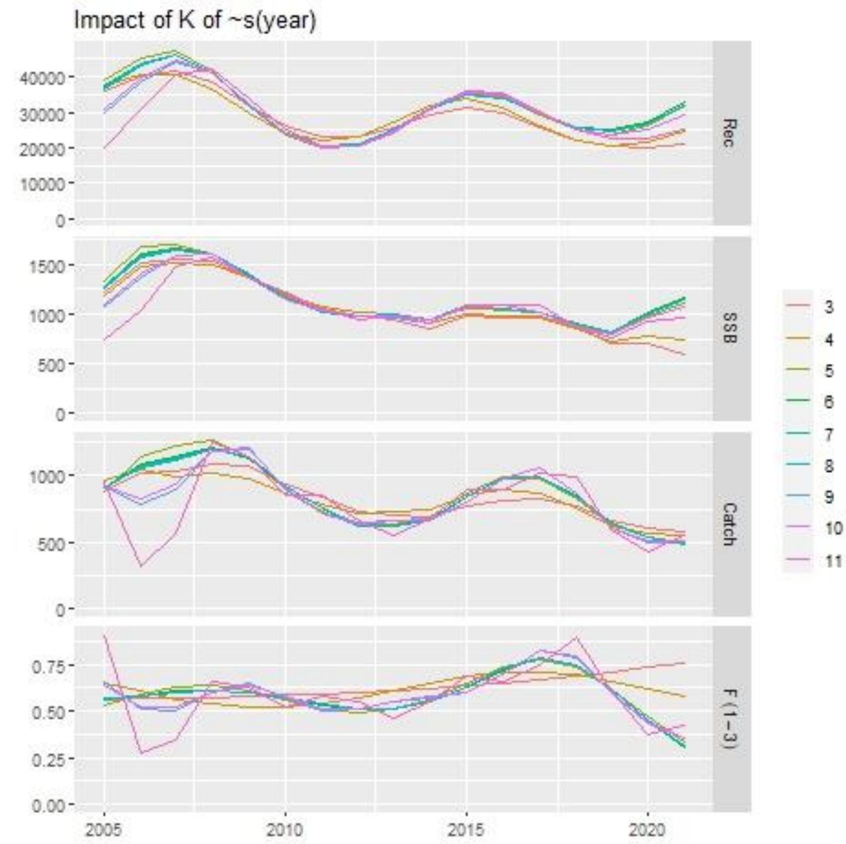


Figure 6.12.47 – Striped red mullet in GSA15_16: Outputs of model runs with different k values on the smoother on year in the fmodel.

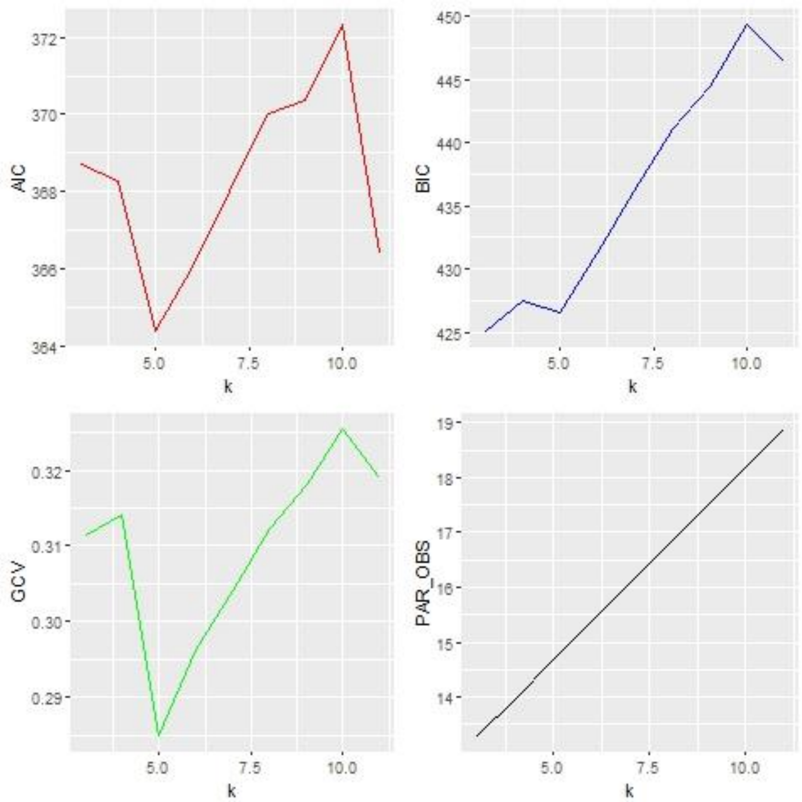


Figure 6.12.48 – Striped red mullet in GSA15_16: AIC, BIC and GCV values estimated on a range of k values of the smoother on year of the fmodel.

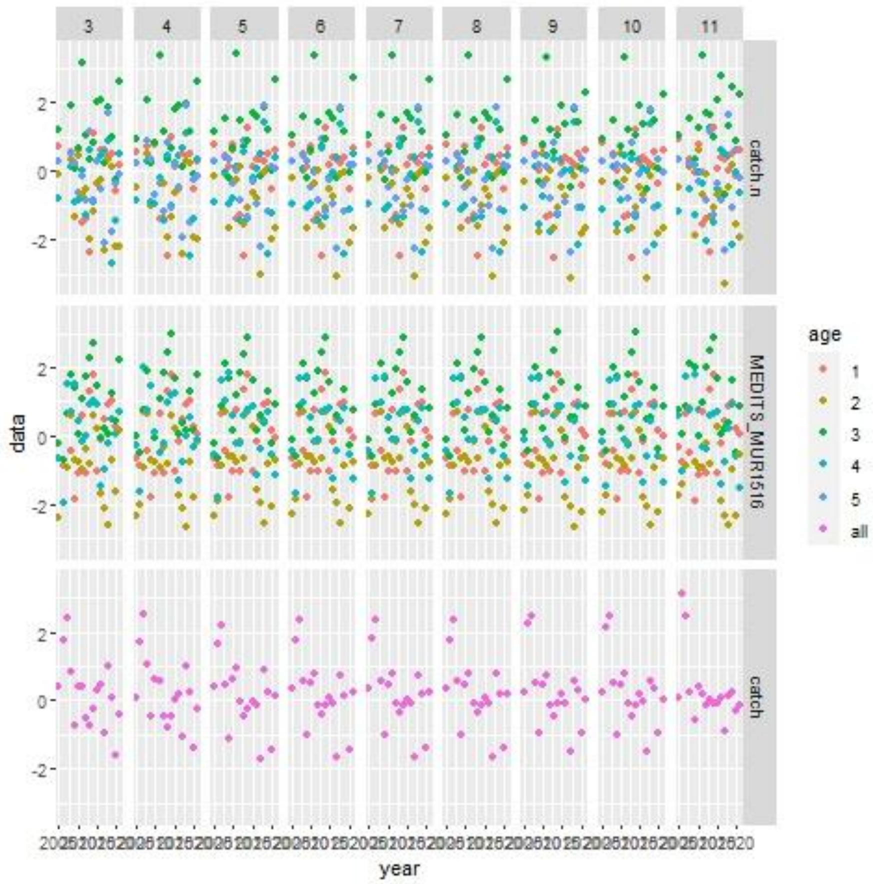


Figure 6.12.49 – Striped red mullet in GSA15_16: Log residuals of catch and abundance indices by age on a range of k values of the smoother on year of the fmodel.

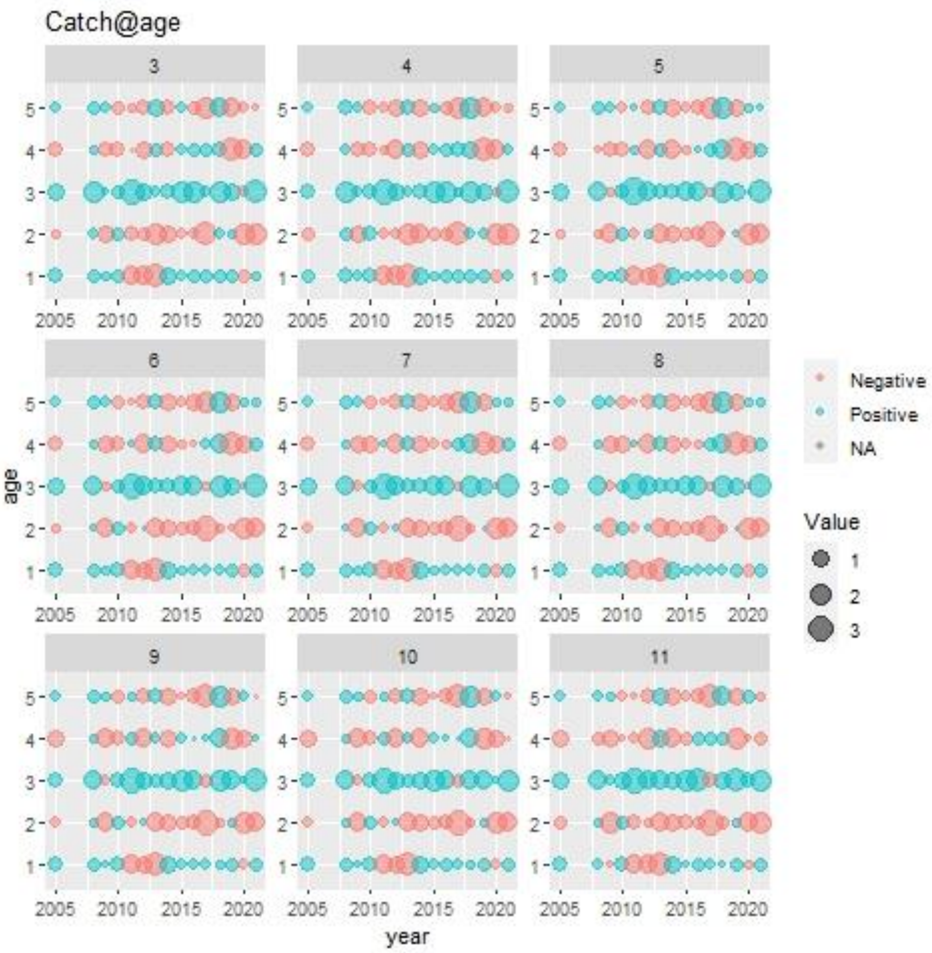


Figure 6.12.50 – Striped red mullet in GSA15_16: Bubble plots of the residuals of catch numbers by age on a range of k values of the smoother on year of the fmodel.

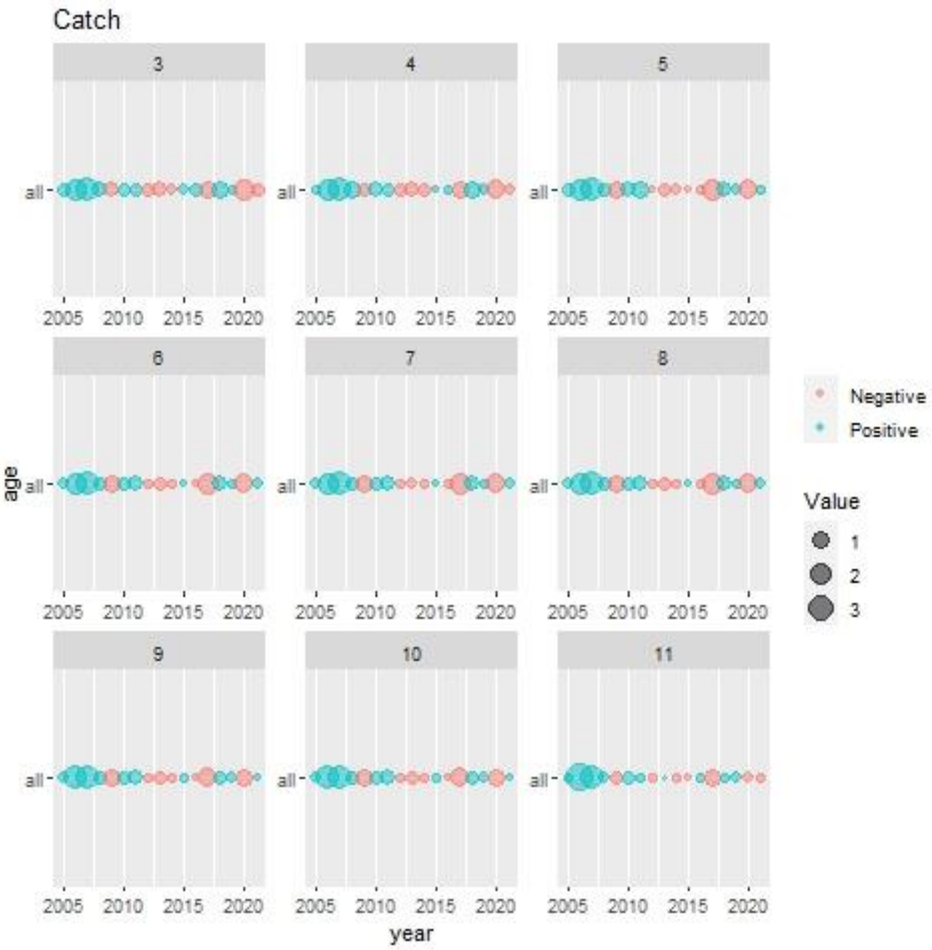


Figure 6.12.51 – Striped red mullet in GSA15_16: Bubble plots of the residuals of the catch on a range of k values of the smoother on year of the f-model.

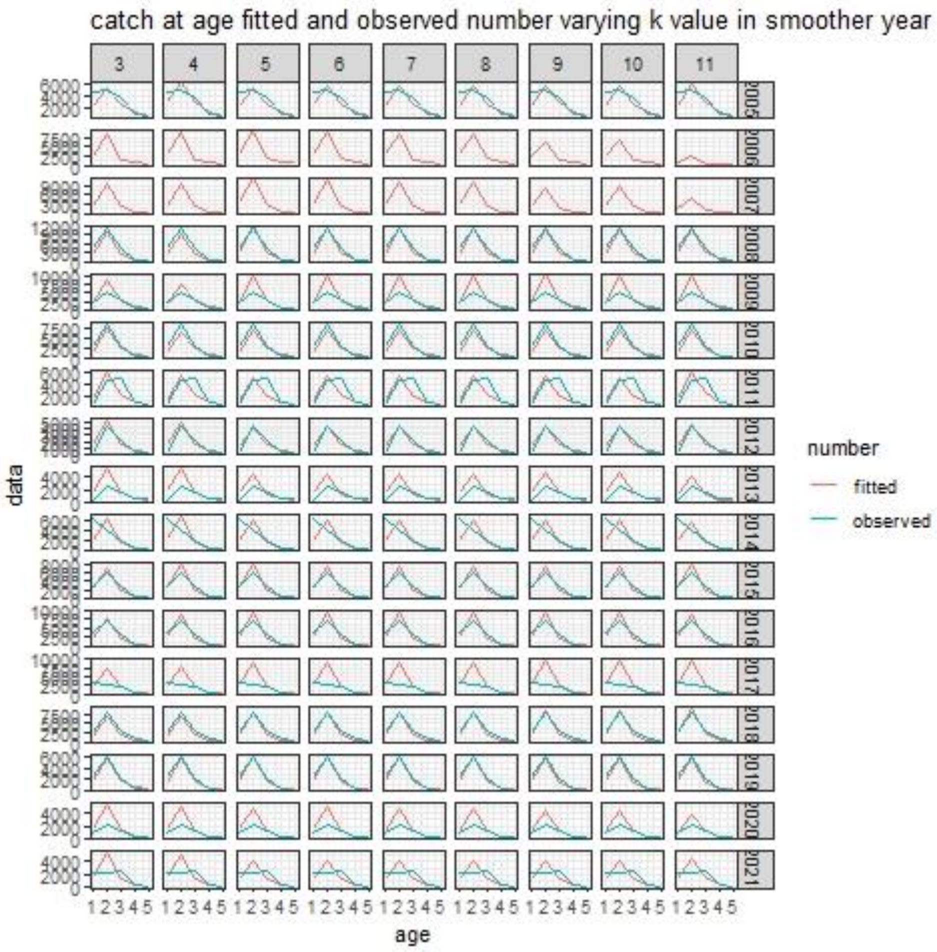


Figure 6.12.52 – Striped red mullet in GSA15_16: Fit of the catch at age numbers on a range of k values of the smoother on year of the fmodel.

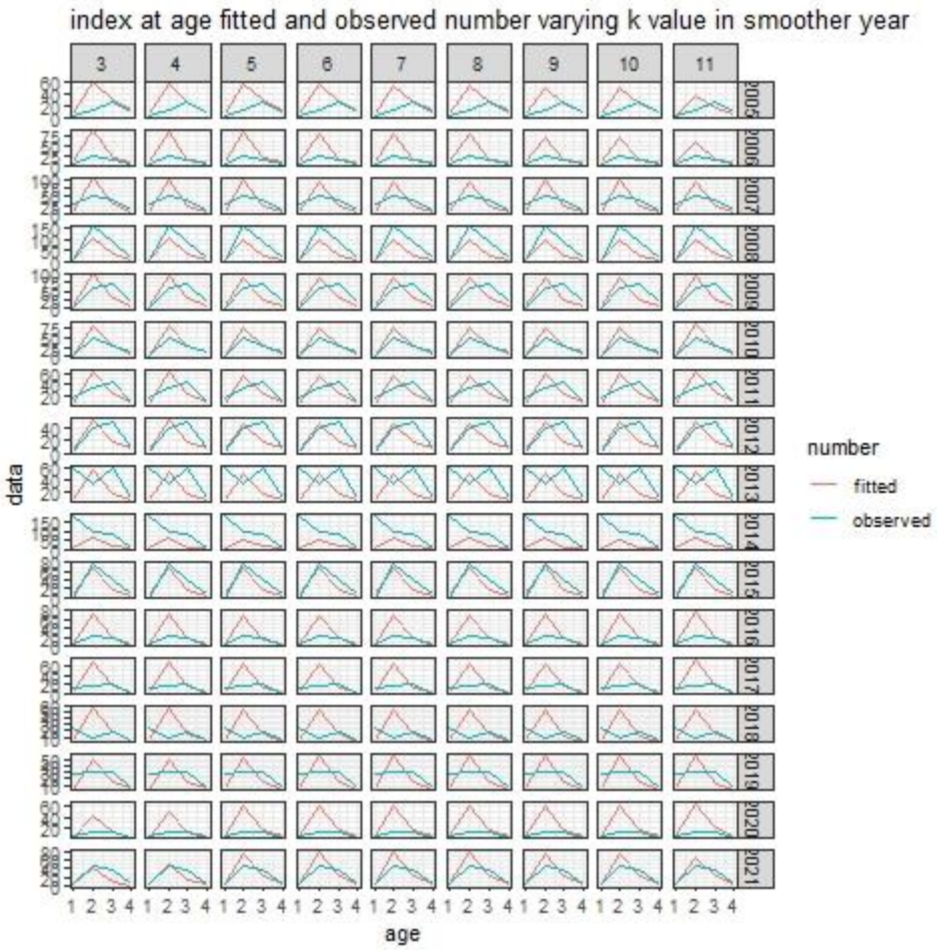


Figure 6.12.53 – Striped red mullet in GSA15_16: Fit of the index at age numbers on a range of k values of the smoother on year of the f-model.

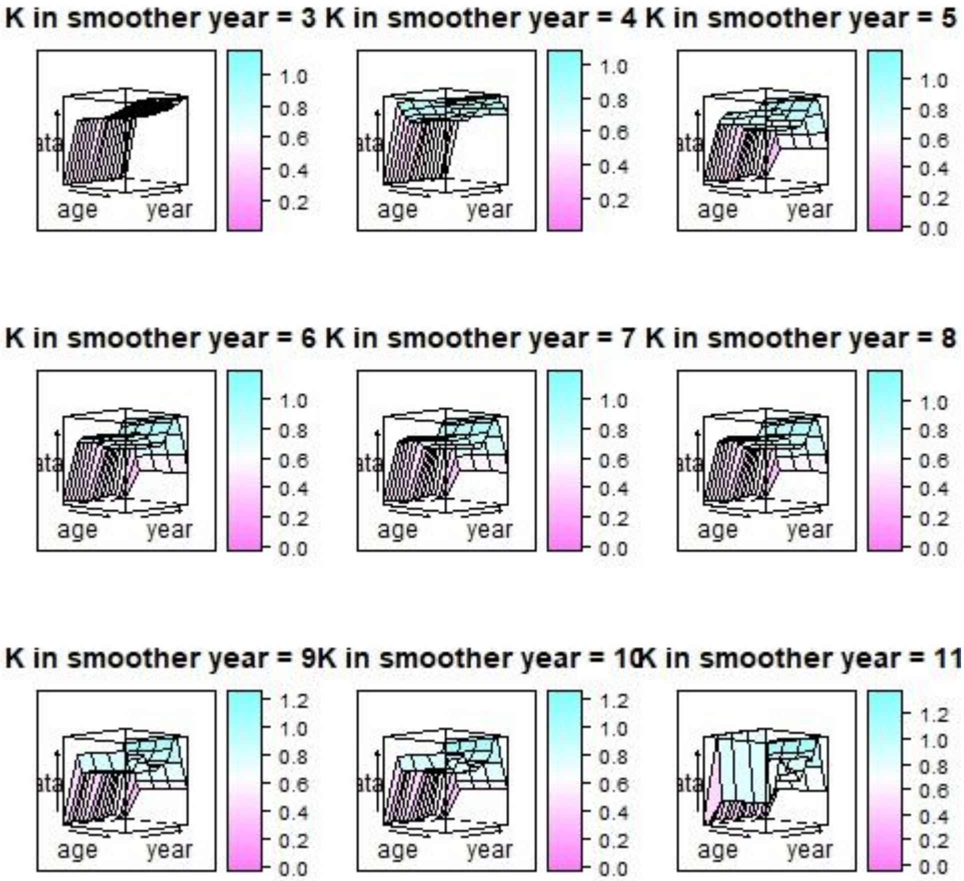


Figure 6.12.54 – Striped red mullet in GSA15_16: Harvest wireframe on a range of k values of the smoother on year of the f-model.

The inputs and the final outputs have been tested also using the ad-hoc a4adiags package which runs tests to evaluate the stability and good of fitness of the model (e.g. hindcasting, MASE value, etc.). The model passed all the tests resulting in a MASE value below the 1 threshold to be accepted.

In Figures 6.12.55-58 the main outputs

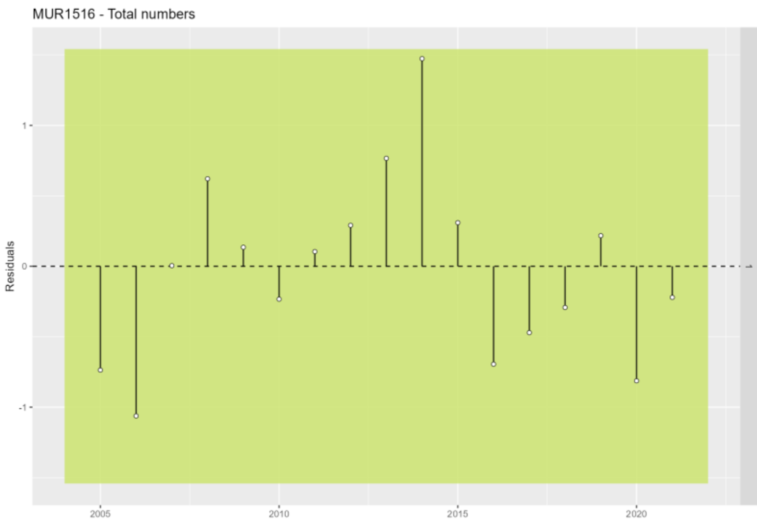


Figure 6.12.55 – Striped red mullet in GSA15_16: Runtest results from the a4adigs package.

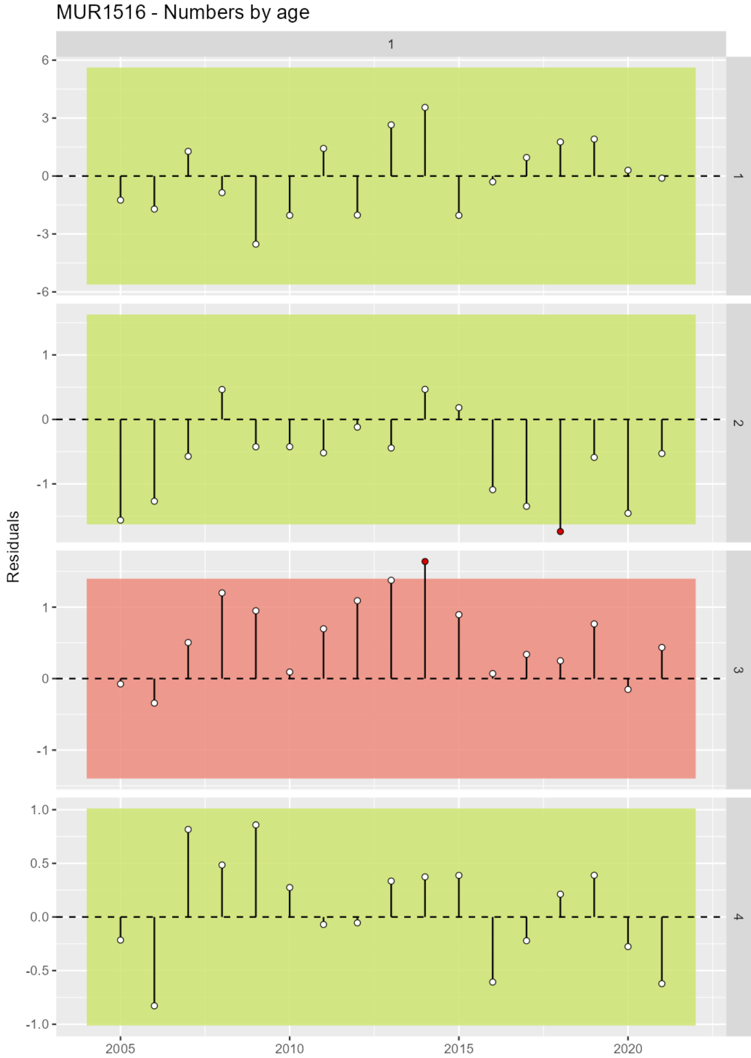


Figure 6.12.56 – Striped red mullet in GSA15_16: RuntestAge results from the a4adiags package.

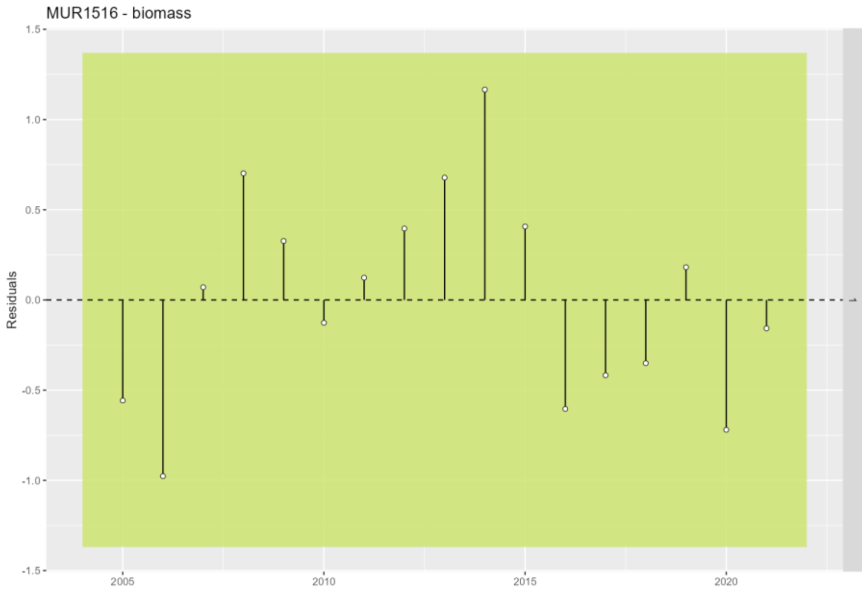


Figure 6.12.57 – Striped red mullet in GSA15_16: RuntestBio results from the a4adiags package.

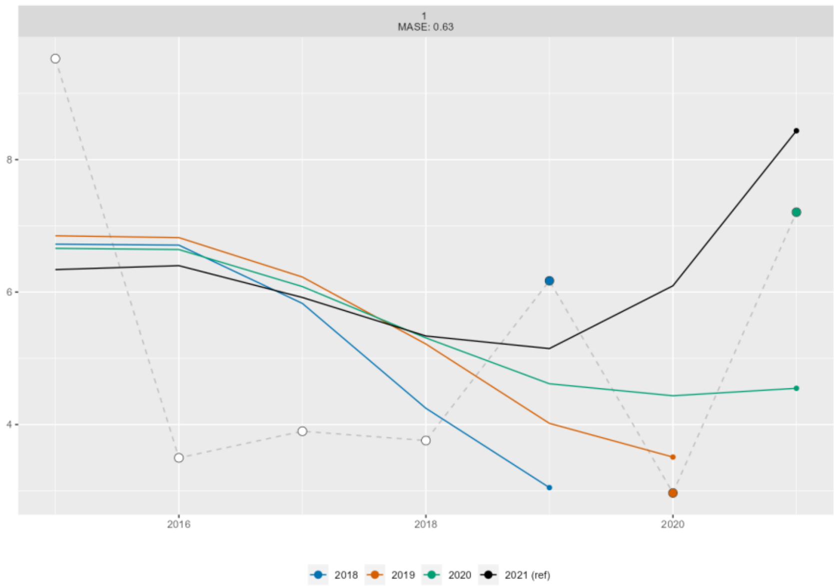


Figure 6.12.58 – Striped red mullet in GSA15_16: Hindcasting and MASE value results from the a4adiags package

Final assessment outcomes are given in Tables 6.12.16-.

Table 6.12.16 – Striped red mullet in GSA15_16: Times series of the recruitment, SSB, catch and fishing mortality estimated by the model.

Year	Recruitment age 0 ('000)	SSB (t)	Catch (t)	Fbar ages 1-4	Total biomass
2005	37505.825	1281.146	902.9112	0.615185	2840.501
2006	43869.646	1602.643	1093.697	0.645833	3674.934
2007	46222.311	1652.148	1149.219	0.669408	3834.219
2008	41099.390	1598.515	1212.285	0.676619	3723.970
2009	31763.444	1390.344	1136.401	0.662194	3185.277
2010	24010.289	1169.952	918.7311	0.629589	2615.699
2011	20365.143	1030.492	757.3571	0.591617	2249.030
2012	20857.199	977.0032	634.5145	0.565839	2116.526
2013	24931.687	993.529	626.4092	0.568562	2170.619
2014	30914.777	942.9379	671.2345	0.610961	2103.179
2015	35002.748	1082.692	839.8255	0.694124	2533.658
2016	34090.998	1051.042	974.6559	0.796816	2580.361
2017	29735.477	1022.458	995.1016	0.864095	2585.200
2018	25878.938	911.0353	852.7108	0.831233	2272.290
2019	24896.187	821.9153	651.3152	0.688809	1925.765
2020	27334.077	1013.624	541.3561	0.501812	2204.930
2021	32626.829	1165.461	478.0739	0.341226	2302.934

Table 6.12.17 – Striped red mullet in GSA15_16: Stock numbers at age.

Year/Age	**1**	**2**	**3**	**4**	**5+**
2005	37505.83	12018.22	5679.656	2378.133	882.2331
2006	43869.65	18811.91	3470.403	1757.398	1068.005
2007	46222.31	21939.03	5226.527	1028.991	895.2853
2008	41099.39	23041.27	5892.249	1505.099	591.1471
2009	31763.44	20460.76	6133.057	1684.864	633.6163
2010	24010.29	15833.23	5557.409	1785.069	714.7684
2011	20365.14	12026.31	4477.521	1685.804	803.6761
2012	20857.2	10256.05	3586.168	1428.458	840.8326
2013	24931.69	10549.56	3151.803	1181.748	794.3483
2014	30914.78	12600.24	3237.598	1033.789	691.8095
2015	35002.75	15507.79	3650.341	1007.81	570.2329
2016	34091.00	17364.07	4040.287	1018.878	468.1072
2017	29735.48	16665.32	3963.213	988.8884	385.1764
2018	25878.94	14411.99	3490.812	890.5317	326.1199
2019	24896.19	12601.97	3151.878	814.0541	301.9587
2020	27334.08	12360.06	3302.154	885.7967	331.2037
2021	32626.83	13948.38	4125.339	1181.25	461.3758

Table 6.12.18 – Striped red mullet in GSA15_16: Fishing mortality at age.

Year/Age	1	2	3	4	5+
2005	0.087	0.791	0.791	0.791	0.791
2006	0.091	0.831	0.831	0.831	0.831
2007	0.094	0.861	0.861	0.861	0.861
2008	0.096	0.870	0.870	0.870	0.870
2009	0.093	0.852	0.852	0.852	0.852
2010	0.089	0.810	0.810	0.810	0.810
2011	0.084	0.761	0.761	0.761	0.761
2012	0.080	0.728	0.728	0.728	0.728
2013	0.080	0.731	0.731	0.731	0.731
2014	0.086	0.786	0.786	0.786	0.786
2015	0.098	0.893	0.893	0.893	0.893
2016	0.112	1.025	1.025	1.025	1.025
2017	0.122	1.111	1.111	1.111	1.111
2018	0.117	1.069	1.069	1.069	1.069
2019	0.097	0.886	0.886	0.886	0.886
2020	0.071	0.645	0.645	0.645	0.645
2021	0.048	0.439	0.439	0.439	0.439

6.12.4 Reference Points

The STECF EWG recommended the use of $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the assessment.

The value of $F_{0.1}$ (Fbar 1-4) calculated by FLBRP package on the a4a assessment results is equal to 0.272. Current F values (2021), as calculated by model a4a, is 0.341 indicating that the stock is in underfishing conditions (Fcurr/ $F_{0.1}$= 1.255). Because of the instability in the retrospective and considering that it was the first year in which for this stock a sensible assessment has been obtained the EWG agreed in providing catch advice only on the fishing mortality status quo basis.

6.12.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the stock assessment.

An average of the last three years has been used for weight at age, maturity at age, natural mortality at age and selectivity at age while the Fbar = 0.341 terminal F (2021) from the a4a assessment was used for F in 2022. Recruitment is in a clear increasing phase over the period of the assessment (Figure 6.11.3.5) so the geometric mean across the last three years has been used as an estimate of recruits from 2022.

Table 6.12.19 – Striped red mullet in GSA15_16: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 1-4 (2022)	0.341	Fsq = F in the last year (2021)
SSB (2022)	1426.98	SSB intermediate year from STF output
Rage1 (2022,2023)	27147.895	Recruitment will be set as geometric mean of the last 12 years
Total Catch (2022)	611.60	Catch intermediate year from STF output

The analysis, carried out with the ad-hoc script developed by JRC and made available to the EWG, shows that fishing at a level equal to Fstatus quo (=0.341) would increase biomass by 9.6 % from 2022 to 2024, while increasing catches by 36.2% from 2021 to 2023.

Table 6.12.20 – Striped red mullet in GSA15_16: Short term forecast table.

Rationale	Ffactor	Fbar	Catch 2021	Catch 2023	SSB* 2022	SSB* 2024	SSB change 2022-2024(%)	Catch change 2021-2023(%)
Zero catch	0	0	478.0	0	1426.9	2439.1	70.93	-100
20% reduction Fsq	0.8	0.272	478.0	540.3	1426.9	1700.5	19.16	13.03
10% reduction Fsq	0.9	0.307	478.0	596.8	1426.9	1630.3	14.24	24.84
Status quo (Fsq)	**1**	**0.341**	**478.0**	**651.1**	**1426.9**	**1564.0**	**9.60**	**36.19**
10% increase Fsq	1.1	0.375	478.0	703.3	1426.9	1501.5	5.22	47.12
20% increase Fsq	1.2	0.409	478.0	753.6	1426.9	1442.5	1.09	57.64

*SSB at mid-year

6.2.2.6 Data Deficiencies

Below the main issues and/or data gaps spotted during the meeting.

Country	Data Requested	Issue
Italy	Maturity ogive at length Maturity ogive at age Growth parameters Sex ratio at length Sex ratio at age	MUR_GSA_16. VBGF parameters are invariant along the time series. Is it correct?
Italy	Maturity ogive at length Maturity ogive at age Growth parameters Sex ratio at length Sex ratio at age	MUR_GSA_16. Maturity vector by length for females in years 2016 and 2021 seem misreported. In 2021 the same issue is present for males. Basically, maturity values decrease in size.
Italy	Landings length	MUR_GSA_16. In 2018 an exceptional specimens of more than 44 cm TL has been observed (bigger of all the VBGF length infinite values reported).
Italy	Landings length	MUR_GSA_16. In GSA16 landings value in weight for gear GTR in 2002 seems misreported considering also that almost zero landing value has been reported for OTB in the same year
Italy	Landings length	MUR_GSA_16. The order of magnitude of the abundance in the first 3 years in OTB_DEF is much higher of the values collected in the time series; moreover the derived mean weights seem not in line with the expected ones for this species. Please check both landing in weight and number by length classes.
Italy	Landings length	MUR_GSA_16. Length distribution in year 2006 for OTB_DEMF seems weird, likely few individuals have been raised to the whole production
Italy	Maturity ogive at length Maturity ogive at age Growth parameters Sex ratio at length Sex ratio at age	MUR_GSA_16. In maturity at length size in 2018 an exceptional specimens of more than 44 cm TL has been observed (bigger of all the VBGF length infinite values reported).
Malta	Catch and Landings length	MUR_GSA_15. In GSA15 reported landings values extracted from catches and landings at length DCF templates are inconsistent up to 2014
Italy	Landings length	MUR_GSA_16. Length distributions in years 2020 and 2021 for GNS_DEF seem weird, likely few individuals have been raised to the whole production
Italy	Landings length	MUR_GSA_16. The order of magnitude of the abundance in year 2011 for GTR_DEF is much higher of the values collected in the time series. Is this year data or the others data years misreported?
Italy	Landings length	MUR_GSA_16. None length distributions available for OTB in 2007
Malta	Landings length	MUR_GSA_15. Abundance in year 2009 for OTB_MDD is weird. Likely numbers have been provided in absolute values not in thousands

Malta	Landings length	MUR_GSA_15. Abundance in years 2010-2012 for OTB_DEMF are weird. Likely numbers have been provided in absolute values not in thousands
Malta	Landings length	MUR_GSA_15. Length distribution in year 2012 for OTB_DWS seems weird. Likely few individuals have been raised to the whole production
Malta	Landings length	MUR_GSA_15. Length distributions in years 2020 and 2021 for GTR_DEF seem weird. Likely few individuals have been raised to the whole production
Malta	Landings length	MUR_GSA_15. Abundance in years 2011-2016 for GTR_DEMF are weird. Likely numbers have been provided in absolute values not in thousands
Malta	Discards length	MUR_GSA_15. LFDs seem weird. Likely very few measured individuals have been raised to the whole production
Italy	Discards length	MUR_GSA_16. LFDs seem weird. Likely very few measured individuals have been raised to the whole production
Italy	MEDITS survey TA	MUR_GSA_16. In many years the MEDITS survey has been conducted in delay (i.e. 2013, 2017, 2020 and 2021). Is it correct?
Malta	MEDITS survey TA	MUR_GSA_15. In year 2018 the MEDITS survey has been conducted in delay. Is it correct?
Italy	MEDITS survey TA	MUR_GSA_16. In GSA16 the number of hauls carried out during the surveys have been changed in time. Indeed, a huge increase in the number of hauls has been observed during the period 2005-2007 planning the total number of hauls equal to 120. However, in 2014 and 2020 have been reported a lower number of hauls comparing the expected 120
Malta	MEDITS survey TA	MUR_GSA_15. One haul has been reported with wrong geographical position (haul 19 in 2019)
Italy	MEDITS survey TC	MUR_GSA_16. A misreported speciment of 199 mm of TL should be removed from the TC file
Malta	MEDITS survey TC	MUR_GSA_15. A misreported speciment of 945 mm of TL should be removed from the TC. Some very suspicious measures should be chekced as well (i.e. males 45 and 20 mm TL in years 2021 and 2019 and females 15 and 25 mm TL in years 2014 and 2013)
Malta	MEDITS survey TB	MUR_GSA_15. The whole 2017 TB dataset is missing
Malta	MEDITS survey TB_TC	MUR_GSA_15. Unconsistencies spotted in total number reported in TB and TC files in year 2019 haul 47 and year 2021 haul 46
Italy	MEDITS survey TB_TC	MUR_GSA_16. Unconsistencies spotted in total number reported in TB and TC files in year 2005 (hauls: 14,37,46,58,59,63,71,74,79,81,93), year 2006 (hauls: 58,62,72), year 2007 (haul 61), year 2008 (haul 26), year 2009 (hauls 16 and 73), year 2010 (haul 26), year 2012 (haul 111), year 2014 (haul 1) and year 2018 (haul 55).
Italy	Landings length	MUR_GSA_16. Implausible huge abundance in total number derived from landings at length file in year 2019 length class 27 and year 2018 length classes 25 and 44. As a general comment there are also others length classes abundance values quite suspicious (very high)likely due in raising few individuals to the whole production.

6.12.6 DATA DEFICIENCIES

Below the main issues and/or data gaps spotted reported according the DTMT guidelines.

MS	Data Requested	Issue
Italy	Landings length	GSA_16_MUR. Length frequencies distributions in OTB_DEF in years 2002-2004 are quite different in term of numbers from the rest of the time series. Length distribution in year 2006 for OTB_DEMF seems weird.
Italy	Landings length	GSA_16_NEP. Length frequencies distribution have been not provided in year 2018
Italy	Landings length	GSA_16_MUR. Landings in weight reported in year 2002 for GTR_DEF and in year 2019 OTB_DWS seem wrong.
Italy	Landings length	GSA_16_MUR. There are some inconsistencies between total weight and total number associated to the OTB_MDD (in 2013) and GTR_DEF (in 2002) metiers resulting in a quite unrealistic mean weight.
Italy	Discards length	GSA_16_MUR. Data are very poor. It seems that few individuals' measures have been raised to the whole production.
Italy	Catches	GSA_16_MUR. Some inconsistencies in the Sum of Product have been spotted both in landings and discards data (15 and 1 respectively see quality report).
Italy	Maturity ogive at age	GSA_15_MUR. Maturity at age for both male and female in year 2021 seems misreported in older ages.
Italy	Maturity ogive at length	GSA_16_MUR. Maturity at length for male in year 2021 and female in years 2021,2018 and 2016 seem misreported in bigger size.
Italy	Age Length Key	GSA_16_MUR. For all the sexes available (female, male and combined) length assigned to age 0 show a quite unrealistic wide range
Italy	MEDITS survey TA	GSA_16_MUR. Number of hauls carried out along the time series change a lot. In particular, in years 2014 and in 2020. In the former year the reduction applied doesn't seem proportional to each strata ending up with a very few hauls carried out in the deeper stratum.
Italy	MEDITS survey TA	GSA_16_MUR. MEDITS survey period has not been always respected. In particular in years 2013, 2017, 2020 and 2021.
Italy	MEDITS survey TB_TC	GSA_16_MUR. Many inconsistencies in total weight or total number reported by haul in TB and TC files have been spotted. In particular in year 2021 haul 61.
Italy	MEDITS survey TC	GSA_16_MUR. In year 2002 wrong length has been reported: 199mm TL.
Malta	Landings length	GSA_15_MUR. No data have been provided from 2005 to 2008.
Malta	Landings length	GSA_15_MUR. Length frequencies distributions provided along the time series seem weird having a derived mean weight as ratio between discards weight and numbers by métier (OTB_MDD, OTB_DWS, OTB_DEMF and GTR), quite unrealistic. Likely numbers have been reported as absolute numbers and not as thousands as MEDBS data call requested.
Malta	Discards length	GSA_15_MUR. Length frequencies distributions provided in year 2019 seem weird having a derived mean weight as ratio between discards weight and numbers by métier (OTB_MDD, OTB_DWS, OTB_DEMF), quite unrealistic. Likely numbers have been reported as absolute numbers and not as thousands as MEDBS data call requested.
Malta	MEDITS survey TB	GSA_15_MUR. TB data for year 2017 are missing.
Malta	MEDITS survey TA	GSA_15_MUR. MEDITS survey period has not been always respected. In particular in year 2018.
Malta	MEDITS survey TB_TC	GSA_15_MUR Inconsistency in total weight reported in year 2013 haul 19 between TB and TC files.
Malta	MEDITS survey TC	GSA_15_MUR. Lengths reported in year 2013 need to be checked (e.g. 945mm TL spotted). In years 2021 and 2019 very small lengths for males have been reported (e.g. 45mm TL and 20 mm TL respectively). In years 2013 and 2014 the same for female (e.g. 25mm TL and 15mm TL respectively).
Malta	Sex ratio at age	GSA_15_MUR. Value for age 3in year 2020 seems misreported or just due to a very low sample.
Malta	Growth parameters	GSA_15_MUR. No growth parameters provided.

6.13 European hake in GSA 20

6.13.1 Stock Identity and Biology

The assessment of European hake carried out during the STECF EWG 22 – 16 considered the stock to be confined inside the area of GSA 20.

Hake is one of the most important fish stocks in GSA 20 for small scale fisheries (nets and longlines) and bottom trawlers. The stock is distributed in depths between 50 and 600 m, with a peak in abundance between 200 and 300 m. The stock is exploited exclusively by the Greek fishing fleet.

Hake is considered a long living species but there are debates regarding its growth rate with different authors proposing either "slow" of "fast" growth rates. In past studies, slow growth rates have been adopted for the area.

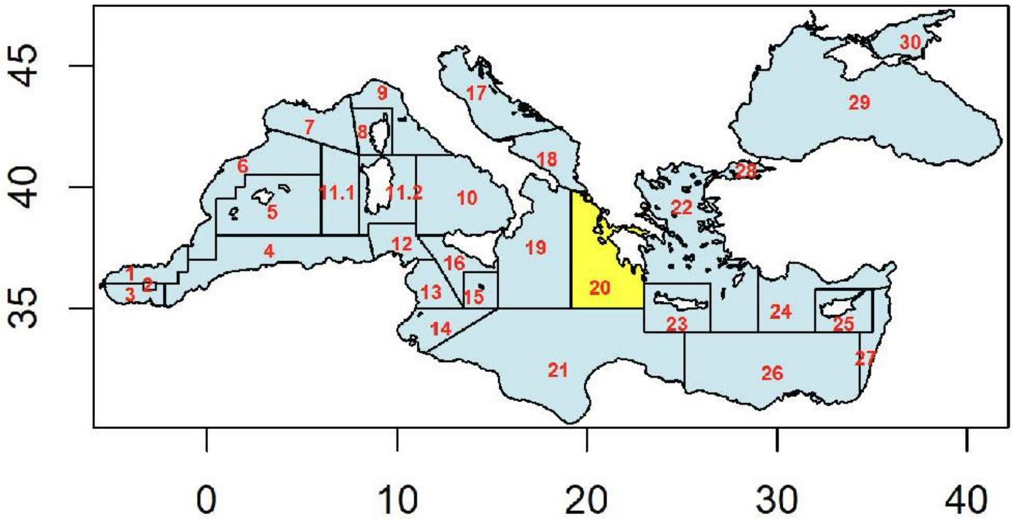


Figure 6.13.1.1. Geographical location of GSA 20.

Growth parameters and length - weight relationship parameters were the ones used during the GFCM's Benchmark assessment on the Mediterranean hake for sex combined. The parameters are reported in Tables 6.13.1.1 – 6.13.1.2.

Table 6.13.1.1 Hake in GSA 20. Growth parameters for sex combined data.

Source	L_{inf}	k	t_0	Sex
GFCM, 2019	104	0.12	-0.01	Combined

Table 6.13.1.2. Hake in GSA 20. Length weight parameters from DCF data

Sex	a	b
Combined	0.0033	3.23

Maturity and Natural mortality have also been assumed to be equal to the values used in the GFCM Benchmark assessment.

Table 6.13.1.3. Hake in GSA 20. Maturity and mortality at age vectors used in the assessment.

Age	0	1	2	3	4	5+
Maturity	0	0.19	0.86	1	1	1
Mortality	1.85	0.8	0.48	0.37	0.28	0.24

6.13.2 **Data**

6.13.2.1 **Catch data (Landings and Discards)**

Landings and discards reported through the DCF are sparse due to non-implementation of the Greek DCF in several years. STECF EWG 22-16 decided to use the official landings reported by the Hellenic Statistical Authority (HELSTAT), as was previously done in several stock assessments of Greek stocks both during STECF EWGs and in GFCM.

The following figures and tables present the DCF and HELSTAT data as they are reported from the two different sources.

