European Commission

JRC SCIENCE FOR POLICY REPORT

Scientific, Technical and Economic Committee for Fisheries (STECF) - Stock Assessments in the Mediterranean Sea – Adriatic, Ionian and Aegean Seas (STECF-20-15)

Edited by John Simmonds, Cecilia Pinto and Alessandro Mannini

Joint Research Centre

EUR 28359 EN

Contact information

Name: STECF secretariat

Address: Unit D.02 Water and Marine Resources, Via Enrico Fermi 2749, 21027 Ispra VA, Italy

E-mail: jrc-stecf-secretariat@ec.europa.eu

Tel.: +39 0332 789343

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JRC122994

EUR 28359 EN

PDF	ISBN 978-92-76-27168-0	ISSN 1831-9424	doi:10.2760/877405
STECF		ISSN 2467-0715	

Luxembourg: Publications Office of the European Union, 2020

How to cite this report: Scientific, Technical and Economic Committee for Fisheries (STECF) Stock Assessments in the Mediterranean Sea – Adriatic, Ionian and Aegean Seas (STECF-20-15). EUR 28359 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-27168-0, doi:10.2760/877405, JRC122994.

Authors:

STECF advice:

Abella, J. Alvaro; Bastardie, Francois; Borges, Lisa; Casey, John; Catchpole, Thomas; Damalas, Dimitrios; Daskalov, Georgi; Döring, Ralf; Gascuel, Didier; Grati, Fabio; Ibaibarriaga, Leire; Jung, Armelle; Knittweis, Leyla; Kraak, Sarah; Ligas, Alessandro; Martin, Paloma; Motova, Arina; Moutopoulos, Dimitrios; Nord, Jenny; Prellezo, Raúl; O'Neill, Barry; Raid, Tiit; Rihan, Dominic; Sampedro, Paz; Somarakis, Stylianos; Stransky, Christoph; Ulrich, Clara; Uriarte, Andres; Valentinsson, Daniel; van Hoof, Luc; Vanhee, Willy; Villasante, Sebastian; Vrgoc, Nedo

EWG-20-15 report:

Edmund John Simmonds (EWG chair), Isabella Bitetto, Cikes Kec Vanja, Georgi Daskalov, Alessandro Ligas, Danai Mantopoulou, Matteo Murenu, Alessandro Orio, Andrea Pierucci, Vjekoslav Ticina, George Tserpes, Athanassios Tsikliras, Cecilia Pinto, Alessandro Mannini

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Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. This report is from STECF Expert Working Group 20-15: 2020 stock assessments of demersal stocks in the Adriatic Ionian and Aegean Seas, from the meeting held remotely from 12th to 21st October 2020. A total of 15 fish stocks were evaluated. The EWG reports age based assessments and short term forecasts for 7 and surplus production advice for 3 of the 15 stocks. Catch advice for two other stocks was based on ICES category 3 evaluations of biomass indices. Three stocks could not be assessed due to inconsistent catch data and sparse survey information. 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 10 stocks, the exploration of assessments and category 3 evaluations for the remaining two stocks with advice. The work to evaluate the three remaining stocks was also reported. The report also contains the STECF observations and conclusions on the assessment report. These conclusions come from the STECF Plenary meeting in November 2020.

SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF) - Stock Assessments in Mediterranean Sea – Adriatic, Ionian and Aegean Seas (STECF-20-15)

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 observations

The expert working group met online from 12th to 20th October 2020. The meeting was attended by 14 experts, including two STECF members and two JRC experts. One DG MARE representative and two observers also attended the meeting.

STECF comments

The expert working group met online from 12th to 20th October 2020. The meeting was attended by 14 experts, including two STECF members and two JRC experts. One DG MARE representative and two observers also attended the meeting.

The main objective of the meeting was to carry out assessments and provide draft advice for the demersal stocks in the Adriatic, Ionian and Aegean Seas as listed in the ToRs. Broadly, the ToRs consisted of data preparation, stock assessment, estimation of reference points, short and medium-term forecasts, identification and reporting of data issues and provision of synoptic overview for management advice.

STECF considers that the EWG addressed adequately all the ToRs and notes that the EWG carefully reviewed the quality of all the assessments produced.

STECF observes that given that the boundaries of some of the suggested stocks are not clear, the EWG therefore worked on the basis of species/areas combinations. Overall, 15 species/areas combinations were evaluated for assessments (Table 5.8.1). Seven of the species corresponding to the Adriatic Sea were assessed last time by STECF in 2019 (STECF EWG 19-16), whereas the five species in the Aegean and Ionian Sea were assessed last time in 2017 (STECF EWG 17-15). The Caramote prawn in Northern Adriatic Sea (GSA 17) was considered for the first time. Additional advice for GSA 17 separately was provided this year for Common cuttlefish and Spottail mantis shrimp.

STECF notes that for seven of these species/areas full catch advice was provided for 2021 based on age-based analytical assessments and short-term forecasts. For one species/area (Norway lobster in GSA 17-18) full catch advice was provided based on a surplus production biomass model (SPiCT). Other two species/areas (common cuttlefish in GSA 17 and in GSA 17-18) were also assessed based on a surplus production model (CMSY) but the catch advice was generic and not specific for 2021. For sole in GSA 17 and Caramote prawn in GSA 17, the catch advice followed the ICES Category 3 advice rule based on abundance indices. As it was unclear if these stocks were exploited above or below F_{MSY}, the precautionary buffer of -20% catch reduction was applied. For hake in GSA 20, hake in GSA 22 and deep-water rose shrimp in GSA 22, it was not possible to obtain either coherent assessments or to give index advice due to uncertain historic catch data and sparse survey indices, so no advice could be provided.

F_{MSY} could be estimated for four species/areas (hake in GSA 17-18, Norway lobster in GSA 17-18 and Common cuttlefish in GSA 17-18 and GSA 17). For all of the other stocks evaluated using a4a, it was not possible to carry out full evaluations of MSY due to the limited number of years of data and $F_{0.1}$ was used as a proxy for MSY. MSY ranges (F_{low} and F_{upp}) were derived from the empirical formulas provided by STECF EWG 15-06. Given that $F_{0.1}$ is considered a precautionary proxy for F_{MSY}, F_{low} which is a lower exploitation rate, is also expected to be precautionary. Therefore, STECF considers that F_{low} and F_{MSY} can be used directly. However, it was not possible to evaluate if F_{upp} is precautionary and STECF considers it should not be used to give catch advice without further evaluation.

Table 5.8.1 Summary of the work attempted and basis for any advice. A4A and SS3 refer to age-based assessment methods, CMSY and SPiCT are biomass surplus production models, STF is a standard short-term projection with assumptions of status quo F and historic recruitment and Index refers to the ICES Category 3 approach to advice for stocks without analytic assessments. Methods that are used for advice are in bold. The assessments noted from 2017 were tested assessment not considered suitable for advice.

Area	Common Species name	2019 Assessment	2020 Assessment
17-18	Hake	SS3 STF	a4a, **SS3 STF**
17-18	Red mullet	a4a STF	**a4a STF**
17-18	Norway lobster	SPiCT STF	**SPiCT STF**
17-18-19	Deep-water rose shrimp	a4a STF	**a4a STF**
17-18	Common cuttlefish	CMSY	SPiCT**, CMSY**
17	Common cuttlefish	CMSY	SPiCT**, CMSY**
17	Sole	a4a STF	a4a, **Index**
17-18	Spottail mantis shrimp	a4a STF	**a4a STF**
17	Spottail mantis shrimp	a4a STF	**a4a STF**
17	Caramote prawn		a4a SPiCT **Index**
19	Hake	a4a GFCM benchmark	**a4a STF**
20	Hake	SPiCT, a4a (2017)	a4a SPiCT **no advice**
22	Hake	SPiCT, a4a (2017)	a4a SPiCT **no advice**
22	Red mullet	SPiCT, a4a (2017)	SPiCT **a4a STF**
22	Deep-water rose shrimp	SPiCT, a4a (2017)	SPiCT **no advice**

The assessments indicate that for most of the stocks, biomass has been increasing over the last 3 years, while catch has been decreasing or stable. Six out of the 12 species/areas combinations are being significantly overfished (F2019> F_{MSY}), one is being fished close to F_{MSY} and three are underexploited (F2019< F_{MSY}), while the two species/areas following the Index advice require small catch reductions. The main results are summarized in the bullet point list below and in Table 5.8.2.

- Hake in GSA 17-18: the biomass is increasing. Catches should be reduced by at least 48% to reach FMSY in 2021.

- Sole in GSA 17: the biomass is stable. Catches may be increased more than 1% to conform to precautionary consideration in 2021.

- Red mullet in GSA 17-18: the biomass is increasing. Catches should be reduced by at least 29% to reach FMSY in 2021.

- Common cuttlefish in GSA 17-18: the biomass is increasing. Catches may be increased by no more than 56% to reach FMSY in equilibrium.

- Common cuttlefish in GSA 17: the biomass is increasing. Catches may be increased by no more than 49% to reach FMSY in equilibrium.

- Norway lobster in GSA 17-18: the biomass is increasing. Catches should be reduced by at least 8% to reach FMSY in 2021.

- Spottail mantis shrimp in GSA 17-18: the biomass is increasing. Catches may be increased by no more than 14% to reach FMSY in 2021.

- Spottail mantis shrimp in GSA 17: the biomass is increasing. Catches may be increased by no more than 41% to reach FMSY in 2021.

- Deep-water rose shrimp in GSA 17-18-19: the biomass is increasing. Catches should be reduced by at least 51% to reach FMSY in 2021.

- Caramote prawn in GSA 17-18: the biomass is fluctuating. Catches may be increased by no more than 11% to conform to precautionary consideration in 2021.

- Hake in GSA 19: the biomass is increasing. Catches should be reduced by at least 36% to reach FMSY in 2021.

- Hake in GSA 20: the biomass is unknown and catch advice is not available.

- Hake in GSA 22: the biomass is unknown and catch advice is not available.

- Red mullet in GSA 22: the biomass is increasing. Catches may be increased by no more than 207% to reach FMSY in 2021.

- Deep-water rose shrimp in GSA 22: the biomass is unknown and catch advice is not available.

Table 5.8.2. Summary of advice from EWG 20-15 by area and species. F 2019 is the estimated F in the assessment and used in the short-term forecast for 2020. Change in F is the difference (as a fraction) between target F in 2021 and the estimated F for 2019. Change in catch is from catch 2019 to catch 2021. Biomass status is given as an indication of trend over the last 3 years for stocks with time series analytical assessments or biomass indices. If the stock is considered to be in a low state or high state due to exploitation rate this is noted too. Biomass reference points are not available for any of these stocks.

Area	Species	Method/	Age	Biomass	Catch	F 2019	F 2021	Change in F	Catch 2019*	Catch 2021	Change in catch
		Basis	Fbar	2017-2019	2017-2019						
17-18	Hake	SS3	1 - 4	increasing	stable	0.41	0.18	-56%	5361	2789	-48%
17	Sole	Index	biomass	stable	stable				1940	1960	1%
17-18	Red mullet	a4a	1-3	increasing	decreasing	0.69	0.34	-51%	4632	3285	-29%
17-18	Common cuttlefish	CMSY	biomass	increasing	stable	0.51 F_{MSY}	0.16	96%	4820	7530^	56%
17	Common cuttlefish	CMSY	biomass	increasing	stable	0.48 F_{MSY}	0.14	108%	4070	6070^	49%
17-18	Norway lobster	SPiCT	biomass	increasing	decreasing	0.40	0.36	-9%	1319	1218	-8%
17-18	Spottail mantis shrimp	a4a	1-3	increasing	declining	0.69	0.45	-35%	4372	4970	14%
17	Spottail mantis shrimp	a4a	1-3	increasing	stable	0.59	0.43	-27%	3201	4515	41%
17-18-19	Deep-water rose shrimp	a4a	0-2	increasing	increasing	1.49	0.50	-66%	5993	2915	-51%
17-18	Caramote prawn	Index	biomass	fluctuating	decreasing				768	864	11%
19	Hake	a4a	0 - 4	increasing	decreasing	0.33	0.14	-58%	594	379	-36%
20	Hake	-					No advice			No advice	
22	Hake	-					No advice			No advice	
22	Red mullet	a4a	1-3	increasing	stable	0.15	0.50	233%	1804	5546	207%
22	Deep-water	-					No			No	

	rose shrimp						advice			advice	

* Estimated Catch from 2020 Assessments STECF EWG 2020

#F for Nephrops in 2021 is reduced slightly from FMSY to assist recovery of biomass because biomass in 2021 less than Bpa

^Common cuttlefish catch in 2021 will depend on recruitment in 2020 which is currently unknown values given for catch are indicative only and are long term mean values not suitable as a catch target for 2020 (See Section 5.4)

STECF considers that all of the 10 assessments presented in the report can be used to provide advice on stock status in terms of F relative to F_{MSY}, from which eight can be used to provide catch advice for 2021. STECF notes that all 7 age based assessments are based on short data series and some degree of uncertainty therefore remain, but STECF considers overall that they provide a robust guidance on the magnitude of changes in F and catches required to reach F_{MSY} by 2021. For the three surplus production models, the assessments are from longer series of data and can be used with MSY reference points.

STECF observes that GFCM agreed to adopt a Multi-Annual Plan (MAP) in the Adriatic Sea, with the objective to achieve F_{MSY} by 2026 (GFCM, 4-8 November 2019, Athens, Greece, http://www.fao.org/gfcm/meetings/info/en/c/1200549). For most stocks assessed, F2019 is substantially higher than F_{MSY} (Table 5.8.2), and it seems likely that some kind of transition approach will be required. Following STECF PLEN 19-03, the EWG has included an additional '$F_{MSY\ Transition}$' option in the short-term forecast tables based on a gradual linear change in F from 2020 to 2026. These entries in the STF table (Section 5 EWG report 20-15) are the best estimates of F and catch required in 2021 to follow a linear transition, but they do not take into account uncertainty in estimates or the current progress in transition. They should be considered as guide for progress towards F_{MSY} in 2026.

In response to one of the ToRs (ToR 1.3), the EWG compiled fishing effort data in GSAs 17, 18, 19, 20 and 22 up to 2019 in terms of days at sea by Member State/Country and fishing gear. Data up to 2018 originated from the Mediterranean and Black Sea data call, whereas data in 2019 were taken from the Fisheries Dependent Information (FDI) Data Call. STECF notes that these effort data are not directly used for any of the stock assessments. Given that these data are compiled and analysed in the FDI EWG, STECF considers the ToR on compilation of annual fishing effort data could be excluded from this assessment EWG without any deterioration of the quality of the stock assessment.

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

Firstly STECF notes that the EWG was not able to give catch advice for three stocks in GSA 20 and 22. This was due both to gaps in data but also due to data coherence issues. STECF notes that DG MARE – Unit C3 have agreed with the Greek Authorities to work together on a "plan of priority list of actions on Data Collection", in order to improve the situation in Greece. As part of that initiative a "Working Group on quality assurance" has been setup in Greece involving scientists from all institutes implementing Greek DCF. This initiative is in collaboration with the local authorities (DG of Fisheries - Ministry of Rural Development and Food). The goal of this WG is to: quality-check past data sets, resubmit historic data series to JRC in the DG MARE Med & BS data call next year, and to compile technical documents describing the sampling scheme and statistical estimation procedures. STECF would like to support and encourage this initiative and looks forward to the improvements in quality that this initiative will bring. STECF notes that the EWG also suggested that this approach could be supplemented by examining if the DCF data could be interpolated and or extended using Hellenic Statistical Authority data, STECF would support such an extension to the data improvement program.

Secondly STECF notes that the specific STECF EWG data processing workshop that was proposed for March 2020 was first delayed and then cancelled due to covid-19. STECF notes that the data problems that were to be addressed by this EWG still exist and considers that the work proposed is still required. Therefore STECF supports the rescheduling of this data EWG at a suitable time in 2021 prior to the other EWGs next year.

STECF conclusions

STECF concludes that the EWG addressed all the ToRs appropriately.

STECF endorses the assessments and evaluations of stock status produced by the EWG. STECF concludes that the results of the assessments accepted by the EWG provide reliable information on the status of the stocks and the trends in stock biomass and fishing mortality and that no advice can be given for the three assessments rejected by the EWG.

Given that the effort data are not directly used in any of the stock assessments and are otherwise analysed by FDI EWG, STECF concludes that the ToR on compilation of annual fishing effort data could be excluded from this EWG (and addressed through the FDI process instead) without any deterioration of the quality of the stock assessment.

STECF concludes that the data errors reported should be addressed and where possible corrected before the next data submission. This is particularly relevant for GSA 20 and 22 where several data issues are hindering the possibilities to obtain reliable stock assessments and provide catch advice.

Contact details of STECF members

[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

Name	**Affiliation[1]**	**Email**
Abella, J. Alvaro	Independent consultant	aabellafisheries@gmail.com

Name	Affiliation[1]	Email
Bastardie, Francois	Technical University of Denmark, National Institute of Aquatic Resources (DTU-AQUA), Kemitorvet, 2800 Kgs. Lyngby, Denmark	fba@aqua.dtu.dk
Borges, Lisa	FishFix, Lisbon, Portugal	info@fishfix.eu
Casey, John	Independent consultant	blindlemoncasey@gmail.com
Catchpole, Thomas	CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, UK, NR33 0HT	thomas.catchpole@cefas.co.uk
Damalas, Dimitrios	Hellenic Centre for Marine Research, Institute of Marine Biological Resources & Inland Waters, 576 Vouliagmenis Avenue, Argyroupolis, 16452, Athens, Greece	shark@hcmr.gr
Daskalov, Georgi	Laboratory of Marine Ecology, Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences	Georgi.m.daskalov@gmail.com
Döring, Ralf (vice-chair)	Thünen Institute [TI-SF] Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute of Sea Fisheries, Economic analyses Herwigstrasse 31, D-27572 Bremerhaven, Germany	ralf.doering@thuenen.de
Gascuel, Didier	AGROCAMPUS OUEST, 65 Route de Saint Brieuc, CS 84215, F-35042 RENNES Cedex, France	Didier.Gascuel@agrocampus-ouest.fr
Grati, Fabio	National Research Council (CNR) – Institute for Biological Resources and Marine Biotechnologies (IRBIM), L.go Fiera della Pesca, 2, 60125, Ancona, Italy	fabio.grati@cnr.it
Ibaibarriaga, Leire	AZTI. Marine Research Unit. Txatxarramendi Ugartea z/g. E-48395 Sukarrieta, Bizkaia. Spain.	libaibarriaga@azti.es

Name	**Affiliation**[1]	**Email**
Jung, Armelle	DRDH, Techopôle Brest-Iroise, BLP 15 rue Dumont d'Urville, Plouzane, France	armelle.jung@desrequinsetdeshommes.org
Knittweis, Leyla	Department of Biology, University of Malta, Msida, MSD 2080, Malta	Leyla.knittweis@um.edu.mt
Kraak, Sarah	Thünen Institute of Baltic Sea Fsheries, Alter Hafen Süd 2, 18069 Rostock, Germany.	sarah.kraak@thuenen.de
Ligas, Alessandro	CIBM Consorzio per il Centro Interuniversitario di Biologia Marina ed Ecologia Applicata "G. Bacci", Viale N. Sauro 4, 57128 Livorno, Italy	ligas@cibm.it; ale.ligas76@gmail.com
Martin, Paloma	CSIC Instituto de Ciencias del Mar Passeig Marítim, 37-49, 08003 Barcelona, Spain	paloma@icm.csic.es
Motova, Arina	Sea Fish Industry Authority, 18 Logie Mill, Logie Green Road, Edinburgh EH7 4HS, U.K	arina.motova@seafish.co.uk
Moutopoulos, Dimitrios	Department of Animal Production, Fisheries & Aquaculture, University of Patras, Rio-Patras, 26400, Greece	dmoutopo@teimes.gr
Nord, Jenny	The Swedish Agency for Marine and Water Management (SwAM)	Jenny.nord@havochvatten.se
Prellezo, Raúl	AZTI -Unidad de Investigación Marina, Txatxarramendi Ugartea z/g 48395 Sukarrieta (Bizkaia), Spain	rprellezo@azti.es
O'Neill, Barry	DTU Aqua, Willemoesvej 2, 9850 Hirtshals, Denmark	barone@aqua.dtu.dk
Raid, Tiit	Estonian Marine Institute, University of Tartu, Mäealuse 14, Tallin, EE-126, Estonia	Tiit.raid@gmail.com
Rihan, Dominic (vice-chair)	BIM, Ireland	rihan@bim.ie

Name	**Affiliation**[1]	**Email**
Sampedro, Paz	Spanish Institute of Oceanography, Center of A Coruña, Paseo Alcalde Francisco Vázquez, 10, 15001 A Coruña, Spain	paz.sampedro@ieo.es
Somarakis, Stylianos	Institute of Marine Biological Resources and Inland Waters (IMBRIW), Hellenic Centre of Marine Research (HCMR), Thalassocosmos Gournes, P.O. Box 2214, Heraklion 71003, Crete, Greece	somarak@hcmr. gr
Stransky, Christoph	Thünen Institute [TI-SF] Federal Research Institute for Rural Areas, Forestry and Fisheries, Institute of Sea Fisheries, Herwigstrasse 31, D-27572 Bremerhaven, Germany	christoph.stransky@thuenen.de
Ulrich, Clara (chair)	IFREMER, France	Clara.Ulrich@ifremer.fr
Uriarte, Andres	AZTI. Gestión pesquera sostenible. Sustainable fisheries management. Arrantza kudeaketa jasangarria, Herrera Kaia - Portualdea z/g. E-20110 Pasaia – GIPUZKOA (Spain)	auriarte@azti.es
Valentinsson, Daniel	Swedish University of Agricultural Sciences (SLU), Department of Aquatic Resources, Turistgatan 5, SE-45330, Lysekil, Sweden	daniel.valentinsson@slu.se
van Hoof, Luc	Wageningen Marine Research Haringkade 1, Ijmuiden, The Netherlands	Luc.vanhoof@wur.nl
Vanhee, Willy	Independent consultant	wvanhee@telenet.be
Villasante, Sebastian	University of Santiago de Compostela, Santiago de Compostela, A Coruña, Spain, Department of Applied Economics	sebastian.villasante@usc.es
Vrgoc, Nedo	Institute of Oceanography and Fisheries, Split, Setaliste Ivana Mestrovica 63, 21000 Split, Croatia	vrgoc@izor.hr

REPORT TO THE STECF

EXPERT WORKING GROUP ON
Stock Assessments in the Mediterranean Sea - Adriatic, Ionian and Aegean Seas
(EWG-20-15)

Virtual meeting, 12-20 October 2020

1 INTRODUCTION

1.1 Approach to the work

The working group was held in remotely, from 12th to 20th Sept 2020. The meeting was attended by 14 experts in total, including two STECF member and two JRC experts. The EWG had two observers who attended part time.

The objective of the Mediterranean Methodology EWG 20-15 was to carry out assessments and provide draft advice for stocks identified in the ToR supplied by STECF. An initial plenary session commenced at 09:30 on the first day. The ToRs were discussed and examined in detail. Stocks were allocated to participants based on expertise. An ftp repository was created ad-hoc to share documents, data and scripts and prepare the report. The stocks were evaluated by the GSA groups identified in the ToRs. Most of the work was concluded by Tuesday 20 Sept, after 7 full days of work, and some additional work at the weekend.

Over the 7 working days plenary sessions were held each day to monitor progress and share results. The overall conclusions for each stock were discussed and finalized in plenary on the Tuesday.

1.2 Impact of Coronavirus / Remote meeting

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

The EWG 20-15 was extended to 7 full working days to account for the uncertainty in working remotely exceeding the STECF allocation by only a single ½ day session, however, some work was carried out during the weekend in excess of allocated resources.

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

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

Overall the meeting was less interactive, particularly for those less assertive individuals, as it is much more difficult to participate in discussions in a remote meeting setting with 14 people.

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

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

1.3 Terms of Reference for EWG-20-15

DG MARE focal point: Giacomo Chato Osio.

Chair: John Simmonds

TERMS OF REFERENCE

For the stocks given in Table 1, the group 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 2019. This should be presented by fishing gear as well as by size/age structure.

3. To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2019. 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 and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort and/or capacity baseline.

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 2019 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.

The EWG shall:

1. Give preference to models that allow estimation of uncertainty, in line with the recommendations of STECF EWG 17-07.

2. Attempt where age length keys (ALK) are considered viable, to convert numbers at length into numbers at age based on the ALKs.

3. Where possible, use fisheries and survey data, recovered and standardized in the context of the EU RECFISH project, to expand the time series in the stock assessments.

4. For stocks previously assessed, take into account discussion on methods and assumptions made in previous expert groups, including the GFCM WG on Stock Assessment for Demersal Species in 2019

ToR 3. To estimate candidate MSY point-value, MSY range values 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 4. To provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, *inter alia*: zero catch, the status quo fishing mortality, and target to F_{MSY} or other appropriate **proxy by 2021 and 2026 for the Adriatic stocks marked with (^)**.

ToR 5. To summarize and concisely describe all data quality deficiencies in particular for areas that have not been recently assessed (GSA 19-20-22), including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched on the May 2020.

ToR 6. To ensure that all unresolved data transmission issues encountered prior to and during the EWG meeting are reported on line via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt. Guidance on precisely what should be inserted in the DTMT, log-on credentials and access rights will be provided separately by the STECF Secretariat focal point for the EWG.

ToR 7. Using the report structure developed in 2018 (EWG 18-12), provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including F_{MSY} value, range of values, conservation reference points and effort levels.

ANNEX I

Table I – List of suggested stocks to be assessed by the EWG 20-15.

Area	**Common name**	**Scientific name**
GSA 17-18*	Hake^	***Merluccius merluccius***
GSA 17-18	Red mullet^	***Mullus barbatus***
GSA 17-18	Norway lobster^	***Nephrops norvegicus***
GSA 17-18-19	Deep-water rose shrimp^	***Parapenaeus longirostris***
GSA 17-18**	Common cuttlefish	***Sepia officinalis***
GSA 17***	Sole^	***Solea vulgaris***
GSA 17-18**	Spottail mantis shrimp	***Squilla mantis***
GSA 17-18**	Caramote prawn	***Penaeus kerathurus***
GSA 19/20/22**	Hake	***Merluccius merluccius***
GSA 22	Red mullet	***Mullus barbatus***
GSA 22	Deep-water rose shrimp	***Parapenaeus longirostris***

* Updated assessment of the GFCM 2019 Hake benchmark assessments (ss3 & a4a)

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

*** A benchmark assessment is expected to be organized by GFCM in the 2020/2021 period; work is expected to contribute to this benchmark.

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.

2 FINDINGS AND CONCLUSIONS OF THE WORKING GROUP

A total of 15 area/species combinations were evaluated for assessments. The EWG has carried out and accepted 7 age based analytical assessments with short term forecasts, F target and catch advice for 2021. Three species area combinations were assessed with surplus production biomass methods. For one (Nephrops 17-18) full catch advice was provided for two (common cuttlefish 17 and 17-18) they were assessed but catch advice is generic and not specific for 2021. For two more (sole 17 and Caromote Prawn 17) index evaluations with catch advice are provided. For three areas (hake 20, hake 22 and Red mullet 22) it was not possible to obtain coherent assessments and not possible to give index advice due to uncertain historic catch data and missing surveys leading to sparse data series in recent years

2.1 Stock-Specific Findings & Conclusions

See the stock specific summary sheets (section 5) for the main details by stock, and the assessments (Section 6) for full details. This section provides collated information on methods and stock status. The methods tested and chosen by stock are provided in Table 2.1. Where possible age based assessments are used, where these do not provide stable enough models, if indices of abundance are available ICES category 3 stock advice is applied. For some stocks where it has not been possible to obtain assessments and survey indices are too sparse in recent years it is not possible to give F or catch advice. The results in terms F and catch and relative changes from 2019 to 2021 are provided in Table 2.2.

Table 2.1 Summary of work was attempted and basis for any advice. A4A and XSA are an age based assessment methods STF is a standard short term projection with assumptions of status quo F and historic recruitment. Index refers to the ICES Category 3 approach to advice for stocks without analytic assessments. Methods that are used for advice are in bold. The assessments noted from 2017 were tested assessment not considered suitable for advice.

Area	Common Species name	2019 Assessment	2020 Assessment
17-18	Hake	SS3 STF	a4a, **SS3 STF**
17-18	Red mullet	a4a STF	**a4a STF**
17-18	Norway lobster	SPICT STF	**SPiCT STF**
17-18-19	Deep-water rose shrimp	a4a STF	**a4a STF**
17-18	Common cuttlefish	CMSY	SPiCT**, CMSY**
17	Common cuttlefish		SPiCT**, CMSY**
17	Sole	a4a STF	a4a, **Index**
17-18	Spottail mantis shrimp	a4a STF	**a4a STF**
17	Spottail mantis shrimp		**a4a STF**
17	Caramote prawn		a4a SPiCT **Index**
19	Hake	a4a GFCM	**a4a STF**
20	Hake	SPiCT (2017)	a4a SPiCT **no advice**
22	Hake	SPiCT (2017)	a4a SPiCT **no advice**
22	Red mullet	SPiCT (2017)	SPiCT **a4a STF**
22	Deep-water rose shrimp	SPiCT(2017)	SPiCT **no advice**

Table 2.2 Summary of advice from EWG 20-09 by area and species. F 2019 is the estimated F in the assessment, and used in the short term forecast for 2020. Change in F is the difference (as a fraction) between target F in 2021 and the estimated F for 2019. Change in catch is from catch 2019 to catch 2021. Biomass status is given as an indication of trend over the last 3 years for stocks with time series analytical assessments or biomass indices. If the stock is considered to be in a low state or high state due to exploitation rate this is noted too. Biomass reference points are not available for any of these stocks.

Area	Species	Method/	Age	Biomass	Catch	F 2019	F 2021	Change in F	Catch 2019*	Catch 2021	Change in catch
		Basis	Fbar	2017-2019	2017-2019						
17-18	Hake	SS3	1 - 4	increasing	stable	0.41	0.18	-56%	5361	2789	-48%
17	Sole	Index	biomass	stable	stable				1940	1960	1%
17-18	Red mullet	a4a	1-3	increasing	decreasing	0.69	0.34	-51%	4632	3285	-29%
17-18	Common cuttlefish	CMSY	biomass	increasing	stable	0.51 F_{MSY}	0.16	96%	4820	7530^	56%
17	Common cuttlefish	CMSY	biomass	increasing	stable	0.48 F_{MSY}	0.14	108%	4070	6070^	49%
17-18	Norway lobster	SPiCT	biomass	increasing	decreasing	0.40	0.36	-9%	1319	1218	-8%
17-18	Spottail mantis shrimp	a4a	1-3	increasing	declining	0.69	0.45	-35%	4372	4970	14%
17	Spottail mantis shrimp	a4a	1-3	increasing	stable	0.59	0.43	-27%	3201	4515	41%
17-18-19	Deep-water rose shrimp	a4a	0-2	increasing	increasing	1.49	0.50	-66%	5993	2915	-51%
17-18	Caramote prawn	Index	biomass	fluctuating	decreasing				768	864	11%
19	Hake	a4a	0 - 4	increasing	decreasing	0.33	0.14	-58%	594	379	-36%
20	Hake	-					No advice			No advice	
22	Hake	-					No advice			No advice	
22	Red mullet	a4a	1-3	increasing	stable	0.15	0.50	233%	1804	5546	207%
22	Deep-water rose shrimp	-					No advice			No advice	

* Estimated Catch from 2020 Assessments STECF EWG 2020

#F for Nephrops in 2021 is reduced slightly from FMSY to assist recobery of biomass because biomass in 2021 less than Bpa

^Common cuttlefish catch in 2021 will depend on recruitment in 2020 which is currently unknown values given for catch are indicative only and are long term mean values not suitable as a catch target for 2020 (See Section 5.4)

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 2019 data shows similar stock SSB, and F as previous 2019 assessment. It shows a sharp increase in SSB in last few years. The retrospective analysis shows small tendency to overestimate SSB and underestimate F. The exploitation rate is shown to be similar in an a4a assessment using all the catch data, the SS3 model omits a few minor fleets, the results of both models are considered directly comparable.

Hake in GSA 19 The EWG used data prepared from 2020 GFCM benchmark, the selected model from the benchmark gave unstable results, the EWG examine two of the next best remaining possible models from the benchmark (these models had identical statistical performance as the selected model) The EWG selected the model with slightly more flexible selection for the MEDITS survey, which is considered more realistic for the survey gear. 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. The benchmark report indicated that there was little to choose between the models, and had the instability been detected it seems unlikely that the chosen model would have been selected over the other two options.

Hake in GSA 20 The EWG tried a4a and SPiCT models, the models gave conflicting results. There are difficulties with both catch and survey data sets. The survey is missing in a number of years. Different sources of catch data (DCF and Hellenic Statistical Authority) have different values for the data set except the most recent years. Data from coastal fleet from 2002 to 2013 was aggregated in the earlier years, and it was not possible to use this data, making the data set incomplete. The details of the data issues are given in Section 3

Hake in GSA 22 The EWG tried a4a and SPiCT models, the models gave conflicting results. There are difficulties with both catch and survey data sets. The survey is missing in a number of years. Different sources of catch data (DCF and Hellenic Statistical Authority) have different values for the data set except the most recent years. Data from coastal fleet from 2002 to 2013 was aggregated in the earlier years, and it was not possible to use this data, making the data set incomplete. The details of the data issues are given in Section 3

Red Mullet

Red Mullet in GSA 17-18 New assessment based on revised length slicing and a revised model with minor changes from last year. RECFISH data was used was Croatian catches for 2006 to 2012. For Albania LFD were reconstructed based on 2019 data. Catches in 2007 to 2011 were replaced by the average of 2012 to 2014 because the reported values were considered too small relative to recent data. These catches are currently being reviewed in Albania. A small retrospective bias in F and SSB, but conclusion on stock status are not affected by this. The instability in F0.1 observed last year is no longer seen in this model.

Red Mullet in GSA 22 Both a4a and SPICT models were applied, which agreed on stock status. The advice was based on the a4a assessment as the scaling of biomass in the

SPiCT model was considered to be questionable. The a4a model used here was similar to the 2017 model but different growth model was applied to split the data. Turkish catches were also included in the assessment and it was assumed that their catch length composition was similar the Greek fleet. There is increased uncertainly in the assessment due to missing survey and lack of catch sampling data for several years.

Sole 17

The WG received feedback from GFCM on the STECF model presented last year and on a GFCM model with different life history parameters. The STECF EWG ran a sensitivity analysis on growth and natural mortality by slicing length using cohort filling, and slicing with GFCM WG parameters. The sensitivity to assessment results was carried out both with growth parameters and 3 different sets of mortality vectors run in combination with the growth. The conclusions were that assessments can give very different conclusions in stock status depending which growth and mortality assumptions are followed. The influence of growth and natural mortality were of similar magnitude, each responsible for about half the overall range of the outcomes. There clearly a need for a benchmark and the STECF EWG would like to support GFCM in this respect. Given this uncertain situation the EWG gave index based advice for this stock this year with the assumption of stock status unknown given that the majority of the analyses indicated F was greater than F_{MSY}.

Nephrops in GSA 17-18

The model settings for the SPiCT assessment are similar to previous years. The MEDITS index was updated for years 1994 to 2001 with data from Italy from GSA 17 which replaces estimated values used previously. The influence of this change on the assessment results was negligible. SSB from the assessment is seen to be increasing but still just below Bpa.

Spottail mantis shrimp GSA 17-18

Assessments for GSAs 17 and 18 combined and for 17 on its own are provided. Most the stock is thought to be in GSA 17. The two assessment models are very similar and the results in terms of F and SSB are compatible. It was not considered possible to give advice for GSA 18 on its own.

Deepwater Rose Shrimp

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 treatment was the same as 2019 with only one extra year added. The choice between a short and longer time series was evaluated and the longer time series was selected, as the performance was similar in terms of the value and quality of the advice but the longer series also provides a more complete view of the stock over time.

Deep-water Rose Shrimp in GSA 22. The EWG tried SPiCT model, but there are difficulties with both catch and survey data sets. The survey is missing in a number of years, while different sources of catch data (DCF and Hellenic Statistical Authority) provide conflicting historical catch estimates. The details of the data issues are given in Section 3.

Common Cuttlefish GSA 17-18

The assessment was slightly modified from last year, with wider priors, which gives a better retrospective performance. With the new setting the biomass has changed, but the status of the stock in terms of F/F_{MSY} and B/B_{MSY} is unchanged. The stock status is unchanged from last year. Sensitivity to different catch data for 2000 to 2007 showed this did not influence the perception of the stock, so uncertainty in these catches is considered acceptable. GFCM noted issues with catch which were explored through sensitivity and found to be negligible. GFCM also noted that the SOLEMON survey may be a better survey, but this survey data set was not available to the EWG. A SPiCT model was tested but did converge and in conclusion the advice is still based on CMSY as it was last year. 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.

Caramote prawn in GSA 17-18

Data from GSA 17 and 18 were evaluated but only data from 17 seems to have the potential for an assessment. Both a4a and SPiCT model were tried. Biological parameters (growth and length/weight relationships) were not available in DCF data and were obtained from the literature. An A4a model with an annual time step did not work as cohorts are seen for too short a time to allow model fitting. If the reported growth is correct, it is unlikely that an age based model with annual time step will succeed. The SPiCT model fitted to available catch data provided a very uncertain and unstable output. A more detailed investigation of historical landings may help, but recent catches are much higher than those from the past. It is unclear if low catches in the earlier years are due to low biomass, lack of reporting or due to environmental changes.

2.3 EFFORT (TOR 1.3)

To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2019. 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 and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort and/or capacity baseline.

Effort data sources

a) DCF Mediterranean data call (file: effort.csv)
b) FDI data call (file: effort-FDIdataset.csv)

In accordance with ToR 1.3, EWG 20-15 analysed effort data (files: effort.csv and effort-FDIdataset.csv) related to demersal fisheries in the Adriatic, Aegean and Ionian Seas (i.e. GSAs 17, 18, 19, 20 and 22). Following previous suggestion of Commission representative (EWG19-10) fishing day has been selected as the most appropriate parameter for fishing effort index. In line with Commission decision 2016/1251, fishing day is defined as any calendar day at sea in which a fishing operation takes place.

Effort data in DCF database (datafile: effort.csv) related to GSAs 17, 18, 19, 20 and 22, as available to EWG20-15, consisted of 14303 records in total, and were submitted by 7 EU Member States (CYP, FRA, GRC, HRV, ITA, MLT and SVN).

Since the occurrence of Cyprus, France and Malta fishing activities in the Adriatic, Ionian and Aegean Sea is quite unexpected (see Tables 2.3.1-3), EWG 20-15 decided not to take data records from these Member States in effort analyses, but suggest that MS concerned should check accuracy of these data records.

Table 2.3.1 Effort data reported by Cyprus in Adriatic, Ionian and Aegean Sea.

countr	yea	quart	vessel_l	gea	mesh_si	fishery	area	s	nominal	gt_days_	no_vess	days_at_sea	fishing_
CYP	2010	-1	VL1218	LLD	-1	LPF	GSA 22	-1	11200	2800	1	35	35
CYP	2010	-1	VL2440	OTB	40D50	DEMSP	GSA 19	-1	2031	860	2	8	8
CYP	2011	-1	VL1218	LLD	-1	LPF	GSA 22	-1	9600	2400	1	30	30
CYP	2012	-1	VL1218	LLD	-1	LPF	GSA 22	-1	9920	2480	1	31	31
CYP	2013	-1	VL1218	LLD	-1	LPF	GSA 22	-1	2560	640	1	8	8
CYP	2014	-1	VL1218	LLD	-1	LPF	GSA 22	-1	14720	3680	1	46	46
CYP	2014	-1	VL1218	LLD	-1	LPF	GSA 20	-1	960	240	1	3	3
CYP	2015	-1	VL1218	LLD	-1	LPF	GSA 22	-1	10560	2640	1	33	33
CYP	2015	-1	VL1218	LLD	-1	LPF	GSA 20	-1	4800	1200	1	15	15
CYP	2016	-1	VL1218	LLD	-1	LPF	GSA 22	-1	33600	8400	1	105	105
CYP	2017	1	VL1218	LLD	-1	LPF	GSA 22	NON	3309,18	633,02	4	19	19
CYP	2017	2	VL1218	LLD	-1	LPF	GSA 22	NON	14168,53	2710,33	8	81,35	81,35
CYP	2017	3	VL1218	LLD	-1	LPF	GSA 22	NON	6792,53	1299,36	3	39	39
CYP	2017	3	VL2440	LLD	-1	LPF	GSA 17	NON	1337,89	341,33	1	4	4
CYP	2017	4	VL1218	LLD	-1	LPF	GSA 22	NON	4702,52	899,56	5	27	27
CYP	2017	4	VL2440	LLD	-1	LPF	GSA 17	NON	11037,62	2816	3	33	33
CYP	2017	4	VL2440	LLS	-1	DEMSP	GSA 17	NON	2316,78	828	2	9	9
CYP	2018	1	VL1218	LLD	-1	LPF	GSA 22	-1	7680	1920	1	24	24
CYP	2018	2	VL1218	LLD	-1	LPF	GSA 22	-1	16320	4080	1	51	51
CYP	2018	2	VL2440	LLS	-1	DEF	GSA 17	-1	9267	3312	1	36	36
CYP	2018	3	VL1218	LLD	-1	LPF	GSA 22	-1	8640	2160	1	27	27
CYP	2018	3	VL2440	LLD	-1	LPF	GSA 17	-1	2059	736	1	8	8
CYP	2018	3	VL2440	LLS	-1	DEF	GSA 17	-1	9267	3312	1	36	36
CYP	2018	4	VL1218	LLD	-1	LPF	GSA 22	-1	6720	1680	1	21	21
CYP	2018	4	VL2440	LLS	-1	DEF	GSA 17	-1	3089	1104	1	12	12

Table 2.3.2. Effort data reported by France in Adriatic and Ionian Sea.

countr	yea	quart	vessel_l	gea	mesh_si	fishery	area	s	nominal	gt_days_	no_vess	days_at_sea	fishing_
FRA	2010	2	VL2440	OTM	20D40	SPF	GSA 18	-1	2844	1341	1	9	8
FRA	2015	1	VL40XX	-1	-1	-1	GSA 19	-1	7927,9	2122,67	1	6,117208116	6,117208
FRA	2015	2	VL2440	-1	-1	-1	GSA 19	-1	15480	6330	2	30	30
FRA	2015	2	VL40XX	-1	-1	-1	GSA 19	-1	35160,36	9478,31	4	31,27001223	31,27001
FRA	2015	3	VL40XX	-1	-1	-1	GSA 19	-1	11631,36	3114,26	1	8,974818187	8,974818
FRA	2015	4	VL40XX	-1	-1	-1	GSA 19	-1	7230,13	1935,84	1	5,578801137	5,578801
FRA	2016	1	VL40XX	PS	-1	BFTE	GSA 19	-1	19440	5205	1	15	15
FRA	2016	2	VL2440	-1	-1	-1	GSA 19	-1	10341,21	4203,27	2	20,04111025	20,04111
FRA	2016	2	VL2440	PS	50D100	BFTE	GSA 19	-1	435,03	185,26	2	0,843085254	0,843085
FRA	2016	2	VL40XX	-1	-1	-1	GSA 19	-1	41081,47	11014,08	3	34,09001587	34,09002
FRA	2016	2	VL40XX	PS	-1	BFTE	GSA 19	-1	10123,81	2710,62	2	7,811970976	7,811971
FRA	2016	3	VL40XX	-1	-1	-1	GSA 19	-1	11844,06	3171,21	1	9,138934352	9,138934
FRA	2016	3	VL40XX	PS	-1	BFTE	GSA 19	-1	12522,67	3352,91	1	9,662553499	9,662553
FRA	2016	4	VL40XX	PS	-1	BFTE	GSA 19	-1	2592	694	1	2	2

Table 2.3.3. Effort data reported by Malta in Adriatic and Ionian Sea.

count	yea	quart	vessel_	gea	mesh_s	fisher	area	s	nomina	gt_days	no_ves	days_at_se	fishing_
MLT	2015	3	VL1824	LLD	-1	LPF	GSA 17	-1	10746	1350	1	24	18
MLT	2015	4	VL1824	LLD	-1	LPF	GSA 17	-1	-1	-1	1	13	-1
MLT	2015	4	VL1824	LLS	-1	DEMF	GSA 17	-1	11343	1425	1	26	19
MLT	2015	4	VL2440	OTB	40SXX	DEMSP	GSA 17	-1	447,6	300	1	6	1
MLT	2016	2	VL0612	SV	-1	DEMSP	GSA 18	-1	37,3	3,32	1	1	1
MLT	2018	1	VL1218	LLS	-1	DEF	GSA 19	-1	281,84	60	1	2	1
MLT	2018	1	VL2440	OTB	40SXX	MDD	GSA 19	-1	16128	5184	1	36	12
MLT	2018	1	VL2440	OTB	40SXX	DWS	GSA 19	-1	2688	864	1	6	3
MLT	2018	2	VL0612	LLD	-1	LPF	GSA 19	-1	29634,84	2277,48	12	211	43
MLT	2018	2	VL1218	LHM	-1	CEP	GSA 19	-1	1100	64,95	1	5	1
MLT	2018	2	VL1218	LLD	-1	LPF	GSA 19	-1	19921,68	3642,13	5	123	22
MLT	2018	2	VL1218	LLD	-1	BFTE	GSA 19	-1	574,96	80	1	4	2
MLT	2018	2	VL1218	LLS	-1	DEF	GSA 19	-1	880	51,96	1	4	1
MLT	2018	2	VL1824	LLD	-1	LPF	GSA 20	-1	1782	572	1	11	1
MLT	2018	2	VL1824	LLD	-1	LPF	GSA 19	-1	2430	780	1	15	2
MLT	2018	2	VL1824	OTB	40SXX	DWS	GSA 20	-1	6379,08	1530	1	17	3
MLT	2018	2	VL2440	OTB	40SXX	DWS	GSA 19	-1	13888	4464	1	31	7
MLT	2018	2	VL2440	PS	14D16	BFTE	GSA 19	-1	3357	520	1	5	1
MLT	2018	3	VL0612	LA	14D16	SLP	GSA 19	-1	339,43	78,82	1	7	5
MLT	2018	3	VL1218	LA	14D16	SLP	GSA 19	-1	1611,36	177,72	1	12	8
MLT	2018	4	VL1218	LA	14D16	SLP	GSA 19	-1	671,4	74,05	1	5	3
MLT	2018	4	VL1218	LHM	-1	CEP	GSA 19	-1	880	51,96	1	4	1
MLT	2018	4	VL1218	LLS	-1	DEF	GSA 19	-1	649,02	44,61	1	3	1
MLT	2018	4	VL1824	LLD	-1	LPF	GSA 20	-1	11700	2304	1	18	1

Data originating from the Mediterranean and Black Sea data call (hereafter MEDBS) (i.e. file: effort.csv) are generally available in period 2002-2018. EWG 20-15 also noted that data entries from 2002 and 2003 are mostly incomplete (i.e. quarter, vessel lengths, number vessels = -1), therefore these two years were excluded from further effort analyses. So, the spatial and temporal data coverage by Member States available from DCF Mediterranean data call were:

- HRV (2012-2018; GSA 17)
- GRC (2004-2018; GSAs 20, 22)
- ITA (2004-2018; GSAs 17, 18, 19)
- SVN (2005-2018); GSA 17

Because the MEDBS Official Data Call ask for these data anymore, data on 2019 year were taken from Fisheries Dependent Information (hereafter FDI) Data Call, i.e. from file effort-FDIdataset.csv and combined.

Beside data records indicating fishing effort performed by active fishing vessels by 19 different gear types, a certain amount of fishing effort is related to unknown gears (i.e. Non available data: gear code -1). Among total number of effort data records (14240 data records, without inactive vessels), approximately 11.5% of effort data (1632 records) are related to unknown gear type (Figure 2.3.1). These records with no gear data were reported by Greece (20 records in 2003-2008 period), Croatia (303 records in 2012-2018 period) and Italy (1309 records in 2002-2018 period).

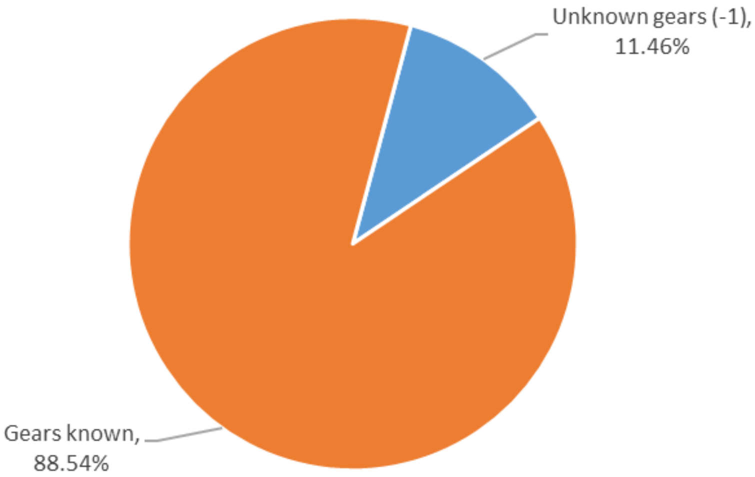


Figure 2.3.1. Amounts of available effort data records with and without information on the gear.

Consequently, 12608 out of 14240 effort data records, related to 19 different gears, were used in further effort data analyses. Results of effort data analyses by Member States, fishing in GSAs 17, 18, 19, 20 and 22 (i.e. GRC, HRV, ITA and SVN), made by year, vessel size and gears are presented together with assessments of species targeted by selected gears.

Selection of principal fishing gears associated with assessments

It was noted that effort data are not species specific, but refers to different GSAs, gears, fisheries, countries, etc. Considering the assessments needed to be performed by EWG 20-15, the experts selected 7 gears that are related to bulk of landings of target species (i.e. >90%) considered in given GSAs by Member States (Table 2.3.4). The main gear included in all assessments was Bottom otter trawl (OTB).

Table 2.3.4 Fishing gears selection (associated with target species assessments) by Member States.

Stock / Gear by MS	GNS	GTR	LLS	FPO	OTB	DRB	TBB
Common cuttlefish (GSA 17-18)	HRV, ITA	HRV, ITA, SVN		ITA	HRV, ITA, SVN	HRV	ITA

Deep-water rose shrimp (GSA 17-18-19)					HRV, ITA		
European hake (GSA 17-18)			HRV,ITA		HRV, ITA, SVN		
Norway lobster (GSA 17-18)				HRV	HRV, ITA		
Red mullet (GSA 17-18)	ITA (18)				HRV, ITA, SVN		
Common sole (GSA 17)	ITA, SVN	HRV, SVN			HRV, ITA	HRV	ITA
Spottail mantis shrimp (GAS 17-18)	ITA, SVN	SVN			HRV, ITA, SVN		ITA
Caramote prawn (GSA 17-18)					ITA, SVN		ITA
Deep-water rose shrimp (GSA 22)					GRC		
European hake (GSA 19)	ITA	ITA	ITA		ITA		
European hake (GSA 20)	GRC	GRC	GRC		GRC		
European hake (GSA 22)	GRC	GRC	GRC		GRC		
Red mullet (GSA 22)	GRC	GRC			GRC		

However, EWG20-15 highlights that gears indicated in the table are used in framework of different fisheries where multispecies catches are obtained. So, it is important to keep in mind that fishing effort data are related to multi-fisheries and multispecies aspects, and not just to one single species in one type of fishery considered in particular assessments.

Amount of fishing vessels in size categories by Member States

EWG20-15 highlights the fact that in DCF effort data file the numbers of active fishing vessels by Member States are reported by quarter, and not by year. Considering the fact that some fishing vessels may be reported operating in one quarter and not in another quarter, the average number of vessels in 4 quarters are likely to be biased. Therefore, EWG20-15 decided to use a maximum number of vessels reported by Member States in any quarter as a proxy to number of vessels per year in Member States.

CROATIA (HRV)

Effort data in terms of amount of fishing vessels for Croatia are available since 2012 year. The most numerous fishing vessels are within size category 6–12m. Fishing vessels in size category 6-12m are using all selected gears, but most of them use gillnets (GNS) as dominant fishing gear. Size structure of fishing fleet in Croatia, as reported in period

2012–2019 using selected gears, is given in Figure 2.3.2. All these Croatian fishing vessels are using selected gears in GSA17 only.

As mentioned before, 2019 data are taken from FDI dataset. During the analyses, EWG20-15 noticed discrepancies between the maximum number of vessels reported in the MEDBS dataset and the maximum values reported for total vessels in the FDI dataset in overlapping period (i.e. 2015-2018).

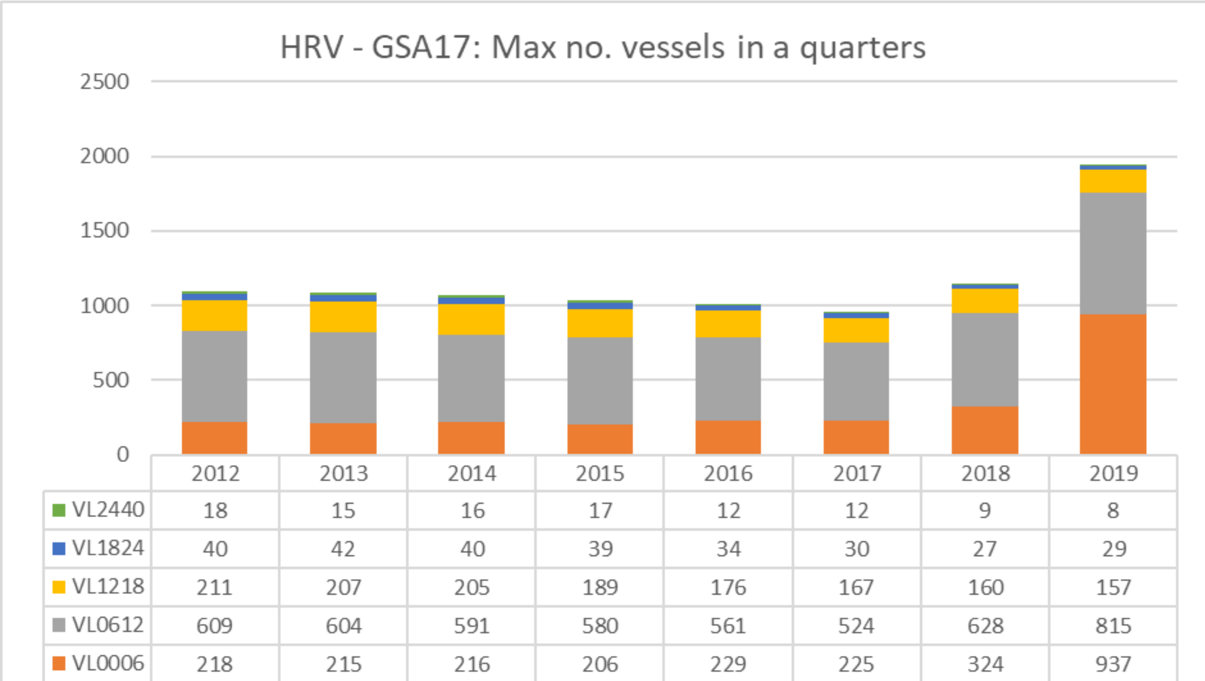


Figure 2.3.2 Estimated amount and size structure of fishing fleet in Croatia, using gears selected (2019 data from FDI).

GREECE (GRC)

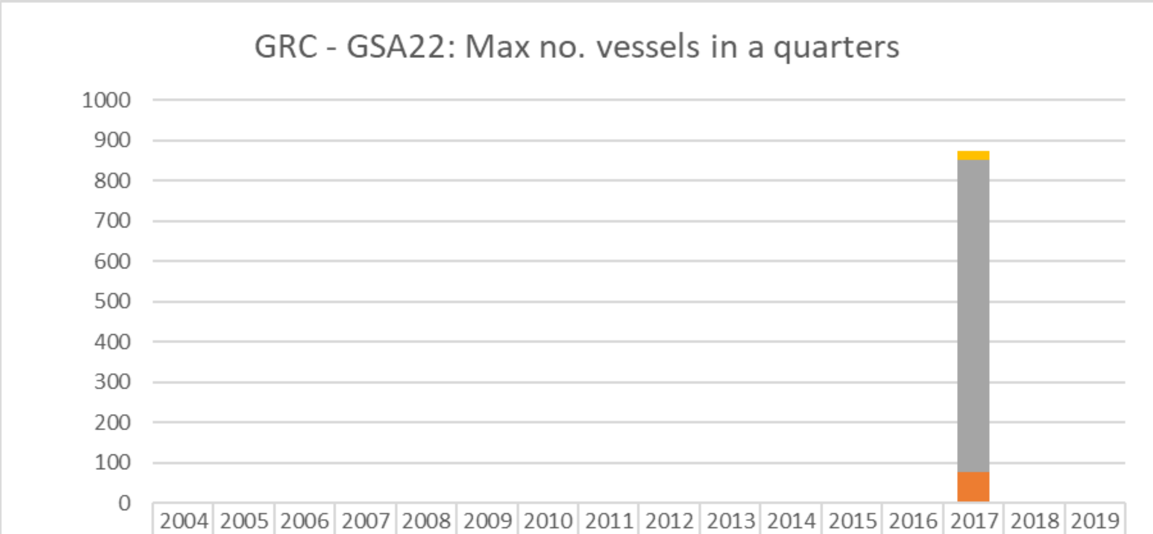
Data in terms of amount of fishing vessels for Greece in GSA20 and GSA22 are expected to be available within dataset from DCF Mediterranean data calls at least since 2004 year. However, this was not the case. As shown in Table 2.3.5 and Figure 2.3.3, data on fishing vessels in GSA20 and GSA22 from MEDBS dataset are largely missing, or were reported as non-available (-1). The only data reported on number of vessels are for 2017 year, for vessel size categories 0-6m, 6-12m and 12-18m. Data related to total vessels in FDI dataset are missing also, or just zero values (0) are probably misreported by GRC.

On the other hand, fishing effort data (fishing days) for gears selected (i.e. GNS, GTR, LLS and OTB) are reported in recent period only, starting from 2014 year. However, fishing days in 2017 related to GTR are missing, while 2017 data for GNS and LLS are odd and should be checked for accuracy.

Table 2.3.5 Data on fishing vessels from Greece in GSA20 for GNS, GTR, LLS and OTB combined.

YEAR	VL0006	VL0612	VL1218	VL1824	VL2440
2004					-1
2005					-1
2006					-1
2007					
2008					-1
2009					
2010					
2011					
2012					
2013	-1	-1	-1	-1	-1
2014	-1	-1	-1	-1	-1
2015	-1	-1	-1	-1	-1
2016	-1	-1	-1	-1	-1
2017			-1	-1	-1
2018	-1	-1	-1	-1	-1
2019*	0	0	0	0	0

Note: * - data from FDI dataset



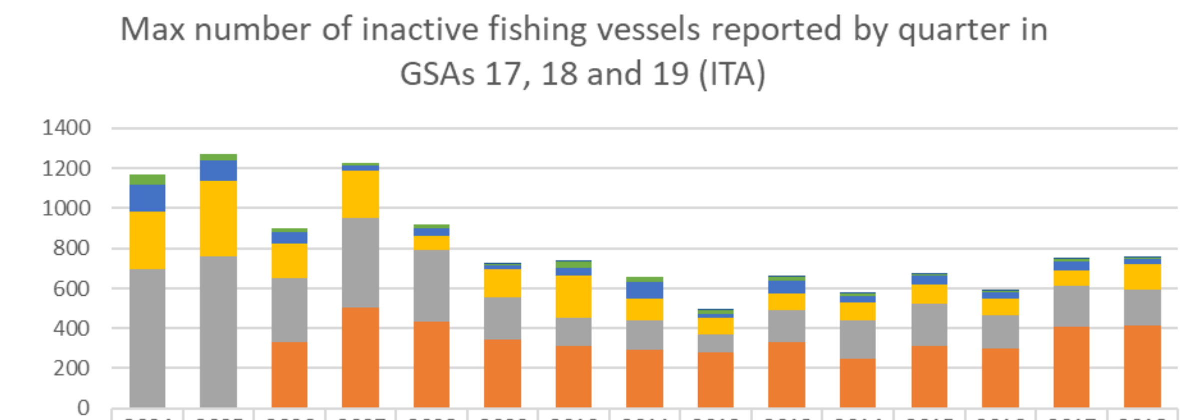
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
VL2440	-1	-1	-1		-1					-1	-1	-1	-1	-1	-1	0
VL1824										-1	-1	-1	-1	-1	-1	0
VL1218										-1	-1	-1	-1	20	-1	0
VL0612										-1	-1	-1	-1	776	-1	0
VL0006										-1	-1	-1	-1	77	-1	0

Figure 2.3.3. Data on fishing fleet in Greece in GSA22, using gears selected. (2019 data from FDI)

In general, this lack of data on amount of vessels and fishing effort from Greece (GRC) has been considered as a very serious issue, preventing EWG20-15 to make analyses of fishing fleet operating in the Aegean and Ionian Seas (GSA20 and GSA22).

ITALY (ITA)

Data in terms of amount of fishing vessels for Italy since 2004 year were considered in analyses. Within areas that need to be analysed by EWG20-15, Italy has a fishing fleet in GSAs 17, 18 and 19. Italy is the only Member State that reported inactive fishing vessels. Maximum number of fishing vessels reported by quarter in inactive fishery by size categories in GSAs 17, 18 and 19 combined are shown in Figure 2.3.4.

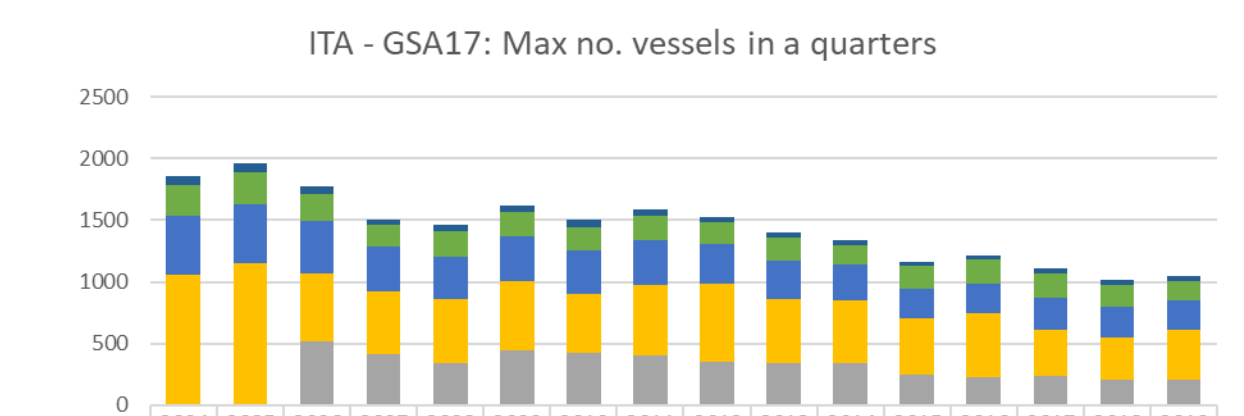


	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
VL40XX						2	2		1	1	1	1	1	1	1
VL2440	51	30	16	15	20	7	32	27	15	18	9	6	7	10	9
VL1824	137	106	58	22	41	15	40	78	24	62	36	40	33	47	24
VL1218	285	375	172	241	67	142	209	108	81	88	89	101	80	78	129
VL0612	697	760	323	445	360	212	140	153	93	158	193	209	166	206	180
VL0006			331	505	432	344	312	290	277	330	245	312	302	405	412

Figure 2.3.4. Size structure of inactive fishing vessels reported by ITA in GSAs 17, 18 and 19 combined.

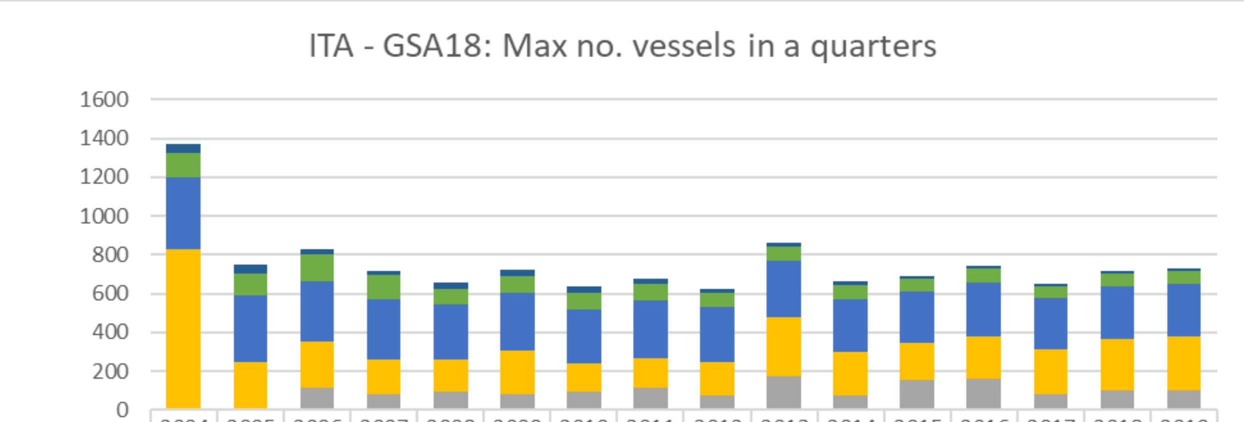
Among active fishing vessels, the most numerous fishing vessels in all these GSAs are within size category 6–12m. Fishing vessels in size category 0-6m are not reported in 2004 and 2005 year. Italian fishing vessels are reporting use of all selected gears, but in some cases (i.e. LLS in GSAs 17 and 18; FPO in GSAs 18 and 19) effort data are not complete, and in few cases data are of questionable reliability (i.e. OTB gear reported for vessels 0-6m in size and too high numbers (> 90) of fishing days by quarter in 2004 and 2005). However, amount of such odd data is very small.

Size structure of fishing fleet in Italy by GSAs, as reported in period 2004–2019 using selected gears, is given in Figures 2.3.5-7. As mentioned before, 2019 data are taken from FDI dataset.



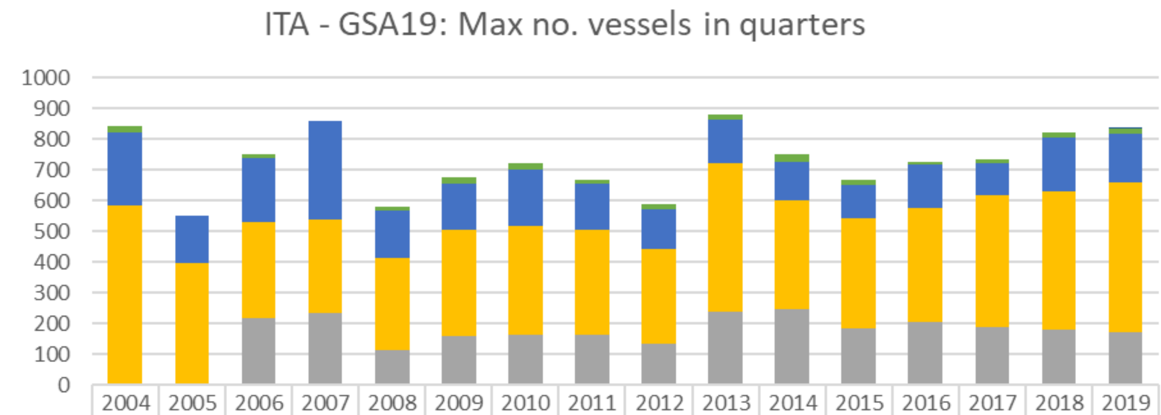
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
VL2440	73	74	58	44	54	55	54	51	39	34	34	31	33	41	39	43
VL1824	255	259	220	182	204	198	194	199	185	192	162	188	192	189	183	156
VL1218	476	481	424	358	349	357	350	362	313	308	293	231	244	267	249	239
VL0612	1058	1149	560	513	520	561	478	577	636	524	508	460	521	376	338	400
VL0006			513	411	338	447	424	401	354	339	338	250	224	233	207	211

Figure 2.3.5. Estimated amount and size structure of fishing fleet in Italy, fishing in GSA17.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
VL2440	47	49	24	23	29	31	29	22	18	16	15	15	13	11	11	11
VL1824	123	114	139	123	84	87	87	89	73	77	73	67	77	59	66	66
VL1218	374	340	315	310	282	296	279	294	286	290	275	267	274	266	274	277
VL0612	827	249	238	182	166	224	147	158	173	301	220	187	220	227	265	277
VL0006			113	80	94	83	92	112	75	175	78	156	160	85	101	99

Figure 2.3.6. Estimated amount and size structure of fishing fleet in Italy, fishing in GSA18.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
VL2440																6
VL1824	23		12		13	22	20	14	17	20	22	17	11	15	16	18
VL1218	235	154	209	321	153	149	181	151	130	139	128	108	140	101	175	157
VL0612	585	395	312	303	300	344	358	341	309	483	352	358	371	432	450	486
VL0006			218	234	114	160	161	163	134	240	247	183	205	187	179	173

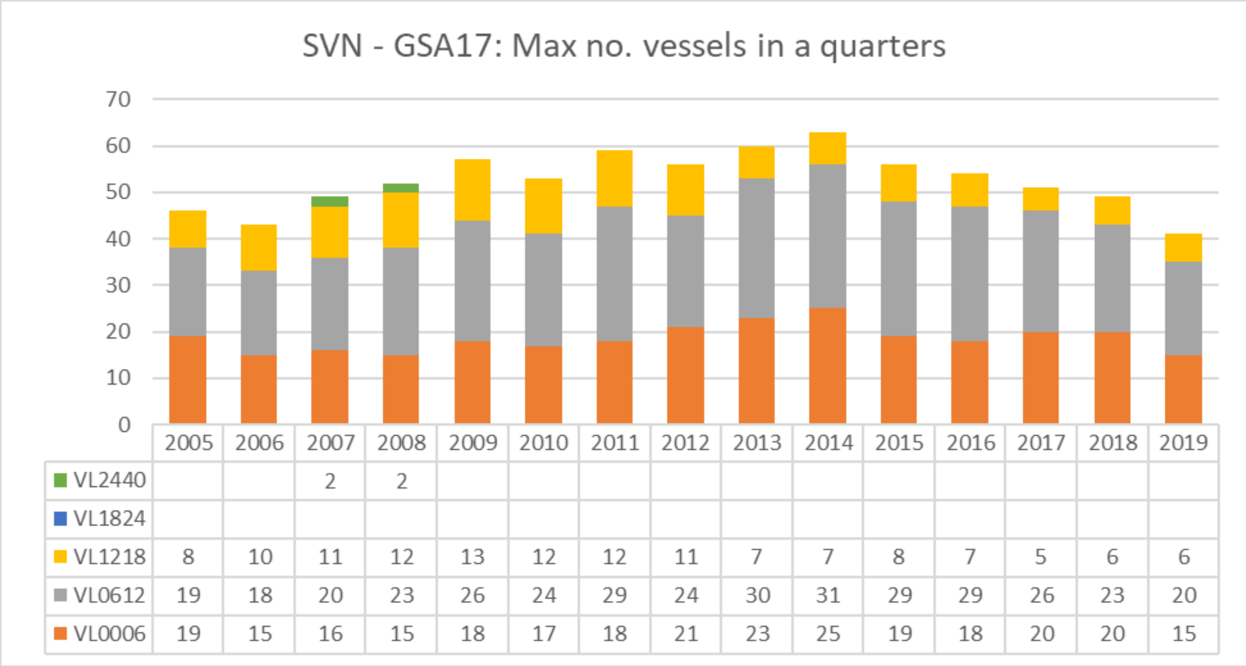
Figure 2.3.7. Estimated amount and size structure of fishing fleet in Italy, fishing in GSA19.

During the analyses, EWG20-15 noticed small discrepancies between maximum number of vessels reported by ITA in MEDBS dataset and maximum values reported for total vessels in FDI dataset in overlapping period (i.e. 2015-2018).

SLOVENIA (SVN)

Effort data in terms of amount of fishing vessels for Slovenia are available since 2005 year. The most numerous fishing vessels are small vessels up to 12m in length, while the amount of vessels >12m in length is very small. Among gears selected, fishing vessels in Slovenia are using GNS, GTR and OTB gears, but most of them use passive gears (i.e. GNS and GTR). Size structure of fishing fleet in Slovenia, as reported in period 2005–2019 using selected gears, is given in Figure 2.3.8. All these Slovenian fishing vessels are operating in GSA17 only.

During the analyses, EWG20-15 noticed small discrepancies between maximum number of vessels reported by SVN in MEDBS dataset and maximum values reported for total vessels in FDI dataset in overlapping period (i.e. 2015-2018).



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
VL2440			2	2											
VL1824															
VL1218	8	10	11	12	13	12	12	11	7	7	8	7	5	6	6
VL0612	19	18	20	23	26	24	29	24	30	31	29	29	26	23	20
VL0006	19	15	16	15	18	17	18	21	23	25	19	18	20	20	15

Figure 2.3.8 Estimated amount and size structure of fishing fleet in Slovenia fishing with GNS, GTR and OTB in GSA17.

3 FOLLOW UP ITEMS

Late arrival of non DCF data

There continue to be problems obtaining catch and sample data for the SOLEMON survey and total landing and sample data from Montenegro and Albania for this meeting. Late arrival, or total absence means that the results are either rushed or preliminary. The catch data can mostly be approximated adequately, but leaves potential political problems. The absence of SOLEMON survey data is more critical resulting in poor results for Common cuttlefish for example. All this just adds problems later on if work has to be revised. For the future we need to make every effort to obtain this data prior to the WG. As the missing SOLEMON data is historic, we should continue efforts now to obtain this data in full.

Greek data

The EWG has identified several issues regarding data from GSA20 and GSA22. Though some issues are thought due to data transmission though there are also possible inconsistencies in DCF not just due to implementation (missing years or partly missing years), but also due to changes in the sampling scheme throughout the time, as well as different sources of information regarding total catches. It’s also possible that data from the Hellenic Statistical Authorities may represent only some fleets and not all of the fisheries. As such these uncertainties in total catch in both data sets may seriously impact assessment estimates, the EWG therefore proposes:

a) the MS to resubmit all data taking into account the issues reported in Data Deficiencies and DTMT.

b) Hellenic Statistical Authorities be asked to check historic data and the give their description of any changes in sampling carried out historically and identify any missing catch due to un-sampled fishery sectors.

c) a development of a concrete methodology and procedures to deal with the inconsistencies of DCF and between DCF and data from the Hellenic Statistical Authorities, with the aim of describing total catch over time.

To facilitate this, a meeting or workshop could be held, involving experts from these areas, to conclude on the methodology to be applied.

4 BASIS OF THE REPORT

4.1 Basis of the catch and fishing mortality advice

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

1) Full assessment and full MSY reference points or with surplus production model with F and biomass relative to F and B_{MSY}: Catch advice at MSY based on short term forecast. Hake 17-18, **Nephrops GSA 17-18 and Common cuttlefish**
2) Full assessment without full evaluation MSY reference points due to short time historic series: Catch advice based on MSY proxy of $F_{0.1}$ based on short term forecast. **Used for all a4a assessments**
3) Assessment providing SSB tend information historic F evaluation, not suitable for STF Catch / Effort advice under precautionary considerations (Patterson 1992) F= F_{MSY} with Harvest Rate (HR) based estimated SSB in most recent year. **No 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 2 stocks this year**.
7) Valid length analysis: statement of stock status, indication of direction of change required. **Not used**

8) No valid analysis: no advice. **Three stocks could not be provided with status or advice**

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

4.2 MSY Reference points for stocks in this report

For hake in GSA 17-18, Nephrops 17-18 and Common cuttlefish in 17-18 and 17 alone the assessments include estimates of Fmsy, Advice is based on these estimated values.

For all of the other stocks evaluated in this assessment meeting using a4a, the number of years of S-R data is very limited and it is not possible to carry out full evaluations of MSY, because the stock - recruit relationships cannot be established.

Following STECF decision in the absence of full MSY evaluations, and/or biomass reference points STECF considers that $F_{0.1}$ forms a good proxy for MSY. Thus for all stocks here with agreed a4a 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 2020 are based on this approach.

4.2.1 MSY Ranges

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

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

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

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

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

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

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

The values of $F_{0.1}$, Fupp and Flow are calculated in the assessment sections Section 6 by species. The values are given in the short term forecast table in the stock assessment sections. These are reproduced in the table in Section 5 but with the Fupp noted as not precautionary and not recommended. This approach conforms to the one used by ICES (ICES 2014, ICES 2015)

4.3 Basis of Short Term Forecasts

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

- Biological conditions are assumed to be recent biological conditions

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

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

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

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

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

4.3.1 MSY Transition

The EWG continues to provide the main catch option presented in section 5 based on the target of FMSY in 2021. This remains the primary advice. However, in Plenary November 2019 The STECF considered 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 7. *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, range of values, conservation reference points and effort levels.*

5.1 Summary sheet for European hake in GSA 17 and 18

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.179 and corresponding catches in 2021 should be no more than 2789 tons.

Stock development over time

Catches have been around 6000 tons in the last five years with a slight decrease in the last year. Female SSB of European hake is relatively stable until 2007, then decreased considerably until 2014 (1312 tons) then rises to the highest value of the time-series in 2020 (4397 tons). Recruitment and $F_{bar(1\text{-}4)}$ show a decreasing trend in the last five years. Recruitment in the last three years is below average. $F_{bar(1\text{-}4)}$ in 2019 (0.41) is the lowest of the time-series.

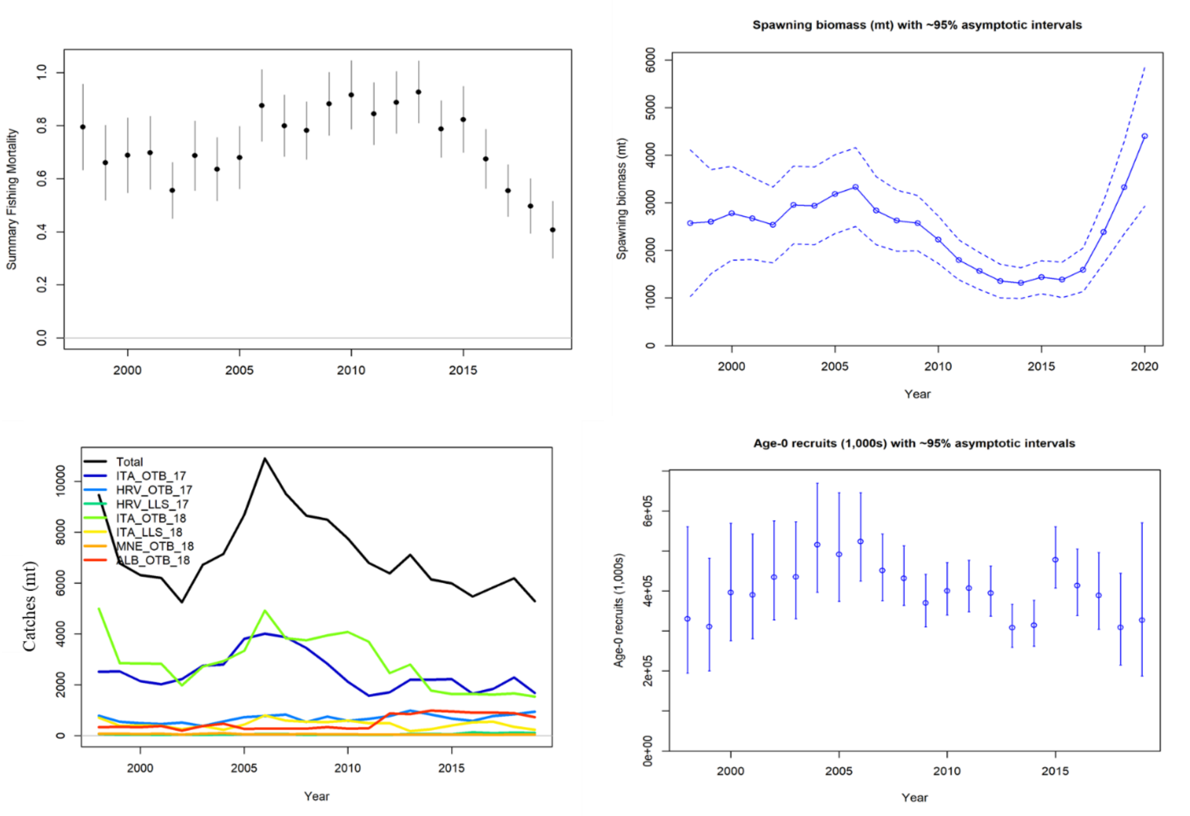


Figure 5.1.1 European hake in GSAs 17 and 18: Trends in catch, recruitment, fishing mortality and **female** SSB resulting from the SS3 model.

Stock and exploitation status

The current level of fishing mortality (0.41) 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	2017	2018	2019
F / F_{MSY}	$F > F_{MSY}$	$F > F_{MSY}$	$F > F_{MSY}$
B / B_{pa}	$B > B_{pa}$	$B > B_{pa}$	$B > B_{pa}$

Catch scenarios

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 2017-2019
$F_{ages\ 1\text{-}4}$ (2020)	0.41	F_{2019} used to give F status quo for 2020
Female SSB (2020)	4397 t	Stock assessment 1 January 2020
R_{age0} (2020,2021,2022)	341,514	Mean of the last 3 years
Total catch (2020)	5565 t	Assuming F status quo for 2020

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

Basis	Total catch (2021)	F_{total} (ages 1-4) (2021)	**Female** SSB (2022)	% **Female** SSB change**	% Catch change***
STECF advice basis					
F_{MSY} / MAP	2789	0.179	7102	61.5	-48.0
$F_{MSY\ Transition}$	4964	0.34	6004	36.5	-7.4
$F_{MSY\ lower}$	1937	0.12	7540	71.5	-63.9
$F_{MSY\ upper*}$	3767	0.25	6605	50.2	-29.7
Other scenarios					
Zero catch	0	0	8549	94.4	-100.0
Status quo	5749	0.41	5615	27.7	7.2
60% of status quo	3699	0.25	6639	51.0	-31.0
80% of status quo	4761	0.33	6105	38.8	-11.2

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

** % change in SSB 2022 to 2020

***Total catch in 2021 relative to Catch in 2019.

Table 5.1.3b European hake in GSAs 17 and 18: Annual catch scenarios by area and gear assuming same catch proportions as 2019

Basis	Total catch (2021)	F_{total} (ages 1-4) (2021)	GSA 17 OTB	GSA 17 LLS	GSA 18 OTB	GSA 18 LLS
STECF advice basis						
F_{MSY} / MAP	2789	0.179	1383	59	1226	121
$F_{MSY\ Transition}$	4964	0.34	2462	105	2182	215
$F_{MSY\ lower}$	1937	0.12	961	41	852	84
$F_{MSY\ upper*}$	3767	0.25	1868	80	1656	163
Other scenarios						
Zero catch	0	0	0	0	0	0
Status quo	5749	0.41	2851	122	2527	249
60% of status quo	3699	0.25	1834	78	1626	160
80% of status quo	4761	0.33	2361	101	2093	206

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

Basis of the advice

Table 5.1.4 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 consistent results for F but not for female SSB which tends to be overestimated. It is suggested to review this model in a new benchmark.

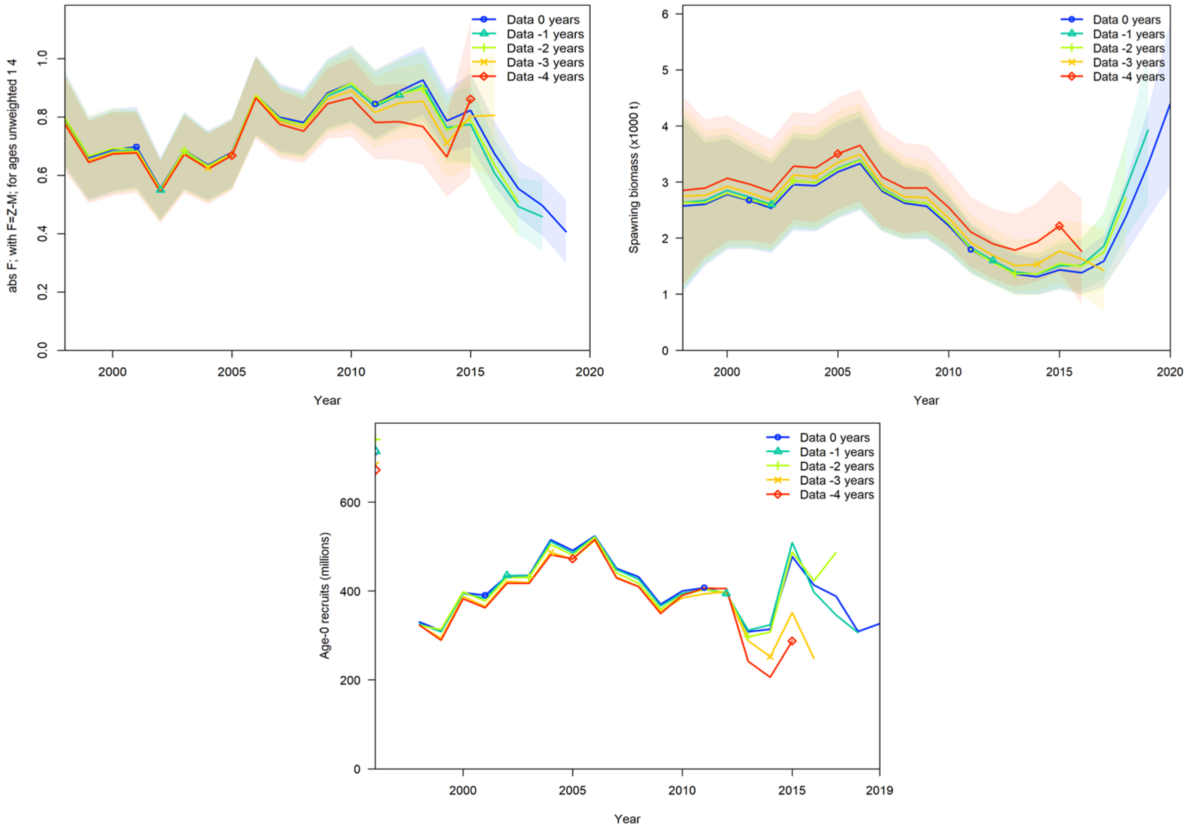


Figure 5.1.2 European hake in GSAs 17 and 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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 20-09

*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	5361	5101	260
2020	F = F_{MSY}	2563			
2021	F = F_{MSY}	2789			

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 2019 as estimated by and reported to STECF.

2019	Landings			Discards
Catch (t)	Otter trawl 91%	Longlines 7%	Other 2%	t
	4755	346	100	263
Effort*	147846 (91%)	15203 (9%)		
	Fishing days			

*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. 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	1013	65	43	851	6732	184006
2014	1584	279	1789	1	774	61	44	902	5434	165560
2015	1614	427	2011	1	769	41	38	914	5815	161645
2016	1672	492	1731	0	585	124	42	948	5594	163311
2017	1682	514	1836	0	783	90	37	940	5882	174275
2018	1650	331	1853	2	815	116	47	872	5686	184078
2019	1481	232	1552	4	943	113	42^^^^	731	5056	163049

*Values in 2002-2003 are catches.
**Values in 2002-2005 are catches.
***Values in 2002-2004 are catches.
^Values in 2002-2012 are catches.
^^Values in 2002-2013 are catches.
^^^Values from GFCM.
^^^^Mean of the last 3 years
¤Values from GFCM.
¤¤Effort only from member states.

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	330173	514622	211833	2571	3862	1280	9441	0.80	0.93	0.66
1999	310817	449054	215135	2602	3522	1681	6666	0.66	0.78	0.54
2000	396011	536734	292183	2779	3605	1953	6268	0.69	0.81	0.57
2001	390241	514554	295961	2673	3399	1946	6206	0.70	0.81	0.58
2002	434047	549778	342678	2534	3203	1865	5442	0.56	0.64	0.47
2003	435097	548286	345275	2953	3641	2266	7322	0.69	0.80	0.58
2004	515399	641560	414047	2934	3620	2249	7336	0.64	0.74	0.54
2005	491384	617730	390880	3182	3879	2486	8772	0.68	0.78	0.58
2006	523789	624030	439650	3329	4025	2633	10832	0.88	0.99	0.76
2007	451137	526733	386390	2834	3432	2236	8959	0.80	0.90	0.70
2008	431987	498795	374127	2623	3161	2085	8312	0.78	0.87	0.69
2009	370280	429158	319479	2570	3059	2081	7998	0.88	0.98	0.78
2010	399877	458790	348529	2222	2637	1807	6923	0.92	1.02	0.81
2011	407012	464638	356533	1796	2149	1443	6416	0.84	0.94	0.75
2012	394737	450684	345735	1567	1891	1244	6818	0.89	0.99	0.79
2013	308184	356504	266413	1357	1654	1061	6753	0.93	1.02	0.83
2014	314177	365783	269852	1312	1585	1040	5493	0.79	0.88	0.70
2015	477898	546392	417990	1437	1726	1148	5817	0.82	0.93	0.72
2016	413331	488879	349457	1383	1696	1070	5764	0.67	0.77	0.58
2017	388696	477036	316716	1589	1974	1204	6033	0.55	0.64	0.47
2018	308999	419289	227720	2384	2933	1834	6091	0.50	0.58	0.41
2019	326847	521448	204870	3322	4139	2505	5361	0.41	0.50	0.32
2020				4397	5627	3167				

*SS3 model provides estimates of SSB only for females.

Sources and references

EWG 20-15

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 advise 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 than 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 thee years the incease in biomass is estimated to be 1.25 times.

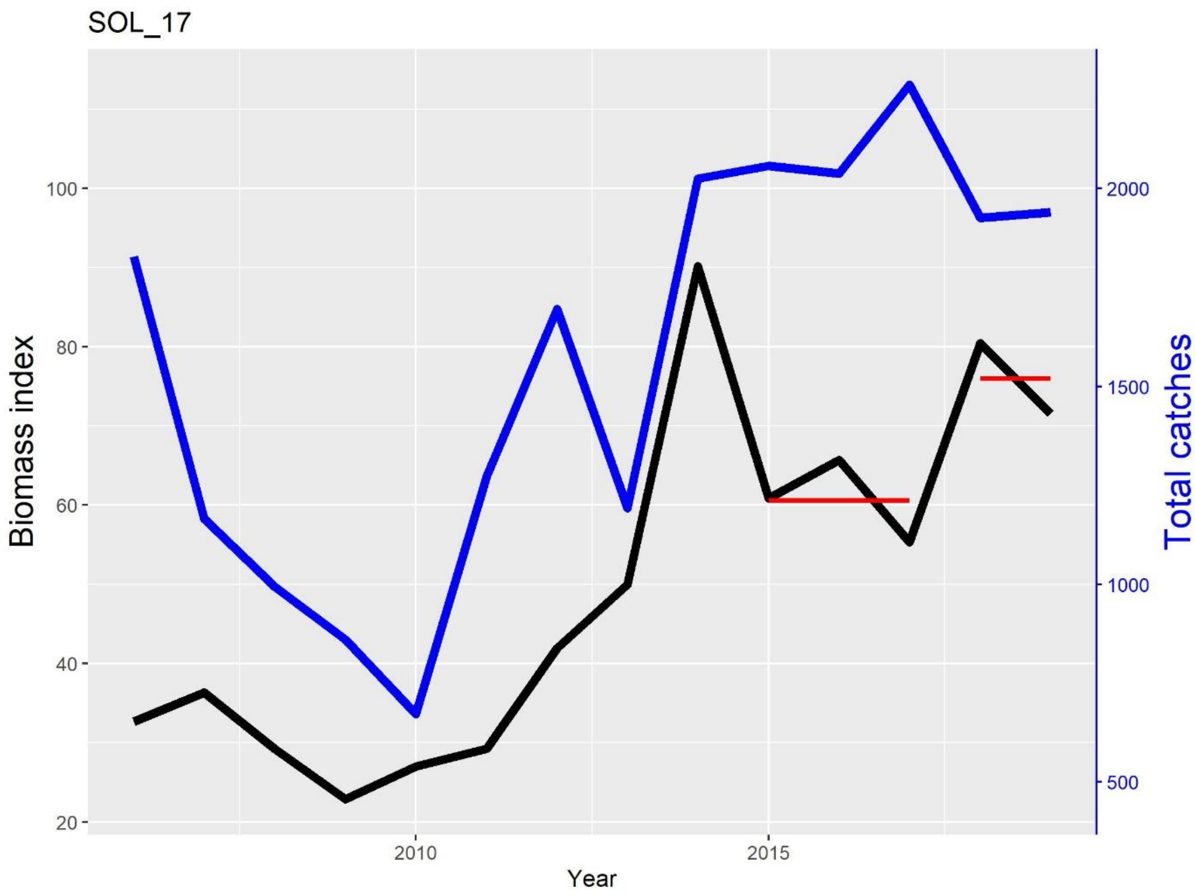


Figure 5.2.1 Common sole in GSA 17 Summary of the SOLEMON survey indicator and total catch by year. The red segments correspond to the reference averages used to estimate the index of variation.

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

EWG 20-15

5.3 Summary sheet for Red mullet in GSA 17 and 18

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.34 and corresponding catches in 2021 should be no more than 3285 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 1.32 and 0.69 (2019).

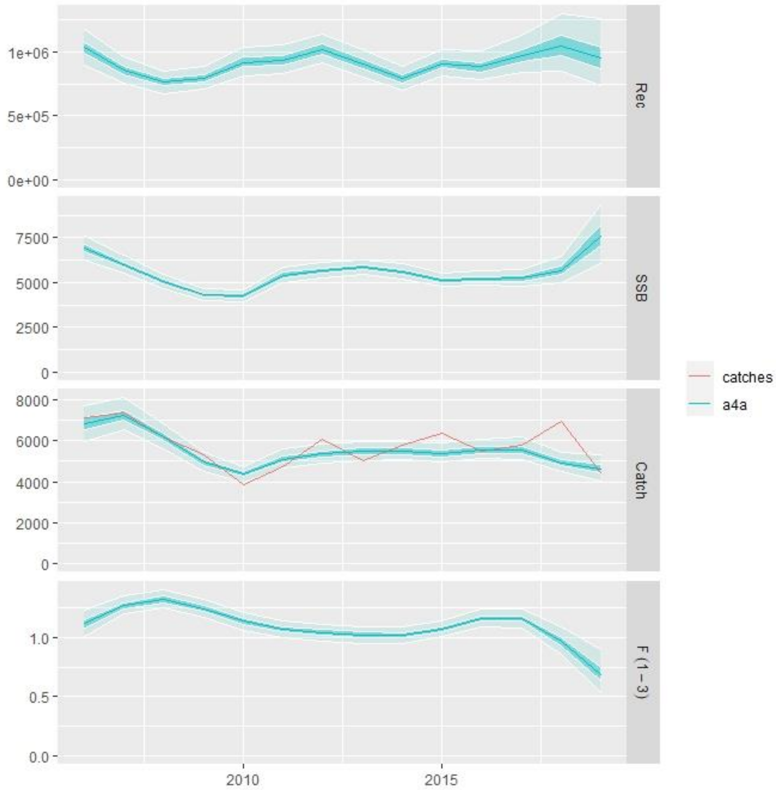


Figure 5.3.1 Red mullet in GSAs 17 and 18: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.34).

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

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

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	0.69	F2019 used to give F status quo for 2020
SSB (2020)	8 306	Stock assessment middle of the year 2020
R_{age0} (2020,2021)	911 735	Mean of the last 14 years (whole series)
Total catch (2020)	5 548	Assuming F status quo for 2020

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

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

Basis	Total catch(2021)	F_{total} (ages 1-3) (2021)	SSB -2022	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	3285	0.34	11703	40.9	-29.1
$F_{MSY\ Transition}$	5092	0.59	9118	9.8	9.9
$F_{MSY\ lower}$	2314	0.23	13220	59.2	-50
$F_{MSY\ upper}$**	4260	0.47	10269	23.6	-8
Other scenarios					
Zero catch	0	0	17184	106.9	-100
Status quo	5708	0.69	8310	0.1	23.2
0.1	754	0.07	15840	90.7	-83.7
0.2	1458	0.14	14630	76.1	-68.5
0.3	2117	0.21	13538	63	-54.3
0.4	2734	0.27	12553	51.1	-41
0.5	3312	0.34	11662	40.4	-28.5
0.6	3853	0.41	10855	30.7	-16.8
0.7	4361	0.48	10124	21.9	-5.8
0.8	4838	0.55	9461	13.9	4.5
0.9	5287	0.62	8859	6.7	14.1

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

Red mullet landings in GSAs 17-18 are predominantly from OTB (about 96% of the landing in tons in 2019) therefore the short term forecast split 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. On an overall basis, the diagnostics were considered acceptable.

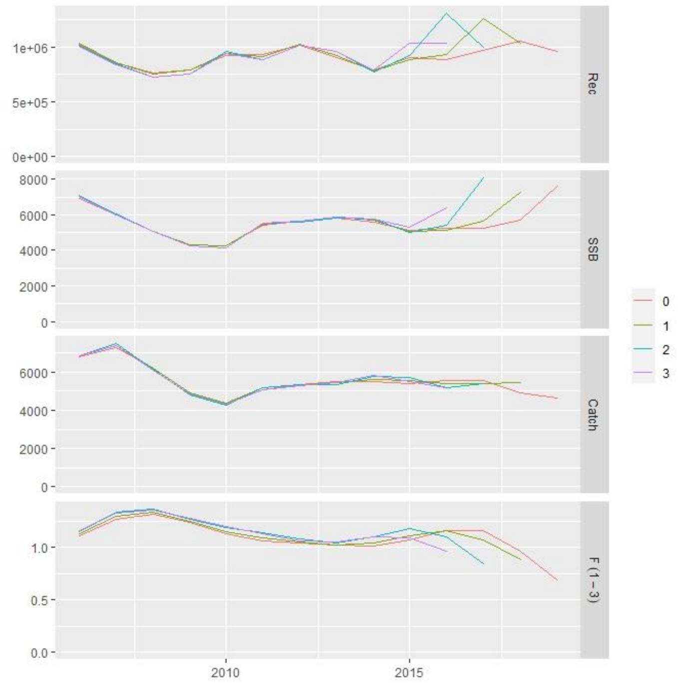


Figure 5.3.2 Red mullet in GSAs 17 and 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.34	$F_{0.1}$ 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}	0.34	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-15
	target range F_{lower}	0.23	Based on regression calculation (see section 2)	STECF EWG 20-15
	target range F_{upper}	0.47	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-15

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 20-15

*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	4632	
2020	$F = F_{MSY}$		6078		
2021	$F = F_{MSY}$		3285		

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).

2019		Wanted catch				Discards
Catch (t)		Otter trawl 95.7%	Gillnets 2.25%	GTR 0.3%	Other 1.75%	t
		3117	73	9.12	139	798
Effort (Fishing days)		298 473	373087	197487		
		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 96%).

Year	ITA 17	HRV	SVN	ITA 18	ALB	MTN	Total	OTB Effort * (fishing days)
2006	3101		2	1934			5037	189181
2007	3298		6	1802			5107	165677
2008	3158		2	961		42	4163	157594
2009	2433		3	1031		40	3507	178099
2010	1796		1	646		38	2482	157246
2011	1890		6	532		35	2463	149019
2012	1525		4	2096	375	39	4038	169736
2013	1979	1084	2	1250	373	35	4724	172071
2014	2399	1152	3	1272	317	45	5188	153144
2015	2220	1128	3	1587	388	40	5366	148737
2016	2042	953	2	1448	396	40	4881	150419
2017	2672	985	3	620	392	40	4712	161943
2018	2517	841	6	1004	289	46	4703	170204
2019	1733	745	4	775	373		3629	288445

*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	1028935	1243388	820004	6893.11	7871	5927	6773	1.12	1.29	0.94
2007	856799.7	1015678	696478	5983.06	6783	5175	7250.2	1.27	1.39	1.15
2008	760745.3	898600	621852	5050.574	5650	4418	6185.5	1.32	1.45	1.20
2009	792092.5	935713	650749	4289.44	4796	3789	4933.2	1.24	1.37	1.12
2010	917327.1	1092717	740853	4271.703	4798	3767	4356.7	1.13	1.25	1.01
2011	933575.2	1102208	764996	5423.692	6076	4754	5092.4	1.07	1.18	0.95
2012	1019042	1202733	831789	5653.982	6319	4985	5335.1	1.04	1.15	0.93
2013	901186.8	1064634	734414	5838.47	6505	5163	5472.2	1.02	1.13	0.91
2014	788470.3	933103	642955	5589.971	6255	4927	5475.4	1.02	1.13	0.91
2015	907848.2	1071512	743732	5132.325	5740	4522	5370.1	1.07	1.18	0.96
2016	881954.3	1051864	712436	5219.23	5857	4574	5553.7	1.16	1.27	1.05
2017	972384.3	1204397	739589	5233.494	5924	4553	5571.3	1.16	1.28	1.03
2018	1048820	1400230	694510	5690.074	6855	4512	4927.4	0.96	1.15	0.78
2019	955114	1359926	540234	7586.975	10124	5073	4632.1	0.69	0.97	0.40

Sources and references

STECF EWG 20-15

5.4 Summary sheet for Common cuttlefish in GSA 17 and 18

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’.

5.4.1 Summary sheet for Common cuttlefish in GSA 17 and 18

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied, fishing mortality can be increased to F_{MSY}. As common cuttlefish is a short lived species, living mostly up to 1-1.5 year, annual catches in 2021 will depend mostly on growth within the 1st year of life, and therefore no specific catch options can be provided for 2021. Catch at F_{MSY} with current biomass (B_{MSY}) is estimated at 7530 tonnes.

Stock development over time

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

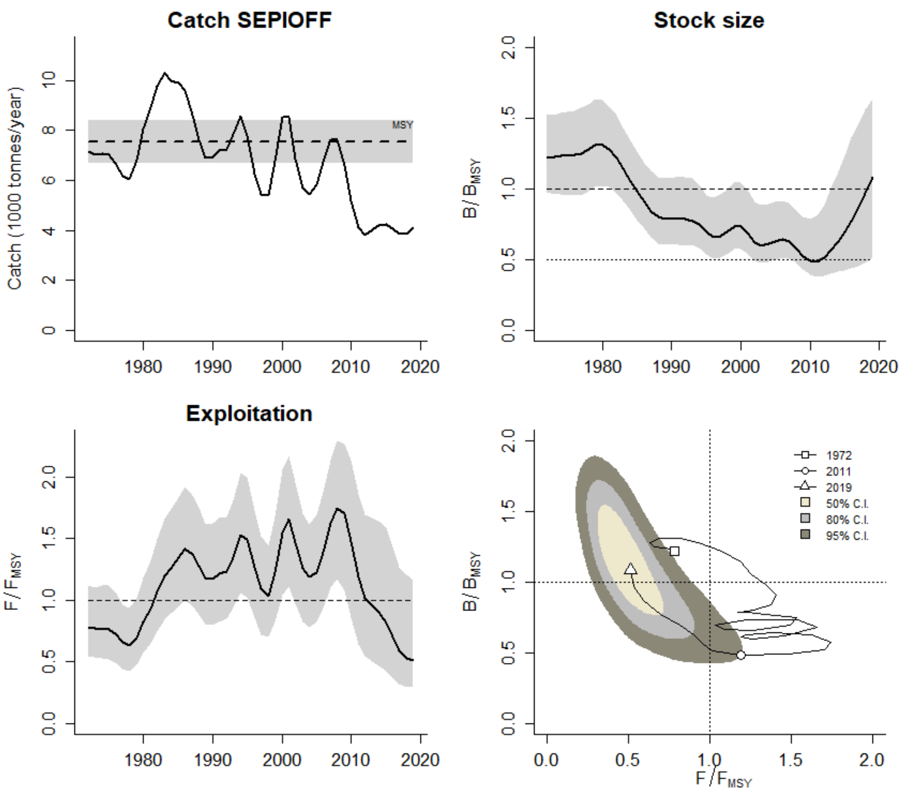


Figure 5.4.1.1 Common cuttlefish in GSA 17-18. Trends in catch, relative biomass and exploitation as given by CMSY model 95% confidence limits (grey) are also indicated.

Stock and exploitation status

The assessment estimates B to be slightly above B_{MSY}; B/B_{MSY} in last year is 1.08. The current level of fishing mortality is below the reference point F_{MSY} (F/ F_{MSY} =0.512).

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

Status	2017	2018	2019
F / F_{MSY}	F < F_{MSY}	F < F_{MSY}	F < F_{MSY}
B / B_{MSY}	B<B_{MSY}	B=B_{MSY}	B>B_{MSY}

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 (B_{MSY}) is estimated at 7830 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.

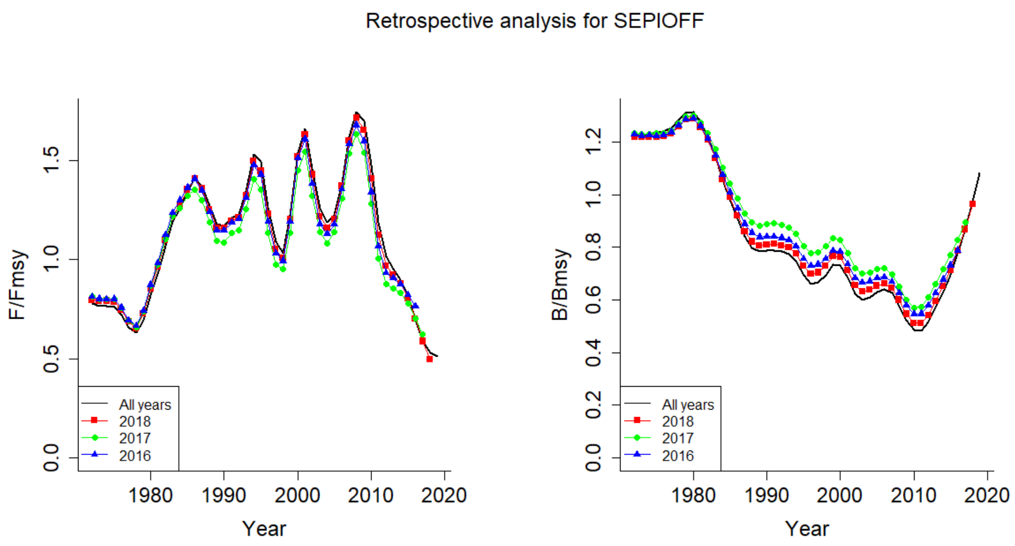


Figure 5.4.1.2. Common cuttlefish in GSA 17-18. Retrospective performance of CMSY assessment showing consistent estimation of F and Biomass.

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	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.159	F_{MSY} estimated from CMSY model	STECF EWG 20-15
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}	0.159	F_{MSY} estimated from CMSY model	
	F_{lower}	0.051	Based on regression calculation	STECF EWG 20-15
	F_{upper}	0.013	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-15

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 20-15

*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
2019	$F=F_{MSY}$	7600		4820
2020	$F=F_{MSY}$	7830		
2021	$F=F_{MSY}$	7850		

* The value provided is the estimated long term yield at F_{MSY}. 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 fishing gears and discard in period 2008-2018 as reported to DCF.

	Landings by gears (DCF landing 2008-2018)						Discards (2008-2018)
Catch	OTB 54.3%	FPO 17.3%	TBB 15.1%	SETNETS 12.0%	FYK 1.3%	OTHER <0.1%	(All gears) <0.1%
(t)	22198	7084	6168	4896	521	11	25 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.

	CROATIA	SLOVENIA	ITALY GSA17	ITALY GSA18	MONTENEGRO	ALBANIA	Ex Yugoslavia (SVN, HRV, MNE)	Total catch (t)
1972			6150.9	1108.5			173.7	7433.1
1973			5818.2	1085.6			159.7	7063.4
1974			5410.9	1062.6			192.3	6665.9
1975			6359.7	1432.3			217.6	8009.5
1976			4845.0	1357.0			243.7	6445.7
1977			5093.0	1273.0			194.2	6560.2
1978			3589.0	1163.0			169.9	4921.9
1979			4441.0	1148.0			140.1	5729.1
1980			9158.0	1289.0			198.9	10645.9
1981			6161.4	869.2			158.7	7189.3
1982			9202.9	1102.9			145.7	10451.5
1983			10379	1808.3			175.5	12363.2
1984			7244.0	1118.1			153.1	8515.2
1985			8954.6	1230.3			148.5	10333.4
1986			7986.5	3068.8			143.8	11199.1
1987			6335.8	1214.8			177.4	7728.0
1988			6534.1	1462.4			219.4	8215.9
1989			4723.6	1224.0			199.8	6147.4
1990			4902.1	834.8			276.4	6013.3
1991			6917.3	1854.3			157.8	8929.4
1992	154.0	12.0	4621.3	1442.1	2.0			6231.4
1993	187.2	21.0	4692.7	1321.7	6.0			6228.6
1994	108.8	4.0	10368	1185.2	5.0			11671.1
1995	108.8	10.0	6192.9	1619.8	9.0	39.0		7979.5
1996	94.0	6.0	4000.3	797.6	10.0	33.0		4940.9
1997	139.2	5.0	4562.6	754.9	9.0	33.0		5503.7
1998	198.2	18.0	3709.9	868.4	10.0	51.0		4855.5
1999	133.7	18.0	3431.4	592.9	10.0	51.0		4237.0
2000	127.2	11.0	6355.6	5319.4	10.0	50.0		11873.2
2001	78.4	72.0	7501.7	2647.5	10.0	22.0		10331.6
2002	41.5	22.0	3231.5	1338.2	10.0	52.0		4695.2
2003	64.5	25.0	4155.5	985.8	10.0	43.0		5283.8
2004	36.0	29.0	4396.1	898.9	10.0	70.0		5440.0
2005	73.8	33.0	4043.3	875.7	8.0	75.0		5108.7
2006	65.5	24.0	4507.5	1343.3	15.0	86.0		6041.3
2007	83.9	41.0	7964.1	969.8	18.0	47.0		9123.8
2008	73.3	15.0	6276.3	959.7	15.0	62.0		7401.3
2009	68.0	14.0	5683.0	1242.8	7.0	126.0		7140.7
2010	86.0	7.0	3375.1	1140.2	9.0	98.0		4715.3
2011	105.0	8.0	2323.7	865.5	11.0	90.0		3403.3
2012	169.0	10.0	2575.2	663.4	12.0	80.0		3509.7
2013	189.0	4.0	2955.6	1018.4	11.0	85.0		4263.1
2014	207.0	6.0	3194.6	810.6	13.0	75.0		4306.2
2015	192.0	4.0	3293.0	879.0	14.0	82.0		4464.0
2016	112.0	5.2	2975.4	970.1	14.0	83.0		4159.7
2017	106.0	3.0	1951.0	1617.0	14.0	83.0		3774.0
2018	89.0	1.6	1476.0	1512.0	11.0	79.0		3168.6

2019	90	5	3975	655	13^	82^		4820.0

^ preliminary values

Summary of the assessment

Table 5.4.1.10 Common cuttlefish 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	Biomass tons	High	Low	Catch tonnes $*10^3$	F/ F_{MSY}	High	Low
2005				21.60			5.11	1.22		
2006				21.99			6.04	1.39		
2007				21.44			9.12	1.62		
2008				19.80			7.40	1.75		
2009				18.06			7.14	1.70		
2010				16.85			4.72	1.48		
2011				16.78			3.40	1.19		
2012				17.80			3.51	1.01		
2013				19.52			4.26	0.95		
2014				21.50			4.31	0.90		
2015				23.82			4.46	0.81		
2016				26.46			4.16	0.70		
2017				29.57			3.77	0.59		
2018				32.94			3.17	0.53		
2019				36.34			4.82	0.51		

Sources and references

EWG 20-15

5.4.2 Summary sheet for Common cuttlefish in GSA 17

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied, fishing mortality can be increased to F_{MSY}. As common cuttlefish is a short lived species, living mostly up to 1-1.5 year, annual catches in 2021 will depend mostly on growth within the 1st year of life, and therefore no specific catch options can be provided for 2021. Catch at F_{MSY} with current biomass (B_{MSY}) is estimated at 6070 tonnes.

Stock development over time

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

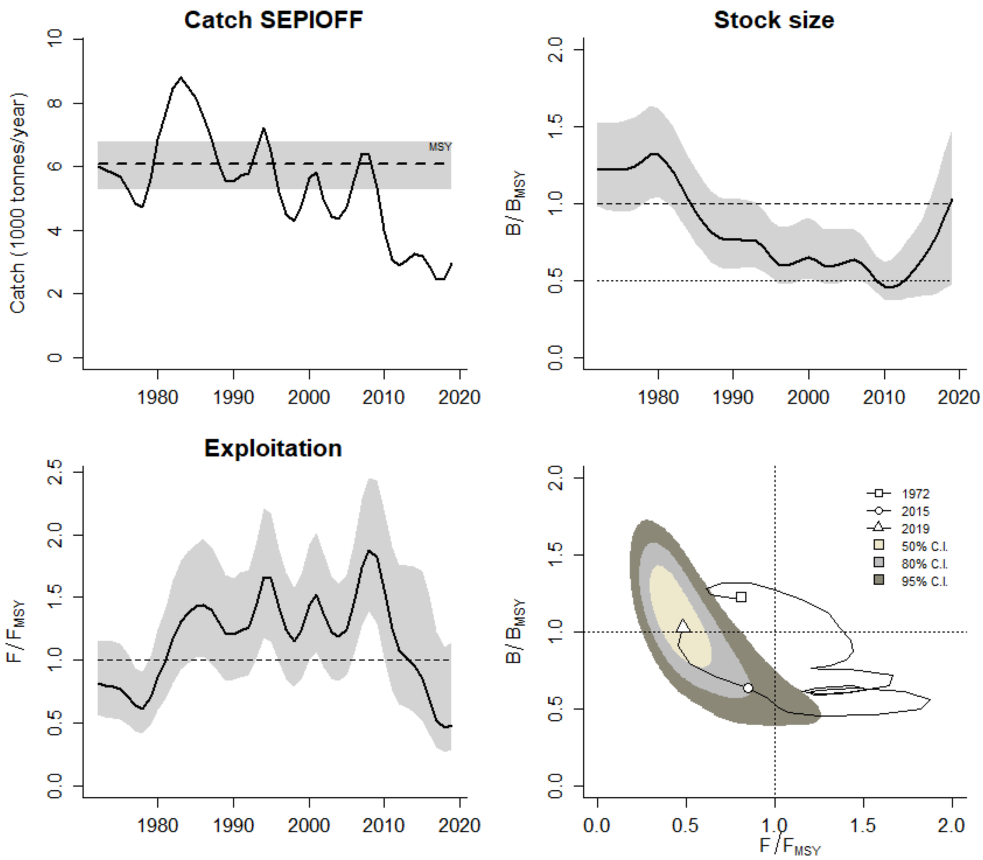


Figure 5.4.2.1 Common cuttlefish in GSA 17. Trends in catch, relative biomass and exploitation as given by CMSY model 95% confidence limits (grey) are also indicated.

Stock and exploitation status

The assessment estimates B to be very slightly above B_{MSY}; B/B_{MSY} in last year is 1.03. The current level of fishing mortality is below the reference point F_{MSY} (F/F_{MSY} =0.483).

Table 5.4.2.1 Common cuttlefish in GSA 17. State of the stock and fishery relative to reference points.

Status	2017	2018	2019
F/F_{MSY}	$F < F_{MSY}$	$F < F_{MSY}$	$F < F_{MSY}$
B/B_{MSY}	$B<B_{MSY}$	$B<B_{MSY}$	$B=B_{MSY}$

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 (B_{MSY}) is estimated at 6070 tonnes.

Basis of the advice

Table 5.4.2.4 Common cuttlefish in GSA 17 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.

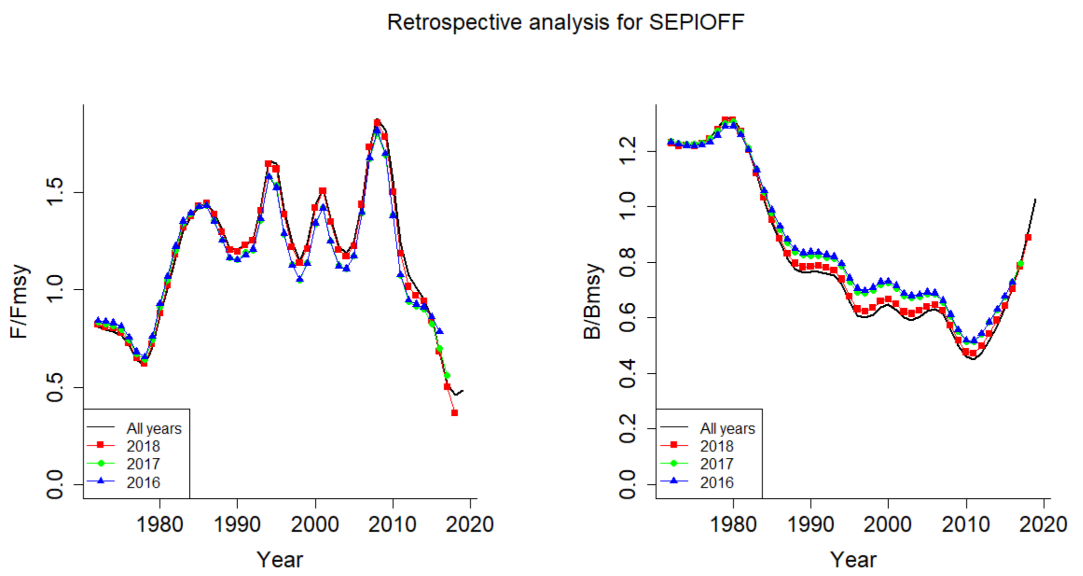


Figure 5.4.2.2. Common cuttlefish in GSA 17. Retrospective performance of CMSY assessment showing consistent estimation of F and Biomass.

Issues relevant for the advice

Common cuttlefish is caught as part of a mixed fishery.

Reference points

Table 5.4.2.5 Common cuttlefish in GSA 17. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.138	F_{MSY} estimated from CMSY model	STECF EWG 20-15
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}	0.138	F_{MSY} estimated from CMSY model	
	F_{lower}	0.044	Based on regression calculation	STECF EWG 20-15
	F_{upper}	0.011	Based on regression calculation but not	STECF

			tested and presumed not precautionary	EWG 20-15

Basis of the assessment

Table 5.4.2.6 Common cuttlefish in GSA 17. 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 20-15

*BMS (Below Minimum Size) landings

History of the advice, catch, and management

Table 5.4.2.7 Common cuttlefish in GSA 17. 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
2021	$F=F_{MSY}$	6070		

* The value provided is the estimated long term yield at F_{MSY}. 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 5.4.2.8 Common cuttlefish in GSA 17. Landing distribution by fishing gears and discard in period 2008-2018 as reported to DCF.

	Landings by gears						Discards
Catch							(All gears) <0.1%
(t)							

Table 5.4.2.9 Common cuttlefish in GSA 17. History of commercial landings of common cuttlefish in GSA 17; both the official reported values and STECF estimated landings are presented by country. All weights are in tonnes.

	CROATIA	SLOVENIA	ITALY GSA17	Ex Yugoslavia (SVN, HRV, MNE) *	Total catch (t)
1972			6150.9	86.85	6238
1973			5818.2	79.85	5898
1974			5410.9	96.15	5507
1975			6359.7	108.8	6469
1976			4845.0	121.85	4967
1977			5093.0	97.1	5190
1978			3589.0	84.95	3674
1979			4441.0	70.05	4511
1980			9158.0	99.45	9258
1981			6161.4	79.35	6241
1982			9202.9	72.85	9276
1983			10379.4	87.75	10467
1984			7244.0	76.55	7321
1985			8954.6	74.25	9029
1986			7986.5	71.9	8059
1987			6335.8	88.7	6425
1988			6534.1	109.7	6644
1989			4723.6	99.9	4824
1990			4902.1	138.2	5040
1991			6917.3	78.9	6996
1992	154.0	12.0	4621.3		4787
1993	187.2	21.0	4692.7		4901
1994	108.8	4.0	10368.1		10481
1995	108.8	10.0	6192.9		6312
1996	94.0	6.0	4000.3		4100
1997	139.2	5.0	4562.6		4707
1998	198.2	18.0	3709.9		3926
1999	133.7	18.0	3431.4		3583
2000	127.2	11.0	6355.6		6494
2001	78.4	72.0	7501.7		7652
2002	41.5	22.0	3231.5		3294
2003	64.5	25.0	4155.5		4245
2004	36.0	29.0	4396.1		4461
2005	73.8	33.0	4043.3		4150
2006	65.5	24.0	4507.5		4597
2007	83.9	41.0	7964.1		8089
2008	73.3	15.0	6276.3		6364
2009	68.0	14.0	5683.0		5765
2010	86.0	7.0	3375.1		3468
2011	105.0	8.0	2323.7		2437
2012	169.0	10.0	2575.2		2754
2013	189.0	4.0	2955.6		3149
2014	207.0	6.0	3194.6		3408
2015	192.0	4.0	3293.0		3489
2016	112.0	5.2	2975.4		3092
2017	106.0	3.0	1951.0		2060
2018	89.0	1.6	1476.0		1567
2019	90	5	3975		4070

*50% of historic reported catches from former Yugoslavia are allocated to GSA 17

Summary of the assessment

Table 5.4.2.10 Common cuttlefish in GSA 17 Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals)

Year	Recruitment age 0 thousands	High	Low	Biomass tons	High	Low	Catch tonnes $*10^3$	F/ F_{MSY}	High	Low
2005				18.51			4.15	1.25		
2006				18.70			4.60	1.45		
2007				18.09			8.09	1.73		
2008				16.54			6.36	1.88		
2009				14.79			5.77	1.82		
2010				13.61			3.47	1.56		
2011				13.41			2.44	1.25		
2012				14.09			2.75	1.07		
2013				15.37			3.15	1.01		
2014				16.87			3.41	0.95		
2015				18.48			3.49	0.85		
2016				20.58			3.09	0.68		
2017				23.30			2.06	0.52		
2018				26.47			1.57	0.46		
2019				29.89			4.07	0.48		

Sources and references

EWG 20-15

5.5 Summary sheet for Norway lobster in GSA 17 and 18

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.36 and corresponding catches in 2020 should be no more than 1217.7 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. Model shows a reduction in B/Bmsy since 60s, with values consistently below 1 since mid-90s with a small increase in the last year. In terms of F/Fmsy the model indicates an increasing since early ‘90s with values over 1 since mid-2000.

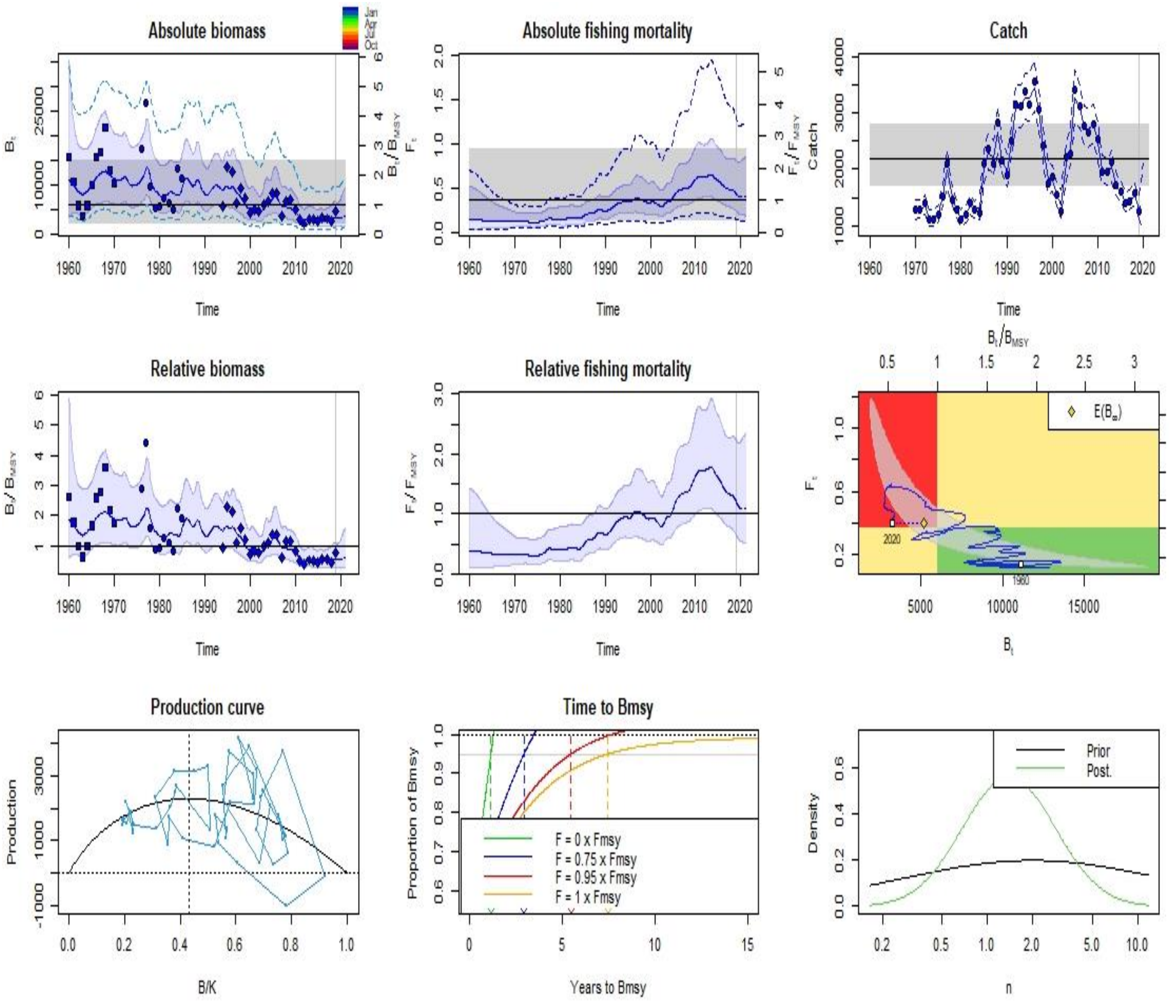


Figure 5.5.1 Norway lobster in GSA 17 and 18. SPICT model main outputs.

Stock and exploitation status

The status of the stock in 2019 using mean value by year, referred to the reference points (B_{MSYs} = 6024.9 and F_{MSYs} = 0.3629) is, F_{2019}/F_{MSYs} = 0.926.

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

Status	2017	2018	2019
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy
B / Bmsy	B < Bmsy	B < Bmsy	B < Bmsy

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
$F_{ages\ all}$ (2020)	0.399	Harvest rate from production model (SPICT)
Catch (2020)	1394.47 t	Equal to catch in 2019
Biomass (2020 & 2021)	3264.79	Equal to biomass in 2019

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

Basis	Total catch* (2021)	F_{msy}** (all) (2021)	SSB (2022)	% SSB change***	% Catch change^^
STECF advice basis					
Reduced FMSY (B< Bpa)	1217.70	0.3619			-13%
F (HR) Transition	1249.04	0.37			-10%
F_{MSY}	1221.049	0.3629			-12%
$F_{MSY\ lower}$	810.8925	0.241			-42%
$F_{MSY\ upper}$**	1662.161	0.494			19%
Other scenarios					
Zero catch	0	0			-100%
Status quo	1394.47	0.399			

** The advised exploitation rate for Nephrops GSA 17&18 is based on a reduced harvest rate due to the low biomass (B< Bpa) FMSY = 0.3629 is reduced to F=0.36191

*** % change in SSB 2022 to 2020

^Total catch in 2021 relative to Catch in 2019.

^^ Total catch in 2021 relative to advice value 2020.

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* (2021)	F_{msy}** (all) (2021)	Catch 2021 GSA 17		Catch 2021 GSA 18
STECF advice basis			OTB	FPO	OTB
Reduced FMSY (B< Bpa)	1217.70	0.3619	584.49	48.71	572.32
F_{MSY}	1221.05	0.3629	586.10	48.84	573.89

Basis	Total catch* (2021)	F_{msy}** (all) (2021)	Catch 2021 GSA 17		Catch 2021 GSA 18
$F_{MSY\ lower}$	810.89	0.241	389.23	32.44	381.12
$F_{MSY\ upper}$	1662.16	0.494	797.84	66.49	781.22

Basis of the advice

Table 5.5.4 Norway lobster in GSA 17 and 18. The basis of the advice.

Advice basis	Reduced FMSY, Bmsy<Bpa
Management plan	

Quality of the assessment

All the diagnostics were considered acceptable.

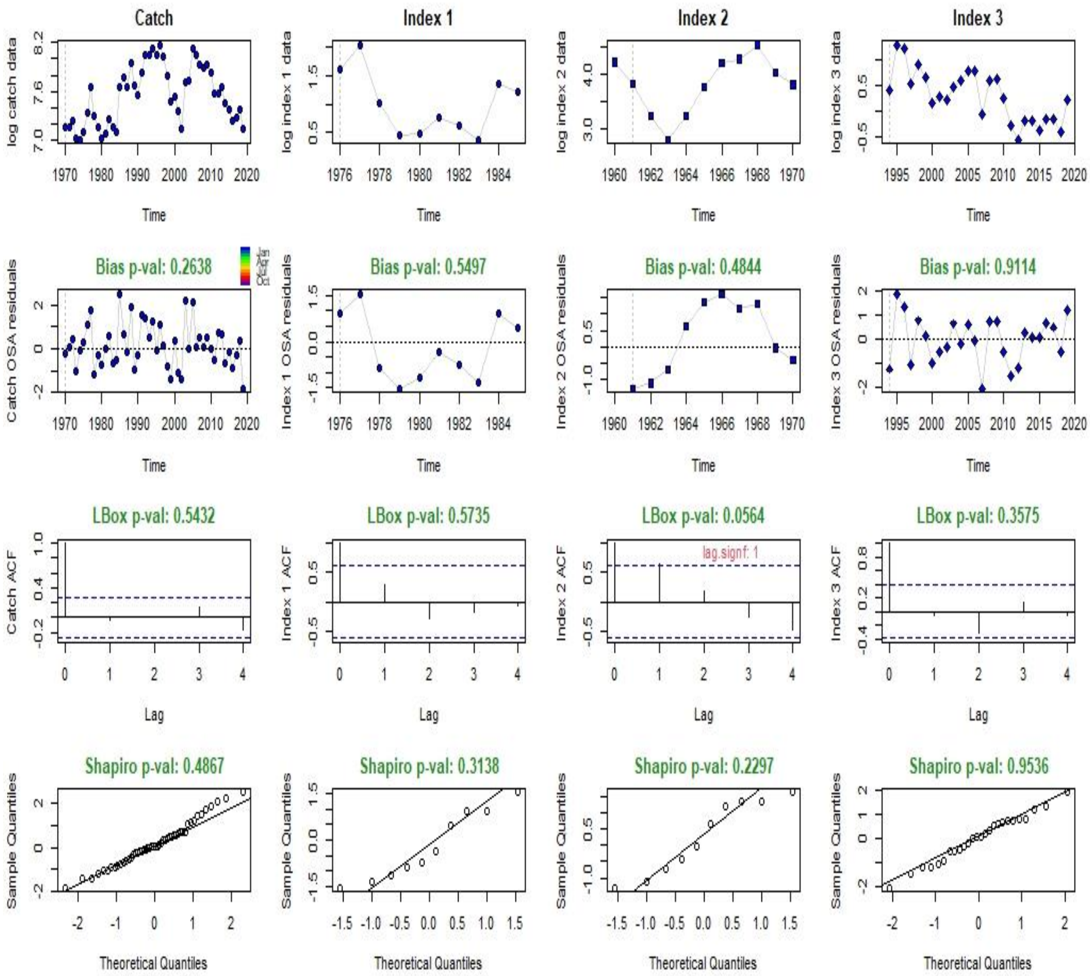


Figure 5.5.2 Norway lobster in GSA 17 and 18. SPICT model diagnostics

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.

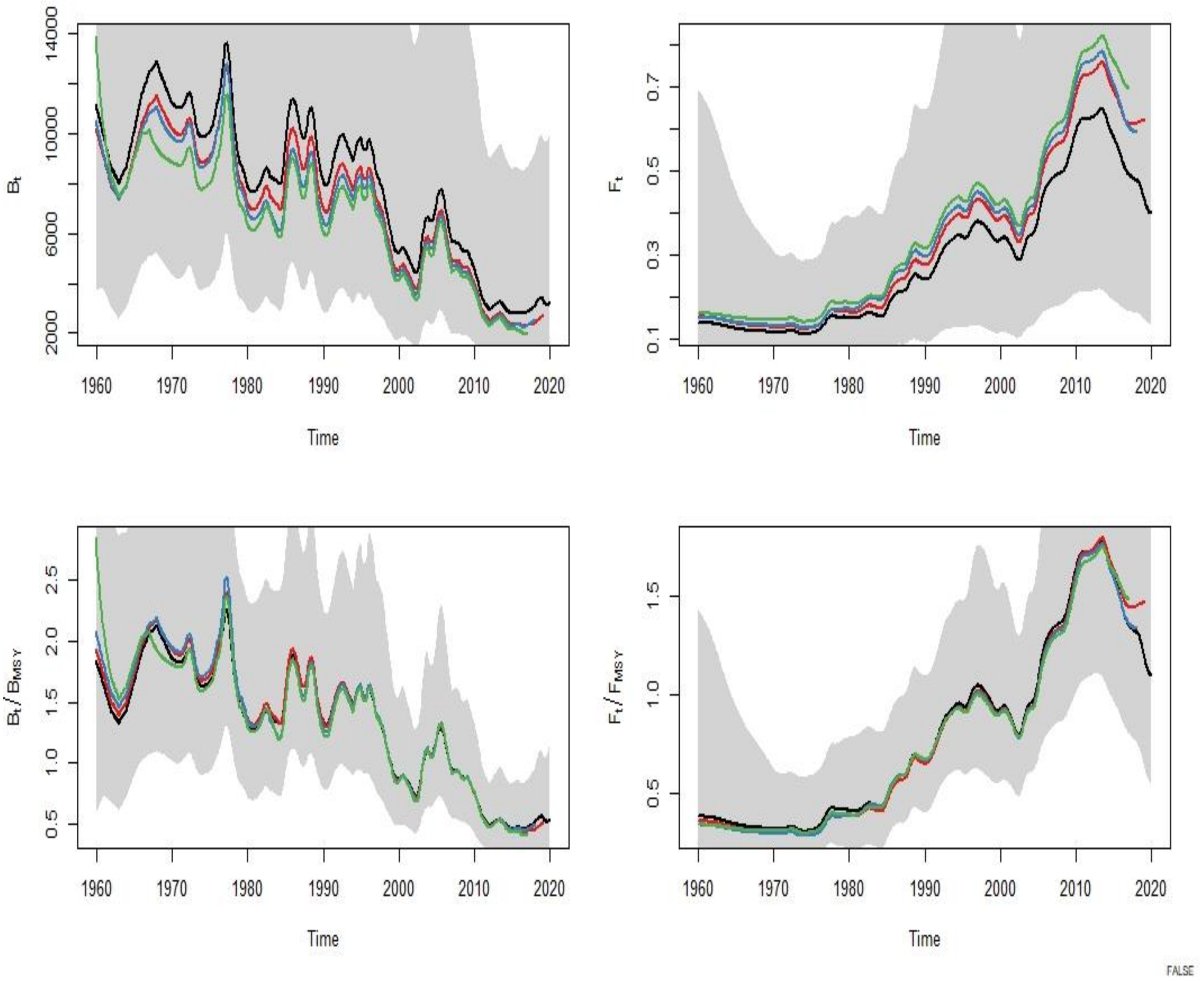


Figure 5.5.3 Norway lobster in GSA 17 and 18. Historical assessment results. (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

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 $B_{trigger}$	3373.942	MSY Btrigger = Bpa = Blim*1.4	STECF EWG 20-15
	F_{MSY}	0.36191	F target (MSY reduced)	STECF EWG 20-15
Precautionary approach	B_{lim}	2409.959	Blim = 40% Bmsy	
	B_{pa}	3373.942	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 20-15
	MAP B_{lim}		Blim = 40% Bmsy	STECF EWG 20-15
	MAP F_{MSY}		F target (MSY reduced)	STECF EWG 20-15
	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 in 2019 only
Indicators	
Other information	
Working group	STECF EWG 20-15

*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		

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.

2019		Wanted catch		Discards
Catch (t)		OTB 0.96%	FPO 0.04%	t
		1194.2	50.7	2.03
Nominal Effort		304839.3	130986	
		(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			2775	189204.1
2008	2654			2654	178527.1
2009	2800			2800	209530.5
2010	2523			2523	178268.9
2011	1956			1956	166983.9
2012	1520		435	1955	198885.0
2013	1441	278.167	398	2117	227575.3
2014	974	342.388	400	1716	179447.8
2015	893	298.550	405	1596	194646.2
2016	755	232.467	411	1398	195973.1
2017	845	197.369	389	1431	186265.4
2018	1036	230.057	257	1523	217350.0
2019	1169	265.855	213	1648	435825.3

*** No landings in Slovenia. We report the effort for HRV from 2012 to 2019 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	9705.53			1270	0.13		
1971	9741.71			1283	0.13		
1972	10127.07			1397	0.14		
1973	8663.75			1113	0.13		
1974	8465.42			1098	0.13		
1975	8986.16			1197	0.13		
1976	10495.21			1520	0.15		
1977	11987.49			2104	0.17		
1978	8632.41			1469	0.17		
1979	7280.13			1288	0.18		
1980	6484.06			1116	0.17		
1981	6690.32			1185	0.18		
1982	7368.16			1407	0.19		
1983	6944.48			1270	0.18		
1984	6940.24			1219	0.18		
1985	9674.53			2109	0.21		
1986	9992.61			2350	0.23		

1987	8881.68	2087	0.24
1988	10147.07	2836	0.27
1989	8083.42	2159	0.27
1990	7101.16	1890	0.27
1991	8333.28	2507	0.30
1992	9364.26	3151	0.33
1993	8849.36	3122	0.35
1994	9202.76	3366	0.36
1995	9143.70	3148	0.35
1996	9297.62	3558	0.38
1997	7985.70	3058	0.38
1998	6499.07	2426	0.37
1999	4817.44	1753	0.37
2000	4615.82	1864	0.40
2001	3988.03	1559	0.39
2002	3547.08	1252	0.37
2003	5067.02	2219	0.42
2004	5149.08	2279	0.45
2005	6145.09	3394	0.54
2006	5146.39	3107	0.60
2007	4362.05	2775	0.63
2008	4134.36	2654	0.65
2009	3893.07	2800	0.72
2010	3145.22	2523	0.80

2011	2387.06	1956	0.82
2012	2335.81	1955	0.83
2013	2465.46	2117	0.84
2014	2168.28	1716	0.80
2015	2129.34	1596	0.75
2016	2069.73	1398	0.68
2017	2195.18	1431	0.66
2018	2171.4	1839	0.71
2019	3364.69	1319	0.40

Sources and references

EWG 20 – 15

5.6 Summary sheet for Spottail mantis shrimp in GSA 17 and 18

Summary sheets for Spottail mantis shrimp are provided for both GSA 17 & 18 combined and for GSA 17 separately. An assessment for GSA 18 was not performed because the MEDITS survey index in GSA 18 was not considered representative of this species. Although the combined area may not constitute a single stock, the joint assessment does reflect the overall joint state of Spottail mantis shrimp in GSA 17-18. If an area contains several stocks the aggregated assessment represents the average conditions in terms of F and biomass, but cannot provide protection for all the individual 'stocks'.

5.6.1 Summary sheet for Spottail mantis shrimp in GSA 17 and 18

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.45 and corresponding catches in 2021 should be no more than 4970 tons.

Stock development over time

Recruitment of Spottail mantis shrimp fluctuated around 1.5 million since the beginning of the time series followed by a rapid increase since 2017 reaching almost 3 million in 2019, though recruitment in 2019 is rather uncertain. SSB showed a decreasing trend in the beginning of the time series stabilizing just above 10000 tonnes for a period of time with an increasing trend the last two years. Catch in the past 5 years has been fluctuating around 4000 tonnes and F is declining since 2016.

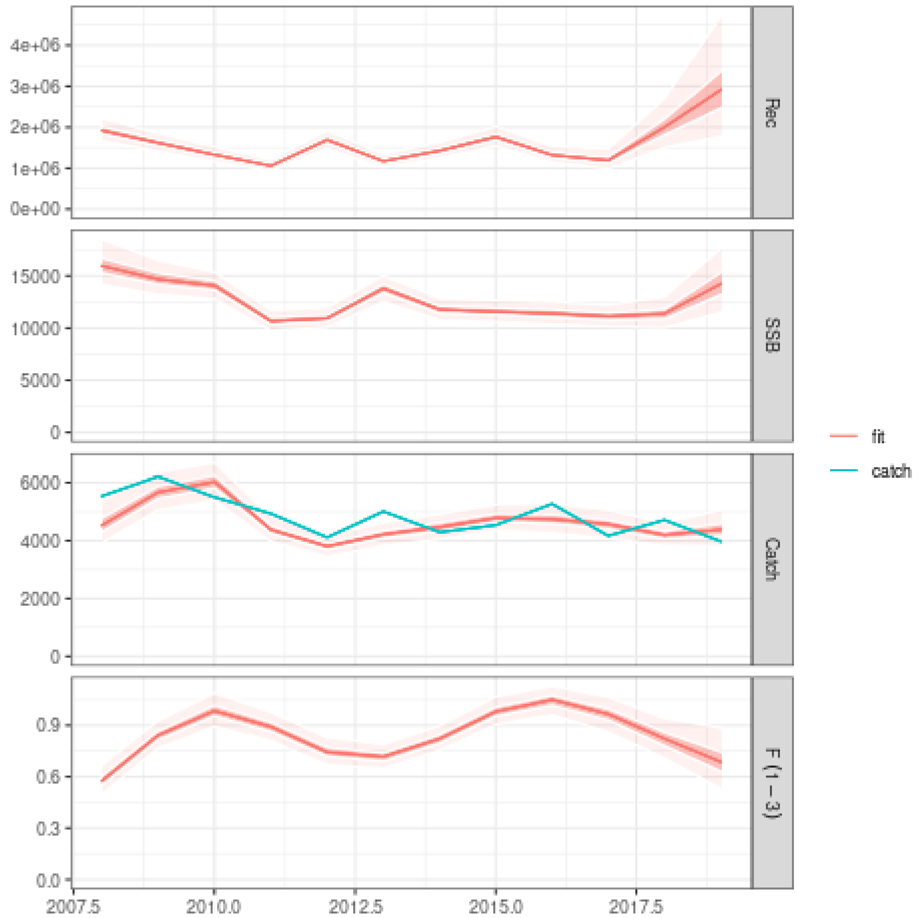


Figure 5.6.1.1 Spottail mantis shrimp in GSA 17 & 18: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.45).

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

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

Catch scenarios

Table 5.6.1.2 Spottail mantis shrimp in GSA 17 & 18: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	0.69	F2019 used to give F status quo for 2020
SSB (2020)	21099	Stock assessment 1 January 2020
R_{age0} (2020,2021)	1556836	Geometric mean of years 2008 to 2019
Total catch (2020)	6279	Assuming F status quo for 2020

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

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

Basis	Total catch* (2021)	F_{total}# (ages 1-3) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	4970	0.45	18790	-11	114
$F_{MSY\ Transition}$	6383	0.62	17326	-18	46
$F_{MSY\ lower}$	3532	0.30	20305	-4	-19
$F_{MSY\ upper}$**	6352	0.90	17358	-18	45
Other scenarios					
Zero catch	0	0	24115	14	-100
Status quo	6894	0.69	16804	-20	58
0.8 * F status quo	5824	0.55	17902	-15	33
0.9 * F status quo	6374	0.62	17335	-18	46

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

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 considered acceptable

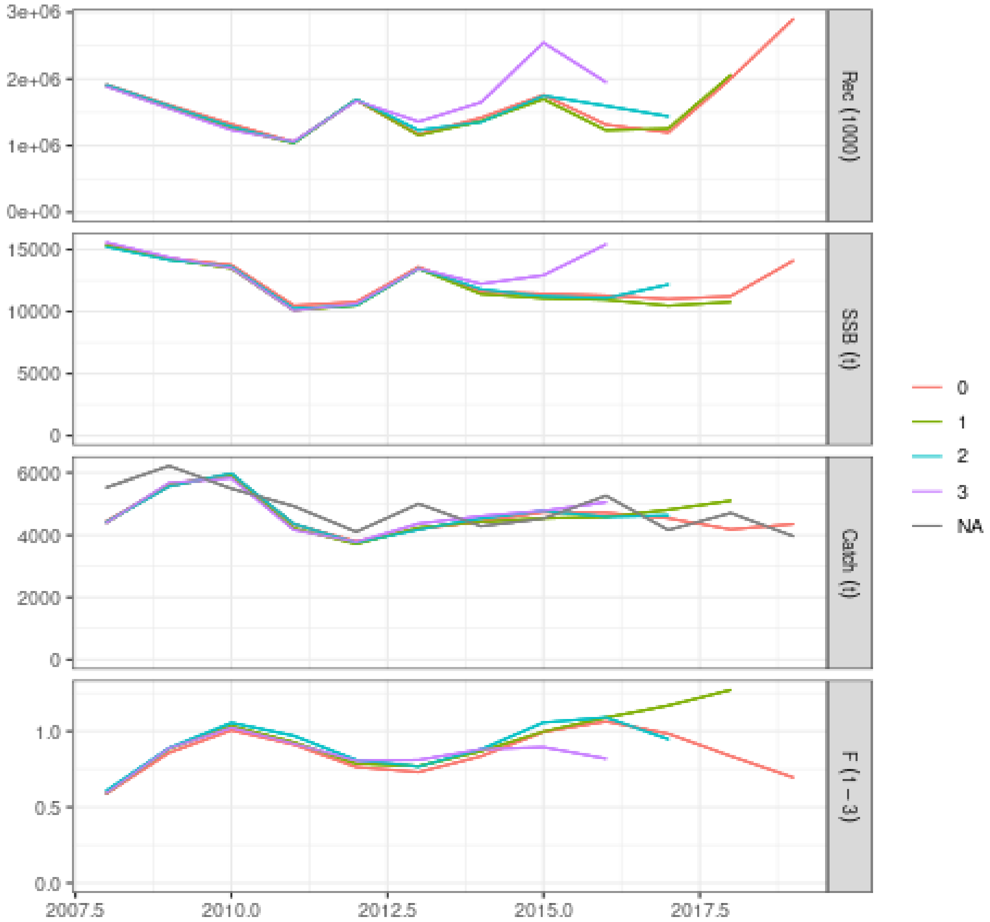


Figure 5.6.1.2 Spottail mantis shrimp in GSA 17 & 18: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

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}	0.45	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	
Management plan	MAP MSY $B_{trigger}$		Not Defined	
	MAP B_{lim}		Not Defined	
	MAP F_{MSY}	0.45	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-15
	MAP target range F_{lower}	0.30	Based on regression calculation (see section 2)	STECF EWG 20-15
	MAP target range F_{upper}	0.61	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-15

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 20-15

*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
2019	F = F_{msy}		4960	4372	
2020	F = F_{msy}		2190		
2021	F = F_{msy}		4970		

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 2008-2019 as estimated by and reported to STECF.

	Landings				Discards	
Catch (t)	Otter trawl 79%	Gillnets 15%	Beam trawl 5%	Other 1%	Otter trawl 99%	Beam trawl 1%
	48011	8874	3261	633	6338	89

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

Year	ITALY GSA17	SLOVENIA	CROATIA	ITALY GSA 18	Total Catch
2008	3999	6.8	8.5	917	4931
2009	3999	3.9	9.3	983	5526
2010	4939	5.4	8.6	547	5500
2011	4508	3.8	7.1	414	4933
2012	3208	0.7	2.2	901	4112
2013	2385	0.3	2.4	2622	5010
2014	3204	0.5	4.5	1083	4292
2015	3399	0.8	7.4	1130	4537
2016	4185	1.9	11.3	1074	5272
2017	3523	7.1	12.7	626	4168
2018	3692	7.9	13.3	1002	4715
2019	3068	6.2	7.3	888	3969

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 tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2008	1922782			15733			4458	0.58		
2009	1620604			14556			5609	0.84		
2010	1329428			13973			5982	0.98		
2011	1059800			10649			4366	0.89		
2012	1689665			10923			3796	0.74		
2013	1171569			13734			4208	0.71		
2014	1427639			11729			4456	0.82		
2015	1765975			11565			4766	0.98		
2016	1321877			11390			4732	1.04		
2017	1200058			11107			4542	0.96		
2018	2009828			11335			4189	0.82		
2019	2901990			14193			4372	0.69		

Sources and references

STECF EWG 20-15

5.6.2 Summary sheet for Spottail mantis shrimp in GSA 17

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.43 and corresponding catches in 2021 should be no more than 4515 tons.

Stock development over time

Recruitment of Spottail mantis shrimp fluctuated around 1 million since the beginning of the time series followed by a rapid increase since 2017 reaching 2 million in 2019. SSB showed a decreasing trend from the beginning of the time series and then since 2015 it has been increasing. Catch and F are declining since 2017.

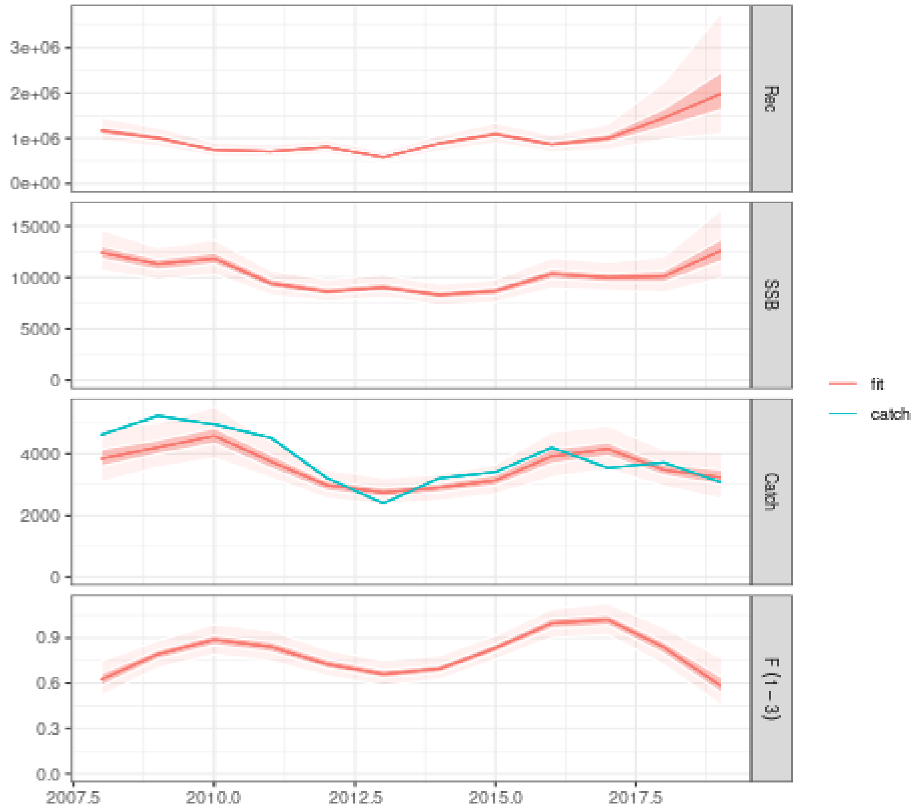


Figure 5.6.2.1 Spottail mantis shrimp in GSA 17: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.43).

Table 5.6.2.1 Spottail mantis shrimp in GSA 17: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.6.2.2 Spottail mantis shrimp in GSA 17: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	0.59	F2019 used to give F status quo for 2020
SSB (2020)	18625	Stock assessment 1 January 2020
R_{age0} (2020,2021)	971609	Geometric mean of years 2008 to 2019
Total catch (2020)	4848	Assuming F status quo for 2020

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

Table 5.6.2.3 Spottail mantis shrimp in GSA 17: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2021)	F_{total}# (ages 1-3) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY} / MAP	4515	0.43	15761	-15	41
$F_{MSY\ Transition}$	5431	0.54	14792	-21	70
$F_{MSY\ lower}$	3277	0.29	17141	-8	1
$F_{MSY\ upper}$**	5740	0.59	14468	-22	79
Other scenarios					
Zero catch	0	0	21218	14	100
Status quo	5770	0.59	14437	-22	80
0.8 * F status quo	4873	0.47	15380	-17	52
0.9 * F status quo	5334	0.53	14894	-20	67

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

Basis of the advice

Table 5.6.2.4 Spottail mantis shrimp in GSA 17: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

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

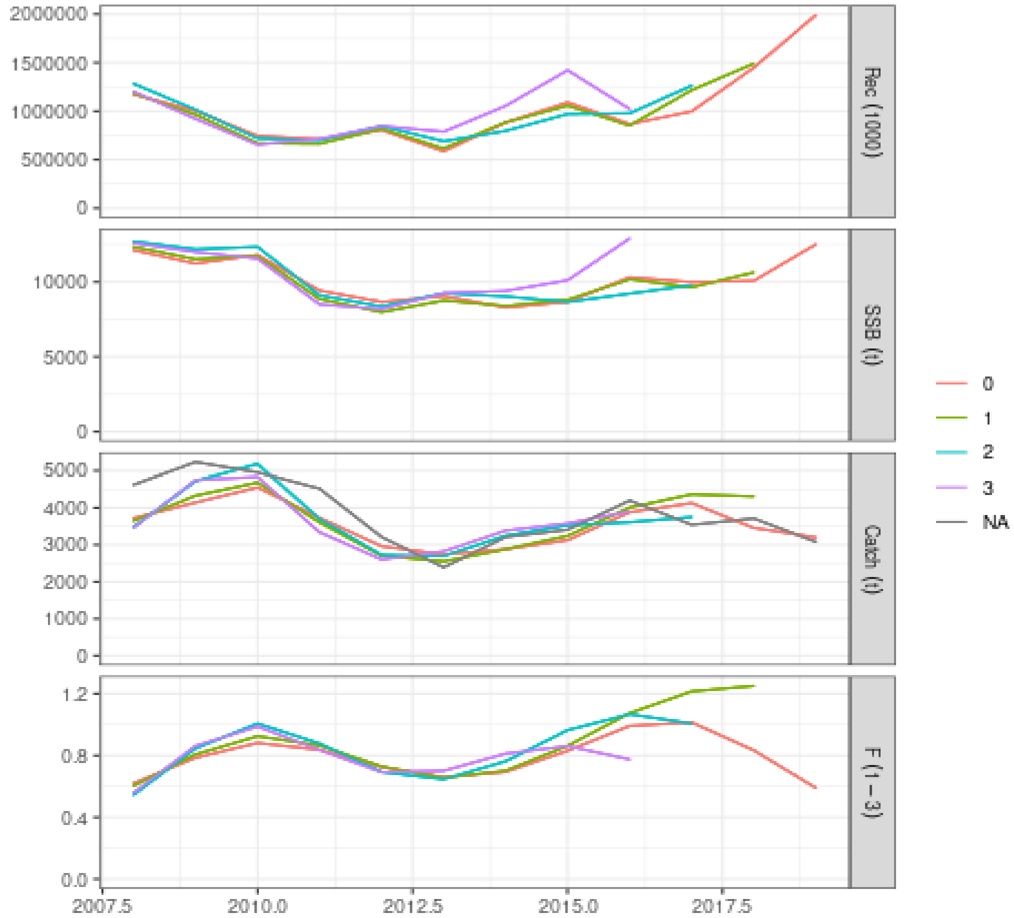


Figure 5.6.2.2 Spottail mantis shrimp in GSA 17: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

No additional relevant issues for the advice.

Reference points

Table 5.6.2.5 Spottail mantis shrimp in GSA 17: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.43	$F_{0.1}$ 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}	0.43	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-15
	MAP target range F_{lower}	0.29	Based on regression calculation (see section 2)	STECF EWG 20-15
	MAP target range F_{upper}	0.59	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 20-15

Basis of the assessment

Table 5.6.2.6 Spottail mantis shrimp in GSA 17: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	DCF commercial data (landings and discards) and scientific survey (SOLEMON) data
Discards, BMS landings*, and bycatch	Discards included
Indicators	
Other information	
Working group	STECF EWG 20-15

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.6.2.7 Spottail mantis shrimp in GSA 17: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	F = F_{msy}		4515		

History of the catch and landings

Table 5.6.2.8 Spottail mantis shrimp in GSA 17: Landings and discards distribution by fleet for years 2008-2019 as estimated by and reported to STECF.

	Landings				Discards	
Catch (t)	Otter trawl 74%	Gillnets 18%	Beam trawl 7%	Other 1%	Otter trawl 98%	Beam trawl 2%
	34346	8162	3459	424	4609	89

Table 5.6.2.9 Spottail mantis shrimp in GSA 17: 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	SLOVENIA	CROATIA	Total Catch
2008	3999	6.8	8.5	4014
2009	3999	3.9	9.3	4542
2010	4939	5.4	8.6	4953
2011	4508	3.8	7.1	4519
2012	3208	0.7	2.2	3211
2013	2385	0.3	2.4	2388
2014	3204	0.5	4.5	3209
2015	3399	0.8	7.4	3407
2016	4185	1.9	11.3	4198
2017	3523	7.1	12.7	3543
2018	3692	7.9	13.3	3713
2019	3068	6.2	7.3	3081

Summary of the assessment

Table 5.6.2.10 Spottail mantis shrimp in GSA 17: Assessment summary. Weights are in tonnes. 'High' and 'Low' are 2 standard errors (approximately 95% confidence intervals).

Year	Recruitment age 0 thousands	High	Low	SSB tonnes	High	Low	Catch tonnes	F ages 1-3	High	Low
2008	1172213			12119			3721	0.62		
2009	1004025			11230			4144	0.79		
2010	745550			11800			4549	0.88		
2011	711659			9426			3730	0.84		
2012	806170			8664			2960	0.73		
2013	586473			9053			2741	0.66		
2014	882207			8290			2880	0.69		
2015	1090459			8658			3126	0.83		
2016	867306			10313			3881	0.99		
2017	997920			9990			4129	1.01		
2018	1447415			10074			3457	0.83		
2019	1989216			12503			3201	0.59		

Sources and references

STECF EWG 20-15

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

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.5 and corresponding catches in 2021 should be no more than 2915 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.

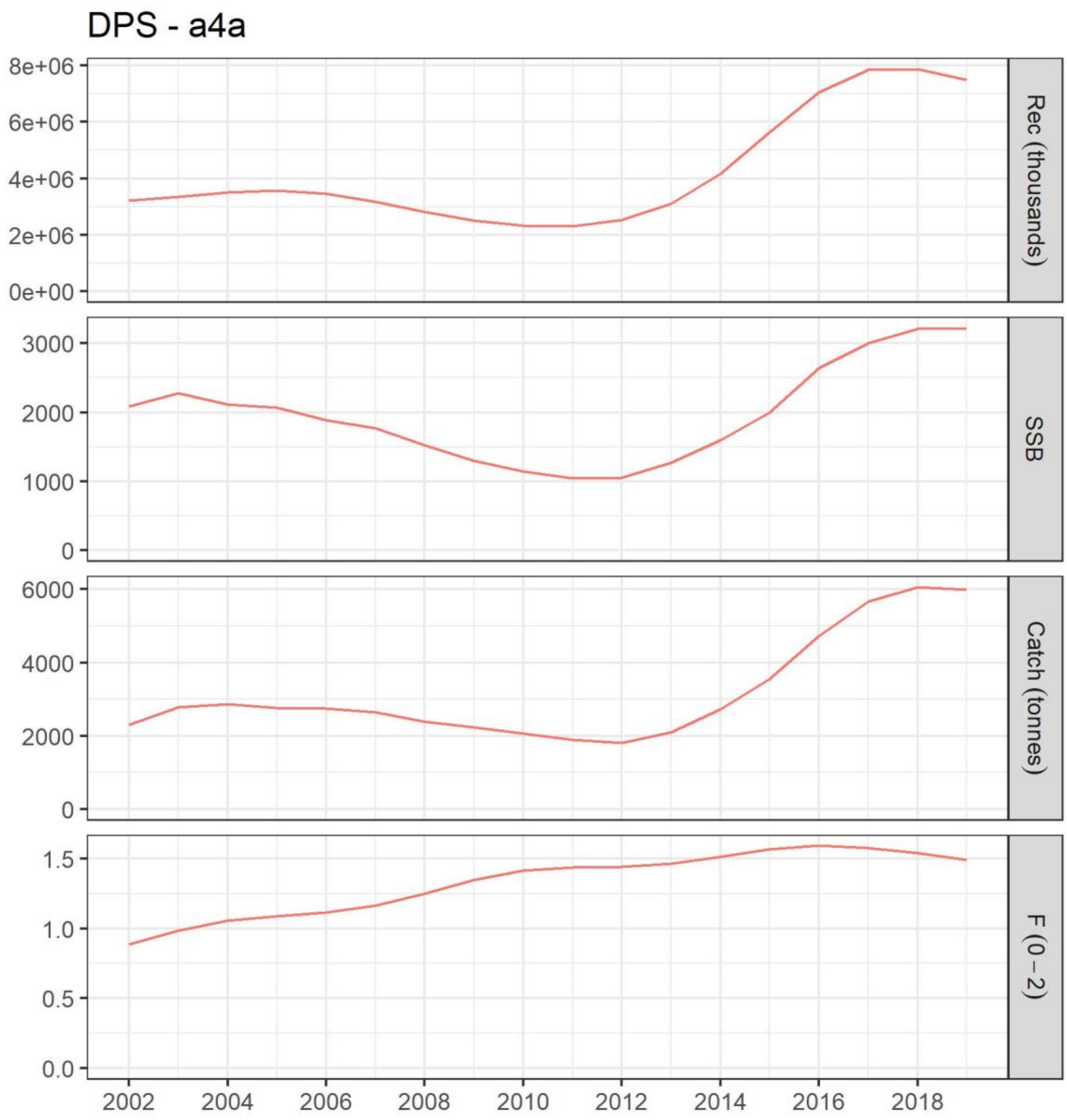


Figure 5.7.1 Deep-water rose shrimp stocks in GSAs 17-19: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model.

Stock and exploitation status

The current level of fishing mortality is above the reference point $F_{0.1}$, used as proxy of FMSY (=0.5). SSB is fluctuating and F at the maximum level of the time series.

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

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

Catch scenarios

Table 5.7.2 Deep-water rose shrimp stocks in GSAs 17-19: 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 2017-2019
Fages 0-2 (2020)	1.49	F2019 (last year F) used to give F status quo for 2020
SSB (2020)	3245.5 t	Stock assessment 1 January 2020
Rage0 (2020,2021)	7730467	Geometric mean of the last 3 years
Total catch (2020)	5952	Assuming F status quo for 2020

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

Basis	Total catch* (2021)	F_{total}# (ages 0-2) (2021)	SSB (2022)	% SSB change***	% Catch change^
F_{MSY}	2915.1	0.50	6624.1	104.1	-51.4
$F_{MSY\ Transition}$	5239.7	1.16	3983.8	22.75	-12.57
$F_{MSY\ lower}$	2088.4	0.34	7795.0	140.2	-65.2
$F_{MSY\ upper}$**	3691.7	0.69	5634.4	73.6	-38.4
Other scenarios					
Zero catch	0.0	0.00	11278.1	247.5	-100.0
Status quo	6056.5	1.49	3285.5	1.2	1.1
Intermediate Options					
F=F2019 * 0.8	5322.4	1.19	3907.8	20.4	-11.2
F=F2019 * 0.6	4428.7	0.89	4794.9	47.7	-26.1
F=F2019 * 0.4	3312.5	0.60	6104.2	88.1	-44.7
F=F2019 * 0.2	1881.5	0.30	8106.7	149.8	-68.6

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

*** % change in SSB 2022 to 2020

^Total catch in 2021 relative to Catch in 2019.

Basis of the advice

Table 5.7.4 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 2019 is high. All the diagnostics were considered acceptable.

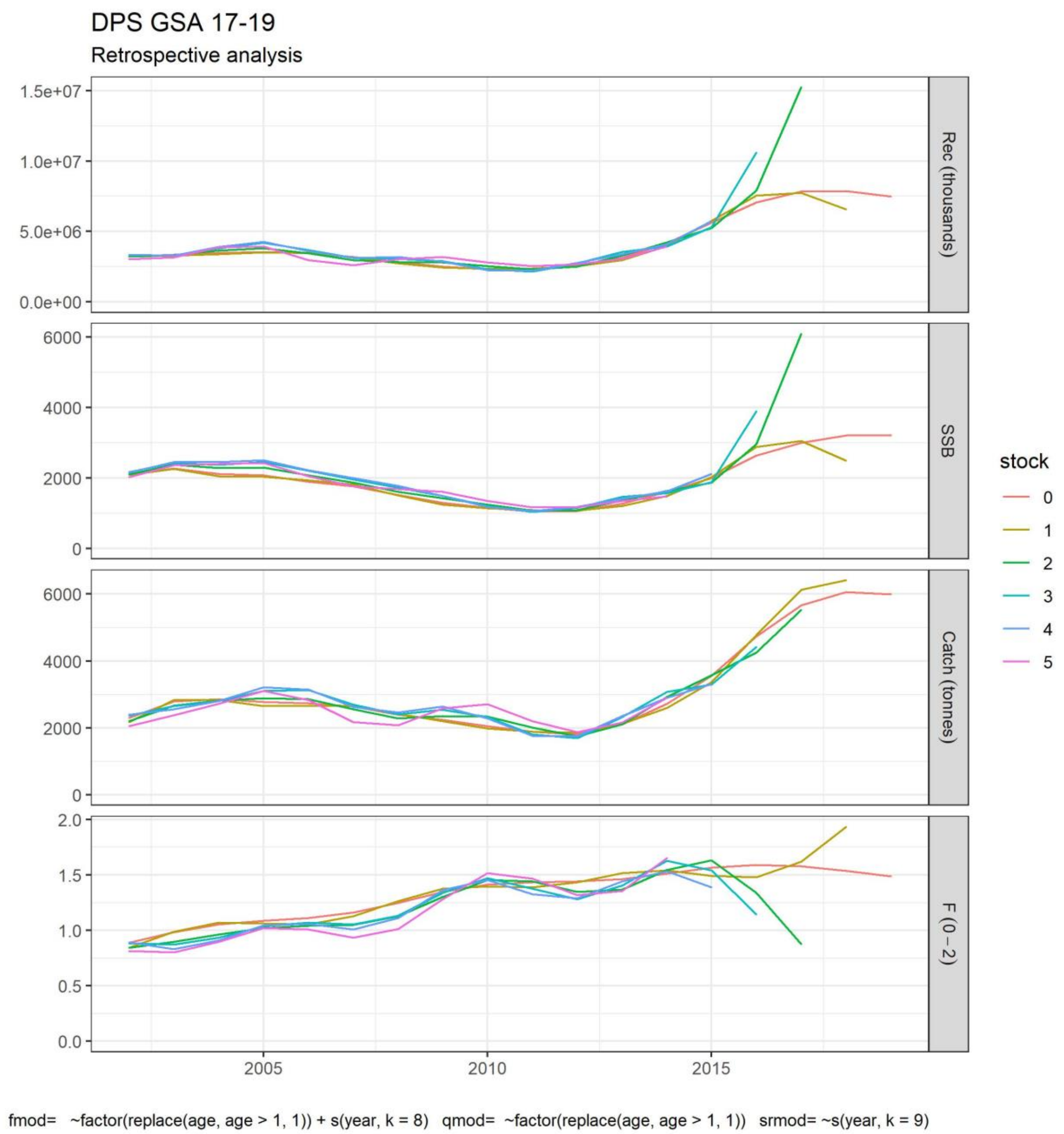


Figure 5.7.2 Deep-water rose shrimp stocks in GSAs 17-19: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

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}	0.5	$F_{0.1}$ 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}	0.5	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 20-15
	target range F_{lower}	0.34	Based on regression calculation (see section 2)	STECF EWG 20-15
	target range F_{upper}	0.69	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	$F = F_{MSY}$		2635	5993	
2020	$F = F_{MSY}$		2290		
2021	$F = F_{MSY}$		2915		

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.

<table>
<tr><td>2019</td><td></td><td colspan="4">Wanted catch</td><td>Discards</td></tr>
<tr><td rowspan="2">Catch
(t)</td><td></td><td>Bottom trawl 100%</td><td></td><td></td><td></td><td>t</td></tr>
<tr><td>landings</td><td>6211</td><td></td><td></td><td></td><td>272</td></tr>
<tr><td rowspan="2">Effort</td><td>effort</td><td>180721</td><td></td><td></td><td></td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="4">Fishing days</td></tr>
</table>

Table 5.7.9 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 are in gt days at sea, days at sea and fishing days.

effort	fishing days	fishing days	fishing days	fishing days	fishing days	gt days at sea	days at sea	fishing days
gear	OTB	OTB	OTB	OTB	OTB	OTB	OTB	OTB
country	HRV	ITA	ITA	ITA	SVN	all	all	all
GSA	17	17	18	19	17	all	all	all
2002	0	220915	138899	131590	0	8976537	359814	491404
2003	0	223216	107183	153810	0	8216292	330399	484209
2004	0	242276	87211	106719	0	8553084	361033	436206
2005	0	203974	79638	56199	831	8076343	316274	340642
2006	0	169108	85122	82371	963	7232934	277841	337564
2007	0	138377	70774	76509	1202	6736348	236411	286862
2008	0	130131	70654	76484	1254	6404946	217606	278523
2009	0	137929	85892	88055	1205	6598041	240290	313081
2010	0	136949	73021	90514	1263	6247228	224028	301747
2011	0	138540	68754	78239	1178	5665265	220725	286711
2012	50835	116850	63411	60017	917	6475409	251297	292030
2013	52973	97982	79244	45588	766	6395602	245363	276553
2014	54650	97868	54851	48040	680	6095721	222763	256089
2015	55076	85984	54774	51394	696	5968121	212800	247924
2016	33715	89376	60876	49784	812	5968169	190103	234563
2017	35649	96415	57053	52214	697	6791333	201527	242028
2018	56844	79551	62311	46672	692	6611946	215224	246070
2019	30997	65911	50169	32875	769	6007135	165885	180721

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	3211860			2089			2303	0.89		
2003	3357245			2275			2789	0.98		
2004	3496761			2112			2861	1.05		
2005	3561511			2069			2771	1.09		
2006	3459154			1888			2741	1.11		
2007	3180805			1765			2641	1.16		
2008	2827686			1521			2388	1.25		
2009	2518958			1298			2243	1.35		
2010	2328360			1148			2058	1.41		
2011	2307545			1048			1891	1.44		
2012	2531322			1056			1810	1.44		
2013	3116128			1269			2102	1.46		
2014	4174441			1601			2725	1.51		
2015	5636747			1997			3555	1.57		
2016	7053569			2636			4732	1.59		
2017	7838641			3005			5660	1.58		
2018	7862464			3208			6065	1.54		
2019	7490295			3221			5993	1.49		

Sources and references

STECF EWG 20-15

5.8 Summary sheet for Caramote prawn in GSA 17

STECF advice on fishing opportunities

Based on precautionary considerations, STECF EWG 20-15 advises to decrease the total catch to 96% of the average 2017-2019 catches equivalent to catches of no more than 864 tons in each of 2021 and 2022 implemented either through catch restrictions or effort reduction for the relevant fleets.

Stock development over time

The relative change in the biomass index from the Solemon survey was used to provide an index for change (Figure 5.8.1). The stock has increased rapidly in the last 5-6 years. Based on the index value in the last two years relative to the previous three years the increase in SSB is estimated to be 1.45 times.

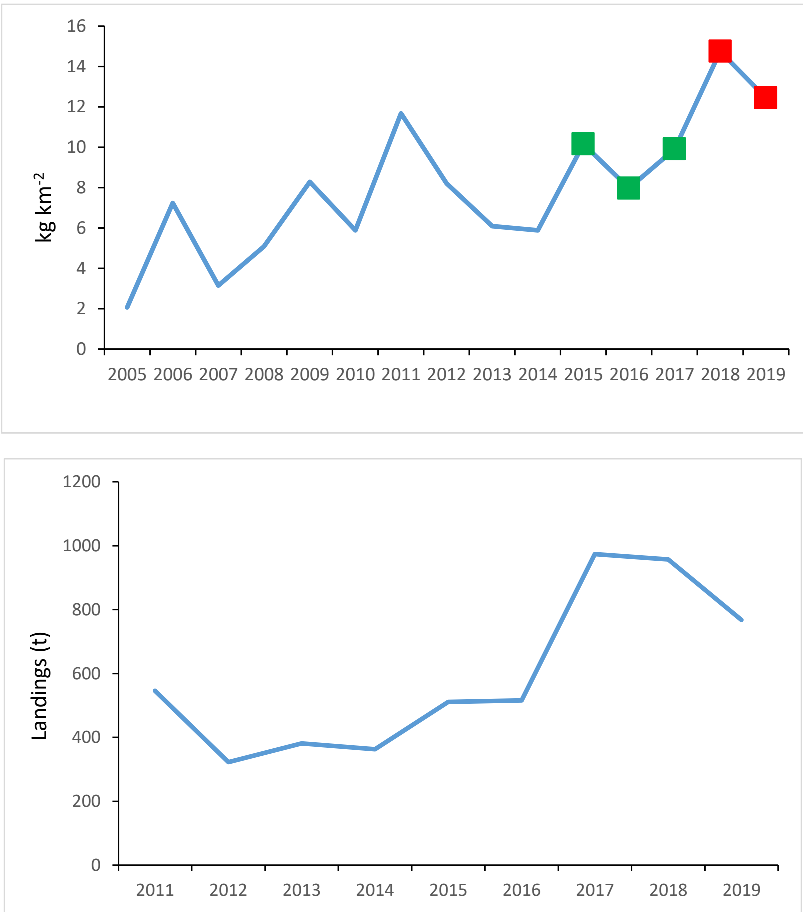


Figure 5.8.1 Caramote prawn in GSA17: Summary of the Solemon stock indicator (upper panel) and catch by year (lower panel).

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown. However, the biomass index of the Solemon survey shows an increase in abundance over the last 15 years. Catches also show a rapid increase in recent years.

Catch scenarios

The advice on fishing opportunities for 2021 and 2022 is based on the recent observed catch adjusted to the change in the stock size index: the biomass index from the Solemon survey. The change is estimated from the two most recent values relative to the three preceding values (see table 5.8.1). A precautionary buffer of -20% is applied because the precautionary status of the stock is not known.

Table 5.8.1 Caramote prawn in GSA17: Assumptions made for the interim year and in the forecast. *

Index A (2018–2019)		13.60
Index B (2015–2017)		9.35
Index ratio (A/B)		1.45
-20% Uncertainty cap	Applied/not applied	Applied
Average catch (2017–2019)		900
Discard rate (2017–2019)		Negligible
-20% Precautionary buffer	Applied/not applied	Applied
Catch advice **		864
Landings advice ***		864
% advice change ^		+11%

* 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 5.8.2 Caramote prawn in GSA17: The basis of the advice.

Advice basis	Precautionary Approach
Management plan	

Quality of the assessment

An age-based assessment (with a4a) was attempted using the Solemon biomass index as a tuning index. VBGF and LW parameters were gathered from the literature, as not available in the official DCF database. Age slicing produced a matrix of catch numbers-at-age of almost one age class (Age class 1), making it impossible to fit any age based model. Historical landings were gathered from the Italian official statistics and the RECFISH project. Several attempts using SPiCT were run with biomass indices from Solemon and MEDITS in GSA17 as tuning information. The outcomes were considered too uncertain and unstable to be used to provide advice for this stock.
Therefore, the EWG 20-15 concluded that none of these model was suitable to provide advice. Advice was therefore based on ICES Category 3 index based approach

Issues relevant for the advice

Caramote prawn is exploited by demersal fisheries exploiting coastal fishing grounds. It is caught as a bycatch in mixed fisheries targeting red mullet, common sole and common cuttlefish.

Reference points

Table 5.8.3 Caramote prawn in GSA17: 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 Caramote prawn in GSA17: Basis of assessment and advice.

Assessment type	Index based assessment
Input data	Landings
Discards and bycatch	Discards not included
Indicators	Solemon survey in GSA17
Other information	
Working group	EWG 20-15

History of the advice, catch, and management

Table 5.8.5 Caramote prawn in GSA17: 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
2021	Reduction of 4% of catch	864			
2022	Reduction of 4% of catch	864			

History of the catch and landings

Table 5.8.6 Caramote prawn in GSA17: Catch distribution by fleet in YEAR as estimated by STECF.

Catch (2019)	Landings			Discards
768.3 t	82.2 % otter trawl	15.0 % beam trawl	2.2 % others	0 t
	636.3 t	119.0 t	13.0 t	

Table 5.8.7 Caramote prawn in GSA17: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

Year	ITA GSA17	SVN GSA17	Discards	Total
2005	-	0.01	-	-
2006	-	0.10	-	-
2007	-	0.35	-	-
2008	-	0.12	-	-
2009	-	0.22	-	-
2010	-	0.06	-	-
2011	546	0.11	5	551
2012	323	0.20	0	323
2013	381	0.04	2	383
2014	363	0.96	0	363
2015	511	1.31	1	512
2016	516	5.25	0	516
2017	974	0.04	28	1002
2018	957	0.01	42	999
2019	768	0.35	0	768

Summary of the assessment

Table 5.8.8 Caramote prawn in GSA17: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2005	2.07	213	-	213
2006	7.24	331	-	331
2007	3.15	691	-	691
2008	5.09	502	-	502
2009	8.28	515	-	515
2010	5.89	550	-	550
2011	11.68	546	5	551
2012	8.21	323	0	323
2013	6.09	381	2	383
2014	5.89	363	0	363
2015	10.16	511	1	512
2016	7.97	516	0	516
2017	9.91	974	28	1002
2018	14.75	957	42	999
2019	12.45	768	0	768

Sources and references

STECF EWG 20-15

5.9 SUMMARY SHEET FOR EUROPEAN HAKE IN GSA 19

STECF advice on fishing opportunities

STECF EWG 20-15 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.135 and corresponding catches of hake in 2021 should not exceed 379 tonnes.

Stock development over time

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

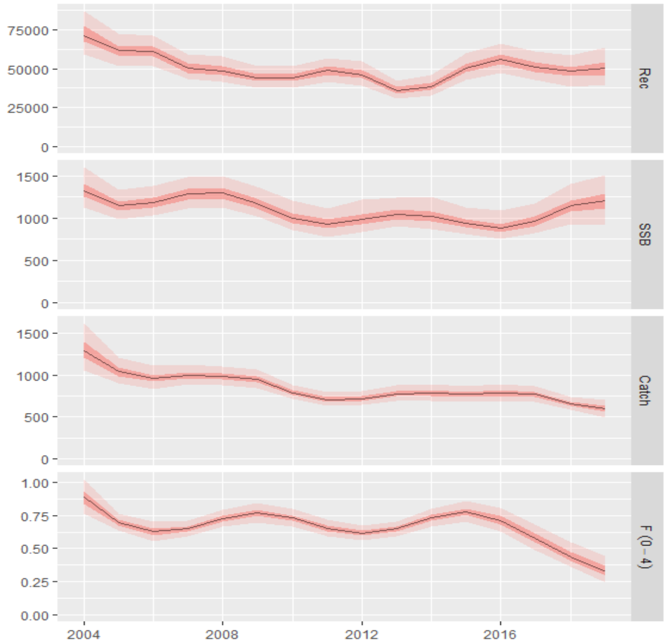


Figure 5.9.1 Hake (HKE) in GSA 19. Outputs of the a4a assessment. SSB and catch are in tonnes, recruitment in number (‘000) of individuals.

Stock and exploitation status

Current Fbar= 0.325 is higher than $F_{0.1}$ (0.135), 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	2017	2018	2019
F / Fmsy	F > Fmsy	F > Fmsy	F > Fmsy

Catch scenarios

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

Variable	Value	Notes
$F_{ages\ 0\text{-}4}$ (2020)	0.325	F status quo (in the interim year 2020) is assumed Fbar in the last assessment year (2019)
SSB (2020)	1876 t	SSB projection based on stock assessment
R_{age0} (2020)	49782	Geometric mean of the whole time series
Total catch (2020)	724 t	Catch at F status quo in 2020

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

Basis	Total catch (2021)	F_{total} (ages 0-4) (2021)	SSB (2022)	% SSB change**	% Catch change^
STECF advice basis					
F_{MSY} / MAP	378.86	0.135	3269.79	74.27	-36.27
$F_{MSY\ Transition}$	693.72	0.260	2892.49	54.16	16.7
$F_{MSY\ upper}$*	520.19	0.190	3099.79	65.21	-12.49
$F_{MSY\ lower}$	263.52	0.092	3409.26	81.71	-55.67
Other scenarios					
Zero catch	0.00	0.00	3730.22	98.81	-100.00
Status quo	838.12	0.325	2721.31	45.04	40.99

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

** % change in SSB 2022 to 2020

^Total catch in 2021 relative to Catch in 2019.

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 for the last time by the STECF EWG in 2017 (STECF EWG 17-15) using XSA and a4a, and at the hake benchmark meeting of GFCM in 2019 (GFCM 2019) using a4a. This is an updated a4a assessment with improved stability over the previous benchmark assessment. The results and the diagnostics the fitted model are very similar to those obtained at the benchmark assessment (GFCM 2019). The conclusion that F>Fmsy is kept by the present assessment **Table 5.9.1**.

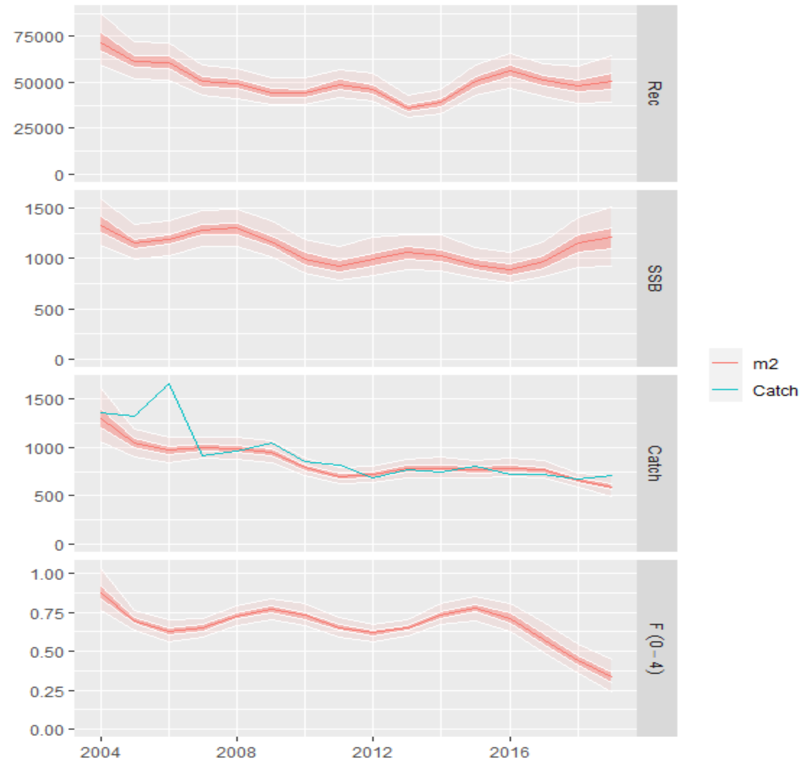


Figure 5.9.2 Hake in GSA 19: Historical assessment results (final-year recruitment estimates included). Retrospective graph.

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}	0.135	$F_{0.1}$ 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}	0.135	$F_{0.1}$ as proxy for F_{MSY}	STECF EWG 2020-15
	MAP target range F_{lower}	0.092	Based on regression calculation (see section 2)	STECF EWG 2020-15

	MAP target range F_{upper}	0.190	Based on regression calculation but not tested and presumed not precautionary	STECF EWG 2020-15

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 2020-15

*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
2021	$F = F_{MSY}$		378.86		

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.

2019		Wanted catch				Discards
Catch (t)		Bottom trawl 100%	Gillnets 0%	Trammel nets 0%	Other 0%	t
		tonnes				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 landing s	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

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, in thousands	SSB, t	Fbar 0-4	Catch, t
2004	71812	1298	0.880	1285
2005	61364	1134	0.695	1039
2006	60903	1177	0.624	964
2007	50509	1280	0.648	1000
2008	48928	1293	0.724	992
2009	44323	1171	0.767	953
2010	44176	995	0.727	797
2011	48618	924	0.652	709
2012	46442	985	0.613	722
2013	36087	1046	0.647	785
2014	38883	1021	0.730	792
2015	50421	935	0.774	774
2016	55855	880	0.710	786
2017	50972	959	0.577	767
2018	47871	1137	0.439	661
2019	50329	1193	0.325	594

Sources and references

STECF EWG 20-15

5.10 Summary sheet for European hake in GSA 20

STECF advice on fishing opportunities

Currently it is not possible to provide an assessment or index advice for this stock because catch data are uncertain with different sources in conflict and survey information is sparse.

Stock development over time

Survey data is sparse, with several years with no data, the index below indicates the recent years are above the long term mean for the survey. Official landings are at around 40% of historical maximum values. However, data on catches is conflicting and historic catches cannot be estimated.

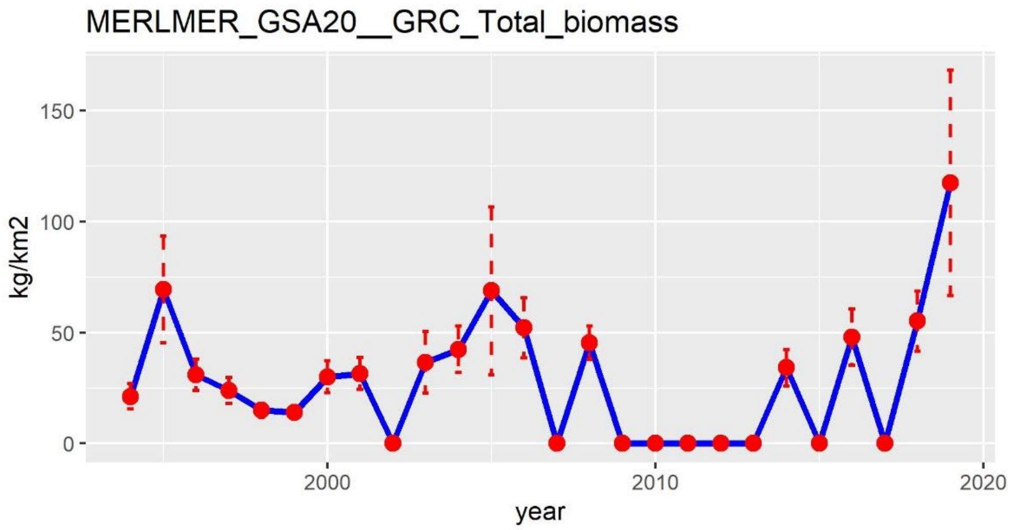


Figure 5.10.1 Summary of the MEDITS survey by year.

