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# REPORT OF THE SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

## 2013 Assessment of Mediterranean Sea stocks part II

## (STECF-14-08)

Edited by Massimiliano Cardinale and Giacomo Chato Osio

This report was reviewed by the STECF during its 45th plenary meeting

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## SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

## 2013 Assessment of Mediterranean Sea stocks - part 2 (STECF-14-08)

**THIS REPORT WAS REVIEWED DURING THE PLENARY MEETING HELD IN BRUSSELS 24-28 March 2014**

### Request to the STECF

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

### Introduction

The report of the Expert Working Group on Assessment of Mediterranean Sea stocks - part 2 (STECF EWG 13-19) was reviewed by the STECF during the plenary meeting held from 24 to 28 March 2013 in Brussels, Belgium. The following observations, conclusions and recommendations represent the outcome of that review.

### STECF observations

The meeting was the second STECF expert meeting for undertaking stock assessments of small pelagic and demersal species in the Mediterranean planned for 2013. The meeting was held in Brussels, Belgium, from 9 to 13 December 2013. The meeting chair person was Massimiliano Cardinale and the EWG was attended by 23 experts in total, including 4 STECF members plus 3 JRC experts.

Historic fisheries and scientific survey data were obtained from the official Mediterranean DCF data call issued to Member States on April 9$^{th}$ 2013 with deadlines on 3$^{rd}$ June and 29$^{th}$ November 2013. The latter deadline had been specifically set to call for in-year (2013) MEDITS and other surveys data to improve the precision of short term forecasts of stock size and catches under various management scenarios. Greece, and Cyprus did not provide any data for the June 2013 deadline, Italy did not provide data for the 29$^{th}$ November deadline and Spain provided data after the second meeting.

In relation to each of the Terms of Reference (ToRs), STECF notes the following:

**ToRs (A-C)**: the EWG 13-19 aimed to undertake assessments for 16 stocks, including red mullet in GSA 17, which was not originally scheduled. In 8 cases analytical results were considered sufficiently acceptable to form the basis for management advice, in 3 cases the results were accepted as being indicative of trends only, 4 were rejected due to poor model convergence (1), or major data inconsistencies (3), and 1 was not even attempted due to insufficient data. Short-term catch forecasts for the 8 stocks with accepted analytical results were carried out. Medium-term forecasting was carried out for only those stocks for which a meaningful stock /recruitment relationship was available (i.e. anchovy and sardine in GSA 17).

**ToR (C.2)**: the EWG 13-19 calculated the reference points for anchovy and sardine in GSA 17 using the WKFRAME methodology.

**ToR (C.3)**: the EWG 13-19 was unable to fully address the request to estimate on the basis of commercial average catch rates by *métier*, the level of fishing effort by *métier* which is commensurate to the sustainable short-term and medium-term forecasts, mainly due to the following reasons:

- the calculation of partial F by fleet/métiers should be carried out with appropriate, more complex multi-fleet models, which allow the possibility to assume different population selection curves for the different fleets. It has not yet been possible to fully utilize such models.
- the lack of long time-series of fishery-dependent and -independent data and lack of knowledge on stock dynamics and connectivity for most of the exploited resources of the Mediterranean, impeded the use of more complex approaches (AlaDym, SS3, ASAP, Fla4a, etc.). In this regard, an explanatory exercise was carried out by the EWG to check the outputs of more complex methods using the AlaDym model, with sole in GSA 17 as the case study;
- time constraints and insufficient expertise in the use of complex multifleet models. In principle, the lack of sufficient expertise, could be solved by promoting appropriate training for example, through ad-hoc courses.

**Tor (D.1) Small pelagic assessments in the Adriatic Sea:** the EWG 13-19 considered that it may be useful to explore additional means to reconstruct the time-series of the landings for GSA 18, in order to combine the two GSAs with the aim of delivering more robust assessment results. No strong scientific evidence emerged to justify separate assessments for the stocks of anchovy and sardine in GSA 17 and 18 and therefore the EWG considers that anchovy and sardine in GSAs 17 and 18 should be combined in a single assessment. However, when combining the two GSAs, it is crucial to avoid the breakdown of the long time series of GSA 17. This is especially important when considering the fact that GSA 17 contains by far the largest part of the stocks of both species. Following the preliminary attempts to assess the stocks for GSA 18, the assessment of anchovy and sardine stocks have been performed/updated only for GSA 17.

The stocks of anchovy and sardine in GSA 17 were assessed using the SAM statistical catch at age model. The spawning stock biomass estimated for anchovy for 2012 was 123,871 t, with 95% confidence limits of 71,052 - 215,957 t. The limit and precautionary biomass reference points adopted by the GFCM-SAC for anchovy are $B_{lim}$=179,000 t and $B_{pa}$=250,600 t respectively. Hence, the estimated spawning stock biomass for anchovy in the Adriatic Sea is considered to be below the limit reference point of 179,000 tons. The spawning stock biomass estimated for sardine for 2012 was equal to 220,577 tons, with 95%

confidence limits of 144,177 - 337,460 tons. The limit and precautionary biomass reference points adopted by the GFCM-SAC for sardine in GSA 17 are $B_{lim}$=78,000 tons and $B_{pa}$=109,200 tons. Hence, sardine spawning stock biomass in the Adriatic Sea is considered well above both the adopted limit and precautionary reference points.

Since the reference points adopted by the GFCM SAC are based on the values derived from the ICA methodology, and which differ from those estimated by the SAM model, STECF concludes that status of both stocks with respect to the GFCM SAC reference points for biomass, should be considered preliminary. STECF also concludes that the SAM model is more appropriate than ICA for assessing anchovy and sardine in GSA 17 and that the biomass reference points should be re- estimated using the outputs from the SAM model.

**Tor(D.2)**: according to the SAM results, the exploitation rate E on anchovy in GSA 17 is slightly above the Patterson reference point of E=0.40, with a value of 0.43 (estimated for ages 1 and 2). For sardine stock in GSA 17, the exploitation rate estimated by SAM for 2012 is also above the E= 0.4 reference point and equals 0.57 (estimated for ages from 2 and 5).

**Tor (E), Evaluation of DCF data quality by EWG experts**: As for previous meetings, the quality of the fisheries data from GSA 11 (Italy) prevented the assessment of the status of striped red mullet in GSA 11. In addition, for GSA 8, the lack of catch data did not allow the EWG to conduct assessments for any of the species in the area. Thus, EWG 13-19 reiterated that the quality of fisheries data from GSA 8 and 11 is a cause for concern. While for GSA 8 suitable data should be available but have not been provided, for GSA 11 a thorough review of the data and the data collection process in particular, is necessary if informative stock assessments are to be undertaken in the future. Quality checks on the MEDITS database showed a clear improvement of the JRC database over time.

**Tor (F), Review of R scripts used for stock assessment, short and medium term forecast and estimation of reference points**: all FLR scripts used for the assessment and forecast were revised before the meeting by the EC JRC team. Development of new R routines for the standardisation of the MEDITS data is at an advanced stage and a stratified index at length can now be produced by linking the R script to the MEDITS database. A Github public repository to store the R scripts for use by the EWG dealing with Mediterranean assessments is now under development. The EWG 13-19 suggested to continue updating and developing the R scripts to improve the efficiency and the quality of the assessments of the EWG.

**Tor (G) 2014 data call evaluation and revision**: the EWG 13-19 concluded that the 2015 data call for 2014 data should remain unchanged and in the current format. There is still scope for improvement in data quality and streamlining the process. A file naming convention with clear guidelines for users would be a helpful development to improve the process. It is clear that the Data Validation Tool developed by JRC has not yet been used systematically and there have been cases where attempts to upload incorrect files to the JRC facility, which is highly inefficient. The Expert Group suggested that JRC move to progressively more restrictive checks at the time of upload in order to ensure conformity of the data with the most important data formatting specifications. Future data calls should stabilize the time-series of data without recalling all the series at every deadline. At the same time it should also be possible to revise data that are already uploaded, as is the case for the improvements to MEDITS database.

**Tor (H)**: the EWG 13-19 ranked the stocks for which DCF data are suitable for stock assessment and for the establishment of long term management plans and also ranked their vulnerability according to their productivity, susceptibility and other criteria based on life history parameters. Such rankings are available in a summary table (Annex IV), which is available at http://stecf.jrc.ec.europa.eu/web/stecf/ewg1319.

**Tor (I) Revision of historical assessments**: In view of some observed abrupt changes in the F or $F_{MSY}$ estimates, the EWG 13-19 was requested to revise the overview table of all the assessments performed since 2008. In general, the most recent assessments are considered more reliable as these were carried out using improved data of improved quality and more appropriate assessment methods. The EWG reported that the differences were mainly due to either a change in the assessment methodologies or in the input parameters of the models (e.g. growth parameters, catch data). In any case, in several occasions the short term differences in the value of fishing mortality and/or different $F_{MSY}$ reference values were not considered significant. The EWG 13-19 noted only one marked difference in $F_{MSY}$ estimates; for hake in GSA 11. The discrepancy in the estimates was attributed to poor quality catch data and ultimately, the EWG 13-19 rejected the assessment.

Finally, EWG 13-19 reiterated the desire to convene an ad-hoc methodological EWG to be held in the beginning of 2015 to set up and test different assumptions of selectivity for a set of stocks and about the use of discard data and slicing methodologies in the future stock assessments. A methodological EWG was regularly held in the past but for several years no such group has met.

**STECF conclusions**

Based on the findings in the EWG 13-19 report, STECF concludes the following:

Among the 16 demersal and small pelagic stocks assessed by the EWG 13-19, overfishing is not occurring on only 1 stock, Sardine in GSA 1. Of the remaining 15 stocks, 9 are currently being exploited at rates not consistent with achieving MSY (overfishing is occurring) and 6 stocks were not assessed due to data deficiencies or poor model fits. A summary of stock status is given in Table 5.1.1.

Table 5.1.1. Summary of stock status for the 16 stocks assessed by the EWG 13-19. In the case of small pelagic stocks the ratio $F/F_{MSY}$ refers to $E/E_{0.4}$.

| GSA | Common name | Species | Assessment | Comment | Status | F/FMSY |
|---|---|---|---|---|---|---|
| 1 | Sardine | *Sardina pilchardus* | SepVPA | Trends only | Overfishing is not occurring | < 1 |
| 5 | Striped red mullet | *Mullus surmuletus* | XSA | Accepted | Overfishing is occurring | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | Red mullet | *Mullus barbatus* | XSA | Accepted | Overfishing is occurring | 6.2 |
| 6 | Red mullet | *Mullus barbatus* | XSA | Accepted | Overfishing is occurring | 3.8 |
| 7 | Sardine | *Sardina pilchardus* | XSA | Not accepted | Unknown | |
| 9 | Sardine | *Sardina pilchardus* | SepVPA | Trends only | Overfishing is occurring | > 1 |
| 11 | Striped red mullet | *Mullus surmuletus* | Data quality issues | | Unknown | |
| 11 | Red mullet | *Mullus barbatus* | XSA | Accepted | Overfishing is occurring | 9.7 |
| 15-16 | Striped red mullet | *Mullus surmuletus* | XSA | Accepted | Overfishing is occurring | 4.1 |
| 4,5,11-16 | Common dolphinfish | *Coryphaena hippurus* | Data quality issues | | Unknown | |
| 17 | Anchovy | *Engraulis encrasicolus* | SAM | Accepted | Overfishing is occurring | 2.1 |
| 17 | Sardine | *Sardina pilchardus* | SAM | Accepted | Overfishing is occurring | 2 |
| 17 | Red mullet | *Mullus barbatus* | SS3 | Accepted | Overfishing is occurring | 2.6 |
| 18 | Anchovy | *Engraulis encrasicolus* | Data quality issues | | Unknown | |
| 19 | Anchovy | *Engraulis encrasicolus* | SepVPA | Trends only | Unknown | |
| 22-23 | Anchovy | *Engraulis encrasicolus* | Data not collected | | Unknown | |

In order to comply with the Commission's requests to provide fleet-based advice and forecasts, the STECF supports the Expert group's proposal to convene a methodological EWG at the earliest convenience. STECF suggests that such a methodological EWG could form part of the 2015 STECF calendar according to the Commissions priorities for STECF or could be convened in a different forum. In either case, STECF proposes that such a group be asked to address the following:

- Collate and assemble the necessary input data by fleet for stocks of hake and Norway lobster in selected GSAs.
- Run statistical catch at age assessment models with different assumptions on selectivity (i.e. dome shaped, logistic, etc).
- Discuss and compare the results with previous assessment conducted by XSA or other models.
- Set up a common methodology to reconstruct time series of discard data by fleet to be used in future stock assessment.
- Decide upon an appropriate slicing methodology to reconstruct time series of catch at age data to be used in future stock assessment.

STECF concludes that the EWG 13-19 adequately addressed the Terms of Reference and endorses the findings presented in the report.

# REPORT TO THE STECF

**EXPERT WORKING GROUP ON Assessment of Mediterranean Sea stocks - part 2 (STECF EWG 13-19)**

## Brussels, Belgium, 9 – 13 December 2013

This report does not necessarily reflect the view of the STECF and the European Commission and in no way anticipates the Commission's future policy in this area

### 1. EXECUTIVE SUMMARY

The meeting was the second of two STECF expert meetings, within STECF's 2013 work programme, planned to undertake stock assessments of demersal and pelagic species in the Mediterranean Sea. The meeting was organized by JRC in Brussels (Belgium) from 9-13 of December 2013. The meeting was chaired by Massimiliano Cardinale and attended by 28 experts in total, including 4 STECF members plus 3 JRC experts (Annex I).

Historic fisheries and scientific survey data were obtained from the official Mediterranean DCF data call issued to Member States on April 9th 2013 with deadlines on 3rd June and 29th November 2013. The latter deadline had been specifically set to call for in-year (2013) MEDITS and other surveys data to improve the precision of short term forecasts of stock size and catches under various management scenarios. Greece, and Cyprus did not provide any data for the June 2013 deadline, Italy did not provide data for the 29th November deadline and Spain provided data after the second meeting.

In fulfillment of **Tor's (A-B)**, the EWG 13-19 undertook the stock assessment of 16 stocks species (including red mullet in GSA 17, which was not scheduled in the ToRs). All a assessed stocks with accepted analytical results were classified as exploited unsustainably, except sardine in GSA 1, which is exploited sustainably. Out of 16 assessments, 8 had accepted analytical results, 3 assessments were accepted for trends only, 1 was not accepted due to poor model convergence, 3 had major data problems that prevented running an assessment, and one was not carried out due to lack of data (Annex II).

Following **Tor (C.1)**, the EWG 13-19 also conducted short term forecasts of stock size and catches for 8 stocks and 2 medium term forecast only for these stocks where a meaningful stock recruitment relationship supported such analyses. For a more logic flow of information, the forecasts are now placed in the detailed stock assessment report rather than in a separate section.

In response to **Tor (B.2),** EWG 13-19 estimated reference points (fishing mortality and biomass) for two stocks, namely anchovy and sardine of GSA 17. Estimation of reference points was done based on the methodology described in Simmonds *et al*., (2011) which originated as a working document to the 2010 WKFRAME meeting (Anon., 2010): the same procedure was applied to the same stocks during the EWG 12-19 (STECF, 2012).

**Tor (C.3),** requested to estimate on the basis of commercial average catch rates by métier, the level of fishing effort by métier which is commensurate to the sustainable short-term and medium-term forecasts.

**Tor (D)** in relation to the GFCM management plan for anchovy and sardine in GSA 17 and 18 requested to advise on:

- the relative position of the mid-year spawning stock biomass with respect to the precautionary and limit reference points both for anchovy and sardine

- the level of exploitation rate with respect to the reference point of E = 0.4

- the uniqueness or separation of the anchovy and sardine stocks between the two GSA 17 and 18.

-the areas of aggregation of anchovy and sardine juveniles in their first year of life.

In response to this Tor, EWG 13-19 attempted to assess the state of both anchovy and sardine stocks of GSA 18. A second attempt was to join the data from GSA 17and 18 for these stocks but problems in reconstructing the historical landings in GSA 18 halted a joint assessment. Thus, anchovy and sardine stocks were assessed in GSA 17 using the SAM model. Finally, the working group explored the available information to give weight to the uniqueness or separation of the anchovy and sardine stocks between the two GSA 17 and 18.

In fulfilment of **Tor (E)**, stock specific evaluation of the data quality were conducted for all stocks requested under ToR (A-C) by the EWG 13-19 experts. Moreover, JRC team examined the data coverage and quality for the fisheries and survey data. This was performed by means of data exploration and the MEDITS SQL quality checks developed by JRC. Results of the evaluations are reported under ToR (e) and at the end of the assessment section of each stock. Data coverage was not always complete in the latest data call: fishing effort data (Table D) for all Italian GSA in 2010 was missing from the files provided. France did not provide any fisheries data (Tables A-D) for GSA 8 (Corsica). The latter is a recurrent omission and with no apparent justification and it undermines the possibility of EWG 13-19 to perform any assessment in GSA 8. Also no data on effort for GSA 7 (Table D) was uploaded. Greece submitted only MEDITS data for GSA 22. Other issues in the data were identified in the stock assessment sections, but of particular concern to the EWG 13-19 is again the quality of the fisheries data from GSA 11 (Italy), which as in previous meetings has impeded the EWG to conduct an assessments of striped red mullet in GSA 11.

To address **Tor (F),** the JRC team distributed the latest releases of Fisheries Libraries in R (FLR) and supported the experts in running assessments and solving specific R issues. JRC distributed a revised and cleaned version of the short and medium term forecast R scripts and continued the redesign and development of the scripts for fisheries and MEDITS data.

In particular, EWG 13-19 extended the existing MEDITS routines and now incorporate a standardized calculation of the stratified numbers ($n/km^2$) at length that reflects the survey stratification to replace the functions previously available in the JRC ACCESS MEDITS database. The transition from the ACCESS routines to R will give more flexibility and will facilitate their use, allowing experts to have more control of the MEDITS data preparation steps. Two deterministic slicing methods were implemented in R during the meeting: “knife-edge” and “proportional”. Investigations were made into generalising the use of the statistical slicing method using the *mixdist* package for R

A code repository was created on GitHub to store R scripts and example data sets that can be used by the Mediterranean working group. The repository, R4Med, can be found at: https://github.com/drfinlayscott/R4Med.

**Tor (G)**, review the DCF data call in 2013 for Mediterranean stocks, fisheries and surveys and were necessary suggest adjustments on data needs and quality of data to be requested in the DCF call in 2014.

**Tor (H)**, EWG 13-19 was requested to rank the stocks for which DCF data is suitable for assessment and for establishment of long term management plans. And additional request was to rank the stocks based on productivity/vulnerability and other life history parameters and complete the list with the MSY reference points were available.

**Tor (I),** since in the stocks assessed since 2008 some show quite big short term differences in the value of fishing mortality and/or different $F_{MSY}$ reference values, the EWG was requested to provide explanations to corroborate the changes and/or to detect possible errors. In fulfilment of the TOR EWG 13-19 revised the complete list of assessments results.

The EWG's report will be presented and reviewed during the STECF spring plenary meeting PLEN 14-01, 24-28 March 2014.

## 2. CONCLUSIONS OF THE WORKING GROUP

**Tor (A-C), Update and assess historic and recent stock parameters:** EWG 13-19 assessed historic and recent parameters and conducted short term forecast for all stocks requested under ToR (A-C). Medium term forecasts were not conducted for any of the stocks requested under ToR (A-C) as no meaningful stock and recruitment relationships were estimated, the only exception are the stocks in Tor C.2. EWG 13-19 concludes that all stocks assessed during this meeting with an analytical result are exploited unsustainably with the exception of sardine in GSA 1, and require a large reduction in F to achieve $F_{MSY}$. Due to data deficiency, the assessment of striped red mullet in GSA 11, Common dolphinfish in GSAs 4,5,11-16 and anchovy in GSA 18 were not accepted. The assessments of sardine in GSA 1 and 9 and of anchovy in GSA 19 were accepted but as only indicative of trends.

**Tor (C.2),** the reference points for anchovy and sardine in GSA 17 were estimated using the WKFRAME methodology.

**Tor (C.3):** EWG 13-19 is not able to fully address the ToR C.3 mainly due to the following reasons:

- the calculation of partial F by fleet/metiers should be carried out with appropriate and more complex multifleet models, which are currently not utilized, allowing the possibility of assuming different population selection curves for the different fleets.
- the lack of long time series of fishery dependent and independent data and lack of knowledge on stock dynamics and connectivity for most of the exploited resources of the Mediterranean, impede the use more complex approaches (AlaDym, SS3, ASAP, Fla4a, etc.). In such context, an exercise using a virtual stock with simulated data and parameters would be an appropriate test in order to confirm the outputs of more complex methods.
- time constraints and lack of expertise in the use of complex multifleet models. Such drawback can be solved with the promotion of a capacity building process in the scientific community involved in stock assessment for example through ad-hoc courses.

**Tor (D.1) Small pelagics assessments in the Adriatic Sea:** The EWG 13-19 considers that could be useful to explore more options in order to reconstruct the time series of the landings for GSA 18, in order to join the two GSAs to produce future more robust assessments. After these preliminary attempts to assess the stocks for GSA 18, the assessment of anchovy and sardine stocks have been performed/updated only for GSA 17, in order to answer, at least partially, this ToR.

The stock of anchovy and sardine in GSA 17 was assessed by the means of SAM during EWG 13-19. The spawning stock biomass estimated for anchovy for 2012 is equal to 123,871tons, with 95% confidence intervals of (71,052, 215,957). The GFCM-SAC limit and precautionary biomass reference points for this stock are equal to respectively $B_{lim}$=179,000 tons and $B_{pa}$=250,600 tons, so anchovy stock biomass in the Adriatic Sea is below the limit reference points of 179,000 tons. The spawning stock biomass estimated for sardine for 2012 is equal to 220,577tons, with 95% confidence intervals of (144,177, 337,460). The GFCM-SAC limit and precautionary biomass reference points for this stock are equal to respectively $B_{lim}$=78,000 tons and $B_{pa}$=109,200 tons, thus sardine stock biomass in the Adriatic Sea is well above both the limit and precautionary reference points. Since those reference points are based on the values in biomass time series estimated with ICA method, which are quite higher than the ones estimated by SAM, the EWG considers that would be reasonable to re-estimate them on the basis of SAM results, in order to have a coherent comparison between the estimated biomass and the reference points.

**Tor(D.2)** According to the SAM results, anchovy stock is slightly above the Patterson exploitation rate reference point of 0.40, with a value of 0.43 (estimated for ages 1 and 2). For sardine stock in GSA17, the exploitation rate estimated by SAM for 2012 is also above the reference point and equals 0.57 (estimated for ages 2 and 5).

**Tor (E), Evaluation of DCF data quality by EWG experts:** As in previous meetings, the quality of the fisheries data from GSA 11 (Italy) has impeded the EWG to conduct an assessment of striped red mullet in GSA 11. Also, lack of catch data for GSA 8 did not allow the EWG to conduct an assessment for any of the species in the area. Thus, EWG 13-19 reiterates that the situation with fisheries data in GSA 8 and 11 is of concerns. While for GSA 8 data should be provided, for GSA 11 a thorough review of the data and the data collection process is deemed necessary to be able to perform proper stock assessments in the future. Quality checks on the MEDITS database show continuous correction of the erroneous records present in the past, which demonstrates a clear improvement of the JRC database over time.

**Tor (F), Review of R scripts used for stock assessment, short and medium term forecast and estimation of reference points:** All FLR scripts used for the assessment and forecast were revised before the meeting by the JRC team. Development of new R routines for the standardisation of the MEDITS data advanced and now a stratified index at length can be produced by linking the R script to the MEDITS database. A Github public repository has been started to store the R scripts in use in the EWG MED working group.

**Tor (G) 2014 data call evaluation and revision:** EWG 13-19 was requested to revise the 2013 data call and to advice on possible improvements or requests of other sources of data. It is concluded that the data call for 2014 should remain stable and in the current format. There are improvements to be made for what concerns the data call process to improve data quality and streamline the process. A file naming conventions should be established with clear guidelines for users. It is clear that the Data Validation Tool developed by JRC and is not being used systematically. This implies attempts of uploading incorrect files to the JRC facilities which is highly inefficient. JRC should move to progressively more restrictive checks at the time of upload to ensure conformity of the data with the most important data formatting specifications. Future data calls should stabilize the time-series of data without recalling at every deadline all the series, at the same time it should be still possible to revise uploaded data in case corrections are performed as shown by the improvements of the MEDITS database.

**Tor (H)** A table was produced for the stocks assessed during EWG 13-19 and it is available at http://stecf.jrc.ec.europa.eu.

**Tor (I) Revision of historical assessments:** EWG 13-19 was requested to revise the overview table of all the assessments performed since 2008 since there were abrupt changes in the F or $F_{MSY}$ values reported. Overall, the latest assessments are considered more reliable as these were performed with improved quality data and methods. The experts reported that the differences were mainly due to either a change in the assessment methodologies or in the input parameters of the models (e.g. growth parameters, catch data). In several occasions the short term differences in the value of fishing mortality and/or different $F_{MSY}$ reference values were not considered significant.

The EWG 13-19 noted only one remarkable difference in $F_{MSY}$ in the case the hake stock in GSA 11. This was explained by the poor quality of the catch data that also let the EWG 13-19 to not accept the stock assessment.

**Others:** None

## 3. SUGGESTIONS OF THE WORKING GROUP

**ToR (A-C), Update and assess historic and recent stock parameters:** The EWG 13-19 stresses the need for a reduction of effort and/or the catches of the relevant fleets' exploiting all stocks listed in Annex II, until fishing mortality is below or at the proposed level of $F_{MSY}$. This is necessary to achieve MSY and to avoid future loss in stock productivity and landings. The $F_{MSY}$ target should be reached by means of a multi-annual management plan taking into account mixed-fisheries effects. Catches and effort consistent with $F_{MSY}$ in the short term were estimated.

**Tor (D1), EWG 13-19** for the biomass reference points of anchovy and sardine in GSA 17, advices to use the results derived from the SAM model and the corresponding long term MSY simulations rather than the ICA ones, in order to have a coherent comparison between the estimated biomass and the reference points in the GFMC-SAC management plan.

**Tor (D2), Merging of Anchovy and Sardine stocks:** No strong scientific evidence emerged to justify assessing the stocks of Anchovy and Sardine separately in GSA 17 and 18 and therefore the two GSAs should be merged in future assessment. However, when combining the two GSAs, it is crucial to avoid the breaking down of the long times series of GSA 17. This is especially important when considering the fact that GSA 17 constitutes by far the largest part of the stock for both species.

**ToR (E), Evaluation of DCF data call by EWG Experts:** Since it is unclear how large is the sampling level in GSA 11 and how the raising from the sample to the total cacthes is performed, the EWG 13-19 considers necessary to access the raw sampling data to verify the raising procedures to be able evaluate properly the fisheries data. The complete lack of data from GSA 8 (France) since many year has not allowed any stock assessment and the status of the resources in the area is unknown. EWG 13-19 stresses the need that such data becomes available.

**ToR (F), Review of R scripts used for stock assessment, short and medium term forecast and estimation of reference points:** EWG 13-19 advices to keep updating and developing the R script that can improve the efficiency and the quality of the assessments of the EWG.

**Tor (G), Review of 2013 Data Call:** EWG 13-19 strongly suggest that the DCF data is checked with the JRC DV TOOL before uploading do detect major problems in the files. This will overall improve data quality and make uploading to JRC facilities more efficient.

**Tor (H):** None

**Tor (I):** None

**Others**

EWG 13-19 reiterates the need of an ad-hoc methodological EWG to be held in the beginning of 2015 to set up and test different assumption of selectivity for a set of stocks and about the use of discard data and slicing methodologies in the future stock assessments. A methodological EWG was regularly held in the past and is now lacking since several years. The ad-hoc methodological EWG should:

- Collate and assemble the necessary input data by fleet for stocks of hake and Norway lobster in selected GSAs.
- Run statistical catch at age assessment models with different assumptions on selectivity (i.e. dome shaped, logistic, etc).
- Discuss and compare the results with previous assessment conducted by XSA or other models.
- Set up a common methodology to reconstruct times series of discard data to be used in future stock assessment.
- Decide upon a common slicing methodology to reconstruct times series of catch at age data to be used in future stock assessment.

**Future planning of Mediterranean expert group meetings:**The next STECF EWG MED expert meetings will be held 14-18 July 2014 and hosted by CNR in Rome (with the data call deadline likely on 10 June 2014), the second meeting will be 26-30 of January 2015 (with the data call deadline for the survey data only likely on January 7th). The stocks to be assessed in 2014 as proposed by EWG 13-19 are listed in the Annex III.

# 4. Introduction

## Terms of Reference for the STECF EWG 13-19

The STECF-EWG 13-19 is requested to:

**A)** update and assess, by all relevant individual GSAs or combined GSAs where appropriate, historic and recent stock parameters for the longest time series possible of the 15 stocks listed in the table below.

In case that data provided by Member States are considered not adequate to carry out the analysis for some of the stocks mentioned in the table then the STECF-EWG shall analyse an equivalent number of stocks for the species listed in the Annex to this ToR reporting Appendix 8 of the DCF data call issued on 9 April 2013[1] . Assessment priority shall be given on stocks/GSAs not yet assessed either analytically or through data-shortage methods; special attention shall be given, in particular, to small pelagic stocks in GSA 1, 5, 6, 7, 20, 22 and main demersal stocks in GSA 1, 6, 7, 10, 11, 17, 18, 22.

Due account shall be given to technical interactions and description of the concerned multispecies and multiple-gears fisheries also in terms of fishing effort deployed (trends over time) and allocation of stock catches among different metier.

To the extent possible, the assessment shall provide the target (biological, bio-economic), the precautionary (threshold) and conservation (limit) reference points, either model based or empirical. The reference points shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels maintain or restore marine biological resources at least at levels which can produce the maximum sustainable yield.

Assessment data and methods are to be fully documented with particular reference to the completeness and quality of the data submitted by Member States as response to the official Mediterranean DCF data call issued on April 2013.

| GSA | CODE | Common name | Species | EWG 13-19 December meeting |
|---|---|---|---|---|
| 1 | PIL | Sardine | *Sardina pilchardus* | 1 |

| | | | | |
|---|---|---|---|---|
| | | | | |
| 5 | MUR | Striped red mullet | *Mullus surmuletus* | 1 |
| 5 | MUT | Red mullet | *Mullus barbatus* | 1 |
| | | | | |
| 6 | MUT | Red mullet | *Mullus barbatus* | 1 |
| | | | | |
| 7 | PIL | Sardine | *Sardina pilchardus* | 1 |
| | | | | |
| 9 | PIL | Sardine | *Sardina pilchardus* | 1 |
| | | | | |
| 11 | MUR | Striped red mullet | *Mullus surmuletus* | 1 |
| 11 | MUT | Red mullet | *Mullus barbatus* | 1 |
| | | | | |
| 15&16 | MUR | Striped red mullet | *Mullus surmuletus* | 1 |
| 4,5,11-16 | DOL | Common dolphinfish | *Coryphaena hippurus* | 1 |
| | | | | |
| 17 | ANE | Anchovy | *Engraulis encrasicolus* | 1 |
| 17 | PIL | Sardine | *Sardina pilchardus* | 1 |
| | | | | |
| 18 | ANE | Anchovy | *Engraulis encrasicolus* | 1 |
| | | | | |
| 19 | ANE | Anchovy | *Engraulis encrasicolus* | 1 |
| | | | | |
| 22&23 | ANE | Anchovy | *Engraulis encrasicolus* | 1 |
| | | | | |
| TOTAL STOCK NUMBER | | | | 15 |

**B)** Provide a synoptic overview on the recent status of exploitation level and stock size of the species analysed under a) in relation to the biological fisheries management reference points.

**C)** provide for each stock a short term and medium term forecasts of stock biomass and yield for the demersal and small pelagic stocks assessed in 2013 including, where advisable, assessments carried out in scientific frameworks other than STECF and funded by the EC.

The forecast scenarios shall include, inter alia:

- the status quo

and

- target to $F_{MSY}$ or other appropriate proxies for 2014, 2015 and 2020, respectively.

Whenever the quality of the data series allow it, please produce catch forecasts to get high yield under different recruitment scenarios while avoiding with high probability the risk that SSB fall under Blim. In particular:

*1)* Estimate the biomass reference points (i.e. $SSB_{trigger}$ both as SSBlim and SSBpa) defined as the levels of SSB below which recruitment is considered likely to become increasingly impaired and thus actions should be taken (i.e. reducing fishing mortality below $F_{MSY}$ or its proxy and the exploitation rate E well below 0.4) when the SSB approaches such stock sizes. Unless other more adequate approach is advisable, a segmented regression based on the stock recruitment data should be used.

*2)* Using the framework developed at ICES-WKFRAME 2010 and adopted in the STECF EWG 12-13, estimate the level of F which minimizes the risk of SSB falling below $SSB_{trigger}$ and maximize the total yield from the stock in the mid-long term (5, 10 and 20 years) at different level of assumed recruitment.

*3)* Estimate on the basis of commercial average catch rates by métier, the level of fishing effort by métier which is commensurate to the sustainable short-term and medium-term forecasts.

Implications of the proposed changes in fishing mortality on the fishing effort exerted by the relevant fisheries/métier concerned have to be identified. The identification and description of fisheries/métier (DCF codification) to be considered are left to the experts on the basis of their knowledge of fisheries in each GFCM-GSA.

The simulation by fishery for the abovementioned targets shall be driven either by the most relevant stock(s) (either in quantity and/or economic value), or the most vulnerable stock or a scientifically weighed mix of MSY targets for the main species involved in the fishery.

Raw data used to generate the input data for the assessment shall be made available to allow for testing different settings and data scenarios.

**D)** GFCM Recommendation 37/2013/1 establishes a multiannual management plan for fisheries on small pelagic stocks in the GFCM-GSA 17 (Northern Adriatic Sea) and transitional conservation measures for fisheries on small pelagic stocks in GSA 18 (Southern Adriatic Sea). The plan for GSA 17 is based on the exploitation rate E lower than 0.4 and on mid-year spawning biomass precautionary and limit reference points respectively of 250600 tonnes and 179000 tonnes for anchovyand of 109200 tonnes and 78000 tonnes for sardine.

The GFCM-SAC is expected to provide on annual basis as from 2014 advice on the status of the small pelagic stocks, including catch forecasts in line with precautionary approach and the MSY, in GSA 17 and GSA 18. The STECF EWG is requested to prepare the ground in support of the forthcoming GFCM-SAC working group and to advise on:

- the relative position of the mid-year spawning stock biomass with respect to the precautionary and limit reference points both for anchovy and sardine
- the level of exploitation rate with respect to the reference point of E = 0.4
- the uniqueness or separation of the anchovy and sardine stocks between the two GSA 17 and 18.

-the areas of aggregation of anchovy and sardine juveniles in their first year of life. To this end it is advisable to use the statistical grids of 30'x30' as established by the GFCM/35/2011/1 concerning the establishment of a GFCM logbook.

**E)** review the quality and completeness of all data resulting from the official Mediterranean DCF data call issued on April 2013. STECF is requested to summarize and concisely describe in detail all data quality deficiencies of relevance for the assessment of stocks and fisheries. Such review and description are to be based the data format of the official DCF data calls for the Mediterranean issued on April 2013. Particular attentions should be devoted to assessing the quality of MEDITS survey for which inconsistencies had emerged during previous EWG meetings.

**F)** Review, update and consolidate the R scripts developed by EWG-MED and JRC over the period 2008-2013 to:

- perform deterministic and statistical age slicing on DCF catch at length and MEDITS data
- extract and standardize MEDITS indexes of biomass and abundance
- R plotting functions to produce standard plots for STECF reports

**G)** review the DCF data call in 2013 for Mediterranean stocks, fisheries and surveys and where necessary suggest adjustments on data needs and quality of data to be requested in the DCF call in 2014.

**H)** Taking into account the fisheries data provided through the data call (catch; length composition, discard, etc) and on the basis of the stocks assessed so far list and describe the fisheries (% of catches and N° of vessels by fishing gear) by country and GSAs for which suitable information is available to establish multiannual management plans for single/mixed species and/or multiple gears fisheries aiming to deploy the maximum sustainable yield exploitation rate(s) with a view to restore and maintain fish stocks above level capable of producing maximum sustainable yield. Rank the list of assessed stocks by GSA on the basis of their production potentials /productivity/vulnerability based on growth, longevity and size/age at first maturity; the most vulnerable species should rank first. Report for each stock the MSY reference point and the most recent estimates of F.