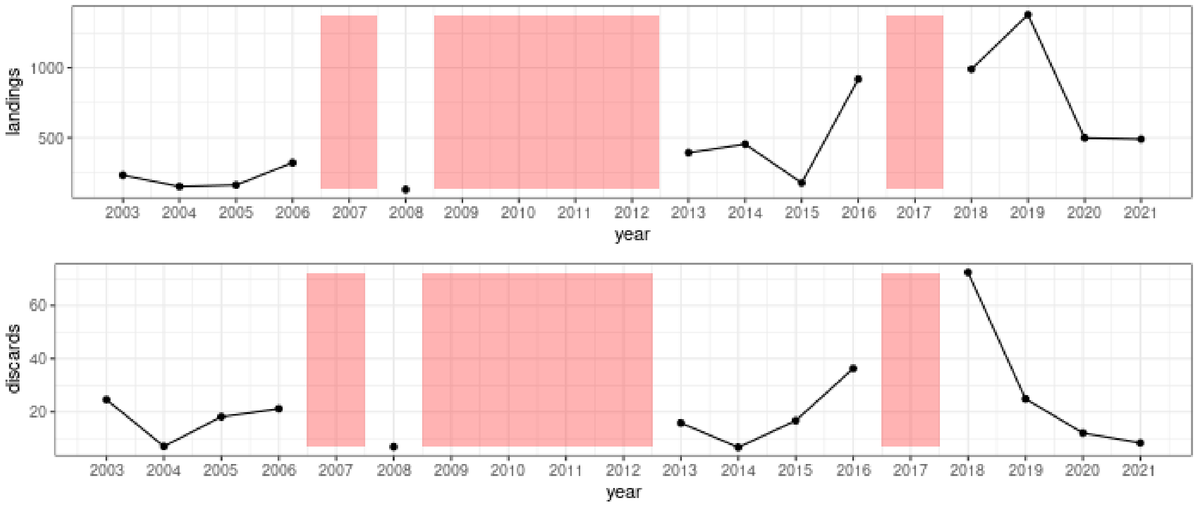


Figure 6.13.2.1.1. **Hake in GSA 20.** Landings and discards as reported through DCF, red areas represent the missing years.

Table 6.13.2.1.1. Hake in GSA 20. Landings and discards as reported through DCF.

year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
landings	230	148	159	319	NA	126	NA	NA	NA	NA
discards	25	7	18	21	NA	7	NA	NA	NA	NA
year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
landings	391	452	174	919	NA	990	1382	497	489	
discards	16	7	17	36	NA	72	25	12	8	

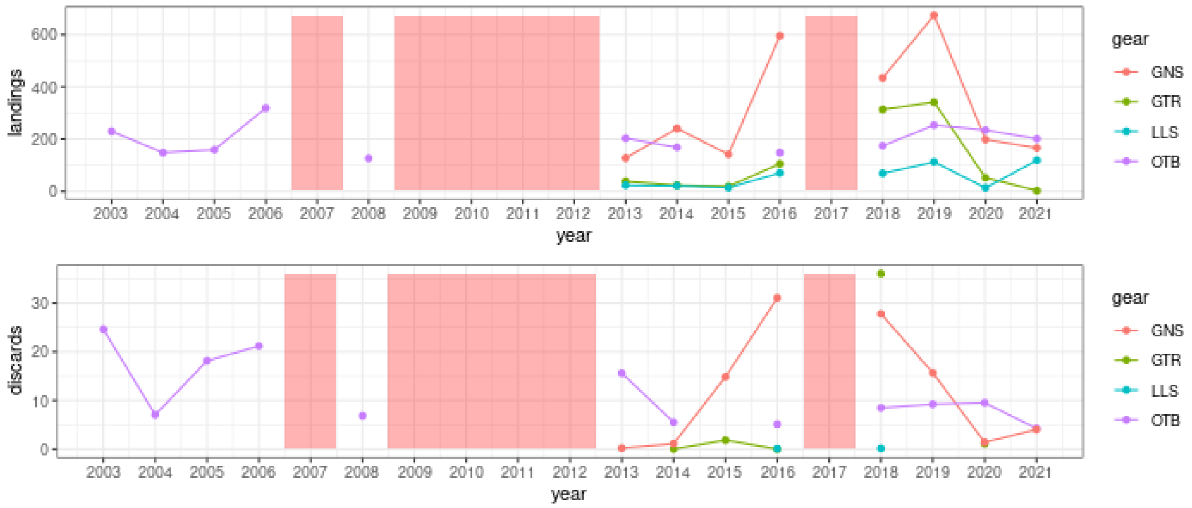


Figure 6.13.2.1.2. Hake in GSA 20. Landings and discards by gear as reported through DCF, red areas represent the missing years.

Table 6.13.2.2 and Figure 6.13.2.3 presents the total landings by gear as reported by the HELSTAT and provided to the STECF EWG 22-16 by the MS. Gear denoted as SSF stands for small scale fisheries i.e. nets and longlines.

Table 6.13.2.1.2. Hake in GSA 20. Landings as reported by HELSTAT.

Year	OTB	PS	SB	SSF
2003	353.64	0.79	31.93	319.71
2004	384.01	4.09	27.36	367.62
2005	492.42	0.52	17.24	394.02
2006	784.76	5.11	31.58	425.89
2007	879.80	0.49	29.50	333.63
2008	1065.44	1.50	25.47	312.16
2009	950.29	1.86	18.84	292.01
2010	790.03	1.07	26.60	267.04
2011	567.73	18.68	18.46	333.81
2012	597.74	9.95	2.50	365.88
2013	590.42	24.32	33.96	387.08
2014	356.03	6.25	5.54	284.06
2015	214.93	12.34	2.41	199.83
2016	170.21	6.84	0.56	350.34
2017	201.35	2.95	0.28	488.53
2018	178.88	0.73	0.44	568.32
2019	291.69	0.07	0.53	693.64
2020	287.15	0.26	0.82	670.39
2021	288.64	0.09	NA	493.57

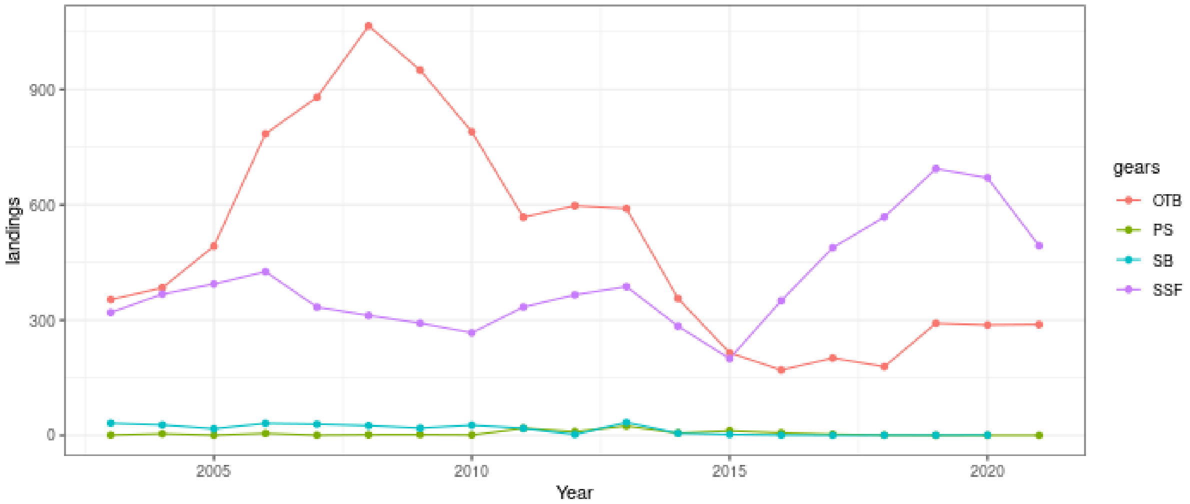
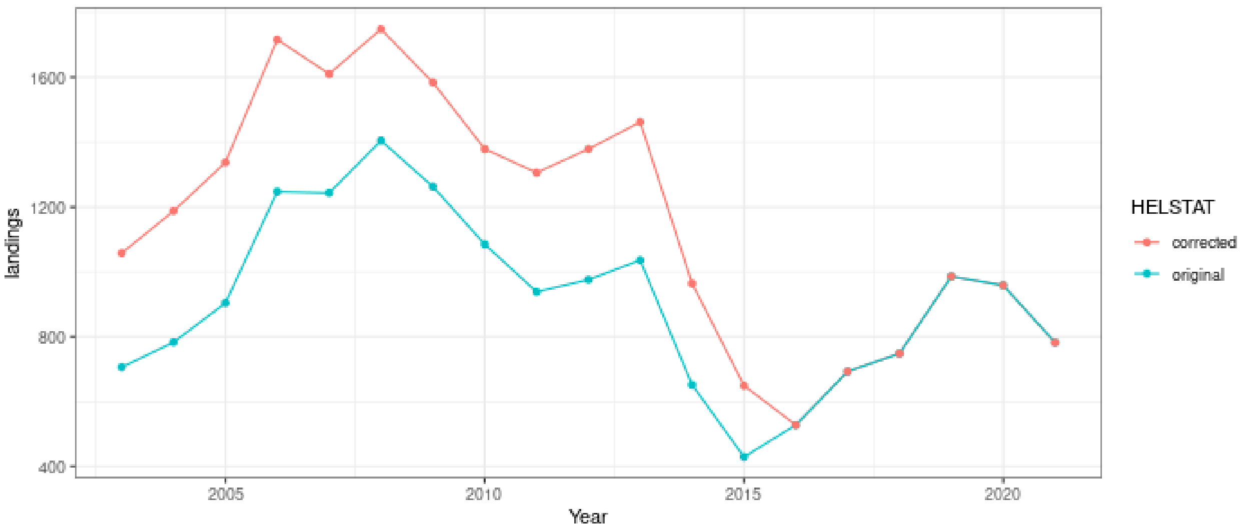


Figure 6.13.2.1.3. **Hake in GSA 20.** Landings by gear reported by HELSTAT.

Up until 2016 HELSTAT small scale fisheries data were reported only for the fleet segment with engine greater than 20HP. In order to apply a correction to the early year period (2003 – 2015) a correction multiplier was applied to this part of the time series. The correction factor was calculated using year 2016 were HELSTAT reported separately the two fleet segments for SSF (total and >20 HP). The ratio was estimated as 2.1.

Figure 6.13.2.4 illustrates the HELSTAT total landings before and after applying the correction factor.

Figure 6.13.2.1.4. **Hake in GSA 20.** HELSTAT landings before and after the correction



Discards are not reported by HELSTAT and STECF EWG 22-16 decided to reconstruct them by gear based on the existing discard ratio reported through DCF data and for the missing years a mean discard ratio of the time series was used. Figures 6.13.2.5 - 6 and Tables 6.13.2.3 - 5 present the final input catch (discards and landings) by gear and in total for the assessment.

Table 6.13.2.1.3. Hake in GSA 20. Landings by gear input for the stock assessment.

year	OTB	PS	SB	SSF
2003	353.6	0.8	31.9	671.4
2004	384.0	4.1	27.4	772.0
2005	492.4	0.5	17.2	827.4
2006	784.8	5.1	31.6	894.4
2007	879.8	0.5	29.5	700.6
2008	1065.4	1.5	25.5	655.5
2009	950.3	1.9	18.8	613.2
2010	790.0	1.1	26.6	560.8
2011	567.7	18.7	18.5	701.0
2012	597.7	10.0	2.5	768.4
2013	590.4	24.3	34.0	812.9
2014	356.0	6.2	5.5	596.5
2015	214.9	12.3	2.4	419.6
2016	170.2	6.8	0.6	350.3
2017	201.3	3.0	0.3	488.5
2018	178.9	0.7	0.4	568.3
2019	291.7	0.1	0.5	693.6
2020	287.1	0.3	0.8	670.4
2021	288.6	0.1	NA	493.6

Table 6.13.2.1.4. Hake in GSA 20. Discards by gear input for the stock assessment.

year	OTB	PS	SSF
2003	37.9	0.0	21.6
2004	18.3	0.1	24.9
2005	56.2	0.0	26.7
2006	52.0	0.1	28.8
2007	49.9	0.0	22.6
2008	57.8	0.0	21.1
2009	53.9	0.0	19.8
2010	44.8	0.0	18.1
2011	32.2	0.4	22.6
2012	33.9	0.2	24.7
2013	45.4	0.5	0.9
2014	11.7	0.1	2.5
2015	12.2	0.2	40.3
2016	5.9	0.1	14.2
2017	11.4	0.1	15.7
2018	8.7	0.0	44.5
2019	10.6	0.0	9.6
2020	11.7	0.0	6.5
2021	6.1	0.0	7.0

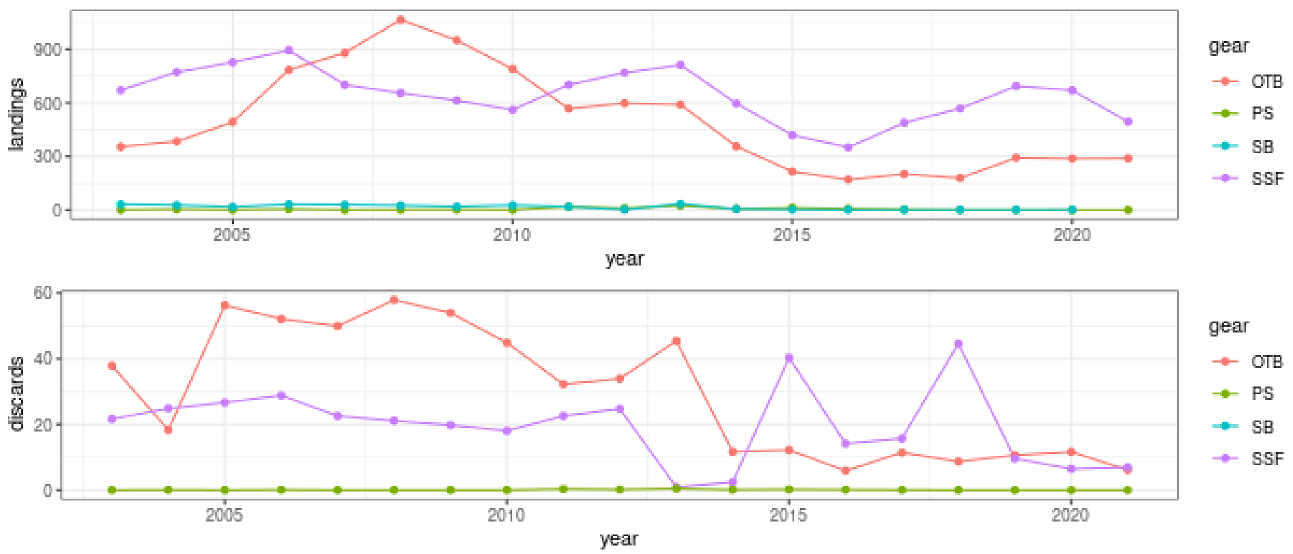


Figure 6.13.2.1.5. **Hake in GSA 20.** Landings and discards by gear used as input for the stock assessment.

Table 6.13.2.1.5. Hake in GSA 20. Total catch input for the stock assessment.

year	landings	discards
2003	1057.7	59.5
2004	1187.5	43.2
2005	1337.6	82.9
2006	1715.8	81.0
2007	1610.4	72.5
2008	1748.0	79.0
2009	1584.2	73.7
2010	1378.5	62.9
2011	1305.9	55.1
2012	1378.5	58.9
2013	1461.6	46.8
2014	964.3	14.3
2015	649.3	52.7
2016	528.0	20.2
2017	693.1	27.2
2018	748.4	53.3
2019	985.9	20.2
2020	958.6	18.1
2021	782.3	13.1

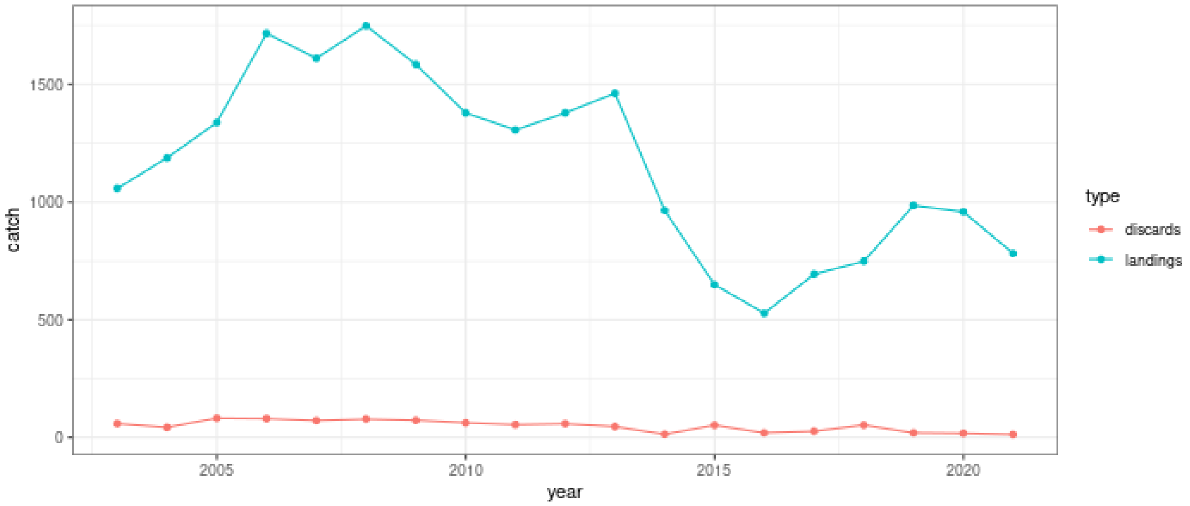


Figure 6.13.2.1.6. **Hake in GSA 20.** Total landings and discards used as input for the stock assessment.

Length frequencies reported through DCF were missing the LFDs from nets and longlines for the early period of the time series and the STECF EWG 22-16 decided to reconstruct these using the mean LFD reported for the years 2013 – 2021 for the small scale fisheries. For the years that the DCF was not implemented the LFDs were not reconstructed and were left to be estimated by the stock assessment model. Original and reconstructed LFDs by gear are reported in the Figures 6.13.2.7 – 10.

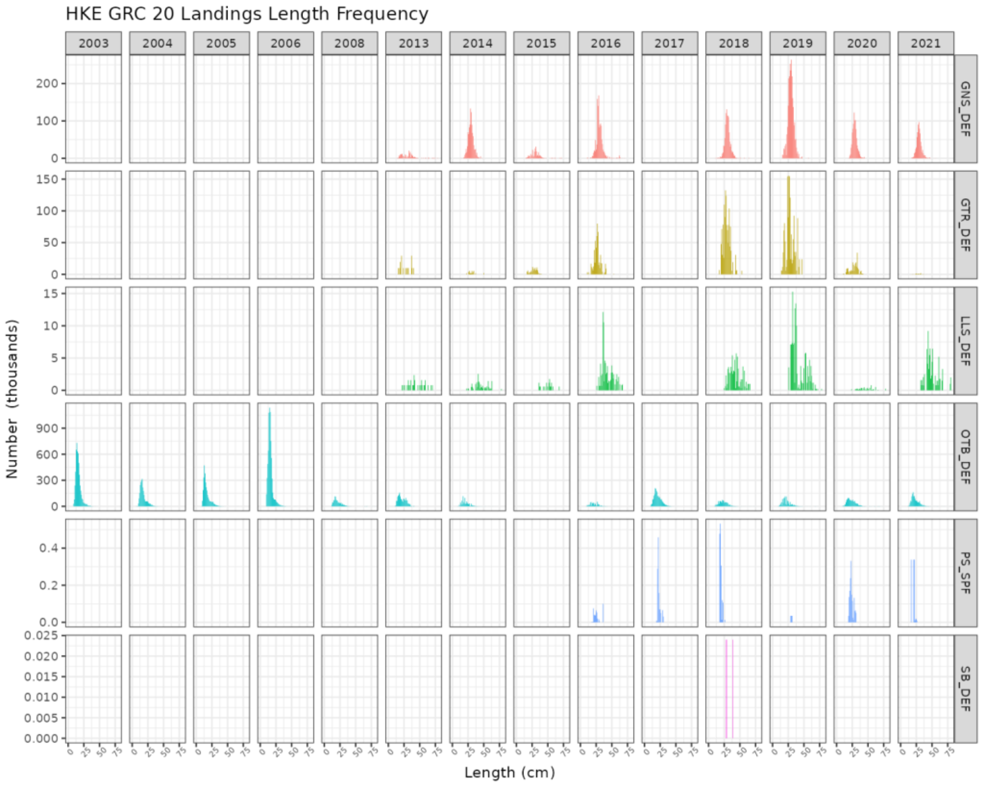


Figure 6.13.2.1.7. **Hake in GSA 20.** Landings length frequency distributions as reported through DCF.

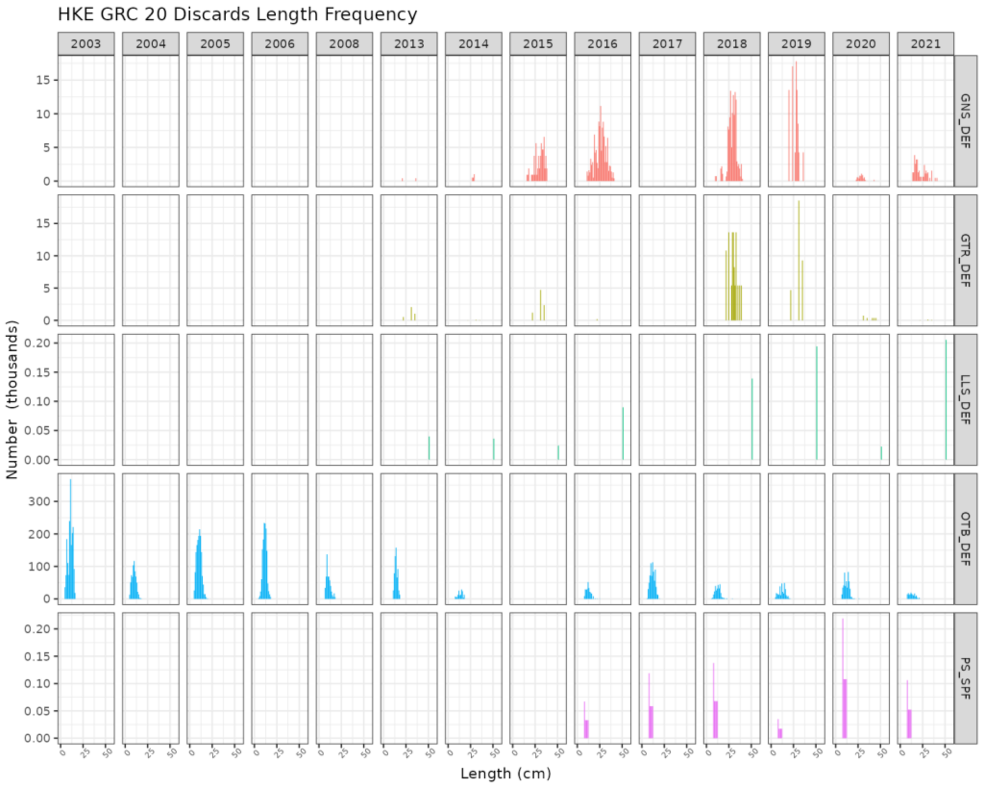


Figure 6.13.2.1.8. **Hake in GSA 20.** Landings length frequency distributions as reported through DCF.

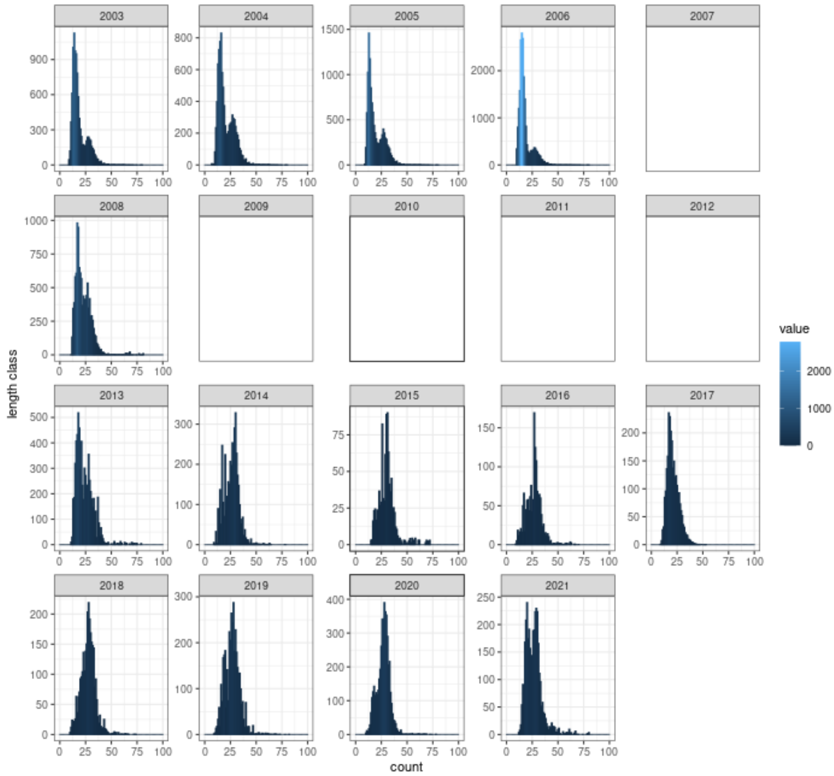


Figure 6.13.2.1.8. **Hake in GSA 20.** Final length frequency distributions used as input in the stock assessment model.

6.13.2.2 Survey Data

The MEDITS (Mediterranean International Trawl Survey) survey is an extensive trawl survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime, following a random stratified sampling by depth (5 strata: 0-50 m, 50-100 m, 100-200 m, 200 - 500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintained fixed throughout the time. Same sampling gear (GOC73), characterized by a 20 mm stretched mesh size cod-end, and is used throughout GSAs and years.

MEDITS survey in GSA 20 has not been carried out for some years due to non-implementation of the DCF in Greece. These years are 2002, 2007, 2009 – 2013, 2015 and 2017. MEDITS abundance and biomass indices as well as combined sex abundances by length were calculated using JRC MEDITS script (Mannini, 2020).

Figures below present the MEDITS index in terms of biomass, abundance and abundance by length for the years 1994 – 2021.

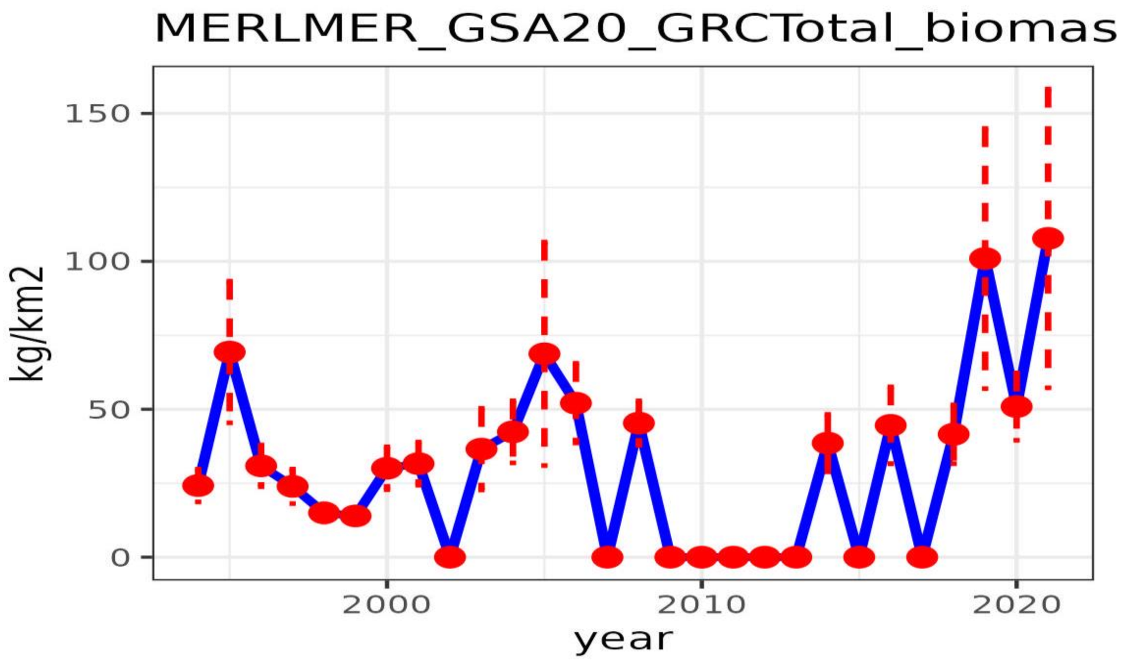


Figure 6.13.2.2.1. Hake in GSA 20. Biomass MEDITS index.

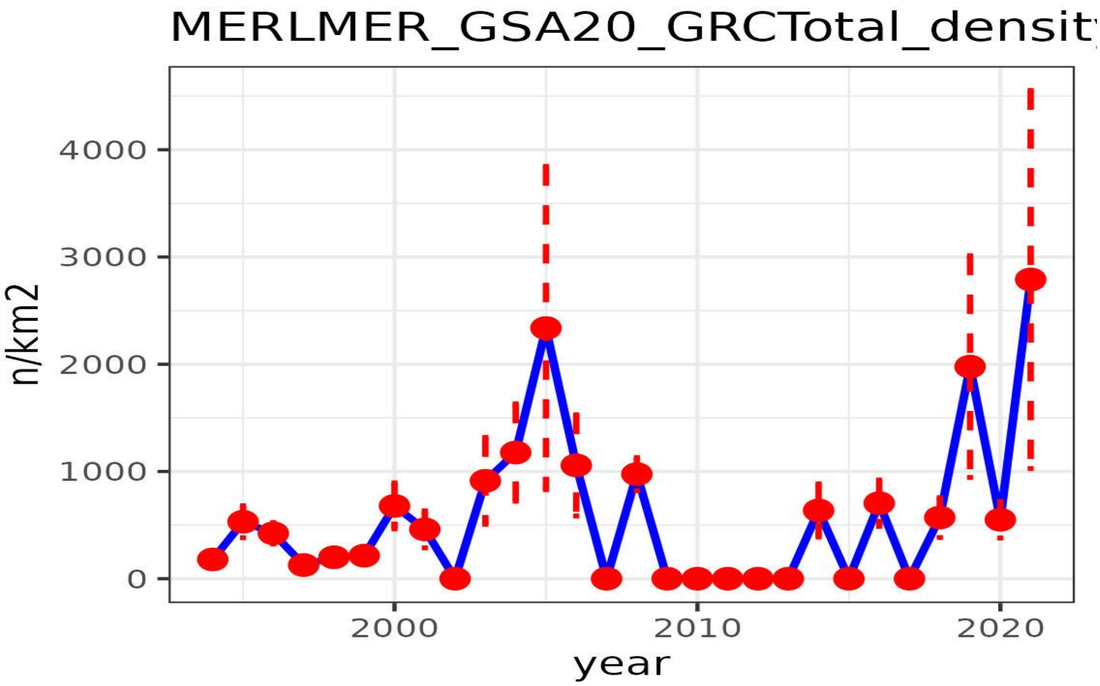


Figure 6.13.2.2.2. Hake in GSA 20. Abundance MEDITS index.

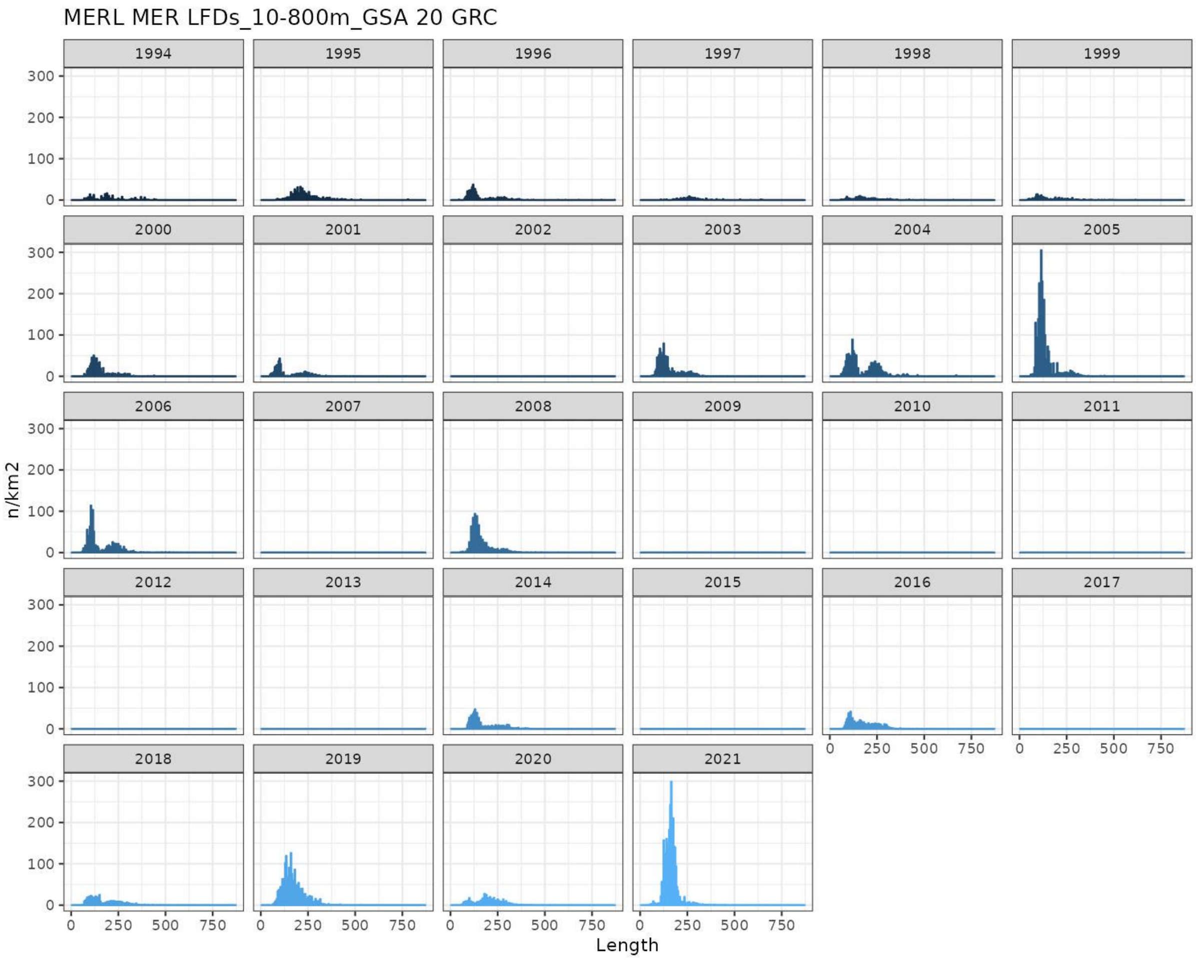


Figure 6.13.2.2.3. Hake in GSA 20. Abundance by length MEDITS index.

6.13.3 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 2003-2021 for catch data and tuning file. Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR. The analyses were carried out for the ages 0 to 5+. Concerning the Fbar, the age range used was 1-3 age classes.

A variety of submodels were tested, from simpler ones to more complex. A tensor with to account for the interaction between age and year was selected along with a smoother. A simple factor was used for the catchability submodel while a smoother with relatively high k was selected for the recruitment.

Input data

The growth parameters used for the VBGF are the ones reported in Table 6.13.1.1 and maturity and natural mortality vectors are reported in table 6.13.1.3.

Table 6.13.3.1 lists the input data for the a4a model, namely catches, catch number at age, weight at age and the tuning index time series by age.

Catches (t)

year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
data	1117.2	1230.7	1420.5	1796.8	1682.9	1826.9	1657.9	1441.4	1361.0	1437.4
year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
data	1508.4	978.6	702.0	548.2	720.3	801.6	1006.2	976.7	795.4	

Catch numbers at age (thousands)

year\age	0	1	2	3	4	5
2003	2355	11172	2821	854	116	67
2004	1215	7814	3633	1044	142	79
2005	2568	10922	4180	1180	160	83
2006	2615	23724	4303	1222	167	91
2007	NA	NA	NA	NA	NA	NA
2008	510	8053	5329	1328	130	152
2009	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA
2013	50	5213	3350	1263	212	163
2014	108	1806	3301	1022	95	45
2015	35	293	1316	744	73	120
2016	233	1025	1645	524	73	52
2017	NA	NA	NA	NA	NA	NA
2018	178	980	2422	949	115	42
2019	195	1590	3067	1032	174	76
2020	282	1399	3522	1011	72	35
2021	72	1401	2251	538	112	112

Mean weight at age (kg)

year	0	1	2	3	4	5
2003	0.007	0.025	0.138	0.302	0.571	1.533
2004	0.007	0.027	0.138	0.301	0.571	1.513
2005	0.007	0.023	0.137	0.302	0.572	1.540
2006	0.007	0.025	0.136	0.303	0.570	1.521
2007	0.007	0.035	0.139	0.304	0.573	1.889
2008	0.008	0.035	0.132	0.301	0.564	2.427
2009	0.007	0.035	0.139	0.304	0.573	1.889
2010	0.007	0.035	0.139	0.304	0.573	1.889
2011	0.007	0.035	0.139	0.304	0.573	1.889
2012	0.007	0.035	0.139	0.304	0.573	1.889
2013	0.008	0.036	0.135	0.320	0.550	2.137
2014	0.007	0.036	0.147	0.303	0.588	1.408
2015	0.007	0.045	0.157	0.310	0.562	1.752
2016	0.007	0.038	0.141	0.301	0.556	1.518
2017	0.007	0.035	0.119	0.304	0.557	1.711
2018	0.007	0.040	0.143	0.300	0.610	1.449
2019	0.007	0.038	0.141	0.305	0.545	1.353
2020	0.007	0.039	0.147	0.297	0.576	1.811
2021	0.007	0.043	0.140	0.305	0.633	1.645

The following figures illustrate the various input data used in the a4a assessment model.

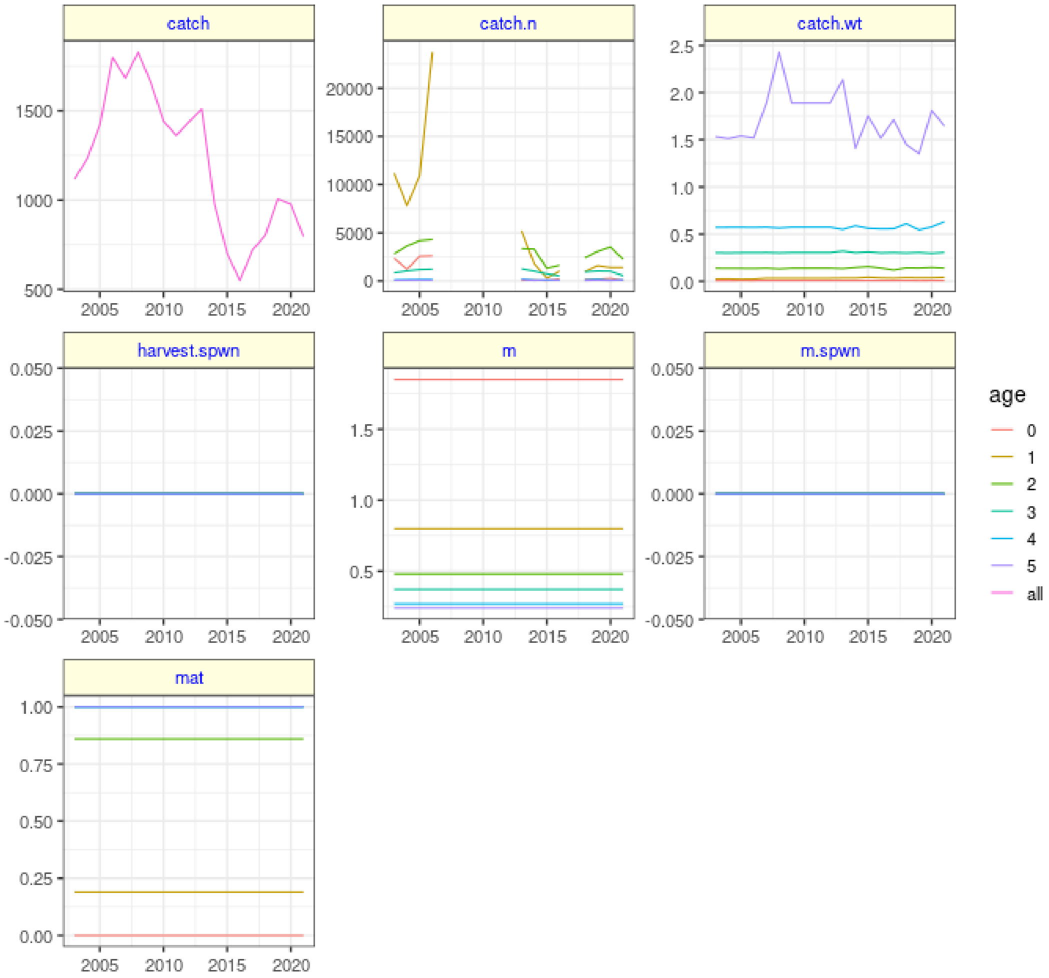


Figure 6.13.3.1. Hake in GSA 20. Stock summary of input data for a4a.

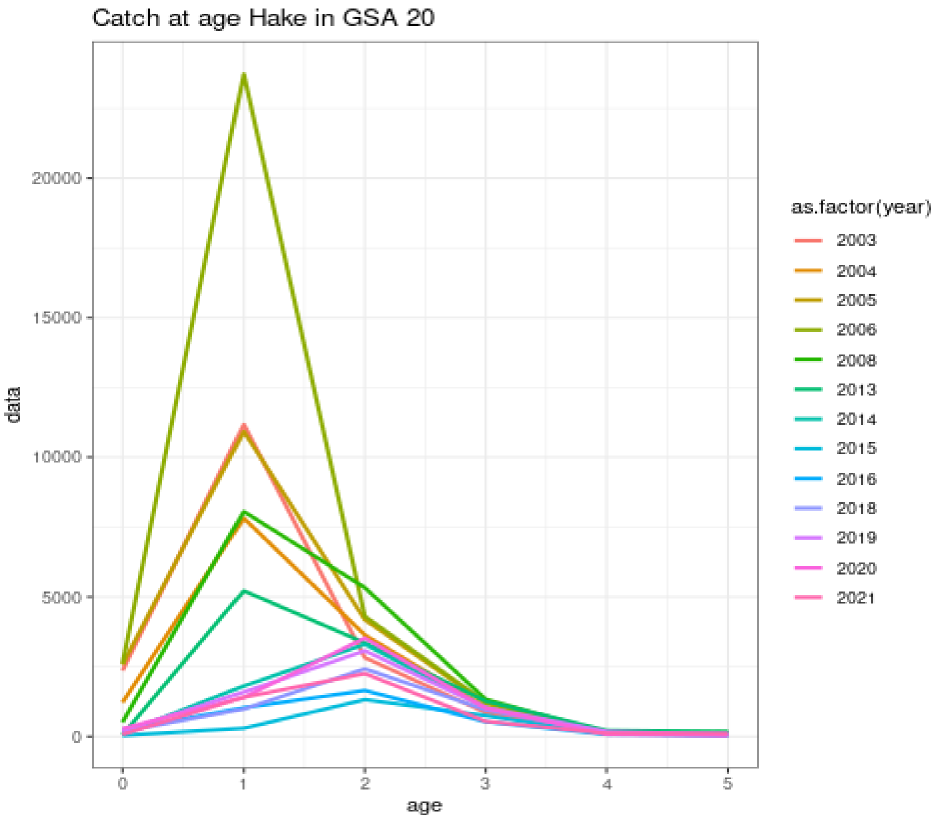


Figure 6.13.3.2. Hake in GSA 20. Catch at age input data.

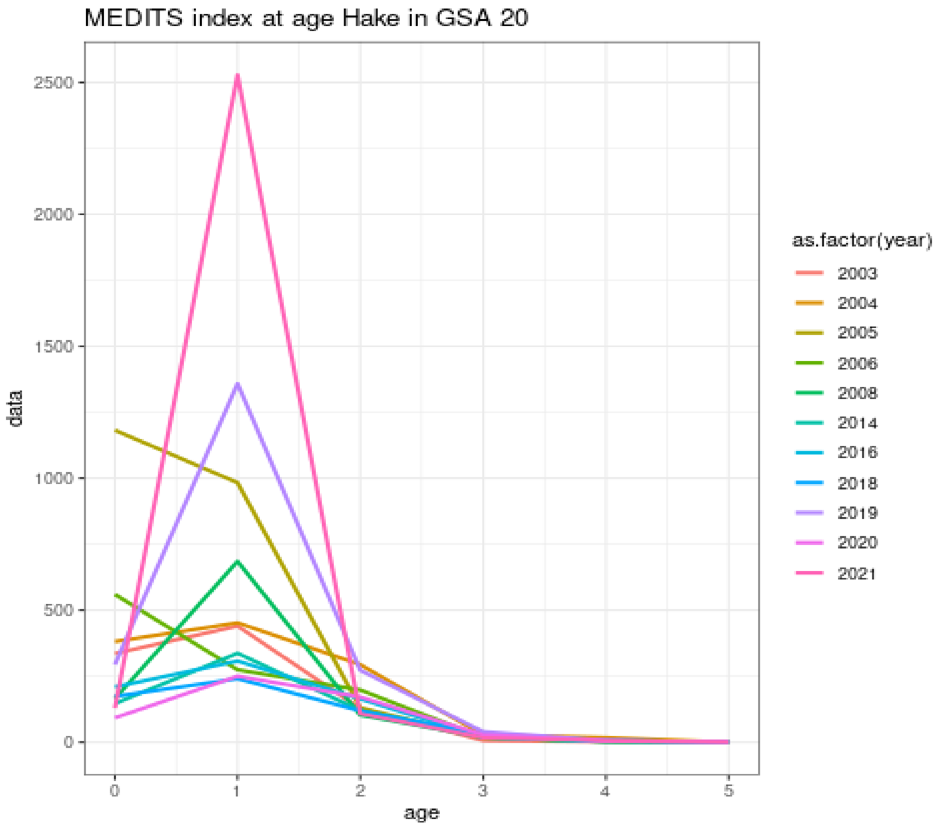


Figure 6.13.3.3. Hake in GSA 20. Index at age input data.