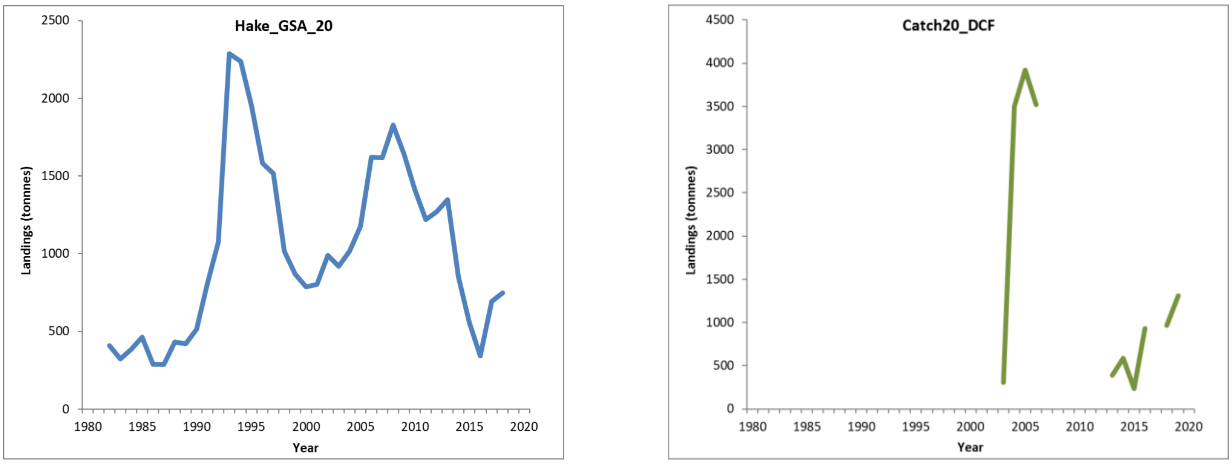


Figure 5.10.2 Different sources of catch data (left: official landings and right: landings from DCF) by year.

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown.

Catch scenarios

Because catches are uncertain it is not possible to give specific catch scenarios.

Basis of the advice

Table 5.10.1 Hake_GSA20: The basis of the advice.

Advice basis	No Advice
Management plan	

Quality of the assessment

The landings as calculated from the DCF data (number of individuals multiplied by their somatic weight) do not correspond to the official landings reported. The DCF dataset contains too many missing points and is inconsistent in terms of landings as the landings reported for 2003-2006 are very high, probably owing to a raising factor error. Towards the end of the time series, after 2014, the DCF dataset seems to converge with the official one but still the two datasets do not agree.

The MEDITS bottom trawl survey was used for the estimation of abundance index of hake in GSA 20. The survey is carried out in June/July each year since 1994. No survey was carried out in 2002, 2007, 2009-2013, 2015 and 2017.

Issues relevant for the advice

There are no additional issues for advice.

Reference points

Table 5.10.2 Hake_GSA20: 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 5.10.3 Hake_GSA20: Basis of assessment and advice.

Assessment type	No assessment
Input data	
Discards and bycatch	

Indicators	
Other information	
Working group	EWG 20-15

History of the advice, catch, and management

Table 5.10.4 Hake_GSA20: 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
2021	No Advice				

History of the catch and landings

Table 5.10.5 Hake_GSA20: Catch distribution by fleet in 2019 as estimated by STECF.

Catch (2019)	Landings			Discards
	19 % trawl	73% set nets	8% LLS	35t (3% of catch)
	1311 t			

Table 5.10.6 Hake_GSA20: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

HKE_20								
Year	Official landings	DCF_GNS	DCF_GTR	DCF_LLS	DCF_OTB	DCF_unspecified	Discards	Total
2003	925	-	-	-	308	-	33	
2004	1026	-	-	-	404	3094	19	
2005	1184	-	-	-	516	3404	831	
2006	1633	-	-	-	754	2768	824	
2007	1630	-	-	-	-	-	-	
2008	1841	-	-	-	459	2821	606	
2009	1655	-	-	-	-	-	-	
2010	1421	-	-	-	-	-	-	
2011	1230	-	-	-	-	-	-	
2012	1279	-	-	-	-	-	-	
2013	1357	128	38	23	203	-	16	
2014	854	241	23	21	300	-	11	
2015	562	141	-	14	64	-	3	
2016	344	596	-	70	157	-	36	
2017	693	-	-	-	-	-	-	
2018	748	433	311	66	151	-	61	
2019	700 (tbc)	655	300	103	253	-	35	

Summary of the assessment

Table 5.10.7 Hake_GSA20: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2003	36.5	925	33	
2004	42.4	1026	19	
2005	68.8	1184	831	
2006	52.1	1633	824	
2007	-	1630	-	
2008	45.3	1841	606	
2009	-	1655	-	
2010	-	1421	-	
2011	-	1230	-	
2012	-	1279	-	
2013	-	1357	16	
2014	34.1	854	11	
2015	-	562	3	
2016	48.3	344	36	
2017	-	693	-	
2018	54.9	748	61	
2019	117.4	700 (tbc)	35	

Sources and references

STECF EWG 20-15

5.11 SUMMARY SHEET FOR EUROPEAN HAKE IN GSA 22

STECF advice on fishing opportunities

Currently it is not possible to provide an assessment or index advice for this stock because catch data are uncertain with different sources in conflict and survey information is sparse.

Stock development over time

Survey data is sparse, with several years with no data, the index below indicates the recent years are close to the long term mean for the survey. Official landings are at around 50% of historical maximum values. However, data on catches is conflicting and historic catches cannot be estimated.

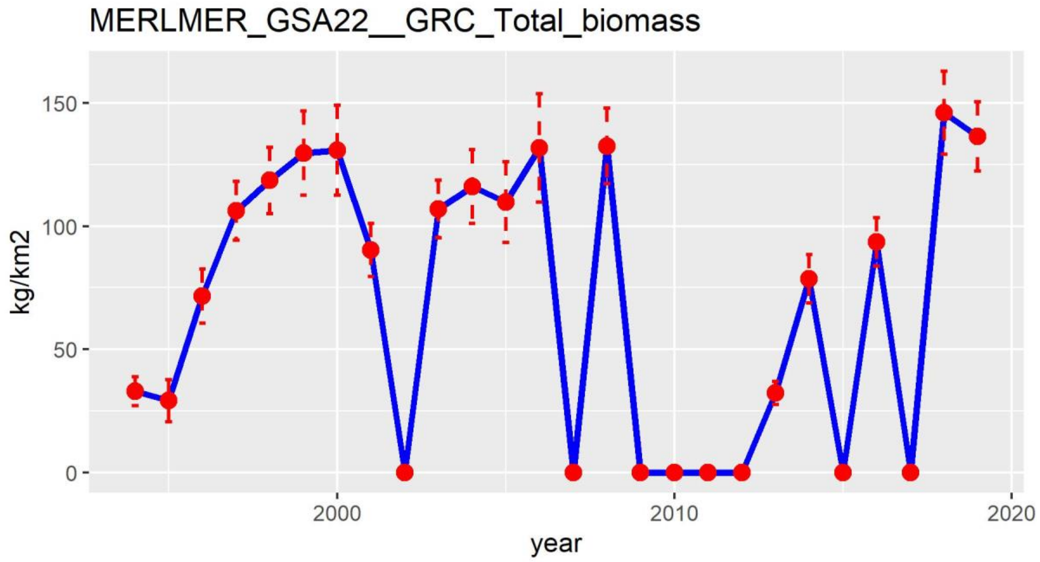


Figure 5.11.1 Hake_GSA22 Summary of the MEDITS survey by year.

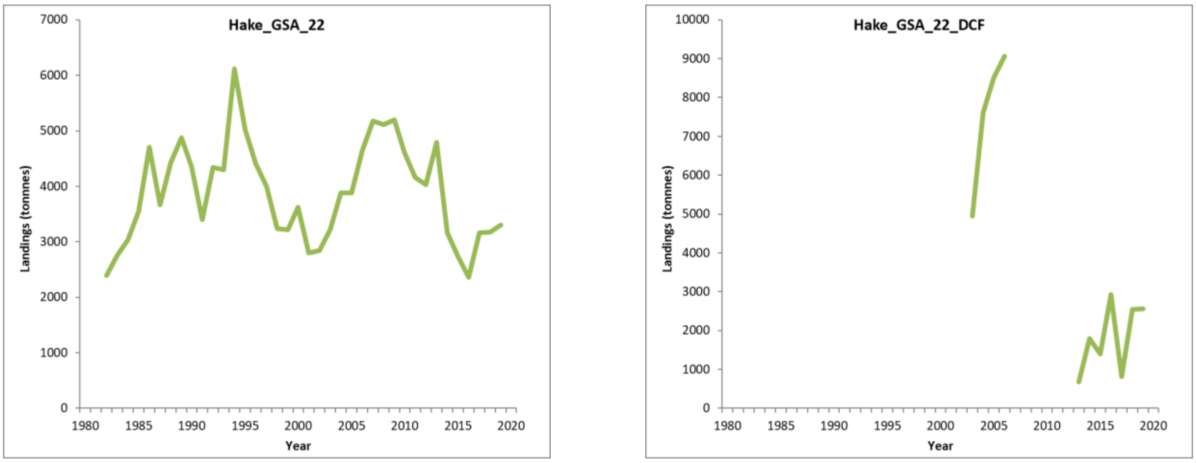


Figure 5.11.2 Hake_GSA22 Summary of the different sources (left: official landings and right: landings from DCF) of catch data by year.

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown.

Catch scenarios

Because catches are uncertain it is not possible to give specific catch scenarios.

Basis of the advice

Table 5.11.1 Hake_GSA22: The basis of the advice.

Advice basis	No Advice
Management plan	

Quality of the assessment

The landings as calculated from the DCF data (number of individuals multiplied by their somatic weight) do not correspond to the official landings reported. The DCF dataset contains too many missing points and is inconsistent in terms of landings as the landings reported for 2003-2006 are very high, probably owing to a raising factor error. In the last years of the time series, the DCF dataset seems to converge with the official one but still the two datasets do not agree.

The MEDITS bottom trawl survey was used for the estimation of abundance index of hake in GSA 20. The survey is carried out in June/July each year since 1994. No survey was carried out in 2002, 2007, 2009-2013, 2015 and 2017.

Issues relevant for the advice

There are no additional issues for advice.

Reference points

Table 5.11.2 Hake_GSA22: 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 5.11.3 Hake_GSA22: Basis of assessment and advice.

Assessment type	No assessment
Input data	
Discards and bycatch	

Indicators	
Other information	
Working group	EWG 20-15

History of the advice, catch, and management

Table 5.11.4 Hake_GSA22: 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
2021	No Advice				

History of the catch and landings

Table 5.11.5 Hake_GSA22: Catch distribution by fleet in 2019 as estimated by STECF.

Catch (2019)	Landings			Discards
	59 % trawl	32 % set nets	9% LLS	244 t (8.7% of catch)
	2555 t			

Table 5.11.6 Hake_GSA22: History of commercial official landings presented by area for each country participating in the fishery. All weights in tonnes.

HKE_20								
Year	Official landings	DCF_GNS	DCF_GTR	DCF_LLS	DCF_OTB	DCF_unspecified	Discards	Total
2003	3216	-	-	-	2444	-	224	
2004	3884	-	-	-	3572	-	610	
2005	3886	-	-	-	3857	-	636	
2006	4646	-	-	-	3835	-	655	
2007	5173	-	-	-	-	-	-	
2008	5111	-	-	-	3793	-	461	
2009	5197	-	-	-	-	-	-	
2010	4607	-	-	-	-	-	-	
2011	4158	-	-	-	-	-	-	
2012	4028	-	-	-	-	-	-	
2013	4792	148	6	-	522	-	24	
2014	3162	362	39	156	1232	-	86	
2015	2731	186	10	287	915	-	57	
2016	2364	708	80	610	1534	-	26	
2017	3159	241	36	54	490	-	30.5	
2018	3179	858	150	309	1220	-	106	
2019	3300	662	159	215	1519	-	244	

Summary of the assessment

Table 5.11.7 Hake_GSA22: Assessment summary (weights in tonnes).

Year	Biomass Index	Landings tonnes	Discards tonnes	Total Catch
2003	104.22	3216	224	
2004	99.90	3884	610	
2005	93.71	3886	636	
2006	114.11	4646	655	
2007	-	5173	-	
2008	108.40	5111	461	
2009	-	5197	-	
2010	-	4607	-	
2011	-	4158	-	
2012	-	4028	-	
2013	26.66	4792	24	
2014	65.85	3162	86	
2015	-	2731	57	
2016	83.65	2364	26	
2017	-	3159	30.5	
2018	135.85	3179	106	
2019	124.85	3300	244	

Sources and references

STECF EWG 20-15

5.12 SUMMARY SHEET FOR RED MULLET IN GSA 22

STECF advice on fishing opportunities

STECF EWG 20-09 advises that when MSY considerations are applied the fishing mortality in 2021 should be no more than 0.5 and corresponding catches in 2021 should be no more than 5546 tons.

Stock development over time

In the last decade, catches show a rather stable pattern, while SSB is increasing. In the most recent years, recruitment is at historically high levels. Since 2008, fishing mortality shows a decreasing trend.

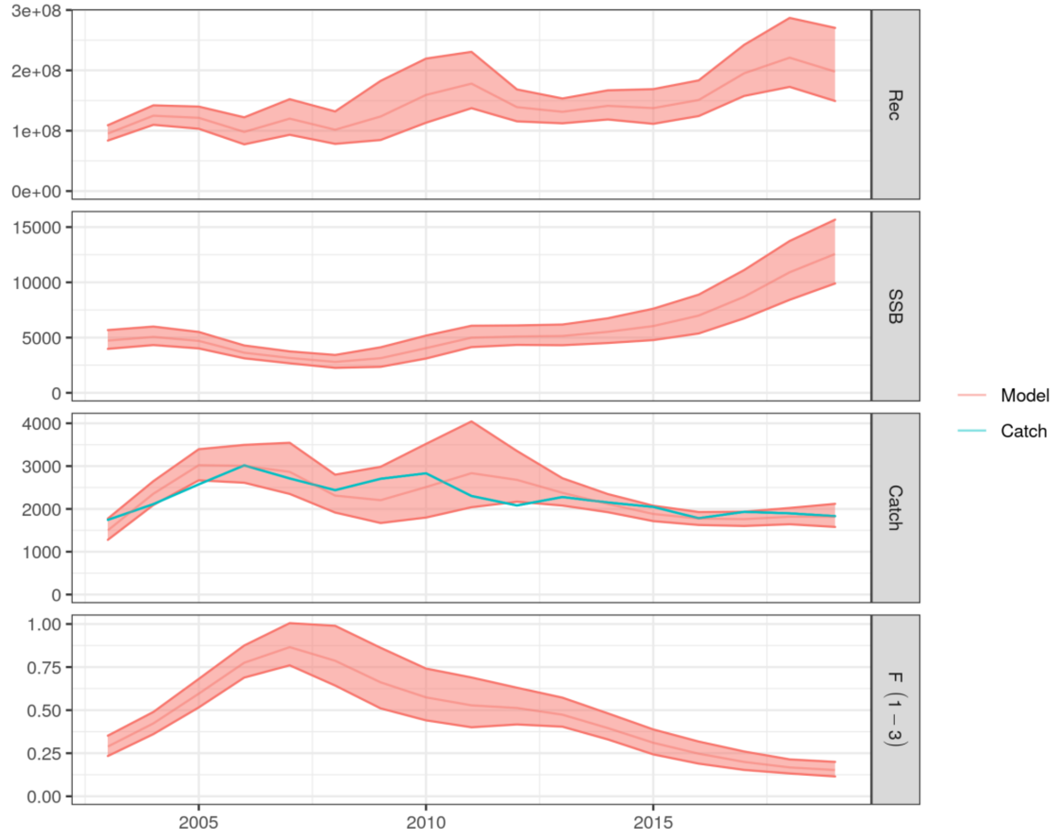


Figure 5.12.1 Red mullet in GSA 22: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. The blue line corresponds to the observed catches.

Stock and exploitation status

The current level of fishing mortality is below the reference point $F_{0.1}$, used as proxy of F_{MSY} (=0.5).

Table 5.12.1 Red mullet in GSA 22: State of the stock and fishery relative to reference points.

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

Catch scenarios

Table 5.12.2 Red mullet in GSA 22: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
$F_{ages\ 1\text{-}3}$ (2020)	0.15	F at 2019 used to give F status quo for 2020
SSB (2020)	12846	Stock assessment 1 January 2020
R_{age1} (2020,2021)	162706547	Geometric mean of years 2010-2019
Total catch (2021)	1934	Assuming F status quo

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

Table 5.12.3 Red mullet in GSA 22: Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2021)	Ftotal# (ages 1-3) (2021)	SSB (2022)	% SSB change***	% Catch change^
STECF advice basis					
F_{MSY}	5546	0.5	8700	-32.28	207.43
$F_{MSY\ Transition}$	3270	0.27	11163	-13.11	81.26
$F_{MSY\ lower}$	3971	0.33	10378	-13.11	120.13
$F_{MSY\ upper}$**	7016	0.68	7245	-43.6	288.97
Other scenarios					
Zero catch	0	0	15112	17.64	-100
Status quo	1934	0.15	12720	-0.98	7.22
Intermediate Options: Ffactor					
0.5	1001	0.07	13854	7.85	-44.5
0.8	1569	0.12	13160	2.44	-13.03
1.2	2289	0.18	12298	-4.27	26.92
1.6	2971	0.24	11504	-10.45	64.7
2	3616	0.3	10772	-16.14	100.44

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

*** % change in SSB 2022 to 2020

^Total catch in 2021 relative to Catch in 2019.

Basis of the advice

Table 5.12.4 Red mullet in GSA 22: The basis of the advice.

Advice basis	F_{MSY}
Management plan	

Quality of the assessment

This stock was previously assessed (STECF EWG 17-15) using a4a and SPiCT, but no advice was provided due to important model uncertainties mainly originating from data gaps. This is an updated a4a assessment with additional data and greatly improved stability over the previous assessment. The model diagnostics were considered acceptable. The retrospective analysis shows some instability, particularly regarding SSB and recruitment, but this is somehow expected, given the existing data gaps. Overall, the assessment is considered suitable to provide estimates of stock status.

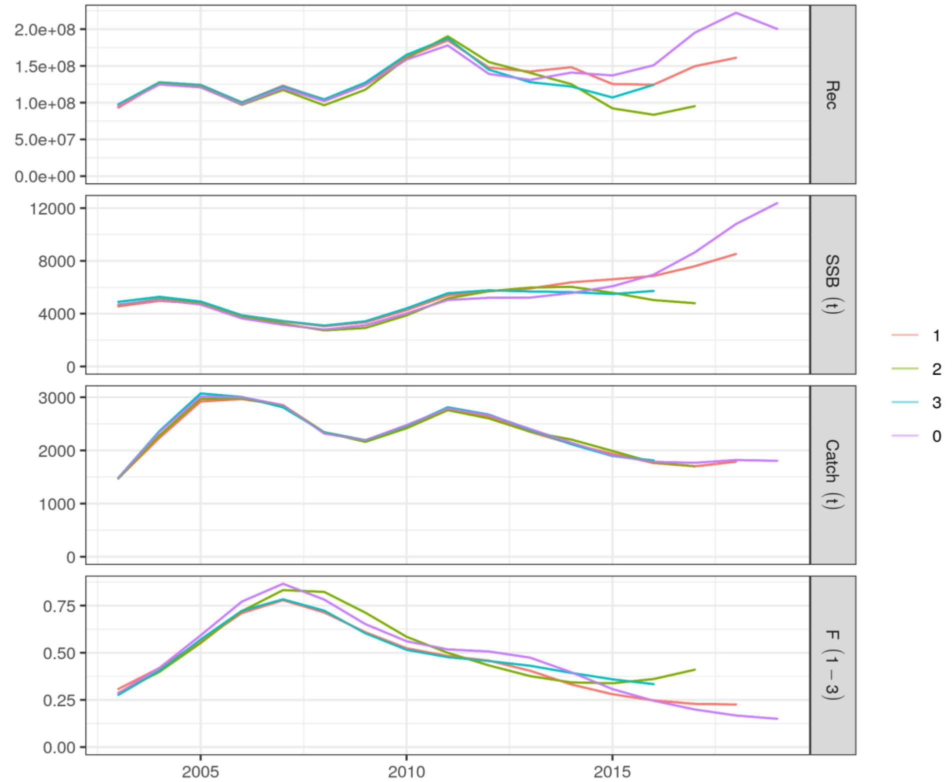


Figure 5.12.2 Red mullet in GSA 22: Historical assessment results (final-year recruitment estimates included). (Retrospective graph)

Issues relevant for the advice

As the species is primarily caught in highly mixed fisheries (bottom trawlers), any fishing effort increases should be faced with caution. Additionally, given the various spatio-temporal bottom trawl fishery closures existing in GSA 22, measures should be taken to avoid local stock depletion in case of local fishing effort increases.

Reference points

Table 5.12.5 Red mullet in GSA 22: Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$		Not Defined	
	F_{MSY}	0.5	$F_{0.1}$ as proxy for F_{MSY}	
Precautionary approach	B_{lim}		Not Defined	
	B_{pa}		Not Defined	
	F_{lim}		Not Defined	
	F_{pa}		Not Defined	

Basis of the assessment

Table 5.12.6 Red mullet in GSA 22: Basis of the assessment and advice.

Assessment type	Statistical catch at age
Input data	Commercial data (landings) from the records of the Hellenic Statistical Authority (ELSTAT), as well as from GFCM/FAO records for the Turkish fisheries. Additionally scientific survey (MEDITS) data were used.
Discards, BMS landings*, and bycatch	Discards not included
Indicators	
Other information	Several gaps exist in catch at size and survey data due to inconsistencies in DCF implementation.
Working group	STECF EWG 20-15

*BMS (Below Minimum Size) landings?

History of the advice, catch, and management

Table 5.12.7 Red mullet in GSA 22: STECF advice and STECF estimates of landings, discards reported to STECF. All weights are in tonnes.

Year	STECF advice	Predicted landings corresponding to advice	Predicted catch corresponding to advice	STECF catch	STECF discards
2021	F = F_{msy}	5546			

History of the catch and landings

Table 5.12.8 Red mullet in GSA 22: Catch and effort distribution by fleet in YEAR as estimated by and reported to STECF.

2019		Wanted catch				Discards
Catch (t)		Otter trawl 63%	Nets 37%			t
		891	523			11
Effort						

		Days at sea	

Table 5.12.9 Red mullet in GSA 22: History of commercial landings by country. All weights are in tonnes.

Year	Greece GSA22	Turkey GSA 22	Total landings
2003	1399	345	1744
2004	1656	456	2112
2005	1812	762	2574
2006	2260	757	3017
2007	2160	552	2712
2008	1928	510	2438
2009	1915	789	2704
2010	2108	724	2832
2011	1846	456	2302
2012	1583	498	2081
2013	1783	494	2277
2014	1799	351	2150
2015	1707	339	2046
2016	1361	421	1782
2017	1488	444	1932
2018	1480	417	1897
2019	1414	417	1831

Summary of the assessment

Table 5.12.10 Red mullet in GSA 22: Assessment summary. Weights are in tonnes.

Year	Recruitment age 1 thousands	SSB	Fbar	Catch
2003	95570	4697	0.28	1483

2004	124708	5053	0.42	2347
2005	120730	4690	0.59	3014
2006	97682	3640	0.77	3001
2007	119481	3155	0.87	2852
2008	101953	2800	0.78	2317
2009	123761	3121	0.65	2191
2010	158594	4022	0.56	2476
2011	177931	5037	0.52	2790
2012	139070	5206	0.51	2667
2013	130930	5221	0.47	2401
2014	140914	5566	0.4	2147
2015	136982	6079	0.31	1901
2016	150874	6960	0.25	1786
2017	195215	8648	0.2	1767
2018	222236	10794	0.17	1819
2019	200298	12379	0.15	1804

Sources and references

STECF EWG 20-15

5.13 SUMMARY SHEET FOR DEEP-WATER ROSE SHRIMP IN GSA 22

STECF advice on fishing opportunities

Currently it is not possible to provide an assessment or index advice for this stock because catch data are uncertain with different sources in conflict and survey information is sparse.

Stock development over time

Survey data is sparse, with several years with no data, the index below indicates the recent years are close to the long term mean for the survey. Data on catches are conflicting and historical catches are highly uncertain.

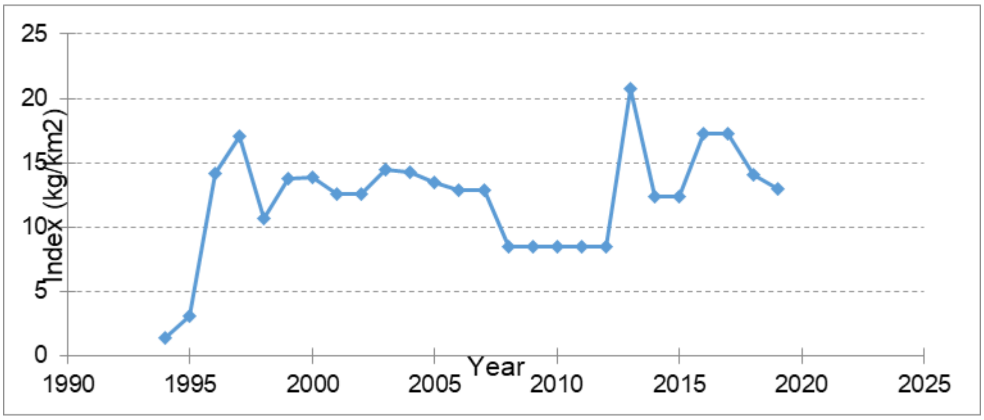


Figure 5.13.1 Evolution of the MEDITS survey index over time. Gaps are due to inconsistencies in DCF implementation

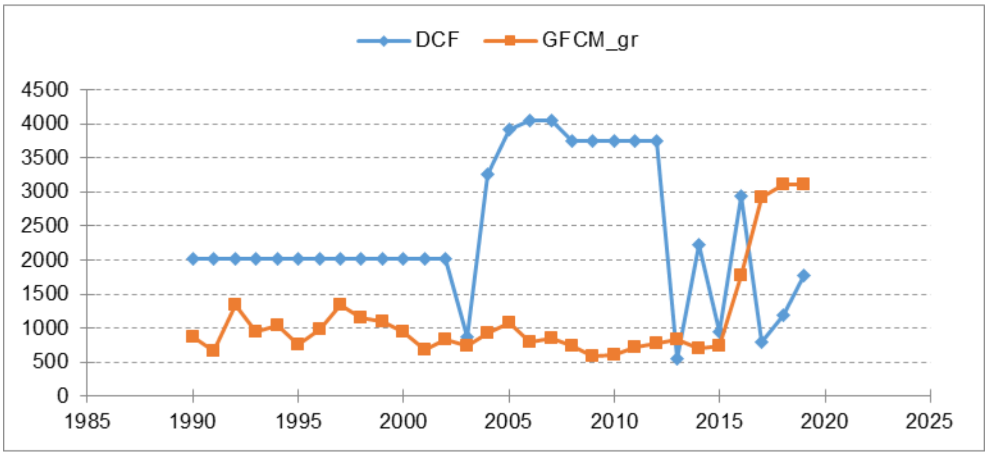


Figure 5.13.2 Landing estimates (t) from two different sources: DCF and GFCM (provided by the Hellenic Statistical Authority).

Stock and exploitation status

The stock status both in terms of SSB and exploitation rate (F) is unknown.

Catch scenarios

Because catches are uncertain it is not possible to give specific catch scenarios.

Basis of the advice

Table 5.13.1 Deep-water rose shrimp in GSA 22: The basis of the advice.

Advice basis	No Advice
Management plan	

Quality of the assessment

Inconsistencies in DCF implementation have resulted in data gaps, regarding catch volume and survey estimates. Other sources of information regarding catch, such as the estimates of the Hellenic Statistical Authority provided in GFCM, are highly incompatible with the existing DCF estimates. This is likely due to some miss sampling, species misreporting, with some unreliable DCF estimates in the early years of the data collection program.

Issues relevant for the advice

There are no additional issues for advice.

Reference points

Table 5.13.3 Deep-water rose shrimp in GSA 22: 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 5.13.4 Deep-water rose shrimp in GSA 22: Basis of assessment and advice.

Assessment type	No assessment
Input data	
Discards and bycatch	
Indicators	
Other information	
Working group	EWG 20-15

History of the advice, catch, and management

Table 5.13.5 Deep-water rose shrimp in GSA 22: STECF advice and official landings.

Year	STECF advice	Predicted landings corresp. to advice	Predicted catch corresp. to advice	STECF catch	STECF discards
2021	No Advice				

History of the catch and landings

Table 5.13.6 Deep-water rose shrimp in GSA 22: Catch distribution by fleet in 2019 as reported to STECF.

Catch (2019)	Landings			Discards
1782	100 % trawl	% set nets	% others	77
	T			

Table 5.13.7 Deep-water rose shrimp in GSA 22: Historical landings and discards by national fisheries All weights in tonnes.

Year	Landings - Greece (DCF)	Landings - Greece (GFCM)	Discards - Greece (DCF)	Landings- Turkey (GFCM)
1990		872.5		0.0
1991		665.4		0.0
1992		1336.2		0.0
1993		953.8		0.0
1994		1032.0		0.0
1995		764.9		0.0
1996		983.8		0.0
1997		1333.8		0.0
1998		1147.2		0.0
1999		1097.2		0.0
2000		944.8		0.0
2001		688.9		0.0
2002		831.6		0.0
2003	866.7	730.8	53.4	0.0
2004	3258.1	927.9	665	0.0
2005	3925.9	1074.5	163.6	0.0
2006	4052.6	786.9	350	0.0
2007		843.9		358.0
2008	3745.5	736.3	763	583.0
2009		580.0		468.0
2010		598.4		531.0
2011		720.3		640.4
2012		772.9		676.5
2013	544.2	836.0	67.3	344.7
2014	2221.0	696.5	143.3	465.5
2015	947.5	746.4	61.4	411.3
2016	2946.0	1778.6	0.07	424.0
2017	793.0	2930.0	11.6	810.0
2018	1181.0	3105.0	137	1234.0
2019	1782		77.7	

Summary of the assessment

Table 5.13.8 Deep-water rose shrimp in GSA 22: Assessment summary (weights in tonnes).

Year	Biomass index	Landings	Discards	Total catch
1990		872.5		
1991		665.4		
1992		1336.2		
1993		953.8		
1994	1.43	1032.0		
1995	3.05	764.9		
1996	14.18	983.8		
1997	17.08	1333.8		
1998	10.72	1147.2		
1999	13.75	1097.2		
2000	13.87	944.8		
2001	12.58	688.9		
2002		831.6		
2003	14.45	730.8		
2004	14.28	927.9		
2005	13.49	1074.5		
2006	12.83	786.9		
2007		843.9		
2008	8.45	736.3		
2009		580.0		
2010		598.4		
2011		720.3		
2012		772.9		
2013	20.76	836.0		
2014	12.38	696.5		
2015		746.4		
2016	17.25	1778.6		
2017		2930.0		
2018	14.09	3105.0		
2019	12.92	1782		

Sources and references

STECF EWG 20-15

6 ASSESSMENTS BY STOCK

ToR 1. Data preparation for the stock assessments:

5. *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.*

6. *To compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2019. This should be presented by fishing gear as well as by size/age structure.*

7. *To compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2019. 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 and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort and/or capacity baseline.*

8. *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 2019 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.*

The EWG shall:

5. *Give preference to models that allow estimation of uncertainty, in line with the recommendations of STECF EWG 17-07.*

6. *Attempt where age length keys (ALK) are considered viable, to convert numbers at length into numbers at age based on the ALKs.*

7. *Where possible, use fisheries and survey data, recovered and standardized in the context of the EU RECFISH project, to expand the time series in the stock assessments.*

8. *For stocks previously assessed, take into account discussion on methods and assumptions made in previous expert groups, including the GFCM WG on Stock Assessment for Demersal Species in 2019*

ToR 3. *To estimate candidate MSY point-value, MSY range values 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 4. *To provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, inter alia: zero catch, the status quo fishing mortality, and target to F_{MSY} or other appropriate* ***proxy by 2021 and 2026 for the Adriatic stocks marked with (^)****.*

ToR 5. *To summarize and concisely describe all data quality deficiencies in particular for areas that have not been recently assessed (GSA 19-20-22), including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched on the May 2020.*

ToR 6. *To ensure that all unresolved data transmission issues encountered prior to and during the EWG meeting are reported on line via the Data Transmission Monitoring Tool (DTMT) available at https://datacollection.jrc.ec.europa.eu/web/dcf/dtmt. Guidance on precisely what should be inserted in the DTMT, log-on credentials and access rights will be provided separately by the STECF Secretariat focal point for the EWG.*

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.

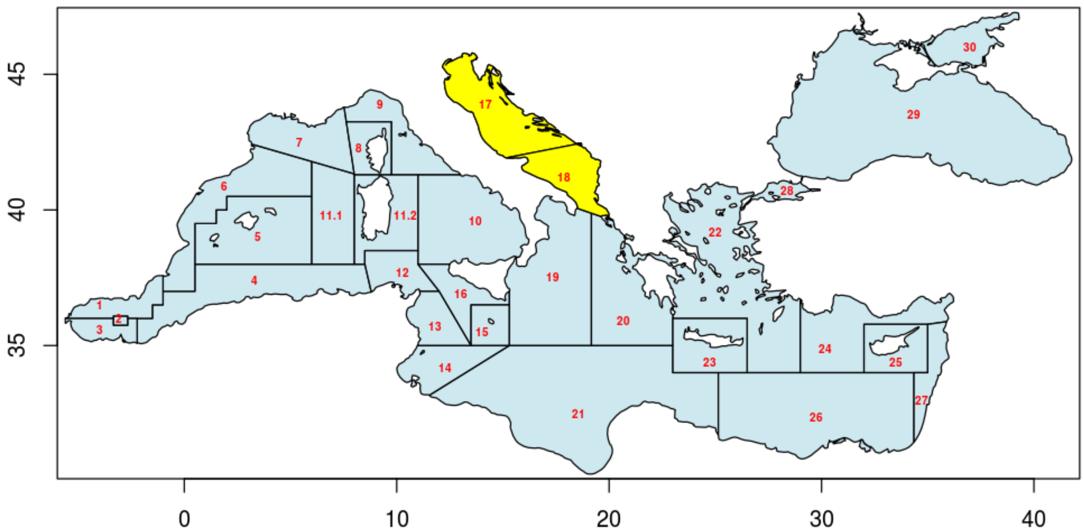


Figure 6.1.1.1 European hake in GSAs 17 and 18. Geographical location of GSAs 17-18

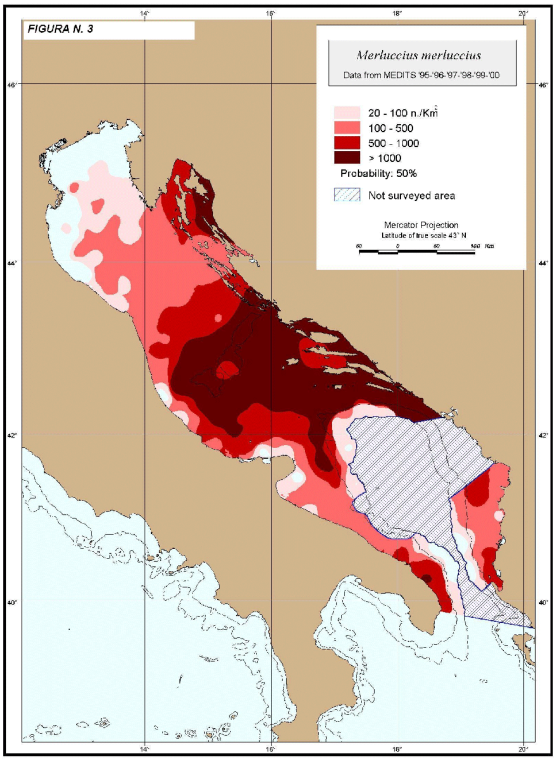


Figure 6.1.1.2 European hake in GSAs 17 and 18. Distribution map in the Adriatic Sea from MEDITS Programme (Sabatella and Piccinetti, 2005)

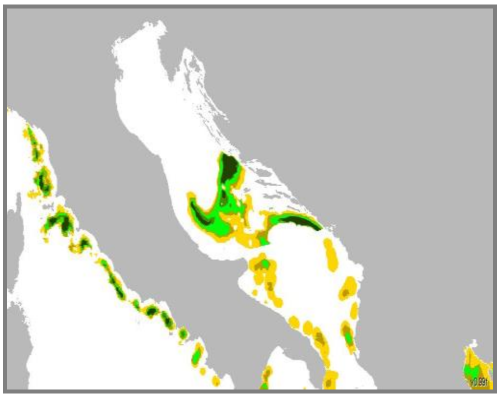


Figure 6.1.1.3 European hake in GSAs 17 and 18. Position of persistent nursery in GSAs 17 and 18 from MEDISEH project.

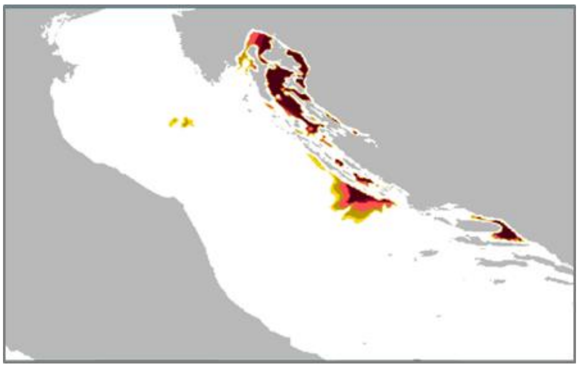


Figure 6.1.1.4 European hake in GSAs 17 and 18. Position of persistent spawning area in GSAs 17 and 18 from MEDISEH project.

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

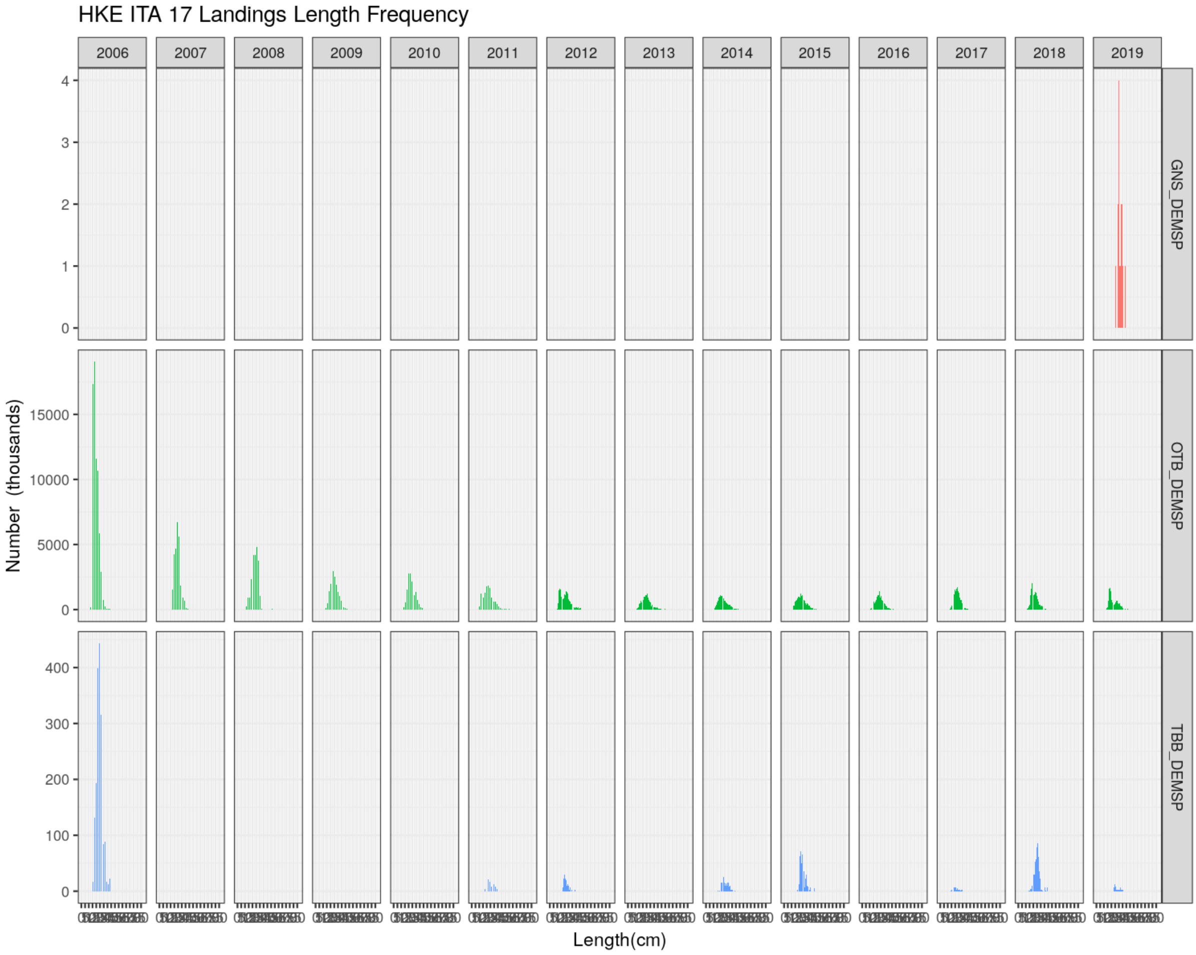
6.1.2 DATA

6.1.2.1 CATCH (LANDINGS AND DISCARDS)

The following table (Tables 6.1.2.1.1, 6.1.2.1.2, 6.1.2.1.3, 6.1.2.1.4) and the following plots (Figures 6.1.2.1.1, 6.1.2.1.2, 6.1.2.1.3, 6.1.2.1.4) 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).

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.* Values have been revised by the EWG as they were provided by MS in duplicate doubling the actual values.

	Landings		Discards	
Year	OTB	TBB	OTB	TBB
2006	3980	237		
2007	3435			
2008	3037			
2009	2549			
2010	1863			
2011	1460	12	9	
2012	1777	15	6	
2013	2192	30	3	
2014	1789	62	11	
2015	2011		13	
2016	1731		61	
2017	1836	6	116	
2018	1853	71	346	
2019	1552*	82*	155	


HKE ITA 17 Landings Length Frequency
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
GNS_DEMSP
OTB_DEMSP
TBB_DEMSP
Number (thousands)
Length(cm)

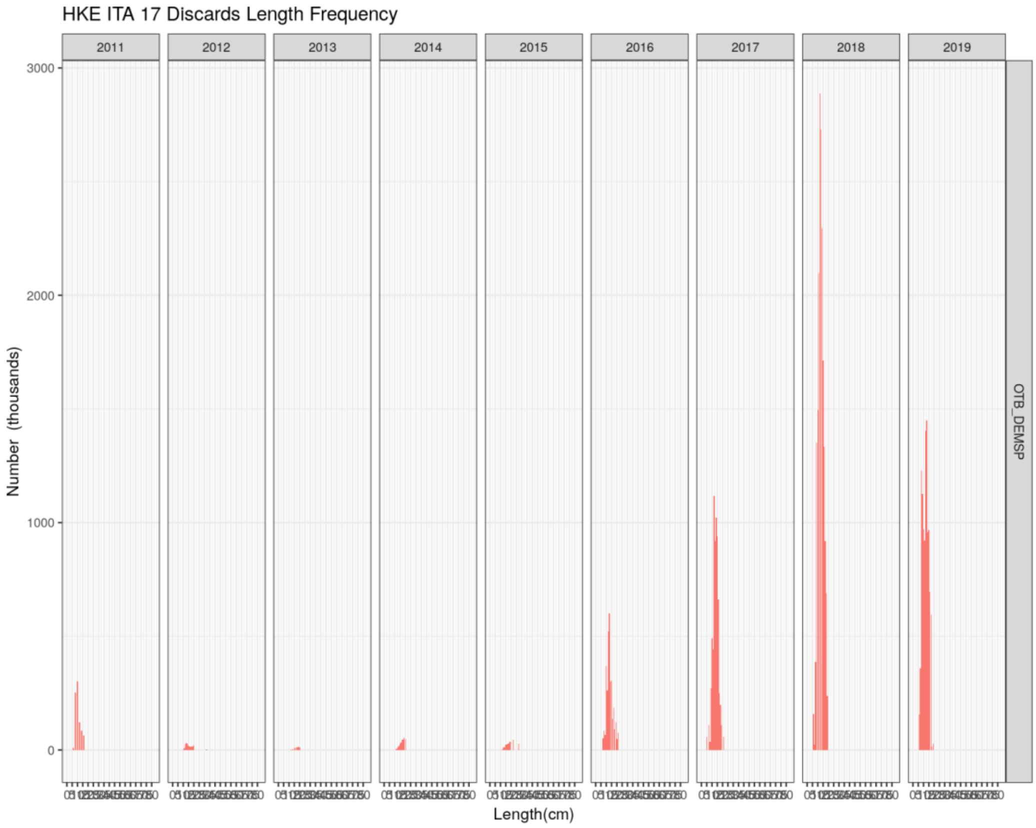


Figure 6.1.2.1.1 European hake in GSAs 17 and 18. Catch (landings and discards) data included in the DCF database for Italy in GSA 17.

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	**GNS**	**GTR**	**LLS**	**OTB**	**GNS**	**GTR**	**LLS**	**OTB**
2002	26			2006				
2003	199			2899				
2004	19	21	233	2932				
2005	38	18	452	3275				
2006	30	26	836	4613				
2007	19	18	620	3497				
2008	15	42	551	3640				
2009	8	20	534	3545				152
2010		19	601	3400				78
2011		18	519	3312				100
2012		20	566	2520			0.32	177
2013			188	2379				15
2014		0	279	1584			0.95	46
2015			427	1614				86
2016	5		492	1672				107
2017	31	3	514	1682				31
2018	15^	0.2	331	1650^				56
2019	5	0.5	232	1481				102

^Corrected from last year.

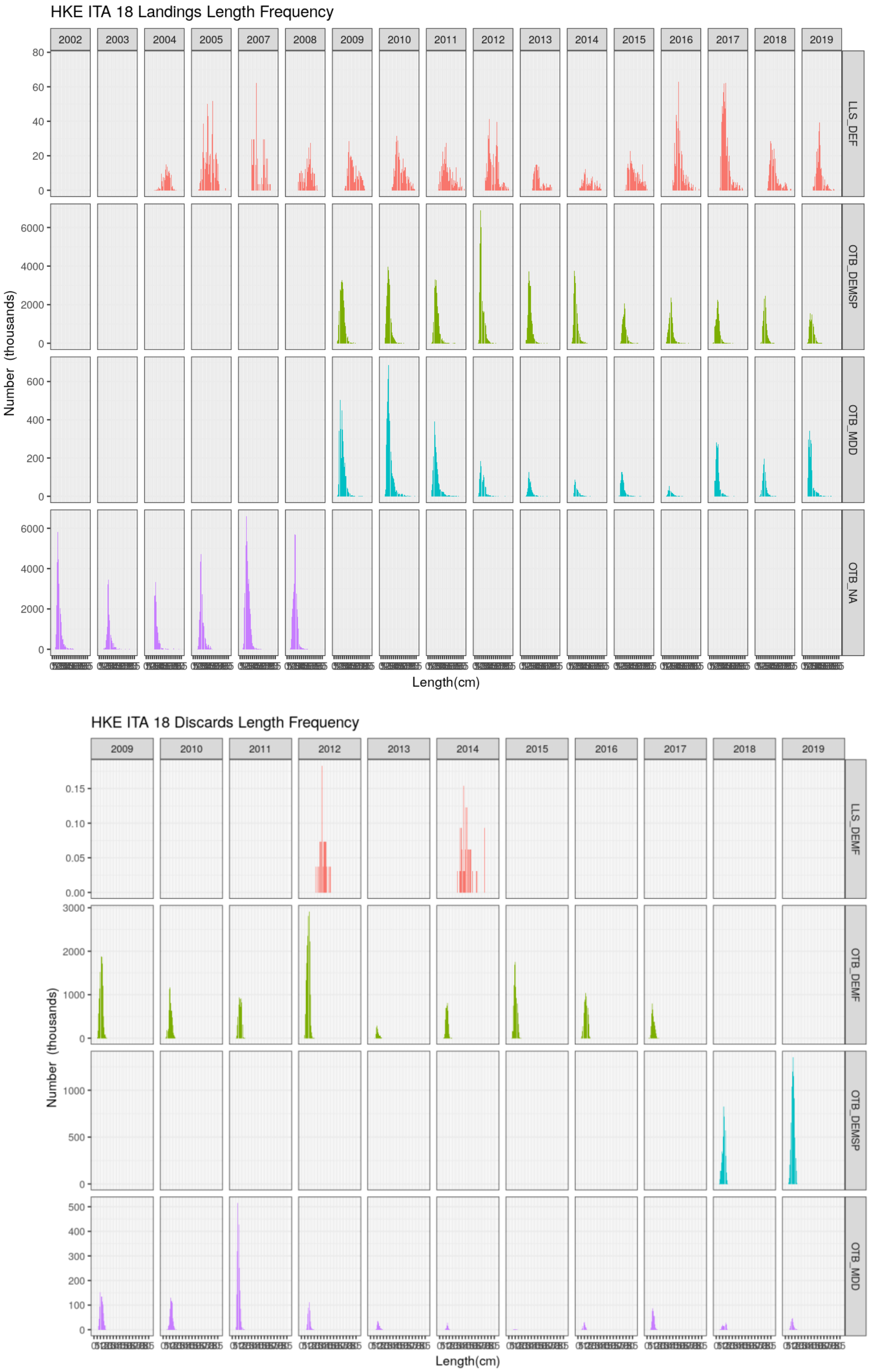
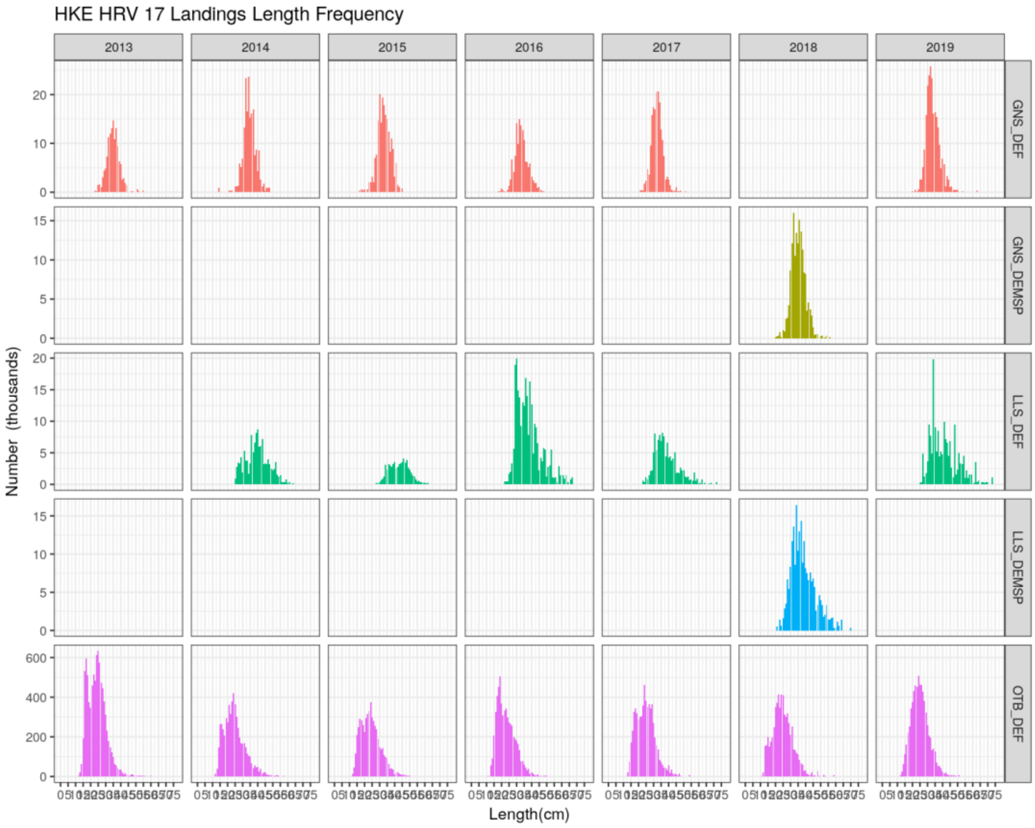


Figure 6.1.2.1.2 European hake in GSAs 17 and 18. Catch (landings and discards) data included in the DCF database for Italy in GSA 18.

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**	**OTB**	**LLS**	**GNS**	**OTB**	**LLS**
2005	SVN	0.13	2				
2006	SVN	1.04	2				
2007	SVN	1.40	5				
2008	SVN	0.28	1				
2009	SVN	0.38	1				
2010	SVN	0.01	0				
2011	SVN	0.14	0				
2012	SVN	0.16	0				
2013	SVN	0.18	1				
2014	SVN	0.22	1				
2015	SVN	0.65	1				
2016	SVN	0.12	0				
2017	SVN	0.10	0			0.002	
2018	SVN	0.42	2			0.01	
2019	SVN	1.41	3.6			0.02	
2013	HRV	43	1013			2.2	
2014	HRV	58	774	61		2.3	
2015	HRV	54	654^	41		1.4	
2016	HRV	39	585	124		1.1	
2017	HRV	47	783	90		2.9	
2018	HRV	55	815	116	2.5^	3.5	0.3^
2019	HRV	68	943	113	2.8*	3.1	0.2*

^Corrected from last year, * estimated values



HKE HRV 17 Landings Length Frequency
2013
2014
2015
2016
2017
2018
2019
GNS_DEF
GNS_DEMSP
LLS_DEF
LLS_DEMSP
OTB_DEF
Number (thousands)
Length(cm)

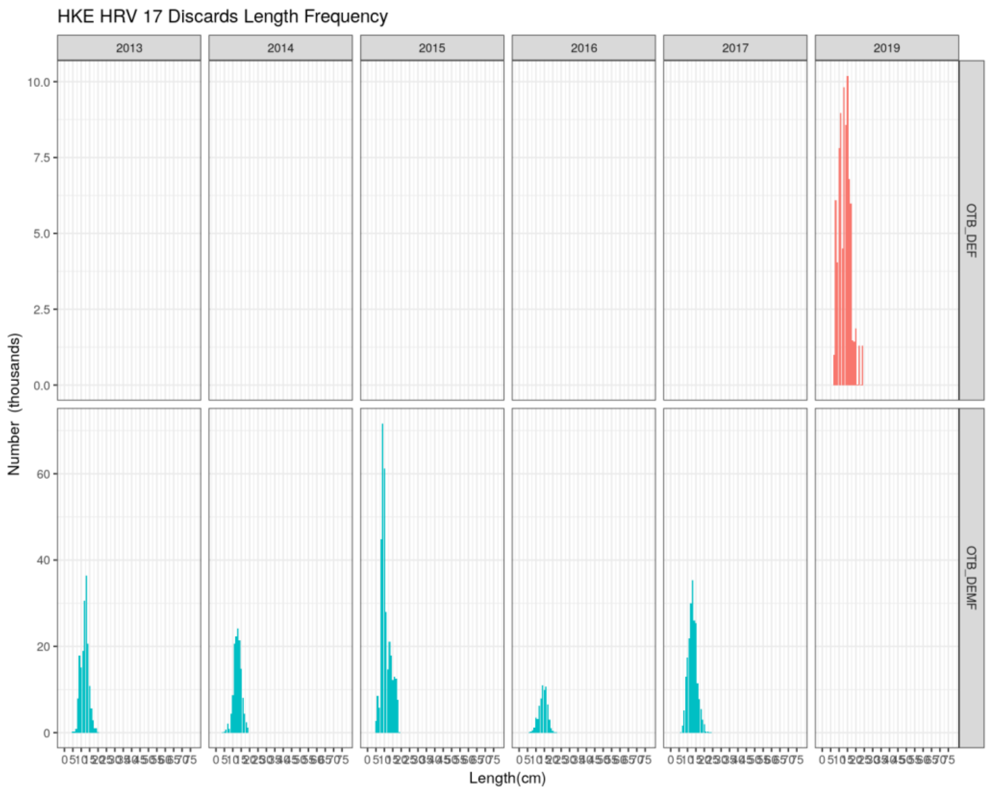


Figure 6.1.2.1.3 European hake in GSAs 17 and 18. Catch data included in the DCF database Croatia and Slovenia in GSA 17.

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	42**	731	5360

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

** Mean of the catches form 2016-2018

LFDs of TBB of Italy in GSA 17 are missing for 2007-2010, 2013 and 2016. LFDs from discards for Italy in GSA 17 are present only for OTB. LFDs of LLS of Italy in GSA 18 are missing for 2002-2003 and 2006. LFDs of OTB of Italy in GSA 18 are missing for 2006. LFDs from discards for Italy in GSA 18 are available only for 2009, for LLS LFDs are missing for 2009-2011, 2013 and 2015-2018. LFDs of LLS of Croatia in GSA 17 are missing for 2013. LFDs from discard for Croatia in GSA 17 are present only for OTB. No LFDs for landings are available for Slovenia in GSA 17.

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. More information are available in section 2.3. In tables 6.1.2.2.1-5 are reported the fishing days by country, year, gear and vessel length.

Table 6.1.2.2.1.1 Effort in term as fishing days for Croatia (HRV) in GSA17 for long lines (LLS) and otter trawl (OTB) by vessel length (VL).

Sum of fishing_days – HRV LLS						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2012	2084.9	7040.5	104.0			9229.4
2013	2448.5	7216.2	48.8			9713.5
2014	2143.1	7079.5	47.1	7.0		9276.7
2015	2016.5	6931.4	53.0	9.2		9010.1
2016	1638.1	6599.9	25.3		1.0	8264.2
2017	1715.8	7102.9	4.1			8822.8
2018	2078.8	7546.4	15.6	1.0		9641.8
2019	2996.0	7108.0	64.0			10168.0
Sum of fishing days – HRV OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2012	24.4	10846.1	17167.3	4694.4	2839.7	35571.9
2013	30.8	10301.6	16849.1	5323.2	2987.1	35491.7
2014	8.2	11251.4	16821.7	5278.3	2927.5	36287.2
2015	0.6	10852.7	16540.3	4331.9	3017.0	34742.5
2016	1.0	10324.7	16256.8	4880.6	2252.0	33715.1
2017	15.2	11825.7	17165.3	4583.6	2059.0	35648.7
2018	6.6	9972.6	17239.3	4182.8	1736.0	33137.3
2019		9076.0	15578.0	4612.0	1731.0	30997.0

Table 6.1.2.2.1.2 Effort in term as fishing days for Italy (ITA) in GSA17 for long lines (LLS) and otter trawl (OTB) by vessel length (VL).

Sum of fishing days - ITA17 LLS						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2004						0.0
2005						0.0
2006		20.8				20.8
2007		41.1				41.1
2008						0.0
2009						0.0
2010						0.0
2011						0.0
2012						0.0
2013						0.0
2014						0.0
2015						0.0
2016		439.0				439.0

2017		361.4				361.4
2018		877.2	8.0	149.3		1034.5
2019		544.8	277.5			822.2

Sum of fishing days - ITA17 OTB						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2004		35664.6	52605.0	34338.4	10421.9	133029.9
2005		10053.4	62455.2	36577.6	12588.1	121674.2
2006	60.7	8066.6	56603.7	29436.6	9887.9	104055.5
2007		6723.6	47687.7	30438.4	8945.2	93794.9
2008		5525.3	44719.5	27976.6	8479.7	86701.1
2009		7634.5	47220.3	28570.9	7618.1	91043.8
2010		5952.1	41995.4	27106.1	7908.8	82962.5
2011		5999.4	40791.7	26424.5	6971.3	80186.8
2012		6047.8	34301.4	25466.2	4787.6	70603.1
2013	760.0	5818.7	33283.2	22577.5	4082.1	66521.5
2014		6219.8	33051.8	21193.8	6027.1	66492.4
2015		2270.7	29581.9	25021.9	4422.4	61296.9
2016		2758.2	29701.1	24561.2	4844.4	61864.8
2017		6338.8	30074.3	30349.9	5615.6	72378.5
2018		4950.8	34676.9	30787.7	5524.5	75940.0
2019		3281.5	31403.4	24641.5	6585.0	65911.3

Table 6.1.2.2.1.3 Effort in term as fishing days for Italy (ITA) in GSA18 for long lines (LLS) and otter trawl (OTB) by vessel length (VL).

Sum of fishing_days ITA18 LLS						
YEAR	**VL0006**	**VL0612**	**VL1218**	**VL1824**	**VL2440**	**Grand Total**
2004		5138.1	2717.2			7855.3
2005		15327.6	3198.3			18525.9
2006	6924.0	9769.3	3532.1			20225.5
2007	6841.3	6891.9	3792.3			17525.6
2008	5320.2	4016.7	3206.0			12542.9
2009	6532.2	5278.4	2968.8			14779.4
2010	6112.0	4968.7	3707.2			14788.0
2011	6230.8	5055.2	3727.1			15013.0
2012	9028.7	6872.8	2570.9			18472.4
2013		542.0	1645.3			2187.3
2014			3066.6			3066.6
2015			3844.9			3844.9
2016			4168.3			4168.3
2017		36.0	3093.6			3129.6
2018		91.0	3008.5	41.3	7.0	3147.8
2019		1825.4	2299.0	50.4		4174.8

Sum of fishing_days ITA18 OTB

YEAR	VL0006	VL0612	VL1218	VL1824	VL2440	Grand Total
2004		9007.5	51197.0	20023.7	6697.0	86925.2
2005		4802.5	47330.0	16897.2	8178.8	77208.6
2006		5549.7	52173.8	22180.6	4258.6	84162.7
2007		3469.5	43554.9	19836.4	3819.0	70679.8
2008		4743.0	45641.5	14281.7	4972.4	69638.6
2009		5760.4	59695.4	14983.8	5410.5	85850.1
2010		5197.2	48371.5	15104.7	4347.2	73020.6
2011		3818.4	47116.4	13130.4	3588.7	67653.9
2012		4583.0	44403.2	11501.3	2156.3	62643.8
2013		5513.5	49028.0	12511.2	2239.2	69291.9
2014		4059.5	33735.6	10181.7	1708.0	49684.8
2015		4014.8	35441.6	10340.8	2204.5	52001.7
2016		3650.3	37510.4	10889.0	1977.9	54027.6
2017		4239.2	36248.4	10622.7	2108.0	53218.2
2018		3487.3	42091.6	12862.1	1993.2	60434.2
2019		1828.5	35762.1	10735.0	1843.7	50169.2

6.1.2.3 SURVEY DATA

MEDITS survey data are available from the official 2020 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 2019 were used. Data were analysed using the JRC script (Mannini, 2020).

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 survey were combined and used together, since there were no specific reasons supporting the use of three separated surveys.

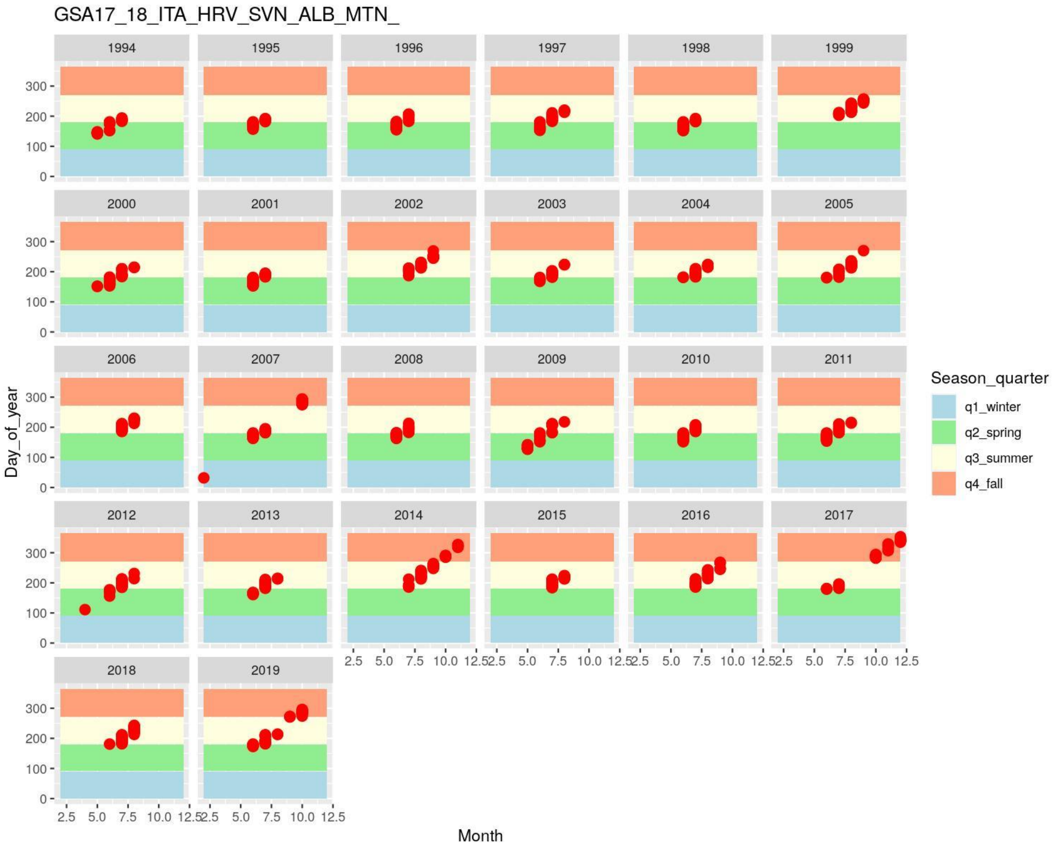


Figure 6.1.2.3.1 European hake in GSAs 17 and 18. MEDITS survey period over 1994-2019.

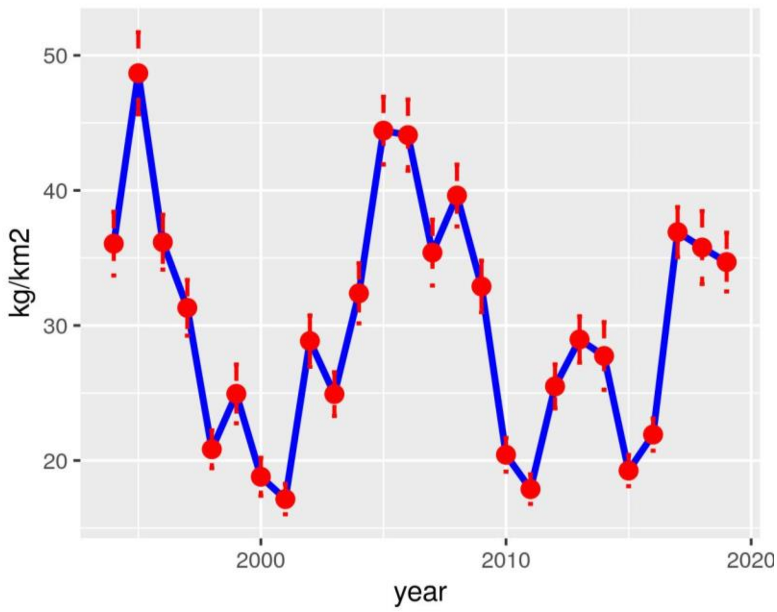


Figure 6.1.2.3.2 European hake in GSAs 17 and 18. MEDITS biomass (kg/km^2) over 1994-2019.

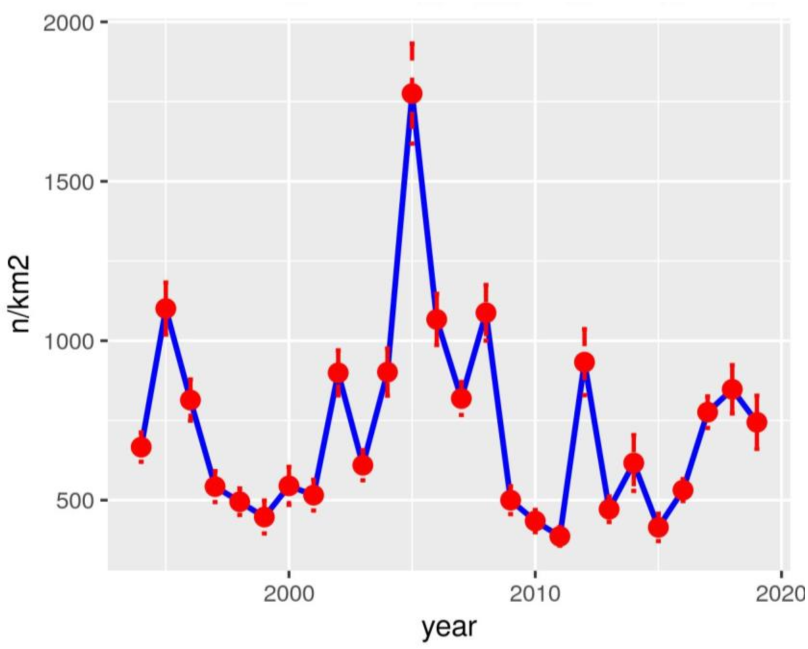


Figure 6.1.2.3.3 European hake in GSAs 17 and 18. MEDITS abundance (n/km²) over 1994-2019.

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

Two stock assessment models, SS3 and a4a, were fitted and compared. The two models gave similar results. 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 2019 missing; 2019 catches assumed to be equal to the mean catches of 2016-2018)

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 2019. The model input data were updated with data from 2019. LFDs from Montenegro were missing for 2019 so are not included in the model. Catches of Montenegro in 2019 were not available and were assumed to be the same as 2018. The catch approximation used and missing LFD have a negligible influence on the assessment.

Two small corrections were made to the 2018 data compared to the ones used in the update assessment performed during STCF EWG 19-16. Italian TBB catches (around 70 tons) and LFDs were removed from the Italian bottom trawl GSA 17 (including also Slovenian data) fleet (in conformity to the GFCM benchmark approach). Less than 10 tons were added to the catches of the Italian bottom trawl GSA 18 fleet.

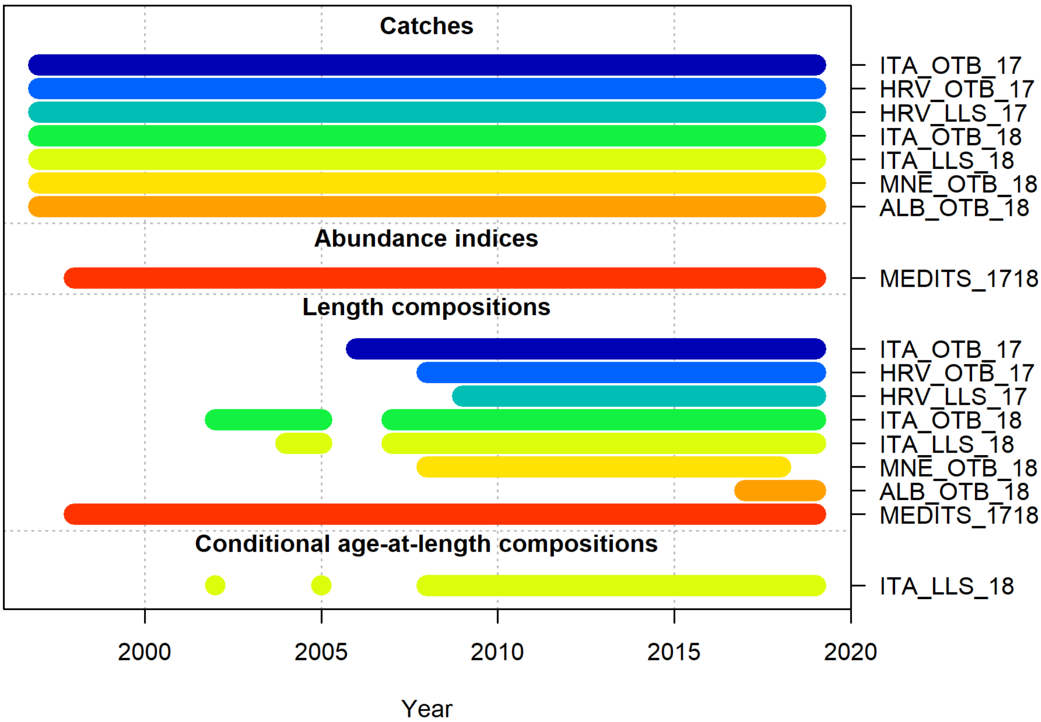
SS3 allows different selectivity by gear (Fig. 6.1.3.1.3.) Specification of selectivity model has been left unchanged compared to the benchmark.

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.

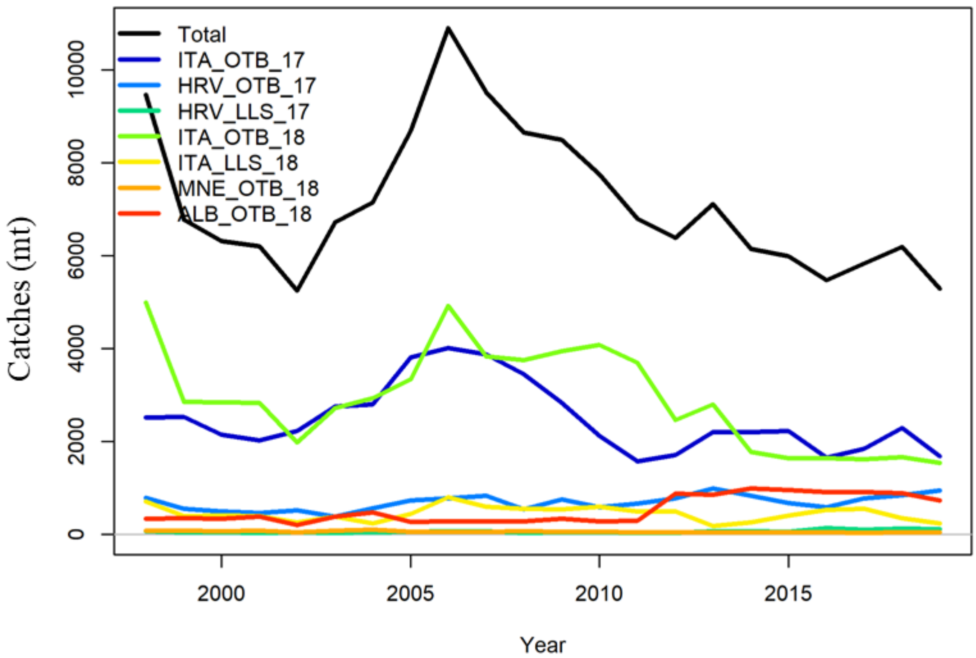


Figure 6.1.3.1.2 European hake in GSAs 17 and 18: Catch data by country, gear and year.

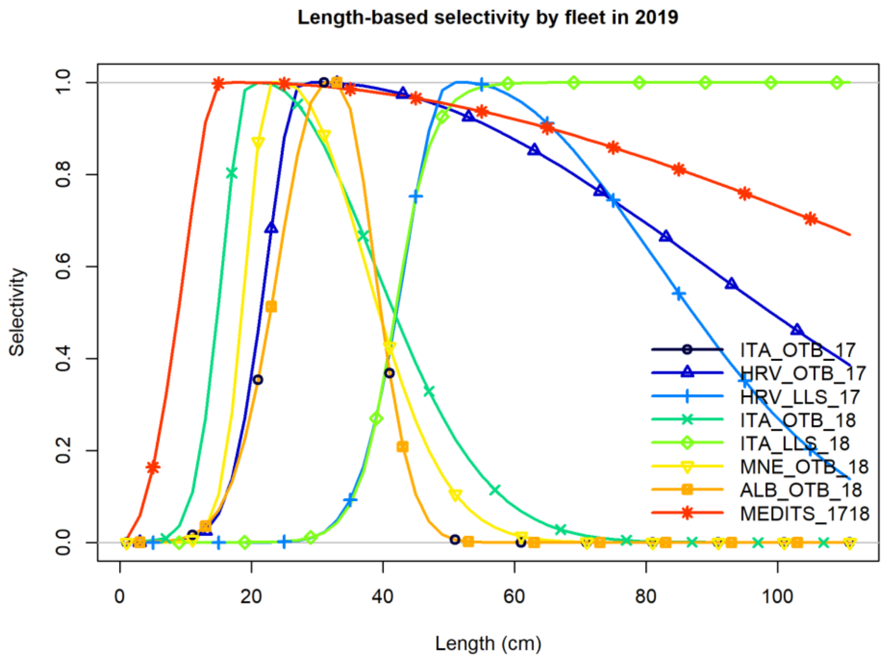


Figure 6.1.3.1.3 European hake in GSAs 17 and 18: Selectivity by fleet in 2019.

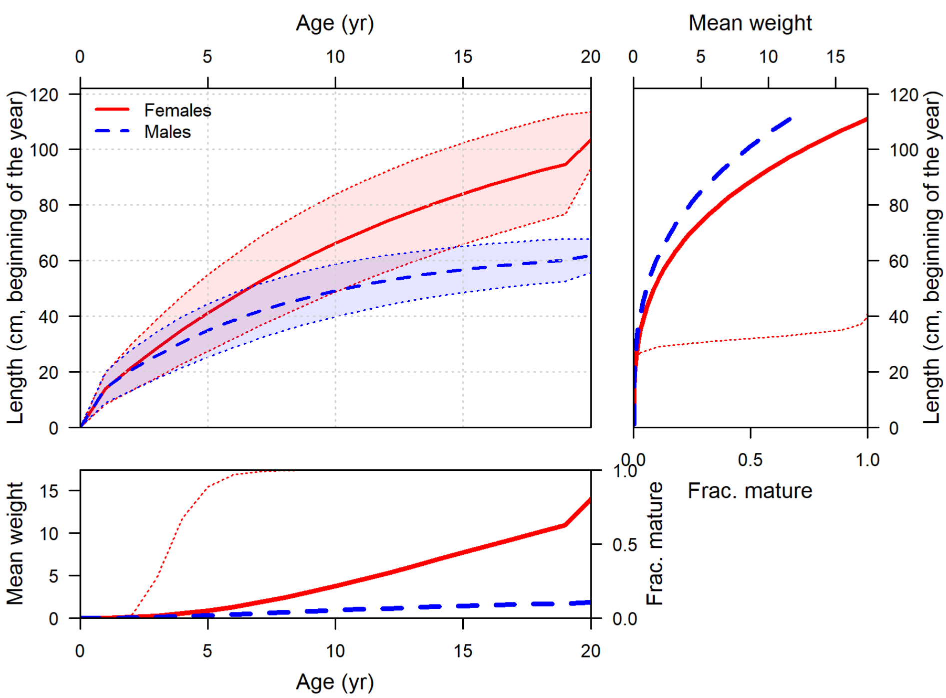


Figure 6.1.3.1.4 European hake in GSAs 17 and 18: Length at age (top-left panel) with weight (thick line) and maturity (thin line) shown in top-right and lower-left panels.

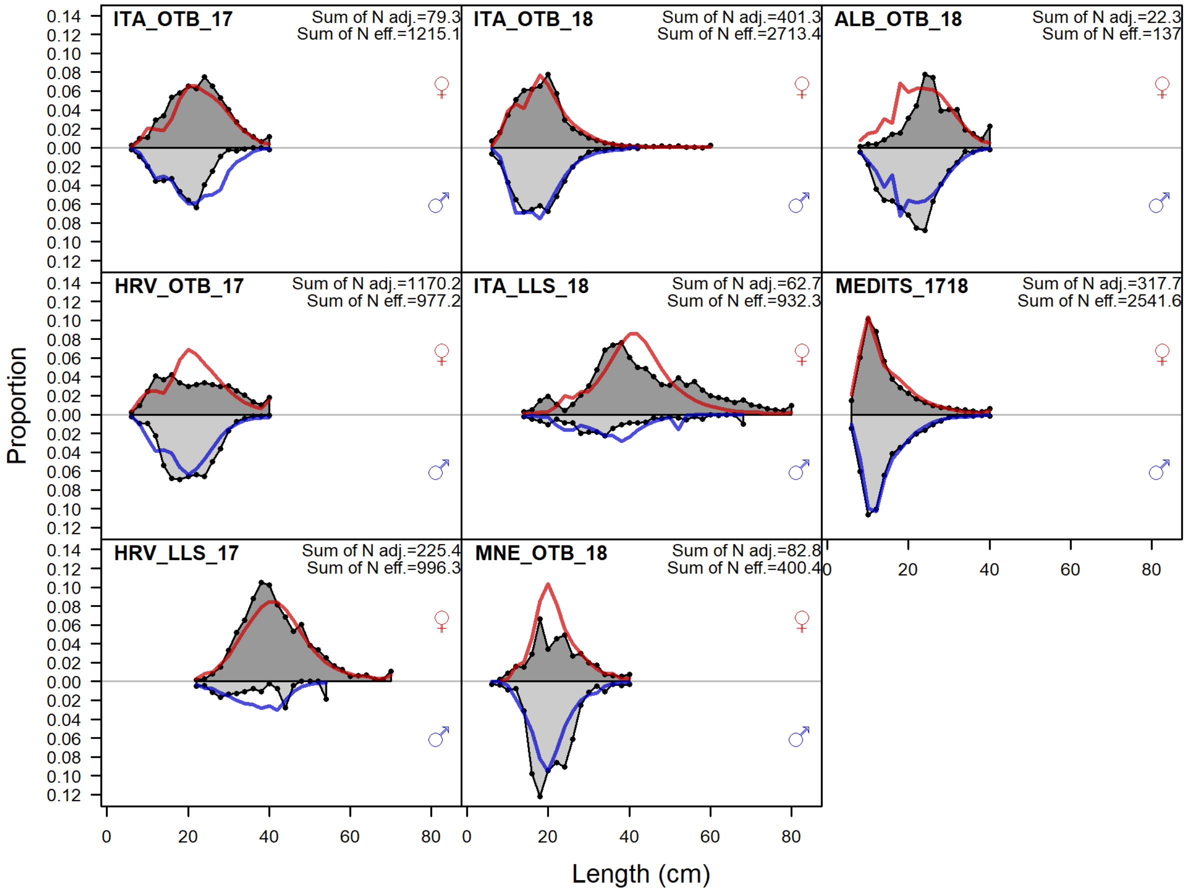


Figure 6.1.3.1.5 European hake in GSAs 17 and 18: Summary of the observed length frequency distribution (grey area) by fleet and the fitting of the model (blue line for the male individuals and red line for the female individuals).

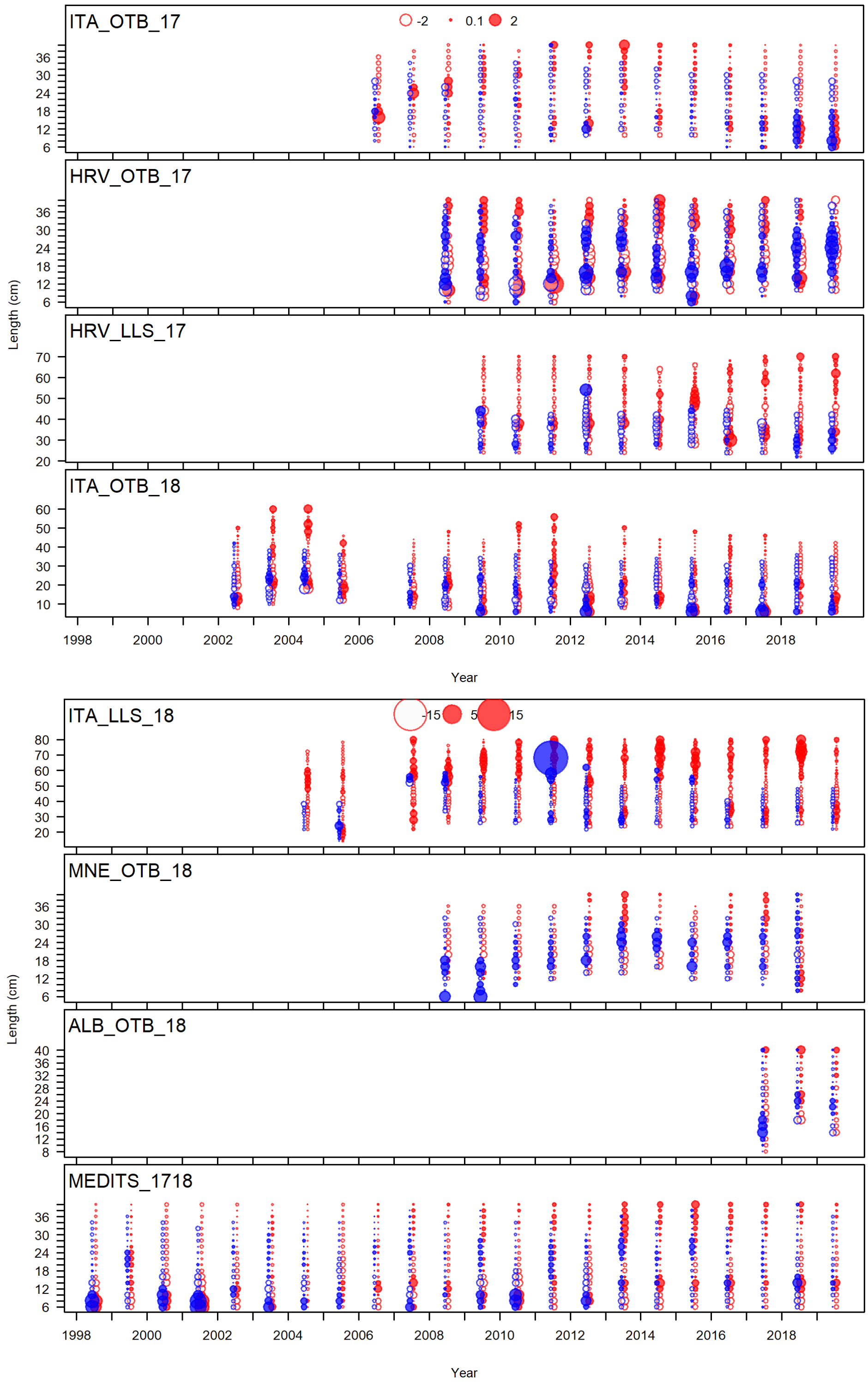


Figure 6.1.3.1.6 European hake in GSAs 17 and 18: Summary of the Pearson residuals for the LFDs by fleet and year. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected). Blue bubbles are used for males, red for females.

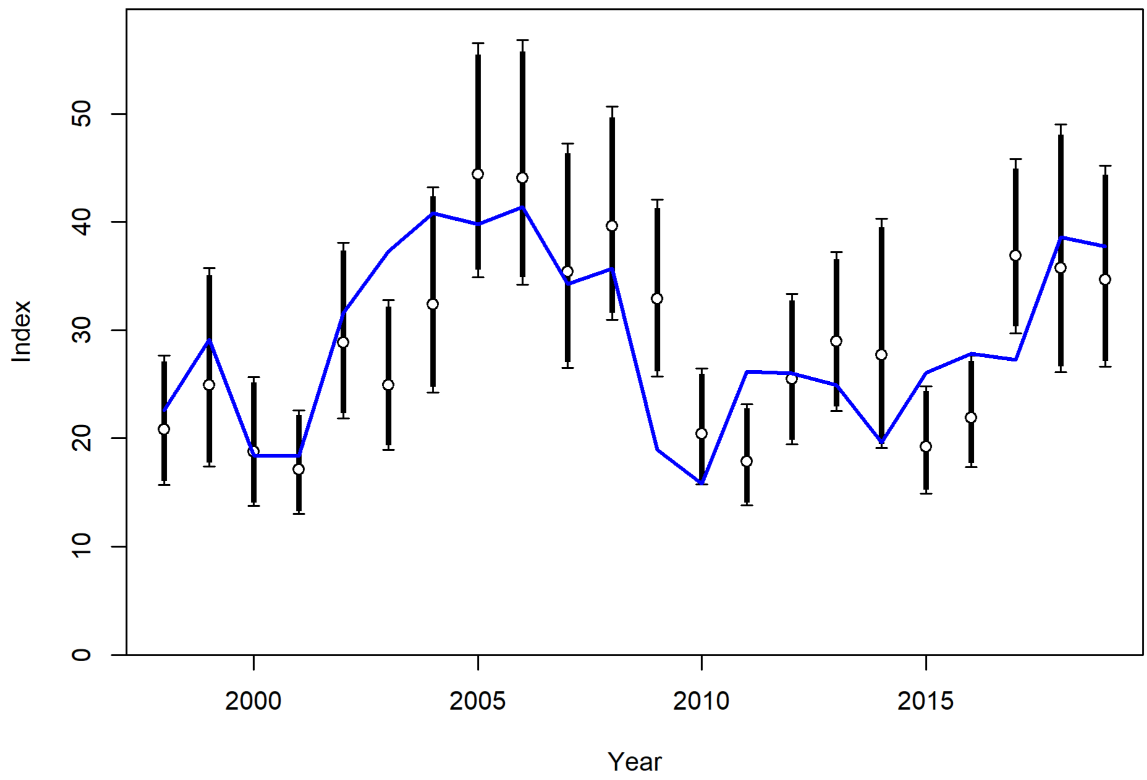


Figure 6.1.3.1.7 European hake in GSAs 17 and 18: Biomass index (Kg/Km^2) and fitting of the model (blue line) for the MEDITS survey.

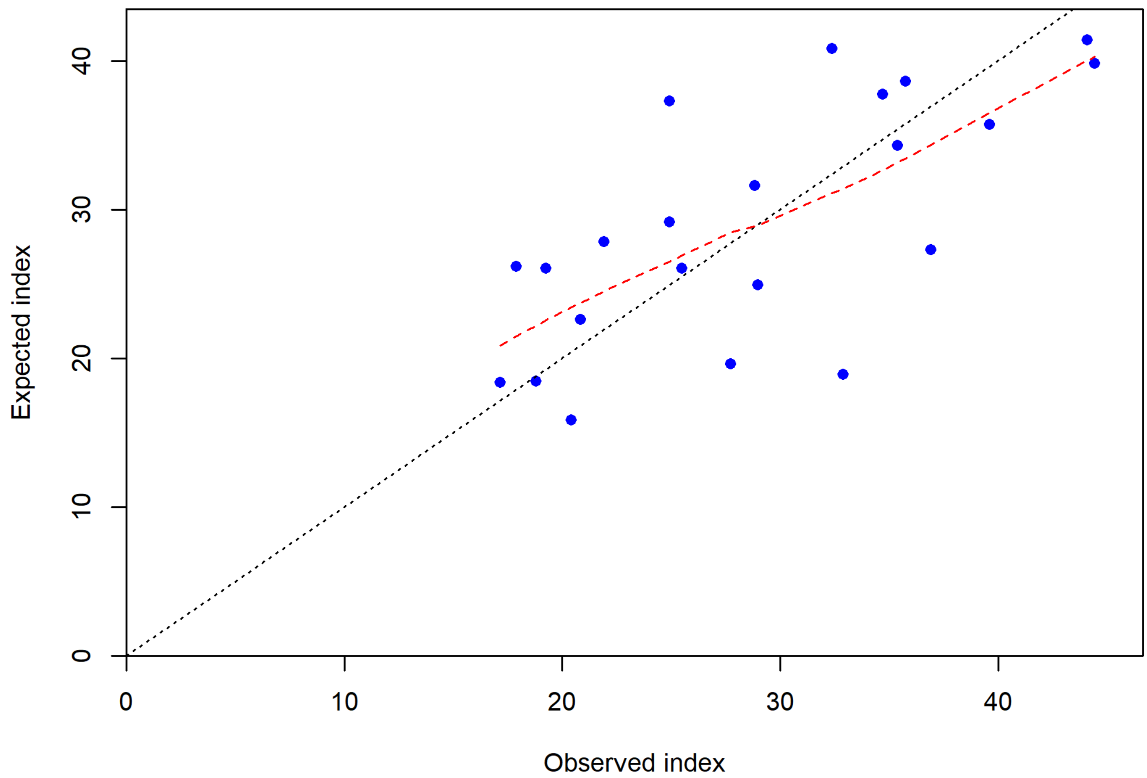


Figure 6.1.3.1.8 European hake in GSAs 17 and 18: Residuals by year for the MEDITS survey.

The setup of the final model was in line with the updated run of STECF EWG 19-16 with the addition of 2019 DCF data with some exceptions. Specifically:

- LFDs from Albania and Montenegro for 2018 were added;
- 2019 catches and LFDs for Montenegro were not available; Catches for 2019 were approximated by mean catches of 2016-2018;
- Values of catches of 2018 for Italian OTB in GSAs 17 and 18 corrected;
- LFDs of 2018 for Italian OTB in GSA 17 corrected;
- 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 19-16 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 (1312 tons) to then rise to the highest value of the time-series in 2020 (4397 tons). Recruitment and $F_{bar\ (1-4)}$ show a decreasing trend in the last five years. Recruitment in the last three years is below average. $F_{bar\ (1-4)}$ in 2019 (0.41) 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	330173	514622	211833	2571	3862	1280	9441	0.80	0.93	0.66
1999	310817	449054	215135	2602	3522	1681	6666	0.66	0.78	0.54
2000	396011	536734	292183	2779	3605	1953	6268	0.69	0.81	0.57
2001	390241	514554	295961	2673	3399	1946	6206	0.70	0.81	0.58
2002	434047	549778	342678	2534	3203	1865	5442	0.56	0.64	0.47
2003	435097	548286	345275	2953	3641	2266	7322	0.69	0.80	0.58
2004	515399	641560	414047	2934	3620	2249	7336	0.64	0.74	0.54
2005	491384	617730	390880	3182	3879	2486	8772	0.68	0.78	0.58
2006	523789	624030	439650	3329	4025	2633	10832	0.88	0.99	0.76
2007	451137	526733	386390	2834	3432	2236	8959	0.80	0.90	0.70
2008	431987	498795	374127	2623	3161	2085	8312	0.78	0.87	0.69
2009	370280	429158	319479	2570	3059	2081	7998	0.88	0.98	0.78
2010	399877	458790	348529	2222	2637	1807	6923	0.92	1.02	0.81
2011	407012	464638	356533	1796	2149	1443	6416	0.84	0.94	0.75
2012	394737	450684	345735	1567	1891	1244	6818	0.89	0.99	0.79
2013	308184	356504	266413	1357	1654	1061	6753	0.93	1.02	0.83
2014	314177	365783	269852	1312	1585	1040	5493	0.79	0.88	0.70
2015	477898	546392	417990	1437	1726	1148	5817	0.82	0.93	0.72
2016	413331	488879	349457	1383	1696	1070	5764	0.67	0.77	0.58
2017	388696	477036	316716	1589	1974	1204	6033	0.55	0.64	0.47
2018	308999	419289	227720	2384	2933	1834	6091	0.50	0.58	0.41
2019	326847	521448	204870	3322	4139	2505	5361	0.41	0.50	0.32
2020				4397	5627	3167				

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	0.192	0.034	0.023	0.252	0.264	0.004	0.026
1999	0.244	0.030	0.016	0.184	0.147	0.006	0.033
2000	0.243	0.030	0.013	0.218	0.139	0.006	0.038
2001	0.251	0.029	0.013	0.215	0.135	0.007	0.047
2002	0.260	0.030	0.014	0.141	0.085	0.004	0.023
2003	0.291	0.020	0.009	0.210	0.113	0.006	0.037
2004	0.259	0.028	0.014	0.213	0.071	0.007	0.044
2005	0.299	0.031	0.017	0.182	0.125	0.003	0.021
2006	0.322	0.033	0.018	0.247	0.230	0.004	0.022
2007	0.316	0.038	0.022	0.197	0.198	0.004	0.024
2008	0.296	0.027	0.012	0.223	0.193	0.005	0.026
2009	0.299	0.044	0.015	0.274	0.209	0.005	0.037
2010	0.254	0.039	0.018	0.297	0.269	0.005	0.035
2011	0.199	0.044	0.020	0.265	0.276	0.004	0.038
2012	0.202	0.058	0.020	0.174	0.327	0.004	0.103
2013	0.297	0.110	0.053	0.196	0.150	0.004	0.116
2014	0.225	0.075	0.045	0.125	0.203	0.004	0.111
2015	0.231	0.057	0.037	0.114	0.279	0.003	0.103
2016	0.141	0.037	0.068	0.079	0.271	0.002	0.076
2017	0.117	0.039	0.041	0.065	0.234	0.002	0.057
2018	0.149	0.042	0.043	0.078	0.124	0.003	0.058
2019	0.125	0.050	0.031	0.082	0.064	0.003	0.053

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

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1998	330174	108691	50401	10621	3326	1072	301	74	14	3	1
1999	310818	80531	33859	12486	2635	935	348	102	26	5	1
2000	396012	77213	28260	9612	3519	869	377	154	48	13	3
2001	390240	97950	26272	7735	2632	1141	351	170	74	24	8
2002	434048	96570	33325	7119	2085	844	460	160	84	38	17
2003	435096	107808	35970	10551	2262	781	393	239	90	49	34
2004	515398	111553	42087	9958	2697	681	302	176	119	48	47
2005	491384	132367	45293	12349	2689	854	276	142	92	67	57
2006	523790	124923	49516	12612	3266	835	335	124	70	48	69
2007	451138	129455	39388	11224	2717	826	265	120	48	29	52
2008	431986	109672	41600	9727	2674	760	288	103	51	21	38
2009	370280	104892	35054	10403	2387	775	275	117	45	24	30
2010	399878	88526	30779	7839	2291	628	258	104	48	20	25
2011	407012	95072	25027	6669	1687	578	193	87	37	18	18
2012	394738	96938	27905	5887	1578	457	184	65	31	14	14
2013	308184	96337	30658	6446	1263	375	125	53	19	9	9
2014	314176	75563	30764	6687	1267	294	112	43	20	8	8
2015	477898	78207	26640	7896	1559	334	93	39	16	8	6
2016	413332	118837	27346	6682	1765	383	95	28	12	5	5

2017	388696	103828	45053	8153	1824	498	114	28	8	3	3
2018	309000	98426	41747	15092	2579	602	175	39	9	3	2
2019	326846	78357	40033	14434	5089	966	260	79	18	4	2

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	0.07	0.51	0.84	0.93	0.90	0.85	0.81	0.77	0.75	0.73	0.67
1999	0.05	0.39	0.70	0.80	0.75	0.65	0.56	0.50	0.45	0.43	0.37
2000	0.06	0.43	0.74	0.83	0.77	0.66	0.56	0.49	0.44	0.41	0.34
2001	0.06	0.43	0.75	0.85	0.78	0.66	0.56	0.48	0.43	0.40	0.33
2002	0.05	0.34	0.59	0.68	0.63	0.52	0.42	0.35	0.31	0.28	0.23
2003	0.02	0.29	0.72	0.90	0.85	0.71	0.59	0.49	0.43	0.38	0.30
2004	0.02	0.25	0.66	0.85	0.80	0.67	0.54	0.44	0.37	0.33	0.24
2005	0.03	0.33	0.72	0.87	0.81	0.69	0.58	0.50	0.44	0.41	0.34
2006	0.06	0.50	0.92	1.07	1.02	0.90	0.80	0.72	0.67	0.64	0.57
2007	0.08	0.48	0.84	0.97	0.92	0.81	0.71	0.64	0.59	0.56	0.50
2008	0.08	0.49	0.83	0.94	0.88	0.77	0.67	0.59	0.55	0.52	0.46
2009	0.09	0.57	0.94	1.05	0.98	0.85	0.75	0.67	0.61	0.58	0.51
2010	0.10	0.61	0.97	1.07	1.02	0.93	0.85	0.79	0.75	0.72	0.65
2011	0.10	0.57	0.89	0.98	0.94	0.88	0.83	0.79	0.77	0.75	0.69
2012	0.07	0.50	0.90	1.08	1.07	1.03	0.99	0.96	0.95	0.94	0.90
2013	0.07	0.49	0.96	1.16	1.11	0.97	0.84	0.75	0.68	0.64	0.55
2014	0.05	0.39	0.80	0.99	0.97	0.89	0.82	0.76	0.73	0.71	0.65
2015	0.05	0.40	0.82	1.03	1.04	0.99	0.94	0.91	0.89	0.88	0.84
2016	0.04	0.32	0.65	0.83	0.89	0.93	0.96	0.98	1.00	1.02	0.99
2017	0.03	0.26	0.53	0.68	0.74	0.76	0.79	0.81	0.83	0.84	0.82
2018	0.03	0.25	0.50	0.62	0.62	0.57	0.53	0.50	0.48	0.47	0.43
2019	0.03	0.21	0.42	0.51	0.49	0.43	0.38	0.34	0.31	0.29	0.25

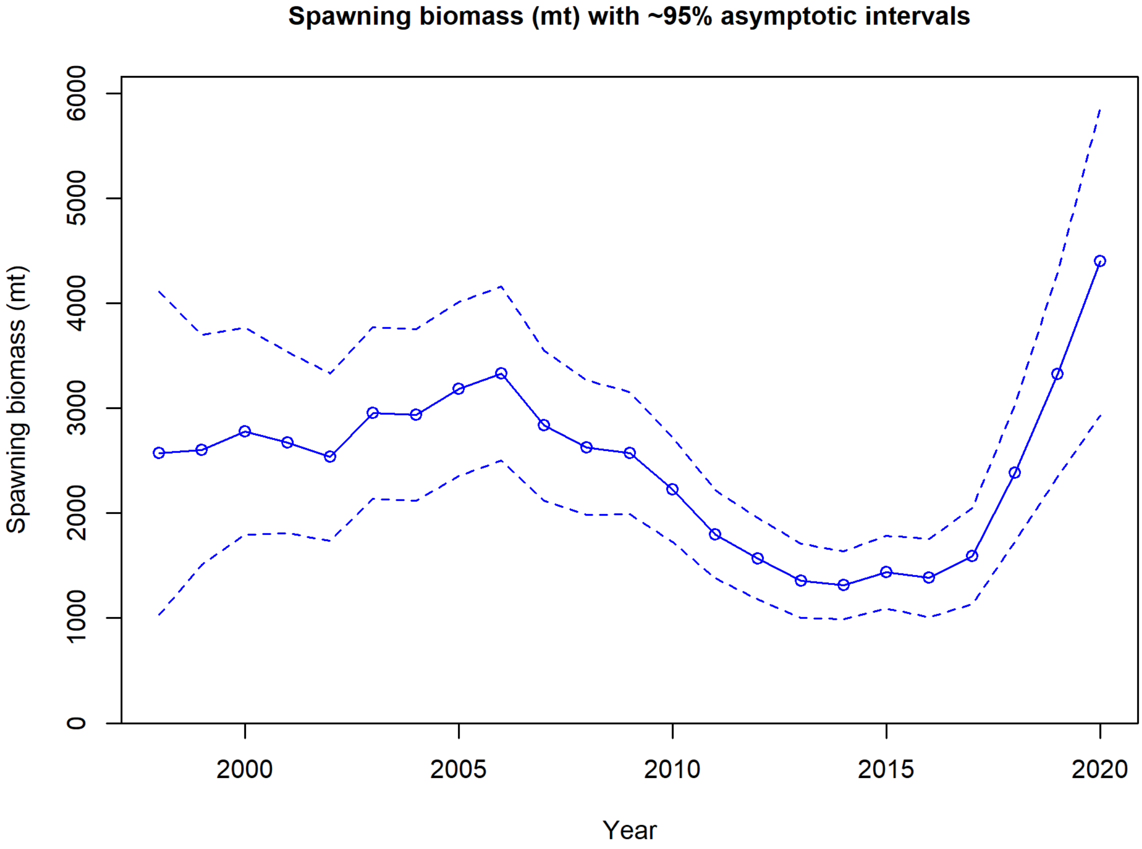


Figure 6.1.3.1.9 European hake in GSAs 17 and 18: Female spawning stock biomass by year estimated by the SS3 model.

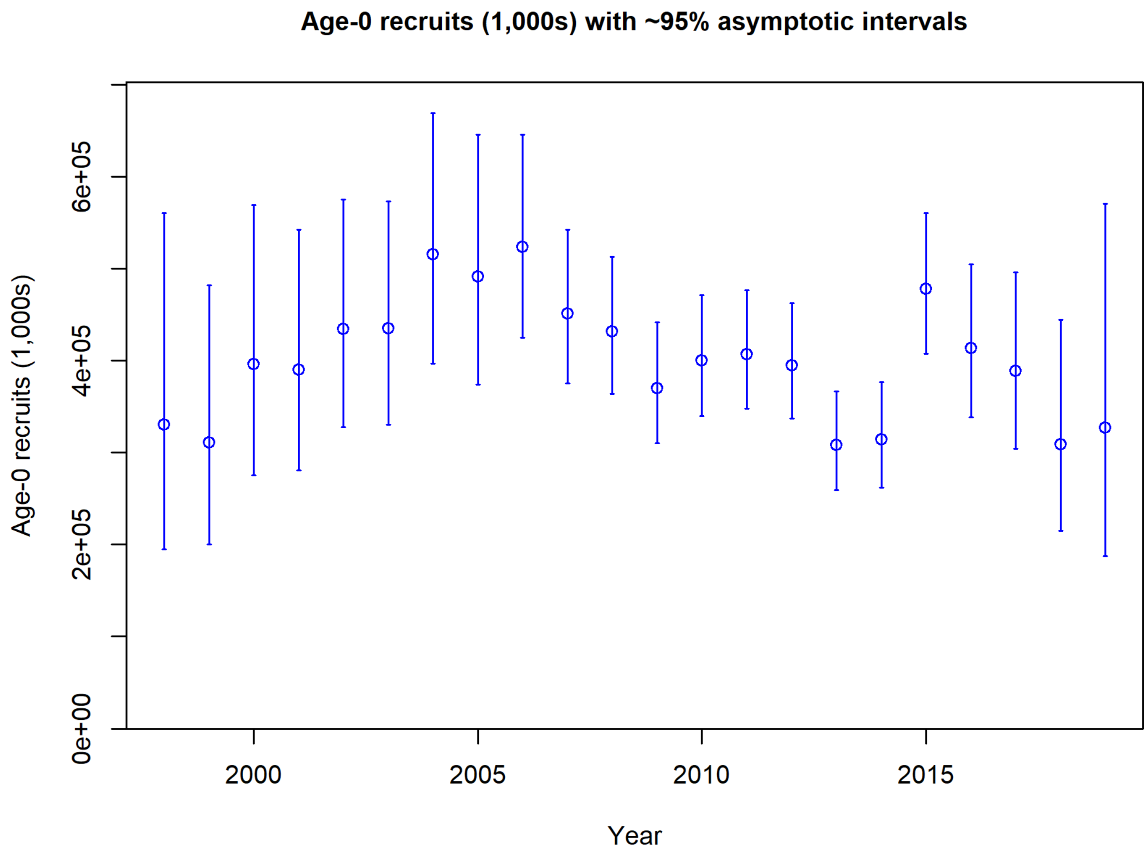


Figure 6.1.3.1.10 European hake in GSAs 17 and 18: Recruitment by year estimated by the SS3 model.

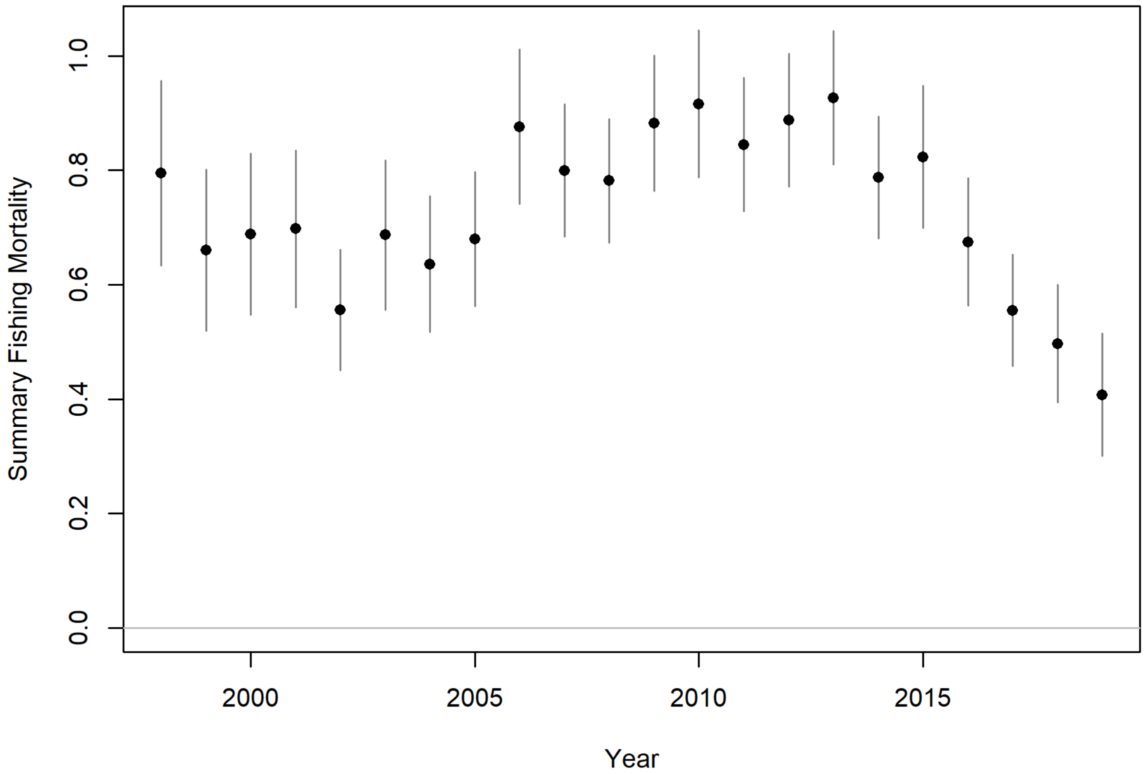


Figure 6.1.3.1.11 European hake in GSAs 17 and 18: Fishing mortality by year estimated by the SS3 model.

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 consistent results for F but not for female SSB which tends to be overestimated. It is suggested to review this aspect of the model in a new benchmark.

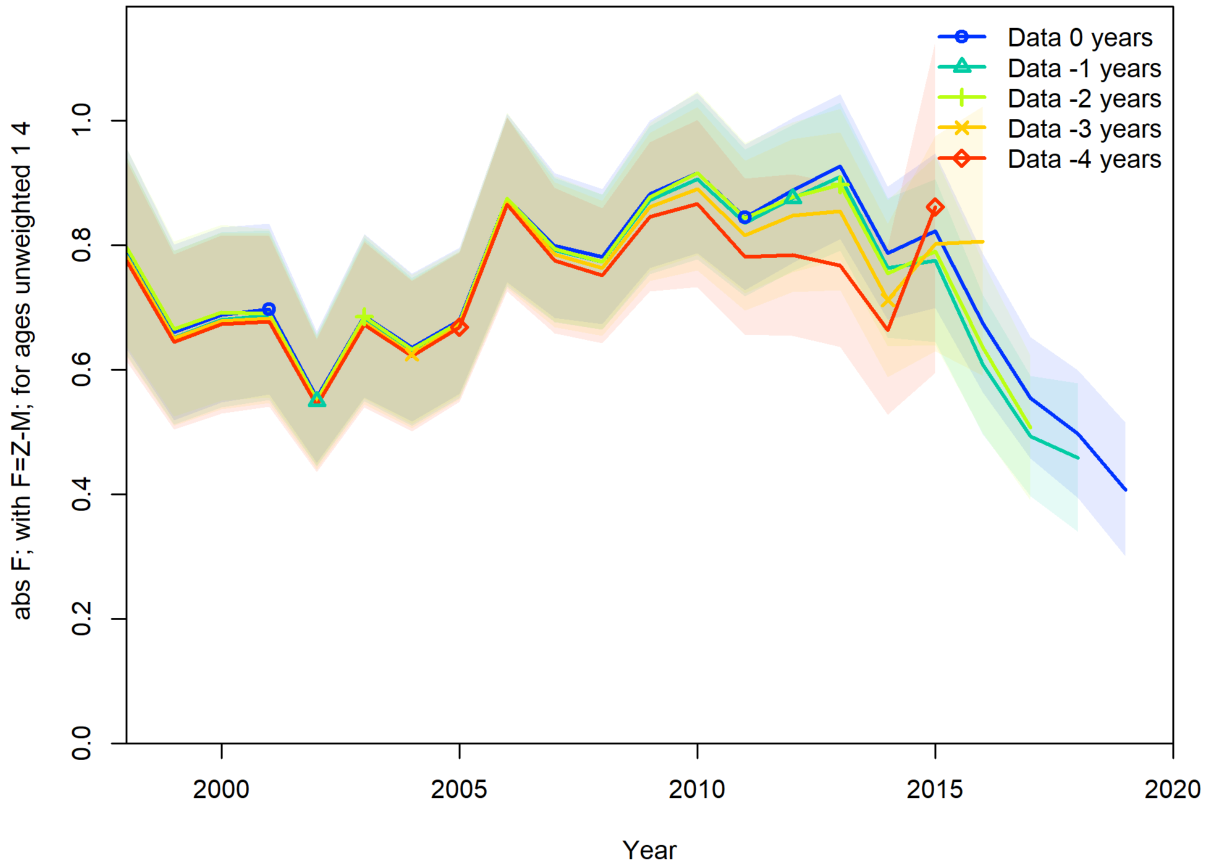


Figure 6.1.3.1.12 European hake in GSAs 17 and 18: Retrospectives – Fishing mortality from SS3.

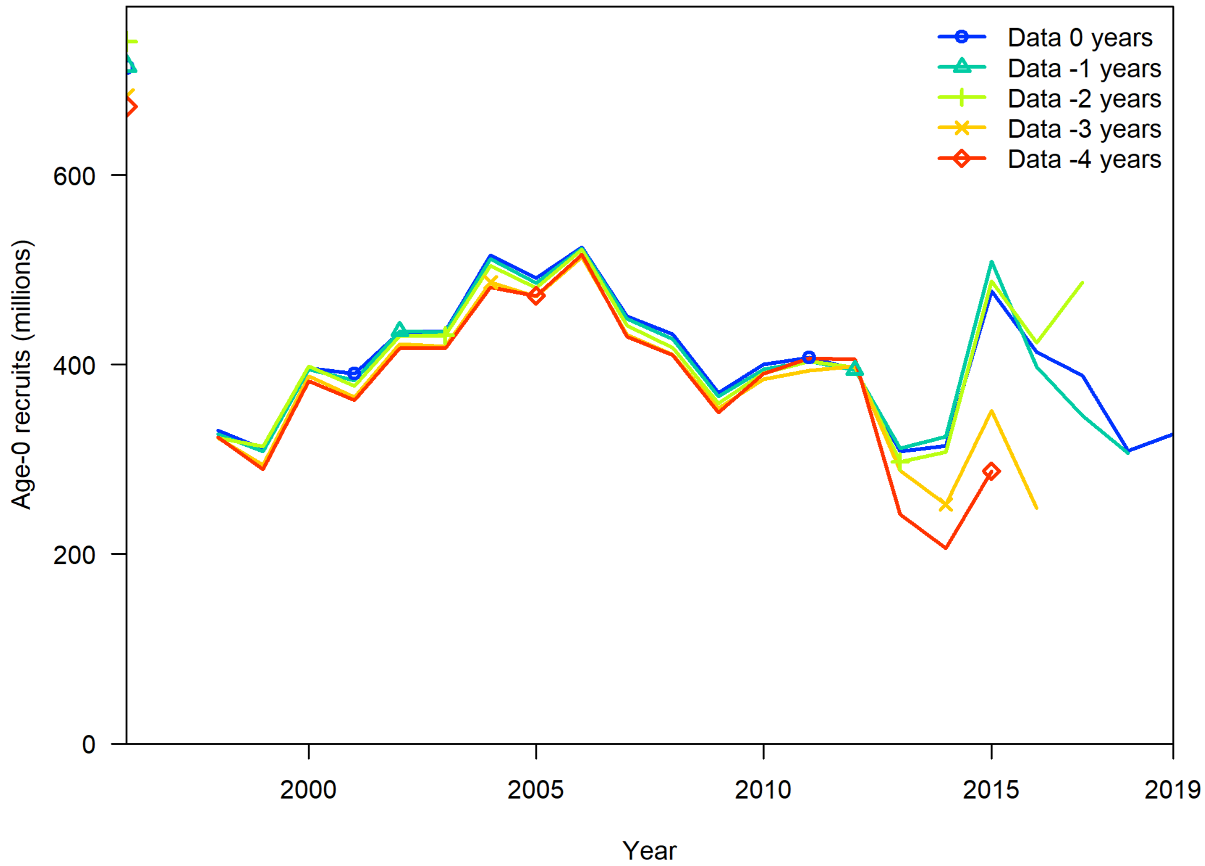


Figure 6.1.3.1.13 European hake in GSAs 17 and 18: Retrospectives – Recruitment from SS3.

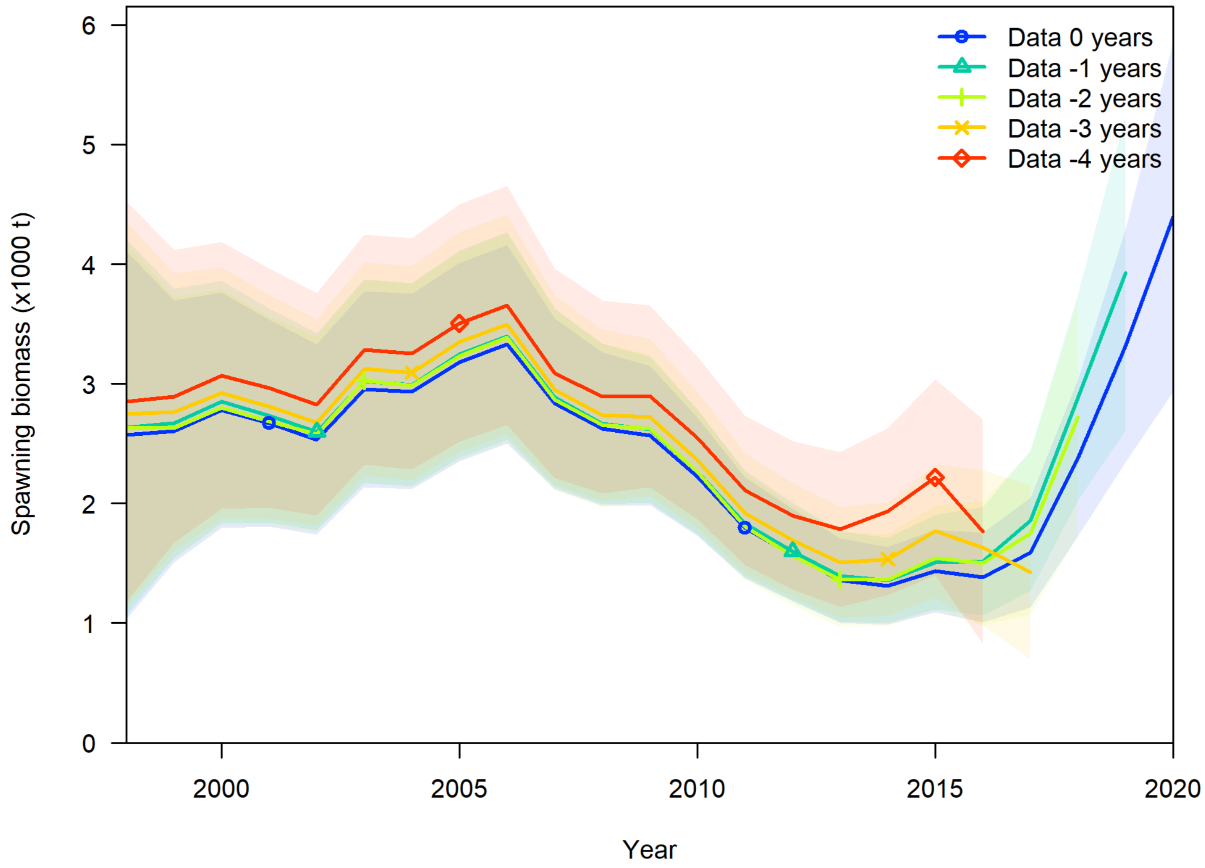


Figure 6.1.3.1.14 European hake in GSAs 17 and 18: Retrospectives – **Female** spawning stock biomass from SS3.

6.1.3.2 A4A (ASSESSMENT FOR ALL)

The a4a stock assessment implements a statistical catch-at-age model in R, making use of the FLR platform (Kell et al., 2007), and using automatic differentiation implemented in ADMB as the optimization engine (Jardim et al. 2014). To fit this model to data, there are certain components (submodels) that need to be given structure: fishing mortality (fmodel), survey catchability (qmodel), recruitment (srmodel), variance (vmodel) and first year's age structure (n1model). In the a4a framework, these submodels can incorporate linear functions of age and year, as well as fixed degrees of freedom splines which can vary with age, year, or both age and year.

Input data

During the EWG 20-15, an a4a assessment was run as a single stock, assembled by applying ALKs by sex to both catch LFDs and MEDITS LFDs.

This exploratory run was done for the first time during the last GFCM WGSAD 2019, and the main object of this update assessment was to check the ALKs and where possible improve the model.

Only 2019 data was added to the dataset used during last GFCM WGSAD 2019 and the STECF EWG 19-16.

LFDs for catches for Montenegro were missing and for this reason only total catch values (tons) were add into the final dataset of 2019. For the previous years (2002-2017), catch data were available for the following fleet segments:

- ITA OTB 17: Total catch for 2002–2017; catch LFDs for 2006–2017. Catch LFDs for 2002–2005 were reconstructed based on the average distribution of the observed catch LFDs;

- ITA OTB 18: Total catch for 2002–2017; catch LFDs for 2002–2017, except for the year 2006. Catch LFD for 2006 was reconstructed based on the average distribution of the observed catch LFDs in 2005 and 2007;

- SVN OTB 17: Total catch for 2002–2017. The catches were very low and they were merged with ITA OTB 17;

- HRV OTB 17: Total catch for 2002–2017; catch LFDs for 2008–2017. Catch LFDs for 2002–2007 were reconstructed based on the average distribution of the observed catch LFDs;

- HRV LLS 17: Total catch for 2002–2017; catch LFDs for 2009–2017. Catch LFDs for 2002–2008 were reconstructed based on the average distribution of the observed catch LFDs;

- MNE OTB 18: Total catch for 2002–2017; catch LFDs for 2008–2017. Catch LFDs for 2002–2007 were reconstructed based on the average distribution of the observed catch LFDs;

- MNE GNS 18: Total catch for 2002–2017; catch LFDs for 2008–2017. Catch LFDs for 2002–2007 were reconstructed based on the average distribution of the observed catch LFDs;

- ITA LLS 18: Total catch for 2002–2017; catch LFDs for 2004–2017, except for the year 2006. Catch LFD for 2006 was reconstructed based on the average distribution of the observed catch LFDs in 2005 and 2007, while catch LFDs for 2002–2003 were reconstructed based on the average distribution of the observed catch LFDs in 2004–2005;

- ALB OTB 18: Total catch for 2002–2017. Catch LFDs for 2002–2017 were reconstructed based on the catch LFDs from ITA OTB 18.

Catch LFDs were available by sex and all relevant reconstructions were carried out separately for males and females.

Catch-at-age and survey index at age matrices from 2002 to 2018 were constructed by applying ALKs by sex to catch LFDs and MEDITS LFDs and for 2019 this was done the same procedure.

The resulting matrices for males and females were then merged into single catch-at-age and survey index at age matrices. Catch-at-age data were SOP-corrected (raised) to the total catches.

Length data had a bin of 2 cm while ALKs were 1 cm. Therefore, it was necessary to convert ALKs at a 2 cm step. Moreover, there were many mismatches between length classes in the time series data (2002-2017). When length was not represented in the ALK, correspondent age was assigned according to the age of the closest length for which ALK was available. The ALKs by sex were available for ITA GSA 17 only for 2017 and for ITA GSA 18 from 2002 onwards (except for the years 2003, 2004 and 2006). For the missing years in GSA 18, an average ALK was applied (mean of the whole period). The complete (2002–2017) GSA 18 ALKs series were applied by sex to all gear available by GSA/country. For 2018 and 2019, were applied the ALK of 2018 and 2019 coming from GSA 18.

Finally, data from the year 2002 was discarded because of the high difference in numbers between the original length frequency and age frequency obtained using the ALK provided for 2002. For this reason, the assessment dataset starts from 2003.

During the EWG 19-16, two runs were compared, one with all availed age classes (catches=9+, index=8) and one with less age classes (catches=7+, index=6), both for catches and survey index. The decision to remove the older and most internally inconsistent age classes from the catches was done to give more stability to the model. The same procedure was done for the index, due to the fact that index doesn't have a real plus group like the catches and older ages have a limited effect on the stock composition, because there were very few individuals.

The model with less age classes was accepted by the EWG.

In figure 6.1.3.2.1 are reported the plots coming from the run with the same data limited to age 7+ for catches and age 6 for index, respectively.

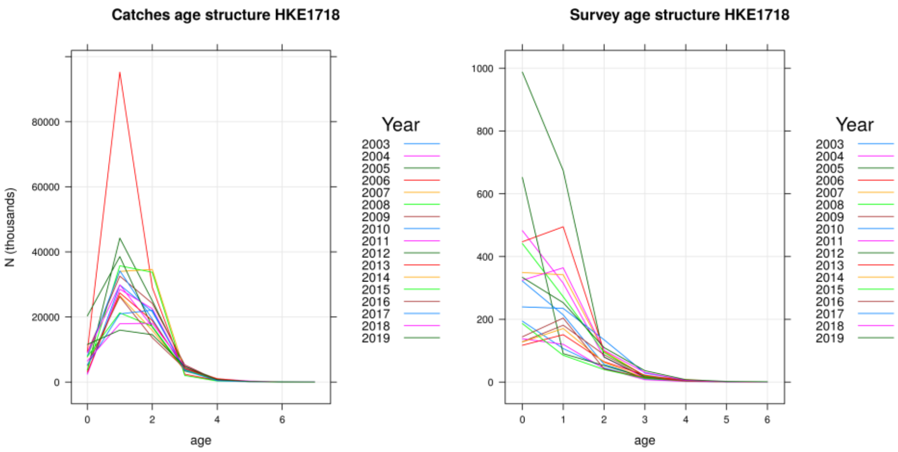


Figure 6.1.3.2.1 European hake in GSAs 17 and 18. Input catch numbers at age (thousands) limited to 7+ age class and survey index at age (thousands) limited to age 6, obtained applying ALKs.

Related cohort consistency and survey index age structure are reported in figure 6.1.3.2.2.

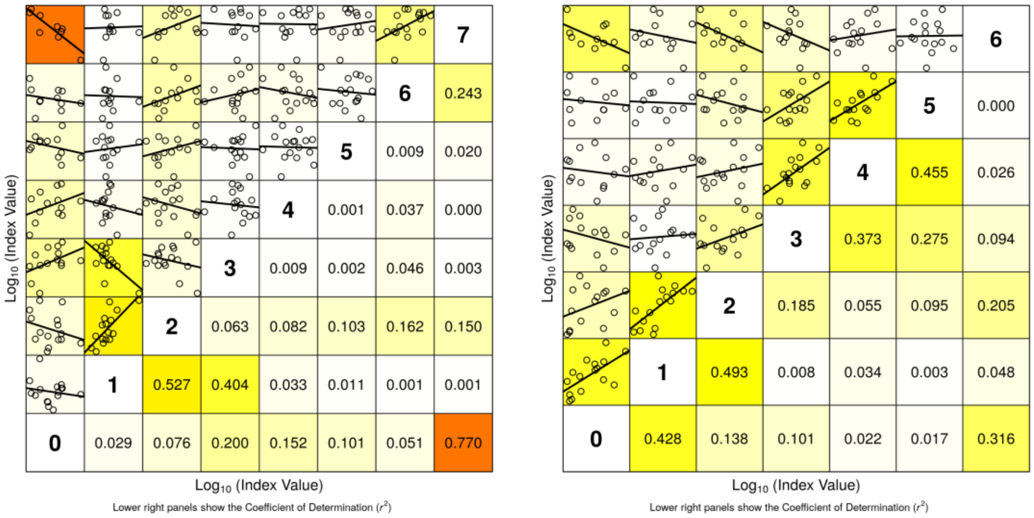


Figure 6.1.3.2.4 European hake in GSAs 17 and 18. Cohort consistency in the catch at age from 0 to 7+ and MEDITS index from 0 to 6 derived from ALKs.

The catch-at-age matrix was constructed by use of age length keys by sex by year. The resulting catch-at-age matrices for males and females were then merged into a single catch-at-age matrix and SOP-corrected (raised) to the total catch. Catch at age matrices are reported in Table 6.1.3.2.1 (commercial) and 6.1.3.2.2 (survey). Plots are in Figures 6.1.3.2.5, 6.1.3.2.6. A single survey index was used for the entire area, by age-slicing the survey LFDs using the same growth parameters used for the age-slicing of the catch.

For every year, the weight at age was weighted by the catch at age number of the same year. The same weight at age was used for the catch and the stock. A single weight-at-age matrix was calculated for both sexes combined. The overall catch in weight by year is reported in Table 6.1.3.2.3 and in Figure 6.1.3.2.7.

The mean weight-at-age is reported in Table 6.1.3.2.4 and in Figure 6.1.3.2.8. The natural mortality vector (estimated using the Chen & Watanabe formula) and the maturity at age are reported in Table 6.1.3.2.5. The M and F before spawning were set equal to 0.0.

Table 6.1.3.2.1 European hake in GSAs 17 and 18. Commercial catch in numbers at age used in the a4a assessment (thousands).

Year/Age	0	1	2	3	4	5	6	7+
2003	2584.269	29866.71	21634.37	4013.864	734.043	209.332	79.377	45.207
2004	2413.175	28547.1	22531.6	3973.965	637.21	271.898	84.801	51.151
2005	3678.061	44238.59	24997.58	4714.525	941.192	181.763	75.09	29.705
2006	9405.87	95234.86	29085.6	2421.469	481.097	128.112	88.027	60.341
2007	7637.212	34015.67	34609.46	3365.22	728.454	57.167	47.97	66.366
2008	3751.88	35722.91	33742.47	2022.829	311.305	150.054	110.425	76.968
2009	9068.333	32557.61	24180.58	5298.323	537.848	139.323	53.199	58.32
2010	7998.439	34187.98	19329.76	3801.129	495.453	179.293	76.855	76.265
2011	9060.782	29888.98	16989.48	3427.576	1004.256	308.982	36.334	66.112
2012	20327.74	38559.84	16933.39	3414.65	856.558	194.862	50.952	29.056
2013	3063.097	27396.41	18904.47	4295.294	1039.26	187.857	40.748	33.762
2014	5039.129	26537.46	15890.24	3581.416	520.954	83.604	37.382	37.129

2015	7832.633	21274.84	17125.81	3739.842	592.047	109.033	34.069	58.747
2016	5169.381	26275.98	13634.18	4161.478	692.558	125.932	52.512	29.998
2017	5315.356	20950.62	22115.61	3547.978	412.149	106.608	26.923	24.067
2018	6463.052	17946.88	18071.01	4918.13	658.453	214.166	34.378	30.337
2019	11561.813	15964.05	14569.75	4806.54	706.210	184.813	21.039	9.304

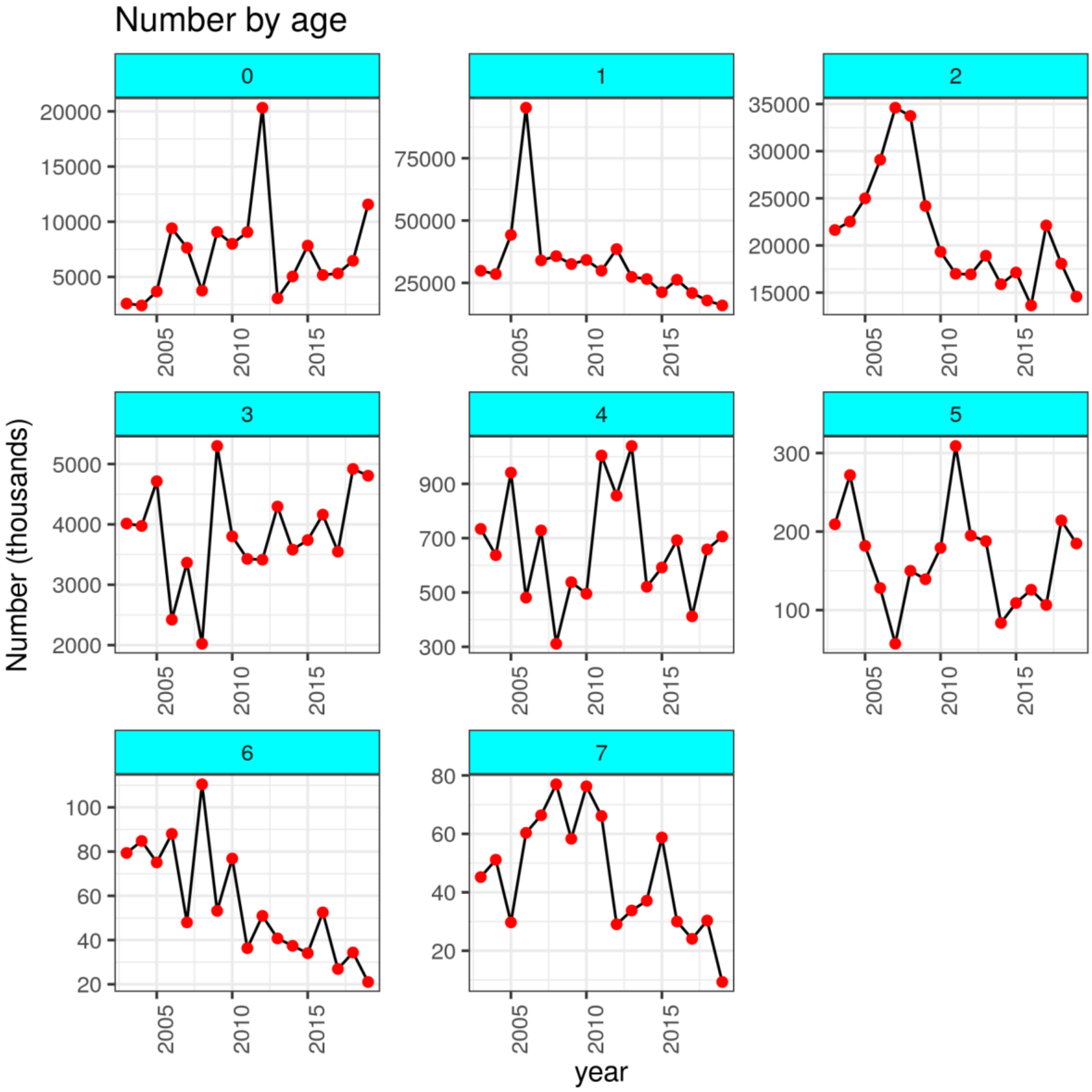


Figure 6.1.3.2.5 European hake in GSAs 17 and 18. Commercial catch in numbers at age used in the a4a assessment (thousands).

Table 6.1.3.2.2 European hake in GSAs 17 and 18. MEDITS catch in numbers at age used in the a4a assessment (N/km^2).

Year/Age	0	1	2	3	4	5	6
2003	321.8653	214.0752	56.46671	13.8665	2.00017	0.36338	0.19463
2004	482.4762	315.1178	79.10053	13.60223	2.91482	0.93611	0.28063
2005	987.4433	673.7068	80.04533	16.24938	3.82782	0.5417	0.20319
2006	447.0618	494.7647	98.01361	19.70397	4.53069	1.19378	0.56476
2007	349.1831	341.9777	98.59488	18.31591	8.72773	0.74894	0.41932
2008	441.2673	271.8738	94.41226	18.33189	5.85772	1.7911	0.75522
2009	128.6706	181.1616	87.1419	20.81102	4.27502	1.11489	0.23351
2010	194.1217	106.86	45.33836	10.71954	2.73863	0.79698	0.52601
2011	138.183	120.3202	43.12485	7.61696	1.80991	0.76102	0.12298
2012	651.9079	90.57228	52.73898	13.82434	2.57201	0.55505	0.27908
2013	117.284	151.0057	65.12044	22.03517	3.11315	0.76538	0.31931
2014	127.8022	170.7415	62.94748	12.73821	2.98777	0.77139	0.49746
2015	186.3748	85.33853	39.96976	11.83388	3.41828	1.0126	0.39041
2016	144.3275	203.9385	41.93422	14.51406	3.72277	0.51291	0.27218
2017	239.6005	234.7762	134.7939	28.58392	5.49396	1.25811	0.33866
2018	324.635	364.000	101.000	30.500	5.300	1.280	0.287
2019	333.569	252.972	109.900	36.252	7.657	2.095	0.849

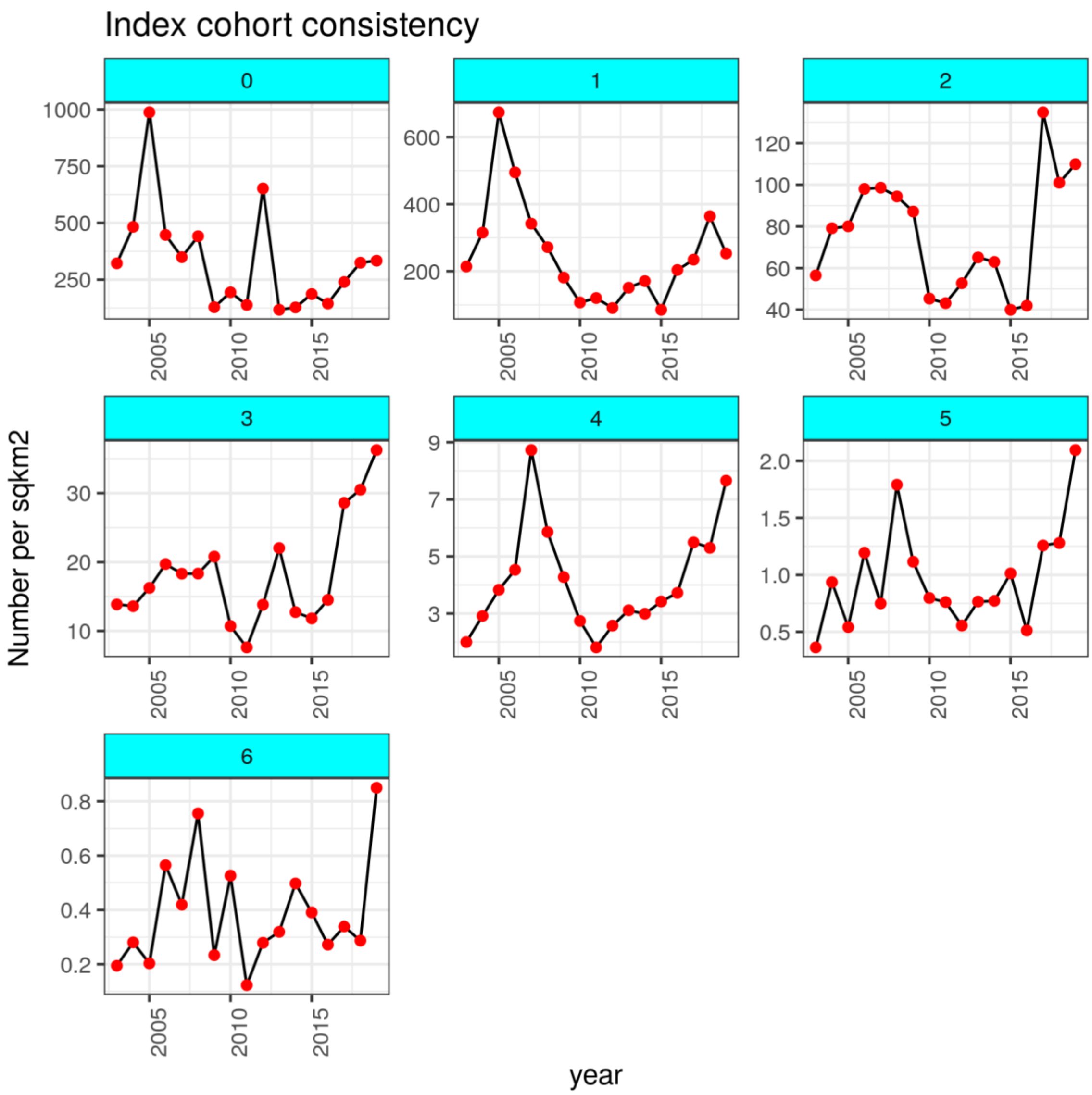


Figure 6.1.3.2.6 European hake in GSAs 17 and 18. MEDITS catch in numbers at age used in the a4a assessment (N/km²).

Table 6.1.3.2.3 European hake in GSAs 17 and 18. Catch in weight by year (tons).

Year	Catch (tons)
2003	7321.9
2004	7335.8
2005	8772.2
2006	10831.3
2007	8959.3
2008	8312.2
2009	7997.6
2010	6923.1
2011	6567.9
2012	6895.3
2013	6852.6
2014	5669.8
2015	5834.4
2016	5812.1
2017	6120.2
2018	6210.4
2019	5564.0

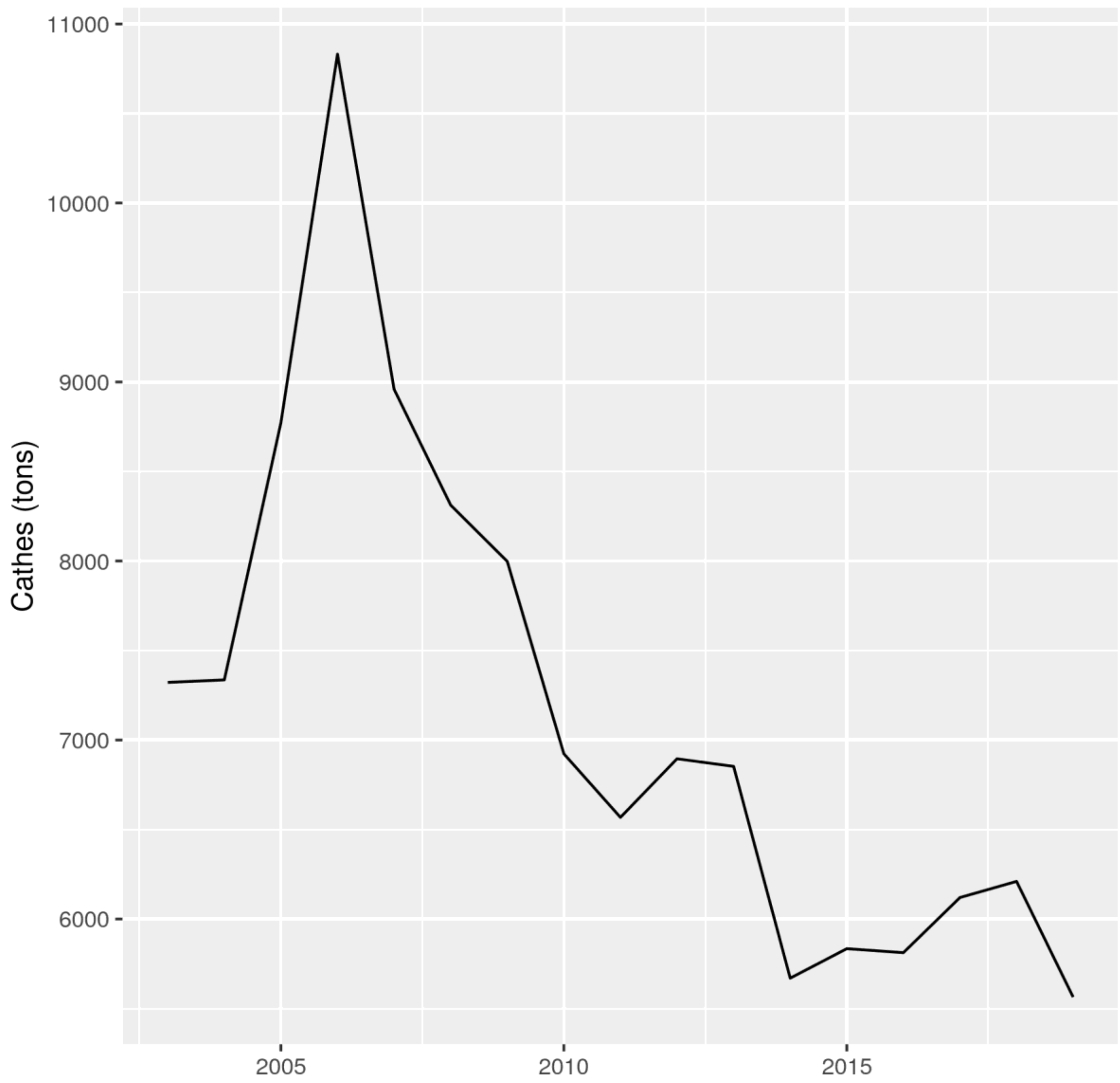


Figure 6.1.3.2.7 European hake in GSAs 17 and 18. Catch in weight by year (tons).

Table 6.1.3.2.4 European hake in GSAs 17 and 18. Individual weight at age for the in the catch and stock (kg).

Year/Age	0	1	2	3	4	5	6	7+
2003	0.018258	0.063162	0.145824	0.345266	0.628255	0.934096	1.33763	1.875575
2004	0.01805	0.064481	0.144481	0.332768	0.623351	0.951336	1.326339	2.059013
2005	0.019465	0.056238	0.148387	0.34104	0.609568	0.915686	1.361059	1.790096
2006	0.01938	0.053596	0.139378	0.347808	0.614407	0.926104	1.400662	1.84297
2007	0.015671	0.059566	0.145235	0.324351	0.616595	0.914371	1.431923	1.887797
2008	0.016507	0.059209	0.143614	0.334949	0.610333	0.932028	1.320086	1.767867
2009	0.013783	0.057329	0.149239	0.334641	0.602341	0.856896	1.269579	1.945864
2010	0.015609	0.054257	0.152582	0.336917	0.611434	0.91582	1.370028	1.846779
2011	0.015035	0.055436	0.151755	0.339947	0.597441	0.850191	1.237478	1.871181
2012	0.013444	0.054359	0.144953	0.354479	0.633097	1.009637	1.271811	1.965124
2013	0.019734	0.055767	0.149873	0.349944	0.610749	0.937942	1.296871	1.902048
2014	0.015119	0.05252	0.153122	0.348474	0.612927	0.922351	1.393391	1.891292
2015	0.011925	0.058202	0.152601	0.340239	0.608307	0.954212	1.33695	1.82377
2016	0.01471	0.057143	0.152604	0.354726	0.625555	0.925906	1.339875	1.919936
2017	0.013608	0.055624	0.146064	0.344585	0.613055	0.88994	1.283103	1.976137
2018	0.015954	0.05696	0.148074	0.341394	0.615247	0.920528	1.324239	2.714294
2019	0.014758	0.056576	0.148914	0.346902	0.617952	0.911212	1.315739	2.203456

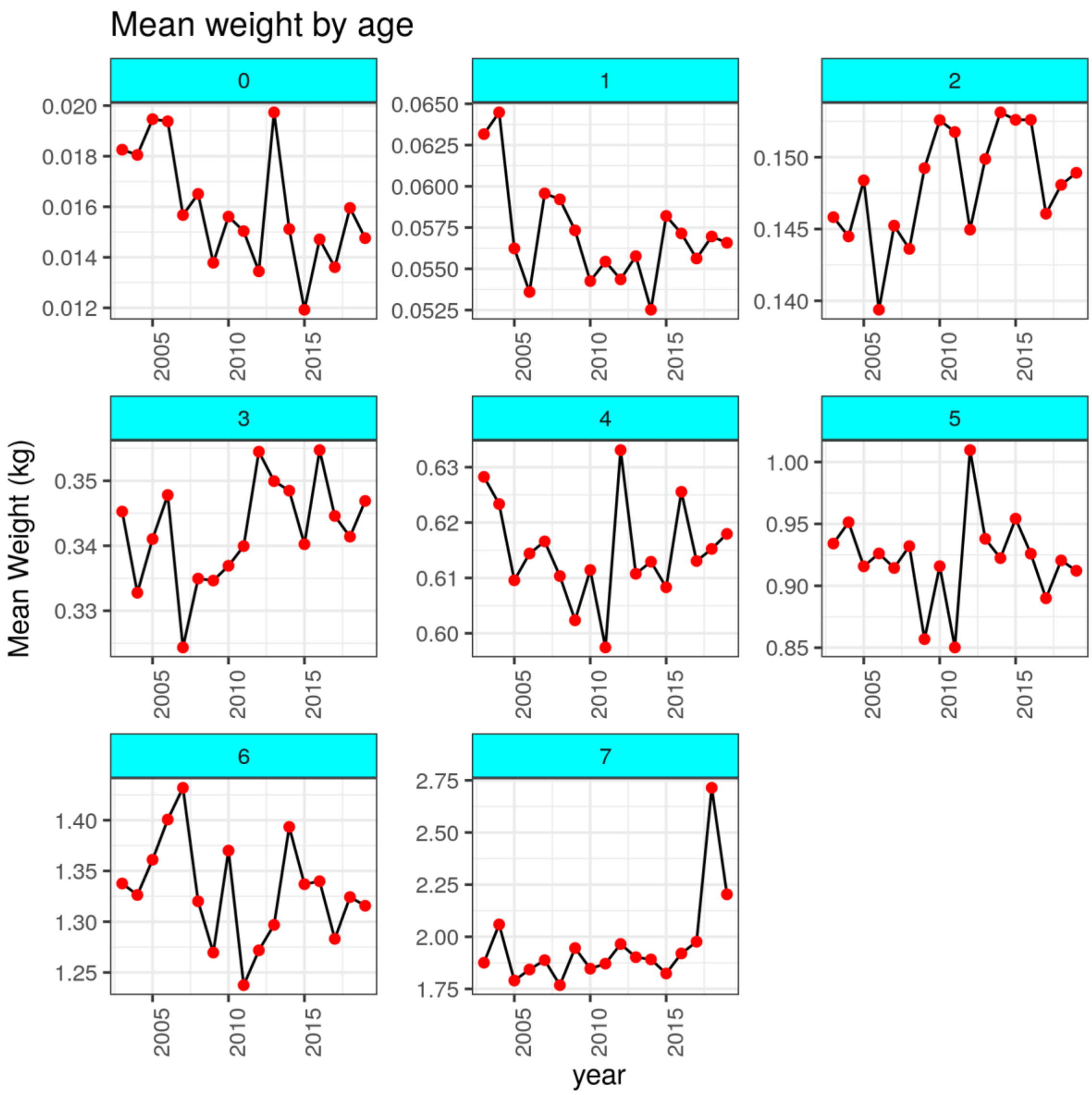


Figure 6.1.3.2.8 European hake in GSAs 17 and 18. Mean weight-at-age (kg).

Table 6.1.3.2.5 European hake in GSAs 17 and 18. Natural mortality vector and proportion of mature individuals by age.

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
Maturity	0	0	0.109	0.676	0.943	1	1	1

Stock assessment settings and outputs

The optimal a4a fit achieved by the end of the STECF EWG 19-16 and used in SETCF EWG 20-15 meeting had the following submodels:

f sub-model: **~s(year, k = 9) + factor(replace(age, age > 5, 5))**

q sub-model: **list(~s(age, k = 4))**

sr sub-model: **~ geomean (CV = 0.25)**

n1model: **~s(age, k=4)**

vmodel: **list(~s(age, k=3),~1)**

An Fbar range between age 1 and 4 was used. The best model (combination of the sub-models in bold) was chosen on the basis of retrospective analysis and residuals.

The estimated F at age is shown in Table 6.1.3.2.6 and Figure 6.1.3.2.9.

Table 6.1.3.2.6 European hake in GSAs 17 and 18. F at age by year.

Year	0	1	2	3	4	5	6	7+
2003	0.024	0.447	1.133	1.071	0.799	0.558	0.558	0.558
2004	0.026	0.493	1.251	1.182	0.883	0.616	0.616	0.616
2005	0.028	0.516	1.310	1.238	0.924	0.645	0.645	0.645
2006	0.028	0.516	1.310	1.238	0.924	0.645	0.645	0.645
2007	0.028	0.519	1.317	1.245	0.929	0.649	0.649	0.649
2008	0.029	0.535	1.356	1.282	0.957	0.668	0.668	0.668
2009	0.029	0.544	1.380	1.305	0.974	0.680	0.680	0.680
2010	0.029	0.534	1.354	1.280	0.956	0.667	0.667	0.667
2011	0.028	0.519	1.316	1.244	0.928	0.648	0.648	0.648
2012	0.028	0.518	1.314	1.242	0.927	0.647	0.647	0.647
2013	0.028	0.528	1.340	1.267	0.945	0.660	0.660	0.660
2014	0.028	0.526	1.336	1.263	0.942	0.658	0.658	0.658
2015	0.027	0.498	1.265	1.195	0.892	0.623	0.623	0.623
2016	0.024	0.449	1.138	1.076	0.803	0.560	0.560	0.560
2017	0.021	0.384	0.974	0.921	0.688	0.480	0.480	0.480
2018	0.017	0.311	0.789	0.746	0.557	0.388	0.388	0.388
2019	0.013	0.241	0.612	0.579	0.432	0.301	0.301	0.301

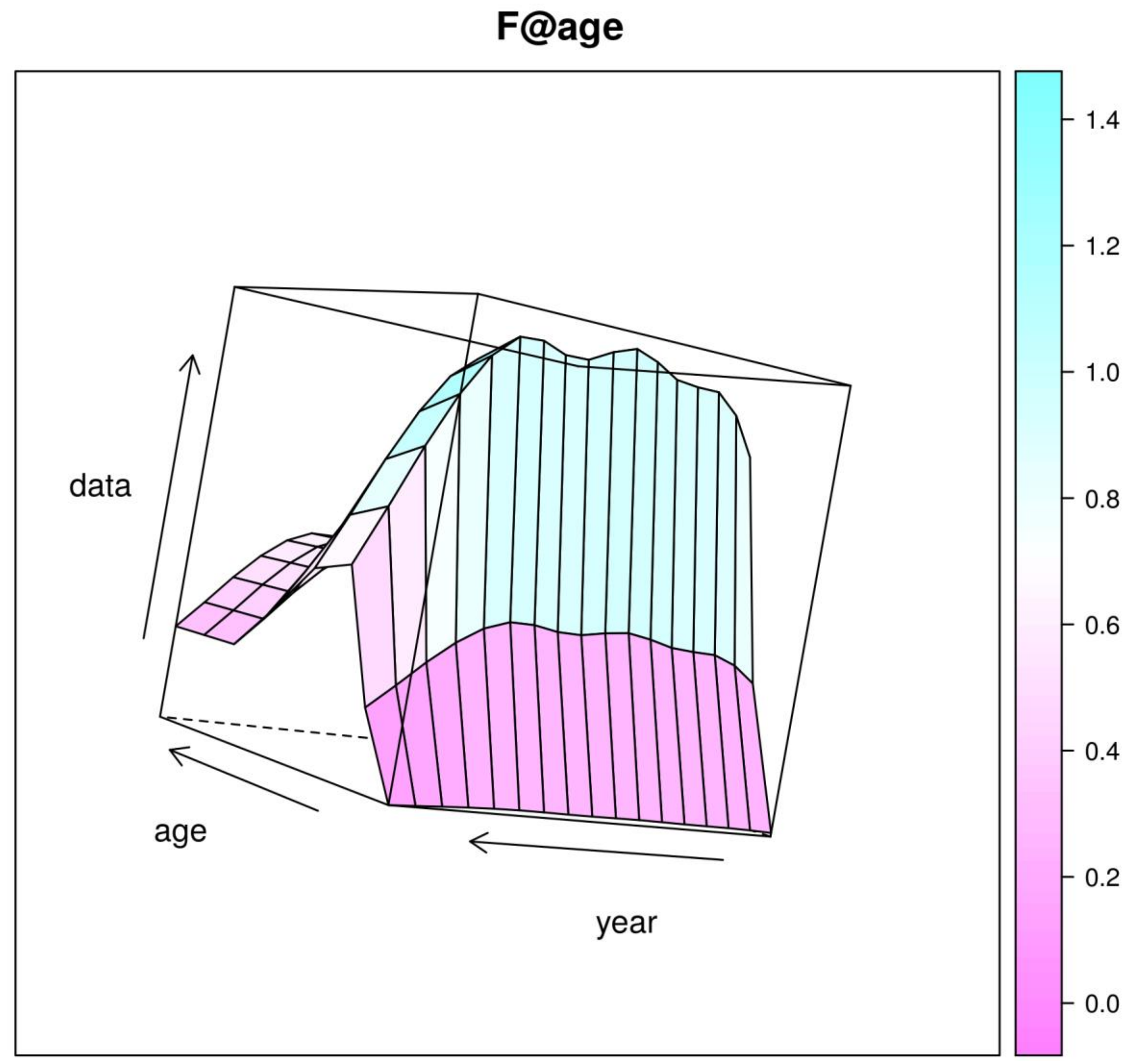


Figure 6.1.3.2.9 European hake in GSAs 17 and 18. Wireframe plot of F (data) at age by year.

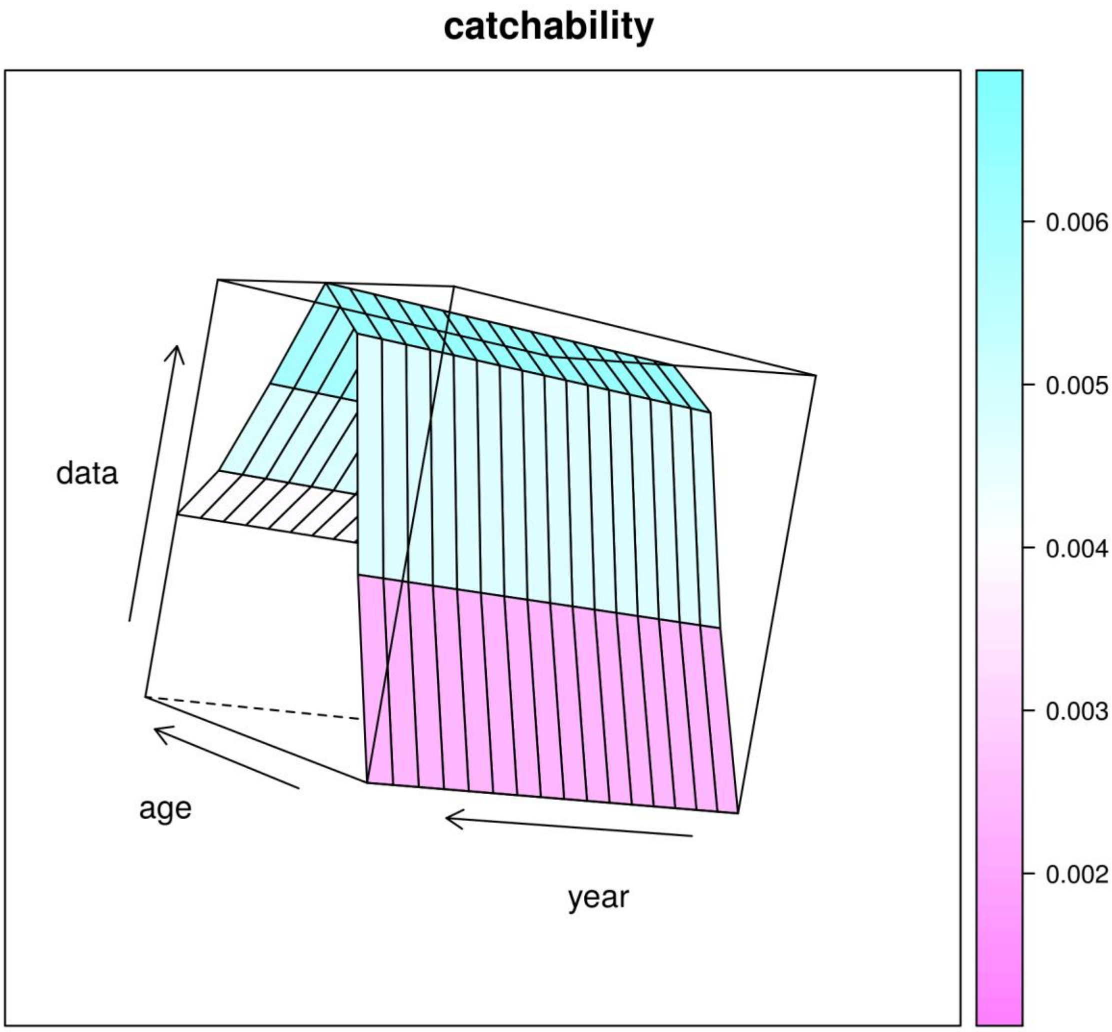


Figure 6.1.3.2.10 European hake in GSAs 17 and 18. Wireframe plot of Medits catchability at age by year.

The estimated abundance (N) at age is shown in Table 6.1.3.2.7. A summary of the main outputs of the stock assessment is shown in Figure 6.1.3.2.11. and Table 6.1.3.2.8.

Table 6.1.3.2.7 European hake in GSAs 17 and 18. Population at age by year (thousands).

Year	0	1	2	3	4	5	6	7+
2003	477583	122899	25526	5684	1435	420	139	49
2004	510260	122089	40766	5222	1354	471	181	84
2005	500619	130118	38657	7411	1112	409	192	111
2006	558236	127500	40257	6627	1493	322	162	123
2007	493132	142174	39444	6900	1335	433	127	116
2008	445138	125572	43852	6710	1380	385	170	99
2009	395123	113258	38142	7175	1294	387	149	107
2010	408811	100481	34075	6091	1352	356	148	101
2011	384592	104019	30541	5585	1176	379	138	99
2012	429015	97937	32106	5205	1119	339	150	97
2013	364364	109254	30248	5480	1044	323	134	100
2014	349699	92738	33399	5031	1073	296	126	94
2015	436847	89014	28398	5579	989	305	116	89
2016	407730	111365	28032	5092	1173	296	123	85
2017	430148	104221	36865	5705	1207	383	127	93
2018	472729	110332	36797	8836	1578	443	179	106
2019	568454	121732	41912	10618	2913	660	226	150

Table 6.1.3.2.8 European hake in GSAs 17 and 18. a4a stock assessment summary (Rec are in thousands while SSB (whole adults fraction), Catch in tonnes).

Year	Total Biomass	SSB	Catch	Rec	F(1-4)
2003	23739	3253	6132	477583	0.862
2004	26414	3473	7807	510260	0.952
2005	26838	3807	8172	500619	0.997
2006	27238	3787	7920	558236	0.997
2007	25784	3711	8401	493132	1.003
2008	24929	3759	8582	445138	1.032
2009	21541	3708	8013	395123	1.051
2010	20627	3449	7104	408811	1.031
2011	19464	3130	6541	384592	1.001
2012	19021	3145	6401	429015	1.000
2013	21039	3059	6647	364364	1.020
2014	18309	2989	6479	349699	1.017
2015	17831	2930	5936	436847	0.963
2016	19782	2982	5856	407730	0.866
2017	20429	3301	5816	430148	0.742
2018	24194	4480	5767	472729	0.601
2019	28231	6098	5717	568454	0.466

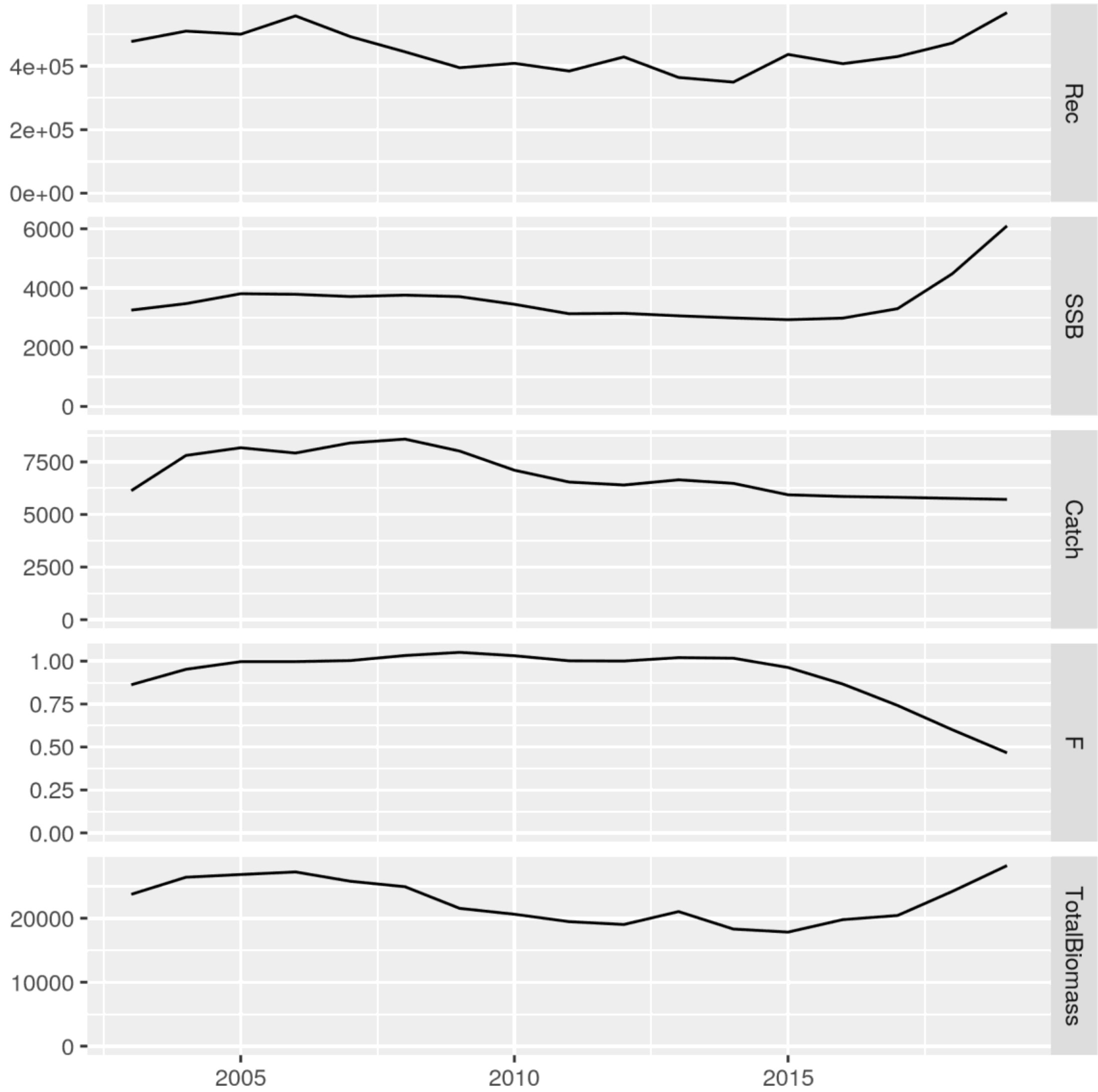


Figure 6.1.3.2.11 European hake in GSAs 17 and 18. a4a stock assessment summary (Rec are in thousands while SSB, Catch and Total Biomass in tonnes).

An a4a stock assessment was also simulate using a variance covariance matrix fit (1000 iterations to generate probability intervals (Figure 6.1.3.2.12).

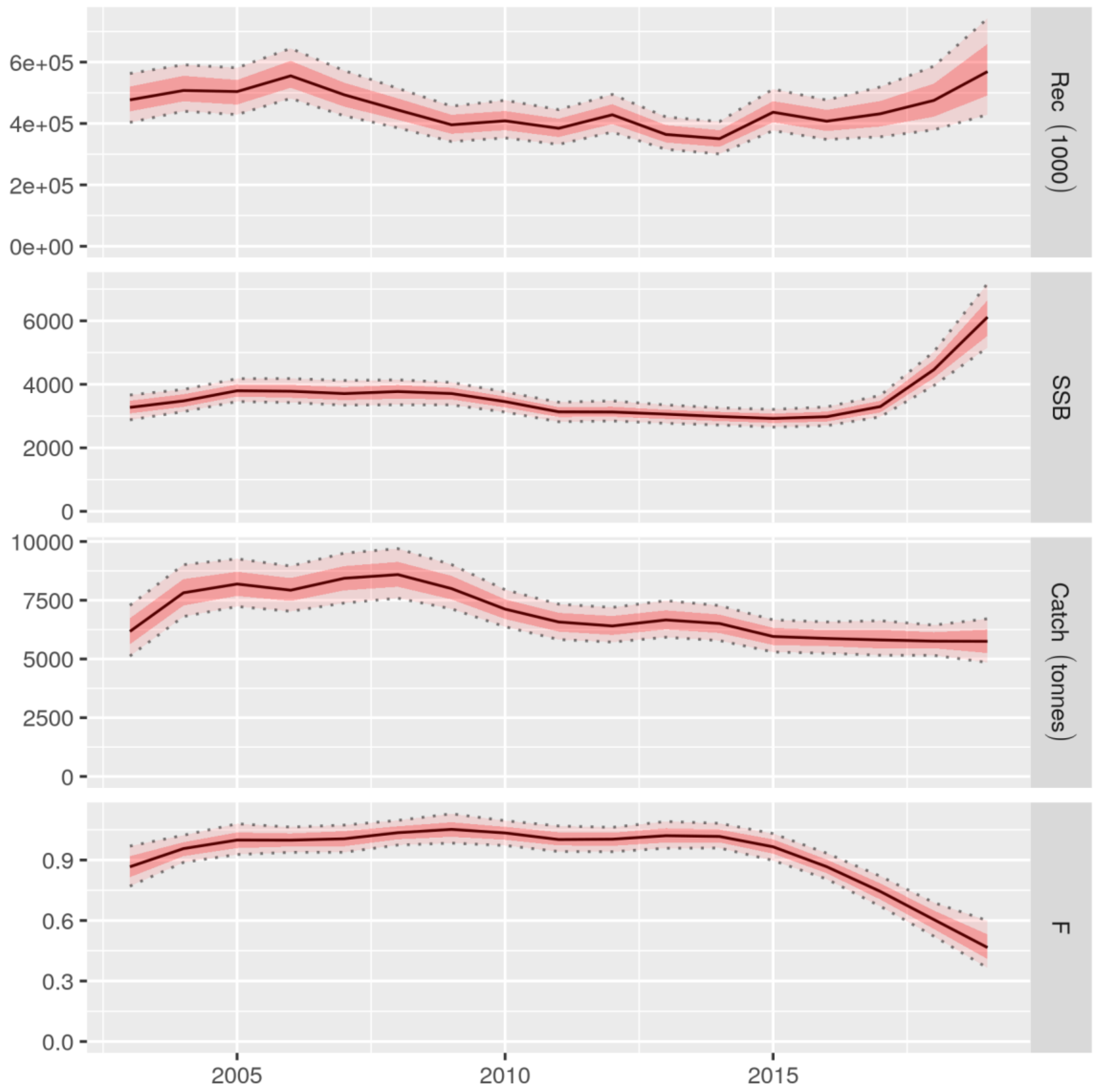


Figure 6.1.3.2.12 European hake in GSAs 17 and 18. a4a stock assessment outputs with a 95 present probability distribution simulated using variance covariance matrix fit (1000 iterations).

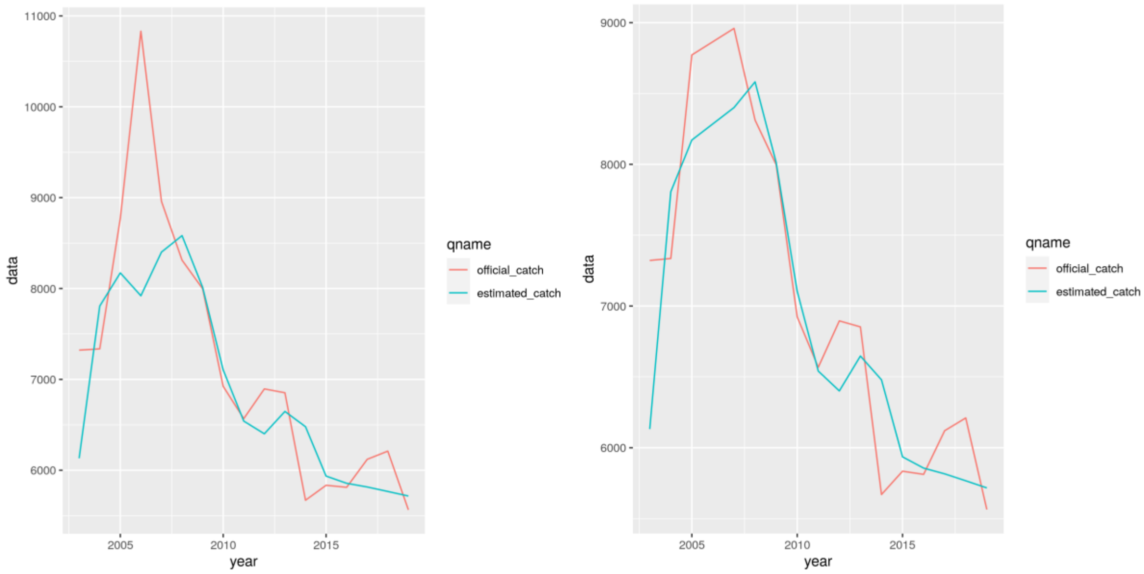


Figure 6.1.3.2.13 European hake in GSAs 17 and 18. Comparison between observed and estimated catches (right panel without 2006 data).

Diagnoses

Residual plots, indicating an overall good fit, are presented in Figure 6.1.3.2.14-6.1.3.2.18. The retrospective fits are presented in Figure 6.1.3.2.19.

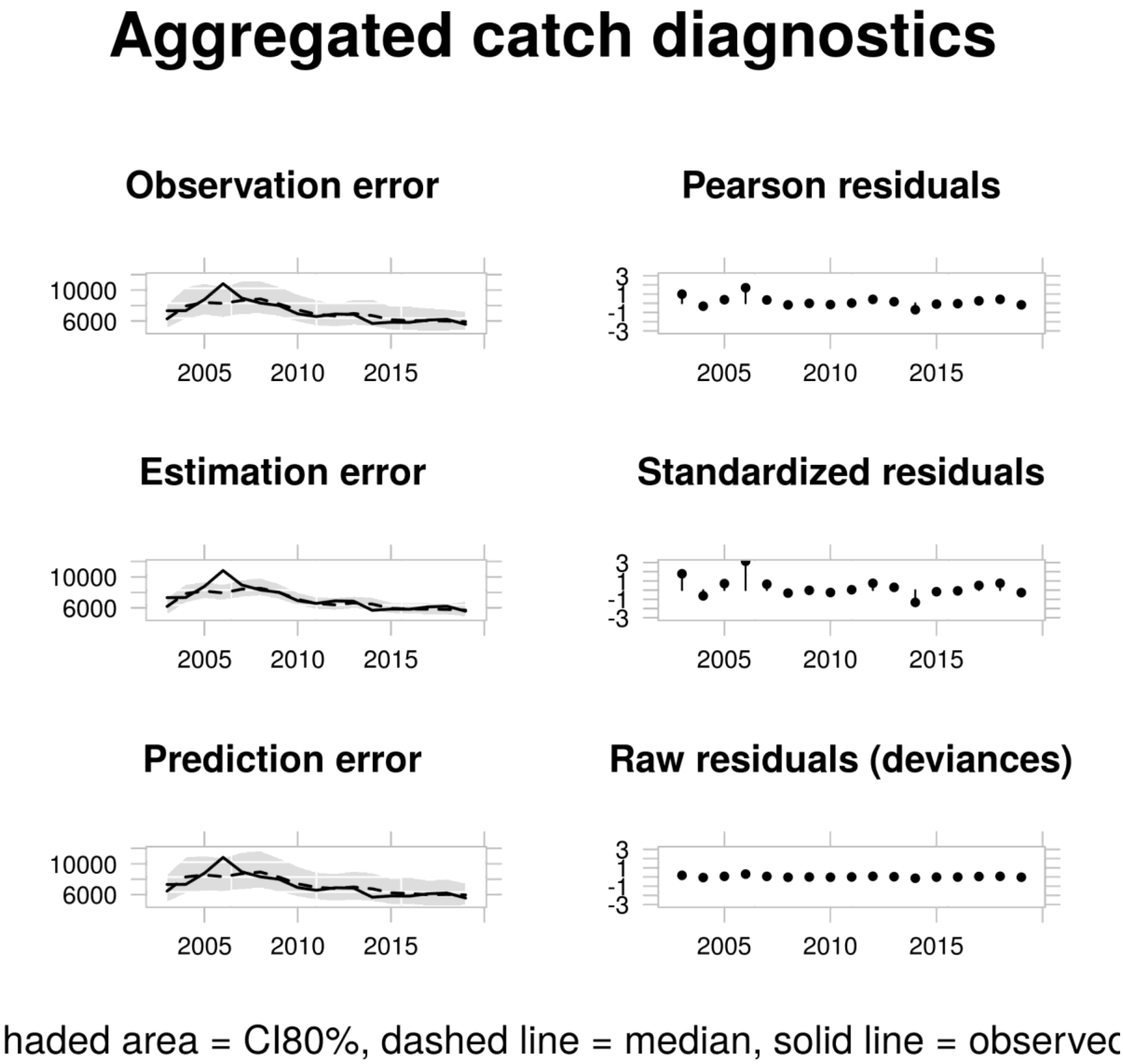


Figure 6.1.3.2.14 European hake in GSAs 17 and 18. Standardised residuals of catch by year.

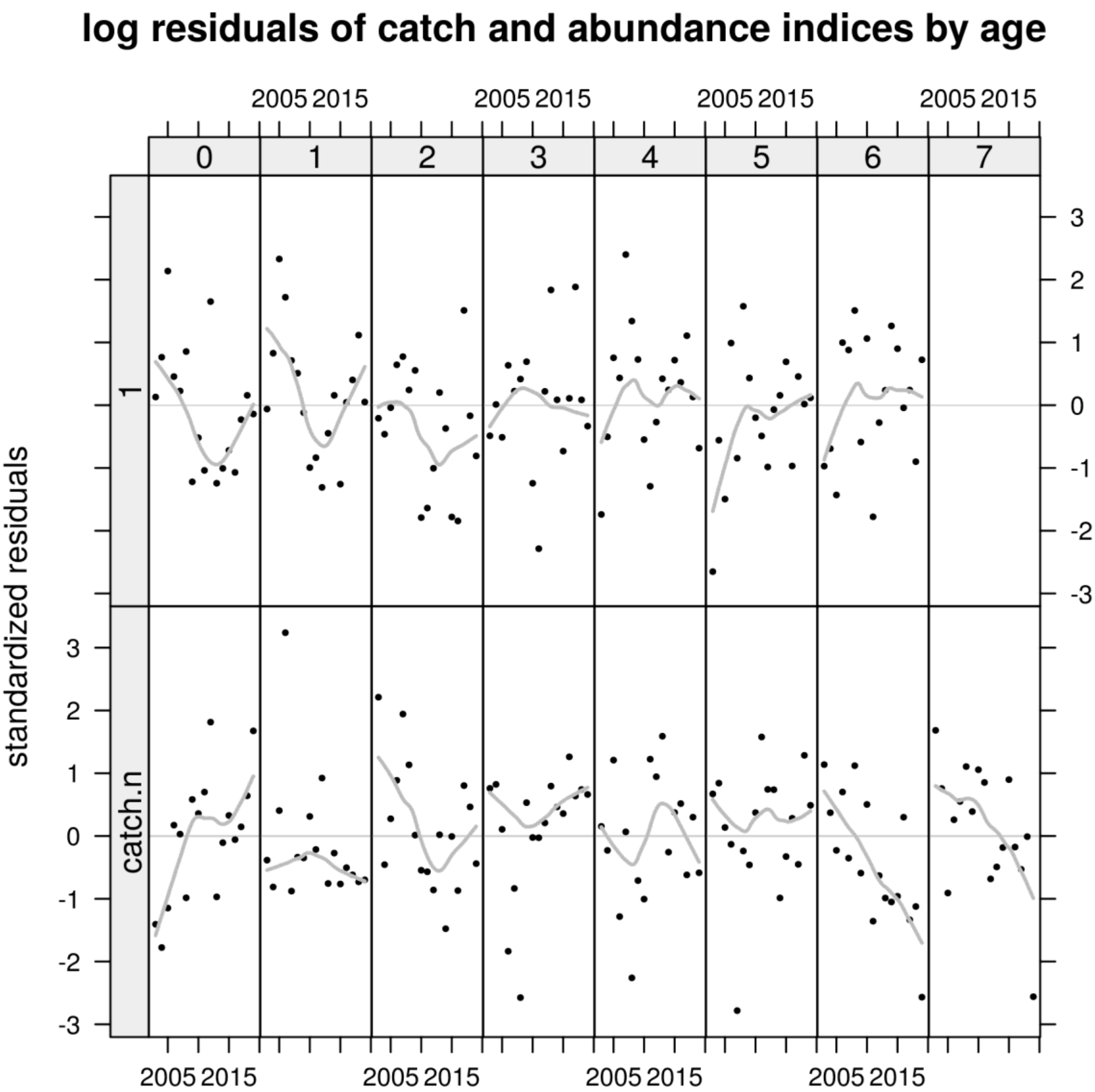


Figure 6.1.3.2.15 European hake in GSAs 17 and 18. Standardised residuals of survey indices and catch numbers by year and age.

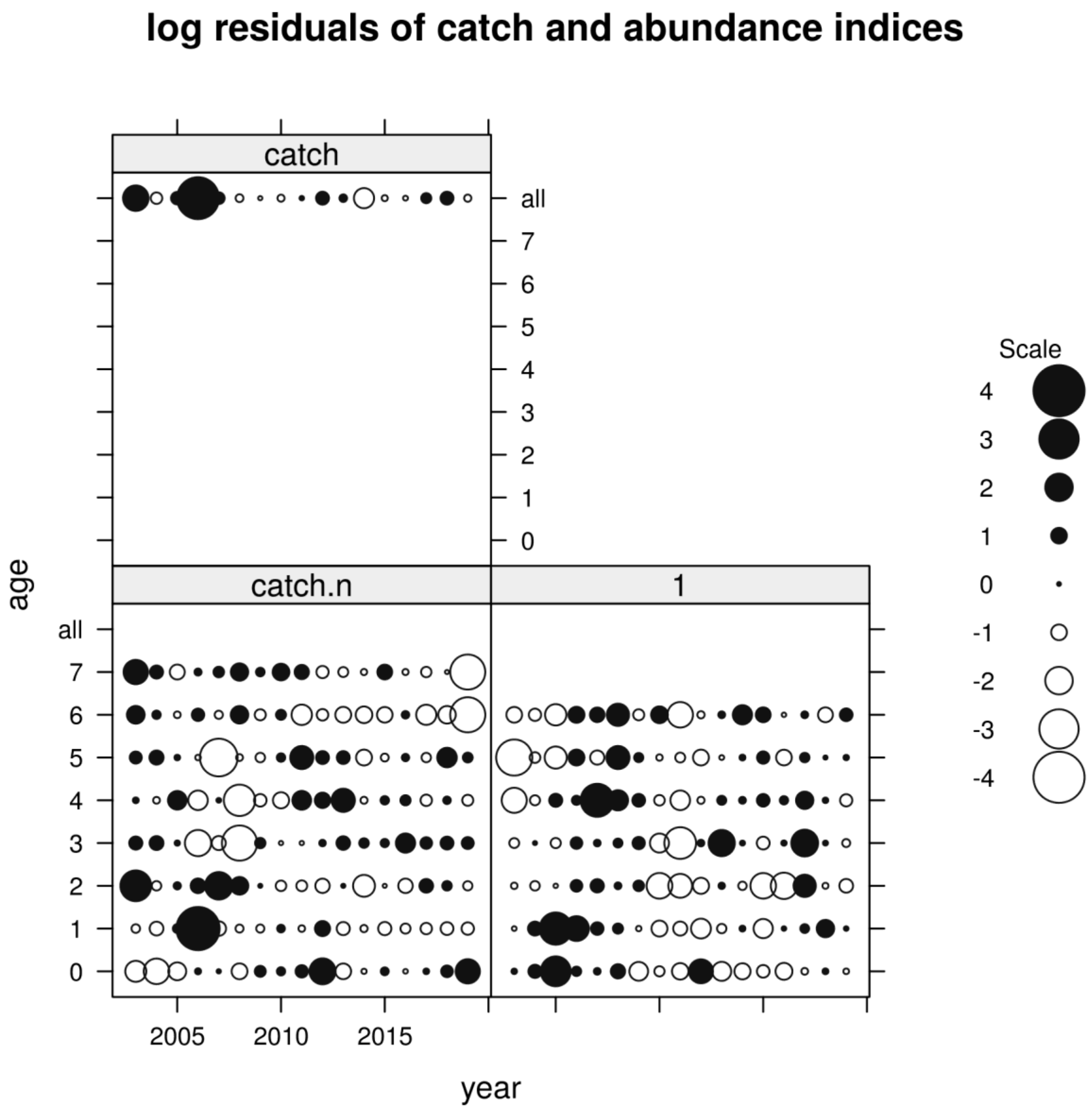


Figure 6.1.3.2.16 European hake in GSAs 17 and 18. Bubble plots of residuals of catch, survey indices and catch numbers by year and age.

