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-

Stock assessments in the Mediterranean Sea

2021 – Adriatic and Ionian Seas

(STECF-21-15)

Edited by EWG John Simmonds & Alessandro Mannini

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TABLE OF CONTENTS

Abstract 1

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Stock Assessments: demersal stocks in the Adriatic and Ionian Seas (STECF-21-15) 2

Request to the STECF 2

STECF comments 2

STECF conclusions 11

Contact details of STECF members 12

Expert Working Group EWG-21-15 report 16

1 Introduction 17

1.1 Approach to the work 17

1.2 Terms of Reference for EWG-21-15 17

1.3 Report Structure 21

2 Findings and Conclusions of the Working Group 21

2.1 Stock-Specific Findings & Conclusions 21

2.2 Quality of the assessments 25

3 Follow up items 26

4 Basis of the report 27

4.1 Data Preparation 27

4.1.1 Fill-in procedures 27

4.1.1.1 Fill in for length Frequency distributions for landings 28

4.1.1.2 Fill-in for discards data 28

4.2 Basis of the catch and fishing mortality advice 29

4.3 MSY Reference points for stocks in this report 30

4.3.1 MSY Ranges 30

4.3.2 Values of F_{MSY} F_{upp} and F_{low} 30

4.4 Basis of Short Term Forecasts 30

4.4.1 MSY Transition 31

5 Summary sheets by stock 33

5.1 Summary sheet for European hake in GSA 17 and 18 33

5.2 Summary sheet for common sole in GSA 17 40

5.3 Summary sheet for red mullet in GSA 17 and 18 44

5.4 Summary sheet for Common cuttlefish in GSA 17 and 18 50

5.5 Summary sheet for Norway lobster in GSA 17 and 18 57
5.6 Summary sheet for Spottail mantis shrimp in GSA 17 and 18 68
5.7 Summary sheet for Deep water rose shrimp in GSA 17, 18 and 1974
5.8 Summary sheet for Giant Red Shrimp in GSA 18, 19 AND 20 82
5.9 Summary sheet for European hake in GSA 19 88
6 Assessments by stock 93
6.1 European hake in GSA 17 and 18 93
6.1.1 Stock Identity and Biology 93
6.1.2 Data 96
6.1.2.1 Catch (landings and discards) 96
6.1.2.2 Effort 107
6.1.2.3 Survey data 110
6.1.3 Stock assessment 112
6.1.3.1 Stock Synthesis (SS3) 112
6.1.4 Reference points 126
6.1.5 Short term Forecast and Catch Options 126
6.1.6 Data Deficiencies 129
6.2 Sole in GSA 17 131
6.3 Red mullet in GSA 17 and 18 147
6.3.1 Stock Identity and Biology 147
6.3.2 Data 148
6.3.2.1 Catch (landings and discards) 148
6.3.2.2 Effort 155
6.3.2.3 Survey data 158
6.3.3 Stock assessment 161
6.3.4 Reference Points 170
6.3.5 Short term Forecast and Catch Options 170
6.3.6 Data Deficiencies 171
6.4 Common cuttlefish in GSA 17 and 18 172
6.4.1 STOCK IDENTITY AND BIOLOGY 172
6.4.2 DATA 175
6.4.2.1 CATCH (LANDINGS AND DISCARDS) 175
6.4.2.2 EFFORT 182
6.4.2.3 SURVEY DATA 184
6.4.3 STOCK ASSESSMENT 192

6.4.3.1 METHOD 1: CMSY 192
6.4.3.2 METHOD 2: SPICT 297
6.4.4 REFERENCE POINTS 306
6.4.5 SHORT TERM FORECAST AND CATCH OPTIONS 306
6.4.6 DATA DEFICIENCIES 306
6.5 Norway lobster in GSA 17 and 18 308
6.5.1 Stock Identity and Biology 308
6.5.2 Data 309
6.5.2.1 Catch (landings and discards) 309
6.5.2.2 Effort 320
6.5.2.3 Survey data 321
6.5.3 Stock assessment 326
6.5.3.1 Surplus Production model in Continuous Time - SPiCT 326
6.5.3.2 Area based biomass indices for Nephrops GSA 17-18. 337
6.5.3.3 a4a stock assessment for GSA 18 340
6.5.3.4 SURBA sub-area assessments 371
6.5.3.4.1 Ancona 374
6.5.3.4.2 Kvarner 384
6.5.3.4.3 Pomo/Jabuka 391
6.5.3.4.4 GSA 18 401
6.5.3.5 Conclusions to sub-area based indices for Nephrops GSA 17-18. 411
6.5.4 Reference Points 414
6.5.5 Short term Forecast and Catch Options 414
6.5.5.1 STF CATCH ESTIMATES FOR THE TOTAL AREA. 414
6.5.5.2 CATCH ALLOCATIONS BY SUB AREA. 418
6.5.6 Data Deficiencies 418
6.6 SPOTTAIL MANTIS SHRIMP IN GSA 17 AND 18 419
6.6.1 STOCK IDENTITY AND BIOLOGY 419
6.6.2 DATA 422
6.6.2.1 CATCH (LANDINGS AND DISCARDS) 422
6.6.2.3 EFFORT 434
6.6.2.4 SURVEY DATA 435
6.6.3 STOCK ASSESSMENT 439
6.6.4 REFERENCE POINTS 453
6.6.5 SHORT TERM FORECAST AND CATCH OPTIONS 453

6.6.6 Discussion 456
6.6.7 DATA DEFICIENCIES 457
6.7 Deep water rose shrimp in GSA17, 18 and 19 458
6.7.1 Stock Identity and Biology 458
6.7.2 Data 461
6.7.2.1 Catch (landings and discards) 461
6.7.2.2 Effort 472
6.7.2.3 Survey data 474
6.7.3 Stock assessment 478
6.7.3.1 Input data 478
6.7.3.2 Results 485
6.7.4 Reference Points 497
6.7.5 Short term Forecast and Catch Options 497
6.7.6 Data Deficiencies 500
6.7.7 Other issues 500
6.8 GIANT RED SHRIMP GSA 18,19,20 506
6.8.1 STOCK IDENTITY AND BIOLOGY 506
6.8.2 DATA 507
6.8.2.1 CATCH (LANDINGS AND DISCARDS) 507
6.8.2.2 SURVEY DATA 510
6.8.3 STOCK ASSESSMENT 512
6.8.4 REFERENCE POINTS 519
6.8.5. SHORT TERM FORECAST AND CATCH OPTIONS 519
6.9 European hake in GSA 19 522
6.9.1 Stock Identity and Biology 522
6.9.2 Data 523
6.9.2.1 Catch (landings and discards) 523
6.9.2.2 Effort 527
6.9.2.3 Survey data 527
6.9.3 Stock assessment 530
6.9.4 Reference Points 539
6.9.5 Short term Forecast and Catch Options 539
6.9.6 Data Deficiencies 540
7 References 541
8 Contact details of EWG-21-15 participants 543

9 List of Annexes 546
10 List of Background Documents 546

Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report is from STECF Expert Working Group 21-15: 2021 stock assessments of demersal stocks in Adriatic, Ionian and Aegean Seas from the meeting held remotely from 18th to 22th October 2021. A total of 9 fish stocks were evaluated. One stock had prior advice from 2020 for 2021 and 2022, and this is reiterated here. Index advice for 2022 and 2023 is provide for one other stock. The EWG reports age based assessments and short term forecasts for 5 of the remaining 7 stocks and surplus production assessments for two stocks. The content of the report gives the STECF terms of reference, the basis of the evaluations and advice, summaries of state of stock and advised based on either the MSY approach for assessed stocks or the precautionary approach for category 3 based advice. The report contains the full stock assessment reports for the 7 assessments, the exploration of assessments and category 3 evaluations for the remaining five stocks. The report also contains the STECF observations and conclusions on the assessment report. These conclusions come from the STECF Plenary meeting November 2021.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Stock Assessments: demersal stocks in the Adriatic and Ionian Seas (STECF-21-15)

Request to the STECF

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

STECF comments

The working group was held remotely, from 18 to 22 October 2021. The meeting was attended by 14 experts in total, including one STECF member and one JRC expert. Two observers also attended the meeting.

The main objective of the meeting was to carry out assessments and provide advice for the demersal stocks in the Adriatic and Ionian Seas as listed in the ToRs of the report. No stocks from the Aegean Sea was assessed this year.

STECF acknowledges that the EWG has addressed adequately all ToRs. STECF notes that the ToRs consisted, as in previous years, of data preparation, stock assessment, estimation of reference points, short-term forecasts, identification and reporting of data issues and synoptic overview for management advice.

Summary of performed assessments

A total of 9 area/species combinations were assessed (Table 1). In the case of Norway lobster in GSAs 17-18 the stock was also evaluated on a sub-area basis in order to specifically address ToR 3. Eight out of the nine species had been assessed in 2020 by STECF EWG 20-15. Only the combined stock (GSA 18, 19 and 20) of Giant red shrimp had not been previously assessed by STECF, while the combined GSAs 18-19 was assessed in 2020 by GFCM using age based assessment method (GFCM 2021).

Table 1 Summary of the work attempted and basis for advice (in Bold). A4a is an age based assessment method, SS3 is an age/length integrated model; SPiCT and CMSY are surplus production methods. STF is a standard short term projection with assumptions of status quo F and historic recruitment. Index refers to the ICES Category 3 approach to advice for stocks without analytic assessments.

Area	Species	Method 2020	Basis 2021
GSA 17-18*	Hake^	SS3	**SS3 STF**
GSA 17*	Sole^	Index 2020	SS3 **Index 2020**
GSA 17-18	Red mullet^	a4a	**a4a STF**
GSA 17-18**	Common cuttlefish	CMSY	SPiCT **CMSY**
GSA 17-18^x	Norway lobster^	SPiCT	**SPiCT STF** Biomass Index SURBA
GSA 17-18**	Spottail mantis shrimp	a4a	**a4a STF**
GSA 17-18-19	Deep-water rose shrimp^	a4a	**a4a STF**

GSA 18-19-20**	Giant red shrimp		A4a **Index 2021**
GSA 19*	Hake	a4a	**a4a STF**

* Stock with a GFCM benchmark. ** Stock boundaries are defined by EWG 21-15 on the basis of expert knowledge. ^ Stocks under the 2019 GFCM demersal MAP (GFCM/43/2019/5). ^{x} In line with ToR 3 in view of the assessment at Adriatic level being considered not precautionary by GFCM WGSAD 2020 in order to explore fishing mortality levels and stock status based on a whole Adriatic assessment vs sub-areas. Index 2020 for Sole is repeated from last year assessment.

The EWG carried out short term forecasts for 5 age-based assessments and one surplus production model. The remaining stock, common cuttlefish, is short-lived and an estimate of equilibrium catch is available, but forecasting two years ahead depends on recruitment in the intermediate year, therefore forecasts were not attempted.

STECF notes that the assessment of two stocks (Sole in GSA 17 and Giant red shrimp in GSA 18-19-20) could not be completed, as complex issues arose, reaching beyond standard assessment procedures that could be achieved in the EWG time frame, and which would require more advanced investigation and dedicated time (see below). Catch advice for these two stocks is thus based on biomass index methods. Sole in GSA 17 had prior advice from 2020 for 2021 and 2022, and this is reiterated here.

STECF notes that the EWG was not able to give catch advice for the Giant red shrimp stock in GSA 20, due to both data gaps and data coherence issues. STECF acknowledges the progresses achieved in spring 2021 for improving the current data coverage of the Greek fisheries during the EWG 21-02. Nevertheless, some data gaps still persist and will need to be further addressed over the coming years before obtaining reliable stock assessments in the area. STECF supports and encourages further progresses in this direction.

Stocks trend and advice

The main results are summarized in the bullet point list below and in Table .2 and Table 3. Table 2 presents stock and fishery status and options for exploitation at F_{MSY}, or based on the precautionary approach if an assessment is not available. Table 3 provides a summary by stock of progress to 2020, based on F_{2020} in the most recent assessment, which includes the effect of any changes implemented before and during 2020. Table 3 also provides the future F and catch options for 2022 based on the linear transition in F from 2019 to F_{MSY} in 2026. Overall, the assessments indicate that 3 out of the 5 age-based assessed stocks are being significantly overfished i.e. F_{2020} is >> F_{MSY} (Hake in GSAs 17-18, Spottail mantis shrimp in GSAs 17-18 and Deep water shrimp in GSAs 17-18), one is being fished close to F_{MSY} (Hake in GSA 19) and one is under-exploited (Red mullet in GSAs 17-18). The two stocks assessed with surplus production models are estimated to be fished below F_{MSY} (Nephrops in GSAs 17-18 and common cuttlefish in GSAs 17-18). For the stocks included in the GFCM MAP only for deep water rose shrimp is the decline in F from 2019 to 2020 shown to be behind the seven year transition in year 1 of the plan.

- Hake in GSAs 17-18: the biomass is increasing. Catches should be reduced by at least 40% to reach F_{MSY} in 2022. F_{2020} is < $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2026 is ahead of transition.
- Sole in GSA 17: the biomass is declining. Catches may be increased by no more than 22% to conform to precautionary considerations in 2022.
- Red mullet in GSAs 17-18: the biomass is increasing. Catches may be increased by no more than 37% to reach F_{MSY} in 2022. F_{2020} is < $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2026 is ahead of transition.

- Common cuttlefish in GSAs 17-18: the biomass is increasing. Current catches are estimated below those corresponding to F_{MSY} in equilibrium.

- Norway lobster in GSAs 17-18: the biomass is increasing. Catches may be increased to some extent without only limited risk of reaching above F_{MSY} in 2022. F is already below F_{MSY}.
- Spottail mantis shrimp in GSAs 17-18: the biomass is increasing. Catches may be increased by no more than 3% to reach F_{MSY} in 2022.
- Deep-water rose shrimp in GSAs 17-18-19: the biomass is stable. Catches should be reduced by at least 40% to reach F_{MSY} in 2022. F_{2020} is > $F_{MSY\ Transition\ 2020}$ so progress to F_{MSY} in 2026 is behind transition.
- Giant red shrimp in GSAs 18-19-20: the biomass is fluctuating. Catches should be reduced by at least 22% to conform to precautionary considerations in 2022.
- Hake in GSA 19: the biomass is increasing. Catches should be reduced by at least 28% to reach F_{MSY} in 2022.

Table 2 Summary of stock and fishery status by area and species, **based on F_{MSY} target for F_{2022}**. F 2020 is estimated F in the assessment. Change in F is the difference (%) between target F (F_{MSY}) in 2022 and the estimated F for 2020. Change in catch is the difference (%) between catch 2020 and catch 2022. Biomass and catch 2018-2020 are given as an indication of trends over the last 3 years for stocks with time series analytical assessments or biomass indices. Biomass reference points are not available for any of these stocks. Shaded cells are precautionary advice based on indices.

Area	Species	Method/	Age	Biomass	Catch	F 2020	F MSY	Change in F	Catch 2020*	Catch 2022 at F_{msy}	Change in catch
		Basis	Fbar	2018-2020	2018-2020						
GSA 17-18	Hake	SS3	1-4	increasing	declining	0.37	0.18	-52%	4841	2920	-40%
GSA 17	Sole	Index 2020	biomass	declining	declining				1605	1960	22%
GSA 17-18	Red mullet	a4a	1-3	increasing	declining	0.37	0.36	-5%	3123	4279	37%
GSA 17-18	Common cuttlefish	CMSY	biomass	increasing	declining	0.07	0.16	123%	2150	7450**	247%
GSA 17-18	Norway lobster	SPiCT	biomass	increasing	declining	0.16	0.37	131%	870	1986	128%
GSA 17-18	Spottail mantis shrimp	a4a	1-3	increasing	fluctuating	0.66	0.44	-33%	4780	4945	3%
GSA 17-18	Deep-water rose shrimp	a4a	0-2	stable	stable	1.61	0.72	-55%	5121	3092	-40%
GSA 18-19-20	Giant red shrimp	Index 2021	biomass	fluctuating	fluctuating				386	303	-22%
GSA 19	Hake	a4a	0-4	increasing	declining	0.29	0.15	-47%	584	420	-28%

* Estimated Catch from 2021 Assessments STECF EWG 21-15 or index based advice. Change in F is % change in F_{2022} relative to F_{2020}, Change in catch % change catch 2022 relative to 2020. ** Catch for common cuttlefish is not advised catch but represents average long term yield at FMSY.

Table 3 Summary of stock and fishery status by area and species, for stocks included in the GCFM 2019 MAP **based on $F_{MSY\ Transition}$ target for F_{2022}. Recent change** gives general change in F and catch over the last three years. F_{2019} and F_{2020} are both estimated F in the 2021 assessment. F_{2026} is F_{MSY} the target for the end of transition, F_{2019} is the starting point of the MAP. The estimate of progress so far is shown as the F change % 2019 to 2020 and the F status relative to $F_{MSY\ Transition2020}$. **Advice for 2022** is based on the $F_{MSY\ Transition2022}$ for the next advice year (2022) which is set at a level to reach F_{MSY} in 2026, the change in F and implied by the MAP is the difference (as a fraction) between $F_{MSY\ Transition}$ in 2022 and the F in 2019 and the most recent year from the available estimates, F in 2020. Change in catch is from required change catch 2020 to catch 2022.

Area	Species	F change 2018-2020	Catch Change 2018-2020	F 2019	F 2020	F_{MSY} Transition 2020	F_{MSY} Transition 2022	Target F 2026 F MSY	F Change % 2019-2020	F Status 2020 Rel to F_{MSY} Transition 2020	F Change % 2019-2022	F Change % 2020-2022	Catch 2020	Catch 2022 F_{MSY} Transition	Catch Change 2020-2022
GSAs 17-18	Hake	declining	declining	0.47	0.37	0.43	0.35	0.18	-22%	ahead of transition	-27%	-6%	4841	5262	9%
GSAs 17	Sole		declining										1605		
GSAs 17-18	Red mullet	declining	declining	0.68	0.37	0.63	0.54	0.36	-45%	ahead of transition	-20%	45%	3123	5979	91%
GSAs 17-18	Norway lobster	declining	declining	0.25	0.16	0.27	0.30	0.37	-37%	F below FMSY	20%	89%	870	1627	87%
GSAs 17-18-19	Deep-water rose shrimp	stable	stable	1.63	1.61	1.50	1.24	0.72	-1%	behind transition	-24%	-23%	5121	4513	-12%

Assessments quality and robustness of advice

Generic comments across all stocks

STECF notes that the assessments are based on short data series and some degree of uncertainty therefore remains, perhaps even more so this year due to a disrupted 2020 MEDITS survey program and in a few cases reduced commercial catch sampling caused by the COVID19. However, STECF considers overall that the values presented in Table 2 provide a robust guidance on the magnitude of changes in F and catches required to reach F_{MSY} by 2022 (except for cuttlefish which is just indicative of MSY at equilibrium), and those provided in Table 3 provide guidance to a linear transition from 2019 to F_{MSY} in 2026 for stocks included in the GCFM 2019 MAP. The 7 assessments form the basis of the detailed advice given in section 5 of the EWG 21-15 report. The estimates of F_{low} and F_{MSY} are considered reasonable estimates that can be expected to be precautionary and STECF considers that they can be used directly in the advice. The values of F_{upper} in the report are indicative only – they are not included in the management plan and they have not been evaluated as precautionary and should not be used to give catch advice without further evaluation. The EWG 21-15 report also contains values of F and associated catch options for a linear transition in F from 2019 to reach F_{MSY} in 2026 in Table 3. These are the best estimates of F and catch required in 2022 to follow a linear transition, irrespective of progress so far. Also they do not take into account uncertainty in estimates. They should be considered as guide for current progress towards F_{MSY} in 2026.

STECF observes that for many of the stocks evaluated the number of years of S-R data is very limited and it is not possible to carry out full evaluations of MSY, because the stock - recruit relationships cannot be established.

STECF notes that the STECF EWG data processing workshop EWG 21-02 did not result in more efficient and accurate data organisation in EWG 21-15 partly due to resubmission of data but also to difficulties in comparing with previous data sets. New issues were thus encountered by EWG 21-15: For deep water rose shrimp processing errors from last year (from EWG 20-15) were found; for spottail mantis shrimp a script error dealing with growth occurred; for giant red shrimp there were data extraction issues within submission in the most recent data call. These diverse issues delayed work and were resolved only for Spottail mantis shrimp during the EWG week, but on the last day. For deep water rose shrimp work was carried out after the EWG 21-15 and the issue resolved. For giant red shrimp a GFCM assessment for GSAs 18-19 was adapted to include GSA 20 but all the issues could not be resolved in time and index advice was used instead. For this stock it is though expected that an assessment can be obtained in the future. These difficulties are in contrast with the situation of the Western Med Assessment EWG (EWG 21-11) which was improved by the data processing workshop (ToR 5.3 of this plenary). STECF notes though that most of these issues relate to data preparation, not to the running of assessments. Therefore, it might be desirable to perform more data checks prior to the EWG as long as the stock list is agreed well in advance of the EWG. However, STECF acknowledges there may be logistical reasons why additional data meeting in the autumn may not be possible. There are a number of improvements that can be made; more extensive exploration of the data prior to the EWG (similar to EWG 21-02); checking new data submissions for data quality to ensure updates do not contain spurious characters; standardised routines that compare updated data sets with the previous checked data to identify quickly which values have changed. However, it is often only when finally running and comparing assessments that problems are fully identified, and only slightly longer meeting (similar to previous years) will be able to react appropriately to the discovery of issues late in the process.

Specific comments

For the two stocks with advice based on abundance indices (sole in GSA 17 and Giant red shrimp in GSAs 18-19-20), a precautionary buffer of -20% catch reduction was included in 2020 or 2021. The advised change in catch for these two stocks is based on the change in stock over the last two years relative to three years before.

In the case of Norway lobster in GSA 17-18, sub-area analysis suggested that two areas (Ancona Grounds and GSA 18) show strong indications of low biomass and are potentially in need of additional reductions in catch beyond the catches allocated proportionally.

STECF also notes that the procedure for providing catch advice from probabilistic models is complex and not yet fully established. This would be a good area for development and cooperation with GFCM or other providers of fisheries advice.

Sole GSA 17 advice

STECF notes that for sole in GSA 17, EWG advice has been provided based on the precautionary approach used by STECF from 2020. The expert group (EWG 21-15) lacked the confidence to use the updated assessment to provide robust advice due to a lack of detail on preparation of data and model implementation as well as some data access issues. During the STECF plenary it was suggested that an updated forecast (see below) could be preferable to the simple biomass-based advice (survey index) put forward by the EWG. Such a forecast was prepared for STECF by members of the EWG during the STECF plenary and is presented below.

Basis of Forecast:

The basis of advice is the 2021 benchmark assessment using data up to 2019 performed by GFCM. Instead of updating the assessment model, only the forecast catches for 2020 were updated for each fleet (i.e. no impact on parameter settings and no new survey data). Catches 2021 were assumed to be equal to 2020 catches. Catches for 2022 and subsequent years were set as 0.8, 0.9, 1.0 and 1.2 times the 2020 catches to provide alternate scenarios. Future catches are predicted without error, i.e. equal to the values provided in the forecast in accordance with the benchmark (Figure 1). Advice is provided on the basis of the GFCM reference points (SPR_{40}, F_{40} and F_{20}), which are generally regarded as relatively conservative reference points compared to F_{MSY} and B_{MSY} or their proxies. The provision of 2022 advice is based on the critical values of F in 2022 and the resultant SSB in 2023 i.e. the F that gives <95% probability of $B_{2023}<B_{lim}$). Applying F40 directly would result in an increase in risk of $B<B_{lim}$, which would not be compatible with the CFP objective of maintaining B above B_{lim} with a high probability.

Results

The median estimates of F/F_{40} from the ensemble (Table 4) indicate that the F target reference point is reached in 2021 (¬50% probability above and below). Further reductions in catches, especially under the predicted increase in biomass indicate the stock would be underexploited.

The biomass targets (SSB_{40}/SSB_{virgin}) from the ensemble indicate that the stock has already recovered to its Biomass target in 2022 and catches of 1.2*Catch 2020 will retain stock levels at this target while constant catch or catch reductions will lead to further increases in SBB.

However, increasing catches to 1.2* Catch 2020 has a greater than 5% probability of SSB falling below the limit threshold of B_{20}, suggesting that it is not possible to keep the stock at the target biomass without some additional risk (around 10%) at equilibrium conditions and this probability is likely to increase with more variable recruitment not considered in the simulations.

As the stock is already within F and biomass targets, but is projected to be just outside precautionary limits in 2023 but returning within precautionary limits with status quo catch in 2024 and 2025, STECF considers that further catch reductions are not necessary.

Table .4. Short term forecast for sole in GSA 17 performed during PLEN 21-03. For four catch options of 0.8, 0.9, 1.0 and 1.2* reported catch 2020 based on 2020 GFCM assessment and 2020 reported catch. Historic values 2017 to 2020 are shaded grey. All scenarios show F < F target in 2022 (yellow shading), SSB just above B target in 2023 (Green shading). Probability of B>Blim (shaded pink) show that catches greater that catch in 2020 imply more than 5% risk of falling B<Blim (P(SSB>SSB20)<95%), while catches equal to or less than catch in 2020 give risk of B in 2023 just around 5% (P(SSB>SSB20) just below 95%) but falling below 5% (P(SSB>SSB20) > 95%) by 2024 and 2025. The status quo catch line 2021-2025 is highlighted in blue.

Scenario	Metric	2017	2018	2019	2020	2021	2022	2023	2024	2025
		observed catches				interim year	TAC year			
Catch2022-2025=0.8*Catch2020	Median SSB/SSB40	0.76	0.70	0.71	0.80	0.93	1.01	1.08	1.15	1.19
	Median F/F40	1.36	1.08	1.01	0.71	0.69	0.55	0.54	0.53	0.53
	P(SSB>SSB20)	0.74	0.69	0.70	0.76	0.85	0.91	0.96	0.99	1.00
	Catch	2305	1935	1933	1536	1536	1229	1229	1229	1229
	Median Fbar	0.36	0.29	0.27	0.19	0.18	0.15	0.14	0.14	0.14
	Median Biomass	3223	2914	2944	3299	3873	4224	4563	4840	5051
Catch2022-2025=0.9*Catch2020	Median SSB/SSB40	0.77	0.70	0.71	0.80	0.93	1.01	1.05	1.07	1.08
	Median F/F40	1.36	1.09	1.01	0.71	0.69	0.62	0.62	0.62	0.61
	P(SSB>SSB20)	0.74	0.69	0.70	0.76	0.86	0.91	0.95	0.98	0.99
	Catch	2305	1935	1933	1536	1536	1382	1382	1382	1382
	Median Fbar	0.36	0.29	0.27	0.19	0.18	0.17	0.16	0.16	0.16
	Median Biomass	3219	2903	2936	3301	3866	4209	4471	4664	4796
Catch2022-2025=Catch2020	Median SSB/SSB40	0.76	0.70	0.71	0.80	0.93	1.01	1.07	1.11	1.14
	Median F/F40	1.36	1.08	1.01	0.71	0.69	0.70	0.70	0.70	0.71
	P(SSB>SSB20)	0.74	0.69	0.70	0.76	0.85	0.91	0.94	0.96	0.98
	Catch	2305	1935	1933	1536	1536	1536	1536	1536	1536
	Median Fbar	0.36	0.29	0.27	0.19	0.18	0.19	0.19	0.19	0.19
	Median Biomass	3227	2907	2940	3298	3879	4219	4377	4495	4562
Catch2022-2025=1.2*Catch2020	Median SSB/SSB40	0.76	0.70	0.71	0.80	0.93	1.01	1.01	0.99	0.98
	Median F/F40	1.36	1.08	1.01	0.71	0.69	0.85	0.88	0.90	0.91
	P(SSB>SSB20)	0.74	0.69	0.70	0.76	0.86	0.91	0.92	0.92	0.92
	Catch	2305	1935	1933	1536	1536	1843	1843	1843	1843
	Median Fbar	0.36	0.29	0.27	0.19	0.18	0.23	0.23	0.24	0.24
	Median Biomass	3221	2906	2946	3298	3876	4234	4221	4139	4077

Advice

The advice is to maintain catches in 2022 at the level reported in 2020, this implies a catch of 1536 tonnes in 2022. The results of the extended projections suggest that with the reduction in catches observed in 2020 the stock was exploited sustainably in 2020 and further reduction in catches are not necessary. In the medium-term some increase in catches may be possible as the biomass increases and if strong recruitment events permit. As F is already below F target no transition to target F is necessary, so no specific F_{MSY} transition scenario is provided.

As this assessment estimates that F is already at F target in 2020, and expected to remain below F target in 2021, no further effort reduction for fleets targeting sole is required for achieving F target for sole in GSA 17 in 2022.

Notes on the assessment quality

STECF has provided advice on the basis of the 2021 GFCM benchmark assessment with data to 2019, but notes that this assessment has shortcomings in the way it treats the length data. It also misses age data and there are some concerns over historic catch treatment and ecological realism / comparison to other sole stocks. Although classified by GFCM as an age-structured length-based model it behaves much more like an age structured production model (ASPM) predominantly relying on historic catch information and recent survey biomass information. The ensemble does relatively little to propagate the uncertainties along the major axes of uncertainty. The conservative choice of reference points is though consistent with reference points applied to biomass models and are suitable for this assessment. Therefore, STECF concludes the advice based on the GFCM benchmark model to be robust, but suggests that a number of model improvements may help reduce uncertainty in the stock dynamics and therefore allow for more precautionary management at higher long-term yield.

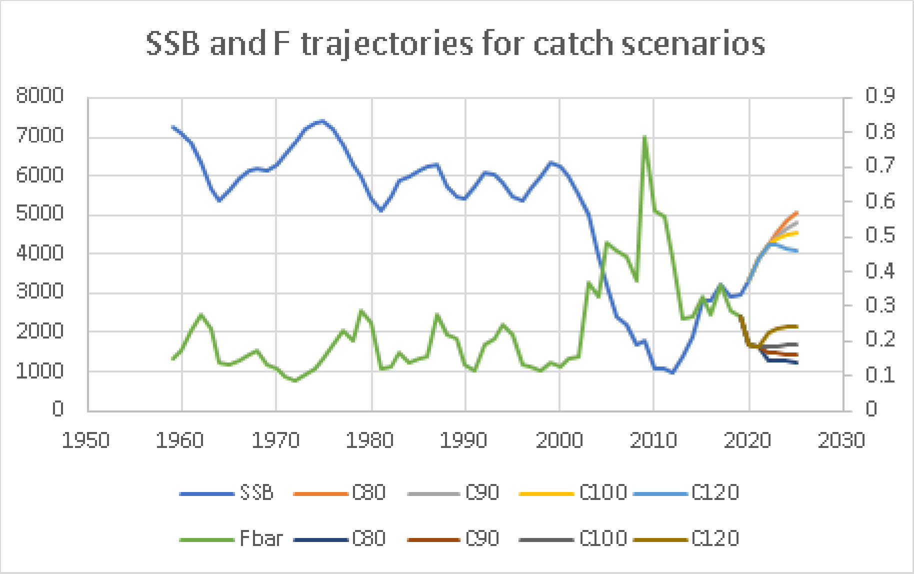

Figure 1. Median SSB and F for Sole in GSA 17 from 1959 to 2020 and short term projection options of 0.8, 0.9, 1.0 and 1.2 times catch in 2020 for 2022 to 2025. Assuming catch in 2021=catch in 2020.

Biomass reference points

STECF notes that for the stocks with long time series (Norway lobster and common cuttlefish) B_{lim} and B_{pa} values are provided. As many of the other stocks have only very short time series, the stock dynamics is often poorly specified. Biological data will also have to be revised and updated. For stocks such as both the hake stocks, it is unclear whether recruitment has been reduced due to low biomass from high exploitation or some other causes. There may be a need to incorporate some standardised stock dynamics in the process in order to evaluate biomass reference points for these stocks, by fitting stock recruitment functions to the data both with and without priors on steepness to determine a plausible range of stock dynamics that both fits the data and conforms to expected ranges of Stock recruit parameters. In addition, the possible impact of climate change on the resilience and stability of Mediterranean stock biological reference points would need to be considered. These approaches need careful evaluation, which would be a good task for a methodological EWG in spring 2022. In addition, STECF suggests that the proposed EWG in 2022 could be adequate to quality check the Mediterranean and Black Sea data currently not scrutinised in STECF stock assessment, using the same methodology as in the EWG-21-02.

EWG duration

STECF notes that 5 days of the specific STECF EWG 21-15 was not sufficient, also considering the additional data issues beyond what had been addressed during EWG 21-02. As discussed above, an extension of the duration of this EWG should therefore be considered. STECF suggests that the EWG should be reinstated at 6.5 days to allow sufficient time to recover from data issues and carrying out a better data checking during the EWG.

STECF conclusions

STECF concludes that the EWG fully addressed all the ToRs. STECF endorses the assessments and evaluations of stock status produced by the EWG. STECF concludes that the assessments completed for five area/species combinations by EWG 21-15 can be used to provide advice on stock status in terms of F relative to F_{MSY} and on being behind/ahead transition to MSY in 2026 for stocks included in the GCFM 2019 MAP.

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

STECF has developed an additional advice procedure for sole in GSA 17, and concludes that further catch reductions are not necessary, but that increasing catches by 20% compared to their 2020 level would increase the risk of SSB falling below Blim above 5%.

STECF supports the review of the model for sole in GSA 17 be passed to the GFCM assessment WG to assist with the benchmark.

STECF concludes that local biomass and exploitation rates vary greatly across Nephrops sub-areas, and additional protective measures may need to be considered around Ancona Ground and in GSA 18.

STECF concludes that for Giant red shrimp in GSAs 18, 19 & 20 the assessment is regarded as preliminary and further work is required to reassemble the Length Frequency data and allow better data exploration.

STECF concludes that to best perform the tasks that EWG for Adriatic, Ionian, and Aegean Seas assessments has taken on, the duration of the EWG next year should be reinstated to 6.5 days.

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

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REPORT TO THE STECF

EXPERT WORKING GROUP ON
Stock assessments in the Mediterranean Sea 2021 – (Adriatic and Ionian Seas)
(EWG-21-15)

Virtual meeting, 18-22 October 2021

1 INTRODUCTION

1.1 Approach to the work

The working group was held in remotely, from 18th to 22th October 2021. The meeting was attended by 14 experts in total, including one STECF member and one JRC experts along with two observers.

The objective of the expert working group on Stock assessments in the Mediterranean Sea 2021 (Adriatic and Ionian Seas) EWG 21-15 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:00 on the first day. The ToRs were discussed and examined in detail. Stocks were allocated to participants based on expertise. An ad-hoc ftp repository was created to share documents, data and scripts and prepare the report. The stock assessments were evaluated by all participants. Following EWG 21-02 data preparation EWG data was available for assessments much earlier in the meeting. However, due to revisions of data following changes in the data call and some discrepancies between FDI and Med and Black Sea data calls, assembling data still used a considerable amount of the meeting. Most data issues were completed for stocks by Wednesday night, but data processing issues were found for two stocks late in the meeting, in one case a coding error and in the other a problem that appeared to be a data processing issue, which was resolved by running the data extraction again by JRC staff, but only by Thursday. The final stock assessment remained unresolved by Friday night. For this meeting it was clear that 5 working days was insufficient. Had all the data been organised for stock assessment prior to the meeting the issues would have been considerably reduced, however, achieving this is difficult given the timescales between data delivery in late August and two assessment meeting by mid-October.

Over the week plenary sessions were held each day to monitor progress and share results. The overall conclusions for each stock were discussed and finalized in plenary on the Friday, except for Deep-water rose shrimp 17,18 & 19 which was concluded on Thursday 4 of November 12 days after the meeting.

1.2 Terms of Reference for EWG-21-15

Chair: John Simmonds

DG MARE focal persons: Chato Osio (MARE D1)

TERMS OF REFERENCE

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*[2] *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 21-02.*

For the stocks given in Annex I, the EWG 21-15 is requested:

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 2020, on the basis of the STECF 21-02 results. 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 2020, 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 amount 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 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

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

[2] https://stecf.jrc.ec.europa.eu/documents/43805/2817637/STECF+21-02+-+Methods+supporting+MED+stock+assessment.pdf/2c6ed3f8-7119-47ec-be1f-29c63d3fd6f4

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

ToR 3. For the stock of Norway lobster in the Adriatic Sea, in view of the assessment at Adriatic level being considered not precautionary by GFCM WGSAD 2020, explore fishing mortality levels and stock status based on a whole Adriatic assessment vs sub-areas. The following approach should be undertaken:

1. As in prior EWGs, update the SPICT assessment to give overall (GSA 17-18) stock assessment which will reflect total and overall exploitation.
2. Explore local trends with the MEDITS biomass indices in 4 areas: Pomo/Jabuka Pit, Ancona , Kverner and GAS 18. Evaluate if trends are different in different areas.
3. Perform assessment by areas, based on length/age from MEDITS. If also catches could be split by area, fit statistical catch at age models and reconcile with overall SPiCT assessment as check.

ToR 4. To estimate candidate MSY point-value and conservation reference points (precautionary and limit) in terms of fishing mortality and stock biomass. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.

ToR 5. Using the report structure developed in 2018 (EWG 18-12), provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including FMSY value, conservation and biomass reference points and effort levels.

For stock under the 2019 GFCM demersal MAP (GFCM/43/2019/5) and marked by (^) in Annex I, provide a summary table showing the progress already made in the transition towards MSY and the F and catch advice for 2022 to reach Fmsy by 2026. For the other stocks provide a short term forecast to reach MSY in 2022.

ToR 6. In line with ToR 5, produce the F and catch advice for 2023 for the fleets listed below to reach Fmsy by 2026, while accounting of a linear reduction of the fishing effort of 7% for OTB and 3% TBB in 2022:

1. LLS gear targeting Mediterranean hake in GSA 17-18.
2. GNS, GTR, DRB and OTB gear targeting common sole in GSA 17.

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

ANNEX I

Table I – List of suggested stocks to be assessed by the EWG 21-15.

	Area	**Common name**	**Scientific name**
1	GSA 17-18*	Hake^	***Merluccius merluccius***
2	GSA 17-18	Red mullet^	***Mullus barbatus***
3	GSA 17-18[x]	Norway lobster^	***Nephrops norvegicus***
4	GSA 17-18-19	Deep-water rose shrimp^	***Parapenaeus longirostris***
5	GSA 17-18**	Common cuttlefish	***Sepia officinalis***
6	GSA 17*	Sole^	***Solea vulgaris***
7	GSA 17-18**	Spottail mantis shrimp	***Squilla mantis***
8	GSA 18-19-20**	Giant red shrimp	***Aristaeomorpha foliacea***
9	GSA 19*	Hake	***Merluccius merluccius***

[x] In line with ToR 3

^ Stocks under GFCM Demersal Plan (GFCM/43/2019/5)

* Stock with a GFCM benchmark

** Stock boundaries to be defined on the basis of expert knowledge

NOTE: The joint assessments have been proposed on the basis of STOCKMED and management needs. However, these suggestions can be modified according to experts' knowledge and to the most recent scientific information.

Clarification of ToRs 3.2, 3.3 and 6 were required during the meeting, the definition of the four sub areas was unclear from the ToRs, as they had not previously been used to split the Nephrops stocks, but one area Pomo/Jabuka Pit did have a legal identity as a closed area. Following discussions the EWG defined the areas based in water depth and coast association to Italian and Croatian areas. For ToR 6 the description of exploitation rates requested was incomplete. Following suggestions from the group a specific choice for the different fleets was agreed and adopted.

1.3 Report Structure

The basic report structure follows earlier years, but with a new additional ToRs fitted into the structure. The report is structured with a summary section (Section 2) providing the headline advice, with tables of F_{MSY} and $F_{MSY\ Transition}$, catch options and notes on the quality of the assessments. The basis of the approach to data management, estimation of F_{MSY} and $F_{MSY\ Transition}$ and the process for short term forecasts are all briefly described in Section 4. ToR 1 and 2 are dealt with in detail in Section 6, by stock. The details of ToR 3 (Nephrops by sub-area) are included in Section 6.5 (Nephrops in GSA 17-18). ToR 4 is documented in Sections 6.X.4 by stock and deals with reference point calculation. The short term forecasts are in Section 6.X.5 by stock. ToR 6 requesting an additional 2023 short term forecast for hake 17-18 and sole 17 could only be carried out for hake 17-18 and is included with the 2022 STF in Section 6.1.5 with the results also included in the summary section for hake in GSA 17-18 Section 5.1. The summaries by stock requested in ToR 5 are in Section 5, with the requested summary tables provided as Table 2.3 in Section 2.

2 FINDINGS AND CONCLUSIONS OF THE WORKING GROUP

A total of 9 area/species combinations were evaluated this year. In addition for Nephrops in GSA 17-18 four subdivisions were evaluated both using biomass indices and age based assessments.

Of the 9 analysed two are based in surplus production methods, and the other seven analyses are age based with two of these based on SS3 multi-fleet models and five using a4a with aggregated catches. Catch advice for two stocks was given using ICES category 3 index based advice. STF for advice for 2022 are provided for all the other stocks except Common Cuttlefish which requires in year management advice due to the short life cycle.

2.1 Stock-Specific Findings & Conclusions

See the stock specific summary sheets (section 5) for the main details by stock, and the assessments (Section 6) for full details. This section provides collated information on methods and stock status. The methods tested and chosen by stock are provided in Table 2.1. Where possible age based assessments are used, or if time series of catch is long, surplus production models are evaluated. Where these do not provide stable enough models, if indices of abundance are available ICES category 3 stock advice is applied. The results in terms of F and catch based on F_{MSY} targets and relative changes from 2020 to 2022 are provided in Table 2.2. 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 6 year linear change in F from 2019 to 2026. The details of this approach are laid out in Section 4.4.1. Table 2.3 provides a summary by stock of progress to 2020, based on F_{2020} in the most recent assessment, which includes the effect of any changes implemented before and during 2020. The future F and catch options for 2022 based on the linear transition are also provided in Table 2.3.

ToR 6 asks for additional fleet wise short term projections for 2023 for hake in GSA 17-18 and sole in GSA 17, the results at fleet level are given within the catch option section for hake 17-18 in Section 5.1. As the sole 17 assessment was not fully completed, ToR 6 for this stock could not be completed.

Table 2.1 Summary of work was attempted and basis for any advice. a4a is an age based assessment method using aggregated catch, SS3 is an integrated SCA model. SPiCT and CMSY are surplus production methods. STF is a standard short term projection with assumptions of status quo F and historic recruitment. Index refers to the ICES Category 3 approach to advice for stocks without analytic assessments. Methods that are used for advice are in bold.

Area	Common Species name	2020 Assessment	2021Assessment
GSA 17-18*	Hake^	SS3 STF	**SS3 STF**
GSA 17*	Sole^	Index 2020	**Index 2020**
GSA 17-18	Red mullet^	a4a STF	**a4a STF**
GSA 17-18**	Common cuttlefish	CMSY	**CMSY**
GSA 17-18ˣ	Norway lobster^	SPiCT STF	**SPiCT STF** Index/a4a/surba by subarea.
GSA 17-18**	Spottail mantis shrimp	a4a STF	**a4a STF**
GSA 17-18-19	Deep-water rose shrimp^	a4a STF	**a4a STF**
GSA 18-19-20**	Giant red shrimp		**Index 2021**
GSA 19*	Hake	a4a STF	**a4a STF**

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

Area	Species	Method/ Basis	Age Fbar	Biomass 2018-2020	Catch 2018-2020	F 2019	F 2022	Change in F	Catch 2020*	Catch 2022	Change in catch
GSA 17-18*	Hake^	SS3 STF	1-4	increasing	declining	0.37	0.18	-52%	4841	2920	-40%
GSA 17*	Sole^	Index	biomass	declining	declining				1605	1960	22%
GSA 17-18	Red mullet^	a4a STF	1-3	increasing	declining	0.37	0.36	-5%	3123	4279	37%
GSA 17-	Common cuttlefish**	CMSY	biomass	increasing	declining	0.07	0.16	123%	2150	7450	247%
GSA 17-18[x]	Norway lobster^	SPiCT STF	biomass	increasing	declining	0.16	0.37	131%	870	1986	128%
GSA 17-	Spottail mantis shrimp	a4a STF	1-3	increasing	fluctuating	0.66	0.44	-33%	4780	4945	3%
GSA 17-18-19	Deep-water rose shrimp	a4a STF	0-2	stable	stable	1.61	0.72	-55%	5121	3092	-40%
GSA 18-19-	Giant red shrimp	Index	biomass	fluctuating	fluctuating				386	303	-22%
GSA 19*	Hake	a4a STF	0-4	increasing	declining	0.29	0.15	-47%	584	420	-28%

* Estimated Catch from 2021 Assessments STECF EWG 21-15 or index based advice. Change in F is % change in F_{2022} relative to F_{2020}, Change in catch % change catch 2022 relative to 2020

** Catch of cuttlefish cannot be predicted for 2022, the value given is the average equilibrium catch at $F=F_{MSY}$

Table 2.3 Summary of stock and fishery status by area and species, **based on $F_{MSY\ Transition}$ target for F_{2022}.** **Recent change** gives general change in F and catch over the last three years. F_{2019} and F_{2020} are both estimated F in the 2021 assessment. F_{2025} is the F_{MSY} target for the end of transition; F_{2019} is the starting point of the MAP. The estimate of progress so far is shown as the F change % 2019 to 2020 and the F status relative to Transition. **Advice for 2022** is based on the $F_{Transition}$ for the next advice year (2022) which is set at a level to reach F_{MSY} in 2025, the change in F and implied by the MAP is the difference (as a fraction) between $F_{Transition}$ in 2022 and the F in 2019 and the most recent year for which we had estimates, F in 2020. Change in catch is from required change catch 2020 to catch 2022. Shaded cells are based on indices.

Area	Species	F change	Catch Change	F	F	Fmsy Transition	Target F 2025	F Change %	F Status 2020	F Change %	F Change %	Catch	Catch 2022	Catch Change
		2018-2020	2018-2020	2019	2020	2022	F MSY	2019-2020	Rel to FMSY transition 2020	2019-2022	2020-2022	2020	Fmsy Transition	2020-2022
GSA 17-18*	Hake^	declining	declining	0.47	0.37	0.35	0.18	-22%	ahead of transition	-27%	-6%	4841	5262	9%
GSA 17*	Sole^		declining									1605		
GSA 17-18	Red mullet^	declining	declining	0.68	0.37	0.54	0.36	-45%	ahead of transition	-20%	45%	3123	5979	91%
GSA 17-18**	Common cuttlefish	declining	declining	0.09	0.07	0.12	0.16	-22%	F below FMSY	31%	69%	2150		
GSA 17-18^{x}	Norway lobster^	declining	declining	0.25	0.16	0.30	0.37	-37%	F below FMSY	20%	89%	870	1627	87%
GSA 17-18**	Spottail mantis shrimp	declining	fluctuating	0.78	0.66	0.64	0.44	-16%	ahead of transition	-18%	-3%	4780	6531	37%
GSA 17-18-19	Deep-water rose shrimp	stable	stable	1.63	1.61	1.24	0.72	-1%	behind transition	-24%	-23%	5121	4513	-12%
GSA 18-19-20**	Giant red shrimp		fluctuating									386		
GSA 19*	Hake	declining	declining	0.37	0.29	0.28	0.15	-23%	ahead of transition	-25%	-3%	584	728	25%

2.2 Quality of the assessments

Hake

Hake in GSA 17-18 Settings used for the SS3 assessment model were similar to those from the January 2019 GFCM benchmark, (with the minor changes noted last year to survey use and fitting process). The model updated with 2020 data shows similar stock SSB, and F as previous 2020 assessment. It shows a sharp increase in SSB in last few years. The retrospective analysis shows stronger tendency to overestimate SSB and underestimate F, highlighting 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. No data was received from Montenegro Official catch was used from Albania, but length data from Albania was not available. ToR 6 requesting a STF to 2023 requested information on TBB but this gear is not included in the GFCM assessment nor is Gill net and Trammel Net fisheries. Catches from these are small but it would be good practice to include these catches so the fishery and survey data are both related to a complete stock unit. There is a need to recheck age length keys as there are some obviously spurious values. Overall given Italian data revisions, missing catch and continuation of the use of age errors a revision of the benchmark should be considered.

Hake in GSA 19 The EWG used revised Benchmark model settings same at 2020. The model performance was very similar to the Benchmark model but has less sensitivity to the 2019 data, and seems to provide a better option. Update is very similar to last year giving similar perception of stock. F is declining still well above FMSY but close the transition value for 2020.

Red Mullet in GSA 17-18

Updated with 2020 data with some additional reconstruction from April, for Slovenian LFDs. RECFISH data was used was for Croatian catches for 2006 to 2012. For Albania LFD were reconstructed based on 2019 data. For 2020 Albania catch was taken as the mean of last three years. Montenegrin catch was filled in as last year. A more serious retrospective bias in F and SSB, which is a cause for some concern, is developing. A benchmark is proposed in 2022 at GFCM, this is to be encouraged. More detailed evaluation of survey might give a way to correct for differing time of year among the surveys. Stock status is F=Fmsy but given the retrospective bias this may be optimistic. The instability in F0.1 observed two years ago is no longer seen with this model.

Sole 17

Advice has been provided based on the precautionary approach used by STECF from 2020. The EWG used the SS3 model provided from GFCM. The model was updated with 2020 survey and catch data. There were some minor concerns regarding the data input, but none that would have invalidated the use of the data. Some issues were encountered regarding the fitting of the model to the data. Within the time frame of the EWG it was not possible to resolve these issues. The ensemble modelling method also requires the additional work to obtain catch advice for fishing mortality scenarios, the GFCM report does not provide sufficient detail or scripts to conclude on advice for 2022 and 2023 in a manner that conforms to the benchmark. Five days was not sufficient for updating such a model. These issues compounded with a lack of confidence in the results due to unfamiliarity with the data, the complex ensemble model method for a STF, and the incomplete definition in the benchmark report resulted in the use of advice from 2020. It is hoped that GFCM will be able to deal with this and provide update advice later this year.

Nephrops in GSA 17-18

The model settings for the SPiCT assessment are similar to previous years. The retrospective performance has deteriorated a bit since last year. F is now F<FMSY. Biomass is between Bpa and BMSY. Fmsy is very similar to last year. Diagnostics are improved, and a two negative production point are present for index 1, suggesting there are issues with this index. Explanation of its utility should be carried. Sensitivity to some priors and model assumptions but current model remains the most robust. Investigations of sub area and biomass indices by sub area derived through SURBA and smoothing of medits biomass data were carried out. These are in good agreement but with more noise from the SURBA indices. This are used to provide sub area catch allocations using the total catch from the main surplus production model (See Section 5.5 and Section 6.5.5). Mortality signals are also available from SURBA and a preliminary a4a assessment. Mortality signals in GSA 18, appear relatively flat but the other here areas show declines, particularly in Pomo/Jakuba Pit. The biomass indices appear to be useful for splitting catch options, but may also indicate that Ancona is at low level for biomass, requiring further reductions (Section 5.5 and Section 6.5.3.5).

Spottail mantis shrimp GSA 17-18

Assessments for GSAs 17 and 18 combined. The 2020 model was run with updated data. Most the stock is thought to be in GSA 17. New data from EWG 21-02 was included along with resubmission from Italy. The same parameterisation was used as last year. Added Albanian catches were raised by rest of the catch. It was not considered possible to give advice for GSA 18 on its own, advice for GSA 17 can be considered similar to GSA 17-18 combined.

Deep-water Rose Shrimp in GSA 17-18-19.

There were small changes to the model from last year following extensive evaluation of possible configurations. Data issues were discovered during the meeting and resolved afterwards treatment of the data was the same as EWG 21-02 with only one extra year added. Errors in scaling resulted in incorrect mean weights in 2020, this did not influence the advice last year, this year the recruitment is rescaled in accordance with correct mean weights. An error in 2019 catch due to Italian double reporting has been corrected, slightly lowering average catch in the last few years.

Common Cuttlefish GSA 17-18

The assessment is very similar to last year, model setting were checked and maintained. Two assessments and advice sheets are available, GSA 17 on its own and GSA 17-18 combined. The results for these two areas are very similar as GSA 17 dominates. It was not considered possible to give stock status for GSA 18 separately.

For Giant red shrimp in GSA 18,19 & 20,

The late inclusion of this stock in the ToRs means that no data preparation had been done prior to the meeting. Issues were found with data extraction that appeared to be linked to formatting errors in the Italian data. Find in this consumed considerable time and little further exploration was possible. A preliminary assessment was run, but further work is required. Index advice based on ICES Category 3 Index approach is provided.

3 FOLLOW UP ITEMS

For Giant red shrimp in GSA 18,19 & 20, the group only managed a preliminary assessment. The late inclusion of this stock in the ToRs meant that no data preparation had been done prior to the meeting. Issues were found with data extraction that appeared to be linked to formatting errors in the Italian data.

Find in this consumed considerable time and little further exploration was possible. To make progress the 2020 data was added to a previously assembled stock object. However, this was based on a different approach to growth to that usually applied for mid-year spawning species. Further work is required to reassemble the LF data and allow better data exploration.

For Sole in GSA 17 advice has been provided based on the precautionary approach used by STECF from 2020. The EWG used the SS3 model provided from GFCM. The model was updated with 2020 survey and catch data. There were some minor concerns regarding the data input, but none that would have invalidated the use of the data. Some issues were encountered regarding the fitting of the model to the data. Within the time frame of the EWG it was not possible to resolve these issues. The ensemble modelling method also requires the additional work to obtain catch advice for fishing mortality scenarios, the GFCM report does not provide sufficient detail or scripts to conclude on advice for 2022 and 2023 in a manner that conforms to the benchmark. Five days was not sufficient for updating such a model. These issues compounded with a lack of confidence in the results due to unfamiliarity with the data, the complex ensemble model method for a STF, and the incomplete definition in the benchmark report resulted in the use of advice from 2020. It is hoped that GFCM will be able to deal with this and provide update advice later this year.

If the EWG is to continue with the assessment there are several items to be followed up. The necessary input data needs to be included in the data call. A few outstanding issues within the modelling need to be explored further. A standardised routine / code is required to run the model over the different modelling options. A standardised routine / code is required to run the STF to give F and SSB results needed for F_{MSY} / $F_{MSY\ transition}$ advice, based on the ensemble model methodology. Currently it’s unclear how this is to be carried out with a multimodal output that can occur with the ensemble approach as defined for sole in GSA 17.

Meeting duration

The five day meeting was too short for a number of stocks, data errors in three stocks resulted in late assessments. Changes are needed to try to ensure this does not happen in future, either through longer meeting or better data preparation. The specific issue with sole GSA 17 is discussed above. The EWG questioned the point of doing assessments which then need to be revised at GFCM.

4 BASIS OF THE REPORT

4.1 Data Preparation

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

4.1.1 Fill-in procedures

All stratified sampling programs can result in fleets or metiers that are missed or severely under-sampled[3]. These strata are most often a very small part of the total catch however; they require the allocation of size/age as part of the stock assessment. This allocation of LFDs can be done within some assessment packages that operate by fleet/metier and handle patchy data on length frequency distributions (LFDs) and

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[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.

fit the missing data as part of the assessment model process. Other packages that operate by combining catch data to the total catch require a procedure that either leaves a year without an LFD, or alternatively fill-ins the small proportion of the catch with a suitable LFD. The modelling methods that work by fleet/metier and fit the missing observation often require more complex modelling but also the strong additional assumption that the catch is a true census (including discards) in order to estimate the missing LFDs. When a combined catch assessment is used with a minor fill-in the assumption that allows some error in catch estimation is then possible. For the purposes of estimating stock status (F and SSB) and giving catch advice the differences between the approaches are usually small, for example hake in GSA 17-18 (REF STECF 2020 report). The procedures used in this EWG for filling in landings and discard LFDs are documented below.

4.1.1.1 Fill in for length Frequency distributions for landings

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

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

- **mean** is used for normal distributions, which have no outliers.
- **median** is generally used to return the central tendency for skewed distribution or when outliers are observed.

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

- **Less than 5%.** If fill-in is a small part of catch (less than 5%) then any solution is acceptable as the impact of the fill-in will be negligible.
- **Trend in mean length:** If there is trend in the LFDs (seen as trends on mean or quartile values) then using adjacent data may be preferable.
- **High annual variability:** If variability in the data (again seen as variability on mean and quartiles) is large then full data set is likely to be better the best source of the fill-in.
- **Similar to a sampled metier:** If the missing LFDs are expected to be similar to another well sampled metier of fleet then data from that fleet is used to provide the LFDs. In some cases this is done by assuming the whole fishery is the best source of information for a year and the whole catch is raised with the available data.
- **Years with substantial gaps:** If a fill-in is more than 50% of the catch users need to consider highlighting this for estimation in the model.

4.1.1.2 Fill-in for discards data

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

Quantities of discards by years:

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

Missing LFDs:

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

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

4.2 Basis of the catch and fishing mortality advice

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

1) Full assessment and full MSY reference points or with surplus production model with F and biomass relative to F and B_{MSY}: Catch advice at MSY based on short term forecast. **Used for hake in GSA 17-18, Nephrops 17-18 and Common Cuttlefish 17-18.**
2) Full assessment without full evaluation MSY reference points due to short time historic series: Catch advice based on MSY proxy of $F_{0.1}$ based on short term forecast. **Used for all a4a assessments**
3) Assessment providing SSB trend information historic F evaluation, not suitable for STF Catch / Effort advice under precautionary considerations (Patterson 1992) F= F_{MSY} with Harvest Rate (HR) based estimated SSB in most recent year. **Not used.**
4) For sparse data with insufficient years for VPA type analysis, but with catch at length or age for most of the fishery: advice is based on pseudo cohort analysis at equilibrium, with estimate of current F relative to $F_{0.1}$. **Not used.**
5) Trend based indicator with exploitation and stock status know to be OK: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend without precautionary buffer, giving 2 years advice. **Not used.**
6) Trend based indictor: Catch / Effort advice under precautionary considerations based on ICES smoothed index of trend with precautionary buffer (20% reduction applied in earlier t=years) **Used for 3 stocks this year and for 2 from last year**.
7) Valid length analysis: statement of stock status, indication of direction of change required. **Not used**
8) No valid analysis: no advice. **Not needed**

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

4.3 MSY Reference points for stocks in this report

For many of the stocks evaluated in this assessment meeting, the number of years of S-R data is very limited and it is not possible to carry out full evaluations of MSY, because the stock - recruit relationships cannot be established. For hake in GSA 17-18 the model is fitted including a stock recruit relationship, but the parameterisation is fixed with a steepness of 0.99, so the effect of the relationship is removed. For Nephrops 17-18 and common cuttlefish long time series of catch are used and the surplus production method gives estimates of F_{MSY}.

Following STECF decision in the absence of full MSY evaluations, and/or biomass reference points STECF considers that $F_{0.1}$ forms a good proxy for MSY. Thus for all stocks here with analytical assessments $F_{0.1}$ has been evaluated based on the stock conditions over the last three years. MSY advice in terms of F and catch for 2019 are based on this approach.

4.3.1 MSY Ranges

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

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

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

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

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

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

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

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

4.4 Basis of Short Term Forecasts

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

- Biological conditions are assumed to be recent biological conditions

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

  - Recruitment - Most probable recruitment
    - If recruitment trend occurs ---- Recent recruitment is selected … Arithmetic Mean of recent years … at least 3 years
    - If no trend occurs expected value……………….Geometric mean of series

- Fishery is assumed to be the same as the recent fishery

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

- F in intermediate year ---- is assumed to be F status quo for all options
    - If F is fluctuating (F_{y-2} outside F_{y-1} and F_{y-3}, or $F_{y-2}=F_{y-3}$) – mean of 3 years
    - F trend - (F_{y-2} between F_{y-1} and F_{y-3} or $F_{y-2}=F_{y-1}$) – F last year of assessment

4.4.1 MSY Transition

The EWG continues to provide the main catch option presented in section 5 based on the target of FMSY in 2021. This remains the primary advice. However, in Plenary November 2019 The STECF considered if it would be possible to give an additional advice option or options associated with the Adriatic Med MAP. The MAPs have the objective of achieving F_{MSY} by 2026. For a few stocks F_{2018} is close to F_{MSY}, but for many stocks such as hake F is substantially higher than F_{MSY} and it seems likely that these stocks will be considered under the objective for reaching F_{MSY} by 2025. For such stocks the plans do not specify how it is expected that F should change over the 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.

$F_{MSY\text{-}Transition}$ (2020) = {•0.857 F (2019) + 0.143• F_{MSY}(2019)}

whereas for the following years:

$F_{MSY\text{-}Transition}$ (2021) = {0.714• F (2019) + 0.286• F_{MSY}(2020)}

$F_{MSY\text{-}Transition}$ (2022) = {0.571• F (2019) + 0.429• F_{MSY}(2021)}

$F_{MSY\text{-}Transition}$ (2023) = {0.429• F (2019) + 0.571• F_{MSY} (2022)}

$F_{MSY\text{-}Transition}$ (2024) = {0.286• F (2019) + 0.714• F_{MSY} (2023)}

$F_{MSY\text{-}Transition}$ (2025) = {0.143• F (2019) + 0.857 • F_{MSY} (2024)}

$F_{MSY\text{-}Transition}$ (2026) = {0.0 • F (2019) + 1.0 • F_{MSY} (2025)}

Where for the first year F_{2019} =F_{2018}, but for subsequent years F_{2019} is the F in 2019 estimated/updated in the subsequent annual assessments and $F_{MSY(year)}$ is the estimate of F_{MSY}

updated as F_{MSY}(2020, 2021 etc.) in each subsequent estimation of reference points following annual assessments.

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

5 SUMMARY SHEETS BY STOCK

ToR 5. *Using the report structure developed in 2018 (EWG 18-12), provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including FMSY value, conservation and biomass reference points and effort levels.*

5.1 SUMMARY SHEET FOR EUROPEAN HAKE IN GSA 17 AND 18

STECF advice on fishing opportunities

STECF EWG 21-15 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.179 and corresponding catches in 2022 should be no more than 2920 tons.

Stock development over time

Catches have been around 6000 tons in the last six years with a slight decrease in the last two years. Female SSB of European hake is relatively stable until 2007, then decreased considerably until 2014 (1384 tons) then rises to the highest value of the time-series in 2021 (4591 tons). $F_{bar(1-4)}$ shows a decreasing trend in the last six years. Recruitment shows a decreasing trend in the last six years with the exception of 2019. Recruitment in the last five years is below average. $F_{bar(1-4)}$ in 2020 (0.37) is the lowest of the time-series.

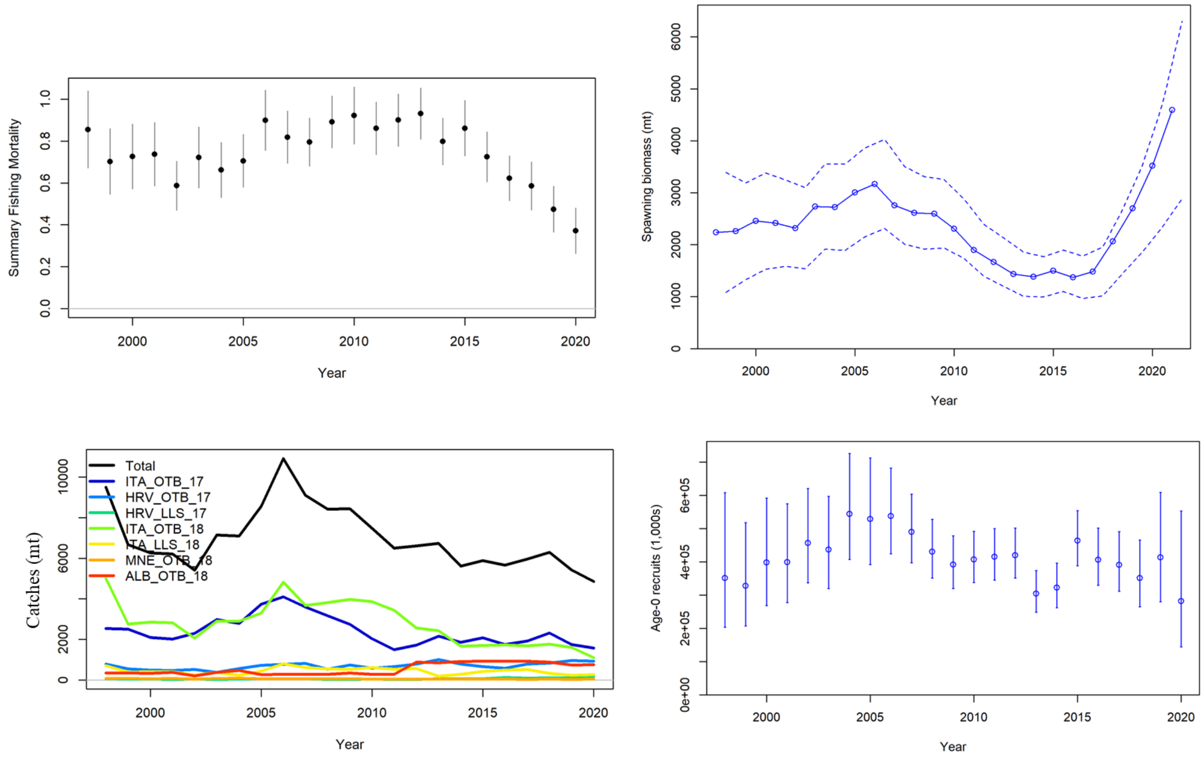


Figure 5.1.1 European hake in GSAs 17 and 18: Trends in catch, recruitment, fishing mortality and **female** SSB resulting from the SS3 model.

Stock and exploitation status

The current level of fishing mortality (0.37) is above the reference point F_{MSY} (0.179) 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	2018	2019	2020
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 2022 and an additional option for a forecast for 2023. The assumptions for 2021 are given in Table 5.1.2a, and results are given in Table 5.1.3a. The further assumptions for 2022 required for the 2023 forecast are in Table 5.1.2b.

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 2018-2020
$F_{ages\ 1\text{-}4}$ (2021)	0.37	F_{2020} used to give F status quo for 2021
Female SSB (2021)	4591 t	Stock assessment 1 January 2021
R_{age0} (2021,2022,2023)	348,562	Mean of the last 3 years
Total catch (2021)	5409 t	Assuming F status quo for 2021

Table 5.1.2b European hake in GSAs 17 and 18: Assumptions made for 2022/2023 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
$F_{ages\ 1\text{-}4}$ (2022)	0.35	7% reduction in partial F_{2022} for all OTB fleets, F_{2020} for all LLS fleets in 2022
R_{age0} (2023)	348,562	Mean of the last 3 years
Female SSB (2022)	5714	Short term forecast 1 January 2022
Total catch (2022)	5282	Assuming F option above

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

Basis	Total catch (2022)	F_{total} (ages 1-4) (2022)	**Female** SSB (2023)	% **Female** SSB change**	% Catch change***
STECF advice basis					
F_{MSY} / MAP	2920	0.179	7852	71.0	-39.7
$F_{MSY\ Transition}$^^	5262	0.35	6590	43.5	8.7
$F_{MSY\ lower}$	2029	0.12	8340	81.7	-58.1
$F_{MSY\ upper}$*	3941	0.25	7298	59.0	-18.6
Other scenarios					
Zero catch	0	0	9466	106.2	-100.0
Status quo	5564	0.37	6430	40.1	14.9

Basis	Total catch (2022)	F_{total} (ages 1-4) (2022)	**Female** SSB (2023)	% **Female** SSB change**	% Catch change***
60% of status quo	3565	0.22	7501	63.4	-26.4
80% of status quo	4761	0.30	6944	51.3	-5.0
7% reduction OTB fleets^	5282	0.35	6572	43.2	9.1

* $F_{MSY\ upper}$ is not tested and is assumed not to be precautionary STECF does not advise fishing at $F>F_{MSY}$
** % change in SSB 2023 to 2021
***Total catch in 2022 relative to catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026
^7% reduction in partial F_{2022} for all OTB fleets, and F_{2022} = F_{2020} 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 2020

Basis	Total catch (2022)	F_{total} (ages 1-4) (2022)	GSA 17 OTB	GSA 17 LLS	GSA 18 OTB	GSA 18 LLS
STECF advice basis						
F_{MSY} / MAP	2920	0.179	1509	108	1144	160
$F_{MSY\ Transition}$	5262	0.35	2719	194	2061	288
$F_{MSY\ lower}$	2029	0.12	1049	75	795	111
$F_{MSY\ upper*}$	3941	0.25	2036	145	1544	216
Other scenarios						
Zero catch	0	0	0	0	0	0
Status quo	5564	0.37	2875	205	2180	304
60% of status quo	3565	0.22	1842	131	1396	195
80% of status quo	4599	0.3	2376	170	1801	252
7% reduction OTB fleets**	5282	0.35	2729	195	2069	289

* $F_{MSY\ upper}$ is not tested and is assumed not to be precautionary STECF does not advise fishing at $F>F_{MSY}$
** 7% reduction in partial F_{2022} for all OTB fleets, and F_{2022} = F_{2020} for all LLS fleets

If Reduction in F are maintained at 7% for OTB fleets through 2022 and 2023 only by reducing the F for the LLS fleets to 0 in 2023 will the total F in 2023 be reduced to $F_{MSY\ Transition}$ = 0.31..

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.

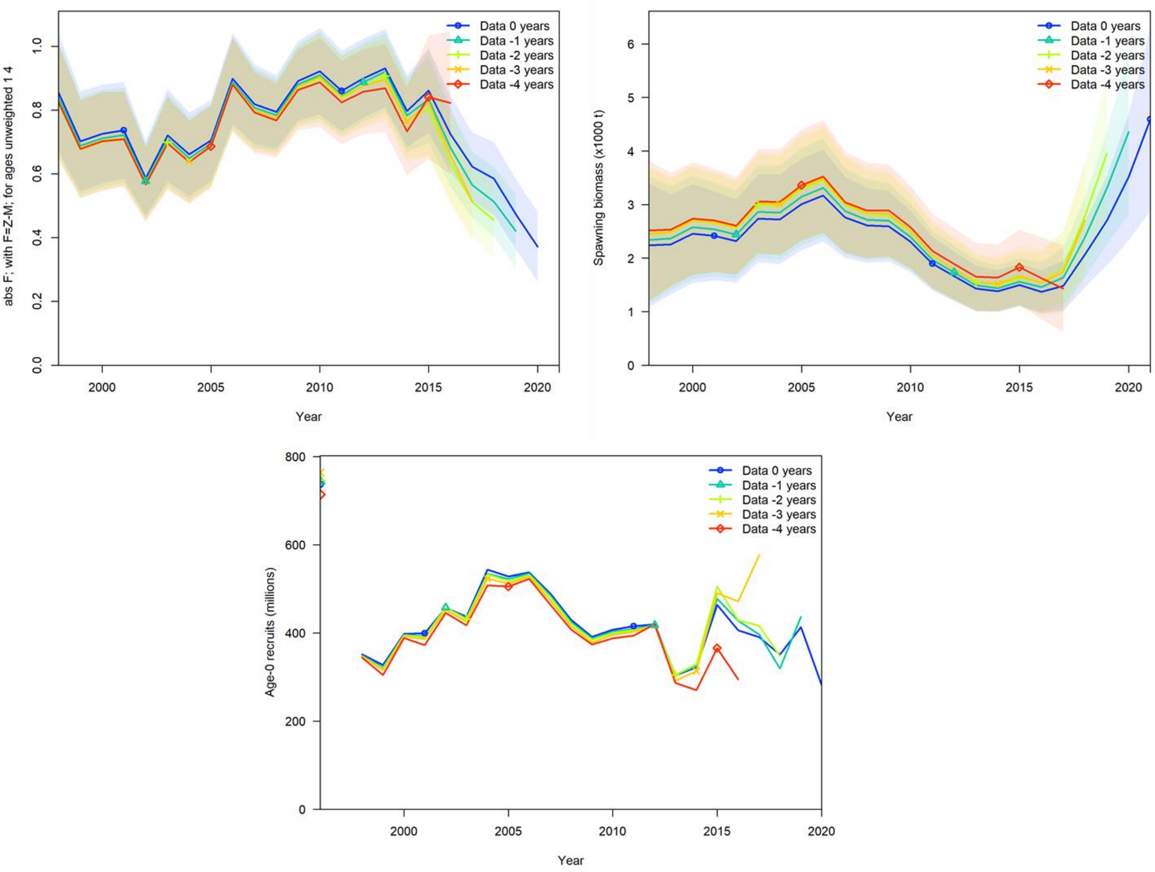


Figure 5.1.2 European hake in GSAs 17 and 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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.

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}	0.179	F_{MSY} from SS3 model	STECF EWG 19-16
Precautionary approach	B_{lim}	1858	B_{loss}	GFCM Benchmark 2019
	B_{pa}	2543	$B_{lim} \cdot exp^{(1.645 \cdot \sigma)}$	GFCM Benchmark 2019
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.179	F_{MSY}	STECF EWG 19-16
	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 21-15

*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			
2022	F = F_{MSY}	2920			

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 5.1.8 European hake in GSAs 17 and 18: Catch and effort distribution by fleet in 2020 as estimated by and reported to STECF.

2020	Landings			Discards
Catch (t)	Otter trawl* 88%	Longlines 9%	Other** 3%	t
	4293	443	123	108
Effort***	130201	16652		
	Fishing days			

*Otter trawl contains all the official landings from the different countries except for Montenegro which is the mean of the landings of 2017-2019 (40 t)
** other fleets not included in the assessment are GNS, GTR and TBB.
***Effort only for member states

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	218259
2006	4613	836	3980	2	768	61	59	280	10599	209482
2007	3497	620	3435	5	818	65	58	275	8773	183253
2008	3640	551	3037	1	532	33	63	275	8132	170149
2009	3545	534	2549	1	734	37	56	336	7792	192903
2010	3400	601	1863	0	572	40	49	280	6805	172050
2011	3312	519	1460	0	653	37	40	286	6307	164050
2012	2520	566	1777	0	796	34	42	899	6634	197517
2013	2379	188	2192	1	1014	65	43	851	6733	184006
2014	1584	279	1789	1	774	61	44	902	5434	165617
2015	1614	427	2011	1	655	56	38	914	5716	162008
2016	1672	518	1731	0	586	124	42	948	5621	163473
2017	1682	515	1836	0	784	90	37	940	5884	174407
2018	1650	335	1853	2	815	116	47	872	5690	183930
2019	1481	235	1552	4	944	116	37	731	5100	165284
2020	1086	265	1488	1	927	178	40^^^	751	4736	145583

*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. ^^^Mean of the last 3 years
¤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	351183	556426	221646	2239	3207	1270	9441	0.86	1.01	0.70
1999	327109	480927	222488	2259	3042	1476	6666	0.70	0.83	0.57
2000	397920	554992	285302	2456	3233	1679	6268	0.73	0.86	0.60
2001	399166	542081	293929	2415	3112	1718	6206	0.74	0.86	0.61
2002	456726	590540	353233	2320	2973	1666	5442	0.59	0.68	0.49
2003	436446	567516	335647	2736	3424	2049	7322	0.72	0.84	0.60
2004	543375	692707	426236	2723	3422	2025	7336	0.66	0.77	0.55
2005	528170	678744	411000	3007	3726	2288	8772	0.71	0.81	0.60
2006	537545	656398	440212	3169	3889	2450	10832	0.90	1.02	0.78
2007	489651	583573	410845	2760	3390	2130	8959	0.82	0.92	0.71
2008	430099	510649	362255	2613	3199	2026	8312	0.79	0.89	0.70
2009	391109	463095	330313	2595	3146	2044	7998	0.89	1.00	0.79
2010	407155	476975	347555	2307	2788	1826	6923	0.92	1.04	0.81
2011	415336	485367	355409	1895	2316	1474	6416	0.86	0.97	0.76
2012	419547	487049	361401	1664	2057	1272	6818	0.90	1.00	0.80
2013	304101	361043	256139	1433	1791	1074	6753	0.93	1.03	0.83
2014	322127	383034	270905	1384	1710	1058	5493	0.80	0.89	0.70
2015	463575	538372	399169	1500	1835	1165	5817	0.86	0.97	0.75
2016	406164	484439	340537	1372	1714	1031	5764	0.73	0.83	0.62
2017	390399	472586	322505	1484	1877	1091	6033	0.62	0.71	0.53
2018	350854	444918	276677	2067	2585	1550	6091	0.59	0.68	0.49
2019	413128	572228	298264	2699	3401	1997	5355	0.47	0.57	0.38
2020	281704	496327	159889	3519	4507	2531	4841	0.37	0.46	0.28
2021				4591	6026	3157				

*SS3 model provides estimates of SSB only for females.

Sources and references

EWG 21-15

5.2 SUMMARY SHEET FOR COMMON SOLE IN GSA 17

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 20-09 advises to increase the total catch of 2019 (1940 t) by 1% which is equivalent to catches of no more than 1960 tons in each of 2021 and 2022. The advised catch (1960 t) corresponds to the 96% of the average reference catch between 2017 and 2019 (2042 t).

Stock development over time

The relative change in the trend of biomass index was used to provide an index for change (Figure 5.2.1). The stock appears to have been quite stable from 2006 to 2012 and then increased rapidly up to 2014. In the last 5 years the stock has stabilized on a higher average biomass compared to the early time series. Based on the index value in the last two years relative to the previous three years the increase in biomass is estimated to be 1.25 times.

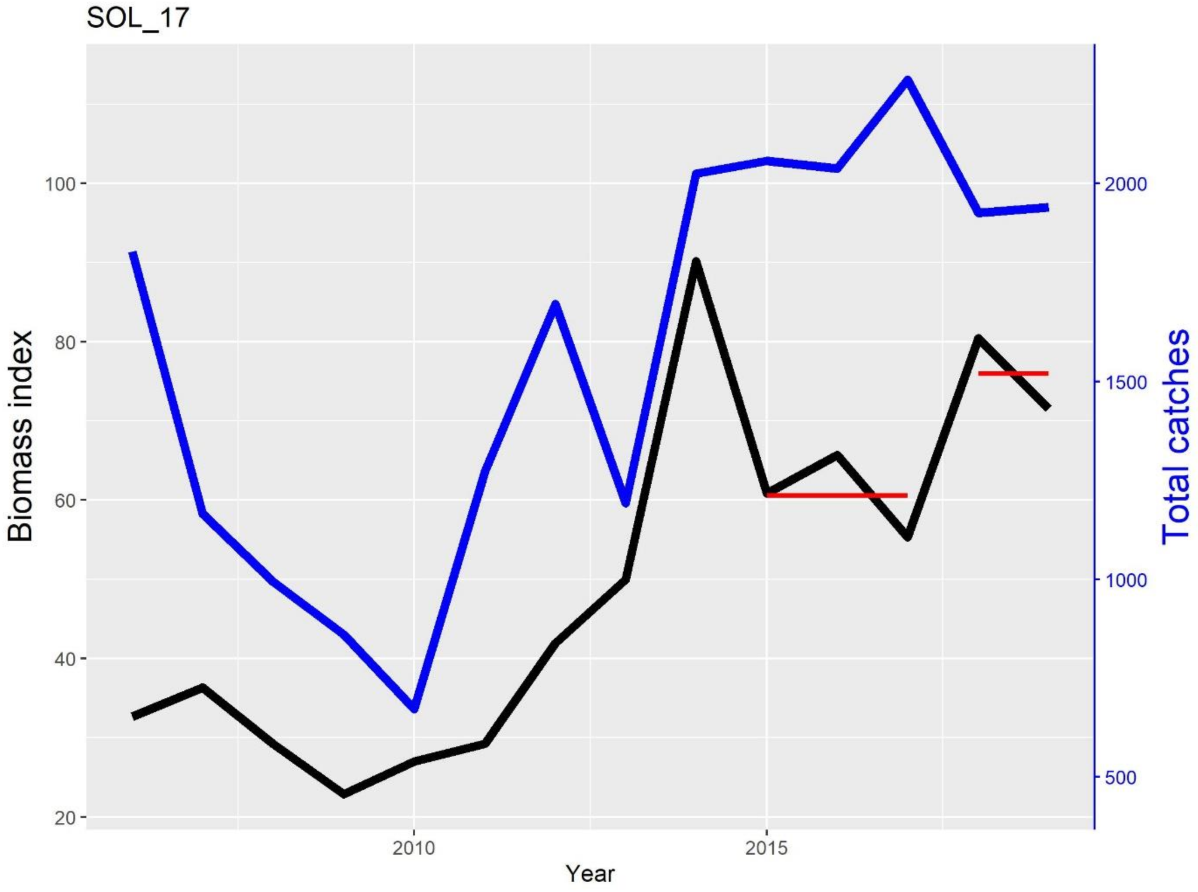


Figure 5.2.1 Common sole in GSA 17 Summary of the SOLEMON survey indicator and total catch by year. The red segments correspond to the reference averages used to estimate the index of variation.

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown. However, the index of biomass shows a stable trend over the last 3 years.

Catch scenarios

The advice on fishing opportunities for 2020 and 2021 is based on the recent observed catch adjusted to the change in the biomass index. The biomass index used to provide the catch scenarios is obtained from the Solemon survey data. The change is estimated from the average of the two most recent values (2018-2019) relative to the average of the three preceding values (2015-2017) (see table 5.2.1). The precautionary buffer of -20% is applied because the precautionary status of the stock is not known.

Table 5.2.1 Common sole in GSA 17: Assumptions made for the interim year and in the forecast. *

Index A (2018–2019)	76	
Index B (2015–2017)	61	
Index ratio (A/B)	1.25	
-20% Uncertainty cap	Applied/not applied	Applied 1.20
Average catch (2017–2019)	2042	
Discard rate (2017–2019)	Negligible	
-20% Precautionary buffer	Applied/not applied	Applied 0.96
Catch advice **	1960	
Landings advice ***	1960	
% advice change ^	+1%	

* The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.
** (average catch × index ratio)
*** catch advice × (1 − discard rate)
^ Advice value 2021 relative to catch value 2019.

Basis of the advice

Table 5.2.2 Common sole in GSA 17: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

A sensitivity analysis was run to account for the suggestions coming from WGSAD 2019 held in GFCM which discarded the assessment presented by STECF (EWG 19-16), due to the rejection of growth parameters used in the assessment process. A sensitivity analysis tested the effect on the assessment outputs of two different sets of growth parameters (one presented at STECF and one at GFCM) and three different natural mortality vectors (two presented at STECF and one at GFCM). As input parameters were varied the dependence of outputs was significant, therefore the EWG suggested to give advice through a biomass index rate of change estimation and supported the GFCM advice which calls for a benchmark for this stock.

Issues relevant for the advice

There are no additional relevant issues

Reference points

Table 5.2.3 Common sole in GSA 17: Reference points, values, and their technical basis.

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

Basis of the assessment

Table 5.2.4 Common sole in GSA 17: Basis of assessment and advice.

Assessment type	Index based assessment
Input data	Landings at length sliced
Discards and bycatch	Discards negligible
Indicators	SOLEMON in GSA 17
Other information	
Working group	EWG 20-15

History of the advice, catch, and management

Table 5.2.5 Common sole in GSA 17: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted landings corresp. to advice	Predicted catch corresp. to advice	STECF catch	STECF discards
2020	Reduction of 1% of catch	1960	1960		
2021	Reduction of 1% of catch	1960	1960		

History of the catch and landings

Table 5.2.6 Common sole in GSA 17: Catch distribution by fleet in 2019 as estimated by STECF.

Catch (2019)	Landings			Discards
1896 t	79% trawl (OTB+TBB)	21% set nets (GNS+GTR)	0% others	negligible
	1896t			

Table 5.2.7 Common sole in GSA 17: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

Year	ITALY GSA17	CROATIA GSA17	SLOVENIA GSA17	Discards	Total
2005	-	-	6	-	6
2006	1823	-	5	-	1828
2007	1158	-	8	-	1166
2008	986	-	7	-	993
2009	850	-	10	-	860
2010	665	-	8	-	673
2011	1260	-	13	-	1273
2012	1687	-	8	-	1695
2013	994	185	14	-	1193
2014	1904	106	14	-	2024
2015	1857	187	13	-	2057
2016	1910	116	11	-	2037
2017	2098	150	13	-	2261
2018	1733	182	10	-	1925
2019	1731	198	11	-	1940

Summary of the assessment

Table 5.2.8 Common sole in GSA 17: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2006	32.67	1828	-	1828
2007	36.35	1166	-	1166
2008	29.2	993	-	993
2009	22.9	860	-	860
2010	27.02	673	-	673
2011	29.22	1273	-	1273
2012	41.95	1695	-	1695
2013	50	1193	-	1193
2014	90.17	2024	-	2024
2015	60.83	2057	-	2057
2016	65.71	2037	-	2037
2017	55.35	2261	-	2261
2018	80.43	1925	-	1925
2019	71.56	1940	-	1940

Sources and references

Reproduced from STECF EWG 20-15 for use in this year’s WG. For original analysis and data supporting this summary sheet see STECF EWG 20-15.

5.3 SUMMARY SHEET FOR RED MULLET IN GSA 17 AND 18

STECF advice on fishing opportunities

STECF EWG 21-15 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.36 and corresponding catches in 2022 should be no more than 4279 tons.

Stock development over time

Catches of red mullet in GSAs 17-18 from 2011 an increasing pattern, with a decrease in the last year. SSB and recruitment show a quite stable pattern, with an increase in recent years. Fishing mortality shows a decreasing trend through the time series, with values varying between 1.31 and 0.36 (2020).

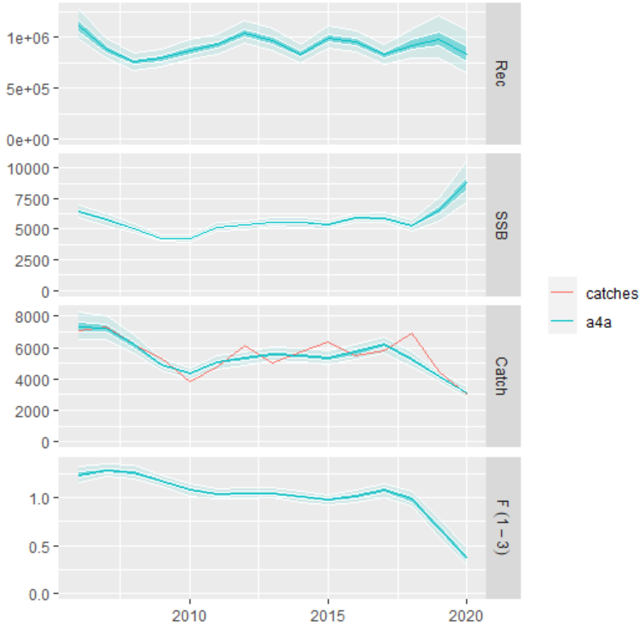


Figure 5.3.1 Red mullet in GSAs 17 and 18: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is slightly above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.36).

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

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

Catch scenarios

Table 5.3.2 Red mullet in GSAs 17 and 18: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1-3}$ (2021)	0.37	F_{2020} used to give F status quo for 2021
SSB (2021)	10 411.4	Stock assessment middle of the year 2021
R_{age0} (2021,2022)	910 679.7	Mean of the last 15 years (whole series)
Total catch (2020)	4089.8	Assuming F status quo for 2021

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

Table 5.3.3a Red mullet in GSAs 17 and 18: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{total}#(ages 1-3) (2022)	SSB2023	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	4279	0.356	12452	19.6	36.99
$F_{MSY\ Transition}$^^	5979	0.541	10169	-2.33	91.43
$F_{MSY\ lower}$	3024	0.238	14271	37.07	-3.19
$F_{MSY\ upper}$**	5525	0.488	10757	3.32	76.9
Other scenarios					
Zero catch	0	0	19091	83.37	-100
Status quo	4454	0.373	12207	17.25	42.6
0.5	2432	0.187	15166	45.67	-22.12
0.6	2867	0.224	14506	39.33	-8.22
0.7	3285	0.261	13882	33.34	5.19
0.8	3689	0.299	13293	27.67	18.12
0.9	4078	0.336	12735	22.32	30.58

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

*** % change in SSB 2023 to 2021

^Total catch in 2022 relative to Catch in 2020.

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

As the red mullet landings in GSAs 17-18 are predominantly from OTB (about 97% of the landing in tons in 2020) the short term forecast by gear was not carried out.

Basis of the advice

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

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Both catches and survey indices showed an acceptable internal consistency. The retrospective analysis run on the a4a model showed some instability, with some patterns in residuals in the 0 and 1 age groups in the survey and in 1 and 2 age groups in the catch. Thus, the results should be considered with caution.

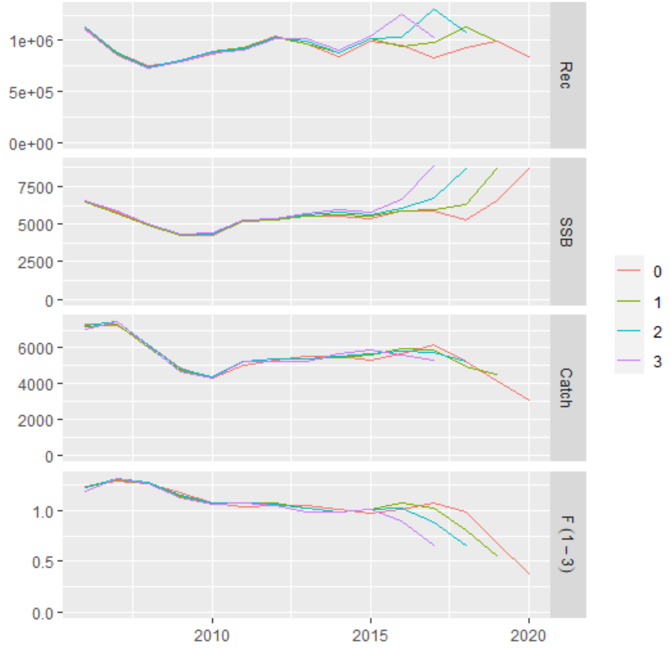


Figure 5.3.2 Red mullet in GSAs 17 and 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.3.5 Red mullet in 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}	0.36	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-15
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}	0.36	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-15
	target range F_{lower}	0.23	Based on regression calculation (see section 2)	STECF EWG 21-15
	target range F_{upper}	0.49	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-15

Basis of the assessment

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

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (MEDITS) data
Discards, BMS landings* and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 21-15

*BMS (Below Minimum Size) landings?

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	3965	
2020	$F = F_{MSY}$		6078	3073	
2021	$F = F_{MSY}$		3285		
2022	$F = F_{MSY}$		4279		

History of the catch and landings

Table 5.3.8 Red mullet in GSAs 17 and 18: Catch and effort distribution by fleet in 2018 as estimated by and reported to STECF (DCF data, Albania and Montenegro not included).

2020		Wanted catch				Discards
Catch (t)		Otter trawl 96%	Gillnets 3%	GTR 0%	Other 1%	t
		2403	68	3	35	
Effort (Fishing days)		128 052	29 393	16 975		
		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	HRV	SVN	ITA 18	ALB	MTN	Total	OTB Effort * (fishing days)
2006	3101		2	1934			5037	189181
2007	3298		6	1802			5106	165677
2008	3158		2	961		42	4163	157594
2009	2433		3	1031		40	3507	178099
2010	1796		1	646		38	2481	157246
2011	1890		6	532		35	2463	149019
2012	1525	1262	4	2096	375	39	5301	169736
2013	1979	1102	2	1250	373	35	4741	172071
2014	2399	1168	3	1272	317	45	5205	153144
2015	2220	1144	3	1587	388	40	5382	148737
2016	2042	972	2	1448	396	40	4900	150419
2017	2672	1001	3	620	392	40	4728	161943
2018	2517	842	6	1004	289	46	4704	170204
2019	1733	748	4	775	373		3632	288445
2020	1276	762	5	466	351.4		2861	128052

*Effort related only to ITA, SVN and HRV. HRV fishing days included only from 2012

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	Recruitment	High	Low	SSB	High	Low	Catch	F	High	Low
2006	1146091			6726			8423	1.3		
2007	889331			5824			7376	1.31		
2008	751260			5099			6187	1.26		
2009	793655			4332			4875	1.15		
2010	853474			4318			4353	1.07		
2011	911950			5129			5071	1.04		
2012	1064667			5245			5280	1.06		
2013	946500			5581			5550	1.05		
2014	831910			5470			5525	1.02		
2015	1029924			5269			5339	1		
2016	956316			5877			5780	1.05		
2017	785539			5837			6195	1.1		
2018	909433			5112			5051	0.97		
2019	1005851			6483			3965	0.66		
2020	845617			8815			3073	0.37		

Sources and references

STECF EWG 20-15

Carbonara P., Intini S., Kolitari J., Joksimović A., Milone N., Lembo G., Casciaro L., Isabella Bitetto, Zupa W., Spedicato M. T. & Sion L., 2018. A holistic approach to the age validation of Mullus barbatus L., 1758 in the Southern Adriatic Sea (Central Mediterranean). Scientific Reports, 8: 13219 https://doi.org/10.1038/s41598-018-30872-1

5.4 SUMMARY SHEET FOR COMMON CUTTLEFISH IN GSA 17 AND 18

STECF advice on fishing opportunities

Summaries are provided for GSA 17-18 combined, and GSA 17 separately. It is not possible to provide advice for GSA 18 alone. If it is necessary to give advice for GSA 18, at the moment the best option is to use the combined area assessment. Although the combined area may not constitute a single stock, the joint assessment does reflect the overall joint state of common cuttlefish in GSA 17-18. If an area contains several stocks the aggregated assessment represents the average conditions, but cannot provide protection for all the individual 'stocks'.

STECF advice on fishing opportunities

STECF EWG 21-15 advises that when MSY considerations are applied, fishing mortality can be increased to FMSY. As common cuttlefish is a short lived species, living mostly upto 1-1.5 year, annual catches in 2022 will depend mostly on growth within the 1st year oflife, and therefore no specific catch options can be provided for 2022. Catch at FMSY with biomass (BMSY) is estimated at 7450 tonnes.

Stock development over time

Biomass has increased in recent years and is estimated to be slightly above BMSY. F has decreased over recent years and is estimated to be well below FMSY. The data does not allow for evaluation of recruitment over time, so current recruitment cannot be compared with historic recruitment.

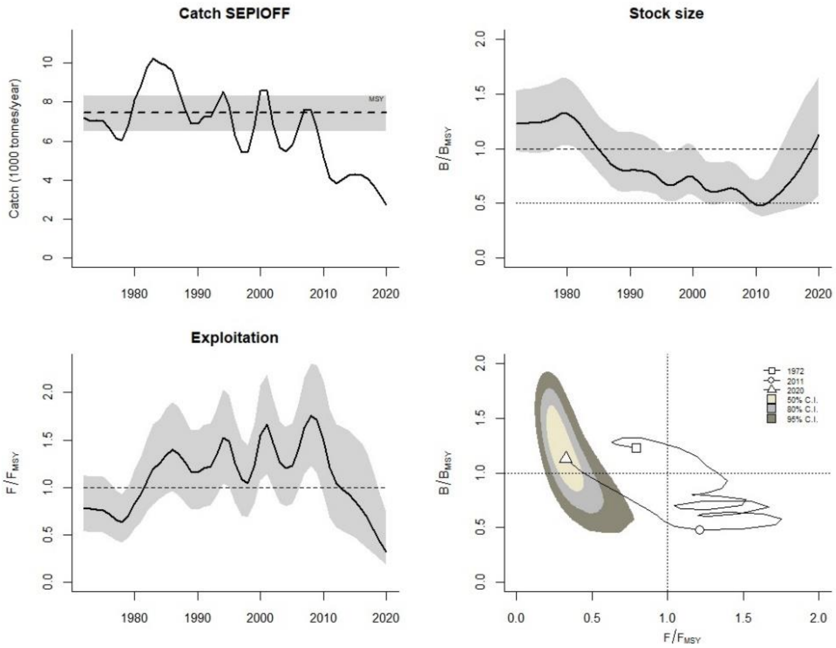


Figure 5.4.1.1 Common cuttlefish in GSA 17-18. Trends in catch, relative biomass and exploitation as given by CMSY model 95% confidence limits (grey) are also indicated.

Stock and exploitation status

The assessment estimates B to be slightly above BMSY; B/BMSY in last year is 1.13. The current level of fishing mortality is below the reference point FMSY (F/ FMSY =0.326).

Table 5.4.1.1 Common cuttlefish in GSA 17-18. State of the stock and fisheryrelative to reference points.

Status	2018	2019	2020
F / FMSY	F < FMSY	F < FMSY	F < FMSY
B / BMSY	B<BMSY	B=BMSY	B>BMSY

Catch scenarios

Considering the fact that common cuttlefish is a short living species, living mostly up to 1-1.5 year, annual catches depend mostly on growth condition of this species within 1st year of life, and therefore short term catch forecast cannot be carried out, and no specific catch options can be provided. Average MSY catch at current biomass (BMSY) is estimated at 7450 tonnes.

Basis of the advice

Table 5.4.1.4 Common cuttlefish in GSA 17-18: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

The current assessment results align well with the observed trends in the surveys (biomass and density indices). Growth and natural mortality of common cuttlefish are assumed constant over the time-series. The MEDITS surveys are assumed to have the same catchability for all the years, but different survey periods in last few years should be taking into consideration. The current assessment suggests a larger stock and lower harvest rate than last year, advised catches and state of stock in terms of B/BMSY and F/FMSY are the same. The retrospective performance of this configuration appears to be better.

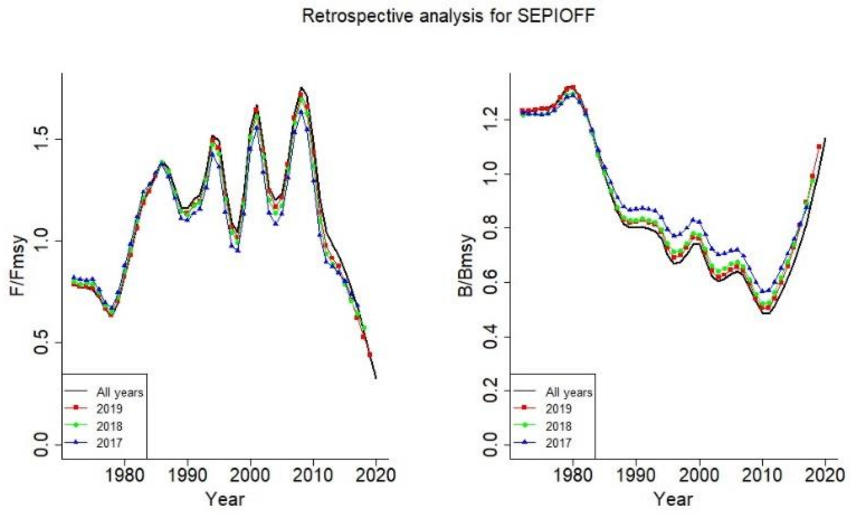


Figure 5.4.1.2. Common cuttlefish in GSA 17-18. Retrospective performance ofCMSY assessment showing consistent estimation of F and Biomass.

Issues relevant for the advice

Common cuttlefish is caught as part of a mixed fishery.

Reference points

Table 5.4.1.5 Common cuttlefish in GSA 17-18. Reference points, values, and their technical basis

Framework	Referenc epoint	Value	Technical basis	Source
MSY approach	MSY Btrigger			
	FMSY	0.156	FMSY estimated from CMSY model	STECF EWG21-15
Precautionar yapproach	B_{lim}		Not defined	
	B_{pa}		Not defined	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY Btrigger		Not defined	
	MAP B_{lim}		Not defined	
	MAP F_{MSY}	0.156	FMSY estimated from CMSY model	
	F_{lower}	0.042	Based on regression calculation	STECF EWG21-15
	F_{upper}	0.14	Based on regression calculation but not tested andpresumed not precautionary	STECF EWG21-15

Basis of the assessment

Table 5.4.1.6 Common cuttlefish in GSA 17-18. Basis of the assessment and advice.

Assessment type	Production model
Input data	DCF commercial data (landing and discard) and Economic transversal data, FAO FishStat, Istat and EUROSTAT database, EU-RECFISH Project, data provided by DG-MARE, national fishery statistics and scientific surveys (MEDITS) data
Discards, BMS landings*, and bycatch	Discard <0.01% (assumption made: landing=catch)
Indicators	
Other information	
Working group	STECF EWG 21-15

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.4.1.7 Common cuttlefish in GSA 17-18. STECF advice, and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted catch corresp. to advice*	Official landings in GSA17-18	STECF Catches
2020	F=FMSY	7830		2147
2021	F=FMSY	7450		

* The value provided is the estimated long term yield at FMSY. Specific annual catch advice is not provided because a Short Term Forecast cannot be provided for 2 years ahead for this species.

History of the catch and landings

Table 5.4.1.8 **Common cuttlefish in GSA 17-18.** Landing distribution by fishinggear and discard in 2020 as reported to DCF.

	Landings by gears (DCF landing 2008-2018)						Discards (2020)
Catch	OTB 54.6%	FPO 17.6%	TBB 12.9%	SETNETS 12.2%	FYK 1.8%	OTHER 0.8%	(All gears) <0.1%
(t)	31194	10069	7379	6998	1052	464	10.8 t

Table 5.4.1.9 Common cuttlefish in GSA 17-18. History of commercial landings of common cuttlefish in the Adriatic Sea (GSA 17 and GSA 18); both the official reported values and STECF estimated landings are presented by country. All weights are in tonnes.

Year	CROATIA	SLOVENIA	ITALY	ITALY	MONTENEGRO	ALBANIA	Ex Yugoslavia	**Total catch (t)**
	GSA 17	GSA 17	GSA 17	GSA 18	GSA 18	GSA 18	(SLO, HRV & MTN)	
1972			6151	1109			174	**7433**
1973			5818	1086			160	**7063**
1974			5411	1063			192	**6666**
1975			6360	1432			218	**8010**
1976			4845	1357			244	**6446**
1977			5093	1273			194	**6560**
1978			3589	1163			170	**4922**
1979			4441	1148			140	**5729**
1980			9158	1289			199	**10646**
1981			6161	869			159	**7189**
1982			9203	1103			146	**10451**
1983			10379	1808			176	**12363**
1984			7244	1118			153	**8515**
1985			8955	1230			148	**10333**
1986			7987	3069			144	**11199**
1987			6336	1215			177	**7728**
1988			6534	1462			219	**8216**
1989			4724	1224			200	**6147**
1990			4902	835			276	**6013**
1991			6917	1854			158	**8929**
1992	154	12	4621	1442	2			**6231**
1993	187	21	4693	1322	6			**6229**
1994	109	4	10368	1185	5			**11671**

1995	109	10	6193	1620	9	39		**7979**
1996	94	6	4000	798	10	33		**4941**
1997	139	5	4563	755	9	33		**5504**
1998	198	18	3710	868	10	51		**4856**
1999	134	18	3431	593	10	51		**4237**
2000	127	11	2756	884	10	50		**3838**
2001	78	72	2707	1220	10	22		**4109**
2002	41	22	1447	981	10	52		**2553**
2003	65	25	2270	710	10	43		**3122**
2004	36	29	2005	597	10	70		**2747**
2005	74	33	4074	1630	8	75		**5893**
2006	65	24	5008	2040	15	86		**7239**
2007	84	41	8603	1207	18	47		**10000**
2008	73	15	6276	960	15	62		**7401**
2009	68	14	5683	1243	7	126		**7141**
2010	86	7	3375	1140	9	98		**4715**
2011	105	8	2324	866	11	90		**3403**
2012	169	10	2575	663	12	80		**3510**
2013	189	4	2956	1018	11	85		**4263**
2014	207	6	3230	811	13	75		**4341**
2015	193	4	3316	879	14	82		**4488**
2016	113	5	2991	970	14	83		**4177**
2017	107	3	2474	1618	8	83		**4293**
2018	92	1.576	2323	1420	11	79		**3927**
2019	91	5	2345	655	13	60		**3169**
2020	103	7	1462	494	^13	67		**2147**

^ preliminary values

Summary of the assessment

Table 5.4.1.10 Common cuttlefish in GSA 17-18 Assessment summary. Weights are in thousands of tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals)

Year	Recruitment age 0 thousands	High	Low	Biomass tons $*10^3$	High	Low	Catch tonnes $*10^3$	F/ FMSY	High	Low
2005				22.08			5.11	1.23		
2006				22.42			6.04	1.40		
2007				21.90			9.12	1.63		
2008				20.32			7.40	1.75		
2009				18.48			7.14	1.71		
2010				17.22			4.72	1.48		
2011				17.09			3.40	1.21		
2012				18.12			3.51	1.05		
2013				19.81			4.26	0.98		
2014				21.74			4.34	0.93		
2015				23.71			4.49	0.86		
2016				26.07			4.18	0.77		
2017				28.71			4.29	0.68		
2018				31.54			3.93	0.55		
2019				34.90			3.17	0.43		
2020				38.67			2.15	0.33		

Sources and references

EWG 21-15

5.5 SUMMARY SHEET FOR NORWAY LOBSTER IN GSA 17 AND 18

STECF advice on fishing opportunities

STECF EWG 21-15 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.37 and corresponding catches in 2022 should be no more than 1986 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 2020 below F_{MSY}.

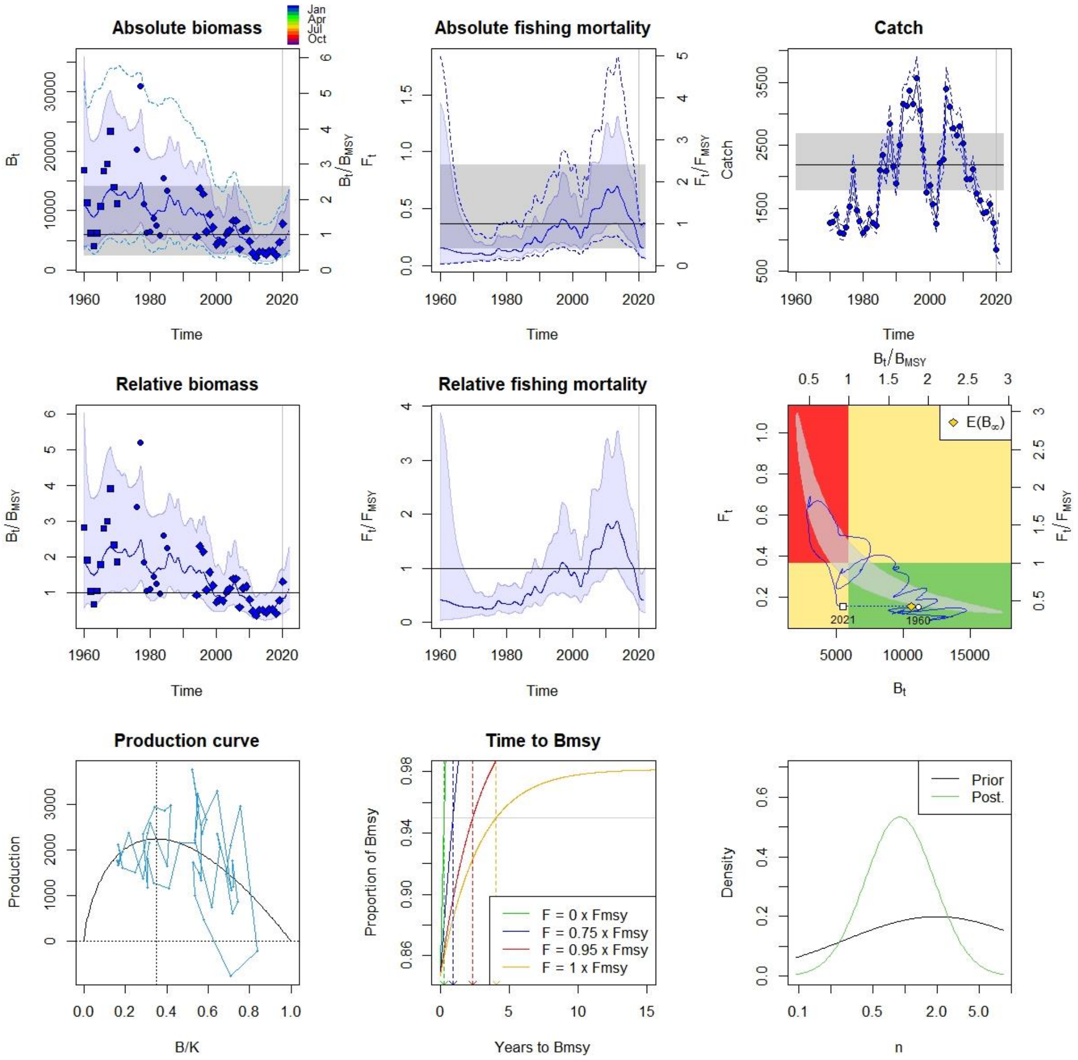


Figure 5.5.1 Norway lobster in GSA 17 and 18. SPICT model main outputs.

Stock and exploitation status

The status of the stock in 2020 using mean value by year, referred to the reference points (B_{MSYs} = 5955.3 and F_{MSYs} = 0.37) is, F_{2020}/F_{MSYs} = 0.44.

Table 5.5.1 Norway lobster in GSA 17 and 18. State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.5.2 Norway lobster in GSA 17 and 18. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ all}$ (2021)	0.16	Harvest rate from production model (SPICT)
Catch (2021)	870 t	
Biomass (2021 & 2022)		

Table 5.5.3a Norway lobster in GSA 17 and 18: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	F_{msy}** (all) (2022)	SSB (2023)	% SSB change***	% Catch change#
STECF advice basis					
FMSY	1986	0.37			+56%
F (HR) Transition ^^	1627	0.30			+47%
$F_{MSY\ lower}$	1311	0.25			+34%
$F_{MSY\ upper}$	2680	0.51			+68%
Other scenarios					
Zero catch	0	0			-100%
Status quo	870	0.16			

*** % change in SSB 2023 to 2021

^Total catch in 2022 relative to Catch in 2020.

Total catch in 2022 relative to advice value 2021.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026

Table 5.5.3 b Norway lobster in GSA 17 and 18: Annual catch scenarios by gears and GSA. All weights are in tonnes.

Basis	Total catch* (2022)	F_{msy**} (all) (2022)	Catch 2022 GSA 17		Catch 2022 GSA 18
STECF advice basis			OTB	FPO	OTB
F_{MSY}	1986	0.37	1032.72	119.16	834.12
$F_{MSY\ lower}$	1311	0.25	681.7	78.66	550.62
$F_{MSY\ upper}$	2680	0.51	1393.6	160.8	1125.6

In addition to the main catch advice for Nephrops, 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 FMSY and FMST Transition.

Table 5.5.3 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 2020	33645	189	393	948	3837
Fmsy from SPiCT Model (HR)	0.37	0.37	0.37	0.37	0.37
F (HR) Transition from F current and FMSY	0.30	0.30	0.30	0.30	0.30
Catch 2020/2021 at F=FMSY	1986	70	145	351	1420
Catch at F transition	1627	57	119	287	1163

Basis of the advice

Table 5.5.4 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.

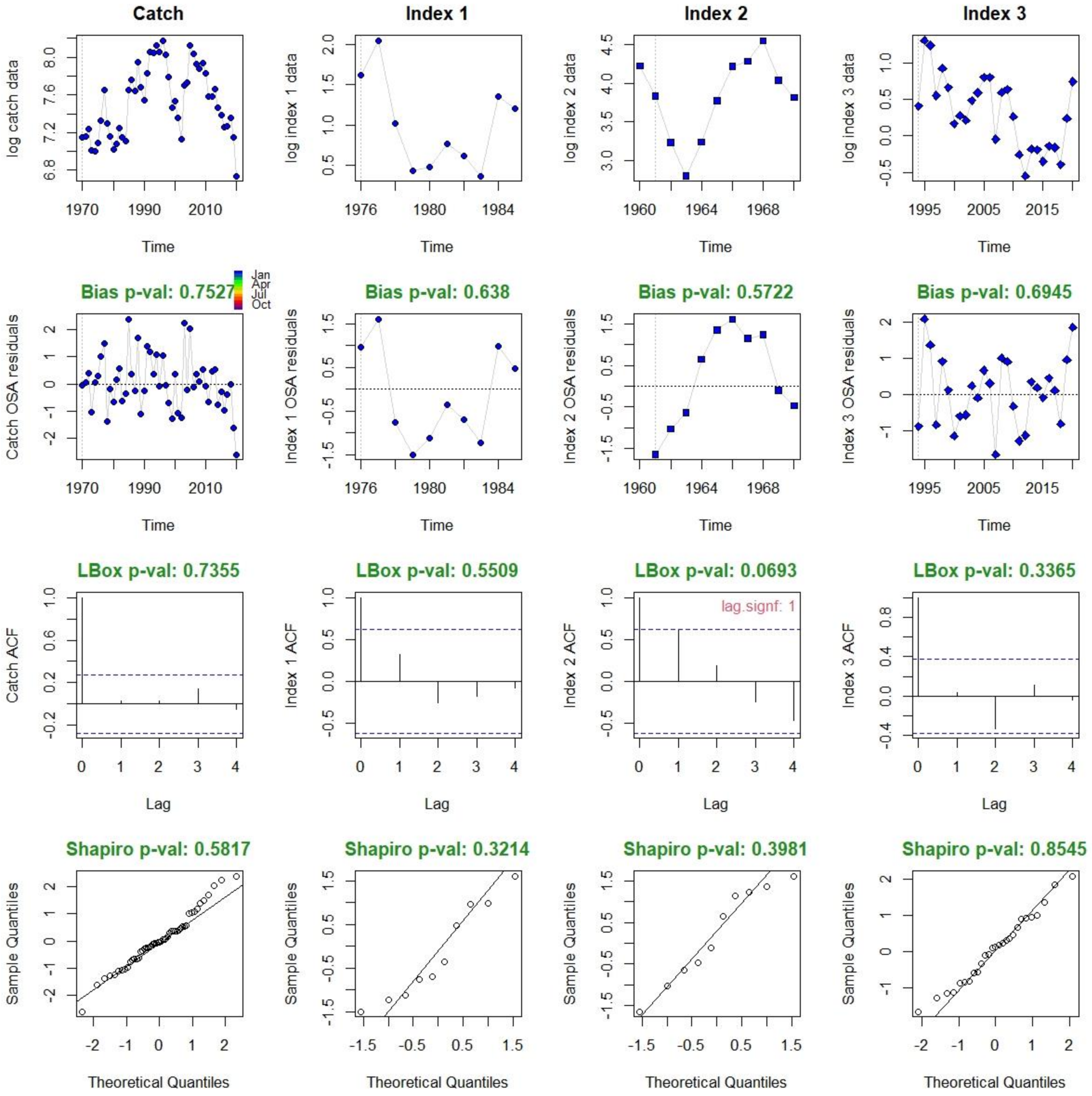


Figure 5.5.2 Norway lobster in GSA 17 and 18. SPICT model diagnostics

The retrospective analysis run on the a4a 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. There is an increase in retrospective revision; with upward revision of biomass and downward revision in F. Catches in 2020 are a significant reduction relative to 2019 and earlier. This big change may also be affecting the retrospective performance. It is common for stock assessments to show more retrospective changes during periods of management change. The wide confidence intervals seen below reflect the uncertainties of this assessment.

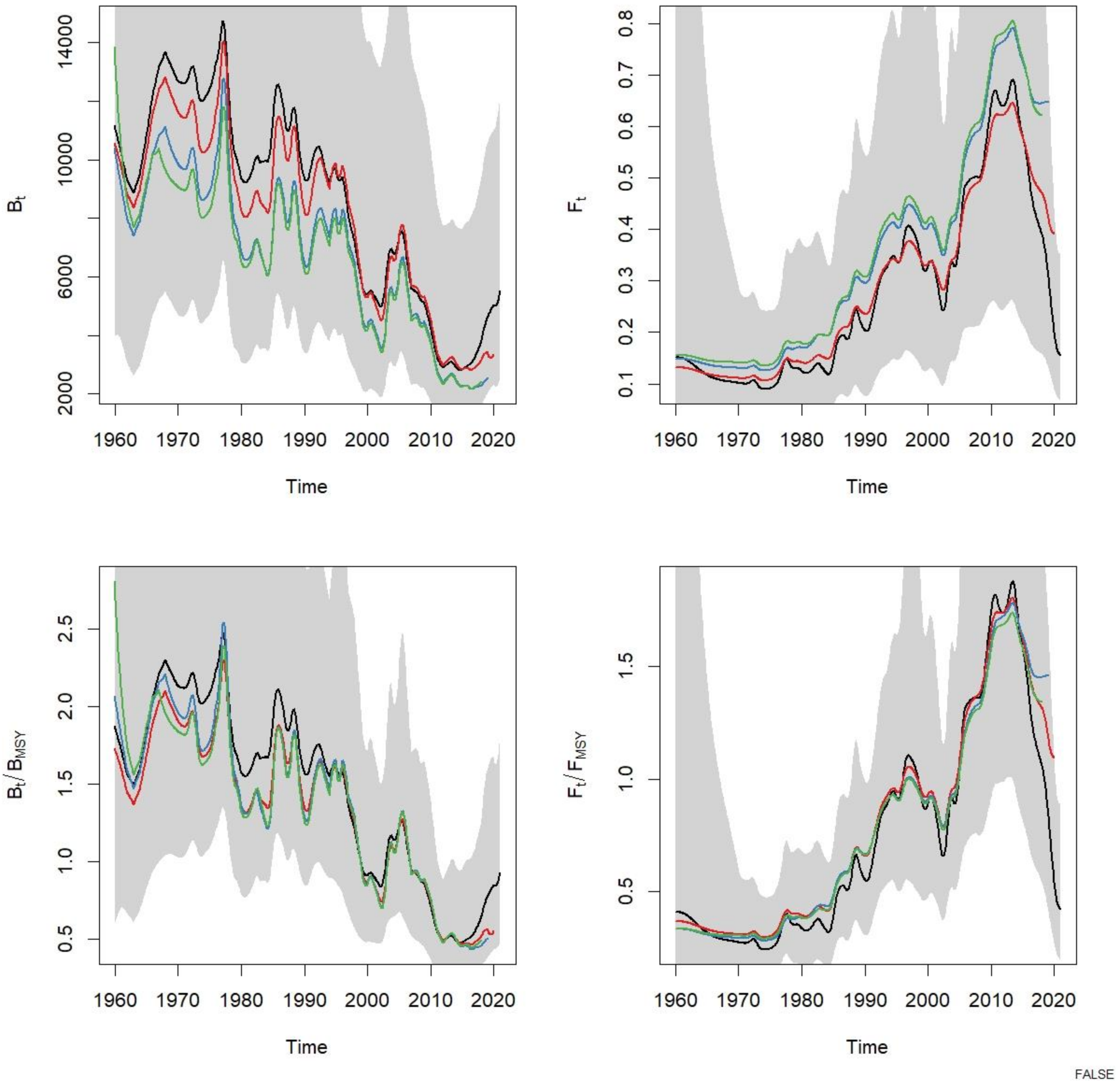


Figure 5.5.3 Norway lobster in GSA 17 and 18. Historical assessment results. (Retrospective graph)

Issues relevant for the advice

The Nephrops sub-area analyses with both biomass and exploitation indices are in general agreement and showing that GSA 18 and Ancona are at a relatively poorer state (Figure 5.5.4)with historically lower biomasses in recent years (0.27 and 0.38 respectively; Table 5.5.5). In contrast the situation for biomass in Kvarner and Pomo/Jakuba Pit is likely to be within acceptable limits (0.74 and 1.59 respectively; Table 5.5.5). 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.

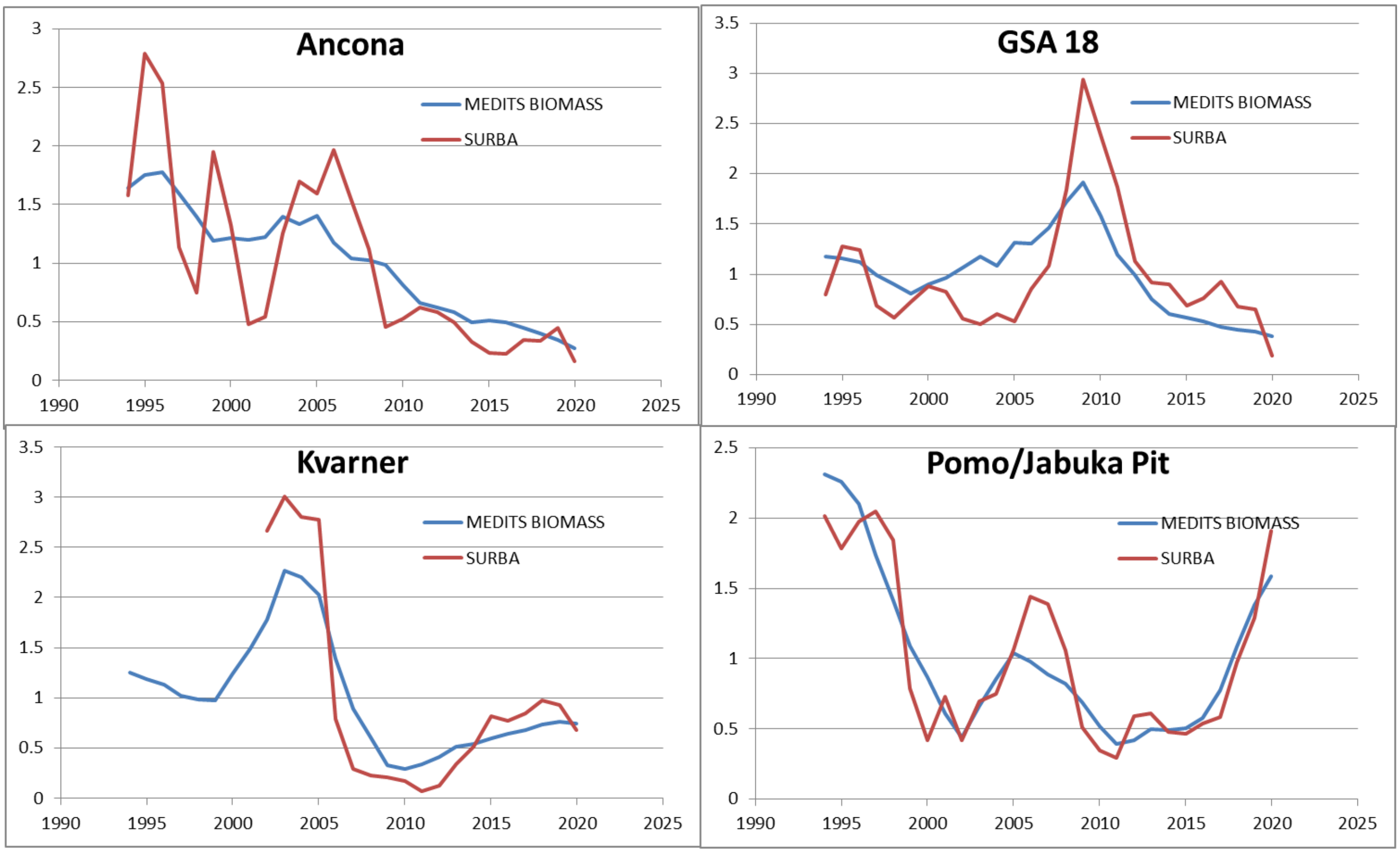


Figure 5.5.4 Norway lobster in GSA 17 and 18. Relative Biomass 1994-2020 by sub-area from MEDITS biomass data (blue) and SURBA analysis of MEDITS catch at length/age data (red). Biomass in Ancona and GSA 18 are at historic lows for the period, Biomass in Kvarner is below average, Biomass in Pomo/Jabuka Pit is above average.

Table 5.5.5 Nephrops in GSA 17-18 biomass by sub area.

	Total GSA 17-18	Ancona	GSA 18	Kvarner	Pomo/Jabuka Pit
Average biomass 94-2020	5419	697	1025	1279	2417
B 2020	5367	189	393	948	3837
B2020/B1994-2020	0.99	0.27	0.38	0.74	1.59

Reference points

Table 5.5.5 Norway lobster in GSA 17 and 18. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	3334.97	MSY Btrigger = Bpa = Blim*1.4	STECF EWG 21-15
	F_{MSY}	0.37	F target (MSY reduced)	STECF EWG 21-15
Precautionary approach	B_{lim}	2382.12	Blim = 40% Bmsy	
	B_{pa}	3334.97	Bpa = Blim*1.4	
	F_{lim}		Not defined	
	F_{pa}		Not defined	
Management plan	MAP MSY $B_{trigger}$		MSY Btrigger = Bpa = Blim*1.4	STECF EWG 21-15
	MAP B_{lim}		Blim = 40% Bmsy	STECF EWG 21-15
	MAP F_{MSY}		F target (MSY reduced)	STECF EWG 21-15
	MAP target range F_{lower}			
	MAP target range F_{upper}			

Basis of the assessment

Table 5.5.6 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 and historical surveys
Discards, BMS landings*, and bycatch	From DCF data
Indicators	
Other information	
Working group	STECF EWG 21-15

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.5.7 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 = FMSY (reduced B<Bpa)		745.4	1319	
2020	F = FMSY (reduced B<Bpa)		785.26		
2021	F = FMSY (reduced B<Bpa)		1217.7		
2022	F = FMSY		1986		

History of the catch and landings

Table 5.5.8 Norway lobster in GSA 17 and 18. Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2020		Wanted catch		Discards
Catch (t)		OTB 0.94%	FPO 0.06%	t
		786	48.2	7.3
Nominal Effort		126660	50473	
		(Days at sea GSA17-18)		

Table 5.5.9 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	201	398	2117	227575.3
2014	993.9	513	400	1738	192153.6
2015	908.8	232	405	1618	182556.1
2016	768.9	504	411	1417	185499.1
2017	847.7	266	389	1438	196024.0
2018	1069.8	731	257	1559	218413.1
2019	788.9	238	213	1269	203901.5
2020	410.9	407	194	843	177132.9

*** No landings in Slovenia. We report the effort for HRV from 2012 to 2020 only.**

Summary of the assessment

Table 5.5.10 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	12635			1271	0.10		
1971	12748			1293	0.10		
1972	13045			1369	0.10		
1973	12160			1129	0.09		
1974	12195			1100	0.09		
1975	12753			1205	0.09		
1976	13789			1543	0.11		
1977	14087			2022	0.14		

1978	11180	1497	0.13
1979	9885	1279	0.13
1980	9266	1128	0.12
1981	9479	1194	0.13
1982	10016	1382	0.14
1983	9935	1270	0.13
1984	10258	1267	0.12
1985	12151	2053	0.17
1986	12042	2319	0.19
1987	11117	2151	0.19
1988	11552	2727	0.24
1989	10010	2181	0.22
1990	9359	1929	0.21
1991	10077	2495	0.25
1992	10326	3106	0.30
1993	9573	3127	0.33
1994	9540	3300	0.35
1995	9388	3206	0.34
1996	8906	3493	0.39
1997	7636	3048	0.40
1998	6562	2418	0.37
1999	5553	1801	0.32
2000	5463	1834	0.34
2001	5197	1550	0.30
2002	5264	1317	0.25
2003	6681	2127	0.32
2004	6913	2353	0.34
2005	7430	3295	0.44
2006	6302	3113	0.49
2007	5510	2761	0.50
2008	5226	2681	0.51
2009	4736	2795	0.59
2010	3802	2512	0.66
2011	3064	1979	0.65
2012	2996	1955	0.65
2013	3045	2078	0.68
2014	2850	1755	0.62
2015	2930	1606	0.55
2016	3108	1431	0.46
2017	3541	1440	0.41
2018	4304	1526	0.36
2019	4990	1257	0.25
2020	5367	870	0.16

Sources and references

EWG 21-15

5.6 SUMMARY SHEET FOR SPOTTAIL MANTIS SHRIMP IN GSA 17 AND 18

STECF advice on fishing opportunities

STECF EWG 21-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.44 and corresponding catches in 2021 should be no more than 4945 tons.

Stock development over time

Recruitment of Spottail mantis shrimp fluctuated around 1 million from the beginning of the time series until 2017 and showed an increasing trend since then, reaching 2 million in 2020; though these estimates are quite uncertain. Spawning Stock Biomass (SSB) showed a decreasing trend in the beginning of the time series until 2018, while it is rising in the last three years. Catch has been fluctuating between 4000 and 5000 tonnes since 2007, while Fishing mortality (F) is in decline since 2016.

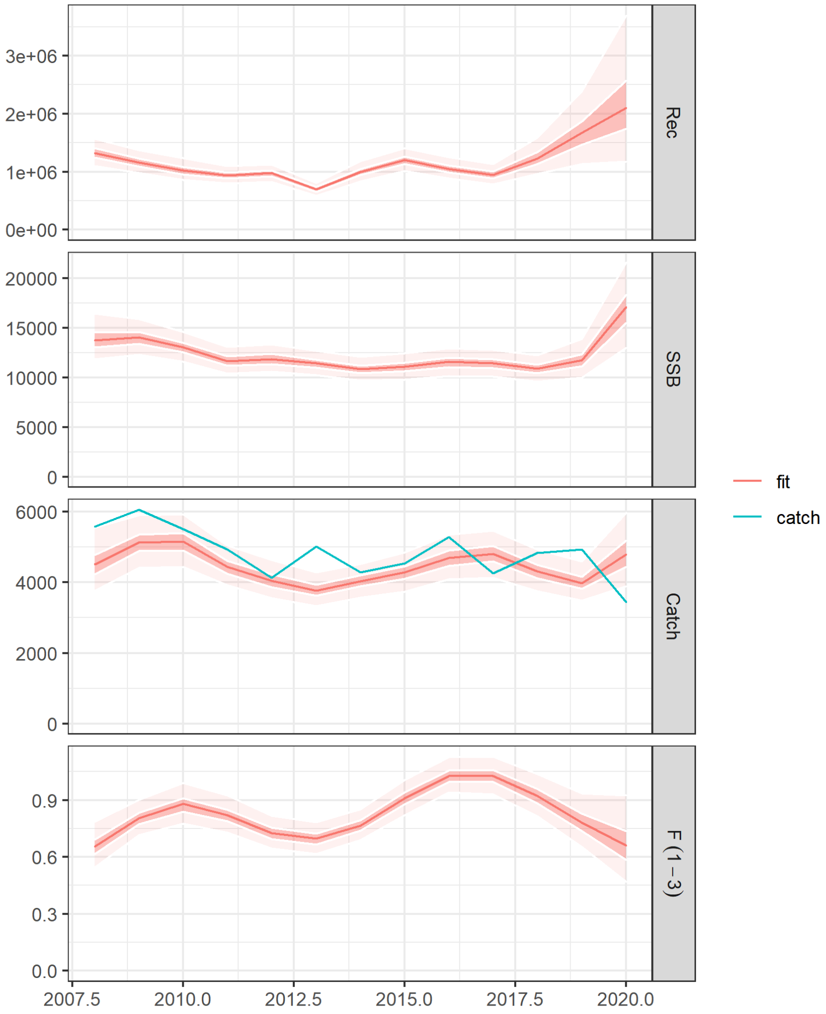


Figure 5.6.1.1 Spottail mantis shrimp in GSA 17 & 18: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

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

Table 5.6.1.1 Spottail mantis shrimp in GSA 17 & 18: State of the stock and fishery relative to reference points in the last three years of assessment.

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

Catch scenarios

Table 5.6.1.2 Spottail mantis shrimp in GSA 17 & 18: Assumptions made for the interim year and in the forecast. Biological parameters (maturity, natural mortality, mean weights) and fishery selection taken as mean of last three years.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2021)	0.658	F_{2020} used to give F status quo for 2021
SSB (2021)	21483	Stock assessment 1 January 2021
R_{age0} (2021,2022)	1131981	Geometric mean of years 2008 to 2020
Total catch (2021)	6338	Assuming F status quo for 2021

Table 5.6.1.3 Spottail mantis shrimp in GSA 17 & 18: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	F_{total}# (ages 1-3) (2021)	SSB (2023)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	4945	0.44	17916	-16.6	3.5
$F_{MSY\ Transition}$ ^^	6531	0.64	16291	-24.2	-26.3
$F_{MSY\ lower}$	3523	0.30	19401	-9.7	-26.3
$F_{MSY\ upper}$**	6304	0.61	16521	-23.1	31.9
Other scenarios					
Zero catch	0	0	23173	7.9	-100
Status quo	6689	0.66	16130	-24.9	40.0
0.8 * F status quo	5656	0.53	17183	-20.0	18.3
0.9 * F status quo	6188	0.59	16639	-22.5	29.5

* The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match the rounded figures in the table

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

*** % change in SSB between 2023 and 2021

^% change in Catch between 2022 and 2020.

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

Basis of the advice

Table 5.6.1.4 Spottail mantis shrimp in GSA 17 & 18: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

Retrospective plots for Spottail mantis showed some inconsistencies especially in the estimation of F. Residuals and diagnostics were considered acceptable.

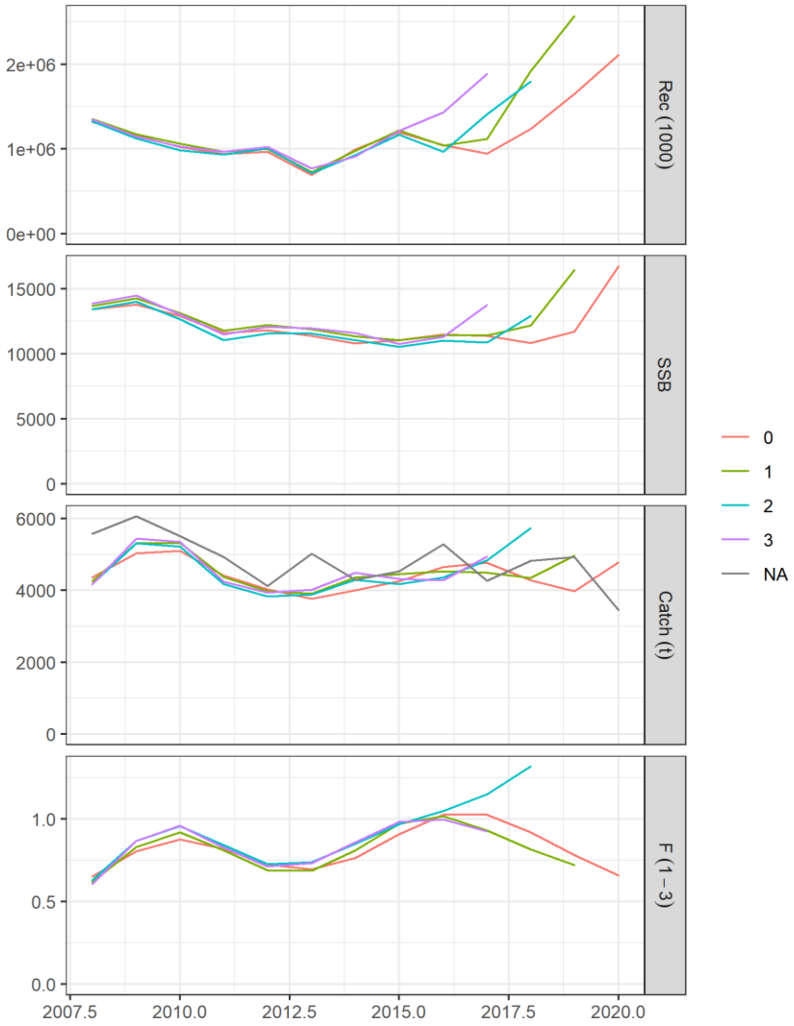


Figure 5.6.1.2 Spottail mantis shrimp in GSA 17 & 18: Historical assessment results (final- year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.6.1.5 Spottail mantis shrimp in GSA 17 & 18: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.44	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.44	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 21-15
	MAP target range F_{lower}	0.30	Based on regression calculation (see section 2)	STECF EWG 21-15
	MAP target range F_{upper}	0.61	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 21-15

Basis of the assessment

Table 5.6.1.6 Spottail mantis shrimp in GSA 17 & 18: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific surveys (SOLEMON and MEDITS in GSA 17 & 18) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 21-15

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.6.1.7 Spottail mantis shrimp in GSA 17 & 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
2020	F = F_{MSY}		2190	4780	
2021	F = F_{MSY}		4970		
2022	F = F_{MSY}		4945		

History of the catch and landings

Table 5.6.1.8 Spottail mantis shrimp in GSA 17 & 18: Landings and discards distribution by fleet for years 2008-2020 as estimated by and reported to STECF.

	Landings				Discards		
Catch (t)	Otter trawl 77.6%	Gillnets 14.5%	Beam trawl 6.4%	Other 1.4%	Otter trawl 98.6%	Beam trawl 1.3%	Other <1%
	41477	7769	3430	762	6697	91	5.5

Table 5.6.1.9 Spottail mantis shrimp in GSA 17 & 18: History of commercial landings; both the official reported values are presented by country, official reported BMS landings and STECF estimated landings are presented. All weights are in tonnes.

Year	ITALY GSA17	SLOVENIA	CROATIA	ITALY GSA18	ALBANIA	Total	Total Effort Fishing days
2008	3999.00	6.23		2587.13		2587.13	348203
2009	4529.00	3.63		1298.85		1307.97	391165
2010	4564.00	4.99		1271.69		1276.53	367264
2011	3786.00	3.59		1258.46		9082.96	376428
2012	3105.00	0.73	2.12	916.82		8927.28	444176
2013	2127.00	0.30	2.30	892.37		9957.63	419170
2014	2806.00	0.48	4.45	454.05		9592.03	392951
2015	3064.00	0.76	7.41	352.27		7931.45	372599
2016	3143.00	1.80	11.21	631.68		6847.38	370278
2017	3076.00	1.18	12.58	2195.94	101.00	6455.14	353265
2018	3169.00	0.98	13.17	1003.89	116.00	6625.75	407410
2019	2577.00	1.27	7.27	1010.75	123.00	7155.09	411690
2020	2370.17	2.52	7.04	929.16	125.00	7241.17	374297

Summary of the assessment

Table 5.6.1.10 Spottail mantis shrimp in GSA 17 & 18: 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	High	Low	Catch	F ages 1-3	High	Low
2008	1320325			13420			4366	0.65		
2009	1159452			13781			5034	0.80		
2010	1023151			12923			5100	0.88		
2011	937134			11609			4409	0.82		
2012	970028			11820			4031	0.72		
2013	691632			11367			3767	0.69		
2014	996798			10802			4011	0.76		
2015	1194410			11037			4254	0.91		
2016	1048355			11485			4655	1.02		
2017	946394			11372			4769	1.02		
2018	1234169			10822			4278	0.92		
2019	1652505			11706			3975	0.78		
2020	2112104			16728			4780	0.66		

Sources and references

STECF EWG 21-15

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

STECF advice on fishing opportunities

STECF EWG 21-15 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.72 and corresponding catches in 2022 should be no more than 3091 tons.

Stock development over time

The Deep-water rose shrimp stocks in GSAs 17-19 shows increasing catch from 2014 to 2019, stable in the previous years. Recruitment and SSB initially fluctuating then increasing from 2014 to 2019. F increasing along the time series with a very slight decrease in the last 3 years.

