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SCIENTIFIC ADVISORY COMMITTEE ON FISHERIES (SAC)

Working Group on Stock Assessment of Demersal species (WGSAD)

Online, 17–21 January 2022
(western Mediterranean)
Online, 24–28 January 2022
(central and eastern Mediterranean and Adriatic Sea)

REPORT

EXECUTIVE SUMMARY

The Working Group on Stock Assessment of Demersal Species (WGSAD)[1] was held online on 17–21 January 2022 (western Mediterranean stocks) and 24–28 January 2022 (central and eastern Mediterranean and Adriatic Sea stocks). The main objectives of this meeting were to: i) review the consistency of procedures to provide advice; ii) review the assessment of demersal stocks; and iii) run a hands-on data session to deal with methodological issues.

Out of the 60 assessments presented, 51 assessments were validated: 45 were accepted as providing quantitative advice, while six were considered as providing qualitative advice. Some of the assessments were accomplished within the framework of the relevant working groups of the Scientific, Technical and Economic Committee for Fisheries of the European Commission. Of the 51 accepted assessments, ten indicated sustainable exploitation: Norway lobster (*Nephrops norvegicus*) in geographical subareas (GSAs) 5 and 10; red mullet (*Mullus barbatus*) in GSAs 9, 10, 16, 22 and 24; spottail mantis shrimp (*Squilla mantis*) in GSA 17; horned octopus (*Eledone chirrhosa*) in GSA 18; and brown comber (*Serranus cabrilla*) in GSA 25.

[1] This meeting was supported by the European Union under grant agreement SI.839872

CONTENTS

OPENING OF THE WORKING GROUP ON STOCK ASSESSMENT OF DEMERSAL SPECIES

1. Due to travel limitations resulting from the COVID-19 pandemic the tasks of the Working Group on Stock Assessment of Demersal Species (WGSAD) were accomplished by means of two online meetings held on 17–21 January 2022 (western Mediterranean stocks) and 24–28 January 2022 (central and eastern Mediterranean and Adriatic Sea stocks). They were attended by a total of 108 participants from 17 Mediterranean riparian countries as well as from the Food and Agriculture Organization of the United Nations (FAO), the Directorate-General for Maritime Affairs and Fisheries of the European Commission (DG MARE) and the Secretariat of the General Fisheries Commission for the Mediterranean (GFCM). The combined list of participants is provided in Appendix 2.

2. Mr George Tserpes, as WGSAD Coordinator, acted as Chairperson. The meeting agenda is provided in Appendix 1 and the combined list of participants is provided in Appendix 2.

3. The WGSAD performed an appraisal of Mediterranean stock assessments for GFCM priority and non-priority species, as summarized below and in the table of advice provided in Appendix 3. Based on discussions, it formulated the conclusions and recommendations included below.

ASSESSMENTS OF PRIORITY STOCKS

European hake (*Merluccius merluccius*)

4. During the session on European hake, assessments covering 20 geographical subareas (GSAs) were presented. In all cases, the stocks were estimated to be in overexploitation, or possibly in overexploitation, with varying relative biomass levels. Further details are provided below.

5. An updated joint assessment for GSAs 1, 5, 6 and 7 was presented, using the assessment for all (a4a) method. The assessment formed the basis of advice for these areas. Results indicated that the stock is in overexploitation with relatively low biomass. Complementary advice was provided by separate assessments accomplished in GSAs 1, 5, and 6 by means of extended survivor analysis (XSA) for GSA 1 and a4a for GSAs 5 and 6. Each of the separate assessments indicated the presence of overexploitation, in line with the joint assessment.

6. An updated XSA joint assessment for GSAs 1 and 3 was performed. Results indicated that the stock is in overexploitation with relatively low biomass. During the discussion the group recommended to move towards a statistical catch-at-age (SCAA) approach.

7. A revised assessment for GSA 4 was presented using two methods, pseudo-cohort analysis (VIT) and length-based spawning potential ratio (LBSPR). The short time series available suggested a qualitative interpretation of the results based on which the stock was considered to be possibly in overexploitation. As a precautionary advice, based on VIT, a reduction of fishing mortality was recommended.

8. The a4a update of the benchmark assessment for GSAs 8–11 (jointly) indicated that the stock is in overexploitation with relatively high biomass. Reduction of fishing mortality was recommended.

9. An update of the benchmark joint assessment for GSAs 12–16 was presented. The results of Stock Synthesis 3 (SS3) model indicated that the stock is in overexploitation and overexploited. Reduction of fishing mortality was recommended.

10. The update of the benchmark assessment for GSAs 17–18 (jointly), using the SS3 method, indicated that the stock is under overexploitation with biomass being above the reference point. Reduction of fishing mortality was recommended.

11. An update of the benchmark assessment for GSA 19 was presented based on a4a. Results indicated that the stock is in overexploitation with relatively high biomass. Reduction of fishing mortality was recommended

12. An updated assessment for GSA 20 was presented, using a4a. Results indicated that the stock is in overexploitation, with relatively high biomass. Reduction of fishing mortality was recommended.

13. A revised assessment, including updated historical catch-at-age data series, was presented for GSA 22, using a4a. Issues were identified with both catch data (information from certain fleets exploiting the area was missing) and the cohort consistency of the available catch-at-age data. Thus, a qualitative interpretation of the results was suggested and based on this the stock was considered to be possibly in overexploitation. As a precautionary advice, a reduction of fishing mortality was recommended.

Deep-water rose shrimp (*Parapenaeus longirostris*)

14. During the session, assessments of deep-water rose shrimp covering 17 Mediterranean GSAs were presented. One assessment was considered preliminary while in all other cases the stocks were found to be in overexploitation or possibly in overexploitation, with varying relative biomass levels. Further details are provided below.

15. The updated assessment of GSA 1 was presented using two catch-at-age methods, XSA and a4a. The a4a model, which formed the basis for the advice, indicated that the stock is in overexploitation with relatively high biomass. The reduction of fishing mortality was recommended.

16. An updated assessment for GSA 3 was presented and a qualitative advice was provided, based on length cohort analysis (LCA) and the biomass dynamic stock assessment model (BioDyn). Results indicated that the stock is possibly in overexploitation. As a precautionary advice, reduction of fishing mortality was recommended.

17. An updated assessment for GSA 4 was presented. Due to the short data series, a qualitative advice was provided based on the VIT method, while the estimates were supported by LBSPR runs. Results indicated that the stock is possibly in overexploitation and reduction of fishing mortality was recommended.

18. The updated assessment of GSA 5 was presented using both XSA and a4a. The XSA method was selected to provide advice. Results indicated that the stock is in overexploitation with relatively high biomass. Reduction of fishing mortality was recommended.

19. An updated assessment for GSA 6 was presented using the XSA method. The results indicated that the stock is in overexploitation, with relatively high biomass and reduction of fishing mortality was recommended. During the discussion it was suggested to move towards a SCAA model.

20. An updated assessment for GSAs 9–11 (jointly) was presented using a4a. Results indicated that the stock is in overexploitation with relatively low biomass and reduction of fishing mortality was recommended.

21. An updated assessment for GSA 12–16 (jointly) was presented, using XSA. Results indicated that the stock is in overexploitation with relatively low biomass. Reduction of fishing mortality was recommended.

22. An updated assessment for GSA 17–19 (jointly) was presented, using a4a. Results indicated that the stock is in overexploitation, with relatively high biomass. Reduction of fishing mortality was recommended. During the discussion, the rationale for joining GSA 19 with GSAs 17–18 and leaving out GSA 20, was questioned.

23. A new assessment for GSA 20 was presented, using the stochastic surplus production model in continuous time (SPiCT). The trajectory of the biomass, especially at the beginning of the time series, was questioned during the discussion and the assessment was considered preliminary.

Red mullet (*Mullus barbatus*)

24. During the session, assessments of red mullet covering 14 GSAs were presented. In eight cases, the stocks were found to be in overexploitation, with varying relative biomass levels. In the remaining cases the stocks were estimated to be under sustainable or possibly sustainable exploitation, with high or intermediate biomass levels. Further details are provided below.

25. The updated assessment for GSA 1 using the a4a method indicated overexploitation with relatively low biomass. The recommendation was to reduce fishing mortality.

26. An updated assessment for GSA 6 was presented using a4a. Results indicated that the stock is in overexploitation with relatively high biomass. Reduction of fishing mortality was recommended.

27. The updated assessment for GSA 7 using a4a, was presented. Results indicated that the stock is in overexploitation with relatively high biomass. The recommendation was to reduce fishing mortality.

28. The updated assessment for GSA 9 using the a4a method indicated that the stock is sustainably exploited with relatively high biomass. The recommendation was not to increase fishing mortality.

29. An updated assessment for GSA 10 using a4a, was presented. Results indicated that the stock is under sustainable exploitation with relatively high biomass. The recommendation was not to increase fishing mortality.

30. An update of the benchmark assessment was presented for GSAs 12–14 (jointly). Estimates obtained from XSA runs revealed that the stock is in overexploitation, with relatively high biomass. Reduction of fishing mortality was recommended. Furthermore, the rationale for joining those GSAs was discussed and it was questioned whether GSA 16 should also be considered together with them. It was noted, however, that there is scientific evidence suggesting that the stocks are different, given that there are differences in growth parameters between stocks inhibiting the Sicilian and Tunisian side.

31. Two assessments were presented for GSA 15, both using the XSA method. An update of the benchmark assessment and a revised one, with different model settings. Both indicated that the stock is in overexploitation with relatively low biomass. The group based its advice on the revised assessment and reduction of fishing mortality was recommended.

32. An update assessment was presented for GSA 16, using XSA. The results indicated that the stock is sustainably exploited, with relatively intermediate biomass. The recommendation was not to increase fishing mortality.

33. An update of the benchmark assessment for GSA 19 was presented, using a4a. The results indicated that the stock is in overexploitation, with relatively low biomass. Reduction of fishing mortality was recommended.

34. An updated assessment for GSA 20 was presented, using a4a. Results indicated that the stock is in overexploitation, with relatively high biomass. Reduction of fishing mortality was recommended.

35. A revised assessment, with updated catch and catch-at-age data series, was presented for GSA 22 using the a4a method. Results indicated that the stock is sustainably exploited, with relatively high biomass. The recommendation was not to increase fishing mortality.

36. An updated assessment for GSA 24 was presented. A qualitative advice was based on the catch-maximum sustainable yield (CMSY) method and the estimates were supported by three additional methods: length-based Bayesian biomass (LBB), LBSPR and length-based integrated mixed effects (LIME). Results indicated that the stock is possibly under sustainable exploitation. As a precautionary advice, to not increase fishing mortality was recommended.

Giant red shrimp (*Aristaemorpha foliacea*)

37. An updated, assessment for GSAs 9–11 (jointly) using the a4a method, was presented. The stock was estimated to be in overexploitation with relatively low biomass. The recommendation was to reduce fishing mortality.

38. A revised assessment, changing individual weight and maturity vector, was presented for GSAs 18–19 using a4a. Results indicated that the stock is in overexploitation with relatively intermediate biomass. Reduction of fishing mortality was recommended.

39. A new assessment for GSA 26 was presented. The results were considered preliminary and the assessment was not validated.

Blue and red shrimp (*Aristeus antenantus*)

40. Assessments of Blue and red shrimp covering ten GSAs were presented during this session. In all validated assessments, the stocks were estimated to be in overexploitation, with intermediate to low biomass levels. Further details are provided below.

41. An updated assessment for GSA 1 using a4a was presented. Results indicated that the stock is in overexploitation, with relatively intermediate biomass. The recommendation was to reduce fishing mortality.

42. An updated assessment for GSA 2 was presented using XSA. Results indicated that the stock is in overexploitation, with relatively intermediate biomass. Reduction of fishing mortality was recommended.

43. An updated assessment for GSA 5 was presented using a4a. Results indicated that the stock is in overexploitation, with relatively low biomass levels. Reduction of fishing mortality was recommended.

44. An updated assessment for GSA 6 was presented using a4a. Results indicated that the stock is in overexploitation, with relatively low biomass levels. Reduction of fishing mortality was recommended.

45. An updated assessment for GSAs 9–11 (jointly) was presented using a4a. Results indicated that the stock is in overexploitation, with relatively low biomass levels. Reduction of fishing mortality was recommended.

46. A new assessment for GSAs 18–19 was presented and various modelling approaches were investigated. The assessment was considered preliminary.

47. A new assessment for GSA 26 was presented. The results were considered preliminary, and the assessment was not validated.

Blackspot seabream (*Pagellus bogaraveo*)

48. The update of benchmark assessment for blackspot seabream in GSAs 1 and 3 (jointly) was presented, based on the Gadget model. Results indicated that the stock is overexploited with low fishing mortality. The recommendation was to reduce fishing mortality and/or implement a recovery plan.

Red coral (*Corallium rubrum*)

49. A new assessment for red coral in GSA 11 was presented using the LBSPR method. Questions were raised regarding the most appropriate approaches for assessing coral stocks and the existing information on the biological parameters of the species. Assessment results were considered preliminary.

Common cuttlefish (*Sepia officinalis*)

50. A revised assessment for common cuttlefish, with changed priors in the model, was presented for GSA 17 using a Bayesian surplus production model (CMSY). Results indicated that the stock is in overexploitation and overexploited. Immediate action to ensure reduction in fishing mortality was recommended.

Spottail mantis shrimp (*Squilla mantis*)

51. An updated assessment for spottail mantis shrimp in GSA 17 was presented. The results of the SS3 model indicated that the stock is overexploited with low fishing mortality. The recommendation was to reduce fishing mortality and/or implement a recovery plan.

Common sole (*Solea solea*)

52. The update of benchmark assessment for common sole in GSA 17 was presented, using SS3. The results of the ensemble SS3 model indicated that the stock is overexploited with low fishing mortality. Reduction fishing mortality and/or implementation of a recovery plan was recommended.

ASSESSMENTS OF NON-PRIORITY STOCKS

Norway lobster (*Nephrops norvegicus*)

53. A new assessment was presented for GSA 5, the assessment was carried out using both XSA and a4a methods. The a4a was selected for advice; the results indicated that the stock is sustainably exploited with relatively intermediate biomass levels. The recommendation was not to increase fishing mortality.

54. An updated assessment for GSA 6 was presented using a4a. The results of the model indicated that the stock is in overexploitation, with relatively low biomass.

55. An updated assessment for GSA 9 was presented using a4a. Results indicated that the stock is in sustainable exploitation with relatively high biomass. It was recommended not to increase fishing mortality.

56. A preliminary assessment for Norway lobster in GSA 17 was presented and various modelling approaches were investigated.

Deep-water rose shrimp (*Parapenaeus longirostris*)

57. A new assessment for deep-water rose shrimp in GSA 22 was presented using both a4a model and SPiCT. During the discussion, various considerations about the model performance were raised and the assessment was considered preliminary.

Horned octopus (*Eledone chirrhosa*)

58. An updated assessment for horned octopus in GSA 18, was presented using CMSY and the Bayesian state-space Schaefer surplus production model (BSM). Results indicated that the stock is sustainably exploited with relatively high biomass. The recommendation was not to increase fishing mortality.

Striped red mullet (*Mullus surmuletus*)

59. A revised assessment for GSA 5, using a new vector of natural mortality (M), was presented. The results of the a4a model indicated that the stock is in overexploitation, with relatively intermediate biomass. Reduction of fishing mortality was recommended.

60. A new assessment in GSA 25, was presented using the state-space assessment model (SAM) method. Given various model uncertainties, the assessment was considered qualitative. Results indicated that the stock is possibly in overexploitation and reduction of fishing mortality was recommended.

Common octopus (*Octopus vulgaris*)

61. A preliminary assessment for common octopus in GSA 14 was presented, using VIT.

Brown comber (*Serranus cabrilla*)

62. A new assessment for brown comber was presented in GSA 25, using the abundance maximum sustainable yield (AMSY) method. The results of the model indicated that the stock is sustainably exploited with high biomass. The recommendation was not to increase fishing mortality.

Marbled spinefoot (*Siganus rivulatus*)

63. A preliminary assessment was presented for marbled spinefoot in GSA 25.

Axillary seabream (*Pagellus acarne*)

64. A new assessment was presented for axillary seabream in GSA 25 using the CMSY++ method. The results indicated that the stock is overexploited and in overexploitation. Immediate action to ensure reduction in fishing mortality was recommended.

SUMMARY ON THE STATUS OF THE DEMERSAL STOCKS IN 2020

65. Out of the 51 validated assessments, 45 were accepted for providing quantitative advice, while six were considered to be qualitative. Some of the assessments were accomplished in the frame of relevant Scientific, Technical and Economic Committee of Fisheries (STECF) working groups. Of the 51 validated assessments, 10 indicated sustainable exploitation and five of these referred to various red mullet stocks.

66. As in previous years, the WGSAD recognized that European hake was the demersal species suffering from the highest fishing mortality. Other commonly exploited species, such as deep-water rose shrimp and red mullet, are generally in better situation and although they are in overexploitation in the majority of the cases, their biomass is mostly at relatively high levels. Such differences among species are indicated in Figure 1.

67. During the sessions on stock assessment, general aspects related to the assessments carried out were reviewed, including methods and data used, stock status and a summary of the resulting scientific advice. In some cases, new analyses were carried out. Comments by the WGSAD on each stock assessment are summarized in the table included in Appendix 3. Creation of the table was facilitated by the STock Assessment Results (STAR) template, which has somewhat automated the process. Individual stock assessment summaries are available in this report and all stock assessment forms (SAFs) are available on the GFCM SharePoint page of the Expert Groups (https://gfcm.sharepoint.com/EG) and will be published online after validation by the SAC in 2022.

68. Out of the 51 validated assessments, 38 were carried out within a single GSA and 13 assessments spanned over several GSAs. With reference to the GFCM subregions, 29 assessments were carried out in the western Mediterranean, six in the eastern Mediterranean and 16 covered GSAs of the central Mediterranean and the Adriatic Sea.

69. As in previous years, in the absence of reference points based on biomass, the WGSAD used the empirical reference framework for the relative level of stock biomass referred to the thirty third and sixty sixth percentile, as agreed at the WGSAD 2012 meeting and as collected in the SAF template approved by the sixteenth session of the SAC (Malta, 2014).

70. A full description of input data, parameters and assumptions for stock assessment were included in the SAFs and the STAR templates. Participants were also reminded that they should provide the GFCM Secretariat with raw input data and with the scripts run to perform the assessments (if any). To facilitate data transmission, an input and raw data folder was made available on the GFCM SharePoint. In this respect, the use of the SharePoint for the sixth consecutive year had proved to be very useful for exchanging information between participants and the working group coordinator.

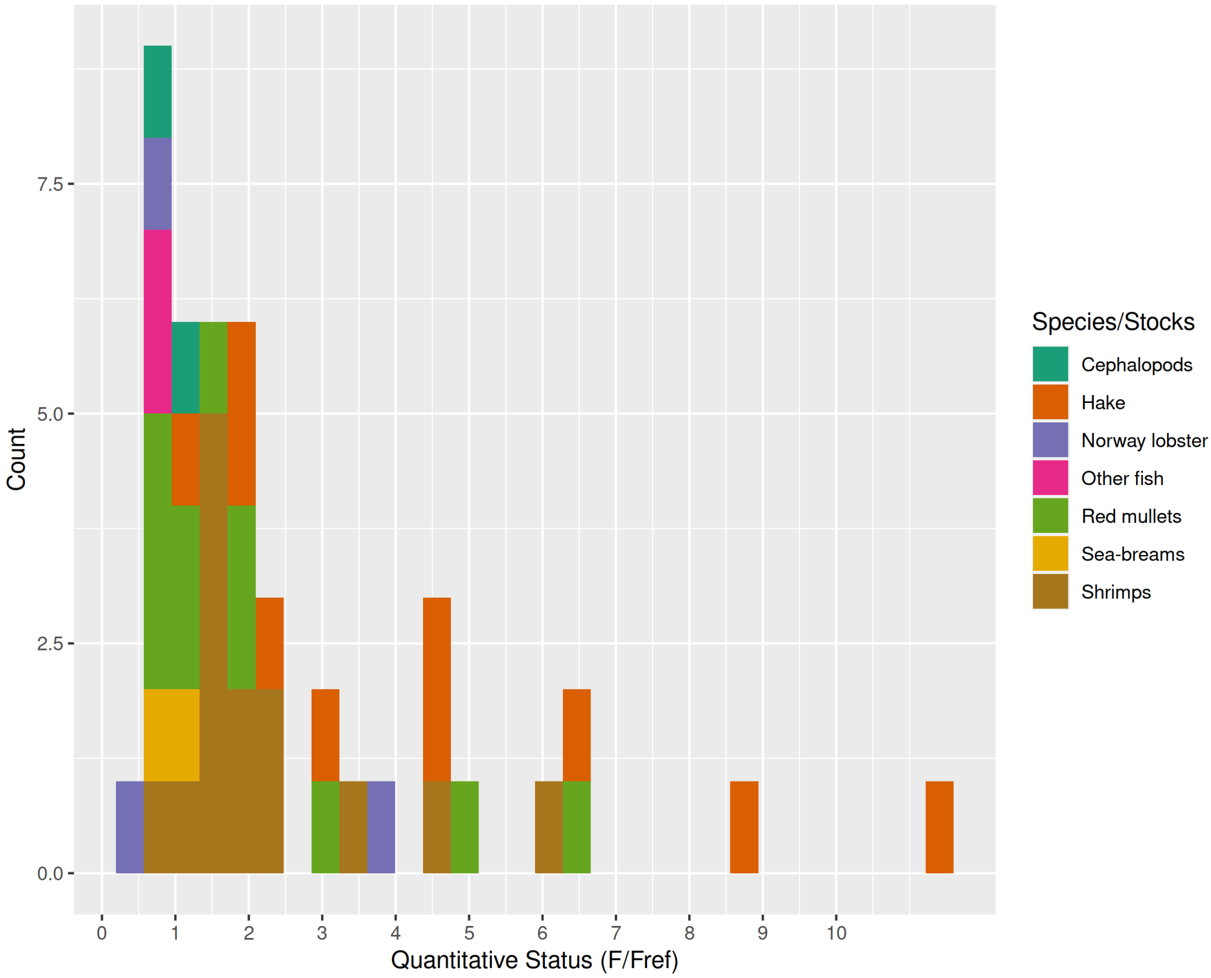


Figure 1. Quantitative status of the main stocks

ASSESSMENT METHODS

71. With regards to the methodology used, the majority (44) of the assessments utilized age-based methods or integrated approaches, while the remaining assessments were mostly based on production models. It should be noted that in several cases more than one approach was tested. The WGSAD welcomed the advancement of methodologies used to assess Mediterranean stocks in the direction indicated by previous WGSAs. Thus, the proportion of stocks assessed using SCAA methods or integrated analysis (e.g. a4a, SAM, SS3) was higher than 60 percent.

72. The WGSAD discussed the use of abundance indices from the traditional trawl surveys, for tuning age-based models for certain crustacean stocks, such as those of Norway lobster. Given that such species may be inadequately sampled by those surveys, it was suggested to explore the use of commercial catch per unit effort (CPUE) indexes, as well as the possibility of developing specific fishery independent surveys in the future.

ASSESSMENT SUMMARY SHEETS

SUMMARY OF ACCEPTED STOCK ASSESSMENTS BY SPECIES AND GSA

(Progressive numbers are referring to the table of advice provided in Appendix 3).

N: 1

Stock: European hake (*Merluccius merluccius*)

GSA: 1, 5, 6, 7

Author(s): STECF

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

Data and parameters: The assessment was carried out between 2007 and 2020 as survey indices data were available only from 2007 for GSA 5 (Balearic Islands). Available catch numbers at length and index numbers at length were sliced using the a4a age slicing routine in the Fisheries Library in R (FLR, l2a). The analyses were carried out for ages 0 to 5 and older. According to the resulting selection pattern, ages classes 1–3 were chosen to compute the current level of fishing mortality. All data were taken from the 2020 European Union data collection framework (DCF) data call.

Assessment method: The assessment of European hake carried out and presented during the GFCM benchmark considered the stock configuration including GSAs 1, 5, 6 and 7 as basis for the advice. According to the a4a method (Jardim *et al.*, 2015) a SCAA assessment was used. The a4a method utilizes catch-at-age data to derive estimates of historical population size and fishing mortality.

Model performance: Available data series both in terms of catches and surveys were considered sufficient to provide advice by analytical model. The retrospective analysis was only applied for the three previous years, due to the short time series. Model results were quite stable in terms of catch and spawning stock biomass (SSB) estimations. The fishing mortality value, removing only one year, was a bit different but remains quite similar to the previous years. Recruitment was quite different when removing two years, but this is not an issue considering the short time series used.

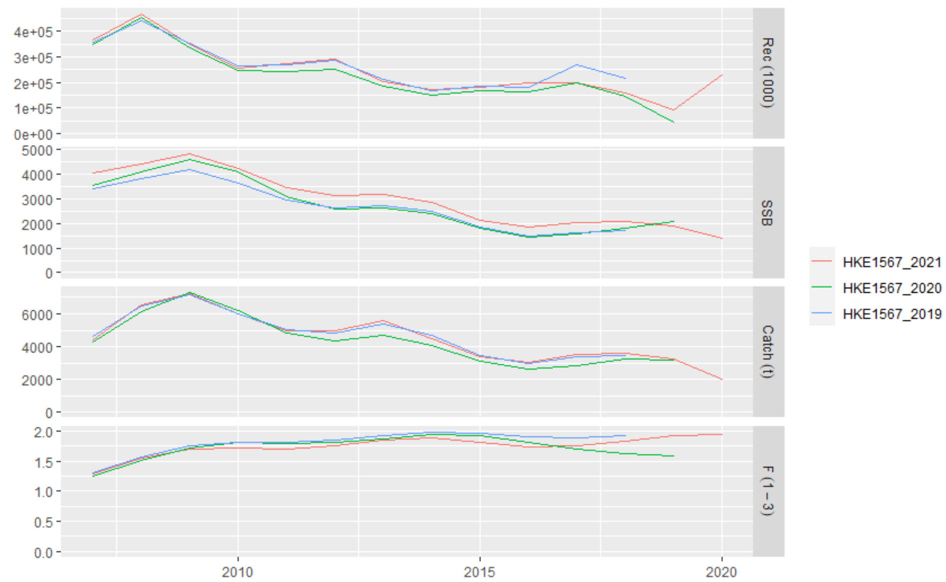
Results: Based on the a4a results, the European hake SSB shows a decreasing trend. The assessment also shows a decreasing trend in the number of recruits, with an increase in the last year. The F_{bar} (1–3) value shows a fairly stable trend at high levels.

$F_{current}$ F_{bar} ages 1–3 (2020)	1.94
$F_{0.1}$ (present assessment)	0.44
$SSB_{current}$ (tonnes)	1 401
SSB (33rd percentile)	2 104
SSB (66th percentile)	3 358
$F_{current}/F_{0.1}$	4.41

Diagnosis of stock status: High overfishing ($F_{current} > F_{0.1}$) is above 1.66 with relatively low biomass (SSB lower than the 33rd percentile).

Advice and recommendations (in terms of research and, when possible, in terms of management).

- Reduce $F_{current}$ towards F_{MSY}



Comparison of the outputs of the previous years' assessments (blue and green lines) and the updated assessments performed this year (red line).

N: 2

Stock: European hake (*Merluccius merluccius*)

GSA: 1

Author(s): Pérez Gil, J.L., Serna-Quintero , J.M.,Meléndez, M.J, García, C.,González, M., Torres, P., García, T., Acosta, J., Galindo, M., León, E., Ciércoles, C. and Martínez, G.

Fishery: European hake (*Merluccius merluccius*, Linnaeus, 1758) is one of the target demersal species of the Mediterranean fishing fleets, largely exploited in GSA 1 mainly by otter bottom trawlers (92 percent of landings) on the shelf and slope and by small-scale fisheries using gillnets (7 percent) and longlines (1 percent) on the shelf (2020). The otter bottom trawl fleet segment in GSA 1 is made up of 116 boats (2020), averaging 35 gross register tonnage (GRT) and 176 horsepower (HP). Catches of European hake show a decreasing trend from 2012 to 2017, with a slight increase in 2018. In the last year there has been a decrease to 171 tonnes (average 2018–2020, 290 tonnes).

Data and parameters: The assessment was carried out using official landings and data on the size composition of otter bottom trawl catches (including discard) for the years 2003–2020. Reconstruction of the length frequency distribution of the 2020 year was carried out for the January–June period. Catch-at-length data were converted into catch-at-age data by cohort slicing procedures. The length–weight relationship and maturity ogive come from Spanish DCF.

Assessment method: The state of exploitation of this stock was assessed by means of XSA (Shepherd, 1999). The software used was the Lowestoft suite (Darby and Flatman, 1994) and FLR. The XSA tuning was performed using abundance index series from the International Bottom Trawl Survey in the Mediterranean (MEDITS). Abundance indices for the year 2020 were reconstructed from a generalized additive model (GAM) analysis, testing five different scenarios. Yield per recruit (Y/R) analyses was conducted based on the exploitation pattern resulting from the XSA model and population parameters.

Model performance: Sensitivity and retrospective analyses were applied in the XSA model in order to check the robustness of the assessment. A deterministic short-term prediction for the period 2021 to 2023 was performed using the FLR libraries and scripts and was based on the results of the XSA stock assessment. The assessment was updated as of 2020.

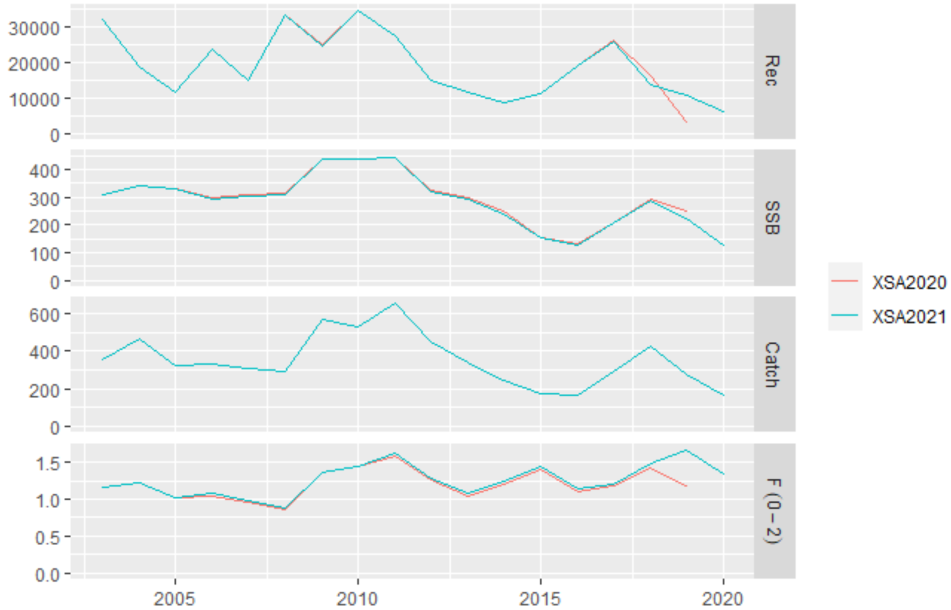
Results: Catches and SSB of European hake showed a decreasing trend from 2012 to 2016, with a slight increase in 2017–2019, decreasing again in 2020. Recruitment showed fluctuations over the series and a steep decline in recent years. The $F_{bar\ (0–2)}$ in recent years, fluctuated around values close to 1.2–1.5 and decreased in 2020.

$F_{current} = F_{bar}$ ages 0–2 (2018–2020)	1.5
$F_{0.1}$(present assessment)	0.23
$F_{current}/F_{0.1}$	6.52
$SSB_{current(2018–2020)}$ (tonnes)	212
SSB 33rd percentile biomass (tonnes)	269
SSB 66th percentile biomass (tonnes)	312

Diagnosis of stock status: The stock is in overexploitation, with relatively low biomass.

Advice and recommendations.

- Reduce $F_{current}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort



Comparison of the outputs of the previous year's assessment (red line) and the updated assessment performed this year (blue line).

N: 3

Stock: European hake (*Merluccius merluccius*)

GSA: 1, 3

Author(s): Settih, J., Pérez Gil, J.L., Elouamari, N., Hernández, P., Galindo, M., González, M., García, C., Serna, J.M., Ciercoles, C. and León, E.[2]

Fishery: European hake (*Merluccius merluccius*) is a target demersal species of the Mediterranean fishing fleets. It is one of the target demersal species of the Mediterranean fishing fleets, largely exploited in GSA 1 mainly by otter bottom trawlers (92 percent of landings) on the shelf and slope and by small-scale fisheries using gillnets (7 percent) and longlines (1 percent) on the shelf (2020). The otter bottom trawl fleet segment in the GSA 1 area is made up of 116 boats (2020), averaging 35 GRT and 176 HP. Catches of European hake show a decreasing trend from 2012 to 2017, with a slight increase in 2018. In the last year, there has been a decrease to 171 tonnes (average 2018–2020, 290 tonnes). The trawl fishing fleet in GSA 3 is heterogeneous; longliners are not found. The number of trawlers operating in this area is 81. European hake in GSA 3 is found at depths ranging from 50 to 510 m. In the period 2018–2020, the mean annual European hake production was 99 tonnes.

Data and parameters: This assessment was done in the framework of the CopeMed II Working Group on demersal species. The meeting was held on the 8 January by video conference was attended by experts from Morocco, and Spain. The assessment was carried out using official landings and data.

Assessment method: The state of exploitation in GSAs 1 and 3 of this stock was assessed by means of XSA (Shepherd, 1999). The software used was the Lowestoft suite (Darby and Flatman, 1994) and FLR.

Model performance: Sensitivity and retrospective analyses were applied in the XSA model in order to check the robustness of the assessment. Results showed no particular retrospective bias in SSB, fishing mortality (F) or recruitment.

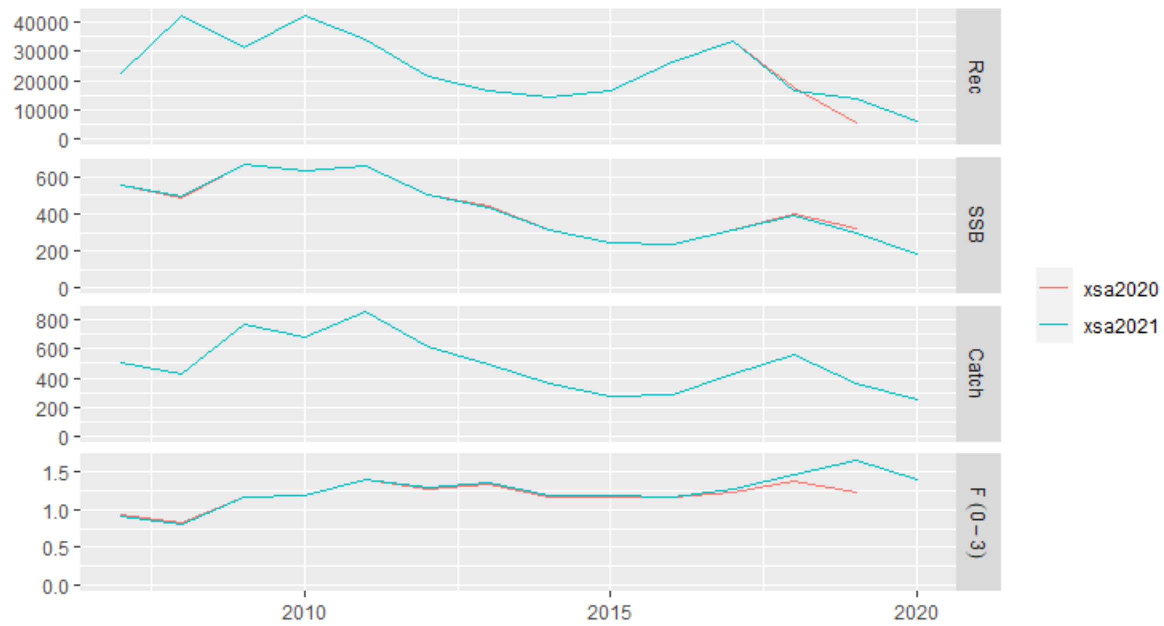
Results: The XSA results revealed that SSB and catch showed a decreasing trend from 2011 to 2016, an increase from 2016 to 2018 and a decrease for the last two years. Recruitment showed a decreasing trend from 2010 to 2015, an increase from 2015 to 2017, and a decrease for the last three years. Fishing mortality ($F_{bar0–3}$) showed a decrease from 2013 to 2016, an increase from 2016 to 2019, and a decrease for the last year. The Y/R analysis showed that the $F_{ref} = F_{current}$ (1.5) exceeded the Y/R $F_{0.1}$ reference point (0.17).