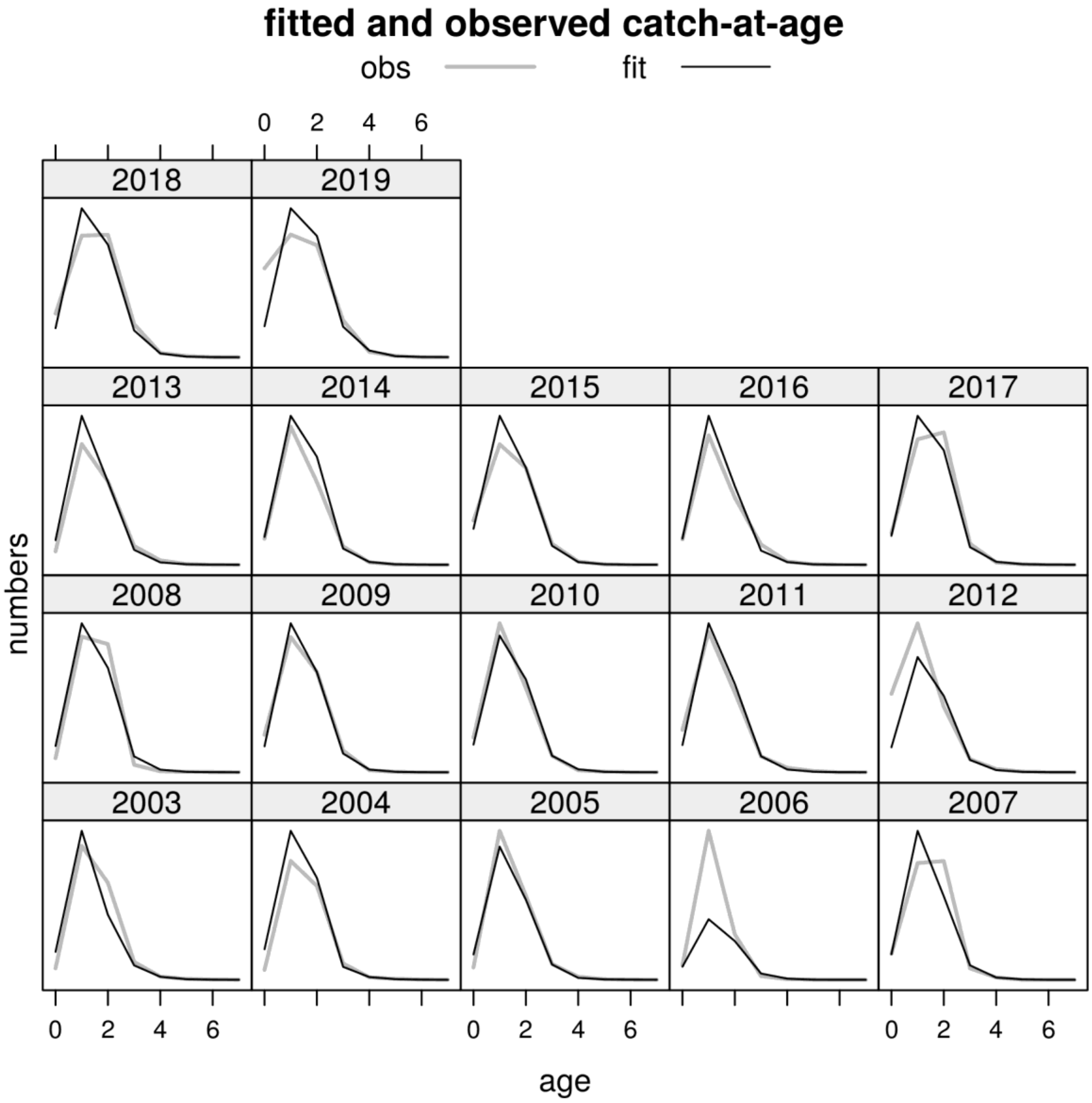


Figure 6.1.3.2.17 European hake in GSAs 17 and 18. Fitted and observed catch at age.

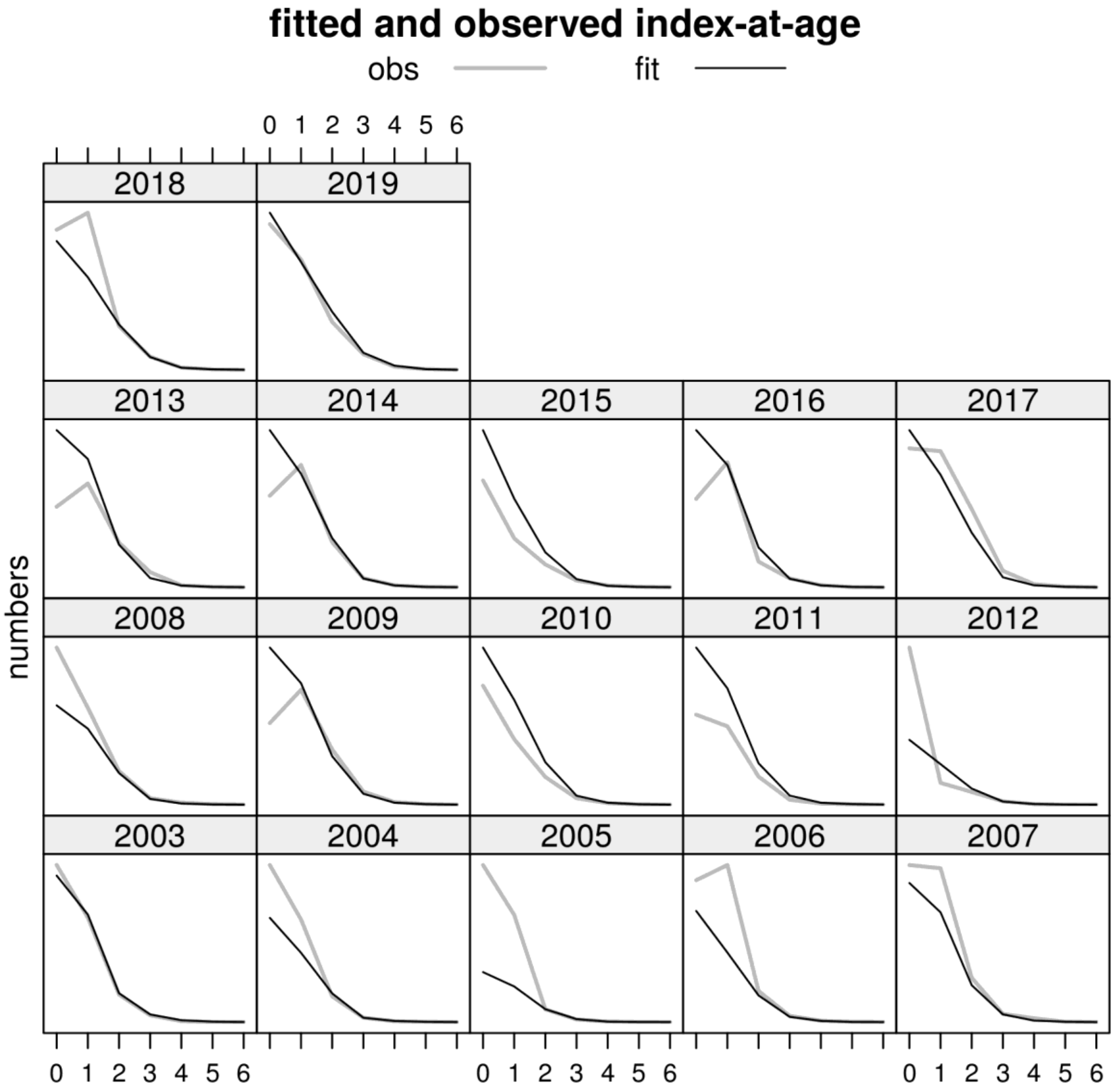


Figure 6.1.3.2.18 European hake in GSAs 17 and 18. Fitted and observed survey index at age

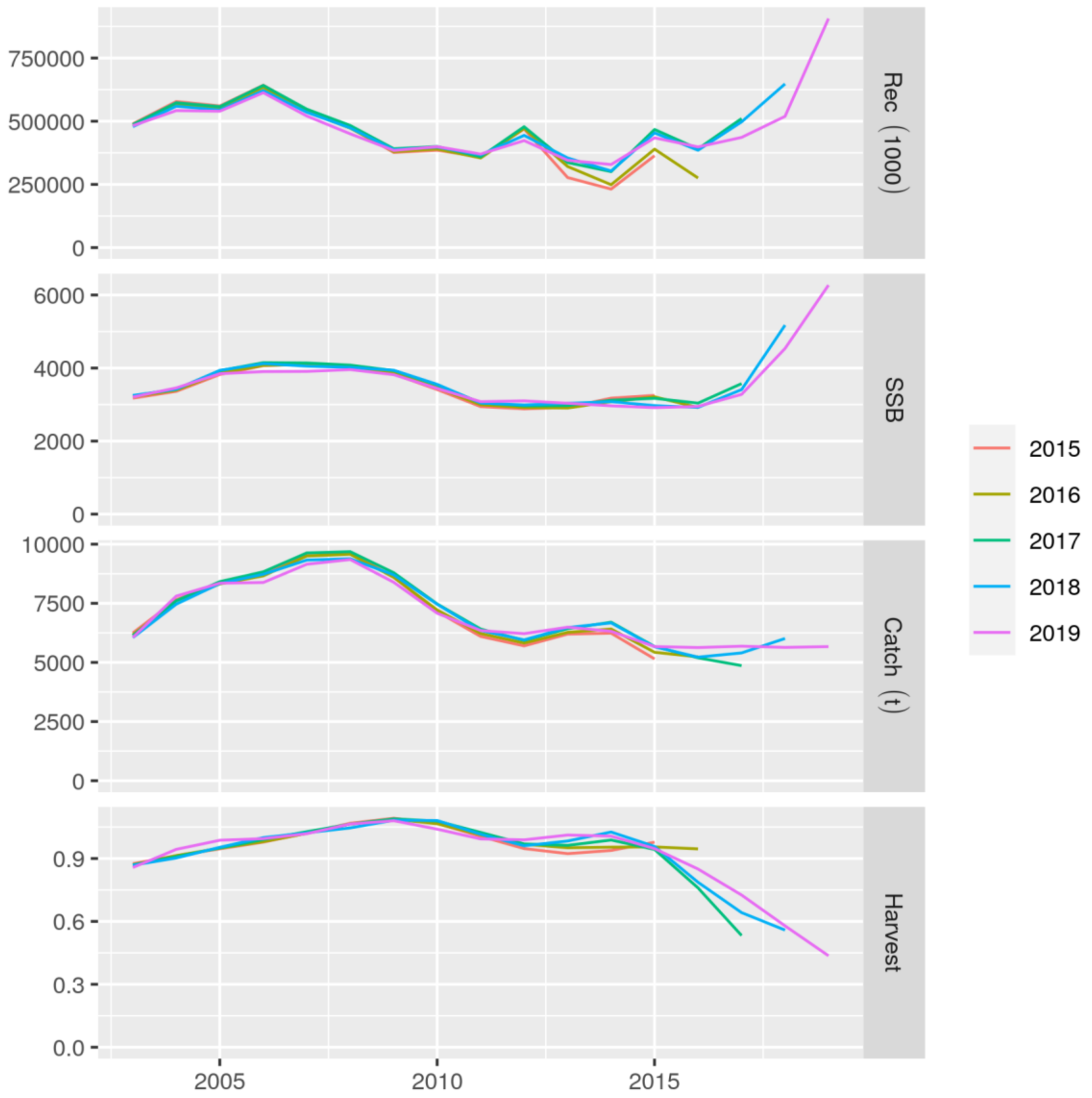


Figure 6.1.3.2.19 European hake in GSAs 17 and 18. Outputs of retrospective a4a runs carried out by omitting 1-3 years from the end of the time-series.

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

Stochastic forecasts for the period 2020 to 2022 were calculated using SS and based on the results of the SS3 stock assessment.

The basis for the choice of values is the decision of the GFCM benchmark. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} =0.41 terminal F (2019) from the SS3 assessment was used for F in 2020. Recruitment (age 0) for 2020 to 2022 has been estimated from the population results as the mean of the last 3 years (341,514).

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 2017-2019
$F_{ages\ 1\text{-}4}$ (2020)	0.41	F_{2019} used to give F status quo for 2020
Female SSB (2020)	4397 t	Stock assessment 1 January 2020

Variable	Value	Notes
R_{age0} (2020,2021,2022)	341,514	Mean of the last 3 years
Total catch (2020)	5565 t	Assuming F status quo for 2020

Table 6.1.5.2 European hake in GSAs 17 and 18: Catch options.

Rationale	F_{factor}	F_{bar} (1-4)	Catch 2019	Catch 2020	Catch 2021	**Female** SSB 2020	**Female** SSB 2021	**Female** SSB 2022	Change **Female** SSB 2020-2022 (%)	Change Catch 2019-2021 (%)
Zero catch	0	0	5361	5565	0	4397	5111	8549	94.4	-100.0
High long term yield (F_{MSY})	0.44	0.179	5361	5565	2789	4397	5111	7102	61.5	-48.0
F_{MSY} transition	0.84	0.34	5361	5565	4964	4397	5111	6004	36.5	-7.4
$F_{MSY\ lower}$	0.30	0.12	5361	5565	1937	4397	5111	7540	71.5	-63.9
$F_{MSY\ upper}$*	0.61	0.25	5361	5565	3767	4397	5111	6605	50.2	-29.7
Status quo	1	0.41	5361	5565	5749	4397	5111	5615	27.7	7.2
Different Scenarios	0.6	0.25	5361	5565	3699	4397	5111	6639	51.0	-31.0
	0.8	0.33	5361	5565	4761	4397	5111	6105	38.8	-11.2

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

Table 6.1.5.3 European hake in GSAs 17 and 18: Annual catch scenarios by area and gear assuming same catch proportions as 2019

Basis	Total catch (2021)	F_{total} (ages 1-4) (2021)	GSA 17 OTB	GSA 17 LLS	GSA 18 OTB	GSA 18 LLS
STECF advice basis						
F_{MSY} / MAP	2789	0.179	1383	59	1226	121
$F_{MSY\ Transition}$	4964	0.34	2462	105	2182	215
$F_{MSY\ lower}$	1937	0.12	961	41	852	84
$F_{MSY\ upper}$*	3767	0.25	1868	80	1656	163
Other scenarios						
Zero catch	0	0	0	0	0	0
Status quo	5749	0.41	2851	122	2527	249
60% of status quo	3699	0.25	1834	78	1626	160
80% of status quo	4761	0.33	2361	101	2093	206

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

A probabilistic forecast was also run to estimate the probabilities of the stock to fall below B_{lim} and $B_{trigger}$ in 2021 and 2022. The results are shown in Table 6.1.5.4 and Figure 6.1.5.1.

Table 6.1.5.4 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} 2021	Probability SSB<B_{lim} 2022	Probability SSB<$B_{trigger}$ 2021	Probability SSB<$B_{trigger}$ 2022
F_{upper}	0	0	0	0
F_{lower}	0	0	0	0
F_{MSY}	0	0	0	0
$F_{MSY\ transition}$	0	0	0	0
Status quo	0	0	<0.01	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

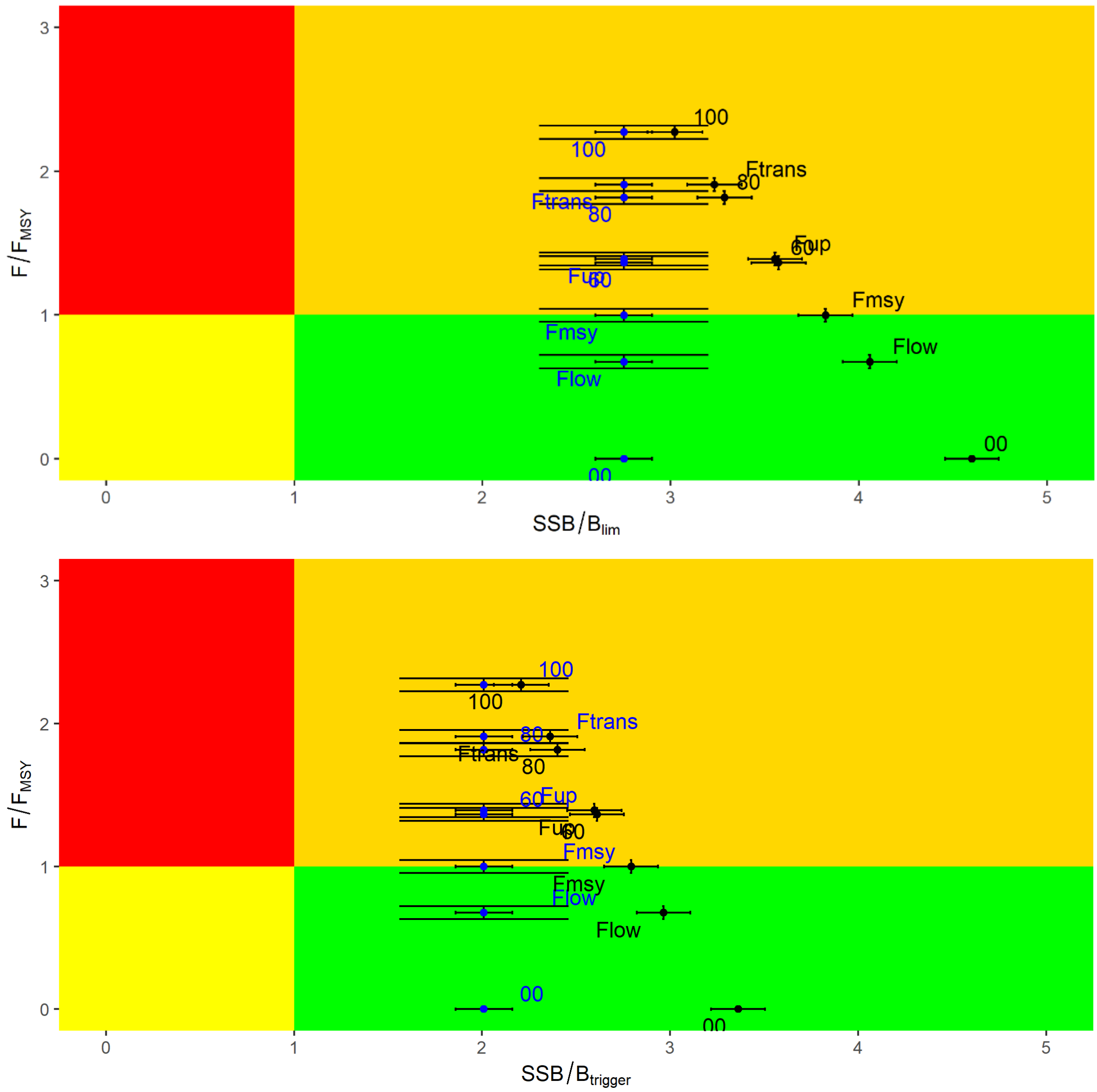


Figure 6.1.5.1 European hake in GSAs 17 and 18: Kobe plots for B_{lim} and $B_{trigger}$.

6.1.6 Data Deficiencies

The data used for the analyses come from the GFCM benchmark (2019) and the last year STECF EWG 19-16. However, the data from the last EU DCF official Data Call (2019) was scrutinized for issues.

The main issue in 2019 data was that Italy (GSA17) submitted landings in weight in duplicate, both at vessel length and not at vessel length basically doubling the total amount.

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).

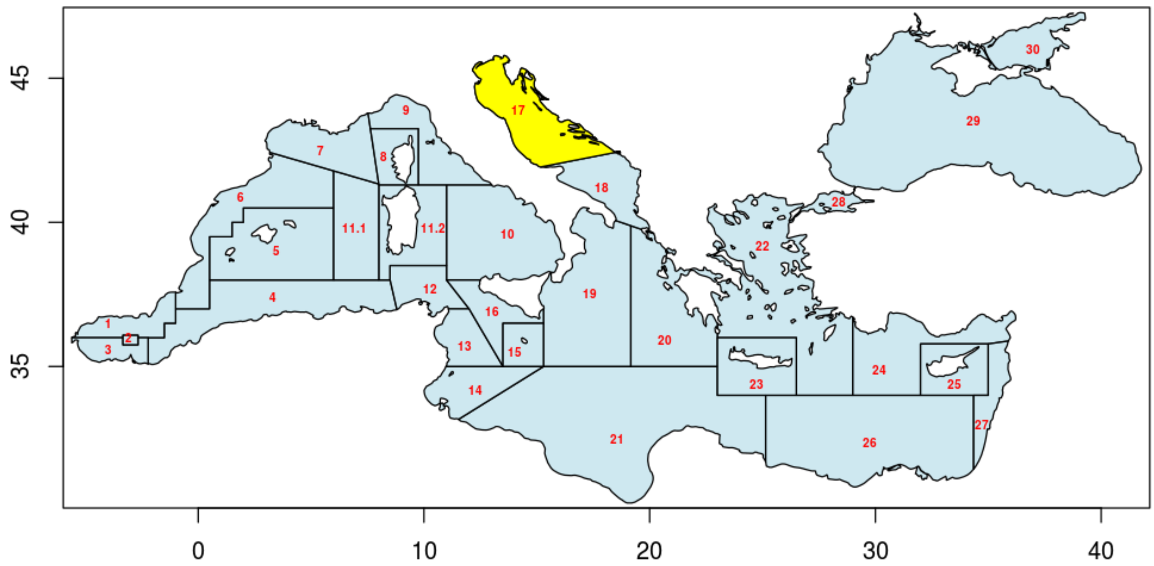


Figure 6.2.1.1 Geographical location of GSA 17.

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 SoleMon project show a higher concentration of reproducers outside the western coast of Istria (Fabi et al., 2009).

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 Adraitic to obtain new growth parameters. This procedure is not yet complete 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 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 (tab. 6.2.1.1) 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.

During GFCM WGSAD 2019 the a4a assessment developed during STECF EWG 19-16 was rejected as the growth parameters estimated within the working group were not considered reliable. A second assessment run in SS3 was presented and accepted during GFCM WGSAD 2019. A different set of growth parameters and a different vector of natural mortality (M) were used within the SS3 assessment (see tab. 6.2.1.3 and 6.2.1.4). The assessment accepted gave a very different perception of the stock from the one based on cohort to the more complete data set.

In order to account for the results presented within WGSAD a sensitivity analysis was run during EWG 20-15 to test the effect of variability of life history parameters within the assessment process. The first run was an update of the STECF 19-16 assessment using the same life history parameters (tab. 6.2.1.1 and 6.2.1.2). See the STECF EWG 19-16 report for details on how these were calculated.

Table 6.2.1.1 Sole in GSA 17 Growth parameters estimated fitting SoleMon LFDs in ELEFAN I during EWG 19-16.

Source	**Sensitivity**	L_{inf}	**k**	t_0	**Sex**
EWG 19-16	VBGP_1	40.50	0.31	-0.125	M+F

Table 6.6.1.2. Sole in GSA 17. Maturity and mortality at age vectors estimated during STECF 19-16.

	0	**1**	**2**	**3**	**4**	**5+**
Maturity	0.0	0.5	1.0	1.0	1.0	1.0
M_1	1.10	0.44	0.32	0.27	0.25	0.23

The same median values of length-weight relationship parameters a (0.00735) and b (3.0585) from EWG 19-16 were used to define the mean weight at age matrix.

To run a stepwise sensitivity analysis the a4a assessment model was rerun first substituting the Von Bertalanffy growth parameters (VBGPs) with the ones presented during WGSAD 2019 (Table 6.2.1.3) (therefore in combination with the M estimated during STECF EWG 19-16), secondly substituting the M vector. The M vector was first substituted with the vector (M_2) presented during WGSAD 2019 (Table 6.2.1.4) and secondly with a vector (M_3) estimated within STECF EWG 20-15 using the STECF EWG 20-15 VBG parameters following the procedure used during WGSAD 2019 (Table 6.2.1.4): averaging three M vectors obtained with ProdBiom, Then et al.(2015) and Chen and Watanabe (1989) (Fig. 6.2.1.2). The substitution of the VBGPs and of the M vector were done separately to be able to quantify the contribution of each set of parameters to the variability on the assessment model outputs. A final run was than implemented using both the VBGPs and M vector presented during WGSAD 2019 to observe the effect on the assessment outputs of the combined parameters (Fig. 6.2.1.2). The combination of different parameters used during the sensitivity analysis is summarized in table 6.2.1.5.

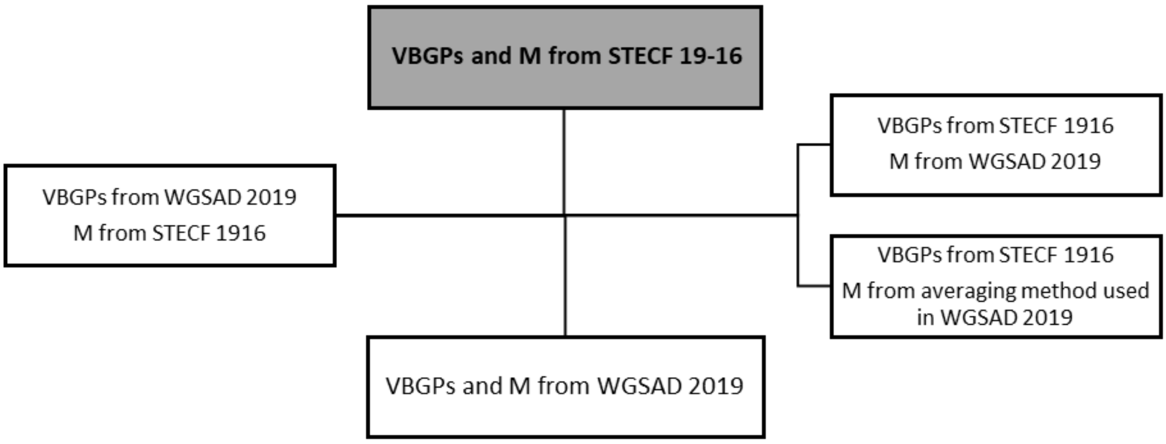


Figure 6.2.1.2 Sole in GSA 17. Graphical representation of the sensitivity analysis ran.

Table 6.2.1.3 Sole in GSA 17 Growth parameters estimated as an average of the parameters estimated by Fabi et al. (2009) and from the SoleMon survey ALK (WGSAD, 2019).

Source	VBGP	L_{inf}	k	t_0	Sex
WGSAD 2019	VBGP_2	35	0.57	-0.38	M+F

Table 6.2.1.4. Sole in GSA 17. Mortality at age vectors used in the sensitivity analysis.

Source	M	0	1	2	3	4	5+
WGSAD 2019	M_2	1.18	0.67	0.62	0.57	0.52	0.47
STECF 20-16	M_3	1.57	0.80	0.55	0.45	0.40	0.37

Table 6.2.1.5. Sole in GSA 17. Scenarios of the sensitivity analysis.

Scenario	Von Bertalanffy growth parameters	Natural mortality vector
1	VBGP_1	M_1
2	VBGP_2	M_1
3	VBGP_1	M_2
4	VBGP_1	M_3

5	VBGP_2	M_2

To obtain more information on the growth parameters (L_{inf}, K, t0) estimated for *Solea solea*, all the available information on FishBase (https://www.fishbase.se/search.php) were downloaded and graphed below. Figure 6.2.1.3 shows the whole range of K available in the dataset, while in figure 6.2.1.4 the range is subdivided by sex and geographical area.

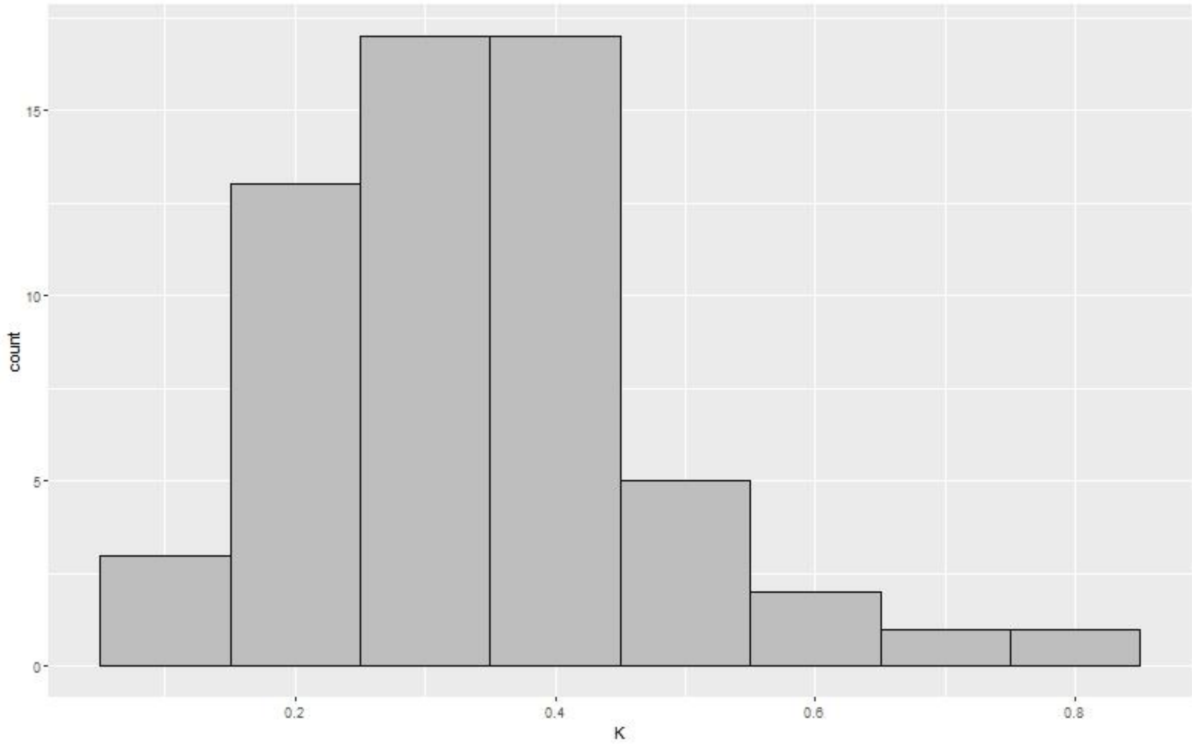


Figure 6.2.1.3 Sole in GSA 17. Complete range of K values available from the literature and published on FishBase.

A linear regression between L_{inf} and K values available from the FishBase website was explored (fig. 6.1.2.5) to show the correlation present between growth parameters and that high K values will correspond to lower values of L_{inf} in order to fit the growth curve to either length or age data.

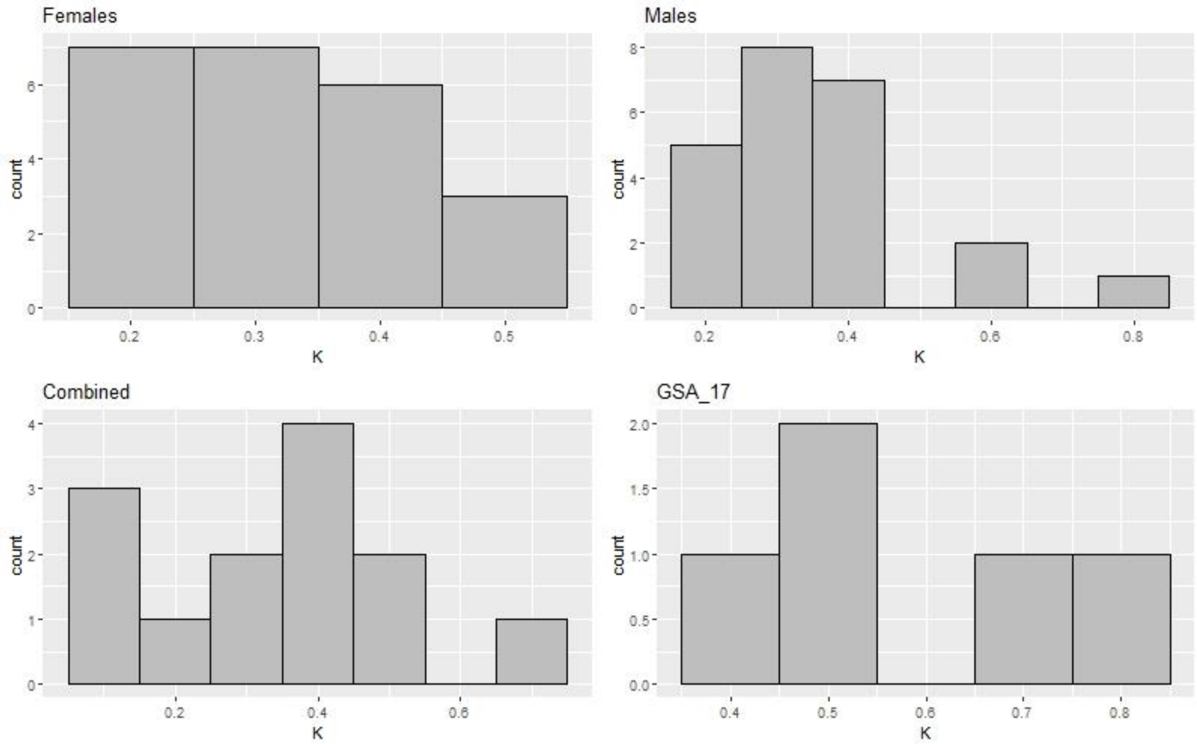


Figure 6.2.1.4 Sole in GSA 17. Subsets of K values estimated for females, males, sex combined and for GSA_17.

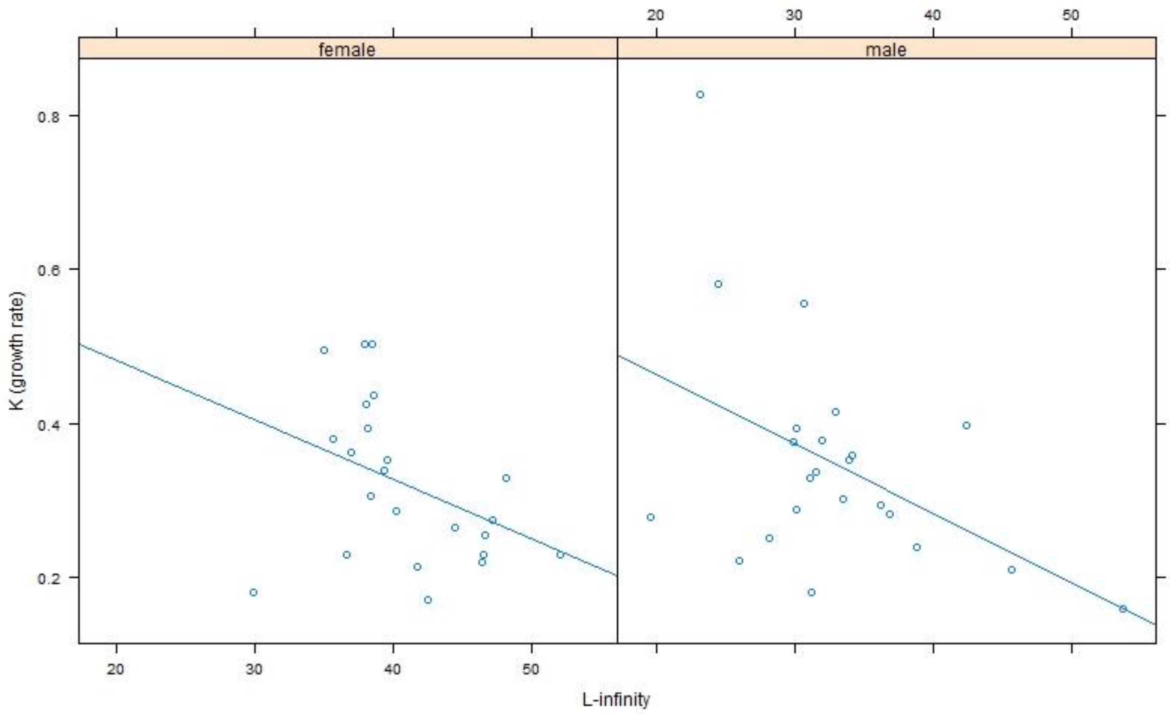


Figure 6.2.1.5 Sole in GSA 17. Linear regression of L_{inf} against K.

6.2.2 Data

6.2.2.1 Catch (landings and discards)

As discards for this species are negligible, the assessment section on landings values will be referring to catch values.

The common sole is a very important commercial species in the central and northern Adriatic Sea (Ghirardelli, 1959; Piccinetti, 1967; Jardas, 1996; Vallisneri et al., 2000; Fabi et al., 2009). It is a target species of set netters (GNS and GTR) and rapido trawlers (TBB), and it represents an accessory species for otter trawlers (OTB). Catches distribution by length, year and country are shown in figures 6.2.2.1.1, 6.2.2.1.2 and 6.2.2.1.3. Italian catches are dominated by smaller individuals mainly caught by TBB and OTB, a smaller proportion of individuals is caught by GNS. On the contrary Croatian and Slovenian catches are dominated by bigger individuals caught by GTR.

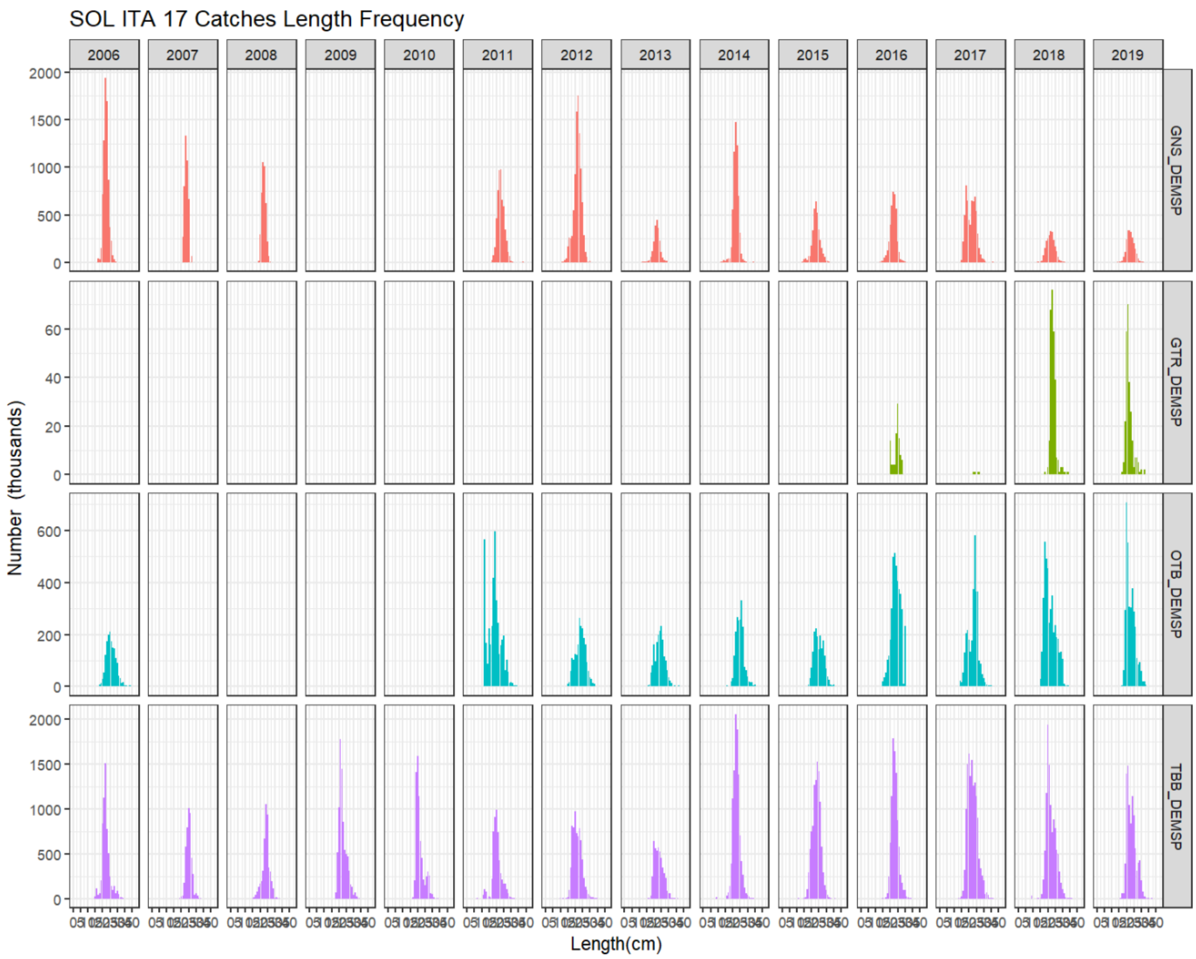


Figure 6.2.2.1.1 Sole in GSA 17. Length frequency distribution of Italian catches.

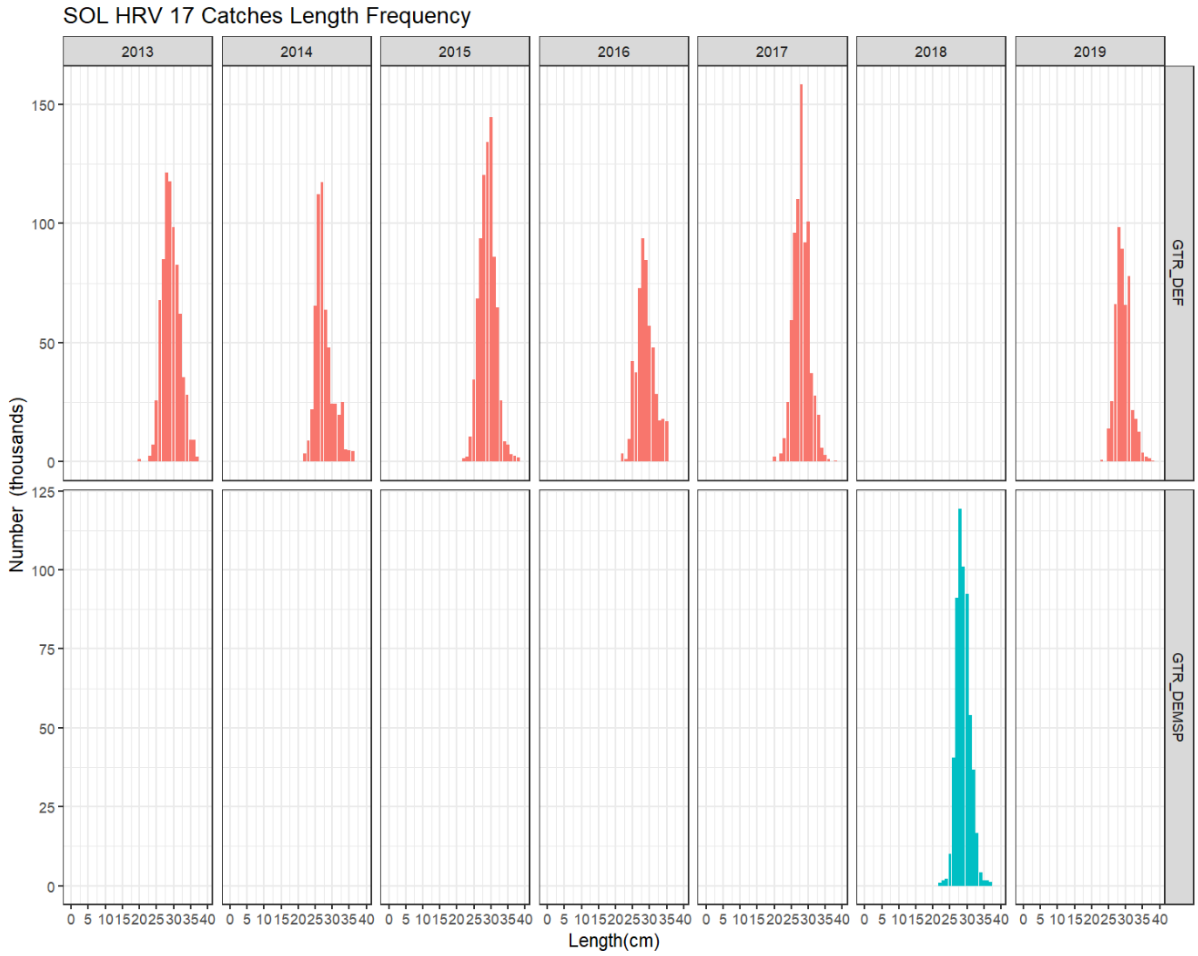


Figure 6.2.2.1.2 Sole in GSA 17. Length frequency distribution of Croatian catches.

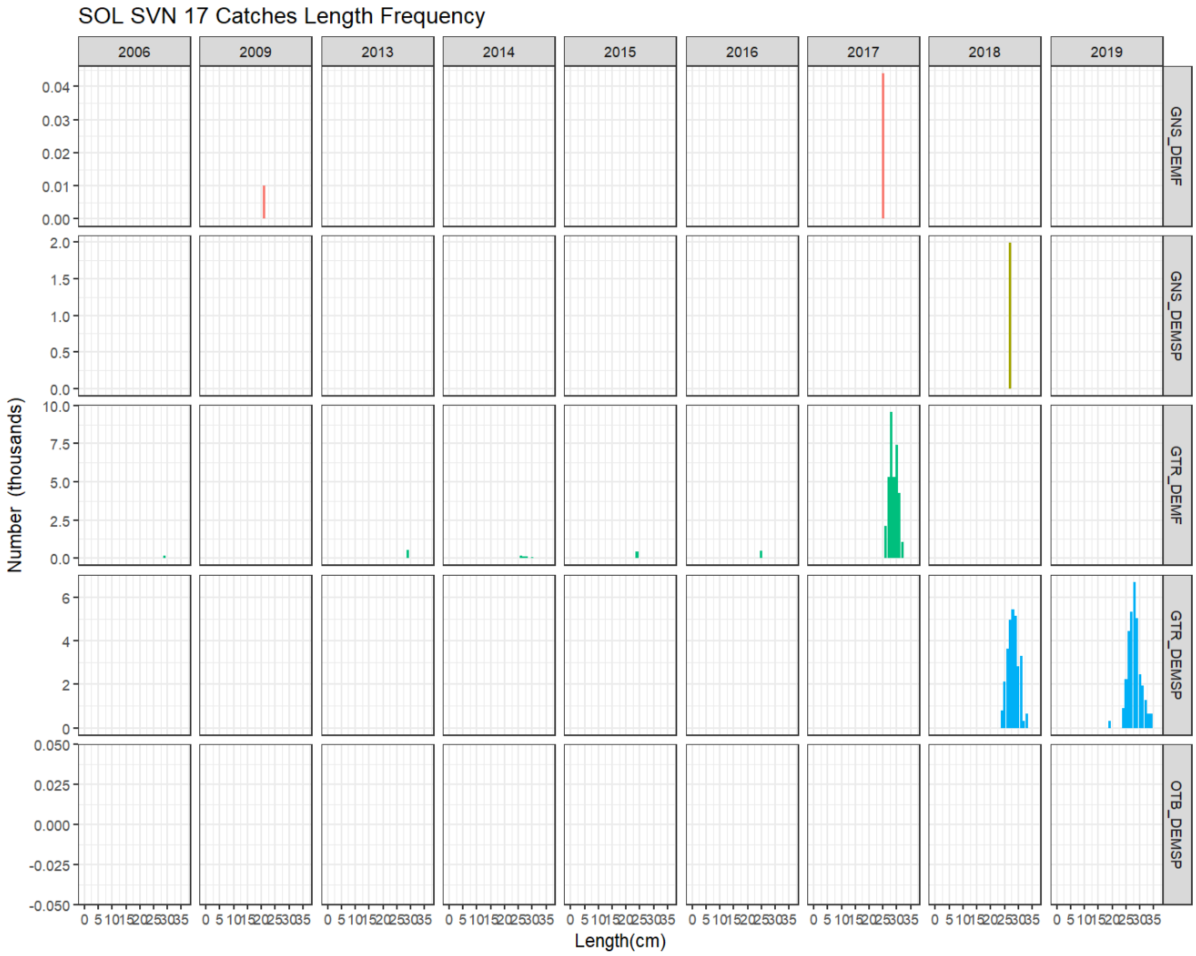


Figure 6.2.2.1.3 Sole in GSA 17. Length frequency distribution of Slovenian catches.

TBB has become dominant in the Italian catches since 2014, while GNS has been decreasing total catches since the same period and OTB catches are increasing slightly since 2015 (fig. 6.2.2.1.4). Croatian total catches for GTR are reported only since 2013 and are stable across years (fig.6.2.2.1.5), while GTR Slovenian catches have slowly increased until 2013 and then stabilized (fig.6.2.2.1.6).

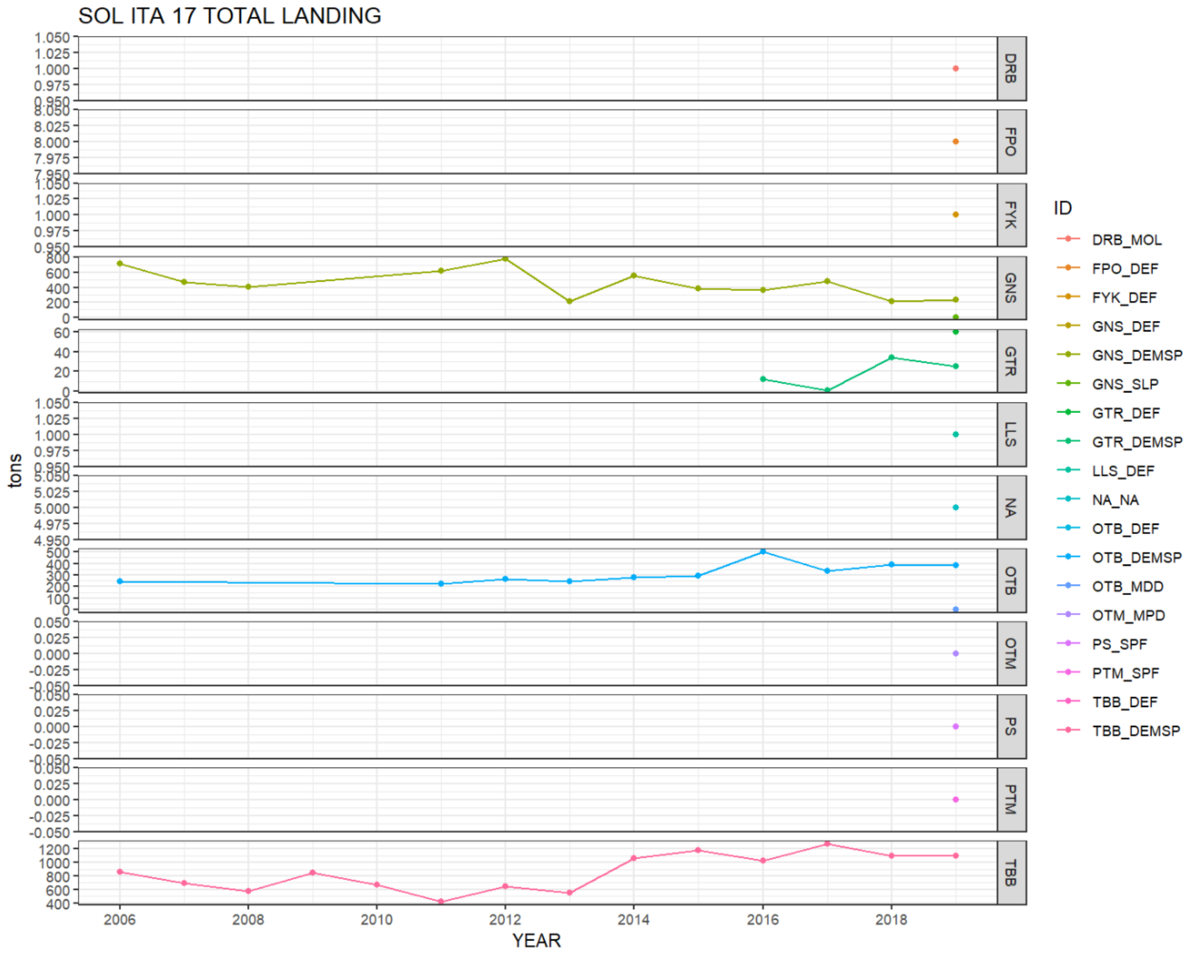


Figure 6.2.2.1.4 Sole in GSA 17. Italian total catches by gear and year.

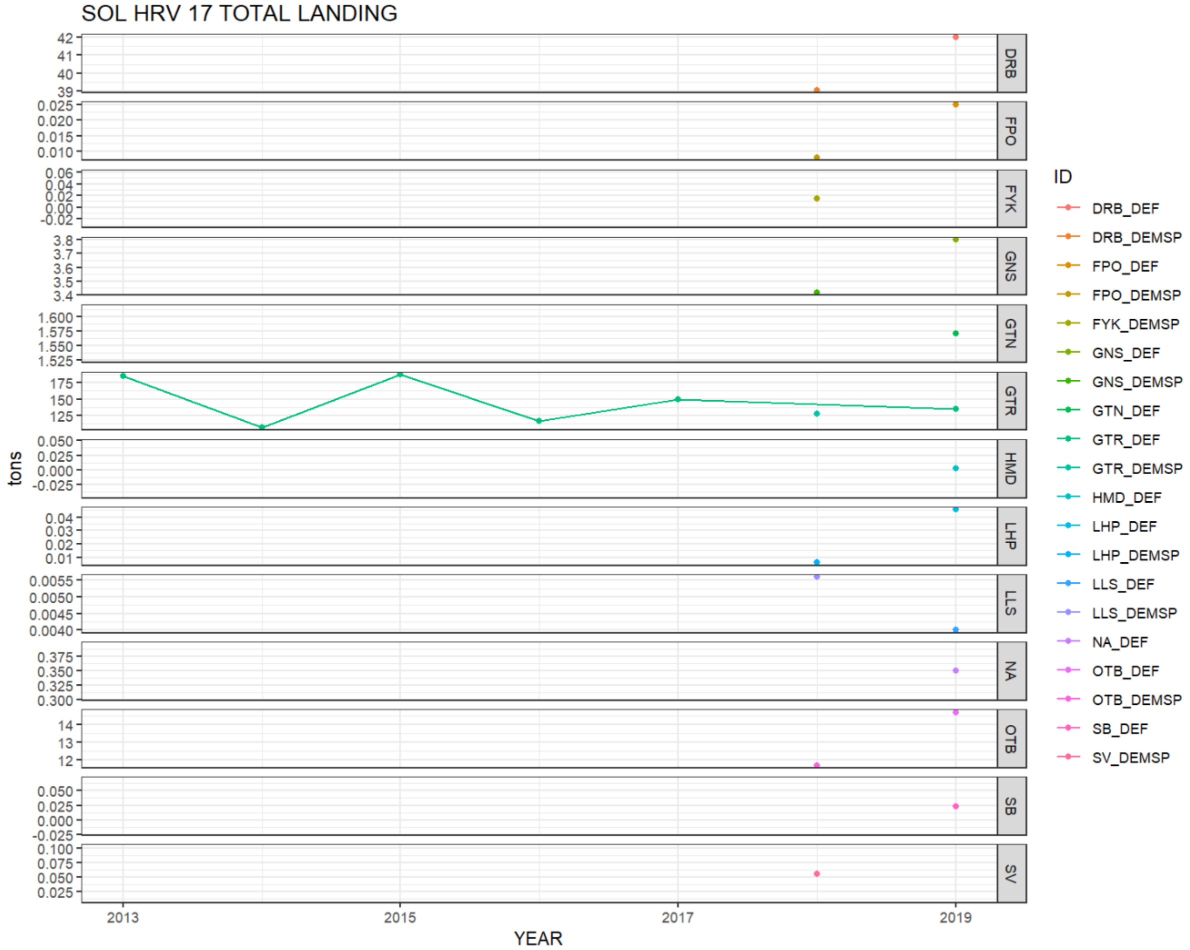


Figure 6.2.2.1.5 Sole in GSA 17. Croatian total catches by gear and year.

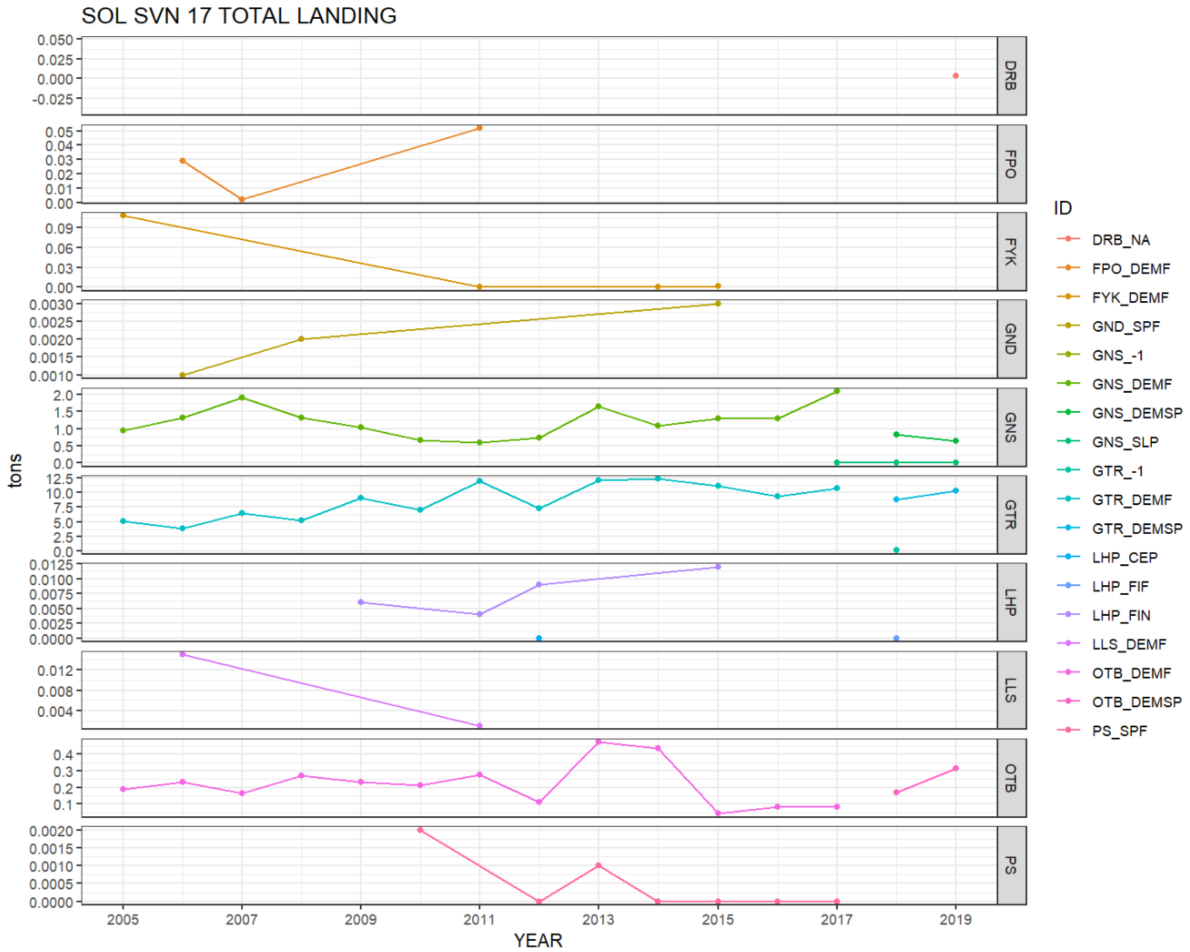


Figure 6.2.2.1.6 Sole in GSA 17. Slovenian total catches by gear and year.

Table 6.2.2.1.1 Sole in GSA 17. Total landings in tonnes by country, gear and year.

	GTR_HRV	GTR_SVN	GNS_ITA	OTB_ITA	TBB_ITA
2005	-	5.08	-	-	-
2006	-	3.86	717	243	863
2007	-	6.40	466	-	692
2008	-	5.24	410	-	576
2009	-	9.03	-	-	850
2010	-	7.06	-	-	665
2011	-	12.04	622	224	414
2012	-	7.33	781	266	640
2013	185	12.19	207	242	545
2014	106	12.35	562	282	1060
2015	187	11.19	388	291	1178
2016	116	9.36	368	504	1026
2017	150	10.81	485	338	1274
2018	128	8.88	212	393	1094
2019	135	10.36	231	382	1093

6.2.2.2 Effort

The effort data are available for GSA17. In Table 6.2.2.2.1 fishing effort is reported as fishing days by country for the main gears targeting common sole in GSA 17.

Table 6.2.2.2.1. Sole in GSA 17. Effort as fishing days.

	GTR_HRV	GTR_SVN	GNS_ITA	OTB_ITA	TBB_ITA
2002	-	-	335599	124529	-
2003	-	-	272040	125106	-
2004	-	-	85709	133030	15302
2005	-	1313	122373	121674	11717
2006	-	1263	107490	104056	15424
2007	-	1969	88820	93795	20276
2008	-	2184	85844	86701	13394
2009	-	2332	104006	91044	13649
2010	-	2388	99265	82962	12392
2011	-	3080	117526	80187	8759
2012	27363	3025	107129	70603	10301
2013	29234	3811	66285	66522	7973
2014	27101	3955	78000	66492	10814
2015	28685	3856	57257	61297	9937
2016	25356	3196	61986	61865	9004
2017	25075	3453	43674	72379	9352
2018	28765	3046	43081	75940	11849
2019	29301	2972	45631	65911	10989

6.2.2.3 Survey data

With reference to the SoleMon project, different rapido trawl fishing surveys were carried out in GSA 17 from 2005 to 2019: two systematic “pre-surveys” (spring and fall 2005), followed by random haul location surveys in spring and fall 2006, and then a sequence of fall surveys from 2007 to 2019. The surveys have a random stratified design with three depth strata (0-30 m, 30-50 m, 50-100m). Hauls were carried out during the day using 2-4 rapido trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83).

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.

The abundance and biomass indices by GSA 17 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 area in GSA 17:

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as standard deviation.

Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA.

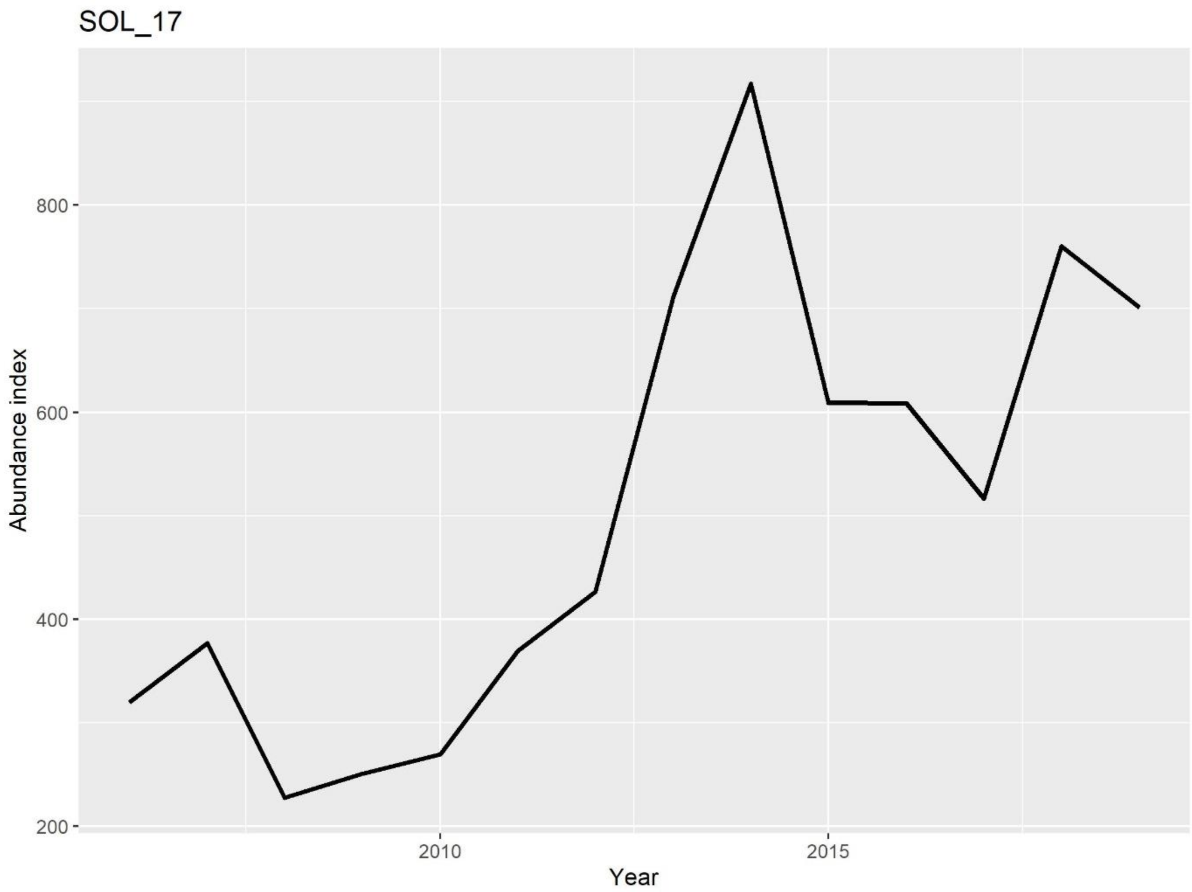


Figure 6.2.2.3.1. Sole in GSA 17. Abundance index by year obtained from Solemon survey data.

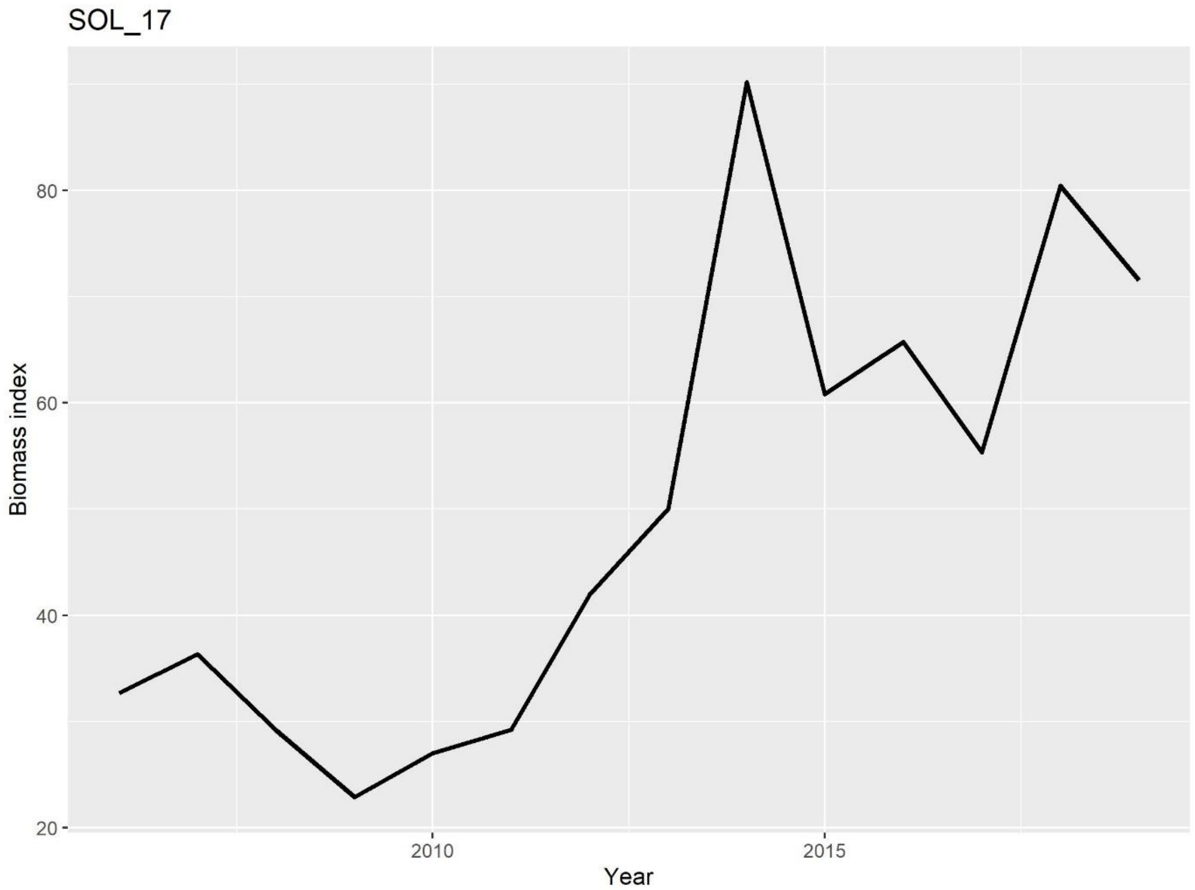


Figure 6.2.2.3.2. Sole in GSA 17. Biomass index by year obtained from Solemon survey data.

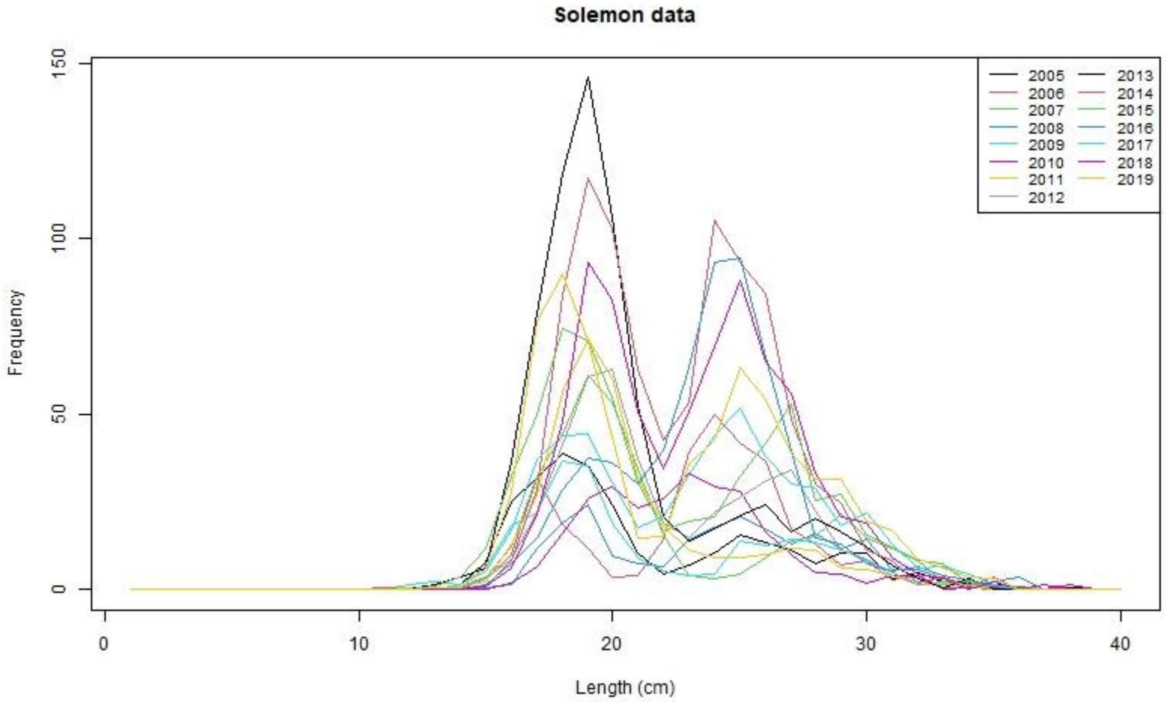


Figure 6.2.2.3.3 Sole in GSA 17. Length frequency distributions from Solemon data 2006-2019.

6.2.3 Sensitivity analysis and assessment results

The sensitivity analysis was run within the FLR framework running the statistical catch at age assessment with the library FLa4a.

Age based matrices to input in the assessment models were obtained slicing the length frequency distributions from commercial data (fig. 6.2.2.1.1, 6.2.2.1.2 and 6.2.2.1.3) and from Solemon survey data (fig. 6.2.2.3.3) with two different sets of Von Bertalanffy growth parameters (tab. 6.2.1.1 and 6.2.1.3). In both catches and survey, a plus group at age 5 was set. Age based matrices of commercial catches were produced by country and then combined into a single catch at age matrix (fig. 6.2.3.1 and 6.2.3.2) as a weighted average.

Three natural mortality vectors (tab. 6.2.1.2 and 6.2.1.4) were used within the sensitivity analysis.

The number of individuals by age was SOP corrected [SOP = Catch / Σa (total catch numbers at age a x catch weight-at-age a)].

F_{bar} range was fixed at 1-4.

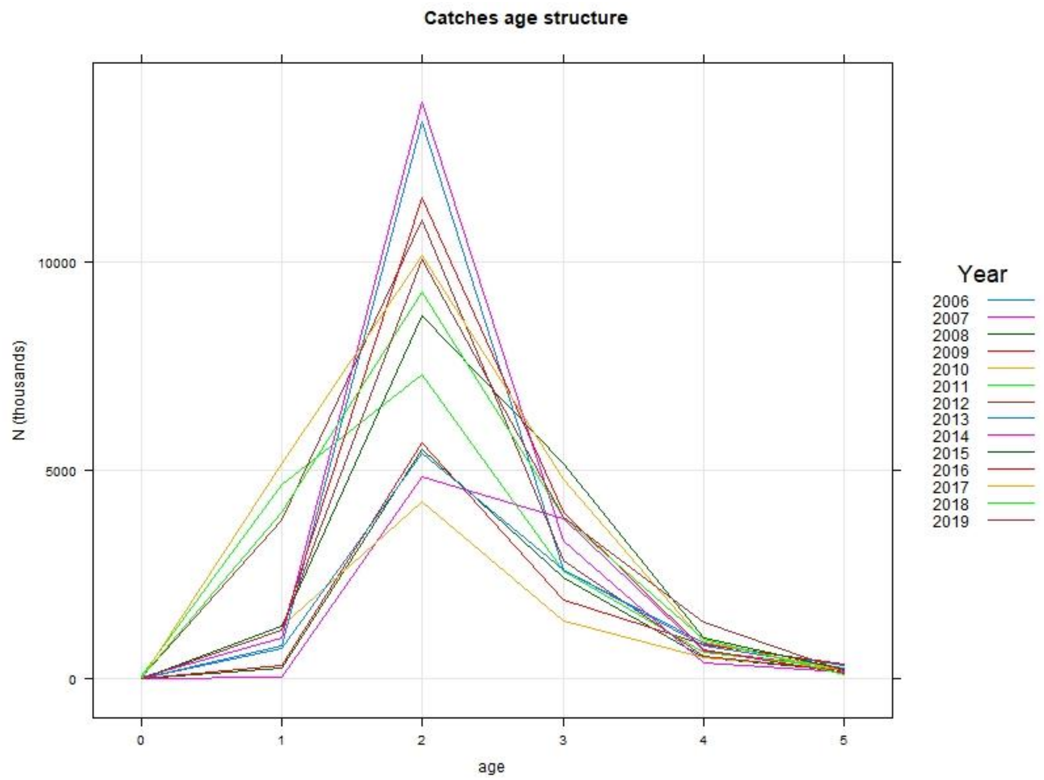


Figure 6.2.3.1 Sole in GSA 17. Catch-at-age distribution by year of the catches (2006-2019) obtained using VBGP_1.

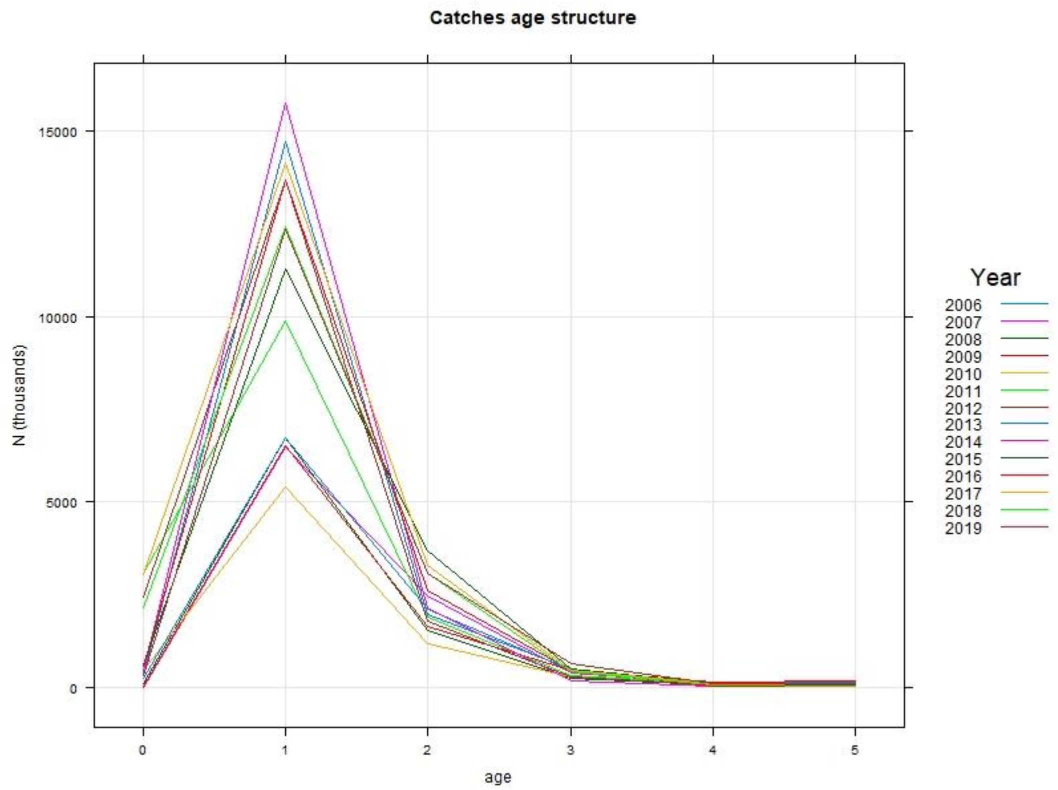


Figure 6.2.3.2 Sole in GSA 17. Abundance at age distribution by year of the Solemon survey (2006-2019) obtained using VBGP_2.

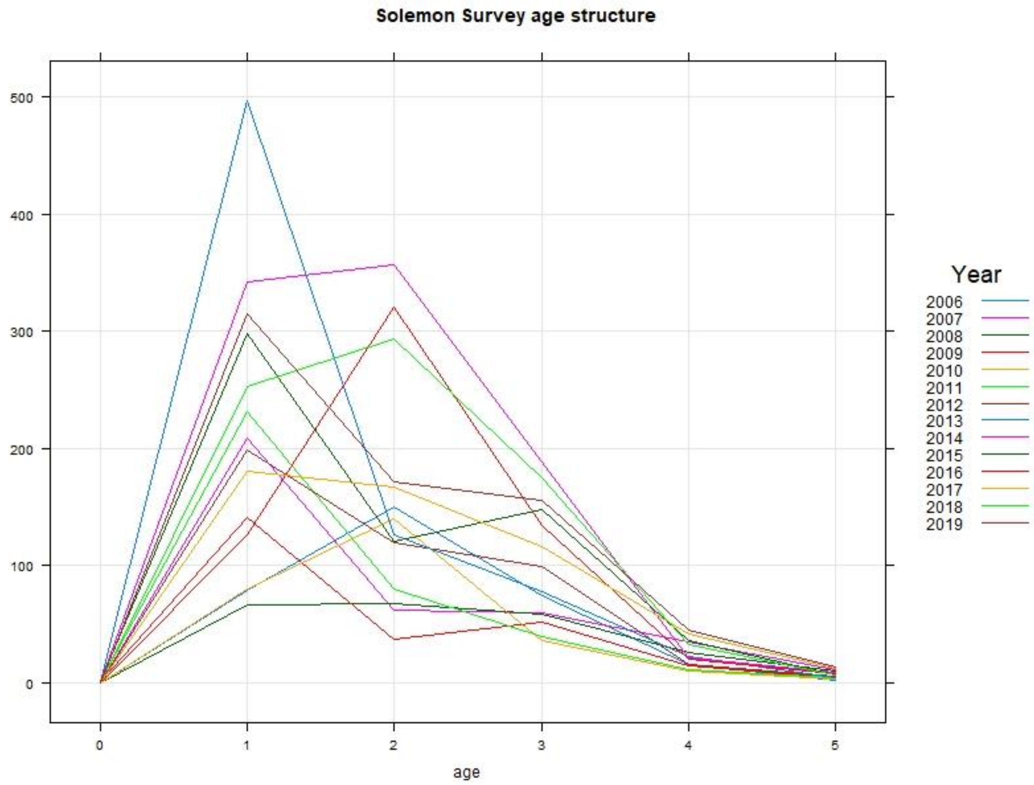


Figure 6.2.3.3 Sole in GSA 17. Abundance at age distribution by year of the Solemon survey (2006-2019) obtained using VBGP_1.

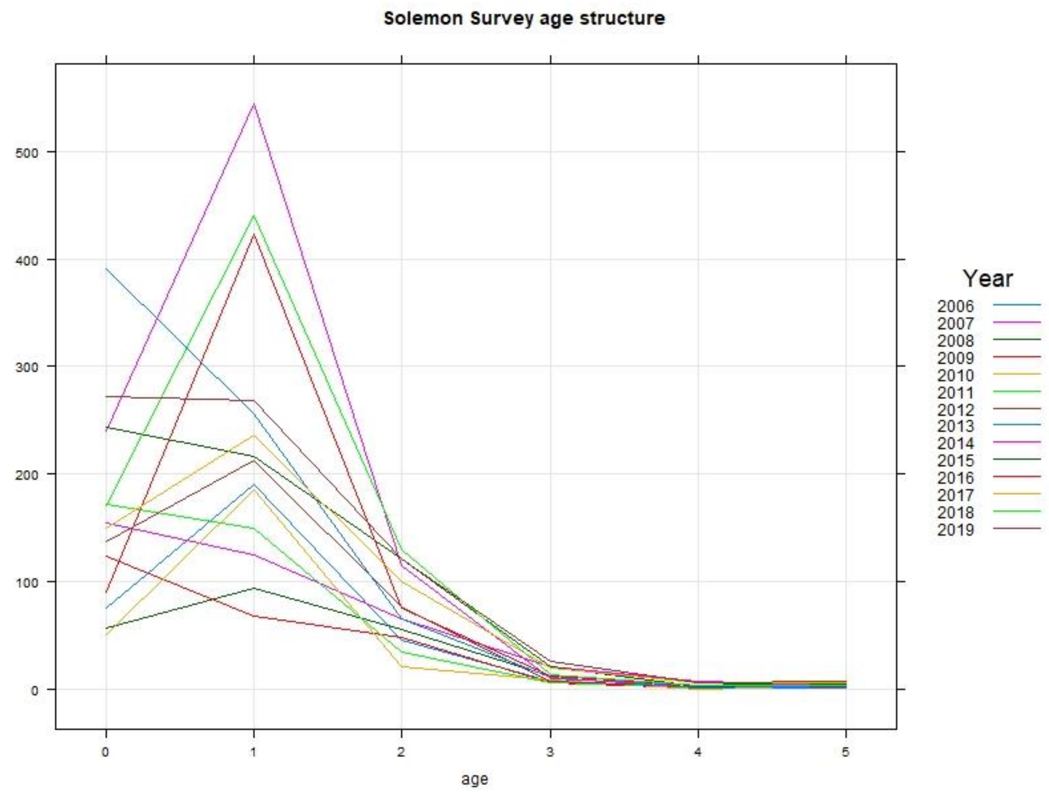


Figure 6.2.3.4 Sole in GSA 17. Abundance at age distribution by year of the Solemon survey (2006-2019) obtained using VBGP_2.

Table 6.2.3.1 Sole in GSA 17. Total catches by year after SOP correction (tons; discards are negligible).

Year	Total Catch
2006	2022
2007	1367
2008	1126
2009	1161
2010	858
2011	1518
2012	1859
2013	1247
2014	2040
2015	2045
2016	2027
2017	2260
2018	1925
2019	1988

Table 6.2.3.2 Sole in GSA 17. Mean weight-at-age matrix (kg) obtained using VBGP_1.

age	2006	2007	2008	2009	2010	2011	2012

0	0.010358	0.010358	0.010358	0.010358	0.010358	0.010078	0.010673
1	0.051407	0.055931	0.053276	0.058735	0.053122	0.044292	0.049625
2	0.094897	0.108274	0.101933	0.094551	0.090941	0.091841	0.094501
3	0.160678	0.157197	0.157198	0.163283	0.164848	0.160013	0.156515
4	0.238686	0.238659	0.234828	0.23847	0.23818	0.237413	0.237705
5+	0.333899	0.333076	0.334614	0.331655	0.333408	0.338959	0.328072
age	2013	2014	2015	2016	2017	2018	2019
0	0.010167	0.006024	0.009728	0.007302	0.010358	0.006044	0.010358
1	0.054143	0.052715	0.053101	0.052143	0.051818	0.052676	0.056149
2	0.094885	0.096637	0.099978	0.098513	0.096296	0.090803	0.092206
3	0.162753	0.156533	0.158531	0.15878	0.15752	0.161535	0.160251
4	0.238843	0.235281	0.2355	0.23764	0.234019	0.233244	0.234149
5+	0.331836	0.334107	0.321579	0.329685	0.318208	0.321365	0.324519

Table 6.2.3.3 Sole in GSA 17. Mean weight-at-age matrix (kg) obtained using VBGP_2.

age	2006	2007	2008	2009	2010	2011	2012
0	0.041427	0.046295	0.046188	0.049915	0.041225	0.035601	0.043574
1	0.096764	0.115863	0.107247	0.096912	0.089888	0.091174	0.095076
2	0.181196	0.176064	0.180988	0.183175	0.182706	0.179347	0.177041
3	0.252017	0.252234	0.252807	0.253631	0.252361	0.253285	0.2528
4	0.294977	0.294977	0.294977	0.294977	0.294977	0.294977	0.294977
5+	0.361623	0.360551	0.363536	0.359838	0.360415	0.368436	0.355384
age	2013	2014	2015	2016	2017	2018	2019
0	0.043034	0.04131	0.045676	0.043895	0.046217	0.04567	0.046094
1	0.098001	0.098918	0.104299	0.101427	0.096527	0.091086	0.095581
2	0.181258	0.17327	0.176442	0.175393	0.175982	0.180164	0.183869
3	0.254019	0.25255	0.251037	0.246203	0.248232	0.249665	0.251763
4	0.294977	0.294977	0.294977	0.294977	0.294977	0.294977	0.294977
5+	0.359415	0.353218	0.359253	0.353472	0.344117	0.354131	0.35052

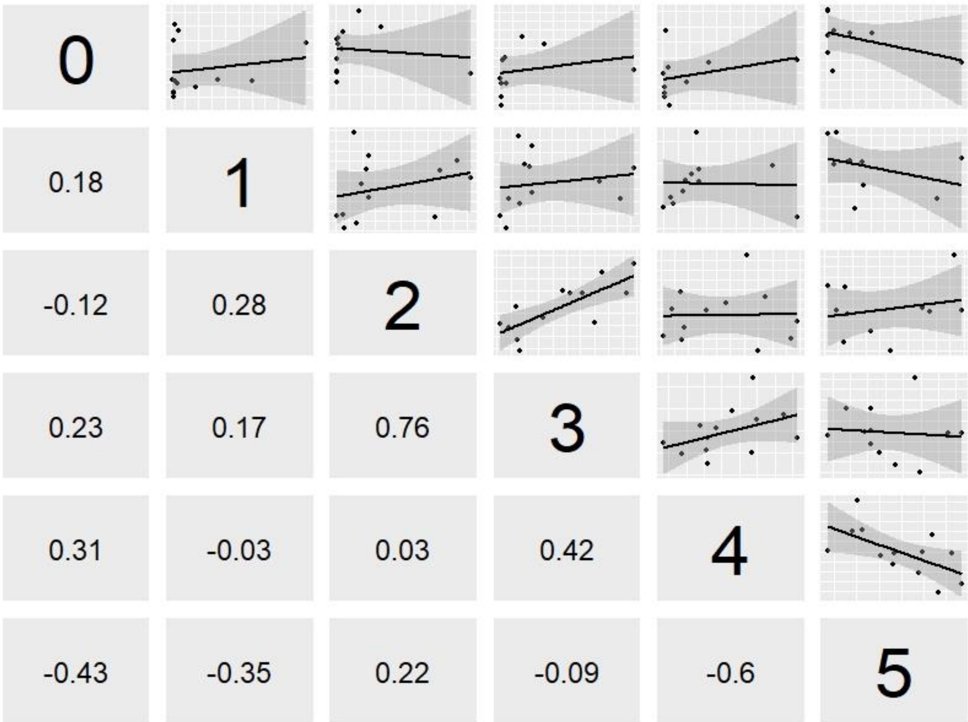


Figure 6.2.3.10 Sole in GSA 17. Internal consistency of the catch-at-age data obtained using VBGP_1.

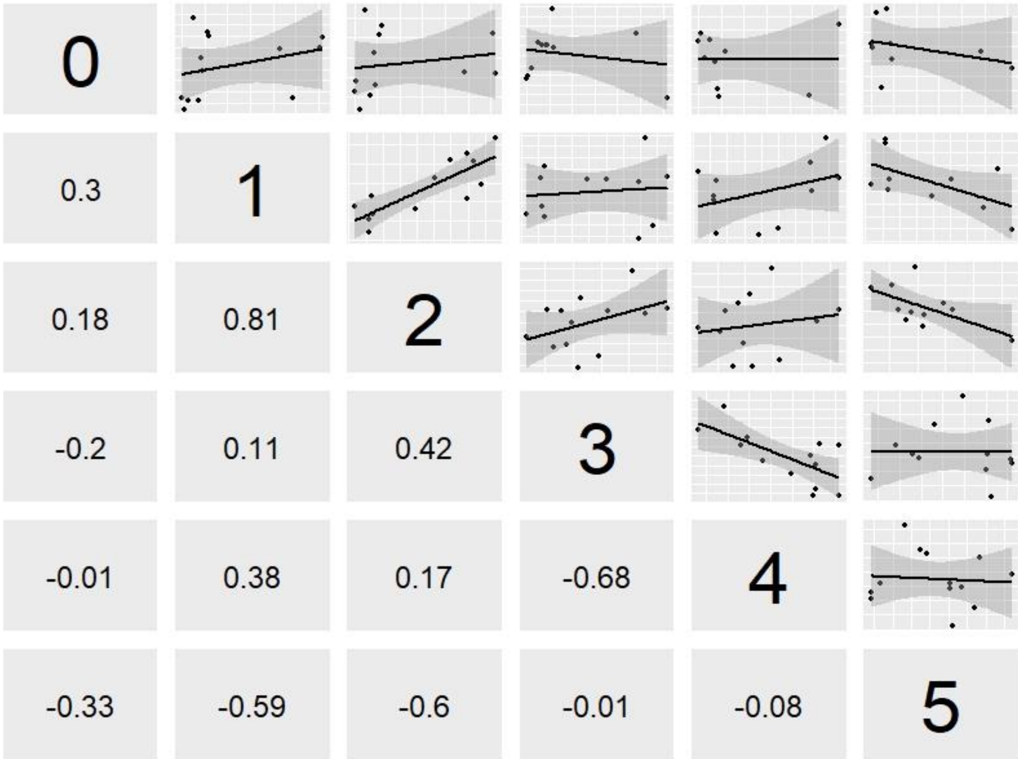


Figure 6.2.3.11 Sole in GSA 17. Internal consistency of the catch-at-age data obtained using VBGP_2.

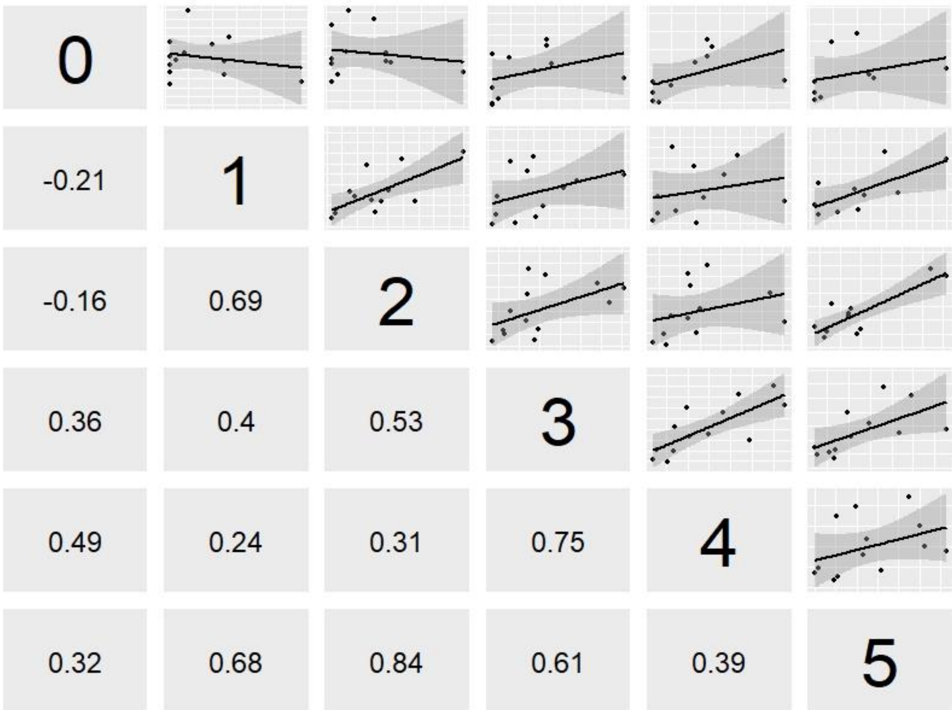


Figure 6.2.3.12 Sole in GSA 17. Internal consistency of the abundance-at-age data of the Solemon survey obtained using VBGP_1.

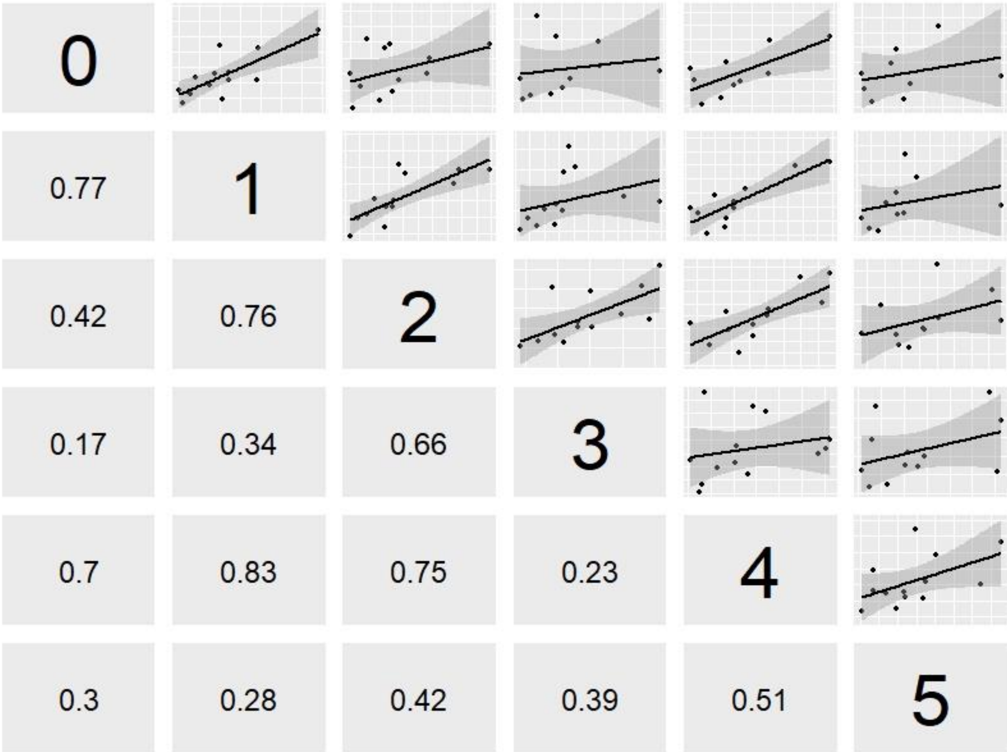


Figure 6.2.3.13 Sole in GSA 17. Internal consistency of the abundance-at-age data of the Solemon survey obtained using VBGP_2.

The a4a assessment models were run to estimate the reference points and quantify the variation introduced by the variation of input parameters within the sensitivity analysis. From the sensitivity analysis resulted that the estimation of the state of the stock varied significantly testing the two different sets of Von Bertalanffy growth parameters (VBGP_1 and VBGP_2) and testing the three different sets of natural mortality vectors (M_1, M_2 and M_3). Therefore, the group supports the suggestion of WGSAD 2019 that a benchmark should be held for the stock of Common sole in GSA 17.

Scenario 1 and scenario 5, being the extreme cases, were run fitting two different assessment models chosen evaluating the best set of diagnostics and the best fit of the estimated catches to the observed ones. Scenario 2, 3 and 4 were ran fitting the same model settings for scenario 1.

6.2.4 Reference Points

The STECF EWG 18-02 recommended using $F_{0.1}$ as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object resulting from the outputs of the a4a assessment.

The reference points here presented have the only aim of showing the variability of outputs observed in the sensitivity analysis when modifying input parameters.

In Table 6.2.4.1 are reported the reference points obtained from the sensitivity analysis, from scenario 1 to scenario 5 the stock evaluation varies from a state of high overexploitation to a state of under exploitation. The intermediate scenarios where only the growth parameters of only the mortality vector are substituted within the analysis, show intermediate levels of exploitation of the stock. Therefore, the contribution of the VBGPs and the M vector to the variation of reference points is equally shared as there is no evidence that one parameter is introducing a greater variability than the other. The extreme cases are represented by scenario 1 and scenario 5: the first one used input parameters estimated during EWG 19-16 and the second one used input parameters presented during WGSAD 2019.

Table 6.2.4.1. Sole in GSA 17. Outputs of scenarios of the sensitivity analysis.

Scenario	Von Bertalanffy growth parameters	Natural mortality vector	F0.1	Fcurrent	F0.1/Fcurrent
1	VBGP_1	M_1	0.182	0.645	3.54
2	VBGP_2	M_1	0.325	0.661	2.04
3	VBGP_1	M_2	0.389	0.503	1.29
4	VBGP_1	M_3	0.292	0.558	1.91
5	VBGP_2	M_2	0.629	0.50	0.79

Conclusions to stepwise sensitivity analysis to growth parameterisation and natural mortality.

The state of stock results shown in Table 6.2.4.1 show that the conclusions of the assessment depend heavily on the growth and to a less though also important extent on the choice of natural mortality. Validated age information to verify the likely growth is would be a considerable aid to resolving the issues. The aging data presented in WGSAD 2019 implies a growth rate in the first year that is very high for sole, and the updated method employed by Fabi et al 2009 when applied to the full time series gives growth more comparable to other sole stocks. Though cohort fitting work more or less equally well for either growth model, with good agreement for a few years though the ages are displaced by one year. The M vectors chosen vary but all imply high mortality for sole in the first year, and this is unusual for this species. There are a considerable number of issues to be resolved, and the EWG 20-15 would fully support a benchmark approach. Under these circumstances the EWG is currently unable to recommend a specific assessment.

6.2.5 Short term Forecast and Catch Options

Since no a4a assessment was chosen to give catch advice due to the high variability observed in the sensitivity analysis, the advice was based on the rate of change of the survey biomass index in the last five years following the ICES procedure for category 3 stocks.

The index of biomass change was obtained by dividing the mean of the last two years (2018-2019) by the mean of the previous three years (2015-2017) and resulted in a value of 1.25 (75.99276/ 60.63066 = 1.253372) (fig. 6.2.5.1 1 and Table 6.2.5.1). As the index is higher than 1.2 the uncertainty cap of 1.2 is applied and given the sensitivity analysis above the state of the stock is considered uncertain therefore STECF 20-15 advises to apply the -20% precautionary buffer on the index calculation bringing it down to a value of 0.96 (Table 6.2.5.1). STECF 20-15 advises to increase the total catch by 1% relative to the total catch in 2019 (1940 t) equivalent to catches of no more than 1960 tons in each of 2021 and 2022 implemented either through catch restrictions or effort reduction for the relevant fleets..

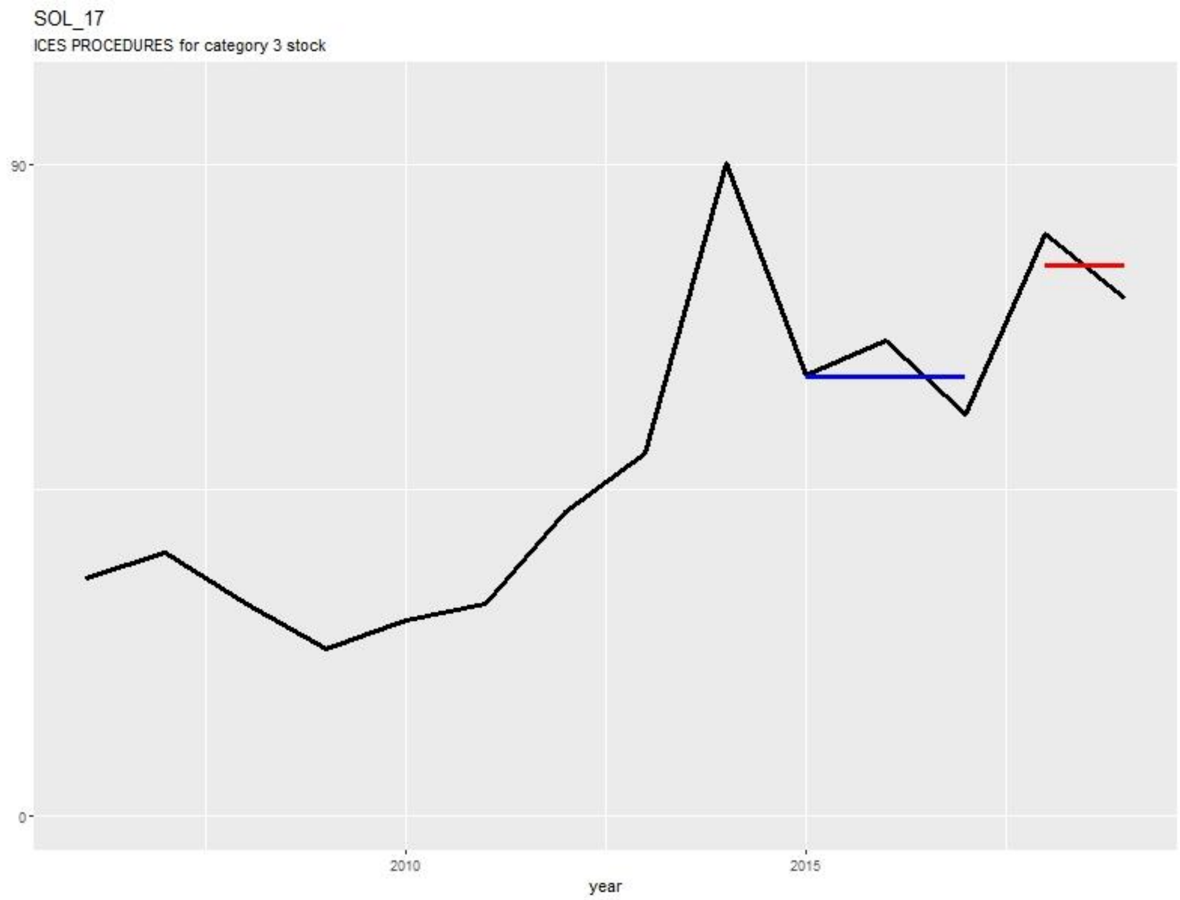


Figure 6.2.5.1 Sole in GSA 17. Biomass index based on Solemon survey data.

Table 6.2.5.1 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	1.20
Average catch (2017–2019)		2058
Discard rate (2017–2019)		Negligible
-20% Precautionary buffer	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.

6.2.6 Data Deficiencies

In the landings file Italian landings data for TBB, OTB, GTR and GNS in 2019 were input twice. Once without vessel length information but with length measurements and once with vessel length information but no length measurements. This created an issue in the calculation of total landings for those gears which were double compared to the correct value.

In the landings file Italian landings data for GTR in 2019 were sampled only partially and length measurements were submitted only for the second and third quarter (2 quarters over 4).

In the catch file total landings of Croatia for DRB and OTB in 2018 are reported in kilograms instead of tonnes.

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 last GFCM SAD working group 2019 was raised the need to further explore the suitability of the combination of the two areas for the stock assessment and to have a benchmark assessment as soon as possible.

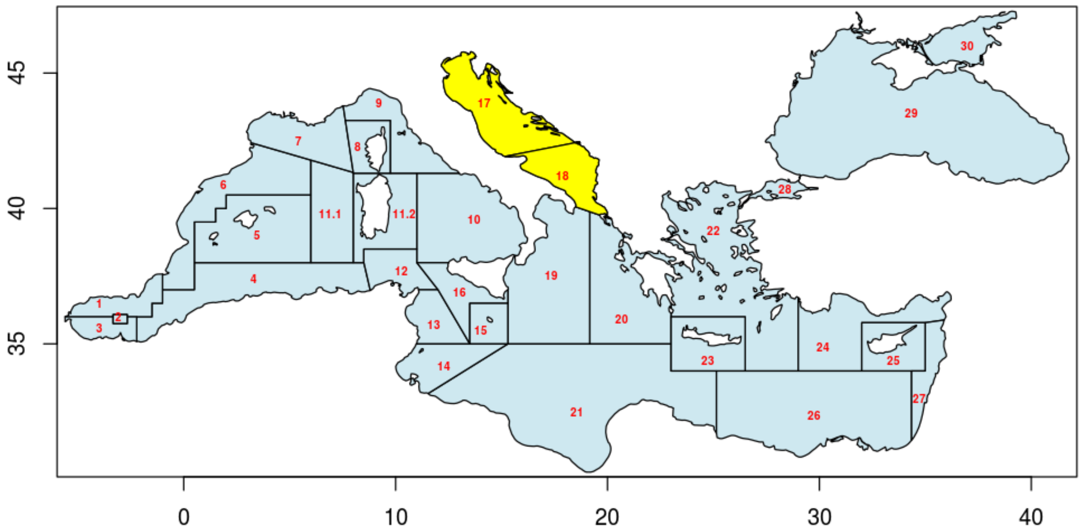
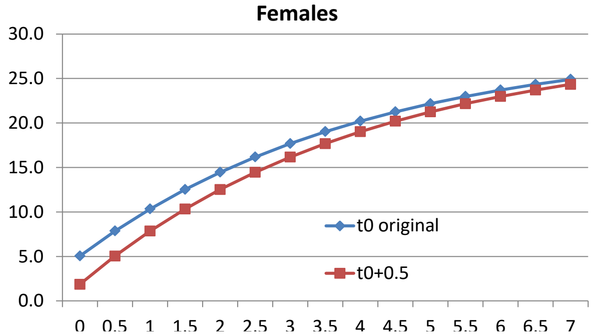


Figure 6.3.1.1.1 Geographical location of GSAs 17 and 18.

Growth

The growth of red mullet has been studied through validation of age reading by Carbonara et al., (2018), providing parameters for the von Bertalanffy growth curve for GSA 18 for males, females and combined sexes. As required by ToR2 (point 4) and the discussion made during the previous STECF EWG, the analysis of the mean length associated to each age class in the two hypotheses, original t0 and t0+0.5, was made in order to select to more appropriate one to slice available LFDs, to align the spawning period (half of the year) with the calendar year (used in the assessment model). The exploration highlighted that the original t0 hypothesis is returns mean length at age more in line with the monthly LFDs observed from MEDITS and GRUND survey in Carbonara et al. 2018 and with the LFD observed in MEDITS 2017, when the survey was carried out at the end of October (Figures 6.3.1.1.2 and 6.3.1.1.3).

Age	Females		Males	
	t0 original	t0+0.5	t0 original	t0+0.5
0	5.0	1.9	5.3	2.2
0.5	7.8	5.0	8.0	5.3
1	10.3	7.8	10.2	8.0
1.5	12.5	10.3	12.1	10.2
2	14.5	12.5	13.7	12.1
2.5	16.2	14.5	15.1	13.7
3	17.7	16.2	16.2	15.1
3.5	19.0	17.7	17.2	16.2
4	20.2	19.0	18.0	17.2
4.5	21.2	20.2	18.8	18.0
5	22.2	21.2	19.4	18.8
5.5	23.0	22.2	19.9	19.4
6	23.7	23.0	20.3	19.9
6.5	24.3	23.7	20.7	20.3
7	24.9	24.3	21.0	20.7



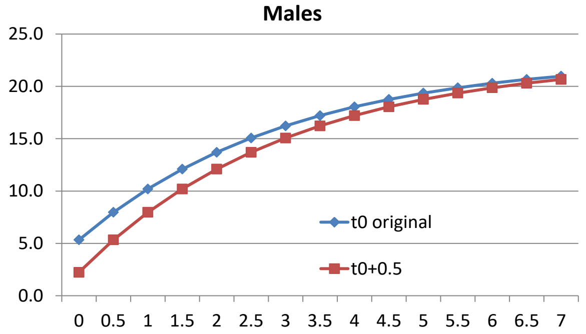


Figure 6.3.1.1.2 Comparison of mean length by age under the growth with original t0 and with t0+0.5.

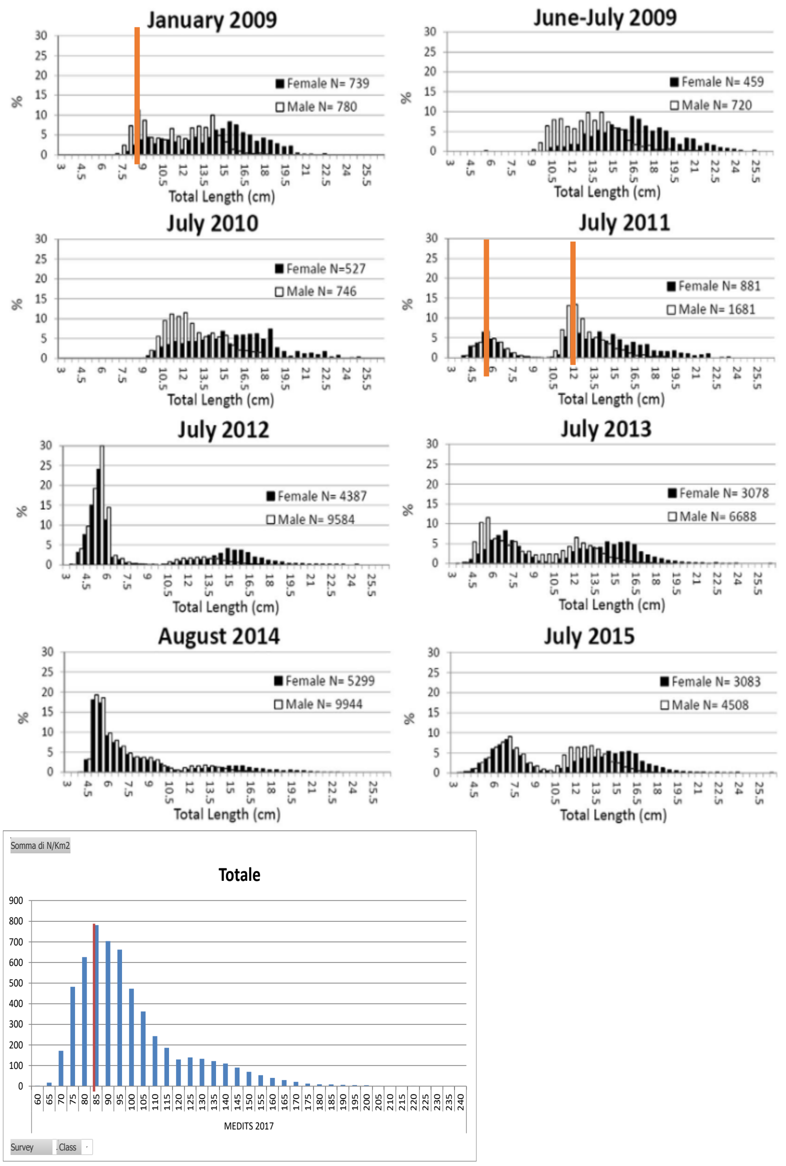


Figure 6.3.1.1.3 LFDs from MEDITS and GRUND survey: on the left the bar plots are from Carbonara et al., 2018, while on the right the bar plot is related to MEDITS 2017 (end of October).

A further exploration was made to compare the parameters of GSA 17 from DCF age-length data with the one from Carbonara et al., 2018, highlighting that the lack of individuals below 7 cm of size in the age reading makes difficult a reliable estimation of t0 (-2.2). For this reason, the parameters reported in table 6.3.1.1.1 are used for the whole area. The a and b parameters of the length-weight relationship are the same used in the last EWG meeting (DCF data) and have been applied to both GSAs. These are reported in table 6.3.1.1.1, and were used for the assessment.

Table 6.3.1.1.1. Growth parameters used for GSA 17-18

Sex	L_{inf}	K	t_0	a	b
Female	29.185	0.247	−0.768	0.00895	3.100137
Male	22.725	0.328	−0.816	0.00868125	3.103919

Maturity

Following the common decision made for all red mullet stocks during the EWG 20-15 and previous EWGs, the vector of proportion of mature individuals by was the one reported in Table 6.3.1.1.2.

Table 6.3.1.1.2. Maturity vector at age used for GSA 17-18.

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

Natural mortality

Following EWG 19-16, the natural mortality vector was estimated according to Chen and Watanabe model on growth parameters listed in Table 6.3.1.1.1.

Table 6.3.1.1.3. 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 96% of the landing in tons in 2019); a small amount is reported for small-scale fishing gears (gillnet and trammel net), which is slightly more important for GSA 18 Italy (about 10%).

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 2019, for GSA 18 Italy from 2002 to 2019, for GSA 17 Croatia from 2013 to 2019 and for GSA 17 Slovenia from 2005 to 2019. For Croatia from 2006 to 2012, the RECFISH data was used, as required in ToR 2 (point 3). For GSA 17 Italy some quarters and gear for 2019 were found to be supplied in the data call duplicated; one of the duplicate pairs were deleted to derive the 2019 landing.

The discard was available for GSA 17 Italy from 2010 to 2019, for GSA 17 Croatia from 2013 to 2019, for GSA 17 Slovenia from 2005 to 2019 and for GSA 18 Italy from 2009 to 2019. 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, 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. For the years from 2012 to 2018 the data indicated in the EWG 19-16 report; for the years from 2006 to 2011, that 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 adopted 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 2006-2019 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; PTM=mid-water pair trawl; TBB=beam trawl; OTB=otter bottom trawl).

country	year	GNS	GTR	OTB	PTM	TBB	Total
HRV	2013			1084.25			1084.25
	2014			1151.71			1151.71
	2015			1128.08			1128.08
	2016			953.36			953.36
	2017			985.50			985.50
	2018	6.00	0.65	825.23			831.88
	2019	7.20	0.76	729.96			737.92
ITA	2006			3101.00			3101.00
	2007			3298.00			3298.00
	2008			3158.00			3158.00
	2009			2433.00			2433.00
	2010			1796.00			1796.00
	2011	31.00		1823.00		36.00	1890.00
	2012	18.00		1464.00		43.00	1525.00
	2013			1946.00	2.00	31.00	1979.00
	2014	8.00		2324.00	3.00	64.00	2399.00
	2015	16.00		2143.00		61.00	2220.00
	2016	5.00		2037.00			2042.00
	2017	9.00		2659.00		4.00	2672.00
	2018	6.00		2471.00		40.00	2517.00
	2019	11.00	0.00	1672	1.00	44.00	1728
SVN	2005		0.00	4.36			4.36
	2006	0.00		1.93			1.93
	2007	0.00	0.01	6.40			6.41
	2008	0.00	0.01	2.01			2.02
	2009	0.00	0.00	2.67			2.67
	2010	0.01	0.00	1.27			1.28
	2011	0.00	0.00	6.05			6.06
	2012	0.01	0.00	3.57			3.58
	2013	0.00	0.00	2.43			2.43
	2014	0.04	0.00	3.27			3.31
	2015	0.01	0.00	3.38			3.39
	2016	0.00	0.00	2.32			2.32
	2017	0.00	0.00	3.35			3.35
	2018	0.01	0.00	6.01			6.03
	2019	0.01	0.00	3.62			3.63

Table 6.3.2.1.2 Red mullet in GSAs 17 and 18. Landings in GSA 18 by fishing gear and country over 2002-2019 as reported in the DCF (tonnes; GNS=gillnet; GTR=trammel net; OTB=otter bottom trawl).

country	year	GNS	GTR	OTB	Total
ITA	2002	89.60		3114.21	3203.81
	2003	311.95		1749.80	2061.76
	2004	82.50		1981.13	2063.62
	2005	99.34		1350.00	1449.34
	2006	123.50	6.27	1803.47	1933.24
	2007	119.77	2.74	1679.60	1802.11
	2008	41.92	4.70	914.20	960.82
	2009	75.87	0.81	954.60	1031.29
	2010	43.97	1.43	600.78	646.18
	2011	37.12	0.40	494.23	531.75
	2012	7.12	0.55	2088.61	2096.28
	2013	47.03		1202.78	1249.81
	2014	4.53	18.11	1249.57	1272.21
	2015	15.28		1572.10	1587.37
	2016	50.48		1397.57	1448.05
	2017	0.18	66.35	552.98	619.51
	2018	78.74	13.15	911.97	1003.85
	2019	54.86	8.36	711.33	774.55

Table 6.3.2.1.3 Red mullet in GSAs 17 and 18. Discards by GSA, fishing gear and country as reported in the DCF (tonnes; GNS=gillnet; TBB=beam trawl; OTB=otter bottom trawl). Note the high amount OTB discards in GSA 17 in relation to landings.

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
ITA	2009		14.73	14.73
	2010	183.00	35.01	218.01
	2011	796.00	13.92	809.92
	2012	325.00	434.05	759.05
	2013	291.00	18.05	309.05
	2014	446.00	119.62	565.62
	2015	910.00	89.37	999.37
	2016	499.00	87.41	586.41
	2017	1069.00	13.17	1082.17
	2018	2038.00	182.87	2220.87
	2019	597.00	198.04	795.04
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

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 the average of the last three years was used. *data estimated.

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*

Table 6.3.2.1.7 Red mullet in GSAs 17 and 18. Landing at age used for Albanian data. From 2006 to 2018 the landings at age were reconstructed on the basis of 2019, for which the data were available.

Year	Age							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2006	26	3085	3243	1352	468	246	55	33
2007	26	3085	3243	1352	468	246	55	33
2008	26	3085	3243	1352	468	246	55	33
2009	26	3085	3243	1352	468	246	55	33
2010	26	3085	3243	1352	468	246	55	33
2011	26	3085	3243	1352	468	246	55	33
2012	27	3259	3426	1428	494	260	58	35
2013	27	3241	3407	1420	491	259	58	35
2014	23	2755	2896	1207	418	220	49	29
2015	28	3372	3544	1477	511	269	61	36
2016	29	3441	3618	1508	522	274	62	37
2017	29	3406	3581	1492	516	272	61	36
2018	21	2513	2642	1101	381	200	45	27
2019	27	3241	3407	1420	491	259	58	35

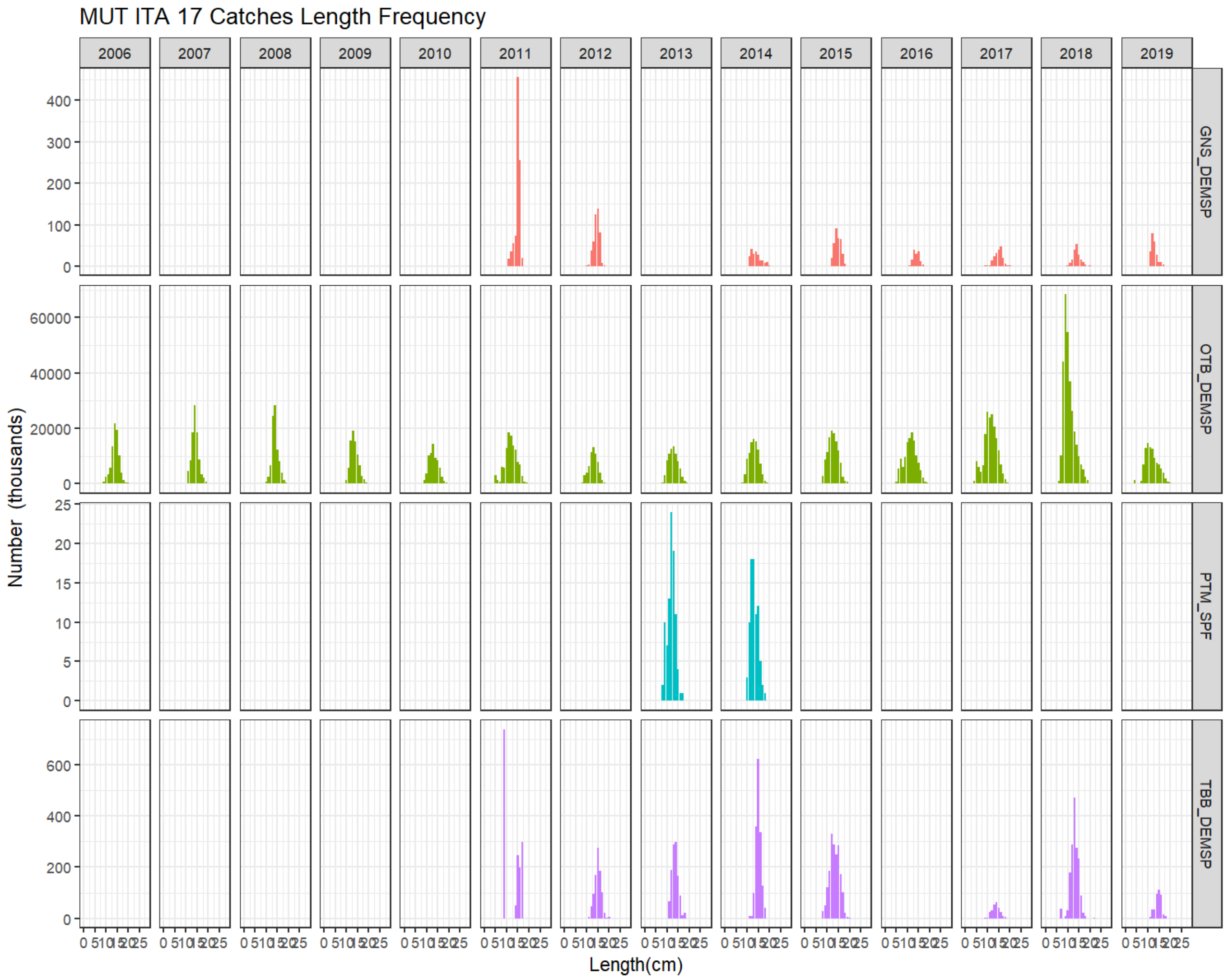


Figure 6.3.2.1.1 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Italy

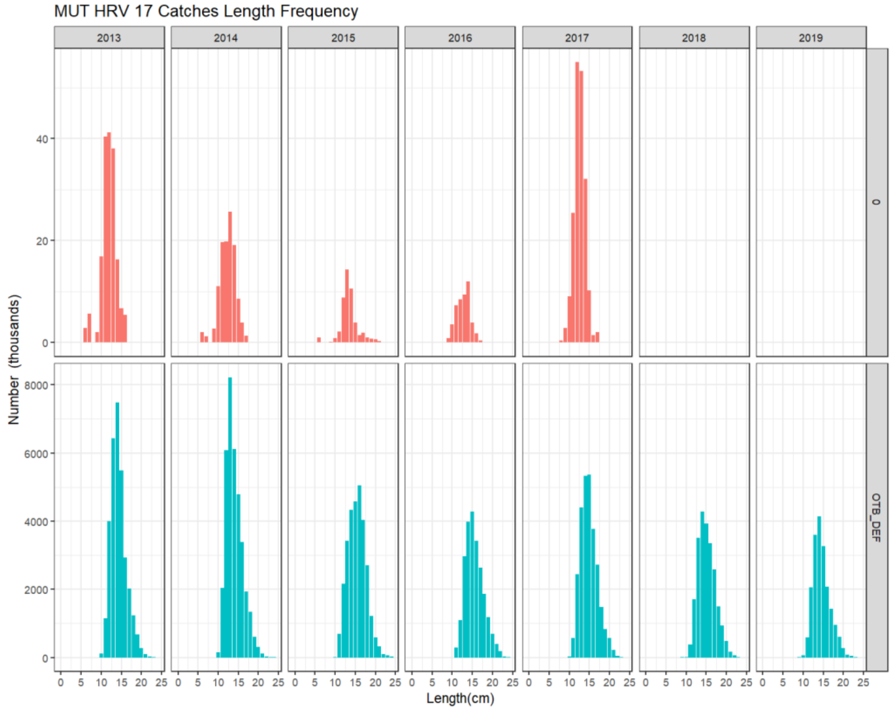


Figure 6.3.2.1.2 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 17, Croatia.

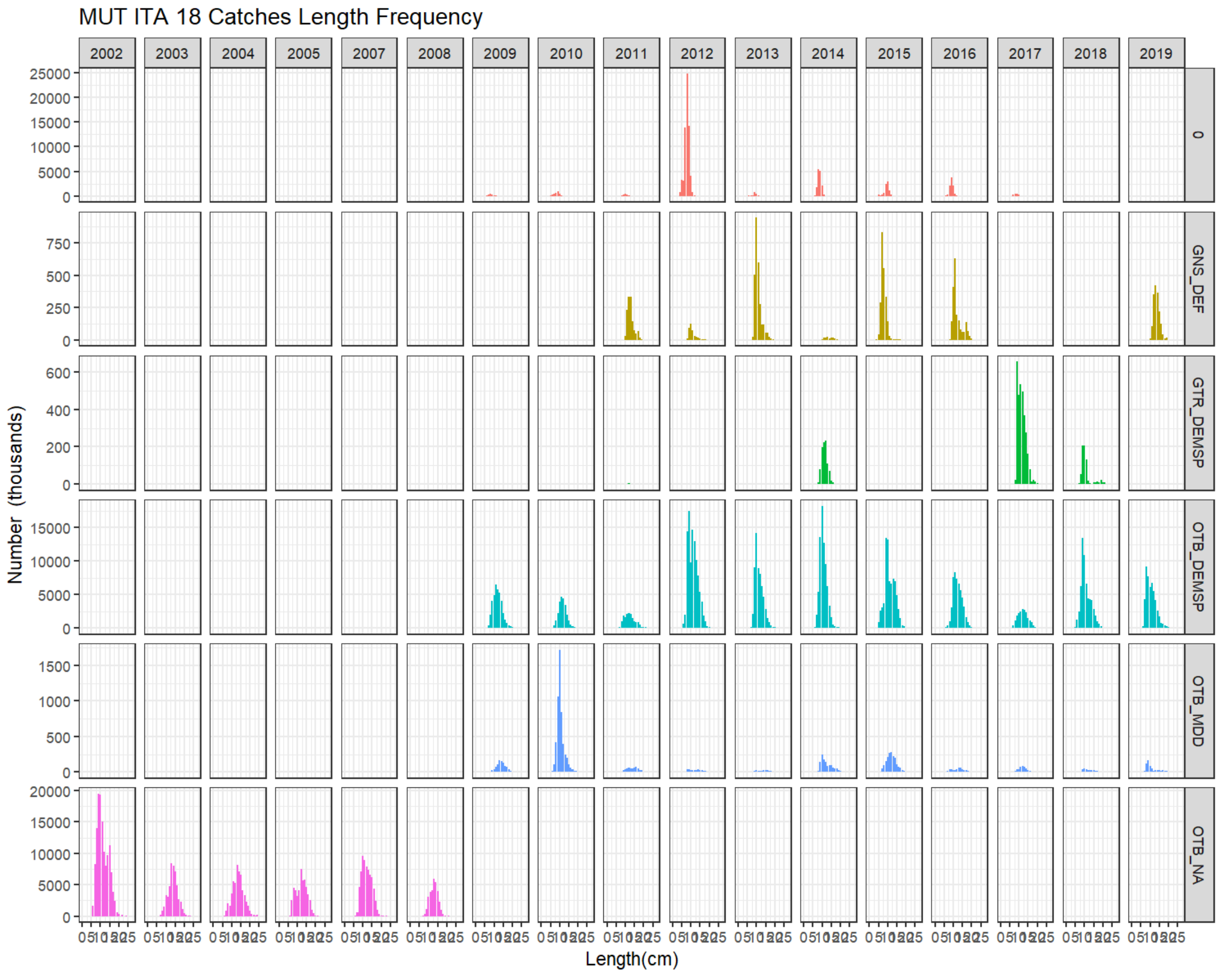


Figure 6.3.2.1.3 Red mullet in GSAs 17 and 18. Catch (landings+discards) LFD in GSA 18, Italy

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 6.3.1.1.1.

Year	Age				
	0	1	2	3	4+
2006	65238	123833	100832	11531	2582
2007	19753	100108	98987	12145	2383
2008	29070	122867	107329	15037	3932
2009	24198	100955	66959	8533	1669
2010	7396	54135	39948	5288	1248
2011	35234	114710	67869	8137	1670
2012	8103	72487	58467	6467	1579
2013	11339	84022	55572	7283	1730
2014	11174	91244	61236	6528	1543
2015	15189	86053	62229	9965	2739
2016	125464	126207	59326	9255	2674
2017	56558	146734	67679	8434	2167
2018	157515	196609	57626	9347	1861
2019	51943	98754	52909	8417	1810

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	0.92
2007	1.08
2008	0.78
2009	1.02
2010	1.32
2011	0.81
2012	1.47
2013	1.21
2014	1.32
2015	1.33
2016	0.87
2017	0.90
2018	0.93
2019	0.91

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 2012-2019 (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 of the Italian trawl fleet both in GSA 17 and GSA 18. The Croatian fleet effort was quite stable in the last three years with an increase in 2017, followed by a decrease in 2018 and 2019. 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

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

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
	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		
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		

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			

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 2019 were used. From 2017 to 2019 the hauls in territorial waters of Albania and Montenegro were not carried out under the DCF. The data were, thus, requested to the Albanian and Montenegrin authorities that allowed their use for the stock assessment purposes.
Thus, the 2017-2019 LFDs and indices take into account the complete set of hauls carried out in the area. Data were analysed using the JRC script (Mannini, 2020)
The long duration and the shift in the survey time in some years (Italy) may be critical for species such as red mullet, with a short spawning period, in late spring, and recruitment in autumn. Thus, in the years when the survey ends in summer, recruits will be absent or their presence very low, while when the survey ends in autumn recruits will be present (see Fig. 6.3.2.3.1).

All the surveys explored reveal a strong increase in the density and in the biomass indices (Figure 6.3.2.3.2) from 2011 onwards, with the 2019 density and biomass values decreasing respect to 2018.

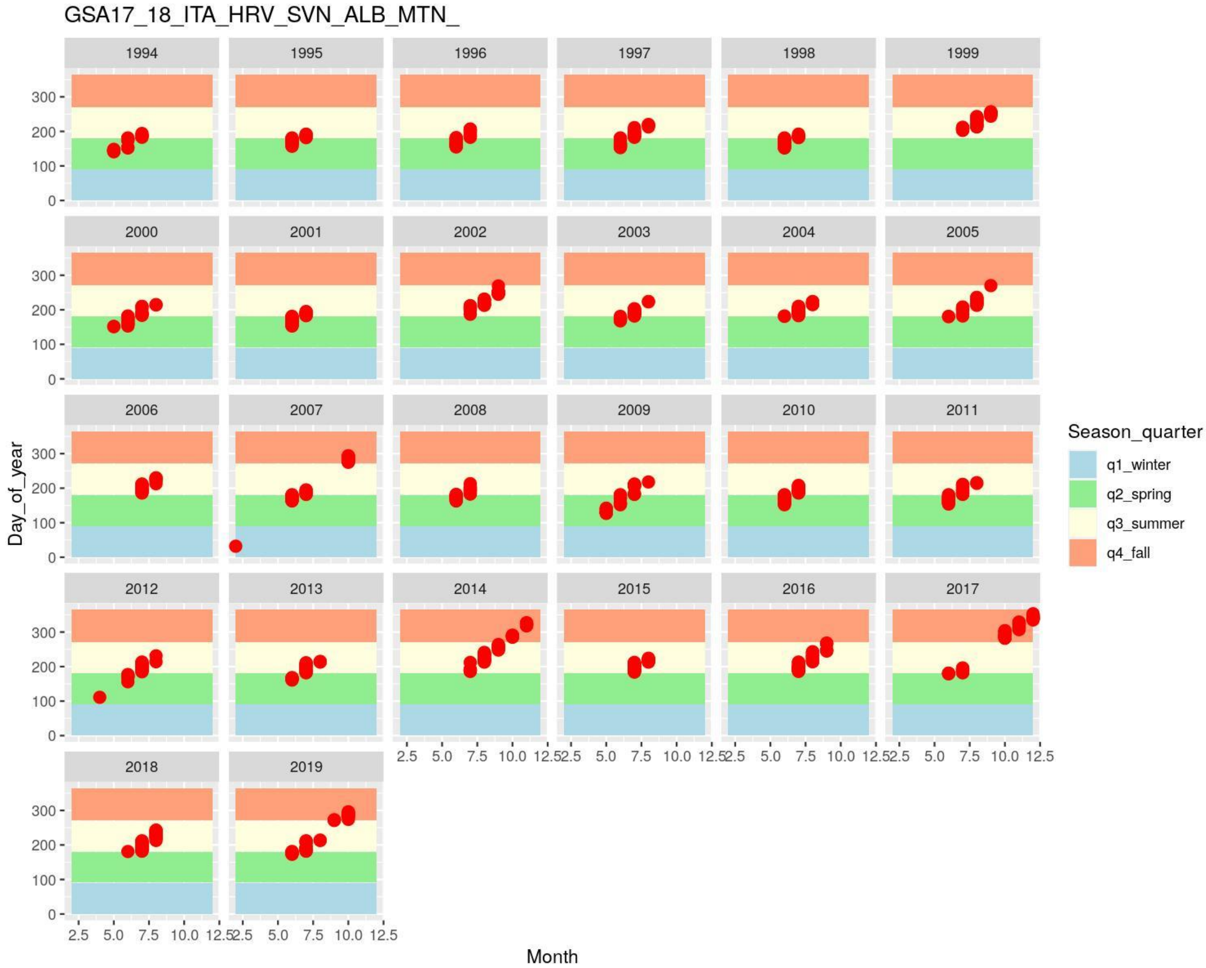


Figure 6.3.2.3.1 Red mullet in GSAs 17 and 18. MEDITS survey period over 1994-2019.

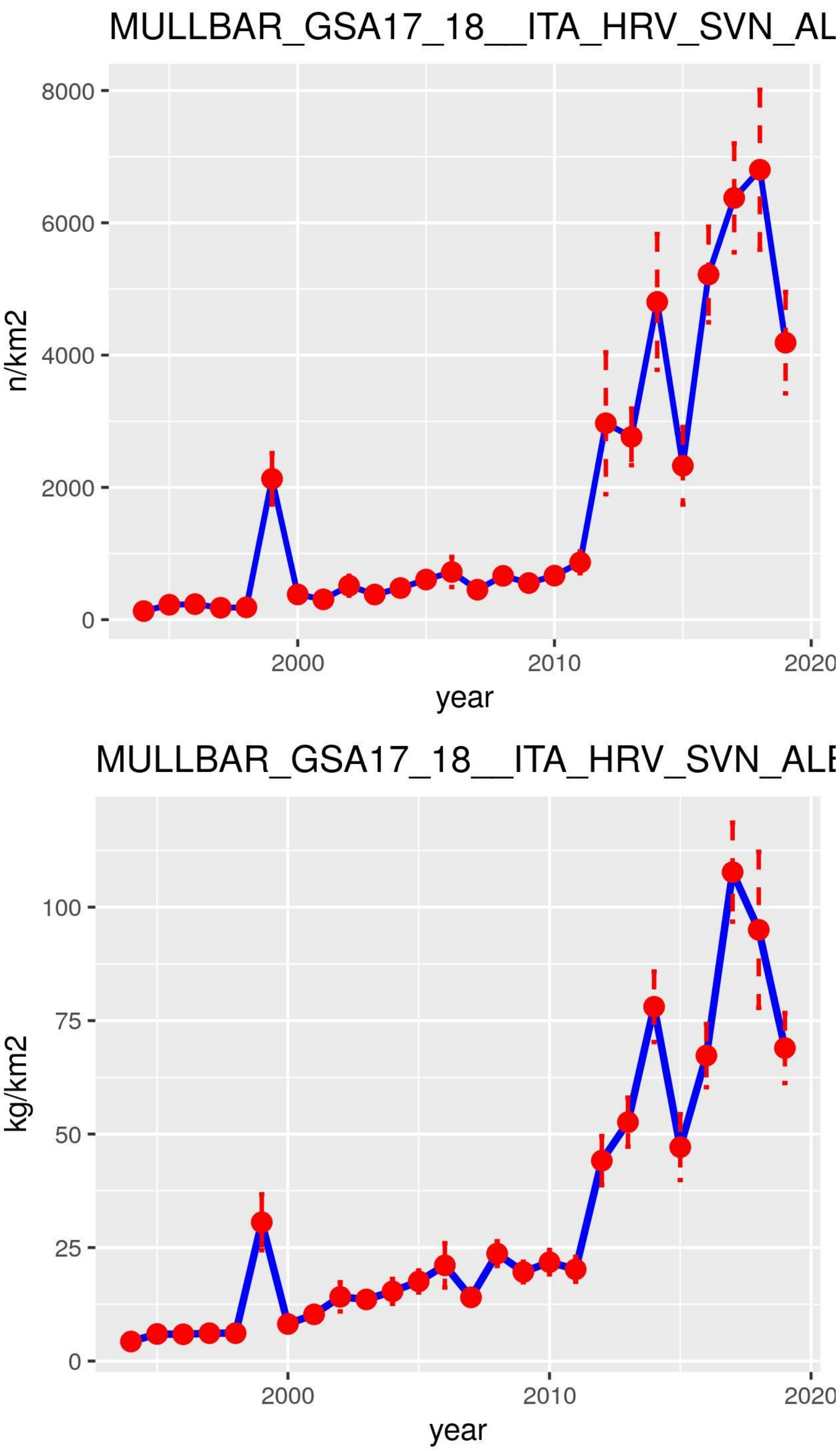


Figure 6.3.2.3.2 Red mullet in GSAs 17 and 18. MEDITS abundance (n/km^2) and biomass (kg/km^2) over 1994-2018.

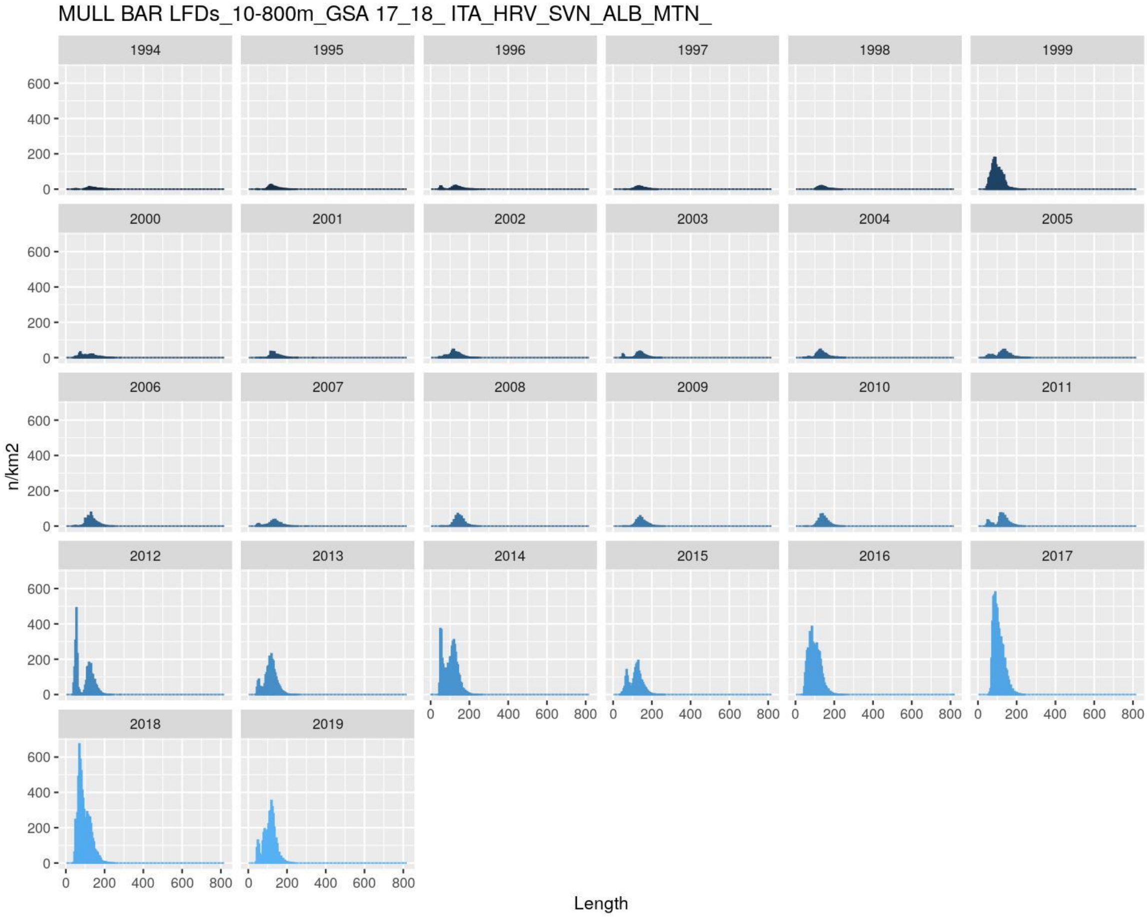


Figure 6.3.2.3.3 Red mullet in GSAs 17 and 18. MEDITS Length frequency distribution (TL mm; n/km2).

6.3.3 STOCK ASSESSMENT

Methods: a4a (Assessment for all)

A4a is a statistical catch at age stock assessment model, based on linear modelling techniques, using combined fleets, and in this case combined sexes not accounting for any sexual dimorphism of the species. The method was developed within FLR framework.

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 differencet in survey time in some years.
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.

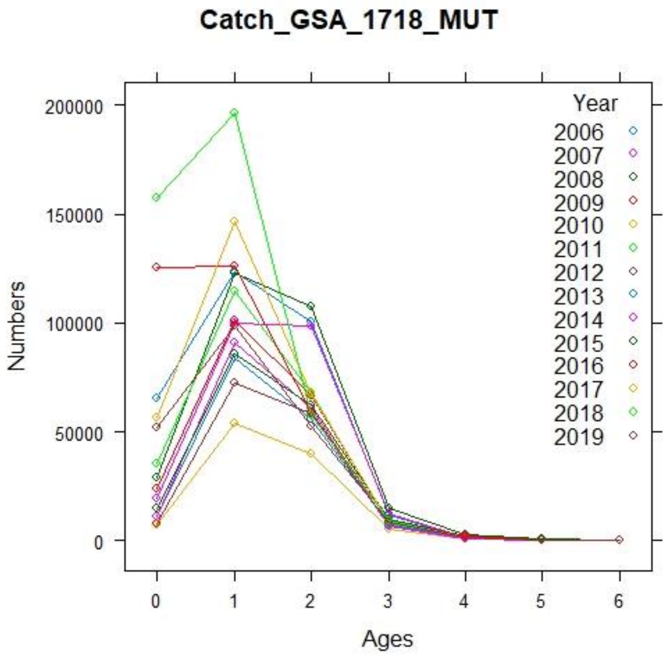


Figure 6.3.3.1 Red mullet in GSAs 17 and 18. Catch at age (landings + discards), all gears and GSAs combined.

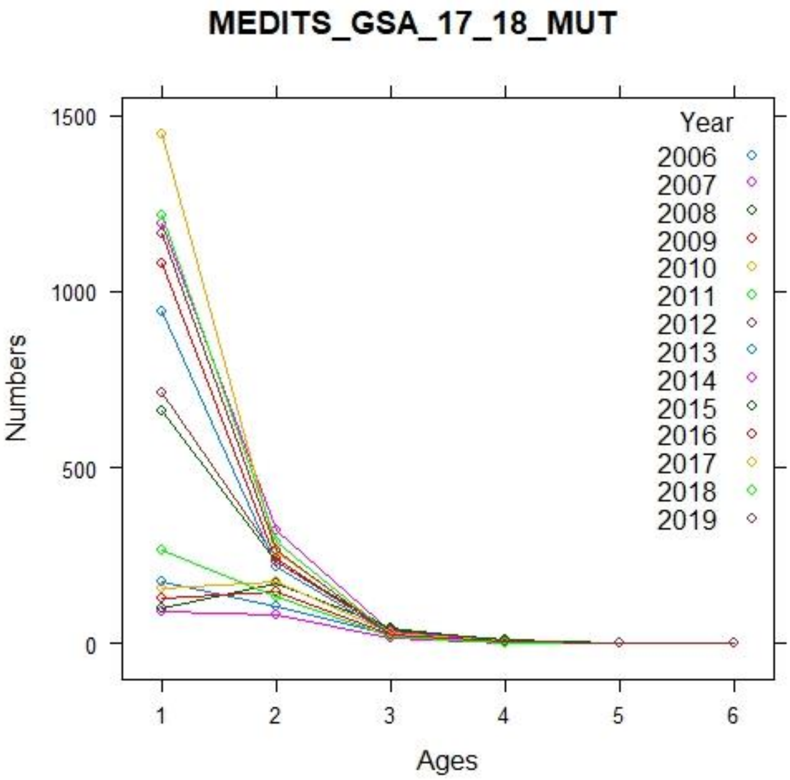


Figure 6.3.3.2 Red mullet in GSAs 17 and 18. Catch at age in the MEDITS survey (GSA17 and 18 combined).

Table 6.3.3.1 Red mullet in GSAs 17 and 18. MEDITS catch in numbers at age used in the a4a assessment (N/km2).

Year	0	1	2	3	4
2006	15.80	176.05	103.90	25.80	3.60
2007	36.27	88.50	81.42	14.78	3.15
2008	1.22	99.07	168.68	41.75	5.91
2009	2.08	129.37	149.46	26.94	2.25
2010	1.83	158.56	173.45	28.89	2.80
2011	84.54	264.03	135.11	19.37	3.29
2012	690.10	710.74	242.88	24.27	2.00
2013	391.91	942.16	219.42	25.27	4.79
2014	1064.80	1194.70	321.60	32.20	5.52
2015	328.43	658.71	232.81	39.72	9.42
2016	1446.20	1077.70	230.96	29.20	5.64
2017	1615.30	1448.00	259.61	29.83	4.18
2018	2231.50	1217.50	286.75	24.23	3.55
2019	707.07	1164.30	264.21	23.15	5.12

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

Year	Catch
2006	7093
2007	7352
2008	6180
2009	5339
2010	3848
2011	4737
2012	6087
2013	5037
2014	5756
2015	6367
2016	5469
2017	5798
2018	6927
2019	4469

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	0.040	0.061	0.090
2007	0.007	0.017	0.040	0.060	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	0.040	0.063	0.094
2017	0.007	0.018	0.040	0.063	0.092
2018	0.007	0.017	0.039	0.063	0.090
2019	0.007	0.018	0.038	0.067	0.096

Different combinations of F, q and stock-recruitment sub-models were explored, using as a basis the best model selected in EWG 19-16:

- fmod <- ~ te(age, year, k = c(3,5)) + s(year, k = 4, by = as.numeric(age==0))
- qmod <- list(~s(age, k=4, by = breakpts(year, 2012)))
- srmod <- ~s(year, k=4)

Different f sub-models were explored, because the fmod of the previous year did not converge with the new catch at age matrices:

- fmod= ~ s(replace(age, age > 2, 2), k = 3) + s(year, k = 8)
- fmod= ~ s(replace(age, age > 3, 3), k = 3) + s(year, k = 8)

The q sub-model was confirmed, because it was observed to reduce the trends in residuals in age 0 and 1 respect to the model without breakpoint.
The sr model was modified in srmod ~ geomean(CV = 0.2), because returning more stable recruitment in retrospective.

An Fbar range age 1 to 3 was used, consistently with the other red mullet stocks assessed in previous EWG. The best model was chosen on the basis of retrospective analysis and residuals.
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.The best set of submodels selected for the assessment 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)

Results

The F time series estimated by a4a ranges between 1.32 and 0.68, 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, without any important trend (Figures 6.3.3.6 and 6.3.3.7).

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)	Catch (Tonnes)	Total biomass (middle of the year)
2006	1.12	1028935	6893	6773	14914
2007	1.27	856800	5983	7250.2	13957
2008	1.32	760745	5051	6185.5	12175
2009	1.24	792092	4289	4933.2	10590
2010	1.13	917327	4272	4356.7	10703
2011	1.07	933575	5424	5092.4	12329
2012	1.04	1019042	5654	5335.1	12893
2013	1.02	901187	5839	5472.2	13187
2014	1.02	788470	5590	5475.4	12154
2015	1.07	907848	5132	5370.1	11677
2016	1.16	881954	5219	5553.7	12265
2017	1.16	972384	5234	5571.3	12627
2018	0.96	1048820	5690	4927.4	13214
2019	0.69	955114	7587	4632.1	14289

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	0.05	0.56	1.40	1.40	1.40
2007	0.06	0.63	1.59	1.59	1.59
2008	0.06	0.66	1.65	1.65	1.65
2009	0.06	0.62	1.56	1.56	1.56
2010	0.05	0.56	1.42	1.42	1.42
2011	0.05	0.53	1.33	1.33	1.33
2012	0.05	0.52	1.30	1.30	1.30
2013	0.05	0.51	1.28	1.28	1.28
2014	0.05	0.51	1.27	1.27	1.27
2015	0.05	0.53	1.34	1.34	1.34
2016	0.06	0.58	1.45	1.45	1.45
2017	0.06	0.58	1.45	1.45	1.45
2018	0.05	0.48	1.21	1.21	1.21
2019	0.03	0.34	0.86	0.86	0.86

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	1028935	443767	116783	21068	2606
2007	856800	382784	137513	17639	3818
2008	760745	316406	109832	17118	2859
2009	792093	280235	88450	12806	2490
2010	917327	292871	81444	11371	2104
2011	933575	340973	89953	12031	2129
2012	1019042	348120	108266	14445	2431
2013	901187	380484	112049	17990	2998
2014	788470	336789	123645	19073	3819
2015	907848	294698	109577	21110	4182
2016	881954	338475	93426	17527	4328
2017	972384	327412	102597	13350	3345
2018	1048820	360987	99260	14667	2557
2019	955114	393021	120660	18135	3365

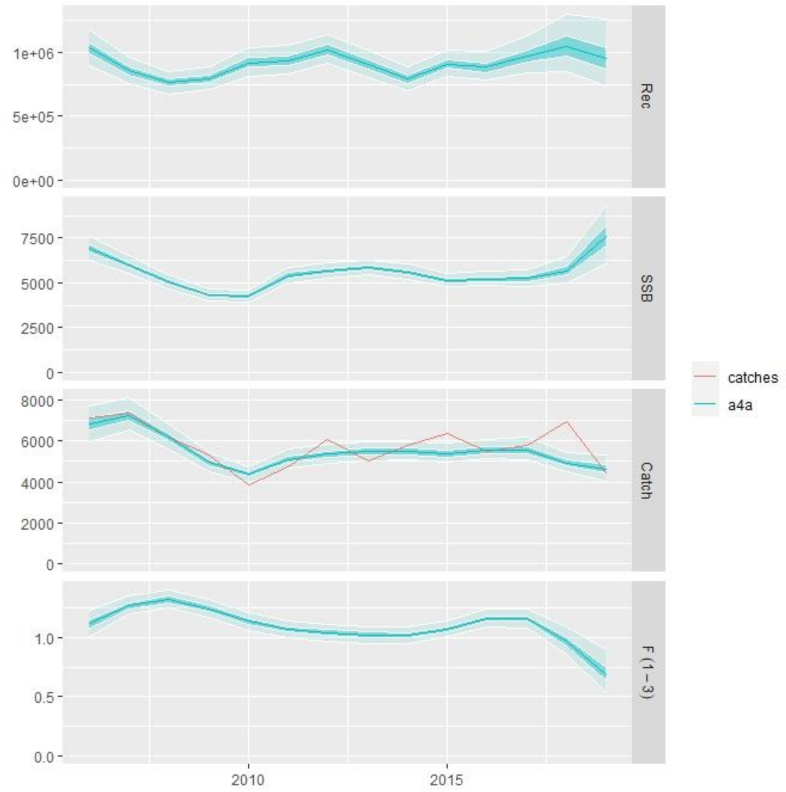


Figure 6.3.3.3 Red mullet in GSAs 17 and 18. Summary of the results. The blue line corresponds to the observed catches.

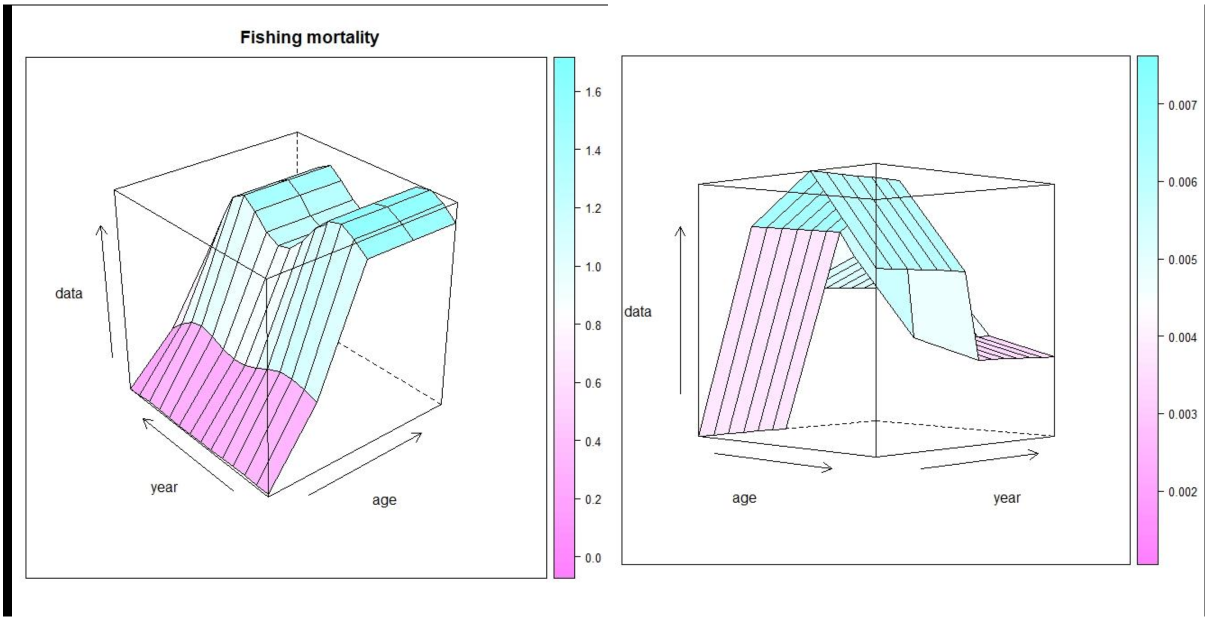


Figure 6.3.3.4 Red mullet in GSAs 17 and 18. Fishing mortality (left) and catchability (right) by age and year.

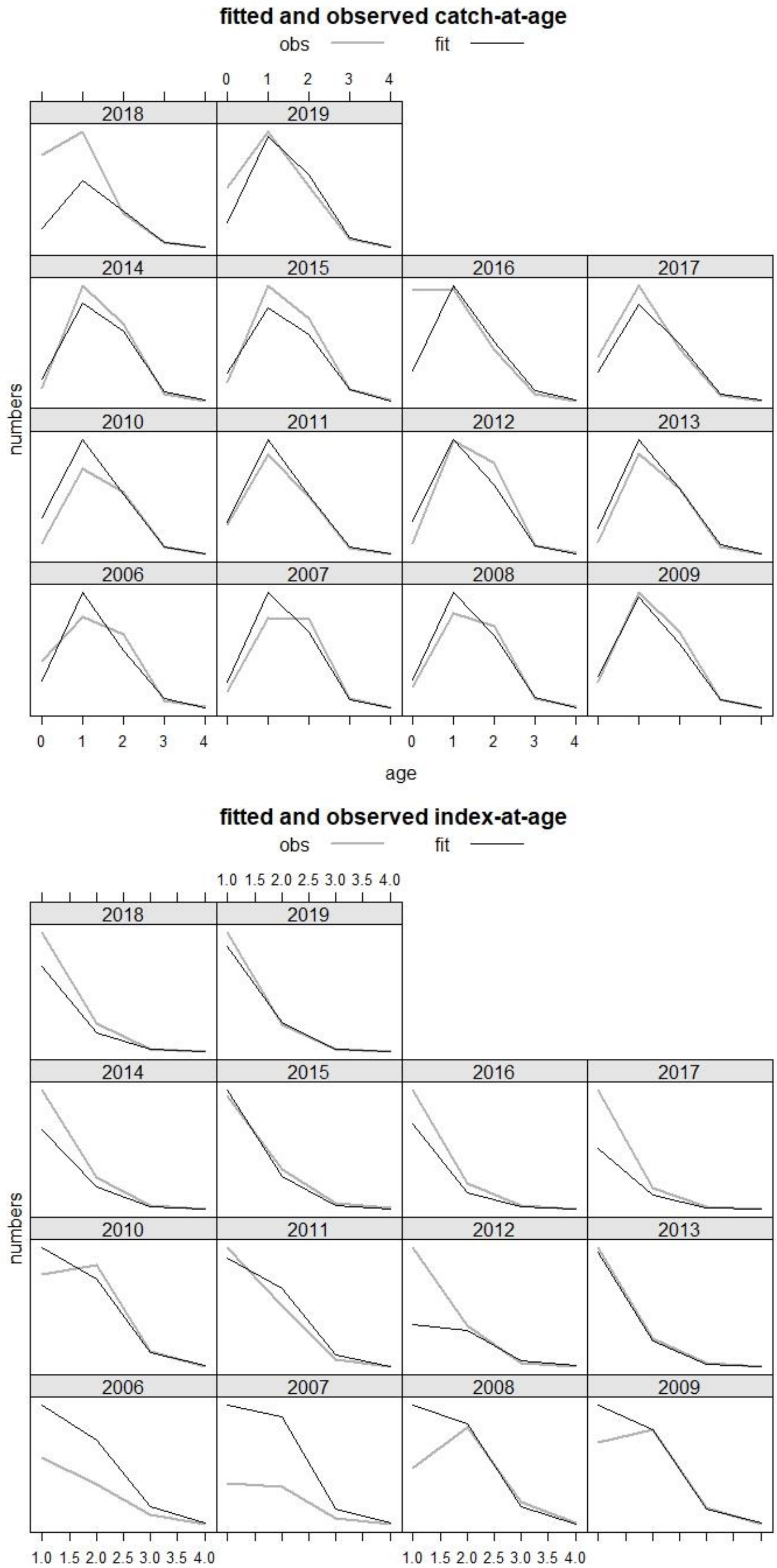


Figure 6.3.3.5 Red mullet in GSAs 17 and 18. Comparison between observed and fitted catch (top) and index (bottom) at age

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 suitable to give stock status relative to F_{MSY}.

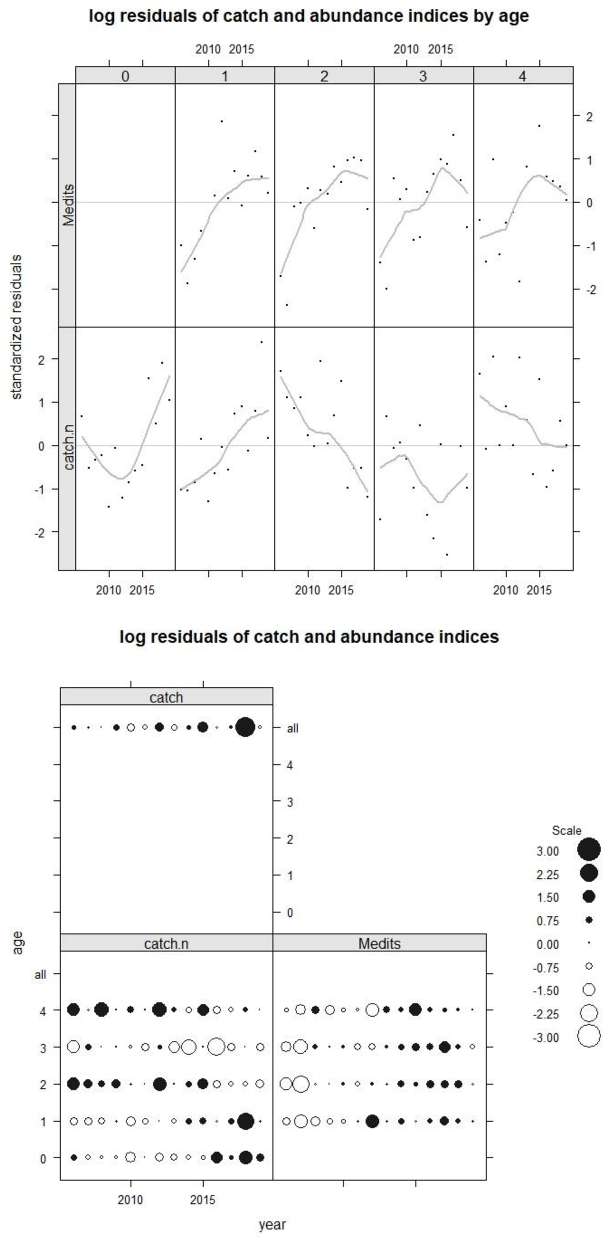


Figure 6.3.3.6 Red mullet in GSAs 17 and 18. Log-residuals and bubble plot of catch and abundance indices by age.

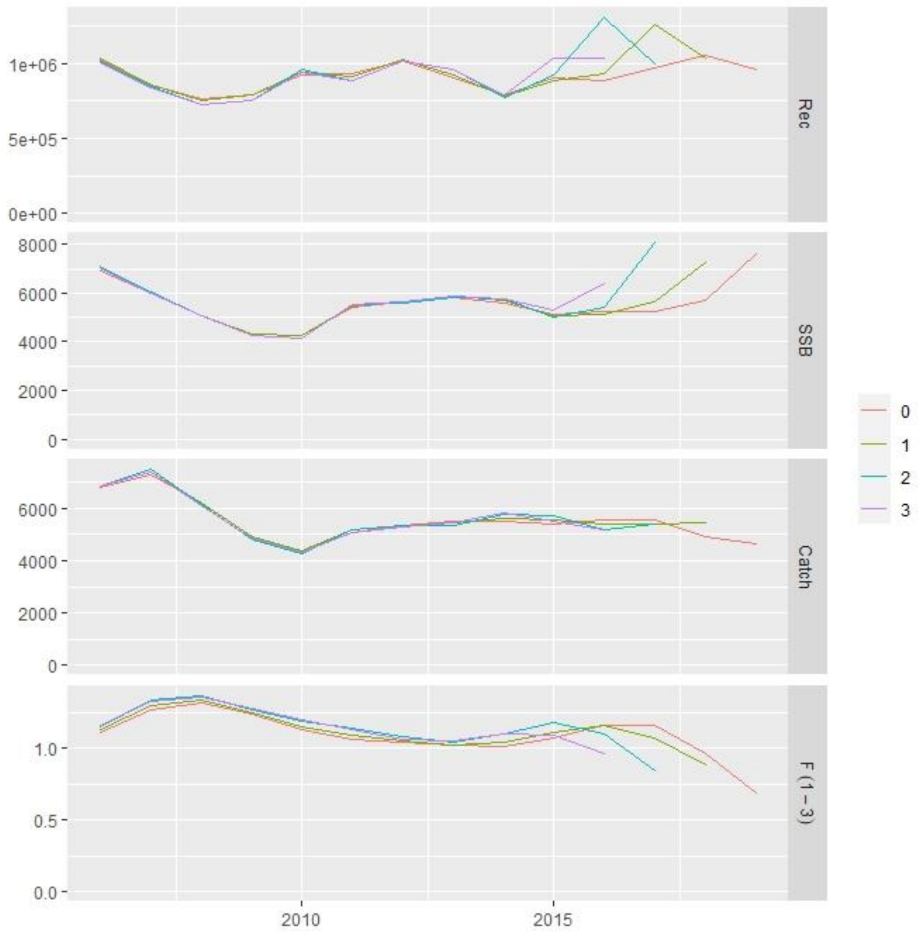


Figure 6.3.3.7 Red mullet in GSAs 17 and 18. Retrospective analysis.

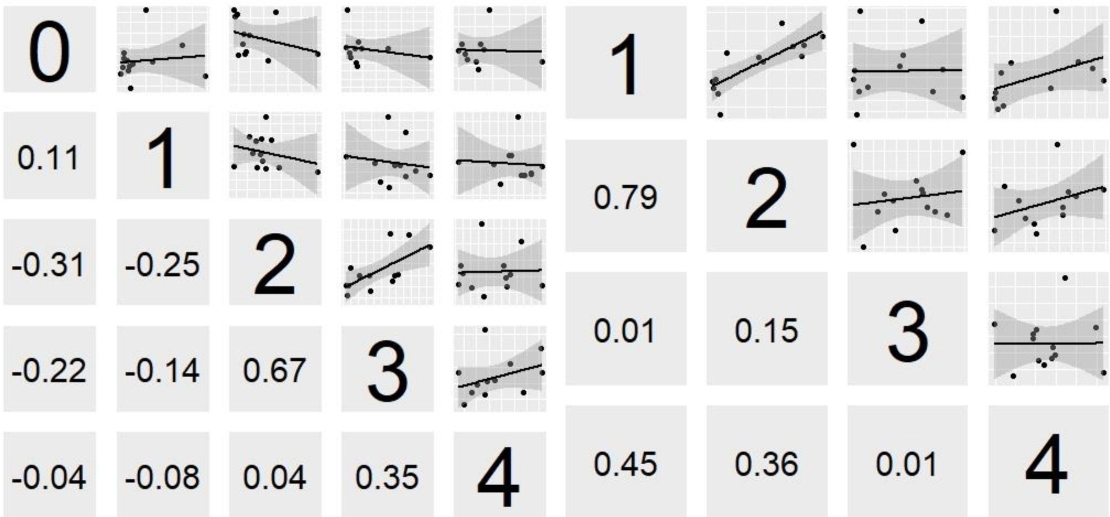


Figure 6.3.3.8 Red mullet in GSAs 17 and 18. Internal consistency in the catches (left) and the index (right).

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 20-15 confirmed the reccomendations to use $F_{0.1}$ as proxy of FMSY. On the basis of the reccomendation of the previous STECF EWG report to further explore the impact of the plus group on the reference point calculation in FLBRP library, the F0.1 was estimated also with 5+, applying the same set of sub-models selected and presented in chapter 6.3.3. The F0.1 seems quite stable in both cases, showing a lower value for the 5+ hypothesis.
Considering the F current of 0.69 estimated for 2019, the fishing mortlity level is well above the reference point $F_{0.1}$ of 0.34.

Table 6.3.4.1 – Estimation of F0.1 with FLBRP library with 4+ and 5+.

Year of RP estimation	4+	5+
2016	0.33	0.298
2017	0.338	0.308
2018	0.341	0.308
2019	**0.34**	0.308

6.3.5 SHORT TERM FORECAST AND CATCH OPTIONS

A deterministic short term prediction for the period 2020 to 2022 was performed using the FLR 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} =0.69 (2019) from the a4a assessment was used for F in 2020. For recruitment, the average along the whole time series (14 years) is used as an estimate of recruits in 2020 and 2021 (911 735 thousands).

Table 6.3.5.1 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 2017-2019
$F_{ages\ 1\text{-}3}$ (2020)	0.69	F(2019) used to give F status quo for 2020
SSB (2020)	8 306	Stock assessment middle of the year 2020
R_{age0} (2020,2021)	911 735	Mean of the last 14 years (whole series)
Total catch (2020)	5 548	Assuming F status quo for 2020

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 decrease the catch from 2019 to 2021 of 29.1%, while the SSB would increase by 40.9%. On the other hand, maintaining the current fishing mortality, would return a change in SSB of +0.1% and in catch of +23.2%. Anyway, these results could be biased by the slight underestimation (around 10%) of the catch by the best a4a model.

Table 6.3.5.2 Red mullet in GSAs 17 and 18: short term forecast.

Rationale	Ffactor	Fbar	Catch2021	SSB2022	SSB_change_2020-2022(%)	Catch_change_2019-2021(%)
High long term yield (F0.1)	0.495	0.34	3285	11703	40.9	-29.1
F upper	0.679	0.47	4260	10269	23.6	-8.0
F lower	0.331	0.23	2314	13220	59.2	-50.0
FMSY transition	0.856	0.59	5092	9118	9.8	9.9
Zero catch	0	0.00	0	17184	106.9	-100.0
Status quo	1	0.69	5708	8310	0.1	23.2
Different Scenarios	0.1	0.07	754	15840	90.7	-83.7
	0.2	0.14	1458	14630	76.1	-68.5
	0.3	0.21	2117	13538	63.0	-54.3
	0.4	0.27	2734	12553	51.1	-41.0
	0.5	0.34	3312	11662	40.4	-28.5
	0.6	0.41	3853	10855	30.7	-16.8
	0.7	0.48	4361	10124	21.9	-5.8
	0.8	0.55	4838	9461	13.9	4.5
	0.9	0.62	5287	8859	6.7	14.1
	1.1	0.76	6104	7810	-6.0	31.8
	1.2	0.82	6478	7354	-11.5	39.8
	1.3	0.89	6830	6937	-16.5	47.4
	1.4	0.96	7162	6555	-21.1	54.6
	1.5	1.03	7476	6205	-25.3	61.4
	1.6	1.10	7772	5884	-29.2	67.8
	1.7	1.17	8052	5588	-32.7	73.8
	1.8	1.24	8317	5315	-36.0	79.6
	1.9	1.30	8569	5064	-39.0	85.0
	2	1.37	8807	4831	-41.8	90.1

6.3.6 DATA DEFICIENCIES

Discards from Italy in GSA 17 in 2018 and 2019 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 quarter, when a high amount of red mullet discard is not expected, considering that the species recruits in the third quarter.
Moreover, the landing of some quarters for some gear (e.g. OTB, GNS and TBB) was duplicated in the DCF data; indeed, the duplicaed records are present both with and without the raised LFD.

6.4 COMMON CUTTLEFISH IN GSA 17 AND 18

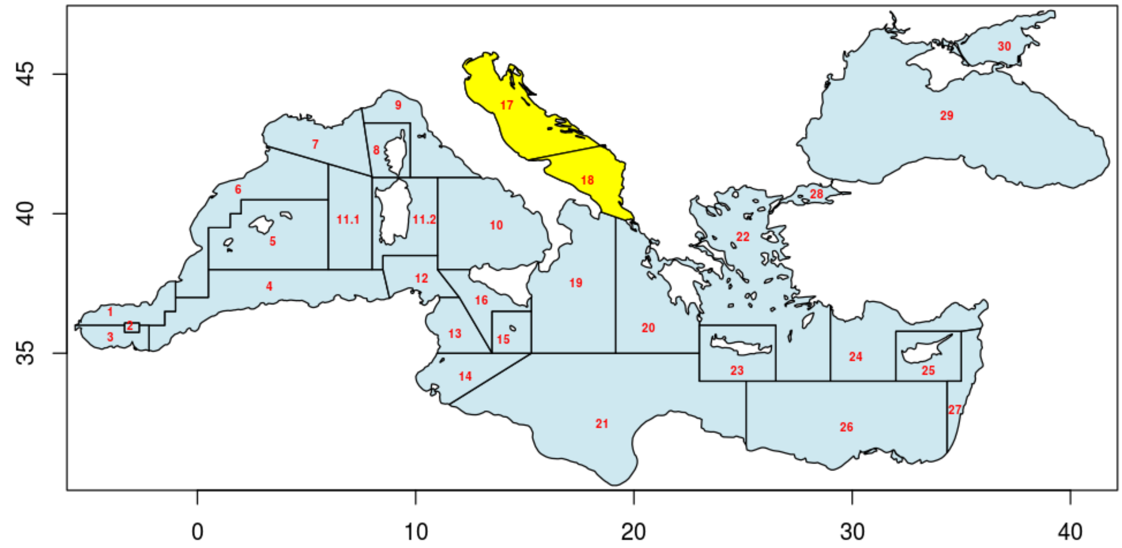


Figure 6.4.1.1 Geographical location of GSAs 17-18.

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). In the 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 stock distribution along coasts of the Adriatic basin (Figure 6.4.1.2).

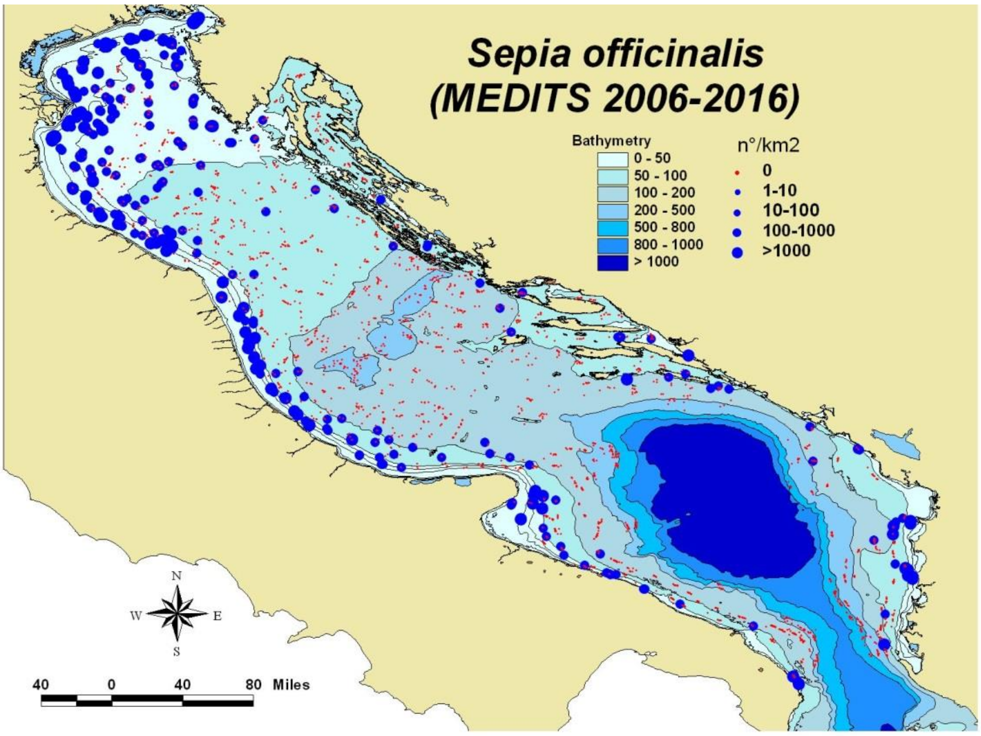


Figure 6.4.1.2 Common cuttlefish in GSA 17-18. Abundance indices in the Adriatic Sea as obtained from the most recent survey data (MEDITS, 2006-2016).

Natural mortality

Due to lack of growth parameters in DCF database, and use of CMSY and SPICT production model (this model has no need for natural mortality estimate) the natural mortality of common cuttlefish was not estimated by EWG 19-16.

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 L_{inf} of 16.6 cm reported by Slovenia (GSA17, period 2014-2016). Other growth 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 Adriatic Sea 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**	**vb_sample_size**	**a**	**b**	**l_w_sample_size**	**l_w_size_range**	**l_w_units**
SVN	SA 17	2016	2018	C	NA	NA	NA	NA	0.2182	2.7572	1036	1.90-15.50 cm	cm
ITA	SA 17	2016	2016	C	NA	NA	NA	NA	0.2112	2.8119	174	4-17 cm	cm/g
ITA	SA 17	2016	2016	M	NA	NA	NA	NA	0.2366	2.7595	71	4-14 cm	cm/g
ITA	SA 17	2016	2016	F	NA	NA	NA	NA	0.2099	2.8176	103	4-17 cm	cm/g
ITA	SA 17	2013	2013	C	NA	NA	NA	NA	0.1893	2.8414	546	2-23 cm	cm/g
ITA	SA 17	2013	2013	M	NA	NA	NA	NA	0.2409	2.7345	252	3-17 cm	cm/g
ITA	SA 17	2013	2013	F	NA	NA	NA	NA	0.1947	2.8381	280	3-23 cm	cm/g
ITA	SA 17	2012	2012	C	NA	NA	NA	NA	0.2356	2.786	493	3-19 cm	cm/g
ITA	SA 17	2012	2012	M	NA	NA	NA	NA	0.2924	2.6764	191	4-18 cm	cm/g
ITA	SA 17	2012	2012	F	NA	NA	NA	NA	0.2418	2.7837	203	4-19 cm	cm/g
ITA	SA 17	2011	2011	C	NA	NA	NA	NA	0.3123	2.6497	798	3-22 cm	cm/g
ITA	SA 17	2011	2011	M	NA	NA	NA	NA	0.399	2.5356	311	3-22 cm	cm/g
ITA	SA 17	2011	2011	F	NA	NA	NA	NA	0.3084	2.6676	391	3-20 cm	cm/g
ITA	SA 17	2010	2010	C	NA	NA	NA	NA	0.368	2.59	2050	3-19 cm	cm/g
ITA	SA 17	2010	2010	M	NA	NA	NA	NA	0.475	2.468	960	3-19 cm	cm/g
ITA	SA 17	2010	2010	F	NA	NA	NA	NA	0.353	2.613	1074	3-18 cm	cm/g

* 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 INPUT 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) is 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 19-16 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). Albanian and Montenegrin data were also provided through the DG-MARE.

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 2006-2018.

Gear	Tons	%
OTB	22198	54.30%
FPO	7084	17.33%
TBB	6168	15.09%
SETNETS	4896	11.98%
FYK	521	1.27%
OTHER	11	<0.1%
Total	**40878**	**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), 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 1999 were provided through activities of EU-RECFISH project (RECovery of FISheries 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 and Transversal datasets. The gap between 2000 to 2007 was the most concerning one considering that different databases (GFCM-FISHSTAT, ISTAT, 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).

In 2018 The gap between 2000 to 2007 was the most concerning (GFCM-FISHSTAT, ISTAT, 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). In order to reconstruct the missing data a linear regression of **y = 1.2292x - 1.5926 (based on estimating 2008 to 2016 DCF transversal data 'x' from** GFCM-FISHSTAT data 'y') was applied based on correlation between DCF transversal to give 2000 to 2007 catch of *S. officinalis. This method was used in 2018 In the 2018 GFCM report the total catches during this period were considered low, but there was no explicit source of alternative catches supplied with the comments.*

In 2019 (EWG 19-16) The landing data of *S. officinalis* from Italian fisheries in GSA 17-18 for period from 2000-2007 were provided by Italian national correspondent during the session of EWG 19-16. The source of data is Italian national statistical bureau ISTAT based on sample survey methodology of collecting the data. (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 transversal (SVN and HRV) datasets or national statistics bureau (HRV). 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.

Sources of data: Historical data for Yugoslavia 1972-1991, Slovenia (1992-2007), Croatia (1992-2005), Montenegro 1992-2016 from FAO Fish Stat. Montenegro 2016-2018 and Albania 1995-2018 DG Mare. Italy 1972-1999 RECFISH project. Italy 2000-2007 Italian correspondent. Italy 2008-20016 DCF transversal database. Croatia 2006-2017 Croatian database. Croatia 2018-2019, Slovenia 2008-2019, Italy 2017-2019 DCF. Montenegro 2019, Albania 2019 assumed equal to 3 previous years.

Year	Croatia GSA 17	Slovenia GSA 17	Italy GSA 17	Italy GSA 18	Montenegro GSA 18	Albania GSA 18	Yugoslavia GSA17-18	Total 17-18	GSA 17	GSA 18
1972			6151	1109			174	7433	6238	1196
1973			5818	1086			160	7063	5898	1166
1974			5411	1063			192	6666	5507	1159
1975			6360	1432			218	8010	6469	1541
1976			4845	1357			244	6446	4967	1479
1977			5093	1273			194	6560	5190	1370
1978			3589	1163			170	4922	3674	1248
1979			4441	1148			140	5729	4511	1218
1980			9158	1289			199	10646	9258	1389
1981			6161	869			159	7189	6241	949
1982			9203	1103			146	10451	9276	1176
1983			10379	1808			176	12363	10467	1896
1984			7244	1118			153	8515	7321	1195
1985			8955	1230			148	10333	9029	1304
1986			7987	3069			144	11199	8059	3141
1987			6336	1215			177	7728	6425	1304
1988			6534	1462			219	8216	6644	1572
1989			4724	1224			200	6147	4824	1324
1990			4902	835			276	6013	5040	973
1991			6917	1854			158	8929	6996	1933
1992	154	12	4621	1442	2			6231	4787	1444
1993	187	21	4693	1322	6			6229	4901	1328
1994	109	4	10368	1185	5			11671	10481	1190
1995	109	10	6193	1620	9	39		7979	6312	1668
1996	94	6	4000	798	10	33		4941	4100	841
1997	139	5	4563	755	9	33		5504	4707	797
1998	198	18	3710	868	10	51		4856	3926	929
1999	134	18	3431	593	10	51		4237	3583	654
2000	127	11	6356	5319	10	50		3838	6494	5379
2001	78	72	7502	2648	10	22		4109	7652	2680
2002	41	22	3231	1338	10	52		2553	3294	1400
2003	65	25	4155	986	10	43		3122	4245	1039
2004	36	29	4396	899	10	70		2747	4461	979
2005	74	33	4043	876	8	75		5893	4150	959
2006	65	24	4508	1343	15	86		7239	4597	1444
2007	84	41	7964	970	18	47		10000	8089	1035
2008	73	15	6276	960	15	62		7401	6364	1037
2009	68	14	5683	1243	7	126		7141	5765	1376
2010	86	7	3375	1140	9	98		4715	3468	1247
2011	105	8	2324	866	11	90		3403	2437	967
2012	169	10	2575	663	12	80		3510	2754	755
2013	189	4	2956	1018	11	85		4263	3149	1114

2014	207	6	3195	811	13	75		4306	3408	899
2015	192	4	3293	879	14	82		4464	3489	975
2016	112	5	2975	970	14	83		4160	3092	1067
2017	106	3	1951	1617	14	83		3774	2060	1714
2018	89	2	1476	1512	11	79		3169	1567	1602
2019	90	5	3975	655	13^	82^		4820	4070	750

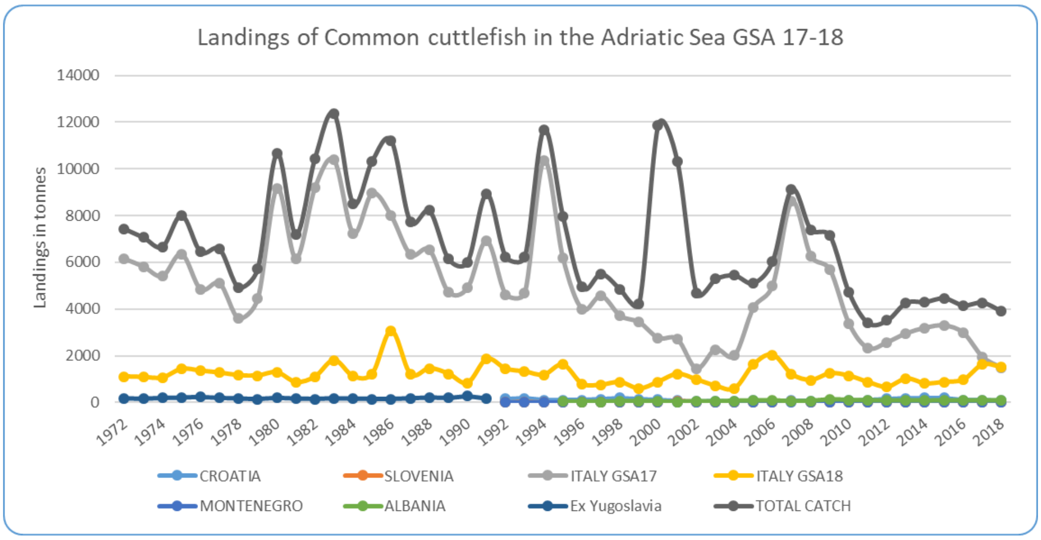


Figure 6.4.2.1.1 Common cuttlefish in GSA 17-18. Total landings.

The landings of common cuttlefish of Albanian fishery fleet were provided by DG-MARE.

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 2017 ranged from 2,553 to 12,363 t with average value approx. 6,500 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 is some data not separated for the states of the former Yugoslavia (Table 6.4.2.1.2) 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

The landing from Italy prior to 2000 were obtained from RECFISH project recently revised catches and these are assumed valid. For 2000 to 2007 the two sources discussed above were a) based on a regression method using the Transversal data as a reference in 2018. This considered by GFCM as an underestimate in 2018, and revised in EWG 19-16 based on reported landing from the Italian DCF data correspondent. The largest differences are in the five years 2000 to 2004. Some uncertainty remains concerning the validity of these values. 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 Transversal database 2018			Italian Correspondents data 2019		
Year	Italy	Italy	Total all countries	Italy	Italy	Total all countries
	GSA17	GSA18	17-18	GSA17	GSA18	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 by gears and by GSAs (GSA 17 and 18) in the period 2006-2017 as shown in Figures 6.4.2.1.2 and 6.4.2.1.3.

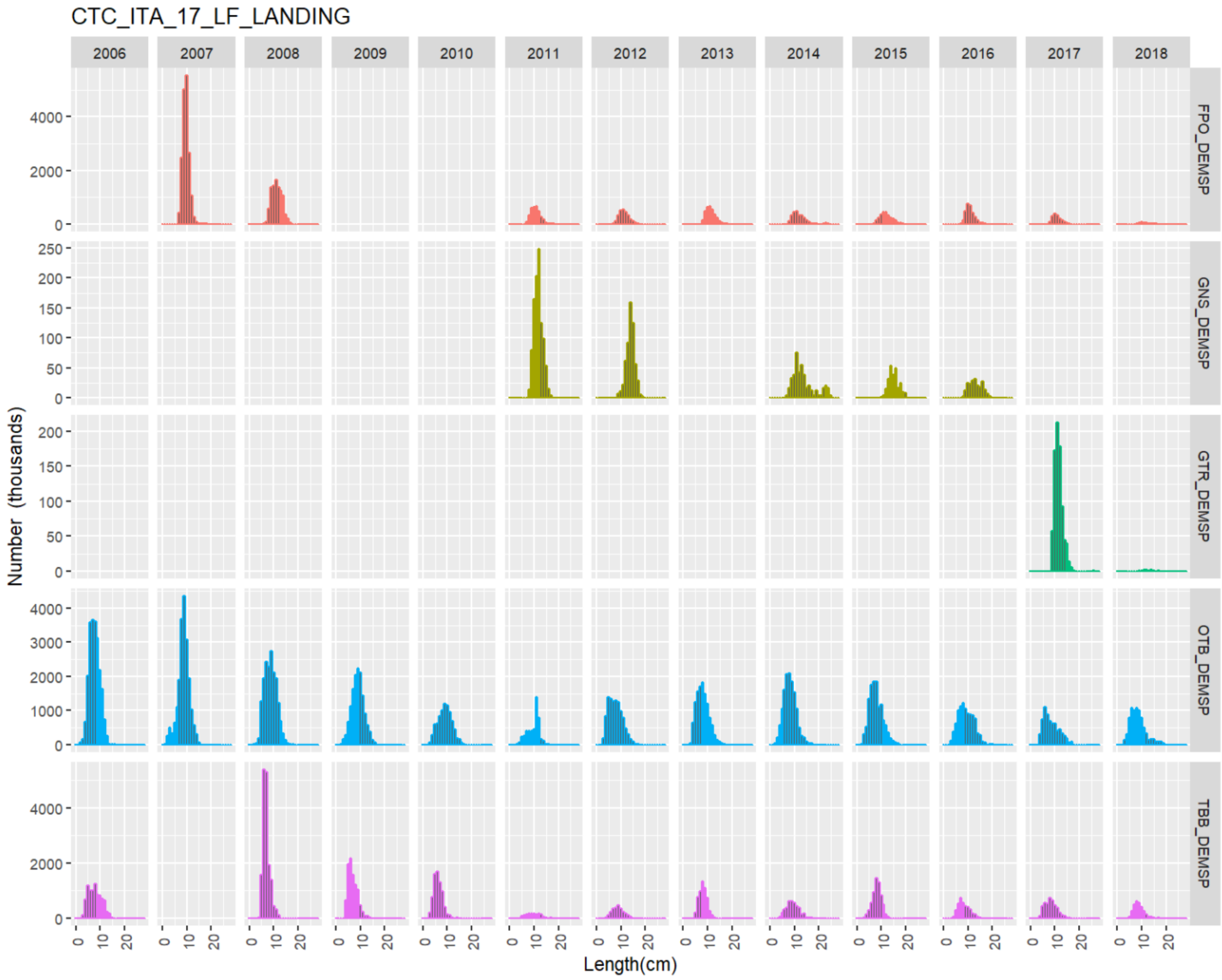


Figure 6.4.2.1.2 Common cuttlefish in GSA 17-18. Catch size distribution (mantle lengths in cm) in the western part of GSA 17 (ITA) by principal fishing gears.