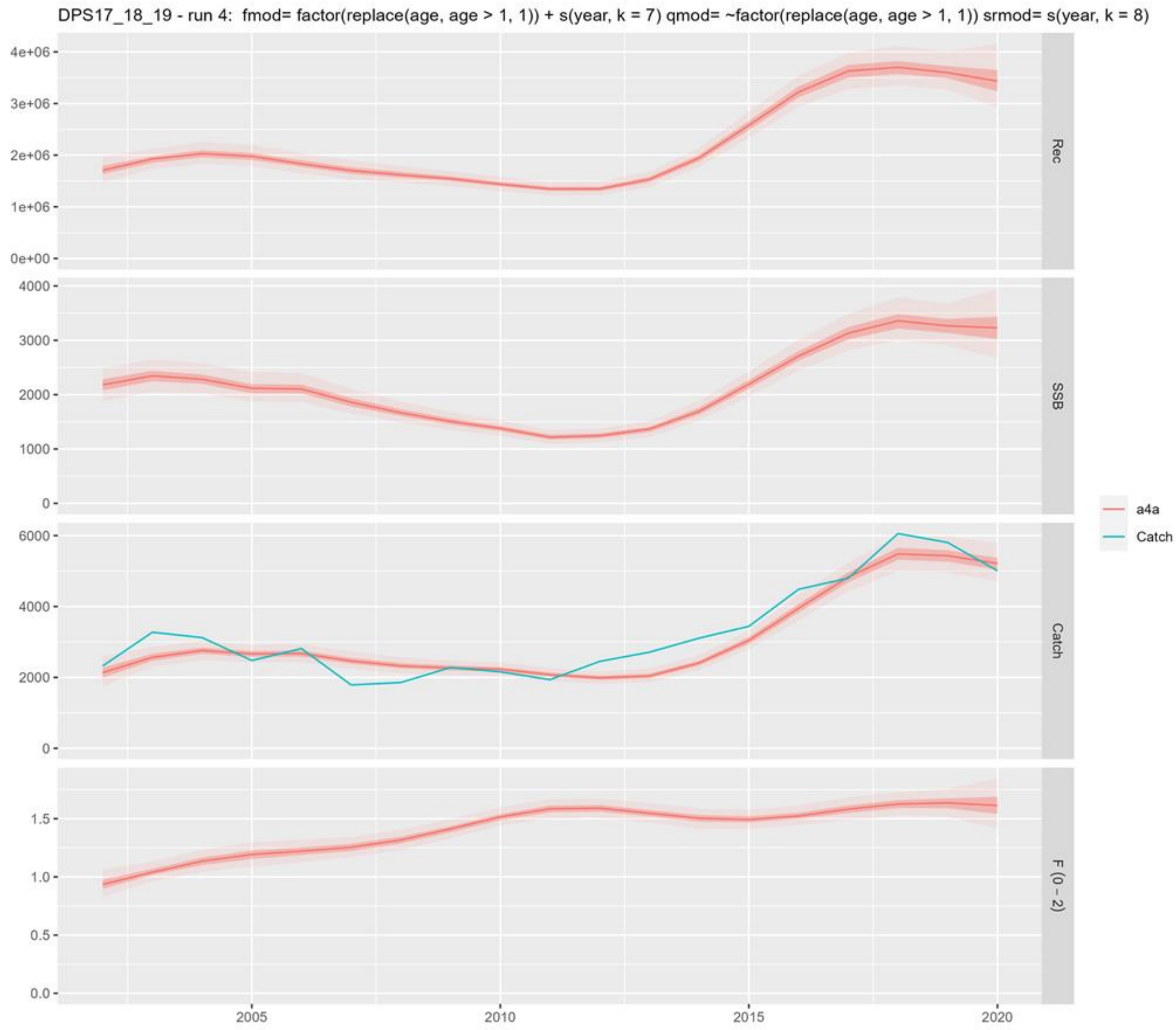


Figure 5.7.1 Deep-water rose shrimp stocks in GSAs 17-19: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of FMSY (=0.72). SSB is fluctuating and F around the maximum level of the time series. F_{2020} is behind FMSY Transition which is 1.50 for 2020 assuming a linear transition from 2019 to 2026.

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

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

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 0-2}$ (2021)	1.624112	Fsq = average of the last 3 years
SSB (2021)	3246.833	SSB intermediate year from STF output
Rage0 (2021,2022)	3590507	Recruitment will be set as geometric mean of the last 3 years
Total catch (2021)	5227.598	Catch intermediate year from STF output

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

Basis	Total catch* (2022)	F_{total}# (ages 0-2) (2022)	SSB (2023)	% SSB change***	% Catch change^
F_{MSY}	3091.9	0.72	5024.1	54.7	-40.7
$F_{MSY\ Transition}$^^	4512.5	1.24	3814.3	17.5	-13.5
$F_{MSY\ lower}$	2247.0	0.48	5908.7	82.0	-56.9
$F_{MSY\ upper}$**	3852.8	0.98	4333.7	33.5	-26.1
Other scenarios					
Zero catch	0.0	0.00	8872.7	173.3	-100.0
Status quo	5317.8	1.62	3275.4	0.9	2.0
Intermediate Options					
F=F2019 * 0.8	4645.1	1.30	3718.5	14.5	-10.9
F=F2019 * 0.6	3845.8	0.97	4339.5	33.7	-26.3
F=F2019 * 0.4	2866.5	0.65	5247.8	61.6	-45.0
F=F2019 * 0.2	1625.9	0.32	6639.0	104.5	-68.8

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

The retrospective analysis run on the a4a model showed some instability 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 2020 is high. All the diagnostics were considered acceptable. Examination of last year’s assessment showed that mean weights had been incorrect, this has been corrected and the recruitment rescaled. The F advice was not affected by this change. A catch tonnage reporting error in 2019 from Italy has been corrected slightly lowering the total catch.

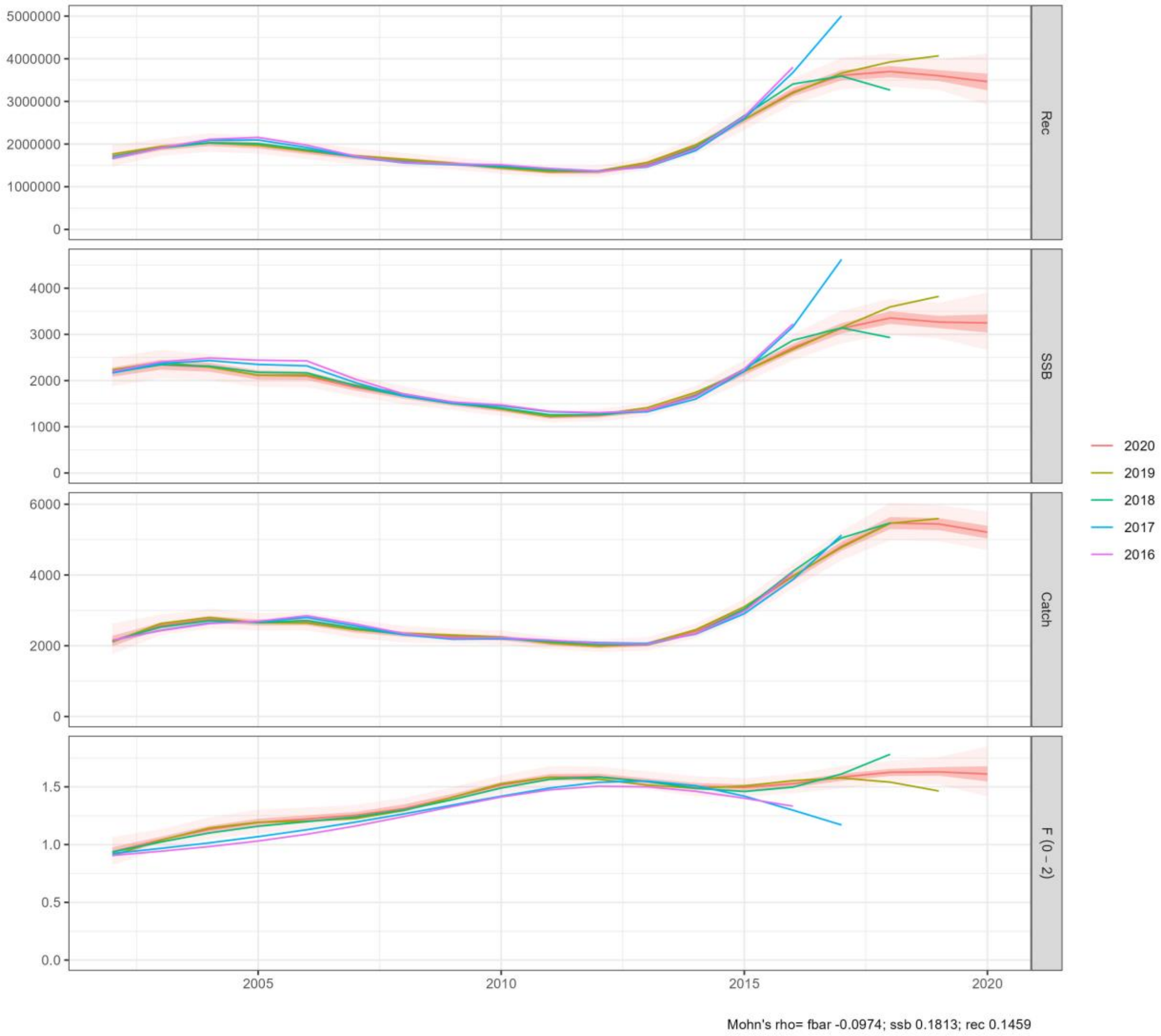


Figure 5.7.2 **Deep-water rose shrimp stocks in GSAs 17-19**: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

This stock is taken in a mixed trawl fisheries.

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}	0.72	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-15
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}	0.72	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-15
	target range F_{lower}	0.48	Based on regression calculation (see section 2)	STECF EWG 20-15
	target range F_{upper}	0.98	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-15

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 plus some commercial data provided by Albania
Discards, BMS landings*, and bycatch	Discards included in the total catch
Indicators	MEDITS survey
Other information	
Working group	STECF EWG 20-15

*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	$F = F_{MSY}$			5667	
2020	$F = F_{MSY}$		5215	5121	
2021	$F = F_{MSY}$		5227		
2022	$F = F_{MSY}$		3092		

History of the catch and landings

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

2020		Wanted catch				Discards
Catch (t)		Bottom trawl 100%				t
	landings	4848				160
Effort	effort	121322*				
		Fishing days				

***ONLY FOR ITALY**

Table 5.7.9 Deep-water rose shrimp stocks in GSAs 17-19: History of commercial landings; the official reported values are presented by country, All weights are in tonnes. Effort is in fishing days.

	Landings and Discards							Effort (fishing days)					
country	HRV	ITA	ITA	ITA	ALB	Discards	Total	HRV	ITA	ITA	ITA	SVN	Total
GSA	17	17	18	19	18		17,18,19	17	17	18	19	17	17,18,19
2002	0	0	1147	1126.2	0	0	2273.2	0	220915	138899	131590	0	491404
2003	0	0	1815.7	1391	0	0	3206.7	0	223216	107183	153810	0	484209
2004	0	0	1857.7	1201	0	0	3058.7	0	242276	87211	106719	0	436206
2005	0	0	1182	1244.1	0	0	2426.1	0	203974	79638	56199	831	339811
2006	0	54	1473	1245.1	0	19	2791.1	0	169108	85122	82371	963	336601
2007	0	0	863	608	198	0	1669	0	138377	70774	76509	1202	285660
2008	0	0	766	785	187	0	1738	0	130131	70654	76484	1254	277269
2009	0	0	939	767	262	85.4	2053.4	0	137929	85892	88055	1205	311876
2010	0	0	888	716	7	53.6	1664.6	0	136949	73021	90514	1263	300484
2011	0	92	870	593	209	21.8	1785.8	0	138540	68754	78239	1178	285533
2012	169.2	0	523	488.1	1170	15.4	2365.7	50835	116850	63411	60017	917	291113
2013	315.4	84	734	335	1210	35	2713.4	52973	97982	79244	45588	766	275787
2014	370.5	202	638	423.8	1430	45.3	3109.6	54650	97868	54851	48040	680	255409
2015	534.2	279	651	622	1290	63.6	3439.8	55076	85984	54774	51394	696	247228
2016	655.1	471	996	647	1460	255.2	4484.3	33715	89376	60876	49784	812	233751
2017	834.4	520	1109	693	1473	171.1	4800.5	35649	96415	57053	52214	697	241331
2018	913.1	835	1962	716	1275	355.3	6056.4	56844	79551	62311	46672	692	245378
2019	715.2	700	2187	965.3	962	272.3	5801.8	30997	65911	50169	32875	769	179952
2020	661	645.2	1835.2	680.2	1026	158.4	5006		56627	39509	25186		121322

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 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 0-2	High	Low
2002	1710161			2164			1583	0.94		
2003	1916919			2336			1515	1.04		
2004	2026625			2282			2925	1.13		
2005	1975589			2120			2683	1.19		
2006	1833002			2104			2655	1.22		
2007	1703895			1862			2350	1.25		
2008	1619353			1668			2299	1.32		
2009	1541422			1507			2215	1.41		
2010	1438376			1379			2165	1.52		
2011	1346085			1218			1969	1.58		
2012	1348740			1244			1916	1.59		
2013	1529795			1363			1966	1.55		
2014	1947296			1697			2427	1.5		
2015	2575489			2190			3109	1.49		
2016	3221716			2710			4079	1.53		
2017	3623722			3133			5117	1.58		
2018	3708076			3362			5900	1.62		
2019	3608000			3273			5667	1.63		
2020	3459810			3238			5121	1.61		

Sources and references

STECF EWG 21-15

5.8 SUMMARY SHEET FOR GIANT RED SHRIMP IN GSA 18, 19 AND 20

STECF advice on fishing opportunities

Based on precautionary considerations, STECF-EWG 21-15 advises that the 2022 catch should be no more than 303t. This corresponds to 22% reduction in relation to the catch of the 2020.

Stock development over time

The relative change in the trend of the MEDITS biomass index in GSAs 18 and 19 (jointly) was used to provide an index for change (Figure 5.8.1). The index of GSA 20 was not used given the existing gaps in the survey in that GSA. In the most recent years the stock fluctuates without any particular trend. Regarding landings, with the exception of the relatively high values observed in the 2015-2017 period, they mostly range from 230 to 430t (Figure 5.8.2). Based on the index value in the last two years relative to the previous three ones the biomass showed a slight increase (1.08 times).

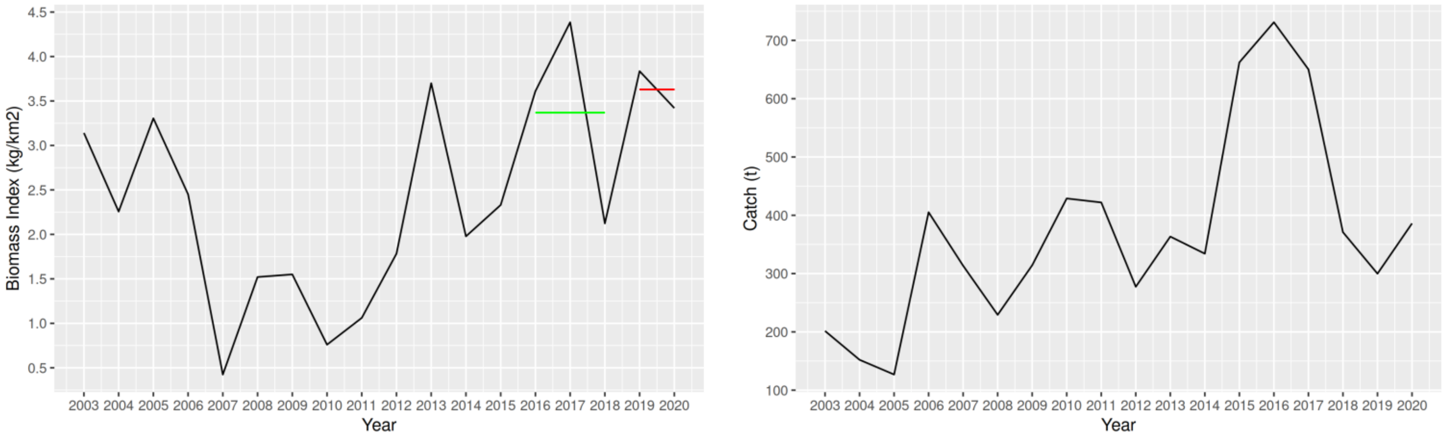


Figure 5.8.1 Giant Red Shrimp in GSAs 18-20: MEDITS survey indicator (biomass index) by year including mean of the last two years (2019-2020, in red) and the previous three years (2016-2018, in green) (left) There are used for calculating catch advice and total catch by year (right).

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown. The biomass fluctuates without trend over the last decade.

Catch scenarios

The advice on fishing opportunities for 2022 is based on the recent observed catch adjusted to the change in the biomass index. The biomass index used to provide the catch scenarios is obtained from the MEDITS survey data. The change is estimated from the average of the two most recent values (2019-2020) relative to the average of the three preceding values (2016-2018) (see table 5.8.1).

Table 5.8.1 Giant Red Shrimp in GSAs 18-20: Assumptions made for the interim year and in the forecast. *

Index A (2019–2020)		3.63
Index B (2016–2018)		3.37
Index ratio (A/B)		1.08
-20% Uncertainty cap	Applied/not applied	Not Applied
Average catch (2018–2020)		352
Discard rate (2019–2020)		Negligible
-20% Precautionary buffer	Applied/not applied	Applied 0.86
Catch advice **		303
Landings advice ***		303
% catch change ^		-22%

* The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.

** (average catch × precautionary buffer)

*** catch advice × (1 – discard rate)

^ Advice value 2022 relative to catch value 2020.

Basis of the advice

Table 5.8.2 Giant Red Shrimp in GSAs 18-20: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

A statistical catch at age (a4a) assessment was attempted and various model runs were carried out. Some input parameters, such as growth, were uncertain and there are important survey gaps GSA 20, so the outputs were questionable. Therefore the EWG is providing advice through a biomass index, based on the consistent surveys which come from the area with most of the fisheries.

Issues relevant for the advice

There are no additional relevant issues

Reference points

Table 5.8.3 Giant Red Shrimp in GSAs 18-20: Reference points, values, and their technical basis.

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

Basis of the assessment

Table 5.8.4 Giant Red Shrimp in GSAs 18-20: Basis of assessment and advice.

Assessment type	Index based assessment
Input data	Landings at length sliced
Discards and bycatch	Discards negligible
Indicators	MEDITS in GSAs 18 and 19 (jointly)
Other information	
Working group	EWG 21-15

History of the advice, catch, and management

Table 5.8.5 Giant Red Shrimp in GSAs 18-20: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted landings corresp. to advice	Predicted catch corresp. to advice	STECF catch	STECF discards
2022	Reduction of 0.78% of catch	303	303		

History of the catch and landings

Table 5.8.6 Giant Red Shrimp in GSAs 18-20: Catch distribution by fleet in 2020 as estimated by STECF.

Catch (2020)	Landings			Discards
386 t	100% trawl (OTB)	0% set nets (GNS+GTR)	0% others	negligible
	386 t			

Table 5.8.7 Giant Red Shrimp in GSAs 18-20: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

Year	ITALY GSA 18	ITALY GSA 19	GREECE GSA 20
2003	198	4	-
2004	89	63	-
2005	72	55	-
2006	169	236	-
2007	115	199	-
2008	97	133	-
2009	88	226	-
2010	127	301	-
2011	75	347	-
2012	15	262	-
2013	15	349	-
2014	8	320	6
2015	9	646	7
2016	14	690	27
2017	141	509	-
2018	176	162	33
2019	106	157	37
2020	133	218	35

Summary of the assessment

Table 5.8.8 Giant Red Shrimp in GSAs 18-20: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings (t)	Discards (t)	Catch (t)
2003	3.14	202	-	202
2004	2.26	152	-	152
2005	3.3	127	-	127
2006	2.45	405	-	405
2007	0.42	313	-	313
2008	1.52	229	-	229
2009	1.55	314	-	314
2010	0.76	429	-	429
2011	1.06	422	-	422
2012	1.78	277	-	277
2013	3.7	363	-	363
2014	1.98	334	-	334
2015	2.33	662	-	662
2016	3.61	731	-	731
2017	4.39	650	-	650
2018	2.12	371	-	371
2019	3.84	300	-	300
2020	3.42	386	-	386

Sources and references

EWG 21-15

5.9 SUMMARY SHEET FOR EUROPEAN HAKE IN GSA 19

STECF advice on fishing opportunities

STECF EWG 21-15 advises that when MSY considerations are applied the fishing mortality in 2022 should be no more than 0.151 and corresponding catches of hake in 2022 should not exceed 420 tonnes.

Stock development over time

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

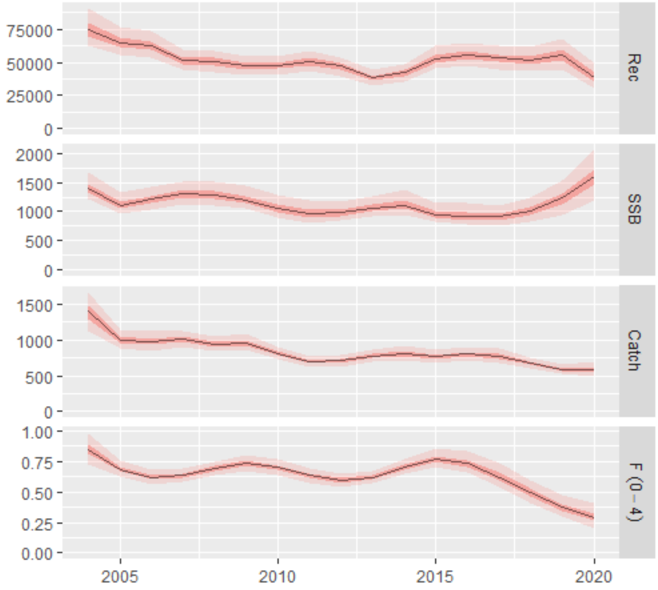


Figure 5.9.1 Hake (HKE) in GSA 19. Outputs of the a4a assessment. SSB and catch are in tonnes, recruitment in number (‘000) of individuals.

Stock and exploitation status

Current Fbar= 0.287 is higher than $F_{0.1}$ (0.151), 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 5.9.1 Hake in GSA 19. State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.9.2 Hake in GSA 19: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 0\text{-}4}$ (2021)	0.287	F status quo (in the interim year 2021) is assumed Fbar in the last assessment year (2020)
SSB (2021)	1971 t	SSB projection based on stock assessment
R_{age0} (2021)	51145	Geometric mean of the whole time series
Total catch (2021)	652 t	Catch at F status quo in 2021

Table 5.9.3 Hake in GSA 19: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	F_{total} (ages 0-4) (2022)	SSB (2023)	% SSB change**	% Catch change^
STECF advice basis					
F_{MSY} / MAP	420	0.151	3226	63.7	-28
$F_{MSY\ Transition}$^^	728	0.277	2853	44.7	24.7
$F_{MSY\ upper}$*	573	0.212	3040	54.2	-1.9
$F_{MSY\ lower}$	292	0.103	3382	71.6	-49.9
Other scenarios					
Zero catch	0.00	0.00	3743	89.9	-100.00
Status quo	792	0.287	2827	43.4	28.4

* Fupper is not tested and is assumed not to be precautionary STECF does not advise fishing at F>Fmsy
** % change in SSB 2023 to 2021
^Total catch in 2022 relative to Catch in 2020.
^^$F_{MSY\ Transition}$ is based on a linear change in F from 2019 to F_{MSY} in 2026

Basis of the advice

Table 5.9.4 Hake in GSA 6: 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 and by STECF EWG 21-02 on the basis of reconstructed data. This a4a assessment uses the same model settings as by EWG 2015 and EWG 2102 an has an improved stability compared to the benchmark assessment. The results and the diagnostics the fitted model are very similar to those obtained by the previous assessments and the benchmark assessment (GFCM 2019). The conclusion that F>Fmsy is kept by the present assessment Table 5.9.1.

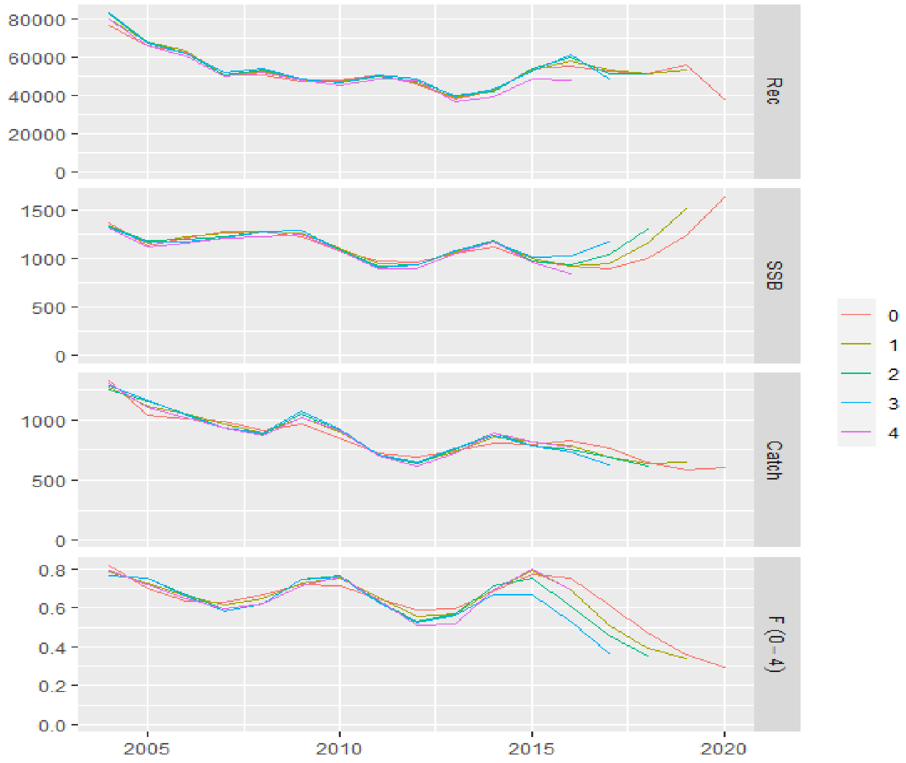


Figure 5.9.2 Hake in GSA 19: Historical assessment results (final-year recruitment estimates included). Retrospective graph.

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.9.5 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}	0.151	$F_{0.1}$ 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}	0.151	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 2021-15
	MAP target range F_{lower}	0.103	Based on regression calculation (see section 2)	STECF EWG 2021-15
	MAP target range F_{upper}	0.212	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 2021-15

Basis of the assessment

Table 5.9.6 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 2021-15

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.9.7 Hake 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
2019	$F = F_{MSY}$				
2020	$F = F_{MSY}$				
2021	$F = F_{MSY}$				
2022	$F = F_{MSY}$		420		

History of the catch and landings

Table 5.9.8 Hake in GSA 19: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2020		Wanted catch				Discards
Catch (t)	614	Bottom trawl 66%	Gillnets 4 %	Trammel nets 7 %	Other 23 %	0.42 t
		Tones				Negligible
Effort		100%	0%	0%	0%	

Table 5.9.9 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	

Summary of the assessment

Table 5.9.10 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	74816	1372	0.844	1366
2005	65108	1101	0.685	996
2006	62629	1201	0.617	974
2007	51153	1298	0.632	1008
2008	50283	1286	0.692	943
2009	46841	1211	0.729	967
2010	47318	1059	0.698	816
2011	50269	970	0.631	700
2012	46853	983	0.592	706
2013	38123	1066	0.619	776
2014	41974	1114	0.702	817
2015	53128	949	0.766	769
2016	55309	917	0.734	804
2017	52778	904	0.621	772
2018	51360	1009	0.492	677
2019	55379	1218	0.372	591
2020	38783	1593	0.287	584

Sources and references

STECF EWG 21-15

6 ASSESSMENTS BY STOCK

6.1 EUROPEAN HAKE IN GSA 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.

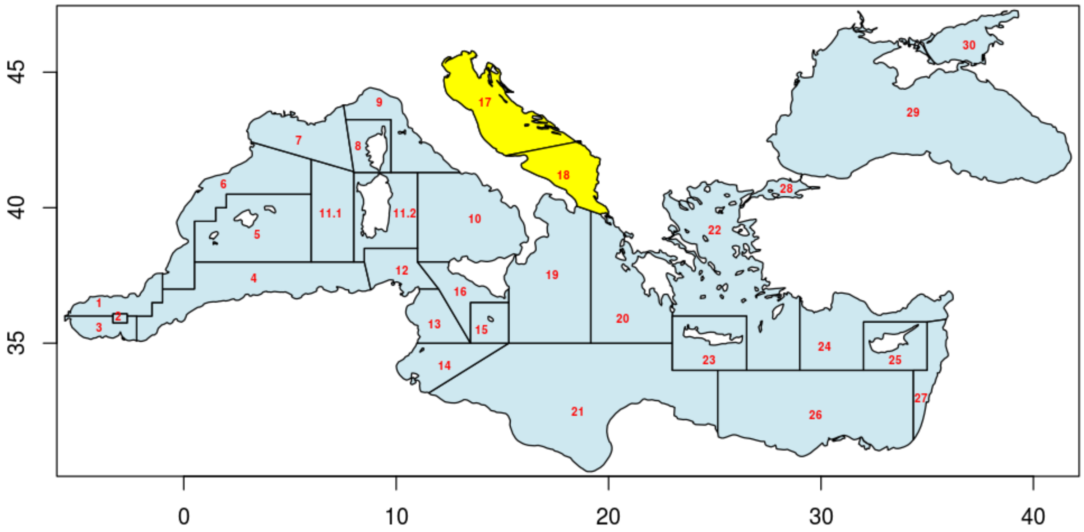


Figure 6.1.1.1 European hake in GSAs 17 and 18. Geographical location of GSAs 17-18

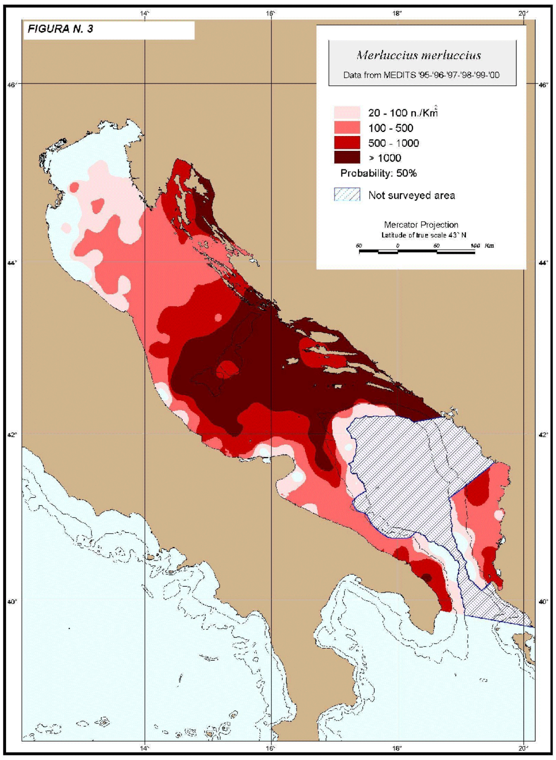


Figure 6.1.1.2 European hake in GSAs 17 and 18. Distribution map in the Adriatic Sea from MEDITS Programme (Sabatella and Piccinetti, 2005)

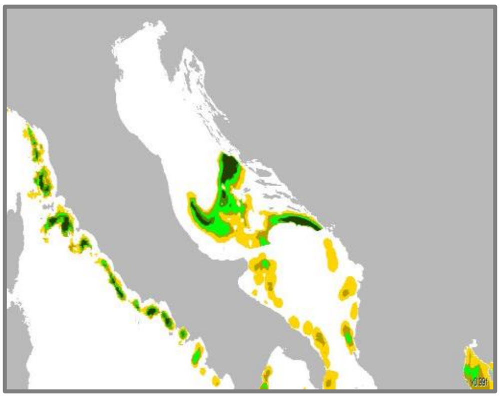


Figure 6.1.1.3 European hake in GSAs 17 and 18. Position of persistent nursery in GSAs 17 and 18 from MEDISEH project.

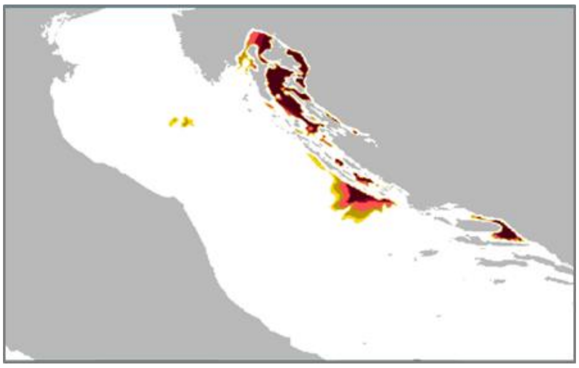


Figure 6.1.1.4 European hake in GSAs 17 and 18. Position of persistent spawning area in GSAs 17 and 18 from MEDISEH project.

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**	**TBB**	**GNS**	**OTB**	**TBB**	**GNS**
2006	3980	237		0	0	
2007	3435			0		
2008	3037			0		
2009	2549			0		
2010	1863			0		
2011	1460	12		9	0	
2012	1777	15		6	0	
2013	2192			3		
2014	1789	30		11	0	
2015	2011	62		13	0	
2016	1731			61		
2017	1836	6		116	0	
2018	1853	71	5	346	4	0
2019	1552	11		155	0	
2020	1488	26		84	0	

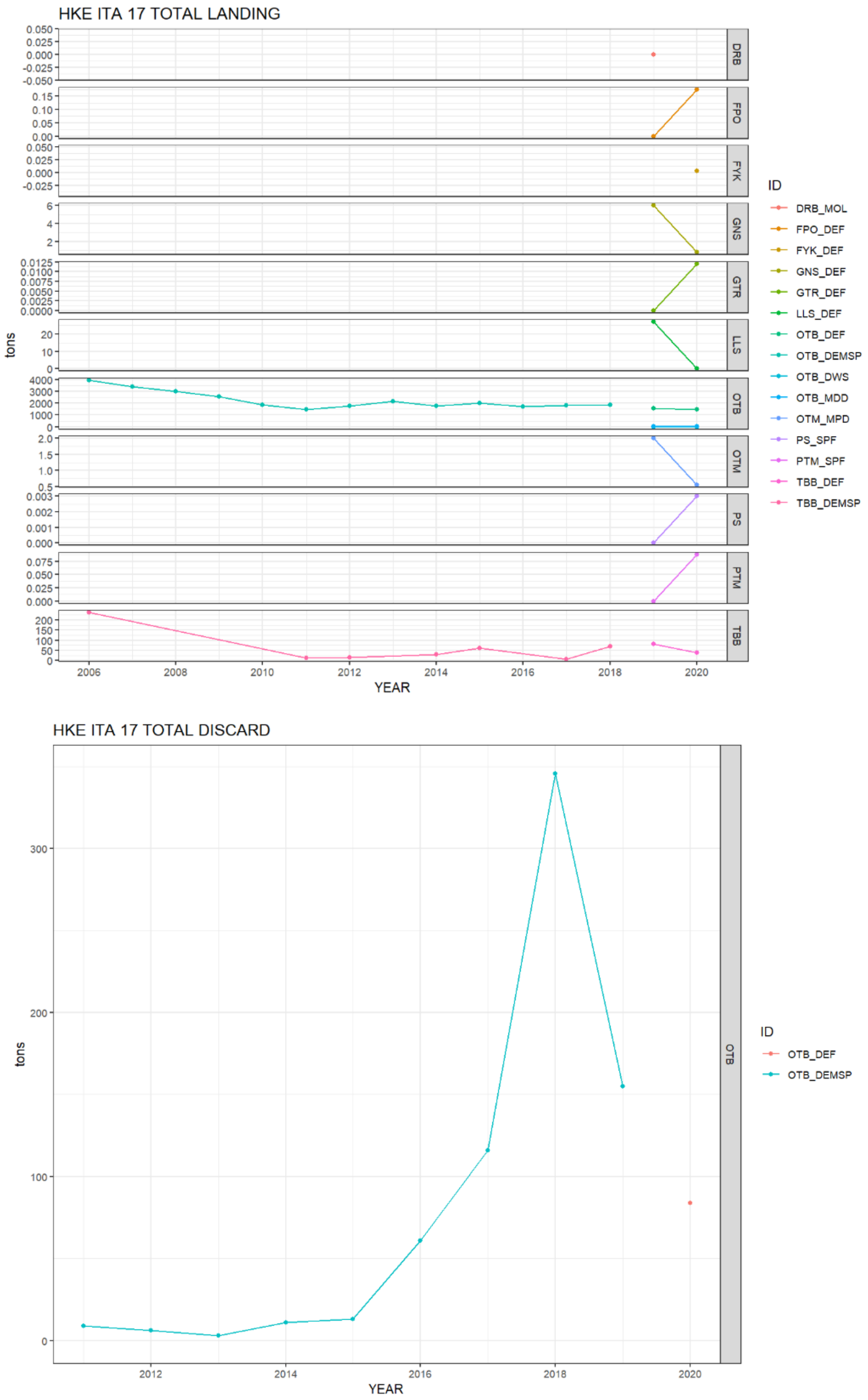


Figure 6.1.2.1.1 European hake in GSAs 17 and 18. Catch (landings and discards) data included in the DCF database for Italy in GSA 17.

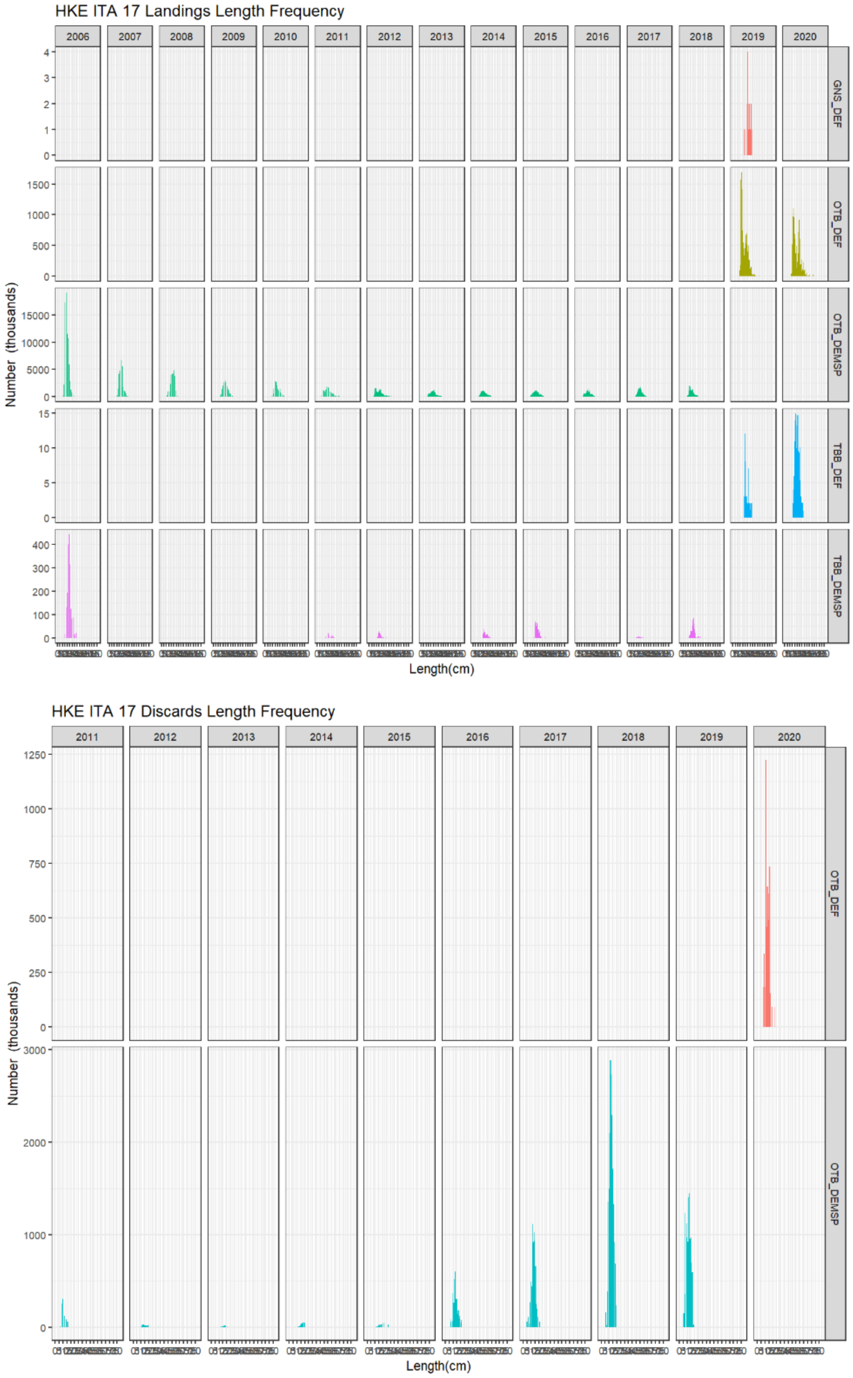


Figure 6.1.2.1.2 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database for Italy in GSA 17.

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

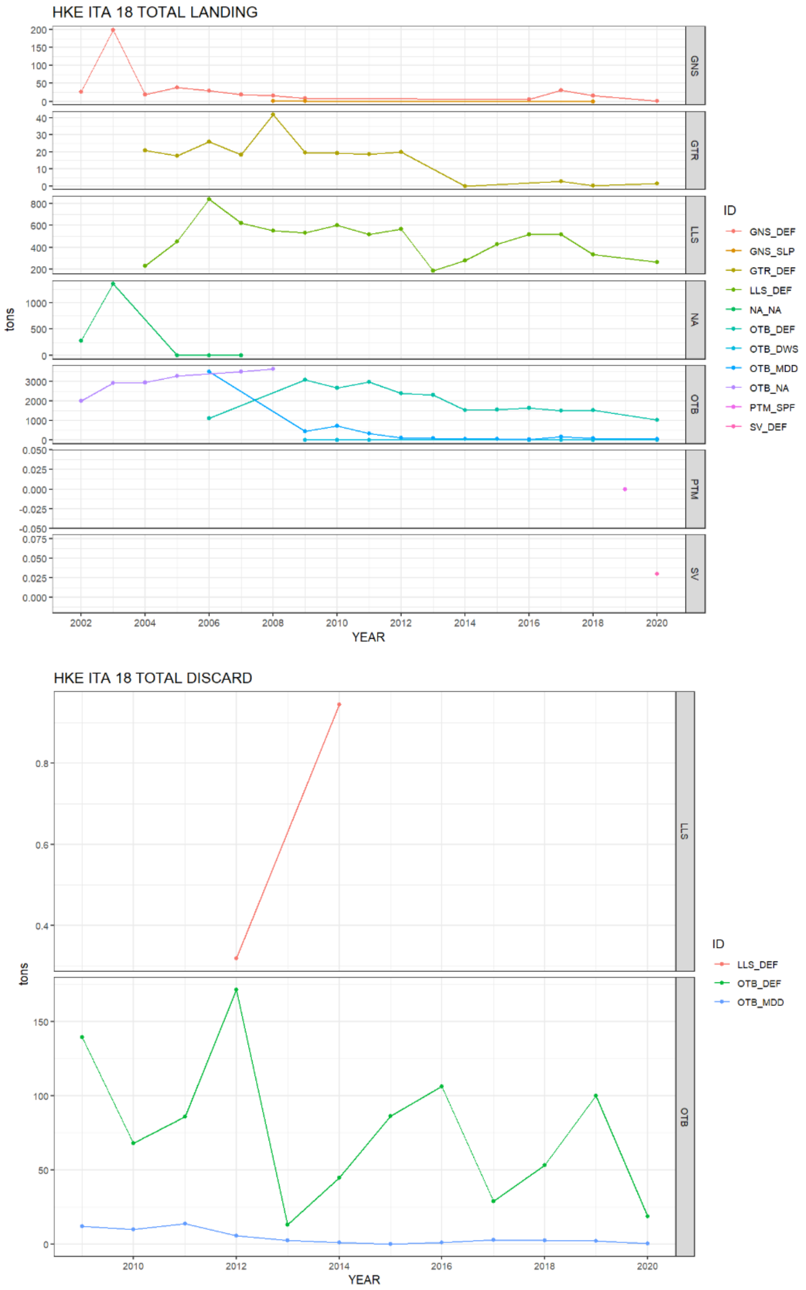
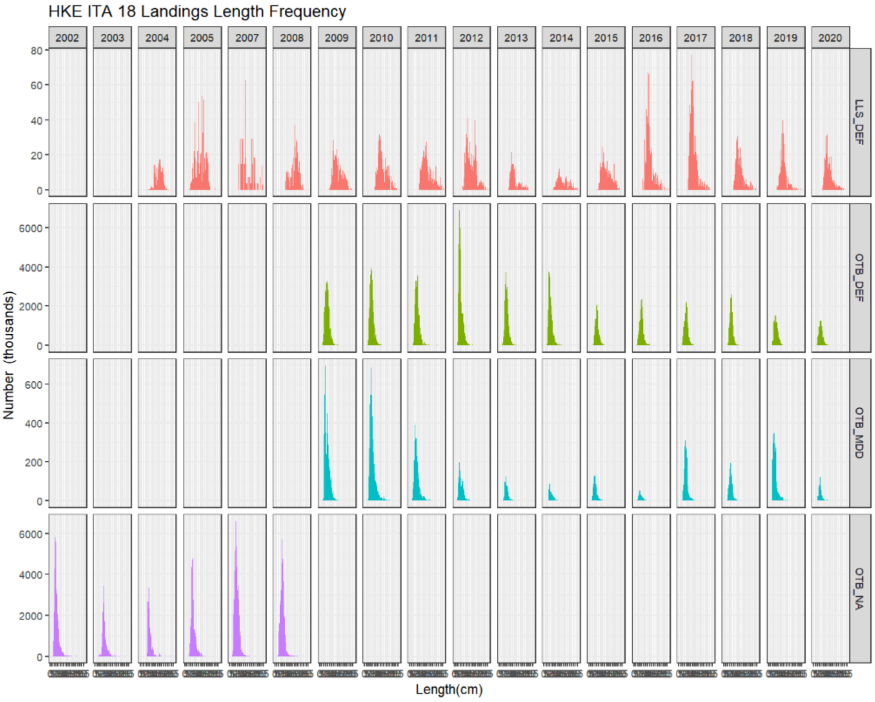


Figure 6.1.2.1.3 European hake in GSAs 17 and 18. Catch (landings and discards) data included in the DCF database for Italy in GSA 18.



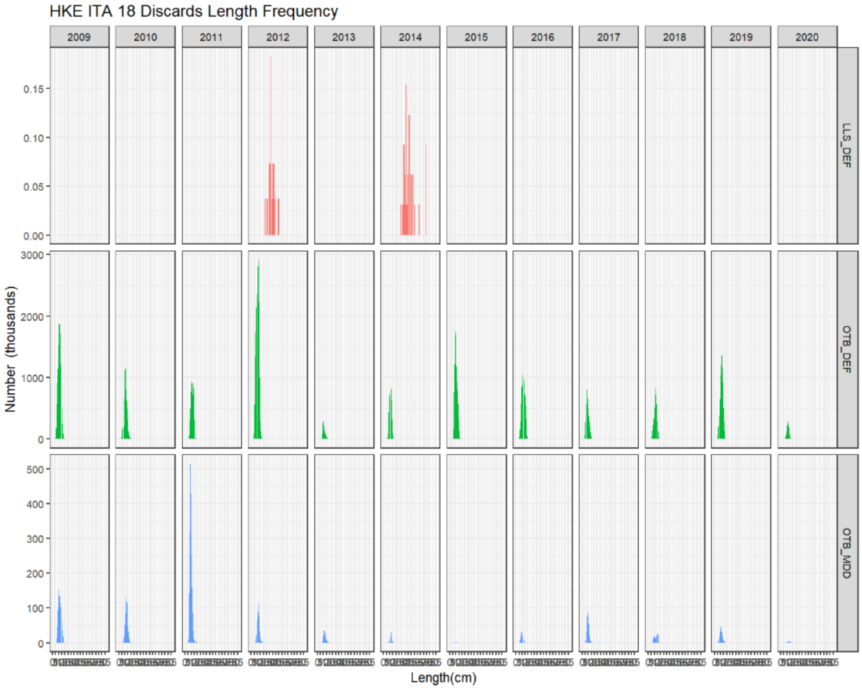


Figure 6.1.2.1.4 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database for Italy in GSA 18.

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	
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	87	5	927	178	3	0.08	2	0.4

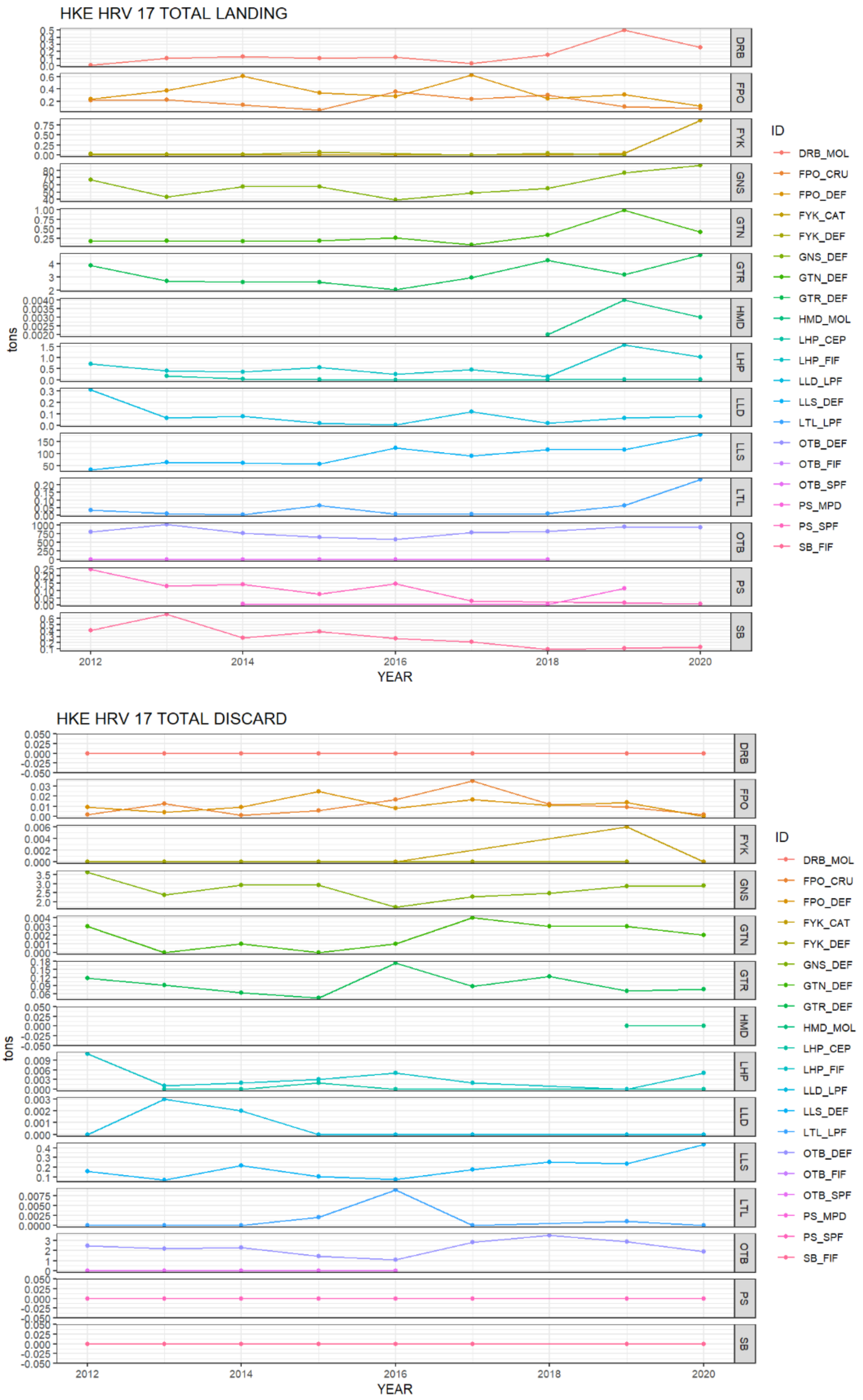
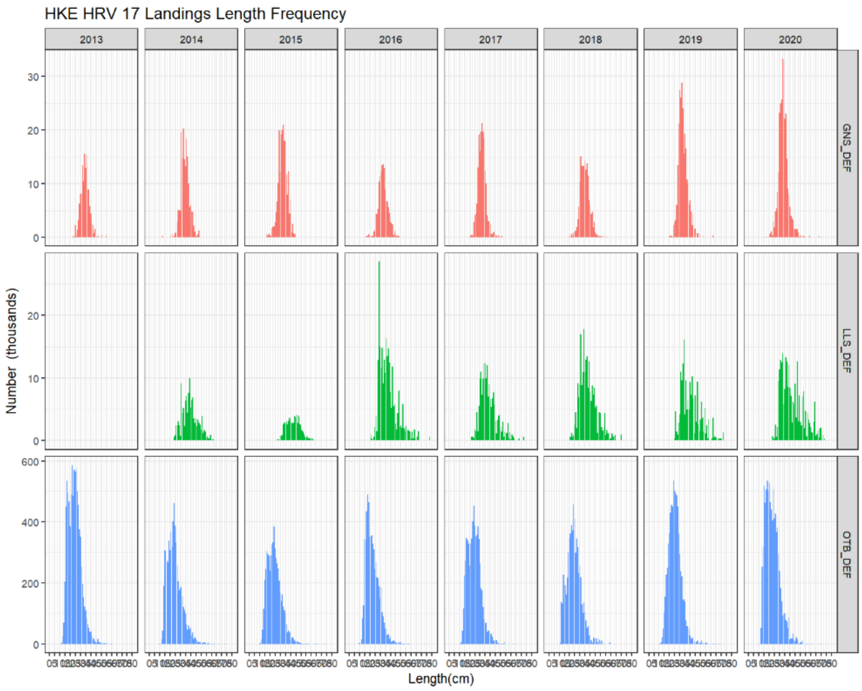


Figure 6.1.2.1.5 European hake in GSAs 17 and 18. Catch data included in the DCF database Croatia in GSA 17.



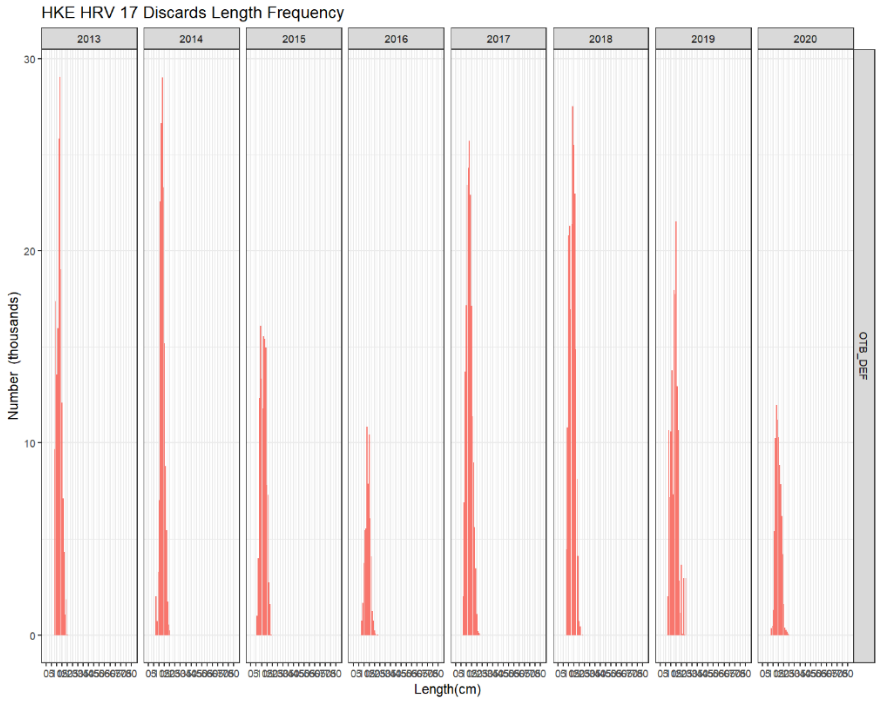


Figure 6.1.2.1.6 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database Croatia in GSA 17.

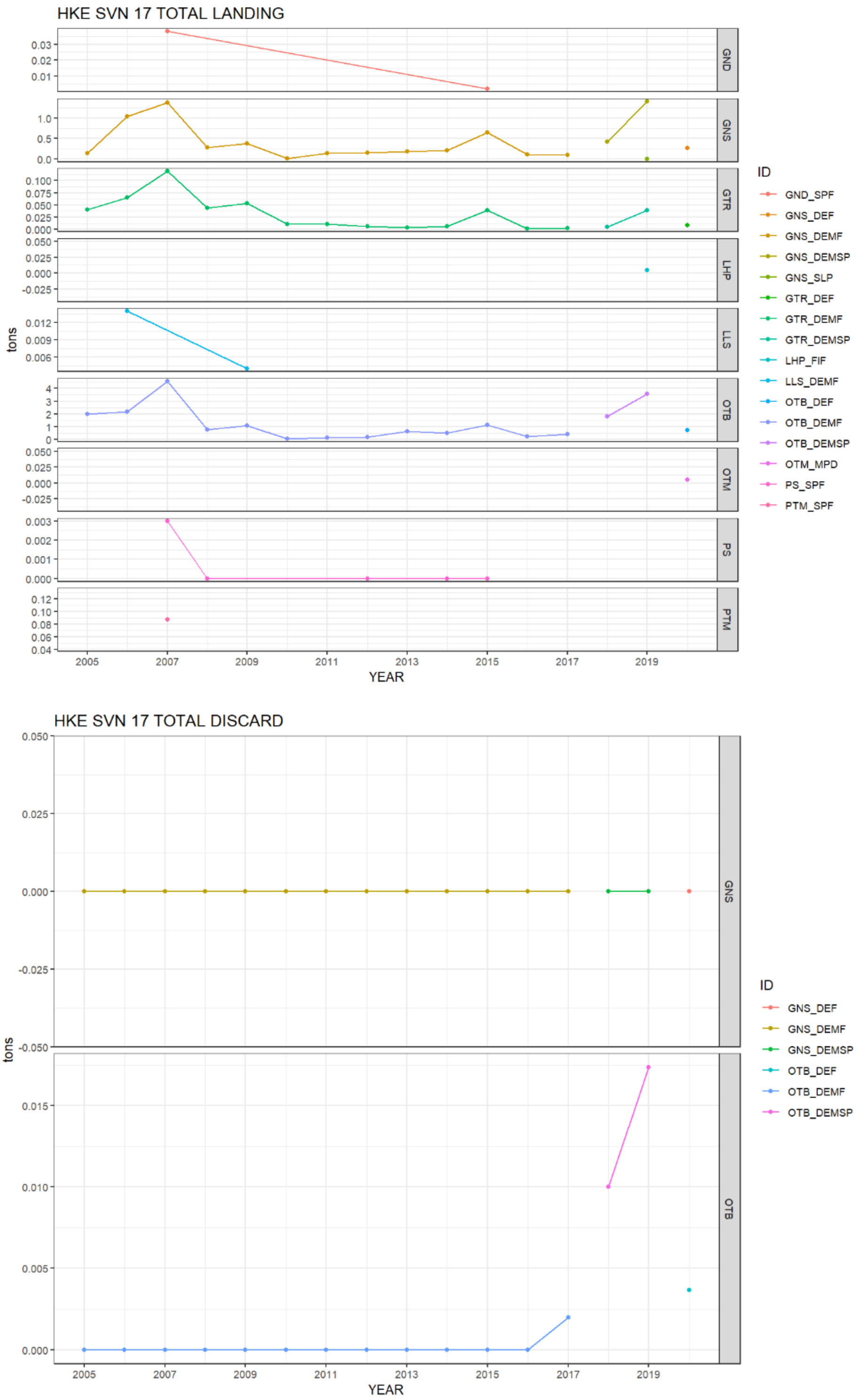


Figure 6.1.2.1.7 European hake in GSAs 17 and 18. Catch data included in the DCF database Slovenia in GSA 17.

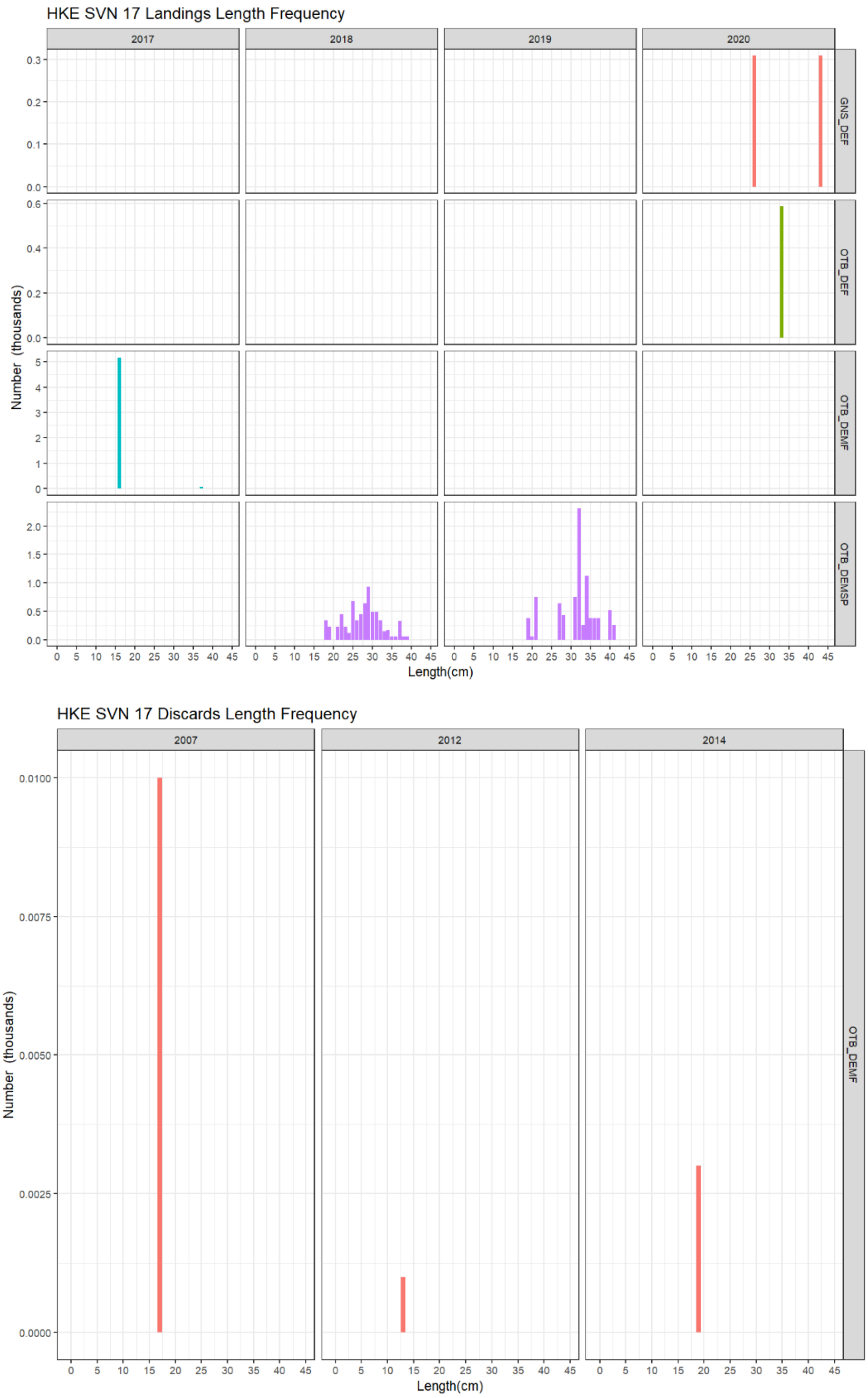


Figure 6.1.2.1.8 European hake in GSAs 17 and 18. Catch (landings and discards) length frequency distributions included in the DCF database Slovenia in GSA 17.

Bottom trawl and longlines catch data (landings plus discards) are included in the stock assessments models. Specifically, for the earlier years for which no discard estimates are available, a mean discard ratio was applied. Also, the Albanian and Montenegrin data included in the GFCM database were included in the assessment input data. For the SS3 model, catch data were included from 1998; the source of this data is FishStatJ. 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	2201	818	116	1706	331	47	872	6091
2019	1712	946	113	1584	232	37	731	5355
2020	1572	929	179	1105	265	40**	751	4841

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

** Mean of the catches form 2017-2019

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 and 2016. LFDs from discards of Italy in GSA 17 are available only for OTB from 2011 to 2020 (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 2020. LFDs from discards of LLS of Italy in GSA 18 are missing for 2009-2011, 2013 and 2015-2020.

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 2020. (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**
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	4804	8116	170		13090

Sum of fishing days – HRV OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
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

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**
2016		439				439
2017		361				361
2018		877	8	149		1035
2019		545	277			822
2020		208	6			214

Sum of fishing days - ITA17 OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
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

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**
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

Sum of fishing_days ITA18 OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
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

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

Sum of fishing_days SVN17 LLS						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2014	66	12				78
2015	53					53
2016	20					20
2017	19					19
2018	47	3				50
2019	28	10				38
2020	8	4				12

Sum of fishing_days SVN17 OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2014	183	482				665
2015	171	499				670
2016	265	512				777
2017	194	503				697
2018	201	491				692
2019	205	564				769

6.1.2.3 SURVEY DATA

MEDITS survey data are available from the official 2021 Data Call for GSA 17 and for GSA 18 from 1994. All the Countries are covered by the survey data. For the present assessment the data from 1998 to 2020 were used. Data were analysed using the JRC script.

The MEDITS survey in GSAs 17 and 18 is performed by 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 1994-2020.

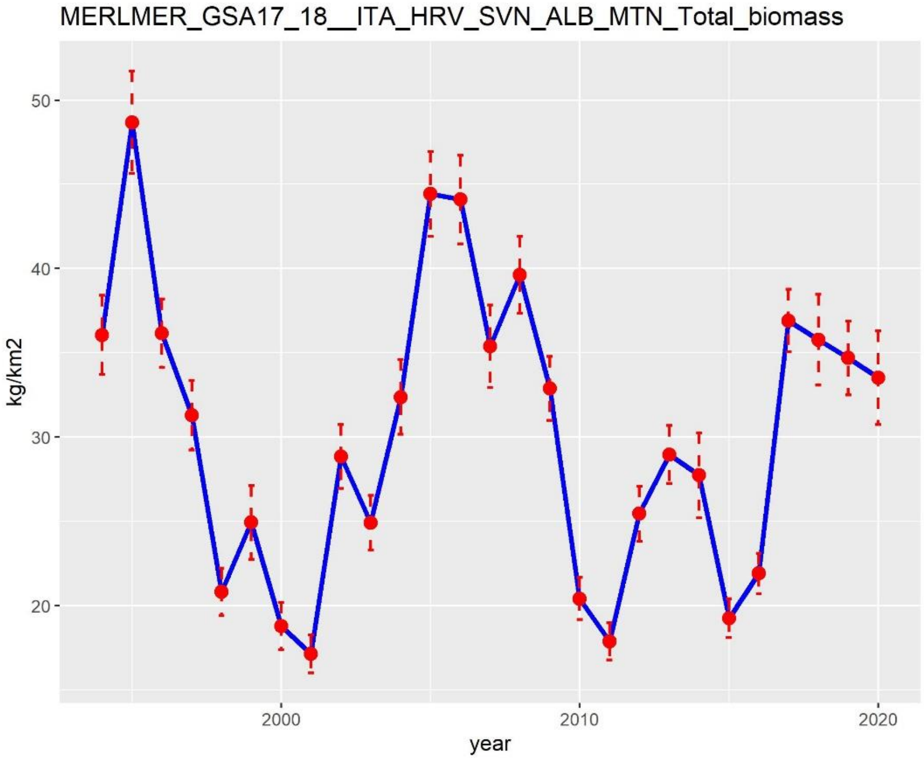


Figure 6.1.2.3.2 European hake in GSAs 17 and 18. MEDITS biomass (kg/km^2) over 1994-2020.

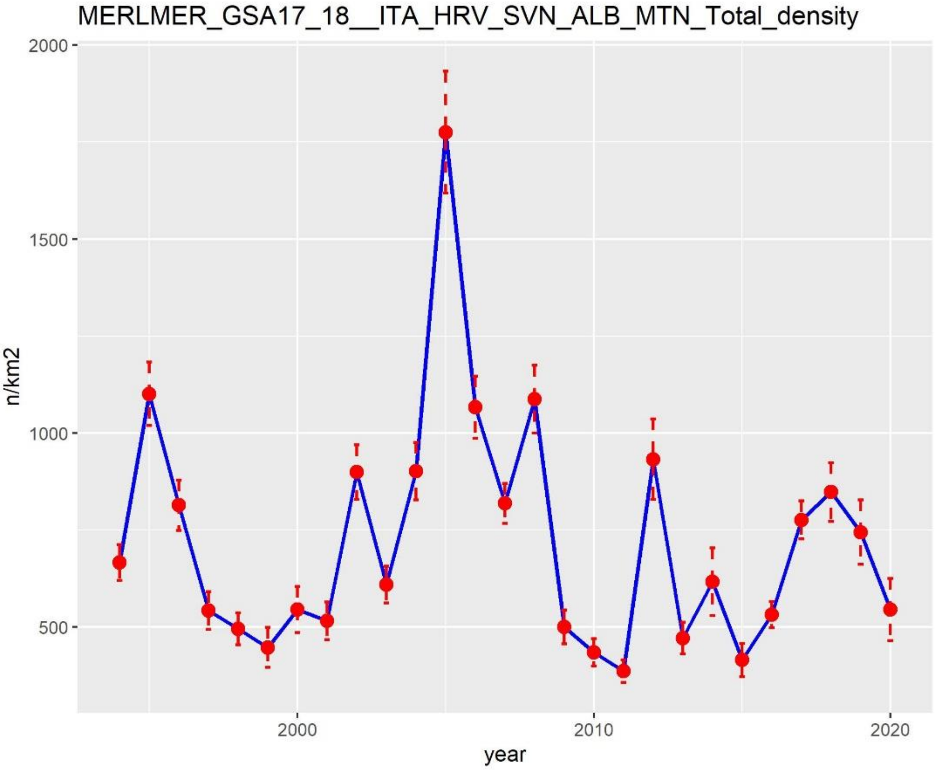


Figure 6.1.2.3.3 European hake in GSAs 17 and 18. MEDITS abundance (n/km^2) over 1994-2020.

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.

6.1.3.1 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 2018). 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; catch and LFD from 2020 missing; 2020 catches assumed to be equal to the mean catches of 2017-2019 and are 0.1% of catches of the stock)
7) Albania bottom trawls (catch and LFD; LFD only for 2017-2019)

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.

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 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 2020. The model input data were updated with data from 2020. LFDs from Montenegro and Albania were missing for 2020 so are not included in the model. Catches of Montenegro in 2020 were not available and were assumed to be the equal to the mean of the three previous years. The catch approximation used for the 0.1 % of total catch with missing LFDs has a negligible influence on the assessment.

One small correction was made to the 2019 data compared to the ones used in the update assessment performed during STCF EWG 20-15. Montenegrin catches for 2019 were updated with official catches used in the last GFCM update assessment.

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). It is recommended to check carefully the ALK in the model since very high residuals are present in the results of the ALK fitting. 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).

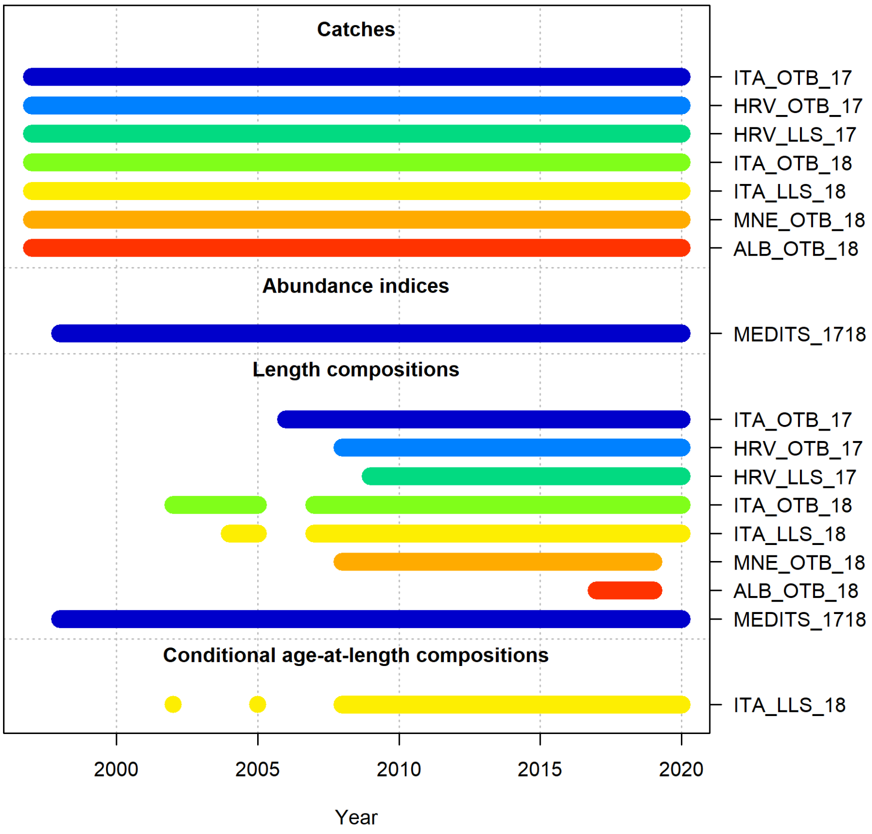


Figure 6.1.3.1.1 European hake in GSAs 17 and 18: Summary of the input included in the SS3 model.

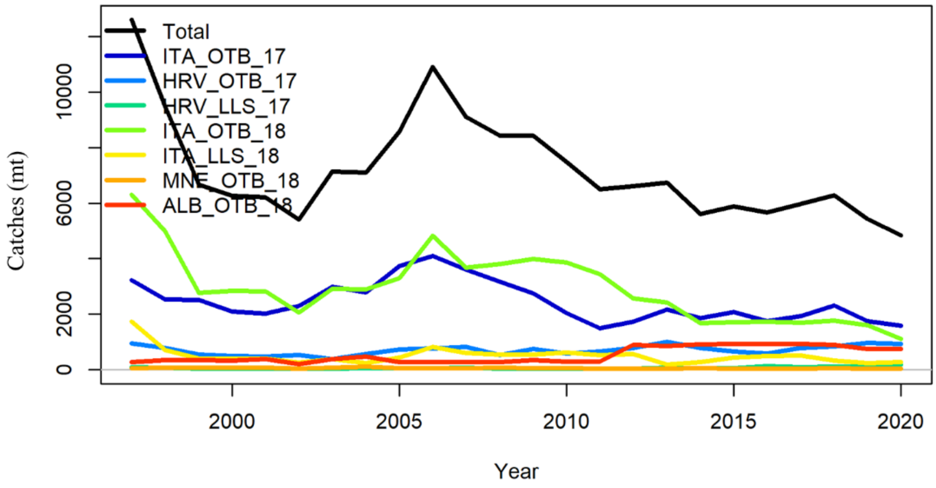


Figure 6.1.3.1.2 European hake in GSAs 17 and 18: Catch data by country, gear and year.

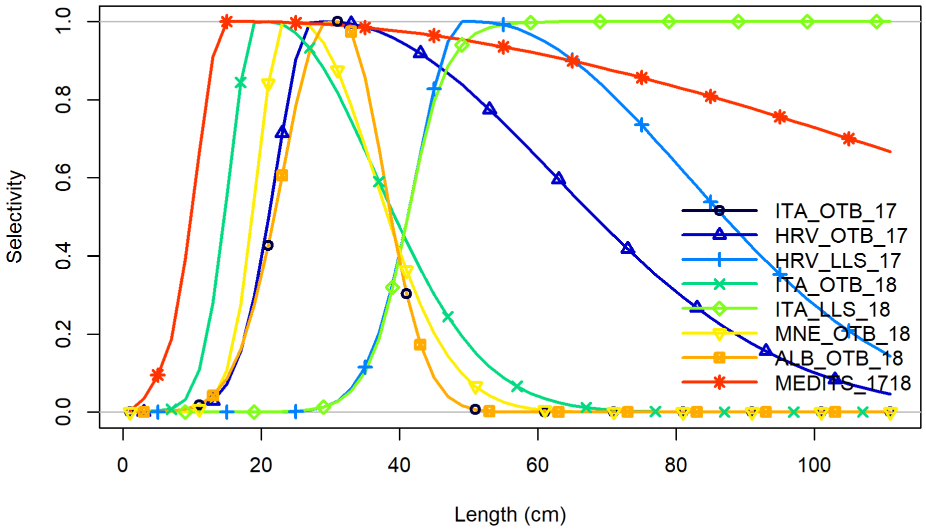


Figure 6.1.3.1.3 European hake in GSAs 17 and 18: Selectivity by fleet in 2020.

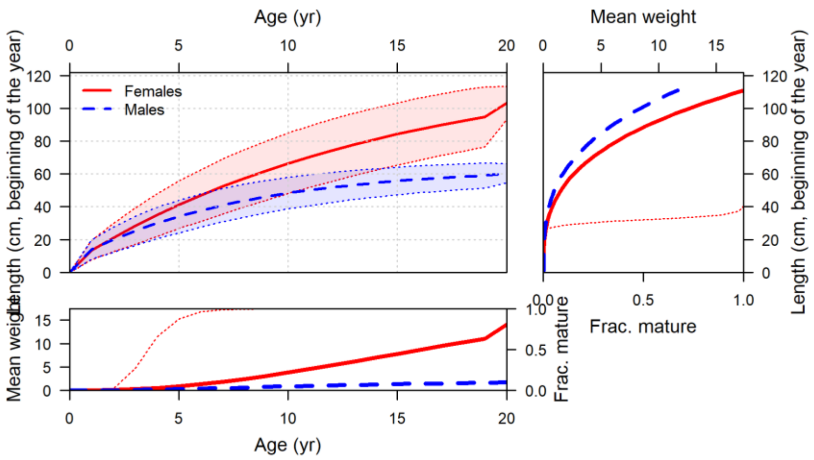


Figure 6.1.3.1.4 European hake in GSAs 17 and 18: Length at age (top-left panel) with weight (thick line) and maturity (thin line) shown in top-right and lower-left panels.

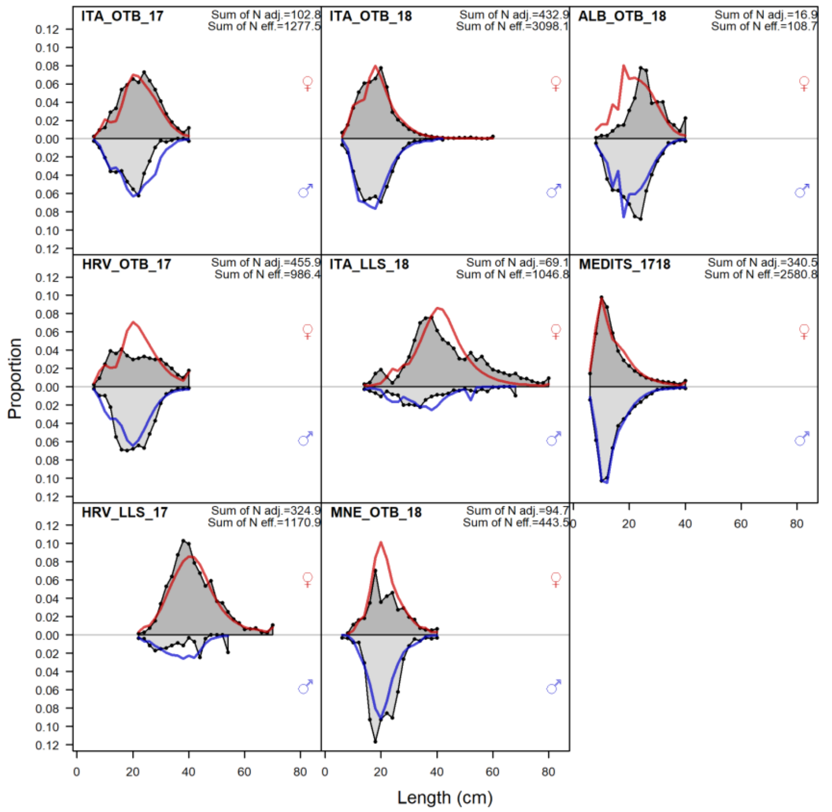


Figure 6.1.3.1.5 European hake in GSAs 17 and 18: Catch at lencth by fleet input data. fitted males and females

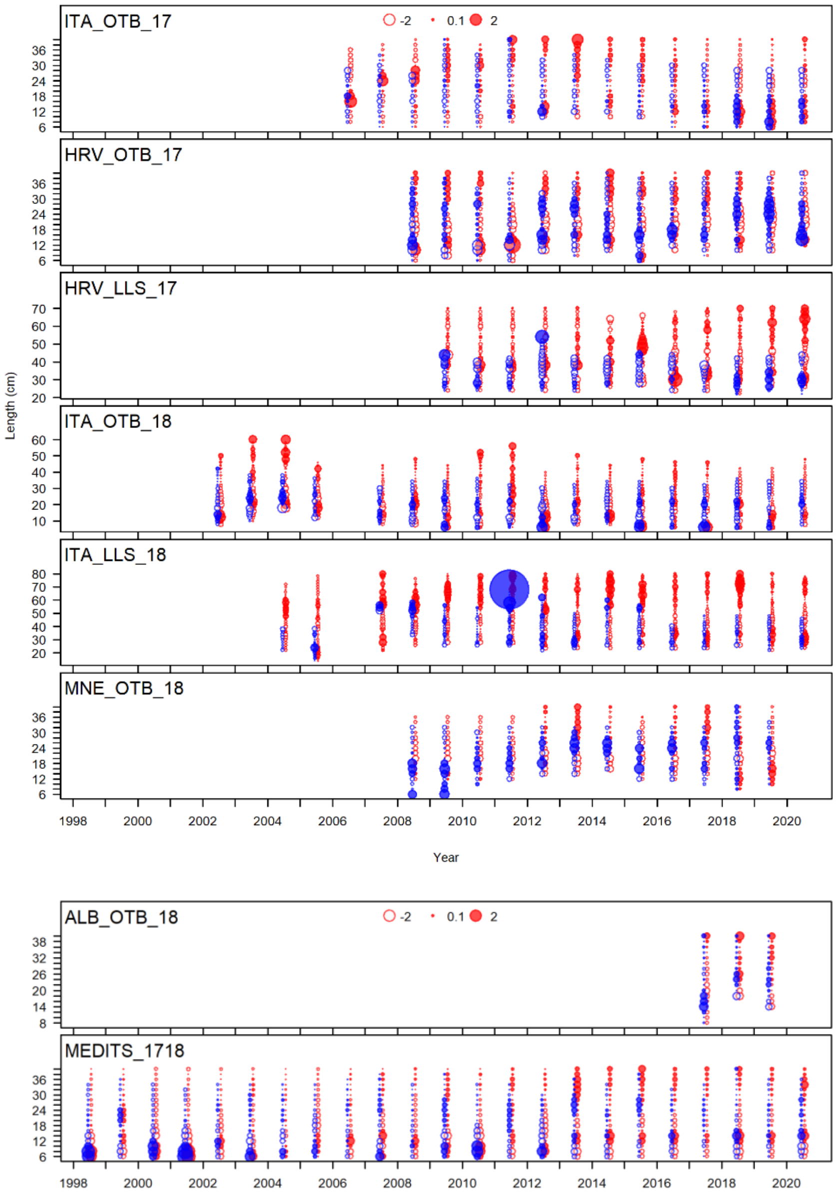


Figure 6.1.3.1.6 European hake in GSAs 17 and 18: Summary of the Pearson residuals for the LFDs by fleet and year. Closed bubbles are positive residuals (observed > expected), and open bubbles are negative residuals (observed < expected). Blue bubbles are used for males, red for females.

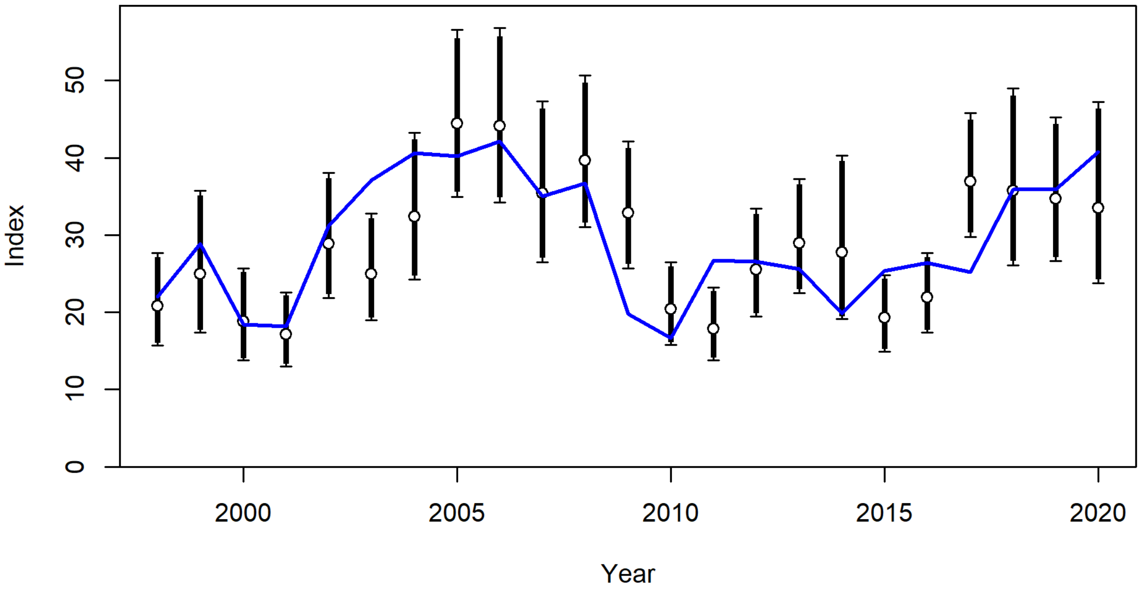


Figure 6.1.3.1.7 European hake in GSAs 17 and 18: Biomass index (Kg/Km^2) and fitting of the model (blue line) for the MEDITS survey.

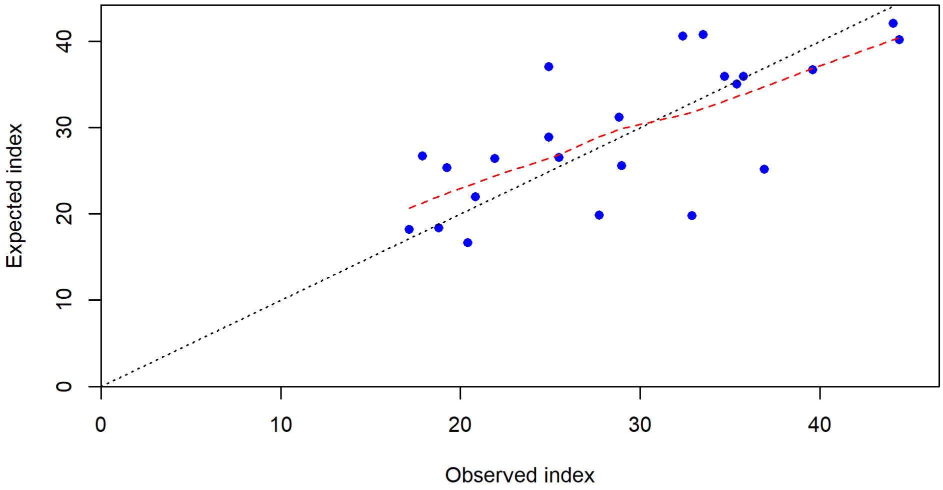


Figure 6.1.3.1.8 European hake in GSAs 17 and 18: Residuals by year for the MEDITS survey.

The setup of the final model was in line with the updated run of STECF EWG 20-15 with the addition of 2020 DCF data with some exceptions. Specifically:

- LFD from Montenegro for 2019 was added;
- 2020 catches and LFDs for Montenegro were not available; Catches for 2020 were approximated by mean catches of 2017-2019;
- 2020 LFD for Albania was not available;
- New SS3 bias adjustment and weighting included as part of the fitting process.

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.

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 2007, then decreased considerably until 2014 (1384 tons) to then rise to the highest value of the time-series in 2021 (4591 tons). $F_{bar(1-4)}$ shows a decreasing trend in the last six years. Recruitment shows a decreasing trend in the last six years with the exception of 2019. Recruitment in the last five years is below average. $F_{bar(1-4)}$ in 2020 (0.37) is the lowest of the time-series.

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. 6.1.3.1.9, 6.1.3.1.10 and 6.1.3.1.11).

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	351183	556426	221646	2239	3207	1270	9441	0.86	1.01	0.70
1999	327109	480927	222488	2259	3042	1476	6666	0.70	0.83	0.57
2000	397920	554992	285302	2456	3233	1679	6268	0.73	0.86	0.60
2001	399166	542081	293929	2415	3112	1718	6206	0.74	0.86	0.61
2002	456726	590540	353233	2320	2973	1666	5442	0.59	0.68	0.49
2003	436446	567516	335647	2736	3424	2049	7322	0.72	0.84	0.60
2004	543375	692707	426236	2723	3422	2025	7336	0.66	0.77	0.55
2005	528170	678744	411000	3007	3726	2288	8772	0.71	0.81	0.60
2006	537545	656398	440212	3169	3889	2450	10832	0.90	1.02	0.78
2007	489651	583573	410845	2760	3390	2130	8959	0.82	0.92	0.71
2008	430099	510649	362255	2613	3199	2026	8312	0.79	0.89	0.70
2009	391109	463095	330313	2595	3146	2044	7998	0.89	1.00	0.79
2010	407155	476975	347555	2307	2788	1826	6923	0.92	1.04	0.81
2011	415336	485367	355409	1895	2316	1474	6416	0.86	0.97	0.76
2012	419547	487049	361401	1664	2057	1272	6818	0.90	1.00	0.80
2013	304101	361043	256139	1433	1791	1074	6753	0.93	1.03	0.83
2014	322127	383034	270905	1384	1710	1058	5493	0.80	0.89	0.70
2015	463575	538372	399169	1500	1835	1165	5817	0.86	0.97	0.75
2016	406164	484439	340537	1372	1714	1031	5764	0.73	0.83	0.62
2017	390399	472586	322505	1484	1877	1091	6033	0.62	0.71	0.53
2018	350854	444918	276677	2067	2585	1550	6091	0.59	0.68	0.49
2019	413128	572228	298264	2699	3401	1997	5355	0.47	0.57	0.38
2020	281704	496327	159889	3519	4507	2531	4841	0.37	0.46	0.28
2021				4591	6026	3157				

*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	0.197	0.038	0.024	0.278	0.287	0.005	0.026
1999	0.252	0.034	0.017	0.201	0.158	0.006	0.034
2000	0.246	0.034	0.014	0.238	0.149	0.007	0.039
2001	0.253	0.033	0.013	0.238	0.143	0.008	0.048
2002	0.266	0.034	0.014	0.156	0.089	0.004	0.023
2003	0.298	0.022	0.009	0.231	0.116	0.007	0.038
2004	0.262	0.031	0.014	0.232	0.072	0.008	0.044
2005	0.305	0.035	0.016	0.199	0.125	0.004	0.022
2006	0.326	0.036	0.017	0.267	0.226	0.004	0.022
2007	0.320	0.043	0.021	0.216	0.191	0.004	0.024
2008	0.300	0.030	0.011	0.242	0.181	0.005	0.026
2009	0.301	0.048	0.013	0.296	0.191	0.005	0.037
2010	0.258	0.044	0.016	0.324	0.240	0.005	0.036
2011	0.205	0.051	0.017	0.300	0.243	0.004	0.039
2012	0.214	0.067	0.018	0.200	0.288	0.004	0.110
2013	0.303	0.116	0.045	0.216	0.127	0.005	0.119
2014	0.236	0.082	0.039	0.144	0.175	0.005	0.116
2015	0.256	0.067	0.033	0.137	0.251	0.004	0.114
2016	0.162	0.046	0.066	0.099	0.262	0.003	0.087
2017	0.138	0.049	0.042	0.082	0.241	0.002	0.067
2018	0.181	0.052	0.046	0.098	0.136	0.003	0.069
2019	0.145	0.061	0.035	0.097	0.073	0.003	0.061
2020	0.115	0.049	0.037	0.058	0.056	0.002	0.055

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	351182	117029	49288	10578	3000	833	201	42	7	1	0
1999	327110	87013	35602	11238	2436	795	257	65	14	3	1
2000	397920	82133	29908	9457	3007	779	313	111	30	7	2
2001	399166	99640	27446	7688	2473	952	310	140	53	15	4
2002	456726	99945	33181	6961	1978	775	380	140	68	27	10
2003	436446	113974	36134	9952	2144	734	361	198	79	40	23
2004	543376	112115	43752	9448	2434	632	282	162	99	43	36
2005	528170	139760	44938	12275	2466	760	256	134	86	57	48
2006	537546	134719	51247	11891	3150	761	301	117	67	46	60
2007	489650	133589	41219	11011	2511	806	248	112	47	29	49
2008	430098	119911	41707	9686	2585	713	290	100	49	22	39
2009	391110	105285	37376	9989	2357	767	269	123	47	24	32
2010	407154	94501	30174	8013	2191	640	269	108	55	22	29
2011	415336	97919	26130	6282	1721	574	211	99	43	23	23
2012	419548	100147	28007	5850	1464	479	195	78	39	18	20
2013	304100	103112	30817	6162	1242	361	142	63	27	14	14
2014	322128	75049	32063	6452	1216	302	116	54	26	12	14
2015	463576	80527	25785	7890	1495	331	103	44	22	11	12
2016	406164	115590	27022	6001	1690	369	99	34	15	8	9
2017	390400	102151	42028	7449	1544	466	112	30	10	5	6

2018	350854	98837	39265	12894	2174	481	159	38	10	4	4
2019	413128	88835	38015	12154	3909	749	195	69	17	5	4
2020	281704	105139	35851	13113	4235	1565	356	99	37	10	5

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	0.06	0.54	0.92	1.01	0.96	0.90	0.85	0.81	0.79	0.77	0.71
1999	0.04	0.42	0.77	0.86	0.79	0.68	0.58	0.52	0.47	0.44	0.38
2000	0.05	0.44	0.80	0.88	0.80	0.68	0.57	0.50	0.45	0.41	0.35
2001	0.05	0.45	0.81	0.90	0.81	0.68	0.57	0.49	0.44	0.40	0.33
2002	0.05	0.36	0.64	0.72	0.64	0.52	0.42	0.35	0.31	0.28	0.22
2003	0.02	0.30	0.78	0.95	0.87	0.73	0.60	0.50	0.43	0.38	0.29
2004	0.02	0.26	0.71	0.88	0.81	0.67	0.54	0.44	0.37	0.32	0.22
2005	0.03	0.35	0.77	0.90	0.82	0.69	0.58	0.49	0.43	0.39	0.32
2006	0.05	0.53	0.98	1.09	1.01	0.88	0.77	0.69	0.64	0.60	0.53
2007	0.07	0.51	0.89	0.99	0.90	0.78	0.68	0.60	0.55	0.52	0.46
2008	0.07	0.51	0.87	0.95	0.86	0.73	0.63	0.55	0.50	0.47	0.41
2009	0.08	0.60	0.98	1.06	0.95	0.81	0.69	0.61	0.55	0.51	0.43
2010	0.09	0.63	1.01	1.08	0.99	0.87	0.77	0.70	0.65	0.62	0.55
2011	0.08	0.60	0.94	1.00	0.92	0.83	0.75	0.70	0.66	0.64	0.57
2012	0.06	0.53	0.95	1.09	1.04	0.96	0.89	0.84	0.81	0.79	0.73
2013	0.06	0.52	1.00	1.16	1.07	0.91	0.77	0.66	0.59	0.54	0.43
2014	0.05	0.42	0.84	1.00	0.95	0.84	0.75	0.68	0.63	0.60	0.52
2015	0.05	0.44	0.90	1.08	1.04	0.95	0.87	0.82	0.78	0.76	0.70
2016	0.04	0.36	0.73	0.89	0.92	0.92	0.91	0.91	0.92	0.91	0.87
2017	0.03	0.30	0.62	0.77	0.80	0.80	0.80	0.81	0.81	0.81	0.78
2018	0.03	0.30	0.61	0.73	0.70	0.64	0.58	0.54	0.51	0.49	0.43
2019	0.03	0.25	0.50	0.59	0.55	0.48	0.42	0.37	0.34	0.32	0.26
2020	0.02	0.19	0.39	0.47	0.45	0.39	0.35	0.31	0.29	0.27	0.22

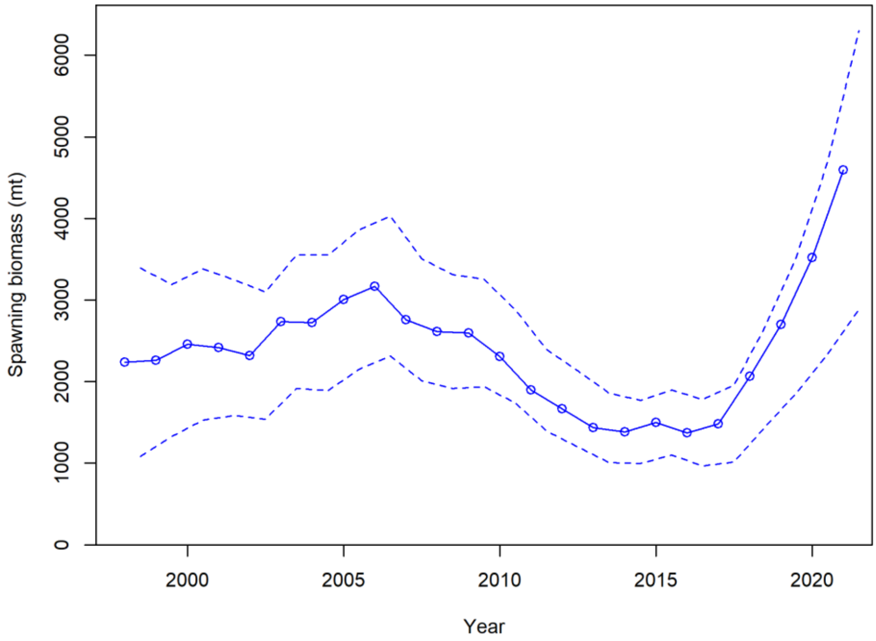


Figure 6.1.3.1.9 European hake in GSAs 17 and 18: Female spawning stock biomass by year estimated by the SS3 model.

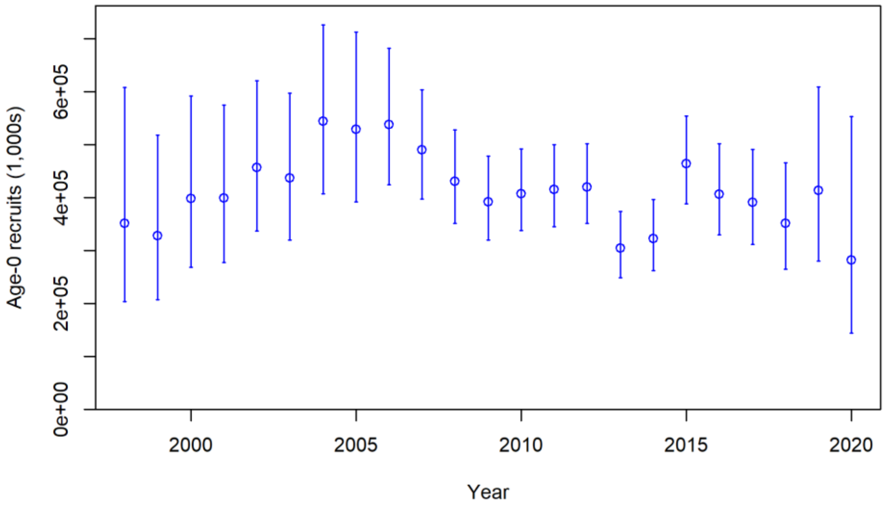


Figure 6.1.3.1.10 European hake in GSAs 17 and 18: Recruitment by year estimated by the SS3 model.

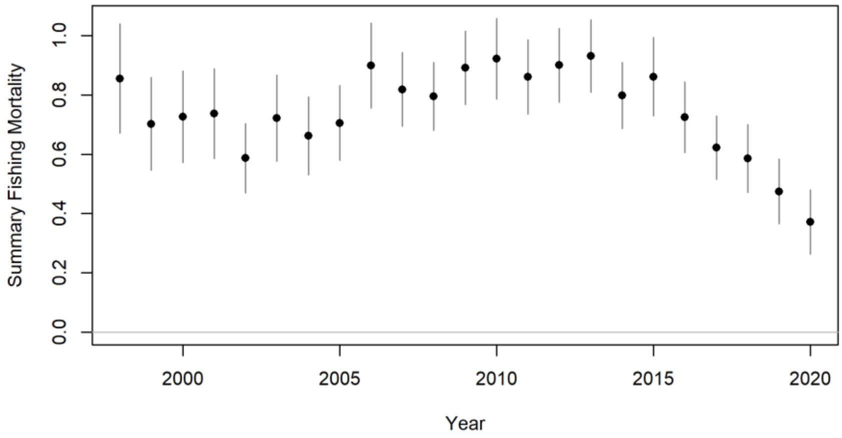


Figure 6.1.3.1.11 European hake in GSAs 17 and 18: Fishing mortality by year estimated by the SS3 model.

Retrospectives

Figures 6.1.3.1.12, 6.1.3.1.13 and 6.1.3.1.14 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.

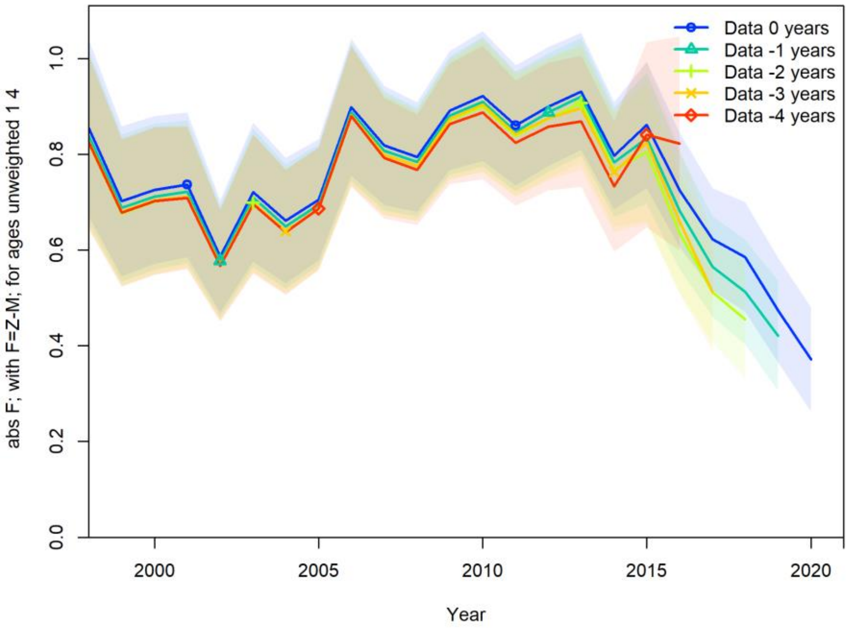


Figure 6.1.3.1.12 European hake in GSAs 17 and 18: Retrospectives – Fishing mortality from SS3.

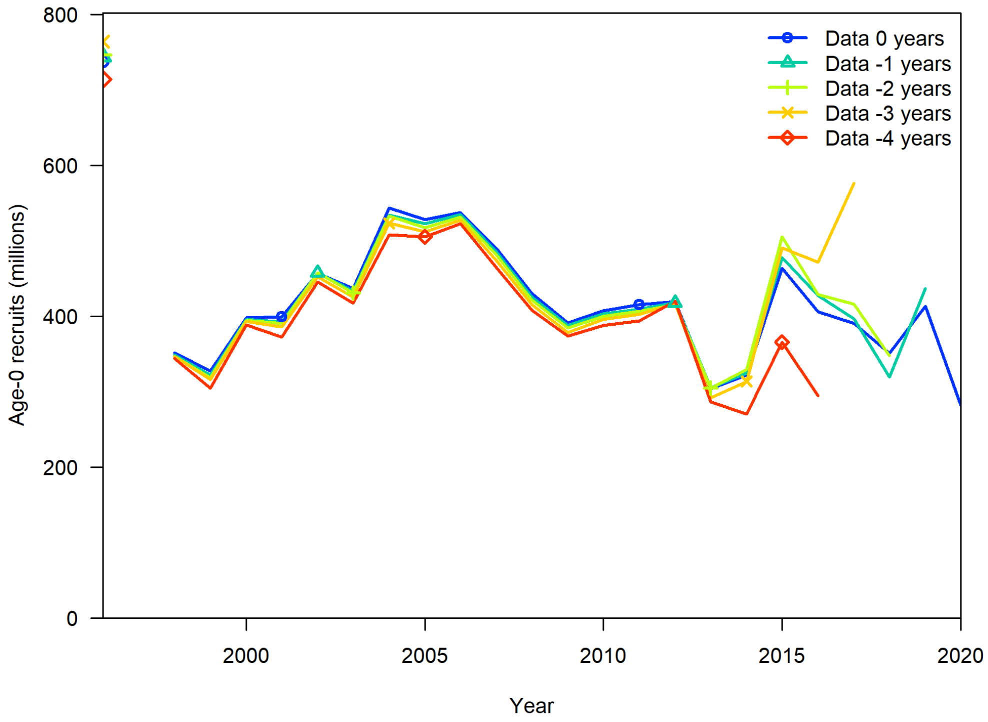


Figure 6.1.3.1.13 European hake in GSAs 17 and 18: Retrospectives – Recruitment from SS3.

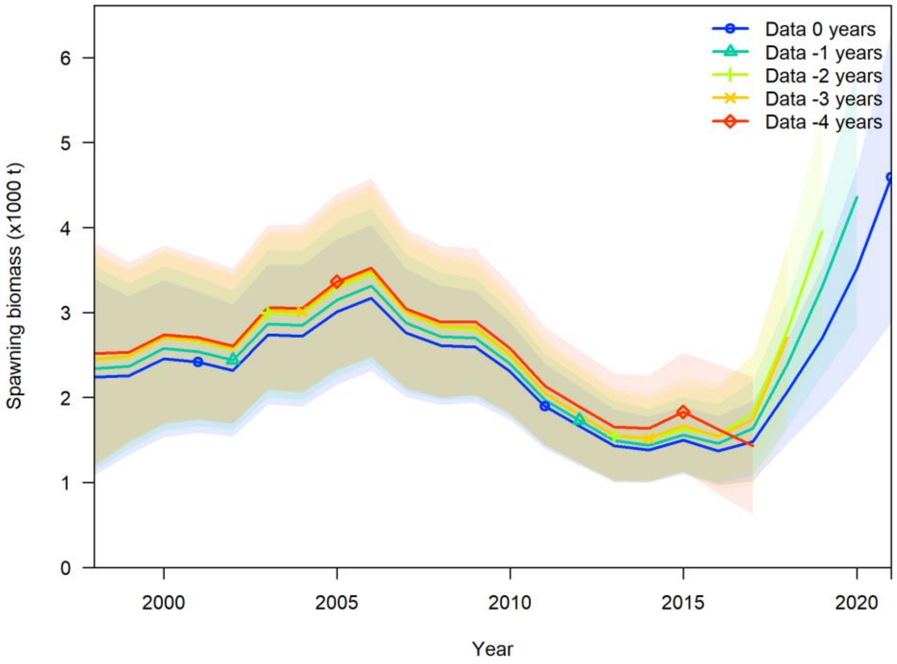


Figure 6.1.3.1.14 European hake in GSAs 17 and 18: Retrospectives – **Female** spawning stock biomass from SS3.

6.1.4 REFERENCE POINTS

The reference points derived from the SS3 assessment 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}	0.179	F_{MSY} from SS3 model	STECF EWG 19-16
Precautionary approach	B_{lim}	1858	B_{loss}	GFCM Benchmark 2019
	B_{pa}	2543	$B_{lim} \cdot exp^{(1.645 \cdot \sigma)}$	GFCM Benchmark 2019
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.179	F_{MSY}	STECF EWG 19-16
	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 2022 and an additional option for a forecast for 2023 requested in ToR 6.1. The assumptions for 2021 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.

ToR 6. Requested "F and catch advice for 2023 for the LLS gear targeting Mediterranean hake in GSA 17-18 below to reach Fmsy by 2026, while accounting of a linear reduction of the fishing effort of 7% for OTB and 3% TBB in 2022. The further assumptions for 2022 and 2023 required for the 2023 forecast are in Table 6.1.5.2.

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. If OTB is maintained at F 2022 *0.93 then only by reducing the F for the LLS fleets to 0 in 2023 the total F in 2023 is 0.31 which is equal to $F_{MSY\ Transition}$. This is because a 7% reduction is insufficient and OTB takes around 91% of the total catch.

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 0.47 in 2019 to 0.37 in 2020, however retrospective analysis (Figure 6.1.3.1.12) 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 2018-2020
$F_{ages\ 1\text{-}4}$ (2021)	0.37	F_{2020} used to give F status quo for 2021
Female SSB (2021)	4591 t	Stock assessment 1 January 2021
R_{age0} (2021,2022,2023)	348,562	Mean of the last 3 years
Total catch (2021)	5409 t	Assuming F status quo for 2021

Table 6.1.5.2 European hake in GSAs 17 and 18: Assumptions made for 2022/2023 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
$F_{ages\ 1\text{-}4}$ (2022)	0.35	7% reduction in partial F_{2022} for all OTB fleets, F_{2020} for all LLS fleets in 2022
R_{age0} (2023)	348,562	Mean of the last 3 years
Female SSB (2022)	5714	Short term forecast 1 January 2022
Total catch (2022)	5282	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 (2022)	F_{total} (ages 1-4) (2022)	**Female** SSB (2023)	% **Female** SSB change**	% Catch change***
STECF advice basis					
F_{MSY} / MAP	2920	0.179	7852	71.0	-39.7
$F_{MSY\ Transition}$	5262	0.35	6590	43.5	8.7
$F_{MSY\ lower}$	2029	0.12	8340	81.7	-58.1
$F_{MSY\ upper*}$	3941	0.25	7298	59.0	-18.6
Other scenarios					
Zero catch	0	0	9466	106.2	-100.0
Status quo	5564	0.37	6430	40.1	14.9
60% of status quo	3565	0.22	7501	63.4	-26.4
80% of status quo	4761	0.30	6944	51.3	-5.0
7% reduction OTB fleets^	5282	0.35	6572	43.2	9.1

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

** % change in SSB 2023 to 2021

***Total catch in 2022 relative to catch in 2020.

^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 2020.

Basis	Total catch (2022)	F_{total} (ages 1-4) (2022)	GSA 17 OTB	GSA 17 LLS	GSA 18 OTB	GSA 18 LLS
STECF advice basis						
F_{MSY} / MAP	2920	0.179	1509	108	1144	160
$F_{MSY\ Transition}$	5262	0.35	2719	194	2061	288
$F_{MSY\ lower}$	2029	0.12	1049	75	795	111
$F_{MSY\ upper*}$	3941	0.25	2036	145	1544	216
Other scenarios						
Zero catch	0	0	0	0	0	0
Status quo	5564	0.37	2875	205	2180	304
60% of status quo	3565	0.22	1842	131	1396	195
80% of status quo	4599	0.3	2376	170	1801	252
7% reduction OTB fleets**	5282	0.35	2729	195	2069	289

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

** 7% reduction in partial F_{2022} for all OTB fleets, and $F_{2022} = F_{2020}$ 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 2022 and 2023. 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} 2022	Probability SSB<B_{lim} 2023	Probability SSB<$B_{trigger}$ 2022	Probability SSB<$B_{trigger}$ 2023
F_{upper}	0	0	<0.01	0
F_{lower}	0	0	<0.01	0
F_{MSY}	0	0	<0.01	0
$F_{MSY\ transition}$	0	0	<0.01	0
Status quo	0	0	<0.01	0
80% of status quo	0	0	<0.01	0
60% of status quo	0	0	<0.01	0
Zero catches	0	0	0	0
7% reduction OTB fleets*	0	0	<0.01	0

* 7% reduction in partial F_{2022} for all OTB fleets, and $F_{2022} = F_{2020}$ for all LLS fleets

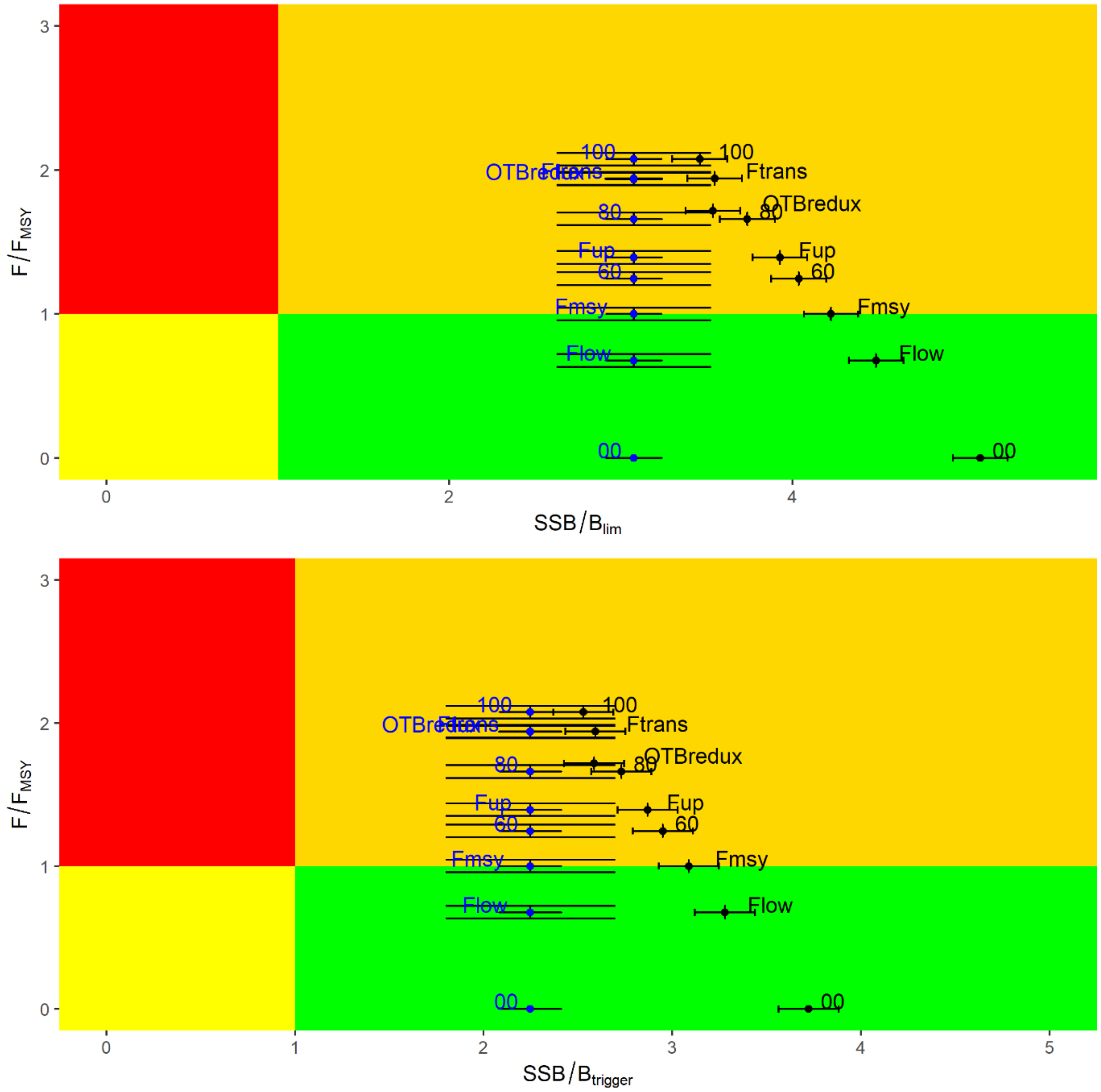


Figure 6.1.5.1 European hake in GSAs 17 and 18: Kobe plots for B_{lim} and $B_{trigger}$.

6.1.6 DATA DEFICIENCIES

The data from the last EU DCF official Data Call (2021) 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 2020.

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 2020. LFDs from discards of LLS of Italy in GSA 18 are missing for 2009-2011, 2013 and 2015-2020.

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 2020.

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 biological parameters (input for a sensitivity analysis)

The assessment on common sole carried out during the STECF EWG 20-15 considered the stock confined within the boundaries of GSA 17 (Fig. 6.2.1.1).

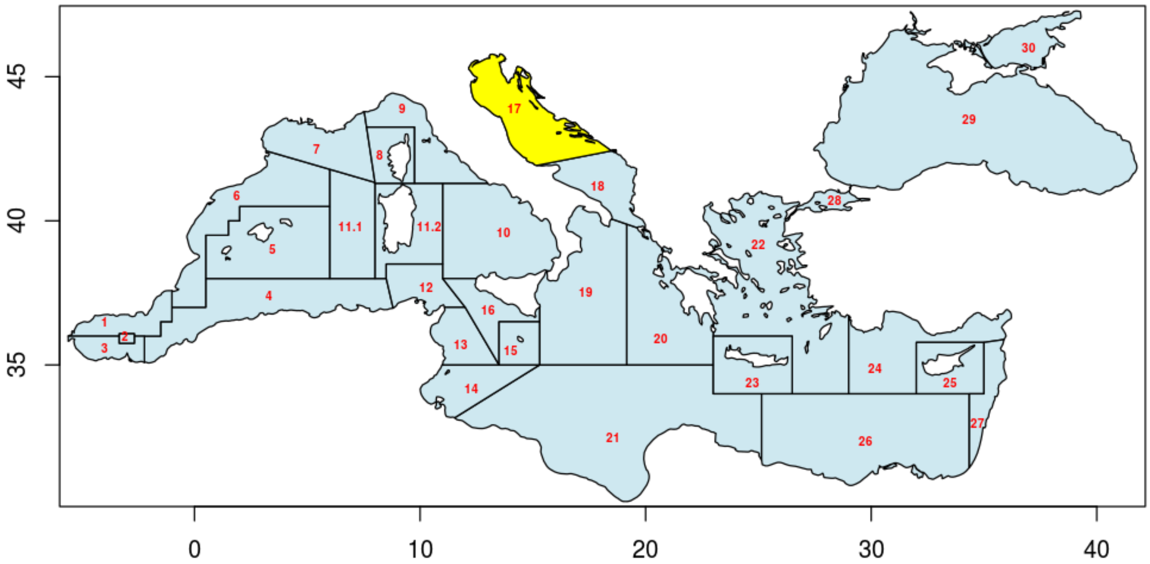


Figure 6.2.1 Geographical location of GSA 17.

Solea solea is a demersal and sedentary species, living on sandy and muddy bottoms (Tortonese, 1975, Fisher et al., 1987, Jardas, 1996). In the central and northern Adriatic Sea the reproduction takes place from November to March. Data on the spatial distribution of spawners provided by the SOLMON project show a higher concentration of reproducers outside the western coast of Istria (Fabi et al., 2009).

EWG 21-15 attempted to update the GCFM (2021) benchmark assessment based on a SS3 ensemble. Data additions for 2020 were made using the DCF database using as far as possible the procedures described in the GFCM Stock Assessment Form version 1.0. Due to a number of issues; unfamiliarity with the detail of the data; an incomplete description of the data manipulations used to fully populate the model in for the years prior to 2020; questions regarding how to provide advice from the assessment produced; and the complexity of the methods used within SS3; it was not possible to develop updated advice with sufficient confidence to provide management advice for 2022 and 2023. For this reason, the previous STECF advice methodology used in EWG 20-15 has been applied

The focus of this report is to highlight the difficulties encountered when updating the assessment as well as provide a review of the assessment procedure and process. The comments should generally be interpreted as questions, the answer to which can then lead to either increased confidence in the assessment or an improved assessment methodology.

General Assessment Approach:

In principle a SS3 ensemble covering the uncertainty in stock status through inclusion of different potential states of nature is a cutting-edge approach to the provision of advice. On the positive side the approach attempts to objectively represent the true uncertainty in advice and integrates the process and data uncertainties into the stock status estimates and the forecast used in the advice process. However, with it comes a high degree of model complexity and an effective reduction in the transparency of process even to those familiar with SS3 models. There is also an increased risk of implementation error due to the large number of steps involved, and some uncertainty in how to interpret the probabilistic outcomes in the current STECF advisory process where a target F based on F_{MSY} is found to advise on the change in F required and the catch associated with that target.

This particular 18 model ensemble integrates uncertainty primarily across 2 different process models regarding the parameterisation of fleet selectivities. Nested within the selection are further uncertainties regarding stock recruit steepness (h) and choice of natural mortality (M) in a latin-square design (3 M-vectors and 3 level of steepness). Growth though a fundamental uncertainty for this stock is included only in a marginal way, although t0 is estimated k and linf are fixed.

Once the new (2020) data is added, for an update assessment each of the 18 models are run with the delta method used to describe the within model uncertainty and a retrospective analysis to assess bias. Semi quantitative 'Suitability Indicators' are used to determine the appropriate weighting of each model in the ensemble.

Final assessment results in terms of stock status are the weighted median of the joint probability of the ensemble. Then catch forecasts are derived by running forecasts with fixed catches (interim year = interim year -1 and interim year + 1 fixed at 80, 90, 100, 120% of interim year catches)

In carrying out this process towards an update assessment a number of issues were encountered.

Some questions regarding the updating of data:

1) What are the exact procedures used to raise the catch data? Most seem to be done quarterly, but quarterly data is not available for all fleets in the assessment

   Generally it was possible to get length frequency proportions to reasonably match those historic values providing some confidence that the 2020 data would be representative of the methodology. The absolute scale, i.e. the catches in the DCF data were also mostly similar but some larger differences were observed for 2019 for some fleets. Is this a difference of calculation or are these revisions within the new data call? The benchmark report states that the data since 2004 "*came from the European Union Data Collection Framework (DCF) both for Italy and Croatia*.". Although one would assume that this information would be identical to that in the EU data call it was not possible to derive exactly the same numbers.
   Regarding Slovenian catches it is stated "*Catch from Slovenia are negligible, therefore Slovenian netters and are added to Croatian GTR data*.", but just adding the catches would create an inconsistency between the length frequencies and the catch information. It is not clear whether the Slovenian samples are included for Slovenian catches and added to Croatian GTR data of if the two are simply treated as the same thing and raised together in which case there may be weighting issues of if those samples are not used at all. Trying the different options experimentally it was not possible to reconstruct what was done since none of the results matched the benchmark data.
   The Croatian *rampon* fishery data is used from 2017 onwards. These data match up reasonably with the HRV-DRB_MOL metier (consistent also with the description of the fishery in the report) in the DCF data in terms of the scale of catches, but seem to have an offset in the length frequencies with the length frequencies being used (those in the assessment appear to be 6 or so cm smaller than

what is in the database). For consistency, the updated data has been equally shifted, but these may in fact be different fleets, since in the EU database there are sizeable catches going back to 2012 not used in the assessment.

The model requires the number of samples (usually lengths measured, but here the number of collections is used). This is a potentially important weighting factor in the statistical catch at age methods, more samples = higher confidence. However, neither the number of lengths nor the number of collections taken can be derived from the EU data call as this is already aggregated and raised at the quarterly level. Looking at the sample sizes used. Looking at the historic sample levels there seemed to be little trend in the number of samples taken by the fleets so 2020 samples were estimated as the rounded mean number of sample from previous years. This may be an over-estimate given the difficulties in sampling due to covid in 2020. For the future the necessary parameters should be included in the data call.

The SOLMON index length frequencies were updated 2020. The LFs used in the assessment for 2019 derived by the TRUST program (unfortunately not available publicly), this provided the same results as the MEDITS data base so it was assumed that the same would be the case for 2020. However, the biomass index was scaled differently, probably to the entire area instead of per km. Because the length frequencies were the same for 2019 the ratio between the 2019 and 2020 MEDITS biomass index was used and multiplied with the 2019 index in the assessment to derive the 2020 biomass index equivalent. This assumes TRUST is using an appropriately weighted biomass index and that the survey did suffer a reduction in survey effort associated with the pandemic. The claim is that a stratified random survey is robust to such changes, but in essence the survey is a fixed station survey with stations having been picked randomly once. The stations fished in 2020 do not appear to be a random subset of the previously fished stations particularly in the offshore strata there is an indication that the more isolated stations are underrepresented. This could potentially lead to temporal biases in the index, though the effect is likely small.

Questions on growth

There is a long section detailing the estimation of growth in previous STECF reports for this stock. This has been built on updated below because of its relevance for this particular assessment:

Von Bertalanffy growth equation parameters available up to now were calculated using various methods (e.g., otolith reading, modal progression analysis) but are all considered questionable. Age estimation obtained from otolith readings were suggested to be unreliable by Italian and Croatian experts, as inconsistencies in the reading procedures were found. Therefore, new age readings were carried out within the project Adriamed with the aim of obtaining consistent readings among the countries fishing for Common sole in the Adriatic to obtain new growth parameters. This procedure is not yet complete (GCFM 2021) so new growth parameters were not publicly available to be used in the assessment process. Within the framework of the SoleMon project, growth parameters of sole were instead estimated through length-frequency distributions (LFDs) obtained from surveys (Fabi et al., 2009). These parameters were considered not reliable by EWG 19-16 due to the short time series used, the lack of internal consistency of estimated cohorts and due to the lack of fitting of the curves estimated in ELEFAN I (FISAT II 1.2.2) to the Solemon data updated to 2018. Therefore, new growth parameters were estimated fitting the LFD data from the Solemon survey from 2005 to 2019. This analysis was updated with 2019 data during EWG 20-15. These parameters were then used in the routine l2a within the FLR framework to slice the LFDs data for survey and catch and obtain new age matrices that were used to update the a4a assessment presented during EWG 19-16.

In 2021 WGSAD developed a new assessment approach using a SS3-ensemble to incorporate uncertainty in mortality and selectivities, but used a largely fixed growth function with k=0.28 and Linf 38.1 t0 was implemented through a random walk for the period 2005-2020 consistent with the available length information (GFCM 2021). However, the scale of variability this introduces is small compared to the variation in the lengths. It therefore does little to aid the fit and one can assume that growth is more or less fixed in the model.

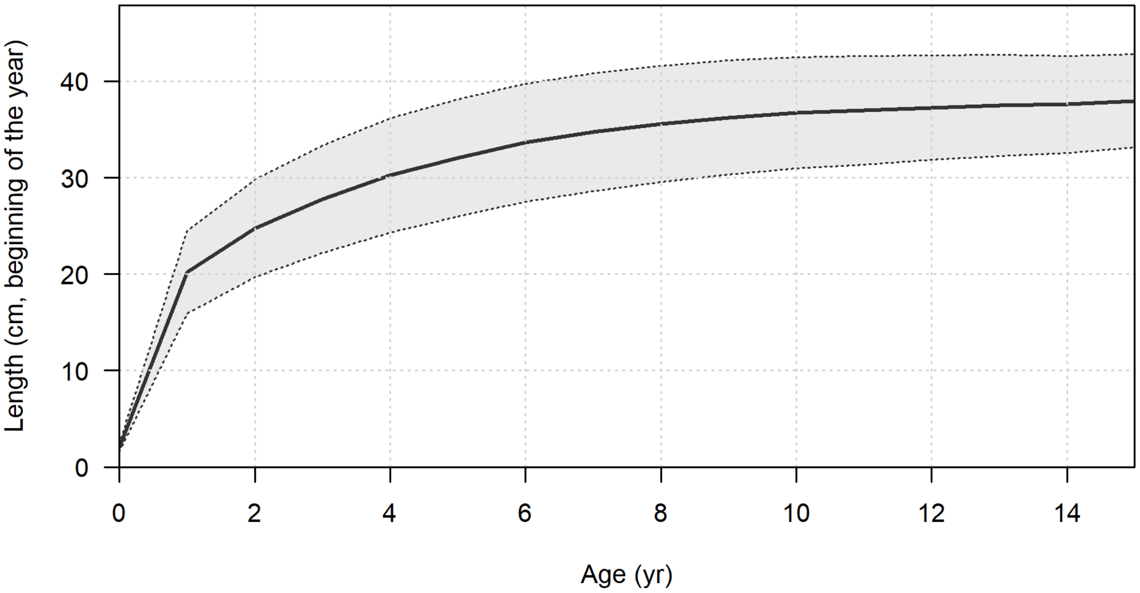


Figure 6.2.2 Time invariant Size-at-age used in the assessment.

Undeniably an appropriate growth function is an important prerequisite for an assessment model, particularly a length based one. Problems with growth models are usually intertwined with issues regarding selectivity functions as the interplay is what allows the model to reconstruct the cohort structure.

The benchmark authors claim that the assessment approach is a length-based approach, but with the growth rate essentially fixed in the model one could argue its more akin to a length slicing technique in the model. A length-based model would more usually adjust the growth parameters to be more consistent with the observed lengths. That aside there are some questions important to clarify:

Why is growth modelled as combined sexes?

Sole and flatfish in general are usually sexually dimorphic with females growing faster and larger past maturity. The combined growth curve used in the assessment actually has an L_{infinity} greater and k smaller than either sex (GCFM 2021 Figure 6.2.3**)** The issue seems to be caused by inappropriate weighting in the minimisation. Is it possible that the length information has not been appropriately weighted given the length stratification of the data? It seems the early part of the curve fits better to the male data and the latter part to the female data, mainly because there are very few older males in the sample (likely because few males grow to this size so that samples are dominated by the females).

Table 2.6.2.3. Growth parameters estimated from otolith readings in GSA 17

	Males	**Females**	**Combined**
L$_\infty$	34.1	38.08	38.1
k	0.34	0.29	0.28
t₀	-1.65	-1.53	-1.7

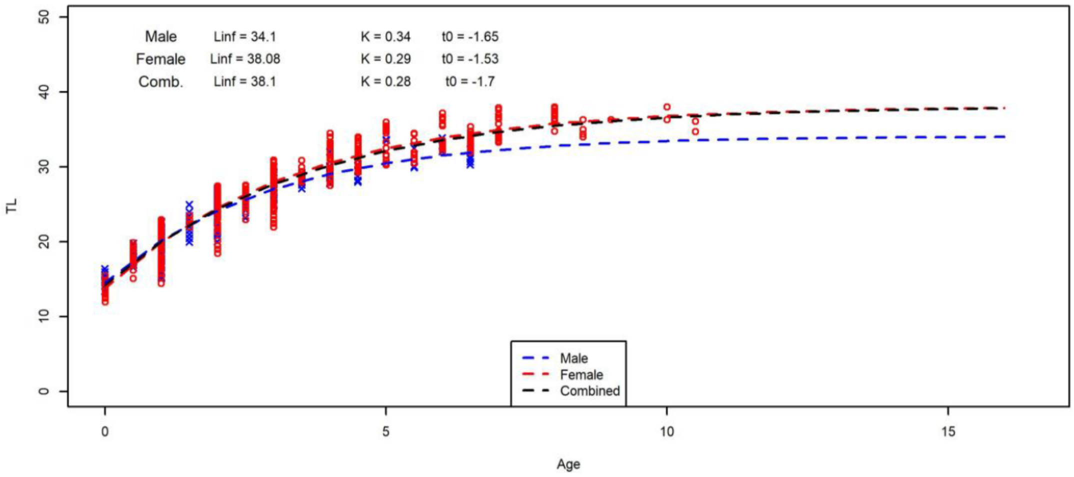


Figure6.2.3 Von Bertalanffy growth curve (by sex and combined) coming from AdriaMed SG-OTH-SOLEA and related growth parameters, reproduced from GCFM 2021)

Could the difficulty in detecting cohort signals from the length frequency distributions arise because the model is trying to interpret the variability in growth as a unimodal error from the central tendency where for the two sexes certainly past age 4 one would expect to see a bi-modal error in length at a given age? This could explain the clear horizontal banding in the length residuals (Figure 6.2.4) seen for most of the fleets predominantly catching the smaller individuals (Including the SOLMON survey).

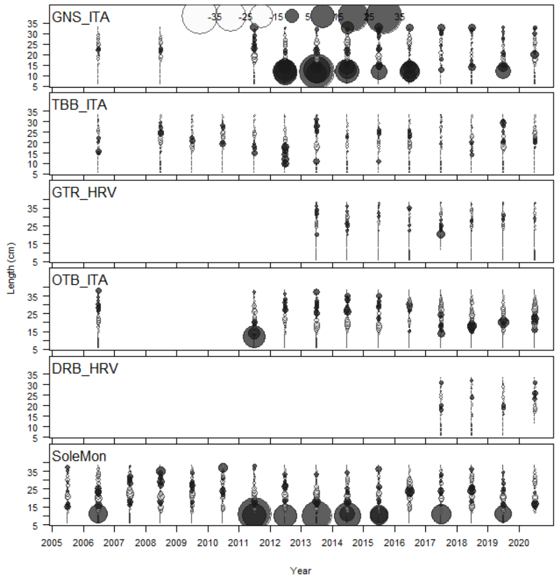


Figure6.2.4 Length residual bubble plots from the trial update assessment as performed by EWG 21-15

Is it appropriate to allocate catches within the year to July for 3 of the 5 fleets? While annual model time steps are reasonable since there are no annual migrations of subpopulations reported. Doing so for a length-based model can have issues. For example what is classed as age 0 fish according to the growth function would be around 12cm. This is below the minimum selectivity at length suggesting the fishery takes no 0 group fish in the perspective of the model (Figure 6.2.5). However, growth is not continuous (GCFM 2021) and in any case sole caught later in the year would certainly be bigger than this so would most likely be classed as 1 group fish in the model perspective. For older ages this could be spread over both the previous and subsequent age. In other words, the cohorts are not matched appropriately which would lead to an over-smoothing of the recruitment deviate vector. F-vectors similarly would be averaged.

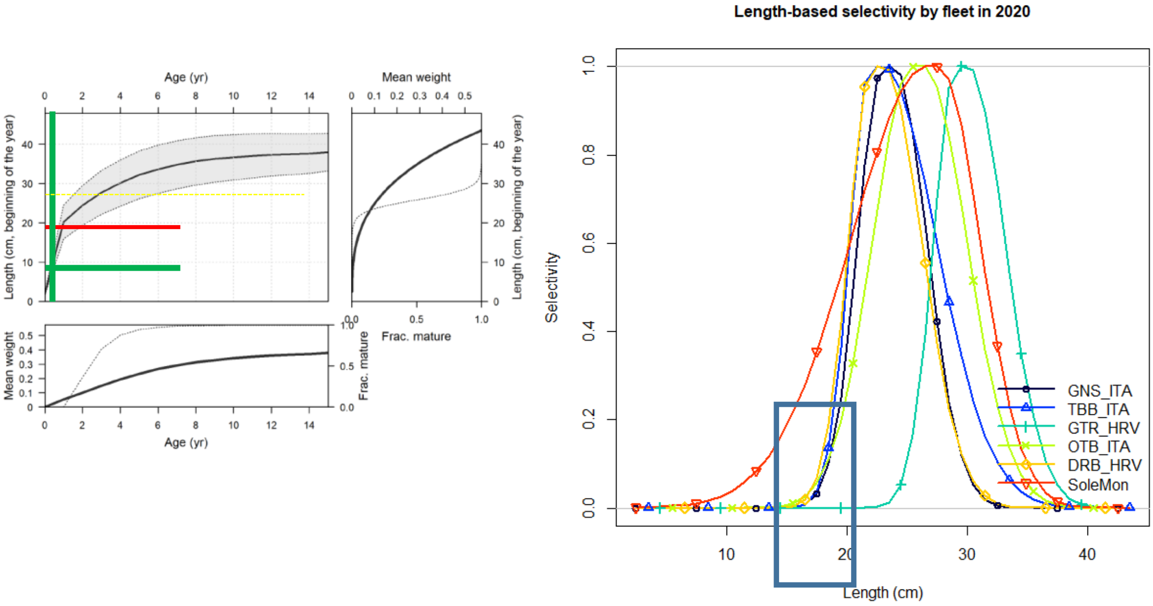


Figure 6.2.5 Issues with assigning commercial catches to July. On the left is the growth model suggesting that in July 0-group fish are between 8 and 15cm in size (green lines). On the right the selectivity curve suggesting that selectivity for that size of individual is near 0. The model must conclude that no 0-individuals are caught in the fishery. By December these individuals are well within the range of the selectivity (about 18-25cm). The model is assigning the individual caught later in the year to the wrong cohort for the fishery, where they appear to form a substantial part of the TBB and DRB catches in terms of numbers). For the survey which has a smaller selectivity size and an appropriate definition of timing (November) these are attributed to 0-groups.Irrespective of any aging errors or overestimation of growth the model is attempting to minimise the same cohort against different criteria

Are the growth parameters ecologically meaningful for a flatfish species? Taking the data as it is the growth parameters appear to be more or less reasonable. However given the uncertainty in the aging process which led to the rejection of the age-based model in the first place, is the rather limited (in terms of sample size) research conclusive? Flatfish are generally more towards the k-end of the productivity spectrum. They have reasonably high investment in an individual egg, relatively even reproduction and generally live to a reasonable age. Sole for example do easily live to 40 years in other regions and even a substantially exploited population will still have a good proportion of 15 year old individuals present (ICES 2021a, 2021b). It is possible that environmental conditions in the northern Adriatic prevent such longevity and the sole respond through faster growth initially.

The risk in accepting this in a form of an assumption is that estimates of M are through the approach directly linked with the assumptions regarding growth. A similarly plausible hypothesis would be that sole grow at similar rates to elsewhere, but due to the environmental conditions in the Adriatic the first growth ring is missing or not very clear (some sole growing 2cm in a year others 2cm in a month seems unlikely and would require modelling morphs in a length-based model). M would then be considerably lower and F higher to explain the paucity of older fish in the population. The SOLMON survey (source MEDITS data) does sometimes capture very small individuals (2cm in size not included in the assessment which starts at 6cm). While these individuals may be born in the same calendar year as those spawned in January which are likely to have a size approaching 20cm, they do not represent the same biological cohort, i.e. are related to the following spawning event. A spawning data (Jan 1) in the middle of the spawning season is not helpful to the model or the estimation of a growth function generally.

Would it be possible to use the age data to age 3 (4+ group)? The benchmark report (Figure 6.2.6 ;GCFM 2021) seems to suggest that historically available ages seem to be reasonably of reasonable utility to age 3. Given that the current growth model does not separate the sexes, it seems unlikely that past this age length offers much information on age in any case. Also the survey is thought to be predominantly informative on recruitment so including the age information with a plus group of 4 seems like a sensible alternative to an entirely length based assessment and would substantially improve the separation of cohorts when using an appropriate effective birth date (not in the middle of the recruitment period).

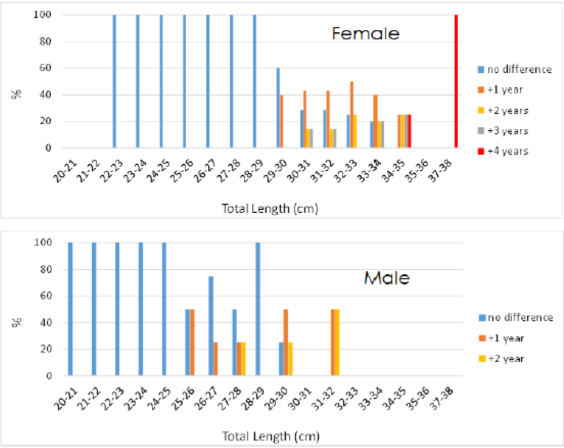


Figure 2.6.2.2. Comparison of modal age between the preparation methods (modal age for sectioned otolith vs modal age for whole otoliths)

Figure 6.2.6 Male and female-at-length aging errors as reported in the 2019 benchmark assessment

Assessment review:

The objective of the ensemble approach as stated was to formally include what was described as major uncertainties (selectivity, mortality and steepness). The results of the 18 models do not bear this out. Generally the trends in SSB, Recruitment and F are very similar with some differences in scaling. In terms of management metrics (F/Fmsy and B/Btrig) the differences are minor for steepness and M. The choice of selectivity does have a larger impact but this is not linked to the fitting method, spline or double normal. Rather it is the fact that a double normal is dome-shaped and leads to an appreciable cryptic biomass, whereas the spline function is constrained to be largely asymptotic for the survey. By definition a cryptic biomass is not a testable hypothesis so does not really offer an alternate state of nature. This is what the CAPAM workshop manual specifically advises against dome-shaped selection patterns for all fleets (Maunder et. al, 2014) simply because the models are unverifiable.

The 18 models all provide more or less the same story of stock development. F, SSB and recruitment have more or less been constant throughout the history of exploitation up to the early 2000's as indicated by the population numbers-at-age plot (Figure 6.2.7).