The table below provides an example of template but experts are free to propose a different format as considered adequate:

| | | | **countries** | XX | | | | | YY | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| | | | **Fishing gears** | Trawler | Bottom set trammel net | Bottom set net gillnet | longline | Other ….. | Trawler | Bottom set trammel net | Bottom set net gillnet | longline | Other ….. |
| | | Fishing mortality exploitation rate | | | | | | | | | | | |
| **GSA** | **Species** | Fmsy or proxy | Both Current F and average F of last three estimates | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | hake | | | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | etc | | | | |
| | Red mullet | | | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | | | | | |
| | Norway lobster | | | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | % by species N° of vessles | | | | | |
| | Rose shrimp | | | % by species N° of vessles | % by species N° of v% by species N° of vessles | % by species N° of vessles | % by species N° of vessles | | | | | | |

%= percentage of catches by country and gear for each assessed stock

**I)** Amongst the stocks so far assessed since 2008 some show quite big short term differences in the value of fishing mortality and/or different Fmsy reference values; the table below reports the different cases where one or both situations occur. Explanations shall be provided to corroborate such changes and/or to detect possible errors.

| species | GSAs |
|---|---|
| Giant red shrimp | 15-16 |
| anchovy | 1, 6, 9 |
| hake | 5, 6, 7, 10, 11, 17 |
| Red mullet | 6, 7, 9, 10, 15-16 |
| Striped mullet | 5 |
| Common pandora | 9 |
| Red and blue shrimp | 6 |
| Deep-water rose shrimp | 6, 9, 10, 15-16 |

**J)** Any Other Business

**ANNEX: reporting Appendix 8 of the DCF data call by DG MARE (**Ares(2013)613197)

| SPECIES | CODE | Common name |
|---|---|---|
| *Aristaeomorpha foliacea* | ARS | Giant red shrimp |
| *Aristeus antennatus* | ARA | Blue and red shrimp |
| *Aspitrigla cuculus* | GUR(c) | Red gurnard |
| *Boops boops* | BOG | Bogue |
| *Citharus linguatula* | CIL([c]) | Spotted flounder |
| *Coryphaena hippurus* | DOL | Common dolphinfish |
| *Dicentrarchus labrax* | BSS | Sea bass |
| *Diplodus spp.* | SRG([a]) | Sargo breams |
| *Eledone cirrhosa* | OCM([c]) | Horned octopus |
| *Eledone moschata* | OCM([c]) | Musky octopus |
| *Engraulis encrasicolus* | ANE | Anchovy |
| *Eutrigla gurnardus* | GUG | Grey gurnard |
| *Galeus melastomus* | SHO | Blackmouth catshark |
| *Helicolenus dactylopterus* | BRF([c]) | Rockfish |
| *Illex coindetii* | SQM([c]) | Broadtail squid |
| *Lepidorhombus boscii* | LDB([c]) | Four-spotted megrim |
| *Loligo vulgaris* | SQC([c]) | European squid |
| *Lophius budegassa* | ANK | Black-bellied angler |
| *Lophius piscatorius* | MON | Anglerfish |
| *Merlangius merlangus* | WHG([b]) | Whiting |
| *Merluccius merluccius* | HKE | European hake |
| *Micromesistius poutassou* | WHB | Blue whiting |
| *Mugilidae* | MUL | Grey mullets |
| *Mullus barbatus* | MUT (a,b) | Red mullet |

| | | |
|---|---|---|
| *Mullus surmuletus* | MUR (a,b) | Striped red mullet |
| *Nephrops norvegicus* | NEP | Norway lobster |
| *Octopus vulgaris* | OCC | Common octopus |
| *Pagellus acarne* | SBA([a,c]) | Axillary seabream |
| *Pagellus bogaraveo* | SBR([a,c]) | Blackspot seabream |
| *Pagellus erythrinus* | PAC | Common Pandora |
| *Parapenaeus longirostris* | DPS | Deep water rose shrimp |
| *Penaeus kerathurus* | TGS | Caramote prawn |
| *Phycis blennoides* | GFB([c]) | Greater forkbeard |
| *Psetta maxima* | TUR | Turbot |
| *Raja clavata* | RJC | Thornback ray |
| *Rapana venosa* | RPW([b]) | Rapa |
| *Sardina pilchardus* | PIL | Sardine |
| *Scomber spp.* | MAZ | Mackerel |
| *Scyliorhinus canicula* | SYC | Small-spotted catshark |
| *Sepia officinalis* | CTC | Common cuttlefish |
| *Solea solea* | SOL | Common sole |
| *Sparus aurata* | SBG | Gilthead seabream |
| *Spicara flexuosa* | PIC([c]) | Picarel |
| *Spicara smaris* | SPC | Picarel |
| *Sprattus sprattus* | SPR | Sprat |
| *Squalus acanthias* | DGS | Piked dogfish |
| *Squilla mantis* | MTS | Spottail mantis squillids |
| *Trachurus mediterraneus* | HMM | Mediterranean horse mackerel |
| *Trachurus trachurus* | HOM | Horse mackerel |

| | | |
|---|---|---|
| *Trigla lucerna* (= *Chelidonichthys lucerna*) | GUU | Tub gurnard |
| *Trigloporus lastoviza* | GUU(c) | Streaked gurnard |
| *Trisopterus minutus* | POD([c]) | Poor cod |
| *Zeus faber* | JOD([c]) | John Dory |

[a] are requested as important under the Mediterranean regulation (Council Regulation (EC) N° 1967/2006)

[b] are requested as important species in the Black Sea

c included in the list of reference species for the Medits survey (Medits, Instruction manual 2007)

## Participants

The full list of participants at EWG 13-19 is presented in the Annex I of this report.

## 5. ToR a-c update and assess historic and recent stock parameters (summary sheets)

The following section of the present report does provide short stock specific assessments in the format of summary sheets. The assessments are presented in geographical order (i.e. by GSA). Detailed versions of the assessments of stocks and fisheries are provided in section 6 of the report.

### 5.1. Summary sheet of sardine in GSA 1

| | |
|---|---|
| Species common name: | Sardine |
| Species scientific name | *Sardina pilchardus* |
| Geographical Sub-area(s) GSA(s): | GSA1 |

**Most recent state of the stock**

State of the adult abundance and biomass
Fishery independent information from acoustic surveys was not available and therefore a separable VPA for three different scenarios of terminal F (0.3, 0.5 and 0.7) was run. The separable VPA estimates an increase in SSB between 2011 and 2012. No precautionary biomass reference points have been proposed for this stock. As a result, EWG 13-19 is unable to evaluate the status of the stock spawning biomass with respect to the precautionary approach.In any case, in the absence of fishery independent information, the results of the present assessment should be considered as indicative of trends but not reliable as absolute values.

State of the juvenile (recruits)
The outputs of separable VPA suggest an increasing recruitment since 2009.

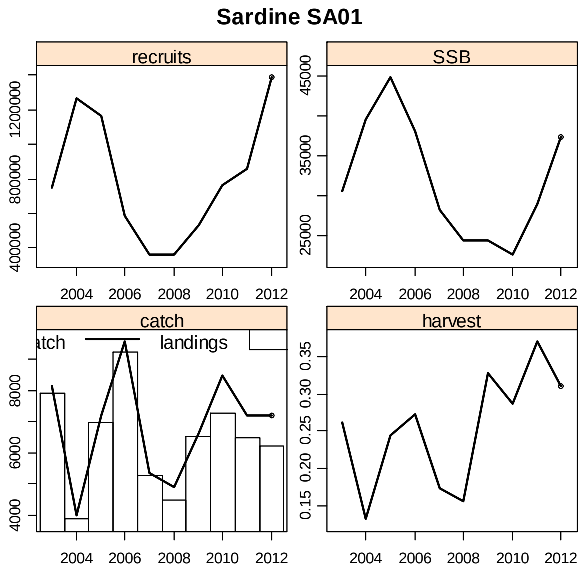
State of exploitation
Considering E=0.4 as reference point, it could be concluded that the sardine stock in GSA1 in the most recent years is being exploited sustainably. E is under $E_{04}$ for all the different scenarios of terminal F (0.3, 0.5 and 0.7).

Source of data and methods
Data from DCF provided to EWG-13-19 on sardine landings and the respective size structure for 2003-2012 were used. A vector of natural mortality value by age was obtained using Gislason method (Gislason *et al*., 2010).Catch at age, weight at age, mortality at age and maturity at age data for 2003-2012 were compiled for age classes 0 to 5+ and used as input data for the separable VPA. Age class 0 was the most abundant in the catches. Separable VPA was performed for three different scenarios of terminal F(0.3, 0.5 and 0.7). The analyses were made using R software and the FLR libraries with scripts provided by JRC.

**Outlook and management advice**
As the assessment is only indicative of trend for SSB and R, EWG 13-19 was not able to provide short term forecast for this stock.

**Fisheries**
The purse seine fleet has continuously decreased in the last two decades, from more than 230 vessels in 1980 to 101 in 2012. Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet in GSA1, but other species with lower commercial value as horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.) and gilt sardine (*Sardinella aurita*) are also caught. In 2011 and 2012, annual sardine landings were around 6300 tonnes.

**Summary of the stock assessment**




*Sardina pilchardus* in GSA 1: Main separable VPA results (recruitment, SSB, catch and harvest-F).Results shown below are these from Scenario 2, with terminal F= 0.5.

These results should be taken only as indicative of trends for SSB and R. Recruitment, SSB and F trends were very similar in the three scenarios. According to these results, recruitment and SSB have increased in the last years.

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| E(0-2) = F/Z | <0.4 |
| $E_{MSY}$(0-2) = | 0.4 |
| $F_{01}$ (ages 1-2) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of sardine in GSA 1 can be found in section 6.1.

## 5.2. SUMMARY SHEET OF STRIPED RED MULLET IN GSA 5

| | |
|---|---|
| Species common name: | Striped red mullet |
| Species scientific name: | *Mullus surmuletus* |
| Geographical Sub-area(s) GSA(s): | GSA 5 |

**Most recent state of the stock**

State of the adult abundance and biomass

The stock abundance has showed a marked decreasing trend along the historical time series, from $11.5 \cdot 10^6$ individuals in 2000 to about $4.4 \cdot 10^6$ individuals in 2012. The SSB has also decreased markedly from 202 t in 2007 to 116 t in 2012.No precautionary biomass reference points have been proposed for this stock. As a result, EWG 13-19 is unable to evaluate the status of the stock spawning biomass with respect to the precautionary approach.

State of the juvenile (recruits)

Recruitment showed a marked decreasing trend throughout the time series, from $8.1 \cdot 10^6$ individuals in 2000 to $2.2 \cdot 10^6$ individuals in 2012.

State of exploitation

The $F_{stq}$ (0.54) is larger than $F_{0.1}$ (0.18), which indicates that striped red mullet in GSA 5 is exploited unsustainably.

Source of data and methods

Landings, tuning fleets (MEDITS and fishery) and size-frequency distributions cover the period from 2000-2012. Growth, maturity and length-weight parameters are from the Spanish DCF. Natural mortality was obtained using PRODBIOM. XSA, Y/R and projections were run using R scripts developed by JRC.

**Outlook and management advice**

The main XSA results are shown in the figure below (recruitment, SSB, catches and harvest-F).

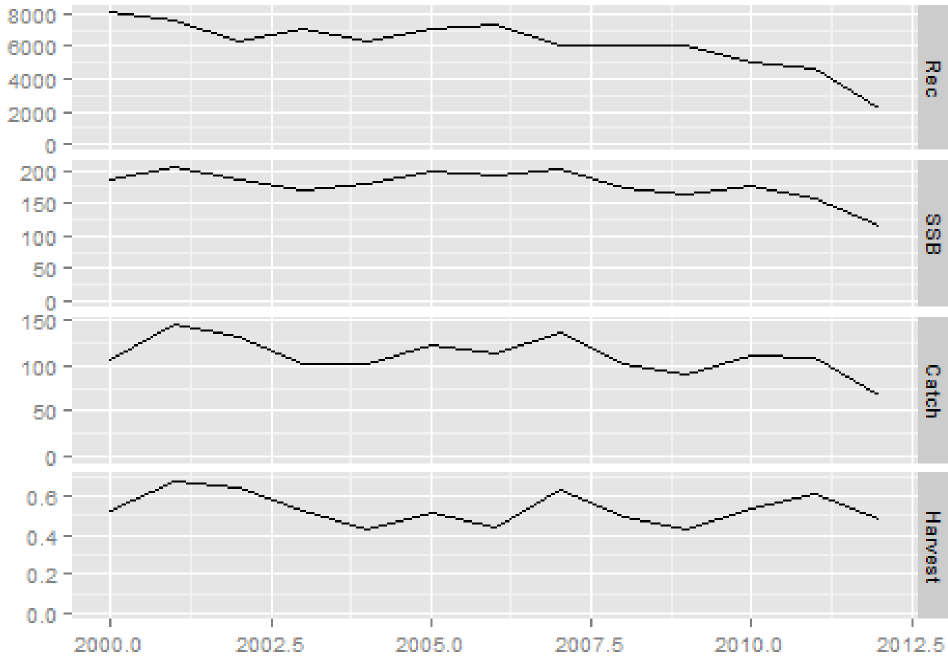
STECF EWG 13-19 suggests that catch in 2014 should not exceed 25 t, corresponding to $F_{0.1}$=0.18.

STECF EWG 13-19 also suggests the relevant fleets' effort and/or catches to be reduced until fishing mortality is below or at the proposed $F_{0.1}$level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations.

**Fisheries**

Striped red mullet is one of the most important target species for the trawl fishery along the continental shelf off Mallorca (~30 vessels). A fraction of the small-scale fleet (~100 boats) also exploit this species during the second semester of the year (July-December), using trammel nets and gillnets. The present assessment represents approximately 95% of the total landings of the GSA 5.

**Summary of the stock assessment**




*Mullus surmuletus* in GSA5: main XSA results (recruitment, SSB, catch and harvest-F).

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19

| | |
|---|---|
| $F_{0.1}$ (0-2) | 0.18 |
| $F_{max}$ (age range) | |
| $F_{msy}$ (0-2) = | 0.18 |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (age range)= | |
| $F_{max}$ (age range)= | |
| $F_{msy}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{msy}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment and the short term forecast of striped red mullet in GSA 5 can be found in section 6.2.

## 5.3. SUMMARY SHEET OF RED MULLET IN GSA 5

| | |
|---|---|
| Species common name: | Red mullet |
| Species scientific name | *Mullus barbatus* |
| Geographical Sub-area(s) GSA(s): | GSA 5 |

**Most recent state of the stock**

State of the adult abundance and biomass

SSB does not show any clear trend during the analyzed period. No precautionary biomass reference points have been proposed for this stock. As a result, EWG 13-19 is unable to evaluate the status of the stock spawning biomass with respect to the precautionary approach.

State of the juvenile (recruits)

Recruitment does not show any clear trend during the analyzed period.

State of exploitation

The current F(0.93) is larger than $F_{MSY}$ (0.14), which indicates that red mullet in GSA 5 is exploited unsustainably.

Source of data and methods

An Extended Survivor Analysis (XSA) was performed using as input data bottom trawl landings and age distributions (derived from sliced length frequency distributions) from 2000-2012 (obtained from the Official DCF Data Call and IEO projects). Biological parameters used correspond to those agreed in SGMED-08-03 or computed using DCF data. Standardized indices from bottom trawl surveys (BALAR and MEDITS) were used as tuning fleets.

**Outlook and management advice**

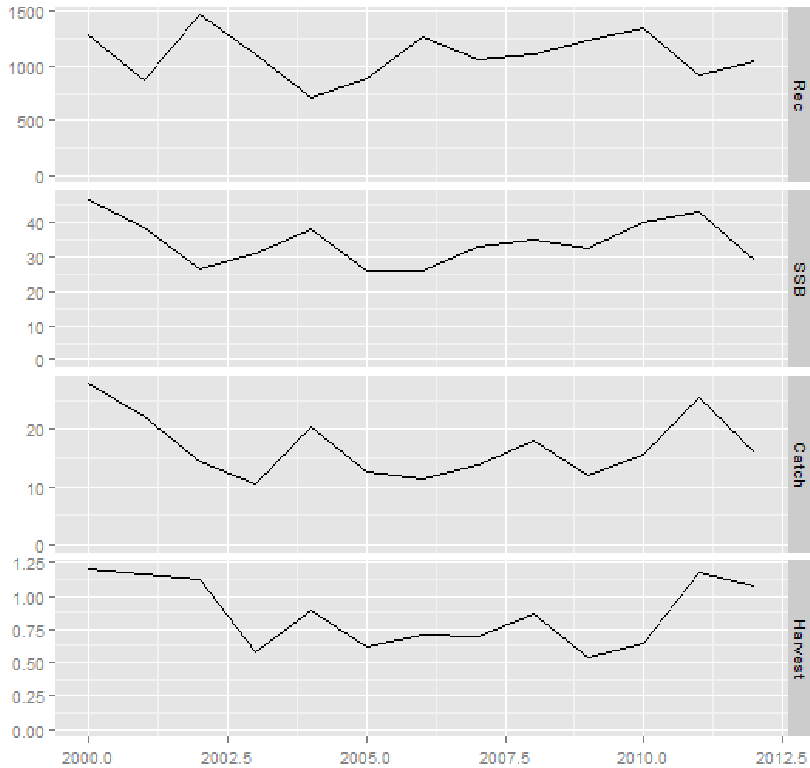
STECF EWG 13-19 suggests that catch in 2014 should not exceed 3.4 t, corresponding to $F_{0.1}$=0.15.

It is also important to consider that red mullet in GSA 5 is only caught as a by-catch in the trawl fishery and the management of this species should be undertaken in the framework of a multispecific approach.

**Fisheries**

In the Balearic Islands (western Mediterranean), commercial trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope (Guijarro and Massutí 2006; Ordines et al. 2006), mainly targeted to: (i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50-80 m); (ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the deep shelf (80-250 m); (iii) *Nephrops norvegicus*, but with an important by-catch of *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 red mullet, *M. barbatus*, is a by-catch species in the shallow and deep shelf.

**Summary of the stock assessment**




*Mullus barbatus* in GSA 5: Main XSA results (recruitment, SSB, catch and harvest-F).

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19

| | |
|---|---|
| $F_{0.1}$ (1-2) = | 0.15 |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (1-2) = | 0.15 |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |

| | |
|---|---|
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of red mullet in GSA 5 can be found in section 6.3.

## 5.4. SUMMARY SHEET OF RED MULLET IN GSA 6

| | |
|---|---|
| Species common name: | Red mullet |
| Species scientific name | *Mullus barbatus* |
| Geographical Sub-area(s) GSA(s): | GSA 6 |

**Most recent state of the stock**

State of the adult abundance and biomass

SSB fluctuated around 2100 t during 2002-2012, with a minimum in 2003 (1745t) and a peak in 2006 (2975 t). The SSB in the last 3 years has been stable around 2000 t. No precautionary biomass reference points have been proposed for this stock. As a result, EWG 13-19 is unable to evaluate the status of the stock spawning biomass with respect to the precautionary approach.

State of the juvenile (recruits)

Recruitment fluctuated over 2002-2012, with the highest values in 2002 and 2005-2007, around a mean of 106 000 thousand individuals. The lowest values, around 80 000 thousand individuals, are observed in the last 4 years of the time series.

State of exploitation

Exploitation is based on age classes 0, 1 and 2, with age 0 as the youngest age fully recruited to the fisheries. By comparing $F_{01}$ against current F, it can be concluded that the stock is exploited unsustainably. Results were the following: $F_{curr} = 1.69$, $F_{01} = 0.45$.

Source of data and methods

The state of exploitation was assessed for the period 2002-2012 applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS). In addition, a yield-per-recruit (Y/R) analysis was carried out. Both methods were performed from the size composition of trawl landings, transforming length data to ages by knife-edge slicing (L2AGE program). Input data were taken from DCF, except landings, which were obtained from local fishery statistics in GSA6. Natural mortality (vector) was estimated using PROBIOM.

**Outlook and management advice**

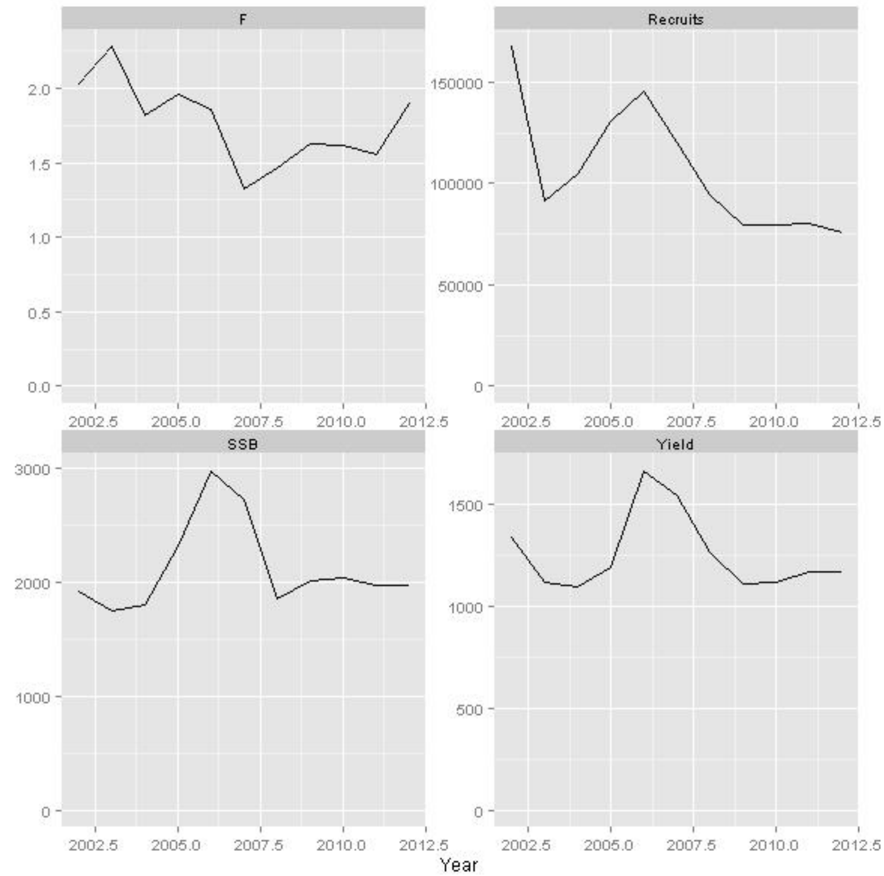
STECF EWG 13-19 suggests that catch in 2014 should not exceed 578 t, corresponding to $F_{0.1}$=0.45.

EWG 13-19 recommends the relevant fleets' effort and/or catches to be reduced until fishing mortality is below or at the proposed level $F_{01}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

**Fisheries**

Red mullet is an important demersal target species of the Mediterranean fishing fleets on continental shelves. In GSA 6 it is exploited mainly by trawlers (about 90% of the landings), with the rest of the landings made by gillnetters. Over the period 2002-2012 annual landings oscillated around 1200 t. Trawl discards in weight are known to be high, especially in the recruitment period (autumn) but the quantities reported in the DCF data set are unrealistically low. In the current stock assessment presented in section 6.4, discard were assumed to be 0.

**Summary of the stock assessment**




*Mullus barbatus* in GSA 6: Main XSA results (recruitment, SSB, catch and harvest-F).

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| $F_{01}$ (ages 0-2) = | 0.45 |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (ages 0-2) = | 0.45 |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |

| | |
|---|---|
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of red mullet in GSA 6 can be found in section 6.4.

## 5.5. SUMMARY SHEET OF SARDINE IN GSA 7

| | |
|---|---|
| Species common name: | European Sardine |
| Species scientific name | *Sardina pilchardus* |
| Geographical Sub-area(s) GSA(s): | GSA 7 |

**Most recent state of the stock**

The results of the assessment were not accepted due to data deficiencies (see details in section 6.5 of this report).

Source of data and methods

Data coming from DCF (catch at age from the French trawlers, French purse seiners) for the period 2003-2012 were used to run an Extended Survivor Analysis (XSA), tuned with PELMED abundance indices for 2003-2012. Discards were not included in the catches.

Age-length keys were derived from otolith readings. 3 different keys were used to take into account changes in the population structure and growth over time. Similarly, the same 3 periods were used to estimate mean weight at age in the catches using different length-weight relationships. Finally, 3 maturity ogives were also used, as fish matured earlier in the 2009-2011 compared to earlier period. Natural mortality was estimated using Lorenzen equation (1996).

**Outlook and management advice**

No advice could be given on the present basis(see details in section 6.5 of this report).

**Fisheries**

Both pelagic trawlers and purse seines are present in the Gulf of Lions. However, due to important changes in the sardine population structure and growth, the number of boats has been decreasing during the last few years and the fleet now only contains 7 trawlers and 3 purse-seines targeting sardines. As a consequence, the total catches have also been decreasing and are now reaching very low levels (less than 700 t). Most regulations (no fishing activity during the week-end, length of trawlers, etc.) are fully respected, except for the limitation of engine power for trawlers. Usually, sardines were mostly fished by pelagic trawlers (~90% of the landings). However, in the past 2 years this trend has been reversed with a decrease in pelagic trawler effort. Most of the sardines (93%) fished in 2012 were landed by purse-seiners.

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| $F_{01}$ (ages range) = | |
| $F_{max}$ (ages range)= | |
| $F_{MSY}$ (ages range) = | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of sardine in GSA 7 can be found in section 6.5.

## 5.6. SUMMARY SHEET OF SARDINE IN GSA 9

| | |
|---|---|
| Species common name: | Sardine |
| Species scientific name | *Sardina pilchardus* |
| Geographical Sub-area(s) GSA(s): | GSA9 |

**Most recent state of the stock**

State of the adult abundance and biomass

Fishery independent information regarding the state of sardine in GSA9 was derived from the international survey MEDITS. The estimated biomass indices reveal a clear decreasing trend. The results of the separable VPA confirm this trend although in the last year the tendency was reversed. However, without a source of fisheries independent information coming from an echo-survey, the results of the present assessment should be considered as indicative of trend only.

State of the juvenile (recruits)

Also for the recruits the outputs of the separable VPA showed a decreasing trend from 2006 until 2011. In the 2012 the trend was reversed. However, without an independent source of fisheries information coming from an echo-survey, the results of the present assessment should be considered as indicative of trend only.

State of exploitation

Separable VPA was computed for three different scenarios of terminal F: 0.3, 0.5 and 0.7. Considering E=0.4 as limit management reference point consistent with high long term yields for small pelagic species, the exploitation rate for sardine in GSA9 was higher than the reference point in all three scenarios. Thus, the stock is considered to be exploited unsustainably.

Source of data and methods

Data from DCF provided at EWG-13-19, containing information on sardine landings and the respective age structure for 2006-2012, were used. A vector of natural mortality value by age was obtained using Gislason method (Gislason et al.,2010).Catch at age, weight at age, mortality at age and maturity at age data for the 2006-2012 period were compiled for age classes 0 to 4+ and used as input data for the Separable VPA. Separable VPA was computed for three different scenarios of terminal F(0.3, 0.5 and 0.7). The computation was made using R software.

**Outlook and management advice**

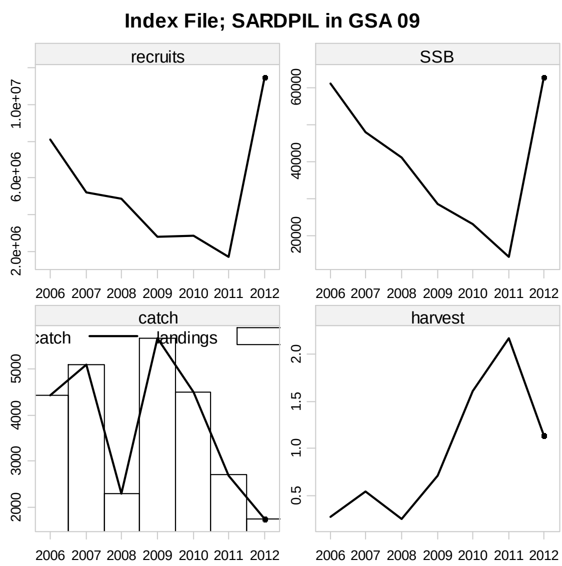
For the relevant fleet effort exploitation rate should be reduced until fishing mortality is below or at the same level of the proposed management reference point. However, as the assessment is only indicative of trend for SSB and R, EWG 13-19 was not able to provide short term forecast for this stock.

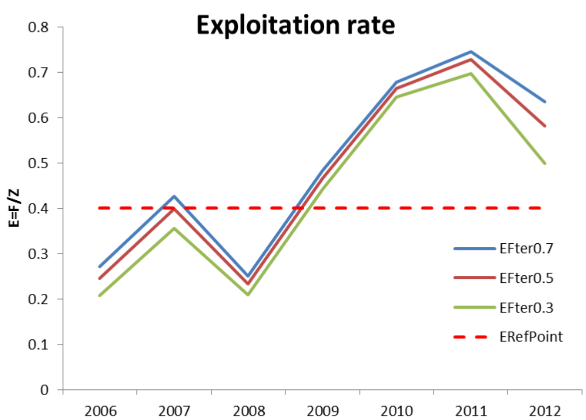
**Fisheries**

In the GSA9, sardine is mainly exploited by purse seiners. Due to its low economic value, however, sardine does not represent the main target species for this fleet, while anchovy (*Engraulis encrasicolus*) is the most important species exploited by this fishery. The fishing season starts in spring (March) and ends in autumn (October). Favourable weather conditions and abundance in the catches can extend the fishing activity to the end of November. However, the maximum activity of the fleet is normally observed in the summer. Some vessels coming from the south of Italy (mainly from GSA10) join the local fleet. Sardine is also a by-catch in the bottom trawl fisheries.

However, the landings yielded by these metiers are very low (about 1%) in comparison to purse seiners. Pelagic trawling is not carried out in the GSA9.

## Summary of the stock assessment




## Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| E(1-3) = F/Z | > 0.4 |
| $E_{MSY}$(1-3) = | 0.4 |
| $F_{01}$ (age range) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of sardine in GSA 9 can be found in section 6.6.

## 5.7. SUMMARY SHEET OF STRIPED RED MULLET IN GSA 11

| | |
|---|---|
| Species common name: | Striped red mullet |
| Species scientific name | *Mullus surmuletus* |
| Geographical Sub-area(s) GSA(s): | GSA 11 |

**Most recent state of the stock**

Due to data deficiencies, EWG 13-19 is unable to evaluate the state of the stock.

Source of data and methods:

A long time series of fishery independent information (MEDITS survey, 1994-2012) are available to EWG 13-19 to but landing information are not available before 2011 (DCF). Moreover DCF catch data shows a series of issues which are probably related to the raising procedure and the sampling design of data collection in GSA11.Because of the shortness of the time series of catch data and because of its questionable quality, EGW 13-19 is unable to apply any method for the evaluation of the state of the stock.

**Outlook and management advice**

EWG 13-19 is unable to give any management advice for red mullet in GSA 11.

### Fisheries

DCF data (2013) shows that in the GSA 11 landings of striped red mullet come mostly exclusively from bottom trawlers (OTB) and trammel nets (GTR). The OTB fleet landed around the 33% and the 54% in 2011 and 2012 respectively. The gill nets (GNS) landings account yearly for about the 5% of the total.

In 2011 the percentage of discards (53%) was incredible high for this species, that generally has low discards. In 2012 discard were less than 14% for the GTR and OTB fleets, but around 45 % for the gillnets (0% in the 2011).

Checks of catch data at length shows that samples are not comparable with independent fishery data (MEDITS) and that particularly for GTR and GNS fisheries samplings have been improperly expanded.

Since it is unclear the sampling level in GSA 11 and how the raising were performed, the EWG 13-19 is unable to fully evaluate the quality of DCF data. STECF EWG considers useful to access the raw sampling data to verify the raising procedures and accurately check the fisheries data.

### Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG

| | |
|---|---|
| $F_{0.1}$ = | |
| $F_{max}$ (age range)= | |

| | |
|---|---|
| $F_{MSY}$ = | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

### Comments on the assessment

The detailed assessment of striped red mullet in GSA 11 can be found in section 6.7 of this report.

## 5.8. SUMMARY SHEET OF RED MULLET IN GSA 11

| | |
|---|---|
| Species common name: | Red mullet |
| Species scientific name | *Mullus barbatus* |
| Geographical Sub-area(s) GSA(s): | GSA 11 |

### Most recent state of the stock

State of the adult abundance and biomass

An Extended Survivor analysis (XSA) was carried out during EGW13-19. Landings at age, catch data and survey data from the DCF were used to assess the stock of *Mullus barbatus* in the GSA 11. SSB oscillated between 155 and 202 t during the first period (2005-2009), then progressively declined to a minimum value of 95 t in the last year (2012). No baseline for comparison of the current values against historic SSB is available. Since no biomass reference point for this stock has been proposed, EWG 13-19 was unable to fully evaluate the state of the spawning stock in comparison to these.

State of the juvenile (recruits)

Recruitment did show a peak of abundance ($6.9 \cdot 10^7$individuals) in the middle of the time series (2008) and a large decreasing trend to $2.6 \cdot 10^7$ individuals in 2012.

State of exploitation

EWG 13-19 proposed $F_{0.1}$ = 0.11 as proxy of $F_{MSY}$. Taking into account the results obtained by the XSA analysis (current F = 1.07), the stock is considered to be exploited unsustainably.

Source of data and methods

An XSA was performed using DCF data over 2005-2012. Landings and discards has been sliced taking in to account the respective length composition of the catches. Catch data was tuned with fishery independent information (i.e. MEDITS survey).Natural mortality vector was derived by PRODBIOM.

### Outlook and management advice

STECF EWG 13-19 suggests that catch in 2014 should not exceed 37 t, corresponding to $F_{0.1}$=0.11.

EWG 13-19 recommends the relevant fleets' effort and/or catches to be reduced until fishing mortality is below or at the proposed $F_{MSY}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations. Catches and effort consistent with $F_{MSY}$ should be estimated.

### Fisheries

DCR landing data shows that red mullet is targeted by one gear only (OTB, otter bottom trawl). Catches from trammel net (GTR) are negligible. During 2005-2012 mean annual catches were 234 t and ranged between 136 t in 2012 and 346 t in 2007. Discards information is available for 5 years only, ranging from 0.1 to 59 t (mean 29 t).

## Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG 13-19

| | |
|---|---|
| $F_{0.1}$ (1-3) = | 0.11 |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (1-3) = | 0.11 |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

## Comments on the assessment

The detailed assessment of red mullet in GSA 11 can be found in section 6.8.

## 5.9. SUMMARY SHEET OF STRIPED RED MULLET IN GSA 15 AND 16

| | |
|---|---|
| Species common name: | Striped red mullet |
| Species scientific name | *Mullus surmuletus* |
| Geographical Sub-area(s) GSA(s): | GSA 15 and 16 |

**Most recent state of the stock**

State of the adult abundance and biomass
SSB is fluctuating around a mean level of 1850 tonnes, with levels recorded in 2012 (2462 tonnes) similar to levels estimated for 2007 and 2002. The lowest levels estimated for the time series were 1043 tonnes in 2009. No precautionary biomass reference points have been proposed for this stock. As a result, EWG 13-19 is unable to evaluate the status of the stock spawning biomass in respect to these.

State of the juvenile (recruits)
Recruitment is fluctuating around a mean level of 52 000 thousands individuals, with levels recorded in 2012 (42 000 thousands individuals) almost half of levels estimated for 2011 (78 000 thousands individuals), but higher than those recorded in 2010 (19 000 thousands individuals), which were the lowest recorded during the time series (2002-2012).

State of exploitation
$F_{bar1-4}$ showed a declining temporal trend from 3.0 in 2002 to 0.78 in 2012. Exploitation is mostly based on age classes 1-3. By comparing $F_{01}$ against current F, it can be concluded that the stock is exploited unsustainably. Results were the following: $F_{curr}$ (2012) = 0.78, $F_{01}$ = 0.19.

Source of data and methods
The state of exploitation was assessed for the period 2002-2012 applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS). In addition, a yield-per-recruit (Y/R) analysis was carried out. Both methods were performed from the size composition of trawl and small-scale fishery landings, transforming length data to ages using the slicing statistical approach developed during STECF-EWG 11-12 (Scott et al., 2011).Input data were taken from DCF. Natural mortality vector was estimated using PRODBIOM.

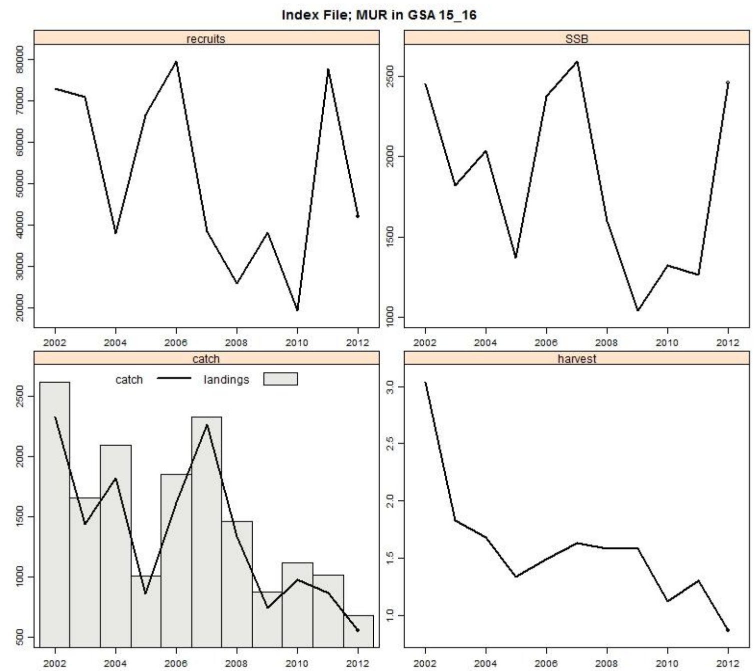
**Outlook and management advice**

STECF EWG 13-19 suggests that catch in 2014 should not exceed 600 t, corresponding to $F_{0.1}$=0.19.

EWG 13-19 recommends the relevant fleets' effort and/or catches to be reduced until fishing mortality is below or at the proposed level $F_{01}$, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries effects.

**Fisheries**
Striped red mullet is an important demersal target species in the Strait of Sicily. In 2012 a total of 750 tonnes of striped red mullet were landed in GSA 15 (Malta) and 16 (Sicily); the Maltese fishing fleet was responsible for 10% of the total catches. Over the available time series of DCF data, an average of 73% and 88% of total striped red mullet landings are from trawlers in GSA 15 and GSA 16, respectively. The great majority of remaining catches are from trammel net fisheries, although small amounts of striped red mullet are landed as by-catch from set gillnets (less than 0.5% of catches in both GSAs).

**Summary of the stock assessment**




*Mullus surmuletus* in GSA 15 and 16: Main XSA results (recruitment, SSB, catch and harvest-F).

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| $F_{01}$ (ages 1-2) = | 0.19 |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (ages 1-2) = | 0.19 |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

**Comments on the assessment**

The detailed assessment of striped red mullet in GSA 15 and GSA 16 can be found in section 6.9.