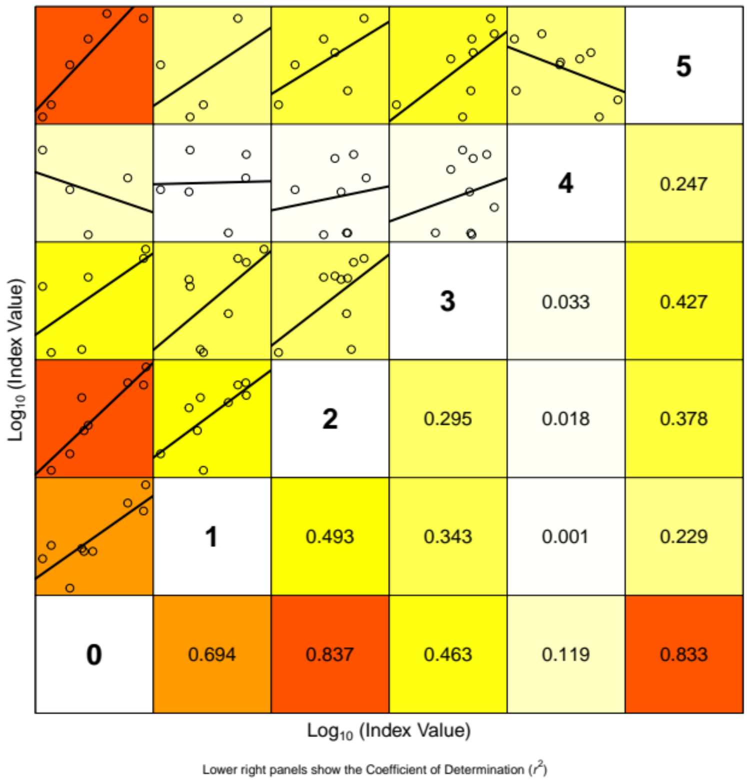


Figure 6.13.3.4. Hake in GSA 20. Catch cohorts' consistency

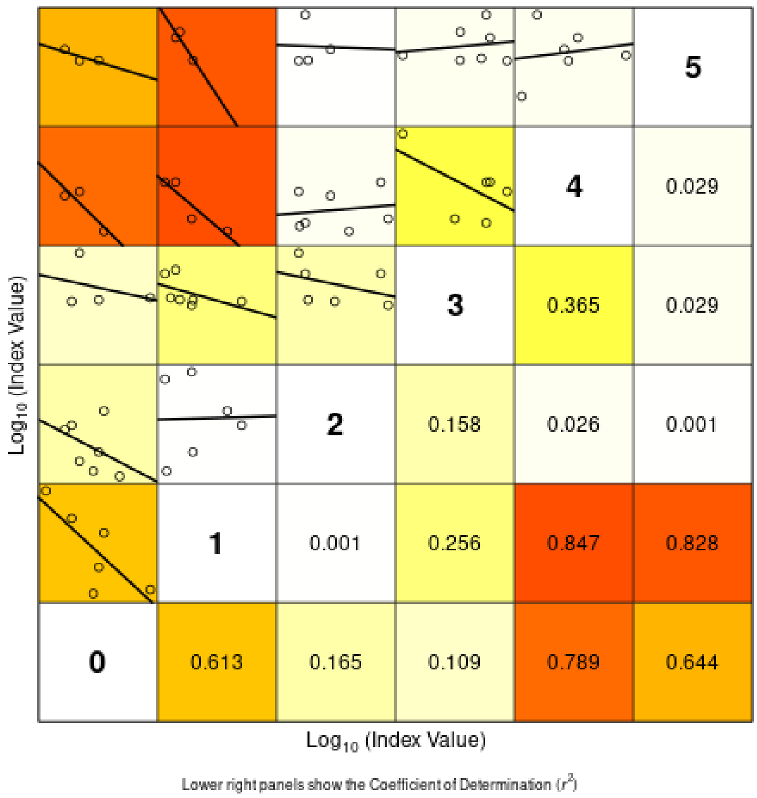


Figure 6.13.3.5. Hake in GSA 20. Index cohorts' consistency

Assessment results

After testing different model formulations the STECF EWG 22-16 decided to adopt the following set of submodels for the a4a assessment:

fmodel: ~te(replace(age, age > 4, 4), year, k = c(3, 4)) + s(year, k = 6, by = as.numeric(age == 0))

srmodel: ~s(year, k = 9)

n1model: ~s(age, k = 3)

qmodel:

MEDITS GSA 20: ~factor(age)

vmodel:

catch: ~s(age, k = 3)

MEDITS GSA 20: ~1

Results of the a4a assessment are shown in Figures 6.13.3.6 – 8

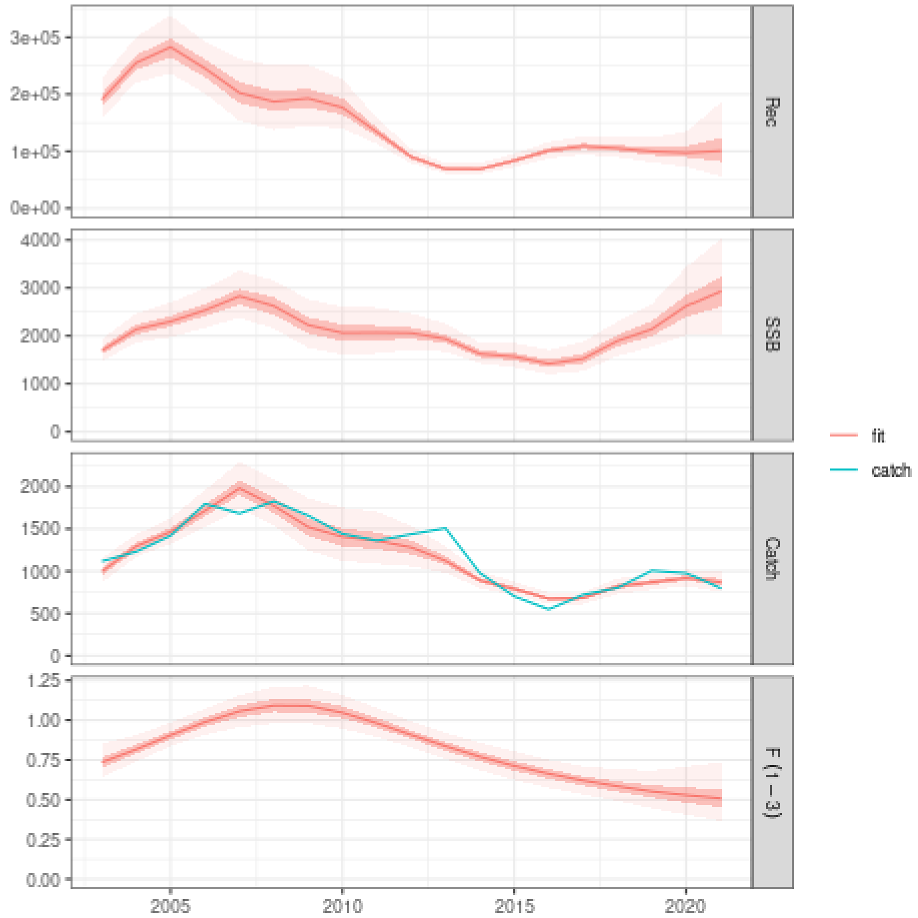


Figure 6.13.3.6 Hake in GSA 20. Stock summary from the final a4a model with simulations for the estimation of confidence limits. Blue line represents the observed catch.

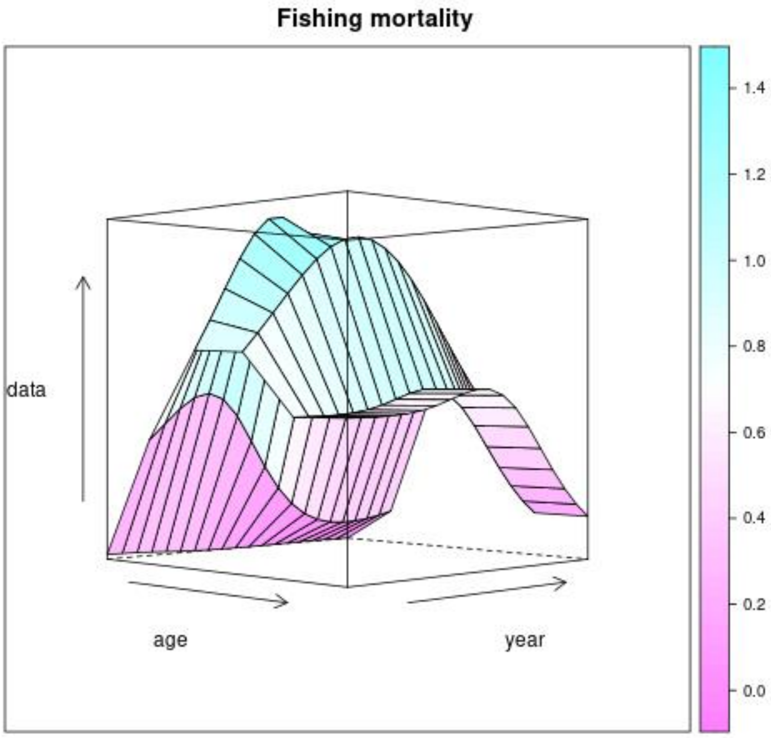


Figure 6.13.3.7. Hake in GSA 20. Wire frame of the estimated fishing mortality by age and year.

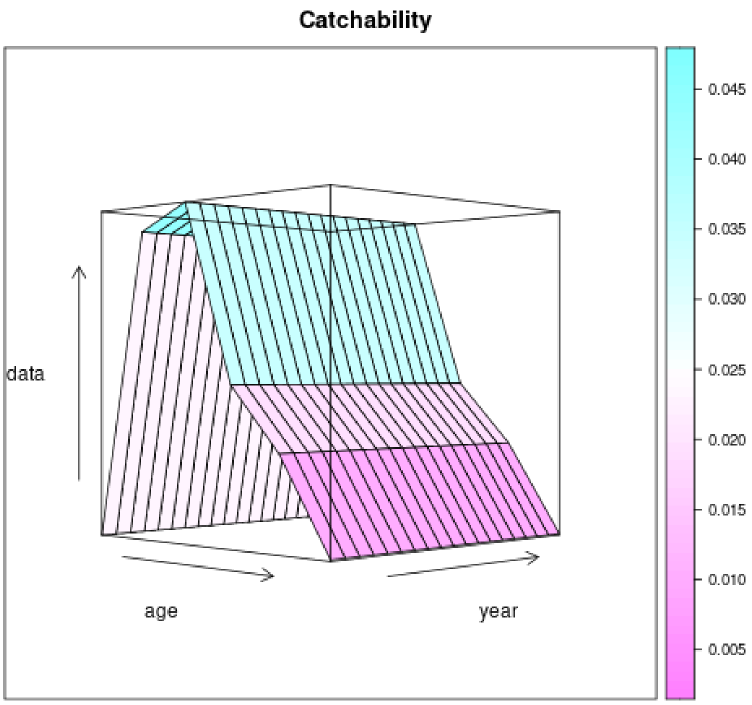


Figure 6.13.3.8. Hake in GSA 20. Wire frame of the estimated catchability of the survey by age and year.

Diagnostics

Figures 6.13.3.9 – 13 illustrate the model diagnostics. The model fitted adequately the total catches and the overall performance of the model considered good, some issued were spotted on the fit of age 3 in the catch numbers.

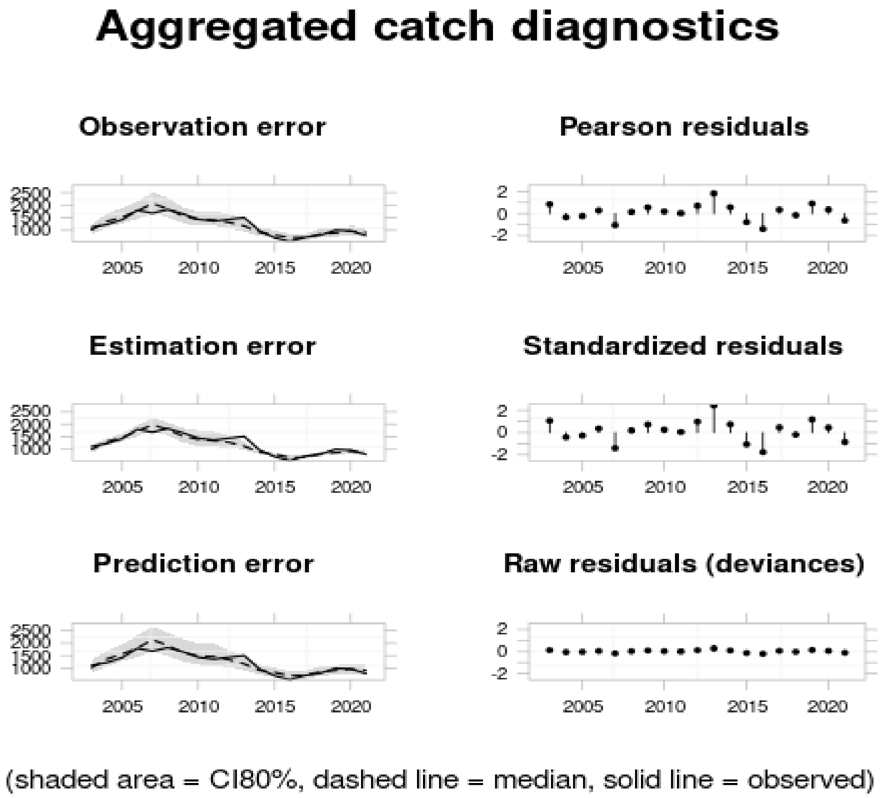


Figure 6.13.3.9. Hake in GSA 20. Total catch residuals.

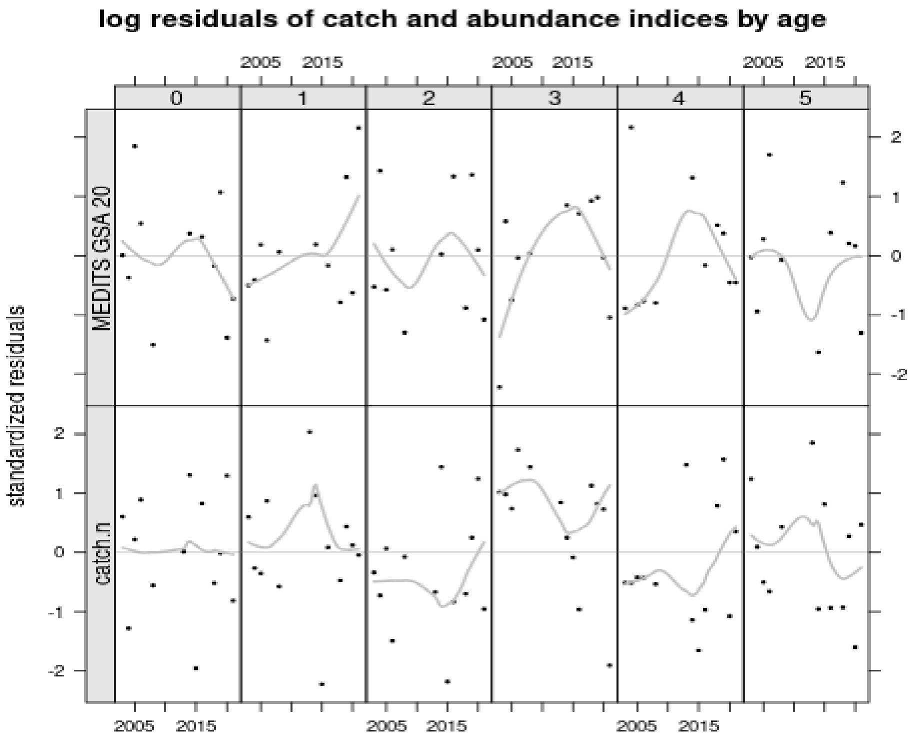


Figure 6.13.3.10. Hake in GSA 20. Standardize residuals for abundance index and catch numbers

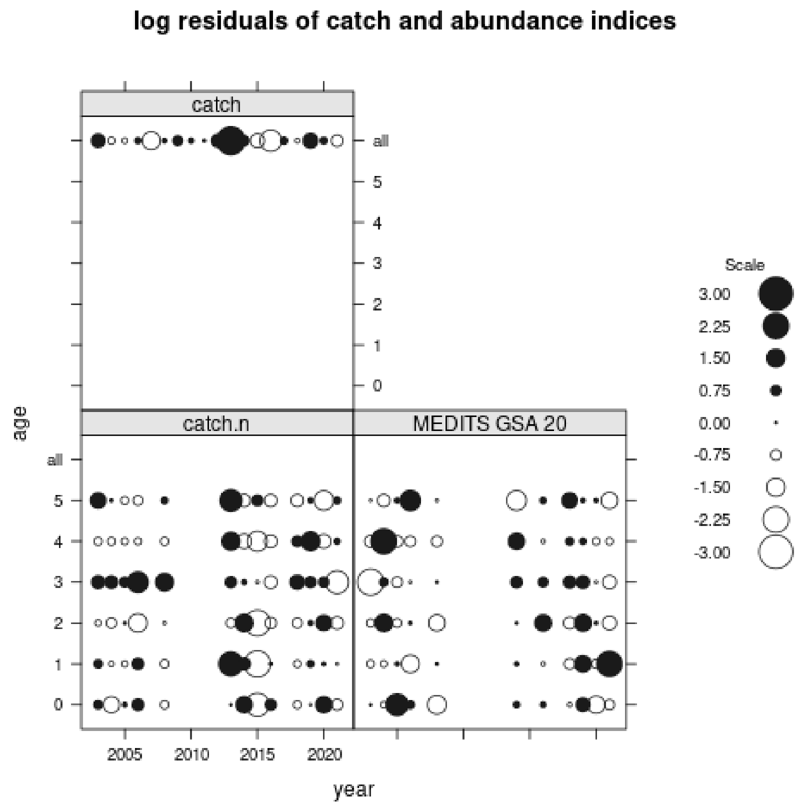


Figure 6.13.3.11. Hake in GSA 20. Standardized residuals for abundance index and catch numbers

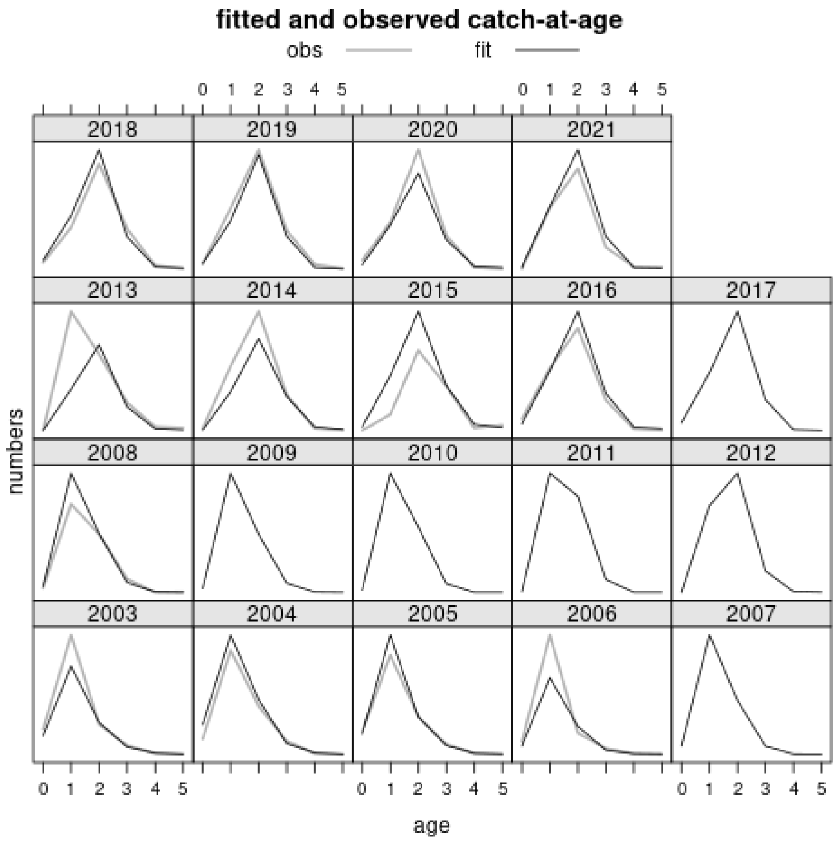


Figure 6.13.3.12. Hake in GSA 20. Fitted and observed catch at age.

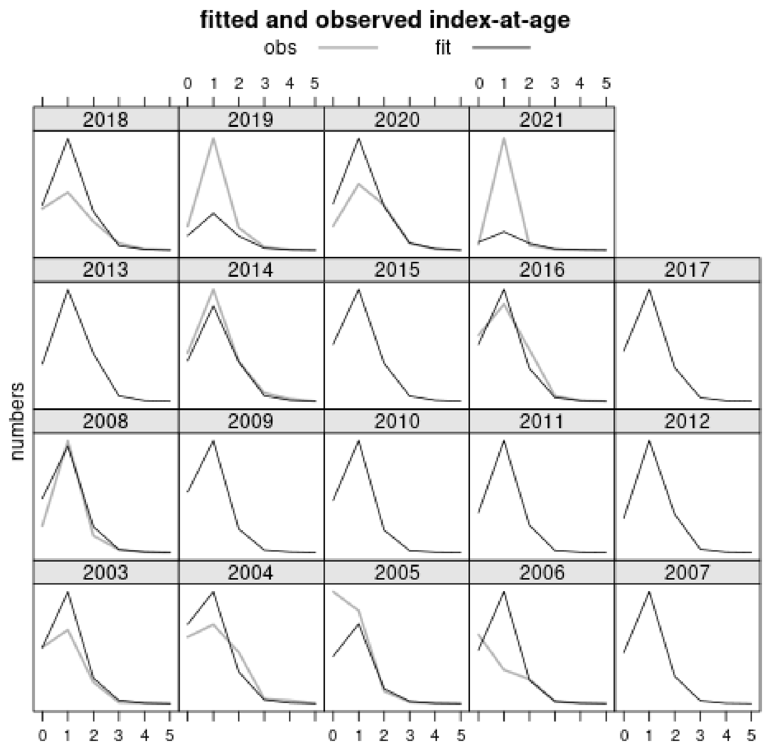


Figure 6.13.3.13. Hake in GSA 20. Fitted and observed index at age.

Retrospective

Retrospective analysis was performed only for 3 years back due to the missing information on both catch numbers and index numbers for the year 2017. Retrospective performance was considered poor with heavy patterns on both SSB and F.

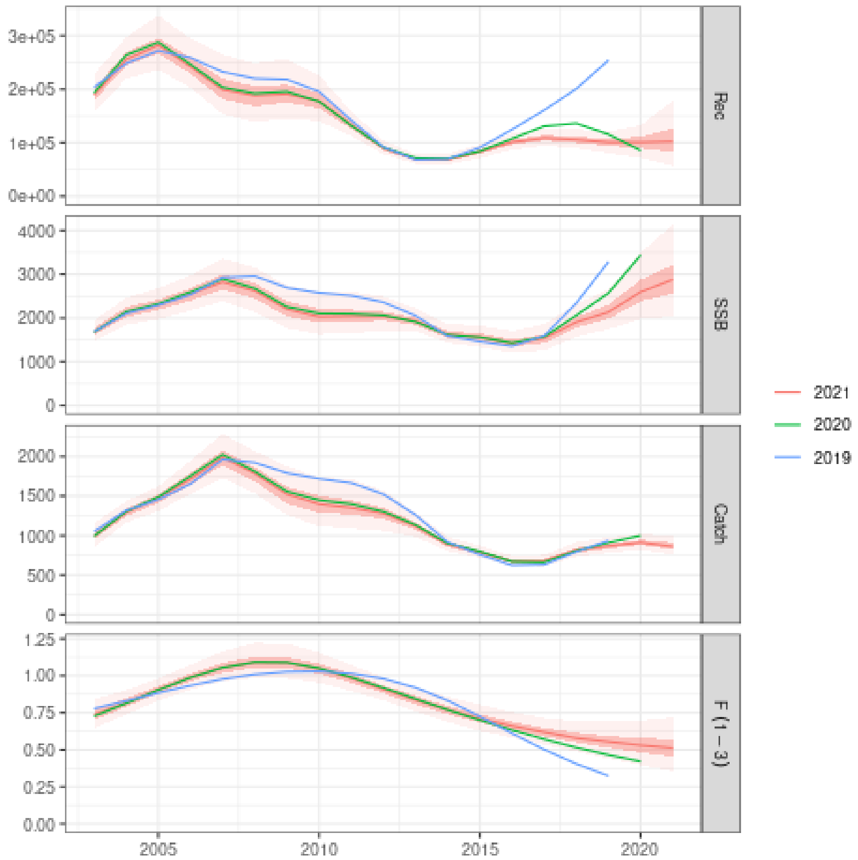


Figure 6.13.3.14. Hake in GSA 20. Retrospective analysis.

In the following tables, the population estimates obtained by the a4a model are provided.

Table 6.13.3.1. Hake in GSA 20. Stock numbers by age as estimated by the a4a model.

year	0	1	2	3	4	5
2003	189646	29579	6371	1444	352	90
2004	256814	29216	8072	1683	430	187
2005	282251	39594	7493	1894	466	261
2006	244691	43586	9563	1550	486	308
2007	200949	37893	10057	1750	368	335
2008	187055	31234	8598	1659	385	296
2009	191553	29180	7264	1328	342	283
2010	178124	29968	7283	1109	259	255
2011	133693	27920	8314	1171	209	206
2012	90128	20977	8650	1472	218	162
2013	69013	14148	7140	1719	276	146
2014	68861	10834	5167	1593	332	162
2015	83279	10808	4152	1275	323	194
2016	101259	13063	4265	1108	277	213
2017	109140	15868	5232	1198	262	218
2018	105583	17086	6389	1516	310	233
2019	100123	16522	6869	1879	431	288
2020	98909	15675	6598	2029	585	412
2021	101361	15501	6192	1944	689	612

Table 6.13.3.2. Hake in GSA 20. F by age as estimated by the a4a model.

year	0	1	2	3	4	5
2003	0.020	0.499	0.851	0.840	0.598	0.598
2004	0.020	0.561	0.970	0.914	0.598	0.598
2005	0.018	0.621	1.096	0.991	0.600	0.600
2006	0.015	0.666	1.219	1.069	0.604	0.604
2007	0.012	0.683	1.322	1.144	0.611	0.611
2008	0.008	0.659	1.388	1.210	0.622	0.622
2009	0.005	0.588	1.399	1.264	0.638	0.638
2010	0.003	0.482	1.347	1.298	0.661	0.661
2011	0.002	0.372	1.251	1.312	0.683	0.683
2012	0.002	0.278	1.136	1.304	0.699	0.699
2013	0.002	0.207	1.020	1.274	0.699	0.699
2014	0.002	0.159	0.919	1.224	0.677	0.677
2015	0.002	0.130	0.841	1.156	0.627	0.627
2016	0.003	0.115	0.790	1.073	0.552	0.552
2017	0.004	0.110	0.759	0.982	0.465	0.465
2018	0.005	0.111	0.744	0.888	0.377	0.377
2019	0.004	0.118	0.739	0.796	0.298	0.298
2020	0.003	0.129	0.742	0.710	0.231	0.231

2021	0.002	0.143	0.748	0.631	0.178	0.178

Table 6.13.3.3. Hake in GSA 20. Summary table of the a4a assessment

years	recruitment	tb	ssb	fbar	catch
2003	189646	3710	1676	0.73	986
2004	256814	4698	2137	0.81	1296
2005	282251	5186	2300	0.90	1468
2006	244691	5317	2539	0.98	1721
2007	200949	5522	2829	1.05	1992
2008	187055	5078	2614	1.09	1785
2009	191553	4522	2195	1.08	1523
2010	178124	4291	2037	1.04	1398
2011	133693	3943	2044	0.98	1354
2012	90128	3453	2052	0.91	1280
2013	69013	3012	1938	0.83	1129
2014	68861	2539	1631	0.77	897
2015	83279	2644	1568	0.71	797
2016	101259	2622	1421	0.66	677
2017	109140	2846	1526	0.62	682
2018	105583	3338	1896	0.58	820
2019	100123	3493	2149	0.55	876
2020	98909	3958	2634	0.53	926
2021	101361	4299	2910	0.51	881

Based on the a4a results, the European hake in GSA 20 shows an increasing trend in SSB since 2017 and a decreasing trend in F since 2009. The catch was at its peak at 2006 and since then it demonstrates a general decreasing trend with little fluctuations the past 5 years. Recruitment was at a peak in the early period of the time series and has fallen in low levels at around 2012.

6.13.4 Reference Points

The time series is too short to fit a stock recruitment relationship, therefore reference points are based on equilibrium methods. The STECF EWG 18-02 recommended using $F_{0.1}$ as a proxy of F MSY. The library FLBRP available in FLR was used to estimate F $F_{0.1}$from the stock object resulting from the outputs of the a4a assessment.

Current F (0.51, corresponding to the F of the last year of the time series) is 2 times higher than $F_{0.1}$ (0.238), 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 GSA 20 is in overexploitation.

6.13.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment.

An average of the last three years was used for weight at age and maturity at age, while the F bar = 0.51 (the last year's F estimated by the assessment model) was used for F in 2021, as F shows a decreasing trend. Recruitment is observed to oscillate over the end of the time series (Figure 6.1.3.9), so the last 3 years are used as an estimate of recruits in 2021 to 2022. Recruitment (age 0) was estimated from the population results as the geometric mean of the last 3 years (149530).

Table 6.13.4.1. Hake in GSA 20. Assumptions for the intermediate year and the forecast

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 1-3 (2022)	0.51	Fsq = F in the last year
SSB (2022)	3179	SSB intermediate year from STF output
Rage0 (2022,2023)	91642	Recruitment will be set as geometric mean of the last 10 years
Total Catch (2022)	962	Catch intermediate year from STF output

Table 6.13.4.2. Hake in GSA 20. Short term forecast for the different F scenarios.

Rationale	Ffactor	Fbar	Catch2023	SSB2024	SSB_change_2022-2024(%)	Catch_change_2021-2023(%)
High long term yield ($F_{0.1}$)	0.47	0.24	528	4026	27	-40
F_{upper}	0.65	0.33	701	3775	19	-20
F_{lower}	0.32	0.16	368	4260	34	-58
Zero catch	0.00	0.00	0	4809	51	-100
Status quo	1.00	0.51	1001	3346	5	14
Different Scenarios	0.10	0.05	123	4625	45	-86
	0.20	0.10	240	4451	40	-73
	0.30	0.15	351	4285	35	-60
	0.40	0.20	458	4129	30	-48
	0.50	0.25	559	3981	25	-37
	0.60	0.30	656	3840	21	-26
	0.70	0.36	748	3707	17	-15
	0.80	0.41	836	3580	13	-5
	0.90	0.46	921	3460	9	4
	1.10	0.56	1078	3237	2	22
	1.20	0.61	1152	3134	-1	31
	1.30	0.66	1223	3036	-5	39
	1.40	0.71	1291	2942	-7	46
	1.50	0.76	1356	2853	-10	54
	1.60	0.81	1419	2767	-13	61
	1.70	0.86	1479	2686	-16	68
	1.80	0.91	1537	2608	-18	74
	1.90	0.96	1592	2534	-20	81
	2.00	1.01	1646	2463	-23	87

6.13.6 Data Deficiencies

LFDs were missing for the small scale fisheries (LLS, GNS, GTR) for the period 2003 – 2009. Besides that no other major issues were encountered in the quality assessment of the data.

6.14 RED MULLET IN GSA 20

No data exploration, analysis or assessment was carried out on red mullet in GSA 20. This was a low priority stock and there were insufficient resources to attempt work on this stock. Previous assessments had failed, however, there has been some work carried out on small scale fisheries which may improve the situation.

6.15 European hake in GSA 22

6.15.1 Stock Identity and Biology

The assessment of hake carried out during the STECF EWG 22-16 considered the stock of GSA 22 (Aegean Sea). Hake is one of the most important fish stocks in GSA 22 for bottom trawlers, nets and longlines. The stock is distributed in depths between 50 and 600 m, with a peak in abundance between 200 and 300 m. The stock is exploited by the Greek and Turkish fishing fleets with the landings of both countries reported by their national statistical authorities (HellStat for Greece, TurkStat for Turkey).

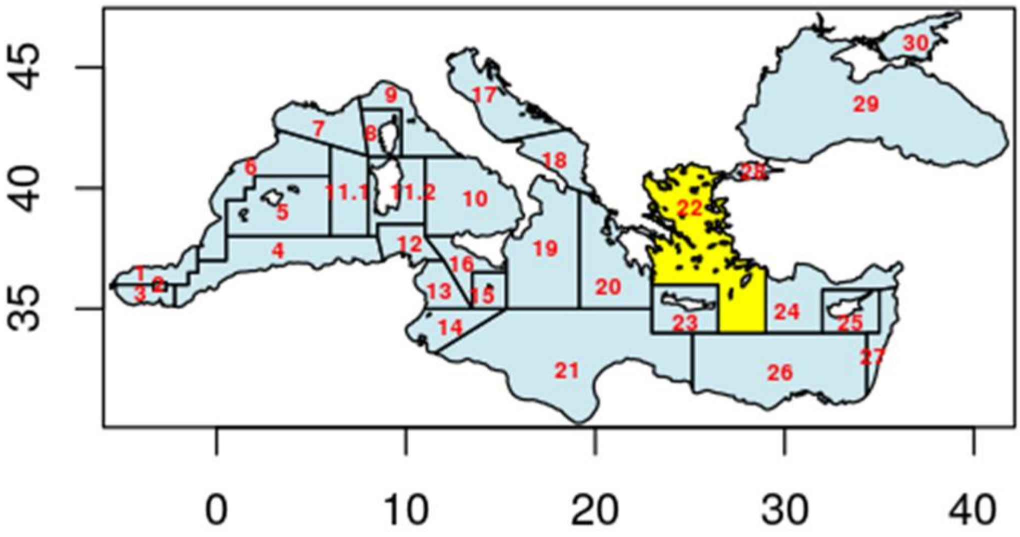


Figure 6.15.1.1. Geographical location of GSA 22.

Growth parameters (Linf= 104.0 cm, k= 0.12 y-1; t0= -0.01 y, sexes combined) and length-weight relationship parameters (a=0.0033, b=3.23), were the same as the ones used in the previous assessment (EWG 20-15) that had been taken from the DCF estimates of hake in GSA 19 and comply with the benchmark assessment of hake for the Mediterranean Sea (GFCM 2019). The VBGF and LW relationship parameters used are summarized in the following Table (Tab. 6.15.1.1).

The vector of proportion of mature individuals by age was also to the same as the previous assessment and follows size at maturity of hake in GSA 20, sexes combined (Table 6.15.1.2). The same proportions of mature individuals were used in the benchmark assessment of hake for the Mediterranean Sea (GFCM 2019).

A vector of natural mortality was estimated using growth and length-weight relationship parameters for sexes combined (Table 6.15.1.3) and were selected to comply with the benchmark assessment of hake for the Mediterranean Sea (GFCM 2019).

Hake spawns throughout the year in many areas of the Mediterranean with a peak of spawning occurring during the summer.

Table 6.15.1.1. Hake in GSA 22. Growth parameters and length-weight relationship parameters used in the assessment.

GSA	Sex	Linf (cm)	K (y-1)	t0 (y)	a	b
22	**combined**	104	0.12	-0.01	0.0033	3.23

Table 6.15.1.2. Hake in GSA 22. Maturity vectors used in the assessment.

Age	0	1	2	3	4	5	6	7
Pmat	0	0.19	0.86	1.00	1.00	1.00	1.00	1.00

Table 6.15.1.3. Hake in GSA 22. Natural mortality vectors used in the assessment.

Age	0	1	2	3	4	5	6	7
M	1.85	0.80	0.48	0.37	0.30	0.27	0.22	0.22

6.15.2 DATA

6.15.2.1 CATCH (LANDINGS AND DISCARDS)

Hake mainly lives on muddy substrates in depths between 50 and 600 m and, in the Greek part of the Aegean Sea (GSA 22), is primarily targeted by the bottom trawl fishery, nets (gill- and trammel) and longlines (Table 6.15.2.1, Figures 6.15.2.1 and 6.15.2.2).

The official landings of hake in the Greek part of the Aegean Sea (Figure 6.15.2.1) are being recorded by the Hellenic Statistical Authority and the same values are reported by the FAO/GFCM databases. However, the structure of the dataset changed after 2015 and includes the landings of an extra small-scale coastal fleet of 10,000 vessels (Tsikliras et al. 2020). To account for these additional landings that artificially inflated the landings time series after 2016, we corrected the hake landings from 1982 to 2015 by multiplying by the difference of hake landings with and without the extra fleet in 2016. The Greek landings with and without the extra fleet are only available for 2016. All these records are public at www.statistics.gr.

The official landings of hake in the Turkish part of the Aegean Sea (Figure 6.15.2.1) are being recorded by the Turkish Statistical Institute but no information on the fleets and gears is apparent in the database, at least to the best of our knowledge and up to the time of the assessment. The Turkish landings with and without the extra fleet are only available for 2016. All these records are public at https://www.tuik.gov.tr/Home/Index.

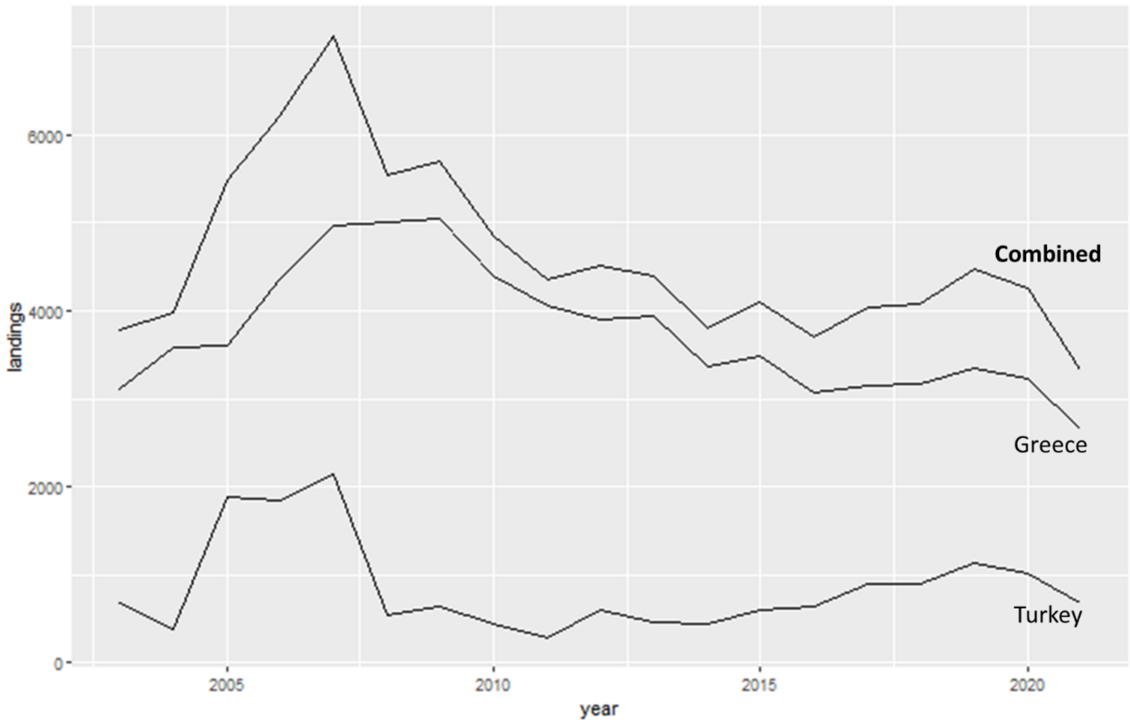


Figure 6.15.2.1 Hake in GSA 22. Hake official landings by the Greek fleet and Turkish fleets in GSA 22 (2003-2020). Greek landings data from Hellenic Statistical Authority corrected for 2003-2015 to account for partial reconstruction of the catch.

The DCF dataset contains too many missing points and is inconsistent in terms of landings as the landings reported for 2003-2006 are very high compared to the recent landings, probably owing to a raising factor error. Towards the end of the time series, the DCF dataset seems to converge with the official one, though only the last two years are close.

The bottom trawl fishery in Greece is a mixed fishery, operating 24hr per day. Bottom trawl fishing targeting hake is taking place mainly during the day in muddy bottoms in depths ranging from 80 to 400 m. Apart from hake, important target species for bottom trawlers are red mullet, deep-water rose shrimps, anglerfish, blue whiting, and other minor target depending on the area.

The gillnets are set in varying depths and operate from close to shore down to depths of 300 m. The mesh size used is usually 32 to 64 mm but smaller mesh sizes are also used for other coastal species. The gillnet hake fishery is carried out all year round (except February) but mainly during summer when bottom trawl fishery is prohibited within the 6 nautical miles from the coast. During the summer months, bottom trawlers are allowed to operate in international waters, i.e., beyond 6 nautical miles. Longline fishery for hake operates in deeper waters, down to 500 m, all year round.

After an increase from 2003 to 2008, the official landings of hake were declining from 2008 to 2016 with a slight increase from 2016 to 2019 and a decline thereafter, i.e., in the last three years (Figure 6.15.2.1, Table 6.15.2.1). Similar trends for the last years are also apparent for the Turkish landings in GSA 22 but some earlier years slightly differ (Figure 6.15.2.1, Table 6.15.2.1). There is no information on the gears used by the Turkish fleet to target hake, nor on the proportion of catch from each gear.

Table 6.15.2.1 Hake in GSA 22. Hake official landings in GSA 22 according to the official statistics as they appear in Greek and Turkish Statistical Authorities databases. The Greek part is corrected prior to 2015 to account for partial reconstruction owing to the inclusion of the landings of an extra fleet in 2016.

Year	Greek landings (t)	Turkish landings (t)	Total GSA 22 landings (t)
2003	3118	672	3790
2004	3585	392	3977
2005	3600	1880	5480
2006	4363	1849	6212
2007	4977	2142	7119
2008	5002	546	5548
2009	5054	644	5698
2010	4405	447	4852
2011	4067	285	4351
2012	3899	607	4506
2013	3950	454	4404
2014	3360	444	3805
2015	3498	599	4097
2016	3067	637	3704
2017	3159	890	4048
2018	3179	900	4080
2019	3342	1143	4485
2020	3240	1015	4255
2021	2649	686	3334

DCF Landings per gear

The assessment was based on data from all gears because the recent reconstruction of the official Greek landings by the inclusion of the catches of an extra fleet (Tsikliras et al. 2020) indicated that the proportion of small-scale coastal vessels to the total catch is higher than estimated before (Figure 6.15.2.2).

The issue with this approach, contrary to including OTB alone, is that the coastal gears GTR, GNS and LLS are only separately reported after 2013, combined before 2008 and are absent between 2009 and 2012, inclusive.

Greek landings data per gear and fleet were reported to STECF EWG 22-16 through the DCF and are presented in Figure 6.15.2.3. GNS, GTR and LLS landings are only available after 2013 and combined as NA before 2008 (2009, 2010, 2011 and 2012 are missing years). Total landings by year are presented in Table 6.15.2.2. The panels with FPO, PS and SB contain total landings <1 t and were ignored as they are probably miss-reports or extremely rare catch.

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.15.2.4 (initial; as reported in DCF) and Figure 6.15.2.5 (corrected; used in the assessment). The final length frequency distribution excludes NA_DEF for 2003 and 2008 because they were based on only a few individuals and includes reconstructed length frequency distributions for all gears for 2017.

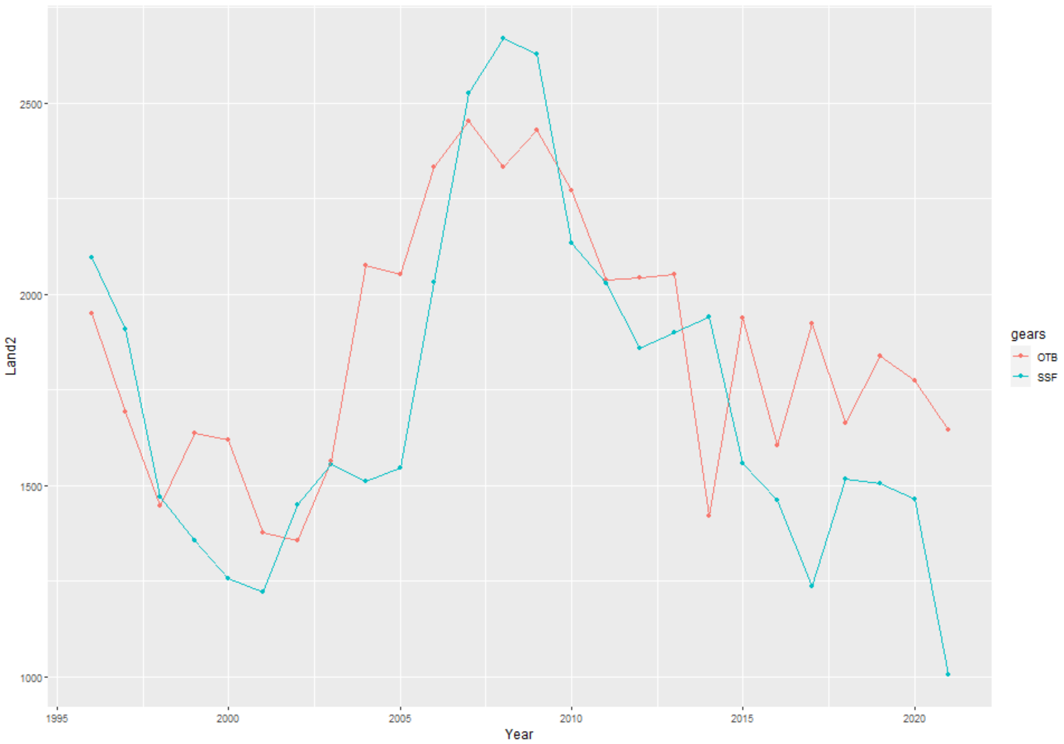


Figure 6.15.2.2. Hake in GSA 22. Landings data in tons by OTB and SSF (GTR, GNS, and LLS) after the reconstruction to account for the catches of the extra fleet added in 2016.

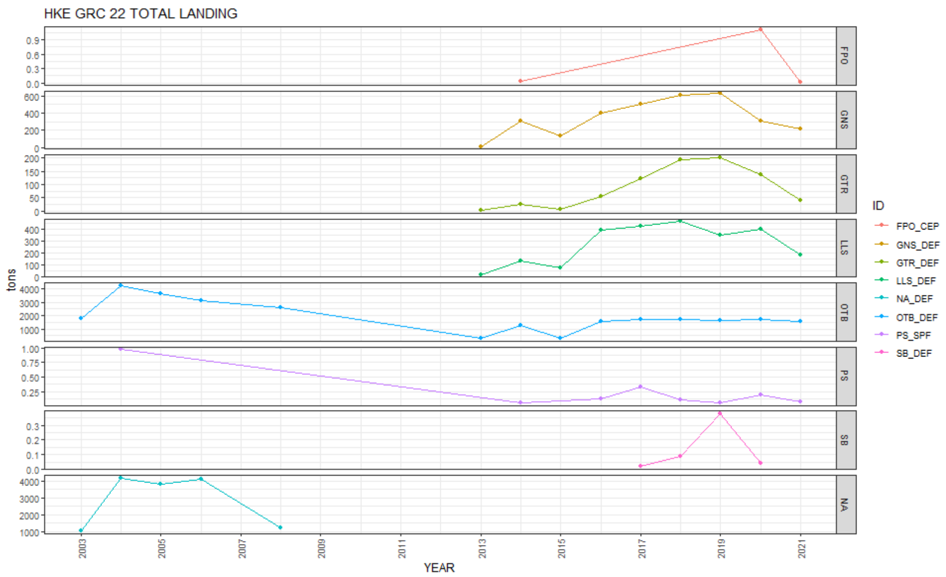


Figure 6.15.2.3. Hake in GSA 22. Landings data in tons by year and fleet.

Table 6.15.2.2. Hake in GSA 22. Hake DCF landings in tonnes by the Greek fleet in GSA 22 from different gears. Years 2007 and 2009-2012 are missing, while data for 2013, 2015 and 2017 come only from the fourth quarter of the year.

Year	GNS Landings (t)	GTR Landings (t)	LLS Landings (t)	OTB Landings (t)	Unspecified (t)	Other (SB, PS, FPO combined) (t)
2003	-	-	-	1769	1042	-
2004	-	-	-	4259	4182	0.97
2005	-	-	-	3624	3787	-
2006	-	-	-	3104	4114	-
2007	-	-	-	-	-	-
2008	-	-	-	2612	1212	-
2009	-	-	-	-	-	-
2010	-	-	-	-	-	-
2011	-	-	-	-	-	-
2012	-	-	-	-	-	-
2013	10	1	16	312	-	0.035
2014	303	26	133	1245	-	0.065
2015	133	5	71	272	-	0
2016	400	54	390	1534	-	0.126
2017	7	3	35	1695	-	0.352
2018	612	192	467	1698	-	0.205
2019	626	201	349	1613	-	0.441
2020	305	137	406	1750	-	1.348
2021	213	40	186	1601	-	0.093

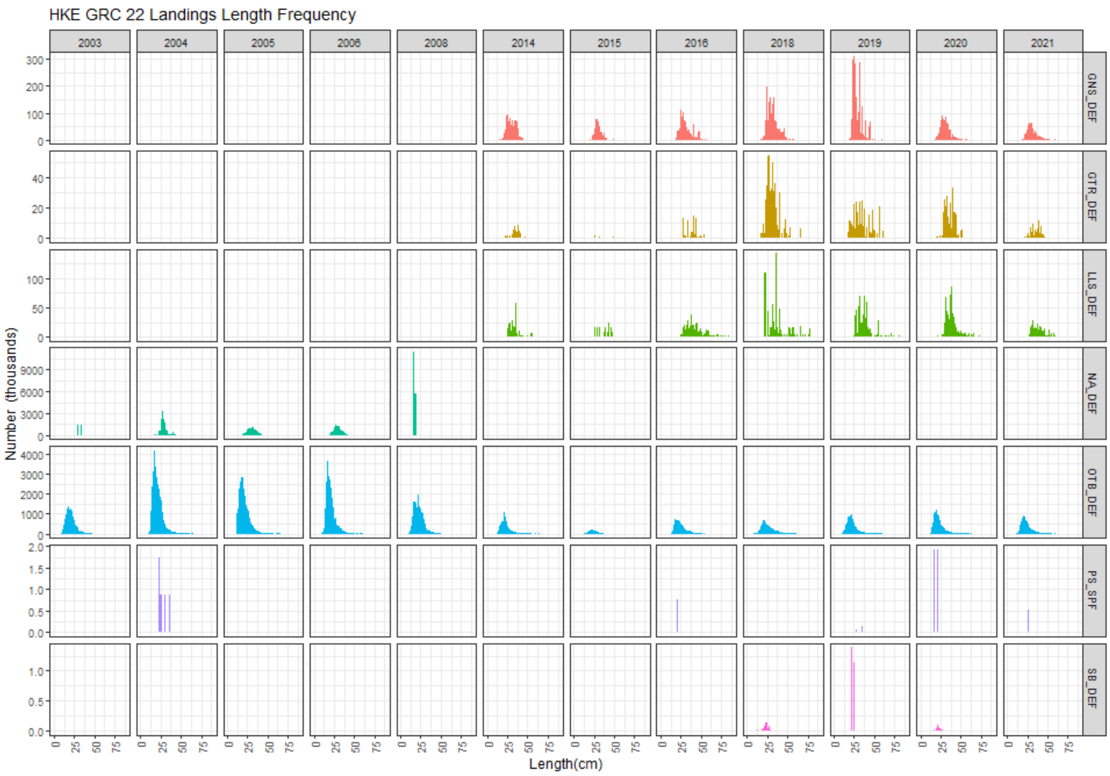


Figure 6.15.2.4. Hake in GSA 22. Initial length frequency distribution of the landings by year and fleet.