$F_{current}$ F_{bar} ages 0–3 (2018–2020)	1.5
$F_{0.1}$ (present assessment)	0.17
$F_{current}/F_{0.1}$	8.8
$SSB_{current(2020)}$tonnes	199
SSB 33rd percentile biomass(tonnes)	318
SSB 66th percentile biomass(tonnes)	496

Diagnosis of stock status: The Y/R analysis showed that the $F_{current}$ = 1.28 exceeded the Y/R $F_{0.1}$ reference point (0.17). The resulting ratio $F_{0.1}/F_{current}$ = 8.8, suggests that for European hake stock in GSAs 1–3, the current exploitation level is in over exploitation and the stock size is unknown.

Advice and recommendations.

- Reduce $F_{current}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort



Comparison of the outputs of the previous year's assessment (blue line) and the updated assessment performed this year (red line).

N: 4

Stock: European hake (*Merluccius merluccius*)

GSA: 4

Author(s): Filali, T., Mennad, M., Ramírez, J., Hernández P., and Vasconcellos, M.

Fishery: European hake is one of the main target species in GSA 4. It is largely exploited by bottom trawlers (OTB) on the shelf and slope, but also by small-scale fisheries using gillnets (GNS) and trammel nets (GTR) with an average of less than 3 percent of catches since 2014. A net decrease in landings of hake was observed in 2019 and 2020. In general, the highest biomass index from Algerian demersal surveys data analysis was observed between 100 to 200 m in depth and the largest specimens of hake are caught in the deepest stratum (Aldem, 2019). The maximum biomass index was observed in the eastern part of GSA 4. Smaller size classes less than 25 cm are the most dominant in OTB catches. Discards data are not available, the project is in progress.

Data and parameters: Length–frequency data from commercial trawl catches of five years (2015–2019) were used to assess stock parameters. Growth parameters from Filali and Hemida (2014), maturity ogive from the Algerian national data collection program (GSA 4) and the average M vector, obtained by different methods as suggested in GFCM hake benchmark session in 2019, were used as input data.

Assessment method:

- VPA: catch-at-age data were constructed using a4a package (slicing function) and pseudocohort and Y/R analysis were performed using Vit software.
- LBSPR, initiated to data poor fisheries was also used to improve the Vit assessment for the last years.

Model performance: The Vit program was developed to assess data poor fishery stocks. It was used to develop qualitative conclusions for several years during GFCM meetings. Quantitative interpretations of stock parameters are recommended when the model is applied to short time series of more than one year and the resulting variation of the parameters is reasonably low. Model sensitivity was tested using several terminal F values from 0 to 2. Mean fishing mortality from the ages most present in catches was used to estimate F_{bar}. Results coming from the model may form the basis for scientifically sound fisheries management advice for medium-term periods. However, the likely low precision of results prevents their transfer to any precise short-term forecasts.

The LBSPR model, an equilibrium model, was used, assuming that the length composition data was representative of the exploited population at steady state. The model was further extended to include dome-shaped selectivity for application for inland fisheries. Additionally, It only requires length composition data and accurate biological information. The estimation performance of LBSPR under various conditions has been well tested through many simulation studies.

Results: Current F is much higher than $F_{0.1}$ which indicates high overfishing status. The LBSPR model confirms the over exploitation situation with SPR > 40 percent.

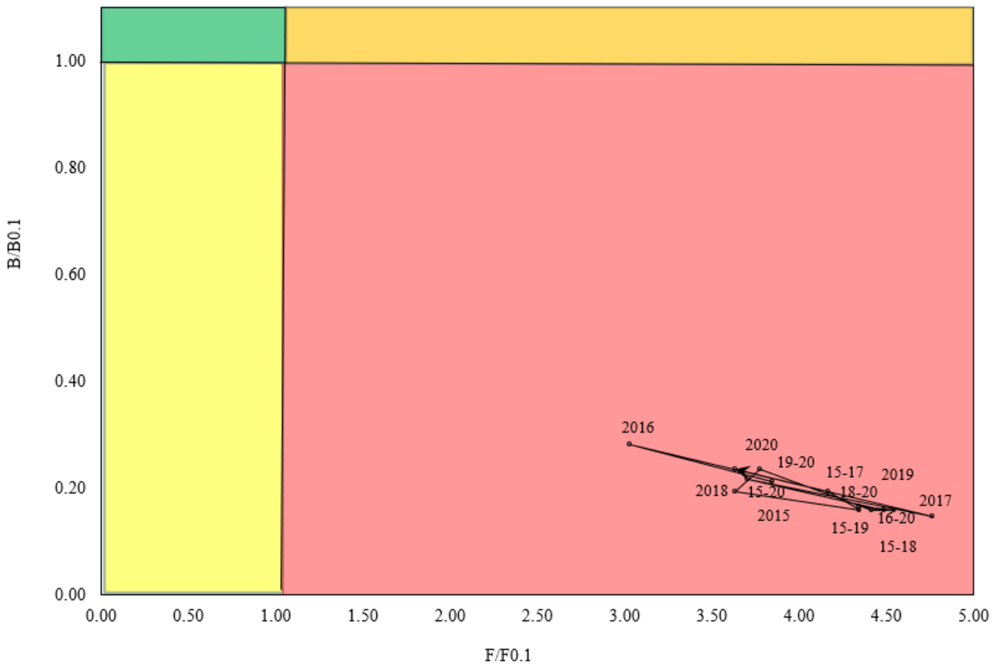
Vit Pseudocohort	$F_{current}$ ($F_{bar\ 1\text{–}3}$ in 2019)	1.06 (± 0.07)
	$F_{0.1}$ (2019)	0.24 (± 0.02)
	$F_{current}/F_{0.1}$	N/A
	Current SSB (tonnes)	442
	33rd percentile biomass (tonnes)	-
	66th percentile biomass (tonnes)	-
LBSPR	raw SL 50	13.71
	raw SL 95	16.27
	raw FM	1.36
	SPR/SPR40%	0.23

Diagnosis of stock status: Possibly in overexploitation.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

- Progressive reduction of fishing effort.



Kobe plot of hake assessment in GSA 4 (time series 2015–2020)

N: 5

Stock: European hake (*Merluccius merluccius*)

GSA: 5

Author(s): Farré, M., Guijarro, B., González, N. and Soldán, V.

Fishery: In the Balearic Islands, commercial bottom trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope, mainly targeted to: i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50–

80 m); ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the deep shelf (80–250 m); iii) *Nephrops norvegicus*, but with an important bycatch of big *Merluccius merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the upper slope (350–600 m) and iv) *Aristeus antennatus* on the middle slope (600–750 m). The European hake (*M. merluccius*) is a target species for this fishery, mainly exploited on the deep shelf and upper slope, with annual landings oscillating between 50 and 2 020 tonnes during the last few decades (1980–2020). All hake catches from this area come exclusively from bottom trawlers.

Data and parameters: Size composition of commercial trawl catches and official landings (1980–2020), calibrating data from survey indices (2001–2020) and CPUE data from commercial fleet (2000–2020). Biological parameters were obtained from scientific studies: growth parameters and maturity ogive from Mellon-Duval *et al.* (2010) and from Spanish National Data Collection Programme; M vector calculated from PRODBIOM.

Assessment method: Both XSA and a4a were used. The a4a assessment was selected to provide the final advice. Additionally, Y/R analysis and short-term forecast analysis were carried out. The assessment is an update from the previous year, 2019.

Model performance: The model showed quite a good fit.

Results: Stock abundance, SSB and recruitment showed noticeable oscillations along the entire data series, showing no clear trends (Figure 1).

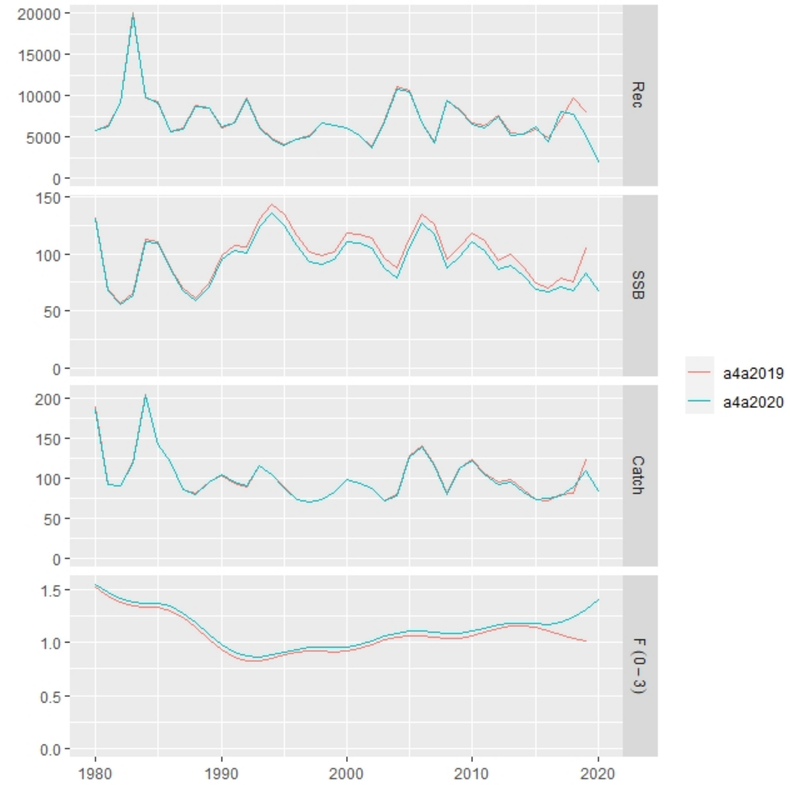
$F_{current}$ (2020, ages 0–3)	1.40
$F_{0.1}$ (2020)	0.32
$F_{current}/F_{0.1}$	4.39
$SSB_{current}$ (2020, tonnes)	68.2
33rd percentile SSB (tonnes)	84.0
66th percentile SSB (tonnes)	103.8

Diagnosis of stock status: The stock is in overexploitation, with relatively low biomass.

Advice and recommendations: To reduce fishing mortality.

Data issues: Information used was the official information submitted to the GFCM. Due to the partial lack of data of the commercial fraction in 2020 due to the COVID-19 outbreak, size composition was completed by weighting the lacking length distribution to the total catch of the year.

Comparative plot:



Comparison of the outputs of the previous year's assessment and the updated assessment performed this year.

N: 6

Stock: European hake (*Merluccius merluccius*)

GSA: 6

Author(s): García-Rodríguez, E., Pérez-Gil, J.L, Vivas, M. and Esteban, A.

Fishery: European hake (*Merluccius merluccius*) is a target demersal species of the Mediterranean fishing fleets. It is largely exploited in GSA 6, mainly by trawlers on the shelf and slope (95 percent landings), but also by small-scale fisheries using longlines (3 percent), gillnets and trammel nets (2 percent) – average percentages estimated between 2017 and 2020. According to official statistics, around 1 000 boats are involved in this fishery, with total annual landings oscillating around 1 700 tonnes for the period 2017–2020 (1 099 tonnes in 2020). The trawler fleet is the largest in number of boats (414).

Data and parameters: The assessment was carried out using official landings and data on the size composition of trawl, longlines and set gillnet catches for the years 2002–2020. Abundance index series from MEDITS surveys were used as indices of abundance independent of the fishery.

Assessment method: An update of an a4a model was used for assessment. Additionally, Y/R analysis was carried out.

Model performance: Sensitivity and retrospective analyses were applied in the a4a model in order to check the robustness of the assessment. Results showed no particular retrospective bias in SSB, fishing mortality or recruitment. The population was not rebuilt for the period 1995–2001. Inconsistencies between population and survey indices cohorts observed in 2018 assessment were corrected.

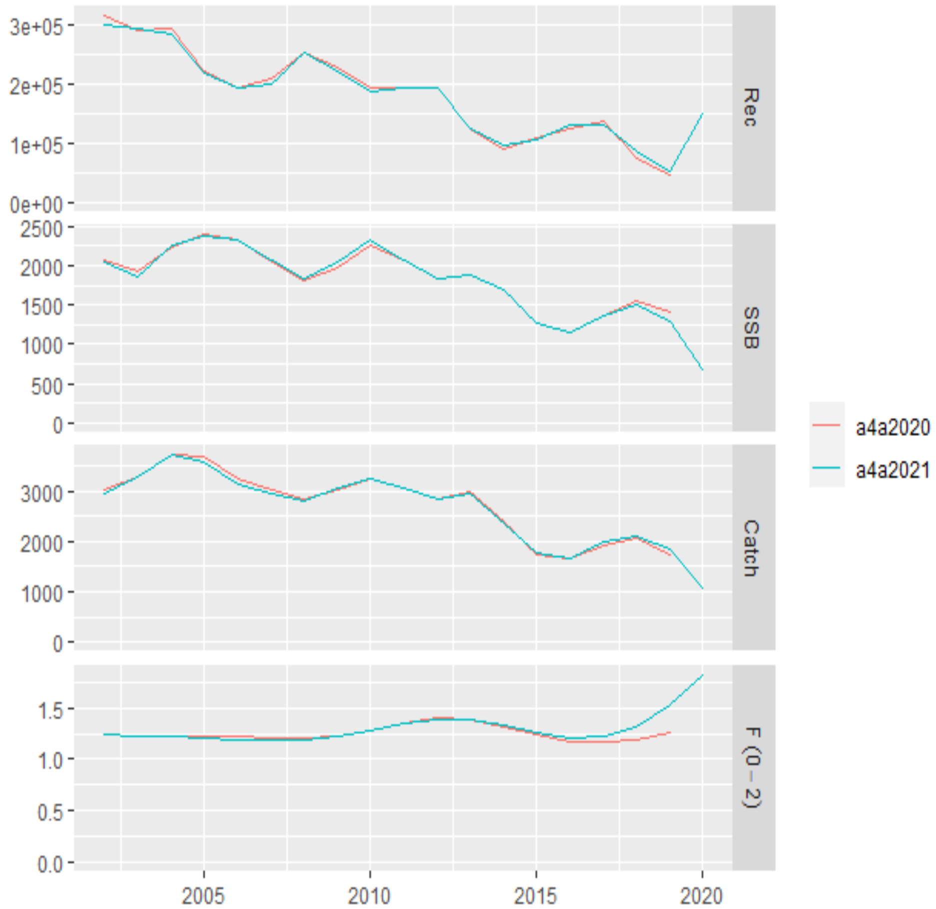
Results: Total biomass (B) and yield (Y) showed a general decreasing trend from 2002 to 2020. Recruitment showed a drastic decline from the maximum observed in 2002. Fishing mortality ($F_{bar0–2}$) showed a slight increase until 2013 and a decreasing trend until 2018, followed by an increase until 2020 when estimated F was 1.73.

$F_{current}$ F_{bar} ages 0–2 (2020)	1.73 (± 0.16)
$F_{0.1}$(present assessment)	0.15
$F_{current}/F_{0.1}$	11.53
$SSB_{current(2018)}$tonnes	729
SSB 33rd percentile biomass (tonnes)	2 486
SSB 66th percentile biomass (tonnes)	3 126

Diagnosis of stock status: The Y/R analysis showed that the $F_{current} = (1.73)$ exceeds the Y/R $F_{0.1}$ reference point = (0.15). The resulting ratio $F_{0.1}/F_{current} = 11.53$, suggests that for European hake stock in GSA 6, the current exploitation level is in over exploitation and the stock size is overexploited with relatively low biomass.

Advice and recommendations.

- Reduce $F_{current}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort



Comparison of the outputs of the previous year's assessment (red line) and the updated assessment performed this year (blue line).

N: 7

Stock: European hake (*Merluccius merluccius*)

GSA: 8, 9, 10, 11

Author(s): Ligas, A., Musumeci, C., Bellodi, A., Bitetto, I., Carbonara, P., Follesa, M.C., Jadaud, A., Massaro, A., Pesci, P., Lanteri, L., Sartor, P., Sbrana, M., Spedicato, M.T. and STECF

Fishery: European hake is one of the main target species in terms of landings, incomes and vessels involved in the area. In GSAs 9 and 10, it is mainly exploited by trawlers on the shelf and slope, but also by small-scale fisheries using set nets (gillnets and trammel nets) and bottom longlines. In GSA 11, although hake is not target of a specific fishery, it is one of the most important species in terms of biomass landed. It is caught exclusively by a mixed bottom trawl fishery that operates at depth between 50 m and 800 m. No gillnet or longline fleets target this species, but it can be found as bycatch of gillnet fleets targeting other species.

In Corsica (GSA 8), six trawlers are active and their average length is 15 m; these vessels operate with bottom trawls nets along the eastern coasts of Corsica targeting demersal species (Norway lobster, striped red mullet, deep-water rose shrimp, etc.).

Data and parameters: Landing data were reported to the benchmark meeting through the official European Union DCF data provided by Italy. In GSAs 9, 10 and 11, most of the landings come from otter trawling. The contribution of set nets to the total landing is around 30 percent in GSAs 9 and 10; longlines in GSA 10 contribute for around the 15 percent of the total landings. In GSA 11, landing data come exclusively from the bottom trawl fishery. In GSA 8, catch data, proceeding from the limited number of trawlers cover only the period 2009–2020. Landings are very low in all the years where data are available and the discards are not included in the catch because no information is available. Reconstructed data were estimated from 2005 to 2008, considering an average of the available information.

Discards were not available in GSAs 9, 10 and 11 for some years, therefore they were estimated using an average proportion between landings and discards computed on the available years.

Taking advantage of the age-length data collected under the European Union DCR/DCF, two sets of Von Bertalanffy Growth Function (VBGF) parameters were computed by sex using the (fisheries stock assessment) FSA package available in R (Ogle, 2016). In order to obtain an estimate of t_0 close to 0, data of age and length of juveniles coming from studies on otolith daily rings (Belcari *et al.*, 2006; Ligas *et al.*, 2015) were added to the data sets.

Length–weight relationship parameters were estimated by sex as the average of those available in GSAs 9, 10 and 11 under European Union DCR/DCF. No biological data are available for hake in GSA 8.

Using the selected VBGF parameters, a combined vector of proportion of maturities-at-age was estimated starting from the vectors of maturity-at-length available under the European Union DCR/DCF.

The selected VBGF and length–weight relationship parameters were used to estimate a range of M vectors using different models and empirical formulas, as agreed during the benchmark meeting.

MEDITS data from 2005 to 2020 were used to compute the tuning information to be used in the assessment.

Assessment method: Statistical catch-at-age (a4a, FLR http://flr-project.org), FLBRP package for Y/R analysis and Flash package for short-term forecast. This assessment was benchmarked in 2019 by the GFCM.

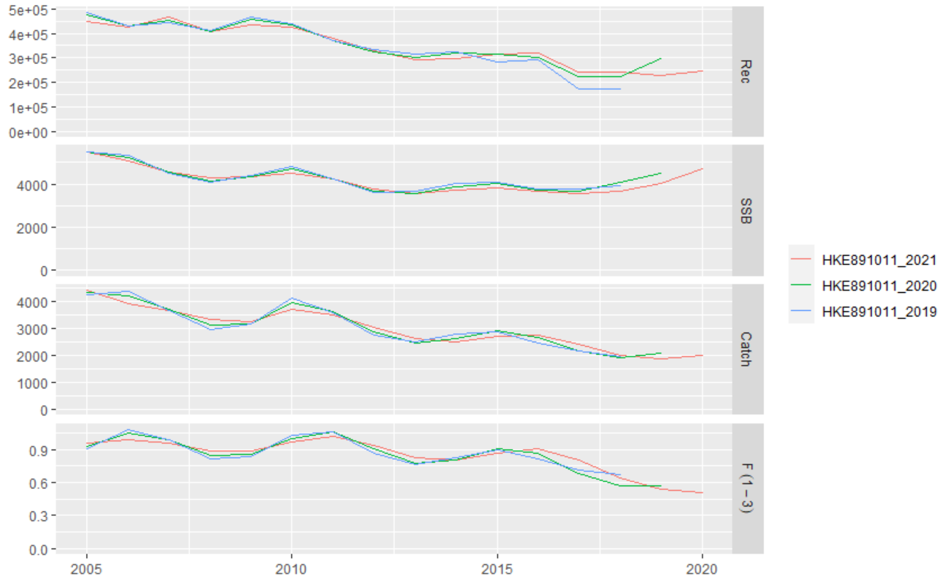
Model performance: Model residuals and retrospective analysis did not show any trends, patterns or violations. The estimates of the coefficients fitted by the selected model, the corresponding standard error and the cryptic biomass were also inspected and provided consistent results.

Results: The results showed a decreasing pattern of fishing mortality, even though the value in 2020 ($F_{bar1-3} = 0.50$) was still well above the reference point ($F_{0.1} = 0.16$) and used as proxy for F_{MSY}, with a ratio of 3.13. Both SSB and recruitment showed a decreasing pattern, with an increase in recent years.

$F_{current}$ (Fbar 1–3 in 2020)	0.50
$F_{0.1}$ (2020)	0.16
$F_{current}/F_{0.1}$	3.13
Current SSB 2020 (tonnes)	4690
33rd percentile biomass (tonnes)	3783
66th percentile biomass (tonnes)	4333

Diagnosis of stock status: The stock is in high overexploitation with relatively high biomass.

Advice and recommendations: Reduce the fishing mortality towards the reference point.



Comparison of the outputs of the previous years' assessments (blue and green lines) and the updated assessment performed this year (red line).

N: 8

Stock: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 1

Author(s): Pérez Gil, J.L., Serna-Quintero, J.M., Meléndez, M.J., García, C., González, M., Torres, P., García, T., Acosta, J., León, E., Ciércoles, C. and Martínez, G.

Fishery: Deep-water rose shrimp (*Parapenaeus longirostris*) is one of the main crustacean species for otter bottom trawl fisheries in GSA 1. It is an important component of landings in some ports and occasionally a target species of the trawl fleet composed of approximately 79 vessels (2020) that operate on the upper slope.

The annual landings (Y) fluctuated during the series and increased in the last five years, reaching 483 tonnes in 2020.

Data and parameters: The assessment was carried out using official landings and data on the length–frequency distribution (LFD) of otter bottom trawl catches for the years 2002–2020. Catch-at-length data were converted into catch-at-age using cohort slicing procedures. The LFD for 2020 was reconstructed (January–June months) based on the 2018–2019 average. The length–weight relationship and maturity ogive came from Spanish DCF and the natural mortality vector was estimated using PRODBIOM (Abella *et al.*, 1997). Abundance index series from MEDITS trawl surveys was used for the XSA and a4a model analysis. Abundance indices for the year 2020 were reconstructed from the GAM estimate, testing five different scenarios.

Assessment method: The state of exploitation of this stock was assessed by means of VPA XSA (Shepherd, 1999) and the SCAA stock assessment model a4a (Jardim and Millar, 2014). The software used for both models was implemented in R (FLR, flr-project.org). Yield per recruit and spawning-per-recruit (SSB/R) analyses were conducted based on the exploitation pattern resulting from the a4a model and population parameters.

Model performance: Sensitivity and retrospective analyses were applied in the a4a model in order to check the robustness of the assessment. A deterministic short-term prediction for the period from 2021 to 2023 was performed using the FLR libraries and scripts and was based on the results of the assessment model. The final model considered for the assessment was a4a. The assessment was updated as of 2020.

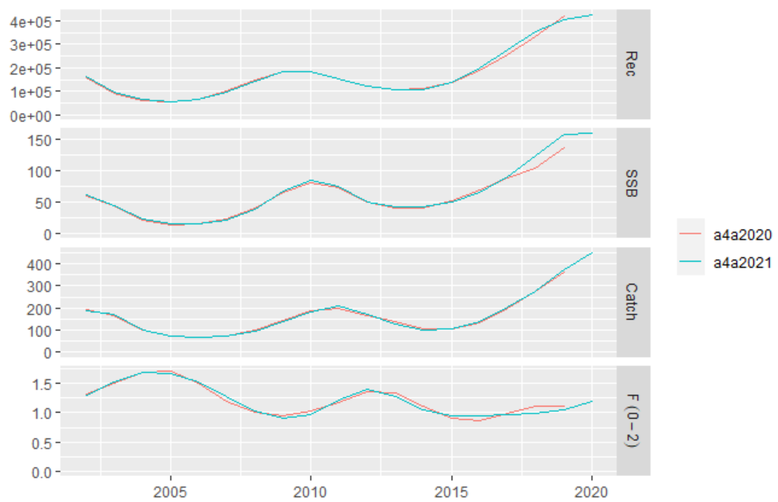
Results: Since 2002, the population indicators (SSB and R) fluctuated, with low recruitment values from 1.4 to close to 1. In the last six years, F remained stable with values close to 1.

$F_{current} = F_{bar}$ ages 0–2 (2020)	1.21 (±0.44)
$F_{0.1}$ (present assessment)	0.7
$F_{current}/F_{0.1}$	1.73
$SSB_{current(2020)\ tonnes}$	157
SSB 33rd percentile biomass(tonnes)	42
SSB 66th percentile biomass(tonnes)	66

Diagnosis of stock status: The stock is in overexploitation, with relatively high biomass.

Advice and recommendations

- Reduce $F_{current}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort



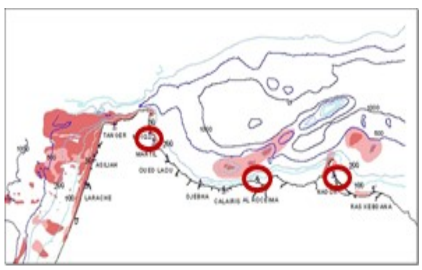
Comparison of the outputs of the previous year's assessment (red line) and the updated assessment performed this year (blue line).

N: 9

Stock: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 3

Author(s): Benchoucha, S., Settih, J. and Hernandez, P.



Fishery: This species is one of the most important commercial demersal species in the Alboran Sea and is targeted by trawl fisheries in GSA 1. The trawlers operating from the M'diq port target this species between Fnideq and Jebha, at depths between 70 m and 360 m; Nador trawlers operate between Saidia and Jebha, at depths ranging from 68 m to 470 m; and Al-Hoceima trawlers operate from Sidi Hssaine to Jebha, at depths of 18 m to 200 m.

This fleet is multi-specific and target shrimp in addition to other groups of fish. All units in the fleet are made of wood, have a mean length of 22 m and conservation the shrimp with ice. While the fleet uses many types of trawls, the most common are: 2 m vertical open trawls, used to catch benthic species like soles, octopus and shrimps; and 5 m vertical open trawls, used to catch benthic and semi-pelagic species.

In 2020, 89 trawlers operated in the Alboran sea and targeted deep-water rose shrimp along with other species including *Octopus vulgaris, Trachurus trachurus* and *Pagellus acarne*. The landing size composition distribution for deep-water rose shrimp in 2020 is unimodal with a mode of about 23 mm (representing 13.5 percent of the exploited sizes). The sizes range between 21 mm and 27 mm with an average carapace length of about 23.80mm. The majority of the population (62 percent) are male and the L50 maturity is about 22.61 mm carapace length.

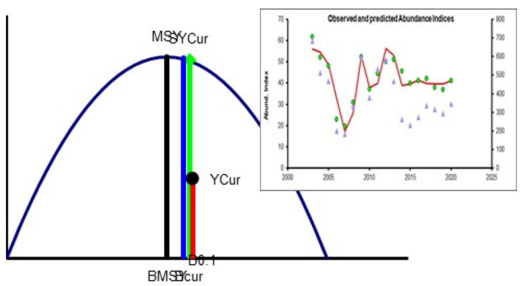
Data and parameters: Official trawler landings and CPUE (fishing days) from 2003 to 2020 were used to run Biodyn. Landing length composition from 2017 to 2020; growth parameters (K = 0.39, L_{inf} = 45 mm); length–weight relationship parameters (a = 0.0019, b = 2.6113; Garcia *et al.*, 2009); and M scalar values of 0.8 year^{-1} (Thomson and Bell), 1.21 year^{-1} (Pauly), 1.41 year^{-1} (Hewitt Hoenig) and 1.47 year^{-1} (Alverson Carney) were used for length cohort analysis (LCA) and Y/R. The results using M = 0.8 year^{-1} (Thomson and Bell) were adopted.

Assessment method: The estimation was performed using the analytical and global assessments approaches: LCA and Y/R as well as the global model BioDyn, based on the Schaeffer production model.

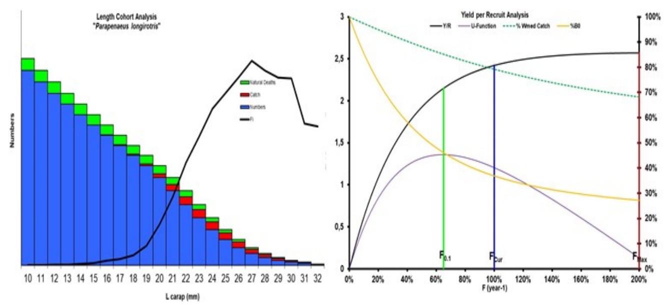
Model performance: The adjustments were very good for the models with a high R Pearson index for the Biodyn model.

Results: The ratio $B_{current}$/ $B_{0.1}$ was about 104 percent, showing an optimal current biomass. The ratio $F_{current}/F_{0.1}$ was 154 percent. The $F_{current}$ exceeded the $F_{0.1}$ by 54 percent, showing a situation of overexploitation.

Biodyn



LCA–Y/R



Diagnosis of stock status: Possibly in overexploitation with biomass above reference point.

Advice and recommendations: Reduce the fishing mortality on a precautionary basis.

N: 10

Stock: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 4

Author(s): Rouidi, S., Filali, T., Ainouche, N., Mennad, M., Hernández P. and Ramirez, J.

Fishery: Deep-water pink shrimp (*Parapenaeus longirostris*) is one of the main crustacean species targeted by trawlers in GSA 4. It is an important component of landings in the western area, occasionally targeted by trawlers operating on the upper slope. In 2020, 59 percent of catches came from the Alboran part of GSA 4. The annual landings fluctuated during all of the assessed series; for 2020, the catches increasing comparatively to the last two years.

Data and parameters: Length–frequency data came from commercial catches of six years (2015–2020) from sampling in the western area and were used to extrapolate national landings. Growth parameters and the length–weight relationship came from national fisheries research programs (CNRDPA, 2017), the ogive maturity was estimated from the national data collection and the M vector was obtained through PRODBIOM (Abella *et al.*1999), all of these parameters were used to run a pseudo-cohort analysis.

Assessment method: National catch-at-age data were constructed using the Plyr package (Slicing), while VIT and Y/R analysis were performed using Vit software for each year separately and the average of three years (i.e. 2015, 2016, 2017, 2018, 2019, 2020, 2015–2017, 2016–2018, 2017–2019 and 2018–2020). In order to provide support for this assessment, a second assessment was performed using the LBSPR model. This model was used to simulate the expected equilibrium length composition, Y/R, and spawning potential ratio (Hordyk *et al.*, 2016), and was performed using the R program.

Model performance: The Vit program was developed to assess exploited fish stocks in data-poor situations. It was used to develop qualitative conclusions for several years during GFCM meetings. Quantitative interpretations of stock parameters are recommended when the model is applied to short time series of more than one year and the resulting variation of the parameters is reasonably low. Sensitivity of the model was tested using several terminal F and mean fishing mortality for the ages most frequently present in catches each year and the average pseudo-cohort was used to estimate $F_{current}$. Results from the model may form the basis for scientifically sound fisheries management advice for medium-term periods. However, the likely low precision of results prevents their transfer to any precise short-term forecasts.

The LBSPR model is fit to length data to estimate selectivity, relative apical fishing mortality, and the spawning potential ratio for data-limited fisheries. The length composition is used to estimate the spawning potential ratio (SPR) for data-limited stocks by developing a computationally efficient length-structured per-recruit model that splits the population into a number of subcohorts, or growth-type-groups, to account for size-dependent fishing mortality rates (Hordyk *et al*., 2016).

Results: The pseudo-cohort analysis (VPA) revealed that age classes 0–2 were the most exploited in GSA 4 and $F_{current}$ was higher than $F_{0.1}$, indicating an overfishing status of deep-sea rose shrimp. The LBSPR model showed that the $SPR/SPR_{40\%}$ ratio was lower than 0.4 which indicates an overfishing status.

VPA with VIT program		LB-SPR model
$F_{current}$ ($F_{bar\ 0–2}$ in 2020)	1.67	raw SL 50 = 21.98
$F_{0.1}$ (2020)	0.72	raw SL 95 = 27.18
$F_{current}/F_{0.1}$	NA	raw FM = 3.19
Current SSB (tonnes)	981	$SPR/SPR_{40\%}$ = 0.31

Diagnosis of stock status: Possibly in overexploitation and biomass above reference point.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

N: 11

Stock: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 5

Author(s): Farré, M., Guijarro, B., González, N. and Soldán, V.

Fishery: In the Balearic Islands, commercial bottom trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope, mainly targeted to: i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50–80 m); ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the deep shelf (80–250 m); iii) *Nephrops norvegicus*, but with an important bycatch of big *Merluccius merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the upper slope (350–600 m); and iv)

Aristeus antennatus on the middle slope (600–750 m). The deep-water rose shrimp (*P. longirostris*) is a bycatch species mainly exploited on the upper slope. The species has importantly increased in landings since 2017, ranging from 60–100 tonnes (mean values of landings were lower than 50 tonnes from 2000 to 2017).

Data and parameters: Size composition of commercial trawl catches and official landings (2001–2020) and survey indices (2001–2020). Biological parameters were obtained from studies carried out in the area: growth from Guijarro *et al.* (2009); length–weight relationship and maturity ogive from the DCF; M vector calculated from PRODBIOM.

Assessment method: Both XSA and a4a were used. XSA was selected to provide the final advice. Yield per recruit analysis and short-term forecast were carried out. The assessment is an update from the previous year, 2019.

Model performance: The XSA residuals did not show any trend and the model showed quite a good fit.

Results: The population parameters showed the highest values at the beginning and at the end of the data series, with very low values in the intermediate years. Historical data show that catches of this species are usually low, with important peaks in certain periods (e.g. 2001–2003 and 2017–2020). Both recruitment and SSB showed minimum values in 2005–2006, with a certain recover since then until a high increase for the last four years.