## 5.10. SUMMARY SHEET OF DOLPHINFISH IN GSA 5-6, 10, 15-16, 19

| | |
|---|---|
| Species common name: | Common dolphinfish |
| Species scientific name | *Coryphaena hippurus* |
| Geographical Sub-area(s) GSA(s): | GSA 5, 6, 10, 15, 16, 19 |

**Most recent state of the stock**

Due to data deficiencies, EWG 13-19 is unable evaluate the state of the stock.

Source of data and methods

The following data was available to EWG 13-19: landings data by fishery for 2002-2012 for Spanish GSAs (5, 6), landings data by fishery for 2004-2012 for Italian GSAs (10, 16, 19), landings data by fishery for Malta (GSA 15).Fishing effort data (both nominal and in terms of GT·days at sea) were available for Malta (2005-2012), Italy (2004-2009, 2011-2012) and Spain (2002-2012). However 67% of catches reported for EU Member States in 2012 came from FAD fishery, and no information on number of FADs or number of FADs targeted per fishing trip was available. No suitable data on CPUE for adults was available to estimate SSB since adults are usually caught as by-catch. Some landings data was available for non-EU MS from the FAO/GFCM capture production database, but no effort data was available for third countries. DCF data on catch length frequency distributions were only available from the Maltese Islands since this is the only country where this fishery is selected for DCF sampling due to its local importance.

**Outlook and management advice**

EWG 13-19 considers that the issue of data quality for this species should be addressed by (i) including the relevant effort parameters (total number of FADs and number of FADs targeted per fishing trip) in the DC-MAP for future monitoring (ii) collecting information on additional variables required for a sound standardization of CPUEs through a series of targeted studies in the EU Member States involved in the fisheries. In addition a series of targeted studies aimed at gathering up to date / historical information on fishing effort, and variables required for standardising CPUE should be conducted in third countries (notably Tunisia and Libya) fishing *C. hippurus*, possibly by involving FAO regional projects.

Moreover, given the problems associated with standardising CPUE for FAD fisheries targeting juveniles EWG 13-19 further considers that studies characterising CPUE for adult specimens should be carried out in order to estimate abundance indices for SSB and/or scientific surveys will be needed in order to run stock assessment methods able to estimate maximum sustainable yield and relevant reference points.

Due to the biology of the species as well as the nature of the fishery, EWG 13-19 considers that *Coryphaena hippurus* should in the future be assessed by the RFMOs GFCM and/or ICCAT.

**Fisheries**

Based on catch data available from the GFCM Capture Production database for the last decade (2000-2010), Italy was responsible for 42%, Tunisia for 36%, Malta for 14%, Spain for 6% and Libya for 2% of landings. Malta clearly has a long history of targeting dolphinfish, and Malta and Spain seem to be the only countries which did not increase their total dolphinfish landings. Italian landings on the other hand seem to have increased dramatically since 2005, however it is likely that such increase can be linked to an improvement of the official statistics. DCF data for the years 2011 and 2012 indicate a decreasing trend in overall catches; however it is not possible to confirm this trend without data for the Tunisian fleet in recent years.

For the European fishing fleets (Spain, Malta and Italy), 67% of catches recorded in 2012 came from fishing vessels using surrounding nets (i.e. the FAD fishery), 28% came from longlines (drifting and set longlines; most of such catches are likely to be by-catch, e.g. from the longline fisheries targeting swordfish), 2% from gill and trammel nets and the remaining percentage from trolling lines and 'mixed gears' reported for Italian GSAs. In the Maltese Islands by-catch of common dolphinfish in longlines and gill and trammel nets were the lowest when compared to other GSAs; 97% of catches came from the traditional FAD fishery.

### Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| $F_{01}$ (age range) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range) = | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

## Comments on the assessment

The detailed review of data and potential future assessment methods for dolphinfish in the Mediterranean Sea can be found in section 6.10.

## 5.11. SUMMARY SHEET OF ANCHOVY IN GSA 17

| | |
|---|---|
| Species common name: | Anchovy |
| Species scientific name | *Engraulis encrasiculos* |
| Geographical Sub-area(s) GSA(s): | GSA 17 |

State of the spawning stock size

The highest value is registered in 2008 with about 850000 tons. On the other hand, results from Stock-space Assessment Model (SAM) shows a declining trend starting in 2005, reaching in 2012 a spawning biomass (estimated for age classes 0-5) level around 124000 tons. Estimates of fishery independent surveys for anchovy in GSA 17 indicated a slight increase from lower levels in 2004 to the most recent estimates in 2012.

Reference points were estimated as described in section 6.18. The level of anchovy SSB in 2012 estimated for age 1 to 5 only (i.e. excluding age 0; 30431 t) is lower than the estimated reference point for both $B_{lim}$ (38791 tons) and $B_{pa}$ (54307 t).

Also, spawning biomass in 2012 (estimated using all age classes, 0-5; 123871 t) is below both the biomass reference points $B_{pa}$ (250600 t) and $B_{lim}$ (179000 t) established by the GFCM-SAC in 2012.

State of recruitment

SAM model estimates had shown that recruitment fluctuates around a minimum value of 15,934,546 thousands specimen in 1986, to a maximum value of 167,752,460 in 1978. A second peak was registered in 2005, with a value of 142,094,090 thousand specimens.

State of exploitation

Based on SAM results, the F of ages 1 and 2 was strongly fluctuating in the observed time series. $F_{bar(1-2)}$ reached high levels between 2009 and 2011 (1.52 in 2011), but in 2012 lower values were estimated (0.80). The $F_{bar(1-2)}$ estimated from the SAM model ($F_{bar(1-2)}$=0.80) is above the $F_{MSY}$ reference point ($F_{MSY}$ = 0.38) estimated during this EWG.

Source of data and methods

The analyses were performed using SAM (Nielsen et al., 2012). The following data was available to EWG 13-19: landings data and catch at age data from 1976 to 2012 for the whole GSA17. Besides, total biomass estimates and numbers at age at sea estimates from acoustic surveys were provided from 2004 to 2012 and were used as tuning index in the assessment model. Discards were not included in the catches. Natural mortality vector was estimated from the Gislason's equation (Gislason et al., 2010), using the growth parameters in Sinovcic (2000).

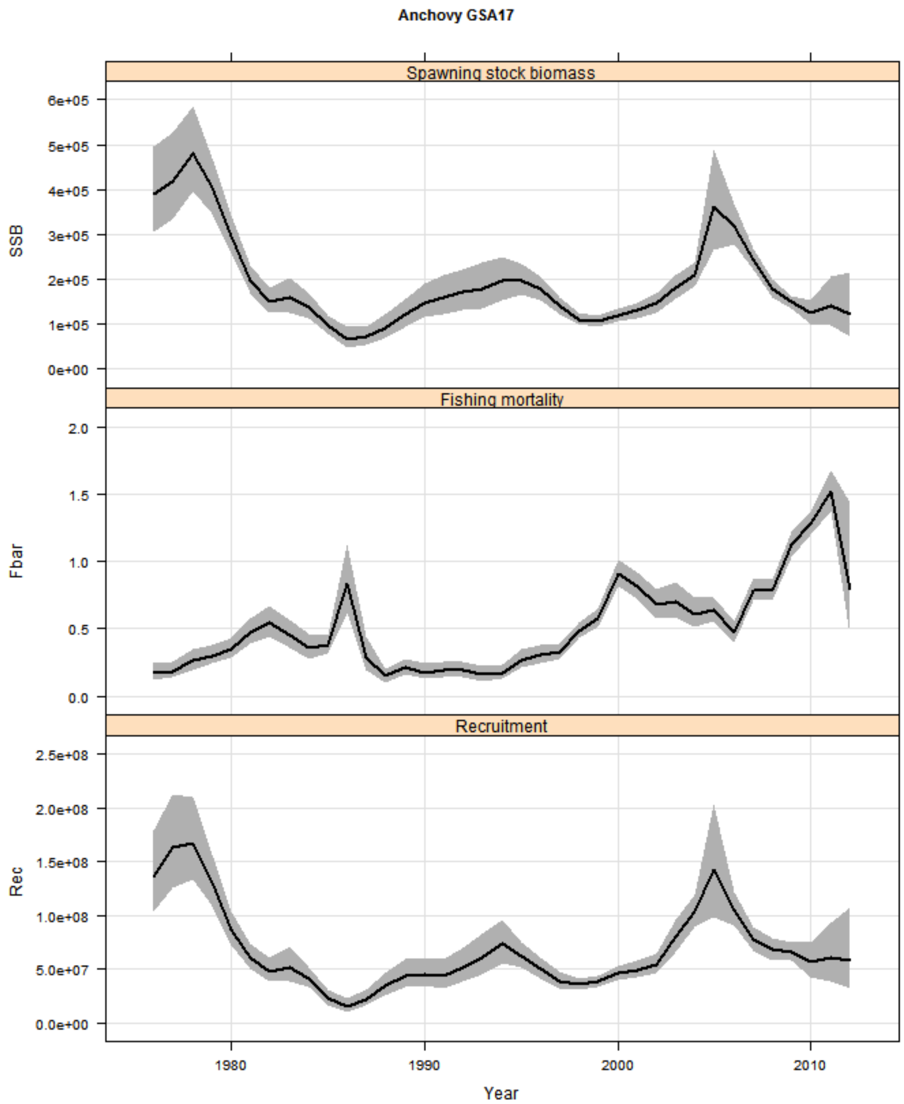
**Fisheries**

Anchovy is commercially very important in the Adriatic Sea. It is targeted by pelagic trawlers (Italy) and purse seiners (Croatia, Slovenia, Italy). The number of vessels targeting this species is around 300. The landings of anchovy in GSA17 dropped from more than 50000 tons in the 1980 to about 6000 tons in 1987; after that the landings started to increase again, reaching the highest value of the time series with 58600 tons in 2007. In the last five years the landings started to decrease again. The 2012 value is equal to 32924 tons, and the average for the last three years is 37496.

### Outlook and management advice

EWG 13-19 considers that fishing mortality in 2014 should not exceed $F_{MSY}$ (F=0.38) corresponding to catches of 13432 tons.

### Summary of the stock assessment




### Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| $F_{01}$ (age range) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range) = | 0.38 |

| | |
|---|---|
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | Blim = 54307 - Bpa = 38791 |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | Blim = 78000 - Bpa = 109200 (GFCM) |

## Comments on the assessment

The detailed assessment of anchovy in GSA 17 can be found in section 6.11.

## 5.12. SUMMARY SHEET OF SARDINE IN GSA 17

| | |
|---|---|
| Species common name: | Sardine |
| Species scientific name | *Sardina pilchardus* |
| Geographical Sub-area(s) GSA(s): | GSA 17 |

State of the spawning stock size

Estimates of fishery independent surveys for sardine in GSA 17 indicated a peak in 2011 in respect to other years (500,000 tons); in 2012 the biomass estimated from acoustic survey is around 200,000 tons. Results of the state-space assessment model (SAM) indicated a constant increase of biomass in the last 10 years, being the 2012 the highest, with 220,577 tons. Reference points were estimated as described in section 6.18. SSB of sardine in 2012 (220,577 t) is higher than the estimated reference point for $B_{lim}$ (167383 t) and slightly lower than the estimated reference point for $B_{pa}$ (234336 t), and it is above both the limit and precautionary reference points $B_{lim}$ (78000 t) and $B_{pa}$ (109200 t) established from the GFCM-SAC in 2012.

State of recruitment

After the drop in recruitment occurred from 1985 to 1998, the recruitment level is following an increasing trend that reaches its maximum in 2012, with an estimate of 15,157,409 thousands specimen.

State of exploitation

Based on SAM results, the $F_{bar\ (2-5)}$ is more or less stable from 2002. The value for 2012 is equal to 0.92, which is larger of the estimated $F_{MSY}$ (0.46) value.

Source of data and methods

The analyses were performed using SAM (Nielsen et al., 2012). The following data was available to EWG 13-19: landings data and catch at age data from 1975 to 2012 for the whole GSA17. Besides, total biomass estimates and numbers at age at sea estimates from acoustic surveys were provided from 2004 to 2012 and were used as tuning index in the assessment model. Discards were not included in the catches. Natural mortality vector was estimated from the Gislason’s equation (Gislason et al., 2010), using the growth parameters in Sinovcic (1984).

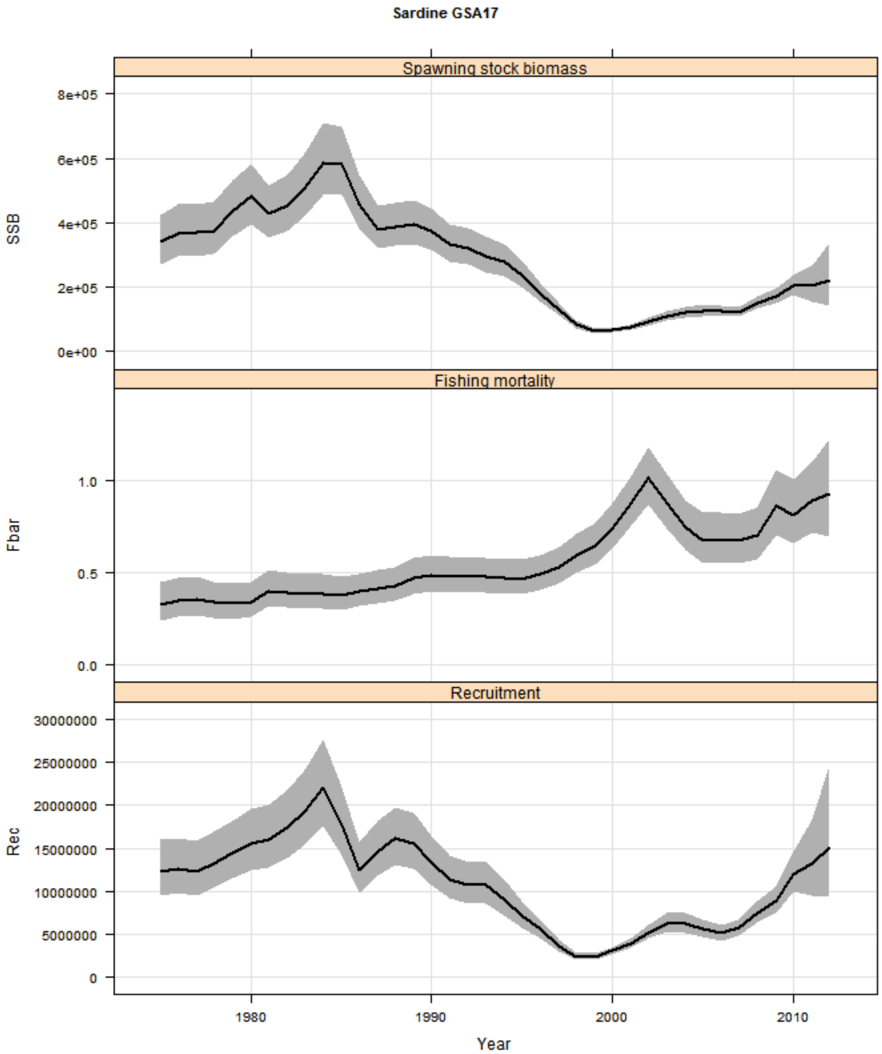
**Fisheries**

Sardine is commercially very important in the Adriatic Sea. It is targeted by pelagic trawlers (Italy) and purse seiners (Croatia, Slovenia, Italy). The number of vessels targeting this species is around 300. The landings of sardine in GSA17 started decreasing in the late eighties reaching a minimum in 2005 with 19,000 tons. In the last 7 years the Croatian catches grew high, reaching the maximum of the entire time series in 2011 with about 46,000 tons (almost 90% of the overall catches). In 2012 the total landings slightly decreased respect to the previous year, with an overall value of 48,941. The average of the last three years (2010-2012) is equal to 43676 tons.

**Outlook and management advice**

EWG 13-19 considers that fishing mortality in 2014 should not exceed $F_{MSY}$= 0.46 corresponding to catches of 36962 tons in 2014.

**Summary of the stock assessment**




**Precautionary and target management reference points or levels**

Table of limit and target management reference points or levels **proposed by SGMED**

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| $F_{01}$ (age range) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range) = | 0.46 |

| | |
|---|---|
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | $B_{lim}$ = 167383;  $B_{pa}$ = 234336 |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | $B_{lim}$ = 78000;  $B_{pa}$ = 109200 (GFCM) |

## Comments on the assessment

The detailed assessment of sardine in GSA 17 can be found in section 6.12.

## 5.13. SUMMARY SHEET OF RED MULLET IN GSA 17

| | |
|---|---|
| Species common name: | Red mullet |
| Species scientific name | *Mullus barbatus* |
| Geographical Sub-area(s) GSA(s): | GSA 17 |

### Most recent state of the stock

State of the adult abundance and biomass

An XSA (Extended Survivor analysis) and SCAA (Statistical Catch at Age) assessment were performed using DCF catch data from Italy and Slovenia together with catch information for the Croatian fishery provided by a Croatian ad-hoc project. According to the XSA and SCAA outputs, the SSB was practically constant in the period 2006-2012, but the estimates made by the SCAA show a critical situation when comparing the stock status with the historical stock trends. The population is characterized by a SSB which is less than 20% of what it was in the 1990s, and show a clear decreasing pattern in the abundance of the older ages individuals. Nevertheless, due to the absence of proposed or agreed biomass management reference points, the EWG 13-19 is unable to fully evaluate the state of the spawning stock in respect to these.

State of the juvenile (recruits)

According to the XSA and SCAA analyses, the recruitment of red mullet in GSA 17 fluctuated without a clear pattern over the time series.

State of exploitation

EWG 13-19 considers that the most accurate methodology to assess the stock is the SCAA carried out with SS3, thus EWG 13-09 proposes $F \leq 0.21$ as proxy for $F_{MSY}$. Given the results of the present analysis (current F is around 0.55), the stock appeared to be exploited unsustainably.

Source of data and methods:

An XSA was performed using 2006-2012 DCF data (landings and age composition of the catches), tuned with fishery independent abundance indices (MEDITS and SoleMon surveys) for the period 2006-2012. An SCAA was performed using 2006-2012 DCF data (landings and age composition of the catches), by gear (otter bottom trawl from Italy, Croatia and Slovenia), tuned with fishery independent abundance indices (MEDITS and SoleMon surveys) for the period 2000-2012. Total landings by gear and country were reconstructed based on data available in the ISTAT and FAO-FishstaJ database. A vector of natural mortality was obtained applying PRODBIOM. In addition, Yield per Recruit (YPR) analysis was performed for the estimation of $F_{0.1}$ (i.e. proxy of $F_{MSY}$).

### Outlook and management advice

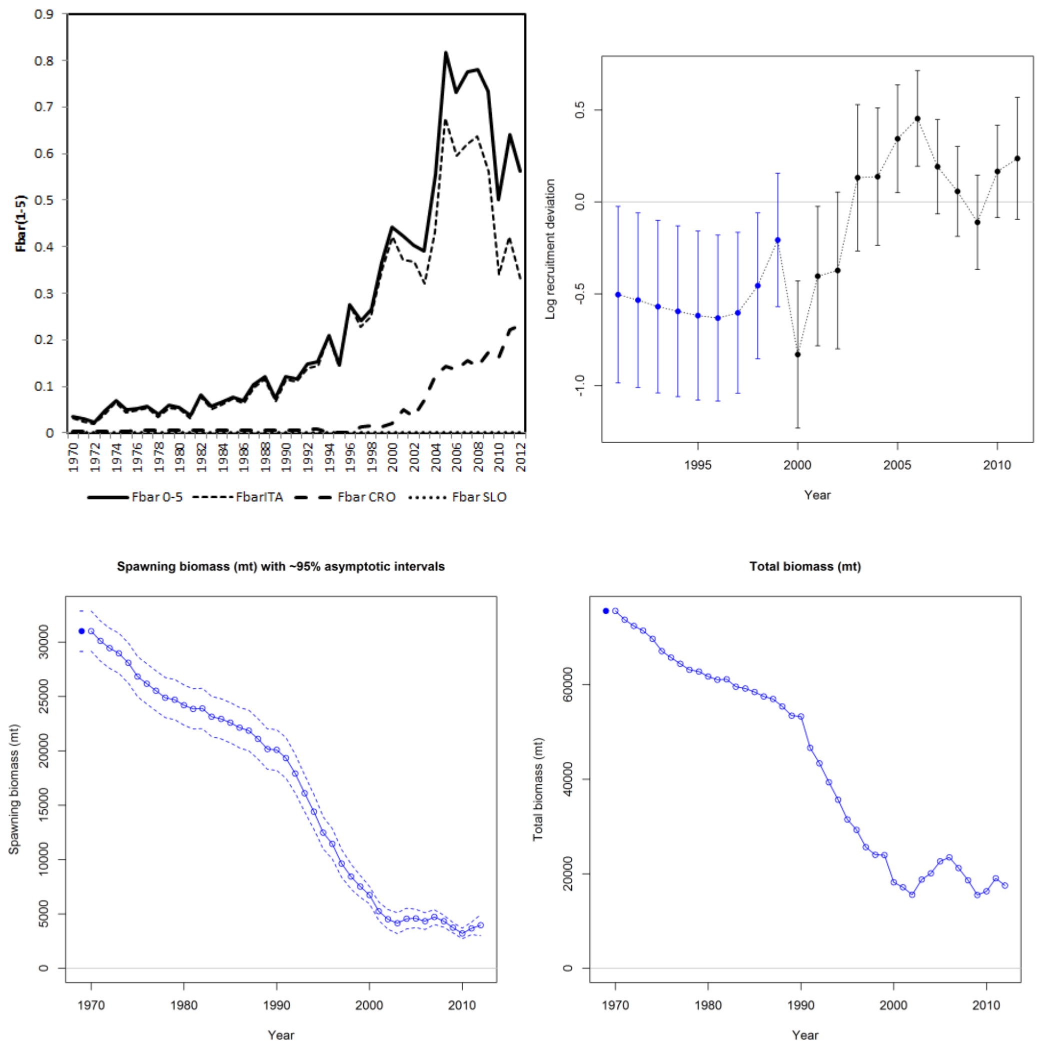
STECF EWG 13-19 suggests that catch in 2014 should not exceed 1441 t, corresponding to $F_{0.1}$=0.21.

EWG 13-19 recommends the fleets' effort or catches to be reduced until fishing mortality is below or at the proposed $F_{MSY}$ level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations.

## Fisheries

The red mullet is a very important commercial species in the central and northern Adriatic Sea. Italian otter trawlers exploit the resource usually providing 70% of landings. Red mullet is also a target species of the Croatian and Slovenian trawlers, and it represents accessory by-catch species for *rapido* trawlers and gillnetters.

### Summary of the stock assessment




## Limit and precautionary management reference points

Table of limit and precautionary management reference points proposed by STECF EWG

| | |
|---|---|
| $F_{0.1}$ (ages 0-5) = | 0.21 |
| $F_{max}$ (ages 0-5)= | |
| $F_{MSY}$ (ages 0-5) = | 0.21 |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{0.1}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

### Comments on the assessment

The detailed assessment of red mullet in GSA 17 can be found in section 6.13.

## 5.14. SUMMARY SHEET OF SARDINE IN GSA 18

| | |
|---|---|
| Species common name: | Sardine |
| Species scientific name | *Sardina pilchardus* |
| Geographical Sub-area(s) GSA(s): | GSA 18 |

### Comments on the assessment

The exploratory assessment of sardine in GSA 18 can be found in section 6.19.

## 5.15. SUMMARY SHEET OF ANCHOVY IN GSA 19

| | |
|---|---|
| Species common name: | Anchovy |
| Species scientific name | *Engraulis encrasiculos* |
| Geographical Sub-area(s) GSA(s): | GSA 19 |

**Most recent state of the stock**

State of the adult abundance and biomass

The results of the separable VPA show a decline of the SSB from 2007 to 2012.However, in the absence of eco-survey data for this stock,the current assessment should be considered as indicative of trends only. Moreover, in the absence of proposed and agreed precautionary management references, EWG 13-19 is unable to fully evaluate the status of SSB in respect to these.

State of the juvenile (recruits)

The separable VPA showed a sharp decrease of recruitment in the last year. However, in the absence of eco-survey data for this stock, the current assessment can only be considered as indicative of trends.

State of exploitation

EWG 13-19 proposes E<=0.4 as limit management reference point of exploitation consistent with high long term yield. Given the results of the present analysis, the current exploitation rate of anchovy in GSA 19 in comparison with the limit management reference point is unknown.

Source of data and methods

For the assessment of anchovy stock in GSA19 the DCF official data of commercial catch have been used. A sex combined analysis has been carried out.

For the GND fleet segment in 2009 and 2010 annual landings data from IREPA have been used. The LFDs for these years have been estimated raising the average LFDs of 2008 and 2011 to the corresponding productions of 2009 and 2010, this because in 2009 and 2010 the GND metier was not selected in the ranking system of DCF.

Catch numbers at age were derived form the DCF annual size distributions using the ALK (age-length key) from DCF to slice the LFDs. The following length-weight relationship (in cm and g) was used: a =0.0035, b =3.28. The maturity at age has been derived by the maturity at length age sliced using the ALK. The natural mortality by age has been calculated using the Gislason method (Gislason et al., 2010).

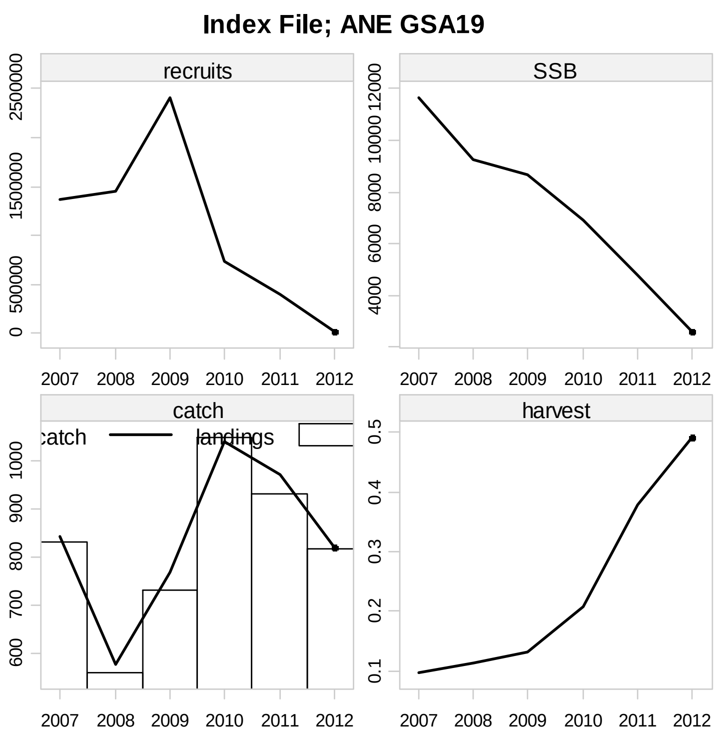
The reference age chosen to run the separable VPA was the one most represented in the catch (i.e. age 1); a sensitivity analysis on the results with F terminal values 0.2, 0.4 and 0.6 has been performed. The intermediate run (terminal F=0.4)has been chosen for the stock trends.

**Outlook and management advice**

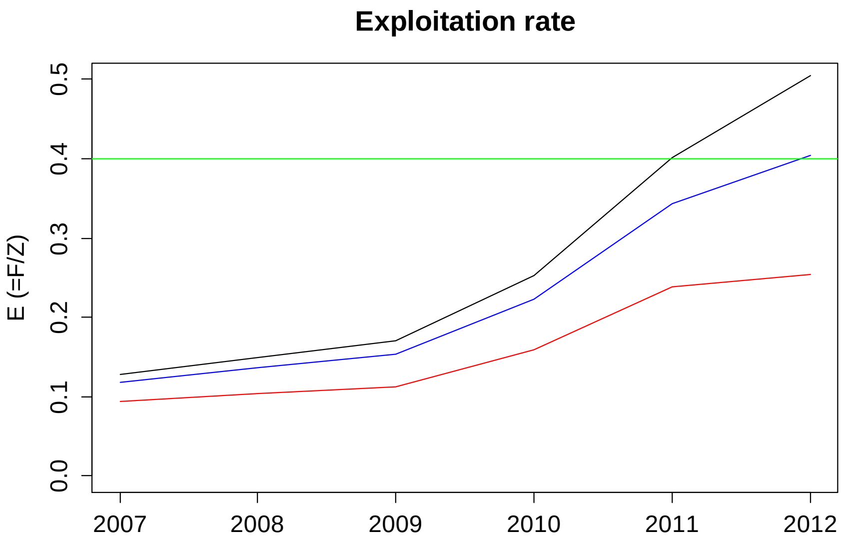
EWG 13-19 proposes E<=0.4 as limit management reference point of exploitation consistent with high long term yield. However, as the assessment is only indicative of trend, EWG 13-19 was not able to provide short term forecast for this stock.

Fisheries

Summary of the stock assessment (terminal F=0.4).




*Engraulis encrasiculos* in GSA 19: Main separable VPA results (recruitment, SSB, catch and harvest-F).




Analysis of the exploitation rate (terminal F =0.2 red, 0.4 blue and 0.6 black) for anchovy GSA19.

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| E (1-3) = F/Z | |
| $E_{MSY}$(1-3)= | 0.4 |
| $F_{01}$ (ages 1-2) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (ages 1-2) = | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

## Comments on the assessment

The detailed assessment of anchovy in GSA 19 can be found in section 6.15.

## 5.16. SUMMARY SHEET OF ANCHOVY IN GSA 22

| | |
|---|---|
| Species common name: | Anchovy |
| Species scientific name | *Engraulis encrasicolus* |
| Geographical Sub-area(s) GSA(s): | GSA 22 |

The stock of anchovy in GSA 22 has been previously assessed by means of Integrated Catch at Age analysis in the framework of SGMED 09-02. In the EWG 12-03 a further assessment of the stock was performed on the same data set following a different analytical methodology. There was no new data made available for anchovy stock in GSA 22 between 2008 and 2012, therefore EWG 13-09 was not able to provide an updated assessment for the species. The results reported here refer to the latest assessment carried out in 2009.

### Most recent state of the stock

State of the adult abundance and biomass

Given the short length of the time series, STECF EWG 13-09 is unable to precisely estimate the absolute levels of stock abundance and biomass. Survey indices and previous VPA analyses indicate that average total biomass and SSB increased since 2006 to 2008. Biomass limit reference points have not been estimated for this stock, and hence advice relative to these cannot be provided by STECF EWG 13-09 in respect to those. There was no new data made available for anchovy stock in GSA 22 between 2008 and 2012, therefore EWG 13-09 was not able to provide an updated assessment of the adult abundance and biomass for this stock.

State of the juvenile (recruits)

FLXSA model estimates performed in EWG 11-20 suggested an increase in recruitment since from 2004 to 2008. There was no new data made available for anchovy stock in GSA 22 between 2008 and 2012, therefore EWG 13-09 was not able to provide an updated assessment of recruitment for this stock.

State of exploitation

STECF EWG 11-20 recommended the application of the proposed exploitation rate $E_{MSY}$=0.4 as management target for stocks of anchovy and sardine in the Mediterranean Sea. A longer time series of data would enable a revision of this number in the future. The mean E=F/Z (F averaged over ages 1 to 3) has been found to fluctuate around 0.39 and in 2008 has been below the empirical level of sustainability suggested as target exploitation level for this stock. There was no new data made available for anchovy stock in GSA 22 between 2008 and 2012, therefore EWG 13-09 was not able to provide an updated assessment of the exploitation rate for this stock.

Source of data and methods

The anchovy data used so far in the previous analyses have been annual anchovy landings, annual anchovy catch at age data (2000-2008), mean weights at age, maturity at age at age and the results of acoustic and DEPM surveys. The application of FLXSA in EWG 11-20 was based on commercial catch data (2000-2008) and as tuning indices were used the numbers at age estimates of the population from acoustic surveys over the period 2003-2008 but with a gap for 2007. Different natural mortality were applied per age group but constant for all years based on ProBiom (Abella *et al.*, 1997) as recommended in the report of the SG-ECA/RST/MED 09-01. Natural mortality values applied for anchovy stock in GSA 22. Age0=1.5, Age1=1, Age2=0.74, Age3=0.66, Age4=0.62. The default values of the FLXSA control were used to run the analysis taking into account that the survey is held in the middle of the year.

### Outlook and management advice

Due to the lack of data since 2008, STECF EWG 13-19 is not able to provide an updated advice for this stock.

**Fisheries**

Anchovy landings showed an increasing trend towards 2008 Anchovy reported landings have showed an increasing trend since 2002, comprising 24,480 tons in 2008. Information regarding the age and length distribution of sardine landings prior to 2003 is based on the Hellenic Centre of Marine Research data collection system. Data of the fishing effort (Days at Sea) and the landings per vessel class indicate that small vessels (12-24 m) are mainly responsible for anchovy catches (i.e. >70% of anchovy catches). Table of anchovy landings (in tonnes) in GSA 22 per vessel size for 2003 to 2006 and 2008 concerning the purse seine fleet in Greek waters is shown below. Since there was no Data Collection Program in Greece in 2007, data concerning this year are an estimations of the Hellenic Centre for Marine Research based on data from other research projects that were carried out in GSA 22. Discards values are less than 1%, reaching approximately 0.06% for GSA 22.

| Year | PS 12-24 m | PS 24-40 m |
|---|---|---|
| 2003 | 12507 | 1495 |
| 2004 | 12222 | 3877 |
| 2005 | 11073 | 5274 |
| 2006 | 16121 | 6190 |
| 2007 | 14875 | 6625 |
| 2008 | 18188 | 6293 |

**Limit and precautionary management reference points**

Table of limit and precautionary management reference points proposed by EWG 13-19.

| | |
|---|---|
| $F_{01}$ (ages range) = | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range) = | |
| $E_{MSY}$ (F/Z, age range 1-3)= | 0.4 |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

Table of limit and precautionary management reference points agreed by fisheries managers

| | |
|---|---|
| $F_{01}$ (mean)= | |
| $F_{max}$ (age range)= | |
| $F_{MSY}$ (age range)= | |

| | |
|---|---|
| $F_{pa}$ ($F_{lim}$) (age range)= | |
| $B_{MSY}$ (spawning stock)= | |
| $B_{pa}$ ($B_{lim}$, spawning stock)= | |

## 6. TOR A-C UPDATE AND ASSESS HISTORIC AND RECENT STOCK PARAMETERS (DETAILED ASSESSMENTS)

The following section of the present report does provide detailed stock specific assessments and all relevant data of such stocks and their fisheries. The assessments are presented in geographic order by GSA. Short versions of the assessments of stocks and fisheries in the format of summary sheets are provided in the preceding section.

## 6 Stock assessment of Sardine in GSA 01

### 6.1.1. Stock identification and biological features

Stock Identification

No information was provided on stock identification of sardine in GSA1 during EWG13-19 meeting. Therefore, due to a lack of information about the stock structure of the sardine population in the western Mediterranean, this stock was assumed to be confined within the GSA 1 boundaries.

The Working Group of Small Pelagic Species of the GFCM-SAC-SCSA in its conclusions and recommendations of the meeting “Preliminary analysis for identification of priority species of small pelagic shared stocks in GSA01 and GSA03 (Alborán Sea)” held in 2011 (Kada *et al.* 2013) proposed “the elaboration, for the next meeting, of a document with relevant information on sardine migration in the Alboran Sea in order to improve the knowledge of the movements of the sardine in the region”.

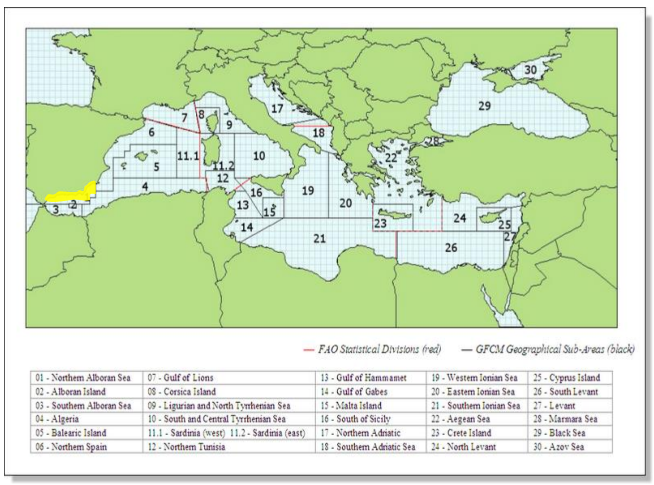



Fig. 6.1.1.1. Geographical location of GSA 1.

Growth

Growth parameters ($L_{inf}$= 22.0; k= 0.45; to= -1.42, males and females combined) and the length-weight relationship parameters (a=0.0059 and b=3.1406) used were the same estimated 1 in 2008-2009 (using DCF data).

Maturity

Maturity at age was estimated throughout the biological sampling from years 2003-2009 (DCF).

Table 6.1.1.3.1. Sardine in GSA1. Maturity ogive.

| ages | 0 | 1 | 2 | 3 | 4 | 5+ |
|---|---|---|---|---|---|---|
| % mature | 0.34 | 0.90 | 0.99 | 1.0 | 1.0 | 1.0 |

### 6.1.2. **Fisheries**

General description of fisheries

The purse seine fleet has continuously decreased in the last two decades, from more than 230 vessels in 1980 to 101 in 2012 (Figure 6.1.2.1). Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet in GSA 1, but other species with lower commercial value as horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.) and gilt sardine (*Sardinella aurita*) are also caught. In 2011 and 2012 annual sardine landings were around 6300 tonnes.