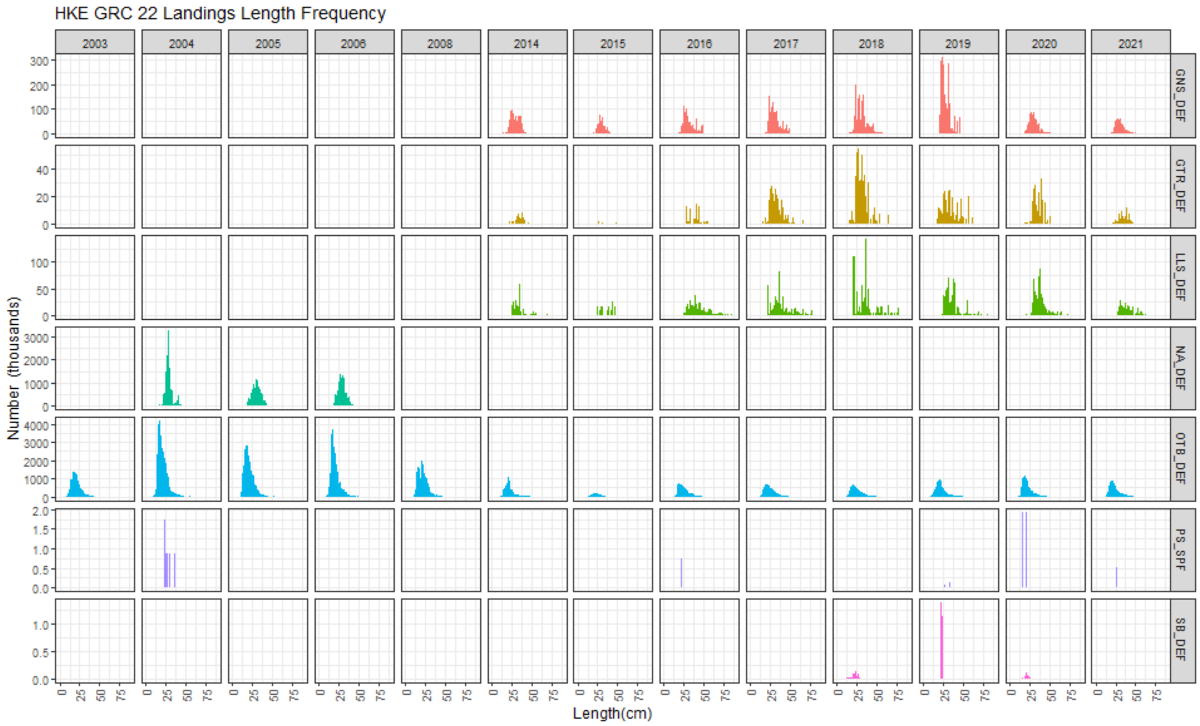


Figure 6.15.2.5. Hake in GSA 22. Final length frequency distribution of the landings by year and fleet after removing NA_DEF for 2003 and 2008 and reconstructing 2017.

Discards

According to the Greek DCF, the discards of haκe in GSA 22 were around 500 t from 2004 to 2008 and declined to negligible values (26 t) in 2016 with zero discards for OTB (Figure 6.15.2.6, Table 6.15.2.3).

The initial and final length frequency distributions of discards are shown in Figures 6.15.2.7 and 6.15.2.8. The description of discards with respect to reporting periods and missing data is similar to that of landings.

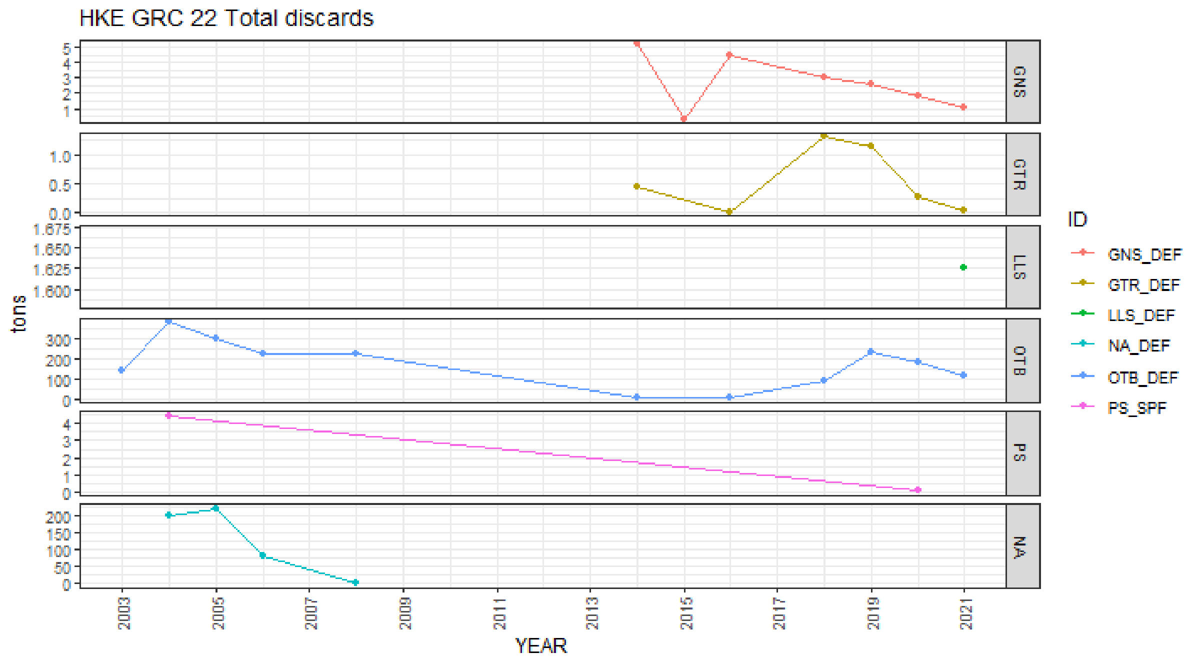


Figure 6.15.2.6. Hake in GSA 22. Hake discards data in tons by year and fleet.

Table 6.15.2.3. Hake in GSA 22. Hake discards in tonnes by fishing gear in GSA 22 as reported by the DCF.

	OTB_Discards (t)	GNS_Discards (t)	GTR_Discards (t)	Unspecified gear	Total
2003	146	-	-	-	146
2004	377	-	-	197	574
2005	296	-	-	221	517
2006	221	-	-	81	302
2007	-	-	-	-	0
2008	22	-	-	224	246
2009	-	-	-	-	0
2010	-	-	-	-	0
2011	-	-	-	-	0
2012	-	-	-	-	0
2013	-	-	-	-	0
2014	11	5.1	0.5	-	16.6
2015	0	0.3	0	-	0.3
2016	8.6	4.4	<0.1	-	13
2017	-	-	-	-	0
2018	66	3.1	1.3	-	70.4
2019	231	2.6	1.1	-	234.7
2020	184	1.8	0.3	-	186.1
2021	116	1.0	-	-	117

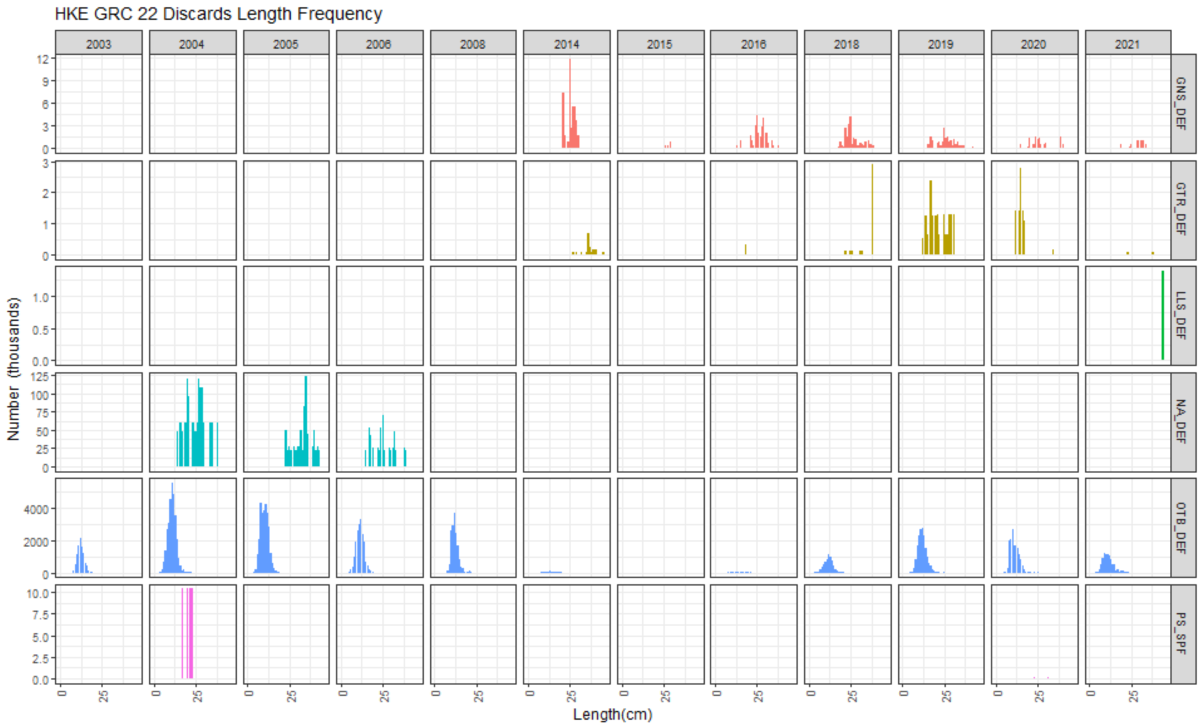


Figure 6.15.2.7. Hake in GSA 22. Initial length frequency distribution of the discards by year and fleet.

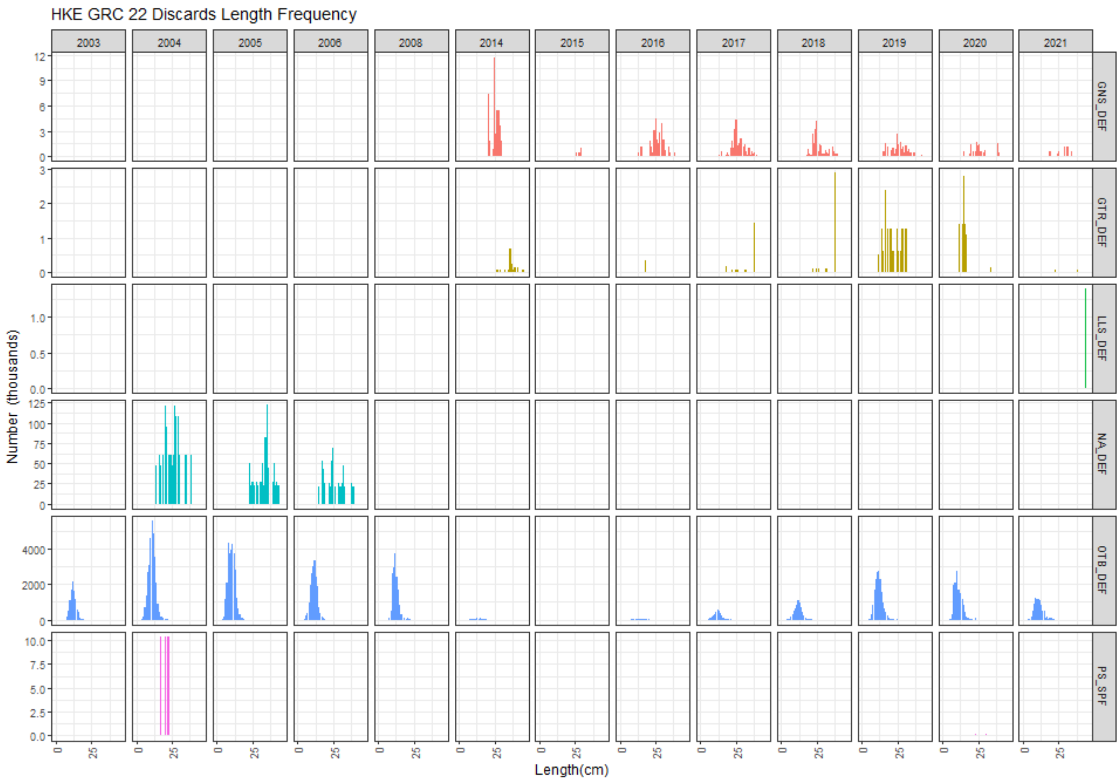


Figure 6.15.2.8. Hake in GSA 22. Final length frequency distribution of the discards by year and fleet.

Effort

Fishing effort data were reported to STECF EWG 22-16 through DCF (Table 6.15.2.4). The effort (days at sea) remains more or less stable since 2014 for OTB and has declined since 2019 for GNS and GTR and since 2020 for LLS. Data for 2015 refers to a single quarter.

Table 6.15.2.4. Hake in GSA 22. Fishing effort in days at sea by year and fishing gear. It refers to the Greek fleet only.

	GNS	GTR	LLS	OTB	Total
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	-	-	-	-
2006	-	-	-	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	-	-	-
2012	-	-	-	-	-
2013	-	-	-	38792	38792
2014	359862	528159	220875	38392	1147288
2015	89687	155567	85067	38348	368669
2016	347566	528235	276635	37896	1190332
2017	-	-	-	39185	39185
2018	377288	563223	240756	38353	1219620
2019	305780	553093	217254	37429	1113556
2020	251769	435106	259565	36533	982973
2021	259299	489760	181975	36754	967788

6.15.2.2 Survey data

The MEDITS bottom trawl survey was used for the estimation of abundance index of hake in GSA 22. The survey is carried out in June/July each year since 1994 but some late surveys that took place in September were observed (Figure 6.15.2.9). No survey was carried out in 2002, 2007, 2009-2012, 2015 and 2017. In 2013 the survey was only conducted in the northern part of the Aegean Sea. Data were extracted using the JRC script (Mannini, 2020)

The estimated biomass index of hake fluctuated quite a lot throughout the time series at around 50 kg/km2 during the last 5-6 years and has declined from 2020 to 2021 (Figure 6.15.2.10, Table 6.15.2.5), whereas the density remains stable in the last 5-6 years but considerably lower compared to the first years of the time series (Figure 6.15.2.11).

The combined MEDITS indexes were calculated using the script provided by JRC (Figures 6.15.2.12 and 6.15.2.13).

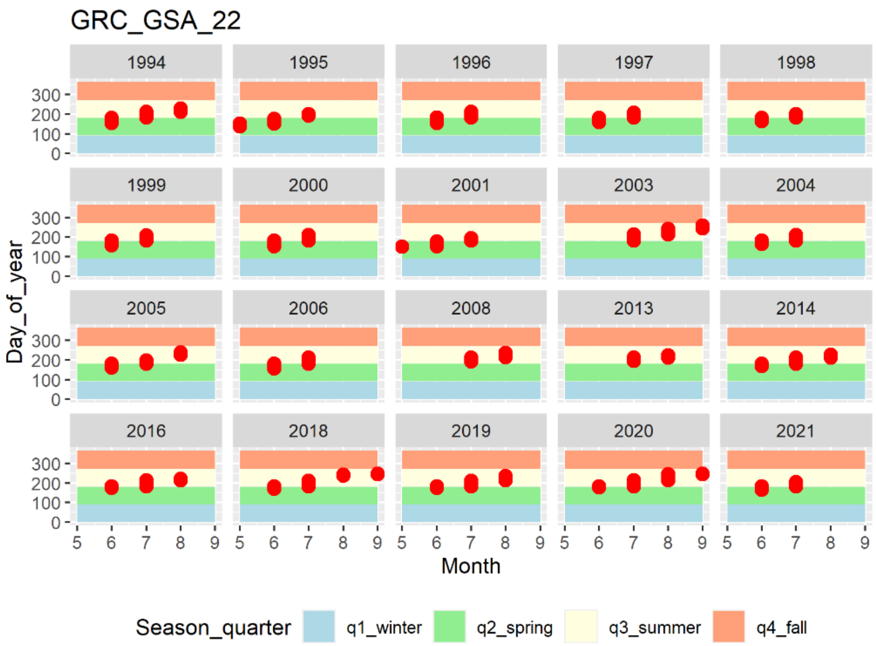


Figure 6.15.2.9. Hake in GSA 22. Time the MEDITS survey took place. The survey is mainly carried out in June/July but some September surveys have been observed.

Table 6.15.2.5. Hake in GSA 22. MEDITS survey abundance index of hake in GSA 20 as reported by DCF. No survey was carried out in 2002, 2007, 2009-2012 and 2015. In 2013 the survey was carried out in the northern Aegean Sea only.

Year	Hake abundance (kg/km^2)
1994	32.79087
1995	29.15822
1996	34.46127
1997	48.52254
1998	44.7184
1999	51.82472
2000	49.31997
2001	35.79744
2002	NA
2003	47.07117
2004	46.75643
2005	47.39797
2006	54.8576
2007	NA
2008	52.35708
2009	NA
2010	NA
2011	NA
2012	NA
2013	30.77215
2014	29.90947
2015	NA
2016	35.75389
2017	NA
2018	55.36181
2019	46.52516
2020	58.40953
2021	42.44307

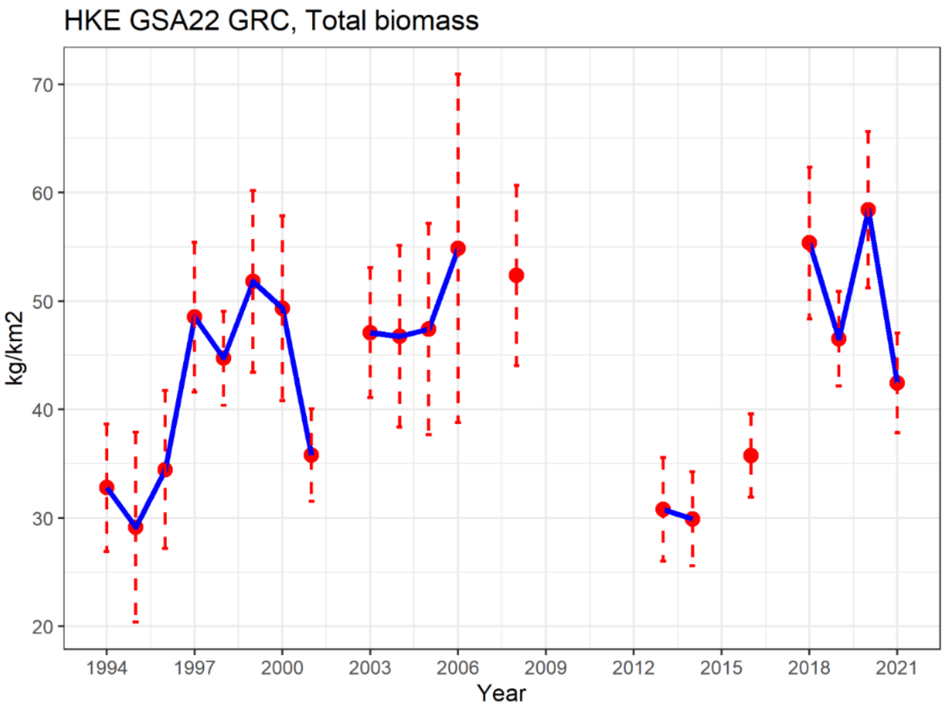


Figure 6.15.2.10. Hake in GSA 22. Estimated biomass indices from the MEDITS survey (kg/km^2).

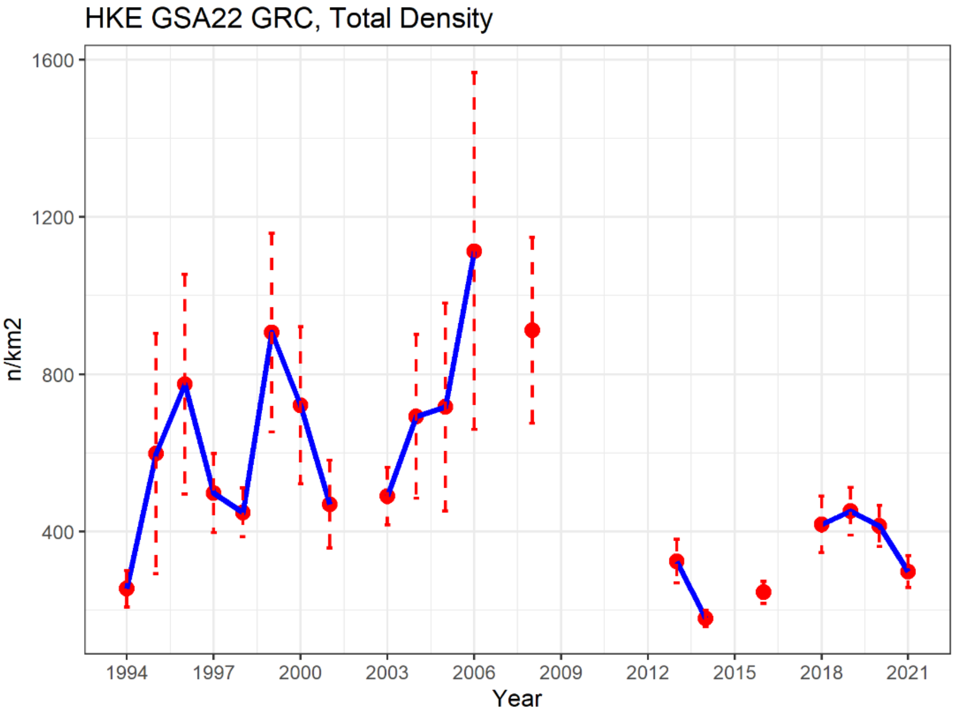
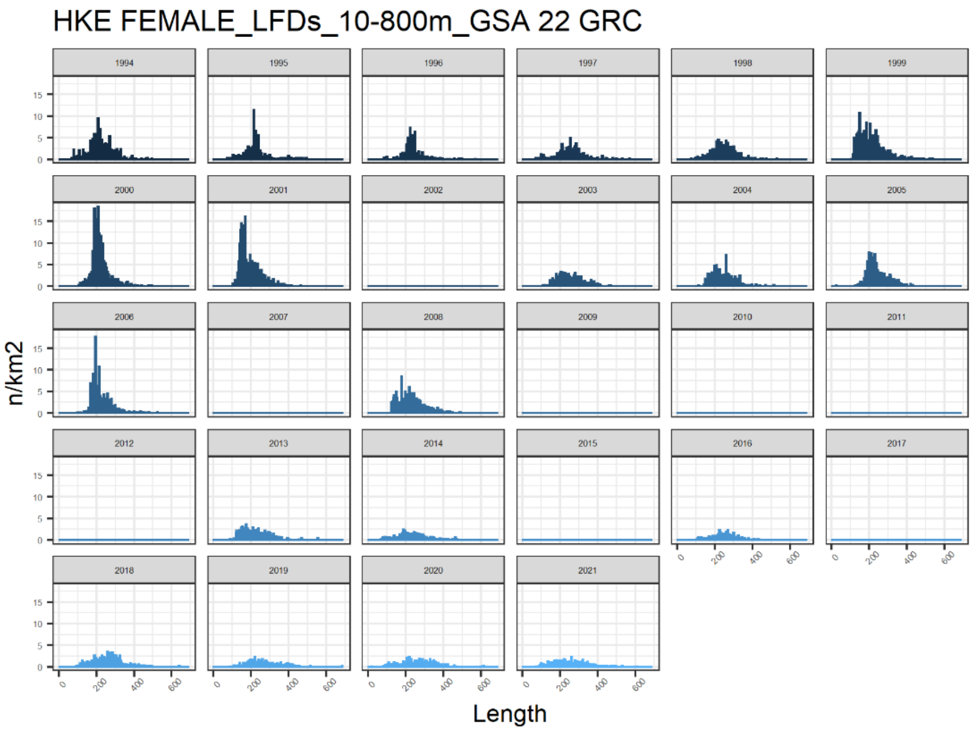
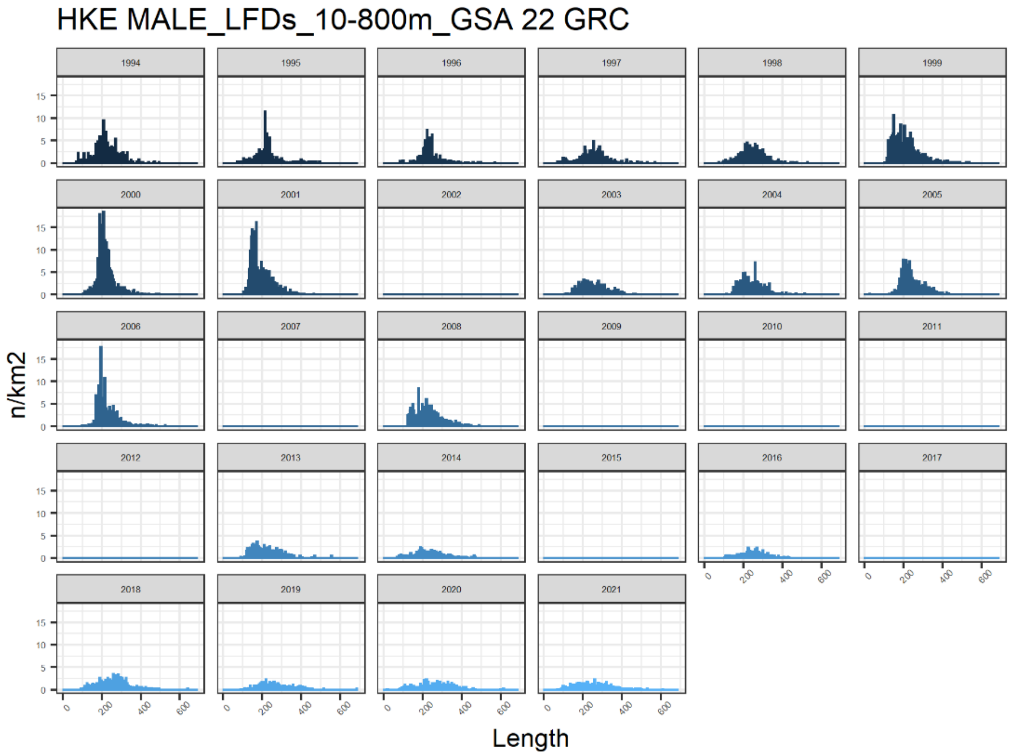


Figure 6.15.2.11. Hake in GSA 22. Mean weight of individuals by haul from the MEDITS survey (g).

The length frequency distributions of females, males and indeterminate individuals in the MEDITS survey by year are shown in Figure 6.15.2.12.





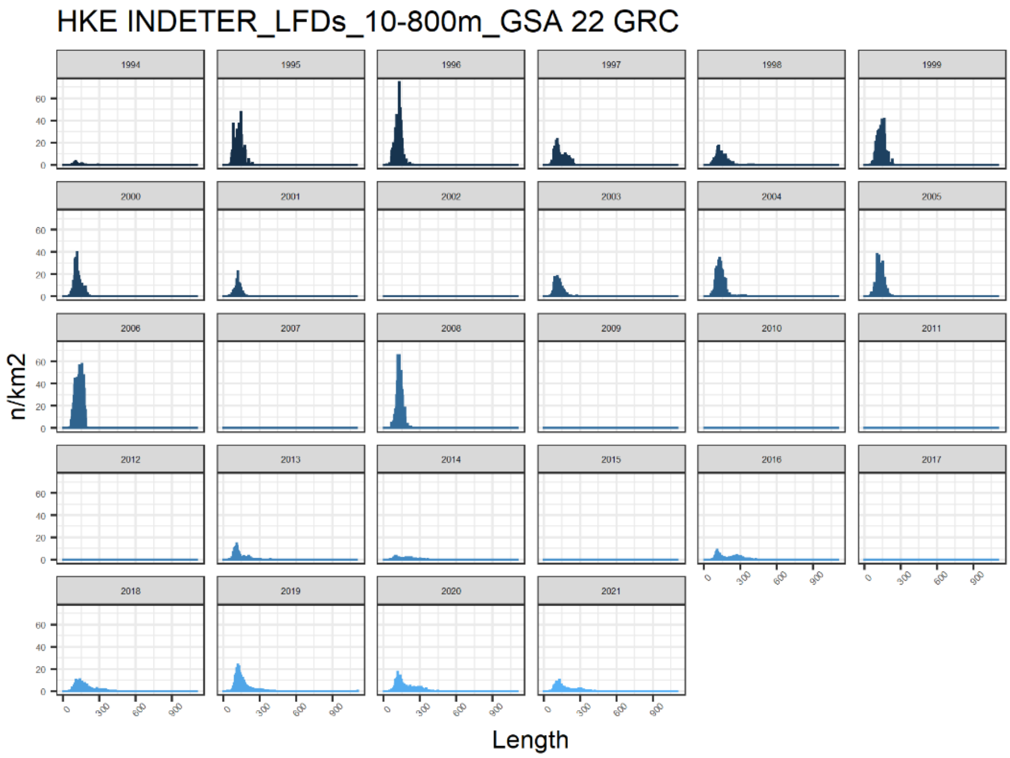


Figure 6.15.2.12. Hake in GSA 22. Length frequency distribution by year and sex and sex combined from MEDITS survey.

6.15.3 Stock assessment

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. However, unlike VPA, model parameters using catch-at-age analysis are estimated by working forward in time and the methods do not require the assumption that removals from the fishery are known without error. Data that are typically used are: catch, abundance index, statistical sample of age composition of catch and abundance index. Assessment was performed with version 1.8.2 of FLa4a, together with version 2.6.15.9005 of the FLR library (FLCore) in FLR environment.

The assessment was carried out using the period 2003-2019 for catch data and tuning file for which data were available. A single tuning fleet was used in both methods based on the CPUE and weight at age estimates from summer bottom trawl surveys (MEDITS) conducted in the Greek part of Aegean Sea (GSA 22) from 2003 to 2021 (with gaps in 2007, 2009-2012, 2015 and 2017) as reported in the DCF.

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 for sexes combined. The plus group was set at 7 because, contrary to the previous assessment that was based on OTB alone, the small-scale coastal fleet catches (GNS, GTR and LLS) were also included in the present assessment. These gears generally collect larger individuals compared to OTB, some of which were aged 5, 6 and 7 years old. Therefore, no trimming of age groups was applied to index and stock objects. Concerning the Fbar, the age range used was 1-3 age groups.

Ages 0, 1, 2 and 3 make up the majority of individuals caught during the MEDITS bottom trawl survey and the catch.

Input data

Total catch (landings and discards from Greek fleet, landings only from Turkish fleet) and catch numbers at age from GSA 22 were used as input data. SOP correction was applied to catch numbers at age and reflects missing data and inconsistent reporting.

Tables 6.15.3.1-6.15.3.3 list the input data for the a4a model, namely catch numbers at age, weight at age, and the tuning series (MEDITS) at age.

Table 6.15.3.1. Hake in GSA 22. Catch numbers at age (thousands)

Year/Age	0	1	2	3	4	5	6	7
2003	8528	38789	14881	1883	448	114	9	21
2004	16498	26129	15566	2396	759	108	36	34
2005	32396	33482	15630	5765	1072	95	82	65
2006	15194	40004	19986	6132	731	148	37	31
2007	NA	NA	NA	NA	NA	NA	NA	NA
2008	13769	42593	25574	2883	589	184	17	34
2009	NA	NA	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA	NA	NA	NA
2014	163	6196	10853	4314	666	198	115	65
2015	77	6246	16366	2828	666	322	20	37
2016	179	5186	8193	2544	993	435	129	169
2017	2195	8459	9465	3347	965	360	152	155
2018	3481	8984	8769	3823	966	334	188	161
2019	12683	23697	13354	3369	1135	288	194	112
2020	12288	18761	10225	3863	1210	304	109	157
2021	7041	10478	8587	2891	1099	338	144	64

Table 6.15.3.2. Hake in GSA 22. Weights at age (Kg)

Year/Age	0	1	2	3	4	5	6	7
2003	0.007	0.037	0.112	0.321	0.576	0.831	1.431	4.330
2004	0.007	0.037	0.131	0.306	0.567	0.943	1.434	2.306
2005	0.007	0.037	0.128	0.315	0.559	0.968	1.473	2.485
2006	0.006	0.039	0.126	0.312	0.570	0.957	1.429	1.926
2007	0.007	0.041	0.124	0.318	0.585	0.935	1.431	2.648
2008	0.008	0.038	0.119	0.317	0.582	0.911	1.415	2.922
2009	0.007	0.041	0.124	0.318	0.585	0.935	1.431	2.648
2010	0.007	0.041	0.124	0.318	0.585	0.935	1.431	2.648
2011	0.007	0.041	0.124	0.318	0.585	0.935	1.431	2.648
2012	0.007	0.041	0.124	0.318	0.585	0.935	1.431	2.648
2013	0.007	0.041	0.124	0.318	0.585	0.935	1.431	2.648
2014	0.007	0.043	0.122	0.328	0.578	0.962	1.382	2.470
2015	0.008	0.045	0.134	0.292	0.589	0.870	1.493	2.698
2016	0.007	0.045	0.128	0.327	0.597	0.942	1.468	2.616
2017	0.004	0.045	0.126	0.323	0.594	0.943	1.438	2.722
2018	0.004	0.044	0.126	0.320	0.593	0.941	1.428	2.825
2019	0.008	0.041	0.119	0.318	0.611	0.962	1.433	2.558
2020	0.006	0.042	0.122	0.327	0.591	0.982	1.401	2.441
2021	0.008	0.045	0.124	0.323	0.595	0.946	1.373	2.225

Table 6.15.3.3. Hake in GSA 22. Survey (MEDITS) numbers at age (n/km^2)

Year/Age	0	1	2	3	4	5	6	7
2003	128.79	182.81	80.06	30.78	12.60	3.91	0.97	1.88
2004	152.98	397.14	94.75	35.98	8.92	1.79	0.62	0.83
2005	179.34	401.47	88.77	35.23	8.85	2.74	0.47	0.71
2006	284.74	716.37	80.01	20.68	6.64	2.99	0.64	1.36
2007	NA	NA	NA	NA	NA	NA	NA	NA
2008	146.22	629.42	90.74	31.56	9.41	3.03	0.36	0.85
2009	NA	NA	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA
2013	78.99	150.32	66.92	18.83	4.12	2.65	1.89	1.10
2014	27.66	65.55	49.92	21.18	7.33	4.26	2.47	1.14
2015	NA	NA	NA	NA	NA	NA	NA	NA
2016	42.34	72.21	90.41	29.76	7.40	2.14	0.96	0.54
2017	NA	NA	NA	NA	NA	NA	NA	NA
2018	53.64	191.31	107.50	47.26	10.63	4.17	1.90	2.09
2019	93.77	245.85	60.94	27.85	14.02	4.27	2.73	2.21
2020	69.70	180.61	90.62	50.10	12.32	4.54	3.01	3.14
2021	58.45	120.56	65.15	36.30	10.46	4.02	1.43	1.80

Catch Data

The time series of official hake landings for the Greek part of Aegean Sea (GSA 22), as they appear in the Hellenic Statistical Authority database was used for the period 2016-2021 and the reconstructed landings because of the inclusion of an extra fleet in the official statistics was used for the period 2003-2015. The DCF reported landings were considered unreliable for the early years of the dataset and were excluded. Although some early values look unrealistic, hake discards were taken directly from the DCF report; recent values were double-checked and they are ok. The time series of official hake landings for the Turkish part of Aegean Sea (GSA 22), as they appear in the Turkish Statistical Institute database was used for the period 2003-2021 but discards data does not exist and the reliability of landings cannot be assured (this holds for the Greek part as well).

No DCF data collection was carried out in 2007, 2009-2012 and DCF covered only the last trimester in 2013, 2015 and 2017. Thus, in the a4a method, NA (non-available) was used for the catch at age data in the years that DCF was not carried out.

The age structure of the catch, the index, the weight at age matrix as well as the catch at age and MEDITS catch at age cohort consistencies are shown in the following figures (Figure 6.15.3.1 to Figure 6.15.3.6).

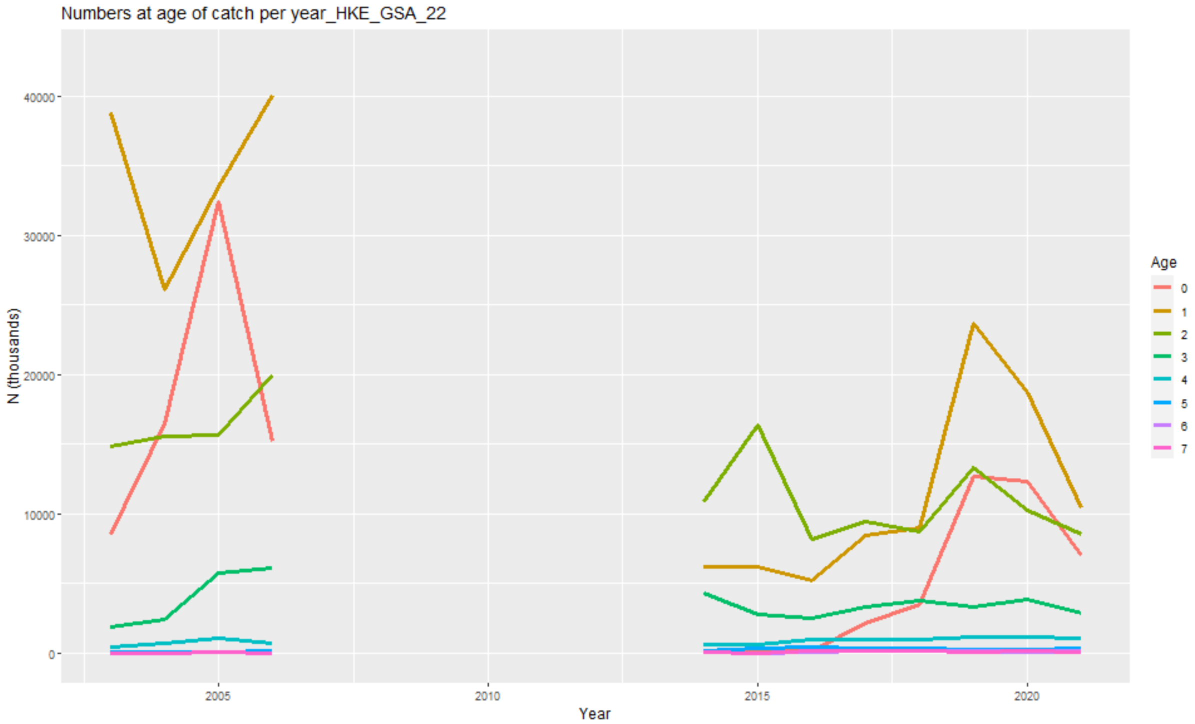


Figure 6.15.3.1. Hake in GSA 22. Catch (N) at age per year input data.

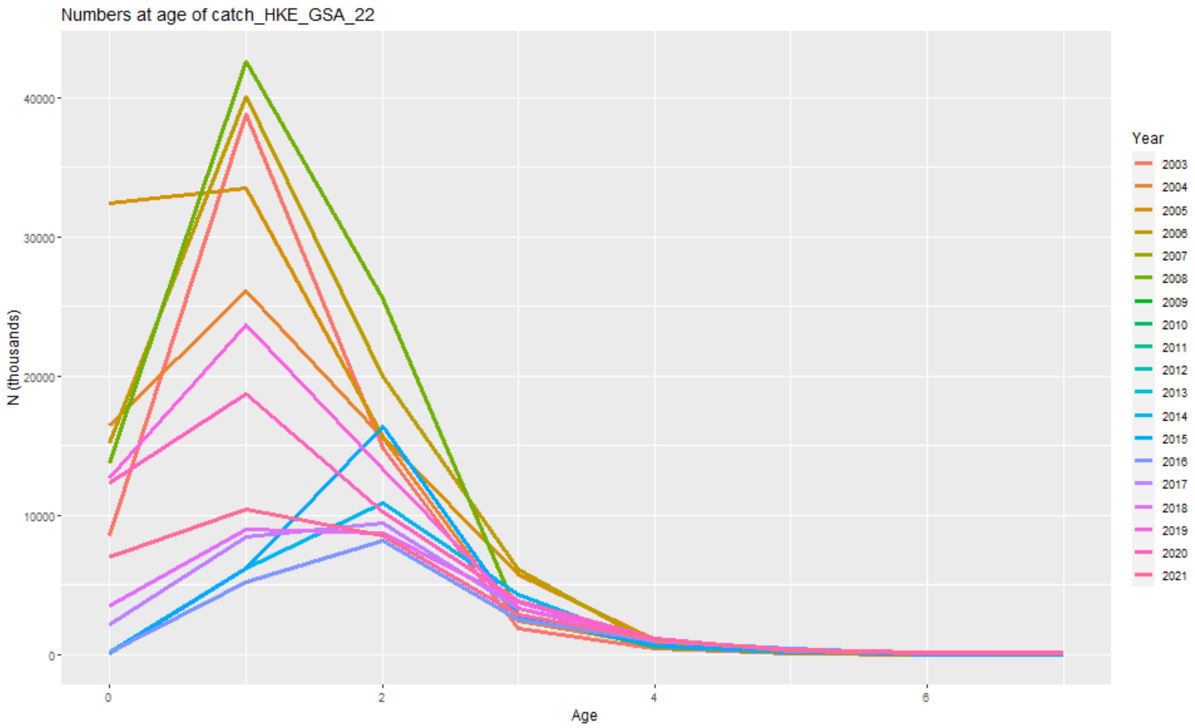


Figure 6.15.3.2. Hake in GSA 22. Age structure of the catch data.

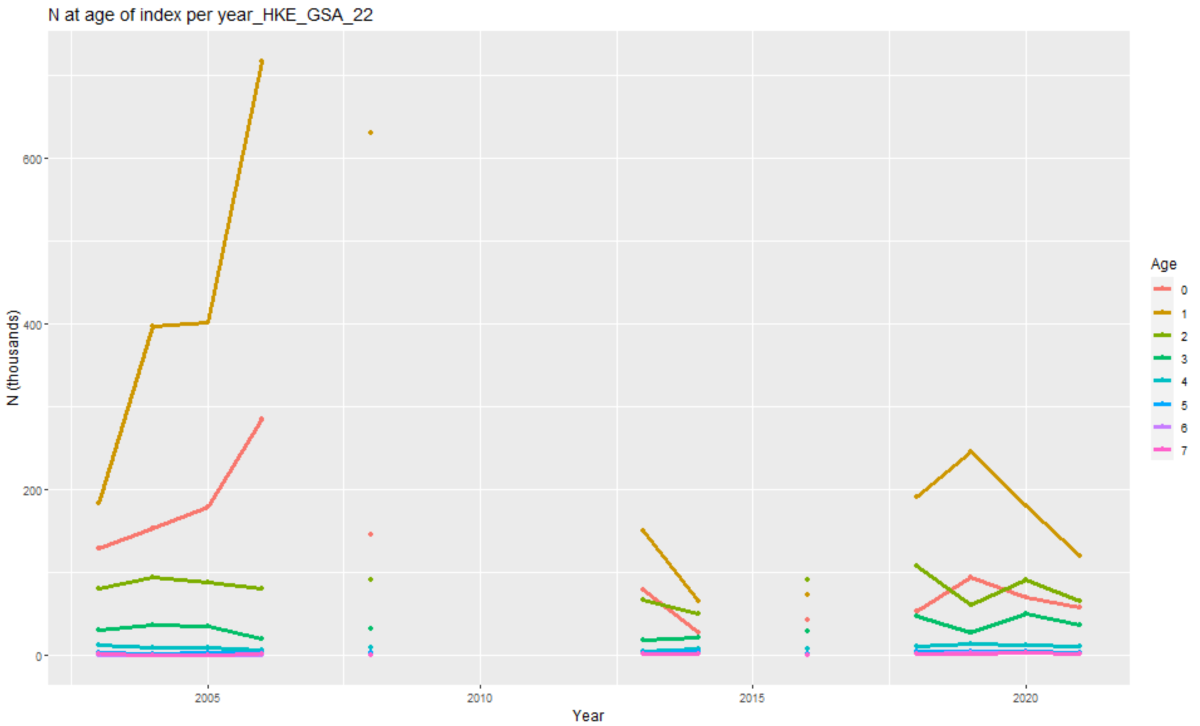


Figure 6.15.3.3. Hake in GSA 22. Index (N) at age per year input data.

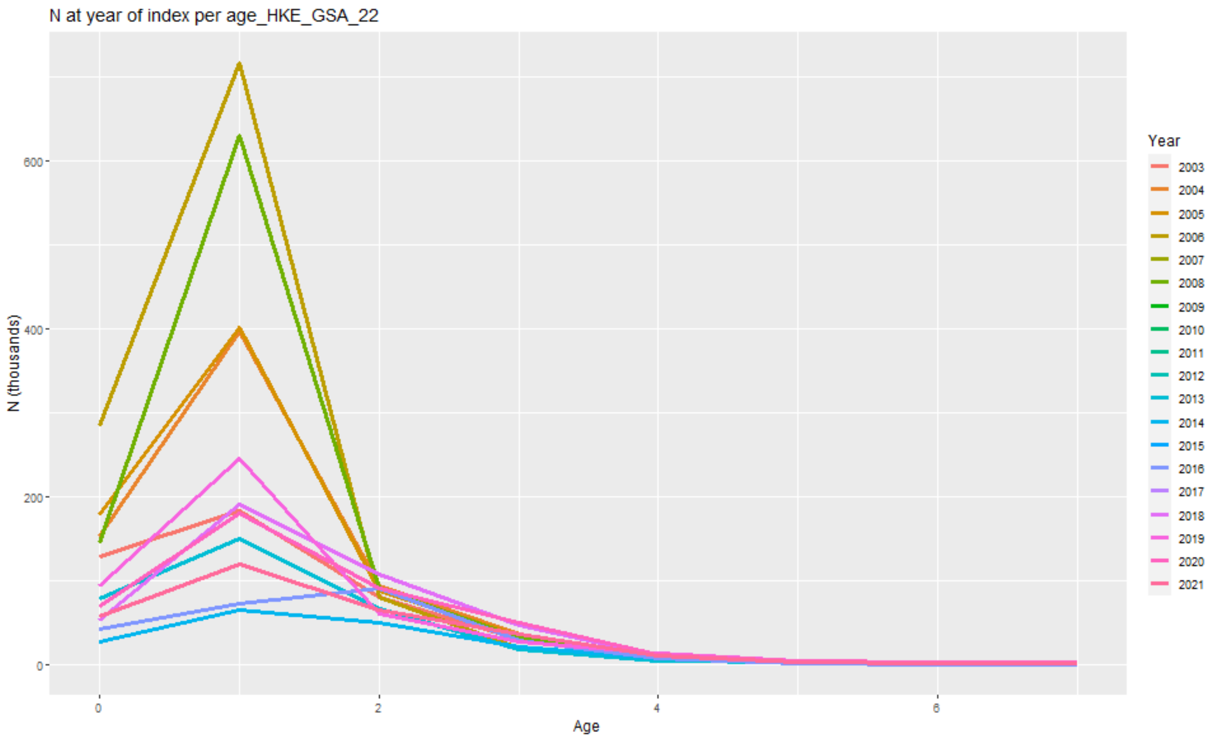


Figure 6.15.3.4. Hake in GSA 22. Age structure of the index.