$F_{current}$ (mean 2018–2020, ages 0–2)	1.70
$F_{0.1}$ (2020)	0.82
$F_{current}/F_{0.1}$	2.07
SSB (mean 2018–2020, tonnes)	78.8
33rd percentile SSB (tonnes)	8.6
66th percentile SSB (tonnes)	27.4

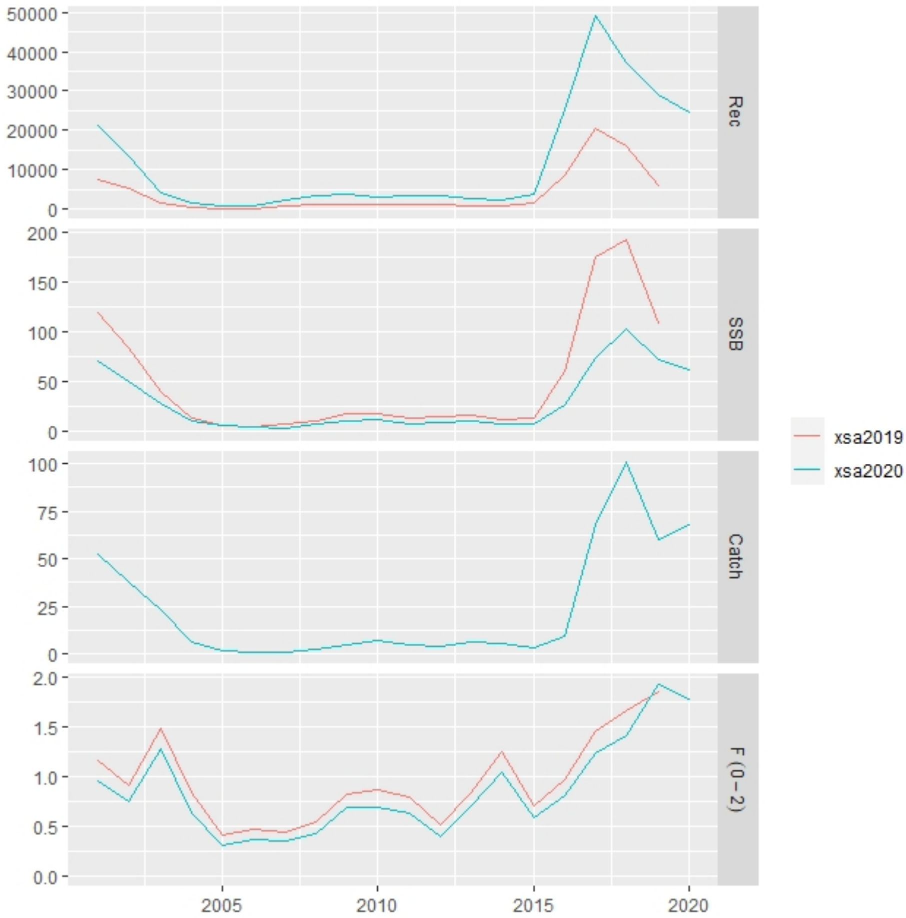
Diagnosis of stock status: The stock is overexploited, with relatively high biomass.

Advice and recommendations: Reduce fishing mortality.

Data issues: Information used was the official one submitted to the GFCM. Due to the partial lack of data of the commercial fraction in 2020 due to the COVID-19 outbreak, size composition was completed, weighting the lacking length distribution to the total catch of the year.

Issues for future benchmarks: Stock boundaries should be investigated. The M value was computed using methodologies created for fish species and therefore other approaches should be taken into account. Slicing may take into account sex-dependent growth parameters.

Comparative plot:



Comparison of the outputs of the previous year's assessment and the updated assessment performed this year.

N: 12

Stock: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 6

Author(s): Vivas, V., Pérez Gil, J.L., García, E. and Esteban, A.

Fishery: Deep-water rose shrimp is exploited by bottom trawlers. This fishery is developed along the deep continental shelf targeting hake and crustaceans. Vessel length is between 12–24 m.

In the area, there are 25 harbours with deep-water rose shrimp landings and a total of 383 vessels as of 2020.

Total landings in GSA 6 between 2001 and 2020 were around 5 879 tonnes with a total effort of 365 207 days. In 2020, landings were around 1 095 tonnes with a total effort of 36 635 fishing days and a mean CPUE of 30.02 kg/day. Discards of deep-water rose shrimp are negligible.

Data and parameters: Size composition of commercial trawl catches, official landings and data from MEDITS surveys (2001–2020). Biological parameters were obtained from studies carried out in the area: growth from Guijarro *et al.*, (2009); length–weight relationship and maturity ogive from the DCF; M vector calculated from PRODBIOM. (Abella *et al.*, 1997)

Assessment method: Extended survivor analysis (FLR), FLBRP package for Y/R analysis and Flash package for short-term forecast. This is an updated assessment.

Model performance: Log catchability residuals and retrospective analysis suggest that the model is consistent.

Results: Recruitment, SSB and landings showed the highest values at the beginning, and particularly at the end of the data series (2001–2020), with very low values in the intermediate years. Both recruitment and

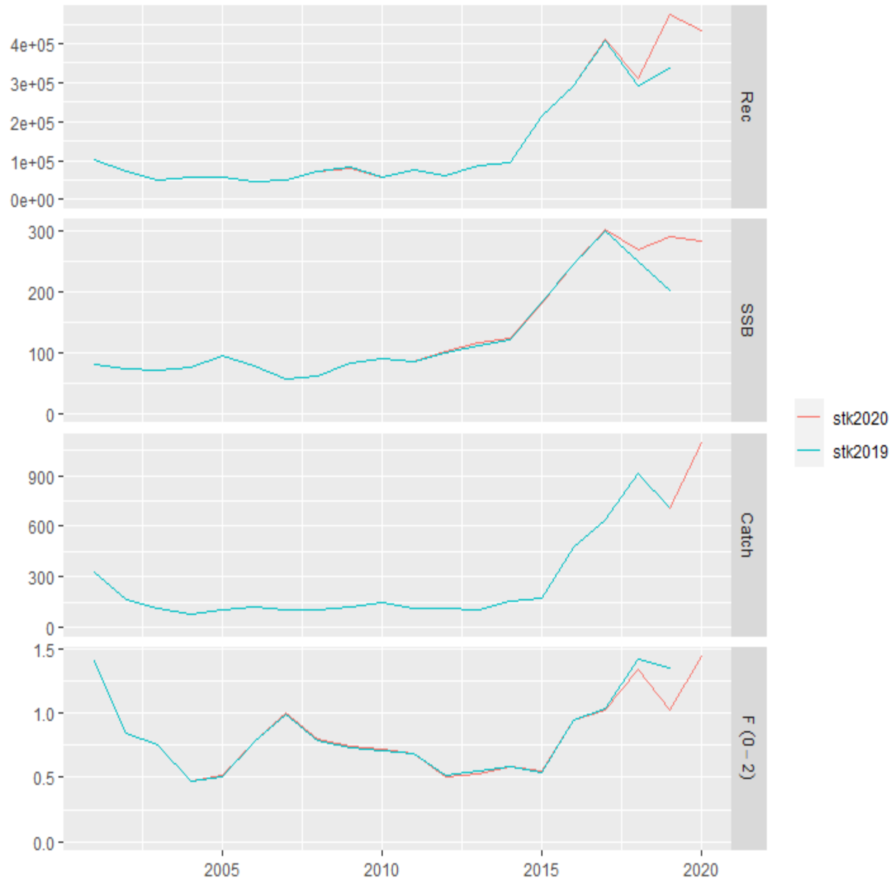
SSB showed minimum values from 2004 to 2008. Fishing mortality showed an increasing trend in last five years.

$F_{current}$ ($F_{bar\ 0-2}$) 2018–2020	1.27
$F_{0.1}$ (2020)	0.79
$F_{current}/F_{0.1}$	1.60
Current SSB (tonnes) 2018–2020	281.7
33rd percentile SSB (tonnes)	81.3
66th percentile SSB (tonnes)	119.8
Recruitment (thousands)	43 3207

Diagnosis of stock status: In intermediate overexploitation, with relatively high biomass.

Advice and recommendations (in terms of research and, when possible, in terms of management):

- Reduce $F_{current}$ towards $F_{0.1}$



Comparison of the outputs of the previous year's assessment (blue line) and the revised assessment performed this year (red line).

N: 13

Stock: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 9, 10, 11

Author(s): STECF

Fishery: In the present assessment, the stock was assumed to be confined within the boundaries of GSAs 9, 10 and 11. In GSA 9, the species shows a wide bathymetric distribution, being present from 50 to 650 m depth with greatest abundance between 150 and 400 m depth over muddy or sandy-muddy bottoms. The highest abundances have been found in the Tyrrhenian part of the GSA (south Tuscany and Latium). In GSA 10, aggregations with higher abundance were localized between 100 and 200 m depth, with some intrusions in the deeper waters of the three subareas. Two of the most important patches are located in the Gulf of Naples and along the Calabrian coasts in correspondence with Cape Bonifati, while a third one is located in the Gulf of Salerno. These are the areas where the main nurseries are also localized. The deep-water rose shrimp, along with hake and red mullet, is a key species of fishing assemblages in the area. In the last decade it was generally also ranked among the species with higher abundance indices (number of individuals) in the trawl surveys as observed for different Mediterranean areas. The species is caught on the same fishing grounds as European hake and the production of this shrimp has been steadily growing in the last decade in the southern basin and reached, in 2006, about 10 percent of demersal landings. The core of the nursery areas in GSA 9 overlap with crinoid bed (*Leptometra phalangium*) areas over the shelf-break. This is a peculiar habitat in GSA 9, which is also an essential fish habitat for other commercially important species as the European hake.

Data and parameters: Size composition of commercial trawl catches and official landings (2009–2020), MEDITS survey indices (2009–2020). Growth parameters and maturity ogives were gathered from the Italian National Data Collection Programme, while the M vector was estimated using the Chen and Watanabe model.

Assessment method: Statistical catch-at-age (a4a, FLR), FLBRP package for Y/R analysis and Flash package for short-term forecast.

Model performance: Model residuals did not show any trends. Overall diagnostics are acceptable, and retrospective analysis is consistent.

Results: Spawning stock biomass showed an increasing trend, reaching a maximum value in 2016, followed by another increase in 2018. A similar trend was observed for recruitment that reached the peak in 2016. F decreased after 2014, but increased again in the last years.

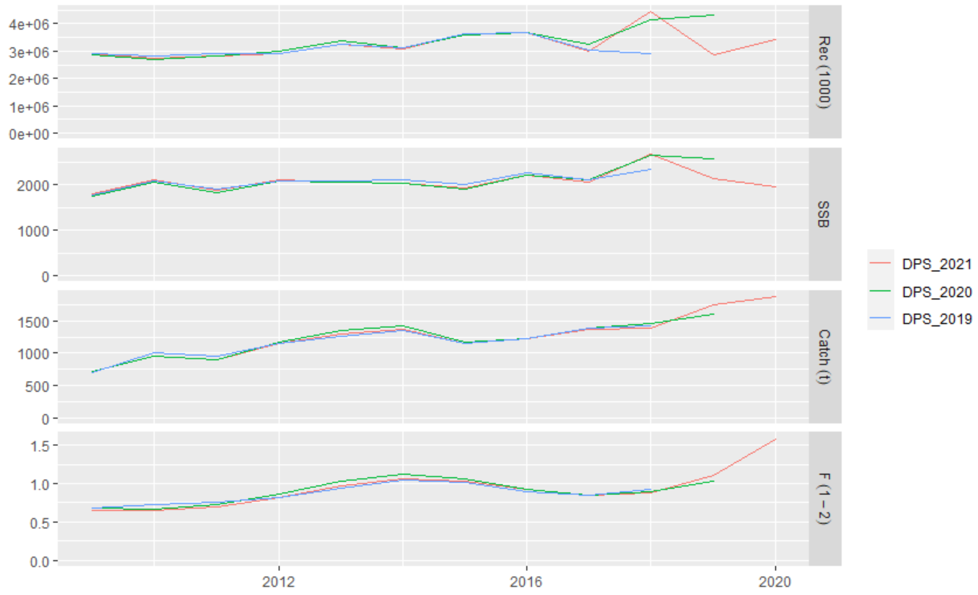
$F_{current}$ (2020, ages 1–2)	1.58
$F_{0.1}$ (2020)	1.29
$F_{current}/F_{0.1}$	1.22
Current SSB (tonnes)	1 960
33rd percentile biomass (tonnes)	2 017
66th percentile biomass (tonnes)	2 112

Diagnosis of stock status: In low overexploitation, with relatively low biomass.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

- Progressive reduction of the fishing effort



Comparison of the outputs of the previous years' assessments (blue and green lines) and the updated assessment performed this year (red line).

N: 14

Stock: Black-spotted seabream (*Pagellus bogaraveo*)

GSA: 1, 3

Author(s): Herrera, J.G., Benziane, M., Rueda, L., Serghini, S., Benchoucha, S. and Hernández, P.

Fishery: This species is one of the most important commercial demersal species in the Strait of Gibraltar area. Discards may be considered negligible. However, there is not much information available on the stock structure of *P. bogaraveo* in this narrow site. The Spanish fishery targeting blackspot seabream has been developing along the Strait of Gibraltar since the early 1980s. It is almost a mono-specific fishery, with one clear target species representing 74 percent of the total landed species, which constitutes a metier by itself. The "voracera", a local mechanized hook line baited with sardine, is the gear used by the fleet from the Tarifa and Algeciras ports in Spain. The most important Moroccan fleets targeting blackspot seabream (among other species) are the longliners mainly based at the port of Tangier and the artisanal fleet of the Strait of Gibraltar area. The fishery is carried out at 200–700 m depth and the gear used is also the longline known as "voracera". The Moroccan fishery is considered multi-specific. A consistent portion of landings (even from Morocco) is sold in the Spanish market.

Data and parameters: Landings, nominal fishing effort and length composition from Spanish and Moroccan "voracera" fleets, when available. Biological parameters (sex ratio) came from Spain and Morocco sampling programmes while ageing came from the Spanish National Data Collection Programme. Standardized CPUEs from Spain and Morocco as biomass index since 2009. The M scalar value of 0.2 and fixed length–weight relationship (a = 3.14 and b = 0.0087, respectively). The model length range was 18 to 62 cm and the ages ranged from 3 to 17. Likelihood weights were fixed from the first draft model (no biomass index in 2020) according to the benchmarks.

Assessment method: Globally applicable area-disaggregated general ecosystem toolbox (gadget) model using the Rgadget package.

Model performance: The assessment presented is an update of the 2019 benchmark model.

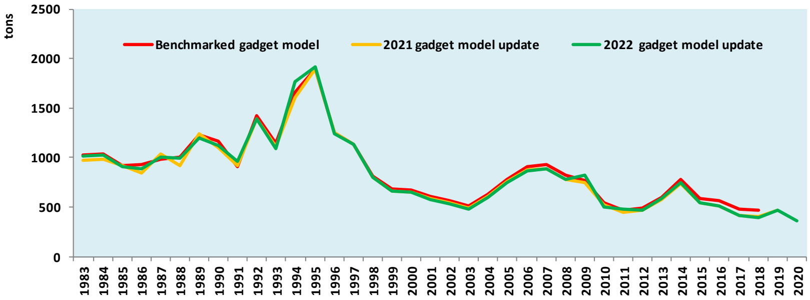
Results:

$F_{current}$ (2020) F_{bar}ages4–16	0.20
F_{MSY} (benchmark assessment)	0.26
Blim (benchmark assessment), females pop (tonnes)	264
$SSB_{current}$ (2020), females pop (tonnes)	241
$F_{current}/F_{MSY}$	0.78

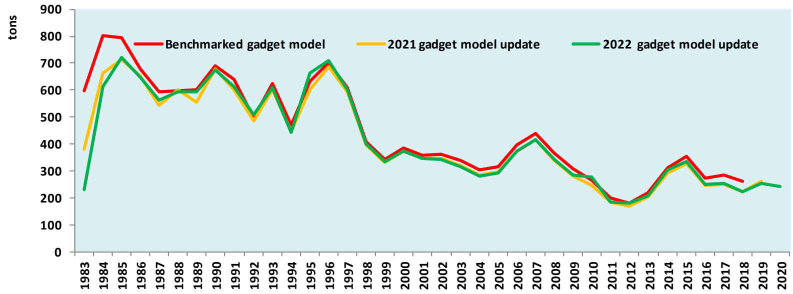
Diagnosis of stock status: Overexploited with a low fishing mortality.

Advice and recommendations:

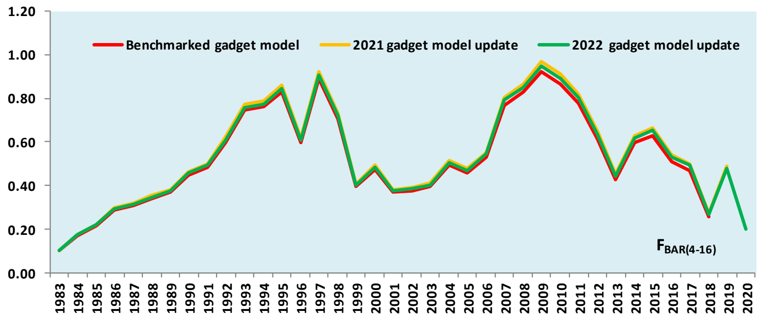
- Reduce fishing mortality and/or implement a recovery plan.



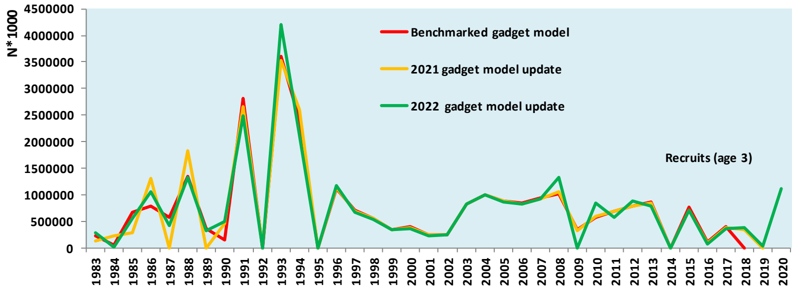
Total stock biomass – males and females.



Spawning stock biomass – females



Fishing mortality rates



Recruits at age 3

Blackspot seabream Strait of Gibraltar population: comparison of the outputs from the benchmark assessment (red line), the 2021 update (orange line) and the 2022 assessment (green line).

N: 15

Stock: Red mullet (*Mullus barbatus*)

GSA: 1

Author(s): García-Rodríguez, E., Vivas, M., Esteban, A., Pérez-Gil, J.L., Ruíz García, C., González, M., Torres, P., Serna, J.M. Acosta, J., Ciercoles, C. and León, E.

Fishery: In GSA 1, red mullet are among the most important target species for the trawl fisheries. It is largely exploited in all trawlable areas, both sandy and muddy bottoms, mainly by trawlers on the shelf, but also by small-scale fisheries in particular trammel nets (about the 12 percent of the catches). The amount of discards reported is very low and considered to be negligible. Trawl fisheries developed along the continental shelf and upper slope are multi-specific. Smaller vessels operate almost exclusively on the continental shelf (targeting red mullets, octopus, hake and sea breams) and bigger vessels operate almost exclusively on the continental slope. Remaining vessels can operate on the continental shelf and slope fishing grounds. Red mullet is intensively exploited during its recruitment from September to November. The total trawl fleet has declined from 2003 to 2020.

Data and parameters: The information used for the assessment were the total annual landings from official statistics, the annual catch in number by size class estimated through monthly port sampling and onboard observers and the abundance index from MEDITS surveys. Growth parameters were those used in previous assessments by STECF and the GFCM for GSA 6 (Demestre *et al*., 1997). Length–weight relationship and maturity ogive came from Spanish DCF and the vector of natural mortality by age was calculated using the Chen and Watannabe model (Chen and Watannabe, 1989). Selectivity experiences carried out by the Spanish Institute of Oceanography (IEO-CSIC) with a 40 mm diamond and square mesh in the codend were also used.

Assessment method: Statistical catch-at-age model (a4a) and Y/R analysis; FLR.

Model performance: Log catchability residuals and retrospective analysis suggest that the model is consistent.

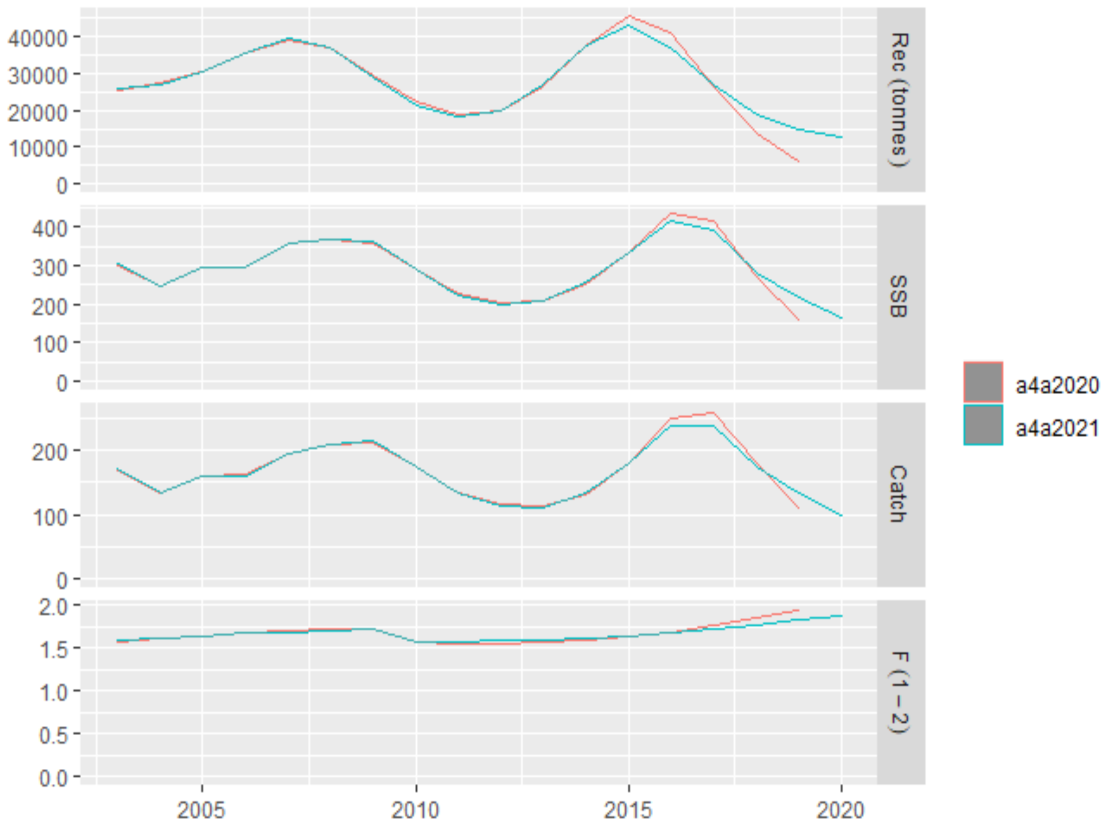
Results: Recruits showed fluctuations from 2003 to 2020 peaking in 2015 and decreasing afterwards. The SSB showed fluctuations during the assessed period with the lowest values from 2011 to 2013 and highest values in 2016 and 2017, decreasing again until 2020. A similar pattern was observed for catch. Fishing mortality showed an increasing trend until 2008 when it began to decrease until 2010, raising afterwards and reaching maximum values during 2020. $F_{current}$ (1.88) is higher than $F_{0.1}$ (0.29), chosen as proxy of FMSY, which indicates that red mullet stock in GSA 1 is in high overfishing with relatively low SSB.

$F_{current}$ (mean FBAR ages 1–2) (2020)	1.88
$F_{0.1}$ (present assessment)	0.29
$SSB_{current}$ (tonnes) (2020)	165
SSB (33rd)	253
SSB (66th)	311
$F_{current}/F_{0.1}$	6.48

Diagnosis of stock status: In overexploitation ($F_{current} > F_{0.1}$) with relatively low biomass ($SSB_{current}$ < SSB at 33rd percentile).

Advice and recommendations (in terms of research and, when possible, in terms of management):

- Reduce $F_{current}$ towards $F_{0.1}$



Comparison of the outputs of the previous year's assessment (red line) and the updated assessment of this year (blue line).

N: 16

Stock: Red mullet (*Mullus barbatus*)

GSA: 6

Author(s): García-Rodríguez, E., Vivas, M., Esteban, A., Pérez-Gil, J.L. and Cristina Ruíz García.

Fishery: Both species of red mullet, *Mullus surmuletus* and *M. barbatus*, are exploited by trawl and artisanal fleets in GSA 6, although small gear (trammel nets and gillnets) account for only 5 percent of the total landings of these species (Demestre *et al.*, 1997). Trawl fisheries developed along the continental shelf and upper slope are multi-specific. Small vessels (12–16 m length) operate mainly on the shallow shelf targeting red mullet, octopus, cuttlefish and seabream. Medium and large vessels usually operate on the deep continental shelf and slope areas targeting hake and crustaceans, but some of these units can also operate on the shallow shelf, depending on weather conditions or market prices. Red mullet is more intensively exploited from September to November coinciding with the recruitment period of this species (Martín *et al.*, 1999). The total trawl fleet in GSA 6 has declined from 810 boats in 1998 to 401 boats in 2020; around 30 percent of these boats regularly operate on the shallow shelf.

According to official statistics, the fishery developed quickly during the 1970s, reaching a maximum of 1 669 tonnes in the year 1982. Since then, landings have widely oscillated around a mean value of 1 205 tonnes (2004–2020) although a decreasing trend has been observed. Catches from the period 2004–2010 were composed mainly by individuals of age groups 0 and 1. After the enforcement of the new mesh type in 2010 (40 mm square, or alternatively, 50 mm diamond), catches from 2011–2020 were composed mainly of individuals of age groups 1 and 2.

Data and parameters: The information used for the assessment were the total annual landings from official statistics, the annual catch in number by size class estimated by monthly port sampling and o board observers and the abundance index from MEDITS surveys. Growth parameters were those used in previous assessments conducted by STECF and the GFCM for GSA 6 (Demestre *et al.*, 1997). Length–weight relationship and maturity ogive came from Spanish DCF and the vector of natural mortality by age was calculated with Caddy´s formula, using the PROBIOM Excel spreadsheet (Abella *et al.*, 1997). Selectivity experiences carried out by the IEO with 40 mm diamond and square mesh in the codend were also used.

Assessment method: Statistical catch-at-age model (a4a), Y/R analysis and short-term projections; FLR.

Model performance: Log catchability residuals and retrospective analysis suggest that the model is consistent.

Results: The average fishing mortality for ages 1–2 and catches showed a slightly decreasing trend, while an increasing trend in SSB and recruitment were identified in the studied period. The $F_{current}$ (1.57) is higher than $F_{0.1}$ (0.31), chosen as proxy of FMS, which indicates that red mullet stock in GSA 6 is in high overfishing with relative high biomass and SSB.

$F_{current}$ (F_{BAR} ages 1–2 (2020)	1.57
$F_{0.1}$ (present assessment)	0.31
$SSB_{current}$ (tonnes)	1171
SSB (33rd)	580
SSB (66th)	826
$F_{current}/F_{0.1}$	5.06

Diagnosis of stock status: In overexploitation ($F_{current} > F_{0.1}$) with relatively high biomass ($SSB_{current}$ > SSB at 66th percentile)

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

Comparison of the outputs of the previous year's assessment (blue line) and the updated assessment performed this year (red line).

N: 17

Stock: Red mullet (*Mullus barbatus*)

GSA: 7

Author(s): STECF

Fishery: Red mullet (*Mullus barbatus*) in the Gulf of Lions (GSA 7) is a shared stock exploited by both Spanish and French trawlers, and since 2011 also by French artisanal gear (GNS, GTR). The French fleet is usually responsible for approximately 90 percent of the catch, most of which results from trawlers (> 95 percent). Trawlers exploit smaller size classes (7–25 cm) than nets (12–30 cm). Landings in recent years vary around 300 tonnes with the maximum in 2016 and the minimum in 2002. Landings of gear other than OTB, GNS and GTR are on average less than 1 percent. Since 2014, the French trawl fleet has been separated by OTB, OTM and OTT trawlers. The majority of landings are due to OTB, but OTT have had an increasing importance in the last few years.

Discards have been regularly reported since 2010. They are mostly composed of small individuals and account for 1–5 percent of the landed biomass, depending on the year. In 2019, discards of small individuals have been particularly important. No analysis on effort data were carried out during the meeting

Data and parameters: The use of fast growth parameters was questioned and they were compared with two alternatives: i) fitting a Von Bertalanffy model to the age-reading data available for GSA 7; and ii) building a global age–length key (ALK) directly from the data. Cohort consistency is clearly improved when age slicing is performed with either the fitted growth model or the ALK. Between both, ALK provides a slightly better cohort consistency. Therefore the choice was for ALK to perform the assessment. For the purpose of computing biomass and average weights at age from numbers at length, a length–weight relationship fitted on individual DCF sample data – the same that were used to produce the ALK – was used. It was assumed that young individuals reach maturity when they arrive at age 1 on 1 July. For ages greater than one, all individuals were considered to be adults. Natural mortality was based on the Chen and Watanabe formula. French and Spanish DCF data were provided from 2002 to 2020. The input data for the assessment were the landings and discards at age; MEDITS data at age; average weight at age of landings, discards and survey.

During STECF Expert Working Group (EWG) 21-02, missing LFDs were reconstructed for the main Spanish fleet with catches of red mullet in GSA 7. The LFDs for the metier OTB_MDD (2009–2019) and OTB_NA (2002–2003) were reconstructed from the median OTB LFDs at fleet level, applying SOP correction (STECF, 2021).

For MEDITS 2020, since abundance at length was corrected, biomass at length was reconstructed from the corrected abundance at length using the length–weight relationship.

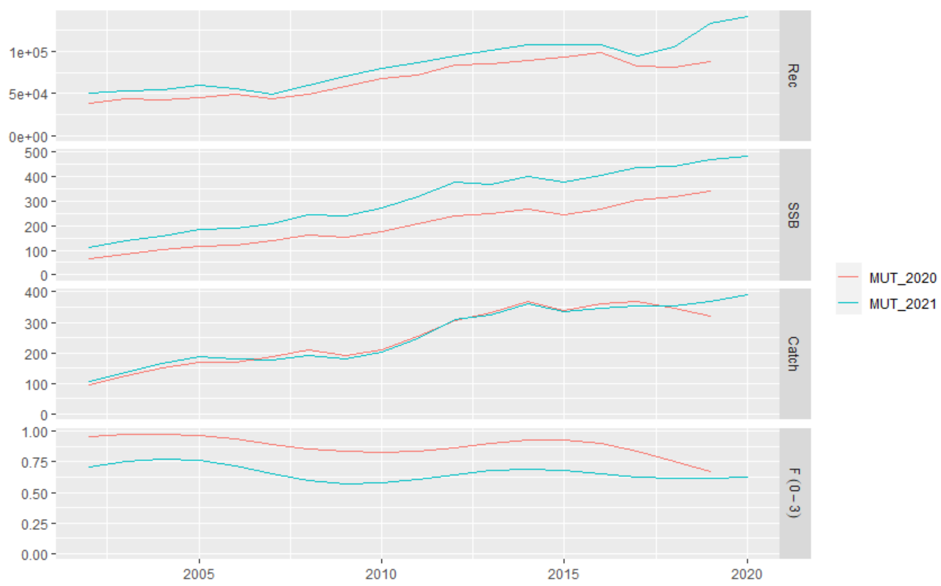
Assessment method: Statistical catch-at-age model (a4a) (Jardim *et al.* 2015) and FLBRP package FLR. The assessment was carried out over the period 2002–2020, calibrated with fishery independent survey abundance index (MEDITS). To select the final model for assessment, combinations of various options for the three submodels regarding fishing mortality, survey catchability and stock-recruitment inspired from previous assessment and other areas (notably GSAs 5 and 6) were investigated. All combinations of options for the three submodels were tested, recovering Bayesian Information Criterion (BIC) and generalized cross-validation (GCV) score for each combination. Compared to last year, the number of knots in the smoother for the year in the F submodel was increased from 5 to 6 to account for the increased time series.

Model performance: Log-residuals exhibited few patterns, except for positive residuals at age 1 for the catch in the first half of the series (up to 2010). Further investigations should be carried out next year to solve this somewhat moderate issue if it remains.

Results:

$F_{current}$ F_{bar} ages 0–3(2020)	0.624
$F_{0.1}$ (present assessment)	0.456
$SSB_{current}$ (tonnes)	483
SSB (33rd)	239
SSB (66th)	375
$F_{current}/F_{0.1}$	1.37

Diagnosis of stock status: To define reference points F01 (as a proxy for FMSY) and Fmax, a Y/R analysis was carried out in R using FLBRP. This led to the following estimates: $F_{01} = 0.456$; $F_{current} = 0.624$ and the resulting ratio $F_{01}/F_{current} = 1.37$, suggesting that the stock is currently over-harvested.



Comparison of the outputs of the previous year's assessment (red line) and the updated assessment performed this year (blue line).

References

STECF. 2021. *Methods for supporting stock assessment in the Mediterranean* (STECF-21-02). Luxembourg, Publications Office of the European Union. https://doi.org/10.2760/457201

N: 18

Stock: Red mullet (*Mullus barbatus*)

GSA: 9

Author(s): STECF

Fishery: The fishing gear used to catch red mullet (*Mullus barbatus*) in GSA 9 together with other species (mixed catches) are gillnets (GNS), trammel nets (GTR) and bottom trawls (OTB).

Discard of red mullet in GSA 9 occurs mainly from the catches of bottom trawls (OTB). Discard data were available in 2006 and for all years since 2009. For the assessment purposes, in the years where discard data were missing, approximations were made taking into account the percentage of catch discarded in previous and/or following years.

Data and parameters: Growth parameters of red mullet in GSA 9 were available from 2006 to 2020 from DCF data. For the aim of the stock assessment a set of von Bertalanffy parameters given by the average along the years was used. Since the assignment of the age in the ALK considered the middle of the year as the birth date of red mullet, while the a4a model was parameterized with the calendar year, it was agreed to shift the growth curve by adding 0.5 to t_0 for internal consistency in the stock assessment model. Natural mortality was estimated according to the Chen and Watanabe model (1989). An agreed vector of maturity was used for all red mullet stocks in the western Mediterranean. The DCF was the source for data on catches, landings, discards, length frequency distributions and MEDITS index over 2004–2019. The MEDITS data showed large variations between years. In 2017 and 2020, the survey was carried out in September–October. Due to the variability of survey timing, age 0 class was not included in the tuning indices used for the assessment. In addition, a sensitivity analysis was performed to show no significant effects of late surveys on the results of the assessment. Age slicing using the length frequency distributions of landings, discards and survey was carried out by sex (in combination with sex ratio at length) and then data were combined.

Assessment method: Statistical catch-at-age model (a4a; Jardim *et al.* 2015) and FLBRP package. FLR.

Model performance: Log residuals of the catch and abundance indices related to outcomes of the best run did not show any particular trends.