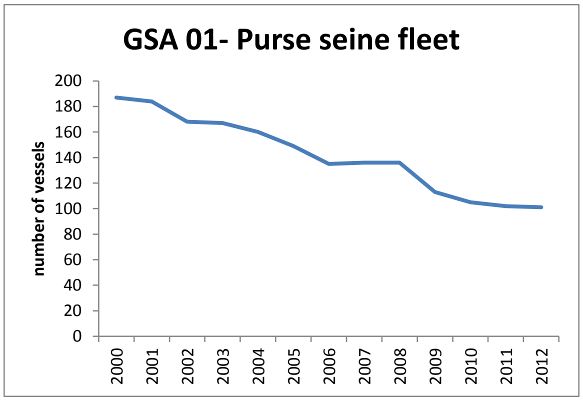



Fig.6.1.2.1.1. Number of vessels of the purse seine fleet in GSA 1 during 2000-2012.

Management regulations applicable in 2011 and 2012

- Fishing license
- Minimum landing size 11cm total length.
- No fishing allowed on weekend.
- Time at sea 12 hours per day and 5 days a week.
- Several technical regulations regarding specifications on the characteristics of the gear, dimension, mesh size, floodlight and light intensity (Orden ARM/2529/2011).
- Authorized target species for purse seining (Orden ARM/2529/2011).
- Daily landing by vessel limited to 5000 kg (Orden ARM/143/2010).

Further details on the purse seining regulations in force can be found in the above mentioned regulations by the Spanish Ministry responsible for fishing issues (Ministerio de Medio Ambiente, y Medio Rural y Marino).

Catches

Sardine landings in GSA1 come from purse seining, although according to DCF, small sardine amounts are fished by GSN and GTR. Discards over 2005- 2012 were very low, with the exception of 2009.

Landings

Table 6.1.2.3.1.1. Sardine annual landings (t) in GSA1, by fishing gear (data source: DCR and DCF).

| Year | GNS | GTR | OTB | PS | Total |
|---|---|---|---|---|---|
| 2002 | | | 252.1 | 5206.3 | 5458.4 |
| 2003 | | | 215.1 | 7679.6 | 7894.7 |
| 2004 | | | 47.8 | 3815.4 | 3863.2 |
| 2005 | | | 27.3 | 6895.5 | 6922.7 |
| 2006 | | | 32.4 | 9129.9 | 9162.3 |
| 2007 | | | 136.8 | 5117.3 | 5254.1 |
| 2008 | | | 13.3 | 4453.0 | 4466.3 |
| 2009 | 25.5 | 2.2 | 16.4 | 5944.8 | 5988.9 |
| 2010 | 8.2 | 1.3 | 14.5 | 7229.8 | 7253.8 |
| 2011 | 43.3 | 3.2 | 5.9 | 6293.3 | 6345.7 |
| 2012 | 5.1 | | 4.1 | 6213.7 | 6222.9 |

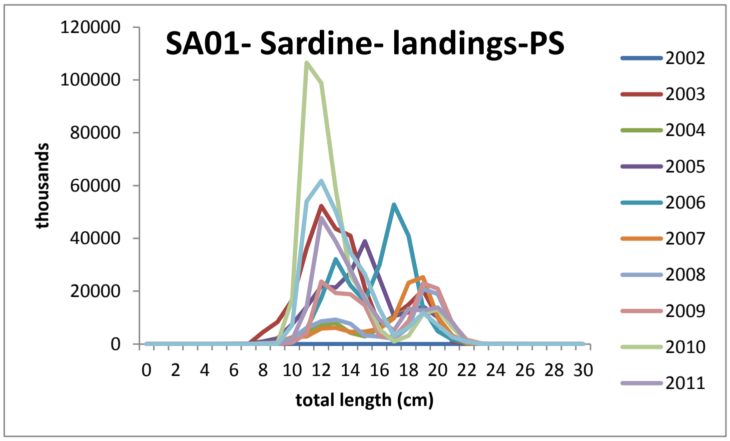



Fig. 6.1.2.3.1.1. Sardine in GSA1. Purse seining landings by length and year (2002- 2012).

Discards

Data on discards are available for the period 2005- 2012 (no data were available for 2007). Discards were very low (≤ 2% of the total catch), with the exception of 2009 (8% of the total catch).

Table 6.1.2.3.1.2. Sardine annual discards (t) in GSA1, by fishing gear (data source: DCR and DCF).

| Year | GTR | OTB | PS | Total |
|---|---|---|---|---|
| 2005 | | 56.5 | | 56.5 |
| 2006 | | | 69.0 | 69.0 |
| 2007 | | | | |
| 2008 | | 5.3 | | 5.3 |
| 2009 | | 27.0 | 496.4 | 523.4 |

| | | | | |
|---|---|---|---|---|
| 2010 | | 18.4 | 5.8 | 24.3 |
| 2011 | 1.8 | | 109.5 | 111.4 |
| 2012 | | 1.4 | | 1.4 |

Fishing effort

Data on purse seining fishing effort in GSA1 are available on a quarterly basis for the period 2009- 2012.

Table 6.1.2.4.1. Purse seining fishing effort (number of vessels and GT·days at sea), by quarter, in GSA1 during 2009-2012.

| NO_VESSELS | | Quarter | | | |
|---|---|---|---|---|---|
| Year | | 1 | 2 | 3 | 4 |
| | 2009 | 115 | 100 | 106 | 113 |
| | 2010 | 101 | 95 | 104 | 105 |
| | 2011 | 92 | 97 | 90 | 102 |
| | 2012 | 92 | 93 | 101 | 100 |
| GT_DAYS_AT_SEA | | Quarter | | | |
| Year | | 1 | 2 | 3 | 4 |
| | 2009 | 36066 | 41309 | 63754 | 80478 |
| | 2010 | 44739 | 53126 | 86784 | 76563 |
| | 2011 | 34384 | 76395 | 73008 | 85614 |
| | 2012 | 49897 | 66688 | 99706 | 64965 |

### 6.1.3. **Scientific surveys**

ECOMED and MEDIAS Acoustic Surveys

Methods

ECOMED and MEDIAS Acoustic Surveys allows for the estimation of abundance index of sardine by GSA (abundance and biomass, by species and area). ECOMED data were available for 2003- 2008 (no data for 2007), and MEDIAS data were available for 2010- 2012. ECOMED and MEDIAS surveys were conducted at different time of the year (in November-December and during summer, respectively), and thus abundance values for the whole data series are not comparable. In addition, data of a number of years as provided to EWG13-19 appear to be not correctly reported (see "data quality" at the end of this section).

Geographical distribution patterns
No analyses were conducted during EWG 13-19.

Trends in abundance and biomass
No analyses were conducted during EWG 13-19.

Trends in abundance by length or age
No analyses were conducted during EWG 13-19.

Trends in growth
No analyses were conducted during EWG13-19.

Trends in maturity
No analyses were conducted during EWG 13-19.

### 6.1.4. **Assessments of historic stock parameters**

Method 1: Separable VPA

Justification
DCF data provided to EWG13-19 included landings, catches and catch at length during2002-2012. Despite these data series were long enough to perform an Extended Survivor Analysis (XSA), the lack of a fishery independent abundance indexes for the same period to be used for model tuning led to the decision of using a separable VPA. The analyses were made using R software and the FLR libraries with scripts provided by JRC.

6.1.4.1.2 Input parameters

The annual size distributions were transformed into ages using L2A using the growth parameters indicated above. M vector was estimated with the method proposed by Gislason et al., 2010.

Table 6.1.4.2.1.1. Separable VPA input parameters: catch numbers at age (thousands); weight at age (kg); and natural mortality at age.

| Age | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 188286.5 | 25890.3 | 85727.3 | 71014.7 | 20460.3 | 31840.9 | 59666.4 | 298463 | 120727.7 | 195821 |
| 1 | 45817.6 | 13601.3 | 76423.4 | 71012.3 | 15198 | 9249.3 | 25141.8 | 32827.3 | 37457.2 | 52726.3 |
| 2 | 22887.4 | 20573.4 | 19704 | 77144.8 | 30760.3 | 8479.9 | 11298.2 | 4288.4 | 17361.2 | 8916.1 |
| 3 | 20555.8 | 14555 | 14603.9 | 13397.8 | 25223 | 21822.4 | 24056.7 | 12199.4 | 13399.5 | 11967.7 |
| 4 | 6638.4 | 6831.7 | 6624.1 | 3214.1 | 6668.6 | 12436.8 | 13719 | 8586.1 | 9108.5 | 4765.8 |
| 5+ | 9450.9 | 6982.3 | 6846.8 | 11400.7 | 12475.5 | 8175 | 9284.4 | 4426 | 6526.5 | 5074.3 |

| Age | Catch Wright in kg | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .017 | .017 | .018 | .020 | .018 | .018 | .020 | .016 | .019 | .017 |
| 1 | .033 | .038 | .034 | .038 | .037 | .034 | .032 | .032 | .033 | .033 |
| 2 | .054 | .053 | .053 | .052 | .055 | .056 | .056 | .056 | .055 | .055 |
| 3 | .067 | .067 | .067 | .067 | .067 | .067 | .067 | .068 | .068 | .067 |
| 4 | .078 | .078 | .078 | .078 | .078 | .078 | .078 | .078 | .078 | .078 |
| 5+ | .082 | .084 | .085 | .086 | .085 | .086 | .086 | .086 | .087 | .086 |

Natural mortality at age

| Age | 0 | 1 | 2 | 3 | 4 | 5+ |
|---|---|---|---|---|---|---|
| M | 0.14 | 0.79 | 0.65 | 0.58 | 0.54 | 0.52 |

6.1.4.1.3 Results

Separable VPA was run setting three different scenarios for terminal F (0.3, 0.5 and 0.7).Results are shown in the following tables and figures.

*Scenario 1: F terminal 0.7*

Table 6.1.4.3.1. Sardine in GSA1. F by age and stock numbers (thousands) ($F_{terminal}$ *0.7*).

F by age

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.241 | 0.120 | 0.222 | 0.250 | 0.158 | 0.142 | 0.299 | 0.267 | 0.357 | 0.320 |
| 1 | 0.302 | 0.151 | 0.279 | 0.314 | 0.198 | 0.178 | 0.375 | 0.335 | 0.448 | 0.401 |
| 2 | 0.315 | 0.158 | 0.291 | 0.328 | 0.207 | 0.186 | 0.391 | 0.349 | 0.468 | 0.419 |
| 3 | 0.573 | 0.287 | 0.529 | 0.596 | 0.377 | 0.338 | 0.711 | 0.635 | 0.850 | 0.762 |
| 4 | 0.527 | 0.263 | 0.486 | 0.547 | 0.346 | 0.310 | 0.653 | 0.583 | 0.781 | 0.700 |
| 5+ | 0.527 | 0.263 | 0.486 | 0.547 | 0.346 | 0.310 | 0.653 | 0.583 | 0.781 | 0.700 |

Stock numbers

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 710990.4 | 1186680.3 | 1099018.5 | 557486.1 | 343211 | 342426 | 498085.4 | 700909.6 | 768044.5 | 1176640.6 |
| 1 | 159358 | 173428 | 326526.1 | 273119.3 | 134702.2 | 90933.9 | 92209.6 | 114658.4 | 166595.4 | 166790.5 |
| 2 | 91948.9 | 75872 | 96039.9 | 159137.8 | 128499 | 71140.3 | 49011.9 | 40826.2 | 52844.4 | 68560.8 |
| 3 | 63968.5 | 48705.2 | 47058 | 52128.7 | 83255.7 | 75849.2 | 42893.5 | 24065.4 | 20904.1 | 24040.2 |
| 4 | 18124.7 | 27524.2 | 27916.7 | 21166.1 | 21929.7 | 43613.9 | 41297.9 | 16079.6 | 9735.4 | 6821.2 |
| 5+ | 2085.5 | 2117.4 | 3351.4 | 1839.5 | 2972.2 | 5856.4 | 9050.4 | 6208.2 | 7900.3 | 3297.8 |

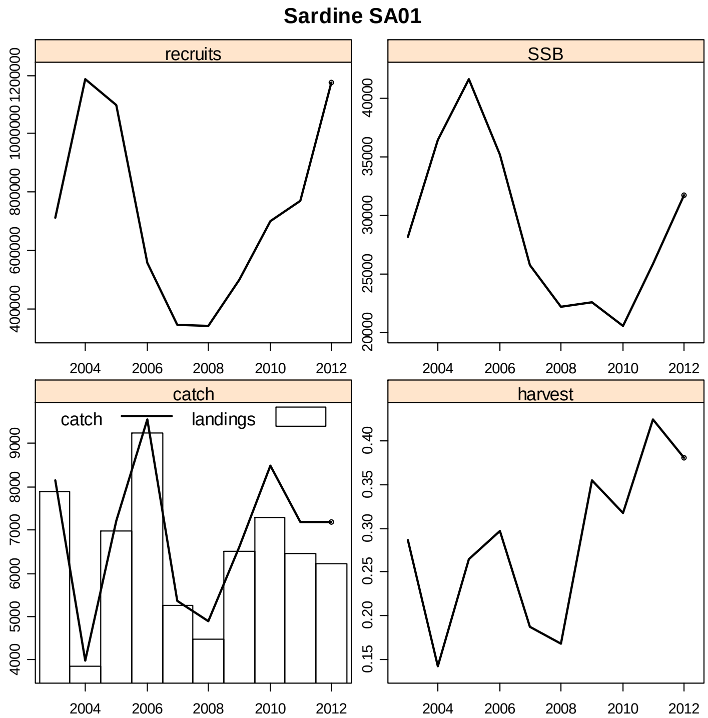



Fig. 6.1.4.3.1. Sardine in GSA1. Main output of the separable VPA *($F_{terminal}$ 0.7)*

*Scenario 1: $F_{terminal}$ 0.5*

Table 6.1.4.3.2. Sardine in GSA1. F by age and stock numbers (thousands) ($F_{terminal}$ *0.5*).

F by age

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.224 | 0.112 | 0.209 | 0.233 | 0.147 | 0.133 | 0.280 | 0.245 | 0.316 | 0.266 |
| 1 | 0.278 | 0.139 | 0.259 | 0.289 | 0.183 | 0.165 | 0.347 | 0.304 | 0.392 | 0.330 |
| 2 | 0.285 | 0.143 | 0.265 | 0.297 | 0.187 | 0.170 | 0.356 | 0.312 | 0.402 | 0.338 |
| 3 | 0..497 | 0..249 | 0..462 | 0.517 | 0.326 | 0.296 | 0.620 | 0.543 | 0.701 | 0.590 |
| 4 | 0.421 | 0.211 | 0.392 | 0.439 | 0.277 | 0.251 | 0.526 | 0.461 | 0.595 | 0.500 |
| 5+ | 0.421 | 0.211 | 0.392 | 0.439 | 0.277 | 0.251 | 0.526 | 0.461 | 0.595 | 0.500 |

Stock numbers

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 753270.2 | 1265031 | 1164093.6 | 587970.7 | 363058.6 | 360750.7 | 531953.8 | 765698.7 | 862051.2 | 1387361.3 |
| 1 | 170689.9 | 186870.6 | 350887.9 | 293288.2 | 144508.9 | 97254.8 | 97987.2 | 124840.3 | 185995.5 | 195013.1 |
| 2 | 101131.5 | 83272 | 104697.5 | 174496.7 | 141436.9 | 77540.4 | 53090.6 | 44624 | 59334.4 | 80933.1 |
| 3 | 71753.7 | 55231 | 52414.3 | 58314.3 | 94174.1 | 85166.2 | 47522.4 | 27017.9 | 23726.5 | 28817.4 |
| 4 | 21639.1 | 33333.8 | 32863 | 25198.9 | 26535.9 | 51868.4 | 48373.1 | 19520.2 | 11978.9 | 8983.7 |
| 5+ | 1927.2 | 1892.6 | 3096.4 | 1704.2 | 2691.3 | 5296.7 | 8457.6 | 5737.7 | 7308.6 | 2971.5 |

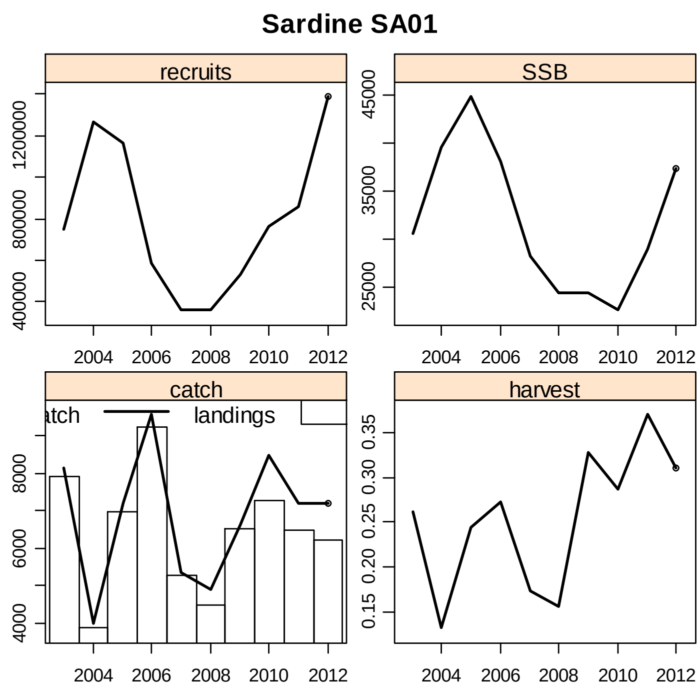



Fig. 6.1.4.3.2. Sardine in GSA1. Main output of the separable VPA *(F $_{terminal}$ 0.5)*

*Scenario 1: F $_{terminal}$ 0.3*

Table 6.1.4.3.3. Sardine in GSA1. F by age and stock numbers (thousands) ($F_{terminal}$ *0.3*).

| | F by age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| age | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| 0 | 0.196 | 0.099 | 0.184 | 0.204 | 0.128 | 0.117 | 0.243 | 0.207 | 0.253 | 0.198 |
| 1 | 0.238 | 0.120 | 0.224 | 0.247 | 0.155 | 0.142 | 0.295 | 0.251 | 0.308 | 0.240 |
| 2 | 0.237 | 0.119 | 0.223 | 0.246 | 0.155 | 0.142 | 0.294 | 0.250 | 0.306 | 0.239 |
| 3 | 0.388 | 0.195 | 0.365 | 0,404 | 0.253 | 0.232 | 0.482 | 0.409 | 0.502 | 0.392 |
| 4 | 0.297 | 0.150 | 0.280 | 0.309 | 0.194 | 0.178 | 0.369 | 0.314 | 0.384 | 0.300 |
| 5+ | 0.297 | 0.150 | 0.280 | 0.309 | 0.194 | 0.178 | 0.369 | 0.314 | 0.384 | 0.300 |
| | Stock numbers | | | | | | | | | |
| age | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| 0 | 843535 | 1430417.3 | 1305789.7 | 657380.5 | 409344.4 | 405385.5 | 608125.1 | 905536.4 | 1059609.7 | 1817374.5 |
| 1 | 194798 | 215234.6 | 402234.3 | 337057.5 | 166411.6 | 111782.7 | 111906.7 | 147981 | 228563.4 | 255250.4 |
| 2 | 120232.1 | 98908.6 | 122969.3 | 207121.3 | 169502.2 | 91751.8 | 62447.3 | 53642 | 74155 | 108223.9 |
| 3 | 87915.1 | 68909.7 | 63750.5 | 71469.9 | 117578 | 105449.6 | 57831.6 | 33798.1 | 30344.3 | 39647.2 |
| 4 | 29004 | 45534.3 | 43265.6 | 33783.4 | 36440.2 | 69658.9 | 63827.5 | 27267.9 | 17133.4 | 14023.8 |
| 5+ | 1667.8 | 1550.9 | 2677.8 | 1478.8 | 2242.8 | 4403.9 | 7429.4 | 4922 | 6273.3 | 2428.6 |

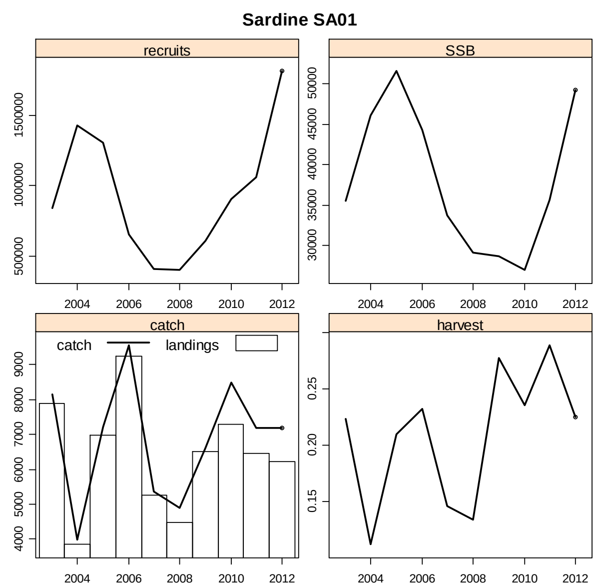



Fig. 6.1.4.3.3. Sardine in GSA 1. Main output of the Separable VPA *(F terminal 0.3)*

These results should be taken as indicative of trend only for SSB and recruitment. According to these results, recruitment did increase since 2009 and SSB has markedly increased in the last two years, 2011 and 2012. The increase in recruitment occurred with a concomitant increase in F.

Age classes 0 to 2 comprise most of the catch. For each scenario, F was estimated for this age range, and for all ages, and these values were used to compute the corresponding exploitation rate to compare with the small pelagics reference point proposed by Patterson (1992). Differences between the exploitation rate for ages 0 to 2 and all ages are explained by the higher M of the younger ages.

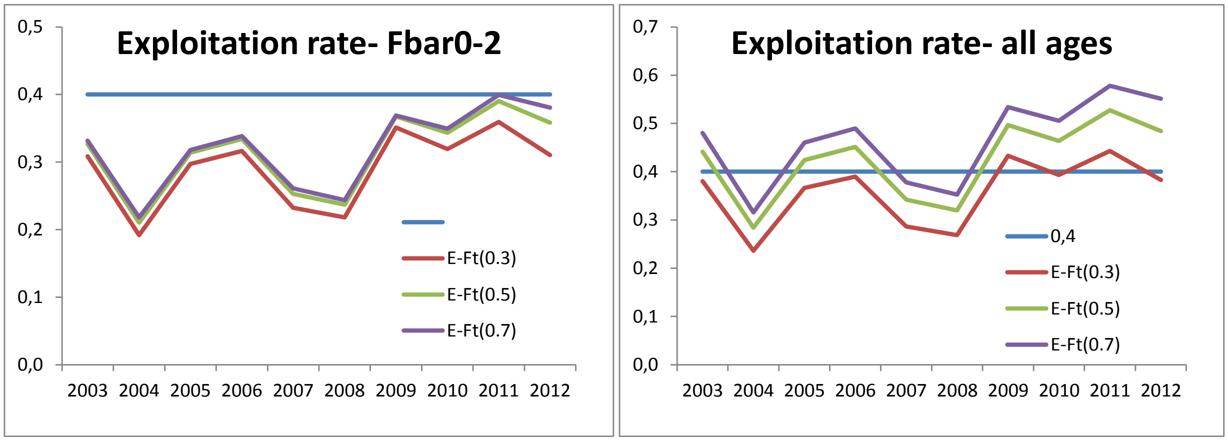



Fig. 6.1.4.3.4. Sardine in GSA 1. Exploitation rate trend for the three scenarios, considering ages 0-2 (left panel) and all ages (right panel), plotted against the reference point E= 0.4.

### 6.1.5. **Long term prediction**

Justification

Input parameters

Results

### 6.1.6. **Short term prediction 2013-2014**

Input parameters

*Recruitment*

### 6.1.7. **Data quality**

Landings

Small differences were observed between the landings data series used in the GFCM 2010 assessment of sardine in GSA 1 and the landings series provided to EWF13-19 (GFCM values higher in 2006 and 2007).

Growth parameters

Sardine growth parameters in GSA 1 should be updated. The growth parameters used in the present analysis were estimated in 2008-2009.

Acoustic surveys

ECOMED 2008 data are different from those presented in the SGMED-10-02 report. In addition, MEDIAS data should be checked as the data appears inconsistent between adjacent years.

Table 6.1.7.1. Sardine abundance in GSA 1 as provided to EWG13-19.

| | ECOMED | ECOMED | ECOMED | ECOMED | ECOMED |
|---|---|---|---|---|---|
| Length | 2003 | 2004 | 2005 | 2006 | 2008 |
| 8 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 |
| 10 | 560 | 2544 | 2066 | 0 | 0 |
| 11 | 3016 | 1154 | 15916 | 388 | 0 |
| 12 | 12357 | 11687 | 219827 | 1320 | 890 |
| 13 | 27511 | 21937 | 616837 | 9279 | 5341 |
| 14 | 90398 | 132023 | 749540 | 13485 | 16813 |
| 15 | 88150 | 101182 | 742386 | 13002 | 16456 |
| 16 | 24976 | 69418 | 374812 | 9105 | 1857 |
| 17 | 5484 | 60724 | 94037 | 13262 | 3785 |
| 18 | 3213 | 72642 | 7439 | 15859 | 734 |
| 19 | 4172 | 32193 | 18820 | 6275 | 13155 |
| 20 | 2898 | 12342 | 20183 | 1730 | 12076 |
| 21 | 585 | 3430 | 8450 | 89 | 3907 |
| 22 | 0 | 262 | 2784 | 0 | 498 |
| 23 | 0 | 0 | 0 | 0 | 56 |

| | MEDIAS | MEDIAS | MEDIAS | MEDIAS | MEDIAS | MEDIAS | MEDIAS |
|---|---|---|---|---|---|---|---|
| SEX | C | F | M | U | F | M | U |
| length | 2010 | 2011 | 2011 | 2011 | 2012 | 2012 | 2012 |
| 8 | 0 | 0 | 0 | 165 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 220 | 0 | 0 | 11241488 |
| 10 | 0 | 0 | 0 | 73 | 0 | 0 | 14824699 |
| 11 | 0 | 0 | 0 | 3644 | 0 | 0 | 16083824 |
| 12 | 13588 | 0 | 1472 | 2832 | 6014656 | 6014656 | 50122137 |
| 13 | 59594 | 285 | 206 | 79 | 30952572 | 30952572 | 14285803 |
| 14 | 42852 | 0 | 0 | 0 | 8744188 | 6558141 | 2186047 |
| 15 | 18175 | 0 | 18 | 0 | 348782 | 348782 | 0 |
| 16 | 871 | 11 | 69 | 0 | 0 | 273280 | 0 |
| 17 | 0 | 102 | 23 | 0 | 251621 | 1006483 | 0 |
| 18 | 0 | 17 | 16 | 0 | 795000 | 1908000 | 0 |
| 19 | 0 | 4 | 0 | 0 | 499577 | 2164835 | 0 |
| 20 | 0 | 0 | 0 | 0 | 2239873 | 1791899 | 0 |
| 21 | 0 | 0 | 0 | 0 | 2514577 | 2514577 | 0 |
| 22 | 0 | 0 | 0 | 0 | 1786208 | 1786208 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### 6.1.8. **Scientific advice**

Short term considerations

State of the stock size

The assessment is only indicative of trend for SSB and R. The separable VPA results suggest an increasing SSB in 2011 and 2012.

State of recruitment

According to separable VPA results, recruitment has increased since 2009.

State of exploitation

Considering E=0.4 as reference point estimated for ages 0-2, it could be concluded that the sardine stock in GSA1 in the most recent years is being exploited sustainably. In any case, in the absence of fishery independent information the results of the present assessment should be considered with caution.

Management recommendations

As the assessment is only indicative of trend for SSB and R, EWG 13-19 was not able to provide short term forecast for this stock.

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## 6.2. **Stock assessment of striped red mullet in GSA 5**

### 6.2.1. **Stock identification and biological features**

Stock Identification

No analyses were conducted during STECF EWG 13-19. Due to a lack of information about the structure of the striped red mullet population in the western Mediterranean, this stock was assumed to be confined within the boundaries of the GSA 5 (see map below, in yellow).The GFCM GSA 5 includes the waters around the Balearic Islands. This Archipelago is constituted by the islands of Mallorca, Menorca, Ibiza and Formentera. From official landings, the striped red mullet *Mullus surmuletus* represents the following percentages by island: 94.8% Mallorca, 2.7% Menorca and 2.5% Ibiza-Formentera. The present assessment has been performed considering exclusively data from Mallorca because: 1) reliability and availability of fishery statistics; and 2) both length and biological (growth, maturity, length-weight) samplings were carried out in this island. Hence, it must be taken into account that the present assessment represents approximately 95% of the total landings of the species in GSA 5.

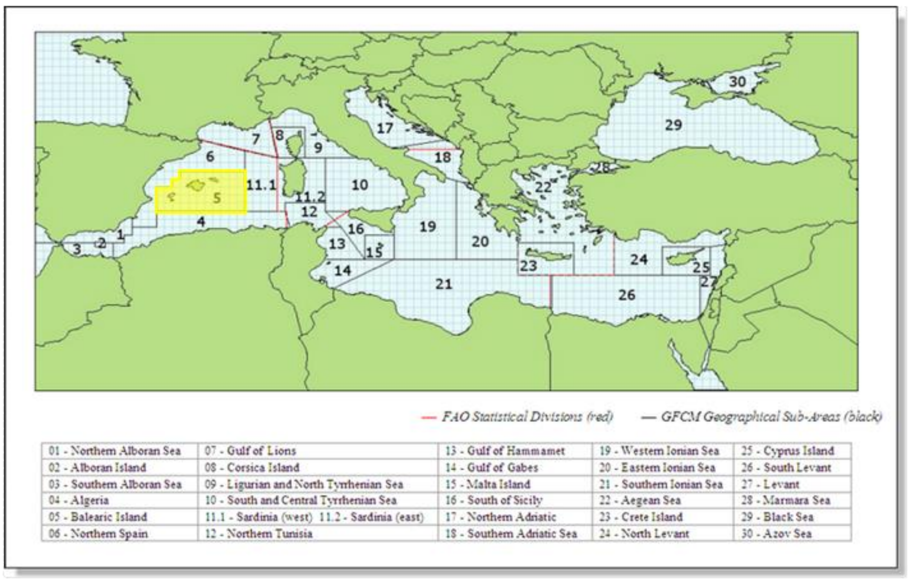



Fig. 6.1.1.1. Geographical location of GSA 5.

Growth

Both growth and length-weight parameters were taken from the Spanish DCF (see tables below).

Maturity

Maturity parameters were also taken from the Spanish DCF (see tables below).

### 6.2.2. **Fisheries**

General description of the fisheries

In the Balearic Islands (GSA 5), commercial trawlers employ up to four different fishing tactics (Palmer et al., 2009), which are associated with the shallow and deep continental shelf, and the upper and middle continental slope

(Guijarro and Massutí 2006; Ordines et al. 2006). Vessels mainly target striped red mullet (*Mullus sumuletus*) and European hake (*Merluccius merluccius*) on the shallow and deep shelf respectively. However, these two target species are caught along with a large variety of fish and cephalopod species. The Norway lobster (*Nephrops norvegicus*) and the red shrimp (*Aristeus antennatus*) are the main target species on the upper and middle slope respectively. The Norway lobster is caught at the same time as a large number of other fish and crustacean species, but the red shrimp fishery is the only Mediterranean fishery that could be considered monospecific.

The species assessed, the striped red mullet, is one of the most important target species in the trawl fishery working on the continental shelf off Mallorca (~30 vessels). A fraction of the small-scale fleet (~100 boats) also directs to this species during the second semester of the year (July-December), using both trammel nets and gillnets.

Management regulations applicable in 2011 and 2012

- Fishing license: number of licenses observed
- Engine power limited to 316 KW or 500 HP: partial compliance (in some cases real HP is at least the double)
- Mesh size in the cod-end (before June 1st 2010: 40 mm diamond: after June 1st 2010: 40 mm square or 50 mm diamond -by derogation-): full compliance
- Time at sea (12 hours per day and 5 days per week): full compliance
- Minimum landing size (EC regulation 1967/2006, 20 mm CL): mostly full compliance

Catches

Landings

Most landings come from trawlers (80%) and a fourth of total landings come from the small-scale fleet (20%) (Fig. 6.2.2.3.1.1A). During 2000 and 2011, the annual landings of striped red mullet in GSA 5 have oscillated between 74 and 117 and 15 and 29 tons in the trawl and small-scale fishery, respectively. However, during the last year assessed (2012) the landings showed their historical minimum, with landings of 58 tons and 9.5 tons for the trawl and small-scale fleets, respectively. The population size structure of red mullet taken by the fishery shows a modal size (16-17 cm) well above the size at first maturity (14 cm) (Fig. 6.2.2.3.1.1B).

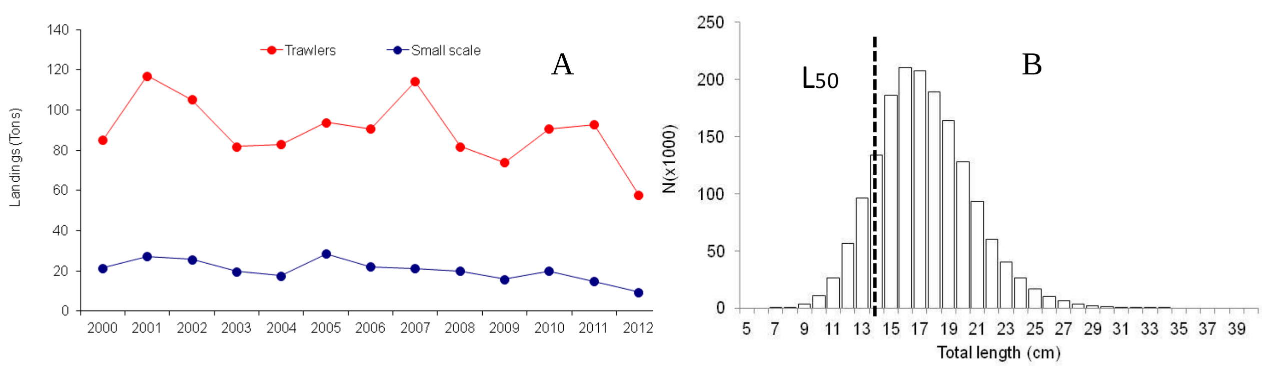



Fig. 6.2.2.3.1.1. *Mullus surmuletus* GSA 5.Annual landings of bottom trawl and small-scale fleets (left) and mean size distribution including $L_{50}$ (right) during 2000-2012.

Discards

The discards of striped red mullet from trawlers are negligible (Carbonell et al., 1997). Considering the small-scale fleet, and according to Mas *et al.* (2004), twelve species were discarded at least in one occasion, and the discarded fraction in this fishery was 1.4% in number. *M. surmuletus* were discarded in 19% of the fishing sets and made up the largest fraction of the discards (42.8% in number).

Fishing effort

The fishing effort (in days) showed a clear decreasing trend with time, from 3500 days in 2001 to 2000 days in 2012; catch-effort data from the time series 2000-2012 showed a highly significant positive relationship (Fig. 6.2.2.3.3.1).

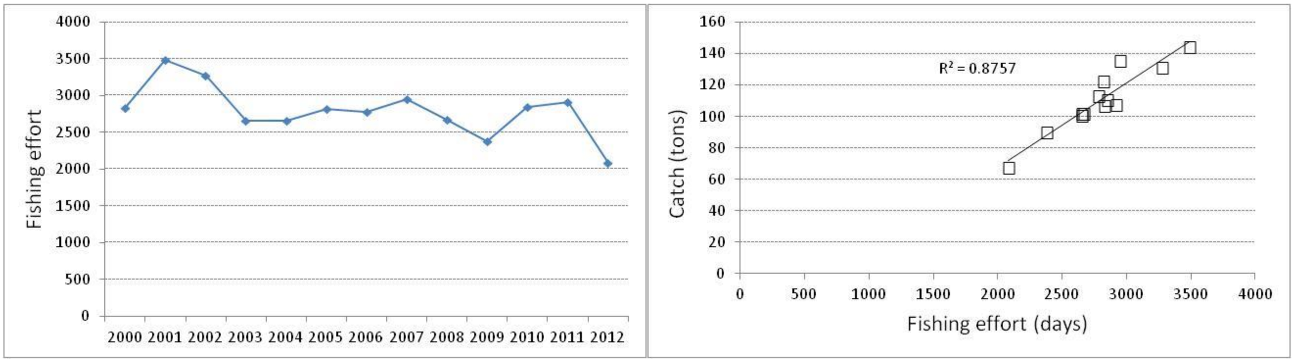



Fig. 6.2.2.3.3.1. *Mullus surmuletus* GSA5.Fishing effort in days (left) and catch-effort relationship (right) during 2000-2012.

### 6.2.3.**Scientific surveys**

BALAR and MEDITS surveys

Methods

In 2007, the GSA 5 was included in the annual MEDITS surveys, although between 2001 and 2006 another series of surveys (BALAR) using the same methodology as MEDITS were carried out in the area.

Geographical distribution patterns

In GSA 5, the striped red mullet is most abundant in the eastern Mallorca and Menorca grounds (>2000 individuals per km$^2$).

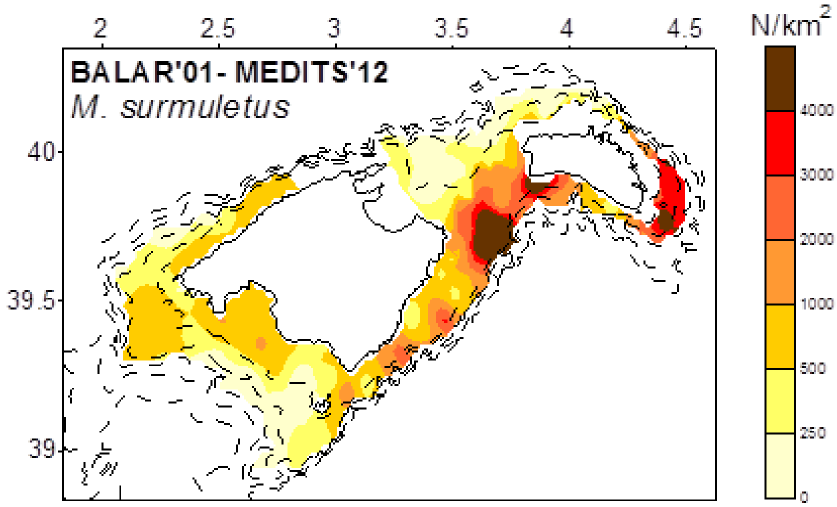



Fig. 6.2.3.1.2.1. *Mullus surmuletus* GSA5: population abundance (n/km$^2$)based on survey data from 2001 to 2012.