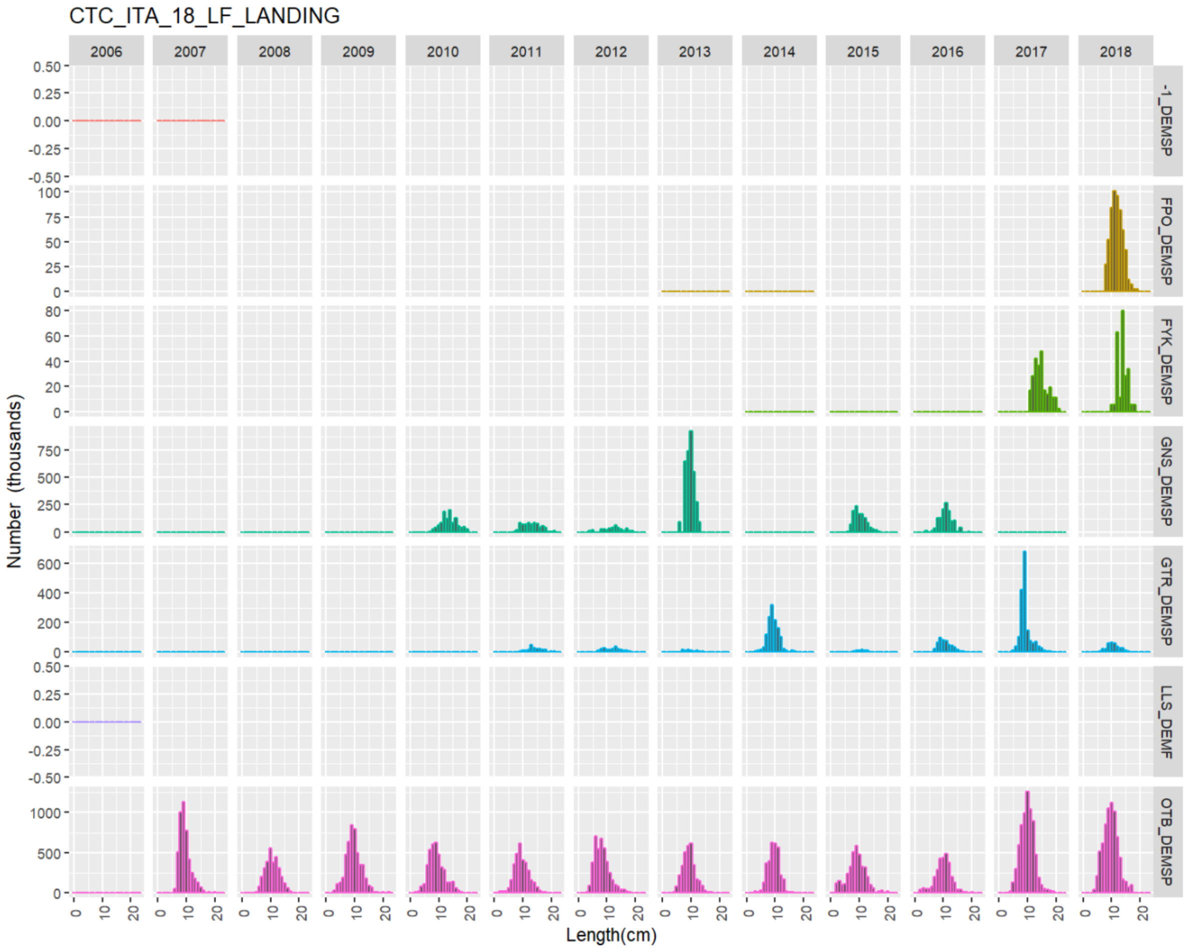


Figure 6.5.2.1.3 Common cuttlefish in GSA 17-18. Catch size distribution (mantle lengths in cm) in the western part of GSA 18 (ITA) by principal fishing gears.

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 between 2006 and 2017 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 2017 with overall average of 9.5 cm (Figure 6.4.2.1.4).

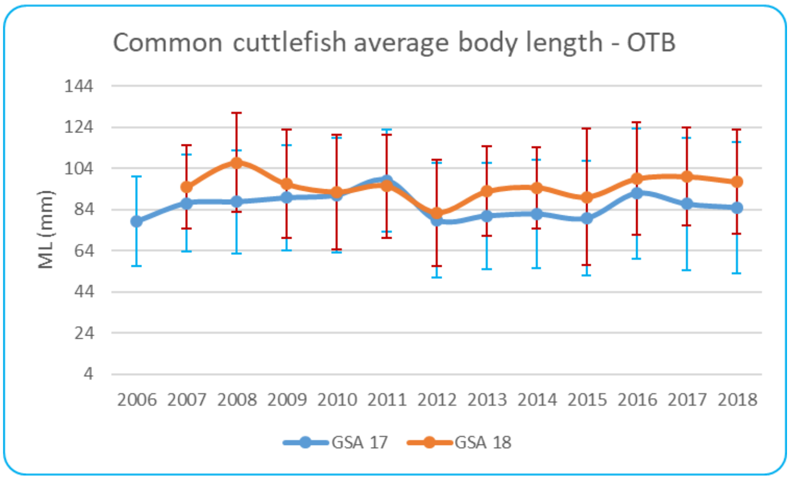


Figure 6.4.2.1.4 Common cuttlefish in GSA 17-18. Average mantle length of individuals landed by bottom trawl fisheries

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 2017 with overall average of 10.6 cm (Figure 6.4.2.1.5).

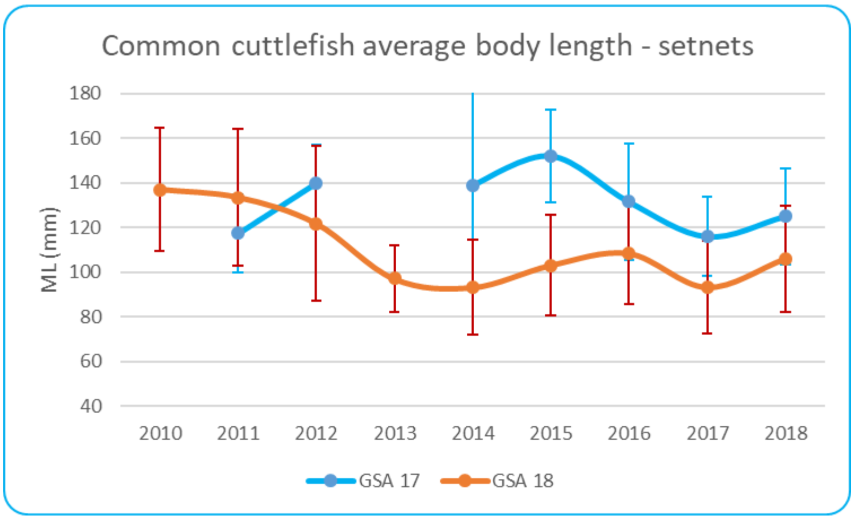


Figure 6.4.2.1.5 Common cuttlefish in GSAs 17 and 18. Average mantle length of common cuttlefish landed by Italian set net fisheries

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 cuttlefish from this fishery were reported only in 2018. 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 10.8 cm. (Figure 6.4.2.1.6). The mantle length of landed specimens in GSA 18 cm varied from 8 to 19 cm with overall average of 11.85 cm.

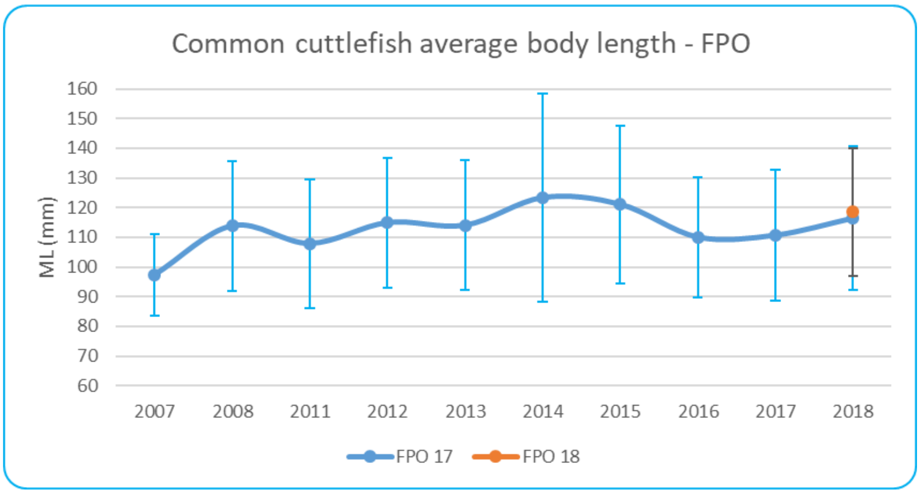


Figure 6.4.2.1.6 Common cuttlefish in GSAs 17-18. Average mantle length (right) of common cuttlefish landed by Italian FPO fishery in GSA 17.

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).

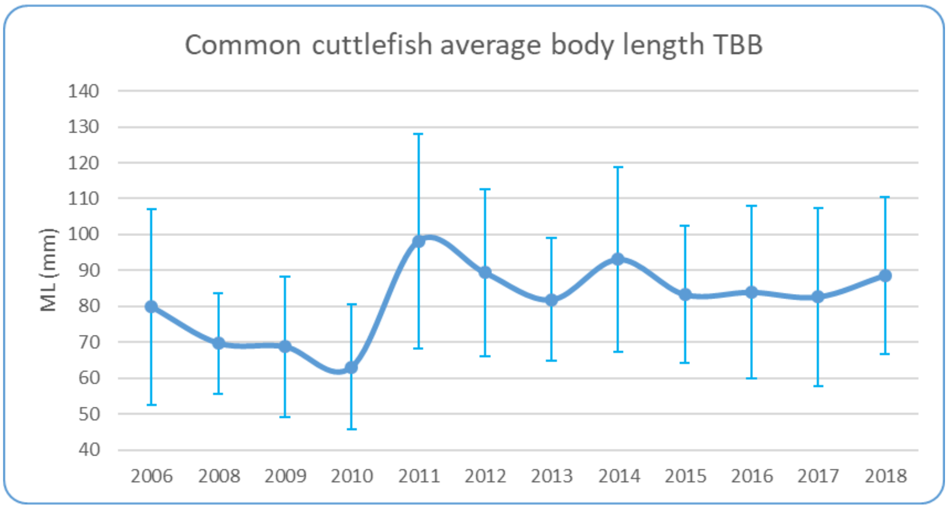


Figure 6.4.2.1.7 Common cuttlefish in GSAs 17-18. Average mantle length (right) of common cuttlefish landed by Italian TBB fishery in GSA 17.

Discards

Only the Slovenian fleet reported information on common cuttlefish discards for entire period covered by their DCF data, but without size structure. Italy reported data on discards are very scarce. Discard of common cuttlefish in Italy is reported in 2015 and 2017 for fishing gear TBB in GSA 17 only. No discards of common cuttlefish are reported by Croatia, and no discards are reported in GSA 18 also. In general, amount of discarded common cuttlefish catch is very low, practically negligible in comparison to the total landings of this species, and EWG 19-16 concluded that landing information 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.

Effort of fleets that report catches of Common Cuttlefish by country and by gear 2005 to 2019 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	39	12446		198883	15		15302
2006		151703		46069	31	29855		188218	15		11717
2007		121526		43602	37	33928		164475	17		15424
2008		112676		55473	40	29729		156340	18		20276
2009		146323		51017	46	40058		176894	19		13394
2010		129160		64821	44	33047		155983	19		13649
2011		144020		67917	48	28986		147841	17		12392
2012	47610	124110	27363	63573	47	32529	35572	133247	16	1883	8759
2013	43354	130490	29234	29909	58	29029	35492	135813	11	2867	10301
2014	45170	99795	27101	47756	59	32810	36287	116177	11	3883	7973
2015	44346	101502	28685	28692	51	20891	34742	113299	12	5303	10814
2016	43324	103659	25356	29800	50	28393	33715	115892	10	5061	9937
2017	44524	60977	25075	42158	44	20607	35649	125597	9	4453	9004
2018	50024	81849	28765	57057	36	49566	33137	136374	9	3606	9352
2019	280046	75896	127771	50957	16	44720	168759	116081	8	21325	11849

Effort data from Croatia in 2019 has been produced on a different basis.

6.4.2.3 SURVEY DATA

Survey data comes from MEDITS surveys. In GSA 17 MEDITS data are available from 1996 to 2018. 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 from 2007 is also available in 2007, but was not available for this species for the 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 2018 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 2018, note late surveys in 2014 and 2017.

The common cuttlefish in GSA 17-18 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 part of the Adriatic Sea were performed in later period (late November in 2014, late September in 2016, and during December in 2017). 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 kgkm^{-2} (2012) to 5.6 kgkm^{-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.

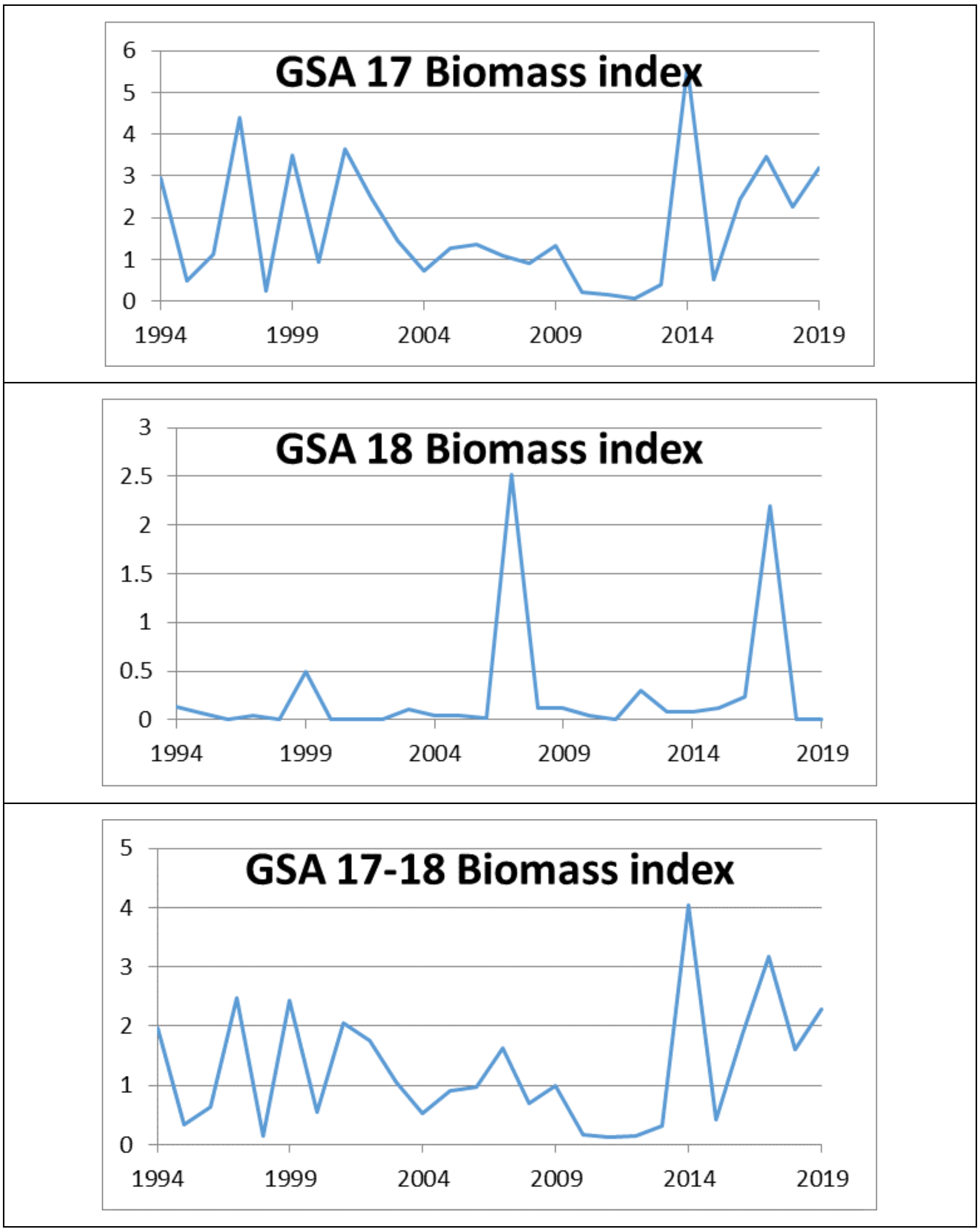


Figure 6.4.2.3.2 Common cuttlefish in GSAs 17 and 18 and 17-18 combined. Trends of biomass indices MEDITS surveys 1994 to 2019

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 2019. 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	2.944376	0.131472	1.955424
1995	0.492642	0.066953	0.34281
1996	1.12575	0	0.622548
1997	4.405324	0.038292	2.467238
1998	0.258028	0	0.143134
1999	3.497788	0.488327	2.437707
2000	0.934583	0	0.541064
2001	3.65637	0	2.055044
2002	2.482983	0	1.759681
2003	1.443066	0.106239	1.062056
2004	0.715533	0.048746	0.530169
2005	1.270892	0.042279	0.905166
2006	1.362497	0.012684	0.960959
2007	1.086709	2.51204	1.617897
2008	0.924813	0.119346	0.686583
2009	1.327142	0.123444	0.999413
2010	0.216242	0.04368	0.170826
2011	0.161967	0.009317	0.11861
2012	0.073452	0.296885	0.150743
2013	0.396414	0.087523	0.31724
2014	5.61273	0.079084	4.038021
2015	0.516199	0.119848	0.41557
2016	2.450195	0.232046	1.854996
2017	3.45293	2.192732	3.172986
2018	2.25386	0.009023	1.603814
2019	3.202155	0	2.282945

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).

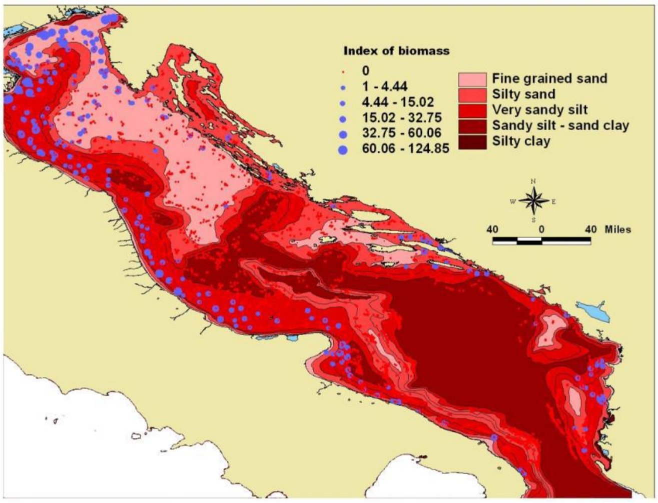


Figure 6.4.2.3.3 Common cuttlefish in GSAs 17 and 18. Distribution of common cuttlefish by depth and sediment type in the Adriatic Sea.

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).

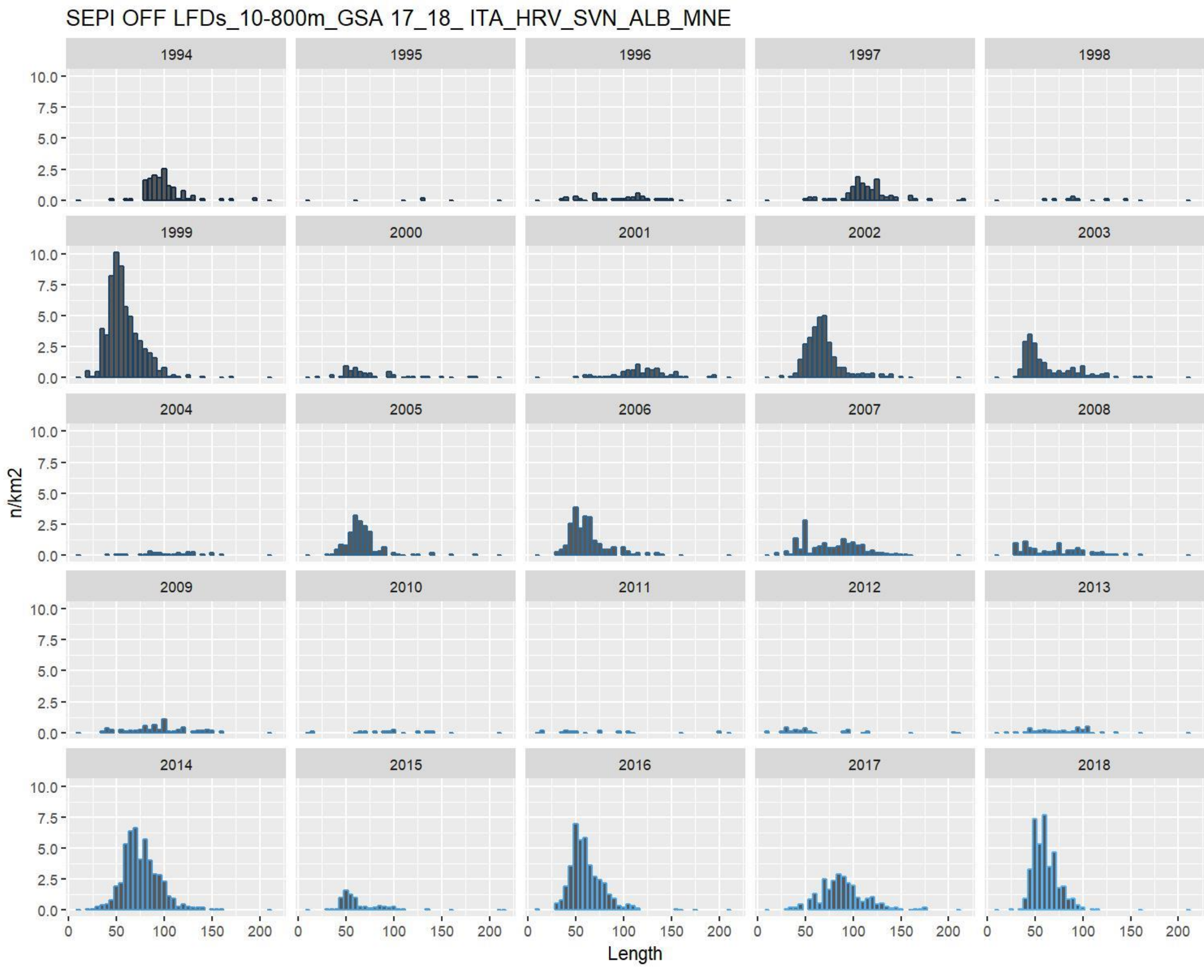


Figure 6.4.2.3.6 Common cuttlefish in GSA 17-18. Length structure (in mm) sampled during surveys in GSA 17 and 18 combined (MEDITS, 1994-2018).

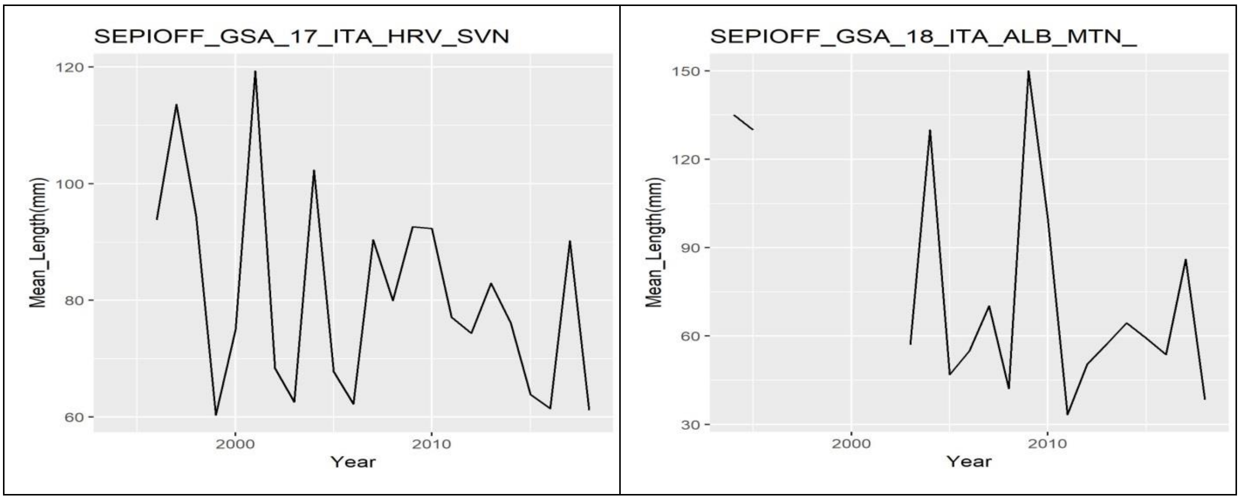


Figure 6.4.2.3.7 Common cuttlefish in GSAs 17 and 18. Trends of average mantle length of common cuttlefish in GSA 17 (a) and GSA 18 (b) during the MEDITS surveys

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 cuttlefish in 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 (CMSY_O_7p.R) and some example input files (O_Stocks_Catch_14_Med.csv and O_Stocks_ID_17_Med.csv) 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

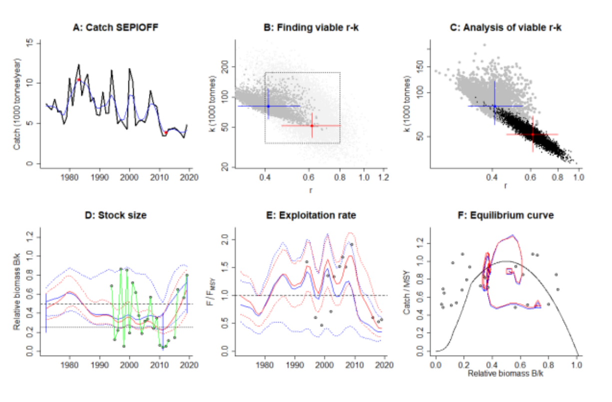
The biomass from MEDITS surveys in GSA 17 and 18 were used as tuning indices (Table 6.4.3.1). Survey data for complete area were available from 1996 onwards. Considering the extreme values of biomass index in 2014 and 2017, which is most likely consequence of conducting the surveys in autumn-winter period, data were excluded for these years for joint GSA 17-18 Index and GSA 17 Index.

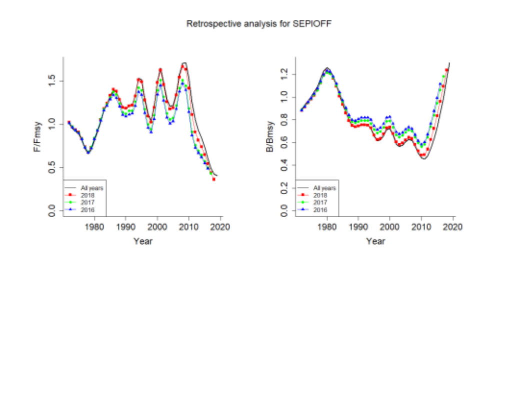
Exploration GSA 17-18

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.

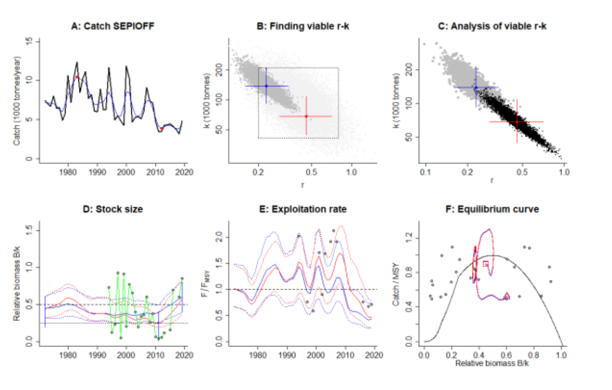
Sensitivity analysis with varying these priors was carried out. The approach was to extend the priors primarily where posterior distributions were observed to be close to the limits. Initial values of r were found almost on the lower bound (Figure 6.4.3.1 a). Also the retrospective for this base case 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.

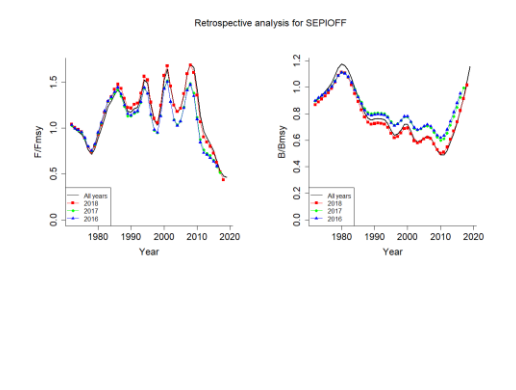
a) Initial settings (see text)



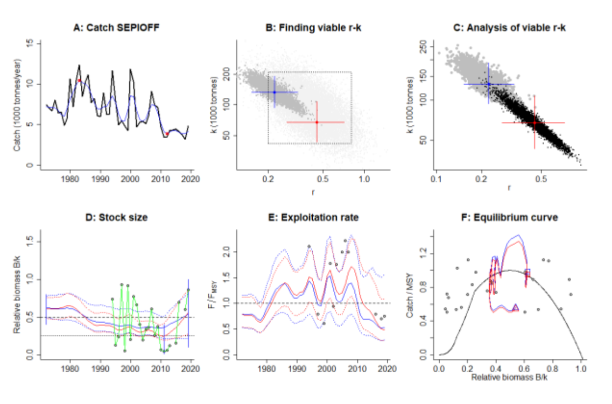


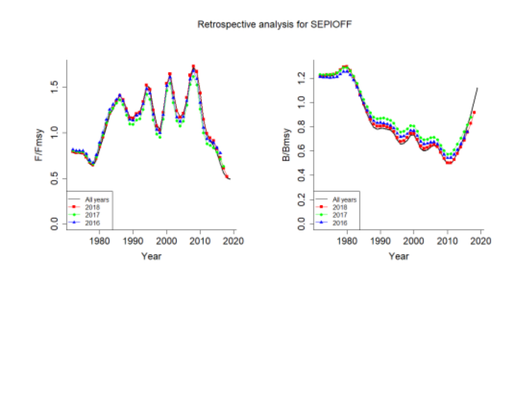
b) r-0.2-0.8



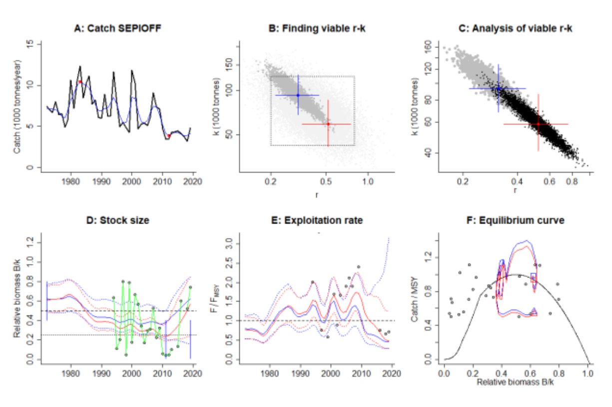


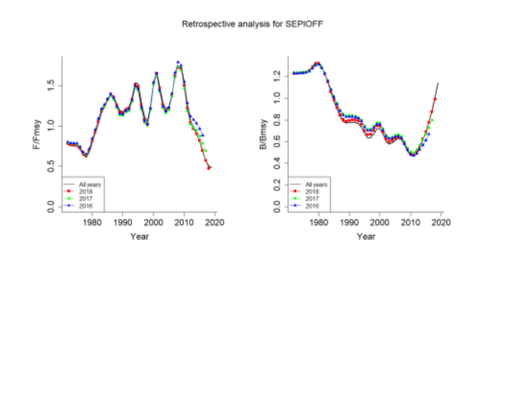
c) Final Biomass wide priors 0.1-1.0



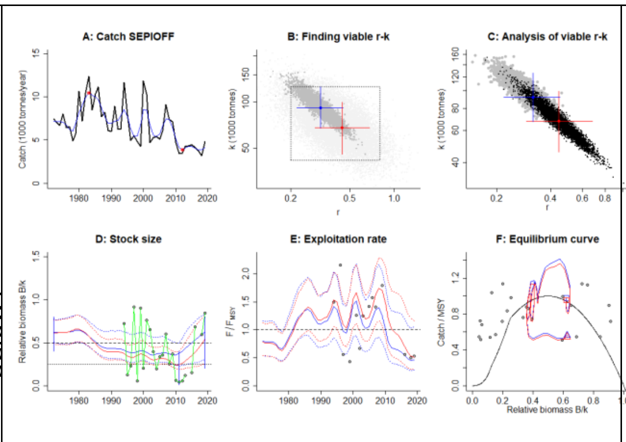


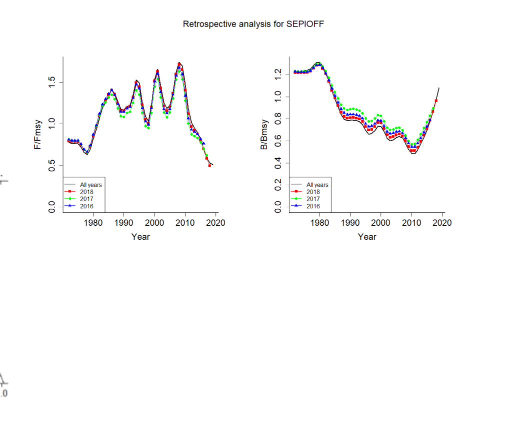
d) No prior on final biomass



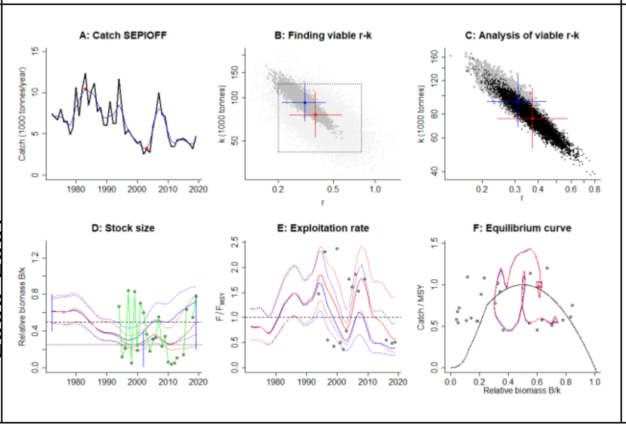


e) Final prior options (see below)





f) Sensitivity to lower catch 2000-2007



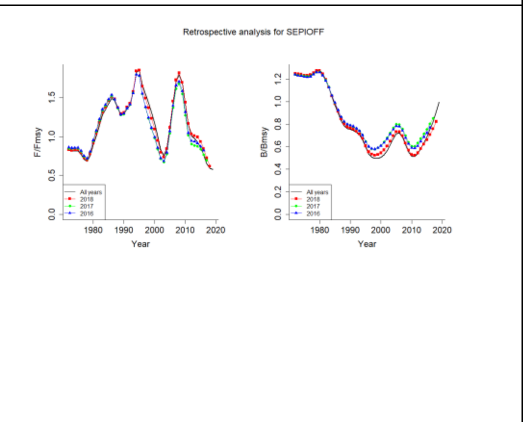


Figure 6.4.3.1 GSA 17-18 Model fit and retrospective performance for different priors (a-e) and sensitivity to choice of catch 2000-2007 (f). Final model setting for priors were; r 0.2 to 0.8, Start biomass 0.4-0.8, end biomass 0.2 0.8. (intermediate biomass was left at default values) The final model 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.

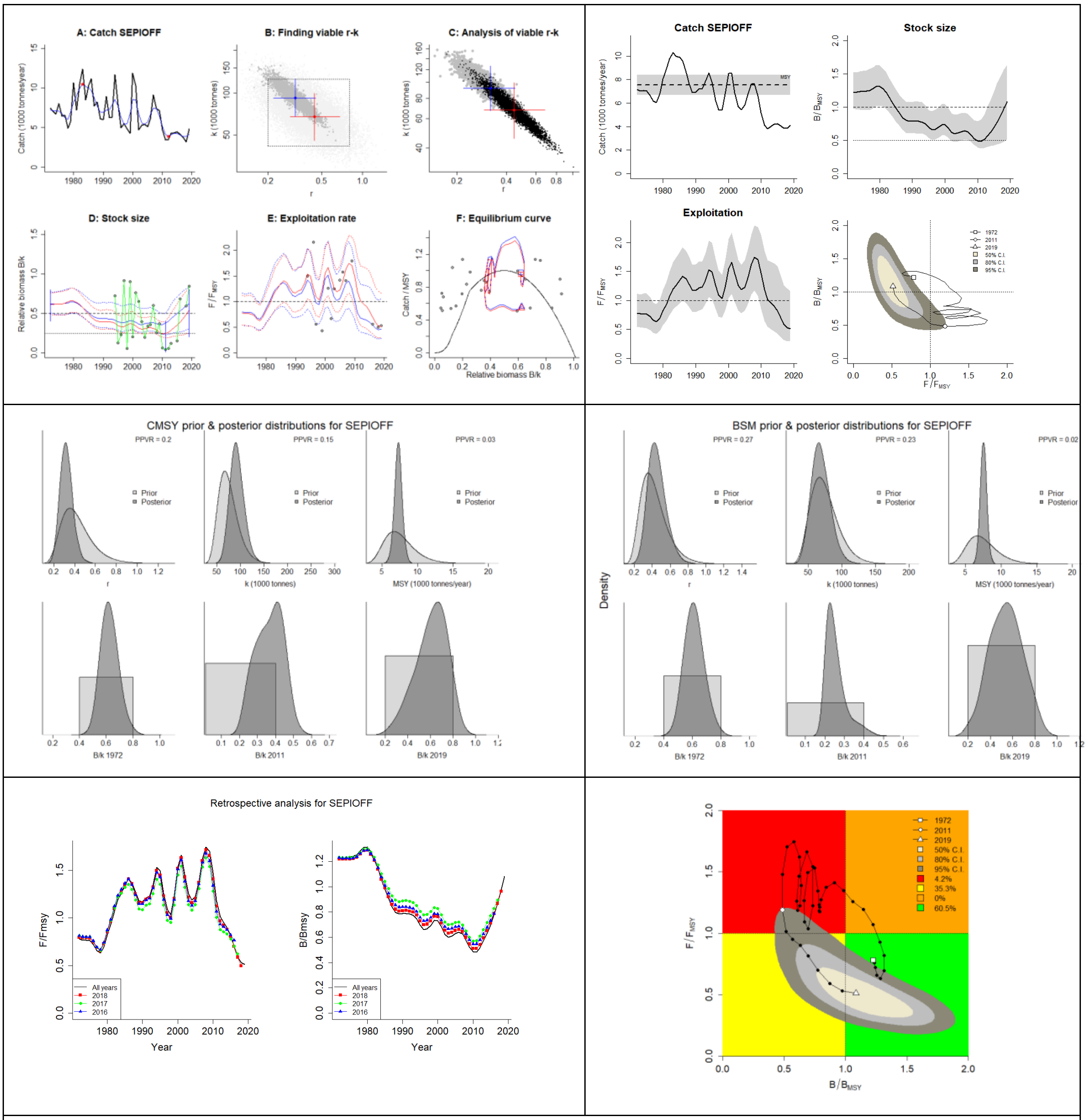


Figure 6.4.3.2 CMSY Assessment GSA 17-18 with higher catch option 2000-2007 (as 2019) a) fitting of model, b) Biomass and F and B/BMSY and F/FMSY. c and d) priors and posteriot distributions. . e) restrospective performance of F/FMSY and B/BMSY f) koby plot showing currentlocation of stock in F and B space.

Results of CMSY model GSA 17-18

startbio= 0.4 0.8 expert , intbio= 2011 0.01 0.4 default , endbio= 0.2 0.8 expert
Running MCMC analysis with only catch data....
Running MCMC analysis with catch and CPUE....

Species: Sepia officinalis , stock: SEPIOFF
Cuttlefish in Adriatic Sea
Region: Mediterranean , Adriatic Sea
Catch data used from years 1972 - 2019 , abundance = CPUE
Prior initial relative biomass = 0.4 - 0.8 expert
Prior intermediate rel. 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
B/k prior used for first year , intermediate year , last year
Prior range of q = 3.78e-05 - 0.000151 , assumed effort creep 0 %

Results of CMSY++ analysis
----
r = 0.319 , 95% CL = 0.22 - 0.45 , k = 91.8 , 95% CL = 67.4 - 125
MSY = 7.32 , 95% CL = 6.26 - 8.38
Relative biomass in last year = 0.626 k, 2.5th perc = 0.303 , 97.5th perc = 0.833
Exploitation F/(r/2) in last year = 0.459 , 2.5th perc = 0.281 , 97.5th perc = 1.05

Results from Bayesian Schaefer model (BSM) using catch & CPUE
----
q = 3.99e-05 , lcl = 2.5e-05 , ucl = 6.12e-05 (derived from catch and CPUE)
r = 0.443 , 95% CL = 0.292 - 0.68 , k = 67.8 , 95% CL = 45.8 - 99.2 , r-k log correlation = -0.917
MSY = 7.53 , 95% CL = 6.68 - 8.41
Relative biomass in last year = 0.542 k, 2.5th perc = 0.255 , 97.5th perc = 0.818
Exploitation F/(r/2) in last year = 0.512 , 2.5th perc = 0.288 , 97.5th perc = 1.16

Results for Management (based on BSM analysis)

Fmsy = 0.159 , 95% CL = 0.11 - 0.225 (if B > 1/2 Bmsy then Fmsy = 0.5 r)
Fmsy = 0.159 , 95% CL = 0.11 - 0.225 (r and Fmsy are linearly reduced if B < 1/2 Bmsy)
MSY = 7.53 , 95% CL = 6.68 - 8.41
Bmsy = 45.9 , 95% CL = 33.7 - 62.7
Biomass in last year = 36.3 , 2.5th perc = 18.6 , 97.5 perc = 56.7
B/Bmsy in last year = 1.08 , 2.5th perc = 0.511 , 97.5 perc = 1.64
Fishing mortality in last year = 0.114 , 2.5th perc = 0.0665 , 97.5 perc = 0.234
Exploitation F/Fmsy = 0.512 , 2.5th perc = 0.288 , 97.5 perc = 1.16

Table 6.4.3.1 Stock Summary Table Common cuttlefish in GSA 17-18

Year	F	F/FMSY	B	B/BMSY	Catch
1972	0.12	0.78	41.74	1.25	7.43
1973	0.12	0.77	41.68	1.24	7.06
1974	0.12	0.77	41.86	1.25	6.67
1975	0.12	0.76	42.05	1.26	8.01
1976	0.12	0.72	42.17	1.26	6.45
1977	0.10	0.66	42.58	1.27	6.56
1978	0.10	0.63	43.47	1.30	4.92
1979	0.11	0.69	44.47	1.33	5.73
1980	0.13	0.82	44.54	1.33	10.65
1981	0.15	0.93	43.44	1.30	7.19
1982	0.17	1.07	41.56	1.24	10.45
1983	0.19	1.19	38.95	1.16	12.36
1984	0.20	1.26	36.09	1.08	8.52
1985	0.21	1.35	33.41	1.00	10.33
1986	0.22	1.41	30.97	0.92	11.20
1987	0.22	1.37	28.81	0.86	7.73
1988	0.20	1.27	27.29	0.81	8.22
1989	0.19	1.18	26.92	0.80	6.15
1990	0.19	1.17	27.03	0.81	6.01
1991	0.19	1.21	27.03	0.81	8.93
1992	0.20	1.23	26.94	0.80	6.23
1993	0.21	1.34	26.50	0.79	6.23
1994	0.24	1.53	25.69	0.77	11.67
1995	0.24	1.50	23.83	0.71	7.98
1996	0.20	1.26	22.65	0.68	4.94
1997	0.17	1.09	22.93	0.68	5.50
1998	0.16	1.03	23.94	0.71	4.86
1999	0.20	1.22	25.25	0.75	4.24
2000	0.25	1.54	25.25	0.75	11.87
2001	0.26	1.66	23.48	0.70	10.33
2002	0.23	1.46	21.43	0.64	4.69
2003	0.20	1.26	20.72	0.62	5.28
2004	0.19	1.19	20.98	0.63	5.44
2005	0.20	1.22	21.60	0.64	5.11
2006	0.22	1.39	21.99	0.66	6.04
2007	0.26	1.62	21.44	0.64	9.12
2008	0.28	1.75	19.80	0.59	7.40
2009	0.27	1.70	18.06	0.54	7.14
2010	0.24	1.48	16.85	0.50	4.72
2011	0.19	1.19	16.78	0.50	3.40
2012	0.16	1.01	17.80	0.53	3.51
2013	0.15	0.95	19.52	0.58	4.26
2014	0.14	0.90	21.50	0.64	4.31
2015	0.13	0.81	23.82	0.71	4.46
2016	0.11	0.70	26.46	0.79	4.16
2017	0.09	0.59	29.57	0.88	3.77

2018	0.08	0.53	32.94	0.98	3.17
2019	0.08	0.51	36.34	1.08	4.82

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 setting are the same as for GSA 17-18 combined, as indices and catches are very similar, as GSA 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 close to F_{MSY} and B close to 50% of B_{MSY}. The overall quality of the assessment is substantively with very similar confidence intervals and values.

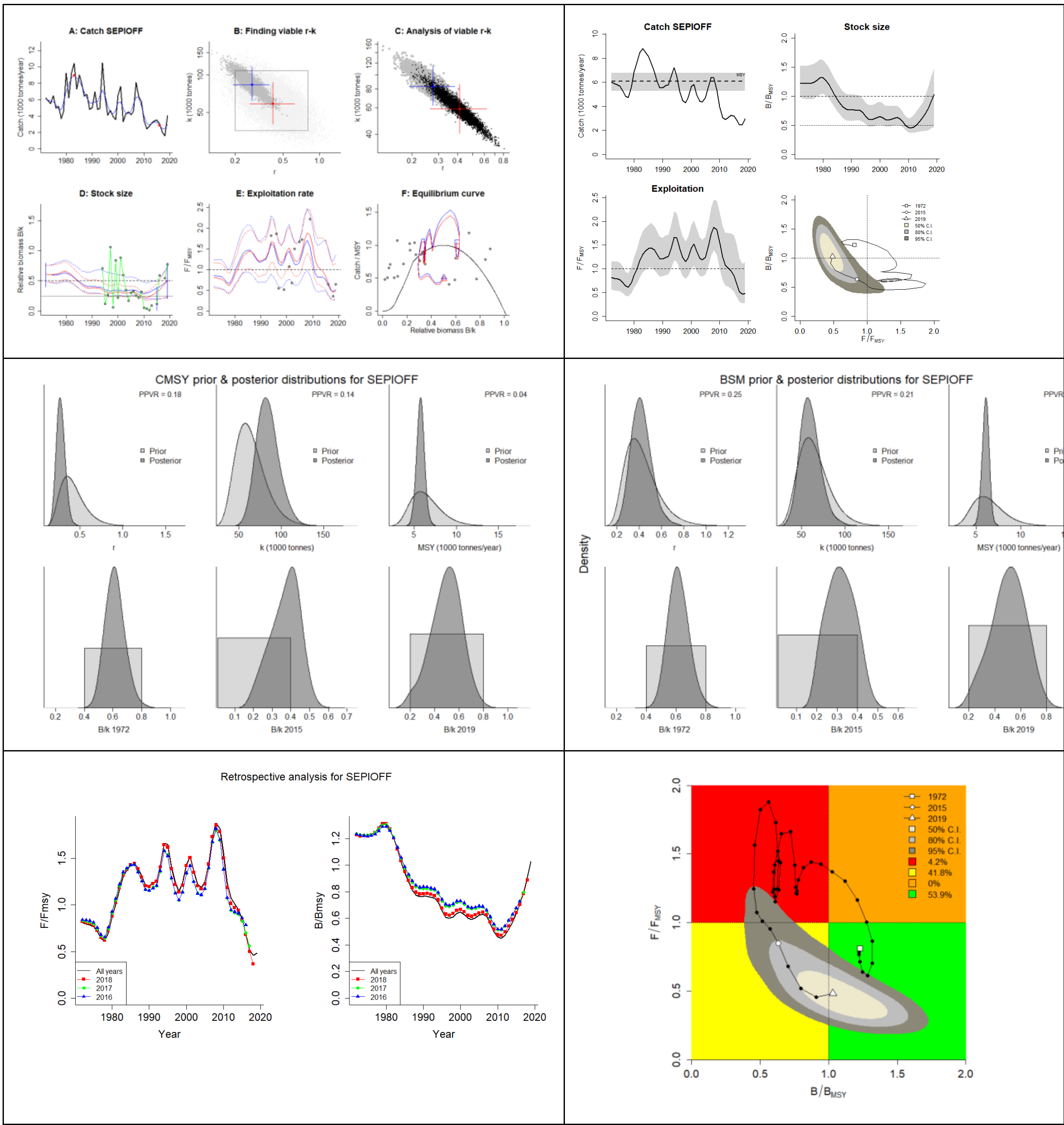


Figure 6.4.3.3 CMSY Assessment GSA 17 with higher catch option 2000-2007 (as 2019) a) fitting of model, b) Biomass and F and B/B_{MSY} and F/F_{MSY}. c and d) priors and posteriot

distributions. . e) restrospective performance of F/F_{MSY} and B/B_{MSY} f) koby plot showing currentlocation of stock in F and B space.

Results of CMSY model GSA 17

* BSM retrospective analysis for SEPIOFF has been enabled
* Retrospective analysis: step n. 1/4. Range of years: [1972 - 2019]
startbio= 0.4 0.8 expert , intbio= 2015 0.01 0.4 default , endbio= 0.2 0.8 expert
Running MCMC analysis with only catch data....
Running MCMC analysis with catch and CPUE....

Species: Sepia officinalis , stock: SEPIOFF
Cuttlefish in Adriatic Sea
Region: Mediterranean , Adriatic Sea
Catch data used from years 1972 - 2019 , abundance = CPUE
Prior initial relative biomass = 0.4 - 0.8 expert
Prior intermediate rel. biomass= 0.01 - 0.4 in year 2015 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
B/k prior used for first year , intermediate year , last year
Prior range of q = 7.32e-05 - 0.000293 , assumed effort creep 0 %

Results of CMSY++ analysis
----
r = 0.276 , 95% CL = 0.193 - 0.384 , k = 83.5 , 95% CL = 62.2 - 113
MSY = 5.77 , 95% CL = 4.86 - 6.69
Relative biomass in last year = 0.504 k, 2.5th perc = 0.223 , 97.5th perc = 0.721
Exploitation F/(r/2) in last year = 0.52 , 2.5th perc = 0.297 , 97.5th perc = 1.35

Results from Bayesian Schaefer model (BSM) using catch & CPUE
----
q = 7.03e-05 , lcl = 4.45e-05 , ucl = 0.00011 (derived from catch and CPUE)
r = 0.412 , 95% CL = 0.264 - 0.62 , k = 58.9 , 95% CL = 40.5 - 86.6 , r-k log correlation = -0.892
MSY = 6.07 , 95% CL = 5.29 - 6.79
Relative biomass in last year = 0.515 k, 2.5th perc = 0.237 , 97.5th perc = 0.744
Exploitation F/(r/2) in last year = 0.483 , 2.5th perc = 0.282 , 97.5th perc = 1.14

Results for Management (based on BSM analysis)

Fmsy = 0.138 , 95% CL = 0.0965 - 0.192 (if B > 1/2 Bmsy then Fmsy = 0.5 r)
Fmsy = 0.138 , 95% CL = 0.0965 - 0.192 (r and Fmsy are linearly reduced if B < 1/2 Bmsy)
MSY = 6.07 , 95% CL = 5.29 - 6.79
Bmsy = 41.7 , 95% CL = 31.1 - 56.6
Biomass in last year = 29.9 , 2.5th perc = 15.1 , 97.5 perc = 45.4
B/Bmsy in last year = 1.03 , 2.5th perc = 0.474 , 97.5 perc = 1.49
Fishing mortality in last year = 0.101 , 2.5th perc = 0.0601 , 97.5 perc = 0.204
Exploitation F/Fmsy = 0.483 , 2.5th perc = 0.282 , 97.5 perc = 1.14
Comment: Catch=landings from FishStat & DCF (Croatia

Table 6.4.3.2 Stock Summary Table Common cuttlefish in GSA 17

Year	F	F/FMSY	B	B/BMSY	Catch
1972	0.17	0.81	36.17	1.25	6.24
1973	0.17	0.80	35.93	1.24	5.90
1974	0.16	0.79	35.92	1.24	5.51
1975	0.16	0.77	36.07	1.24	6.47
1976	0.15	0.71	36.19	1.25	4.97
1977	0.13	0.64	36.61	1.26	5.19
1978	0.13	0.61	37.69	1.30	3.67
1979	0.15	0.70	38.76	1.34	4.51
1980	0.18	0.86	38.76	1.34	9.26
1981	0.21	1.00	37.46	1.29	6.24
1982	0.24	1.16	35.48	1.22	9.28
1983	0.27	1.30	32.90	1.13	10.47
1984	0.29	1.37	30.21	1.04	7.32
1985	0.30	1.43	27.83	0.96	9.03
1986	0.30	1.44	25.66	0.88	8.06
1987	0.29	1.40	23.94	0.82	6.43
1988	0.27	1.31	22.84	0.79	6.64
1989	0.25	1.21	22.42	0.77	4.82
1990	0.25	1.21	22.46	0.77	5.04
1991	0.26	1.23	22.51	0.78	7.00
1992	0.26	1.26	22.36	0.77	4.79
1993	0.30	1.42	22.12	0.76	4.90
1994	0.35	1.66	21.23	0.73	10.48
1995	0.34	1.65	19.28	0.66	6.31
1996	0.30	1.42	17.94	0.62	4.10
1997	0.26	1.24	17.77	0.61	4.71
1998	0.24	1.15	18.17	0.63	3.93
1999	0.26	1.24	18.91	0.65	3.58
2000	0.30	1.44	19.18	0.66	6.49
2001	0.32	1.52	18.63	0.64	7.65
2002	0.29	1.37	17.83	0.61	3.29
2003	0.26	1.22	17.67	0.61	4.25
2004	0.25	1.19	18.01	0.62	4.46
2005	0.26	1.25	18.51	0.64	4.15
2006	0.30	1.45	18.70	0.64	4.60
2007	0.36	1.73	18.09	0.62	8.09
2008	0.39	1.88	16.54	0.57	6.36
2009	0.38	1.82	14.79	0.51	5.77
2010	0.33	1.56	13.61	0.47	3.47
2011	0.26	1.25	13.41	0.46	2.44
2012	0.22	1.07	14.09	0.49	2.75
2013	0.21	1.01	15.37	0.53	3.15
2014	0.20	0.95	16.87	0.58	3.41
2015	0.18	0.85	18.48	0.64	3.49
2016	0.14	0.68	20.58	0.71	3.09

2017	0.11	0.52	23.30	0.80	2.06
2018	0.10	0.46	26.47	0.91	1.57
2019	0.10	0.48	29.89	1.03	4.07

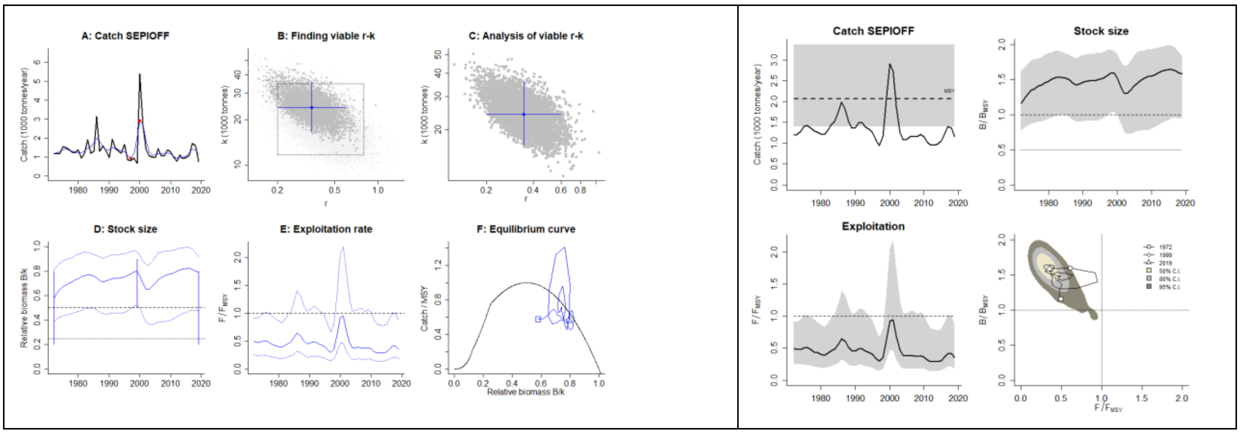
Conclusions to CMSY model for GSA 17

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.



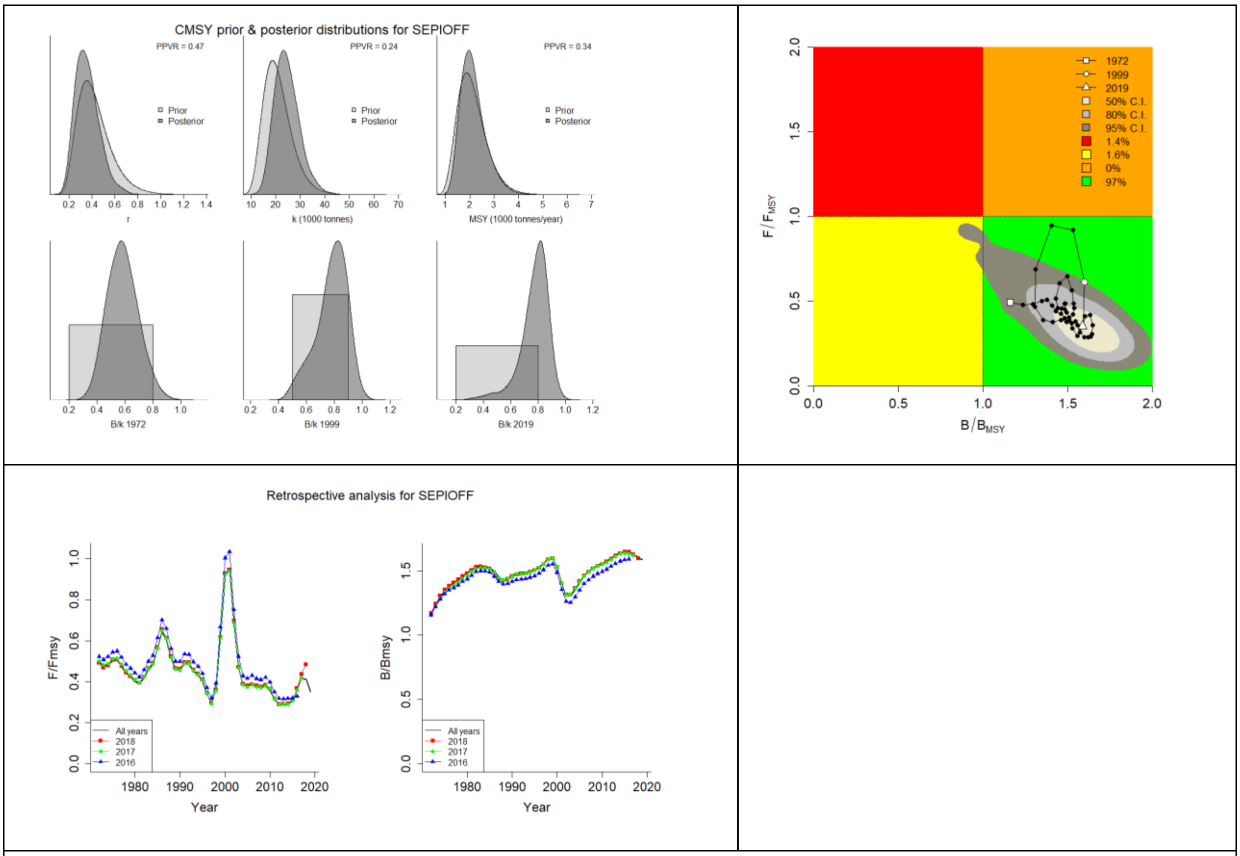


Figure 6.4.3.4 CMSY Assessment GSA 18 with higher catch option 2000-2007 (as 2019) a) fitting of model, b) Biomass and F and B/B$_{MSY}$ and F/F$_{MSY}$. c priors and posteriot distributions. d) koby plot showing currentlocation of stock in F and B space.. e) restrospective performance of F/F$_{MSY}$ and B/B$_{MSY}$

Results of CMSY model GSA 18

startbio= 0.2 0.8 expert , intbio= 1999 0.5 0.9 default , endbio= 0.2 0.8 expert
Running MCMC analysis with only catch data....

Species: Sepia officinalis , stock: SEPIOFF
Cuttlefish in Adriatic Sea
Region: Mediterranean , Adriatic Sea
Catch data used from years 1972 - 2019 , abundance = None
Prior initial relative biomass = 0.2 - 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
----
r = 0.347 , 95% CL = 0.201 - 0.601 , k = 24.1 , 95% CL = 16.6 - 36
MSY = 2.06 , 95% CL = 1.4 - 3.36
Relative biomass in last year = 0.793 k, 2.5th perc = 0.48 , 97.5th perc = 0.924
Exploitation F/(r/2) in last year = 0.352 , 2.5th perc = 0.182 , 97.5th perc = 0.865

Results for Management (based on CMSY analysis)

Fmsy = 0.173 , 95% CL = 0.101 - 0.301 (if B > 1/2 Bmsy then Fmsy = 0.5 r)
Fmsy = 0.173 , 95% CL = 0.101 - 0.301 (r and Fmsy are linearly reduced if B < 1/2 Bmsy)
MSY = 2.06 , 95% CL = 1.4 - 3.36
Bmsy = 12.1 , 95% CL = 8.29 - 18
Biomass in last year = 18.7 , 2.5th perc = 10.6 , 97.5 perc = 29.6
B/Bmsy in last year = 1.59 , 2.5th perc = 0.96 , 97.5 perc = 1.85
Fishing mortality in last year = 0.062 , 2.5th perc = 0.0362 , 97.5 perc = 0.116
Exploitation F/Fmsy = 0.352 , 2.5th perc = 0.182 , 97.5 perc = 0.865
Comment: Catch=landings from FishStat & DCF (Croatia

Table 6.4.3.3 Stock Summary Table Common cuttlefish in GSA 18

Year	F	F/FMSY	B	B/BMSY	Catch
1972	0.085	0.492	13.939	1.185	1.196
1973	0.082	0.477	14.702	1.250	1.166
1974	0.083	0.482	15.435	1.312	1.159
1975	0.087	0.502	15.946	1.355	1.541
1976	0.088	0.508	16.277	1.383	1.479
1977	0.082	0.475	16.610	1.412	1.370
1978	0.076	0.440	16.827	1.430	1.248
1979	0.074	0.425	17.131	1.456	1.218
1980	0.069	0.401	17.403	1.479	1.389
1981	0.067	0.389	17.645	1.500	0.949
1982	0.073	0.421	17.927	1.524	1.176
1983	0.079	0.459	18.057	1.535	1.896
1984	0.084	0.484	17.948	1.525	1.195
1985	0.098	0.565	17.894	1.521	1.304
1986	0.112	0.645	17.552	1.492	3.141
1987	0.104	0.604	17.064	1.450	1.304
1988	0.089	0.515	16.829	1.430	1.572
1989	0.079	0.459	16.997	1.445	1.324
1990	0.079	0.456	17.184	1.461	0.973
1991	0.084	0.487	17.415	1.480	1.933
1992	0.084	0.486	17.359	1.475	1.444
1993	0.078	0.452	17.367	1.476	1.328
1994	0.075	0.432	17.484	1.486	1.190
1995	0.070	0.402	17.647	1.500	1.668
1996	0.059	0.340	17.773	1.511	0.841
1997	0.051	0.294	18.156	1.543	0.797
1998	0.062	0.358	18.567	1.578	0.929
1999	0.106	0.613	18.747	1.593	0.654
2000	0.159	0.920	17.954	1.526	5.379
2001	0.164	0.947	16.389	1.393	2.680
2002	0.119	0.690	15.350	1.305	1.400
2003	0.081	0.468	15.282	1.299	1.039
2004	0.067	0.386	15.848	1.347	0.979
2005	0.066	0.379	16.528	1.405	0.959
2006	0.067	0.390	17.088	1.452	1.444
2007	0.065	0.378	17.508	1.488	1.035
2008	0.064	0.369	17.841	1.516	1.037
2009	0.066	0.379	18.074	1.536	1.376
2010	0.062	0.360	18.242	1.550	1.247
2011	0.055	0.317	18.405	1.564	0.967
2012	0.050	0.287	18.716	1.591	0.755
2013	0.049	0.285	19.015	1.616	1.114
2014	0.050	0.289	19.205	1.632	0.899
2015	0.053	0.306	19.352	1.645	0.975
2016	0.062	0.358	19.407	1.650	1.067

2017	0.072	0.416	19.231	1.634	1.714
2018	0.071	0.411	18.942	1.610	1.602
2019	0.061	0.352	18.707	1.590	0.750

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 2014 and 2017 values replaced with NA, as the survey was much later and the values very different.

SPiCT Settings

Model was not able converge using catch data series from years before the tuning index data was available (1994). Therefore, a shorten data series of catches, concurrent with survey data were used.

No priors on any of the model parameters or variables were required for the model to converge. The Schaefer production model was selected.

SPiCT Results

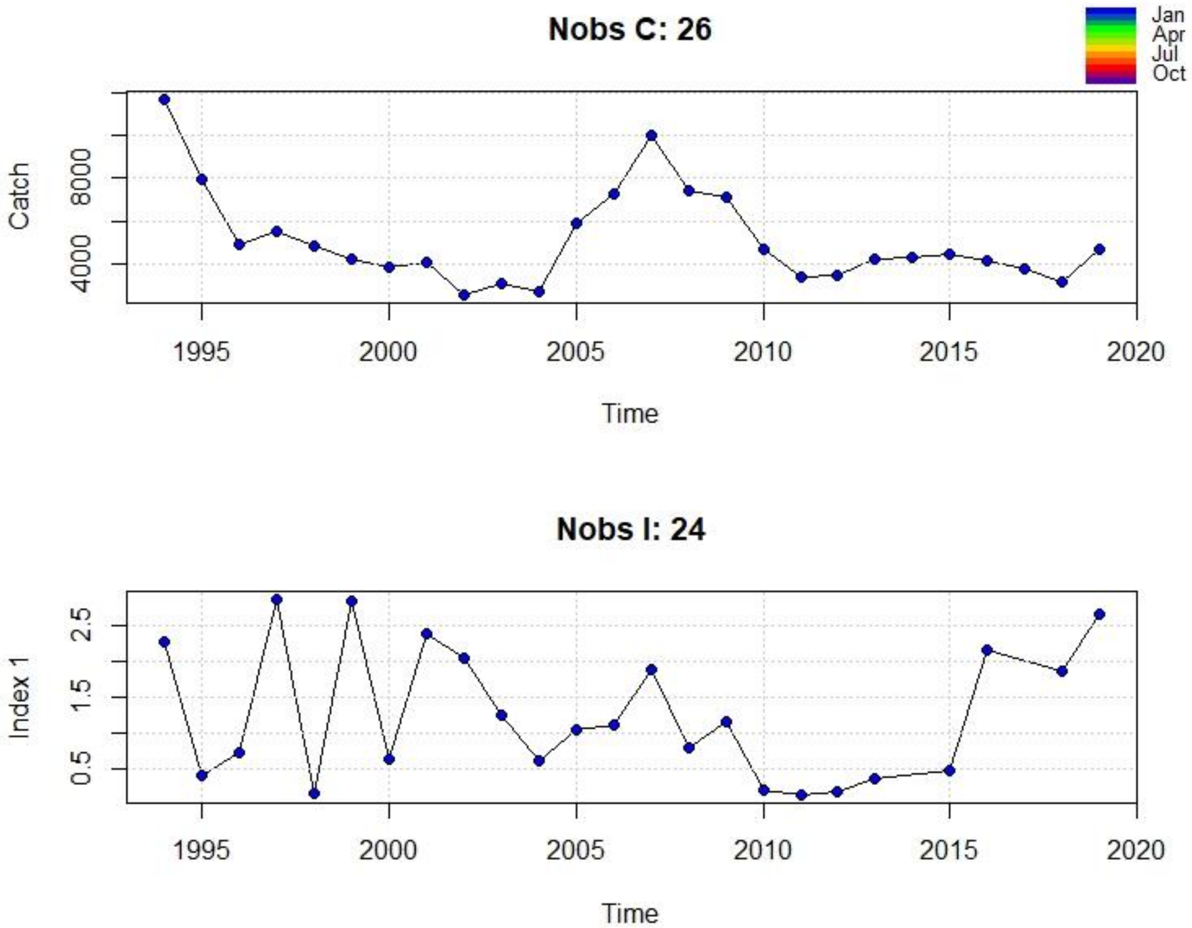


Figure 6.4.3.5 Common cuttlefish in GSAs 17 and 18. Input data for stock assessment of common cuttlefish in GSA 17-18 (Survey values for 2014 and 2017 excluded- see text)

The assessment results show that for the period 2010-2015, the common cuttlefish stock was 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)

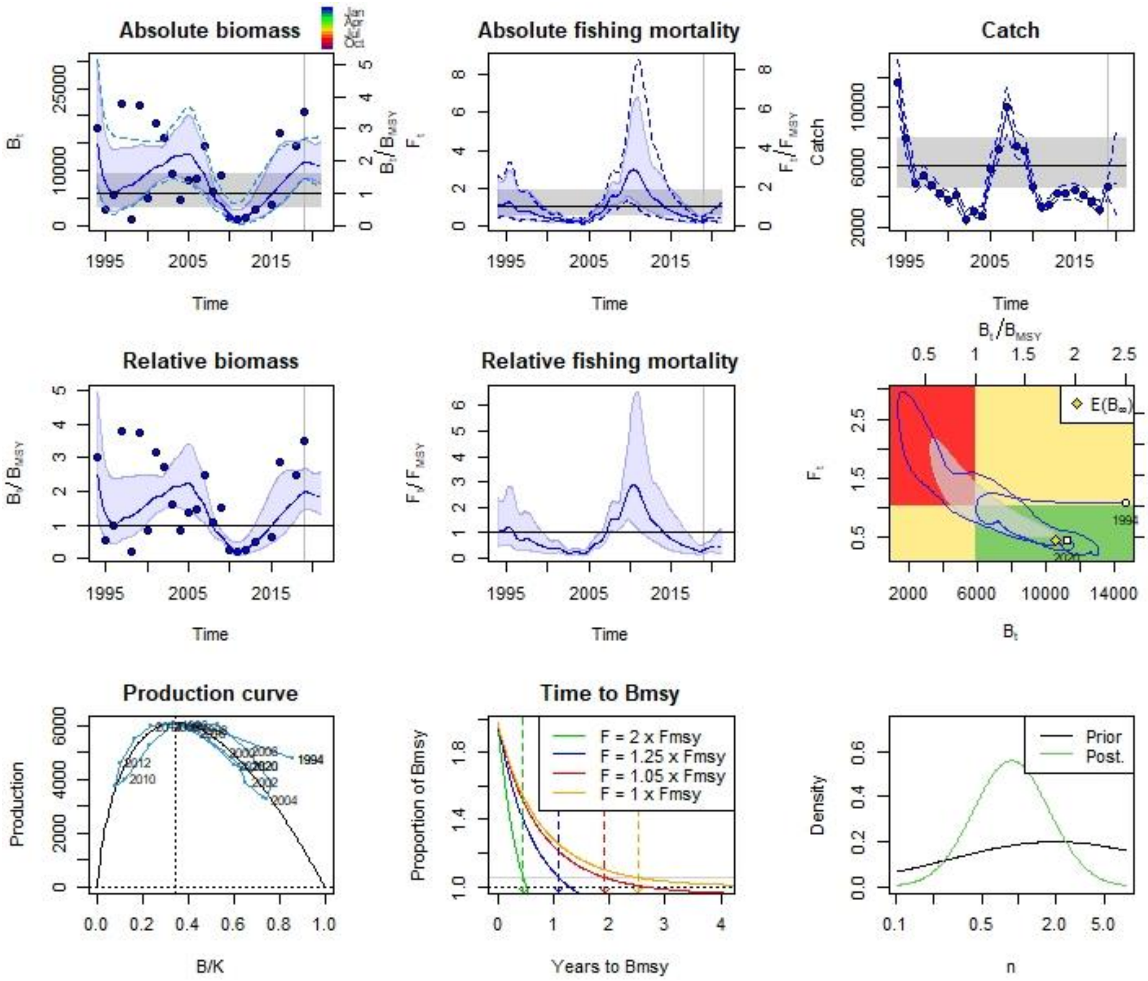


Figure 6.4.3.6 Common cuttlefish in GSAs 17 and 18. Summary of the final SPiCT model fit and output. Absolute and relative Biomass and Fishing mortality, state of the stock in F/B space and relative to estimated production.

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

Convergence: 0 MSG: relative convergence (4)
Objective function at optimum: 43.5450272
Euler time step (years): 1/16 or 0.0625
Nobs C: 26, Nobs I1: 24

Priors
    logn ~ dnorm[log(2), 2^2]
    logalpha ~ dnorm[log(1), 2^2]
    logbeta ~ dnorm[log(1), 2^2]

Model parameter estimates w 95% CI

	estimate	cilow	ciupp	log.est
alpha	9.8815678	0.8356097	116.8552485	2.2906712
beta	0.1452734	0.0169377	1.2460003	-1.9291379
r	0.9062404	0.1829756	4.4884222	-0.0984507
rc	2.0704882	1.1486289	3.7322075	0.7277844
rold	7.2725057	0.0000897	589833.9958831	1.9841009
m	6097.1490781	4645.2801851	8002.7953964	8.7155766
K	17136.3785947	8041.5148438	36517.4319821	9.7489589
q	0.0001283	0.0000725	0.0002271	-8.9610701
n	0.8753881	0.2170062	3.5312556	-0.1330879
sdb	0.0700765	0.0060749	0.8083559	-2.6581682
sdf	0.4078161	0.2739346	0.6071301	-0.8969389
sdi	0.6924654	0.5125728	0.9354931	-0.3674970
sdc	0.0592448	0.0086333	0.4065594	- 2.8260769

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	5889.576324	3670.7074553	9449.706819	8.6809393
Fmsyd	1.035244	0.5743144	1.866104	0.0346372
MSYd	6097.149078	4645.2801851	8002.795396	8.7155766

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	5877.033411	3655.6865031	9448.162931	8.6788074	-0.00213422525
Fmsys	1.035221	0.5745312	1.865316	0.0346149	-0.00002240044
MSYs	6084.027631	4653.6191350	7954.108649	8.7134222	-0.00215670409

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2019.00	11615.5036130	8524.4239686	15827.4535242	9.3600960
F_2019.00	0.3299205	0.2077689	0.5238877	-1.1089035
B_2019.00/Bmsy	1.9764229	1.4623122	2.6712815	0.6812886
F_2019.00/Fmsy	0.3186957	0.1825267	0.5564500	-1.1435184

Predictions w 95% CI (inp$msytype: s)

	prediction	cilow	ciupp	log.est
B_2020.00	11253.2219401	7890.9203582	16048.1918819	9.3284098
F_2020.00	0.4497480	0.2563817	0.7889534	-0.7990679
B_2020.00/Bmsy	1.9147793	1.4355991	2.5539022	0.6496024
F_2020.00/Fmsy	0.4344464	0.2410838	0.7828966	-0.8336828
Catch_2020.00	4951.6299529	2855.8671643	8585.3570140	8.5074721
E(B_inf)	10563.6486006	NA	NA	9.2651740

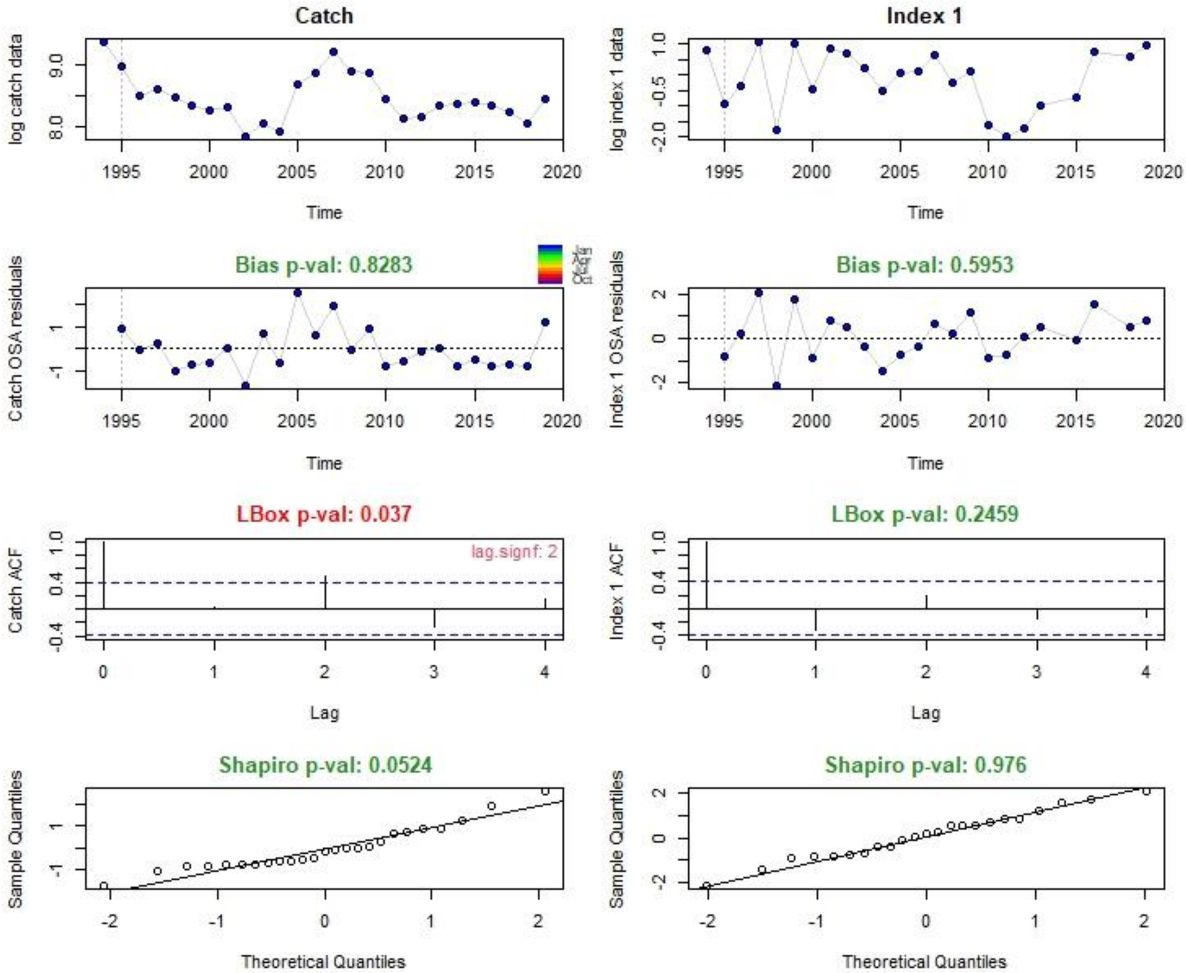


Figure 6.4.3.7 Common cuttlefish in GSAs 17 and 18. Diagnostics from SPiCT model for common cuttlefish in GSA 17-18.

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}

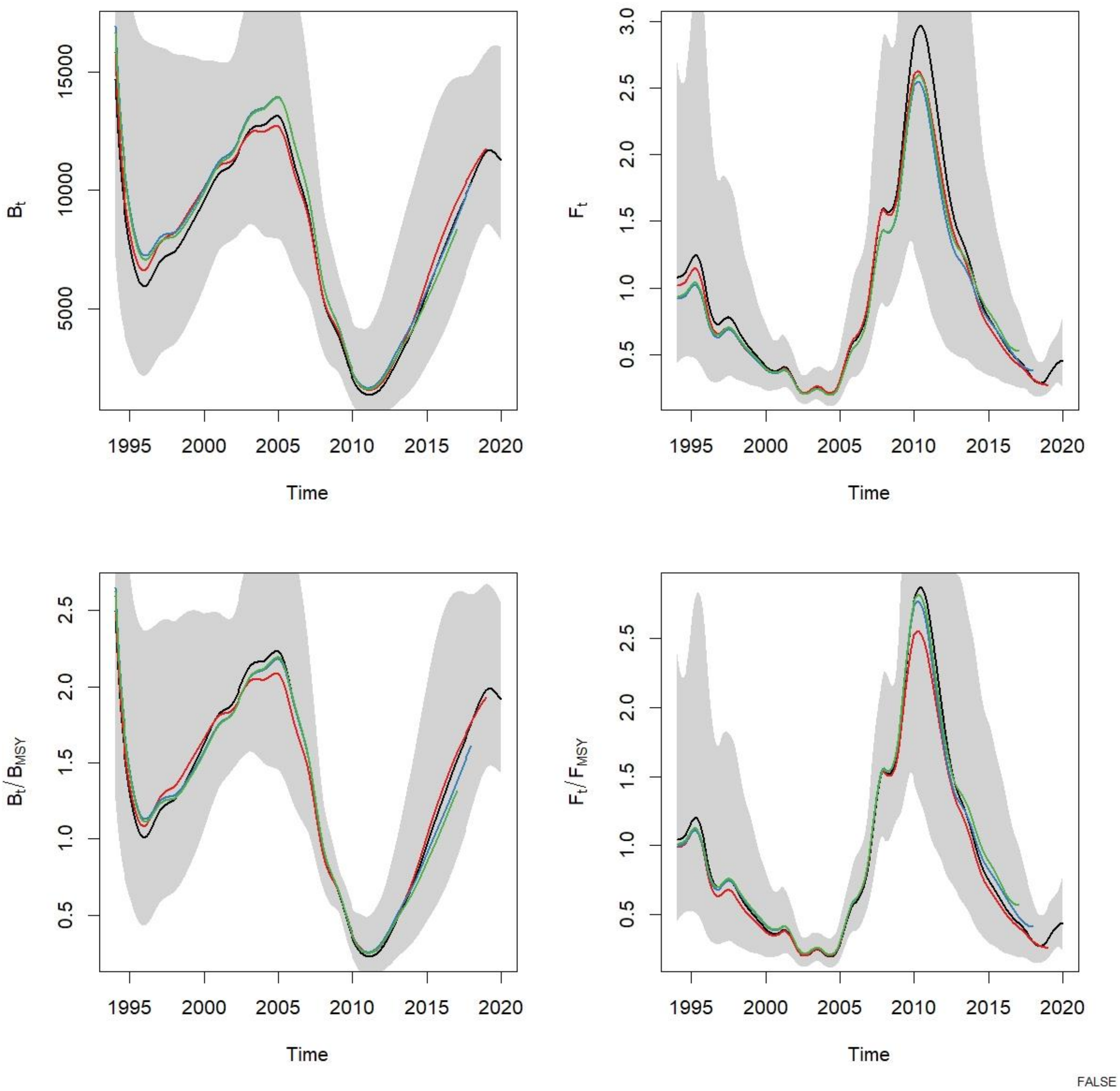
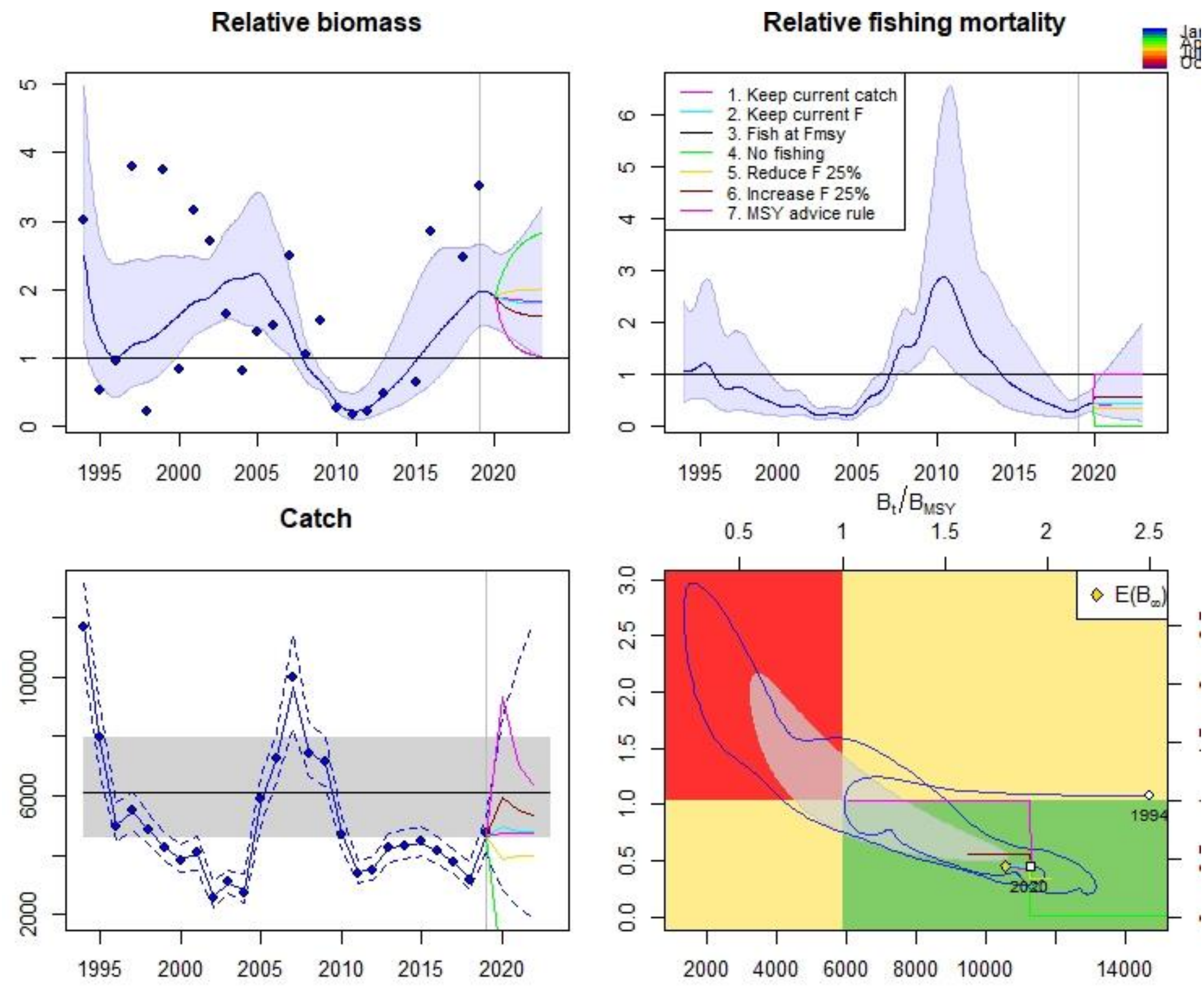


Figure 6.4.3.8 Common cuttlefish in GSAs 17 and 18. Retrospective analysis for the SPiCT model for common cuttlefish in GSA 17-18

STF

	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



Conclusions to Assessment Modelling

The CMSY model indicating the recent recovery of 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 SPiCT model would not fit to the full data series, but only to a period with both survey and catch data available. The SPiCT model conveys a different perception of biomass and to some extent F. The CMSY model estimates much higher biomass during the period not covered by the SPiCT model, leaving the SPiCT model with a shorter time frame giving an incomplete perception of the stock dynamics.

It is considered that the CMSY model is better placed to locate the current state of the stock in terms of B/BMSY and F/FMSY due to the longer time series and greater range of Biomass observed. The estimates of MSY by both models is similar SPiCT 6084 (cl: 4653 7954) and CMSY 7530 (cl 6680 - 8410) the SPiCT model gives a wider range that includes the CMSY estimate, so the values are not significantly different. The difference of 21% between the estimates of MSY is driven mostly by the greater annual catches in the earlier years, catch from 1972-1993 are 29% greater than catch from 1994 onwards. The shorter time series also give a different perception of stock dynamics, with r greater in SPiCT, again the difference in catches between these different time periods leads to lower values of r when considering longer term changes in stock dynamics. These longer time scale changes may be driven by changing environmental conditions, and it is these rather than inter-annual variability that may be being expressed in the lower value of r seen in the CMSY model.

It is concluded that the longer time-series better represents the dynamics of the stock and CMSY is used for the assessment.

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 to succeed 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 = 0.159 , 95% CL = 0.11 - 0.225 (if B > 1/2 Bmsy then Fmsy = 0.5 r)
MSY = 7.53 , 95% CL = 6.68 - 8.41
Bmsy = 45.9 , 95% CL = 33.7 - 62.7

GSA 17

Fmsy = 0.138 , 95% CL = 0.0965 - 0.192 (if B > 1/2 Bmsy then Fmsy = 0.5 r)
MSY = 6.07 , 95% CL = 5.29 - 6.79
Bmsy = 41.7 , 95% CL = 31.1 - 56.6

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 2021. 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	F2019	F_{MSY}	Change in F	Catch 2019	MSY	Change in catch
GSA 17-18	Common cuttlefish	CMSY	0.51 F_{MSY}	0.159	96%	4820	7530	56%
GSA 17	Common cuttlefish	CMSY	0.48 F_{MSY}	0.138	108%	4070	6070	49%

6.4.6 Data Deficiencies

The late arrival of Albanian and Montenegrin catch data has minor consequences, for the assessment.

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

6.5.1 Stock Identity and Biology

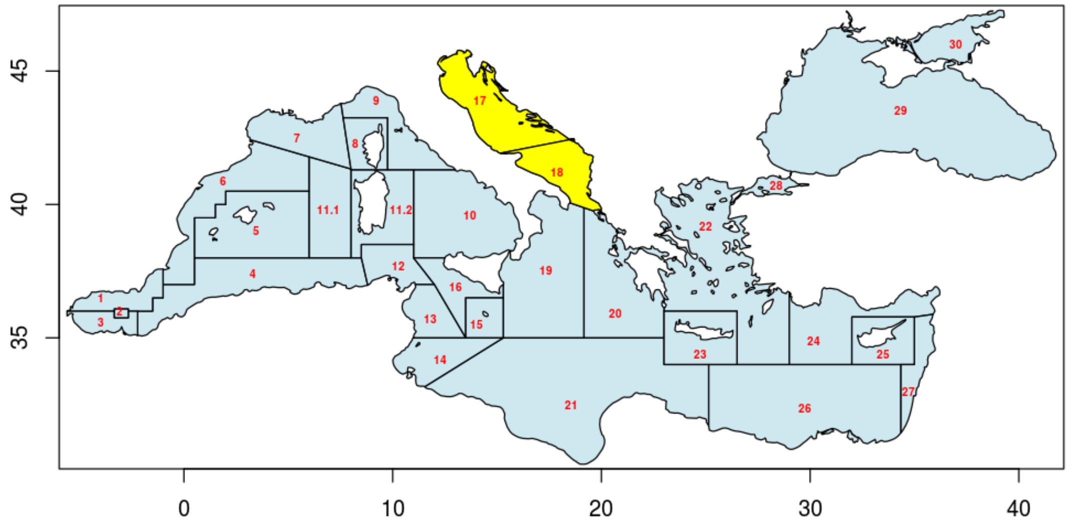


Figure 6.5.1.1 Norway lobster in GSA 17 and 18. Geographical location of GSAs 17-18.

The main biological traits of the species in the Adriatic have been discussed during the EWG 15-16, EWG 18-16, and revised during EWG 19-16, accordingly we update the assessment using the same production model (SPICT) adding the data of 2019 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 6.3.1.2). In GSA 18 the more persistently abundant adult aggregations occur on the SE and SW edges of the South Adriatic Pit (Figure 6.3.1.3).

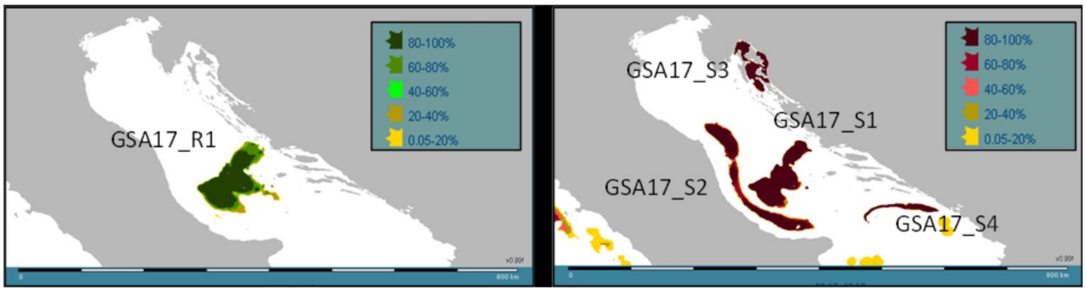


Figure 6.5.1.2 Norway lobster in GSA 17 and 18. Position of persistent nursery (left) and spawning areas (right) in GSA 17 as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

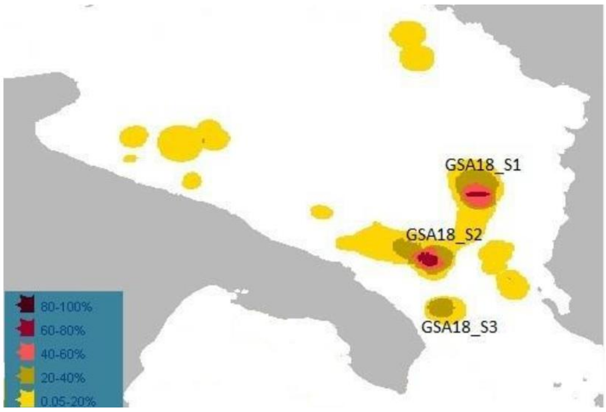


Figure 6.5.1.3 Norway lobster in GSA 17 and 18 Position of persistent spawning areas in GSA 18 of as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

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 (no data were available for Albania during the meeting).

LANDINGS

Landings in weight

Landings data by gear for Croatia were available for the period 2013-2019.

Table 6.5.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2019.

Gear	2013	2014	2015	2016	2017	2018	2019
FPO	0	17.171	29.935	29.669	38.656	47.232	50.7
OTB	278.167	325.217	268.615	202.798	158.713	182.826	214.246
Total	**278.167**	**342.388**	**298.550**	**232.467**	**197.369**	**230.057**	**264.946**

Table 6.5.2.1.2 Norway lobster in GSA 17 and 18. Proportion of Croatian landings data by gear for the period 2013-2019.

Gear	2013	2014	2015	2016	2017	2018	2019
FPO	0.00	0.05	0.10	0.13	0.20	0.21	0.19
OTB	1.00	0.95	0.90	0.87	0.80	0.79	0.81

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.

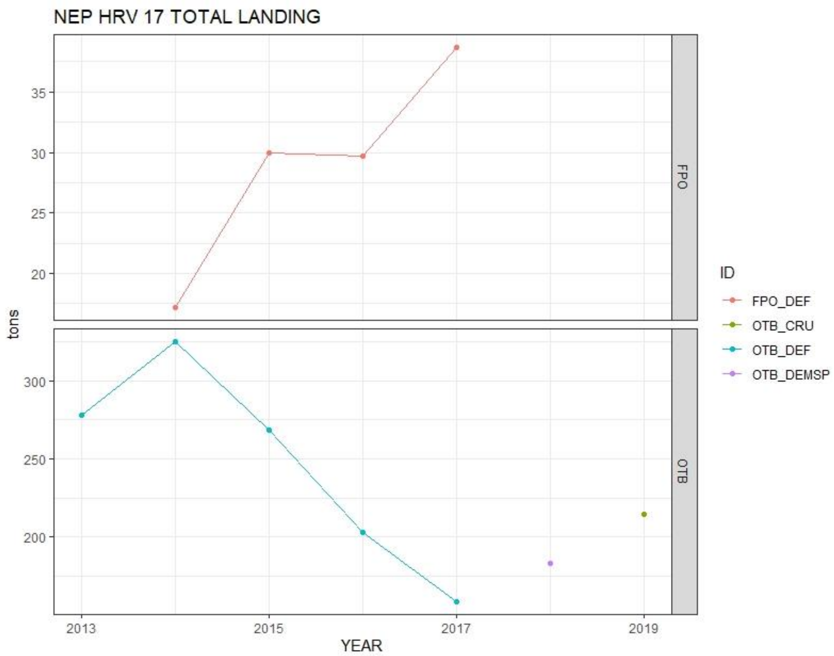


Figure 6.5.2.1.1 Norway lobster in GSA 17 and 18. Croatian landings data by gear for the period 2013-2019 for GSA 17.

Landings data by gear for Italy (GSA17) were available for the period 2006-2019.

Table 6.5.2.1.2 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2019.

Total landings in weight (tonnes)	
Year	OTB
2006	1462.369
2007	1259.422

2008	1270.441
2009	1378.788
2010	1215.949
2011	936.590
2012	801.527
2013	606.542
2014	528.592
2015	450.143
2016	359.472
2017	288.000
2018	387.000
2019	392.000

Otter trawler (OTB) is the only gear catching Norway Lobster in the GSA17 Italian side. There is a clear decreasing trend in the landings from almost 1500 tonnes in 2006 to just below 300 tonnes in 2017, with an increase to almost 400 in 2019.

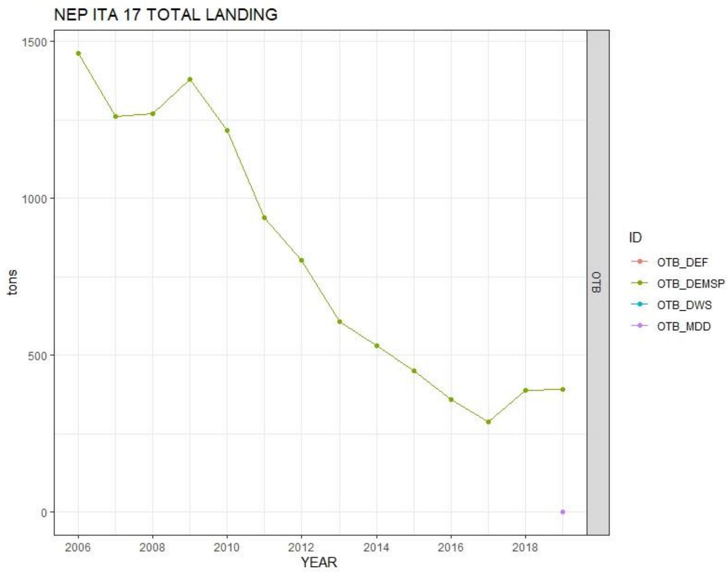


Figure 6.5.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA17) landings data by gear for the period 2006-2019.

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 data by gear for the period 2002-2019.

	Total landings in weight (tonnes)			
year	-1	GNS	OTB	**Total**
2002	36.317		442.156	**478.473**
2003	141.766	5.528	1039.255	**1186.550**
2004			1218.430	**1218.430**
2005		2.274	1196.402	**1198.676**

2006	0.477	9.551	1436.620	**1446.647**
2007		14.743	1299.891	**1314.634**
2008		9.836	1002.964	**1012.800**
2009			1092.894	**1092.894**
2010			1023.423	**1023.423**
2011			759.169	**759.169**
2012			458.704	**458.704**
2013			833.833	**833.833**
2014			444.717	**444.717**
2015			442.753	**442.753**
2016			395.072	**395.072**
2017			556.178	**556.178**
2018			648.184	**648.184**
2019			375.508	**375.508**

Table 6.5.2.1.5 Norway lobster in GSA 17 and 18. Proportion of Italian (GSA18) landings data by gear for the period 2002-2019.

	Proportion by gear type		
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

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.

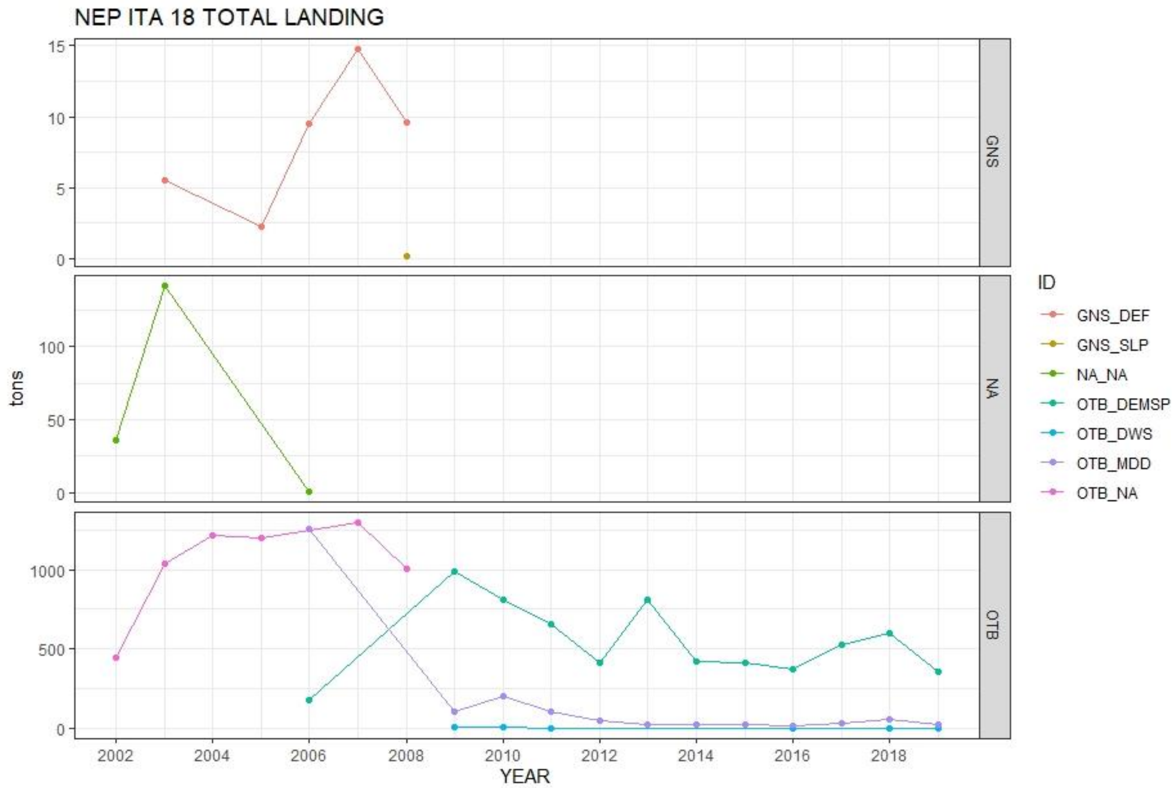


Figure 6.5.2.1.3 Norway lobster in GSA 17 and 18. Italian (GSA18) landings data by gear for the period 2002-2019.

For Albania landings were available from 2012-2019 2019 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 2012-2019.

Albania_GSA18_NEP_Landings	
Year	Tonnes
2012	435
2013	398
2014	400
2015	405
2016	411
2017	389
2018	257
2019	213

Size distributions of the landings

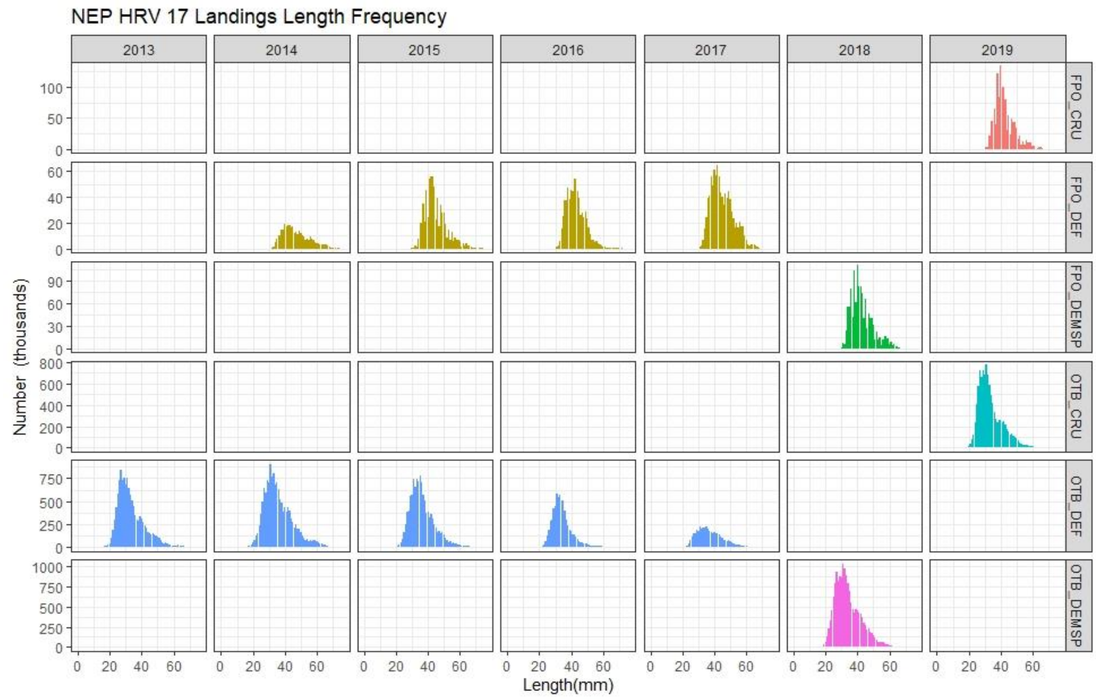


Figure 6.5.2.1.4 Norway lobster in GSA 17 and 18. Length frequency distributions of the Croatian landings by gear in the period 2013-2019.

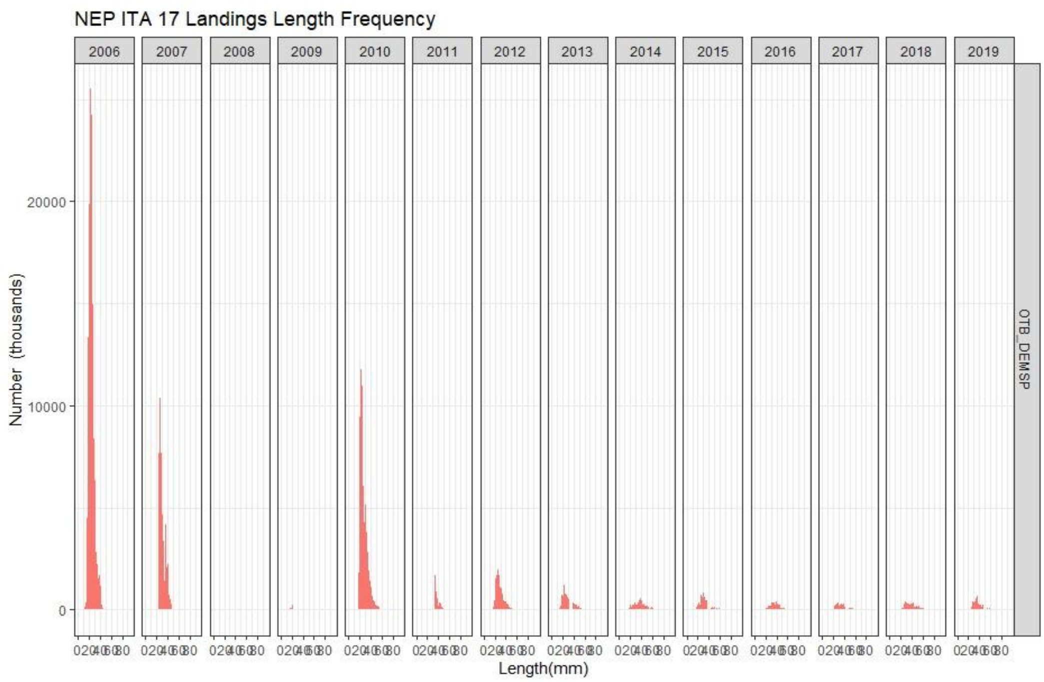


Figure 6.5.2.1.5 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA17) landings by gear in the period 2006-2019

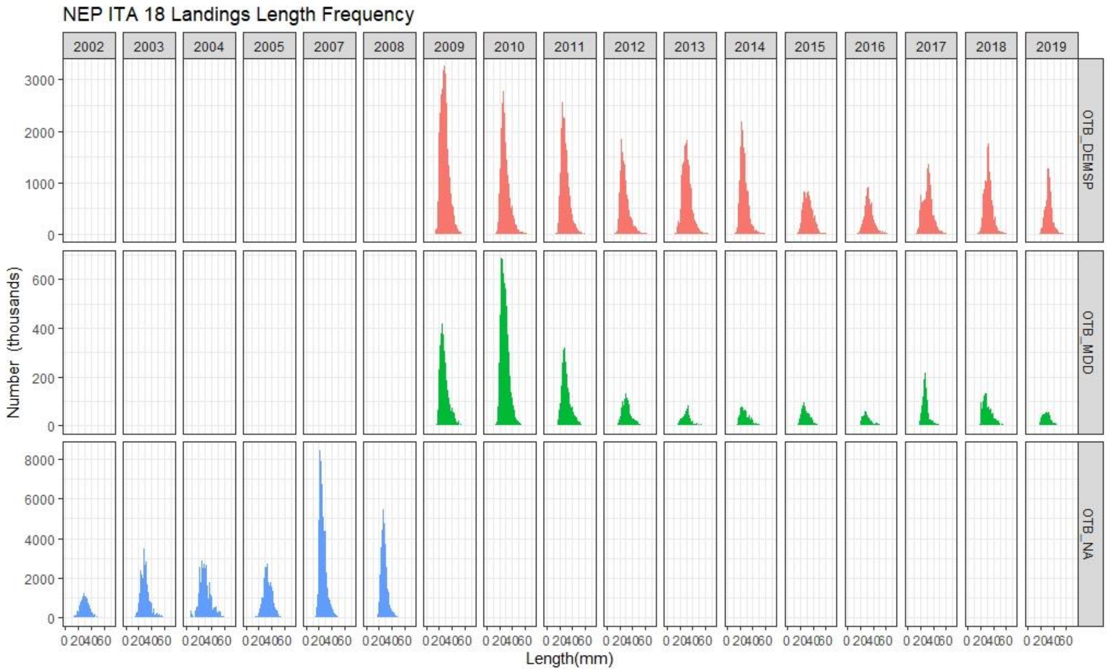


Figure 6.5.2.1.6 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA18) landings by gear in the period 2002-2019.

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 2013-2019.

Table 6.5.2.1.7 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2013-2019.

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

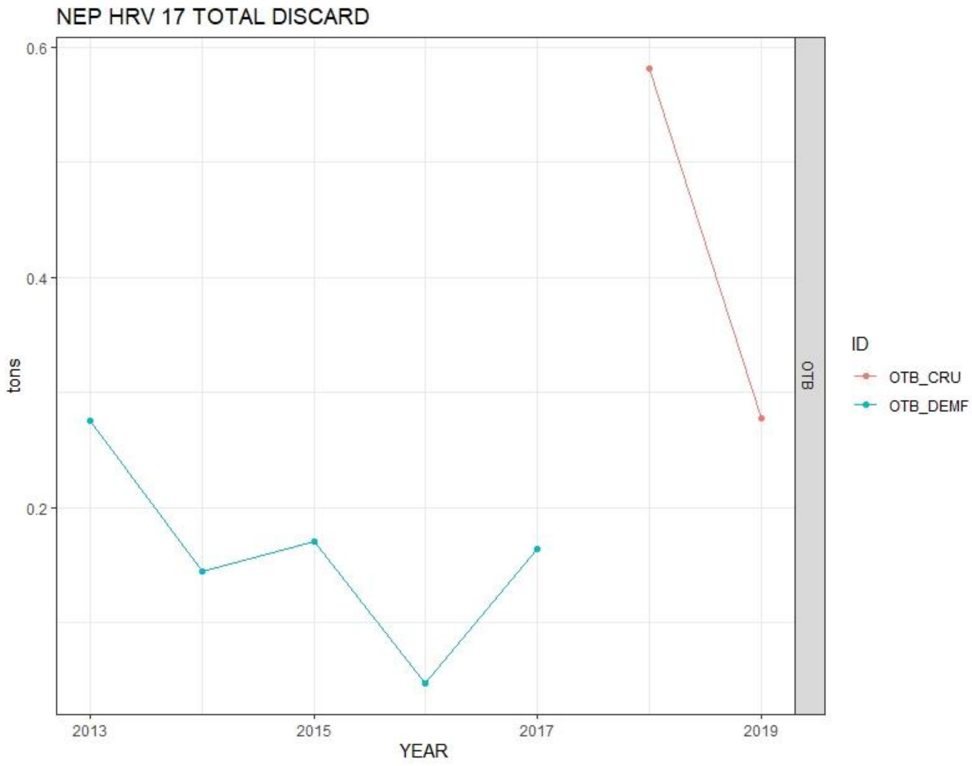


Figure 6.5.2.1.7 Norway lobster in GSA 17 and 18. Croatian discards data by gear for the period 2012-2019.

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 2009-2019.

Total discards in weight (tonnes)	
Year	OTB
2009	66.77
2010	6.23
2011	0.83
2012	3.99
2013	2.27
2014	5.07
2015	2.05
2016	0.74
2017	2.95
2018	3.59
2019	0.09

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

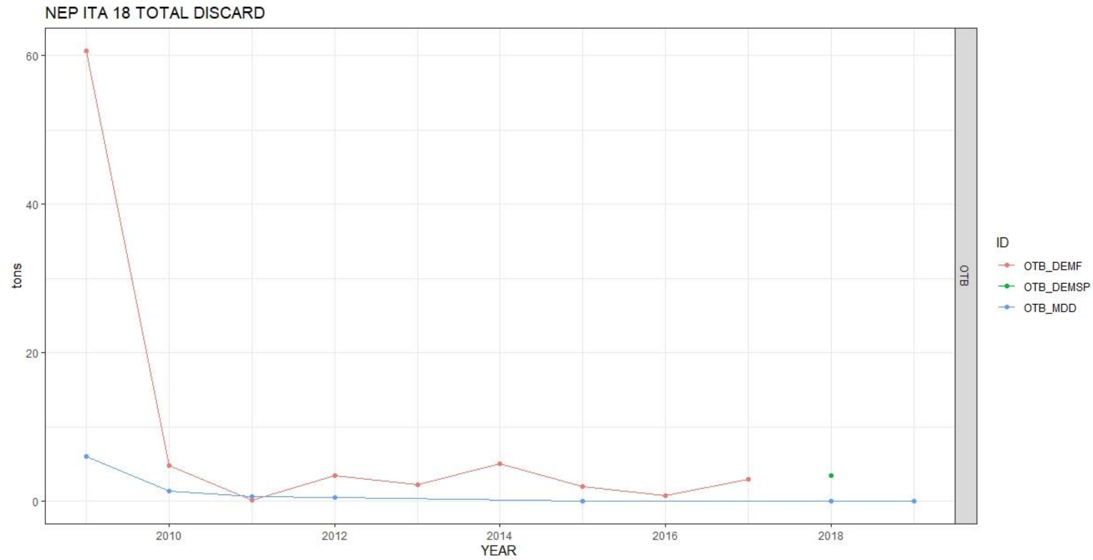


Figure 6.5.2.1.8 Norway lobster in GSA 17 and 18. Italian (GSA18) discards data by gear for the period 2009-2019.

Size distributions of the discards

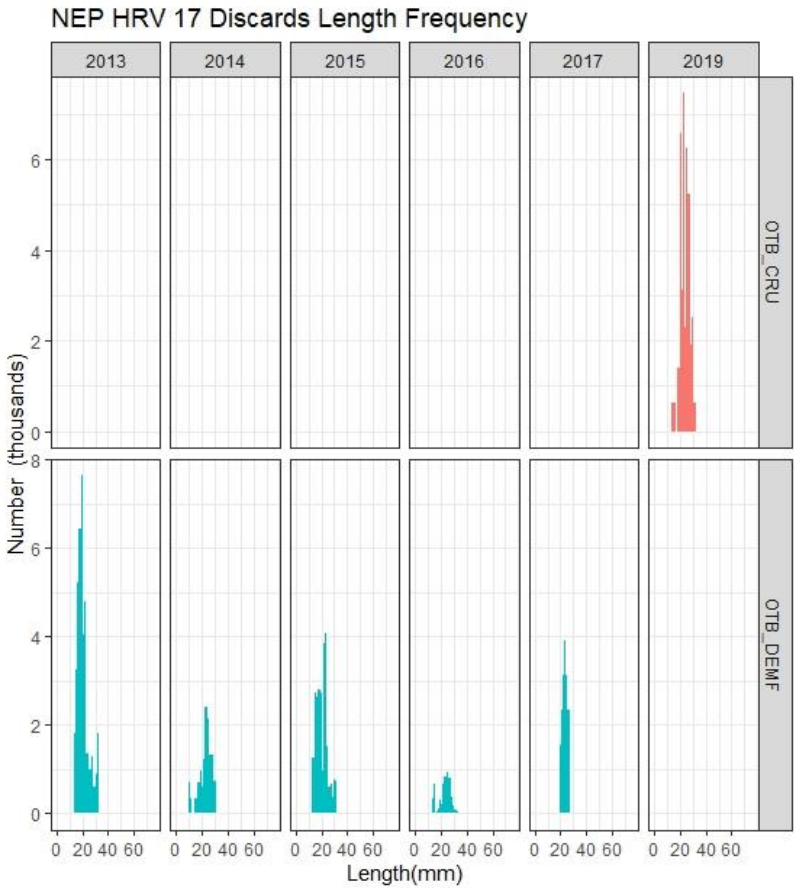


Figure 6.5.2.1.9 Norway lobster in GSA 17 and 18. Length frequency distributions of the Croatian discards by gear in the period 2013-2019.

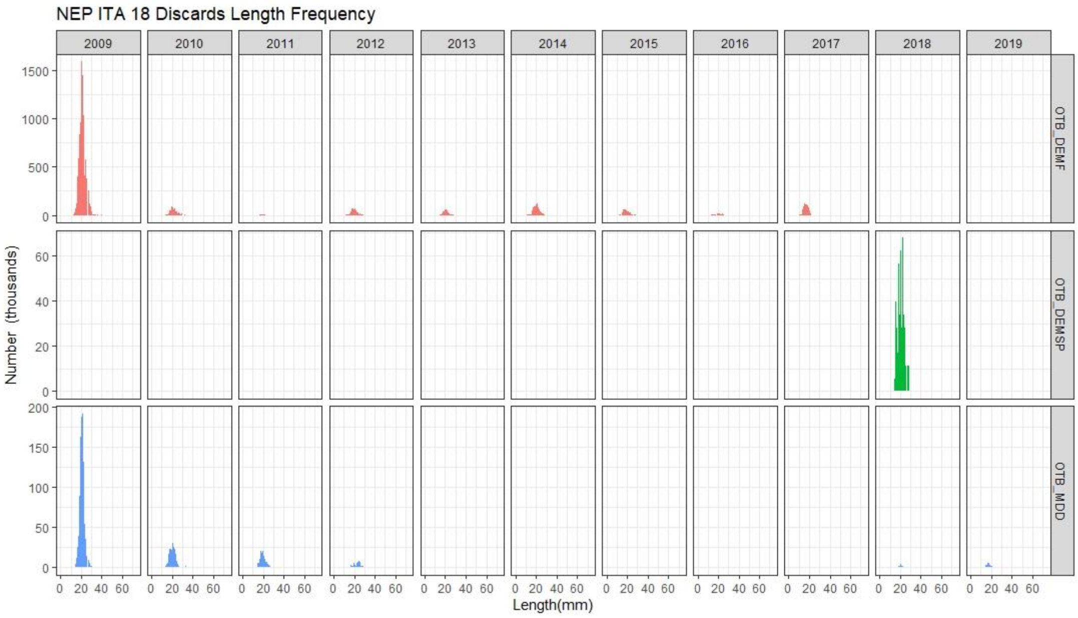


Figure 6.5.2.1.10 Norway lobster in GSA 17 and 18. Length frequency distributions of the Italian (GSA18) discards by gear in the period 2009-2019.

In the production model (SPICT) landings series was updated according to revised Albanian landings (2012-2019) and to Italian and Croatian DCF landings (2006-2019).

In the analytical assessment both data in landings and discards available from 2006 onward were used. Catches data were computed according to both (Table 6.3.2.1.9 and Figure 6.3.2.1.11).

Table 6.5.2.1.9 Norway lobster in GSAs 17 and 18. Landings and discards data by GSA for the period 2006-2019.

	ITA17		HRV17		ITA18		ALB18	GSA17_18			
year	landings	discards	landings	discards	landings	discards	landings	**Total landings**	**Total discards**	Total catches	%discards
2006	1462.37	0.00	223.00	0.00	1446.65	0.00	0.00	**3132.02**	**0.00**	3132.02	0.000
2007	1259.42	0.00	198.00	0.00	1314.63	0.00	0.00	**2772.06**	**0.00**	2772.06	0.000
2008	1270.44	0.00	201.00	0.00	1012.80	0.00	0.00	**2484.24**	**0.00**	2484.24	0.000
2009	1378.79	0.00	371.00	0.00	1092.89	66.77	0.00	**2842.68**	**66.77**	2909.46	2.295
2010	1215.95	0.00	328.00	0.00	1023.42	6.23	0.00	**2567.37**	**6.23**	2573.60	0.242
2011	936.59	4.92	284.00	0.00	759.17	0.83	0.00	**1979.76**	**5.75**	1985.51	0.290
2012	801.53	0.00	260.00	0.00	458.70	3.99	435.00	**1955.23**	**3.99**	1959.23	0.204
2013	606.54	0.00	278.17	0.28	833.83	2.27	398.00	**2116.54**	**2.55**	2119.09	0.120
2014	528.59	0.00	342.39	0.15	444.72	5.07	400.00	**1715.70**	**5.21**	1720.91	0.303
2015	450.14	0.00	298.55	0.17	442.75	2.05	405.00	**1596.45**	**2.23**	1598.67	0.139
2016	359.47	0.00	232.47	0.05	395.07	0.74	411.00	**1398.01**	**0.79**	1398.80	0.056
2017	288.00	0.00	197.37	0.16	556.18	2.95	389.00	**1430.55**	**3.11**	1433.66	0.217
2018	387.00	0.00	230.06	0.59	648.18	3.59	257.00	**1522.24**	**4.18**	1526.42	0.274
2019	392.00	0.00	265.86	1.94	375.59	0.09	213.00	**1246.45**	**2.03**	1248.48	0.160

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

In green outliner discards data from GSA18.
In black bold landings and discards data used in the analytical assessments

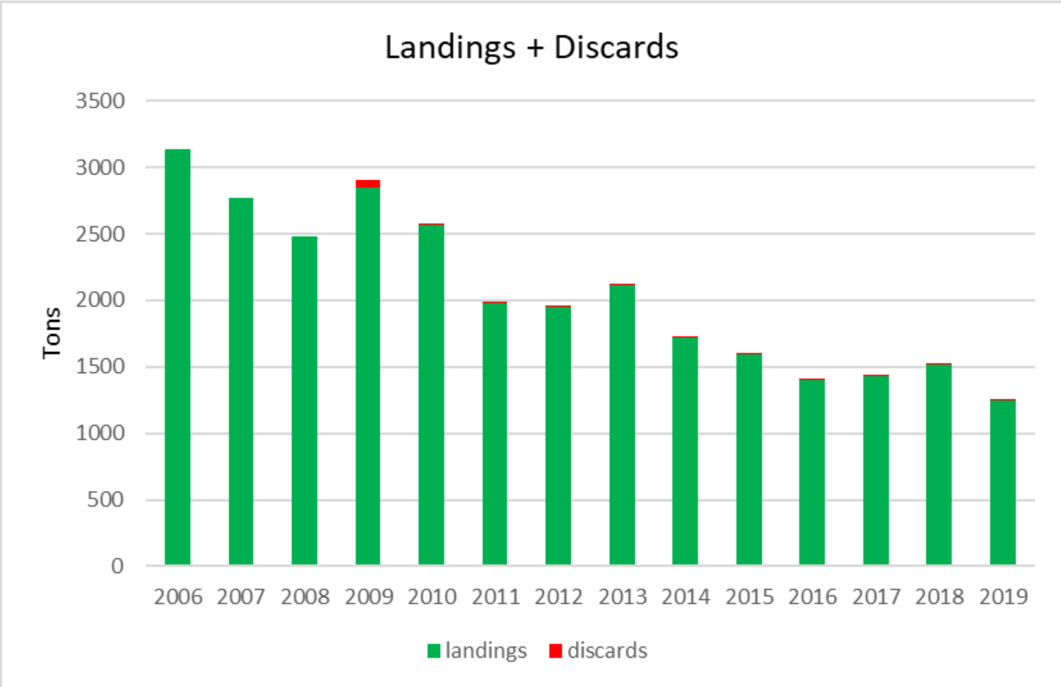


Figure 6.5.2.1.11 Norway lobster in GSA 17 and 18. Total catches in GSAs 17 and 18 in the period 2006-2019.

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 2012-2018 (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.

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. (* Values for Croatia in 2019 are thought to be on a different basis to earlier years.)

Year	FPO	OTB
2012	18769.6	35571.9
2013	18922.9	35491.7
2014	19235.6	36287.2
2015	19926.9	34742.5
2016	21195.9	33715.1

2017	19730.1	35648.7
2018	21987.4	33137.3
2019	130986.0*	168759.0*

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	133029.87
2005	121674.24
2006	104055.54
2007	93794.88
2008	86701.07
2009	91043.78
2010	82962.48
2011	80186.84
2012	70603.08
2013	66521.53
2014	66492.43
2015	61296.88
2016	61864.79
2017	72378.54
2018	75940.04
2019	65911.34

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	86925.2
2005	77208.6
2006	84162.7
2007	70679.8
2008	69638.6
2009	85850.1
2010	73020.6
2011	67653.9
2012	62643.8
2013	69291.9
2014	49684.8
2015	52001.7
2016	54027.6
2017	53218.2
2018	60434.2
2019	50169.2

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

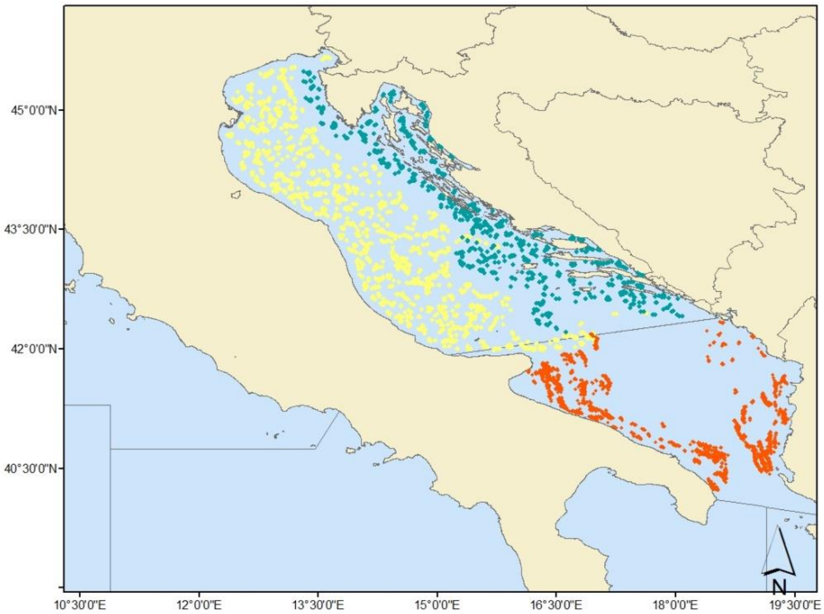


Figure 6.5.2.3.1 Norway lobster in GSA 17 and 18. MEDITS trawl survey, distribution of the hauls carried out in the area.

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

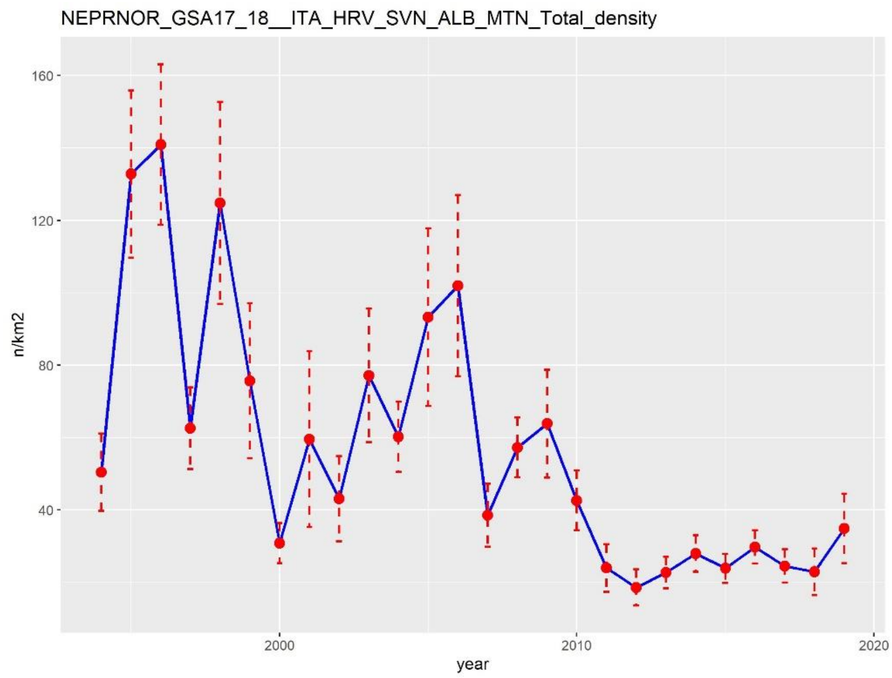


Figure 6.5.2.3.2 Norway lobster in GSA 17 and 18. Abundance indices from the MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro of GSA 17 and 18 during 1994 – 2019.

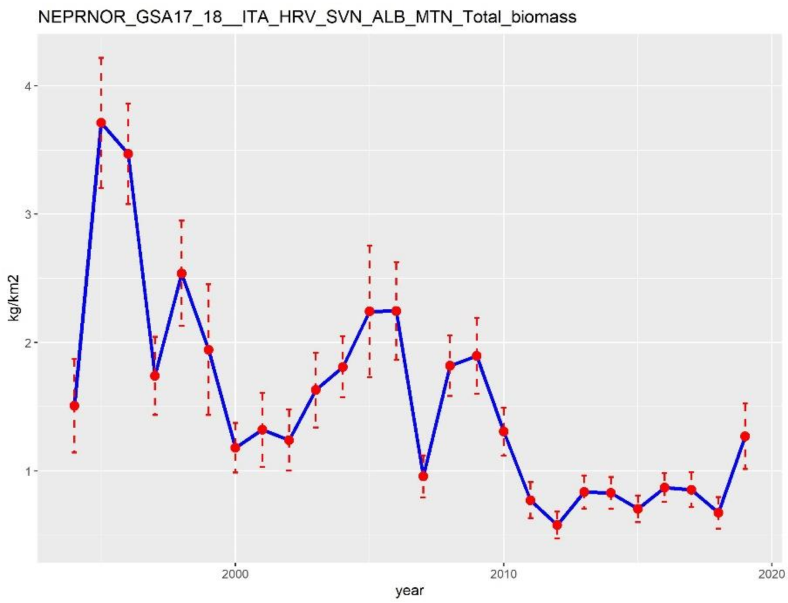


Figure 6.5.2.3.3 Norway lobster in GSA 17 and 18. Biomass indices from the MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro of GSA 17 and 18 during 1994 – 2019.

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.

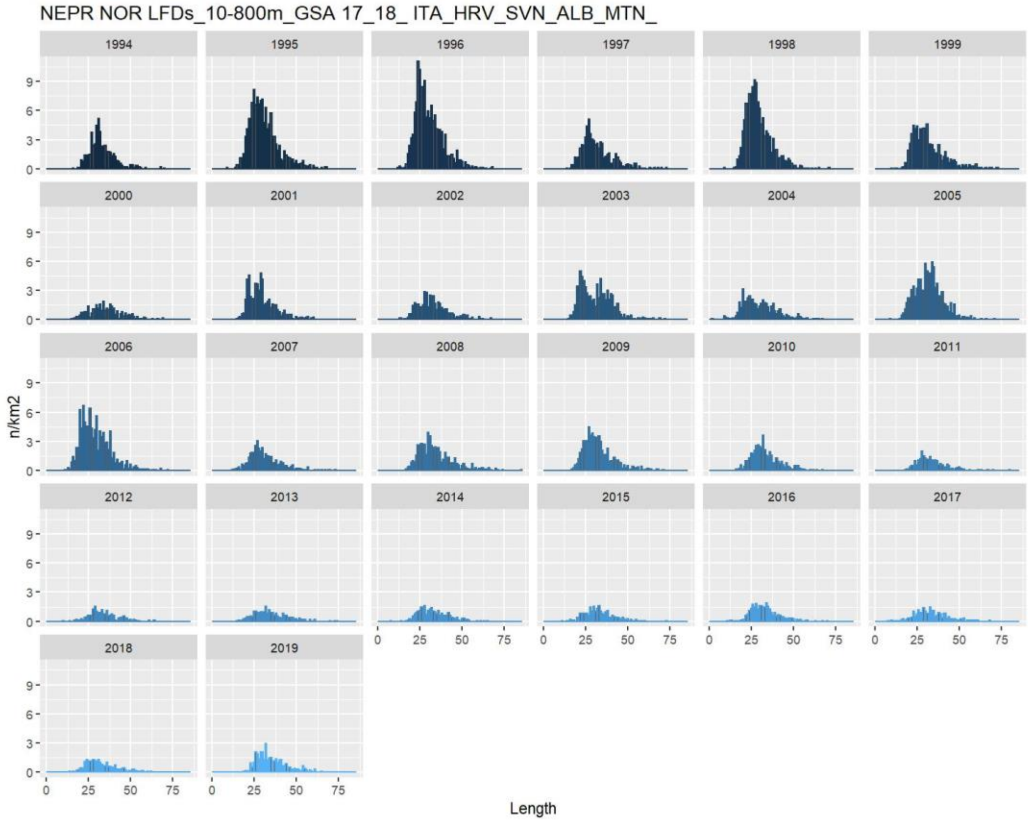


Figure 6.5.2.3.4. Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (sex combined) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2019.

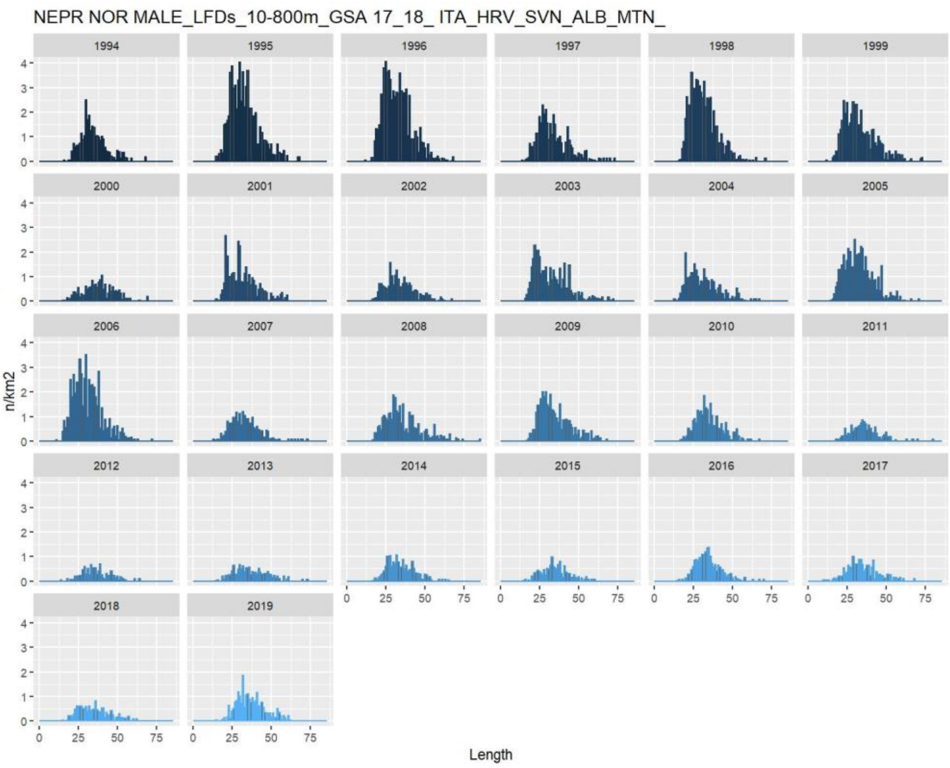


Figure 6.5.2.3.5 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (Male) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2019.

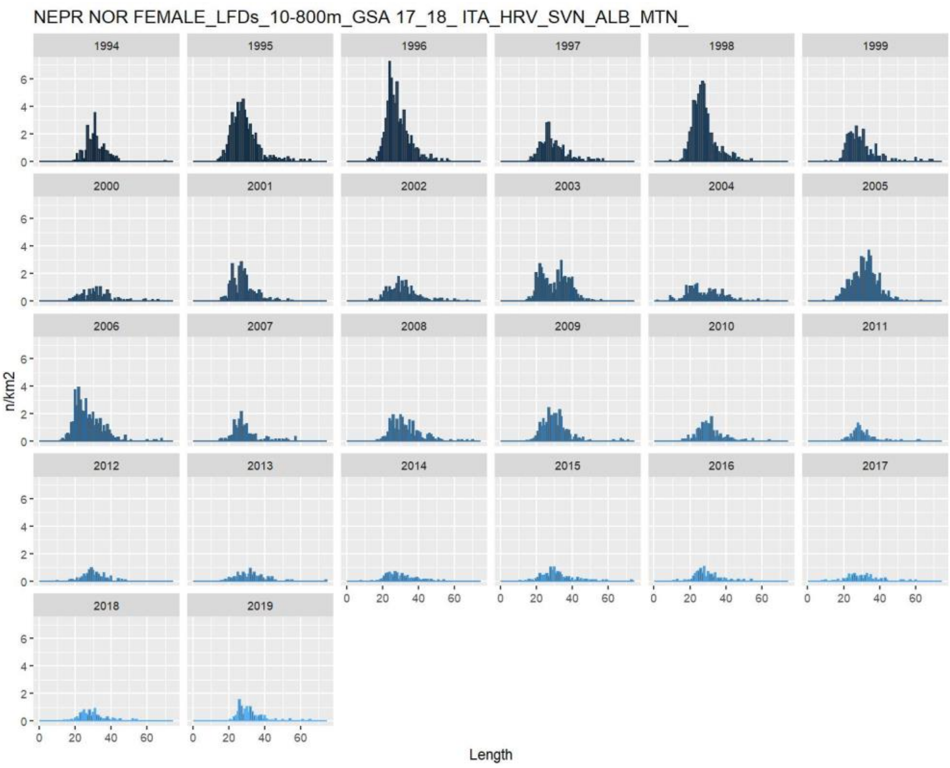


Figure 6.5.2.3.6 Norway lobster in GSA 17 and 18. Length frequency distributions of Norway lobster (Female) of MEDITS survey in Italy, Croatia, Slovenia, Albania and Montenegro in GSA17 and 18 in 1994-2019.

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).

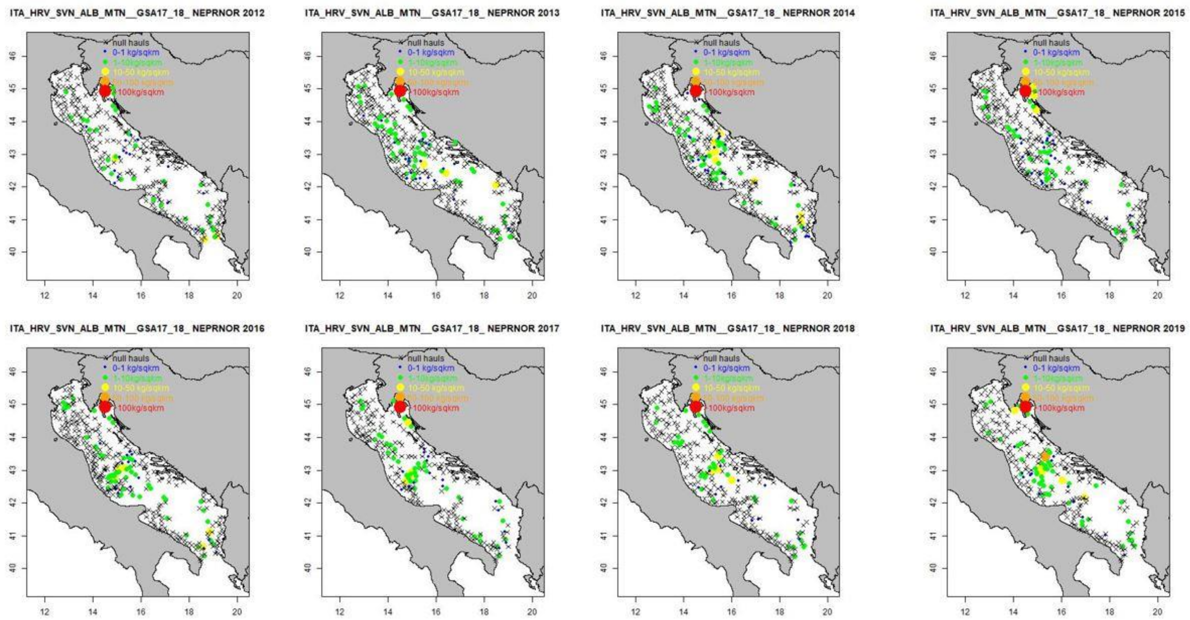


Fig. 6.5.2.3.7 Norway lobster in GSA 17 and 18. Spatial distribution of relative biomass (kg km^{-2}) during Medits from 2012 to 2019.

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.

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 include all parameter estimates and the most interesting derived quantities are the 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 19-16) with addition of 2019 data.

MEDITS time series was updated adding 2019 data. Also the data from 1994 to 2001 were updated according to the new availability of ITA GSA 17 data*.

LANDINGS data were updated according to revised Albania data and 2019 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)**

1269.995 1283.481 1397.000 1113.000 1098.000 1197.000 1520.000 2104.000 1469.000
1288.000 1116.000 1185.000 1407.000 1270.000 1219.000 2109.000 2350.000 2087.000
2836.000 2159.000 1890.000 2507.000 3151.000 3122.000 3366.000 3148.000 3558.000
3058.000 2426.000 1753.000 1864.000 1558.737 1252.473 2218.550 2279.430 3393.676
3107.017 2775.057 2654.241 2799.682 2523.373 1955.759 1955.231 2116.542 1715.697
1596.447 1398.011 1430.547 1587.977 1258.431

$timeC **(COMBINED Catches GSA 17 + 18)**

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 2014 2015 2016 2017
2018 2019

$timeI[[1]] **(from Froglia 1988)**

1976 1977 1978 1979 1980 1981 1982 1983 1984 1985

$timeI[[2]] **(from Jukic 1975)**

1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970

$timeI[[3]] **(MEDITS)**

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

$obsI[[2]] **(from Froglia 1988)**

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)**

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)**

1.5070003 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 0.5772707 0.8351504 0.8274774 0.7034858 0.8706164 0.8521668

0.6732885 1.2695929

* In red the updated data.

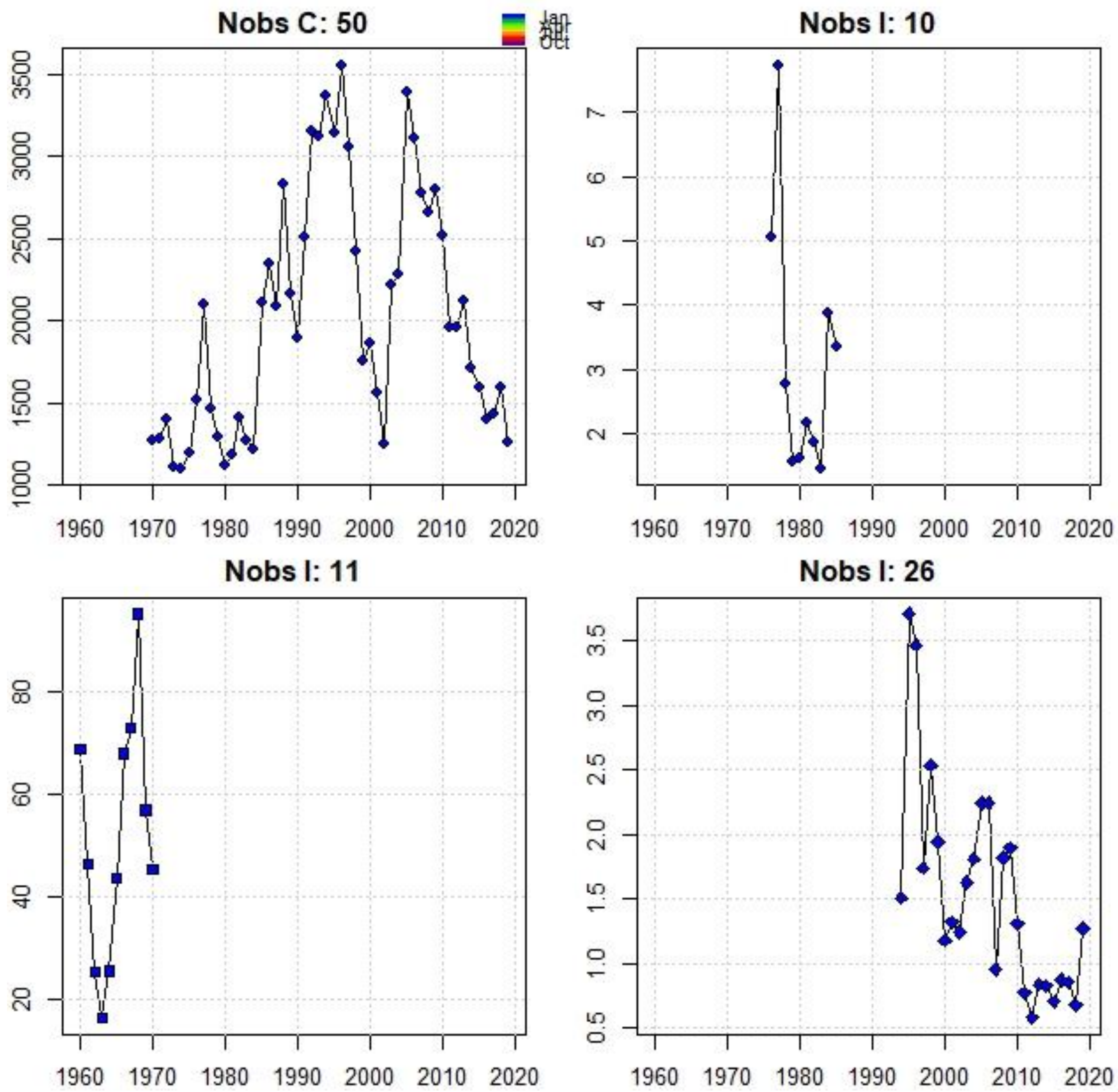


Figure 6.5.3.1.1 Norway lobster in GSA 17 and 18. Input Data from Norway lobster GSA 17-18. Index 1 = Froglia, Index 2 = Jukic, Index 3 = MEDITS.

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).

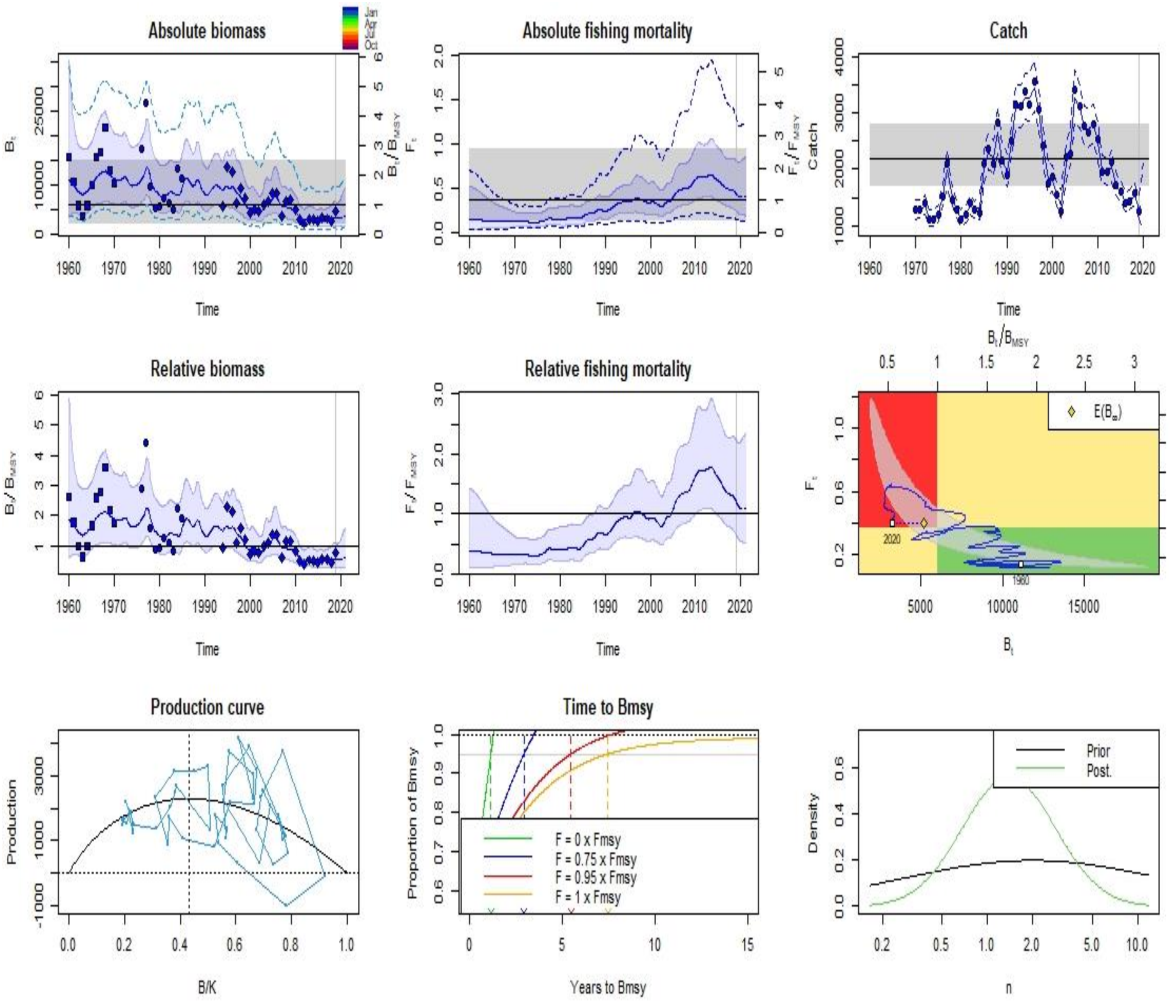


Figure 6.5.3.1.2 Norway lobster in GSA 17 and 18. SPiCT model fit with full time series and 3 CPUE indexes.

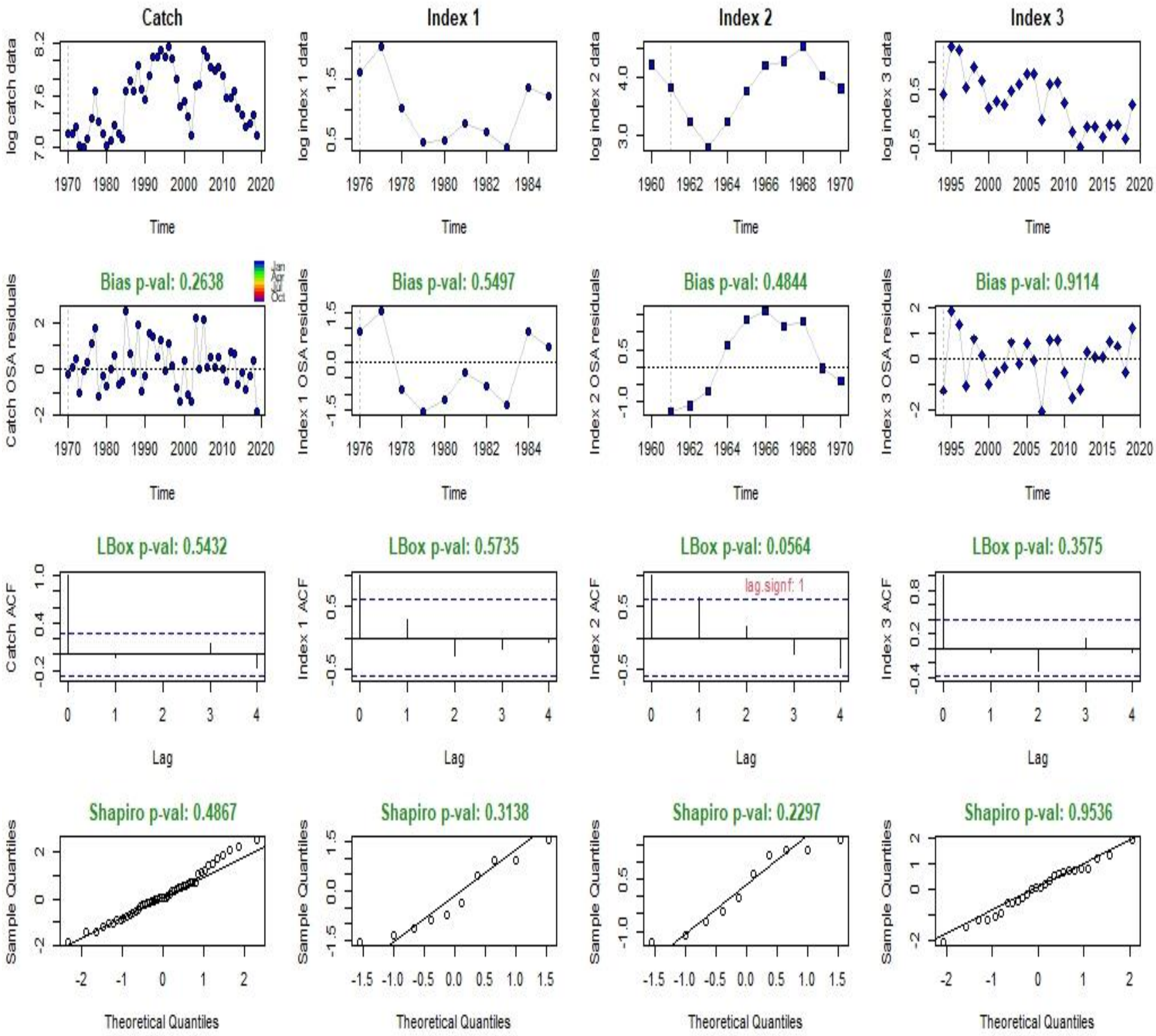


Figure 6.5.3.1.3 Norway lobster in GSA 17 and 18. Diagnostics for SPICT model of Norway lobster GSA 17-18. Index 1 = Froglia, Index 2 = Jukic, Index 3 = MEDITS.

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).

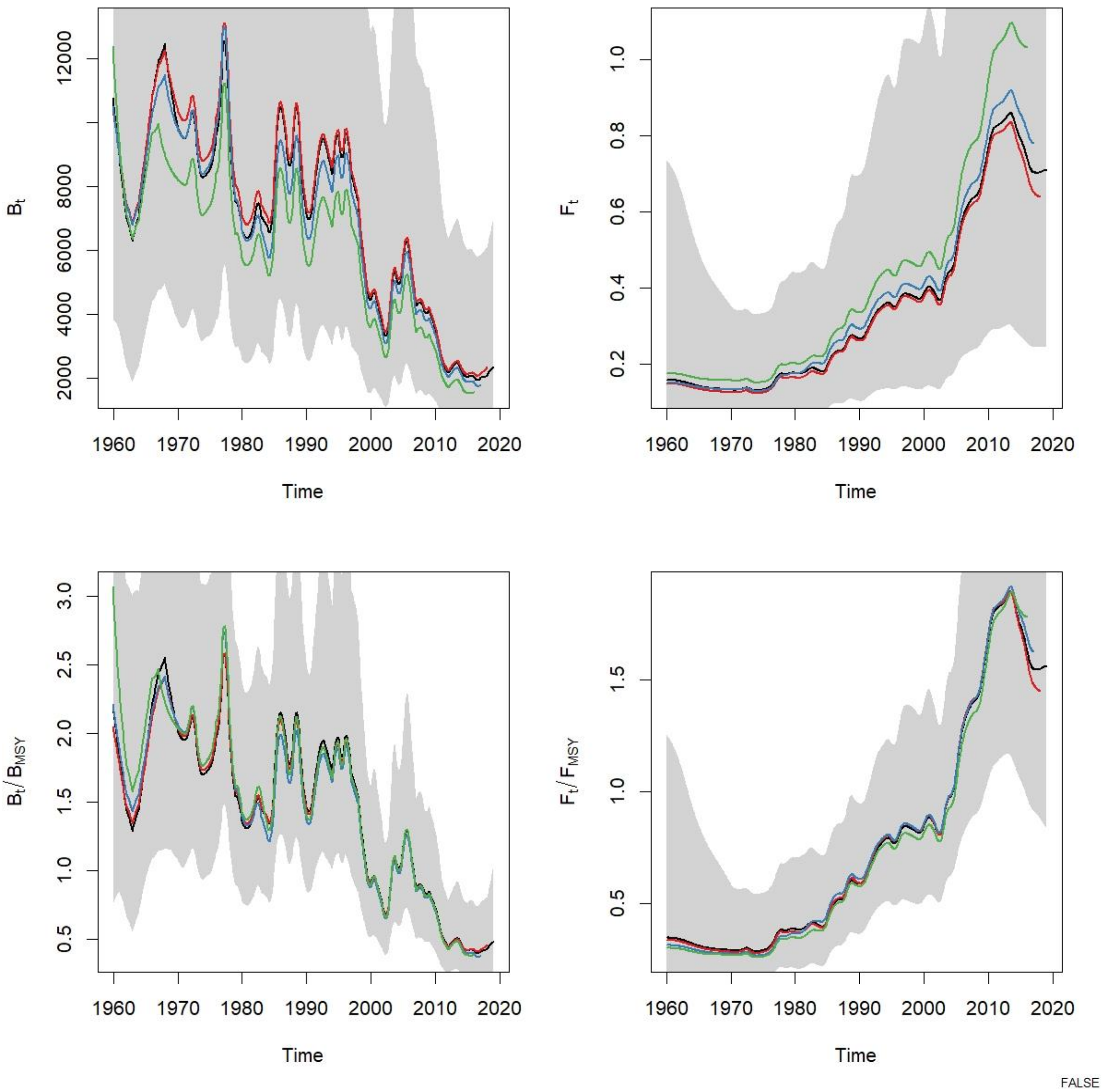


Figure 6.5.3.1.4 Norway lobster in GSA 17 and 18. Retrospective analysis for Norway lobster in GSA 17-18.

Table 6.5.3.2 **Norway lobster in GSA 17 and 11:** Model estimates, reference points and summaries are reported below:

Convergence: 0 MSG: both X-convergence and relative convergence (5)

Objective function at optimum: 31.1640351
Euler time step (years): 1/16 or 0.0625
Nobs C: 50, Nobs I1: 10, Nobs I2: 11, Nobs I3: 26

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	2.105101e+00	0.9032112	4.906330e+00	0.7443636
alpha2	2.002352e+00	0.6357387	6.306698e+00	0.6943223
alpha3	1.264695e+00	0.5772902	2.770621e+00	0.2348307
beta	4.697299e-01	0.1360843	1.621394e+00	-0.7555974
r	5.112338e-01	0.1157833	2.257320e+00	-0.6709282
rc	7.340174e-01	0.2894899	1.861141e+00	-0.3092226
rold	1.300933e+00	0.0273905	6.178884e+01	0.2630817
m	2.302143e+03	1747.1911240	3.033362e+03	7.7415958
K	1.457966e+04	6140.1066955	3.461934e+04	9.5873825
q1	2.913000e-04	0.0001142	7.427000e-04	-8.1412674
q2	4.368500e-03	0.0017569	1.086210e-02	-5.4333283
q3	2.709000e-04	0.0000968	7.580000e-04	-8.2136986
n	1.392975e+00	0.3466707	5.597181e+00	0.3314415
sdb	2.085981e-01	0.1095655	3.971428e-01	-1.5673459
sdf	1.467118e-01	0.0805205	2.673153e-01	-1.9192850
sdi1	4.391201e-01	0.2656465	7.258762e-01	-0.8229823
sdi2	4.176867e-01	0.2062660	8.458117e-01	-0.8730235
sdi3	2.638129e-01	0.1843370	3.775544e-01	-1.3325152
sdc	6.891490e-02	0.0256798	1.849420e-01	-2.6748824

Deterministic reference points (Drp)

	estimate	cilow	ciupp	log.est
Bmsyd	6272.7212324	2506.5401639	1.569775e+04	8.743965
Fmsyd	0.3670087	0.1447449	9.305705e-01	-1.002370
MSYd	2302.1431124	1747.1911240	3.033362e+03	7.741596

Stochastic reference points (Srp)

	estimate	cilow	ciupp	log.est	rel.diff.Drp
Bmsys	6024.8974947	2415.7674101	1.502603e+04	8.703656	-0.04113327
Fmsys	0.3629497	0.1405574	9.372149e-01	-1.013491	-0.01118330
MSYs	2185.7288958	1714.8704713	2.785873e+03	7.689705	-0.05326105

States w 95% CI (inp$msytype: s)

	estimate	cilow	ciupp	log.est
B_2019.00	3364.6999967	1151.6580507	9830.353776	8.1210941
F_2019.00	0.4344395	0.1465376	1.287982	-0.8336986
B_2019.00/Bmsy	0.5584659	0.2869060	1.087060	-0.5825617
F_2019.00/Fmsy	1.1969689	0.6438606	2.225225	0.1797924

Predictions w 95% CI (inp$msytype: s)

	prediction	cilow	ciupp	log.est
B_2020.00	3264.7931438	1064.7519874	10010.663889	8.0909517
F_2020.00	0.3986487	0.1322985	1.201229	-0.9196746
B_2020.00/Bmsy	0.5418836	0.2481067	1.183514	-0.6127041
F_2020.00/Fmsy	1.0983580	0.5461709	2.208815	0.0938164
Catch_2020.00	1394.4702608	928.8467457	2093.507155	7.2402699

E(B_inf)	5181.2025737	NA	NA	8.5527925

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	9705.53	1270	0.13
1971	9741.71	1283	0.13
1972	10127.07	1397	0.14
1973	8663.75	1113	0.13
1974	8465.42	1098	0.13
1975	8986.16	1197	0.13
1976	10495.21	1520	0.15
1977	11987.49	2104	0.17
1978	8632.41	1469	0.17
1979	7280.13	1288	0.18
1980	6484.06	1116	0.17
1981	6690.32	1185	0.18
1982	7368.16	1407	0.19
1983	6944.48	1270	0.18
1984	6940.24	1219	0.18
1985	9674.53	2109	0.21
1986	9992.61	2350	0.23
1987	8881.68	2087	0.24
1988	10147.07	2836	0.27
1989	8083.42	2159	0.27
1990	7101.16	1890	0.27
1991	8333.28	2507	0.30
1992	9364.26	3151	0.33
1993	8849.36	3122	0.35
1994	9202.76	3366	0.36
1995	9143.70	3148	0.35
1996	9297.62	3558	0.38
1997	7985.70	3058	0.38
1998	6499.07	2426	0.37
1999	4817.44	1753	0.37
2000	4615.82	1864	0.40
2001	3988.03	1559	0.39
2002	3547.08	1252	0.37
2003	5067.02	2219	0.42
2004	5149.08	2279	0.45
2005	6145.09	3394	0.54
2006	5146.39	3107	0.60
2007	4362.05	2775	0.63
2008	4134.36	2654	0.65
2009	3893.07	2800	0.72
2010	3145.22	2523	0.80
2011	2387.06	1956	0.82
2012	2335.81	1955	0.83
2013	2465.46	2117	0.84
2014	2168.28	1716	0.80
2015	2129.34	1596	0.75
2016	2069.73	1398	0.68
2017	2195.18	1431	0.66
2018	2171.4	1839	0.71
2019	3364.69	1319	0.40

Changes in length distributions of Nephrops in GSA 17-18

The combined LFDs for catch were examined to determine if length frequency distributions were showing an changes resulting either from the reduced F or a change in catch due to the closure of the Pomo Pit where the size of Norway lobster are expected to be different. Figure 6.5.3.1.5 shows the cumulative probability distribution of length by year allowing a comparison of the length distribution independently of the total catch. However, if changes in managements of Norway lobster fishery have been adopted in the last years (for example the closure of Pomo area), there is no relevant evidence in the patterns emerging in the overall LFD observed. In most years the L50 is similar at 36-38 mm implying a largely unchanging size range. In 2015 the L50 decreases t o31 mm but the lowest L50 of 26 mm in 2018, but the following year the L50 rises again to 36mm. It is possible that the reduction in size in 2018 is due to a change in the fishery, or to an increase in small recruiting Norway lobster joining the fishery but there is no evidence of the fishery avoiding smaller sizes. There can be a number of reasons for sizes to change, for example if the fishery moves away from smaller individuals but increased recruitment occurs at the same time, the influence of these two events are in different directions and it may not be easy to separate the two effects.

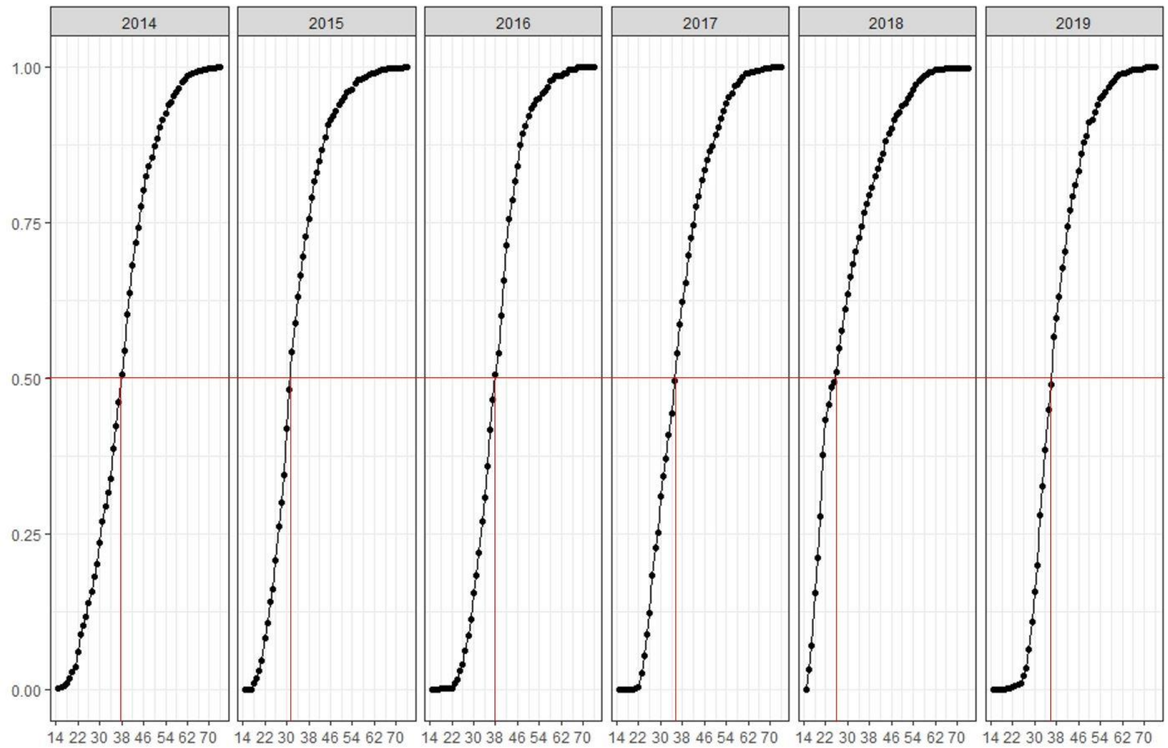


Figure 6.5.3.1.5 Norway lobster in GSA 17 and 18. Cumulative distribution curves for Norway lobster's LFD from 2014 to 2019.

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} 0.3629 y^{-1}

and B_{MSYs} = 6024.897 t , while the deterministic reference points are F_{MSYd} = 36.60 and B_{MSYd} = 6272.72 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 20-15 considers the stock has been depleted slightly below B_{MSY} and been overexploited (F> F_{MSY}) in the 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}	2409.959	B_{lim} = 40% B_{MSY}	STECF EWG 20-15
	B_{pa}	3373.942	B_{pa} = B_{lim} *1.4	STECF EWG 20-15
	F_{lim}		Not defined	
	F_{pa}		Not defined	
MSY Approach	MSY $B_{trigger}$	3373.942	MSY Btrigger = B_{pa} = B_{lim} *1.4	STECF EWG 20-15
	F_{MSY}	0.36191	F0.1 as proxy for F_{MSY}	STECF EWG 20-15

6.5.5 Short term Forecast and Catch Options

The SPiCT model was used to carry out a short term forecast with the following conditions:

Observed interval, index: 1960.00 - 2019.00
Observed interval, catch: 1970.00 - 2020.00

Fishing mortality (F) prediction: 2023.00
Biomass (B) prediction: 2023.00
Catch (C) prediction interval: 2022.00 - 2023.00

Predictions

	C	B	F	B/Bmsy	F/Fmsy	perc.dB	perc.dF
1. Keep current catch	1261.3	3498.7	0.358	0.581	0.987	7.2	-10.1
2. Keep current F	1718.2	4474.7	0.399	0.743	1.098	37.1	0.0
3. Fish at Fmsy	1664.1	4797.5	0.363	0.796	1.000	46.9	-9.0
4. No fishing	3.4	9410.1	0.000	1.562	0.001	188.2	-99.9
5. Reduce F 25%	1530.0	5427.3	0.299	0.901	0.824	66.2	-25.0
6. Increase F 25%	1804.0	3672.5	0.498	0.610	1.373	12.5	25.0
7. MSY advice rule	1664.1	4797.5	0.363	0.796	1.000	46.9	-9.0

95% CIs of absolute predictions

	C.lo	C.hi	B.lo	B.hi	F.lo	F.hi
1. Keep current catch	1117.9	1423.1	495.7	24696.6	0.051	2.508
2. Keep current F	922.2	3201.3	1409.2	14208.7	0.119	1.337

3. Fish at Fmsy	885.7	3126.5	1606.0	14331.1	0.108	1.217
4. No fishing	1.3	8.5	5068.0	17472.5	0.000	0.001
5. Reduce F 25%	790.8	2960.0	2015.0	14618.6	0.089	1.003
6. Increase F 25%	956.3	3403.0	963.2	14003.1	0.149	1.672
7. MSY advice rule	885.7	3126.5	1606.0	14331.1	0.108	1.217

95% CIs of relative predictions

	B/Bmsy.lo	B/Bmsy.hi	F/Fmsy.lo	F/Fmsy.hi
1. Keep current catch	0.117	2.888	0.224	4.350
2. Keep current F	0.262	2.105	0.466	2.590
3. Fish at Fmsy	0.295	2.151	0.424	2.358
4. No fishing	0.729	3.345	0.000	0.003
5. Reduce F 25%	0.360	2.255	0.349	1.943
6. Increase F 25%	0.184	2.018	0.582	3.238
7. MSY advice rule	0.295	2.151	0.424	2.358

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	0.4076	3087.8	1258.3
	2021	0.3898	3243.0	1264.0
	2022	0.3698	3411.1	1261.3
	2023	0.3510	3646.1	1279.5
Keep current F	2020	0.3986	3498.0	1394.5
	2021	0.3986	3945.1	1572.7
	2022	0.3986	4310.1	1718.2
	2023	0.3986	4596.7	1832.5
Fish at F_{MSY}	2020	0.3629	3553.7	1289.8
	2021	0.3629	4116.7	1494.2
	2022	0.3630	4584.9	1664.1
	2023	0.3630	4955.7	1798.7
No fishing	2020	0.0004	4188.8	1.7
	2021	0.0004	6318.1	2.5
	2022	0.0004	8406.8	3.4
	2023	0.0004	10162.4	4.1
Reduce F 25%	2020	0.2990	3656.3	1093.2
	2021	0.2990	4442.5	1328.2
	2022	0.2990	5117.1	1530.0
	2023	0.2990	5659.1	1692.0
Increase F 25%	2020	0.4983	3348.4	1668.6
	2021	0.4983	3501.6	1744.9
	2022	0.4983	3620.2	1804.0
	2023	0.4983	3710.9	1849.2

As can be seen in the table 6.5.5.1 above, F in 2020 cannot be set independently of F in 2021 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 2020 through to 2021. As in 2018 and 2019 the EWG has provided an alternative STF with no stock growth in 2020.

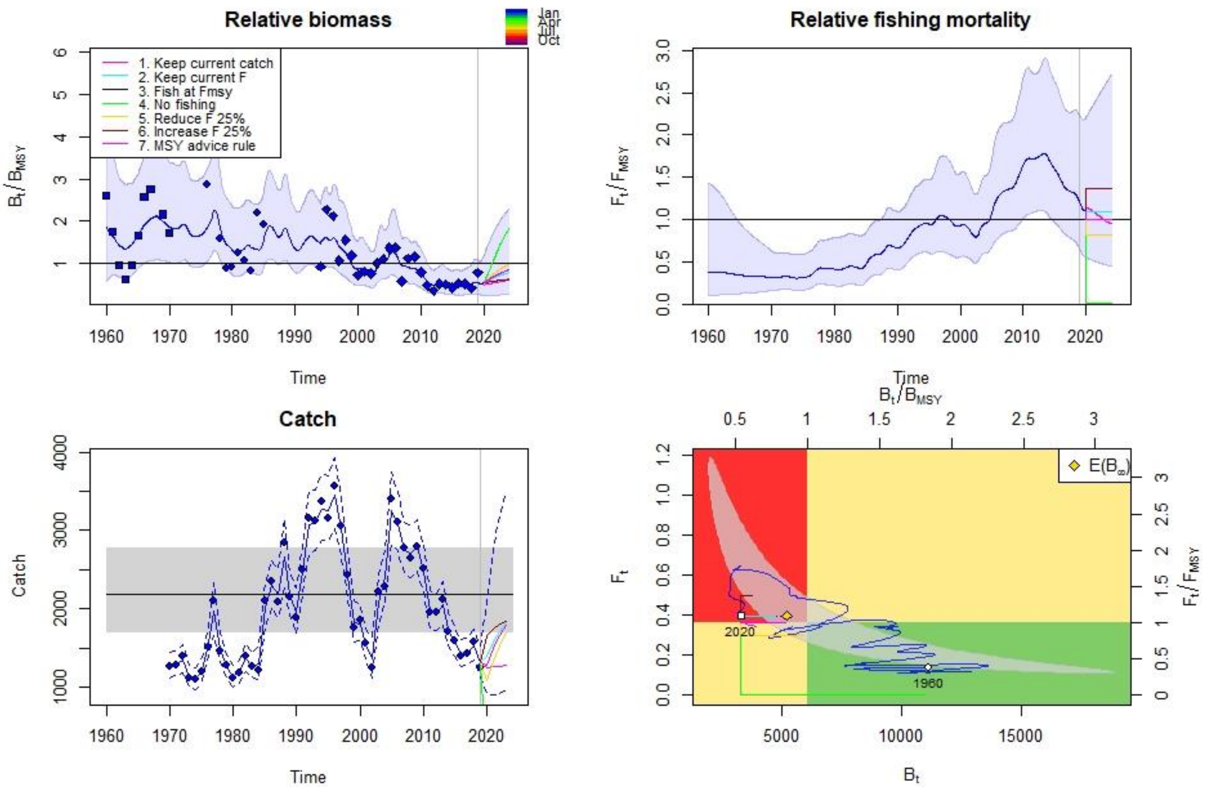


Figure 6.5.5.1 Norway lobster in GSA 17 and 18. Short term forecast for the period 2020-2023 according to different scenarios: keep current catch, keep current F, fishing at F_{MSY}, no fishing, reduce F by 25%, increase F by 25%.

As can be seen in the table 6.5.5.1 above, in a SPiCT forecast F in 2020 cannot be set independently of F in 2021 and subsequent years. 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, and the growth implied by the SPiCT forecast is mean growth for the time series. The EWG considers that these conditions provide unrealistic expectations of growth in the stock in 2020 through to 2021. So in accordance with the procedure used in 2018 and 2019 the EWG has provided an alternative STF with no stock growth in 2020. This forecast which is shown in Table 6.5.5.2 is used for the catch options in Section 5.5. The forecast also includes a small reduction F from 0.3629 to 0.3619 to accounts for the reduced biomass B<Bpa. The reduced F which is calculated based on the different between B_{2019} and Bpa is intended to increase the biomass of the stock above Bpa in 2021.

Table 6.5.5.2 Norway lobster in GSA 17-18. Short term assuming no stock growth in 2021.

Catch 2019	1319
f current (HR 2019) = Catch2019/B 2019	0.392011
Fmsy from SPiCT Model (HR)	0.3629
B 2019	3364.7
Bmsy From SPICT Model	6024.897
Blim = 40% Bmsy	2409.959
MSY Btrigger = Bpa = Blim*1.4	3373.942
HR 2019 (to check that F is HR in SPICT)	0.392011
B 2019/Bpa (reduction because B<Bpa)	0.99726
F target (MSY reduced)	0.361906

F (HR) Transition from F current and FMSY	0.371218
Catch 2020/2021 at F=FMSY	1221.049
Catch 2020/2021 = F Reduced	1217.704
Catch at F transition	1249.035
Biomass status	0.558466

6.5.6 DATA DEFICIENCIES

- Italian landings data in GSA 17 in 2019 were reported twice in DCF file
- Lengths of Croatian Medits data of GSA 17 in 2016 were wrongly reported (those should be divided by 10)
- Lengths of Italian Medits data of GSA 17 in 2017 were wrongly reported (those should be divided by 10)

6.6 Spottail Mantis shrimp in GSA 17 and 18

6.6.1 Stock Identity and Biology

BIOLOGY

The spot-tail mantis shrimp 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 not a 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 whole 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 spot-tail 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, as a matter of fact 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 their borrowing behaviour. It is a strongly sedentary species and seasonal trends appearing in catch data are due more 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.

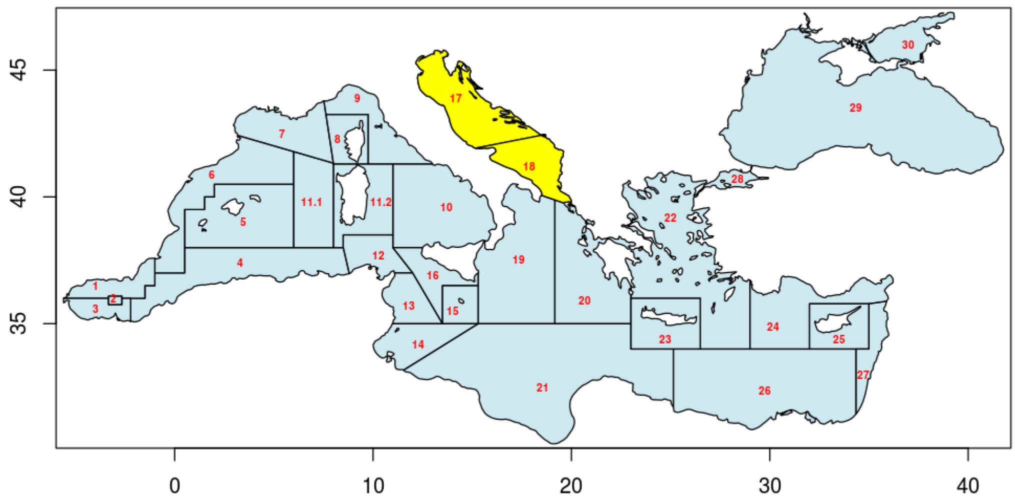


Figure 6.6.1.1 Geographical location of GSAs 17 and 18

GROWTH

Froglia *et al*. (1996) used an indirect method to study the growth of Spot-tail 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 Spot-tail 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 of life. It seems that mantis shrimp individuals live up to five or six years of age.
The Von Bertalanffy (VBGF) parameters were computed using the above data and are presented in Table 6.6.1.1. The length weight relationship parameters were derived from the STECF 17 – 15 EWG and are in line with the growth parameters also used in the assessment of Spottail mantis shrimp in that EWG.

Table 6.6.1.1 Spottail mantis shrimp in GSA 17. Von Bertalanffy growth parameters and length weight relationship parameters.

L_{inf}	k	t_0	a	b
41.53	0.49	-0.0105	0.00133	3.045

New growth parameters were provided from the DCF for GSA 18 and an exploratory analysis was performed to account for these new parameters (See Section 6.6.6).

Table 6.6.1.2 Spottail mantis shrimp in GSA 18. Von Bertalanffy growth parameters and length weight relationship parameters provided from DCF data for GSA 18 in 2018.

L_{inf}	k	t_0	a	b
46.3	0.49	-0.29	0.0042	2.7197

Maturity

The life cycle of this species 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 was reported 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 regarding only GSA 17 a maturity at age vector derived from STECF EWG 19-16 was used while combined maturity at age factors were calculated as a weighted average using the stock numbers for the assessment in GSA 17 & 18 combined. 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 GSA 17	0.003	0.816	1	1	1	1	1
Maturity GSA 17 & 18	0.011	0.809	1	1	1	1	1

Natural Mortality
The vector of natural mortality as obtained from PRODBIOM model (Abella *et al*., 1998) using the growth parameters in Table 6.6.1.1 and is shown in Table 6.6.1.4.

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 *S. mantis* 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 *S. mantis* 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, *S. mantis* 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).
The species is absent from the landings reported from Croatia in the DCF database. Landings from Croatia where provided to the present EWG by experts attending the meeting for the years 2012 – 2017.
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)

In GSA 17 landings data for Italy where available since 2007, for Slovenia since 2005 and for Croatia data were not available in the DCF database but where provided in the EWG by experts from Croatia. In GSA 18 Italian landings were available since 2006.
In Table 6.6.2.1.5 landings data are presented by country and GSA.

Table 6.6.2.1.5 Spottail mantis shrimp in GSAs 17 and 18. Landings data in tonnes by country.

	GSA 17				GSA 18	
	HRV	**ITA**	**SVN**	**Total**	**ITA**	**Total**
2004					2587.1	**2587.1**
2005			4.6	**4.6**	1298.9	**1298.9**
2006	6.7		2.4	**9.2**	1271.7	**1271.7**
2007	6.7	3905.0	7.2	**3919.0**	1258.5	**1258.5**
2008	8.5	3999.0	6.2	**4013.7**	916.8	**916.8**
2009	9.3	4529.0	3.6	**4542.0**	892.4	**892.4**
2010	8.6	4564.0	5.0	**4577.6**	454.1	**454.1**
2011	7.1	3786.0	3.6	**3796.7**	352.3	**352.3**
2012	2.2	3105.0	0.7	**3107.9**	631.7	**631.7**
2013	2.4	2127.0	0.3	**2129.7**	2195.9	**2195.9**
2014	4.5	2806.0	0.5	**2810.9**	1003.9	**1003.9**
2015	7.4	3064.0	0.8	**3072.2**	1010.8	**1010.8**
2016	11.3	3143.0	1.8	**3156.1**	929.2	**929.2**
2017	12.7	3076.0	1.2	**3089.8**	600.1	**600.1**
2018	13.1	3169.0	1.0	**3183.1**	774.7	**774.7**
2019	7.2	2575.0	1.3	**2583.5**	692.0	**692.0**

Figure 6.6.2.1.1. Spottail mantis shrimp in GSAs 17 and 18. Landings trend in tonnes by GSA and country from 2005 to 2019.

In the following figure (Figure 6.6.2.1.2) total landings are presented for both GSA 17 & 18. Missing landings from Italy for the beginning of the time series are responsible for the very low landings in the early years. After 2008 there is a slight increase in the trend followed by a slow decline until 2012. After 2012 landings are fluctuating around 4000 tonnes. It is clear that the trend in the landings data is governed by the landings of the Italian fleet.

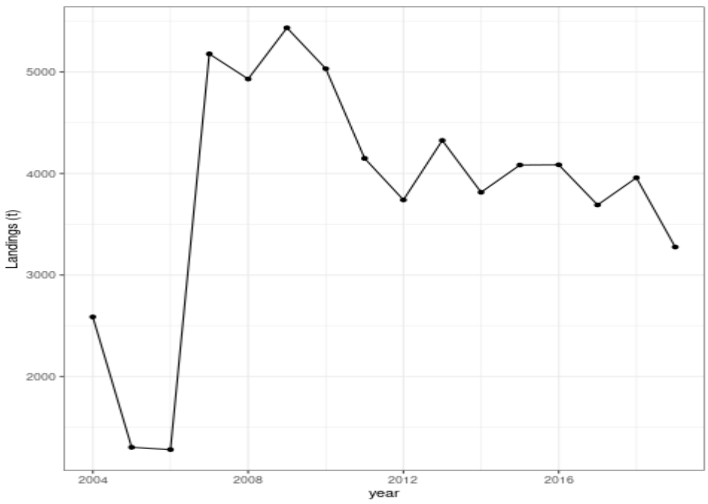


Figure 6.6.2.1.2 Spottail mantis shrimp in GSAs 17 and 18. Total landings in tonnes for both GSA's 17 and 18.