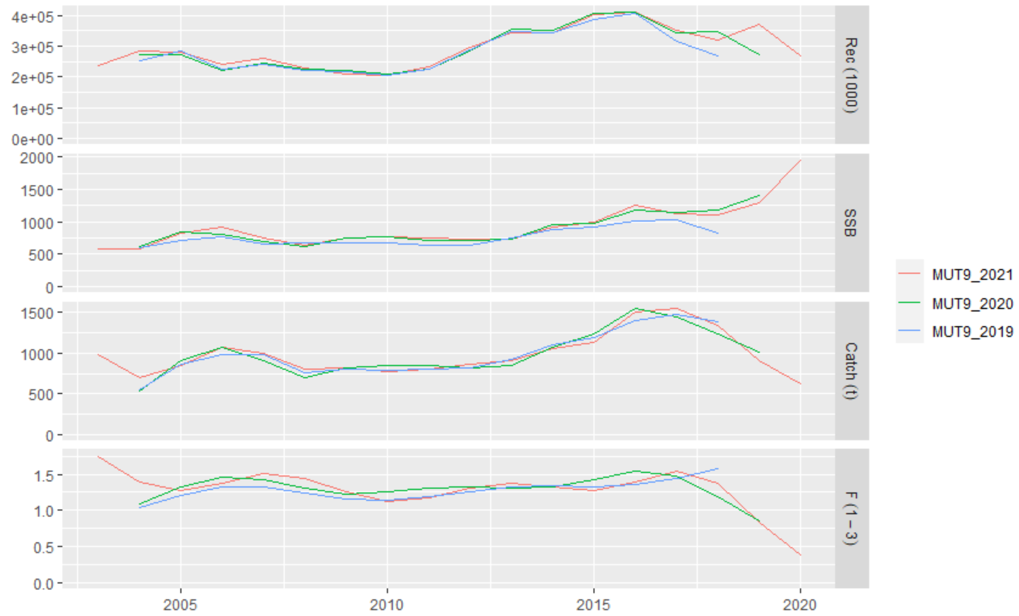
Results: The estimated SSB and recruitment show a sharp increase in recent years and are the highest of the time series. This is consistent with the increase in total catch and the increase in the MEDITS abundance survey indices.

$F_{current}$ F_{bar} ages 1–3 (2020)	0.37
$F_{0.1}$ (present assessment)	0.52
$SSB_{current}$ (tonnes)	1950
SSB (33rd)	744
SSB (66th)	942
$F_{current}/F_{0.1}$	0.71

Diagnosis of stock status: Sustainable exploitation ($F_{current} < F_{0.1}$) is above 1.66 with relatively high biomass (SSB higher than the 66th percentile).

Advice and recommendations:

- Not to increase fishing mortality



Comparison of the outputs of the previous years' assessments (blue and green lines) and the updated assessment performed this year (red line).

N: 19

Stock: Red mullet (*Mullus barbatus*)

GSA: 10

Author(s): STECF

Fishery: The fishing gear used to catch red mullet in GSA 10 together with other species (mixed catches) are gillnets (GNS), trammel nets (GTR) and bottom trawls (OTB).

The discard data, in the years with no available information, were reconstructed on the basis of the discard data available and included in the assessment.

Data and parameters: The information on the ALK and on the growth von Bertalanffy parameters was available from 2002 and appeared consistent with the recent paper of Carbonara *et al.* (2018) on age validation of red mullet in Adriatic Sea. Natural mortality was estimated according to the Chen and Watanabe model (1989). Maturity ogives by length and age were available from 2002 to 2018 by sex. The DCF was the data source for landings, discards and MEDITS survey. The MEDITS data showed large variations between years. In 2017, the survey was carried out in October–November. Data on landings and discards in 2017 were incomplete. Age 0 class was not included in the tuning indices used for the assessment.

Assessment method: Statistical catch-at-age model (a4a; Jardim *et al.* 2015) and FLBRP package; FLR.

Model performance: The assessment was carried out over the period 2004–2020. Log residuals of the catch and MEDITS abundance indices related to the best run do not show any particular trends over time with the possible exception of MEDITS ages 1, 3 and 4, which might be due to the change in timing for the survey over time. However the fit to catch was without trend.

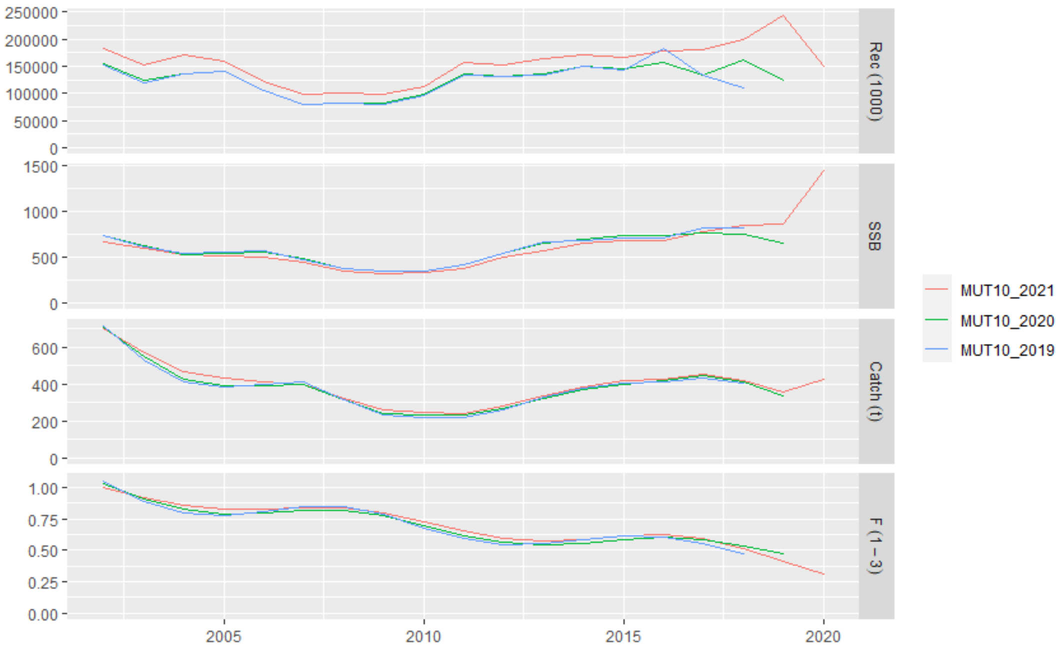
Results: The estimated SSB and recruitment show an increase in recent years, current values are the highest of the time series. This is consistent with the increase in the MEDITS abundance indices and the decrease in the fishing mortality, the latter being well below the reference point $F_{0.1}$, used as proxy of F_{MSY}. F displayed a decreasing trend all through the analysed period and is now very close to the reference point.

$F_{current}$ F_{bar} ages 1–3 (2019)	0.31
$F_{0.1}$ (present assessment)	0.40
$SSB_{current}$ (tonnes)	1449
SSB (33rd)	498
SSB (66th)	671
$F_{current}/F_{0.1}$	0.78

Diagnosis of stock status: Sustainably exploited ($F_c < F_{0.1}$) with relatively high biomass (SSB larger than the 66th percentile).

Advice and recommendations:

- Not increase fishing mortality.



Comparison of the outputs of the previous years' assessments (blue and green lines) and the updated assessment performed this year (red line).

N: 20

Stock: Striped red mullet (*Mullus surmuletus*)

GSA: 5

Author(s): Guijarro, B., Farré, M., Soldán, V. and Ordines, F.

Fishery: In the Balearic Islands (western Mediterranean) commercial trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope (Guijarro and Massutí 2006; Ordines *et al.* 2006), mainly targeted to: i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50–80 m); ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the deep shelf (80–250 m); iii) *Nephrops norvegicus*, but with an important bycatch of big *M. merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the upper slope (350–600 m) and iv) *Aristeus antennatus* on the middle slope (600–750 m). The striped red mullet, *Mullus surmuletus*, is one of the target species in the shallow shelf, although it is also caught in the deep shelf. It is also the target species of part of the artisanal fleet, being caught during the second semester of the year mainly by trammel nets but also by gillnets.

Data and parameters: Size composition of commercial trawl catches and official landings (2000–2020) and indexes from bottom trawl surveys (2001–2021). All information was recomputed from a natural to an artificial year (1 July to 30 June). The final year used corresponds to July 2020 to June 2021 and the 2021 survey. Growth parameters were computed from otolith reading in the study area. Length–weight relationship and maturity ogive were obtained in the area from monthly biological samplings in the Spanish National Data Collection Programme. The M vector was updated using Gislason.

Assessment method: A SCAA model (a4a) was used. Yield per recruit analysis and short-term forecast were carried out. The assessment is a revision from the previous year, as the M was modified and the F model slightly changed.

Model performance: The best model showed a good fit for the commercial data but poor for the surveys. Residuals did not show any trend but the retrospective for F show overestimation.

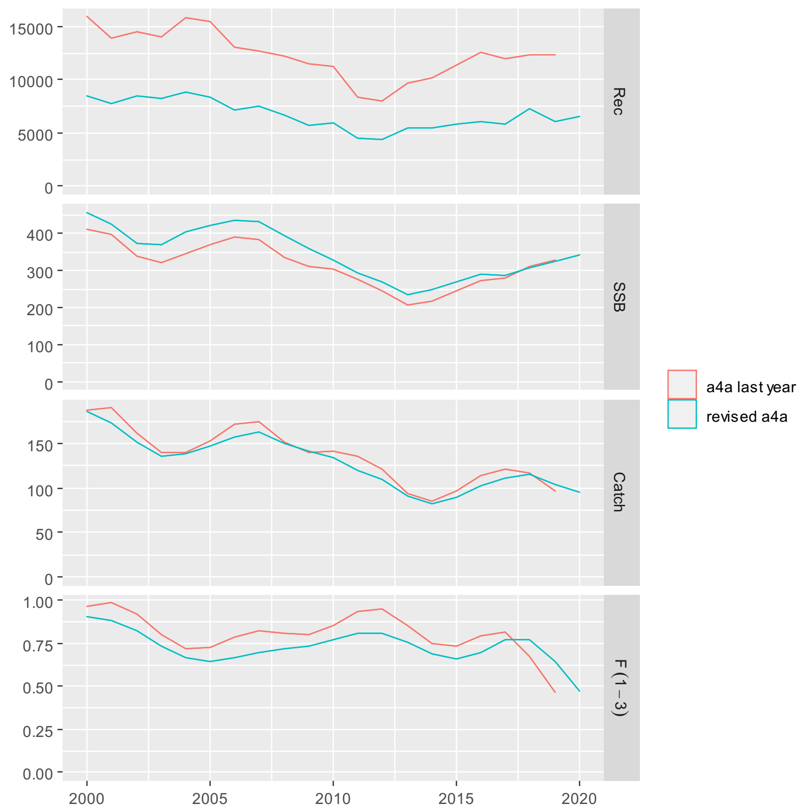
Results: Recruitment showed a decreasing trend between 2004 and 2011, an increasing trend since then. Spawning stock biomass showed a decreasing trend between 2006 and 2013, with an increasing trend since them. F showed the lowest values of the data series in the last year.

$F_{current}$ (2020, ages 1–3)	0.47
$F_{0.1}$	0.24
$F_{current}/F_{0.1}$	1.97
SSB (2020, tonnes)	342
33rd percentile SSB (tonnes)	303
66th percentile SSB(tonnes)	378

Diagnosis of stock status: The stock is in overexploitation, with relatively intermediate biomass.

Advice and recommendations:

- Reduce fishing mortality.



Comparison of the outputs of the previous year's assessment (red line) and the revised assessment performed this year (blue line).

N: 21

Stock: Blue and red shrimp (*Aristeus antennatus*)

GSA: 1

Author(s): Pérez Gil, J.L, Serna-Quintero, J.M., Meléndez, M.J., García, C., Torres, P.,González, M., García, T., Acosta, J., Hidalgo, L., Herrera, J., León, E., Ciércoles, C. and Martínez, G.

Fishery: Blue and red shrimp (*Aristeus antennatus*) is the most important resource of slope bottom trawling in GSA 1 (northern Alboran Sea) and is targeted by the largest vessels of the deep-water trawl fleet segment. The bottom otter trawl fleet catch red shrimp on the slope on muddy bottoms between depths of 400 to 800 m. A total of 38 vessels (2020) had fishing activities directed towards the blue and red shrimp in the GSA 1 fishing ground. This segment fleet catches about 131 tonnes of blue and red shrimp per year (average of 2018–2020) and caught 137 tonnes in 2020.

Data and parameters: The assessment was carried out using official landings and data on the size composition of otter bottom trawl catches for the years 2002–2020. Catch-at-length data were converted into catch-at-age data by cohort slicing procedures (R software). Length frequency distribution for 2020 (January to June), was reconstructed using the time series 2015–2019. Length–weight relationship and maturity ogive came from Spanish DCF and the natural mortality vector was estimated using PRODBIOM (Abella *et al.*, 1997).

Assessment method: The state of exploitation of this stock was assessed using a SCAA stock assessment model (a4a) (Jardim and Millar, 2014). The assessment was performed using abundance index series from MEDITS trawl surveys. Abundance indices for 2020 were estimated using GAM adjustment. Yield per recruit analyses were conducted based on the exploitation pattern resulting from the a4a model and population parameters.

Model performance: Sensitivity and retrospective analyses were applied in the a4a models in order to check the robustness of the assessment. The final model considered for the update assessment and to provide the final outputs of the assessment was a4a. Short term forecast analysis was performed.

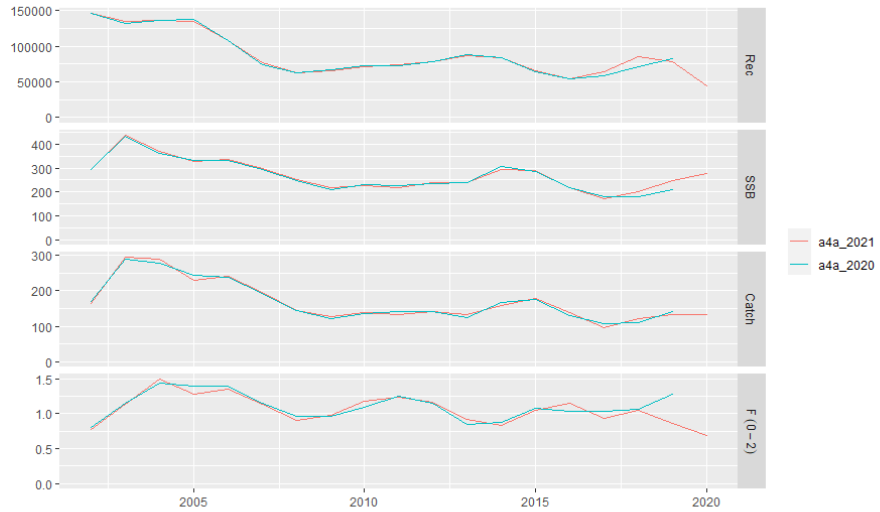
Results: Recruitment, declined until 2007 and has been relatively stable over the 2008–2015 period, decreasing in the last years. Spawning stock biomass showed a decreasing trend in 2015–2017 period, increasing in the last year. Fishing mortality ($F_{bar\ 0–2}$) with values close to one in the 2007–2017 period, decreased to 0.69 in the last year.

$F_{current} = F_{bar}$ ages 0–2 (2020)	0.69
$F_{0.1}$(present assessment)	0.42
$F_{current}/F_{0.1}$	1.64
$SSB_{current(2020)\ tonnes}$	287
SSB 33rd percentile biomass (tonnes)	240
SSB 66th percentile biomass (tonnes)	295

Diagnosis of stock status: The stock is in overexploitation, with relatively intermediate biomass.

Advice and recommendations.

- Reduce $F_{current}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort



Comparison of the outputs of the previous year's assessment (blue line) and the updated assessment performed this year (red line).

N: 22

Stock: Blue and red shrimp (*Aristeus antennatus*)

GSA: 2

Author(s): PérezGil, J.L., Serna-Quintero, J.M., Meléndez, M.J, García, C,González, M.,Torres, P., García, T., Acosta, J., Herrera, J., Hidalgo, L., León, E., Ciércoles, C. And Martínez, G.

Fishery: Blue and red shrimp (*Aristeus antennatus*) is the most important resource of slope bottom trawling in the GSA 2 (Alboran Island) and is targeted by the largest vessels of the deep-water otter bottom trawl fleet segment. In GSA 2, bottom trawl operates, mainly in the middle slope, targeting blue and red shrimp. In this area, fishing trips last for 4–5 days, in contrast to the rest of the western Mediterranean where fishing trips for trawlers only last one day. The main base port of this fleet is Almería (39 tonnes landed in 2020), and the fishing period goes from May to October.

A total of 16 vessels (average 2018–2020) had fishing activities directed towards the blue and red shrimp in the GSA 2 fishing ground. This segment fleet catches about 54 tonnes of this species per year (average 2018–2020) and caught 42 tonnes in 2020.

Data and parameters: The assessment was carried out using official landings and data on the size composition of trawl catches for the years 2009–2020. Catch-at-length data were converted into catch-at-age data using cohort slicing by sex procedures. Length frequency distribution for 2020 (January to June), was reconstructed using the time series 2015–2019. Length–weight relationship and maturity ogive came from Spanish DCF and the natural mortality vector was estimated using PRODBIOM (Abella *et al.*, 1997).

Assessment method: The state of exploitation of this stock was assessed by means of VPA XSA (Shepherd, 1999). The assessment was performed using abundance index series from MEDITS trawl surveys. Abundance indices for 2020 were estimated by GAM adjustment. Yield per recruit analyses were conducted based on the exploitation pattern resulting from the XSA model and population parameters.

Model performance: Sensitivity and retrospective analyses were applied in the XSA model in order to check the robustness of the assessment. This assessment is based on the assessment done in 2020. Short term forecast analysis was performed.

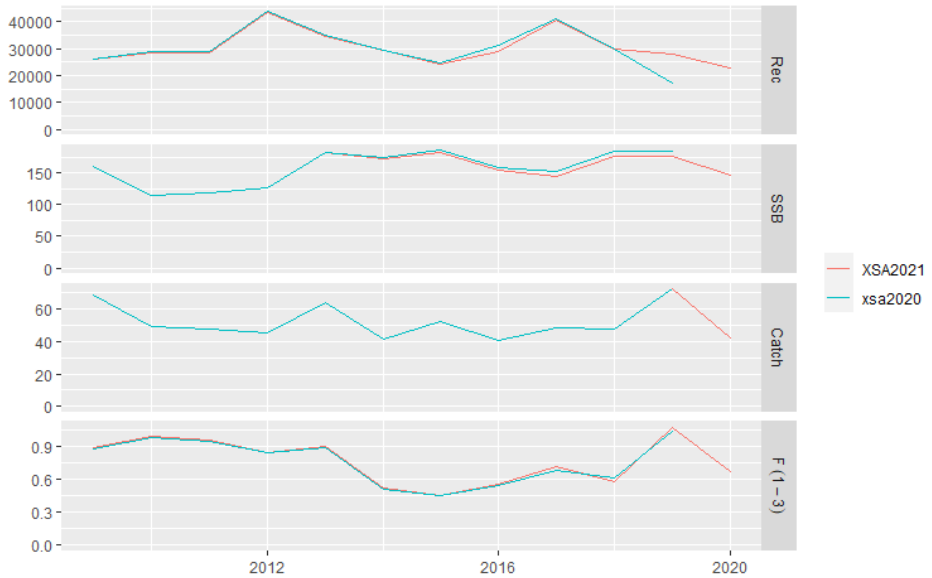
Results: Recruitment, declined until 2014 and decreased over the 2017–2020 period. Spawning stock biomass remained stabilized from 2013. Fishing mortality ($F_{bar\ 1\text{–}3}$) was stabilized around values close to 0.5 for the 2014–2020 period. A decreasing trend in the last year was observed.

$F_{current} = F_{bar}$ages 1–3 (2018–2020)	0.77
$F_{0.1}$(present assessment)	0.46
$F_{current}/F_{0.1}$	1.68
SSB (2018–2020) tonnes	166
SSB 33rd percentile biomass (tonnes)	145
SSB 66th percentile biomass (tonnes)	173

Diagnosis of stock status: The stock is in overexploitation, with relatively intermediate biomass.

Advice and recommendations.

- Reduce $F_{current}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort



Comparison of the outputs of the previous year's assessment (blue line) and the updated assessment performed this year (red line).

N: 23

Stock: Blue and red shrimp (*Aristeus antennatus*)

GSA: 5

Author(s): Guijarro, B and Farré, M.

Fishery: In the Balearic Islands, commercial bottom trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope, mainly targeted to: i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50–80 m); ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the deep shelf (80–250 m); iii) *Nephrops norvegicus*, but with an important bycatch of big *Merluccius merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the upper slope (350–600 m) and iv) *Aristeus antennatus* on the middle slope (600–750 m). *Aristeus antennatus* is a target species with a high economic importance.

Data and parameters: Size composition of commercial trawl catches and official landings (1992–2020), indices from bottom trawl surveys (2001–2020). Growth parameters, length–weight relationship and maturity ogive were obtained in the study area (Carbonell *et al.*, 1999, DCF data). Length was transformed to age by sex and the combined results were used for the assessment.

Assessment method: Statistical catch-at-age (a4a, FLR) and Y/R (FLRBRP).

Model performance: Model residuals did not show any trends. Overall diagnostics are acceptable and retrospective analysis is consistent.

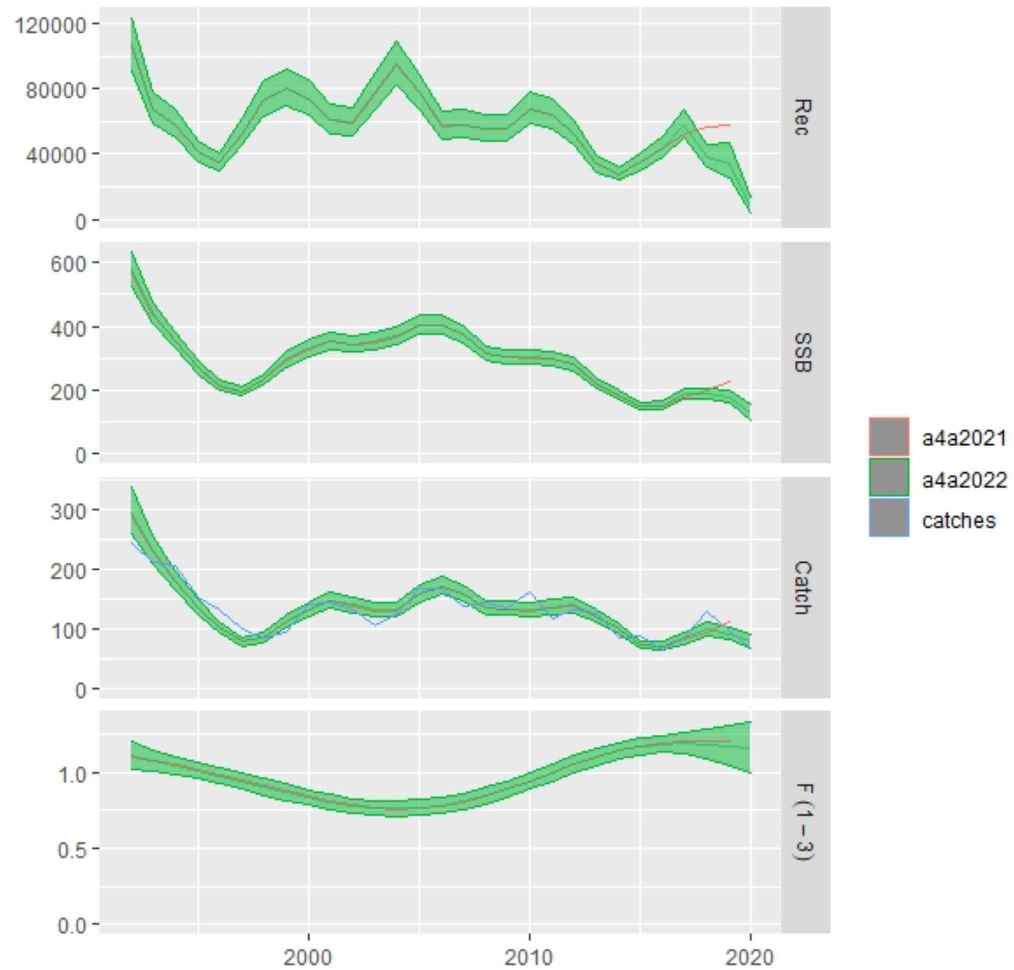
Results: Recruitment showed oscillations along the data series, with a decreasing trend for the last three years. The SSB also showed a decreasing trend, with the lowest values in the last five years. The F values were stable for the last four years of the data series.

$F_{current}$(2020, ages 1–3)	1.16
$F_{0.1}$ (2020)	0.32
$F_{current}/F_{0.1}$	3.61
Current SSB (tonnes)	128
33rd percentile biomass (tonnes)	222
66th percentile biomass (tonnes)	336

Diagnosis of stock status: In overexploitation, with relatively low biomass.

Advice and recommendations:

- Reduce fishing mortality.



Comparison of the outputs of the previous year’s assessment (red line) and the updated assessment performed this year (green line). The blue line represents the real catches.

N: 24

Stock: Blue and red shrimp (*Aristeus antennatus*)

GSA: 6

Author(s): Esteban, A., García, E., Vivas, V. and Perez Gil, J.L.

Fishery: Trawl fleet fishing effort in the ports of GSA 6 were quite stable for the period studied with small variations in the number of vessels in recent years. Vessel length was between 12–24 m and the gear used corresponded to a trawl net with 60 m and 100 m longest rope. The vertical opening was between 1–3 m and the codend mesh size used was a squared 40 mm of mesh opening. The net was rigged with two doors between 500–800 kg. The trawl fleet in the four ports conducts daily trips with a unique haul directed towards blue and red shrimp for a duration of 5–7 hours. In the area, there are 26 harbours with red shrimp fleets and 189 boats. Discards of blue and red shrimp are null.

In 2020, landings were around 537 tonnes and with a total effort of 13 963 fishing days per year and a medium CPUE of 38.5 kg/day

Data and parameters: Size composition of commercial trawl catches by sex, official landings and data from MEDITS surveys (2000–2020). The growth parameters were from length–weight and age–length relationships from DCF (2013–15). The M vector came from PRODBIOM (Abella *et al*., 1997).

Assessment method: Statistical catch-at-age (a4a, FLR), FLBRP package for Y/R analysis and Flash package for short-term forecast.

Model performance: Log catchability residuals and retrospective analysis suggest that the model is consistent.

Results: Stock biomass showed oscillations for the entire data series with a general decreasing trend. Recruitment was decreasing and F increased last year with fluctuations along the time series.

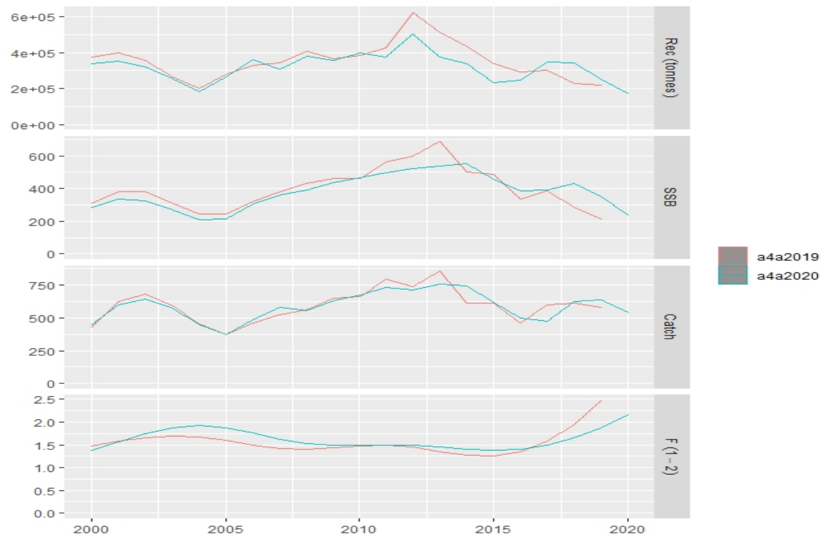
$F_{current}$ ($F_{bar\ 1–2}$) 2020	2.17 ± 0.32
$F_{0.1}$ (2020)	0.35
$F_{current}/F_{0.1}$	6.20
Current SSB (tonnes) 2020	241.90 ± 62.4
33rd percentile SSB (tonnes)	333
66th percentile SSB (tonnes)	436

Diagnosis of stock status: In overexploitation, with relatively low biomass.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

- Reduction of fishing effort.



Comparison of the outputs of the previous year's assessment (red line) and the revised assessment performed this year (blue line).

N: 25

Stock: Blue and red shrimp (*Aristeus antennatus*)

GSA: 9, 10, 11

Author(s): Paola, P., Follesa, M.C., Bitetto, I., Carbonara, P., Sbrana, M., Ligas, A., Lanteri, L. and STECF

Fishery: In the Mediterranean, blue and red shrimp is a dominant species of bathyal megafaunal assemblages and is sympatric with giant red shrimp. Both species have considerable interest for fisheries. Blue and red shrimp is one of the most important target species of the fishery carried out on the muddy bottoms of the upper and middle slope. The species is almost exclusively exploited with otter bottom trawling. In the past, in particular in GSA 10, there was a gillnet fleet (GNS) targeting blue and red shrimp associated with very low landings (less than 1.5 tonnes). The assessment of blue and red shrimp was carried out considering the stock shared by the GSAs 9, 10 and 11.

Data and parameters: Size composition of commercial trawl catches and official landings (2006–2020), MEDITS survey indices (2006–2020). Growth parameters and maturity ogive were gathered from the Italian National Data Collection Programme, while the M vector was estimated using the Chen and Watanabe model.

Assessment method: Statistical catch-at-age (a4a, FLR), FLBRP package for Y/R analysis and Flash package for short-term forecast.

Model performance: Model residuals did not show any trends. Overall diagnostics are acceptable and retrospective analysis is consistent.

Results: Stock biomass showed oscillations for the entire data series, with a decreasing trend in the last years. Recruitment decreased as well, reaching the lowest value of the entire time series in the last year. F showed a steady increase with a more pronounced trend occurring after 2016 and reached its highest value in 2020.

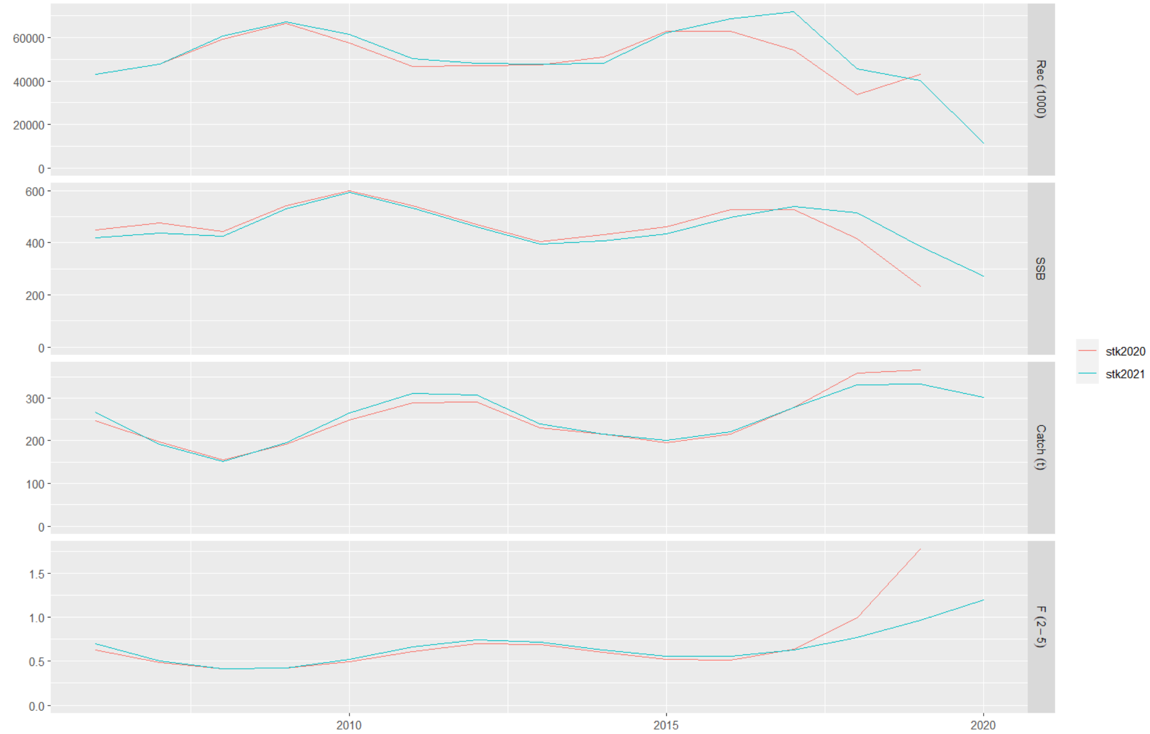
$F_{current}$ ($F_{bar\ 2\text{–}5}$ in 2020)	1.20
$F_{0.1}$ (2020)	0.261
$F_{current}/F_{0.1}$	4.59
Current SSB (tonnes)	271
33rd percentile biomass (tonnes)	422
66th percentile biomass (tonnes)	501

Diagnosis of stock status: In overexploitation, with relatively low biomass.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

- Progressive reduction of the fishing effort



Comparison of the outputs of the previous year's assessment (red line) and the updated assessment performed this year (blue line).

N: 26

Stock: Giant red shrimp (*Aristaeomorpha foliacea*)

GSA: 9, 10, 11

Author(s): Paola, P., Follesa, M.C., Bitetto, I., Carbonara, P., Sbrana, M., Ligas, A., Lanteri, L. and STECF

Fishery: In the Mediterranean, the giant red shrimp (*Aristaeomorpha foliacea*; Risso, 1827) is a dominant species of bathyal megafaunal assemblages and is sympatric with *Aristeus antennatus*. Both species have considerable interest for fisheries.

The giant red shrimp is mainly found in the epibathyal and mesobathyal waters of the Mediterranean. Due to a lack of information about the structure of giant red shrimp in the western Mediterranean, this stock was assumed to be confined within the boundaries of GSAs 9, 10 and 11.

Seasonal fluctuations are a proper characteristic of the landings of this species. The highest catch rates are observed in late spring-summer; although peaks due to recruitment and other biological aspects do exist, the main factor affecting this seasonal pattern is the spatial distribution of the fishing effort. In fact, the fishing grounds where the giant red shrimp is targeted are distant from the coast, thus this fishery is strongly influenced by the weather conditions (Sartor *et al.*, 2003; Sbrana *et al.*, 2003).

Data and parameters: Size composition of commercial trawl catches and official landings (2005–2020), MEDITS survey indices (2005–2020). Growth parameters and maturity ogive were gathered from the Italian National Data Collection Programme, while the M vector was estimated using the Chen and Watanabe model.

Assessment method: Statistical catch-at-age (a4a, FLR), FLBRP package for Y/R analysis and Flash package for short-term forecast.

Model performance: Model residuals did not show any trends. Overall diagnostics are acceptable, and retrospective analysis is consistent.

Results: Since 2018, a gradual decrease in SSB was observed while recruitment remained constant. F has been steadily increasing since 2016.