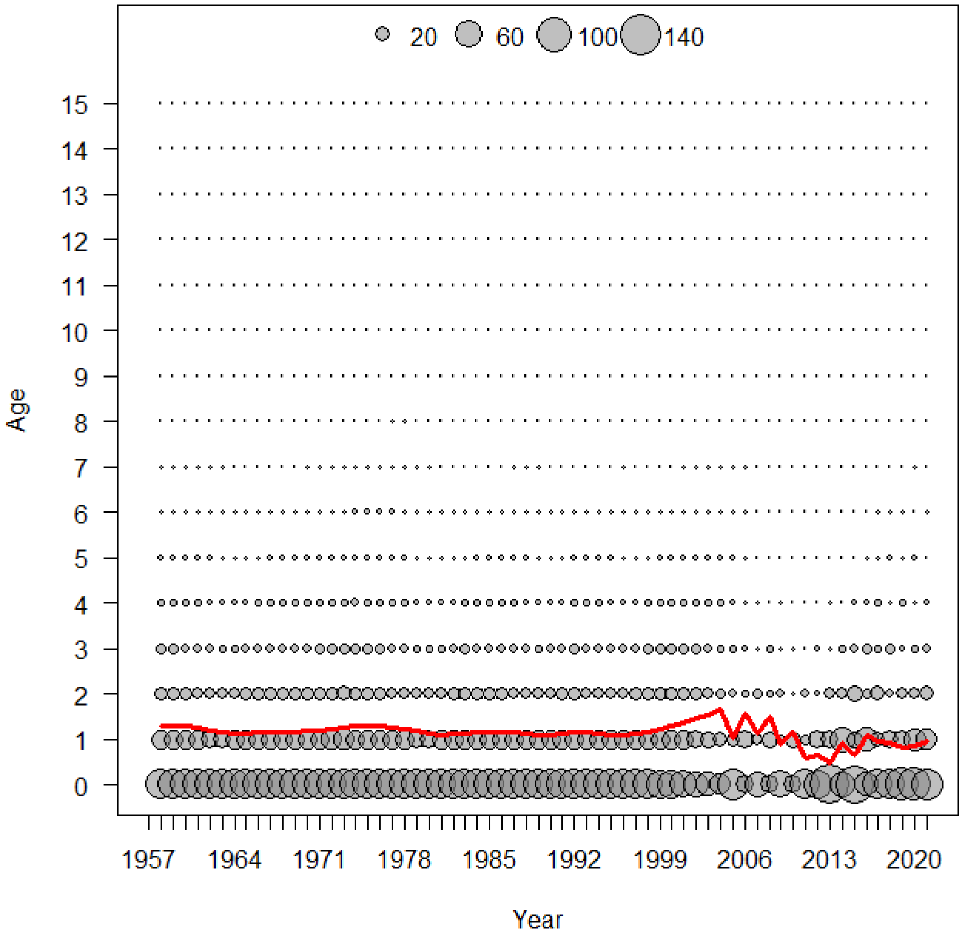


Figure 6.2.7 Bubble plot of population numbers-at-age for run1 with other runs 2-18 showing similar relative trend. Red line indicates the mean age of the population which rises in correspondence to the decline in recruitment followed by a declining trend a small recovery and settling on a new lower plateau.

Just prior to the first survey data point in 2005 recruitment numbers start to decline leading to an increase in the average age in the population indicating the model interprets the data up to this point as having been in equilibrium. Recruitment then starts to vary more based on the data from the survey. Virtually the entire age structure is then decimated in a very short time 2005 to 2012 (commensurate with a tripling of F. Stronger recruitments in 2012 and 2014 then lead to a rapid rebuilding of the age structure to near previous levels after which everything settles to a new equilibrium with slightly lower average age and a 50% reduction in F.

The difference between the runs can be summarised as follows, the difference in selectivity scales the population size, with dome-shaped allowing for a more extensive age structure (higher SSB), but a steeper temporary population collapse. Higher steepness allows a quicker recovery post collapse because the population is less restricted in the recruitment, but the survey fits the data worse. The effect of the different mortality vectors is highly correlated the effect of the different selectivities in the benchmark assessment. However, in the update assessment the model struggles to maintain a population with the low mortality vector and an asymptotic selection vector for the survey (run 10-12). Interestingly the only model of the three that did converge according to the diagnostics was the one with steepness of 0.8, the intermediate value. This suggests that different parameters are coming up on the bounds with the new data added. A detailed MCMC analysis is required to ascertain which parameters are coming up against the bounds and which ones they are correlated to.

Currently the data weighting in all 18 runs is arbitrary in the sense that the variance estimates are specified (constant for the catch and LF data). Sample sizes used appear to refer to the number of length samples not the number of lengths as is more usual for SS3 models. The effective sample size is therefore an underestimate of the true sample size. No reweighting Dirichlet or Francis is carried out with all weightings set to 1. More usually even in ensembles the weighting is updated for each individual model when using the Francis method. However, the runs do not seem to be particularly sensitive to the weighting with doubling or halving of the survey data having no discernible impact of the stock dynamics.

How can we explain the population dynamics?

The benchmark report seems to imply the beginning of serious exploitation of the stock started at the beginning of the time series. One would therefore expect the stock to have been at least close to unfished. 40 years of catches, variable but largely without trend had little impact on the stock in terms of its SSB. Then a minor reduction in recruitment for about 5 years lead to a stock collapse from which the stock recovered in roughly 5-6 years due to a slightly increased recruitment in 2012 and subsequent years.

Figure 6.2.8 Means standardised indices-at-age for the SOLMON survey reproduced from the ICES 2021 WGBEAM report showing little variation in the cohort strength for the 2008 to 2019 cohorts .Note this data starts in 2007 due to inconsistent sampling design , whereas the data in the assessment uses data from 2005.

There seems little if any evidence in the data for the dynamics described above, considering the survey age data (Figure 6.2.8, ICES 2021c) WGBEAM report: admittedly length sliced but only for the first 4 ages). There was insufficient time to examine the length data, but with an effectively consistent slicing method across the time the picture is likely to be the same. For age 1-3 the data suggest a high degree of cohort consistency which can only happen when age slicing is relatively accurate because the different data points for a single cohort (vertical line) represent different years of sampling.

What might have caused the absence of the 2007 cohort in the modelled population (the largest in recent years according to the survey) where it appears to be substantially smaller than the adjacent cohort and certainly smaller than the 2012 and 2014 cohorts deemed to be large in the assessment.

Catches have varied without trend over the entire time period with interannual variability varying more in the historic period and less since the establishment of the DCF (Figure 6.2.9) Despite this apparent constancy the most parsimonious solution for these models (Figure 6.2.10) is to assume a dramatic increase in F, (100-150% increases in F).

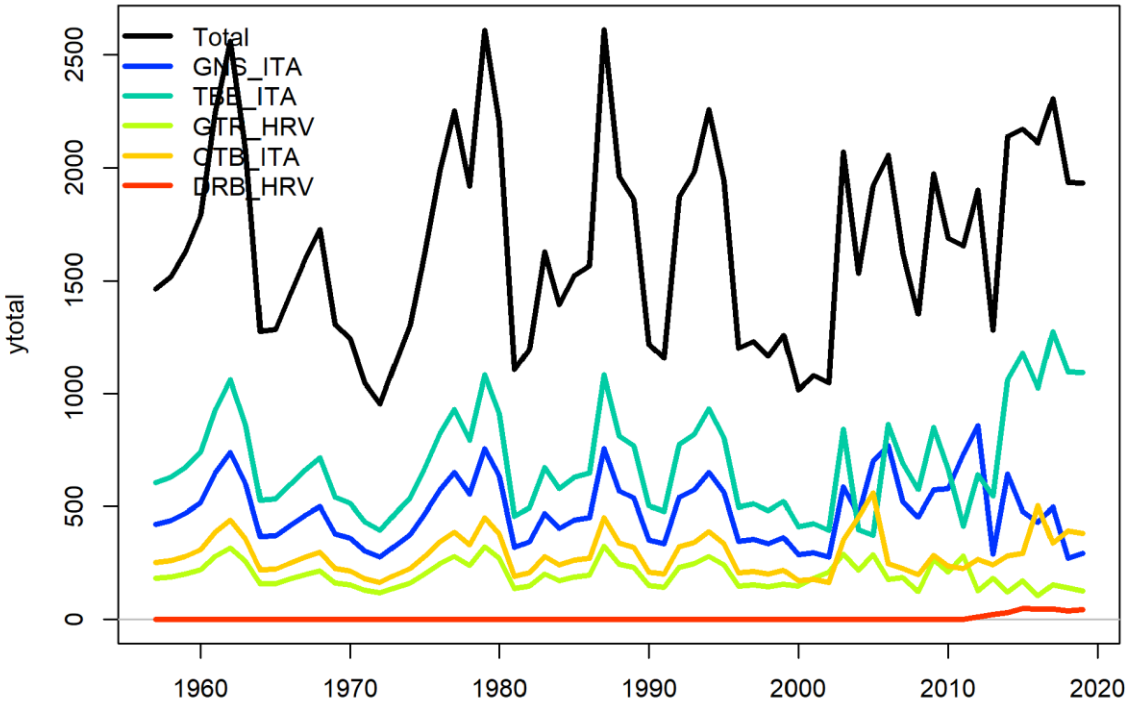


Figure 6.2.9 Catches by fleet as used in the benchmark model

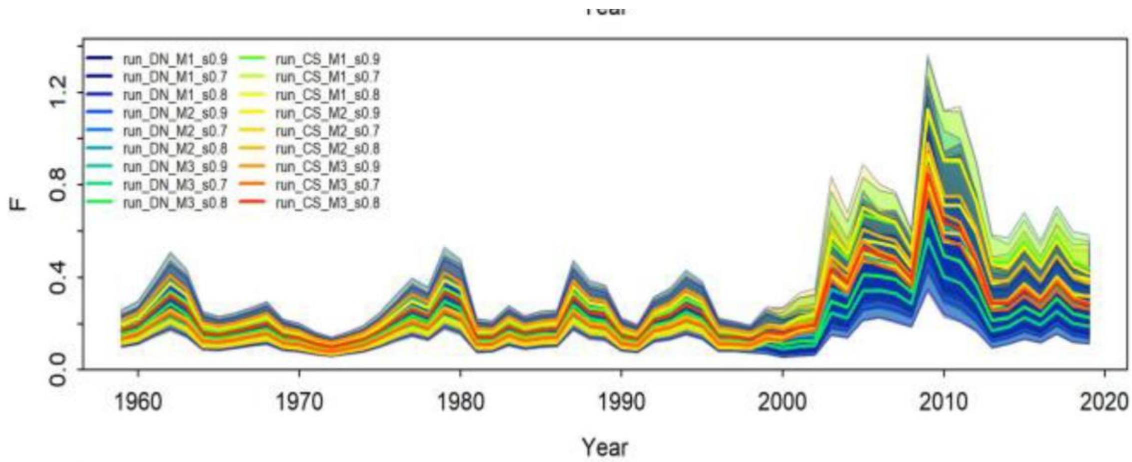


Figure 6.2.10 F-estimates with confidence limits for each of the 18 runs as presented in the benchmark report illustrating substantial spikes in F 2004 and 2008 with a subsequent reduction in 2013

While F may not be a precise indicator of F due to improvements in catchability it is difficult to explain these spikes as catchability trends because a they are too abrupt to be associated with gear improvements which tend to be more gradual as they dissipate through the fleet and what would be the incentive for the fleet to reduce catchability once the population recovered? Without prior knowledge of the fishery and the stock it is not possible to dismiss the possibility of a dramatic increase in F but it would be useful to present some independent evidence of this in the benchmark report.

The survey also does not indicate any increase in fishing mortality for age 1-3 fish during this period or else (Figure 6.2.8)would indicate different orders of the lines for the different age estimates within the cohort (i.e. early on old ages should be proportionally more abundant for a cohort while later on younger ones would be proportionally more abundant).as with recruitment the length information may represent a slightly different picture but not one that matches the high Fs determined by the model.

The models appear to be robust and have reasonable short-term predictability, a highly desirable characteristic for management. At least some of the robustness is driven by the data assumptions and constraints rather than the data. For the most part the model seems to be acting like an age structured production model also explaining the similarity of the SS3 model with biomass-based approaches also reported on in the benchmark report. Particularly illustrative are the differences in the JABBA runs (run1, B_{prior}, and COM). The SS3 model runs largely behave like the run1, with little depletion in the stock until 2005. The lightly constrained JABBA assumes no depletion because of the long-term stability in catches. The SS3 runs are constrained by the constant ration fleet catches (artefact of the creation of the catch time series). of fleets with different selectivities in conjunction with the penalty of F deviates as there is no information to balance the deviate penalty. In the JABBA 'B_{prio}r'_run, a prior fixes the scaling at the beginning of the time period and therefore forces depletion, while run1 fixes it at a later date and crashes the population but other priors could lead to the other two scenarios.

There is a risk of overreliance on the generalised MASE and prediction indicators to diagnose the models? The criteria are in this case based on the fisheries metrics, which are important in the management process but are not good indicators of process error in general. For example, had one performed a retrospective analysis over the period stock collapse almost certainly most of the 18 runs would have failed the test. Why should these models now pass? Have the processes changed, or are we simply back to a more stable data position where a simple average catches model would also pas the retrospective test? Should we not be including the length information in these tests? Almost certainly the model cannot predict the length composition of future catches reliably given the systematic residual patterns in length. This means also that it cannot predict the catch by fleet. Why then can it predict, as it apparently does, the total catch appropriately?

From this one can conclude:

There is little information in the catch data to describe the productivity of the stock, priors (biomass models) and settings (SS3) are driving the assessments.

Differences between JABBA and SS3 in the rate of stock recovery since 2012 are simply the assumed process (implicit, JABBA and age explicit; SS3).

The defining period in this assessment is the period 2005-2012. Bounds hit or parameters defined in this period almost certainly define all the current management metrics as indicated by the maximum contrast. Less clear is if this contrast is real or an artefact of model specification and data availability.

The SS3 model seems to struggle to make sense of the length information. Three reasons are possible: a) the fixed proportion of catches by fleet conflicts with the recent length data, b) the growth function and its variance are incorrectly specified, or c) the attribution of fleet catches fails to reflect the relevant age composition.

It is likely that actually the dominant dimension of uncertainty related to management metrics in this assessment lie with the correct interpretation of the growth / length data, not with steepness and natural mortality

Possible improved base models should include:

A better way to represent growth or the translation of length into age.

Selection of a better nominal birthdate and or variance estimates that does not aggregate across spawning events / cohorts.

A more realistic way to attribute catches to the appropriate expected length distributions that help the model to better separate cohort signals

Models that can better explain the predicted population crash in 2005.

Other questions:

What is the evidence / criteria for the statement "The primary reason for these models not performing as well as SS3 is not the production function or *r*. It is the extreme dome-shaped survey selectivity (typical for Mediterranean stocks)".: in what way do the models perform better, and what evidence is there that there is dome shaped selectivity in the survey? The survey does cover the area of the stock unlike many of the MEDITS surveys. It is unclear if the domed shaped selection gives a better fit as some models fits would work equally well it would be helpful to explore alternatives.

The trial run carried out at the benchmark (GCFM 2021) using the age data from the survey which independently indicates high internal consistency (ICES 2021c) was excluded from the ensemble on the grounds of diagnostic, but of course the diagnostics are bad because there is conflict of information sources in the system. Could the removal of one of the sources not appear to be subjective?

Similarly, the reconstruction of the historic eastern Adriatic catches were dismissed because they suggested a higher proportion of catches from this area, but in terms of the stock development it would be more consistent with a depletion of the biomass since one would expect the proportion of older to younger fish to change in the population (and catches in a more usual F-proportional scenario). Should this not at least be an alternative in the ensemble?

The make-up of the ensemble

The makeup of the ensemble is a critical part of the utility of the ensemble-based advice. Its objective is to test alternative states of nature to ensure the robustness of the advice to such alternative hypothesis. In the case of GSA17 sole the major dimensions of uncertainty tested were the selectivity and nested within this a grid of M and steepness estimation.

The ensemble approach is always a trade-off between the too many models to be able to say anything at all and too few models or too similar models that do not represent the uncertainty appropriately. Ensembles are no doubt a sensible way to represent uncertainty in principle but this comes at the cost of transparency when the initial choice of models is subjective or at least not clearly explained. Or when the fit to each different state of nature is similar, giving little power with which to wait the ensemble.

More detailed understandings of the base model processes and how they interact with the data would almost certainly improve the understanding of uncertainty. It may be generally true that dome or asymptotic selectivity along with h and M are major uncertainties in determining B_0 and F_{MSY} or proxies there of.

Given the similarity in stock dynamics included in the ensemble, is this a realistic representation of the overall uncertainty given the model issues and the potentially informative data *a priori* excluded from the mode? Some notable additions to the ensemble could be:

- A shorter time series of catch data that avoids the transition from what is essentially a B0 equilibrium state (without information on population substructure) to a much more dynamic population supported by relatively detailed information on lengths and CPUE. With a shorter time series we might expect B0 to be poorly defined / dependent on the choice of h and M but the benchmark evaluations suggest that there is little or no information in the longer time series to estimate these anyway.

- Inclusion in the model of the age data from the survey and ideally the inclusion of parameters for the growth-curve used in the length splicing for the survey information as this was found to be consistent with the survey length distributions at least.

- Inclusion of the age data for catches up to the age/size where age reading is still thought to be reliable

- Inclusion of alternate catch data reconstructions

- More parsimonious estimation of selectivity

- Some as yet undefined scenarios that explain the absence of older/larger fish in the observations that do not rely on increasing F or implementing dome-shaped selectivity patterns.

Evaluating the ensemble not just the individual models in the ensemble

The use of indicators to weight the different model scenarios is a valuable addition to the process. The process is still semi-quantitative, and the indicators used are not widely tested, but the approach is logical.

Model stability is tested in the process of weighting the ensemble, however no tests have been performed to indicate whether the ensemble is stable. Differing trends in the dynamics of the models can alter the stability of the ensemble in terms of predictability and retrospective.

The total likelihood:

Updating the assessments in 2021 was difficult as described earlier so that the results shown here should be considered illustrative only of what can happen rather than interpreting as to what has happened. However the additional amount of data is proportionally small and individual models did not show inconsistent behaviour in the recent period. It is still possible to derive some conclusions regarding the assessment process even if there is insufficient confidence in the output to provide management advice due to the uncertainty in update procedures.

While the central tendency of the ensemble has remained relatively stable with 2020 data added the ensemble uncertainty has increased considerably (Figure 6.2.11). The figure does include the unconverted runs (10 and 12) as the script requires manual exclusion of these runs only realised at the end of the EG, but the following conclusions are insensitive to this error:

- The correlation between the $SSB/SSB_{reference}$ point and $F/F_{reference}$ point has decreased in the update, but the two base case selectivity models have separated more and there is now relatively little overlap between the alternate states of nature.

- The unconverged runs are in the high F area of the plot their removal would move the ensemble mean further towards the green sector, but would also change the basis of advice. With the need to remove runs the ensemble advice is unlikely to have good prediction properties despite the indicators for the individual models indicating good prediction skills. A more comprehensively examined ensemble with more realistic states of nature and a more symmetrically overlapping likelihood would considerably reduce this undesirable behaviour.

- The weighted ensemble mean remains on the main axis of correlation, but it is noted that this is not necessarily the case and one could potentially arrive at estimates of exploitation and biomass which are dynamically more incompatible. Using the joint mode rather than marginally derived statistics avoid the dissociation of F and SSB metrics, but in this case would effectively limit the advice to the cubic spline runs (run 10-18)

- It is possible or even likely that in future the cubic spline runs will dissociate further from the double normal runs. This is because the associated model settings at the benchmark were necessarily chosen to be compatible with both selectivity options. As more information is added to the models, necessarily their dynamics have to diverge because they are following different processes. It seems likely that in future years the alternate selectivity hypothesis may separate entirely and the marginal stock status estimates are likely to diverge further from the joint mode estimates. In fact, they are likely to become highly implausible in any of the model runs.

- Given the rate of dissociation observed since the benchmark the current ensemble make up is unlikely to provide robust management advice for a prolonged period.

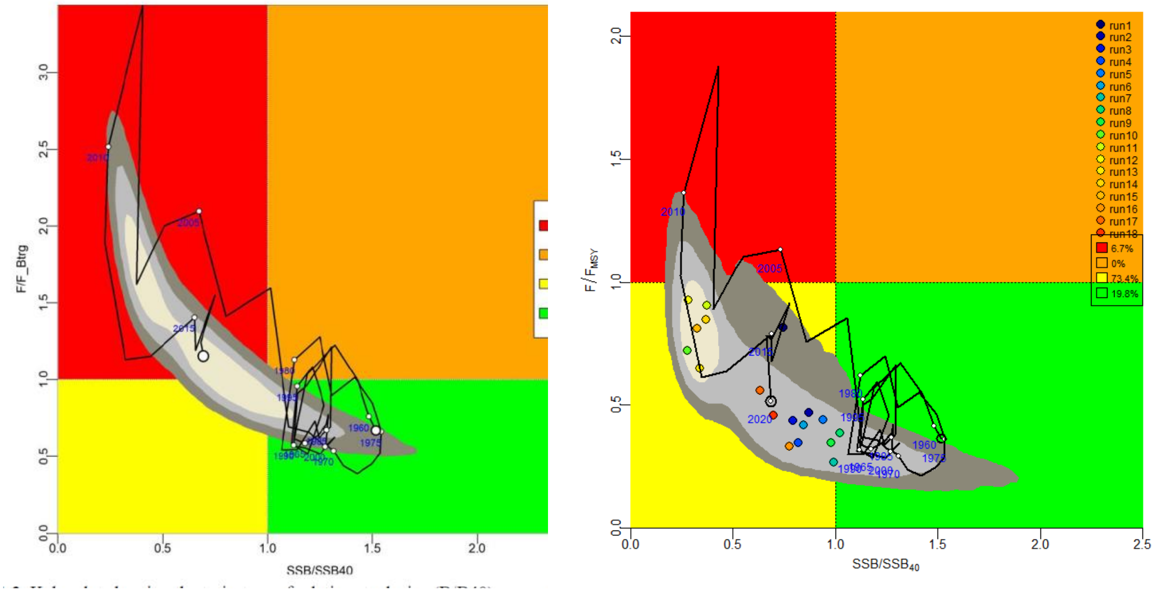


Figure 1.2.11 Ensemble Kobe plots from the benchmark (left) and the update (right) assessments. Note the coloured shading is different due to the use of alternative management metrics by the GFCM and STECF so it is not possible to directly compare status estimates. The update plot includes the final stock status estimates for the individual runs with the double normal selectivity runs(run1-9) indicating low F high SSB and the cubic spline runs(run10-18) indicating higher F and lower SSB

Testing the ensemble through retrospective analysis is an option that should be explored, ensuring a broader perspective on possible states of nature is likely to more appropriately reflect uncertainty but may also increase the likelihood of clustering in the joint probability. But the whole point of the ensemble is to learn what scenarios are more likely so there is a paradox in this that need further investigation. As more data becomes available more solutions / models become plausible while others plausibility tends to 0. How do we add and remove scenarios objectively from the model without undermining the purpose of the ensemble for advice?

Providing management advice:

The ensemble approach only provides probabilistic advice, its translation into a management system such as operates in the EU where advice is based on a single point is not immediately clear. Strictly speaking the same is true for statistical catch at age models but here the central tendencies are usually much better behaved, i.e. unimodal and without dissociation between SSB and F ratios. How do we describe the uncertainty around this value and the value itself in a meaningful way?

The easiest way is to provide the Kobe plot and let policy figure it out as this is strictly speaking their remit. We have however to acknowledge that they may not have a sufficiently sound bases in probability theory to interpret possible scenarios appropriately and some sort of coming together is necessary.

From the perspective of the STECF expert group the ToRs are problematic as this requires filling in a catch table based on the most likely stock status estimates. This in turn is dependent on criteria used to define the most likely stock status which as far as the EG is aware have not been defined in this context. This problem may also occur within GFCM.

Predicting Catches.

The EG only got as far as predicting F_{sq} advice. The creation of a F-options table is very time-consuming dependent on how it is done. If replicating the benchmark process, it requires running each of the 18 models multiple times for each F reference point (ideally reweighting according to the Francis method), iteratively adjusting the future catches to match future F to the reference point. The benchmark ran 4 simple catch multipliers for each model resulting in 72 runs, but realistically for an option table roughly 5 times that would be required without reweighting and likely 15 times that with reweighting. Quality assuring this process with the current implementation through simple text files in different directories is not feasible without a significant increase in resources.

The benchmark implemented catch scenario method assumed the same catch for the interim year for all models irrespective of status and a catch multiplier for the second year of the forecast. However, given that management is through effort rather than quota and there is a significant difference in the probability of attaining the interim year fixed catch in the different scenarios. It therefore implies different Fs for the different models and different starting points for the second year in the forecast. The basis of the assumption should be an F multiplier for the interim year and an individually fixed catch for the second year to be consistent with the STECF advisory process. This is currently not straight forward to implement in SS3 and would require a further doubling of the runs.

Conclusions to the exploration

Given the extreme time constraints, the difficulty in conveying the probabilistic format and high risk of quality assurance issues the EWG did not consider it useful to carry out the production of a complete options table for sole in GSA 17. Instead, the EWG would like STECF to consider a number of issues raised by this study:

- Fisheries science has long pushed for probabilistic advice, it is being adopted in other RFMOs and the technical advances are considered to be the state of the art, however, further consideration is necessary how to retain compatibility with the commissions management approach which is generally still ‘looking for a number’, without losing the advantages of the approach.

- The conclusions of the benchmark suggests that we know relatively little about the true stock dynamics for sole in GSA 17. Catching less will improve stock status, but is this likely to get us closer to F_{MSY}? This is entirely dependent on how one interprets the current stock status. MSEs would be required to ensure that the management is robust to such methodologies.

- Running an MSE on a model ensemble of this nature is extremely time consuming and technically not yet possible, but most importantly the loglikelihoods of such an exercise are likely so flat that we have to assume we know very little beyond ‘if we fish less stock status will likely be better, if we fish more it is likely to be worse’.

- A fisheries scientist perspective of this might be:

  - Given the explosion of uncertainty in the ensemble approach, the risk of technical mistakes and the resource required to implement what ultimately is very uncertain management requires such precautionary approaches to exploitation that the trade-off in yield does not offset the reduction in management risk

- There are few basic indicators that the stock is in immediate danger of collapse, though there is a considerable risk in the assessment of underestimating the rate of exploitation due to the makeup of the ensemble unless the cryptic biomass can be proven to actually exist.
- Even if it were possible to estimate Fmsy usefully the exploitation pattern implied indicates that yield is suboptimal and technical measures to shift the exploitation to mature individuals would improve both yield and stock stability.

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.

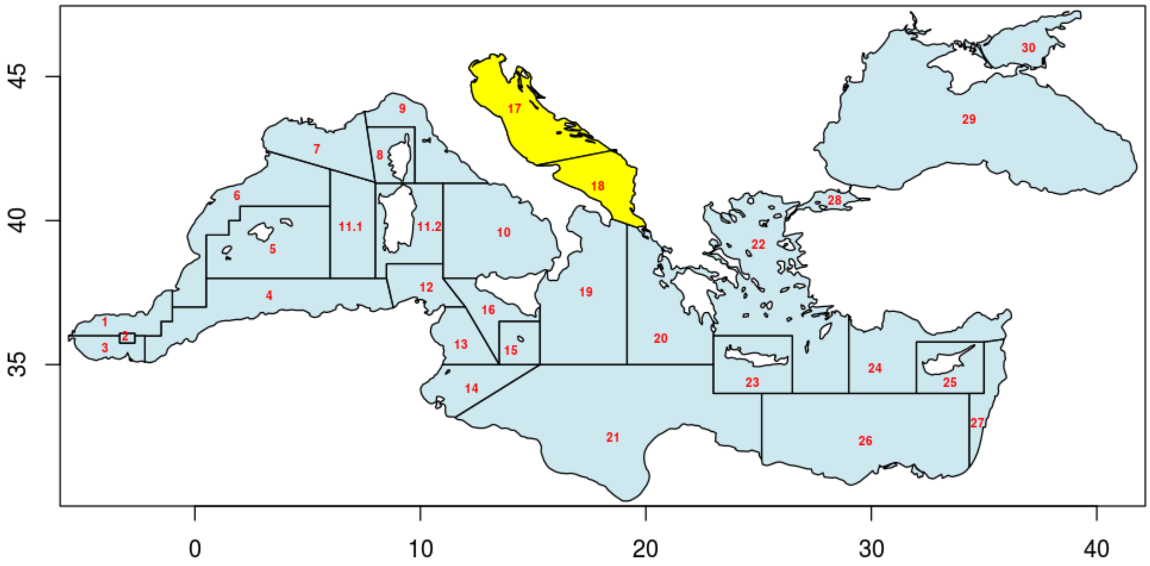


Figure 6.3.1.1 Geographical location of GSAs 17 and 18.

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 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, and were used for the assessment.

Table 6.3.1.1. 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

Age slicing using l2a was used to convert the proportions of matures by length into proportions by age. Following the common decision made for all red mullet stocks during previous STECF EWGs, the vector of proportion of mature individuals by was the one reported in Table 6.3.1.2.

Table 6.3.1.2. Maturity vector at age used for GSA 17-18.

Age	Maturity
0	0
1	1
2	1
3	1
4	1

Natural mortality

Following EWG 19-16, the natural mortality vector was estimated according to Chen and Watanabe model on growth parameters listed in Table 6.3.1.1.

Table 6.3.1.3. Natural Mortality vector at age used for GSA 17-18.

Age	M
0	0.93564
1	0.61635
2	0.49473
3	0.43316
4+	0.39752

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 2020); 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 2020, for GSA 18 Italy from 2002 to 2020, for GSA 17 Croatia from 2013 to 2020 and for GSA 17 Slovenia from 2005 to 2020. For Croatia from 2006 to 2012, the RECFISH data was used, as required in ToR 2 (point 3).

The discard was available for GSA 17 Italy from 2010 to 2020, for GSA 17 Croatia from 2013 to 2020, for GSA 17 Slovenia from 2005 to 2020 and for GSA 18 Italy from 2009 to 2020. 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 for Montenegro and Albania were updated using the data reported in the EWG 19-16 report. Montenegrin landings from that report was used for all the years until 2018, while for 2019 and 2020, when the data were not provided, an average of the last three years was used. For Albania, landings data and LFD for 2019 was provided by national authorities during EWG 20-15 and used to reconstruct the previous Albanian LFDs. For the years from 2012 to 2018 the landing data indicated in the EWG 19-16 report were used; for the years from 2006 to 2011, which are under revision by the Albanian authorities, an average of the first three years was used. No discard data were available for Albania and Montenegro.

The length frequency distributions of all the fleets and the MEDITS survey on the whole area were age-sliced by means of a deterministic slicing (l2a function available in FLR) using the von Bertalanffy parameters from Carbonara *et al.* (2018). The LW relationship parameters for GSA 18 were used to calculate the mean weight-at-age. Age slicing and the computation of mean weight-at-age were performed by sex, then age structures were pooled together, while the mean weight-at-age for sex combined was estimated as a weighted average of the mean weight-at-age by sex.

Table 6.3.2.1.1 Red mullet in GSAs 17 and 18. Landings in GSA 17 by fishing gear and country over 2006-2020 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
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
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

Table 6.3.2.1.2 Red mullet in GSAs 17 and 18. Landings in GSA 18 by fishing gear and country over 2002-2020 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

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
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

country	year	GSA 17	GSA 18	Total
	2019	597.00	198.04	795.04
	2020	129.60	21	150.60
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

Table 6.3.2.1.4 Red mullet in GSAs 17 and 18. Reconstructed discards (tons).

	OTB GSA 18 Italy	OTB GSA 17 Italy	OTB GSA 17 HRV
2006	67.8	786.1	1.5
2007	63.1	836.1	1.8
2008	34.4	800.6	1.5
2009		616.8	1.6
2010			1.5
2011			2.0
2012			2.4

Table 6.3.2.1.5 Red mullet in GSAs 17 and 18. Reconstructed discard at age.

Age	OTB GSA 18 Italy			OTB GSA 17 Italy			
	2006	2007	2008	2006	2007	2008	2009
0	6160.6	5737.4	3122.8	10589.3	30286.1	2772.3	44.9
1	1833.4	1707.5	929.4	11262.0	32210.1	2948.4	47.7
2	7.7	7.2	3.9	10784.0	30842.8	2823.3	45.7
3				8308.2	23762.0	2175.1	35.2
4	OTB GSA 17 HRV						
Age	2006	2007	2008	2009	2010	2011	2012
0	4.6	5.4	4.7	4.8	4.5	6.3	7.4
1	59.9	70.7	61.4	62.8	58.9	82.0	95.7
2	16.8	19.8	17.3	17.6	16.5	23.0	26.9
3	0.5	0.6	0.5	0.5	0.5	0.7	0.8

Table 6.3.2.1.6 Red mullet in GSAs 17 and 18. Total catch (tonnes). Albanian data from 2012 until 2018 were obtained from EWG 19-16, while for 2006-2011 an average of the first three years was used. 2019 Albanian data were obtained by National authorities. For Montenegro from 2008 to 2018 the data were obtained from EWG 19-16, while for 2006-2007 an average of the first three years was used. For 2019 and 2020 the average of the last three years was used.

Year	Albania	Montenegro
2006	355*	40*
2007	355*	40*
2008	355*	42
2009	355*	40
2010	355*	38
2011	355*	35
2012	375	39
2013	373	35
2014	317	45
2015	388	40
2016	396	40
2017	392	40
2018	289	46
2019	373	42*
2020	351*	42*

*data estimated.

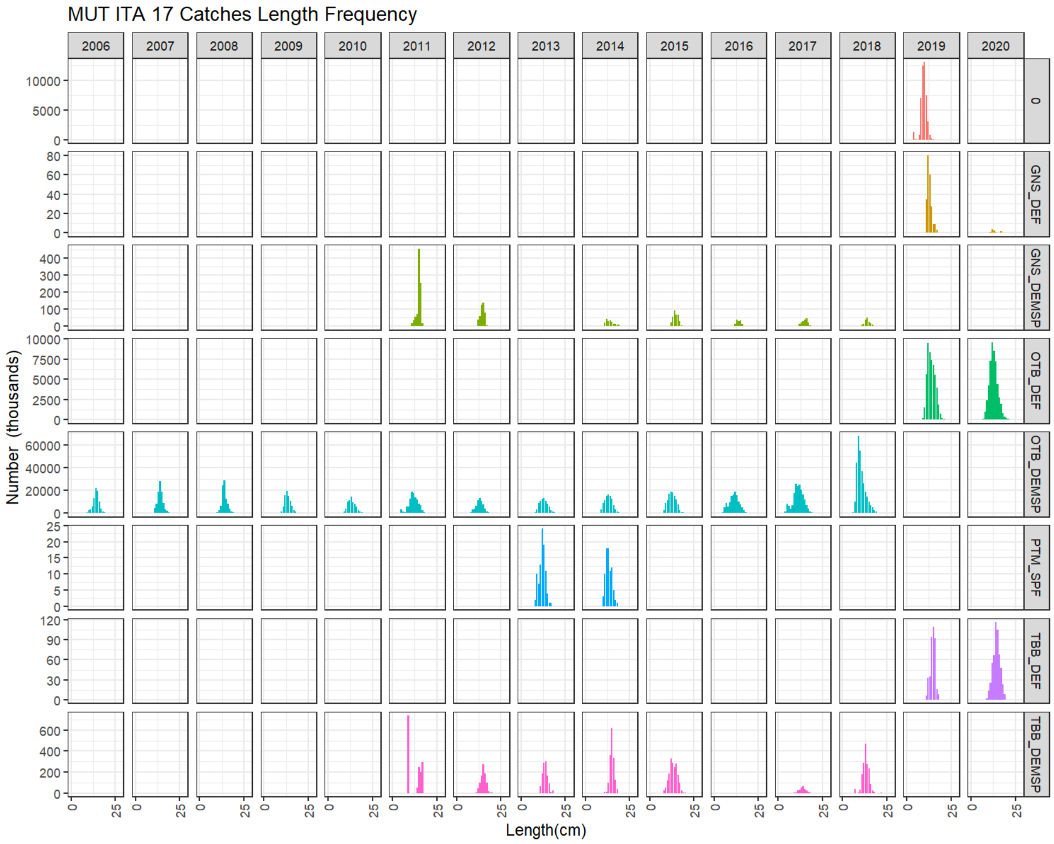


Figure 6.3.2.1.1 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Italy

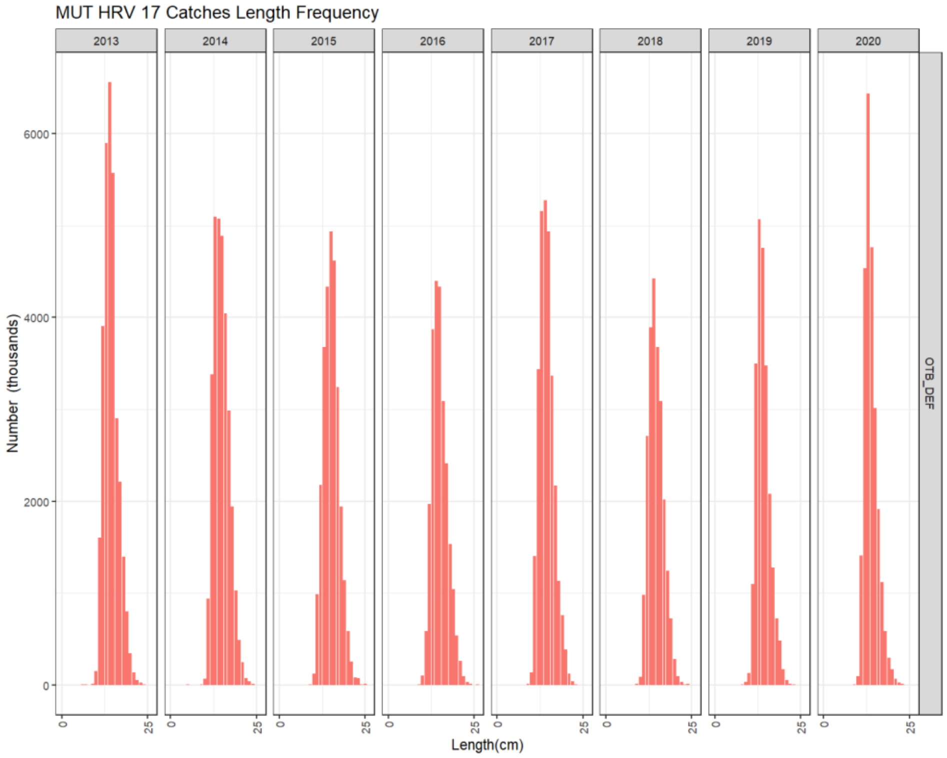


Figure 6.3.2.1.2 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Croatia.

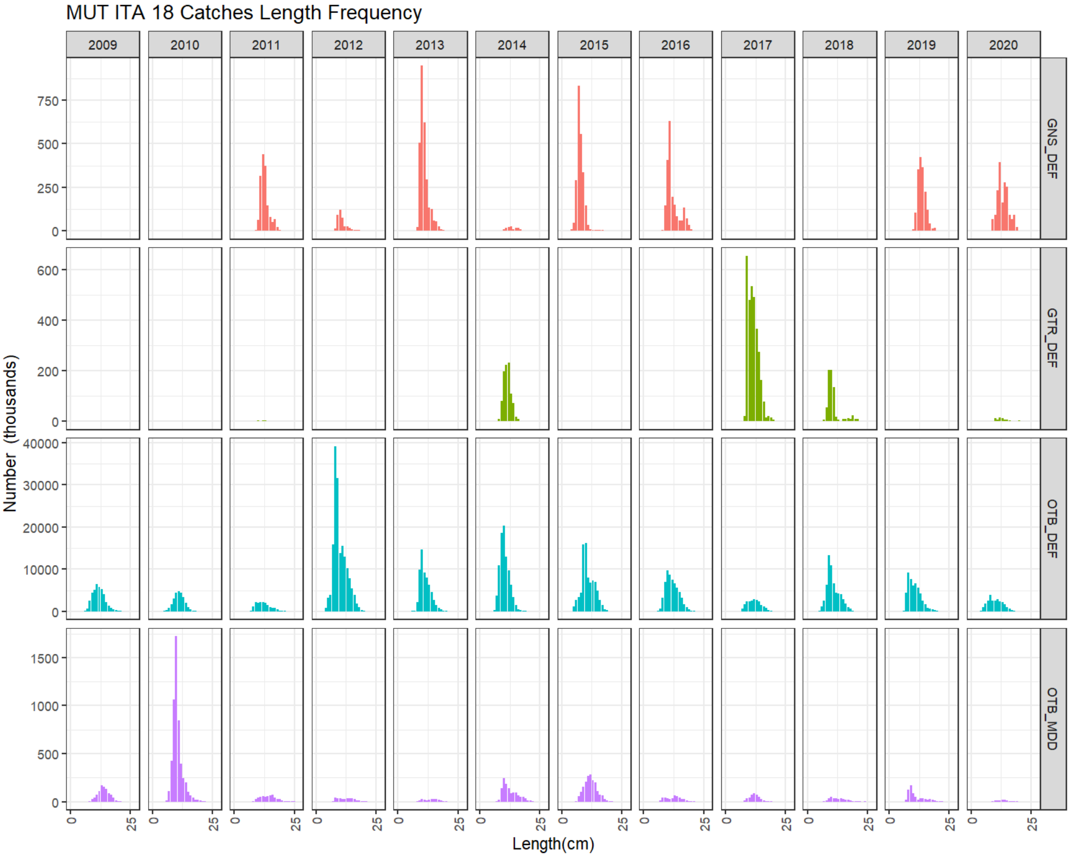


Figure 6.3.2.1.3 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 18, Italy

Table 6.3.2.1.8. Red mullet in GSA 17 and 18. Commercial catch in numbers at age (thousands), obtained from LFD sliced with l2a FLR function using growth parameters in Table 6.3.1.1.

	Age				
Year	**0**	**1**	**2**	**3**	**4**
2006	17349	70032	71695	6171	1570
2007	29434	114307	96075	9909	1664
2008	15593	96329	81646	7001	1404
2009	16172	102297	60166	7037	1646
2010	8886	72724	44105	5687	1352
2011	20805	89627	54400	6675	1795
2012	98304	107336	63919	7852	1727
2013	16403	101028	56852	7171	1641
2014	37467	121634	63161	6765	1571
2015	41511	115507	73419	10535	2505
2016	41778	107266	56014	9276	2798
2017	49086	119390	64181	8343	2110
2018	147412	172655	60924	10283	1931
2019	43757	82897	43559	7730	1894
2020	3569	45286	29811	4333	1361

Differences on total catch and total of catch at age, aggregated across all GSAs and country, were checked through the sum of products correction (SOP). The catches at age were raised to the total catch by applying the SOP. The SOP applied by year are reported below in Table 6.3.2.1.9.

Table 6.3.2.1.9 – SOP correction applied to the catches in Table 6.3.2.1.8.

Year	SOP correction
2006	1.48
2007	1.09
2008	1.10
2009	1.10
2010	1.13
2011	1.02
2012	1.07
2013	1.12
2014	1.14
2015	1.09
2016	1.05
2017	1.01
2018	0.96
2019	1.07
2020	1.30

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 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. 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.

YEAR	Sum of fishing_days				
	VL0006	VL0612	VL1218	VL1824	VL2440
2012	24.4	10846.1	17167.3	4694.4	2839.7
2013	30.8	10301.6	16849.1	5323.2	2987.1
2014	8.2	11251.4	16821.7	5278.3	2927.5
2015	0.6	10852.7	16540.3	4331.9	3017.0
2016	1.0	10324.7	16256.8	4880.6	2252.0
2017	15.2	11825.7	17165.3	4583.6	2059.0
2018	6.6	9972.6	17239.3	4182.8	1736.0
2019		9076.0	15578.0	4612.0	1731.0
2020		10170	16075	4151	1520

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		35664.6	52605.0	34338.4	10421.9
2005		10053.4	62455.2	36577.6	12588.1
2006	60.66	8066.6	56603.7	29436.6	9887.9
2007		6723.6	47687.7	30438.4	8945.2
2008		5525.3	44719.5	27976.6	8479.7
2009		7634.5	47220.3	28570.9	7618.1
2010		5952.1	41995.4	27106.1	7908.8
2011		5999.4	40791.7	26424.5	6971.3
2012		6047.8	34301.4	25466.2	4787.6
2013	760.03	5818.7	33283.2	22577.5	4082.1
2014		6219.8	33051.8	21193.8	6027.1
2015		2270.7	29581.9	25021.9	4422.4
2016		2758.2	29701.1	24561.2	4844.4
2017		6338.8	30074.3	30349.9	5615.6
2018		4950.8	34676.9	30787.7	5524.5
2019		3281.5	31403.4	24641.5	6585.0
2020		1332	27162	22482	5651

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.

YEAR	Sum of fishing_days OTB				
	VL0006	VL0612	VL1218	VL1824	VL2440
2004		9007.5	51197.0	20023.7	6697.0
2005		4802.5	47330.0	16897.2	8178.8
2006		5549.7	52173.8	22180.6	4258.6
2007		3469.5	43554.9	19836.4	3819.0
2008		4743.0	45641.5	14281.7	4972.4
2009		5760.4	59695.4	14983.8	5410.5
2010		5197.2	48371.5	15104.7	4347.2
2011		3818.4	47116.4	13130.4	3588.7
2012		4583.0	44403.2	11501.3	2156.3
2013		5513.5	49028.0	12511.2	2239.2
2014		4059.5	33735.6	10181.7	1708.0
2015		4014.8	35441.6	10340.8	2204.5
2016		3650.3	37510.4	10889.0	1977.9
2017		4239.2	36248.4	10622.7	2108.0
2018		3487.3	42091.6	12862.1	1993.2
2019		1828.5	35762.1	10735.0	1843.7
2020		608	28042	9241	1618

	Sum of fishing_days GNS				
YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2004		36337.1			
2005		39700.5			
2006	9224.9	34770.0	218.5		
2007	7976.4	24729.4			
2008	4645.1	22187.4			
2009	9679.6	32636.7			
2010	7609.6	22285.8			
2011	7350.9	19143.2			
2012	5684.2	11296.6			
2013	26097.1	38107.3			
2014	14047.7	7747.9			
2015	17566.7	26678.2			
2016	16503.4	25169.7			
2017	12012.8	5216.8	72.9		
2018	12916.9	25612.4	232.7		6.0
2019	10265.5	19842.5	157.1		
2020	4423	24873	97		

YEAR	Sum of fishing_days GTR				
	VL0006	VL0612	VL1218	VL1824	VL2440
2004		20137.8	440.0		
2005		22616.8	104.5		

2006	20665.7	6917.0			
2007	11725.5	10035.0			
2008	17788.5	21778.8			
2009	16646.5	14519.6			
2010	18126.5	25314.2			
2011	20763.1	25179.8			
2012	12948.7	27020.1			
2013		8196.0			
2014	9016.0	25070.7			
2015	959.0	8474.4			
2016	1088.0	4524.0			
2017	8910.1	10610.1			
2018	9684.4	10227.7	513.0		
2019	9966.4	7744.4	249.7		
2020	12269	4626	80		

Table 6.3.2.2.4 Red mullet GSA 17 and 18. Fishing days for Slovenian OTB fleet in GSA 17 per LOA.

YEAR	Fishing days					
	VL0006	VL0612	VL1218	VL1824	VL2440	VL40XX
2005	4.0	358.0	469.0			
2006		356.0	607.0			
2007		343.0	858.0		1.0	
2008		316.0	937.0		1.0	
2009		229.0	976.0			
2010		305.0	958.0			
2011		270.0	908.0			
2012		124.0	793.0			
2013		157.0	609.0			
2014		180.0	500.0			
2015		159.0	537.0			
2016		156.0	656.0			
2017		194.0	503.0			
2018		201.0	491.0			
2019		205.0	564.0			
2020		293	586			

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. For the present assessment the data from 2006 to 2020 were used. From 2017 to 2019 the hauls in territorial waters of Albania and Montenegro were not carried out under the DCF. In 2020 they have not carried out.

The longer survey 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 2011 onwards, with the 2020 density stable and biomass value slightly decreasing respect to 2019.

Figure 6.3.2.3.1 Red mullet in GSAs 17 and 18. MEDITS survey period over 1994-2020.

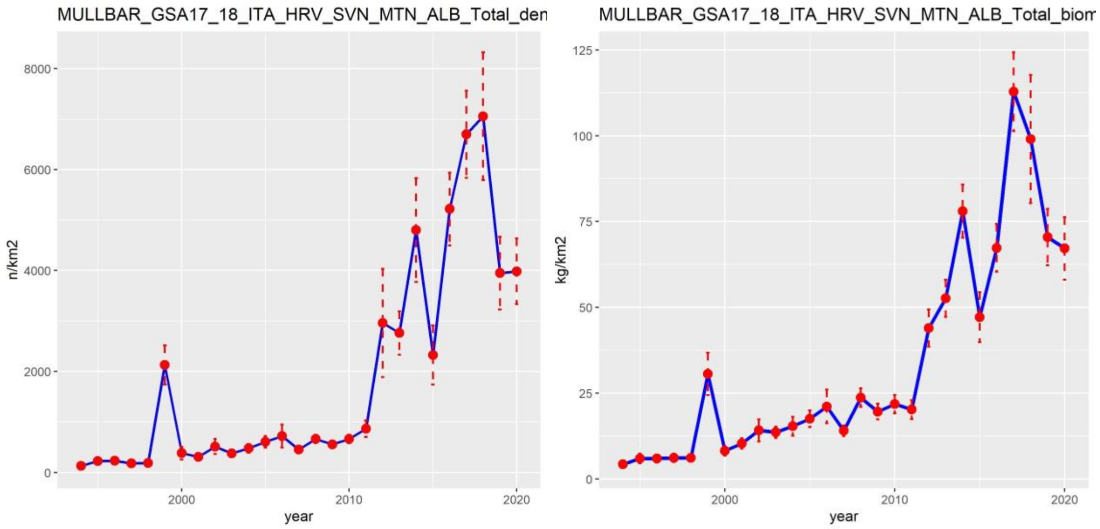


Figure 6.3.2.3.2 Red mullet in GSAs 17 and 18. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2020.

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

Methods: a4a (Assessment for all)
The a4a model, developed within FLR framework, is a flexible statistical catch at age stock assessment model, based on linear modelling techniques, not working by gear, nor by sex.

Input data
The MEDITS indices by length were estimated treating the two GSAs combined as a unique area, starting from the TC files and re-stratifying the single hauls in the TA files. Age 0 was not used in the assessment for tuning, because the recruitment is not detected regularly due to the shift in survey time.
Commercial catch, LFDs were available from 2002 only in GSA 18 (Italy); therefore, it was decided to use data from 2006 onwards.
The catch-at-age matrices are reported in Table 6.3.2.1.8 (commercial) and 6.3.3.1 (survey). The overall catch in weight by year is reported in Table 6.3.3.2. The age structure of catch and survey is also shown in Figures 6.3.3.1 and 6.3.3.2.
The natural mortality vector and the maturity at age are the same reported in paragraph 6.3.1. The M and F before spawning were set equal to 0.5. In Table 6.3.3.3, the mean weights-at-age for the stock and for the catch are reported.

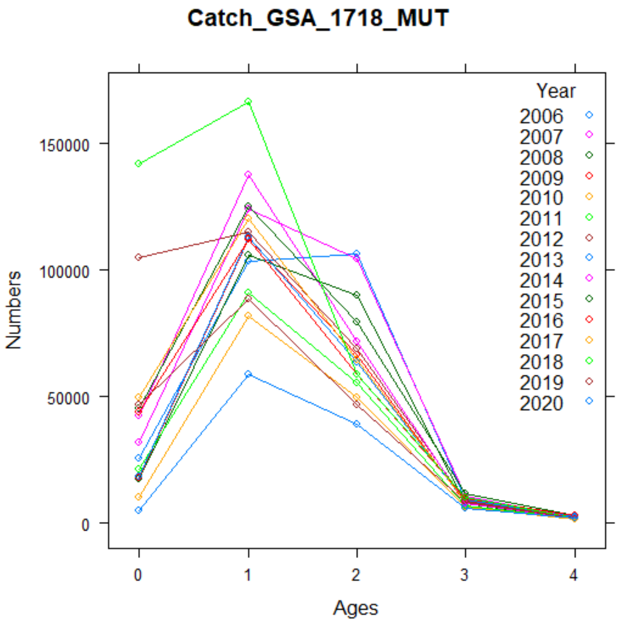


Figure 6.3.3.1 Red mullet in GSAs 17 and 18. Catch at age (landings+discards), all gears and GSAs combined.

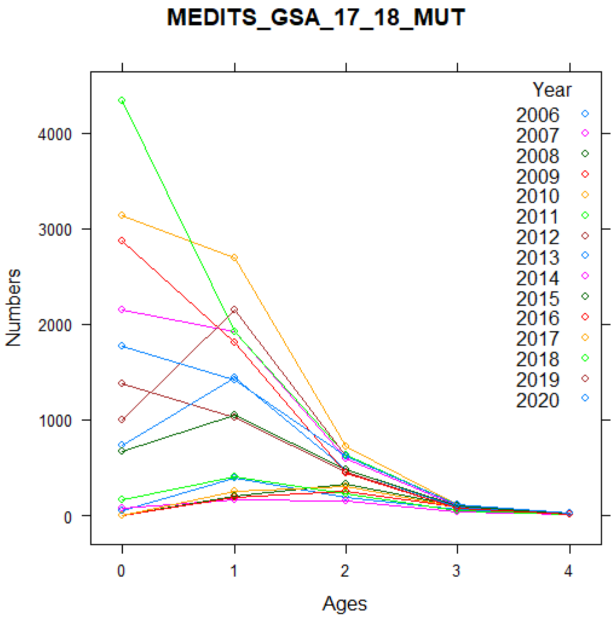


Figure 6.3.3.2 Red mullet in GSAs 17 and 18. Catch at age in the MEDITS survey (GSA17 and 18 combined).

Table 6.3.3.1 Red mullet in GSAs 17 and 18. MEDITS catch in numbers at age used in the a4a assessment (N/km$_2$).

Year	0	1	2	3	4
2006	52.671	394.42	192.84	64.581	14.011
2007	74.562	166.99	153.85	43.518	11.593
2008	2.9398	206.19	324.13	103.76	19.377
2009	2.7921	185.95	255.81	92.055	13.79
2010	3.9702	257.2	301.21	84.636	15.58
2011	169.96	401.13	226.57	56.091	10.673
2012	1375.4	1023	461.97	76.027	9.0918
2013	733.47	1438.3	486.21	89.305	12.304
2014	2152	1923.5	599.38	104.95	18.151
2015	668.91	1053.5	480.06	101.1	15.732
2016	2867.2	1814.4	444.95	77.985	12.741
2017	3139.3	2688.6	719.47	118.02	28.324
2018	4335	1926.7	631.92	120.14	24.259
2019	995.91	2149	617.42	108.3	20.517
2020	1768.7	1421.1	624.92	109.57	21.778

Table 6.3.3.2 Red mullet in GSAs 17 and 18. Catch in weight by year (tons).

Year	Catch
2006	7094
2007	7355
2008	6182
2009	5340
2010	3850
2011	4740
2012	6068
2013	5055
2014	5773
2015	6383
2016	5488
2017	5814
2018	6928
2019	4472
2020	3055

Table 6.3.3.3 Red mullet in GSAs 17 and 18. Individual weight at age for the in the catch and stock (kg).

Year	0	1	2	3	4+
2006	0.006	0.018	0.04	0.061	0.09
2007	0.007	0.017	0.04	0.06	0.089
2008	0.007	0.019	0.039	0.057	0.091
2009	0.007	0.018	0.038	0.065	0.097
2010	0.007	0.017	0.037	0.061	0.096
2011	0.007	0.018	0.042	0.066	0.098
2012	0.007	0.018	0.039	0.061	0.089
2013	0.008	0.016	0.038	0.061	0.091
2014	0.007	0.016	0.037	0.066	0.095
2015	0.006	0.017	0.039	0.061	0.093
2016	0.007	0.017	0.04	0.063	0.094
2017	0.007	0.018	0.04	0.063	0.092
2018	0.007	0.017	0.039	0.063	0.09
2019	0.007	0.018	0.038	0.067	0.096
2020	0.006	0.017	0.038	0.063	0.092

During the EWG 21-15 the model used during the last assessment (EWG 20-15) was applied, though an exploration to simplify the qmodel, avoiding to set the breakpoint in 2012, was carried out. The MEDITS survey was split into two different tuning indices according to the survey period (spring-summer, summer-autumn). A set of different model was tested, but some models had convergence problems, due to the few years in the summer-autumn tuning series. Even the model converging, did not show any improvement of the retrospecitve analysis.

The model finally used was:

- fmod= ~ s(replace(age, age > 2, 2), k = 3) + s(year, k = 8)
- qmod <- list(~s(age, k=4, by = breakpts(year, 2012)))
- srmod ~ geomean(CV = 0.2)

An Fbar range age 1 to 3 was used, consistently with the other red mullet stocks assessed in previous EWG. In the best model, it was confirmed the assumption of a change in survey catchability from 2012, due to a change in the survey period and in the vessel carrying out the Eastern side hauls of GSA 17. The F is a separable model.

Results

The F time series estimated by a4a ranges between 1.31 and 0.36, with an overall decrease with time. In the last years, the model estimates a strong increase in SSB and recruitment (Table 6.3.3.4; Figure 6.3.3.3).
The fishing mortality at age shows the maximum values from age 2 to 4, decreasing in time (Table 6.3.3.5; Figure 6.3.3.4).
In general, the fitting of the commercial catch at age and survey index at age is acceptable (Figure 6.3.3.5). The internal consistency of both catches and survey indices is good (Figure 6.3.3.8), particularly for the survey in ages 1 and 2 which dominate the population (age 0 was not used for the assessment). The residuals are generally small (between -3 and 3) and quite random distributed by age, except for MEDITS, showing some trends in the recent years (Figures 6.3.3.6 and 6.3.3.7). The retrospective show some signals of instability.

Table 6.3.3.4 Red mullet in GSAs 17 and 18. Results of the final a4a run: F_{bar} (1-3) overall, SSB, Recruitment and total biomass.

Year	Fbar	Recruitment	SSB (middle of the year)	Total biomass (middle of the year)
2006	1.3	1146091	6726	22753
2007	1.31	889331	5824	19514
2008	1.26	751260	5099	16975
2009	1.15	793655	4332	14879
2010	1.07	853474	4318	14812
2011	1.04	911950	5129	16815
2012	1.06	1064667	5245	17869
2013	1.05	946500	5581	18603
2014	1.02	831910	5470	17082
2015	1	1029924	5269	17111
2016	1.05	956316	5877	18703
2017	1.1	785539	5837	17803
2018	0.97	909433	5112	17057
2019	0.66	1005851	6483	18358
2020	0.37	845617	8815	18748

Table 6.3.3.5 Red mullet in GSAs 17 and 18. Results of the final a4a run: F-at-age.

Year	age				
	0	1	2	3	4+
2006	0.08	0.67	1.78	1.45	1.45
2007	0.08	0.67	1.80	1.46	1.46
2008	0.07	0.65	1.72	1.40	1.40
2009	0.07	0.59	1.58	1.29	1.29
2010	0.06	0.55	1.46	1.19	1.19
2011	0.06	0.54	1.43	1.17	1.17
2012	0.06	0.54	1.45	1.18	1.18
2013	0.06	0.54	1.44	1.18	1.18
2014	0.06	0.52	1.40	1.14	1.14
2015	0.06	0.52	1.37	1.12	1.12
2016	0.06	0.54	1.44	1.17	1.17
2017	0.06	0.57	1.50	1.22	1.22
2018	0.06	0.50	1.33	1.09	1.09
2019	0.04	0.34	0.90	0.74	0.74
2020	0.02	0.19	0.50	0.41	0.41

Table 6.3.3.6 Red mullet in GSAs 17 and 18. Results of the final a4a run: Stock numbers-at-age.

Year	age				
	0	1	2	3	4+
2006	1146091	461344	147167	13839	3456
2007	889331	416339	127532	15112	2649
2008	751260	322861	114456	12904	2683
2009	793655	273598	91227	12458	2501
2010	853474	290832	81582	11459	2696
2011	911950	314323	90585	11508	2807
2012	1064667	336333	99112	13203	2915
2013	946500	392341	105310	14178	3231
2014	831910	348882	123116	15153	3507
2015	1029924	307293	111514	18604	3913
2016	956316	380767	98965	17193	4797
2017	785539	352552	119637	14288	4448
2018	909433	288803	108167	16213	3602
2019	1005851	336808	94431	17364	4363
2020	845617	379519	129486	23324	6800

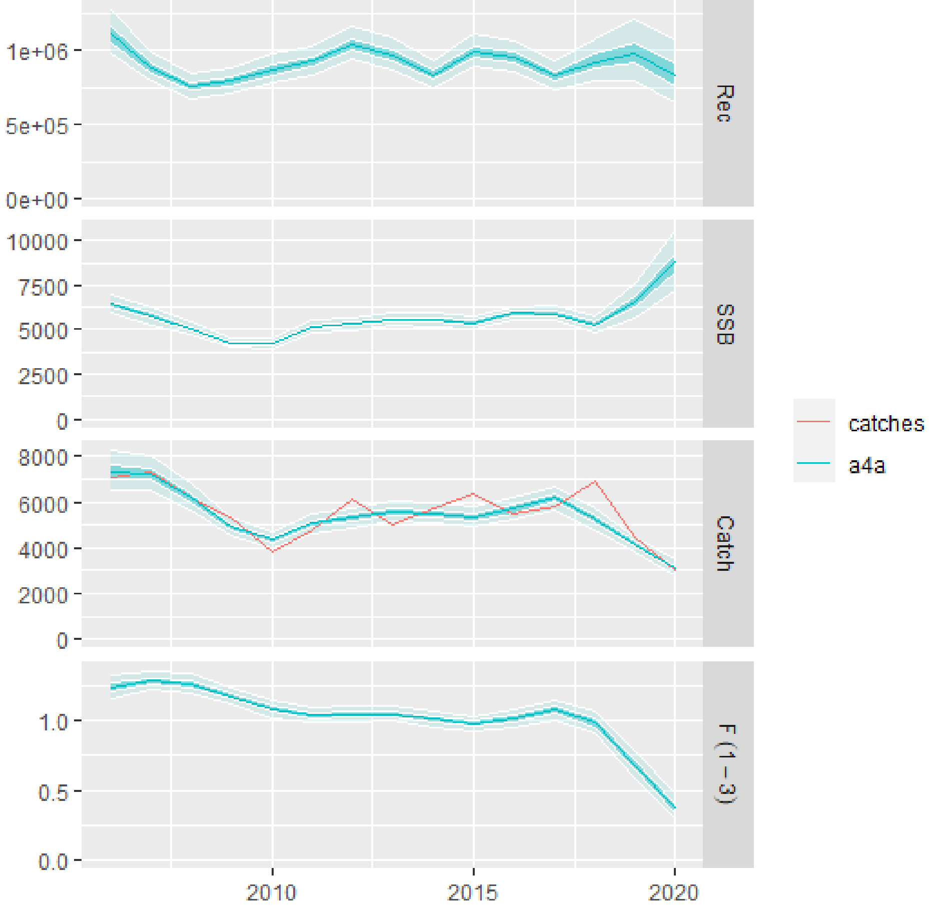


Figure 6.3.3.3 Red mullet in GSAs 17 and 18. Summary of the results. The blue line corresponds to the observed catches.

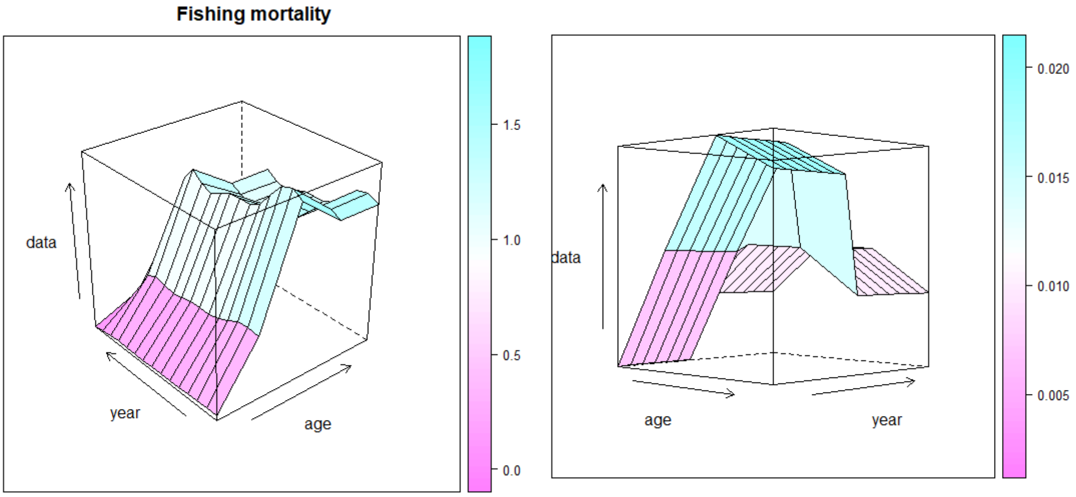


Figure 6.3.3.4 Red mullet in GSAs 17 and 18. Fishing mortality (left) and catchability (right) by age and year.

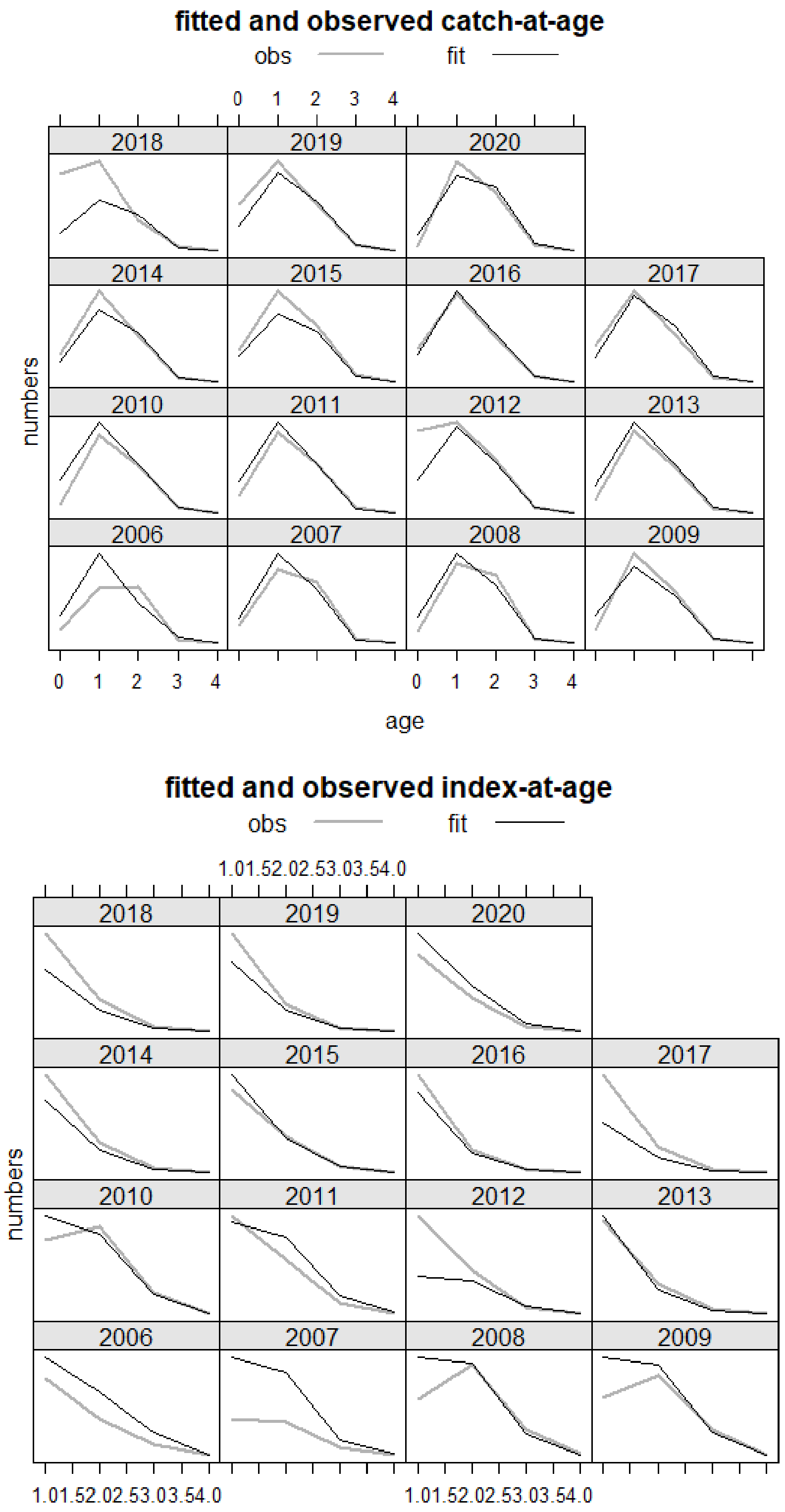


Figure 6.3.3.5 Red mullet in GSAs 17 and 18. Comparison between observed and fitted catch (top) and index (bottom) at age

The residuals show some trends in the 0-years and 1 years age groups in the survey and in age 1 and 2 years groups in the catch (Figure 6.3.3.6). The retrospective analysis shows some instability, especially in SSB and F (Figure 6.3.3.7). Overall the assessment is considered still suitable to give stock status relative to F_{MSY}, although the results should be considered with caution.

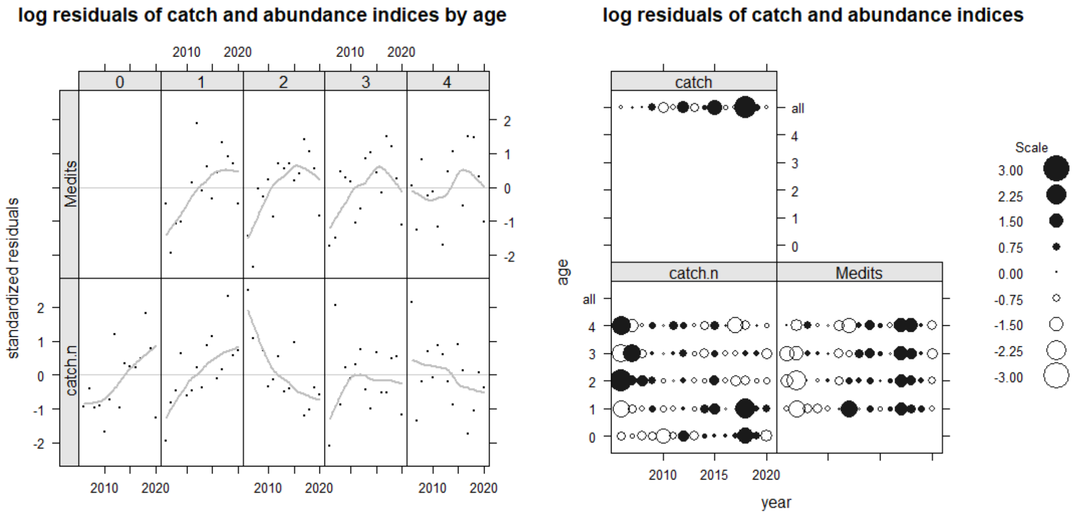


Figure 6.3.3.6 Red mullet in GSAs 17 and 18. Log-residuals and bubble plot of catch and abundance indices by age.

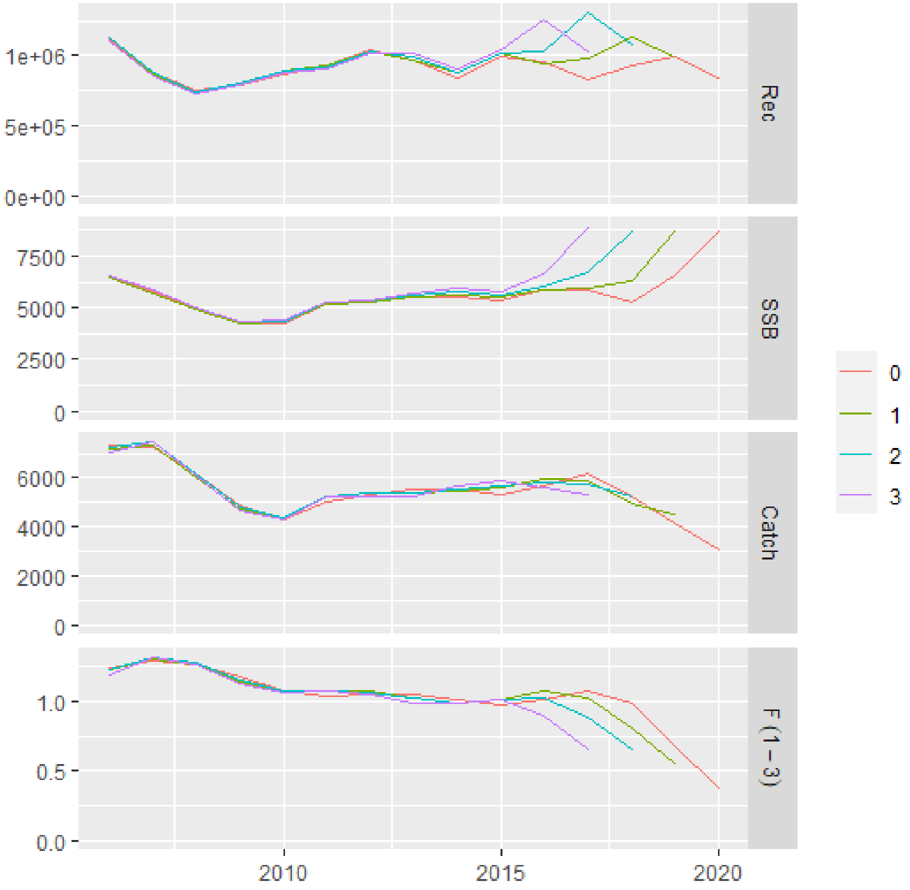


Figure 6.3.3.7 Red mullet in GSAs 17 and 18. Retrospective analysis.

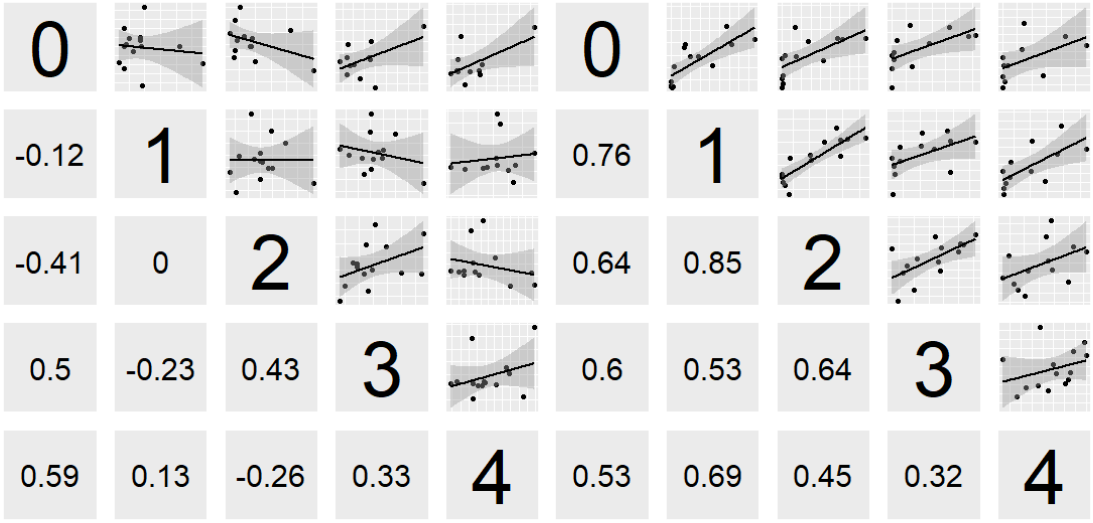


Figure 6.3.3.8 Red mullet in GSAs 17 and 18. Internal consistency in the catches (left) and the index (right).

6.3.4 Reference Points

The time series is too short to give stock recruitment relatonships, so reference points are based on equilibrium methods. The STECF EWG 21-15 confirmed the reccomendations to use $F_{0.1}$ as proxy of FMSY. For the exploration carried out on the stability of the F0.1 respect to the plus group, see the EWG 20-15 report. Considering the F current of 0.37 estimated for 2020, the fishing mortlity level is practically in line with the reference point $F_{0.1}$ of 0.36 (as riestimated this year).

6.3.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts, and based on the results of the stock assessment.
The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} =0.37 (2020) from the a4a assessment was used for F in 2021. For recruitment, the average along the whole time series (15 years) is used as an estimate of recruits in 2021 and 2022 (910 679.7thousands).

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

Variable	Value	Notes
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2018-2020
$F_{ages\ 1\text{-}3}$ (2021)	0.37	F(2020) used to give F status quo for 2021
SSB (2021)	10411.4	Stock assessment middle of the year 2021
R_{age0} (2021,2022)	910 679.7	Mean of the last 14 years (whole series)
Total catch (2021)	4089.8	Assuming F status quo for 2021

The results of the short term forecasts shows that, on the basis of the current situation of the stock fishing at F0.1 level would increase the catch from 2020 to 2022 of 36.99%, while the SSB would increase by 19,6%. On the other hand, maintaining the current fishing mortality, would return a change in SSB of +17.25% and in catch of +42.6%. Anyway, these results shoul be consired with caution, due to the instability detected in the final model.

Table 6.1.5.2 Red mullet in GSAs 17 and 18: short term forecast.

Rationale	Ffactor	Fbar	Catch2022	SSB2023	SSB_change_2021-2023(%)	Catch_change_2020-2022(%)
High long term yield (F0.1)	0.95	0.356	4279	12452	19.6	36.99
F upper	1.31	0.488	5525	10757	3.32	76.9
F lower	0.64	0.238	3024	14271	37.07	-3.19
FMSY transition	1.45	0.541	5979	10169	-2.33	91.43
Zero catch	0	0	0	19091	83.37	-100
Status quo	1	0.373	4454	12207	17.25	42.6
Different Scenarios	0.1	0.037	524	18214	74.94	-83.23
	0.2	0.075	1028	17385	66.98	-67.09
	0.3	0.112	1514	16603	59.47	-51.54
	0.4	0.149	1981	15864	52.37	-36.56
	0.5	0.187	2432	15166	45.67	-22.12
	0.6	0.224	2867	14506	39.33	-8.22
	0.7	0.261	3285	13882	33.34	5.19
	0.8	0.299	3689	13293	27.67	18.12
	0.9	0.336	4078	12735	22.32	30.58
	1.1	0.411	4816	11708	12.45	54.2
	1.2	0.448	5166	11235	7.91	65.39
	1.3	0.486	5503	10787	3.6	76.19
	1.4	0.523	5828	10362	-0.47	86.61
	1.5	0.56	6143	9960	-4.33	96.68
	1.6	0.598	6446	9579	-8	106.4
	1.7	0.635	6740	9217	-11.47	115.79
	1.8	0.672	7023	8874	-14.76	124.86
	1.9	0.71	7297	8549	-17.89	133.63
	2	0.747	7562	8240	-20.86	142.1

6.3.6 Data Deficiencies

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 forth quarter, when a high amount of red mullet discard is not expected, considering that the species recruits in the third quarter. These reported discard amounts need to be checked.

6.4 Common cuttlefish in GSA 17 and 18

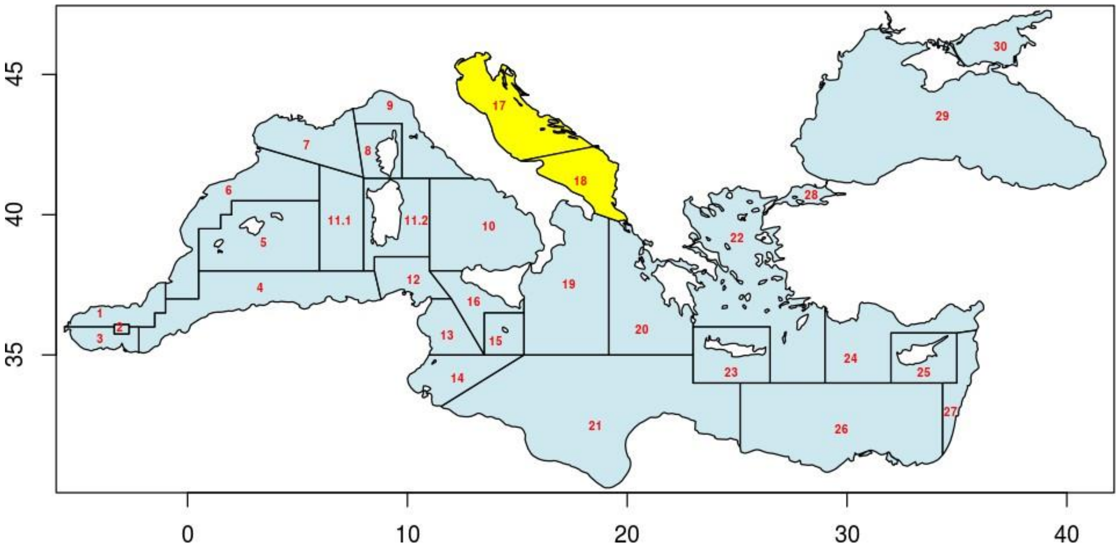


Figure 6.4.1.1 Geographical location of GSAs 17-18.

6.4.1 STOCK IDENTITY AND BIOLOGY

Common cuttlefish is found throughout the Mediterranean basin and the eastern Atlantic Ocean, from the Baltic Sea to about 17° N. It is a demersal species, more abundant in coastal waters on muddy and sandy bottoms covered with seaweed and phanerogams, but its distribution can be extended to a depth of about 200 m (Relini et al., 1999). Inthe Adriatic Sea (GSA 17-18) common cuttlefish (*Sepia officinalis*) inhabits the shelf zone at depths up to 200m, but MEDITS findings indicate that this species is mainly concentrated up to 100 m depth.

During the winter period, common cuttlefish resides mostly in circalitoral zone where it matures. In spring, it migrates to the shallower infralitoral region to spawn (Mandić, 1984). In the central and northern Adriatic Sea it occurs predominantly on sandy and muddy bottoms up to 100-150 m deep (Županović and Jardas, 1989). In the southern Adriatic, in the colder part of the year common cuttlefish is the most abundant at depths from 50 to 60 m. During the warmer part of the year, it migrates closer to the coast for spawning and forms dense settlements at 10 to 30 m depth (Mandić, 1984). The common cuttlefish is an active predator. It feeds mostly on crustaceans, especially decapods, but also fish. In the absence of this food, it can become cannibalistic (Fabi, 2001). According to Fisher et al. (1987) longevity of common cuttlefish is 18 to 30 months.

In the past, EWG 17-02 indicated that no evidence support existence of more than one single stock of common cuttlefish in the Adriatic Sea. In addition, EWG 18-16 analysed the most recent available geo-referenced spatial survey data (MEDITS data - period 2006-2016) from the Adriatic Sea, pointing out the continuity of common cuttlefish stockdistribution along coasts of the Adriatic basin (Figure 6.4.1.2).

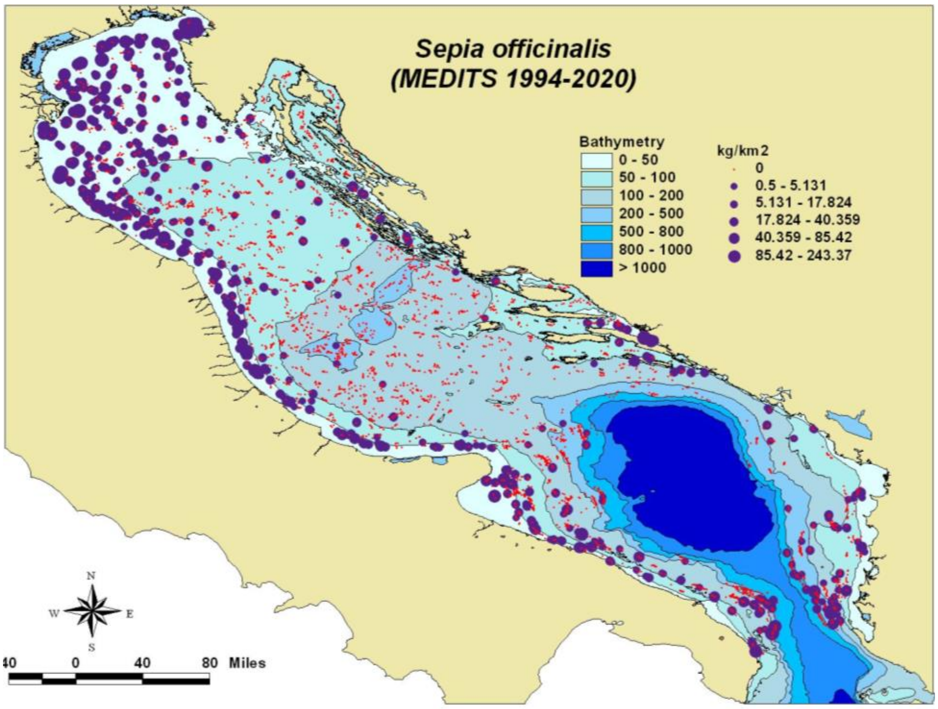


Figure 6.4.1.2 Common cuttlefish in GSA 17-18. Biomass indices in the AdriaticSea as obtained from the survey data (MEDITS, 1994-2020).

Natural mortality

Due to lack of growth parameters in DCF database, and use of CMSY and SPICTproduction model (this model has no need for natural mortality estimate) the natural mortality of common cuttlefish was not estimated by EWG 21-15.

Growth

The information on the age-length key (ALK) and on the growth von Bertalanffy parameters was not available for common cuttlefish in GSAs 17 and 18. The only Von Bertalanffy growth parameter for common cuttlefish in the Adriatic Sea available in DCF biological data is Linf of 16.6 cm reported by Slovenia (GSA17, period 2014-2016). Othergrowth parameters were not reported in DCF data for GSAs 17 and 18.

Maximum size of mantle length (ML) reported to DCF (landing table) is 29 cm (ITA, GSA17, 2015, FPO), while the maximum ML registered in MEDITS data in the AdriaticSea was 21.5 cm.

All available DCF data on mantle length (ML, cm) – weight (g) relationship of common cuttlefish indicate negative alometric growth of this species in the Adriatic Sea.

Table 6.4.1.1 Common cuttlefish in GSA 17-18. Availability of growth parameters.(Source: DCF database)

country	area	start_year	end_year	sex	vb_linf	vb_k	vb_t0	a	b	l_w_samp	l_w_size_	l_w_units
SVN	GSA 17	2018	2020	C	NA	NA	NA	0.2182	2.7572	1036	1.90-15.50	cm
ITA	GSA 17	2019	2019	C	NA	NA	NA	0.2365	2.7438	135	3-13 cm	cm/g
ITA	GSA 17	2019	2019	F	NA	NA	NA	0.2293	2.7628	74	3-13 cm	cm/g
ITA	GSA 17	2019	2019	M	NA	NA	NA	0.2537	2.7044	61	3-13 cm	cm/g
ITA	GSA 17	2016	2016	C	NA	NA	NA	0.2112	2.812	174	4-17 cm	cm/g
ITA	GSA 17	2016	2016	F	NA	NA	NA	0.2099	2.818	103	4-17 cm	cm/g
ITA	GSA 17	2016	2016	M	NA	NA	NA	0.2366	2.76	71	4-14 cm	cm/g
ITA	GSA 17	2013	2013	C	NA	NA	NA	0.1893	2.841	546	2-23 cm	cm/g
ITA	GSA 17	2013	2013	F	NA	NA	NA	0.1947	2.838	280	3-23 cm	cm/g
ITA	GSA 17	2013	2013	M	NA	NA	NA	0.2409	2.735	252	3-17 cm	cm/g
ITA	GSA 17	2012	2012	C	NA	NA	NA	0.2356	2.786	493	3-19 cm	cm/g
ITA	GSA 17	2012	2012	F	NA	NA	NA	0.2418	2.784	203	4-19 cm	cm/g
ITA	GSA 17	2012	2012	M	NA	NA	NA	0.2924	2.676	191	4-18 cm	cm/g
ITA	GSA 17	2011	2011	C	NA	NA	NA	0.3123	2.65	798	3-22 cm	cm/g
ITA	GSA 17	2011	2011	F	NA	NA	NA	0.3084	2.668	391	3-20 cm	cm/g
ITA	GSA 17	2011	2011	M	NA	NA	NA	0.399	2.536	311	3-22 cm	cm/g
ITA	GSA 17	2010	2010	C	NA	NA	NA	0.368	2.59	2050	3-19 cm	cm/g
ITA	GSA 17	2010	2010	F	NA	NA	NA	0.353	2.613	1074	3-18 cm	cm/g
ITA	GSA 17	2010	2010	M	NA	NA	NA	0.475	2.468	960	3-19 cm	cm/g
ITA	GSA 18	2007	2007	C	NA	NA	NA	0.2878	2.6807	522	41.67-996.	cm
ITA	GSA 18	2008	2008	C	NA	NA	NA	0.2984	2.6745	1384	14.53-912.	cm
ITA	GSA 18	2009	2009	C	NA	NA	NA	0.2771	2.7043	1557	4.3-1032.1	cm
ITA	GSA 18	2010	2010	C	NA	NA	NA	0.2726	2.7006	1929	4.05-926.6	cm
ITA	GSA 18	2011	2011	C	NA	NA	NA	0.2799	2.6913	1776	1.7-1408.8	cm
ITA	GSA 18	2012	2012	C	NA	NA	NA	0.2957	2.6777	2336	8.32-1279.	cm
ITA	GSA 18	2013	2013	C	NA	NA	NA	0.2675	2.7159	1788	6.2-973.2	cm
ITA	GSA 18	2014	2014	C	NA	NA	NA	0.2732	2.7013	1507	5.4-1072.2	cm
ITA	GSA 18	2015	2015	C	NA	NA	NA	0.29	2.67	1987	1.4-1326.6	cm
ITA	GSA 18	2016	2016	C	NA	NA	NA	0.3587	2.593	1839	1.8-828.71	cm
ITA	GSA 18	2017	2017	C	NA	NA	NA	0.2584	2.7251	2742	11.89-125	cm
ITA	GSA 18	2018	2018	C	NA	NA	NA	0.2679	2.7167	1910	10.84-881.	cm
ITA	GSA 18	2019	2019	C	NA	NA	NA	0.2632	2.7156	2067	5.27-1016.	cm
ITA	GSA 18	2020	2020	C	NA	NA	NA	0.2862	2.6806	902	10-929.75	cm

Source: DCF

Stock related biological variables are very scarce, and were not provided by Croatia, since exemption rules were applied for this species.

Maturity

Maturity data by length and/or age are not available in DCF database for common cuttlefish in GSAs 17 and 18.

However, according to published work of Manfrin Piccinetti and Giovanardi (1984) the length of the mantle at first sexual maturity of common cuttlefish in the Adriatic Sea is about 10 cm. The spawning period of this species extends throughout the year, with peaks in spring and summer. In the northern and central Adriatic, it reproduces in April and May, but females with mature eggs can be found even in June and July. In the southern Adriatic, it spawns from February to September, but with a peak from April to June. The diameter of the eggs is from 6 to 8 mm (Mandić, 1984).

6.4.2 DATA

6.4.2.1 CATCH (LANDINGS AND DISCARDS)

The available information on the common cuttlefish in GSA 17-18 was very limited due to very low catches of this species along eastern coast of the Adriatic Sea. Also, fisheries from the eastern Adriatic coast of GSA 18 (i.e. non-EU countries Albania and Montenegro) are not included in DCF.

Data regarding the common cuttlefish, collected under framework of Data Collection Framework program, were assumed reliable, but stock related variables were not provided by Croatia at all, since exemption rules (due to low catches) were applied for this species. Data on size structure of common cuttlefish landings have been available only from Italy (i.e. western side of the Adriatic Sea) since 2006.

With aim of obtaining the longest reliable catch data series, beside DCF database, EWG 21-15 considered alternative catch data sources, such as economic transversal data, Istat, EUROSTAT and FAO FishStat databases, as well as outcomes of EU-RECFISH Project and data provided by DG-MARE. Data from non-EU countries, Albania and Montenegro, are currently available from FAO FishStat database (up to 2016), but referring to different statistical division (i.e. Ionian Sea).

Common cuttlefish usually occurs as a by-catch, caught together with other species by the same gear (mixed catches). The main fishing gears are bottom trawls (OTB), pots and traps (FPO) and "rapido" beam trawls (TBB). In addition, gillnets (GNS), and trammel nets (GTR), are also important fishing gears where common cuttlefish may occur as a part of the catches (Table 6.4.2.1.1). Because of that, EWG 19-16 found difficulties in data interpretation of historical catch data, collected outside DCF, considering that this species was usually reported together with other species from families Sepiidae and Sepiolidae (e.g. *S. elegans, S. orbignyana, Rossia macrosoma*, etc.) or was not reported at all.

Taking in consideration that data by species collected through DCF are assumed reliable, the average ratio between catches of other species belonging to Sepiidae and Sepiolidae families were calculated separately for each country based on available data. Then this information was used for estimating the historical catch data of common cuttlefish from fisheries statistic databases (EUROSTAT, FAO FishStat and historical national statistics).

Table 6.4.2.1.1 Common cuttlefish in GSA 17-18. Catch of common cuttlefish in GSA 17 -18 by fishing gears from 2004-2020.

Gear	Tons	%
OTB	31193.45	54.58%
FPO	10069.07	17.62%
TBB	7379.341	12.91%
GNS	4379.067	7.66%
GTR	2618.779	4.58%
FYK	1052.236	1.84%
DRB	261.094	0.46%
Other	202.6862	0.35%
Total	57155.72	100.00%

However, when compared, tables that were provided by different DCF data calls, such as MED & BS data call with transversal datasets (EAR data call) and FDI, it seems that not all gears, having common cuttlefish as a part of the catch, are reported in catch and landing data tables. Therefore, the tables of MED &BS data seem to be underestimating total catches of common cuttlefish in comparison with corresponding catch data from other sources.

Regarding the stock assessment of common cuttlefish in the Adriatic Sea (GSA 17-18), the major concern was the availability and reliability of historical catch data. In order to describe the historical catch of this species in the Adriatic, data from several available sources (such as: FAO FishStat, ISTAT, National statistics databases, DCF - Transversal data, DCF commercial data and data from EU-RECFISH project) were extracted and compared with each other.

The catch of the common cuttlefish by Italian fishery fleet in the Adriatic Sea for period from 1972 to 2007 were provided through activities of EU-RECFISH project (RECovery ofFISheries Historical time series for the Mediterranean and Black Sea stock assessment- EASME/EMFF/2016/1.3.2.5/01/SI2.770039). It is assumed that these values are the best currently available for the counties covered by RECFISH. The landings and discard data of common cuttlefish caught by Italian fishery fleet for period from 2008 to 2017 were available through DCF MED&BS, Transversal datasets and FDI. The gap between 2000 to 2007 was the most concerning one considering that different databases (GFCM- FISHSTAT, ISTAT, and EUROSTAT) contain different values for the same years. Although GFCM-FISHSTAT database contains the complete data from 1972 to the recent, the landings of *S. officinalis* were reported together with other similar species (Sepiidae, Sepiolidae etc.). Additional difficulty was that landings from GSA 18 were reported as part of Ionian statistical division (GFCM 37.2.2). Therefore, RECFISH data were used for that period. (Table 6.4.2.1.2).

The landings and discards of common cuttlefish of Slovenian, Croatian and Montenegrin fishery fleets were provided through GFCM-FISHSTAT and DCF (SVN and HRV) datasets. For the period before 2008 in the landings of Croatian fishery fleet this species was reported together with similar species (Sepiidae, Sepiolidae etc.). In order to reconstruct the historical dataset, the average ratio between the catches of common cuttlefish and other similar species was calculated based on available data from 2008-2016. The average share in catch of 0.078 of the other species were applied on historical data to calculate the Croatian landings of common cuttlefish.

Table 6.4.2.1.2 Common cuttlefish in GSA 17-18. History of commercial catches (t) by countries and GSAs (all fishing gears combined) as used in assessment.

Year	CROATIA GSA 17	SLOVENIA GSA 17	ITALY GSA 17	ITALY GSA 18	MONTENEGRO GSA 18	ALBANIA GSA 18	Ex-Yugoslavia (SLO, HRV & MTN)	Total catch (t)
1972			6151	1109			174	7433
1973			5818	1086			160	7063
1974			5411	1063			192	6666
1975			6360	1432			218	8010
1976			4845	1357			244	6446
1977			5093	1273			194	6560
1978			3589	1163			170	4922
1979			4441	1148			140	5729
1980			9158	1289			199	10646
1981			6161	869			159	7189
1982			9203	1103			146	10451

1983			10379	1808			176	12363
1984			7244	1118			153	8515
1985			8955	1230			148	10333
1986			7987	3069			144	11199
1987			6336	1215			177	7728
1988			6534	1462			219	8216
1989			4724	1224			200	6147
1990			4902	835			276	6013
1991			6917	1854			158	8929
1992	154	12	4621	1442	2			6231
1993	187	21	4693	1322	6			6229
1994	109	4	10368	1185	5			11671
1995	109	10	6193	1620	9	39		7979
1996	94	6	4000	798	10	33		4941
1997	139	5	4563	755	9	33		5504
1998	198	18	3710	868	10	51		4856
1999	134	18	3431	593	10	51		4237
2000	127	11	2756	884	10	50		3838
2001	78	72	2707	1220	10	22		4109
2002	41	22	1447	981	10	52		2553
2003	65	25	2270	710	10	43		3122
2004	36	29	2005	597	10	70		2747
2005	74	33	4074	1630	8	75		5893
2006	65	24	5008	2040	15	86		7239
2007	84	41	8603	1207	18	47		10000
2008	73	15	6276	960	15	62		7401
2009	68	14	5683	1243	7	126		7141
2010	86	7	3375	1140	9	98		4715
2011	105	8	2324	866	11	90		3403
2012	169	10	2575	663	12	80		3510
2013	189	4	2956	1018	11	85		4263
2014	207	6	3230	811	13	75		4341
2015	193	4	3316	879	14	82		4488
2016	113	5	2991	970	14	83		4177
2017	107	3	2474	1618	8	83		4293
2018	92	1.576	2323	1420	11	79		3927
2019	91	5	2345	655	13	60		3169
2020	103	7	1462	494	13	67		2147

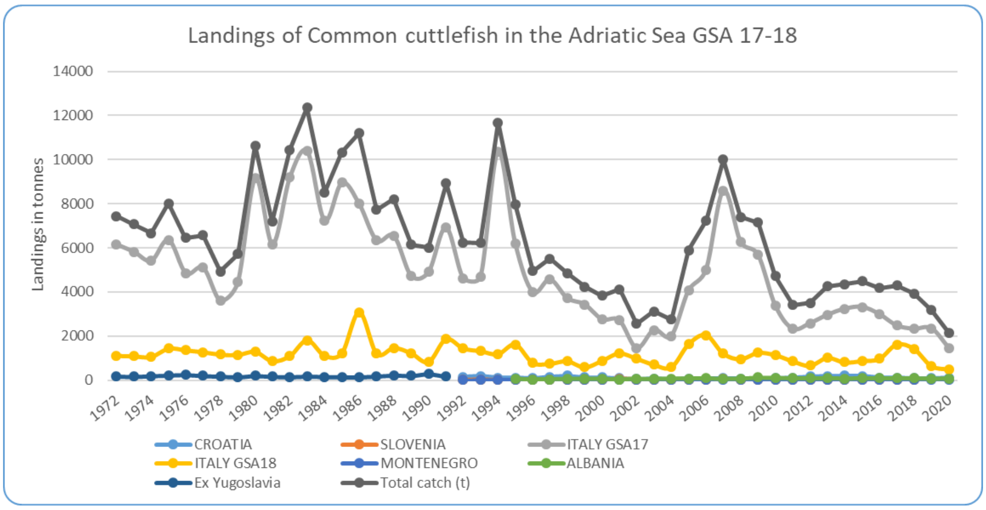


Figure 6.4.2.1.1 Common cuttlefish in GSA 17-18. Total landings (t).

The combined data form all sources is shown in Table 6.4.2.1.2 to obtain the best input data for stock assessment. The total landings of common cuttlefish in the Adriatic Sea (GSA 17 and 18) from 1972 to 2020 ranged from 2,147 to 12,363 t with average value approx. 6,300 t (Figure 6.4.2.1.1). The largest amount of common cuttlefish in the Adriatic Sea has been landed by Italian fishing fleet.

The combined landings for common cuttlefish in GSA 17-18 are given in Table 6.4.2.1.2. For the two GSAs separately. Data already split by GSA is allocated accordingly. Only for the early years some data are not separated by states of the former Yugoslavia (Table6.4.2.1.2), the amounts are small, typically between 2 and 4% of the total, and for simplicity this small percentage was allocated to GSA 17 and GSA 18 equally (Table 6.4.2.1.2).

Conclusions to Landing data

Some uncertainty still remains regarding concerning the validity of these data based on different datasets that should be further investigated. The largest differences are in the five years 2000 to 2004.. The two data sets (Table 6.4.2.1.3) were both tested in the assessment this year and a sensitivity test run for to evaluate the effect of the differences. They caused very minor differences to the stock assessment for the years concerned but had no significant effect at all on the current state of the stock or the estimate of B_{MSY} or MSY. See Section 6.4.3 for sensitivity analysis.

Table 6.4.2.1.3 Common cuttlefish in GSA 17-18. Commercial catches (t) by from Italian data 2000 to 2007.

	ISTAT regression with Transversaldatabase 2018			Italian Correspondents data 2019		
Year	Italy GSA17	Italy GSA18	Total all countries 17-18	Italy GSA17	Italy GSA18	Total all countries 17-18
2000	2756	884	3838	6356	5319	11873
2001	2707	1220	4109	7502	2648	10332
2002	1447	981	2553	3231	1338	4694
2003	2270	710	3122	4155	986	5284
2004	2005	597	2747	4396	899	5440

2005	4074	1630	5893	4043	876	5109
2006	5008	2040	7239	4508	1343	6041
2007	8603	1207	10000	7964	970	9124

Catch at length

Data on catch size structure were available only from Italian side of the Adriatic Sea bygears and by GSAs (GSA 17 and 18) in the period 2006-2020 as shown in Figures 6.4.2.1.2 and 6.4.2.1.3.

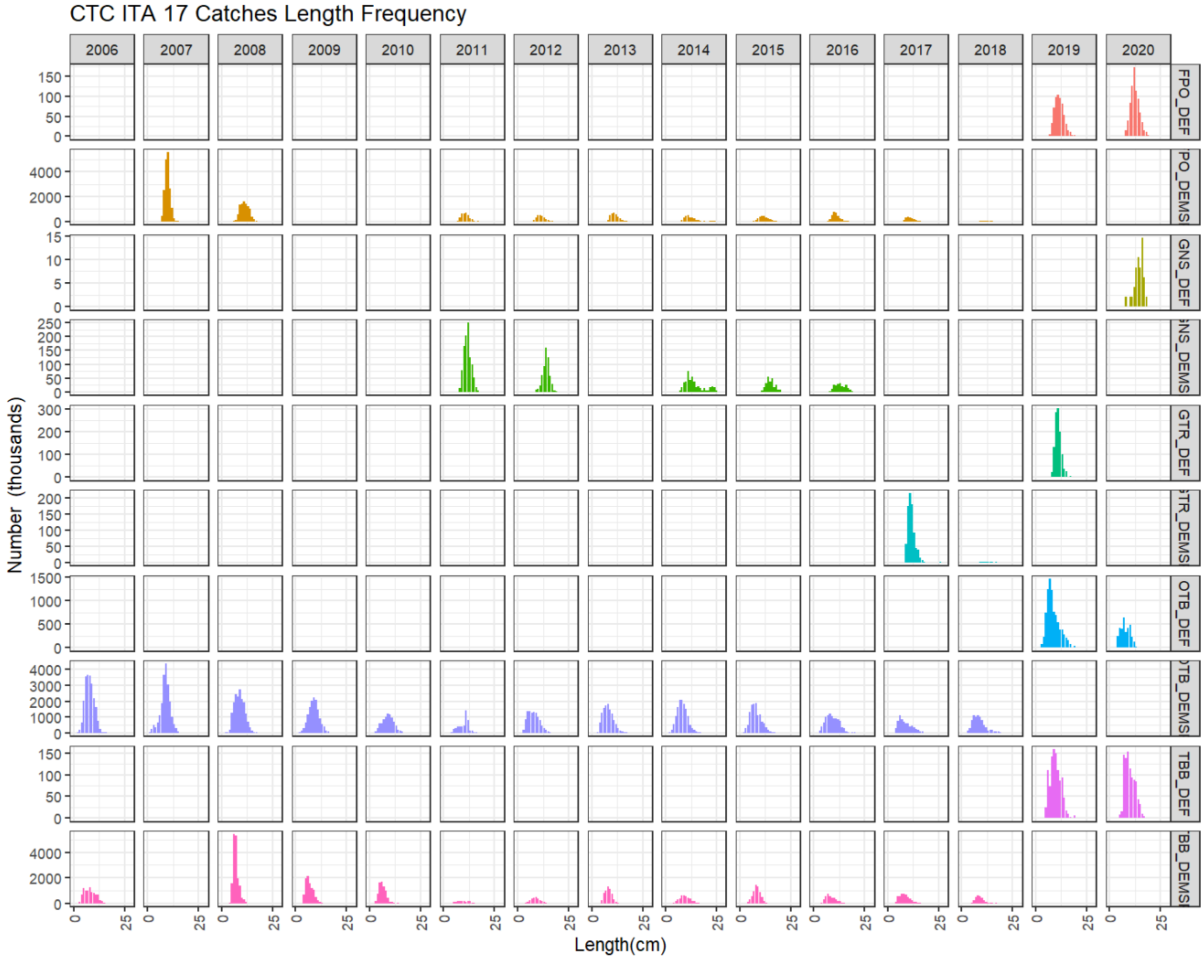


Figure 6.4.2.1.2 Common cuttlefish in GSA 17-18. Catch size distribution (mantle lengths in cm) in the western part of GSA 17 (ITA) by principal fishing gears.

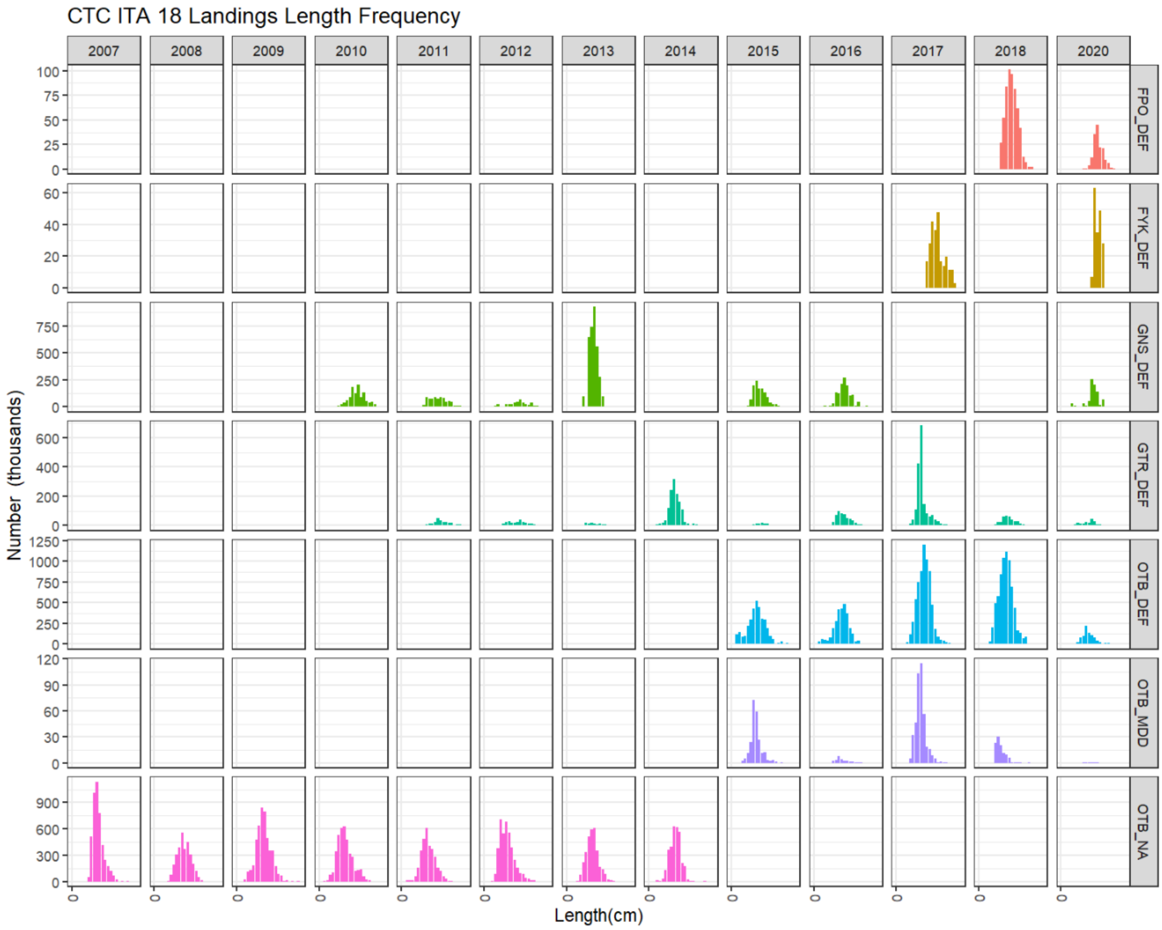


Figure 6.5.2.1.3 Common cuttlefish in GSA 17-18. Catch size distribution (mantle lengths in cm) in the western part of GSA 18 (ITA) by principal fishing gears.

Data on size distribution of common cuttlefish caught by Italian bottom trawlers in GSA 17 ranged from 1 to 27 cm (ML), while in GSA 18 the range was from 2 to 24 cm (Figure 6.4.2.1.2 and 6.4.2.1.3). Average mantle length of landed specimens in GSA 17 between2006 and 2020 varied from 7.8 to 9.8 cm with overall average of 8.5 cm. In GSA 18 average length varied between 8.2 to 10.7 cm from 2007 to 2020 with overall averageof 9.5 cm (Figure 6.4.2.1.4).

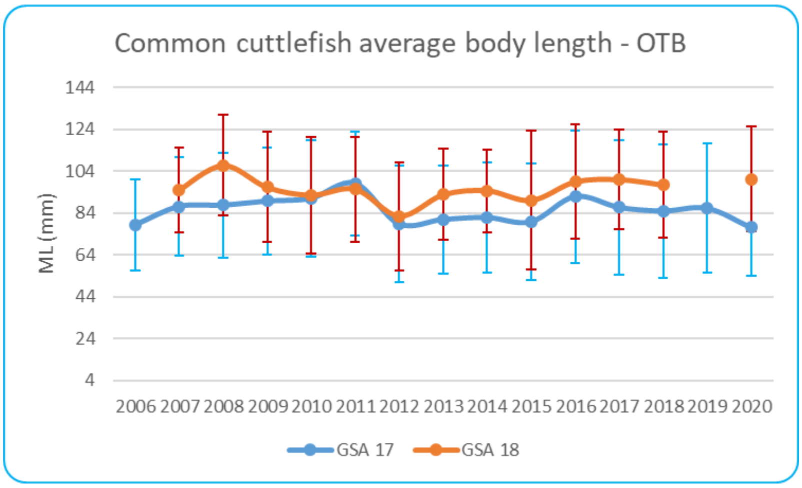


Figure 6.4.2.1.4 Common cuttlefish in GSA 17-18. Average mantle length of individuals landed by bottom trawl fisheries

Data on size distribution of common cuttlefish caught by Italian set net fisheries were scarce and available only for last several years. In GSA 17 it ranged from 7 to 25 cm(ML) (Figure 6.4.2.1.2), while in GSA 18 the range was from 3 to 23 cm (Figure 6.4.2.1.3). Average mantle length of landed specimens in GSA 17 between 2011 and 2017 varied from 11.6 to 15.2 cm with overall average of 12.7 cm. In GSA 18 average length varied between 9.3 to 13.7 cm from 2010 to 2020 with overall average of 10.6

cm (Figure 6.4.2.1.5).

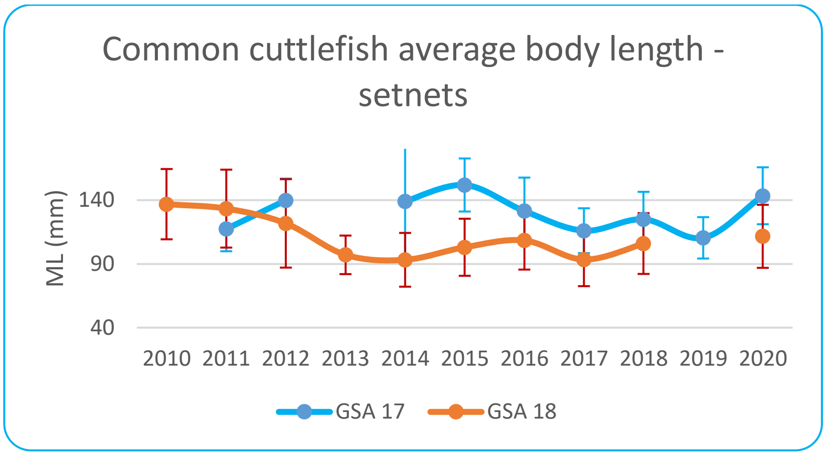


Figure 6.4.2.1.5 Common cuttlefish in GSAs 17 and 18. Average mantle length of common cuttlefish landed by Italian set net fisheries

Size distribution of common cuttlefish caught by Italian pot and traps (FPO) fisheries in GSA 17 ranged from 4 to 29 cm (ML), while in GSA 18 catches of common cuttlefishfrom this fishery were reported only in 2018 and 2020. The average length of landed specimens in GSA 17 between 2006 and 2017 varied from 9.7 to 12.1 cm with overall average of 10.8cm. (Figure 6.4.2.1.6). The mantle length of landed specimens in GSA 18 cm variedfrom 8 to 19 cm with overall average of 11.85 cm.

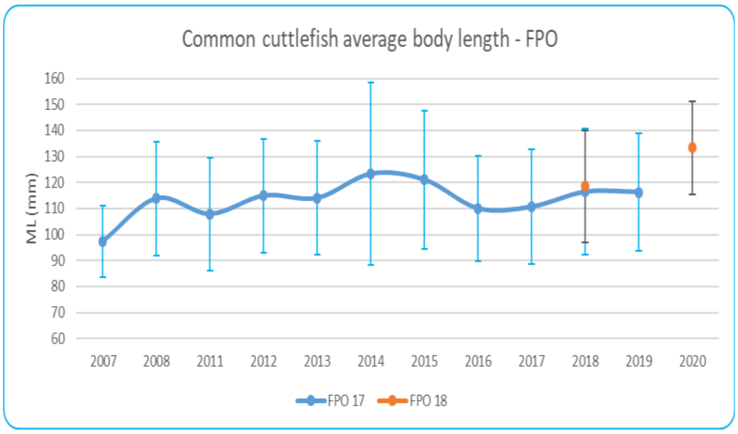


Figure 6.4.2.1.6 Common cuttlefish in GSAs 17-18. Average mantle length (right) of common cuttlefish landed by Italian FPO fishery in GSA 17.

Size distribution of common cuttlefish caught by Italian rapido fisheries (TBB) fisheries in GSA 17 ranged from 4 to 23 cm (ML), while in GSA 18 catches of common cuttlefish from this fishery are not reported in DCF tables. Average mantle length of landed specimens in GSA 17 between 2006 and 2017 varied from 6.3 to 9.8 cm with overall

average of 7.7 cm. (Figure 6.4.2.1.7).

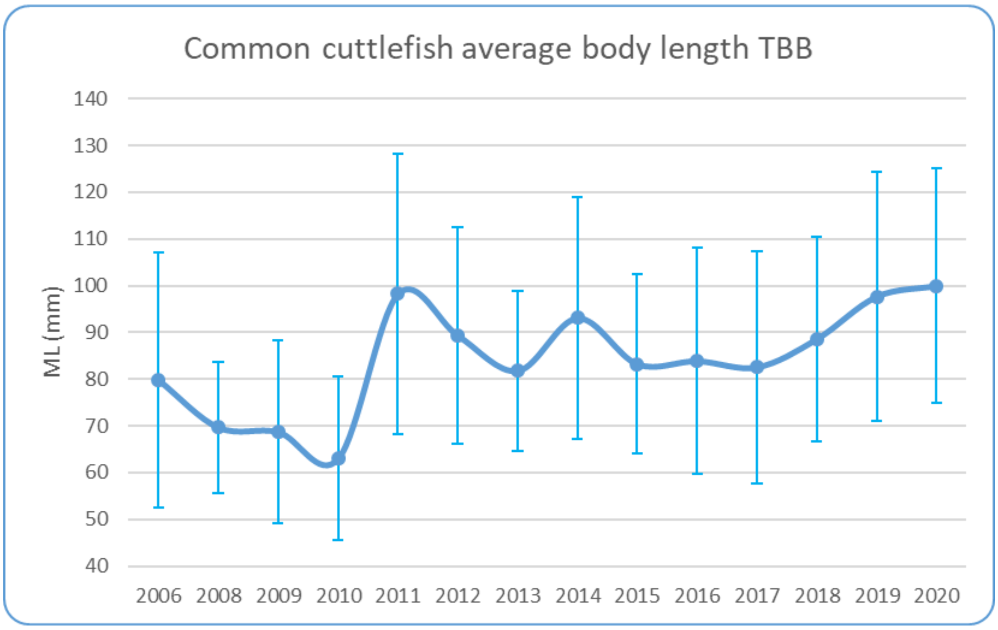


Figure 6.4.2.1.7 Common cuttlefish in GSAs 17-18. Average mantle length (right) of common cuttlefish landed by Italian TBB fishery in GSA 17.

Discards

Since discards of common cuttlefish in the Adriatic Sea is less than 1 % in compare to landings no biological data could be collected from commercial fishery. Therefore, landings of this species, can be considered as catch data of this species.

6.4.2.2 EFFORT

Common cuttlefish is caught by mixed fisheries, using several fishing gears (gillnets, trammel nets, trawls), by fishing boats of different sizes (different metiers, VL0006 - VL1824). In such situation, being common cuttlefish only one component of entire catches, fishing effort related to common cuttlefish only cannot be obtained. The effort of these fleets is given in Table 6.4.2.2.1.

Table 6.4.2.2.1 Effort of fleets that report catches of Common Cuttlefish by country and by gear 2005 to 2020 for Italy and Slovenia, 2012-2019 for Croatia.

Year	GNS		GTR			FPO	OTB			DRB	TBB
	HRV	ITA	HRV	ITA	SVN	ITA	HRV	ITA	SVN	HRV	ITA
2005		162073		43309	1313	12446		198883	831		15302
2006		151703		46069	1263	29855		188218	963		11717
2007		121526		43602	1969	33928		164475	1202		15424
2008		112676		55473	2184	29729		156340	1254		20276
2009		146323		51017	2332	40058		176894	1205		13394
2010		129160		64821	2388	33047		155983	1263		13649
2011		144020		67917	3080	28986		147841	1178		12392
2012	47610	124110	27363	63573	3025	32529	35572	133247	917	1883	8759
2013	43354	130490	29234	29909	3811	29029	35492	135813	766	2867	10301
2014	45170	99795	27101	47756	5346	32810	36287	116177	665	3883	7973
2015	44346	101502	28685	28692	5230	20891	34742	113299	670	5303	10814
2016	43324	103659	25356	29800	4058	28393	33715	115892	777	5061	9937
2017	44524	60977	25075	42158	3453	20607	35649	125597	697	4453	9004
2018	50024	81849	28765	57057	3046	49566	33137	136374	692	3606	9352
2019	91084	75896	29349	50957	2972	44720	30977	116081	769	2934	11849
2020	91909	65093	34150	41377	2868	40107	30187	93136	879	2778	7602

6.4.2.3 SURVEY DATA

Survey data comes from MEDITS surveys. In GSA 17 MEDITS data are available from 1996 to 2020. In GSA 18 Italian data were available from 1994, while in Albania first survey has been held in 1996, while in Montenegro MEDITS survey start from 2008.

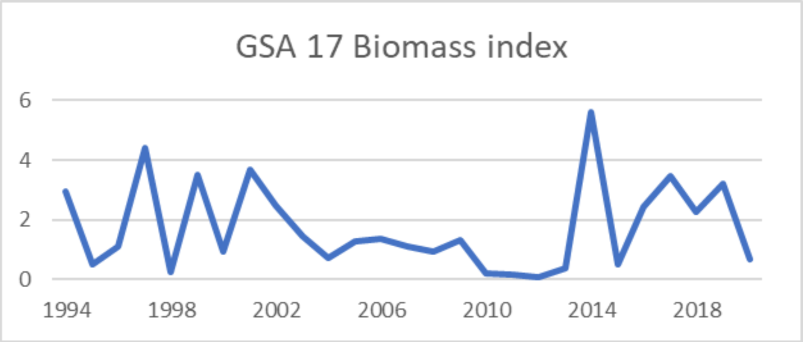
A SOLEMON survey data was not available for this EWG. It is hoped that in future this survey will provide additional or alternative tuning indices.

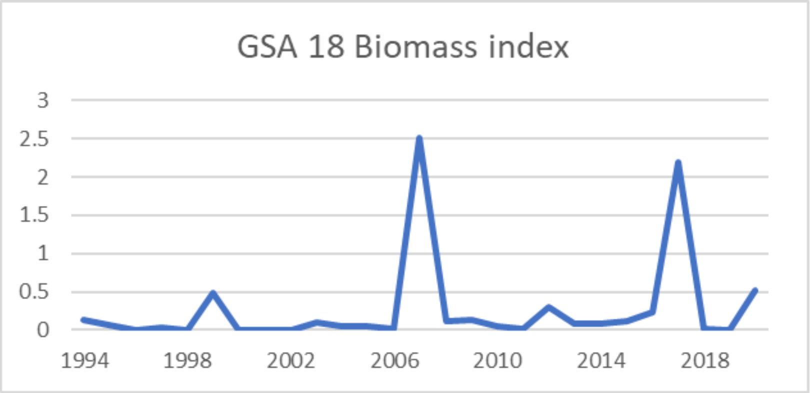
The MEDITS surveys were carried out annually, usually during spring-summer period by all Adriatic countries. However, in some years MEDITS surveys, covering western part of the Adriatic Sea, were delayed and carried out in autumn, even in winter period (2007 in Slovenian waters) (Figure 6.4.2.3.1.). All available MEDITS data (survey indices) from Adriatic countries (GSAs 17 and GSA 18) were combined and data series from 1994 to 2020 is obtained. Data were analysed using the JRC script (Mannini, 2020)

Figure 6.4.2.3.1 Common cuttlefish in GSA 17-18. MEDITS survey period in GSA 17 and 18 from 1994 to 2020, note late surveys in 2014, 2017 and 2020.

The common cuttlefish in GSA 17-18 in MEDITS survey shows oscillating trend in their mean standardized abundance/biomass indices during the time series analysed, but in generally, negative trend is visible from 2002 to 2011. Starting from 2012, positive trend appears with significantly high values in 2014, and 2017 (Figure 6.4.2.3.2). However, these values should be taken with caution considering that in these years' surveys in the western partof the Adriatic Sea were performed in later period (late November in 2014, late September in 2016, during December in 2017 and October 2020). The noted high values could be affected by behavioural characteristics of common cuttlefish like seasonal migration and grouping of individuals. The values for 2014 and 2017 are particularly high and have been removed from the series for the purposes of using the survey biomass indices for the assessment.

Biomass indices in GSA 17 ranged from 0.07 kg/km^{-2} (2012) to 5.6 kg/km^{-2} 2014. Higher values in some years should be taken with caution considering the period when survey has been conducted (in 2002 and 2016 in late September, while in 2014 and 2017 it was late November and in December). Since occurrence of common cuttlefish in GSA 18 is sporadic, fluctuation of the indices are more pronounced. Trends of indices by GSA are showed on Figure 6.4.2.3.2.





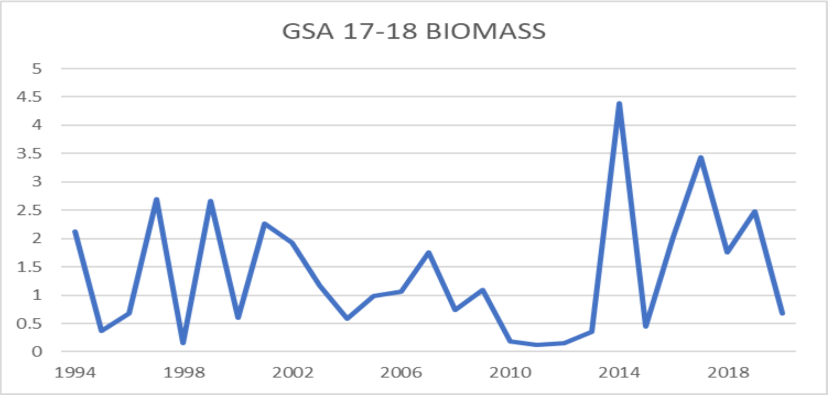


Figure 6.4.2.3.2 Common cuttlefish in GSAs 17 and 18 and 17-18 combined. Biomass indices MEDITS surveys 1994 to 2020

Table 6.4.2.3.1 Common cuttlefish in GSAs 17 and 18 and 17-18 combined. Trends of biomass indices MEDITS surveys 1994 to 2020. Values highlighted in grey were omitted from the assessment due to atypical survey timing. Zero values for GSA 18 were substituted with low values equivalent to 50% of lowest observed real value (0.004512) to allow fitting in a model with assumption of lognormal distributions.

Year	GSA 17	GSA 18	GSA 17-18
1994	2.94	0.13	2.13
1995	0.49	0.07	0.37
1996	1.13	0.00	0.68
1997	4.41	0.04	2.70
1998	0.26	0.00	0.16
1999	3.50	0.49	2.67
2000	0.93	0.00	0.59
2001	3.66	0.00	2.26
2002	2.48	0.00	1.93
2003	1.44	0.11	1.16
2004	0.72	0.05	0.58
2005	1.27	0.04	0.98
2006	1.36	0.01	1.06
2007	1.09	2.51	1.76
2008	0.92	0.12	0.74
2009	1.33	0.12	1.09
2010	0.22	0.04	0.19
2011	0.16	0.01	0.13
2012	0.07	0.30	0.16
2013	0.40	0.09	0.35
2014	5.61	0.08	4.39
2015	0.52	0.12	0.45
2016	2.45	0.23	2.03
2017	3.45	2.19	3.44
2018	2.25	0.01	1.76
2019	3.20	0.00	2.49
2020	0.69	0.52	0.68

Geomorphological characteristics in the Adriatic Sea (GSA 17 and GSA 18), like type of sediment and area of depth strata, have an influence on distribution of this species. In GSA 17 the shallower area covered with sandy sediments along Italian coast predominates in comparison to “rocky” Croatian coast and southern part of Adriatic (GSA 18). Southern part is characterized with narrow costal platform covered mostly by muddy sediments which limits distribution of common cuttlefish. Its occurrence fluctuates during the MEDITS surveys time series, but in generally is usually significantly higher in GSA 17 showing that *Sepia officinalis* is more abundant and widespread in GSA 17 than in GSA 18. (Figure 6.4.2.3.3 and 6.4.2.3.4).

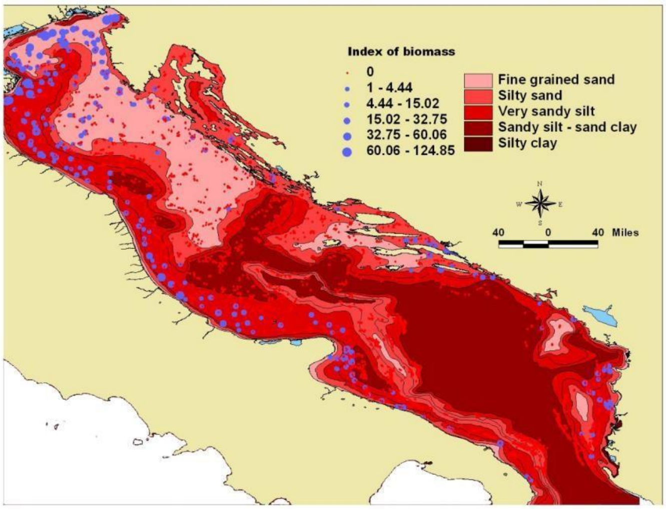


Figure 6.4.2.3.3 Common cuttlefish in GSAs 17 and 18. Distribution of common cuttlefish by depth and sediment type in the Adriatic Sea.

Length distributions and size trends The overall size distribution of common cuttlefish in GSA 17 and 18 from the MEDITS surveys ranged from 1.5 to 21.5 cm of mantle length with average of 8.27 cm in GSA 17 and 8.37 cm in GSA 18 (Figure 6.4.2.3.6 and 6.4.2.3.7).

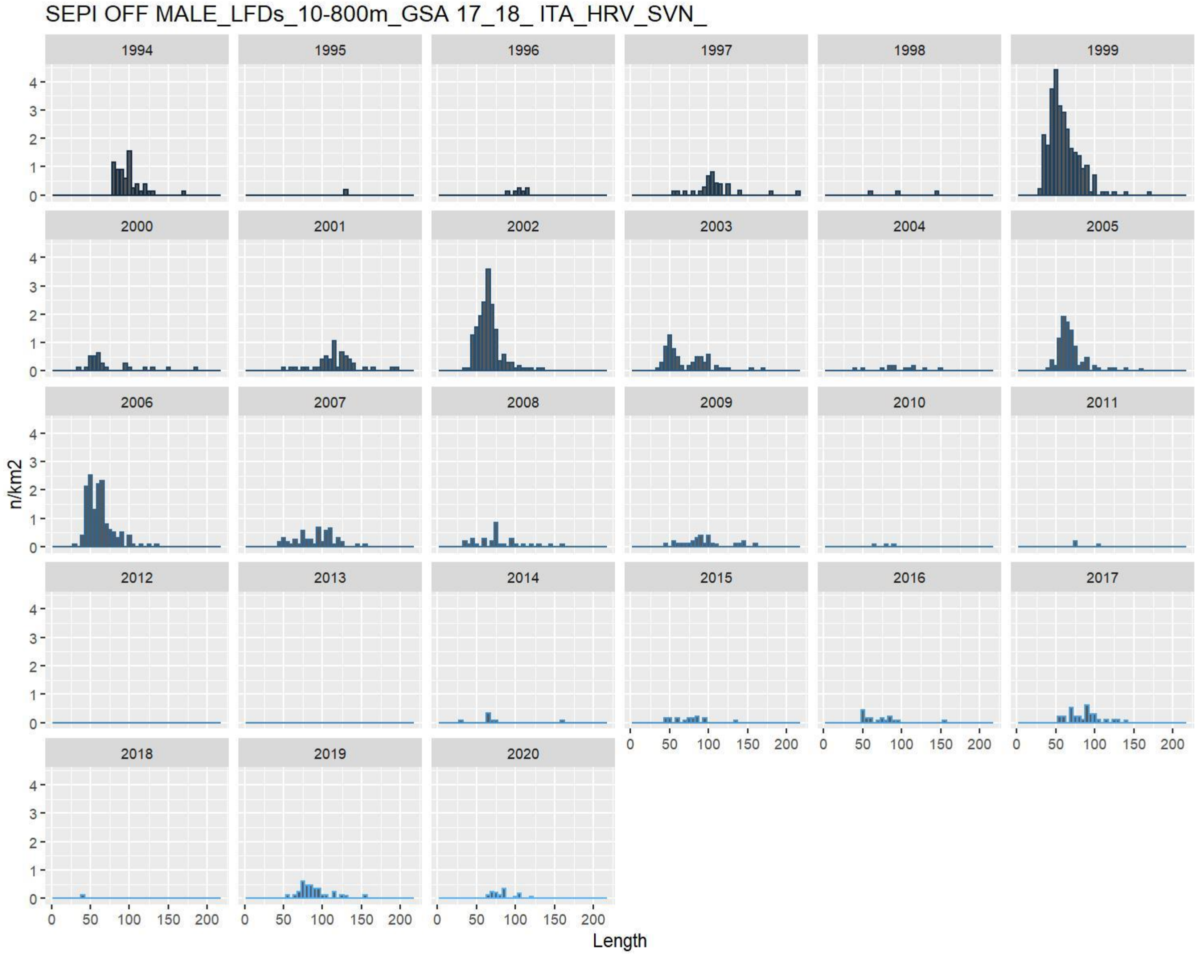


Figure 6.4.2.3.6 Common cuttlefish in GSA 17-18. Length structure (in mm) sampled during surveys in GSA 17 and 18 combined (MEDITS, 1994-2020).

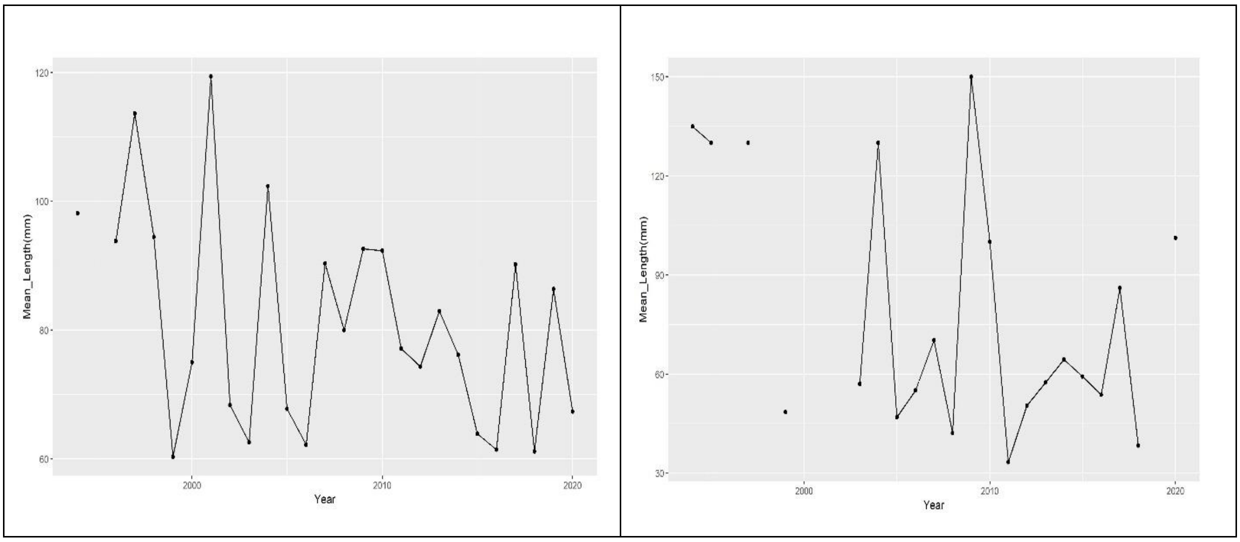


Figure 6.4.2.3.7 Common cuttlefish in GSAs 17 and 18. Trends of average mantle length of common cuttlefish in GSA 17 (a) and GSA 18 (b) during the MEDITS surveys

6.4.3 STOCK ASSESSMENT

After comprehensive analysis of the data provided throughout the DCF data call and fisheries statistical databases for this area EWG 19-16 noticed some shortages of information. The main issues were partial availability of size data from commercial fisheries and insufficiency of growth parameters for this species. This data limited situation prevents possibility to use age/size based assessment models. Therefore, taking in consideration shortage of biological data and the biological cycles of common production models were used in order to conduct stock assessment of common cuttlefishin GSA 17 and 18 combined and in GSA 17 alone.

6.4.3.1 METHOD 1: CMSY

CMSY is a Monte-Carlo method that estimates fisheries reference points (MSY, F_{MSY}, B_{MSY})as well as relative stock size (B/ B_{MSY}) and exploitation (F/ F_{MSY}) from catch data and broad priors for resilience or productivity (r) and for stock status (B/k) at the beginning and the end of the time series. Part of the CMSY package is an advanced Bayesian state-space implementation of the Schaefer surplus production model (BSM). The main advantage of BSM compared to other implementations of surplus production models is the focus on informative priors and the acceptance of short and incomplete (= fragmented) abundance data. The required R-code can be downloaded from https://github.com/SISTA16/cmsy. The version used for these assessments is CMSY++12b.R with the most recent version of the JAGS Gibbs sampler. The revised version provides greater control of priors and diagnostic plots along with improved section of r-k options.

Input data

Data as presented in Table 6.4.2.1.2.

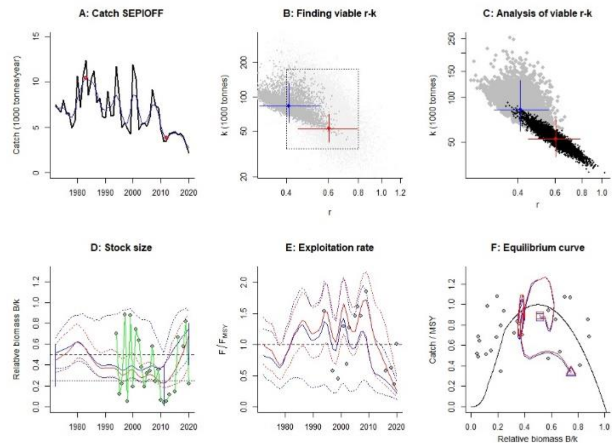
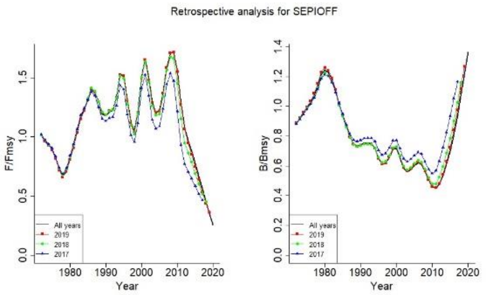
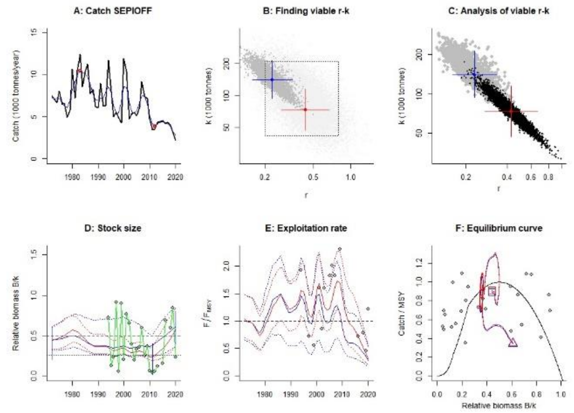
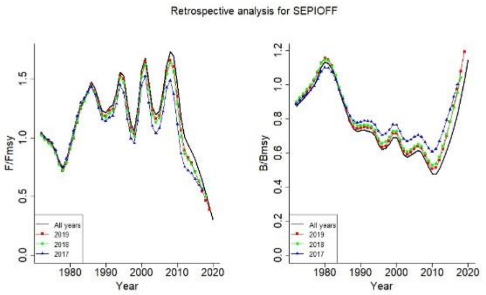
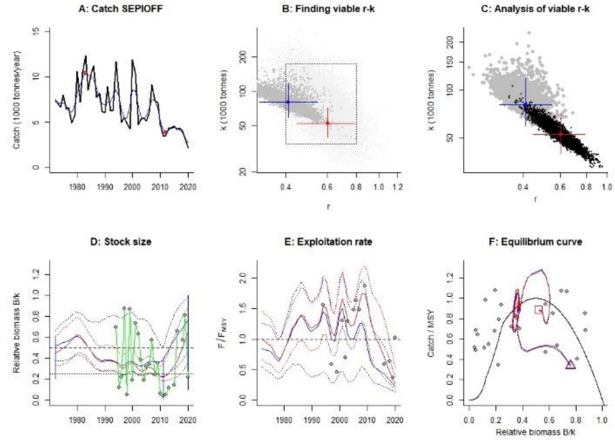
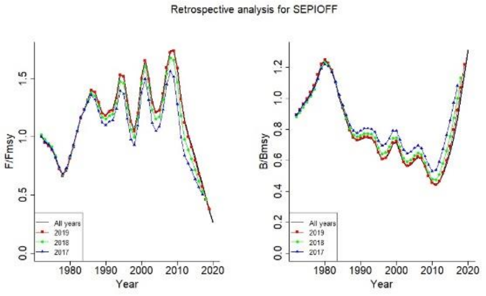
Biomass

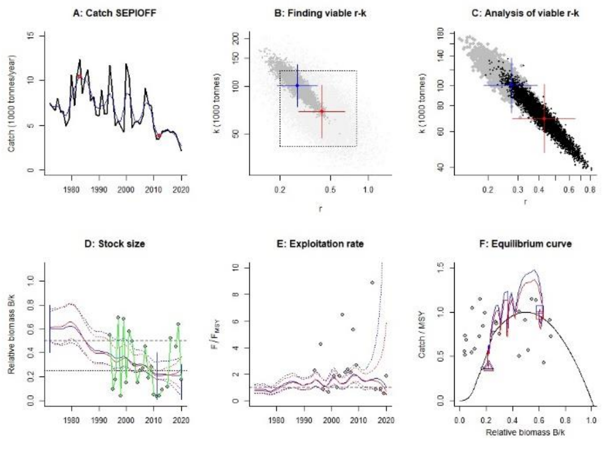
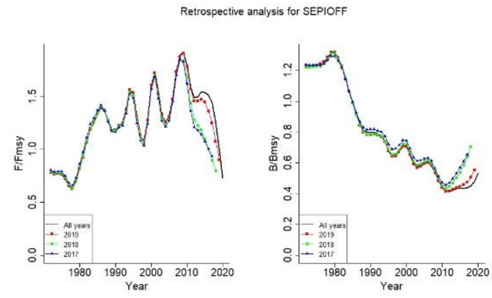
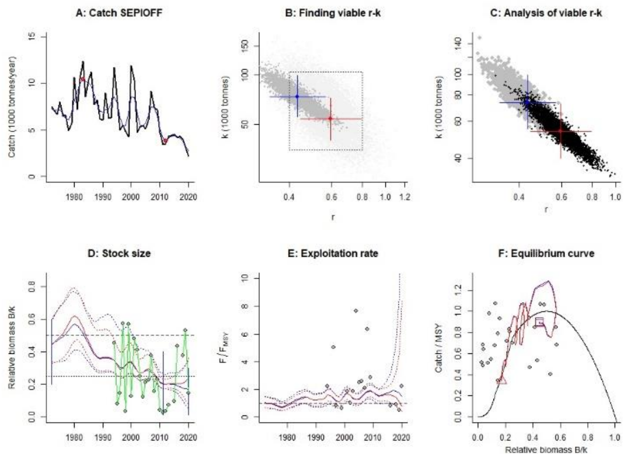
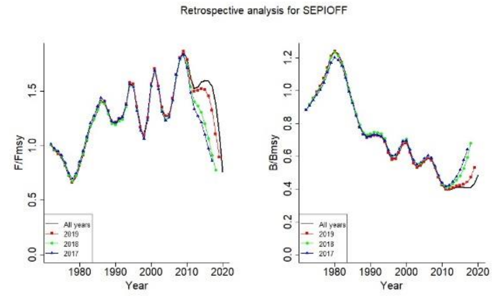
The biomass from MEDITS surveys in GSA 17 and 18 were used as tuning indices (Table6.4.3.1). Survey data for complete area were available from 1996 onwards. Considering the extreme values of biomass index in 2014 and 2017, which is most likely consequence of conducting the surveys in autumn-winter period, data were excluded for these years for joint GSA 17-18 Index and GSA 17 Index.