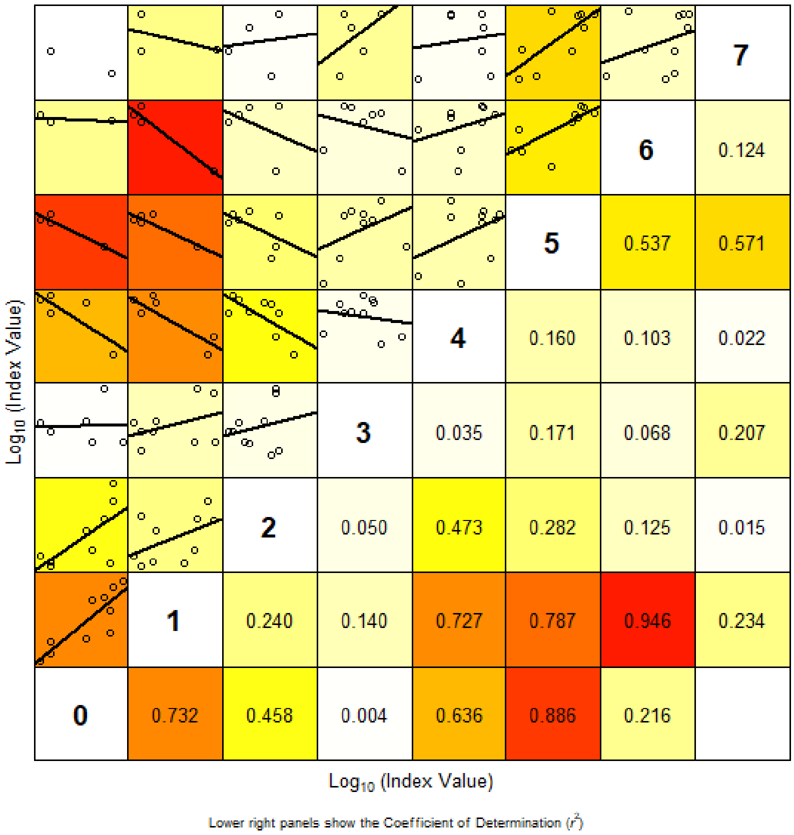


Figure 6.15.3.5. Hake in GSA 22. Catch at age cohort consistency

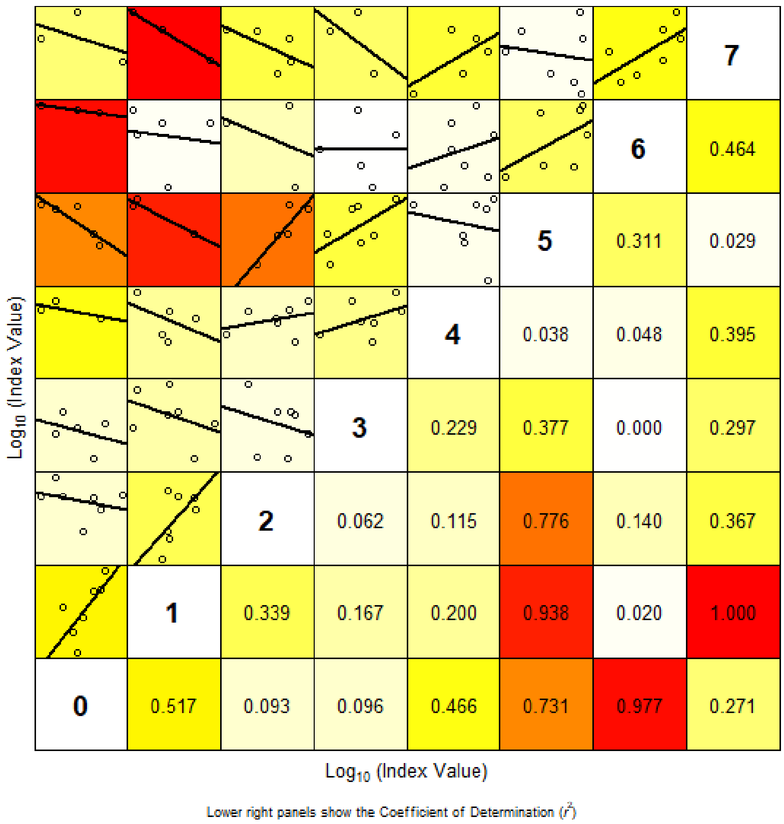


Figure 6.15.3.6. Hake in GSA 22. Index at age cohort consistency

Assessment results

Different a4a models were examined (combination of different f and q). The best model (according to residuals and retrospective) included the following sub models:

a4a model fit for: HKE_GSA_22

Submodels:

fmod<- ~te(replace(age,age>4,4),year, k=c(4,6)) + s(year,k=4)

qmod <- list(~ factor(replace(age, age>4,4)))

srmod <- ~geomean(CV=0.3)

The results of the assessment are shown in Figures 6.15.3.7 – 6.15.3.13.

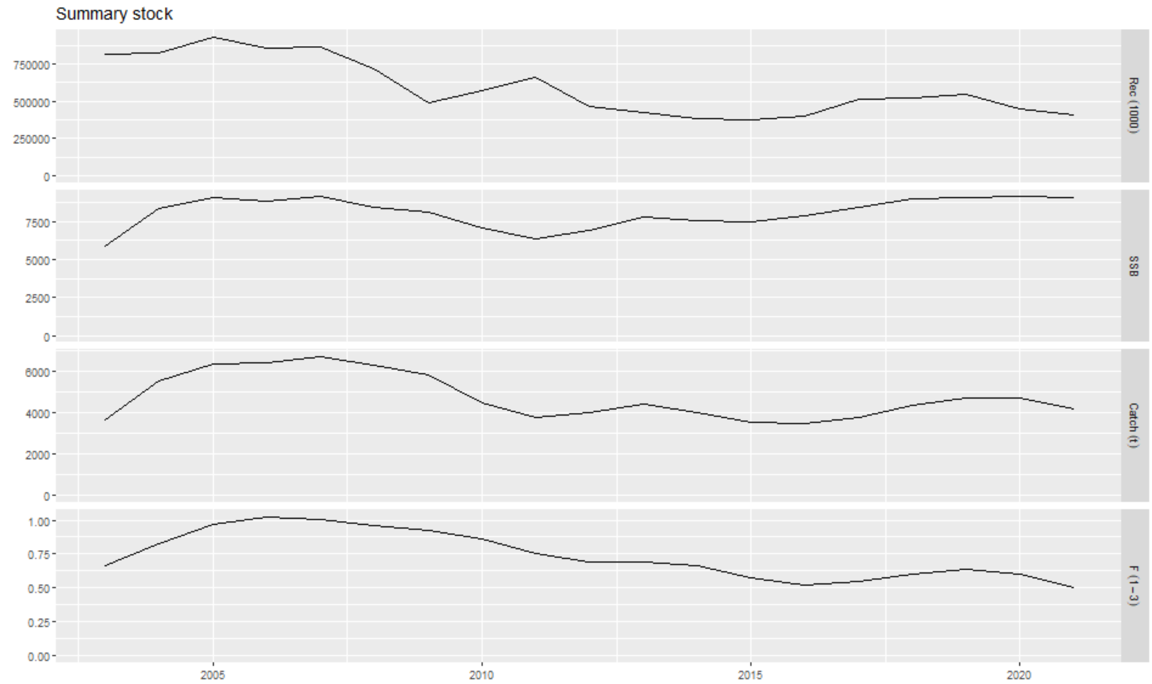


Figure 6.15.3.7. Hake in GSA 22. Stock summary from the final a4a model.

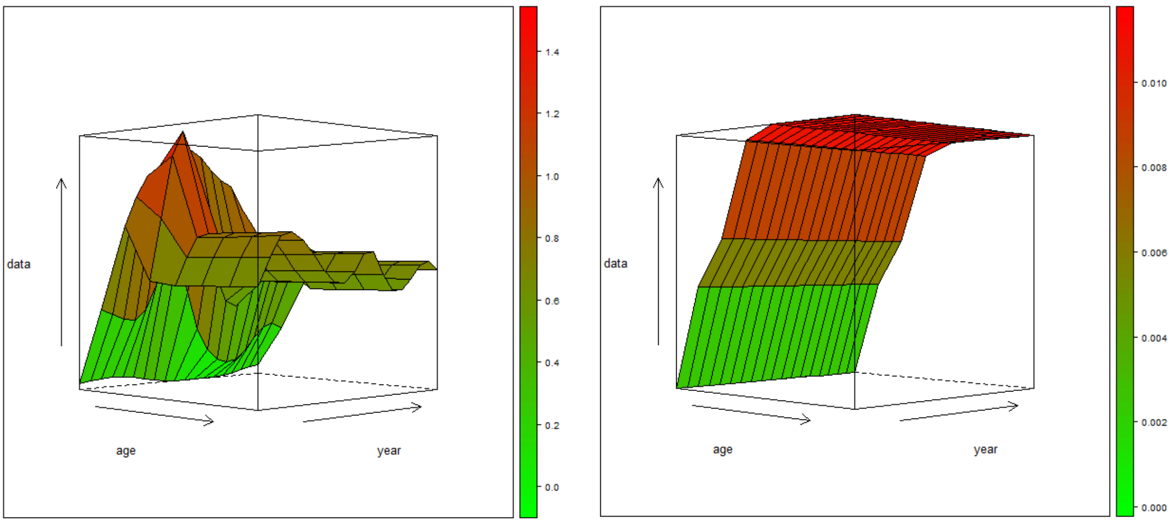


Figure 6.15.3.8. Hake in GSA 22. 3D contour plots of estimated fishing mortality (left) and estimated catchability (right) at age and year.

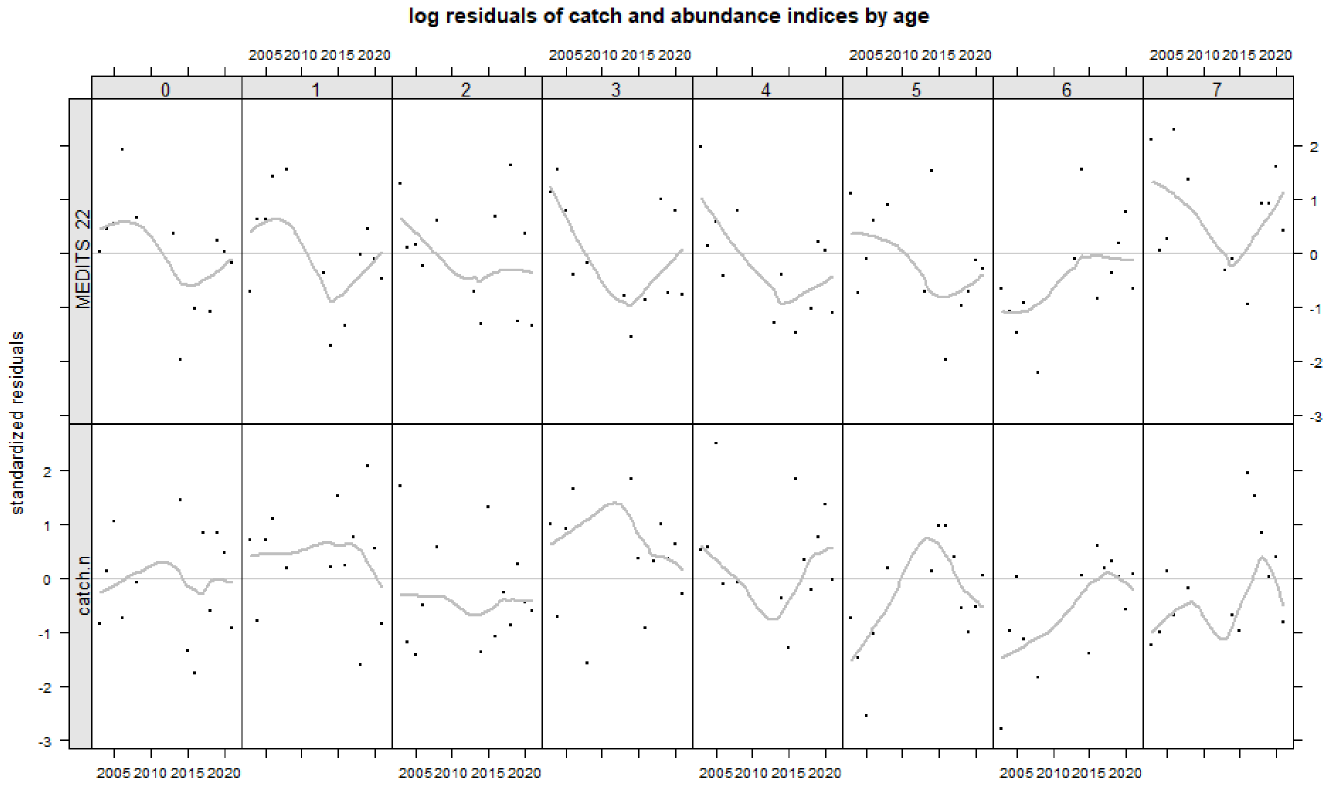


Figure 6.15.3.9. Hake in GSA 22. Standardized residuals by age for abundance index and for catch numbers. Each panel is coded by age class; dots represent standardized residuals and lines simple smoothers.

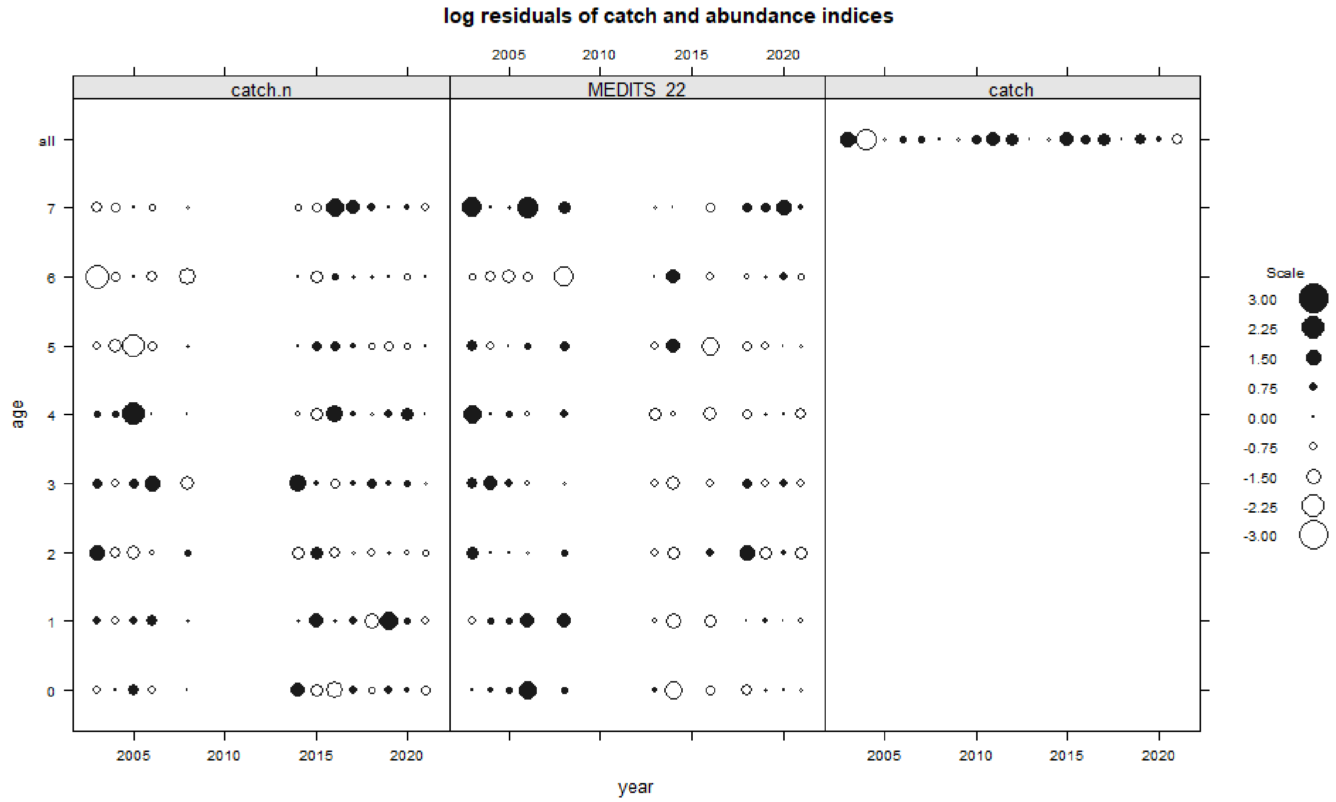


Figure 6.15.3.10. Hake in GSA 22. Standardized residuals for abundance index and for catch numbers.

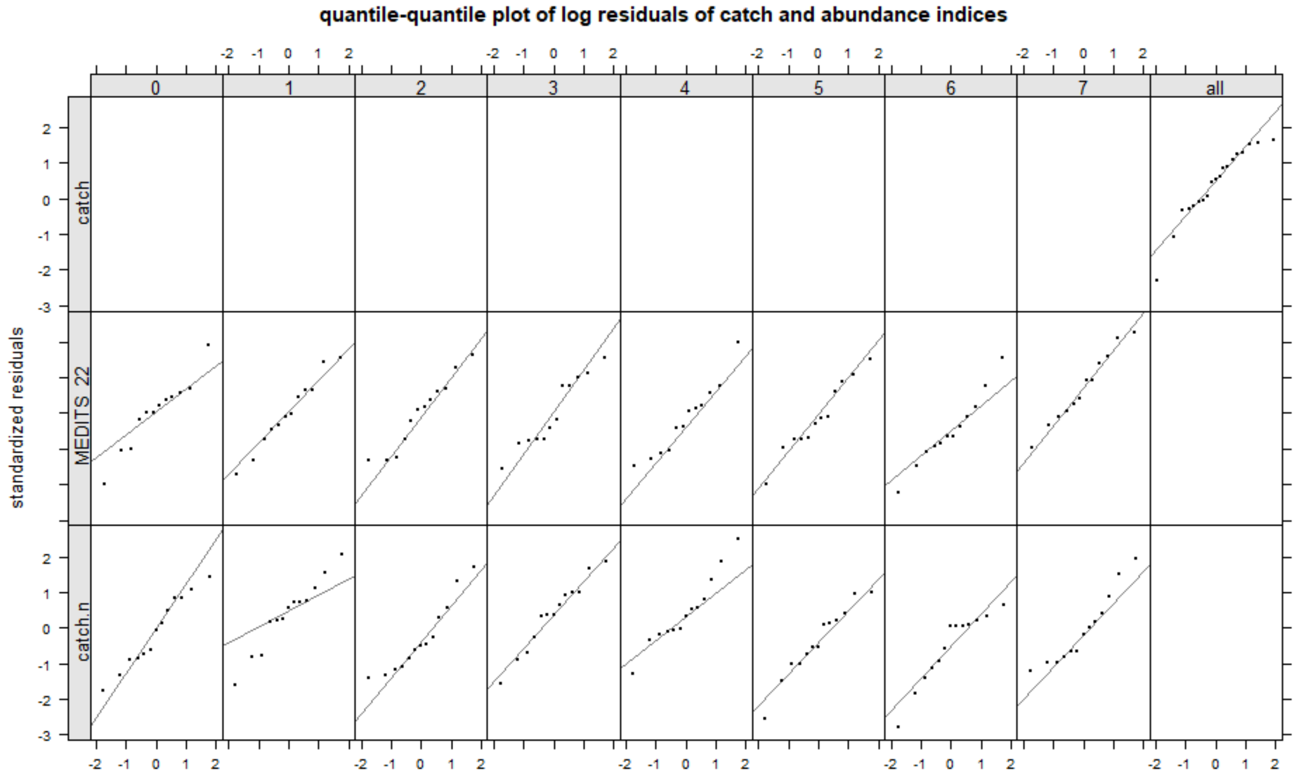


Figure 6.15.3.11. Hake in GSA 22. Quantile plot of standardized residuals for abundance index and for catch numbers.

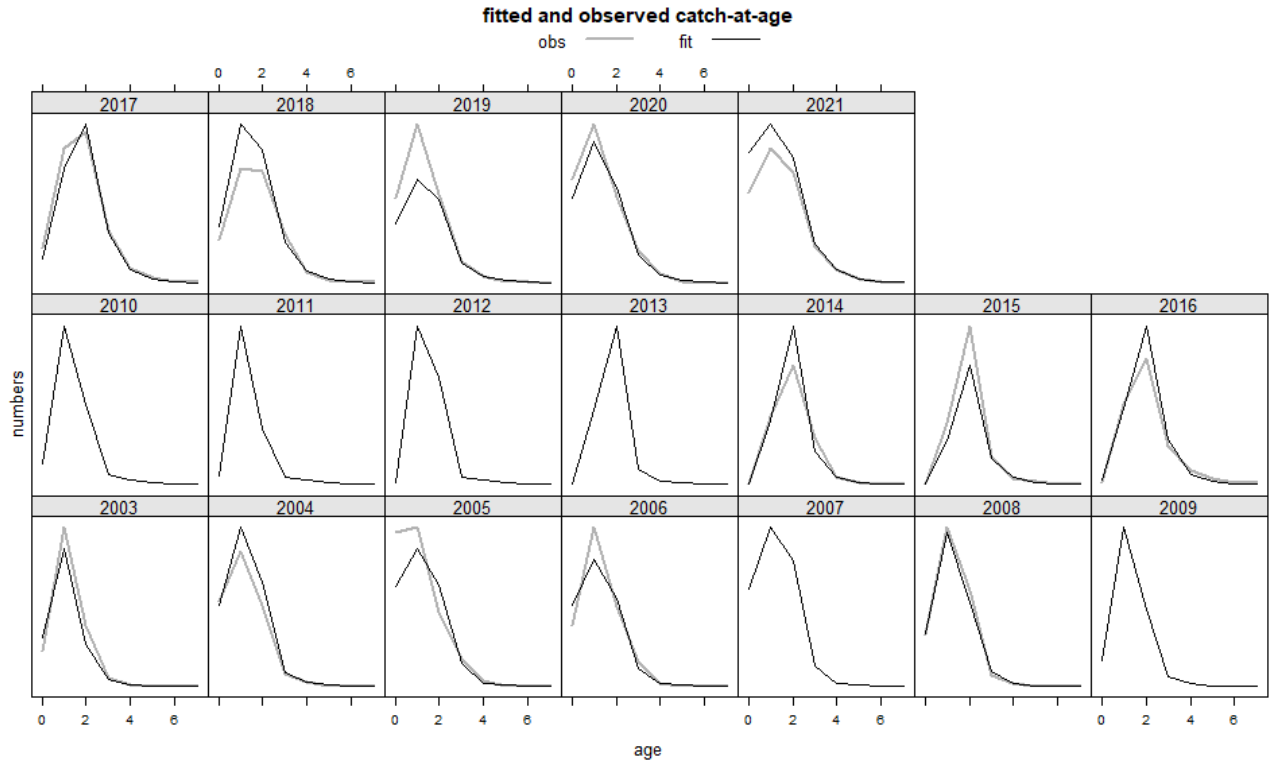


Figure 6.15.3.12. Hake in GSA 22. Fitted and observed catch at age.

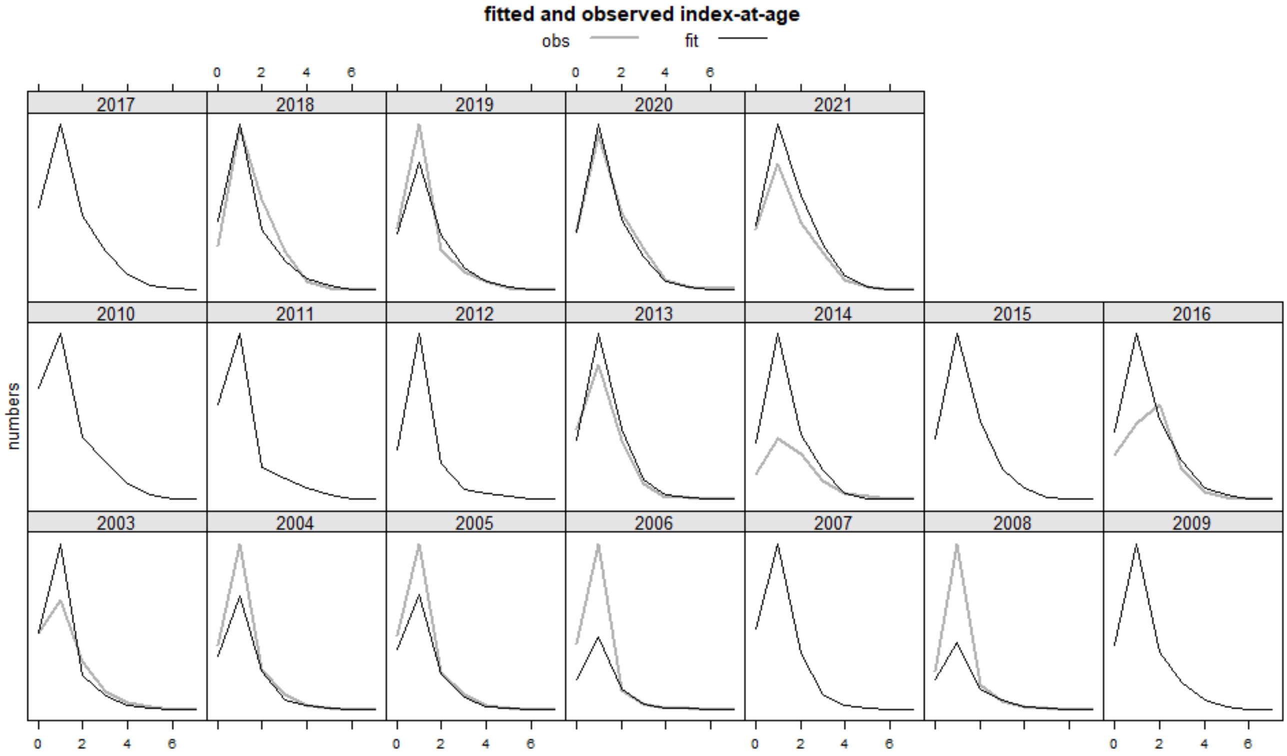


Figure 6.15.3.13. Hake in GSA 22. Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up to two years back because the 2017 dataset was missing. Model results are quite stable (Figure 6.15.3.14) and show a slight tendency to overestimate SSB (Mohn's rho 0.07) and F (Mohn's rho 0.03).

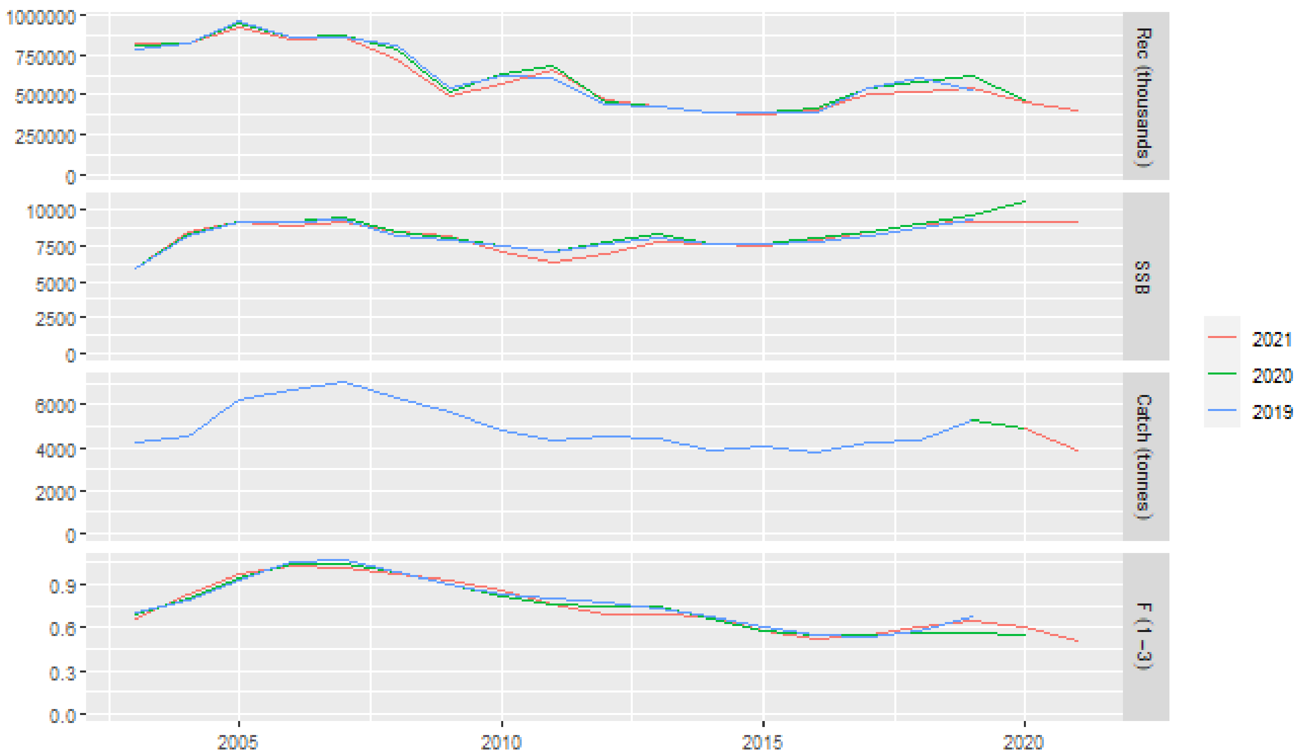


Figure 6.15.3.14. Hake in GSA 22. Retrospective analysis.

All diagnostics were also acceptable regarding the residuals of total numbers (Figure 6.15.3.14), biomass (Figure 6.15.3.15) and numbers by age (Figure 6.15.3.16).

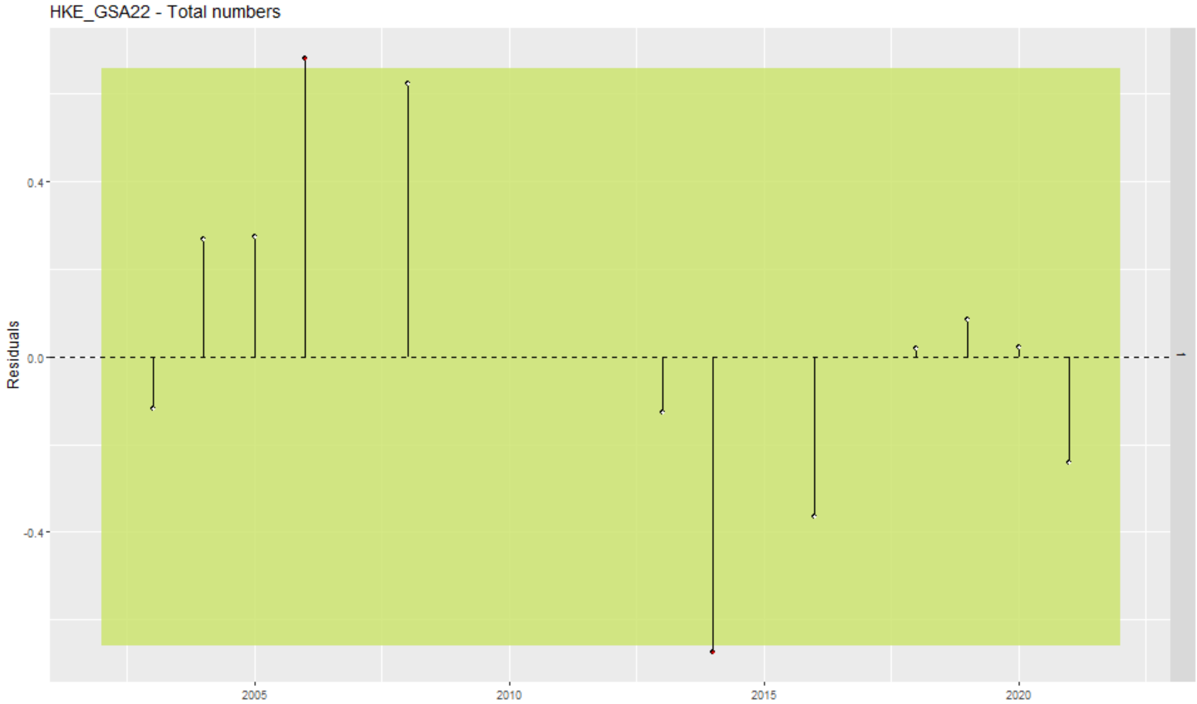


Figure 6.15.3.15. Hake in GSA 22. Residuals of total numbers.

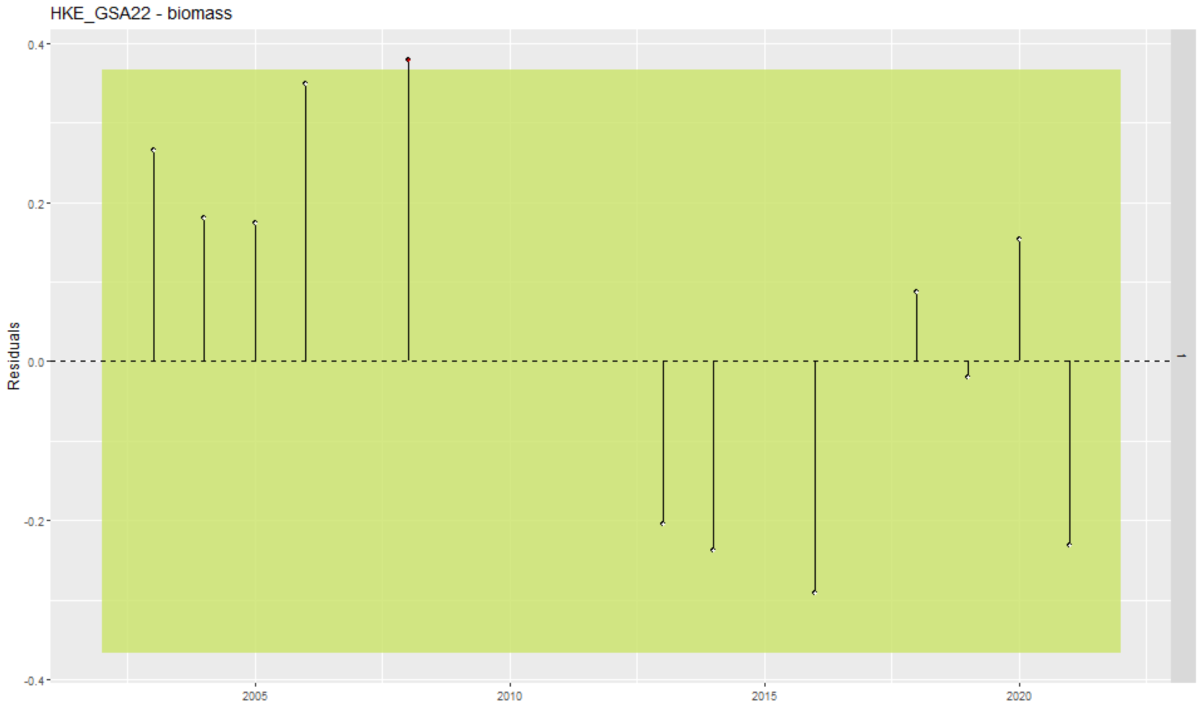


Figure 6.15.3.16. Hake in GSA 22. Residuals of biomass.

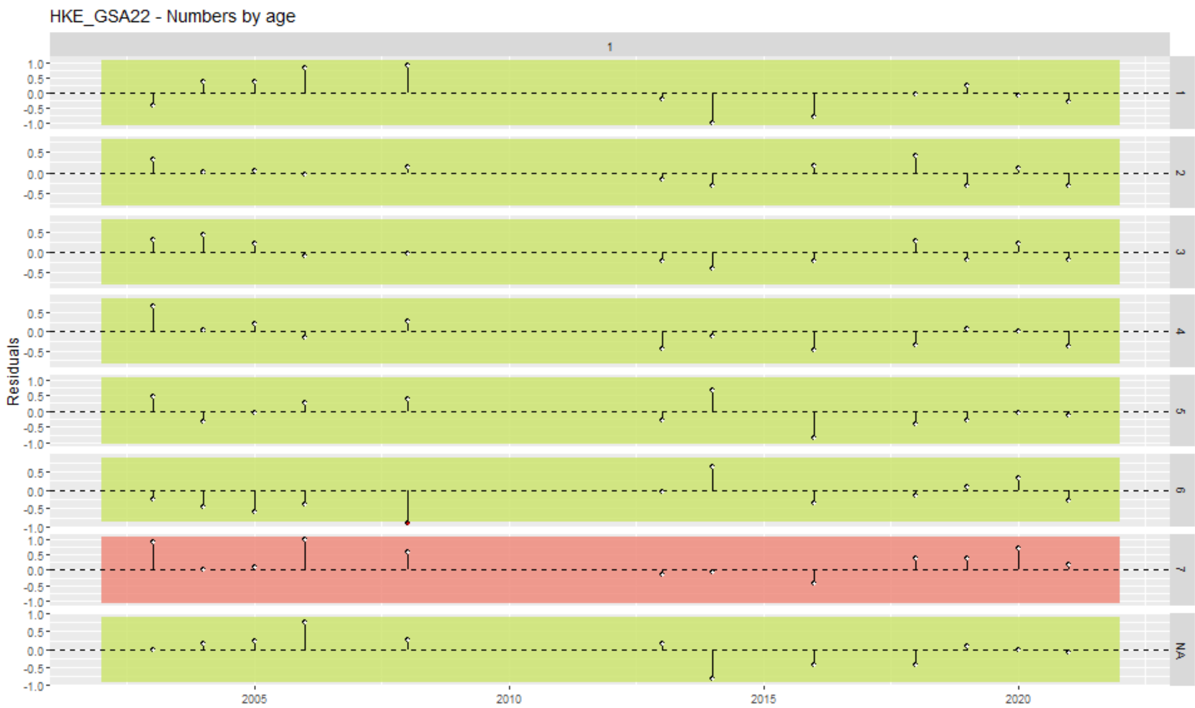


Figure 6.15.3.17. Hake in GSA 22. Residuals per number at age.

Simulations

In the following figures and tables, the population estimates obtained by the a4a model are provided.

Based on the a4a results, hake SSB showed an increasing trend from 2012 to 2019. The number of recruits decreased since 2019. Fbar (1-3) was declining up to 2016 and has been increasing thereafter.

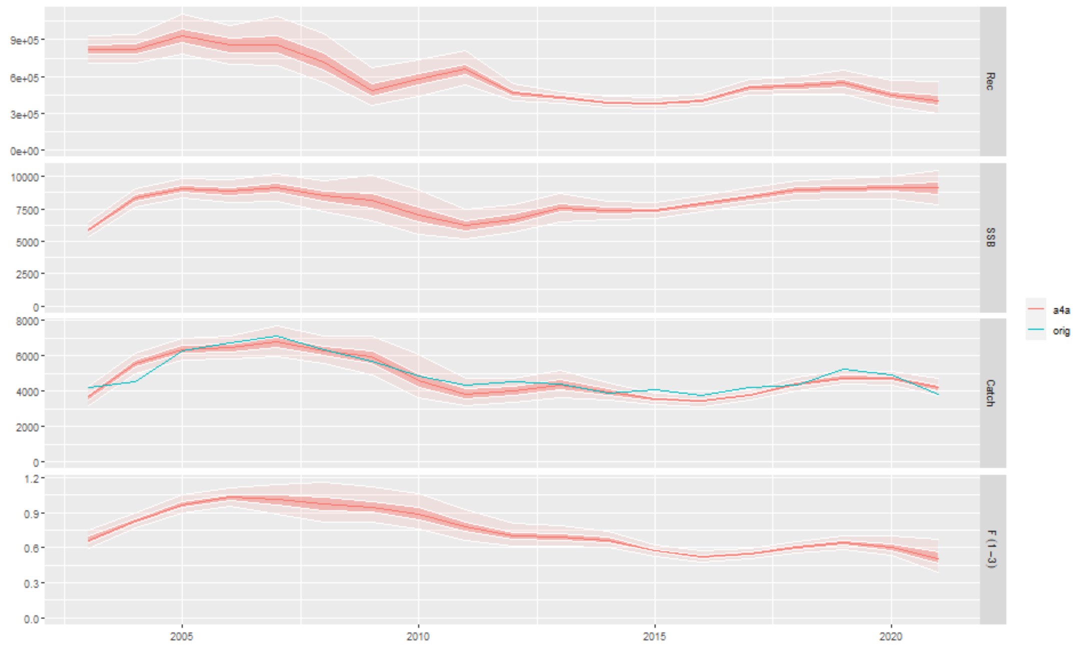


Figure 6.15.3.18. Hake in GSA 22. Stock summary of the simulated and fitted data for the a4a model.

Table 6.15.3.3. Hake in GSA 22. Stock numbers at age (thousands) as estimated by a4a.

Year/Age	0	1	2	3	4	5	6	7
2003	11985	33459	10301	1566	408	153	78	46
2004	15653	30662	20073	2724	685	197	76	64
2005	21084	28832	21203	4860	689	267	80	59
2006	20404	31815	22211	4522	744	224	90	48
2007	19828	32498	25559	4156	554	225	70	45
2008	14146	41037	22563	3828	597	170	72	38
2009	6489	41006	19944	2453	827	193	57	38
2010	3725	28466	14250	1707	843	295	71	36
2011	1475	26541	9456	1216	854	339	123	46
2012	335	20004	13484	1002	709	370	153	79
2013	132	9082	19079	1864	529	297	161	104
2014	91	5913	14492	3077	708	186	109	100
2015	132	4545	12304	2644	834	216	59	68
2016	364	4942	10318	2996	716	293	79	48
2017	1551	7202	9977	3148	908	305	130	58
2018	4445	12512	10549	3184	999	417	146	92
2019	8976	15441	12571	3142	989	433	187	110
2020	10126	16718	11256	3440	952	376	171	121
2021	10152	12408	9786	3035	1101	328	135	108

Table 6.15.3.4. Hake in GSA 22. a4a summary results Fbar age 1-3, recruitment (thousands), catch, SSB and total biomass (tonnes).

	SSB	Recruitment (age1)	Catch	Fbar (1-3)	Total biomass
2003	817992	5857	3644	0.665	15871
2004	822643	8371	5547	0.823	18224
2005	931254	9088	6364	0.967	19572
2006	852895	8838	6430	1.027	19408
2007	861812	9123	6730	1.005	19785
2008	720802	8469	6288	0.964	18539
2009	489587	8091	5848	0.924	15506
2010	573563	7051	4486	0.86	13730
2011	657020	6347	3788	0.756	13921
2012	464775	6900	4014	0.689	13807
2013	426058	7799	4434	0.687	13627
2014	385530	7539	4024	0.667	13046
2015	377189	7474	3576	0.572	13067
2016	402021	7917	3468	0.521	13169
2017	510389	8445	3773	0.543	13418
2018	522931	8963	4380	0.602	14570
2019	548089	9066	4755	0.638	16343
2020	447207	9127	4730	0.605	14942
2021	408386	9090	4214	0.506	15093

Table 6.15.3.5. Hake in GSA 22. a4a results F at age.

F at age	0	1	2	3	4	5	6	7
2003	0.033	0.456	0.919	0.619	0.600	0.600	0.600	0.600
2004	0.042	0.428	1.082	0.958	0.745	0.745	0.745	0.745
2005	0.051	0.399	1.200	1.301	0.852	0.852	0.852	0.852
2006	0.054	0.391	1.250	1.440	0.875	0.875	0.875	0.875
2007	0.051	0.447	1.288	1.281	0.833	0.833	0.833	0.833
2008	0.044	0.590	1.344	0.958	0.761	0.761	0.761	0.761
2009	0.029	0.741	1.362	0.670	0.677	0.677	0.677	0.677
2010	0.014	0.749	1.326	0.504	0.618	0.618	0.618	0.618
2011	0.005	0.542	1.254	0.471	0.615	0.615	0.615	0.615
2012	0.002	0.324	1.198	0.545	0.673	0.673	0.673	0.673
2013	0.001	0.197	1.164	0.701	0.766	0.766	0.766	0.766
2014	0.001	0.136	1.051	0.813	0.779	0.779	0.779	0.779
2015	0.001	0.114	0.846	0.757	0.654	0.654	0.654	0.654
2016	0.002	0.128	0.734	0.700	0.567	0.567	0.567	0.567
2017	0.007	0.179	0.736	0.715	0.568	0.568	0.568	0.568
2018	0.019	0.254	0.784	0.768	0.630	0.630	0.630	0.630
2019	0.036	0.318	0.803	0.794	0.704	0.704	0.704	0.704
2020	0.051	0.337	0.738	0.739	0.729	0.729	0.729	0.729
2021	0.056	0.307	0.600	0.610	0.680	0.680	0.680	0.680

6.15.4 REFERENCE POINTS

The STECF EWG 22-16 recommended using $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

Current F (0.506, estimated as the F_{bar1-3} in the last year of the time series, 2021, because the last-three year trend was consistently declining) is higher than $F_{0.1}$ (0.106), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that hake stock in GSA 22 is highly overfished.

Table 6.15.4.1 Hake in GSA 22. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.106	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
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}	0.106	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 22-16
	target range $F_{MSY\ lower}$	0.073	Based on regression calculation (see section 2)	STECF EWG 22-16
	target range $F_{MSY\ upper}$	0.151	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 22-16

6.15.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short-term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment. An average of the last three years has been used for biological parameters (natural mortality, maturity, mean weight at age).

F status quo was set equal to the last year (2021) because the last three-year trend (2019, 2020, 2021) was consistently declining. Therefore, Fbar value was 0.506.

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 (564218 individuals). The assumptions are summarized in Table 6.15.5.1, and the results of the short term forecast are given in Table 6.15.5.2

Table 6.15.5.1 Hake in GSA 22. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
$F_{ages\ 1-3}$ (2022)	0.506	F 2021 used to give F status quo for 2023
SSB (2022)	9326	SSB intermediate year from STF output
R_{age0} (2022,2023)	564218	Recruitment will be set as geometric mean of the last 19 years
Total catch (2022)	4134	Catch intermediate year from STF output

Table 6.15.5.2 Hake in GSA 22. Short term forecast in different F scenarios.

Rationale	Ffact	Fbar	Recruitment	Fsq 2022	Catch 2021	Catch 2022	Catch 2023	SSB* 2022	SSB* 2024	Change_SSB 2022-2024 (%)	Change_Catch 2021-2023 (%)
High long term yield	0.21	0.106	564218	0.506	4214	4134	1094	9326	15043	61.3	-74.04
F upper	0.299	0.151	564218	0.506	4214	4134	1521	9326	14386	54.26	-63.89
F lower	0.145	0.073	564218	0.506	4214	4134	766	9326	15550	66.73	-81.83
Zero catch	0	0	564218	0.506	4214	4134	0	9326	16736	79.46	-100
Status quo	1	0.506	564218	0.506	4214	4134	4287	9326	10208	9.45	1.75
Different Scenarios	0.1	0.051	564218	0.506	4214	4134	536	9326	15905	70.55	-87.28
	0.3	0.152	564218	0.506	4214	4134	1526	9326	14379	54.18	-63.78
	0.5	0.253	564218	0.506	4214	4134	2419	9326	13016	39.56	-42.6
	0.7	0.354	564218	0.506	4214	4134	3224	9326	11797	26.5	-23.49
	0.9	0.455	564218	0.506	4214	4134	3951	9326	10708	14.82	-6.24
	1.1	0.556	564218	0.506	4214	4134	4608	9326	9734	4.37	9.35
	1.3	0.657	564218	0.506	4214	4134	5203	9326	8861	-4.98	23.47
	1.5	0.758	564218	0.506	4214	4134	5742	9326	8079	-13.37	36.27
	1.7	0.86	564218	0.506	4214	4134	6231	9326	7378	-20.89	47.89
	1.9	0.961	564218	0.506	4214	4134	6676	9326	6749	-27.63	58.45

* SSB at mid-year

STECF EWG 22-16 advises that when MSY considerations are applied the fishing mortality in 2023 should be no more than 0.106 and corresponding catches in 2023 should be no more than 1094 tons.

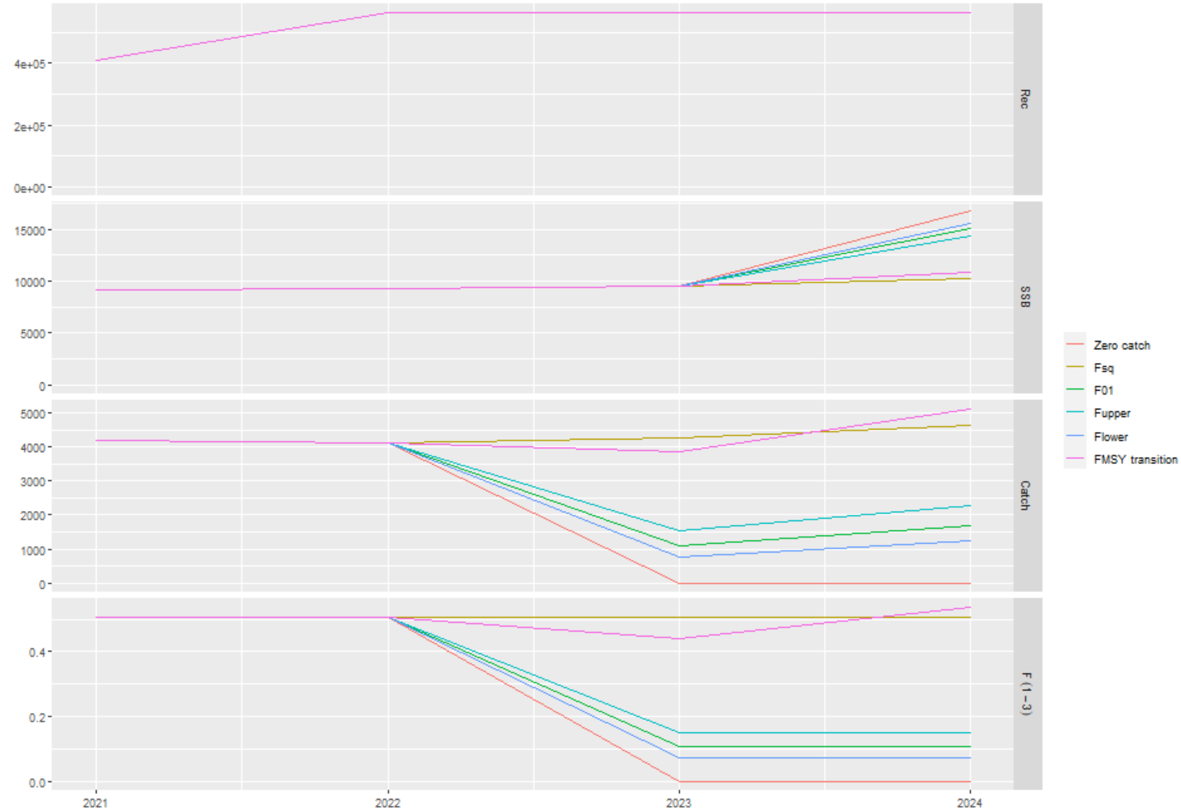


Figure 6.15.5.1 Hake in GSA 22. Graphical representation of the main scenarios of the short term forecast.