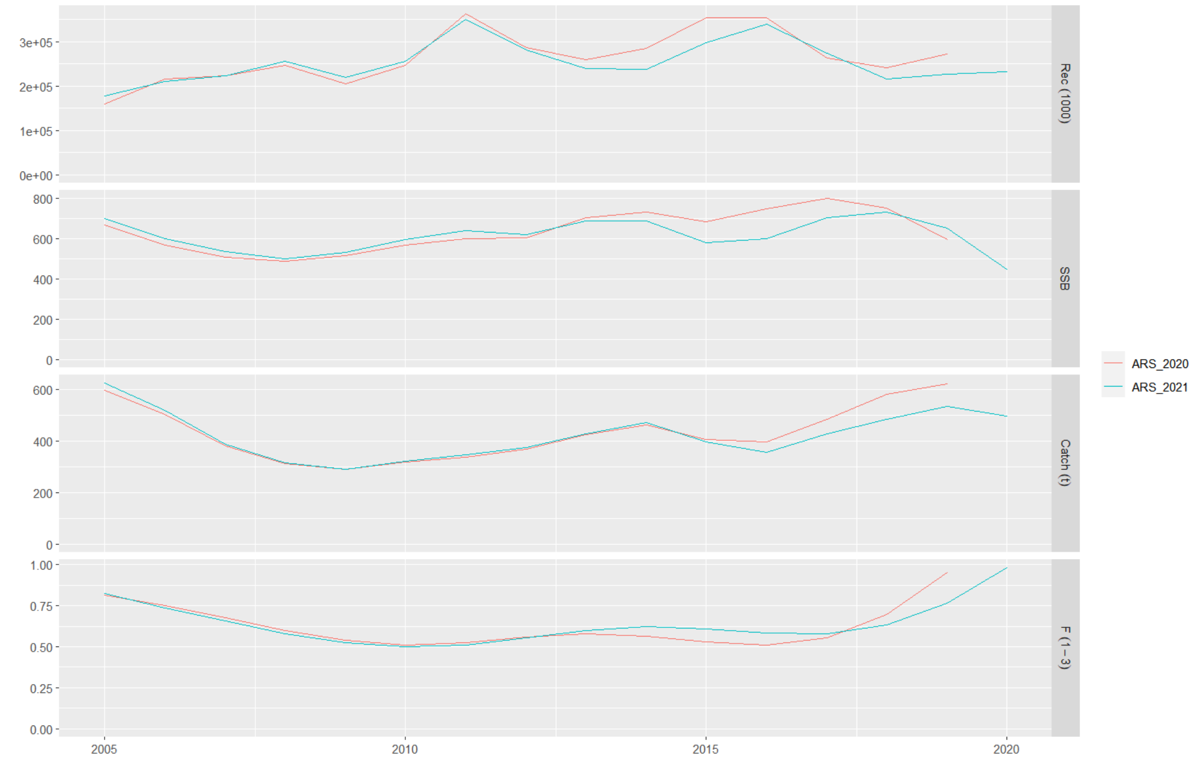
$F_{current}$ ($F_{bar\ 1\text{–}3}$ in 2020)	0.98
$F_{0.1}$ (2020)	0.46
$F_{current}/F_{0.1}$	2.13
Current SSB (tonnes)	445
33rd percentile biomass (tonnes)	592
66th percentile biomass (tonnes)	647

Diagnosis of stock status: In overexploitation, with relatively intermediate biomass.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

- Progressive reduction of the fishing effort



Comparison of the outputs of the previous year's assessment (red line) and the updated assessment performed this year (blue line).

N: 27

Stock: Norway lobster (*Nephrops norvegicus*)

GSA: 5

Author(s): Guijarro, B. and Farré, M.

Fishery: In the Balearic Islands, commercial bottom trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope, mainly targeted to: i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50–80 m); ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the deep shelf (80–250 m); iii) *Nephrops norvegicus*, but with an important bycatch of big *Merluccius merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the upper slope (350–600 m); and iv) *Aristeus antennatus* on the middle slope (600–750 m). Norway lobster is a target species with high economic importance.

Data and parameters: Size composition of commercial trawl catches and official landings (2002–2020), indexes from bottom trawl surveys (2002–2020). Growth parameters, length–weight relationship and maturity ogive were obtained in the study area (Guijarro *et al.*, 2013). Length was transformed to age by sex combined.

Assessment method: Extended Survivor Analysis (FLR), SCAA (a4a, FLR) and Y/R (FLRBRP package). Final advice was provided based on a4a.

Model performance: Model residuals did not show any trends. Overall diagnostics are acceptable and retrospective analysis is consistent.

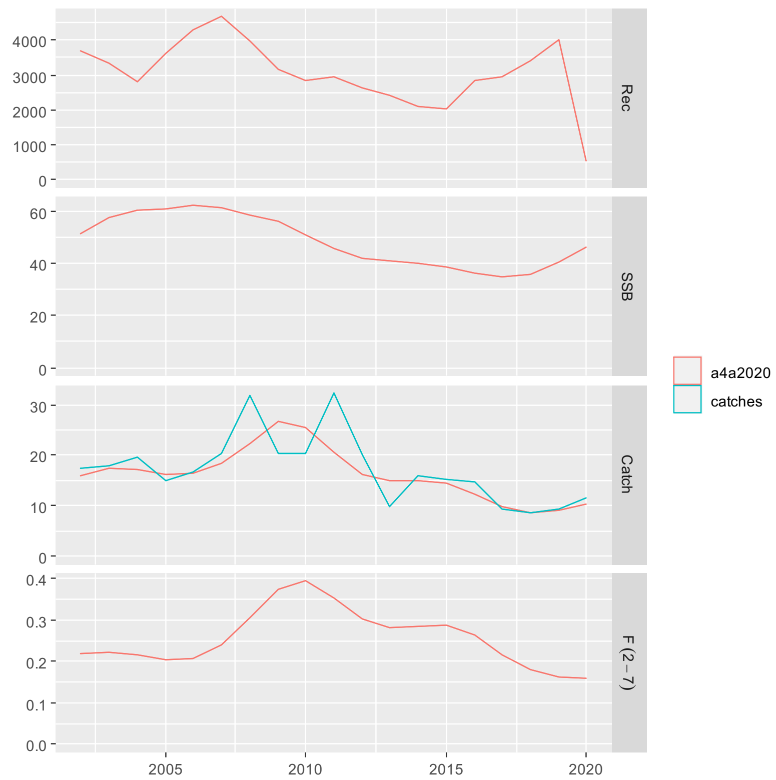
Results: Recruitment showed oscillations during the entire data series, with an increasing trend during the last few years, except for the final year, which showed very low values. The SSB showed a decreasing trend until 2017 and has been increasing since. The F values have shown a decreasing trend since 2010.

$F_{current}$(2020, ages 2–7)	0.16
$F_{0.1}$ (2020)	0.23
$F_{current}/F_{0.1}$	0.69
Current SSB (tonnes)	46
33rd percentile biomass (tonnes)	41
66th percentile biomass (tonnes)	55

Diagnosis of stock status: Sustainably exploited, with relatively intermediate biomass.

Advice and recommendations:

- Reduce fishing mortality



Results from the assessment carried out using a4a (red line); the blue line represents observed catches.

N: 28

Stock: Norway lobster (*Nephrops norvegicus*)

GSA: 6

Author(s): Esteban, A., García, E., Vivas, M. and Delgado, J.

Fishery: Trawl fleet fishing effort in the ports of GSA 6 were quite stable for the period studied with small variations in the number of vessels in recent years. Vessel length was between 12–24 m and the gear used corresponded to a trawl net with 60 m and 100 m longest rope. The vertical opening was between 1–3 m and the codend mesh size used was a squared 40 mm of mesh opening. The net was rigged with two doors of between 500–800 kg. Trawl fleets in the four ports conduct daily trips with a unique haul directed to the red shrimp, with a duration between 5–7 hours.

In the area, there are 31 harbours with Norway lobster (*Nephrops norvegicus*) fleets and 338 boats.

Discards of Norway lobster are null.

In 2020, landings were around 266 tonnes with a total effort of over 23 021 fishing days per year and a medium CPUE of 12.7 kg/day

Data and parameters: Size composition of commercial trawl catches, official landings and data from MEDITS surveys (2009–2020). Growth parameters from length–weight and age–length relationships came from DCF (2013–15) and the M vector came from PRODBIOM (Abella *et al.*, 1997)

Assessment method: Statistical catch-at-age (a4a, FLR), FLBRP package for Y/R analysis and Flash package for short-term forecast.

Model performance: Log catchability residuals and retrospective analysis suggest that the model is consistent.

Results: Stock biomass showed oscillations for the entire data series, with a general decreasing trend. Recruitment decreased and F increased in the last year with fluctuation along the time series studied.

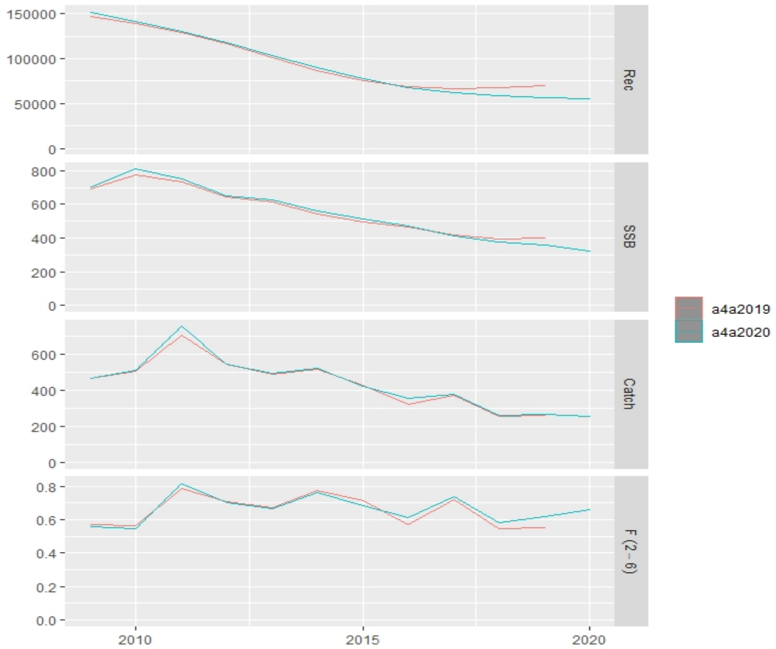
$F_{current}$ ($F_{bar\ 2\text{–}6}$) 2020	0.57±0.13
$F_{0.1}$ (2020)	0.15
$F_{current}/F_{0.1}$	3.80
Current SSB (tonnes) 2020	372±78.7
33rd percentile SSB (tonnes)	447
66th percentile SSB (tonnes)	622

Diagnosis of stock status: In overexploitation, with relatively low biomass.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

- Reduction of fishing effort



Comparison of the outputs of the previous year assessment (red line) and revised assessment performed this year (blue line).

N: 29

Stock: Norway lobster (*Nephrops norvegicus*)

GSA: 9

Author(s): STECF

Fishery: Due to a lack of information about the structure of the Norway lobster (*Nephrops norvegicus*) population in the western Mediterranean, this stock was assumed to be confined within the boundaries of GSA 9.

Landings of Norway lobster in GSA 9 from the period 1994–2002 were gathered from the Italian official statistics (prior to DCR/DCF) which were collected and stored under the RECFISH project (Ligas, 2019). Although the bulk of the production in GSA 9 is coming from the trawl fisheries (mostly demersal species and mixed demersal and deep-water species trawling), other fisheries (mostly gillnets) provide some contribution to the total production.

Discards of Norway lobster are low. Low values of discards (from OTB) are reported in GSA 9 from 2009 onwards. Despite the low values of discards, LFDs are available, and the data were included in the stock assessment.

Data and parameters: For *N. norvegicus*, there is a difference in growth between males and females, with males attaining greater lengths at ages and maximum sizes compared to females. Several sets of VBGF parameters were reported. For the length–weight relationship, several sets of parameters by sex were provided for GSA 9. The VBGF and LW relationship parameters used for the assessment are summarized in the following table.

		Units	Females	Males
VBGF parameters	**L_∞**	mm	56.0	72.1
	k	year^{-1}	0.21	0.17
	t_0	years	0.0	0.0
LW relationship	**a**	mm/g	0.00032	0.00038
	b	mm/g	3.24848	3.18164

A vector of proportion of maturity by age was computed as a weighed average of the vectors available from the DCF database in GSA 9. A natural mortality vector was estimated by sex using the Chen and Watanabe equation and the growth parameters described above. A combined natural mortality vector was then computed as a weighed average of the vectors by sex.

Assessment method: Statistical catch-at-age model (a4a; Jardim *et al.* 2015) and FLBRP package. FLR.

Model performance: Some pattern in the residuals from the tuning index (MEDITS survey). The assessment is mostly driven by the information provided by the catches.

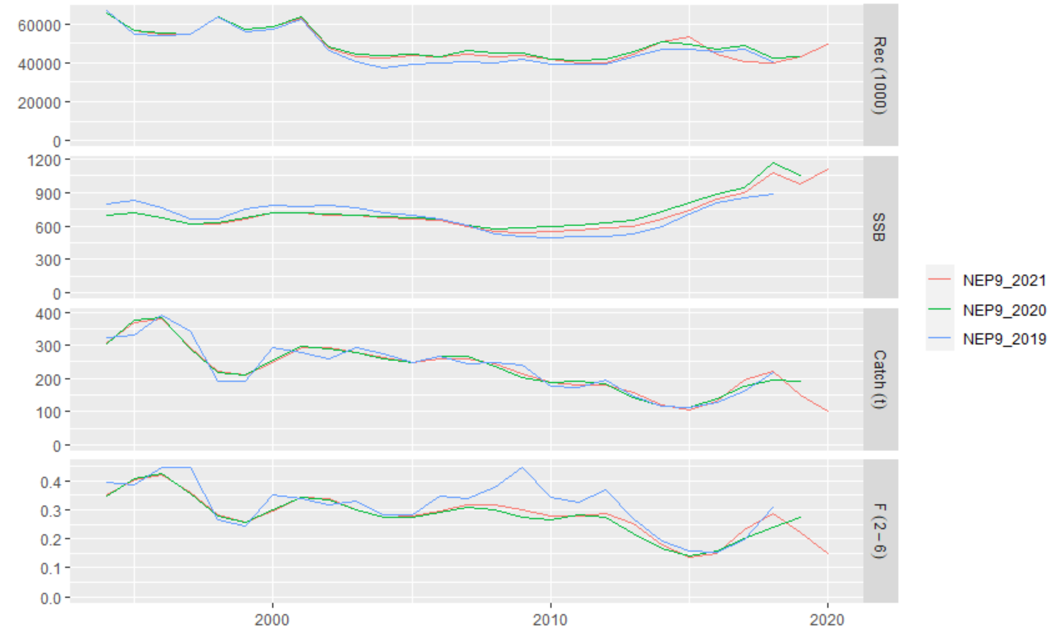
Results: The estimated SSB showed an increasing trend in recent years reaching the highest values of the whole time series. This is consistent with the increase in total catch and the increase in the MEDITS abundance survey indices.

$F_{current}$ F_{bar} ages 2–6 (2020)	0.15
$F_{0.1}$ (present assessment)	0.30
$SSB_{current}$ (tonnes)	1255
SSB (33rd percentile)	743
SSB (66th percentile)	838
$F_{current}/F_{0.1}$	0.50

Diagnosis of stock status: Sustainable exploitation with relatively high biomass (SSB higher than the 66th percentile).

Advice and recommendations

- Not increase $F_{current}$



Comparison of the outputs of the previous years' assessments (blue and green lines) and the updated assessment performed this year (red line). In 2019, a larger number of knots in the tensor in the F submodel was used, thus determining a slightly different pattern of F.

N:30

Stock: Giant red shrimp (*Aristaeomorpha foliacea*)

GSA: 18–19

Author(s): Bitetto, I., Zupa, W., Carbonara, P., Neglia, C., Pierucci, A., Maiorano, P., Carlucci, R., Cipriano, G., Lembo, G. and Spedicato, M.T.

Fishery: The giant red shrimp (*Aristaeomorpha foliacea*) is one of the most important demersal species in the area, in terms both of landing and income. This resource is exploited by trawlers, targeting deep-water species as well as mixed deep-water and demersal species.

Data and parameters: Following the STECF EWG 16-08 and, more recently, the Joint EastMed/MedSudMed/GFCM data preparation meeting for deep-water red shrimp (14–18 October 2019), the assessment was performed joining the two GSAs from the previous WGSAD.

The assessment was carried out using LFD abundance indices (N/km2), GSA 18 and 19 (MEDITS data, available from 1994, used from 2003 to 2020); length structure of landings (discard negligible) by fishing segment and landing in weight from DCF (2003–2020). The growth parameters were estimated within DCF, as well as length–weight relationship and maturity ogive. The vector of natural mortality by age was calculated applying the Chen and Watanabe method. The catch-at-age matrices (for landing and survey) were derived according to deterministic age slicing procedure.

Assessment method: The assessment was carried out using two different assessment methods: XSA and a4a. Despite the comparability of the results from the two methods, the a4a was retained this year, in an attempt to move towards statistical stock assessment methods. The FLBRP package was used to calculate the reference point $F_{0.1}$. This year, the catch-at-age matrices and the a4a model were revised.

Model performance: The results show a decrease in F in the last years, consistent with the recent decrease in landings (from 2016). The SSB also shows a decrease with respect to 2016. The residuals do not show any trends and the overall absolute values are quite small. The retrospective analysis shows a consistent pattern.

Results: Fishing mortality showed an average value of 0.62 (F_{bar}(0–3)) in 2020. The estimated $F_{0.1}$ value was 0.45.

$F_{current}$ (2020)	0.62
F01	0.45
$F_{current}$/F01	1.38
$B_{current}$ (tonnes) (2020)	285
B 33rd percentile(tonnes)	249
B 66th percentile (tonnes)	291

Diagnosis of stock status: Overexploited ($F_{current} > F_{0.1}$) with relatively intermediate biomass (SSB 66th percentile > $SSB_{current}$ > SSB 33rd percentile)

Advice and recommendations:

- Reduce fishing mortality towards the agreed reference point

Comparative plot between this year's XSA assessment and a4a assessments

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N: 31

Stock: Hake (*Merluccius merluccius*)

GSA: 20

Author(s): Mantopoulou-Palouka, D., Sgardeli, V. and Tserpes, G.

Fishery: The stock is exploited by various Greek fleet segments, including bottom trawlers and artisanal fisheries using gillnets and demersal longlines. More than 50 percent of the landings come from bottom trawlers. The Greek bottom trawl fishery has multi-species characteristics and, similar to most Mediterranean demersal trawl fisheries, captures more than 100 commercial species. However, hake together with red mullets, and shrimps compose the main bulk of landings. Hake alone comprises 5–15 percent of the total landings in the Ionian Sea.

Data and parameters: Biological information on growth (i.e. the von Bertalanffy parameters) as well the length–weight relationship were derived within DCF. Natural mortality and maturity vectors were the ones used in 2019 benchmark. The official landings data as reported through the Hellenic Statistical Authority (HELSTAT) were used in the assessment. The ratio of discards to landings was estimated using DCF data and total discards were calculated using the HELSTAT data. Catch at size data as reported in DCF were used in the assessment. Both catch numbers at length and index number at length were sliced using the l2a age slicing function of FLR.

Assessment method: A SCAA model (a4a) was used along with the FLBRP package for Y/R analysis, both part of FLR. The assessment was carried out over the period 2003–2020, calibrated with fishery independent survey abundance index (MEDITS). This is an updated assessment and the submodel configurations were the ones used in the previous assessment.

Model performance: Residuals are considered acceptable, while retrospective plots exhibit few unstable patterns mainly due to missing years in both catch-at-age and index data. The effect of missing information is also apparent in the estimated confidence limits of estimated harvest, catch, SSB and recruitment.

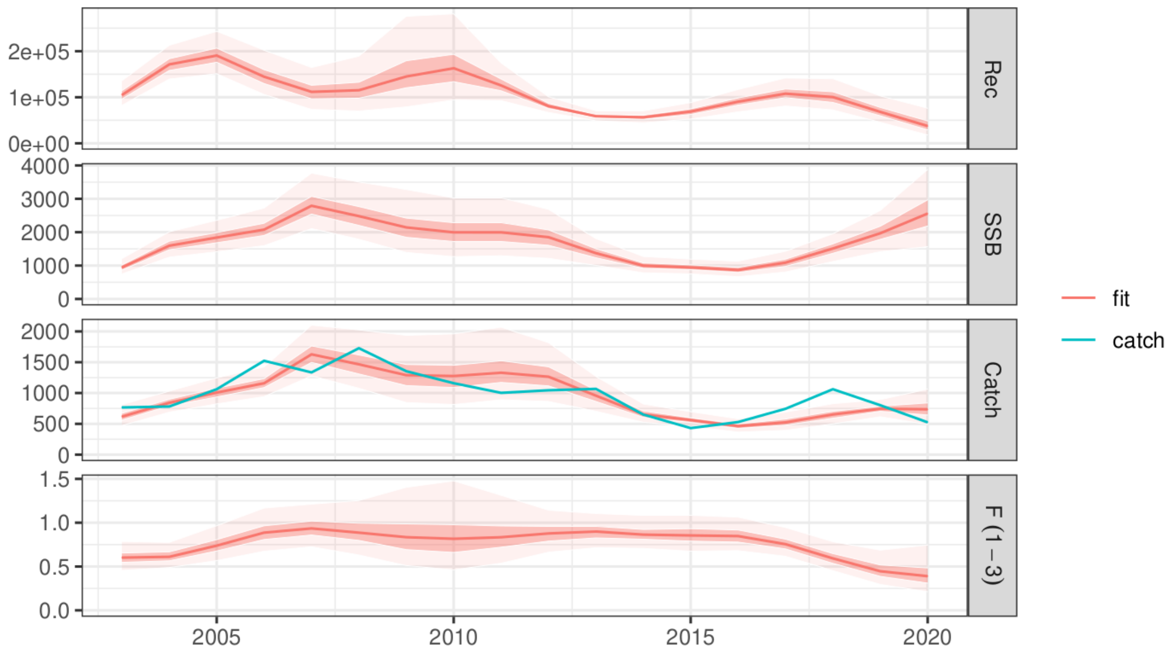
Results: In the most recent years, biomass showed increasing trends, while F decreased**.**

$F_{current}$ F_{bar} ages 1–3(2020)	0.38
$F_{0.1}$ (present assessment)	0.204
$SSB_{current}$ (tonnes)	2550
SSB (33rd percentile)	1488
SSB (66th percentile)	1971
$F_{current}/F_{0.1}$	1.861

Diagnosis of stock status: In overexploitation, with relatively high biomass.

Advice and recommendations:

- Reduce fishing mortality towards $F_{0.1}$



The figure depicts estimated recruitment, SSB, catches, Fbar (ages: 1– 3) and their respective confidence limits; blue line represents the observed catch.

N: 32

Stock: Hake (*Merluccius merluccius*)

GSA: 22

Author(s): Mantopoulou-Palouka, D and Tserpes, G.

Fishery: 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 majority of landings (roughly 60 percent) comes from bottom trawlers (Anonymous, 2013). The Greek bottom trawl fishery has multi-species characteristics and, similar to most Mediterranean demersal trawl fisheries, captures more than 100 commercial species. However, hake together with red mullets and shrimp compose the main bulk of landings.

Data and parameters: Biological information on growth (i.e. the von Bertalanffy parameters) as well as the length–weight relationship were derived within DCF. The natural mortality vector was estimated using the Chen and Watannabe method while the proportion of mature individuals at age was based on recent bibliography. The official landings data, as reported through the HELSTAT, were used in the assessment. Catch at size data, as reported in DCF, were used in the assessment. Both catch numbers at length and index numbers at length were sliced using the l2a age slicing function of FLR.

Assessment method: Biological information on growth (i.e. the von Bertalanffy parameters) as well as the length–weight relationship were derived within DCF. The natural mortality and maturity vectors were the ones used in last year's benchmark. The official landings data, as reported through the HELSTAT, were used in the assessment. The ratio of discards to landings was estimated using DCF data and total discards were calculated using the HELSTAT data. Catch at size data, as reported in DCF, were used in the assessment. Both catch numbers at length and index numbers at length were sliced using the l2a age slicing function of FLR.

Model performance: Both residuals and retrospective plots were considered acceptable, however due data deficiencies and the high value of $F_{current}$, the model was not considered suitable to give quantitative advice.

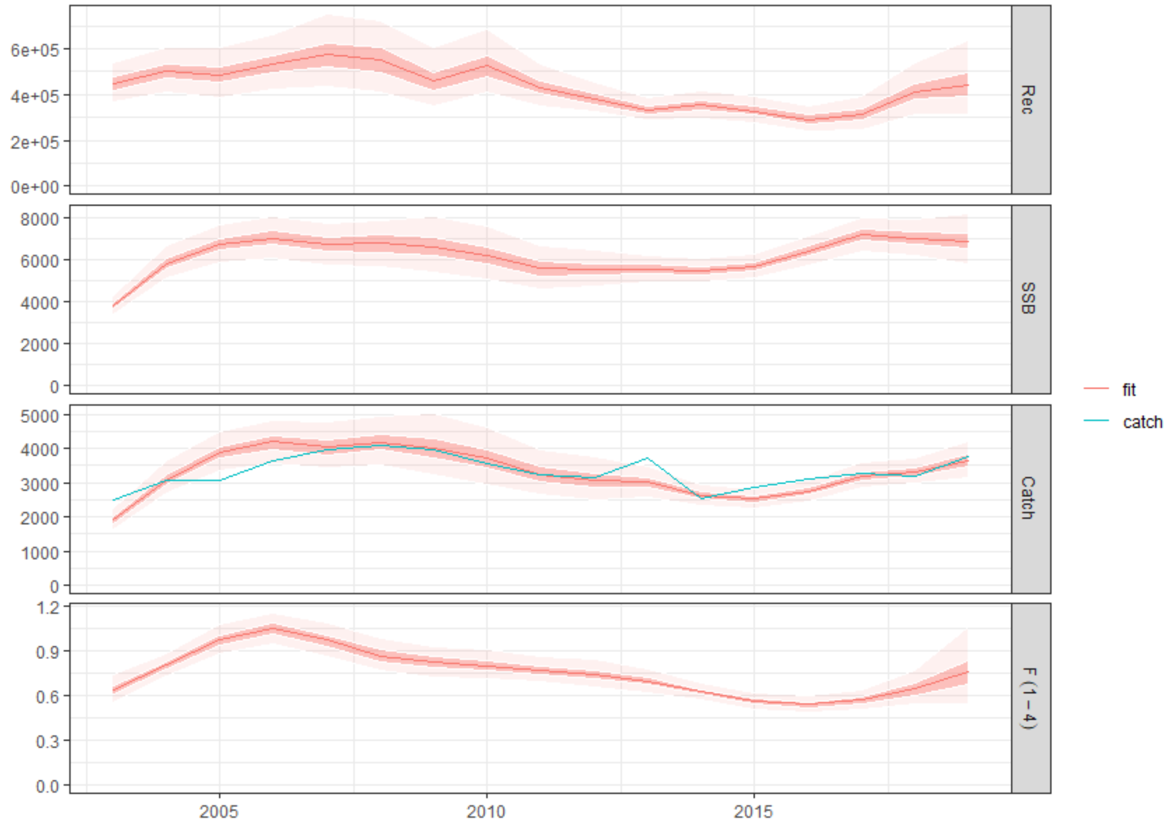
Results: In the most recent years, biomass showed increasing trends, while F has showed a constant decreasing trend since 2007**.**

$F_{current}$ F_{bar} ages 0–2(2020)	0.4
$F_{0.1}$ (present assessment)	0.236
$SSB_{current}$ (tonnes)	20 234
SSB (33rd percentile)	12 290
SSB (66th percentile)	19 871
$F_{current}/F_{0.1}$	NA

Diagnosis of stock status: Possibly in overexploitation

Advice and recommendations:

- Reduce fishing mortality



Estimated recruitment, SSB, catch, Fbar (ages: 1– 3) and their respective confidence limits; blue line represents the observed catch

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N: 33

Stock: Red mullet (*Mullus barbatus*)

GSA: 20

Author(s): Tserpes, G. and Mantopoulou-Palouka, D.

Fishery: Red mullet (*Mullus barbatus*) is exploited by bottom trawlers and various artisanal fisheries using gillnets. Most catches come from the Greek fleets exploiting the area and the majority originates from bottom trawlers (roughly 80 percent). The Greek bottom trawl fishery has multi-species characteristics and, similar to most Mediterranean demersal trawl fisheries, captures more than 100 commercial species. However, few species, such as red mullets, European hake and shrimps, compose the main bulk of landings, with red mullet being one of the most important targets.

Data and parameters: Biological information on growth (i.e. the von Bertalanffy parameters) as well the length–weight relationship were derived within DCF. The natural mortality vector was estimated using the Chen and Watannabe method while maturity vectors were derived within DCF. The official landings data, as reported through the HELSTAT, were used in the assessment. Catch at size data, as reported in DCF, were used in the assessment. Both catch numbers at length and index numbers at length were sliced using the l2a age slicing function of FLR.

Assessment method: A SCAA model (a4a) was used as well as the FLBRP package for Y/R analysis, both part of FLR. The assessment was carried out over the period 2003–2020, calibrated with the fishery independent survey abundance index (MEDITS). This is an updated assessment and the submodel configurations were the ones used in the previous assessment.

Model performance: Residuals are considered acceptable, while retrospective plots exhibit few unstable patterns mainly due to missing years in both catch-at-age and index data. The effect of missing information is also apparent in the estimated confidence limits of estimated harvest, catch, SSB and recruitment.

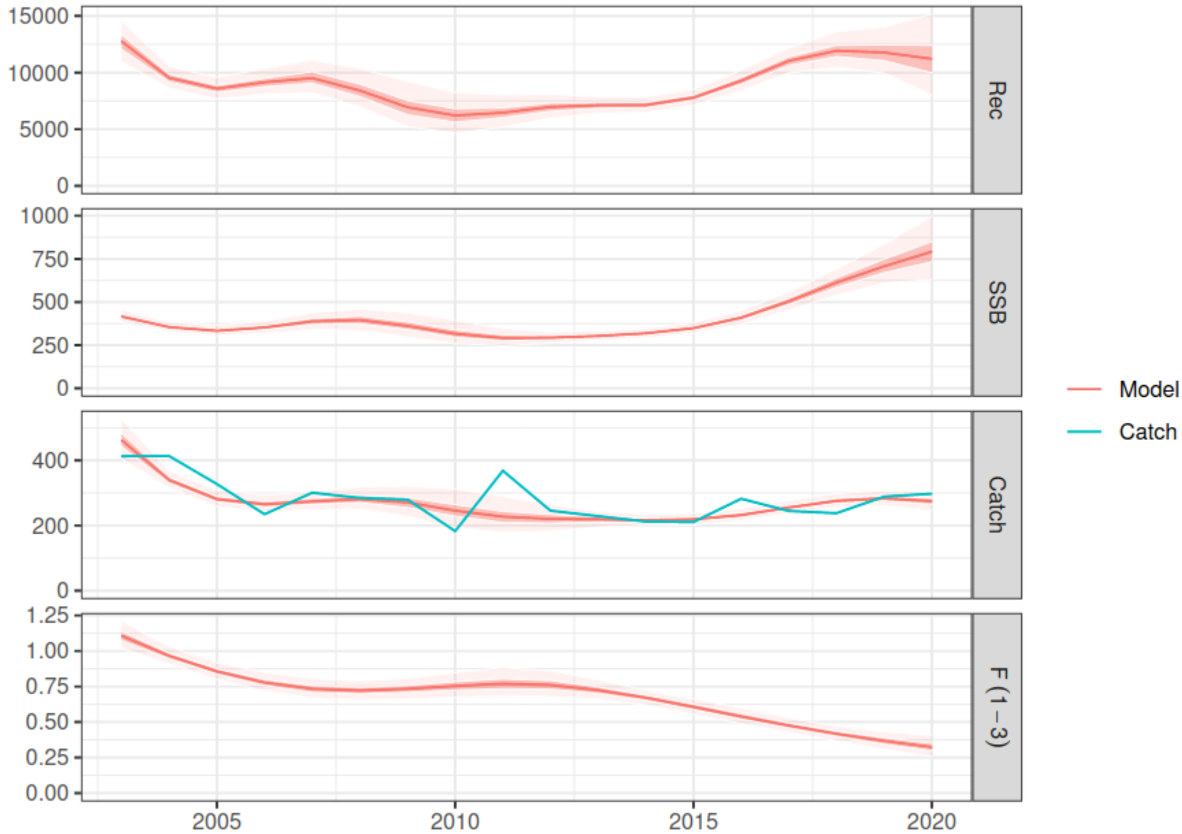
Results: In the most recent years, biomass showed increasing trends, while F decreased.

$F_{current}$ F_{bar} ages 1–3(2020)	0.32
$F_{0.1}$ (present assessment)	0.29
$SSB_{current}$ (tonnes)	792
SSB (33rd percentile)	343
SSB (66th percentile)	398
$F_{current}/F_{0.1}$	1.1

Diagnosis of stock status: In overexploitation, with relatively high biomass.

Advice and recommendations:

Reduce fishing mortality towards $F_{0.1}$.



Estimated recruitment, SSB, catch, Fbar (ages: 1– 3) and their respective confidence limits; blue line represents the observed catch.

N: 34

Stock: Red mullet (*Mullus barbatus*)

GSA: 22

Author(s): Tserpes, G. and Mantopoulou-Palouka, D.

Fishery: Red mullet (*Mullus barbatus*) is exploited by bottom trawlers and various artisanal fisheries using gillnets. Most catches come from the Greek fleets exploiting the area and the majority originates from bottom trawlers (roughly 80percent). The Greek bottom trawl fishery has multi-species characteristics and, similar to most Mediterranean demersal trawl fisheries, captures more than 100 commercial species.

However, only a few species, such as red mullets, European hake and shrimp, compose the main bulk of landings, with red mullet being one of the most important targets.

Data and parameters: Biological information on growth (i.e. the von Bertalanffy parameters) as well the length–weight relationship were derived within DCF. The natural mortality vector was estimated using the Chen and Watannabe method while the proportion of mature individuals at age was based on recent bibliography. The official landings data, as reported through the HELSTAT, were used in the assessment. Catch at size data, as reported in DCF, were used in the assessment. Revised total catches and catch numbers were used in this assessment compared to the one performed in WGSAD 2020. Both catch numbers at length and index numbers at length were sliced using the l2a age slicing function of FLR.

Assessment method: A SCAA model (a4a) was used as well as the FLBRP package for Y/R analysis, both part of FLR. The assessment was carried out over the period 2003–2020, calibrated with the fishery independent survey abundance index (MEDITS). To select the final model for assessment, combinations of various options for submodels regarding fishing mortality, survey catchability and stock-recruitment were investigated. The best model was selected on the basis of better residuals and retrospective patterns.

Model performance: Residuals are considered acceptable, while retrospective plots exhibit few unstable patterns mainly due to missing years in both catch-at-age and index data. The effect of missing information is also apparent in the estimated confidence limits of estimated harvest, catch, SSB and recruitment.

Results: In the most recent years, biomass showed increasing trends, while F has shown a constant decreasing trend since 2007.

$F_{current}$ F_{bar} ages 1–3(2020)	0.25
$F_{0.1}$ (present assessment)	0.26
$SSB_{current}$ (tonnes)	8195
SSB (33rd)	2528
SSB (66th)	3276
$F_{current}/F_{0.1}$	0.97

Diagnosis of stock status: Sustainably exploited, with relatively high biomass.