Trends in abundance and biomass

Biomass CPUEs from fisheries and MEDITS did not show consistent patterns; whereas fishery CPUEs remained rather constant at about 40 kg/day in most years, survey CPUEs displayed important inter-annual fluctuations. In the last two years, however, fishery CPUEs have decreased from 40 kg in 2010 to about 30 kg/day in 2012.

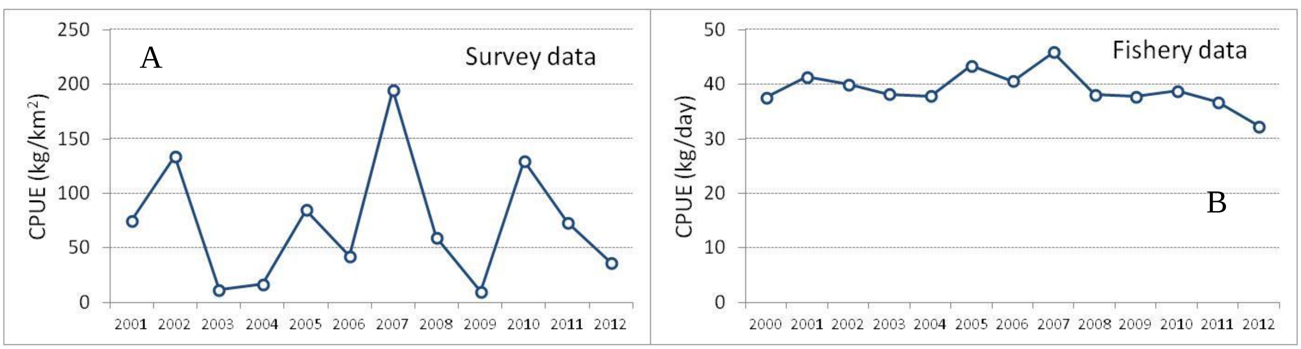



Fig. 6.2.3.1.3.1. *Mullus surmuletus* GSA 5. Abundance indices from the MEDITS surveys during 2001-2012 (A) and the fishery (CPUE) during 2000-2012 (B).

Trends in abundance by length or age

No major changes were found in abundance by length during the time series from 2000 to 2012 (Fig. 6.2.3.1.4.1). The comparison of the size distributions between MEDITS surveys and the fishery fleet also did not show important differences, neither for the modal size nor the size range (Fig. 6.2.3.1.4.2).

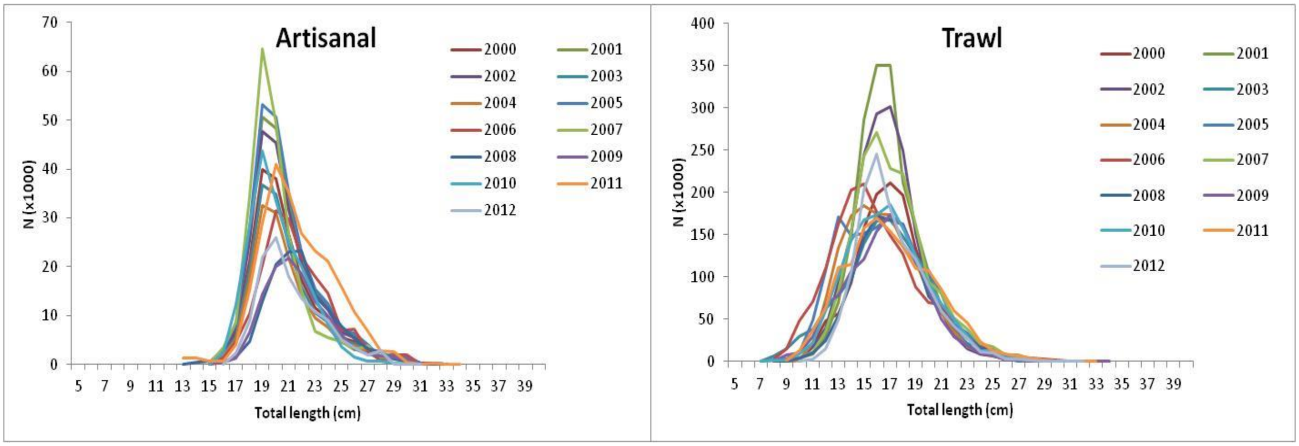



Fig. 6.2.3.1.4.1. *Mullus surmuletus* GSA 5: size-structure of populations from artisanal and bottom trawl fleets during 2000-2012.

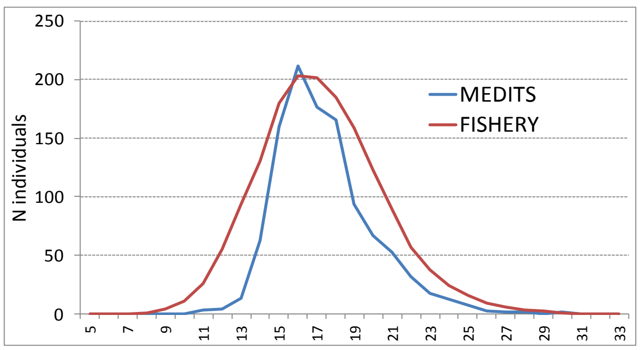



Fig. 6.2.3.1.4.2. *Mullus surmuletus* GSA 5. mean size-structure of populations from MEDITS surveys and the fishery fleet during 2000-2012.

Trends in growth

No analyses were conducted during the STECF EWG 13-19 meeting.

Trends in maturity

No analyses were conducted during the STECF EWG 13-19 meeting.

### 6.2.4. **Assessment of historic stock parameters**

The last assessment of *Mullus surmuletus* from GSA 5 was done during the SGMED-10-02 using XSA tuned with MEDITS survey data. This assessment showed the stock being overexploited, since $F_{ref}$ (0.73) was higher than $F_{0.1}$ (0.28). The total biomass showed a progressive decreasing trend throughout the series, from 610 tons in 2001 to 411 tons in 2009. However, the SSB was rather constant near 225 tons between 2000 and 2007, but it decreased during the last two years to 185 tons in 2008 and 170 tons in 2009. In spite of this, the SB/SSB relationships increased with time from 40% in 2000 to 45% in 2008. Recruitment showed a clear decreasing trend along the series; the number of recruits decreased from 9 to $5 \cdot 10^6$ individualsbetween 2000 and 2008.

Method 1: XSA

Justification

The length of the data series available (13 years, from 2000 to 2012) together with the availability of data from two different fleets (trawl and small-scale vessels) allowed the use of a VPA (XSA) tuned with surveys data and commercial CPUE.

Input parameters

Landings time series: 2000-2012.

Size-distributions were sliced into age-distributions using the L2AGE4 software. Plus group was set at age 5. The number of individuals by age was SOP corrected [SOP = Landings / $\Sigma_a$ (total catch numbers at age *a* x catch weight-at-age *a*)].

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SOP | 0.922 | 0.917 | 0.917 | 0.918 | 0.920 | 0.920 | 0.921 | 0.906 | 0.938 | 0.905 | 0.919 | 0.967 | 0.918 |

| Growth parameters (from DCF 2003-2012) | | |
|---|---|---|
| $L_{inf}$ | K | $t_0$ |
| 40.05 | 0.164 | -1.883 |

| LWR (from DCF 2003-2012) | |
|---|---|
| a | b |
| 0.0084 | 3.118 |

| Natural mortality (from PROBIOM) | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 1 | 0.6 | 0.4 | 0.3 | 0.3 | 0.3 |

| Maturity (from DCF 2003-2012) | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 0.15 | 0.39 | 0.79 | 0.95 | 1 | 1 |

The XSA input parameters are shown in the table below.

| CATCH | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 106.5 | 144.4 | 131 | 101.6 | 100.5 | 122.5 | 112.9 | 135.5 | 101.8 | 89.8 | 110.6 | 107.4 | 67.3 |

| CATNUM | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 245.6 | 293.8 | 324.6 | 344.8 | 421 | 504.5 | 630.5 | 311.6 | 203.4 | 312.2 | 355.2 | 311.9 | 128.2 |
| 1 | 751.2 | 1179.6 | 1065.8 | 613.7 | 659.7 | 645.5 | 644.7 | 955.4 | 621 | 584 | 687.8 | 569 | 497.4 |
| 2 | 424.7 | 502.4 | 464 | 414.6 | 367.4 | 475.7 | 331 | 517.1 | 348.4 | 344 | 418.5 | 367.7 | 242.4 |
| 3 | 90.3 | 120.2 | 93.8 | 101.9 | 90.5 | 137.7 | 130.1 | 127.8 | 124.3 | 92.7 | 125.7 | 129.4 | 70.9 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 24.7 | 38.9 | 28.7 | 26 | 25.7 | 36 | 44.1 | 40 | 36.5 | 23.9 | 28.5 | 35 | 17.9 |
| 5+ | 10.7 | 12.1 | 14.4 | 10 | 9.7 | 14.5 | 20.8 | 19.2 | 14.6 | 9.6 | 9.1 | 17.9 | 7.2 |

| CATWT | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.029 | 0.031 | 0.031 | 0.026 | 0.030 | 0.028 | 0.027 | 0.031 | 0.031 | 0.028 | 0.029 | 0.028 | 0.033 |
| 1 | 0.059 | 0.058 | 0.059 | 0.059 | 0.058 | 0.059 | 0.056 | 0.058 | 0.059 | 0.059 | 0.059 | 0.058 | 0.057 |
| 2 | 0.099 | 0.099 | 0.098 | 0.100 | 0.099 | 0.101 | 0.102 | 0.099 | 0.100 | 0.099 | 0.100 | 0.101 | 0.100 |
| 3 | 0.152 | 0.153 | 0.152 | 0.153 | 0.151 | 0.153 | 0.154 | 0.152 | 0.152 | 0.152 | 0.151 | 0.152 | 0.152 |
| 4 | 0.209 | 0.210 | 0.210 | 0.208 | 0.209 | 0.208 | 0.209 | 0.209 | 0.209 | 0.207 | 0.208 | 0.210 | 0.208 |
| 5+ | 0.290 | 0.298 | 0.288 | 0.300 | 0.298 | 0.298 | 0.307 | 0.285 | 0.287 | 0.309 | 0.297 | 0.287 | 0.280 |

XSA tuning were performed using abundance indices from MEDITS surveys (n/km$^2$) developed during 2001–2012 around the Balearic Islands and CPUEs of daily landings from the trawling fleet of one port of Mallorca (Santanyí). It was used this port, situated in the south-east part of the island, because its fleet works basically on the continental shelf, and thus it can be considered that their CPUEs are a good indicator of the species abundance (i.e. *Mullus surmuletus* inhabits mainly the shelf). Length-distributions from Santanyi were also available from on-board sampling. The landings of this port represented 12–30% of the total catch of Mallorca during the assessed period. Abundance indices from surveys were calculated considering different bathymetric strata. For tuning VPA, the values obtained in the stratum corresponding to the continental shelf (<100 m depth) were used because they best reflected the evolution of the commercial landings.

Given that the landings were composed mainly of individuals between 0 and 2 years, these ages were selected as the $F_{bar}$ (Fig.6.2.4.1.2.1).

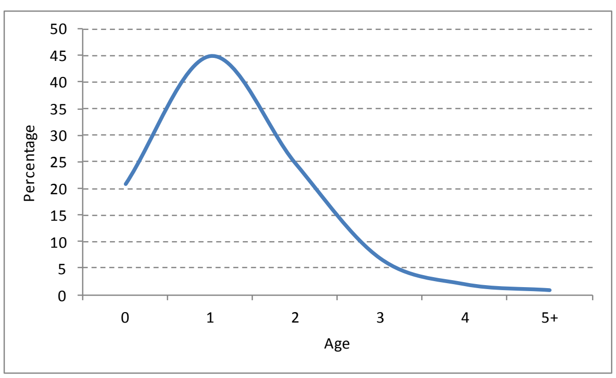



Fig.6.2.4.1.2.1.*Mullus surmuletus* GSA05: composition (percentage) of landings by age.

Different sensitivity analyses were performed before running the final XSA. The first sensitivity analysis tested different shrinkage weights (0.5, 1.0, 1.5, 2.0 and 2.5); since the results did not show important differences (Fig.6.2.4.1.2.2A), the middle option (1.5) was chosen. The second sensitivity analysis tested different shrinkage ages (1, 2 and 3) using shrinkage weight of 1.5.Again, as the results did not show important differences (Fig.6.2.4.1.2.2B), the middle option (2 ages shrinkage) was selected.

Based on these simulation analyses, the following inputs were selected to run the final XSA:

| fse | rage | qage | shk.n | shk.f | shk.yrs | shk.ages |
|---|---|---|---|---|---|---|
| 1.5 | -1 | 3 | TRUE | TRUE | 3 | 2 |

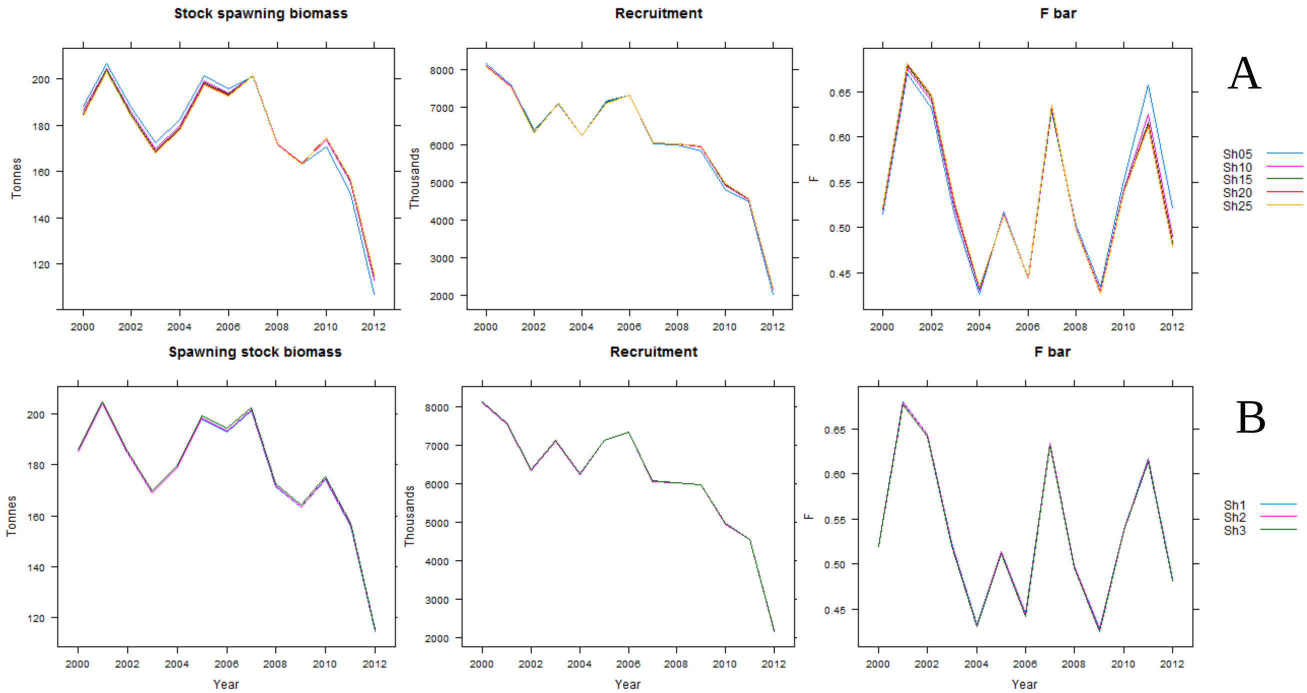



Fig.6.2.4.1.2.2. *Mullus surmuletus* GSA 5.Sensitivity analyses using different shrinkage weights (A) and shrinkage ages (B). Shrinkage weights modeled were 0.5, 1.0, 1.5, 2.0 and 2.5 (Sh05 to Sh25) and shrinkage ages were 1, 2 and 3 (Sh1, Sh2 and Sh3).

Results

Residuals from both tuning fleets (MEDITS, Santanyi) per age and year were relatively low, ranging from 3 to -3, and did not show any trend with time (Fig. 6.2.4.1.3.1). Consequently, the XSA was performed considering all ages and years available from both tuning fleets.

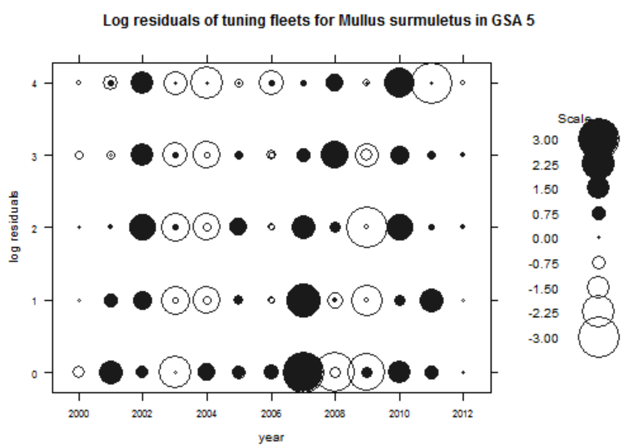



Fig. 6.2.4.1.3.1. *Mullus surmuletus* GSA 5.Log residuals for the tuning fleets.

Results of XSA (Fig. 6.2.4.1.3.2) showed a marked decrease in recruitment, from $8.1 \cdot 10^6$ individuals in 2000 to $2.2 \cdot 10^6$ individuals in 2012. The SSB also decreased markedly from about 200 tons in 2007 to 116 tons in 2012. The fishing mortality ranged between 0.43 and 0.68 through the time series.

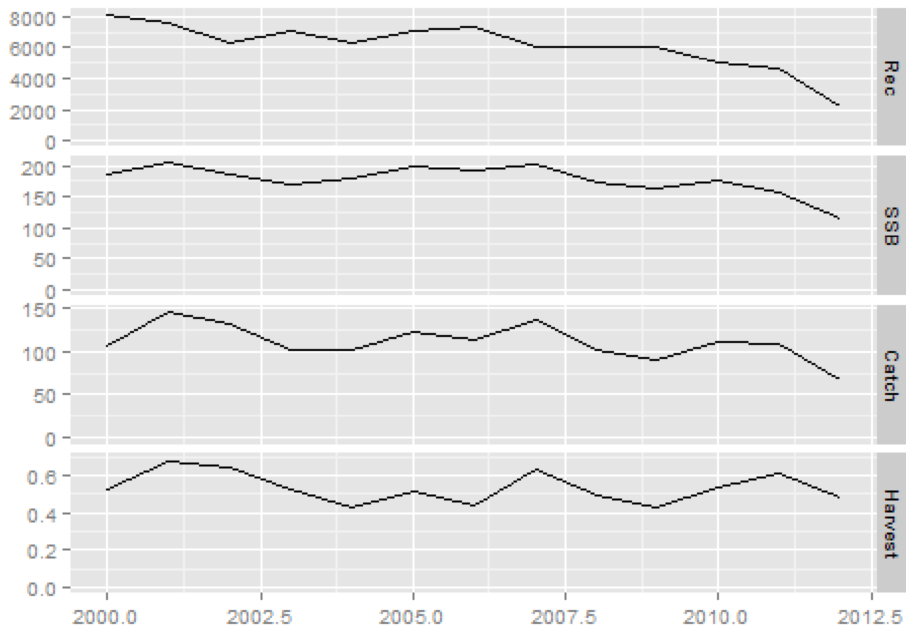



Fig. 6.2.4.1.3.2. *Mullus surmuletus* GSA 5.XSA results.

The XSA diagnostics are reported below:

CPUE data from indices

Catch data for 13 years 2000 to 2012. Ages 0 to 5.

| | fleet | first age | last age | first year | last year | alpha | beta |
|---|---|---|---|---|---|---|---|
| 1 | Santanyi 2000-12 | 0 | 4 | 2000 | 2012 | <NA> | <NA> |
| 2 | Surveys (N/km2) | 0 | 4 | 2001 | 2011 | <NA> | <NA> |

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages >   3

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 3 years or the 2 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.5

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

| age | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| all | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Fishing mortalities

| age | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.076 | 0.108 | 0.113 | 0.139 | 0.080 | 0.053 | 0.081 | 0.115 | 0.115 | 0.091 |
| 1 | 0.435 | 0.412 | 0.491 | 0.419 | 0.686 | 0.481 | 0.413 | 0.544 | 0.607 | 0.527 |
| 2 | 1.056 | 0.775 | 0.931 | 0.770 | 1.129 | 0.951 | 0.785 | 0.952 | 1.110 | 0.814 |
| 3 | 1.110 | 0.873 | 0.974 | 0.910 | 0.981 | 1.342 | 0.864 | 0.989 | 1.325 | 0.751 |
| 4 | 1.356 | 1.186 | 1.379 | 1.249 | 0.930 | 1.095 | 1.230 | 0.864 | 1.103 | 0.672 |
| 5 | 1.356 | 1.186 | 1.379 | 1.249 | 0.930 | 1.095 | 1.230 | 0.864 | 1.103 | 0.672 |

XSA population number (Thousand)

| year | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 2003 | 7121 | 2156 | 713 | 162 | 37 | 14 |
| 2004 | 6254 | 2428 | 766 | 166 | 40 | 14 |
| 2005 | 7135 | 2066 | 882 | 237 | 51 | 20 |
| 2006 | 7357 | 2343 | 694 | 233 | 66 | 30 |
| 2007 | 6065 | 2354 | 846 | 215 | 70 | 33 |
| 2008 | 6044 | 2060 | 651 | 183 | 60 | 23 |
| 2009 | 5995 | 2108 | 699 | 168 | 36 | 14 |
| 2010 | 4975 | 2034 | 765 | 214 | 53 | 16 |
| 2011 | 4585 | 1632 | 648 | 198 | 59 | 29 |
| 2012 | 2238 | 1504 | 488 | 143 | 39 | 15 |

Estimated population abundance at 1st Jan 2013

| year | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 2013 | 49 | 752 | 487 | 145 | 50 | 15 |

Fleet: Santanyi 2000-12

Log catchability residuals.

| age \ year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | -0.473 | -0.364 | -0.113 | -0.006 | 0.248 | 0.460 | 0.636 | 0.046 | -0.414 | 0.427 | -0.439 | -0.022 | 0.013 |
| 1 | -0.016 | 0.199 | 0.219 | -0.108 | -0.283 | -0.023 | -0.159 | 0.361 | 0.079 | -0.063 | -0.271 | 0.075 | -0.010 |
| 2 | 0.000 | 0.060 | -0.010 | 0.118 | -0.300 | -0.154 | -0.218 | 0.195 | 0.226 | -0.101 | 0.130 | 0.004 | 0.050 |
| 3 | -0.296 | -0.003 | -0.157 | 0.115 | -0.144 | -0.104 | -0.153 | 0.257 | 0.315 | -0.481 | 0.304 | 0.291 | 0.057 |
| 4 | -0.080 | 0.111 | -0.104 | 0.016 | 0.009 | 0.025 | 0.105 | 0.163 | -0.125 | -0.226 | 0.080 | 0.017 | -0.048 |

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Mean_Logq | -10.0094 | -8.2181 | -7.8373 | -7.9109 | -7.9109 |
| S.E_Logq | 0.2243 | 0.2243 | 0.2243 | 0.2243 | 0.2243 |

Fleet: Surveys (N/km2)

Log catchability residuals.

| age \ year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.077 | 0.502 | -1.553 | 0.777 | -0.526 | -0.126 | 2.048 | -1.971 | -1.827 | 1.026 | 0.574 |
| 1 | 0.579 | 0.843 | -1.377 | -1.275 | 0.359 | -0.180 | 1.653 | -0.663 | -1.486 | 0.429 | 1.117 |
| 2 | 0.072 | 1.199 | -1.391 | -1.298 | 0.724 | -0.141 | 1.071 | 0.425 | -2.031 | 1.260 | 0.110 |
| 3 | -0.242 | 1.051 | -1.144 | -1.322 | 0.263 | -0.316 | 0.579 | 1.292 | -1.067 | 0.852 | 0.054 |
| 4 | -0.587 | 1.061 | -1.078 | -1.568 | -0.291 | -1.188 | -0.039 | 0.729 | 0.000 | 1.418 | -2.054 |

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

| | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| Mean_Logq | -4.3136 | -1.1507 | -1.0117 | -0.950 | -0.950 |
| S.E_Logq | 1.0810 | 1.0810 | 1.0810 | 1.081 | 1.081 |

Terminal year survivor and F summaries:

Age 0 Year class =2012

| source | scaledWts | survivors | yrcls |
|---|---|---|---|
| Santanyi 2000-12 | 0.935 | 762 | 2012 |

```
fshk               0.065      623  2012

Age 1 Year class =2011

source
              scaledWts survivors yrcls
Santanyi 2000-12     0.937       482  2011
fshk               0.063      474  2011

Age 2 Year class =2010

source
              scaledWts survivors yrcls
Santanyi 2000-12     0.917       152  2010
fshk               0.083      111  2010

Age 3 Year class =2009

source
              scaledWts survivors yrcls
Santanyi 2000-12     0.922        53  2009
fshk               0.078       29  2009

Age 4 Year class =2008

source
              scaledWts survivors yrcls
Santanyi 2000-12     0.927        14  2008
fshk               0.073       12  2008
```

*Mullus surmuletus* GSA 5.The XSA stock summary results are reported in the table below.

| Year | Population numbers | Population weight | Recruitment numbers | SSB | $F_{0-2}$ |
|---|---|---|---|---|---|
| 2000 | 11458.206 | 487.346 | 8115.88 | 185.09 | 0.520 |
| 2001 | 11451.163 | 521.750 | 7562.315 | 203.94 | 0.678 |
| 2002 | 9943.688 | 463.185 | 6352.529 | 184.74 | 0.643 |
| 2003 | 10203.738 | 420.414 | 7120.924 | 169.22 | 0.522 |
| 2004 | 9667.873 | 441.931 | 6254.091 | 179.38 | 0.432 |
| 2005 | 10391.521 | 463.645 | 7135.326 | 198.95 | 0.512 |

| | | | | | |
|---|---|---|---|---|---|
| 2006 | 10723.597 | 459.636 | 7356.957 | 194.09 | 0.443 |
| 2007 | 9582.738 | 464.844 | 6065.275 | 202.51 | 0.632 |
| 2008 | 9020.913 | 420.999 | 6043.889 | 172.55 | 0.495 |
| 2009 | 9019.034 | 398.611 | 5994.715 | 164.27 | 0.426 |
| 2010 | 8056.607 | 388.874 | 4974.623 | 175.36 | 0.537 |
| 2011 | 7150.830 | 339.331 | 4584.592 | 157.23 | 0.611 |
| 2012 | 4426.816 | 242.526 | 2237.726 | 116.14 | 0.477 |

Finally, retrospective analyses showed consistent results, with the only exceptions of the last years of the series beginning in 2009 (blue line in Fig. 6.2.4.1.3.3).

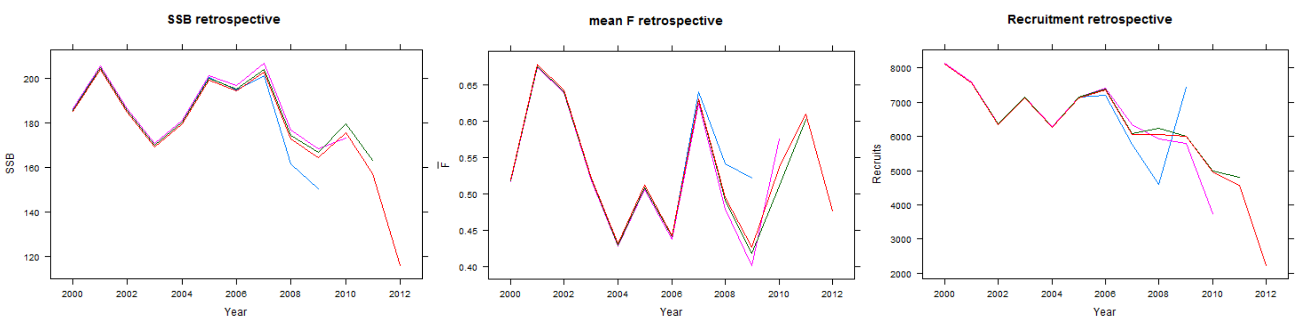



Fig. 6.2.4.1.3.3. *Mullus surmuletus* GSA 5.XSA retrospective analyses.

Yield per recruit analysis was used to calculate the reference point $F_{0.1.}$ Reference F was estimated using the R script provided by STECF EWG 13-19, which used the default assumptions agreed in the meeting, e.g., weights are means of the last 3 years and future recruitment are obtained as the geometric mean of the last 3 years.

The yield per recruit analyses of *M. surmuletus* in GSA 5 is shown in Fig. 6.2.4.1.3.4.

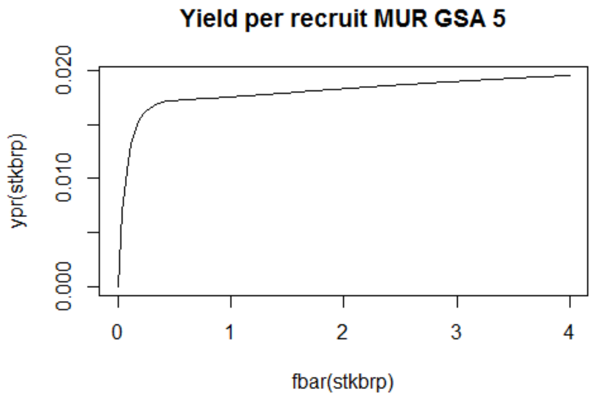



Fig. 6.2.4.1.3.4. *Mullus surmuletus* GSA05.Yield per recruit.

The reference point $F_{0.1}$ and the estimated current fishing mortality ($F_{curr}$) were:

| | |
|---|---|
| $F_{0.1}$ | 0.18 |
| $F_{curr}$ (2011-2013; ages 0-2) | 0.54 |

## 6.2.5. **Short term prediction 2013-2015**

Method and justification

A deterministic short term prediction for the period 2013 to 2015 was performed using the FLR routines provided by JRC, which takes into account the catch and landings in numbers and weight and the discards.

Input parameters

The same input parameters used in the XSA analysis shown above were used.

Different scenarios of constant harvest strategy with $F_{bar}$ calculated as the average of ages 0 to 2 and F status quo ($F_{stq}$ = 0.54) were performed.

Recruitment (class 0) has been estimated from the population results from the geometric mean of the last three years 2010-2012 (3650 thousands individuals) estimated with FLR.

Results

A short term projection (Table 6.2.5.3.1), assuming an $F_{stq}$ of 0.54 in 2012 and a recruitment of 3709 thousands individuals show that:

- Fishing at the $F_{stq}$ (0.54) generates a decrease of the catch of 9% from 2012 to 2014 along with an increase of the spawning stock biomass of 0.6% from 2014 to 2015.

- Fishing at $F_{0.1}$ (0.18) generates a decrease of the catch of 63% from 2012 to 2014 and an increase of the spawning stock biomass of 37% from 2014 to 2015.

Table 6.2.5.3.1. Short term forecast in different F scenarios computed for striped red mullet in GSA 5. Basis: F(2013) = mean($F_{bar}$0-2 2010-2012)= 0.54; R(2012) = geometric mean of the recruitment of the last 3years; R = 3709 (thousands); SSB(2012) = 116 t, Catch (2012)= 67 t.

| **Rationale** | **Ffactor** | **fbar** | **Catch 2014** | **Catch 2015** | **SSB 2015** | **Change SSB 2014-2015 (%)** | **Change Catch 2012-2014 (%)** |
|---|---|---|---|---|---|---|---|
| zero catch | 0.000 | 0.000 | 0.000 | 0.000 | 156.175 | 63.168 | -100.000 |
| High long-term yield (F0.1) | 0.335 | 0.181 | 25.064 | 34.714 | 130.843 | 36.702 | -62.758 |
| Status quo | 1.000 | 0.539 | 61.214 | 62.496 | 96.281 | 0.592 | -9.043 |
| Different scenarios | 0.100 | 0.054 | 8.075 | 12.711 | 147.917 | 54.540 | -88.002 |
| | 0.200 | 0.108 | 15.620 | 23.257 | 140.281 | 46.562 | -76.790 |
| | 0.300 | 0.162 | 22.677 | 31.997 | 133.215 | 39.180 | -66.304 |
| | 0.400 | 0.216 | 29.284 | 39.229 | 126.673 | 32.345 | -56.488 |
| | 0.500 | 0.269 | 35.474 | 45.206 | 120.612 | 26.013 | -47.289 |
| | 0.600 | 0.323 | 41.281 | 50.136 | 114.995 | 20.143 | -38.661 |
| | 0.700 | 0.377 | 46.732 | 54.196 | 109.784 | 14.699 | -30.561 |
| | 0.800 | 0.431 | 51.856 | 57.531 | 104.947 | 9.646 | -22.948 |
| | 0.900 | 0.485 | 56.675 | 60.263 | 100.455 | 4.953 | -15.787 |
| | 1.000 | 0.539 | 61.214 | 62.496 | 96.281 | 0.592 | -9.043 |
| | 1.100 | 0.593 | 65.493 | 64.315 | 92.398 | -3.465 | -2.686 |
| | 1.200 | 0.647 | 69.530 | 65.791 | 88.785 | -7.240 | 3.313 |
| | 1.300 | 0.700 | 73.343 | 66.983 | 85.420 | -10.756 | 8.980 |
| | 1.400 | 0.754 | 76.949 | 67.942 | 82.284 | -14.032 | 14.338 |
| | 1.500 | 0.808 | 80.363 | 68.708 | 79.358 | -17.088 | 19.410 |
| | 1.600 | 0.862 | 83.597 | 69.317 | 76.628 | -19.940 | 24.215 |
| | 1.700 | 0.916 | 86.665 | 69.797 | 74.078 | -22.605 | 28.774 |
| | 1.800 | 0.970 | 89.578 | 70.171 | 71.695 | -25.095 | 33.102 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1.900 | 1.024 | 92.346 | 70.460 | 69.465 | -27.425 | 37.216 |
| | 2.000 | 1.078 | 94.981 | 70.680 | 67.377 | -29.606 | 41.131 |

### 6.2.6. **Medium term prediction**

Method and justification

Following the agreement reached during the discussions of the EWG-13-19, medium term prediction would only be performed if there is a reliable fit of a stock-recruitment relationship. Since the fit for the striped red mullet from GSA 5 was not considered reliable (Fig. 6.2.6.1.1), medium term predictions were not carried out.

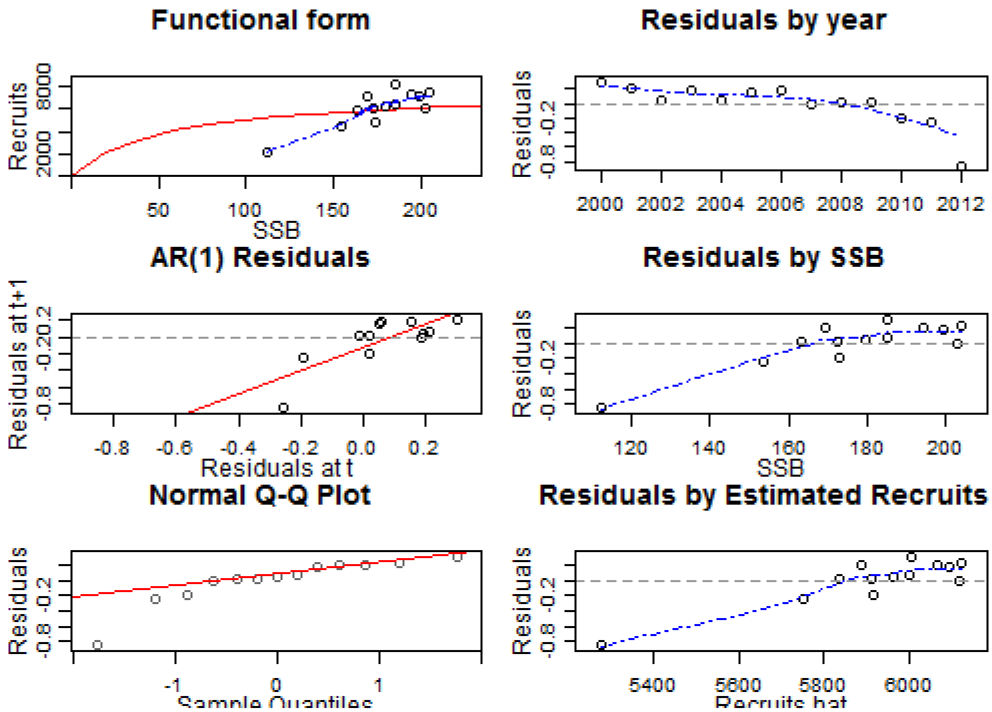



Fig. 6.2.6.1.1. Beverton and Holt stock recruitment relationship for striped red mullet in GSA 5 (steepness= 0.5).

### 6.2.7. **Data quality**

Data from DCF 2013 were used. The data available are of sufficient quality to perform XSA. The data submitted to the EWG 13-19 are in general of good quality. Reported discards are negligible and this is reasonable, considering the important commercial value of the species in GSA 5.

### 6.2.8. **Scientific advice**

Short term considerations

State of the stock size

The stock size has showed a marked decreasing trend along the historical time series, from $11.5 \cdot 10^6$ individuals in 2000 to about $4.4 \cdot 10^6$ individuals in 2012. The SSB has also decreased markedly from 202 t in 2007 to 116 t in 2012.