6.15.6 DATA DEFICIENCIES

No DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, and 2012. Catch-at-age data were provided only for the last quarter for 2013 2015 and 2017. No MEDITS surveys took place in 2002, 2007, 2009-2013, 2015 and 2017. In 2018 and 2020 the survey period was extended in September.

The landings as calculated from the DCF data (number of individuals multiplied by their somatic weight) do not correspond to the official landings reported. This issue is greater for the years 2003-2006 and fades out after 2016.

Finally, the gears of the small-scale coastal fleet (GTR, GNS, LLS) are reported aggregated before 2014 and separately afterwards. However, because of the recent increase in the proportion of the small-scale fleet in the official landings of hake because of the addition of an extra fleet, the landings of these gears were included aggregated in the present assessment.

6.16 RED MULLET IN GSA 22

6.16.1 Stock Identity and Biology

GSA 22 has been considered as a unique area for management purposes due to its specific geo-physical characteristics and its separation from nearby areas, such as GSA 23 (Crete), through the Cretan Sea which is a deep (2500m) and large in volume particularly oligotrophic basin (Psarra et al., 1996; Lykousis et al., 2002). In addition, fishery exploitation patterns differ between the two nearby areas, with the trawling activities being much less intense in GSA 23.

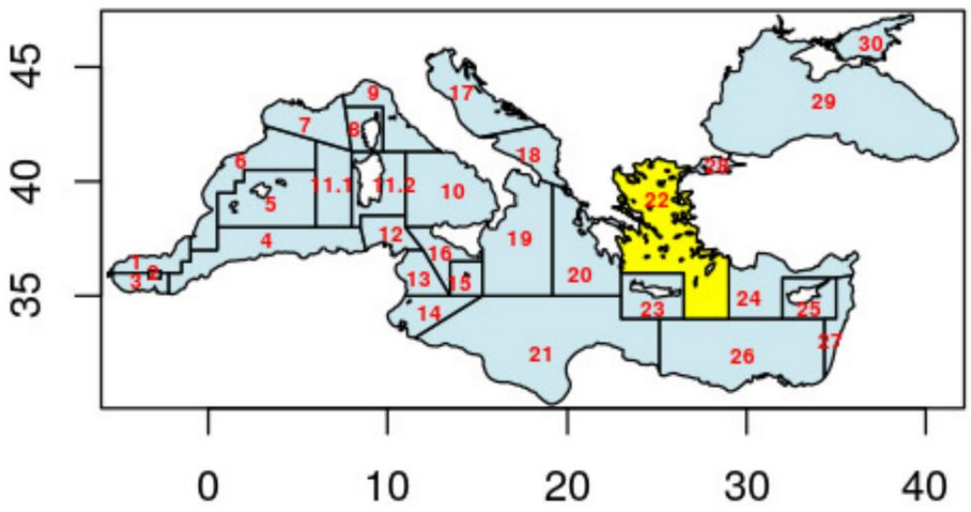


Figure 6.16.1.1. Geographical location of GSA 22.

Biological information on growth, i.e. the von Bertalanffy parameters, from DCF for this area was not consistent throughout the years. EWG 22-16 decided to apply growth parameters from Carbonara et al., (2018), which are already applied in GSAs 17,18 (EWG 21-15) without t0 correction. To explore the applicability of this growth model on the GSA22 data, the MEDITS Length frequency distributions per sex was used (Figure 6.16.1.2). This exploration highlighted that the mean lengths at age are in line with the monthly LFDs observed from MEDITS, confirming the applicability of Carbonara et al., (2018) to GSA22 data.

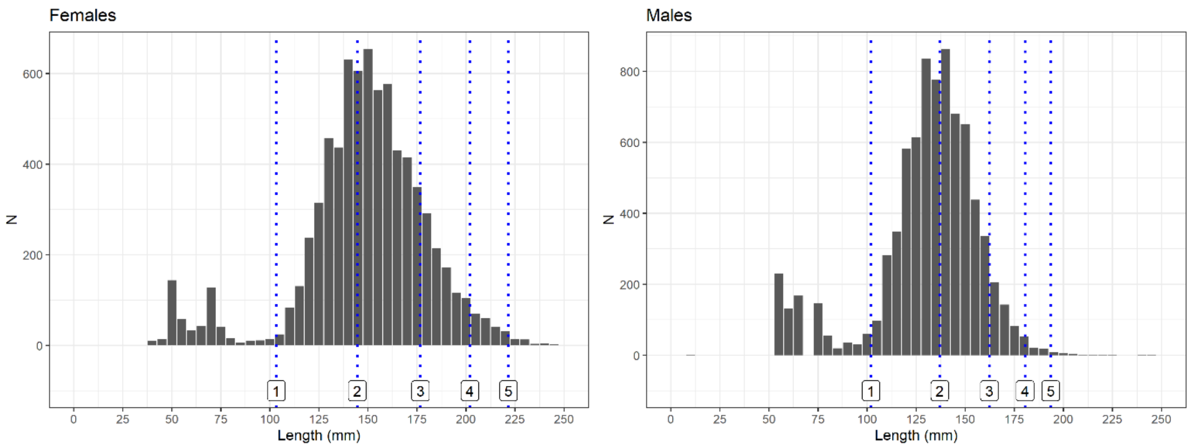


Figure 6.16.1.2. Red mullet in GSA 22. MEDITS Length frequency distribution for females and males. The blue vertical lines correspond to the ages estimated using the Carbonara et al. (2018) growth models.

Table 6.16.1.1 Red mullet in GSA 22. Von Bertalanffy growth (VBGF) and length-weight relationship parameters.

	VBGF			Length/weight	
	L_{oo}	k	t_0	a	b
F	29.185	0.247	-0.768	0.00895	3.10014
M	22.725	0.328	-0.816	0.00868	3.10392

Following the common decision made for all red mullet stocks during previous STECF EWGs, the vector of proportion of mature individuals was the one reported in Table 6.16.1.2. The natural mortality vector was estimated by using the Chen and Watanabe model on growth parameters listed in Table 6.16.1.1.

Table 6.16.1.2. Red mullet in GSA 22. Proportion of mature and natural mortality (M) at age per sex

Age	0	1	2	3	4
Maturity	0	1	1	1	1
$M_{Females}$	0.92	0.58	0.45	0.40	0.34
M_{Males}	0.94	0.62	0.49	0.43	0.4

6.16.2 Data

6.16.2.1 Catch (landings and discards)

In GSA22, red mullet is exploited mainly by bottom trawlers, as well as from gillnets and trammel nets from artisanal fisheries. Red mullet catches in GSA 22 are primarily coming from Greek fishing vessels, while catches from Turkish fisheries are also reported in GFCM. Greek bottom trawl catches usually represent 60-70% of the total Greek catch.

Trends in landing estimates by national fishery are shown in Figure 6.16.2.1.1. In the case of the Greek fisheries, landing estimates were obtained from two different independent sources: (a) the DCF and (b) the Hellenic Statistical Authority (reported also in GFCM). Given that there are gaps in DCF data due to inconsistencies in the implementation of the DCF, the Hellenic Statistical Authority (HELSTAT) data were used. It must be noted that HELSTAT data were available separately for bottom trawlers, purse seiners, beach trawlers and small-scale fisheries, without distinguishing the fishing gear in the latter. HELSTAT data before 2016 were corrected based on Tsikliras et al. 2020. Hence total landings in GSA22 were considered as the sum of the Greek and Turkish landings (Table 6.16.2.1.1).

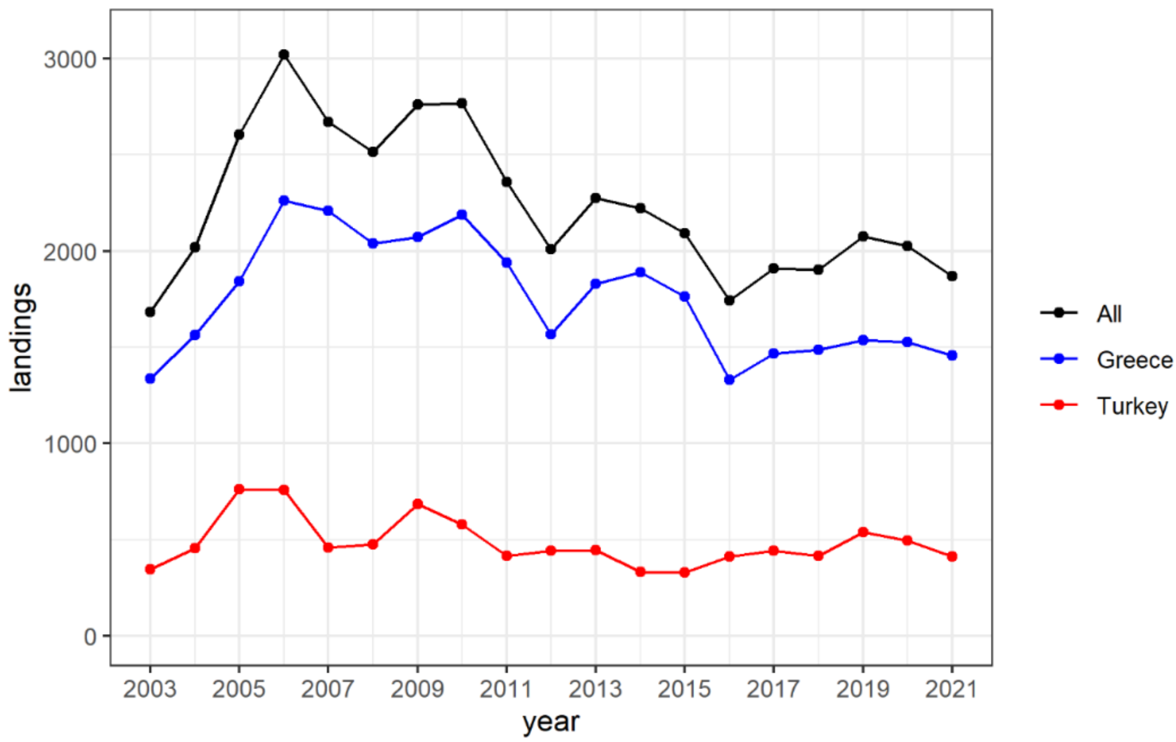


Figure 6.16.2.1.1 Red mullet in GSA 22. Landings (t) by national fishery.

Table 6.16.2.1.1 Red mullet in GSA 22. Landings in GSA 22. Greek data derive from HELSTAT and Turkish data from TURKSTAT.

	GREECE				TURKEY	
Year	**OTB**	**SSF**	**PS**	**SB**	**ALL**	**TOTAL LANDINGS**
2003	791	452	10	85	345	1683
2004	1026	464	11	63	456	2019
2005	1022	774	6	40	762	2605
2006	1304	879	17	63	757	3020
2007	1227	927	8	47	460	2669
2008	925	1056	3	54	475	2513
2009	973	1043	3	55	687	2761
2010	1204	951	2	31	578	2766
2011	994	890	12	43	417.3	2358
2012	918	590	42	16	444.2	2010
2013	972	783	62	14	445.6	2276
2014	951	876	50	13	331.6	2222
2015	930	760	63	9	328.9	2092
2016	834	448	45	4	411.5	1742
2017	988	469	6	5	442.5	1910
2018	904	566	5	12	414.9	1902
2019	995	528	1	14	537.8	2075
2020	976	540	1	9	497.5	2024
2021	956	501	0		412.8	1870

DCF LFDs had several gaps (2007, 2009-2012) and in some years data were only partially collected (2013, 2015). In 2017, a LFD for OTB was available and to include this information, the LFDs for GNS and GTR were reconstructed by using the 2016, 2018 data.

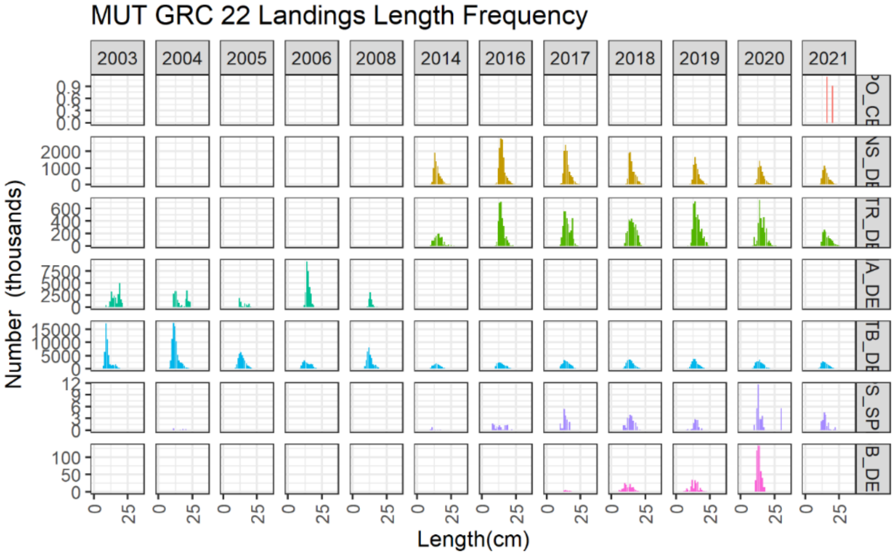


Figure 6.16.2.1.2 Red mullet in GSA 22. Length frequency distribution per métier and year from DCF.

Figure 6.16.2.1.3 illustrates the length frequency distributions of the total GSA 22 landings, assuming that the size composition of the Turkish catches is similar to the Greek ones. Catches are dominated by specimens up to 20cm length.

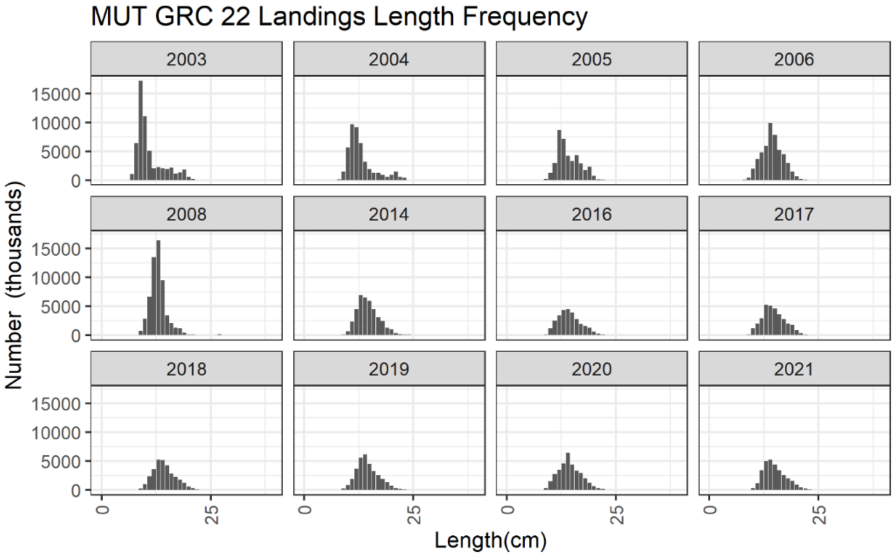


Figure 6.16.2.1.3. Red mullet in GSA 22. Length frequency distribution of the GSA 22 landings by year.

Discards for red mullet are negligible (<1% in terms of weight in 2021). Nevertheless, they were included in the assessment. For years 2007, 2009-2013 and 2015 where no discard values were reported, the mean discard ratio of the remaining years was applied on the corresponding landings to estimate yearly discard weight.

Table 6.16.2.1.2 Red mullet in GSA 22. Total Discards.

Year	Discards
2003	78.59
2004	31.35
2005	45.34
2006	4.45
2007	48.91
2008	22.59
2009	45.90
2010	48.44
2011	42.95
2012	34.66
2013	40.52
2014	23.86
2015	39.02
2016	26.11
2017	52.48
2018	39.45
2019	51.38
2020	16.80
2021	14.92

In Figure 6.16.2.1.4 the length frequency distributions of the total GSA 22 discards are presented.

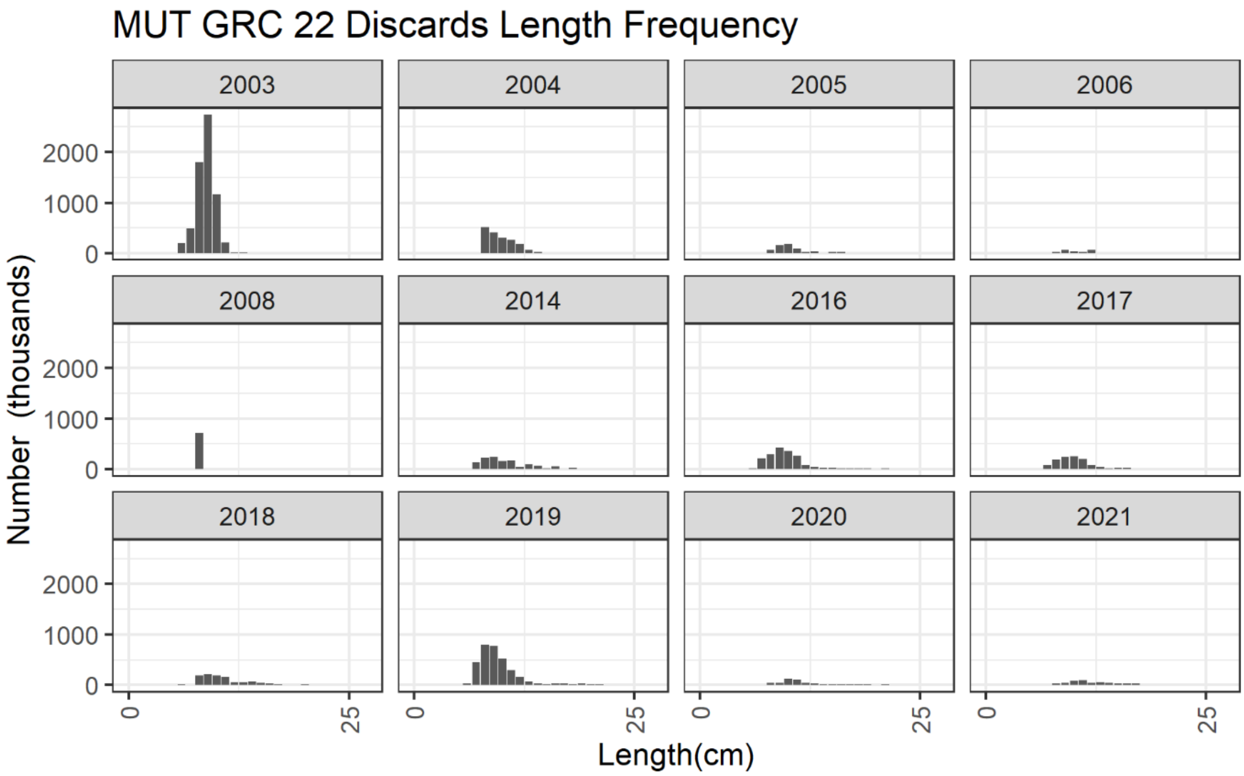


Figure 6.16.2.1.4. Red mullet in GSA 22. Length frequency distribution of the GSA 22 discards by year.

6.16.2.2 Effort

The effort in GSA22 is available only for the Greek fishing fleet since 2013, from the FDI data call. In 2013 and 2017 the effort for small scale fisheries is not available, due to inconsistencies in the DCF program implementation in Greece, while in 2015, the effort for small scale fisheries is available only for the last quarter of the year. Beach seiners, a fishery with a special license in Greece, didn't operate in 2021 and prior to 2016. A small reduction in the total effort is noticed in the last two years (2020, 2021) probably due to the coved pandemic.

Table 6.16.2.2.1 Red mullet in GSA 22. The effort of the Greek fishing fleet in GSA22 in fishing days.

year	FPO	GNS	GTR	LLS	OTB	PS	SB	Total
2013					38792	31447		70239
2014	92243	359862	528159	220875	38392	33075		1272606
2015	13411	89687	155567	85067	38348	34934		417014
2016	46311	347566	528235	276635	37896	37713		1274356
2017					39185	35692	4505	79382
2018	63659	377288	563223	240756	38353	35551	8294	1327124
2019	61066	305780	553093	217254	37429	35114	8456	1218192
2020	51131	251769	435106	259565	36533	31166	3523	1068793
2021	60265	259299	489760	181975	36754	26013		1054066

6.16.2.3 Survey data

Since 1994, MEDITS trawl surveys has been regularly carried out yearly during summer. In some cases, sampling was extended in September (Figure 6.16.2.3.1). However, due to inconsistencies in DCF implementation the survey was not accomplished in 2007, 2008-2012, 2015, 2017, while it was partially accomplished in 2013. According to the MEDITS protocol, a random stratified sampling scheme by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m) was applied. Survey stations are presented in Figure 6.16.2.3.2. Survey abundance and biomass data were standardized to square kilometer, using the swept area method, following the MEDITS protocol procedures. Data were analysed using the JRC script (Mannini, 2020).

Observed abundance and biomass indices of red mullet, as well as the length frequency distributions are given in figures 6.16.2.3.3 - 6.16.2.3.4. Both abundance and biomass indices display very high values in the last four years of the survey. It was also decided to exclude haul 225 from 2014, due to the opportunistic catch of newly born individuals (<5cm) resulting in very high (not representative) abundance values.

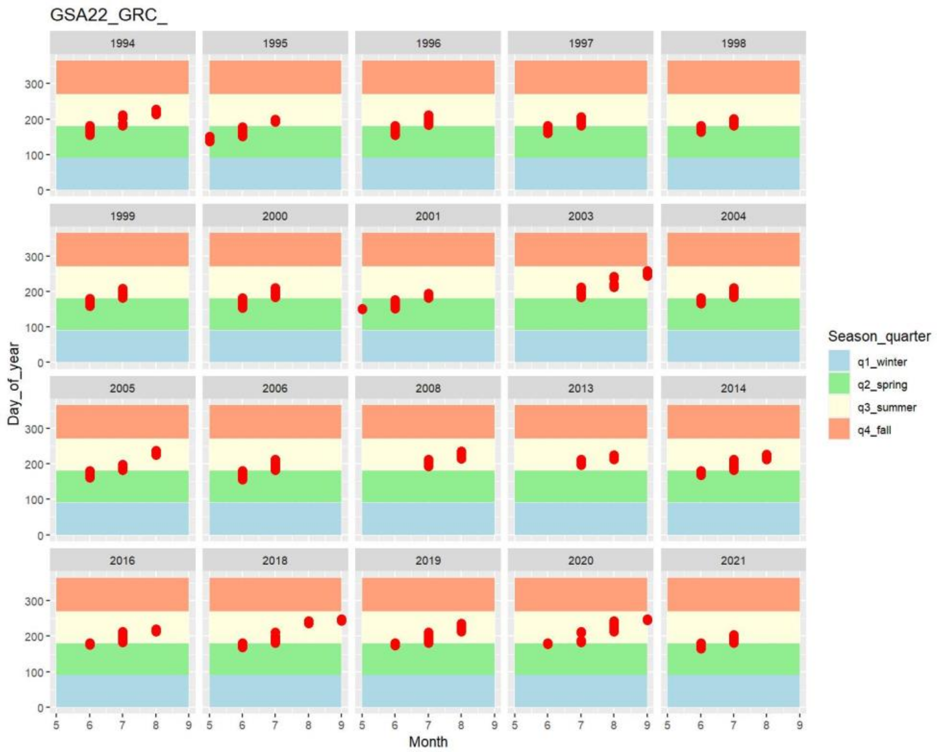


Figure 6.16.2.3.1. Red mullet in GSA 22. Month of the year when the hauls of MEDITS surveys were conducted in GSA 22.

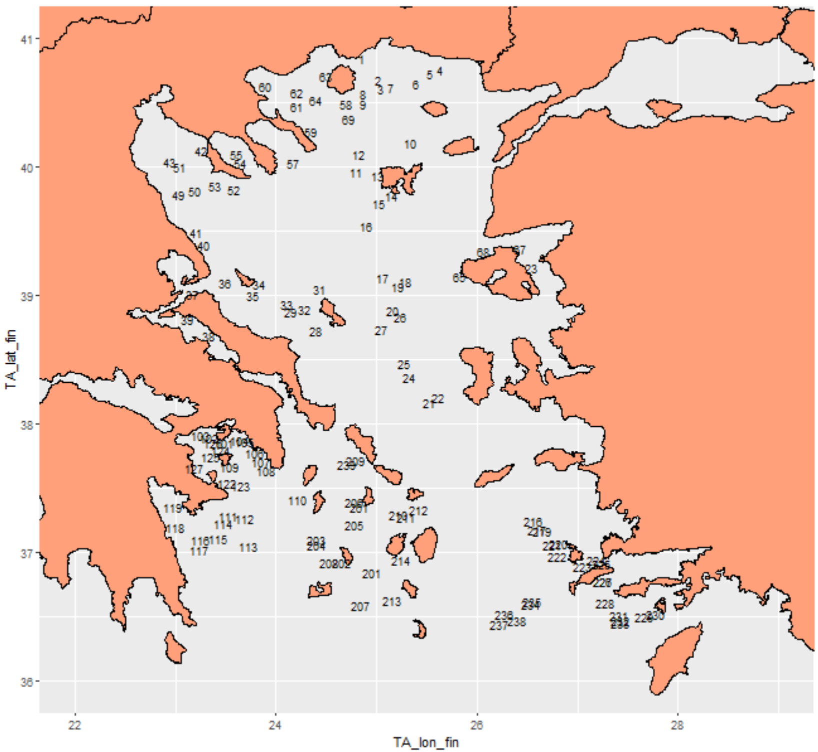


Figure 6.16.2.3.2. Red mullet in GSA 22. Distribution of MEDITS stations in GSA 22 for 2021.

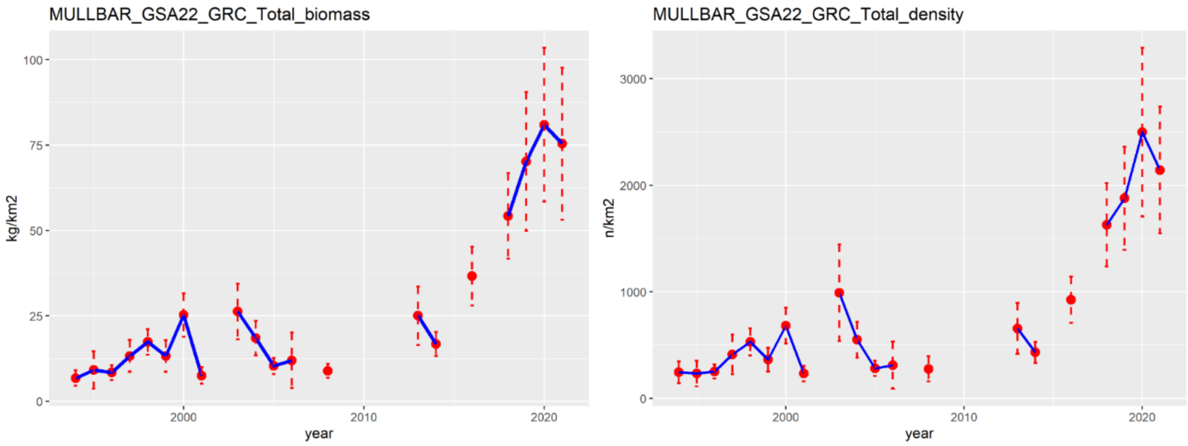


Figure 6.16.2.3.3 Red mullet in GSA 22. Estimated biomass (kg/km2) (left), and abundance (N/km2) (right) indices over the 1994-2021 period. Gaps (2002, 2009-2012, 2015 & 2017) correspond to the years the survey was not accomplished.

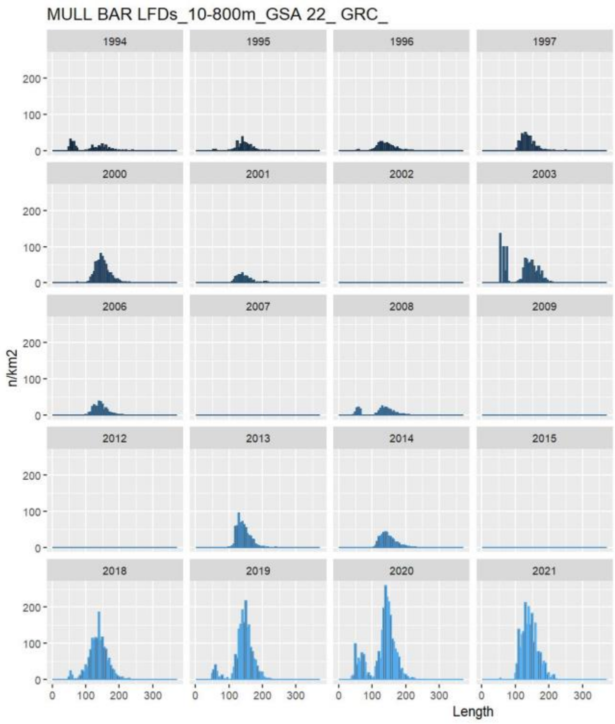


Figure 6.16.2.3.4. Red mullet in GSA 22. Length frequency distribution of the MEDITS survey abundance index (n/km^2).

6.16.3 Stock Assessment

This stock was previously assessed by the STECF EWG in 2020 (STECF EWG 20-15) using a4a and SPiCT. Since then, DCF data, including landings and discard lengths as well as MEDITS data were subjected to various changes/improvements based on various data quality checks. As a result of these changes and probably due to the addition of the 2020 and 2021 data, the STECF EWG 20-15 model configuration for a4a, as well as other model aspects, such as the growth model applied, maturity, etc., couldn't produce on the new dataset as reliable outputs as in the past.

In the EWG 22-16 the statistical catch-at-age modelling framework - Assessment for all (a4a, Jardim et al., 2014) in FLR (http://www.flr-project.org/) was used to assess the status of red mullet in GSA 22.

a4a Input data and parameters

Catch-at-age estimates were based on the catch-at-length data for the years 2003 onwards, based on information from the Greek DCF. The estimates covered all national fleets operating in GSA 22 (see section 6.16.2.1). Discards, although negligible, were included in the stock object. The MEDITS abundance index by age, expressed in terms of N/km^2 was used for tuning purposes. As already mentioned (section 6.16.2.1), important gaps exist in catch at size and survey data due to inconsistencies in DCF implementation. Growth, maturity and natural mortality parameters were those presented in section 6.16.2.1. Catch data were SOP corrected using the ratio between total catch and SOPs at year.

The catch at age matrices are shown on Tables 6.16.3.1.1 and 6.16.3.1.2 for the catch and survey data respectively and the relevant trends are illustrated in Figure 6.16.3.1.1. Relatively good consistency is observed between cohorts particularly in the survey data (Figure 6.16.3.1.2). In Table 6.16.3.1.3 the mean weights-at-age for the stock and for the catch are reported. The M and F before spawning were set equal to 0.5 and an Fbar range 1-3 was used.

Table 6.16.3.1.1 Red mullet in GSA 22. Catch numbers at age obtained from sliced LFDs (in thousands).

Year	0	1	2	3	4+
2003	43644.75	32631.57	9319.63	5738.91	2199.34
2004	3549.15	45965.10	9774.31	3125.25	5504.03
2005	809.75	36087.19	21782.67	10519.67	3350.91
2006	955.11	25980.70	37756.31	11076.17	3326.32
2007					
2008	2234.75	61600.04	23619.75	3961.08	1225.86
2009					
2010					
2011					
2012					
2013					
2014	898.83	20433.42	23873.81	7872.81	3505.88
2015					
2016	1414.75	18868.24	17926.10	6331.00	2640.66
2017	774.03	16940.16	19892.16	7694.71	3165.68
2018	5150.68	19468.01	19866.17	6658.48	2861.83
2019	2902.96	19889.10	22459.91	7465.12	3288.01
2020	712.32	18862.59	22261.08	7351.59	3094.13
2021	203.19	14072.70	18815.41	7082.27	3566.60

Table 6.16.3.1.2 Red mullet in GSA 22. MEDITS index at age (n/km^2) obtained from sliced LFDs.

Year	0	1	2	3	4+
2003	371.45	173.63	305.25	113.48	25.49
2004	0.68	265.86	205.06	55.79	23.10
2005	1.09	113.55	121.42	36.23	9.69
2006	1.33	139.10	134.57	26.90	10.25
2007					
2008	67.91	73.24	101.52	26.71	7.76
2009					
2010					
2011					
2012					
2013	0.21	269.81	300.52	76.11	8.47
2014	0.42	154.39	185.89	68.03	18.04
2015					
2016	2.27	261.53	455.00	164.77	42.49
2017					
2018	125.24	669.03	633.60	158.05	41.21
2019	144.18	437.95	975.10	267.65	52.55
2020	502.46	558.92	1096.75	284.24	56.89
2021	5.11	905.41	848.97	316.25	67.39

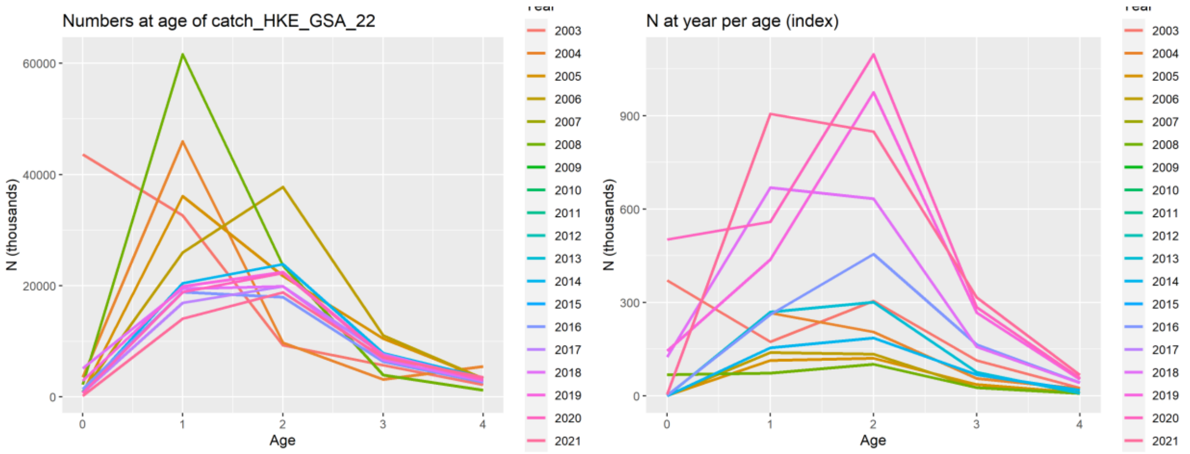


Figure 6.16.3.1.1 Red mullet in GSA 22. Numbers at age in landings (left) and the survey (right).

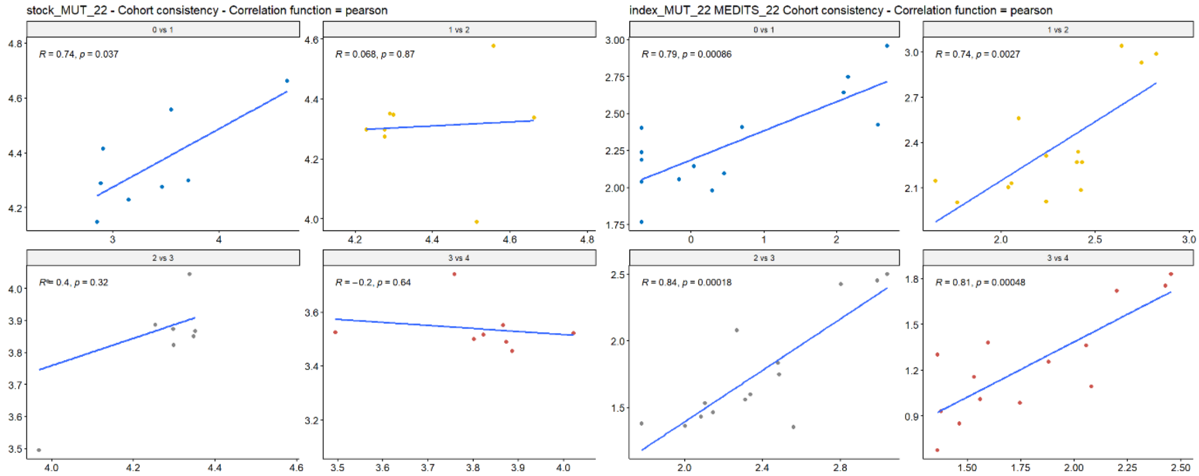


Figure 6.16.3.1.2 Red mullet in GSA 22. Internal consistency in the catches (left) and the index (right).

Table 6.16.3.1.3 Red mullet in GSA 22. Red mullet in GSA 22. Individual weight at age for the catch and stock (kg).

year	0	1	2	3	4+
2003	0.007	0.014	0.041	0.068	0.091
2004	0.008	0.018	0.039	0.065	0.113
2005	0.008	0.020	0.042	0.065	0.094
2006	0.008	0.020	0.040	0.063	0.094
2007	0.008	0.020	0.040	0.065	0.097
2008	0.008	0.020	0.036	0.062	0.123
2009	0.008	0.020	0.040	0.065	0.097
2010	0.008	0.020	0.040	0.065	0.097
2011	0.008	0.020	0.040	0.065	0.097
2012	0.008	0.020	0.040	0.065	0.097
2013	0.008	0.020	0.040	0.065	0.097
2014	0.007	0.021	0.040	0.063	0.101
2015	0.008	0.020	0.040	0.065	0.097
2016	0.007	0.020	0.040	0.065	0.098
2017	0.008	0.020	0.040	0.065	0.096
2018	0.007	0.020	0.040	0.065	0.099
2019	0.007	0.021	0.040	0.065	0.097
2020	0.008	0.020	0.040	0.064	0.100
2021	0.007	0.022	0.040	0.065	0.102

Results

Different combinations of F, q and stock-recruitment sub-models were explored. However, all model combinations displayed a consistent pattern in the residuals in the last years of the index at-age, were the models fail to predict the very high values of the MEDITS survey (see Figures 6.16.2.3.3 and 6.16.3.2.8). To explore whether it was possible to fix this inconsistency, different stock recruitment sub-models were applied, and the behavior of each model was examined and cross-compared.

The following sub-models were employed:

Fishing mortality: ~s(replace(age,age>3,3),k=3)+s(year,k=6)+s(year,k=6,by= as.numeric(age==0))

Survey catchability: list(~ factor(replace(age,age>3,3)))

Stock-recruitment1: ~geomean(CV=0.30)

Stock-recruitment2: ~geomean(CV=0.40)

Stock-recruitment3: ~geomean(CV=0.50)

Stock-recruitment4: ~geomean(CV=0.60)

Stock-recruitment5: ~geomean(CV=0.70)

Stock-recruitment6: ~ s(year, k=6)

In Figure 6.14.3.2.1 the fitting of each model to the index in comparison to the observed values is presented. In general, fitting to the last years of the survey seem to be improved slightly as the geomean CV of the sr sub-model increases, while the best fitting, at least for years 2019-2020 correspond to the Stock-recruitment6: s(year, k=6) sr sub-model. However, as it is obvious in the Figures 6.16.3.2.2 and 6.16.3.2.3, good fitting to the last years data for Stock-recruitment6 model is achieved through very high recruitment values resulting in unrealistically high SSB increase (about 7-8 times higher in 5 years' time). Nevertheless, the fitting of all the models to the catch (Figure 6.16.3.2.4) is similar, apart from the years 2009-2013 where no catch data were available. Additionally, for all the models applied fbar/$F_{0.1}$ for the last two years is below 1, indicating that the stock is now probably being exploited sustainably regardless the stock recruitment sub-model we use.

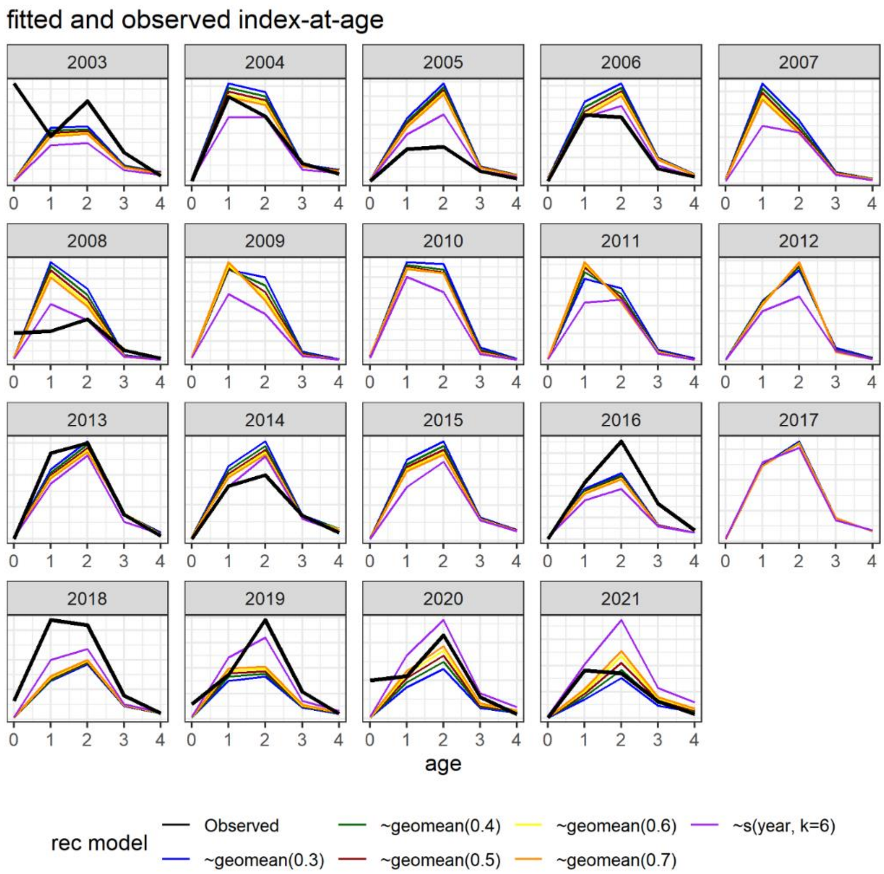


Figure 6.16.3.2.1 Red mullet in GSA 22. Observed and fitted index-at-age for the different sr models explored

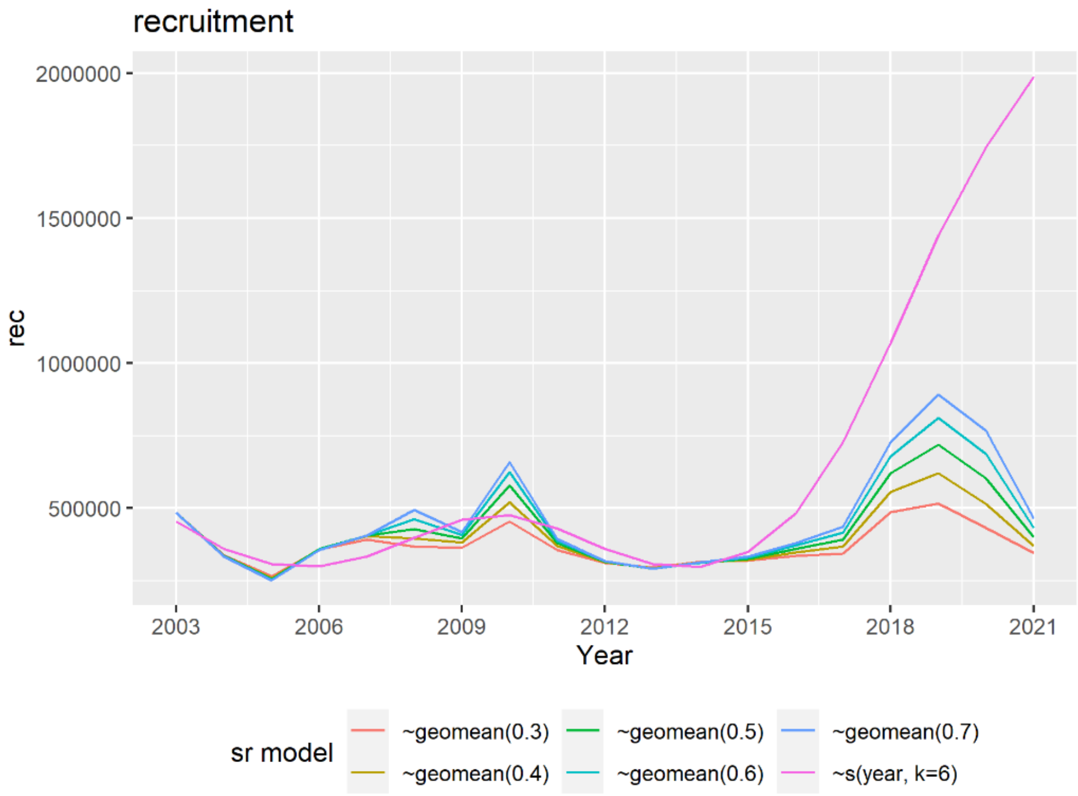


Figure 6.16.3.2.2 Red mullet in GSA 22. Recruitment for the different sr sub-models explored

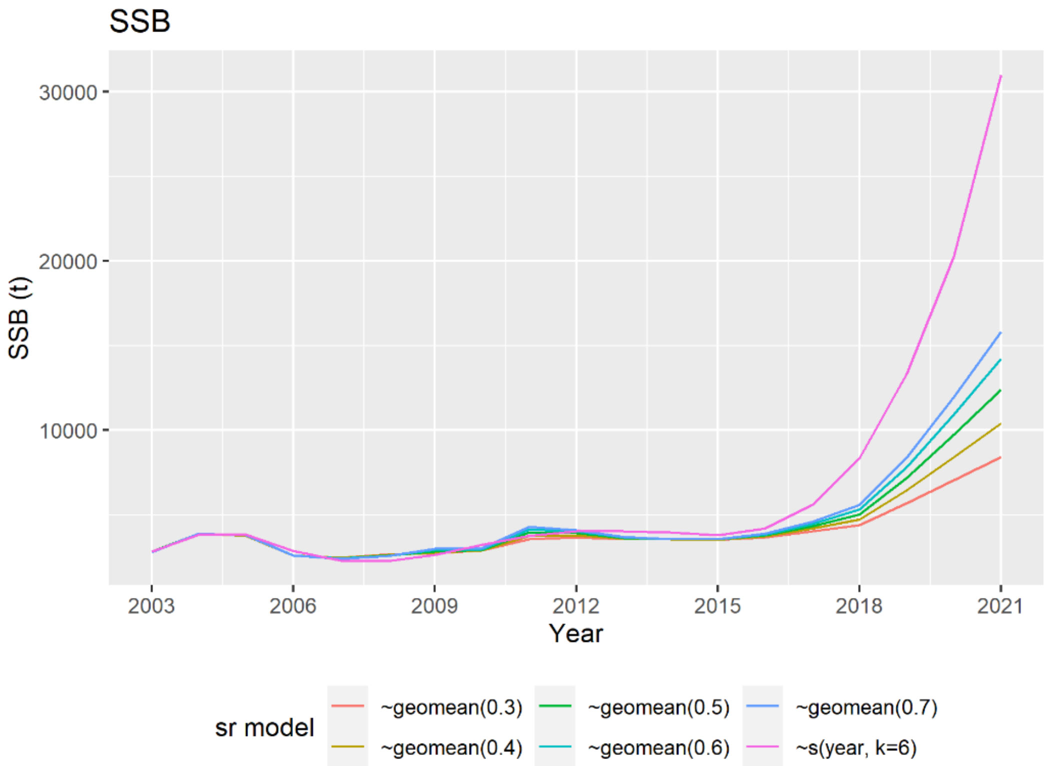


Figure 6.16.3.2.3 Red mullet in GSA 22. SSB for the different sr sub-models explored

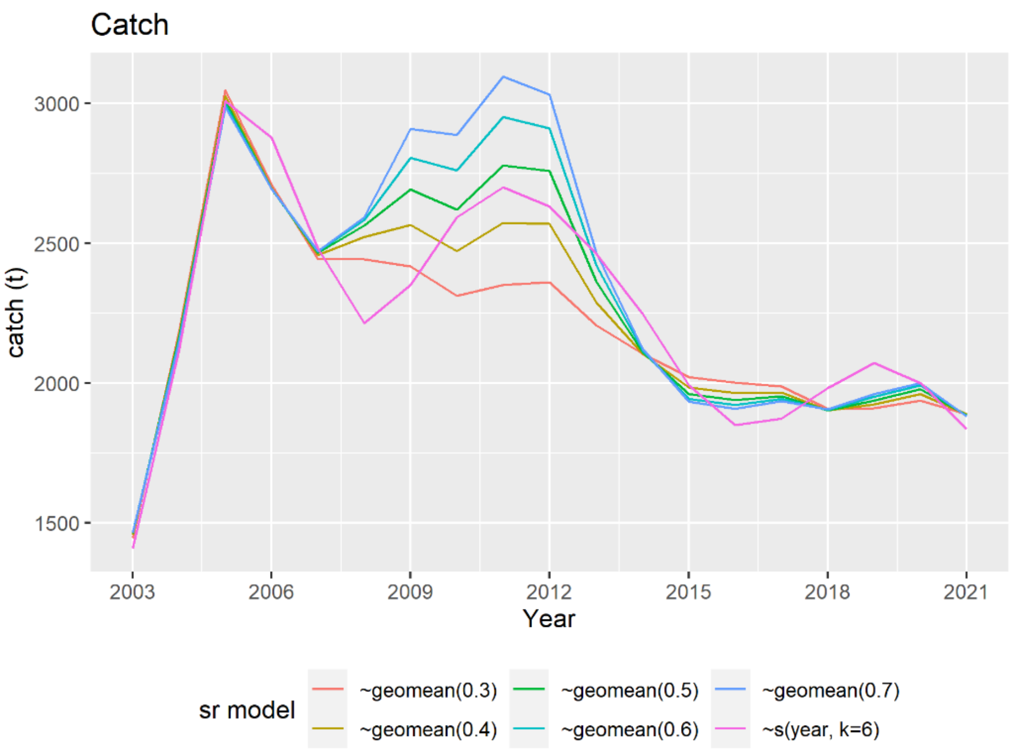


Figure 6.16.3.2.4 Red mullet in GSA 22. Catch for the different sr sub-models explored

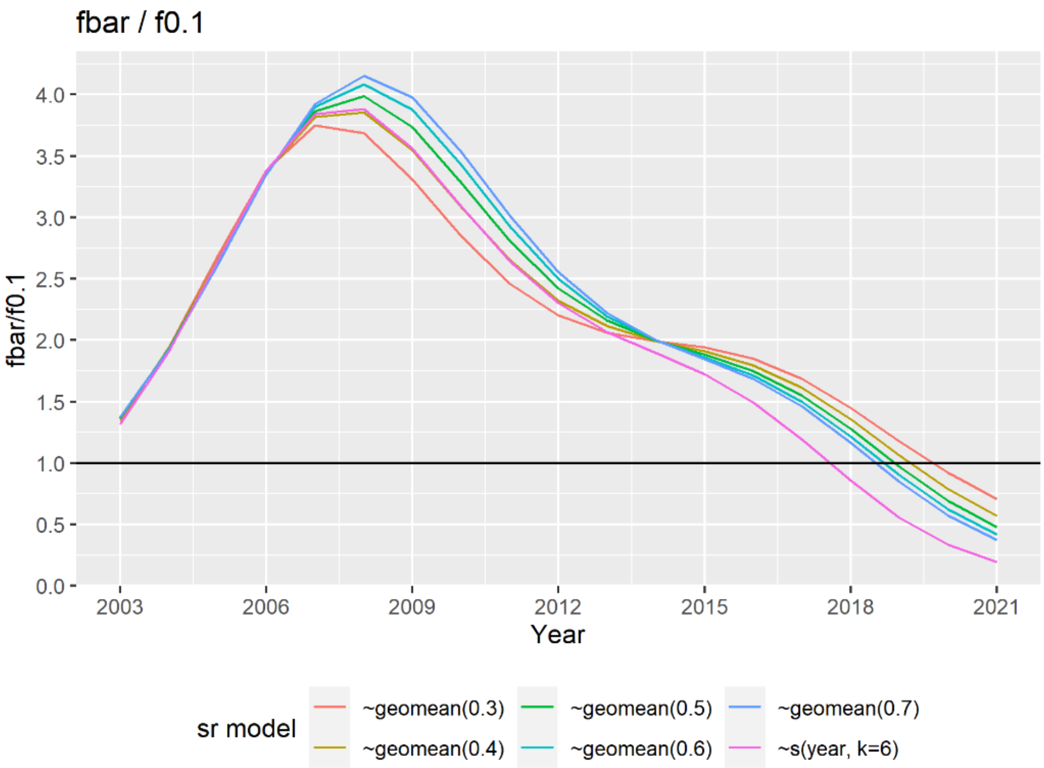


Figure 6.16.3.2.4 Red mullet in GSA 22. Fbar/$F_{0.1}$ for the different sr sub-models explored

Based on the above exploration, it was decided not to select Stock-recruitment6 model which produces unrealistically high values of SSF and recruitment. Taking also into account that Stock-recruitment1 model displayed the lowest AIC value from the geomean(CV) models (Table 6.16.3.2.1) , it was decided to select Stock-recruitment1 as the final, optimal compromise for model fitting.