Advice and recommendations:

- Not to increase fishing mortality

Estimated recruitment, SSB, catch, Fbar (ages: 1– 3) and their respective confidence limits; blue line represents the observed catch.

N: 35

Species: Red mullet (*Mullus barbatus*)

GSA: 24

Author(s): Kılıç, S.

Fishery: Red mullet (*Mullus barbatus*) is an important species for commercial fisheries, as it is one of the most landed demersal species in GSA 24. During 2020, 177 bottom trawls and 982 gillnet boats fished in GSA 24. Overall, about 80 percent of red mullet is fished by bottom trawls and the remainder is largely fished by gillnets. The stock in the eastern side is mainly exploited by bottom trawls, whereas in the western side, bottom trawling is very limited due to the 3 mile trawl exclusion zone where red mullet is mainly fished by artisanal fishers in negligible quantities.

Data and parameters: Official landing data of red mullet by region was obtained from the Turkish Statistical Institute for the assessment. Biological and monthly length frequency data were collected from commercial fisheries by the Mediterranean Fisheries Research, Production, and Training Institute (MEDFRI) between 2018 and 2021, supported by the FAO EastMed project. Von Bertalanffy growth parameters reported in the previous stock assessment were used. The L50 values were estimated using the biological data from MEDFRI.

Assessment method: The LBB, LB-SPR and LIME length-based data limited stock assessment models were used in addition to catch-based data limited stock assessment model CMSY.

Results:

F_{MSY}	0.377
Fc	0.315
Fc/F_{MSY}	0.836

Diagnosis of stock status: Possibly sustainably exploited.

Advice and recommendations:

- Not to increase fishing mortality.

N:36

Species: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 12, 13, 14, 15, 16

Author(s): Gancitano, V., Scannella, D., Falsone, F., Fezzani, S., Cherif, M., Ben Meriem, S., Ben Abdallah, O., Ceriola, L., Jarboui, O., Gambin, M., Mifsud, J., Pisani, L., Vitale, S. and Fiorentino, F.

Fishery: Deep-water rose shrimp (*Parapenaeus longirostris*) is caught by bottom otter trawlers in the Strait of Sicily together with other commercial species such as Norway lobster (*N. norvegicus*), giant red shrimp (*A. foliacea*), European hake (*M. merluccius*), scorpionfish (*H. dactylopterus*), grater forkbeard (*P. blennioides*), Atlantic horse mackerel (*T. trachurus)* and monkfish (*Lophius spp.*). Available scientific data available indicate that the fishing fleets of Tunisia, Malta, Libya and Italy target a single shared stock of deep-water rose shrimp. Four fishing segments were considered in the stock assessment: Italian coastal trawlers, Italian distant trawlers, Maltese trawlers and Tunisian trawlers. Information on Libyan fisheries were not currently available. Sicilian coastal trawlers (LOA between 12 and 24 m) targeting deep-water rose shrimp are based in seven harbours along the southern coasts of Sicily. These trawlers operate mainly on short-distance fishing trips, which range from 1 to 2 days at sea. Sicilian distant trawlers (LOA > 24 m) perform longer fishing trips, which may last up to 4 weeks, and operate offshore, in both Italian and international waters of the south-central Mediterranean. In the Maltese Islands, small vessels measuring 12 to 24 m in length target deep-water rose shrimp at depths up to 600 m. The fishing grounds for Maltese vessels are located to the north and northwest of Gozo. Tunisian trawl vessels that target deep-water rose shrimp measure around 24 m in LOA and operate primarily in Northern Tunisia (GSA 12) where 90 percent of the country's total *P. longirostris* catches originate. The great majority of these catches are landed in the port of Bizerte and Kelibia.

Data and parameters: Catch-at-age and landing data matrices from Italy (OTB 12–24 m and OTB > 24), Malta and Tunisia for 2007 to 2020. Number at age came from MEDITS survey in GSA 15 and 16 for tuning. Von Bertalanffy growth function and length weight relationships were used: $L\infty = 42.705$, $k = 0.67$, $t0 = -0.208$, $a = 0.0029$, $b = 2.4818$ for females and $L\infty = 33.56$, $k = 0.73$, $t0 = -0.13$, $a = 0.0034$, $b = 2.4096$ for males. Natural mortality was estimated using the PRODBIOM method (forced).

Assessment method: The assessment was performed using XSA as implemented in the FLR. According to the recommendations of the WGSAD, the current F was obtained as the average of the last three years (2017–2020).

Model performance: Model residuals did not show any trends. Overall diagnostics are acceptable, and retrospective analysis is consistent.

Results: Current $F_{(0–2)}$ estimated using the average of three years was 1.13. The value of $F_{0.1}$ was estimated by using FLR routine and the National Oceanic and Atmospheric Association (NOAA) Y/R tool (version 3.3) resulted in a value that ranged between 0.84 and 0.93. The SSB estimated using the average of three years (2017–2020) was lower than the 33rd percentile of the SSB time series. The results obtained in terms of the stock status are reported in the table below.

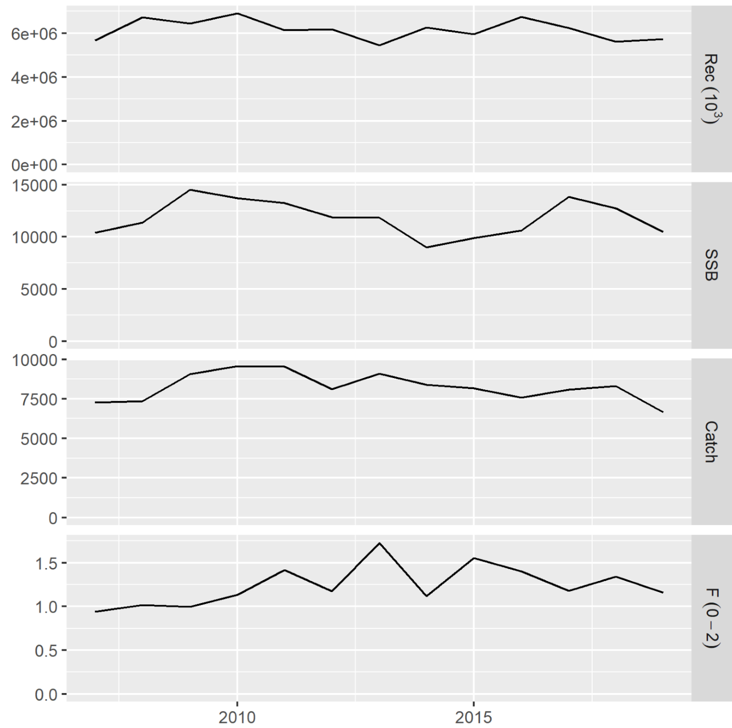
$F_{current}$ (F_{bar} ages 0–2 (2018–2020))	1.13
F_{target} (last benchmark)	0.84
$F_{current}/F_{target}$	1.34
$SSB_{current(2018–2020)}$ (tonnes)	10102
SSB 33rd percentile biomass (tonnes)	10383
SSB 66th percentile biomass(tonnes)	12342

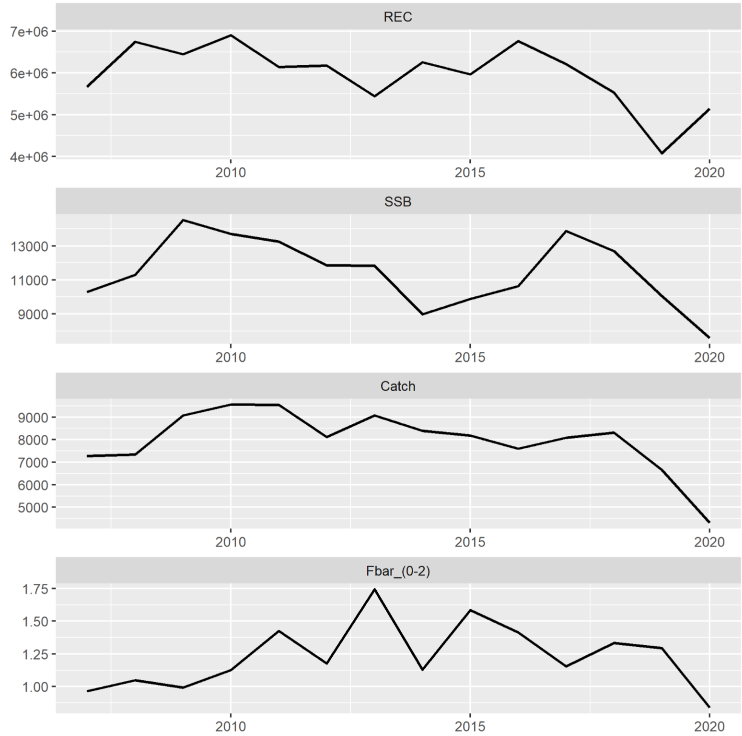
Diagnosis of stock status: In overexploitation and overexploited status.

Advice and recommendations:

- Move $F_{current}$ towards $F_{0.1}$ by reducing the fishing effort and catches of undersized shrimps

Comparative plots:





Comparison of the outputs of the previous year's assessment (2007–2019) and the updated assessment performed this year (2007–2020)

N:37

Stock: Deep-water rose shrimp (*Parapenaeus longirostris*)

GSA: 17–19

Author(s): *Simmonds, J., Bitetto, I, Cikes Kec, V., Daskalov, G., Isajlovic, I., Kupshus, S., Mantopoulou, D. , Murenu, M. , Orio, A., Pierucci, A. , Sgardeli, V., Touloumis, K., Tserpes, G. and Mannini, A.

Fishery: Deep-water rose shrimp (*Parapenaeus longirostris*) is one of the most important demersal species in the area, in terms both of landings and income. This resource is exploited by trawlers targeting deep-water species as well as mixed deep-water and demersal species.

Data and parameters The STECF EWG 19-16 ran an assessment on GSA 19 to check whether or not the use of different growth parameters by individual sex rather than by combined sexes would improve the consistency of the cohort evolution (STECF, 2019). The exercise did not result in consistent differences because males and females grow in a similar way when they are small and few males are found at larger sizes. As such female growth provides a good model to cover the full range of sizes observed. For the purposes of the assessment, STECF EWG 21-15 then decided to perform age slicing on the commercial catches and the survey index by using the combined sex parameters as was done in the previous meeting. Growth parameters and length–weight relationship parameters for combined sexes came from DCF (STECF, 2021). This assessment was performed by joining the three GSAs (GSAs 17, 18 and 19).

The assessment was carried out using LFD abundance indices (N/km2) for GSAs 18 and 19 (MEDITS data, available from 1994, was used from 2008 to 2020); length structure of landings (discard negligible) by fishing segment and landing in weight came from DCF (2002–2020). Several landing and discard reconstructions were also performed. The growth parameters were estimated within DCF, as was the case for the length–weight relationship and maturity ogive. The vector of natural mortality by age was calculated applying the Chen and Watanabe method. The catch-at-age matrices (for landing and survey) were derived according to deterministic age slicing procedure

Assessment method: The assessment was carried out using an a4a model with sex combined age slicing.

Model performance: The results show an almost stable F in the last years. The SSB and recruitment show a small recent decrease. The residuals show some trends in the first years of the index. The overall absolute values of residual are acceptable. The retrospective analysis, on an overall basis, still shows a consistent pattern.

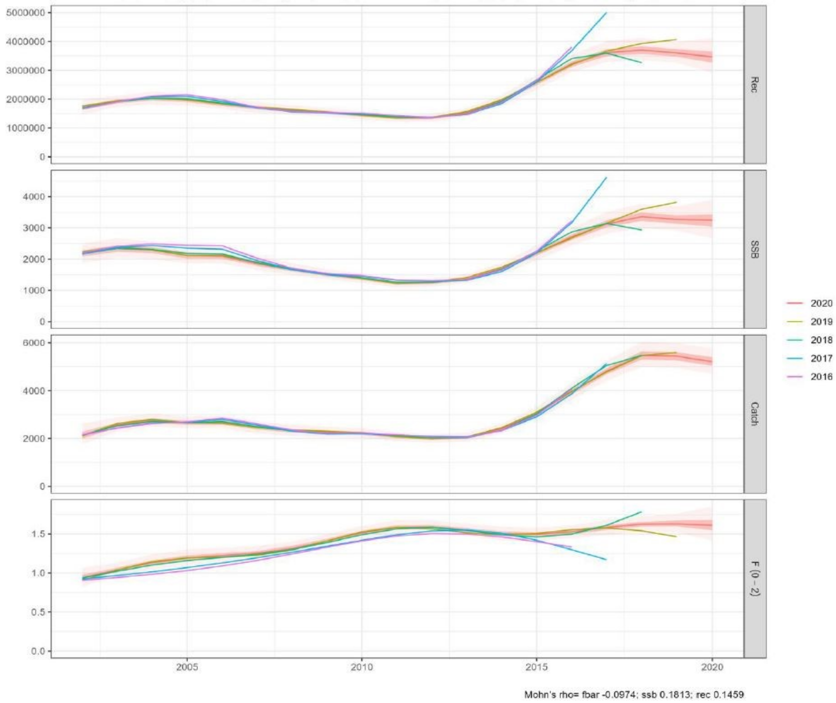
Results: The fishing mortality (F_{bar}(1–3)) and $F_{0.1}$ values estimated were 1.62 and 0.72, respectively, in 2020.

$F_{current}$ (2020)	1.62
F_{01}	0.72
$F_{current}/F_{01}$	2.25
$B_{current}$ (tonnes) (2020)	3 238
B 33rd percentile(tonnes)	1 697
B 66th percentile (tonnes)	2 282

Diagnosis of stock status: In overexploitation ($F_{current} > F_{0.1}$) with relatively low biomass (SSB $_{current}$ > SSB 33 percentile).

Advice and recommendations:

- Reduce the fishing mortality



Retrospective analysis for the a4a assessment

References

STECF. 2021. *Stock assessments in the Mediterranean Sea 2021–Adriatic and Ionian Seas* (STECF-21-15). Luxembourg, Publication Office of the European Union. https://doi.org/10.2760/59806

STECF. 2019. *Stock Assessments Part 2: European fisheries for demersal species in the Adriatic Sea* (STECF-19-16). Luxembourg, Publication Office of the European Union. https://doi.org/10.2760/95875

N: 38

Stock: Common cuttlefish (*Sepia officinalis*)

GSA: 17

Author(s): Armelloni E.N., Scanu M., Masnadi F., Polidori P., Pellini G., Ferrà C., Salvalaggio V., Montagnini L., Grati F., Angelini S., Santojanni A., Domenichetti F., Colella S., Donato F., Martinelli M., Giovanardi O., Raicevich S., Sabatini L., Franceschini G., Fortibuoni T., Marceta B, Fabi G., Ikika Z., Kule M., Milone N., Arneri E. and Scarcella G.

Fishery: The common cuttlefish (*Sepia officinalis*) is a valuable resource in the northern Adriatic Sea (GSA 17) where it is targeted by trawled gear (otter trawl, "Rapido" trawl) and set gear (trammel nets, pots and fyke nets). The stock is shared by Slovenian, Croatian and Italian fleets, with the latter accounting for an average of more than 90 percent of catches per year. The reproductive behaviour of the species influences its catchability: during autumn, the recruits move from coastal waters (nursery) to the circalittoral zone (feeding ground) and in the next spring the same cohort goes back to the shallower infralittoral region to spawn and, subsequently, die (semelparous species). Indeed, recruits dominate trawl landings whether the coastal fishery targets mainly adults during the spawning time. The trend of historical catches is declining and from 2010 onward some of the lowest values have been registered.

Data and parameters: Landings for Italy (1973–2020), Slovenia (1992–2020) and Croatia (1992–2020); SoleMon survey index (2005–2020).

Data issues: Data for Croatia and Slovenia were available from 1992 onward, while Italian data were available from 1973. To obtain a coherent time series, Croatian and Slovenian landings were reconstructed back to 1973 for each country (x) and year (y) as:

$$\text{Catch}_{x,y} = \text{Catch}_{ITA,y} * \frac{\sum_{k=1992}^{2019} \frac{\text{catch}_{k,x}}{\text{catch}_{k,ITA}}}{2019-1992}$$

Assessment method: CMSY (Froese *et al.,* 2017), BSM. Priors for final depletion obtained with AMSY (Froese *et al*., 2020). Comparisons were made with the Just Another Bayesian Biomass Assessment (JABBA) model (Winker *et al.*, 2018) and the SPiCT model.

Model performance: Overall diagnostics are acceptable and a sensitivity analysis was conducted to test the prior's choice. The sensitivity analysis confirmed the model results, however in the final model, wide ranges of uncertainties for the F/F_{msy} and B/B_{msy} ratio were observed.

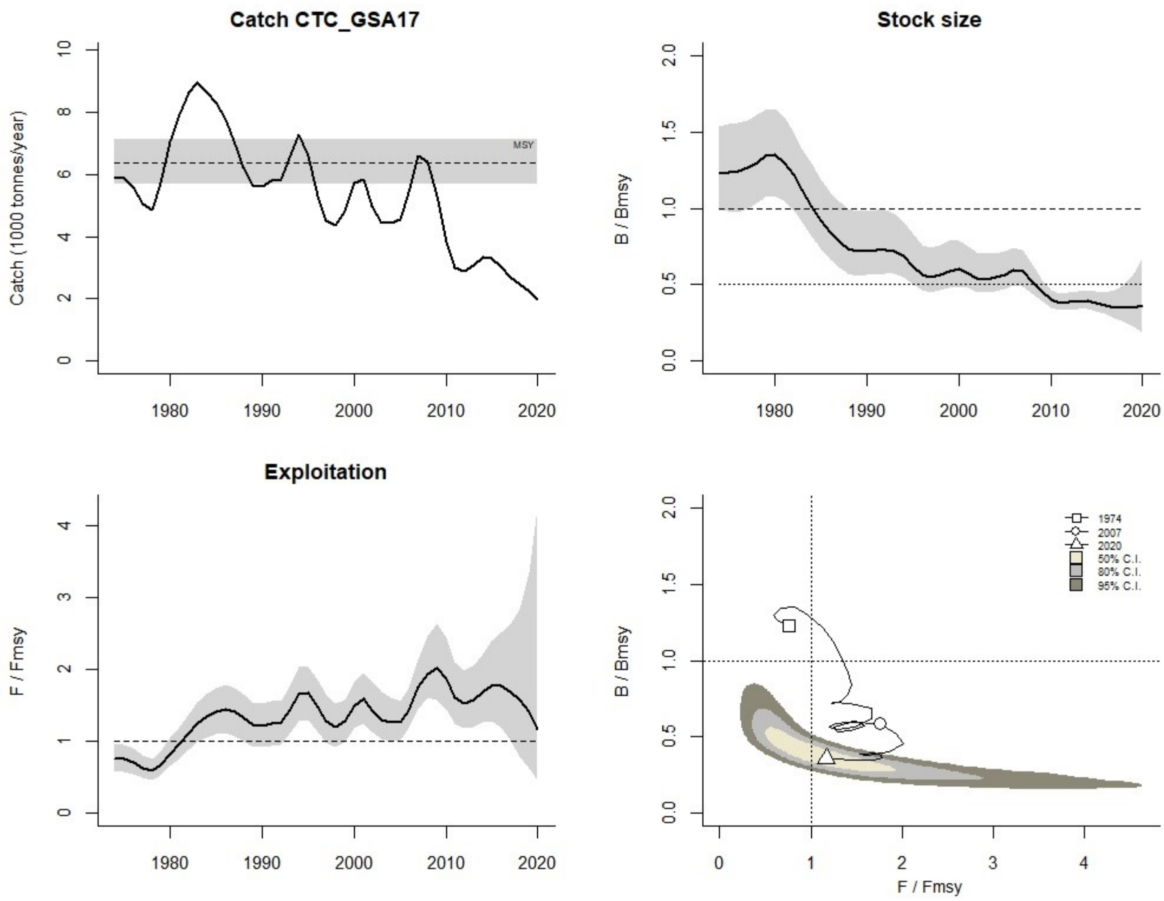
Results: The biomass trend showed an almost monotonous decline in the early part of the time series, until 1988, then it oscillated without large spikes until 2007. In 2008, a steep decline was observed which led the biomass to fall below 0.5 B/Bmsy in 2009. From 2012 onward, the biomass gradually increased, but remained below 0.5 B/Bmsy as of 2020. Exploitation highly oscillated during the whole time series. Up to 2010 high spikes in exploitation were observed and alternated with years of exploitation at values close to F_{msy}. Subsequently, F remained quite far above F_{msy} for the period 2002–2016, with many up and downs. During the years 2016–2019, F continuously declined and in 2020, it was only slightly higher than F_{msy}.

$F_{current}$ (2020)	0.214
Lower limit (95% c.i.)	0.115
Upper limit (95% c.i.)	0.408
F_{msy} (2020)	0.181
$F_{current}/F_{msy}$	1.172
Lower limit F_{curr}/F_{msy} (95% c.i.)	0.462
Upper limit F_{curr}/F_{msy} (95% c.i.)	4.246
Current biomass (thousand tonnes)	9.196
B_{msy} (thousand tonnes)	25.416
Current biomass / B_{msy}	0.362
Lower limit current biomass/B_{msy} (95% c.i.)	0.189
Upper limit current biomass/B_{msy} (95% c.i.)	0.675
MSY (thousand tonnes)	6.367
Catches 2020 (thousand tonnes)	1.562

Diagnosis of stock status: In overexploitation with low biomass.

Advice and recommendations:

- Reduce fishing mortality



Summary of the CMSY best model

N: 39

Stock: Spottail mantis shrimp (*Squilla mantis*)

GSA: 17

Author(s): Scanu M., Masnadi F., Armelloni E.N., Polidori P., Pellini G., Ferrà C., Salvalaggio V., Montagnini L., Grati F., Angelini S., Santojanni A., Domenichetti F., Colella S., Donato F., Martinelli M., Giovanardi O., Raicevich S., Sabatini L., Franceschini G., Fortibuoni T., Fabi G., Arneri E., Cardinale M. and Scarcella G.

Fishery: Spottail mantis shrimp (*Squilla mantis*) in GSA 17 ranks first among the crustaceans landed in the Adriatic ports. It is an important component of the local multispecies trawl and gillnet fishery and a specialized pot fishery is developing. The Adriatic Sea accounts for around 80 percent of the Italian annual landings for this species. Compared to 2019, 2020 landings of GSA 17 decreased by 8 percent: OTB decreased by 5 percent, nets decreased by 38 percent, TBB decreased by 28 percent, and pots increased by 380 percent. The species is also present in Croatian and Slovenian statistics (maximum of 10 tonnes per year), however, considering the small amount of catches, these data have been summed up with the Italian fleet using the same gear.

Catches show marked dial periodicity with significantly more animals caught at night. The burrowing behaviour of the spottail mantis shrimp provides protection and as a result, individuals are only vulnerable when they are out of their burrows which 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 increase in winter, when mating takes place. Catches increase further in late autumn with the arrival of new recruits.

Data and parameters: There has been a clear. Increase in catches since the 1950s, although there are cyclical peaks and troughs every 3–4 years. A strong decrease was evident between 2010 and 2013 while from 2014 to 2016, a slight increasing trend was registered.

The SS3 analyses was carried out considering the following four fleets: OTB, GNS, TBB and FPO.

The Stock Synthesis model used in this assessment was a seasonal size structure data model based on the separate fleet LFD from 2009 to 2020; some LFD were excluded from the assessment due to small sampling effort highlighted in the data section. The pots and traps fleet only has LFD from 2020. The age classes considered ranged from 0 to 4, but the plug group was set at age 6 in order to avoid forcing the model to fit. Tuning data provided by the SOLEMON survey, carried out in autumn for the years 2005–2020, along with LFD from 2012 to 2020 were also used as input data. Due to missing hauls in 2020, a spatio-temporal ecological model was used to predict the biomass index at missing points, and the abundance index for the whole area was estimated in combination with real observations. The growth parameters used to run the assessment were those studied by Froglia (1996) in GSA 17. Since the data included specimens that were very big compared to these parameters, the WGSAD asked for a reinvestigation of all biological parameters. The natural mortality vector was obtained from PRODBIOM model (Abella *et al.*, 1998) and maturity from the literature (Colella *et al.*, 2016).

Data and parameters issues: Since the data included specimens that were very big compared to Froglia's (1996) parameters, the WGSAD asked for a reinvestigation of all biological parameters. The WGSAD also pointed out issues related to the LFDs.

Assessment method: The fundamental idea of this stock assessment is to use the integrated approach of stock synthesis (version SS3.3) to model the size structure data available for the mantis shrimp. The SS3 model uses forward projection of population in the SCAA approach. To follow the stepwise growth of this crustacean species, a seasonal model was developed.

Model performance: No particular trends were evident in the residuals. The tests that were run on all fleets and survey data, hindcasting and retrospective analysis were considered acceptable.

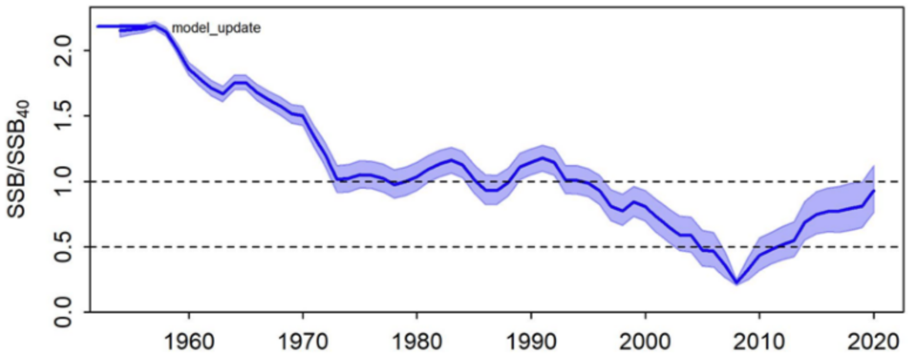
Results: The resulting SSB was 5 834 tonnes and the estimated current F was 0.26.

$F_{current}$ ($F_{bar\ 1-3}$ in 2020)	0.26 (± 0.05)
$F_{40\%}$ (2019)	0.33
$F_{current}/F_{40\%}$	0.78
Current SSB (tonnes)	5 834 (± 870)
$SSB_{40\%}$ (2020)	6 314

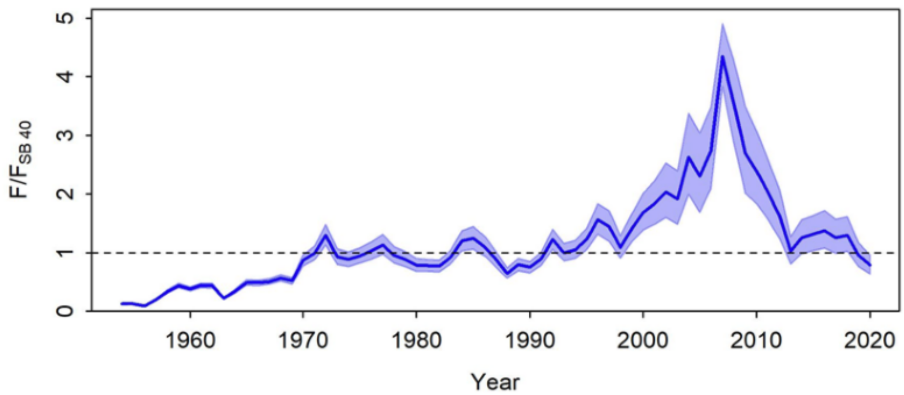
Diagnosis of stock status: Considering the results of the analyses conducted, spottail mantis shrimp in GSA 17 is subject to sustainable exploitation at the current F(1–3) of 0.26, as estimated by the SS3 model, which is lower than the proposed reference point (F40% = 0.33). Based on the SSB, the stock is in a state of low biomass as the current SSB estimated by the SS3 model (5 834 tonnes) is lower than SSB40% (6 314).

Advice and recommendations:

- Do not increase fishing mortality



Spawning stock biomass and standard deviation calculated by the SS3 model (blue), with SSB40% (black dotted line).



Fishing effort and standard deviation calculated by the SS3 model (blue) and F40% (black dotted line).

References:

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Colella, S., Donato, F., Panfili, M., & Santojanni, A. 2016. Reproductive parameters and sexual maturity of *Squilla mantis* L., 1758 (Crustacea: Stomatopoda) in the north-central Adriatic Sea (GSA 17). *Biologia Marina Mediterranea*, 23(1): 258.

N:40

Stock: European hake (*Merluccius merluccius*)

GSA: 12, 13, 14, 15, 16

Author(s): Falsone F.*, Fiorentino F., Gancitano V., Scannella D., Colloca F., Ben Abdellah O., Ben Mariem S., Jarboui O., Fezzani S., Cherif M., Di Maio F., Gambin M., Fezzani S., Quattrocchi F., Vitale S., Ceriola L., Arneri E. and Cardinale M.

Fishery: In the Strait of Sicily, European hake (*Merluccius merluccius*) is fished by six fishing fleets: Italian coastal trawlers, Italian distant trawlers, Tunisian trawlers, Maltese trawlers, Tunisian artisanal vessels and Italian artisanal vessels. Mean annual landings of hake for 2017–2020 were about 778 tonnes for Italian and Maltese trawlers and about 1 415 tonnes for Tunisian trawlers. Hake is the main commercial bycatch species of deep-water shrimp fisheries and is a target species for vessels using longlines and gillnets. Trawlers catching hake exploit a highly diversified species assemblage, the main other commercial species being deep-water rose shrimp (*Parapenaeus longirostris*; generally the main target species), striped mullet (*Mullus surmuletus*) and red mullet (*Mullus barbatus*). Size structures of hake catches range between 4 and 72 cm total length for the Italian-Maltese trawlers, 6–68 cm for the Tunisian trawlers and 10–64 cm for the Italian-Tunisian passive gear.

Data and parameters: Fishery dependent data used for the stock assessment in the GSA 16 are reported in the following table:

<table>
<tr><th>Fishery</th><th>Data type</th><th>Fleet</th><th>Period</th><th>Source</th></tr>
<tr><td rowspan="7">Italian-Maltese trawlers</td><td rowspan="2">Commercial landings (tonnes)</td><td>Italian trawlers</td><td>1947–2020</td><td>ISTAT (1947–2001)
DCF (2002–2020)</td></tr>
<tr><td>Maltese trawlers</td><td>2009–2020</td><td rowspan="6">DCF</td></tr>
<tr><td>Discards (tonnes)</td><td>Italian trawlers</td><td>2009–2020</td></tr>
<tr><td rowspan="2">Length composition of commercial landings (N thousand)</td><td>Italian trawlers</td><td>2009–2020</td></tr>
<tr><td>Maltese trawlers</td><td>2009–2020</td></tr>
<tr><td>Length composition of discards (N thousand)</td><td>Italian trawlers</td><td>2009–2020</td></tr>
<tr><td>Age length key</td><td>Italian trawlers</td><td>2004–2020</td></tr>
<tr><td rowspan="3">Tunisian trawlers</td><td>Commercial landings (tonnes)</td><td>Tunisian trawlers</td><td>1950–2020</td><td rowspan="3">Official Tunisian landing statistics</td></tr>
<tr><td>Length composition of commercial landings (N thousand)</td><td>Tunisian trawlers</td><td>2007–2020</td></tr>
<tr><td>Discards (tonnes)</td><td>Tunisian trawlers</td><td>2007–2020</td></tr>
<tr><td rowspan="4">Italian–Tunisian passive gear</td><td rowspan="2">Commercial landings (tonnes)</td><td>Italian fixed nets</td><td>2004–2020</td><td>DCF</td></tr>
<tr><td>Tunisian passive gear</td><td>2014–2020</td><td>Official Tunisian landing statistics</td></tr>
<tr><td rowspan="2">Length composition of commercial landings (N thousand)</td><td>Italian fixed nets</td><td>2010–2020</td><td>DCF</td></tr>
<tr><td>Tunisian passive gear</td><td>2010–2020</td><td>Official Tunisian landing statistics</td></tr>
</table>

Stock abundance indices were available from the MEDITS survey carried out in GSA 16 and conducted mainly in the third quarter of the year. Data on biomass index and length composition are available from 1994 to 2020.

Moreover, the same parameters of the benchmark model were used with the exception of the Tunisian selectivity which was set as time varying for the years 2019 and 2020. However, the sensitivity analysis showed that this modification improved the diagnostic of the model and overall, all tested configurations estimated similar values in terms of SSB, F and recruitment.

Assessment method: The assessment was performed through SS3.

Model performance: No particular trends are evidenced in residuals and the retrospective analyses is consistent as well as the root mean square error (RMSE) diagnosis performed on the biomass index. In addition, hindcasting performed well on the mean lengths with the exception of those from the combined Italian and Maltese fleets. Overall, the hindcasting of the MEDITS survey performed well but the model was not able to predict the biomass index in 2020.

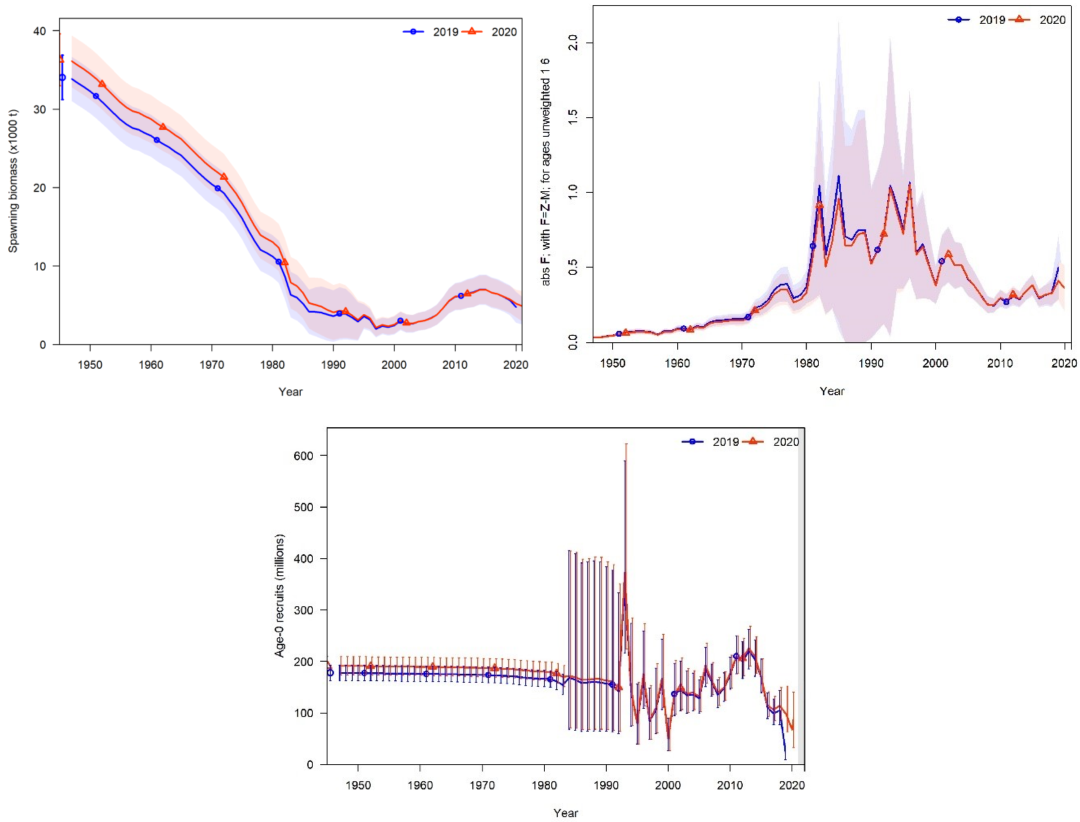
Results: The final results of the model were: current F (0.36, estimated as the $F_{1\text{–}6}$ in the last year of the time series, 2020) was higher than F_{MSY} indicating that European hake stock in GSAs 12,13,14,15,16 is over-exploited (F/F_{MSY} = 1.24). Moreover, the model estimated a SSB (2021, that correspond to first January) of 4885 tonnes.