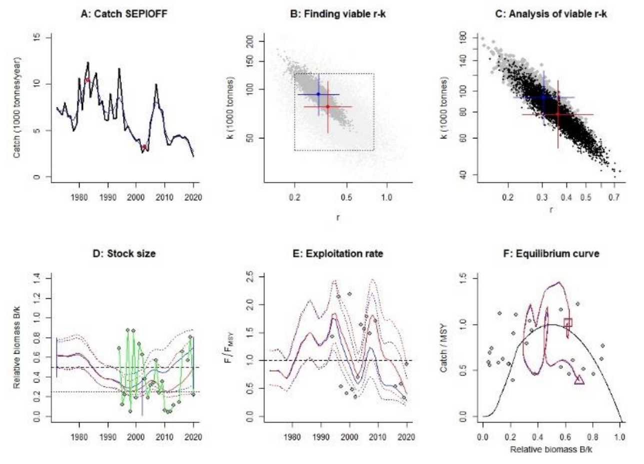
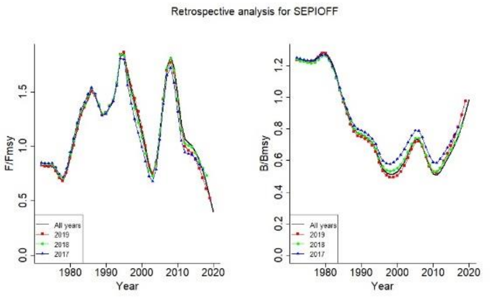
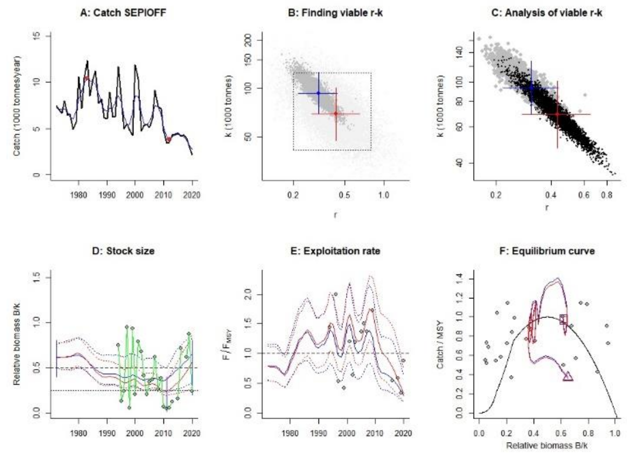
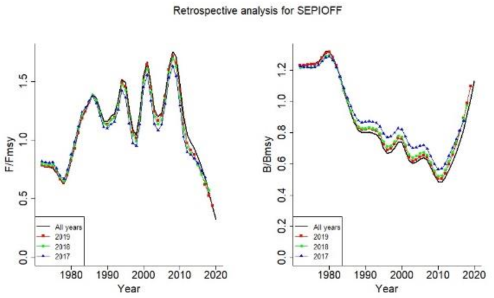
Exploration GSA 17-18

Most of the exportation was carried out on the combined data set, however as most of the catch and survey biomass come from GSA 17, the two assessments are very similar in terms of residuals and fit. Considering biology of this species that is described as fast growing, short living species with higher reproductive potential (Relini et al., 1999; Vrgoč et al. 2004), resilience or productivity (r) prior was set initially at 0.4-0.8 range. Considering the strong positive trends in the index of biomass in recent years and occurrence of common cuttlefish during the last MEDITS surveys and only slight positive trends in the catches of commercial fisheries, the final prior of relative biomass was set at midrange. Initial biomass 0.2-0.6, final biomass 0.4-0.8, intermediate biomass prior and year were left as defaults.

Sensitivity analysis with varying these priors was carried out. The approach was to extend the priors primarily where posterior distributions were observed to be close to the limits. Initial values of r were found almost on the lower bound (Figure 6.4.3.1 a). Also, the retrospective for this base case was poor, particularly for F. So, the prior on r was widened until the posterior lay well within the prior, thus the fit was based more on the data (b). Then the biomass prior options on both start and final biomass were also extended successively including the option of removing all priors on the final biomass (d). Both posterior distribution and retrospective performance were used to evaluate the model and the choice was based on less informative priors except where model retrospectives deteriorated. In the final assessment model (e) the results predominantly followed the data with slight influence from the final biomass prior. This option gave the best retrospective performance, giving stable results over time. Finally the model was tested for sensitivity to the catch 2000 to 2007.

a) Initial settings (see text)		
b) r-0.2-0.8		
c) Final Biomass wide priors 0.1-1.0		

d) No prior on final biomass		
e) r 0.4-0.8; b start 0.2-0.6 end 0.3-0.7		

Sensitivity with low catches 2000-2007		
e) Final prior options (see below)		

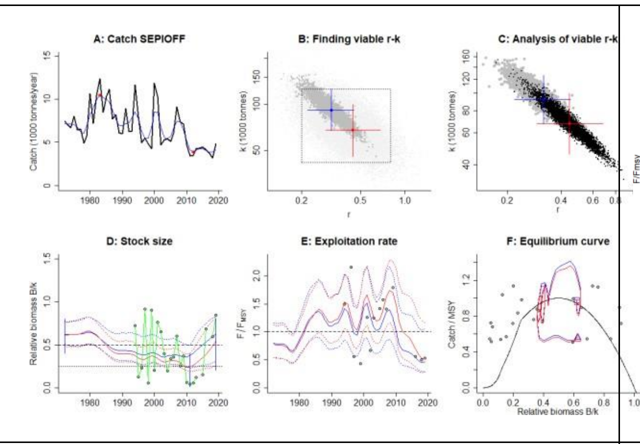
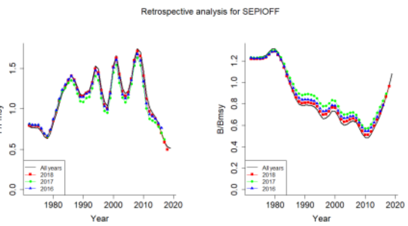
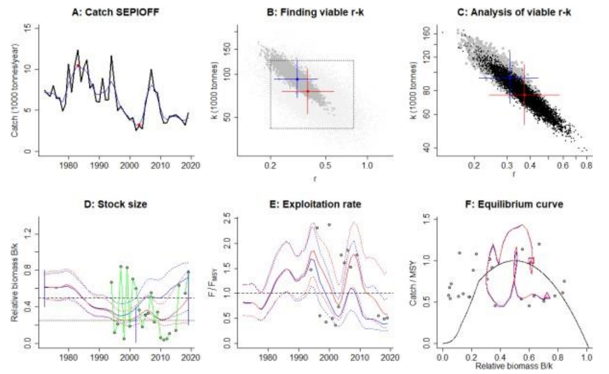
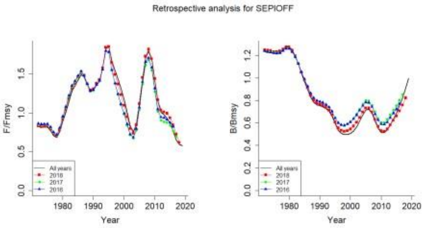
e) Final prior options (seebelow)		
f) Sensitivity to lower catch2000-2007		

Figure 6.4.3.1 GSA 17-18 Model fit and retrospective performance for different priors (a-e) and sensitivity to choice of catch 2000-2007 (f). Final model setting for priors were; r 0.2 to 0.8, Start biomass 0.4-0.8, end biomass 0.2 0.8. (Intermediate biomass was left at default values) The final model output and diagnostics are given in Table 6.4.3.1 and Figure 6.4.3.2. The posterior distributions are in within the range of priors and the retrospective is good.

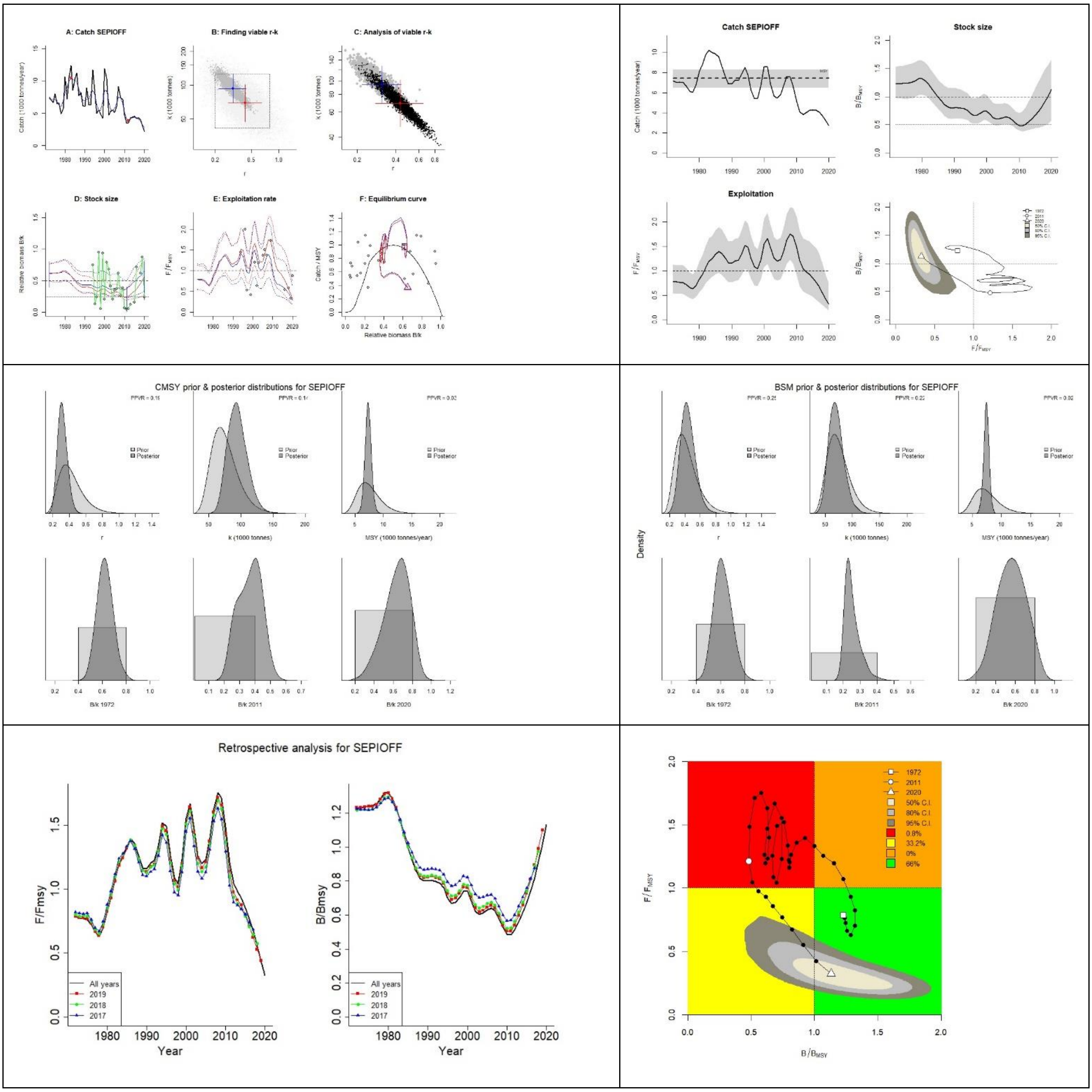


Figure 6.4.3.2 CMSY Assessment GSA 17-18 with higher catch option 2000-2007 (as 2020)

a) Fitting of model, b) Biomass and F and B/BMSY and F/FMSY. c and d) priors and posterior distributions. e) retrospective performance of F/FMSY and B/BMSY f) kobe plot showing current location of stock in F and B space.

Results of CMSY model GSA 17-18

Results for management (based on BSM analysis

Fmsy = 0.156, 95% CL = 0.109 - 0.219 (if B ¿ 1/2 Bmsy then Fmsy = 0.5 r)

Fmsy = 0.156, 95% CL = 0.109 - 0.219 (r and Fmsy are linearly reduced if B ¡ 1/2 Bmsy)

MSY = 7.45, 95% CL = 6.5 - 8.33; Bmsy = 46.7, 95% CL = 34.8 - 63.2 (1000 tonnes)

Biomass in last year = 38.7, 95% CL = 21.2 - 58.6 (1000 tonnes)

B/Bmsy in last year = 1.13, 95% CL = 0.571 - 1.66

Fishing mortality in last year = 0.071, 95% CL =0.0423 - 0.14

F/Fmsy = 0.326, 95% CL = 0.188 - 0.736

Results of CMSY++ analysis conducted in JAGS

r = 0.313, 95% CL = 0.218 - 0.439; k = 93.4, 95% CL = 69.6 - 126 (1000 tonnes)

MSY = 7.31, 95% CL = 6.26 - 8.44 (1000 tonnes/year)

Relative biomass last year = 0.652 k, 95% CL = 0.341 - 0.853

Exploitation F/(r/2) in last year = 0.363

Results from Bayesian Schaefer model using catch and CPUE

r = 0.43, 95% CL = 0.278 - 0.652; k = 69.4, 95% CL = 47.6 - 101

MSY = 7.45, 95% CL = 6.5 - 8.33 (1000 tonnes/year)

Relative biomass in last year = 0.652 k, 95% CL = 0.341 - 0.853

Exploitation F/(r/2) in last year = 0.221

q = 4.11e-05, 95% CL = 2.64e-05 - 6.33e-05

Prior range of q = 3.98e-05 - 0.000159

Relative abundance data type = CPUE

Prior initial relative biomass = 0.4 - 0.8 expert

Prior intermediate relative biomass = 0.01 - 0.4 in year 2011 default

Prior final relative biomass = 0.2 - 0.8 expert

Prior range for r = 0.2 - 0.8 expert, prior range for k = 41.8 - 125 (1000 tonnes) default

Source for relative biomass: NA

Table 6.4.3.1 Stock Summary Table Common cuttlefish in GSA 17-18 (t *10^3)

Year	Catch	F/Fmsy	B	F	B/Bmsy
1972	7.43	0.79	42.45	0.17	1.23
1973	7.06	0.77	42.40	0.17	1.23
1974	6.67	0.77	42.64	0.17	1.24
1975	8.01	0.76	42.71	0.16	1.24
1976	6.45	0.73	42.75	0.16	1.24
1977	6.56	0.66	43.36	0.14	1.26
1978	4.92	0.63	44.34	0.14	1.28
1979	5.73	0.70	45.38	0.15	1.32
1980	10.65	0.83	45.45	0.18	1.32
1981	7.19	0.93	44.31	0.20	1.28
1982	10.45	1.07	42.49	0.23	1.23
1983	12.36	1.20	39.96	0.26	1.15
1984	8.52	1.26	37.11	0.27	1.07
1985	10.33	1.33	34.58	0.29	1.00
1986	11.20	1.40	32.16	0.30	0.92
1987	7.73	1.36	29.92	0.29	0.86
1988	8.22	1.26	28.50	0.27	0.82
1989	6.15	1.16	27.88	0.25	0.80
1990	6.01	1.16	28.05	0.25	0.80
1991	8.93	1.20	28.03	0.26	0.80
1992	6.23	1.22	27.76	0.26	0.80
1993	6.23	1.34	27.42	0.29	0.79
1994	11.67	1.52	26.43	0.33	0.76
1995	7.98	1.49	24.64	0.32	0.70
1996	4.94	1.26	23.36	0.27	0.67
1997	5.50	1.09	23.65	0.23	0.67
1998	4.86	1.04	24.62	0.22	0.70
1999	4.24	1.23	25.90	0.26	0.74
2000	11.87	1.55	25.91	0.33	0.74
2001	10.33	1.67	24.04	0.36	0.69
2002	4.69	1.47	21.91	0.31	0.62
2003	5.28	1.26	21.17	0.27	0.60
2004	5.44	1.20	21.45	0.26	0.61
2005	5.11	1.23	22.08	0.26	0.63
2006	6.04	1.40	22.42	0.30	0.64
2007	9.12	1.63	21.90	0.35	0.63
2008	7.40	1.75	20.32	0.37	0.58
2009	7.14	1.71	18.48	0.36	0.53
2010	4.72	1.48	17.22	0.30	0.49
2011	3.40	1.21	17.09	0.24	0.48

2012	3.51	1.05	18.12	0.21	0.51
2013	4.26	0.98	19.81	0.20	0.56
2014	4.34	0.93	21.74	0.20	0.61
2015	4.49	0.86	23.71	0.18	0.67
2016	4.18	0.77	26.07	0.16	0.74
2017	4.29	0.68	28.71	0.14	0.82
2018	3.93	0.55	31.54	0.12	0.91
2019	3.17	0.43	34.90	0.09	1.01
2020	2.15	0.33	38.67	0.07	1.13

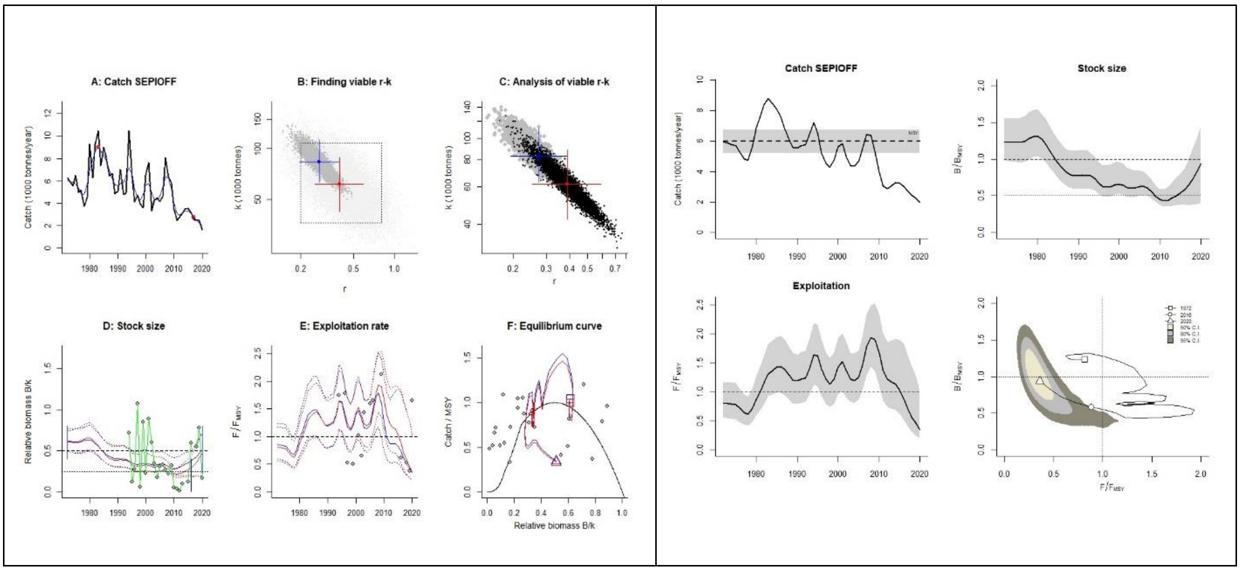
Conclusions to Assessment model for GSA 17-18

The CMSY model indicating the recent recovery of common cuttlefish stock with negative trends in exploitation rate and fisheries mortality and with biomass slightly above the level of B_{MSY}. However, the estimated confidence intervals were significant concerning the estimates relative biomass.

CMSY for GSA 17

The input data for GSA 17 are given in Tables 6.4.2.1.2 and 6.4.2.3.1. The model settingare the same as for GSA 17-18 combined, as indices and catches are very similar, asGSA 18 provides only a small catch and minor addition to the survey abundance data.

The assessment results are provided in Figure 6.4.3.3 and Table 6.4.3.4.2. The model diagnostics and results are similar to those for GSA 17-18 combined with similar good retrospective performance. The state of the stock is similar F below to F_{MSY} and B close to 30% of B_{MSY}. The overall quality of the assessment is substantively with very similar confidence intervals and values.



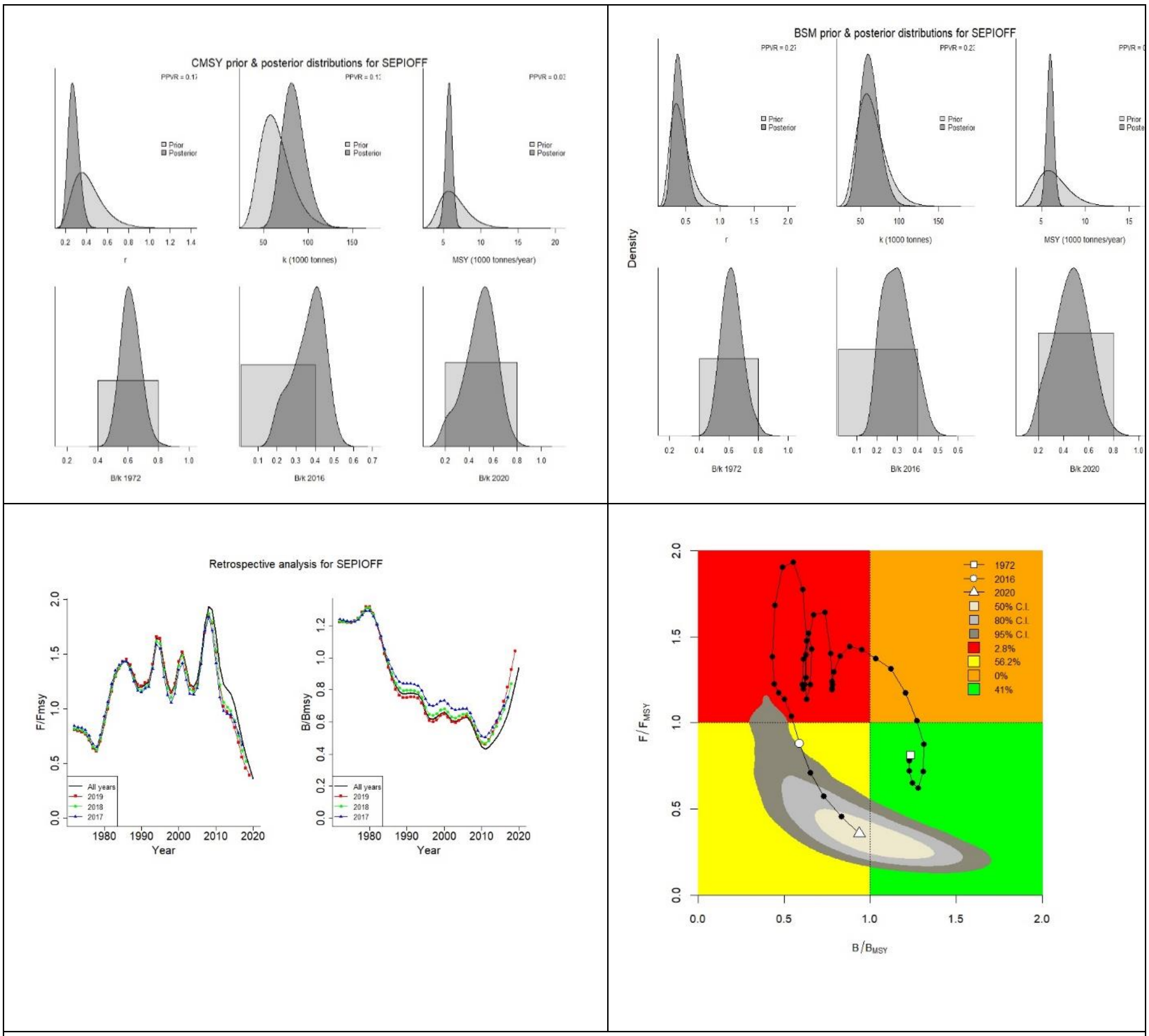


Figure 6.4.3.3 CMSY Assessment GSA 17 with higher catch option 2000-2007 a) fitting of model, b) Biomass and F and B/B$_{MSY}$ and F/F$_{MSY}$. c and d) priors and posterior distributions. e) retrospective performance of F/F$_{MSY}$ and B/B$_{MSY}$ f) kobe plot showing current location of stock in F and B space.

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Species: Sepia officinalis, stock: SEPIOFF
Cuttlefish in Adriatic Sea
Region: Mediterranean, Adriatic Sea
Catch data used from years 1972 - 2020, abundance = CPUE
Prior initial relative biomass = 0.4 - 0.8 expert
Prior intermediate rel. biomass= 0.01 - 0.4 in year 2016 default
Prior final relative biomass   = 0.2 - 0.8 expert
Prior range for r = 0.2 - 0.8 expert, prior range for k = 35.9 - 108
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B/k prior used for first year, intermediate year, last year
Prior range of q = 6.95e-05 - 0.000278, assumed effort creep 0 %

Results of CMSY++ analysis
-------------------------
r   = 0.274, 95% CL = 0.194 - 0.385, k = 83.1, 95% CL = 62.7 - 112
MSY = 5.72, 95% CL = 4.85 - 6.58
Relative biomass in last year = 0.509 k, 2.5th perc = 0.204, 97.5th perc = 0.714
Exploitation F/(r/2) in last year = 0.35, 2.5th perc = 0.207, 97.5th perc = 1.04

Results from Bayesian Schaefer model (BSM) using catch & CPUE
------------------------------------------------------------
q   = 6.71e-05, lcl = 4.26e-05, ucl = 0.000105 (derived from catch and CPUE)
r   = 0.39, 95% CL = 0.254 - 0.591, k = 61.3, 95% CL = 42.3 - 88.6, r-k log correlation = -0.898
MSY = 5.98, 95% CL = 5.22 - 6.76
Relative biomass in last year = 0.469 k, 2.5th perc = 0.203, 97.5th perc = 0.725
Exploitation F/(r/2) in last year = 0.359, 2.5th perc = 0.204, 97.5th perc = 1.02

Results for Management (based on BSM analysis)
-------------------------------------------------------------
Fmsy = 0.137, 95% CL = 0.0972 - 0.192 (if B > 1/2 Bmsy then Fmsy = 0.5 r)
Fmsy = 0.137, 95% CL = 0.0972 - 0.192 (r and Fmsy are linearly reduced if B < 1/2 Bmsy)
MSY  = 5.98 , 95% CL = 5.22 - 6.76
Bmsy = 41.6 , 95% CL = 31.4 - 55.9
Biomass in last year = 28.5 , 2.5th perc = 13.2 , 97.5 perc = 44.3
B/Bmsy in last year  = 0.937 , 2.5th perc = 0.407 , 97.5 perc = 1.45
Fishing mortality in last year = 0.0707 , 2.5th perc = 0.0406 , 97.5 perc = 0.157
Exploitation F/Fmsy  = 0.359 , 2.5th perc = 0.204 , 97.5 perc = 1.02

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Table 6.4.3.2 Stock Summary Table Common cuttlefish in GSA 17 (t*10^3)

Year	Catch	F	F.Fmsy	B	B.Bmsy
1972	6.24	0.16	0.81	37.90	1.24
1973	5.90	0.16	0.80	37.72	1.23
1974	5.51	0.15	0.79	37.60	1.22
1975	6.47	0.15	0.78	37.56	1.22
1976	4.97	0.14	0.72	37.71	1.23
1977	5.19	0.13	0.65	38.26	1.25
1978	3.67	0.12	0.62	39.30	1.28
1979	4.51	0.14	0.72	40.03	1.31
1980	9.26	0.17	0.88	40.10	1.31
1981	6.24	0.20	1.01	38.82	1.27

1982	9.28	0.23	1.17	36.89	1.21
1983	10.47	0.26	1.31	34.48	1.12
1984	7.32	0.27	1.37	31.66	1.03
1985	9.03	0.28	1.42	29.41	0.95
1986	8.06	0.28	1.44	27.30	0.88
1987	6.43	0.27	1.39	25.49	0.83
1988	6.64	0.25	1.30	24.49	0.79
1989	4.82	0.23	1.20	24.05	0.78
1990	5.04	0.23	1.19	24.20	0.78
1991	7.00	0.24	1.22	24.25	0.78
1992	4.79	0.24	1.24	24.11	0.78
1993	4.90	0.27	1.40	23.86	0.77
1994	10.48	0.32	1.64	22.82	0.74
1995	6.31	0.32	1.63	20.92	0.67
1996	4.10	0.27	1.39	19.51	0.63
1997	4.71	0.24	1.22	19.27	0.62
1998	3.93	0.22	1.14	19.54	0.63
1999	3.58	0.24	1.22	20.24	0.65
2000	6.49	0.28	1.43	20.49	0.66
2001	7.65	0.29	1.52	19.88	0.64
2002	3.29	0.26	1.37	18.94	0.61
2003	4.25	0.24	1.22	18.67	0.60
2004	4.46	0.23	1.20	18.89	0.61
2005	4.15	0.24	1.26	19.30	0.62
2006	4.60	0.29	1.48	19.45	0.63
2007	8.09	0.35	1.78	18.71	0.61
2008	6.36	0.38	1.93	17.06	0.55
2009	5.77	0.36	1.90	15.13	0.49
2010	3.47	0.29	1.68	13.73	0.45
2011	2.44	0.23	1.38	13.31	0.43
2012	2.75	0.21	1.23	13.69	0.44
2013	3.15	0.21	1.17	14.53	0.47
2014	3.44	0.21	1.14	15.48	0.50
2015	3.51	0.20	1.04	16.54	0.54
2016	3.11	0.17	0.88	17.94	0.59
2017	2.58	0.14	0.71	19.82	0.65
2018	2.42	0.11	0.57	22.25	0.73
2019	2.44	0.09	0.46	25.28	0.83
2020	1.57	0.07	0.36	28.50	0.94

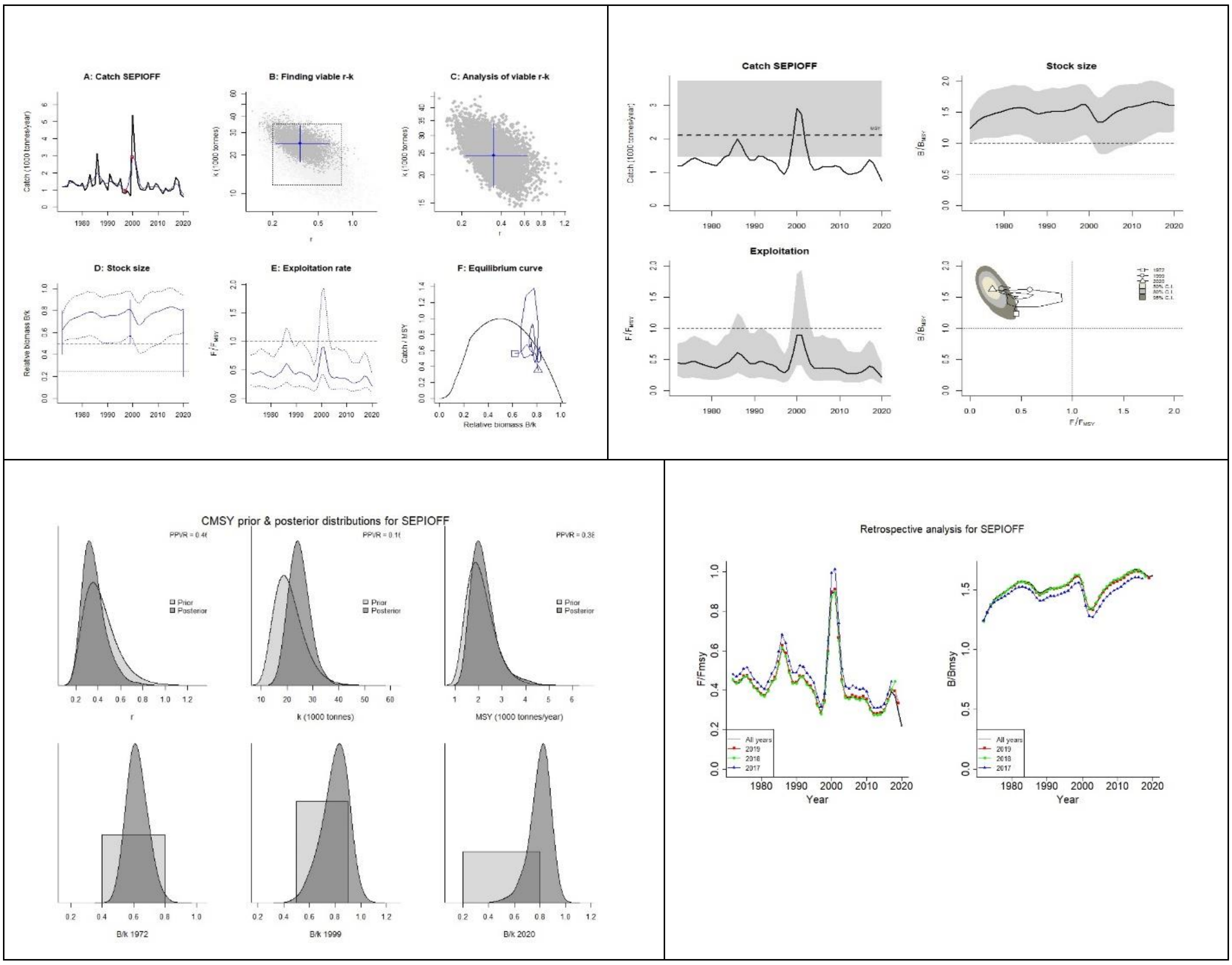
Conclusions to CMSY model for GSA 17

The CMSY model indicates that GSA 17 has similar properties to the combined stock in GSA 17-18 as the area contains most of the stock, there is a recent recovery of common cuttlefish stock with negative trends in exploitation rate and fisheries mortality and with biomass slightly above the level of B$_{MSY}$. However, the estimated confidence intervals were significant concerning the estimates relative biomass. Considering these results and short lifecycles that is highly dependent on environmental factors, EWG recommends the precautionary approach.

CMSY for GSA 18

The input data for GSA 18 are given in Tables 6.4.2.1.2 and 6.4.2.3.1. Initially a model similar to the one used for GSA 17-18 was tested, but fit to the survey was very poor the survey was not considered informative for the GSA. The range of biomass very limited. An alternative catch only model was tested with priors similar to those for GSA 17-18 combined.

The assessment results are provided in Figure 6.4.3.4 and Table 6.4.3.4.3. The model diagnostics indicate a poor assessment with the location of the stock dependent almost entirely on the priors (Figure 6.4.3.4c). The stock is seen to have a very small range of biomass on the right side of the yield curve, but r and k are located substantively by the priors.



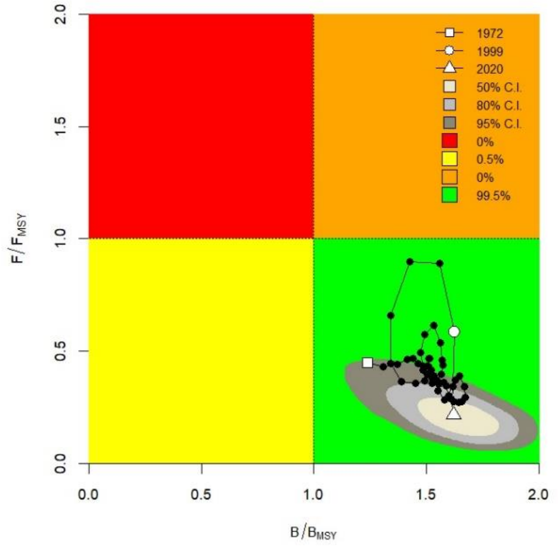


Figure 6.4.3.4 CMSY Assessment GSA 18 with higher catch option 2000-2007 a) fitting of model, b) Biomass and F and B/B$_{MSY}$ and F/F$_{MSY}$. c priors and posterior distributions. d) kobe plot showing current location of stock in F and B space. e) retrospective performance of F/F$_{MSY}$ and B/B$_{MSY}$

Results of CMSY model GSA 18

Species: Sepia officinalis , stock: SEPIOFF

Cuttlefish in Adriatic Sea

Region: Mediterranean , Adriatic Sea

Catch data used from years 1972 - 2020 , abundance = None

Prior initial relative biomass = 0.4 - 0.8 expert

Prior intermediate rel. biomass= 0.5 - 0.9 in year 1999 default

Prior final relative biomass = 0.2 - 0.8 expert

Prior range for r = 0.2 - 0.8 expert, , prior range for k = 11.6 - 34.9

B/k prior used for first year , intermediate year , last year

Results of CMSY++ analysis

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r = 0.348 , 95% CL = 0.214 - 0.626 , k = 24.4 , 95% CL = 17.6 - 33.8

MSY = 2.11 , 95% CL = 1.45 - 3.73

Relative biomass in last year = 0.811 k, 2.5th perc = 0.6 , 97.5th perc = 0.936

Exploitation F/(r/2) in last year = 0.217 , 2.5th perc = 0.108 , 97.5th perc = 0.436

Results for Management (based on CMSY analysis)

Fmsy = 0.174 , 95% CL = 0.107 - 0.313 (if B > 1/2 Bmsy then Fmsy = 0.5 r)

Fmsy = 0.174 , 95% CL = 0.107 - 0.313 (r and Fmsy are linearly reduced if B < 1/2 Bmsy)

MSY = 2.11 , 95% CL = 1.45 - 3.73

Bmsy = 12.2 , 95% CL = 8.79 - 16.9

Biomass in last year = 19.5 , 2.5th perc = 13 , 97.5 perc = 28.3

B/Bmsy in last year = 1.62 , 2.5th perc = 1.2 , 97.5 perc = 1.87

Fishing mortality in last year = 0.0381 , 2.5th perc = 0.0238 , 97.5 perc = 0.0629

Exploitation F/Fmsy = 0.217 , 2.5th perc = 0.108 , 97.5 perc = 0.436

Table 6.4.3.3 Stock Summary Table Common cuttlefish in GSA 18 ($t*10^3$)

Year	Catch	F	F.Fmsy	B	B.Bmsy
1972	1.20	0.08	0.45	15.16	1.24
1973	1.17	0.08	0.43	15.96	1.31
1974	1.16	0.08	0.44	16.71	1.37
1975	1.54	0.08	0.47	17.15	1.42
1976	1.48	0.08	0.47	17.49	1.44
1977	1.37	0.08	0.44	17.71	1.46
1978	1.25	0.07	0.42	17.93	1.48
1979	1.22	0.07	0.40	18.16	1.50
1980	1.39	0.07	0.38	18.37	1.52
1981	0.95	0.06	0.37	18.64	1.55
1982	1.18	0.07	0.40	18.79	1.56
1983	1.90	0.08	0.44	18.91	1.57
1984	1.20	0.08	0.46	18.89	1.57
1985	1.30	0.09	0.54	18.75	1.56
1986	3.14	0.11	0.61	18.45	1.53
1987	1.30	0.10	0.57	17.96	1.49
1988	1.57	0.09	0.49	17.69	1.47
1989	1.32	0.08	0.44	17.87	1.48
1990	0.97	0.08	0.43	18.05	1.50
1991	1.93	0.08	0.47	18.16	1.51
1992	1.44	0.08	0.47	18.17	1.51
1993	1.33	0.08	0.43	18.15	1.51
1994	1.19	0.07	0.42	18.23	1.52
1995	1.67	0.07	0.39	18.46	1.53
1996	0.84	0.06	0.33	18.58	1.55

1997	0.80	0.05	0.28	18.85	1.58
1998	0.93	0.06	0.34	19.27	1.62
1999	0.65	0.10	0.59	19.40	1.62
2000	5.38	0.16	0.89	18.67	1.56
2001	2.68	0.16	0.90	17.13	1.42
2002	1.40	0.12	0.66	16.12	1.34
2003	1.04	0.08	0.45	16.11	1.34
2004	0.98	0.06	0.37	16.72	1.39
2005	0.96	0.06	0.36	17.46	1.45
2006	1.44	0.06	0.37	17.89	1.49
2007	1.04	0.06	0.36	18.35	1.53
2008	1.04	0.06	0.35	18.62	1.55
2009	1.38	0.06	0.36	18.86	1.58
2010	1.25	0.06	0.34	18.98	1.59
2011	0.97	0.05	0.30	19.18	1.60
2012	0.76	0.05	0.28	19.46	1.62
2013	1.11	0.05	0.27	19.72	1.64
2014	0.90	0.05	0.28	19.93	1.66
2015	0.98	0.05	0.30	20.10	1.67
2016	1.07	0.06	0.34	20.05	1.67
2017	1.71	0.07	0.39	19.95	1.65
2018	1.51	0.07	0.37	19.59	1.63
2019	0.73	0.05	0.29	19.41	1.61
2020	0.57	0.04	0.22	19.47	1.62

Conclusions to CMSY model for GSA 18

There is insufficient catch variability over time allow a surplus production model to capture the stock dynamics. It is not possible to give catch advice from this model. If it is necessary to give advice, at the moment the best option is to use the combined area assessment. Although the combined area may not constitute a single stock, the joint assessment does reflect the overall joint state of common cuttlefish in GSA 17-18. If an area contains several stocks the aggregated assessment represents the average conditions, but cannot provide protection for all the individual 'stocks'

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6.4.3.2 METHOD 2: SPICT

The stochastic surplus production model in continuous-time (SPiCT) incorporates dynamics in both biomass and fisheries and observation error of both catches and biomass indices. The model has a general state-space form that as special cases contain process and observation-error models as well as state-space models that assume error free catches. More information on the SPiCT assessment method is described in Pedersen and Berg (2016).

Input data

Data as presented in Table 6.4.2.1.2.

Biomass

The biomass from MEDITS surveys in GSA 17 and 18 was used as tuning index. Survey data for complete area were available by from 1994 onwards (Table 6.4.2.3.1) with 2014and 2017 values replaced with NA, as the survey was much later and the values very different.

SPiCT Settings

The setup of the model parameters and variables on relative biomass, relative fishing mortality and K for the start years were required for the model to converge. The priors were setup taking into consideration of the biology of this species that is described as fast growing, short living species with higher reproductivity potential, and the assumption on status of the stock at the beginning of catch time series. The Schaefer production model was selected.

SPiCT Results

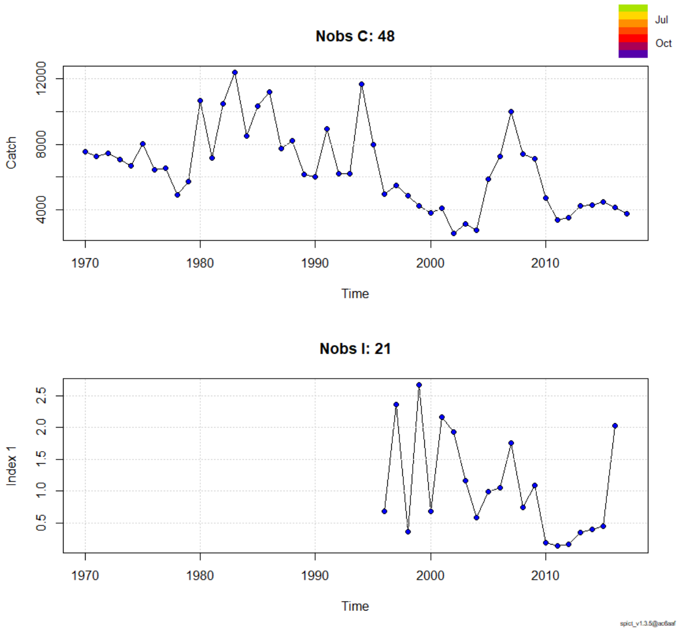


Figure 6.4.3.5 Common cuttlefish in GSAs 17 and 18. Input data for stock assessment of common cuttlefish in GSA 17-18 (Survey values for 2014 and 2017 excluded- see text)

The assessment results show that for the period 2010-2015, the common cuttlefish stockwas not fished in a sustainable manner. The current biomass and fishing mortality are above B_{MSY} and below F_{MSY} estimates, but the uncertainty around those estimates is high.(Figure 6.4.3.6)

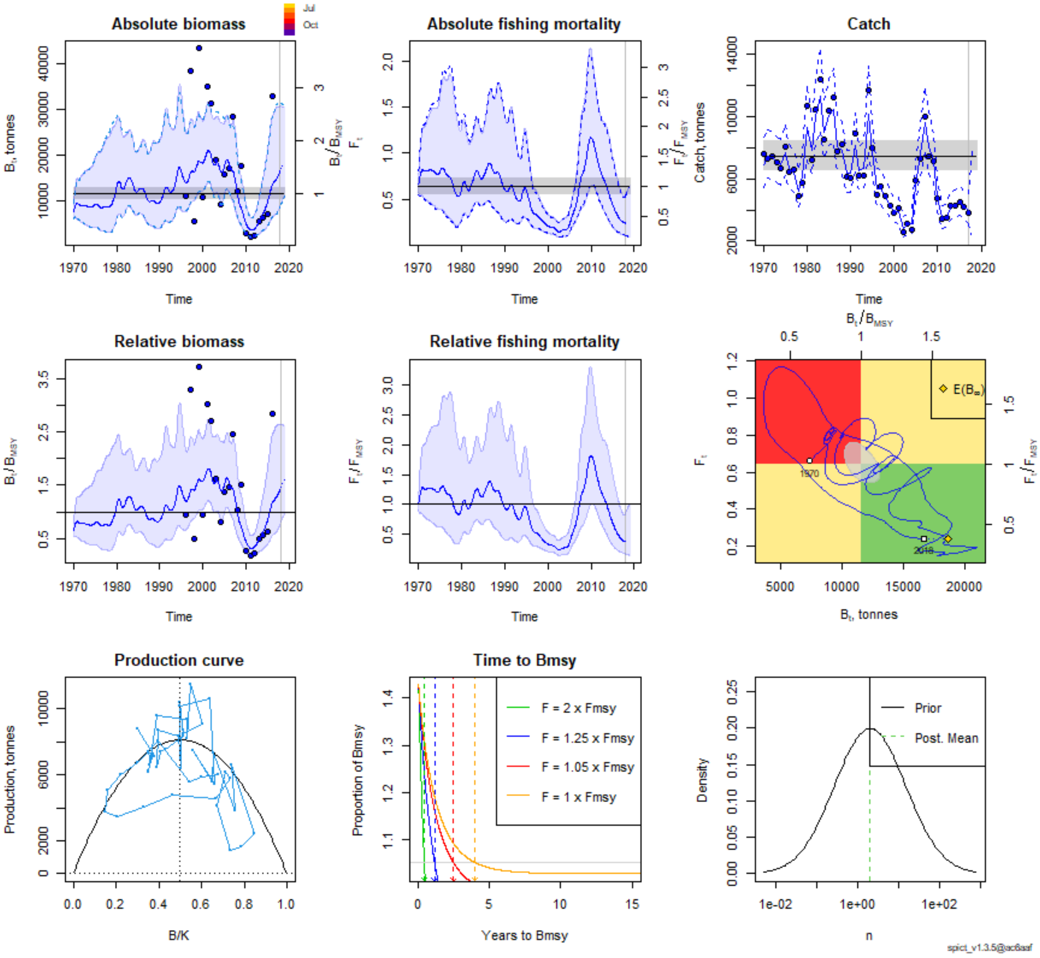


Figure 6.4.3.6 Common cuttlefish in GSAs 17 and 18. Summary of the final SPiCT model fit and output. Absolute and relative Biomass and Fishing mortality, state of the stock in F/B space and relative to estimated production.

The outputs of the model (Model estimates, reference points and summaries) are reported below:-

```
[1] "Convergence: 0 MSG: both X-convergence and relative convergence (5)"
 [2] "Objective function at optimum: 57.4787591"
 [3] "Euler time step (years):  1/16 or 0.0625"
 [4] "Nobs C: 51, Nobs I1: 26"
 [5] "Catch/biomass unit: tonnes”
 [6] ""
```

```
 [7] "Priors"
 [8] "            logn  ~  dnorm[log(2), 2^2]"
 [9] "        logalpha  ~  dnorm[log(1), 2^2]"
[10] "         logbeta  ~  dnorm[log(1), 2^2]"
[11] " logBBmsy1970.00  ~  dnorm[log(0.6), 0.1^2]"
[12] " logFFmsy1970.00  ~  dnorm[log(1), 0.1^2]"
[13] ""
[14] "Fixed parameters"
[15] "   fixed.value  "
[16] " K       24726  "
[17] " n           2  "
[18] ""
[19] "Model parameter estimates w 95% CI "
[20] "        estimate    cilow    ciupp log.est  "
[21] " alpha  2.71e+00 1.37e+00 5.35e+00   0.996  "
[22] " beta   1.17e+00 4.51e-01 3.04e+00   0.158  "
[23] " r      1.48e+00 1.18e+00 1.85e+00   0.389  "
[24] " rc     1.48e+00 1.18e+00 1.85e+00   0.389  "
[25] " rold   1.48e+00 1.18e+00 1.85e+00   0.389  "
[26] " m      9.12e+03 7.28e+03 1.14e+04   9.118  "
[27] " q      4.77e-05 3.11e-05 7.30e-05  -9.951  "
[28] " sdb    3.25e-01 1.82e-01 5.81e-01  -1.124  "
[29] " sdf    1.44e-01 7.69e-02 2.69e-01  -1.940  "
[30] " sdi    8.80e-01 6.51e-01 1.19e+00  -0.128  "
[31] " sdc    1.68e-01 9.42e-02 3.01e-01  -1.782  "
[32] " "
[33] "Deterministic reference points (Drp)"
[34] "       estimate    cilow    ciupp log.est  "
[35] " Bmsyd 1.24e+04 1.24e+04 1.24e+04   9.422  "
[36] " Fmsyd 7.38e-01 5.89e-01 9.24e-01  -0.304  "
[37] " MSYd  9.12e+03 7.28e+03 1.14e+04   9.118  "
[38] "Stochastic reference points (Srp)"
[39] "       estimate    cilow    ciupp log.est rel.diff.Drp  "
```

```
[40] " Bmsys 11251.46 1.00e+04 1.26e+04   9.328      -0.0988  "
[41] " Fmsys     0.72 5.76e-01 9.01e-01  -0.328      -0.0241  "
[42] " MSYs   8086.00 6.71e+03 9.74e+03   8.998      -0.1280  "
[43] ""
[44] "States w 95% CI (inp$msytype: s)"
[45] "                  estimate    cilow    ciupp log.est  "
[46] " B_2020.94      1.83e+04 1.12e+04 2.97e+04   9.813  "
[47] " F_2020.94      1.39e-01 8.56e-02 2.26e-01  -1.973  "
[48] " B_2020.94/Bmsy 1.62e+00 1.03e+00 2.55e+00   0.485  "
[49] " F_2020.94/Fmsy 1.93e-01 1.17e-01 3.19e-01  -1.645  "
[50] ""
[51] "Predictions w 95% CI (inp$msytype: s)"
[52] "                  prediction    cilow    ciupp log.est  "
[53] " B_2022.00        2.06e+04 1.33e+04 3.19e+04   9.934  "
[54] " F_2022.00        1.39e-01 7.90e-02 2.44e-01  -1.973  "
[55] " B_2022.00/Bmsy   1.83e+00 1.19e+00 2.83e+00   0.606  "
[56] " F_2022.00/Fmsy   1.93e-01 1.08e-01 3.45e-01  -1.645  "
[57] " Catch_2021.00    2.74e+03 1.64e+03 4.55e+03   7.914  "
[58] " E(B_inf)         2.05e+04       NA       NA   9.930  "
```

Prediction

```
               prediction    cilow    ciupp log.est
B_2022.00        2.06e+04 1.33e+04 3.19e+04   9.934
F_2022.00        1.39e-01 7.90e-02 2.44e-01  -1.973
B_2022.00/Bmsy   1.83e+00 1.19e+00 2.83e+00   0.606
F_2022.00/Fmsy   1.93e-01 1.08e-01 3.45e-01  -1.645
Catch_2021.00    2.74e+03 1.64e+03 4.55e+03   7.914
E(B_inf)         2.05e+04       NA       NA   9.930
```

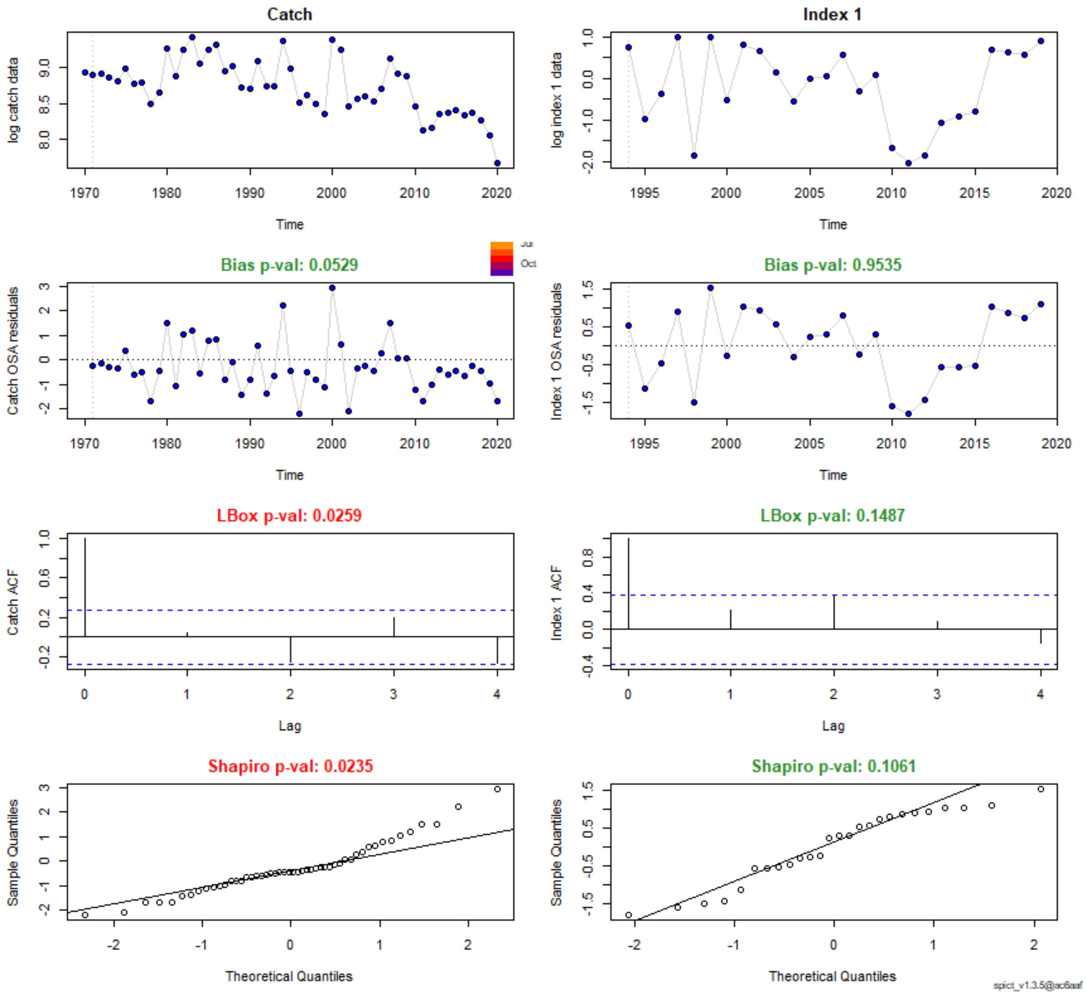


Figure 6.4.3.7 Common cuttlefish in GSAs 17 and 18. Diagnostics from SPiCT model for common cuttlefish in GSA 17-18.

Retrospective analysis

A retrospective analysis was run with 3 retro years, but the retrospective patterns showed instability in final years and wide range of intervals of confidence. Patterns were consistent across years in terms of B/ B_{MSY} and in terms of F/ F_{MSY}

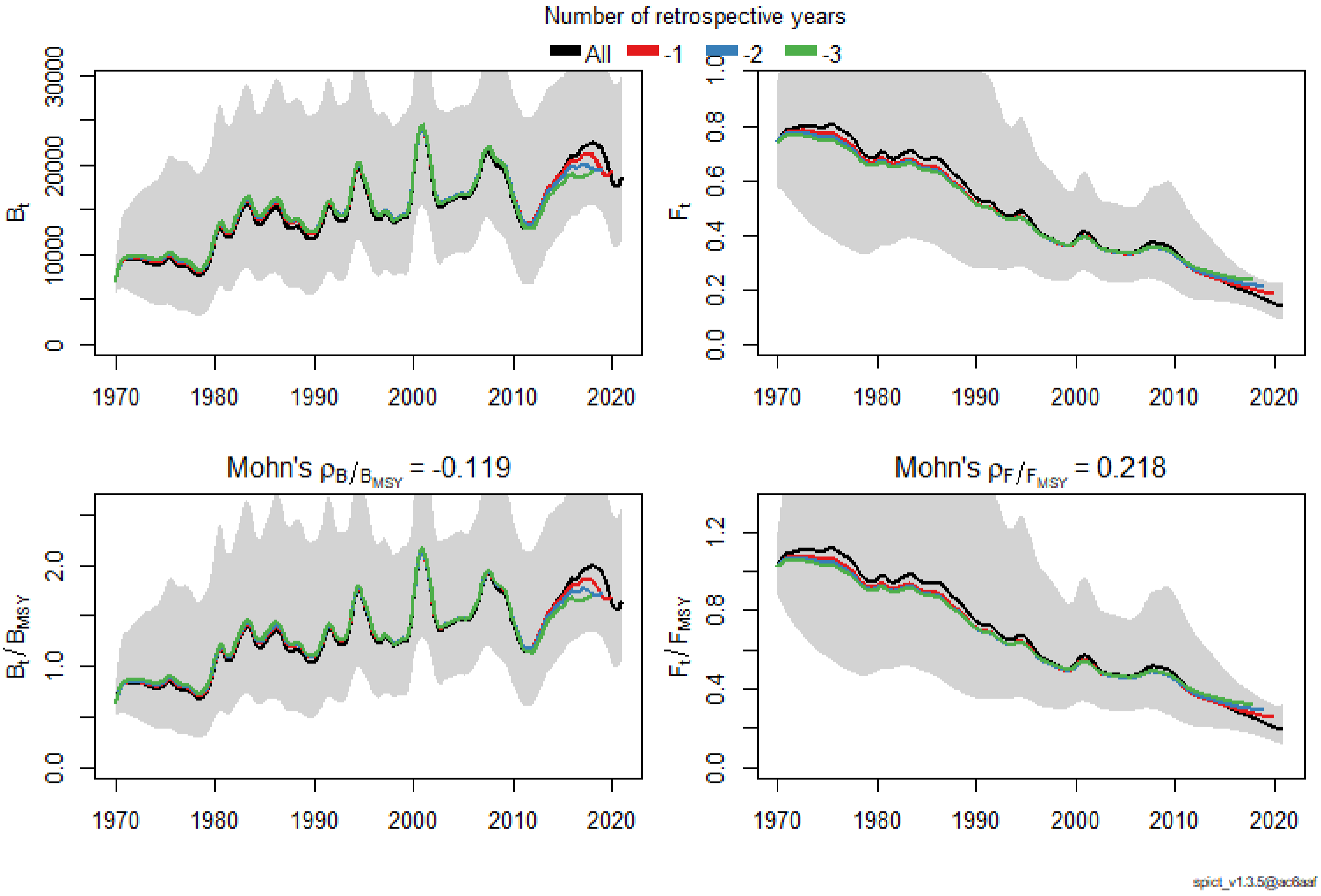


Figure 6.4.3.8 Common cuttlefish in GSAs 17 and 18. Retrospective analysis forthe SPiCT model for common cuttlefish in GSA 17-18

Table 6.4.3.4 Common cuttlefish in GSAs 17 and 18. STF from SPiCT assessment

	year	F	B	C
Keep current catch	2019	0.40	11552.4	4644.8
	2020	0.43	11092.2	4738.7
	2021	0.43	10908.6	4719.7
	2022	0.44	10784.1	4723.2
Keep current F	2019	0.40	11554.2	4654.8
	2020	0.45	11009.8	4951.6
	2021	0.45	10724.9	4823.5
	2022	0.45	10621.1	4776.8
Fishing at FMSY	2019	0.40	11554.2	4654.8
	2020	1.04	8993.2	9309.9
	2021	1.04	6806.8	7046.5
	2022	1.04	6180.4	6398.1
No fishing	2019	0.40	11554.2	4654.8
	2020	0.00	12983.7	5.8
	2021	0.00	15344.2	6.9
	2022	0.00	16377.5	7.4
Reduce F of 25%	2019	0.40	11554.2	4654.8
	2020	0.34	11464.6	3867.2
	2021	0.34	11721.6	3953.8
	2022	0.34	11819.6	3986.9
Increase F of 25%	2019	0.40	11554.2	4654.8
	2020	0.56	10578.5	5947.1
	2021	0.56	9817.9	5519.5
	2022	0.56	9553.3	5370.7

Predicted catch for management period and states at management evaluation time:

Management evaluation: 2022.00

	C	B/Bmsy	F/Fmsy
1. Keep current catch	2527.8	1.84	0.18
2. Keep current F	2735.4	1.83	0.19
3. Fish at Fmsy	11592.0	1.27	1.00
4. No fishing	2.9	1.99	0.00
5. Reduce F by 25%	2076.4	1.87	0.14
6. Increase F by 25%	3378.4	1.80	0.24
7. MSY hockey-stick rule	11592.0	1.27	1.00
8. ICES advice rule	10605.2	1.34	0.89

Conclusions to Assessment Modelling

The CMSY model indicates a recent recovery of the common cuttlefish stock with negative trends in exploitation rate and fishing mortality and with biomass slightly above the level of B_{MSY}. However, the estimated confidence intervals were significant concerning the estimates relative biomass.

The estimates of MSY by both models is similar SPiCT 8086 (cl 6710-9740 and CMSY 7450 (cl = 6.5 - 8.33) the SPiCT model gives a wider range that includes most of the CMSY estimate, so the values are not significantly different. The difference in catches between the different time periods included in the two models leads to lower values of r when considering longer term changes in stock dynamics covered by CMSY.

Assessments for GSA 17 and 18 separately using SPiCT were not considered, as these would suffer from the same issues as the combined area for GSA 17 and were unlikely tosucceed with GSA 18 on its own.

Considering all these results and short lifecycles that is highly dependent on environmental factors, EWG recommends the precautionary approach for management.

If managers wish to manage GSA 17 and 18 separately, it is possible to provide an assessment for GSA 17 alone, but not for GSA 18 (see above). The current GSA 17 assessment suggests a larger stock and lower harvest rate than last year's assessment, (r is lower) advised catches and state of stock in terms of B/B_{MSY} and F/F_{MSY} are the same. The retrospective performance of this configuration appears to be better than last year's configuration.

If it is necessary to give advice for GSA 18, at the moment the best option is to use the combined area assessment. Although the combined area may not constitute a single stock, the joint assessment does reflect the overall joint state of common cuttlefish in GSA 17-18. If an area contains several stocks the aggregated assessment represents the average conditions, but will not provide detailed information protection for all the individual 'stocks' or 'functional units'. While functional unit separation as adult stage is rather likely, movement of larvae may give some linkage between areas and functional units.

6.4.4 REFERENCE POINTS

The MSY reference points are estimated directly in CMSY.

GSA 17-18 combined

Fmsy = 0.156, 95% CL = 0.109 - 0.219 (if B ¿ 1/2 Bmsy then Fmsy = 0.5 r)
MSY = 7.45, 95% CL = 6.5 - 8.33

Bmsy = 46.7, 95% CL = 34.8 - 63.2

GSA 17

Fmsy = 0.137 , 95% CL = 0.0972 - 0.192 (if B > 1/2 Bmsy then Fmsy = 0.5 r)

MSY = 5.98 , 95% CL = 5.22 - 6.76

Bmsy = 41.6 , 95% CL = 31.4 - 55.9

6.4.5 SHORT TERM FORECAST AND CATCH OPTIONS

As common cuttlefish is a short lived species it is not possible to give specific year advice for 2022. Based on exploitation at FMSY the following table shows the catches and changes in F implied by long term exploitation at F=FMSY . The catch shown are long term means, and do not reflect actual catches available in any specific year.

Area	Species	Method/ basis	F 2020	F 2021	Change in F	Catch 2020	Catch 2021	Change in catch	Biomass (status)
GSA 17-18	Common cuttlefish	CMSY	0.326 F MSY	F=F MSY	123%	2150	7450	247%	At Bmsy
GSA 17	Common cuttlefish	CMSY	0.359 F MSY	F=F MSY	95%	1570	5980	281%	At Bmsy

6.4.6 DATA DEFICIENCIES

The inability to obtain historic SOLEMON survey data on common cuttlefish and restricted the EWGs ability to test the assessment with a survey preferred by GFCM.

6.5 NORWAY LOBSTER IN GSA 17 AND 18

Evaluations of Nephrops in GSA 17 and 18 have been carried out at regional and sub area levels. The regional analysis is given in Section 6.5.3 where a SPiCT assessment similar to the one presented in 2020 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 2020. The sub areas based partially on the analyses in Canu *et al* 2021 and observation on differences in maturation at size are described in Section 5.3.3. The analysis of sub-area survey biomass is given in Section 5.3.2. An analysis of age length based indices is given in Section 5.3.3 and a preliminary a4a stock assessment based on catches and survey data in GSA 18 is given in Section 5.3.4. The overall results of these analyses are summarized in Section 5.3.5, and additional information for management is given in Sections 6.5.5 and summarized in Section 5.5 along with the regional catch advice.

6.5.1 STOCK IDENTITY AND BIOLOGY

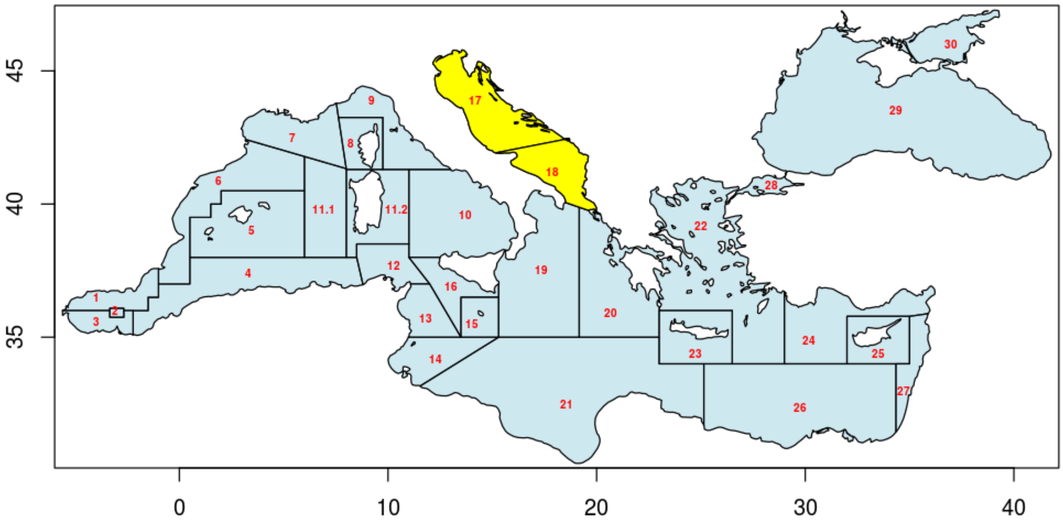


Figure 6.5.1.1 Norway lobster in GSA 17 and 18. Geographical location of GSAs 17-18.

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 accordingly we update the assessment using the same production model (SPICT) adding the data of 2020 only.

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 6.5.1.2). In GSA 18 the more persistently abundant adult aggregations occur on the SE and SW edges of the South Adriatic Pit (Figure 6.5.1.3).

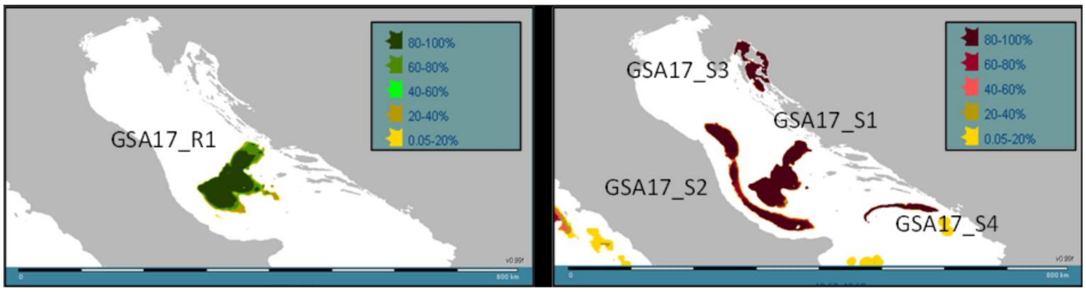


Figure 6.5.1.2 Norway lobster in GSA 17 and 18. Position of persistent nursery (left) and spawning areas (right) in GSA 17 as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

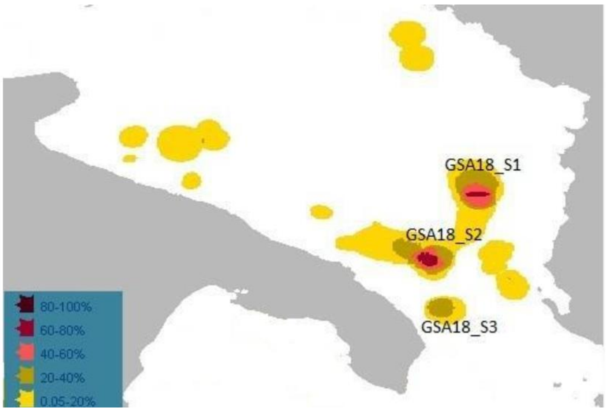


Figure 6.5.1.3 Norway lobster in GSA 17 and 18 Position of persistent spawning areas in GSA 18 of as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

6.5.2 DATA

6.5.2.1 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 structures by gear are reported.

LANDINGS

Landings in weight

Landings data by gear for Croatia were available for the period 2013-2020.

Table 6.5.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2020.

Gear	2013	2014	2015	2016	2017	2018	2019	2020
FPO	0	18	33.8	33.6	40.7	48.2	50.7	48.2
OTB	278.167	325	269	203	159	183	214	188
Total	**278.167**	**343**	**302.8**	**236.6**	**199.7**	**231.2**	**264.7**	**236.2**

Table 6.5.2.1.2 Norway lobster in GSA 17 and 18. Proportion of Croatian landings data by gear for the period 2013-2020.

Gear	2013	2014	2015	2016	2017	2018	2019	2020
FPO	0.00	0.05	0.11	0.14	0.20	0.20	0.19	0.20
OTB	1.00	0.95	0.89	0.86	0.80	0.80	0.81	0.80

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.

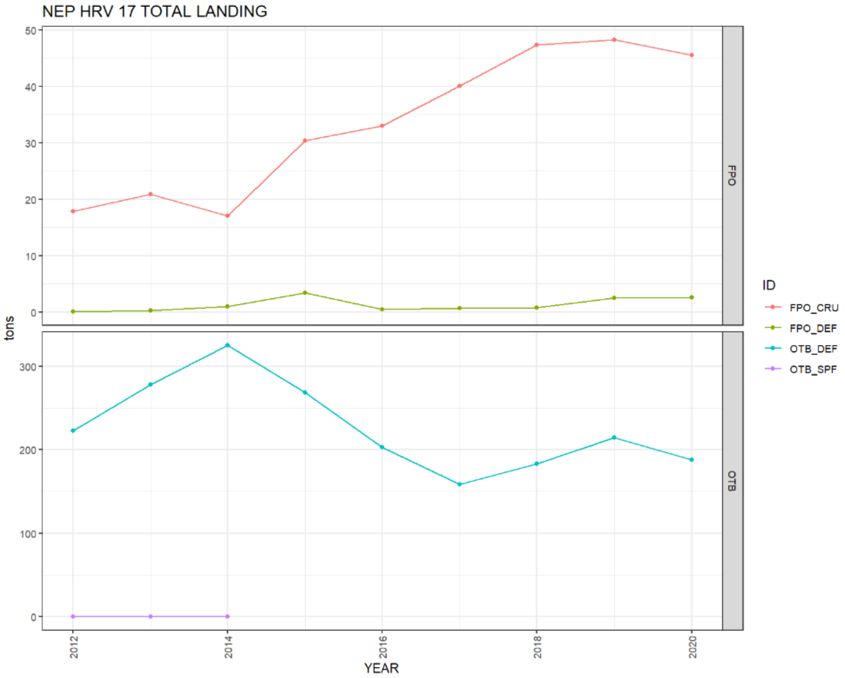


Figure 6.5.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2020 for GSA 17.

Landings data by gear for Italy (GSA17) were available for the period 2006-2020.

Table 6.5.2.1.2 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2020.

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

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 350 tonnes in 2020.

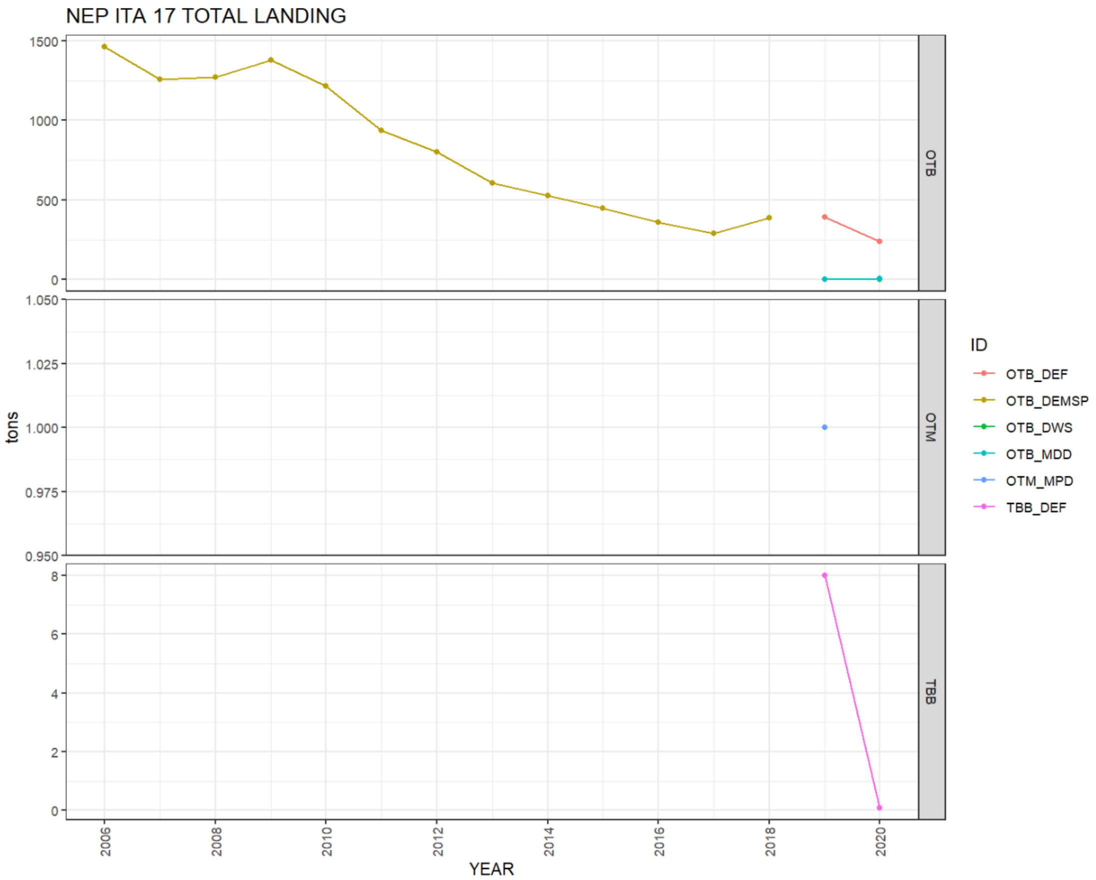


Figure 6.5.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2020.

Data by gear for Italy (GSA18) were available for the period 2002-2019.

Table 6.5.2.1.4 Norway lobster in GSA 17 and 18. Italian (GSA18) landings (t) by gear for the period 2002-2020.

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**

Table 6.5.2.1.5 Norway lobster in GSA 17 and 18. Proportion of Italian (GSA18) landings data by gear 2002-2020.

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

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.

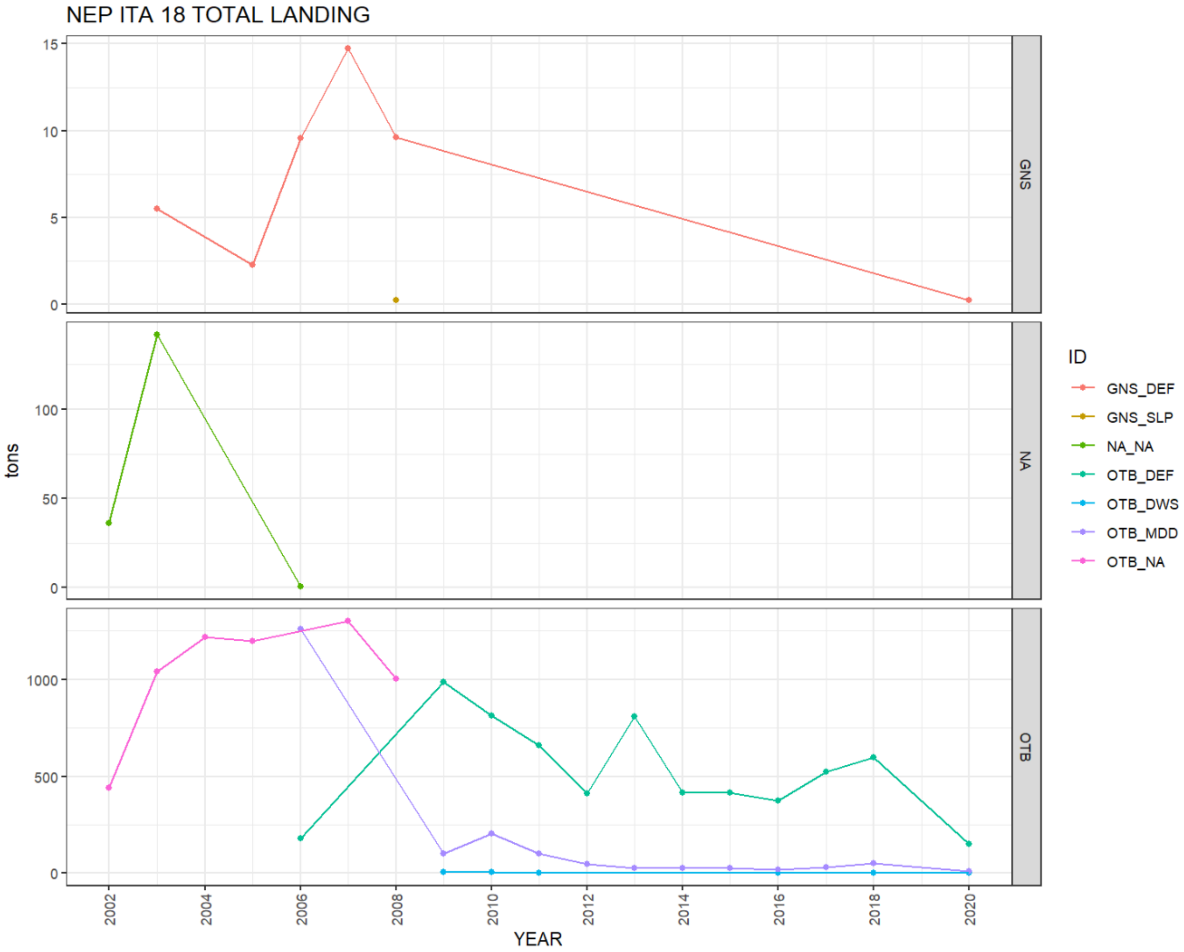


Figure 6.5.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA18) landings data by gear for the period 2002-2020.

For Albania landings were available from 2012-2020. 2020 values were obtained during the meeting and included in the assessment.

Table 6.5.2.1.6 Norway lobster in GSA 17 and 18. Albanian (GSA18) landings data for the period 2012-2020.

Albania_GSA18_NEP_Landings

Year	Tonnes
2012	435
2013	398
2014	400
2015	405
2016	411
2017	389

2018	257
2019	213
2020	194

Size distributions of the landings

The size distribution is given in Figures 6.5.2.1.4-6

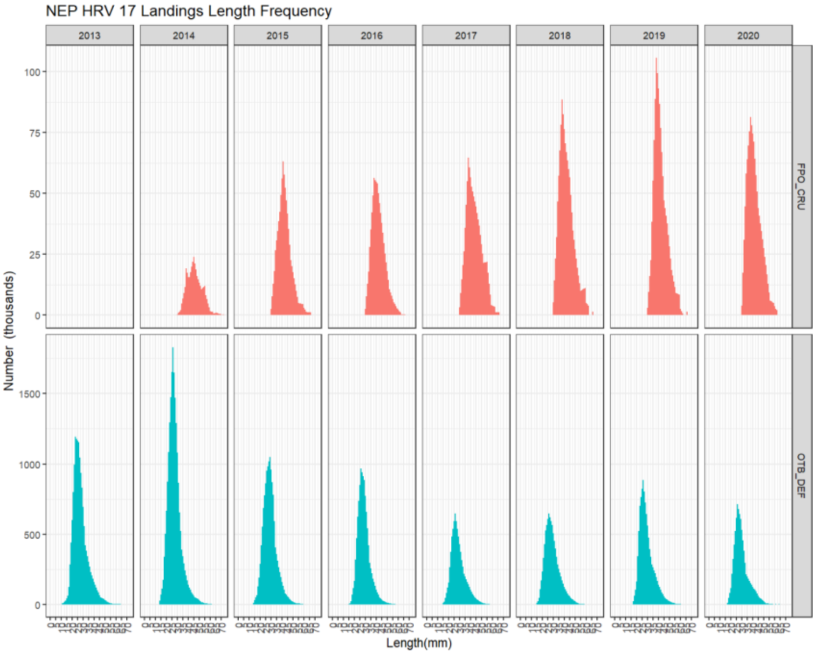


Figure 6.5.2.1.4 Norway lobster in GSA 17 and 18. Length frequency distributions of the Croatian landings by gear in the period 2013-2020.

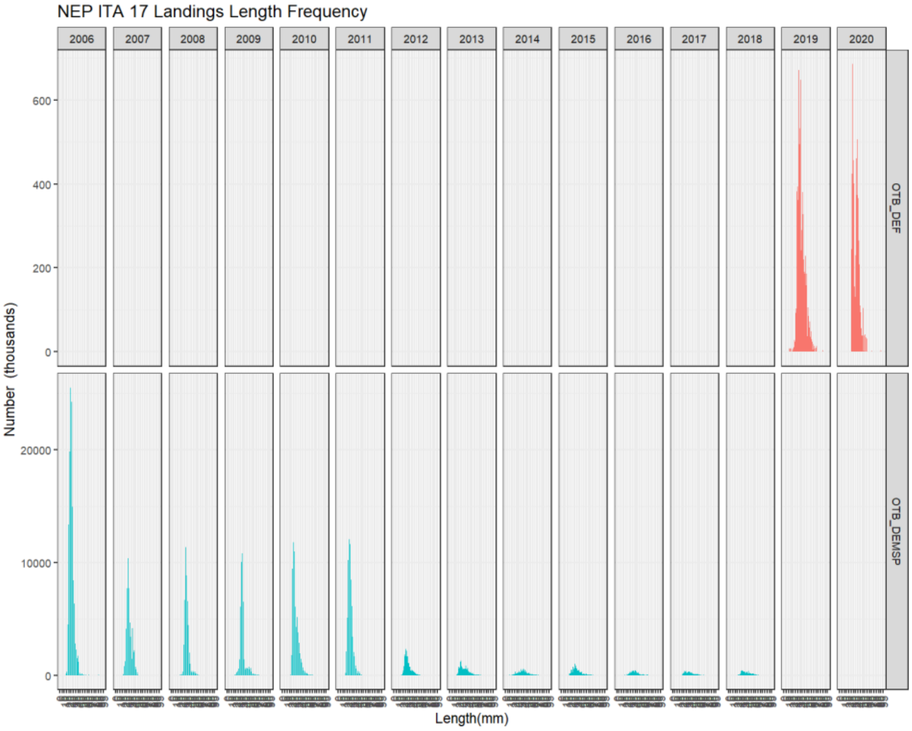


Figure 6.5.2.1.5 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA17) landings by gear in the period 2006-2020

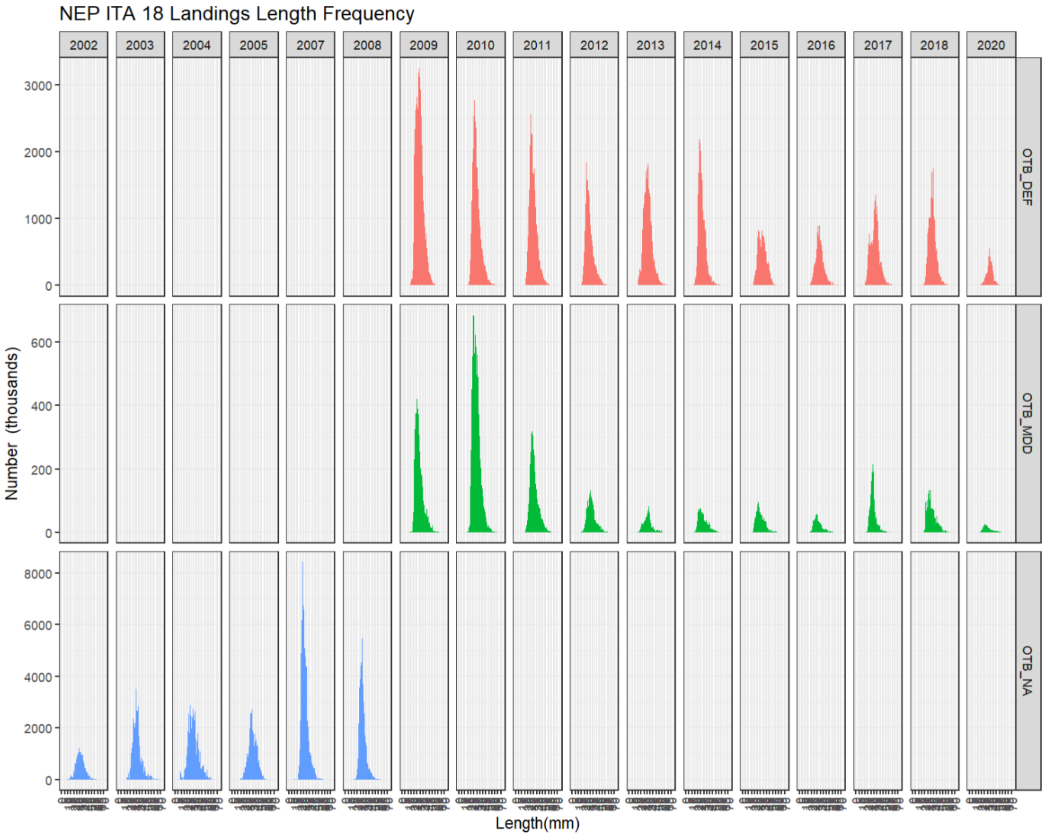


Figure 6.5.2.1.6 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA18) landings by gear in the period 2002-2020.

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 2013-2020.

Table 6.5.2.1.7 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2013-2020.

	Total discards in weight (tonnes)							
Gear	2013	2014	2015	2016	2017	2018	2019	2020
OTB	0.275	0.145	0.171	0.047	0.164	0.582	1.94	0.281

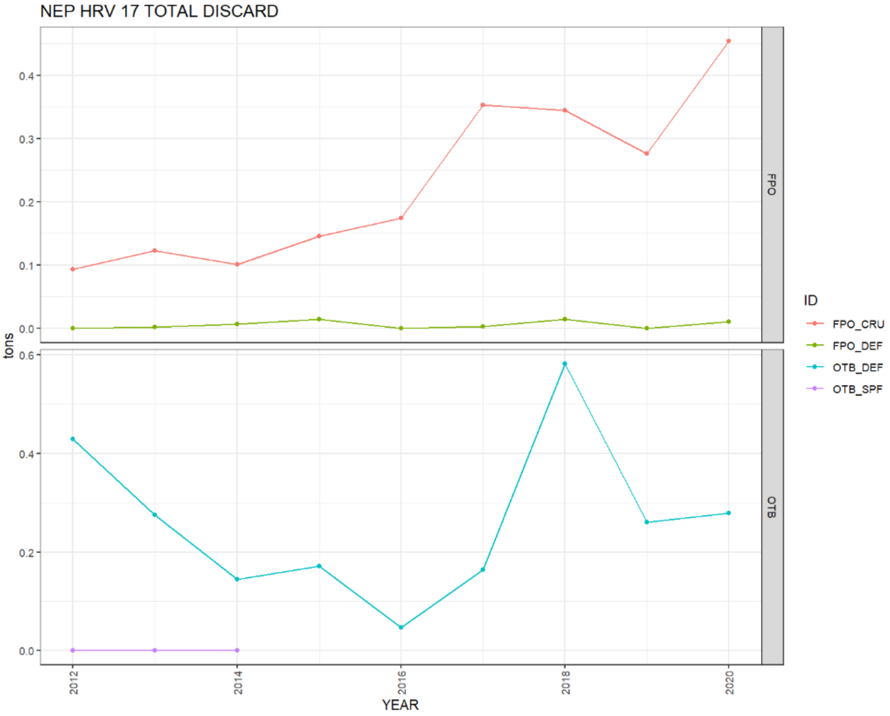


Figure 6.5.2.1.7 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2012-2020.

In Italy (GSA17) discard was observed only in 2011 (4.92 tonnes OTB) and 2018 (61 tonnes).

Table 6.5.2.1.8 Norway lobster in GSA 17 and 18. Italian (GSA18) discards data by gear for the period 2009-2020.

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

Discards values were always very low aside in the 2009 (66 tonnes).

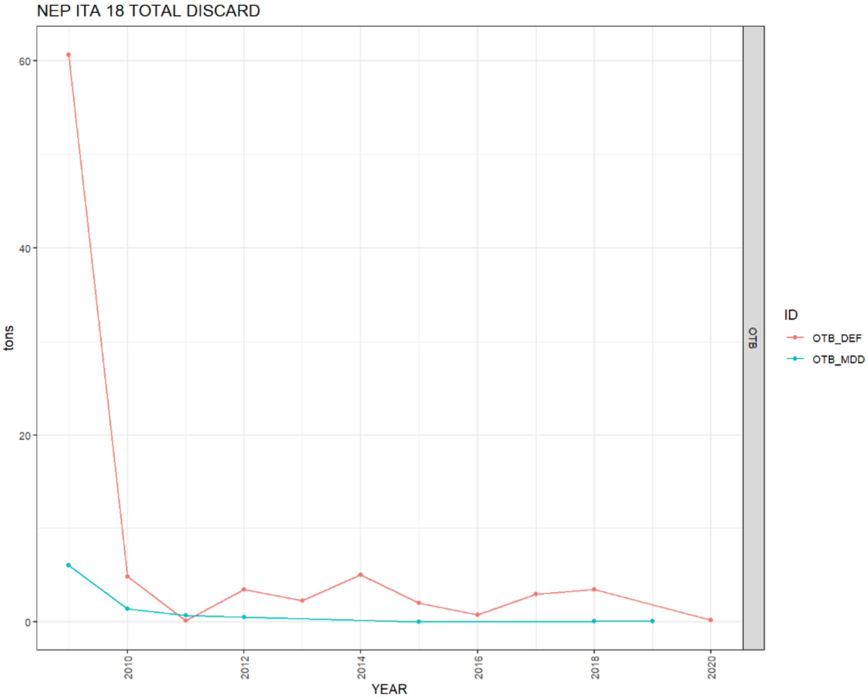


Figure 6.5.2.1.8 Norway lobster in GSA 17 and 18. Italian (GSA18) discards data by gear for the period 2009-2020.

Size distributions of the discards

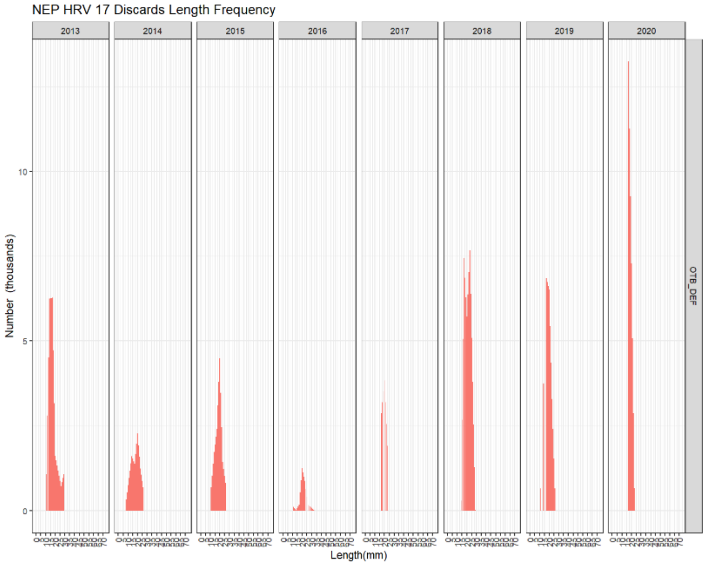


Figure 6.5.2.1.9 Norway lobster in GSA 17 and 18. Length frequency distribution of the Croatian discards by gear in the period 2013-2020.

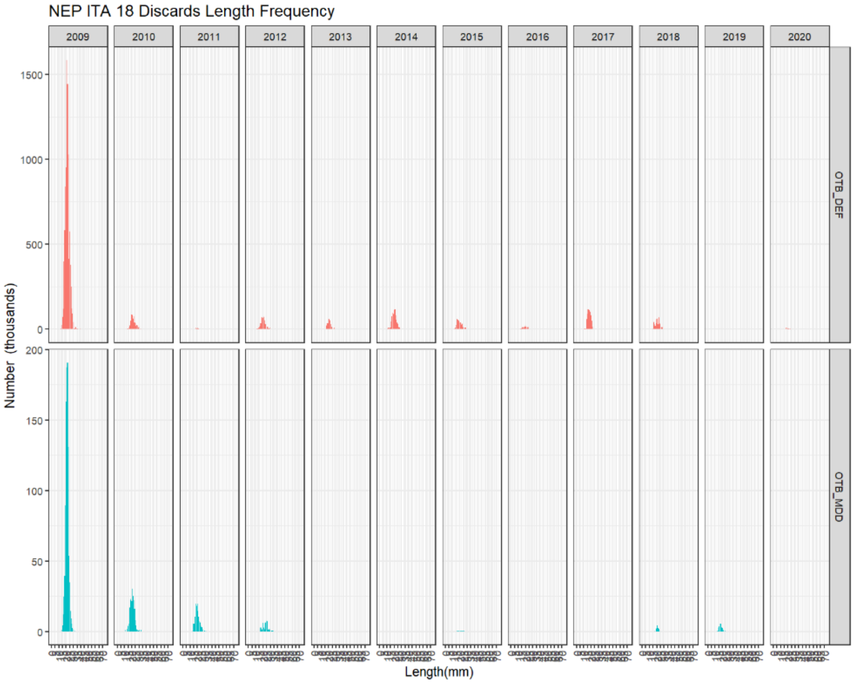


Figure 6.5.2.1.10 Norway lobster in GSA 17 and 18. Length frequency distribution of the Italian (GSA18) discards by gear in the period 2009-2020.

In the production model (SPICT) landings series was updated according to revised Albanian landings (2012-2020) and to Italian and Croatian DCF landings (2006-2020).

In the analytical assessment both data in landings and discards available from 2006 onward were used. Catches data were computed according to both (Table 6.5.2.1.9 and Figure 6.5.2.1.11).

Table 6.5.2.1.9 Norway lobster in GSAs 17 and 18. Landings and discards data by GSA for the period 2006-2020.

	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	5	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

In red are reported Croatian landings data extracted from FishStatJ FAO database.

6.5.2.2 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 2012-2020 (Table 6.5.2.2.1-3, Figure 6.5.2.2.1). 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 2020 the data have been updated from FDI database.

Table 6.5.2.2.1 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

Table 6.5.2.2.2 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

Table 6.5.2.2.3 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

6.5.2.3 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 6.5.2.3.1). 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

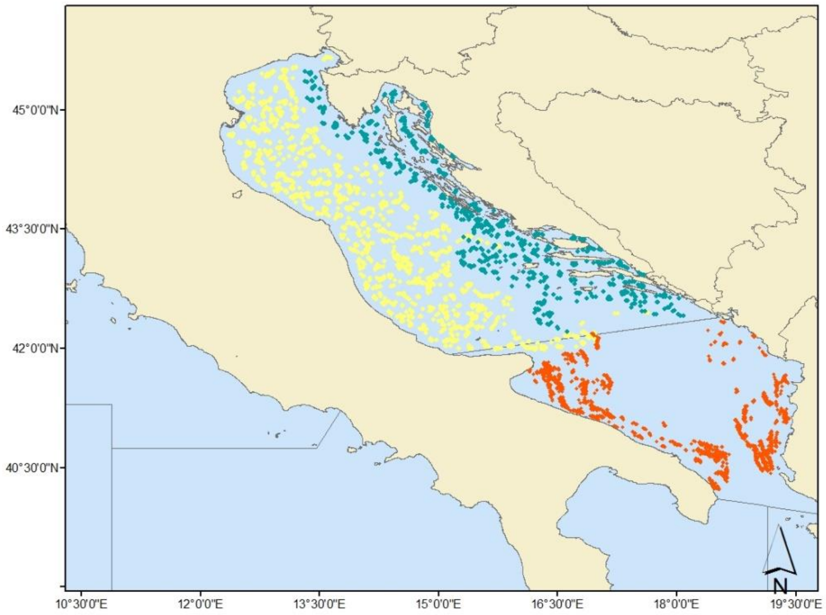


Figure 6.5.2.3.1 Norway lobster in GSA 17 and 18. MEDITS trawl survey, distribution of the hauls carried out in the area.

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 6.5.2.3.2). 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 6.5.2.3.3).

GSA 17 and 18 ITA HRV SVN ALB MTN

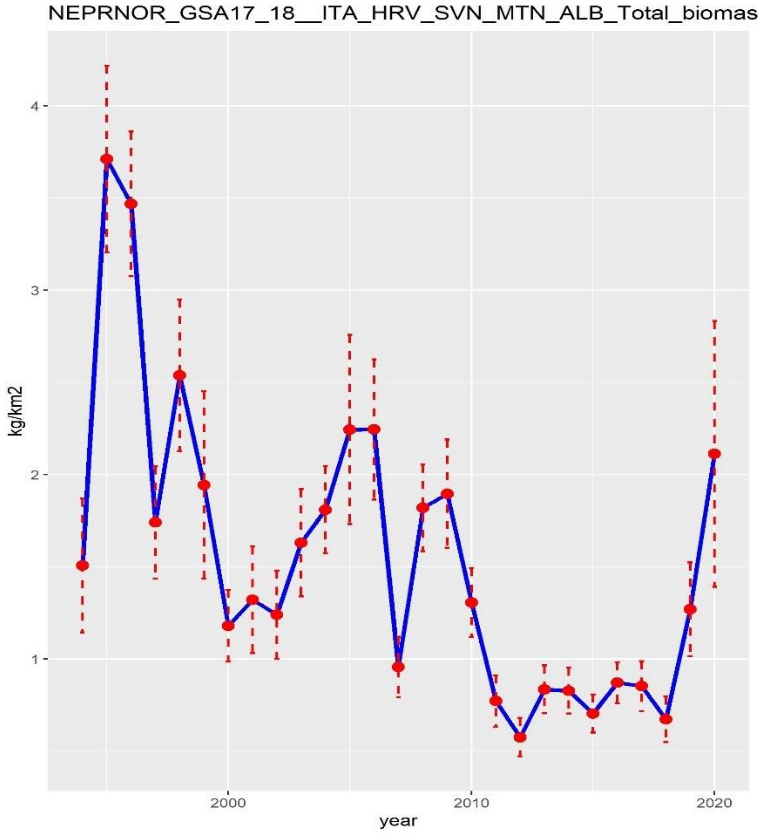


Figure 6.5.2.3.2 Norway lobster in GSA 17 and 18. Abundance indices from the MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro of GSA 17 and 18 during 1994 – 2020.

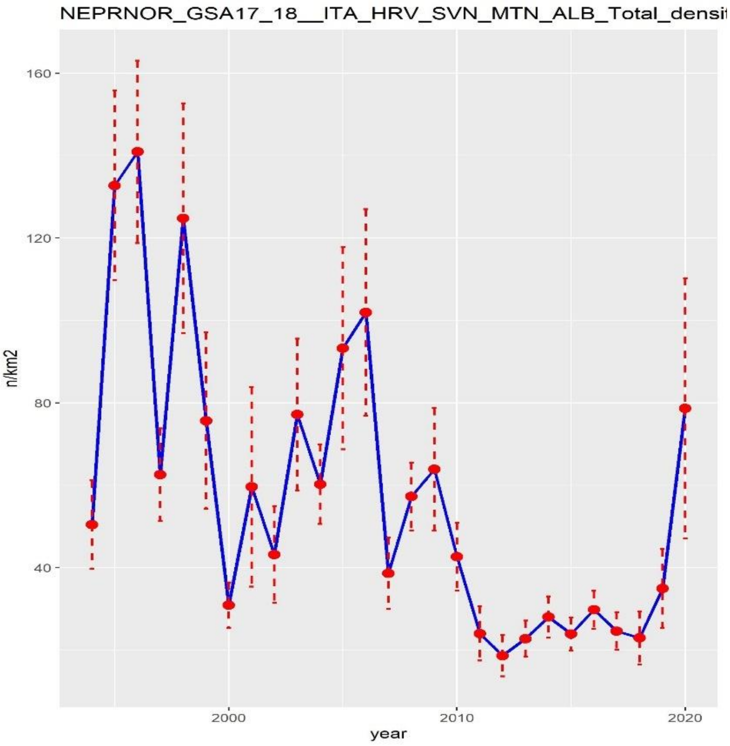


Figure 6.5.2.3.3 Norway lobster in GSA 17 and 18. Biomass indices from the MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro of GSA 17 and 18 during 1994 – 2020.

Length frequency distributions of the Medits surveys are showed in Figures 6.5.2.3.4-6. 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.

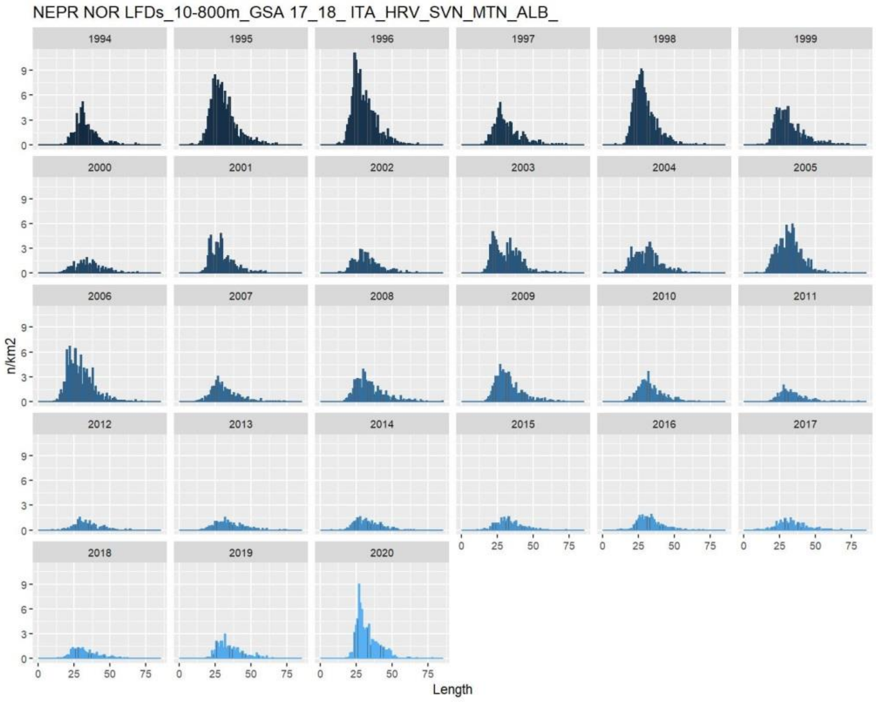


Figure 6.5.2.3.4. Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2020.

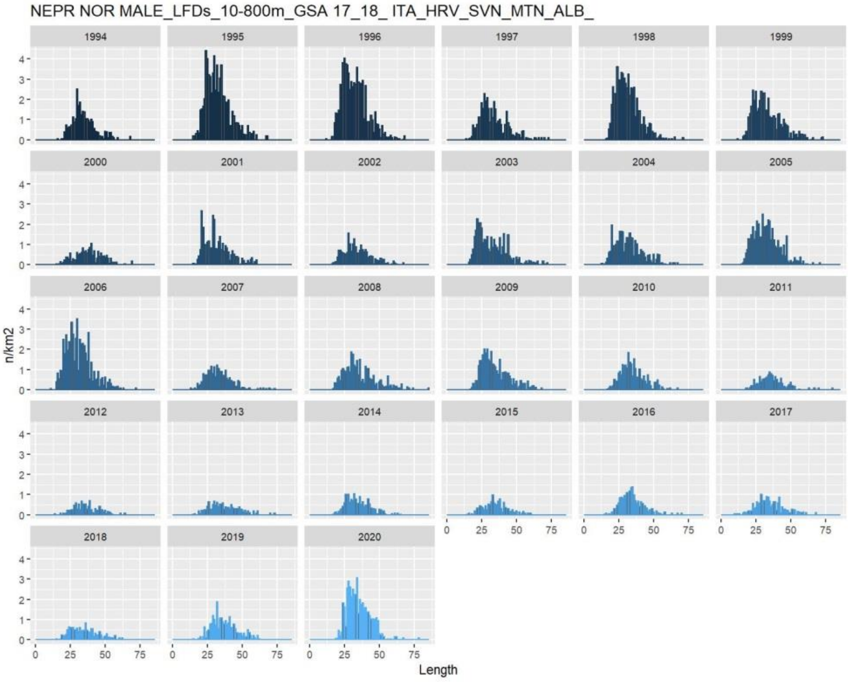


Figure 6.5.2.3.5 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (Male) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2020.

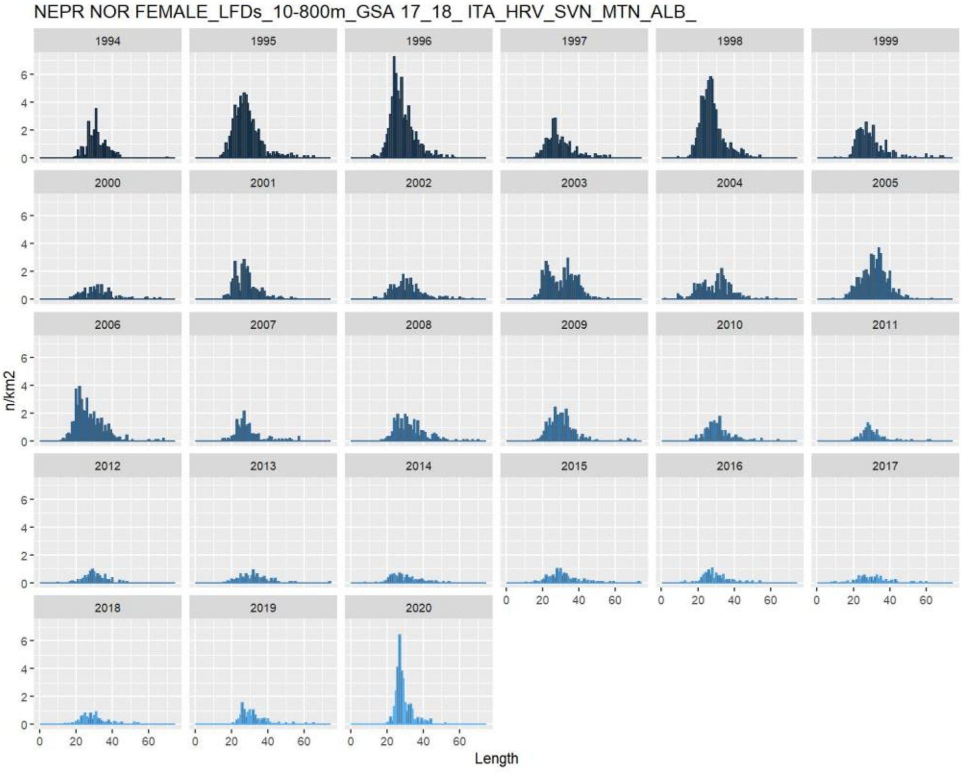


Figure 6.5.2.3.6 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (Female) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2020.

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. 6.5.2.3.7).

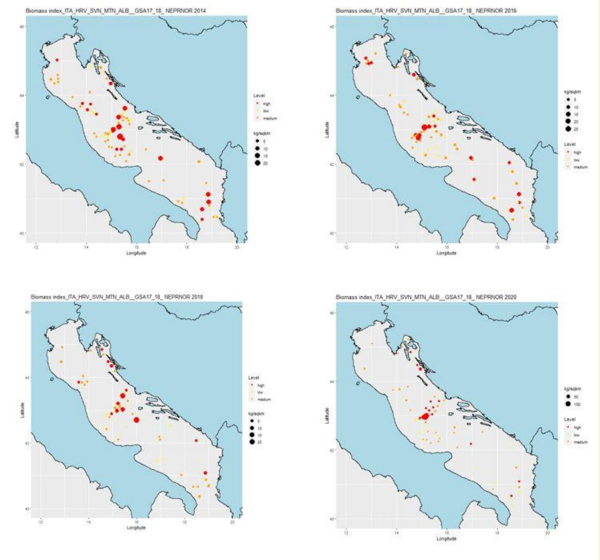


Fig. 6.5.2.3.7 Norway lobster in GSA 17 and 18. Spatial distribution of relative biomass (kg km^{-2}) during Medits from 2012 to 2020.

6.5.3 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 and EWG 19-16. 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 Nephrops from GSA 17 and 18 (STECF EWG 16-08 and EWG 19-16), 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.

6.5.3.1 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.

Main assumptions

SPiCT shares many assumptions with other surplus production models:

1. No emigration/immigration, changes in biomass occur through growth (r and K) and fishing.
2. No lagged effects in the biomass dynamics
3. Constant catchability i.e. no change in technology of fishing technique that changes q.
4. Gear selectivity is not modelled
5. 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).

INPUT Data

The data input used were the same of the previous assessment (STECF 20-15) with addition of data from 2014 to 2020.

MEDITS time series was updated adding 2020 data.

LANDINGS data were updated according to revised Albania data and 2020 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 Nephrops GSA 17-18 combined

Table 6.5.3.1 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 1288.0000 1116.0000 1185.0000 1407.0000 1270.0000 1219.0000 2109.0000 2350.0000 2087.0000 2836.0000 2159.0000 1890.0000 2507.0000

[23] 3151.0000 3122.0000 3366.0000 3148.0000 3558.0000 3058.0000 2426.0000 1753.0000 1864.0000 1558.7367 1252.4735 2218.5499 2279.4303 3393.6758 3107.0166 2775.0568 2654.2410 2799.6820 2523.3727 1955.7586 1955.2312 2116.5424

[45] 1738.3813 1617.4878 1417.3120 1438.2062 1559.3179 1268.6368 843.3556

$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 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

[45] 2014 2015 2016 2017 2018 2019 2020

$timeI

$timeI[[1]] **(from Froglia 1988)**

[1] 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985

```
$timeI[[2]] (from Jukic 1975)

 [1] 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970


$timeI[[3]] (MEDITS)

 [1] 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020




$obsI

$obsI[[1]] (from Froglia 1988)

 [1] 5.044500 7.740429 2.766750 1.551000 1.621000 2.169400 1.867563 1.449312 3.866662 3.348465


$obsI[[2]] (from Jukic 1975)

 [1] 68.64132 46.32997 25.28125 16.38208 25.47517 43.61067 67.90581 72.84041 95.12000 56.87619 45.43182


$obsI[[3]] (MEDITS)

 [1]  1.5070003  3.7113814  3.4686277  1.7402263  2.5383215  1.9438871  1.1795964  1.3204727  1.2397093  1.6297903  1.8098053  2.2438719  2.2446129
0.9568427 1.8191501 1.8959946 1.3056366 0.7714247 0.5757058 0.8351504 0.8274774 0.7034858

[23] 0.8706164 0.8521668 0.6732885 1.2695929 2.1124762
```

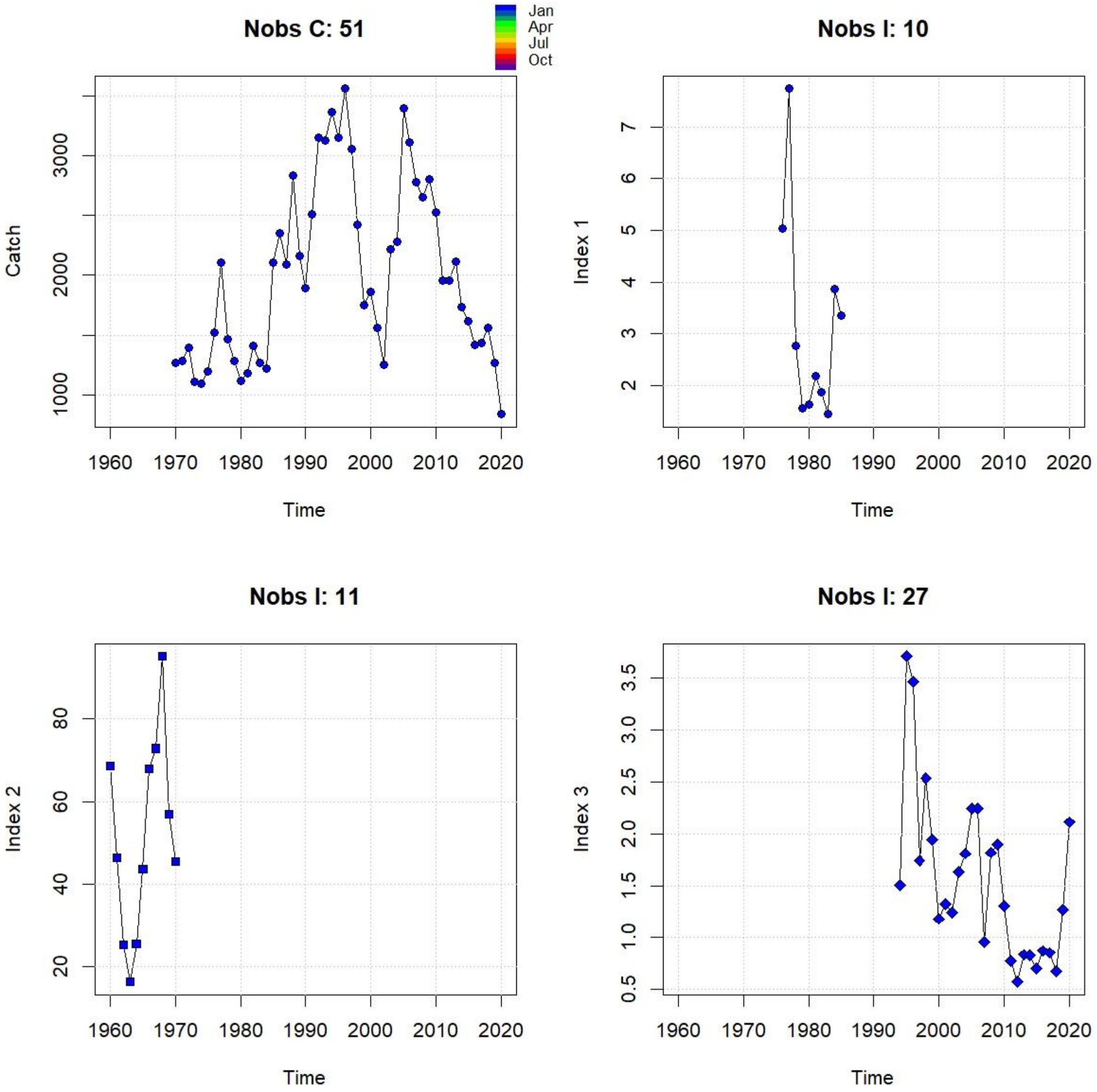


Figure 6.5.3.1.1 Norway lobster in GSA 17 and 18. Input Data from Norway lobster GSA 17-18. Index 1 = Froglia, Index 2 = Jukic, Index 3 = MEDITS.

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 3 tuning indexes (Figures 6.5.3.1.2-3).

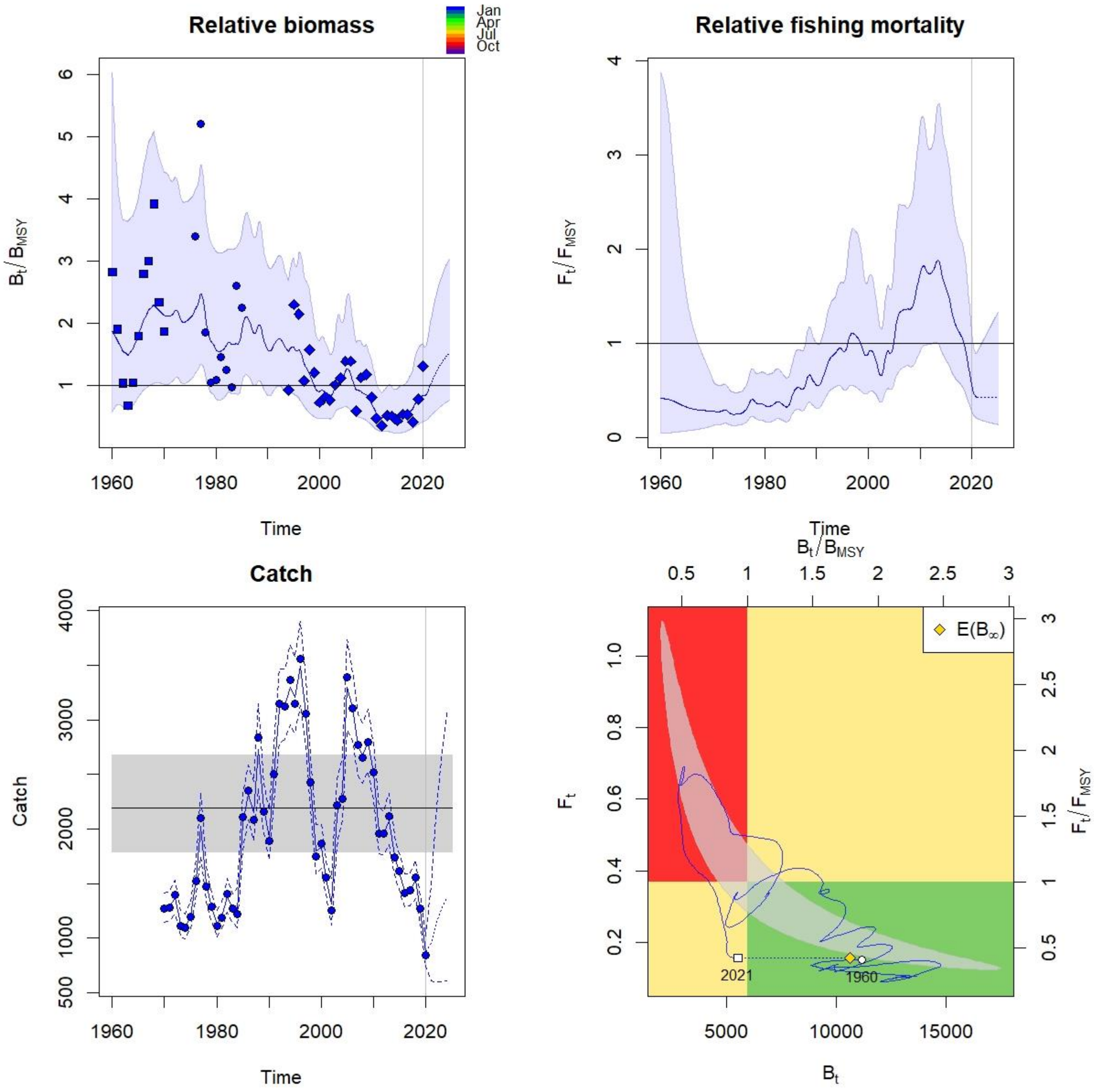


Figure 6.5.3.1.2 Norway lobster in GSA 17 and 18. SPiCT model fit with full time series and 3 CPUE indexes.

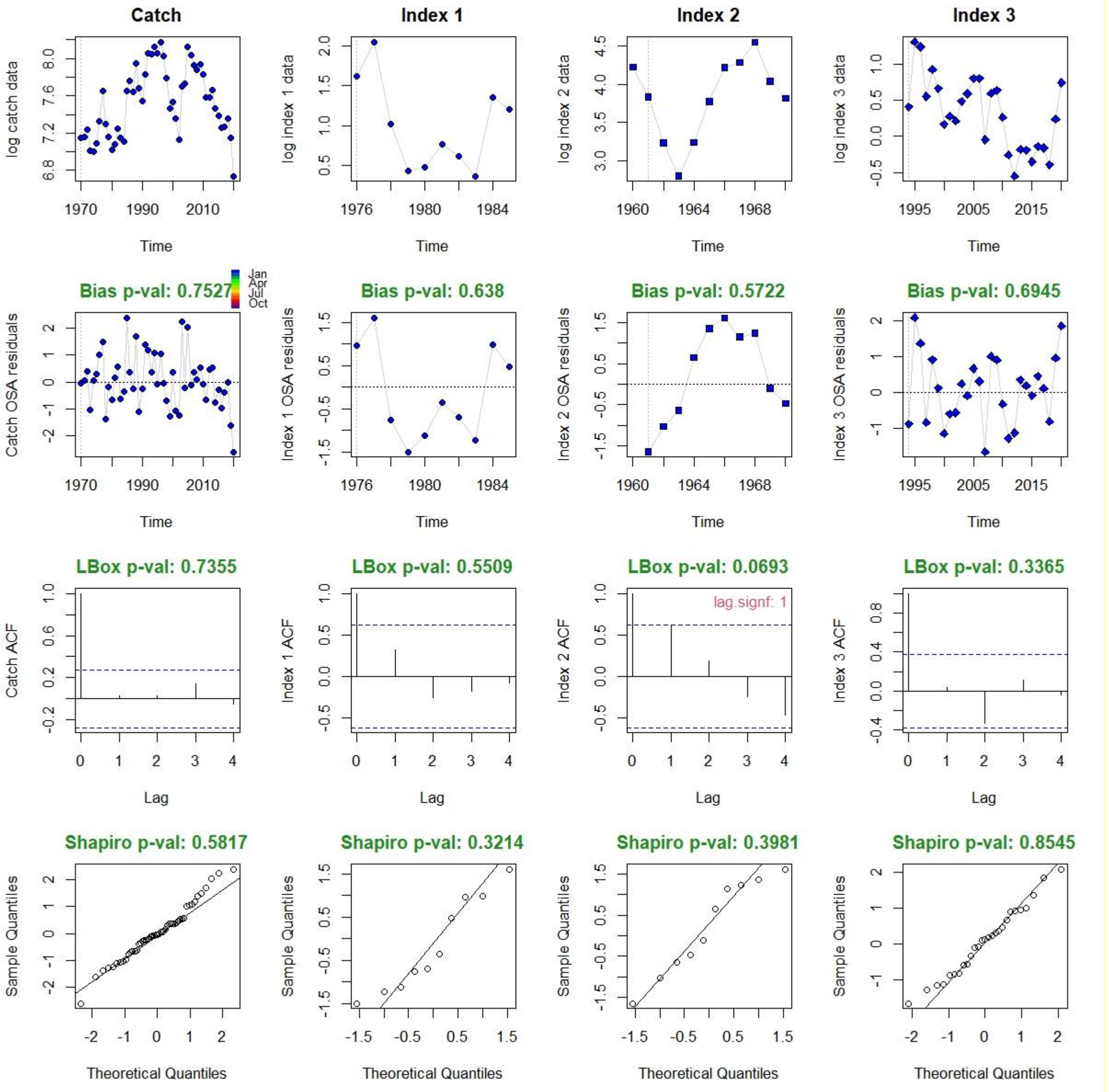


Figure 6.5.3.1.3 Norway lobster in GSA 17 and 18. Diagnostics for SPICT model of Norway lobster GSA 17-18. Index 1 = Froglia, Index 2 = Jukic, Index 3 = MEDITS.

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 6.5.3.1.4).

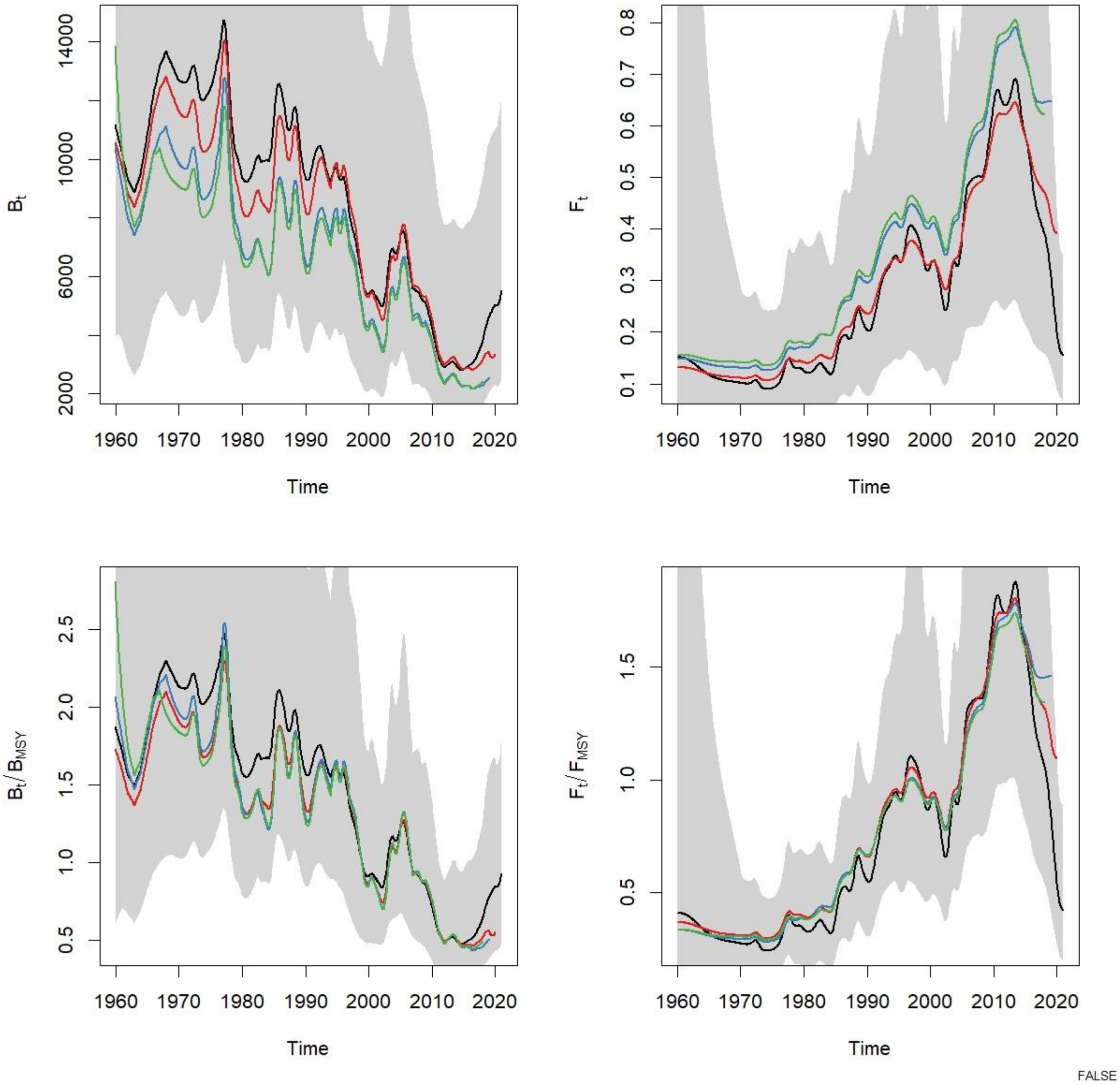


Figure 6.5.3.1.4 Norway lobster in GSA 17 and 18. Retrospective analysis for Norway lobster in GSA 17-18.