State of recruitment

Recruitment also showed a marked decreasing trend throughout the time series, from $8.1 \cdot 10^6$ individuals in 2000 to $2.2 \cdot 10^6$ individuals in 2012.

State of exploitation

The $F_{stq}$ (0.54) is larger than $F_{0.1}$ (0.18), which indicates that *Mullus surmuletus* from GSA 5 is fished unsustainably.

Management recommendations

STECF EWG 13-19 suggests that catch in 2014 should not exceed 25 t, corresponding to $F_{0.1}$=0.18.

EWG 13-19 recommends the relevant fleets' effort and/or catches to be reduced until fishing mortality is below or at the proposed $F_{0.1}$level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations.

## 6.3. **Stock assessment of red mullet in GSA 5**

### 6.3.1. **Stock identification and biological features**

GSA 5 (Figure 6.3.1.1) has been pointed as an individualized area for assessment and management purposes in the western Mediterranean (Quetglas *et al.*, 2012) due to its main specificities. These include: 1) Geomorphologic ally, the Balearic Islands (GSA 5) are clearly separated from the Iberian Peninsula (GSA 6) by depths between 800 and 2000 m, which would constitute a natural barrier to the interchange of adult stages of demersal resources; 2) Physical geographically-related characteristics, such as the lack of terrigenous inputs from rivers and submarine canyons in GSA 5 compared to GSA 6, give rise to differences in the structure and composition of the trawling grounds and hence in the benthic assemblages; 3) Owing to these physical differences, the faunistic assemblages exploited by trawl fisheries differ between GSA 5 and GSA 6, resulting in large differences in the relative importance of the main commercial species; 4) There are no important or general interactions between the demersal fishing fleets in the two areas, with only local cases of vessels targeting red shrimp in GSA 5 but landing their catches in GSA 6; 5) Trawl fishing exploitation in GSA 5 is much lower than in GSA 6; the density of trawlers around the Balearic Islands is one order of magnitude lower than in adjacent waters; and 6) Due to this lower fishing exploitation, the demersal resources and ecosystems in GSA 5 are in a healthier state than in GSA 6, which is reflected in the population structure of the main commercial species (populations from the Balearic Islands have larger modal sizes and lower percentages of small-sized individuals), and in the higher abundance and diversity of elasmobranch assemblages.

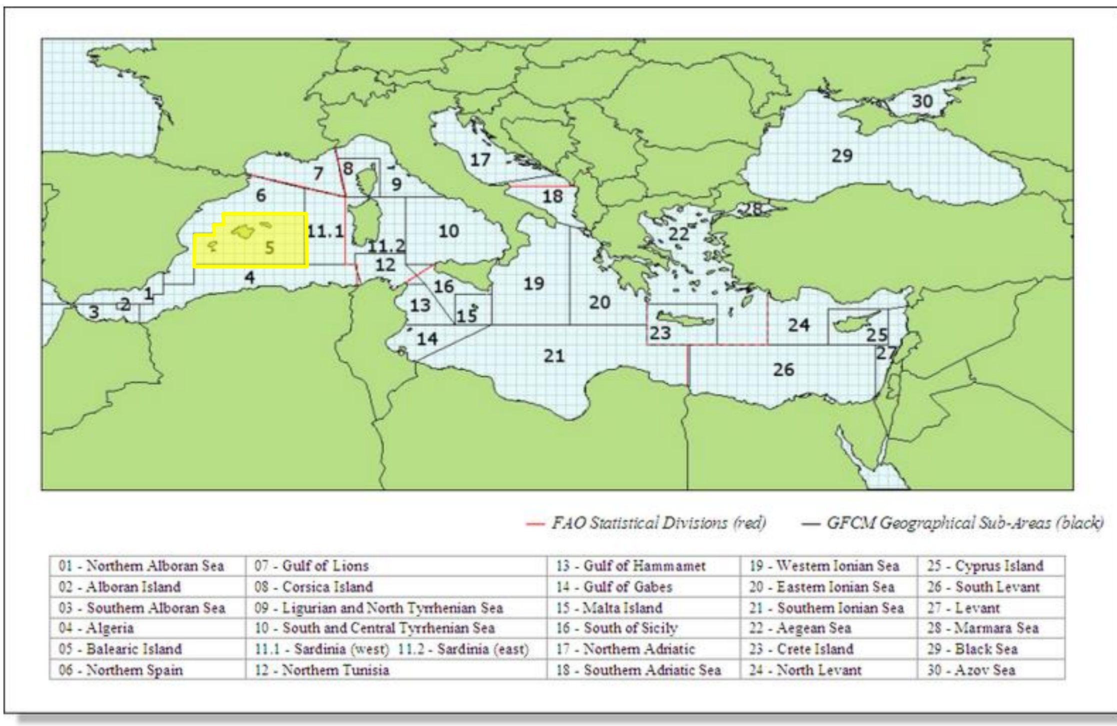



Figure 6.3.1.1. Geographical localization of GSA 5.

Growth

The growth parameters used during the EWG 13-19 were those agreed during the SGMED-08-03. During that meeting, two sets of parameters were agreed (Table 6.3.1.2.1), one related to fast and one to slow growth. Although this, the slicing is not very different for the first age classes (Table 6.3.1.2.1),trial runs with both set of parameters were carried out, considering ages 0-5 and 0-3+ for the fast growth and ages 0-5+ for the slow growth. Results from slow growth trial were considered more realistic and robust, so the final assessment used the slow growth parameters.

Table 6.3.1.2.1. *Mullus barbatus* GSA5: ‘Upper’ and ‘lower’ growth parameter estimates agreed during the SGMED-08-03. The table also shows the length (in cm) limits for the age slicing for each model.

| SGMED-08-03 | Fast | Slow |
|---|---|---|
| Origin | Length | Otoliths |
| $L_{inf}$ (cm) | 34.5 | 26.0 |
| k | 0.34 | 0.41 |
| $t_0$ | -0.143 | -0.4 |
| Age slicing | | |
| 1 | 11.1 | 11.4 |
| 2 | 17.9 | 16.3 |
| 3 | 22.6 | 19.5 |
| 4 | 26.1 | 21.7 |
| 5 | 28.5 | 23.2 |

The length data from the data call have been converted to age using the L2Age program (i.e. knife edge slicing).

Maturity

The maturity ogive was obtained from stock-related sampling carried out in the Spanish DCF.

| Age | 0 | 1 | 2 | 3 | 4 | 5+ |
|---|---|---|---|---|---|---|
| Prop. matures | 0.02 | 0.94 | 1.00 | 1.00 | 1.00 | 1.00 |

### 6.3.2. **Fisheries**

General description of the fisheries

In the Balearic Islands (western Mediterranean), commercial trawlers develop up to four different fishing tactics, which are associated with the shallow shelf, deep shelf, upper slope and middle slope (Guijarro and Massutí 2006; Ordines et al. 2006), mainly targeted to: (i) *Spicara smaris*, *Mullus surmuletus*, *Octopus vulgaris* and a mixed fish category on the shallow shelf (50-80 m); (ii) *Merluccius merluccius*, *Mullus* spp., *Zeus faber* and a mixed fish category on the deep shelf (80-250 m); (iii) *Nephrops norvegicus*, but with an important by-catch of big *M. merluccius*, *Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the upper slope (350-600 m) and (iv) *Aristeus antennatus* on the middle slope (600-750 m). The red mullet, *M. barbatus*, is a by-catch species in the shallow and deep shelf.

Management regulations

- Fishing license: number of licenses observed
- Engine power limited to 316 KW or 500 HP: not fully observed.
- Mesh size in the cod-end (before Jun 1st 2010: 40 mm diamond: after Jun 1st 2010: 40 mm square or 50 mm diamond -by derogation-): fully observed.
- Time at sea (12 hours per day and 5 days per week): fully observed.
- Minimum landing size (EC regulation 1967/2006, 11 cm TL): mostly fully observed.

Catches

Landings

Red mullet landings came mostly exclusively from bottom trawlers (OTB) in GSA 5 as they represent 98% approximately. The rest of the landings come from trammel nets (GTR). The following table shows the annual landings in tones from OTB between 2000 and 2012 (2000-2001: Spanish Institute of Oceanography IEO data; 2002-2012: DCF data).

| | | | | | | |
|---|---|---|---|---|---|---|
| 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
| 27.8 | 22.3 | 14.4 | 10.5 | 20.3 | 12.7 | 11.3 |
| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | |
| 13.7 | 17.9 | 11.9 | 15.7 | 25.5 | 15.9 | |

Historical data landings showed important oscillations between 10 and 30 t, without a clear trend (Figure 6.3.2.3.1.1).

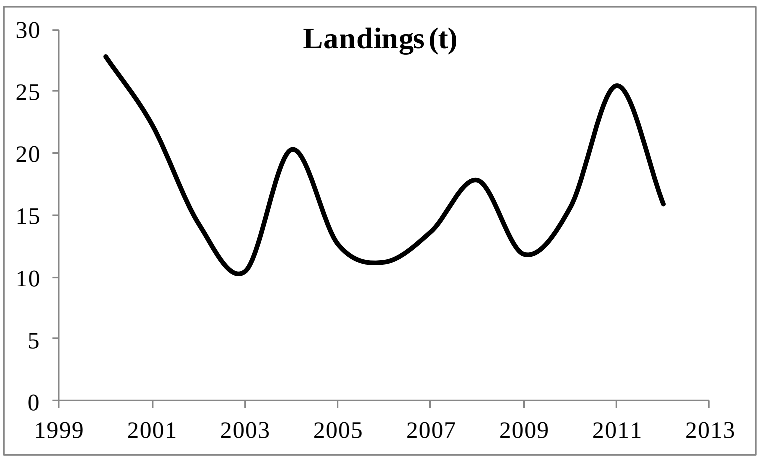



Figure 6.3.2.3.1.1. *Mullus barbatus* GSA 5. Historical data landings.

Discards

Discard of red mullet in GSA 5 can be considered as negligible (the mean values 2002-2012 represent less than 1% in OTB and less than 0.5% in GTR, in weight).

Fishing effort

Fishing effort available from the Data Call included years 2009-2012. Table 6.3.2.3.3.1. summarizes the effort data for the gear OTB according to the DCF Data Call in terms of nominal effort and GT days at sea. Number of boats cannot be calculated from the information available in the Data Call as it is disaggregated by quarter and my métier (OTB_DEF, OTB_MDD and OTB_DWS) and thus it cannot be cumulated, as the same boat may be included in different quarters and/or in different métiers.

Table 6.3.2.3.3.1. Effort data for OTB according to the DCF Data Call.

| | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| Nominal effort | 2784175 | 2927650 | 2694399 | 2675591 |
| GT days at sea | 648576 | 672070 | 616593 | 630594 |

Available fishing effort information, as number of fishing trips (days at sea), comes from IEO for the period 2000-2012 (Figure 6.3.2.3.3.1).

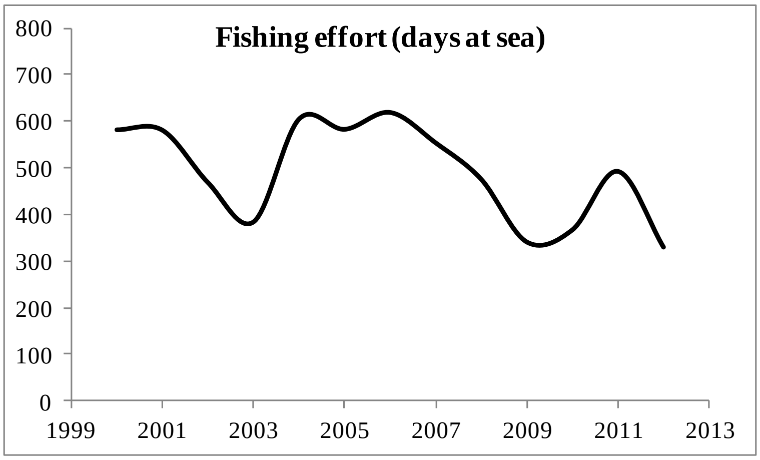



Figure 6.3.2.3.3.1. Red mullet in GSA 5: Fishing effort (as number of days at sea) for OTB.

## 6.3.3. Scientific surveys

BALAR and MEDITS surveys

Methods

From 2001, the Spanish Institute of Oceanography has performed annual bottom trawl surveys following the same methodology and sampling gear described in the MEDITS protocol (BALAR surveys, Massutí and Reñones, 2005). Since 2007, this survey has been included in the MEDITS program (Bertrand *et al.*, 2002). Mean stratified abundances and biomasses by $km^2$ has been computed using the methodology described by Grosslein and Laurec (1982), with the following formulas:

- Mean catch by stratum: $\bar{Y}_{st} = \frac{1}{N_h} * \sum Y_h$
- Variance by stratum: $S^2(\bar{Y}_{st}) = \frac{1}{N_{h-1}} * \sum (Y_h - \bar{Y}_{st})^2$
- Mean total catch: $Y_t = \frac{1}{A} * \sum (\bar{Y}_{st} * A_h)$
- Total variance: $S^2(\bar{Y}_t) = \frac{1}{A^2} * \sum \frac{S^2(\bar{Y}_{st}) * A_h^2}{N_h}$
- SE (standard error): $SE = \sqrt{S^2(\bar{Y}_{st})}$

Nh: number of hauls in each sub-stratum; Yh: mean catch by haul in each sub-stratum; A: total stratum area; Ah: sub-stratum area; $S^2(\bar{Y}_{st})$ variance in each sub-stratum.

Geographical distribution patterns

The red mullet is mainly distributed in the south of Mallorca island, in the fishing grounds distributed in the shallow and depth shelf (Figure 6.3.3.1.2.1.).

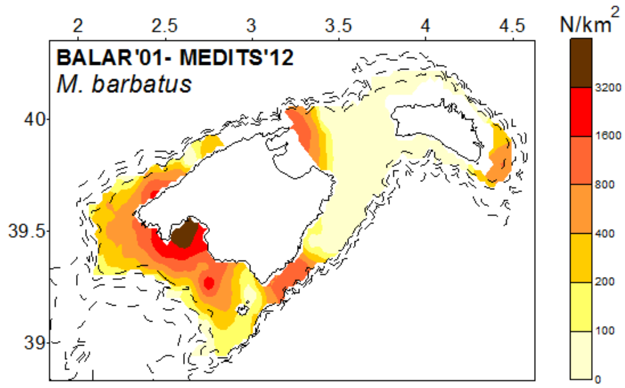



Figure 6.3.3.1.2.1. Red mullet in GSA 5: Geographical distribution based on bottom trawl surveys (2001-2012).

Trends in abundance and biomass

Abundance and biomass indices from the surveys showed a similar trend, with clear oscillations, a maximum in 2007 and a clear decreasing trend since then. Minimum values were found in 2005 and 2012. (Figure 6.3.3.1.3.)

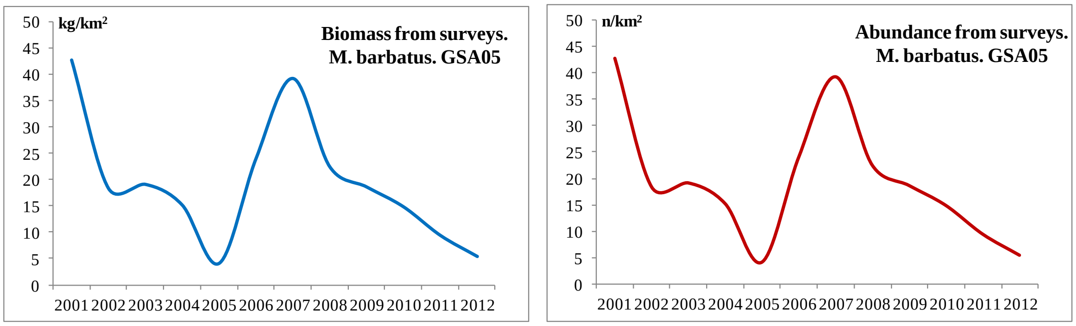



Figure 6.3.3.1.3. Red mullet in GSA 5. Abundance and biomass indices from the bottom trawl surveys.

Trends in abundance by length or age

No analysis were conducted during EWG 13-19.

Trends in growth

No analysis were conducted during EWG 13-19.

Trends in maturity
No analysis were conducted during EWG 13-19.

### 6.3.4. **Assessment of historic stock parameters**

Method 1: XSA
Justification
The assessment has been performed with an Extended Survivor Analysis (XSA) using the FLR library in R. This assessment is an update of the one performed in 2010 (SGMED-10-02).

Input parameters
The data used in the assessment were: (i) Landings time series 2000-2012 from OTB; (ii) Age distributions obtained from slicing of length distributions 2000-2012 (Figure 6.3.4.1.2.1); (iii) Set of growth parameters adopted in the SGMED-08-03 meeting (slow growth parameters from otolith reading) and (iv) BALAR-MEDITS survey used as tuning fleet (abundances by age in n/km$^2$, Figure 6.3.4.1.2.1).

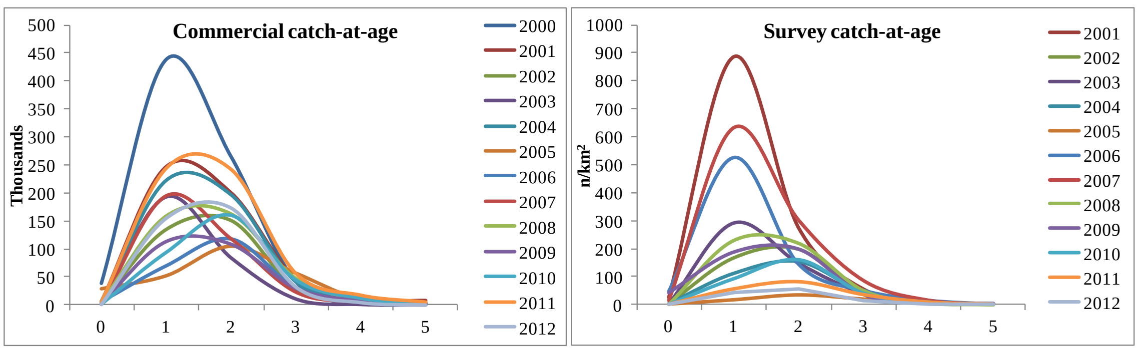



Figure 6.3.4.1.2.1. Red mullet. GSA 5. Age distribution by year for the commercial and survey data.

| Mean weight in catch | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5+ |
| 0.011 | 0.031 | 0.054 | 0.086 | 0.110 | 0.118 |

| Growth parameters | | |
|---|---|---|
| $L_\infty$ | k | $t_0$ |
| 26.0 | 0.41 | -0.4 |

| Length-weight relationship | |
|---|---|
| a | b |
| 0.00624 | 3.1597 |

| Maturity ogive | | | | | | |
|---|---|---|---|---|---|---|
| Age | 0 | 1 | 2 | 3 | 4 | 5+ |
| Prop. Matures | 0.02 | 0.94 | 1.00 | 1.00 | 1.00 | 1.00 |

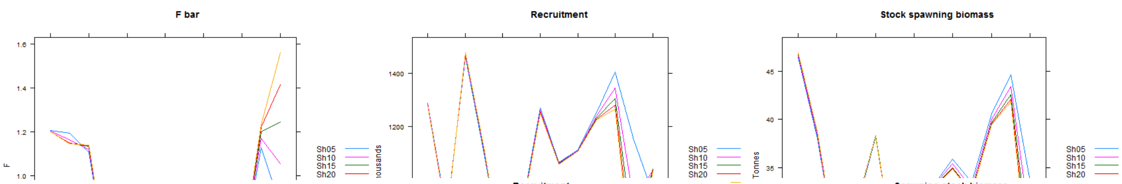
| Natural mortality (PROBIOM; Abella et al., 1997) |
|---|

| Age | 0 | 1 | 2 | 3 | 4 | 5+ |
|---|---|---|---|---|---|---|
| M | 0.80 | 0.38 | 0.29 | 0.26 | 0.24 | 0.23 |

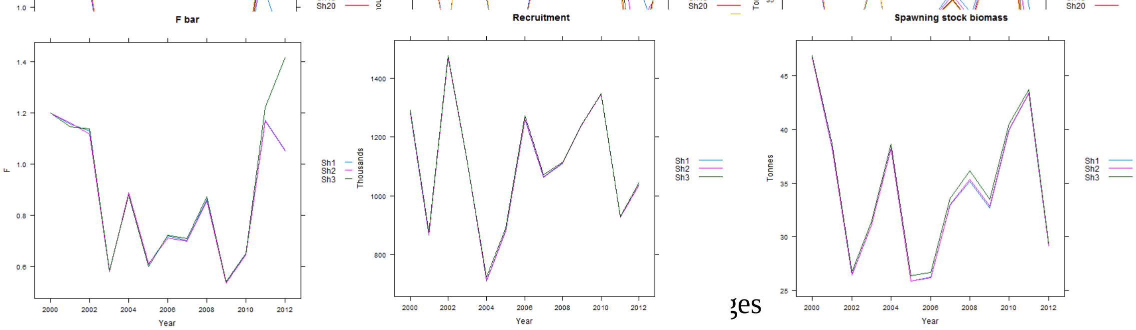
The number of individuals by age was SOP corrected [SOP = Landings / Σ*a* (total catch numbers at age *a* x catch weight-at-age *a*)] before performing any analysis.

| 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| 0.91 | 0.91 | 0.92 | 0.90 | 0.90 | 0.92 | 0.92 |
| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | |
| 0.91 | 0.92 | 0.91 | 0.92 | 0.91 | 0.91 | |

Different sensitivity analyses were performed before running the final XSA, considering different weights and ages for shrinkage and different ages for catchability. For weight shrinkage, results were quite robust, although F showed differences in the last year (Figure 6.3.4.1.2.2). For the age shrinkage, results were quite robust for recruitment and SSB, but F showed very different results for the last year when considering 3 ages (Figure 6.3.4.1.2.3). For the catchability, the results were very robust independently of the ages considered, except for the recruitment in the last year (Figure 6.3.4.1.2.4).




SSB.




ges

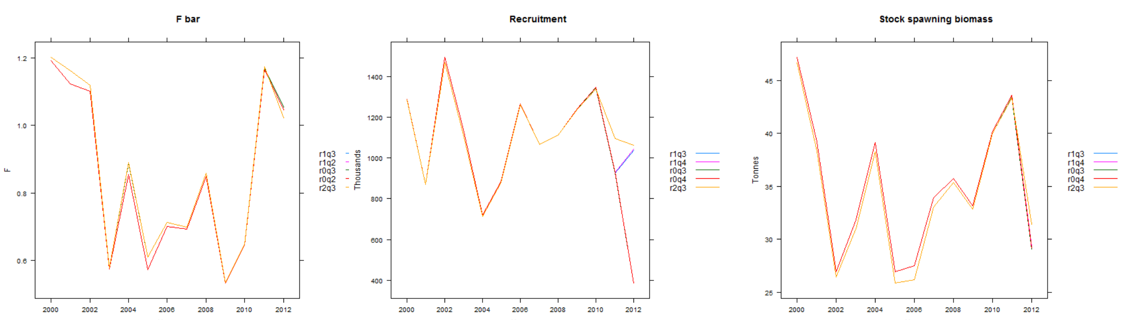



Figure 6.3.4.1.2.4. Sensitivity analysis considering different ages for catchability for F, R and SSB.

For the final XSA run, the following settings were used:

| fse | rage | qage | shk.n | shk.f | shk.yrs | shk.ages |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 0 | 3 | TRUE | TRUE | 3 | 2 |

Results

Both recruitment and SSB showed some oscillations along the data series, without a clear trend, similarly to F (Figure 6.3.4.1.3.1, Table 6.3.4.1.3.1).

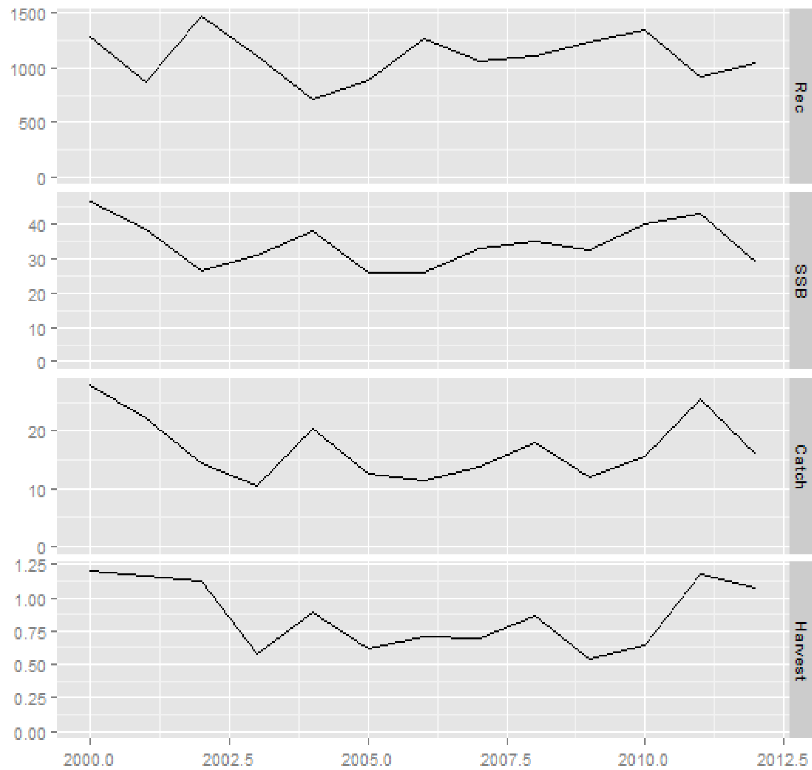



Fig 6.3.4.1.3.1. *Mullus barbatus* GSA 5. XSA summary results.

Table 6.3.4.1.3.1. *Mullus barbatus* GSA 5. XSA summary results.

| | Population in number (thousands) | Population in weight (tons) | Recruitment number (thousands) | SSB | $F_{1-2}$ |
|---|---|---|---|---|---|
| 2000 | 2551.9 | 62.0 | 1283.6 | 46.7 | 1.20 |
| 2001 | 1753.0 | 49.7 | 868.4 | 38.4 | 1.16 |
| 2002 | 2094.9 | 44.5 | 1468.5 | 26.5 | 1.12 |
| 2003 | 1963.7 | 43.1 | 1113.1 | 31.0 | 0.58 |
| 2004 | 1582.3 | 46.8 | 712.6 | 38.2 | 0.89 |
| 2005 | 1458.4 | 34.9 | 880.1 | 25.8 | 0.61 |

| | | | | | |
|---|---|---|---|---|---|
| 2006 | 1878.6 | 41.6 | 1260.1 | 26.1 | 0.72 |
| 2007 | 1886.8 | 48.6 | 1064.2 | 32.9 | 0.70 |
| 2008 | 1905.7 | 48.2 | 1111.0 | 35.3 | 0.86 |
| 2009 | 2007.9 | 47.1 | 1240.2 | 32.8 | 0.54 |
| 2010 | 2240.6 | 58.2 | 1342.1 | 40.0 | 0.65 |
| 2011 | 1913.7 | 56.2 | 914.9 | 43.3 | 1.17 |
| 2012 | 1726.1 | 39.0 | 1045.1 | 28.9 | 1.07 |

Residuals from the BALAR-MEDITS tuning fleet show low values for all the ages and years considered. After some trials, in the last run only ages 1-4 were considered (Figure 6.3.4.1.3.2).

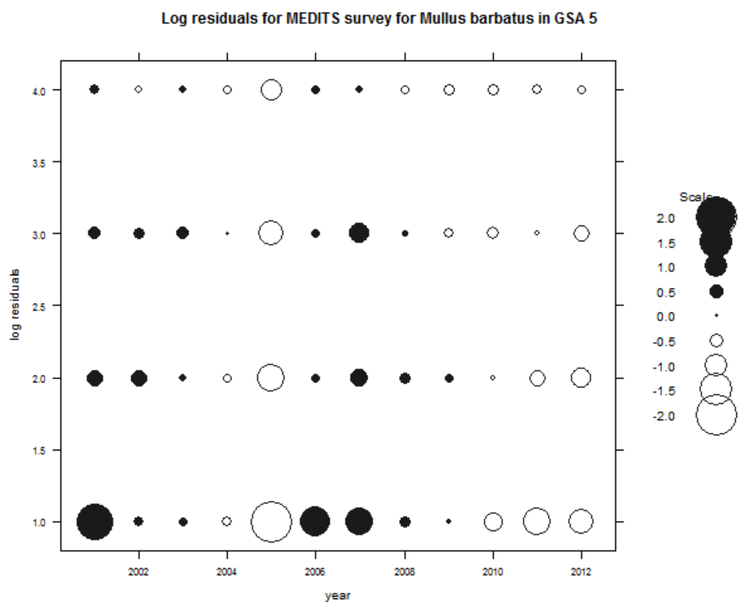
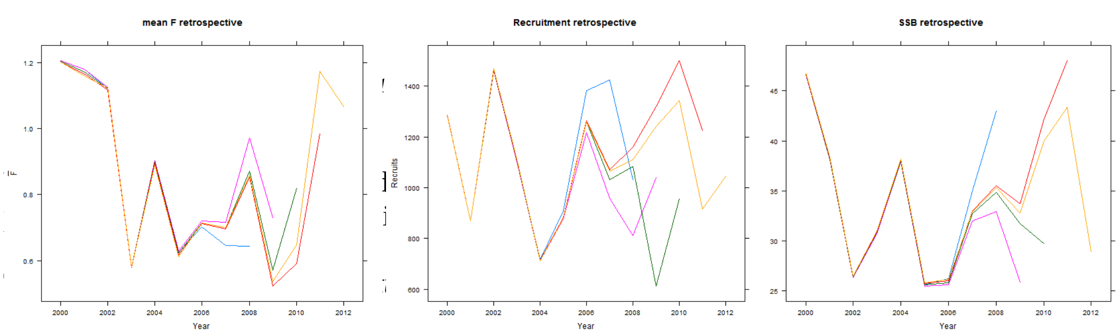



Figure 6.3.4.1.3.2. Log catchability residual plots (XSA) for BALAR-MEDITS surveys.

Retrospective analysis was performed, showing quite robust results for R, SSB and F (Figure 6.3.4.1.3.3).




vell as the reference

| | |
|---|---|
| $F_{curr\ (1\text{-}3,\ 2010\text{-}2012)}$ | 0.93 |
| $F_{0.1}$ | 0.15 |

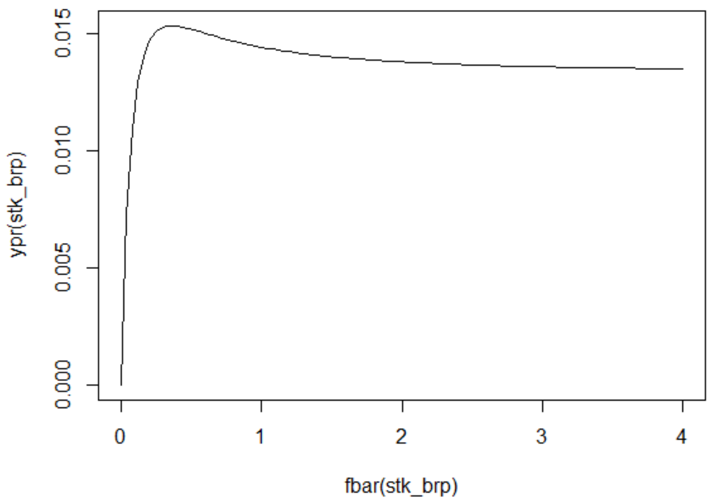



Figure 6.3.4.1.3.4. *Mullus barbatus* GSA 5. Yield per recruit.

### 6.3.5. **Short term prediction 2013-2015**

Method and justification

A deterministic short term prediction for the period 2013 to 2015 was performed using the FLR routines provided by JRC, which takes into account the catch and landings in numbers and weight and the discards, and based on the results of the XSA stock assessments performed during EWG13-09 for the years 2003–2012.

Input parameters

The input parameters were the same used for the XSA stock assessment and its results.

Different scenarios of constant harvest strategy with $F_{bar}$ calculated as the average of ages 1 to 2 ($F_{bar}$ ages 1-2) and F status quo ($F_{curr}$ = 0.93) were performed.

Recruitment (class 0) has been estimated as the geometric mean of the last three years 2010-2012 estimated with XSA.

Results

A short term projection (Table 6.3.5.3.1), assuming an $F_{stq}$ of 0.93 in 2013 and a recruitment of 1087 thousands individuals, shows that:

- Fishing at the $F_{stq}$ (0.93) generates a decrease of the catch of 8% from 2012 to 2014 along with an increase of the spawning stock biomass of 3% from 2014 to 2015.

- Fishing at $F_{0.1}$ (0.15) generates a decrease of the catch of 78% from 2012 to 2014 and an increase of the spawning stock biomass of 52% from 2014 to 2015.

**Outlook until 2013**

Table 6.3.5.3.1. *Mullus barbatus* GSA 5. Short term forecast in different F scenarios.

Basis: F(2013) = mean($F_{bar}$1-3 2010-2012)= 0.93; R(2012) = geometric mean of the recruitment of the last 3years; R = 1087 (thousands); SSB(2012) = 28.9 t, Catch (2012)= 15.9 t.

| Rationale | Ffactor | Fbar | Catch 2014 | Catch 2015 | SSB 2015 | Change SSB 2014-2015 (%) | Change Catch 2012-2014 (%) |
|---|---|---|---|---|---|---|---|
| zero catch | 0.00 | 0.00 | 0.0 | 0.0 | 49.9 | 67.8 | -100.0 |
| High long-term yield ($F_{0.1}$) | 0.15 | 0.14 | 3.4 | 6.3 | 45.4 | 52.4 | -78.5 |
| Status quo | 1.00 | 0.93 | 14.7 | 15.4 | 30.8 | 3.5 | -7.8 |
| Different scenarios | 0.10 | 0.09 | 2.3 | 4.4 | 46.9 | 57.5 | -85.7 |
| | 0.20 | 0.19 | 4.3 | 7.7 | 44.2 | 48.5 | -72.9 |
| | 0.30 | 0.28 | 6.1 | 10.0 | 41.8 | 40.4 | -61.5 |
| | 0.40 | 0.37 | 7.8 | 11.7 | 39.6 | 33.2 | -51.2 |
| | 0.50 | 0.47 | 9.2 | 13.0 | 37.7 | 26.8 | -42.0 |
| | 0.60 | 0.56 | 10.5 | 13.9 | 36.0 | 21.1 | -33.8 |
| | 0.70 | 0.65 | 11.7 | 14.5 | 34.5 | 16.0 | -26.3 |
| | 0.80 | 0.75 | 12.8 | 14.9 | 33.1 | 11.4 | -19.5 |
| | 0.90 | 0.84 | 13.8 | 15.2 | 31.9 | 7.2 | -13.4 |
| | 1.00 | 0.93 | 14.7 | 15.4 | 30.8 | 3.5 | -7.8 |
| | 1.10 | 1.03 | 15.5 | 15.5 | 29.8 | 0.1 | -2.6 |
| | 1.20 | 1.12 | 16.2 | 15.6 | 28.9 | -3.0 | 2.0 |
| | 1.30 | 1.21 | 16.9 | 15.6 | 28.0 | -5.8 | 6.4 |
| | 1.40 | 1.31 | 17.5 | 15.6 | 27.3 | -8.4 | 10.3 |
| | 1.50 | 1.40 | 18.1 | 15.5 | 26.5 | -10.8 | 14.0 |
| | 1.60 | 1.49 | 18.7 | 15.5 | 25.9 | -12.9 | 17.4 |
| | 1.70 | 1.59 | 19.2 | 15.5 | 25.3 | -14.9 | 20.5 |
| | 1.80 | 1.68 | 19.6 | 15.4 | 24.8 | -16.8 | 23.5 |
| | 1.90 | 1.77 | 20.1 | 15.4 | 24.2 | -18.5 | 26.2 |
| | 2.00 | 1.87 | 20.5 | 15.3 | 23.8 | -20.1 | 28.8 |

### 6.3.6. **Medium term prediction**

Method and justification

Following the agreement reached during the discussions of the EWG-12-19, medium term prediction would only be performed if there is a reliable fit of a stock-recruitment relationship. In this case, no medium term predictions were made, as a reliable stock-recruitment relationship could not be fit (Figure 6.3.6.1.1).

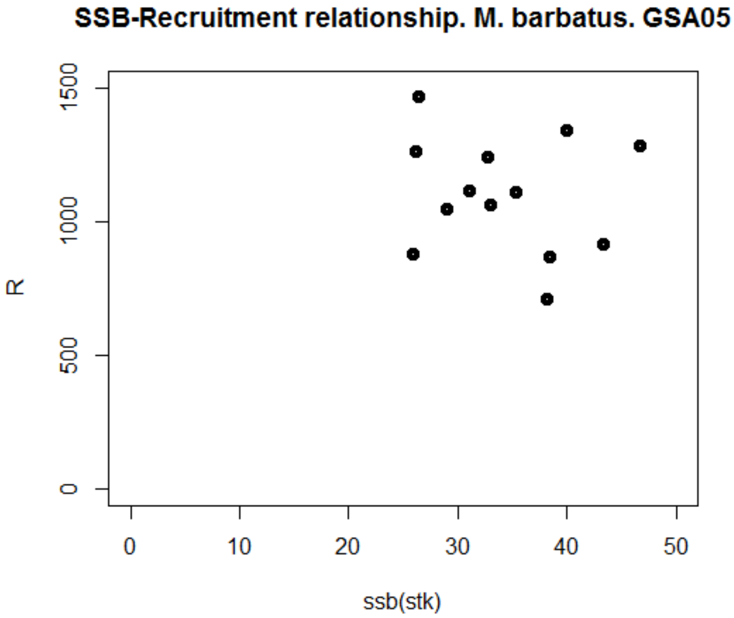



Figure 6.3.6.1.1. *Mullus barbatus* GSA 5. Stock recruitment relationship.