The following Tables present the landings of Spottail mantis shrimp in tonnes for GSA's 17 and 18 by country and gear.

Table 6.6.2.1.6 Spottail mantis shrimp in GSA 17. Landings in tonnes by country and gear.

	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	0.0	0.1	0.1
2014	296.0		2326.0	184.0	0.0	0.0	0.1	0.3
2015	325.0		2477.0	262.0	0.0	0.0	0.1	0.6
2016	408.0	9.0	2531.0	195.0	0.0	0.0	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	0.0	0.3	0.6
2019	242.0	121.0	1933.0	232.0	0.1	0.1	0.3	0.8

Table 6.6.2.1.7 Spottail mantis shrimp in GSA 18. Landings in tonnes by country and gear.

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

Length frequency distribution was available for the years 2007 – 2019 for both GSA's. The following graphs present the length structure of Spottail mantis shrimp for GSA 17 and GSA 18 first by GSA, year and gear and then in total for both GSA's through years.

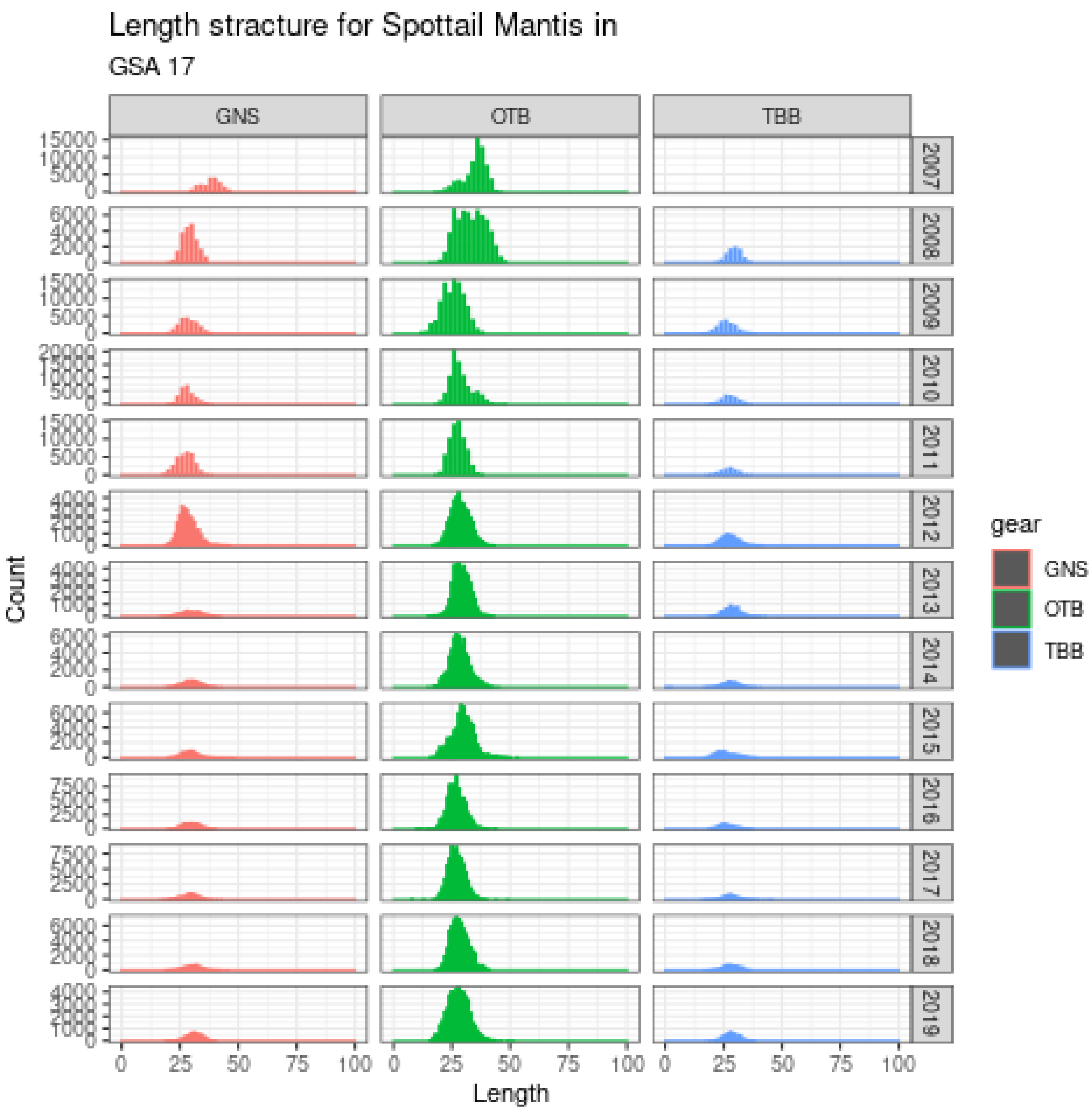


Figure 6.6.2.1.3 Spottail mantis shrimp in GSA 17. Length structure for by year and gear.

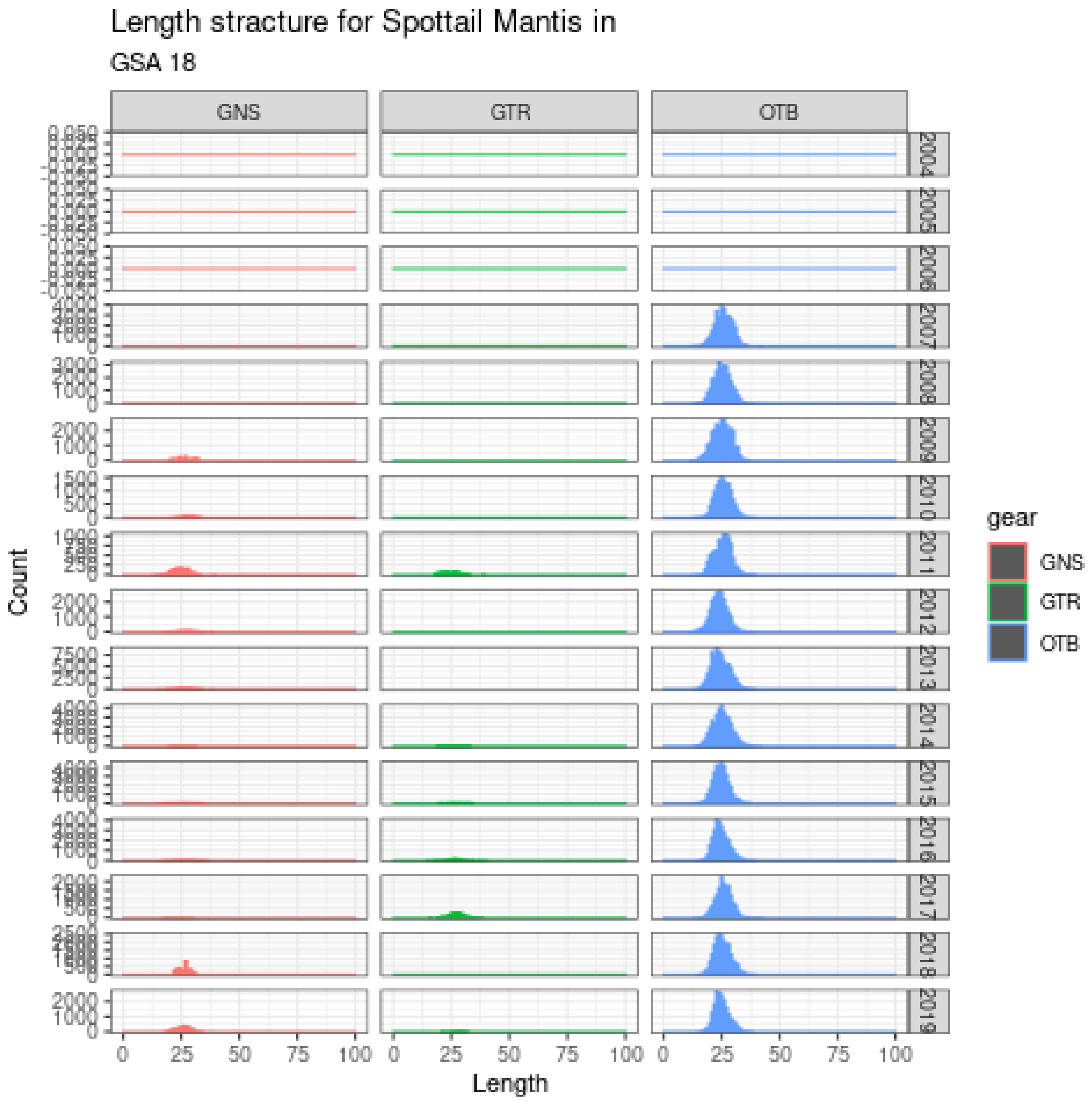


Figure 6.6.2.1.4 Spottail mantis shrimp in GSA 18. Length structure for by year and gear.

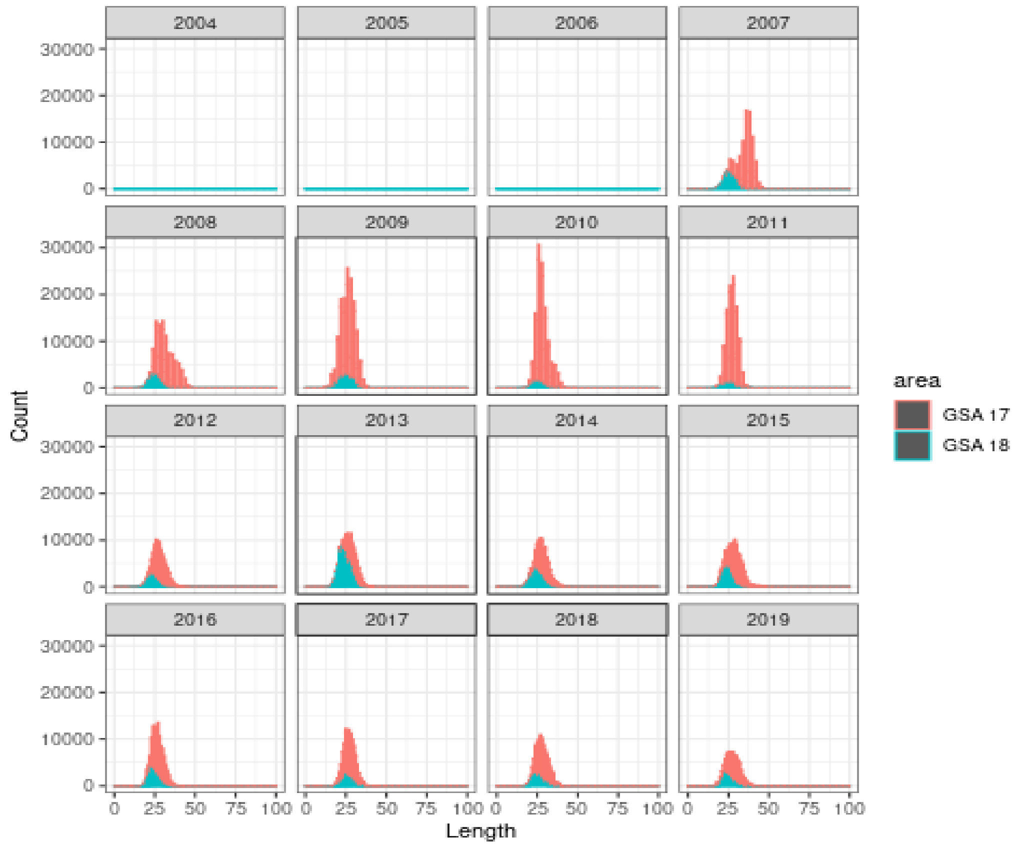


Figure 6.6.2.1.5 Spottail mantis shrimp in GSAs 17 & 18. Length structure by year
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DISCARDS
Discards data were available in the DCF database. With the main bulk of the discards coming from the Italian part. In the following table discards data in tonnes are presented.

Table 6.6.2.1.8 Spottail mantis shrimp in GSAs 17 and 18. Discards data in tonnes by country and year.

	GSA 17				GSA 18	
	ITA			SVN	ITA	
	OTB	TBB	GNS	OTB	GNS	OTB
2005			0.0	0.4		
2006			0.0	0.1		
2007			0.0	0.9		
2008			0.0	0.5		
2009			0.0	0.3		90.9
2010	375.0		0.0	0.4		93.2
2011	705.0	16.0	0.0	0.3	1.2	60.8
2012	103.0		0.0	0.0	0.6	268.7
2013	258.0		0.0	0.0	2.9	423.5
2014	394.0	4.0	0.0	0.0		78.7
2015	324.0	11.0	0.0	0.1		119.5
2016	1042.0		0.0	0.1		144.4
2017	403.0	44.0	3.0	0.1		25.4
2018	513.0	10.0	2.0	0.1		227.3

2019	489.0	4.0	1.0	0.1		195.8

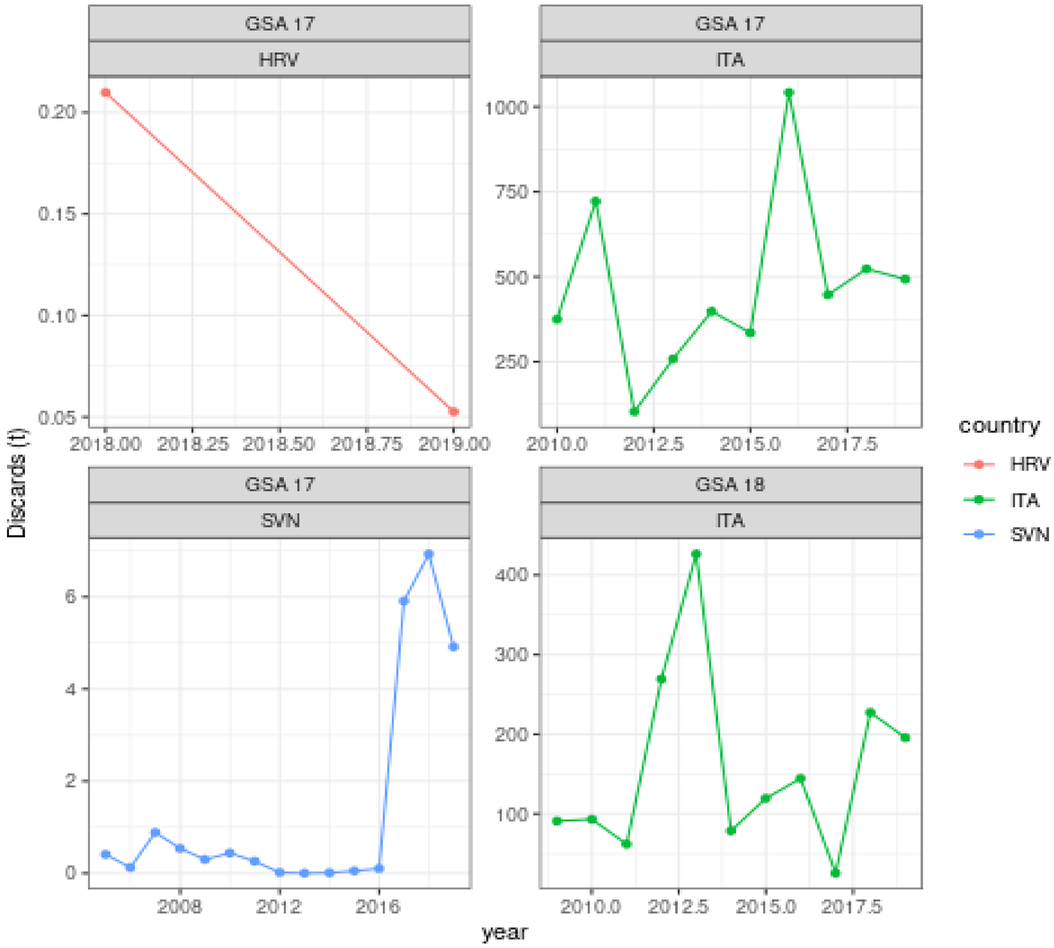


Figure 6.6.2.1.6 Spottail mantis shrimp in GSAs 17 and 18. Discards data in tonnes by country.

In the following graphs length frequency distribution of discards by GSA is being presented as most of the discards come from OTB a presentation of discards structure by gear would not be informative.

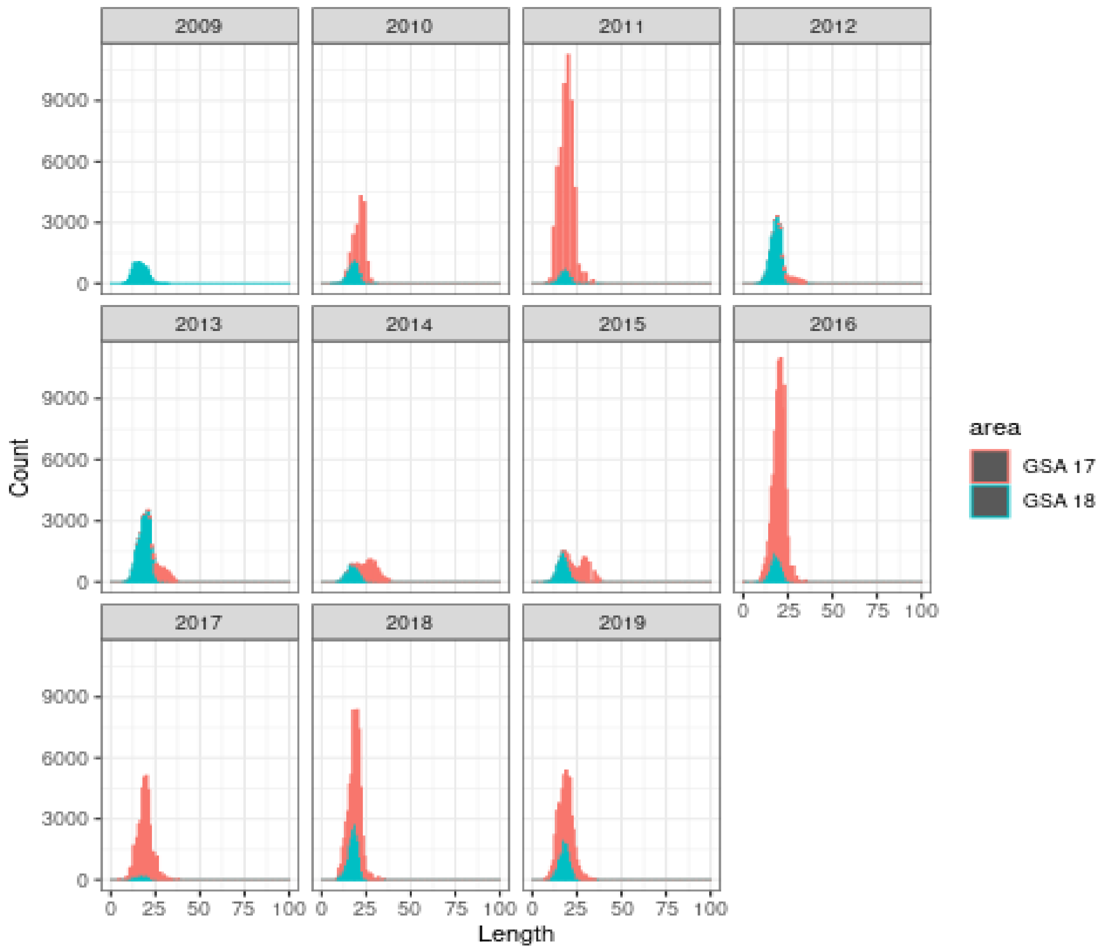


Figure 6.6.2.1.7 Spottail mantis shrimp in GSAs 17 and 18. Discards structure for GSA 17 and 18 for years 2009 to 2018

6.6.2.2 EFFORT

Effort data is dealt with in detail in Section 2.3, the main gears are the OTB, TBB, GNS and GTR.

6.6.2.3 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).

The abundance and biomass indices by GSA 17 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 area in the GSA 17:

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval:

Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to a number of different factors including the change in the number of hauls over time, and change of the survey time over the years. Precision may also be affected by the choice of parametric distribution, a normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-Poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al.* 2004).

Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA.

Given that in the present EWG a stock object for the tuning index was provided from the STECF EWG 17 – 15 and no analytical data for the abundance by haul of the survey were available, no calculations were made for the previous years. Abundance by length was provided for the years 2017 - 2019 and it was age sliced using the same growth parameters as the rest of the years.

The SoleMon trawl surveys provided trend in abundance for *S. mantis.* Figure 6.6.2.3.1. displays the stratified abundance indices by age obtained in GSA 17 from 2005 to 2017 during fall survey. The trends in biomass and abundance indices show a clear decrease of the stock in 2007 followed by an increase in the rest of the time series with a peak in 2015. Years 2016 and 2017 shows a decline in the end of the time series followed by an increase, reaching the peak of the time series in 2019.

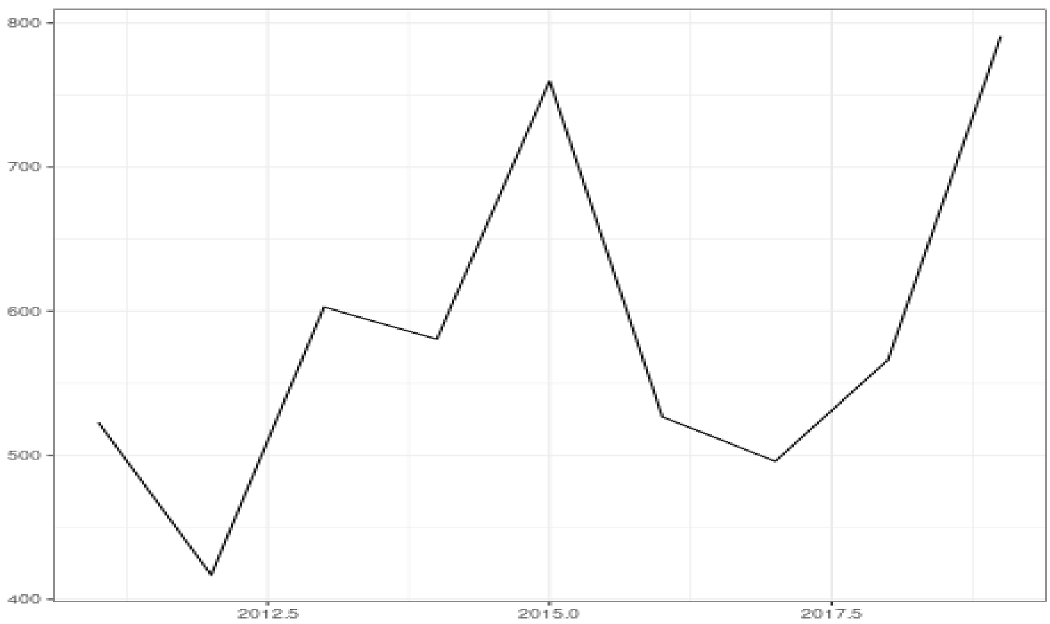


Figure 6.6.2.3.1 Spottail mantis shrimp in GSAs 17 and 18. Abundance by km^2 for SOLEMON survey for the years 2005 – 2019.

Size and therefore age distribution was only available through years 2011 through 2019 and these were the years used in the analytical assessments. The following figure (Figure 6.6.2.3.2) displays the age structure by age for Spottail mantis shrimp.

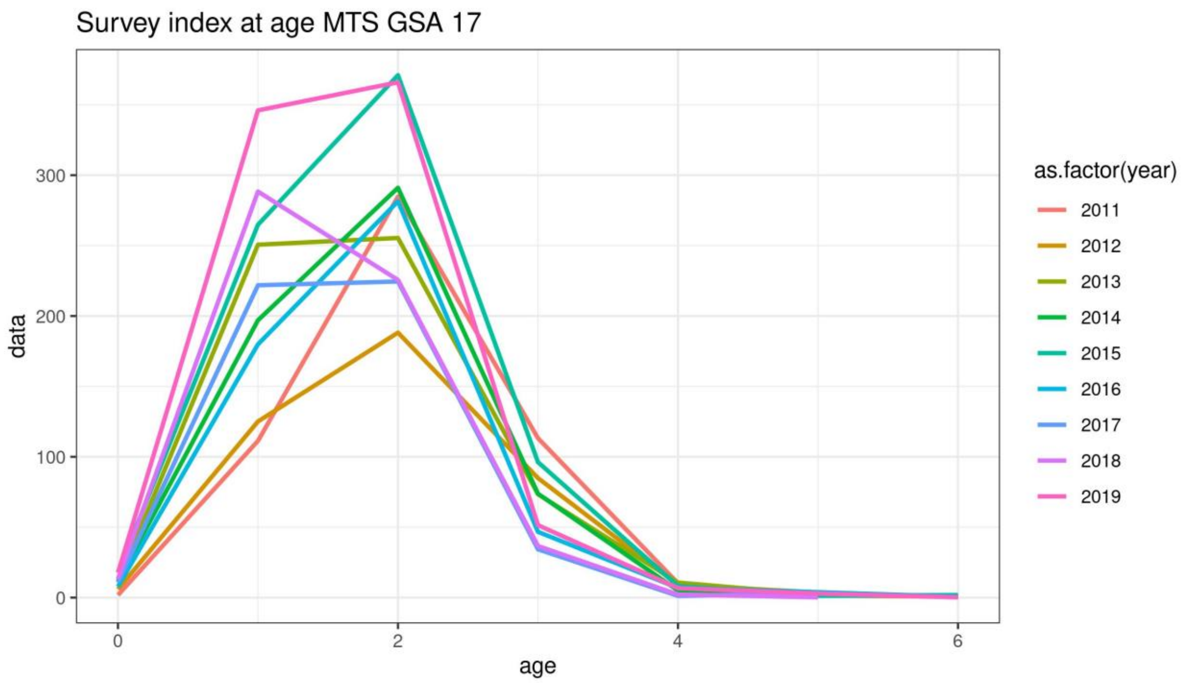


Figure 6.6.2.3.2 Spottail mantis shrimp in GSAs 17 and 18. Age structure of SOLEMON survey for ages 2011 – 2019.

Medits survey

Medits survey was carried out in GSAs 17 and 18 since 1994. Although the target of the survey are demersal species, Spot-tail mantis shrimp is scarcely caught. This is due to the behaviour of the species that spends most of the time borrowed during the daylight hours. 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.
However, based on the DCF data call, abundance and biomass indices were calculated for GSAs 17 and 18 using the ad hoc script.
MEDITS survey was used as a biomass in the combined GSAs assessment. Data were analysed using the JRC script (Mannini, 2020)

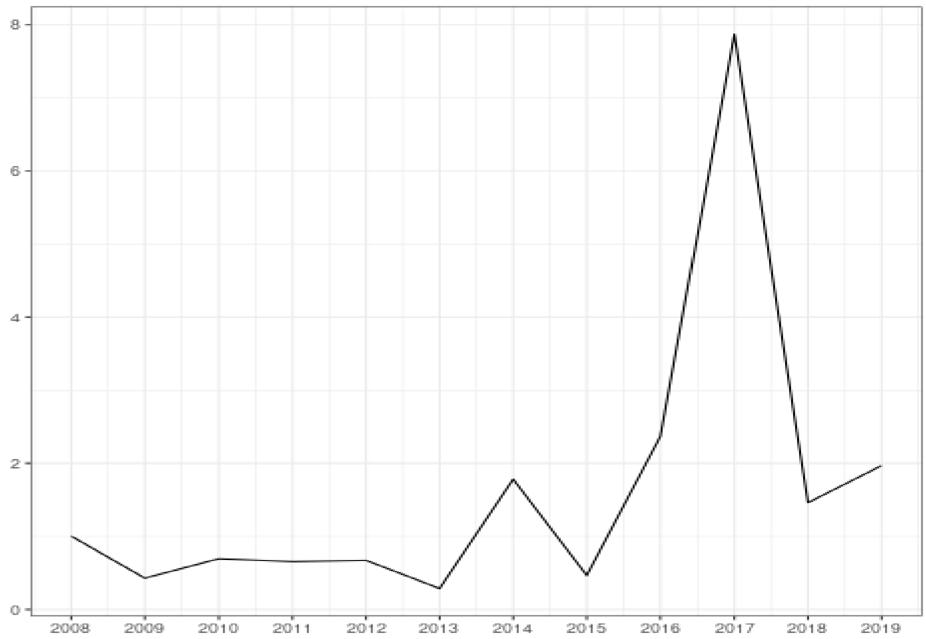


Figure 6.6.3.1.3 Spottail mantis shrimp in GSAs 17 and 18. MEDITS in GSA 17 & 18 combined biomass index.

6.6.3 STOCK ASSESSMENT

The EWG 20-15 decided to perform two separate stock assessments for the mantis shrimp in GSA 17 and 18. One for the GSA 17 alone, where the main bulk of the catch comes from, and one for the two GSAs combined. In 2018, new growth parameters were reported in the DCF for GSA 18, suggesting different growth between two areas. The EWG 20-15 was asked to perform sensitivity tests regarding the different growth. The EWG 20-15 decided to assess combined areas using each set of growth parameters to slice separate the length distributions and weight according the catch numbers other life history parameters.

During EWG 20-15 both stock assessments were performed over the period 2008-2019. Discards were included in the analysis. Since no discard data were available for 2008-

2009 in GSA 17 and for 2008 in GSA 18, an estimate based on the average discard ratios and discard age structures of the available nearest years was performed.

In the case of Spottail mantis catch data provided in the DCF database were used for the period 2008 - 2019. The statistical sample of age composition as well as the mean weight at age, were calculated using the provided growth and length weight relationship parameters. Landings and Discards in numbers at age were derived from deterministic age slicing the numbers at length provided from the DCF. Age slicing performed by using the l2a function of FLR and growth parameters reported in the section 6.6.1. The age classes considered from the catches range from 0 to 7; plus group was set at age 6.

A natural mortality vector based on growth parameters (Section 6.6.1) computed using ProdBiom (Abella *et al.*, 1998) was used for GSA 17 for GSA 18 Chen and Watannabe natural mortality vector was estimated and for the combined GSAs the vectors were weighted according the catch numbers. The analyses were performed by sex combined, as growth is very similar between the two sexes. Given that the catches were composed mainly of individuals between 1 and 3 years, these ages were selected as the Fbar in both GSA 17 and GSA 17 & 18 combined.

6.6.3.1 STOCK ASSESSMENT OF SPOTTAIL MANTIS SHRIMP IN GSA 17 AND 18

SoP correction was applied to catch numbers at age. Table 6.6.3.1.1 present the SoP correction vector applied. The empty years correspond to the absence of catch at age data for these years.
The SoleMon trawl survey and was used as tuning index of abundance in the assessment and the age range used goes from 0 to 6. Age data from SoleMon were available for the period 2011-2018. An additional biomass index was used in the assessment, the Medits index for GSA 17& 18 combined.

The method for the assessment is a4a, a 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 for the years 2008 - 2019.

year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
SoP	1.15	1.02	1.08	1.04	1.03	1.02
year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
SoP	0.91	1.01	1.09	1.05	1.07	1.11

The following tables (Tables 6.6.3.1.2 – 6.6.3.1.3) present total catch and catch at age used in the stock assessment of Spottail mantis shrimp.

Table 6.6.3.1.2 Spottail mantis shrimp GSA 17 and 18. Total catch in tonnes 2008 – 2019.

year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
data	5538	6213	5500	4933	4112	5010

year	2014	2015	2016	2017	2018	2019
data	4292	4537	5272	4168	4715	3969

Table 6.6.3.1.3 Spottail mantis shrimp GSA 17 and 18. Catch numbers at age in thousands.

age	2008	2009	2010	2011	2012	2013
0	5345.7	16668.1	9430.7	15809.9	27280.9	43528.1
1	47456.7	107839.7	47391.5	80975.8	40730.4	74209.7
2	35882.0	78385.7	78446.6	68177.2	48348.3	40519.2
3	15910.6	20595.5	16297.5	15183.6	14920.5	13418.9
4	6420.9	2123.2	5230.3	674.1	2125.4	1546.0
5	5164.7	537.1	3400.9	146.1	516.2	222.1
6+	10637.2	38.1	1633.3	38.1	618.4	428.2
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	12415.4	16062.6	20049.5	9634.8	28104.5	25728.8
1	45346.9	48626.4	121449.6	73769.5	75972.4	67751.6
2	50796.2	41138.9	50368.0	52181.8	45766.7	36370.2
3	13746.6	18302.0	9920.5	9298.4	14573.0	12270.1
4	2637.1	3173.4	967.9	933.0	1424.3	1871.4
5	881.5	671.6	223.5	198.4	667.5	448.9
6+	833.9	2258.3	173.3	76.2	583.4	729.1

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	0.010	0.010	0.011	0.007	0.011	0.012
1	0.025	0.019	0.022	0.020	0.024	0.027
2	0.036	0.034	0.033	0.034	0.036	0.038
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	0.107	0.107	0.107	0.105	0.099
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	0.012	0.012	0.010	0.005	0.009	0.008
1	0.025	0.024	0.022	0.022	0.023	0.022

2	0.037	0.038	0.036	0.036	0.036	0.037
3	0.057	0.058	0.056	0.056	0.057	0.056
4	0.076	0.075	0.075	0.074	0.075	0.075
5	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

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

For the tuning index of the both assessment methods the STECF EWG decided to use the SOLEMON abundance index for the period 2011 – 2019. The following table presents the estimated numbers at age for the SOLEMON tuning index.

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
0	1.81	5.97	10.69	11.79
1	111.32	125.11	250.63	196.99
2	284.76	188.2	255.42	291.07
3	113.21	84.9	73.47	73.78
4	10.17	9.04	10.66	5.01
5	1.48	3.64	2	1.87
age	**2016**	**2017**	**2018**	**2019**
0	7.8	10.837	13.27233	17.64918
1	179.9	221.84	288.38178	346.0557
2	281.49	224.506	225.60309	365.97819

3	46.71	34.294	36.66091	51.4534
4	6.84	1.242	2.17412	6.75573
5	3.87	3.092	0.19712	2.89141

The following figures (Figures 6.6.3.1.1 to 6.6.3.1.3) show the catch at age, index at age and weight at age for the input data of the assessments.

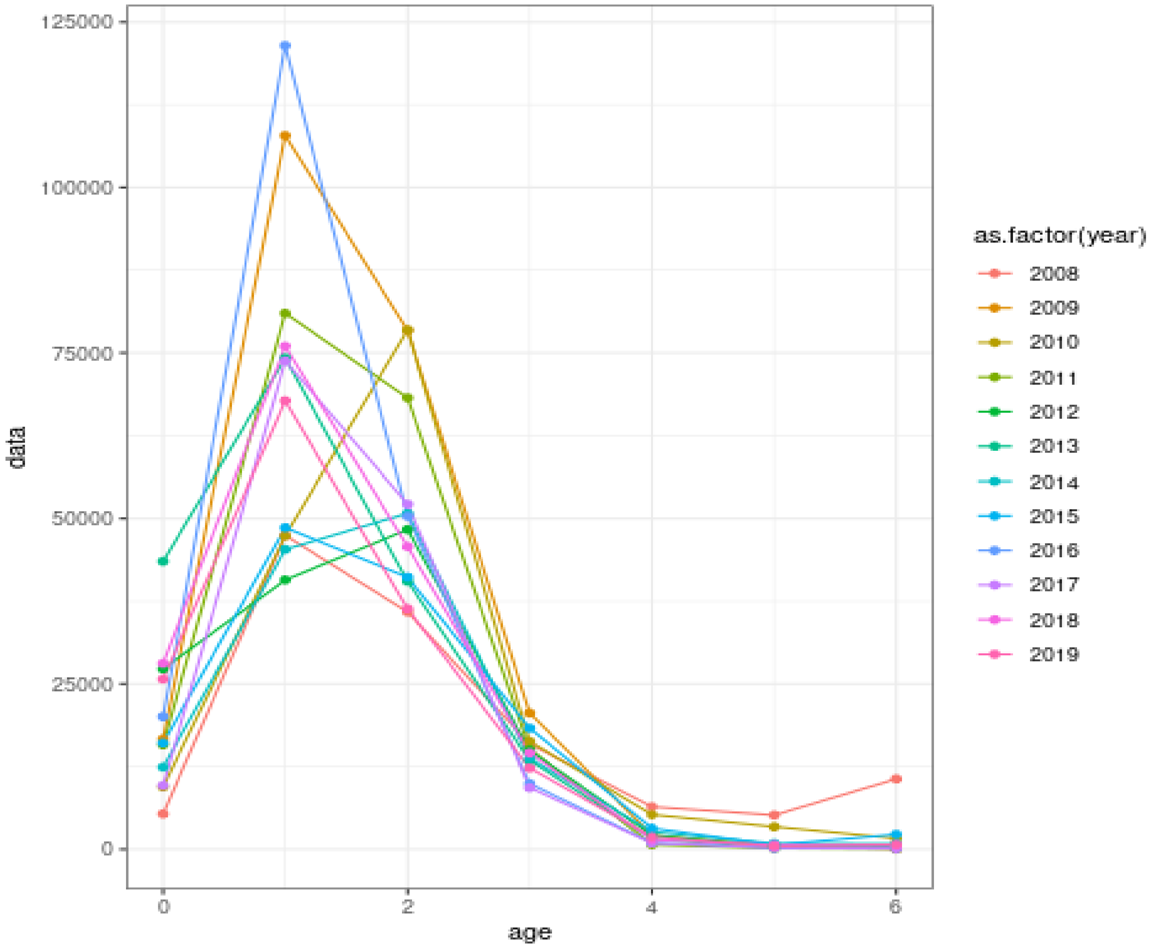


Figure 6.6.3.1.1 Spottail mantis shrimp in GSAs 17 and 18. Catch numbers in thousands at age.

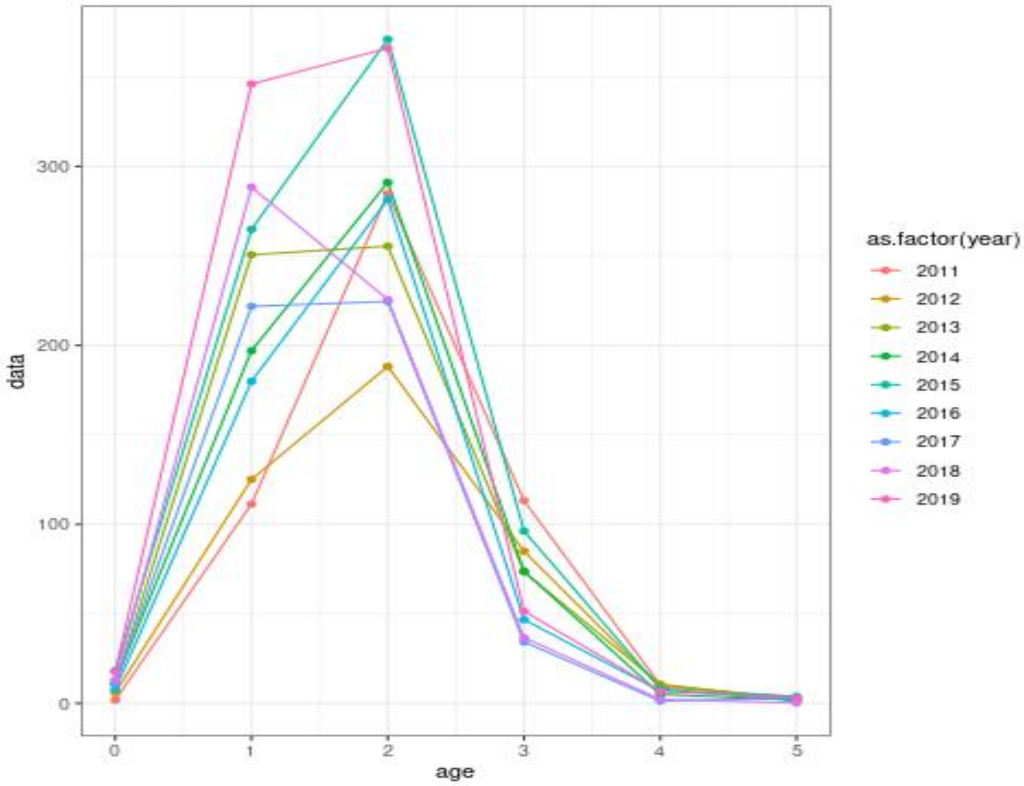


Figure 6.6.3.1.2 Spottail mantis shrimp in GSAs 17 and 18. SOLEMON tuning index numbers at age.

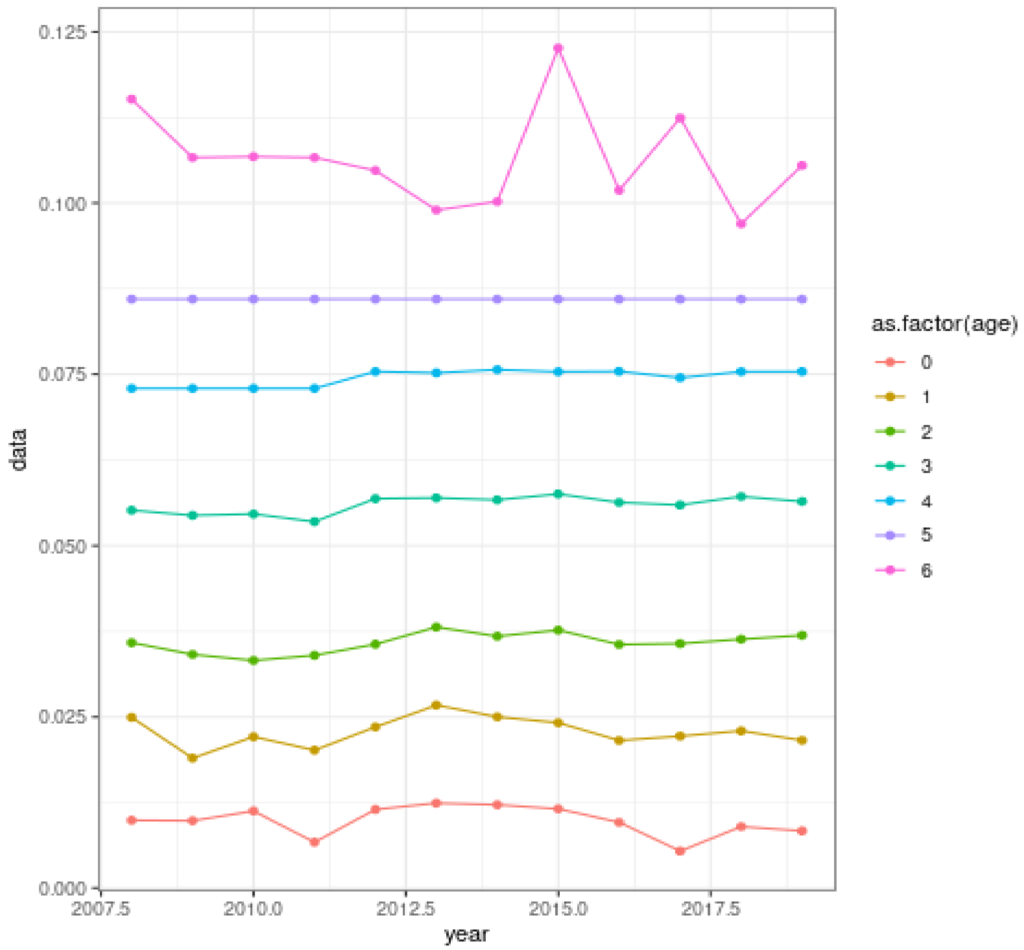


Figure 6.6.3.1.3 Spottail mantis shrimp in GSAs 17 and 18. Mean weight at age.

A4A ASSESSMENT RESULTS FOR GSA 17 AND 18

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

fmodel4 <- ~ factor(replace(age, age>4,4))+s(year, k=6)
qmodel2<- list(~ factor(replace(age, age>4,4)),~1)
srmodel1 <- factor(year)

Additional case studies using different growth and input data were carried out (see Section 6.6.6) overall this assessment had greater internal consistency in input data from catch and survey at age and better model fit.

Results are shown in figures 6.6.3.1.4 – 6.6.3.1.6, namely the estimated recruits, spawning stock biomass catch and harvest rates for ages 1 - 3. Fishing mortality through all ages and years and catchability of the gear of the SOLEMON survey tuning index:

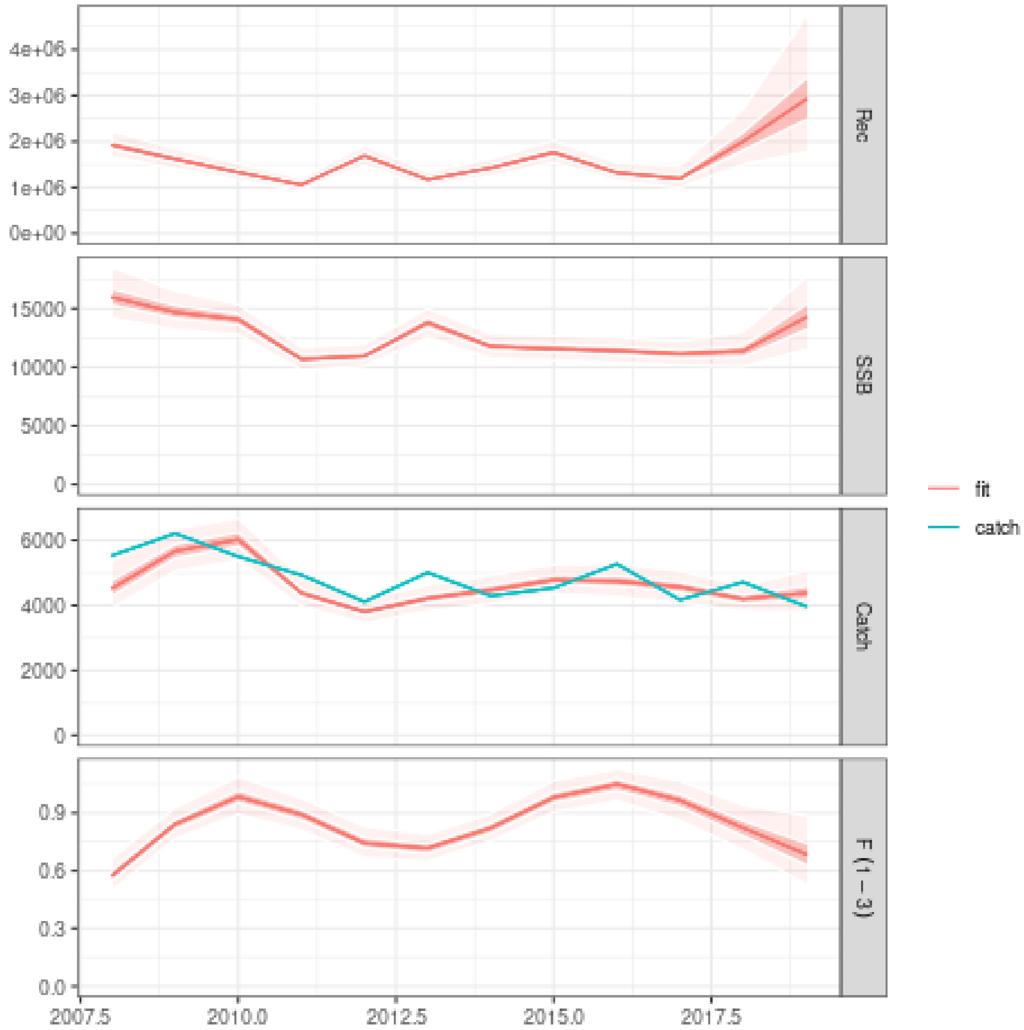


Figure 6.6.3.1.4 Spottail mantis shrimp in GSAs 17 and 18. Stock summary from the a4a model for Spottail mantis shrimp in GSAs 17 and 18, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

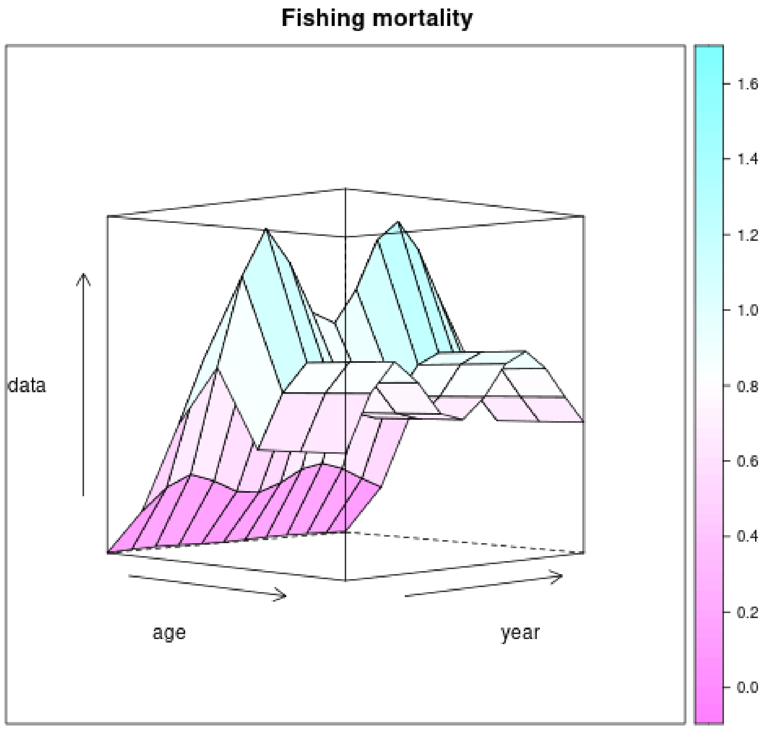


Figure 6.6.3.1.5 Spottail mantis shrimp in GSAs 17 and 18. 3D contour plot of estimated fishing mortality by age and year.

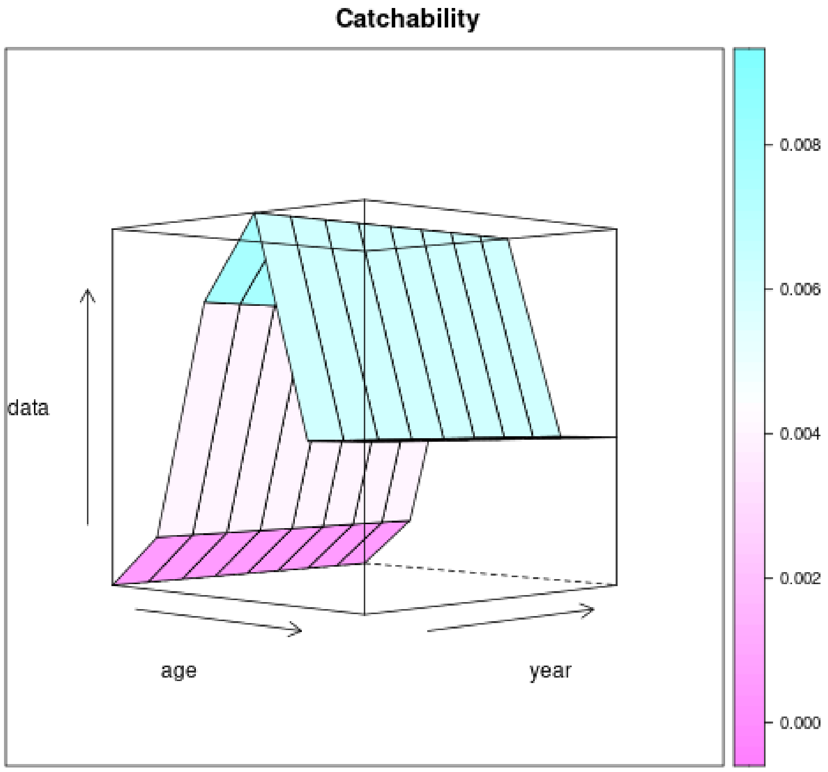


Figure 6.6.3.1.6 Spottail mantis shrimp in GSAs 17 and 18. 3D contour plot of estimated catchability by age and year.

Diagnostics

Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of Spottail mantis shrimp stock. Residuals of the total catch where evenly distributed around zero. Residuals at age in the catch and the survey do not show problematic effects, they are well scattered positive and negative values in the catch and the occasional year effect in the survey.

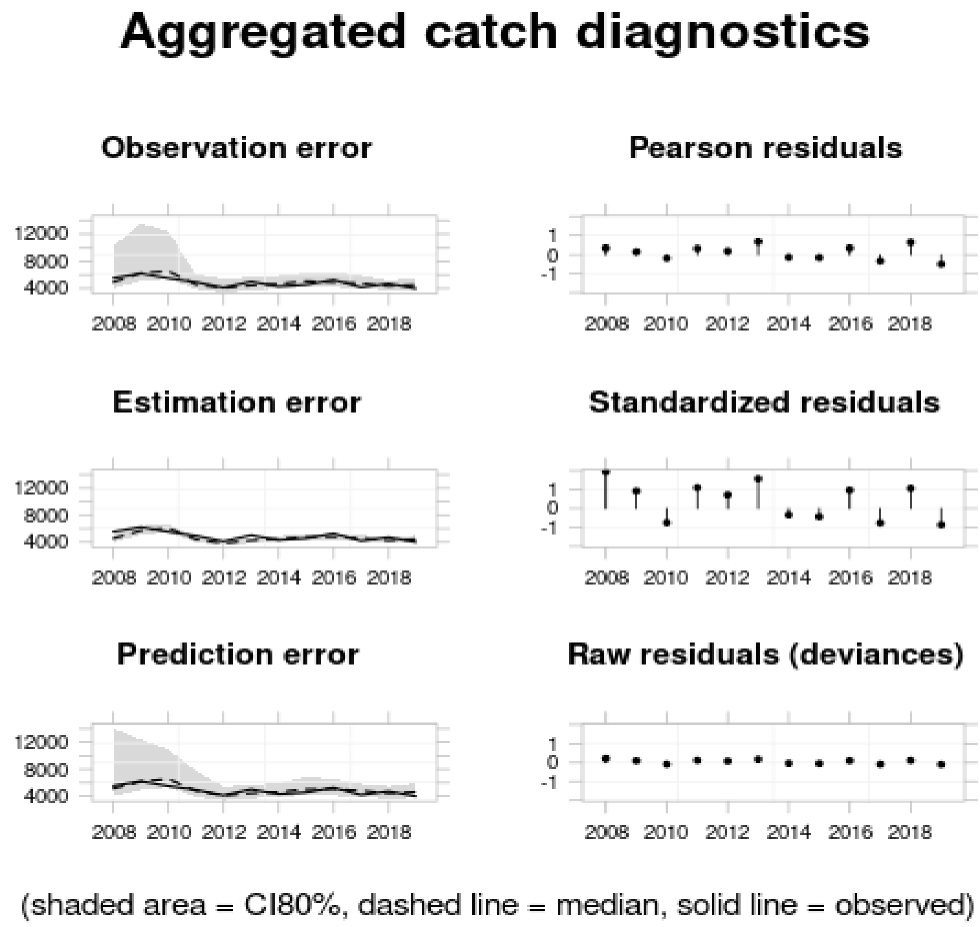


Figure 6.6.3.1.7 Spottail mantis shrimp in GSAs 17 and 18. Aggregated catch diagnostics.

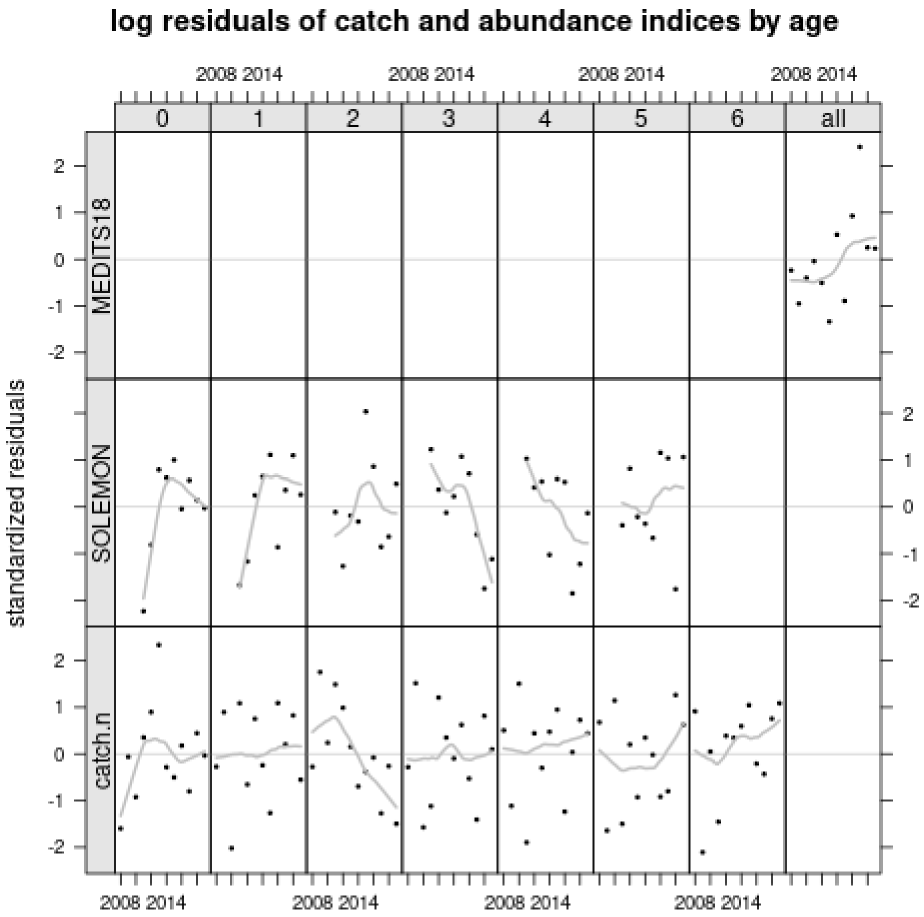


Figure 6.6.3.1.8 Spottail mantis shrimp in GSAs 17 and 18. Standardized log residuals for the fitted model for catch numbers at age and index abundances.

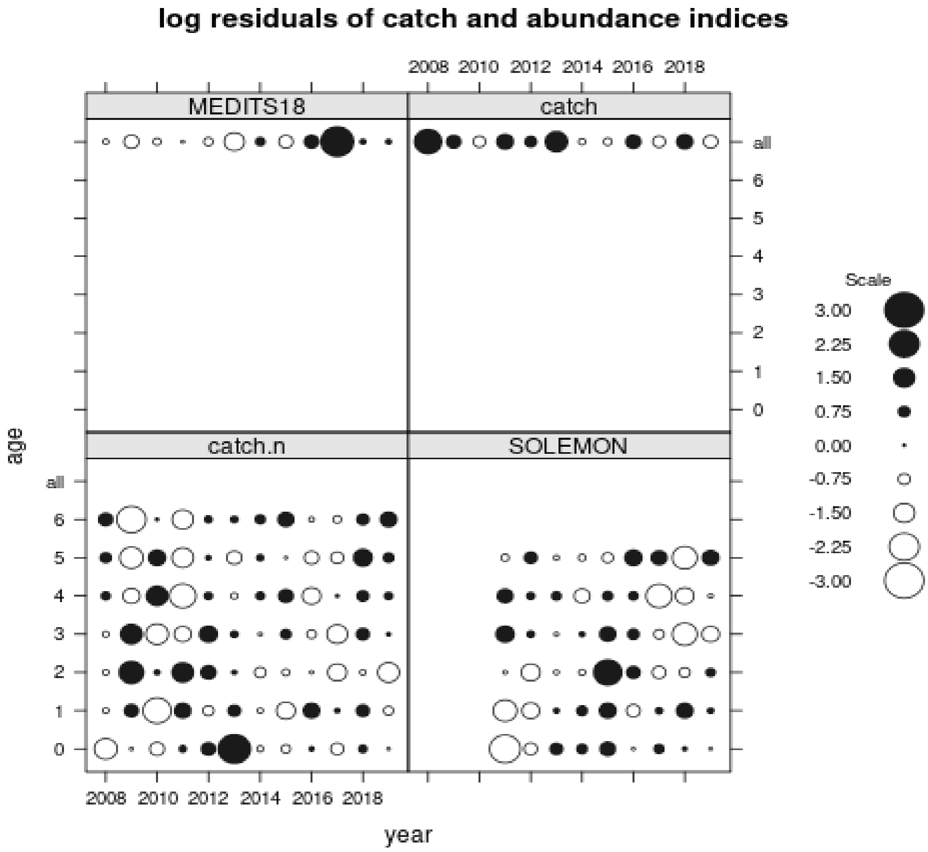


Figure 6.6.3.1.8 Spottail mantis shrimp in GSAs 17 and 18. Standardized log residuals for the fitted model for catch numbers at age, index abundances and total catch presented in a bubble plot.

Fitted versus observed catch at age (Figure 6.6.3.1.9) show a fairly good fit for the model to the data. Some problems are apparent in the years 2013 and 2016 mainly in the age 1.

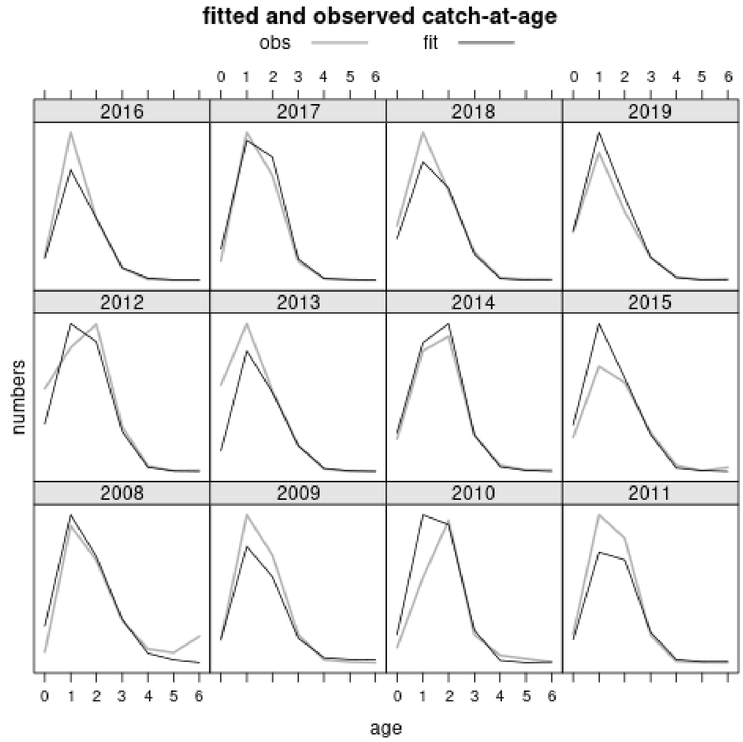


Figure 6.6.3.1.10 Spottail mantis shrimp in GSAs 17 and 18. Estimated versus observed catch at age.

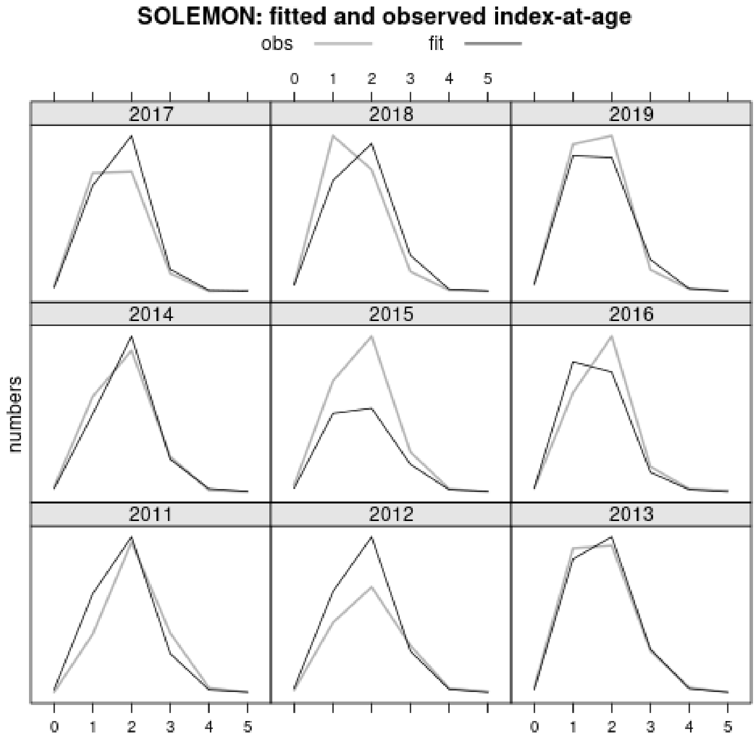
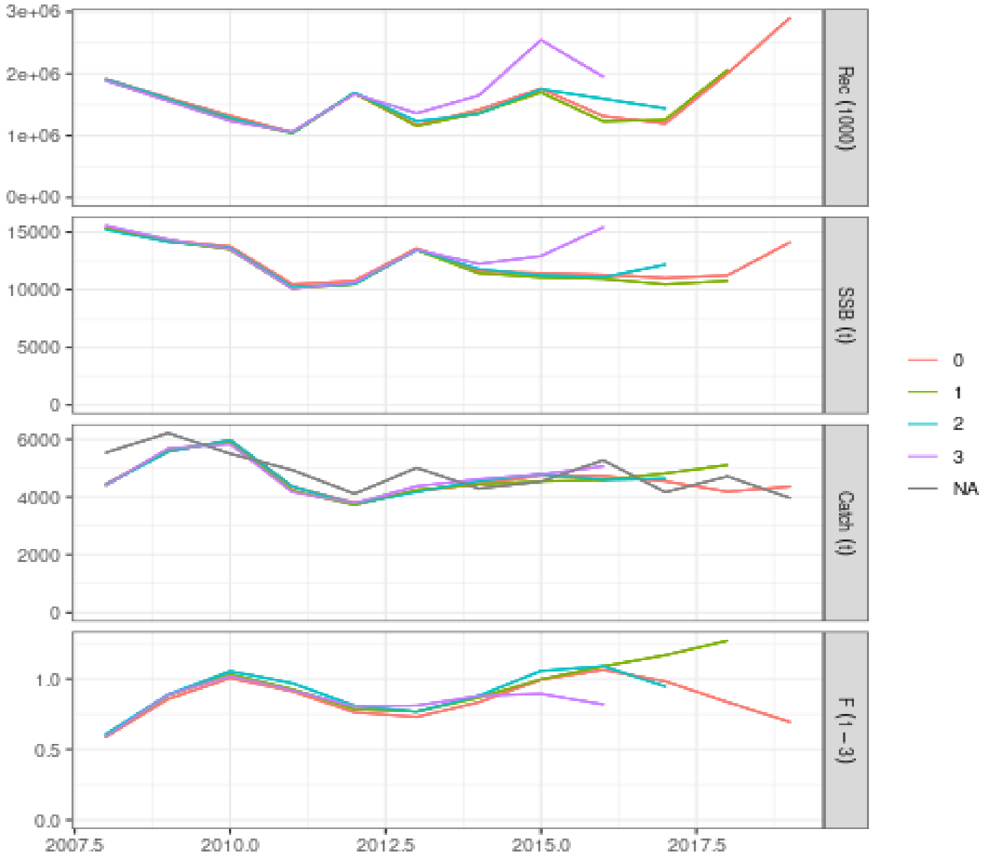


Figure 6.6.3.1.11 Spottail mantis shrimp in GSAs 17 and 18. Estimated versus observed index at age.

Retrospective



Retrospective plots seemed quite stable for catch with the greater instability for Recruitment and especially for F. Fishing mortality seem to be much lower than the previous year, but being consistently above the proxy of F_{MSY}, $F_{0.1}$ for all years in all retrospective runs.

Figure 6.6.3.1.12 Spottail mantis shrimp in GSAs 17 and 18. Retrospective analysis for the a4a model.

Table 6.6.3.1.7 Spottail mantis shrimp in GSAs 17 and 18. Stock summary results for a4a model.

year	rec	ssb	catch	fbar	tb
2008	1922782	15733	4458	0.58	36082
2009	1620604	14556	5609	0.84	31750
2010	1329428	13973	5982	0.98	30149
2011	1059800	10649	4366	0.89	18762
2012	1689665	10923	3796	0.74	31169
2013	1171569	13734	4208	0.71	29648
2014	1427639	11729	4456	0.82	29930
2015	1765975	11565	4766	0.98	32954
2016	1321877	11390	4732	1.04	25424
2017	1200058	11107	4542	0.96	18808

2018	2009828	11335	4189	0.82	30452
2019	2901990	14193	4372	0.69	40019

Based on a4a results spawning stock biomass of Spottail mantis shrimp is decreasing the last three years. Catch is around 4000 tonnes the last five years with the maximum appearing in 2010 early in the time series. The recruitment is increasing rapidly the last three years reaching the maximum of the time series in 2019 of around 3 million, while Fbar is increasing for the last four years with an fbar in 2019 at 0.69.

Table 6.6.3.1.8 Spottail mantis shrimp in GSAs 17 and 18. Fishing mortality at age.

age	2008	2009	2010	2011	2012	2013
0	0.01	0.02	0.02	0.02	0.02	0.02
1	0.22	0.33	0.38	0.35	0.29	0.28
2	0.63	0.91	1.07	0.97	0.81	0.78
3	0.88	1.28	1.50	1.35	1.13	1.09
4	0.53	0.77	0.90	0.81	0.68	0.65
5	0.53	0.77	0.90	0.81	0.68	0.65
6	0.53	0.77	0.90	0.81	0.68	0.65
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	0.02	0.02	0.03	0.02	0.02	0.02
1	0.32	0.38	0.41	0.37	0.32	0.27
2	0.89	1.07	1.13	1.04	0.89	0.75
3	1.25	1.49	1.59	1.46	1.25	1.04
4	0.75	0.89	0.95	0.88	0.75	0.63
5	0.75	0.89	0.95	0.88	0.75	0.63
6	0.75	0.89	0.95	0.88	0.75	0.63

Table 6.6.3.1.8 Spottail mantis shrimp in GSAs 17 and 18. Estimated Catch numbers at age.

age	2008	2009	2010	2011	2012	2013
0	14090	17321	16513	12756	15837	10552
1	51067	84794	81421	60500	48535	60650
2	37173	62627	76073	56348	42597	39726
3	16330	17908	18841	16832	13347	12992
4	4960	3743	2430	1768	1696	1799
5	2782	2401	1198	573	429	517
6	1825	2230	1482	631	292	220
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	14758	21770	18006	15659	21449	26280
1	48386	68271	90650	69805	60887	78575
2	55518	43210	50869	61406	47311	44048

3	13869	17276	10414	10587	13518	12161
4	2072	1958	1817	914	984	1495
5	641	684	516	411	211	254
6	263	299	259	176	136	89

The EWG 20-15 concluded that the a4a model was suitable to provide the basis of the current status of the stock.

6.6.4.1 Reference Points

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as F_{max} and $F_{0.1}$. Yield per Recruit computation was made using R project software and the FLR libraries. 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 input parameters were the same used for the a4a stock assessment and its results. In a4a the $F_{0.1}$ was estimated using FLBRP package and the value estimated was 0.45. EWG 20-15 decided that the a4a model was the most suitable to estimate the status of the stock of Spottail mantis shrimp. Fbar calculated as the last year’s value, Fbar = 0.69, thus F/ $F_{0.1}$ = 1.53 and the stock is considered overexploited.

6.6.5.1 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2019 to 2021 was performed using the FLR routines provided by JRC and based on the results of the a4a stock assessments performed during EWG 20-15. The input parameters were the same used for the a4a stock assessment and its results. F status quo is equal the last year’s value, corresponding to a catch in 2019 of 4960 t. Recruitment 2019 and 2020 is 1124384 thousands (equal to the geometric mean recruitment of all the years in the assessment).

Table 6.6.5.1.1 Spottail mantis shrimp in GSA 17 & 18: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological parameters		maturity, natural mortality, mean weights and fishery selection taken as mean of last three years 2017-2019
$F_{ages\ 1\text{-}3}$ (2020)	0.69	F2019 used to give F status quo for 2020
SSB (2020)	21099	Stock assessment 1 January 2020
R_{age0} (2020,2021)	1556836	Geometric mean of the time series
Total catch (2019)	6279	Assuming F status quo for 2020

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

Table 6.6.5.1.2 Spottail mantis shrimp in GSAs 17 – 18. Short term forecasts showing catch options for different fishing mortalities reductions.

Rationale	F factor	Fbar	F 2020	Catch 2021	SSB 2020	SSB 2022	SSB_change 2020-2022(%)	Catch_change 2019-2021(%)
High long term yield (F0.1)	0.66	0.45	0.69	4970	21099	18790	-11	14
F upper	0.90	0.61	0.69	6352	21099	17358	-18	45
F lower	0.44	0.30	0.69	3532	21099	20305	-4	-19
FMSY transition	0.90	0.62	0.69	6383	21099	17326	-18	46
Zero catch	0.00	0.00	0.69	0	21099	24115	14	-100
Status quo	1.00	0.69	0.69	6894	21099	16804	-20	58
Different Scenarios	0.10	0.07	0.69	896	21099	23138	10	-79
	0.20	0.14	0.69	1737	21099	22227	5	-60
	0.30	0.21	0.69	2527	21099	21378	1	-42
	0.40	0.27	0.69	3269	21099	20585	-2	-25
	0.50	0.34	0.69	3966	21099	19845	-6	-9
	0.60	0.41	0.69	4623	21099	19154	-9	6
	0.70	0.48	0.69	5241	21099	18507	-12	20
	0.80	0.55	0.69	5824	21099	17902	-15	33
	0.90	0.62	0.69	6374	21099	17335	-18	46
	1.10	0.75	0.69	7385	21099	16306	-23	69
	1.20	0.82	0.69	7849	21099	15838	-25	80
	1.30	0.89	0.69	8289	21099	15399	-27	90
	1.40	0.96	0.69	8705	21099	14987	-29	99
	1.50	1.03	0.69	9100	21099	14598	-31	108
	1.60	1.10	0.69	9475	21099	14233	-33	117
	1.70	1.17	0.69	9832	21099	13888	-34	125
	1.80	1.23	0.69	10170	21099	13564	-36	133
	1.90	1.30	0.69	10493	21099	13257	-37	140
	2.00	1.37	0.69	10800	21099	12968	-39	147

6.6.3.2 STOCK ASSESSMENT OF SPOTTAIL MANTIS SHRIMP IN GSA 17

SoP correction was applied to catch numbers at age. Table 6.6.3.1.1 present the SoP correction vector applied. The empty years correspond to the absence of catch at age data for these years. The SoleMon trawl survey and was used as tuning index of abundance in the assessment and the age range used goes from 0 to 6. Age data from SoleMon were available for the period 2011-2018.

The method for the assessment is a4a, a statistical catch at age framework developed by the Joint Research Centre (Jardim *et al*., 2015).

Table 6.6.3.2.1 Spottail mantis shrimp GSA 17. Vector of Sum of Products correction for the years 2008 - 2019.

year	2007	2008	2009	2010	2011	2012	2013
SoP	0.70	0.88	1.20	1.07	1.08	1.06	1.01
year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	
SoP	1.06	0.85	0.95	0.95	0.97	1.03	

The following tables (Tables 6.6.3.2.2 – 6.6.3.2.3) present total catch and catch at age used in the stock assessment of Spottail mantis shrimp.

Table 6.6.3.2.2 Spottail mantis shrimp GSA 17. Total catch in tonnes 2008 – 2019.

year	2008	2009	2010	2011	2012	2013
data	4621	5229	4953	4519	3211	2388
year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
data	3209	3407	4198	3543	3713	3081

Table 6.6.3.2.3 Spottail mantis shrimp GSA 17. Catch numbers at age in thousands.

age	2008	2009	2010	2011	2012	2013
0	346.3	1346.5	257.8	9203.1	0.0	36.2
1	22689.9	84838.5	34337.2	70959.0	20255.6	8770.4
2	33405.2	75766.0	77243.9	67511.6	47550.4	35141.9
3	15896.5	20584.8	16287.5	15159.1	14905.4	13377.2
4	6420.9	2124.2	5230.3	674.5	2125.4	1546.0
5	5164.7	537.4	3400.9	146.2	516.2	222.1
6	10633.7	38.1	1633.3	38.1	618.4	428.2
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	10.6	0.0	6043.7	5883.9	7896.6	9475.8
1	19235.2	17898.9	92179.9	57470.8	52422.7	45061.6
2	47663.2	39400.2	48558.5	50554.8	43714.7	34836.8
3	13618.2	18234.3	9877.8	9237.6	14554.9	12264.9
4	2632.8	3173.4	967.9	918.7	1424.3	1871.4

5	881.5	671.6	223.5	198.4	667.5	448.9
6	833.9	2258.3	173.3	76.2	583.4	729.1

Table 6.6.3.2.4 Spottail mantis shrimp GSA 17. Catch mean weight at age in kg.

age	2008	2009	2010	2011	2012	2013
0	0.003	0.004	0.003	0.003	0.003	0.005
1	0.020	0.016	0.019	0.019	0.020	0.021
2	0.035	0.033	0.033	0.034	0.035	0.036
3	0.055	0.054	0.055	0.053	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	0.107	0.107	0.107	0.105	0.099
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	0.002	0.003	0.003	0.001	0.003	0.003
1	0.020	0.018	0.020	0.020	0.021	0.019
2	0.036	0.037	0.035	0.035	0.036	0.036
3	0.056	0.057	0.056	0.056	0.057	0.056
4	0.076	0.075	0.075	0.074	0.075	0.075
5	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

Table 6.6.3.2.5 Spottail mantis shrimp in GSA 17. Maturity, natural mortality, proportion of m and f before spawning.

age	1	2	3	4	5	6	7
Natural mortality	1.2	0.7	0.6	0.52	0.480	0.480	0.480
maturity	0.003	0.809	1.000	1.000	1.000	1.000	1.000
Harvest before spawn	0	0	0	0	0	0	0
Maturity before spawn	0	0	0	0	0	0	0

For the tuning index of the both assessment methods the STECF EWG decided to use the SOLEMON abundance index for the period 2011 – 2019. The following table presents the estimated numbers at age for the SOLEMON tuning index.

Table 6.6.3.2.6 Spottail mantis shrimp in GSA 17. SOLEMON numbers per km^2 at age.

age	2011	2012	2013	2014
0	1.81	5.97	10.69	11.79
1	111.32	125.11	250.63	196.99
2	284.76	188.2	255.42	291.07
3	113.21	84.9	73.47	73.78
4	10.17	9.04	10.66	5.01
5	1.48	3.64	2	1.87
age	**2016**	**2017**	**2018**	**2019**
0	7.8	10.837	13.27233	17.64918
1	179.9	221.84	288.38178	346.0557
2	281.49	224.506	225.60309	365.97819
3	46.71	34.294	36.66091	51.4534
4	6.84	1.242	2.17412	6.75573
5	3.87	3.092	0.19712	2.89141

The following figures (Figures 6.6.3.2.1 to 6.6.3.2.3) show the catch at age, index at age and weight at age for the input data of the assessments.

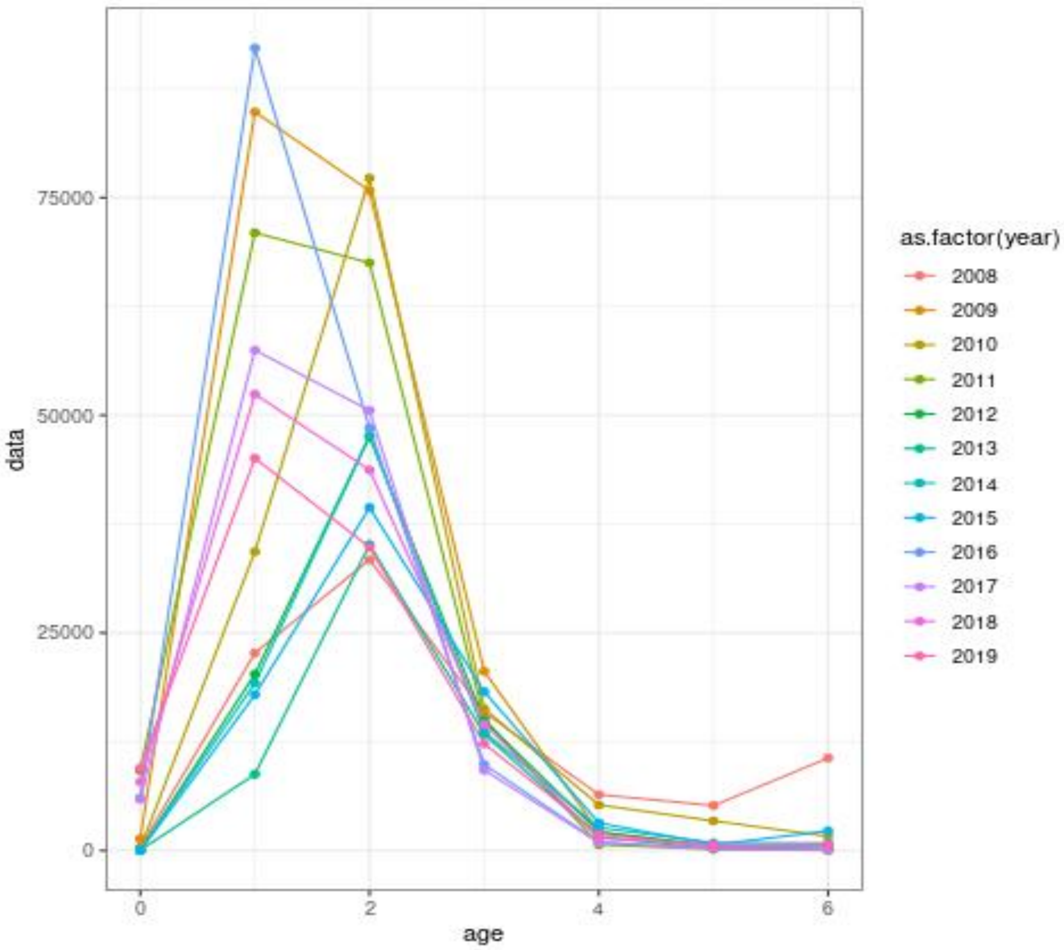


Figure 6.6.3.2.1 Spottail mantis shrimp in GSAs 17. Catch numbers in thousands at age.

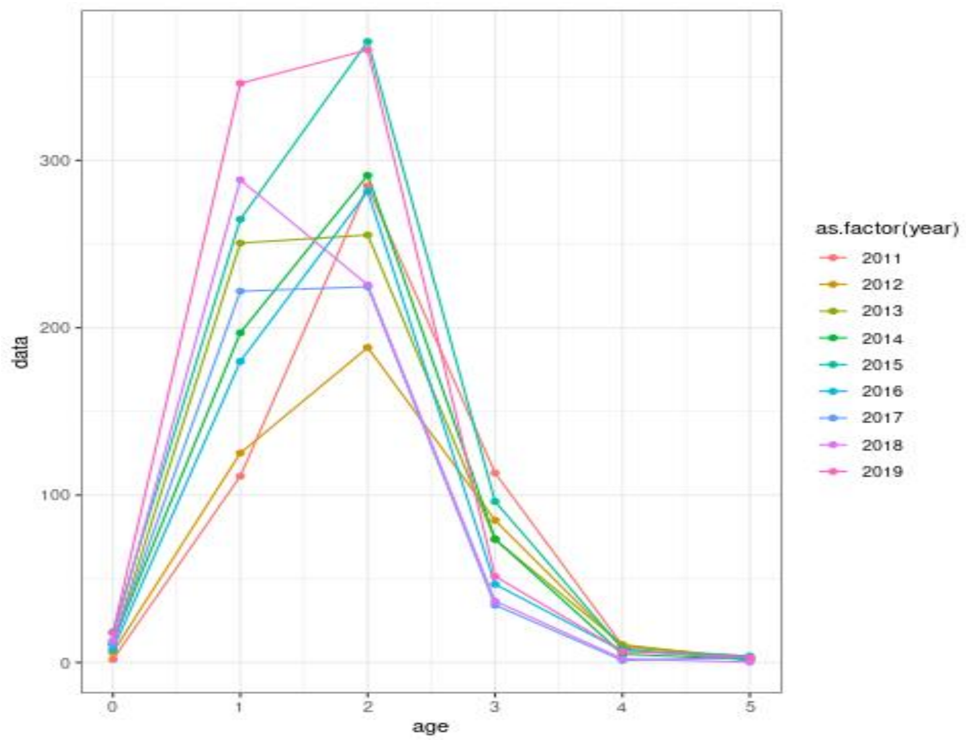


Figure 6.6.3.2.2 Spottail mantis shrimp in GSAs 17. SOLEMON tuning index numbers at age.

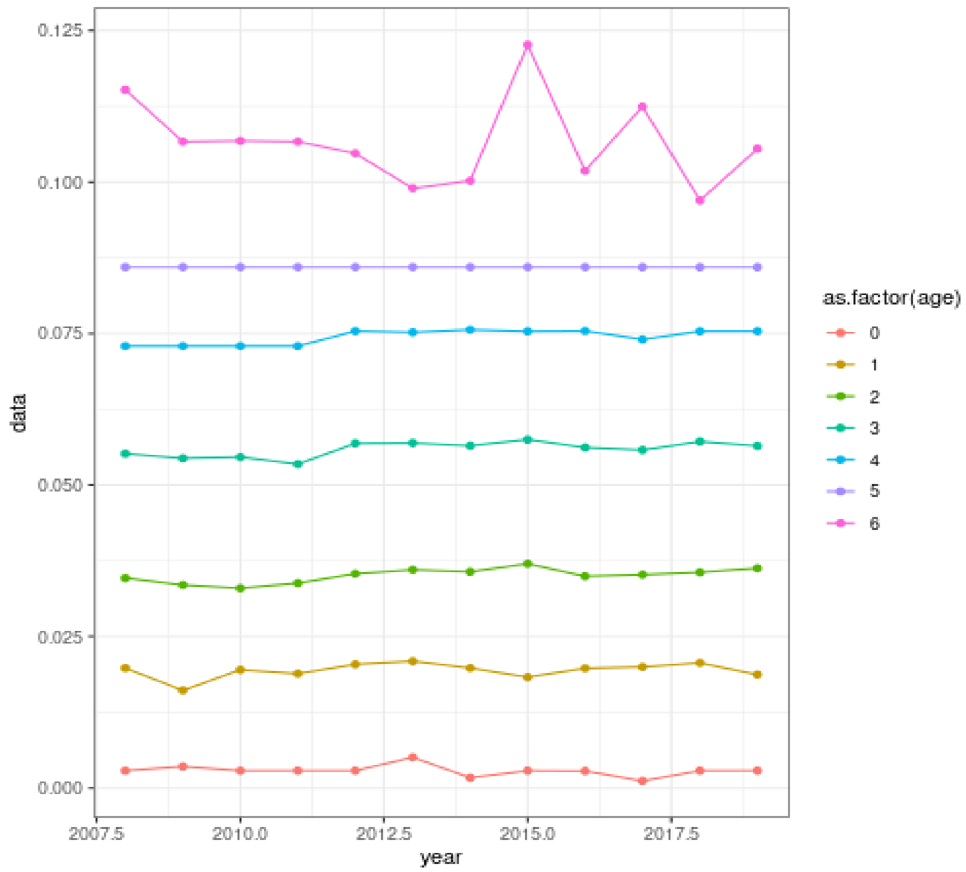


Figure 6.6.3.2.3 Spottail mantis shrimp in GSAs 17. Mean weight at age.

A4A ASSESSMENT RESULTS FOR GSA 17

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

fmodel <- ~ factor(replace(age, age>4,4))+s(year, k=5)
qmodel<- list(~ factor(replace(age, age>4,4)))
srmodel <- factor(year)

Additional case studies using different growth and input data were carried out (see Section 6.6.6) overall this assessment had greater internal consistency in input data from catch and survey at age and better model fit.

Results are shown in figures 6.6.3.2.4 – 6.6.3.2.6, namely the estimated recruits, spawning stock biomass catch and harvest rates for ages 1 - 3. Fishing mortality through all ages and years and catchability of the gear of the SOLEMON survey tuning index:

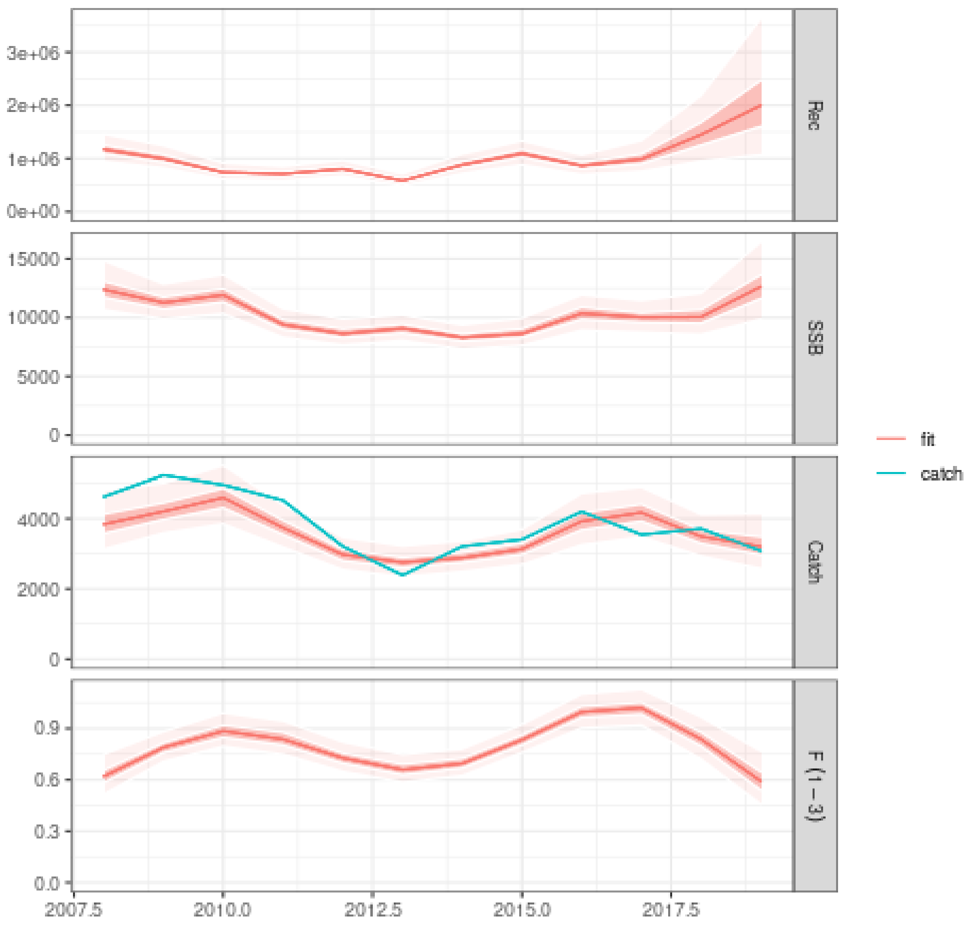


Figure 6.6.3.2.4 Spottail mantis shrimp in GSA 17. Stock summary from the a4a model for Spottail mantis shrimp in GSA 17, recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality for ages 1 to 3).

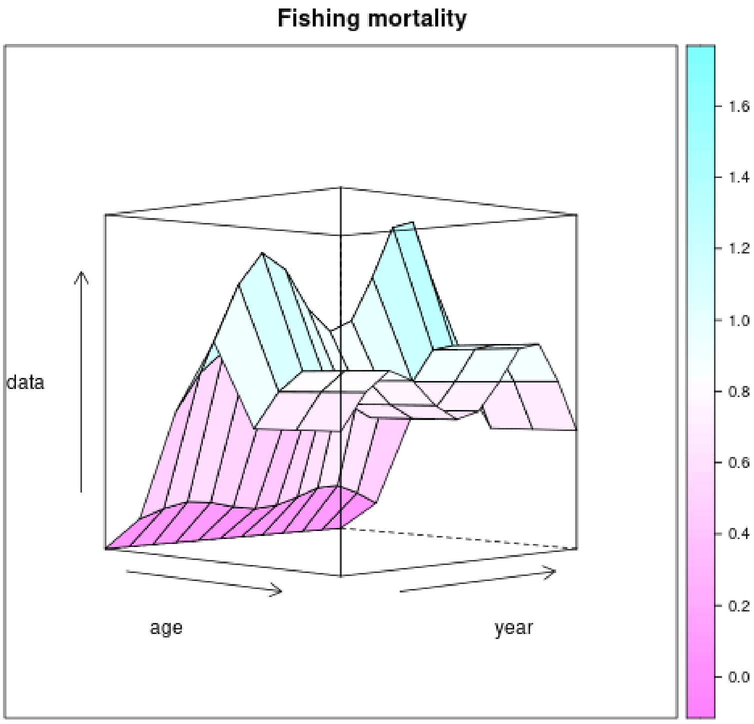


Figure 6.6.3.2.5 Spottail mantis shrimp in GSAs 17. 3D contour plot of estimated fishing mortality by age and year.

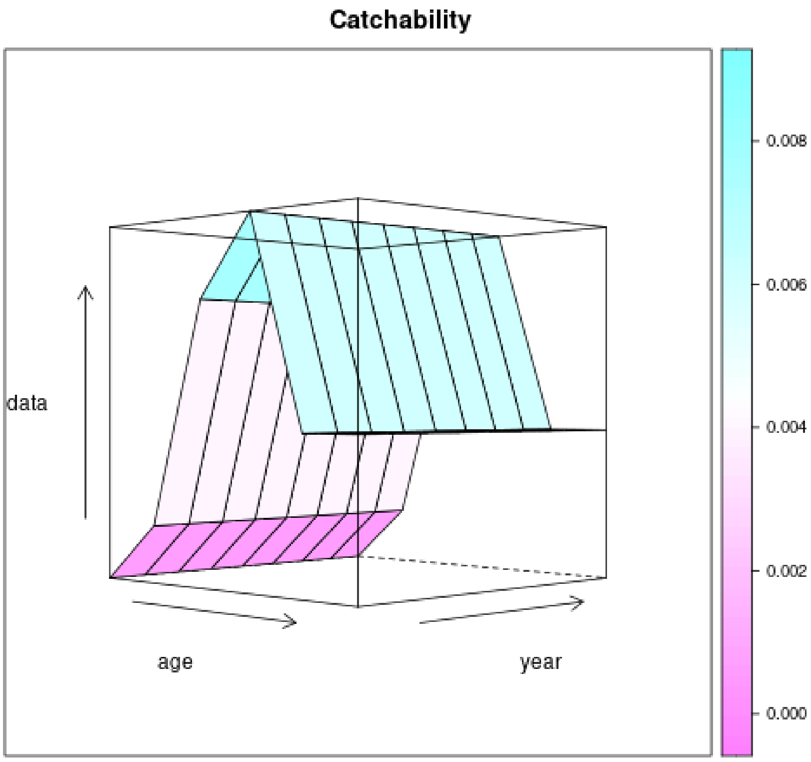


Figure 6.6.3.2.6 Spottail mantis shrimp in GSA 17. 3D contour plot of estimated catchability by age and year.

Diagnostics
Several diagnostic plots presented below for the goodness of fit of the selected model for the assessment of Spottail mantis shrimp stock. Residuals of the total catch where evenly distributed around zero. Residuals at age in the catch and the survey do not show problematic effects, they are well scattered positive and negative values in the catch and the occasional year effect in the survey.

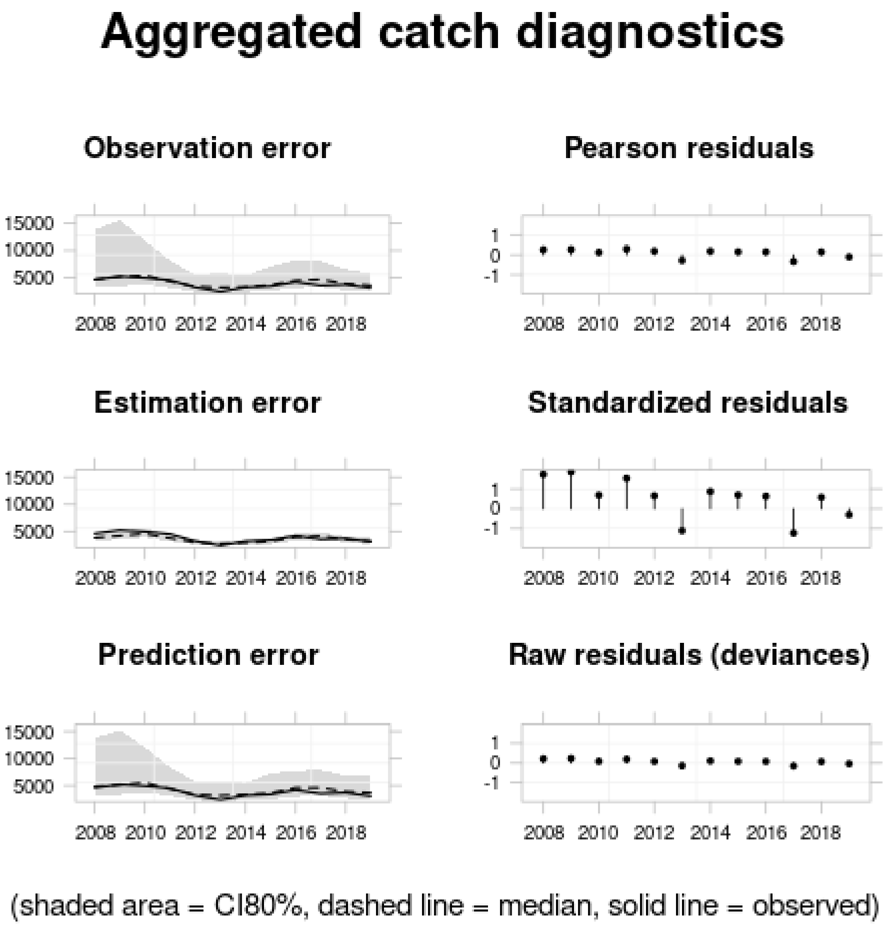


Figure 6.6.3.2.7 Spottail mantis shrimp in GSAs 17. Aggregated catch diagnostics.

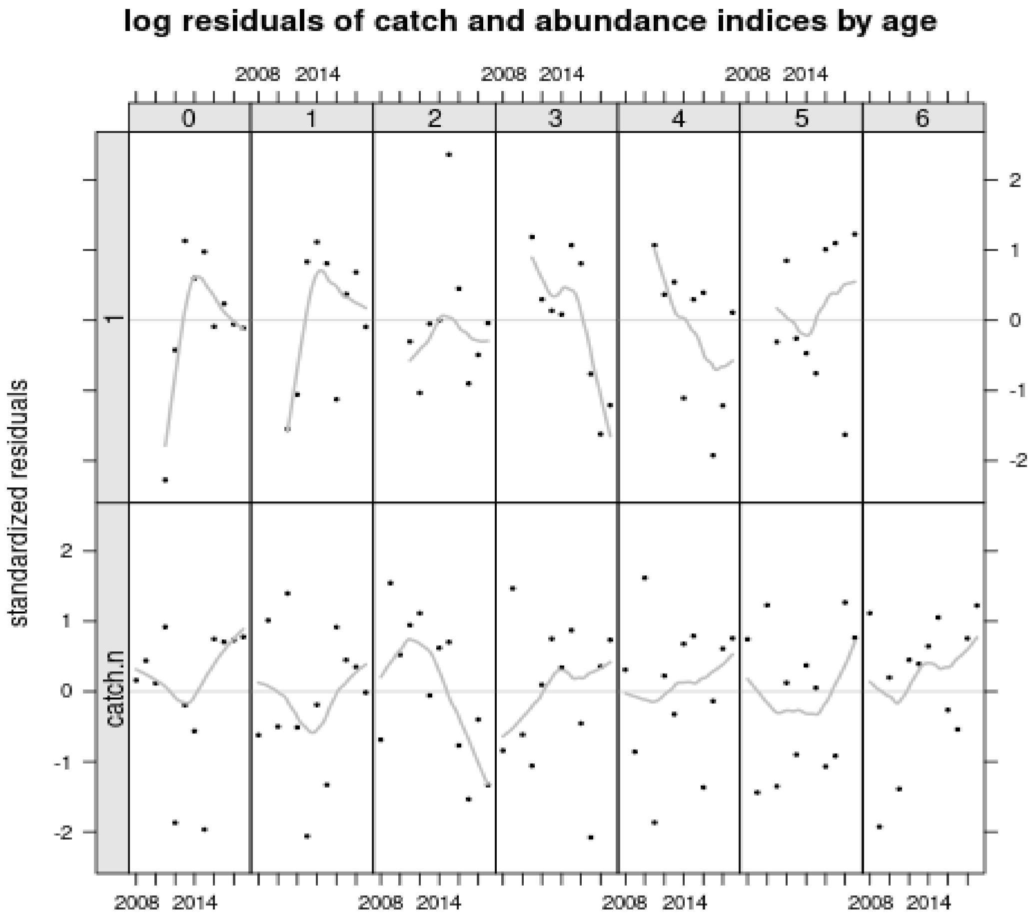


Figure 6.6.3.2.8 Spottail mantis shrimp in GSA 17. Standardized log residuals for the fitted model for catch numbers at age and index abundances.

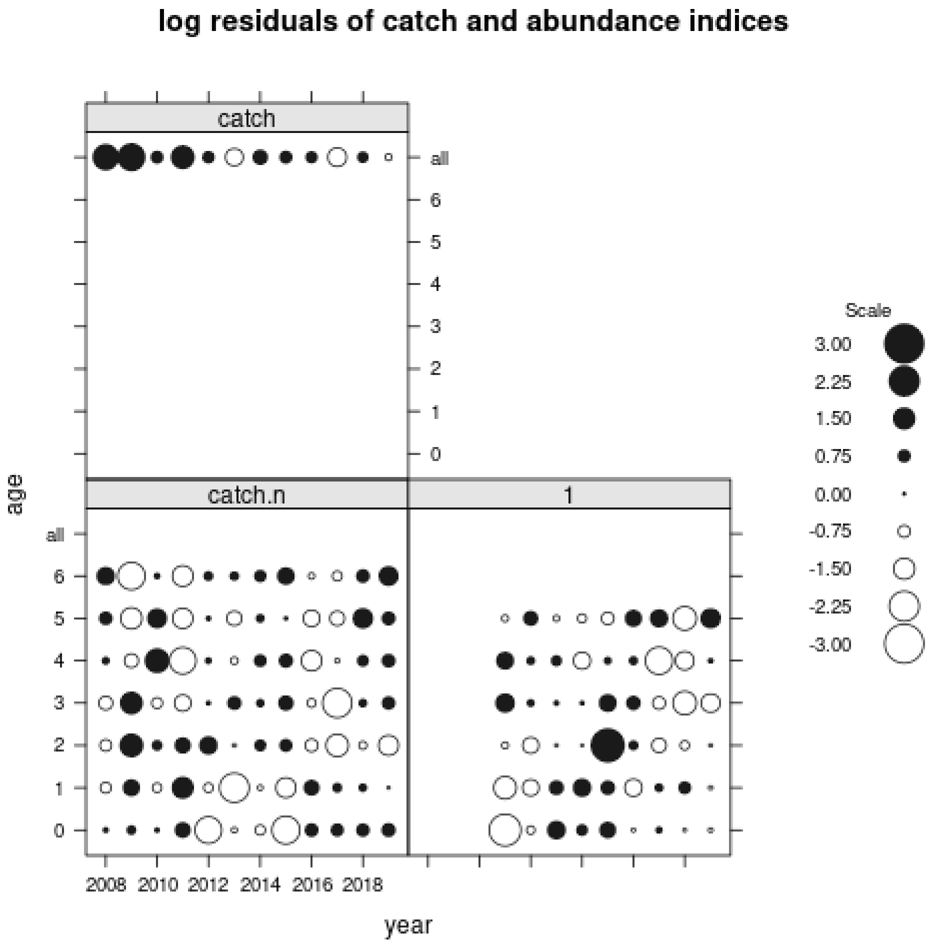


Figure 6.6.3.2.8 Spottail mantis shrimp in GSAs 17. Standardized log residuals for the fitted model for catch numbers at age, index abundances and total catch presented in a bubble plot.

Fitted versus observed catch at age (Figure 6.6.3.2.9) show a fairly good fit for the model to the data. Some problems are apparent in the years 2013 and 2016 mainly in the age 1.

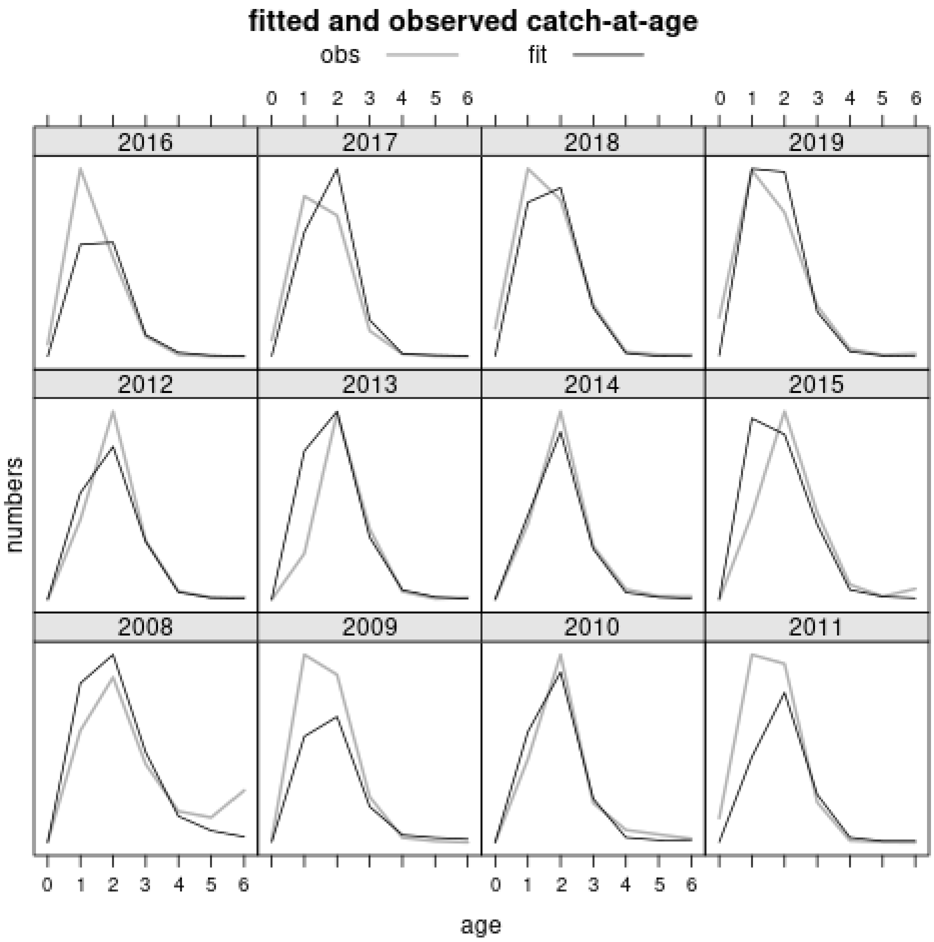


Figure 6.6.3.2.10 Spottail mantis shrimp in GSAs 17. Estimated versus observed catch at age.

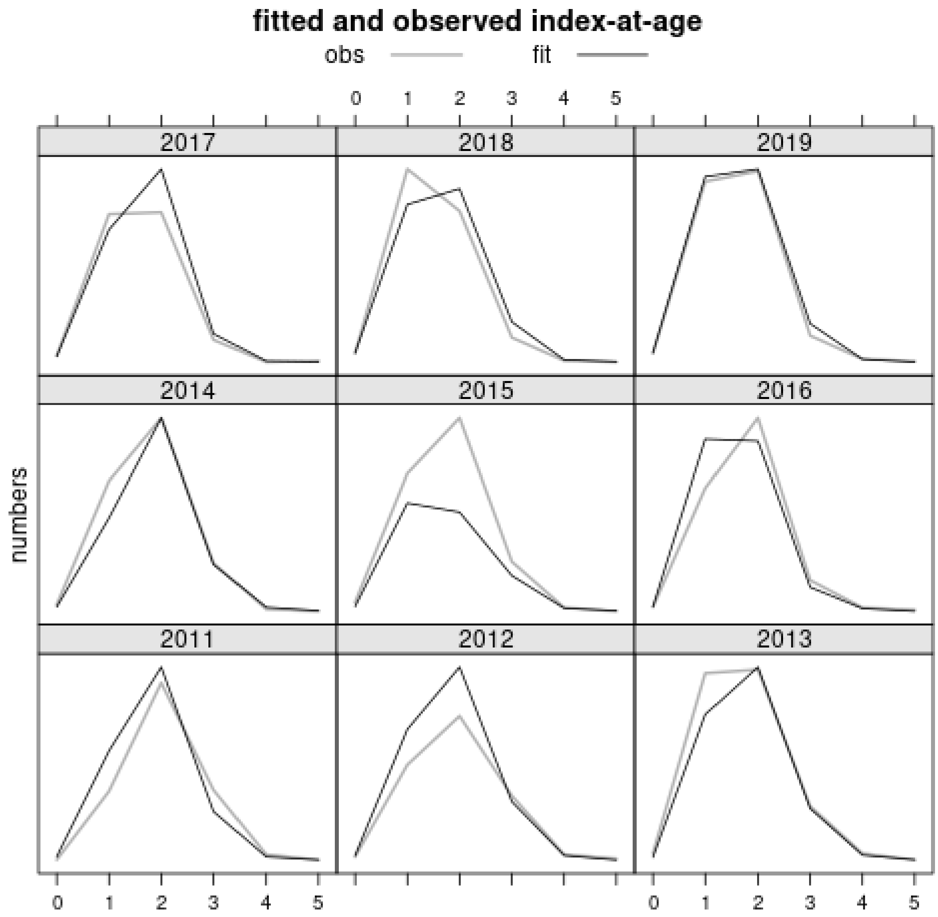


Figure 6.6.3.2.11 Spottail mantis shrimp in GSA 17. Estimated versus observed index at age.

Retrospective

Retrospective plots seemed quite stable for catch with the greater instability for Recruitment and especially for F. Fishing mortality seem to be much lower than the previous year, but being consistently above the proxy of F_{MSY}, $F_{0.1}$ for all years in all retrospective runs.

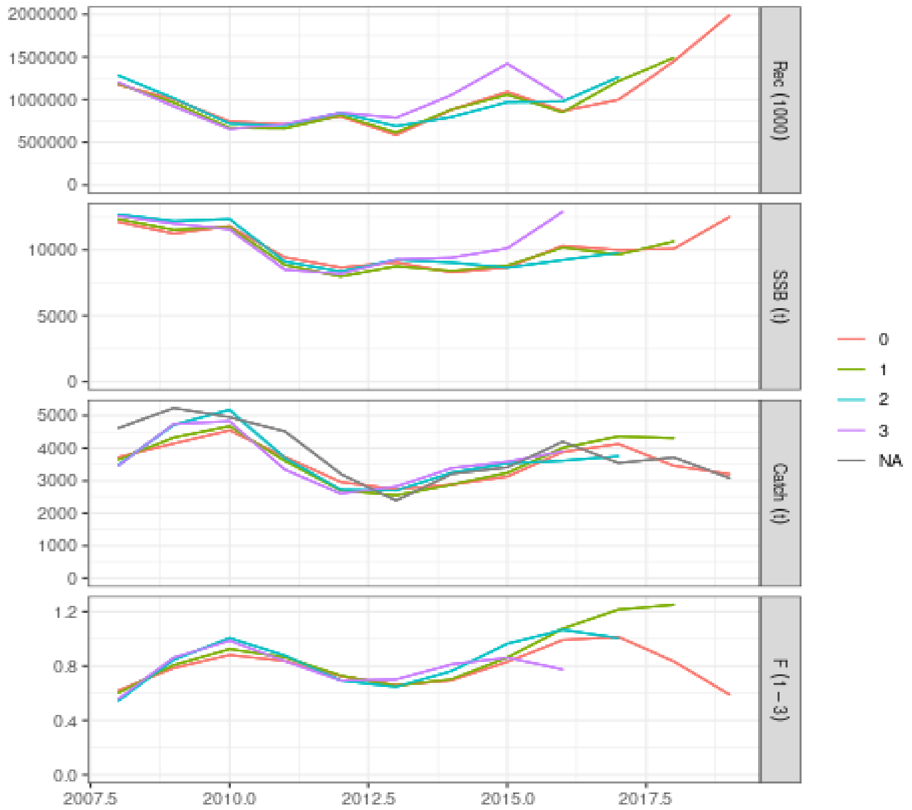


Figure 6.6.3.2.12 Spottail mantis shrimp in GSA 17. Retrospective analysis for the a4a model.

Table 6.6.3.2.7 Spottail mantis shrimp in GSA 17. Stock summary results for a4a model.

year	rec	ssb	catch	fbar
2008	1172213	12119	3721	0.62
2009	1004025	11230	4144	0.79
2010	745550	11800	4549	0.88
2011	711659	9426	3730	0.84
2012	806170	8664	2960	0.73
2013	586473	9053	2741	0.66
2014	882207	8290	2880	0.69
2015	1090459	8658	3126	0.83
2016	867306	10313	3881	0.99
2017	997920	9990	4129	1.01
2018	1447415	10074	3457	0.83

2019	1989216	12503	3201	0.59

Based on a4a results spawning stock biomass of Spottail mantis shrimp is decreasing the last three years. Catch is around 4000 tonnes the last five years with the maximum appearing in 2010 early in the time series. The recruitment is increasing rapidly the last three years reaching the maximum of the time series in 2019 of around 3 million, while Fbar is increasing for the last four years with an fbar in 2019 at 0.69.

Table 6.6.3.2.8 Spottail mantis shrimp in GSA 17. Fishing mortality at age.

age	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.16	0.21	0.23	0.22	0.19	0.17
2	0.69	0.87	0.98	0.93	0.80	0.73
3	1.01	1.28	1.44	1.36	1.18	1.07
4	0.62	0.78	0.88	0.83	0.72	0.65
5	0.62	0.78	0.88	0.83	0.72	0.65
6	0.62	0.78	0.88	0.83	0.72	0.65
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.18	0.22	0.26	0.27	0.22	0.16
2	0.77	0.92	1.10	1.12	0.92	0.65
3	1.13	1.35	1.62	1.65	1.36	0.96
4	0.69	0.83	0.99	1.01	0.83	0.59
5	0.69	0.83	0.99	1.01	0.83	0.59
6	0.69	0.83	0.99	1.01	0.83	0.59

Table 6.6.3.2.9 Spottail mantis shrimp in GSA 17. Catch numbers at age.

age	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
0	167	181	151	137	134	89
1	32221	47908	45550	32283	27033	28046
2	37975	56808	70068	56612	38631	35518
3	18295	16112	18052	18091	14674	11801
4	5419	3401	2153	1878	1880	1847
5	2523	2148	1042	536	458	528
6	1271	1504	1119	538	262	202
age	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
0	140	208	197	232	277	269
1	21401	37937	54998	44642	43066	45445
2	42463	34564	56053	67320	47101	44669
3	12868	15761	10657	13072	13720	10848
4	1816	2057	2049	990	1020	1234
5	617	639	626	480	197	215
6	244	303	287	214	138	71

The EWG 20-15 concluded that the a4a model was suitable to provide the basis of the current status of the stock.

6.6.4.2 Reference Points in GSA 17

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as F_{max} and $F_{0.1}$. Yield per Recruit computation was made using R project software and the FLR libraries. 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 input parameters were the same used for the a4a stock assessment and its results. In a4a the $F_{0.1}$ was estimated using FLBRP package and the value estimated was 0.43. EWG 20-15 decided that the a4a model was the most suitable to estimate the status of the stock of Spottail mantis shrimp. Fbar calculated as the last year's value, Fbar = 0.59, thus F/ $F_{0.1}$ = 1.37 and the stock is considered overexploited.

6.6.5.2 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2019 to 2021 was performed using the FLR routines provided by JRC and based on the results of the a4a stock assessments performed during EWG 20-15. The input parameters were the same used for the a4a stock assessment and its results. F status quo is equal the last year's value, corresponding to a catch in 2019 of 3201 t. Recruitment 2019 and 2020 is 1025051 thousands (equal to the geometric mean recruitment of all the years in the assessment).

Table 6.6.5.2.1 Spottail mantis shrimp in GSA 17: Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
Biological parameters		maturity, natural mortality, mean weights and fishery selection taken as mean of last three years 2017-2019
$F_{ages\ 1\text{-}3}$ (2020)	0.59	F2019 used to give F status quo for 2020
SSB (2020)	18625	Stock assessment 1 January 2020
R_{age0} (020,2021)	971609	Geometric mean of the time series
Total catch (2020)	4848	Assuming F status quo for 2020

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

Table 6.6.5.2.2 Spottail mantis shrimp in GSA 17. Short term forecasts showing catch options for different fishing mortalities reductions.

Rationale	F factor	Fbar	Fsq 2020	Catch 2020	Catch 2021	SSB 2020	SSB 2022	SSB_change 2020-2022(%)	Catch_change 2019-2021(%)
High long term yield (F0.1)	0.73	0.43	0.59	4848	4515	18625	15761	-15	41
F upper	0.99	0.59	0.59	4848	5740	18625	14468	-22	79
F lower	0.48	0.29	0.59	4848	3227	18625	17141	-8	1
FMSY transition	0.92	0.54	0.59	4848	5431	18625	14792	-21	70
Zero catch	0.00	0.00	0.59	4848	0	18625	20675	11	-100
Status quo	1.00	0.59	0.59	4848	5770	18625	14437	-22	80
Different Scenarios	0.10	0.06	0.59	4848	748	18625	19847	7	-77
	0.20	0.12	0.59	4848	1450	18625	19075	2	-55
	0.30	0.18	0.59	4848	2111	18625	18352	-1	-34
	0.40	0.24	0.59	4848	2732	18625	17677	-5	-15
	0.50	0.30	0.59	4848	3316	18625	17045	-8	4
	0.60	0.35	0.59	4848	3866	18625	16453	-12	21
	0.70	0.41	0.59	4848	4385	18625	15899	-15	37
	0.80	0.47	0.59	4848	4873	18625	15380	-17	52
	0.90	0.53	0.59	4848	5334	18625	14894	-20	67
	1.10	0.65	0.59	4848	6181	18625	14009	-25	93
	1.20	0.71	0.59	4848	6570	18625	13606	-27	105
	1.30	0.77	0.59	4848	6938	18625	13228	-29	117
	1.40	0.83	0.59	4848	7286	18625	12873	-31	128
	1.50	0.89	0.59	4848	7616	18625	12538	-33	138
	1.60	0.94	0.59	4848	7929	18625	12223	-34	148
	1.70	1.00	0.59	4848	8226	18625	11927	-36	157
	1.80	1.06	0.59	4848	8508	18625	11647	-37	166
	1.90	1.12	0.59	4848	8776	18625	11383	-39	174

	2.00	1.18	0.59	4848	9030	18625	11134	-40	182

6.6.6 Discussion and Different Case Studies for spottail mantis shrimp IN GSA 17,18

Following the recommendations of the STECF EWG 20-15 as well as the comments of the GFCM - WGSAD, different growth parameters were tested for the length slicing of the two different areas. For GSA 17 the Froglia et al. (1996) VB growth parameters were considered as the most suitable ones while for the GSA 18 both Froglia et al (1996) and the parameters provided from DCF were tested. The DCF VB growth parameters showed a slightly better cohorts consistency for GSA 18. Moreover, experts from GSA 17 and 18 suggested that the species follow different growth curve between the two areas, and have different length distribution across areas (Figure 6.6.6.1). GSA 18 has smaller individual overall, L50 for GSA17 is around 27.75 while for GSA 17 around 24.5. To ensure that the differences are accounted for the EWG 20 – 15 decided to slice separately the length distributions and weight, and raise according the catch numbers The other life history parameters were also calculated separately by GSA. Specifically the growth parameters presented in table 6.6.1.1 were used to slice GSA 17 as well as the SOLEMON survey while the growth parameters presented in table 6.6.1.2 were used to slice GSA 18.

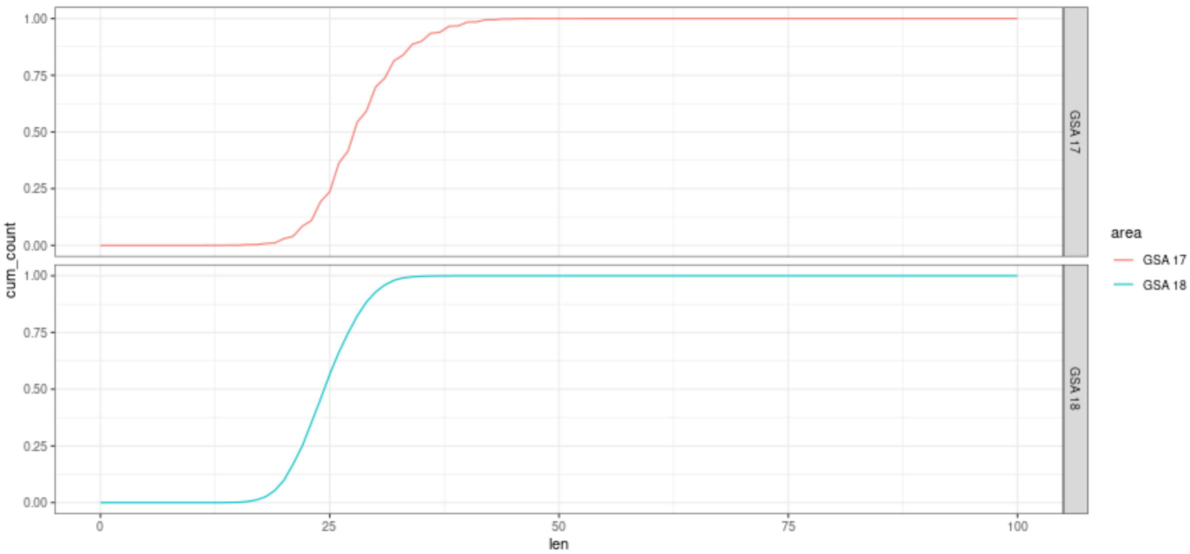


Figure 6.6.6.1 Spottail mantis shrimp in GSA 17 and 18. Cumulative length frequency distributions for the different areas for years 2008 -2019 combined. L50 for GSA17 is 27.75 while for GSA 17 is 24.5

The assessment results were quite similar in both cases. In Figure 6.6.6.2 the results for the different assessments are presented. SSB and recruitment revealed the same trend, especially in the last few years. The same stands for Fbar which follows the same pattern almost through all the time series. In both cases the stock status remained the same with F being above the proxy of F_{MSY} , $F_{0.1}$ though the combined area shows a slightly higher (but not significant) estimate of $F/F_{0.1}$. Table 6.6.6.1 and Figure 6.6.6.2. Values of SSB, recruitment and catch are of course lower for GSA 17 alone.

Table 6.6.6.1 Spottail mantis shrimp in GSA 17 and 18. F and F/F0.1 for the two different assessments

Area	F	$F/F_{0.1}$
GSA 17	0.59	1.37
GSA 17 & 18	0.69	1.53

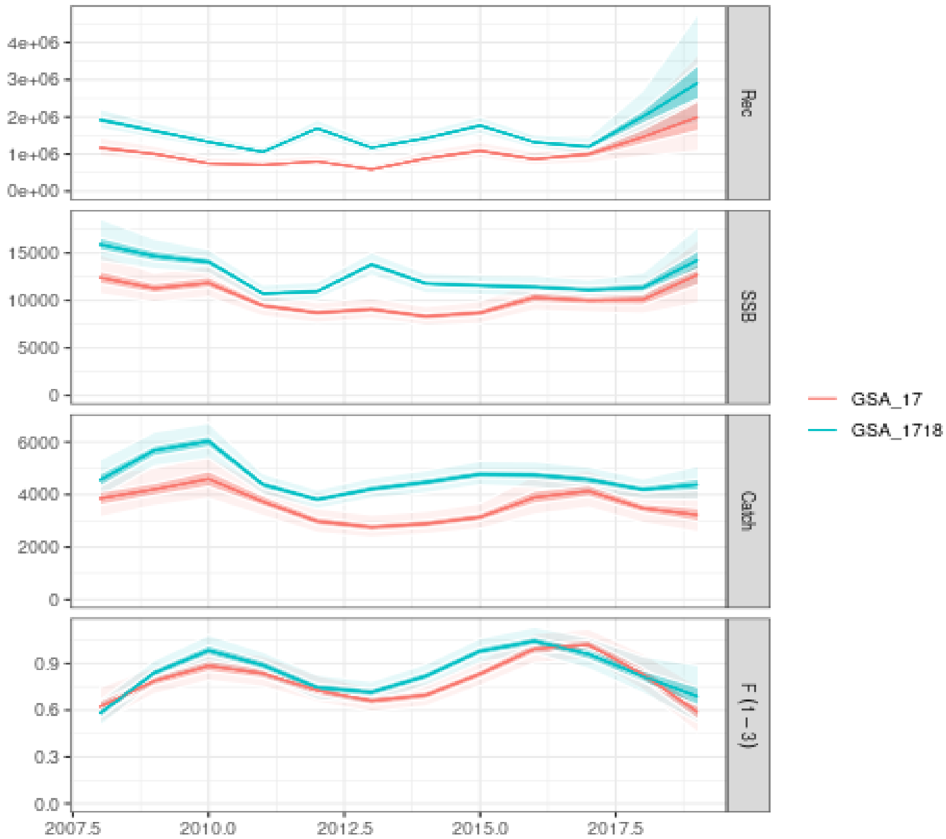


Figure 6.6.6.2 Spottail mantis shrimp in GSA 17 and 18. Assessment results for GSA 17 and GSA 17 & 18 combined.

6.6.7 Data Deficiencies

Landings in GSA17 were provide duplicated in 2019.

6.7 DEEPWATER ROSE SHRIMP IN GSA 17, 18 AND 19

6.7.1 Stock Identity and Biology

STECF EWG 20-15 was asked to assess the state of Deep-water rose shrimp stocks in the Adriatic and Ionian Sea by GSAs combined.

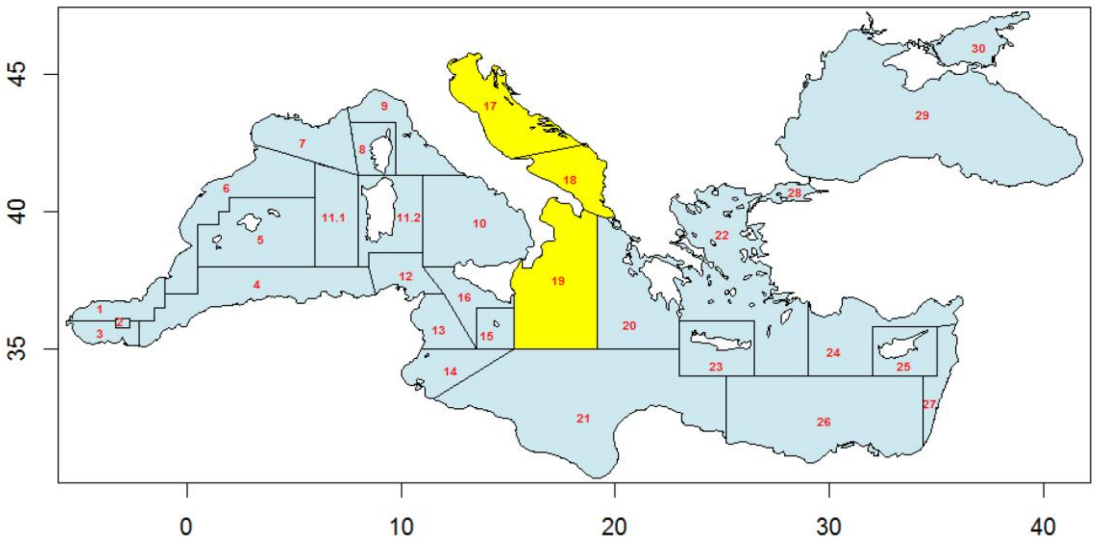


Figure 6.7.1.1. Geographical location of GSAs 17,18 and 19.

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 20-15 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.

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

All data from used in the EWG 19-16 were updated with the last year from 2019 DCF data call.

6.7.2.1 Catch (landings and discards)

Catch data were reported to STECF EWG 20-15 through the DCF. 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. For 2002 and 2003 gear not samples (gear=-1) were considered belonging to OTB.

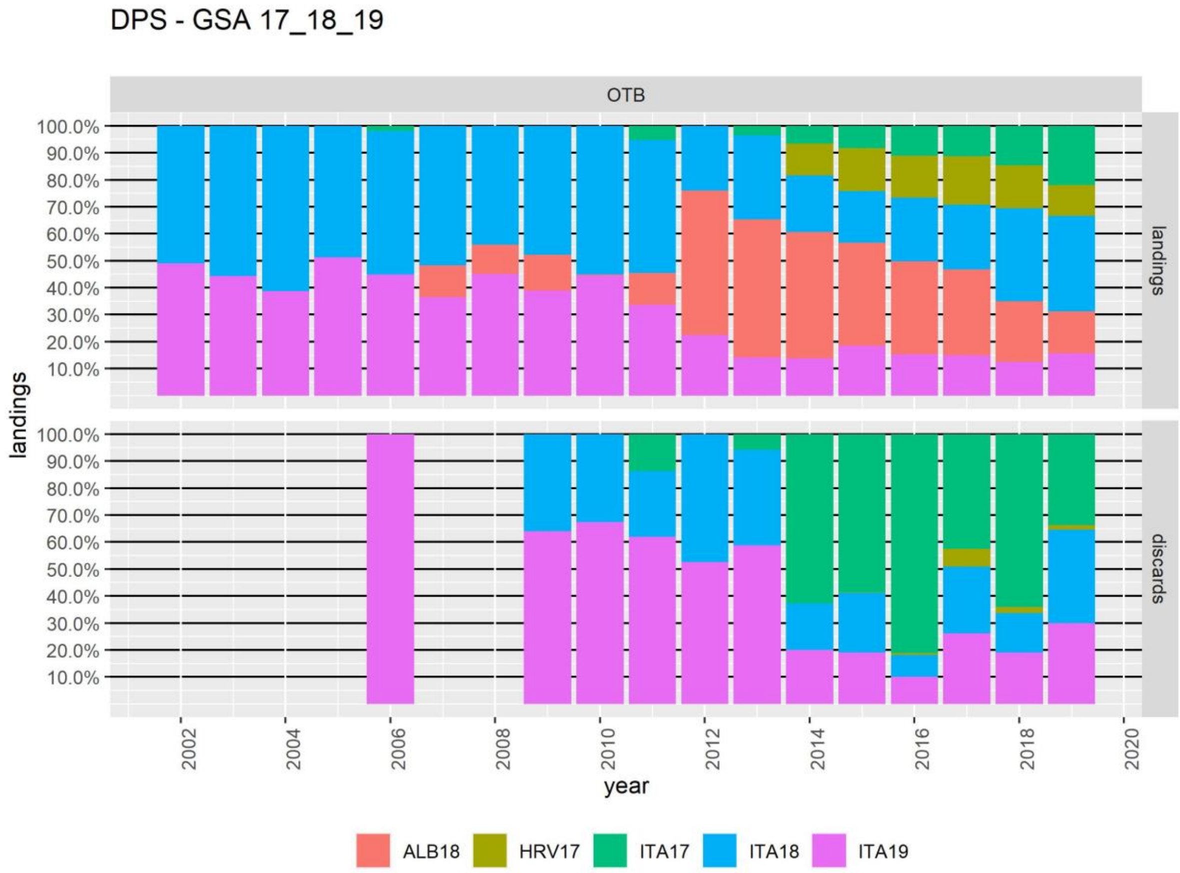


Figure 6.7.2.1.1. Deep-water rose shrimp stocks in GSAs 17-19: OTB landings and discards percentage composition by main fleet from DCF 2020.

In the rest of the report, we will refer to and present only data for otter trawl and we will not consider the data from Malta fleet that occurs only in 2015 and 2019 and seems to be not consistent with the time series. SoP corrections are applied to catch numbers at age and these corrections account for catches of other fleets in the years they occur. Thus they are assigned the age stucture of the 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 2020.

A

Lan

gsa	country	gear2	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
18	ALB	OTB	NA	NA	NA	NA	NA	198	187	262	215.6	209	1170	1210	1430	1290	1460	1473	1275	962
17	HRV	GNS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	59	0.1
17	HRV	GTR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.4	0
17	HRV	LLS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5	NA
17	HRV	OTB	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	535.6	653.7	833.5	912.5	714
17	HRV	OTH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	27	0.1
18	ITA	GNS	NA	66.7	7.2	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
18	ITA	LLS	NA	NA	1.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	ITA	OTB	1147.2	1749.3	1847.7	1181.5	1473.2	863.1	766.2	939.4	888.1	869.6	522.8	733.7	637.7	651.3	996.4	1109.4	1962	2187
19	ITA	GNS	NA	NA	7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	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
19	ITA	LLS	NA	NA	8.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	ITA	OTB	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
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

B: discards

gsa	country	gear2	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
17	HRV	GNS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0
17	HRV	GTR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0
17	HRV	LLS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA
17	HRV	OTB	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1	1.9	11.2	8.3	4.5
17	HRV	OTH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	0
18	ITA	GNS	NA	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	ITA	GTR	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	ITA	LLS	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	ITA	OTB	0	0	0	0	0	0	0	30.8	17.5	5.3	7.2	12.3	7.7	13.9	20.8	42.3	52	94.1
19	ITA	GNS	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA
19	ITA	GTR	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	0	NA	NA	NA	NA	NA
19	ITA	LLS	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	ITA	OTB	0	0	0	0	19	0	0	54.6	36.1	13.5	8	20.4	8.9	12	25.5	44.7	67.7	81.7
19	ITA	OTH	0	NA	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

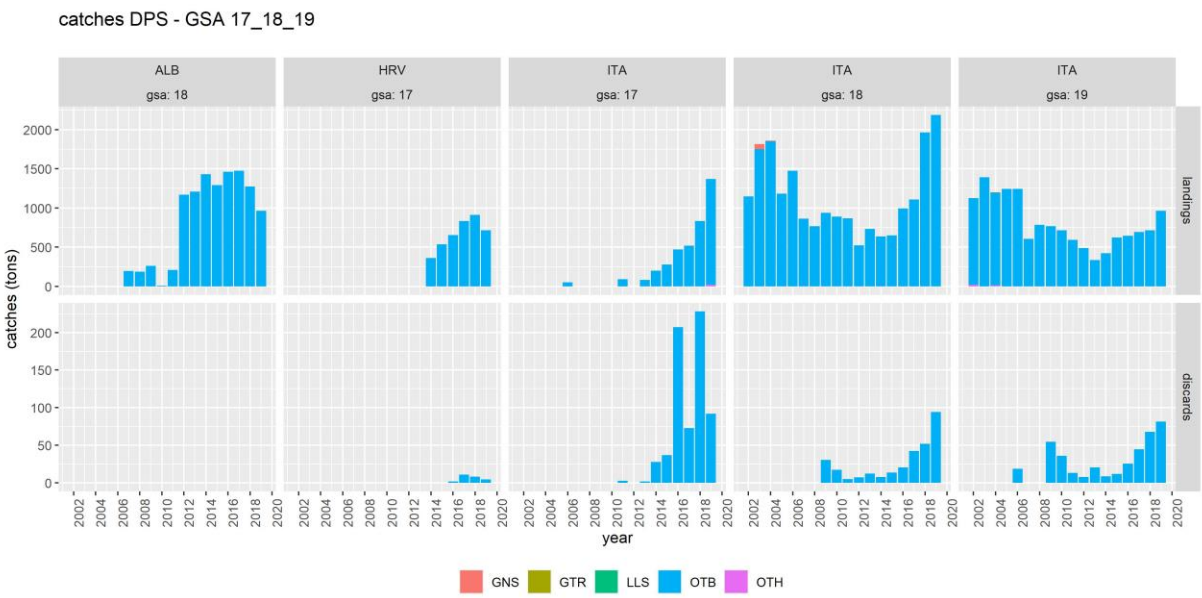


Figure 6.7.2.1.2. Deep-water rose shrimp stocks in GSAs 17-19: OTB Landings and discards data by main fleet from DCF 2020.

Landings data for GSA 17 were incomplete. Italian landings were present just for 2006, 2011, and from 2013 to 2019. Croatian landings were present just from 2014 to 2019 in the DCF database because previously there was no obligation to monitor that species. Landings data for GSA 18 were missing for Montenegro, while data from Albania (from 2007 to 2018) comes from latest FAO Fishery and Aquaculture Statistics. Landings data for GSA 19 were complete.

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 from DCF 2020.

variable	gsa	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
landings	17	NA	NA	NA	NA	54	NA	NA	NA	NA	92	NA	84	564.7	814.6	1125.8	1353.5	1747.5	2065
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
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
discards	17	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	NA	2	28	37.1	208.9	84.2	236.3	96.5
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
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

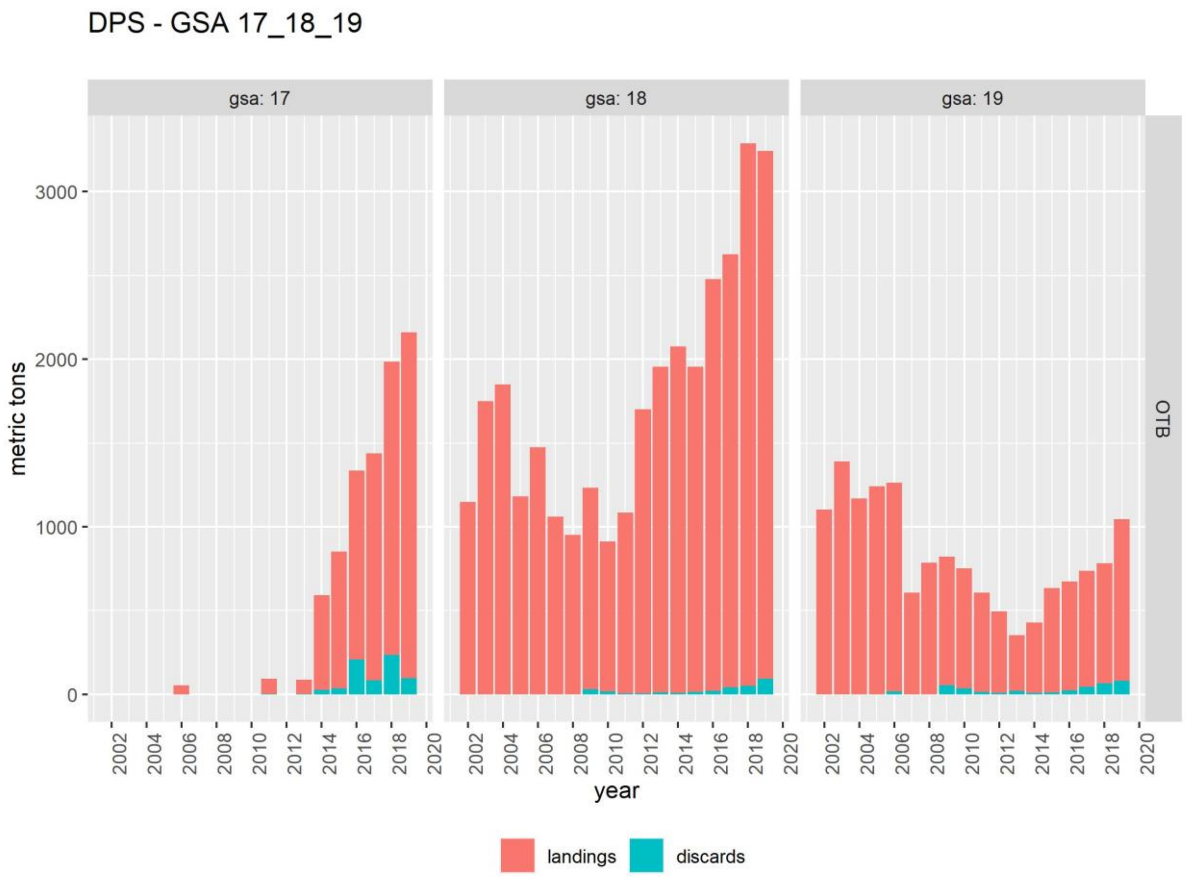


Figure 6.7.2.1.3. Deep-water rose shrimp stocks in GSAs 17-19: OTB Landings and discards data by gsa from DCF 2020.

For the puproses of the assessment EWG 20-15 uses the reconstruction of missing data done during the EWG 19-16 (Table 6.7.2.1.3, Figure 6.7.2.1.4), which takes in to account all the available information to fill gaps on catches by fleet (i.e. by GSA, country and gear). However some changes were made. For Albania catches in 2007-2009 were updated with data from FAO fishieries statistic, and thus the mean values calculated in 2010 and 2002-2006 were updated. Moreover for 2002 and 2003 in GSA 18 and 19, and for 2006 in GSA 18 the catch matrix was updated and landings of gear not sampled (gear=-1) were included.

Table 6.7.2.1.3. Deep-water rose shrimp stocks in GSAs 17-19: Landings data in tonnes by OTB as recontstruct by EWG18-16. The landings data present in the DCF database are in white. Landing reconstructed based on the mean proportions between landings and discards in closest years of each fleet are highlighted in blue. Landings taken from previous report are in bold, and those updated in bold and italic.

area	country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
17	HRV	140.7	140.7	140.7	140.7	140.7	140.7	**71.2**	**138.5**	**174.0**	**151.1**	168.8	314.8	362.7	535.6	654.8	833.5	912.6	714
17	ITA	53.8	53.8	53.8	53.8	54.1	**70.1**	53.9	43.8	64.7	92.5	52.8	84.3	202.3	278.6	471.0	520.0	835.0	1351
18	ALB	215.6	215.6	215.6	215.6	215.6	198	187	262	215.6	209.0	1170.0	1210.0	1430.0	1290.0	1460.0	1473.0	1275.0	962
18	MNE	34.6	34.6	34.6	34.6	34.6	**39.0**	**39.0**	**36.0**	**32.0**	**27.0**	**22.0**	**31.0**	**28.0**	**31.0**	**32.0**	28.8	47.4	33.4
18	ITA	***1147***	***1749***	1847.7	1181.5	***1473.2***	863.1	766.2	939.4	888.1	869.6	522.8	733.7	637.7	651.3	996.4	1109.4	1947.2	2187
19	ITA	***1103***	***1391***	1170.1	1243.1	1244.6	607.5	785.0	767.3	715.6	592.8	487.6	334.5	421.5	622.4	647.4	692.8	716.3	963.9

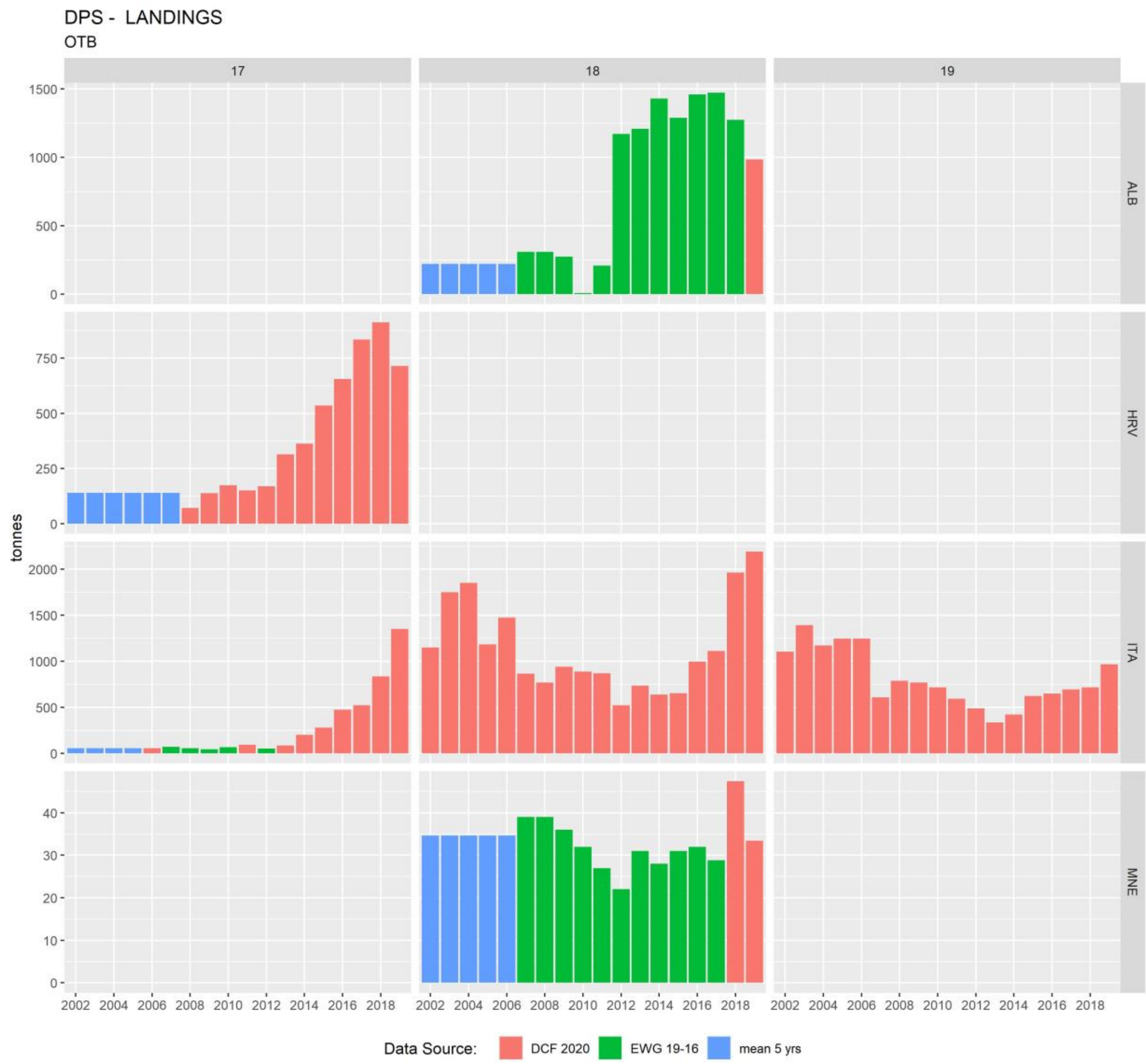


Figure 6.7.2.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Total landings in tonnes by fleet and data source (blank GSA-country panels indicate no catch in that GSA by that country).

To fill gap in discards by country and area in missing years EWG 20-15, as was done in the EWG 19-16, first used the DCF db at fleet segment level by year. Missing data were reconstruct by applying to landings the mean proportions between discard and landings found in other fleet segment of the same year. When no discard information were available data were derived by the mean value of discards for the same GSA and country in the neighboroud five years (Table 6.7.2.1.4, Figure 6.7.2.1.5).

Table 6.7.2.1.4. Deep-water rose shrimp stocks in GSAs 17-19: Discards data in tonnes by OTB as recontstruct by EWG20-15. The discards data present in the DCF database are in white. Discards reconstructed based on the mean proportions between landings and discards for each fleet of the same year are in bold and red. Discards reconstructed based on the mean proportions between landings and discards of the available time series are highlighted in blue. Discards taken from previous report are in bold character.

Area	country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
17	HRV	0.8	0.8	0.8	0.8	0.8	0.8	0.4	0.8	1.0	0.8	0.9	1.7	2.0	0.1	1.9	11.2	8.3	4.5
17	ITA	4.3	4.3	4.3	4.3	8.2	6.2	4.0	3.5	5.2	3.2	4.4	1.6	28.1	36.9	206.9	73.0	228.0	92
18	ITA	16.6	23.1	34.0	21.8	23.8	15.9	16.0	31.0	17.7	5.3	7.2	12.3	7.7	13.9	20.8	42.3	52.0	94.1
19	ITA	26.8	23.5	42.5	45.2	19.0	22.1	28.5	54.6	36.1	13.5	8.0	20.4	8.9	12.0	25.5	44.7	67.7	81.7

Figure 6.7.2.1.5. Deep-water rose shrimp stocks in GSAs 17-19: Total discards in tonnes by fleet and data source.

Landings and discards data as reconstructed by fleet (figure 6.7.2.1.6) where then summarised by year to be used as input data for the assessment (Table 6.7.2.1.5, Figure 6.7.2.1.7).

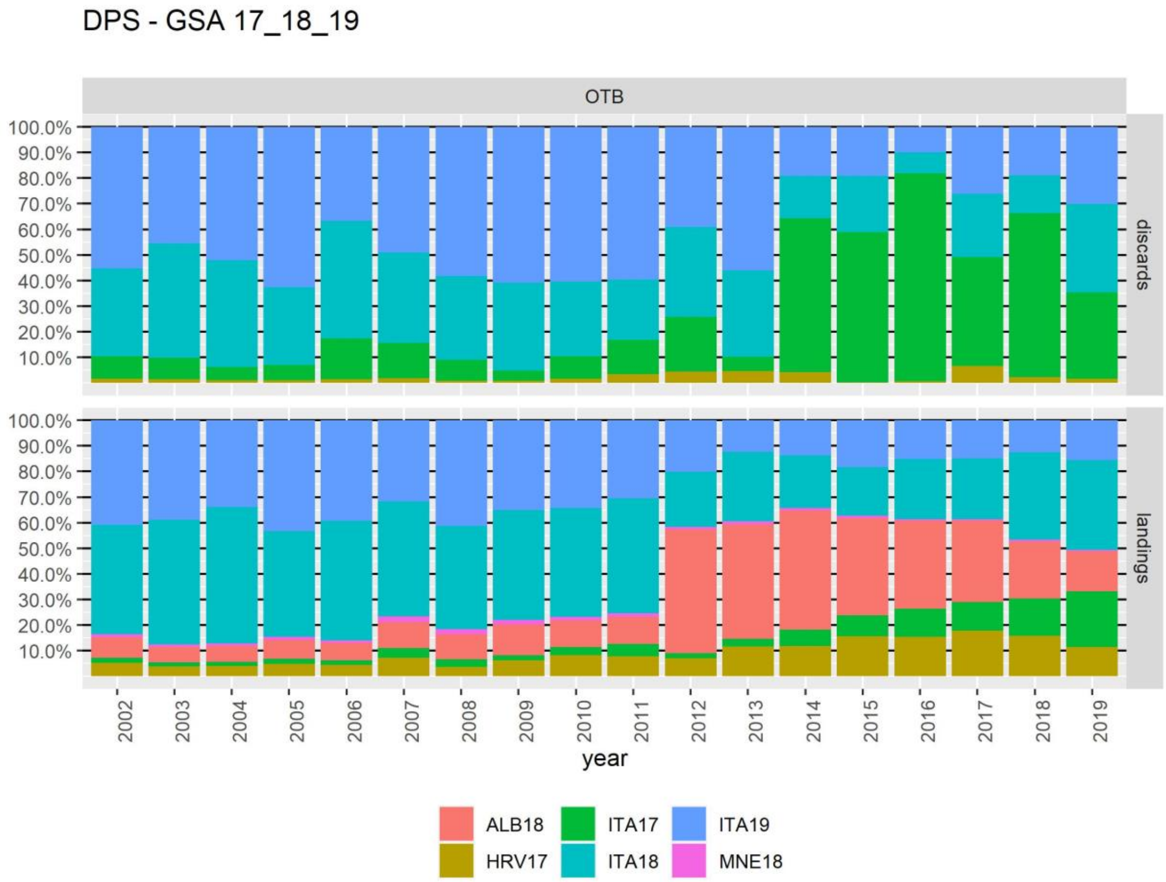


Figure 6.7.2.1.6. Deep-water rose shrimp stocks in GSAs 17-19: OTB landings and discards percentage composition by main fleet after the data adjustment from EWG20-15.

Table 6.7.2.1.5. Deep-water rose shrimp stocks in GSAs 17-19: Total landing, discards and catch by year as reconstructed by EWG 20-15.

OTB	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
landings	2695.2	3585.0	3462.6	2869.3	3162.7	1918.4	1902.3	2187.0	2090.0	1942.0	2424.0	2708.0	3081.9	3409.3	4261.6	4657.5	5748.2	6211.3
discards	48.5	51.7	81.6	72.1	51.8	45.0	48.9	89.7	59.8	22.6	20.5	36.4	46.6	63.0	255.2	171.2	356.0	272.3
catch	2743.7	3636.7	3544.2	2941.4	3214.5	1963.4	1951.2	2276.7	2149.8	1964.6	2444.5	2744.4	3128.5	3472.3	4516.8	4828.7	6104.2	6483.6

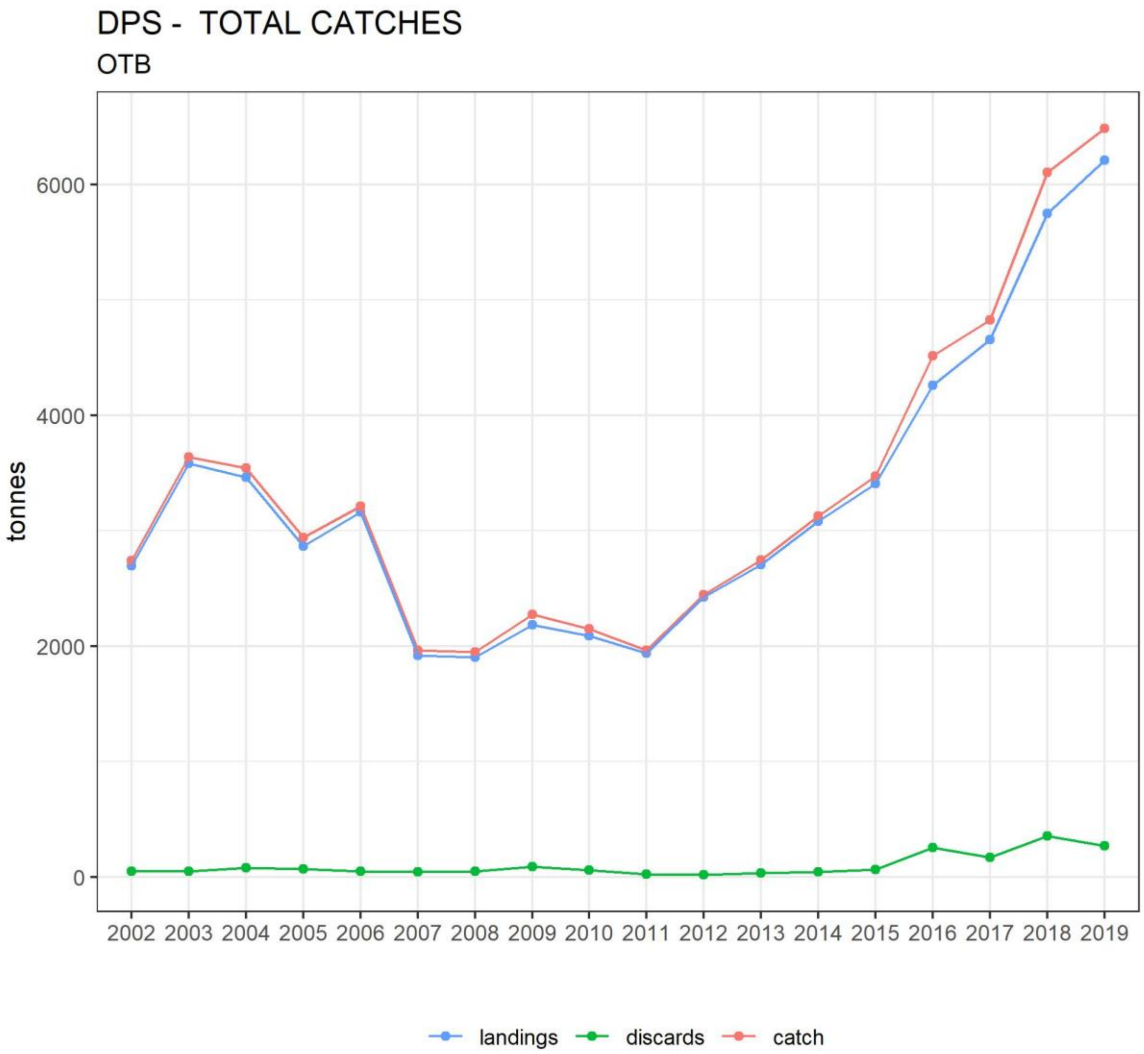


Figure 6.7.2.1.7. Deep-water rose shrimp stocks in GSAs 17-19: Total landing, discards and catch by year as reconstructed by EWG 20-15.

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.

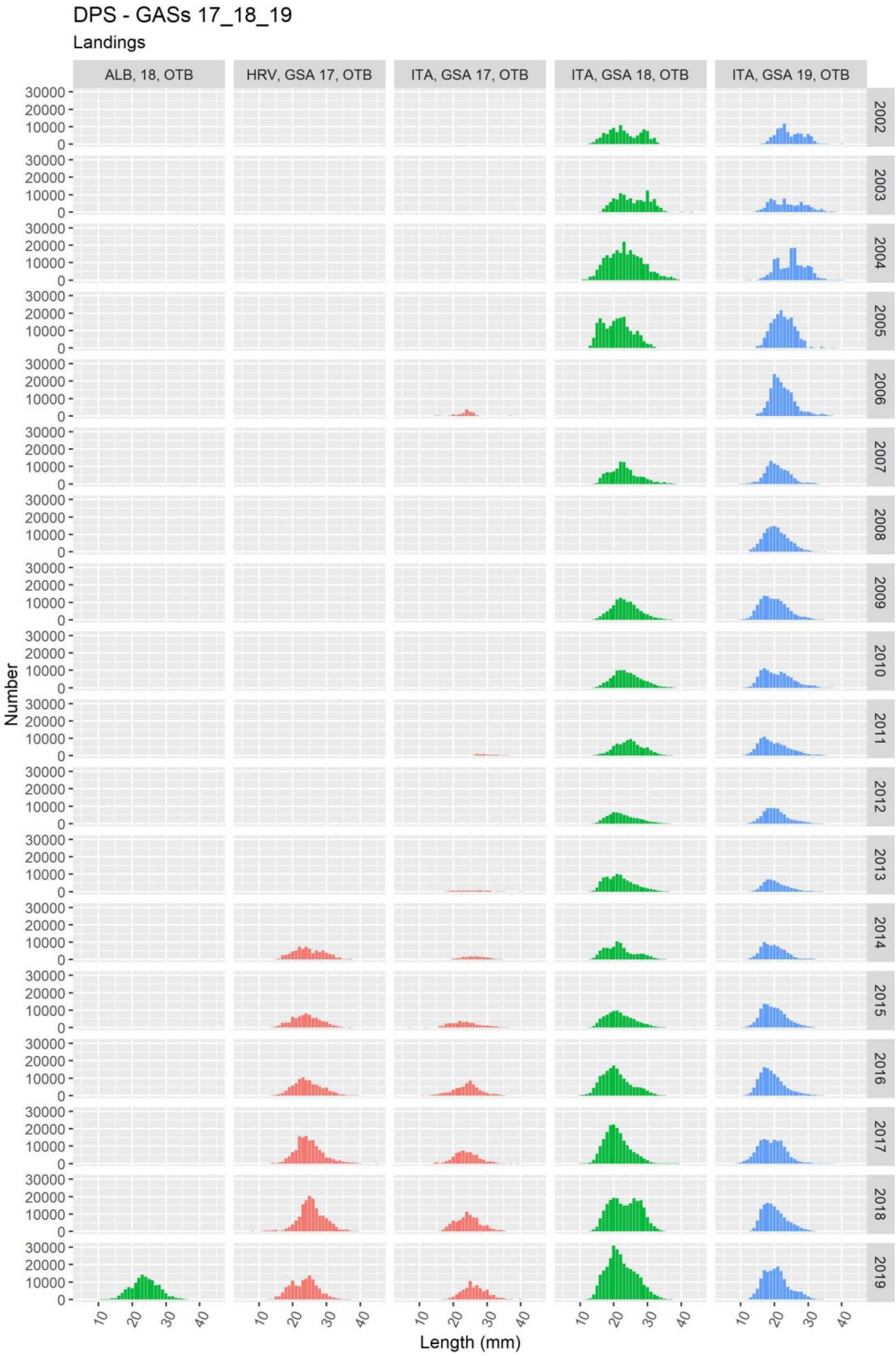


Figure 6.7.2.1.8. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution of the landings by year and fleet.

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)

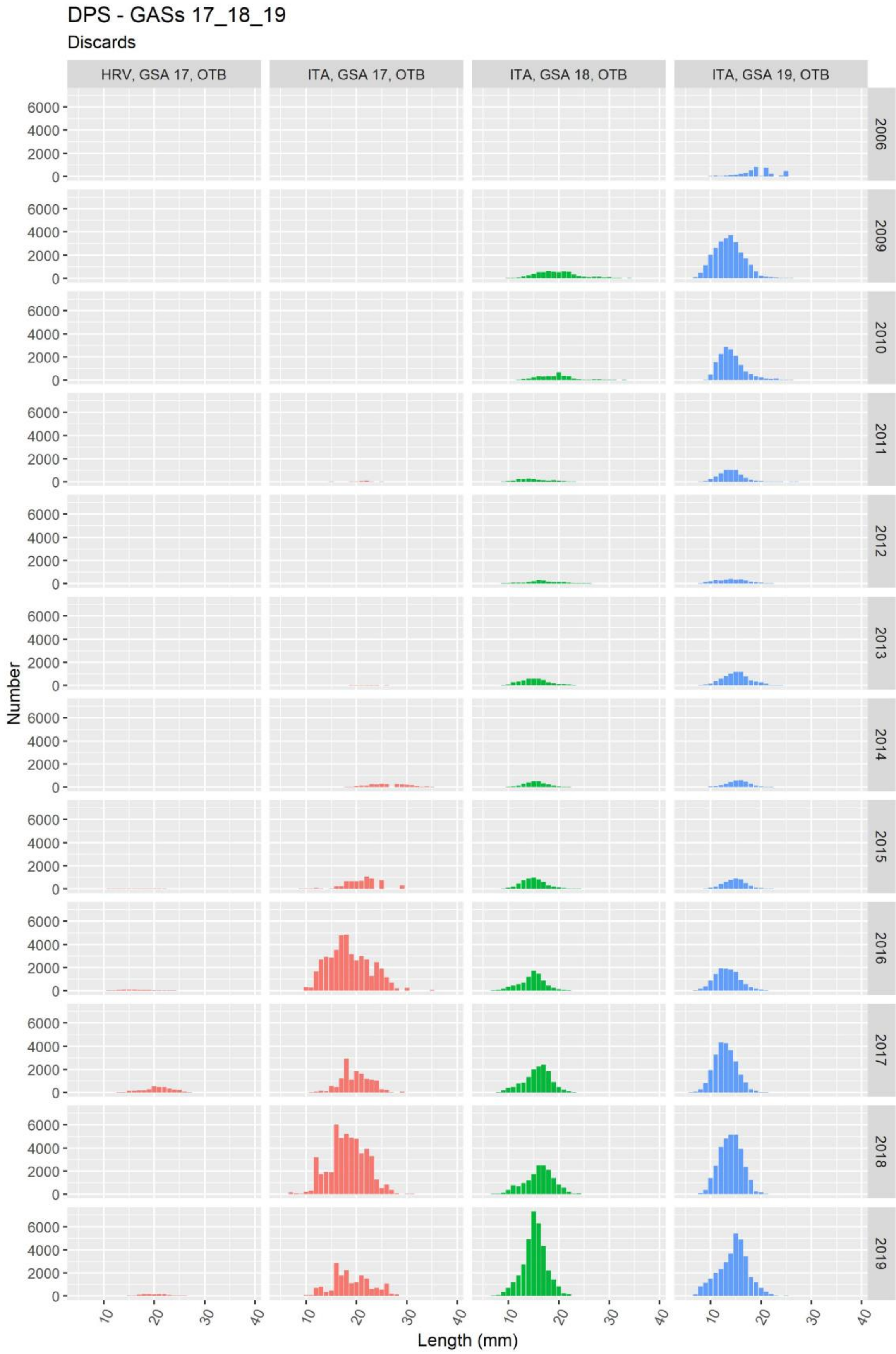
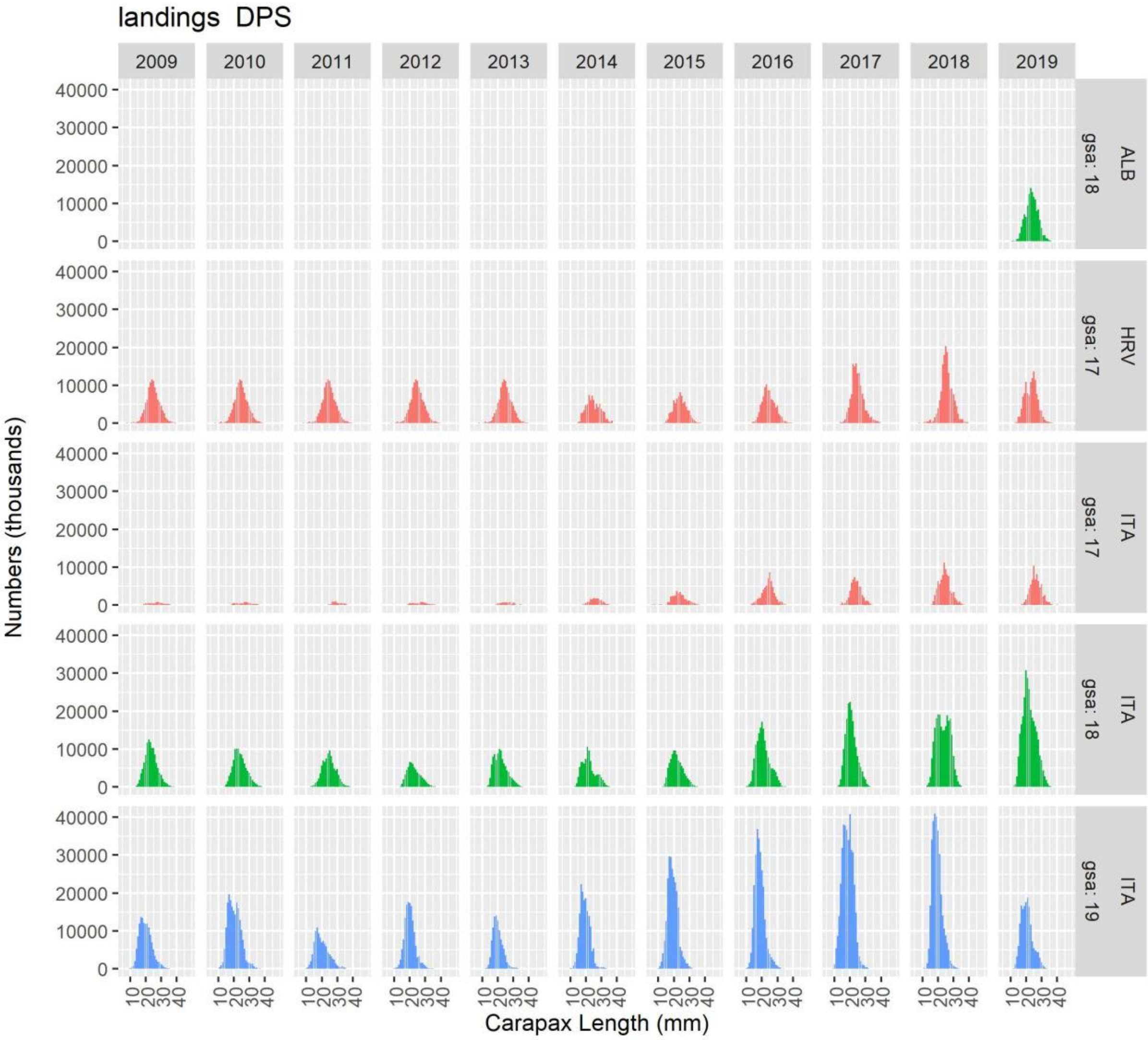


Figure 6.7.2.1.9. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution of the discards by year and fleet.

Catches at length information derived from EWG 19-16, which reconstructed some some missing data, were updated with the latest data of 2019 (Figure 6.7.2.1.10 A,B).



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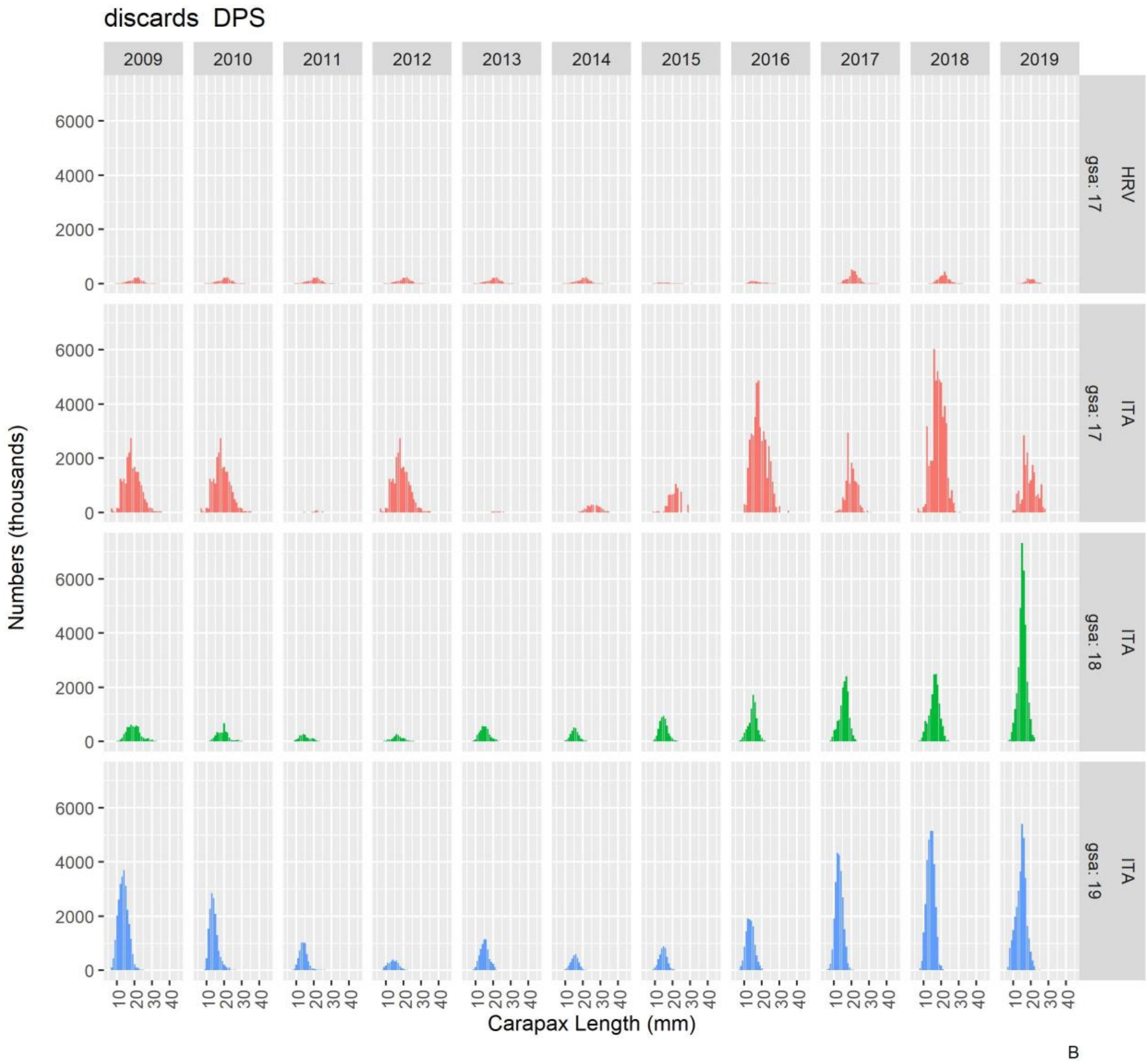


Figure 6.7.2.1.10. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution of landing (A) and discards (B) by year and fleet reconstructed for missing years.

6.7.2.2 Effort

Fishing effort data were reported to STECF EWG 20-15 through DCF. Some effort reported in some year by France and Malta is removed to better see the effort ripartion among countries in the area studied. In all the GSAs caonsidered, the fishing effort related to fleets that report catches of some DPS is almost exclusively from bottom trawl gears. Table 6.7.2.2.1 show effort values of OTB by country and gsa. In Figure 6.7.2.2.1 the information of other gears are also reported.

Table 6.7.2.2.1. Deep-water rose shrimp stocks in GSAs 17-19: Fishing effort in nominal effort, GT*Days at sea and Days at sea by year and fishing gear.

effort	country	gsa	2002	2003	2004	2005	2006	2007	2008	2009	2010
nominal_effort	HRV	17	0	0	0	0	0	0	0	0	0
nominal_effort	ITA	17	35557229	34526294	34180031	29600723	23853978	22089191	21069152	21128055	20006166
nominal_effort	ITA	18	24389301	18947787	14452332	13554356	14789797	12843683	12037200	14276680	12237984
nominal_effort	ITA	19	18242722	14146274	7294426	5263524	8547062	7060336	7149130	7993503	9326888
nominal_effort	SVN	17	0	0	0	112663	143526	183978	198181	200880	207862
gt_days_at_sea	HRV	17	0	0	0	0	0	0	0	0	0
gt_days_at_sea	ITA	17	5181729	5005393	5605547	5375775	4226493	4155019	3987386	3846030	3818477
gt_days_at_sea	ITA	18	3303404	2726690	2511331	2359926	2668877	2294467	2139037	2438930	2127004
gt_days_at_sea	ITA	19	1959807	1597278	932651	563762	860998	673429	775963	924774	1090477
gt_days_at_sea	SVN	17	0	0	0	9155	12291	17413	18858	18191	18235
days_at_sea	HRV	17	0	0	0	0	0	0	0	0	0
days_at_sea	ITA	17	220915	223216	269267	222218	176645	146788	128096	136204	132769
days_at_sea	ITA	18	138899	107183	91766	84901	88905	72210	70652	85895	73024
days_at_sea	ITA	19	131590	153810	100310	61638	88016	75692	74965	82277	84430
days_at_sea	SVN	17	0	0	0	831	963	1202	1254	1205	1263
fishing_days	HRV	17	0	0	0	0	0	0	0	0	0
fishing_days	ITA	17	220915	223216	242276	203974	169108	138377	130131	137929	136949
fishing_days	ITA	18	138899	107183	87211	79638	85122	70774	70654	85892	73021
fishing_days	ITA	19	131590	153810	106719	56199	82371	76509	76484	88055	90514
fishing_days	SVN	17	0	0	0	831	963	1202	1254	1205	1263

effort	country	gsa	2011	2012	2013	2014	2015	2016	2017	2018	2019
nominal_effort	HRV	17	0	7565348	7929270	8127711	7997636	6795609	6811898	7261759	5748026
nominal_effort	ITA	17	18883207	16022699	13976084	15760004	15128138	15630079	18195447	17446692	15158164
nominal_effort	ITA	18	11411534	9776170	10549934	7786075	7217434	7911036	11437731	10088060	8716311
nominal_effort	ITA	19	8278182	7027768	6521410	6460203	6409917	6131873	7165739	5088587	5127855
nominal_effort	SVN	17	188621	153646	113694	99847	101476	110971	107421	111129	142785
gt_days_at_sea	HRV	17	0	1321402	1408705	1416463	1385375	1231785	1169370	1136770	1058883
gt_days_at_sea	ITA	17	3474346	3205908	2717507	2947989	2951121	3067580	3552875	3580453	3353523
gt_days_at_sea	ITA	18	1904208	1656069	1992837	1475180	1383701	1434241	1827060	1648653	1414008
gt_days_at_sea	ITA	19	994747	855083	664445	652821	773434	836160	904799	700081	727411
gt_days_at_sea	SVN	17	17782	15063	11960	9372	9990	10534	10214	9986	13323
days_at_sea	HRV	17	0	59574	62114	64067	64462	37201	38131	63850	30516
days_at_sea	ITA	17	134201	113249	95284	94660	83868	84071	96155	79700	70231
days_at_sea	ITA	18	68742	63411	76005	54664	54480	58297	57027	61688	51815
days_at_sea	ITA	19	75487	57579	45429	47962	50396	48980	51897	45204	33448
days_at_sea	SVN	17	1178	917	766	680	696	812	697	692	769
fishing_days	HRV	17	0	50835	52973	54650	55076	33715	35649	56844	30997
fishing_days	ITA	17	138540	116850	97982	97868	85984	89376	96415	79551	65911
fishing_days	ITA	18	68754	63411	79244	54851	54774	60876	57053	62311	50169
fishing_days	ITA	19	78239	60017	45588	48040	51394	49784	52214	46672	32875
fishing_days	SVN	17	1178	917	766	680	696	812	697	692	769

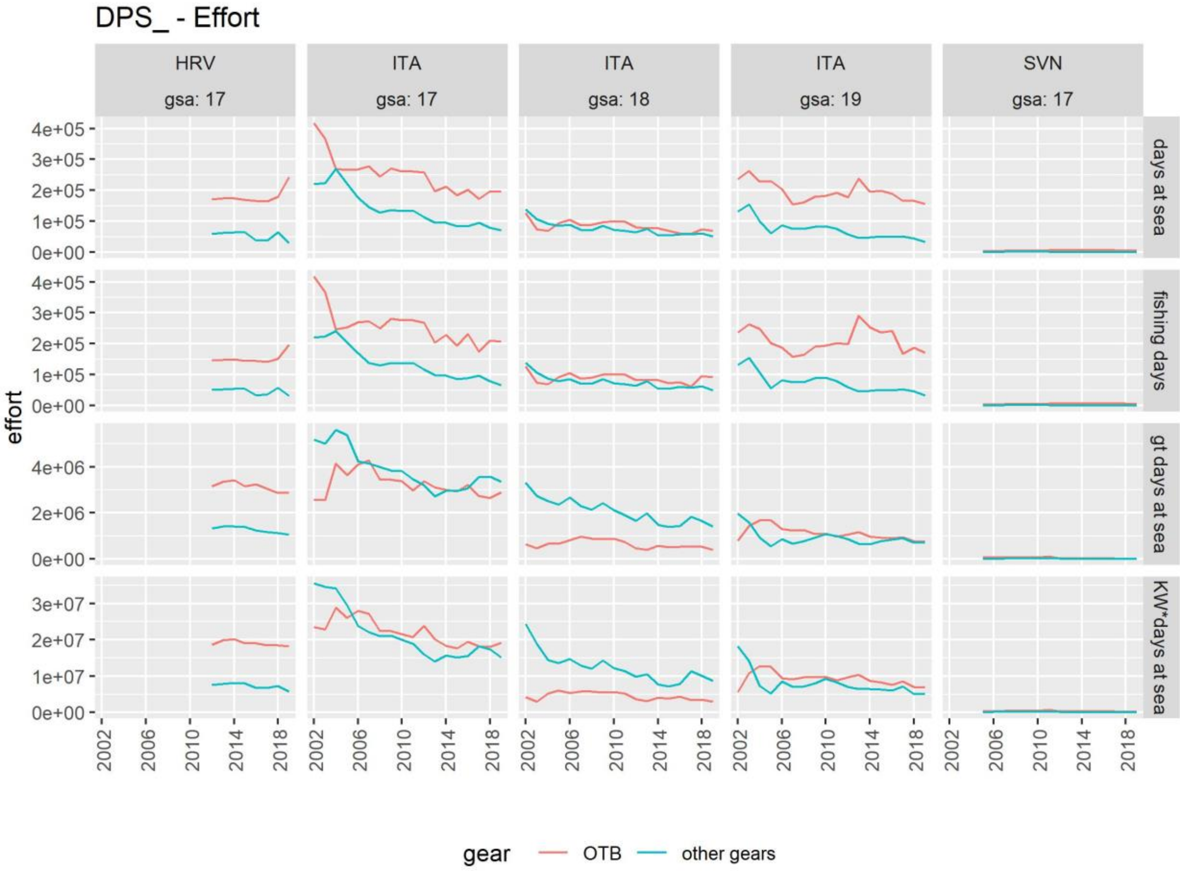


Figure 6.7.2.1. Deep-water rose shrimp stocks in GSAs 17-19: Fishing effort in nominal effort, GT*days at sea, days at sea and fishing days by year, fishing gear, country and GSA.

Fishing effort expressed as fishing days all the tre GSAs is drawn in figure 6.7.2.2.2.

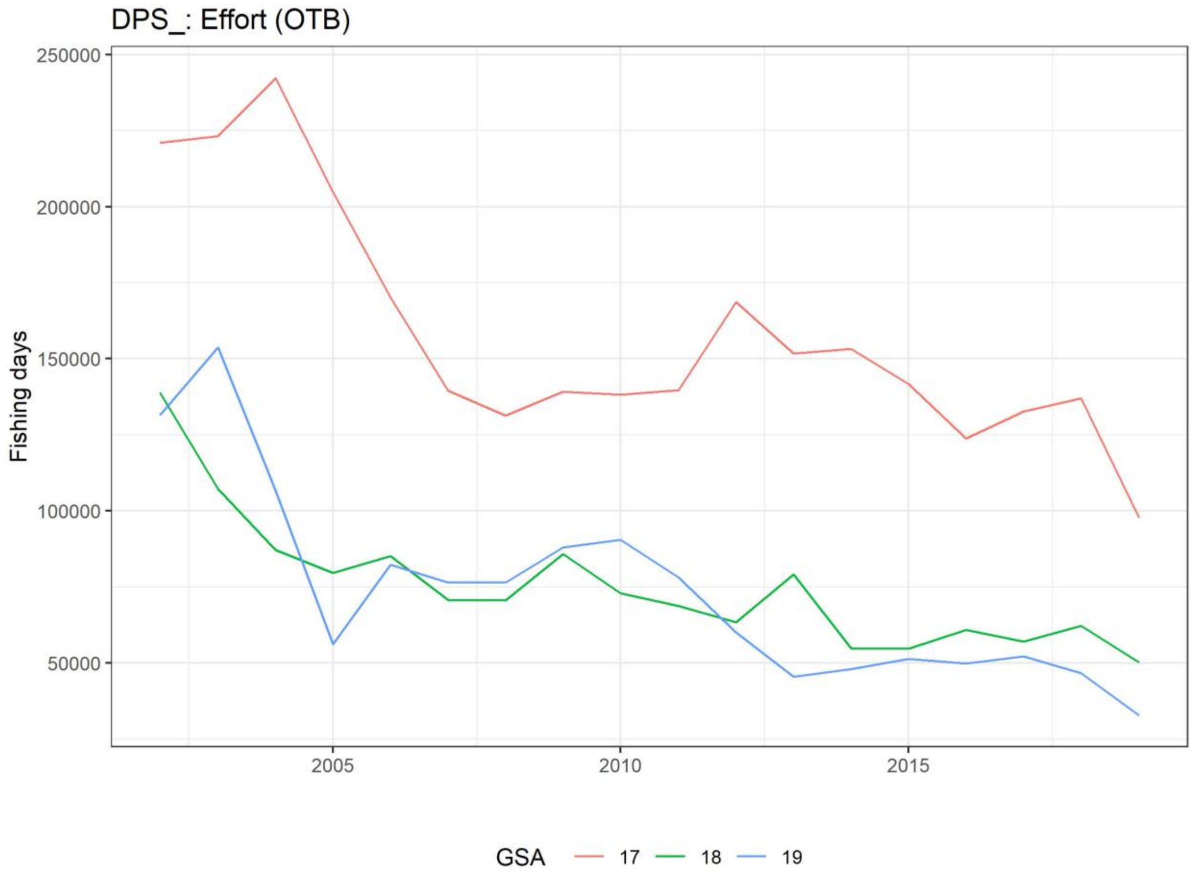


Figure 6.7.2.2. Deep-water rose shrimp stocks in GSAs 17-19: Effort in fishing days by OTB and year in the three GSAs.

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. Data were analysed using the JRC script (Mannini, 2020)

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

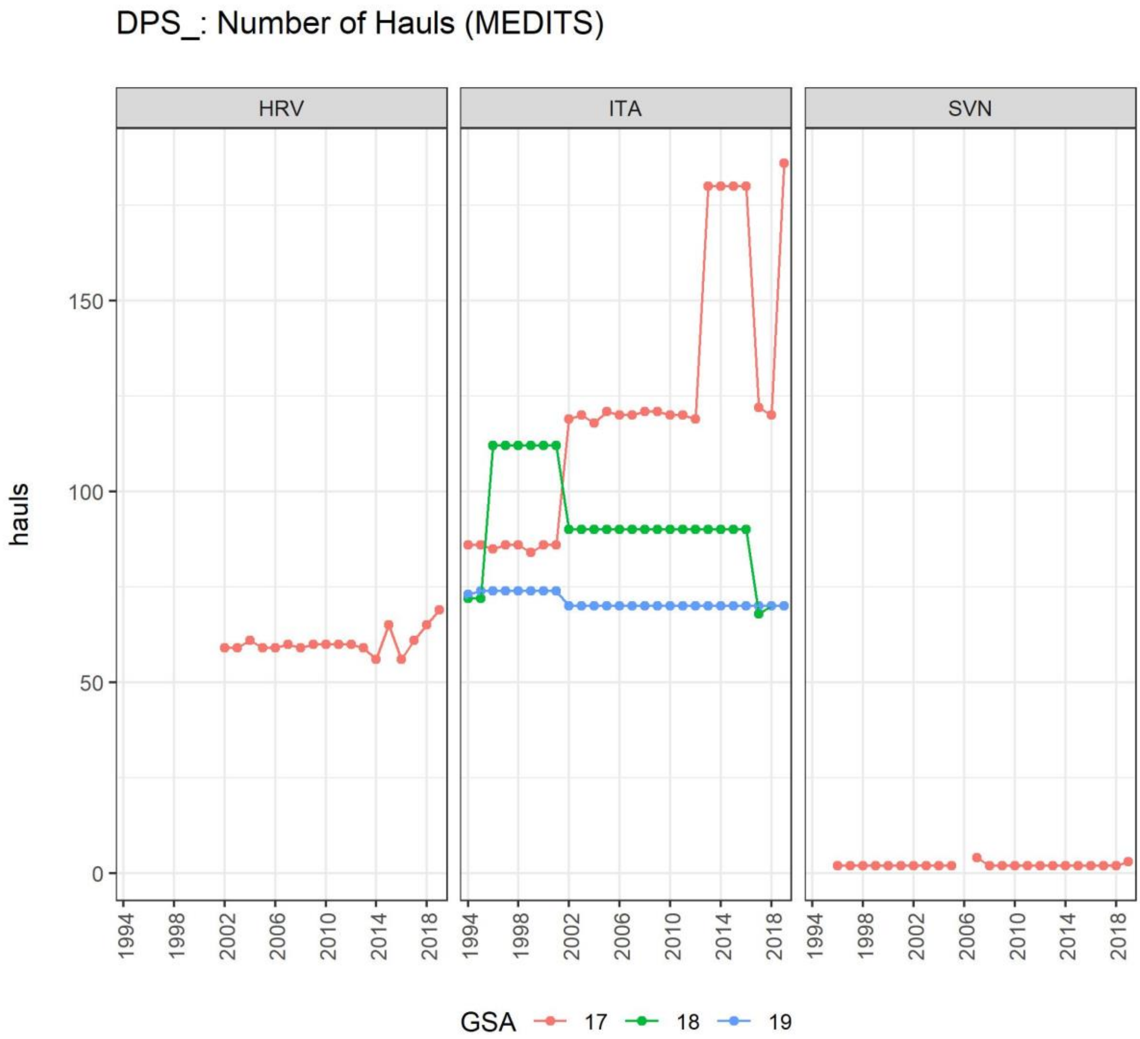


Figure 6.7.2.3.2. Total number of MEDITS hauls per year and country.