Table 6.5.3.2 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: 36.3970809

Euler time step (years): 1/16 or 0.0625

Nobs C: 51, Nobs I1: 10, Nobs I2: 11, Nobs I3: 27

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
 alpha1  2.518014e+00    0.7811345 8.116905e+00   0.9234705
 alpha2  2.463982e+00    0.6206213 9.782468e+00   0.9017788
 alpha3  1.607422e+00    0.5534972 4.668144e+00   0.4746315
 beta    2.554926e-01    0.0529215 1.233459e+00  -1.3645618
 r       3.293648e-01    0.0663128 1.635901e+00  -1.1105893
 rc      7.350813e-01    0.3079855 1.754448e+00  -0.3077741
 rold    3.170983e+00    0.0000026 3.923683e+06   1.1540417
 m       2.245453e+03 1790.7724348 2.815579e+03   7.7166628
 K       1.756072e+04 6754.4051047 4.565599e+04   9.7734201
 q1      2.494000e-04    0.0000925 6.727000e-04  -8.2964438
 q2      4.076000e-03    0.0016117 1.030870e-02  -5.5026311
 q3      2.707000e-04    0.0001149 6.380000e-04  -8.2143681
 n       8.961316e-01    0.2068004 3.883222e+00  -0.1096680
 sdb     1.760181e-01    0.0705973 4.388607e-01  -1.7371683
 sdf     2.177385e-01    0.1391265 3.407695e-01  -1.5244604
 sdi1    4.432161e-01    0.2614635 7.513114e-01  -0.8136977
 sdi2    4.337055e-01    0.2227506 8.444444e-01  -0.8353895
 sdi3    2.829354e-01    0.1985493 4.031866e-01  -1.2625368
 sdc     5.563060e-02    0.0139445 2.219340e-01  -2.8890221

Deterministic reference points (Drp)
            estimate        cilow        ciupp   log.est
 Bmsyd  6109.4014546 2597.8198726 14367.734471  8.717584
 Fmsyd     0.3675407    0.1539928     0.877224 -1.000921
 MSYd   2245.4534561 1790.7724348  2815.578979  7.716663
Stochastic reference points (Srp)
           estimate        cilow        ciupp   log.est  rel.diff.Drp
 Bmsys  5955.3524554 2513.9615682 1.410770e+04 8.6920457 -0.025867319
```

```
Fmsys        0.3683044    0.1536791       8.826712e-01  -0.9988455  0.002073659
MSYs   2193.5001833 1793.1999645    2.683160e+03  7.6932538 -0.023685101

States w 95% CI (inp$msytype: s)
                        estimate         cilow                ciupp            log.est
B_2020.94      5446.6493111   2471.0891079     1.200523e+04    8.6027559
F_2020.94        0.1561252            0.0688306      3.541313e-01   -1.8570972
B_2020.94/Bmsy    0.9145805       0.4685975     1.785024e+00   -0.0892898
F_2020.94/Fmsy    0.4239025       0.2006289     8.956505e-01    -0.8582517

Predictions w 95% CI (inp$msytype: s)
                        prediction             cilow                 ciupp          log.est
B_2022.00      6.729593e+03     3282.0864181       1.379836e+04    8.8142699
F_2022.00      1.561254e-01     0.0616203             3.955696e-01   -1.8570960
B_2022.00/Bmsy 1.130007e+00  0.5624155           2.270416e+00  0.1222242
F_2022.00/Fmsy 4.239031e-01    0.1779857           1.009597e+00 -0.8582505
Catch_2021.00    9.537592e+02  614.6381817       1.479987e+03   6.8604112
E(B_inf)              1.062240e+04            NA                   NA           9.2707205
```

Table 6.5.3.3 **Norway lobster in GSA 17 and 11:** Assessment summary. Weights are in tonnes.

Year	Biomass (tonnes)	Catch (tonnes)	F all ages
1970	12635	1271	0.10
1971	12748	1293	0.10
1972	13045	1369	0.10
1973	12160	1129	0.09
1974	12195	1100	0.09
1975	12753	1205	0.09
1976	13789	1543	0.11
1977	14087	2022	0.14
1978	11180	1497	0.13
1979	9885	1279	0.13
1980	9266	1128	0.12
1981	9479	1194	0.13
1982	10016	1382	0.14
1983	9935	1270	0.13
1984	10258	1267	0.12
1985	12151	2053	0.17
1986	12042	2319	0.19
1987	11117	2151	0.19
1988	11552	2727	0.24
1989	10010	2181	0.22
1990	9359	1929	0.21
1991	10077	2495	0.25
1992	10326	3106	0.30
1993	9573	3127	0.33
1994	9540	3300	0.35
1995	9388	3206	0.34
1996	8906	3493	0.39
1997	7636	3048	0.40
1998	6562	2418	0.37
1999	5553	1801	0.32
2000	5463	1834	0.34
2001	5197	1550	0.30
2002	5264	1317	0.25
2003	6681	2127	0.32
2004	6913	2353	0.34
2005	7430	3295	0.44
2006	6302	3113	0.49
2007	5510	2761	0.50
2008	5226	2681	0.51
2009	4736	2795	0.59
2010	3802	2512	0.66
2011	3064	1979	0.65
2012	2996	1955	0.65
2013	3045	2078	0.68
2014	2850	1755	0.62
2015	2930	1606	0.55
2016	3108	1431	0.46
2017	3541	1440	0.41
2018	4304	1526	0.36

2019	4990	1257	0.25
2020	5367	870	0.16

The SPiCT assessment this year is showing some considerable retrospective bias, revising biomass upwards and F downwards. 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, such a change in exploitation may result in some revisions to earlier estimates. Secondly the overall exploitation rate has decreased considerably in 2020 from 0.36 in 2018, to 0.25 in 2019 and 0.16 in 2020, possibly influenced by this closure but also by other effort measures. Changes in retrospective performance are common where rapid changes in catch od size of individual in catch occurs. The wide confidence intervals seen in this assessment reflect the considerable uncertainty in the assessment.

6.5.3.2 AREA BASED BIOMASS INDICES FOR NEPHROPS GSA 17-18.

Tor 3.2 For Nephrops 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.

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 6.5.3.4. The estimated biomass indices by area are given in Figure 6.5.3.2.1. 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 6.5.3.3) 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 6.5.3.2.1 can be removed (Figure 6.5.3.2.2). A good match between the combined sub area indices and the SPICT biomass (Figure 6.5.3.2.3) 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 6.5.3.2.4 and Table 6.5.3.2.1.

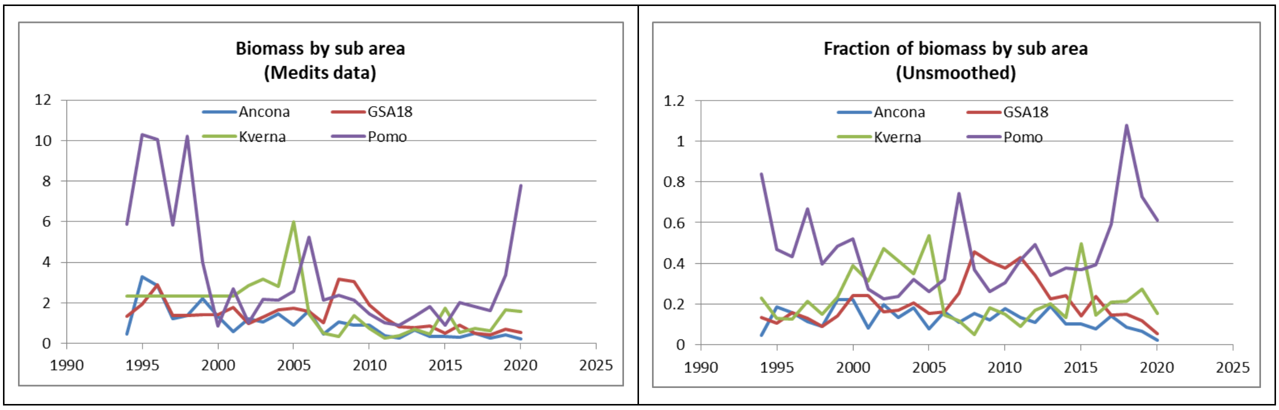


Figure 6.5.3.2.1 MEDITS sub area indices for the four sub areas GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit (Left) 1994 to 2020, and fraction of total biomass calculated from the indices (Right)

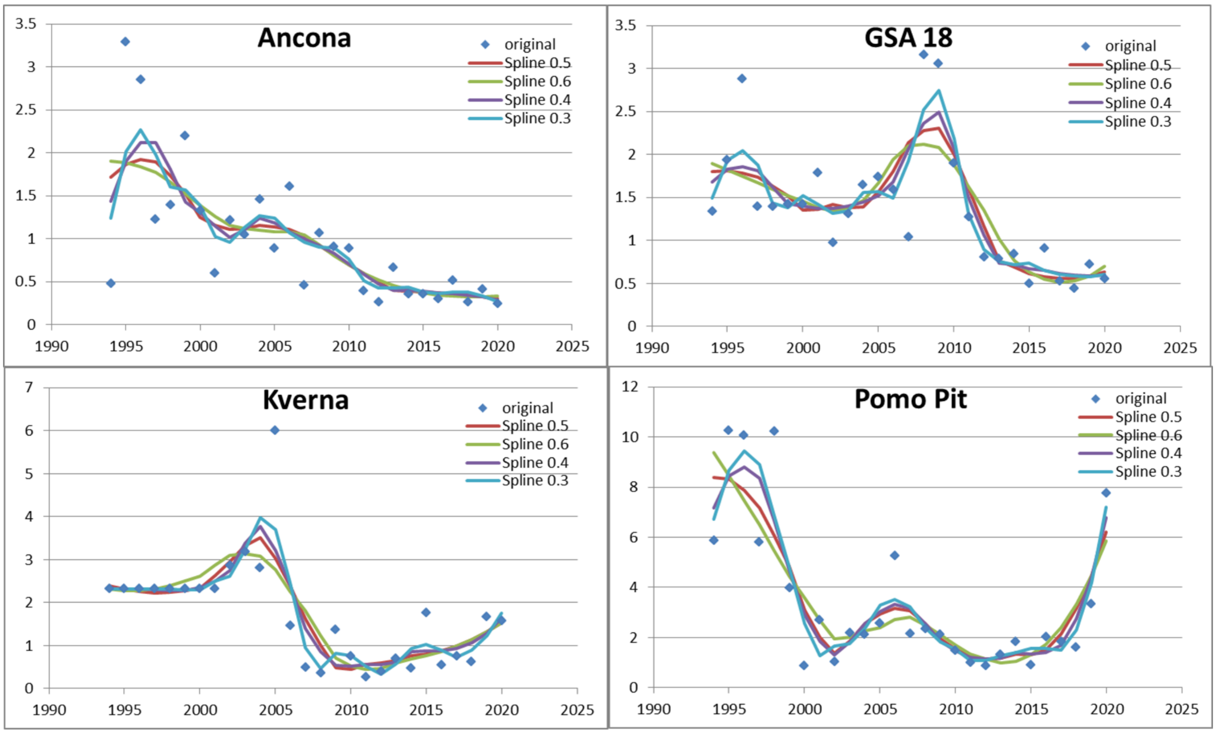


Figure 6.5.4.2.1 MEDITS sub area indices for the four sub areas GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit with original data (points) and a range of smoothing options.

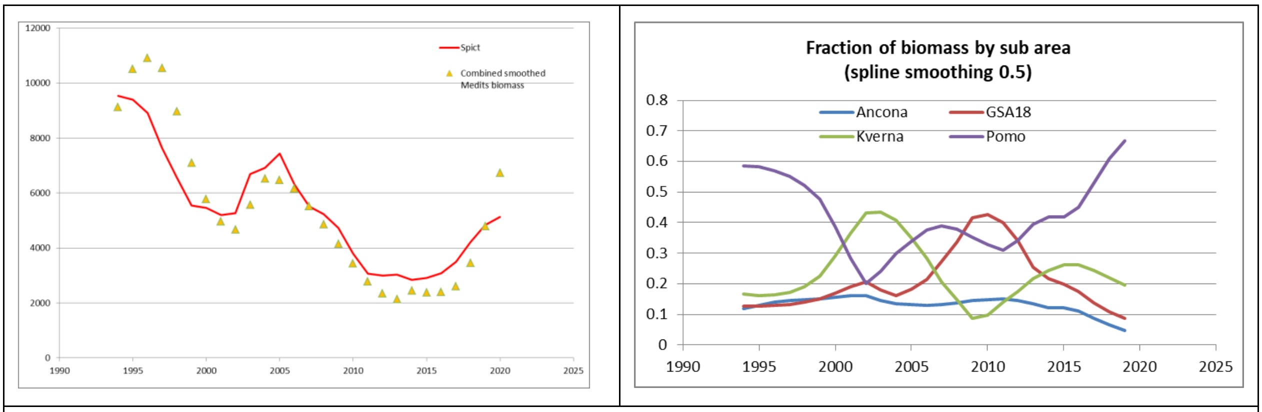


Figure 6.5.4.2.3 Combined smoothed MEDITS index with best fit to assessment compared with SPiCT assessment biomass (Left) (MEDITS

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 (Right) 1994 to 2020.

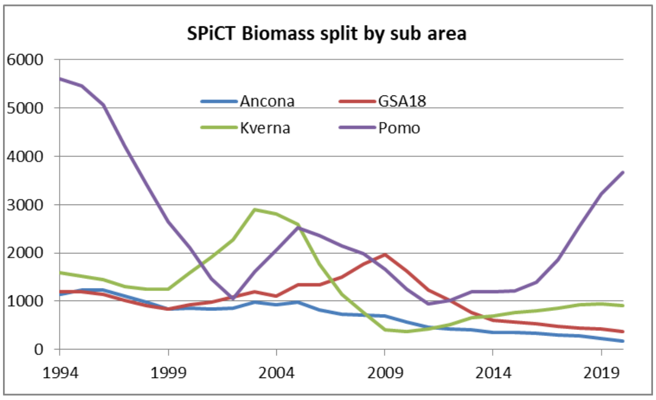


Figure 6.5.4.2.4 SPiCT biomass split using smoothed MEDITS for the four sub areas GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit (left) 1994 to 2020.

Table 6.5.3.2.1 Nephrops in GSA 17-18 biomass indices by sub area; GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit 1994 to 2020.

year	**Ancona**	**GSA18**	**Kverna**	**Pomo**	**SPiCT**
1994	1143	1204	1599	5594	9540
1995	1225	1188	1515	5459	9388
1996	1237	1149	1450	5070	8906
1997	1112	1017	1305	4203	7636
1998	975	918	1253	3416	6562
1999	831	831	1246	2645	5553
2000	849	921	1588	2105	5463
2001	837	988	1904	1469	5197
2002	850	1088	2271	1055	5264
2003	976	1204	2893	1608	6681
2004	928	1111	2813	2061	6913

2005	978	1347	2592	2513	7430
2006	821	1342	1777	2361	6302
2007	724	1499	1136	2151	5510
2008	715	1762	772	1978	5226
2009	688	1966	416	1666	4736
2010	566	1620	367	1249	3802
2011	459	1227	432	946	3064
2012	432	1019	525	1019	2996
2013	407	772	661	1205	3045
2014	348	615	692	1195	2850
2015	357	580	765	1228	2930
2016	348	542	816	1402	3108
2017	310	485	866	1879	3541
2018	281	461	944	2618	4304
2019	241	436	978	3336	4990
2020	189	393	948	3837	5367

6.5.3.3 a4a stock assessment for GSA 18

As part of the sub area analysis of Nephrops in GSA 17-18, the EWG 21-15 was requested to assess the Norway lobster stock in GSA 18 using a statistical catch – at – age approach (ToR 3.3). It was not possible to split catches to sub area for GSA 17, so the sub areas in GSA 17 are evaluated using SURBA in Section 6.5.3.4 along with a discussion of sub area allocation. Assessment for all (a4a, Jardim et al., 2014) was applied to the GSA 18 data provided by the DCF and two candidate models were selected as preliminary assessments of the status of the stock. As the assessments were considered unstable and lacked acceptable diagnostics, only F trends were considered and compared the ones provided by survey based assessments (See section 6.5.x.x).

6.5.3.3.1. Input data

The growth parameters used to slice length frequency data were provided by the DCF and a sex separated slicing procedure was performed using l2a() function of FLR (http://www.flr-project.org/). Table 6.5.3.3.1.1 shows the VBGF parameters used. The parameters of length – weight relationship used to inform the assessment, were also provided by the DCF.

Table 6.5.3.3.1.1 Norway lobster in GSA 18. VBGF and length – weight relationship parameters

	L_{inf}	k	t_0	a	b
Females	60.59	0.19	-0.5	0.00052857	3.07952
Males	79.78	0.17	-0.5	0.000464	3.12002

Natural mortality (M) by age was estimated using the Chen – Watanabe formula and maturity vector was provided by the DCF. Natural mortality and maturity by age are presented in Table 6.5.3.3.1.2.

Table 6.5.3.3.1.2 Norway lobster in GSA 18. Natural mortality and maturity vectors by age.

Age:	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
M	1.0897	0.59325	0.42985	0.35119	0.30433	0.27355	0.25342	0.24082
Maturity	0	0.172	0.847	0.997	0.999	1	1	1

Commercial catch and catch numbers were available from 2002 and ages 0 to 7 used in the assessment. MEDITS indices by length were sliced using the same growth parameters and ages from 1 – 6 were used to tune the assessment. The M and F before spawning were set to 0.5 and a 7 plus group was set for the catch. The age structure of the catch by year and the cohort consistency of the of the catch are presented in Figures 6.5.3.3.1.1 – 6.5.3.3.1.2 and the MEDITS abundance indices by age along with the cohort consistency are presented in Figures 6.5.3.3.1.3 – 6.5.3.3.1.4. Fbar was set to ages 1-3 as they were the most represented in the catch.

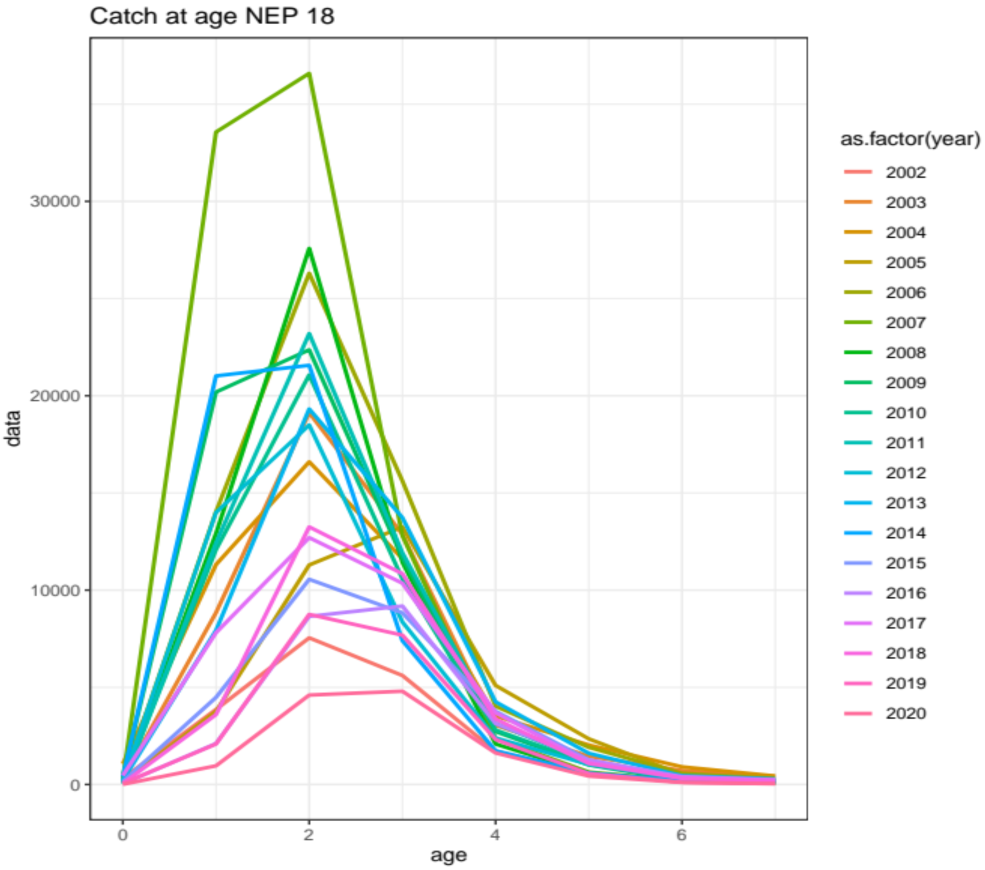


Figure 6.5.3.3.1.1 Norway lobster in GSA 18. Age structure of the catch by year.

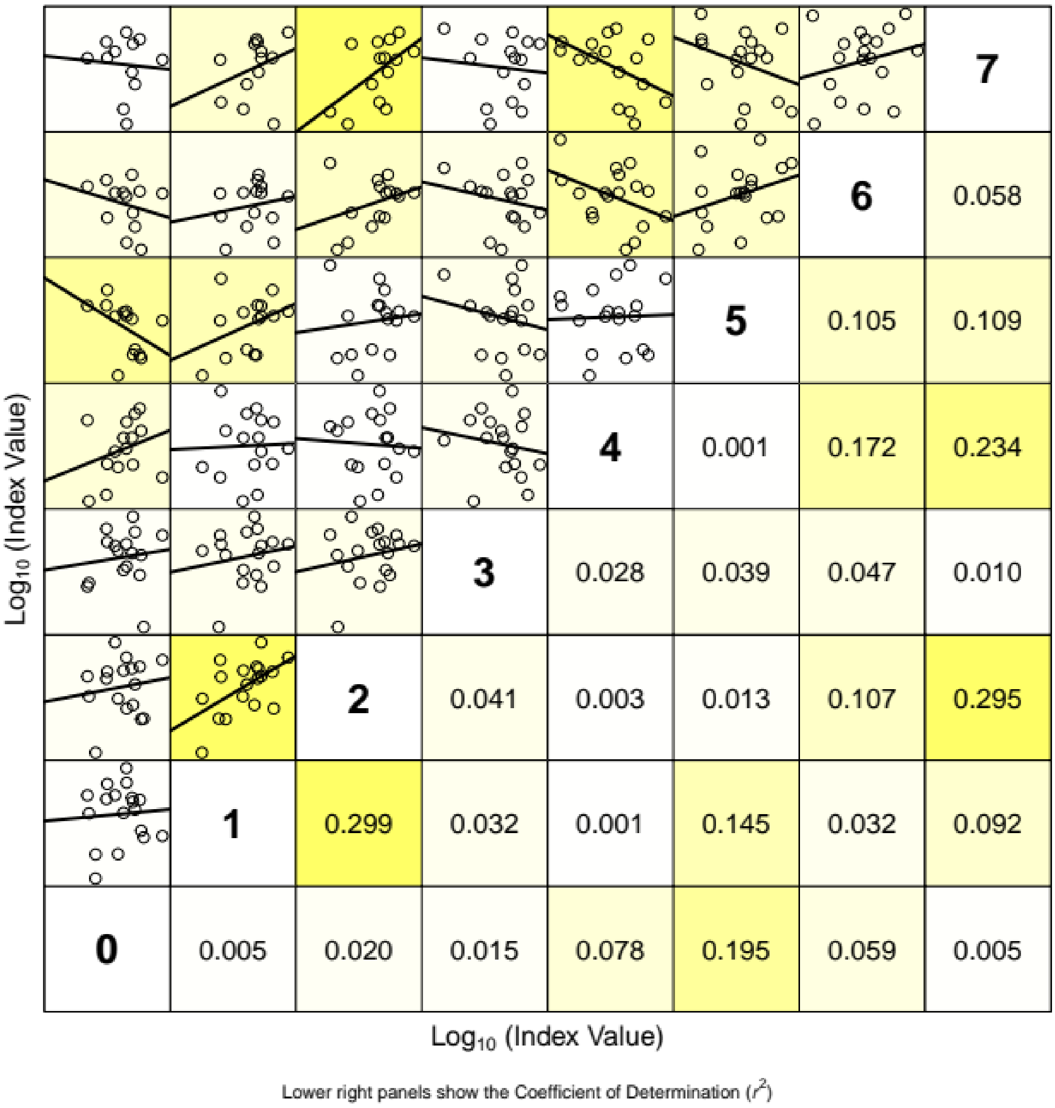


Figure 6.5.3.3.1.2 Norway lobster in GSA 18. Cohort consistency of the catch.

The cohort consistency of the catch is not good in almost all ages except from 1 to 2 where there is a medium positive consistency of 0.3.

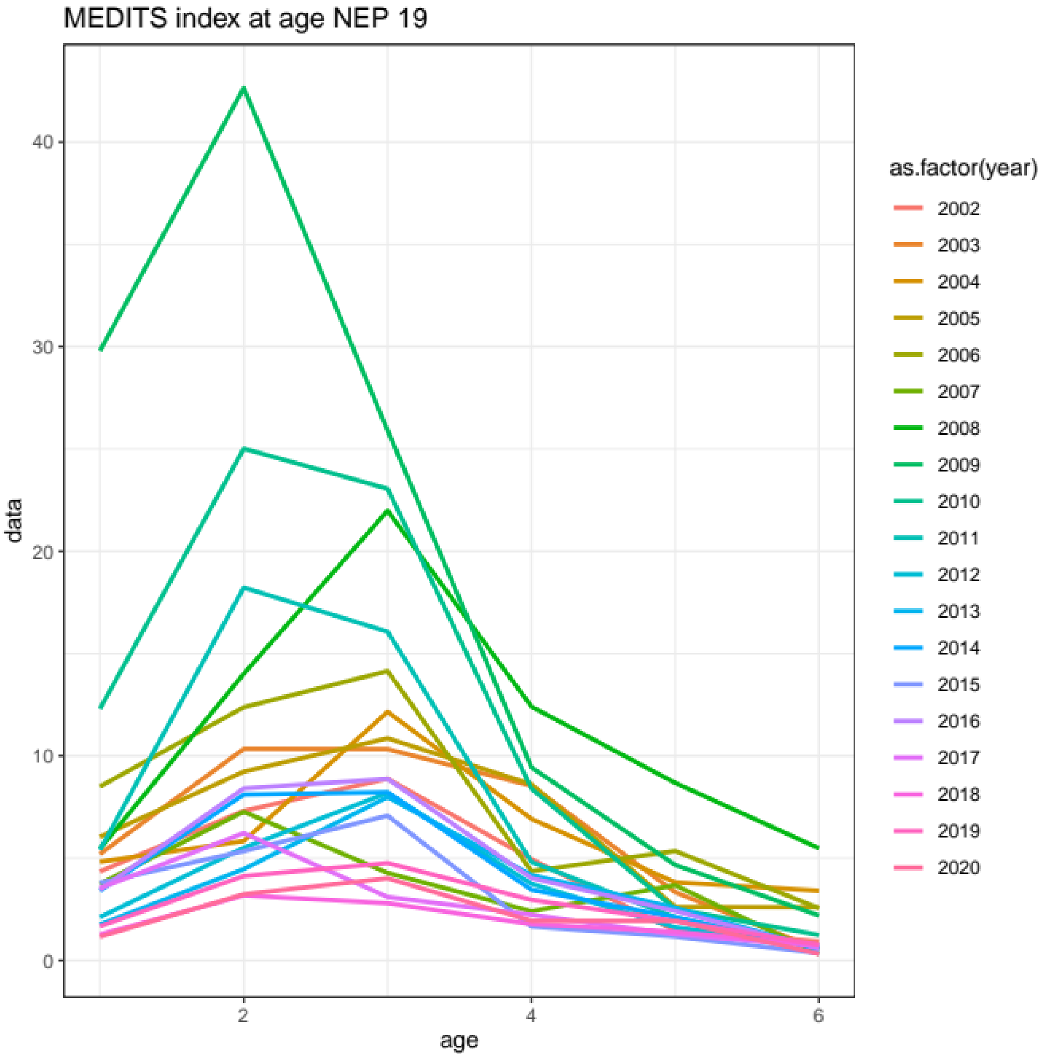


Figure 6.5.3.3.1.3 Norway lobster in GSA 18. MEDITS age structure by year.

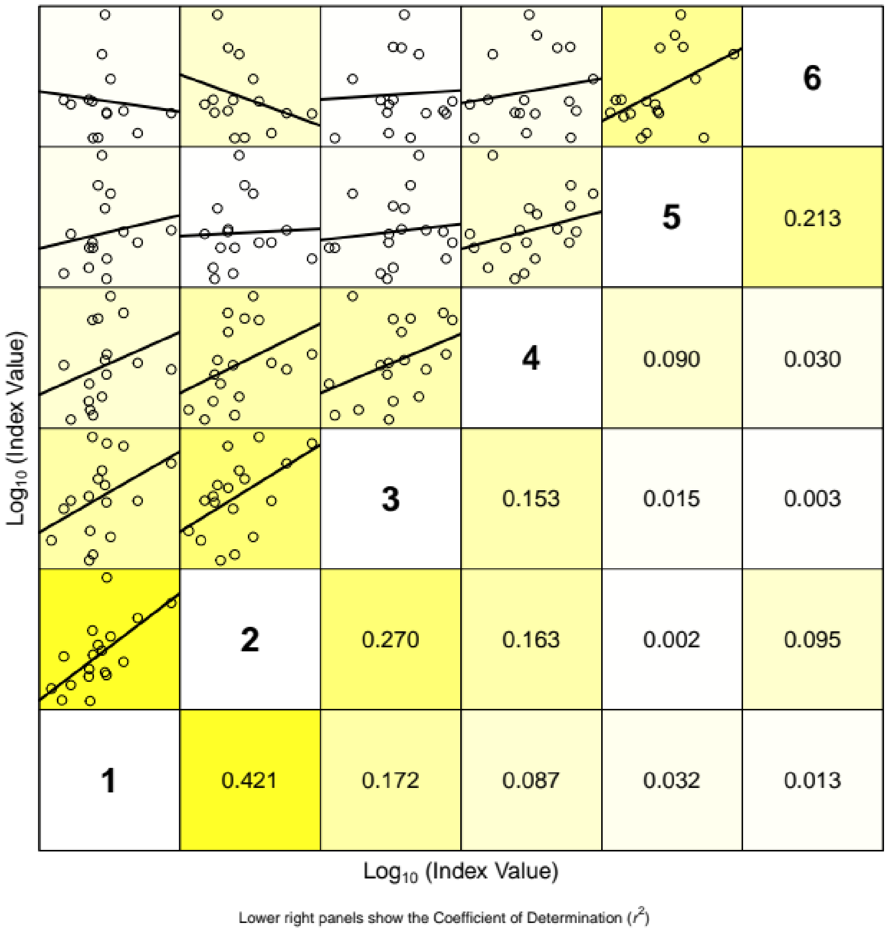


Figure 6.5.3.3.1.4 Norway lobster in GSA 18. MEDITS Index cohort consistency.

Total catch, catch numbers by age, individual weight by age and MEDITS abundance indices by age are presented in Tables 6.5.3.3.1.3 – 6.5.3.3.1.6.

Table 6.5.3.3.1.3 Norway lobster in GSA 18. Catch in tonnes

Year	Catch (tonnes)
2002	481
2003	1192
2004	1224
2005	1205
2006	1456
2007	1321
2008	1018
2009	1099
2010	1030
2011	1123
2012	898
2013	1234
2014	850
2015	850
2016	807
2017	948
2018	911
2019	591
2020	374

Table 6.5.3.3.1.4 Norway lobster in GSA 18. Catch at age by year.

year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2002	311	3858	7545	5607	1710	586	115	62
2003	282	8840	19126	12867	3050	1449	719	419
2004	1063	11313	16601	11618	3524	2030	909	437
2005	126	3760	11294	13251	5096	2348	516	192
2006	210	14035	26303	15616	4028	1912	571	313
2007	270	33567	36585	12797	2371	641	198	49
2008	89	12912	27581	11431	2081	594	162	60
2009	384	20191	22362	11665	2722	1003	213	90
2010	86	12085	21070	10576	2802	1071	312	223
2011	37	12436	23199	11919	3141	1156	317	156
2012	185	13994	18495	8361	2394	1028	296	187
2013	213	7929	19319	13726	4251	1606	453	289
2014	408	21022	21565	7399	1734	590	193	119
2015	144	4481	10555	8831	3764	1268	325	163
2016	39	2107	8650	9180	3134	1258	407	247
2017	458	7809	12700	10356	3690	1138	360	232
2018	53	3596	13253	10844	3370	1078	317	162
2019	52	2082	8752	7683	2311	563	118	52
2020	7	960	4601	4798	1623	431	103	37

Table 6.5.3.3.1.5 Norway lobster in GSA 18. Catch weight by age and year.

year	0	1	2	3	4	5	6	7
2002	0.002	0.009	0.019	0.031	0.047	0.066	0.083	0.091
2003	0.003	0.009	0.018	0.029	0.047	0.071	0.106	0.151
2004	0.001	0.008	0.017	0.031	0.051	0.074	0.106	0.117
2005	0.003	0.009	0.021	0.034	0.053	0.067	0.077	0.08
2006	0.003	0.009	0.017	0.029	0.049	0.072	0.1	0.112
2007	0.003	0.008	0.014	0.027	0.047	0.056	0.08	0.084
2008	0.003	0.01	0.016	0.025	0.046	0.064	0.082	0.094
2009	0.003	0.008	0.017	0.029	0.048	0.065	0.078	0.093
2010	0.003	0.009	0.016	0.029	0.049	0.068	0.091	0.126
2011	0.003	0.009	0.017	0.029	0.049	0.068	0.09	0.106
2012	0.003	0.009	0.016	0.029	0.051	0.07	0.093	0.115
2013	0.003	0.009	0.018	0.03	0.047	0.07	0.093	0.127
2014	0.003	0.008	0.015	0.027	0.046	0.071	0.096	0.116
2015	0.003	0.01	0.019	0.033	0.052	0.065	0.077	0.094
2016	0.003	0.01	0.021	0.032	0.049	0.068	0.099	0.125
2017	0.003	0.008	0.019	0.031	0.047	0.068	0.09	0.122
2018	0.003	0.01	0.02	0.031	0.046	0.066	0.09	0.117
2019	0.003	0.01	0.021	0.03	0.043	0.062	0.08	0.096
2020	0.002	0.01	0.022	0.032	0.044	0.061	0.084	0.091

Table 6.5.3.3.1.6 Norway lobster in GSA 18. Abundance indices by age from MEDITS survey.

year	1	2	3	4	5	6
2002	4.35	7.314	8.882	4.953	1.456	0.933
2003	5.205	10.34	10.328	8.54	3.337	0.522
2004	4.825	5.837	12.152	6.919	3.818	3.409
2005	6.044	9.23	10.855	8.619	2.622	2.605
2006	8.501	12.376	14.145	4.36	5.347	2.556
2007	3.748	7.269	4.279	2.405	3.675	0.321
2008	5.461	14.012	21.984	12.408	8.681	5.481
2009	29.798	42.645	25.914	9.441	4.666	2.194
2010	12.304	25.017	23.058	8.404	2.517	1.243
2011	5.415	18.225	16.069	4.815	2.108	0.595
2012	2.122	5.509	8.19	3.749	1.62	0.742
2013	1.762	4.464	7.984	4.173	2.581	0.558
2014	3.41	8.11	8.223	3.456	2.112	0.564
2015	3.798	5.341	7.077	1.656	1.17	0.356
2016	3.454	8.411	8.876	4.027	2.421	0.572
2017	3.529	6.225	3.104	2.236	1.277	0.693
2018	1.271	3.178	2.802	1.778	1.4	0.763
2019	1.676	4.125	4.761	2.965	1.934	0.77
2020	1.164	3.236	4.014	1.942	1.937	0.318

a4a submodels formulation:

Different combinations of F, q and recruitment sub-models were explored in order to select the one that represents best the knowledge of the fisheries in the area as well as having the best diagnostics and retrospective performance. The best candidate model was:

- fmodel <- ~s(year, k = 10)+factor(replace(age, age>4,4))
- qmodel <- list(~factor(replace(age, age>4,4)))
- srmodel <- ~geomean(CV=0.3)

Figures 6.5.3.3.1.5 – 6.5.3.3.1.7 present stock assessment results, 3D plot of fishing mortality by age and year and 3D plot of catchability by age and year. The 3D plots of harvest and catchability reflect the assumption of constant age effect on F and q after age 4. Table 6.5.3.3.1.7 shows the main results of the assessment.

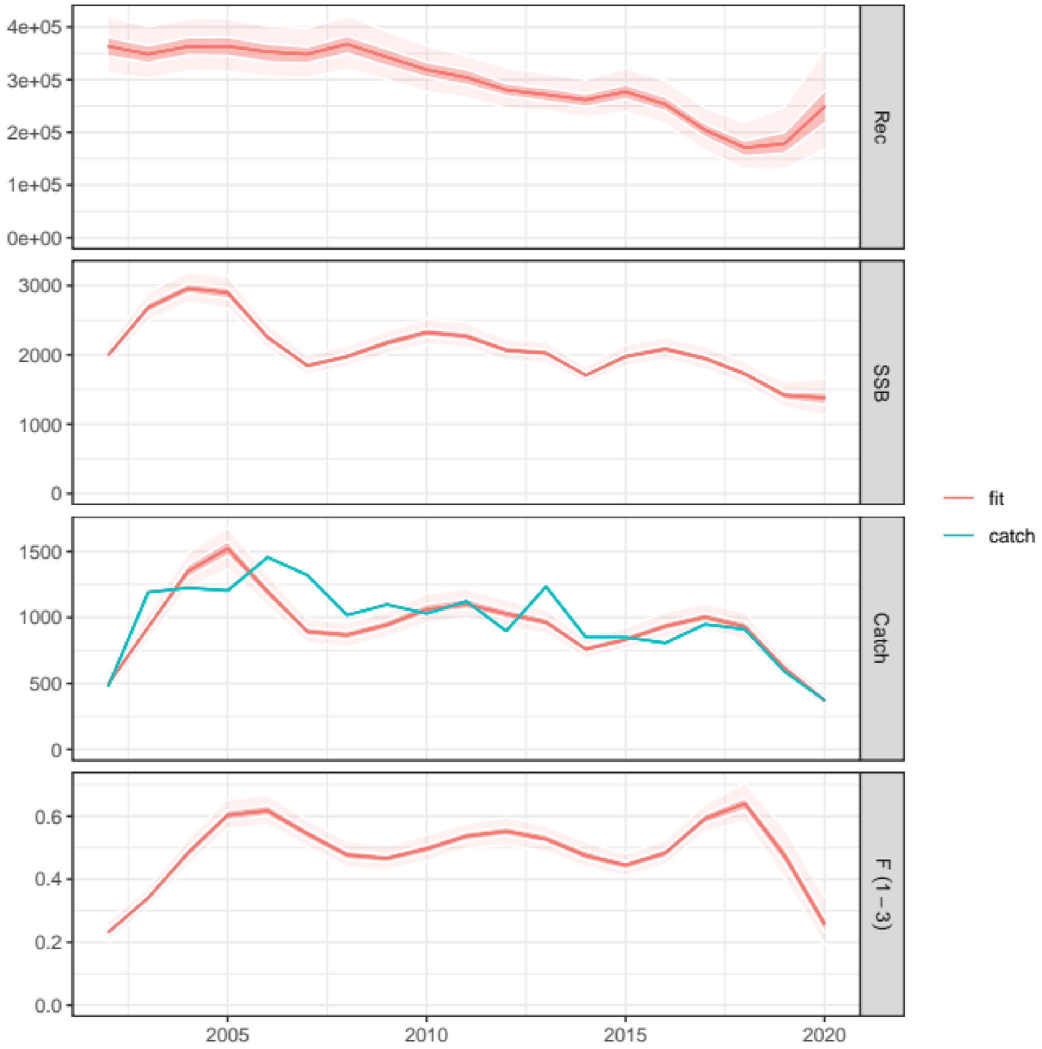


Figure 6.5.3.3.1.5 Norway lobster in GSA 18. Results of the stock assessment with 95% confidence limits and the observed catch.

Using the model above, recruitment shows a decline almost to half of what it was in the beginning of the time series, with signs of recovery for the past two years. SSB also shows a declining trend in line with the recruitment. Estimated catch deviates from the observed catches, especially in the beginning of the time series while in the end of the time series they generally overlap. F for most of the years fluctuates around 0.5 with a peak in 2018, followed by a steep decrease for the past two years, following the reduction in catch.

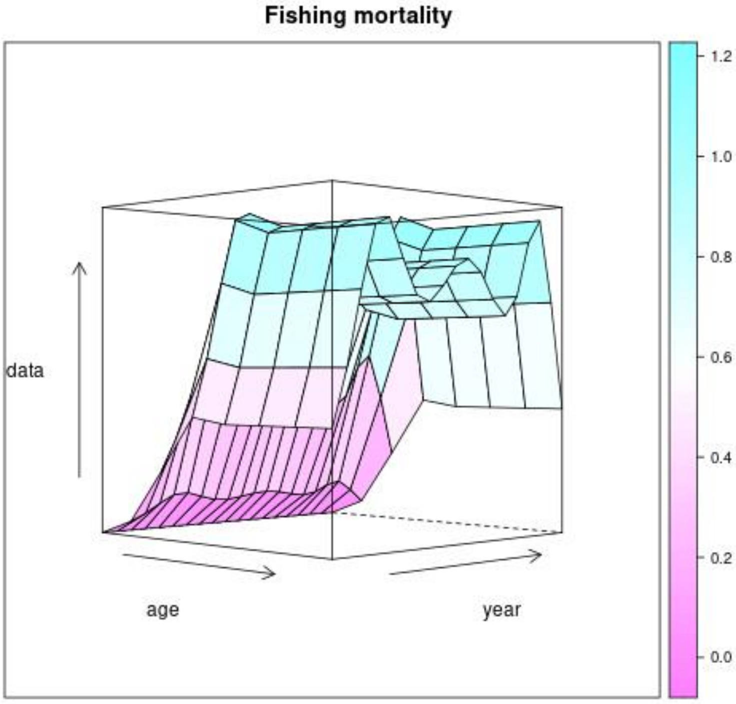


Figure 6.5.3.3.1.6 Norway lobster in GSA 18. 3D plot of fishing mortality by age and year.

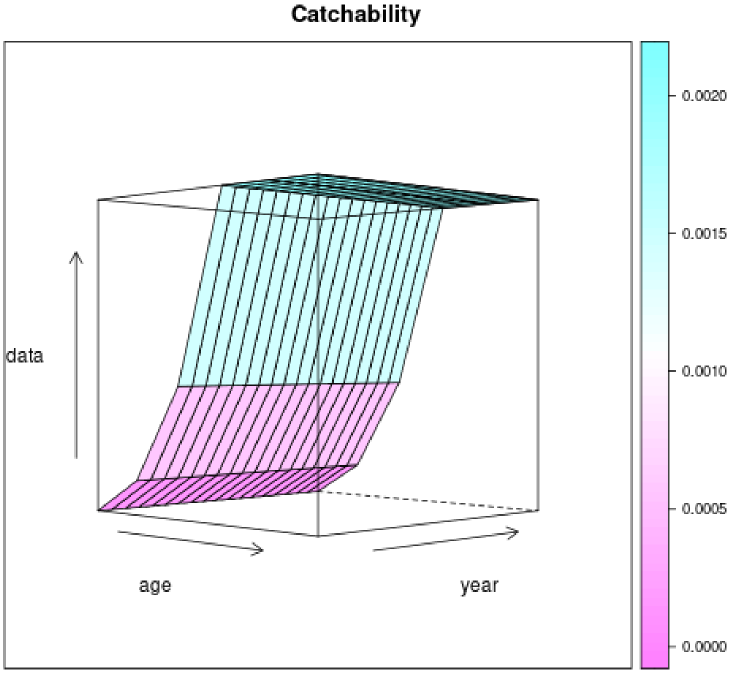


Figure 6.5.3.3.1.7 Norway lobster in GSA 18. 3D plot of catchability by age and year.

Table 6.5.3.3.1.7 Norway lobster in GSA 18. Assessment results.

year	**recruitment**	**SSB**	**catch**	**Fbar**
2002	362772	1999	498	0.232
2003	348782	2681	924	0.34
2004	363294	2956	1348	0.482
2005	362666	2892	1518	0.603
2006	351144	2251	1193	0.618
2007	347571	1844	892	0.543
2008	366562	1973	865	0.477
2009	342913	2171	943	0.465
2010	318090	2320	1060	0.496
2011	303850	2272	1100	0.536
2012	280915	2068	1027	0.552
2013	273077	2025	962	0.528
2014	261600	1705	760	0.476
2015	277468	1979	835	0.444
2016	253865	2083	933	0.482
2017	202774	1945	1000	0.592
2018	168983	1724	929	0.639
2019	179639	1409	615	0.475
2020	246022	1368	371	0.256

The Figures 6.5.3.3.1.8 – 6.5.3.3.1.13 present the diagnostics of the assessment. Total catch residuals did not show any particular pattern, however, the residuals of the abundance index by age exhibited a strong pattern across all ages being positive for the years 2008-2011 and negative for the later years.

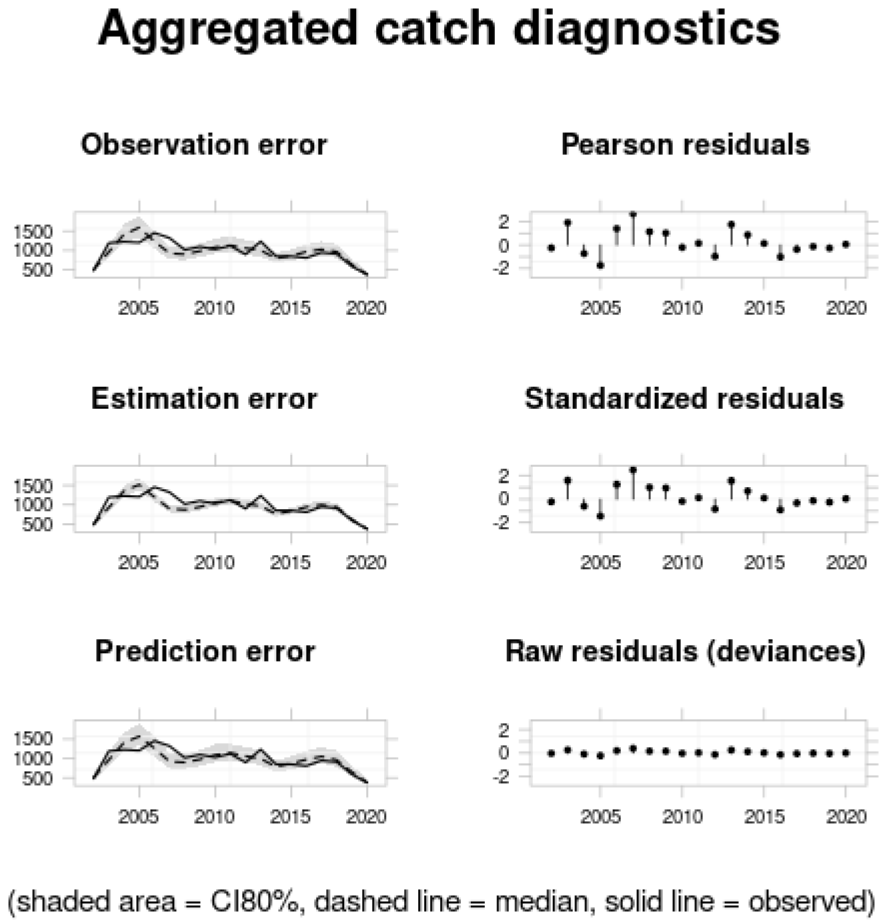


Figure 6.5.3.3.1.8 Norway lobster in GSA 18. Total catch diagnostics.

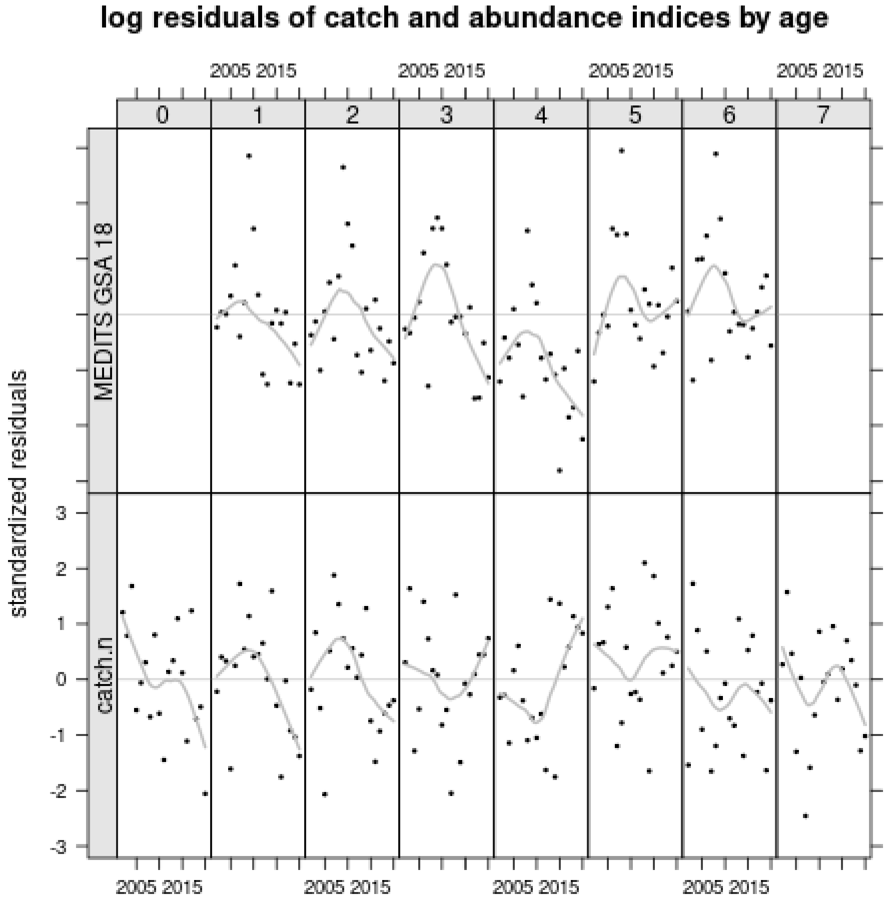


Figure 6.5.3.3.1.9 Norway lobster in GSA 18. Standardized log residuals of catch numbers by year and abundance indices by age and year.

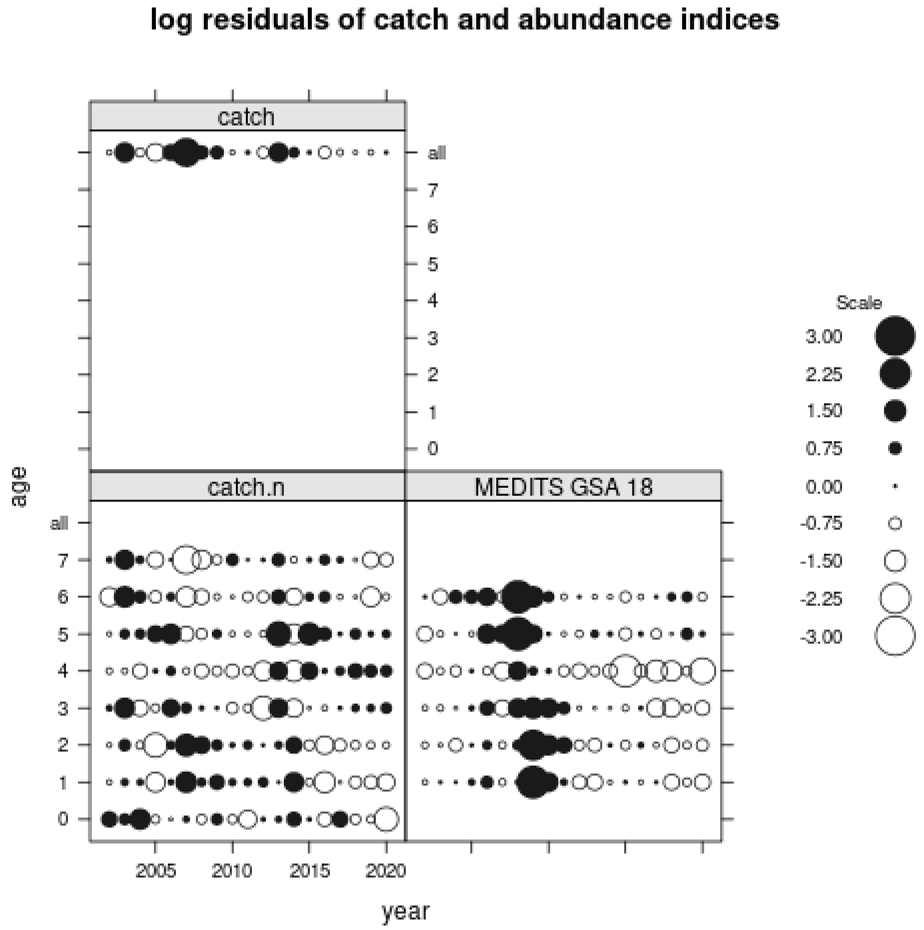


Figure 6.5.3.3.1.10 Norway lobster in GSA 18. Bubble plot of the log residuals for catch, catch numbers by age and MEDITS abundance index.

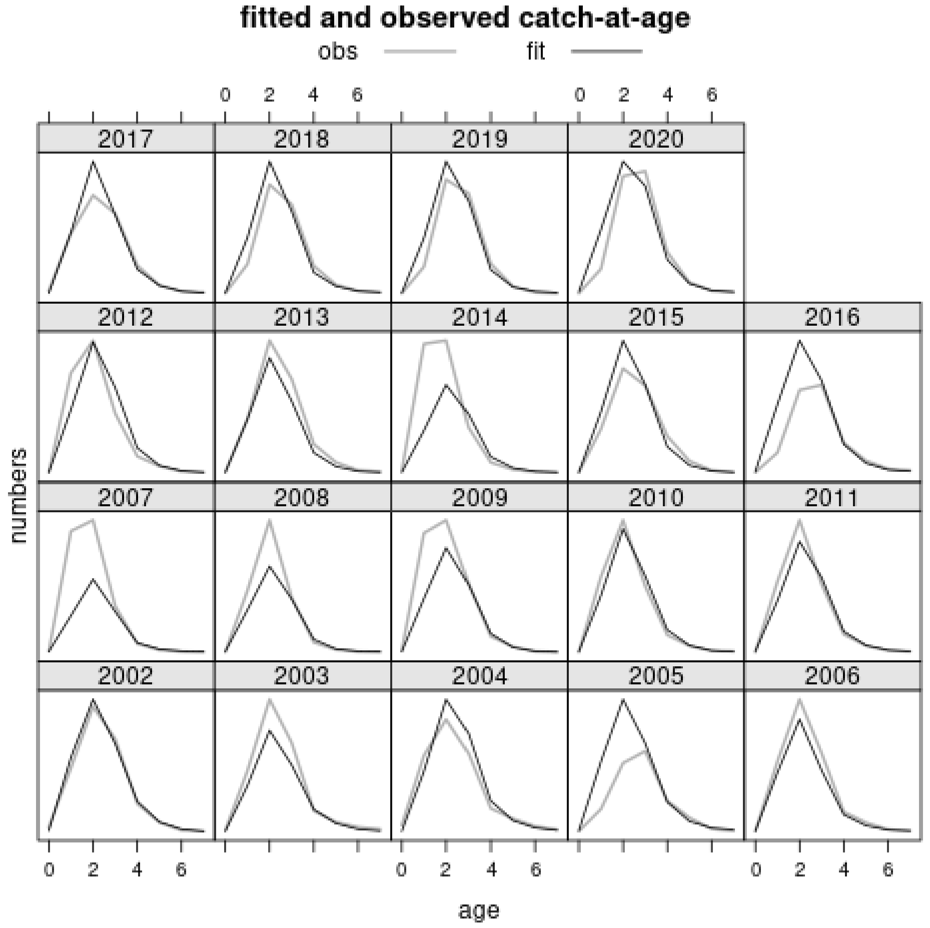


Figure 6.5.3.3.1.11 Norway lobster in GSA 18. Fitted and observed catch at age.

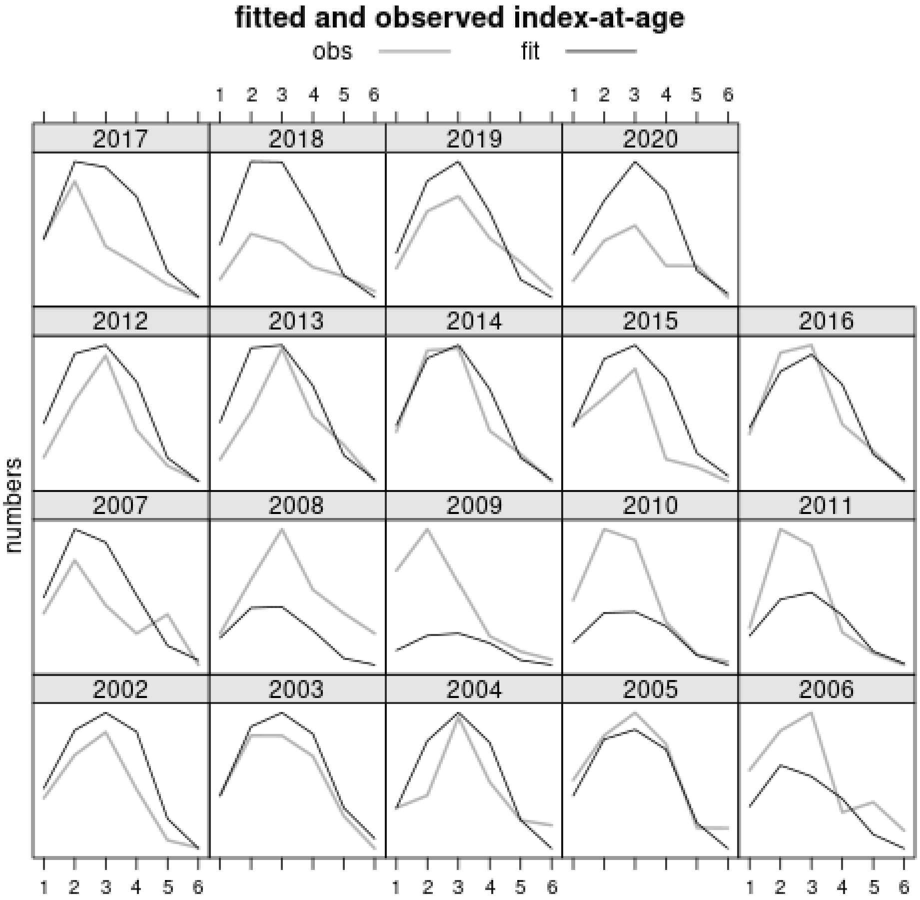


Figure 6.5.3.3.1.12 Norway lobster in GSA 18. Fitted and observed abundance index at age.

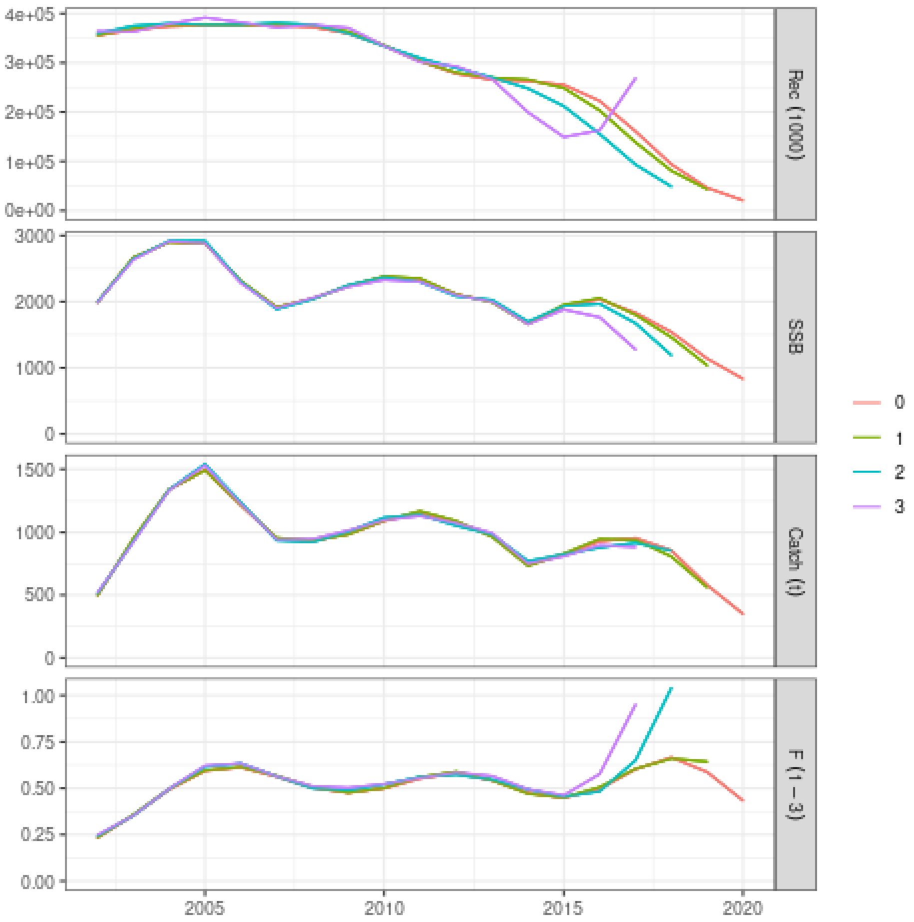


Figure 6.5.3.3.1.13 Norway lobster in GSA 18. Retrospective plot for 3 years back.

Both residual patterns and the retrospective plot indicate that, the model fits the catches and does not follow the abundance index signal, with blocks of residuals, positive in 2008-2011 and negative in the last four years 2017-2018. For this reason, an alternative approach was tested, trying to find a model to fit better the abundance indices. The likelihood of the a4a model consists of two likelihood components, one of the observed catches and one of the observed indices. By default, the model weights the likelihood components using the inverse variance. In order to constrain the model to fit better the observed abundance indices an external weighting of the likelihood components was applied. The rest of the model's settings like the submodels structure were kept the same.

Figures 6.5.3.3.1.14 – 6.5.3.3.1.16 and Table 6.5.3.3.1.8 present the main results of the alternative run.

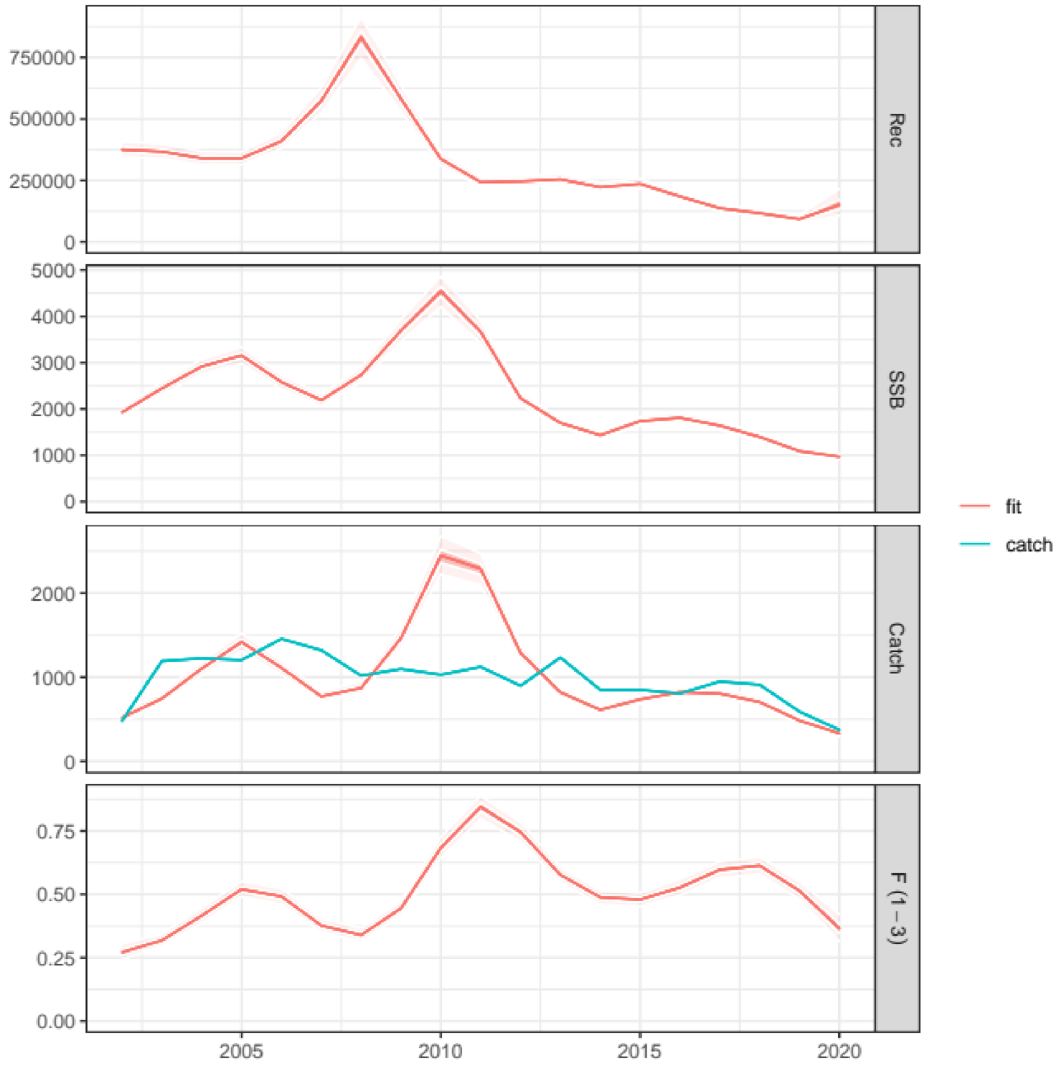


Figure 6.5.3.3.1.14 Norway lobster in GSA 18. Results of the stock assessment with 95% confidence limits and the observed catch.

Although the perception of the stock for the middle years of the assessment is completely different compared to the previous assessment, for the final years the results are similar, with F declining from about 0.6 to 0.3 from 2018 to 2029. This assessment reduces the extent of the blocks of residuals (Figure 6.5.3.3.1.19), but does not remove the effect completely. Recent retrospective performance is slightly improved (Figure 6.5.3.3.1.22) especially for SSB.

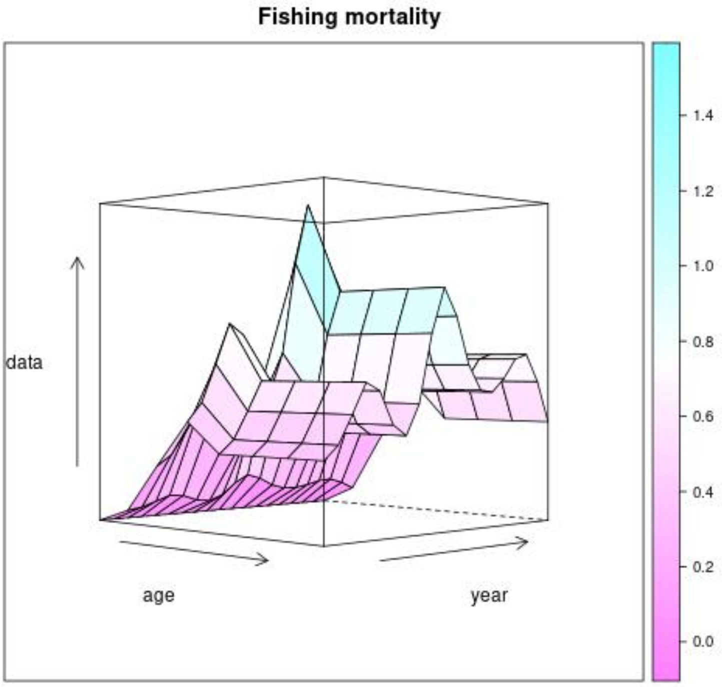


Figure 6.5.3.3.1.15 Norway lobster in GSA 18. 3D plot of fishing mortality by age and year.

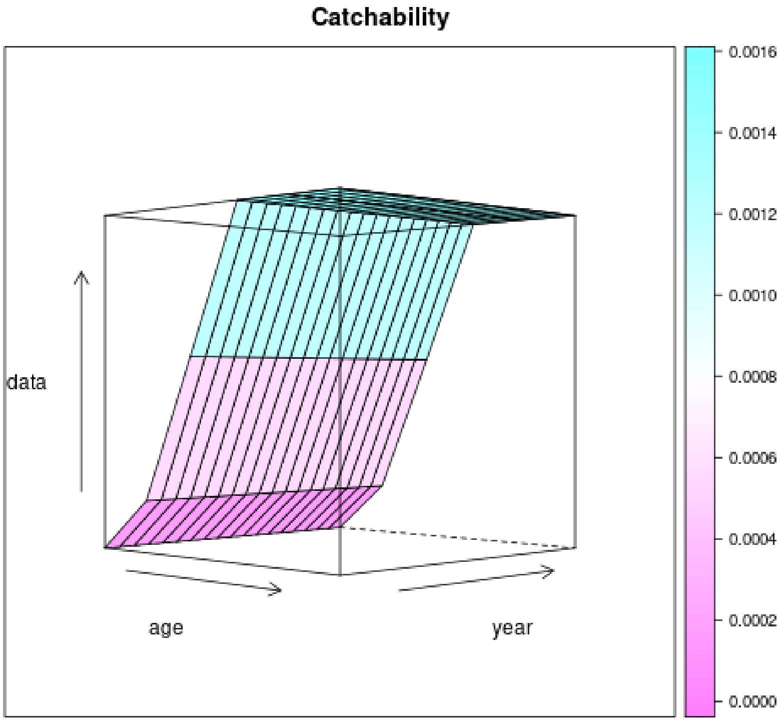


Figure 6.5.3.3.1.16 Norway lobster in GSA 18. 3D plot of catchability by age and year.

Table 6.5.3.3.1.8 Norway lobster in GSA 18. Assessment results.

year	**recruitment**	**SSB**	**catch**	**Fbar**
2002	362772	1999	498	0.232
2003	348782	2681	924	0.34
2004	363294	2956	1348	0.482
2005	362666	2892	1518	0.603
2006	351144	2251	1193	0.618
2007	347571	1844	892	0.543
2008	366562	1973	865	0.477
2009	342913	2171	943	0.465
2010	318090	2320	1060	0.496
2011	303850	2272	1100	0.536
2012	280915	2068	1027	0.552
2013	273077	2025	962	0.528
2014	261600	1705	760	0.476
2015	277468	1979	835	0.444
2016	253865	2083	933	0.482
2017	202774	1945	1000	0.592
2018	168983	1724	929	0.639
2019	179639	1409	615	0.475
2020	246022	1368	371	0.256

Figures 6.5.3.3.1.17 – 6.5.3.3.1.22 present the diagnostics of the assessment.

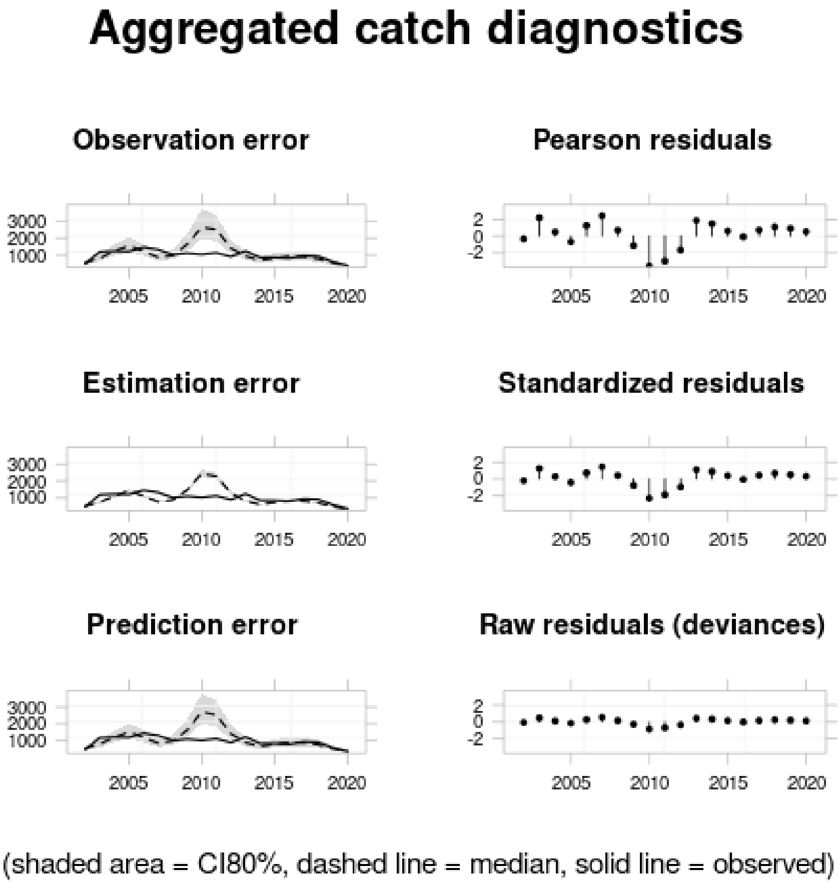


Figure 6.5.3.3.1.17 Norway lobster in GSA 18. Total catch diagnostics

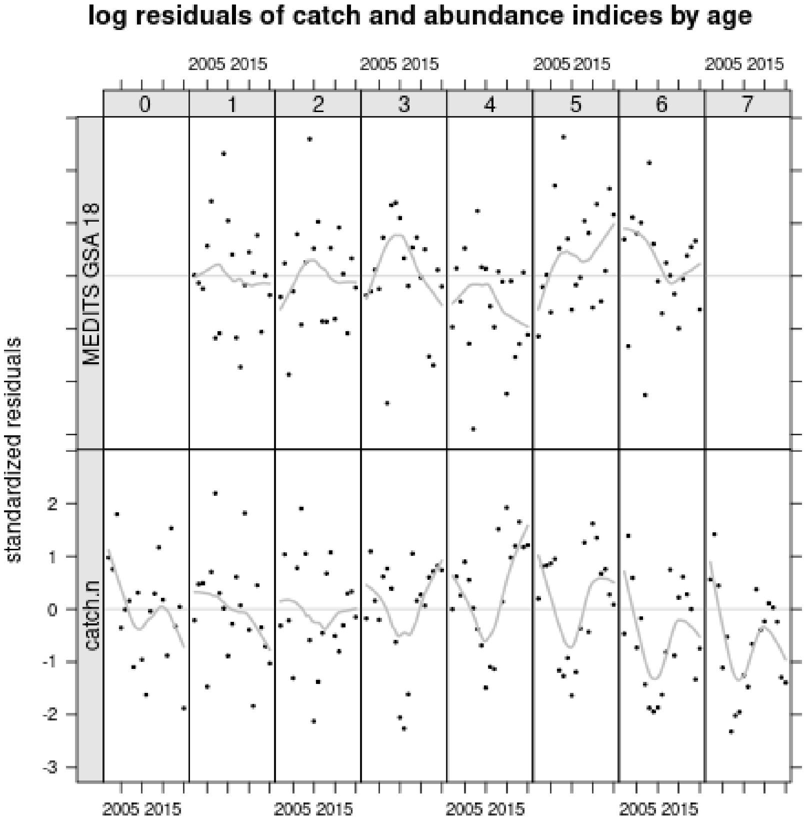


Figure 6.5.3.3.1.18 Norway lobster in GSA 18. Standardized log residuals of catch numbers by year and abundance indices by age and year.

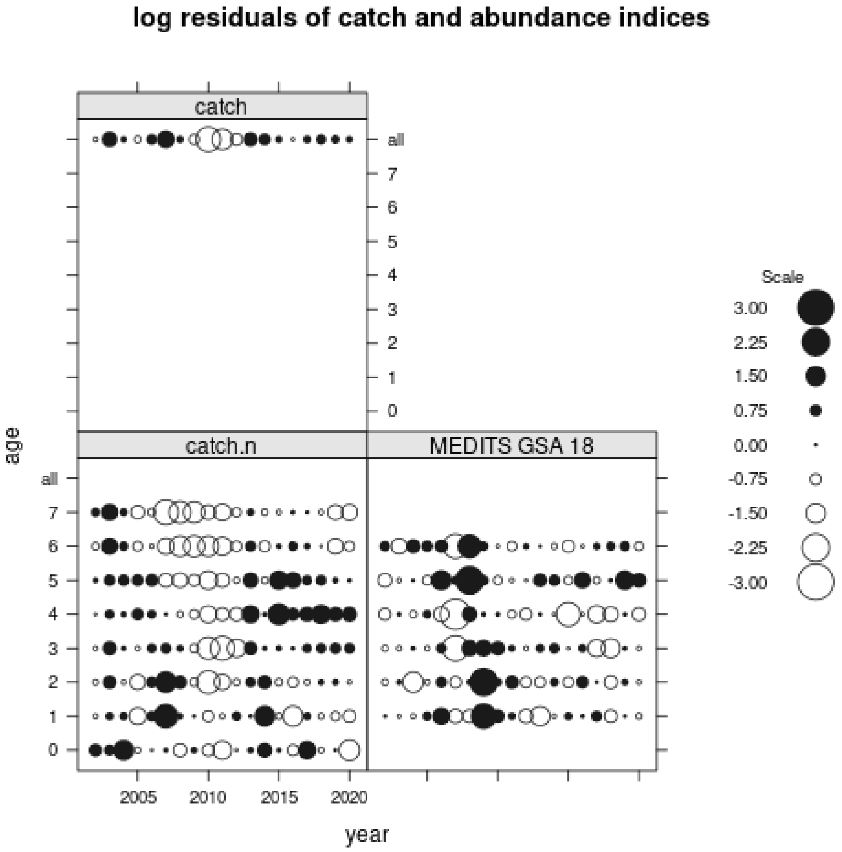


Figure 6.5.3.3.1.19 Norway lobster in GSA 18. Bubble plot of log residuals by age and year.

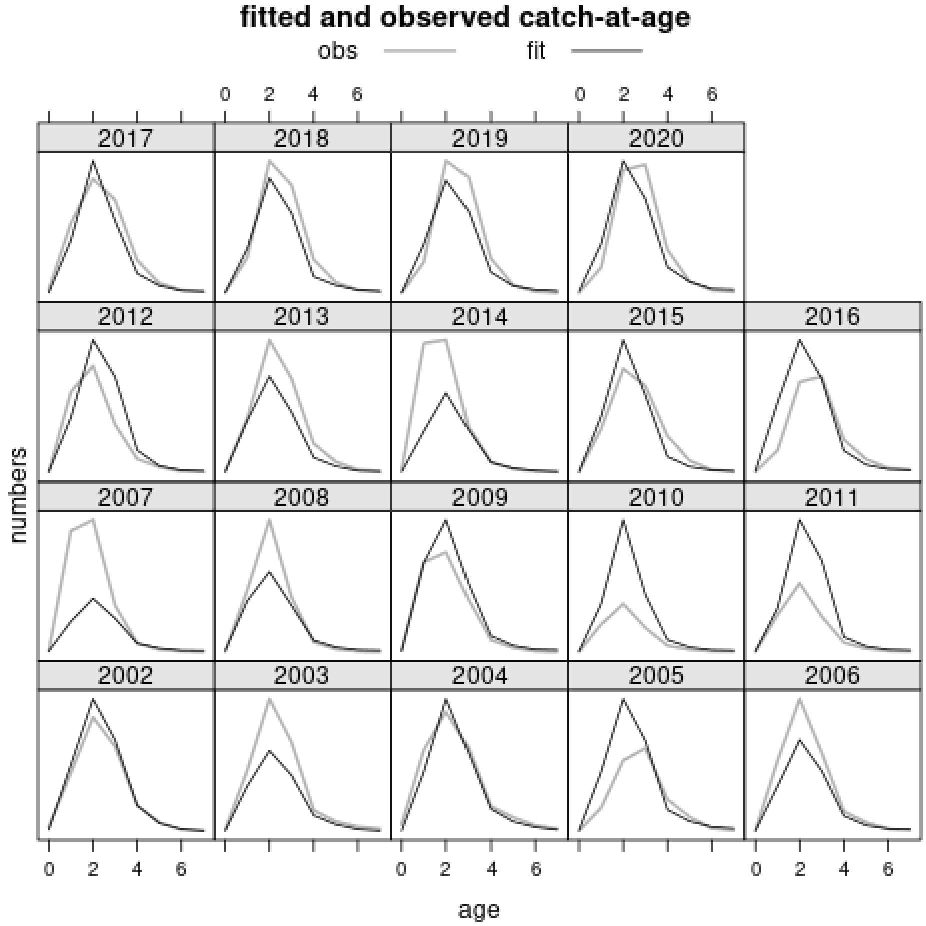


Figure 6.5.3.3.1.20 Norway lobster in GSA 18. Fit and observed catch at age.

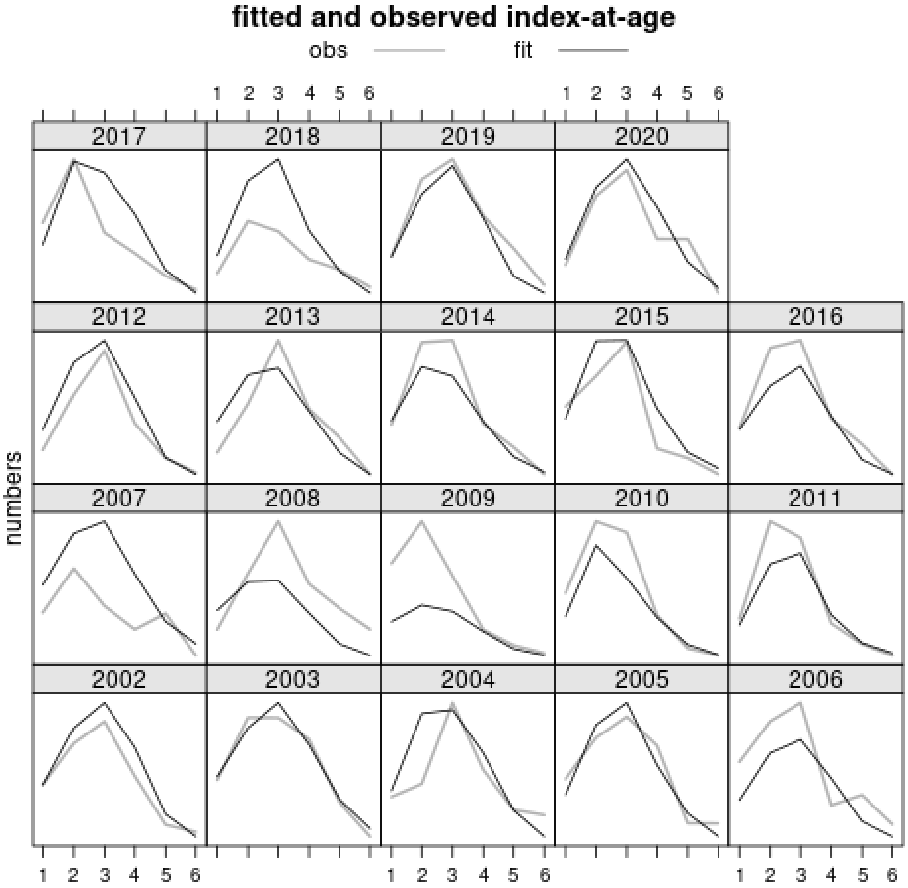


Figure 6.5.3.3.1.21 Norway lobster in GSA 18. Fit and observed index at age.

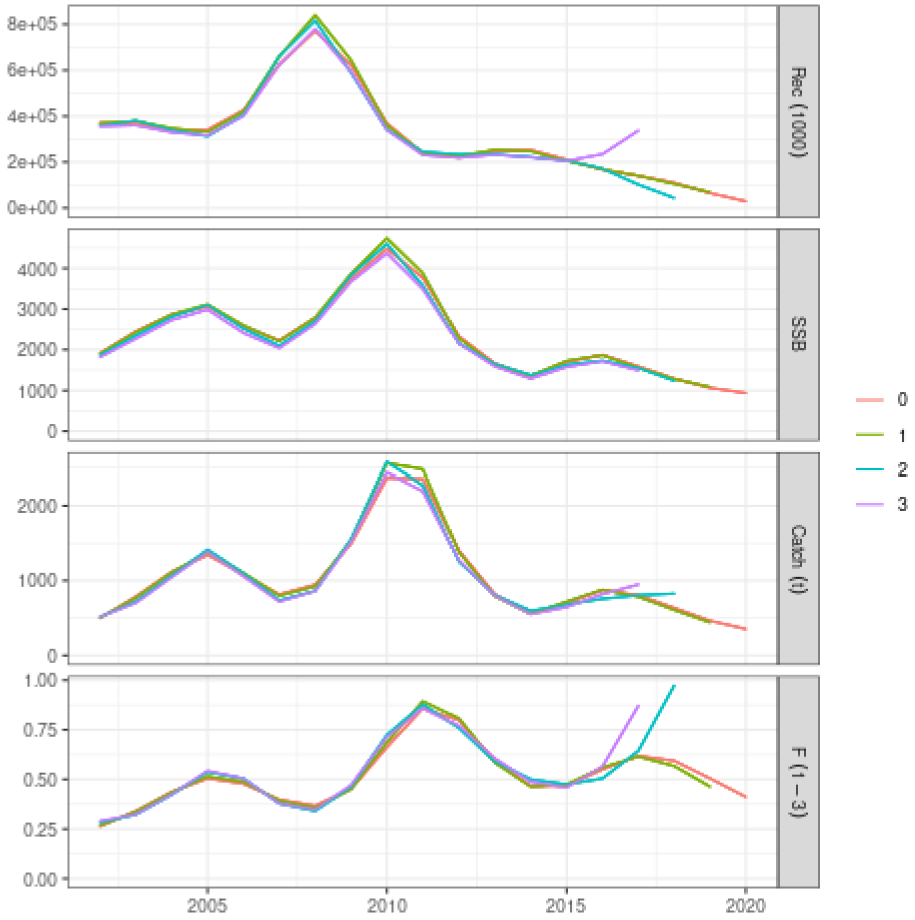


Figure 6.5.3.3.1.22 Norway lobster in GSA 18. Retrospective plot for 3 years back.

The Figure 6.5.3.3.1.23 presents the comparison between the two assessments. It is clear that when the model is allowed to follow better the abundance indices, it is not able to cope with the catch and for the years between 2009 and 2012 it estimates a much larger catch than it was observed. However, the perception of the stock in the end of the time series it is very close between the two assessments.

All of the issues mentioned above, led the EWG 21-15 not to give advice based on the analytical catch at age model (a4a). The different signals in catch and MEDITS index may be because GSA 18 does not form a complete stock or group of stocks, or because catches reported to GSA 18 are taken in the productive southern areas of GSA 17, but landed in GSA 18.

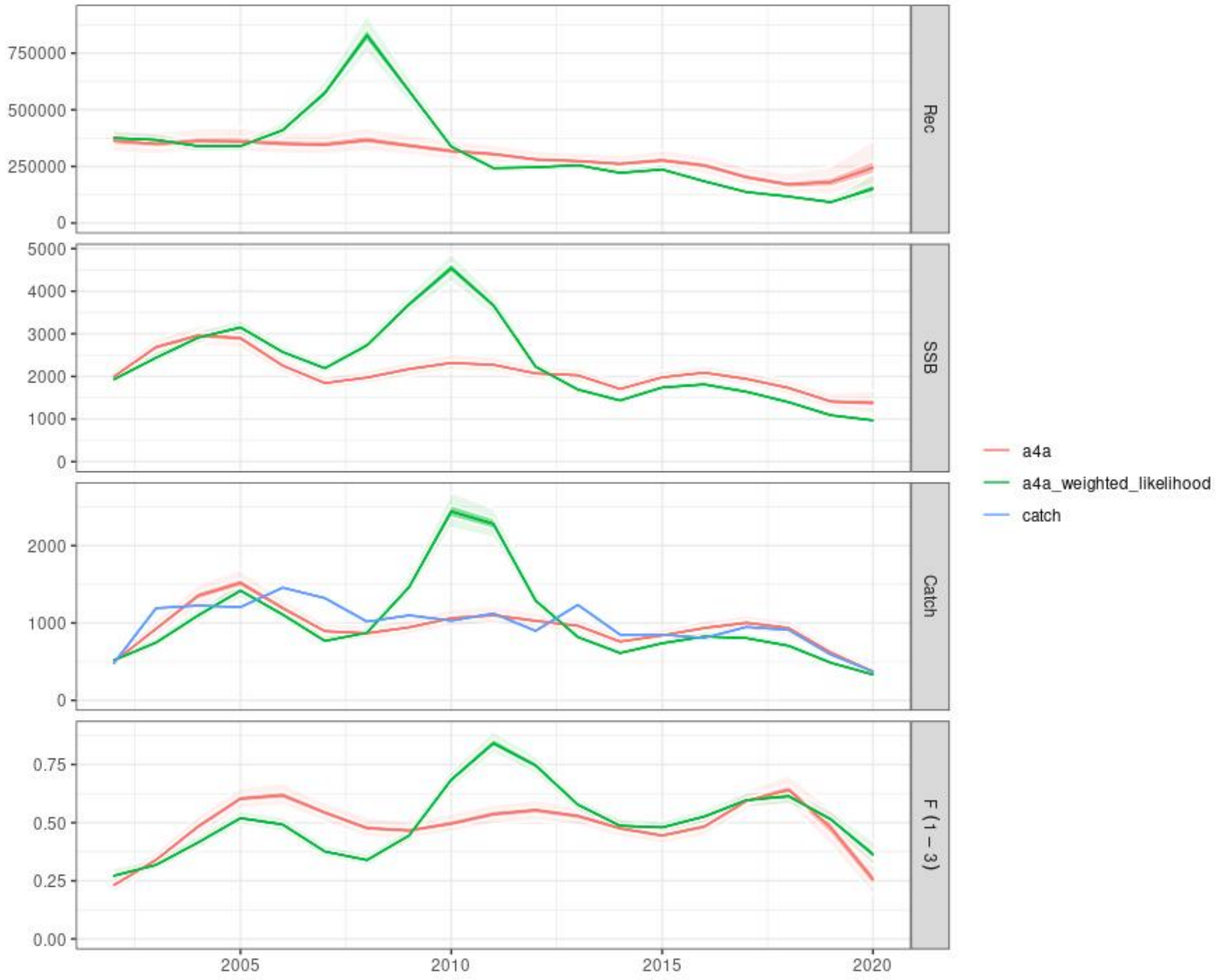


Figure 6.5.3.3.1.23 Norway lobster in GSA 18. Comparison of the two a4a assessments.

6.5.3.4 SURBA sub-area assessments

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 6.5.3.4.1) 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.

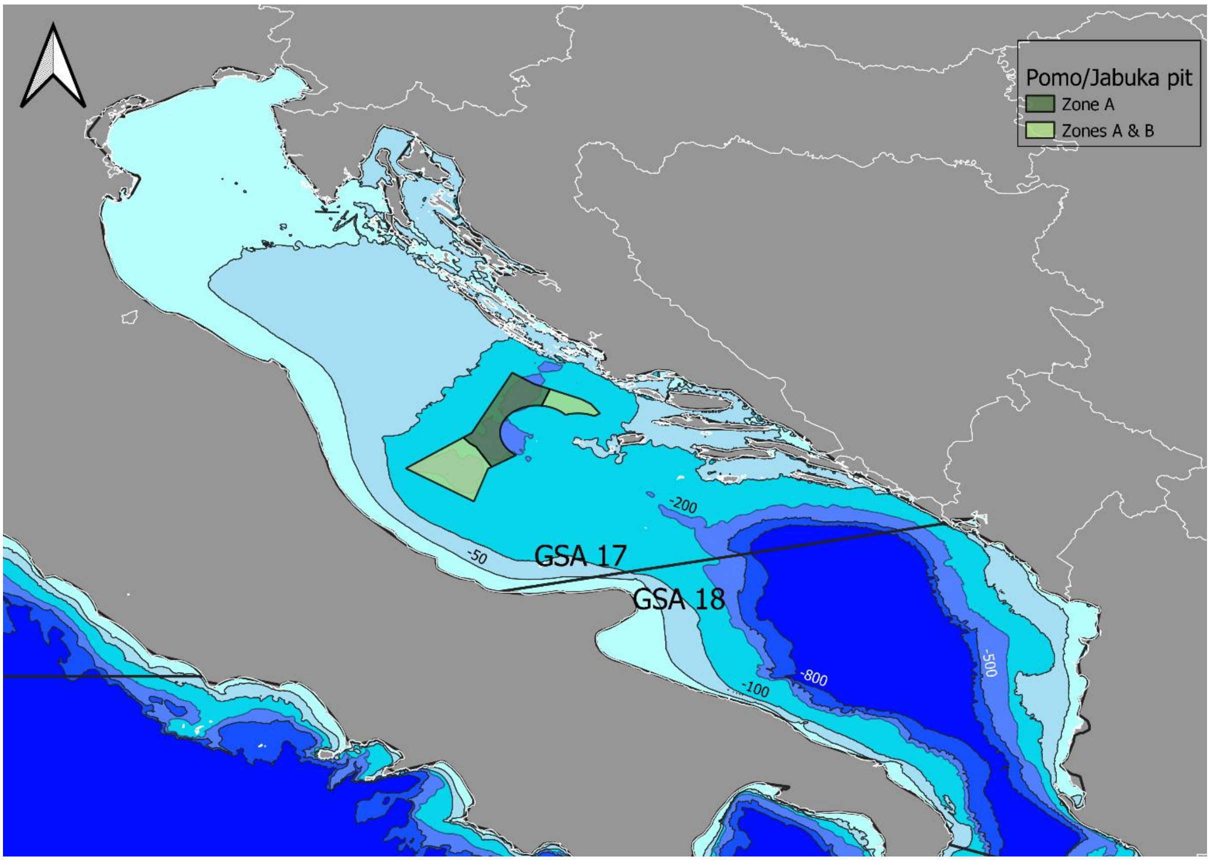


Figure 6.5.3.4.1 The Pomo/Jabuka Pit closure regulation areas within the Adriatic Sea. Contoured areas are depth ranges: 0, 50, 100, 200, 500 and 800 meters.

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.

GSA 18 has catches split to area, and is evaluated with catch data in Section 6.5.3.3. Here assessments were attempted by using SURBA, which is a survey-based separable model of mortality (Cook, 1997; Beare, 2005) for all four named sub-areas. This model is based on the assumption that fishing mortality per age and year (F_{ay}) is separable to an age (s_a) and year effect (f_y,) such as:

$$F_{ay} = s_a \times f_y$$

The model uses an applied vector of fixed catchability at age (c_a) values to minimise the sum-of-squares difference of observed and estimated abundance indices. The outputs of the model are the mean standardised survey abundance indices by age and year, the trend in mean F, the trend in F by age, as well as the trend in relative SSB. This method can be considered a useful technique for investigating the dynamics of the fishery independently of the commercial catch and CPUE data.

Selecting area boundaries

The first step towards applying the SURBA model at an area-specific level was splitting MEDITS hauls (and calculating abundance indices accordingly), to four parts: (i) hauls corresponding to Ancona region, (ii) Kvarner Gulf hauls, (iii) Pomo/Jabuka pit hauls, and (iv) GSA 18 hauls. Although isolating GSA 18 hauls was straightforward, for the remaining areas assumptions had to be made, since all of them are located within the GSA 17.

In order to assign the GSA 17 MEDITS hauls to the three sub-areas (hereafter Ancona, Kvarner and Pomo/Jabuka); the biological properties of the Norway lobster population in GSA 17 were examined. More specifically, based on the species biology (see section 6.5.1 and figures 6.5.1.2 and 6.5.1.3) it was assumed that significant difference in length-at-maturity ogives should be detected in the Pomo/Jabuka subpopulation (detected at the deepest waters of the area) in comparison to the continental shelf located subpopulations of Ancona and Kvarner. These differences should be reflected in maturity ogives patterns per depth stratum based on MEDITS hauls, which should be distinctively different between the shallower depth strata (10-50m and 50-100m) and deeper strata (100-200m and 200-500m).

To that end, maturity stages per individual were obtained from the MEDITS dataset and was converted to a binary maturity category (immature = 0 or mature =1) based on MEDITS manual (Anonymous, 2017). Binomial Generalized Linear Models (GLM) were applied using MEDITS depth strata (10-50m, 50-100m, 100-200m, 200-500m and 500-800m) as a factor, while the differences in α and β parameters of the logistic regression curve between depth strata were examined through Maximum Likelihood Estimation. α and β parameters were also used to calculate Length-at-maturity per stratum (L50).

In Figure 6.5.3.4.1 the outcome of the above analysis is depicted. More specifically, two groups of quite similar maturity ogives are formed: group a (shallower waters), with the maturity ogives for depth strata 10-50m and 50-100m and group b (deeper waters) with the 100-200m and 200-500m ogives. All pairwise comparisons between group a and b maturity ogives are statistically significant ($p<0.001$), while within group a pairwise comparisons between the 10-50m and 50-100m show no significant difference between them (for parameter a: $p= 0.837$ and for b: $p=0.642$).

Within group b pairwise comparisons between the 100-200m and 200-500m show significant difference between them (for parameter a: $p < 0.001$ and for b: $p = 0.019$). The value for L50 for every depth stratum ogive is shown in Table 6.5.3.4.1.

In any case, the ogives for the specimens caught in depths <100m show slow maturity development, reaching L50 at ~33mm while deeper caught specimens (depth >100m) develop faster, and they reach L50 at around 24-25mm. These outcomes are in agreement with Froglia and Gramitto (1988), who established that the Pomo/Jabuka Norway lobster (here coincide with group b-deeper waters) reach L50 at lower lengths that the shelf subpopulation of the species (group a-shallower waters).

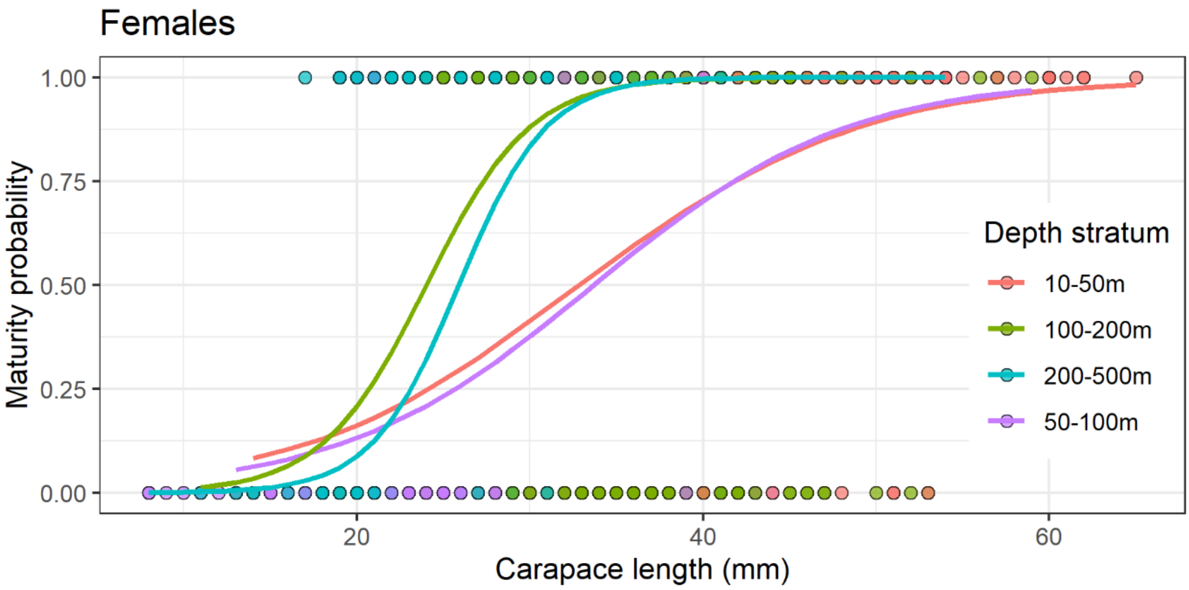


Figure 6.5.3.4.2 Maturity ogives per depth stratum for the GSA 17 for female specimens.

Table 6.5.3.4.1 L50 values for different depth strata of MEDITS hauls

Depth stratum	L50 (mm)
10-50m	32.96
50-100m	33.75
100-200m	23.99
200-500m	25.91

Based on these outcomes, it was decided that splitting the population between Pomo/Jabuka and Ancona-Kvarner based on the 100m isobath would was well supported by the phenotypic differences in maturation, while the division between Ancona and Kvarner hauls for the <100m strata could be performed based on their geographical position (Italian MEDITS hauls for Ancona and Croatian MEDITS hauls for Kvarner) (Figure 6.5.3.4.3). The split between

Ancona and Kvarner was also associated well with the divisions in the fishery, making this a suitable management boundary too.

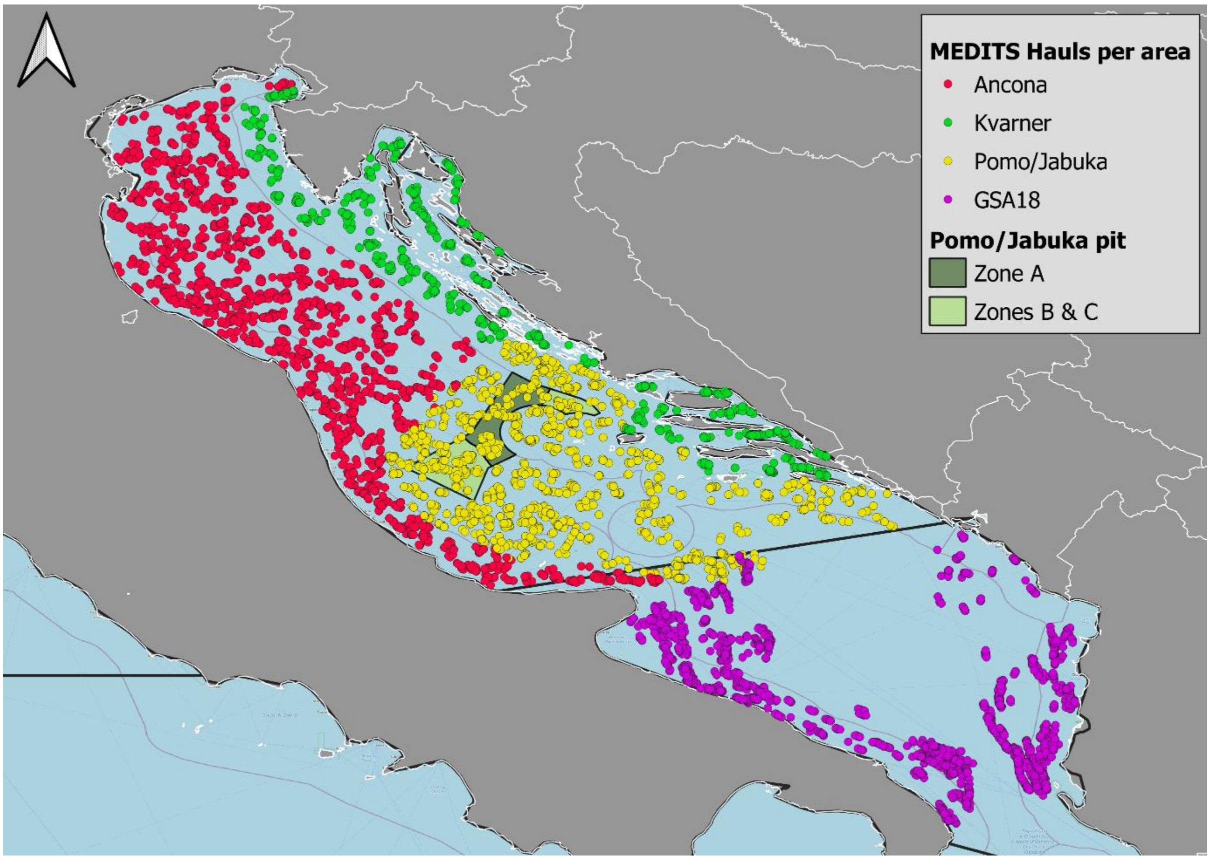


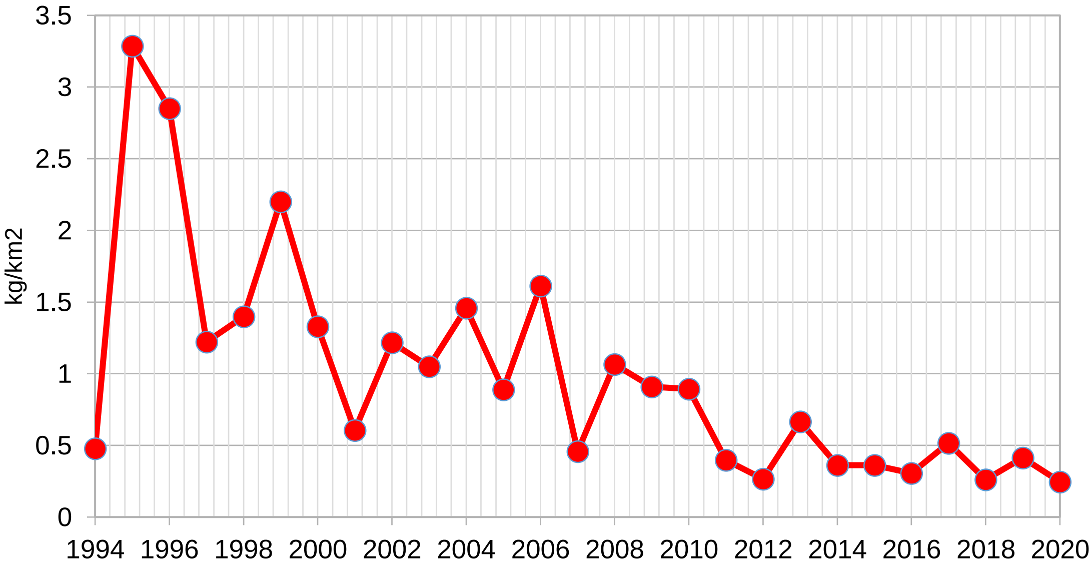
Figure 6.5.3.4.3 Distribution of MEDITS hauls in the four GSA17-GSA18 sub-areas.

SURBA assessments for these four areas are presented below.

6.5.3.4.1 Ancona

Splitting MEDITS hauls based on the rationale described in section 6.5.3.4 resulted in the total biomass and density indices described in figure 6.5.3.4.1.1.

a) Total Biomass Index, Ancona (GSA17)



b) Total Density Index, Ancona (GSA17)

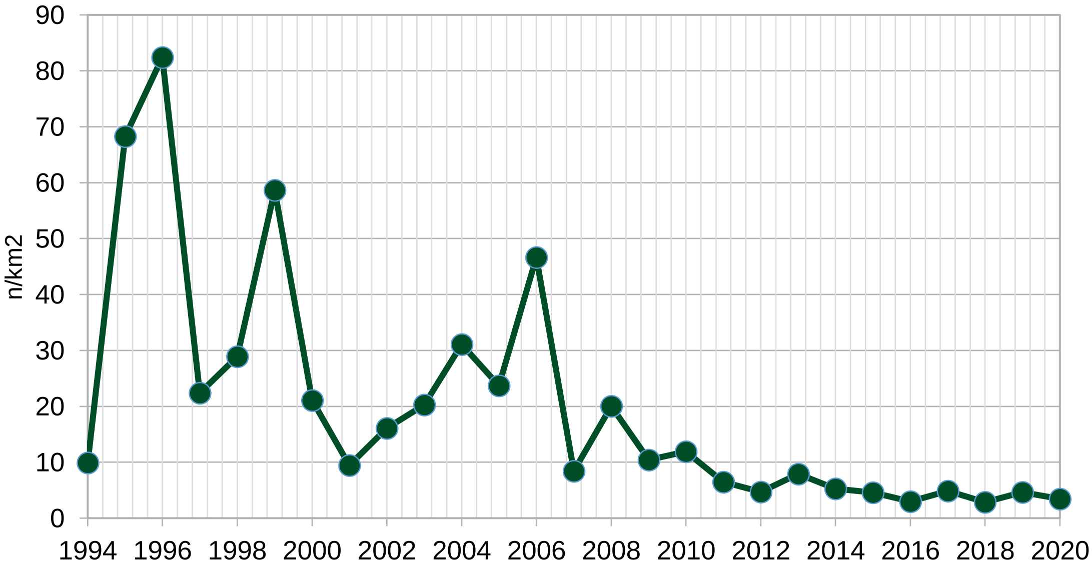


Figure 6.5.3.4.1.1 Norway lobster in GSA 17 (Ancona area). (a): Total Biomass index and (b): Total Density index for Ancona area.

SURBA main input consists of abundance index and mean weight per age, derived by MEDITS. Data were prepared separately for males and females by using the growth parameters shown in Table 6.5.3.4.1.1. The age range used was 1-6+ years. In Table 6.5.3.4.1.2, abundance index per age is shown.

Table 6.5.3.4.1.1 Norway lobster in GSA 17 (Ancona area). Growth parameters used

Area	**Linf (mm)***	**k***	**t0***	**a****	**b****	**Sex**	**Reference**
Ancona	62.5126	0.432	0.1417	0.0006720	3.05798	male	Froglia & Gramitto, 1988*,DCF**
Ancona	53.678	0.528	0.1233	0.0010909	2.9614	female	Froglia & Gramitto, 1988*, DCF**

Table 6.5.3.4.1.2 Norway lobster in GSA 17 (Ancona area). Abundance index per age

year	**age 1**	**age 2**	**age 3**	**age 4**	**age 5**	**age 6**
1994	3.304	4.720	0.231	1.347	0.447	0.402
1995	31.542	17.081	8.731	3.410	0.682	4.843
1996	31.329	22.487	7.042	2.547	0.563	1.610
1997	2.621	8.661	5.380	1.524	0.799	3.409
1998	8.409	12.011	5.424	1.162	0.526	1.124
1999	28.122	15.798	7.122	2.095	1.273	3.999
2000	2.997	9.250	2.313	2.827	1.028	2.655
2001	1.248	2.495	2.079	1.142	1.386	1.248
2002	2.190	5.815	2.747	0.915	0.277	4.220
2003	9.093	5.077	1.858	1.333	0.668	1.675
2004	12.497	11.077	3.339	0.923	0.277	1.896
2005	11.938	6.900	2.698	1.335	0.806	0.187
2006	27.894	14.352	1.124	0.957	0.277	1.858
2007	2.641	4.109	0.587	0.180	0.277	1.078
2008	7.263	7.532	2.152	0.538	0.277	2.561
2009	1.105	1.658	3.298	0.630	0.795	3.022
2010	2.458	3.687	2.084	1.470	0.614	1.578
2011	2.758	1.753	0.369	0.370	0.277	1.488
2012	0.571	1.910	1.713	0.379	0.277	0.334
2013	0.494	2.799	2.179	0.674	0.277	1.919
2014	0.376	2.065	1.688	0.749	0.277	0.375
2015	0.732	1.098	0.552	0.930	0.504	1.016
2016	0.291	0.394	0.788	0.266	0.484	1.059
2017	0.647	0.833	0.671	0.927	0.416	1.855
2018	0.378	0.197	0.859	0.953	0.277	0.859
2019	0.670	1.735	0.382	0.383	0.277	1.742
2020	0.381	1.148	0.861	0.180	0.277	0.847

In Table 6.5.3.4.1.3 mean weight per age is shown.

Table 6.5.3.4.1.3 Norway lobster in GSA 17 (Ancona area). Mean weight per age

year	age 1	age 2	age 3	age 4	age 5	age 6
1994	0.026	0.048	0.084	0.121	0.139	0.176
1995	0.021	0.046	0.085	0.121	0.131	0.183
1996	0.025	0.047	0.085	0.113	0.125	0.160
1997	0.026	0.052	0.080	0.120	0.130	0.207
1998	0.023	0.051	0.082	0.114	0.135	0.227
1999	0.021	0.048	0.080	0.117	0.144	0.242
2000	0.026	0.050	0.086	0.117	0.139	0.206
2001	0.024	0.049	0.076	0.111	0.151	0.166
2002	0.023	0.054	0.084	0.115	0.132	0.177
2003	0.020	0.052	0.093	0.110	0.146	0.232
2004	0.021	0.048	0.080	0.121	0.132	0.210
2005	0.021	0.049	0.082	0.119	0.138	0.205
2006	0.021	0.045	0.083	0.124	0.132	0.260
2007	0.021	0.048	0.079	0.113	0.132	0.187
2008	0.026	0.050	0.082	0.108	0.132	0.273
2009	0.027	0.050	0.083	0.126	0.135	0.240
2010	0.030	0.050	0.079	0.123	0.133	0.188
2011	0.027	0.049	0.099	0.120	0.132	0.257
2012	0.019	0.051	0.082	0.115	0.132	0.189
2013	0.031	0.053	0.086	0.119	0.132	0.217
2014	0.031	0.048	0.088	0.112	0.132	0.169
2015	0.026	0.049	0.087	0.110	0.137	0.202
2016	0.022	0.047	0.080	0.114	0.126	0.204
2017	0.027	0.061	0.080	0.115	0.138	0.188
2018	0.014	0.050	0.081	0.117	0.132	0.154
2019	0.024	0.048	0.090	0.126	0.132	0.181
2020	0.031	0.052	0.087	0.113	0.132	0.267

SURBA also needs as input maturity and natural mortality per age. In Table 6.5.3.4.1.4 maturity per age derived by MEDITS data is shown.

Table 6.5.3.4.1.4 Norway lobster in GSA 17 (Ancona area). Maturity per age

age 1	age 2	age 3	age 4	age 5	age 6
0.32	0.64	0.83	0.90	0.94	1

In Table 6.5.3.4.1.5 natural mortality per age, calculated using Chen-Watanabe equation is shown

Table 6.5.3.4.1.5 Norway lobster in GSA 17 (Ancona area). Natural mortality per age

year	**age 1**	**age 2**	**age 3**	**age 4**	**age 5**	**age 6**
1994	1.02	0.69	0.59	0.51	0.50	0.48
1995	1.00	0.71	0.59	0.53	0.51	0.51
1996	1.00	0.71	0.58	0.55	0.54	0.51
1997	1.01	0.71	0.59	0.53	0.52	0.51
1998	1.00	0.71	0.59	0.54	0.50	0.49
1999	1.00	0.70	0.58	0.54	0.49	0.51
2000	1.00	0.70	0.59	0.53	0.51	0.52
2001	0.99	0.70	0.61	0.56	0.49	0.49
2002	1.00	0.72	0.61	0.52	0.52	0.53
2003	1.01	0.71	0.58	0.56	0.50	0.47
2004	0.99	0.71	0.61	0.52	0.52	0.50
2005	1.00	0.70	0.59	0.54	0.51	0.50
2006	1.00	0.70	0.58	0.52	0.52	0.52
2007	1.01	0.69	0.60	0.55	0.52	0.51
2008	1.00	0.72	0.57	0.55	0.52	0.50
2009	0.99	0.71	0.61	0.52	0.51	0.50
2010	1.00	0.70	0.61	0.52	0.52	0.52
2011	0.98	0.68	0.58	0.53	0.52	0.50
2012	1.00	0.72	0.59	0.53	0.52	0.49
2013	1.01	0.71	0.61	0.52	0.52	0.49
2014	1.00	0.69	0.59	0.53	0.52	0.50
2015	0.99	0.71	0.59	0.56	0.50	0.54
2016	1.01	0.71	0.58	0.54	0.54	0.49
2017	0.98	0.70	0.62	0.52	0.51	0.50
2018	0.99	0.71	0.61	0.52	0.52	0.52
2019	0.98	0.72	0.58	0.53	0.52	0.49
2020	1.01	0.72	0.59	0.55	0.52	0.49

Different scenarios of catchability at age were tested. It was decided to run the model with a realistic catchability at-age producing the better fitting showed in figure 6.5.3.4.1.2

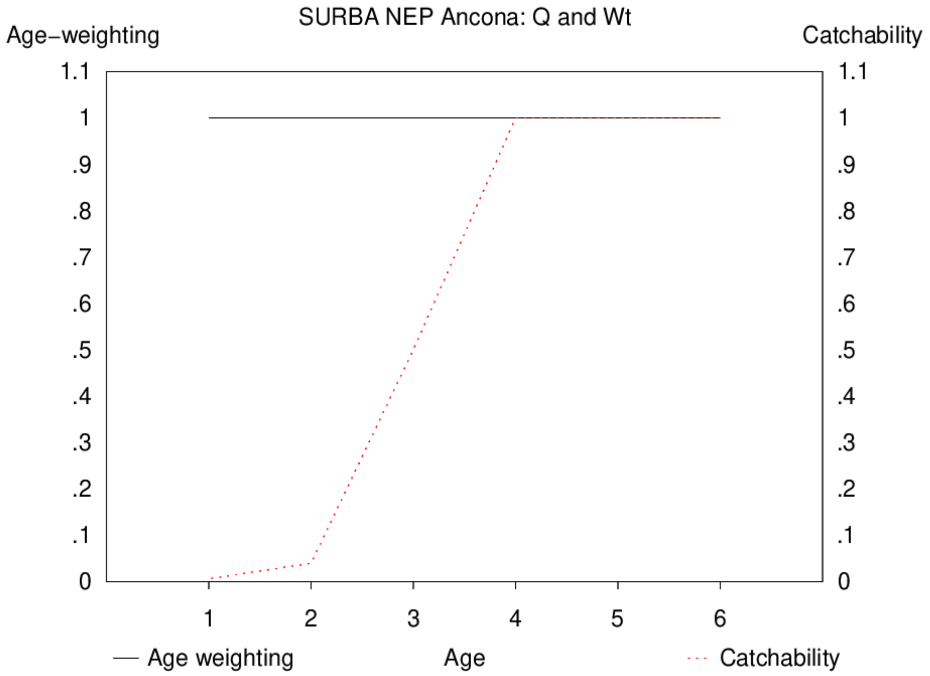


Figure 6.5.3.4.1.2 Norway lobster in GSA 17 (Ancona area). Catchability at-age scenario used in the SURBA model.

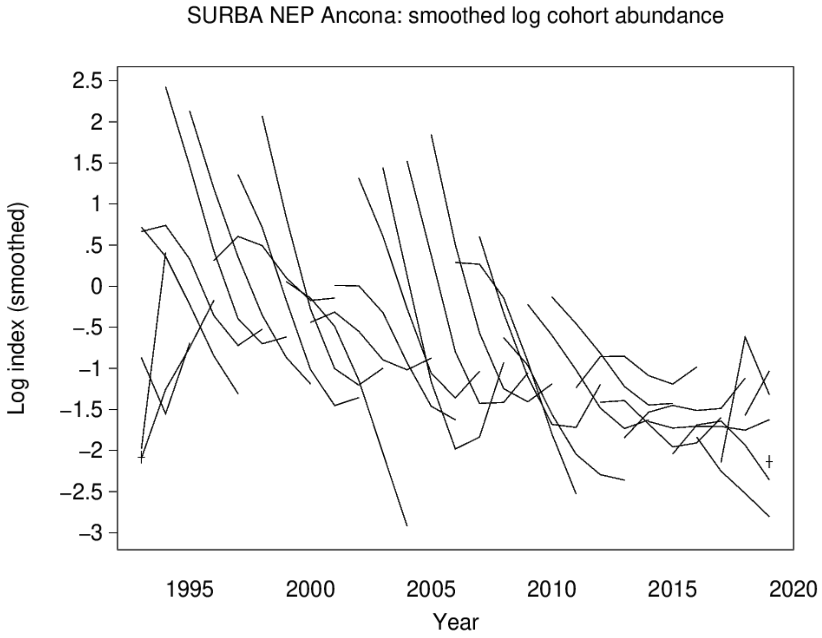
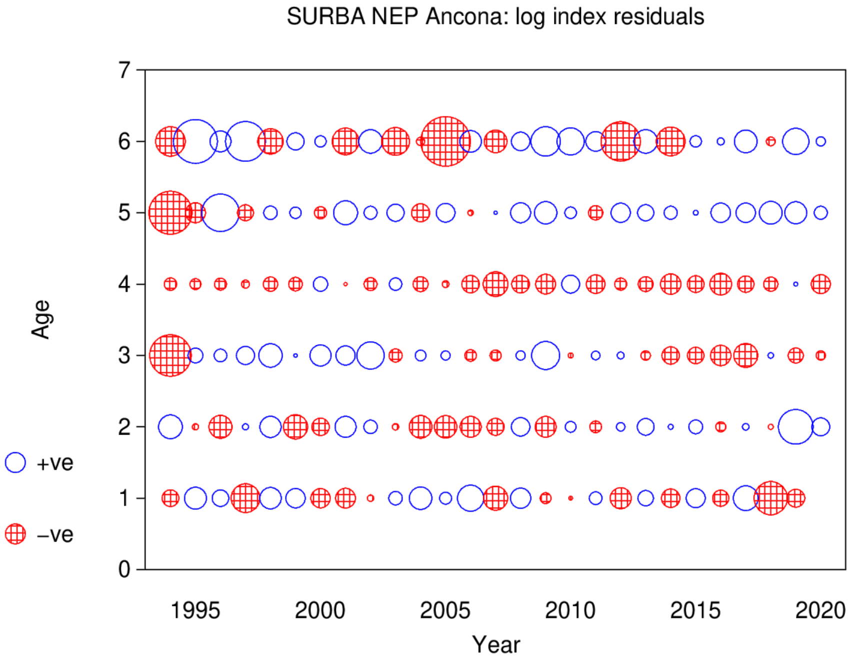


Figure 6.5.3.4.1.3 Norway lobster in GSA 17 (Ancona area). Log cohort abundances at age from the SURBA analysis.

Results

In general terms, cohort abundance follows a linear, exponential decline after log transformation, with a few exceptions (Figure 6.5.3.4.1.3).



In the bubble plot of figure 6.5.3.4.1.4 the log residuals of the index per age are presented. Generally, the residuals are distributed randomly and their values (at least for the ages 1-5) are quite low.

Figure 6.5.3.4.1.4 Norway lobster in GSA 17 (Ancona area). Log index residuals at age from the SURBA analysis. Model fitting is quite consistent (Figure 6.5.3.4.1.5).

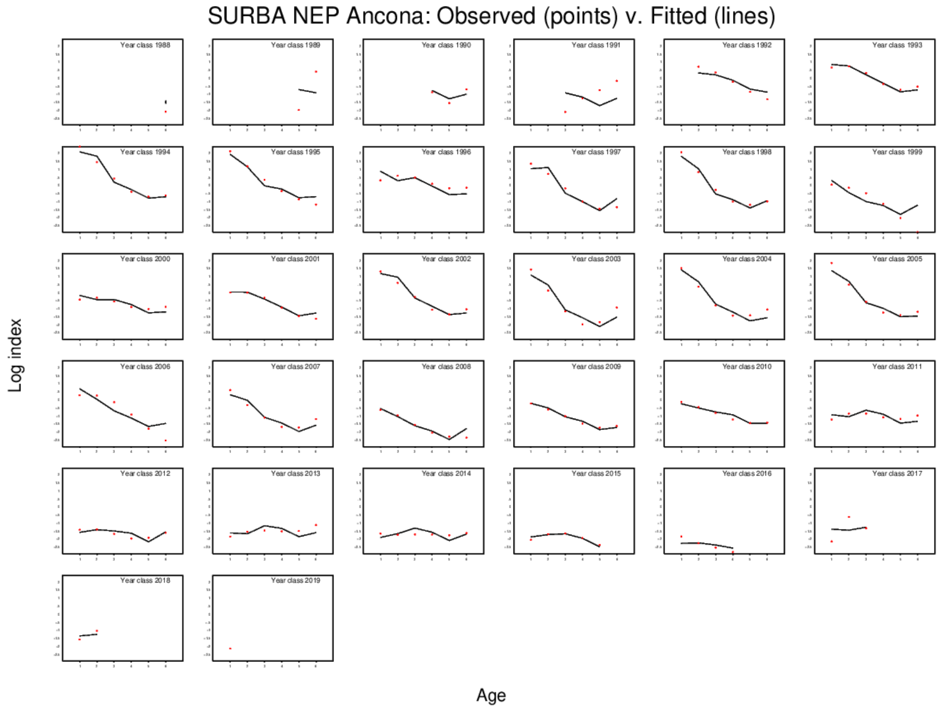


Figure 6.5.3.4.1.5 Norway lobster in GSA 17 (Ancona area). Scatter plots of log indices at consecutive ages from the SURBA analysis.

Model retrospective is also quite stable (Figure 6.5.3.4.1.6).

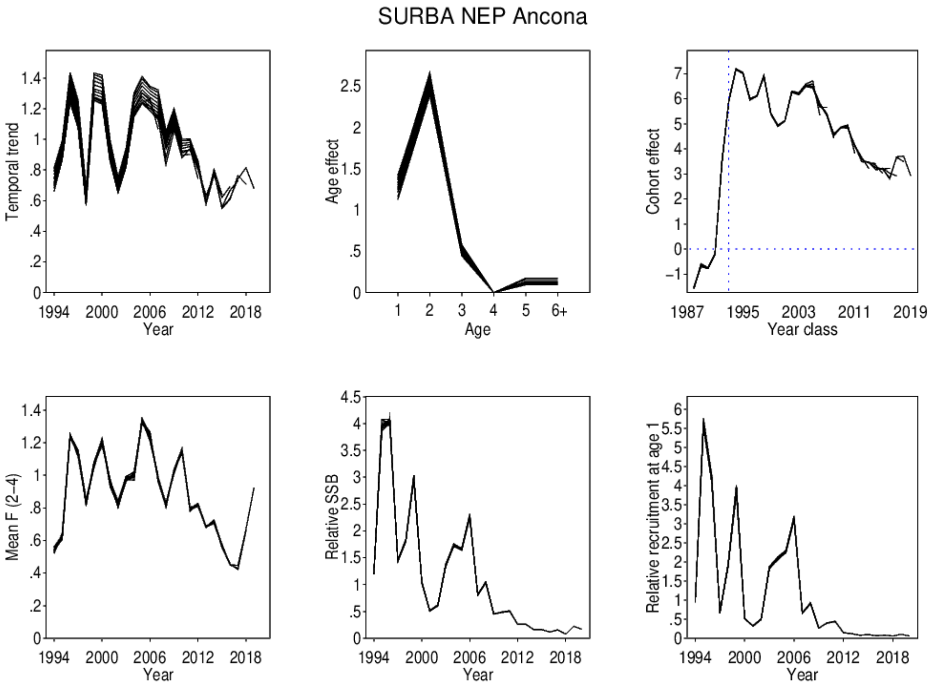


Figure 6.5.3.4.3.6 Norway lobster in GSA 17 (Ancona area). Retrospective plots from the SURBA analysis.

The trend for relative Mean F for ages 1-3 (Figure 6.5.3.4.1.7) doesn’t show clear trend in F. Indeed the values are constantly quite high even if in average a slight decrease seems occur in the last years. Relative SSB (Figure 6.5.3.4.1.8) show highest values at the beginning of the series and lowest ones in the last 10 years.

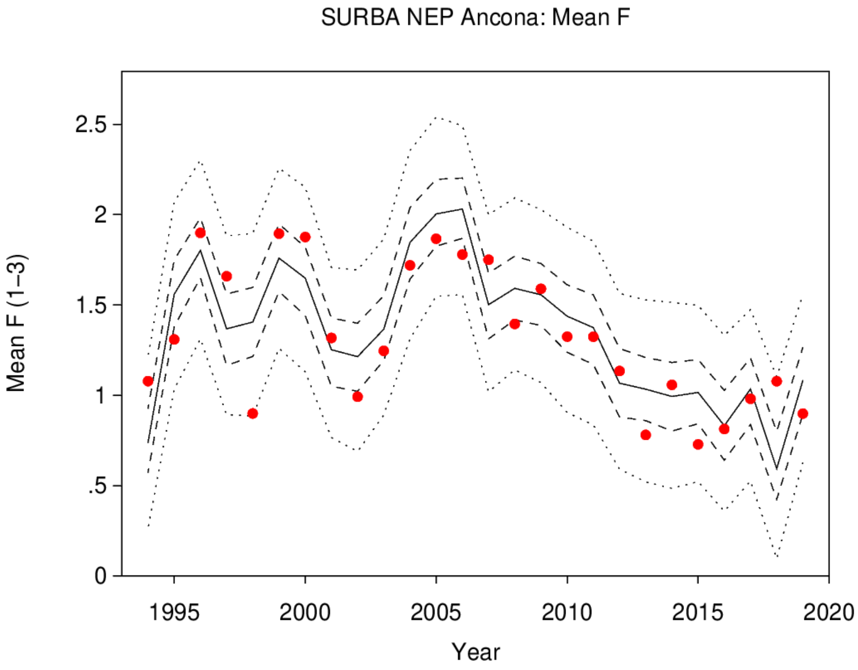


Figure 6.5.3.4.1.7 Norway lobster in GSA 17 (Ancona area). Relative mean F(1-3) in time from the SURBA analysis.

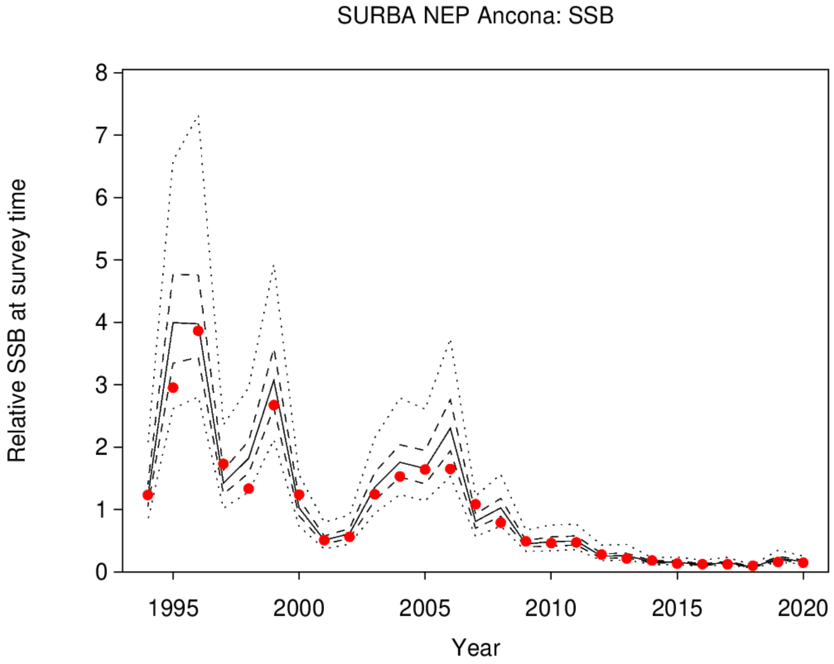
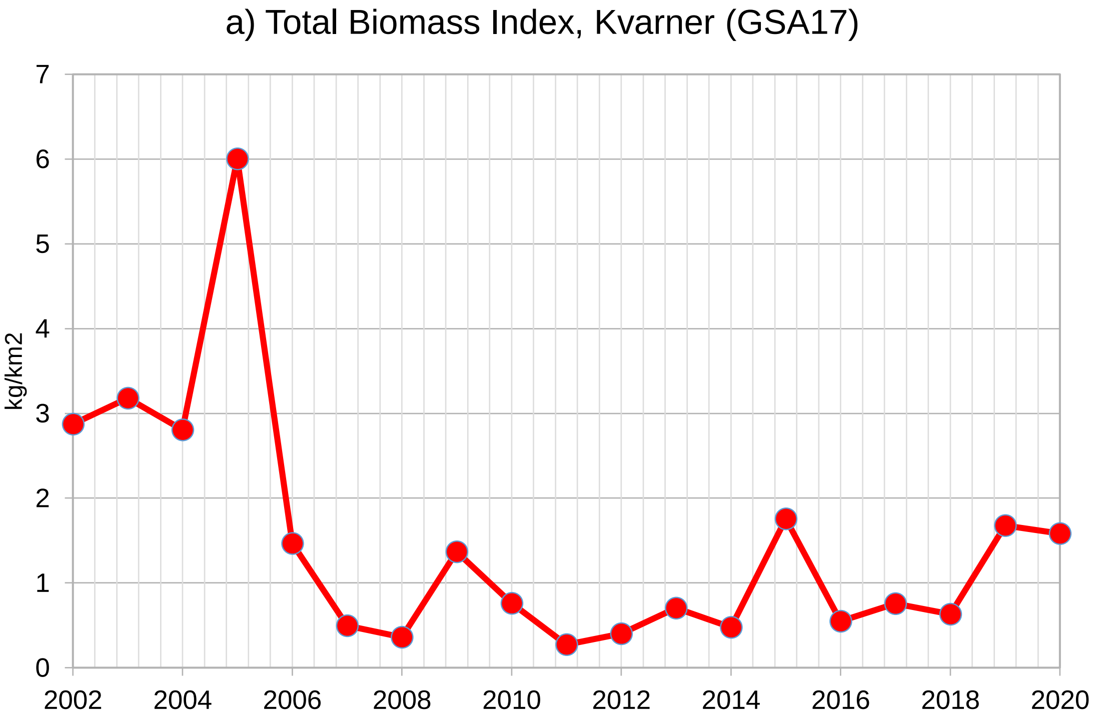


Figure 6.5.3.4.1.8 Norway lobster in GSA 17 (Ancona area). Relative SSB in time from the SURBA analysis.

6.5.3.4.2 Kvarner

Input data

Splitting MEDITS hauls based on the rationale described in section 6.5.3.4 resulted in the total biomass and density indices described in figure 6.5.3.4.2.1.



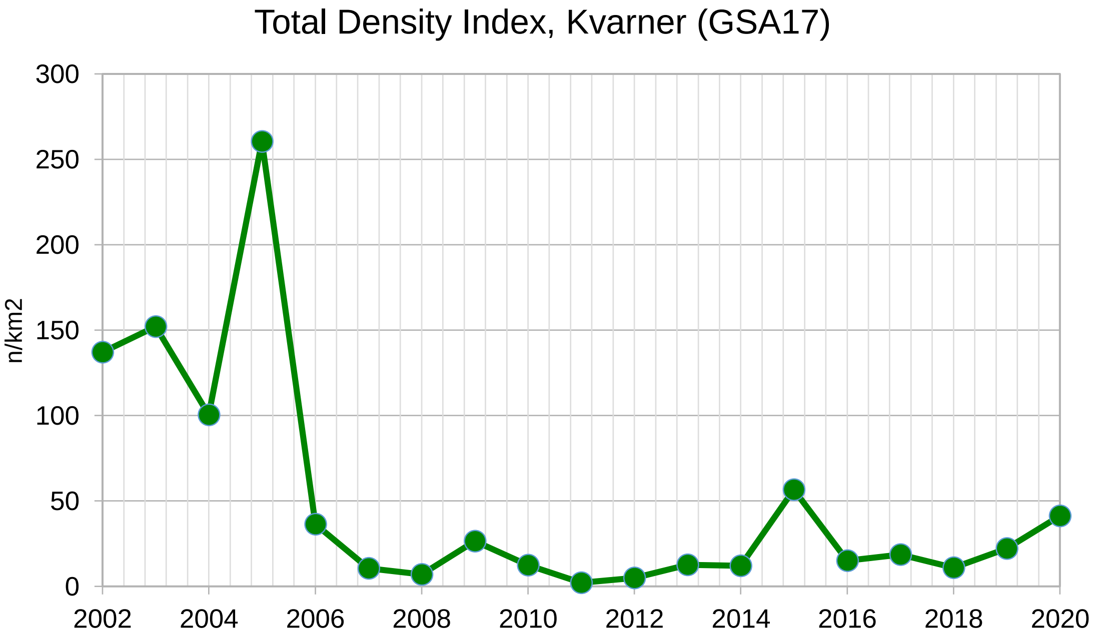


Figure 6.5.3.4.2.1 Norway lobster in GSA 17 (Kvarner area). (a): Total Biomass index and (b): Total Density index for Ancona area.

SURBA main input consists of abundance index and mean weight per age, derived by MEDITS. Data were prepared separately for males and females by using the growth parameters shown in Table 6.5.3.4.2.1. The age range used was 1-6+ years. In Table 6.5.3.4.2.2, abundance index per age is shown.

Table 6.5.3.4.2.1 Norway lobster in GSA 17 (Kvarner area). Growth parameters used

Area	**Linf (mm)***	**k***	**t0***	**a****	**b****	**Sex**	**Reference**
Kvarner	62.5126	0.432	0.1417	0.0006720	3.05798	male	Froglia & Gramitto, 1988*,DCF**
Kvarner	53.678	0.528	0.1233	0.0010909	2.9614	female	Froglia & Gramitto, 1988*, DCF**

Table 6.5.3.4.2.2 Norway lobster in GSA 17 (Kvarner area). Abundance index per age

year	**age 1**	**age 2**	**age 3**	**age 4**	**age 5**	**age 6**
2002	102.322	31.575	2.140	0.543	1.427	0.543
2003	42.717	90.257	14.469	1.325	0.526	3.285
2004	64.072	22.321	5.716	1.715	0.526	0.543
2005	111.262	122.291	20.387	1.681	3.270	1.589
2006	6.019	14.712	10.031	2.907	1.607	1.337
2007	2.554	4.217	3.158	0.543	0.526	1.138
2008	0.854	3.456	2.041	0.845	0.526	0.845
2009	7.015	10.253	4.857	1.888	1.888	1.349
2010	0.894	6.672	2.461	2.903	0.526	0.543
2011	0.566	0.652	1.252	0.543	0.526	1.150
2012	0.566	1.644	2.505	0.817	0.526	0.817
2013	3.781	2.269	3.781	1.257	1.025	1.262
2014	5.922	4.609	1.053	0.543	0.526	1.010
2015	33.929	12.387	5.924	0.813	1.077	1.616
2016	7.211	4.327	1.698	1.442	0.526	0.543
2017	6.628	9.543	2.120	0.872	0.526	0.543
2018	2.782	3.338	4.007	0.543	0.826	0.826
2019	4.665	8.172	1.646	3.110	3.681	1.782
2020	12.444	20.381	7.859	0.543	0.526	0.924

In Table 6.5.3.4.2.3 mean weight per age is shown.

Table 6.5.3.4.2.3 Norway lobster in GSA 17 (Kvarner area). Mean weight per age

year	**age 1**	**age 2**	**age 3**	**age 4**	**age 5**	**age 6**
2002	0.024	0.044	0.074	0.113	0.129	0.180
2003	0.028	0.049	0.078	0.112	0.132	0.207
2004	0.020	0.045	0.087	0.117	0.132	0.180
2005	0.025	0.047	0.080	0.108	0.135	0.220
2006	0.029	0.048	0.082	0.116	0.144	0.145
2007	0.031	0.053	0.089	0.113	0.132	0.173
2008	0.031	0.050	0.083	0.108	0.132	0.161
2009	0.027	0.047	0.082	0.120	0.140	0.174
2010	0.029	0.057	0.077	0.119	0.132	0.180
2011	0.026	0.049	0.095	0.113	0.132	0.233
2012	0.026	0.044	0.090	0.117	0.132	0.200
2013	0.024	0.050	0.077	0.126	0.135	0.167
2014	0.021	0.050	0.097	0.113	0.132	0.182
2015	0.024	0.046	0.081	0.111	0.129	0.158
2016	0.022	0.044	0.100	0.115	0.132	0.180
2017	0.029	0.050	0.082	0.118	0.132	0.180
2018	0.030	0.057	0.082	0.113	0.144	0.186
2019	0.028	0.053	0.086	0.126	0.140	0.248
2020	0.026	0.051	0.083	0.113	0.132	0.188

SURBA also needs as input maturity and natural mortality per age. In Table 6.5.3.4.2.4 maturity per age derived by MEDITS data is shown.

Table 6.5.3.4.2.4 Norway lobster in GSA 17 (Kvarner area). Maturity per age

age 1	**age 2**	**age 3**	**age 4**	**age 5**	**age 6**
0.32	0.64	0.83	0.90	0.94	1

In Table 6.5.3.4.2.5 natural mortality per age, calculated using Chen-Watanabe equation is shown

Table 6.5.3.4.2.5 Norway lobster in GSA 17 (Kvarner area). Natural mortality per age

year	**age 1**	**age 2**	**age 3**	**age 4**	**age 5**	**age 6**
2002	1.00	0.72	0.57	0.55	0.53	0.50
2003	1.01	0.72	0.61	0.55	0.52	0.48
2004	1.00	0.73	0.59	0.54	0.52	0.50
2005	1.01	0.72	0.61	0.56	0.52	0.50
2006	1.02	0.73	0.58	0.55	0.49	0.50
2007	1.02	0.71	0.57	0.55	0.52	0.50
2008	1.01	0.70	0.58	0.53	0.52	0.49
2009	1.01	0.72	0.60	0.52	0.49	0.48
2010	1.01	0.71	0.60	0.52	0.52	0.50
2011	1.00	0.70	0.60	0.55	0.52	0.48
2012	1.00	0.70	0.57	0.53	0.52	0.49
2013	1.01	0.72	0.62	0.53	0.50	0.53
2014	1.00	0.72	0.59	0.55	0.52	0.48
2015	1.00	0.70	0.60	0.56	0.52	0.49
2016	0.99	0.71	0.58	0.55	0.52	0.50
2017	1.00	0.70	0.57	0.53	0.52	0.50
2018	1.01	0.70	0.57	0.55	0.51	0.49
2019	0.99	0.72	0.58	0.52	0.49	0.53
2020	0.99	0.71	0.59	0.55	0.52	0.49

Different scenarios of catchability at age were tested. It was decided to run the model with a realistic catchability at-age producing the better fitting showed in figure 6.5.3.4.2.2

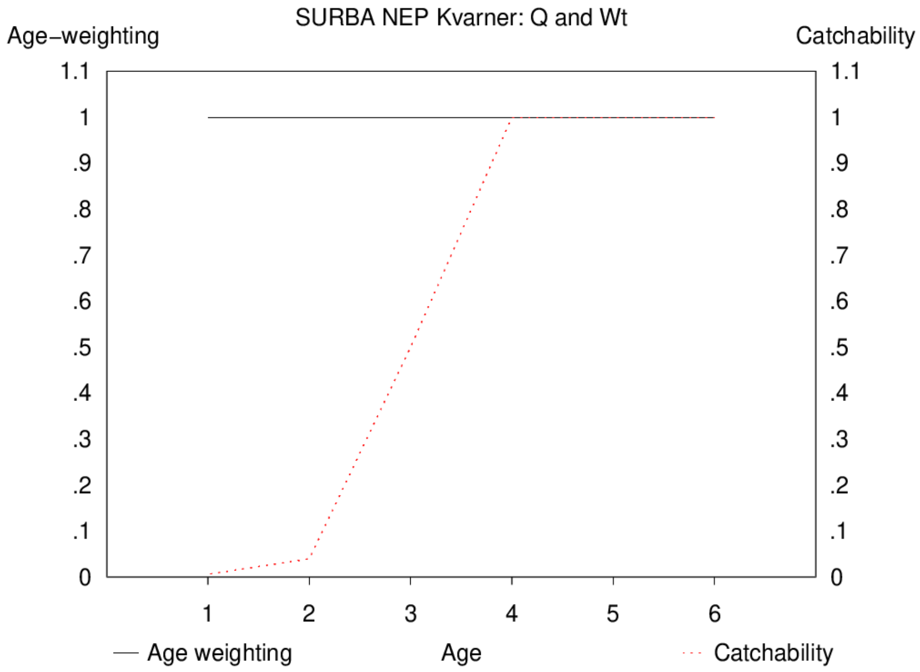


Figure 6.5.3.4.2.2 Norway lobster in GSA 17 (Kvarner area). Catchability at-age scenario used in the SURBA model.

Results

In general terms, cohort abundance follows a linear, exponential decline after log transformation, with a few exceptions (Figure 6.5.3.4.2.3).

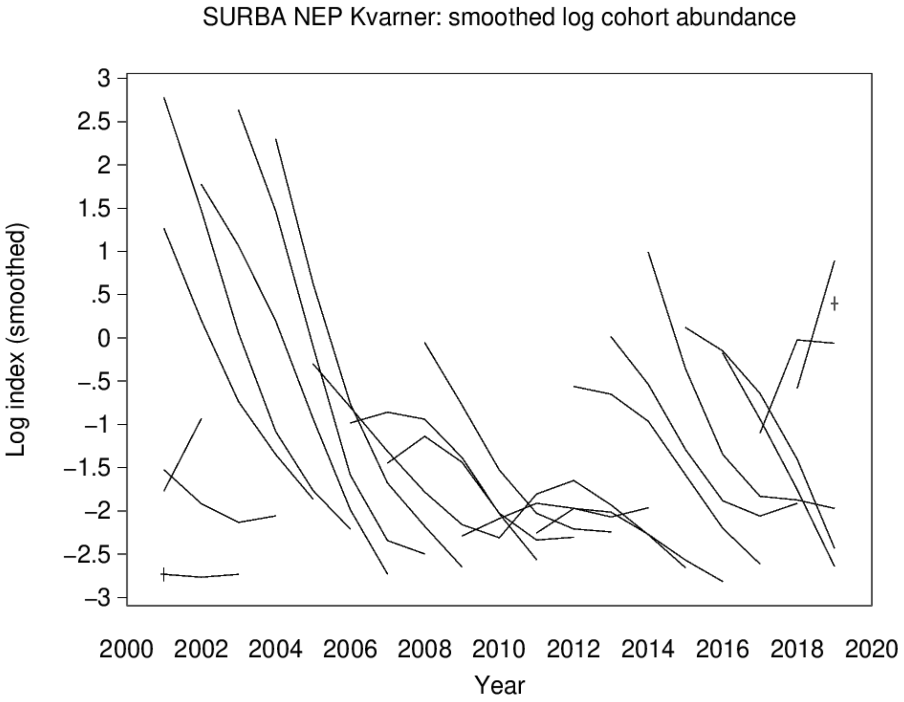


Figure 6.5.3.4.2.3 Norway lobster in GSA 17 (Kvarner area). Log cohort abundances at age from the SURBA analysis.

In the bubble plot of figure 6.5.3.4.2.4 the log residuals of the index per age are presented. Generally, the residuals are distributed randomly and their values are quite low.

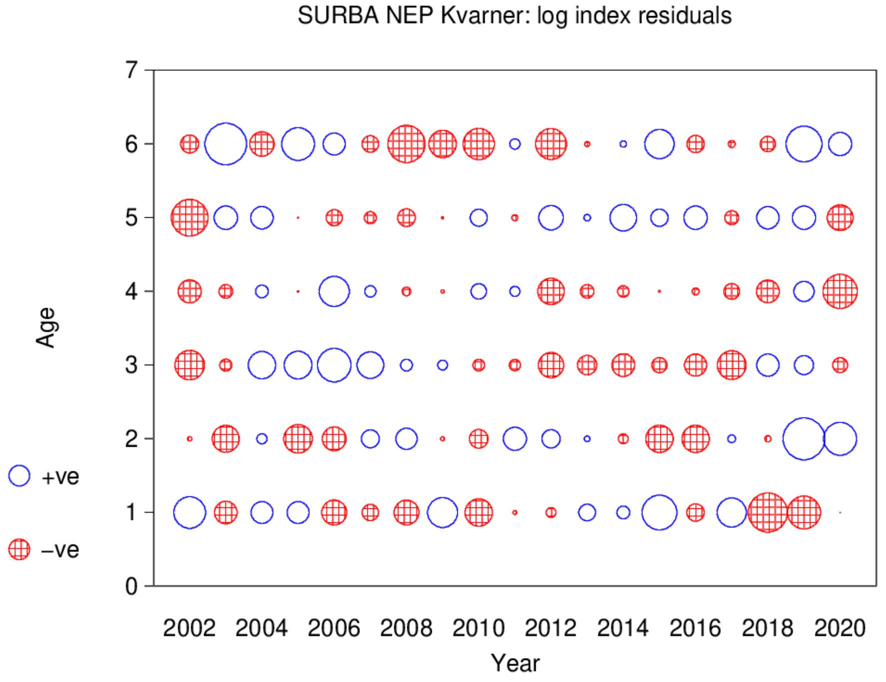


Figure 6.5.3.4.2.4 Norway lobster in GSA 17 (Kvarner area). Log index residuals at age from the SURBA analysis.

Model fitting is quite consistent (Figure 6.5.3.4.1.5).

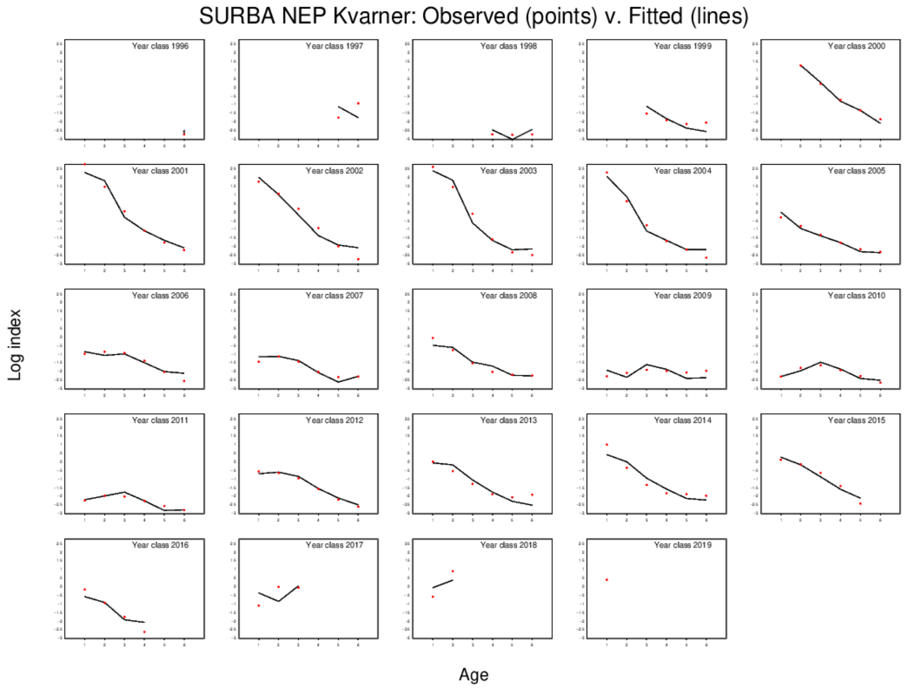


Figure 6.5.3.4.2.5 Norway lobster in GSA 17 (Kvarner area). Scatter plots of log indices at consecutive ages from the SURBA analysis.

Model retrospective is also quite stable (Figure 6.5.3.4.1.6).

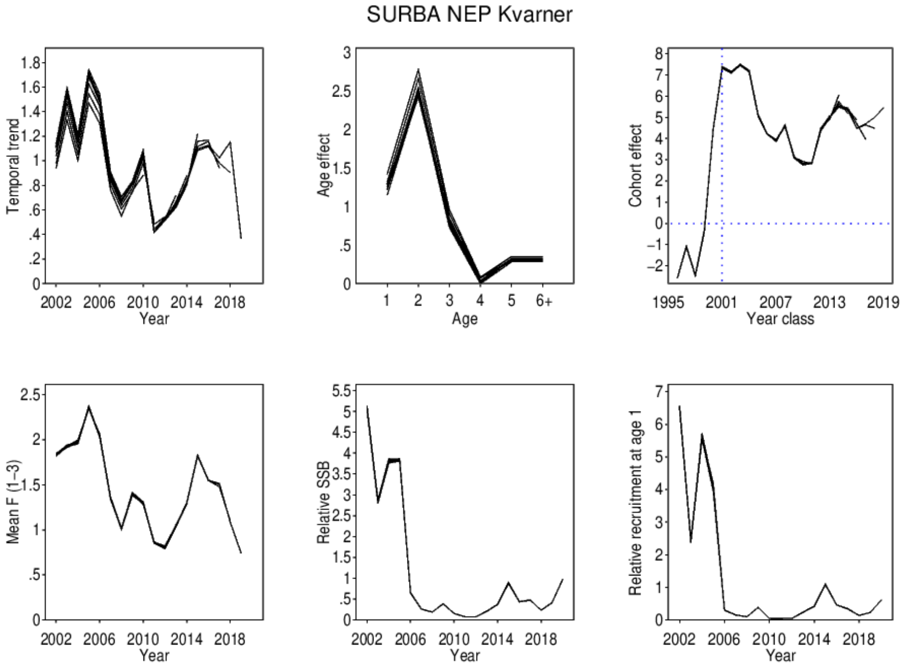


Figure 6.5.3.4.2.6 Norway lobster in GSA 17 (Kvarner area). Retrospective plots from the SURBA analysis.

The trend for relative Mean F for ages 1-3 (Figure 6.5.3.4.2.7) show high variations even if in the first 5 years the values were the highest. In the last year F value is the lowest in the series. Relative SSB (Figure 6.5.3.4.2.8) show highest values at the beginning of the series then SSB remains quite stable at low levels in the following years.

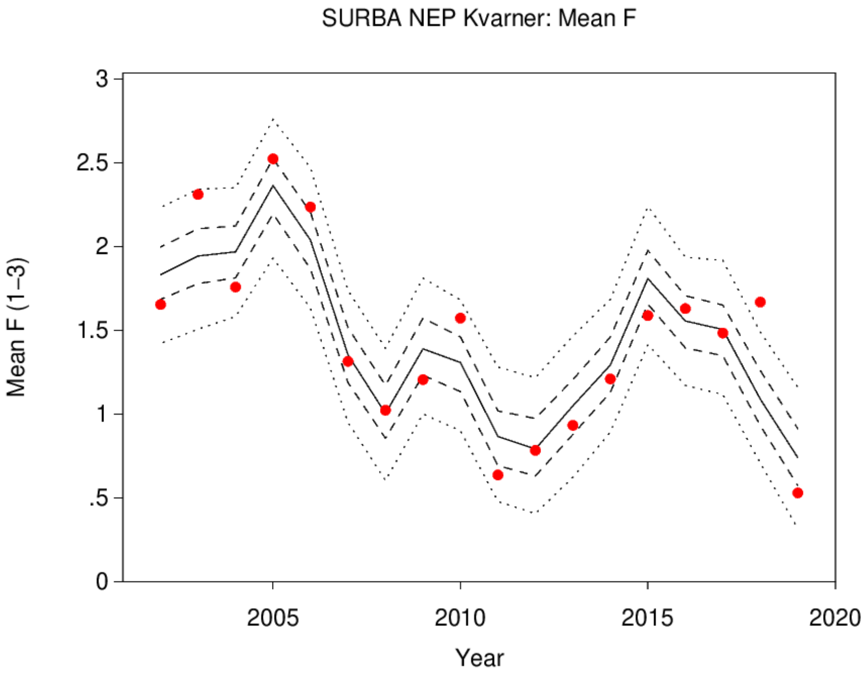


Figure 6.5.3.4.2.7 Norway lobster in GSA 17 (Ancona area). Relative mean F(1-3) in time from the SURBA analysis.

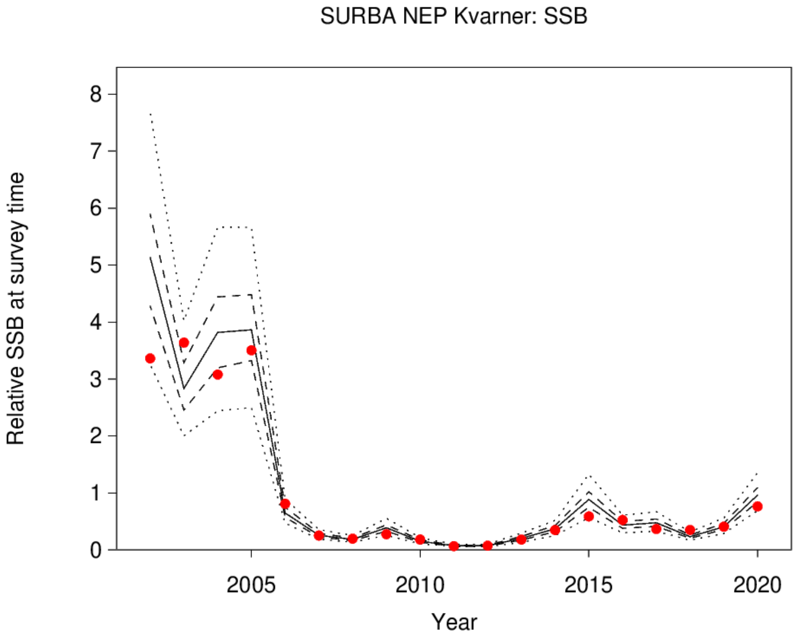


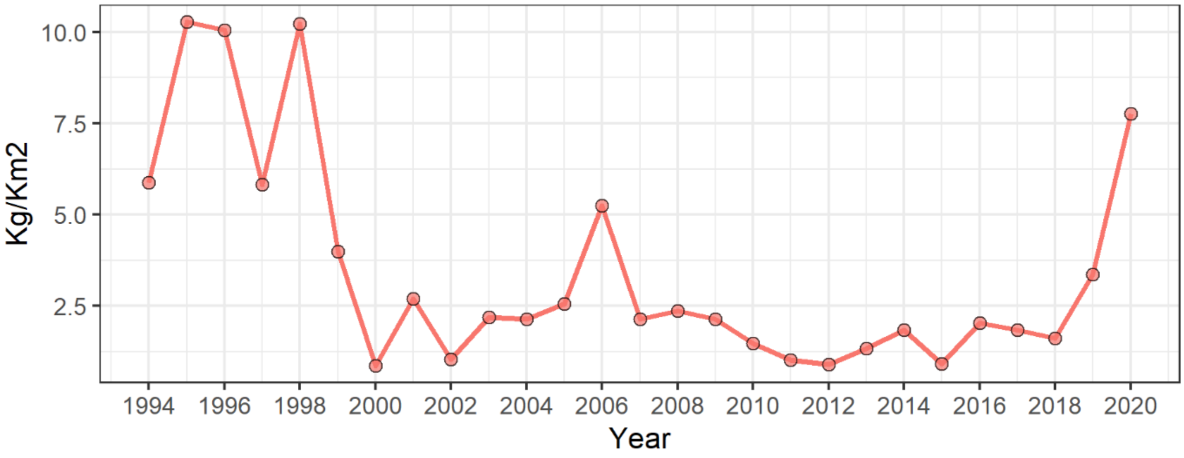
Figure 6.5.3.4.2.8 Norway lobster in GSA 17 (Ancona area). Relative SSB in time from the SURBA analysis.

6.5.3.4.3 Pomo/Jabuka

Input data

Splitting MEDITS hauls based on the rationale described in section 6.5.3.4 resulted in the total biomass and density indices described in figure 6.5.3.4.3.1.

(a) Total Biomass Index, Pomo/Jabuka area (GSA 17)



(b) Total Abundance Index, Pomo/Jabuka area (GSA 17)

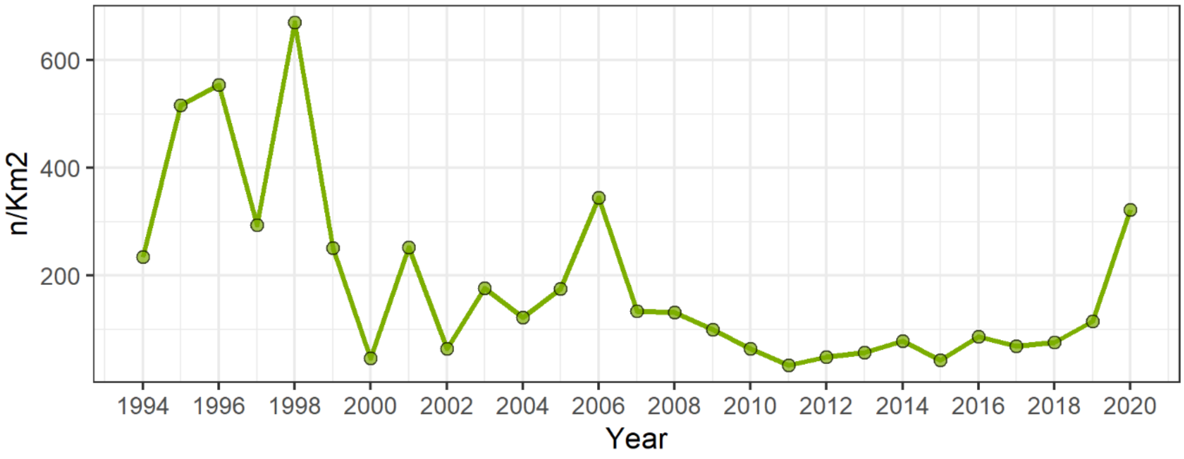


Figure 6.5.3.4.3.1 Norway lobster in GSA 17 (Pomo/Jabuka area). (a): Total Biomass index and (b): Total Density index for Pomo/Jabuka area.

SURBA main input consists of abundance index and mean weight per age, derived by MEDITS. Data were prepared separately for males and females by using the growth parameters shown in Table 6.5.3.4.3.1. The age range used was 1-6+ years. In Table 6.5.3.4.3.2, abundance index per age is shown.

Table 6.5.3.4.3.1 Norway lobster in GSA 17 (Pomo/Jabuka area). Growth parameters used

Area	Linf(mm)	k	t0	a	b	Sex	Reference
Pomo/Jabuka	58.348	0.324	-0.1592	0.00067	3.0580	male	Froglia & Gramitto, 1988
Pomo/Jabuka	45.165	0.528	-0.0225	0.00109	2.9614	female	Froglia &

							Gramitto, 1988

Table 6.5.3.4.3.2 Norway lobster in GSA 17 (Pomo/Jabuka area). Abundance index per age

year	age 1	age 2	age 3	age 4	age 5	age 6
1994	84.96	108.57	27.32	4.55	1.52	6.88
1995	295.35	147.06	34.51	8.79	1.32	2.86
1996	351.10	120.25	46.29	9.96	4.94	5.05
1997	179.69	68.35	17.59	8.83	2.30	2.98
1998	439.26	165.71	31.00	7.88	4.83	9.33
1999	159.77	59.57	12.06	7.50	0.86	5.21
2000	26.36	11.95	4.43	1.34	0.37	1.09
2001	168.78	65.87	11.87	2.29	0.89	0.81
2002	36.16	14.85	8.83	1.55	0.57	1.67
2003	130.53	23.01	10.50	1.42	1.39	3.63
2004	68.88	29.71	8.44	1.28	0.92	1.38
2005	113.76	42.89	6.39	2.57	0.22	0.49
2006	208.99	75.64	22.60	6.85	1.90	2.27
2007	74.08	37.94	9.58	1.57	0.51	0.58
2008	72.53	48.21	4.68	4.04	0.75	0.75
2009	35.44	45.70	12.75	3.07	1.25	1.25
2010	23.31	30.26	5.73	2.93	1.00	1.13
2011	12.17	10.88	5.88	1.50	0.65	1.66
2012	21.04	19.90	4.94	0.61	0.42	0.95
2013	23.33	21.86	6.05	2.21	0.74	1.17
2014	32.15	20.86	7.66	3.63	0.66	0.90
2015	20.02	11.18	7.12	1.98	0.90	0.47
2016	32.92	35.62	11.70	3.49	1.19	0.80
2017	24.23	19.67	10.55	2.35	1.29	1.19
2018	35.23	24.72	10.03	2.25	0.67	1.61
2019	37.37	45.33	17.32	8.39	3.33	3.85
2020	152.76	101.64	36.72	15.14	10.67	4.54

In Table 6.5.3.4.3.3 mean weight per age is shown.

Table 6.5.3.4.3.3 Norway lobster in GSA 17 (Pomo/Jabuka area). Mean weight per age

year	age 1	age 2	age 3	age 4	age 5	age 6
1994	0.016	0.028	0.050	0.068	0.075	0.125
1995	0.014	0.028	0.048	0.070	0.086	0.124
1996	0.013	0.029	0.049	0.072	0.091	0.121
1997	0.014	0.028	0.051	0.072	0.085	0.173
1998	0.014	0.029	0.049	0.071	0.089	0.107
1999	0.012	0.026	0.052	0.076	0.091	0.156
2000	0.012	0.028	0.047	0.074	0.089	0.154
2001	0.013	0.027	0.048	0.066	0.086	0.151
2002	0.012	0.029	0.049	0.071	0.093	0.100
2003	0.011	0.029	0.048	0.070	0.083	0.126
2004	0.011	0.029	0.049	0.066	0.086	0.114
2005	0.012	0.029	0.049	0.070	0.085	0.150
2006	0.012	0.028	0.050	0.070	0.092	0.129
2007	0.015	0.029	0.050	0.070	0.085	0.098
2008	0.014	0.029	0.053	0.073	0.088	0.118
2009	0.016	0.030	0.051	0.073	0.095	0.154
2010	0.016	0.028	0.049	0.072	0.088	0.119
2011	0.016	0.031	0.052	0.069	0.093	0.112
2012	0.017	0.029	0.048	0.063	0.085	0.105
2013	0.014	0.029	0.051	0.074	0.090	0.131
2014	0.014	0.028	0.051	0.070	0.086	0.116
2015	0.015	0.030	0.051	0.067	0.090	0.101
2016	0.015	0.029	0.051	0.072	0.092	0.130
2017	0.014	0.028	0.052	0.076	0.093	0.126
2018	0.014	0.030	0.050	0.073	0.090	0.123
2019	0.016	0.029	0.052	0.073	0.093	0.128
2020	0.017	0.029	0.050	0.074	0.093	0.126

SURBA also needs as input maturity and natural mortality per age. In Table 6.5.3.4.3.4 maturity per age derived by MEDITS data is shown.

Table 6.5.3.4.3.4 Norway lobster in GSA 17 (Pomo/Jabuka area). Maturity per age

age 1	age 2	age 3	age 4	age 5	age 6
0.44	0.91	0.99	1	1	1

In Table 6.5.3.4.3.5 natural mortality per age, calculated using Chen-Watanabe equation is shown

Table 6.5.3.4.3.5 Norway lobster in GSA 17 (Pomo/Jabuka area). Natural mortality per age

year	age 1	age 2	age 3	age 4	age 5	age 6
1994	0.89	0.63	0.54	0.50	0.50	0.43
1995	0.88	0.60	0.50	0.44	0.39	0.39
1996	0.89	0.61	0.48	0.42	0.39	0.38
1997	0.88	0.61	0.48	0.42	0.44	0.37
1998	0.89	0.61	0.51	0.44	0.42	0.51
1999	0.86	0.57	0.49	0.42	0.40	0.37
2000	0.87	0.62	0.51	0.45	0.42	0.38
2001	0.89	0.59	0.50	0.42	0.40	0.38
2002	0.87	0.57	0.50	0.44	0.40	0.43
2003	0.87	0.60	0.53	0.44	0.45	0.44
2004	0.85	0.59	0.47	0.47	0.40	0.37
2005	0.86	0.58	0.49	0.42	0.44	0.50
2006	0.87	0.59	0.49	0.44	0.39	0.39
2007	0.89	0.61	0.47	0.43	0.41	0.48
2008	0.87	0.61	0.47	0.45	0.40	0.38
2009	0.88	0.64	0.51	0.42	0.39	0.38
2010	0.87	0.60	0.47	0.45	0.40	0.42
2011	0.90	0.62	0.49	0.44	0.40	0.39
2012	0.91	0.63	0.51	0.51	0.41	0.43
2013	0.88	0.62	0.50	0.43	0.42	0.38
2014	0.87	0.59	0.47	0.43	0.40	0.38
2015	0.90	0.63	0.49	0.47	0.40	0.41
2016	0.88	0.58	0.47	0.42	0.39	0.38
2017	0.87	0.59	0.47	0.42	0.39	0.38
2018	0.88	0.62	0.50	0.42	0.40	0.40
2019	0.89	0.61	0.48	0.42	0.39	0.39
2020	0.90	0.60	0.48	0.42	0.39	0.37

Different scenarios of catchability at age were tested. It was decided to run the model with a realistic catchability at-age producing the better fitting showed in figure 6.5.3.4.3.2

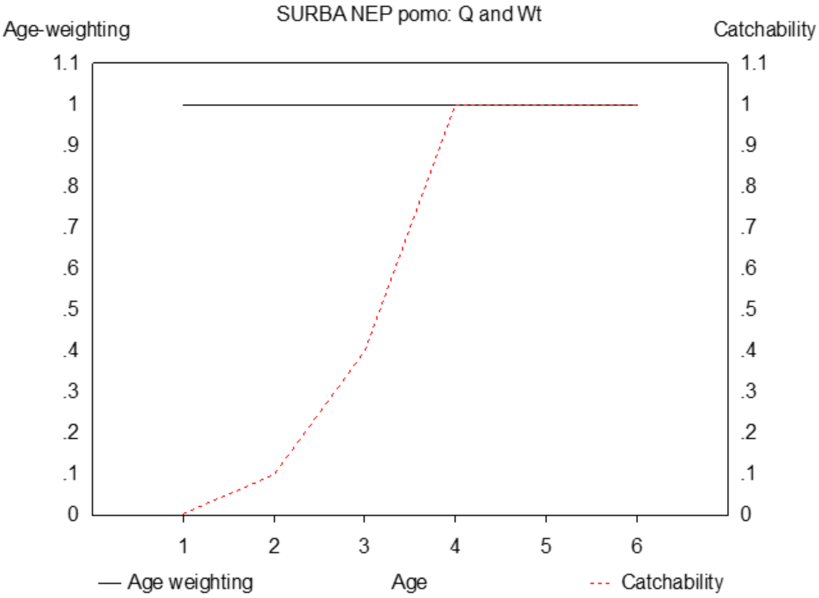


Figure 6.5.3.4.3.2 Norway lobster in GSA 17 (Pomo/Jabuka area). Catchability at-age scenario used in the SURBA model.

Results

In general terms, cohort abundance follows a linear, exponential decline after log transformation, with a few exceptions (Figure 6.5.3.4.3.3).

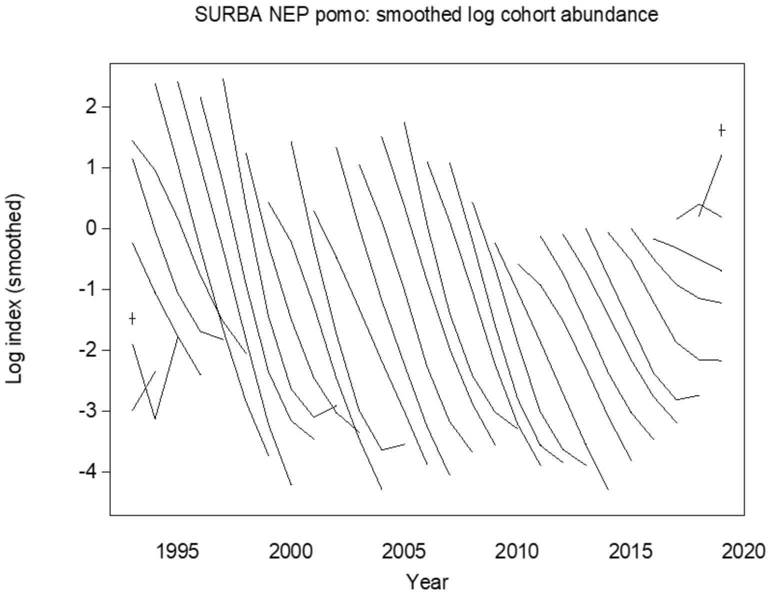


Figure 6.5.3.4.3.3 Norway lobster in GSA 17 (Pomo/Jabuka area). Log cohort abundances at age from the SURBA analysis.

In the bubble plot of figure 6.5.3.4.3.4 the log residuals of the index per age are presented. Generally, the residuals are distributed randomly and their values (at least for the ages 1-5) are low.

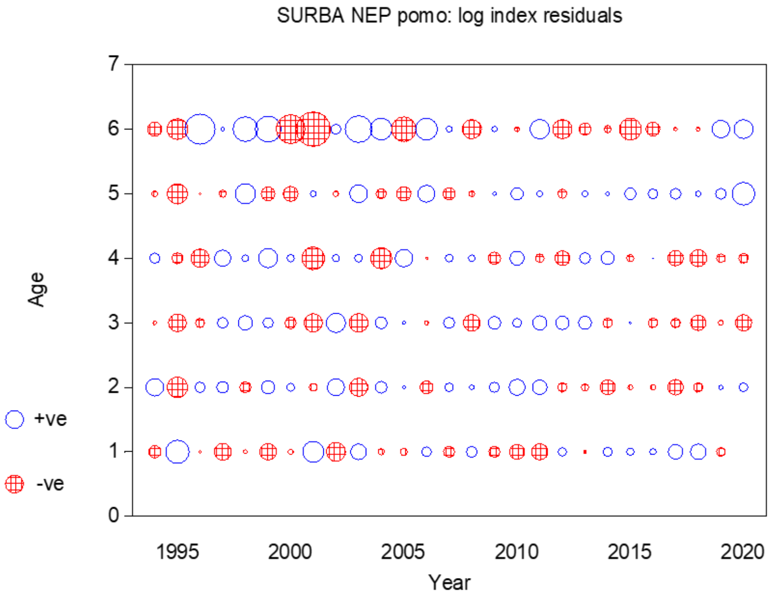


Figure 6.5.3.4.3.4 Norway lobster in GSA 17 (Pomo/Jabuka area). Log index residuals at age from the SURBA analysis.

Model fitting is quite consistent (Figure 6.5.3.4.3.5).

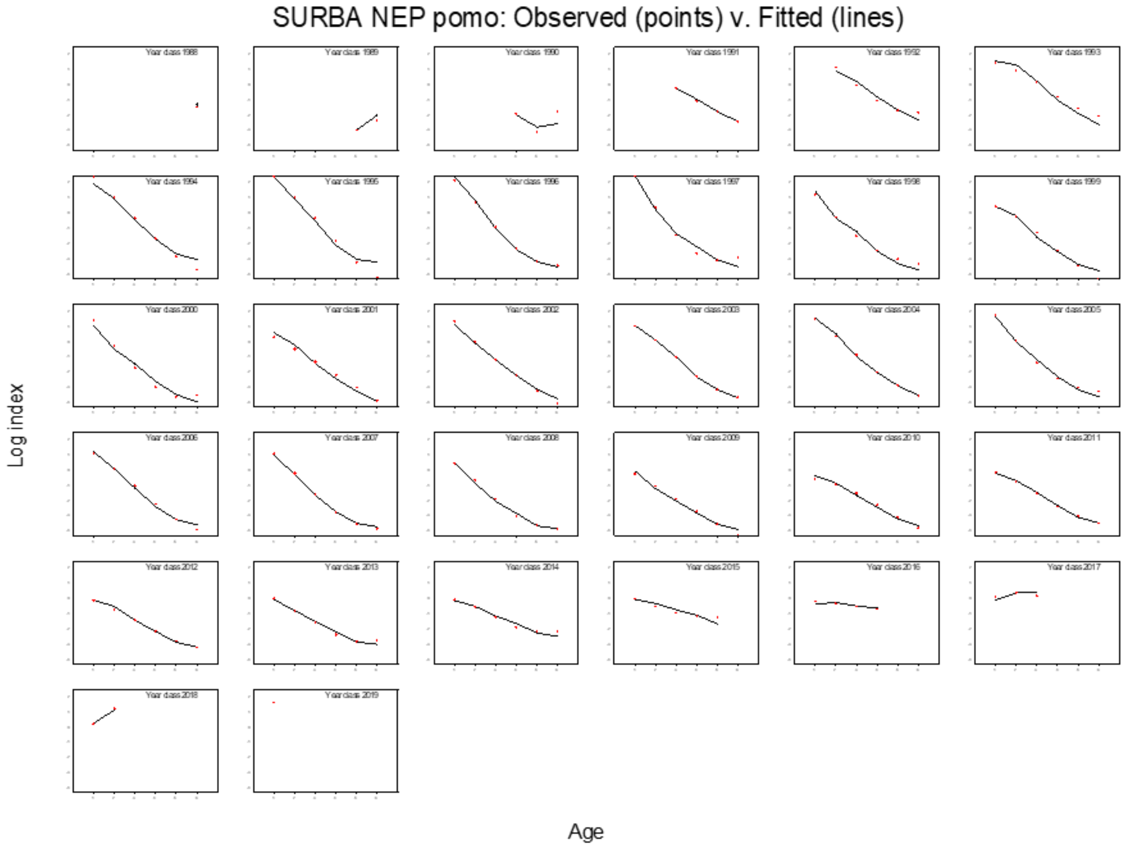


Figure 6.5.3.4.3.5 Norway lobster in GSA 17 (Pomo/Jabuka area). Scatter plots of log indices at consecutive ages from the SURBA analysis.

Model retrospective is also quite stable (Figure 6.5.3.4.3.6).

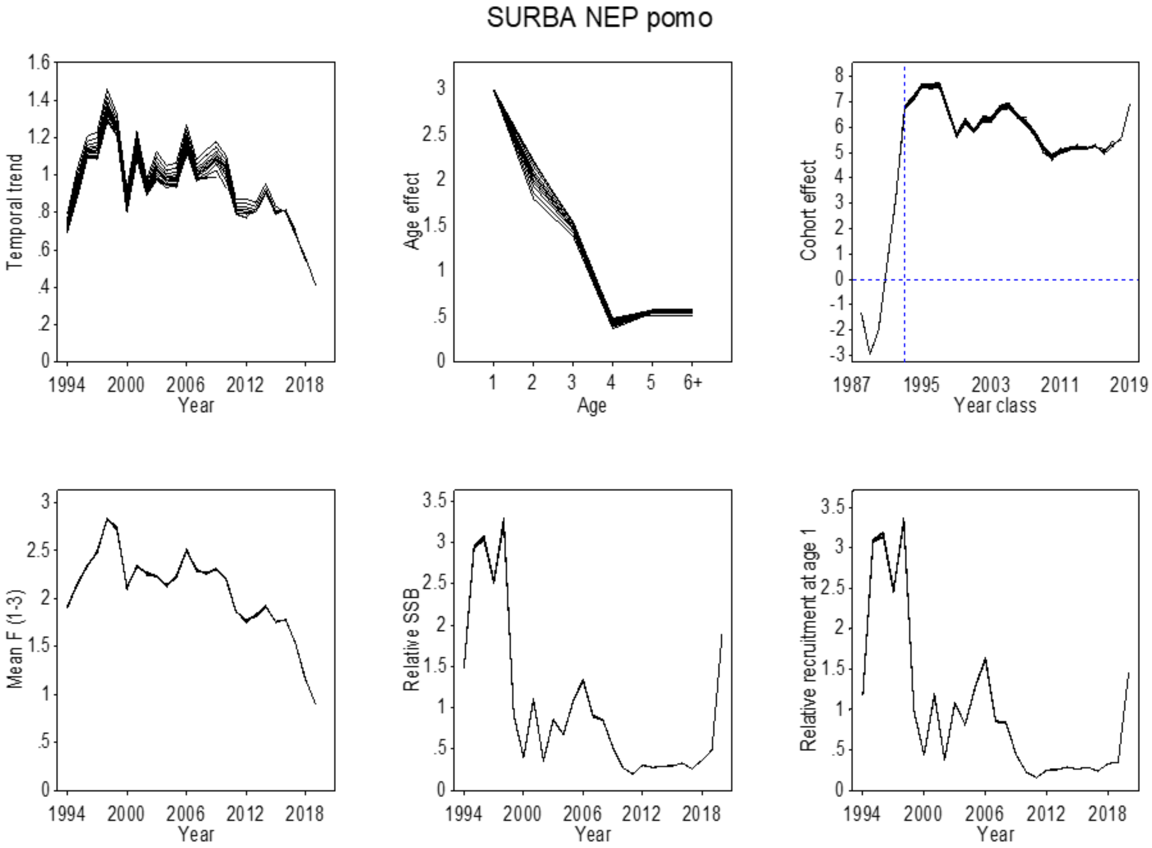


Figure 6.5.3.4.3.6 Norway lobster in GSA 17 (Pomo/Jabuka area). Scatter plots of log indices at consecutive ages from the SURBA analysis.

The trend for relative Mean F for ages 1-3 (Figure 6.5.3.4.3.7) reveals high values of F for the years 1994-2005 and a decrease afterwards, which is steeper at the final years of the time series; this is in accordance with the implementation of the FRA measures in the Pomo/Jabuka area. Accordingly, relative SSB (Figure 6.5.3.4.3.8) display high values between 1994-1998, and a sharp decrease to values below to 1 afterwards. A secondary peak is displayed in 2006, which follows from an increase in recruitment in 2003, followed again by a sharp decrease afterwards. Finally, signs of recovery are shown in the last years and especially in 2020 were a high increase in relative SSB is observed.

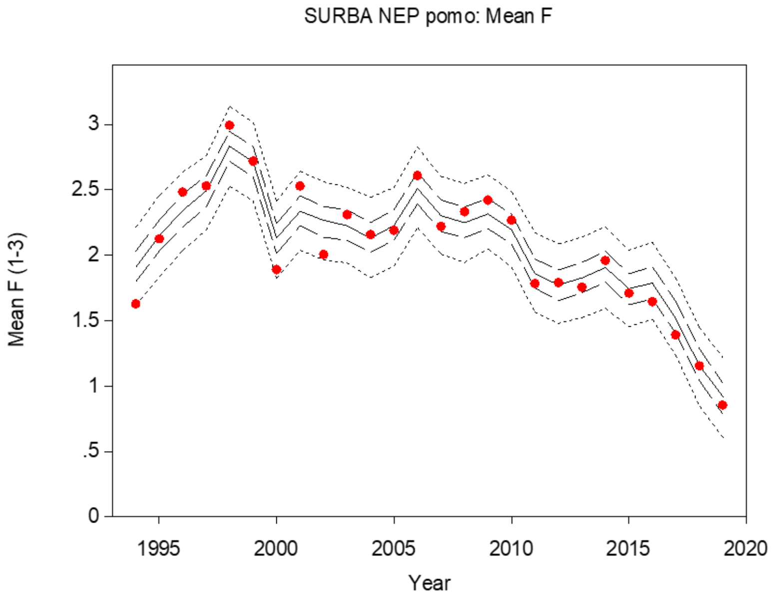


Figure 6.5.3.4.3.7 Norway lobster in GSA 17 (Pomo/Jabuka area). Relative mean F(1-3) in time from the SURBA analysis.

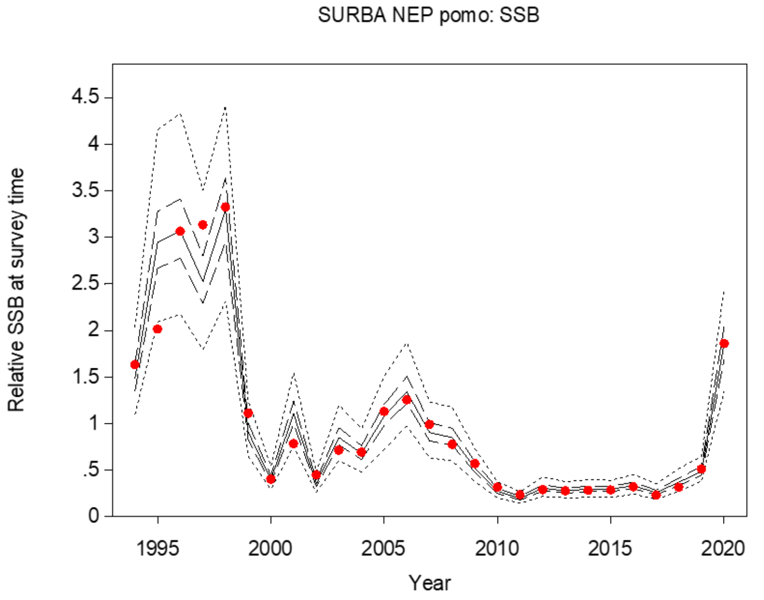


Figure 6.5.3.4.3.8 Norway lobster in GSA 17 (Pomo/Jabuka area). Relative SSB in time from the SURBA analysis.

6.5.3.4.4 GSA 18

In figure 6.5.3.4.4.1 the total biomass and density indices for GSA18 are shown.

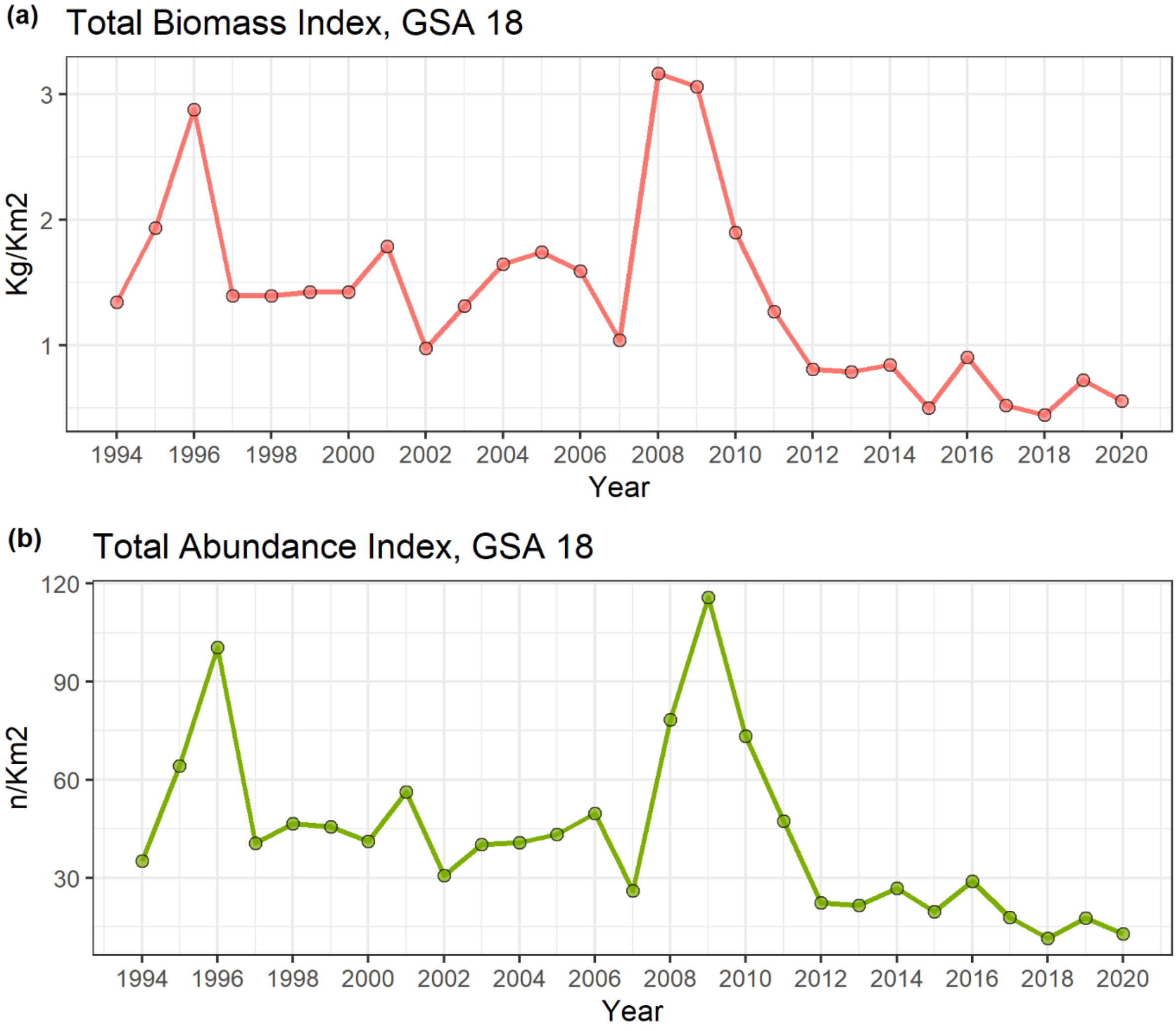


Figure 6.5.3.4.4.1 Norway lobster in GSA 18. (a): Total Biomass index and (b): Total Density index for GSA 18.

SURBA main inputs consist of abundance index and mean weight per age, derived by MEDITS. Data were prepared separately for males and females by using the growth parameters shown in Table 6.5.3.4.4.1. Under the assumption that the GSA18 subpopulation of Norway lobster communicates with the Pomo/Jabuka subpopulation, and the population occupies similar depths, the Pomo/Jabuka pit growth parameters were also used for GSA18. The age range used was 1-6+ years. In Table 6.5.3.4.4.2, abundance index per age is shown.

Table 6.5.3.4.4.1 Norway lobster in GSA 18. Growth parameters used

Area	Linf(mm)	k	t0	a	b	Sex	Reference
GSA 18	58.348	0.324	-0.1592	0.00067	3.0580	male	Froglia & Gramitto, 1988
GSA 18	45.165	0.528	-0.0225	0.00109	2.9614	female	Froglia & Gramitto, 1988

Table 6.5.3.4.4.2 Norway lobster in GSA 18. Abundance index per age

year	age 1	age 2	age 3	age 4	age 5	age 6
1994	4.57	13.09	8.80	4.10	1.04	3.35
1995	22.08	21.08	10.98	4.89	1.82	3.44
1996	46.45	25.75	11.53	4.85	2.64	7.42
1997	11.43	16.42	4.78	2.94	0.79	4.04
1998	16.01	15.33	6.87	3.03	2.29	2.24
1999	16.13	14.60	6.72	2.39	2.19	2.87
2000	10.04	14.11	8.14	3.30	2.45	2.27
2001	20.48	17.23	9.27	3.48	0.94	3.16
2002	9.50	6.79	5.61	2.76	1.75	2.23
2003	8.37	13.80	7.18	6.82	0.61	3.10
2004	7.62	11.57	8.06	3.69	1.21	6.21
2005	10.64	13.01	5.40	4.04	3.53	5.91
2006	15.77	14.41	9.64	1.60	1.15	6.70
2007	7.50	5.14	3.05	3.07	1.58	5.06
2008	11.89	23.43	17.65	5.18	1.53	18.64
2009	56.34	33.44	12.44	5.80	2.47	4.52
2010	26.96	26.90	10.38	3.92	1.36	2.69
2011	18.46	16.12	7.27	2.79	1.06	1.71
2012	4.99	7.73	5.24	1.74	0.93	1.24
2013	4.35	7.40	4.79	1.85	1.53	1.73
2014	7.11	9.89	4.89	2.26	0.80	1.83
2015	5.82	7.70	3.41	0.83	0.69	0.71
2016	7.26	10.37	5.29	2.19	1.73	1.58
2017	5.09	6.37	1.68	1.54	1.03	1.39
2018	2.93	3.30	1.65	1.27	0.76	1.52
2019	3.35	4.90	4.63	1.29	0.64	2.44
2020	2.33	3.75	2.85	1.55	1.29	1.16

In Table 6.5.3.4.4.3 mean weight per age is shown.

Table 6.5.3.4.4.3 Norway lobster in GSA 18. Mean weight per age

year	age 1	age 2	age 3	age 4	age 5	age 6
1994	0.015	0.031	0.050	0.069	0.088	0.130
1995	0.015	0.030	0.051	0.072	0.093	0.126
1996	0.014	0.030	0.049	0.071	0.088	0.128
1997	0.014	0.030	0.049	0.069	0.093	0.132
1998	0.014	0.030	0.050	0.070	0.090	0.124
1999	0.014	0.031	0.052	0.071	0.088	0.133
2000	0.014	0.031	0.051	0.074	0.090	0.116
2001	0.014	0.030	0.050	0.072	0.087	0.122
2002	0.014	0.029	0.050	0.070	0.087	0.132
2003	0.013	0.031	0.053	0.072	0.076	0.151
2004	0.014	0.031	0.051	0.072	0.081	0.122
2005	0.014	0.030	0.052	0.070	0.087	0.138
2006	0.014	0.029	0.050	0.070	0.089	0.117
2007	0.016	0.028	0.049	0.069	0.083	0.157
2008	0.014	0.032	0.052	0.067	0.079	0.135
2009	0.014	0.029	0.050	0.072	0.089	0.135
2010	0.015	0.030	0.050	0.073	0.089	0.120
2011	0.017	0.030	0.049	0.071	0.093	0.103
2012	0.016	0.031	0.049	0.071	0.091	0.113
2013	0.015	0.032	0.051	0.071	0.092	0.117
2014	0.015	0.031	0.051	0.070	0.085	0.127
2015	0.014	0.030	0.048	0.074	0.081	0.105
2016	0.014	0.031	0.050	0.069	0.092	0.114
2017	0.015	0.030	0.049	0.074	0.089	0.121
2018	0.015	0.032	0.051	0.072	0.085	0.119
2019	0.015	0.032	0.050	0.071	0.081	0.123
2020	0.017	0.029	0.051	0.070	0.092	0.124

SURBA also needs as input maturity and natural mortality per age. In Table 6.5.3.4.4.4 maturity per age derived by MEDITS data is shown. The maturity vector used was the same with Pomo/Jabuka subpopulation.

Table 6.5.3.4.4.4 Norway lobster in GSA 18. Maturity per age

age 1	age 2	age 3	age 4	age 5	age 6
0.44	0.91	0.99	1	1	1

In Table 6.5.3.4.4.5 natural mortality per age, calculated using Chen-Watanabe equation is shown.

Table 6.5.3.4.4.5 Norway lobster in GSA 18. Natural mortality per age

year	age 1	age 2	age 3	age 4	age 5	age 6
1994	0.90	0.65	0.51	0.47	0.44	0.40
1995	0.90	0.63	0.50	0.43	0.39	0.39
1996	0.88	0.63	0.52	0.45	0.41	0.44
1997	0.88	0.62	0.50	0.46	0.40	0.39
1998	0.87	0.63	0.50	0.44	0.40	0.42
1999	0.88	0.66	0.50	0.44	0.41	0.40
2000	0.90	0.64	0.51	0.43	0.41	0.39
2001	0.89	0.64	0.54	0.44	0.40	0.41
2002	0.89	0.64	0.50	0.43	0.41	0.43
2003	0.88	0.63	0.52	0.44	0.51	0.41
2004	0.88	0.66	0.54	0.46	0.47	0.43
2005	0.86	0.65	0.51	0.46	0.39	0.42
2006	0.90	0.64	0.54	0.49	0.41	0.42
2007	0.85	0.59	0.47	0.49	0.46	0.46
2008	0.88	0.64	0.54	0.51	0.48	0.45
2009	0.88	0.62	0.52	0.45	0.41	0.40
2010	0.89	0.63	0.52	0.44	0.40	0.41
2011	0.90	0.63	0.51	0.42	0.40	0.43
2012	0.89	0.63	0.52	0.45	0.40	0.42
2013	0.89	0.65	0.53	0.43	0.40	0.38
2014	0.86	0.64	0.52	0.46	0.46	0.46
2015	0.88	0.64	0.50	0.44	0.47	0.43
2016	0.87	0.64	0.51	0.47	0.40	0.44
2017	0.84	0.60	0.52	0.45	0.40	0.45
2018	0.87	0.62	0.52	0.47	0.44	0.43
2019	0.89	0.64	0.53	0.48	0.45	0.43
2020	0.88	0.60	0.48	0.44	0.40	0.43

Different scenarios of catchability at age were tested. It was decided to run the model with the same catchability pattern as in Pomo/Jabuka area, as showed in figure 6.5.3.4.4.2

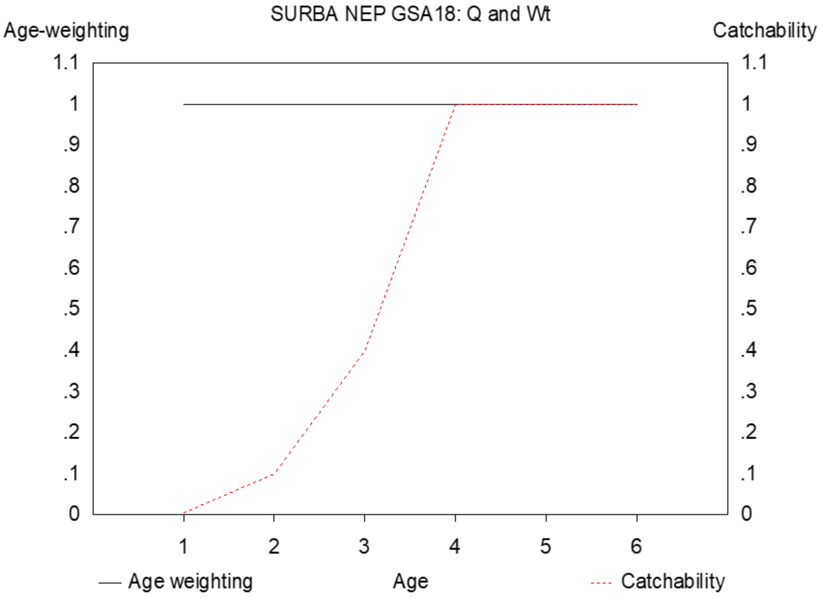


Figure 6.5.3.4.4.2 Norway lobster in GSA 18. Catchability at-age scenario used in the SURBA model.

Results

In general terms, the decline in numbers did not always follow the expected exponential decline nor linear after the log transformation, with a few exceptions (Figure 6.5.3.4.4.3). These departures from exponential decline suggest that the fishery has an age dependent selectivity, which may be either gear or space related.

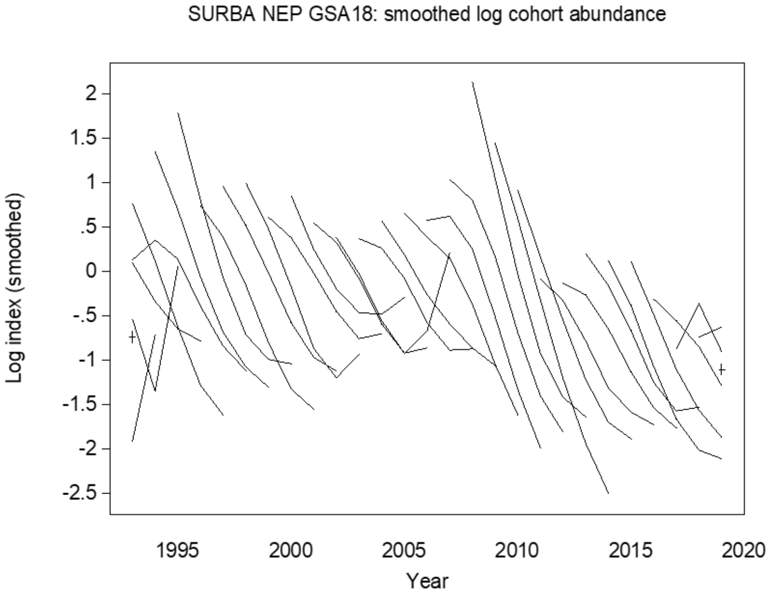


Figure 6.5.3.4.4.3 Norway lobster in GSA 18. Log cohort abundances at age from the SURBA analysis.

In the bubble plot of figure 6.5.3.4.4.4 the log residuals of the index per age are presented. Although their values for ages 1-5 are low, some patterns of negative or positive numbers are apparent, in years 2000-2007 and 2008-2014 respectively, in ages 1-4.

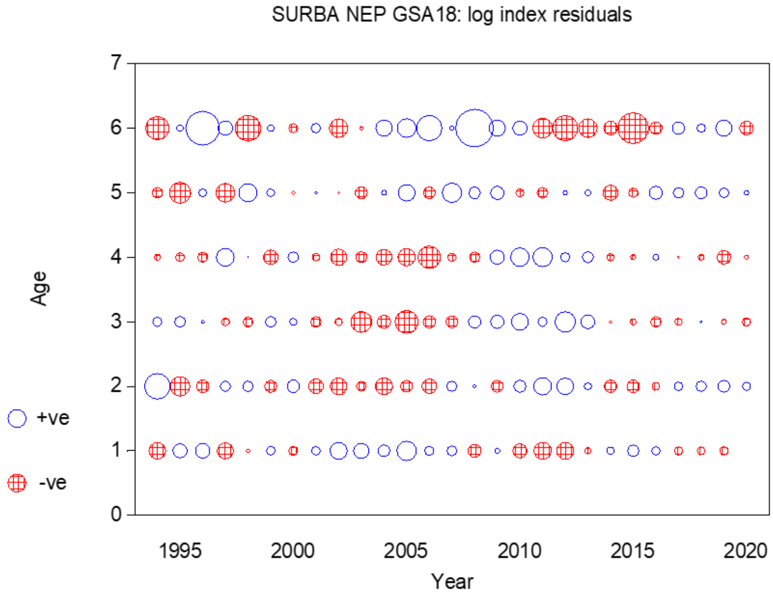


Figure 6.5.3.4.4.4 Norway lobster in GSA 18. Log index residuals at age from the SURBA analysis.

Nevertheless, model fitting is quite consistent, with few exceptions (for example in year 2002) (Figure 6.5.3.4.4.5).

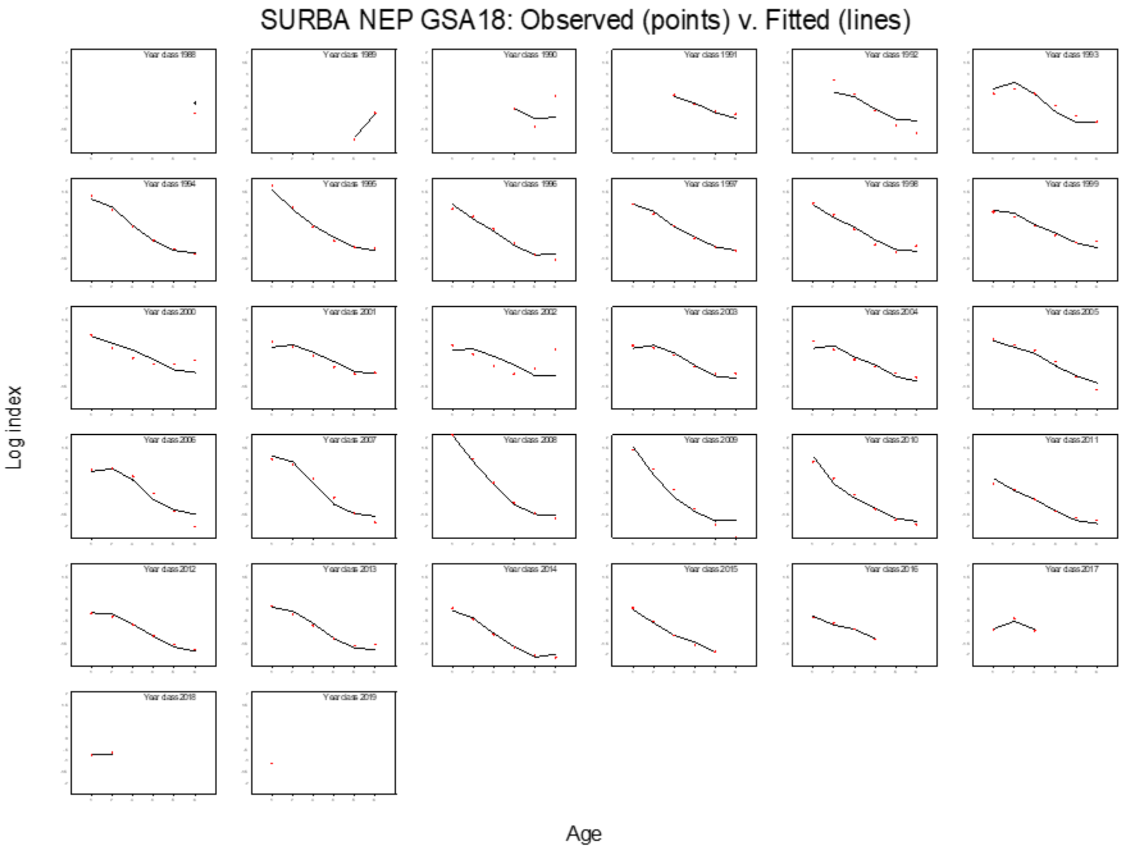


Figure 6.5.3.4.4.5 Norway lobster in GSA 18. Scatter plots of log indices at consecutive ages from the SURBA analysis.

Model retrospective is also quite stable (Figure 6.5.3.4.4.6).

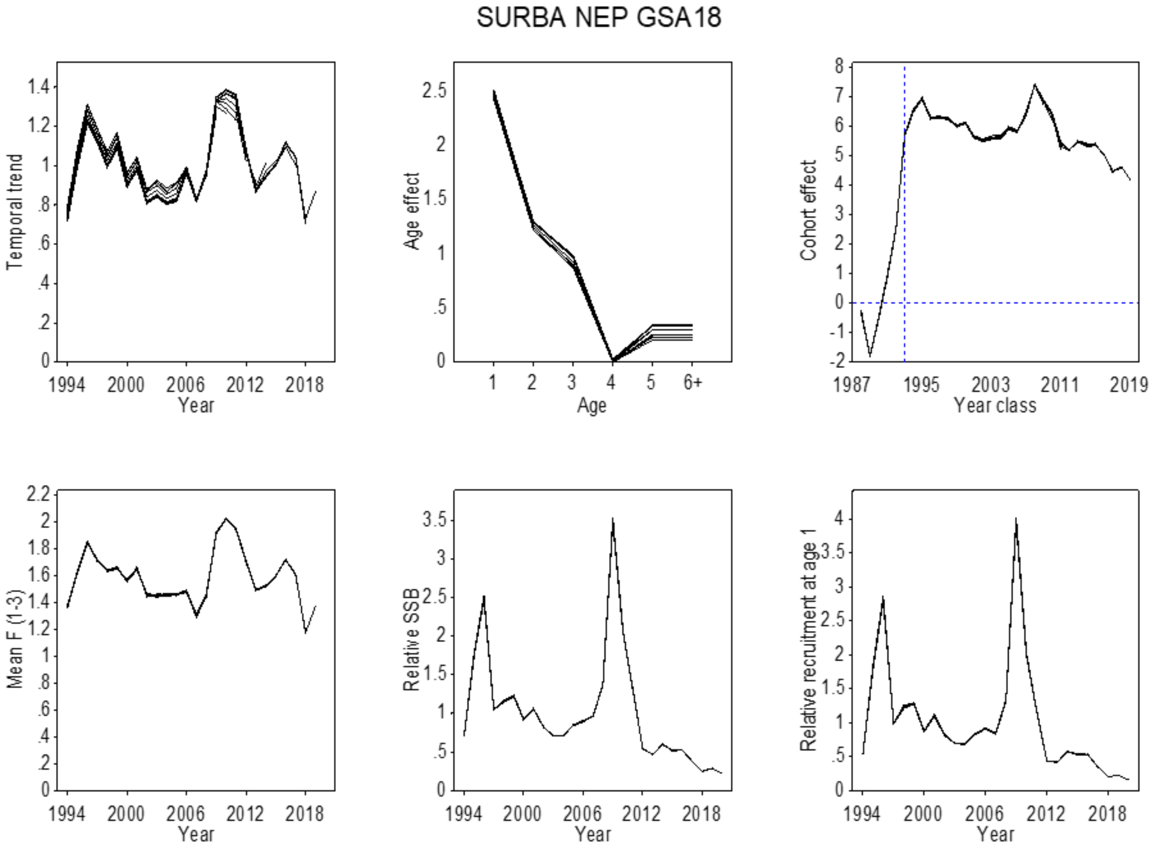


Figure 6.5.3.4.4.6 Norway lobster in GSA 18. Scatter plots of log indices at consecutive ages from the SURBA analysis.

The trend for relative Mean F for ages 1-3 (Figure 6.5.3.4.4.7) is rather stable throughout the years. Higher values of relative F are observed for the years 2009-2011. Afterwards, the trend is generally decreasing. On the other hand, relative SSB (Figure 6.5.3.4.4.8) displays two high values peaks, one in 2009 and to a lesser extent a second in 1996. A sharp decrease in SSB is observed between 2009 and 2012, followed by a less dramatic decline until 2020. The SSB is shown to be a historic low in 2020.

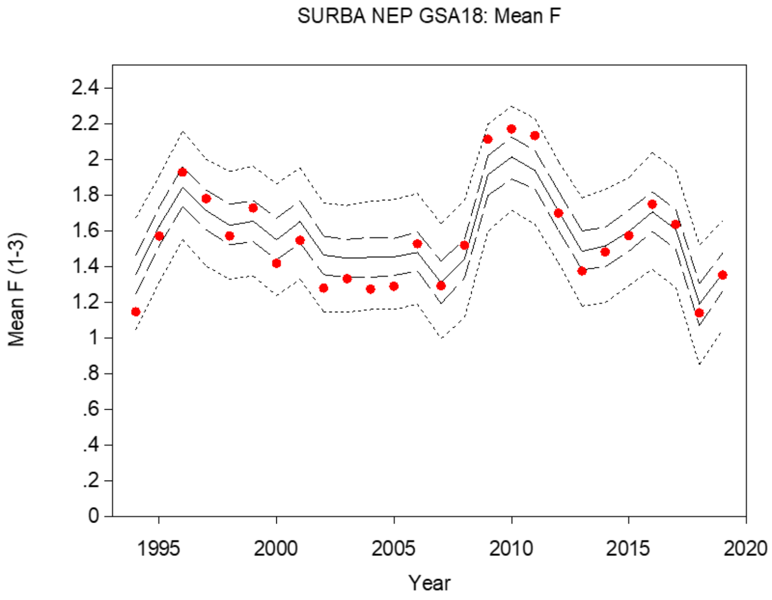


Figure 6.5.3.4.4.7 Norway lobster in GSA 18. Relative mean F(1-3) in time from the SURBA analysis.

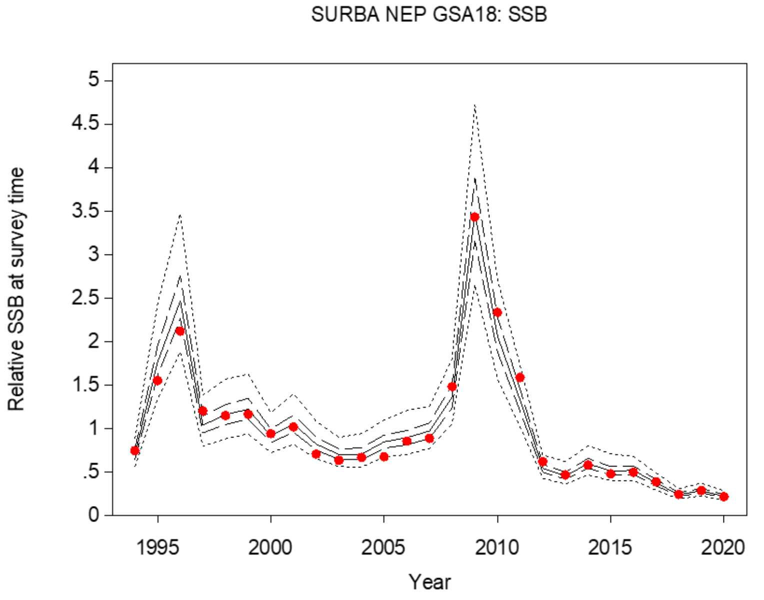


Figure 6.5.3.4.4.8 Norway lobster in GSA 18. Relative SSB in time from the SURBA analysis.

References

6.5.3.5 CONCLUSIONS TO SUB-AREA BASED INDICES FOR NEPHROPS GSA 17-18.

For biomass indices, Figure 6.5.3.5.1 shows a comparison of the Smoothed MEDITS biomass and the SURBA age based biomass indices rescaled to SPiCT total biomass by sub area. Both methods use rescaling by the mean biomass from MEDITS for the whole period to match to the assessed stock biomass from SPiCT. The SURBA estimates are thought to capture more of the detailed dynamics because they include size/age data, but the underlying variability of the survey also come through in the year on year variability, particularly for Ancona. The smoothed MEDITS biomass indices which are matched not just on average biomass but also variability with the SPiCT model give a better 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 Nephrops in GSA 17-18 in Section 6.5.5.2.

For general stock biomass considerations, the overall estimated biomass in 2020 from the SPiCT assessment is B= 5367 = 0.9 B_{MSY} , which is almost equal to the average biomass for the survey period 1994 to 2020 where B = 5419. The 2020 biomass in the four sub areas is shown in Table 6.5.3.2.1. The average biomass B $_{94-2020}$ is in Table 6.5.3.5.1, along with the ratio of B_{2020} to the average B $_{94-2020}$ while relative B in the Pomo/Jabuka Pit is at 1.6, 2020 relative biomass in Ancona and GSA 18 are much lower at 0.27 and 0.38 average biomass, and relative biomass in Kvarner is in a much better state at 0.74. This suggests that Nephrops 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 close to 90% BMSY, the values of at 0.27 and 0.38 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 3108 to 5367 (Medits Biomass index) from 2016 to 2020 (see Figure 6.5.3.5.1 and Table 6.5.3.2.1.). Both SURBA and MEDITS Biomass indices shows a similar change (see Figure 6.5.3.5.1).

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 year. An indication of the four sub area exploitation rates are available in relative index form from the SURBA analyses of all four areas, and from a preliminary assessment using a4a for GSA 18. However, the quality of sub area exploitation rates is poor, either because it has not been possible to allocate catches to sub area within GSA 17, or in the case GSA 18 the a4a assessment has issues with conflict between survey and catch data, which is thought to be because either the 'stock' extends outside GSA 18, or catches reported to GSA 18 may come from the Pomo/Jabuka Pit. Figure 6.5.3.5.2 shows estimates of indices of fishing mortality by sub area from SURBA using the MEDITS catch at length/age data. Ancona, Kvarner and Pomo/Jabuka Pit all show declines in exploitation rate, though the extent of the decline is less in Ancona. For GSA 18 the SURBA index and the a4a assessment show much less evidence for declining exploitation over the period.

In conclusion, both biomass and exploitation indices are in general agreement with the biomass indices showing 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.

Table 6.5.3.5.1 Nephrops in GSA 17-18 biomass by sub area.

	Total GSA 17-18	Ancona	GSA 18	Kvarner	Pomo/Jabuka Pit
Average biomass 94-2020	5419	697	1025	1279	2417
B2020/B1994-2020	0.99	0.27	0.38	0.74	1.59

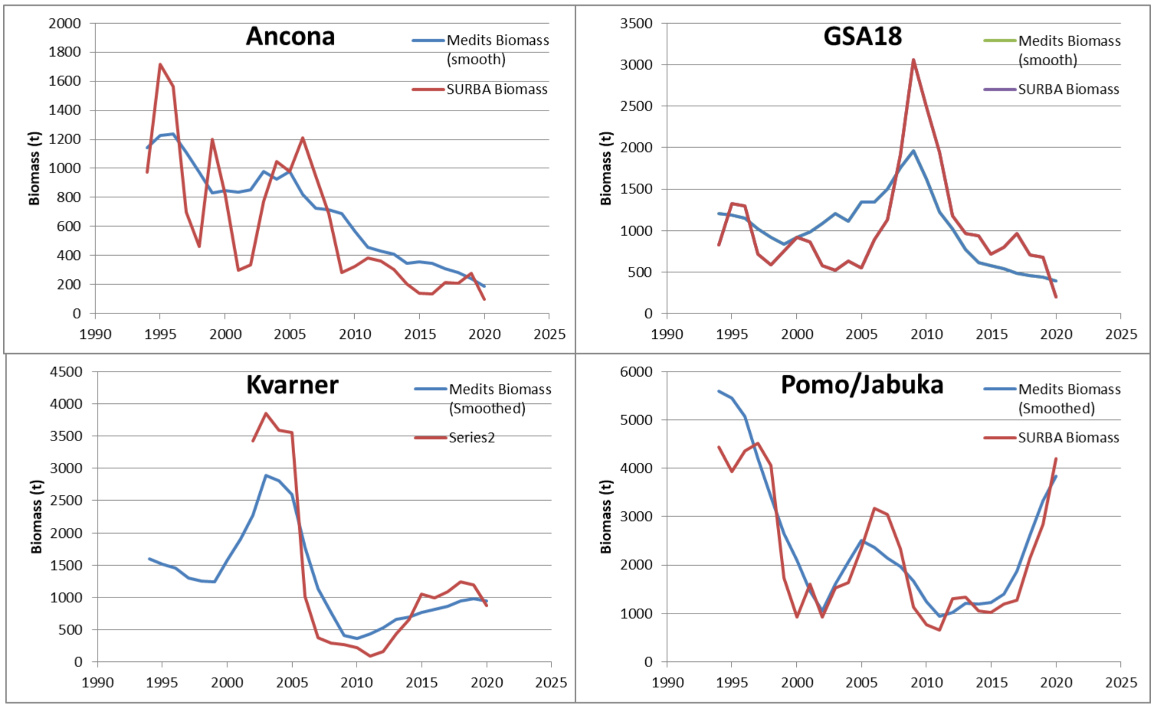


Figure 6.5.3.5.1 Nephrops in GSA 17-18 biomass indices by sub area; GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit 1994 to 2020. SURBA age and survey based assessment(red) and smoothed biomass indices from MEDITS (blue).

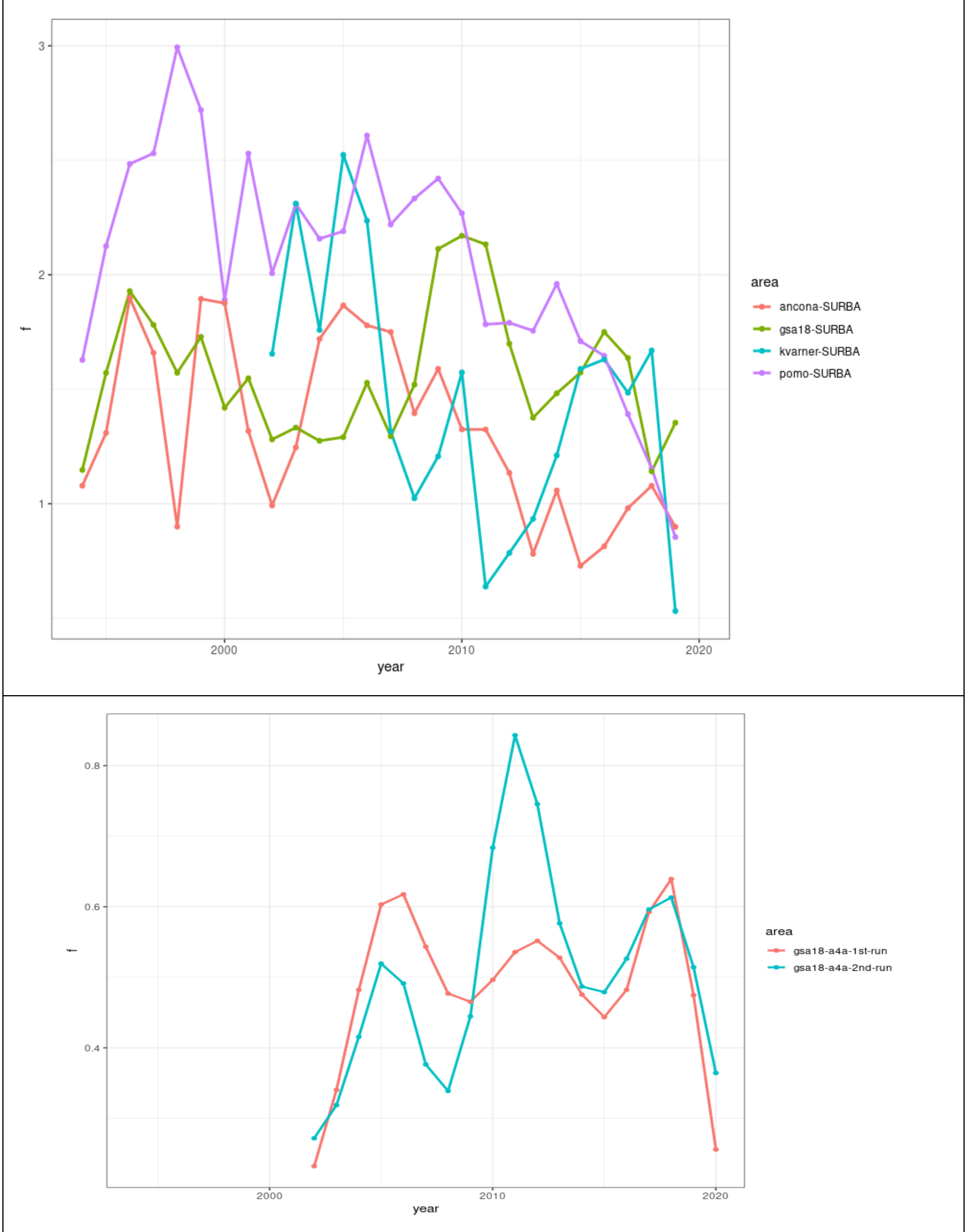


Figure 6.5.3.5.2 Nephrops in GSA 17-18 Exploitation indices by sub area; GSA 18, Ancona, Kvarner and Pomo/Jabuka Pit 1994 to 2020. SURBA age and survey based assessment upper panel. a4a preliminary

assessment for Nephrops GSA 18.

6.5.4 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} 0.37 y^{-1} and B_{MSYs} = 5955.3 t. Based on agreed procedure for estimating Blim in the absence of a S/R relationship B_{lim} is estimated as B_{MSY}*0.40. Based on these results STECF-EWG 21-15 considers the stock sustainably exploited (F< F_{MSY}) in recent years.

Table 6.5.4.1 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}	2382.12	B_{lim} = 40% B_{MSY}	STECF EWG 20-15
	B_{pa}	3334.97	B_{pa} = B_{lim} *1.4	STECF EWG 20-15
	F_{lim}		Not defined	
	F_{pa}		Not defined	
MSY Approach	MSY $B_{trigger}$	3334.97	MSY Btrigger = B_{pa} = B_{lim} *1.4	STECF EWG 20-15
	F_{MSY}	0.37	F0.1 as proxy for F_{MSY}	STECF EWG 20-15

6.5.5 SHORT TERM FORECAST AND CATCH OPTIONS

6.5.5.1 STF CATCH ESTIMATES FOR THE TOTAL AREA.

The SPiCT model was used to carry out a short term forecast with the following conditions:

Observed interval, index: 1960 - 2020

Observed interval, catch: 1970 - 2021

Fishing mortality (F) prediction: 2024

Biomass (B) prediction: 2024