### 6.3.7. Data quality

Information about catches and length and age frequency distributions was available through the Official Data Call for all the years. Effort information was available only for 2009-2012. MEDITS data was also available.

### 6.3.8. Scientific advice

Short term considerations

State of the stock size

No clear trend was identified for SSB, with oscillations along the entire data series.

State of the recruitment

No clear trend was identified for R, with oscillations along the entire data series.

State of exploitation

The current F(0.93) is larger than $F_{MSY}$ (0.15), which indicates that red mullet in GSA 5 is exploited unsustainably.

Management recommendations

STECF EWG 13-19 suggests that catch in 2014 should not exceed 3.4 t, corresponding to $F_{0.1}$=0.15.

It is also important to consider that red mullet in GSA 5 is only caught as a by-catch in the trawl fishery and the management of this species should be undertaken in the framework of a multispecific approach.

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## 6.4. **Stock assessment of red mullet in GSA 6**

### 6.4.1. **Stock Identification**

Due to the lack of information about the structure of red mullet (*Mullus barbatus*) population in the western Mediterranean, this stock was assumed to be confined within the GSA 6 boundaries. (Figure 6.4.1.1).

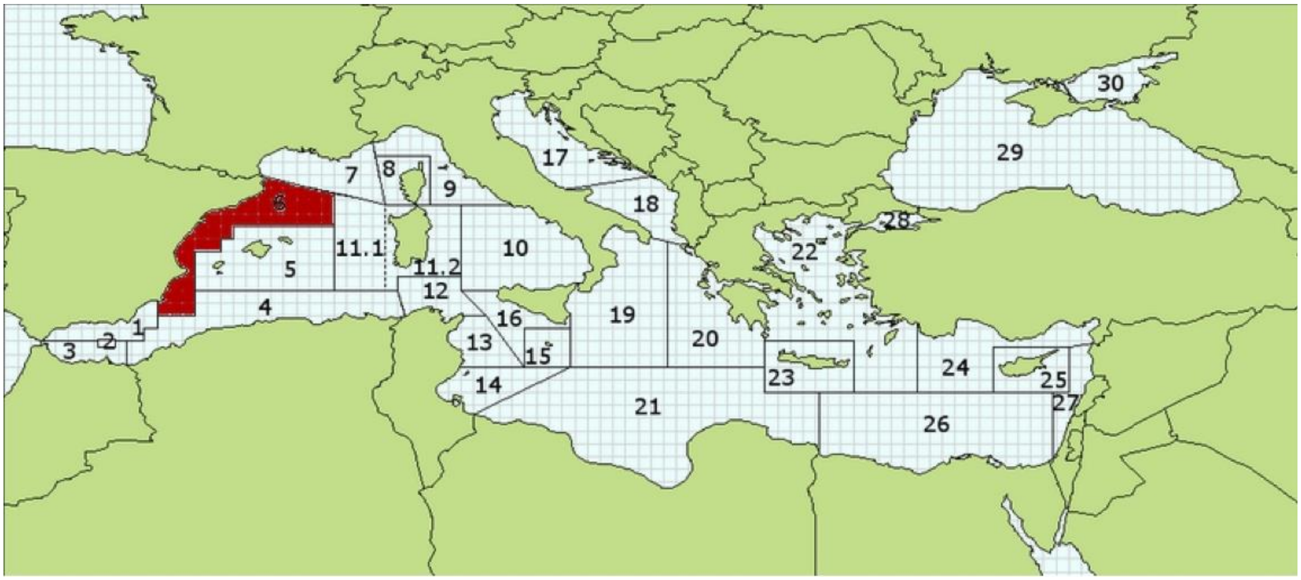



Figure 6.4.1.1. Geographical location of GSA 6.

Growth

EWG 13-19 notes that no growth parameters were available from the DCF for red mullet in GSA 6 for 2012. Assessments run with the parameters available in the previous stock assessment (STECF 11-14), corresponding to a "slow growth" hypothesis, produced unrealistically high fishing mortalities. The growth parameters used in the present assessment correspond to a "fast growth" hypothesis and are in line with the growth parameters used in stock assessments of GSA 7 and GSA 9. The values of the von Bertalanffy growth function parameters were $L_\infty$ = 29.0 cm, k= 0.60, $t_0$=-0.10 (STECF 12-19). The length-weight relationship parameters are: a=0.00624 and b=3.1597 (Fernandez, 2010).

Maturity

Maturity ogive was taken from GFCM demersal working groups assessments corresponding to 2008 (reports available in www.gfcm.org), with size at first maturity (50 %) at 12.2 cm TL.

| age class | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|
| Maturity ratio | 0.46 | 0.76 | 0.88 | 0.93 | 1 |

### 6.4.2. **Fisheries**

General description of fisheries

Red mullet is captured in GSA 6 mainly by bottom trawlers fishing on the continental shelf, between 50 and 200 m depth. The amount of catches captured by other fishing gears, practically all from trammel nets, is estimated at about 10% of the total. Very small individuals (under the minimum legal size of 11 cm TL), corresponding to autumn recruits, were captured and landed in large amounts in the early 2000s but have now practically disappeared from the landings. The trawl fleet in GSA 6 has been decreasing over the last 10 years, with a loss of about 200 units between 2002 and 2012.

Management regulations applicable in 2010 and 2011

Trawl fisheries in GSA 6 are regulated by "Orden AAA/2808/2012" published in the Spanish Official Bulletin (BOE nº 313 29 December 2012) containing an Integral Management Plan for Mediterranean fishery resources. To the traditional fisheries regulations already in place (e.g. the daily and weekly fishing effort limited to 12 hours per day five days a week; trawl cod end 40 mm square mesh or 50 mm diamond stretched mesh; engine power of maximum 373 kW; license system; minimum landing size of 20 mm CL), this plan adds that fishing mortality for *Mullus surmuletus* in GSA 6 should be kept at or below the reference value $F_{01} = 0.17$, and that fishing effort be reduced by 20% or more over the period 2013-2017 (based on the effort established on 1 January 2013). This fishing effort reduction will be measured in terms of number of vessels, engine power and tonnage.

Catches

Landings

Because of the problems mentioned in the section "Data quality and availability" the landings used in the present assessment were not those given in the DCF 2012 call, but instead the catches reported in table 6.4.2.3.1.1 correspond to landings reported by the Fisheries Directorate of the Autonomous Communities of Catalonia and Valence. This problem was reported earlier (see STECF 11-14) and has been corrected for the years 2011-2012, when the two data series coincide. The table reports also the proportion of catches corresponding to trammel netters, estimated from the DCF 2012 call. The landings do not show any clear trend, with maximum values in the years 2006-2007.

Table 6.4.2.3.1.1. GSA 6 Red mullet. Annual landings (t).

| | Landings reported in DCF 2012 data call | Landings reported by local authority | % Trammel net (GTR) |
|---|---|---|---|
| 2002 | 1159 | 305.37 | 0.74% |
| 2003 | 1004 | 1399.98 | 1.36% |
| 2004 | 985 | 1692.82 | 1.79% |
| 2005 | 1055 | 577.13 | 1.32% |
| 2006 | 1477 | 826.71 | 0.89% |
| 2007 | 1384 | 721.04 | 1.14% |
| 2008 | 1145 | 558.79 | 1.81% |
| 2009 | 1011 | 520.90 | 2.25% |

| | | | |
|---|---|---|---|
| 2010 | 1032 | 514.13 | 2.20% |
| 2011 | 1063.1 | 1063.06 | 13.17% |
| 2012 | 1069.9 | 1069.88 | 7.22% |

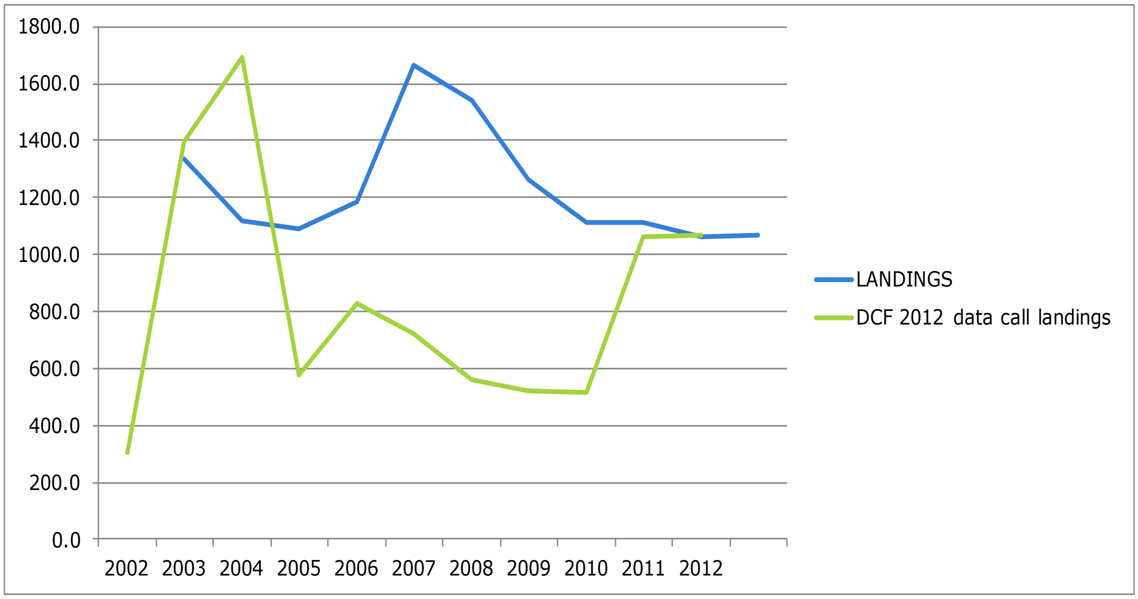



Figure 6.4.2.3.1.1. GSA 6 red mullet. Annual landings (t).

The proportion of undersized individuals, according to data in the DCF 2012 call, has decreased largely over the 2002-2012 period, as shown in Fig. 6.4.2.3.1.2.

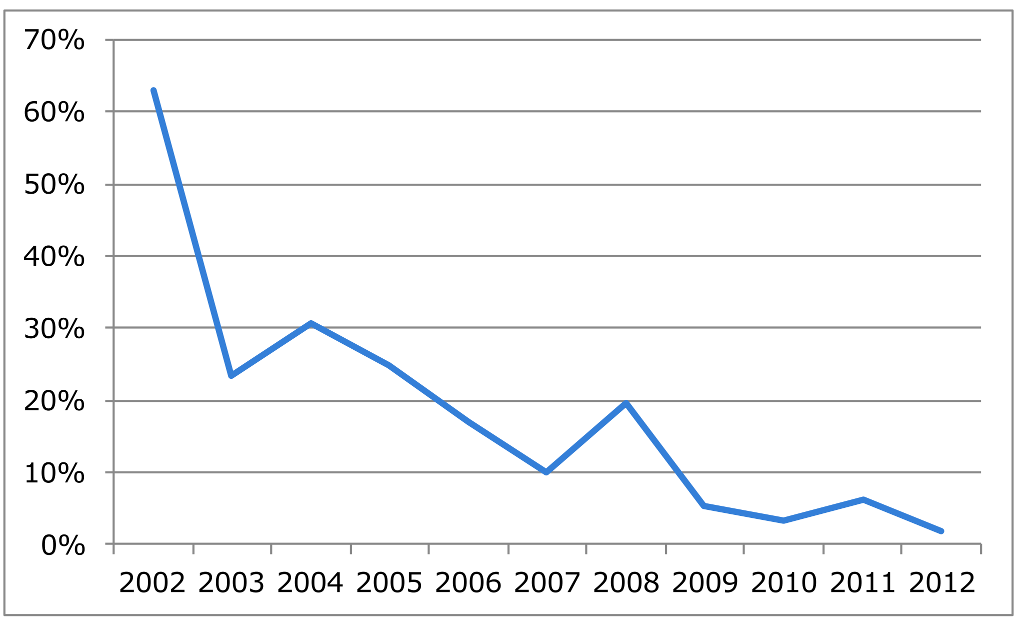


Figure 6.4.2.3.1.2. GSA 6 red mullet. Proportion of landings below the MLS of 11 cm TL.

The size frequency of the landings is shown in Figure 6.4.2.3.1.3. The years 2002 and 2008 show exceptionally high landings of undersized fish.

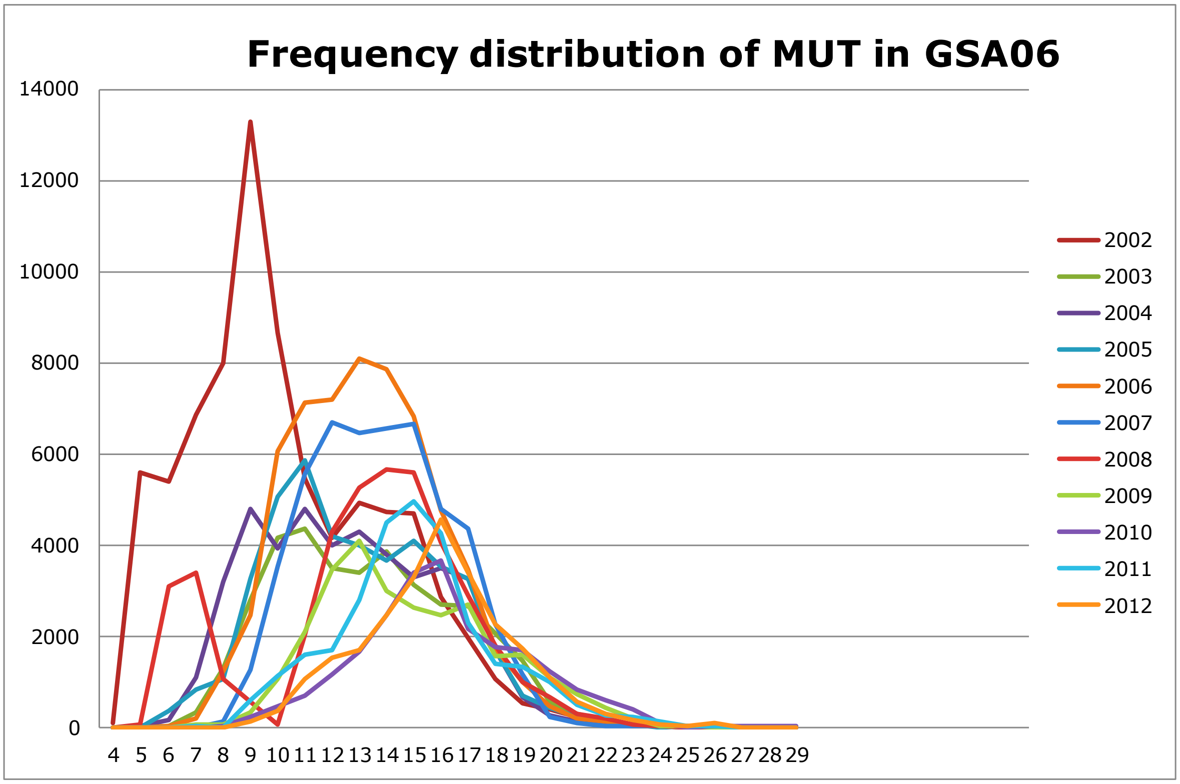



Fig. 6.4.2.3.1.3. Frequency distribution of the sampled commercial landings.

Discards

OTB data on discards are available for the period 2008-2012. Discards represent less than 2% of the OTB catches in weight, which is considered unrealistically low. Discards were assumed to be 0 in the present stock assessment.

Fishing effort

Trawl (OTB) fishing effort data for GSA 6 was submitted by quarter, area, gear, fishery and vessel length class for the years 2009-2012 in the new data call. Landings of red mullet are produced mainly by trawlers in length classes VL1218 and VL1824. Table 6.4.2.4.1 and Figure 6.4.2.4.1 shows the nominal effort and capacity data for the 2009-2012 period. The reduction in fishing effort is apparent, in accordance with the Integral Plan previously mentioned aiming to reduce fishing effort.

Table 6.4.2.3.3.1 GSA 6 red mullet. Number of vessels, nominal fishing effort and capacity.

| Year | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Vessels | 558 | 546 | 540 | 540 |
| Nominal effort kW x days at sea (000s) | 17940 | 16525 | 15417 | 14574 |
| GT x days at sea (000s) | 3771 | 3511 | 3254 | 3087 |

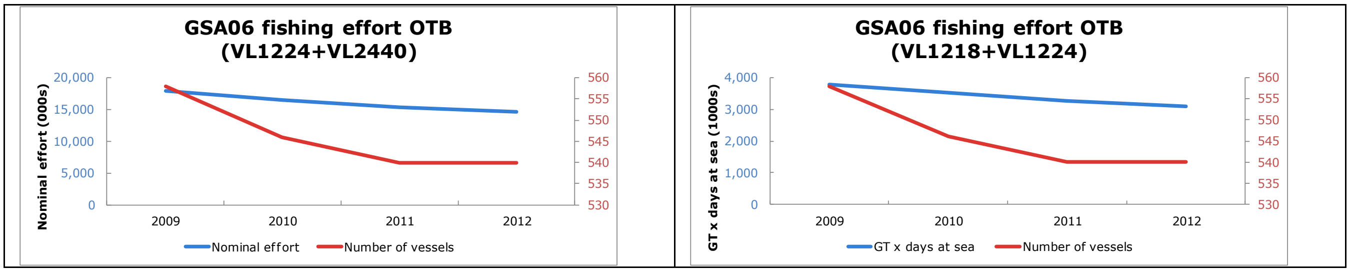



Figure 6.4.2.3.3.1. GSA 6 red mullet. Number of vessels, nominal effort (000s of kW*days at sea) and nominal capacity (GT*days at sea).

### 6.4.3. **Scientific surveys**

MEDITS

Methods

Since 1994 standard bottom trawl surveys have been conducted in GSA 6 in spring, following the general methodology of the MEDITS protocol described in Bertrand et al. (2002). In GSA 6 the following number of hauls was reported per depth stratum in the DCF 2012 data call:

Table 6.4.3.1.1.1. GSA 6 red mullet. Number of hauls per year and depth stratum in GSA 6, 1994-2012.

| DEPTH_STRATUM | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 7 | 8 | 7 | 8 | 7 | 8 | 9 | 7 | 10 |
| 050-100 | 21 | 27 | 27 | 25 | 27 | 28 | 30 | 29 | 34 |
| 100-200 | 10 | 18 | 16 | 14 | 12 | 16 | 18 | 18 | 19 |
| 200-500 | 9 | 15 | 9 | 10 | 6 | 12 | 11 | 15 | 16 |
| 500-800 | 8 | 11 | 10 | 8 | 4 | 10 | 7 | 8 | 7 |

| DEPTH_STRATUM | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 8 | 8 | 11 | 11 | 5 | 7 | 6 | 5 | 7 | 9 |
| 050-100 | 37 | 30 | 31 | 33 | 26 | 29 | 28 | 20 | 28 | 34 |
| 100-200 | 20 | 16 | 17 | 18 | 14 | 20 | 20 | 12 | 20 | 22 |
| 200-500 | 17 | 15 | 14 | 17 | 10 | 13 | 14 | 10 | 15 | 17 |
| 500-800 | 11 | 11 | 8 | 12 | 9 | 9 | 7 | 8 | 8 | 8 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. The abundance and biomass indices by

GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Y_{st} = \Sigma (Y_i * A_i) / A$$

$$V(Y_{st}) = \Sigma(A_i^2 * s_i^2 / n_i) / A^2$$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum n=number of hauls in the GSAYi=mean of the i-th stratumYst=stratified mean abundance V(Yst)=variance of the stratified mean. The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / nLength distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA.

Geographical distribution patterns

No specific analyses were conducted, but it is well-known that red mullet is distributed over muddy bottoms on continental shelves, down to 250 m approximately.

Trends in abundance and biomass

Fishery independent information from the MEDITS surveys in the period 1994-2012 was used to derive indices of abundance and biomass for red mullet in GSA 6 (Figure 6.4.3.1.4.1). Both abundance and biomass have fluctuated in the area during this period with no clear trend, but high abundances are apparent in the years 2006-2007.

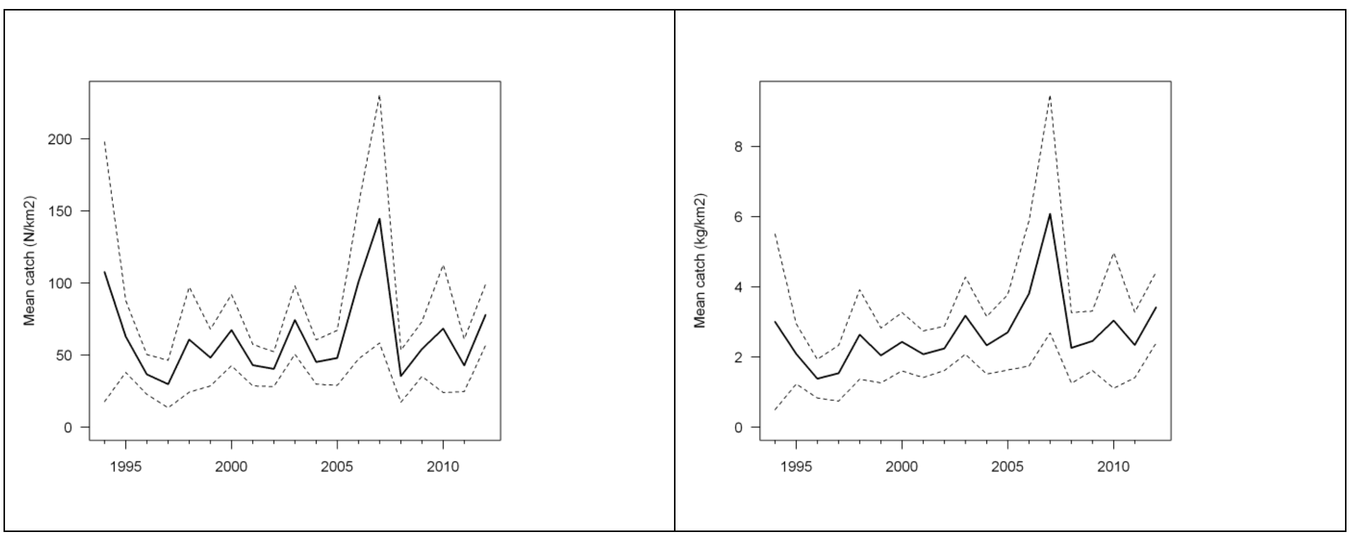
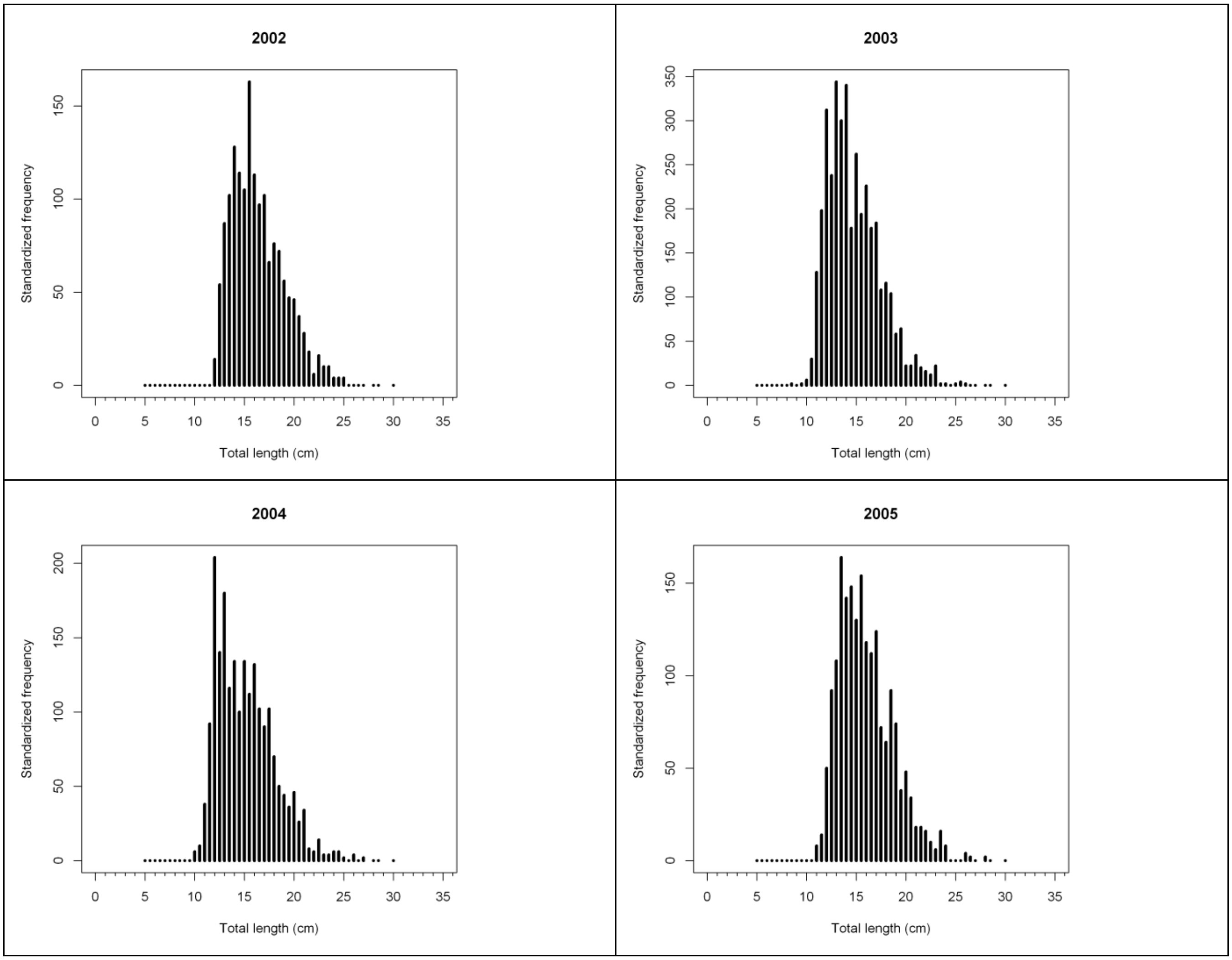
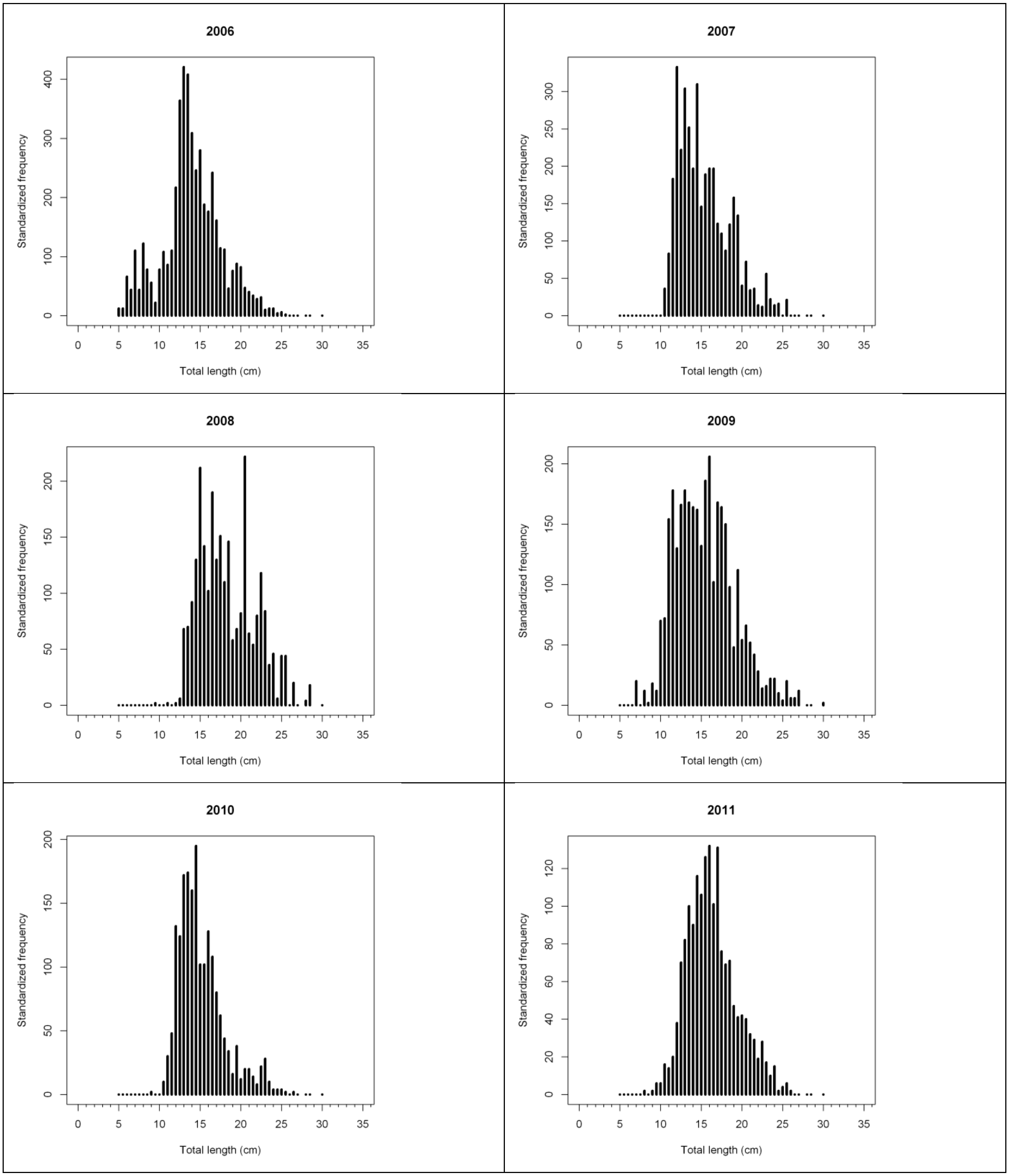



Figure 6.4.3.1.3.1. GSA 6 red mullet. Abundance and biomass indices from MEDITS surveys (mean and 95% confidence intervals).

Trends in abundance by length or age

Figure 6.4.3.1.4.1 show the standardized size frequencies of red mullet in GSA 6 in the period 2002-2012 from MEDITS. Individuals are usually between 10 and 20 cm TL, corresponding to 1 and 2 year old fish, although a mode below 10 cm is apparent in 2006.




2006
Standardized frequency
Total length (cm)
2007
Standardized frequency
Total length (cm)
2008
Standardized frequency
Total length (cm)
2009
Standardized frequency
Total length (cm)
2010
Standardized frequency
Total length (cm)
2011
Standardized frequency
Total length (cm)

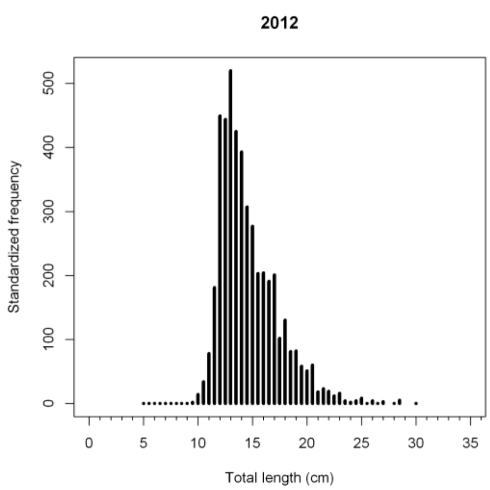



Fig 6.4.3.1.4.1. GSA6 red mullet. Standardized size frequencies for the period 2002-2012 from MEDITS surveys.

Trends in growth
No specific analyses were carried out.

Trends in maturity
No specific analyses were carried out.

### 6.4.4. Assessments of historic stock parameters

Method 1: XSA

Justification
Stock assessment using XSA was performed, calibrated with fishery independent survey abundance indices (MEDITS) for the period 2002-2012.

Input parameters

The growth parameters used for VBGF were $L_{inf}$= 29.0 cm; k = 0.60 $yr^{-1}$; $t_0$= -0.10 yr (based on the fast growth hypothesis, from GSA 7). The length-weight coefficients used were those recently estimated by the Spanish Data Collection Programme for the years 2011-2012: a= 0.006240, b= 3.15970.

Numbers at age were estimated transforming the annual size distribution of the landings to ages using the L2Age4 software. The source of commercial landings are the official databases in the Autonomous Communities of Valence and Catalonia. The tuning parameters (MEDITS) were calculated by transforming standardized MEDITS length distributions to ages using L2Age4 software.

Table 6.4.4.1.2.1 lists the input parameters to the XSA, namely catch at age, weight at age, maturity at age, natural mortality at age and the tuning series at age (MEDITS), corresponding to ages 1-3 only because age 0 is not well represented in the MEDITS surveys. Natural mortality values (vector) were computed using PROBIOM. M for age group 0 is the mean over the first 12 months.

Table 6.4.4.1.2.1. Input parameters to the XSA model.

Catch at age matrix

| Age | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 67592.6 | 19872.8 | 26294 | 24671.6 | 32495.2 | 23713 | 19808.4 | 11183.4 | 4278.1 | 7852.8 | 4784.3 |
| 1 | 16055.4 | 16190.5 | 16365.7 | 17212 | 25925.2 | 25823.9 | 21431.3 | 14768.8 | 16048.3 | 19447.7 | 18483.2 |
| 2 | 546.7 | 663.3 | 271.2 | 564 | 466.4 | 226.4 | 740.1 | 1633.9 | 2136.8 | 1266.7 | 1317.1 |
| 3 | 42.6 | 47.5 | 11.8 | 30.5 | 24.1 | 18.7 | 24.5 | 54.3 | 62.5 | 120.8 | 121.9 |
| 4+ | 1.2 | 5.5 | 0.2 | 4.3 | 3.8 | 3.6 | 1.1 | 6.5 | 20.8 | 17.1 | 56.5 |

Weight at age matrix

| Age | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.009 | 0.014 | 0.013 | 0.014 | 0.016 | 0.017 | 0.013 | 0.018 | 0.018 | 0.017 | 0.018 |
| 1 | 0.041 | 0.047 | 0.044 | 0.045 | 0.042 | 0.043 | 0.043 | 0.049 | 0.049 | 0.045 | 0.049 |
| 2 | 0.110 | 0.108 | 0.104 | 0.107 | 0.105 | 0.107 | 0.107 | 0.107 | 0.111 | 0.11 | 0.107 |
| 3 | 0.161 | 0.162 | 0.16 | 0.17 | 0.166 | 0.167 | 0.163 | 0.168 | 0.159 | 0.162 | 0.176 |
| 4+ | 0.196 | 0.196 | 0.197 | 0.215 | 0.2 | 0.203 | 0.196 | 0.21 | 0.212 | 0.208 | 0.198 |

Maturity and natural mortality vectors.

| Age class | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|
| Maturity | 0.46 | 0.76 | 0.88 | 0.93 | 1 |
| M | 0.99 | 0.46 | 0.3 | 0.24 | 0.21 |

Tuning parameters (MEDITS)

| | age 1 | age 2 | age 3 |
|---|---|---|---|
| 2002 | 1202.2 | 108.9 | 8.1 |
| 2003 | 2038.3 | 118 | 8.1 |
| 2004 | 1163.1 | 87.8 | 12.2 |
| 2005 | 1331.2 | 107.4 | 4.3 |
| 2006 | 2138.5 | 188.2 | 12.4 |
| 2007 | 2044.5 | 220.7 | 37.4 |
| 2008 | 1731 | 582.6 | 96.2 |
| 2009 | 1778 | 225.7 | 40.9 |
| 2010 | 1088.3 | 115.1 | 10.2 |
| 2011 | 1167.6 | 167.9 | 14.5 |
| 2012 | 2303.7 | 121.5 | 16.1 |

Results including sensitivity analyses

Different sensitivity analyses were performed before running the final XSA, considering different ages for shrinkage.

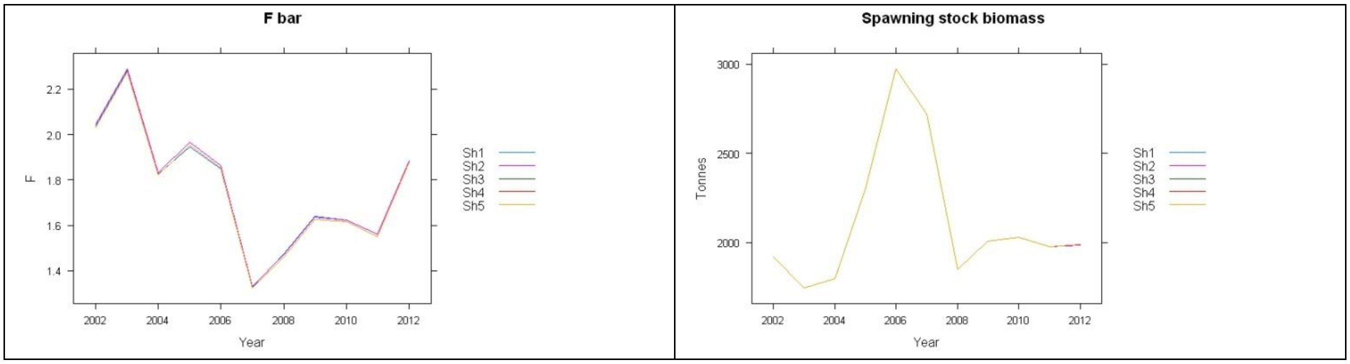



Figure 6.4.4.1.3.1. GSA 6 red mullet. Sensitivity analysis considering different ages for shrinkage.

Table 6.4.4.1.3.1. GSA 6 red mullet. Parameters used in the XSA assessment.

| fse | r age | q age | shk n | shk f | shk yrs | shk ages |
|---|---|---|---|---|---|---|
| 2.0 | 1 | 2 | True | True | 3 | 3 |

A first run with ages 0-4 form the tuning fleet (MEDITS) produced large residuals corresponding to age classes 0 and 4. This is because the MEDITS survey, carried out in spring, fails to adequately represent the size of the age 0 class (recruits). Age class 4 and higher are not well represented in the MEDITS trawl surveys. Re-running the XSA assessment with tuning fleet classes 1-3 showed improved residuals pattern (Figure 6.4.4.1.3.2).