Observed abundance and biomass indices of Deep-water rose shrimp stocks from MEDITS are given in the figure 6.7.2.3.3).

Both estimated abundance and biomass indices show similar trends, with very high increas of value in last four years.

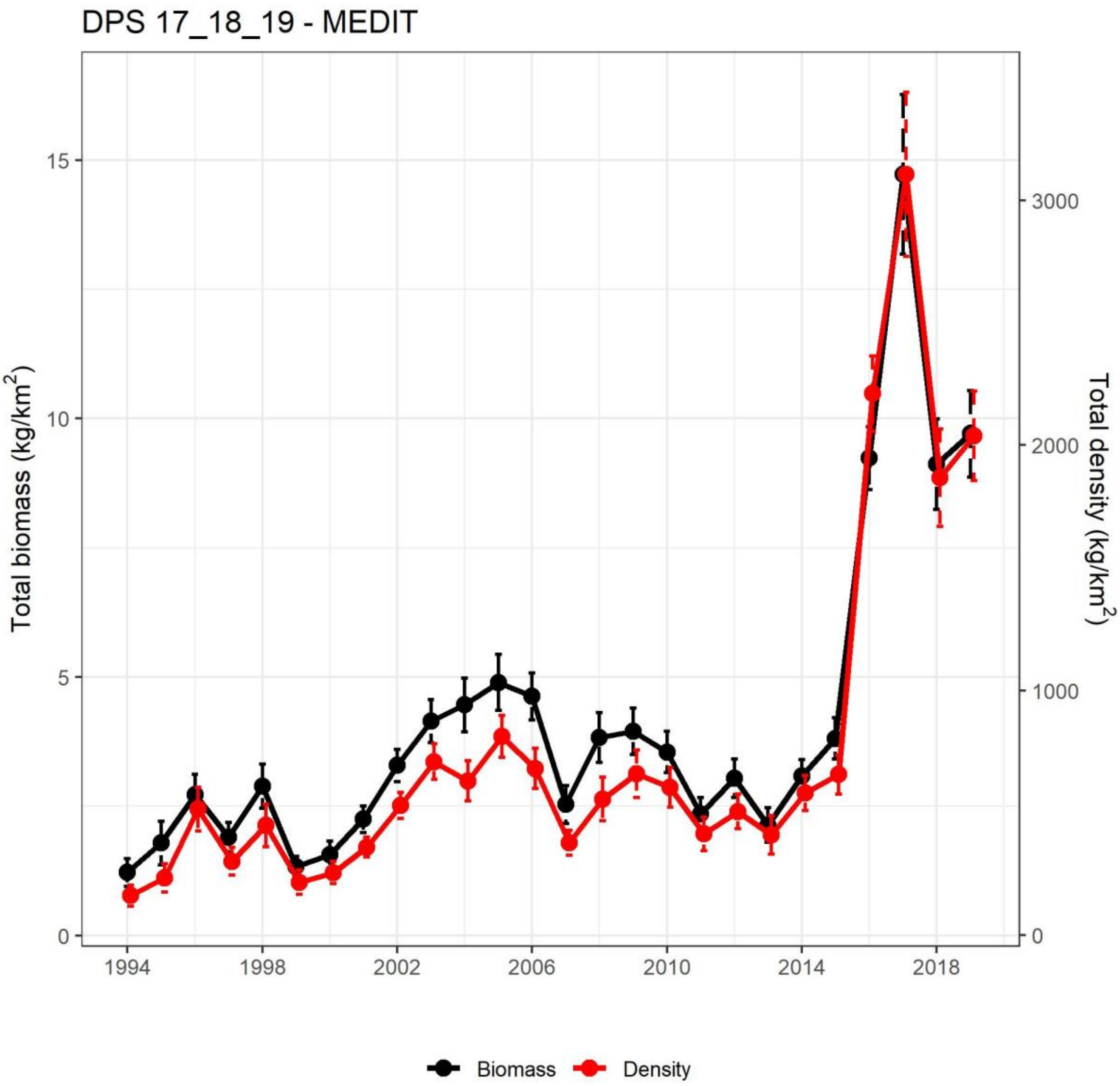


Figure 6.7.2.3.3. Deep-water rose shrimp stocks in GSAs 17-19: Estimated biomass (kg/km^2) and density indices (N/km^2).

Length frequency distribution of Deep-water rose shrimp stocks from Medist are given in the figure below (Figure 6.7.2.3.3-5).

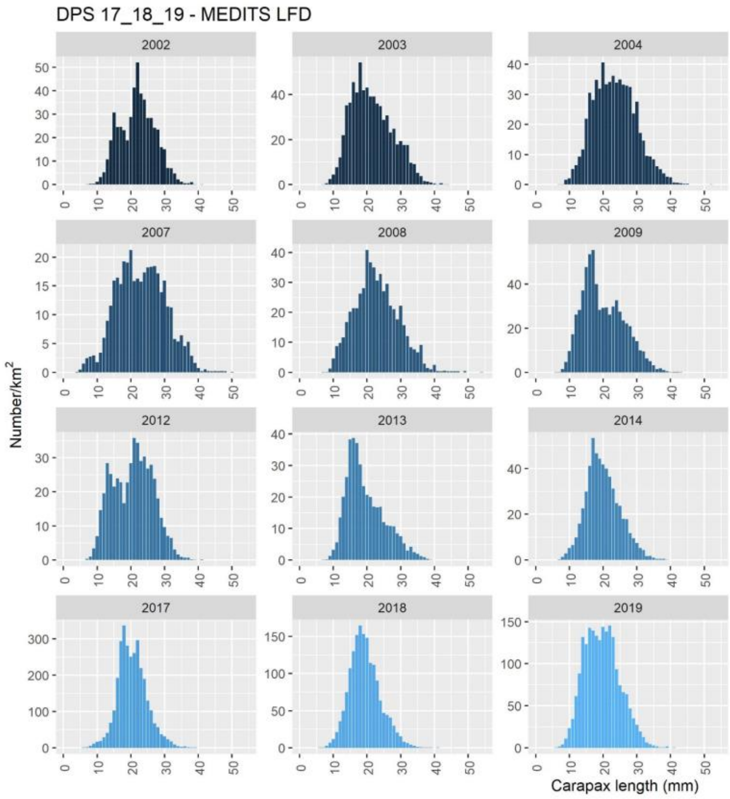


Figure 6.7.2.3.5. Deep-water rose shrimp stocks in GSAs 17-19: Length frequency distribution by year of MEDITS.

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 2019. In addition data on discards at length are availble only from 2009 and thus were reconstructed by multiplying for the missing years the numbers of length at landings for the average ratio of discards and landings in neighbours years.

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.

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 6.7.1.4. These parameters were taken from the DCF data call and considered reasonable.

Stock assessment input data for the a4a model are given in tables 6.7.3.1-6 and figures 6.7.3.1-4.

Input data

The catch age matrix from the slicing of MEDITS catch rate at length data is reported in Figure 6.7.3.1 and Table 6.7.3.1.

Table 6.7.3.1. Deep-water rose shrimp stocks in GSAs 17-19: MEDITS tuning index of abundance by age and by year.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	324	461.3	329.2	515.9	367.1	197.4	313.4	464.6	394.5	291.1	335.2	313.4	429.7	422.7	1865.4	2432.2	1377.8	1449.9
1	186.6	214.9	251.4	262.8	282.5	142.2	200.6	176.4	191.6	115.7	162.6	85.8	122.7	224.6	338.4	657.5	276.1	570.3
2	9.4	29.3	38.7	30.5	27.5	27.5	34.6	18	13.6	7.4	7.2	10.9	5.5	9.4	10.1	20.5	8.9	15.3
3	1.4	4.1	11.3	4.6	4.2	7.2	8.1	2	1.7	0.4	0.5	0.6	0.7	0.5	0.5	1.1	0.5	1.9

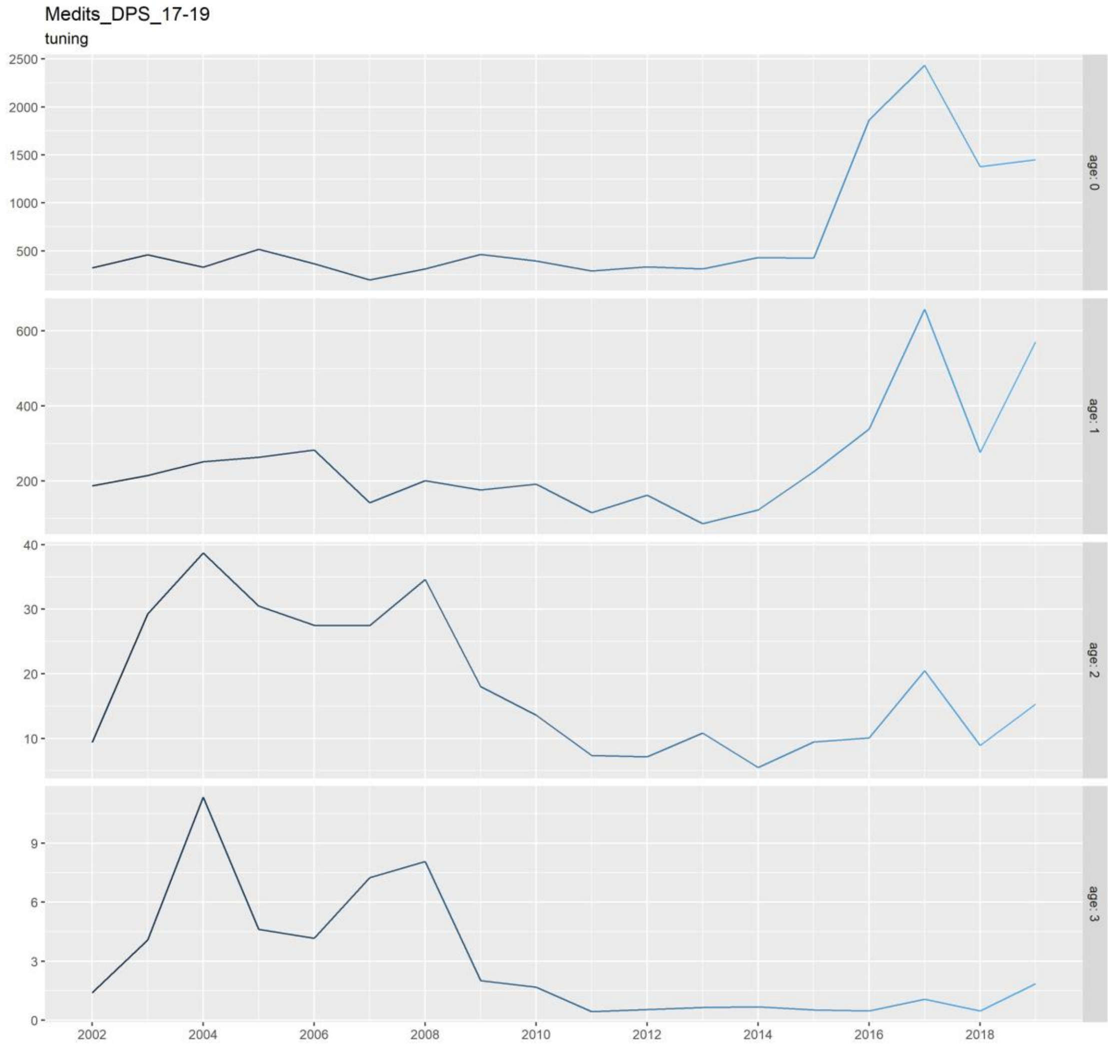


Figure 6.7.3.1. Deep-water rose shrimp stocks in GSAs 17-19: MEDITS mean catch/rate at age by year derived from length by slicing.

The catch at age from deterministically length slicing is reported in table 6.7.3.2.

Table 6.7.3.2. Deep-water rose shrimp stocks in GSAs 17-19: Catch at age by year (sum of landings and discards after slicing).

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	107449	93361	171052	239093	196880	141561	155563	238155	251372	143382	205018	188944	231883	322301	454319	577259	521101	484372
1	114792	118229	218821	159636	162679	82575	89925	180326	203164	164744	140326	136737	122758	141776	182049	238160	367780	378024
2	2347	11159	15833	1825	11332	3994	3488	8666	10215	10381	7212	6305	5911	4297	5735	6605	11357	10909
3	208	749	1851	364	2156	181	191	776	897	866	687	626	149	262	342	926	643	304

Differences on total catch and total of catch at age were checked and the sum of products correction (SOP) need was checked (figure 6.7.3.2). The SoP correction comes from different sources in the time series. For the years up to 2009 part of the contribution comes partly from the added catch due to filling in Croatian Albanian and Montenegrin Catches without data at length or age. From 2009 the SoP correction results predominately from the use of Italian OTB from GSA 17 as the preferred source of length data so Italian OTB is being raised to the full catch. In the last year there is also missing catch data from Albania.

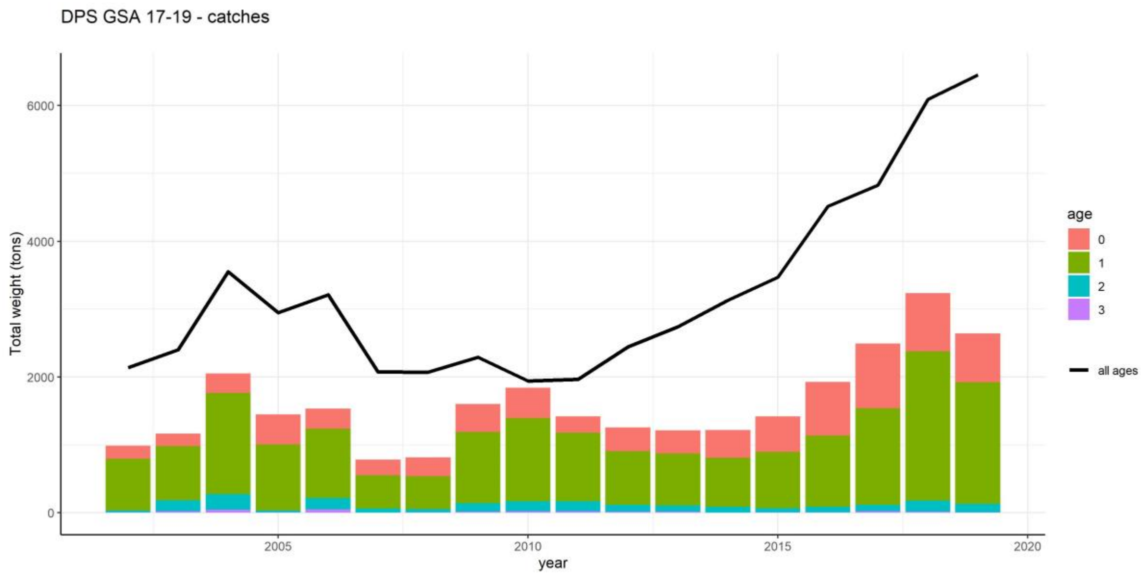


Figure 6.7.3.2. Deep-water rose shrimp stocks in GSAs 17-19: Differences on total catch and total weigth of catch at age.

The catches at age was raised to the total catch by applying the SOP. The SOP corrected catch at age matrix and applied SOP factors are reported below on tables 6.7.3.3 and 6.7.3.4 respectively.

Table 6.7.3.3. Deep-water rose shrimp stocks in GSAs 17-19: The new catch at age matrix SOP corrected.

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	297730	291322	295685	485951	412870	354092	371904	338302	293765	198100	398891	426987	595688	787895	1063149	1117712	982475	974106
1	318079	368921	378261	324457	341149	206547	214983	256155	237427	227614	273024	309006	315355	346584	426011	461135	693407	760233
2	6503	34820	27369	3708	23765	9991	8338	12311	11938	14342	14032	14248	15186	10505	13419	12788	21412	21938
3	576	2337	3200	739	4521	452	457	1102	1049	1196	1336	1414	384	640	801	1794	1213	612

Table 6.7.3.4. Deep-water rose shrimp stocks in GSAs 17-19: SOP corrections for years applied to raised catch at length/age used in the assessment.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
SOP catch	2.8	3.1	1.7	2.0	2.1	2.5	2.4	1.4	1.2	1.4	1.9	2.3	2.6	2.4	2.3	1.9	1.9	2.0

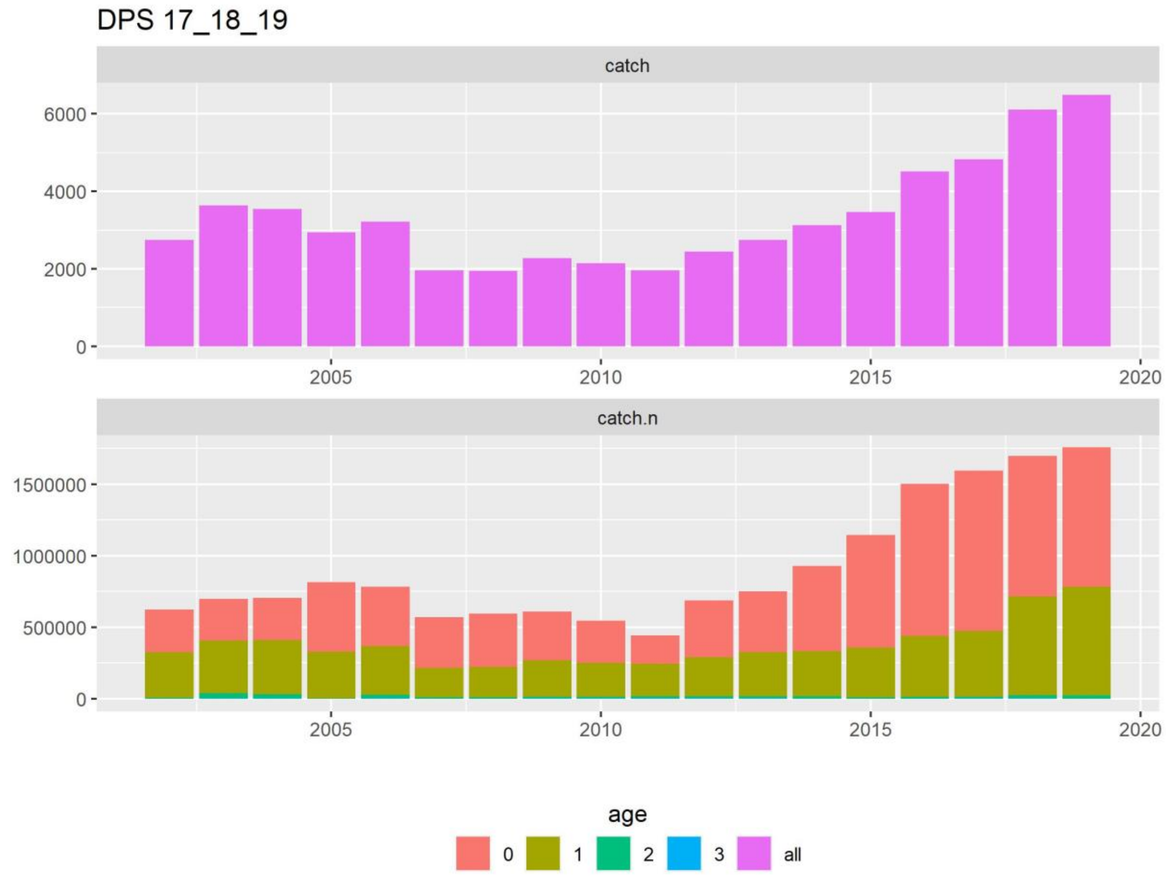


Figure 6.7.3.2. Deep-water rose shrimp stocks in GSAs 17-19: catch (tons) and catch at age (number) by year from length slicing and SOP correction.

The trend of catches shows used in the assessment is reported in figure 6.7.3.4 and table 6.7.3.5.

Table 6.7.3.5. Deep-water rose shrimp stocks in GSAs 17-19: Total Catch by year in tonnes

OTB	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
landings	2695.2	3585	3462.6	2869.3	3162.7	1918.4	1902.3	2187	2090	1942	2424	2708	3081.9	3409.3	4261.6	4657.5	5748.2	6211.3
discards	48.5	51.7	81.6	72.1	51.8	45	48.9	89.7	59.8	22.6	20.5	36.4	46.6	63	255.2	171.2	356	272.3
catch	**2744**	**3637**	**3544**	**2941**	**3215**	**1963**	**1951**	**2277**	**2150**	**1965**	**2445**	**2744**	**3129**	**3472**	**4517**	**4829**	**6104**	**6484**

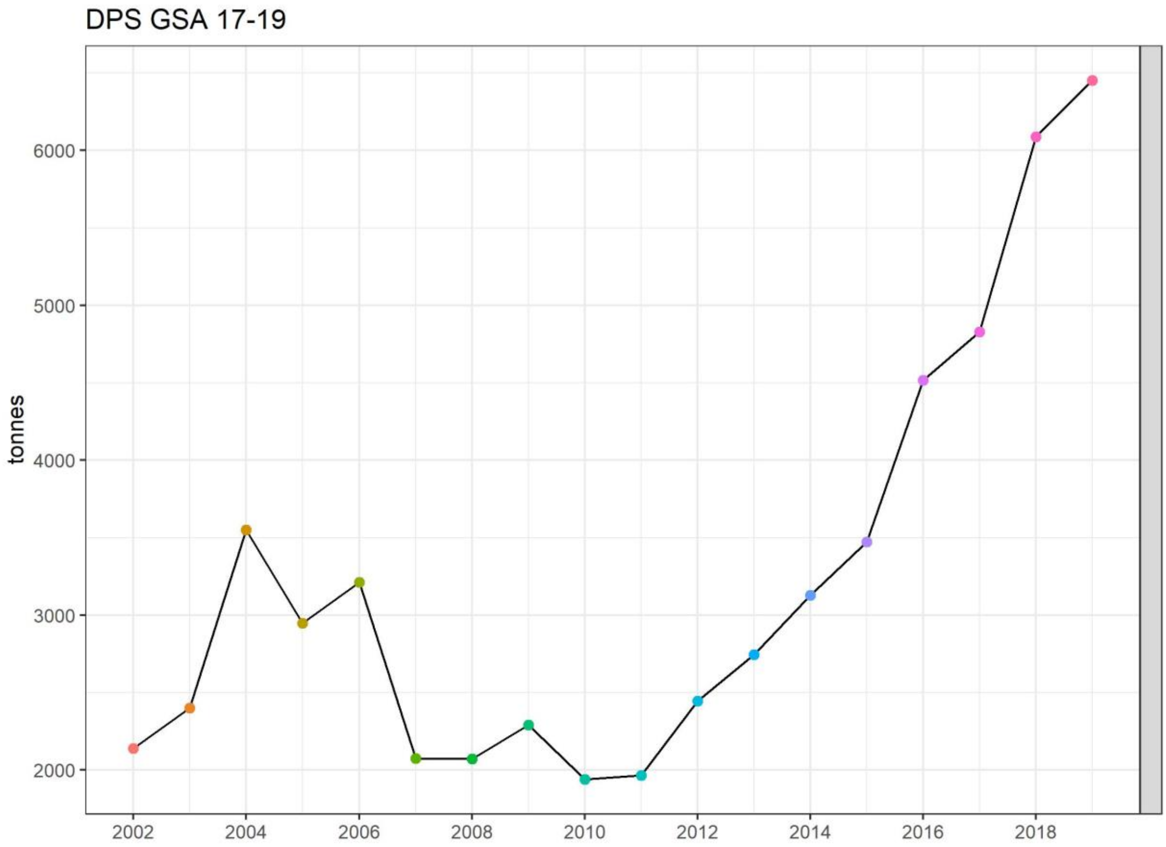


Figure 6.7.3.4. Deep-water rose shrimp stocks in GSAs 17-19: Trend of total catch in tonnes used as input in the assessment.

Input data on maturity, natural Mortality derived by the Chan-Watanabe method, and catch weights at age are reported on table 6.7.3.6.

Table 6.7.3.6. 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
weights at age (kg)	0.002	0.007	0.014	0.024

Average spawning time was set 0.5 (1st July) according to the biology of the species.

Catch were used from 2002 to 2019.

The age age range used in the assessment was 0 to 3+.

Fbar was set from 0 to 2.

DPS 1171819 Sensitivity analysis

An extensive sensitivity analysis of possible model configuration was carried out both using the whole time series (2002-2019) and the shorter one (2009-2019).

Simple models considering fishing mortality by separable age and year, and catchability at age without year trend do not converge for either in the longer or the short time series. The following configurations were inspected.

for the long time series models tested were:

fmodel: 6 configurations ~ from
factor(replace(age, age > 1, 1)) + s(year, k = 5) to
factor(replace(age, age > 1, 1)) + s(year, k = 10)

srmodel: 9 Configurations
six options s(year, k = Kx) with Kx ranging from 5 to 10 and
three options geomean(CV = y) with y= 0.10, 0.15, 0.20

qmodel: 2 configurations
factor(replace(age, age > 1, 1)) and replace(age, age > 2, 2)

for the short time series models were:

fmodel: 2 configurations ~ from
factor(replace(age, age > 1, 1)) + s(year, k = 2)
to factor(replace(age, age > 1, 1)) + s(year, k = 3)

srmodel: 4 Configurations
s(year, k = 3) and
geomean(CV = y) with y= 0.10, 0.15, 0.20

qmodel: 2 configurations
factor(replace(age, age > 1, 1)) and
replace(age, age > 2, 2)
Modelling fishing mortality with a separable smoother by age and year, together with catchability at age without year trend gives better results. With this model a sensitivity on different recruitment models was carried out.

Models without smoothing on recruitment do not converge. Differences were found by using a smoothing or a geometric mean function (with different values of CVs) to account for rectruitment modellization. The best option was to use a smoother in recruitment (with K= 9 for the long time series and K= 3 for the shorter one). To select between the different timeseries options the best approach for each timeseries were compared and the results are given below. (Figg. 6.7.3.5 to 6.7.3.13).

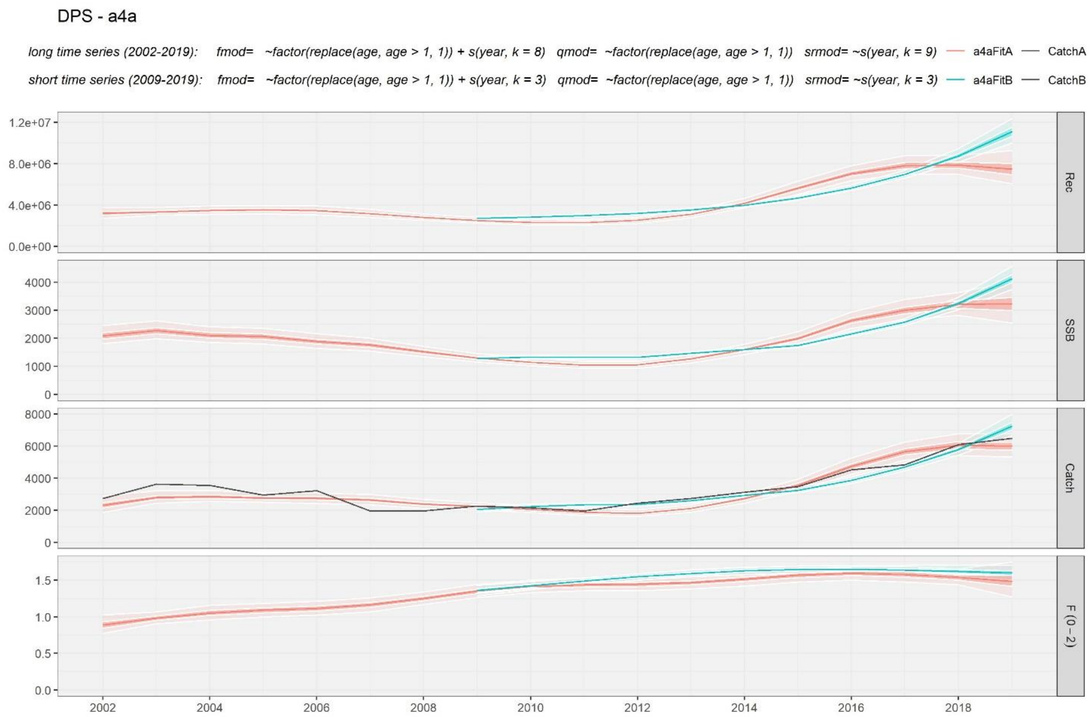


Figure 6.7.3.5. Deep-water rose shrimp stocks in GSAs 17-19: Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals for the two time series considered.

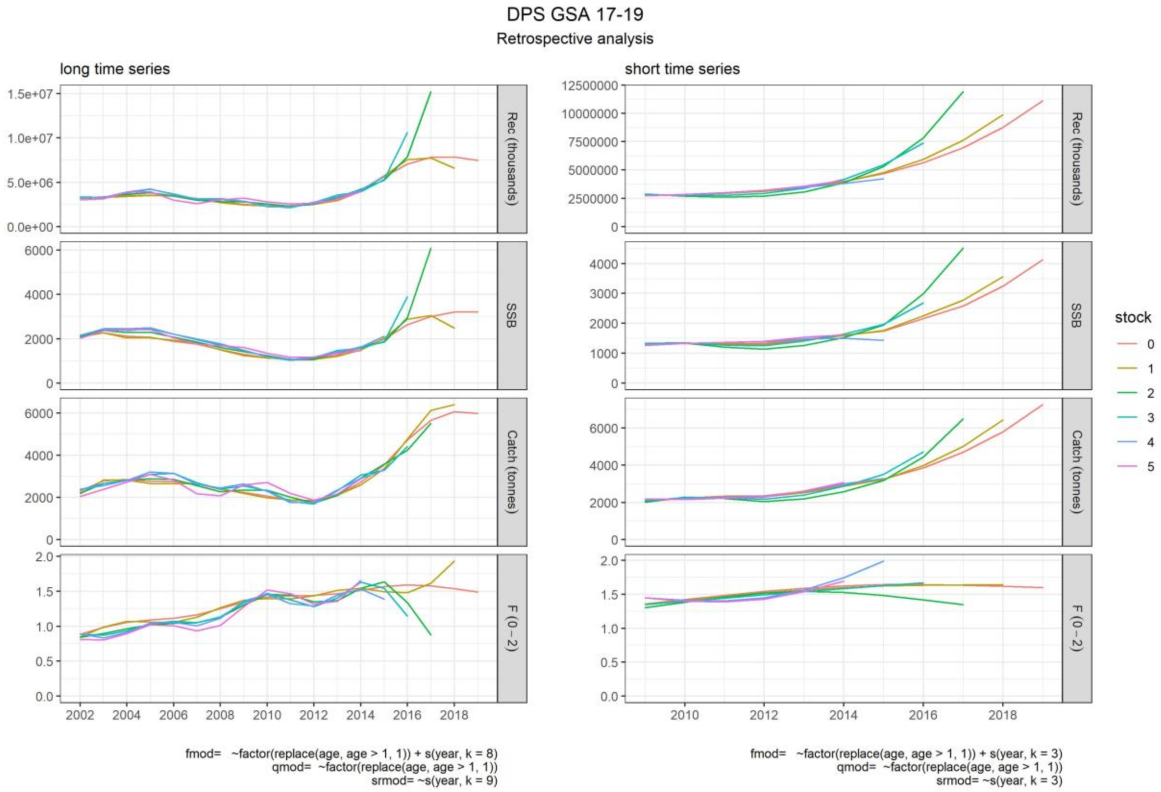


Figure 6.7.3.6. Deep-water rose shrimp stocks in GSAs 17-19: retrospective analysis for the two time series considered.

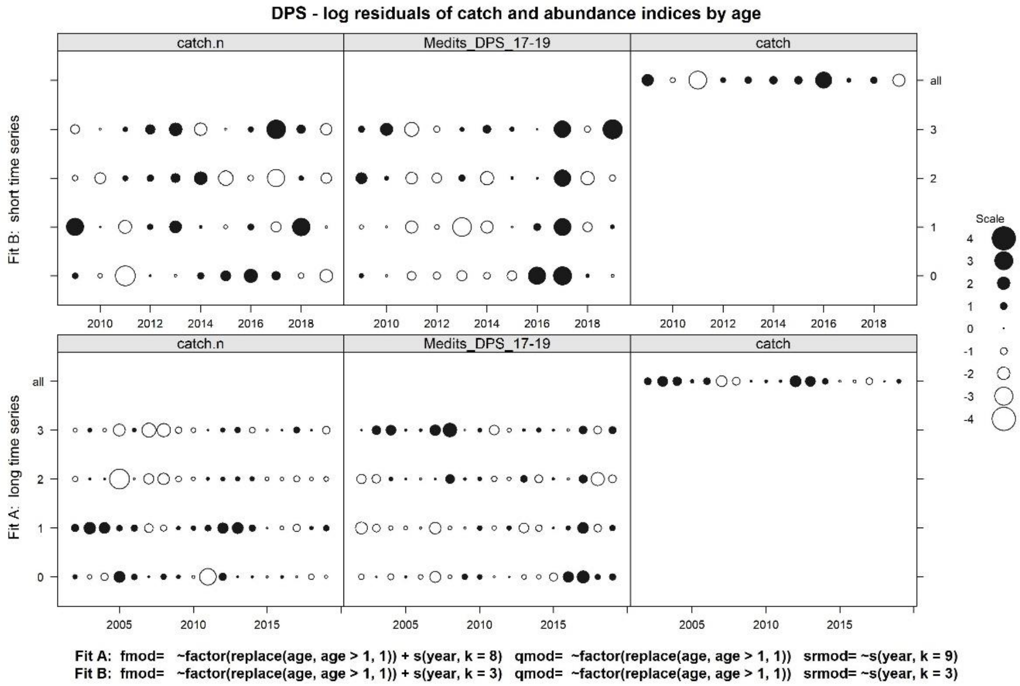


Figure 6.7.3.7. Deep-water rose shrimp stocks in GSAs 17-19. Residuals of residuals for abundance indices and catch by age for the two time series considered.

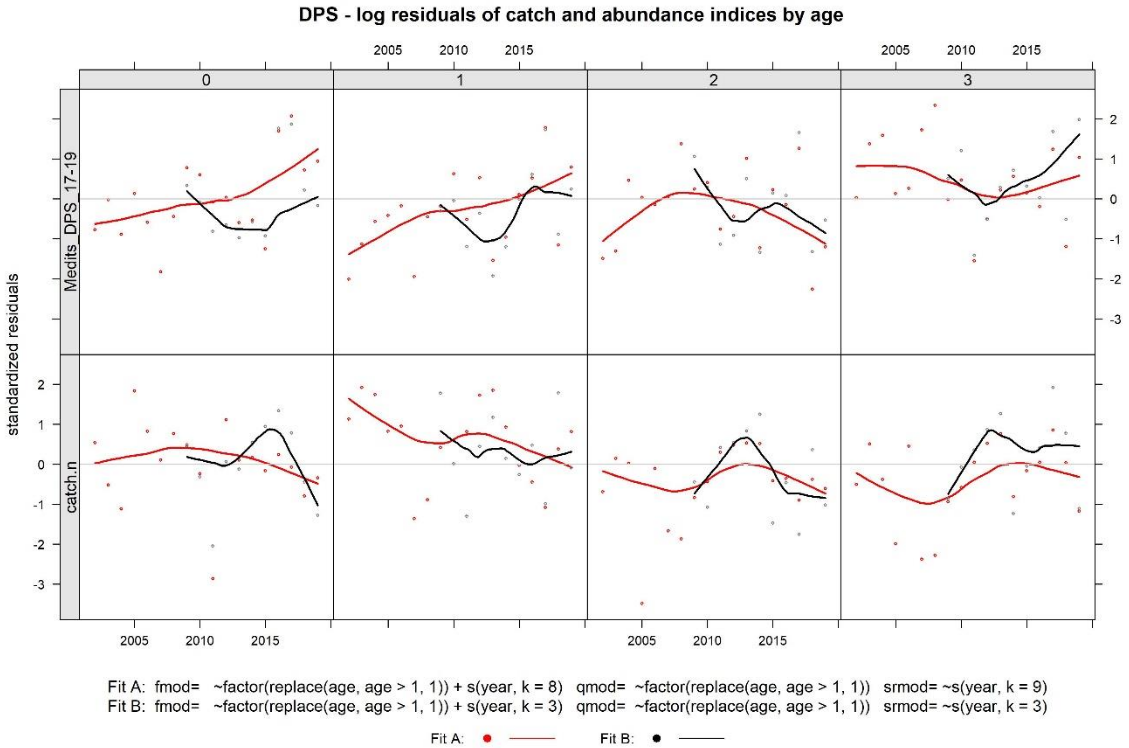


Figure 6.7.3.8. Deep-water rose shrimp stocks in GSAs 17-19. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines with different colours for the two time series considered.

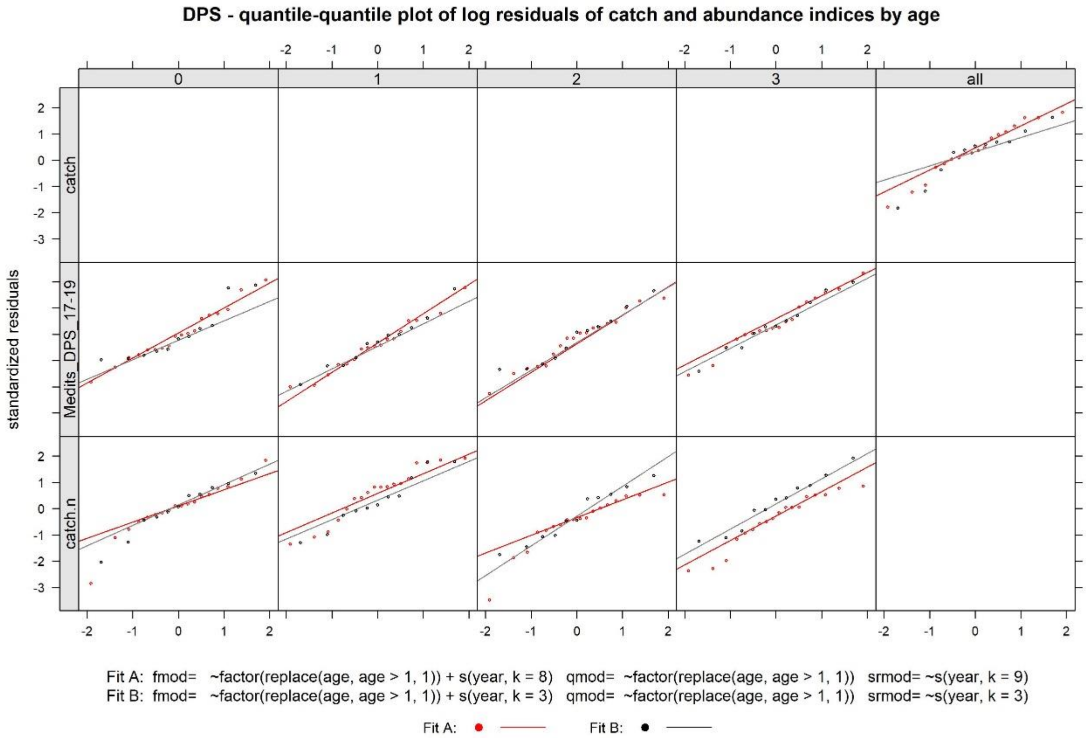
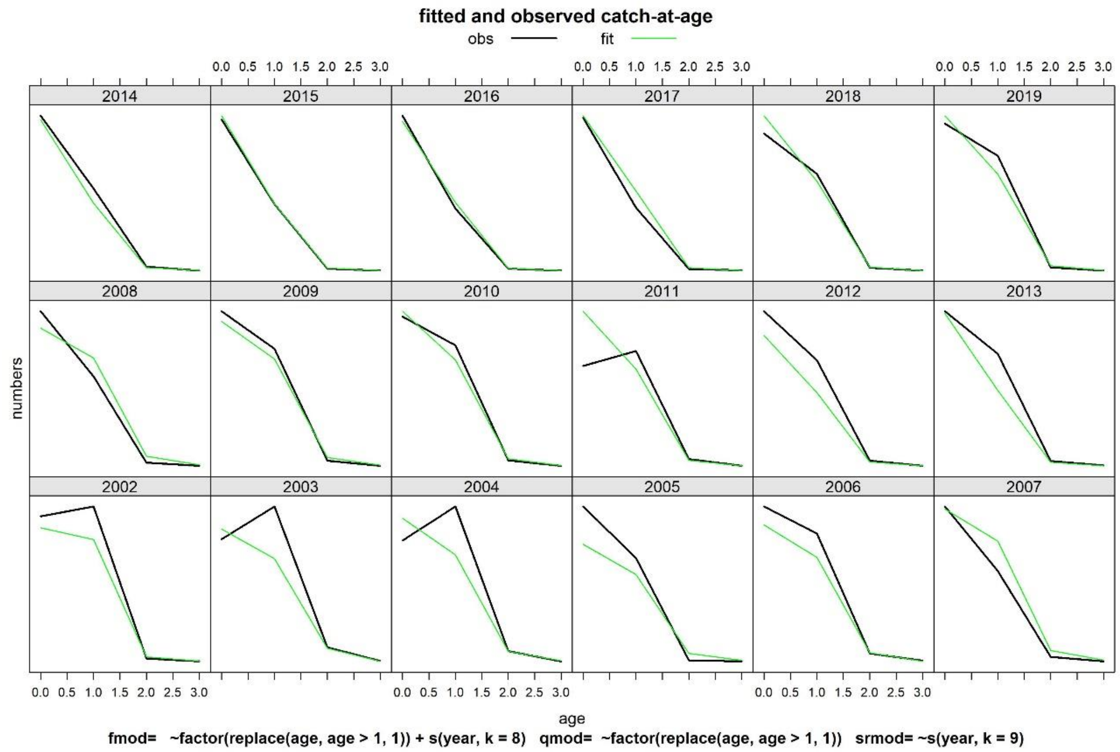
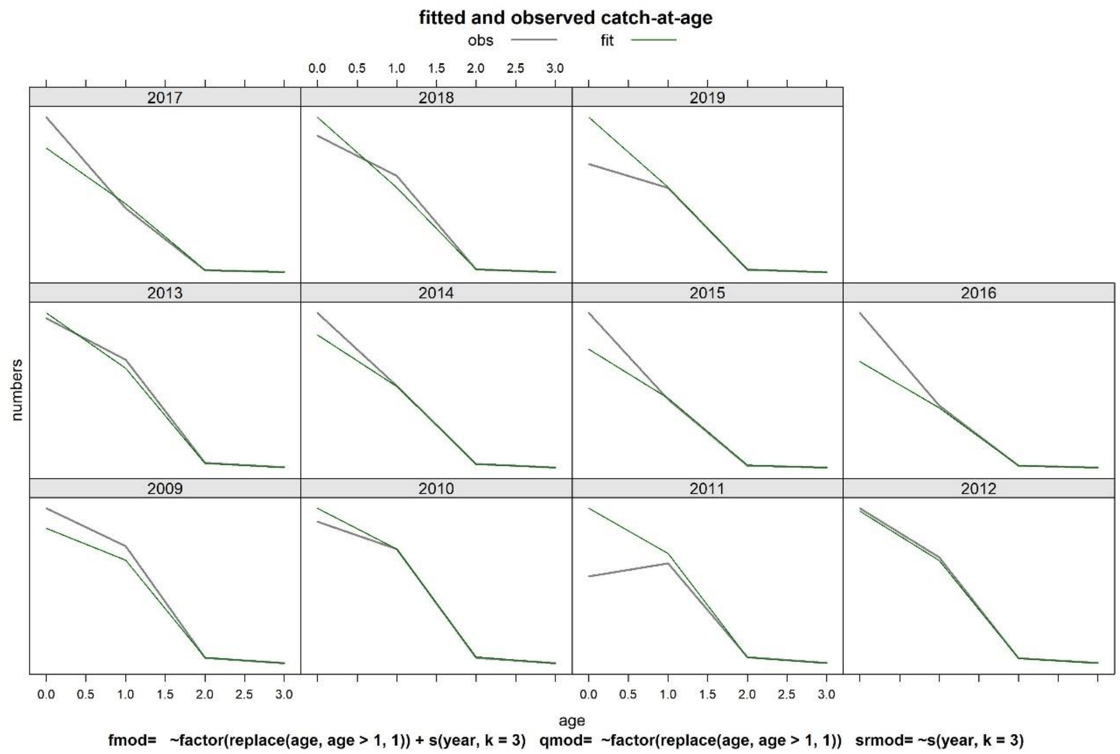


Figure 6.7.3.9. Deep-water rose shrimp stocks in GSAs 17-19. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and lines the normal distribution quantiles with different colours for the two time series considered.

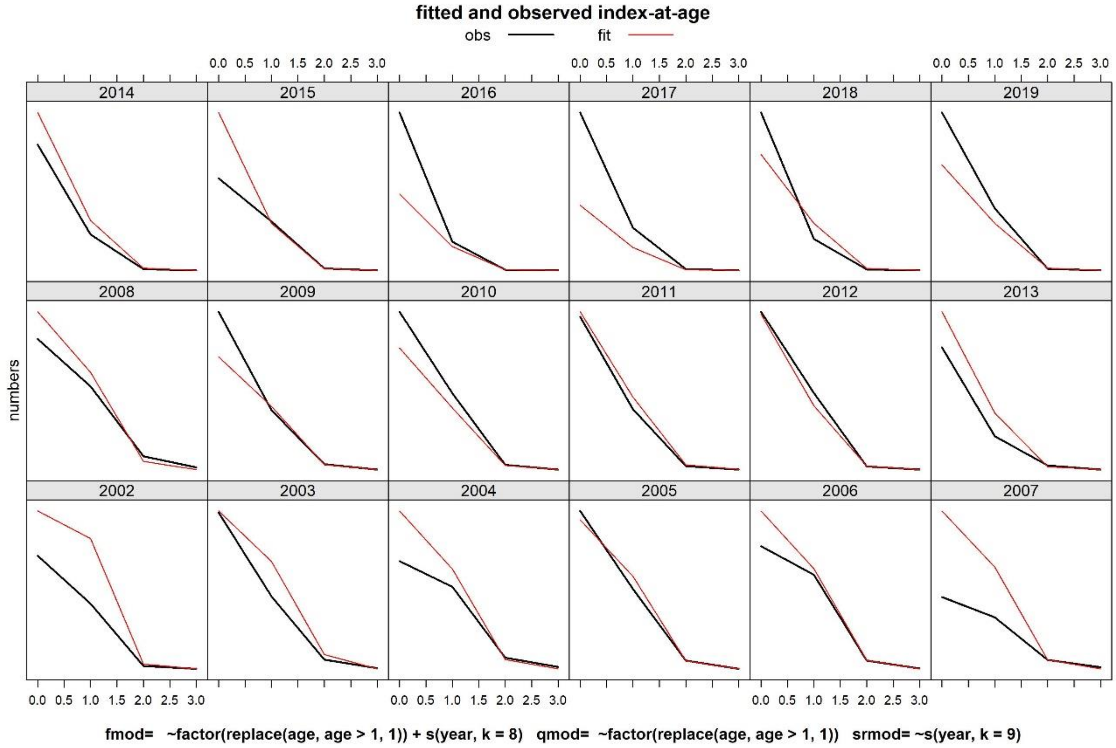


A

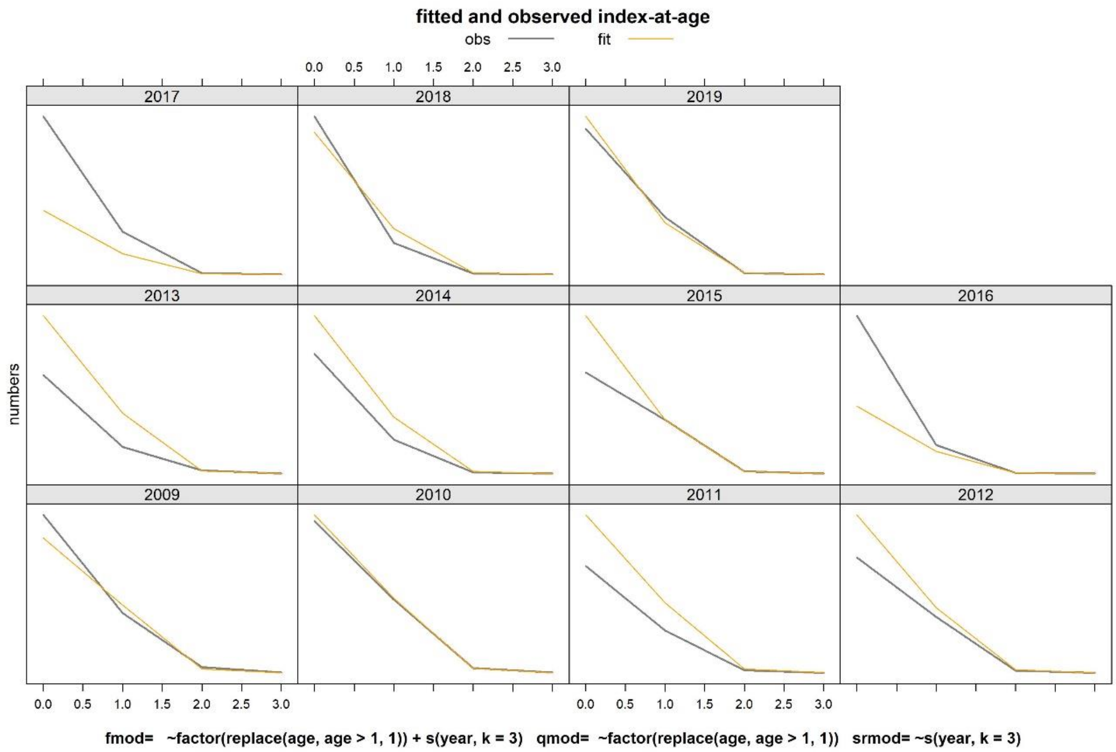


B

Figure 6.7.3.10. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed catch at age for the long (A) and short time series (B).



A



B

Figure 6.7.3.11. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed index at age for the long (A) and short time series (B).

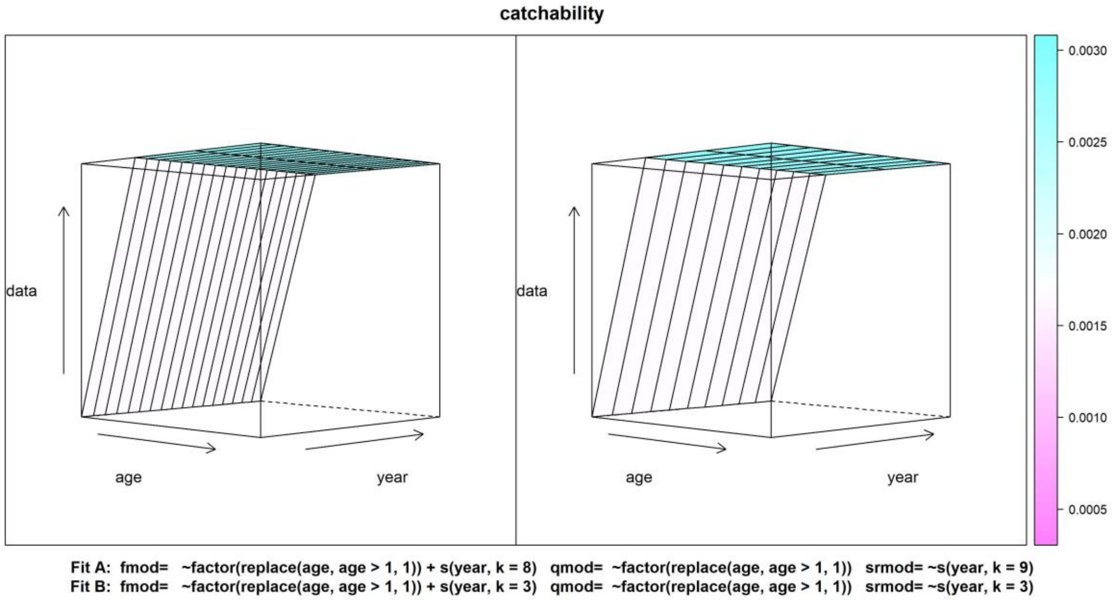


Figure 6.7.3.12. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated fishing mortality at age and year for the two time series considered.

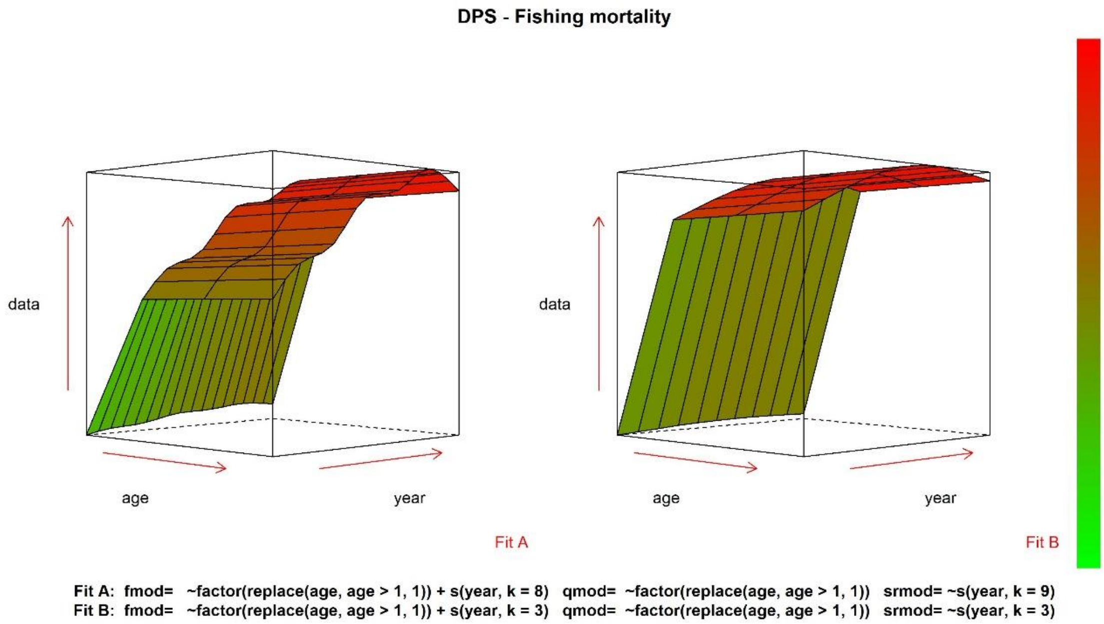


Figure 6.7.3.13. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated catchability at age and year for the two time series considered.

Following these evaluations the stock assessment was based on the following submodels:

fmodel: ~factor(replace(age, age > 1, 1)) + s(year, k = 8) (separable model with light smoothing for year)

srmodel: ~s(year, k = 9) (recruitment with light smoothing for year)

n1model: ~s(age, k = 3)

qmodel: ~factor(replace(age, age > 1, 1)) (catchability indipendent and costant after age 1)

vmodel: catch: ~s(age, k = 3) (smooth catch model)

IND: ~1 (One index)

Stock Assessment Results

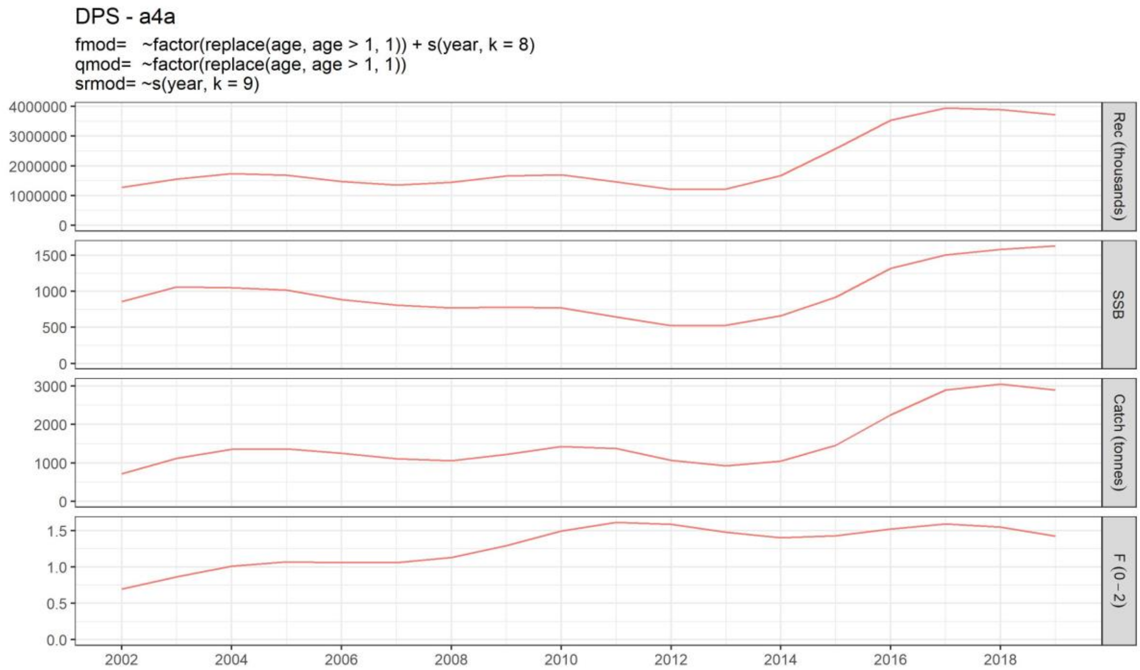


Figure 6.7.3.14. Deep-water rose shrimp stocks in GSAs 17-19: Stock summary from the a4a model for recruits, SSB (Stock Spawning Biomass), catch and harvest (fishing mortality).

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	0.89	3211860	2089	9331	2303
2003	0.98	3357245	2275	10537	2789
2004	1.05	3496761	2112	9893	2861
2005	1.09	3561511	2069	10228	2771
2006	1.11	3459154	1888	9011	2741
2007	1.16	3180805	1765	8737	2641
2008	1.25	2827686	1521	7986	2388
2009	1.35	2518958	1298	7048	2243
2010	1.41	2328360	1148	6466	2058
2011	1.44	2307545	1048	5994	1891
2012	1.44	2531322	1056	6197	1810
2013	1.46	3116128	1269	7678	2102
2014	1.51	4174441	1601	9877	2725
2015	1.57	5636747	1997	12504	3555
2016	1.59	7053569	2636	16673	4732
2017	1.58	7838641	3005	18583	5660
2018	1.54	7862464	3208	19339	6065
2019	1.49	7490295	3221	18902	5993

Table 6.7.3.8. Deep-water rose shrimp stocks in GSAs 17-19: Stock number by age and by year in thousands.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	274288.2	315152.4	350288.2	367607.9	364182.2	348617.9	331047	315673	304607.3	305942.6	336634.7	420502.9	580366.3	807693.1	1024759	1130220	1108259	1025740
1	250504.8	245544.1	261258.2	272556.5	278618.8	275322.1	259498.1	234419	208818.3	191488.8	189175.3	208755.4	259270.9	348369.3	467959.3	580455.4	640323.9	639219.5
2	9516.7	32206.8	27076.8	25513.8	25195.5	25178.1	23482.1	19558.2	15193.4	12158.8	10769.7	10622.1	11412.1	13211.4	16370.9	21049.3	26439.7	30755.6
3	860	1558.5	4346.9	3603.3	3159.6	3006.2	2820.3	2328	1667.8	1154.9	880.5	768.7	731.5	727	769.7	906	1175	1558

Table 6.7.3.9. Deep-water rose shrimp stocks in GSAs 17-19: Fishing Mortality by age and by year

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.19	0.21	0.23	0.24	0.24	0.25	0.27	0.29	0.31	0.31	0.31	0.32	0.33	0.34	0.35	0.34	0.34	0.32
1	1.23	1.37	1.47	1.51	1.55	1.62	1.74	1.87	1.97	2.00	2.00	2.04	2.11	2.18	2.21	2.19	2.14	2.07
2	1.23	1.37	1.47	1.51	1.55	1.62	1.74	1.87	1.97	2.00	2.00	2.04	2.11	2.18	2.21	2.19	2.14	2.07
3	1.23	1.37	1.47	1.51	1.55	1.62	1.74	1.87	1.97	2.00	2.00	2.04	2.11	2.18	2.21	2.19	2.14	2.07

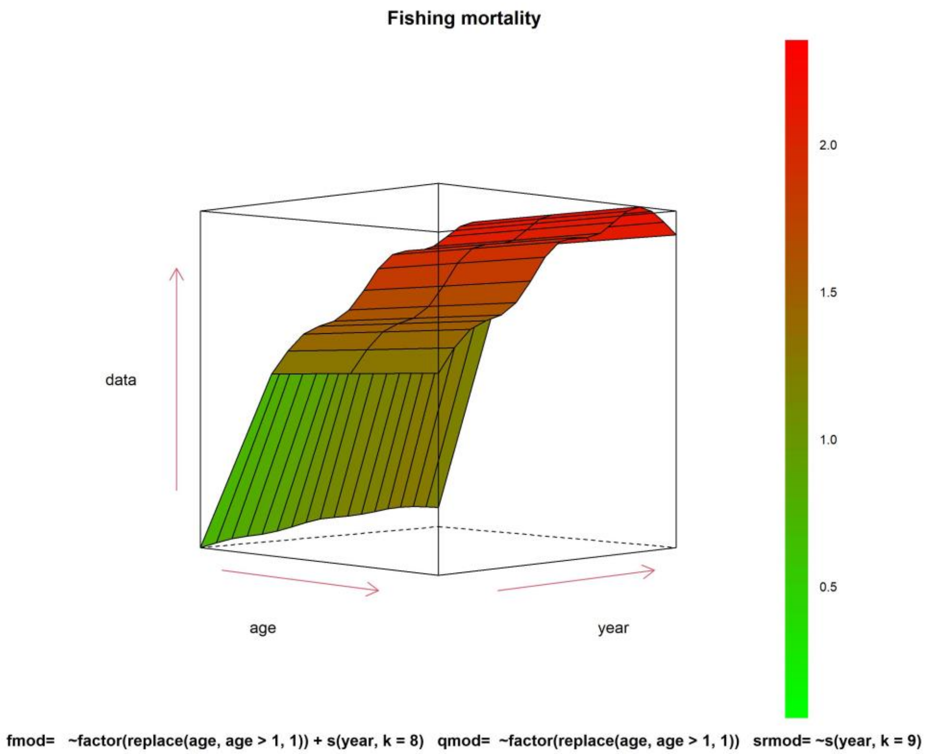


Figure 6.7.3.15. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated fishing mortality at age and year.

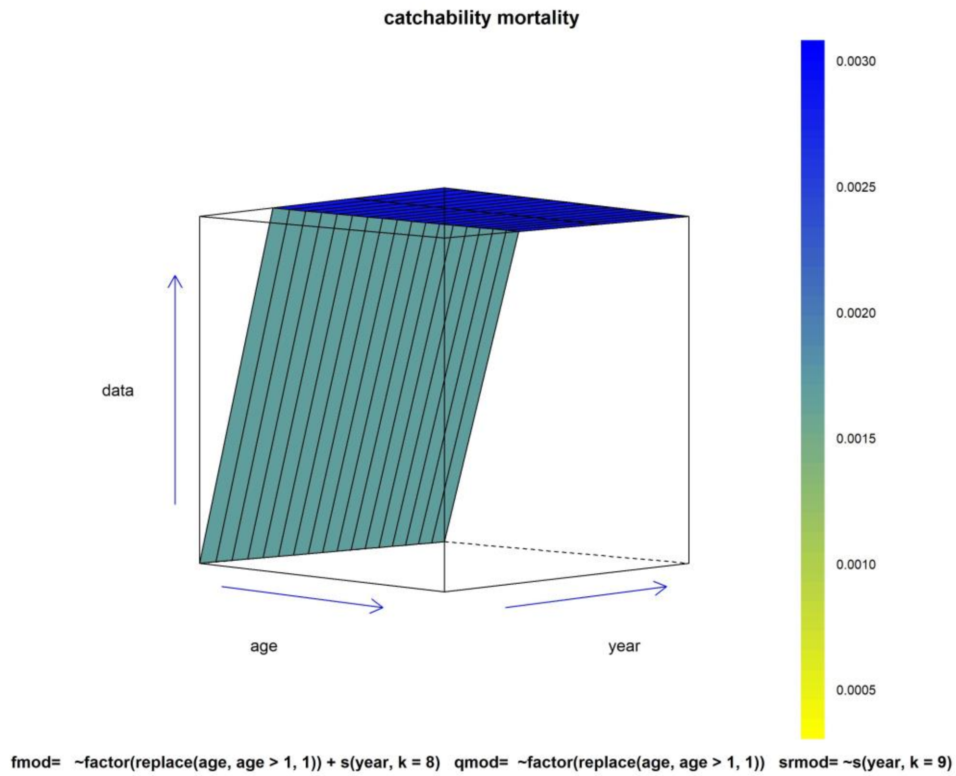


Figure 6.7.3.16. Deep-water rose shrimp stocks in GSAs 17-19. 3D contour plot of estimated catchability at age and year.

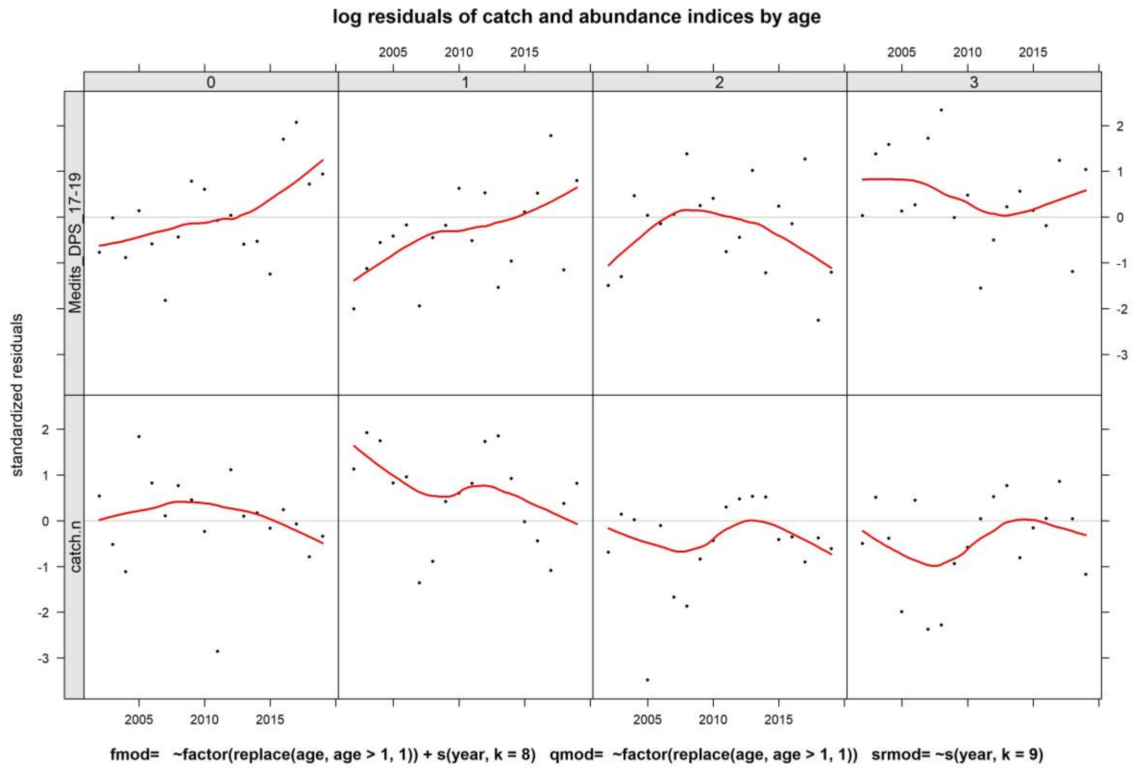


Figure 6.7.3.17. Deep-water rose shrimp stocks in GSAs 17-19. Standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and red lines a simple smoother.

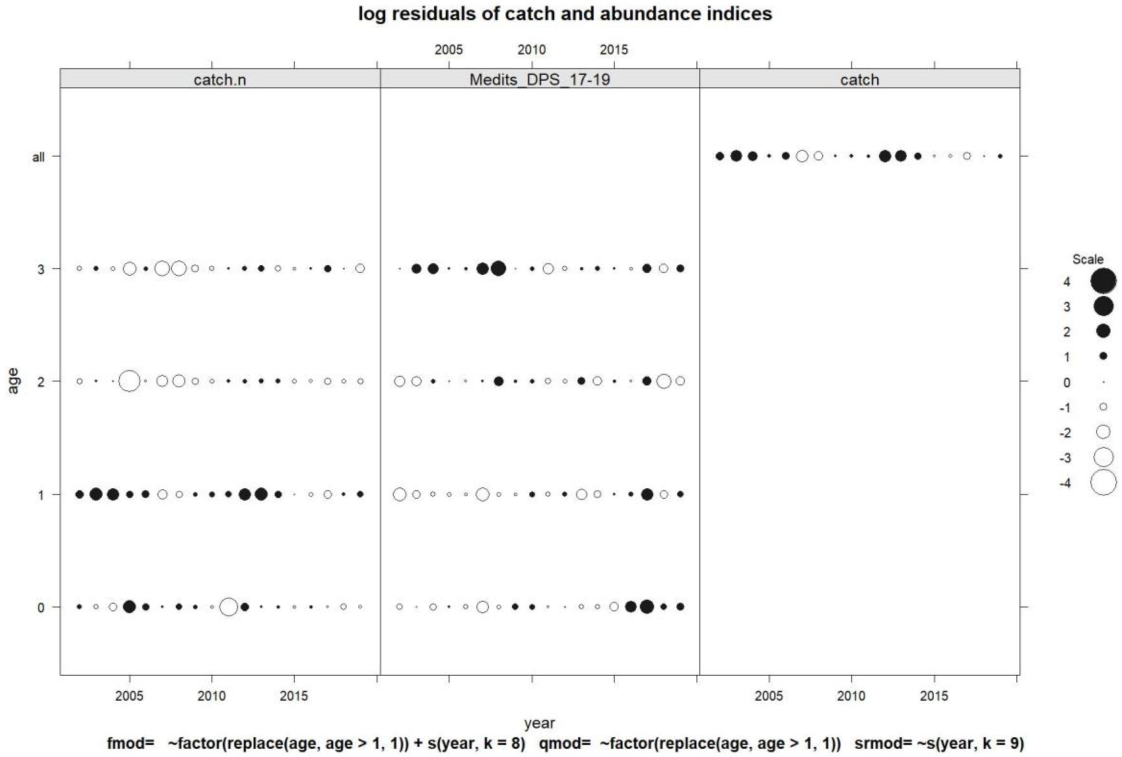


Figure 6.7.3.18. Deep-water rose shrimp stocks in GSAs 17-19. Residuals of residuals for abundance indices and catch by age.

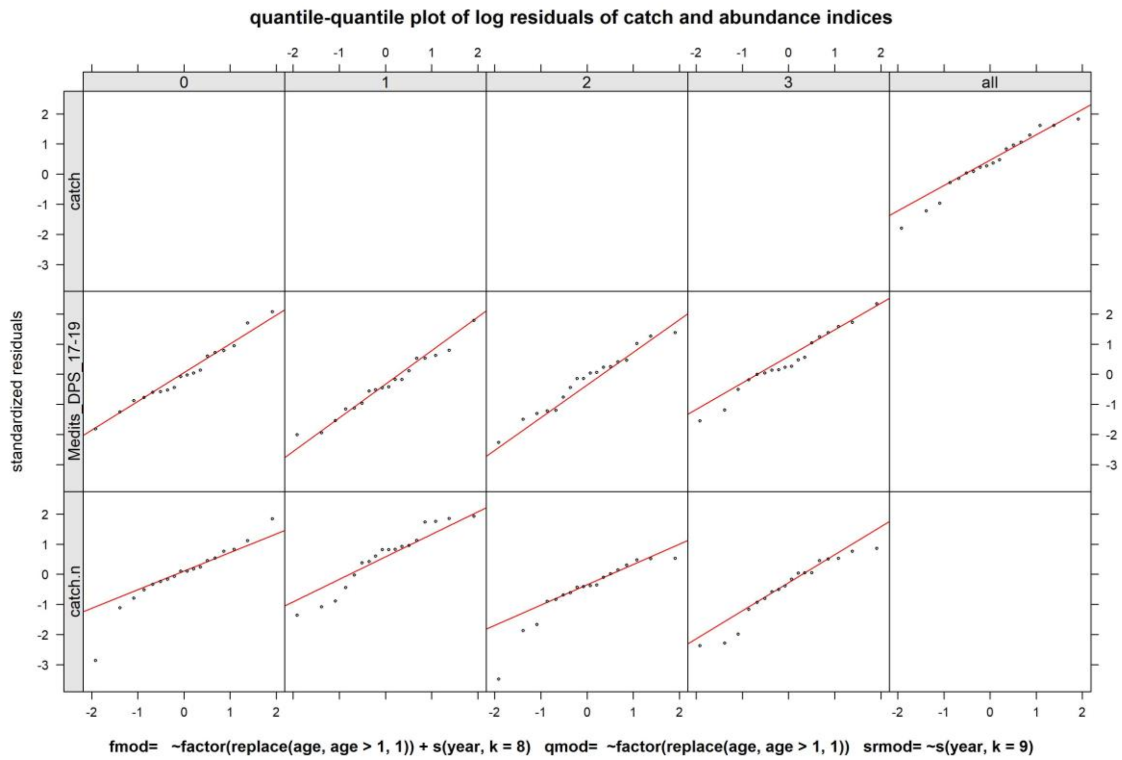


Figure 6.7.3.19. Deep-water rose shrimp stocks in GSAs 17-19. Quantile-quantile plot of standardized residuals for abundance indices and for catch numbers (catch.n). Each panel is coded by age class, dots represent standardized residuals and red lines the normal distribution quantiles.

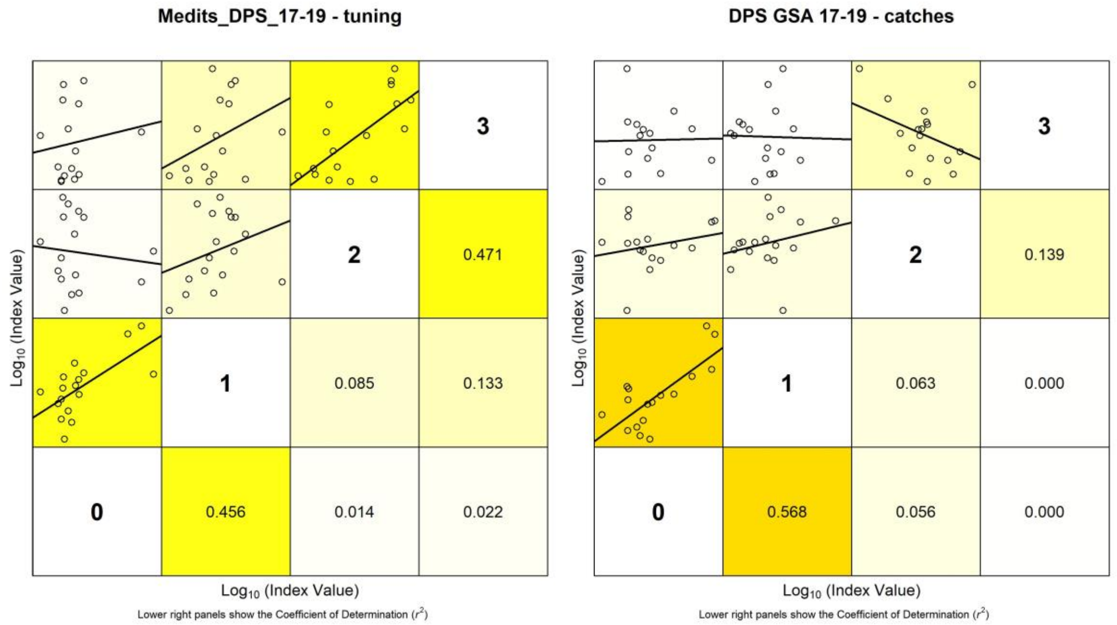


Figure 6.7.3.20. Deep-water rose shrimp stocks in GSAs 17-19. Internal consistency in tuning index and catches.

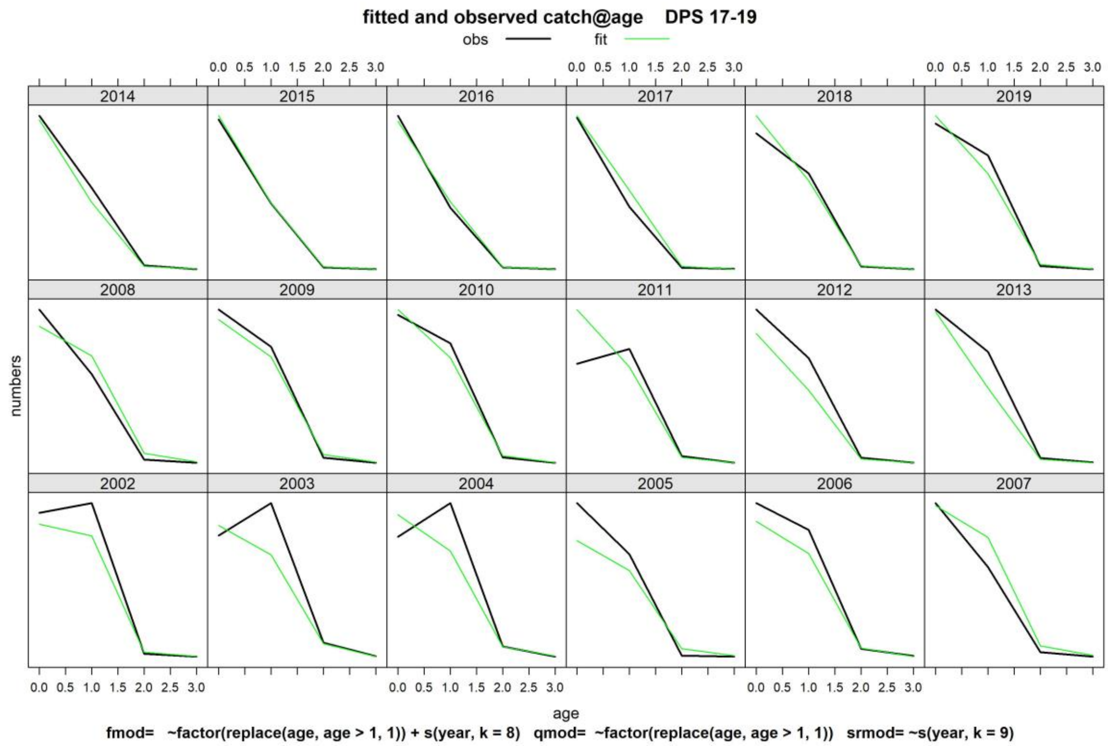


Figure 6.7.3.21. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed catch at age.

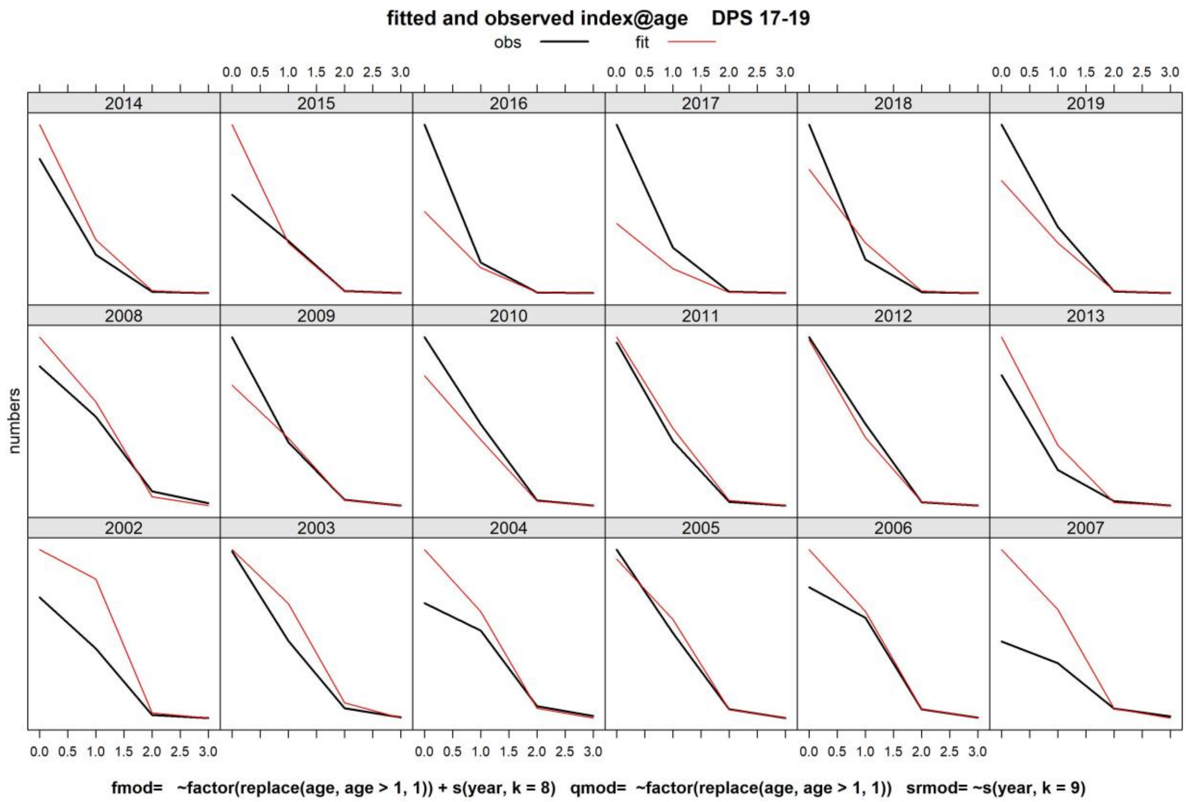


Figure 6.7.3.22. Deep-water rose shrimp stocks in GSAs 17-19. Fitted and observed index at age.

Retrospective

The retrospective analysis applied up to 3 years back shows quite moderate stability for the models (Figure 6.7.3.14).

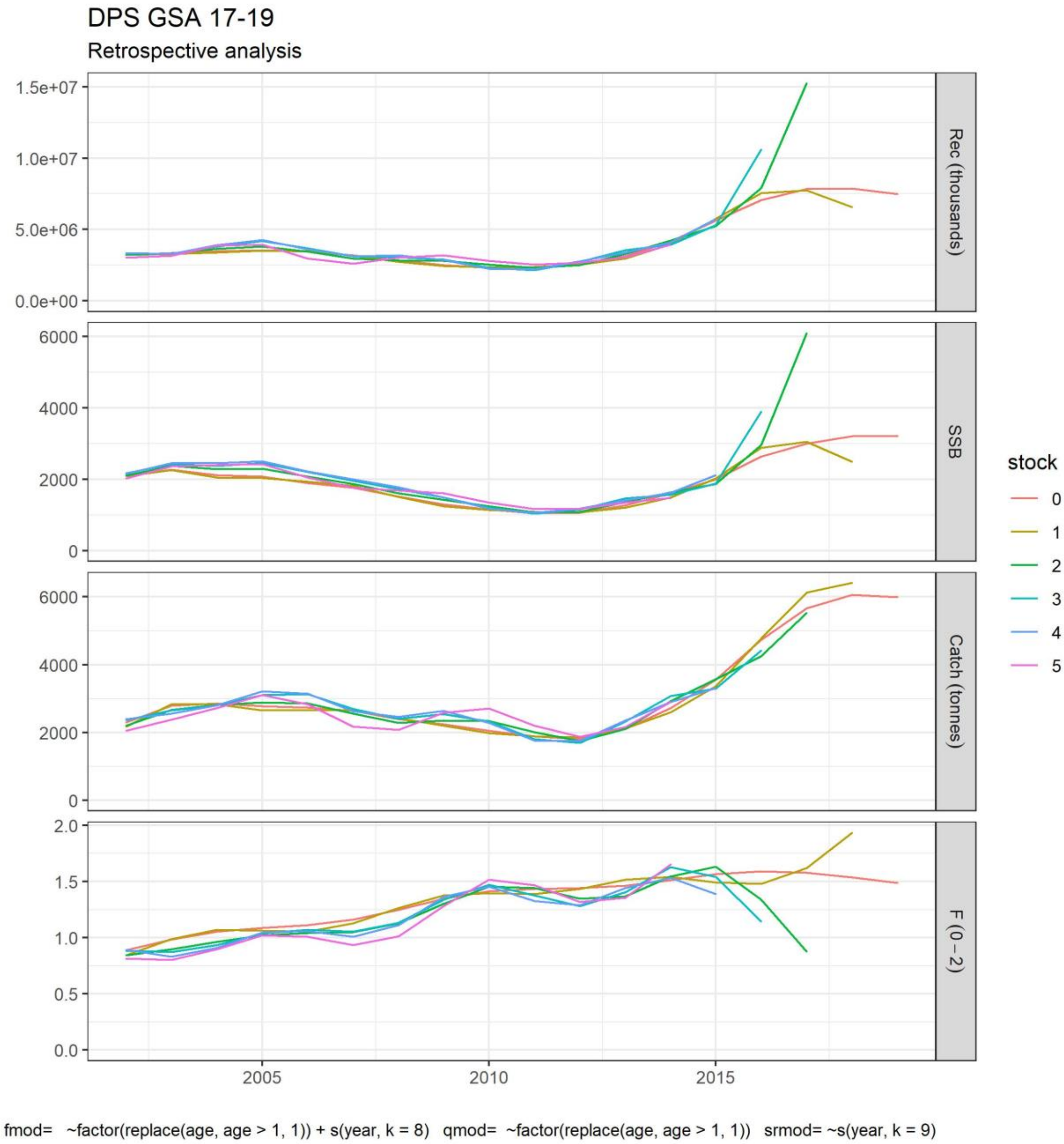


Figure 6.7.3.23. Deep-water rose shrimp stocks in GSAs 17-19: retrospective analysis.

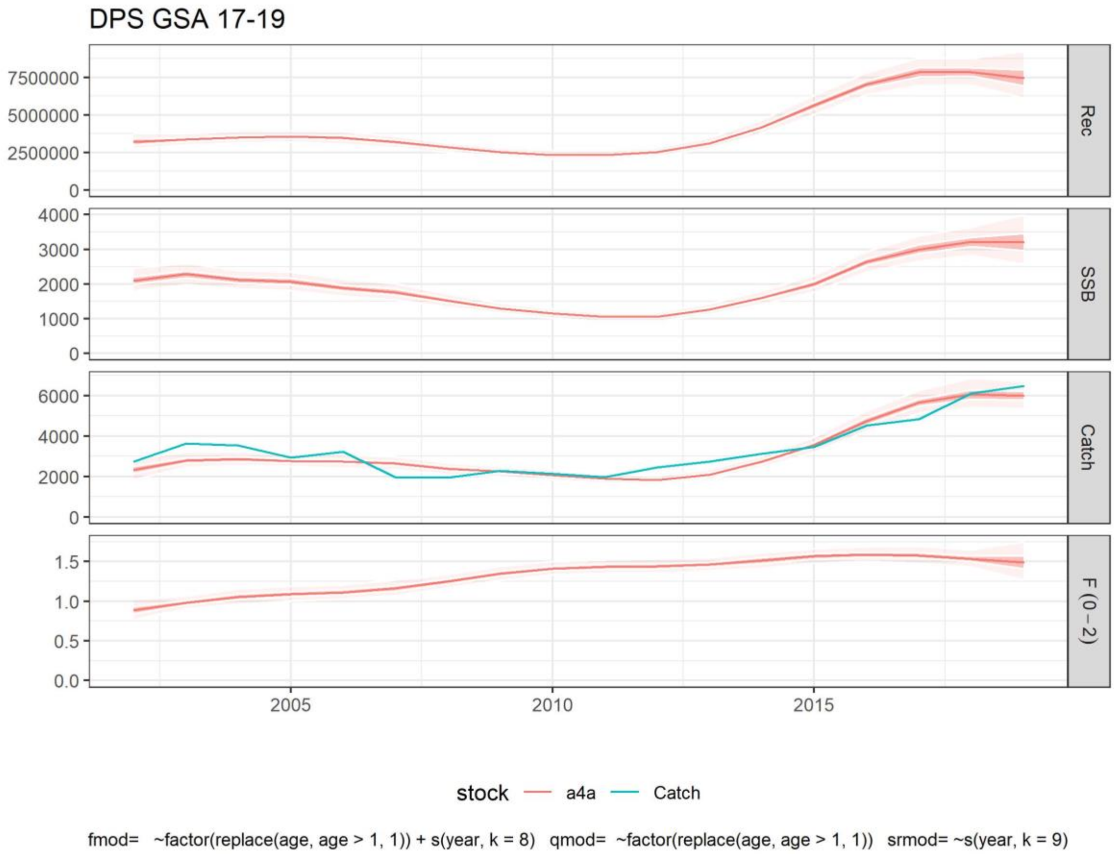


Figure 6.7.3.24. Deep-water rose shrimp stocks in GSAs 17-19: Stock summary (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals.

Conclusions to the assessment

After an extensive sensitivity analysis of possible model configuration, small changes to the previous EWG 19-16 model have been made. Moreover the choice of using a short (2009-2019) and longer (2002-2019) time series was evaluated.

Based on the comparison of the a4a results, the performance of the shorter time series was quantitatively and qualitatively similar to the longer time series, that was finally used for the assessment to give a wider view of the stock over time (Figure **6.7.3.16)**. The shorter timeseries requires greater smoothing, resulting in the greater departure from the mean at the end of the series where the model has greater freedom.

Based on the assessment results, the Deep-water rose shrimp stocks in GSAs 17-19 shows SSB high fluctuated around a mean value of 1811 tons and, after an increasing trend in the number of recruits in the last five years, a sligthly decreasing pattern to a value of 7490295 thousands individuals in 2019. Fbar (0-2) fluctuated and shows a increasing trend in the last years up to a value of 1.49 in 2019.

This assessment is considered acceptable. Retrospective performance is sensetive 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.

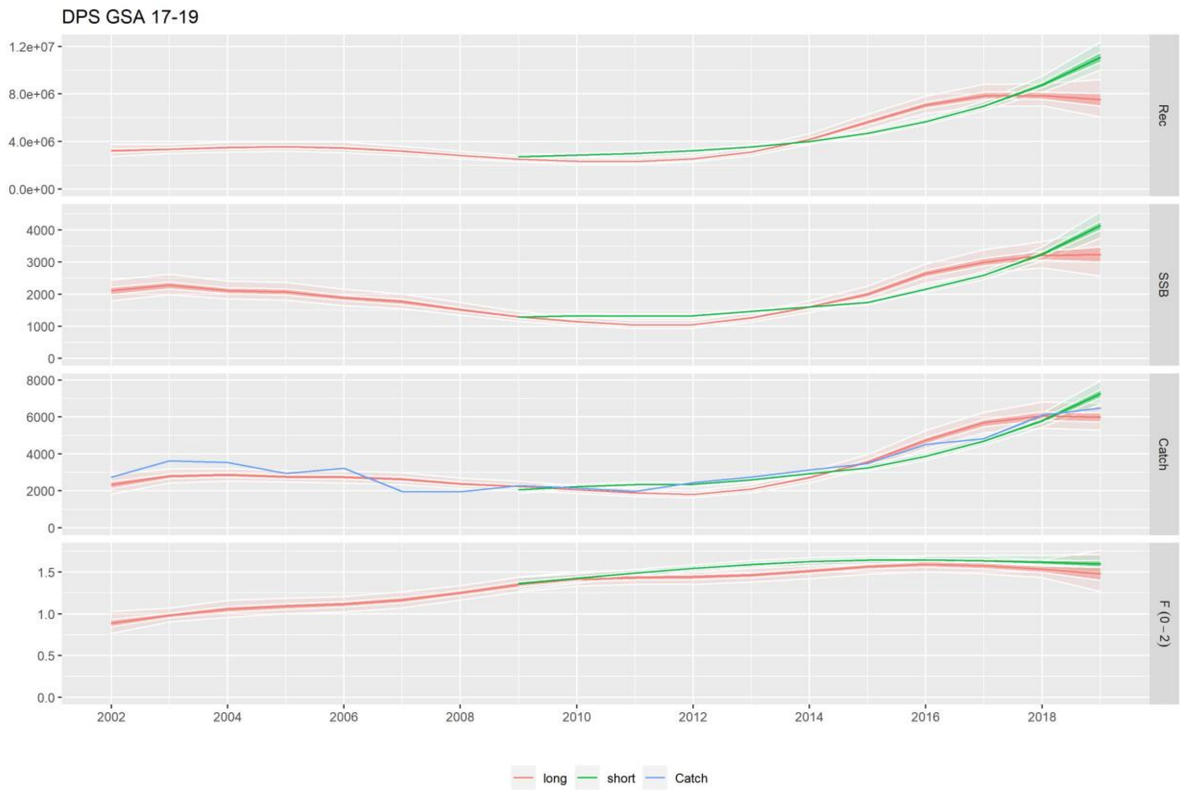


Figure 6.7.3.16. Deep-water rose shrimp stocks in GSAs 17-19: Stock simulations (Recruitment, SSB, catch and Fishing mortality) and 90% confidence intervals for long (2002-2019) and short (2009-2019) time series.

6.7.4 Reference Points

Reference points are based on equilibrium methods. The STECF EWG 20-15 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	0.504	0. 000648	1	0.001	0. 000991

6.7.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2020 to 2022 was performed using the FLR libraries and scripts, and based on the results of the A4A stock assessment.

The basis for the choice of values is given in Section 4.3. An average of the last three years has been used for weight at age, maturity at age, while the F_{bar} =1.49 terminal F (2019) from the a4a assessment was used for F in 2020. Recruitment (age 0) for 2020 to 2022 has been estimated from the population results as the geometric mean of the last 3 years (7730467) because of the recent much higher recruitment observed in the assesment.

Fishing at $F_{0.1}$ in 2021 leads to reduce catch of about 51% (Table 6.7.5.1).

Table 6.7.5.2. Deep-water rose shrimp stocks in GSAs 17-19: 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 2017-2019
$F_{ages\ 0-2}$ (2020)	1.49	F2019 (last year F) used to give F status quo for 2020
SSB (2020)	3245.5 t	Stock assessment 1 January 2020
Rage0 (2020,2021)	7730467	Geometric mean of the last 3 years
Total catch (2020)	5952	Assuming F status quo for 2020

Table 6.7.5.2. Deep-water rose shrimp stocks in GSAs 17-19: Catch options.

Rationale	Ffactor	Fbar	Catch2021	SSB2022	SSB change 2020-2022(%)	Catch change 2019-2021(%)
High long term yield (F0.1)	0.339	0.50	2915.1	6624.1	104.10	-51.36
F upper	0.463	0.69	3691.7	5634.4	73.61	-38.40
F lower	0.226	0.34	2088.4	7795.0	140.18	-65.15
FMSY transition	0.780	1.16	5239.7	3983.8	22.75	-12.57
Zero catch	0	0.00	0.0	11278.1	247.50	-100.00
Status quo	1	1.49	6056.5	3285.5	1.23	1.06
Different Scenarios	0.1	0.15	1007.8	9504.7	192.86	-83.18
	0.2	0.30	1881.5	8106.7	149.78	-68.60
	0.3	0.45	2643.6	6995.3	115.54	-55.89
	0.4	0.60	3312.5	6104.2	88.08	-44.72
	0.5	0.74	3903.4	5383.3	65.87	-34.86
	0.6	0.89	4428.7	4794.9	47.74	-26.10
	0.7	1.04	4898.9	4310.3	32.81	-18.25
	0.8	1.19	5322.4	3907.8	20.41	-11.19
	0.9	1.34	5706.3	3570.5	10.01	-4.78
	1.1	1.64	6378.0	3043.0	-6.24	6.43
	1.2	1.79	6674.7	2834.9	-12.65	11.38
	1.3	1.93	6950.0	2655.1	-18.19	15.97
	1.4	2.08	7206.9	2498.7	-23.01	20.26
	1.5	2.23	7447.5	2361.9	-27.22	24.28
	1.6	2.38	7674.0	2241.4	-30.94	28.05
	1.7	2.53	7888.0	2134.7	-34.22	31.63
	1.8	2.68	8090.9	2039.7	-37.15	35.01
	1.9	2.83	8284.0	1954.7	-39.77	38.23
	2	2.98	8468.1	1878.2	-42.13	41.31

6.7.6 DATA DEFICIENCIES

The data used for the analyses come from the last EU DCF official Data Call (2019). The data related to non-EU countries was provided during the meeting for Albania but for last years only. Data from Montenegro were not available. Landings LFDs from GSA19 and GSA18 (Italy) were available from 2002. In GSA18 LFDs were missing in 2006 and 2008 for italy and in all 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 years.

Finally 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.

6.8 CARAMOTE PRAWN IN GSA 17 AND 18

6.8.1 STOCK IDENTITY AND BIOLOGY

Panaeus kerathurus is a demersal species living in coastal areas or in brackish water on sandy or sandy mud bottoms. It can be found at depths of 0.5 to 100 m but it is common between 5 and 40 m, usually at less than 60 meters depth (Froglia et al., 2013). Camarote prawn is a euryhaline species; during the breeding season it goes closer to coast and mouths of rivers and can also be found in lagoons (Falciai and Minervini, 1992). This species has extremely varied feeding habits and mostly influenced by seasonal availability of benthonic preys, mainly crustaceans anellids and molluscs. Besides active predation, it does not disdain organic remains, which represent a necrophagous component of its diet (Bolognini, 2017).

Juveniles enter lagoons and are common on coastal grounds in late summer and autumn (Palmeggiano, 1983; Scovacricchi et al., 1994). It is a demersal species, spends the day burrowed in the sediment. It goes out only during the night in order to feed on and mate. It is a typically resident species, and migrates towards and from the coast only to favour reproduction (Lumare et al., 1971).

Nowadays, it is a highly valuable fishery resource in the Northern and central Adriatic Sea (GSA-17), with annual landings estimated around 500 tons, and a peak in the last quarter of the year, when the new generation of shrimps, born in summer, move offshore and is fully recruited to the fishery.

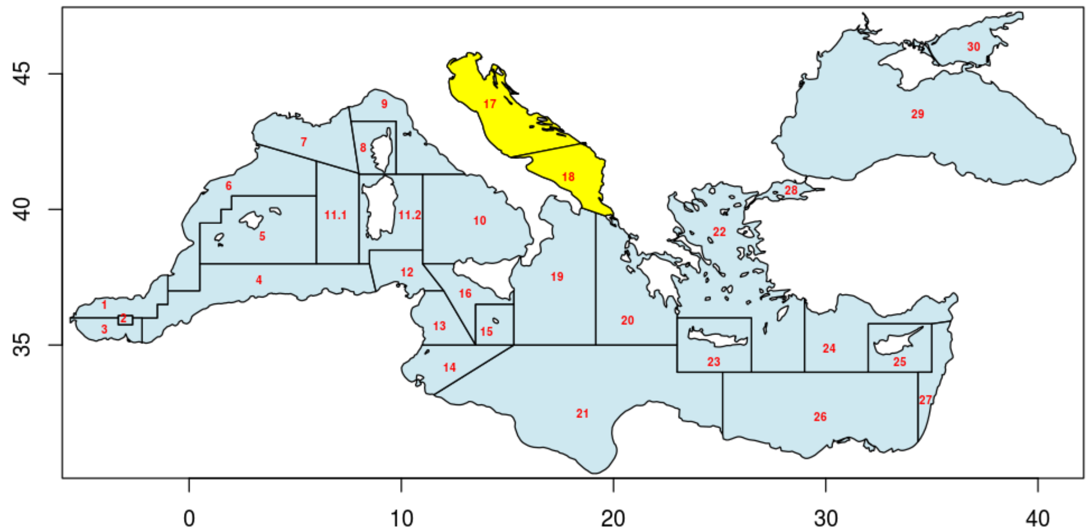


Figure 6.8.2.1 Caramote prawn in GSAs 17 and 18. Geographical location of GSAs 17-18

STECF EWG 20-15 was asked to assess the state of Caramote prawn stocks in the Adriatic Sea by GSAs combined.

However, due to the landing data time series recovered coming mainly from the GSA 17 (landings from GSA 18 are in most of the time series negligible) and survey data coming almost exclusively from GSA 17, the decision was taken to make assessment only for GSA 17.

Age and growth

Like most of the penaeids, also *P. kerathurus* shows clear sexual dimorphism, due above all to the large sizes of females which, in the Mediterranean, may reach a maximum total length of 225 mm, whilst in males the maximum size is of 180 mm (Bolognini, 2017). The maximum age is about 20 months (Rodriguez, 1987) and only few specimens can reach the third year of life (Vitale et al., 2010).

Table 6.8.2.1 parameters used for growth and weight at length taken from literature.

Growth Equation	$L\infty$	k	t_0
$L(t) = L_\infty *[1 - exp(-K*(t-t_0))]$	72	0.78	-0.5
Weight at Length	a	b	
aL^b	0.00469	2.406	

The length data sliced to ages gave almost exclusively a single age 1 yearclass for each year. Due to the lack of continuity across years for the age cohorts represented in the catch, EWG 20-15 decided to not use the growth parameters based lengths slicing approach from DCF data. This lack of multiple observations of each cohort made age based assessment impossible and it was agreed not to be used.

Natural mortality

A natural mortality vector by age was estimated using the Chen and Watanabe model from the growth parameters derived from the literature. This vector was used to perform an attempt with an age-based assessment model (a4a).

	Age 0	Age 1	Age 2	Age 3+
M	2.415	1.131	0.909	0.834

Maturity

The sexual activity is strongly affected by water temperature (Holtius, 1980); reproduction occurs in shallow waters. Actually, gonadal maturation takes place during spring/summer (Lumare et al., 1971) and June and July are the months when a high percentage of mature females can be found (Lumare et al., 2011). The penaeids that inhabit temperate zones are characterized by one and well-defined recruitment period, recorded in GSA 17 as a conspicuous spawning peak in July. Differently the tropical and subtropical penaeids exhibit a bimodal seasonal spawning pattern (Bolognini et al., 2017). In GSA 17, a sex-ratio biased toward female was observed (0.466) and a 30.7 mm of carapace length size at first sexual maturity was estimated for females (Bolognini et al., 2017). This size is lower respect to what reported for the same species in the

South-Eastern coast of Italy by Lumare et al. (2011). The number of eggs varies according to the animal size and, upon spawning, their diameter is 0.2-0.3 mm (Scovacricchi, 1994). Hatching begins after about 14 days, and the larval succession is represented by 3 stages: nauplius, zoea and mysis. At the end of the summer season juvenile specimens leave coastal areas, and settle on infralittoral sandy bottoms, where waters are less affected by surface temperature variations (Scovacricchi, 1994).

General description of Fisheries

Italian and Slovenian commercial fleets target Caramote prawn. Since Slovenian landings represent less than 1% of the total, only the Italian fleet has been considered for this stock assessment.

The caramote prawn is an important commercial resource and one of the most appreciated crustacean species (Lumare & Scordella, 2001), exploited almost exclusively by Italy. However, catches of this species were not deemed important, from an economical point of view, until few years ago, considering modest landings; indeed it appears in FAO statistics only in 2005 (Bolognini, 2017). It does not represent a targeted species but is a by-catch of bottom trawl fishery. It is caught mainly with bottom and beam ("rapido") trawl nets, but gillnets and trammel nets are used as well. In the Adriatic Sea, is also an important target of small-scale artisanal fishing activity.

Management regulations

In Italy and Slovenia, the main rules in force are based on the applicable EU regulations (mainly EC regulation 1967/206):

– Minimum landing sizes: NA

– Codend mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod-end with 40 mm (stretched) square meshes or a codend with 50 mm (stretched) diamond meshes.

– Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

– Set net minimum mesh size: 16 mm stretched.

– Set net maximum length x vessel x day: 5,000 m Italy has also a national regulation:

– Fishing closure for trawling: 30-45 days in late summer (not every year the same days)

– Trawling activity banned up to 6 nautical miles 3 months after the summer closure.

6.8.2 DATA

Data from DCF dated from 2011 till 2019. It contained total landings from Italy (GSA 17 and 18) and Slovenia. Discards were very scarce just for some years and were negligible.

Longer time series were recovered from Italian Official Statistics data back to 1972 for GSA17.

Length data from DCF data were available for the period from 2011 to 2019, from few fishing gears (OTB, TBB, GNS, GTR). Due to the problems in the transferring length into age data producing practically only one age class, they were not used in assessment (see Section 6.8.1 above).

6.8.2.1 CATCH (LANDINGS AND DISCARDS)

Caramote prawn catches in GSA 17 are collected from Italian official statistics, for the period from 1972 to 2010, and from DCF data, from 2011 onwards. Catches are from bottom trawl, beam trawl, gill net and trammel net fisheries.

Discards as well as the catches from Slovenia were negligible. In Croatia caramote prawn has no record of being either a target or a bycatch species (Table 6.8.3.1.1.).

In GSA 18 landings of this species are not negligible (from 5.5 to 357 t, average of 147 t, 27% of GSA 17 landings) but since there is no long-term data from the surveys in GSA 18 and data from landing from other countries in GSA 18 is lacking, EWG 20-15 decided that all assessments and advice will be based on GSA 17 data.

Total landings in GSA 17 of this species were low until 2006 and after that an obvious increasing trend has started (Figure 6.8.3.1.1).

Table 6.8.3.1.1. Caramote prawn stock in GSA17: Landings and discards data in tones by gear as reported from DCF 2019.

Year	ITA GSA17	SVN GSA17	Discards	Total
2005	-	0.01	-	-
2006	-	0.10	-	-
2007	-	0.35	-	-
2008	-	0.12	-	-
2009	-	0.22	-	-
2010	-	0.06	-	-
2011	546	0.11	5	551
2012	323	0.20	0	323
2013	381	0.04	2	383
2014	363	0.96	0	363
2015	511	1.31	1	512
2016	516	5.25	0	516
2017	974	0.04	28	1002
2018	957	0.01	42	999
2019	768	0.35	0	768

Table 6.8.3.1.2. Caramote prawn stock in GSA17: Catch data (landings) in tones by ITA in GSA 17 (from 1972 till 2011 from Italian official statistic, from 2011 till 2019 from DCF data)

year	Total landing	year	Total landing	year	Total landing
1972	185.3	1988	139.0	2004	168.0
1973	155.5	1989	138.3	2005	212.5
1974	125.7	1990	117.6	2006	330.6
1975	158.9	1991	145.3	2007	690.5
1976	160.5	1992	217.1	2008	502.1
1977	154.4	1993	141.7	2009	515.4
1978	115.5	1994	142.4	2010	550.4
1979	130.0	1995	195.9	2011	546.0
1980	133.4	1996	205.3	2012	323.0

1981	133.4	1997	170.6	2013	381.0
1982	136.8	1998	150.7	2014	363.0
1983	136.0	1999	176.8	2015	511.0
1984	152.2	2000	191.7	2016	516.0
1985	146.8	2001	319.1	2017	974.0
1986	159.6	2002	146.1	2018	957.0
1987	168.8	2003	163.2	2019	768.0

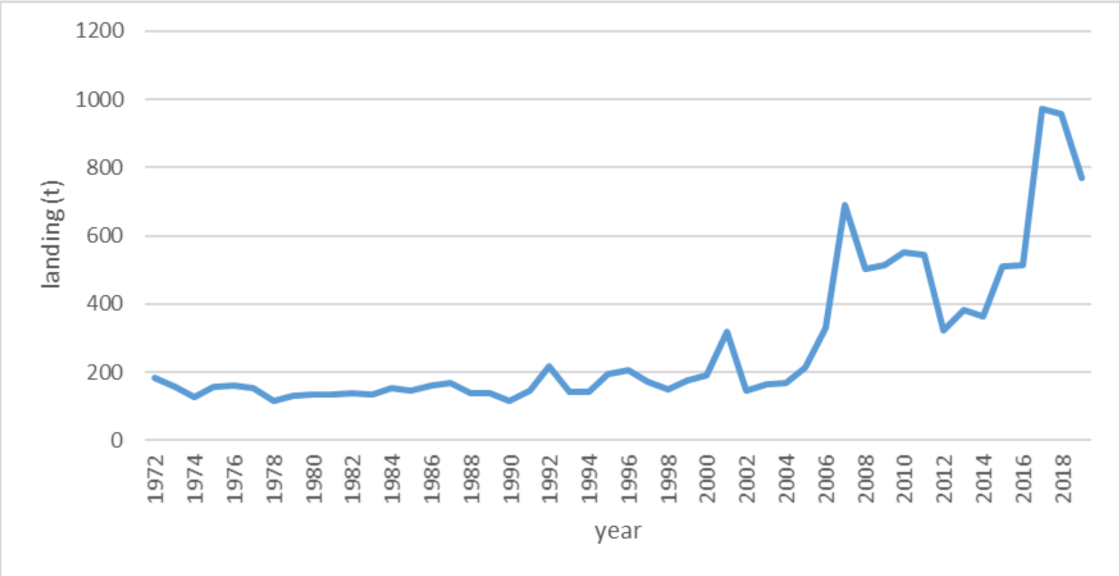
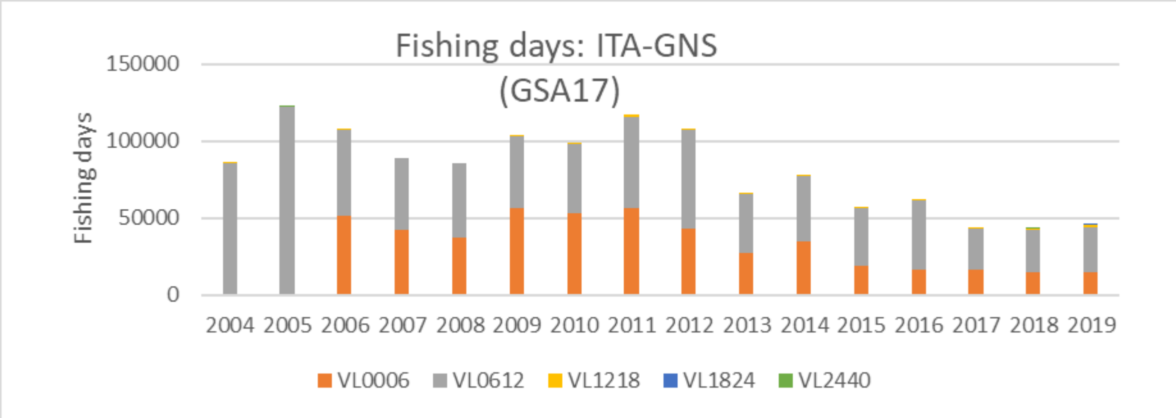
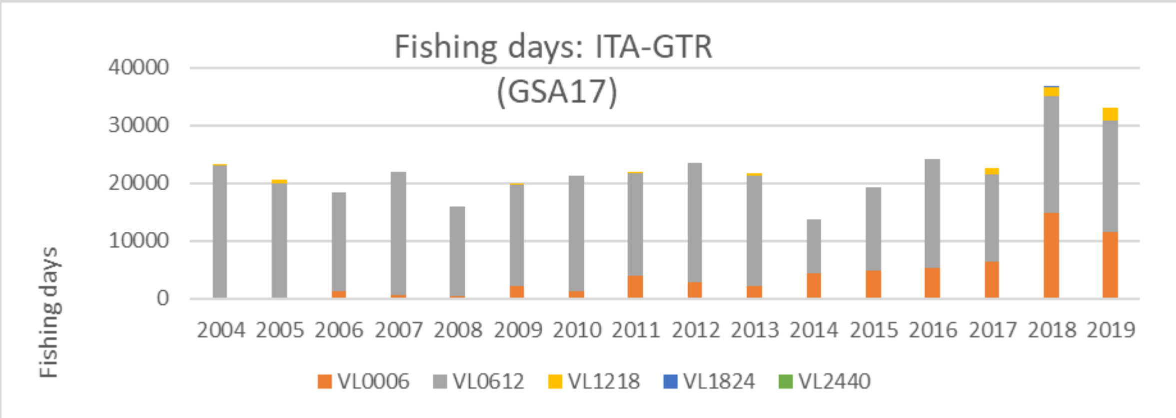


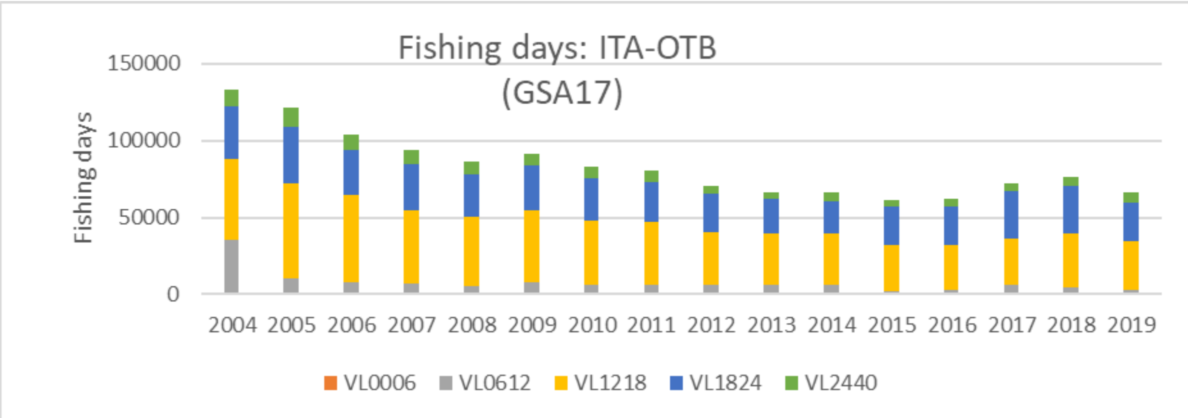
Figure 6.8.3.1.1. Caramote prawn stock in GSA17: Total landings in tons.

6.8.2.2 EFFORT

Fishing effort data were reported to STECF EWG 20-15 through DCF. Italy and Slovenia are the countries involved with fishing on this stock in GSA17.different fishing gears have reported catches of caramote prawn, however most of the catches deriving from bottom trawl fishery and to a lesser extent for the gill net, trammel net and beam trawl fisheries.


Fishing days: ITA-GNS (GSA17)
Fishing days
150000
100000
50000
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
VL0006 VL0612 VL1218 VL1824 VL2440


Fishing days: ITA-GTR (GSA17)
Fishing days
40000
30000
20000
10000
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
VL0006 VL0612 VL1218 VL1824 VL2440


Fishing days: ITA-OTB (GSA17)
Fishing days
150000
100000
50000
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
VL0006 VL0612 VL1218 VL1824 VL2440

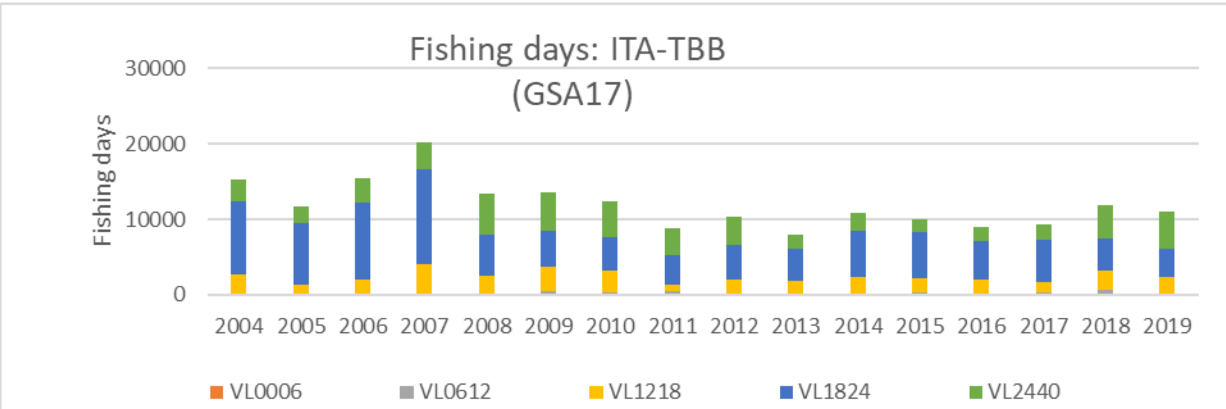

Fishing days: ITA-TBB (GSA17)
Fishing days
30000
20000
10000
0
2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
VL0006 VL0612 VL1218 VL1824 VL2440

Figure 6.8.3.2.1. Caramote prawn stock in GSA17: Fishing effort in days at sea and fishing days by year, fishing gear, country (Italy and Slovenia) and GSA.

6.8.2.3 SURVEY DATA

MEDITS

In GSA 17 MEDITS data are available from 1994 to 2019. 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). Data were analysed using the JRC script (Mannini, 2020)

Biomass index of caramote prawn shows slight increasing trend. The values at the beginning of the time series (from 1994 even till 2012) were around 0, with peak in 2001. In 2013 till 2017 increase can be observed (with low values in 2015) and in 2018 significant drop in the biomass index was observed.

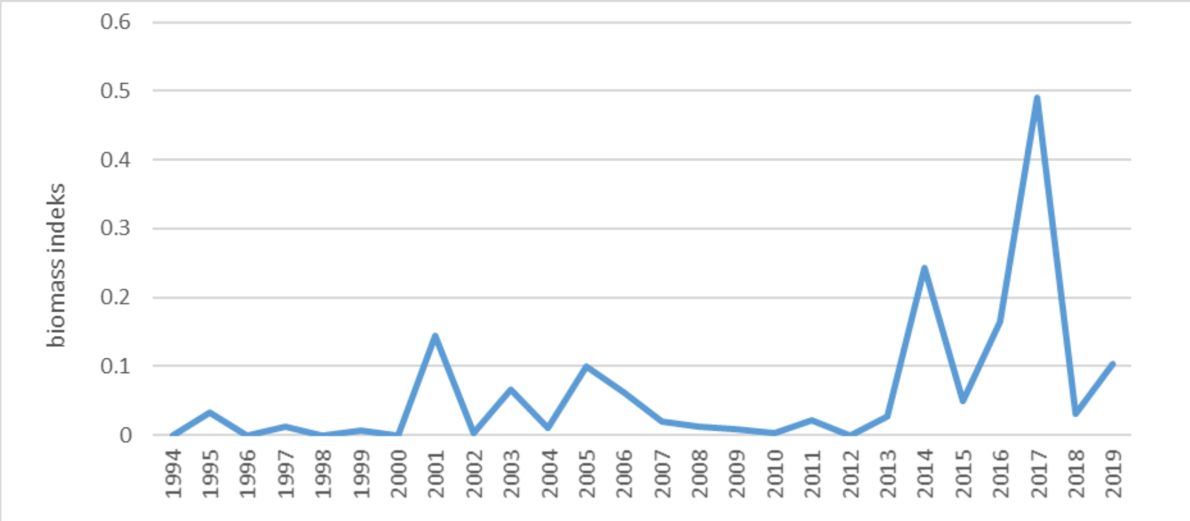


Figure 6.8.3.3.1. Caramote prawn stock in GSA17: Estimated biomass index (kg/km^2). MEDITS survey.

SoleMon

Rapido trawl fishing surveys were carried out in GSA 17 from 2005 to 2019: two systematic "pre - surveys" (spring and fall 2005) and random surveys (spring and fall 2006, fall 2007-2019) 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).

The abundance and biomass indices by GSA 17 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 area in the GSA 17.

It was noted that while this is a standard approach, the calculation may be biased due to a number of different factors including the change in the number of hauls over time, and change of the survey time over the years. Precision may also be affected by the choice of parametric distribution, a normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-Poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. 2004).

The SoleMon trawl surveys provided trend in abundance for caramote prawn. The trends in biomass indices show a clear increase in the stock from 2005, with rather big fluctuations during time series.

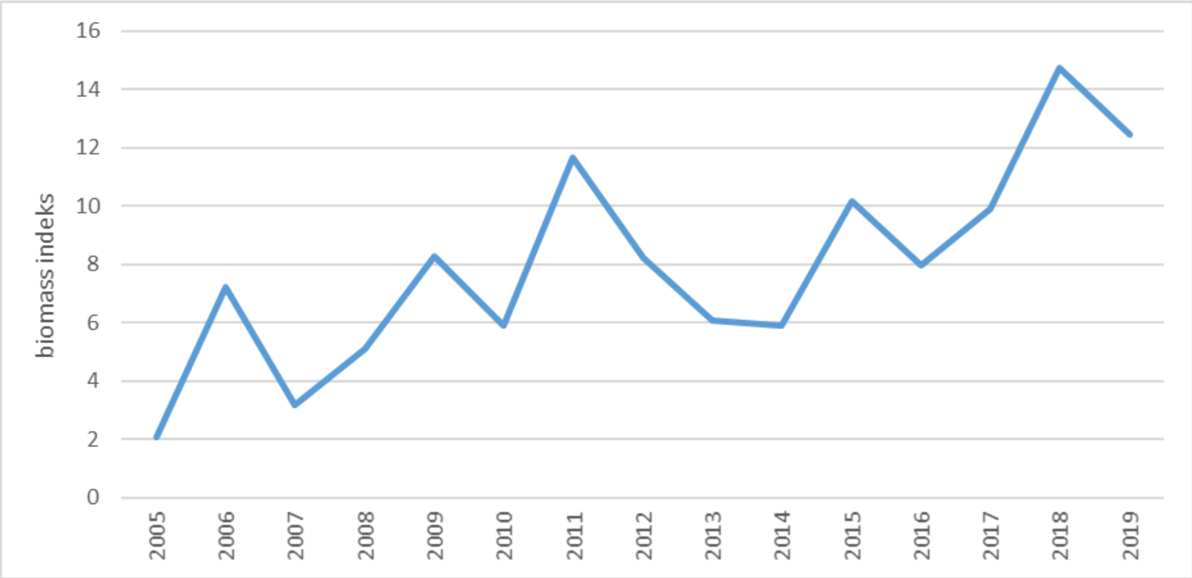


Figure 6.8.3.3.2. Caramote prawn stock in GSA17: Estimated biomass index (kg/km^2). SoleMon survey.

6.8.4 Stock assessment

Stock assessment for the caramote prawn in EWG 20-15 was attempted with two approaches: an age-based assessment using a4a and a surplus production model with SPiCT. However, both models were discarded and catch advice was provided based on the biomass index from the SoleMon survey. A brief overview of the two assessments is provided as a record of what was carried out by the EWG.

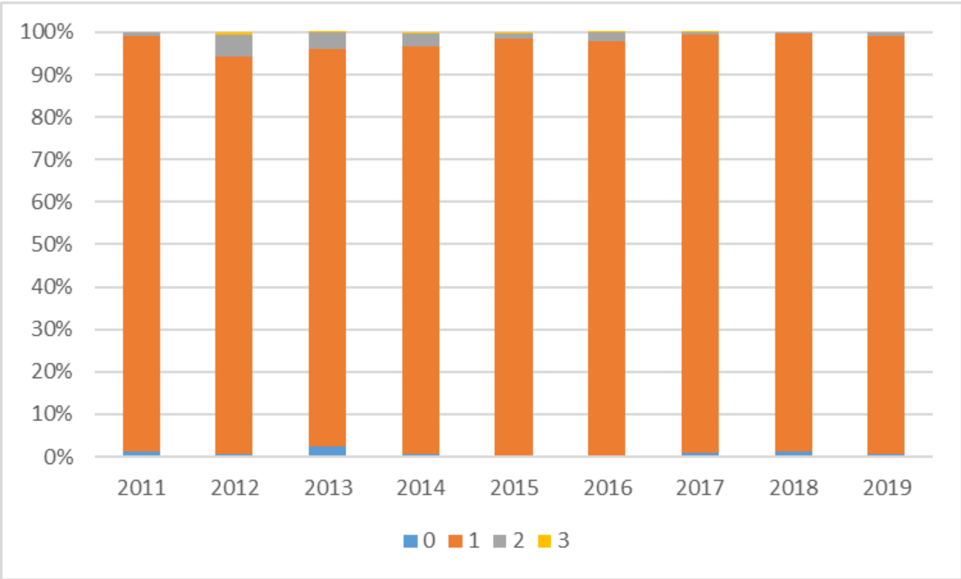
6.8.4.1 Method1: a4a

FLR libraries were employed in order to carry out a Statistical Catch-at-age (a4a) assessment.

Input data

LFDs from DCF landing data from DCF were transformed by deterministic age slicing with VBGF parameters (Linf, k) gathered from the literature and with agreed t0. However, results of age slicing showed mainly just one age group (age 1) that was not suitable for running an age-based model, like a statistical catch-at-age model with a4a.

Furthermore, the internal consistency between cohorts obtained by means of age slicing was very poor (Figure 6.8.4.3).



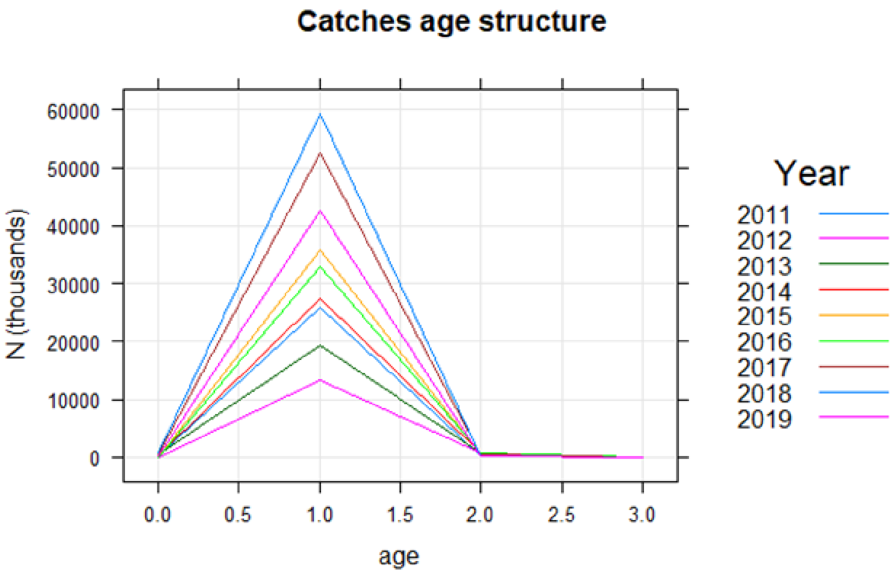


Figure 6.8.4.1.1. Caramote prawn stock in GSA17: age composition after deterministic age slicing.

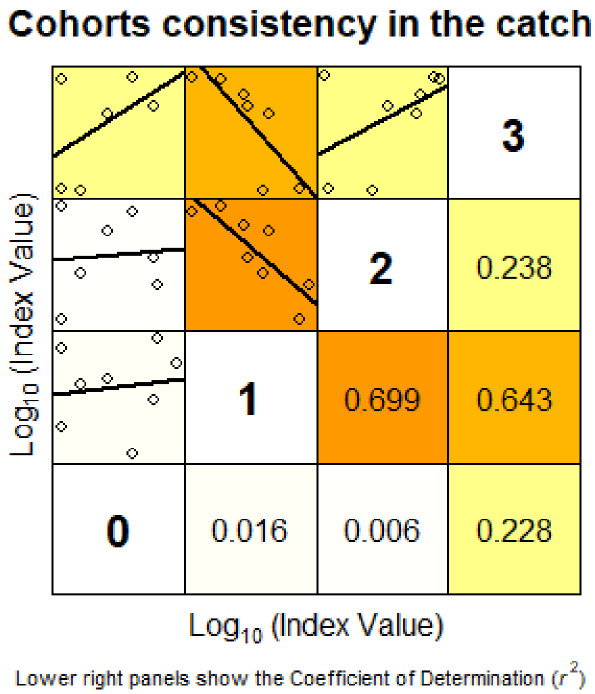


Figure 6.8.4.1.2. Caramote prawn stock in GSA17; internal consistency of the catch.

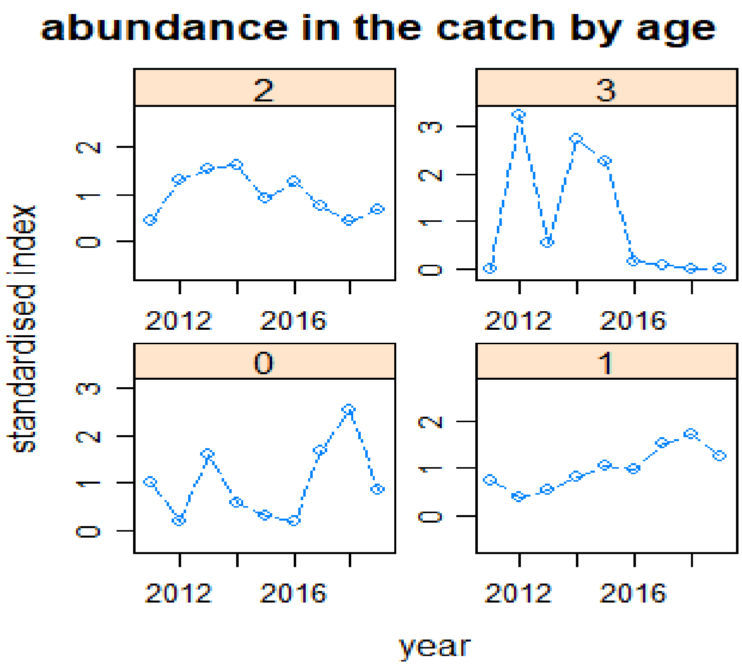


Figure 6.8.4.1.3. Caramote prawn stock in GSA17: abundance in the catch by age.

As tuning index in the a4a run, the SoleMon biomass index was used (Figure 6.8.3.3.2.). Some simple model settings were attempted, and none of them converged

Retrospective

Since the model did not converge, no retrospective was produced.

6.8.4.2 METHOD 2: SPICT

EWG 20-15 thus decided to try with a surplus production model with SPiCT using landing data and biomass indices from both SoleMon and MEDITS surveys. For this, data from Italian official statistics and the RECFISH project (Ligas, 2019) were recovered starting from year 1972.

The landings and tuning indexes MEDITS (from 1994 to 2019) and SOLEMON (from 2005 to 2019) biomass index are shown in Figure 6.8.4.2.1.

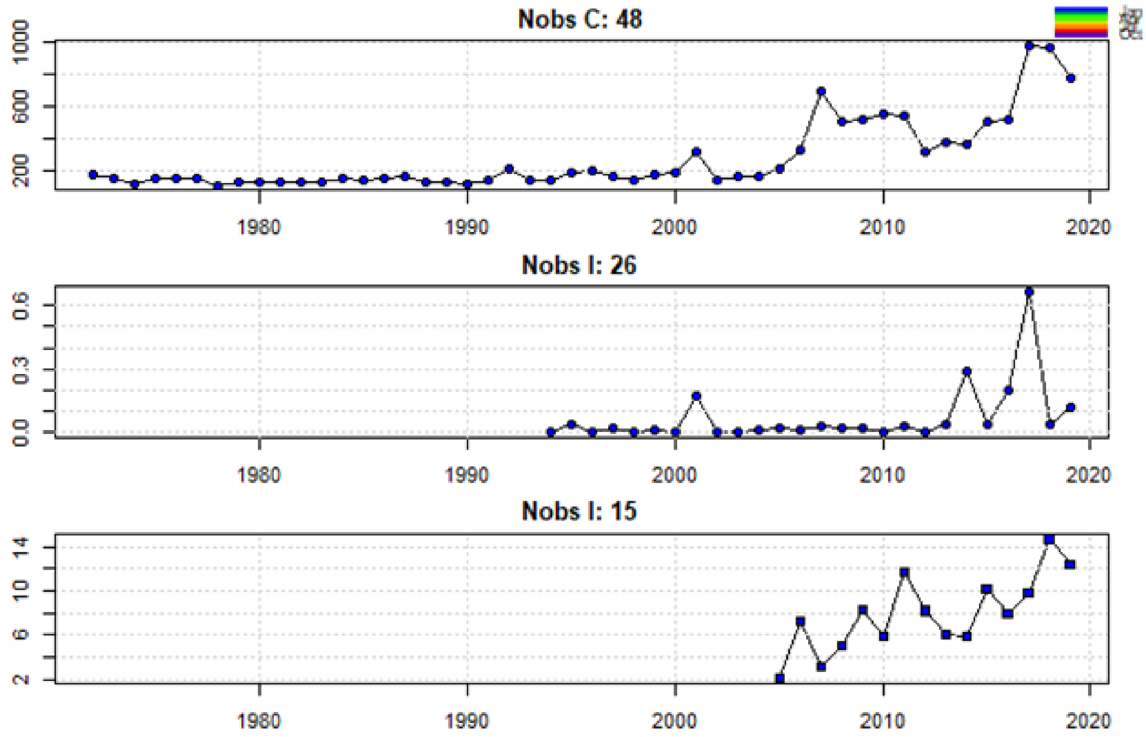


Figure 6.8.4.2.1. Caramote prawn stock in GSA17: input data for SPiCT model: landings, MEDITS and SoleMon indexes.

Several SPiCT runs were attempted, all of them producing uncertain and unstable and considered not suitable and robust enough to be used to provide advice on the status of this stock.

Below, the outputs of the run performed using a shortened time series of landings (from 1994 to align with MEDITS) and a prior for r (0.57, 95% CL 0.37-0.85; from www.sealifebase.se, computed on 4 stocks) are presented.

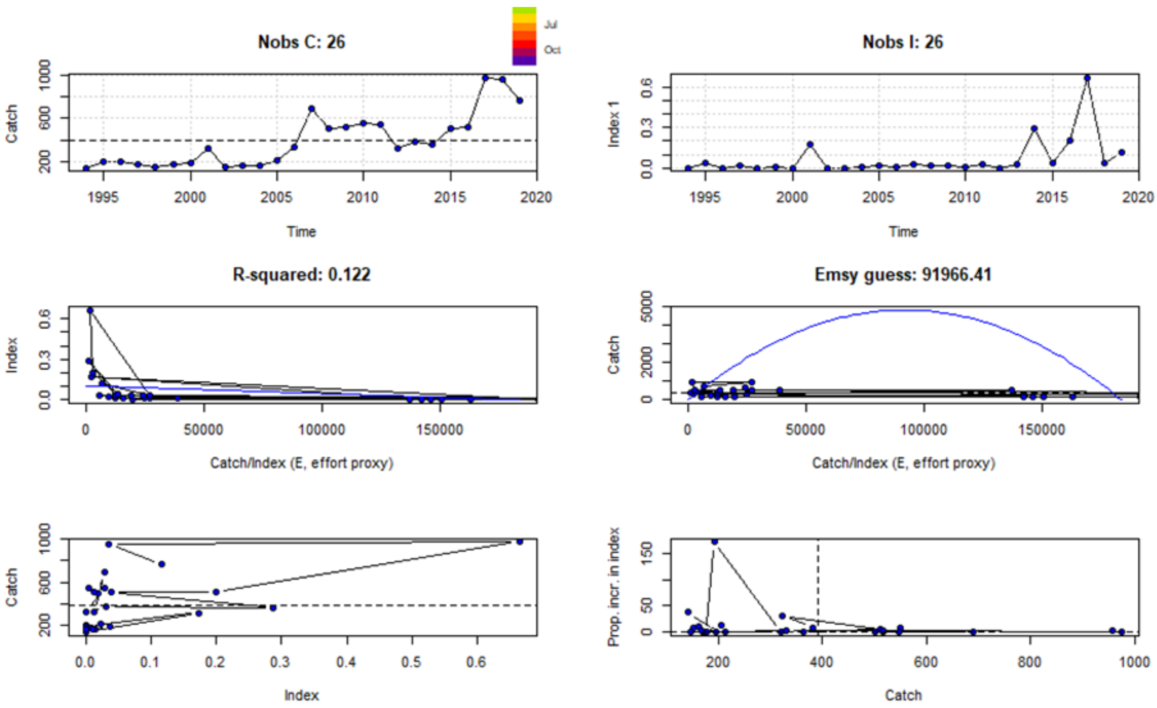


Figure 6.8.4.2.2. Caramote prawn stock in GSA17: Fitting of the input data (landings vs MEDITS biomass index).

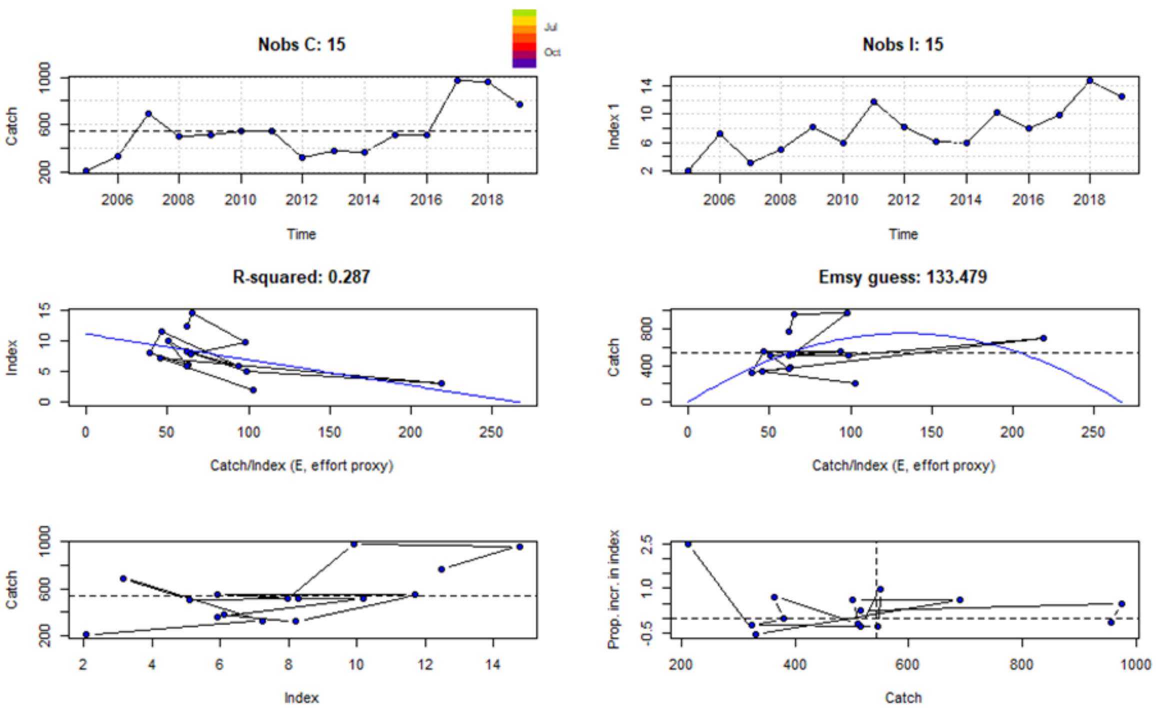


Figure 6.8.4.2.3. Caramote prawn stock in GSA17: Fitting of the input data (landings vs SoleMon biomass index).

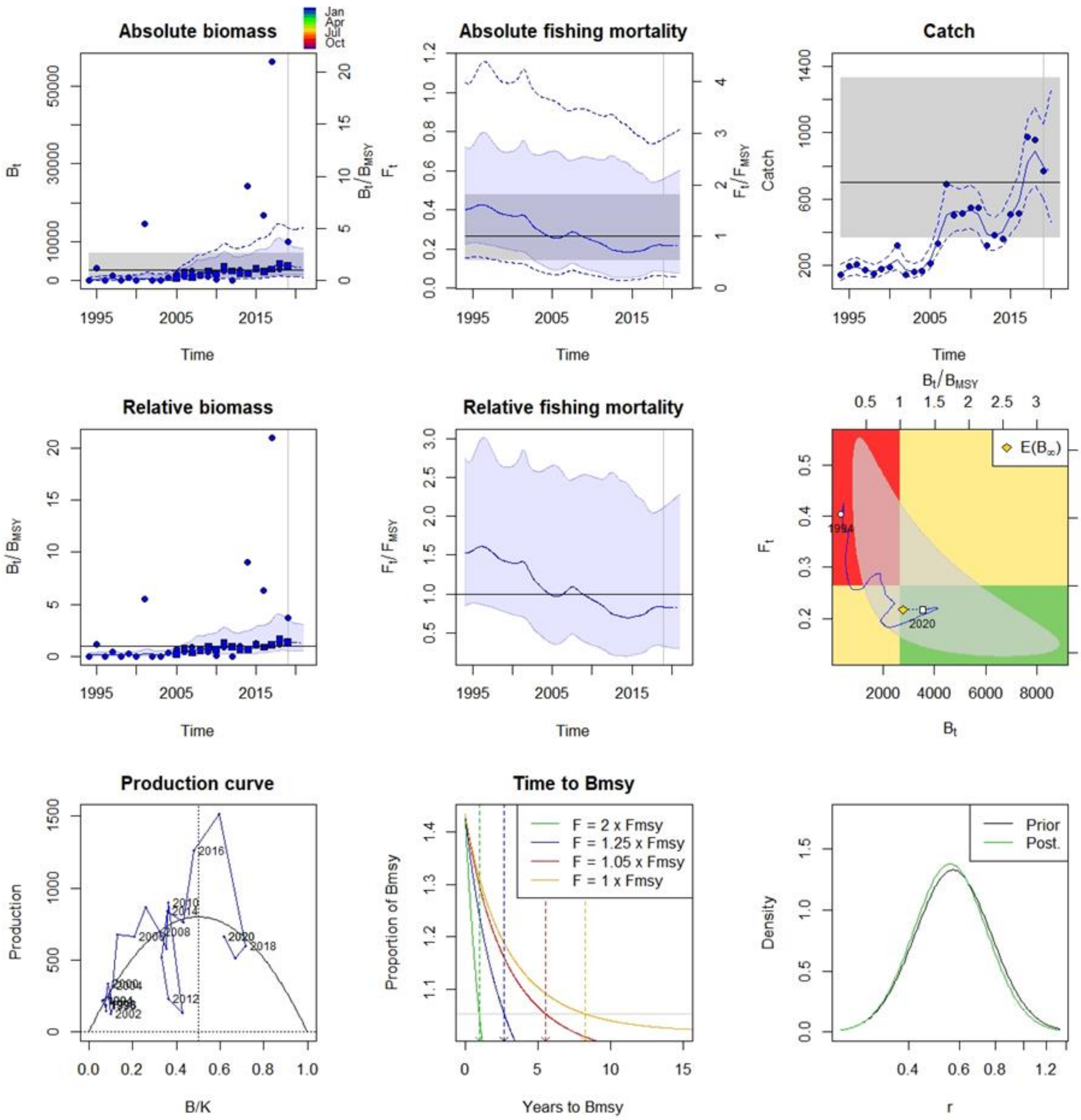


Figure 6.8.4.2.4. Caramote prawn stock in GSA17: Plot of the main results of the model.

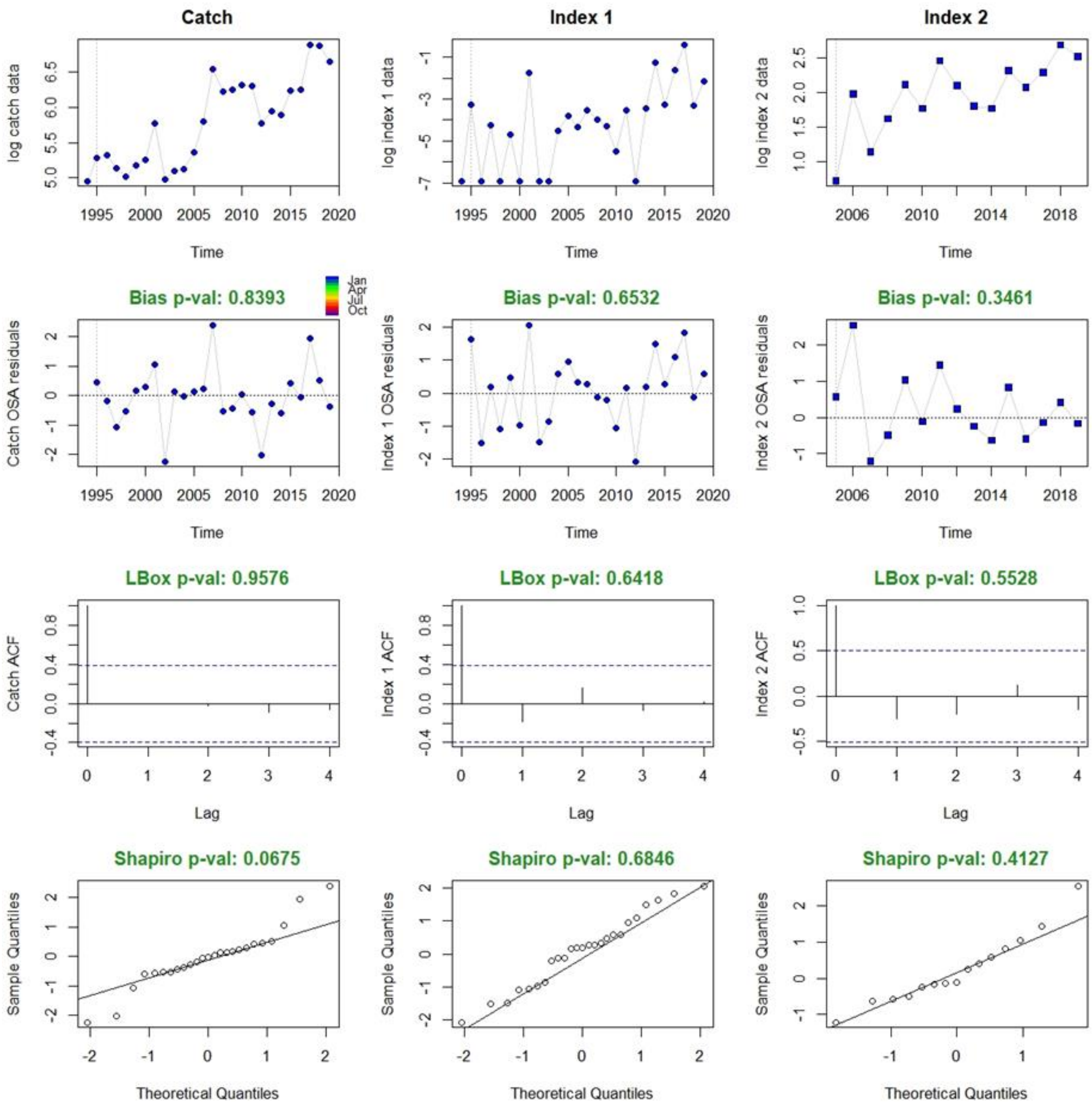


Figure 6.8.4.2.5. Caramote prawn stock in GSA17: Plot of the diagnostics.

Retrospective

The retrospective analysis applied up to 3 years back shows no stability at all in the all of the model runs.

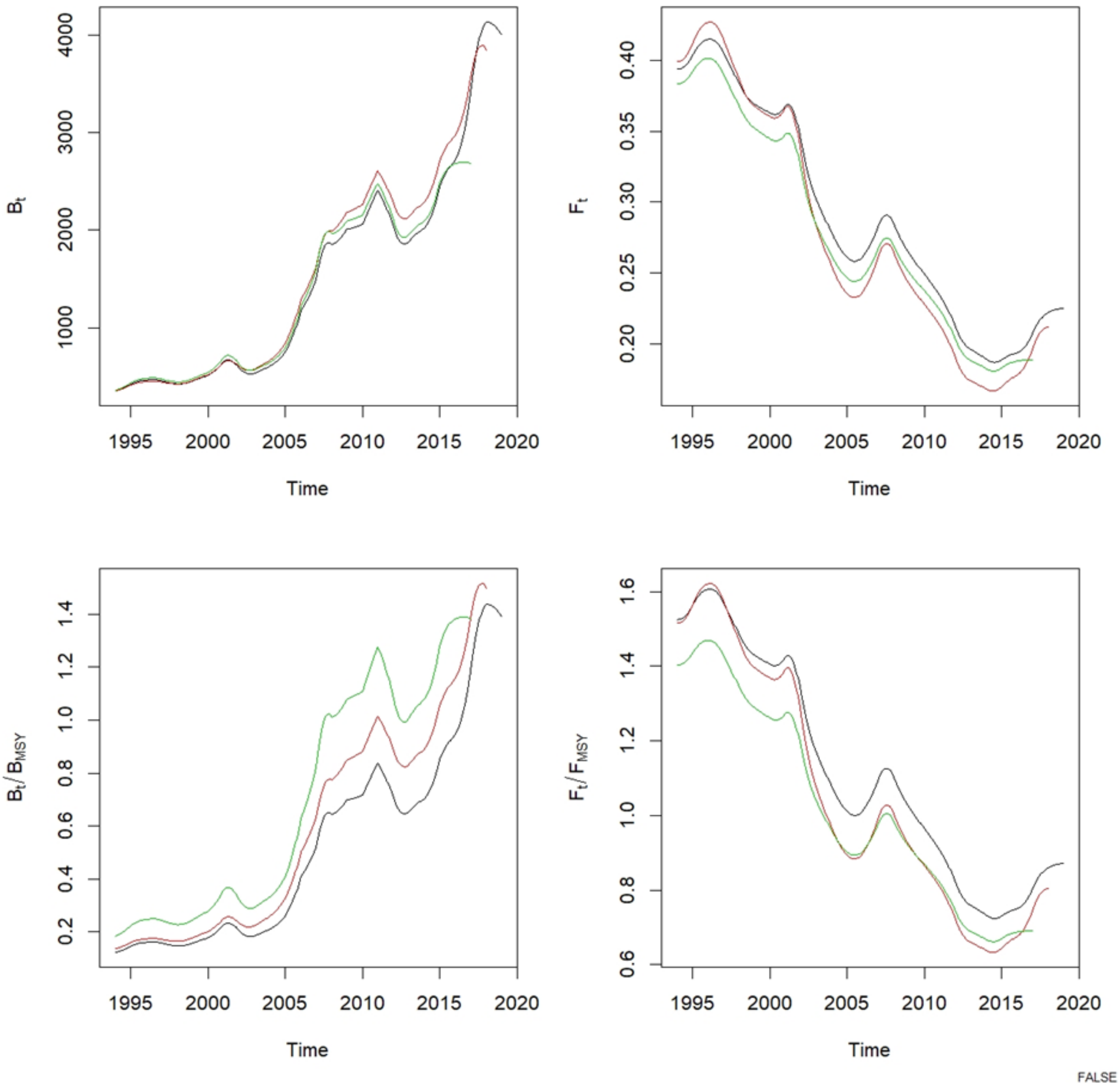


Figure 6.8.4.2.6. Caramote prawn stock in GSA17: Retrospective analysis.

Conclusions to the assessment

An age-based assessment (with a4a) was attempted using the SoleMon biomass index as a tuning index. VBGF and LW parameters were gathered from the literature, as not available in the official DCF database. Age slicing produced a matrix of catch numbers-at-age almost made by one age class (Age class 1), making impossible to fit any model. Historical landings were gathered from the Italian official statistics and the RECFISH project. Several attempts using SPiCT were run with biomass indices from SoleMon and MEDITS in GSA17 as tuning information. The SPiCT model does not appear to capture the dynamics of the population, the observations lie almost exclusively to one side of the yield curve, and the population follows a single direction trajectory (rising B and declining F, which is not normally considered suitable for a surplus production model fit. The outcomes were considered too uncertain and unstable to be used to provide advice for this stock.

Therefore, the EWG 20-15 concluded that none of these models was suitable to provide advice.
The stock status both in terms of SSB and exploitation rate (F) is unknown. However, the biomass index of the SoleMon survey shows a rapid increase in abundance over the last 2 to 3 years.
Landings also show a rapid increase in recent years. The status of the stock is unknown. However, both fishery-dependent and –independent information is showing an increase of the stock abundance in recent years.

6.8.4 Reference Points

Reference points were not estimated during EWG 20-15, as no agreed assessment have been made.

6.8.5 Short term Forecast and Catch Options

The stock status both in terms of SSB and exploitation rate (F) is unknown. However, the biomass index of the SoleMon survey shows a rapid increase in abundance over the last 2 to 3 years.

The relative change in the biomass index from the SoleMon survey was used to provide an index for change (Figure 6.8.3.3.2). The stock has increased rapidly in the last 5-6 years. Based on the index value in the last two years relative to the previous three years the increase in SSB is estimated to be 1.45 times.

Following the ICES procedures for category 3 stocks the change in the biomass index (SoleMon survey) over the last five years was used to provide an index for change (Figure 6.8.5.1) which is then translated into advice for a change in catch.

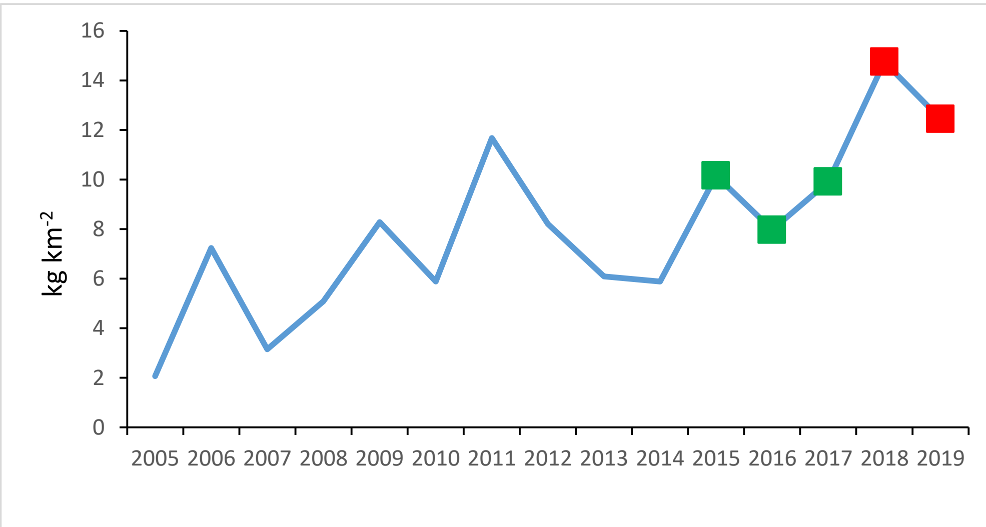


Figure 6.8.5.1 Caramote prawn in GSA17: Summary of the SoleMon stock indicator and catch by year.

As the biomass index change is higher than 1.2 (=1.45), STECF EWG 20-15 advises to not increase the total catch more than the 20% of the average catch for the last three years. Because the exploitation rate is unknown but may be above FMSY and the state of the stock relative to Bmsy is unknown, a precautionary buffer (catch multiplier of -20%) is applied giving a final catch change factor of 0.96. Mean landings (Italy) for the last three years is 900 tonnes. The catch advice, which is applicable for two years, 2021 and 2022, is 864 tonnes.

The advice on fishing opportunities for 2021 and 2022 is based on the recent observed catch adjusted to the change in the stock size index: the biomass index from the SoleMon survey. The change is estimated from the two most recent values relative to the three preceding values (see table 5.8.1). The precautionary buffer of -20% is applied because the precautionary status of the stock is not known.

Table 6.8.6.1. Caramote prawn stock in GSA17: Assumptions made for the interim year and in the forecast.

Index A (2018–2019)	13.60
Index B (2015–2017)	9.35
Index ratio (A/B)	1.45
-20% Uncertainty cap	Applied
Average catch (2017–2019)	900
Discard rate (2017–2019)	Negligible
-20% Precautionary buffer	Applied
Catch advice **	864
Landings advice ***	864
% advice change ^	+11%

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

6.8.6 DATA DEFICIENCIES

Landings in 2019 provided by Italy for GSA17 were duplicated. Biological data are not available (e.g., sex-ratio by length/age, maturity by length/age, growth parameters, length-weight relationship, etc.).

6.9 EUROPEAN HAKE IN GSA 19

This stock has been assessed for the last time by the STECF EWG in 2017 (STECF EWG 17-15) using XSA and a4a, and at the hake benchmark meeting of GFCM in 2019 (GFCM 2019) using a4a.

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%).

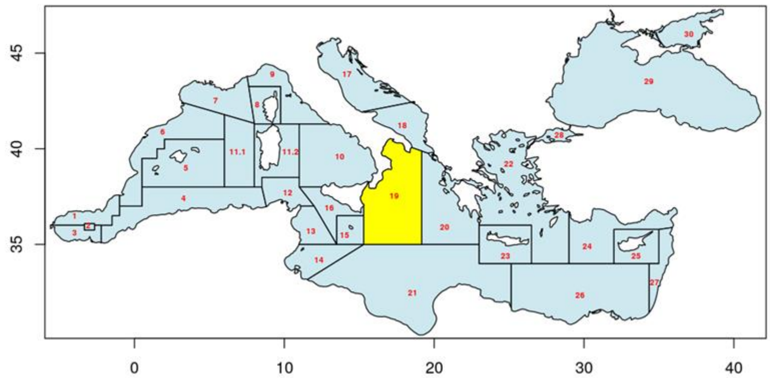


Figure 6.9.1.1. Geographical location of GSA 19.

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
Females	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%.

Catch data from DCF were analyzed. 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 700 tons compared with 1630 tons in 2006. Discards also tend to decrease.

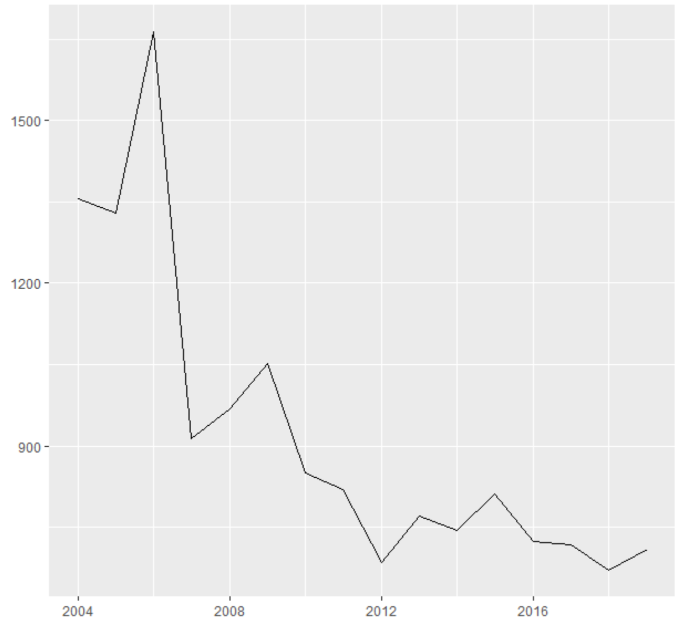


Figure 6.9.2.1. Hake in GSA 19. Hake DCF total catch (t), in GSA 19.

Table 6.9.2.1. Hake DCF landings (t) and discards (t) in GSA 19, SoP and SoP correction

year	Landings, t	Discards, t	Total, t	SOP	Catch/SOP
2004	1299	56	1355	1359.06	1.00
2005	1271	58	1329	1243.47	1.07
2006	1629	34	1663	1558.86	1.07
2007	882	31	913	878.21	1.04
2008	932	37	969	936.79	1.03
2009	999	53	1052	1044.90	1.01
2010	839	11	850	848.51	1.00
2011	810	9	819	818.25	1.00
2012	675	11	686	682.70	1.01
2013	760	11	772	770.27	1.00
2014	740	4	744	749.05	0.99
2015	807	5	812	735.29	1.10
2016	707	18	725	609.10	1.19
2017	714	5	719	534.83	1.34
2018	660	12	672	544.30	1.23
2019	669	40	709	833	0.85

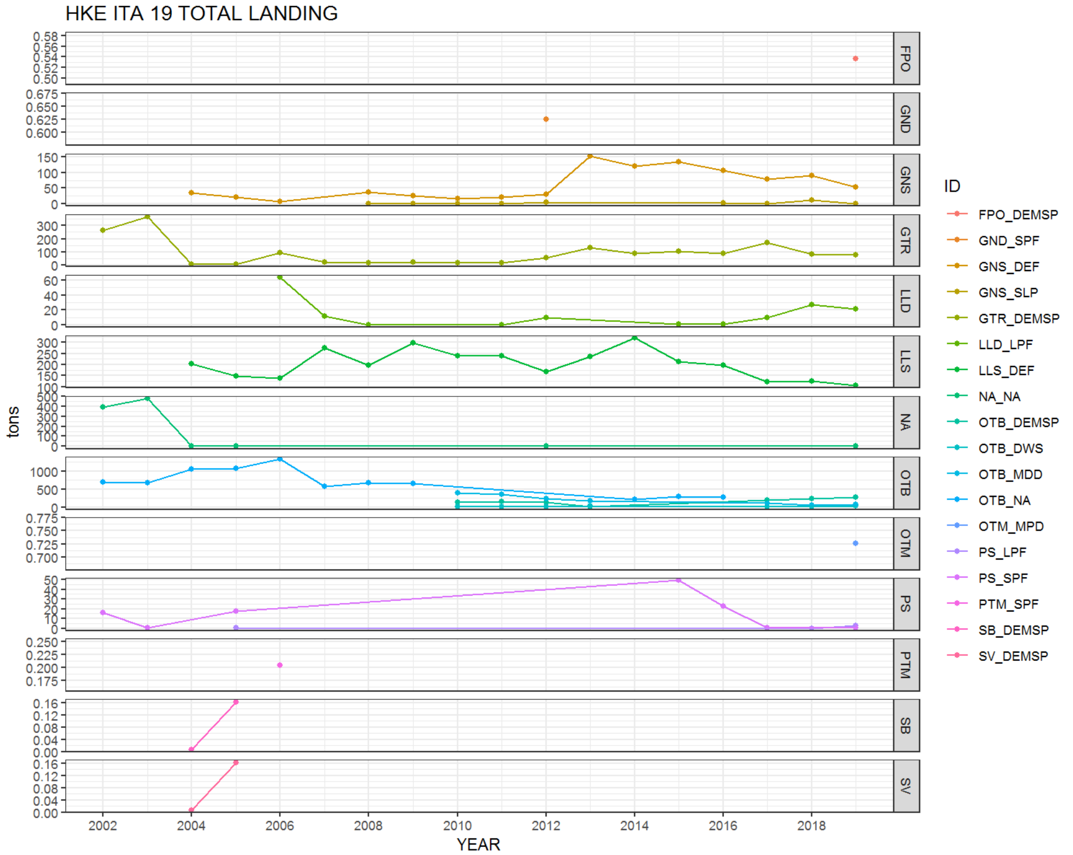


Figure 6.9.2.2. Hake total landing by metier in GSA 19.

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. Discard varied from year to year and was about 1.5-6% of landings. 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 at the hake benchmark meeting (GFCM 2019) 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.

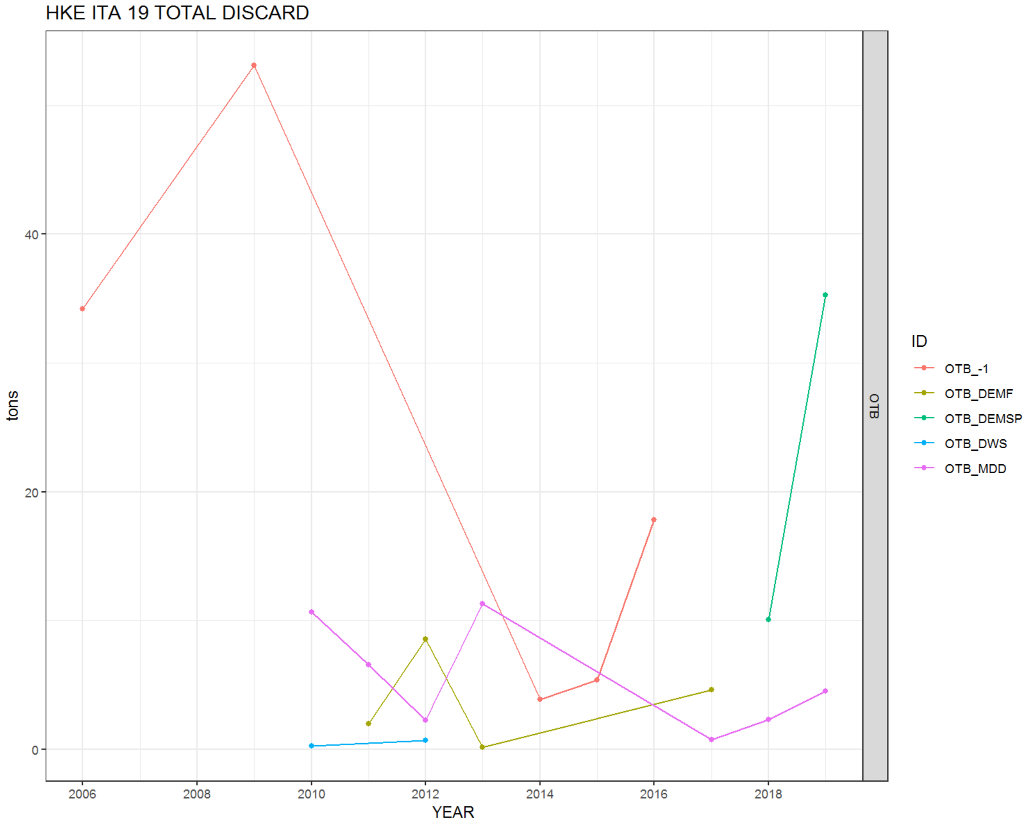


Figure 6.9.2.3. Hake total discards by metier in GSA 19

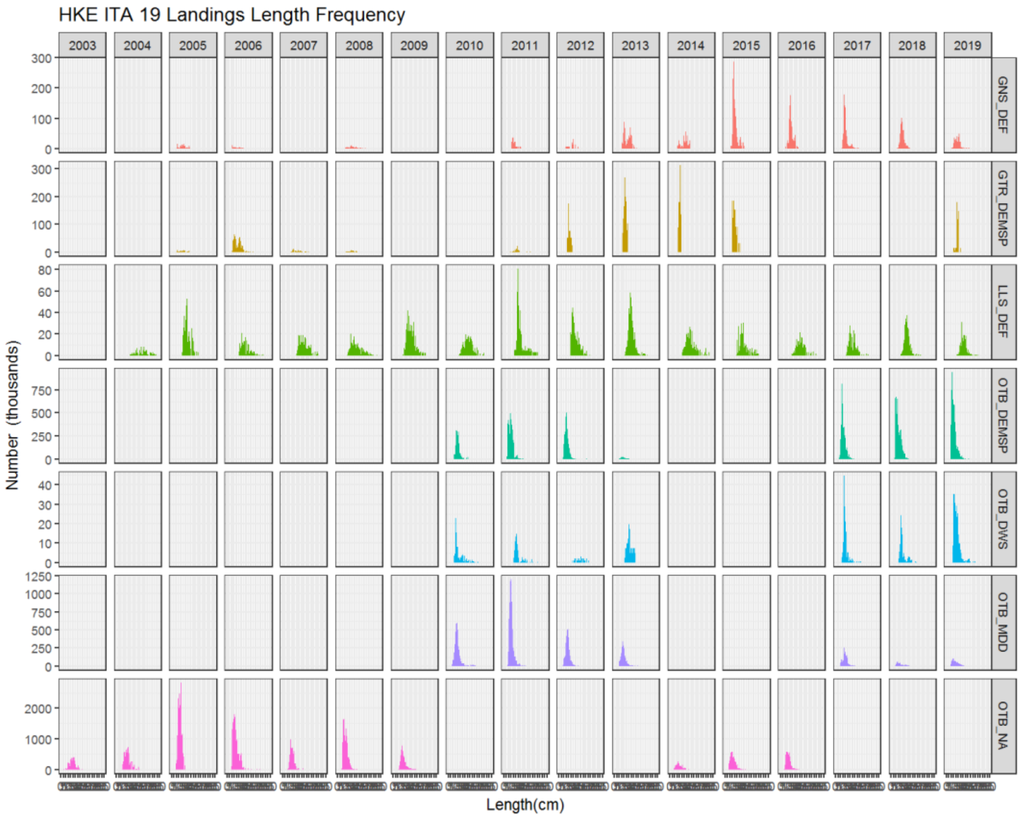


Figure 6.9.2.4. Hake in GSA 19 length frequency distribution of catch by metier.

6.9.2.2 Effort

Fishing effort data were reported to STECF EWG 20-15 through DCF **Table 6.9.2.2. Figure 6.9.2.5.** There is a decreasing trend in the last years after 2013.

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

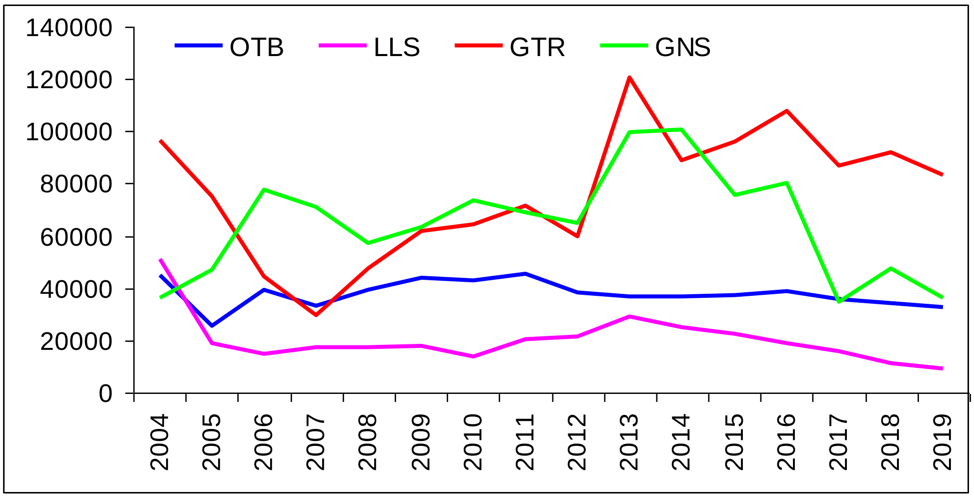


Figure 6.9.2.5. Hake GSA 19. Fishing effort in Fishing days by year and fleets targeting hake.

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 and in 2017 – in November-December. 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.**

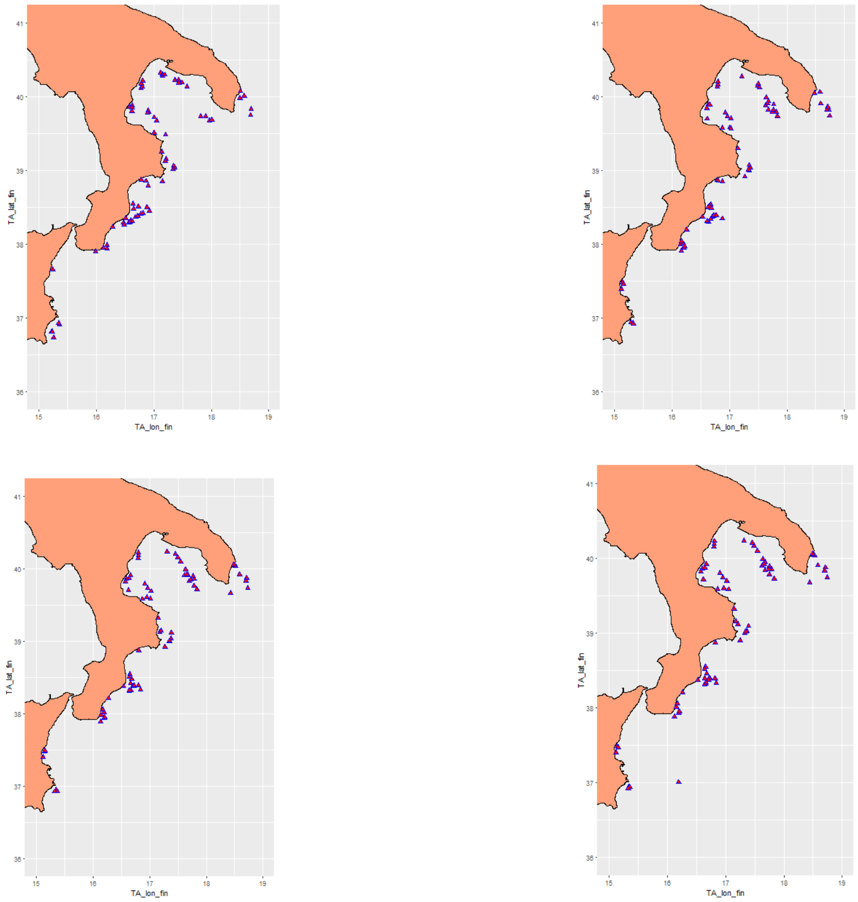


Figure 6.9.2.7. Geographical distribution of hake in GSA 19 based on the biomass index of MEDITS survey in 1994, 2003, 2012 and 2019.

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.**.

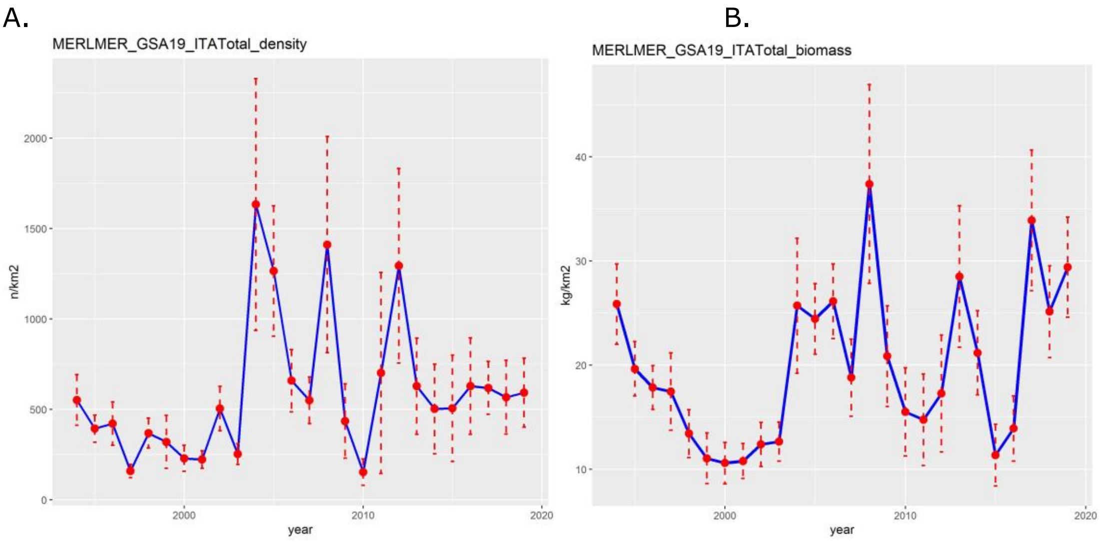


Figure 6.9.2.9. Hake in GSA 19. Estimated A. abundance (N/km2,), and B biomass (kg/km2) indices and from the MEDITS survey.

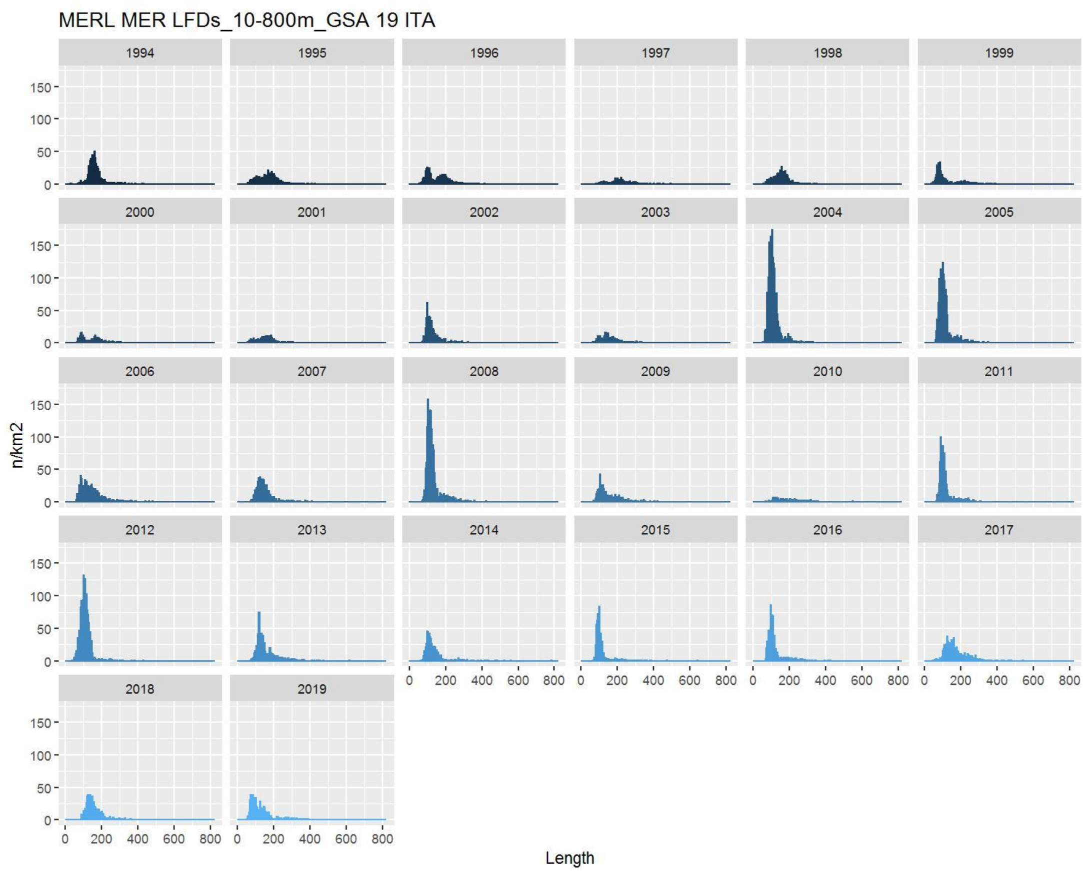


Figure 6.9.2.10. Hake in GSA 19. Length frequency distribution of the MEDITS survey abundance index (n/km^2) of hake in GSA 19 as reported by DCF.

6.9.3 STOCK ASSESSMENT

This stock was assessed for the last time by the STECF EWG in 2017 (STECF EWG 17-15) using XSA and a4a, and at the hake benchmark meeting of GFCM in 2019 (GFCM 2019) using a4a. The present assessment was carried out using a statistical catch-at-age modeling framework - Assessment for all (a4a, Jardim et al., 2014) in FLR (http://www.flr-project.org/).

6.9.3.1. Input data

Input data for the last year 2019 as extracted and sliced from DCF data were added to the stock object from the hake benchmark from last year (GFCM 2019). The weight at age estimated from the 2019 DCF data using the growth parameters from the benchmark were consistently lower then weights at age in years prior to 2019 compared to those estimated at the hake benchmark. There were also minor differences in numbers at age when recalculating the years prior to 2019, though these were thought to be derived from the process of discard reconstruction. Considerable effort was spent trying to track down the reason for the differences but given the limited time and prior information accessible at the EWG 20-15 we could not find the causes of these descrepancies. Therefore the EWG 20-15 decided to use the N at age and weight at age from the benchmark prior to 2019 and to use average weight at age for 2016-2018 from the benchmark assessment (GFCM 2019) to substitute for the weight at age in 2019. The assessment is not sensetive in terms of fit or estimated F to the choice of mean weight at age.
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**. No such discrepencies were found following the length to age proceedures from the benchmark when analysing the MEDITS data.
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 (Fig. 6.9.3.3.6).

6.9.3.3 Stock assessment models and results

The a4a models used in the hake GSA19 benchmark assessment (GFCM 2019) were tested with the new data added in 2019. The EWG found that the original submodels used for the benchmark assessment resulted in high instability of the present assement the survey catchability (originaly qmodel <- list(~factor(age), GFCM 2019) was replaced by a model assigning equal catchability at ages >2 (**Figure 6.9.3.3.7 B).** Fishing mortaliy and Stock-recruit sub-models remain the same as used for the benchmark assessment (GFCM 2019). The replacement q model was chosen specifically from those evaluated at the benchmark.There were two other models which had similar statistical performance to the one chosen at the benchmark, the option selected was the closest of the two available to the origonal benchmark selection. The replacement model gave very similar results in terms of F and SSB. The problem with the benchmark model was due to the substsntial flexibility of both q and f models, by reducing the flexibility of the q model the assessment has greater stability and it is hoped will perform better in the future

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 of the fitted model are very similar to those obtained at the benchmark assessment (GFCM 2019). The retrospective analysed do not show consistent pattern of under- or overestimation of Recruits, SSB and Fbar, in the last years. The estimated catch follows the trend of the input catch data (except for 2006). The stock summary with simulated confidence intervals is presented at Figure 6.9.3.3.12. The SSB is increasing after 2016 while fishing mortality is decreasing. Estimated stock numbers and fishing mortality at age, as well as stock summary are presented at **Tables 6.9.3.3.4** to **6.9.3.3.6.**

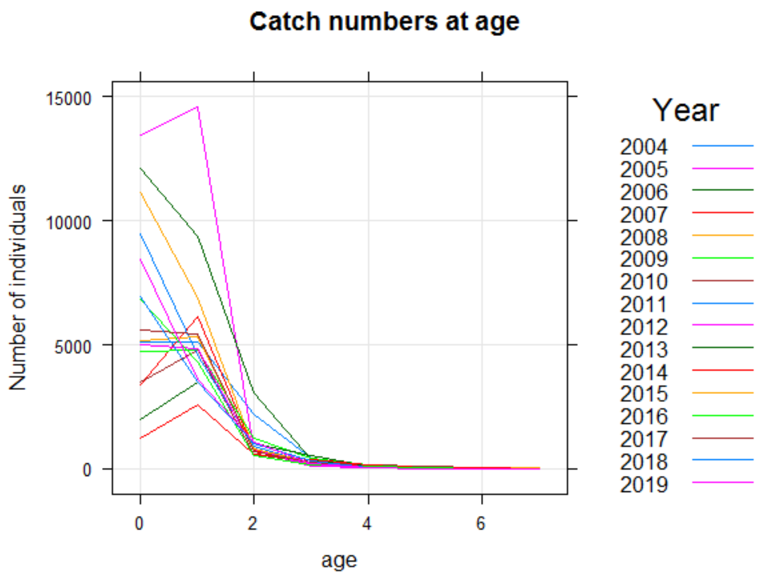


Figure 6.9.3.3.1 Hake in GSA 19. Hake number of individuals (thousands) at age of the catch in GSA 19. Data from DCF.

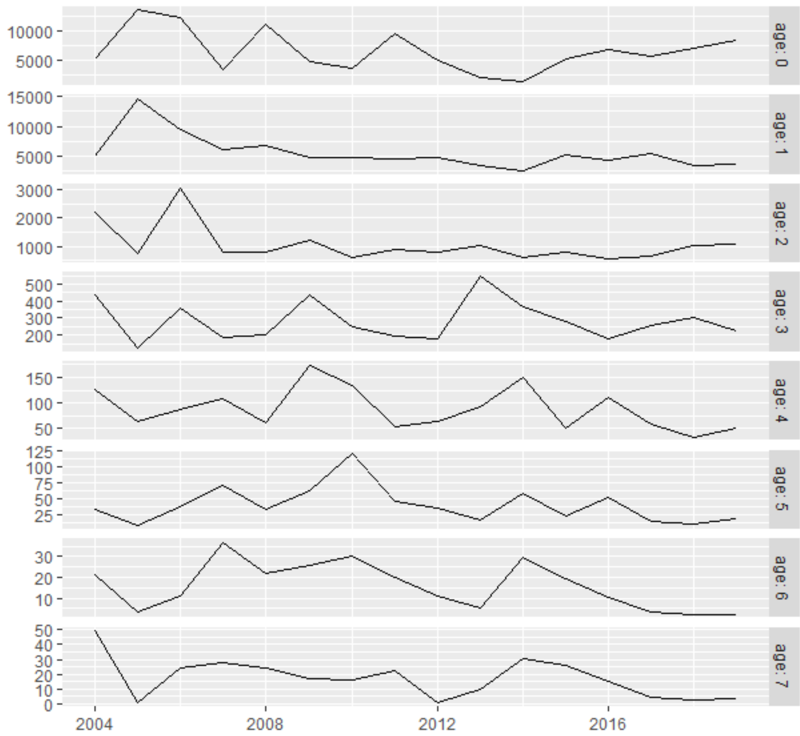


Figure 6.9.3.3.2 Hake in GSA 19. Hake number of individuals per year by age group of the catch in GSA 19 (2004-2019). Data from DCF.

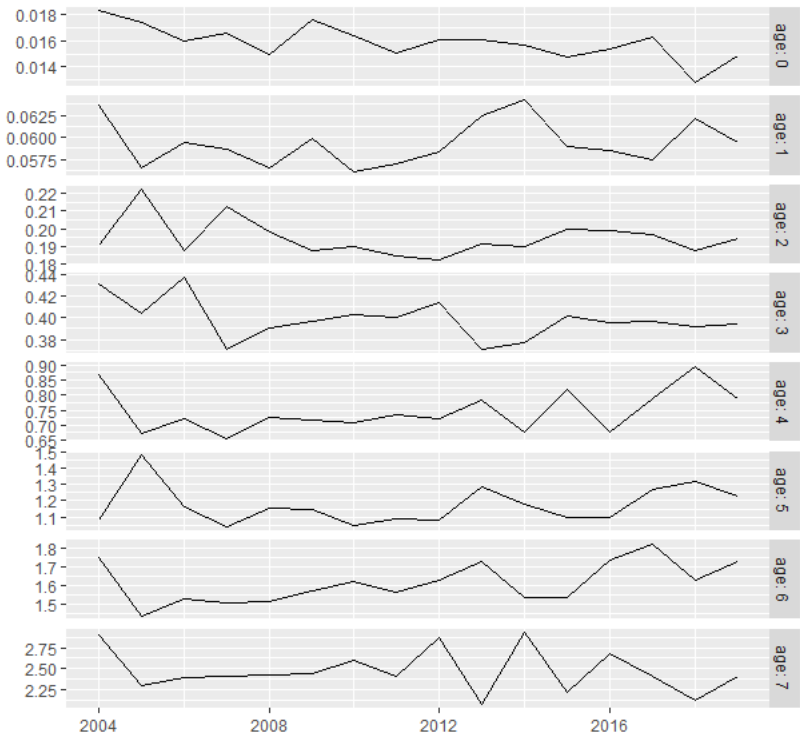


Figure 6.9.3.3.3. Hake in GSA 19. Hake mean weight (kg) at age of catches per year in GSA 19 (2004-2019). Data from DCF.