Table 6.16.3.2.1 Red mullet in GSA 22. AIC values for the different sr sub-models applied.

model	**AIC**
Stock-recruitment1	280.38
Stock-recruitment2	286.83
Stock-recruitment3	291.64
Stock-recruitment4	295.49
Stock-recruitment5	298.7
Stock-recruitment6	256.78

Summary results from the final a4a model are presented in Figures 6.16.3.2.5, 6.16.3.2.6 and Tables 6.16.3.2.2 -6.16.3.2.4. In the last decade, catches show a rather stable pattern, while SSB is increasing. In the most recent years, recruitment is at historically high levels, but it decreases since 2019. Since 2008, fishing mortality shows decreasing trends.

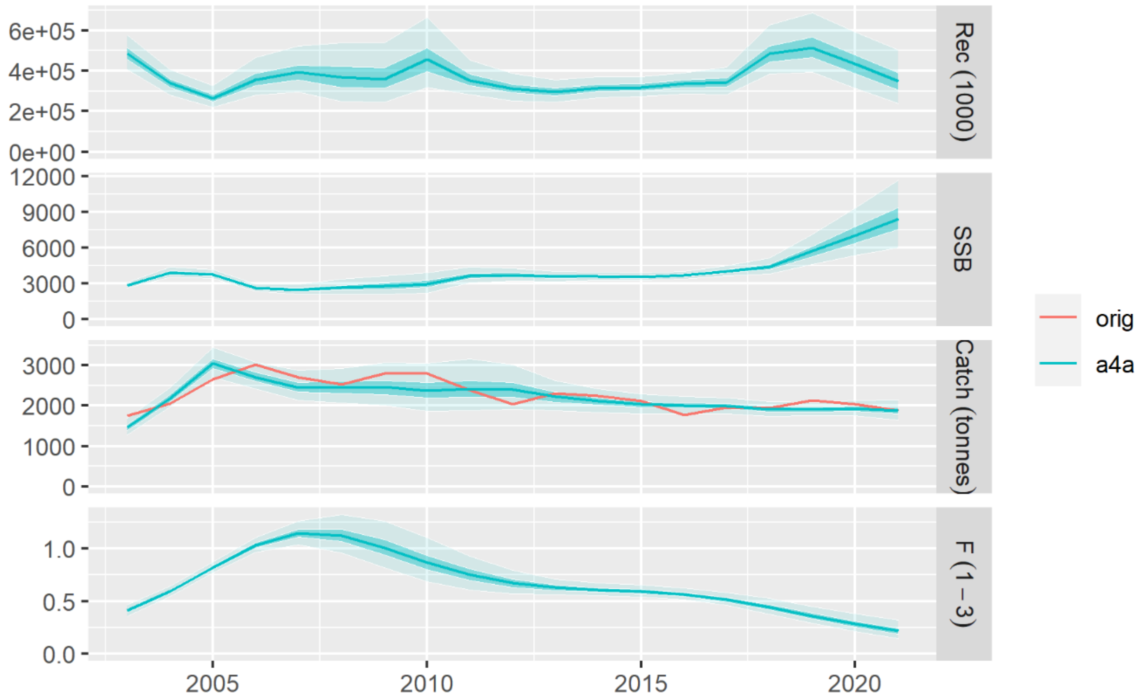


Figure 6.16.3.2.5 Red mullet in GSA 22, Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. The blue line corresponds to the observed catches.

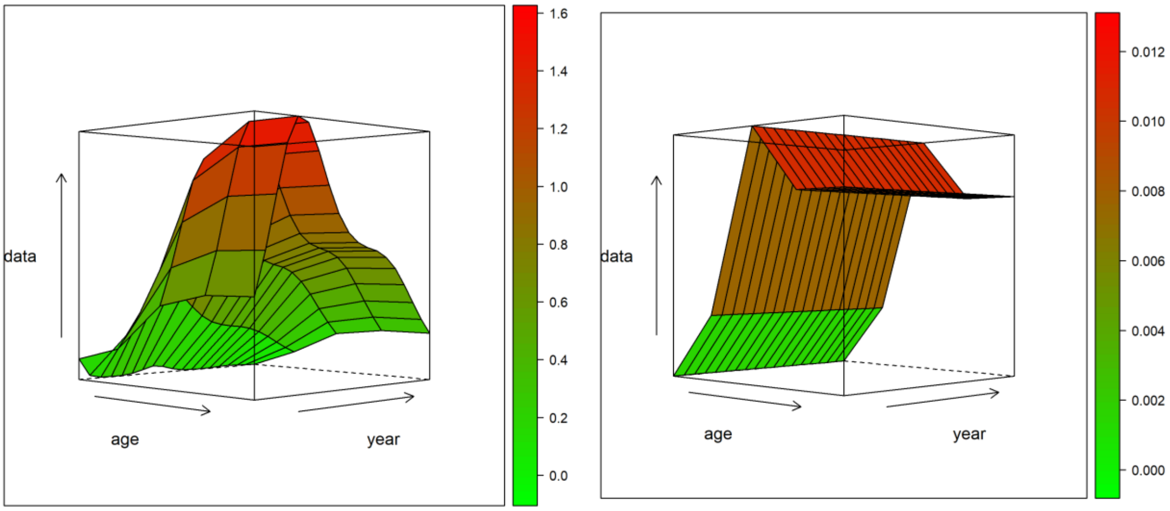


Figure 6.16.3.2.6 Red mullet in GSA 22: Fishing mortality and catchability by age and year

Table 6.16.3.2.2 Red mullet in GSA 22. Recruitment, SSB, Fbar (1-3) and Catch estimates from the final a4a model. Recruitment is in thousands.

Year	Recruitment	SSB (t)	Fbar	Catch (t)
2003	483971	2817	0.41	1447
2004	337548	3899	0.59	2183
2005	266552	3750	0.82	3048
2006	358710	2603	1.03	2710
2007	393205	2462	1.14	2442
2008	368743	2642	1.12	2444
2009	365134	2726	1.01	2417
2010	455056	2902	0.87	2311
2011	356303	3556	0.75	2351
2012	311622	3667	0.67	2360
2013	296482	3564	0.63	2206
2014	315267	3566	0.61	2106
2015	319227	3532	0.59	2021
2016	336544	3668	0.56	2002
2017	343740	4013	0.51	1988
2018	486994	4389	0.44	1908
2019	517250	5686	0.36	1909
2020	432920	7038	0.28	1938
2021	345755	8408	0.21	1888

Table 6.16.3.2.3 Red mullet in GSA 22. Estimates of stock numbers at age from the final a4a model, in thousands

year	0	1	2	3	4+
2003	483971	106021	30931	12912	7713
2004	337548	168357	47272	12122	8153
2005	266552	130703	68336	14904	6310
2006	358710	104821	47261	16598	4817
2007	393205	141393	34051	8960	3656
2008	368743	154812	43374	5674	1865
2009	365134	144247	47974	7357	1139
2010	455056	140395	47393	9351	1494
2011	356303	171587	49554	10882	2300
2012	311622	135280	64320	13056	3276
2013	296482	120819	52786	18573	4512
2014	315267	116300	48189	16026	6752
2015	319227	124138	46874	14960	6869
2016	336544	125760	50433	14843	6728
2017	343740	132402	51810	16456	6905
2018	486994	134810	55965	17938	7987
2019	517250	190660	59104	21048	9759
2020	432920	203067	87168	24460	12939
2021	345755	170639	96625	39542	17451

Table 6.16.3.2.4 Red mullet in GSA 22. Estimates of fishing mortality at age from the final a4a model.

year	0	1	2	3	4+
2003	0.128	0.21	0.47	0.54	0.54
2004	0.021	0.3	0.69	0.79	0.79
2005	0.005	0.42	0.95	1.09	1.09
2006	0.003	0.52	1.2	1.37	1.37
2007	0.004	0.58	1.33	1.52	1.52
2008	0.01	0.57	1.31	1.49	1.49
2009	0.028	0.51	1.17	1.34	1.34
2010	0.047	0.44	1.01	1.15	1.15
2011	0.04	0.38	0.87	1	1
2012	0.02	0.34	0.78	0.89	0.89
2013	0.008	0.32	0.73	0.83	0.83
2014	0.004	0.31	0.71	0.81	0.81
2015	0.004	0.3	0.69	0.79	0.79
2016	0.005	0.29	0.66	0.75	0.75
2017	0.008	0.26	0.6	0.68	0.68
2018	0.01	0.22	0.51	0.59	0.59
2019	0.007	0.18	0.42	0.48	0.48
2020	0.003	0.14	0.33	0.37	0.37
2021	0.001	0.11	0.25	0.29	0.29

Various model diagnostics are presented in Figures 6.16.3.2.7 - 6.16.3.2.9. The residuals are generally small (between -2.7 to 2.5). There is consistent pattern in the last years of index-at-age fitting where fitted values are systematically lower than the observed. The retrospective analysis (Figure 6.16.3.2.10) shows some instability regarding recruitment, but this is somehow expected, given the existing data gaps. Due to the above, the assessment is considered suitable to provide only qualitative changes and status quo F and catch on stock status.

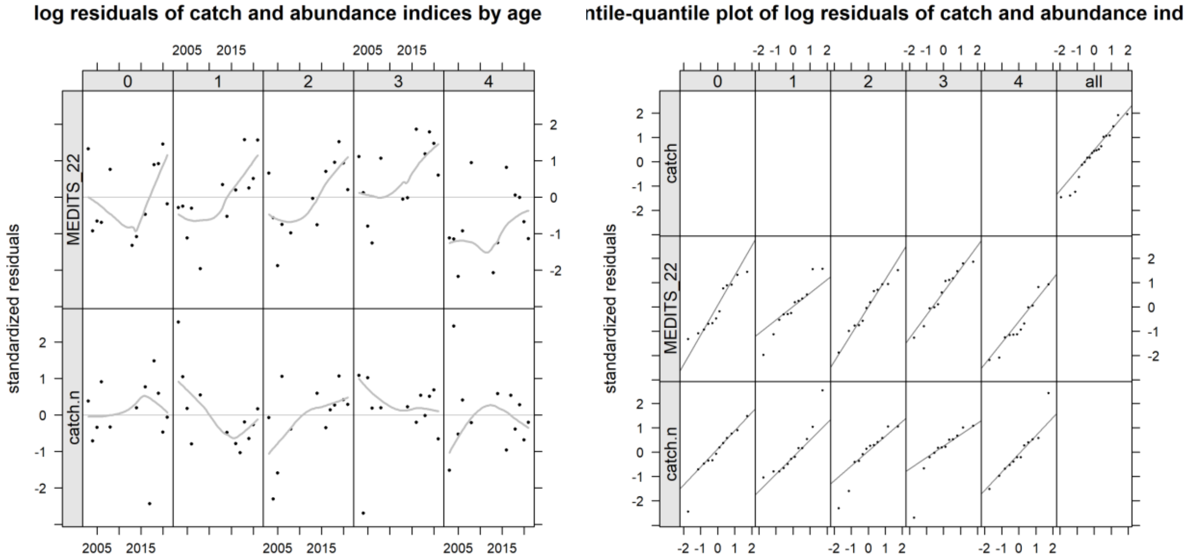


Figure 6.16.3.2.7 Log-residuals and qq-plots of catch and abundance indices (MEDITS) by age.

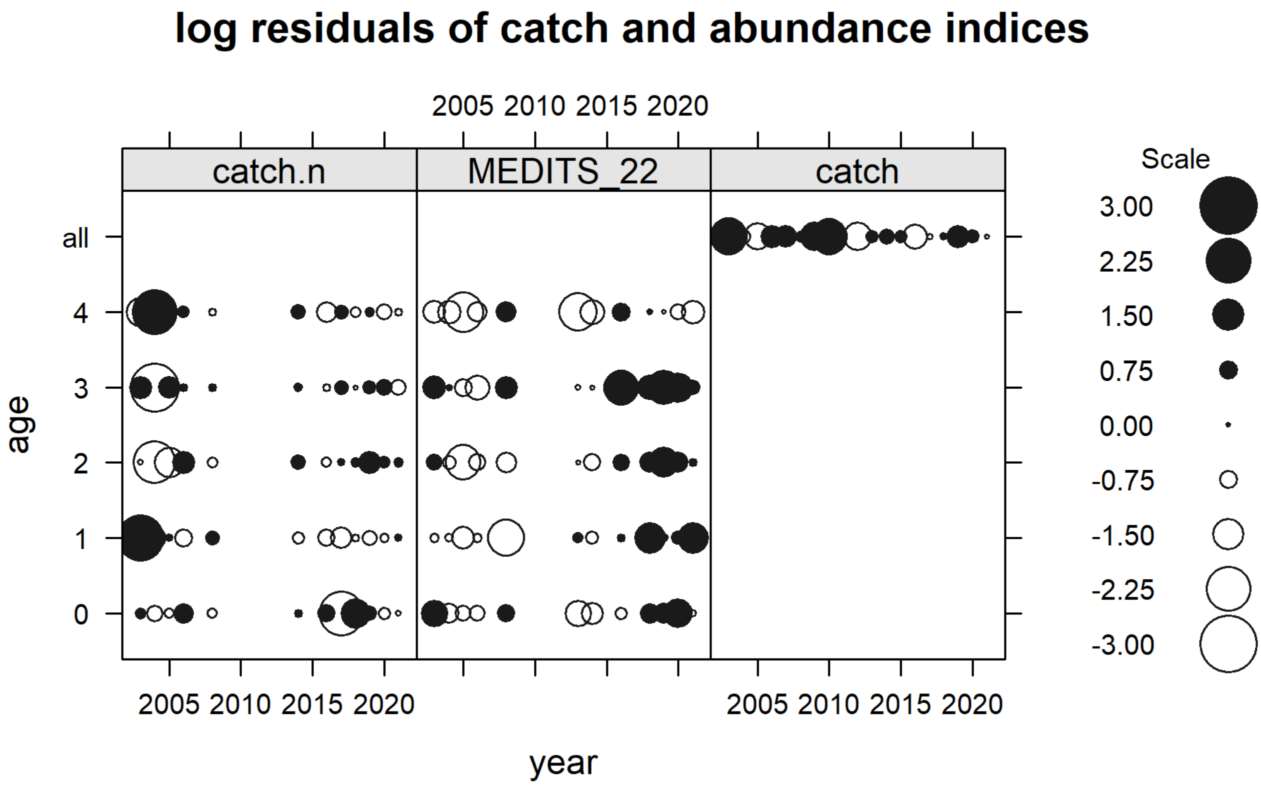


Figure 6.16.3.2.8 Bubble plot of log-residuals of catch and abundance indices (MEDITS) by age.

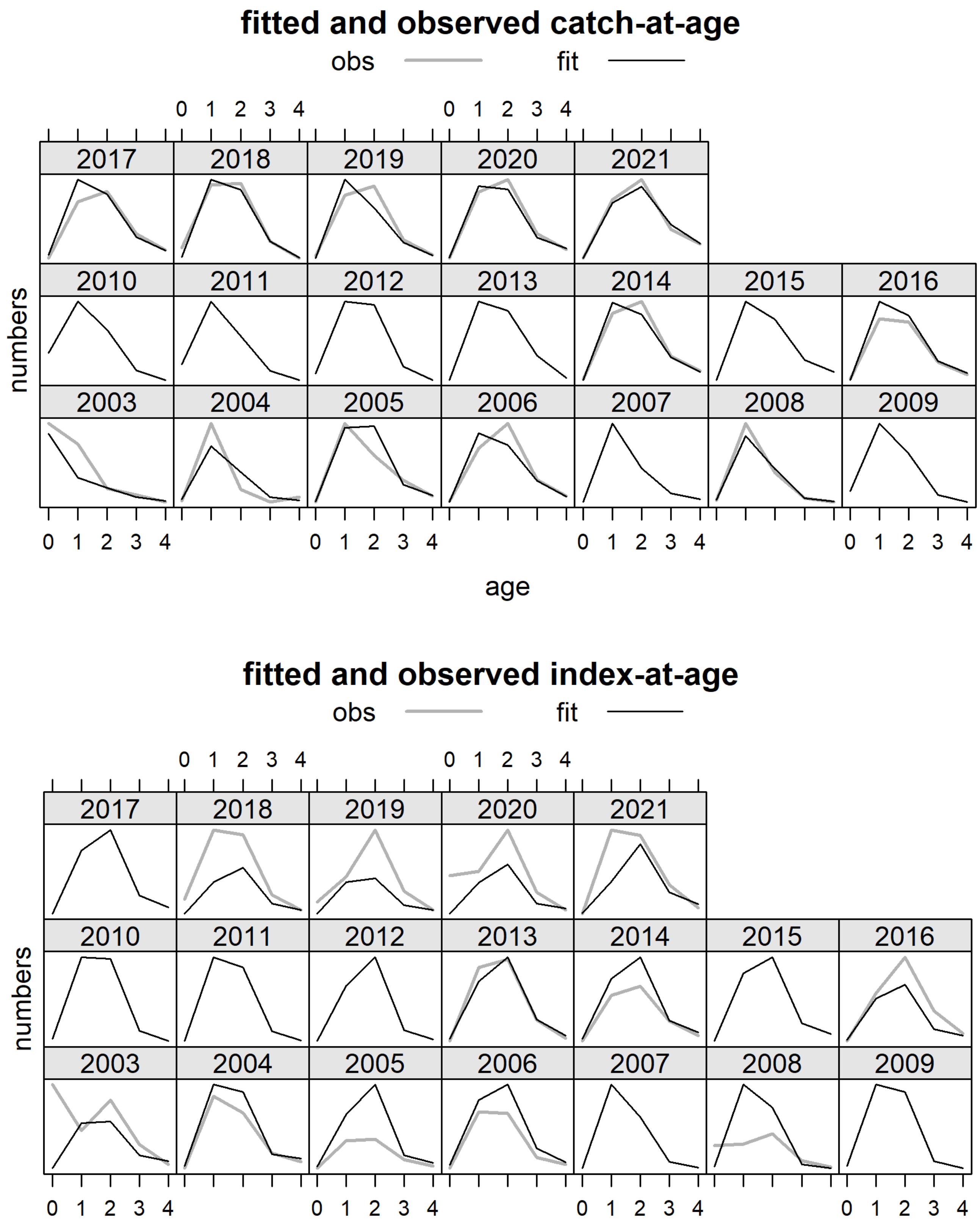


Figure 6.16.3.2.9 Comparisons between observed and fitted catch and index data at age.

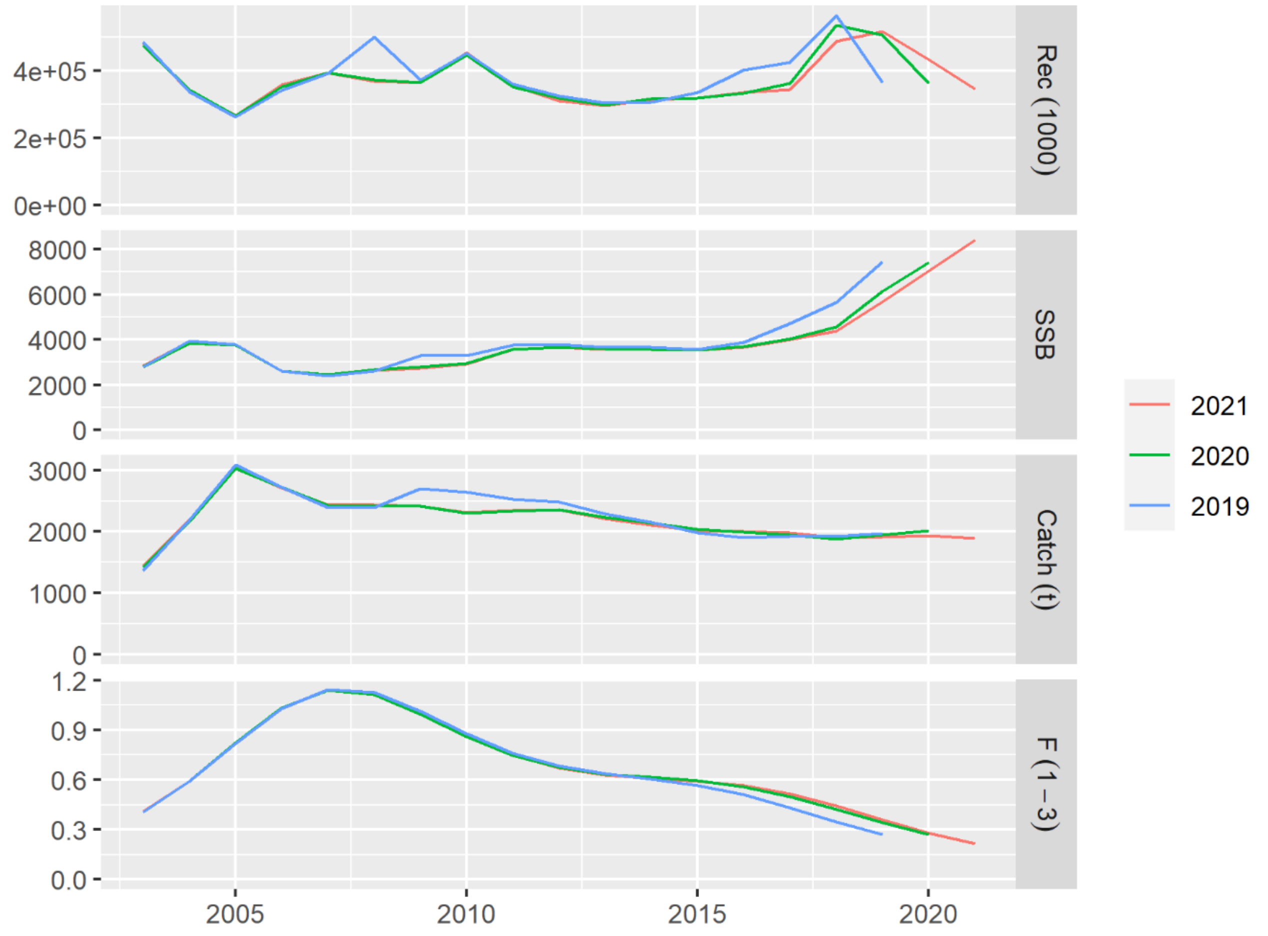


Figure 6.16.3.2.10 Red mullet in GSA 22. Retrospective analysis output.

Conclusion to the assessments

The a4a assessment, under each model explored, concluded that the stock is currently exploited sustainably; however, the magnitude of the under-exploitation is uncertain. This uncertainty possibly stems from contrasting trends between the tuning indexes (derived from MEDITS survey) with catch and recruitment during the last years. Due to this discrepancy, the model seems to be highly sensitive on the applied recruitment model; different recruitment models provide a wide range of possible model outcomes. However, since in all possible model combinations the value on fbar/ $F_{0.1}$ for 2021 is below 1, STECF EWG 22-16 decided to provide relative trends for stock outcomes based on the most reliable applied model.

6.16.4 Reference Points

Estimates of reference points were based on the a4a assessment and the $F_{0.1}$ was used as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object. Current Fbar= 0.21 (2021, mean($Fbar_{2019-2021}$)=0.285) is lower than $F_{0.1}$ (0.305), indicating that the red mullet stock in GSA 22 seems to be sustainably exploited.

6.16.5 Short term Forecast and Catch Options

A deterministic short-term prediction for the period 2022 to 2024 was performed using the FLR libraries and scripts and based on the results of the a4a stock assessment (Ch. 6.16.3) only to estimate status quo catch for based on status quo Fbar. Due to its declining trend, the last value of Fbar was used as status quo Fbar. (Table 6.16.5.1).

Table 6.16.5.1 Red mullet in GSA 22: Assumptions made for the interim year (2022) and in the STF forecast.

Variable	Value	Notes
Biological Parameters		mean weights at age, maturity at age, natural mortality at age and selection at age, based on average of 2019-2021
$F_{ages\ 1\text{-}3}$ (2022)	0.2149	F status quo (in the interim year 2022) is assumed the Fbar at 2022
SSB (2022)	8580t	SSB projection based on stock assessment
R_{age1} (2020)	404214	Recruitment will be set as geometric mean of the last 6 years (thousands)
Total catch (2021)	2063.56 t	Catch at F status quo

The results of the short-term forecasts for red mullet in GSA 22 are shown on Table 6.16.5.2. Under the F status quo = 0.215 (Fbar at 2021) the 2023 catch is expected to increase by about 11.55%.

Table 6.16.5.2 Short term forecast for red mullet in GSA 22. Catch and SSB estimates are in tonnes.

Basis	Total catch* (2023)	F_{total}# (ages 1-3) (2023)	SSB (2024)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	2851.35	0.305			50.99
$F_{MSY\ lower}$	2013.24	0.204			6.61
$F_{MSY\ upper}$**	3699.55	0.419			95.90
Other scenarios					
Zero catch	0	0			-100
Status quo	2106.62	0.215			11.55

6.16.6 Data Deficiencies

Several data gaps exist due to inconsistencies in the implementation of DCF. Some uncertainties exist on the volume of landings in the earlier years as different sources of information (DCF and Hellenic Statistical Authority) provide incompatible estimates. Besides, uncertainties exist regarding the adopted assumption in the a4a assessment that the unknown size composition of the Turkish catches is similar to the Greek ones.

6.17 Effort Data

ToR 1.3 *For GSA 17&18 to compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2021, based on the FDI database for the recent part and from prior Mediterranean & Black Sea Data calls for the older part. This should be described in terms of number of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size (linear and/or GT), engine power kW, etc.) by Member State/Country, vessel length and fishing gear. Data shall be the most detailed possible to support the implementation of a fishing effort management regime.*

Analysing the sources of information available for GSA17 and GSA18 on fishing effort, EWG 22-16 noted that for the recent years FDI data cover period 2013-2021 for all EU Member States concerned (e.g. Croatia, Italy and Slovenia). Prior to this period effort data indices are available from Mediterranean & Black Sea Data calls (MBS data) but for different periods. Data time series available from EU-MS is related to Member State accession to EU. Therefore, MBS data covering the Adriatic Sea (e.g. GSA17&18) are available from all Adriatic EU Member States from 2012 only (e.g. beginning of Croatian data set). Slovenian MBS data set start with year 2005 and Italian MBS data series start from 2002 year. However, data submitted by Italy to MBS Data calls for 2002 and 2003 are not complete (i.e. quarter, vessel lengths, number vessels = -1), therefore these two years (2002 and 2003) are excluded from further analyses as did before by EWG 20-15.

Beside data from three principal Adriatic (GSA17&18) EU Member States (HRV, ITA, SVN), data on fishing effort in GSAs 17&18 are occasionally reported by non-Adriatic EU Member States, such as Cyprus, France, Malta and Spain (Table 16.7.1). Due to low importance to exploitation of stocks in Annex 1, fishing effort from these countries were not included in further analyses. EWG 22-16 noted that some catch data from non-EU Adriatic countries were provided, but without related fishing effort. Therefore, effort analyses in GSAs 17&18 do not include fishing effort of fishing fleets from Albania and Montenegro.

Table 16.7.1 Data series available: Only data from Croatia, Italy and Slovenia analysed

	Adriatic EU-Member States						Other EU-Member States							
Year	Croatia (HRV)		Italy (ITA)		Slovenia (SVN)		Cyprus (CYP)		France (FRA)		Malta (MLT)		Spain (ESP)	
2004				MBS										
2005				MBS		MBS								
2006				MBS		MBS								
2007				MBS		MBS								
2008				MBS		MBS								
2009				MBS		MBS								
2010				MBS		MBS				MBS				
2011				MBS		MBS								
2012		MBS		MBS		MBS								
2013	FDI	MBS	FDI	MBS	FDI	MBS								
2014	FDI	MBS	FDI	MBS	FDI	MBS								
2015	FDI	MBS	FDI	MBS	FDI	MBS						MBS		
2016	FDI	MBS	FDI	MBS	FDI	MBS						MBS		
2017	FDI	MBS	FDI	MBS	FDI	MBS	FDI	MBS						
2018	FDI	MBS	FDI	MBS	FDI	MBS	FDI	MBS					FDI	
2019	FDI		FDI		FDI		FDI							
2020	FDI		FDI		FDI		FDI							
2021	FDI		FDI		FDI		FDI							

6.17.1 Fishing effort described in terms of number of vessels and boat sizes

In relation to task to provide fishing effort in GSA 17&18 on annual basis, in terms of number of vessels by Member states, vessel lengths and vessels fishing activity reported, EWG22-16 analysed FDI data (Table J) as a source of information for the most recent period (2013-2021). However, EWG 22-16 noted that information in FDI Table J are not related to fishing gears, but to fishing activities. Therefore, EWG22-16 used the information from FDI Table J in order to describe fishing effort in terms of number of vessels on annual basis in the most recent period (2013-2021) for GSA 17&18 by MS-Croatia, MS-Italy and MS-Slovenia.

Fishing power of fishing fleets is described in terms of boat sizes (e.g. vessel length categories) and their fishing activity. In order to support the implementation of a fishing effort management regime, detailed numerical data by Member State/Country and vessel length are given in Figures and Tables of this section.

6.17.1.1 MS-Croatia (HRV) - GSA17 - FDI data on annual number of fishing vessels by size

In case of MS-Croatia, EWG22-16 noted that significant amounts of inactive fishing vessels are reported in FDI data call (Table 6.17.2, Figure 6.17.1). Eventually EWG22-16 decided to exclude these inactive vessels from further analyses of fishing effort from Croatia (Figure 6.17.2).

Table 6.17.2. Fishing effort on annual basis in terms of number of vessels by vessel lengths and vessels fishing activity reported to FDI data call from MS-Croatia.

MS: CROATIA (HRV) - GSA17	Sum of totves								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
VL0006	**1520**	**1544**	**2632**	**3865**	**4469**	**4283**	**4400**	**4406**	**4379**
ACTIVE	820	790	851	2891	3525	3593	3715	3740	3752
INACTIVE	700	754	1781	974	944	690	685	666	627
VL0612	**2181**	**2183**	**4564**	**3253**	**3279**	**2872**	**2869**	**2844**	**2829**
ACTIVE	1502	1451	1502	1991	2102	2082	2122	2132	2105
INACTIVE	679	732	3062	1262	1177	790	747	712	724
VL1218	**399**	**400**	**394**	**386**	**363**	**350**	**345**	**343**	**337**
ACTIVE	303	293	289	275	259	246	237	238	237
INACTIVE	96	107	105	111	104	104	108	105	100
VL1824	**128**	**128**	**128**	**118**	**115**	**111**	**104**	**103**	**103**
ACTIVE	96	95	93	83	80	71	70	68	69
INACTIVE	32	33	35	35	35	40	34	35	34
VL2440	**129**	**129**	**130**	**124**	**123**	**115**	**111**	**112**	**109**
ACTIVE	85	86	87	84	86	71	72	73	72
INACTIVE	44	43	43	40	37	44	39	39	37
VL40XX	**1**	**1**	**1**						
ACTIVE	1	1	1						
INACTIVE									

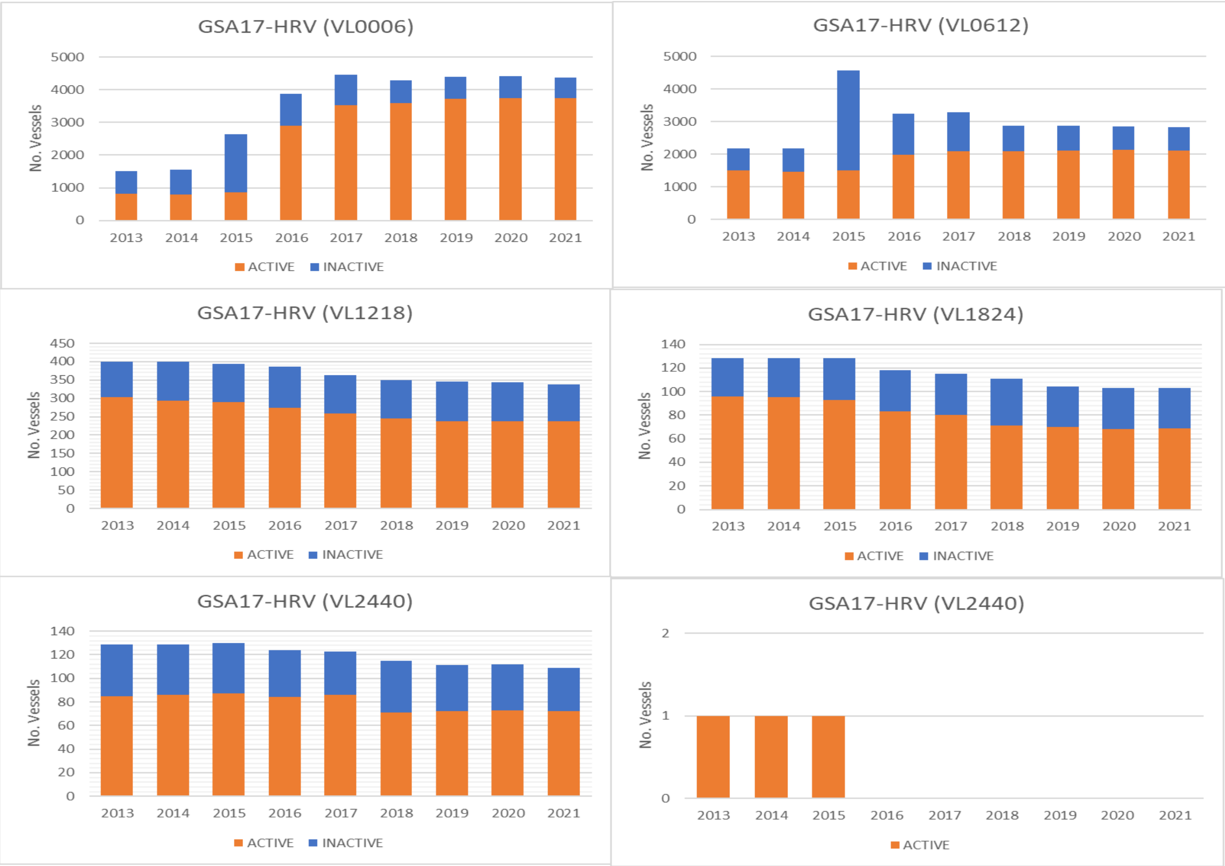


Figure 6.17.1. Fishing effort on annual basis in terms of number of vessels by vessel lengths and vessels fishing activity reported from MS-Croatia.

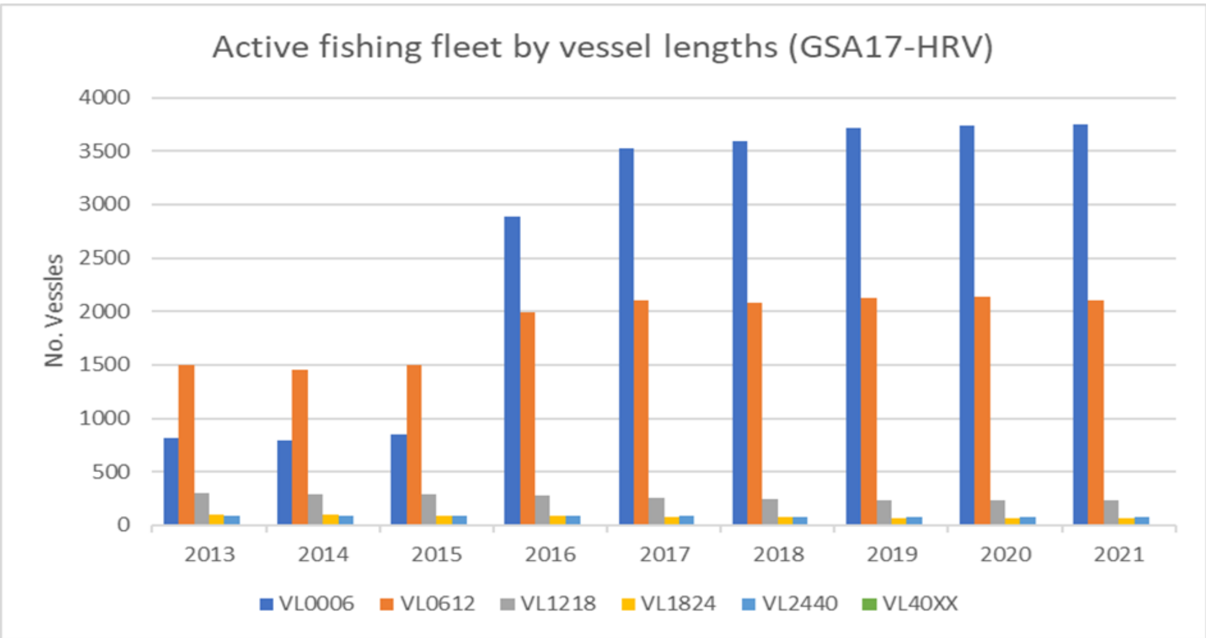


Figure 6.17.2. Fishing effort on annual basis in terms of number of active fishing vessels by vessel lengths and vessels fishing activity reported from MS-Croatia.

Furthermore, EWG 22-06 noticed differences in no. vessels (all sizes) estimated from MBS data call (e.g. max no. vessels reported in any quarter) vs. FDI information reported by HRV on total number of active vessels in data overlapping period 2013-2018 (Table 6.17.3). In general, Croatia reported much higher number of vessels in FDI than previously estimated from MBS data call in the same years. EWG22-16 compiled and provide complete sets of annual data on number of active fishing vessels in Croatia by boat size categories for the longest time series available (2012-2021), based on the FDI database for the recent part (2013-2021) and from prior Mediterranean & Black Sea Data calls for the 2012 year (Figure 6.17.3).

Table 6.17.3. Comparison of FDI data on active fishing vessels numbers vs. estimates from MBS data.

	HRV - GSA17: Number of Total vessels					HRV - GSA17: Max no. vessels reported in a quarter										
			FDI					MBS				DIFFERENCE (FDI-MBS)				
	VL0006	VL0612	VL1218	VL1824	VL2440	VL0006	VL0612	VL1218	VL1824	VL2440	YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2012						218	609	211	40	18						
2013	820	1502	303	96	85	215	604	207	42	15	**2013**	*605*	*898*	*96*	*54*	*70*
2014	790	1451	293	95	86	216	591	205	40	16	**2014**	*574*	*860*	*88*	*55*	*70*
2015	851	1502	289	93	87	206	580	189	39	17	**2015**	*645*	*922*	*100*	*54*	*70*
2016	2891	1991	275	83	84	229	561	176	34	12	**2016**	*2662*	*1430*	*99*	*49*	*72*
2017	3525	2102	259	80	86	225	524	167	30	12	**2017**	*3300*	*1578*	*92*	*50*	*74*
2018	3593	2082	246	71	71	324	628	160	27	9	**2018**	*3269*	*1454*	*86*	*44*	*62*

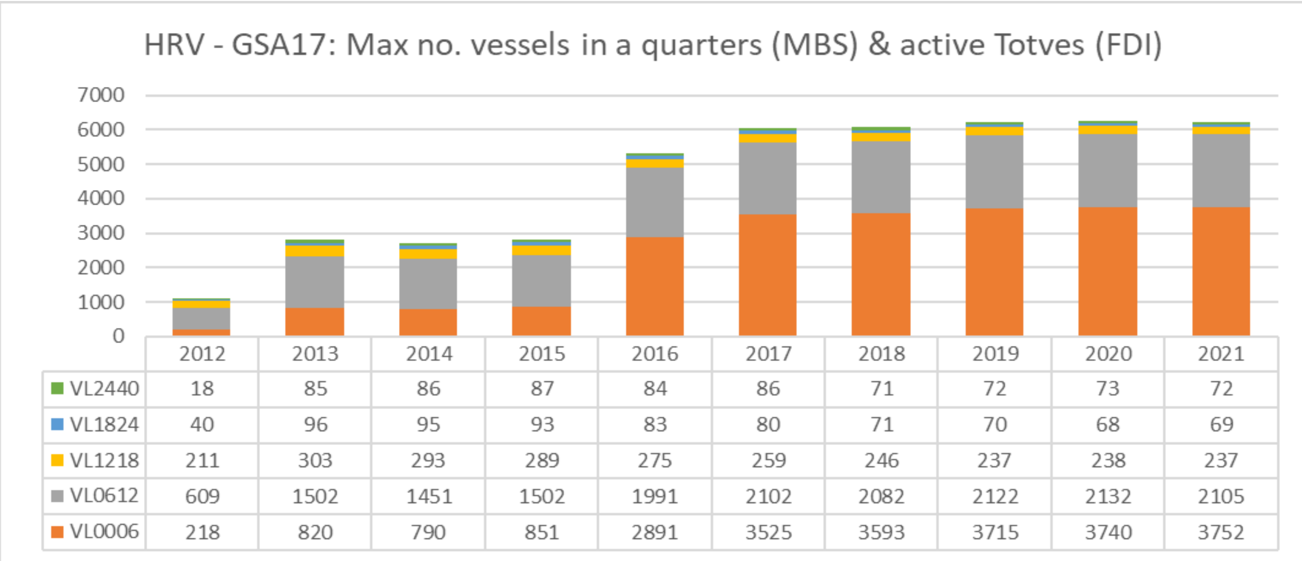


Figure 6.17.3. Annual data on number of active fishing vessels in Croatia by boat size categories for the longest time series available (2012-2021), based on the FDI database for the recent part (2013-2021) and from MBS Data calls for the 2012 year.

Based on the data set analysed, it seems that fishing power of Croatian fishing fleet increased after 2015 due to large increase in number of active small fishing boats, up to 12 meters in length. However, at the same time EWG22-16 noted decreasing trend in numbers of active fishing vessels of >12 meters in length in Croatian fishing fleet. Furthermore, EWG22-16 noted huge discrepancies in estimated maximum numbers of fishing vessels from MBS data set and number of active fishing vessels reported to FDI data call (Table 3) for Croatian fishing fleet in GSA17.

6.17.1.2 MS-ITALY (ITA) - GSA17 - FDI DATA ON ANNUAL NUMBER OF FISHING VESSELS BY SIZE

In case of MS-Italy for the Northern Adriatic (GSA17), EWG22-16 noted that small amount of 76 inactive fishing vessels is reported in FDI data call for 2013 year only (Table 6.17.4, Figure 6.17.4). After 2013 year, no inactive fishing vessels were reported by Italy. Eventually EWG22-16 decided to exclude these inactive vessels in 2013 from further analyses of fishing effort from Italy (Figure 6.17.5).

Table 6.17.4. Fishing effort on annual basis in terms of number of vessels by vessel lengths and vessels fishing activity reported to FDI data call from MS-Italy.

Sum of totves	Column Labels								
GSA17-ITA	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
VL0006	**695**	**670**	**642**	**623**	**622**	**616**	**459**	**448**	**478**
INACTIVE	76								
ACTIVE	619	670	642	623	622	616	459	448	478
VL0612	**1216**	**1194**	**1165**	**1150**	**1133**	**1136**	**918**	**833**	**911**
INACTIVE	94								
ACTIVE	1122	1194	1165	1150	1133	1136	918	833	911
VL1218	**980**	**982**	**932**	**921**	**942**	**909**	**852**	**801**	**805**
INACTIVE	21								
ACTIVE	959	982	932	921	942	909	852	801	805
VL1824	**240**	**227**	**249**	**263**	**266**	**236**	**235**	**202**	**215**
INACTIVE	11								
ACTIVE	229	227	249	263	266	236	235	202	215
VL2440	**121**	**118**	**88**	**91**	**88**	**95**	**131**	**93**	**106**
INACTIVE	1								
ACTIVE	120	118	88	91	88	95	131	93	106
VL40XX			**1**	**1**	**1**	**1**			**1**
ACTIVE			1	1	1	1			1

Figure 6.17.4. Fishing effort on annual basis in terms of number of vessels by vessel lengths and vessels fishing activity reported from MS-Italy in GSA17.