```
Catch (C) prediction interval:    2023 - 2024


Predictions
                              C          B        F      B/Bmsy    F/Fmsy   perc.dB    perc.dF
1. Keep current catch     844.2   8418.2   0.100     1.378       0.271         52.3   -36.2
2. Keep current F        1262.3   8474.6   0.156     1.387       0.424         53.3     0.0
3. Fish at Fmsy        2105.6     5740.5     0.368      0.940      1.000     3.8      135.9
4. No fishing             1.6     11323.4   0.000      1.853       0.000     104.8   -99.9
5. Reduce F 25%        1009.5      9109.5   0.117      1.491      0.318       64.8   -25.0
6. Increase F 25%       1479.9      7885.3   0.195      1.291      0.530       42.6    25.0
7. MSY advice rule      2105.6      5740.5 0.368        0.940      1.000       3.8   135.9


95% CIs of absolute predictions
                            C.lo      C.hi       B.lo       B.hi        F.lo      F.hi
1. Keep current catch     762.6     934.5     4240.0    16713.7    0.050    0.199
2. Keep current F         605.1    2633.3    4140.5    17345.5    0.052    0.473
3. Fish at Fmsy          1175.2    3772.6    2234.0    14750.7    0.122    1.116
4. No fishing                0.7        4.0    6269.9    20450.1   0.000    0.000
5. Reduce F 25%            467.1    2182.1    4615.7    17978.3  0.039    0.355
6. Increase F 25%          733.6    2985.6    3706.3    16776.4 0.064    0.591
7. MSY advice rule        1175.2     3772.6    2234.0    14750.8 0.122    1.116


95% CIs of relative predictions
                          B/Bmsy.lo    B/Bmsy.hi      F/Fmsy.lo      F/Fmsy.hi
1. Keep current catch        0.670          2.833           0.124           0.589
2. Keep current F            0.691          2.784           0.147           1.220
3. Fish at Fmsy              0.394          2.243           0.347           2.878
4. No fishing                0.963          3.566           0.000           0.001
5. Reduce F 25%              0.757          2.935           0.110           0.915
6. Increase F 25%            0.628          2.653           0.184           1.525
7. MSY advice rule           0.394          2.243           0.347           2.878
                               C        B          F     B/Bmsy     F/Fmsy        perc.dB       perc.dF
1. Keep current catch     844.2    8418.2     0.100      1.378       0.271           52.3      -36.2
2. Keep current F        1262.3    8474.6     0.156      1.387        0.424          53.3        0.0
3. Fish at Fmsy          2105.6   5740.5      0.368       0.940      1.000            3.8      135.9
4. No fishing                 1.6 11323.4     0.000      1.853       0.000         104.8      -99.9
```

5. Reduce F 25%	1009.5	9109.5	0.117	1.491	0.318	64.8 -25.0
6. Increase F 25%	1479.9	7885.3	0.195	1.291	0.530	42.6 25.0
7. MSY advice rule	2105.6	5740.5	0.368	0.940	1.000	3.8 135.9

Full time series of forecasts are outlined in Table 6.5.3.1 and Figure 6.5.3.5

Table 6.5.5.1 Norway lobster in GSA 17-18. Short term forecasts of status quo and different fishing mortalities options

Forecast Scenario	Year	Fishing mortality (F)	Biomass (B)	Catch
Keep current catch	2020	0.16	5367	870
	2021	0.13	6271	842
	2022	0.12	7197	846
	2023	0.11	8029	844
	2024	0.10	8786	849
Keep current F	2020	0.17	5124	876
	2021	0.16	6109	954
	2022	0.16	7208	1125
	2023	0.16	8085	1262
	2024	0.16	8760	1368
Fish at Fmsy	2020	0.17	5124	876
	2021	0.37	5577	2054
	2022	0.37	5659	2084
	2023	0.37	5717	2106
	2024	0.37	5757	2120
No fishing	2020	0.17	5124	876
	2021	0.00	6544	1
	2022	0.00	8623	1
	2023	0.00	10460	2
	2024	0.00	11984	2
Reduce F25%	2020	0.17	5124	876
	2021	0.12	6214	728
	2022	0.12	7538	883
	2023	0.12	8622	1010
	2024	0.12	9471	1109
Increase F25%	2020	0.17	5124	876
	2021	0.20	6006	1172
	2022	0.20	6893	1345
	2023	0.20	7583	1480

As can be seen in the table 6.5.5.1 above, F in 2021 cannot be set independently of F in 2022 etc. In addition recruitment to the stock (or growth in the stock) has been observed to be low in recent years and SSB is still below Bpa. The EWG considers that this provides unrealistic expectations of growth in the stock in 2021 through to 2022. As in 2018, 2019 and 2020 the EWG has provided an alternative STF with no stock growth in 2021.

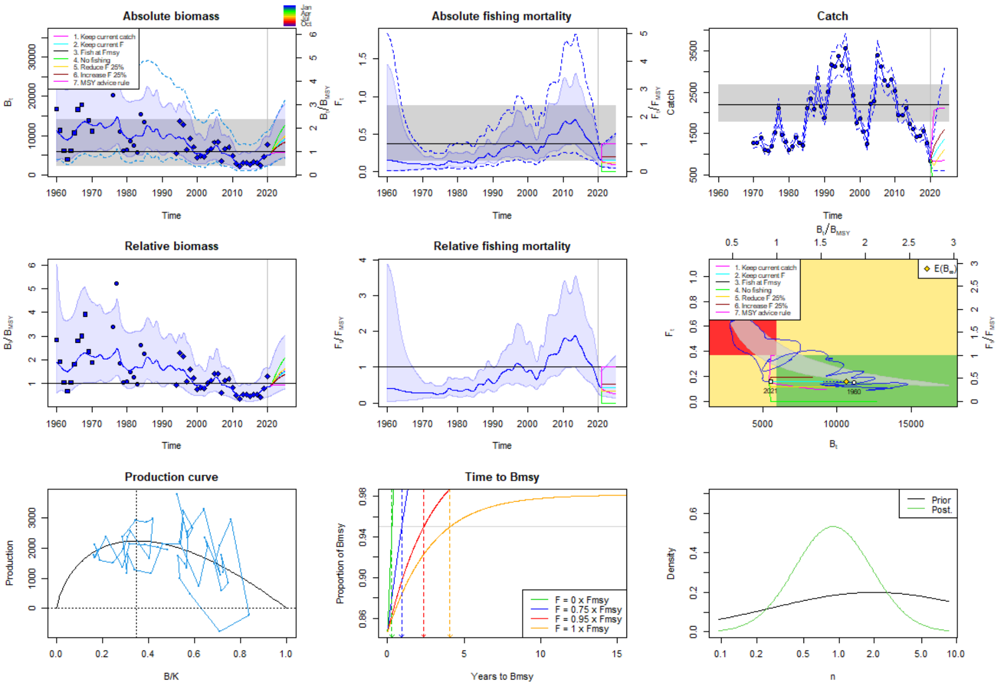


Figure 6.5.5.1 Norway lobster in GSA 17 and 18. Short term forecast for the period 2021-2024 according to different scenarios: keep current catch, keep current F, fishing at F_{MSY}, no fishing, reduce F by 25%, and increase F by 25%.

As can be seen in the table 6.5.5.1 above, in a SPiCT forecast, F in 2021 cannot be set independently of F in 2022 and subsequent years. In addition, recruitment to the stock (or growth in the stock) has been observed to increase in recent years and SSB, is now above Bpa, 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 6.5.3.5) and EWG considers that these 'average' conditions for stock growth may provide unrealistic expectations of growth in the stock in 2021 through to 2022. So in accordance with the procedure used in 2018, 2019 and 2020 the EWG has provided an alternative STF with no stock growth in 2021. This forecast which is shown in Table 6.5.5.2 is used for the catch options in Section 5.5.

Table 6.5.5.2 Norway lobster in GSA 17-18. Short term assuming no stock growth in 2022.

Catch 2020	869.6069
f (2019)	0.25
f current (HR 2020) = Catch2020/B 2020	0.162019
Fmsy from SPiCT Model (HR)	0.37
B 2020	5367.313
Bmsy From SPICT Model	5955.3
Blim = 40% Bmsy	2382.12
MSY Btrigger = Bpa = Blim*1.4	3334.968
HR 2020 (to check that F is HR in SPICT)	0.162019
F (HR) Transition from F current and FMSY	0.303066
Catch 2021/2022 at F=FMSY	1985.906
Catch at F transition	1626.649

Biomass status	0.901267

6.5.5.2 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 6.5.4.2) Using the same exploitation rates for all areas the catch options by sub area are provided n Table 6.5.4.2.2. 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 = 0.27 and 0.38 respectively Table 6.5.3.5.2.). 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 = 0.74 and 1.59 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 6.5.5.2.1.

Table 6.5.5.2.1 Nephrops in GSA 17-18 catch options by sub area.

	Total GSA 17-18	Ancona	GSA 18	Kvarner	Pomo/Jabuka Pit
B 2020	5367	189	393	948	3837
Fmsy from SPiCT Model (HR)	0.37	0.37	0.37	0.37	0.37
F (HR) Transition from F current and FMSY	0.30	0.30	0.30	0.30	0.30
Catch 2020/2021 at F=FMSY	1986	70	145	351	1420
Catch at F transition	1627	57	119	287	1163

6.5.6 DATA DEFICIENCIES

No data deficiencies reported

6.6 SPOTTAIL MANTIS SHRIMP IN GSA 17 AND 18

6.6.1 STOCK IDENTITY AND BIOLOGY

BIOLOGY

The spottail mantis shrimp (Squilla mantis) is found in the Mediterranean and in the adjacent eastern Atlantic Ocean, from the Gulf of Cadiz to Angola. It is found from sub littoral depths on sandy and muddy bottoms to around 150 m depth (Abelló et al., 2002). There is no clear distribution pattern by size and depth; however, juveniles are generally more abundant in waters shallower than 30 m depth (Abelló and Martín, 1993). In the Italian waters, it is found along the coasts of the peninsula, and is particularly abundant in the northern and central Adriatic Sea, where it ranks amongst the most relevant species exploited by commercial fisheries (Froglia, 2010).

The spottail mantis shrimp digs U-shaped burrows in which it hides during the day. It has therefore a preference for areas with suitable burrowing substrate, such as fine sand and sandy-muddy bottoms, especially where the influence of river sediment intakes is important (Froglia, 1996; Atkinson et al., 1997). In fact, it is very abundant on the continental shelves at the mouths of Ebro, Rhone, Po, and Nile rivers. In general, the species is very abundant in the western side of the Adriatic basin, while it is almost absent in the eastern side, where the sediment features are not as suitable for its borrowing behaviour. It is a strongly sedentary species and seasonal trends appearing in catch data are mostly due to its reproductive and burrowing behaviour, and recruitment pattern, than to temporal changes in its distribution (Maynou et al., 2004).

In the present assessment, the combined data coming from the two Adriatic GSAs (17 and 18) have been used. These include fisheries data from Italy (ITA), Slovenia (SVN), Croatia (HRV) and Albania (ALB) in GSA17 and Italy in GSA18. Montenegro is also fishing in GSA17 but no data were available from this country.

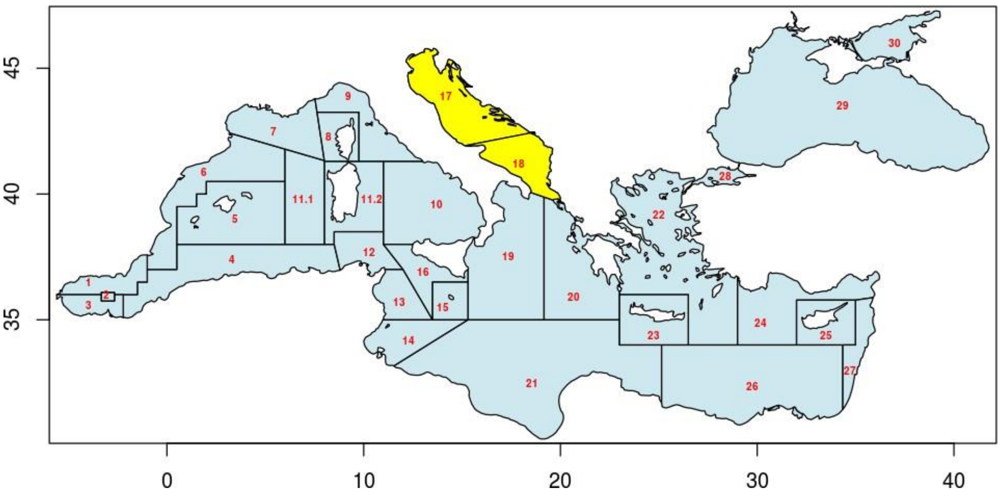


Figure 6.6.1.1 Geographical location of GSAs 17 and 18. Countries fishing in the area are Italy, Slovenia, Croatia, Albania and Montenegro.

GROWTH

Froglia et al. (1996) used an indirect method to study the growth of spottail mantis shrimp in GSA 17. The length frequency distributions for males and females recorded during experimental trawls carried out in the central area of the GSA 17 in 1994 and 1995 (Froglia et al., 1996) showed similar size ranges for both sexes. The largest specimens were collected in September 1994 (39 mm CL for males and females) and the smallest specimens were observed in November 1994 (5 mm CL for males and females). The last probably represent the new generation of spottail mantis shrimps whose larvae settled on the bottom in late summer and early autumn of the same year. The results of the study indicated that the growth rate is similar for males and females, both sexes reaching around 18 mm CL at the end of the first year of life and around 32 mm CL at the end of the third year. It seems that mantis shrimp individuals live up to five or six years of age.

The above experimental data have been used to derive the Von Bertalanffy (VBGF) parameters and length-weight relationships, which have been used in the previous assessment of spottail mantis shrimp (STECF 20-15) and are also adopted here. These are contained in Tables 6.6.1.1 and 6.6.1.2. The VBGF were used to perform age slicing in GSAs 17 ad 18 separately. The length-weight relationships were used to estimate weight by length, which was then transformed to weight by age through the VBGF by GSA.

Table 6.6.1.1 Spottail mantis shrimp in GSAs 17 & 18. Von Bertalanffy growth parameters per GSA (both sexes).

GSA	linf	k	t0
17	41.53	0.49	-0.0105
18	46.30	0.49	-0.2900

Table 6.6.1.2 Spottail mantis shrimp in GSAs 17 & 18. Parameters of the length weight relationship per GSA (both sexes).

GSA	a	b
17	0.00133	3.0450
18	0.00420	2.7197

Maturity

The life cycle of spottail mantis shrimp is well known: the spawning period is concentrated from winter to spring and planktonic larvae are found in summer, with the settlement of post-larvae occurring from the end of summer to mid-autumn. Recruitment to the fishery starts in late autumn, with full recruitment being reached between January and May (Maynou et al., 2004). In the central Adriatic (GSA 17), the peak of ovarian maturity occurs in February and March, when up to 80% of the females had ripe ovaries (Froglia, 1996). Spent females were mainly observed from April to September, when the sex ratio (M/F) is strongly in favour of males (Piccinetti and Piccinetti Manfrin, 1971; Froglia et al., 1996). According to

Abelló and Martín (1993) and Froglia (1996), settlement of post-larvae takes place at the end of summer and the beginning of autumn at 17-20 mm Total Length (TL), or 3-4 mm Carapace Length (CL). In GSA 18, the monthly percentage of female maturity stages shows that the reproductive period extends from October to June with a peak during the coldest months (winter-early spring). L50 (±s.e.) for GSA 18 is 21.1 mm (Carbonara et al., 2013).

For the assessment in GSAs 17 and 18 combined, the maturity at age was adopted from STECF 20-15. The vector of maturity at age is presented in Table 6.6.1.3.

Table 6.6.1.3 Spottail mantis shrimp in GSAs 17 and 18. Maturity by age.

age	0	1	2	3	4	5	6+
maturity	0.011	0.809	1	1	1	1	1

Natural Mortality

The vector of natural mortality was adopted from STECF 20-15 (see Table 6.6.1.4). This has been obtained from PRODBIOM model (Abella et al., 1998) using the growth parameters of Table 6.6.1.1.

Table 6.6.1.4 Spottail mantis shrimp in GSAs 17 and 18. Mortality by age.

age	0	1	2	3	4	5	6+
mortality	1.2	0.7	0.6	0.52	0.48	0.48	0.48

Fishery

Catches show marked dial periodicity with significantly more animals caught at night (Froglia and Giannini, 1989; Froglia and Gramitto, 1989). The burrowing behaviour of spottail mantis shrimp makes it vulnerable only when individuals are out of their burrows and this occurs mainly at night, between sunset and sunrise. Seasonal variations in catchability result from reduced out-of-burrow activity, because females rarely exit their burrow when they are incubating their egg mass in spring and early summer. Conversely, catches increases in winter, when mating takes place. Catches increase further in late autumn with the arrival of new recruits. The reproductive behaviour of the species also influences the relative proportion of males and females in the catches by season: females outnumber males only in winter (mating season), while the sex-ratio is biased towards males in spring and summer. Additionally, weather and sea conditions represent an important influence on the catchability of this species, as catches increase after prolonged bad weather conditions probably because of disturbance of the burrow systems as a result of the high turbidity (Froglia et al., 1996).

Although spottail mantis shrimp ranks first among the crustaceans landed in the Adriatic ports of GSA 17, it is not the target of a specialized fishery, but it is an important component of local multispecies trawl and gillnet fisheries. It is caught by 4 fisheries, namely DEMF, DEMSP, MDPSP and SPF within which 10 different fishing gears are being used. The main species caught in GSA 17 associated with mantis shrimp are Sepia officinalis, Trigla lucerna, Merluccius merluccius, Mullus barbatus and Eledone spp. As concerns artisanal fisheries, spottail mantis shrimp is a by catch (only in few cases it also targeted) of gillnetters targeting Solea solea, especially during spring-summer seasons in the coastal area. Only in the Gulf of Trieste it is the target of a directed fishery; a small artisanal fishery with creels (Froglia and Giannini, 1989).

Like in GSA 17, mantis shrimp in GSA 18 is mainly a by-catch of trawlers and to a much lesser extent by small scale fisheries using gillnets and trammel nets. Fishing grounds are located along the coasts of the whole GSA 18. The species is landed with other important commercial species such as Mullus spp., Pagellus sp., Eledone moschata, Octopus vulgaris., M. merluccius, etc. The exploitation of mantis shrimp is mainly by the bottom trawlers, both on the western and the eastern sides. The main bulk of the catches both in GSA 17 and GSA 18 comes from the Italian fleet.

6.6.2 DATA

6.6.2.1 CATCH (LANDINGS AND DISCARDS)

Landings and discards data for spottail mantis shrimp in GSAs 17 and 18 were retrieved from the DCF 2021 data call. The quality of the data was checked and the landings and discards length frequency distributions (LFDs) were reconstructed using the ad-hoc scripts supplied by JRC. In GSA18, landings and discards data by length were available from Italy (ITA) since 2006. In GSA17, LFDs were available from Italy since 2007 and from Slovenia (SVN) since 2005, while Croatia (HRV) provides total landings and discards by gear and year since 2012. Finally, total landings data from Albania (ALB) for the period 2017-2020 were made available to the EWG group of STECF 21-15 and were used in the assessment. In effect, the data from Croatia and Albania only add to the total catch and scale the LFDs during the SoP (sum of products) correction (see section 6.6.3.1).

Table 6.6.2.1.5 and Figure 6.6.2.1.1 present landings data by country and GSA. The majority of landings come from the Italian fleet from GSAs 17 and 18. The rest of the landings from Slovenia, Albania and Croatia comprise less than 2% of total landings. It is apparent that the landings’ trend is governed by the Italian fleet (see Figure 6.6.2.1.2). The landings show a generally declining trend since 2004, falling from around 5000t in 2004 to around 3000t in 2020. Discards are fluctuating between 500t and 1000t in the same period (Figure 6.6.2.1.2). Tables 6.6.2.1.6 and 6.6.2.1.7 show landings by country, gear and GSA for gears with “significant” landings (at least 0.1t for at least four years). OTB is the gear with most landings, followed by GNS, TBB and GTR. The length frequency distributions of landings by gear (for most important gears) are presented in Figures 6.6.2.1.3 and 6.6.2.1.4 for GSAs 17 and 18 respectively. Finally, Figure 6.6.2.1.5 shows the length frequency distribution of landings by year in both GSAs.

Table 6.6.2.1.5 Spottail mantis shrimp in GSAs 17 & 18. Landings data in tonnes by GSA and country.

	GSA 17					GSA 18	
	ALB	**HRV**	**ITA**	**SVN**	**Total**	**ITA**	**Total**
2004						2587.13	**2587.13**
2005				4.56	**4.56**	1298.85	**1298.85**
2006				2.42	**2.42**	1271.69	**1271.69**
2007			3905.00	7.25	**3912.25**	1258.46	**1258.46**
2008			3999.00	6.23	**4005.23**	916.82	**916.82**
2009			4529.00	3.63	**4532.63**	892.37	**892.37**
2010			4564.00	4.99	**4568.99**	454.05	**454.05**
2011			3786.00	3.59	**3789.59**	352.27	**352.27**
2012		2.12	3105.00	0.73	**3107.85**	631.68	**631.68**
2013		2.30	2127.00	0.30	**2129.60**	2195.94	**2195.94**
2014		4.45	2806.00	0.48	**2810.93**	1003.89	**1003.89**
2015		7.41	3064.00	0.76	**3072.17**	1010.75	**1010.75**
2016		11.21	3143.00	1.80	**3156.00**	929.16	**929.16**
2017	101.00	12.58	3076.00	1.18	**3190.75**	600.12	**600.12**
2018	116.00	13.17	3169.00	0.98	**3299.15**	774.65	**774.65**
2019	123.00	7.27	2577.00	1.27	**2708.54**	692.02	**692.02**
2020	125.00	7.04	2370.17	2.52	**2504.73**	572.79	**572.79**

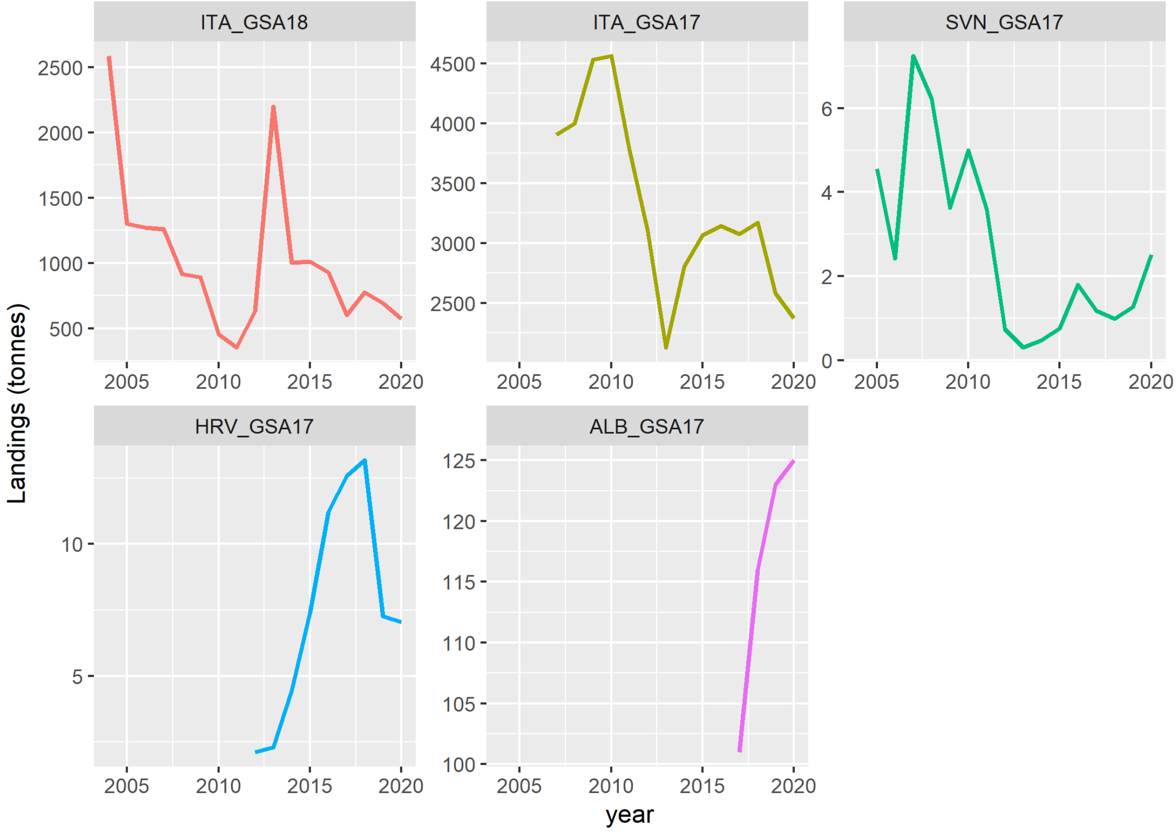


Figure 6.6.2.1.1. Spottail mantis shrimp in GSAs 17 & 18. Landings trend in tonnes by GSA and country from 2004 to 2020.

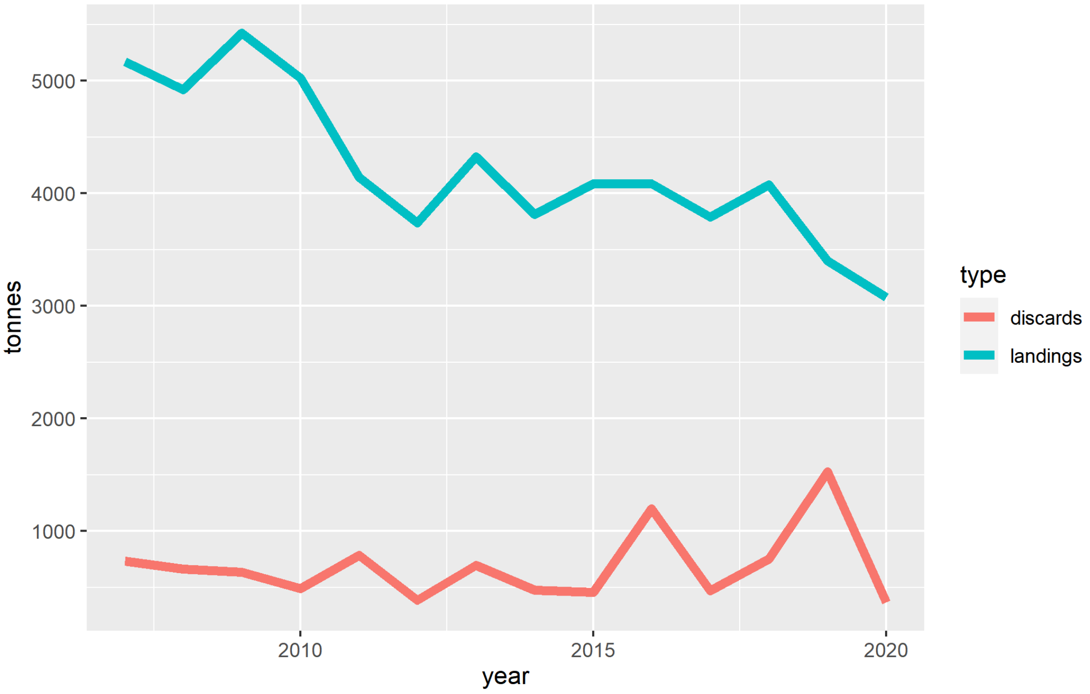


Figure 6.6.2.1.2 Spottail mantis shrimp in GSAs 17 & 18. Total landings and discards in tonnes for GSA's 17 & 18 combined.

Table 6.6.2.1.6 Spottail mantis shrimp in GSA 17. Landings in tonnes by country and gear. Only gears with important landings are shown (i.e. landings of the order of 0.1 tonnes for at least four year).

	GSA 17							
	ITA				**SVN**			
	GNS	**GTR**	**OTB**	**TBB**	**FPO**	**GNS**	**GTR**	**OTB**
2005					0.7	0.2	0.5	3.2
2006					0.4	0.2	0.3	1.5
2007	936.0		2969.0		0.3	0.4	0.5	6.1
2008	831.0		2859.0	309.0	0.4	0.9	1.2	3.7
2009	872.0		3167.0	490.0	0.3	0.5	0.6	2.2
2010	961.0		3163.0	440.0	0.4	0.3	1.0	3.2
2011	1136.0		2399.0	251.0	0.8	0.2	0.4	2.2
2012	1141.0		1681.0	283.0	0.1	0.1	0.2	0.4
2013	205.0		1682.0	240.0	0.0	<0.1	0.1	0.1
2014	296.0		2326.0	184.0	0.0	<0.1	0.1	0.3
2015	325.0		2477.0	262.0	0.0	<0.1	0.1	0.6
2016	408.0	9.0	2531.0	195.0	0.0	<0.1	0.1	1.7
2017	318.0	124.0	2458.0	176.0	0.1	0.1	0.4	0.6
2018	245.0		2723.0	199.0	0.1	<0.1	0.3	0.6
2019	242.0	121.0	1933.0	233.0	0.1	0.1	0.3	0.8
2020	157.7	71.3	1838.3	168.0	0.0	0.1	0.3	2.2

	HRV				
	DRB	**FPO**	**GNS**	**GTR**	**OTB**
2012	0.0	0.1	<0.1	0.1	1.9
2013	<0.1	0.1	<0.1	<0.1	2.1
2014	<0.1	0.0	<0.1	0.1	4.3
2015	0.5	0.0	0.1	0.3	6.6
2016	0.4	0.0	0.1	0.3	10.4
2017	0.5	0.0	<0.1	0.4	11.6
2018	0.3	0.0	0.1	0.8	11.9

2019	0.5	0.1	0.1	0.2	6.3
2020	0.2	0.0	0.1	0.3	6.5

Table 6.6.2.1.7 Spottail mantis shrimp in GSA 18. Landings in tonnes by country and gear. Only gears with important landings are shown (i.e. landings of the order of 0.1 tonnes for at least four year).

GSA 18			
ITA			
	GNS	**GTR**	**OTB**
2004	140.9	5.1	2437.7
2005	106.7	12.3	1169.7
2006	160.9	25.8	1076.0
2007	87.9	12.6	1157.9
2008	51.9	31.0	833.9
2009	54.1	18.1	820.1
2010	19.1	19.2	415.8
2011	44.3	19.4	288.6
2012	16.9	19.9	594.8
2013	45.0		2151.0
2014	0.5	4.3	999.2
2015	5.8	11.6	993.4
2016	16.2	36.1	876.8
2017	0.9	74.5	524.7
2018	108.8	0.0	665.8
2019	95.0	5.0	591.9
2020	168.5	1.0	403.3

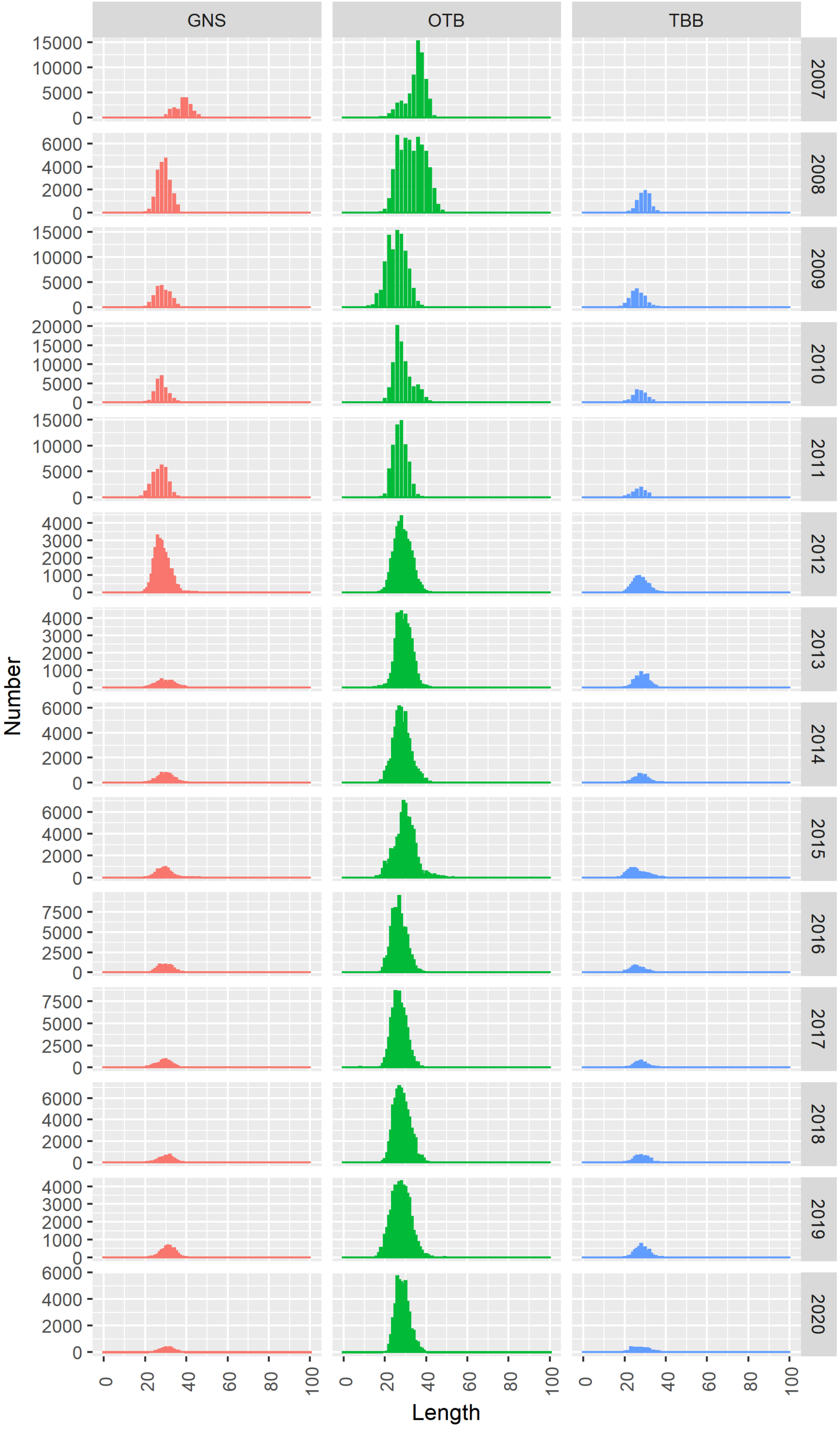


Figure 6.6.2.1.3 Spottail mantis shrimp in GSA 17. Length structure by year and gear. Italy and Slovenia length distributions combined. Only gears with significant landings are shown.

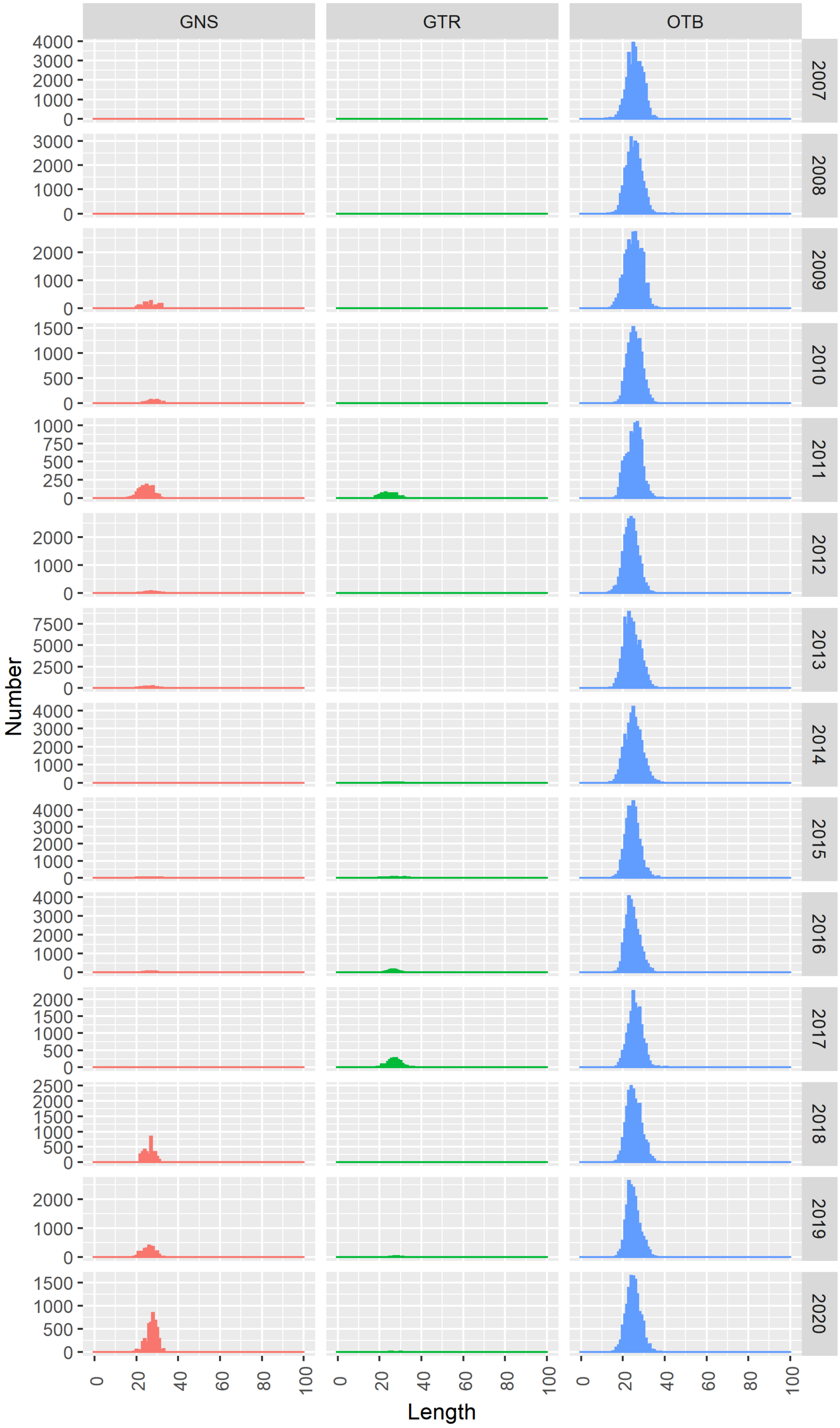


Figure 6.6.2.1.4 Spottail mantis shrimp in GSA 18. Length structure by year and gear for gears with significant landings.

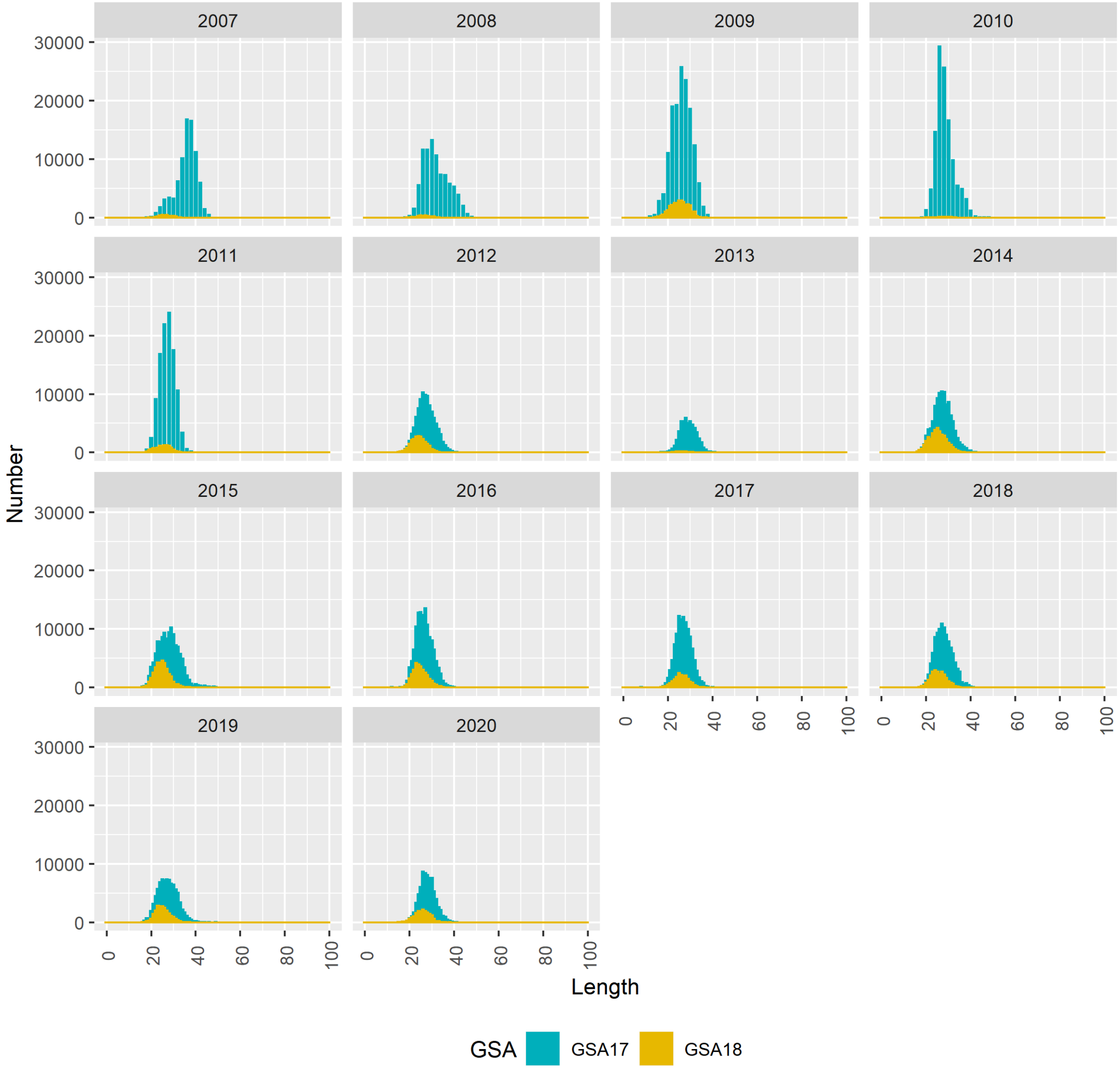


Figure 6.6.2.1.5 Spottail mantis shrimp in GSAs 17 & 18. Length structure of landings by year. GSA17 length distribution (blue) is stacked on top of GSA18 length distribution so that the full height of the bars represents the length distribution in GSA's 17 and 18 combined.

DISCARDS

Discards data were available in the DCF database. As with landings, the bulk of discards come from the Italian fleets in GSAs 17 and 18. Tables 6.6.2.1.8 and 6.6.2.1.9 show discards by year, country and GSA and by year, country, GSA and gear for gears with significant discards (i.e. of more than 0.1t for at least three years). The trend of discards by country and GSA is presented in Figure 6.6.2.1.6. Figure 6.6.2.1.7 shows the length frequency distribution of discards in GSAs 17 and 18 combined.

Table 6.6.2.1.8 Spottail mantis shrimp in GSAs 17 and 18. Discards data in tonnes by GSA and country.

	GSA 17				GSA 18	
	HRV	**ITA**	**SVN**	**Total**	**ITA**	**Total**
2004					297.3	**297.3**
2005			0.4	**0.4**	138.1	**138.1**
2006			0.1	**0.1**	137.0	**137.0**
2007		487.6	0.9	**488.5**	247.0	**247.0**
2008		485.0	0.5	**485.5**	177.5	**177.5**
2009		544.6	0.3	**544.9**	92.9	**92.9**
2010		398.0	0.4	**398.4**	93.9	**93.9**
2011		722.0	0.3	**722.3**	62.0	**62.0**
2012	<0.1	118.2	0.0	**118.2**	269.6	**269.6**
2013	<0.1	270.2	0.0	**270.2**	426.4	**426.4**
2014	0.0	398.3	0.0	**398.3**	78.7	**78.7**
2015	0.0	335.3	0.1	**335.3**	119.7	**119.7**
2016	<0.1	1052.2	0.1	**1052.3**	145.1	**145.1**
2017	<0.1	447.3	0.1	**447.4**	25.4	**25.4**
2018	0.2	523.2	0.1	**523.5**	231.4	**231.4**
2019	0.1	1328.7	0.1	**1328.8**	199.4	**199.4**
2020	<0.1	325.4	0.2	**325.6**	41.6	**41.6**

Table 6.6.2.1.9 Spottail mantis shrimp in GSAs 17 and 18. Discards data in tonnes by country and year. Only gears with important discards are shown (i.e. discards of the order of 0.1 tonnes for at least three year).

	GSA 17			**GSA 18**	
	ITA		**SVN**	**ITA**	
	OTB	**TBB**	**OTB**	**GNS**	**OTB**
2005			0.4		
2006			0.1		
2007			0.9		
2008			0.5		
2009			0.3	0.0	90.9
2010	375.0	0.0	0.4	0.0	93.2
2011	705.0	16.0	0.3	1.2	60.8
2012	103.0	0.0	<0.1	0.6	268.7
2013	258.0	0.0	<0.1	2.9	423.5
2014	394.0	4.0	<0.1	0.0	78.7
2015	324.0	11.0	0.1	0.0	119.5
2016	1042.0	0.0	0.1	0.0	144.4
2017	403.0	44.0	0.1	0.0	25.4
2018	513.0	10.0	0.1	0.0	227.3
2019	489.0	4.0	0.1	0.0	195.8
2020	323.5	1.5	0.2	0.0	35.2

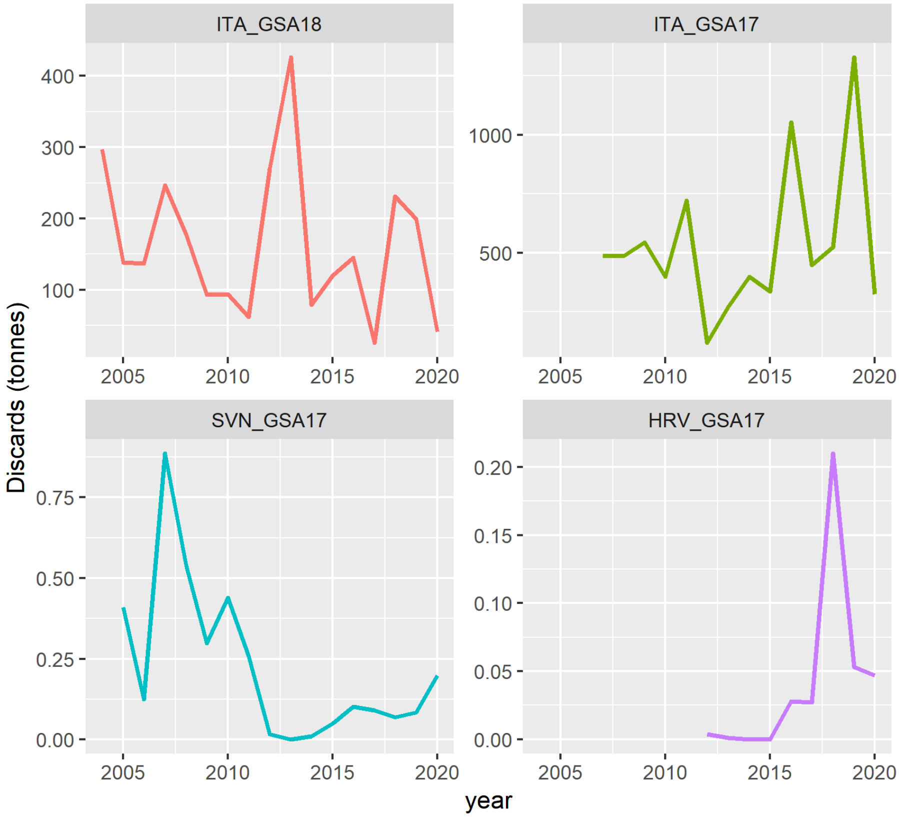


Figure 6.6.2.1.6 Spottail mantis shrimp in GSAs 17 and 18. Discards data in tonnes by country.

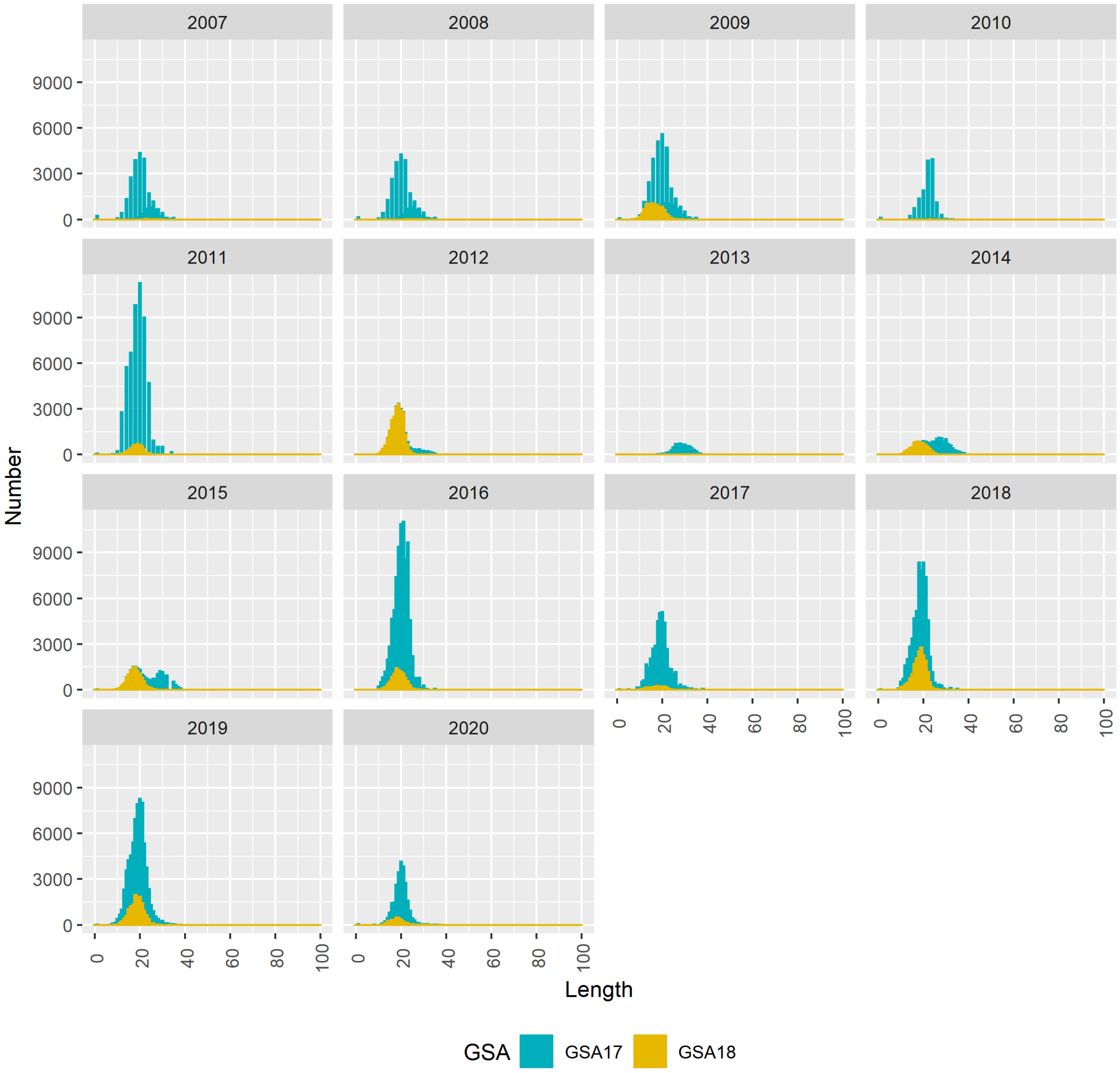


Figure 6.6.2.1.7 Spottail mantis shrimp in GSAs 17 and 18. Discards length structure for GSA 17 and 18 by year. GSA17 length distribution (blue) is stacked on top of GSA18 length distribution so that the full height of the bars represents the discards length distribution in GSA's 17 and 18 combined.

6.6.2.3 EFFORT

Table 6.6.2.3.1. Effort in fishing days by year by country and gear for main gears fishing MTS species. Effort from Italy (ITA) regards both GSAs 17 and 18, except from TBB operating only in GSA 18.

year	**GNS**			**GTR**			**OTB**			**TBB**
	HRV	ITA	SVN	HRV	ITA	SVN	HRV	ITA	SVN	ITA (GSA17)
2005		162073			43309	1313		198883	831	15302
2006		151703			46069	1263		188218	963	11717
2007		121526			43602	1969		164475	1202	15424
2008		112676			55473	2184		156340	1254	20276
2009		146323			51017	2332		176894	1205	13394
2010		129160			64821	2388		155983	1263	13649
2011		144020			67917	3080		147841	1178	12392
2012	47610	124110		27363	63573	3025	35572	133247	917	8759
2013	43354	130490		29234	29909	3811	35492	135813	766	10301
2014	47746	99795	3568	24738	47756	5346	36346	116177	665	10814
2015	48388	101502	3893	26047	28692	5230	34941	113299	670	9937
2016	46256	103659	3861	23003	29800	4058	33968	115892	777	9004
2017	48408	60977	3727	23147	42158	3453	35749	125597	697	9352
2018	60346	77607	3070	26273	55393	3046	33104	136031	692	11848
2019	91084	75896	2594	29349	50957	2972	30997	116083	769	10989
2020	91909	65093	2367	34150	41377	2868	31916	96136	879	7602

6.6.2.4 SURVEY DATA

SoleMon survey

Sixteen rapido trawl fishing surveys were carried out in GSA 17 from 2005 to 2018: two systematic "pre - surveys" (spring and fall 2005) and fourteen random surveys (spring and fall 2006, fall 2007-2018) stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). Hauls were carried out by day using 2- 4 rapido trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83). Abundance and biomass indexes from rapido trawl surveys were computed using ATrIS software (Gramolini *et al*., 2005), which also allowed drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles. Underestimation of small specimens in catches due to gear selectivity was corrected using the selective parameters given by Ferretti and Froglia (1975).

More details on the methodology of estimating the biomass and abundance index of SoleMon survey can be found in STECF EWG 20-15 report (STECF, 2020).

In STEC 21-15 EWG the SoleMon survey data were provided for years 2019 and 2020. The index at length for these years were retrieved using the ad-hoc JRC script (Mannini, 2020) and were age sliced using the same growth parameters as for the landings data (Table 6.6.1.1). For previous years (2011- 2018), the index at age was retrieved directly from the a4a index object of the previous assessment of the spottail mantis shrimp by STECF EWG 20-15. Figure 6.6.2.3.1. displays the stratified abundance indices by age obtained in GSA 17 from 2011 to 2020. Figure 6.6.2.3.2 displays the structure of the index by age.

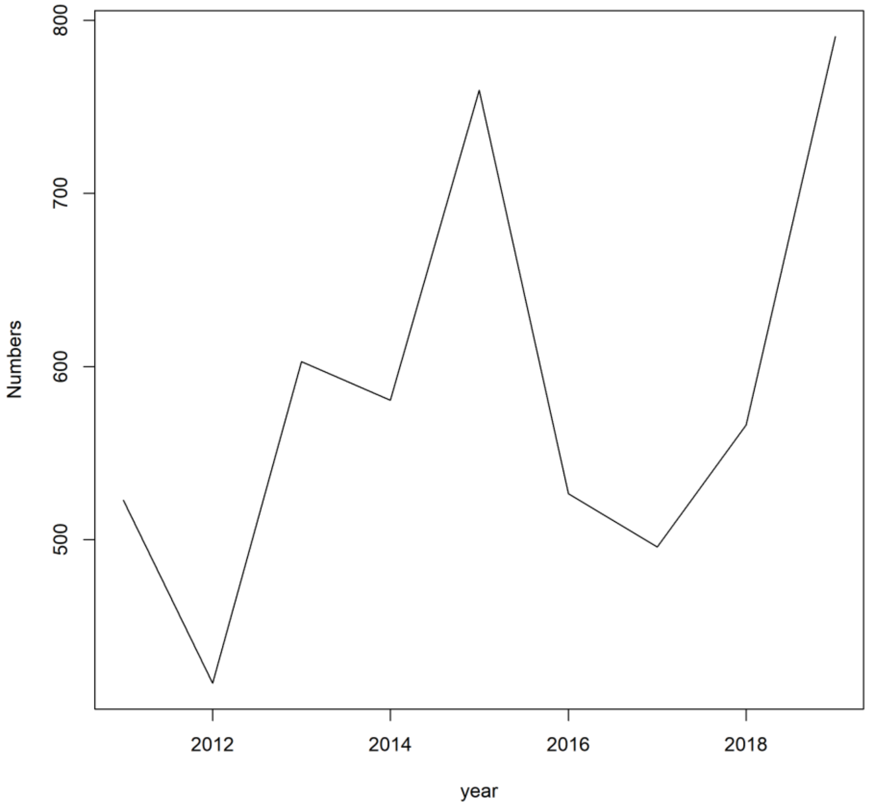


Figure 6.6.2.3.1 Spottail mantis shrimp in GSAs 17 & 18. Abundance by km^2 for SoleMon survey (GSA17) for the years 2011 – 2020.

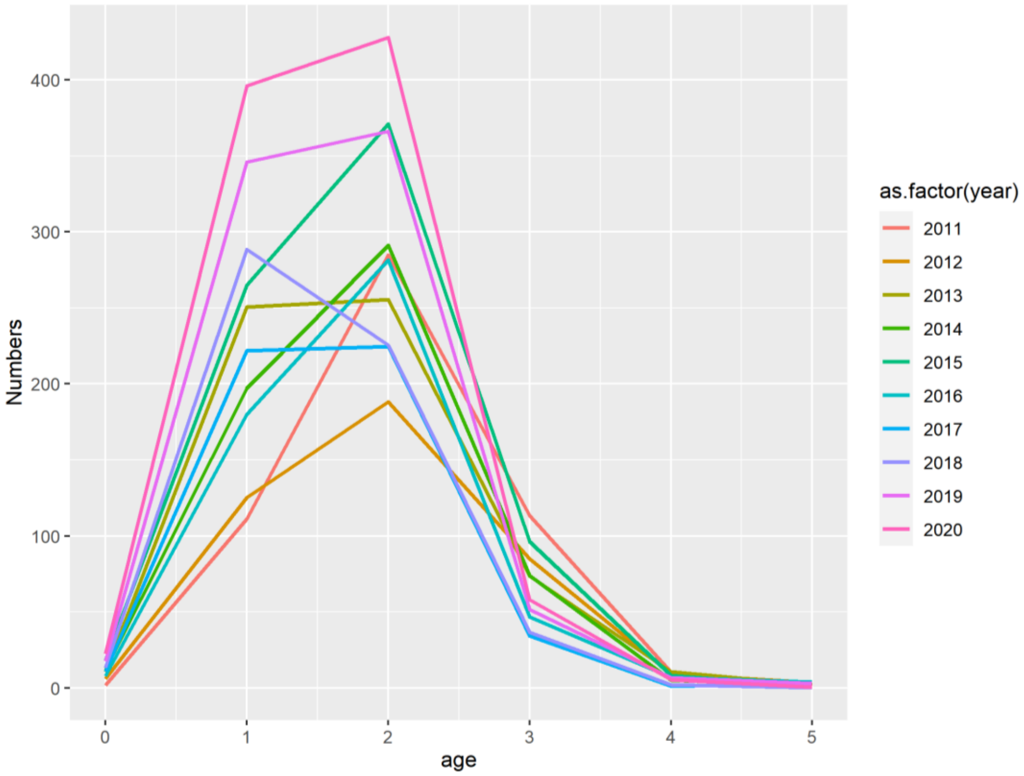


Figure 6.6.2.3.2 Spottail mantis shrimp in GSAs 17 and 18. Age structure of SOLEMON survey for years 2011 – 2019.

MEDITS survey

Medits survey is carried out in GSAs 17 and 18 since 1994. Although the targets of the survey are demersal species, Spottail mantis shrimp is scarcely caught. This is because the species spends most of its time in borrows during the daylight hours when the survey takes place. In GSA 17, the number of specimens measured in 2009, 2010, 2011 and 2013 was really low mainly due to the paucity of individuals in the catches.

Following the previous assessment (STECF 20-15), MEDITS survey index was used as a biomass index along with the age-structured SoleMon index. This was estimated from DCF 2021 data call for GSAs 17 and 18 combined, using the ad-hoc JRC script (Mannini, 2020).

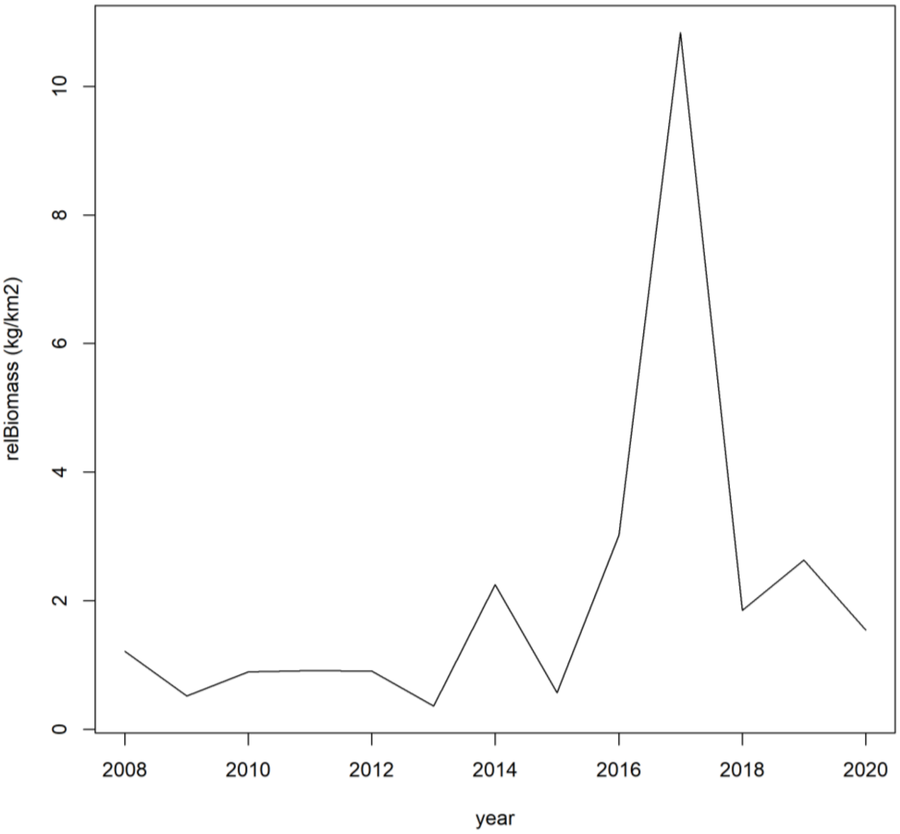


Figure 6.6.3.1.3 Spottail mantis shrimp in GSAs 17 & 18. MEDITS biomass index in GSAs 17 and 18 combined.

6.5.1 STOCK ASSESSMENT

The EWG 21-15 decided to perform an update assessment of spottail mantis shrimp in GSAs 17 and 18 combined. For this, Von Bertallanfy (VBGF) growth parameters, length-weight relationships, natural mortality and maturity were adopted from STECF 20-15 assessment. The length distributions of landings and discards (LFDs) were translated to

age distributions per country and GSA (ITA in GSA18, ITA in GSA17 and SVN in GSA17) using the corresponding VBGF relationship of Table 6.6.1.1. The analysis was performed by sex combined, as growth is very similar between the two sexes. The resulting age distributions were added to obtain the length frequency distributions of landings and discards in GSAs 17 and 18 combined. The total landings, discards and catch were obtained by adding the data from both GSAs and all countries (ITA in GSAs 18 and 17, and SVN, ALB and HRV in GSA 17). The mean-weight by age and year was estimated by dividing the total weight of each age class by the total number of individuals of the class. Finally, the catch at age distribution was re-scaled to sum up to the total catch using SoP correction. The above were performed with the ad-hoc scripts provided from JRC.
The assessment was performed over the period 2008-2019. Although data exist since 2004, these do not include Italian landings and LFDs from GSA17, which comprise the majority of landings in the rest of the years (after 2007). Following STECF 20-15, fbar was estimated as the average fishing mortality of ages 1-3, as the catches are composed mainly of individuals of age between 1 and 3 years.

6.6.3 STOCK ASSESSMENT

A4A ASSESSMENT INPUT DATA FOR GSA 17 AND 18

SoP correction was applied to catch numbers at age. Table 6.6.3.1.1 presents the SoP correction factor applied by year. The SoleMon trawl survey was used as tuning index of abundance in the assessment together with the aggregated Medits biomass index.
The assessment was performed with a4a statistical catch at age framework developed by the Joint Research Centre (Jardim *et al*., 2015).

Table 6.6.3.1.1 Spottail mantis shrimp GSA 17 and 18. Vector of Sum of Products correction applied to the catch distributions prior to assessment for years 2008 to 2020.

year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	
SoP	1.04	1.11	1.17	1.07	1.03	2.06	
year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
SoP	1.01	0.88	0.96	0.99	0.99	1.17	1.06

Tables 6.6.3.1.2 to 6.6.3.1.5 contain input data of the assessment of spottail mantis shrimp: total catch, catch at age, mean weight at age, maturity and natural mortality vectors and SoleMon index catch numbers at age. Figures 6.6.3.1.1 and 6.6.3.1.2 show the age distributions of the catch and the SoleMon index by year. The mean weight by age of the catch by year is shown in Figure 6.6.3.1.3.

Table 6.6.3.1.2 Spottail mantis shrimp GSA 17 & 18. Total catch in tonnes.

year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	
data	5906.2	5585.1	6062.9	5515.3	4926.1	4127.4	
year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
data	4291.8	4537.9	5282.6	4263.7	4828.7	4928.8	3444.7

Table 6.6.3.1.3 Spottail mantis shrimp GSA 17 & 18. Catch numbers at age in thousands.

age	2008	2009	2010	2011	2012	2013	
0	2186	19857	531	15993	27362	267	
1	28790	103435	39345	80634	40874	21298	
2	40880	74578	85396	67599	47072	72550	
3	18987	19413	17951	15050	14465	27457	
4	7545	1964	5751	671	2059	3172	
5	6093	524	3767	172	526	508	
6+	12482	0	1784	0	598	877	
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
0	13715	13911	18600	9624	26947	28961	6330
1	47182	45028	120090	74741	75834	95258	47857
2	48924	42108	51166	53845	46745	41868	40833
3	13130	18847	10114	9616	14943	14031	9974
4	2516	3272	988	964	1463	2133	1493
5	841	692	252	205	710	540	363
6+	795	2327	176	79	598	828	201

Table 6.6.3.1.4 Spottail mantis shrimp GSA 17 and 18. Catch mean weight at age in kg.

age	2008	2009	2010	2011	2012	2013	
0	0.004	0.012	0.005	0.008	0.014	0.012	
1	0.021	0.020	0.020	0.020	0.024	0.022	
2	0.035	0.034	0.033	0.034	0.036	0.036	
3	0.055	0.054	0.055	0.054	0.057	0.057	
4	0.073	0.073	0.073	0.073	0.075	0.075	
5	0.086	0.086	0.086	0.086	0.086	0.086	
6+	0.115	0.100	0.107	0.100	0.105	0.099	
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
0	0.014	0.015	0.011	0.006	0.011	0.010	0.012
1	0.026	0.024	0.021	0.022	0.023	0.021	0.024
2	0.037	0.038	0.035	0.036	0.036	0.037	0.036
3	0.057	0.058	0.056	0.056	0.057	0.056	0.056
4	0.076	0.075	0.075	0.074	0.075	0.075	0.075
5	0.086	0.086	0.086	0.086	0.086	0.086	0.086

6+	0.100	0.123	0.102	0.112	0.097	0.105	0.095

Table 6.6.3.1.5 Spottail mantis shrimp in GSA 17 and 18. Maturity, natural mortality, proportion of m and f before spawning.

age	1	2	3	4	5	6+
Natural mortality	1.505	0.773	0.604	0.520	0.480	0.480
Maturity	0.014	0.824	1.000	1.000	1.000	1.000
Harvest before spawn	0	0	0	0	0	0
Maturity before spawn	0	0	0	0	0	0

Table 6.6.3.1.6 Spottail mantis shrimp in GSA 17 and 18. SoleMon numbers per km^2 at age.

age	2011	2012	2013	2014	2015
0	1.81	5.97	10.69	11.79	18.17
1	111.32	125.11	250.63	196.99	264.81
2	284.76	188.2	255.42	291.07	371.03
3	113.21	84.9	73.47	73.78	96.21
4	10.17	9.04	10.66	5.01	8.19
5	1.48	3.64	2.00	1.87	1.26
age	**2016**	**2017**	**2018**	**2019**	**2020**
0	7.80	10.84	13.27	17.64918	22.58
1	179.90	221.84	288.38	346.0557	396.18
2	281.49	224.51	225.60	365.9782	427.96
3	46.71	34.29	36.66	51.4534	57.85
4	6.84	1.24	2.17	6.75573	5.28
5	3.87	3.09	0.20	2.89141	0.65

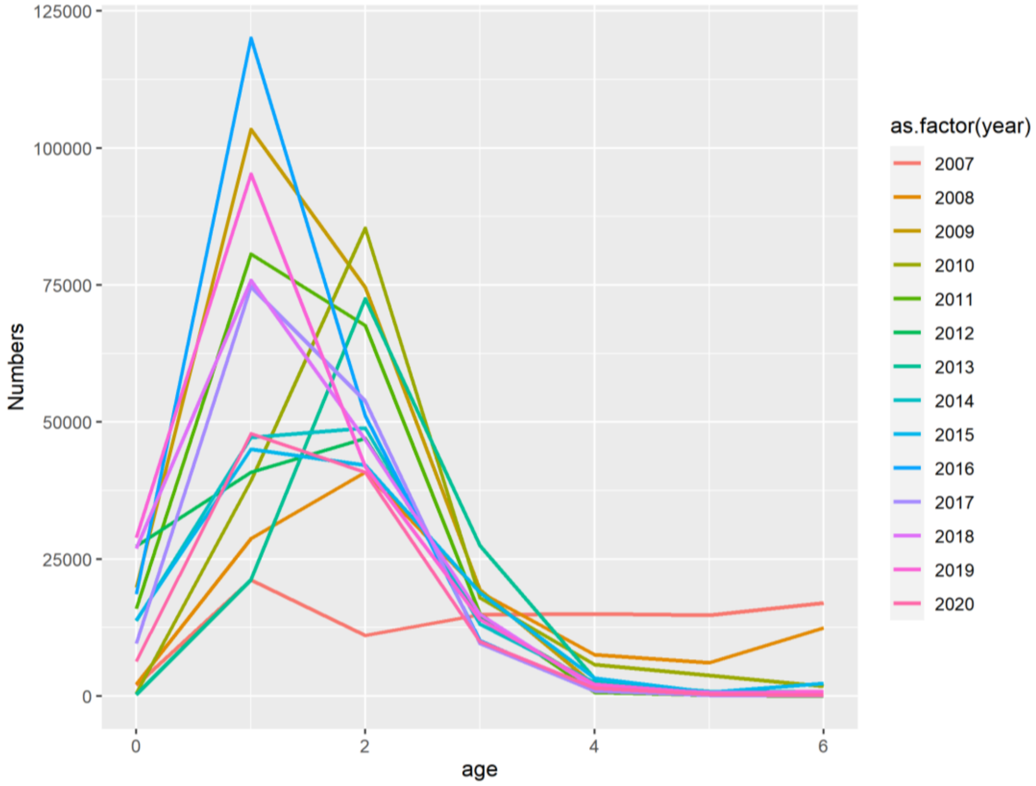


Figure 6.6.3.1.1 Spottail mantis shrimp in GSAs 17 & 18. Catch numbers in thousands at age.

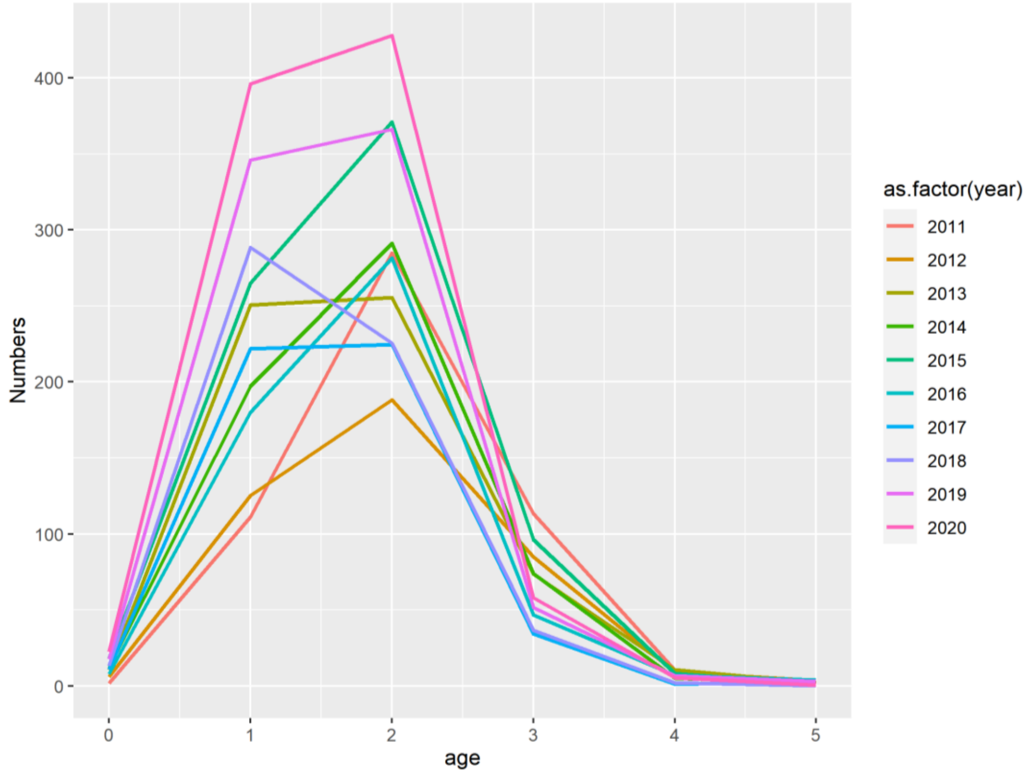


Figure 6.6.3.1.2 Spottail mantis shrimp in GSAs 17 and 18. SoleMon tuning index numbers at age.

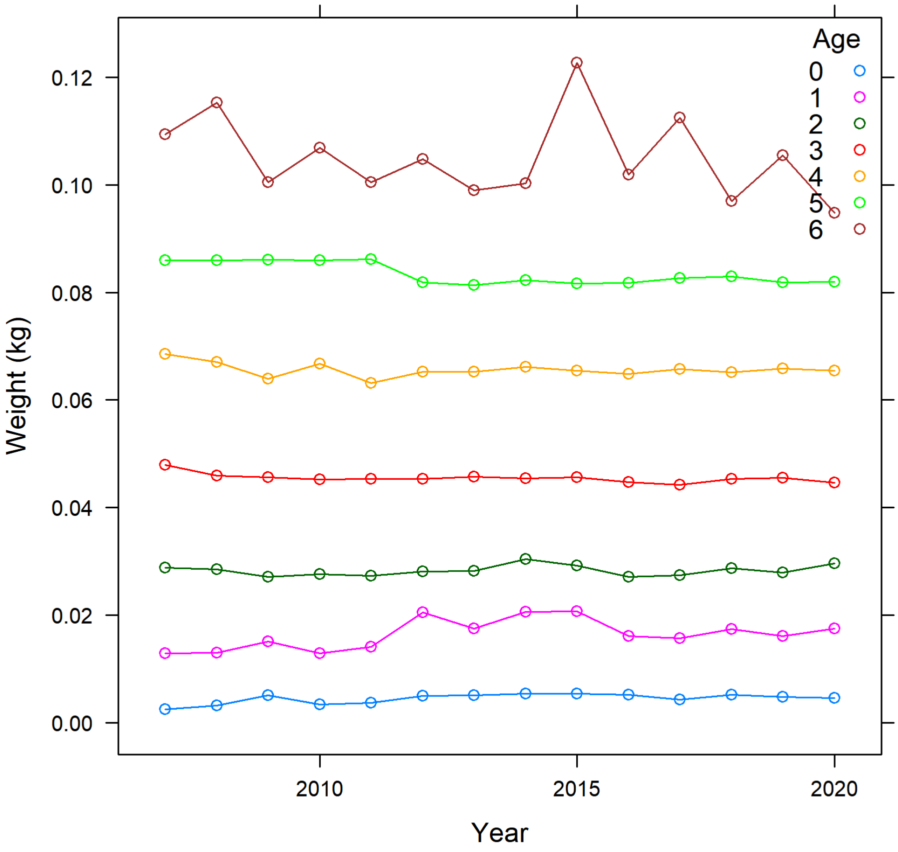


Figure 6.6.3.1.3 Spottail mantis shrimp in GSAs 17 & 18. Mean weight at age.

A4A ASSESSMENT RESULTS FOR GSA 17 AND 18

The final a4a model settings adopted were the same as those of the previous spottail mantis shrimp assessment performed in STECF 20-15. In this, the fishing mortality was assumed to be a factor of age (constant after age 4) and a 6th order spline of year. Catchability was assumed to be a factor of age (constant after age 4) and stock recruitment a factor of year. In particular,