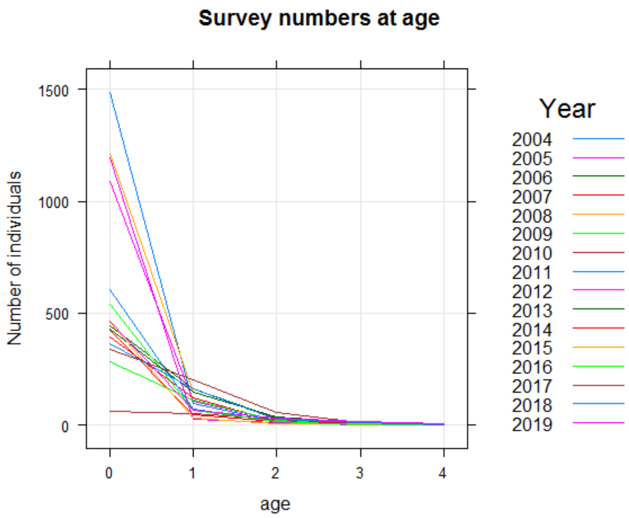


Figure 6.9.3.3.4 Hake in GSA 19. Age composition of the MEDITS survey of hake in GSA 19 as reported by DCF.

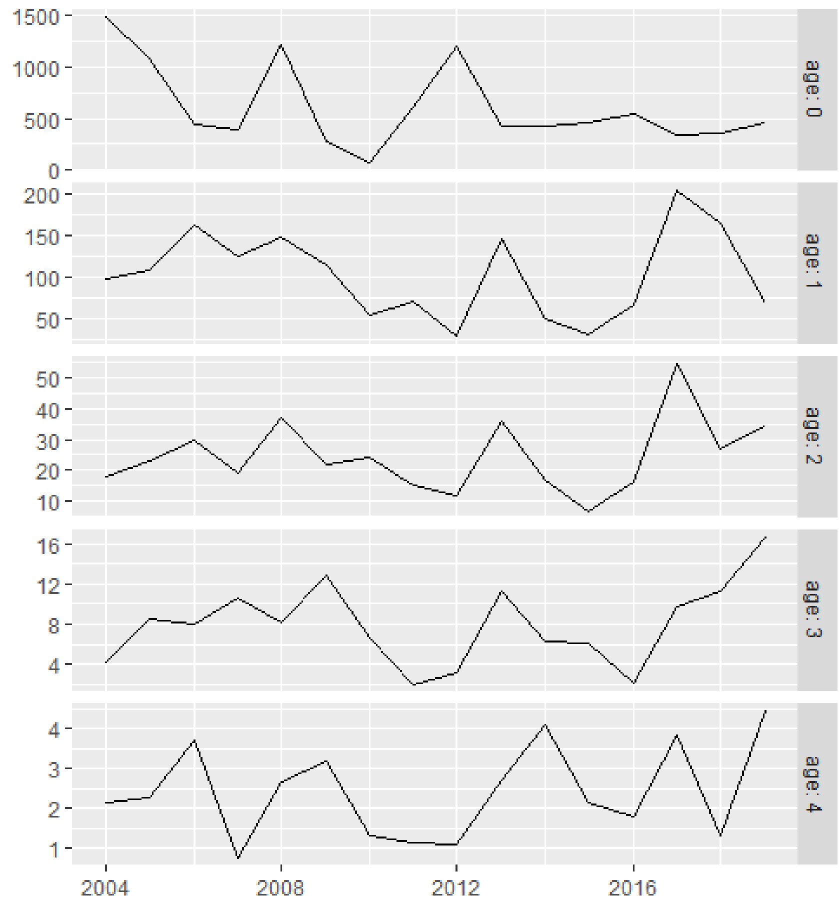


Figure 6.9.3.3.5 Hake in GSA 19. Number of individuals per year by age group (ages 1-4) according to MEDITS surveys (2004-2019).

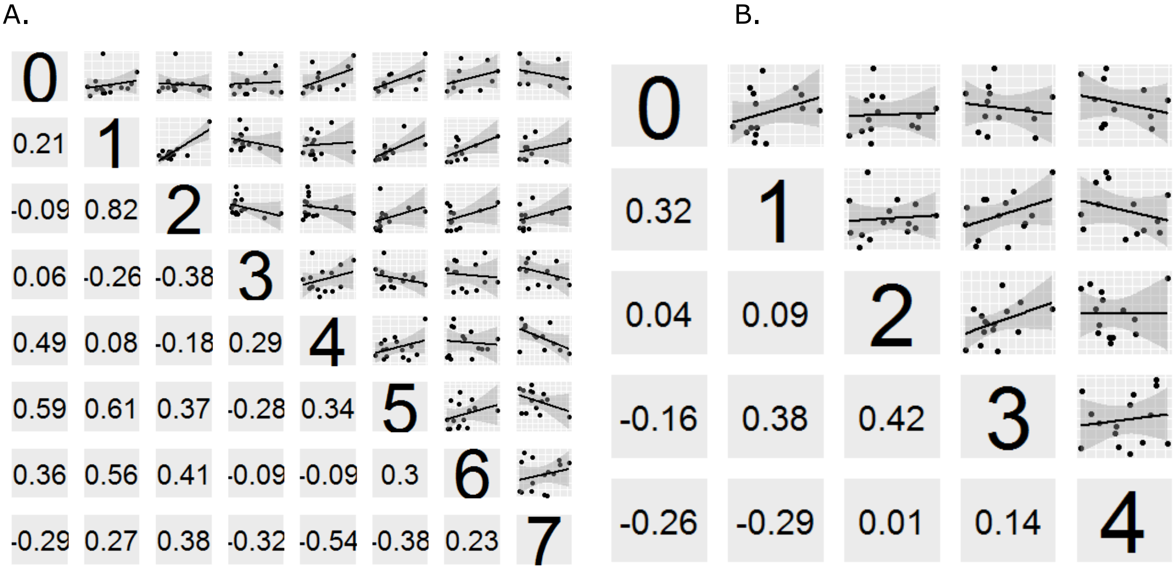


Figure 6.9.3.3.6 Hake in GSA 19. A.Cohorts consistency in the catch, and B. in MEDITS survey.

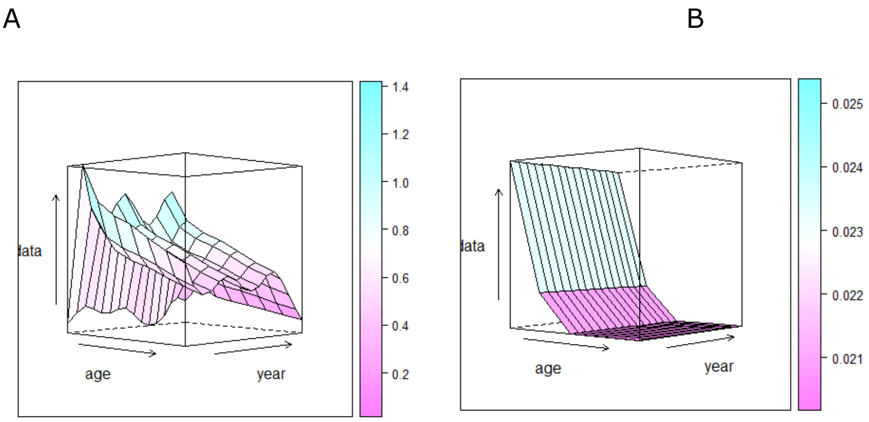
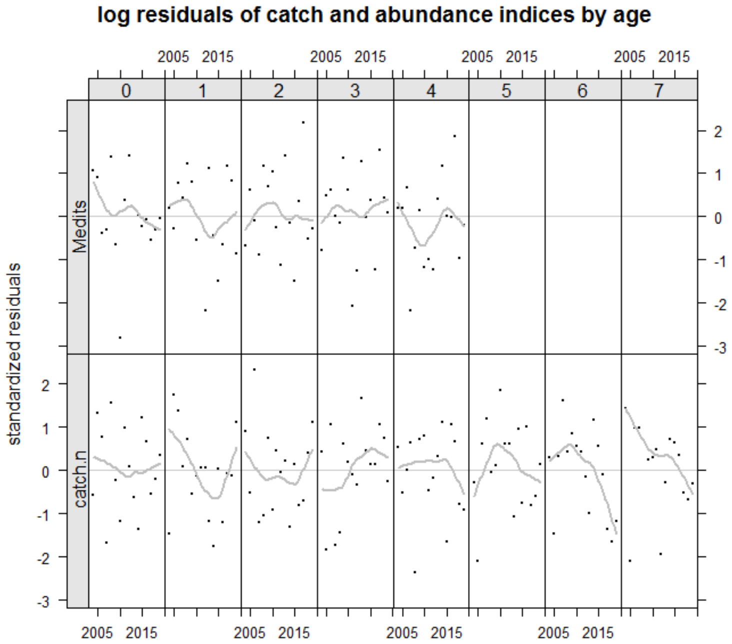


Figure 6.9.3.3.7 Hake in GSA 19. 3D plots of fishing mortality (A), and survey catchability (B) at age and year

A.



B.

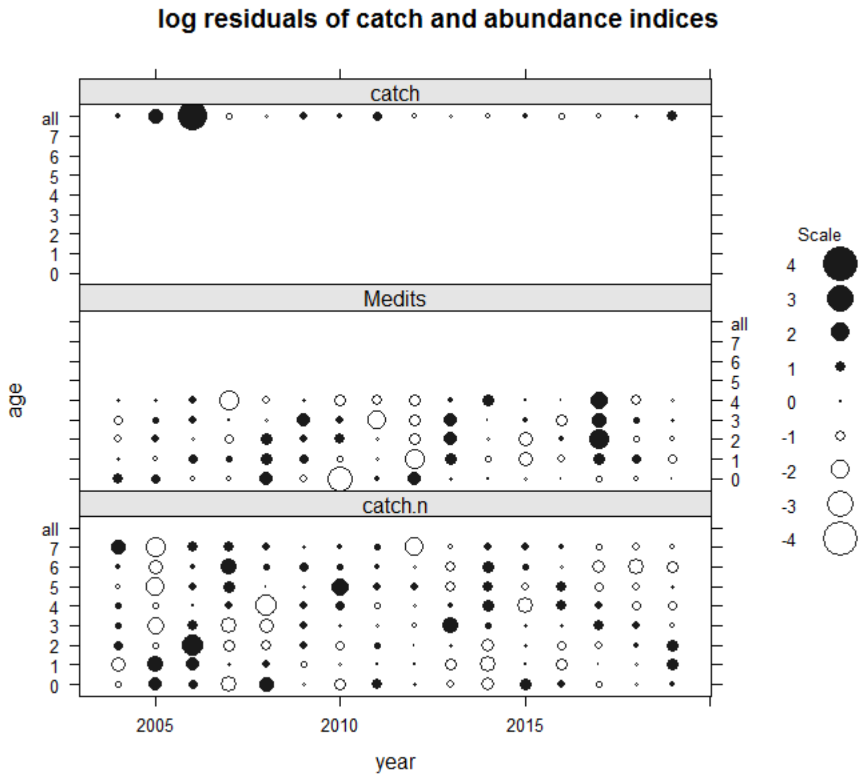
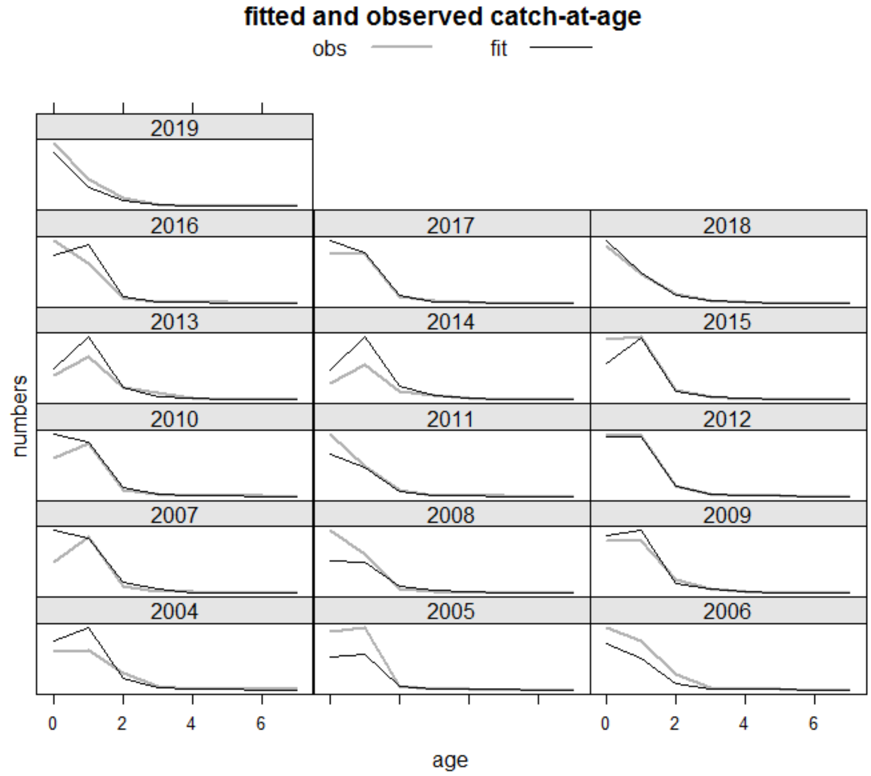
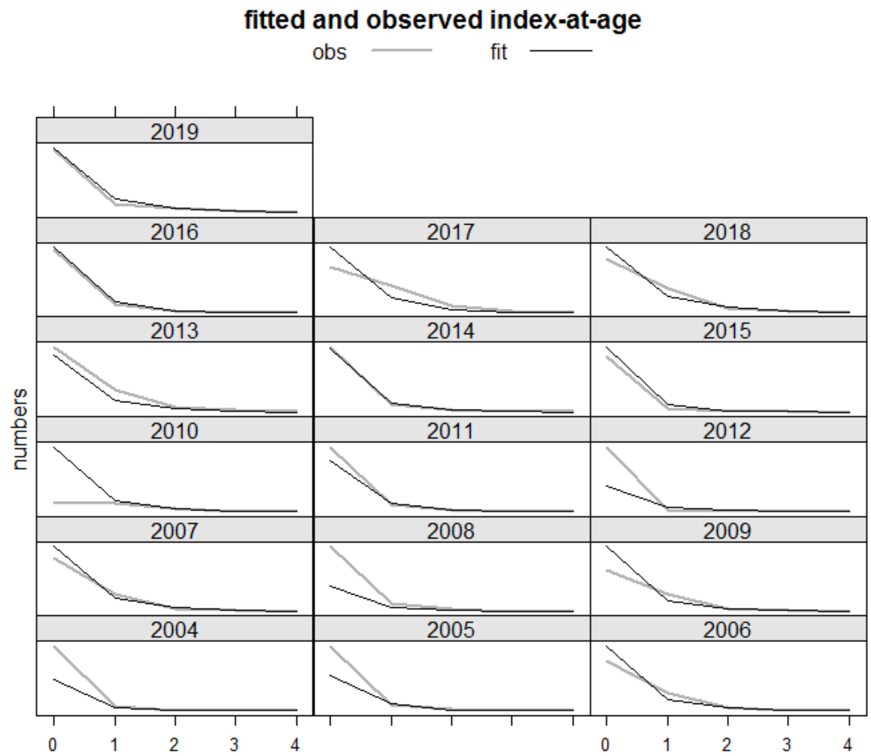


Figure 6.9.3.3.8 Hake in GSA 19. Standardized residuals for abundance indices (MEDITS) and catch at age data. Each panel present residuals by age and year.

A.


fitted and observed catch-at-age
obs
fit
2019
2016
2017
2018
2013
2014
2015
2010
2011
2012
2007
2008
2009
2004
2005
2006
numbers
0
2
4
6
age

B.


fitted and observed index-at-age
obs
fit
2019
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2012
2007
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2004
2005
2006
numbers
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1
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3
4

Figure 6.9.3.3.9 Hake in GSA 19. Fitted and observed catch (A.) and survey (B) numbers at age.

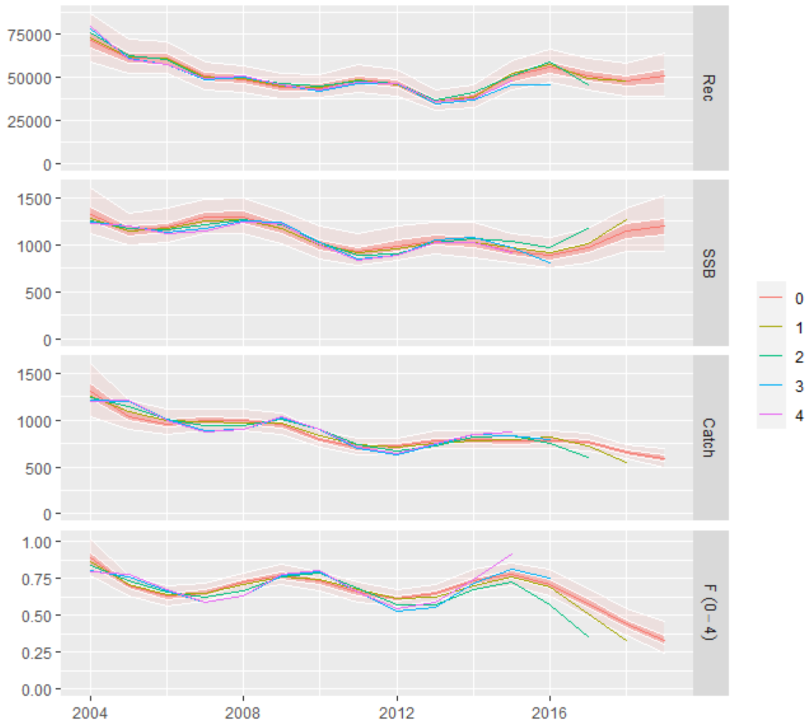


Figure 6.9.3.3.10 Hake in GSA 19. Retrospective analysis output.

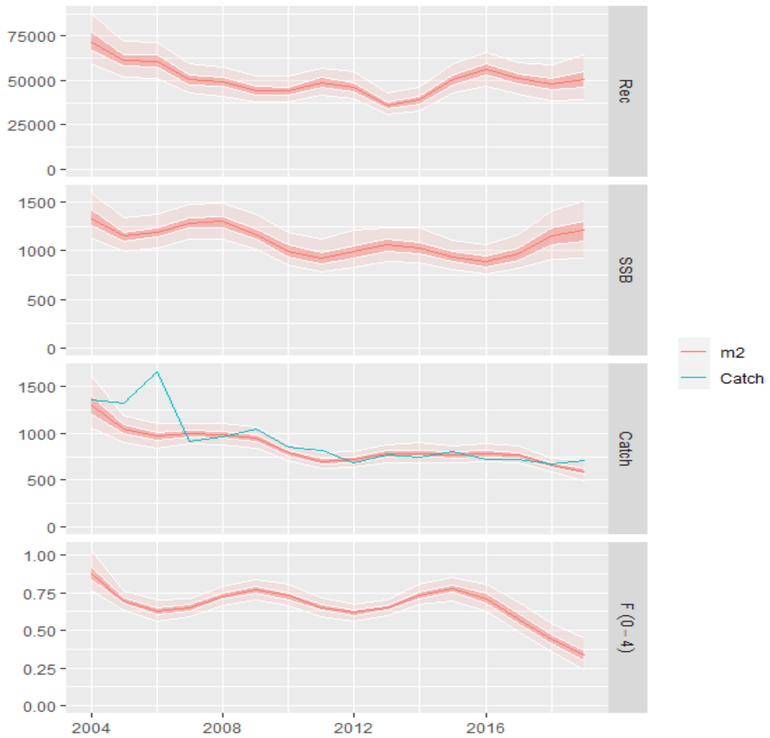


Figure 6.9.3.3.11 Hake in GSA 19. Stock summary for hake in GSA 19, recruits ('000), SSB (t), catch (t) and Fbar (age 0-4). Estimated catch is compared to recorded catch.

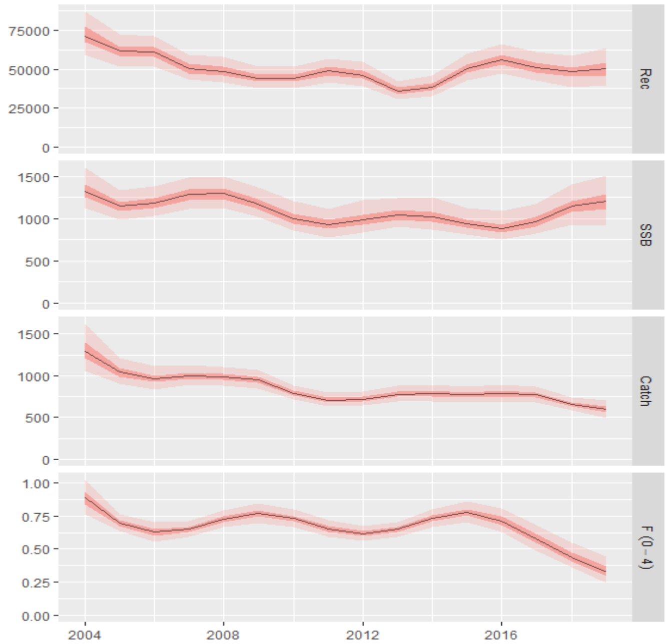


Figure 6.9.3.3.12 Hake in GSA 19. Stock summary of the simulated and fitted model from a4a. Stock summary for hake in GSA 19, recruits ('000), SSB (t), catch (t) and Fbar (age 0-4).

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
0	5099	13465	12112	3388	11119	4725	3486	9495	5018	1980	1224	5176	6837	5605	6924	8456
1	5127	14579	9368	6122	6898	4775	4791	4557	4857	3476	2592	5333	4302	5454	3499	3578
2	2217	721	3079	773	812	1231	597	889	781	1042	606	783	531	670	1034	1060
3	437	124	357	183	199	440	245	196	180	545	369	280	179	260	303	227
4	126	65	88	108	61	174	135	55	65	93	150	50	112	59	34	50
5	32	8	37	69	34	62	120	45	35	16	57	22	53	13	10	18
6	21	3	11	37	22	26	30	20	11	5	29	19	10	3	2	2
7+	49	1	24	28	24	17	16	23	1	10	31	26	15	4	3	4

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
0	0.018	0.017	0.016	0.017	0.015	0.018	0.016	0.015	0.016	0.016	0.016	0.015	0.015	0.016	0.013	0.015
1	0.064	0.056	0.059	0.059	0.056	0.060	0.056	0.057	0.058	0.062	0.064	0.059	0.058	0.057	0.062	0.059
2	0.191	0.223	0.187	0.213	0.198	0.188	0.190	0.184	0.182	0.191	0.190	0.200	0.199	0.197	0.187	0.194
3	0.431	0.405	0.437	0.371	0.390	0.396	0.403	0.401	0.413	0.371	0.377	0.401	0.395	0.397	0.391	0.394
4	0.868	0.671	0.719	0.657	0.727	0.717	0.707	0.735	0.720	0.783	0.677	0.819	0.676	0.787	0.895	0.786
5	1.082	1.482	1.160	1.038	1.151	1.144	1.051	1.088	1.076	1.290	1.182	1.099	1.095	1.268	1.322	1.228
6	1.755	1.435	1.525	1.505	1.513	1.571	1.618	1.566	1.630	1.734	1.533	1.534	1.737	1.826	1.626	1.729
7+	2.914	2.297	2.391	2.413	2.427	2.443	2.606	2.410	2.876	2.065	2.932	2.211	2.681	2.406	2.115	2.401

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

0	1487	1089	442	395	1212	281	64	606	1193	430	422	459	541	340	363	466
1	96	109	162	125	148	114	54	70	27	146	49	31	65	203	163	67
2	18	23	30	19	37	22	24	15	12	36	17	7	16	55	27	34
3	4	8	8	11	8	13	7	2	3	11	6	6	2	10	11	17
4	2	2	4	1	3	3	1	1	1	3	4	2	2	4	1	4

Table 6.9.3.3.4 Hake in GSA 19. Number of individuals at age in the stock (2002-2019)

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	71812	61364	60903	50509	48928	44323	44176	48618	46442	36087	38883	50421	55855	50972	47871	50329
1	14379	17005	13482	12845	10905	10935	9925	9649	10595	10696	8879	9862	12629	13159	10935	9811
2	2905	1907	3089	2773	2526	1883	1763	1718	1881	2156	2022	1459	1519	2191	2899	3034
3	670	642	541	968	839	689	486	482	516	585	632	530	363	416	725	1153
4	196	184	221	203	352	278	217	161	174	192	207	202	162	121	164	338
5	76	61	71	92	82	131	99	81	65	72	76	74	70	60	53	84
6	37	27	26	33	41	34	52	41	36	30	32	31	29	29	29	29
7+	21	24	25	26	30	34	31	39	40	40	35	31	28	27	30	35

Table **6.9.3.3.5** Hake in GSA 19. Hake fishing mortality at age (2002-2019)

Year/Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.171	0.245	0.286	0.263	0.228	0.227	0.251	0.254	0.198	0.132	0.102	0.114	0.176	0.269	0.315	0.287
1	1.330	1.016	0.891	0.937	1.066	1.135	1.064	0.945	0.902	0.976	1.116	1.181	1.062	0.823	0.592	0.420
2	1.060	0.809	0.710	0.746	0.850	0.904	0.847	0.753	0.719	0.778	0.889	0.940	0.846	0.655	0.472	0.335
3	0.953	0.728	0.639	0.671	0.764	0.813	0.762	0.677	0.646	0.699	0.799	0.846	0.761	0.589	0.424	0.301
4	0.886	0.677	0.594	0.624	0.710	0.756	0.709	0.629	0.601	0.650	0.743	0.786	0.707	0.548	0.394	0.280
5	0.798	0.609	0.535	0.562	0.640	0.681	0.638	0.567	0.541	0.585	0.669	0.708	0.637	0.493	0.355	0.252
6	0.705	0.539	0.473	0.496	0.565	0.602	0.564	0.501	0.478	0.517	0.591	0.626	0.563	0.436	0.314	0.223
7+	0.630	0.481	0.422	0.444	0.505	0.538	0.504	0.448	0.427	0.463	0.529	0.559	0.503	0.390	0.281	0.199

Table **6.9.3.3.6** Stock summary: number of recruits, SSB, Fbar 1-2**,** estimated catch

Year	Recruitment age 0, in thousands	SSB, t	Fbar 0-4	Catch, t
2004	71812	1298	0.880	1285
2005	61364	1134	0.695	1039
2006	60903	1177	0.624	964
2007	50509	1280	0.648	1000
2008	48928	1293	0.724	992
2009	44323	1171	0.767	953
2010	44176	995	0.727	797
2011	48618	924	0.652	709
2012	46442	985	0.613	722
2013	36087	1046	0.647	785
2014	38883	1021	0.730	792
2015	50421	935	0.774	774
2016	55855	880	0.710	786
2017	50972	959	0.577	767
2018	47871	1137	0.439	661
2019	50329	1193	0.325	594

6.9.4 Reference Points

The STECF EWG 20-15 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= 0.325 is higher than $F_{0.1}$ (0.135), 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 6 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 2020 to 2022 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 (2020) and in the STF forecast.

Variable	Value	Notes
Biological Parameters		mean weights at age, maturation at age, natural mortality at age and selection at age, based average of 2017-2019
$F_{ages\ 0\text{-}4}$ (2020)	0.325	F status quo (in the interim year 2020) is assumed Fbar in the last assessment year (2019)
SSB (2020)	1876 t	SSB projection based on stock assessment
R_{age0} (2020)	49782	Geometric mean of the whole time series
Total catch (2020)	724 t	Catch at F status quo in 2020

6.9.5.2 Results

The results of the short term forecasts for hake (GSA 19) are shown in Fig. 6.9.5.1. and Table 6.9.5.1.

The F status quo = 0.325 (assumed Fbar in the last assessment year 2019) is larger than $F_{0.1}$ (0.135), 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 $F_{0.1}$ (0.135), should not exceed 497 tonnes, 36% less than the current estimated catch (594 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	Catch 2019	Catch 2020	Catch 2021	Catch 2022	SSB 2020	SSB 2022	SSB change 2020-2022 (%)	Catch change 2019-2021 (%)
High long term yield ($F_{0.1}$)	0.42	0.135	594.45	724.34	378.86	497.61	1876.25	3269.79	74.27	-36.27
F_{upper}	0.59	0.190	594.45	724.34	520.19	650.12	1876.25	3099.79	65.21	-12.49
F_{lower}	0.28	0.092	594.45	724.34	263.52	359.90	1876.25	3409.26	81.71	-55.67
FMSY transition	0.8	0.260	594.45		693.72		1876.25	2892.49	54.16	16.7
Zero catch	0	0.000	594.45	724.34	0.00	0.00	1876.25	3730.22	98.81	-100.00
Status quo	1	0.325	594.45	724.34	838.12	929.16	1876.25	2721.31	45.04	40.99
Scenarios	0.1	0.032	594.45	724.34	95.48	137.73	1876.25	3613.58	92.60	-83.94
	0.2	0.065	594.45	724.34	188.14	263.41	1876.25	3500.76	86.58	-68.35
	0.3	0.097	594.45	724.34	278.07	377.93	1876.25	3391.64	80.77	-53.22
	0.4	0.130	594.45	724.34	365.35	482.09	1876.25	3286.09	75.14	-38.54
	0.5	0.162	594.45	724.34	450.08	576.68	1876.25	3184.00	69.70	-24.29
	0.6	0.195	594.45	724.34	532.33	662.40	1876.25	3085.24	64.44	-10.45
	0.7	0.227	594.45	724.34	612.18	739.91	1876.25	2989.69	59.34	2.98
	0.8	0.260	594.45	724.34	689.72	809.83	1876.25	2897.26	54.42	16.03
	0.9	0.292	594.45	724.34	765.01	872.74	1876.25	2807.83	49.65	28.69
	1.1	0.357	594.45	724.34	909.13	979.59	1876.25	2637.59	40.58	52.94
	1.2	0.389	594.45	724.34	978.10	1024.50	1876.25	2556.58	36.26	64.54
	1.3	0.422	594.45	724.34	1045.10	1064.30	1876.25	2478.19	32.08	75.81
	1.4	0.454	594.45	724.34	1110.18	1099.40	1876.25	2402.33	28.04	86.76
	1.5	0.487	594.45	724.34	1173.42	1130.17	1876.25	2328.92	24.13	97.40
	1.6	0.519	594.45	724.34	1234.86	1156.94	1876.25	2257.87	20.34	107.73
	1.7	0.552	594.45	724.34	1294.56	1180.05	1876.25	2189.10	16.67	117.78
	1.8	0.584	594.45	724.34	1352.58	1199.78	1876.25	2122.54	13.13	127.54
	1.9	0.617	594.45	724.34	1408.97	1216.41	1876.25	2058.11	9.69	137.02
	2	0.649	594.45	724.34	1463.79	1230.20	1876.25	1995.75	6.37	146.24

6.9.6 DATA DEFICIENCIES

No issues

6.10 EUROPEAN HAKE IN GSA 20

6.10.1 STOCK IDENTITY AND BIOLOGY

The assessment of hake carried out during the STECF EWG 20-15 considered the stock of GSA 20. The previous assessment of this stock was in 2017 (EWG 17-15) and in 2012 (EWG 12-21). Hake is one of the most important fish stocks in GSA 20 for bottom trawlers, nets and longlines. The stock is distributed in depths between 50 and 600 m, with a peak in abundance between 200 and 300 m. The stock is exploited almost exclusively by the Greek fishing fleet.

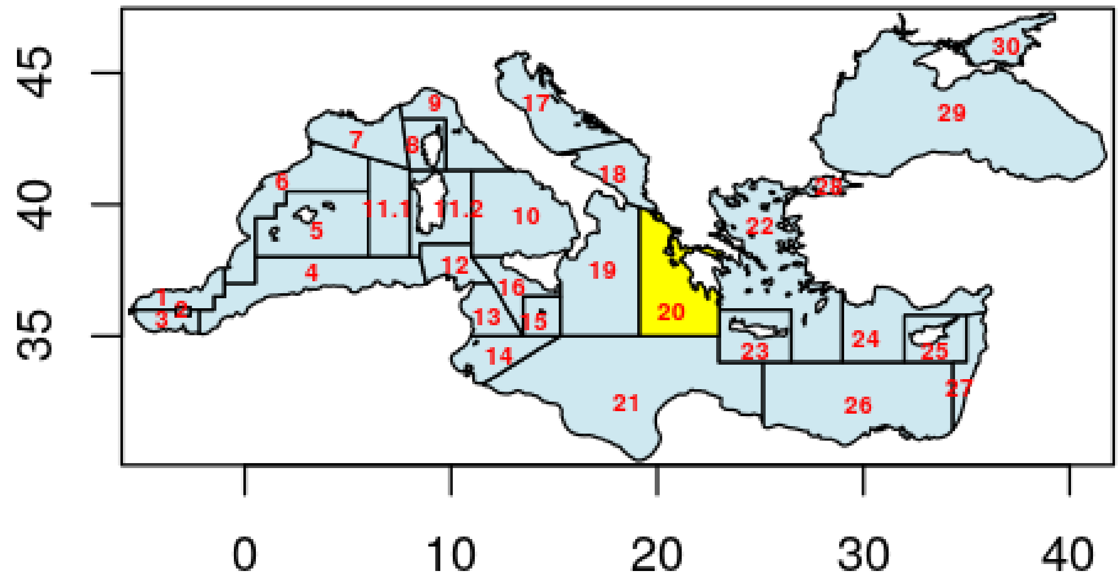


Figure 6.17.1.1. Geographical location of GSA 20.

Growth parameters (Linf= 104.0 cm, k= 0.12 y-1; t0= -0.01 y, sexes combined) and length-weight relationship parameters (a=0.0033, b=3.23), were the same as the ones used in the previous assessment (EWG 17-15) that had been taken from the DCF estimates of hake in GSA 19. The VBGF and LW relationship parameters used are summarized in the following Table (Tab. 6.10.1.1).

The vector of proportion of mature individuals by age was also according to the previous assessment that followed size at maturity of hake in GSA 19, sexes combined (Table 6.10.1.2).

A vector of natural mortality was estimated by PRODBIOM method (Abella et al., 1997) using growth and length-weight relationship parameters for sexes combined (Table 6.10.1.3).

Hake spawns throughout the year in many areas of the Mediterranean with a peak of spawning occurring during the summer.

Table 6.10.1.1. Hake in GSA 20. Growth parameters and length-weight relationship parameters used in the assessment.

GSA	Sex	Linf (cm)	K (y-1)	t0 (y)	a	b
20	**Combined**	104	0.12	-0.01	0.0033	3.23

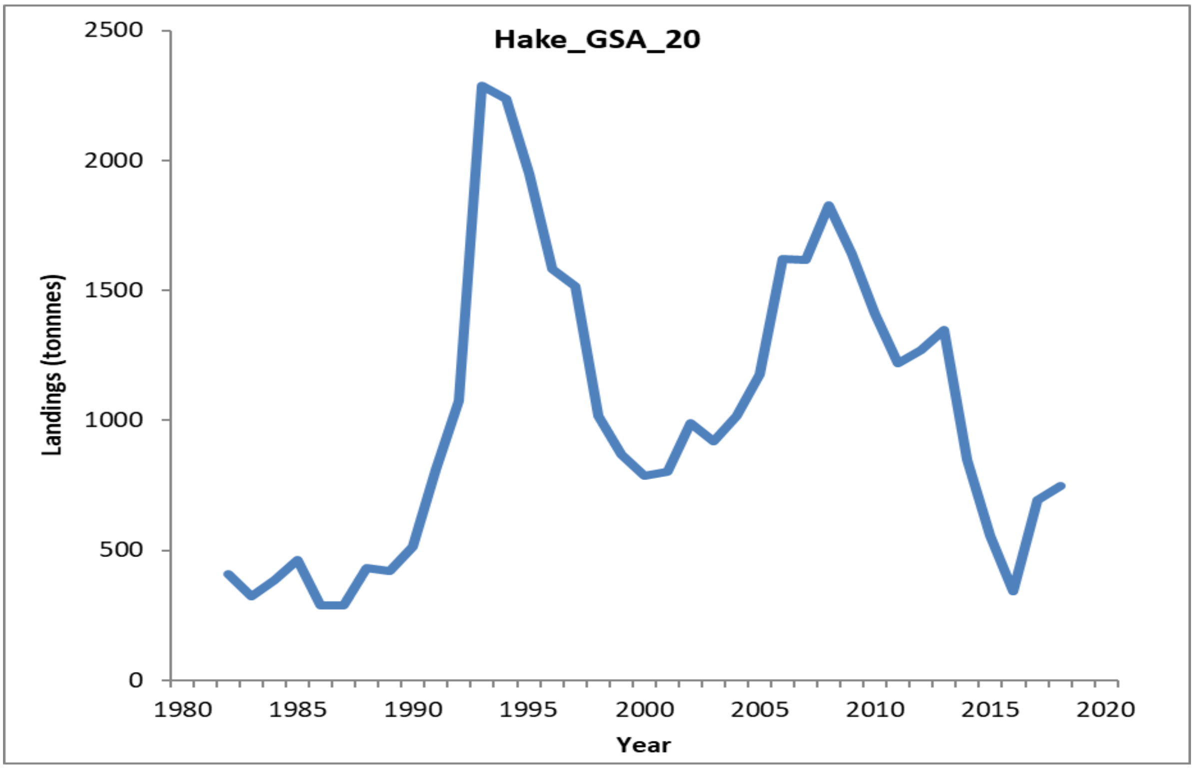


Table 6.10.1.2. Hake in GSA 20. Maturity vectors used in the assessment.

Age	**0**	**1**	**2**	**3**	**4**	**5**
Pmat	0	0.19	0.86	1.00	1.00	1.00

Table 6.10.1.3. Hake in GSA 20. Natural mortality vectors used in the assessment.

Age	**0**	**1**	**2**	**3**	**4**	**5**
M	1.24	0.73	0.48	0.39	0.35	0.32

6.10.2 Data

6.10.2.1 Catch (Landings and Discards)

Hake mainly lives on muddy substrates in depths between 50 and 600 m and, in the Greek part of the Ionian Sea (GSA 20), is primarily targeted by the bottom trawl fishery, nets (gill- and trammel) and longlines (Table 6.10.2.1, Figures 6.10.2.1 and 6.10.2.2).

The official landings of hake (Figure 6.17.2.1) are being recorded by the Hellenic Statistical Authority and the same values are reported by the FAO/GFCM databases. However, the structure of the dataset changed after 2015 and includes the landings of an extra small-scale coastal fleet of 10,000 vessels (Tsikliras et al. 2020). To account for these additional landings that inflated the landings time series after 2016, we corrected the hake landings from 1982 to 2015 by multiplying by 1.31, which is the difference of hake with and without the extra fleet.

Figure 6.10.1.2.1 Hake in GSA 20. Hake official landings by the Greek fleet in GSA 20 (1982-2020). Data from Hellenic Statistical Authority corrected to account for partial reconstruction.

The DCF dataset contains too many missing points and is inconsistent in terms of landings as the landings reported for 2003-2006 are very high, probably owing to a raising factor error (Figures 6.10.2.2). Towards the end of the time series, the DCF dataset seems to converge with the official one.

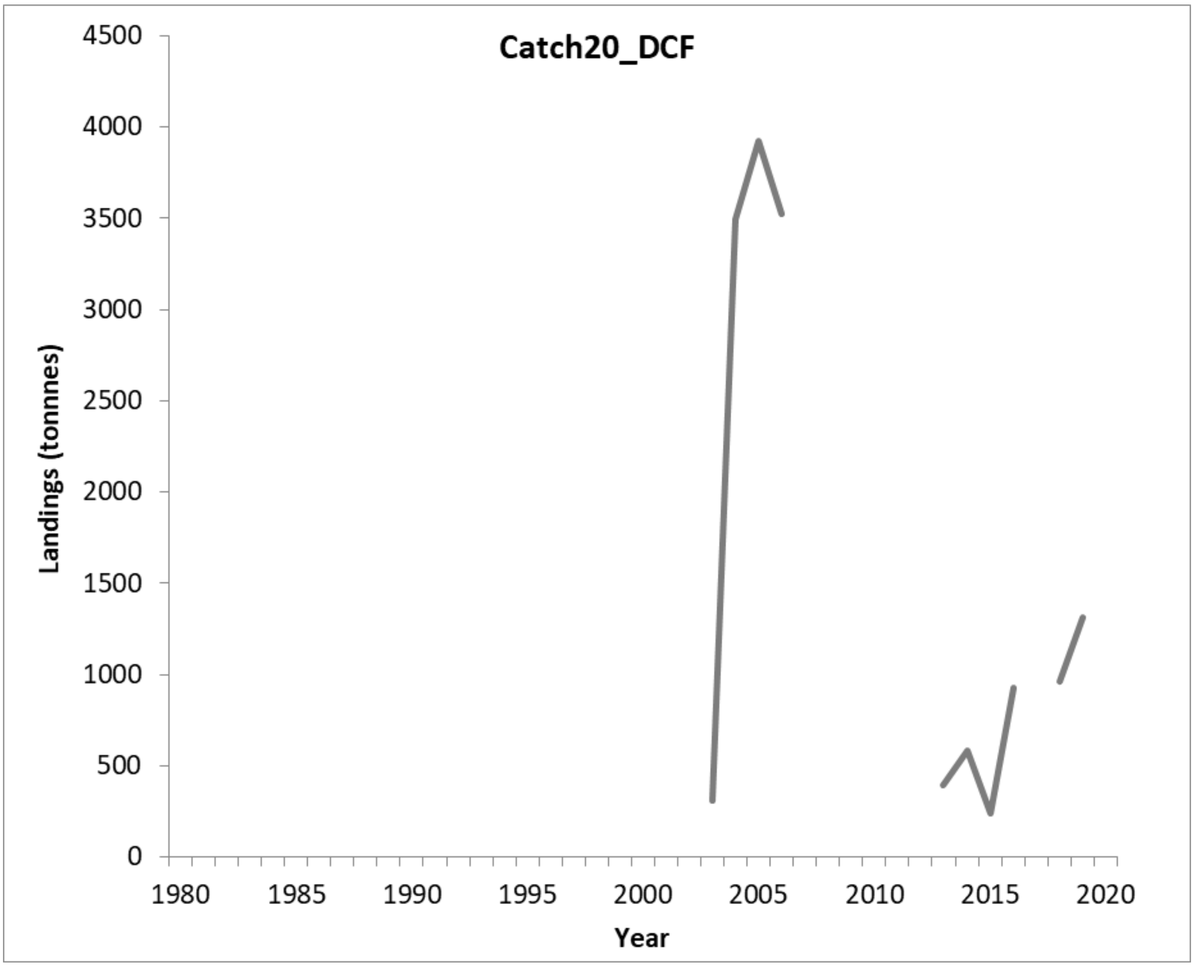


Figure 6.10.1.2.2 Hake in GSA 20. Hake DCF landings by the Greek fleet in GSA 20 (2003-2019). Years 2007, 2009-2013, 2015 and 2017 are missing.

The bottom trawl fishery in Greece is a mixed fishery, operating 24hr per day. Bottom trawl fishing targeting hake is taking place mainly during the day in muddy bottoms in depths ranging from 80 to 400 m. Apart from hake, important target species for bottom trawler are shrimps, anglerfish, blue whiting, and red mullet.

The gill nets are set in depths ranging from 80 to 300 m. The mesh size used is usually 48 to 64 mm. The fishery is carried out mainly during summer when bottom trawl fishery is prohibited. Longline fishery for hake operates in deeper waters, down to 500 m, mainly during the summer.

The main landing port in GSA 20 is the port of Patras.

After an increase from 2000 to 2008, the official landings of hake are continuously declining since 2008 with a slight increase in the last three years (Figure 6.10.2.1, Table 6.10.1.2.1).

Table 6.10.1.2.1 Hake in GSA 20. Hake landings in GSA 20 according to the official statistics as they appear in Hellenic Statistical Authorities database corrected to account for partial reconstruction.

Year	Hake official landings (t)
1982	407
1983	324
1984	385
1985	462
1986	287
1987	286
1988	432
1989	419
1990	512
1991	811
1992	1074
1993	2289
1994	2236
1995	1962.38
1996	1595.58
1997	1528.77
1998	1024.42
1999	875.08
2000	792.55
2001	808.27
2002	998.22
2003	924.86
2004	1025.73
2005	1184.24
2006	1633.57
2007	1629.64
2008	1840.55
2009	1654.53
2010	1421.35
2011	1230.09
2012	1278.56
2013	1357.16
2014	854.12
2015	561.99
2016	344
2017	693
2018	748
2019	700 (tbc)

DCF Landings per gear

Landings data per gear and fleet were reported to STECF EWG 20-15 through the DCF and are presented in Figure 6.10.2.1.3. Total landings by year are presented in Table 6.10.2.1.2.

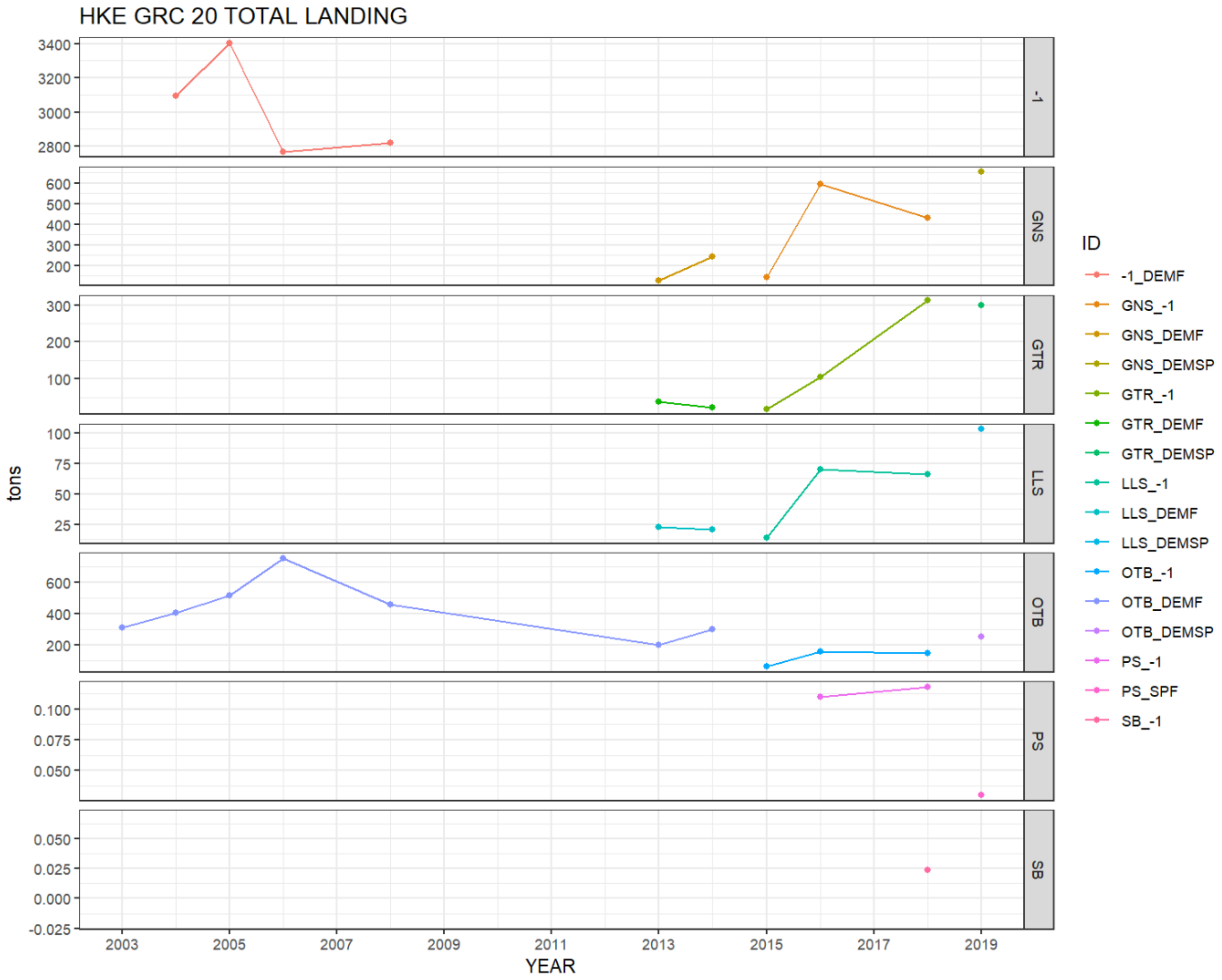


Figure 6.10.2.1.3. Hake in GSA 20. Landings data in tons by year and fleet.

Table 6.10.2.1.2. Hake in GSA 20. Hake DCF landings in tonnes by the Greek fleet in GSA 20 from different gears. Years 2007 and 2009-2012 and 2017 are missing, while data from 2013, 2015 come only from the fourth quarter of the year.

Year	GNS Landings (t)	GTR Landings (t)	LLS Landings (t)	OTB Landings (t)	Other/ unspecified (t)
2003	-	-	-	308	
2004	-	-	-	404	3094
2005	-	-	-	516	3404
2006	-	-	-	754	2768
2007	-	-	-	-	-
2008	-	-	-	459	2821
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	-	-	-
2012	-	-	-	-	-
2013	128	38	23	203	-
2014	241	23	21	300	-
2015	141	-	14	64	-
2016	596	-	70	157	-
2017	-	-	-	-	-
2018	433	311	66	151	-
2019	655	300	103	253	-

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.10.2.1.4 and that of OTB in 6.10.2.1.5. The assessment was based on OTB data only because the coastal gears GTR, GNS and LLS are separately reported only after 2013.

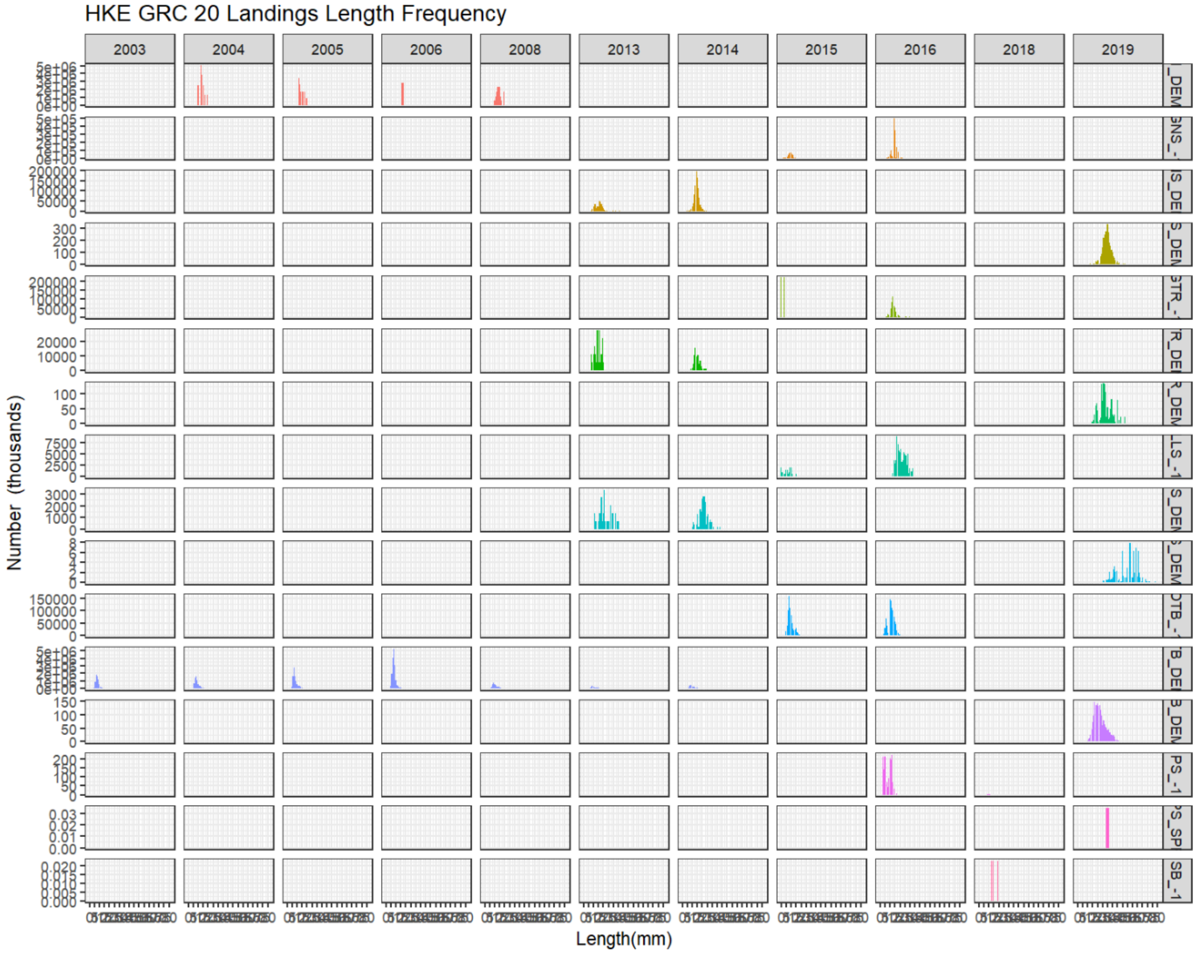


Figure 6.10.2.1.4. Hake in GSA 20. Length frequency distribution of the landings by year and fleet.

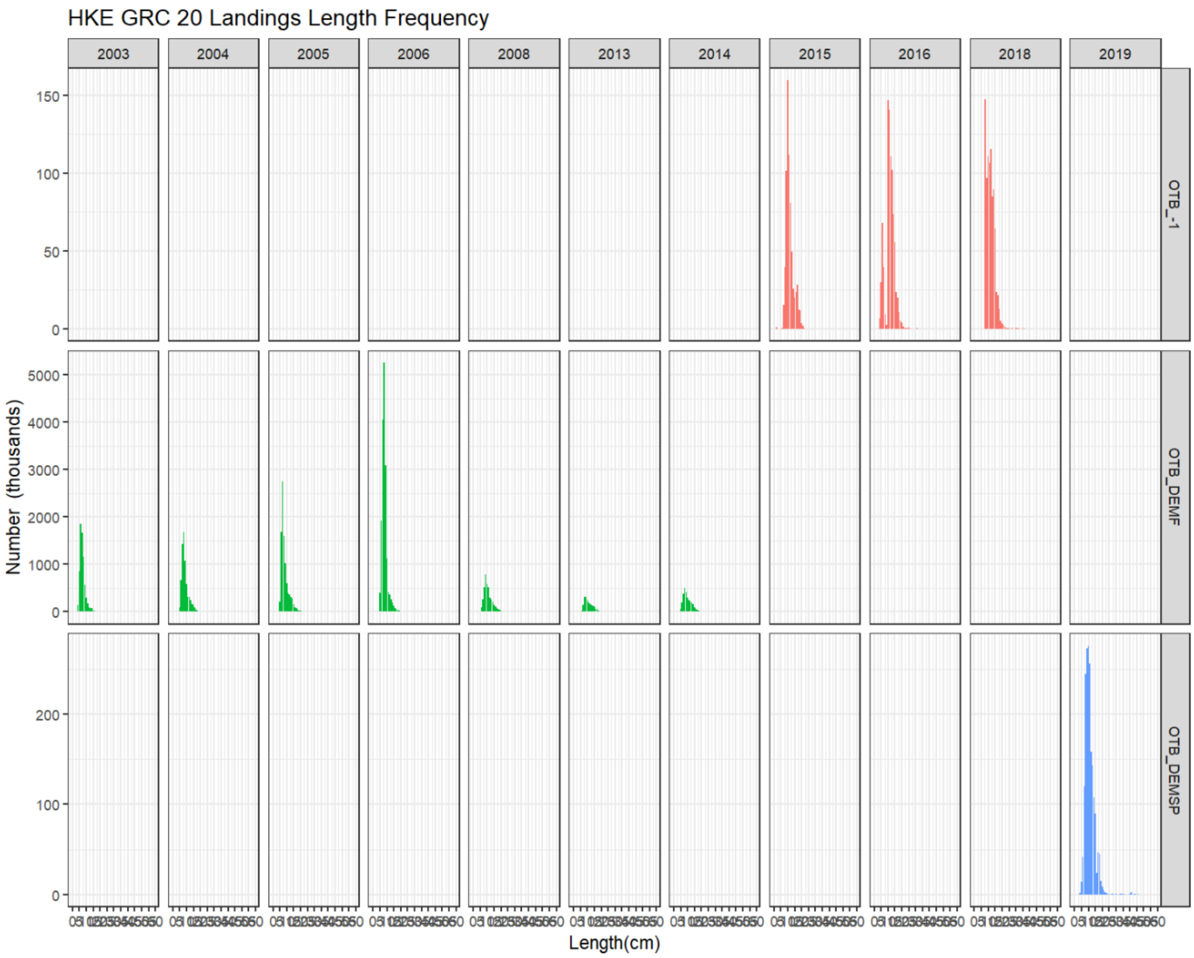


Figure 6.10.2.1.5. Hake in GSA 20. Length frequency distribution of the OTB landings.

Discards
According to the Greek DCF, the discards of haκe in GSA 20 were over 750 t in the mid- 2000s and have been declined to negligible values (<15t) for OTB since 2013 with the exception of GNS and GTR discards that exceed 30 t after 2016 (Figure 6.10.1.2.6, Table 6.10.1.2.3). The highest proportion of total discards (88% in 2018) is no longer attributed to OTB but to nets, which is bizarre as nets with large mesh size do not usually discard any fish.

Table 6.10.2.1.3. Hake in GSA 20. Hake discards in tonnes by fishing gear in GSA 20 as reported by the DCF.

	OTB_Discards (t)	**GNS_Discards (t)**	**GTR_Discards (t)**	**Unspecified gear Discards (t)**	**Total**
2003	33	-	-	-	**33**
2004	19	-	-	-	**19**
2005	70	-	-	761	**831**
2006	50	-	-	774	**824**
2007	-	-	-	-	**-**
2008	25	-	-	581	**606**
2009	-	-	-	-	**-**
2010	-	-	-	-	**-**
2011	-	-	-	-	**-**
2012	-	-	-	-	**-**
2013	16	-	-	-	**16**
2014	10	1	-	-	**11**
2015	2	1	-	-	**3**
2016	5	31	-	-	**36**
2017	-	-	-	-	**-**
2018	7	27	27	-	**61**
2019	12	23	-	-	**35**

Length and age frequency distributions of the discards are shown in Figure 6.10.2.1.6.

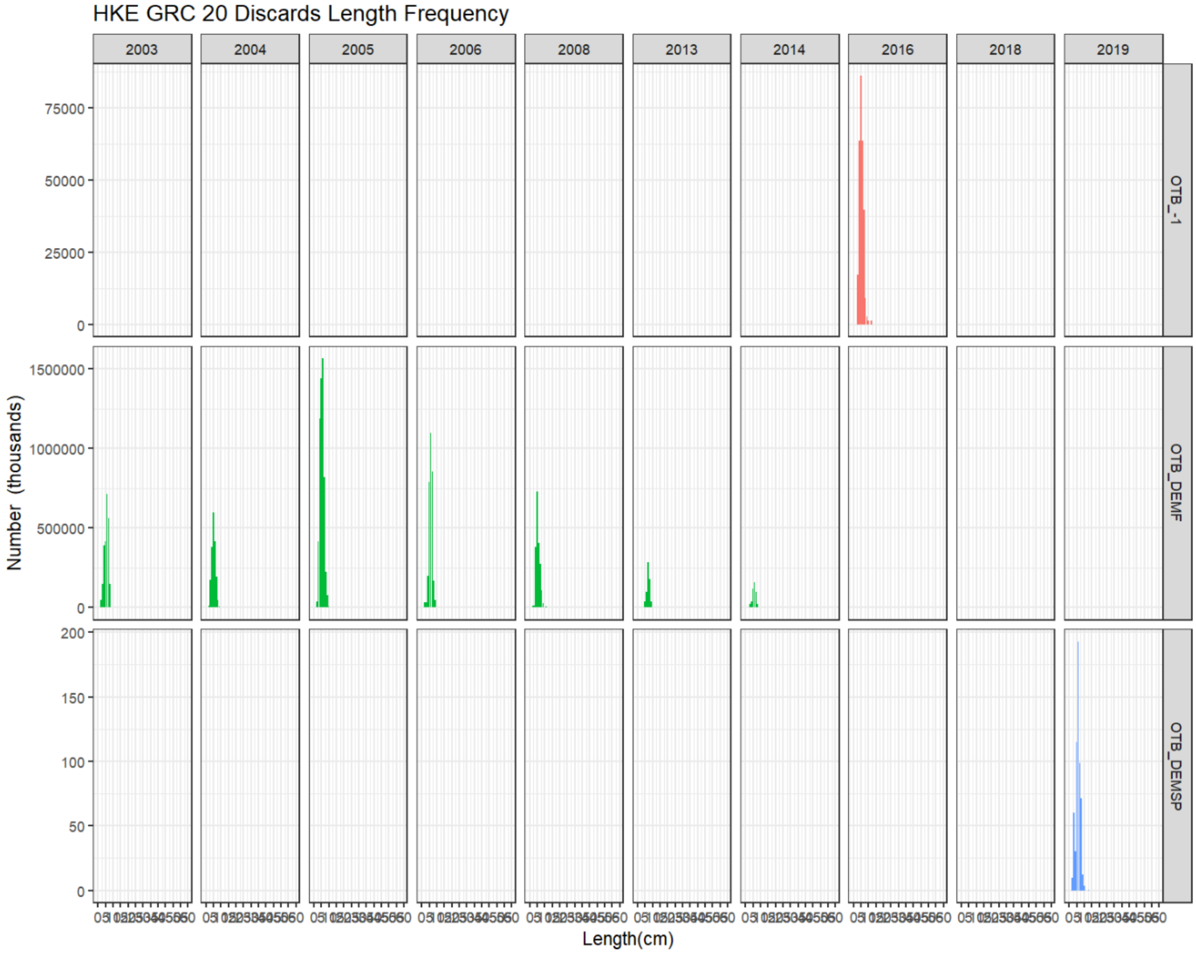


Figure 6.10.2.1.6. Hake in GSA 20. Length frequency distribution of the discards by year for OTB.

6.10.2.2 EFFORT

Fishing effort data were reported to STECF EWG 20-15 through DCF (Table 6.10.2.2.1).

Table 6.10.2.2.1. Hake in GSA 20. Fishing effort in days at sea by year and fishing gear.

	GNS	GTR	LLS	OTB
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	79355	309170	60591	7008
2015	27911	112443	19197	5037
2016	136021	307374	93648	5001
2017	-	-	-	-
2018	95537	388291	54733	5110
2019	132389	308633	52924	5400

6.10.2.3 SURVEY DATA

The MEDITS bottom trawl survey was used for the estimation of abundance index of hake in GSA 20. The survey is carried out in June/July each year since 1994. No survey was carried out in 2002, 2007, 2009-2013, 2015 and 2017. Data were analysed using the JRC script (Mannini, 2020)

A decline in the abundance of hake was observed from 2005 (highest value) to 2014 and a slight increase in 2016 and 2018 and a doubling of the index in 2019 (Figure 6.10.2.3.1, Table 6.10.2.3.1), owing to a large capture of juveniles in two hauls.

The combined MEDITS indexes were calculated using the script provided by JRC (Figures 6.10.2.3.1 and 6.10.2.3.2).

Table 6.10.2.3.1 Hake in GSA 20. MEDITS survey abundance index of hake in GSA 20 as reported by DCF. No survey was carried out in 2002, 2007, 2009-2013 and 2015. The survey is carried out in June/July.

Year	Hake abundance (kg/km^2)
1994	21.8
1995	69.4
1996	34.1
1997	23.9
1998	14.9
1999	13.9
2000	30.1
2001	31.5
2002	-
2003	36.5
2004	42.4
2005	68.8
2006	52.1
2007	-
2008	45.3
2009	-
2010	-
2011	-
2012	-
2013	-
2014	34.1
2015	-
2016	48.3
2017	-
2018	54.9
2019	117.4

Ages 0, 1 and 2 make up the majority of individuals caught during the MEDITS bottom trawl survey (Figure 6.10.2.3.2) while the mean weight of individuals is lower than 50 g, with a peak of over 150 g in the 1990s (Figure 6.10.2.3.2).

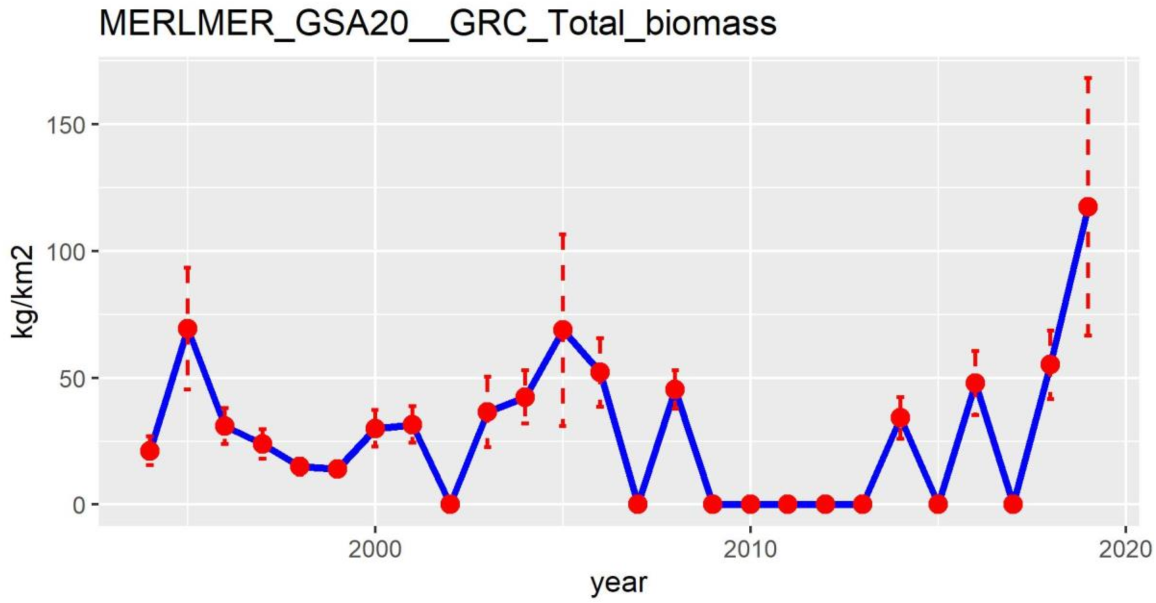


Figure 6.10.2.3.1. Hake in GSA 20. Estimated biomass indices from the MEDITS survey (kg/km^2).

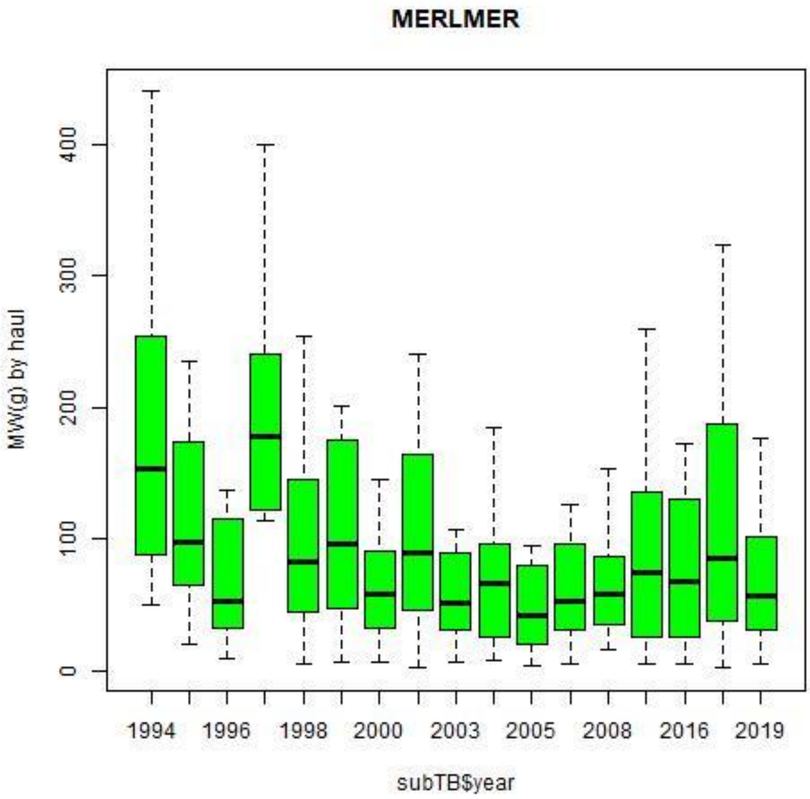
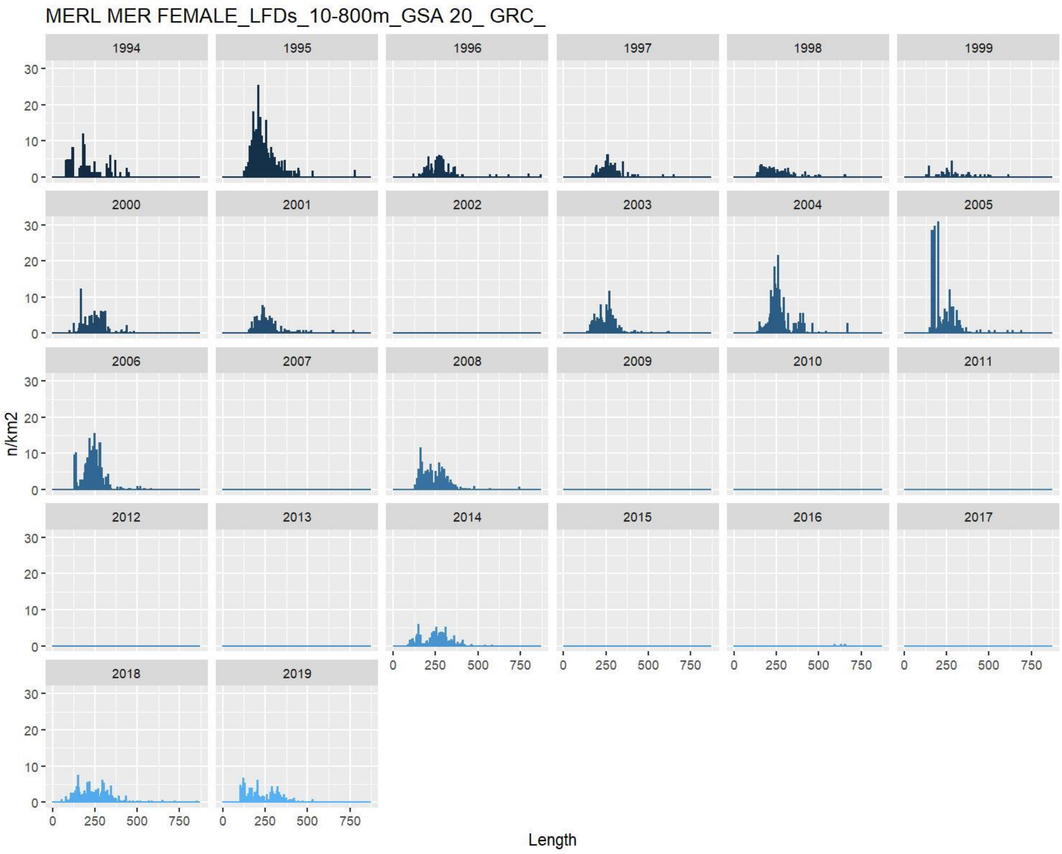
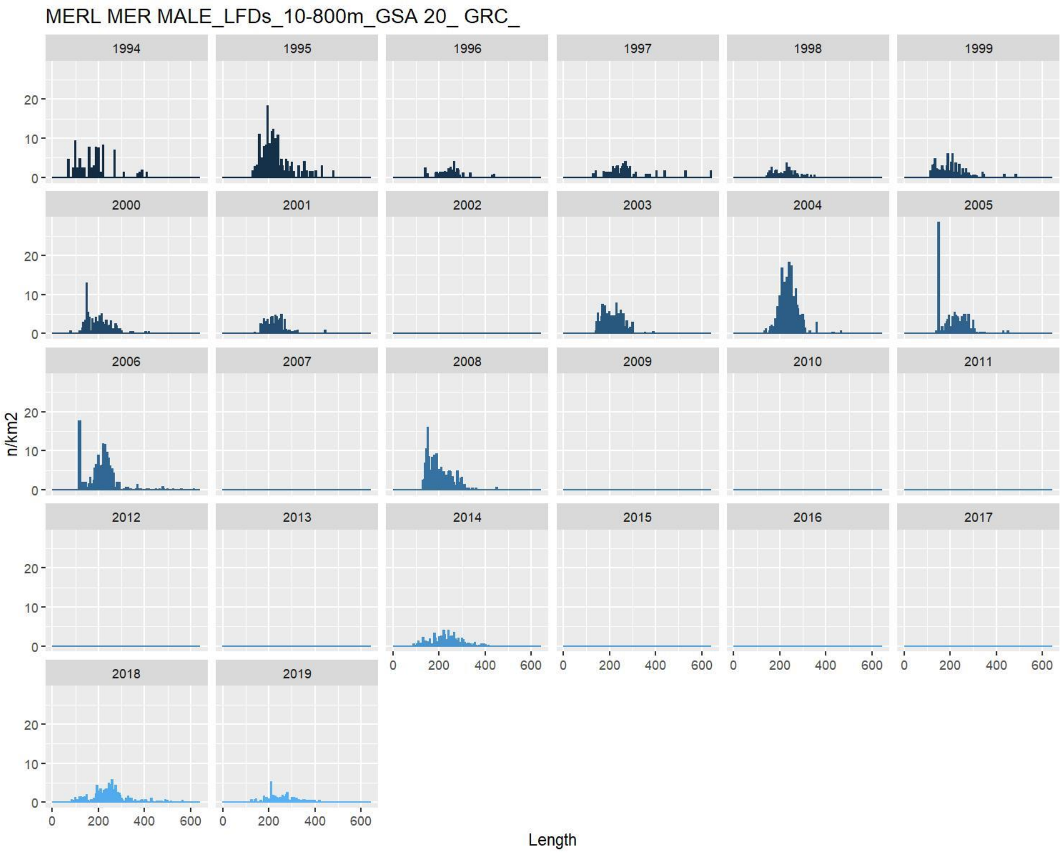


Figure 6.10.2.3.2. Hake in GSA 20. Mean weight of individuals by haul from the MEDITS survey (g).

The estimated biomass index fluctuated throughout the time series. Size structure indices for males, females and total individuals are shown in Figure 6.10.2.3.3.



MERL MER FEMALE_LFDs_10-800m_GSA 20_ GRC_
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
n/km2
Length



MERL MER MALE_LFDs_10-800m_GSA 20_ GRC_
1994
1995
1996
1997
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2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
n/km2
Length

Figure 6.10.2.3.3. Hake in GSA 20. Length frequency distribution by year and sex of MEDITS survey.

6.10.3 Stock assessment

6.17.3.1 Method1: a4a

The Assessment for All Initiative (a4a) (Jardim et al., 2014), a4a, a statistical catch-at-age analysis method were used for this stock that utilize catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike VPA, model parameters using catch-at-age analysis are estimated by working forward in time and the methods do not require the assumption that removals from the fishery are known without error. Data that are typically used are: catch, abundance index, statistical sample of age composition of catch and abundance index. Assessment was performed with version 1.8.2 of FLa4a, together with version 2.6.15.9005 of the FLR library (FLCore) in FLR environment.

The assessment was carried out using the period 2003-2019 for catch data and tuning file for which data were available. A single tuning fleet was used in both methods based on the CPUE and weight at age estimates from summer bottom trawl surveys (MEDITS) conducted in the Greek part of Ionian Sea (GSA 20) from 2003 to 2019 (with gaps in 2007, 2009-2013, 2015 and 2017) as reported in the DCF.

Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR, using for each GSA the corresponding growth parameters for sexes combined. The plus group was set at 5 but then the data were sliced to 0-4 The analysis was carried out for the ages 0 to 4+ class for the a4a. Concerning the Fbar, the age range used was 1-3 age groups.

Input data

Total catches and catch numbers at age from the single GSAs were used as input data. SOP correction was applied to catch numbers at age and reflects missing data and inconsistent reporting.

Tables 6.10.3.2.1-6.10.3.2.4 list the input data for the a4a model, namely catch numbers at age, weight at age, and the tuning series (MEDITS) at age.

Table 6.10.3.2.1. Hake in GSA 20. Catch numbers at age (thousands)

Year/Age	0	1	2	3	4	5
2003	14928	20111	1475.8	116.84	10.455	0.52274
2004	2381.8	15700	2904	248.51	20.941	8.3796
2005	18778	16019	3687.7	317.6	21.569	3.923
2006	72011	32613	2852.4	218.66	13.055	6.5215
2007	NA	NA	NA	NA	NA	NA
2008	7851.2	21748	5064	529.96	19.628	215.91
2009	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA
2013	52555	28708	454.24	642.8	85.707	21.427
2014	3757.4	9674.9	3134.3	179.04	41.856	9.3014
2015	836.15	7408	1631.2	264.04	2.9276	0.14711
2016	793.24	2255.5	1516.6	121.6	11.837	8.6136
2017	NA	NA	NA	NA	NA	NA
2018	9043.3	11753	1727.1	126.94	34.948	46.546
2019	935.7	6383.4	2173	385.69	30.263	35.222

Table 6.10.3.2.2. Hake in GSA 20. Weights at age (Kg)

Year/Age	0	1	2	3	4	5
2003	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2004	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2005	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2006	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2007	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2008	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2009	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2010	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2011	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2012	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2013	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2014	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2015	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2016	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2017	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2018	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2019	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349

Table 6.10.3.4. Hake in GSA 20. MEDITS numbers at age (n/km^2)

Year/Age	0	1	2	3	4	5
2003	336.13	439.92	127.11	6.83	2.06	1.03
2004	381.23	438.58	279.93	27.69	17.76	3.51
2005	1181.81	982.82	130.77	16.35	2.83	3.54
2006	559.47	274.13	197.62	17.84	3.07	4.86
2007	0.00	0.00	0.00	0.00	0.00	0.00
2008	164.70	683.35	102.30	18.50	2.37	1.68
2009	0.00	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00	0.00
2014	131.90	292.02	101.96	22.73	6.89	0.42
2015	0.00	0.00	0.00	0.00	0.00	0.00
2016	187.90	230.79	95.46	0.56	0.00	1.10
2017	0.00	0.00	0.00	0.00	0.00	0.00
2018	234.83	316.60	152.88	38.37	7.10	4.94
2019	333.24	1566.00	322.13	46.05	7.30	1.37

Catch Data

The time series of official landings for the Greek part of Ionian Sea (GSA 20), as they appear in the Hellenic Statistical Authority database was used for the period 2003-2019. The DCF reported landings and discards were considered unreliable for the early years of the dataset and were excluded. Based on the DCF report, hake discards were considered negligible in GSA 20 for the years after 2013 although considerable quantities had been discarded from 2003 to 2006. The total landings data used for assessment are reported in Table 6.10.2.3. Catch was considered equivalent to landings.

Landings at age data for the period 2003-2016 were those reported by the DCF. No DCF was carried out in 2007, 2009-2012 and 2017 and DCF covered only the last trimester in 2013 and 2015. Thus, in the a4a method, NA (non-available) was used for the catch at age data in the years that no DCF was carried out. Age structure of the landings data used for assessment is the DCF reported age readings (Figure 6.10.2.1).

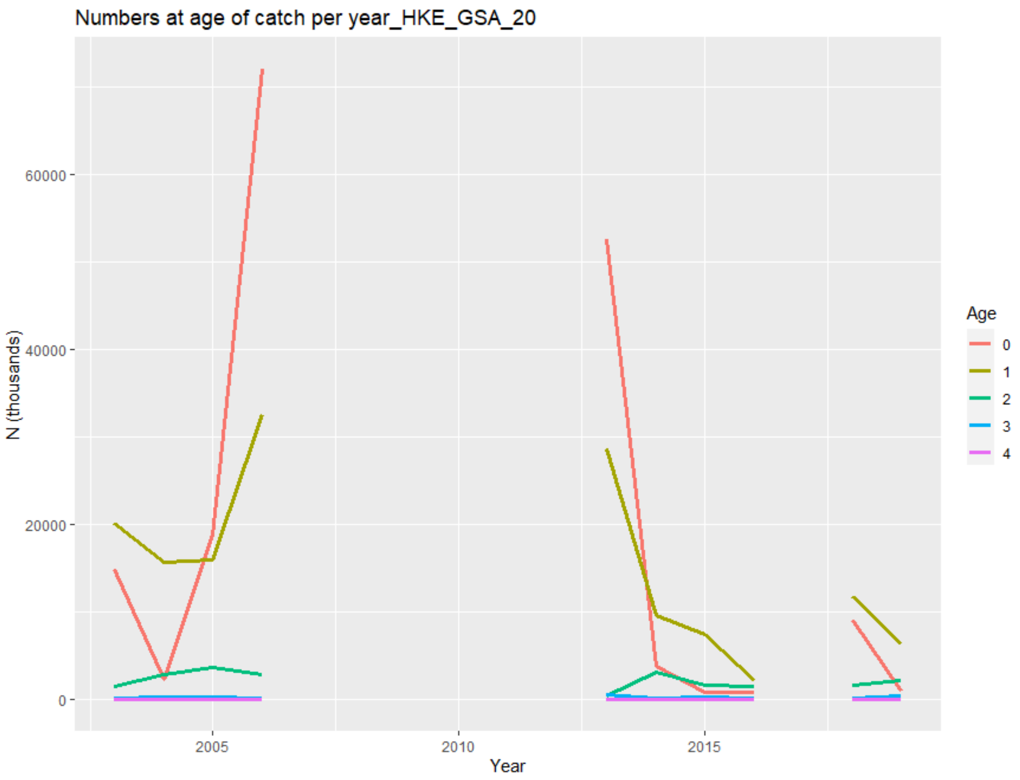

Figure 6.10.3.1. Hake in GSA 20. Catch (N) at age per year input data.

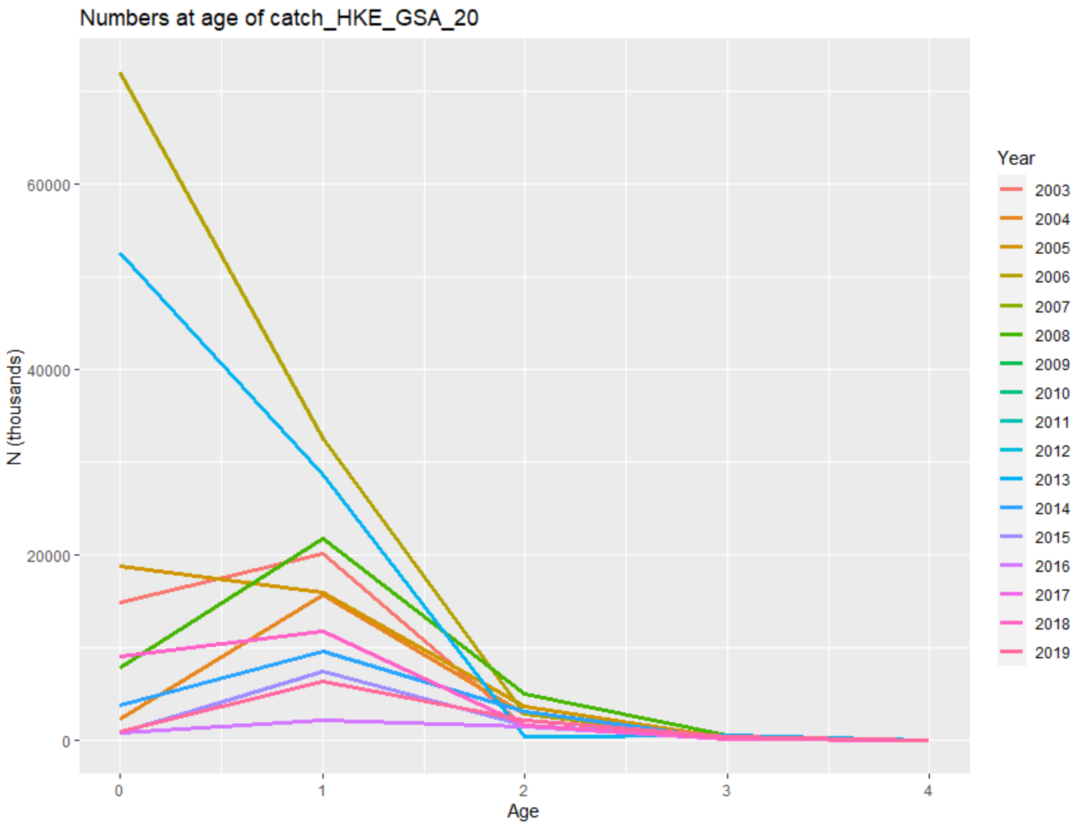

Figure 6.10.3.2. Hake in GSA 20. Age structure of the catch data.

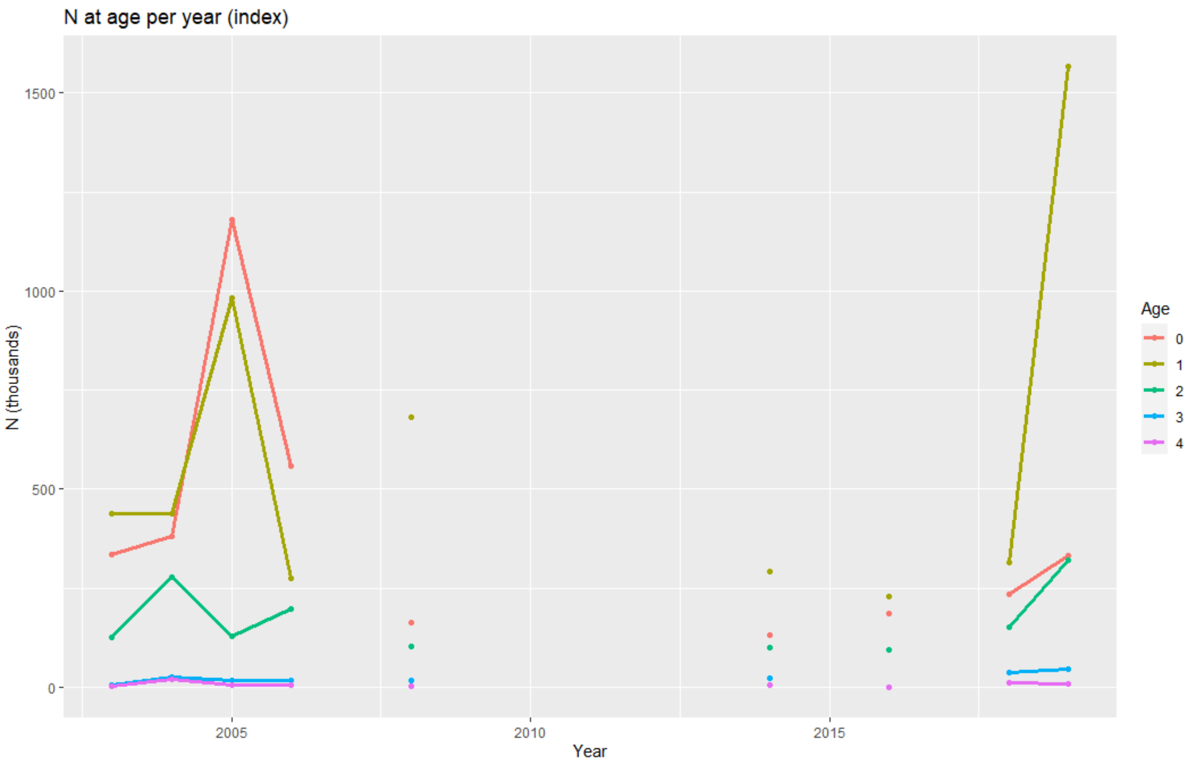

Figure 6.10.3.1. Hake in GSA 20. Index (N) at age per year input data.

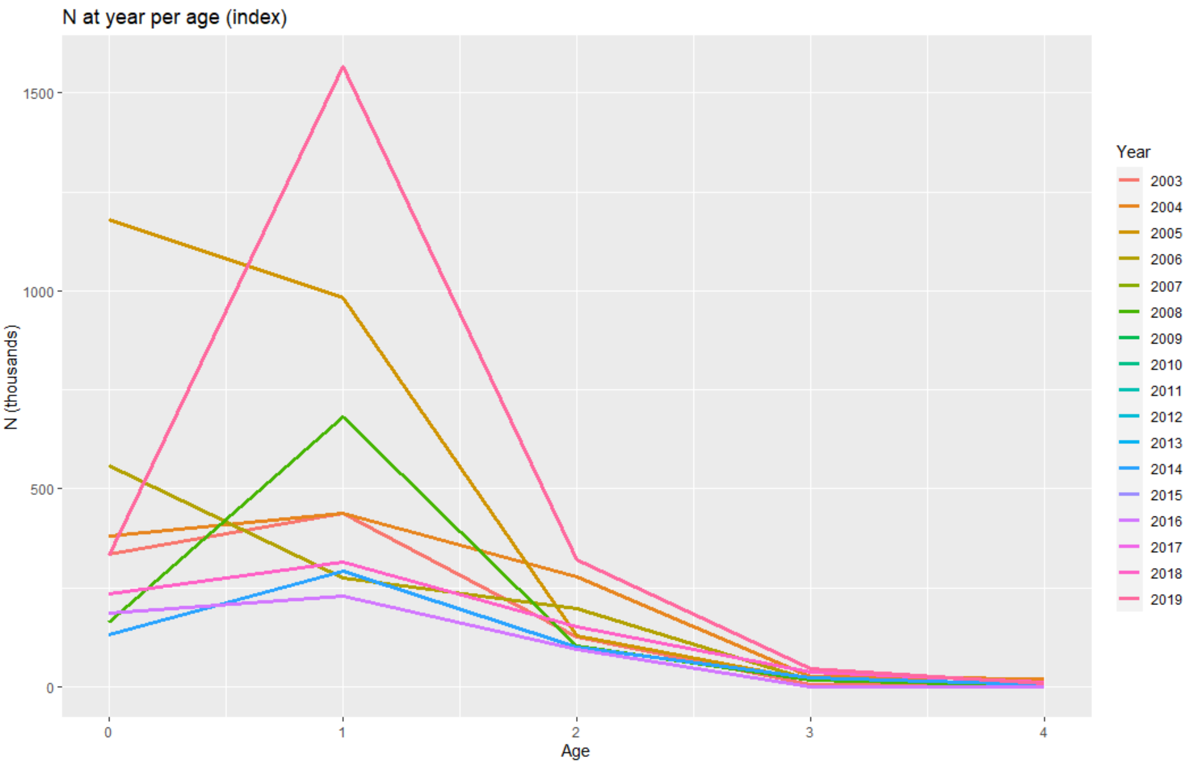

Figure 6.10.3.2. Hake in GSA 20. Age structure of the index.

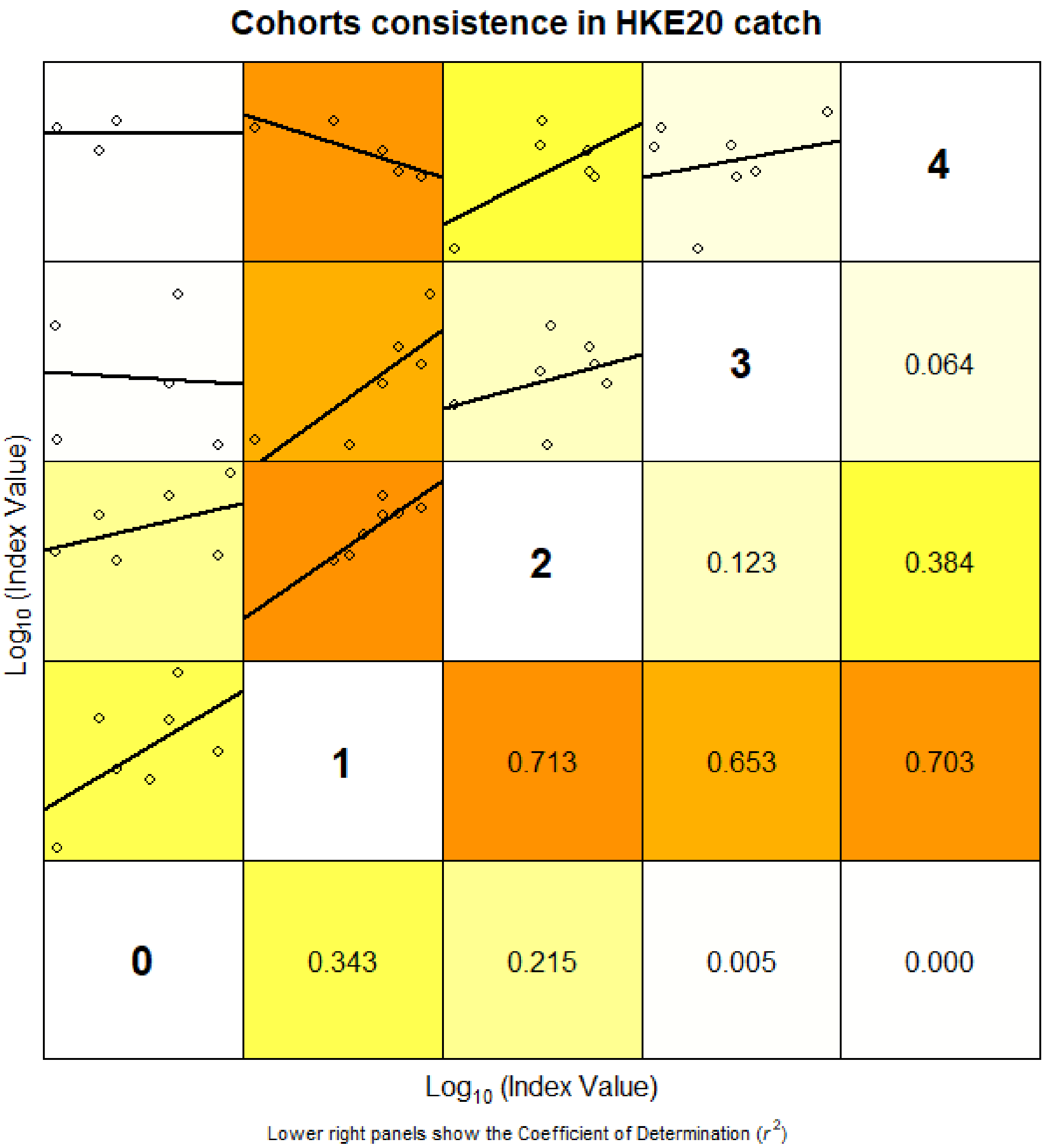

Figure 6.10.3.3. Hake in GSA 20. Catch at age cohort consistency

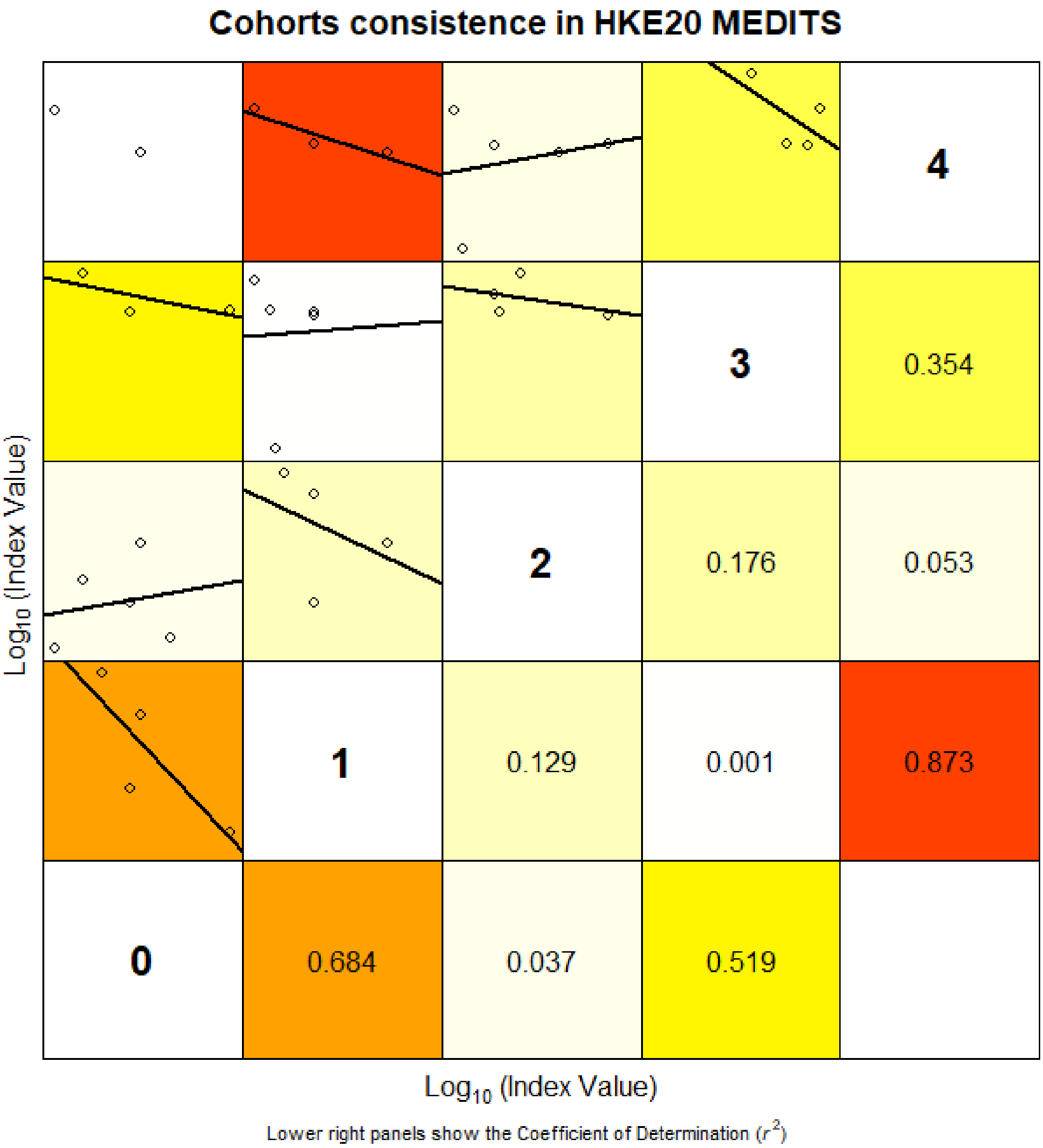

Figure 6.10.3.4. Hake in GSA 20. Index at age cohort consistency

Assessment results
Different a4a models were examined (combination of different f and q). The best model (according to residuals and retrospective) included:

a4a model fit for: HKE_GSA_20

Submodels:
fmod <- ~factor(replace(age, age>2,2)) + s(year, k=6)
qmod <- list(~ factor(age))
srmod <- ~geomean(cv=0.3)

The results of the assessment are shown in Figures 6.10.3.5 – 6.10.3.11.

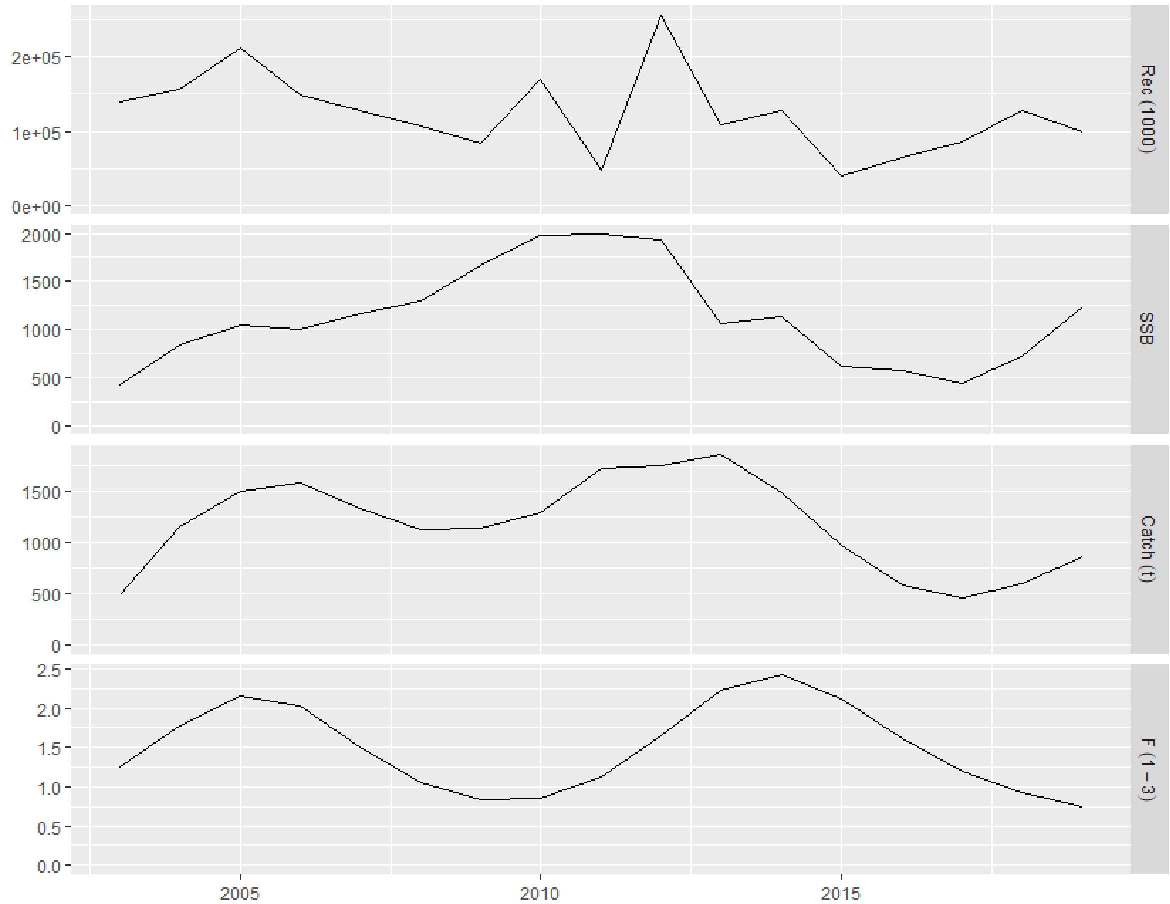

Figure 6.10.3.5. Hake in GSA 20. Stock summary from the final a4a model.

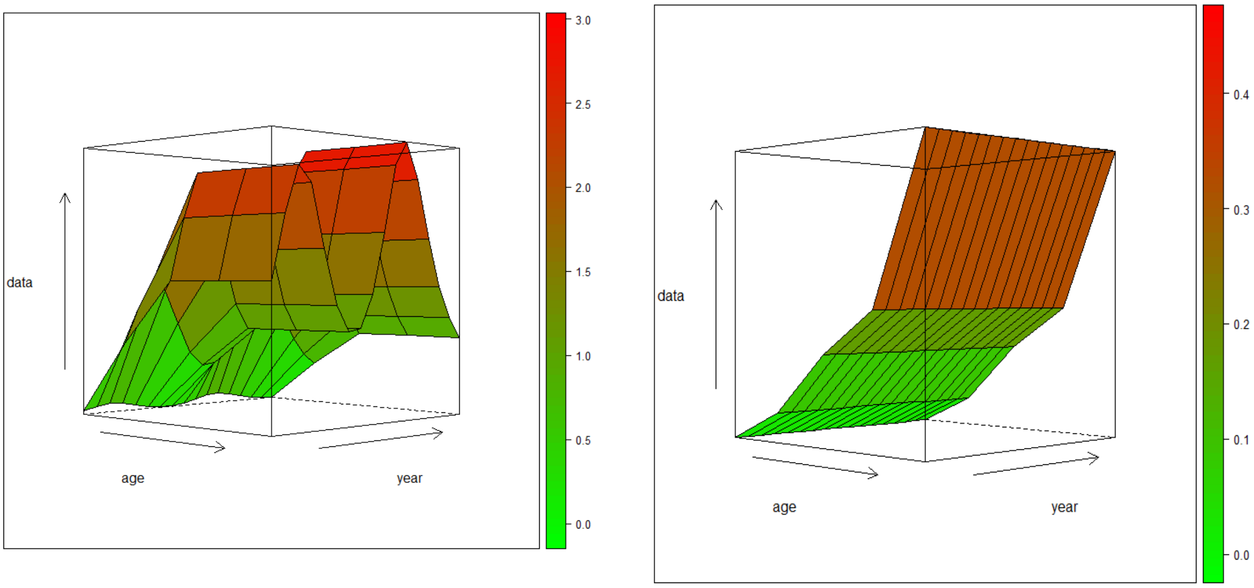

Figure 6.10.3.6. Hake in GSA 20. 3D contour plot of estimated catchability (top) and 3D contour plot of estimated fishing mortality (bottom) at age and year.

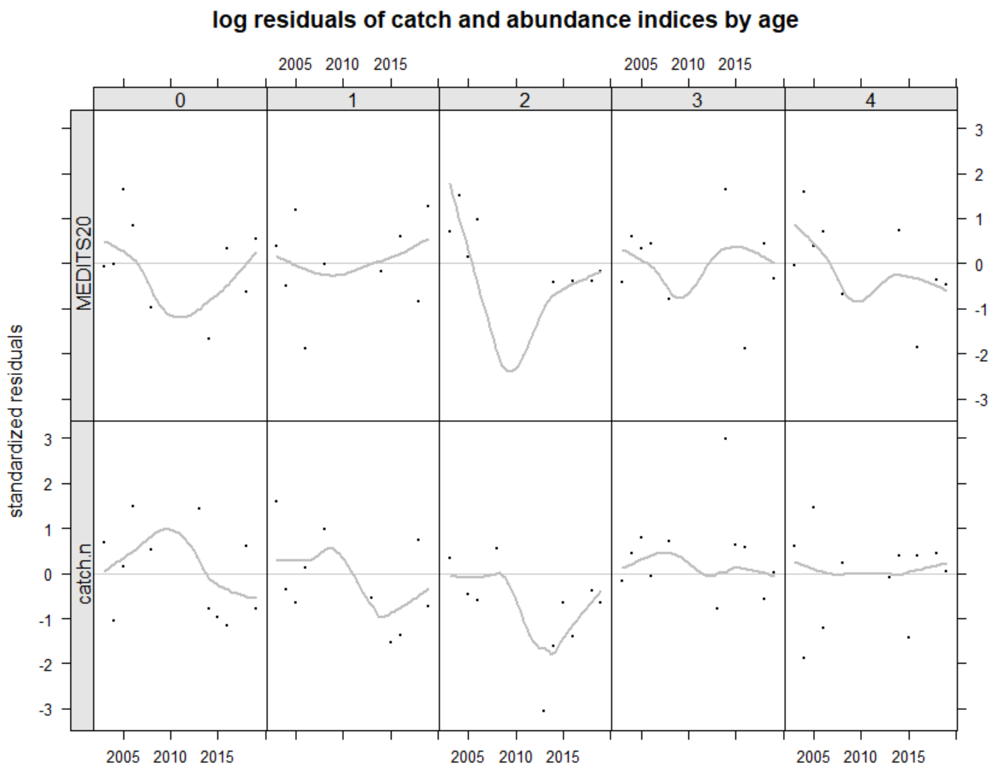

Figure 6.10.3.7. Hake in GSA 20. Standardized residuals by age for abundance index and for catch numbers.

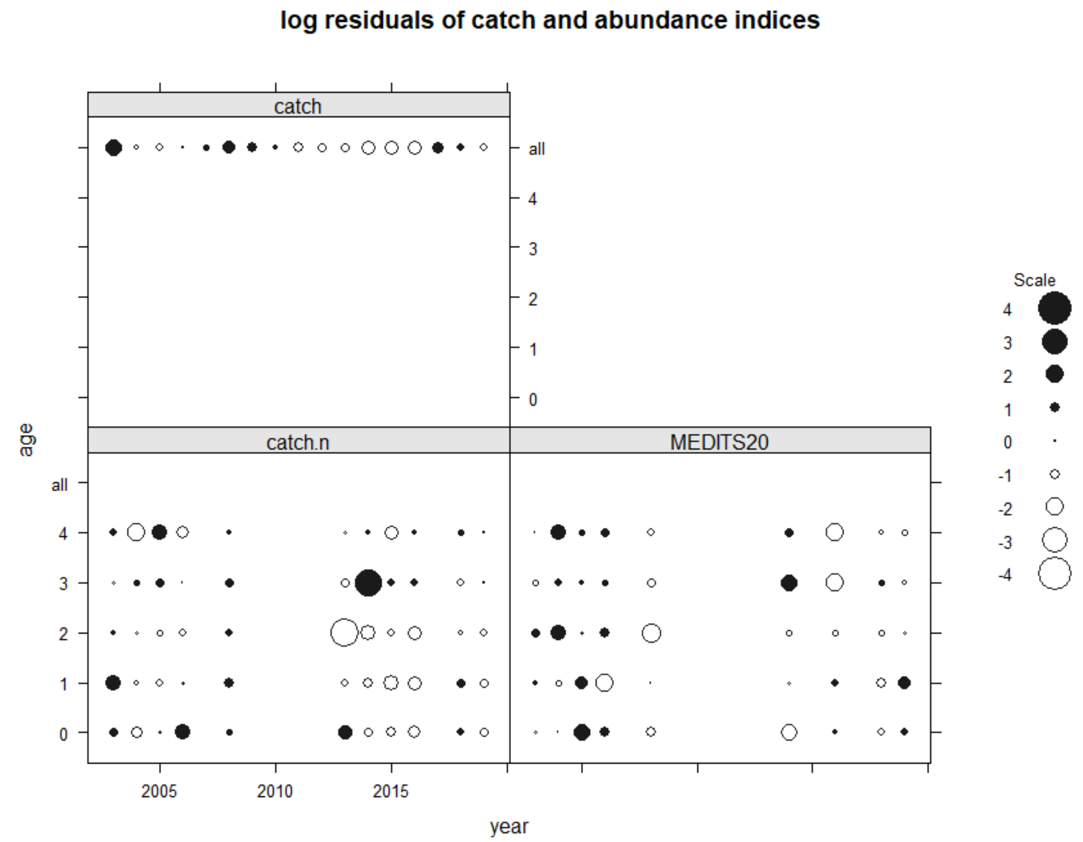

Figure 6.10.3.8. Hake in GSA 20. Standardized residuals for abundance index and for catch numbers.

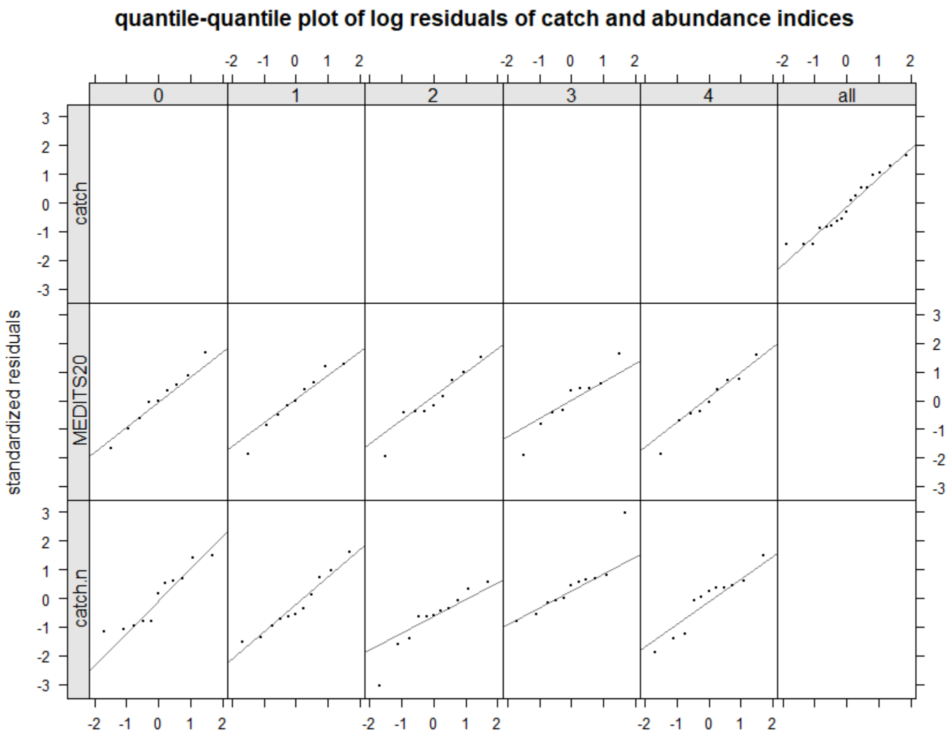

Figure 6.10.3.9. Hake in GSA 20. Quantile plot of standardized residuals for abundance index and for catch numbers.

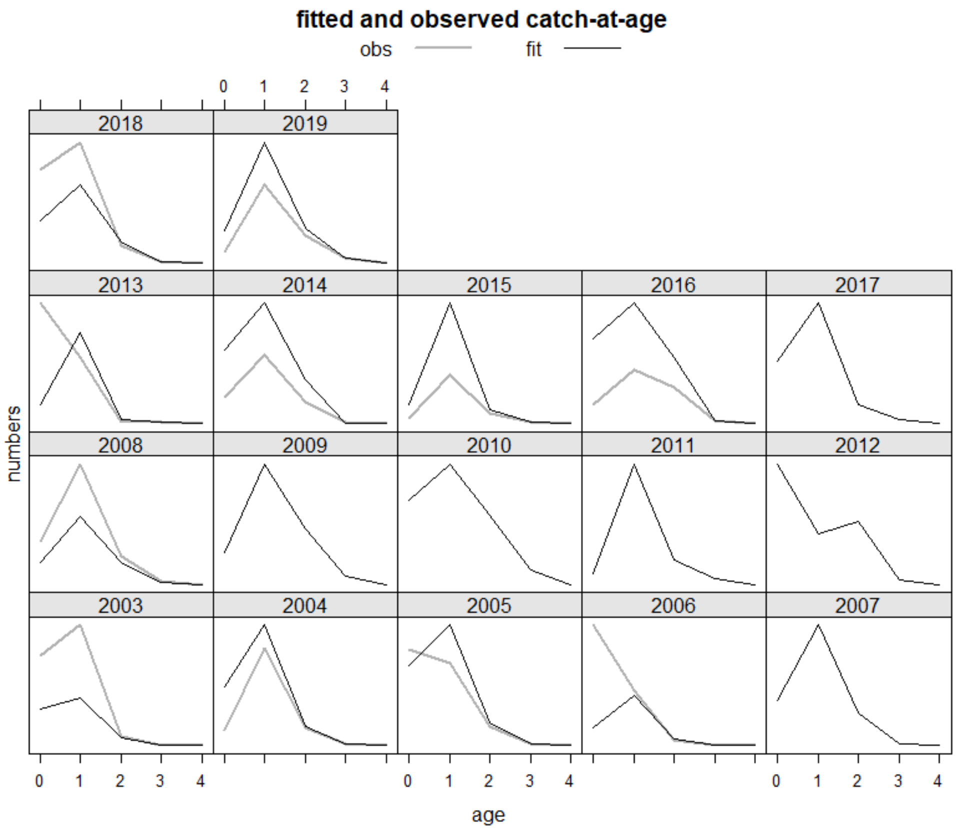

Figure 6.10.3.10. Hake in GSA 20. Fitted and observed catch at age.

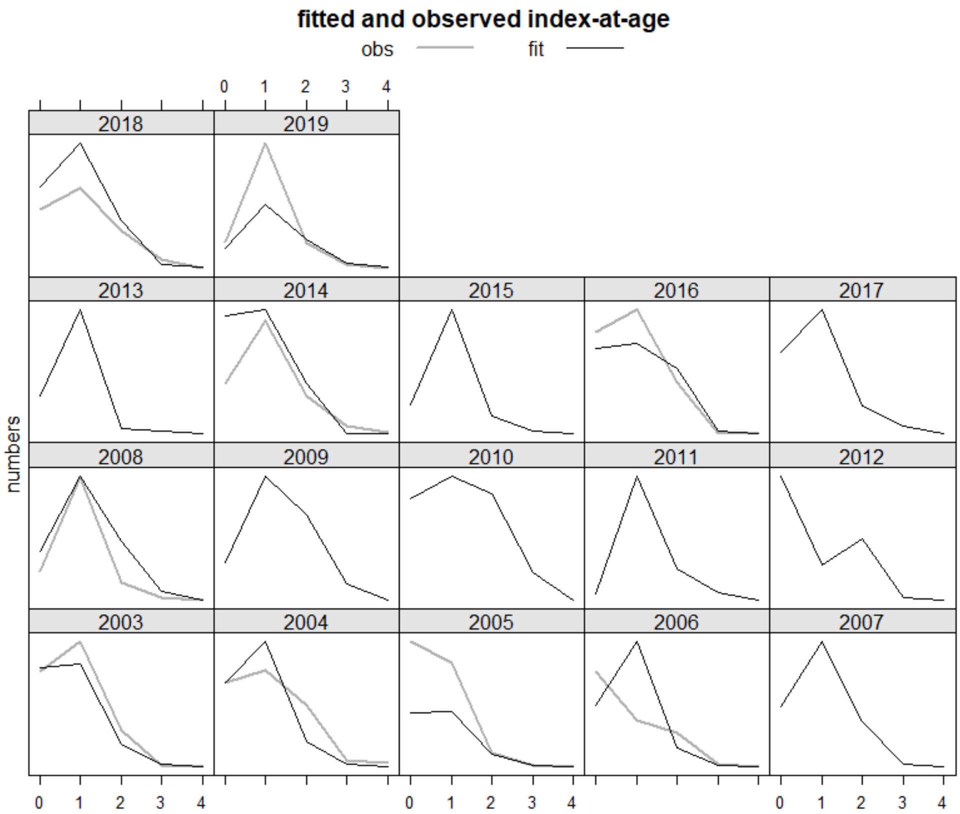

Figure 6.10.3.10. Hake in GSA 20. Fitted and observed index at age.

Retrospective
The retrospective analysis could not be applied because the 2017 dataset was missing.

Simulations
In the following figures and tables, the population estimates obtained by the a4a model are provided.

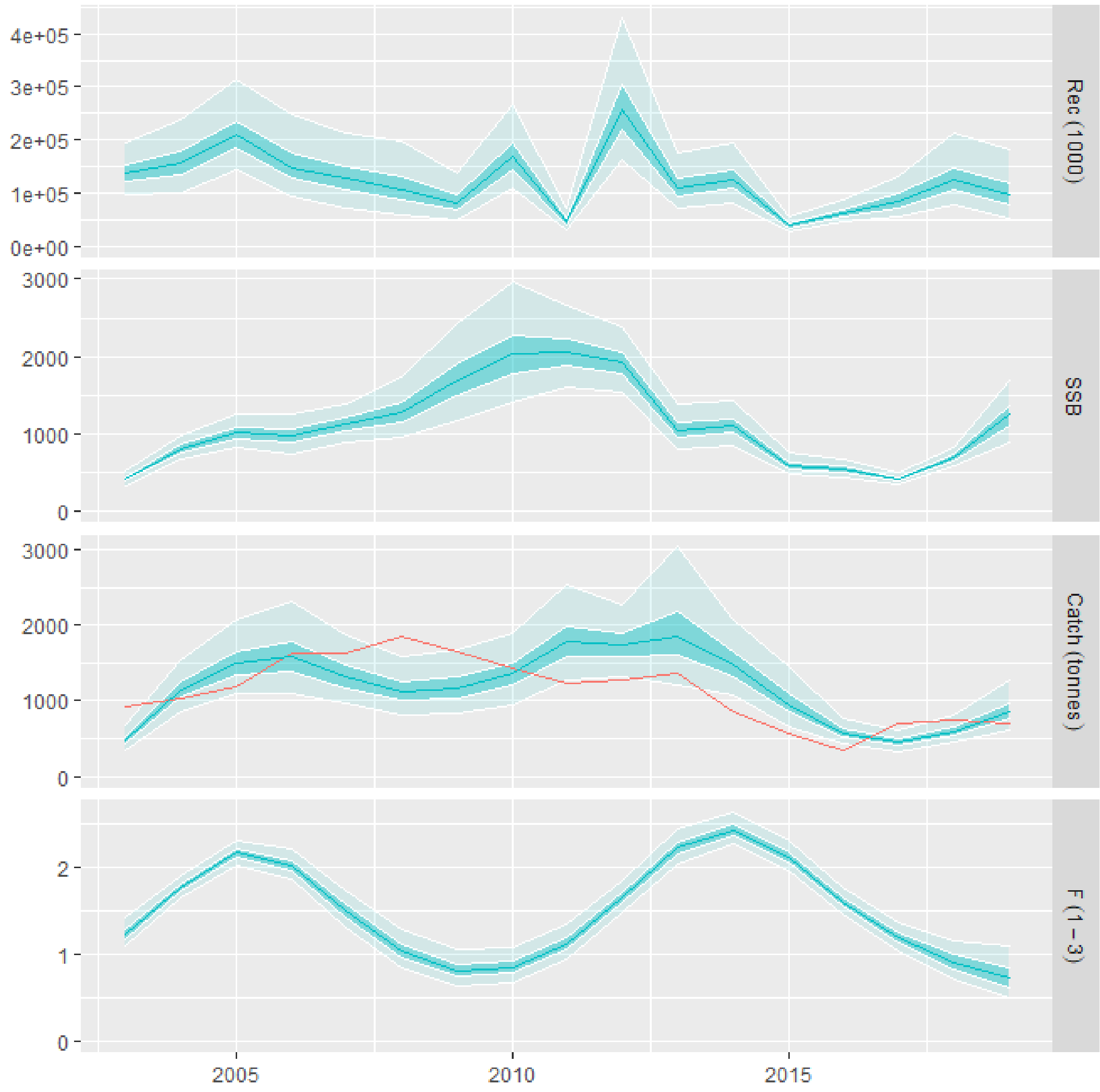

Figure 6.10.3.11. Hake in GSA 20. Stock summary of the simulated and fitted data for the a4a model.

Table 6.10.3.3. Hake in GSA 20. Stock numbers at age (thousands) as estimated by a4a.

Year/Age	0	1	2	3	4
2003	139100	18954	1991	185	15
2004	156000	37234	4043	287	29
2005	211860	40390	5612	314	24
2006	149480	53537	4722	277	17
2007	127220	38091	6832	272	17
2008	107210	33490	6827	722	31
2009	84307	29051	8121	1239	143
2010	170080	23158	8120	1899	317
2011	47244	46644	6366	1843	472
2012	257210	12737	10724	1050	333
2013	109360	67111	2081	961	103
2014	127450	27529	7538	95	48
2015	40407	31677	2706	273	4
2016	64195	10238	3808	140	15
2017	84879	16790	1715	357	14
2018	127070	22787	3695	262	60
2019	98572	34698	5989	774	60

Table 6.10.3.4. Hake in GSA 20. a4a summary results Fbar age 1-3, recruitment (thousands), catches, SSB and total biomass (tonnes).

	Fbar (1-3)	**Recruitment (age1)**	**SSB**	**Total Biomass**	**Catch**
2003	1.24	139104	429	1131	490
2004	1.77	155995	832	2076	1156
2005	2.16	211862	1046	2469	1510
2006	2.03	149478	1003	2682	1594
2007	1.51	127221	1159	2446	1339
2008	1.05	107210	1294	2436	1128
2009	0.83	84307	1671	2694	1150
2010	0.86	170078	1973	2942	1300
2011	1.13	47244	1988	3397	1730
2012	1.65	257208	1940	2788	1748
2013	2.22	109357	1060	2998	1862
2014	2.42	127450	1138	2160	1486
2015	2.12	40407	616	1551	976
2016	1.61	64195	578	998	595
2017	1.19	84879	441	1017	461
2018	0.92	127067	712	1535	608
2019	0.74	98572	1237	2384	872

Current F (0.74, estimated as the F_{bar1-3} in the last year of the time series, 2019) is higher than $F_{0.1}$ (0.36), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that hake stock in GSA 20 is overfished.

Table 6.10.3.5. Hake in GSA 20. a4a results F at age.

F at age	**0**	**1**	**2**	**3**	**4**
2003	0.08	0.81	1.46	1.46	1.46
2004	0.11	1.16	2.08	2.08	2.08
2005	0.14	1.42	2.53	2.53	2.53
2006	0.13	1.33	2.37	2.37	2.37
2007	0.09	0.99	1.77	1.77	1.77
2008	0.07	0.69	1.23	1.23	1.23
2009	0.05	0.54	0.97	0.97	0.97
2010	0.05	0.56	1.00	1.00	1.00
2011	0.07	0.74	1.32	1.32	1.32
2012	0.10	1.08	1.93	1.93	1.93
2013	0.14	1.46	2.60	2.60	2.60
2014	0.15	1.59	2.84	2.84	2.84
2015	0.13	1.39	2.48	2.48	2.48
2016	0.10	1.06	1.89	1.89	1.89
2017	0.08	0.78	1.40	1.40	1.40
2018	0.06	0.61	1.08	1.08	1.08
2019	0.05	0.49	0.87	0.87	0.87

Based on the a4a results, hake SSB showed a constant declining trend from 2010 to 2017 and increased the last two years. The number of recruits a fluctuating pattern until a maximum value reached in 2018 but declined again in 2019. Fbar (1-3) shows a fluctuating pattern with an increase up to 2014 and decline in the last years (Fbar 2019 = 0.74).

6.10.3.2 METHOD2: SPICT (SURPLUS PRODUCTION)

The Surplus Production in Continuous time (SPiCT) assessment method is fully described in Pedersen and Berg (2016). SPiCT is available as an R (R Core Team 2015) package in the github online repository: https://github.com/map/spict.

SPiCT requires a time series of catches and one (or more) time series of tuning index (CPUE or biomass; in this case MEDITS index). The expected output includes management reference points F/Fmsy and B/Bmsy that quantify the exploitation rate and stock status. A forecasting period and a fishing management scenario can be tested by changing the multiplication factor that is applied to the current fishing mortality and projecting to the future. Main advantages of SPiCT are:

1. All estimated reference points (MSY, Fmsy, Bmsy) are reported with uncertainties.
2. The model can be used for short-term forecasting and management strategy evaluation.
3. The model is fully stochastic in that observation error is included in catch and index observations, and process error is included in fishing and stock dynamics.
4. The model is formulated in continuous-time and can therefore incorporate arbitrarily sampled data.

Input data

Landings
The official landings of hake (Figure 6.10.3.2.1) are being recorded by the Hellenic Statistical Authority and the same values are reported by the FAO/GFCM databases. However, the structure of the dataset changed after 2015 and includes the landings of an extra small-scale coastal fleet of 10,000 vessels (Tsikliras et al. 2020). To account for these additional landings that artificially inflated the landings time series after 2016, we corrected the hake landings from 1982 to 2015 by multiplying by 1.31, which is the difference of hake with and without the extra fleet. According to the DCF report, the discards of hake by weight in GSA 20 are negligible; thus, they were excluded from the analysis.

Biomass
The CPUE from MEDITS bottom trawl surveys that were conducted in Ionian Sea was used as tuning index. Survey data were available by DCF from 1994 onwards (with gaps in 2002, 2007, 2009-2013, 2015 and 2017).

Settings
No priors on any of the model parameters or variables were required for the model to converge.
The Schaefer production model was selected.

Table 6.10.3.2.1 Hake in GSA 20. Official landings (tons) for hake in GSA 20.

Year	Greek landings (t)
1995	1962.38
1996	1595.58
1997	1528.77
1998	1024.42
1999	875.08
2000	792.55
2001	808.27
2002	998.22
2003	924.86
2004	1025.73
2005	1184.24
2006	1633.57
2007	1629.64
2008	1840.55
2009	1654.53
2010	1421.35
2011	1230.09
2012	1278.56
2013	1357.16
2014	854.12
2015	561.99
2016	344
2017	693
2018	748
2019	700 (tbc)

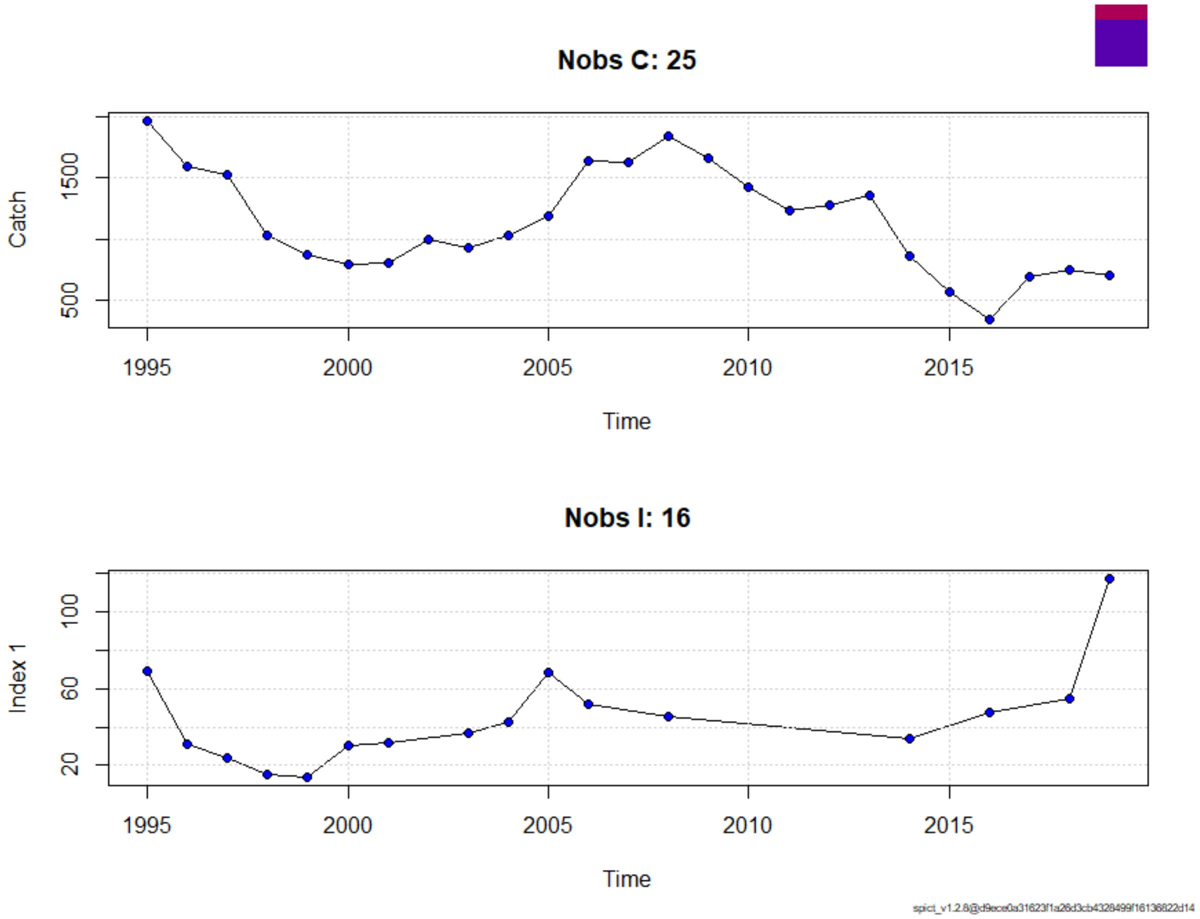

Figure 6.10.3.2.1 Hake in GSA 20. Input data for hake in GSA 20.

Assessment results
The output 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: 19.247241"
 [3] "Euler time step (years):  1/16 or 0.0625"
 [4] "Nobs C: 25,  Nobs I1: 16"
 [5] "Catch/biomass unit: tones "
 [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] ""
[12] "Fixed parameters"
[13] "   fixed.value  "
[14] " n           2  "
[15] ""
[16] "Model parameter estimates w 95% CI "
[17] "            estimate       cilow       ciupp    log.est  "
[18] " alpha     5.7351629   0.5472189  60.1077431  1.7466162  "
[19] " beta      0.1636124   0.0267234   1.0017054 -1.8102550  "
[20] " r         1.0919076   0.6459759   1.8456760  0.0879263  "
```

```
[21] " rc        1.0919076    0.6459759    1.8456760  0.0879263  "
[22] " rold      1.0919076    0.6459759    1.8456760  0.0879263  "
[23] " m      1402.7474132 1296.9763445 1517.1443284  7.2461880  "
[24] " K      5138.7036146 3085.3645645 8558.5590573  8.5445561  "
[25] " q         0.0163173    0.0105310    0.0252828 -4.1155301  "
[26] " sdb       0.0460521    0.0043491    0.4876366 -3.0779821  "
[27] " sdf       0.3429624    0.2421431    0.4857590 -1.0701345  "
[28] " sdi       0.2641162    0.1831539    0.3808676 -1.3313659  "
[29] " sdc       0.0561129    0.0106845    0.2946944 -2.8803895  "
[30] " "
[31] "Deterministic reference points (Drp)"
[32] "           estimate       cilow       ciupp    log.est  "
[33] " Bmsyd 2569.3518073 1542.682282 4279.279529  7.8514089  "
[34] " Fmsyd    0.5459538    0.322988    0.922838 -0.6052209  "
[35] " MSYd  1402.7474132 1296.976345 1517.144328  7.2461880  "
[36] "Stochastic reference points (Srp)"
[37] "           estimate        cilow       ciupp    log.est  "
[38] " Bmsys 2564.6310684 1537.3165220 4278.450418  7.8495699  "
[39] " Fmsys    0.5454984    0.3227865    0.921874 -0.6060555  "
[40] " MSYs  1398.9998921 1293.6456218 1512.934195  7.2435129  "
[41] "        rel.diff.Drp  "
[42] " Bmsys -0.0018407088  "
[43] " Fmsys -0.0008348546  "
[44] " MSYs  -0.0026787143  "
[45] ""
[46] "States w 95% CI (inp$msytype: s)"
[47] "                    estimate        cilow        ciupp  "
[48] " B_2019.00      4348.6524164 2720.9264663 6950.1245524  "
[49] " F_2019.00         0.1647112    0.0954885    0.2841156  "
[50] " B_2019.00/Bmsy    1.6956249    1.5147872    1.8980514  "
[51] " F_2019.00/Fmsy    0.3019462    0.2195464    0.4152722  "
[52] "                 log.est  "
[53] " B_2019.00       8.3776213  "
[54] " F_2019.00      -1.8035619  "
[55] " B_2019.00/Bmsy  0.5280514  "
[56] " F_2019.00/Fmsy -1.1975064  "
[57] ""
[58] "Predictions w 95% CI (inp$msytype: s)"
[59] "                  prediction        cilow        ciupp  "
[60] " B_2020.00      4365.3631356 2671.5096176 7133.1935998  "
[61] " F_2020.00         0.1590579    0.0847188    0.2986281  "
[62] " B_2020.00/Bmsy    1.7021408    1.5593242    1.8580377  "
[63] " F_2020.00/Fmsy    0.2915827    0.1905977    0.4460729  "
[64] " Catch_2020.00   695.4063127  413.9028671 1168.3657644  "
[65] " E(B_inf)       4379.5351715           NA           NA  "
[66] "                 log.est  "
[67] " B_2020.00       8.3814567  "
[68] " F_2020.00      -1.8384871  "
[69] " B_2020.00/Bmsy  0.5318867  "
[70] " F_2020.00/Fmsy -1.2324316  "
[71] " Catch_2020.00   6.5444963  "
[72] " E(B_inf)        8.3846979  "
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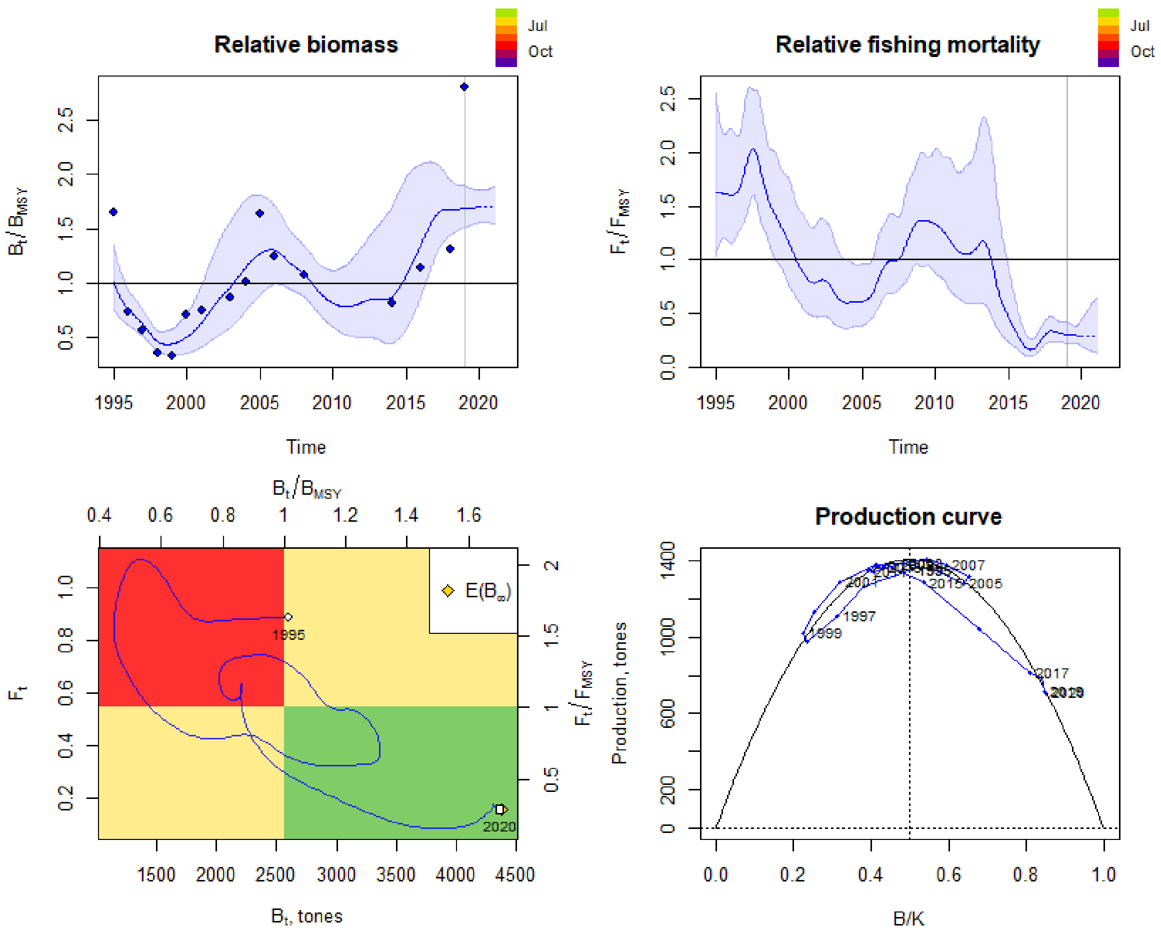


Figure 6.10.3.2.1 Hake in GSA 20. Relative biomass and fishing mortality, F/B plot and production curve as given by the SPiCT model for hake in GSA 20.

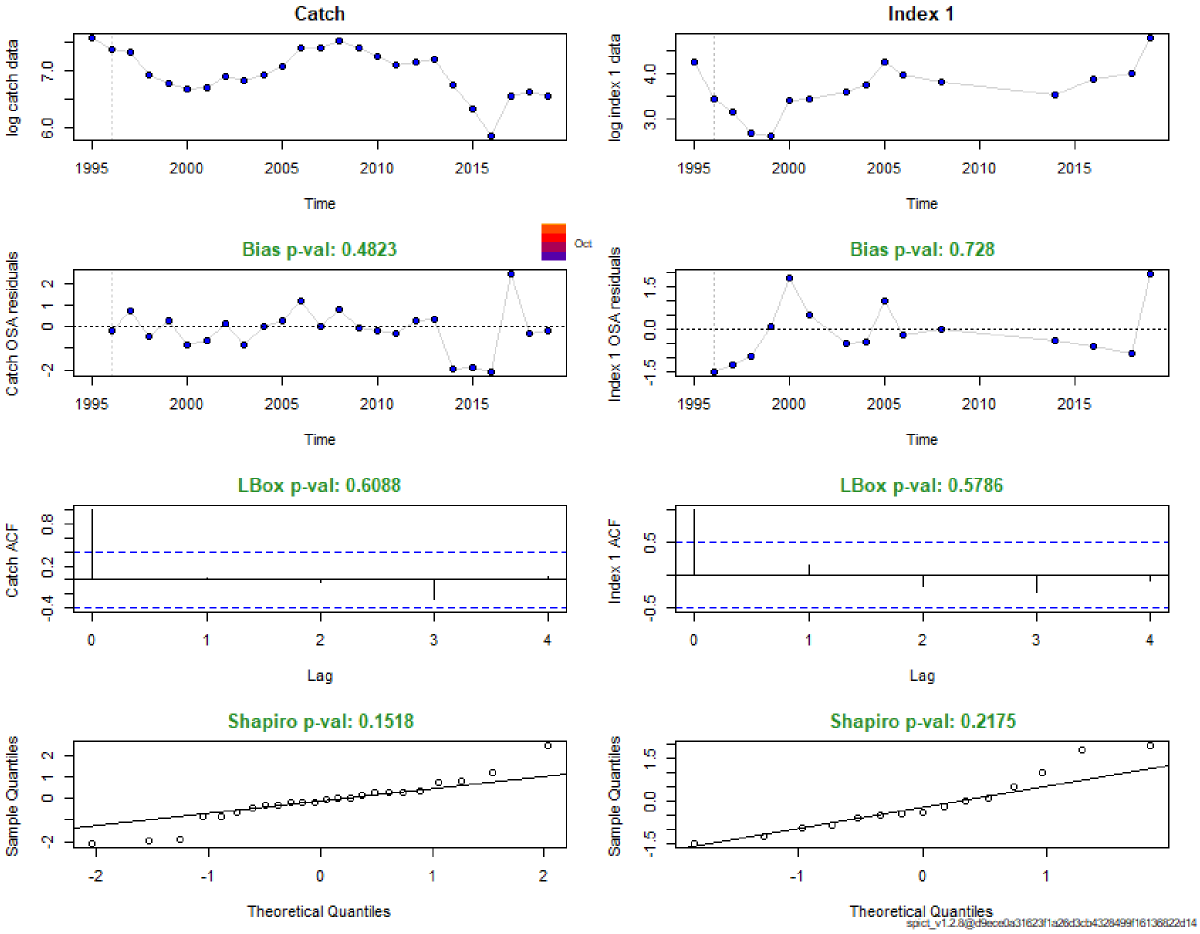


Figure 6.10.2.19 Hake in GSA 20. Diagnostics from SPiCT model for hake in GSA 20.

Retrospective analysis

A retrospective analysis was run with 5 retro years. The retrospective patterns are rather consistent across in terms of B/Bmsy but results in poorer performance when F/Fmsy is concerned.

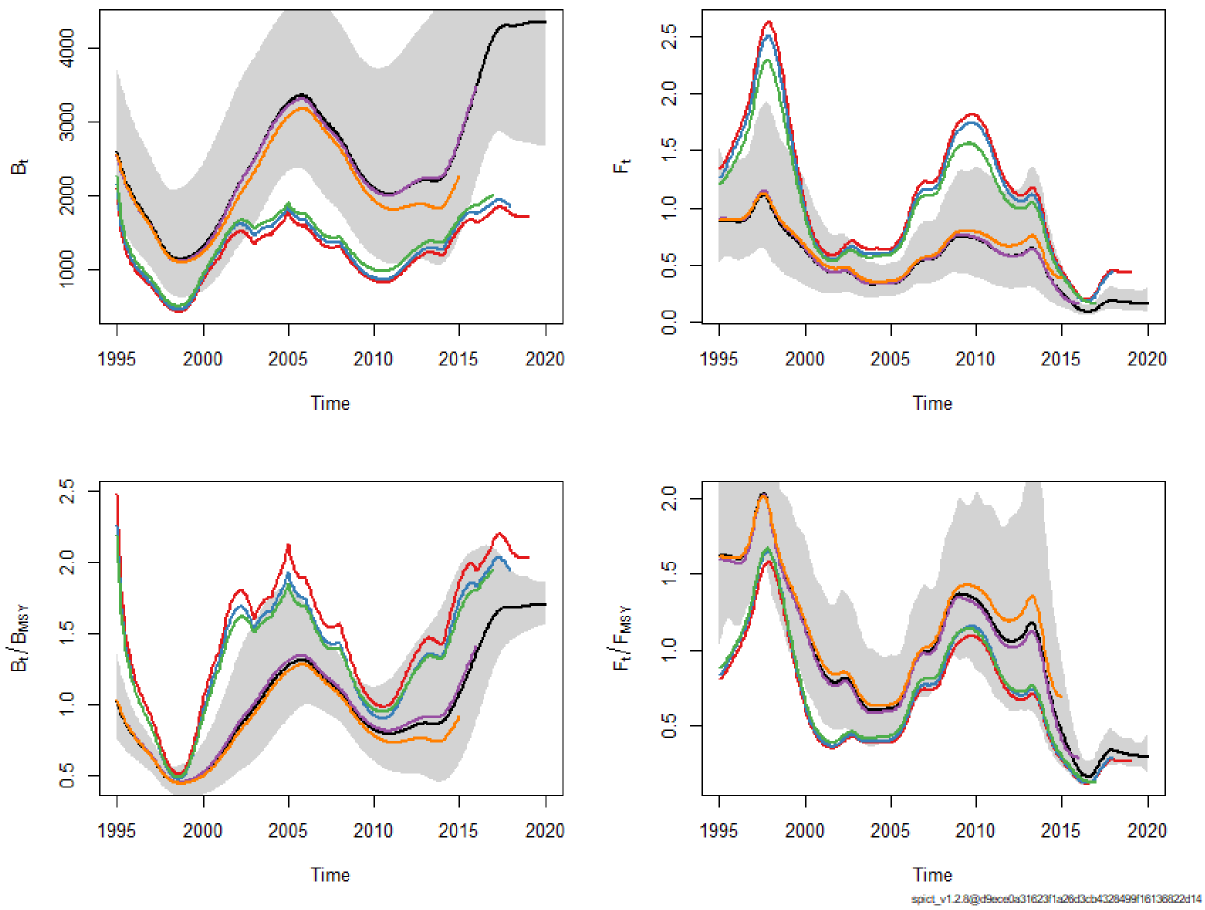


Figure 6.10.2.20 Hake in GSA 20. Retrospective analysis for the SPiCT model for hake in GSA 20.

Conclusions to SPiCT model

The SPICT model estimates B_2019/Bmsy=1.69 and F_2019/Fmsy=0.30. However, the contrasting reference points with the analytical models lead the EWG 20-15 to decide that the model results were not able to determine current stock status or biomass; thus, this assessment will not be used for specific advice.

Comparison of assessments

The two assessment model results give completely different perspectives of the stock. The SPiCT model implies that the stock status healthy and its biomass way over Bmsy. However, it has poor retrospective results that indicate instability of the model .In contrast, the age-based model a4a suggests overexploitation of the hake stock. The divergence among models in the last year is of concern. Overall, the a4a model is considered to best represent the current state of the stock. However, due to the considerable uncertainty in the model because of the missing and inconsistent data, the model is not considered suitable for catch advice.

6.10.4 REFERENCE POINTS

The STECF EWG 20-15 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 resulting from the outputs of the a4a assessment.

The EWG 20-15 concluded that the output of these models were not suitable to provide an indication of the current status of the stock and due to the lack of surveys and catch-at-age data and agreed not to provide forward projections and catch advice based on this assessment.

6.10.5 SHORT TERM FORECAST AND CATCH OPTIONS

No short term forecast and catch options were carried out for hake stock in GSA 20 within STECF EWG 20-15.

6.10.6 DATA DEFICIENCIES

Many deficiencies were found in the DCF data provided. Specifically, no DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, 2012 and 2017. Catch-at-age data were provided only for the last trimester for 2013 and 2015. No MEDITS surveys took place in 2002, 2007, 2009-2013, 2015 and 2017.

The landings as calculated from the DCF data (number of individuals multiplied by their somatic weight) do not correspond to the official landings reported. This issue is stronger for the years 2003-2006 and fades out after 2016. The numbers and weights at length are not reported consistently (step size, initial value, unit of measurement vary among years). In fact, every year has its own peculiarities and inconsistencies. Year 2019 was the best reported and the methodology followed there should be expanded to the rest of the years. Similar issues with length data and number of individuals were observed in the index data.

Discards data are also inconsistent with several hundred tonnes of discarded reported before 2014, which miraculously disappears afterwards. It appears that nets discarded eight (8) times more hake than the trawlers. Raising factors should be cross-checked.

Finally, the coastal gears (GTR, GNS, LLS) are reported aggregated before 2014 and separately afterwards; therefore, their inclusion in the models is impossible.

6.11 EUROPEAN HAKE IN GSA 22

6.11.1 STOCK IDENTITY AND BIOLOGY

The assessment of hake carried out during the STECF EWG 20-15 considered the stock of GSA 22. Hake is one of the most important fish stocks in GSA 22 for bottom trawlers, nets and longlines. The stock is distributed in depths between 50 and 600 m, with a peak in abundance between 200 and 300 m. The stock is exploited by the Greek and Turkish fishing fleets but the landings of hake of the Turkish fleet are not reported by the FAO/GFCM databases.

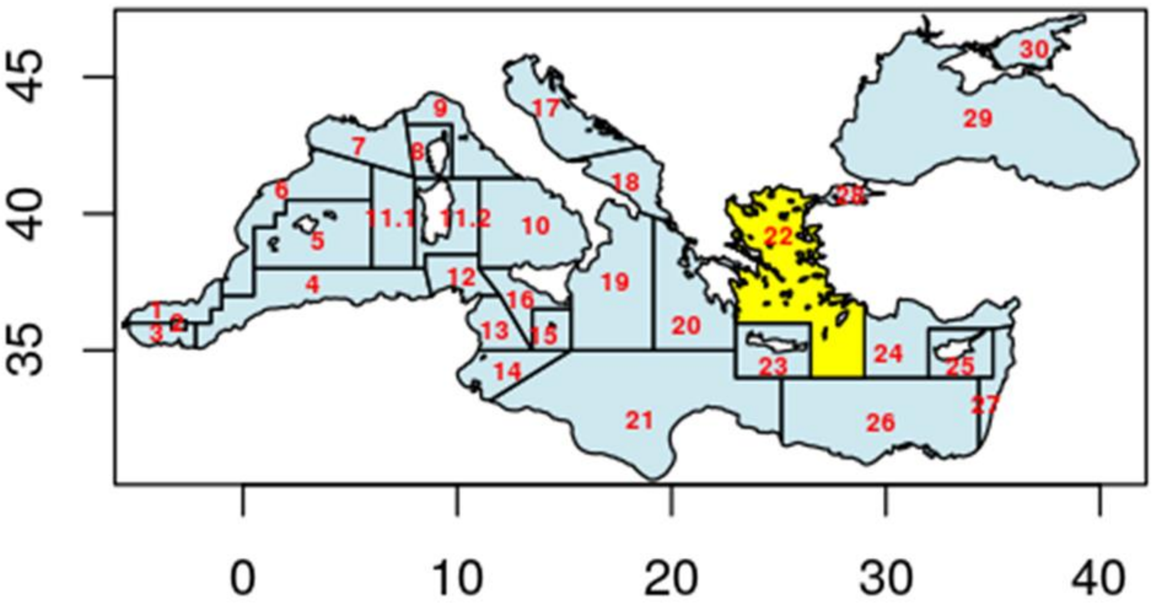


Figure 6.11.1.1. Geographical location of GSA 22.

Growth parameters (Linf= 104.0 cm, k= 0.12 y-1; t0= -0.01 y, sexes combined) and length-weight relationship parameters (a=0.0033, b=3.23), were the same as the ones used in GSA 20 that had been taken from the DCF estimates of hake in GSA 19. The VBGF and LW relationship parameters used are summarized in the following Table (Tab. 6.11.1.1).

The vector of proportion of mature individuals by age was also according to the previous assessment that followed size at maturity of hake in GSA 20, sexes combined (Table 6.11.1.2).

A vector of natural mortality was estimated by PRODBIOM method (Abella et al., 1997) using growth and length-weight relationship parameters for sexes combined (Table 6.11.1.3).

Hake spawns throughout the year in many areas of the Mediterranean with a peak of spawning occurring during the summer.

Table 6.11.1.1. Hake in GSA 22. Growth parameters and length-weight relationship parameters used in the assessment.

GSA	Sex	Linf (cm)	K (y-1)	t0 (y)	a	b
22	**combined**	104	0.12	-0.01	0.0033	3.23

Table 6.11.1.2. Hake in GSA 22. Maturity vectors used in the assessment.

Age	0	1	2	3	4	5
Pmat	0	0.19	0.86	1.00	1.00	1.00

Table 6.11.1.3. Hake in GSA 22. Natural mortality vectors used in the assessment.

Age	0	1	2	3	4	5
M	1.24	0.73	0.48	0.39	0.35	0.32

6.11.2 DATA

6.11.2.1 CATCH (LANDINGS AND DISCARDS)

Hake mainly lives on muddy substrates in depths between 50 and 600 m and, in the Greek part of the Aegean Sea (GSA 22), is primarily targeted by the bottom trawl fishery, nets (gill- and trammel) and longlines (Table 6.11.2.1, Figures 6.11.2.1 and 6.11.2.2).

The official landings of hake (Figure 6.11.2.1) are being recorded by the Hellenic Statistical Authority and the same values are reported by the FAO/GFCM databases. However, the structure of the dataset changed after 2015 and includes the landings of an extra small-scale coastal fleet of 10,000 vessels (Tsikliras et al. 2020). To account for these additional landings that artificially inflated the landings time series after 2016, we corrected the hake landings from 1982 to 2015 by multiplying by 1.31, which is the difference of hake with and without the extra fleet.

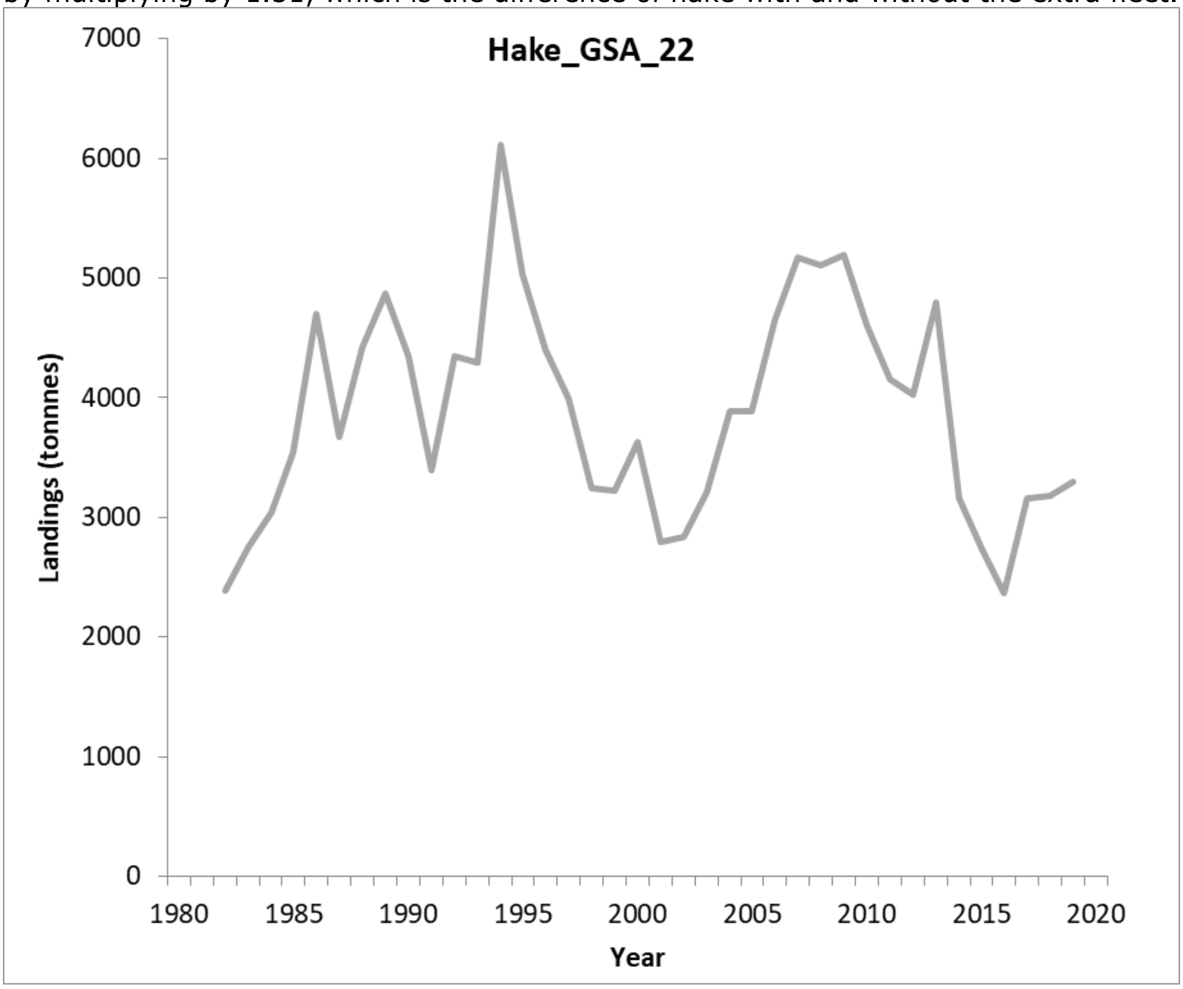


Figure 6.11.1.2.1 Hake in GSA 22. Hake official landings by the Greek fleet in GSA 22 (1982-2020). Data from Hellenic Statistical Authority corrected for 1982-2014 to account for partial reconstruction of the catch.

The DCF dataset contains too many missing points and is inconsistent in terms of landings as the landings reported for 2003-2006 are very high, probably owing to a raising factor error (Figures 6.11.2.2). Towards the end of the time series, the DCF dataset seems to converge with the official one, though only the last two years are close.

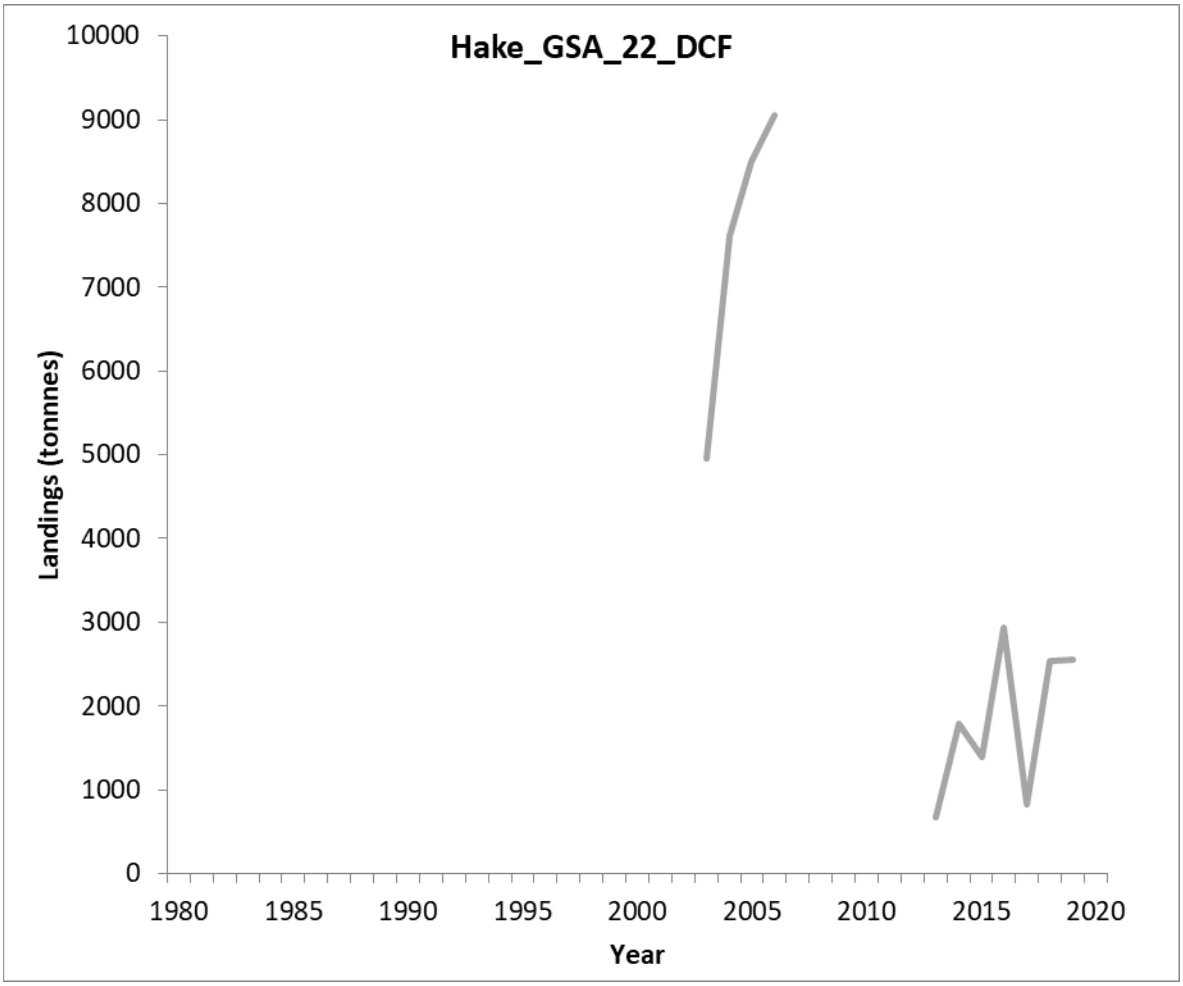


Figure 6.11.1.2.2 Hake in GSA 22. Hake DCF landings by the Greek fleet in GSA 22 (2003-2019). Years 2007, 2009-2013 are missing.

The bottom trawl fishery in Greece is a mixed fishery, operating 24hr per day. Bottom trawl fishing targeting hake is taking place mainly during the day in muddy bottoms in depths ranging from 80 to 400 m. Apart from hake, important target species for bottom trawler are shrimps, anglerfish, blue whiting, and red mullet.

The gill nets are set in depths ranging from 80 to 300 m. The mesh size used is usually 48 to 64 mm. The fishery is carried out mainly during summer when bottom trawl fishery is prohibited. Longline fishery for hake operates in deeper waters, down to 500 m, mainly during the summer.

After an increase from 2000 to 2008, the official landings of hake were continuously declining from 2008 to 2015 with a slight increase in the last three years (Figure 6.11.2.1, Table 6.11.1.2.1).

Table 6.11.1.2.1 Hake in GSA 22. Hake landings in GSA 22 according to the official statistics as they appear in Hellenic Statistical Authorities database corrected to account for partial reconstruction.

Year	Hake official landings (t)
1982	2389
1983	2754
1984	3037
1985	3546
1986	4704
1987	3672
1988	4427
1989	4873
1990	4352
1991	3396
1992	4343
1993	4297
1994	6117
1995	5029
1996	4402
1997	3995
1998	3243
1999	3221
2000	3626
2001	2799
2002	2841
2003	3216
2004	3884
2005	3886
2006	4646
2007	5173
2008	5111
2009	5197
2010	4607
2011	4158
2012	4028
2013	4792
2014	3162
2015	2731
2016	2364
2017	3159
2018	3179
2019	3300

DCF Landings per gear

Landings data per gear and fleet were reported to STECF EWG 20-15 through the DCF and are presented in Figure 6.11.2.1.3. GNS, GTR and LLS landings are only available after 2013 Total landings by year are presented in Table 6.11.2.1.2.

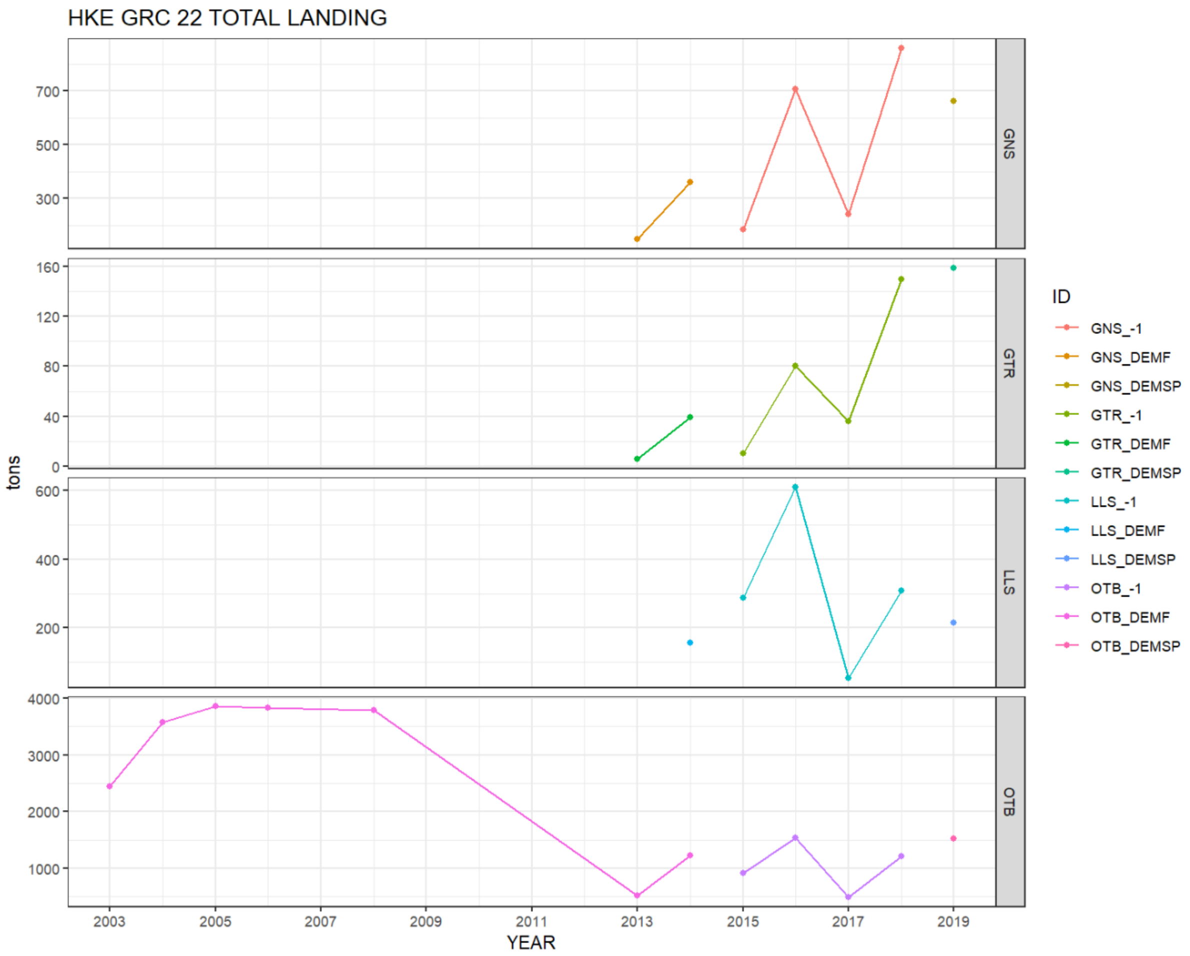


Figure 6.11.2.1.3. Hake in GSA 22. Landings data in tons by year and fleet.

Table 6.112.1.2. Hake in GSA 22. Hake DCF landings in tonnes by the Greek fleet in GSA 22 from different gears. Years 2007 and 2009-2012 are missing, while data for 2013, 2015 and 2017 come only from the fourth quarter of the year.

Year	GNS Landings (t)	GTR Landings (t)	LLS Landings (t)	OTB Landings (t)	Other/ unspecified (t)
2003	-	-	-	2444	
2004	-	-	-	3572	
2005	-	-	-	3857	
2006	-	-	-	3835	
2007	-	-	-	-	
2008	-	-	-	3793	
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	-	-	-
2012	-	-	-	-	-
2013	148	6	-	522	-
2014	362	39	156	1232	-
2015	186	10	287	915	-
2016	708	80	610	1534	-
2017	241	36	54	490	-
2018	858	150	309	1220	-
2019	662	159	215	1519	-

Length frequency distribution of the landings by year and fleet from the DCF database are presented in Figure 6.11.2.1.4 and that of OTB in 6.11.2.1.5. The assessment was based on OTB data only because the coastal gears GTR, GNS and LLS are separately reported after 2013 and are completely absent before 2013.

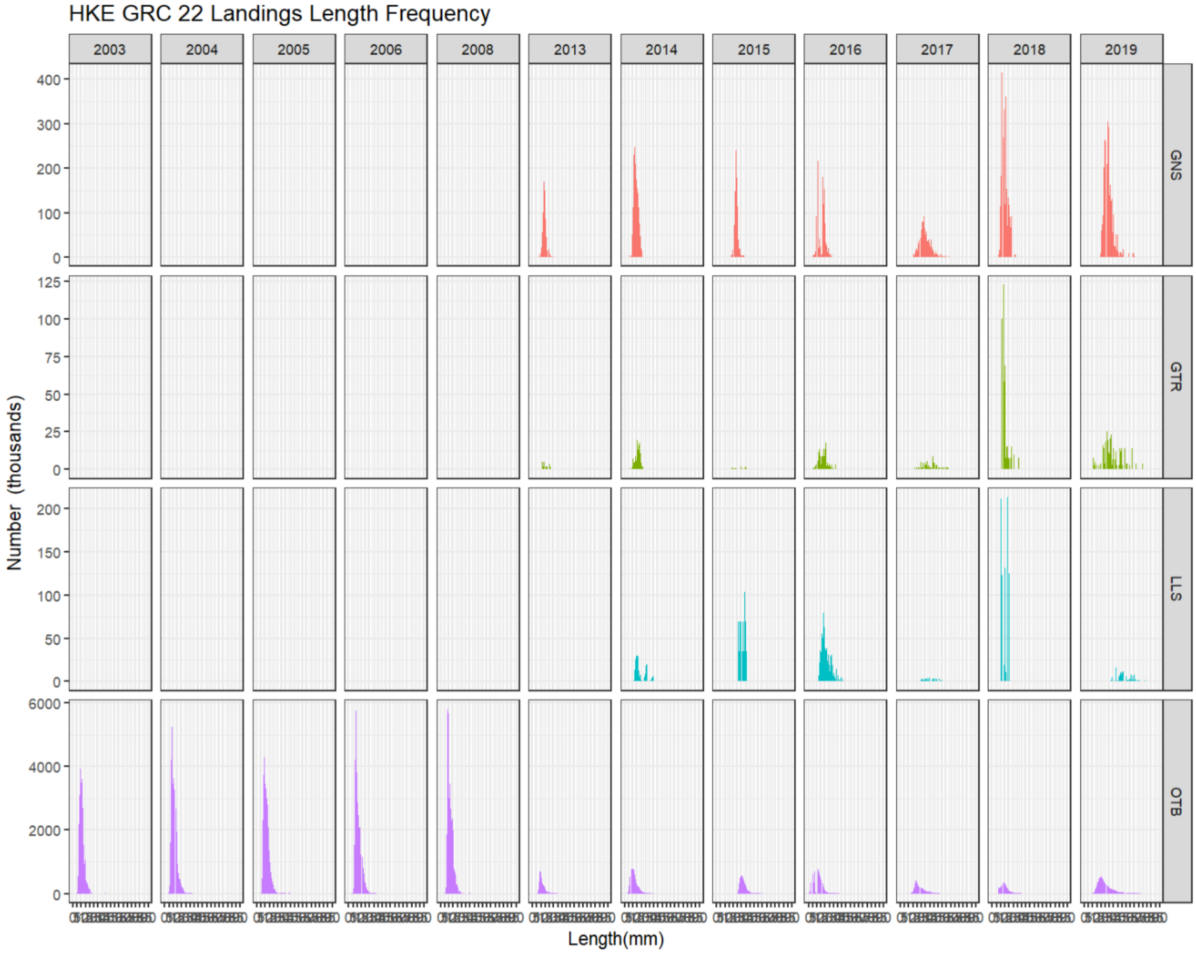


Figure 6.11.2.1.4. Hake in GSA 22. Length frequency distribution of the landings by year and fleet.

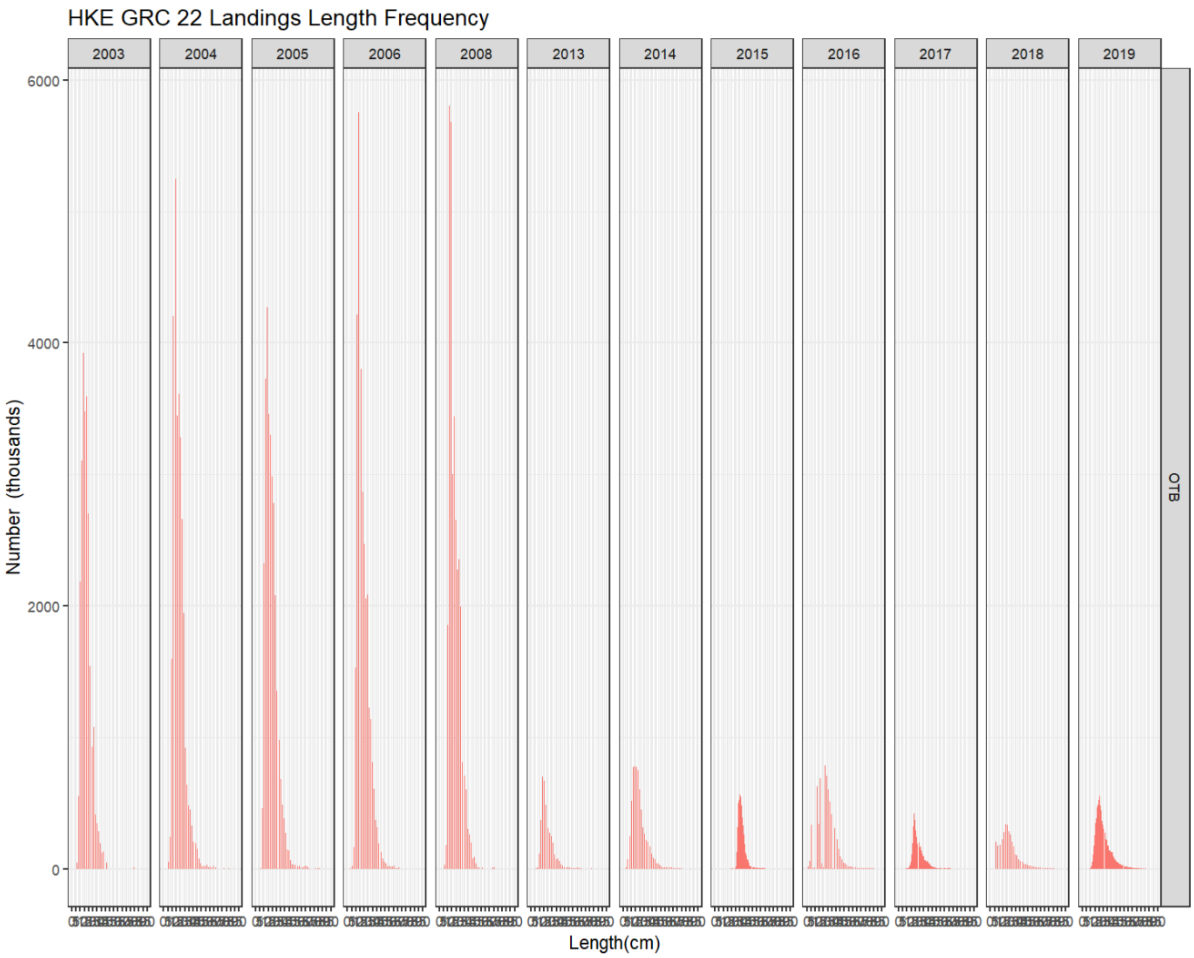


Figure 6.11.2.1.5. Hake in GSA 22. Length frequency distribution of the OTB landings as reported in the DCF. Note that the years are not consecutive.

Discards
According to the Greek DCF, the discards of haκe in GSA 22 were around 500 t from 2004 to 2008 and declined to negligible values (26t) in 2016 with zero discards for OTB (Figure 6.11.1.2.6, Table 6.11.1.2.3).

Table 6.11.2.1.3. Hake in GSA 22. Hake discards in tonnes by fishing gear in GSA 22 as reported by the DCF.

	OTB_Discards (t)	**GNS_Discards (t)**	**GTR_Discards (t)**	**Unspecified gear Discards (t)**	**Total**
2003	224	-	-	-	**224**
2004	355	-	-	255	**610**
2005	362	-	-	274	**636**
2006	551	-	-	104	**655**
2007	-	-	-	-	**-**
2008	461	-	-	-	**461**
2009	-	-	-	-	**-**
2010	-	-	-	-	**-**
2011	-	-	-	-	**-**
2012	-	-	-	-	**-**
2013	19	4	1	-	**24**
2014	69	11	6	-	**86**
2015	51	6	-	-	**57**
2016	0	26	-	-	**26**
2017	27	3	0.5	-	**30.5**
2018	106	-	-	-	**106**
2019	231	11	2	-	**244**

Length and age frequency distributions of the discards are shown in Figure 6.11.2.1.6.

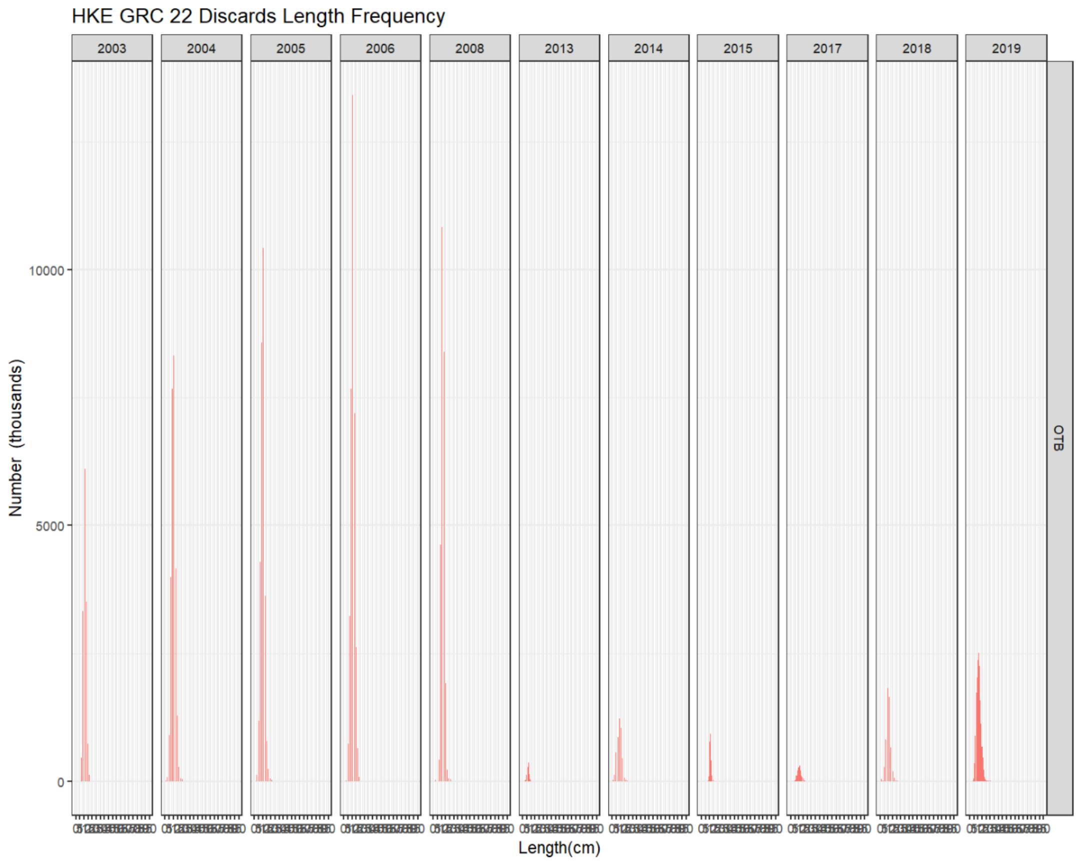


Figure 6.11.2.1.6. Hake in GSA 22. Length frequency distribution of the discards by year for OTB.

6.11.2.2 Effort

Fishing effort data were reported to STECF EWG 20-15 through DCF (Table 6.11.2.2.1). The effort (days at sea) remains more or less stable since 2014 for all gears.

Table 6.11.2.2.1. Hake in GSA 22. Fishing effort in days at sea by year and fishing gear.

	GNS	GTR	LLS	OTB
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	385442	601502	259992	39153
2015	115020	160781	99771	37762
2016	415065	523530	319625	39565
2017	642	-	81	39185
2018	353903	525694	185256	34307
2019	314202	552702	254102	37457

6.11.2.3 SURVEY DATA

The MEDITS bottom trawl survey was used for the estimation of abundance index of hake in GSA 22. The survey is carried out in June/July each year since 1994. No survey was carried out in 2002, 2007, 2009-2013, 2015 and 2017. Data were analysed using the JRC script (Mannini, 2020)

The abundance of hake fluctuates around 100 kg/km2 and has increased during the last two years (Figure 6.11.2.3.1, Table 6.11.2.3.1).

The combined MEDITS indexes were calculated using the script provided by JRC (Figures 6.11.2.3.1 and 6.11.2.3.2).

Table 6.11.2.3.1 Hake in GSA 22. MEDITS survey abundance index of hake in GSA 20 as reported by DCF. No survey was carried out in 2002, 2007, 2009-2013 and 2015. The survey is carried out in June/July.

Year	Hake abundance (kg/km^2)
1994	22.52
1995	18.99
1996	39.06
1997	100.37
1998	100.04
1999	96.12
2000	105.34
2001	76.51
2002	-
2003	104.22
2004	99.90
2005	93.71
2006	114.11
2007	-
2008	108.40
2009	-
2010	-
2011	-
2012	-
2013	26.66
2014	65.85
2015	-
2016	83.65
2017	-
2018	135.85
2019	124.85

Ages 0, 1 and 2 make up the majority of individuals caught during the MEDITS bottom trawl survey (Figure 6.11.2.3.2) while the mean weight of individuals is rather stable at around 100 g (Figure 6.17.2.3.2).

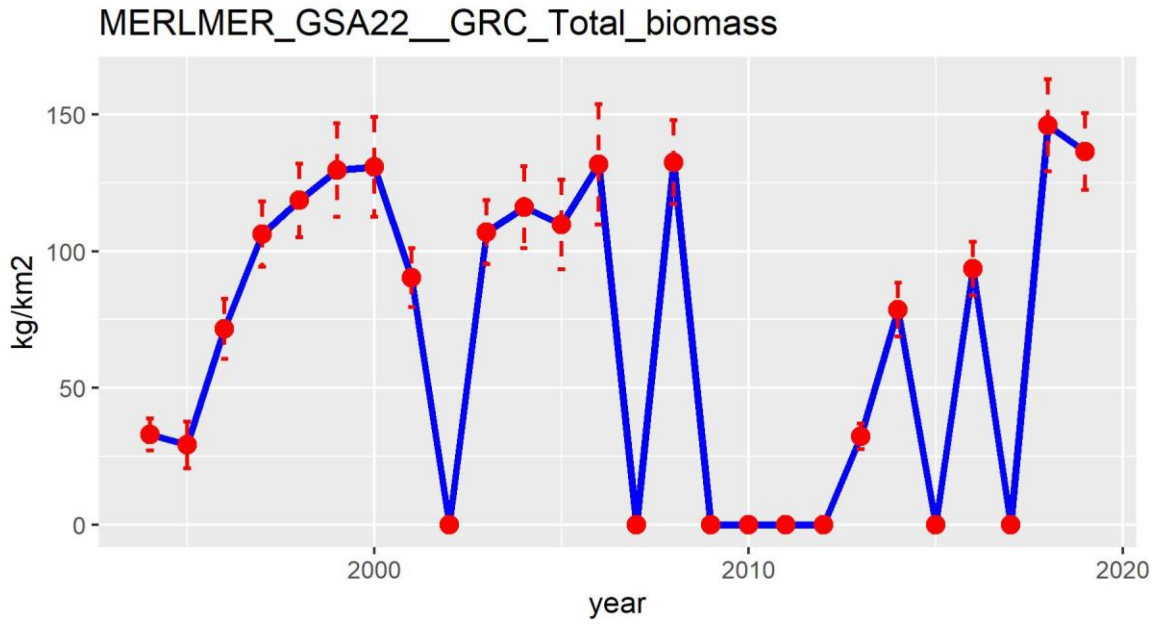


Figure 6.11.2.3.1. Hake in GSA 22. Estimated biomass indices from the MEDITS survey (kg/km^2).