$F_{current\ (SS3)}$	0.36
F_{MSY}	0.29
$F_{current}/F_{MSY}$	1.24
Current SSB (tonnes)	4 885
SSB_{MSY}	7 021
SSBcurrent/ SSB_{MSY}	0.70

Diagnosis of stock status: Hake in GSA 12–16 is in overexploitation and overexploited

Advice and recommendations:

- Reduce fishing mortality



Comparisons of SSB, F and recruitment between the current (red) and previous (blue) assessments.

N:41

Stock: European hake (*Merluccius merluccius*)

GSA: 19

Author(s): Bitetto, I., Carbonara, P., Donnaloia, M., Casciaro, L., Spedicato, M.T., Maiorano, P., Cipriano, G., Sion, L. and Carlucci, R. (benchmark); STECF (benchmark update).

Fishery: Following the last SAC meeting (Cairo, Egypt, 24–27 June 2019), the benchmark stock assessment of European hake (*Merluccius merluccius*) was carried out assuming the stock was contained in the boundaries of the western Ionian Sea (GSA 19). European hake represents one of the most important demersal species in terms of landings and income in GSA 19, especially for longlines (accounting for about 20 percent of hake landings), gillnets and trammel nets (about 20 percent of hake landings), but also for trawlers (about 60 percent of hake landings).

Data and parameters: Official landings were obtained from DCF (2002–2020) and MEDITS survey indices (available from 1994, used from 2002 to 2020). The discard data are present from 2006 to 2020 with a gap in 2007 and 2008 (not mandatory). In the years 2004, 2005, 2007 and 2008, the discard (weight and LFDs) was estimated according to the average discard ratio of the years 2006 and 2009. Biological information on growth von Bertalanffy parameters, maturity at length and length–weight relationships were derived within DCF (2002–2020). The natural mortality vector was estimated as an average of different methods – Gislason, PRODBIOM revised version with unique solution, Chen and Watanabe, Brodziak (2011 and 2012), Lorenz and Gulland – consistent with the approach used in the benchmark assessment of hake in Adriatic Sea in 2019.

Deterministic age slicing using DCF growth parameters was used to produce catch-at-age input for assessment.

Assessment method: Statistical catch-at-age a4a (http://flr-project.org/FLa4a) was performed at the hake benchmark meeting (GFCM, 2020).

Last year, the original survey catchability submodel used for the benchmark assessment resulted in high instability of the present assessment, in particular the original qmodel <- list(~factor(age), gcv = 0.5). It was replaced by a model assigning equal catchability at ages greater than two that was also considered at the benchmark (GFCM, 2020) and was deemed to have similar goodness of fit diagnostics (gcv = 0.5) as the model accepted at the benchmark (qmodel <- list(~factor(age)). Fishing mortality and stock-recruit submodels remained the same as those used for the benchmark assessment. This year, the same revised model was utilized:

Fishing mortality: 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)

Model performance: Model residuals and retrospective analysis did not show any trends, patterns or violations. The results and the diagnostics of the fitted model were very similar to those obtained at the GFCM benchmark assessment. Short-term forecast was carried out.

Results: The results showed a decreasing pattern for the fishing mortality, that in 2018 was still well above the proxy of $F_{0.1}$ (0.14), with a ratio of 2.32. The SSB showed some increase in recent years, while the recruitment remained stable.

$F_{current}$ (Fbar 0–4 in 2020)	0.287
$F_{0.1}$ (2018)	0.154
$F_{current}$/F0.1	19
Current SSB 2020 (tonnes)	1 593
33rd percentile biomass (tonnes)	1 023
66th percentile biomass (tonnes)	1 207

Diagnosis of stock status: The stock is in overexploitation with relatively high biomass.

Advice and recommendations: Reduce the fishing mortality towards the reference point, progressively reducing the fishing effort.

Comparison plot between the last year's assessment and the update from this year.

References:

GFCM. 2020. *Working Group on Stock Assessment of Demersal Species (WGSAD) Benchmark session for the assessment of European hake in GSAs 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 22, 23 and 26.* FAO headquarters, Rome, Italy, 2–7 December 2019. Final Report. Rome.

N:42

Stock: European hake (*Merluccius merluccius*)

GSA: 17–18

Author(s): Angelini, S., Armelloni, E.N., Arneri, E., Belardinelli, A., Bitetto, I., Boscolo-Palo, G., Cacciamani, R., Calì, F., Carbonara, P., Cardinale, M., Casciaro, L., Ceriola, L., Colella, S., Domenichetti, F., Donato, F., Ikica, Z., Isajlovic, I., Kule, M., Manfredi, C., Marceta, B., Martinelli, M., Milone, N., Panfili, M., Piccinetti, C., Romagnoni, G., Santojanni, A., Scarcella, G., Spedicato, M, Tesauro, C. and Vrgoc N.

Fishery: European hake (*Merluccius merluccius*) is one of the most important demersal species for the Adriatic Sea. In this area, European hake is exploited mainly by bottom trawlers and in the southern part of the Adriatic Sea and in Croatian waters, longlines are also relevant. Landings fluctuated throughout the time series being considered and reached the highest value in 2006 and the lowest value in 2020. This species is mainly exploited by Italy; in particular, Italian bottom trawl catches of GSAs 17 and 18 represents around 75 percent of the total Adriatic catches. Bottom trawl catches are mainly composed of age 0, 1 and 2, whereas longlines exploit bigger individuals.

Data and parameters: The biological information, specifically growth and length–weight relationship parameters, are assumed to be equal to those estimated by the DCF sampling protocol in the Italian GSA 18. Catch data are included by country and gear, as well as the length composition of catches. Survey data correspond to the MEDITS index including both GSA 17 and 18.

Assessment method: The present assessment is an update of the evaluation presented in 2021. The fundamental idea of this stock assessment is to use the integrated approach of stock synthesis (version

SS3.30.18) to model the size structure data available for the hake. The SS3 model uses forward projection of population in the SCAA approach.

Model performance: The model fits well with the length composition data and the MEDITS index, however the retrospective analysis shows some instability, particularly for the SSB. The run tests show a good fit for the length data of the each fleet, while the mean absolute standard error (MASE) is less than one for most of the fleets, except the Italian bottom trawlers operating in GSA 17, the bottom trawlers of Montenegro and the MEDITS data.

Results: The overall stock status conclusions confirm the positive trend depicted in the last assessment; SSB shows a continuous increasing trend, while fishing mortality has constantly decreased since 2015. Recruitments follow a fairly stable trend. The fishing mortality reference point (F_{MSY}) was estimated from the SS model run during the benchmark assessment (GFCM, 2019), while the biomass reference points (B_{lim} and B_{pa}) were estimated following the ICES procedure (ICES 2017).

$F_{current}$ ($F_{bar\ 1–4}$ in 2020)	0.41
F_{MSY}	0.167
$F_{current}/F_{MSY}$	2.46
Current SSB (tonnes) 2021	3 983
B_{lim} (tonnes)	1 858
$B_{trigger} = B_{pa}$ (tonnes)	2 543
$B_{current}/B_{lim}$	2.14
$B_{current}/B_{pa}$	1.57

Diagnosis of stock status: Considering the results of the analyses conducted, European hake in GSAs 17–18 is subjected to high overfishing – current $F_{bar(1–4)}$ (0.41) is higher than the proposed reference point (F_{MSY} = 0.167). Based on the biomass level (SSB), the stock is in a state of relative high biomass – current SSB (2021, 3 983 tonnes) is higher than B_{pa} and B_{lim}. According to Table 10 of the framework for describing stock status and providing management advice in relation to reference points (GFCM, 2014), the stock has biomass above the reference point and in overexploitation. The establishment of a fisheries restricted area (FRA) in the Jabuka/Pomo pit could potentially have driven the increase in hake biomass observed in the recent years.

Advice and recommendations:

- Reduce fishing mortality. The need for a new benchmark or inter-benchmark session was submitted to the working group, in order to produce a more stable model for the next year, evaluate the possibility of including historical data and eventually revise the reference points.

N:43

Stock: Red mullet (*Mullus barbatus*)

GSA: 12–14

Author(s): Ben Abdallah, O., Ben Hadj Hamida, N., Cherif, M. and Jarboui. O.

Fishery: The red mullet (*Mullus barbatus*) is an important demersal species for commercial fisheries in GSAs 12–14. It is exploited by trawl and artisanal fleet. Small gear (trammel nets and gillnets) account for 5 percent of the total landings of red mullet (average for the 2010–2020 period) while the trawl fleet accounts for 2 759 tonnes (average 2010–2020 period).

The trawl fishery exploits a highly diversified species assemblage, the main commercial species being the caramote prawn (*Penaeus kerathurus)*, striped mullet (*Mullus surmuletus*), hake (*Merluccius merluccius*), sparid fish (*Pagellus erythrinus*, *Diplodus annularis*, *Sparus auratus*, etc.). Length catches of red mullet range between 8 and 26 cm total length, with an average size of 14 cm.

Data and parameters: Stock assessment of red mullet was carried out using the official Tunisian catch data of bottom trawling in GSAs 12–14. Number-at-age data from experimental trawl surveys carried out in the

GSAs in question, were used as tuning data. The vector of natural mortality by age was calculated using the Gislason model. The biological parameters used were: $L\infty = 25.96$, $k = 0.309$, $t_0 = -0.824$, $a = 0.0044$, $b = 3.29$ for combined sexes. Maturity by age data was estimated using the maturity ogive parameters of female red mullet.

Assessment method: The assessment was performed using XSA as implemented in the FLR. Model settings in terms of shrinkages and catchability of the best benchmark model (GFCM Benchmark session on red mullet, 2018) were assumed. According to the recommendations of the GFCM WGSAD, current F was obtained as am average of three previous years (2018–2020).

Model performance: Model residuals did not show any trends. Overall diagnostics are acceptable, and retrospective analysis is consistent.

Results: According to the recommendations of the GFCM WGSAD, current $F_{(current)}$ was estimated as an average of the last three years of the time series being considered (i.e. 2018–2020) and was equal to 1.47; $F_{0.1}$ was estimated using FLR routine. The result obtained in terms of stock status are reported in the table below.

$F_{current\ (ages\ 0–2;\ 2018–2020)}$	1.47
$F_{0.1}$ (2018)	0.47
$F_{current}/F_{0.1}$	3.15
Current SSB (tonnes)	2 391.7
33rd percentile biomass (tonnes)	2 490.9
66th percentile biomass (tonnes)	2 295.3

Diagnosis of stock status: In high overfishing status with relatively low biomass.

Advice and recommendations:

- Reduce $F_{current}$ towards $F_{0.1}$

- Progressive reduction of fishing effort

N: 44

Stock: Red mullet (*Mullus barbatus*)

GSA: 15

Authors: Gambin, M., Mifsud, J., Gancitano, V., Scannella, D., Falsone, F., Ben Meriem, S., Ben Abdallah, O., Arneri, E., Ceriola, L., Jarboui, O., Vitale, S. and Fiorentino, F.

Fishery: Red mullet (Mullus barbatus) is one of the main coastal demersal resources in the Mediterranean. It is fished by otter trawls, trammel nets and gillnets (Voliani, 1999; Griffiths *et al.,* 2007). Red mullet is caught together with other important species, such as striped red mullet (*Mullus surmuletus*), European hake (*Merluccius merluccius*), *Pagellus spp*. (seabreams, pandoras), stargazer (*Uranoscopus scaber*), rays (*Raja spp*.), weevers (*Trachinus spp.*), common octopus (*Octopus vulgaris*), common cuttlefish (*Sepia officinalis*), horned and musky octopuses (*Eledone spp.*), and anglerfish (*Lophius spp*.). Red mullet is fished almost exclusively by trawling on shelf bottoms. Based on available knowledge, red mullets inhabiting the continental shelf of GSA 15 are considered to be a stock unit, with an average annual landing for the period 2009–2020 of about 15 tonnes.

Data and parameters: Number at length from commercial catches and from the MEDITS survey were converted to catch number-at-age and survey number-at-age using ALK from GSA 16. The Maltese landings were used and the natural mortality was estimated using the Gislason method.

Assessment method: The assessment was performed using XSA as implemented in the FLR. According to the recommendations of the GFCM WGSAD, current F was obtained as the geometric mean of the last three years (2018–2020).

Model performance: Overall diagnostics are acceptable.

Results: Current $F_{(1–3)}$ estimated by an average of three years was equal to 0.589. The $F_{0.1}$ value was estimated using the FLR routine. The SSB in 2020 was below the 33rd percentile of the SSB time series. The results obtained in terms of stock status are reported in the table below.

$F_{current}$	0.589
$F_{0.1}$ (Benchmark assessment)	0.402
$F_{current}/F_{0.1}$	1.465
Current SSB in 2020 (tonnes) from XSA	8.479
33rd percentile SSB (tonnes) – 2020	52.280
66th percentile SSB (tonnes) – 2020	64.238

Diagnosis of stock status: In intermediate overfishing with relatively low biomass.

Advice and recommendations:

- Decrease fishing mortality; revise the benchmark

N: 45

Stock: Red mullet (*Mullus barbatus*)

GSA: 15

Authors: Gambin, M., Mifsud, J., Gancitano, V., Scannella, D., Falsone, F., Ben Meriem, S., Ben Abdallah, O., Arneri, E., Ceriola, L., Jarboui, O., Vitale, S. and Fiorentino, F.

Fishery: Red mullet (*Mullus Barbatus*) is one of the main coastal demersal resources in the Mediterranean. It is fished by otter trawls, trammel nets and gillnets (Voliani, 1999; Griffiths *et al.,* 2007). Red mullet is caught together with other important species, such as striped red mullet (*Mullus surmuletus*), European hake (*Merluccius merluccius*), *Pagellus spp*. (seabreams, pandoras), stargazer (*Uranoscopus scaber*), rays (*Raja spp*.), weevers (*Trachinus spp.*), common octopus (*Octopus vulgaris*), common cuttlefish (*Sepia officinalis*), horned and musky octopuses (*Eledone spp.*), and anglerfish (*Lophius spp*.). Red mullet is fished almost exclusively by trawling on shelf bottoms. Based on available knowledge, red mullets inhabiting the continental shelf of GSA 15 are considered to be a stock unit, with an average annual landing for the period 2009–2020 of about 15 tonnes.

Data and parameters: A revised LFD from commercial landings was proposed; years with few data points were based on LFDs from the closest available year and raising to the landings was done by length class using a = 0.0078, b = 3.0135 (for combined sexes) for the length–weight conversion. The obtained number at length from commercial landings and from the MEDITS survey were converted to catch number-at-age and survey number-at-age using ALK from GSA 16. The Maltese landings were used and the natural mortality was estimated using the Gislason method.

Assessment method: The assessment was performed using XSA as implemented in the FLR.

Model performance: Overall diagnostics are acceptable.

Results: The results obtained in terms of stock status are reported in the below table. According to the recommendations of the GFCM WGSAD, current $F_{(1–3)}$ was obtained as the geometric mean of the last three years (2018–2020). The $F_{0.1}$ value was estimated using FLR routine; to allow comparisons, the model was also run with 2009–2017 revised LFD data to replicate the benchmark and this reference point was used below. The SSB in 2020 was below the 33rd percentile of the SSB time series.

$F_{(1–3)\ current}$	0.541
$F_{0.1}$ (Revised benchmark assessment)	0.295
$F_{current}/F_{0.1}$	1.833
Current SSB in 2020 (tonnes) from XSA	8.087
33rd percentile SSB (tonnes) – 2020	57.553
66th percentile SSB (tonnes) – 2020	82.787

Diagnosis of stock status: In high overfishing with relatively low biomass.

Advice and recommendations:

- Decrease fishing mortality; revise benchmark

N:46

Stock: Red mullet (*Mullus barbatus*)

GSA: 16

Author(s): Scannella, D., Gancitano, V., Falsone, F., Vitale, S., Ceriola, L. and Fiorentino, F.

Fishery: Red mullet (*Mullus barbatus*) is an important species commercial for demersal fisheries in the Strait of Sicily (south-central Mediterranean Sea). It is fished almost exclusively by trawling on shelf bottoms. Based on available knowledge (Gargano *et al.*, 2017), red mullets inhabiting the continental shelf of GSA 16 are considered to be a stock unit with average annual landings for the period 2006–2020 of about 520 tonnes. In the year 2020, mainly due to the COVID-19 pandemic and the lockdown imposed by the Italian government, a strong decrease in landings of the coastal trawlers fleet, about 40 percent less than in 2019, was recorded.

Data and parameters: The data and the parameters used for the stock assessment in the GSA 16 were: i) catch composition and total catch (2006–2020) according to official national data from Italy; ii) ALK from commercial catch; iii) tuning data from MEDITS surveys; and iv) biological parameters (sex combined): $L\infty = 24.1$cm, $k = 0.42$, $t0 = -0.8$, $a = 0.0087$ and $b = 3.07711$. The natural mortality as vector by age group was estimated through the Gislason method. The $F_{0.1}$ value estimated during the last benchmark was adopted.

Assessment method: The assessment was performed through XSA as implemented in the FLR using catch data from Italy and MEDITS data for GSA 16 as tuning.

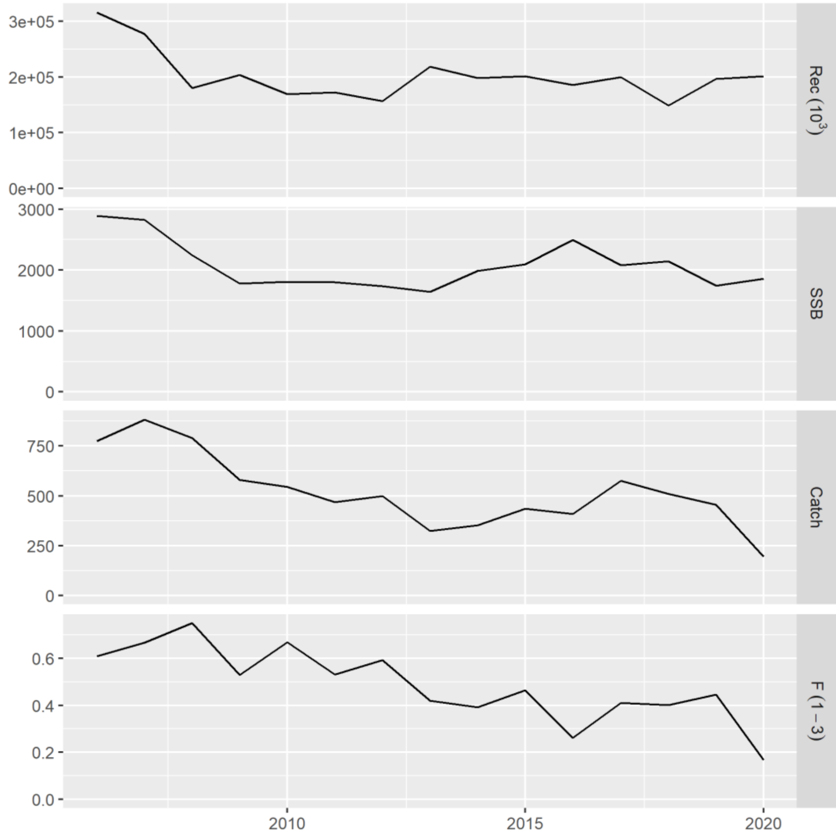
Results: According to the recommendations of the GFCM WGSAD, current F bar(1–3) was estimated as the geometrical mean of the last three years of the time series (2018–2020) and equal to 0.31. The estimation of $F_{0.1}$ was 0.42. The main results obtained by XSA in terms of stock status are reported in the table below.

$F_{current}$	0.31
$F_{0.1}$	0.42
$F_{current}/F_{0.1}$	0.74
Current SSB (tonnes) (average from 2018–2020)	1 916
33rd percentile biomass (tonnes)	1 807
66th percentile biomass (tonnes)	2 109

Diagnosis of stock status: The stock is sustainably exploited (Fcurrent < $F_{0.1}$) with relatively intermediate biomass (33rd percentile < SSB current < 66th percentile). The trawl survey data (MEDITS) time series indicated the relatively high biomass of the stock in 2020.

Advice and recommendations:

- To not increase the fishing mortality on the species and maintain the trawling ban in late summer-early autumn to avoid the catch of juveniles.



N:47

Stock: Red mullet (*Mullus barbatus*)

GSA: 19

Author(s): Bitetto, I., Zupa, W., Carbonara, P., Neglia, C., Maiorano, P., Carlucci, R., Lembo, G. and Spedicato, M.T.

Fishery: Red mullet (*Mullus barbatus*) is an important species in the area, targeted by trawlers and small-scale fisheries using mainly gillnets and trammel nets. Fishing grounds are located along the coasts of the entire GSA within the continental shelves.

Data and parameters: The benchmark assessment in 2018 was carried out using standardized LFD abundance indices (N/km2) for GSA 19 (MEDITS data 2002–2017); and length structure of catches by fishing segment and aggregated catches (landing and discard) from DCF (2002–2017). The growth parameters were estimated according to the age reading procedure described in Carbonara *et al.* (2018) and were consistent with the parameters estimated in GSA 18 in the same paper and in DCF. Length–weight relationship and maturity ogive came from DCF and the vector of natural mortality by age was calculated applying two different methods: Chen and Watanabe and a revised version of PRODBIOM with a unique solution. At the benchmark, PRODBIOM was retained. The catch-at-age matrices (for catch and survey) were derived according to two different methods: age slicing and ALK. At the benchmark, the age slicing was retained.

This third update was carried out using a similar method as the second one, adding the data of 2020 to the second update of last year both for the catch (landing and discard) and the MEDITS index, deriving the catch-at-age using the age slicing. The other biological information and all the settings were maintained as at the benchmark.

Assessment method: At the benchmark, the assessment was carried out using two different assessment methods: XSA and a4a. XSA was retained. The FLBRP package was used to calculate the reference point $F_{0.1}$.

The update was carried out, also this year, applying XSA with the same settings selected in the benchmark.

Model performance: The updated XSA results show a decrease of fishing mortality in 2020 with respect to the value of 2019, consistent with the recent decrease observed in the catch. The SSB also shows a recent decrease, followed by an increase in 2020. The residuals of the update do not show any particular trends and the overall absolute values remain low. The retrospective analysis, on an overall basis, still shows a consistent pattern, despite some instability on the SSB.

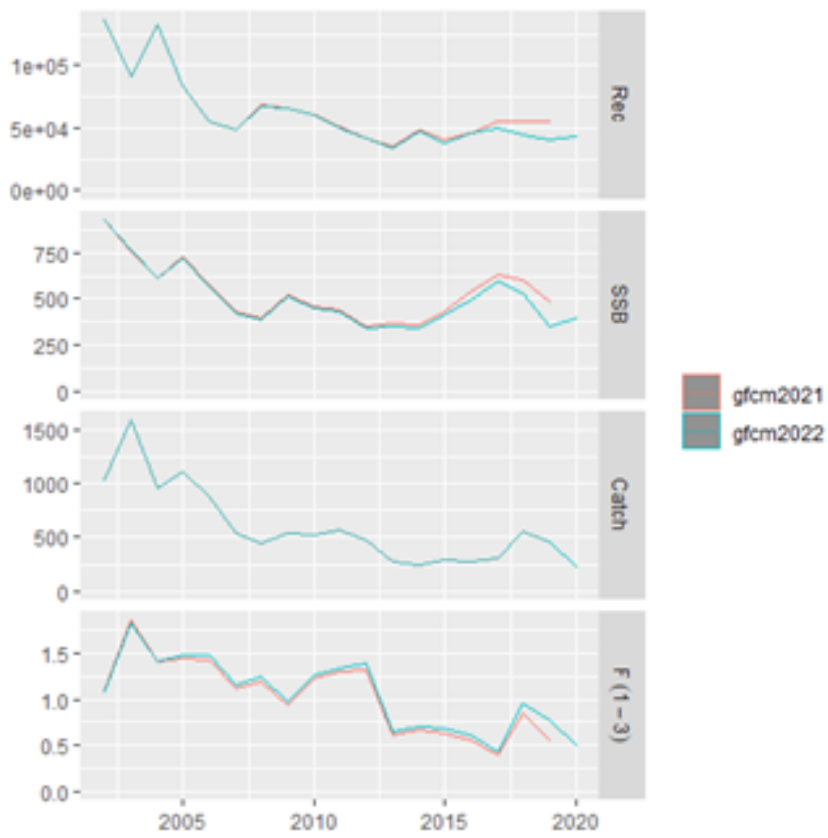
Results: Fishing mortality showed an average value of 0.747 (Fbar(1–3)) in 2018–2020. The $F_{0.1}$ value estimated in the benchmark and maintained in the update was 0.4.

$F_{current}$ (2018–2020)	0.747
F01	0.4
$F_{current}/F_{0.1}$	1.87
$B_{current}$ (tonnes) (average 2018–2020)	394
B 33rd percentile(tonnes)	409
B 66th percentile (tonnes)	526

Diagnosis of stock status: The stock is overexploited ($F_{current} > F_{0.1}$) with relatively low biomass ($SSB_{current}$ < SSB 33rd percentile)

Advice and recommendations:

- Reduce the fishing mortality towards the agreed reference point.



Comparative plot of the assessment results of the second and the third update of the benchmark.

N: 48

Stock: Common sole (*Solea solea*)

GSA: 17

Author(s): Masnadi, F., Cardinale, M., Carbonara, P., Donato, F., Sabatini, L., Pellini, G., Armelloni, E.N., Scanu, M., Ferrà, C., Angelini, S., Polidori, P., Martinelli, M., Domenichetti, F., Santojanni, A., Colella, S., Giovanardi, O., Raicevich, S., Fabi, G., Marceta, B., Vrgoč, N., Isajlovic, I., Milone, N., Arneri, E., Scarcella, G.

Fishery: Common sole (*Solea solea*) is a demersal and sedentary species, living on sandy and muddy bottoms (Fisher *et al.*, 1987) and is one of the most commercially important species of the Mediterranean and the Black Sea; in the Adriatic, common sole represent more than EUR 20 million of landing value. In 2020, 55 percent of the catches were provided by the Italian rapido trawl fleets (TBB); 23 percent from the Italian, Slovenian and Croatian set netters (GNS and GTR) operating mostly within 3 nautical miles from the coast;19 percent from the Italian otter trawlers (OTB); and the remaining 3 percent from the Croatian rampon fishery (DCF ITA HRV). Furthermore, landings in 2020 were almost 25 percent less than in 2019.

Assessment method: An ensemble modelling approach (Dietterich, 2000) was used to present results with a quantitative criterion based on diagnostic scores for weighting the runs. In summary, to address structural uncertainties, a range of alternative SS3 models (Methot and Wetzel 2013) was selected through diagnostics (interconnected diagnostic tests; Carvalho *et al.* 2021, Maunder *et al.* 2020), to be stitched together using a delta-multivariate log-normal estimator (delta-MVLN; Winker *et al.* 2019).

Data and parameters: The model use a very long historical series of catches, 1953–2019. The model used was organized into six fleets: five commercial and one survey. The commercial fleets, each with its own selectivity, are represented by individual gear (Italian trawlers, Italian *rapido*, Italian nets, Croatian and Slovenian nets and Croatian *rampon*) while the survey included as a tuning index was the SoleMon (2005–2019). In addition, the model includes, where available, length structures by fleet. Size are then converted to age inside the model.

In collaboration with to the study group of the AdriaMed regional project - FAO (SG-OTHSOLEA), the von Bertalanffy growth parameters used were estimated by applying a non-linear least square algorithm to age data collected in GSA 17 following the methodology by Carbonara and Follesa (2019).

The ensemble approach was selected as the best solution because it represents all possible states of nature of the stock under analysis based on a number of sources of natural and fishery uncertainty. Major uncertainly was linked to an alternative hypothesis of selectivity which had a large influence on the assessment (double normal vs cubic splines settings). Other alternative plausible hypothesis were based on three different levels of natural mortality and steepness. The final model grid for the ensemble included all combinations of alternative values for these three nested variables (18 runs).

Model performance: Interconnected diagnostic tests (cookbook by Carvalho *et al.,* 2021) were carried out on all ensemble candidate runs. Moreover, diagnostic scores were used as weighting factors during the ensemble procedure. Most configurations passed 100 percent of diagnostics with the exception of three runs that had a score of 0.93.

Results: The final results of the model for the last year (2020) were an SSB of 3 037 tonnes and an estimated recruitment of 159 254 thousand specimens. The current F was 0.19.

$F_{current}$ ($F_{bar\ 1–4}$ in 2020)	0.19 (0.10–0.34)
$F_{current}/F_{40\%}$	0.81 (0.43–1.57)
Current SSB (tonnes)	3 037 (1 524–7 855)
$SSB_{current}/SSB_{40\%}$	0.73 (0.30–1.38)
Recruitment (thousands)	159 254 (87 561–290 927)

Diagnosis of stock status: The spawning biomass was estimated to be below the reference point (SSB40; biomass equal to 40 percent of unfished biomass) and fishing mortality was estimated to be below the reference value (fishing mortality level at SSB40). In the last year, the trajectory of the stock from the Kobe plot reflected its recovering status.

Advice and recommendations:

- Though F is less than target reference point, it is recommended to reduce fishing mortality due to the low spawning biomass of the stock.

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N: 49

Stock: Horned Octopus (*Eledone cirrhosa*)

GSA: 18

Author(s): Romagnoni, G., Bitetto, I., Zupa, W., Lembo, G. and Spedicato, M.T.

Fishery: The horned octopus (*Eledone cirrhosa*) is a commercially important species. It is fished mainly with bottom trawl nets (OTB). Catch from gillnets and other artisanal gear are minor to negligible. Discards appear negligible in the Italian fleet and no information is available from other countries. Landings are reported from Italy (accounting for 85–99 percent of reported landings), Montenegro and Albania.

Data and parameters: Catches were assumed to be identical to landings. Landings for the Italian fleet were obtained from DCF data (2004–2020). Historical landings (1972–1999) for the Italian fleet were obtained from the Italian National Institute of Statistics (ISTAT and reconstructed to account for the misreporting of species using the proportion of landings by species from DCF (2004–2009). Data from Montenegro were obtained from FishStat (2006–2018), while data from Albania were only available for the years 2019–2020. For these two countries, landings were reported as aggregate *Eledone spp.,* thus landings of the assessed species were reconstructed using the proportion of landings of the two species in Italian DCF data (2006–2018). Standardized biomass index data were provided by the MEDITS survey (1994–2020). The resilience (r) parameter was set as high, based on the reported Von Bertalanffy (k) parameter. Priors for initial, intermediate and final B/B_0 values were set as medium depletion, low depletion and low depletion, respectively, based on the criteria outlined by Froese *et al.* (2017) and consistent with the previous assessment (2020).

Assessment method: CMSY is a Monte-Carlo method that estimates fisheries reference points (MSY, Fmsy, Bmsy) as well as relative stock size (B/Bmsy) and exploitation (F/Fmsy) 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.

Model performance: No particular trends are evidenced in residuals and the retrospective analyses is adequate. A sensitivity analysis was carried out by testing other runs with different parameter settings using objective methods for B/B0, alternative model settings and a shorter time series (focusing on the time period with data collected under the DCF, 2004–2020).

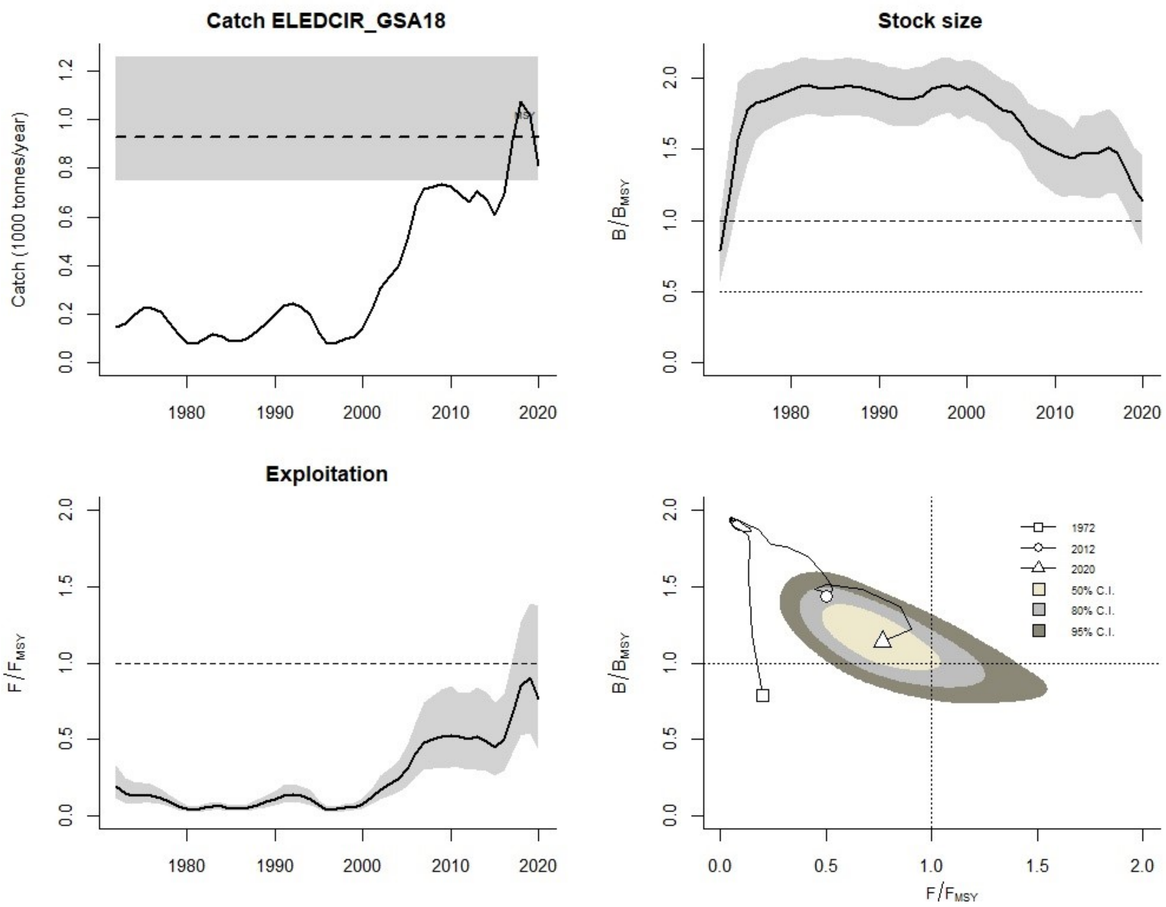
Results: The final results of the model for the last year (2020) were a B/BMSY value of 1.14 and an estimated F/FMSY of 0.766.

$F_{current}$	0.378
Lower limit (95% ci)	0.188
Upper limit (95% ci)	0.722
FMSY	0.491
$F_{current}$/FMSY	**0.77**
Lower limit F/FMSY (95% ci)	0.427
Upper limit F/FMSY (95% ci)	1.37
$B_{current}$ (thousand tonnes)	2.13
BMSY (thousand tonnes)	1.89
$B_{current}$/BMSY	**1.14**
Lower limit B/BMSY (95% ci)	0.821
Upper limit B/BMSY (95% ci)	1.46
MSY (1000s tonnes)	0.928
Lower limit MSY (95% ci)	0.747
Upper limit MSY (95% ci)	1.26

Diagnosis of stock status: Sustainably exploited, with relatively high biomass.