```
fmodel4   <- ~ factor(replace(age, age>4,4))+s(year, k=6)
qmodel2  <- list(~ factor(replace(age, age>4,4)),~1)
srmodel1 <- factor(year)
```

The results of the assessment are presented in Figures 6.6.3.1.4 to 6.6.3.1.6. Estimated recruits, spawning stock biomass, catch and harvest rates for ages 1 – 3 are shown in Figure 6.6.3.1.4. Fishing mortality by age and year and catchability of the gear of the SoleMon survey tuning index by age and year are shown in Figures 6.6.3.1.5 and 6.6.3.1.6 respectively.

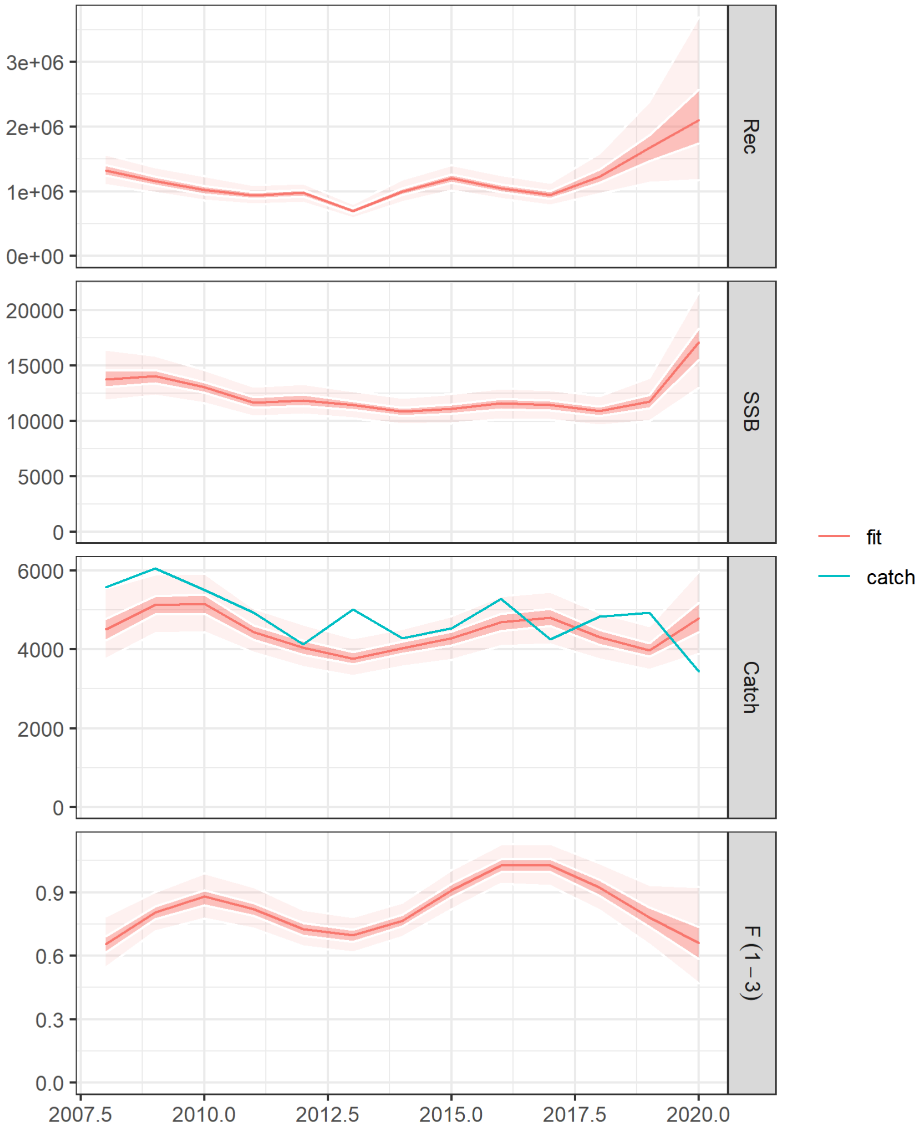


Figure 6.6.3.1.4 Spottail mantis shrimp in GSAs 17 and 18. Stock summary of the a4a model for Spottail mantis shrimp in GSAs 17 and 18 combined. Evolution of recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3) in the period 2008 to 2020.

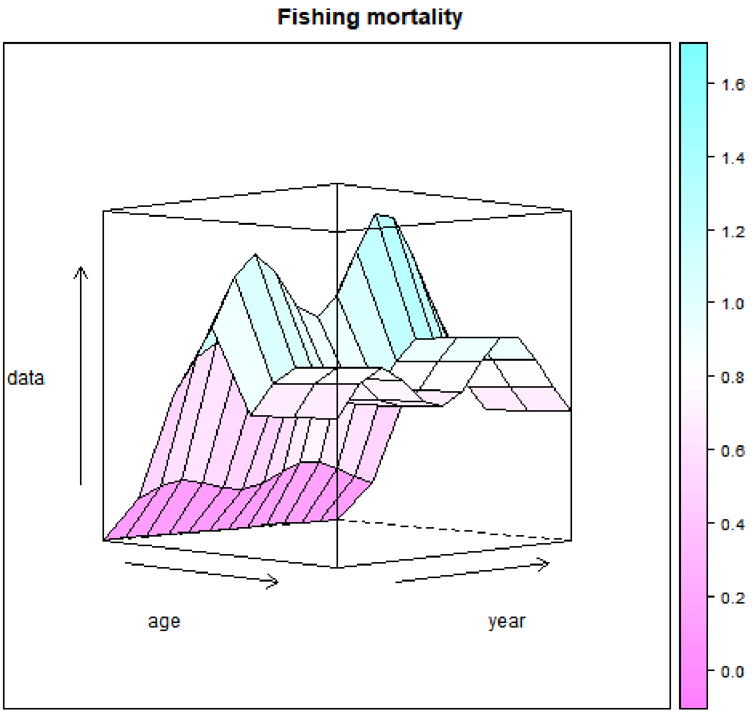


Figure 6.6.3.1.5 Spottail mantis shrimp in GSAs 17 and 18. 3D contour plot of estimated fishing mortality by age and year.

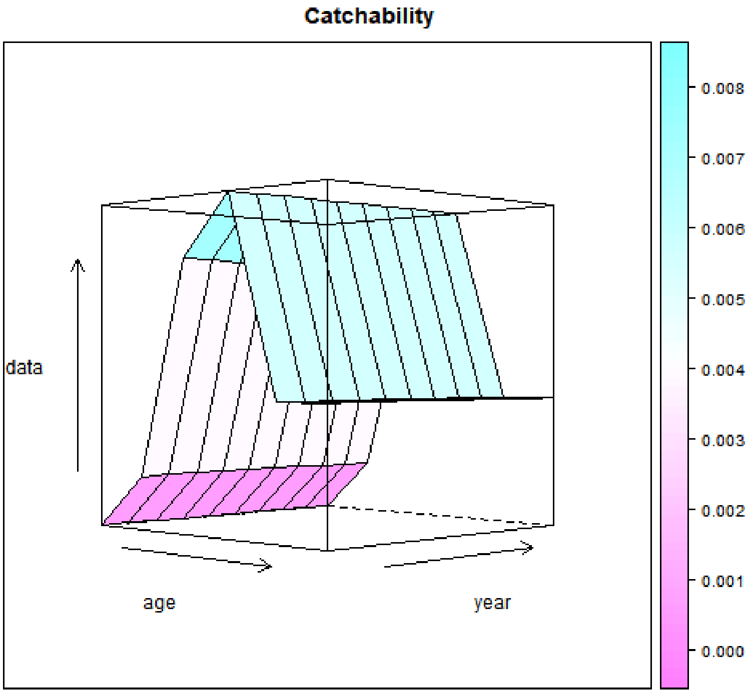


Figure 6.6.3.1.6 Spottail mantis shrimp in GSAs 17 and 18. 3D contour plot of estimated catchability of the SoLeMon tuning index by age and year.

Diagnostics

Diagnostic plots for the goodness of fit of the selected model for the assessment of Spottail mantis shrimp stock are presented in Figures 6.6.3.1.7 -6.6.3.1.11. Residuals of the total catch were evenly distributed around zero (Figure 6.6.3.1.7). Residuals at age in the catch and the survey do not show any particular patterns (Figures 6.6.3.1.8 and 6.6.3.1.9). Fitted versus observed catch at age and SoleMon index at age show a fairly good fit of the model to the data (Figure 6.6.3.1.10 and 6.6.3.1.11).

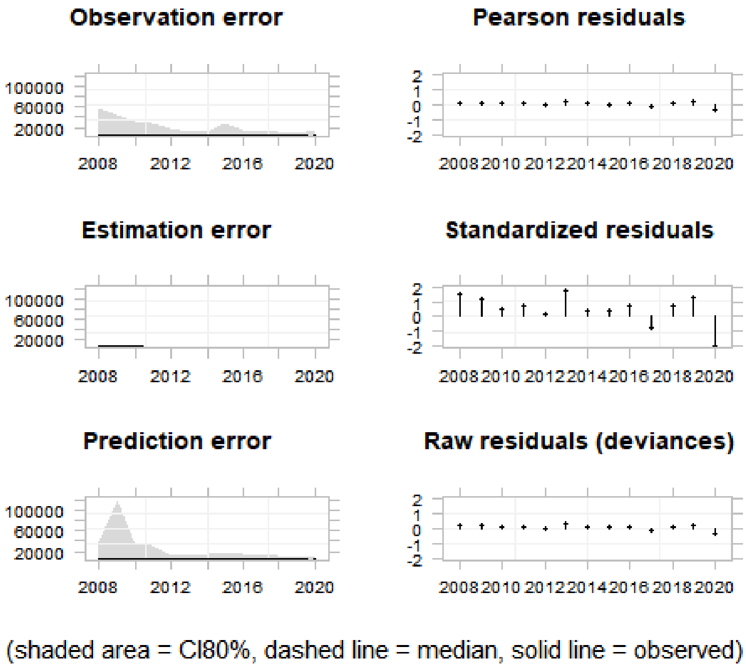


Figure 6.6.3.1.7 Spottail mantis shrimp in GSAs 17 and 18. Aggregated catch diagnostics.

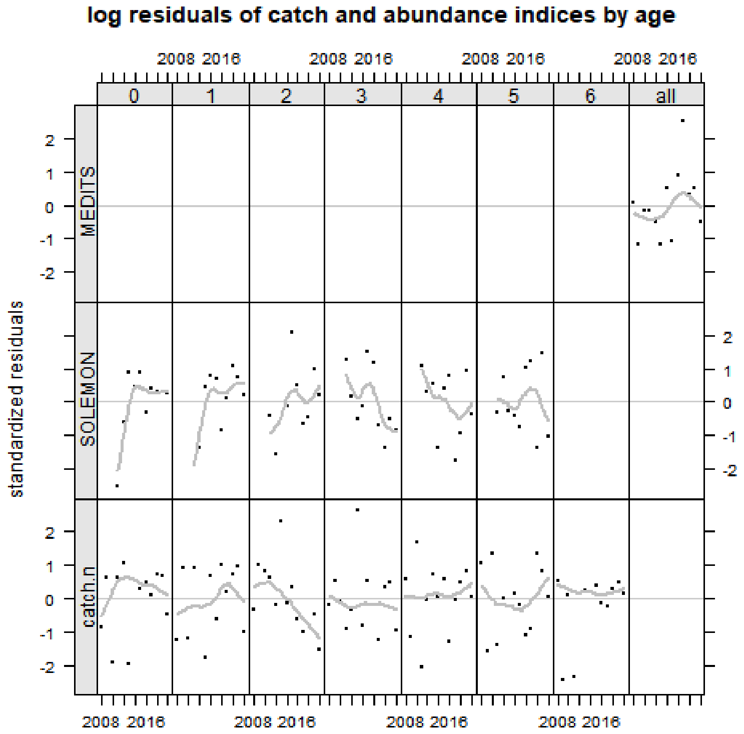


Figure 6.6.3.1.8 Spottail mantis shrimp in GSAs 17 and 18. Standardized log residuals for the fitted model for catch numbers at age and index abundances.

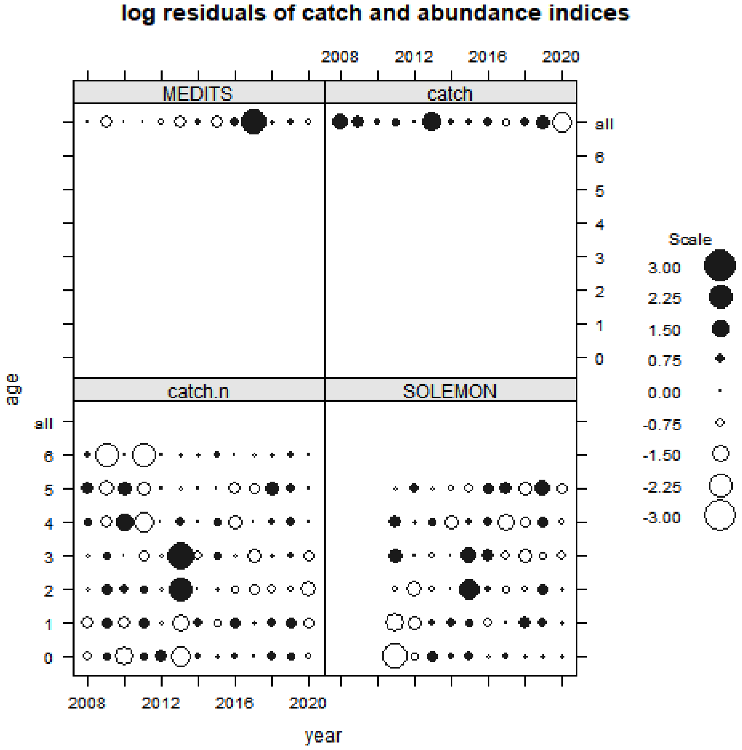


Figure 6.6.3.1.9 Spottail mantis shrimp in GSAs 17 and 18. Standardized log residuals for the fitted model for catch numbers at age, index abundances and total catch presented in a bubble plot.

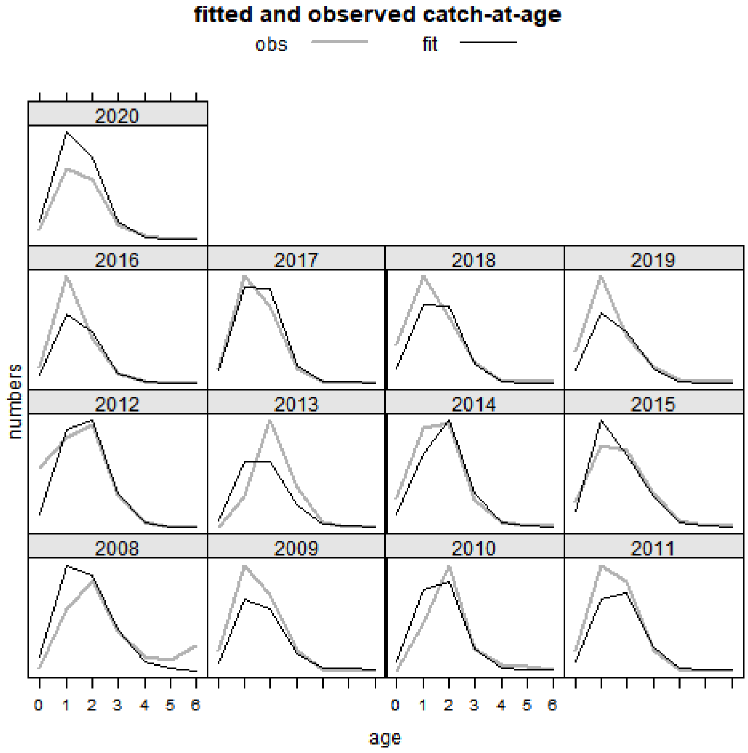


Figure 6.6.3.1.10 Spottail mantis shrimp in GSAs 17 and 18. Estimated versus observed catch at age.

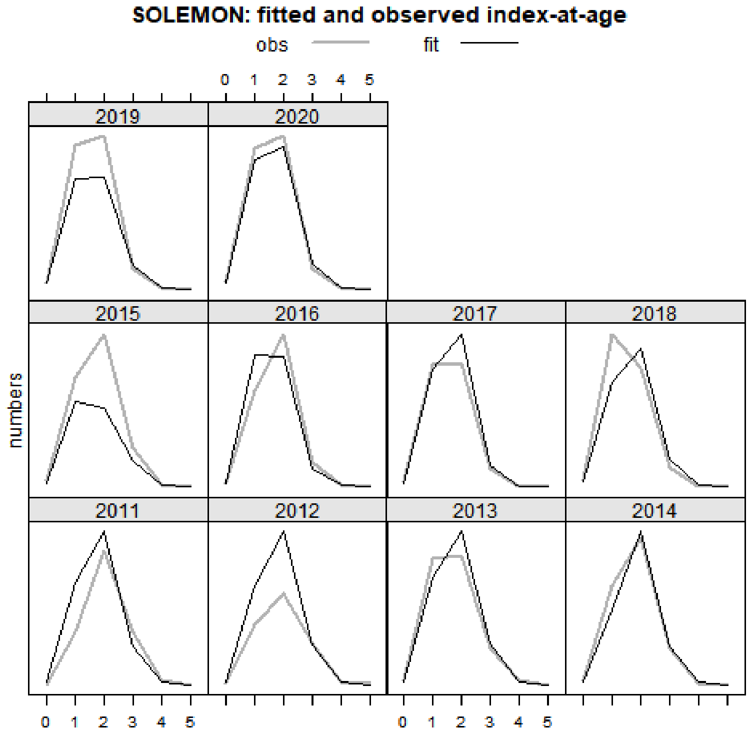


Figure 6.6.3.1.11 Spottail mantis shrimp in GSAs 17 and 18. Estimated versus observed index at age.

Retrospective

Retrospective plots are quite stable with consistent trends. The greater uncertainty is observed in the recruitment and the fishing mortality. However, fishing mortality is consistently above F0.1 reference point for all years in all retrospective runs.

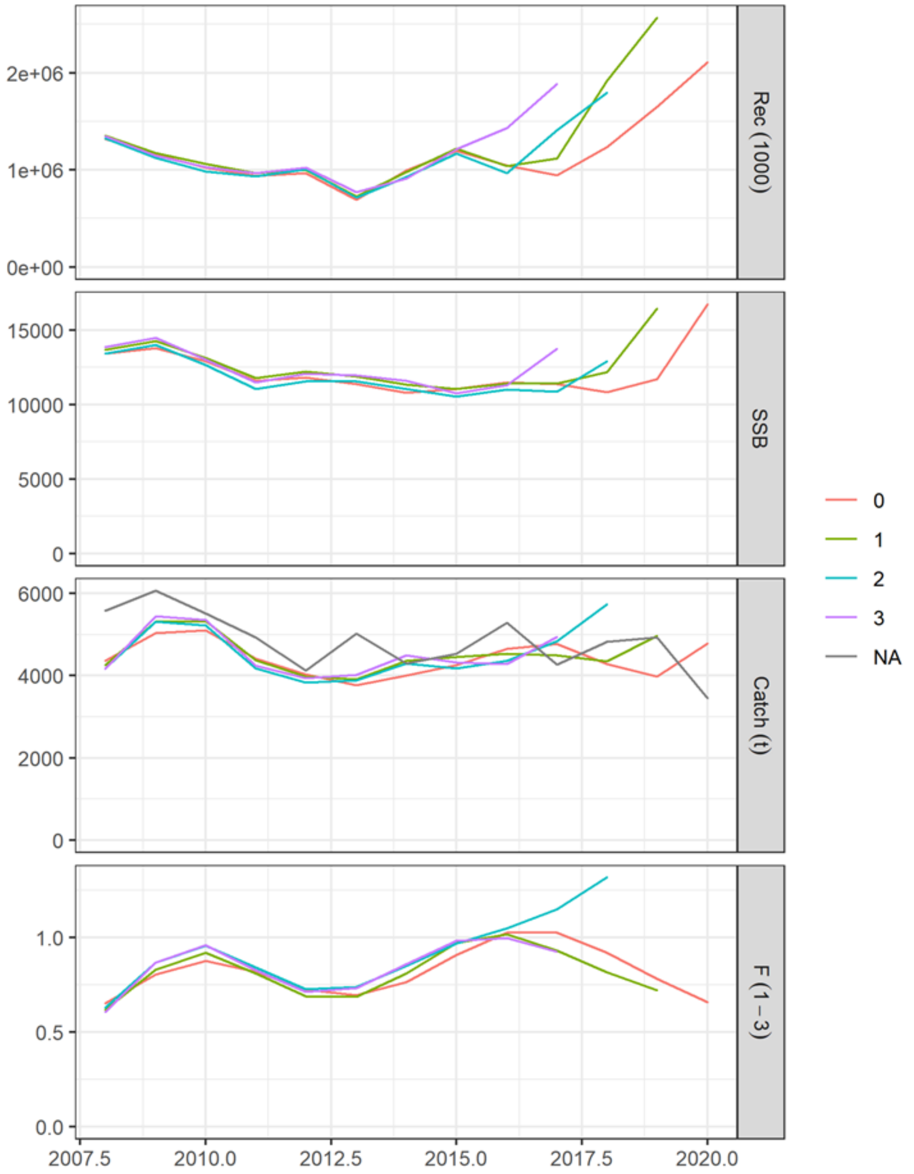


Figure 6.6.3.1.12 Spottail mantis shrimp in GSAs 17 and 18. Retrospective plots for recruitment, SSB (Spawning Stock Biomass), Catch and Harvest rate (ages 1-3). The different trajectories are obtained by removing 0 to 3 final years of data and re-running the assessment.

Stock Summary

Table 6.6.3.1.7 presents a summary of the a4a stock assessment for spottail mantis shrimp, showing average values of recruitment, ssb, catch, fishing mortality and total biomass per year. Tables 6.6.3.1.8 and 6.6.3.1.9 contain fishing mortality at age and catch at age per year. The assessment results show an increase of recruitment and spawning stock biomass in recent years. Catch is fluctuating around 4000 tonnes having declined since 2010 when it reached a maximum of 5000 tonnes. The average fishing mortality, Fbar, is decreasing in recent years and is estimated to 0.658 in 2020. The EWG 21-15 concluded that the a4a model was suitable to provide the basis of the current status of the stock.

Table 6.6.3.1.7 Spottail mantis shrimp in GSAs 17 & 18. Stock summary results for a4a model. Recruitment (age0), spawning stock biomass (ssb), catch, mean fishing mortality of ages 1-3 (fbar) and total biomass.

year	recruitment (numbers)	ssb (tonnes)	catch (tonnes)	fbar	total biomass (tonnes)
2008	1320325	13420	4366	0.65	19724
2009	1159452	13781	5034	0.80	29267
2010	1023151	12923	5100	0.88	19420
2011	937134	11609	4409	0.82	19981
2012	970028	11820	4031	0.72	26404
2013	691632	11367	3767	0.69	20487
2014	996798	10802	4011	0.76	25637
2015	1194410	11037	4254	0.91	29632
2016	1048355	11485	4655	1.02	24322
2017	946394	11372	4769	1.02	18371
2018	1234169	10822	4278	0.92	25736
2019	1652505	11706	3975	0.78	29741
2020	2112104	16728	4780	0.66	44952

Table 6.6.3.1.8 Spottail mantis shrimp in GSAs 17 & 18. Fishing mortality at age by year.

age	2008	2009	2010	2011	2012	2013	
0	0.01	0.01	0.01	0.01	0.01	0.01	
1	0.22	0.28	0.30	0.28	0.25	0.24	
2	0.72	0.88	0.96	0.90	0.80	0.76	
3	1.01	1.25	1.36	1.27	1.13	1.08	
4	0.62	0.77	0.84	0.78	0.69	0.66	
5	0.62	0.77	0.84	0.78	0.69	0.66	
6+	0.62	0.77	0.84	0.78	0.69	0.66	
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
0	0.01	0.01	0.02	0.02	0.01	0.01	0.01
1	0.26	0.31	0.35	0.35	0.32	0.27	0.23

2	0.84	1.00	1.13	1.13	1.01	0.86	0.72
3	1.19	1.41	1.59	1.59	1.43	1.22	1.02
4	0.73	0.87	0.98	0.98	0.88	0.75	0.63
5	0.73	0.87	0.98	0.98	0.88	0.75	0.63
6+	0.73	0.87	0.98	0.98	0.88	0.75	0.63

Table 6.6.3.1.8 Spottail mantis shrimp in GSAs 17 & 18. Estimated Catch numbers at age by year.

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	7412	8003	7699	6603	6045	4133	6558	9306	9225	8329	9740	11105	11964
1	48474	69552	65766	54706	44945	44857	34885	58327	77500	67910	55783	63232	72750
2	43574	60324	72222	59125	48889	44966	50341	39165	57861	66434	54451	45921	55818
3	19831	17142	18252	18406	15602	15183	15725	16700	10559	12716	13842	12510	12313
4	5547	3617	2325	2018	2108	2154	2414	2379	2000	992	1113	1351	1455
5	2335	2134	1101	595	522	632	735	807	668	464	214	256	350
6+	1039	1298	1045	549	296	245	299	346	324	230	150	84	88

6.6.4 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 (2020) was estimated to $F_{0.1}$=0.444. Given that the fishing mortality in 2020 was estimated to Fbar=0.658, the stock is considered overexploited with Fbar/ $F_{0.1}$ = 1.482.

6.6.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2020 to 2022 was performed using the FLR routines provided by JRC. F status quo was set equal to the fishing mortality of the end year of the assessment (2020), corresponding to a catch of 4780 t.

Recruitment 2020 and 2021 was set to 1131981 thousands (equal to the geometric mean recruitment of all the years in the assessment). Biological parameters (maturity, natural mortality, mean weights) and fishery selection were set to the mean of the last three assessment years. Table 6.6.5.1 includes information on the conditioning of the short term forecast. Table 6.6.5.2 contains the forecast results, namely the expected catch and spawning stock biomass under a range of different fishing mortality scenarios.

Table 6.6.5.1 Spottail mantis shrimp in GSA 17 & 18: 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 2018-2020
$F_{ages\ 1\text{-}3}$ (2021)	0.658	F_{2020} used to give F status quo for 2021
SSB (2021)	21483.36	Stock assessment 1 January 2021
R_{age0} (2021,2022)	1131981	Geometric mean of the time series
Total catch (2021)	6338.12	Assuming F status quo for 2021
Fbar (2019)	0.781	MAP base year fishing mortality from current assessment
a & b values	a=0.57 b=0.43	Regression parameters from F transition regression line

Table 6.6.5.2 Spottail mantis shrimp in GSAs 17 & 18. Short term forecasts showing catch options and ssb (spawning stock biomass) for different fishing mortality scenarios.

Rationale	Ffactor	Fbar	F 2021	Catch 2022	SSB 2021	SSB 2023	SSB 2021-2023 (%change)	Catch 2020-2022 (%change)
High long-term yield (F0.1)	0.67	0.44	0.66	4944.8	21483.4	17916.1	-16.6	3.5
F upper	0.92	0.61	0.66	6303.9	21483.4	16520.7	-23.1	31.9
F lower	0.45	0.30	0.66	3523.3	21483.4	19401.4	-9.7	-26.3
FMSY transition	0.97	0.64	0.66	6530.5	21483.4	16290.6	-24.2	36.6
Zero catch	0	0.00	0.66	0.0	21483.4	23172.9	7.9	-100.0
Status quo	1	0.66	0.66	6689.4	21483.4	16129.8	-24.9	40.0
Different Scenarios	0.1	0.07	0.66	872.7	21483.4	22228.3	3.5	-81.7
	0.2	0.13	0.66	1690.8	21483.4	21348.8	-0.6	-64.6
	0.3	0.20	0.66	2458.2	21483.4	20529.2	-4.4	-48.6
	0.4	0.26	0.66	3178.7	21483.4	19765.0	-8.0	-33.5
	0.5	0.33	0.66	3855.6	21483.4	19052.0	-11.3	-19.3
	0.6	0.39	0.66	4492.2	21483.4	18386.3	-14.4	-6.0
	0.7	0.46	0.66	5091.3	21483.4	17764.4	-17.3	6.5
	0.8	0.53	0.66	5655.6	21483.4	17183.0	-20.0	18.3
	0.9	0.59	0.66	6187.6	21483.4	16639.0	-22.5	29.5
	1.1	0.72	0.66	7163.3	21483.4	15652.7	-27.1	49.9
	1.2	0.79	0.66	7611.2	21483.4	15205.4	-29.2	59.2
	1.3	0.86	0.66	8034.8	21483.4	14785.7	-31.2	68.1
	1.4	0.92	0.66	8435.9	21483.4	14391.7	-33.0	76.5
	1.5	0.99	0.66	8815.9	21483.4	14021.4	-34.7	84.4
	1.6	1.05	0.66	9176.2	21483.4	13673.1	-36.4	92.0
	1.7	1.12	0.66	9518.2	21483.4	13345.4	-37.9	99.1
	1.8	1.18	0.66	9843.1	21483.4	13036.8	-39.3	105.9
	1.9	1.25	0.66	10152.0	21483.4	12745.8	-40.7	112.4
	2	1.32	0.66	10445.9	21483.4	12471.3	-41.9	118.5

6.6.6 DISCUSSION

Following the recommendations of the STECF EWG 21-15, the assessment of spottail mantis shrimp adopted the parameterization of the previous assessment of the species by STECF EWG 20-15. In particular, Von Bertalanffy growth parameters, length-weight relationship, maturity and mortality by age were all adopted from EWG 20-15 assessment. The same parameters were also used to age-slice the SoleMon survey index. In addition, all other model settings (fmodel, qmodel, srmodel, etc.) were the same as in STECF EWG 20-15 assessment. The model was informed with data from DCF 2021 data call, which showed no significant differences to last year's data call, except from 2019 discards from Italy, which have been revised upwards. Furthermore, data from Albania between 2017-2020 have been provided to the group and added to the total landings. The results of this year's (EWG 21-15) and last year's (EWG 20-15) assessments are compared in Figure 6.6.6.1, while Table 6.6.6.1 compares the fishing mortality and reference points of the two assessments. In general, the perception of the stock's historical evolutions and its current status are the same in both assessments. In EWG 21-15 assessment, the recruitment of the whole historical period is estimated to be lower than that estimated in last year's assessment. These differences are similar to the retrospective patterns seen in Figure 6.5.6.6.3.1.12. The reduction in recruitment comes from a very small change in selection at the youngest age between this year and last year but has no other impact on the assessment.

Table 6.6.6.1 Spottail mantis shrimp in GSA 17 and 18. F and F/F0.1 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 20-15 (ref year 2019)	0.69	1.53
EWG 20-15 (ref year 2020)	0.66	1.48

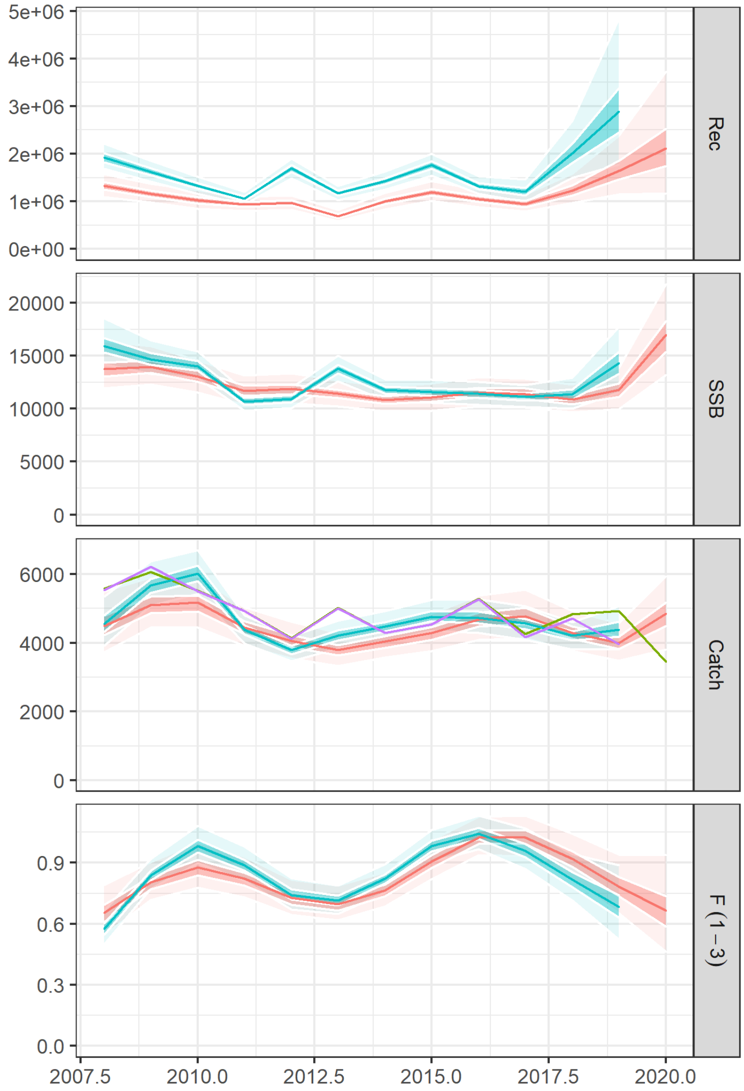


Figure 6.6.6.1 Spottail mantis shrimp in GSA 17 & 18. Comparison of results between this year's update assessment (EWG 21-15, red) and last year's assessment (EWG 20-15, blue).

6.6.7 DATA DEFICIENCIES

Landings and discards frequency distributions are missing for HRV (Croatia) GSA17.

6.7 DEEP WATER ROSE SHRIMP IN GSA17, 18 AND 19

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.

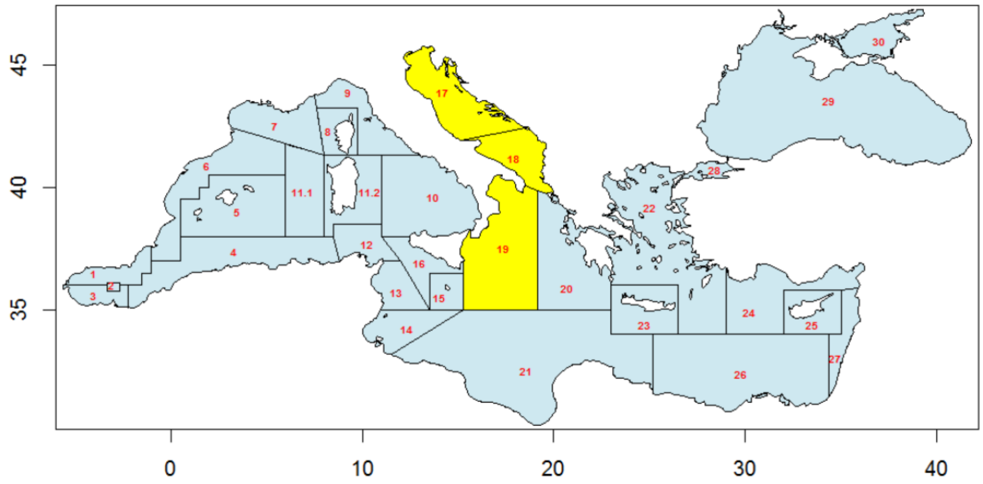


Figure 6.7.1.1. Geographical location of GSAs 17,18 and 19.

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 comes from DCF (see Table 6.7.1.1).

Table 6.7.1.1 parameters used for growth and weight at length taken from DCF data.

Growth Equation	L∞	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

A vector of natural mortality was estimated by the Chen and Watanabe (1989) function using growth and length-weight relationship parameters for sex combined (Table 6.7.1.2).

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 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.

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 17-18-19: 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 21-15 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.

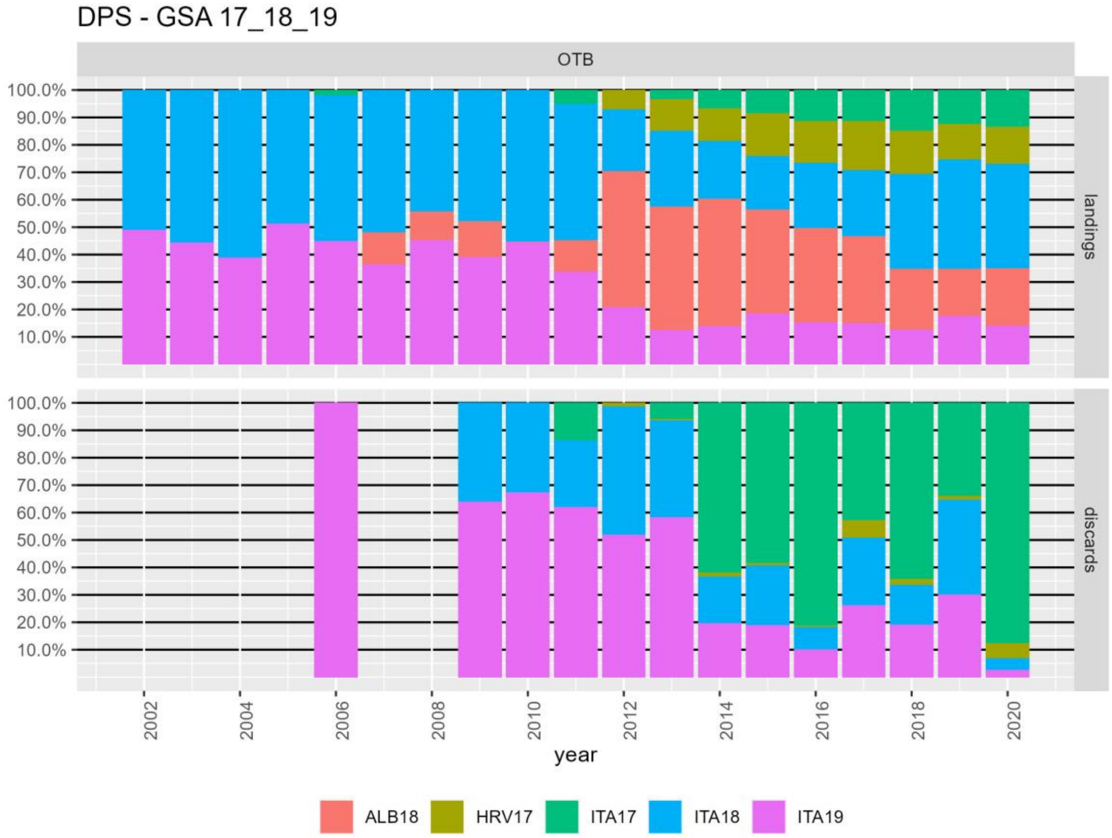


Figure 6.7.2.1.1. Deep-water rose shrimp stocks in GSAs 17-19: OTB landings and discards percentage composition by main fleet from DCF 2020.

In the rest of the report, we will refer to and present only data for otter trawl.

Landings and discards by main gear, year and fleet are presented in figure 6.7.2.1.2 and table 6.7.2.1.1.

Table 6.7.2.1.1. Deep-water rose shrimp stocks in GSAs 17-19: Catch data (A=landings, B=discards) in tonnes by fleet as reported by DCF 2021.

A (landings)

gsa	country	gear	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
17	HRV	GNS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0.3	0.4	0.1	0.1	0	0.1	0.1	0
17	HRV	GTR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0
17	HRV	LLS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	0	NA	0	0	NA
17	HRV	OTB	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	169	315	370	534	655	834	913	715	661
17	HRV	OTH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2	0.1	0.1	0.1	0	0.4	0	0.1	0
17	ITA	OTB	NA	NA	NA	NA	54	NA	NA	NA	NA	92	NA	84	202	279	471	520	835	679	644
17	ITA	OTH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	21	1.2
18	ALB	OTB	NA	NA	NA	NA	NA	198	187	262	7	209	1170	1210	1430	1290	1460	1473	1275	962	1026
18	ITA	GNS	NA	66.7	7.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	ITA	GTR	NA	NA	1.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.2
18	ITA	LLS	NA	NA	1.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	ITA	OTB	1147	1749	1848	1182	1473	863	766	939	888	870	523	734	638	651	996	1109	1962	2187	1834

19	ITA	GNS	NA	NA	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA
19	ITA	GTR	3	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1	NA	1.8	NA	NA	NA	NA	NA	2.2
19	ITA	LLS	NA	NA	8.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	ITA	OTB	1103	1391	1170	1243	1245	608	785	767	716	593	488	335	422	622	647	693	716	964	678
19	ITA	OTH	20.2	NA	15.3	1.1	0.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.3	NA

B (discards)

gsa	country	gear	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
17	HRV	GNS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	NA	0	0
17	HRV	GTR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	NA	0	0
17	HRV	LLS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	0	NA	NA	0	NA
17	HRV	OTB	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2	0.3	0.7	0.7	1.9	11.1	7.6	4.5	9.2
17	HRV	OTH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	NA	0	0
17	ITA	OTB	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	NA	2	28	37	207	73	228	92	138.5
18	ITA	OTB	NA	NA	NA	NA	NA	NA	NA	30.8	17.5	5.3	7.2	12.3	7.7	13.9	20.8	42.3	52	94.1	6.5
19	ITA	OTB	NA	NA	NA	NA	19	NA	NA	54.6	36.1	13.5	8	20.4	8.9	12	25.5	44.7	67.7	81.7	4.2

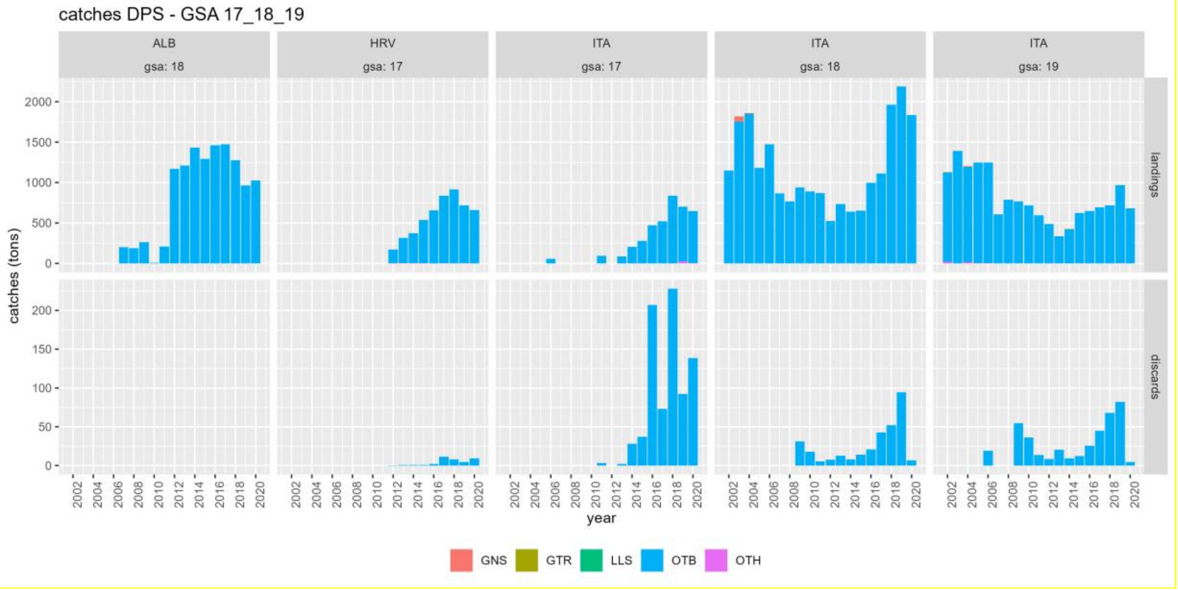


Figure 6.7.2.1.2. Deep-water rose shrimp stocks in GSAs 17-19: OTB Landings and discards data by main fleet from DCF 2020.

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 (2002-2020) for Italy, were missing for Montenegro, while data from Albania (from 2007 to 2020) comes from latest FAO Fishery and Aquaculture Statistics. Landings data for GSA 19 were complete (2002-2020).

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).

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 reported by DCF 2021.

variable	gsa	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
landings	17	NA	NA	NA	NA	54	NA	NA	NA	NA	92	168.5	398.5	571.6	813.3	1125.8	1353.9	1747.5	1393.6	1305.1
landings	18	1147.2	1749.3	1847.7	1181.5	1473.2	1061.1	953.2	1201.4	895.1	1078.6	1692.8	1943.7	2067.7	1941.3	2456.4	2582.4	3237	3149	2859.8
landings	19	1103.3	1391	1170.2	1243.1	1244.6	607.5	785	767.3	715.6	592.8	487.6	334.5	421.5	622.4	647.4	692.8	716.3	963.9	678.4
discards	17	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	0.2	2.3	28.7	37.7	208.9	84.1	235.6	96.5	147.6
discards	18	NA	NA	NA	NA	NA	NA	NA	30.8	17.5	5.3	7.2	12.3	7.7	13.9	20.8	42.3	52	94.1	6.5
discards	19	NA	NA	NA	NA	19	NA	NA	54.6	36.1	13.5	8	20.4	8.9	12	25.5	44.7	67.7	81.7	4.2

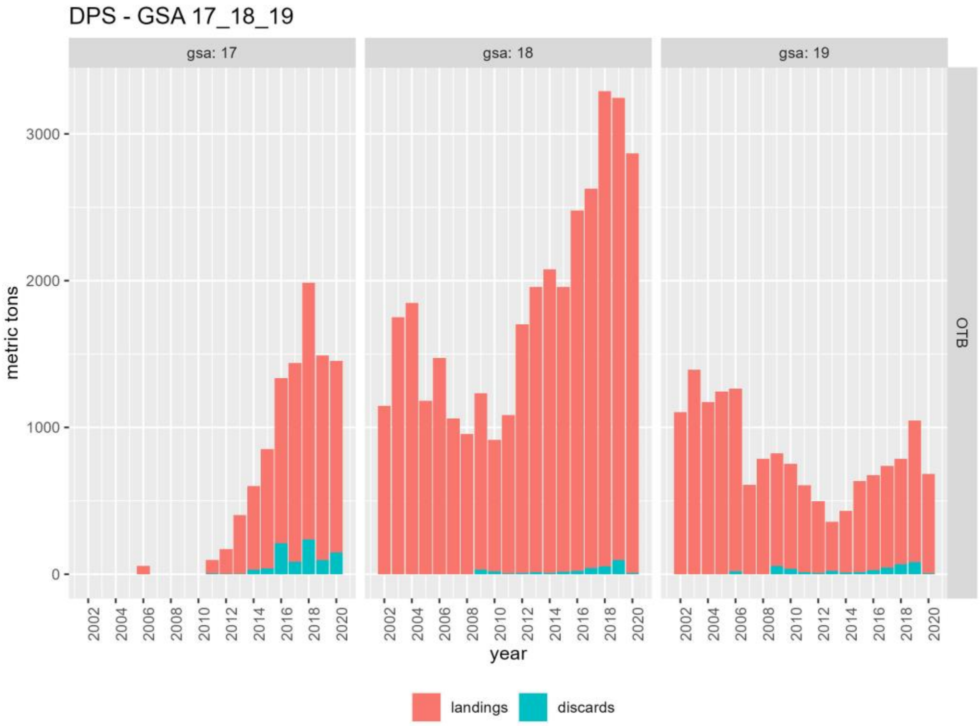


Figure 6.7.2.1.3. Deep-water rose shrimp stocks in GSAs 17-19: OTB Landings and discards data by gsa from DCF 2020.

For the puproses of the assessment EWG 21-15 the reconstruction of missing data done during the EWG 21-02, which takes in to account all the available information to fill gaps on catches by fleet (i.e. by GSA, country and gear), was updated with the 2020 data information and, for Albania, with the most updated information reported by FAO fishieries statistic. For Italy, GSA17, gaps from 2007 to 2010 and 2021 were filled with mean of landings in adiacent years (2006,2011,2013) because in since 2014 landings were too much higher. This reconstruction was carried out sligthly modifying the "Landings_LFgaps_metier" routine provided by JRC. For the other reconstruction the default routine was used. Finally, for 2002 and 2003 in GSA 18 and 19, and for 2006 in GSA 18 the catch matrix was updated to include and consider landings of gear coded NA as OTB (Table 6.7.2.1.3, Figure 6.7.2.1.4).

Table 6.7.2.1.3. Deep-water rose shrimp stocks in GSAs 17-19: Landings data in tonnes by OTB as recontstruct by EWG21-15.

country	gsa	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
HRV	17	NA	NA	NA	NA	NA	NA	NA	139	175	152	169	315	370	535	655	834	913	715	661
ITA	17	NA	NA	NA	NA	54	77	77	77	77	92	77	84	202	279	471	520	835	700	646
ALB	18	NA	NA	NA	NA	NA	198	187	262	236	209	1170	1210	1430	1290	1460	1473	1275	962	1026
ITA	18	1147	1816	1857	1181	1473	863	766	939	888	870	523	734	638	651	996	1109	1962	2187	1835
ITA	19	1127	1391	1201	1244	1245	608	785	767	716	593	488	334	423	622	647	693	716	965	681

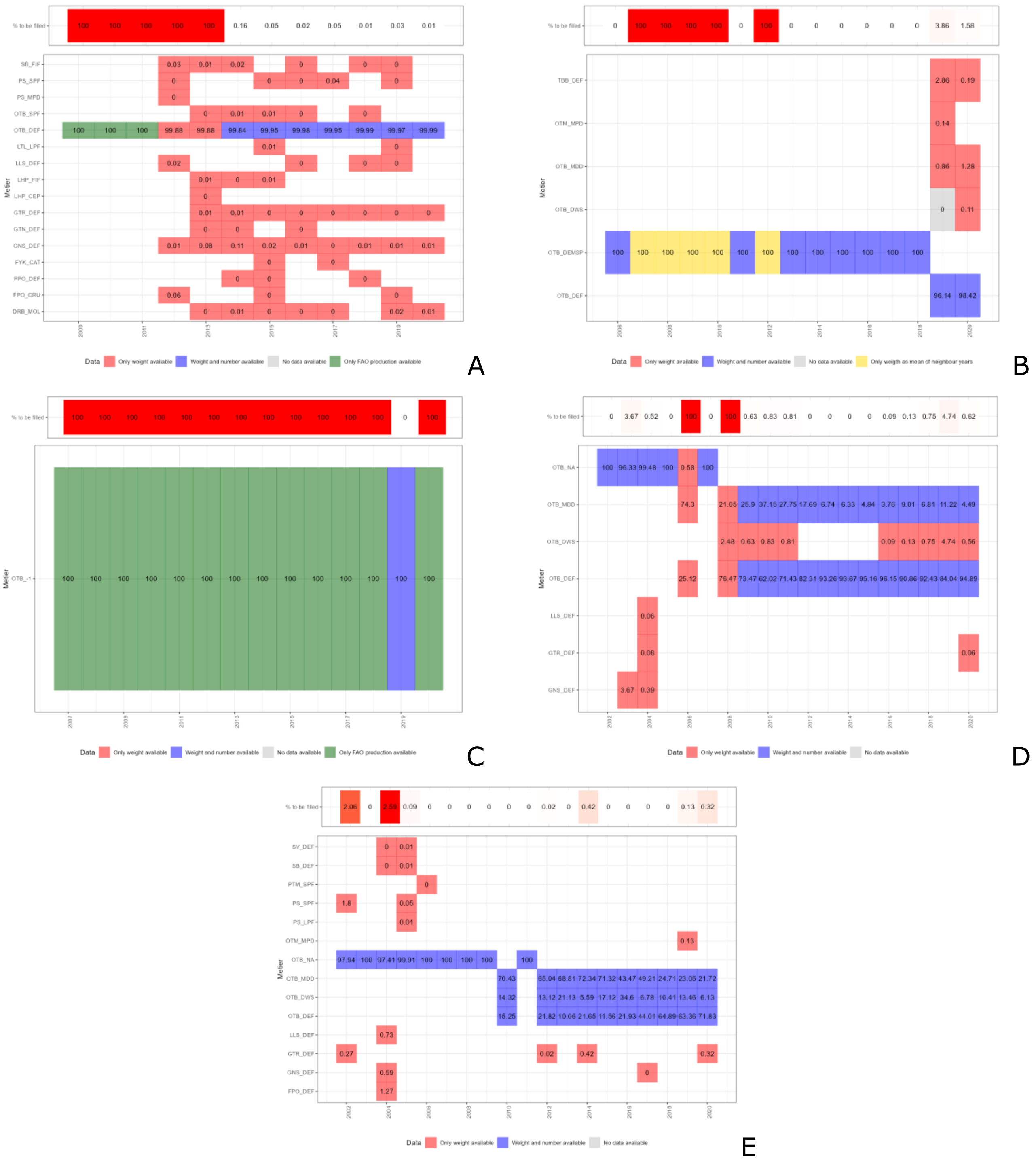


Figure 6.7.2.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Summary % of landings without length data (A=HRV 17, B=ITA 17, C=ALB 18, D=ITA 18, E=ITA 19)

Gaps in discards by country and area were filled following the same procedure of EWG 21-02, but updating the year 2020 also. For Albania total discard in 2009, 2010 and 2011 were updated with data production derived from FAO statistics (Table 6.7.2.1.4, Figure 6.7.2.1.5). Finally, for ITA17 years from 2007 to 2010 and 2012 missing data were reconstructed considering the mean values of neighboroud years (2006,2011,2013) slightly modifying the "Discards_LFgaps_metier" routine (Figure 6.7.2.1.5 B).

Table 6.7.2.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Discards data in tonnes by OTB as recontstruct by EWG21-15.

country	gsa	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
HRV	17	NA	NA	NA	NA	NA	NA	NA	0.4	0.5	0.4	0.2	0.3	0.7	0.7	1.9	11.1	7.6	4.5	9.2
ITA	17	NA	NA	NA	NA	7.5	10.6	10.6	10.6	10.6	3	10.6	2	28	37	207	73	228	92.8	139.7
ALB	18	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ITA	18	23.3	35.5	37.5	24	15.6	17.5	13.7	31	17.7	5.4	7.2	12.3	7.7	13.9	20.8	42.3	52.2	96.2	7.3
ITA	19	25.1	31.6	26.6	28.3	19	13.8	17.8	54.6	36.1	13.5	8	20.4	8.9	12	25.5	44.7	67.7	81.7	4.5

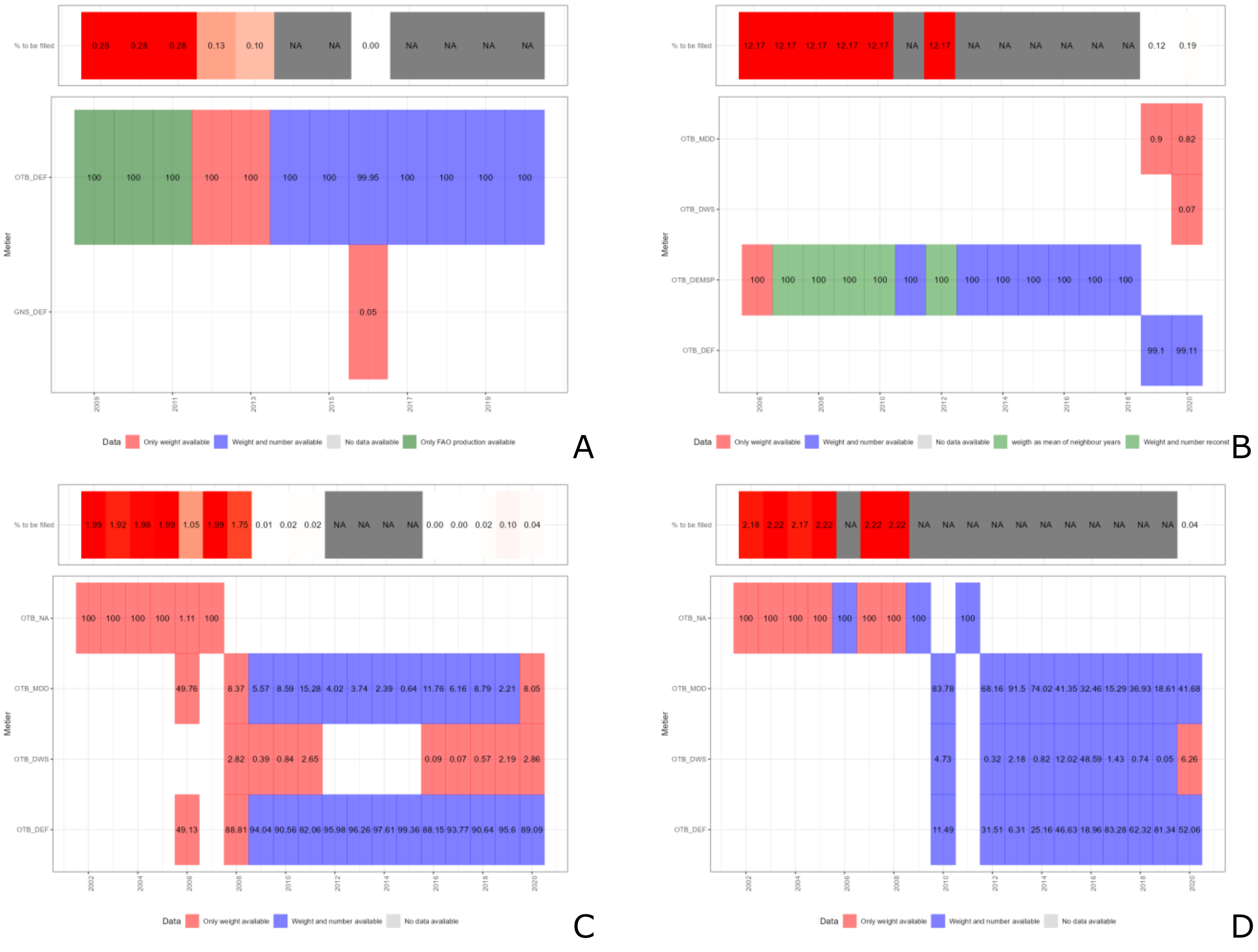


Figure 6.7.2.1.5. Deep-water rose shrimp stocks in GSAs 17-19: Summary % of catch without discard length data (A=HRV 17, B=ITA 17, C=ITA 18, D=ITA 19)

Landings and discards data as reconstructed by fleet (figure 6.7.2.1.6) were then summarised by year and used as input data for the assessment (Table 6.7.2.1.5, Figure 6.7.2.1.6).

Table 6.7.2.1.5. Deep-water rose shrimp stocks in GSAs 17-19: Total landings, discards and catches of OTB as reconstructed by EWG 21-15.

variable	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
landings	2274	3207	3059	2426	2772	1745	1815	2184	2091	1916	2426	2677	3063	3377	4230	4630	5701	5529	4848
discards	48.4	67.1	64.1	52.3	42	42	42.1	96.5	64.9	22.3	26	35	45.2	63.6	255.2	171.1	355.5	275.3	160.6
catches	2322	3274	3123	2478	2814	1787	1857	2281	2156	1938	2452	2712	3108	3441	4485	4801	6056	5804	5009

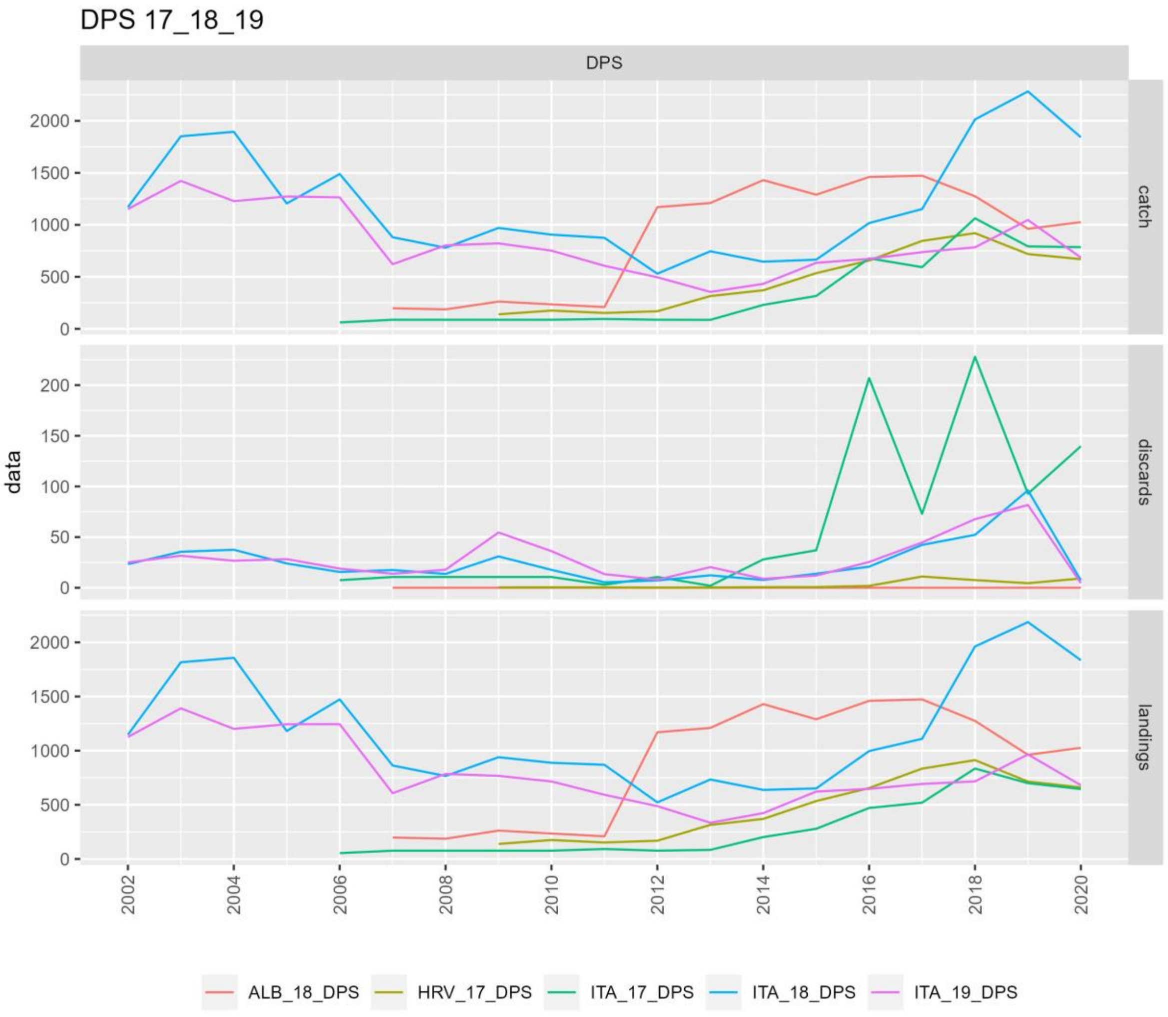


Figure 6.7.2.1.6. Deep-water rose shrimp stocks in GSAs 17-19: Total landing, discards and catch by year as reconstructed by EWG 21-15.

Information on landings at length is available for the whole time series (2002-2019) 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 2013-2019 for Italy and from 2014 onwards in Croatia (Figure 6.7.2.1.8). For Albania in GSA 18 information is available only in 2019.

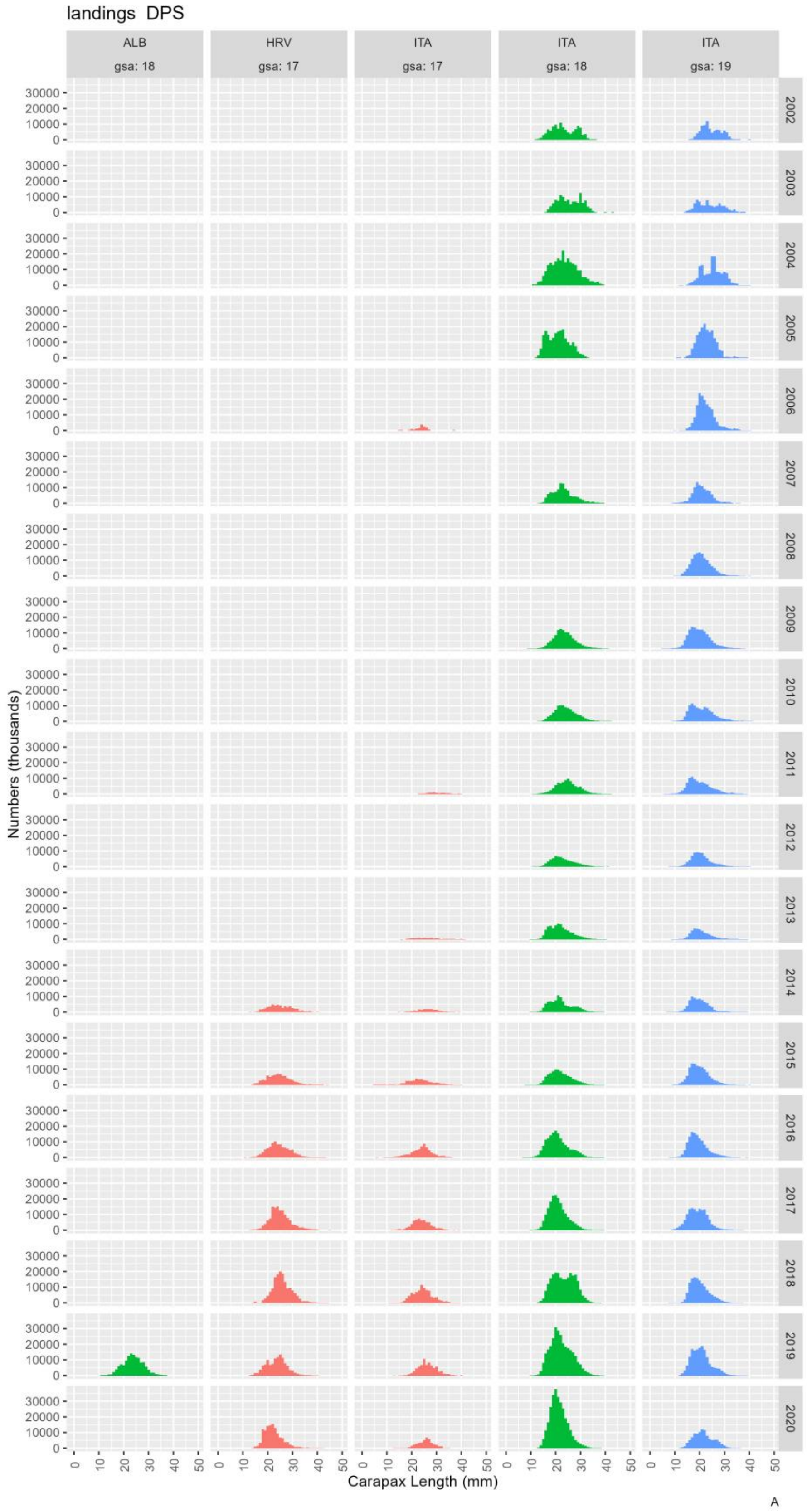


Figure 6.7.2.1.8. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution of the landings by year and fleet.

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)

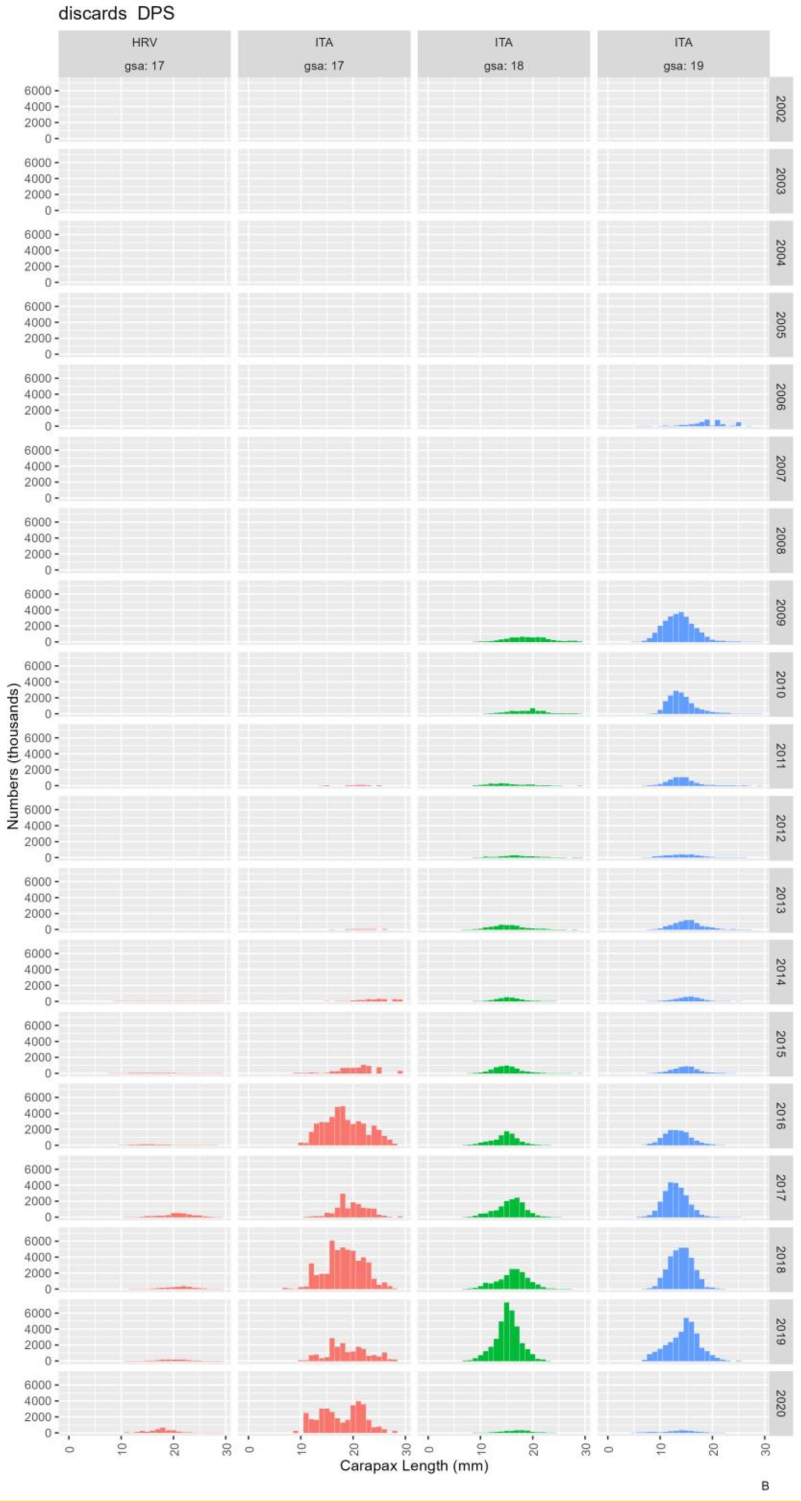


Figure 6.7.2.1.9. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution of the discards by year and fleet.

Landings and discards at length information derived from EWG 21-02, which reconstructed some missing years, were updated with the latest data of 2020 and with the information for Albania (Figure 6.7.2.1.10 A,B).

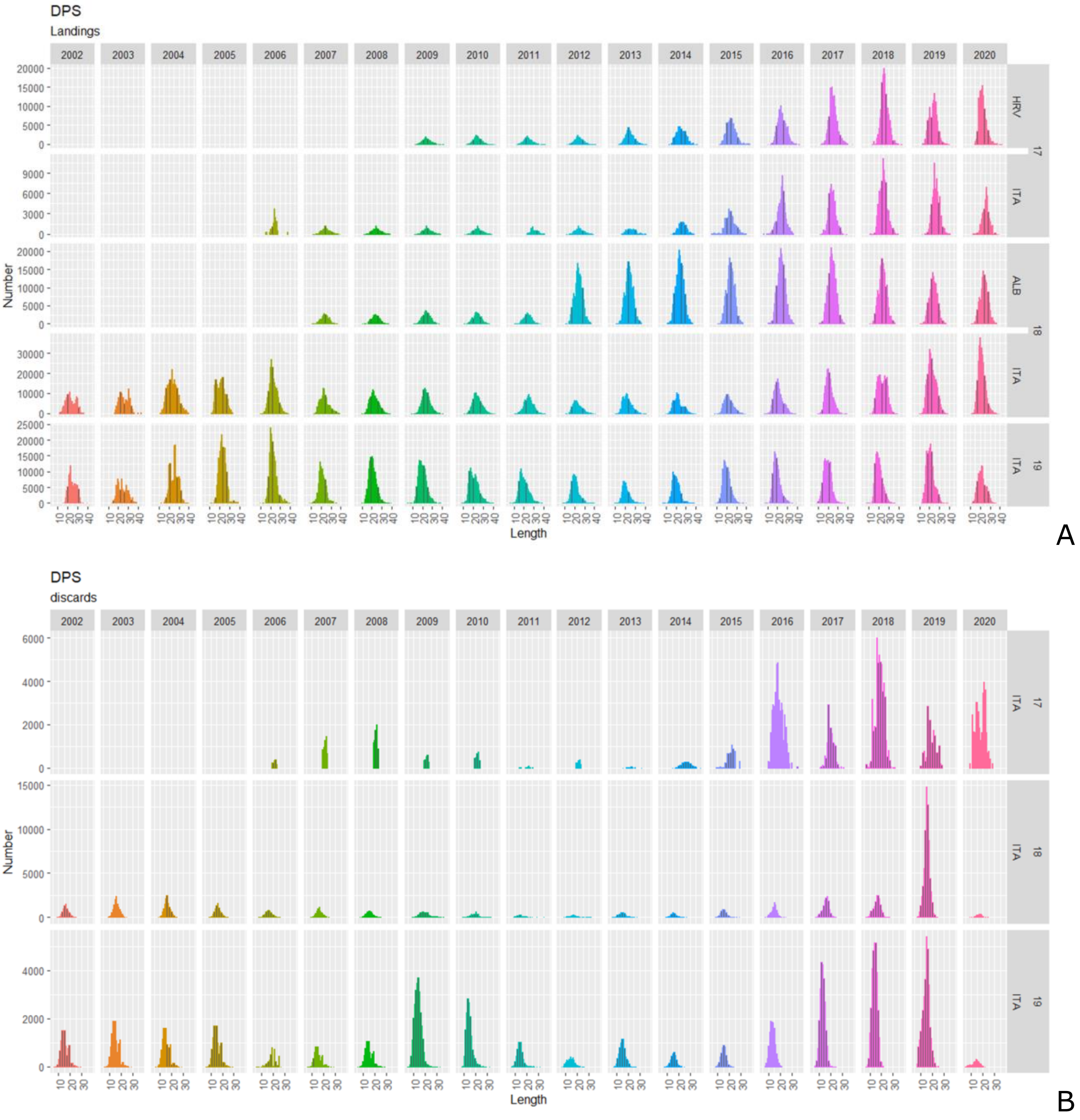


Figure 6.7.2.1.10. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution of landing (A) and discards (B) by year and fleet reconstructed for missing years.

6.7.2.2 Effort

Fishing effort data were reported to STECF EWG 21-15 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	

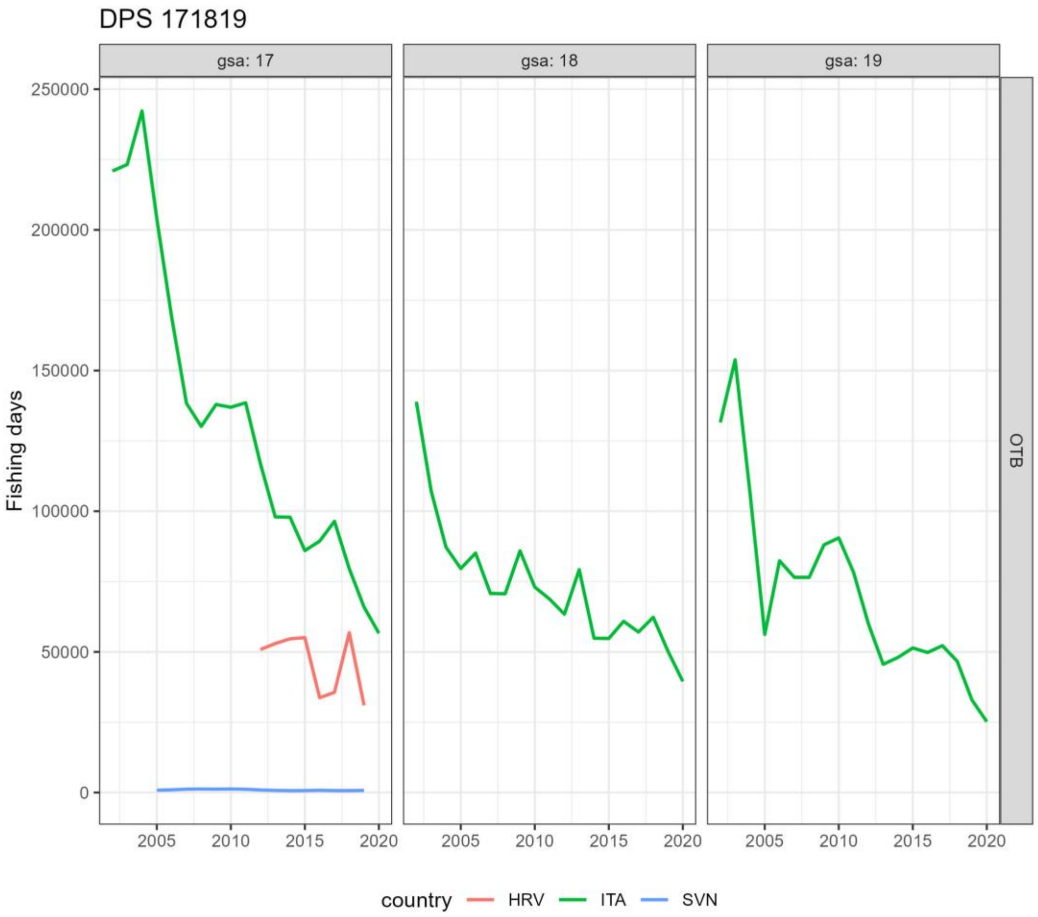


Figure 6.7.2.2.1. Deep-water rose shrimp stocks in GSAs 17-19: trend of effort in fishing days.

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.

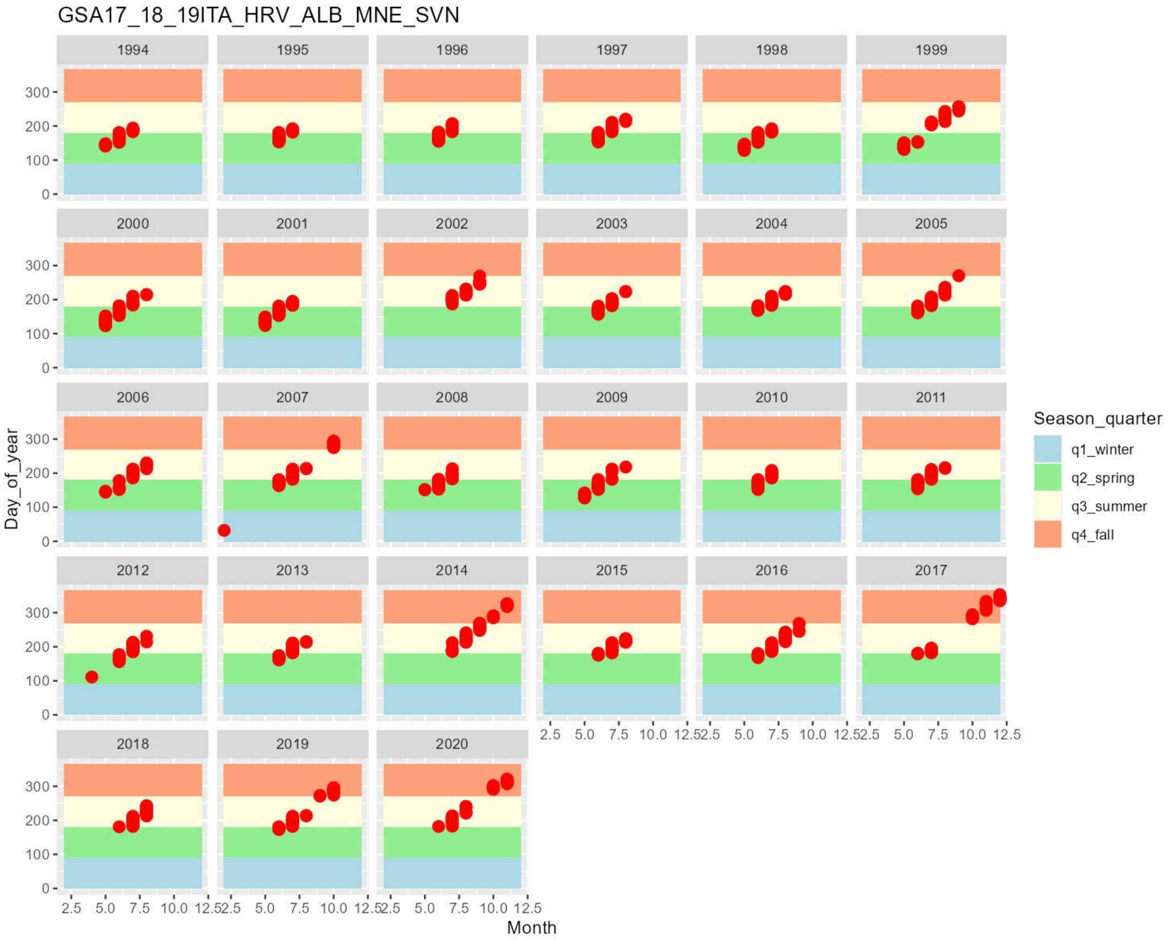


Figure 6.7.2.3.1. Period of MEDITS survey in GSAs 17, 18, 19.

Table 6.7.2.3.1. Total number of MEDITS hauls per year and country.

country	HRV	ITA	ITA	ITA	SVN
area	17	17	18	19	17
1994	0	86	72	73	0
1995	0	86	72	74	0
1996	0	85	112	74	2
1997	0	86	112	74	2
1998	0	86	112	74	2
1999	0	84	112	74	2
2000	0	86	112	74	2
2001	0	86	112	74	2
2002	59	119	90	70	2
2003	59	120	90	70	2
2004	61	118	90	70	2
2005	59	121	90	70	2
2006	59	120	90	70	0
2007	60	120	90	70	4
2008	59	121	90	70	2
2009	60	121	90	70	2
2010	60	120	90	70	2
2011	60	120	90	70	2
2012	60	119	90	70	2
2013	59	180	90	70	2
2014	56	180	90	70	2
2015	65	180	90	70	2
2016	56	180	90	70	2
2017	61	122	68	70	2
2018	65	120	70	70	2
2019	69	186	70	70	3
2020	58	179	70	70	3

Observed abundance and biomass indices of Deep-water rose shrimp stocks from Medist are given in the figure 6.7.2.3.3).

Both estimated abundance and biomass indices show similar trends, with a peak in 2017.

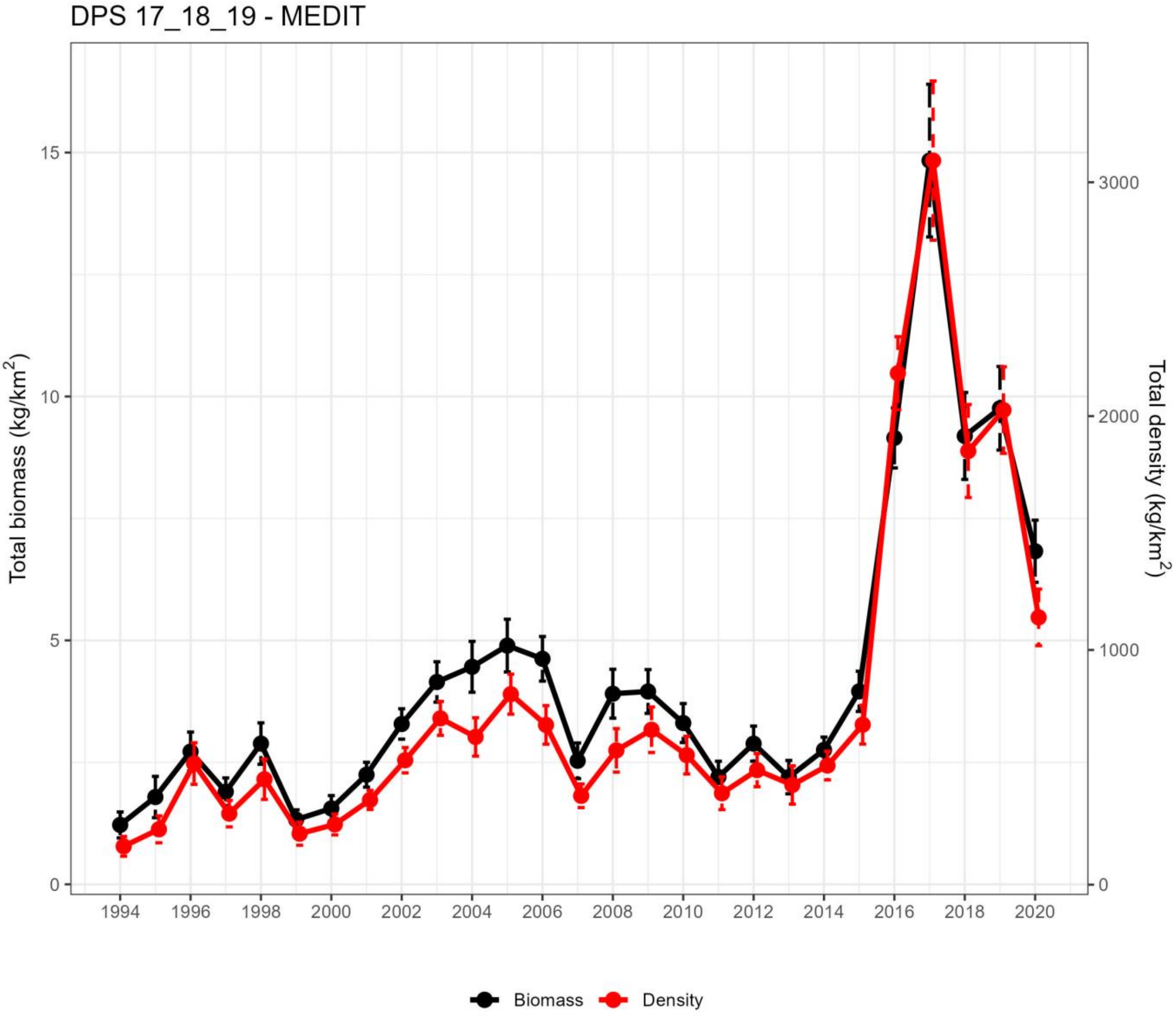


Figure 6.7.2.3.3. Deep-water rose shrimp stocks in GSAs 17-19: Estimated biomass (kg/km^2) and density indices (N/km^2).

Length frequency distribution of Deep-water rose shrimp stocks from Medist are given in the figure below (Figure 6.7.2.3.4).

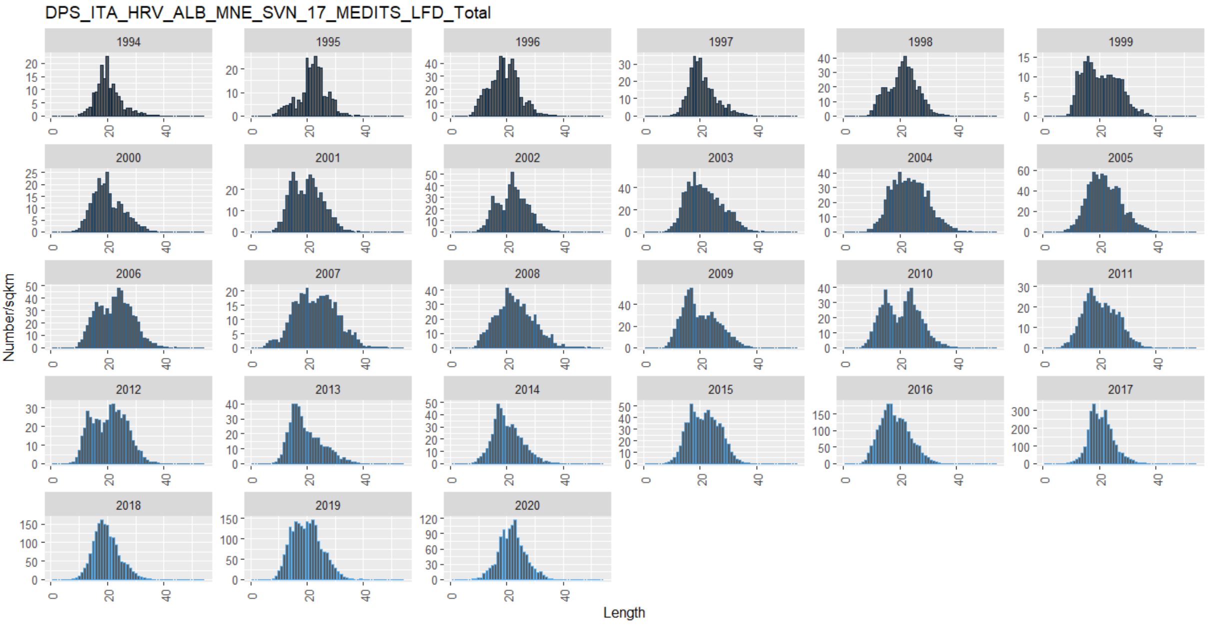


Figure 6.7.2.3.4. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution by year of MEDITS.

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.

6.7.3 Stock assessment

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 20-15).

6.7.3.1 Input data

Stock assessment input data for the a4a model are given in this section below.

Data used in the last EWG 20-15 were revised and uptaded using the raw data from 2021 DCF data call. In particular the catch at age matrix, the catch at weight matrix and the catch matrix were corrected for each country and gsa taking in to consideration the outcomes from EWG 21-02 and some additional checks and adjustments performed by EWG 21-15 (see below on chp 6.7.7).

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	284.4	225.1	9.4	1.4
2003	424.6	250.6	29.2	4.1
2004	292.4	286.8	38.5	11.3
2005	471.9	305.2	30.4	4.6
2006	325.5	323.3	27.5	4.2
2007	181.2	157.7	27.4	7.2
2008	291.3	236.7	35.8	8.3
2009	434.2	205.9	18	2
2010	317.7	214.8	13.6	1.8
2011	250.2	130.6	7.4	0.5
2012	294.1	185	7.5	0.6
2013	306.7	105.6	11.3	0.7
2014	337.8	139.8	5.7	0.7
2015	392.3	279.2	9.8	0.5
2016	1737.4	434.1	10.5	0.5
2017	2176.8	892	21.1	1.1
2018	1254	372.5	9.3	0.5
2019	1424.7	583.2	15.8	1.9
2020	644.5	477.6	15.6	1.1

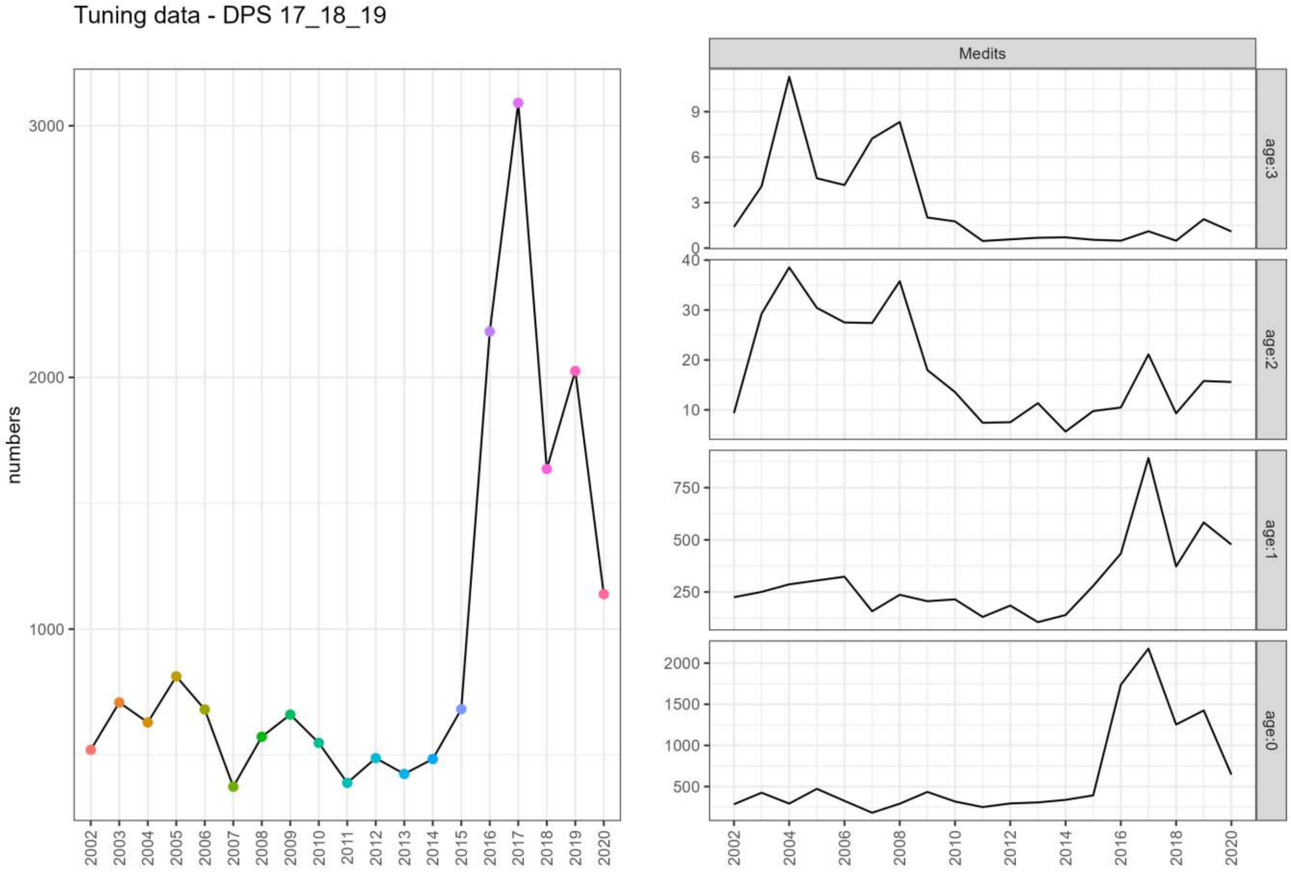


Figure 6.7.3.1.1. Deep-water rose shrimp stocks in GSAs 17-19: MEDITS mean catch/rate at age by year and numbers at age derived from length by slicing.

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 21-02 and updated by EWG 21-15.

The catch, catch at age and catch weight at age data by country and gsa are shonw in Figure 6.7.3.1.2.

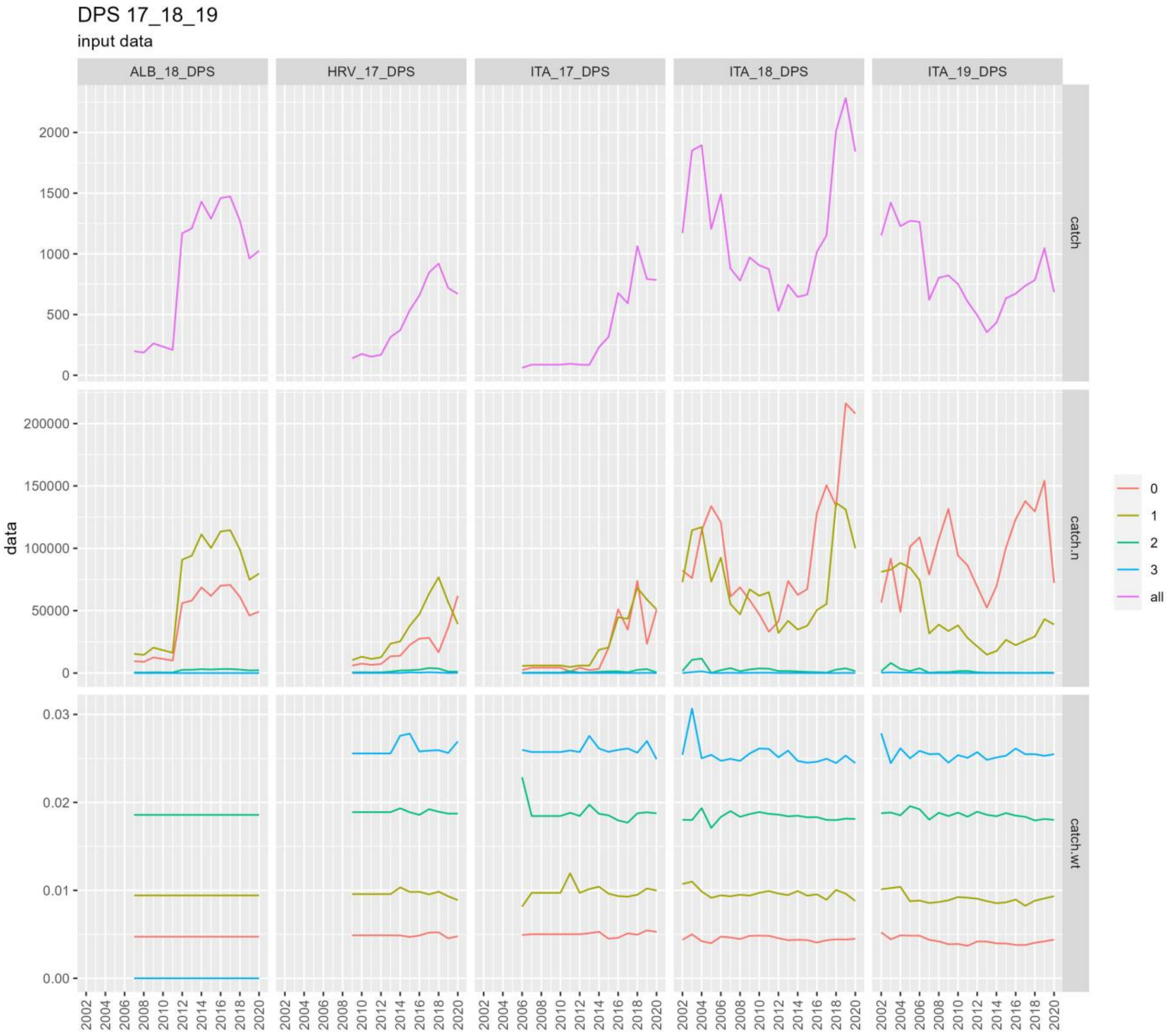


Figure 6.7.3.1.2. Deep-water rose shrimp stocks in GSAs 17-19: catch, catch at age and catch weight data by country and gsa used to derive the stock object for the whole area.

The input data were SoP corrected raising catches at age to total catches by country and gsa. The SoP correction factors are reported in Table 6.7.3.1.2.

Table 6.7.3.1.2. Deep-water rose shrimp stocks in GSAs 17-19: SoP correction factors by year, country and gsa.

country	gsa	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
HRV	17	NA	NA	NA	NA	NA	NA	NA	1	1	1	1	1	0.81	0.85	0.81	0.72	0.62	0.81	0.82
ITA	17	NA	NA	NA	NA	0.54	0.99	0.99	0.99	0.99	0.96	0.99	1.05	1.15	0.99	0.93	1.07	1.06	0.94	1.32
ALB	18	NA	NA	NA	NA	NA	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.95	0.98
ITA	18	1.28	1.51	0.95	0.99	0.99	1.05	0.99	1.05	1.04	1.07	1.12	1.13	1.06	1.04	1.06	1.03	1.04	1.02	1.05
ITA	19	1.41	1.97	0.93	0.99	1.07	1.07	1.05	1.02	1.04	1.08	1.12	1.09	1.03	1.03	1.04	0.98	0.94	0.98	1.02

After the SoP correction, input data were aggregated for the whole area and assembled in a unique stock object (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	138703.1	154020.4	3114.53	296.29
2003	167847.3	197386.9	18705.91	1253.99
2004	163247.3	205245.5	14911.02	1746.49
2005	235000.5	157686.8	1788.58	362.69
2006	232020.6	172600	6322.36	262.79
2007	154115	108523	4990.15	195.86
2008	189410.1	106407.3	2993.3	66.56
2009	212878	137556	5056.71	222.37
2010	164435.3	137641.5	6732.93	360.54
2011	137219.6	125219.4	7663.51	437.91
2012	178214	163132.9	5784.34	145.35
2013	200040.7	180163	6275.04	252.73
2014	218077.5	207561.7	7767.19	104.68
2015	272706.5	223264.6	7541.3	666.34
2016	400452.3	278256.5	8296.02	309.53
2017	422005.8	302639.9	8389.8	661.84
2018	415292.8	409778.4	11889.48	387.38
2019	476374.9	364827.4	10613.54	287.98
2020	441936.5	309010.8	5628.71	204.88

Table 6.7.3.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Total Catch by year in tonnes

year	landings	discards	catches
2002	2274	48.4	2322
2003	3207	67.1	3274
2004	3059	64.1	3123
2005	2426	52.3	2478
2006	2772	42	2814
2007	1745	42	1787
2008	1815	42.1	1857
2009	2184	96.5	2281
2010	2091	64.9	2156
2011	1916	22.3	1938
2012	2426	26	2452
2013	2677	35	2712
2014	3063	45.2	3108
2015	3377	63.6	3441
2016	4230	255.2	4485
2017	4630	171.1	4801
2018	5701	355.5	6056
2019	5529	275.3	5804
2020	4848	160.6	5009

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	0.0047	0.0104	0.0184	0.0278
2003	0.0047	0.0107	0.0184	0.0281
2004	0.0044	0.0101	0.0192	0.0252
2005	0.0044	0.0089	0.0194	0.025
2006	0.0048	0.0091	0.019	0.0257
2007	0.0045	0.0091	0.0189	0.025
2008	0.0043	0.0092	0.0185	0.0251
2009	0.0042	0.0093	0.0186	0.0255
2010	0.0043	0.0095	0.0188	0.0258
2011	0.0041	0.0097	0.0187	0.026
2012	0.0045	0.0094	0.0187	0.0255
2013	0.0045	0.0094	0.0187	0.0264
2014	0.0044	0.0096	0.0188	0.0263
2015	0.0043	0.0094	0.0186	0.0274
2016	0.0042	0.0095	0.0184	0.0257
2017	0.0043	0.0092	0.0188	0.0259
2018	0.0045	0.0097	0.0186	0.0259
2019	0.0044	0.0096	0.0185	0.0262
2020	0.0046	0.0092	0.0185	0.0263

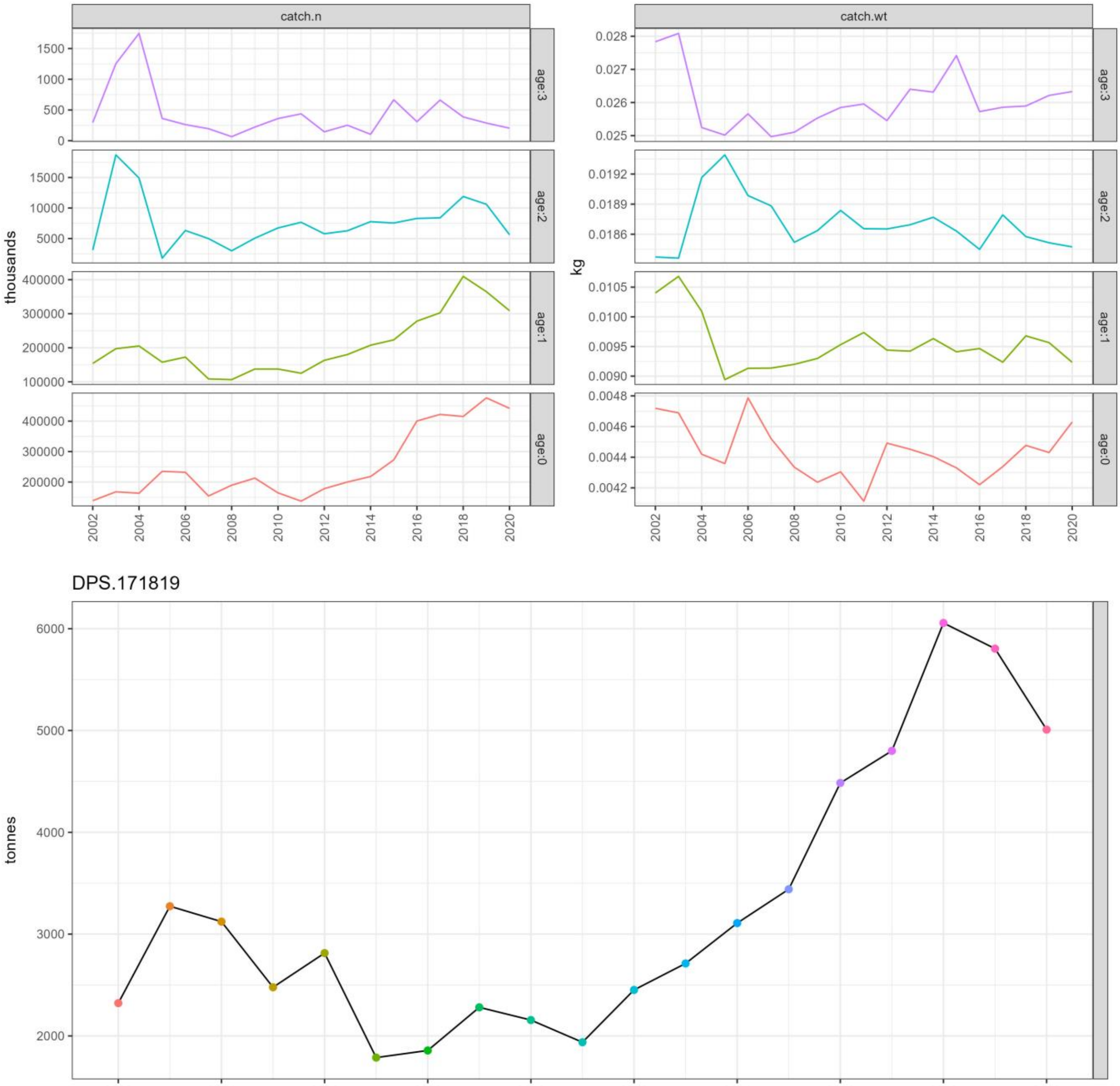


Figure 6.7.3.1.3. Deep-water rose shrimp stocks in GSAs 17-19: Trends of total catch in tonnes, and catch at age and catch weigth used as input in the assessment.

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

6.7.3.2 Results

For the assessment catch were used from 2002 to 2019 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)

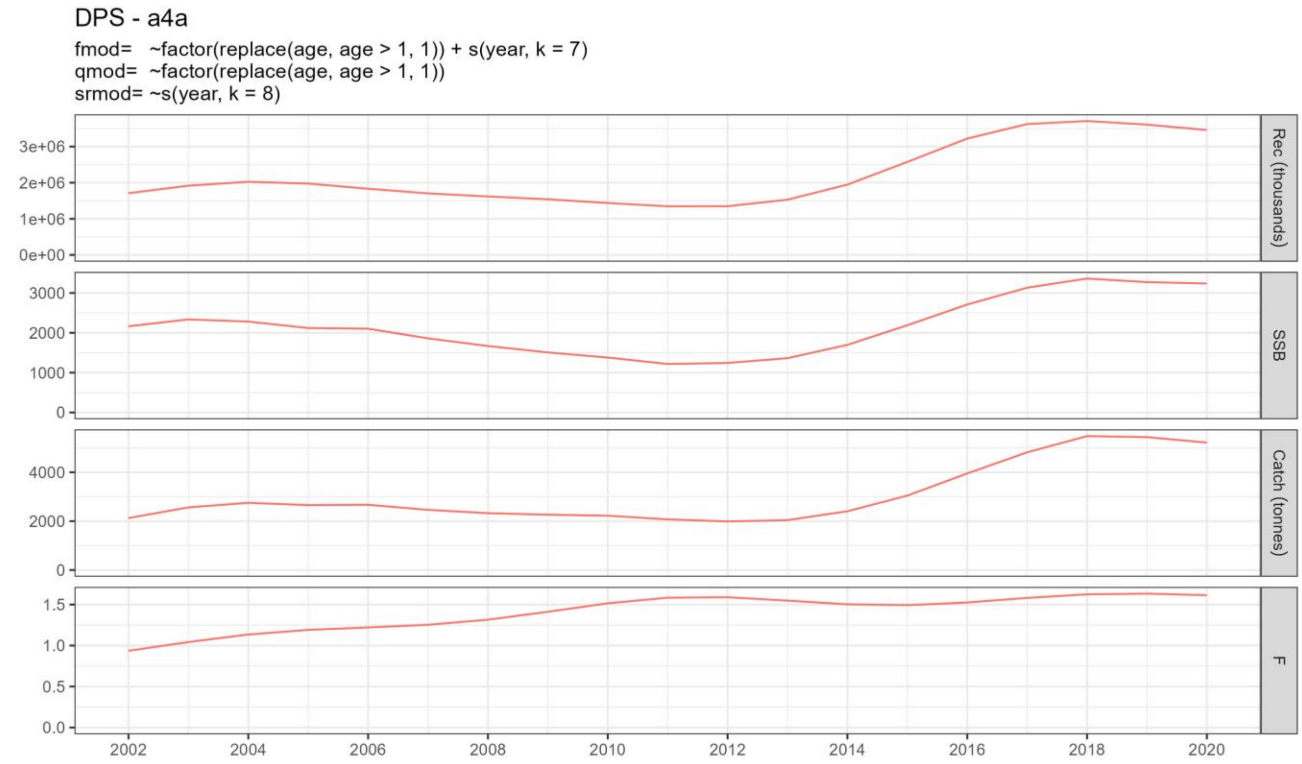


Figure 6.7.3.5. Deep-water rose shrimp stocks in GSAs 17-19: Stock summary from the a4a model for recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality).

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	0.94	1710161	2164	10926	1583
2003	1.04	1916919	2336	12184	1515
2004	1.13	2026625	2282	12235	2925
2005	1.19	1975589	2120	11644	2683
2006	1.22	1833002	2104	11738	2655
2007	1.25	1703895	1862	10434	2350
2008	1.32	1619353	1668	9535	2299
2009	1.41	1541422	1507	8883	2215
2010	1.52	1438376	1379	8403	2165
2011	1.58	1346085	1218	7569	1969
2012	1.59	1348740	1244	7863	1916
2013	1.55	1529795	1363	8600	1966
2014	1.5	1947296	1697	10651	2427
2015	1.49	2575489	2190	13747	3109
2016	1.53	3221716	2710	17045	4079
2017	1.58	3623722	3133	19921	5117
2018	1.62	3708076	3362	21493	5900
2019	1.63	3608000	3273	20907	5667
2020	1.61	3459810	3238	20657	5121

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	1710161	257774.8	8384.85	726.55
2003	1916919	249654.5	27034.57	1163.09
2004	2026625	274314.8	22531.99	3088.36
2005	1975589	285092.8	21762.5	2481.79
2006	1833002	274971.3	20875.89	2164.59
2007	1703895	253712.9	19308.38	1971.4
2008	1619353	234420.6	17022.47	1739.52
2009	1541423	220218	14411.41	1405.32
2010	1438376	205898	11828.81	1034.81
2011	1346085	188447.6	9558.16	726.87
2012	1348740	174124.7	7947.63	527.59
2013	1529795	174277	7283.14	430.89
2014	1947296	199202.9	7725.8	415.46
2015	2575489	255698.3	9405.1	466.81
2016	3221716	338869.2	12257.08	574.54
2017	3623722	421315.3	15514.34	713.11
2018	3708076	468969	17830.69	833.6
2019	3608000	475986.3	18664.08	901.66
2020	3459810	462414	18720.45	934.19

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	0.17	1.32	1.32	1.32
2003	0.19	1.47	1.47	1.47
2004	0.21	1.6	1.6	1.6
2005	0.22	1.68	1.68	1.68
2006	0.23	1.72	1.72	1.72
2007	0.23	1.76	1.76	1.76
2008	0.25	1.85	1.85	1.85
2009	0.26	1.99	1.99	1.99
2010	0.28	2.13	2.13	2.13
2011	0.3	2.23	2.23	2.23
2012	0.3	2.24	2.24	2.24
2013	0.29	2.18	2.18	2.18
2014	0.28	2.11	2.11	2.11
2015	0.28	2.1	2.1	2.1
2016	0.28	2.15	2.15	2.15
2017	0.3	2.22	2.22	2.22
2018	0.3	2.29	2.29	2.29
2019	0.3	2.3	2.3	2.3
2020	0.3	2.27	2.27	2.27

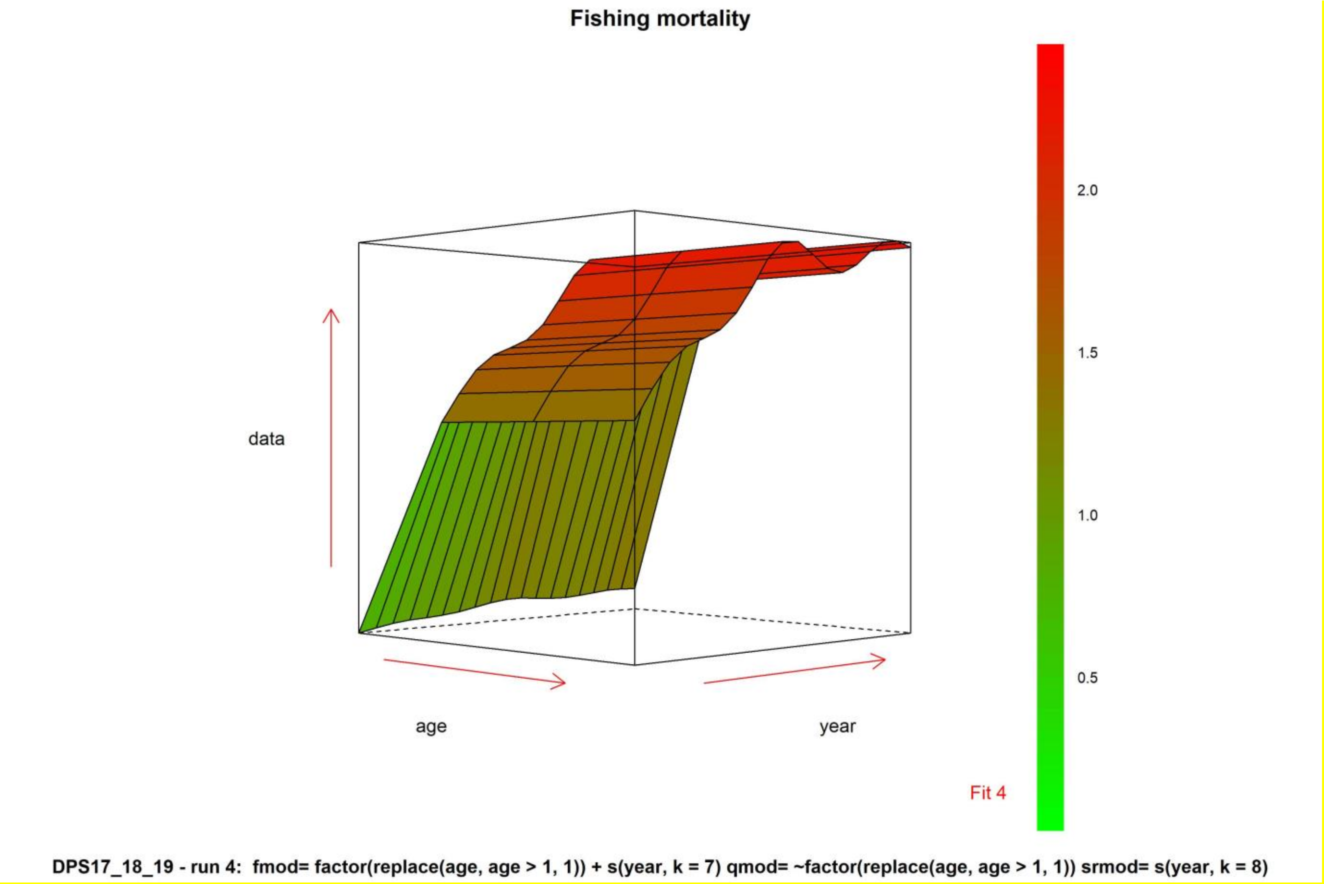


Figure 6.7.3.6. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated fishing mortality at age and year.

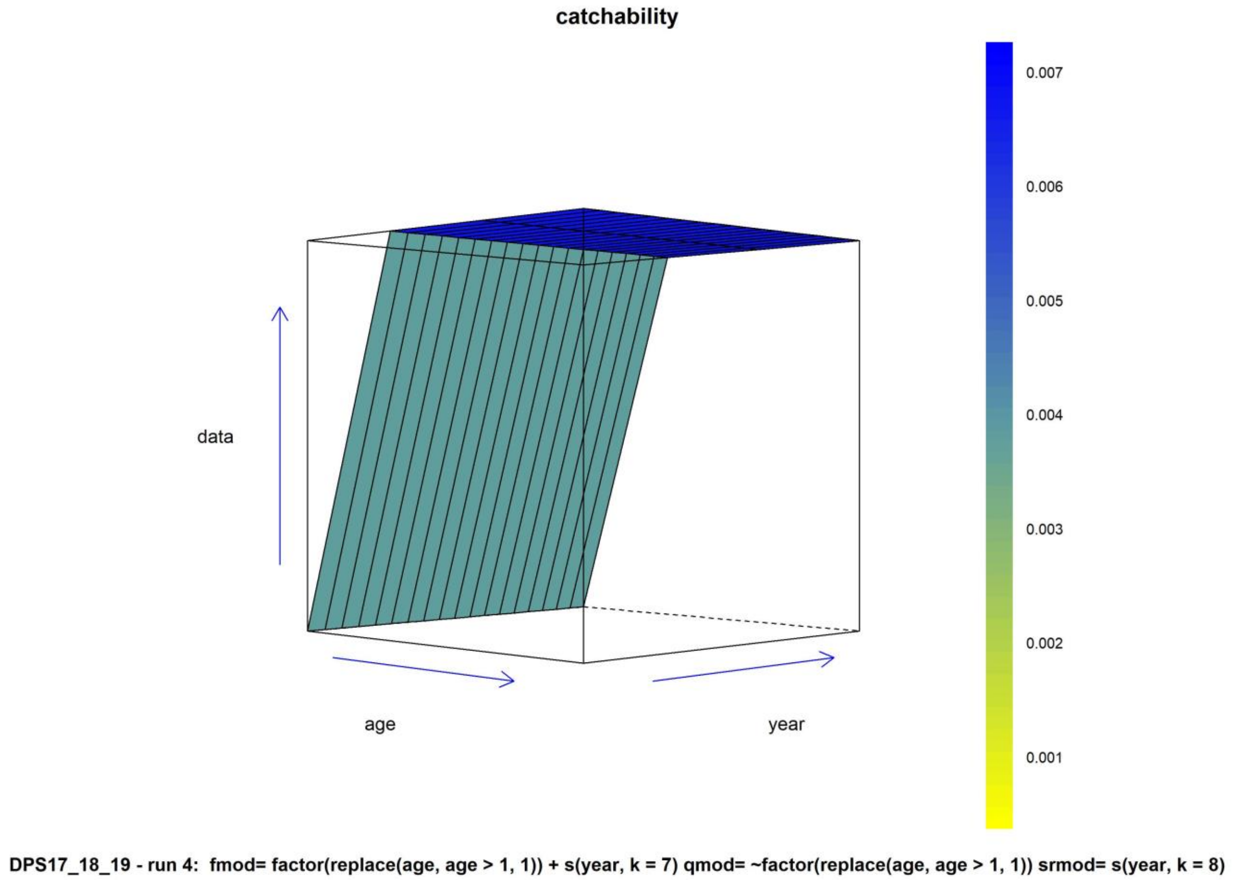


Figure 6.7.3.7. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated catchability at age and year.

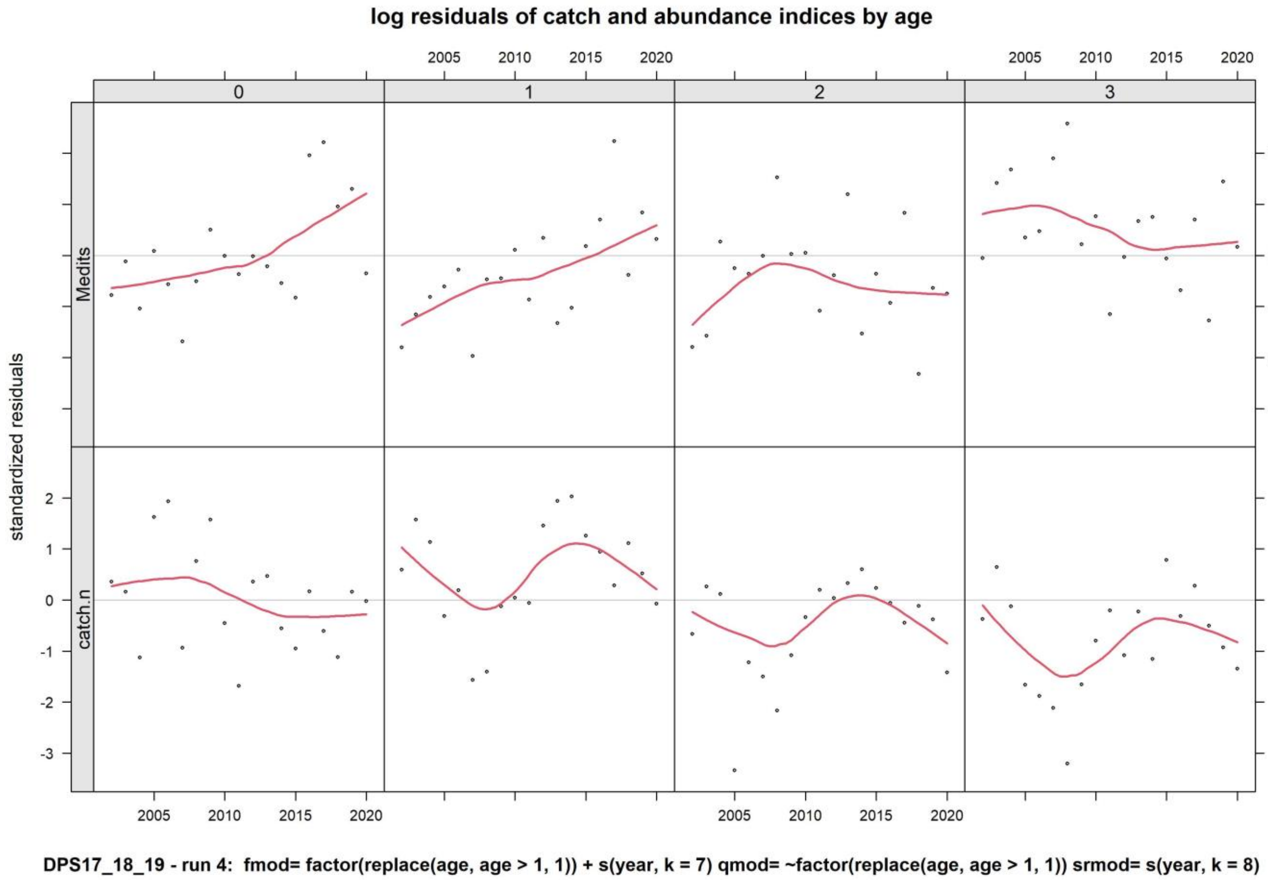


Figure 6.7.3.8. Deep-water rose shrimp stocks in GSAs 17-19. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and red lines a simple smoother.

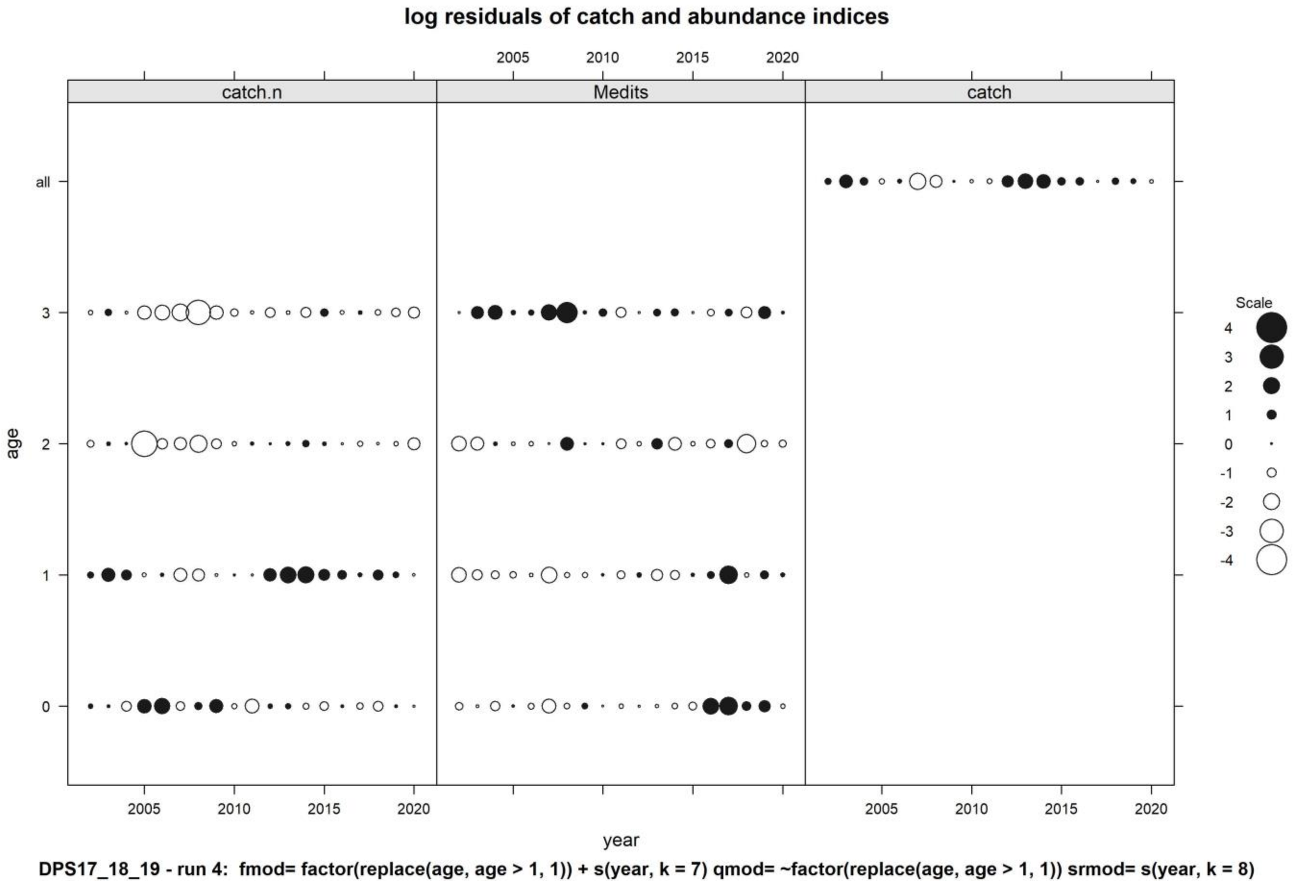


Figure 6.7.3.9. Deep-water rose shrimp stocks in GSAs 17-19. Residuals of residuals for abundance indices and catch by age.

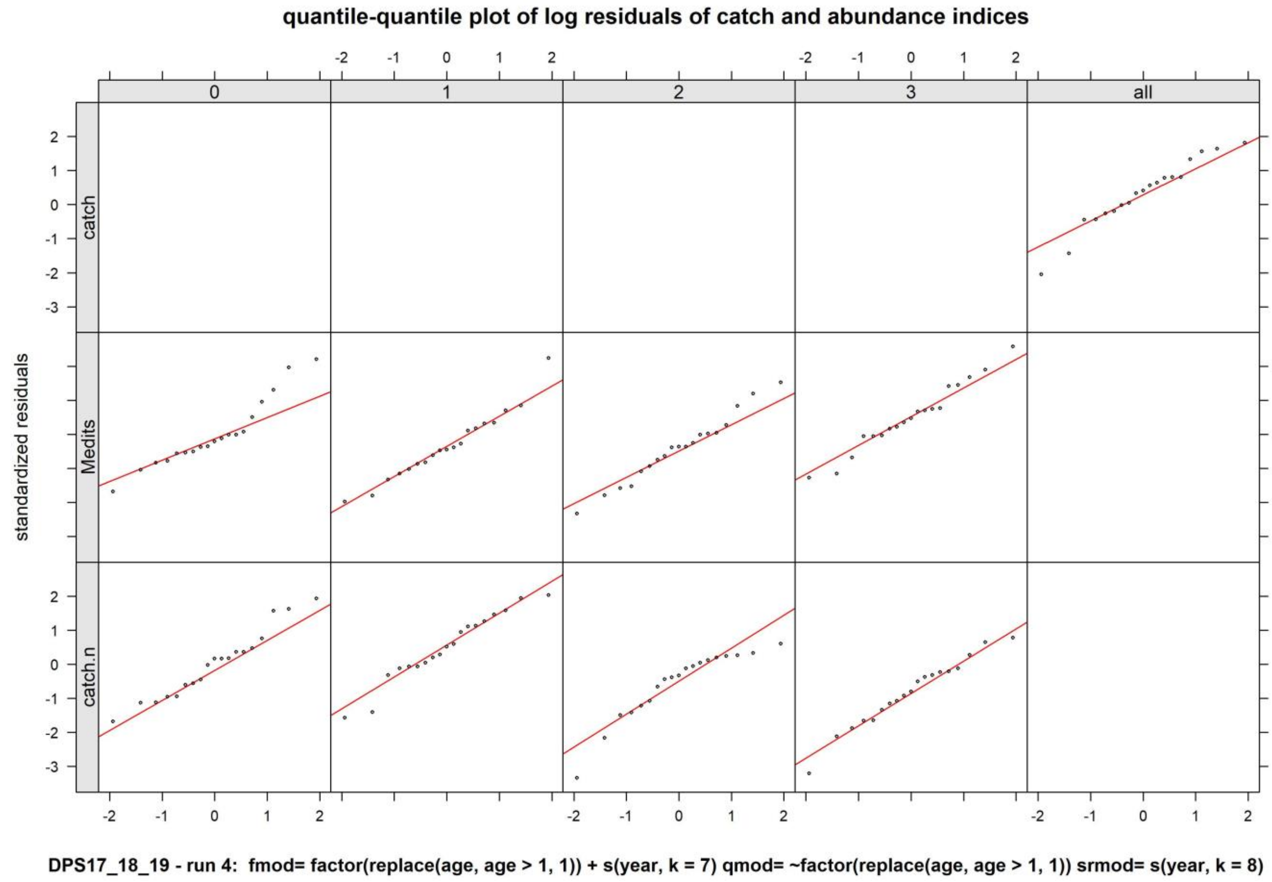
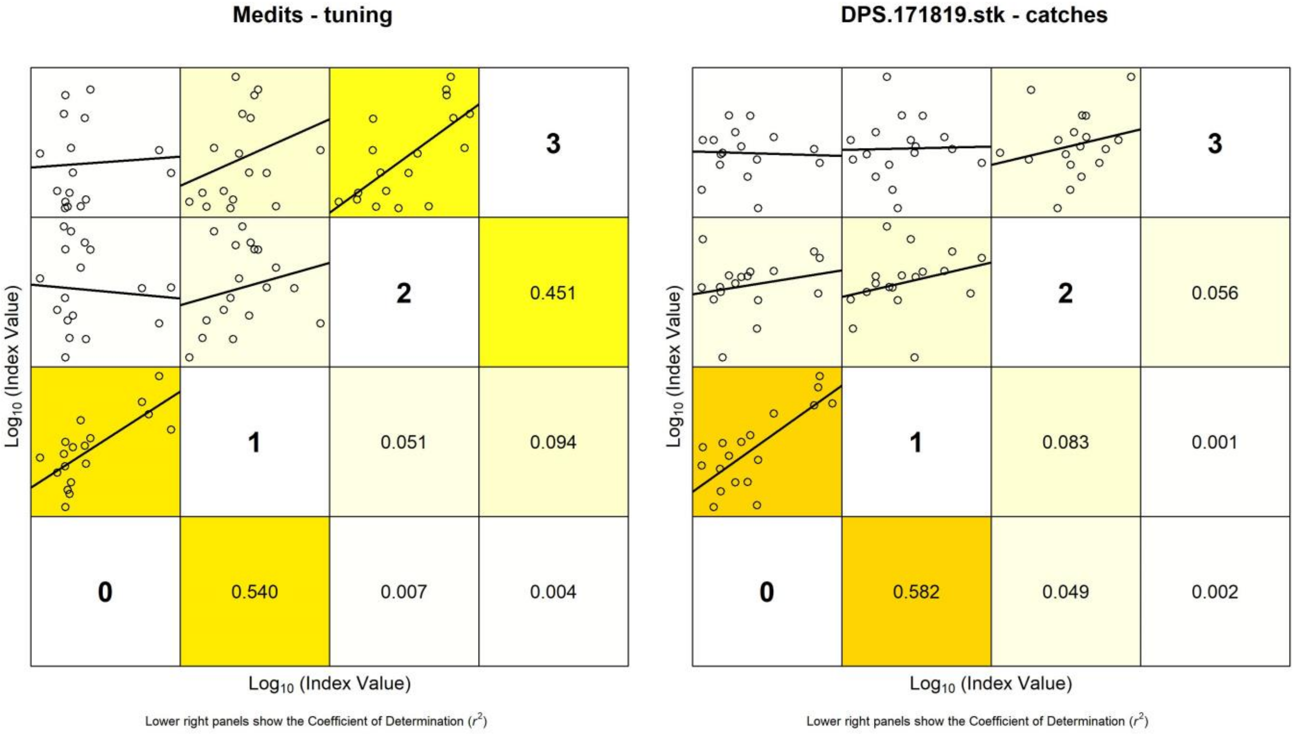


Figure 6.7.3.10. Deep-water rose shrimp stocks in GSAs 17-19. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and red lines the normal distribution quantiles.



Medits - tuning

DPS.171819.stk - catches

Figure 6.7.3.11. Deep-water rose shrimp stocks in GSAs 17-19. Internal consistency in tuning index and catches.

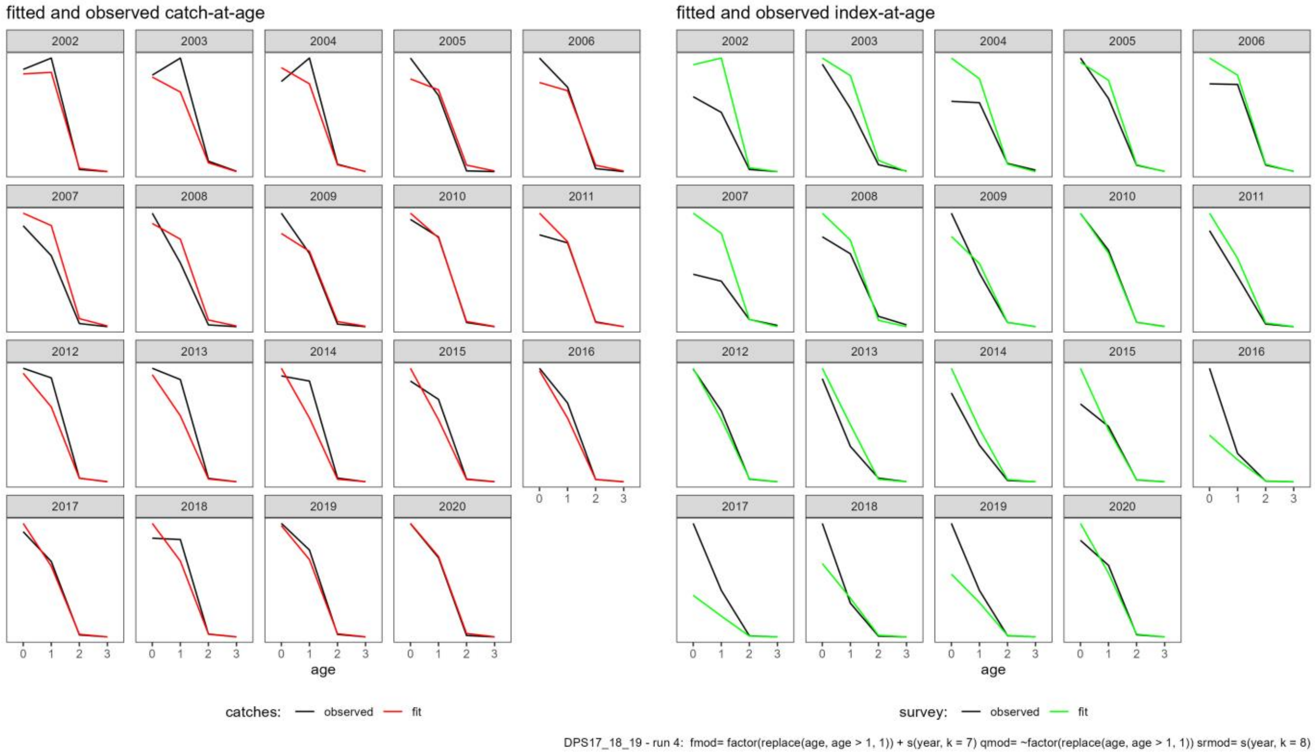


Figure 6.7.3.12. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed catch at age(left panel) and index at age (right panel).

Retrospective

The retrospective analysis applied up to 3 years back shows quite moderate stability for the models (Figure 6.7.3.14).

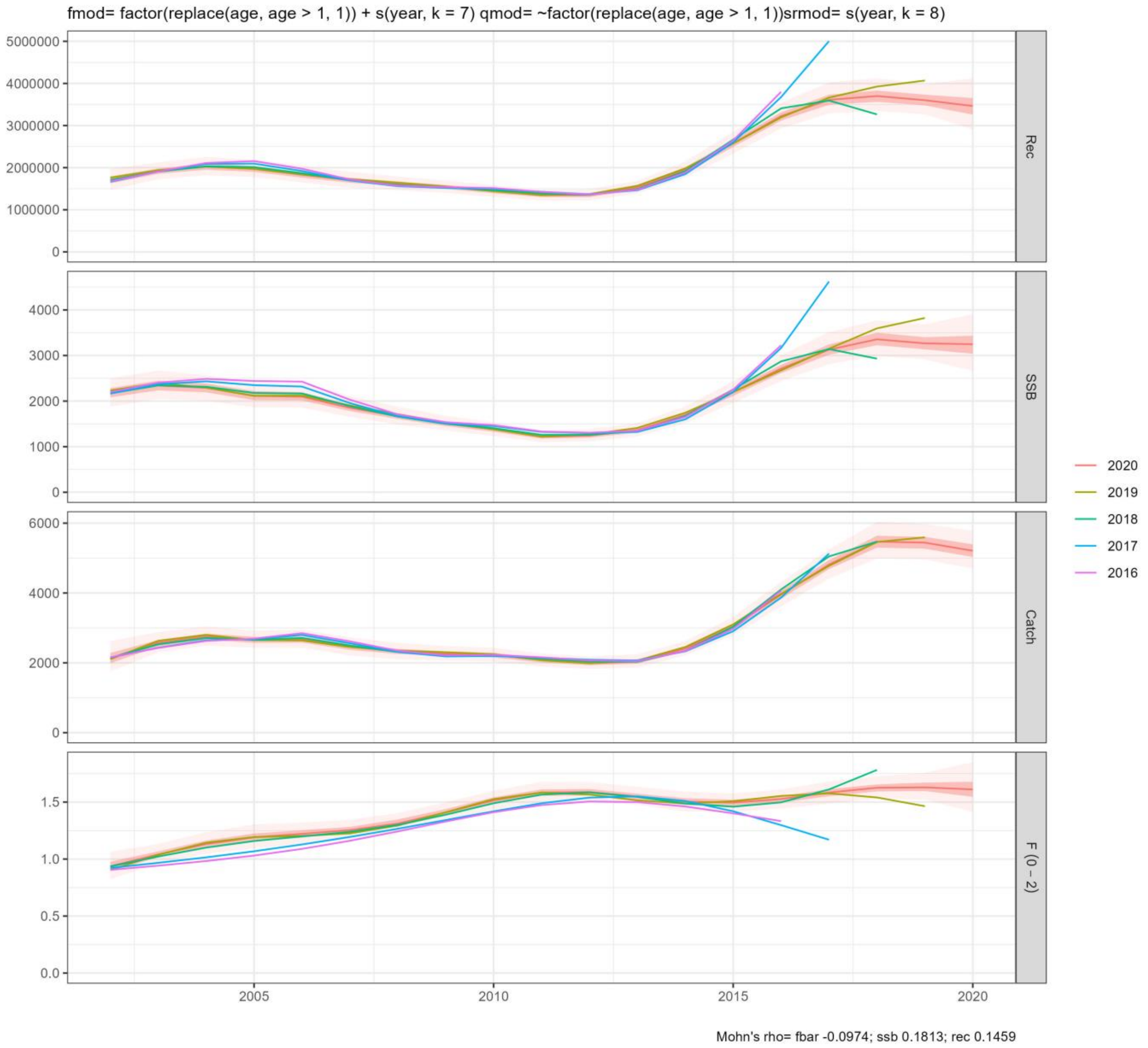


Figure 6.7.3.14. Deep-water rose shrimp stocks in GSAs 17-19: retrospective analysis.

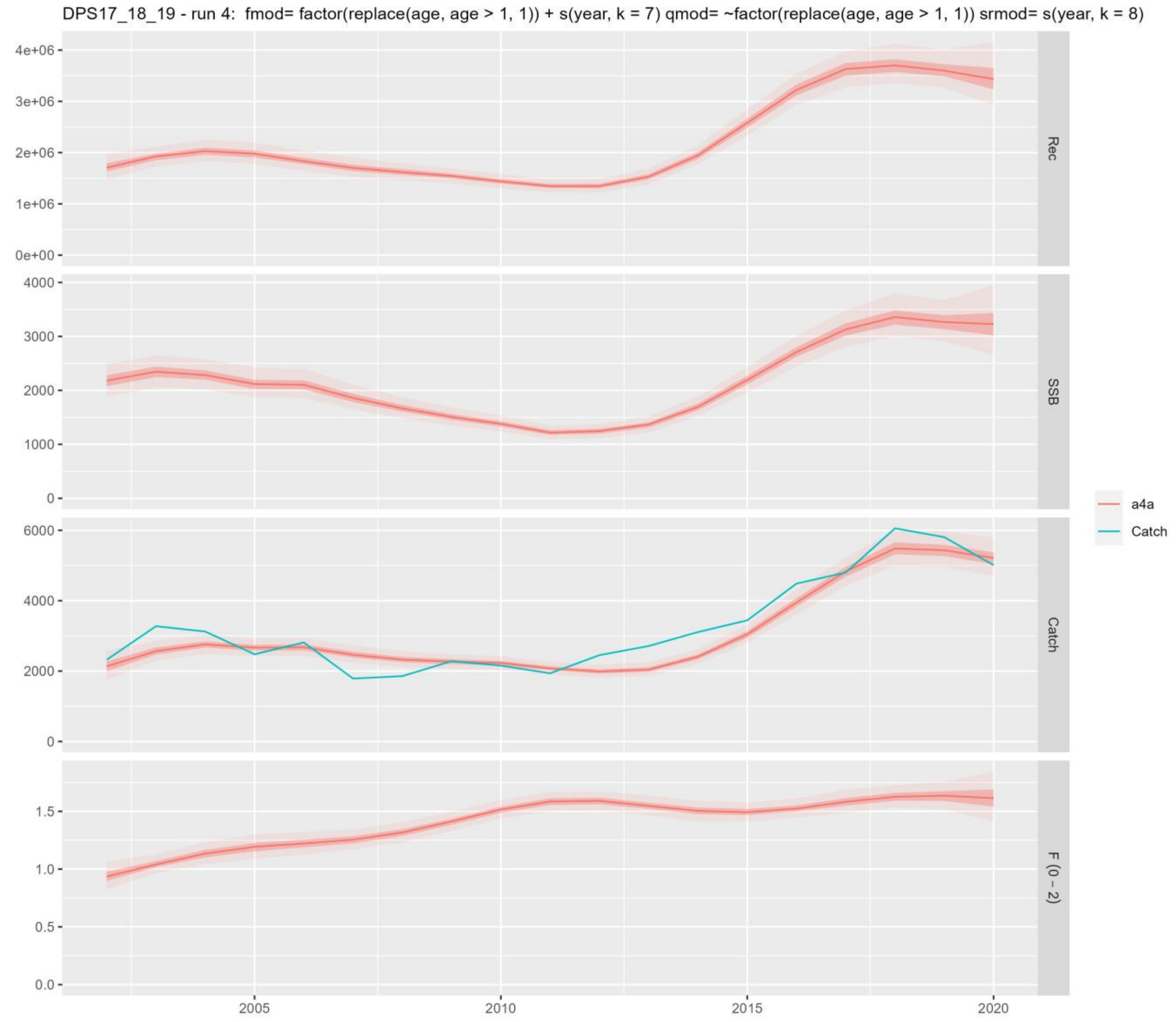


Figure 6.7.3.15. Deep-water rose shrimp stocks in GSAs 17-19: Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals.

Conclusions to the assessment

After an extensive sensitivity analysis of possible model configuration, small changes to the previous EWG 20-15 model have been made.

Based on the assessment results, the Deep-water rose shrimp stocks in GSAs 17-19 shows SSB high fluctuated around a mean value of 2150 tons and, after an increasing trend in the number of recruits from 2014 to 2018, a sligthly decreasing pattern to a value of 3459810 thousands individuals in 2020. Fbar (0-2) fluctuated and shows a increasing trend, with a sligthly deacrease in the last two years (1.61 in 2020).

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, results confirm stock explitation status throughout as being highwith F>F_{MSY} in all retrospective runs in all years, and 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 F0.1 as proxy of FMSY. Reference points were estimated using the FLBRP package and given in Table 6.7.4.1

Considering the F current of 1.49 estimated for 2019, the fishing mortlity level estimated by a4a is well above the reference point F0.1 of 0.504, 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
f0.1	0.718	0. 000111	1	0.00147	0. 00252

6.7.5 Short term Forecast and Catch Options

Arithmetic Mean of last 3 years

F last year of assessment

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} =1.62 as the average of last 3 years from the a4a assessment was used for F in 2021. Recruitment (age 0) for 2020 to 2022 has been estimated from the population results as the geometric mean of the last 3 years (3590507).

Fishing at $F_{0.1}$ in 2020 leads to reduce catch of about 41% (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)	1.624112	Fsq = average of the last 3 years
SSB (2021)	3246.833	SSB intermediate year from STF output

Variable	Value	Notes
Rage0 (2021,2022)	3590507	Recruitment will be set as geometric mean of the last 3 years
Total catch (2021)	5227.598	Catch intermediate year from STF output
Fbar (2019)	1.633247	MAP base year fishing mortality from current assessment
a and b values	a=0.57, b=0.43	Regression parameters from Ftransition regression line

Table 6.7.5.2. Deep-water rose shrimp stocks in GSAs 17-19: Catch options.

Rationale	Ffactor	Fbar	Rt 2021	Fsq 2021	Catch 2020	Catch 2021	Catch 2022	SSB 2023	SSB_change 2021-2023(%)	Catch_change 2020-2022(%)
High long term yield (F0.1)	0.442	0.72	3590507.2	1.62	5215.8	5227.6	3091.9	5024.1	54.7	-40.7
F upper	0.602	0.98	3590507.2	1.62	5215.8	5227.6	3852.8	4333.7	33.5	-26.1
F lower	0.294	0.48	3590507.2	1.62	5215.8	5227.6	2247.0	5908.7	82.0	-56.9
FMSY transition	0.764	1.24	3590507.2	1.62	5215.8	5227.6	4512.5	3814.3	17.5	-13.5
Zero catch	0	0.00	3590507.2	1.62	5215.8	5227.6	0.0	8872.7	173.3	-100.0
Status quo	1	1.62	3590507.2	1.62	5215.8	5227.6	5317.8	3275.4	0.9	2.0
Different Scenarios	0.1	0.16	3590507.2	1.62	5215.8	5227.6	871.1	7618.3	134.6	-83.3
	0.2	0.32	3590507.2	1.62	5215.8	5227.6	1625.9	6639.0	104.5	-68.8
	0.3	0.49	3590507.2	1.62	5215.8	5227.6	2285.4	5865.7	80.7	-56.2
	0.4	0.65	3590507.2	1.62	5215.8	5227.6	2866.5	5247.8	61.6	-45.0
	0.5	0.81	3590507.2	1.62	5215.8	5227.6	3382.9	4748.2	46.2	-35.1
	0.6	0.97	3590507.2	1.62	5215.8	5227.6	3845.8	4339.5	33.7	-26.3
	0.7	1.14	3590507.2	1.62	5215.8	5227.6	4264.1	4001.4	23.2	-18.2
	0.8	1.30	3590507.2	1.62	5215.8	5227.6	4645.1	3718.5	14.5	-10.9
	0.9	1.46	3590507.2	1.62	5215.8	5227.6	4994.7	3479.5	7.2	-4.2
	1.1	1.79	3590507.2	1.62	5215.8	5227.6	5618.4	3099.7	-4.5	7.7
	1.2	1.95	3590507.2	1.62	5215.8	5227.6	5899.5	2947.1	-9.2	13.1
	1.3	2.11	3590507.2	1.62	5215.8	5227.6	6164.1	2813.5	-13.3	18.2
	1.4	2.27	3590507.2	1.62	5215.8	5227.6	6414.1	2695.6	-17.0	23.0
	1.5	2.44	3590507.2	1.62	5215.8	5227.6	6651.5	2590.9	-20.2	27.5
	1.6	2.60	3590507.2	1.62	5215.8	5227.6	6877.6	2497.2	-23.1	31.9
	1.7	2.76	3590507.2	1.62	5215.8	5227.6	7093.9	2413.0	-25.7	36.0
	1.8	2.92	3590507.2	1.62	5215.8	5227.6	7301.3	2336.7	-28.0	40.0
	1.9	3.09	3590507.2	1.62	5215.8	5227.6	7500.8	2267.3	-30.2	43.8
	2	3.25	3590507.2	1.62	5215.8	5227.6	7692.9	2203.7	-32.1	47.5

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 not provided during the meeting. For Albania only one year (2019) of length data was available, wihle for Montenegro no data were provided to EWG 21-15. 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.

6.7.7 Other issues

During the EWG 21-15 some inconsistences were discovered in the data of previous assessment meeting (EWG 20-15). To identify issues and sources of problems a full comparison of raw input data and procedures to generate stock objects used during EWG 20-15 and EWG 21-15 was carried out.

The checking process indicates that during the EWG 20-15 the reconstruction of data particularly in some of the early years was wrong, because data were not scaled correctly. Moreover, a catch weight at age matrix with low values for all ages was used due to an error in the procedure, and double records for 2019 were not removed for GSA 17 as they should be (Figure 6.7.2.1.1). Further for Croatia length distributions from EWG 20-15 and EWG 21-15 are not fully aligned in some years (Figure 6.7.2.1.2).

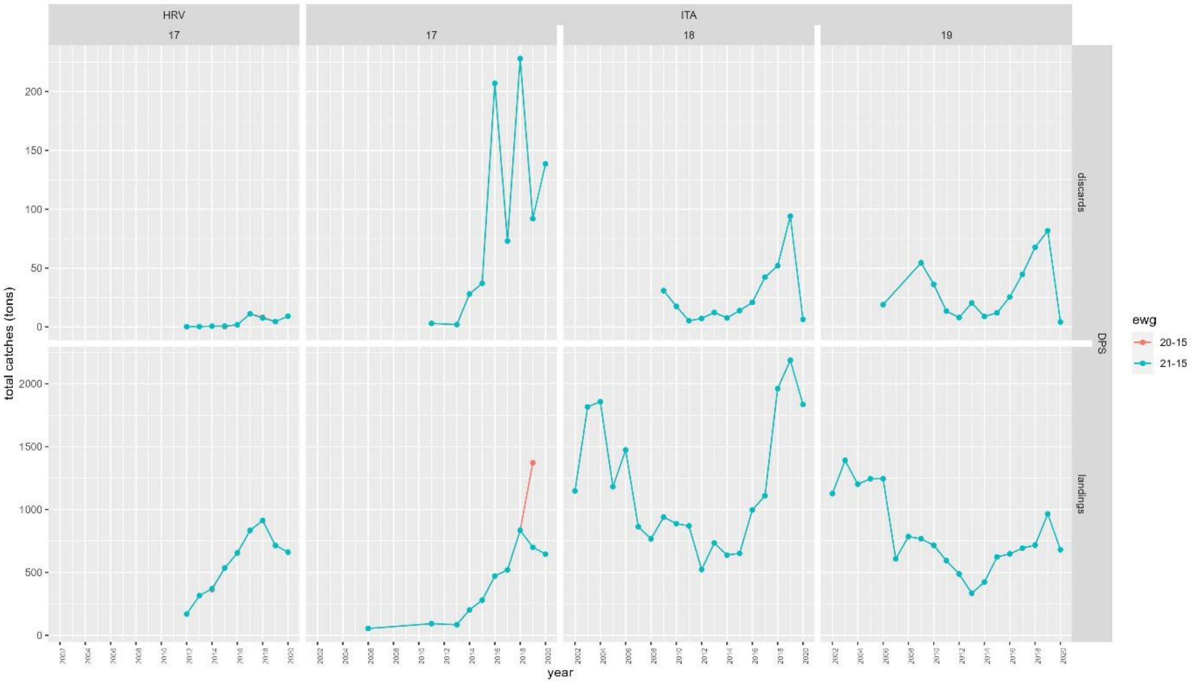


Figure 6.7.2.1.1. Deep-water rose shrimp stocks in GSAs 17-19: Differences in DCF landings and discards given as input to EWG 21-15 and EWG 20-15 (before any reconstruction process).

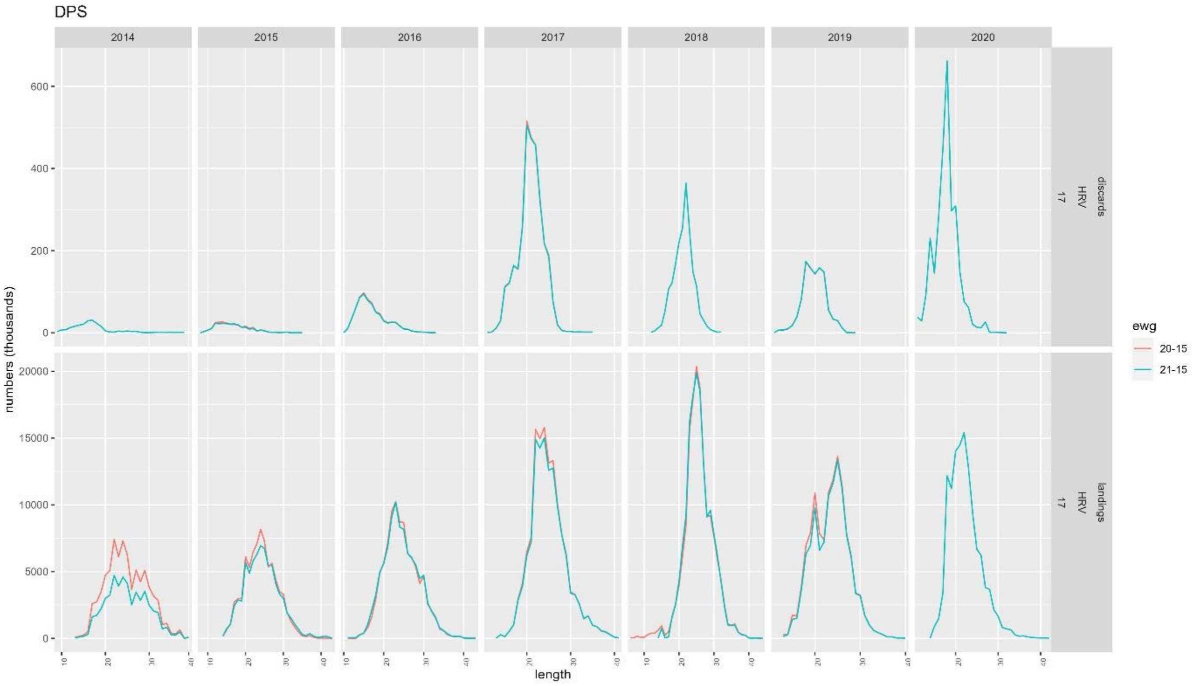


Figure 6.7.2.1.2. Deep-water rose shrimp stocks in GSAs 17-19: Differences in DCF frequency distribution given as input to EWG 21-15 and EWG 20-15 (before any reconstruction process).

When scaling the input data used improperly last year during the EWG 20-15 and updating the catch weight at age matrix with the correct values, a closer picture to the input data used this year during the EWG 21-15 is observed (Figure 6.7.2.1.3).

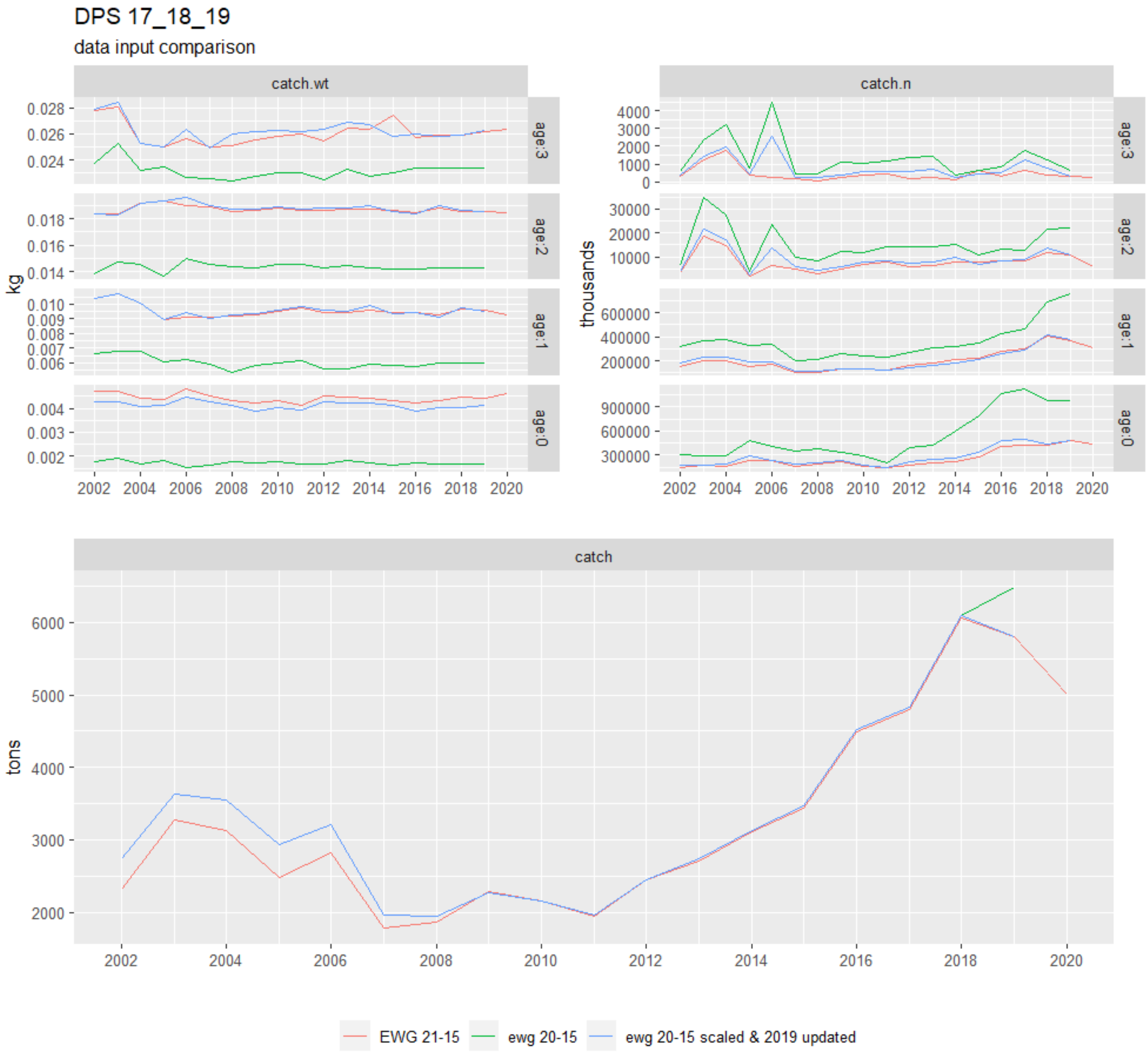
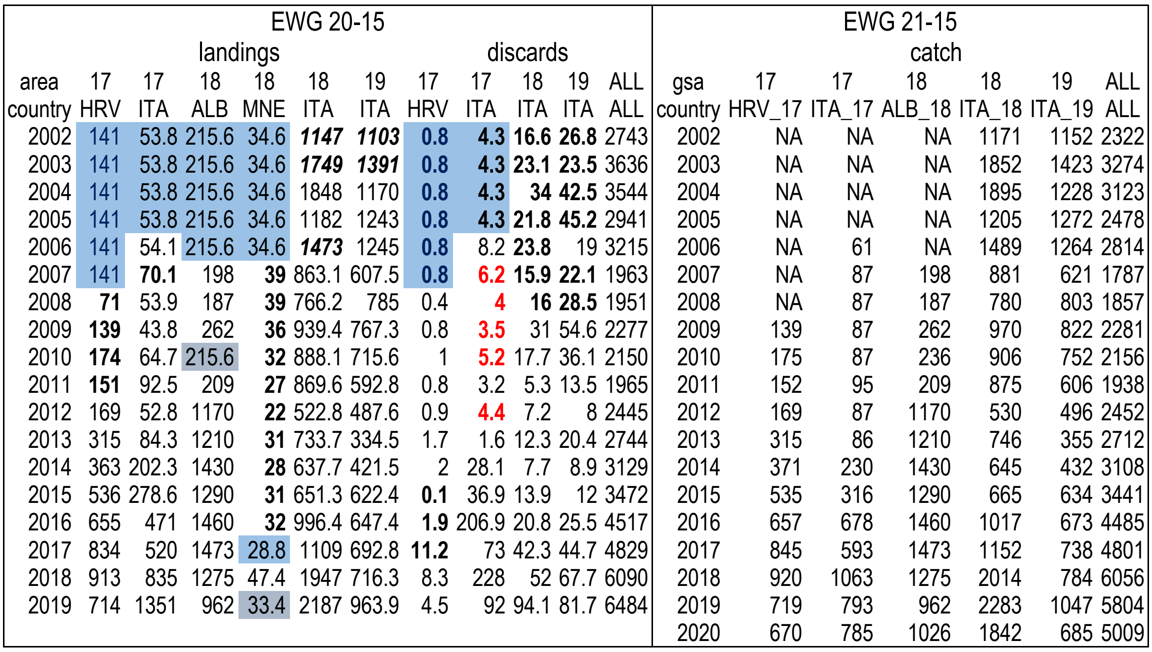


Figure 6.7.2.1.3. Deep-water rose shrimp stocks in GSAs 17-19: Differences in input data between EWG 21-15, last EWG 20-15 as presented in the report, and EWG 20-15 as should be (not present in the EWG 20-15 report).

In terms of total catches the (apart from the 2019 error) the main differences are found at the beginning of the time series (2002-2008) because EWG 20-15 used old reconstruction from other EWGs in which data reconstruction was done also for the years when neither catch nor catch at length were available, and in which data for Montenegro were reconstructed by using few recent years to derive value back to the past for many years (Table 6.7.2.1.1.).

On the contrary, EWG 21-15, following the new procedure introduced by EWG 21-02, generally did not reconstruct data when landings or discards are not available. Very few exceptions were considered when data gaps are limited to few years and in neighbours' years data are present.

Table 6.7.2.1.1. Deep-water rose shrimp stocks in GSAs 17-19: Comparison of catch data in tonnes by OTB as recontstruct by EWG20-15 and EWG21-15. For EWG 20-15 data reconstructed considering the mean proportions between landings and discards in closest years of each fleet are highlighted in blue, data taken from previous report are in bold, data updated by EWG are in bold and italic.



	EWG 20-15										
	landings						discards				
area	17	17	18	18	18	19	17	17	18	19	ALL
country	HRV	ITA	ALB	MNE	ITA	ITA	HRV	ITA	ITA	ITA	ALL
2002	141	53.8	215.6	34.6	***1147***	***1103***	**0.8**	**4.3**	**16.6**	**26.8**	2743
2003	141	53.8	215.6	34.6	***1749***	***1391***	**0.8**	**4.3**	**23.1**	**23.5**	3636
2004	141	53.8	215.6	34.6	1848	1170	**0.8**	**4.3**	**34**	**42.5**	3544
2005	141	53.8	215.6	34.6	1182	1243	**0.8**	**4.3**	**21.8**	**45.2**	2941
2006	141	54.1	215.6	34.6	***1473***	1245	**0.8**	8.2	**23.8**	19	3215
2007	141	**70.1**	198	**39**	863.1	607.5	**0.8**	**6.2**	**15.9**	**22.1**	1963
2008	**71**	53.9	187	**39**	766.2	785	0.4	**4**	**16**	**28.5**	1951
2009	**139**	43.8	262	**36**	939.4	767.3	0.8	**3.5**	31	54.6	2277
2010	**174**	64.7	215.6	**32**	888.1	715.6	1	**5.2**	17.7	36.1	2150
2011	**151**	92.5	209	**27**	869.6	592.8	0.8	3.2	5.3	13.5	1965
2012	169	52.8	1170	**22**	522.8	487.6	0.9	**4.4**	7.2	8	2445
2013	315	84.3	1210	**31**	733.7	334.5	1.7	1.6	12.3	20.4	2744
2014	363	202.3	1430	**28**	637.7	421.5	2	28.1	7.7	8.9	3129
2015	536	278.6	1290	**31**	651.3	622.4	**0.1**	36.9	13.9	12	3472
2016	655	471	1460	**32**	996.4	647.4	**1.9**	206.9	20.8	25.5	4517
2017	834	520	1473	28.8	1109	692.8	**11.2**	73	42.3	44.7	4829
2018	913	835	1275	47.4	1947	716.3	8.3	228	52	67.7	6090
2019	714	1351	962	33.4	2187	963.9	4.5	92	94.1	81.7	6484

	EWG 21-15					
			catch			
gsa	17	17	18	18	19	ALL
country	HRV_17	ITA_17	ALB_18	ITA_18	ITA_19	ALL
2002	NA	NA	NA	1171	1152	2322
2003	NA	NA	NA	1852	1423	3274
2004	NA	NA	NA	1895	1228	3123
2005	NA	NA	NA	1205	1272	2478
2006	NA	61	NA	1489	1264	2814
2007	NA	87	198	881	621	1787
2008	NA	87	187	780	803	1857
2009	139	87	262	970	822	2281
2010	175	87	236	906	752	2156
2011	152	95	209	875	606	1938
2012	169	87	1170	530	496	2452
2013	315	86	1210	746	355	2712
2014	371	230	1430	645	432	3108
2015	535	316	1290	665	634	3441
2016	657	678	1460	1017	673	4485
2017	845	593	1473	1152	738	4801
2018	920	1063	1275	2014	784	6056
2019	719	793	962	2283	1047	5804
2020	670	785	1026	1842	685	5009

To see the impact of these differences in term of the assessment, EWG 21-15 models with the same settings all the three different data sources. The exercise shows that the major differences are on SSB and recruitment estimations and are due to both differences in reconstructed data and catch at weight at age structures (Figure 6.7.2.1.4).

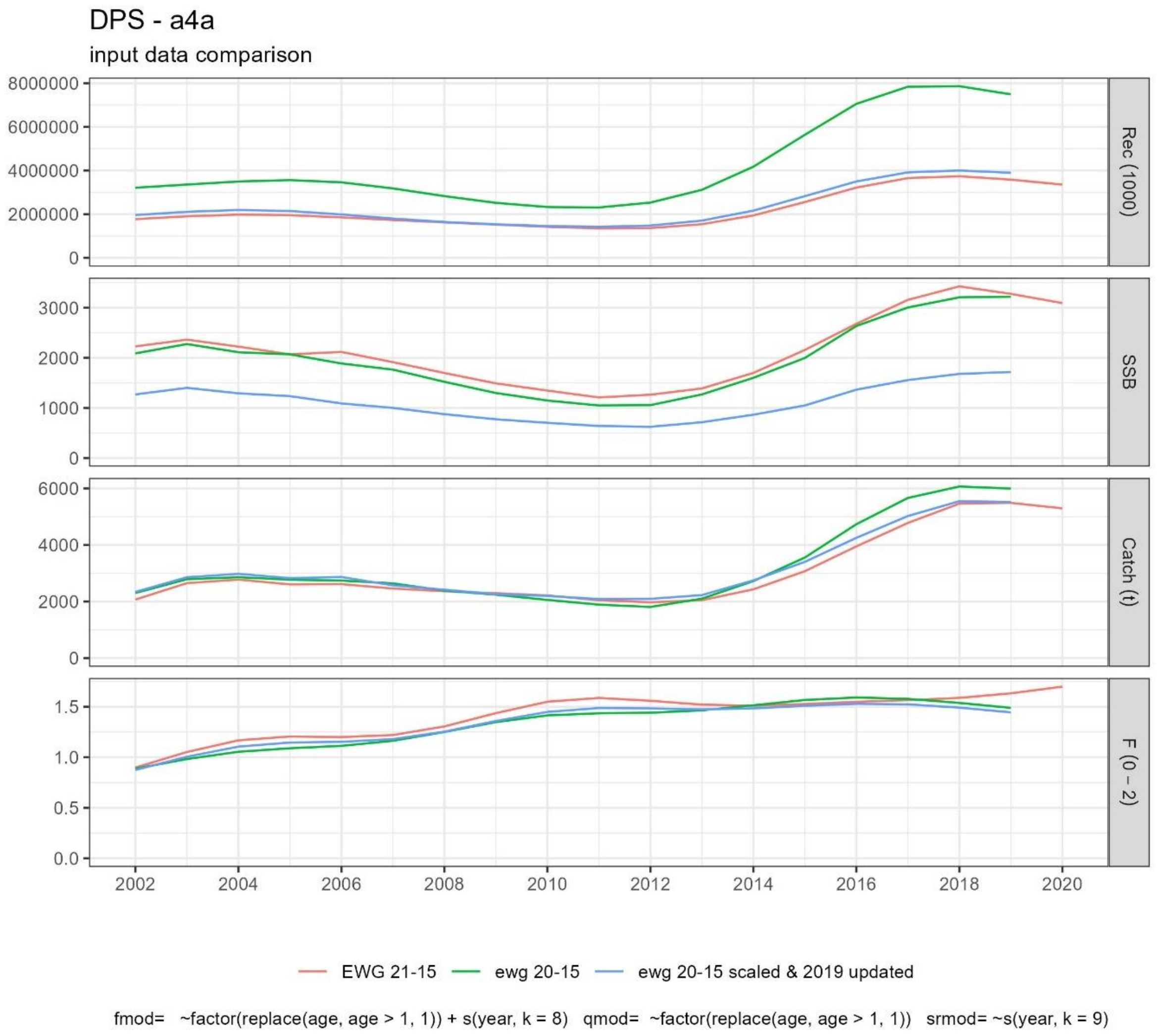


Figure 6.7.2.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Comparison of stock summaries using with different data sources the same a4a model for recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality).

Considering the thoughtful and meticulous quality check by EWG 21-02 and by EWG 21-15 and taking in to account the comparison of outputs from the same model run with different data, EWG 21-15 conclude that the new data input set for the assessment of DPS in GSAs 17, 18 and 19 combined, are to be used for the evaluation of the status of this stock in the Adriatic Sea.

When considering the consequences of the scaling that was incorrect in 2020 the comparison of the two sets in Figure 6.7.2.1.4. F was effectively unaffected by the issues, thus f advice in terms of F0.1 and F status quo were unaffected. SSB was effectively unaffected by the differences. Recruitment last year was incorrectly scaled to compensate for the errors in mean weights, however the relative recruitment was unaffected and the influence on catch advice of incorrect recruitment did not in itself effect the advice for 2021. Due mostly to the double reported catch in 2019 the overall catch was changed by around 10% in the last years, this would have resulted in a small change in advised catch in 2021 given last year, however the F advice was unaffected. So overall the conclusion is that although incorrect scaling occurred the main advice parameters in F were not significantly affected.

6.8 GIANT RED SHRIMP GSA 18,19,20

6.8.1 STOCK IDENTITY AND BIOLOGY

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. The species has been reported to occur in the Mediterranean, the Atlantic, the Indian Ocean, the western Pacific (Perez Farfante and Kensley, 1997) and South Africa (Bianchini, 1999). 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 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.

The assessment on giant red shrimp carried out during the STECF EWG 21-15 considered the stock confined within the boundaries of GSA 18, 19 and 20 (Fig.). As initial stock object was used one for giant red shrimp assessed within GFCM, 2020 in GSA 18-19.

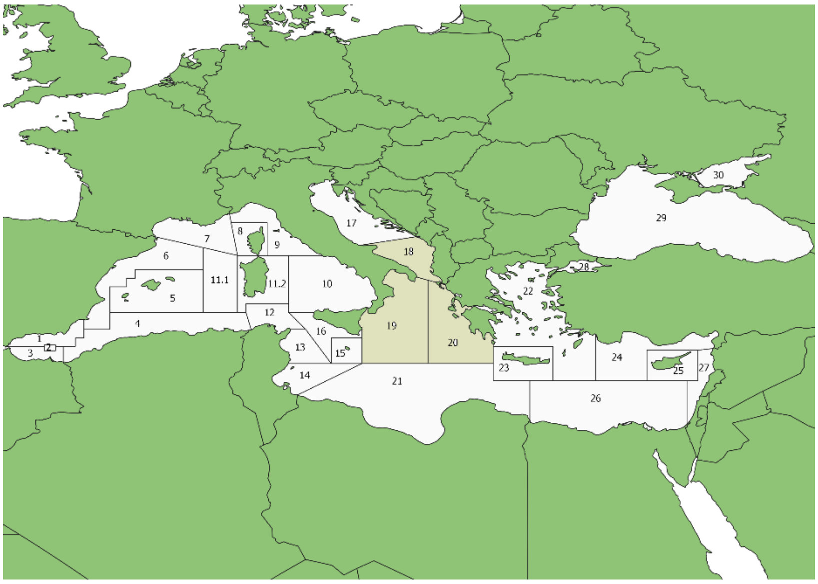


Figure 6.8.1.1. Geographical location of the GSA 18, GSA 19 and GSA 20

Table 6.8.1.1 Giant red shrimp in GSA 18-20 Growth parameters from DCF data

Source	L_{inf}	k	t_0	Sex
GFCM, 2020	53	0.36	-0.1	M
	74	0.44	-0.16	F

Growth parameters used in EWG 21-15 were ones used in the previous assessment of GFCM, differentiating between males and females. There were applied to the 2020 length data and added to previous stock object.

Table 6.8.1.2. Giant red shrimp in GSA 18-20. Length weight parameters from DCF data

	a	b
Males	0.001	2.75
Females	0.001	2.65

Length-weight parameters used in EWG 21-15 were ones used in the previous assessment of GFCM, differentiating between males and females.

Table 6.8.1.3. Giant red shrimp in GSA 18-20. Maturity and mortality at age vectors used in the assessment.

	0	1	2	3	4
Maturity	0	0.3185	0.9580	1	1

Maturity parameters used in EWG 21-15 were ones used in the previous assessment of GFCM, suggesting all of the specimens were mature after second year of life.

6.8.2 DATA

6.8.2.1 CATCH (LANDINGS AND DISCARDS)

Data used in the last GFCM assessment was used with one more year (2020) added to GSA 18 and GSA 19 data. Additionally, GSA 20 landings, which are not big amount in relationship with other areas, was added and SOP was applied effectively applying LFD from 18/19 to the small additional landings from GSA 20.

Table 6.8.2.1. Giant red shrimp in GSA 18-20. Landings by GSA. The value for GSA 20 in 2017 is not known.

Year	ITALY GSA 18	ITALY GSA 19	GREECE GSA 20
2003	198	4	-
2004	89	63	-
2005	72	55	-
2006	169	236	-
2007	115	199	-
2008	97	133	-
2009	88	226	-
2010	127	301	-
2011	75	347	-
2012	15	262	-
2013	15	349	-
2014	8	320	6
2015	9	646	7
2016	14	690	27
2017	141	509	-
2018	176	162	33
2019	106	157	37
2020	133	218	35

Discards for this species were negligible so all of the analyses were done on the catch data. Almost all of the landings were done with otter bottom trawl fishing gear in GSA 18 and 19 by Italy (fig 6.8.2.1.1-.3.).

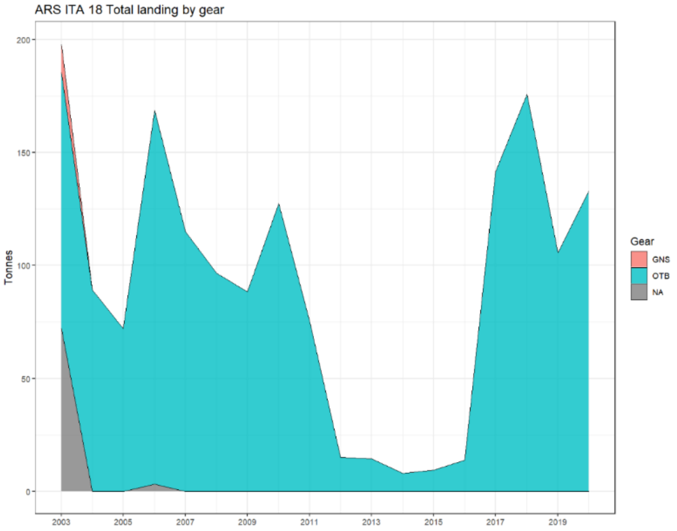


Figure 6.8.2.1.1. Giant red shrimp in GSA 18-20. Landings (in tonnes) in GSA 18

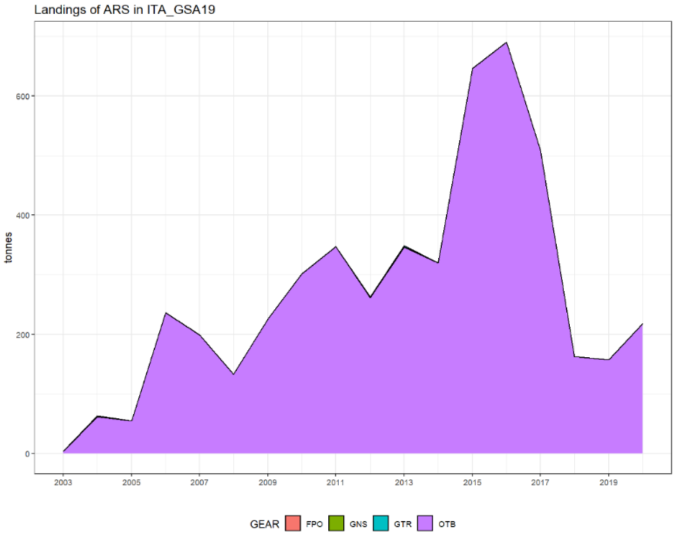


Figure 6.8.2.1.2. Giant red shrimp in GSA 18-20. Landings (in tonnes) in GSA 19

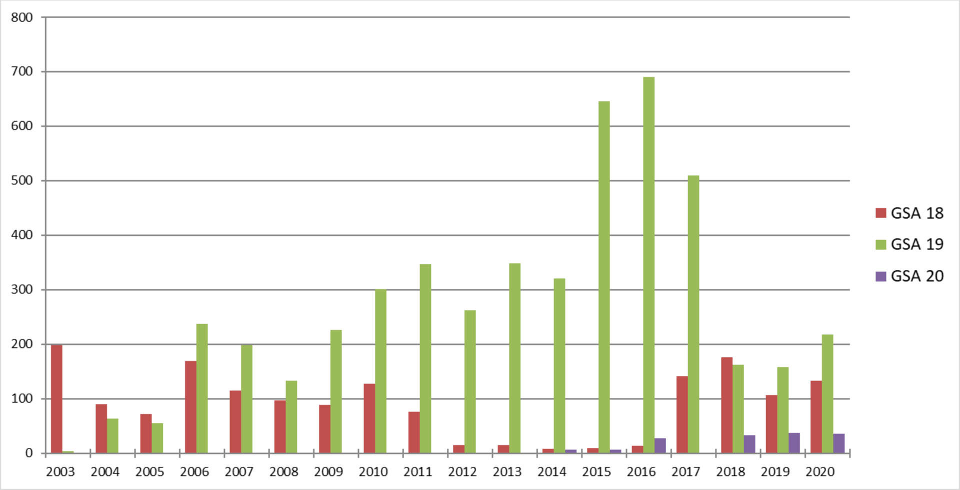


Figure 6.8.2.1.3. Giant red shrimp in GSA 18-20. Landings (in tonnes) in GSA 18-20

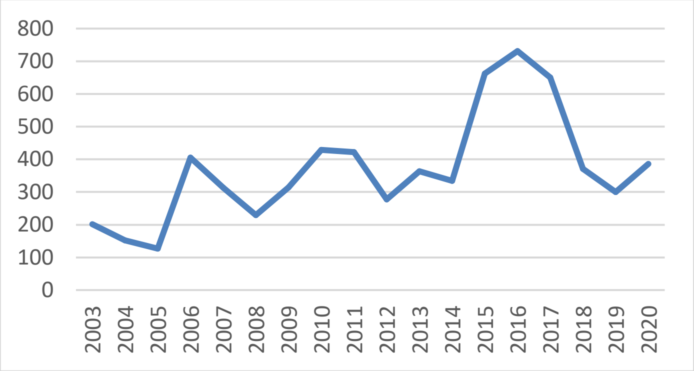


Figure 6.8.2.1.4. Giant red shrimp in GSA 18-20. Total Landings (in tonnes).

6.8.2.2 SURVEY DATA

Since 1994, one survey has been carried out every year, during the spring and the beginning of summer. The duration of the hauls is fixed to 30 minutes on depths less than 200 m and 60 minutes on more important depths. 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. 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 kilometre, using the swept area method. Since 1994, MEDITS trawl surveys has been regularly carried out yearly during the spring season (May-July Figure 6.8.2.2.1.). In 2014 the survey was carried out in September and in 2017 – in November-December. Data were analysed using the JRC script (Mannini, 2020). For the assessment only MEDITS data from GSA 18 and 18 were used and the index of GSA 20 was not used given the gaps in the survey in that GSA in years 2002, 2009-2013 and 2015.

Figure 6.8.2.2.1. Giant red shrimp in GSA 18-20 survey periods for GSA 18-19

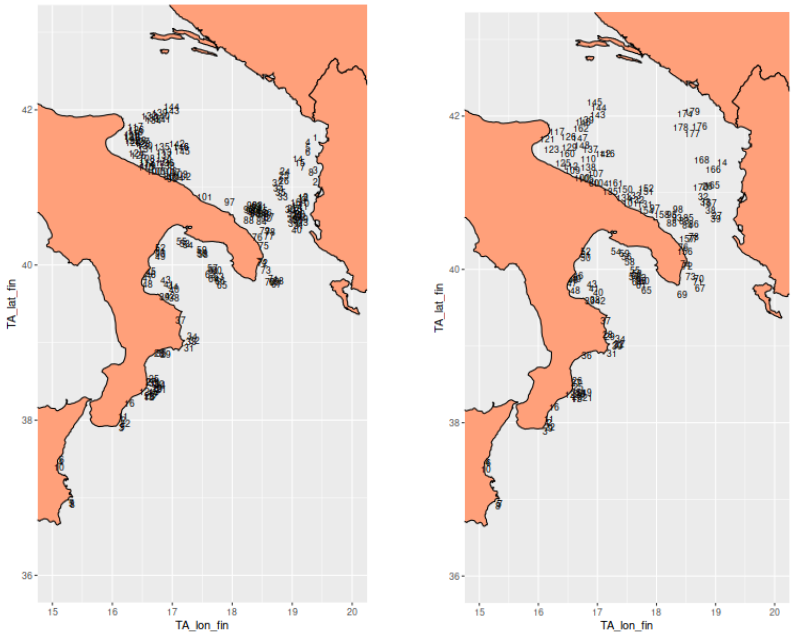


Figure 6.8.2.2.2. Giant red shrimp in GSA 18-19 positioning of the hauls (in two example years) for GSA 18-19

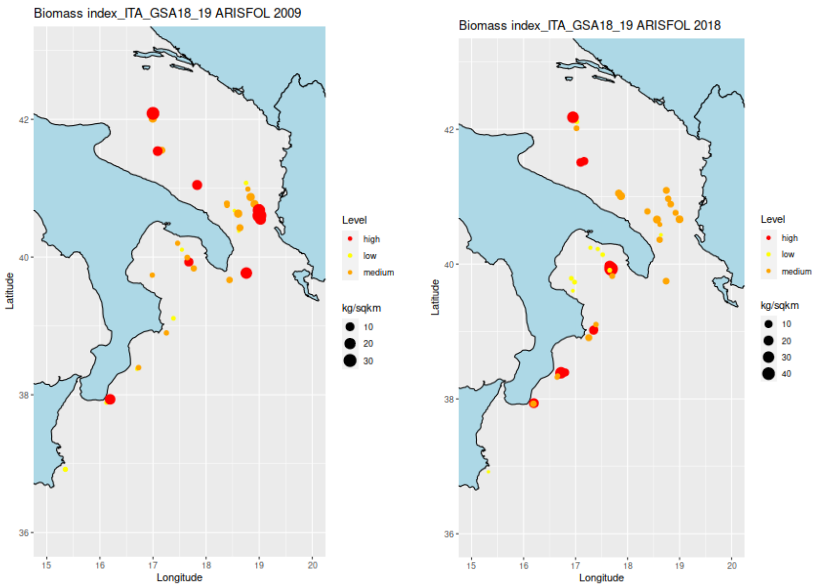


Figure 6.8.2.2.3. Giant red shrimp in GSA 18-19 biomass index (in two example years) for GSA 18-19

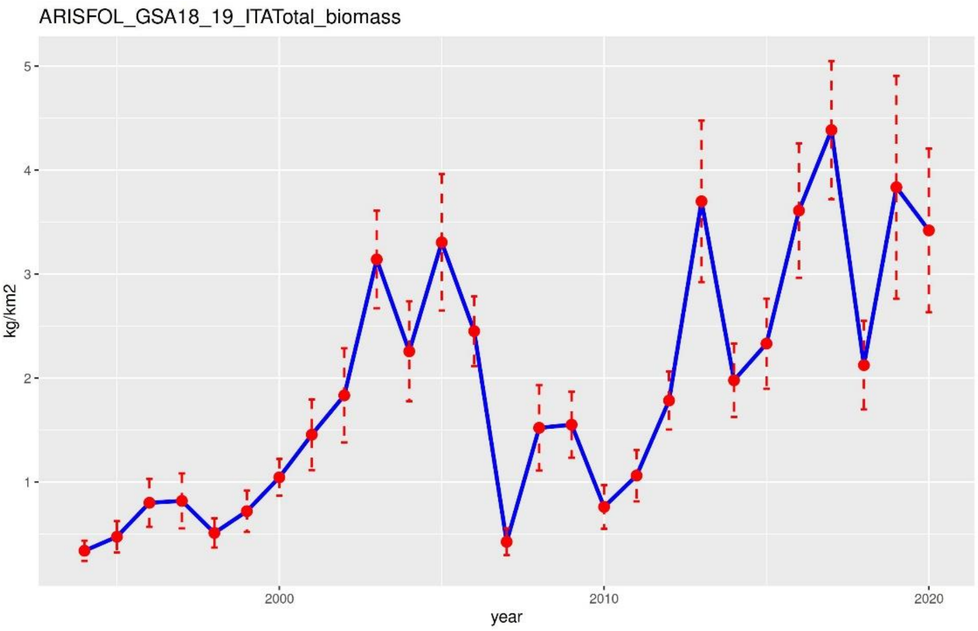


Figure 6.8.2.2.4. Giant red shrimp in GSA 18-19 biomass index

6.8.3 STOCK ASSESSMENT

The whole stock (GSA 18, 19 & 20) was not previously assessed. A part of the stock including only GSAs 18 and 19 was assessed by the GFCM in 2019 (GFCM 2019) using a4a. The present assessment was carried out using a statistical catch-at age modelling framework - Assessment for all (a4a, Jardim et al., 2014) in FLR (http://www.flr-project.org/).

A statistical catch at age (a4a) assessment was attempted and various model runs were accomplished. As certain input parameters, such as growth, were uncertain and important survey gaps exist in GSA 20, the outputs were questionable. Therefore, the EWG suggested providing advice through a biomass index, based on the temporary consistent surveys.

Input data

As discards for this species are negligible, assessment section landings values will be referring to catch values.

Data suggested that most of the specimens were of age 1 or 2 with increased presence of age 4 in some of the years (fig 6.8.3.1). Mean weight of the ages varied slightly over the years (fig 6.8.3.2.).

Internal consistency showed not very consistent cohort development over time especially within MEDITS index (Figure 6.8.3.5).

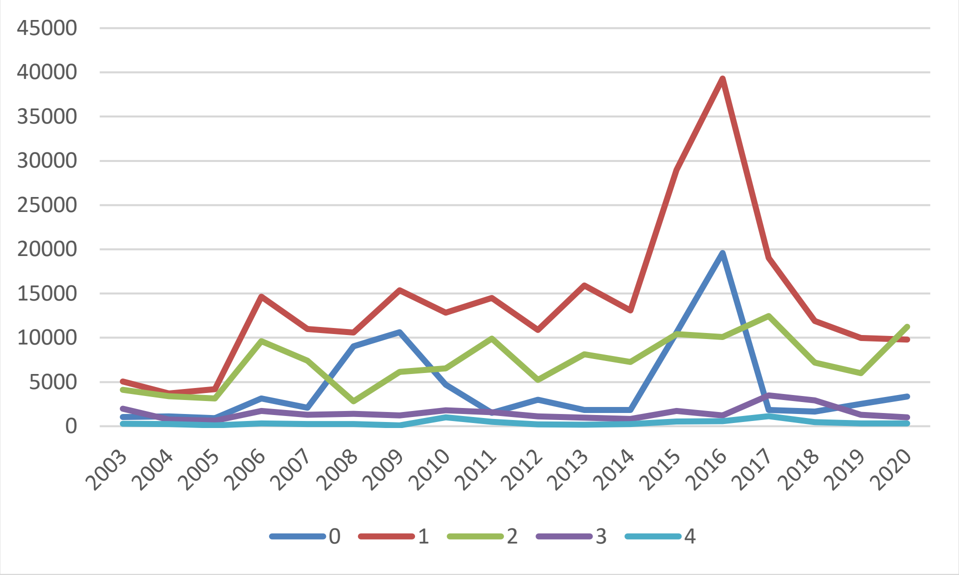


Figure 6.8.3.1. Giant red shrimp in GSA 18-20. Catch numbers for stock

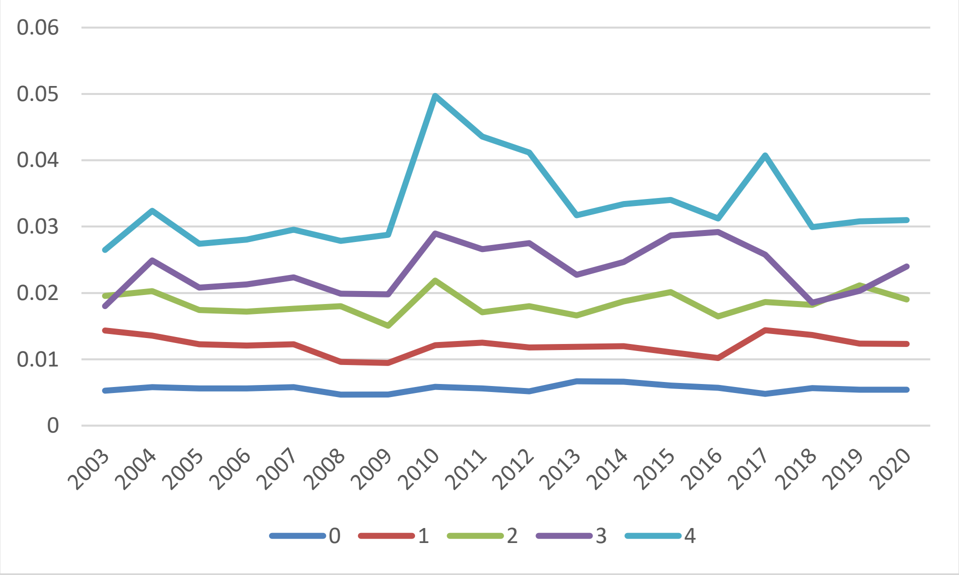


Figure 6.8.3.2. Giant red shrimp in GSA 18-20. Weight at age for stock

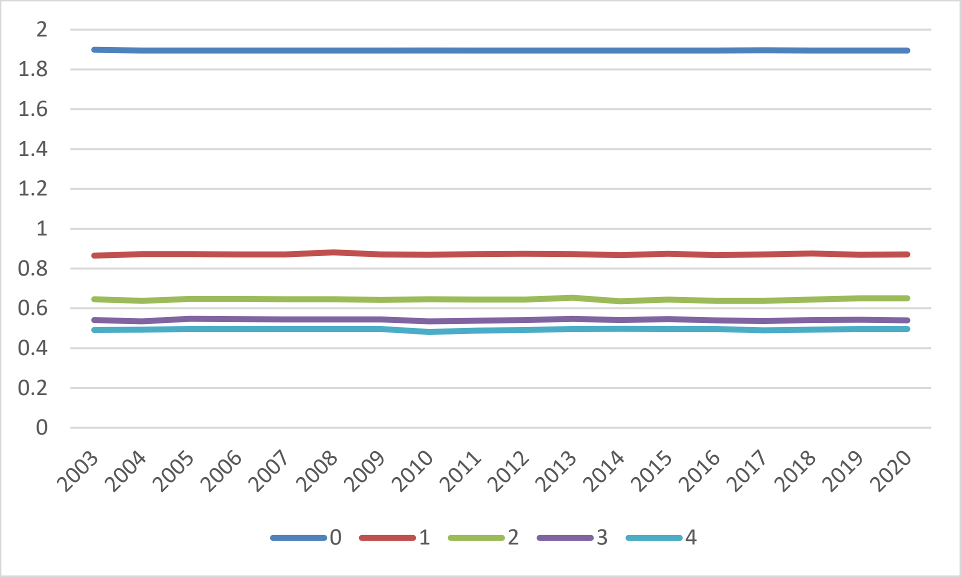


Figure 6.8.3.3. Giant red shrimp in GSA 18-20. Natural mortality at age for stock

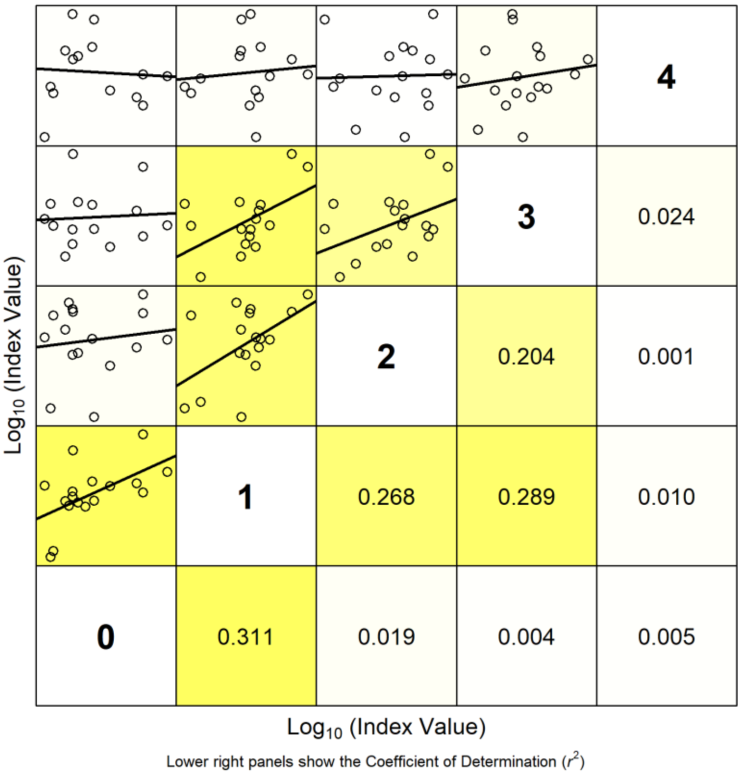


Figure 6.8.3.4. Giant red shrimp in GSA 18-20. Catch internal consistency plot

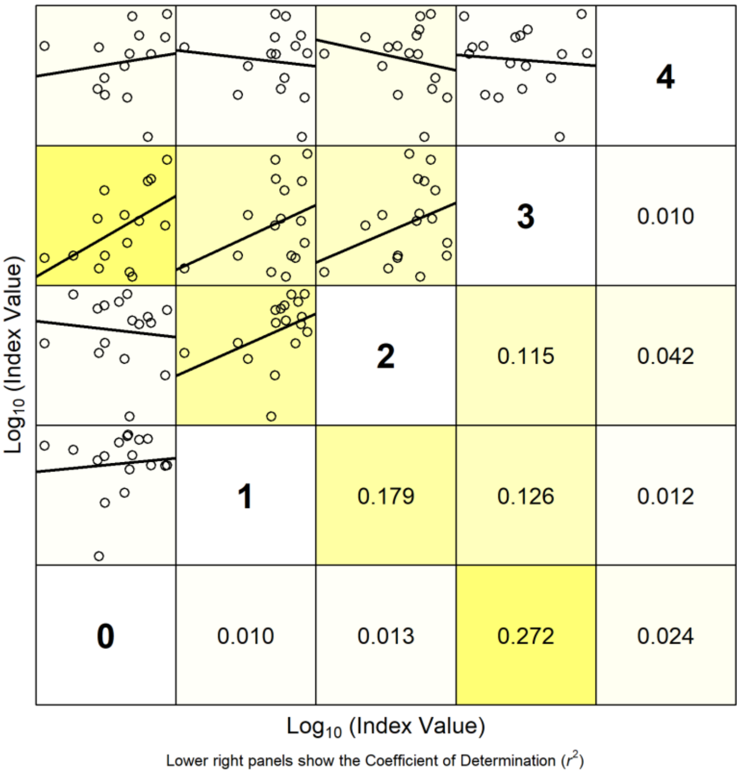


Figure 6.8.3.5. Giant red shrimp in GSA 18-20. MEDITS Index internal consistency table

Assessment results

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. 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.

Model selection procedure was performed taking into account statistical measures (AIC, BIC) and model diagnostics (residuals, retrospective) and fitting.

The final model selected was:

```
fmod <-~s(replace(age,age>3,3),k=3)+s(year,k=3,by = as.numeric(age == 0))+s(year, k=11)

qmod <- list(~te(age, year,k=c(3,5)))

srmod <- ~geomean(CV=0.20)
```

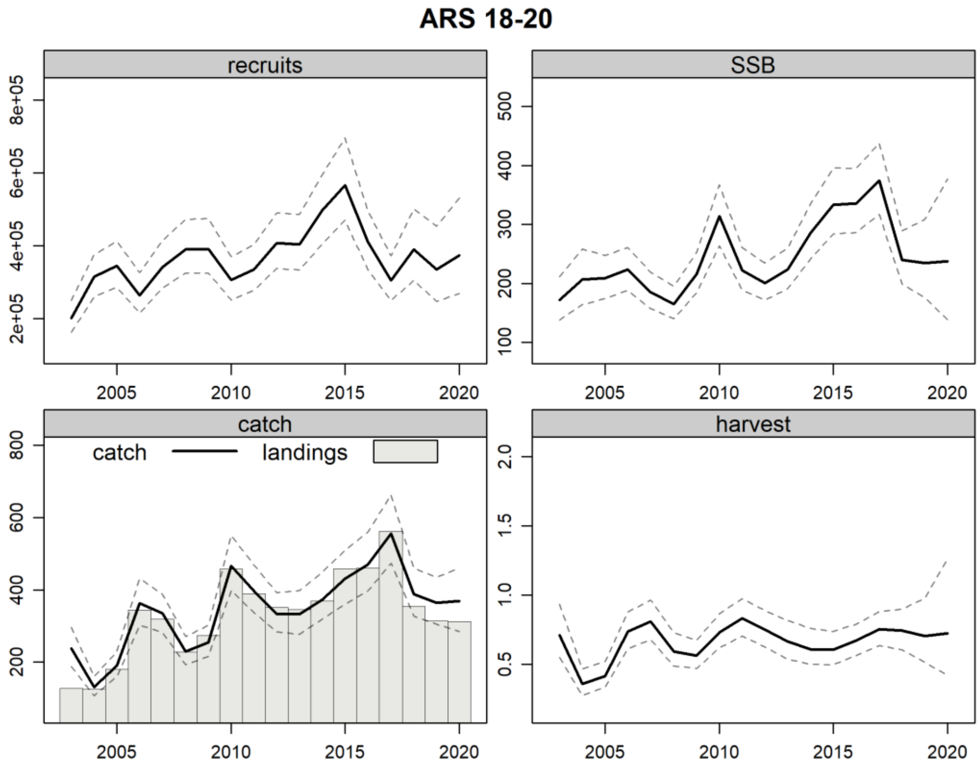


Figure 6.8.3.6. **Giant red shrimp in GSA 18-20.** Results of the a4a model

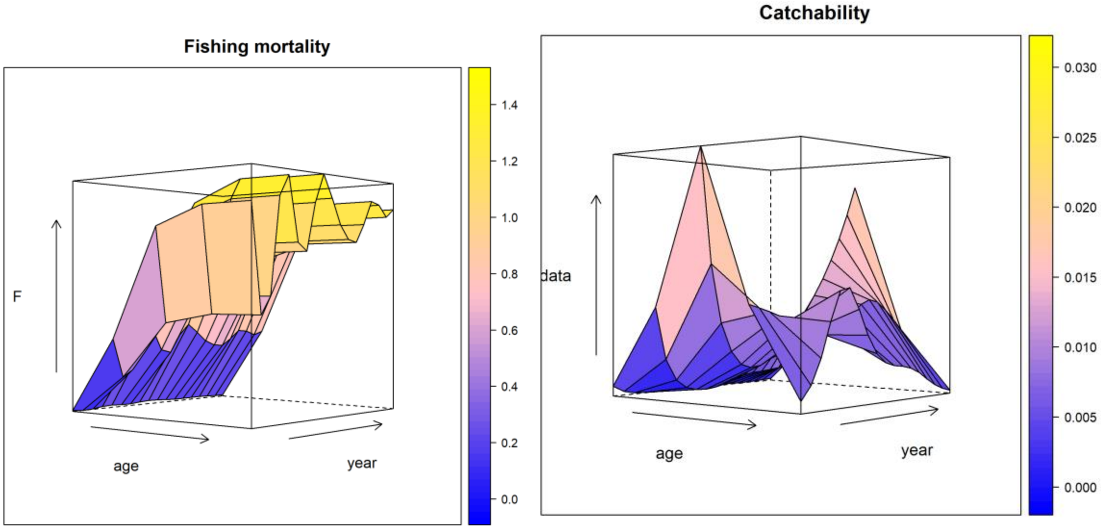


Figure 6.8.3.7. **Giant red shrimp in GSA 18-20.** 3D contour plot of estimated fishing mortality and 3D contour plot of estimated survey catchability at age and year.

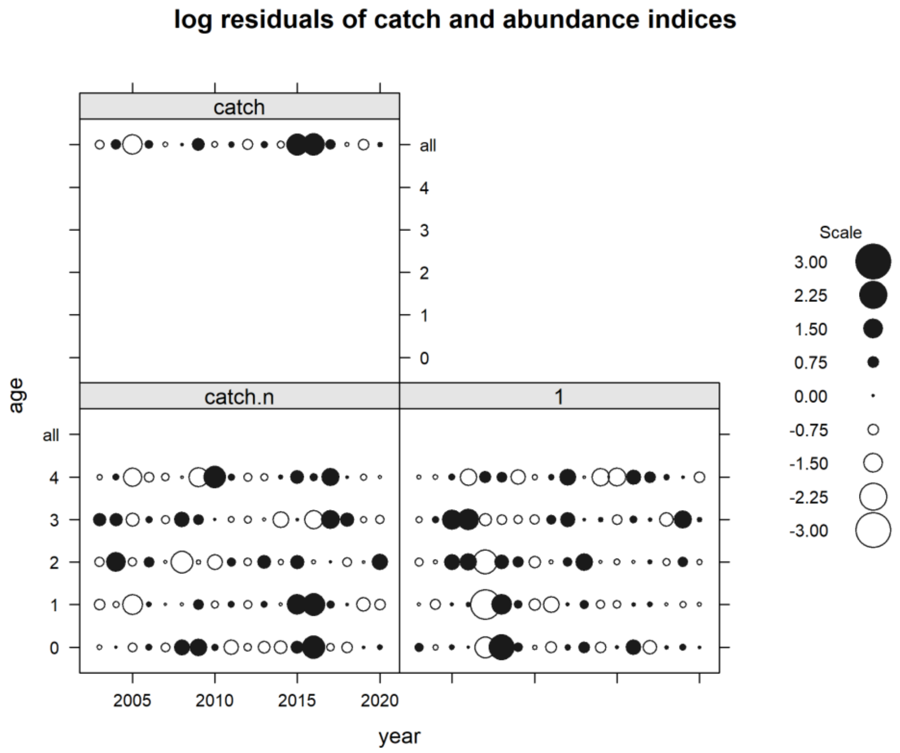


Figure 6.8.3.8. **Giant red shrimp in GSA 18-20.** Standardized residuals for abundance indices and for catch numbers.

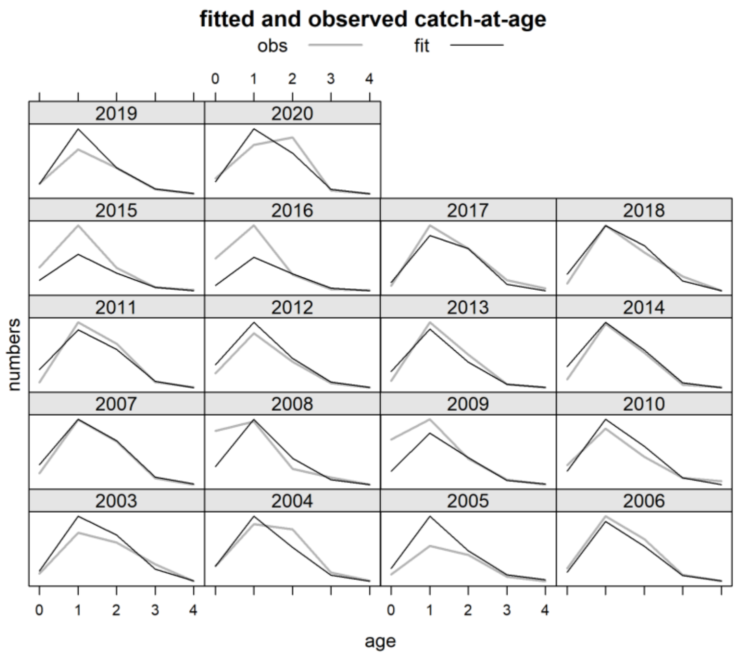


Figure 6.8.3.9. **Giant red shrimp in GSA 18-20.** Fitted and observed catch at age.

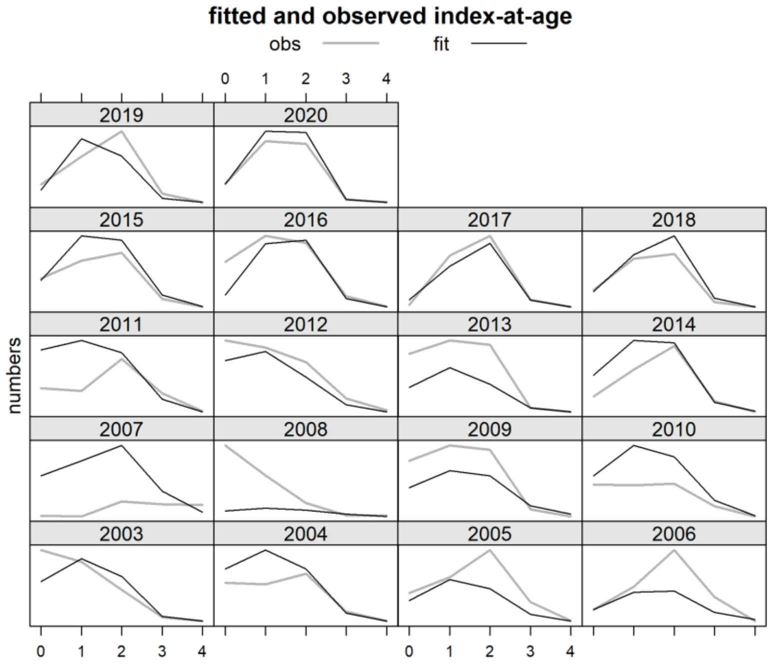


Figure 6.8.3.10. **Giant red shrimp in GSA 18-20.** Fitted and observed index at age.

Retrospective

The retrospective analysis was applied up only to 3 years back, due to the length of time series. Models results were quite stable (Figure 6.8.3.11) for recruitment and SSB.

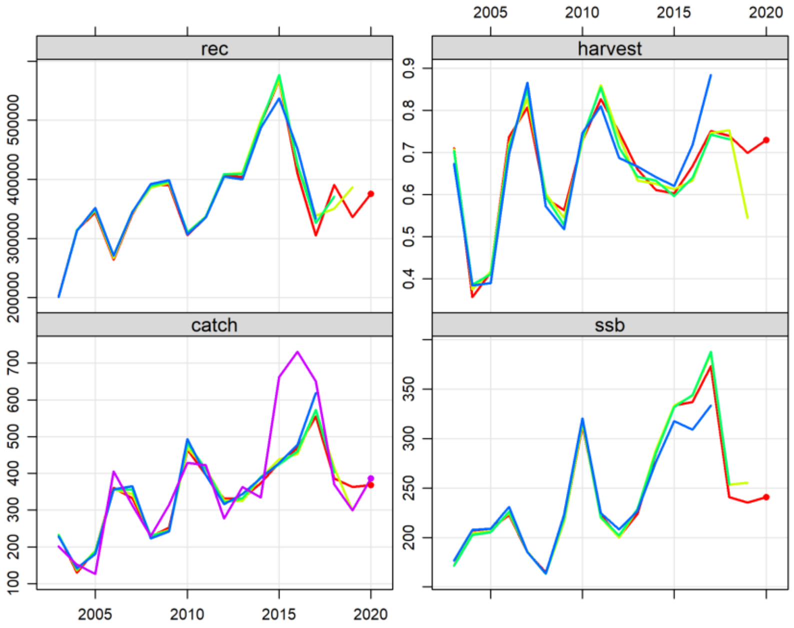


Figure 6.8.3.10. **Giant red shrimp in GSA 18-20.** Retrospective analysis

Conclusions to the assessment

The model chosen and fitted includes considerable variation in the survey index over time. However, the survey (in GSA 18 and 19) has generally been conducted in the same manner and same time of year over most of the time series apart from a few years noted above in Section 6.8.2.3. The coherence of the growth curve used to age slice the data and the size at year transition (December to January) has not been checked. There was not sufficient time within the meeting to assemble the length data needed to test different slicing approaches. The model also needs further exploration to determine of the survey should or should not be fitted with varying catchability. Due to these difficulties the assessment is regarded as preliminary, and advice is based on ICES category 3 survey index approach (see section 6.8.5)

6.8.4 REFERENCE POINTS

A statistical catch at age (a4a) assessment was attempted and various model runs were accomplished. As certain input parameters, such as growth, were uncertain and important survey gaps exist in GSA 20, the outputs were questionable. Therefore, the EWG suggested providing advice through a biomass index, based on the temporary consistent surveys. Therefore, no reference points were provided.

6.8.5. SHORT TERM FORECAST AND CATCH OPTIONS

No short-term forecast was attempted.

The advice on fishing opportunities for 2022 is based on the recent observed catch adjusted to the change in the biomass index. The biomass index used to provide the catch scenarios is obtained from the MEDITS survey data- the relative change in the trend of the MEDITS biomass index in GSAs 18 and 19 (jointly) (Figure **6.8.5.1**). The index of GSA 20 was not used given the existing gaps in the survey in that GSA.

In the most recent years the stock fluctuates without any particular trend. Regarding landings, with the exception of the relatively high values observed in the 2015-2017 period, they mostly range from 230 to 430t (Figure 6.8.2.1.4.). Based on the index value in the last two years relative to the previous three ones the biomass showed a slight increase (1.08 times). The change is estimated from the average of the two most recent values (2019-2020) relative to the average of the three preceding values (2016-2018) table 6.8.4.1).

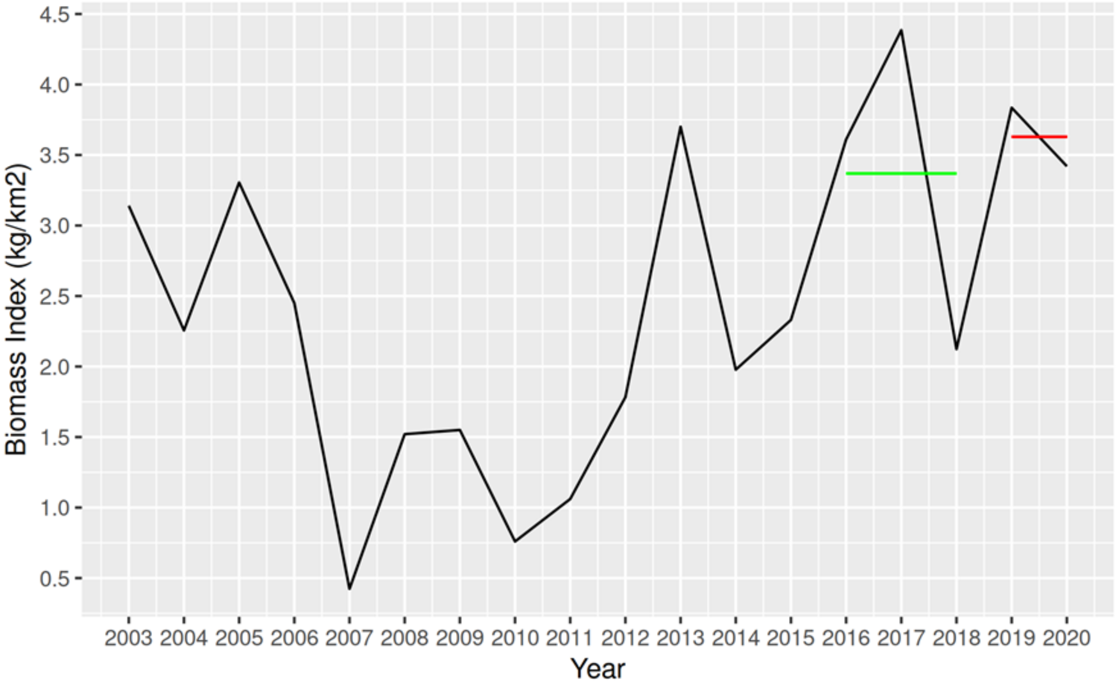


Figure 6.8.5.1 Giant Red Shrimp in GSAs 18-20: MEDITS survey indicator (biomass index) by year including mean of the last two years (2019-2020, in red) and the previous three years (2016-2018, in green), used for calculating catch advice.

Table 6.8.5.1 Giant Red Shrimp in GSAs 18-20: Assumptions made for the interim year and in the forecast. *

Index A (2019–2020)	3.63	
Index B (2016–2018)	3.37	
Index ratio (A/B)	1.08	
-20% Uncertainty cap	Applied/not applied	Not Applied
Average catch (2018–2020)	352	
Discard rate (2019–2020)	Negligible	
-20% Precautionary buffer	Applied/not applied	Applied 0.86
Catch advice **	303	
Landings advice ***	303	
% catch change ^	-22%	

* The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.

** (average catch × precautionary buffer)

*** catch advice × (1 – discard rate)

^ Advice value 2022 relative to catch value 2020.

Table 5.8.5.2. Giant Red Shrimp in GSAs 18-20: STECF advice and official landings. All weights tonnes.

Year	STECF advice	Predicted landings corresp. to advice	Predicted catch corresp. to advice	STECF catch	STECF discards
2022	Reduction of 0.78% of catch	303	303		

6.9 EUROPEAN HAKE IN GSA 19

This stock was assessed using a4a at the hake benchmark meeting of GFCM in 2019 (GFCM 2019), by STECF EWG 2015 in 2020, and by STECF EWG 2102 on the basis of reconstructed data.

6.9.1 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 confined in GSA 19 (Figure 6.9.1.1). *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%).

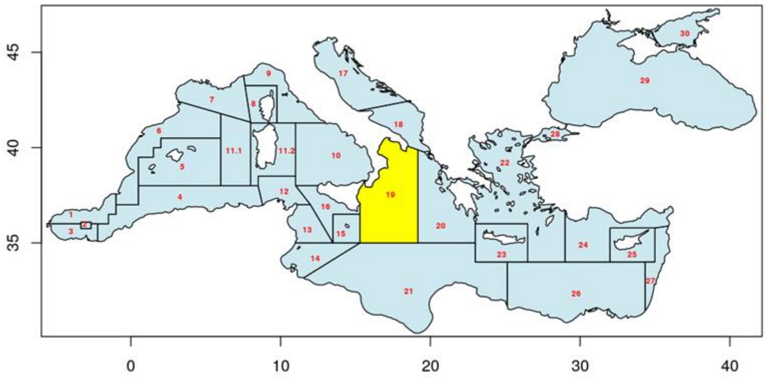


Figure 6.9.1.1. Geographical location of GSA 19.

The GSA 19 covers a surface of about 16500 km2 in the depth range between 10-800 m along a coast line 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 parameters, maturity at length, length-weight relationship were derived within DCF (2002-2019). The von Bertalanffy growth parameters, length-weight relationship **Table 6.9.1.1**, maturity and natural mortality at age **Table 6.9.1.2** are obtained as determined at the hake benchmark meeting (GFCM 2019)

Table 6.9.1.1 Hake in GSA 19. Von Bertalanffy growth (VBGF) and length-weight relationship parameters

	VBGF			Length/weight	
	Loo	k	t0	A	b
Famales	111	0.1	-0.6	0.0055	3.1
Males	73	0.15	- 0.73	0.005	3.04

Table 6.9.1.2. Hake in GSA 19. Proportion of mature specimens at age. Natural mortality (M) at age

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

6.9.2 DATA

6.9.2.1 CATCH (LANDINGS AND DISCARDS)

General description of Fisheries

On average along the years, the catch from longlines represent about the 20% of the total hake landing, the gillnets and trammel nets around the 20% (together), while the trawlers are about the 60%. In 2020 these proportions are 66% bottom trawl; 11% gillnets and trammel nets, and 23 % others predominantly longlines.

Catch data from DCF were analysed. The overall catches, as landings and discards are listed in **Table 6.9.2.1.** and **Figure 6.9.2.1.**. While the landings are reported for all years, discards are missing in 2002-2005 and 2007-2008, as collection of discard data was not foreseen by DCF. Discard data were subsequently reconstructed for the missing years (GFCM 2019). As shown on **Figure 6.9.2.1.** catches after a peak in 2006 decrease to minimum values in the last 8 years. Current level of landing is around 614 tons compared with 1630 tons in 2006. Discards also tend to decrease.

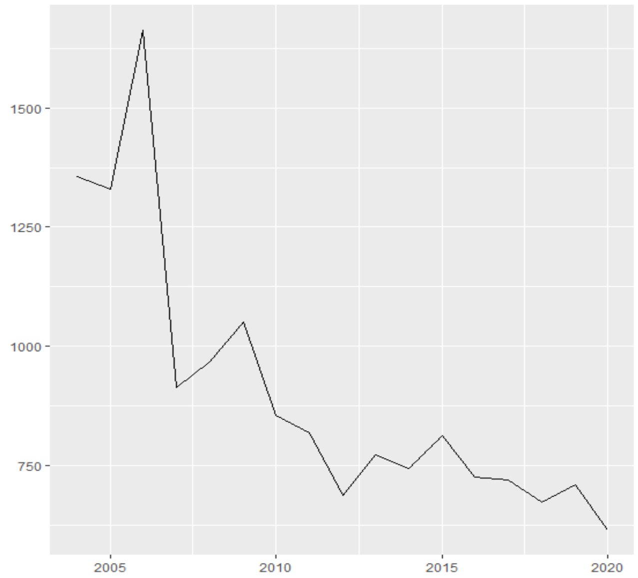


Figure 6.9.2.1. Hake in GSA 19. Hake DCF total catch (t), in GSA 19.

Table 6.9.2.1. Hake DCF landings (t) and discards (t) in GSA 19, 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

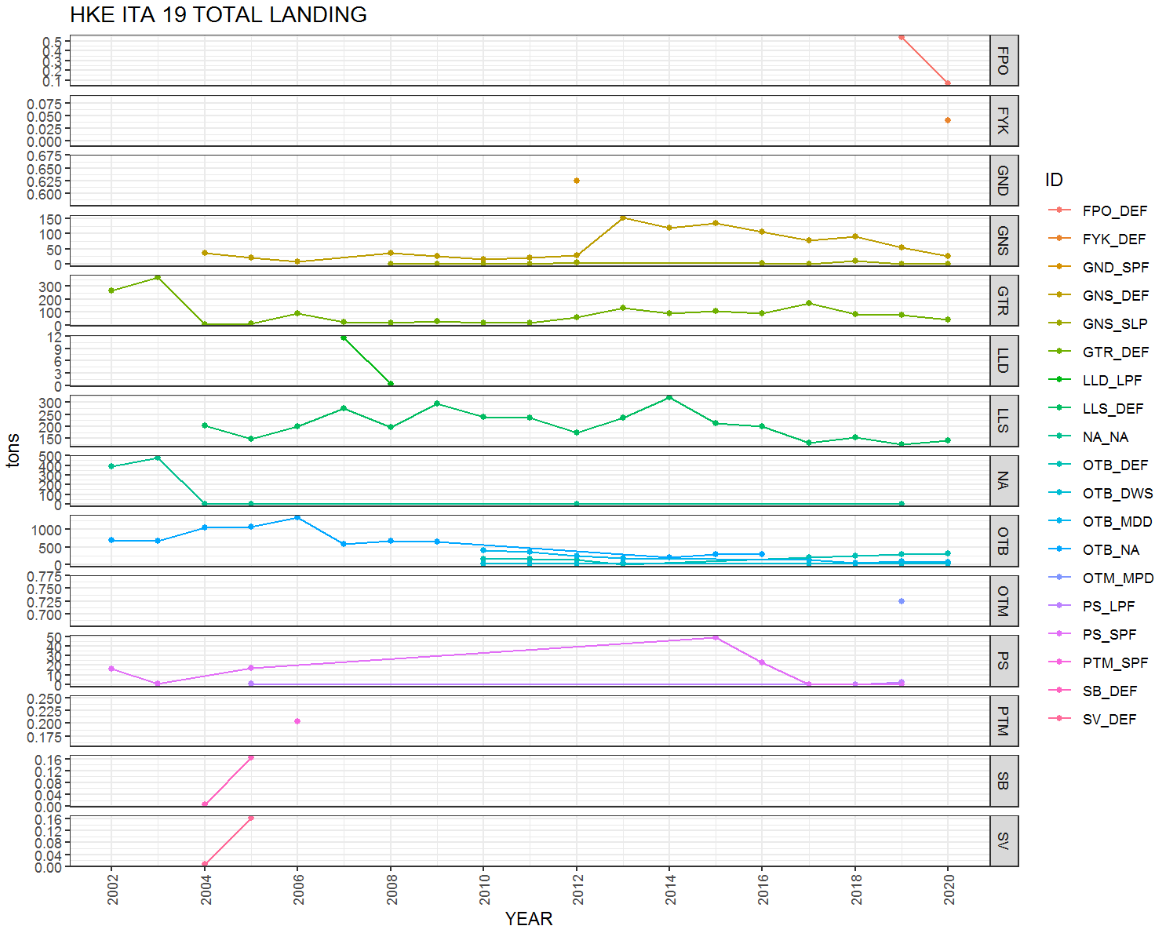


Figure 6.9.2.2. Hake total landing by metier in GSA 19.

With regards of the catch composition by gear (**Figure 6.9.2.2.**) the bulk of catches are taken by bottom otter trawls (OTB) and longlines (LLS) for the landing fraction, and by OTB for the discard component. Discards have varied from year to year and were about 2.5 % of landings on average. Taking in to account the fleet targeting hake, the decrease in landings in bottom trawlers is contrasted by the increasing of landings in longlines and nets (**Figure 6.9.2.2.**)

Figure 6.9.2.4. reports the length frequency distributions of the catches (landings+discards). Generally these distributions are dominated by individuals up to 30 cm total length. As seen on Figure 6.9.2.4**.** different gears have different size selectivity for hake.

Missing discard data have been reconstructed (GFCM 2019, STECF 2021) and are considered in this assessment.The landings and discards at length were then split into ages by applying the L2a routine as implemented in a4a package.

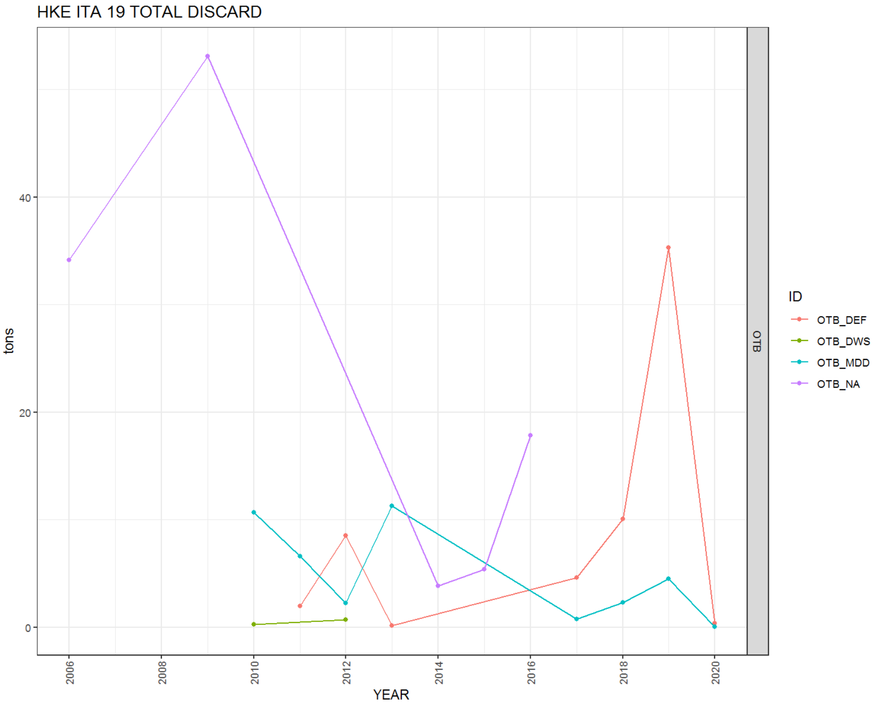


Figure 6.9.2.3. Hake total discards by metier in GSA 19

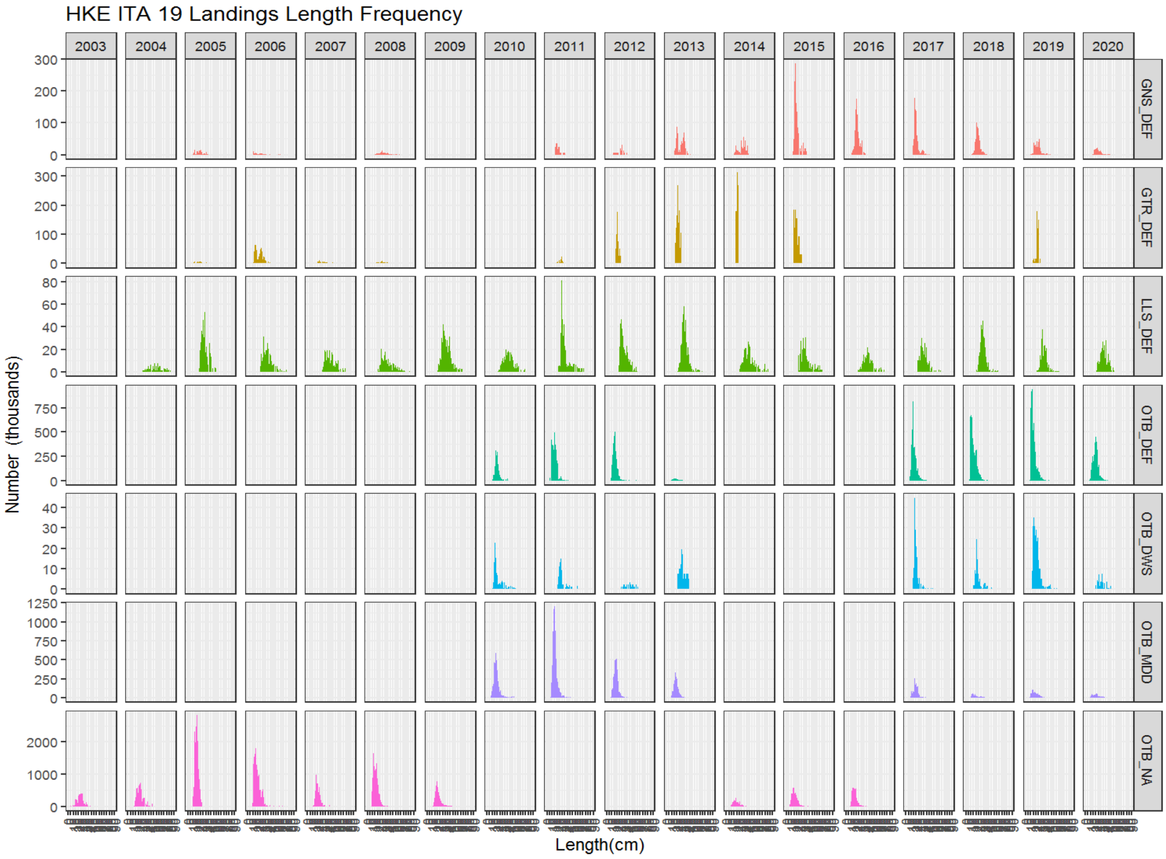


Figure 6.9.2.4. Hake in GSA 19 length frequency distribution of catch by metier.

6.9.2.2 EFFORT

Fishing effort data were not reported to STECF EWG 21-15 and Effort data is now assembled from the FDI data call.

Table 6.9.2.2. Hake GSA 19. Fishing effort in Fishing days by year and fleets targeting hake.

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	13983	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	32876	9422	83327	36437

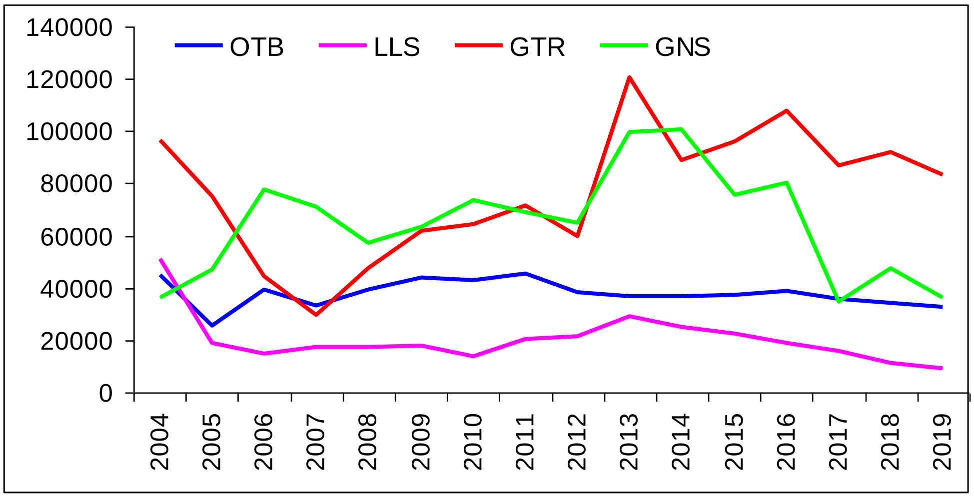


Figure 6.9.2.5. Hake GSA 19. Fishing effort in Fishing days by year and fleets targeting hake.

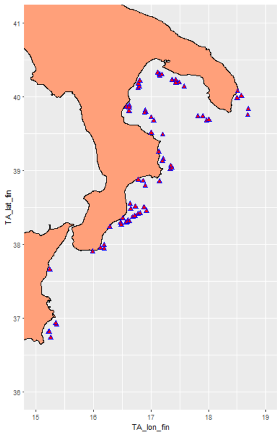
6.9.2.3 SURVEY DATA

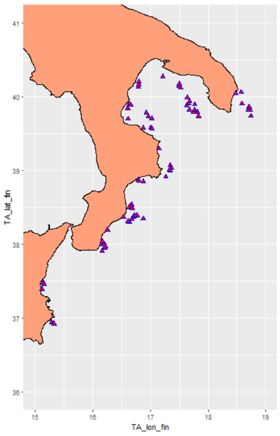
Since 1994, MEDITS trawl surveys has been regularly carried out yearly during the spring season (May-July Figure 6.9.2.6.). In 2014 the survey was carried out in September, in 2017 – in November-December, and in 2020 – in October. According to the MEDITS protocol (Bertrand *et al.*, 2002) a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m) was applied. 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 kilometer, using the swept area method. Data were analysed using the JRC script (Mannini, 2020)

Figure 6.9.2.6. Month of the year when the hauls of MEDITS surveys being conducted in GSA 19.

Geographical distribution

The hake is mainly concentrated along the shelf. The distribution did not show substantial variation across time Figure 6.9.2.7.





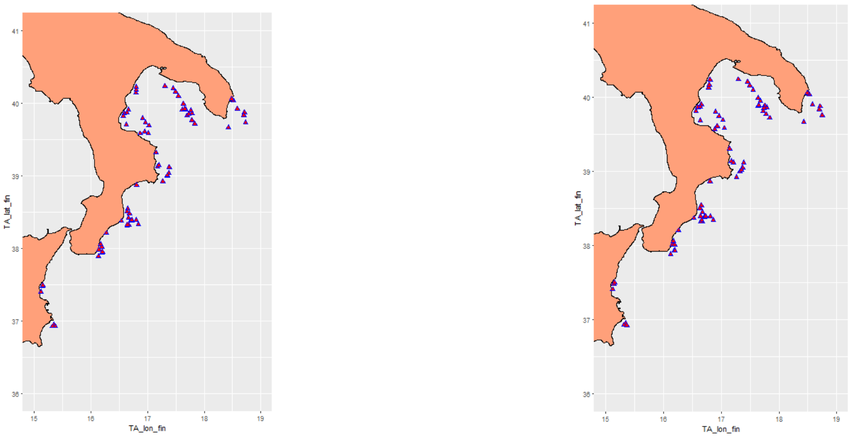


Figure 6.9.2.7. Geographical distribution of hake in GSA 19 based on the biomass index of MEDITS survey in 1994, 2003, 2012 and 2019.

Trends in abundance and biomass

Based on the DCF data call input, abundance and biomass indices were recalculated. Observed abundance and biomass indices of hake and the length frequency distributions are given on the figures below (Figure 6.9.2.9., Figure 6.9.2.10**.**).Both abundance and biomass indices show increase between 2005 and 2013 with a drop around 2010. In the last 3 year the biomass go up while the density remain at average levels Figure 6.9.2.9. In 2020 the total density substantially drops due to the relatively low number of small individuals in the survey catches.

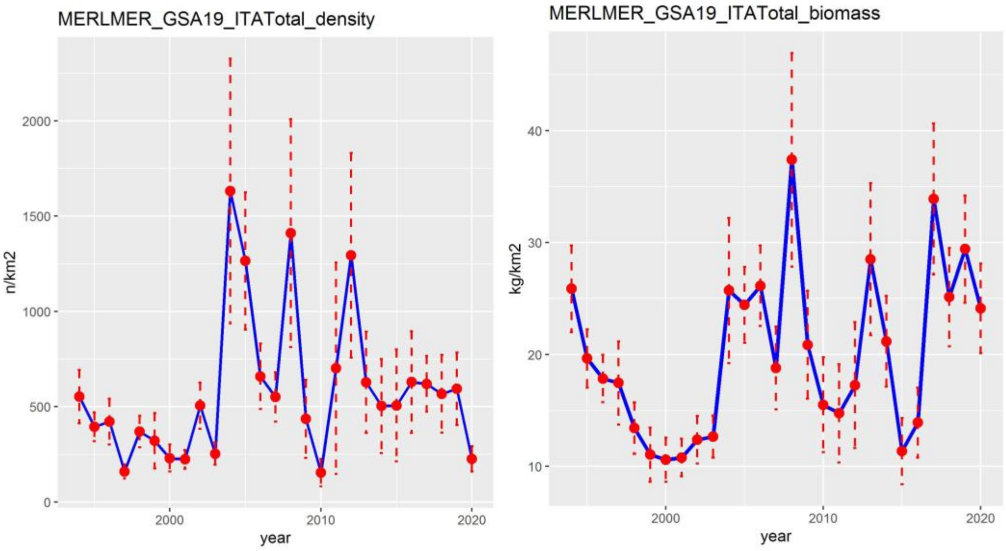

A.
B.

Figure 6.9.2.9. Hake in GSA 19. Estimated A. abundance (N/km2,), and B biomass (kg/km2) indices and from the MEDITS survey.

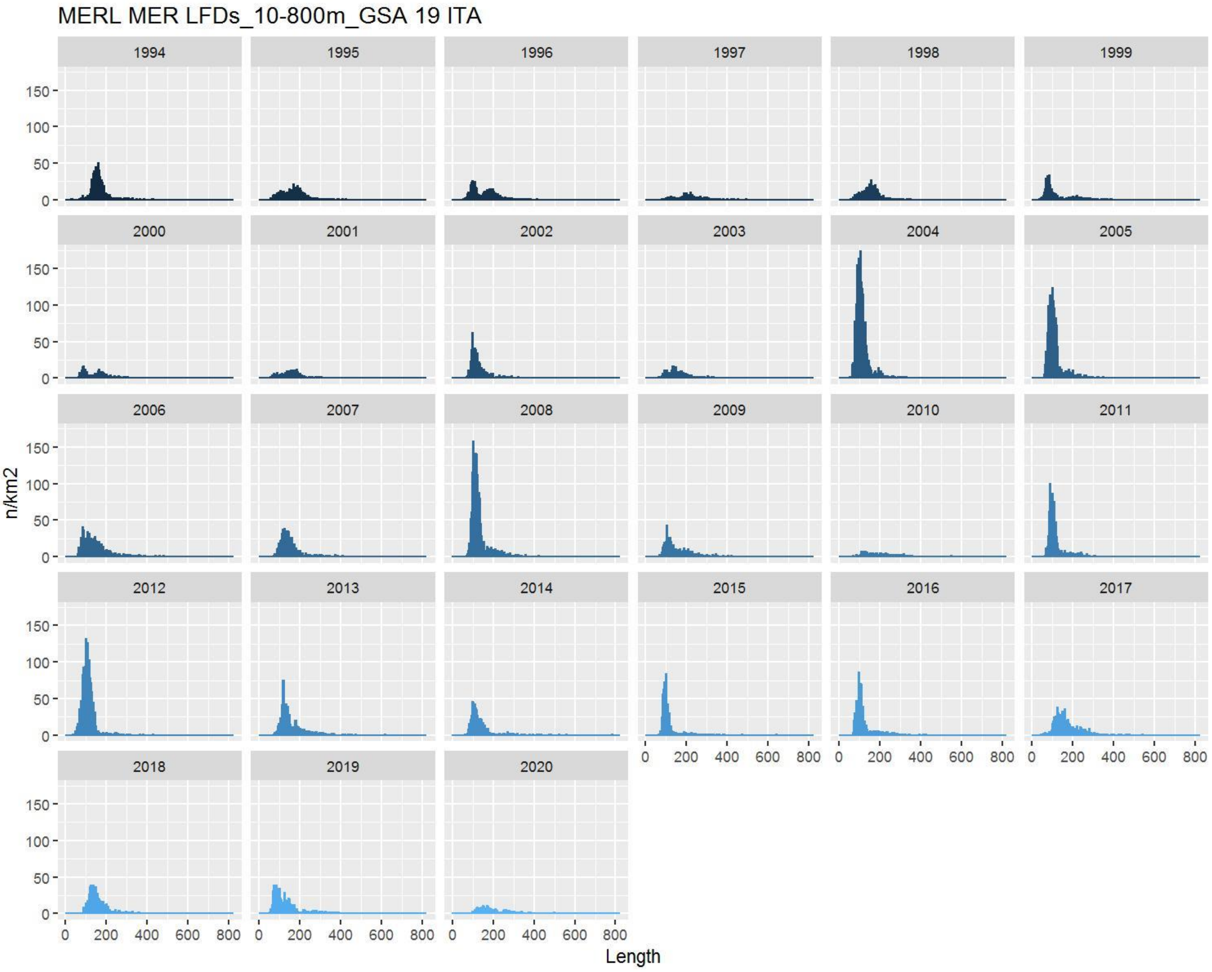


Figure 6.9.2.10. Hake in GSA 19. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of hake in GSA 19 as reported by DCF.

6.9.3 STOCK ASSESSMENT

This stock was assessed using a4a at the hake benchmark meeting of GFCM in 2019 (GFCM 2019), by STECF EWG 2015 in 2020, and by STECF EWG 2102 on the basis of reconstructed data. The present assessment was carried out using a statistical catch-at-age modeling framework - Assessment for all (a4a, Jardim et al., 2014) in FLR (http://www.flr-project.org/).

6.9.3.1. Input data

Catch and discards data have been checked and missing data reconstructed at the hake benchmark assessment (GFCM 2019), and reevaluated and again corrected at the STECF EWG 20-02 (STECF 2021). Here we checked and extracted data from DCF for 2020, that were added to the data matrices produced by the EWG 20-02.

Input data in terms of catch numbers and mean weight at age, and tuning data in terms of catch numbers from the MEDITS survey are shown in Figure 6.9.3.3.1 to Figure 6.9.3.3.5 and Tables 6.9.3.3.1 to 6.9.3.3.3. Proportion of mature and M at age are shown in Table 6.9.1.2. 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 assessement model. The age range of Fbar was set to age 0-4 as the majority of the catches were represented within these age classes.

Catch data were SOP corrected using the ratio between total catch and SOPs at year Table 6.9.2.1..

Relativly good consistency is observed between cohorts in the catch and survey data (Figure 6.9.3.3.6).

6.9.3.3 Stock assessment models and results

This a4a assessment uses the same model settings as by EWG 2015 and EWG 2102 an which considered as improved version of the benchmark assessment model with improved stability (STECF 2020).

a4a submodels:

Fishing mortaliy: fmodel <- ~ s(age, k=5)+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: srmodel <- ~ geomean(CV=0.2)

Summary results and diagnostics from the a4a model are presented in Figure 6.9.3.3.8 to Figure 6.9.3.3.12.

The results and the diagnostics the fitted model are very similar to those obtained by the previous assessments and the benchmark assessment (GFCM 2019, STECF 2020, STECF 2021). 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 6.9.3.3.12. The SSB is increasing after 2016 while fishing mortality is decreasing. Recruitment in 2020 is low, consistent with evidence from catch and survey data (Figure 6.9.3.3.1, Figure 6.9.3.3.5). Estimated stock numbers and fishing mortality at age, as well as stock summary are presented at Tables 6.9.3.3.4 to 6.9.3.3.6.

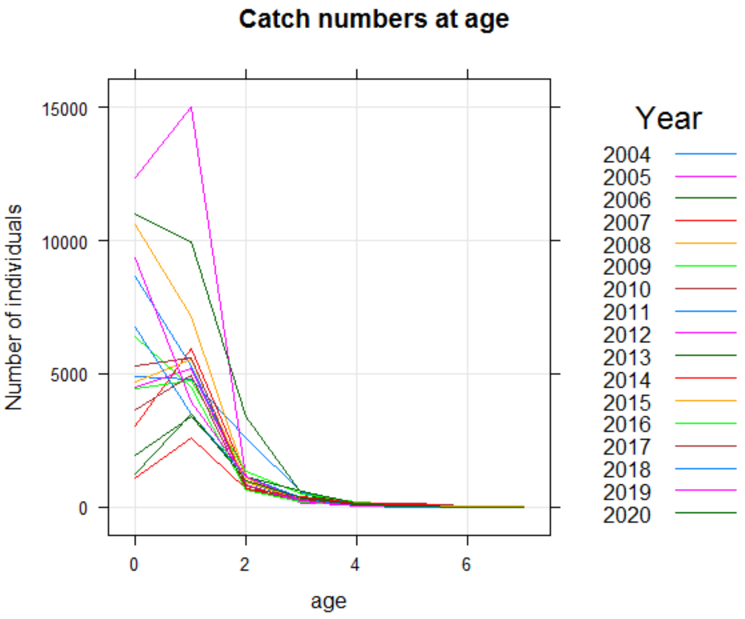


Figure 6.9.3.3.1 Hake in GSA 19. Hake number of individuals (thousands) at age of the catch in GSA 19. Data from DCF.

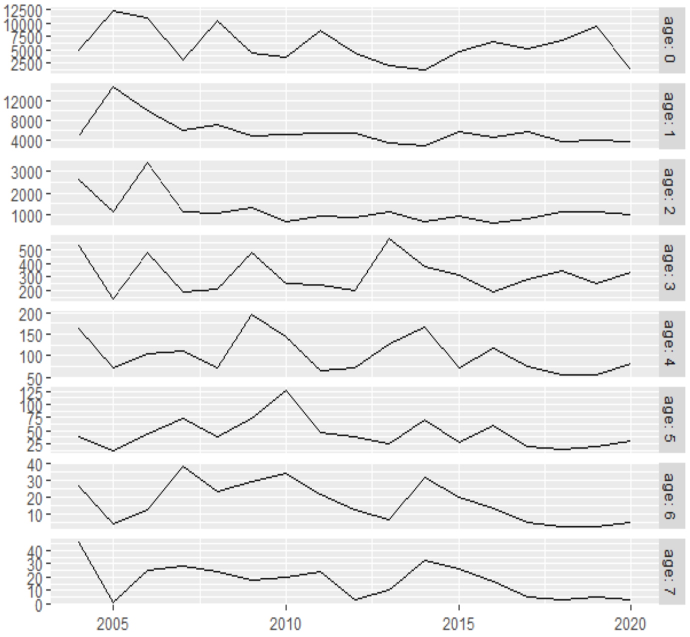


Figure 6.9.3.3.2 Hake in GSA 19. Hake number of individuals per year by age group of the catch in GSA 19 (2004-2019). Data from DCF.

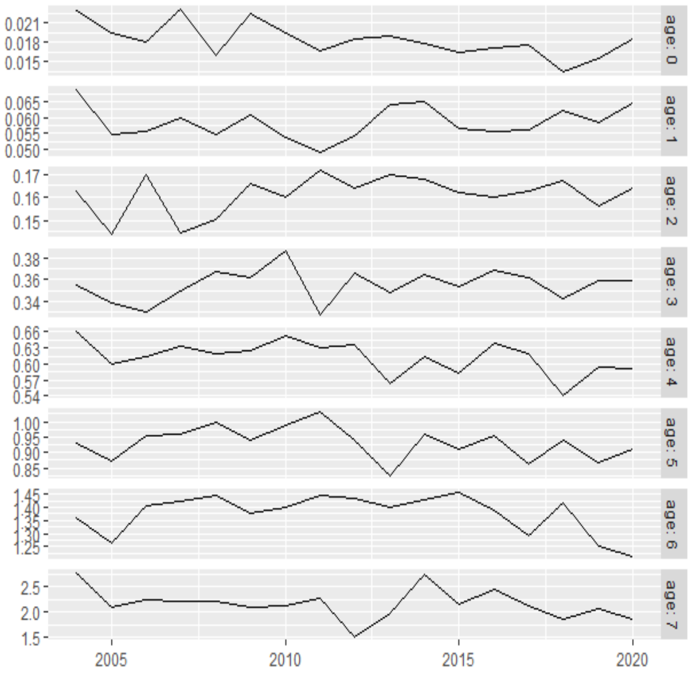


Figure 6.9.3.3.3. Hake in GSA 19. Hake mean weight (kg) at age of catches per year in GSA 19 (2004-2019). Data from DCF.

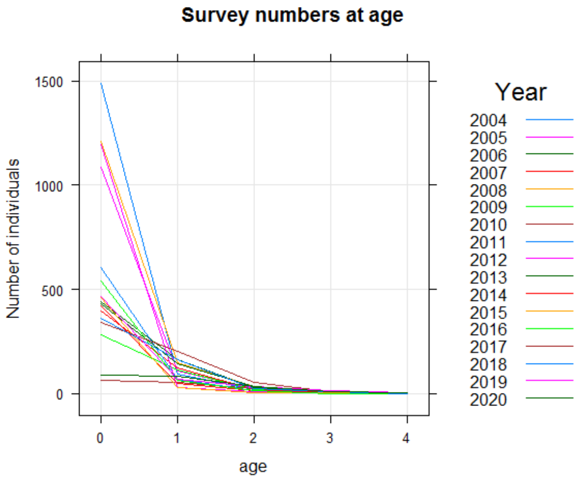


Figure 6.9.3.3.4 Hake in GSA 19. Age composition of the MEDITS survey of hake in GSA 19 as reported by DCF.

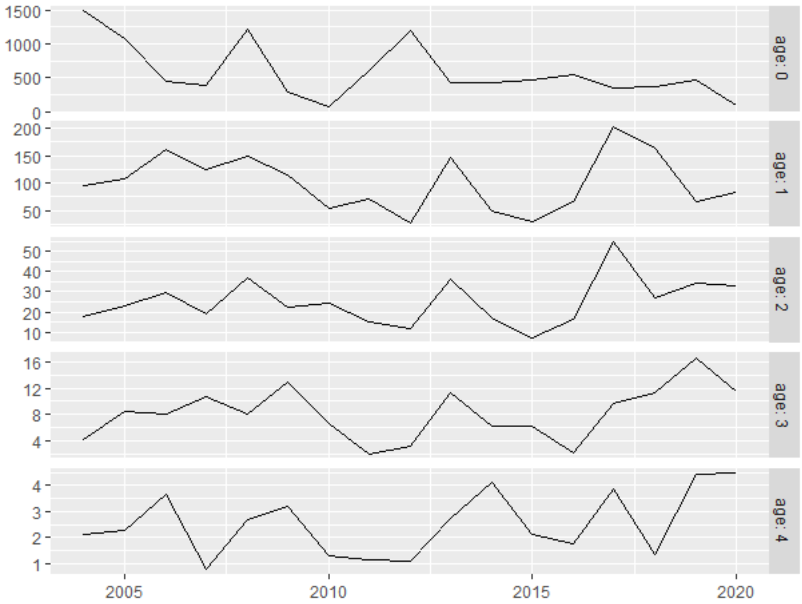


Figure 6.9.3.3.5 Hake in GSA 19. Number of individuals per year by age group (ages 1-4) according to MEDITS surveys (2004-2019).

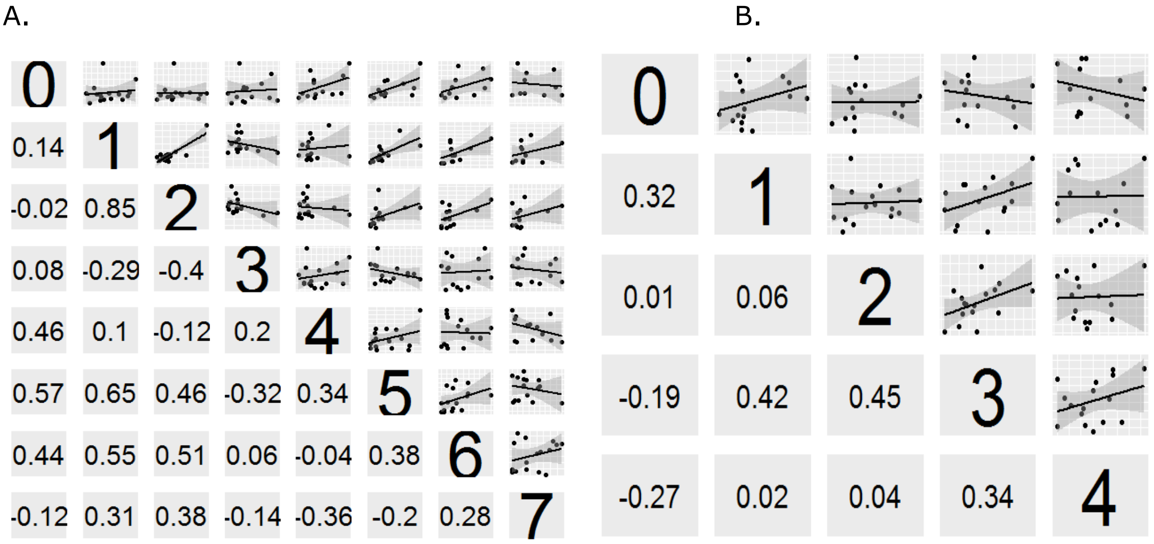


Figure 6.9.3.3.6 Hake in GSA 19. A.Cohorts consistency in the catch, and B. in MEDITS survey.

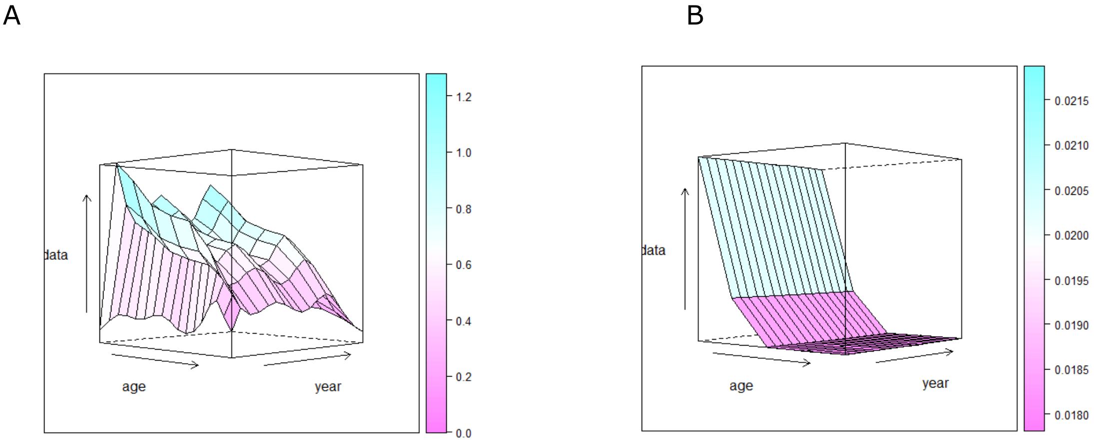


Figure 6.9.3.3.7 Hake in GSA 19. 3D plots of fishing mortality (A), and survey catchability (B) at age and year

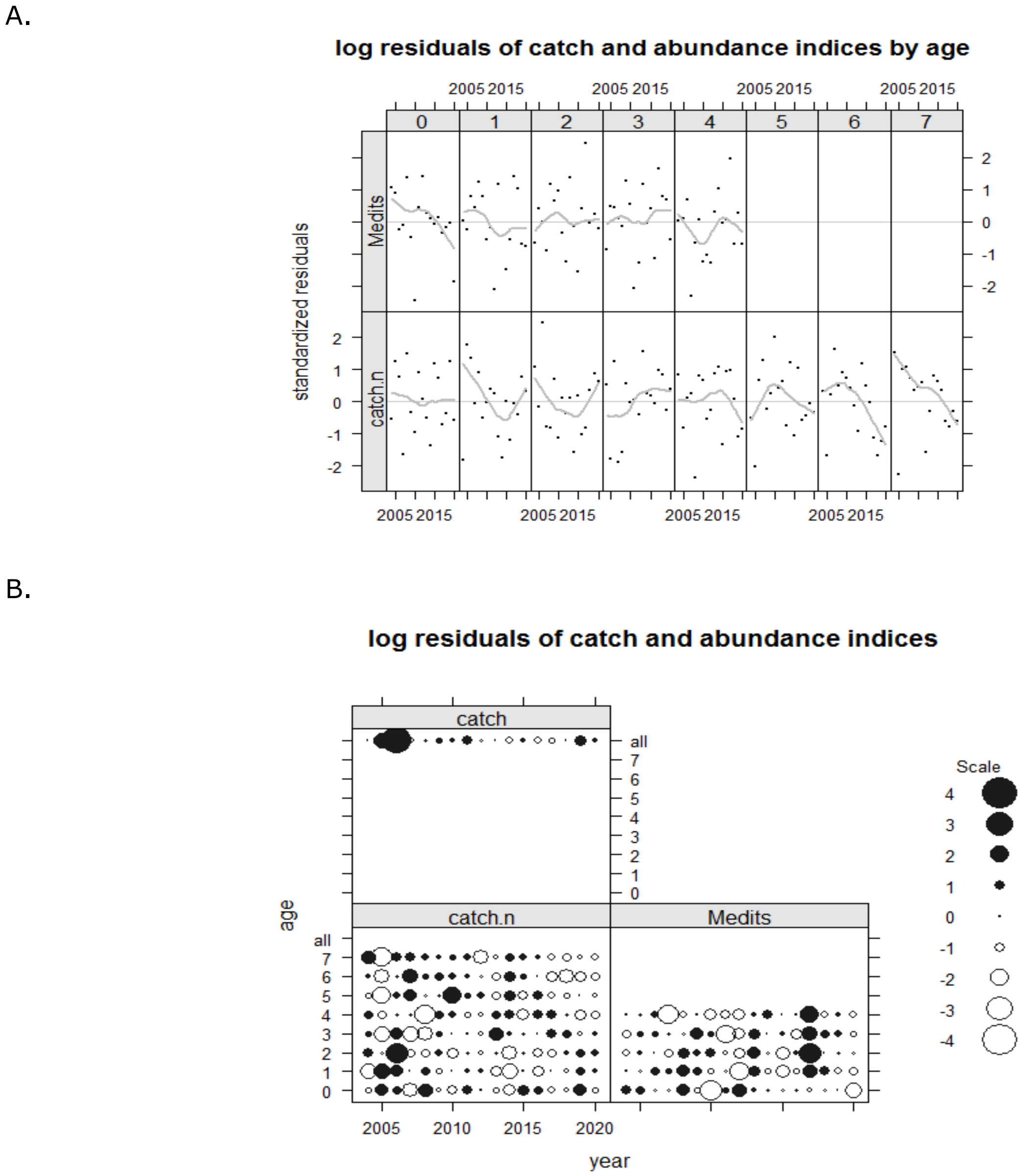
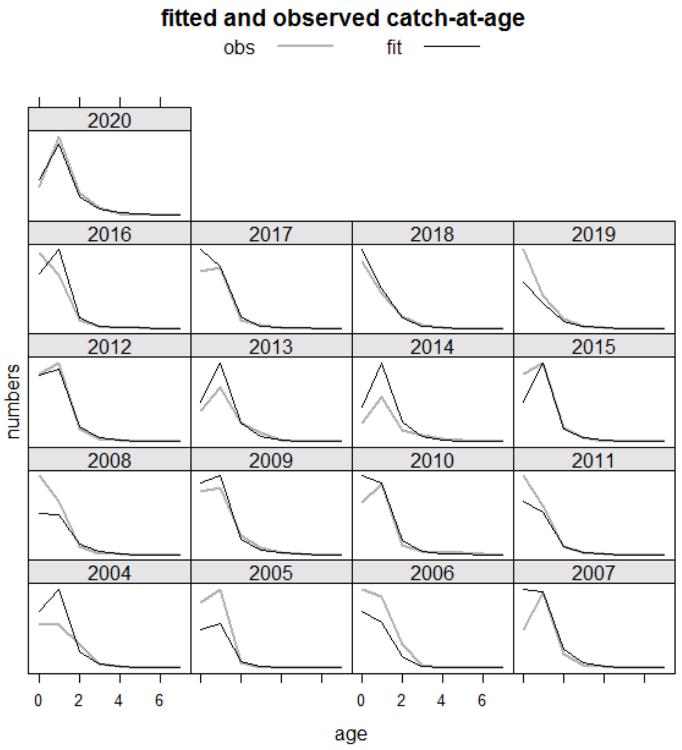


Figure 6.9.3.3.8 Hake in GSA 19. Standardized residuals for abundance indices (MEDITS) and catch at age data. Each panel present residuals by age and year.

A.



B.

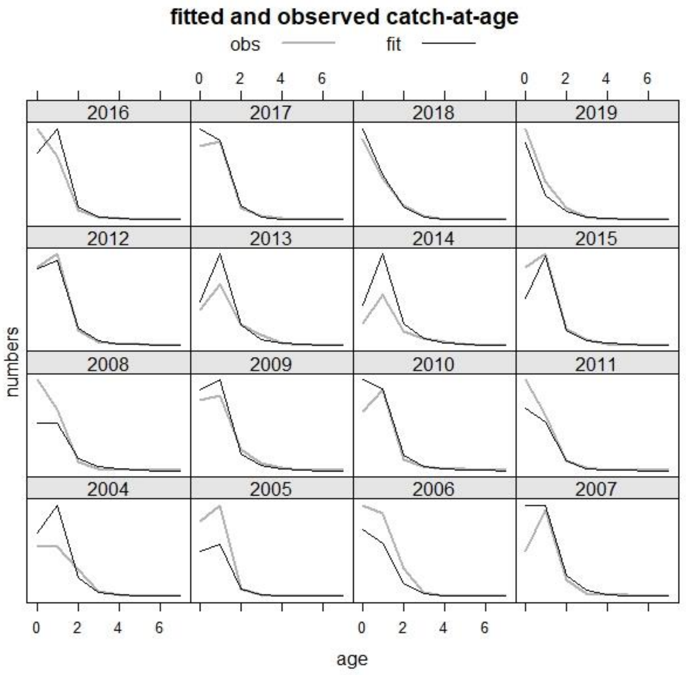


Figure 6.9.3.3.9 Hake in GSA 19. Fitted and observed catch (A.) and survey (B) numbers at age.

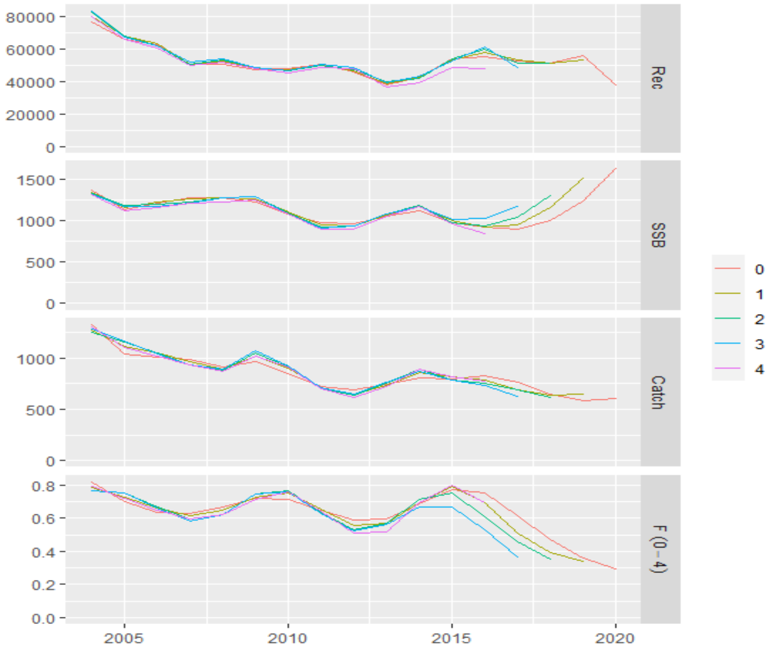


Figure 6.9.3.3.10 Hake in GSA 19. Retrospective analysis output.

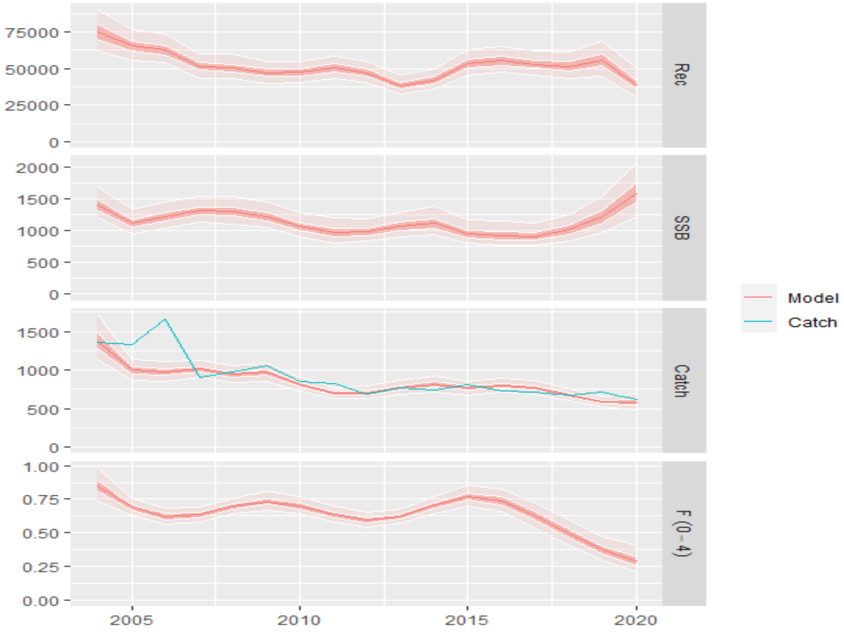


Figure 6.9.3.3.11 Hake in GSA 19. Stock summary for hake in GSA 19, recruits (‘000), SSB (t), catch (t) and Fbar (age 0-4). Estimated catch is compared to recorded catch.

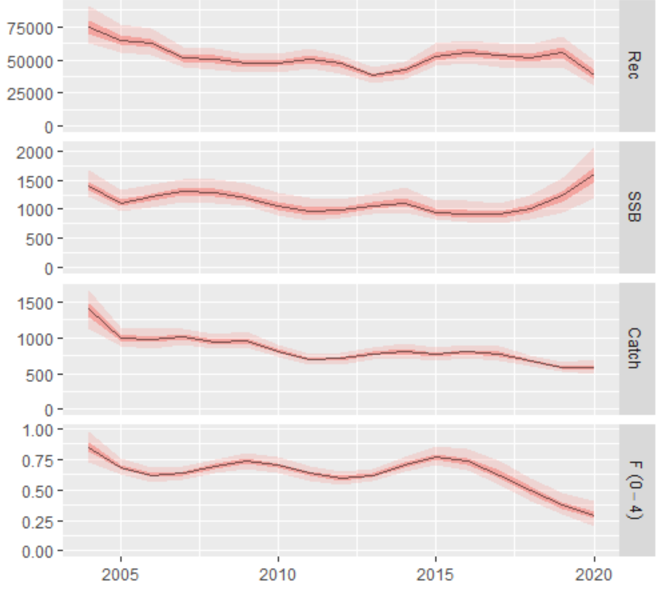


Figure 6.9.3.3.12 Hake in GSA 19. Stock summary of the simulated and fitted model from a4a. Stock summary for hake in GSA 19, recruits ('000), SSB (t), catch (t) and Fbar (age 0-4).

Table 6.9.3.3.1 Hake in GSA 19. Number of individuals per year by age group (ages 0-5) in the catch (2002-2019). Data from DCF.

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	4912	12375	10986	3049	10582	4442	3643	8630	4486	1949	1119	4709	6408	5293	6772	9375	1237
1	4790	14998	9973	5924	7166	4726	4962	5320	5217	3386	2574	5535	4488	5602	3499	3941	3478
2	2587	1106	3384	1121	1076	1363	696	952	862	1167	685	964	653	808	1158	1162	977
3	524	147	473	191	212	473	251	239	203	577	381	317	190	284	346	249	333
4	165	72	103	110	71	195	144	64	73	128	166	71	118	74	56	56	81
5	38	13	45	74	39	73	126	47	39	24	71	27	60	19	14	20	31
6	26	4	12	38	23	29	35	21	13	6	32	20	13	5	2	3	5
7+	46	1	25	29	24	18	19	24	2	10	32	27	17	5	3	4	3

Table **6.9.3.3.2** Hake in GSA 19. Weight of individuals at age in the catch (2002-2019). Data from DCF.

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
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
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
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
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
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
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
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
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

Table **6.9.3.3.3** Hake in GSA 19. Number of individuals per year by age group (ages 1-4) according to MEDITS surveys.

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	1487	1089	442	395	1212	281	64	606	1193	430	422	459	541	340	363	466	89
1	96	109	162	125	148	114	54	70	27	146	49	31	65	203	163	67	83
2	18	23	30	19	37	22	24	15	12	36	17	7	16	55	27	34	33
3	4	8	8	11	8	13	7	2	3	11	6	6	2	10	11	17	11
4	2	2	4	1	3	3	1	1	1	3	4	2	2	4	1	4	4

Table 6.9.3.3.4 Hake in GSA 19. Number of individuals at age in the stock

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	74816	65108	62629	51153	50283	46841	47318	50269	46853	38123	41974	53128	55309	52778	51360	55379	38783
1	16154	17984	14793	13766	11368	11433	10676	10615	11298	11034	9515	10791	13538	13266	11323	10615	12895
2	3330	2442	3499	3209	2912	2186	2080	2045	2243	2493	2300	1740	1799	2411	2881	3011	3251
3	787	722	665	1050	941	784	560	558	599	684	722	592	412	452	724	1038	1232
4	237	222	247	248	384	319	255	189	204	226	247	236	180	132	169	316	505
5	96	76	85	102	101	146	117	96	77	85	91	90	81	65	55	81	167
6	49	33	31	38	45	41	57	47	42	35	37	36	34	31	29	28	45
7+	29	36	37	38	42	45	45	53	56	55	50	46	41	38	39	42	46

Table **6.9.3.3.5** Hake in GSA 19. Hake fishing mortality at age

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.156	0.212	0.245	0.234	0.211	0.209	0.225	0.223	0.176	0.118	0.088	0.097	0.158	0.269	0.307	0.187	0.074
1	1.199	0.947	0.838	0.863	0.959	1.014	0.963	0.865	0.821	0.878	1.009	1.102	1.035	0.837	0.635	0.493	0.401
2	1.078	0.852	0.754	0.776	0.862	0.912	0.866	0.777	0.738	0.789	0.907	0.991	0.931	0.753	0.571	0.444	0.361
3	0.926	0.732	0.648	0.667	0.741	0.784	0.744	0.668	0.634	0.678	0.779	0.851	0.800	0.647	0.490	0.381	0.310
4	0.862	0.680	0.602	0.620	0.689	0.729	0.692	0.621	0.590	0.631	0.725	0.792	0.744	0.601	0.456	0.355	0.288
5	0.819	0.647	0.572	0.590	0.655	0.693	0.658	0.591	0.561	0.600	0.689	0.752	0.707	0.572	0.433	0.337	0.274
6	0.658	0.519	0.460	0.473	0.526	0.556	0.528	0.474	0.450	0.481	0.553	0.604	0.568	0.459	0.348	0.271	0.220
7+	0.429	0.339	0.300	0.309	0.343	0.363	0.344	0.309	0.293	0.314	0.361	0.394	0.370	0.299	0.227	0.176	0.143

Table **6.9.3.3.6** Stock summary: number of recruits, SSB, Fbar 1-2**,** estimated catch

Year	Recruitment age 0 ‘000	SSB, t	Fbar 0-4	Catch, t
2004	74816	1372	0.844	1366
2005	65108	1101	0.685	996
2006	62629	1201	0.617	974
2007	51153	1298	0.632	1008
2008	50283	1286	0.692	943
2009	46841	1211	0.729	967
2010	47318	1059	0.698	816
2011	50269	970	0.631	700
2012	46853	983	0.592	706
2013	38123	1066	0.619	776
2014	41974	1114	0.702	817
2015	53128	949	0.766	769
2016	55309	917	0.734	804
2017	52778	904	0.621	772
2018	51360	1009	0.492	677
2019	55379	1218	0.372	591
2020	38783	1593	0.287	584

6.9.4 REFERENCE POINTS

The STECF EWG 21-15 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 Fbar= 0.287 is higher than $F_{0.1}$ (0.154), 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.

6.9.5 SHORT TERM FORECAST AND CATCH OPTIONS

6.9.5.1 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 (Ch. 6.9.3.2).

Table 6.9.5.1 Hake in GSA 19: Assumptions made for the interim year (2021) and in the STF forecast.

Variable	Value	Notes

Variable	Value	Notes
Default assumptions on biology	3	Number of years in which M, Mat, Mean weight, etc. were averaged
Fages 0-4 (2021)	0.287	Fsq = F in the last year
SSB (2021)	1971	SSB intermediate year from STF output
Rage0 (2021,2022)	51145.5	Recruitment will be set as geometric mean of the last 17 years
Total Catch (2021)	651.9	Catch intermediate year from STF output
Fbar (2019)	0.372053	MAP base year fishing mortality from current assessment
a and b values	a=0.57 and b=0.43	Regression parameters from Ftransition regression line

6.9.5.2 Results

The results of the short term forecasts for hake (GSA 19) are shown in **Table 6.9.5.1**.

The F status quo = 0.287 (assumed Fbar in the last assessment year 2020) is larger than $F_{0.1}$ (0.151), 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 $F_{0.1}$ (0.151), should not exceed 420 tonnes, 28% less than the current estimated catch (584 t).

Table 6.9.5.1 Hake (HKE) in GSA 19 short term forecast. Annual catch scenarios and predictions of catch and SSB. Catch and SSB are in tonnes.

Rationale	Ffactor	Fbar	Recruitment2021	Fsq2021	Catch2020	Catch2022	SSB2021	SSB2023	SSB_change_2021-2023(%)	Catch_change_2020-2022(%)
High long term yield (F0.1)	0.53	0.15	51146	0.29	584	420	1971	3226	63.7	-28.0
F upper	0.74	0.21	51146	0.29	584	573	1971	3040	54.2	-1.9
F lower	0.36	0.10	51146	0.29	584	292	1971	3382	71.6	-49.9
FMSY transition	0.97	0.28	51146	0.29	584	728	1971	2853	44.7	24.7
Zero catch	0	0.00	51146	0.29	584	0	1971	3743	89.9	-100.0
Status quo	1	0.29	51146	0.29	584	749	1971	2827	43.4	28.4
Different Scenarios	0.1	0.03	51146	0.29	584	84	1971	3638	84.6	-85.5
	0.2	0.06	51146	0.29	584	167	1971	3537	79.4	-71.5
	0.3	0.09	51146	0.29	584	247	1971	3439	74.5	-57.8
	0.4	0.11	51146	0.29	584	324	1971	3343	69.6	-44.4
	0.5	0.14	51146	0.29	584	400	1971	3250	64.9	-31.5
	0.6	0.17	51146	0.29	584	474	1971	3161	60.4	-18.8
	0.7	0.20	51146	0.29	584	545	1971	3073	55.9	-6.6
	0.8	0.23	51146	0.29	584	615	1971	2989	51.6	5.4
	0.9	0.26	51146	0.29	584	683	1971	2907	47.5	17.0
	1.1	0.32	51146	0.29	584	814	1971	2750	39.5	39.4
	1.2	0.34	51146	0.29	584	877	1971	2675	35.7	50.2
	1.3	0.37	51146	0.29	584	938	1971	2602	32.0	60.6
	1.4	0.40	51146	0.29	584	997	1971	2531	28.4	70.8
	1.5	0.43	51146	0.29	584	1055	1971	2462	24.9	80.8
	1.6	0.46	51146	0.29	584	1112	1971	2396	21.5	90.4
	1.7	0.49	51146	0.29	584	1167	1971	2331	18.3	99.9
	1.8	0.52	51146	0.29	584	1220	1971	2268	15.1	109.0
	1.9	0.54	51146	0.29	584	1273	1971	2207	12.0	118.0
	2	0.57	51146	0.29	584	1324	1971	2148	9.0	126.7

6.9.6 DATA DEFICIENCIES

No issues

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8 CONTACT DETAILS OF EWG-21-15 PARTICIPANTS

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

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9 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
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List of electronic annexes documents:

EWG-21-15 – Annex 1 – Final stock obejcts.zip

EWG-21-15 – Annex 2 - Rscripts

10 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
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List of background documents:

EWG-21-15 – Doc 1 - Declarations of invited and JRC experts (see also section 7 of this report – List of participants)

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