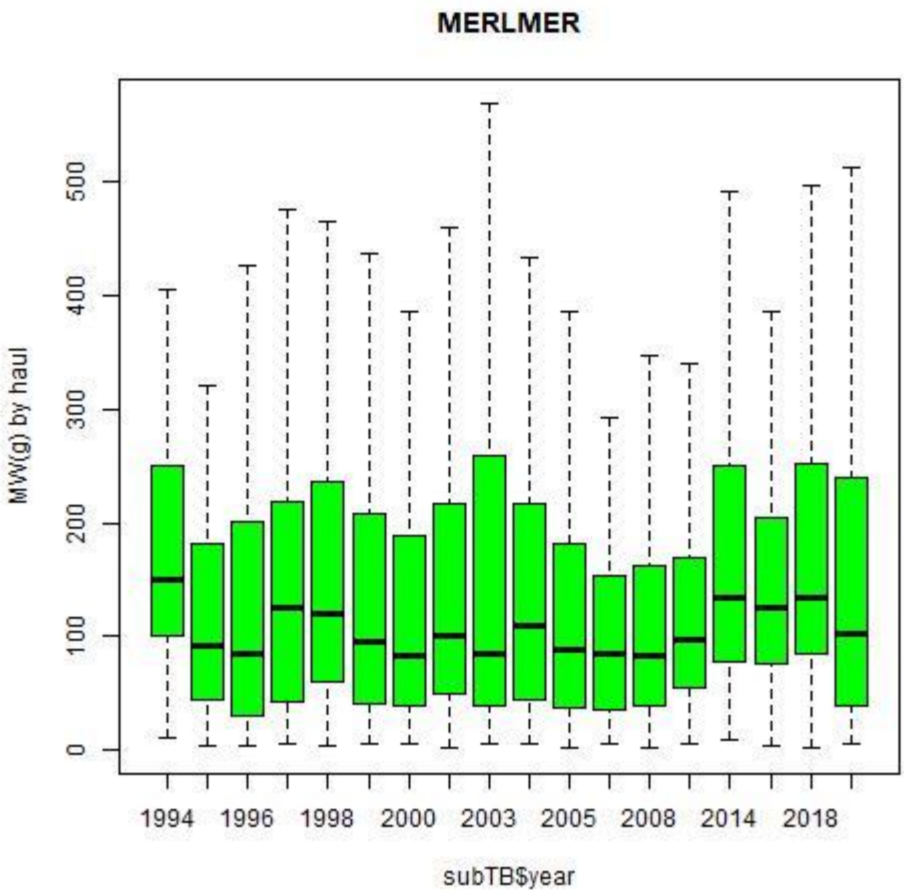
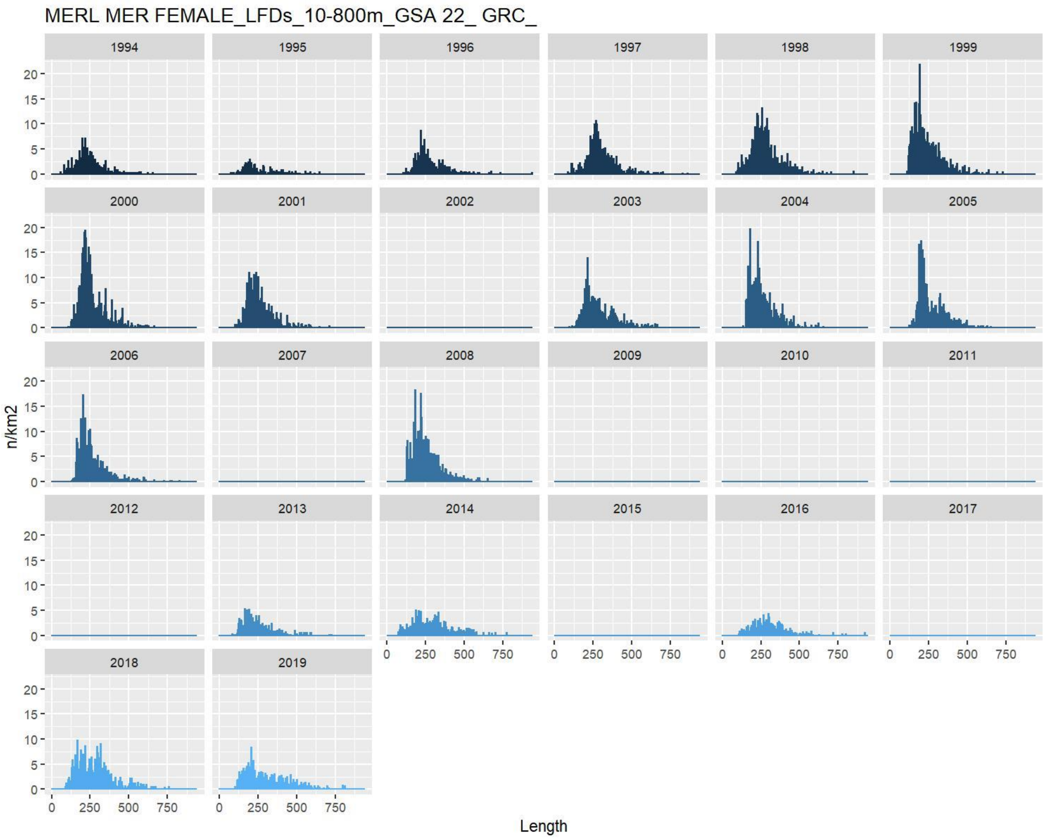


Figure 6.11.2.3.2. Hake in GSA 22. Mean weight of individuals by haul from the MEDITS survey (g).

The estimated biomass index fluctuated throughout the time series. Size structure indices for males, females and total individuals are shown in Figure 6.11.2.3.3.


MERL MER FEMALE_LFDs_10-800m_GSA 22_ GRC_
n/km2
Length

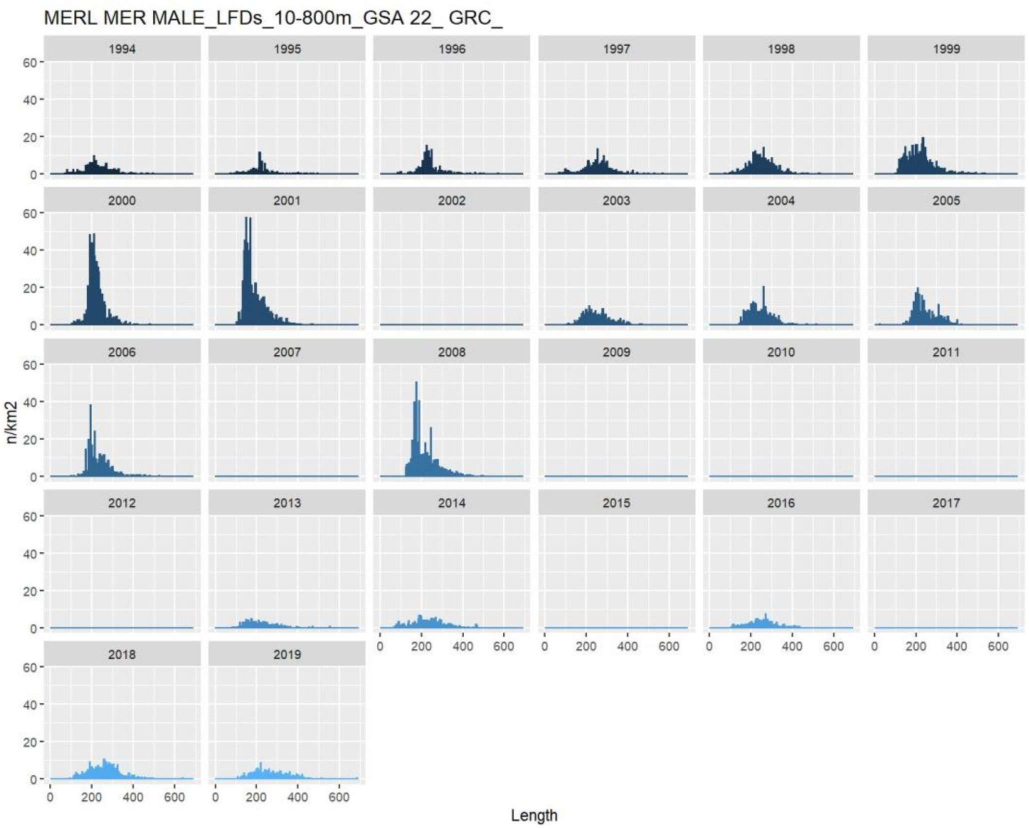

MERL MER MALE_LFDs_10-800m_GSA 22_ GRC_
n/km2
Length

Figure 6.11.2.3.3. Hake in GSA 22. Length frequency distribution by year and sex of MEDITS survey.

6.11.3 Stock assessment

6.11.3.1 Method1: a4a

The Assessment for All Initiative (a4a) (Jardim et al., 2014), a4a, a statistical catch-at-age analysis method were used for this stock that utilize catch-at-age data to derive estimates of historical population size and fishing mortality. However, unlike VPA, model parameters using catch-at-age analysis are estimated by working forward in time and the methods do not require the assumption that removals from the fishery are known without error. Data that are typically used are: catch, abundance index, statistical sample of age composition of catch and abundance index. Assessment was performed with version 1.8.2 of FLa4a, together with version 2.6.15.9005 of the FLR library (FLCore) in FLR environment.

The assessment was carried out using the period 2003-2019 for catch data and tuning file for which data were available. A single tuning fleet was used in both methods based on the CPUE and weight at age estimates from summer bottom trawl surveys (MEDITS) conducted in the Greek part of Aegean Sea (GSA 22) from 2003 to 2019 (with gaps in 2007, 2009-2013, 2015 and 2017) as reported in the DCF.

Both catch numbers at length and index number at length were sliced using the a4a age slicing routine in FLR, using for each GSA the corresponding growth parameters for sexes combined. The plus group was set at 5 but then the catch data were sliced to 0-5 and index data to 0.4 and the larger individuals were absent. Concerning the Fbar, the age range used was 1-3 age groups.

Input data
Total catches and catch numbers at age from the single GSAs were used as input data. SOP correction was applied to catch numbers at age and reflects missing data and inconsistent reporting.

Tables 6.11.3.2.1-6.11.3.2.4 list the input data for the a4a model, namely catch numbers at age, weight at age, and the tuning series (MEDITS) at age.

Table 6.11.3.2.1. Hake in GSA 22. Catch numbers at age (thousands)

Year/Age	0	1	2	3	4	5
2003	24960	41672	8472	1433	86	30
2004	34928	39110	10140	1803	437	94
2005	39726	32563	11427	1860	378	90
2006	43413	48047	11848	2408	482	88
2007	NA	NA	NA	NA	NA	NA
2008	32143	55841	14569	2438	386	31
2009	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA
2013	15192	35462	12591	2615	529	212
2014	22168	20008	6920	2091	624	154
2015	9291	13455	10060	2736	919	174
2016	932	3796	6747	1522	555	130
2017	NA	NA	NA	NA	NA	NA
2018	29553	13460	6053	1687	682	306
2019	17732	17417	5340	1600	560	221

Table 6.11.3.2.2. Hake in GSA 22. Weights at age (Kg)

Year/Age	0	1	2	3	4	5
2003	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2004	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2005	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2006	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2007	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2008	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2009	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2010	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2011	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2012	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2013	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2014	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2015	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2016	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2017	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2018	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349
2019	0.00118	0.0325	0.1394	0.3432	0.6453	1.0349

Table 6.11.3.4. Hake in GSA 22. MEDITS numbers at age (n/km^2)

Year/Age	0	1	2	3	4	5
2003	301.6	412.0	187.2	64.9	25.9	9.1
2004	375.8	965.9	270.5	74.7	19.2	3.5
2005	355.3	926.8	209.0	87.0	21.5	5.4
2006	898.1	1718.7	211.9	49.9	14.7	5.8
2007	NA	NA	NA	NA	NA	NA
2008	450.1	2659.9	259.6	77.8	20.1	7.1
2009	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA
2013	58.3	150.0	73.4	19.7	4.7	2.9
2014	90.0	206.5	148.9	56.5	15.8	10.2
2015	NA	NA	NA	NA	NA	NA
2016	97.5	172.5	225.4	77.2	19.1	3.5
2017	NA	NA	NA	NA	NA	NA
2018	128.8	548.7	278.7	120.5	27.2	10.3
2019	242.2	697.0	190.0	85.4	39.2	11.4

Catch Data

The time series of official landings for the Greek part of Aegean Sea (GSA 22), as they appear in the Hellenic Statistical Authority database was used for the period 2003-2019. The DCF reported landings and discards were considered unreliable for the early years of the dataset and were excluded. Based on the DCF report, hake discards were considered negligible in GSA 22 for the years after 2013 (ranged between 0 and 10% of the landings) although considerable quantities had been discarded from 2003 to 2006. The total landings data used for assessment are reported in Table 6.11.2.3. Catch was considered equivalent to landings.

Landings at age data for the period 2003-2016 were those reported by the DCF. No DCF was carried out in 2007, 2009-2012 and DCF covered only the last trimester in 2013, 2015 and 2017. Thus, in the a4a method, NA (non-available) was used for the catch at age data in the years that no DCF was carried out. Age structure of the landings data used for assessment is the DCF reported age readings (Figure 6.11.2.1).

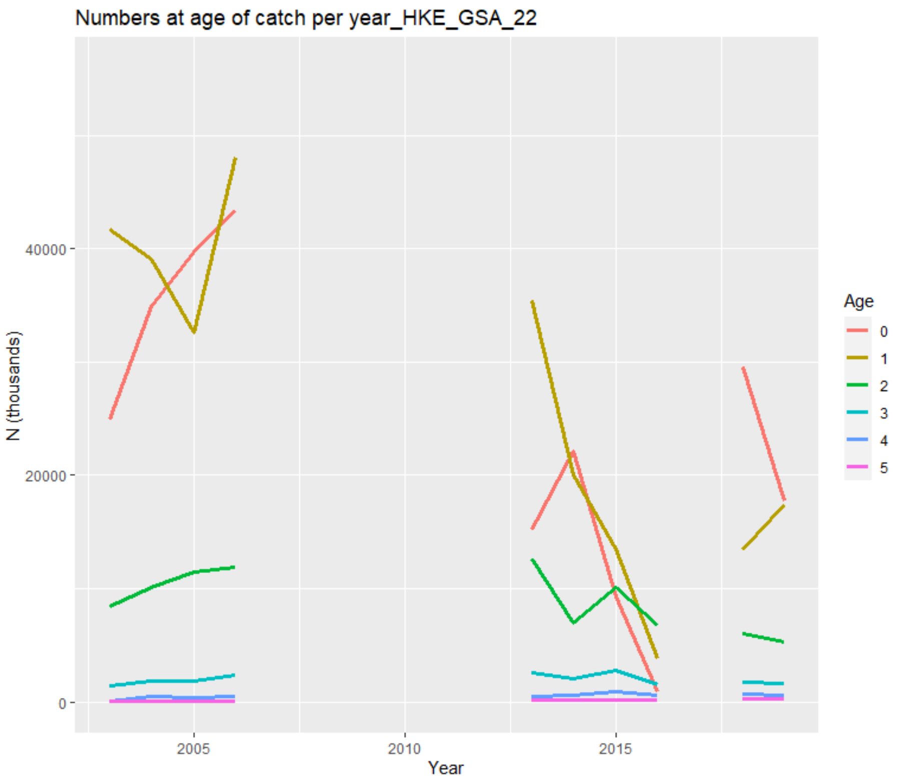


Figure 6.11.3.1. Hake in GSA 22. Catch (N) at age per year input data.

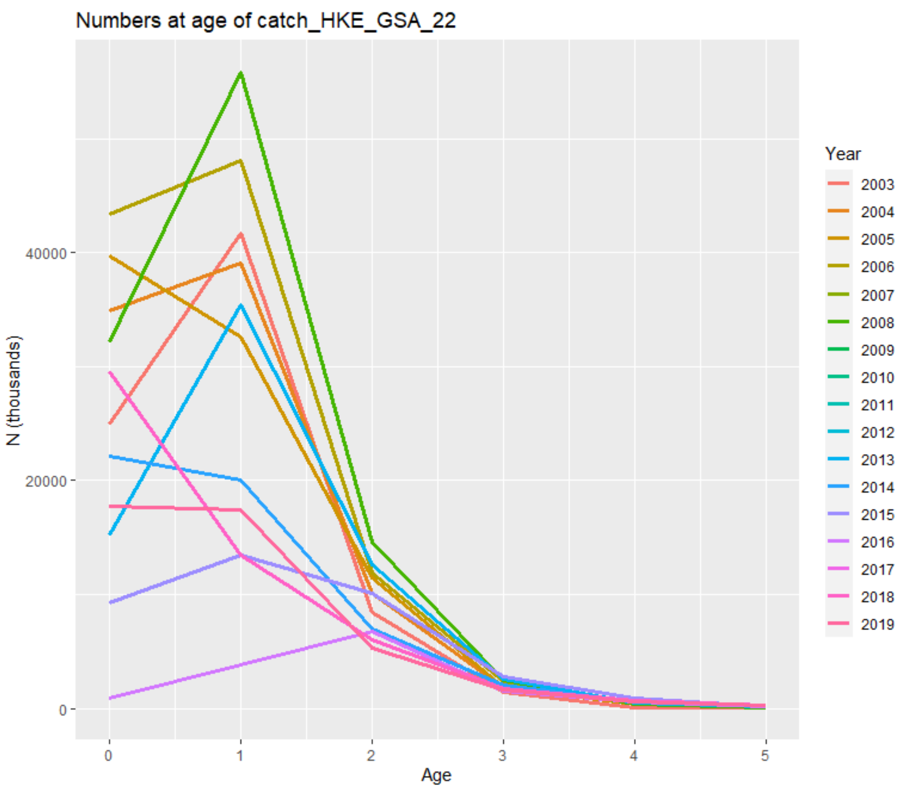


Figure 6.11.3.2. Hake in GSA 22. Age structure of the catch data.

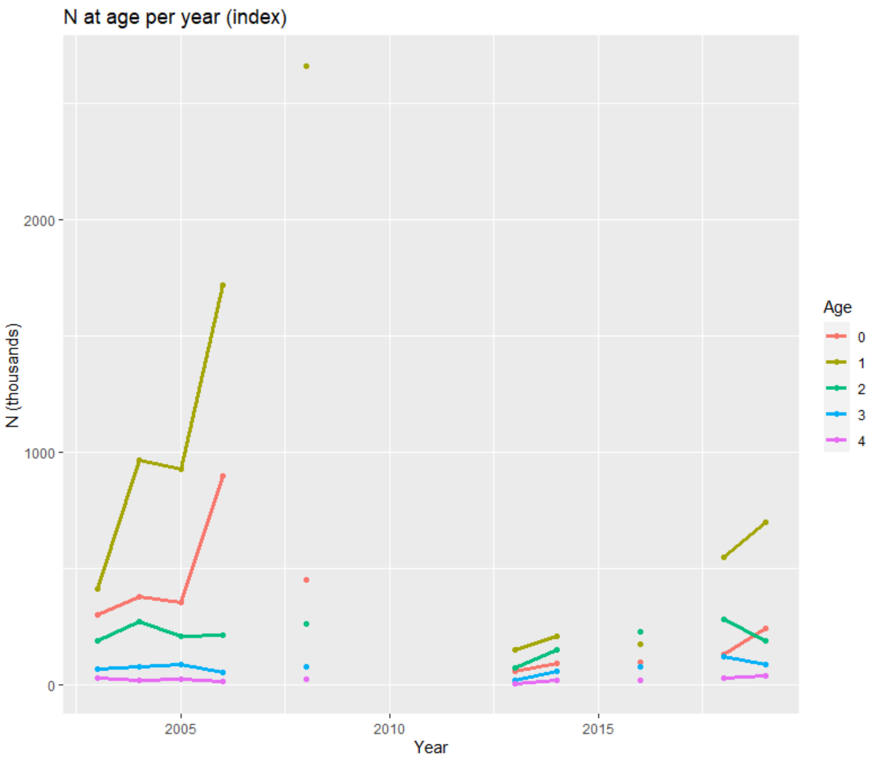


Figure 6.11.3.1. Hake in GSA 22. Index (N) at age per year input data.

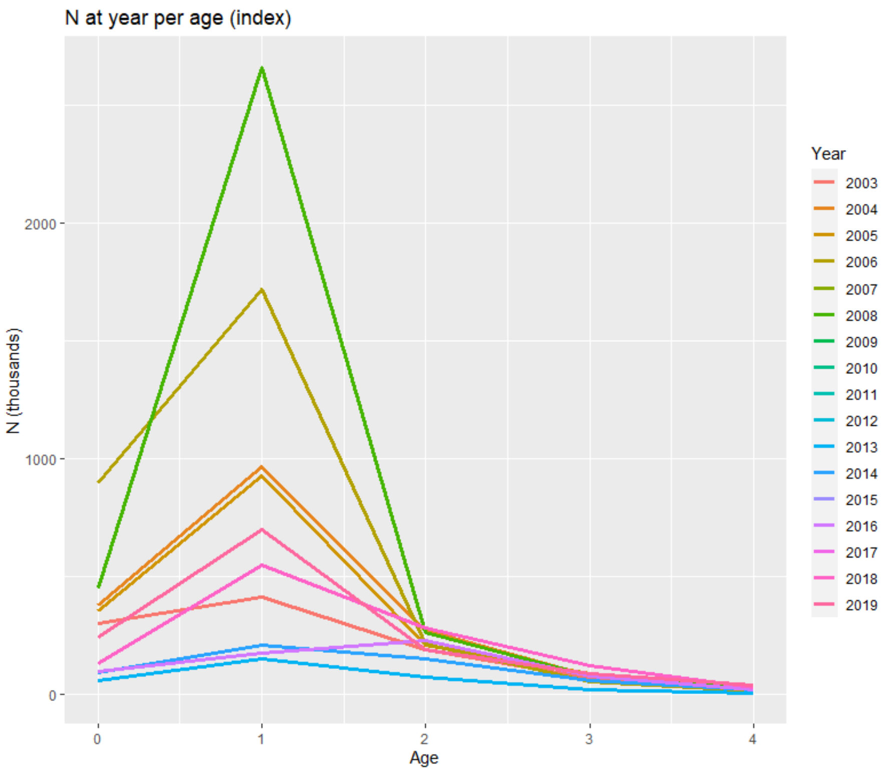


Figure 6.11.3.2. Hake in GSA 22. Age structure of the index.

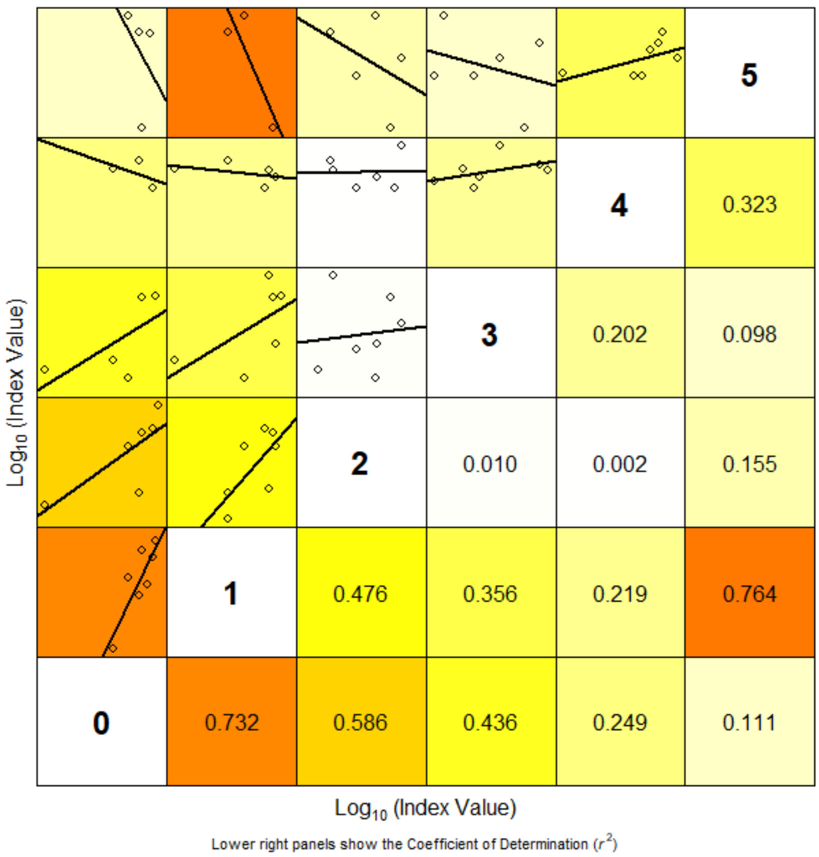


Figure 6.11.3.3. Hake in GSA 22. Catch at age cohort consistency

Figure 6.11.3.4. Hake in GSA 22. Index at age cohort consistency

Assessment results

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

a4a model fit for: HKE_GSA_22

Submodels:
fmod <- ~factor(replace(age, age>2,2)) + s(year, k=6)
qmod <- list(~ factor(age))
srmod <- ~geomean(cv=0.3)

The results of the assessment are shown in Figures 6.11.3.5 – 6.11.3.11.

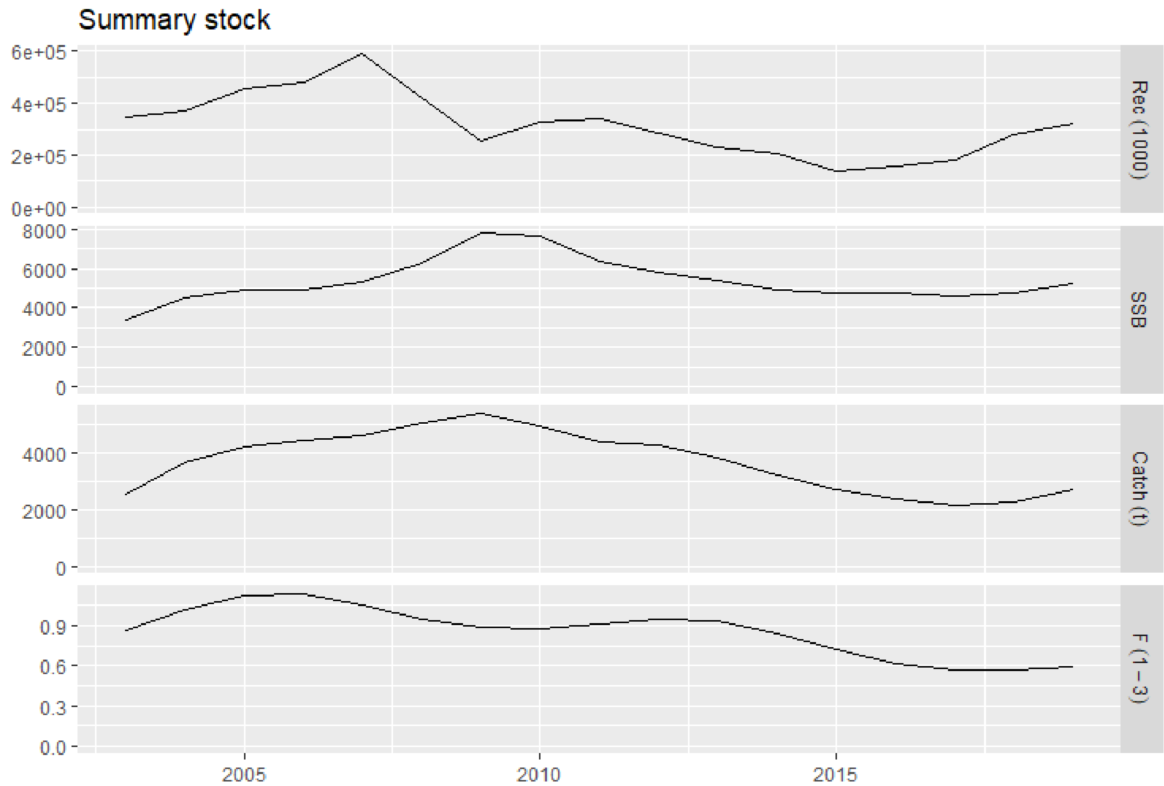


Figure 6.11.3.5. Hake in GSA 22. Stock summary from the final a4a model.

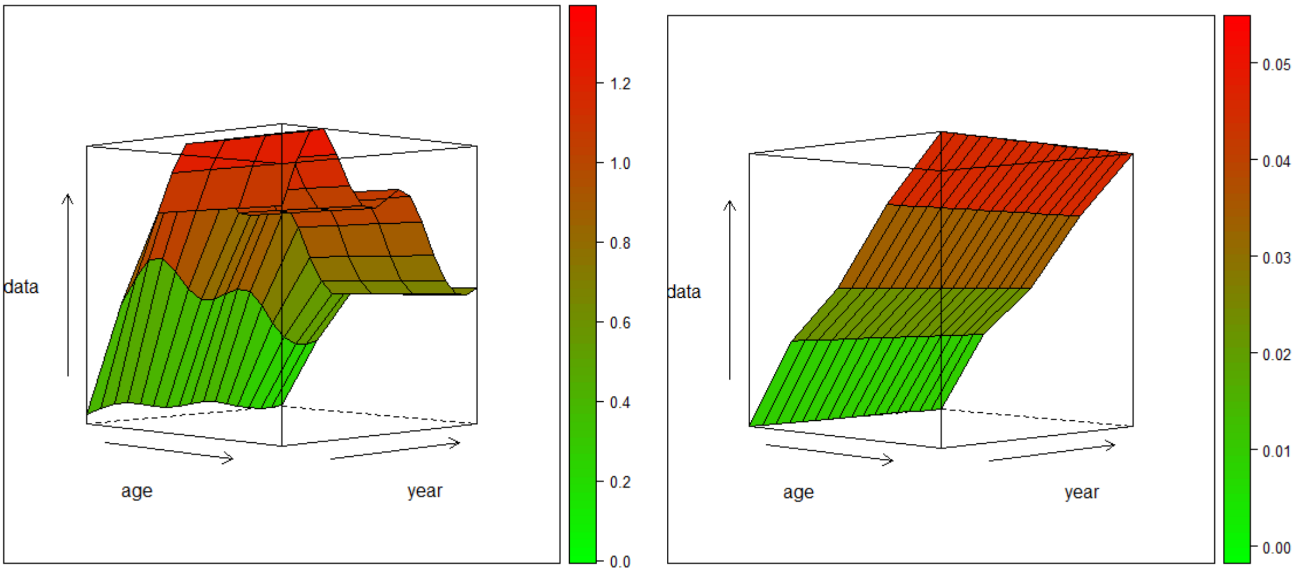


Figure 6.11.3.6. Hake in GSA 22. 3D contour plot of estimated fishing mortality (left) and estimated catchability (right) at age and year.

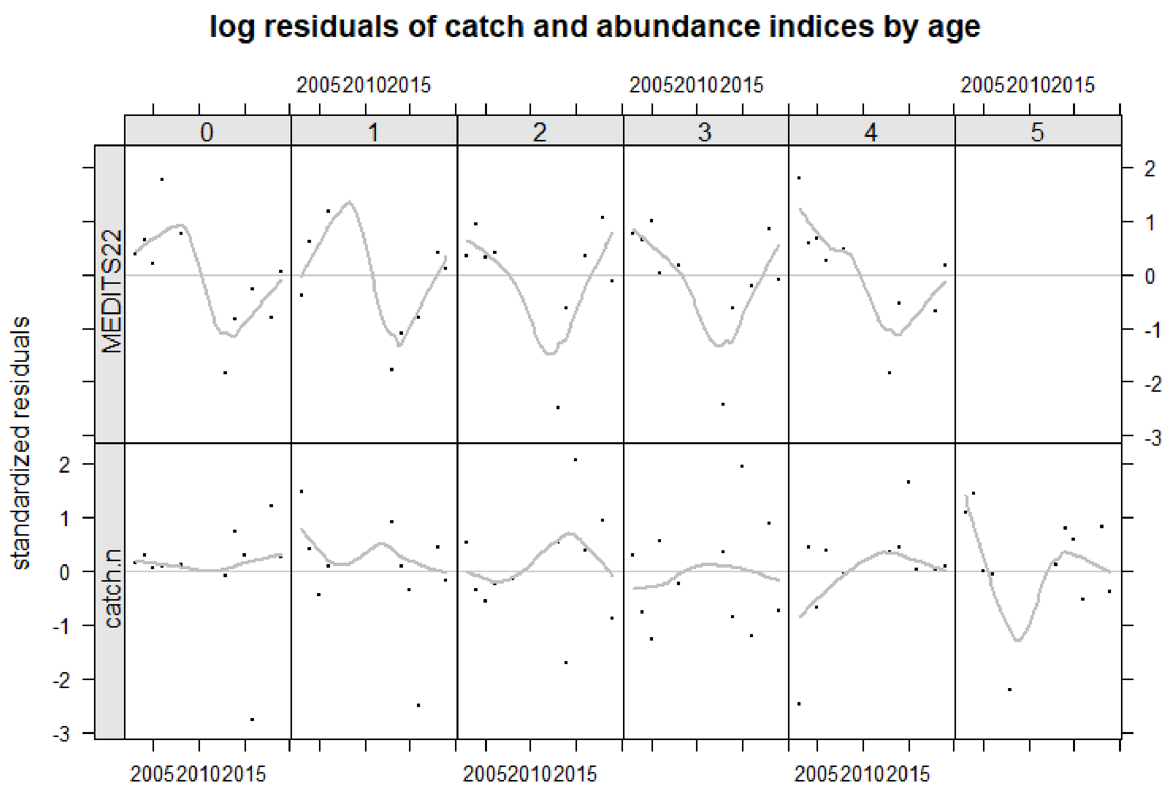


Figure 6.11.3.7. Hake in GSA 22. Standardized residuals by age for abundance index and for catch numbers.

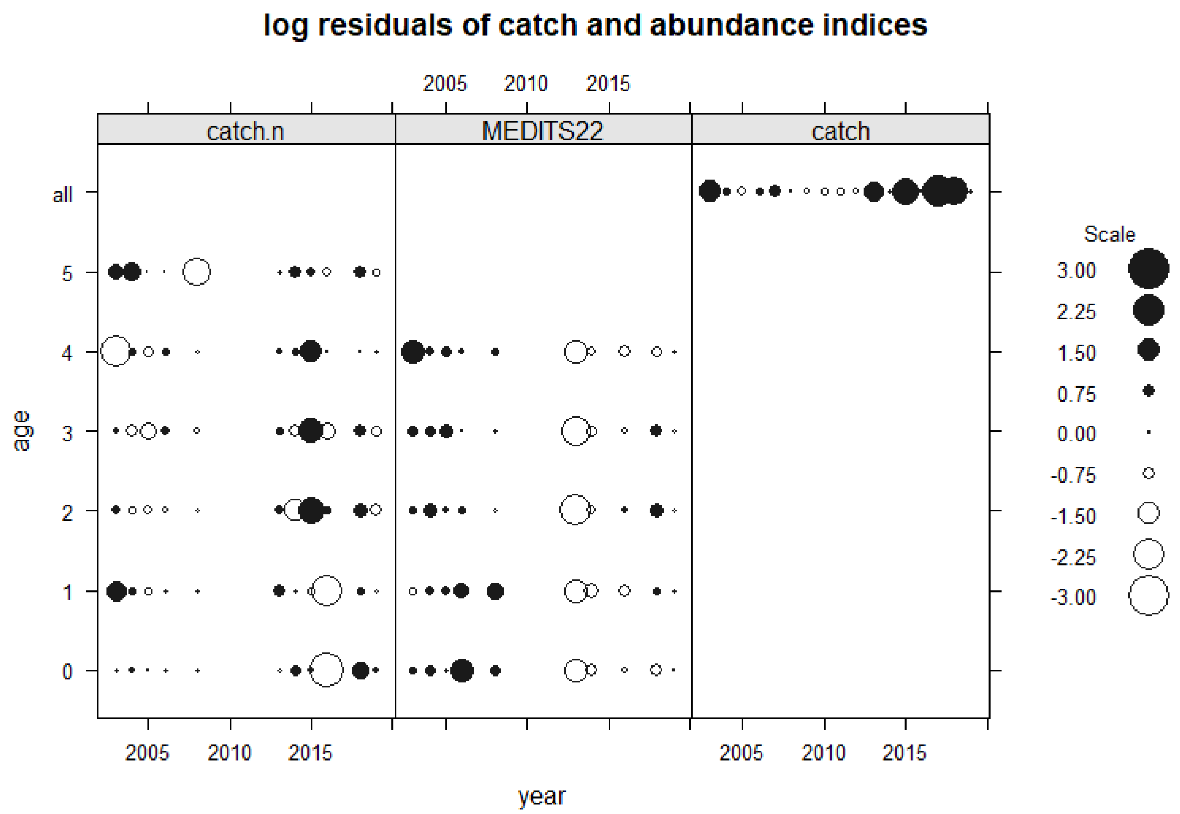


Figure 6.11.3.8. Hake in GSA 22. Standardized residuals for abundance index and for catch numbers.

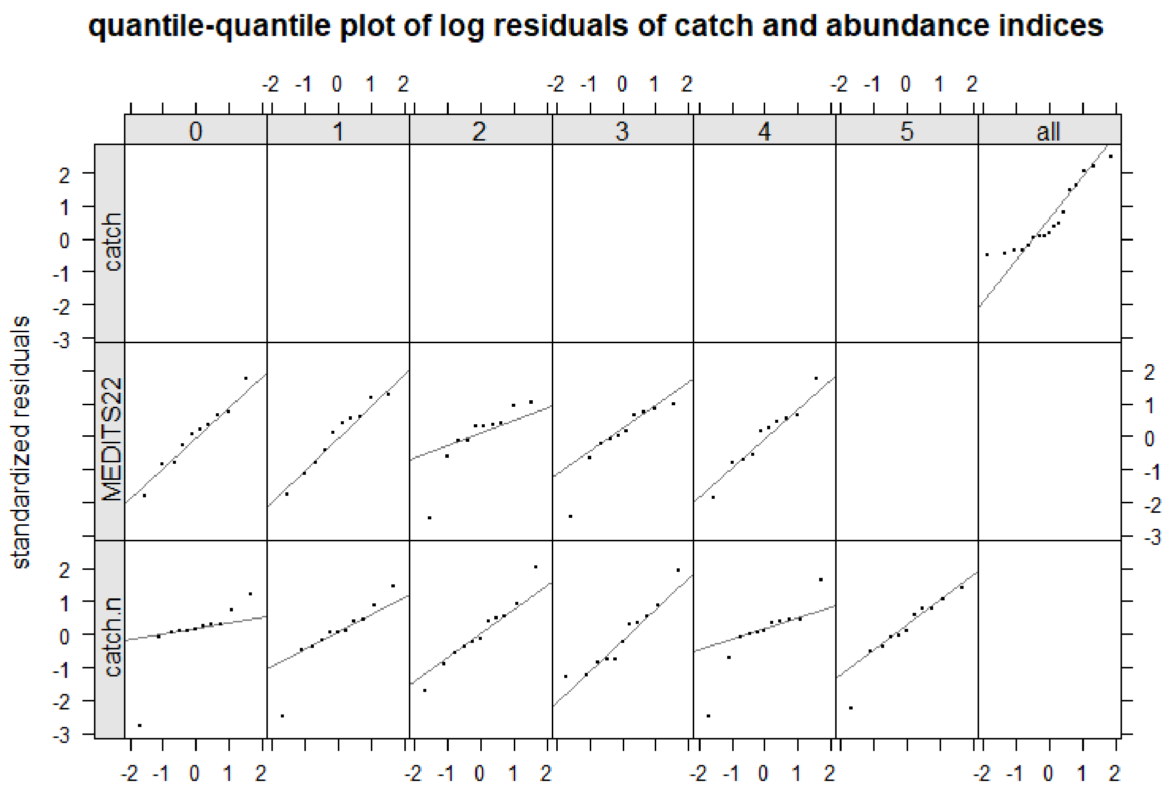


Figure 6.11.3.9. Hake in GSA 22. Quantile plot of standardized residuals for abundance index and for catch numbers.

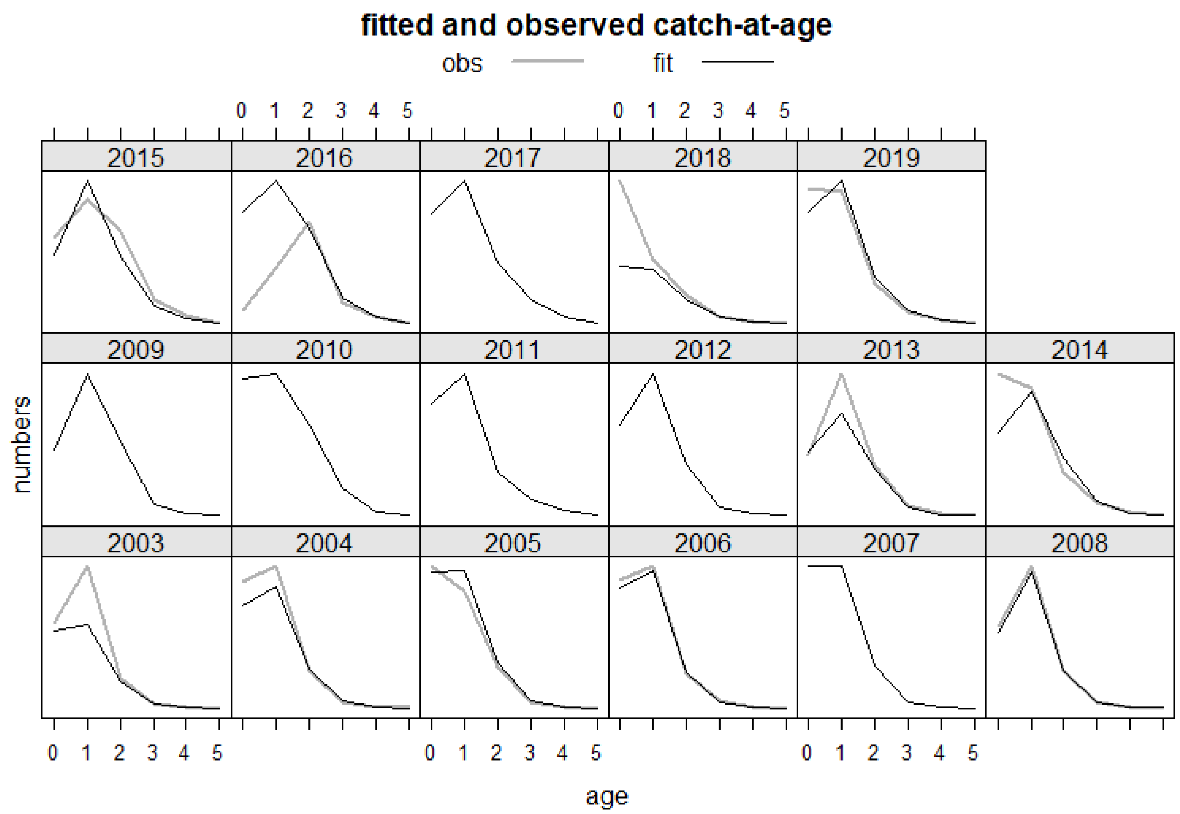


Figure 6.11.3.10. Hake in GSA 22. Fitted and observed catch at age.

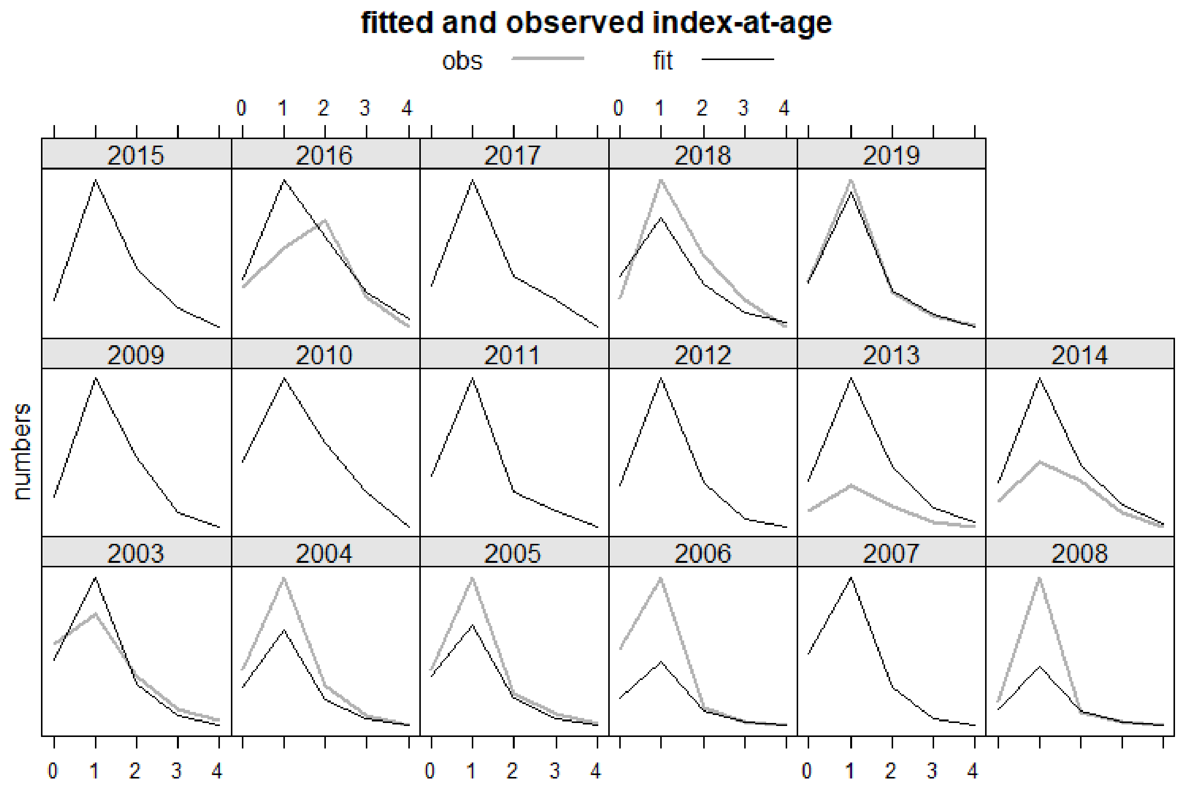


Figure 6.11.3.10. Hake in GSA 22. Fitted and observed index at age.

Retrospective
The retrospective analysis could not be applied because the 2017 dataset was missing.

Simulations
In the following figures and tables, the population estimates obtained by the a4a model are provided.

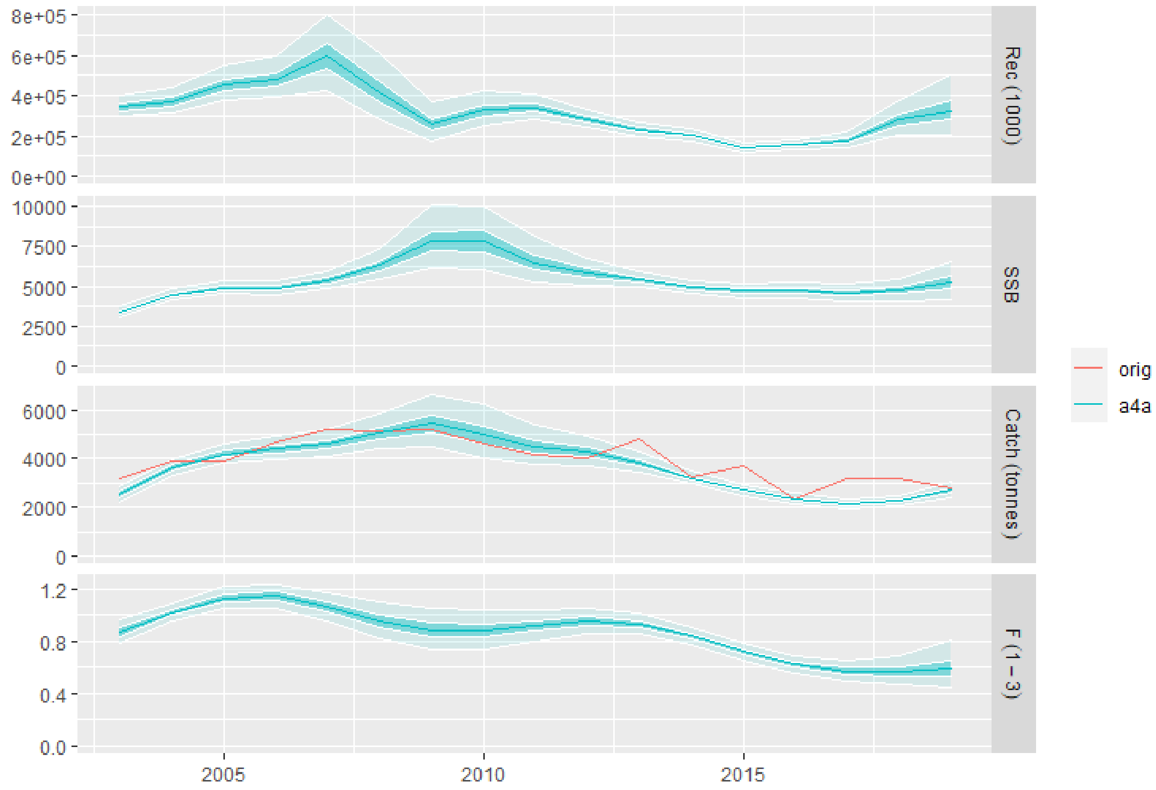


Figure 6.11.3.11. Hake in GSA 22. Stock summary of the simulated and fitted data for the a4a model.

Table 6.11.3.3. Hake in GSA 22. Stock numbers at age (thousands) as estimated by a4a.

Year/Age	0	1	2	3	4	5
2003	343709	72282	15019	2548	325	34
2004	371134	88286	18829	3444	639	85
2005	455455	93379	20670	3635	728	141
2006	482154	112850	20198	3512	676	141
2007	591120	119275	24210	3387	644	129
2008	419960	147896	27127	4461	683	135
2009	256033	106631	36293	5650	1017	162
2010	327585	65620	27462	8172	1392	261
2011	340632	84033	16977	6229	2028	360
2012	283169	86917	21153	3684	1479	501
2013	232449	71897	21327	4405	840	351
2014	204755	59192	17909	4550	1028	204
2015	138927	52804	15740	4246	1180	278
2016	156309	36430	15302	4287	1266	366
2017	178273	41543	11316	4662	1429	439
2018	279819	47703	13364	3648	1644	525
2019	323072	74905	15377	4322	1291	606

Table 6.11.3.4. Hake in GSA 22. a4a summary results Fbar age 1-3, recruitment (thousands), catches, SSB and total biomass (tonnes).

	Fbar (1-3)	Recruitment (age1)	SSB	Total Biomass	Catch
2003	0.86	344996	3371	5984	2495
2004	1.02	385029	4543	7711	3680
2005	1.15	484073	4965	8495	4316
2006	1.16	517660	4981	9153	4580
2007	1.07	761790	5519	10282	4830
2008	0.96	518670	6777	12970	5746
2009	0.89	265501	9282	13977	6513
2010	0.89	345104	9260	12122	5915
2011	0.94	352934	7249	10337	5015
2012	0.98	284440	6201	9332	4585
2013	0.95	228506	5490	8080	3928
2014	0.84	195869	4882	6990	3166
2015	0.70	127554	4646	6432	2629
2016	0.60	144605	4663	6007	2264
2017	0.56	165329	4495	5912	2094
2018	0.58	272327	4561	6293	2230
2019	0.65	352081	4877	7486	2720

Current F (0.60, estimated as the F_{bar1-3} in the last year of the time series, 2019) is higher than $F_{0.1}$ (0.27), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long-term yields, which indicates that hake stock in GSA 22 is overfished.

Table 6.11.3.5. Hake in GSA 22. a4a results F at age.

F at age	0	1	2	3	4	5
2003	0.119	0.615	0.993	0.993	0.993	0.993
2004	0.140	0.722	1.165	1.165	1.165	1.165
2005	0.155	0.801	1.292	1.292	1.292	1.292
2006	0.157	0.809	1.306	1.306	1.306	1.306
2007	0.146	0.751	1.211	1.211	1.211	1.211
2008	0.131	0.675	1.089	1.089	1.089	1.089
2009	0.121	0.627	1.011	1.011	1.011	1.011
2010	0.121	0.622	1.004	1.004	1.004	1.004
2011	0.126	0.649	1.048	1.048	1.048	1.048
2012	0.131	0.675	1.089	1.089	1.089	1.089
2013	0.128	0.660	1.065	1.065	1.065	1.065
2014	0.115	0.595	0.959	0.959	0.959	0.959
2015	0.099	0.509	0.821	0.821	0.821	0.821
2016	0.085	0.439	0.709	0.709	0.709	0.709
2017	0.078	0.404	0.652	0.652	0.652	0.652
2018	0.078	0.402	0.649	0.649	0.649	0.649
2019	0.081	0.420	0.677	0.677	0.677	0.677

Based on the a4a results, hake SSB showed an increasing trend from 2017 to 2019. The number of recruits also increased since 2015. Fbar (1-3) was declining up to 2016 and has been increasing thereafter.

6.11.3.2 METHOD2: SPICT (SURPLUS PRODUCTION)

The Surplus Production in Continuous time (SPiCT) assessment method is fully described in Pedersen and Berg (2016). SPiCT is available as an R (R Core Team 2015) package in the github online repository: https://github.com/mawp/spict.

SPiCT requires a time series of catches and one (or more) time series of tuning index (CPUE or biomass; in this case MEDITS index). The expected output includes management reference points F/Fmsy and B/Bmsy that quantify the exploitation rate and stock status. A forecasting period and a fishing management scenario can be tested by changing the multiplication factor that is applied to the current fishing mortality and projecting to the future. Main advantages of SPiCT are:

1. All estimated reference points (MSY, Fmsy, Bmsy) are reported with uncertainties.
2. The model can be used for short-term forecasting and management strategy evaluation.
3. The model is fully stochastic in that observation error is included in catch and index observations, and process error is included in fishing and stock dynamics.
4. The model is formulated in continuous-time and can therefore incorporate arbitrarily sampled data.

Input data

Landings

The official landings of hake (Figure 6.11.3.2.1) are being recorded by the Hellenic Statistical Authority and the same values are reported by the FAO/GFCM databases. However, the structure of the dataset changed after 2015 and includes the landings of an extra small-scale coastal fleet of 10,000 vessels (Tsikliras et al. 2020). To account for these additional landings that artificially inflated the landings time series after 2016, we corrected the hake landings from 1982 to 2015 by multiplying by 1.31, which is the difference of hake with and without the extra fleet. According to the DCF report, the discards of hake by weight in GSA 22 are negligible (ranged from 1-10% since 2013); thus, they were excluded from the analysis.

Biomass

The CPUE from MEDITS bottom trawl surveys that were conducted in Aegean Sea was used as tuning index. Survey data were available by DCF from 1994 onwards (with gaps in 2002, 2007, 2009-2013, 2015 and 2017).

Settings

No priors on any of the model parameters or variables were required for the model to converge.
The Schaefer production model was selected.

Table 6.11.3.2.1 Hake in GSA 22. Official landings (tons) for hake in GSA 22.

Year	Greek landings (t)
1997	3995.5
1998	3243.56
1999	3219.98
2000	3626.08
2001	2798.16
2002	2841.39
2003	3216.05
2004	3884.15
2005	3886.77
2006	4646.57
2007	5173.19
2008	5110.31
2009	5196.77
2010	4607.27
2011	4157.94
2012	4028.25
2013	4791.98
2014	3252.73
2015	3700.75
2016	2364
2017	3159
2018	3179
2019	3300

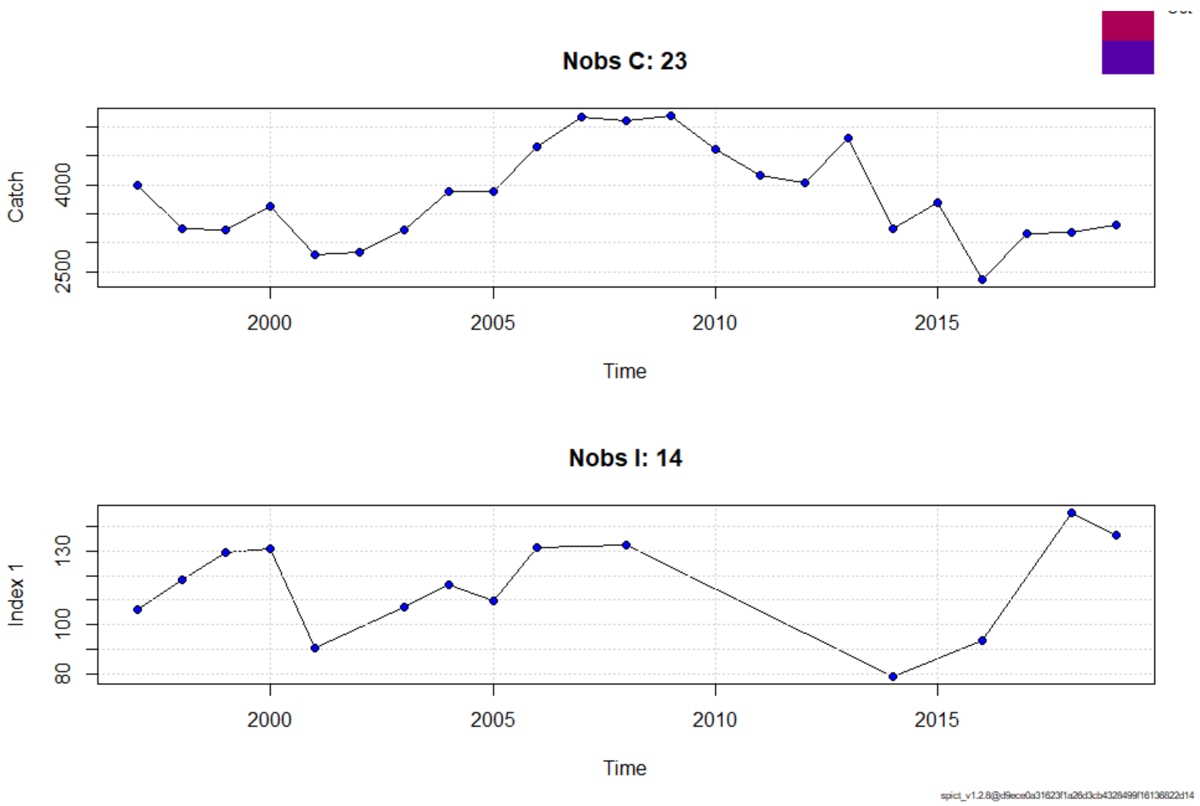


Figure 6.11.3.2.1 Hake in GSA 22. Input data for hake in GSA 22.

Assessment results

The output of the model (Model estimates, reference points and summaries) are reported below.

```
[1] "Convergence: 0  MSG: relative convergence (4)"
[1] "Convergence: 0  MSG: relative convergence (4)"
 [2] "Objective function at optimum: 1.4347085"
 [3] "Euler time step (years):  1/16 or 0.0625"
 [4] "Nobs C: 23,  Nobs I1: 14"
 [5] "Catch/biomass unit: tones "
 [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] ""
[12] "Fixed parameters"
[13] "   fixed.value  "
[14] " n           2  "
[15] ""
[16] "Model parameter estimates w 95% CI "
[17] "            estimate       cilow       ciupp  "
[18] " alpha  7.263578e-01    0.0504140 1.046527e+01  "
[19] " beta   5.632614e-01    0.1816052 1.746995e+00  "
[20] " r      1.142014e+00    0.2955325 4.413036e+00  "
[21] " rc     1.142014e+00    0.2955325 4.413036e+00  "
[22] " rold   1.142014e+00    0.2955325 4.413036e+00  "
[23] " m      4.300197e+03 3397.3077477 5.443043e+03  "
[24] " K      1.506180e+04 4154.2102583 5.460915e+04  "
[25] " q      1.183500e-02    0.0032726 4.279970e-02  "
[26] " sdb    1.280269e-01    0.0342212 4.789680e-01  "
[27] " sdf    1.589926e-01    0.0819950 3.082952e-01  "
[28] " sdi    9.299330e-02    0.0202241 4.275955e-01  "
[29] " sdc    8.955440e-02    0.0453119 1.769951e-01  "
[30] "           log.est  "
[31] " alpha  -0.3197126  "
[32] " beta   -0.5740115  "
[33] " r       0.1327933  "
[34] " rc      0.1327933  "
[35] " rold    0.1327933  "
[36] " m       8.3664161  "
[37] " K       9.6199171  "
[38] " q      -4.4366982  "
[39] " sdb    -2.0555151  "
[40] " sdf    -1.8388973  "
[41] " sdi    -2.3752277  "
[42] " sdc    -2.4129088  "
[43] " "
[44] "Deterministic reference points (Drp)"
[45] "          estimate       cilow       ciupp  "
[46] " Bmsyd 7530.900863 2077.1051291 27304.572605  "
[47] " Fmsyd    0.571007    0.1477663     2.206518  "
[48] " MSYd  4300.196777 3397.3077477  5443.043050  "
[49] "          log.est  "
[50] " Bmsyd  8.9267700  "
[51] " Fmsyd -0.5603539  "
```

```
[52] " MSYd   8.3664161  "
[53] "Stochastic reference points (Srp)"
[54] "          estimate        cilow      ciupp  "
[55] " Bmsys 7425.0370474 1995.0541734 27633.9239  "
[56] " Fmsys    0.5675635    0.1469094     2.1927  "
[57] " MSYs  4213.8156126 3346.6672137  5305.6491  "
[58] "          log.est rel.diff.Drp  "
[59] " Bmsys  8.9126130 -0.014257682  "
[60] " Fmsys -0.5664026 -0.006067085  "
[61] " MSYs   8.3461238 -0.020499512  "
[62] ""
[63] "States w 95% CI (inp$msytype: s)"
[64] "                   estimate       cilow  "
[65] " B_2019.00      1.135843e+04 3346.3883939  "
[66] " F_2019.00      2.870535e-01    0.0851396  "
[67] " B_2019.00/Bmsy 1.529747e+00    1.1031806  "
[68] " F_2019.00/Fmsy 5.057645e-01    0.2930851  "
[69] "                      ciupp    log.est  "
[70] " B_2019.00      3.855317e+04  9.3377153  "
[71] " F_2019.00      9.678183e-01 -1.2480868  "
[72] " B_2019.00/Bmsy 2.121254e+00  0.4251024  "
[73] " F_2019.00/Fmsy 8.727761e-01 -0.6816842  "
[74] ""
[75] "Predictions w 95% CI (inp$msytype: s)"
[76] "                 prediction       cilow  "
[77] " B_2020.00      1.126961e+04 3220.2651902  "
[78] " F_2020.00      2.902284e-01    0.0826949  "
[79] " B_2020.00/Bmsy 1.517785e+00    1.1199875  "
[80] " F_2020.00/Fmsy 5.113585e-01    0.2925454  "
[81] " Catch_2020.00  3.257614e+03 2390.0780272  "
[82] " E(B_inf)       1.099332e+04           NA  "
[83] "                      ciupp    log.est  "
[84] " B_2020.00      3.943904e+04  9.3298652  "
[85] " F_2020.00      1.018594e+00 -1.2370870  "
[86] " B_2020.00/Bmsy 2.056873e+00  0.4172523  "
[87] " F_2020.00/Fmsy 8.938357e-01 -0.6706844  "
[88] " Catch_2020.00  4.440043e+03  8.0887503  "
[89] " E(B_inf)                 NA  9.3050433  "
```

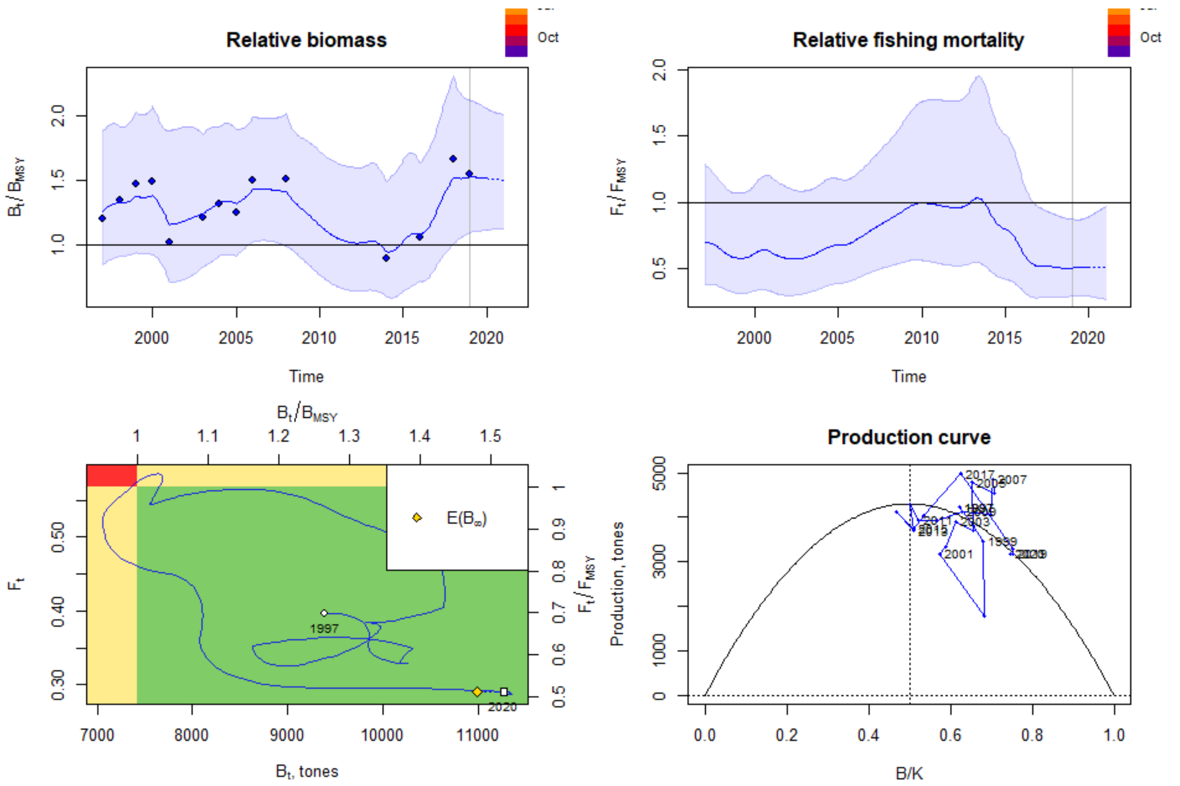


Figure 6.11.3.2.1 Hake in GSA 22. Relative biomass and fishing mortality, F/B plot and production curve as given by the SPiCT model for hake in GSA 22.

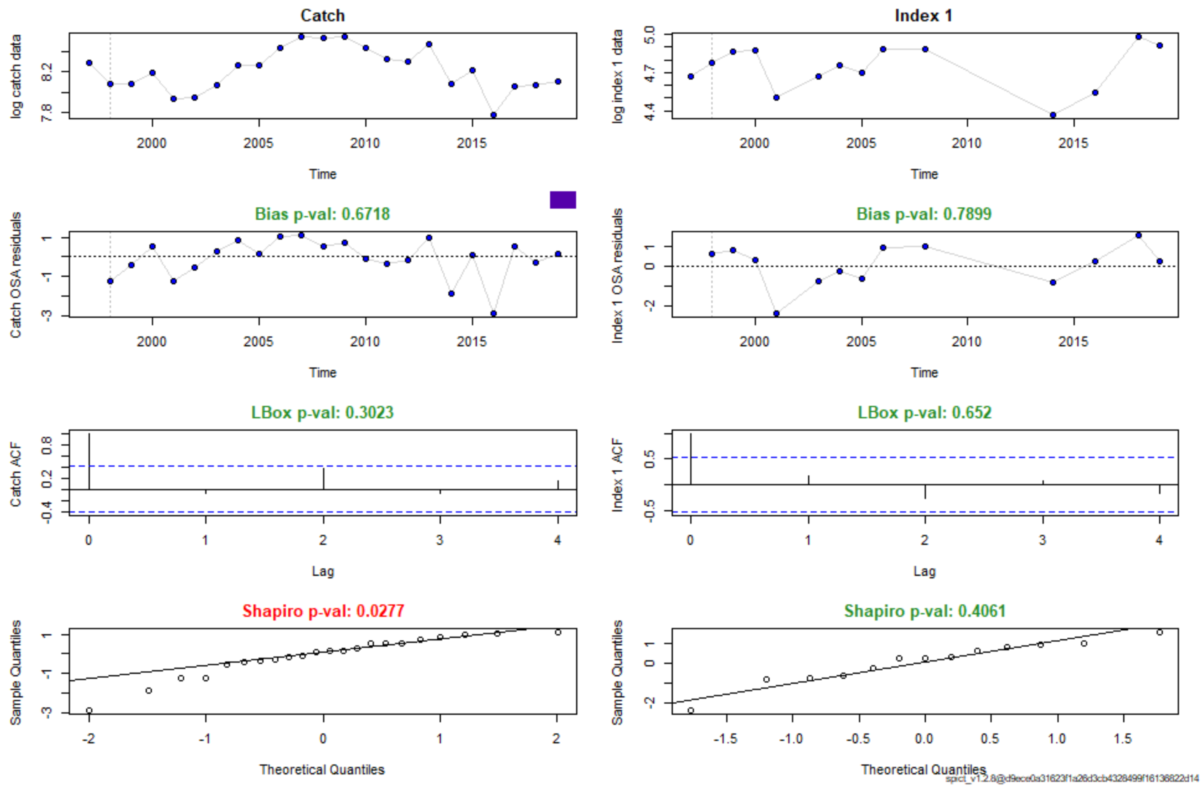


Figure 6.11.2.19 Hake in GSA 22. Diagnostics from SPiCT model for hake in GSA 22.

Retrospective analysis

A retrospective analysis was run with 5 retro years. The retrospective patterns are rather consistent across in terms of B/Bmsy but results in poorer performance when F/Fmsy is concerned.

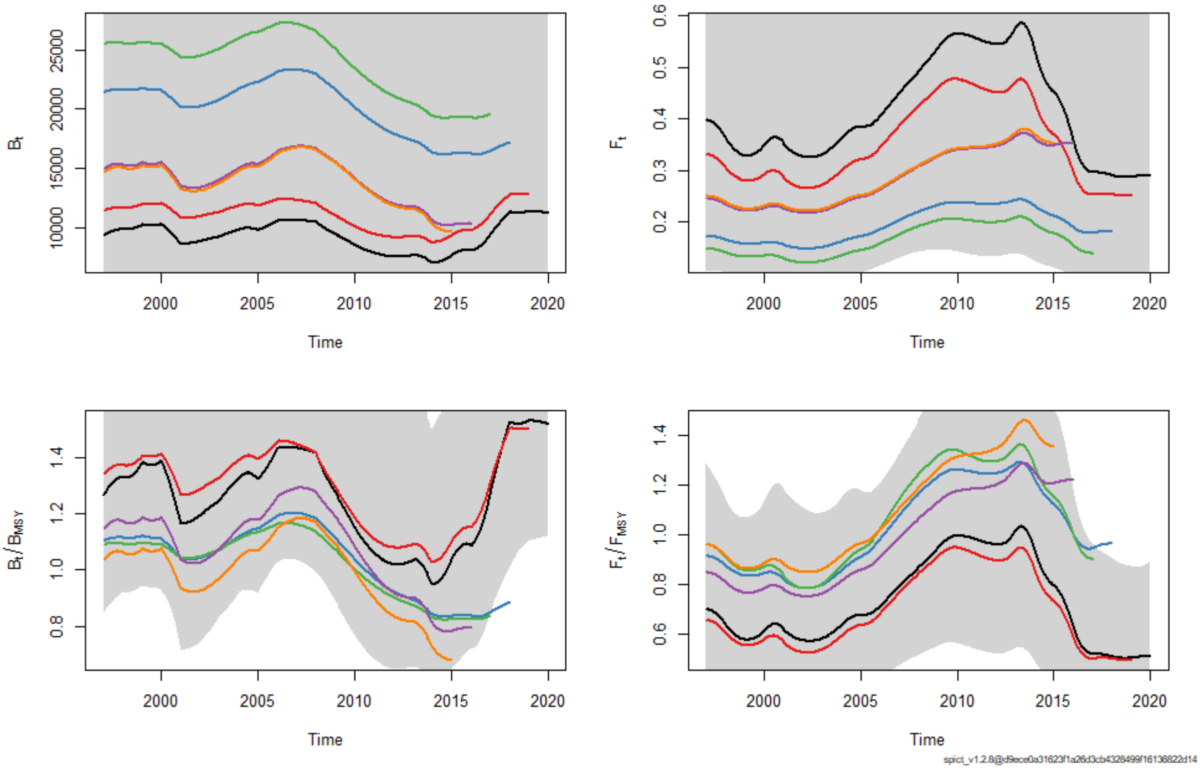


Figure 6.11.2.20 Hake in GSA 22. Retrospective analysis for the SPiCT model for hake in GSA 22.

Conclusions to SPiCT model

The SPICT model estimates B_2019/Bmsy=1.52 and F_2019/Fmsy=0.52. However, the lack of stability of the model in the retrospective analysis and the contrasting reference points with the analytical models lead the EWG 20-15 to decide that the model results were not able to determine current stock status or biomass; thus, this assessment will not be used for specific advice.

Comparison of assessments

The two assessment model results give completely different perspectives of the stock. The SPiCT model implies that the stock status healthy and its biomass way over Bmsy. However, it has poor retrospective results that indicate instability of the model . In contrast, the age-based model a4a suggests overexploitation of the hake stock. The divergence among models in the last year is of concern. Overall, the a4a model is considered to best represent the current state of the stock. However, due to the considerable uncertainty in the model because of the missing and inconsistent data, the model is not considered suitable for catch advice.

6.11.4 Reference Points

The STECF EWG 20-15 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 resulting from the outputs of the a4a assessment.

The EWG 20-15 concluded that the output of these models were not suitable to provide an indication of the current status of the stock and due to the lack of surveys and catch-at-age data and agreed not to provide forward projections and catch advice based on this assessment.

6.11.5 Short term Forecast and Catch Options

No short term forecast and catch options were carried out for hake stock in GSA 22 within STECF EWG 20-15.

6.11.6 Data Deficiencies

Many deficiencies were found in the DCF data provided. Specifically, no DCF catch / catch-at-length / catch-at-age data were provided for 2007, 2009, 2010, 2011, and 2012. Catch-at-age data were provided only for the last trimester for 2013 2015 and 2017. No MEDITS surveys took place in 2002, 2007, 2009-2013, 2015 and 2017.

The landings as calculated from the DCF data (number of individuals multiplied by their somatic weight) do not correspond to the official landings reported. This issue is stronger for the years 2003-2006 and fades out after 2016. The numbers and weights at length are not reported consistently (step size, initial value, unit of measurement vary among years). In fact, every year has its own peculiarities and inconsistencies. Year 2019 was the best reported and the methodology followed there should be expanded to the rest of the years. Similar issues with length data and number of individuals were observed in the index data.

Finally, the coastal gears (GTR, GNS, LLS) are reported aggregated before 2014 and separately afterwards; therefore, their inclusion in the models is impossible.

6.12 Red mullet in GSA 22

6.12.1 Stock Identity and Biology

GSA 22 has been considered as a unique area for management purposes due to its specific geo-physical characteristics and its separation from nearby areas, such as GSA 23 (Crete), through the Cretan Sea which is a deep (2500m) and large in volume particularly oligotrophic basin (Psarra et al., 1996; Lykousis et al., 2002). In addition, fishery exploitation patterns differ between the two nearby areas, with the trawling activities being much less intense in GSA 23 (Anonymous, 2013).

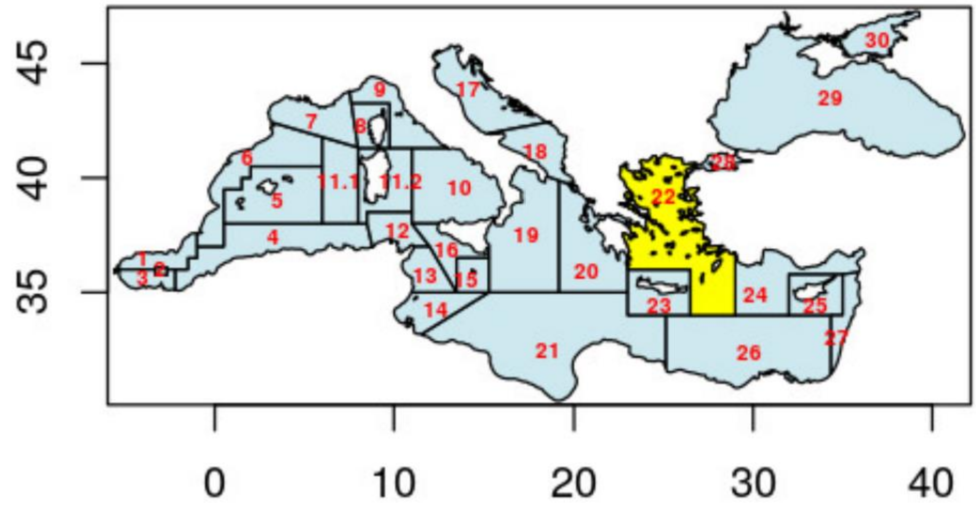


Figure 6.12.1.1. Geographical location of GSA 22.

Biological information on growth, i.e. the von Bertalanffy parameters, as well the length-weight relationship were derived within DCF (2002-2019). Similarly to EWG 17-15, the proportion of mature individuals at-age was based on Tserpes et al. (2016), while the natural mortality at age estimates were similar to those used in EWG 17-15. The parameter values used are reported below. For the length to age conversions used for the age slicing of the catch, the t_0 value of the growth curve was corrected, adding +0.5, to account for the difference between biological birthday (set at July 1st) and the fact that the stock assessment model works using the calendar year.

Table 6.12.1.1 Red mullet in GSA 22. Von Bertalanffy growth (VBGF) and length-weight relationship parameters.

	VBGF			Length/weight	
	L_{oo}	k	t_0	a	b
All sexes	326	0.17	-1.78	0.00885	3.07

Table 6.12.1.2. Red mullet in GSA 22. Proportion of mature and natural mortality (M) at age

Age	1	2	3	4	5
Maturity	0.72	0.89	0.98	1	1
M	0.61	0.54	0.50	0.50	0.50

6.12.2 Data

6.12.2.1 Catch (landings and discards)

Red mullet is mostly exploited by bottom trawlers and to a lesser extent from various artisanal fisheries using various type of nets. Red mullet catches in GSA 22 are primarily coming from Greek fishing vessels, while catches from Turkish fisheries are also reported in GFCM. Greek bottom trawl catches usually represent 60-70% of the total Greek catch.

Trends in landing estimates by national fishery are shown in Figure 6.12.2.1.1. In the case of the Greek fisheries, landing estimates were obtained from two different independent sources: (a) the DCF and (b) the Hellenic Statistical Authority (reported also in GFCM). Given that there are gaps in DCF data due to inconsistencies in the implementation of the DCF, the Hellenic Statistical Authority (ELSTAT) data were used. ELSTAT data previous to 2016 were corrected based on Tsikliras et al. 2020. Hence total landings in GSA22 were considered as the sum of the Greek and Turkish landings.

Discards are inconsistently reported through DCF but seem to be negligible (<1% in terms of weight in 2019). Hence, they were not considered in the assessment.

Table 6.12.2.1.1 indicates the final landing estimates used and the SoP corrected values employed in the analytical assessment model.

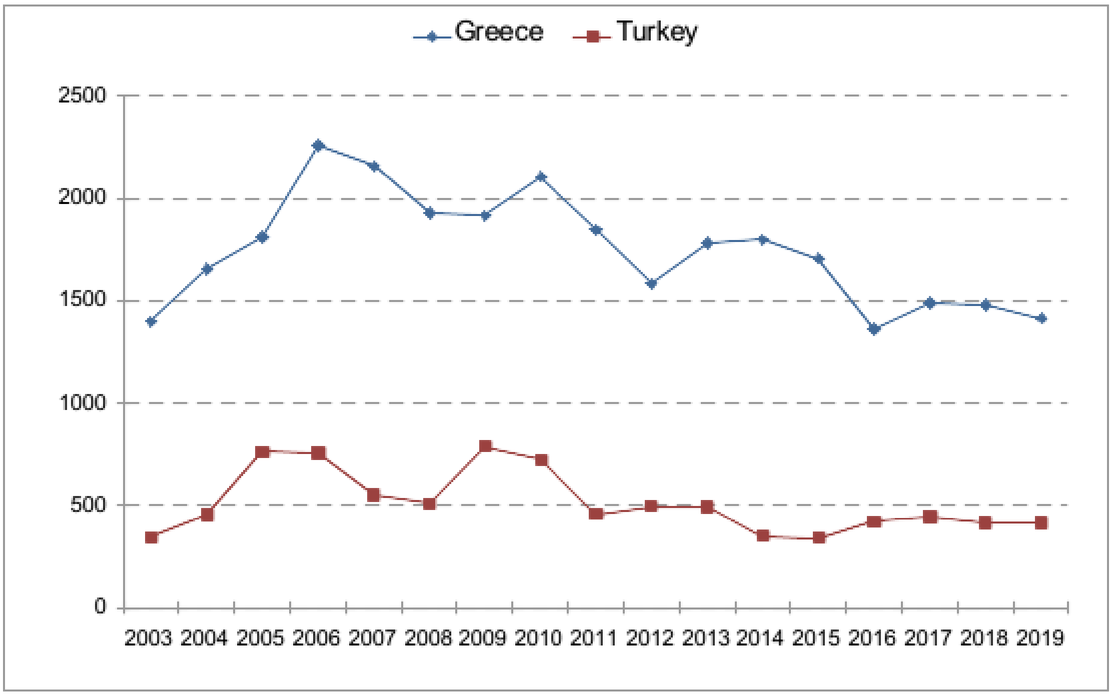


Figure 6.12.2.1.1 Red mullet in GSA 22. Landings (t) by national fishery.

Table 6.12.2.1.1 Actual landings in GSA 22 and the corresponding estimates with SoP correction

Year	Landings (t)	SoP	Landings/SoP
2003	1744	1483	1.18
2004	2112	2347	0.89
2005	2574	3014	0.85
2006	3017	3001	1.00
2007	2712	2852	0.95
2008	2438	2317	1.05
2009	2704	2191	1.24
2010	2832	2476	1.14
2011	2302	2790	0.82
2012	2081	2667	0.78
2013	2277	2401	0.95
2014	2150	2147	1.00
2015	2047	1901	1.07
2016	1782	1786	1.00
2017	1932	1767	1.09
2018	1897	1819	1.04
2019	1831	1804	1.01

Figure 6.12.2.1.2 illustrates the length frequency distributions of the total GSA 22 landings, assuming that the size composition of the Turkish catches is similar to the Greek ones. Information is missing for the years that DCF was not at all implemented (2007, 2009-2012). Catches are dominated by specimens up to 20cm length.

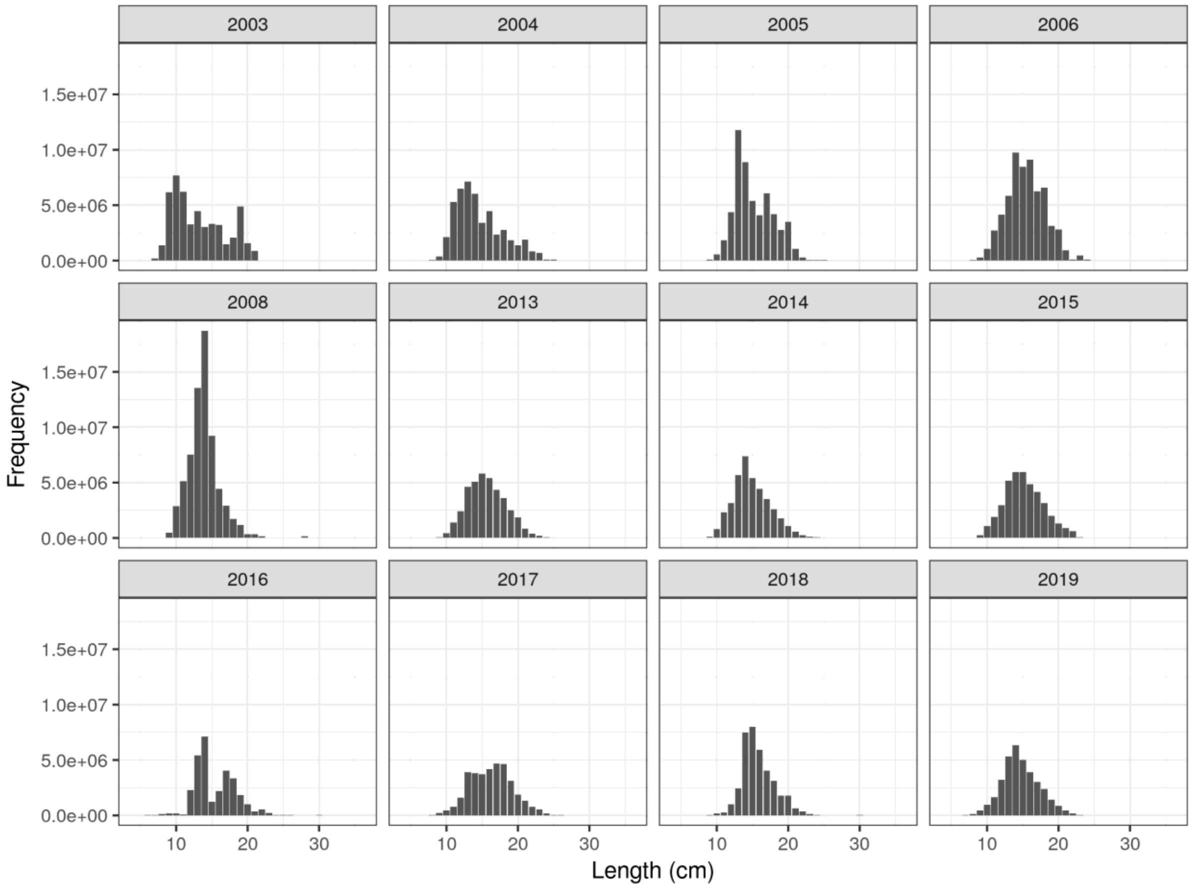


Figure 6.12.2.1.2. Length frequency distribution of the GSA 22 landings by year.

6.12.2.2 Effort

See Section 2.3

6.12.2.3 Survey data

Since 1994, MEDITS trawl surveys has been regularly carried out yearly during summer. In very few cases sampling was extended in September or started in late May (Figure 6.12.2.3.1). However, due to inconsistencies in DCF implementation the survey was not accomplished in 2007, 2008-2012, 2015, 2017, while it was partially accomplished in 2013. According to the MEDITS protocol, a random stratified sampling scheme by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m) was applied. Survey stations appear in Figure 6.12.2.3.2. Survey abundance and biomass data were standardized to square kilometer, using the swept area method, following the MEDITS protocol procedures. Data were analysed using the JRC script (Mannini, 2020)

Observed abundance and biomass indices of red mullet, as well as the length frequency distributions are given in figures 6.12.2.3.3 - 6.12.2.3.4. Both abundance and biomass indices show increasing trends in the last years. The high abundance value in 2014 is due to the opportunistic catch of newly born individuals (<5cm) in few stations.

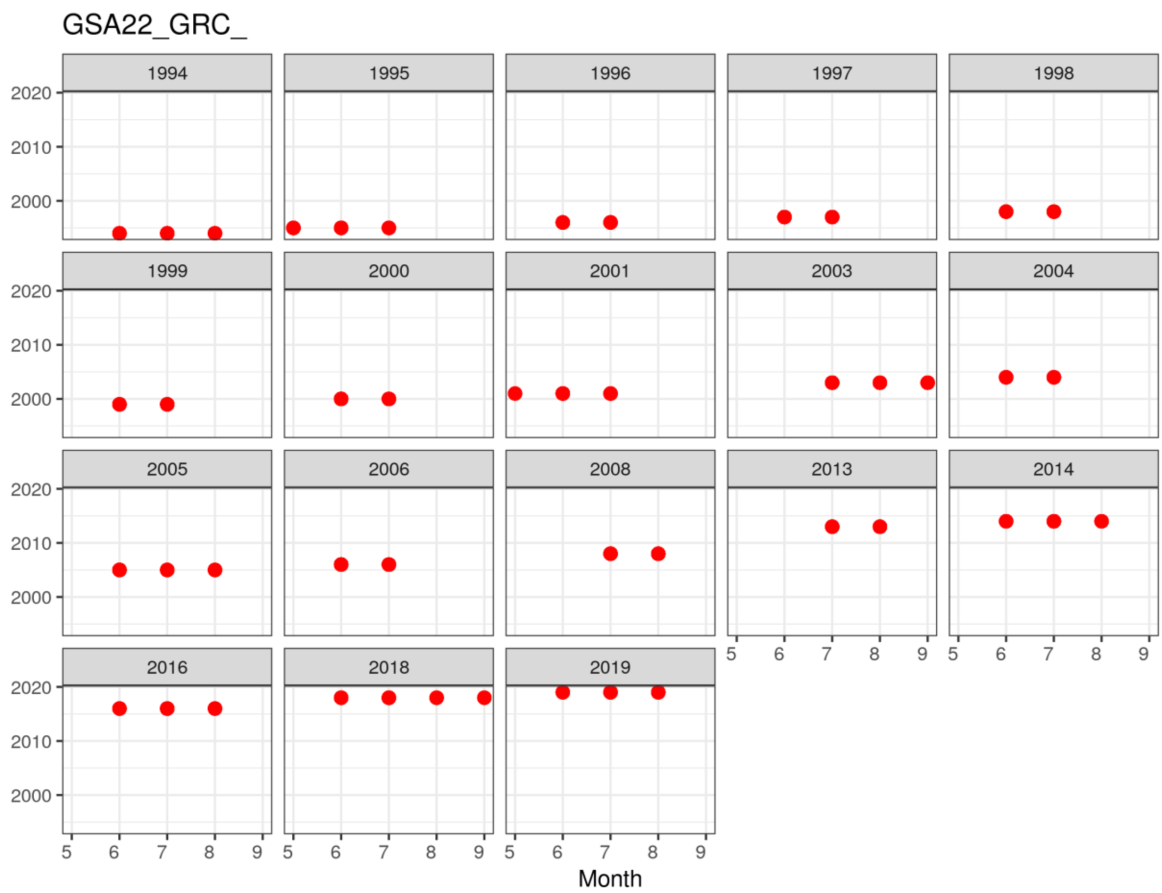


Figure 6.12.2.3.1. Month of the year when the hauls of MEDITS surveys were conducted in GSA 22.

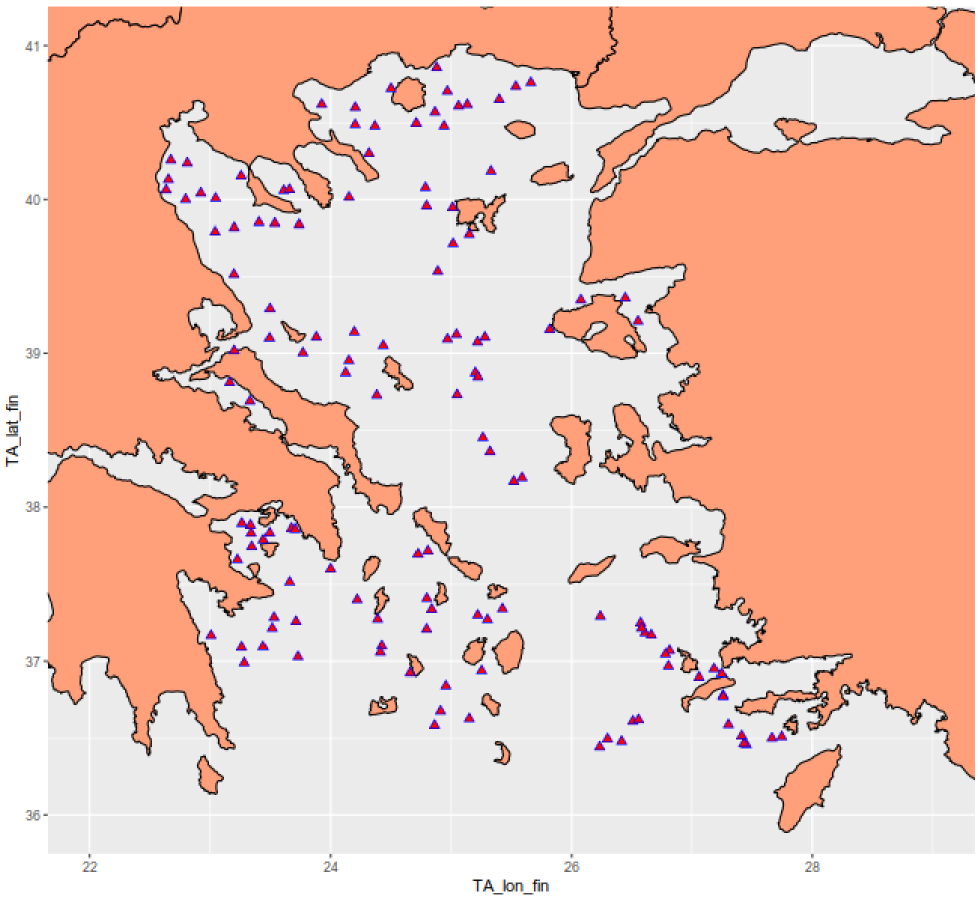
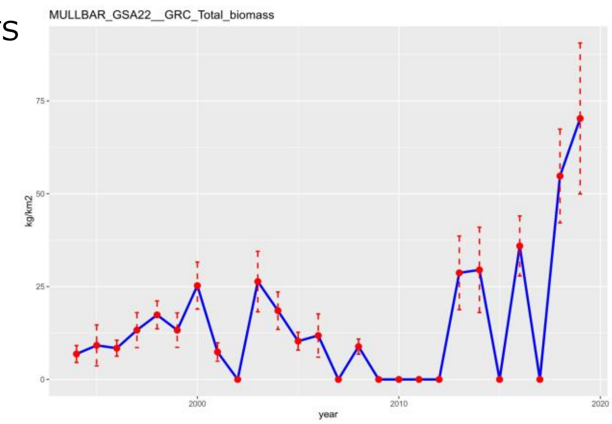


Figure 6.12.2.3.2. Distribution of MEDITS stations in GSA 22.



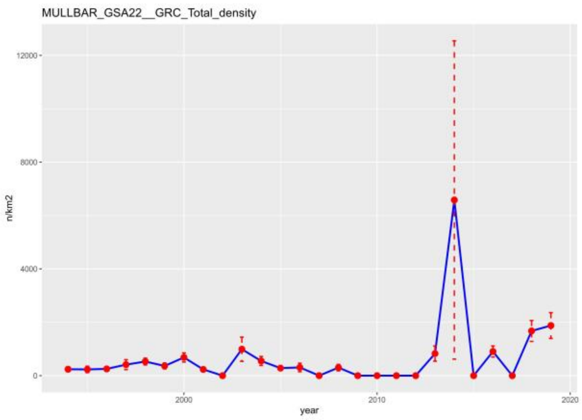


Figure 6.12.2.3.3 Red mullet in GSA 22. Estimated abundance (N/km2) (left), and biomass (kg/km2) (right) indices over the 1994-2019 period. Zero values (2002, 2009-2012, 2015 & 2017) correspond to the years the survey was not accomplished.

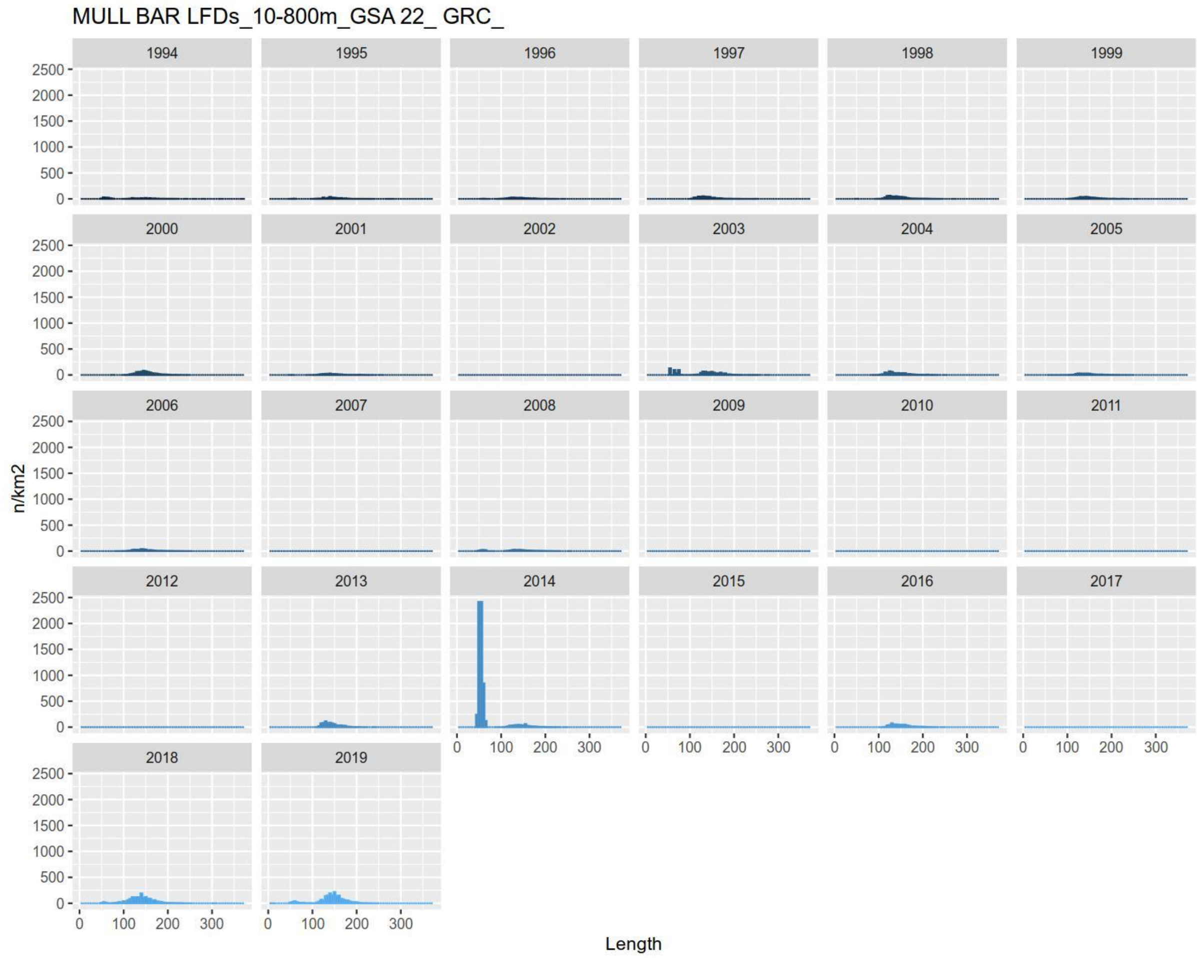


Figure 6.12.2.3.4. Red mullet in GSA 22. Length frequency distribution of the MEDITS survey abundance index (n/km^2).

6.12.3 Stock assessment

This stock was previously assessed by the STECF EWG in 2017 (STECF EWG 17-15) using a4a and SPiCT and in the WGSAD of GFCM in the same year using SPiCT. The a4a and SPiCT approaches followed in the STECF EWG 17-15 were also applied in the present assessment and details are provided in the following sections.

6.12.3.1 Method 1: a4a

The statistical catch-at-age modelling framework - Assessment for all (a4a, Jardim et al., 2014) in FLR (http://www.flr-project.org/) was used to assess the status of red mullet in GSA 22.

6.12.3.1.1 Input data and parameters

Catch-at-age estimates were based on the catch-at-length data for the years 2003 onwards, based on information from the Greek DCF. The estimates covered all national fleets operating in GSA 22 (see section 6.12.2.1). Discards were considered negligible; hence, landings data were considered as representing the total catch. The MEDITS abundance index by age, expressed in terms of N/km^2 was used for tuning purposes. As already mentioned (section 6.12.2.1), important gaps exist in catch at size and survey data due to inconsistencies in DCF implementation. Growth, maturity and natural mortality parameters were those mentioned in section 6.12.2.1. As already mentioned (see Table 6.12.2.1.1) catch data were SOP corrected using the ratio between total catch and SOPs at year.

The catch at age matrices are shown on Tables 6.12.3.1.1.1 and 6.12.3.1.1.2 for the catch and survey data respectively and the relevant trends are illustrated in Figure 6.12.3.1.1.1. Relatively good consistency is observed between cohorts particularly in the survey data (Figure 6.12.3.1.1.2). In Table 6.12.3.1.1.3 the mean weights-at-age for the stock and for the catch are reported. The M and F before spawning were set equal to 0.5 and an Fbar range 1-3 was used.

Table 6.12.3.1.1.1. Red mullet in GSA 22. Catch numbers at age obtained from sliced LFDs.

Year	1	2	3	4	5+
2003	24688170	7997146	6961774	2446286	18449
2004	27040208	10256862	4604151	3273249	1714660
2005	27406153	15575908	6937562	4541244	417957
2006	23499406	23792003	9720938	3720776	664522
2007					
2008	47837515	16555585	2919106	697644	347682
2009					
2010					
2011					
2012					
2013	14014186	15535245	6117610	2677138	724007
2014	19301987	13328722	4346372	1644804	540484
2015	17104375	14983592	5161741	2172309	717922
2016	15127790	7487940	5184927	1374147	884293
2017	10565100	12581400	7745400	3194100	1618500
2018	11336960	17980160	4890880	2464000	623360
2019	17518200	11950560	3835170	1309350	219300

Table 6.12.3.1.1.2. Red mullet in GSA 22. MEDITS index at age (n/km2) obtained from sliced LFDs.

Year	1	2	3	4	5+
2003	197.02	323.51	77.04	18.58	1.56
2004	281.16	208.53	35	18.56	5.07
2005	121.06	122.45	26.98	8.5	1.43
2006	115.17	161.57	19.99	7.9	1.33
2007					
2008	84.31	105.61	18.03	8.32	1.31
2009					
2010					
2011					
2012					
2013	371.57	357.52	48.91	8.65	2.05
2014	167.03	242.38	37.58	19.91	3.21
2015					
2016	211.67	305.47	43.22	27.79	3.35
2017					
2018	647.83	716.44	113.31	32.34	10.39
2019	470.85	1028.22	170.44	56.07	6.96

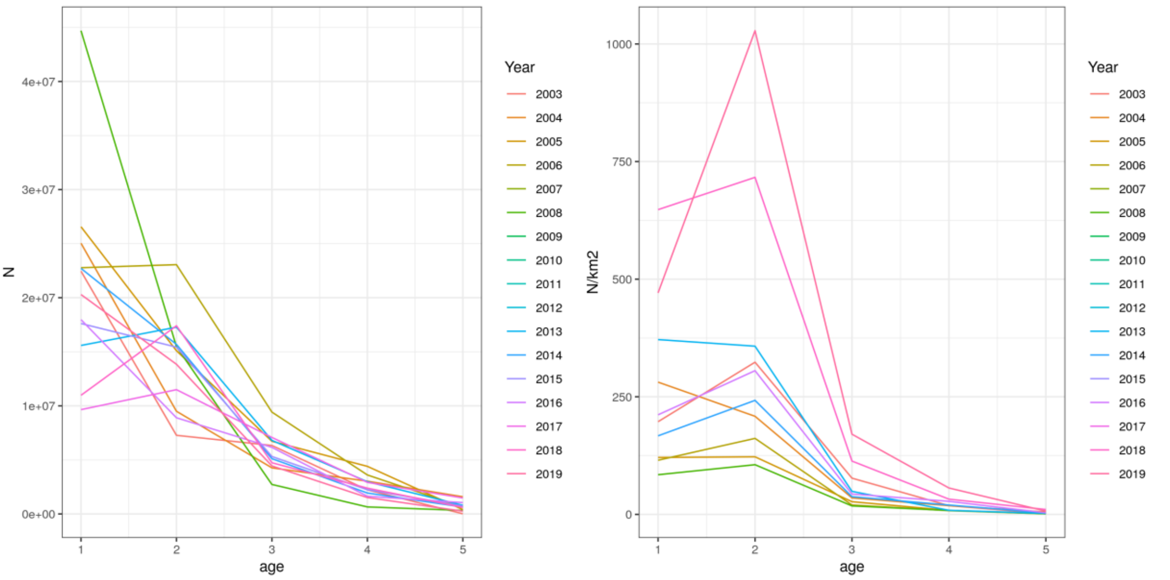


Figure 6.12.3.1.1.1. Numbers at age in landings (left) and the survey (right).

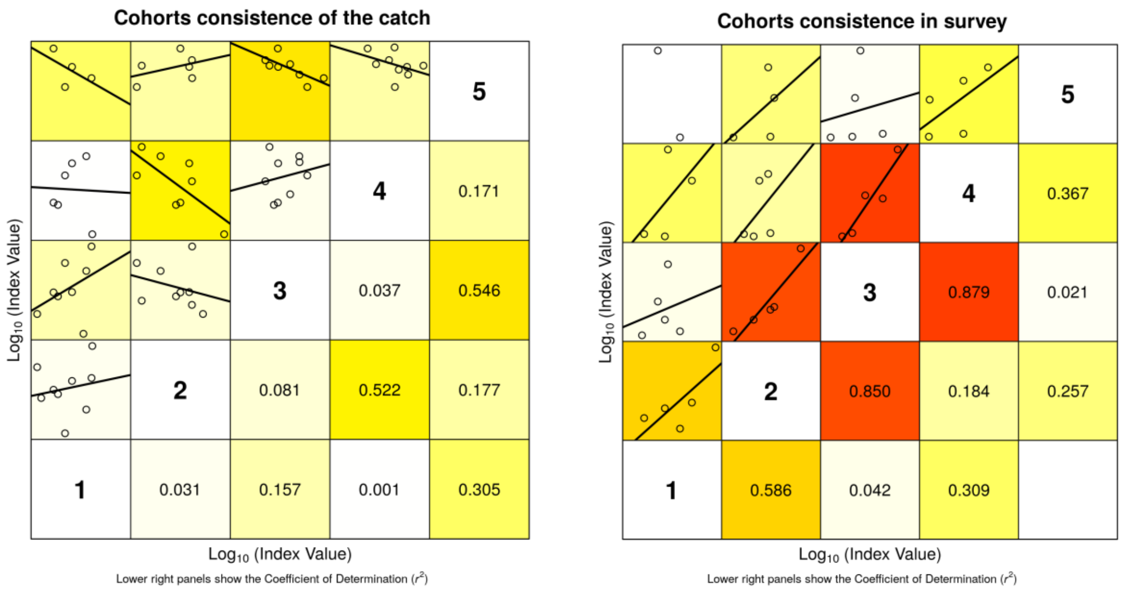


Figure 6.12.3.1.1.2. Internal consistency in the catches (left) and the index (right).

Table 6.12.3.1.1.3. Red mullet in GSA 22. Individual weight at age for the catch and stock (kg).

Year	1	2	3	4	5+
2003	0.03	0.05	0.075	0.103	0.16
2004	0.03	0.05	0.075	0.103	0.16
2005	0.03	0.05	0.075	0.103	0.16
2006	0.03	0.05	0.075	0.103	0.16
2007	0.03	0.05	0.075	0.103	0.16
2008	0.03	0.05	0.075	0.103	0.16
2009	0.03	0.05	0.075	0.103	0.16
2010	0.03	0.05	0.075	0.103	0.16
2011	0.03	0.05	0.075	0.103	0.16
2012	0.03	0.05	0.075	0.103	0.16
2013	0.03	0.05	0.075	0.103	0.16
2014	0.03	0.05	0.075	0.103	0.16
2015	0.03	0.05	0.075	0.103	0.16
2016	0.03	0.05	0.075	0.103	0.16
2017	0.03	0.05	0.075	0.103	0.16
2018	0.03	0.05	0.075	0.103	0.16
2019	0.03	0.05	0.075	0.103	0.16

6.12.3.1.2 Results

Different combinations of F, q and stock-recruitment sub-models were explored and the best model was chosen on the basis of retrospective analysis and residuals.

The following sub-models were employed in the final run:

Fishing mortality: ~te(age, year, k = c(3, 5))+s(year, k=4)+s(age, k=3)

Survey catchability: list(~ factor(age))

Stock-recruitment: ~geomean(CV=0.30)

Summary results from the final a4a model are presented in Figures 6.12.3.1.2.1, 6.12.3.1.2.2 and Tables 6.12.3.1.2.1-6.12.3.1.2.3. In the last decade, catches show a rather stable pattern, while SSB is increasing. In the most recent years, recruitment is at historically high levels. Since 2008, fishing mortality shows decreasing trends.

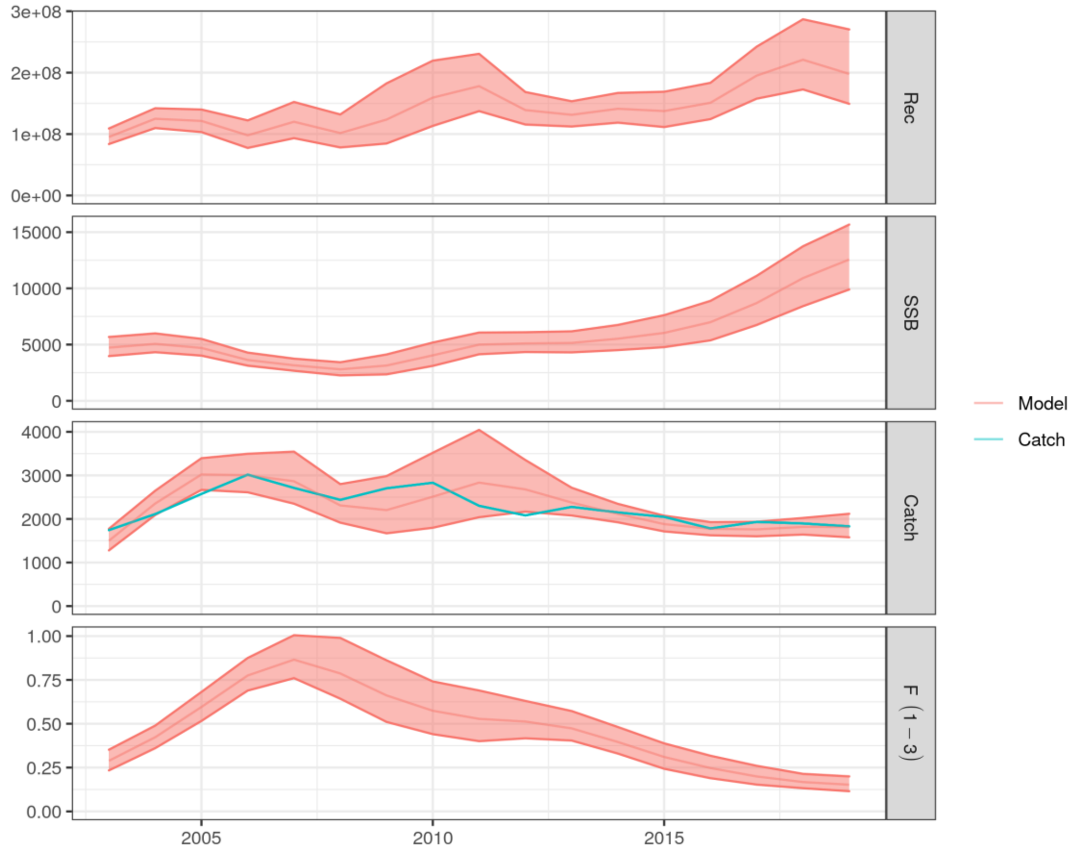


Figure 6.12.3.1.2.1 Red mullet in GSA 22: Trends in catch, recruitment, fishing mortality and SSB resulting from the a4a model. The blue line corresponds to the observed catches.

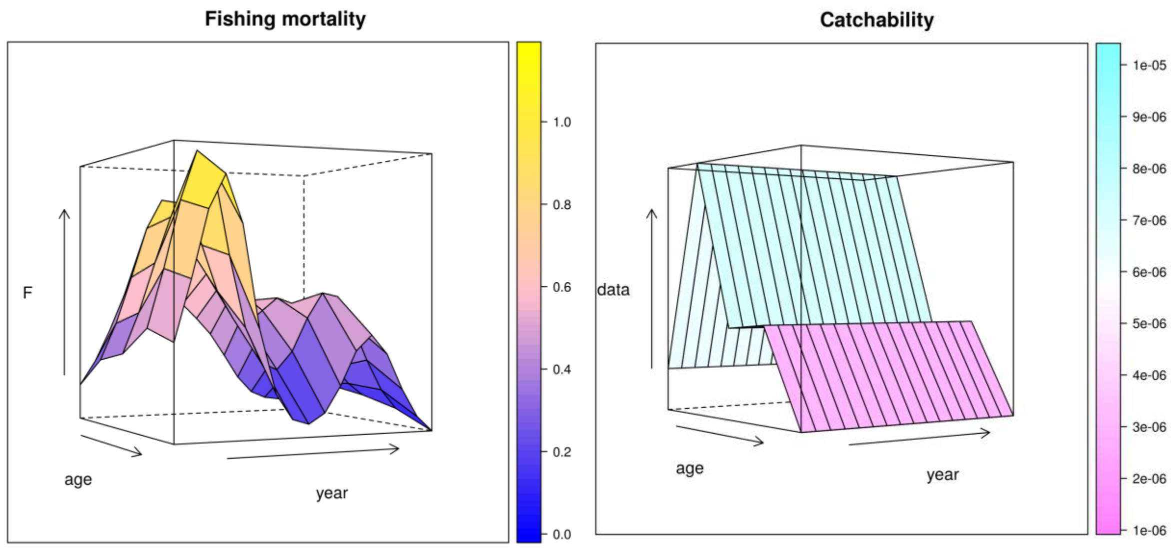


Figure 6.12.3.1.2.2 Red mullet in GSA 22: Fishing mortality and catchability by age and year

Table 6.12.3.1.2.1. Red mullet in GSA 22. Recruitment, SSB, Fbar (1-3) and Catch estimates from the final a4a model.

Year	Recruitment	SSB (t)	Fbar	Catch (t)
2003	95570	4697	0.28	1483
2004	124708	5053	0.42	2347
2005	120730	4690	0.59	3014
2006	97682	3640	0.77	3001
2007	119481	3155	0.87	2852
2008	101953	2800	0.78	2317
2009	123761	3121	0.65	2191
2010	158594	4022	0.56	2476
2011	177931	5037	0.52	2790
2012	139070	5206	0.51	2667
2013	130930	5221	0.47	2401
2014	140914	5566	0.4	2147
2015	136982	6079	0.31	1901
2016	150874	6960	0.25	1786
2017	195215	8648	0.2	1767
2018	222236	10794	0.17	1819
2019	200298	12379	0.15	1804

Table 6.12.3.1.2.2. Red mullet in GSA 22. Estimates of stock numbers at age from the final a4a model.

Year	1	2	3	4	5+
2003	95569812	35468058	23399242	8257435	1558718
2004	124707763	42751536	15125391	10023155	3809129
2005	120730296	50518482	15741323	5526713	4322522
2006	97682320	42801836	15405113	4736706	2405261
2007	119480699	29678170	10671216	3867641	1469846
2008	101953422	32390722	6575812	2543406	1201360
2009	123761458	28080468	7742630	1839818	1208233
2010	158594358	36701459	7668979	2599781	1300788
2011	177931291	50506192	11018838	2864356	1848565
2012	139069570	60344080	15841089	4212494	2315915
2013	130930291	50554034	19198849	5757056	3008092
2014	140914338	52330331	16977665	6628877	3585931
2015	136982080	62176559	19647071	5993633	3749590
2016	150873806	64663024	26114207	7570969	3542921
2017	195214969	73226297	29022253	11025291	4402558
2018	222236462	95607997	34297290	13371785	7021576
2019	200298068	108604333	46013436	16958001	10475810

Table 6.12.3.1.2.3. Red mullet in GSA 22. Estimates of fishing mortality at age from the final a4a model.

Year	1	2	3	4	5+
2003	0.19	0.31	0.35	0.45	0.41
2004	0.29	0.46	0.51	0.67	0.63
2005	0.43	0.65	0.7	0.93	0.88
2006	0.58	0.85	0.88	1.12	1.01
2007	0.7	0.97	0.93	1.06	0.83
2008	0.68	0.89	0.77	0.73	0.45
2009	0.61	0.76	0.59	0.45	0.22
2010	0.53	0.66	0.48	0.32	0.12
2011	0.47	0.62	0.46	0.29	0.1
2012	0.4	0.61	0.51	0.36	0.14
2013	0.31	0.55	0.56	0.49	0.24
2014	0.21	0.44	0.54	0.58	0.37
2015	0.14	0.33	0.45	0.57	0.43
2016	0.11	0.26	0.36	0.46	0.35
2017	0.1	0.22	0.27	0.32	0.22
2018	0.11	0.19	0.2	0.2	0.11
2019	0.12	0.18	0.15	0.12	0.05

Various model diagnostics are presented in Figures 6.12.3.1.2.3 - 6.12.3.1.2.5. The residuals are generally small (between -2 to 2) without any particular pattern by age, while model fit to catch and survey data is adequate. The retrospective analysis (Figure 6.12.3.1.2.6) shows some instability, particularly regarding SSB and recruitment, but this is somehow expected, given the existing data gaps. Overall, the assessment is considered suitable to provide estimates on stock status.

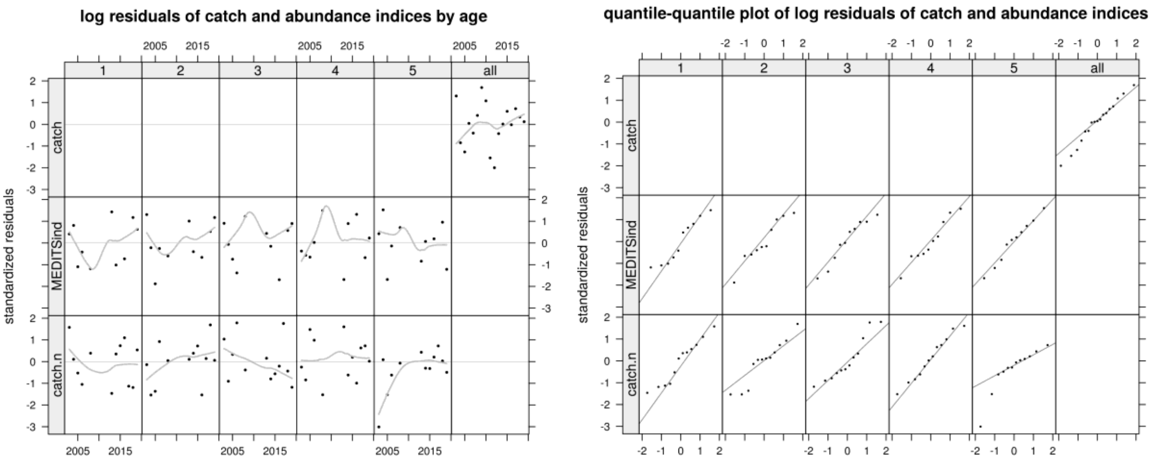


Figure 6.12.3.1.2.3 Log-residuals and qq-plots of catch and abundance indices (MEDITS) by age.

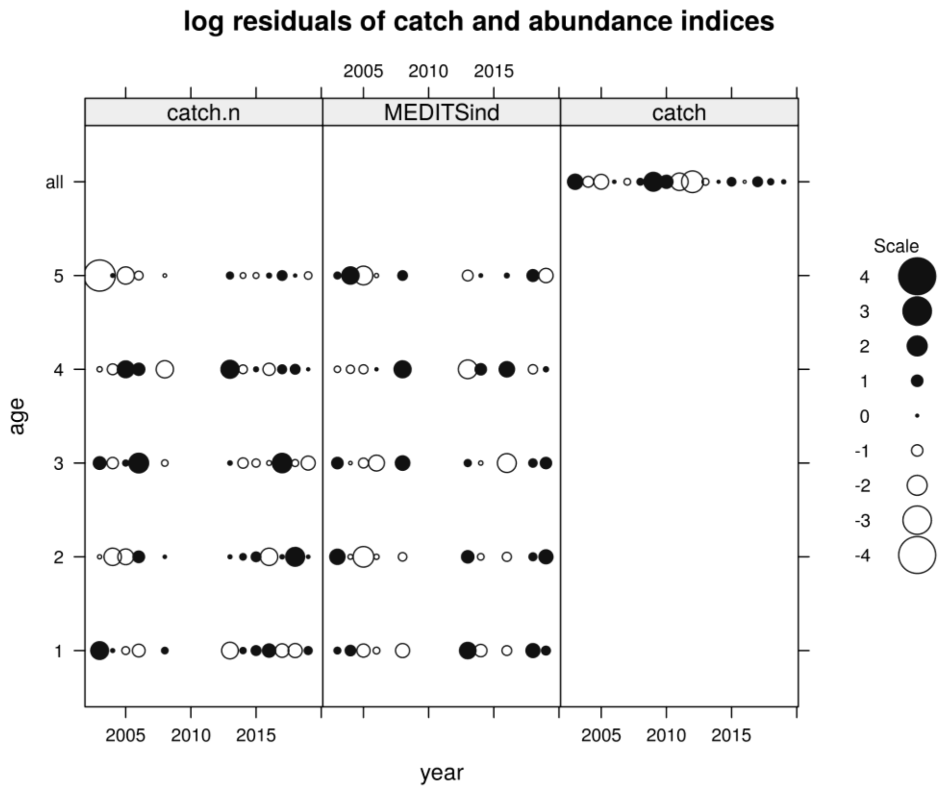


Figure 6.12.3.1.2.4 Bubble plot of log-residuals of catch and abundance indices (MEDITS) by age.

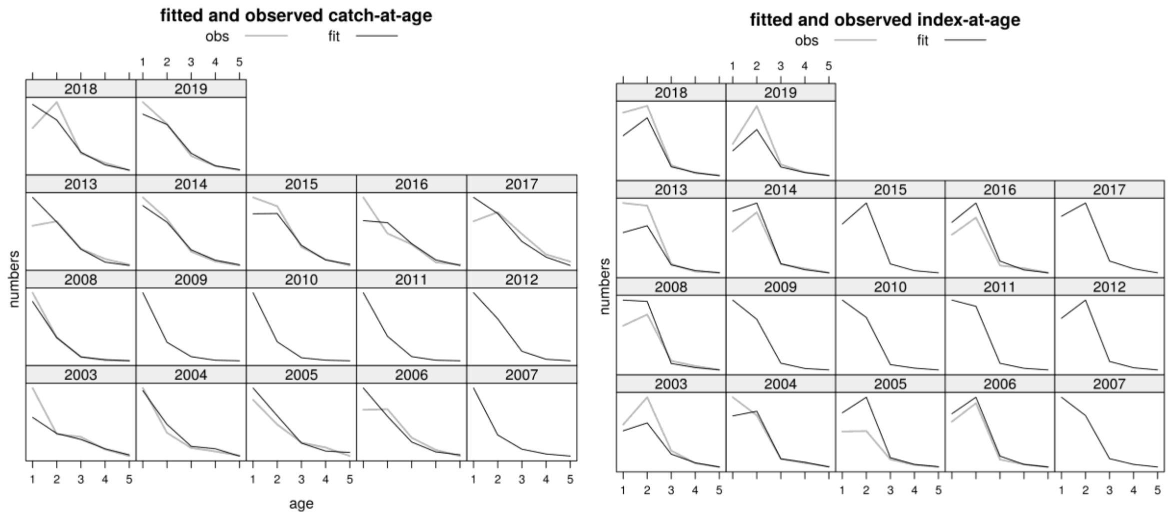


Figure 6.12.3.1.2.5 Comparisons between observed and fitted catch and index data at age.

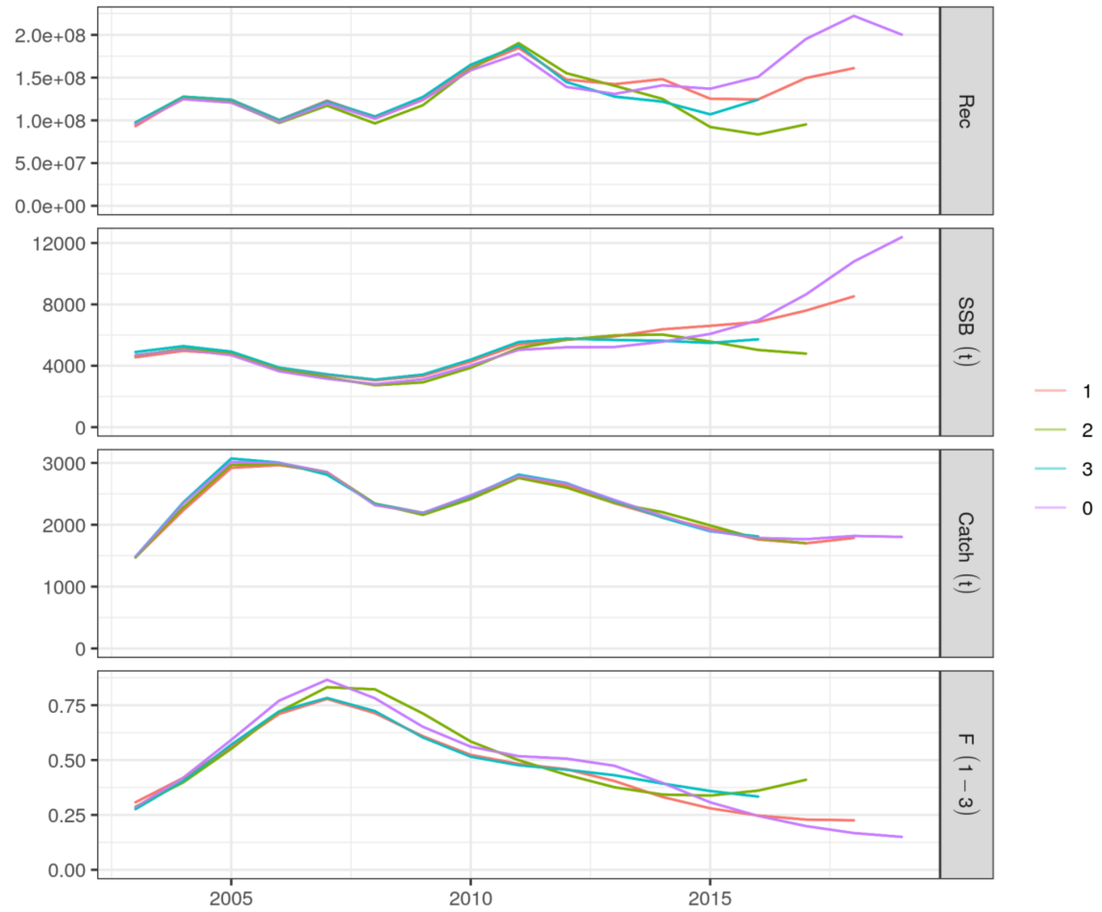


Figure 6.12.3.1.2.6. Red mullet in GSA 22. Retrospective analysis output.

6.12.3.2 METHOD 2: SPICT

The assessment is based on a state-space surplus production model implemented with the SPiCT package (Pedersen and Berg, 2017) under the R-language environment.

6.12.3.2.1 Input data and parameters

Similarly to the a4a assessment, the SPiCT assessment was based on a time series of landings from the Greek and Turkish fleets in GSA 22 and the biomass index from the MEDITS trawl survey. In this case, however, the data were extended back to 1990 (Table 6.12.3.2.1.1 and Figure 6.12.3.2.1.1). Several gaps exist in survey data, due to inconsistencies in DCF implementation.

In order to facilitate model convergence and improve diagnostics, a prior for the intrinsic growth rate *(r)* was used, as it was done in EWG 17-15. The prior was estimated from data on life history parameters (i.e., fecundity by age, mortality by age, natural mortality and growth) using Kreb's demographic method (McAllister et al., 2001). For the *r* prior a log-normal distribution was assumed (log(0.86), standard deviation=0.3). Additionally, a log-normal prior (log(2), standard deviation=0.2) was set for the parameter *n* of the Pella-Tomlinson model determining the skewness of the production curve.

Table 6.12.3.2.1.1 Red mullet in GSA 22. Landings and survey data for the period 1990-2019.

Year	Landings (t)	Survey index (kg/km2)
1990	3389	
1991	5323	
1992	4189	
1993	4192	
1994	5049	6.85
1995	3954	9.17
1996	3259	8.41
1997	3174	13.28
1998	2478	17.38
1999	2642	13.28
2000	2506	25.27
2001	2202	7.4
2002	2028	
2003	1744	26.35
2004	2112	18.51
2005	2574	10.3
2006	3017	11.83
2007	2712	
2008	2438	8.84
2009	2704	
2010	2832	
2011	2302	
2012	2081	
2013	2277	28.7
2014	2150	29.49
2015	2047	
2016	1782	35.94
2017	1932	
2018	1897	54.78
2019	1831	70.27

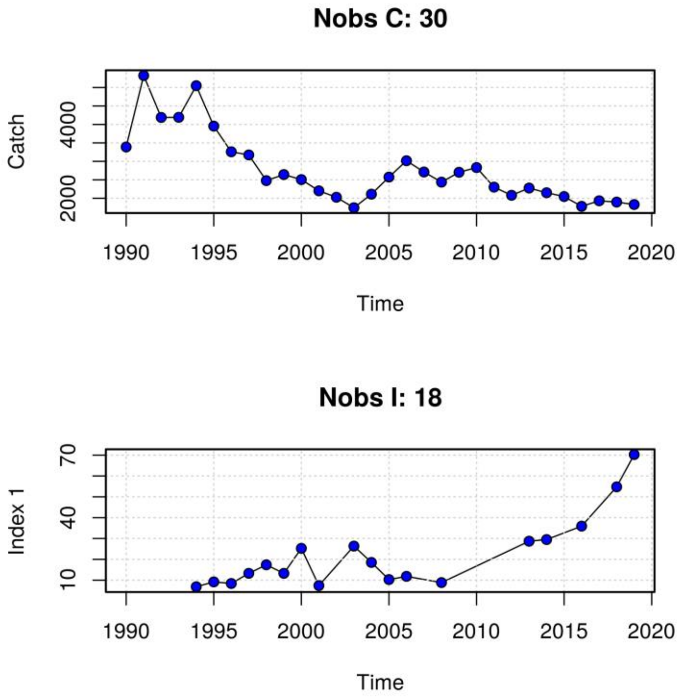


Figure 6.12.3.2.1.1 Red mullet in GSA 22. Plot of landings and survey data for the period 1990-2019.

6.12.3.2.2 Results

Figures 6.12.3.2.2.1 and Table 6.12.3.2.2.1 show the results of the assessment. They indicate that the stock is under sustainable exploitation with slightly increasing biomass and stable fishing mortality in the most recent years. There is some conflict between catch and survey index over the years 2015 onwards, the SPiCT model follows the catch. F is estimated to be low even though the model does not follow the rapid increase observed in the survey since 2015.

Diagnostic plots of the fit for the residuals of the catch and abundance index series do not show any particular pattern (Figure 6.12.3.2.2.2) and the same is valid for the retrospective analysis, which shows consistent trends of relative biomass and fishing mortality (6.12.3.2.2.3) over the full set of retrospective runs.

Figure 6.12.3.2.2.4 compares prior and posterior distribution for the parameters for which priors were set.

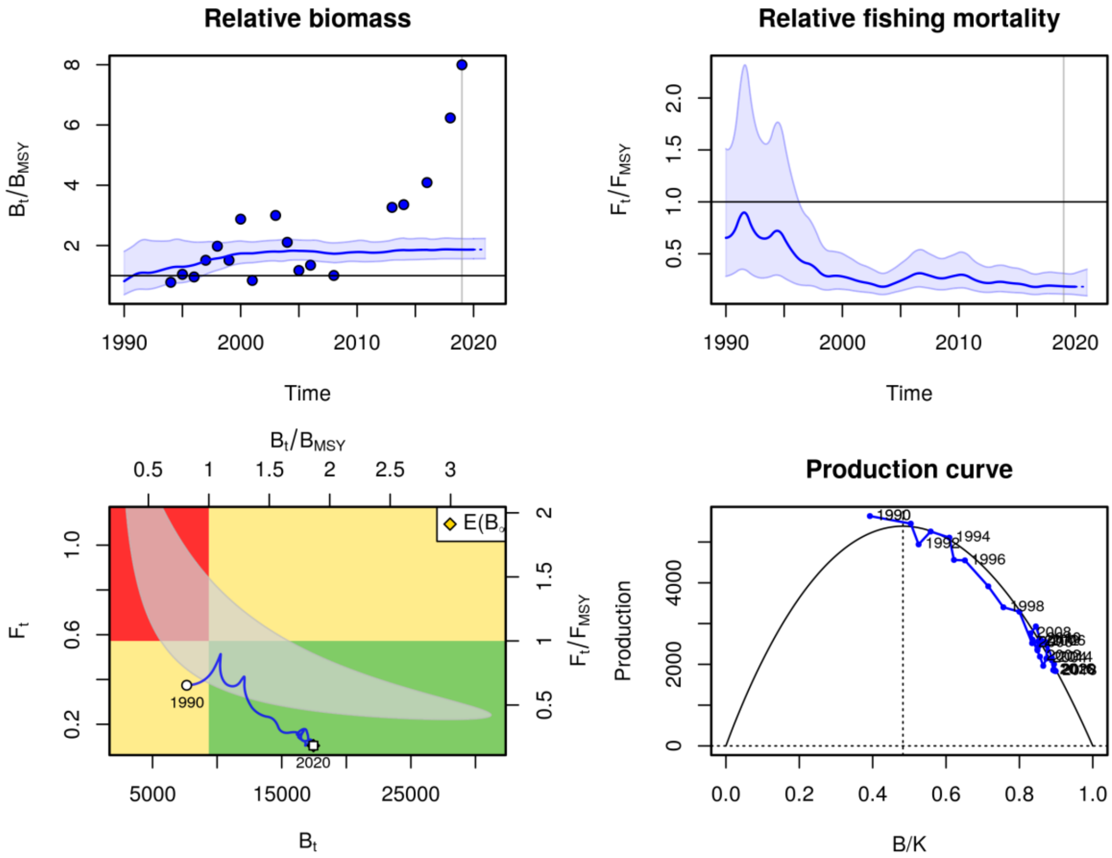


Figure 6.12.3.2.2.1 Stock assessment results for red mullet in GSA 22. *Top row*: median (blue solid line) of relative biomass and relative fishing mortality with 95% CI (blue shaded area). *Bottom row*: Kobe plot of relative fishing mortality versus relative biomass (left) and production curve (right).

Table 6.12.3.2.2.1 Stock assessment results for red mullet in GSA 22. Estimates of model parameters and dynamical components. *K*: biomass carrying capacity, *r*: intrinsic growth rate, *MSY*: Maximum Sustainable Yield, B_{msy}: biomass at *MSY*, F_{msy}: fishing mortality at *MSY*, B/B_{msy}: relative biomass in 2019, F/F_{msy}: relative fishing mortality in 2019

Parameter	**Estimate**
K	19479 (t)
R	1.05
MSY	5355 (t)
B_{msy}	9358 (t)
F_{msy}	0.57
B/B_{msy}(2019)	1.86
F/F_{msy}(2019)	0.19

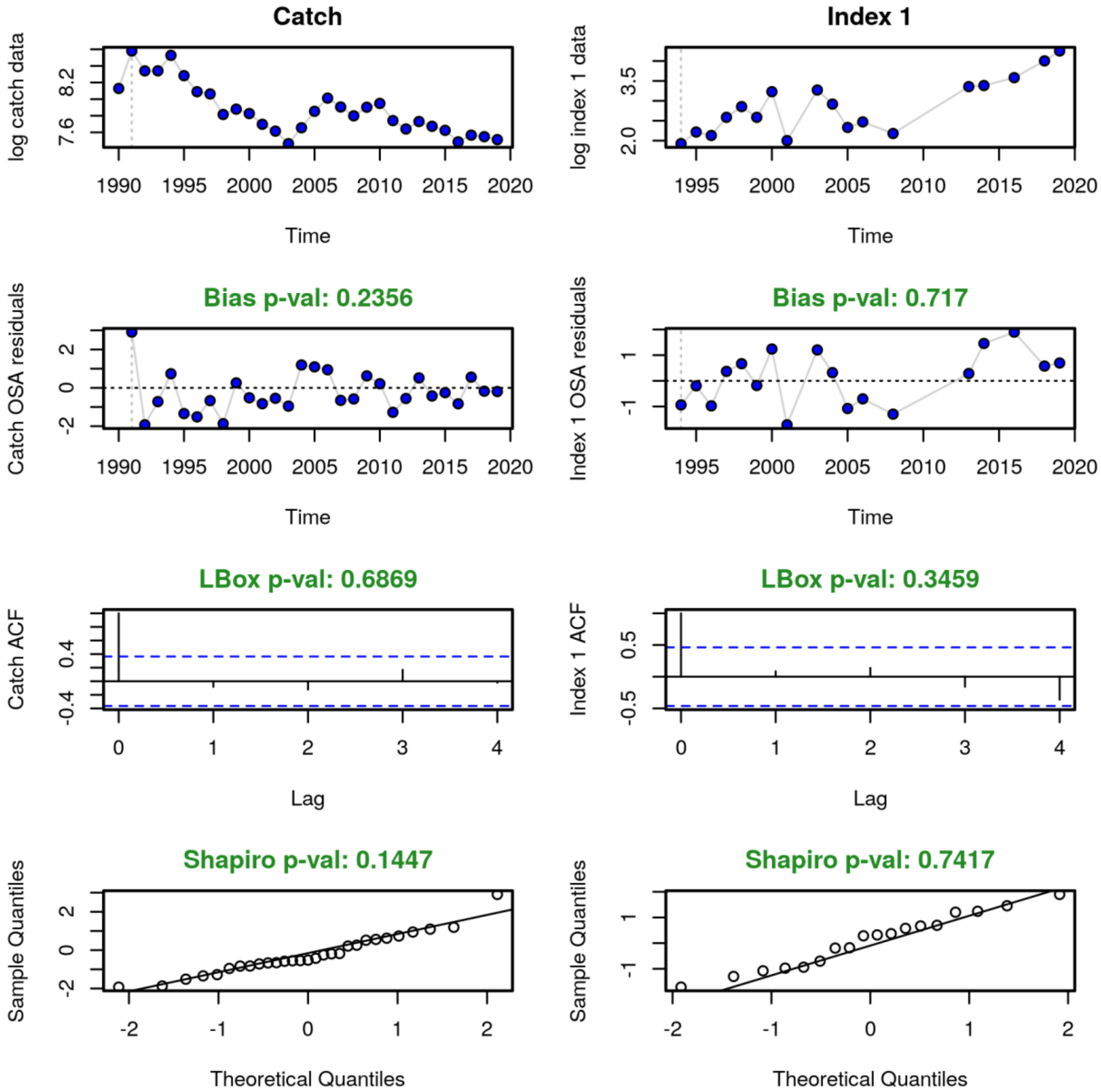


Figure 6.12.3.2.2.2. Diagnostic test of the fit for the residuals of the catch and abundance index series. *First row*: log of input data series. S*econd row*: residuals plot. *Third row*: autocorrelation of residuals and f*ourth row*: normality of residuals. If the header is green the test is not significant, otherwise the header is red.

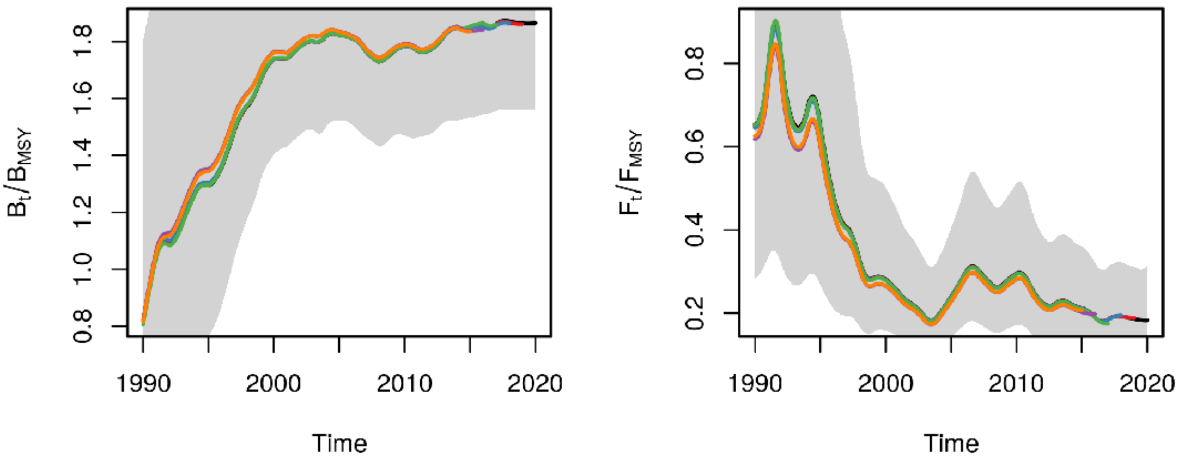


Figure 6.12.3.2.2.3. Retrospective plots of relative biomass and relative fishing mortality for the stock assessment of red mullet in GSA 22, produced by repeating the stock assessment after excluding 1-5 final year observations of the catch and abundance index time series.

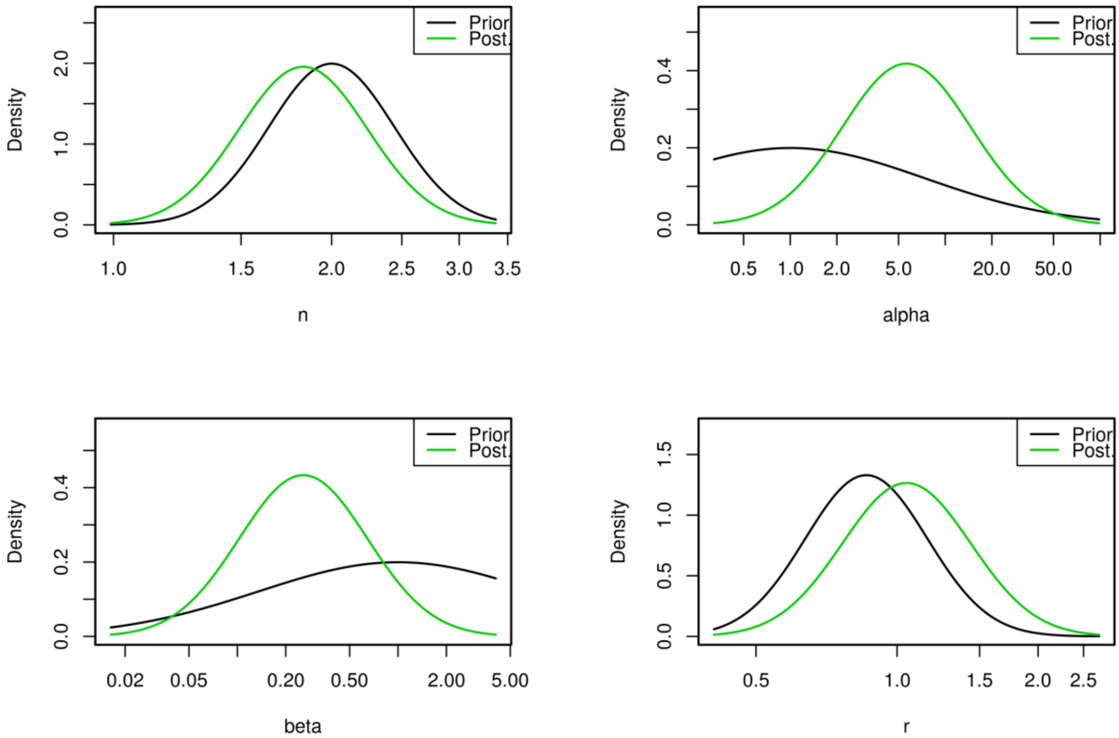


Figure 6.12.3.2.2.4. Comparison of prior and posterior distribution of parameters. *Top left:* parameter of the Pella-Tomlinson model determining the skewness of the production curve, *n*. *Top right:* ratio of observation to process error, σ_I/σ_B in the biomass process (default model settings). *Bottom left*: ratio of observation to process error, σ_C/σ_F, in the catch process (default model settings). *Bottom right*: intrinsic growth rate, *r*.

Conclusion to the assessments

Both a4a and SPiCT assessments conclude that the stock is under exploited, though the magnitude of the under exploitation is different. The signal from the MEDITS survey is that the stock is increasing in recent years. The a4a assessment is considered the better basis for catch advice, taking into account observations on magnitude of individual year classes. The assumptions of the SPiCT model are not particularly suited to catch predictions for a species like red mullet with short lifespan and varying recruitment. The a4a assessment is therefore used for reference points and STF.

6.12.4 Reference Points

Estimates of reference points was based on the a4a assessment and the $F_{0.1}$ was used as proxy of F_{MSY}. The library FLBRP available in FLR was used to estimate $F_{0.1}$ from the stock object. Current Fbar= 0.17 (2017-2019 mean) is lower than $F_{0.1}$ (0.50), indicating that the red mullet stock in GSA 22 is under-exploited. This finding is also in line with the output of the production model.

6.12.5 Short term Forecast and Catch Options

A deterministic short term prediction for the period 2020 to 2022 was performed using the FLR libraries and scripts, and based on the results of the a4a stock assessment (Ch. 6.12.3.1). An average of the last three years has been used for the Fbar, while for recruitment the geometric mean of the last ten years was used (Table 6.12.5.1).

Table 6.12.5.1 Red mullet in GSA 22: Assumptions made for the interim year (2020) and in the STF forecast.

Variable	Value	Notes
Biological Parameters		mean weights at age, maturity at age, natural mortality at age and selection at age, based on average of 2017-2019
$F_{ages\ 1\text{-}3}$ (2020)	0.15	F status quo (in the interim year 2020) is assumed the Fbar at 2019
SSB (2020)	12739 t	SSB projection based on stock assessment
R_{age1} (2020)	162706547	Geometric mean of the last ten years (2010-2019)
Total catch (2021)	1934 t	Catch at F status quo

The results of the short term forecasts for red mullet in GSA 22 are shown on Table 6.12.5.2. Under the F status quo = 0.15 (Fbar at 2019) the 2021 catch is expected to increase by about 7%, while SSB will slightly decrease (~1%).

Table 6.12.5.2 Short term forecast for red mullet in GSA 22. Catch and SSB estimates are in tonnes.

Rationale	Ffactor	F_{bar}	Catch 2021	SSB 2022	% SSB change 2020-2022	% Catch change 2019-2021
High long term yield ($F_{0.1}$)	3.35	0.5	5546	8700	-32.28	207.43
$F_{MSY\ Transition}$	1.78	0.27	3270	11163	-13.11	81.26
$F_{MSY\ lower}$	2.23	0.33	3971	10378	-19.22	120.13
$F_{MSY\ upper}$	4.57	0.68	7016	7245	-43.6	288.97
Zero catch	0	0	0	15112	17.64	-100
Status quo	1	0.15	1934	12720	-0.98	7.22
Different scenarios						
	0.1	0.01	206	14850	15.6	-88.58
	0.2	0.03	409	14593	13.6	-77.33
	0.3	0.04	609	14342	11.64	-66.23
	0.4	0.06	807	14095	9.72	-55.29
	0.5	0.07	1001	13854	7.85	-44.5
	0.6	0.09	1193	13618	6.01	-33.86
	0.7	0.1	1382	13386	4.2	-23.37
	0.8	0.12	1569	13160	2.44	-13.03
	0.9	0.13	1753	12937	0.71	-2.83
	1.1	0.16	2113	12507	-2.64	17.14
	1.2	0.18	2289	12298	-4.27	26.92
	1.3	0.19	2463	12093	-5.86	36.56
	1.4	0.21	2635	11893	-7.42	46.07
	1.5	0.22	2804	11696	-8.95	55.45
	1.6	0.24	2971	11504	-10.45	64.7
	1.7	0.25	3135	11315	-11.92	73.82
	1.8	0.27	3298	11131	-13.35	82.82
	1.9	0.28	3458	10950	-14.76	91.69
	2	0.3	3616	10772	-16.14	100.44

6.12.6 Data Deficiencies

Several data gaps are existing due to inconsistencies in the implementation of DCF. Some uncertainties exist on the volume of landings in the earlier years as different sources of information (DCF and Hellenic Statistical Authority) provide incompatible estimates. Besides, uncertainties exist regarding the adopted assumption in the a4a assessment that the unknown size composition of the Turkish catches is similar to the Greek ones.

6.13 DEEP-WATER ROSE SHRIMP IN GSA 22

6.13.1 STOCK IDENTITY AND BIOLOGY

GSA 22 has been considered as a unique area for management purposes due to its specific geo-physical characteristics and its separation from nearby areas, such as GSA 23 (Crete), through the Cretan Sea which is a deep (2500m) and large in volume particularly oligotrophic basin (Psarra et al., 1996; Lykousis et al., 2002). In addition, fishery exploitation patterns differ between the two nearby areas, with the trawling activities being much less intense in GSA 23 (Anonymous, 2013).

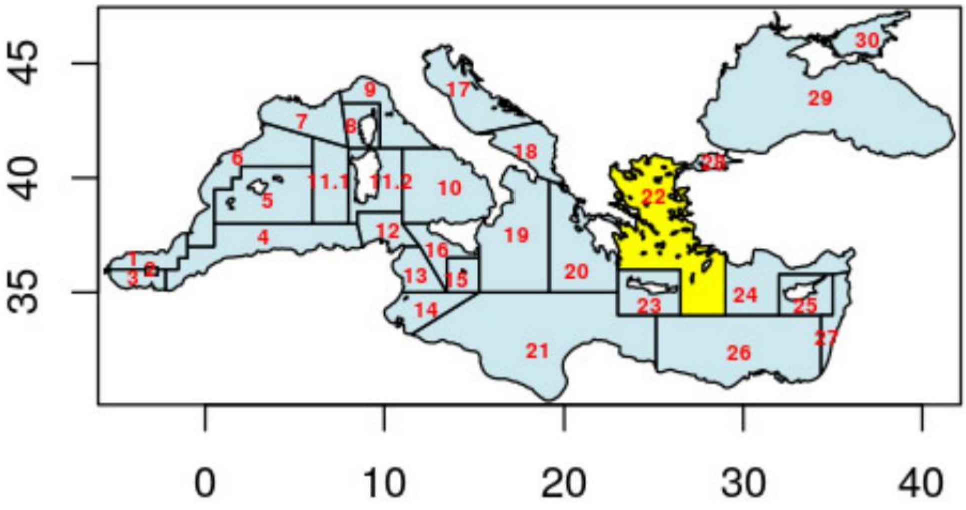


Figure 6.12.1.1. Geographical location of GSA 22.

6.13.2 DATA

6.13.2.1 Catch (landings and discards)

Deep-water rose shrimp is exploited by bottom trawlers and landing estimates were obtained from two different independent sources: (a) the DCF and (b) the Hellenic Statistical Authority (reported also in GFCM). Given that there are gaps in DCF data due to inconsistencies in the implementation of the DCF, the Hellenic Statistical Authority (ELSTAT) data from 1990 onwards were used in the assessment. It should be noted that there are large discrepancies between DCF and ELSTAT estimates, most likely due to species misreporting (Figure 6.13.2.1.1). The marked differences in DCF values and ELSTAT for 2004 to 2008 and variability in DCF 2013-2016 also need to be evaluated.

Discards are inconsistently reported through DCF but they were not considered in the assessment due to the data gaps.

Table 6.13.2.1.1 indicates the final landing estimates used in the assessment.

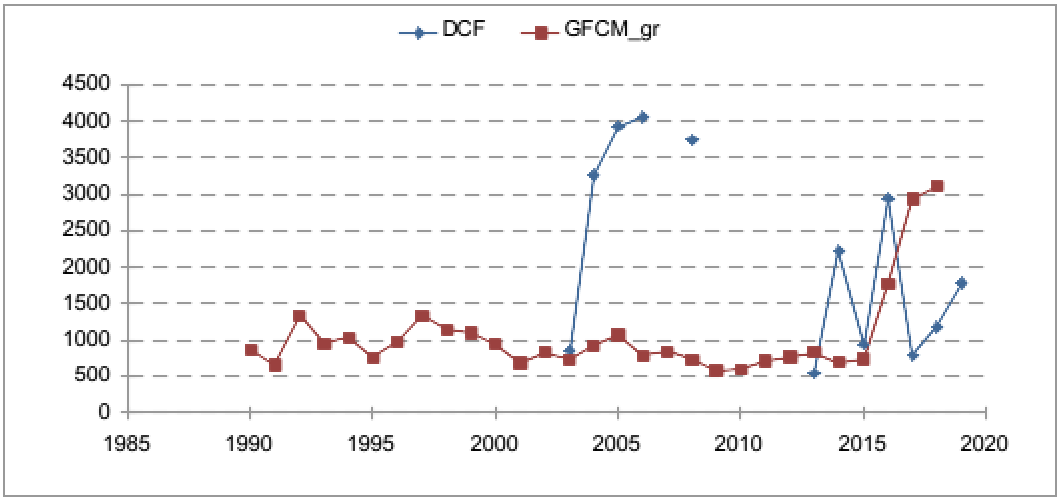


Figure 6.13.2.1.1 Deep-water rose shrimp in GSA 22. Landing estimates (t) from two different sources: DCF and GFCM (provided by the Hellenic Statistical Authority).

Table 6.13.2.1.1 Deep-water rose shrimp in GSA 22: Historical landings and discards All weights in tonnes.

Year	Landings (DCF)	Landings (GFCM)	Discards (DCF)
1990		872.5	
1991		665.4	
1992		1336.2	
1993		953.8	
1994		1032.0	
1995		764.9	
1996		983.8	
1997		1333.8	
1998		1147.2	
1999		1097.2	
2000		944.8	
2001		688.9	
2002		831.6	
2003	866.7	730.8	53.4
2004	3258.1	927.9	665
2005	3925.9	1074.5	163.6
2006	4052.6	786.9	350
2007		843.9	
2008	3745.5	736.3	763
2009		580.0	
2010		598.4	
2011		720.3	
2012		772.9	
2013	544.2	836.0	67.3
2014	2221.0	696.5	143.3
2015	947.5	746.4	61.4
2016	2946.0	1778.6	0.07
2017	793.0	2930.0	11.6
2018	1181.0	3105.0	137
2019	1782	1782	77.7

Figure 6.13.2.1.2 illustrates the length frequency distributions of the GSA 22 landings. Information is missing for the years that DCF was not at all implemented (2007, 2009-2012). Catches are dominated by specimens up to 35mm carapace length.

Figure 6.13.2.1.2. Length frequency distribution of the GSA 22 landings by year.

6.13.2.2 EFFORT

See Section 2.3

6.13.2.3 Survey data

Since 1994, MEDITS trawl surveys has been regularly carried out yearly during summer. In very few cases sampling was extended in September or started in late May (Figure 6.13.2.3.1). However, due to inconsistencies in DCF implementation the survey was not accomplished in 2007, 2008-2012, 2015, 2017, while it was partially accomplished in 2013. According to the MEDITS protocol, a random stratified sampling scheme by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m) was applied. Survey stations appear in Figure 6.13.2.3.2. Survey abundance and biomass data were standardized to square kilometer, using the swept area method, following the MEDITS protocol procedures.

Observed abundance and biomass indices of red mullet, as well as the length frequency distributions are given in figures 6.13.2.3.3 - 6.13.2.3.4. Both abundance and biomass indices show increasing trends in the last years. The high abundance value in 2014 is due to the opportunistic catch of newly born individuals (<5cm) in few stations.

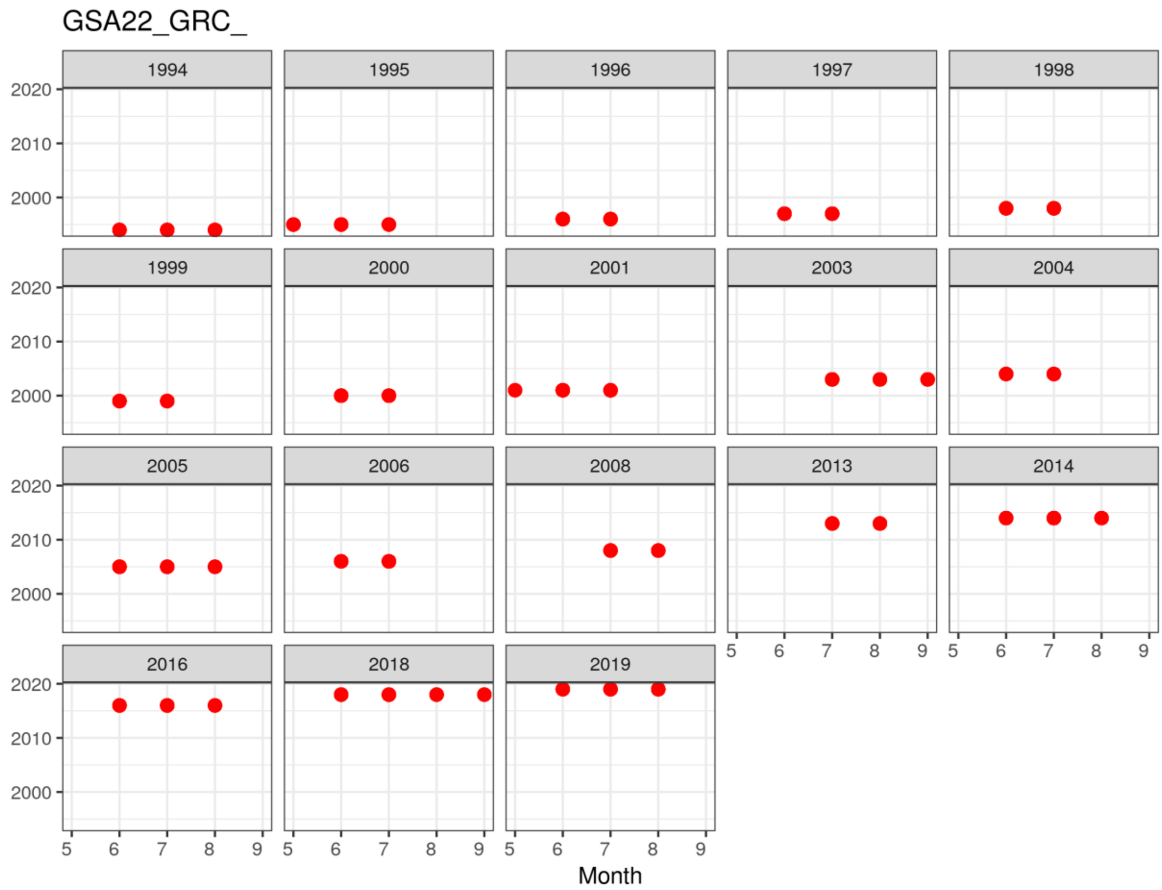


Figure 6.13.2.3.1. Month of the year when the hauls of MEDITS surveys were conducted in GSA 22.

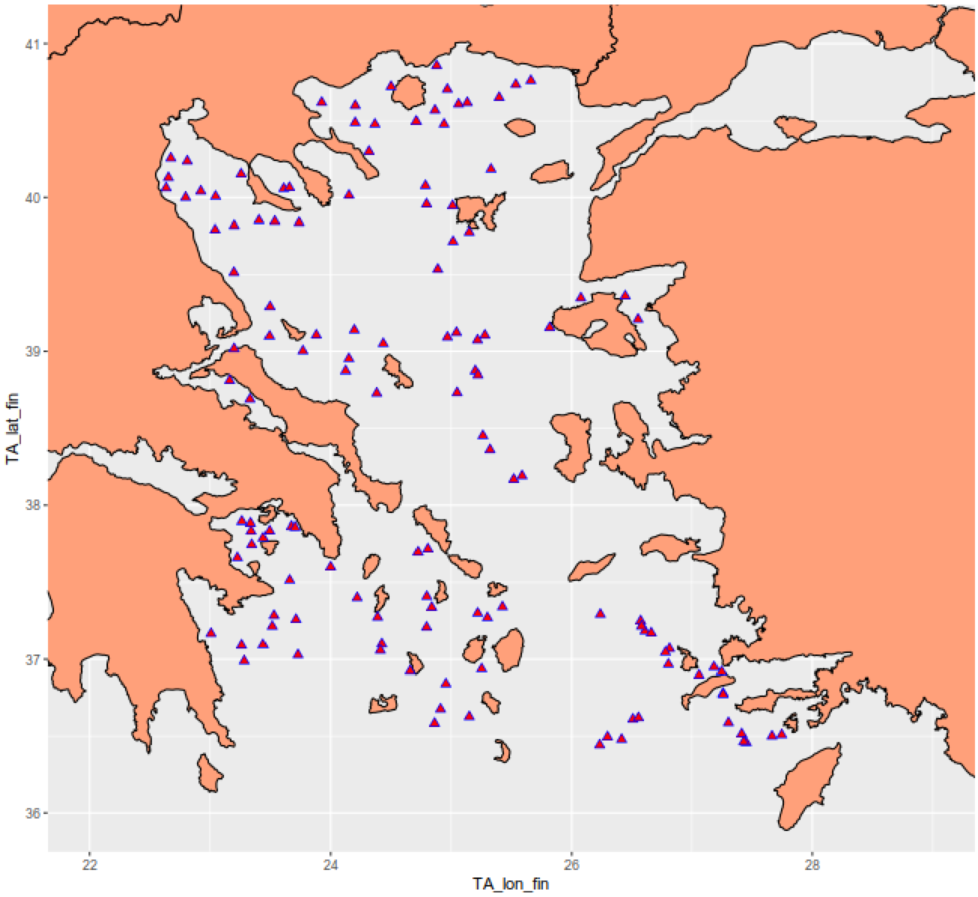


Figure 6.13.2.3.2. Distribution of MEDITS stations in GSA 22.

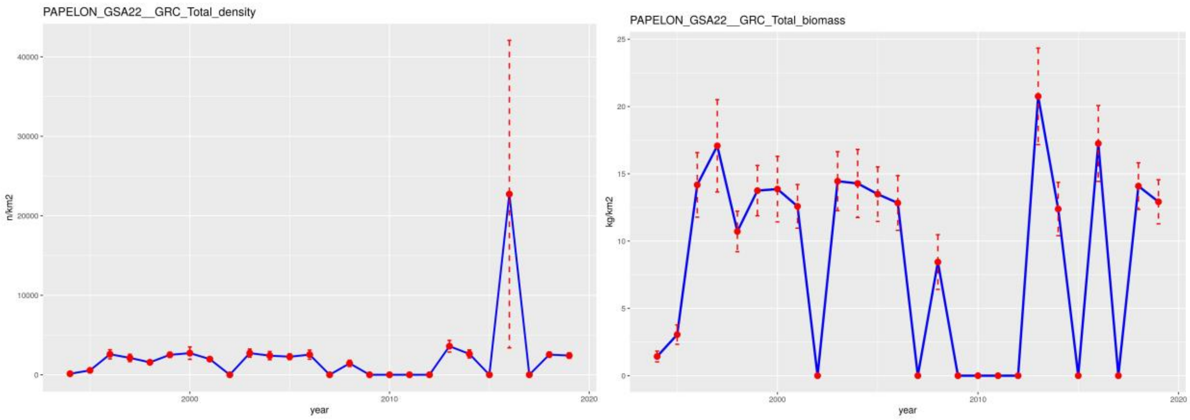


Figure 6.13.2.3.3 Deep-water rose shrimp in GSA 22. Estimated abundance (N/km2) (left), and biomass (kg/km2) (right) indices over the 1994-2019 period. Zero values (2002, 2008, 2009-2012 2015 & 2017) correspond to the years the survey was not accomplished.

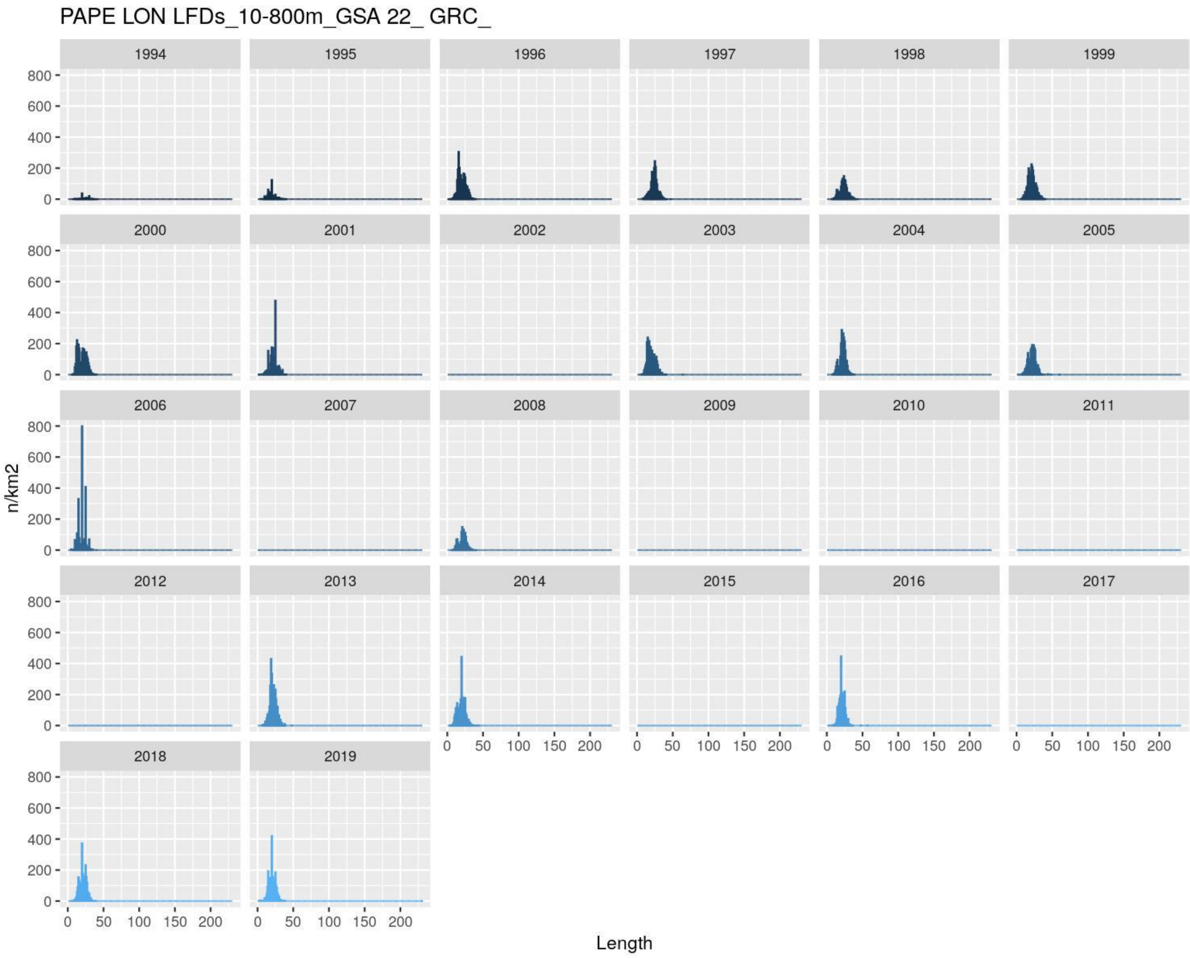


Figure 6.13.2.3.4. Deep-water rose shrimp in GSA 22. Length frequency distribution of the MEDITS survey abundance index (n/km²).

6.13.3 Stock assessment

The stock was assessed for the last time by the STECF EWG in 2017 (STECF EWG 17-15) by means of surplus production models and the same approach was followed in the present case. In particular, the assessment is based on a state-space surplus production model implemented with the SPiCT package (Pedersen and Berg, 2017) under the R-language environment.

6.13.3.1 Input data and parameters

The SPiCT assessment was based on a time series of landings from the Greek fleets in GSA 22 and the biomass index from the MEDITS trawl survey. The data were extended back to 1990 (Table 6.13.3.1.1 and Figure 6.13.3.1.1), but several gaps exist in survey data, due to inconsistencies in DCF implementation.

Initially SPiCT was run with default parameters but convergence was not achieved. In order to achieve model convergence, a prior for the intrinsic growth rate, *r*, was used as it was done in EWG 17-15. For the prior, a log-normal distribution was assumed (log(0.56), standard deviation=0.4). Additionally, a log-normal prior (log(2), standard deviation=0.4) was set for the parameter *n* of the Pella-Tomlinson model determining the skewness of the production curve.

To assess the sensitivity of the model to the first years of the survey index which are considerably lower than the rest of the records and their reliability was doubted, the assessment was repeated after removing these two records and using the same parameterization as before.

Table 6.13.3.1.1 Deep-water rose shrimp in GSA 22. Landings and survey data for the period 1990-2019.

Year	Survey index (kg/km2)	Landings (t)
1990		872.5
1991		665.4
1992		1336.2
1993		953.8
1994	1.43	1032.0
1995	3.05	764.9
1996	14.18	983.8
1997	17.08	1333.8
1998	10.72	1147.2
1999	13.75	1097.2
2000	13.87	944.8
2001	12.58	688.9
2002		831.6
2003	14.45	730.8
2004	14.28	927.9
2005	13.49	1074.5
2006	12.83	786.9
2007		843.9
2008	8.45	736.3
2009		580.0
2010		598.4
2011		720.3
2012		772.9
2013	20.76	836.0
2014	12.38	696.5
2015		746.4
2016	17.25	1778.6
2017		2930.0
2018	14.09	3105.0
2019	12.92	1782

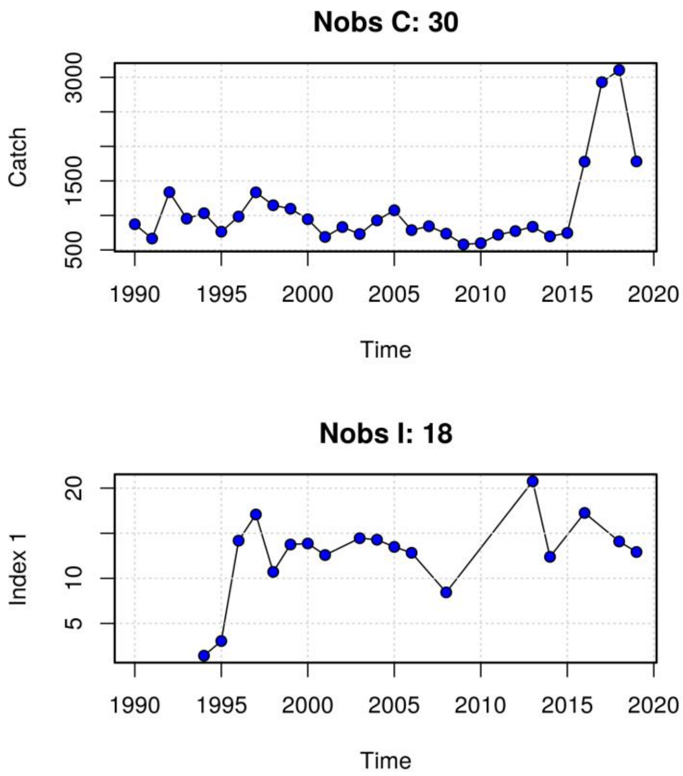


Figure 6.13.3.1.1 Deep-water rose shrimp in GSA 22. Plot of landings and survey data for the period 1990-2019.

6.13.3.2 Results

Figures 6.13.3.2.1 and Table 6.13.3.2.2 show the results of the assessment. They indicate that up to 1995 the stock was overfished, while after that is at optimum levels and fishing mortality is stable, at low levels during the last 25 years.

Diagnostic plots of the fit for the residuals of the catch and abundance index series do not show any particular pattern (Figure 6.13.3.2.2), while somehow different patterns are observed in the retrospective analysis, regarding relative biomass and fishing mortality (6.13.3.2.3).

Figure 6.13.3.2.4 compares prior and posterior distribution for the parameters for which priors were set.

By removing the survey index from 1994-95 the model was impossible to converge indicating that the two first records of abundance index have a great effect on the assessment output. For this reason it was decided that the current state of the stock is uncertain and no state (under fishing or overfishing), reference points or advice are given.

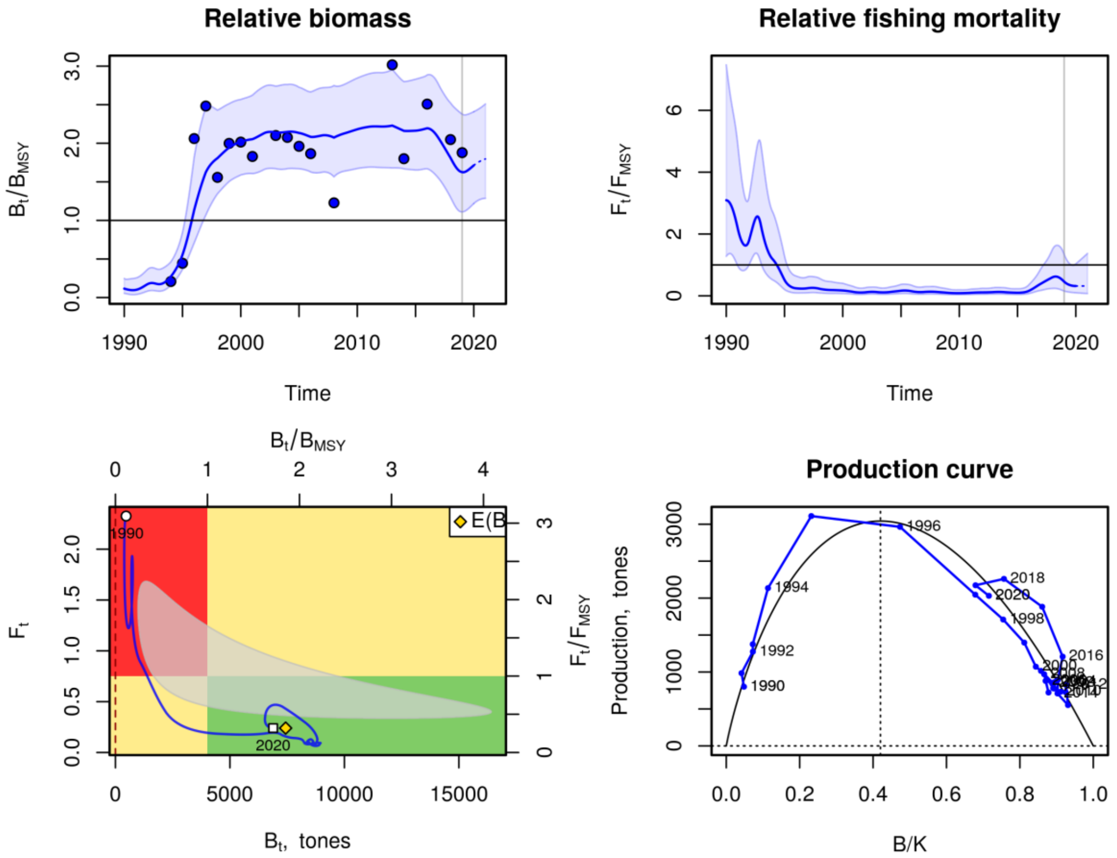


Figure 6.13.3.2.1 Stock assessment results for deep-water rose shrimp in GSA 22. *Top row*: median (blue solid line) of relative biomass and relative fishing mortality with 95% CI (blue shaded area). *Bottom row*: Kobe plot of relative fishing mortality versus relative biomass (left) and production curve (right).

Table 6.13.3.2.1 Stock assessment results for deep-water rose shrimp in GSA 22. Estimates of model parameters and dynamical components. *K*: biomass carrying capacity, *r*: intrinsic growth rate, *MSY*: Maximum Sustainable Yield, B_{msy}: biomass at *MSY*, F_{msy}: fishing mortality at *MSY*, B/B_{msy}: relative biomass in 2019, F/F_{msy}: relative fishing mortality in 2019

Parameter	**Estimate**
K	9624 (t)
r	0.99
MSY	3022 (t)
B_{msy}	4019 (t)
F_{msy}	0.75
B/B_{msy}(2019)	1.63
F/F_{msy}(2019)	0.46

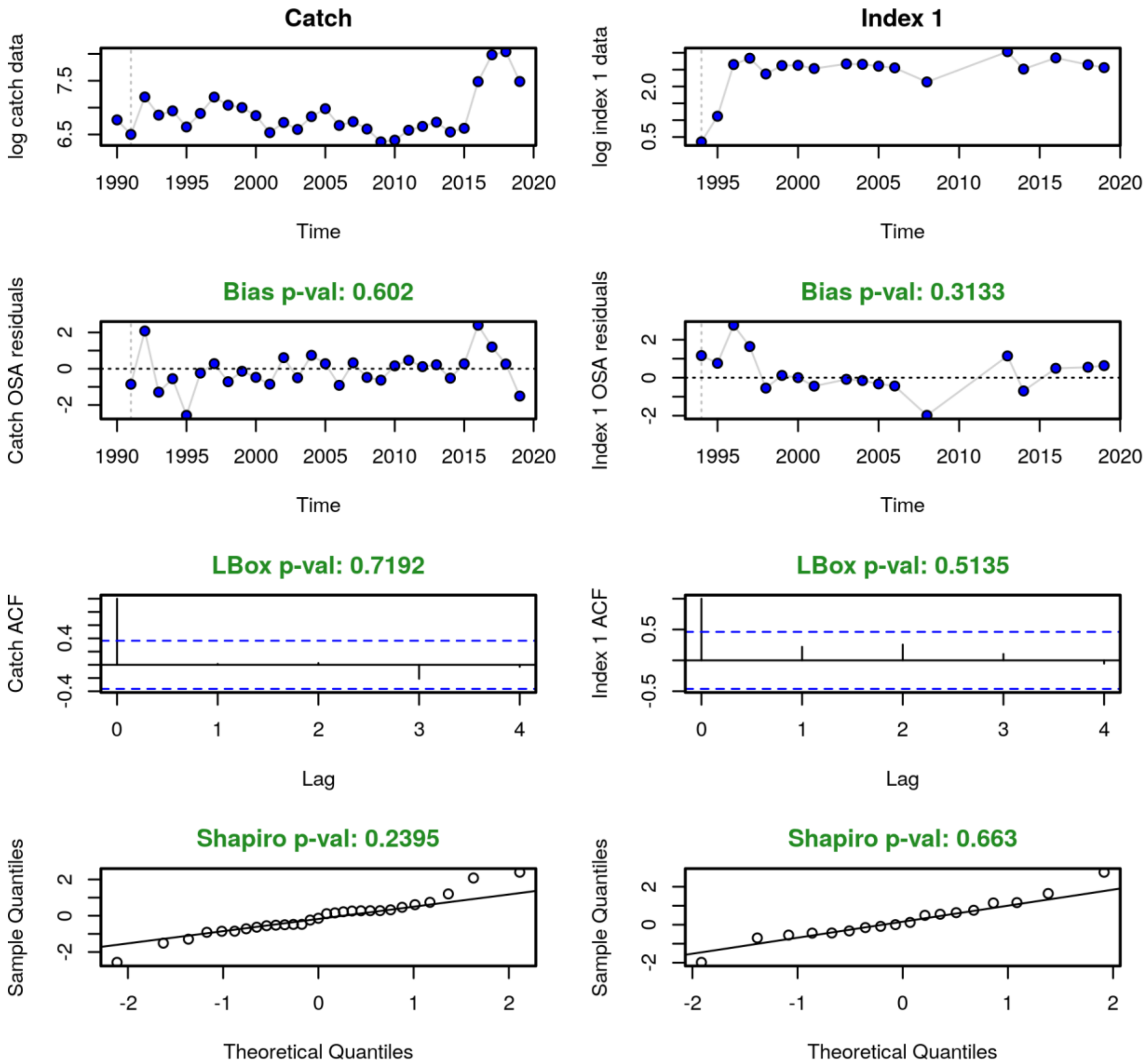


Figure 6.13.3.2.2. Diagnostic test of the fit for the residuals of the catch and abundance index series. *First row*: log of input data series. S*econd row*: residuals plot. *Third row*: autocorrelation of residuals and f*ourth row*: normality of residuals. If the header is green the test is not significant, otherwise the header is red.

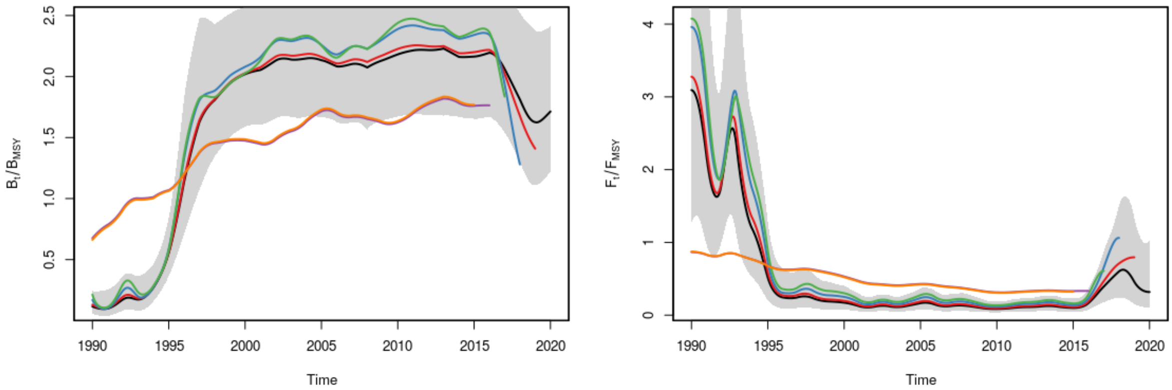


Figure 6.13.3.2.3.Retrospective plots of relative biomass and relative fishing mortality for the stock assessment of deep-water rose shrimp in GSA 22, produced by repeating the stock assessment after excluding 1-5 final year observations of the catch and abundance index time series.

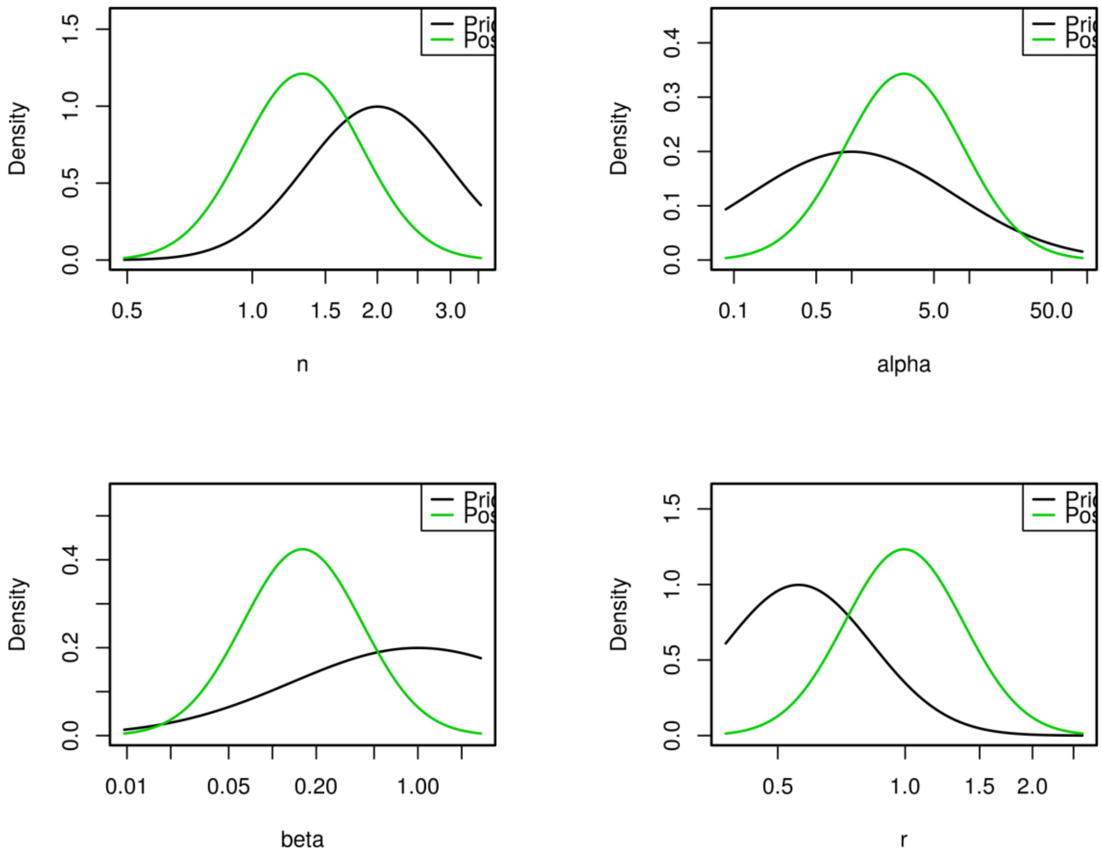


Figure 6.13.3.2.4. Comparison of prior and posterior distribution of parameters. *Top left:* parameter of the Pella-Tomlinson model determining the skewness of the production curve, *n*. *Top right:* ratio of observation to process error, σ_I/σ_B in the biomass process (default model settings). *Bottom left*: ratio of observation to process error, σ_C/σ_F, in the catch process (default model settings). *Bottom right*: intrinsic growth rate, *r*.

6.13.4 Reference Points

Due to the data and model uncertainties mentioned in the previous chapters no reference points are provided.

6.13.5 Data Deficiencies

Several gaps in the survey index are existing due to inconsistencies in the implementation of DCF. Additionally, uncertainties exist regarding the volume of landings as different sources of information (DCF and Hellenic Statistical Authority) provide incompatible estimates.

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8 CONTACT DETAILS OF EWG-20-15 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

Participant table to be updated by secretariat

STECF members		
Name	**Affiliation[1]**	**Email**
Alessandro Ligas	CIBM – Italy	ligas@cibm.it
Georgi Daskalov	IBER-BAS – Bulgaria	georgi.m.daskalov@gamil.com

Invited experts		
Name	**Affiliation[1]**	**Email**
Isabella Bitetto	COISPA Tecnologia & Ricerca - Italy	bitetto@coispa.it
Vanja Cikes Kec	Institute of Oceanography and Fishery - Croatia	cikes@izor.hr
Danai Mantoupoulou	HCMR – Greece	danaim@hcmr.gr
Matteo Murenu	University of Cagliari – Italy	mmurenu@unica.it
Alessandro Orio	Swedish University of Agriculture Sciences (SLU) – Sweden	alessandro.orio@slu.se

Andrea Pierucci	University of Cagliari – Italy	andrea.pierucci@hotmail.it
John E. Simmonds	Private Consultant (EWG Chair) –UK	ejsimmonds@gmail.com
Vjekoslav Ticina	Institute of Oceanography and Fishery - Croatia	ticina@izor.hr
George Tserpes	HCMR – Greece	gtserpes@hcmr.gr
Athanassios Tsikliras	Aristotele University of Thessaloniki - Greece	atsik@bio.auth.gr

JRC experts		
Name	**Affiliation[1]**	**Email**
Alessandro Mannini	DG JRC	alessandro.mannini@ec.europa.eu
Cecilia Pinto	DG JRC	cecilia.pinto@ec.europa.eu

European Commission		
Name	**Affiliation[1]**	**Email**
Alessandro Mannini	DG JRC, STECF secretariat	Jrc-stecf-secretariat@ec.europa.eu
Giacomo Chato Osio	DGMare D1	giacomo-chato.osio@ec.europa.eu

Observers

Name	**Affiliation**[1]	**Email**
Marzia Piron	MEDAC	marzia_piron@hotmail.com
Ivana Vukov	Ministry of Agriculture, Directorate of Fisheries, Unite for Data Collection Programme in Fisheries - Croatia	ivana.vukov@mps.hr

9 LIST OF ANNEXES

Electronic annexes are published on the meeting's web site on:
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List of electronic annexes documents:
Annex I: analytical assessments final stock objects
Annex II: MEDITS JRC script Tech. Document

10 LIST OF BACKGROUND DOCUMENTS

Background documents are published on the meeting's web site on:
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List of background documents:

EWG-20-15 – Doc 1 - Declarations of invited and JRC experts (see also section 8 of this report – List of participants)

KJ-AX-20-016-EN-N

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doi:10.2760/877405

ISBN 978-92-76-27168-0