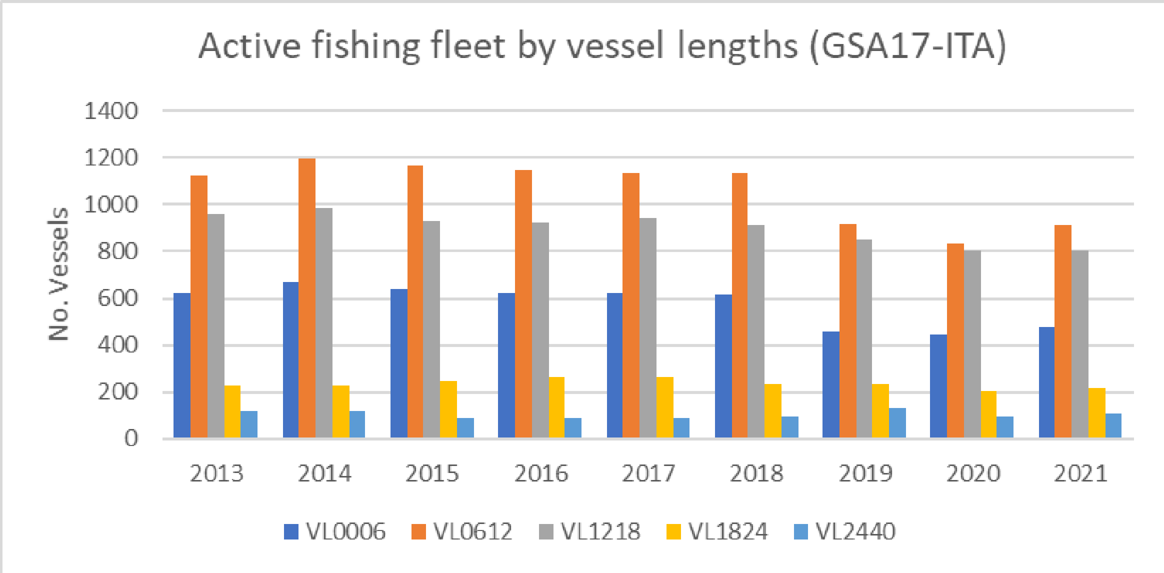
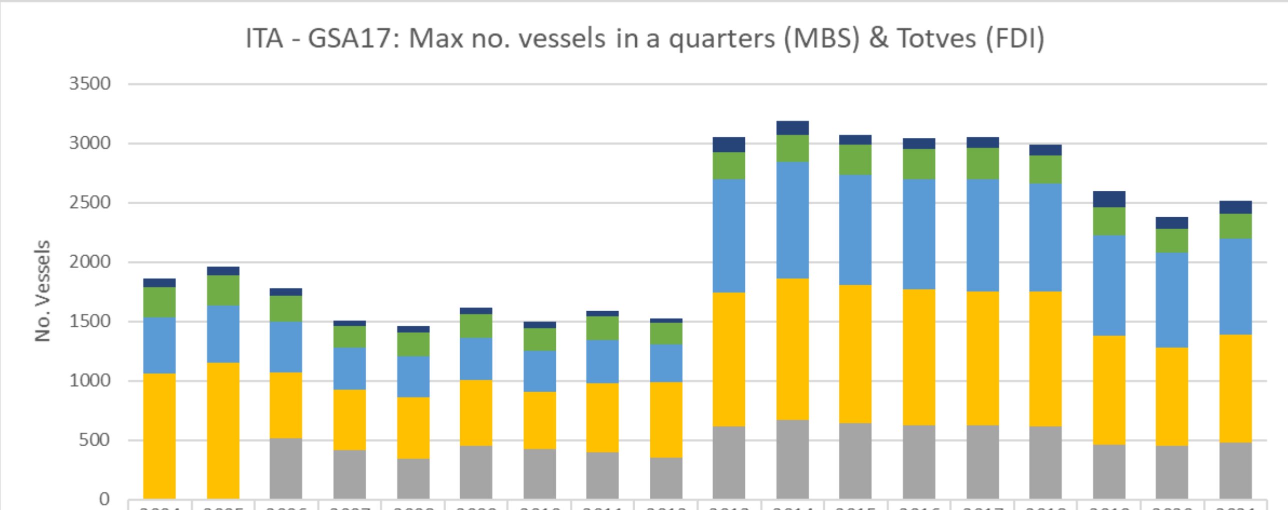


Figure 6.17.5. Fishing effort on annual basis in terms of number of active fishing vessels by vessel lengths and vessels fishing activity reported from MS-Italy in GSA17.

Furthermore, EWG 22-06 noticed differences in no. vessels (all sizes) estimated from MBS data call (e.g. max no. vessels reported in any quarter) vs. FDI information reported by ITA on total number of active vessels in data overlapping period 2013-2018. In general, Italy reported higher number of vessels in FDI than previously estimated from MBS data call in the same years (Table 6.17.5). EWG22-16 compiled complete sets of annual data on number of active fishing vessels in Italy by boat size categories for the longest time series available (2004-2021), based on the FDI database for the recent part (2013-2021) and from prior MBS Data calls for 2004-2012 period (Figure 6).

Table 6.17.5. Comparison of FDI data on active fishing vessels numbers vs. estimates from MBS data.

	ITA - GSA17: Number of Total vessels					ITA - GSA17: Max no. vessels reported in a quarter										
			FDI					MBS					DIFFERENCE (FDI-MBS)			
	VL0006	VL0612	VL1218	VL1824	VL2440	VL0006	VL0612	VL1218	VL1824	VL2440		VL0006	VL0612	VL1218	VL1824	VL2440
2013	619	1122	959	229	120	339	524	308	192	34	**2013**	280	598	651	37	86
2014	670	1194	982	227	118	338	508	293	162	34	**2014**	332	686	689	65	84
2015	642	1165	932	249	88	250	460	231	188	31	**2015**	392	705	701	61	57
2016	623	1150	921	263	91	224	521	244	192	33	**2016**	399	629	677	71	58
2017	622	1133	942	266	88	233	376	267	189	41	**2017**	389	757	675	77	47
2018	616	1136	909	236	95	207	338	249	183	39	**2018**	409	798	660	53	56



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
VL2440	73	74	58	44	54	55	54	51	39	120	118	88	91	88	95	131	93	106
VL1824	255	259	220	182	204	198	194	199	185	229	227	249	263	266	236	235	202	215
VL1218	476	481	424	358	349	357	350	362	313	959	982	932	921	942	909	852	801	805
VL0612	1058	1149	560	513	520	561	478	577	636	1122	1194	1165	1150	1133	1136	918	833	911
VL0006			513	411	338	447	424	401	354	619	670	642	623	622	616	459	448	478

Figure 6.17.6. Annual data on number of active fishing vessels in GSA17-Italy by boat size categories for the longest time series available (2012-2021), based on the FDI database for the recent part (2013-2021) and from MBS Data calls for the 2004-2012 period.

Based on the FDI data set analysed, it seems that fishing power of Italian fishing fleet in GSA17 slightly decreased in terms of number of active fishing vessels after 2013. However, at the same time EWG22-16 noted huge discrepancies in estimated maximum numbers of fishing vessels from MBS data set and number of active fishing vessels reported to FDI data call (Table 6.17.5, Figure 6.17.6) for Italian fishing fleet in GSA17.

6.17.1.3 MS-Italy (ITA) - GSA18 - FDI data on annual number of fishing vessels by size

In the Southern Adriatic (GSA18) data are available from its western part only (ITA), while no effort data are available from its eastern part (e.g. Albania and Montenegro). EWG22-16 noted that, as like as in GSA17, an amount of inactive fishing vessels is reported by ITA in FDI data call for 2013 year only (Table 6.17.6, Figure 6.17.7). After 2013 year, no inactive fishing vessels were reported by Italy in GSA18. Eventually EWG22-16 decided to exclude these inactive vessels in 2013 from further analyses of fishing effort from Italy in GSA18 (Figure 6.17.8).

Table 6.17.6. Fishing effort on annual basis in terms of number of vessels by vessel lengths and vessels fishing activity reported to FDI data call from MS-Italy in GSA18.

Sum of totves	Column Labels								
ITA-18	2013	2014	2015	2016	2017	2018	2019	2020	2021
VL0006	**174**	**176**	**174**	**174**	**171**	**170**	**169**	**128**	**160**
ACTIVE	154	176	174	174	171	170	169	128	160
INACTIVE	20								
VL0612	**344**	**338**	**335**	**331**	**335**	**326**	**324**	**310**	**335**
ACTIVE	321	338	335	331	335	326	324	310	335
INACTIVE	23								
VL1218	**410**	**401**	**393**	**395**	**390**	**386**	**336**	**314**	**302**
ACTIVE	341	401	393	395	390	386	336	314	302
INACTIVE	69								
VL1824	**77**	**79**	**83**	**77**	**68**	**75**	**71**	**69**	**56**
ACTIVE	77	79	83	77	68	75	71	69	56
INACTIVE									
VL2440	**57**	**49**	**46**	**38**	**38**	**29**	**28**	**27**	**13**
ACTIVE	57	49	46	38	38	29	28	27	13
INACTIVE									
VL40XX							**1**		
ACTIVE							1		
INACTIVE									

Figure 6.17.7. Fishing effort on annual basis in terms of number of vessels by vessel lengths and vessels fishing activity reported from MS-Italy in GSA18.

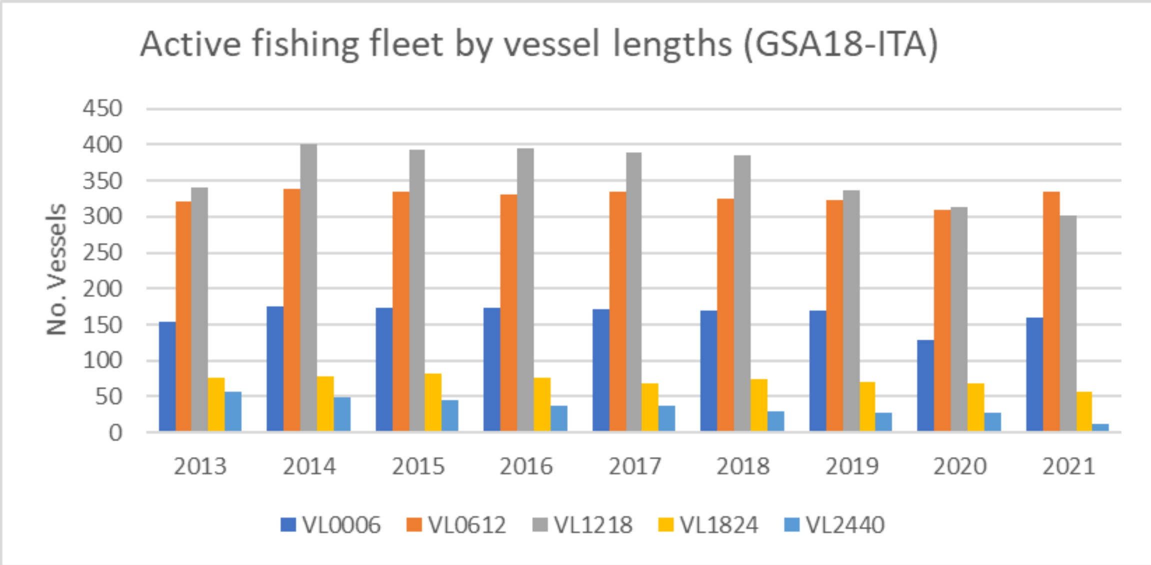
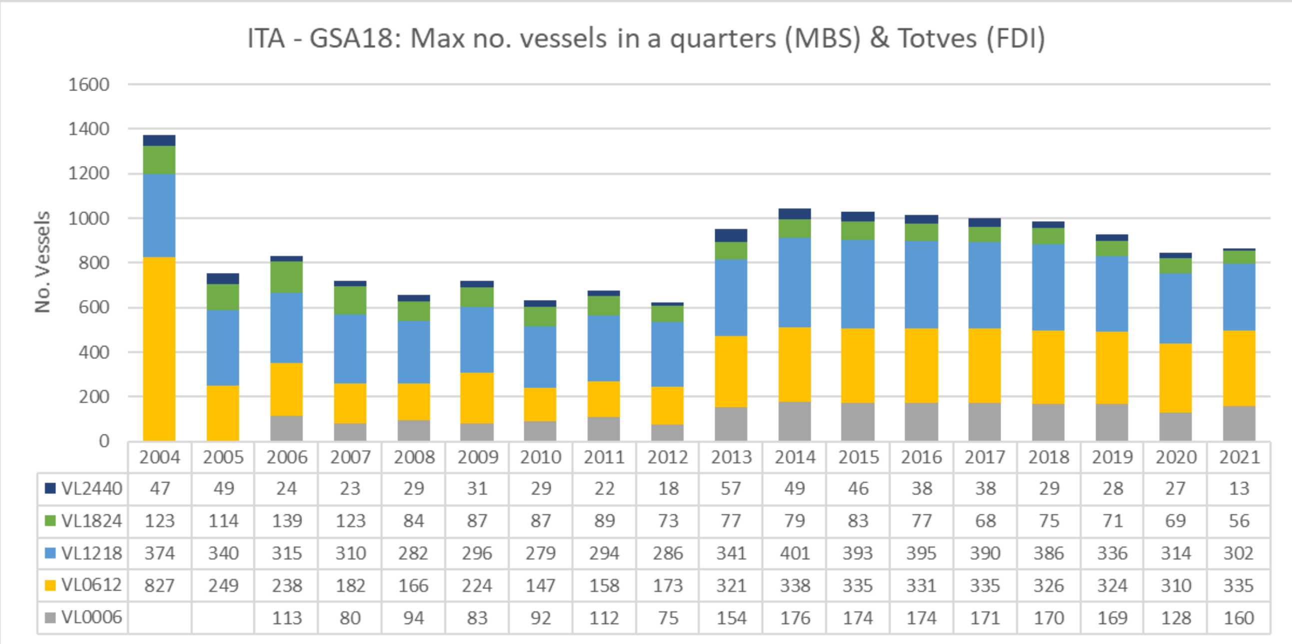


Figure 6.17.8. Fishing effort on annual basis in terms of number of active fishing vessels by vessel lengths and vessels fishing activity reported from MS-Italy in GSA18.

EWG 22-06 also noticed differences in no. vessels (all sizes) estimated from MBS data call (e.g. max no. vessels reported in any quarter) vs. FDI information reported in GSA18 by ITA on total number of active vessels in data overlapping period 2013-2018. In most cases, except in the cases of VL0006 in 2013 year and VL1824 in 2013 and 2016, MS-Italy in GSA18 reported higher numbers of vessels in FDI than estimated from MBS data call in the same years (Table 6.17.7). EWG22-16 compiled complete sets of annual data on number of active fishing vessels in GSA18-Italy by boat size categories for the longest time series available (2004-2021), based on the FDI database for the recent part (2013-2021) and from prior MBS Data calls for 2004-2012 period (Figure 6.17.9).

Table 6.17.7. Comparison of FDI data on active fishing vessels numbers vs. estimates from MBS data.

	ITA - GSA18: Number of Total vessels					ITA - GSA18: Max no. vessels reported in a quarter										
			FDI					MBS				DIFFERENCE (FDI-MBS)				
	VL0006	VL0612	VL1218	VL1824	VL2440	VL0006	VL0612	VL1218	VL1824	VL2440		VL0006	VL0612	VL1218	VL1824	VL2440
2013	154	321	341	77	57	175	301	290	77	16	**2013**	-21	20	51	0	41
2014	176	338	401	79	49	78	220	275	73	15	**2014**	98	118	126	6	34
2015	174	335	393	83	46	156	187	267	67	15	**2015**	18	148	126	16	31
2016	174	331	395	77	38	160	220	274	77	13	**2016**	14	111	121	0	25
2017	171	335	390	68	38	85	227	266	59	11	**2017**	86	108	124	9	27
2018	170	326	386	75	29	101	265	274	66	11	**2018**	69	61	112	9	18



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
VL2440	47	49	24	23	29	31	29	22	18	57	49	46	38	38	29	28	27	13
VL1824	123	114	139	123	84	87	87	89	73	77	79	83	77	68	75	71	69	56
VL1218	374	340	315	310	282	296	279	294	286	341	401	393	395	390	386	336	314	302
VL0612	827	249	238	182	166	224	147	158	173	321	338	335	331	335	326	324	310	335
VL0006			113	80	94	83	92	112	75	154	176	174	174	171	170	169	128	160

Figure 6.17.9. Annual data on number of active fishing vessels in GSA18-Italy by boat size categories for the longest time series available (2012-2021), based on the FDI database for the recent part (2013-2021) and from MBS Data calls for the 2004-2012 period.

Based on the MBS data set analysed, it seems that fishing power of Italian fishing fleet in GSA18 was strongly reduced after 2004, mainly due to large reduction in number of active fishing boats, up to 12 meters in length. However, EWG22-16 also noted differences between number of active fishing vessels estimated from MSB data set and number of vessels reported to FDI data call (Table 6.17.7). Based on these differences it seems that power of Italian fishing fleet in GSA18 increased from 2012 to 2013 due to increase in numbers of active large fishing vessels in all length categories. Fishing power of Italian fishing fleet reported in GSA18 has slightly decreasing trend since 2014, but with significant decrease in number of large fishing vessels (VL2440) in 2021.

6.17.1.4 MS-Slovenia (SVN) - GSA17 - FDI data on annual number of fishing vessels by size

In the GSA17 data available from Slovenia (SVN), EWG22-16 noted that no inactive fishing vessels in effort data are reported in Slovenian fishing fleet (Table 6.17.8, Figure 6.17.10).

Table 6.17.8. Fishing effort on annual basis in terms of number of active vessels reported by vessel lengths reported to FDI data call from MS-Slovenia in GSA17.

MS: SLOVENIA (SVN) - GSA17	Sum of totves								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
VL0006	32	35	34	31	30	29	26	23	25
VL0612	38	44	43	41	40	37	36	38	38
VL1218	12	12	9	9	7	8	10	9	9
VL1824									
VL2440									
VL40XX									

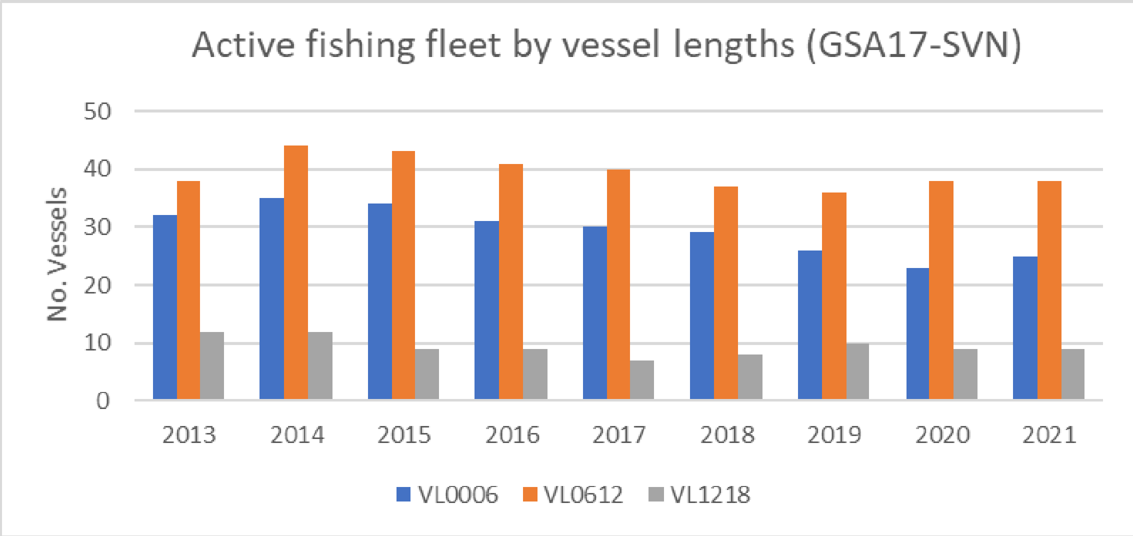


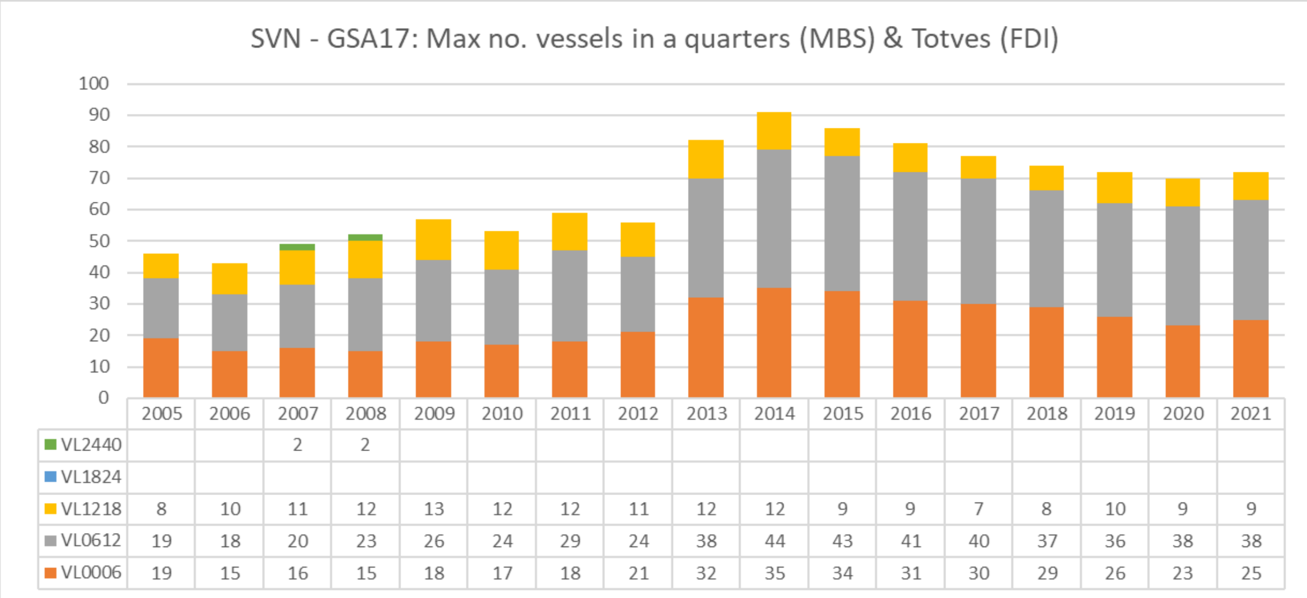
Figure 6.17.10. Fishing effort on annual basis in terms of number of vessels by boat size categories reported from MS-Slovenia to FDI data call in GSA17.

Some differences in no. vessels (all sizes) estimated from MBS data call (e.g. max no. vessels reported in any quarter) vs. FDI information reported in GSA17 by SVN are noticed by EWG 22-06 on total number of active vessels in data overlapping period 2013-2018 (Table 6.17.9). In all cases, MS-Slovenia in GSA17 reported higher numbers of vessels in FDI than estimated from MBS data call in the same years. EWG22-16 compiled complete sets of annual data on number of fishing vessels in GSA187-Slovenia by boat size categories for the longest time series available (2005-2021), based on the FDI database for the recent part (2013-2021) and from prior MBS Data calls for 2005-2012 period (Figure 6.17.11).

Table 6.17.9. Comparison of FDI data on active fishing vessels numbers vs. estimates from MBS data.

	SVN - GSA17: Number of Total vessels			SVN - GSA17: Max no. vessels reported in a quarter						
			FDI			MBS		DIFFERENCE (FDI-MBS)		
	VL0006	VL0612	VL1218	VL0006	VL0612	VL1218	YEAR	VL0006	VL0612	VL1218
2013	32	38	12	23	30	7	**2013**	*9*	*8*	*5*
2014	35	44	12	25	31	7	**2014**	*10*	*13*	*5*
2015	34	43	9	19	29	8	**2015**	*15*	*14*	*1*
2016	31	41	9	18	29	7	**2016**	*13*	*12*	*2*
2017	30	40	7	20	26	5	**2017**	*10*	*14*	*2*
2018	29	37	8	20	23	6	**2018**	*9*	*14*	*2*

Table 6.17.7. Comparison of FDI data on active fishing vessels numbers vs. estimates from MBS data.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
VL2440			2	2													
VL1824																	
VL1218	8	10	11	12	13	12	12	11	12	12	9	9	7	8	10	9	9
VL0612	19	18	20	23	26	24	29	24	38	44	43	41	40	37	36	38	38
VL0006	19	15	16	15	18	17	18	21	32	35	34	31	30	29	26	23	25

Figure 6.17.9. Annual data on number of active fishing vessels in GSA18-Italy by boat size categories for the longest time series available (2012-2021), based on the FDI database for the recent part (2013-2021) and from MBS Data calls for the 2004-2012 period.

Slovenian fishing fleet is the smallest one in GSA17, consisted mainly of small size fishing vessels with low fishing power. Based on the data set analysed, it seems that fishing power of Slovenian fishing fleet has been increasing up to 2015, following by slight decrease in number of fishing vessels up to 2020. However, EWG22-16 noted discrepancies in estimated maximum numbers of fishing vessels from MBS data set and number of active fishing vessels reported to FDI data call (Table 6.17.9) for Slovenian fishing fleet in GSA17.

6.17.2 Fishing effort described in terms of fishing time

Following previous practices from EWG20-15 (virtual), and in line with suggestion of Commission representative (Arona, EWG19-10), fishing day has been selected by EWG22-16 as the most appropriate parameter to describe fishing time as an index of fishing effort. FDI data Table G has been used as principal data source for this purpose.

With aim to provide fishing time/effort indices associated with stock assessments and their related fisheries in the GSA17&18 (Adriatic Sea), EWG22-16 used information provided in FDI Table A. To select the most important fishing gears producing the bulk of total landings of given species, EWG22-16 analysed landing of assessed species in GSA17&18 by fishing gear (Table 6.17.10.)

Table 6.17.10. Selection of principal fishing gears (yellow) related to 6 stock assessments in GSA17&18.

species	**HKE**	**species**	**MUR**	**species**	**NEP**	**species**	**SOL**	**species**	**DPS**	**sub_region**	**GSA17**
sub_regi	**GSA17**	**sub_region**	**GSA17**	**sub_region**	**GSA17**	**sub_region**	**GSA17**	**sub_region**	**GSA17**	**species**	**SVE**
Row Labe	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg
OTB	23533	OTB	219	OTB	5556	TBB	9017	OTB	10064	DRB	137270
LLS	1035	GNS	70	FPO	369	OTB	3130	TBB	21	FPO	0
GNS	571	SB	32	TBB	28	GNS	2835	OTM	4	GNS	0
TBB	416	GTR	16	GNS	7	GTR	1978	GNS	1	GTN	0
GTR	34	GTN	3	OTM	3	DRB	373	PS	0	GTR	0
OTM	25	TBB	2	GTR	1	FPO	41	DRB	0	LHP	0
FYK	11	NK	1	NK	1	FYK	18	SB	0	LLD	0
LHP	5	LLS	1	LHP	0	GTN	15	LLS	0	LLS	2
FPO	5	FPO	0	LLS	0	NK	8	LHP	0	NK	0
GTN	3	LHP	0	SB	0	LLS	1	NK	0	OTB	7
SB	2	DRB	0	GTN	0	PTM	1	GTR	0	PS	0
DRB	2	PTM	0	PS	0	OTM	1	LTL	0	SB	0
NK	2	PS	0	DRB	0	LHP	0	FYK	0	TBB	0
PTM	1	OTM	0	LTL	0	SB	0	FPO	0		
PS	1	LTL	0	HMD	0	LTL	0	GTN	0		
LTL	0	FYK	0			PS	0				
LLD	0	HMD	0			LHM	0				
HMD	0					GND	0				
LHM	0					HMD	0				
GND	0										

species	**HKE**	**species**	**MUR**	**species**	**NEP**	**species**	**SOL**	**species**	**DPS**	**sub_region**	**GSA18**
sub_regi	**GSA18**	**sub_region**	**GSA18**	**sub_region**	**GSA18**	**sub_region**	**GSA18**	**sub_region**	**GSA18**	**species**	**SVE**
Row Labe	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg	Row Labels	Sum of totwghtlandg
OTB	14378	GNS	576	OTB	3989	OTB	588	OTB	11790	DRB	2886
LLS	2920	OTB	210	GNS	0	GNS	147	GTR	1	OTB	1
GNS	59	GTR	147			GTR	6				
GTR	5	DRB	0			FYK	0				
PTM	1	NK	0			SV	0				
PS	0	PTM	0								
NK	0	SV	0								
SV	0										
FPO	0										
OTM	0										

Consequently, EWG22-16 selected 7 principal fishing gears for analyses of fishing time/effort, in relation to stock assessments in GSA17&18 suggested, as follow:

1. Boat dredges (DRB) – associated to Venus clam assessment;
2. Pots and traps (FPO) – associated to Norway lobster assessment;
3. Set gillnets (GNS) – associated to Hake, Red mullet and Sole assessments;
4. Trammel nets (GTR) – associated to Hake, Red mullet and Sole assessments;
5. Set longlines (LLS) – associated to Hake assessment;
6. Bottom otter trawl (OTB) – associated to Hake, Red mullet, Sole (SOL), Norway lobster and Deep-water rose shrimp assessments;
7. Beam trawl (TBB) – associated to Hake and Sole assessments.

In addition to fishing days as a principal fishing time/effort parameter selected, EWG22-16 analysed also days-at-sea as an additional index of fishing effort, and made a comparison between those two effort indices from FDI table G, by Member State / area / fishing gears (Figures 6.17.10-6.17.13).

Figure 6.17.10. Comparisons FDI data on annual number of fishing days and days-at-sea by gears as reported by MS-Croatia in GSA17.

Figure 6.17.11. Comparisons FDI data on annual number of fishing days and days-at-sea by gears as reported by MS-Italy in GSA17.

Figure 6.17.12. Comparisons FDI data on annual number of fishing days and days-at-sea by gears as reported by MS-Slovenia in GSA17.

Figure 6.17.13. Comparisons FDI data on annual number of fishing days and days-at-sea by gears as reported by MS-Italy in GSA18.

In line with Commission decisions (2016/1251, 2021/1167) day-at-sea and fishing day are defined as follow:

1) <u>day-at-sea</u>: any continuous period of 24 hours (or part thereof) during which a vessel is present within a defined fishing area and absent from port;

2) <u>Fishing day</u>: any calendar day at sea in which a fishing activity takes place, without prejudice to the international obligations of the Union and its Member States. One fishing trip can contribute to both the sum of the fishing days for passive gears and the sum of the fishing days for active gears used on that trip.

Therefore, in accordance to these two definitions, there are possibilities that both indices (fishing days and days-at-sea) may be higher or lower than other one to some extent. However, similar numbers of fishing days and days-at-sea are expected, as these are mostly the cases in fishing effort reported by Italy. EWG22-16 noticed that in some cases differences between reported numbers of fishing days vs. days-at-sea are higher than expected (e.g. FPO, GNS, GTR and LLS in HRV; GNS and GTR in SVN; FPO in GSA18 in ITA). These differences are not considered as data issues, and probably indicate slightly different fishing effort reporting practices between EU Member States.

Given the fact that fishing effort data from MBS data call (up to 2018) were available to EWG22-16 also, the group compared data reported by Member States during overlapping period of MBS and FDI data calls. Outcomes of comparison of fishing time/effort, in terms of fishing days, reported by HRV, ITA and SVN in GSA17&18 are shown in Figures 6.17.14-6.17.17.

Figure 6.17.14. Comparisons of fishing effort (fishing days) by gears as reported to MBS and FDI data calls by MS-Croatia in GSA17.

Figure 6.17.15. Comparisons of fishing effort (fishing days) by gears as reported to MBS and FDI data calls by MS-Italy in GSA17.

Figure 6.17.16. Comparisons of fishing effort (fishing days) by gears as reported to MBS and FDI data calls by MS-Slovenia in GSA17.

Figure 6.17.17. Comparisons of fishing effort (fishing days) by gears as reported to MBS and FDI data calls by MS-Italy in GSA18.

EWG22-16 noticed that in some cases data on fishing days reported between MBS and FDI data calls match very well (e.g. most of Italian data), but in some cases differences in reported number of fishing days between MBS and FDI data calls are large (e.g. for FPO in 2014 and 2015 for SVN). Effort data matching rates, in terms of fishing days, submitted to MBS and FDI data calls by Member States by gears are summarised in Table 6.17.11. Differences observed are provided numerically, and grouped visually by colour into three categories (up to 2%, from 2% to 10% and >10%), and shown in Table 11 following a traffic-light approach.

Table 6.17.11. Matching rates of effort (fishing days) datasets compared as MBS/FDI

GSA17: HRV	2013	2014	2015	2016	2017	2018
DRB	100%	101%	101%	100%	100%	100%
FPO	80%	80%	79%	85%	81%	85%
GNS	94%	95%	92%	94%	92%	83%
GTR	108%	110%	110%	110%	108%	109%
LLS	101%	100%	98%	101%	100%	97%
OTB	100%	100%	99%	99%	100%	100%
TBB	no FDI data	no FDI data	no FDI data	no FDI data	no FDI data	no FDI data
GSA17: ITA	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
DRB	100%	100%	100%	100%	100%	100%
FPO	109%	100%	100%	100%	100%	100%
GNS	105%	100%	100%	100%	100%	100%
GTR	110%	100%	100%	100%	100%	100%
LLS	no data	no data	no data	100%	100%	100%
OTB	100%	100%	100%	100%	100%	100%
TBB	100%	100%	100%	100%	100%	100%
GSA17: SVN	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
FPO	96%	272%	136%	99%	100%	100%
GNS	66%	75%	67%	69%	100%	99%
GTR	78%	74%	74%	79%	100%	100%
LLS	87%	92%	100%	100%	100%	100%
OTB	104%	102%	104%	105%	100%	100%
GSA18: ITA	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
DRB	100%	100%	100%	100%	100%	100%
FPO	120%	100%	100%	100%	100%	117%
GNS	107%	100%	100%	100%	100%	112%
GTR	148%	100%	100%	100%	100%	109%
LLS	103%	100%	100%	100%	100%	101%
OTB	100%	100%	100%	100%	100%	101%

Differences up to 2%
Differences >2% up to 10%
Differences >10%

During these comparisons EWG22-16 spotted two data issues in terms of coverage (data missing), as it was the case of missing Croatian TBB effort data in FDI data call for period 2013-2021, and missing Italian effort data for LLS in GSA17 in 2013-2015 period.

Finally, in EWG22-16 opinion, Member States could be invited to check the cases where different effort data in two data calls (MBS and FDI) were provided, and correct or explain differences. It would be necessary precondition before compiling unique effort data set on fishing days originating from MBS and FDI data calls.

7 DATA DEFICIENCIES

Hake in GSA 17-18

The data from the last EU DCF official Data Call (2022) was scrutinized for issues.

LFDs from landings of Italy in GSA 17 are available only for OTB and TBB and only for 2019 for GNS. LFDs from landings of TBB of Italy in GSA 17 are missing for 2007-2010, 2013 and 2016. LFDs from discards of Italy in GSA 17 are available only for OTB from 2011 to 2021.

LFDs from landings of Italy in GSA 18 are available only for OTB and LLS from 2002 to 2021. LFDs from landings of LLS of Italy in GSA 18 are missing for 2002-2003 and 2006. LFDs from landings of OTB of Italy in GSA 18 are missing from 2004 to 2008. LFDs from discards of Italy in GSA 18 are available only for OTB and LLS from 2009 to 2021. LFDs from discards of LLS of Italy in GSA 18 are missing for 2009-2011, 2013 and 2015-2021. There is no LFDs data in 2019 and 2020 in the last EU DCF official Data Call (2022); however, this is due to some misreporting since the data has been collected and available in the previous data call.

LFDs from landings of Croatia in GSA 17 are available only for OTB, LLS and GNS from 2013 to 2021. LFDs from landings of LLS of Croatia in GSA 17 are missing for 2013. LFDs from discards of Croatia in GSA 17 are available only for OTB from 2013 to 2021.

LFDs from landings and discards of Slovenia in GSA 17 needs to be thoroughly checked because they are deemed not reliable.

Sole in GSA 17

The data used in the sole in GSA 17 stock assessment was reviewed by GFCM and did not use the data from the MED-BS data call under the DFC directly so not data quality information is provided for the DTMT. General issues with data are provided in the GFCM report

EWG 2216 discussed the interpolation of the survey data for 2020 and 2021 for the SOLEMON survey which was not carried out in its entirety in these years. Two different methods were applied to the two years although overall this had relatively little impact on the survey index so it is not expected that the assessment is sensitive to the uncertainty in methods.

Red Mullet in GSA 17-18

The landings and LFDs of GSA 18 in 2013, 2019 and 2020 was not reported in the last Data call, while in the catch table the age distribution for 2021 was not available. Discards from Italy in GSA 17 from 2018 was reported by quarter, differently from the other years for which it was reported annually. The discard amount in all the quarters of 2018 and 2019 seems anomalously high, especially in the first and fourth quarter, when a high amount of red mullet discard is not expected, considering that the species recruits in the third quarter. In 2021 the Italian data for GSA 17 was reported only for the 4th quarter.

Norway lobster in GSA 17-18

No data deficiencies reported

Deep-water rose shrimp in GSA 17-18-19

The data used for the analyses come from the last EU DCF official Data Call (2021). The update of data related to non-EU countries was provided during the meeting. For Albania five years (from 2017 to 2021) of length data was available, but seems to be cutted at length size of 19 mm ant then missing for younger specimens. For Montenegro no catch data were provided to EWG 22-16. Landings LFDs from GSA19 and GSA18 (Italy) were available from 2002. In GSA18 LFDs were missing in 2006 and 2008 for italy and in most of the years for non-EU countries. Regarding GSA17, LFDs from Italy were available continuously from from 2013 for Italy and from 2014 for Croatia. For Italy (both GSA17 and 18), the time period of the survey has changed in some last years.

As regards the catch information, from different sources are not equal. In particulary in the database "catches.csv" no data on DPS are available for Italy in GSA 17, while they are present in both landings.csv and discard.csv database. Moreover total landing in some years also differ from quantities reported in FDI.

Hake in GSA 19

No issues

Red mullet in GSA 19

Survey sampling period (MEDITS) has been done in different year periods. The displacement of MEDITS survey to August (2007), September (2014), December 2017 and October 2020 that it is the recruitment period for red mullet, difficult the tuning of the VPA.

Giant red shrimp in GSA 18-19-20

MEDITS TC file for GSA 20 was not provided to DCF and was provided to EWG 22-16.

Blue and red shrimp in GSA 18-19-20

Data deficiencies were described in STECF 22-03. Main issues detected were:

The same VBGF parameters have been provided for both sexes for both GSA 19 and GSA 18 (ITA). This issue has been dealt with. Since STECF 22-03, Italy provided revised growth parameters separate by sex for both GSAs 19 and 18.

No landings data were reported from 2002 to 2007 and 2019 for GSA 18 (ITA). This was not the case with data provided to STECF 22-16, were landings were missing for years 2002, 2003, 2013, 2019 and 2020 (see below).

No landings data were reported for 2002 for GSA 19 (ITA). This was still the case with data provided to STECF 22-16.

During STECF 22-16 additional data issues detected were:

No landings data reported in years 2002, 2003, 2013, 2019 and 2020 for GSA 18 (ITA) in the provided data. These were retrieved from 2021 DCF data call.

NA in gear in GSA 18 for year 2006.

NA in gear in GSA 19 for year 2003.

Venus Clam in GSA 17-18

Data available to STECF EWG 22-16 concerning both landings and survey data were limited to the past 10 years. Other data were made available from other official sources (historical survey data and landings data from the FishStat platform). However, especially for survey data, direct comparisons between data collected in recent and past surveys should be considered with caution due to differences in sampling strategy and standardisation between surveys. To allow for honest comparisons, recent data were standardised to report the biomass of clams with a total length (TL) greater than 25mm in one metre square as in the previous survey. Therefore, a more accurate study could be conducted if the raw data collected during past surveys are made available.

The time of the year in which the DRESS surveys take place sometimes differs between districts. Given the changes in catchability of the species between winter and summer, with the first being lower than the second, biomass information could be biased by this and other environmental factors.

Given the lack of length frequency distributions (LFDs) on the landings, it was not considered appropriate to standardise the landings as only relating to clams with TL greater than 25, because the LFDs derived from the DRESS only reflect the population structure during a small period of the year.

Survey and landing data from GSA 18 were not included in the analyses because inconsistencies were found in the sampling design that required further investigation before the collected data could be used.

Croatian data from GSA 17 are negligible and do not allow for assessing the state of the resource in the North Eastern Adriatic Sea.

Norway lobster in GSA 15-16

Data from DCF 2021 as submitted through the Official data call in 2022 were used.

In GSA 16, the Italian length frequencies distributions provided have a 2 mm length class step which is not in agreement with the template requested by the Mediterranean and Black Sea Data Call.

In GSA 16, the Italian length frequencies distribution provided in 2016 for the metier OTB MDD have both 2 mm and 1 mm length class step.

In GSA 16, the Italian length frequencies distribution have been not provided in year 2018.

In GSA 16, the Italian length samples are not covering consistently each quarter and metier available in the area.

In GSA 16, the Italian length frequencies distributions in numbers are quite poor in the last years. It is not clear whether due to a not appropriate samplings or a huge reduction of the abundance of the species in the area.

In GSA 16, the numbers for Italy in year 2016, quarter 4, vessel length 1218, gear OTB and fishery MDD seem reported in total numbers not in thousands as requested in the Mediterranean and Black Sea Data Call.

In GSA 16 for Italy, an inconsistent Sum of Product has been spotted in year 2009, quarter -1, gear OTB, fishery DEMSP. Please check total landings and number reported.

In GSA 16 for Italy, an unrealistic maturity at length reported in years 2015 and 2016 for female.

In GSA 16 for Italy, maturity at length have been reported having 2 mm length class step.

In GSA 16 for Italy, length weight parameter a in 2019 for sex combined (C) is likely misreported. Indeed, a is equal to 0.005 while 0.0005 is expected.

In GSA 16 for Italy, in the MEDITS TA file the number of hauls carried out along the time series change a lot. In particular, in years 2014 and in 2020. In the former year the reduction applied doesn’t seem proportional to each stratum ending up with a very few hauls carried out in the deeper stratum.

In GSA 16 for Italy, the MEDITS survey period has not been always respected. In particular in years 2013, 2017, 2020 and 2021.

In GSA 16 for Italy, many inconsistencies in total weight or total number reported by haul in the MEDITS TB and TC files have been spotted.

In GSA 15 for Malta, no landings LFD have been provided from 2005 to 2008 and in 2013.

In GSA 15 for Malta, the mean weight derived as ratio between landings in weight and numbers by length classes for each metier combinations seem quite unrealistic in 2009, 2010, 2011, 2012, 2014 and 2019 in OTB_MDD and in 2017 in OTB_DEMF.

In GSA 15 for Malta, the discards length frequencies distributions for year 2012 seems related just to one measures while the derived mean length as ration between discards weight and numbers by metier seem quite unrealistic. Likely numbers have been reported as absolute numbers and not as thousands as MEDBS data call requested.

In GSA 15 for Malta, the MEDITS TB data for year 2017 are missing.

In GSA 15 for Malta, the MEDITS survey period has not been always respected. In particular in year 2018.

In GSA 15 for Malta, in the MEDITS TB file the total weight in year 2009 hauls 21, 22 and 70 and likely also in haul 11 is misreported.

In GSA 15 for Malta, in the MEDITS TC file the total weight in year 2009 hauls 21, 22 and 70 and likely also in haul 11 is misreported.

Striped red mullet in GSA 15-16

Below the main issues and/or data gaps spotted reported according the DTMT guidelines.

MS	Data Requested	Issue
Italy	Landings length	GSA_16_MUR. Length frequencies distributions in OTB_DEF in years 2002-2004 are quite different in term of numbers from the rest of the time series. Length distribution in year 2006 for OTB_DEMF seems weird.
Italy	Landings length	GSA_16_NEP. Length frequencies distribution have been not provided in year 2018
Italy	Landings length	GSA_16_MUR. Landings in weight reported in year 2002 for GTR_DEF and in year 2019 OTB_DWS seem wrong.
Italy	Landings length	GSA_16_MUR. There are some inconsistencies between total weight and total number associated to the OTB_MDD (in 2013) and GTR_DEF (in 2002) metiers resulting in a quite unrealistic mean weight.
Italy	Discards length	GSA_16_MUR. Data are very poor. It seems that few individuals' measures have been raised to the whole production.
Italy	Catches	GSA_16_MUR. Some inconsistencies in the Sum of Product have been spotted both in landings and discards data (15 and 1 respectively see quality report).
Italy	Maturity ogive at age	GSA_15_MUR. Maturity at age for both male and female in year 2021 seems misreported in older ages.
Italy	Maturity ogive at length	GSA_16_MUR. Maturity at length for male in year 2021 and female in years 2021,2018 and 2016 seem misreported in bigger size.
Italy	Age Length Key	GSA_16_MUR. For all the sexes available (female, male and combined) length assigned to age 0 show a quite unrealistic wide range
Italy	MEDITS survey TA	GSA_16_MUR. Number of hauls carried out along the time series change a lot. In particular, in years 2014 and in 2020. In the former year the reduction applied doesn't seem proportional to each strata ending up with a very few hauls carried out in the deeper stratum.
Italy	MEDITS survey TA	GSA_16_MUR. MEDITS survey period has not been always respected. In particular in years 2013, 2017, 2020 and 2021.
Italy	MEDITS survey TB_TC	GSA_16_MUR. Many inconsistencies in total weight or total number reported by haul in TB and TC files have been spotted. In particular in year 2021 haul 61.
Italy	MEDITS survey TC	GSA_16_MUR. In year 2002 wrong length has been reported: 199mm TL.
Malta	Landings length	GSA_15_MUR. No data have been provided from 2005 to 2008.
Malta	Landings length	GSA_15_MUR. Length frequencies distributions provided along the time series seem weird having a derived mean weight as ratio between discards weight and numbers by métier (OTB_MDD, OTB_DWS, OTB_DEMF and GTR), quite unrealistic. Likely numbers have been reported as absolute numbers and not as thousands as MEDBS data call requested.
Malta	Discards length	GSA_15_MUR. Length frequencies distributions provided in year 2019 seem weird having a derived mean weight as ratio between discards weight and numbers by métier (OTB_MDD, OTB_DWS, OTB_DEMF), quite unrealistic. Likely numbers have been reported as absolute numbers and not as thousands as MEDBS data call requested.
Malta	MEDITS survey TB	GSA_15_MUR. TB data for year 2017 are missing.
Malta	MEDITS survey TA	GSA_15_MUR. MEDITS survey period has not been always respected. In particular in year 2018.
Malta	MEDITS survey TB_TC	GSA_15_MUR Inconsistency in total weight reported in year 2013 haul 19 between TB and TC files.
Malta	MEDITS survey TC	GSA_15_MUR. Lengths reported in year 2013 need to be checked (e.g. 945mm TL spotted). In years 2021 and 2019 very small length for males has been reported (e.g. 45mm TL and 20 mm TL respectively). In years 2013 and 2014 the same for female (e.g. 25mm TL and 15mm TL respectively).
Malta	Sex ratio at age	GSA_15_MUR. Value for age 3in year 2020 seems misreported or just due to a very low sample.
Malta	Growth parameters	GSA_15_MUR. No growth parameters provided.

Hake in GSA 20

LFDs were missing for the small scale fisheries (LLS, GNS, GTR) for the period 2003 – 2009. Besides that no other major issues were encountered in the quality assessment of the data.

Hake in GSA 22

No DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, and 2012. Catch-at-age data were provided only for the last quarter for 2013 2015 and 2017. No MEDITS surveys took place in 2002, 2007, 2009-2013, 2015 and 2017. In 2018 and 2020 the survey period was extended in September.

The landings as calculated from the DCF data (number of individuals multiplied by their somatic weight) do not correspond to the official landings reported. This issue is greater for the years 2003-2006 and fades out after 2016.

Finally, the gears of the small-scale coastal fleet (GTR, GNS, LLS) are reported aggregated before 2014 and separately afterwards. However, because of the recent increase in the proportion of the small-scale fleet in the official landings of hake because of the addition of an extra fleet, the landings of these gears were included aggregated in the present assessment.

Red mullet in GSA 22

Several data gaps exist due to inconsistencies in the implementation of DCF. Some uncertainties exist on the volume of landings in the earlier years as different sources of information (DCF and Hellenic Statistical Authority) provide incompatible estimates. Besides, uncertainties exist regarding the adopted assumption in the a4a assessment that the unknown size composition of the Turkish catches is similar to the Greek ones.

Effort Data

In terms of data coverage, EWG22-16 noted that effort data for LLS from ITA in GSA17 are missing for period 2013-2015 (FDI data call). Also, it has been noted that no effort data in FDI data call on TBB are provided by HRV in entire period (2013-2021), while effort data for this gear (TBB) were provided previously by HRV in MBS data call.

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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/web/stecf/ewg2216

List of electronic annexes documents:

EWG-22-16 – Annex 1 – Final stock objects.zipXXXXX
EWG 22-16 – Annex 1 – Rscripts.zip

11 List of Background Documents

Background documents are published on the meeting's web site on:
https://stecf.jrc.ec.europa.eu/web/stecf/ewg02216

List of background documents:

EWG-22-16 – Doc 1 - Declarations of invited and JRC experts (see also section 9 of this report – List of participants)

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