Advice and recommendations:

- Do not increase fishing mortality



N:50

Stock: Striped red mullet (*Mullus surmuletus*)

GSA: 25

Author(s): Charilaou, C., Thasitis, I.

Fishery: Red mullet (*Mullus surmuletus*) is an important commercial species in GSA 25, exploited by trawlers and polyvalent small scale vessels using set nets. In both fisheries the species, is exploited along with a number of other demersal species.

Over the period 1985–2015 catches of the polyvalent small scale fleet showed fluctuations with a declining trend; from 2006 the values remained at similar low values. Landings from trawlers showed a decreasing trend as well, with a sharp decrease in 1995; from 2011 landings seem to have remained at the same levels.

During the period of the assessment (2005–2015), there were changes in the two fisheries exploiting the species, mainly a reduction in the number of fishing licenses and an increase in mesh sizes of set and bottom trawl nets.

Catches of red mullet over the assessment period had a declining trend, reaching the highest value in 2007 (47.4 tonnes) and the lowest value in 2012 (15.2 tonnes). The average contribution of each fleet to the catches for this period were 52 percent for the trawl fleet and 48 percent for the small scale fleet. In 2015, the trawler fleet was composed of two vessels, while the small scale fleet was composed of 393 vessels; the catches during the year were around 22 tonnes, of which almost 65 percent was fished by the trawl fleet.

Data and parameters: The assessment was carried out using official data on commercial catches (2005–2015) and abundance indices from the Cyprus MEDITS survey (2006–2013, 2015). Catch-at-length data were converted into catch-at-age data using ALKs, derived from the Cyprus Data Collection Programme under the European Union DCF. Growth parameters, length–weight relationship and maturity ogive at age were based on data from the Cyprus National Data Collection Programme. A vector of natural mortality by age was used, calculated from Caddy's formula, using the PRODBIOM Excel spreadsheet (Abella *et al.*, 1997).

Assessment method: The stock was assessed with XSA, using abundance indices from the Cyprus MEDITS trawl survey as tuning data. Due to the fact that no MEDITS survey was carried out in 2014, the 2015 MEDITS data were used as a separate tuning fleet in addition to the 2006–2013 MEDITS data. Reference point $F_{0.1}$ was estimated based on Y/R analysis, which was carried out based on the results of the XSA model. Stochastic short term projections, assuming equilibrium conditions, were also produced. All methods were performed using FLR.

Model performance: The residuals and the retrospective analysis did not show any trends.

Results: Spawning stock biomass showed a high increasing trend from 2011 until 2014, while recruitment oscillated. Catches had a decreasing trend from 2007 until 2012, but remained relatively stable in the last three years. Fishing mortality had a high decreasing trend over the years 2010–2012, remained at similar levels in 2013–2014 and showed an increase in the last year of the assessment.

Current fishing mortality ($F_{current}$(1–2)) was calculated as the average of the last three years and had a value of 0.26. This fishing mortality value corresponds to both fishing fleets that exploit red mullet and was further allocated to each fleet using the estimated F-at-age matrix and the proportion of catches at age by each fleet. The $F_{current}$(1–2) attributed to the bottom trawlers was calculated as 60 percent of $F_{current}$(1–2), and had a value of 0.16. The $F_{current}$(1–2) attributed to the small scale inshore fleet had a value of 0.10.

$F_{current}$ (mean 2013–2015, ages 1–2)	0.26
$F_{0.1}$	0.32
$F_{current}/F_{0.1}$	0.81
Biomass index (SSB $_{2013–2015}$)(tonnes)	125
SSB biomass index 33rd percentile (tonnes)	52.9
SSB biomass index 66th percentile (tonnes)	64.6

Diagnosis of stock status: The stock seems to be sustainably exploited with relatively high biomass.

Advice and recommendation:

- Not to increase fishing mortality.

Discussion: Considering that the scientific survey that was used as a tuning fleet for the model was not carried out for one year (2014), the group advised that in the future assessments, the 2014 values are estimated, or preferably an integrated assessment method is used to allow the use of not continuous time series of tuning fleets.

N:51

Stock: Comber (*Serranus cabrilla*)

GSA: 25

Author(s): Thasitis, I. and Charilaou, C.

Fishery: Comber (*Serranus cabrilla*) is a species exploited by almost all fleets in GSA 25. The majority of catches come from trawls and small-scale vessels using set nets. Marine recreational fisheries using boats also interact with the species using handlines and bottom longlines. The exact magnitude of recreational catches is unknown as there was no catch declaration nor sampling on these landings.

Comber landings get mixed together considerably with other low value species. As a result, historical landings are not considered reliable for use in an assessment.

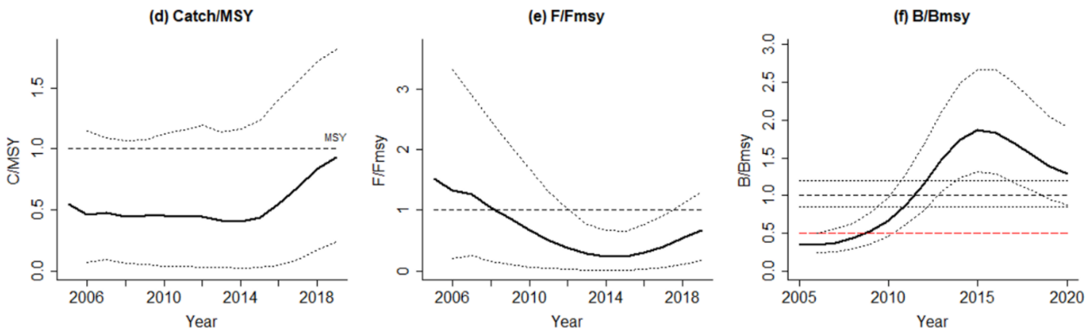
Data and parameters: The assessment was carried out using official length data of commercial biological sampling (2012–2020) and abundance index from the Cyprus MEDITS survey (2005–2020).

Assessment method: Due to the issues presented in catch data, an alternative approach was used based on AMSY methodology. In order to better inform the resilience priors of the AMSY, an LBB model was formulated using length data from 2012 to 2020. The results of the best fitted year (2016) were used to dictate the resilience boundaries of the species for AMSY. To account for the missing year (2014) in the

MEDITS time series, a state space analysis was used (BCrump R code) to interpolate the 2014 data and validate the favourable statistical qualities of the survey for the species (RMSE = 16.6 percent). Using growth parameters from LBB and bibliographic values, an LBSPR and a LIME model were built in order to compare the results with AMSY.

Model performance: The retrospective analysis did not show any trends.

Results: The time series of the median relative catch predicted by AMSY remained stable from the beginning of the timeseries until 2016 when there was a significant increase. Fishing pressure expressed as F/Fmsy decreased from 2005 to 2015 and then increased slightly, but remained below the ratio of 1. The time series for CPUE, expressed as B/B0, had a similar trend with MEDITS index and remained above the ratio of 1 from 2012 onwards.



F/F_{msy}	0.66 (2019)
B/B_{msy}	1.28 (2020)

Diagnosis of stock status: The stock seems to be sustainably exploited with relatively high biomass.

Advice and recommendation:

- In sustainable exploitation.

Discussion: Generation of biological parameters from local stock will help to better inform length-based methodologies.

N:52

Stock: Axillary seabream (*Pagellus acarne*)

GSA: 25

Author(s): Thasitis, I. and Charilaou, C.

Fishery: Axillary seabream (*Pagellus acarne*) is a commercial low value species caught mainly by small-scale vessels using set nets. Trawlers also catch the species together with other species. Both fleets do not target the species as it has low value and the market cannot absorb large quantities. Marine recreational fisheries using boats also interact with the species while using handlines and bottom longlines. The exact magnitude of recreational catches is unknown but, due to the low appreciation of the species, targeting effort is considered to be low.

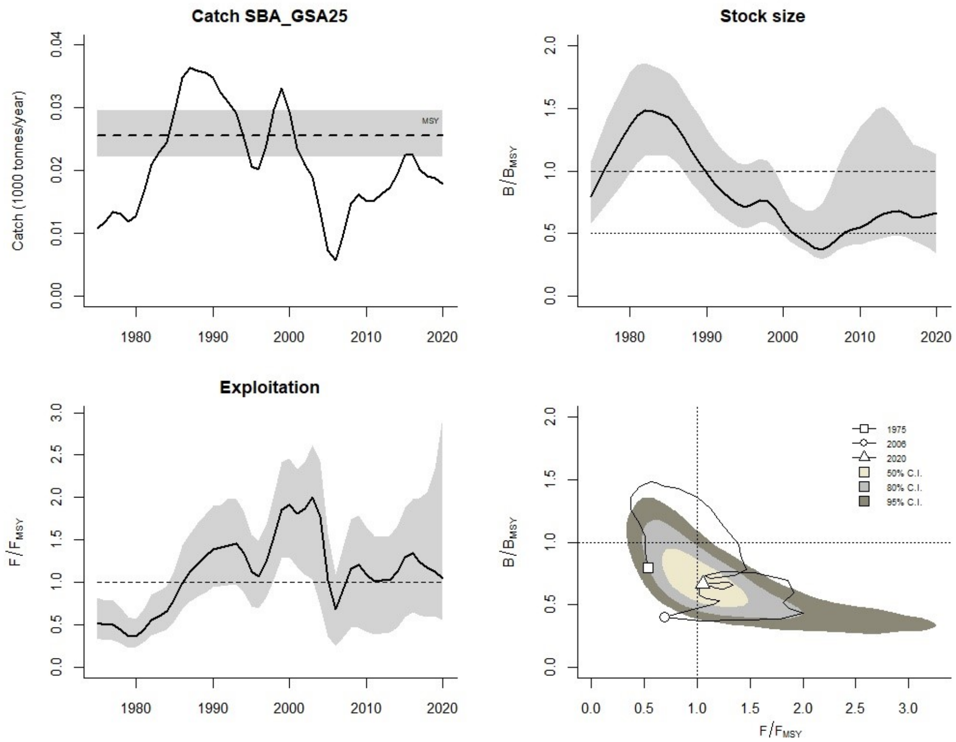
Comber landings get mixed together with other low value species depending on their size. However, some degree of analogies for this separation can be derived from the biological field sampling. An important issue in sampling is the mismatch of length measurements as the majority of the samples come from trawlers which hold a small part of the landings and are characterized by a lower mean landing length distribution compared to nets.

Data and parameters: The assessment was carried out using official landings data from 1975 to 2020 and biomass index from the Cyprus MEDITS survey (2005–2020).

Assessment method: The CMSY++ (Froese *et al.*, 2021) Bayesian implementation of the Schaefer surplus production model was used as a validation method for the stock. Resilience priors were donated from FishBase. Due to issues with length sampling coverage on landings it was not able to produce a valid LBB model to generate resilience priors for CMSY++. Although the available LFDs created some challenges for length-based methods an attempt was made to run LBSPR and LIME.

Model performance: The diagnostic tools of residuals, retrospective analysis as well as prior posterior distributions were accepted.

Results: Biomass increased well above the ratio of 1, in terms of the B/Bmsy analogy, until 1983. From 1985 onwards there was a sharp decline reaching the lowest point of the estimations in 2005, below the 0.5 ratio of B/Bmsy. From then on, a steady increase occurred until the end of the analysis when biomass reached a B/Bmsy ratio equal to 0.667. Exploitation remained well below the ratio of 1 for F/Fmsy in the first years of the assessment. In 1986, there was a transition to ratios well over 1 which peaked in 2005. A significant drop succeeded this period and F/Fmsy reached sustainable ratios until 2008. Following this, a short spike oscillation occurred above sustainable ratios and reached a F/Fmsy ratio equal to 1.05 in 2020.



$F_{current}$ (2020)	0.239
Lower limit (2.5 percentile)	0.126
Upper limit (97.5 percentile)	0.497
F_{msy} (2020)	0.227
$F_{current}/F_{msy}$	1.05
Lower limit F_{curr}/F_{msy} (2.5 percentile)	0.564
Upper limit F_{curr}/F_{msy} (97.5 percentile)	2.95
Current biomass (thousand tonnes)	0.075
B_{msy}(thousand tonnes)	0.112
Current B/ B_{msy}	0.667
Low limit Current B/B_{msy} (2.5 percentile)	0.342
Upper limit Current B/B_{msy}(97.5 percentile)	1.14
MSY (thousand tonnes)	0.025
Catches 2020 (thousand tonnes)	0.016

Diagnosis of stock status: In overexploitation, with relatively intermediate biomass

Advice and recommendation:

- Reduce fishing effort

GENERAL CONCLUSIONS AND RECOMMENDATIONS

The WGSAD, according to its terms of reference for 2022 and based on scientific evidence found and discussions undertaken, agreed upon the following final remarks:

Joint WGSAs Session

73. The WGSAs utilized the STAR Excel templates proposed by the GFCM Secretariat last year, aiming to gather detailed summaries of validated stock assessments including metadata, results and the information required to produce the table of advice. It is expected that the data submitted with STAR templates will be later imported in a database and will comprise the basis for future quality-controlled products. The WGSAs welcomed the GFCM Secretariat initiative of inviting experts to present specific key issues relevant to stock assessment, during the joint WGSAs Session.

Assessments

74. Out of the 55 assessments presented, 51 were validated and adopted during the WGSAD meeting with 12 of them (approximately 23 percent) indicating sustainable stock exploitation. This represents the highest proportion of sustainably exploited stocks estimated in recent years. The majority of sustainably exploited stocks were for red mullet.

75. All hake stocks were found to be in overexploitation, or possibly in overexploitation (in the case of qualitative assessments), with varying biomass levels.

76. Assessments of deep-water rose shrimp were performed in 16 GSAs of the western, central and Adriatic regions. In all cases, the stocks were estimated to be in overexploitation, or possibly in overexploitation, with varying relatively biomass levels.

77. Assessments of red mullet were performed in 14 GSAs throughout the Mediterranean. In two-thirds of the cases, the stocks were found to be in overexploitation with varying biomass levels.

78. Assessments of blue and red shrimp were performed in seven GSAs of the western and central Mediterranean. In all cases, the stocks were found to be in overexploitation, with relatively low or intermediate biomass levels.

79. Assessments of giant red shrimp were performed in five GSAs of the western and central Mediterranean and the stocks were found to be in overexploitation.

80. Assessments of Norway lobster were performed in three GSAs of the western Mediterranean (5, 6 and 9). The stocks were found to be in overexploitation in GSA 6 and in sustainable exploitation in GSAs 5 and 9. A preliminary assessment was performed for Norway lobster in GSA 17 exploring different assessment methodologies.

81. Common cuttlefish and spottail mantis shrimp were assessed in GSA 17 (northern Adriatic). Both stocks were found to be overexploited (i.e. at low biomass levels), while only spottail mantis was found to be in sustainable exploitation.

82. Blackspot seabream was assessed in the Alboran Sea GSAs (1 and 3) and was found to be overexploited but in sustainable exploitation (i.e. low fishing mortality).

83. Striped red mullet was assessed in GSAs 5 and 25 and was found to be in overexploitation (GSA 5) or possibly in overexploitation (GSA 25).

84. Horned octopus was assessed in GSA 18 and found to be sustainably exploited.

85. Brown comber was assessed in GSA 25 and found to be under sustainable exploitation with high biomass levels.

86. Axillary seabream was assessed in GSA 25 and was found to be overexploited and in overexploitation.

Methods

87. The WGSAD acknowledged the gradual progress from VPA-like models towards SCAA methods, following its previous advice. However, further work is needed to allow the application of SCAA assessments on additional stocks.

88. For the assessment of species with very different growth rates by sex (e.g. European hake, red mullet, shrimps, etc.), the WGSAD advised the consideration of separate age slicing by sex, when relevant data are available. Stock dependent specifications of age slicing approaches should be discussed and verified within benchmark or inter-benchmark sessions.

89. The WGSAD stressed the importance of providing adequate diagnostics of the a4a model fitness utilizing newly available tools and packages (e.g. "a4adiags"). In general, the combination of different diagnostic tools is considered important to evaluate model fits to the data and identify the most appropriate model runs for providing advice, towards ensuring stability in the future. The group also noted that the Mohn's rho index is primarily relevant to SSB and suggested thresholds should be applied according to the life-history of the stock being assessed (i.e. short- vs long-lived species). In addition, even if the diagnostics are acceptable, it should be always considered whether the results are consistent with the biology of the species and the fisheries exploitation pattern.

90. The WGSAD noted that the MEDITS survey may not always provide sufficient information on the abundance of certain crustacean species (e.g. Norway lobster), due to their particular life cycle characteristics. In this context, the use of standardized commercial CPUE indices in the short and medium term and the development of specific surveys (e.g. underwater camera survey) that can be used in the long term could be beneficial.

91. The importance of providing consistent information in the table of advice, following the terminology that has been already agreed was again noted. For example, "new assessment" refers to a new combination of GSA/species or a stock that has not been assessed for a long term; "updated" refers to assessments keeping the same assumptions (biological parameters, model settings, etc.) as a previously presented assessment and adding one more year of data; and "revised" refers to assessments carried out regularly, when there are significant changes (methods, data, etc.). The WGSAD encouraged experts to document changes or differences and future work in the comments section of the table of advice and provide details, including issue lists, in the stock assessment forms and summary sheets.

92. To fill data gaps in survey or catch-at-size data the use of modelling approaches that take into account spatial and temporal parameters was encouraged. This will increase the robustness of estimates, overcoming the limitations of simple interpolation techniques. It was noted that capacity-building activities on such approaches may be useful in this respect.

93. For the assessment of short-lived species (e.g. cephalopods), the application of two-stage Bayesian production models or other alternatives should be explored. In addition, the possibility of including environmental variability in integrated stock assessment models should be investigated.

Advice

94. To ensure consistency over time and facilitate comparisons with previous advice, it was reminded that the various model settings (fbar, sub-models, etc.) in the updated assessments should remain the same, as much as possible. This is particularly important in the case of benchmark updates, where reference points should also be kept the same. Should the assessment estimates from benchmark updates not be considered robust enough for providing advice, results of alternative approaches (e.g. alternative model settings) should be presented together with those deriving from the benchmark update. Should the WGSAD deem such changes major, they should be compiled and discussed in relevant benchmark sessions or inter-benchmark sessions.

95. The group acknowledged the efforts made to provide assessments and advice for new stocks (red coral, blue whiting, Norway lobster, non-indigenous species, etc.) and recommended further work to accomplish assessments for additional stocks that have not yet been assessed, particularly for priority species.

96. An inter-benchmark session for blackspot seabream was recommended to be held by the end of 2022 to address questions on model applications and implement a workplan, as described in Appendix 1, to determine the elements for a new benchmark in 2023/2024. The WGSAD also recommended the

accomplishment of benchmarks or new benchmarks for certain stocks of priority species, such as: i) hake in the Adriatic (GSAs 17 and 18), to improve model fit and revise data, including historical series; ii) red mullet in GSAs 12–14, as well as, 15 and 16 to progress towards SCAA models and confirm the current stock boundaries; iii) deep-water rose shrimp in GSAs 17–20, to further explore the assumptions about stock structure; iv) deep-water rose shrimp in GSAs 12–16, to explore the application of new modelling approaches; and v) spottail mantis shrimp in the Adriatic to further explore the biological parameters of the species.

97. The WGSAD noted that the MedSea4Fish project is a new tool able to provide technical assistance and capacity-building, when needed, to improve stock assessments in the region.

98. Given their economic importance and their inclusion in a European Union multi-annual management plan with a recent implementation of catch limits, the WGSAD recommended including blue and red shrimp and giant red shrimp in the priority list of species for the western Mediterranean.

99. When biomass reference points are not estimated by the assessment model, reporting on relative biomass levels in the table of advice could be misleading, especially when using age-based models that do not include a stock–recruitment relationship. The WGSAD suggested this issue be tackled in the imminent revision of the GFCM framework for the provision of advice. The WGSAD, nevertheless, noted that reporting on trends for standing stock is still useful and, in this sense, the most recent period was deemed more meaningful, although short time series should be taken with caution.

100. The WGSAD noted that efforts should be made to understand variations in landings and survey time series in the context of assessing the effectiveness of specific management measures, such as the closure of the Jakuba/Pomo pit, for the corresponding local stocks.

OTHER MATTERS

101. The WGSAD unanimously proposed Mr George Tserpes to be renewed as chair of the WGSAD for the next three years and submitted this proposal to the SAC for approval.

FUNCTIONING OF THE WGSAD

102. The conclusions and recommendations were adopted by the WGSAD on 28 January 2022. The entire report was adopted after revisions and amendments by electronic correspondence.

Appendix 1

Meeting agenda

1. Opening and arrangements for the WGSAD-W and WGSAD-C-E-AS stocks
2. Introductory session for the WGSAD-W and WGSAD-C-E-AS stocks
3. Assessment of priority stocks
4. Updates of benchmark assessments
5. Assessments of non-priority species – updates of previous assessments
6. Assessments of non-priority species – new assessments
7. Closing session

Appendix 2

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Scientific advice on the status of the stocks assessed, including WGSAD comments

No	GSA	Species	Method	Current levels	Reference points	Quantitative status	Stock status	Scientific advice	WGSAD comments
1	1, 5, 6, 7	*Merluccius merluccius*	a4a	Fc = 1.94, Bc = 1401	$F_{0.1}$ = 0.44	F/Fref = 4.41	In overexploitation, with relatively low biomass	Reduce fishing mortality; partial F and STF available	Basis for advice. Updated assessment
2	1	*Merluccius merluccius*	XSA	Fc = 1.5, Bc = 212	$F_{0.1}$ = 0.23	F/Fref = 6.52	In overexploitation, with relatively low biomass	Reduce fishing mortality; STF available	Complementary advice. Updated assessment
3	1, 3	*Merluccius merluccius*	XSA	Fc = 1.5, Bc = 199	$F_{0.1}$ = 0.17	F/Fref = 8.8	In overexploitation, with relatively low biomass	Reduce fishing mortality	Complementary advice. Basis for advice for GSA03. Updated assessment
4	4	*Merluccius merluccius*	VIT	Fc = 1.06	$F_{0.1}$ = 0.24	NA	Possibly in overexploitation	Reduce fishing mortality	Precautionary advice. Updated assessment.
5	5	*Merluccius merluccius*	a4a	Fc = 1.4, Bc = 68	$F_{0.1}$ = 0.32	F/Fref = 4.39	In overexploitation, with relatively low biomass	Reduce fishing mortality; STF available	Complementary advice. Updated assessment
6	6	*Merluccius merluccius*	a4a	Fc = 1.73, Bc = 729	$F_{0.1}$ = 0.15	F/Fref = 11.53	In overexploitation, with relatively low biomass	Reduce fishing mortality	Complementary advice. Updated assessment
7	8, 9, 10, 11.1, 11.2	*Merluccius merluccius*	a4a	Fc = 0.50, Bc = 4690	$F_{0.1}$ = 0.16	F/Fref = 3.13	In overexploitation, with relatively high biomass	Reduce fishing mortality; Partial F and STF available	Benchmark update
8	1	*Parapenaeus longirostris*	a4a	Fc = 1.21, Bc = 157	$F_{0.1}$ = 0.7	F/Fref = 1.73	In overexploitation, with relatively high biomass	Reduce fishing mortality; STF available	Updated assessment
9	3	*Parapenaeus longirostris*	BioDyn and LCA/yield per recruit	Fc = 1 , Bc = 554	$F_{0.1}$ = 0.65 , $B_{0.1}$ = 535 BMSY = 486	NA	Possibly in overexploitation and biomass above reference point	Reduce fishing mortality	Precautionary advice. Updated assessment
10	4	*Parapenaeus*	VIT	Fc = 1.67	$F_{0.1}$ = 0.72	NA	Possibly in overexploitation	Reduce fishing	Precautionary advice.

		longirostris						mortality	Updated assessment
11	5	*Parapenaeus longirostris*	XSA	Fc = 1.7, Bc = 79	$F_{0.1}$ = 0.82	F/Fref = 2.07	In overexploitation, with relatively high biomass	Reduce fishing mortality; STF available	Updated assessment
12	6	*Parapenaeus longirostris*	XSA	Fc = 1.27, Bc = 282	$F_{0.1}$ = 0.79	F/Fref = 1.6	In overexploitation, with relatively high biomass	Reduce fishing mortality	Updated assessment
13	9, 10, 11.1, 11.2	*Parapenaeus longirostris*	a4a	Fc = 1.58, Bc = 1960	$F_{0.1}$ = 1.29	F/Fref = 1.22	In overexploitation, with relatively low biomass	Reduce fishing mortality; STF available	Updated assessment
14	1,3	*Pagellus bogaraveo*	Gadget	Fc = 0.2, Bc = 241	Fmsy = 0.26, Blim = 264	F/Fref = 0.78, B/Blim = 0.91	Overexploited with a low fishing mortality	Reduce fishing mortality and/or implement a recovery plan	Benchmark update
15	1	*Mullus barbatus*	a4a	Fc = 1.88, Bc = 165	$F_{0.1}$ = 0.29	F/Fref = 6.48	In overexploitation, with relatively low biomass	Reduce fishing mortality	Updated assessment
16	6	*Mullus barbatus*	a4a	Fc = 1.57, Bc = 1171	$F_{0.1}$ = 0.31	F/Fref = 5.06	In overexploitation, with relatively high biomass	Reduce fishing mortality	Updated assessment
17	7	*Mullus barbatus*	a4a	Fc = 0.624, Bc = 483	$F_{0.1}$ = 0.456	F/Fref = 1.369	In overexploitation, with relatively high biomass	Reduce fishing mortality; STF available	Updated assessment
18	9	*Mullus barbatus*	a4a	Fc = 0.37, Bc = 1950	$F_{0.1}$ = 0.52	F/Fref = 0.71	Sustainably exploited, with relatively high biomass	Not to increase fishing mortality; STF available	Updated assessment
19	10	*Mullus barbatus*	a4a	Fc = 0.31, Bc = 1449	$F_{0.1}$ = 0.4	F/Fref = 0.78	Sustainably exploited, with relatively high biomass	Reduce fishing mortality STF available	Updated assessment
20	5	*Mullus surmuletus*	a4a	Fc = 0.47, Bc = 342	$F_{0.1}$ = 0.24	F/Fref = 1.97	In overexploitation, with relatively intermediate biomass	Reduce fishing mortality; STF available	Revised assessment with a new M vector
21	1	*Aristeus antennatus*	a4a	Fc = 0.69, Bc = 287	$F_{0.1}$ = 0.42	F/Fref = 1.64	In overexploitation, with relatively intermediate biomass	Reduce fishing mortality; STF available	Updated assessment
22	2	*Aristeus*	XSA	Fc = 0.77,	$F_{0.1}$ = 0.46	F/Fref = 1.68	In overexploitation, with relatively intermediate	Reduce fishing mortality; STF	Updated assessment

		antennatus		Bc = 166			biomass	available	
23	5	*Aristeus antennatus*	a4a	Fc = 1.16, Bc = 128	$F_{0.1}$ = 0.32	F/Fref = 3.61	In overexploitation, with relatively low biomass	Reduce fishing mortality; STF available	Updated assessment
24	6	*Aristeus antennatus*	a4a	Fc = 2.17, Bc = 242	$F_{0.1}$ = 0.35	F/Fref = 6.2	In overexploitation, with relatively low biomass	Reduce fishing mortality	Updated assessment
25	9, 10, 11.1, 11.2	*Aristeus antennatus*	a4a	Fc = 1.2, Bc = 271	$F_{0.1}$ = 0.261	F/Fref = 4.6	In overexploitation, with relatively low biomass	Reduce fishing mortality; STF available	Updated assessment
26	9, 10, 11.1, 11.2	*Aristaeomorpha foliacea*	a4a	Fc = 0.98, Bc = 445	$F_{0.1}$ = 0.46	F/Fref = 2.13	In overexploitation, with relatively low biomass	Reduce fishing mortality; STF available	Updated assessment
27	5	*Nephrops norvegicus*	a4a	Fc = 0.16, Bc = 46	$F_{0.1}$ = 0.23	F/Fref = 0.69	Sustainably exploited, with relatively intermediate biomass	Not to increase fishing mortality; STF available	New assessment
28	6	*Nephrops norvegicus*	a4a	Fc = 0.57, Bc = 372	$F_{0.1}$ = 0.15	F/Fref = 3.8	In overexploitation, with relatively low biomass	Reduce fishing mortality	Updated assessment
29	9	*Nephrops norvegicus*	a4a	Fc = 0.15, Bc = 1255	$F_{0.1}$ = 0.30	F/Fref = 0.5	Sustainably exploited, with relatively high biomass	Not to increase fishing mortality; STF available	Updated assessment
30	18, 19	*Aristaeomorpha foliacea*	a4a	Fc = 0.62, Bc = 285	$F_{0.1}$ = 0.45	F/Fref = 1.38	In overexploitation, with relatively intermediate biomass	Reduce fishing mortality	Revised assessment
31	20	*Merluccius merluccius*	a4a	Fc = 0.38, Bc = 2551	$F_{0.1}$ = 0.204	F/Fref = 1.86	In overexploitation, with relatively high biomass	Reduce fishing mortality	Updated assessment. STF available. Request for benchmark.
32	22	*Merluccius merluccius*	a4a	Fc = 0.4, Bc = 20234	$F_{0.1}$ = 0.236	NA	Possibly in overexploitation	Reduce fishing mortality	Revised assessment. Qualitative advice due to missing data and poor cohort consistency
33	20	*Mullus barbatus*	a4a	Fc = 0.32, Bc = 792	$F_{0.1}$ = 0.29	F/Fref = 1.1	In overexploitation, with relatively high biomass	Reduce fishing mortality	Updated assessment. STF available. Request for benchmark.

34	22	*Mullus barbatus*	a4a	Fc = 0.25, Bc = 8196	$F_{0.1}$ = 0.26	F/Fref = 0.96	Sustainably exploited, with relatively high biomass	Do not increase fishing mortality	Revised assessment. Total catches and catch numbers revised. STF available.
35	24	*Mullus barbatus*	CMSY in addition to LBB, LBSPR and LIME	Fc = 0.32	Fmsy = 0.377	NA	Possibly in sustainable exploitation	Not increase fishing mortality	Updated assessment
36	12, 13, 14, 15, 16	*Parapenaeus longirostris*	XSA	Fc = 1.13, Bc = 10102	$F_{0.1}$ = 0.84	F/Fref = 1.34	In overexploitation with relatively low biomass	Reduce fishing mortality	Updated assessment
37	17, 18, 19	*Parapenaeus longirostris*	a4a	Fc = 1.62, Bc = 3291	$F_{0.1}$ = 0.7	F/Fref = 2.31	In overexploitation, with relatively high biomass	Reduce fishing mortality	Updated assessment. STF available. Request for benchmark.
38	17	*Sepia officinalis*	CMSY	Fc = 0.21, Bc = 9196	Fmsy = 0.18, Bmsy = 25415	F/Fref = 1.17, B/Btarget = 0.36	Overexploited and in overexploitation	Immediate action to ensure reduction in fishing mortality	Revised assessment. Priors in the model were changed
39	17	*Squilla mantis*	SS3	Fc = 0.26, Bc = 5834	F40 = 0.33, SSB40 = 6314	F/Fref = 0.79, B/Btarget = 0.92	Overexploited with low fishing mortality	Reduce fishing mortality and/or implement a recovery plan	Updated assessment. STF available. Request for benchmark.
40	12, 13, 14, 15, 16	*Merluccius merluccius*	ss3	Fc = 0.36, Bc = 4885	Fmsy = 0.29, Bmsy = 7021	F/Fref = 1.24, B/Btarget = 0.7	overexploited and in overexploitation	Immediate action to ensure reduction in fishing mortality	Updated benchmark assessment
41	19	*Merluccius merluccius*	a4a	Fc = 0.29, Bc = 1593	$F_{0.1}$ = 0.154	F/Fref = 1.86	In overexploitation with relatively high biomass	Reduce fishing mortality	Updated benchmark assessment
42	17, 18	*Merluccius merluccius*	ss3	Fc = 0.41, Bc = 3983	Fmsy = 0.167, Bpa = 2453, Blim = 1858	F/Fref = 2.47, B/Bthreshold = 1.62, B/Blimit = 2.14	In overexploitation	Reduce fishing mortality	Request for a new benchmark/inter-benchmark session.
43	12, 13, 14	*Mullus barbatus*	XSA	Fc = 1.47, Bc = 2518	$F_{0.1}$ = 0.47	F/Fref = 3.13	In overexploitation, with relatively high biomass	Reduce fishing mortality	Updated benchmark assessment
44	15	*Mullus barbatus*	XSA	Fc = 0.59, Bc = 24	$F_{0.1}$ = 0.402	F/Fref = 1.47	In overexploitation, with relatively low biomass	Decrease fishing mortality	Asked for an update of benchmark assessment.
45	15	*Mullus barbatus*	XSA	Fc = 0.54, Bc = 25	$F_{0.1}$ = 0.295	F/Fref = 1.83	In overexploitation, with relatively low biomass	Decrease fishing mortality	Revised model; asked for an update of benchmark assessment. Suggested as

									basis of advice
46	16	*Mullus barbatus*	XSA	Fc = 0.31, Bc = 1916	$F_{0.1}$ = 0.42	F/Fref = 0.74	Sustainably exploited, with relatively intermediate biomass	Not increase fishing mortality	Update of benchmark assessment
47	19	*Mullus barbatus*	XSA	Fc = 0.75, Bc = 423	$F_{0.1}$ = 0.4	F/Fref = 1.87	In overexploitation with relatively low biomass	Reduce fishing mortality	Updated benchmark assessment
48	17	*Solea solea*	SS3	Fc = 0.19, Bc = 3038	F40 = 0.238, SSB40 = 4160.274, Blim = 2080	F/Fref = 0.81, B/Btarget = 0.73, B/Blimit = 1.46	Overexploited with low fishing mortality	Reduce fishing mortality and/or implement a recovery plan	The reference points are expressed in relative terms as 40% of B0 (Btarget) and the F that brings the stock to Btarget. Moreover, both reference points are the median of the model ensemble and therefore the absolute value will change when updating the model.
49	18	*Eledone cirrosa*	CMSY-BSM	Fc = 0.38, Bc = 2	Fmsy = 0.491, Bmsy = 1.89	F/Fref = 0.77, B/Btarget = 1.13	Sustainably exploited, with relatively high biomass	Do not increase fishing mortality	Updated assessment. STF available. Request for benchmark.
50	25	*Mullus surmuletus*	SAM	Fc = 1.08, Bc = 70	$F_{0.1}$ = 0.31	NA	Possibly in overexploitation	Reduce fishing mortality	New assessment
51	25	*Serranus cabrilla*	AMSY			F/Fmsy = 0.69, B/Bmsy = 1.28	Sustainably exploited, with high biomass	Do not increase fishing mortality	New assessment
52	25	*Pagellus acarne*	CMSY++	Fc = 0.239, Bc = 75.1	Fmsy = 0.227, Bmsy = 112	F/Fref = 1.05, B/Bref = 0.667	Overexploited and in overexploitation	Immediate action to ensure reduction in fishing mortality	New assessment