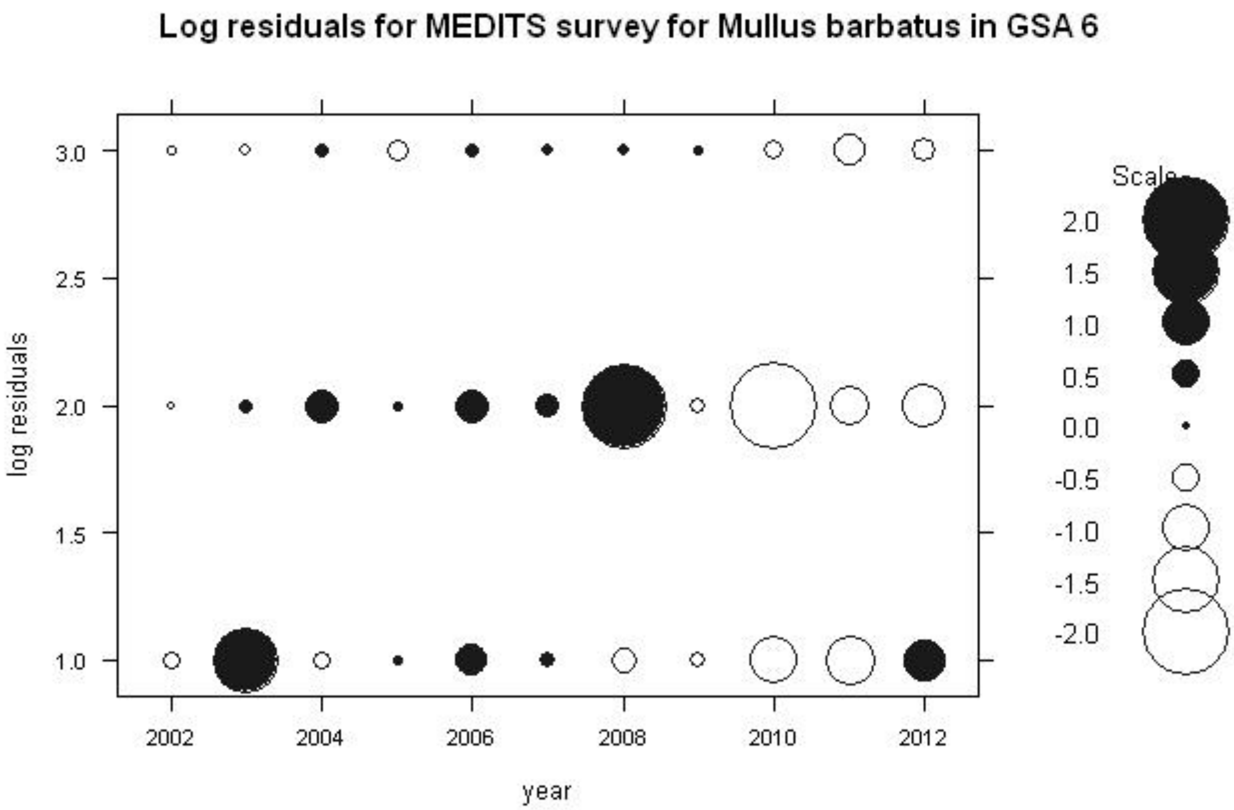



Figure 6.4.4.1.3.2. GSA 6 red mullet. Log catchability residuals of the tuning data used from the MEDITS surveys.

The results of the retrospective analysis (Fig. 6.4.4.1.3.3) show that the results are robust.

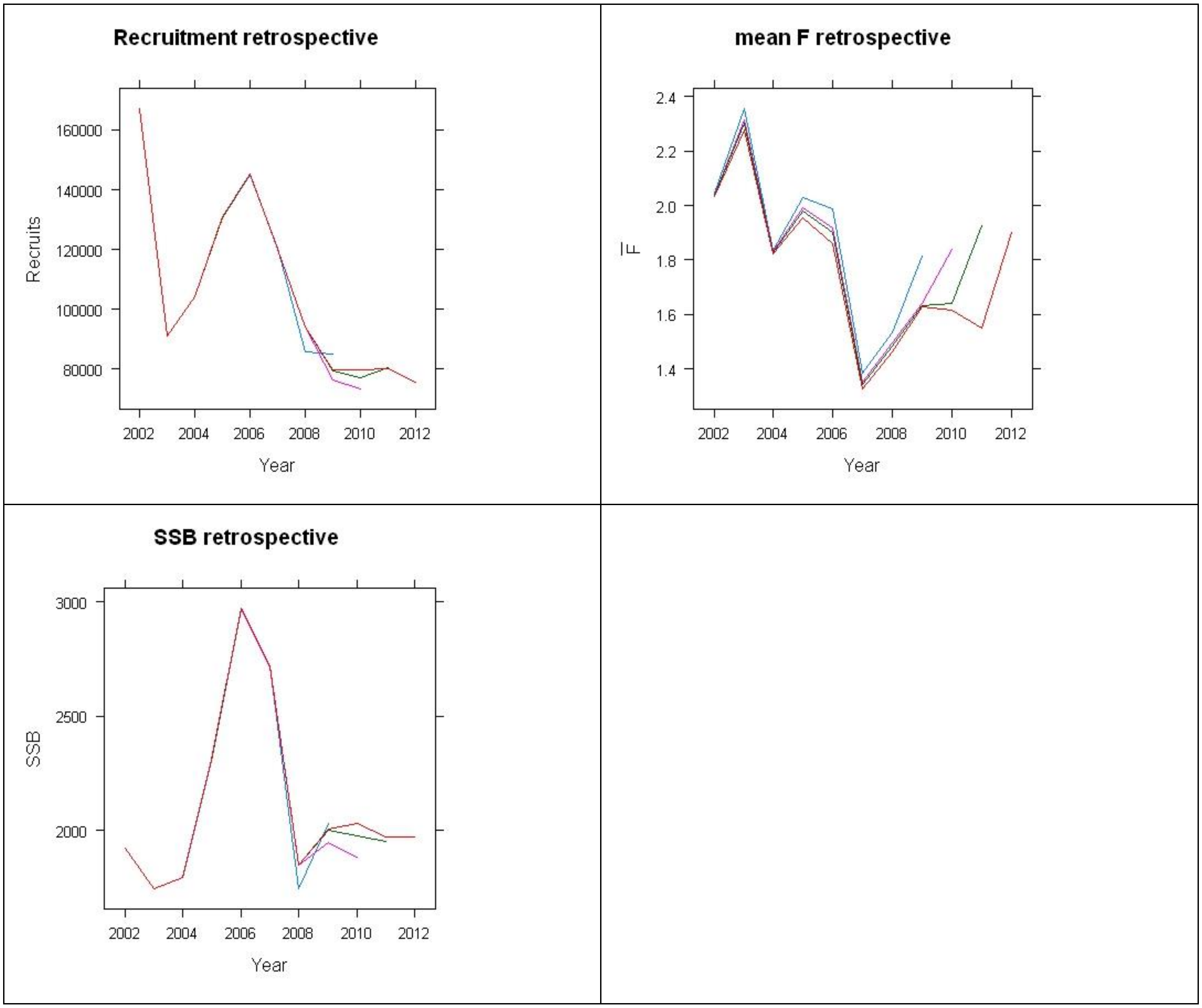



Figure 6.4.4.1.3.3. GSA 6 red mullet: Retrospective analysis.

The following table provides the population parameter estimates of *Mullus barbatus* obtained by XSA:

| year | RECRUITS | TOTALBIO | TOTSPBIO | LANDINGS | YIELD/SSB | Fbar (0-2) |
|---|---|---|---|---|---|---|
| 2002 | 167283 | 2474.8 | 1921.8 | 1333.8 | 0.694037 | 2.0319 |
| 2003 | 91092 | 2359.6 | 1744.7 | 1119.6 | 0.641715 | 2.2773 |
| 2004 | 104352 | 2356.9 | 1795.7 | 1092 | 0.608119 | 1.8227 |
| 2005 | 130893 | 2940.2 | 2309.8 | 1186.4 | 0.513638 | 1.9551 |
| 2006 | 145247 | 3815.9 | 2973.5 | 1662.5 | 0.559105 | 1.8582 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2007 | 120037 | 3596.7 | 2720.7 | 1541.6 | 0.566619 | 1.3262 |
| 2008 | 93950 | 2674.2 | 1849.7 | 1262.5 | 0.682543 | 1.4643 |
| 2009 | 79830 | 2797.2 | 2008 | 1110.3 | 0.552938 | 1.6281 |
| 2010 | 79781 | 2870.9 | 2030 | 1114.9 | 0.549212 | 1.617 |
| 2011 | 80231 | 2792.4 | 1971.7 | 1063.1 | 0.539158 | 1.5523 |
| 2012 | 75635 | 2799.5 | 1972.7 | 1069.9 | 0.542344 | 1.8992 |
| Arithmetic mean | | | | | | |
| | 106212 | 2862 | 2118 | 1232 | 0.586 | 1.767 |
| Units | (Thousands) | (Tonnes) | (Tonnes) | (Tonnes) | | |

No SSB/R relationship could be estimated from these results; for this reason no medium term forecast has been performed.

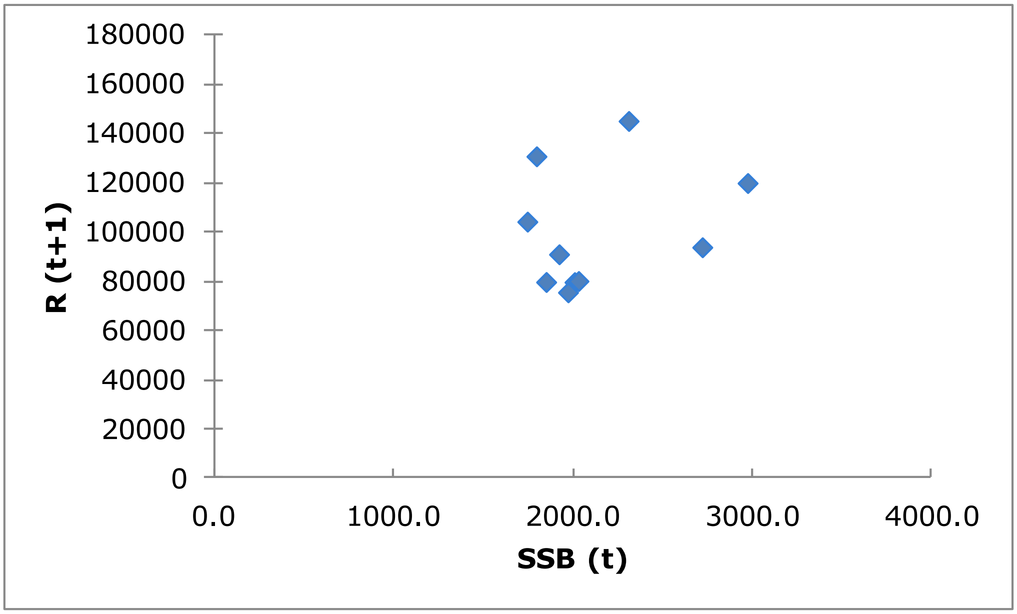



Figure 6.4.4.1.3.4. GSA 6 red mullet. Spawning stock biomass to recruitment relationship.

The XSA results are also shown in Fig. 6.4.4.1.3.5. Fishing mortality has decreased over the period and in recent years is estimated at $F_{bar(0-2)}$ around 1.7. Recruitment shows high values in 2002 and 2005-2007 but in recent years it is at the lowest level in the series. SSB and landings are overall stable, but show a peak in the years 2006-2007, corresponding to the recruitment peak observed in 2005-2007.

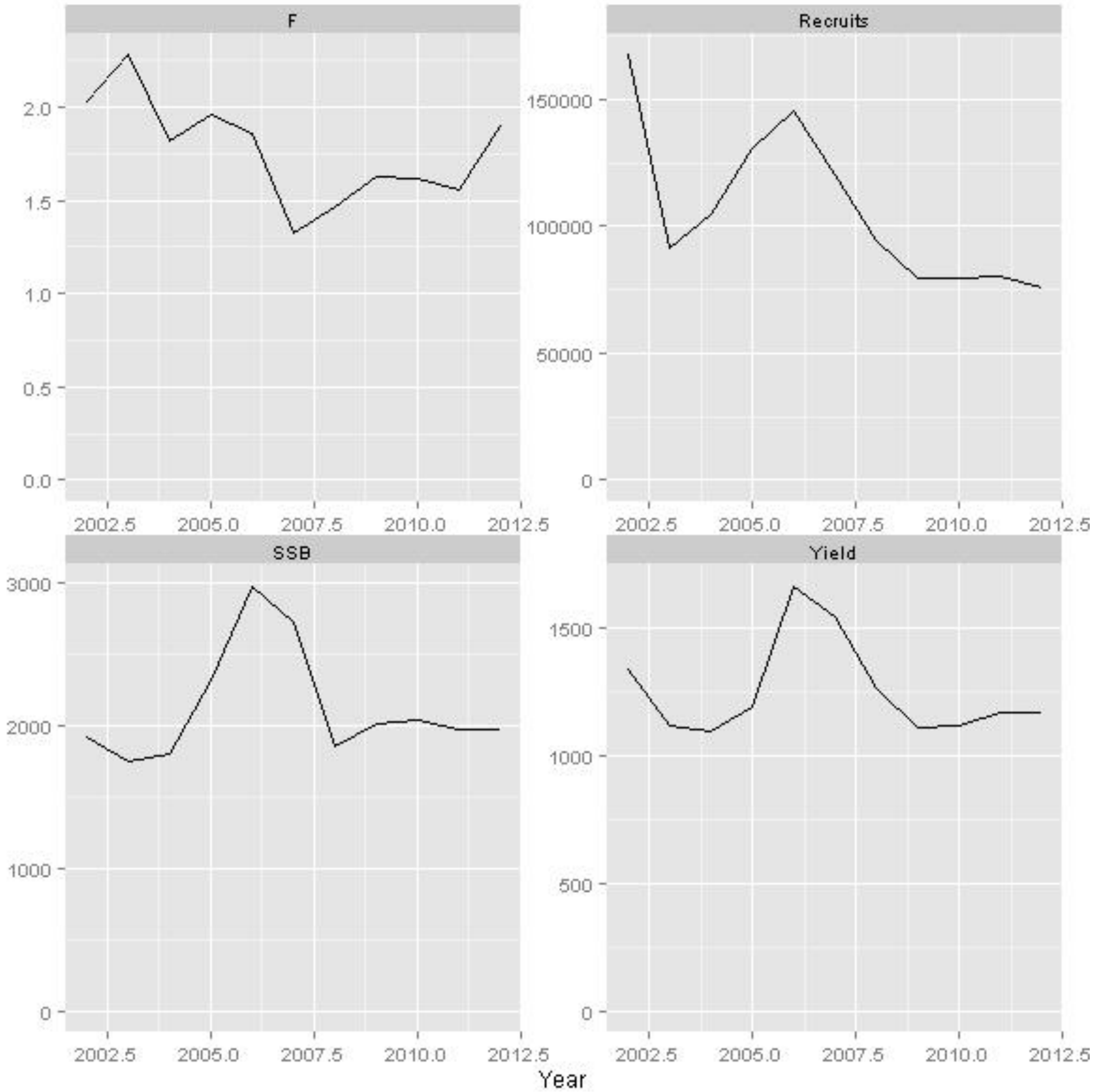



Figure 6.4.4.1.3.5. GSA 6 red mullet. Stock assessment results.

### 6.4.5. **Long term prediction**

Justification

Yield per Recruit (Y/R) analysis was run to estimate the exploitation reference point using NOAA's YPR tool.

Input parameters

F was averaged over ages 0-2. The other input parameters are shown in Table 6.4.5.1.1.1:

Table 6.4.5.1.1.1. GSA 6 red mullet. Input parameters for the Y/R analysis.

| age group | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| stock weight (g) | 0.018 | 0.048 | 0.109 | 0.166 | 0.206 |
| catch weight (g) | 0.018 | 0.048 | 0.109 | 0.166 | 0.206 |
| maturity ratio | 0.460 | 0.760 | 0.880 | 0.930 | 1.000 |
| SSB weights (g) | 0.008 | 0.036 | 0.096 | 0.154 | 0.206 |
| Fishery selectivity at age | 0.500 | 1.000 | 1.000 | 1.000 | 1.000 |
| M | 0.990 | 0.460 | 0.300 | 0.240 | 0.210 |

Results

$F_{curr}$ equals 1.69 and was computed as the mean F over the most recent 3 years (2010-21012). $F_{0.1}$ is 0.45 (i.e. 27% of $F_{curr}$) and Y/R at this fishing mortality would produce 17.1 g/recruit. The maximum yield of 17.6 g/recruit would be obtained at $F_{max}$ = 0.64 (i.e. 37.9% of $F_{curr}$). In the previous assessment carried out in STECF 11-14, a $F_{0.1}$ value of 0.38 was reported, albeit the assessment was based on the “slow growth” hypothesis. The updated value estimated here ($F_{01}$ = 0.45) is in line with the value reported for other *Mullus barbatus* stocks in the Western Mediterranean Sea.

Table 6.4.5.1.2.1. GSA 6 red mullet. Summary indicators of the Y/R analysis.

| | Factor | Absolute F | Y/R (grams) | B/R (grams) | SSB/R |
|---|---|---|---|---|---|
| Virgin | 0 | 0 | 0 | 98.1 | 97.1 |
| $F_{0.1}$ | 0.27 | 0.45 | 17.1 | 38.9 | 32.1 |
| $F_{curr}$ | 1.00 | 1.69 | 14.2 | 10.4 | 7.0 |
| $F_{max}$ | 0.38 | 0.64 | 17.6 | 28.6 | 22.8 |

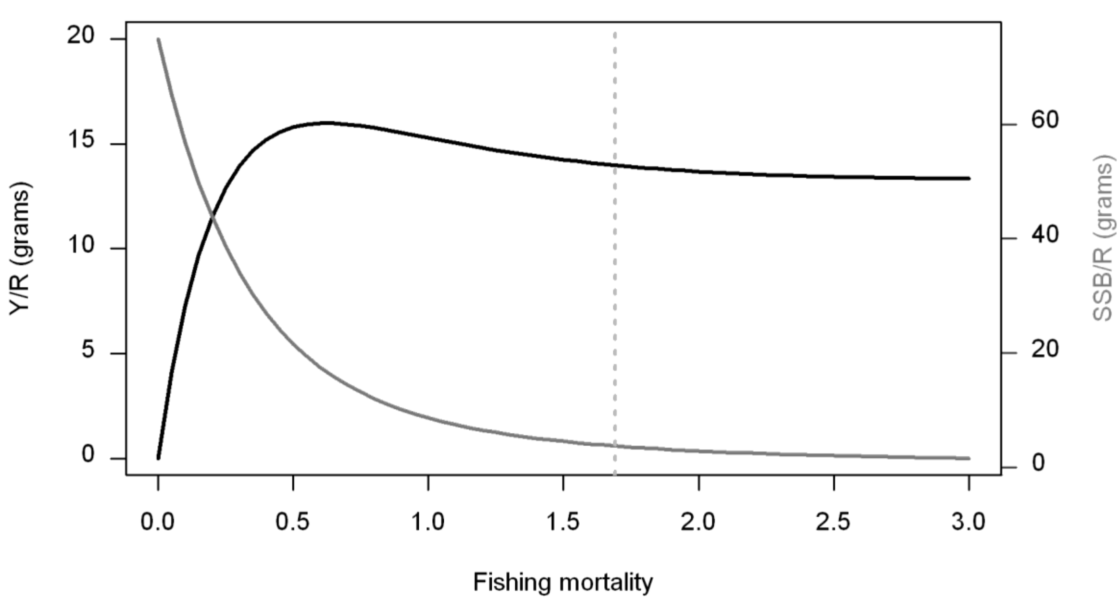


Figure 6.4.5.1.2.1. GSA 6 red mullet. Results of the Y/R anaysis. Vertical dotted line indicates current $F_{(0-2)}$ = 1.69.

### 6.4.6. **Short term prediction 2013-2014**

Input parameters

An average of the last three years has been used for weight at age, maturity at age and F at age. Mortality at age was the same as used as input data in the XSA.

*Recruitment*

Recruitment (class 0+) in 2013 has been estimated as the geometric mean (2010-2012), taken from XSA results = 78 521 (thousands).

A short term projection table (Table 6.5.6.1.1). assuming a current F of $F_{curr}$=1.69 in 2013 and a recruitment of 78 521 thousand individuals shows that:

- Fishing at $F_{curr}$ from 2013 to 2014 would produce an increase in catches of 4.56% and an inappreciable increase in SSB of 0.09% between 2014 and 2015.

- Fishing at $F_{0.1}$ (0.45) from 2013 to 2014 would generate a decrease of 50.38% of the catches and an increase of 15.51% in SSB.

- Catches of red mullet in 2014 does not exceed 578 t, consistent with $F_{0.1.}$=0.45.

Table 6.4.6.1.1. GSA 6 red mullet. Short term forecast for different F scenarios computed for *Mullus surmuletus* in GSA 6. Basis: F(2013) =1.69; R(2013-2015): 78 521 (thousands); SSB(2012)= 1972.72 t; landings(2012)= 1165 t.

| **Rationale** | **F scenario** | **F factor** | **Catch 2014** | **Catch 2015** | **SSB 2015** | **Change SSB 2014-2015 (%)** | **Change catch 2012-2014 (%)** |
|---|---|---|---|---|---|---|---|
| zero catch | 0 | 0 | 0 | 0 | 2591.93 | 30.32 | -100.00 |
| High long-term yield (F0.1) | 0.45 | 0.27 | 578.28 | 999.52 | 2297.39 | 15.51 | -50.38 |
| Status quo | 1.68 | 1.00 | 1218.54 | 1224.44 | 1990.84 | 0.09 | 4.56 |
| Different scenarios | 0.17 | 0.10 | 254.92 | 549.32 | 2460.83 | 23.73 | -78.13 |
| | 0.34 | 0.20 | 461.39 | 867.18 | 2356.03 | 18.46 | -60.41 |
| | 0.50 | 0.30 | 629.35 | 1047.06 | 2271.96 | 14.23 | -46.00 |
| | 0.67 | 0.40 | 766.66 | 1145.54 | 2204.22 | 10.82 | -34.21 |
| | 0.84 | 0.50 | 879.54 | 1196.65 | 2149.36 | 8.07 | -24.53 |
| | 1.01 | 0.60 | 972.92 | 1220.75 | 2104.66 | 5.82 | -16.51 |
| | 1.18 | 0.70 | 1050.72 | 1229.91 | 2067.97 | 3.97 | -9.84 |
| | 1.35 | 0.80 | 1116.03 | 1231.18 | 2037.61 | 2.45 | -4.23 |
| | 1.51 | 0.90 | 1171.31 | 1228.60 | 2012.25 | 1.17 | 0.51 |
| | 1.85 | 1.10 | 1259.25 | 1219.89 | 1972.56 | -0.82 | 8.06 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2.02 | 1.20 | 1294.70 | 1215.57 | 1956.76 | -1.62 | 11.10 |
| | 2.19 | 1.30 | 1325.86 | 1211.71 | 1942.94 | -2.31 | 13.77 |
| | 2.36 | 1.40 | 1353.55 | 1208.39 | 1930.68 | -2.93 | 16.15 |
| | 2.52 | 1.50 | 1378.37 | 1205.58 | 1919.68 | -3.48 | 18.28 |

### 6.4.7. Data quality

Data from DCF 2012 were used. The data available are of sufficient quality to perform XSA. The data submitted to the EWG 13 19 group are in general of good quality. The only important discrepancy for this stock regards the total landings by the fleet, which before 2011 were taken from fishermen's log books and amounted to about 1/3 of the landings reported by the official statistics of the Fisheries Directorates of the Autonomous Governments of Valence and Catalonia. The latter are considered more accurate and were used in the present stock assessment, following the same criterion as in the previous assessment of this stock available (STECF 11 14). Reported discards are negligible, but this needs a more detailed analysis in the future.

The growth parameters of the VBGF used here are different from the previous assessment in STECF 11 14, which were based on length frequencies analysis assuming a slow grow hypothesis. The growth parameter used is here is based on the fast growth hypothesis, in line with the parameters used in other northwestern Mediterranean GSAs (GSA07 and GSA09). The length-weight coefficients used were those recently estimated by the Spanish Data Collection Programme for the years 2011-2012.

### 6.4.8. Scientific advice

Short term considerations

State of the stock size

The SSB in 2012, and the previous 3 years, is stable around the long term average of 2100 t.

State of recruitment

The recruitment estimated for 2012, and the previous 3 years, is stable around 80 000 thousand individuals, although lower than the long term series average. However, recruitment may not be well estimated with the approach presented here because it must be taken into account that age 0 group juveniles (recruits) are not well represented in the commercial landings or in the MEDITS trawl surveys. The 1-year old individuals are already mostly mature and are well represented in the scientific trawl surveys. It must be noted also that the MEDITS data (which mainly concentrates on the spawning fraction of the population because it is carried out in spring) shows a positive trend in the abundance indices (Fig. 6.4.6.1.3.1).

State of exploitation

The size composition of landings indicates that the exploitation is based on young age classes, mainly 0 to 2 year old individuals. Fishing mortality (and effort) should be decreased until fishing mortality is below or at the proposed level $F_{msy}$ (based on $F_{01}$=0.45), in order to avoid future loss in stock productivity and landings. The value is consistent with the $F_{0.1}$ estimated for other red mullet stocks. With the $F_{curr}$ being estimated at 1.69, EWG 13-19 concludes the stock is exploited unsustainably. Trawlers account for about. 90% of the landings. The implementation of the use of the 40 mm square mesh (or 50 mm diamond) in the cod-end (June 2010) may have stopped the decline of red mullet stock perceived in the previous assessment (STCEF 11-14), although the stock remains overexploited.

Management recommendations

STECF EWG 13-19 suggests that catch in 2014 should not exceed 578 t, corresponding to $F_{0.1}$=0.45.

## 6.5. **Stock assessment of sardine in GSA 07**

### 6.5.1. **Stock Identification**

The assessment covers the whole GSA 7 area corresponding to the Gulf of Lions. However, the Gulf of Lions may not correspond to a complete stock unit. Hydrological exchanges between the Gulf of Lions and the Catalan Sea for instance are well known, which should at least affect larval transport and then recruitment of juvenile sardine in both areas. Similarly, part of the young recruited in the Gulf of Lions sardine population may come from larval transport from spawners of the Ligurian Sea. Further, preliminary genetic analyses have shown no differences between Spanish and French stocks of sardines in the North-Western Mediterranean Sea. Finally, the stock is shared between French (trawlers and purse seines) and Spanish (purse seines) fleets. However, due to a lack of specific information about the stock structure of the sardine population in the western Mediterranean, this stock was assumed to be confined within the GSA 07 boundaries in this assessment.

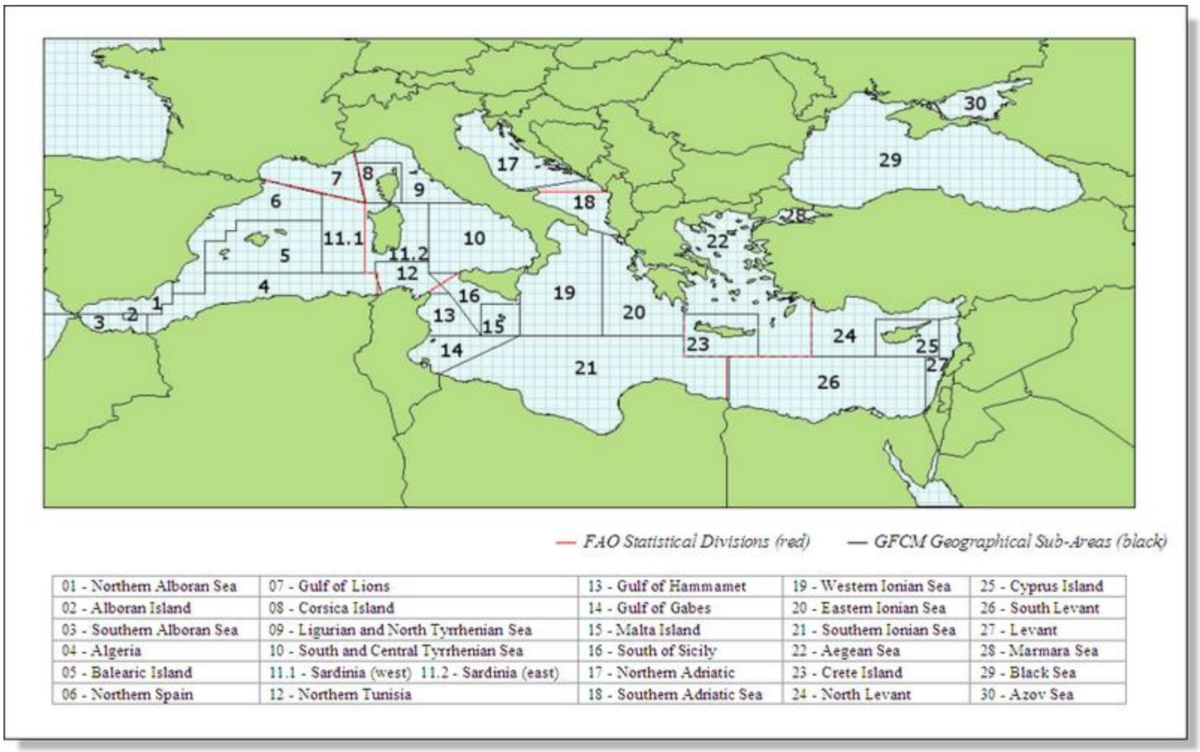



Figure 6.5.1.1.1 Geographical location of GSA 7.

Growth

Growth parameters have been estimated from 5465 otolith readings. A recent analysis of these readings (Van Beveren et al. in prep) has shown the existence of 3 periods with different growth parameters.

Table 6.5.1.2.1.Sardines GSA 7. Growth parameters.

| Period | $L_\infty$ | K | $t_0$ |
|---|---|---|---|
| 2002-2005 | 18.38 | 0.45 | -1.73 |

| | | | |
|---|---|---|---|
| 2006-2008 | 18.88 | 0.56 | -1.64 |
| 2009-2012 | 33.57 | 0.09 | -4.1 |

Note that for the last period, $L_\infty$ is very high, as the diminution in growth rate did not enable us to reach the "plateau". $L_\infty$ is probably lower even in the last period and the results presented here are likely to be biased. However, it is important to notice that number of fish at age were derived directly from otolith readings, so the growth parameters were not directly used in the assessment.

Maturity

We did not compute annual maturity at age, as data was missing in 2008 and was scarce in 2005. Nonetheless, the annual maturity ogives displayed important changes across time. Except for 2012, during the period dominated by small individuals and low growth, sardines seemed to mature earlier. Three different maturity ogives were then used (see table below) using a total of 5440 samples.

Table 6.5.1.3.1. Sardines GSA7. Maturity ogives.

| Period | Age0 | Age1 | Age2 | Age3 | Age4 | Age5 | Age6+ |
|---|---|---|---|---|---|---|---|
| 2003-2008 | 0.123 | 0.849 | 0.959 | 0.992 | 0.998 | 0.992 | 1 |
| 2009-2011 | 0.729 | 0.918 | 0.959 | 0.992 | 0.998 | 0.992 | 1 |
| 2012 | 0.157 | 0.969 | 0.959 | 0.992 | 0.998 | 0.992 | 1 |

Sampled fish came either from scientific survey (PELMED) or from fishermen. Individuals fished at age 0+ are thus the largest of the first age class (i.e. usually larger than 6 or 7cm), so that the % of individuals mature at age 0+ is overestimated.

## 6.5.2. **Fisheries**

General description of fisheries

Both French pelagic trawlers and French and Spanish purse seiners are present in the Gulf of Lions. The Spanish fleet accounts for less than 5% of the sardine landings (according to DCF Data-Call) and is not especially targeting sardine, which appears as a by-catch for Spanish boats. Therefore, we only considered the French fleet in the analyses.

French fleet: Due to important changes in the sardine population structure and growth, the number of boats has been decreasing these last few years and the fleet now contains only 7 trawlers and 3 purse-seiners targeting sardine. As a consequence, the total landings have also been decreasing and are now reaching very low levels (less than 700 t). Most regulations (no fishing activity during the week-end, length of trawlers, etc.) are fully respected, with the exception for the limitation of engine power for trawlers. Usually, sardines were mostly fished by trawlers (~90% of the landings). However, in the past 2 years this trend has been reversed with a decrease in trawler effort, so that most of the sardines (93%) fished in 2012 were landed by purse-seiners.

Management regulations applicable in 2012

- Exclusive license for trawling, with a given number each year (both for small pelagics and demersals) - fully respected
- Limited engine power for trawlers to 318 kW or 430 hp - not respected
- Length of fishing trawlers inferior to 25 meters - fully respected
- Fishing effort limitation :
  - No fishing on Saturdays and Sundays, authorized hours trip: 3.00am to 8.00pm - fully respected
  - Trawling forbidden from coast to 3NM - not fully respected
  - Professional organization regulations: Additional holidays: on average 40 days/year - fully respected

Catches

Landings

Table 6.5.2.1. Sardine GSA 7. Landings from 2003 to 2012.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| Landings | 5095 | 7493 | 9472 | 10381 | 13340 | 6740 | 3620 | 907 | 748 | 635 |

Discards

Discard data are not available and were considered as negligible in the stock assessment.

Fishing effort

Due to important diminution in sardine stock biomass and size distribution, the fishing effort (both in terms of number of boats and number of days at sea) has largely decreased.

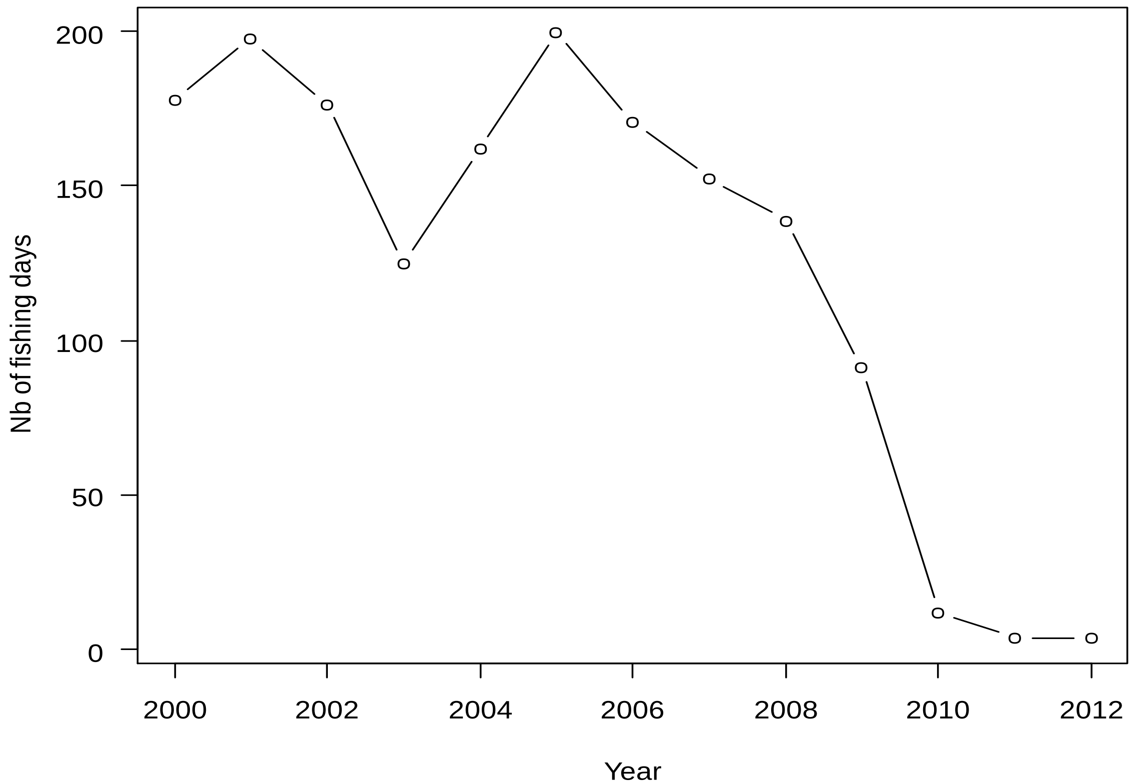



Figure 6.5.2.4.1. Average number of fishing days per month by French pelagic trawlers in GSA 7.

### 6.5.3. **Scientific surveys**

The scientific survey used is an acoustic and trawl-survey that has been conducted every July since 1993. It follows the Mediterranean Acoustic Survey (MEDIAS) protocol.

Methods

Sampling was performed along 9 parallel and regularly interspaced transects (inter-transect distance = 12 nautical miles). Acoustic data were obtained by means of echo sounders (Simrad ER60) and recorded at constant speed of 8 nm.h-1. The size of the elementary distance sampling unit (EDSU) was 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output (Simmons & MacLennan 2005). Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a 30 min-trawl at 4 nm.h-1 in order to evaluate the proportion of each species (by randomly sampling and sorting of the catch before counting and weighing each individual species). While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminarily treated with Movies + software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts.

Geographical distribution patterns

No information on geographical distribution is available at the meeting.

Trends in abundance and biomass

Biomass of sardines has decreased largely after 2006. However, the abundance recovered after the 2006 decrease. The number of sardines is nowadays the highest observed in the time series, while biomass still remains low. This shows important changes in the population demographic structure. Both fish size and mean weight (per size class) have decreased and the proportion of old fish has drastically decreased as well (Van Beveren et al. in prep).

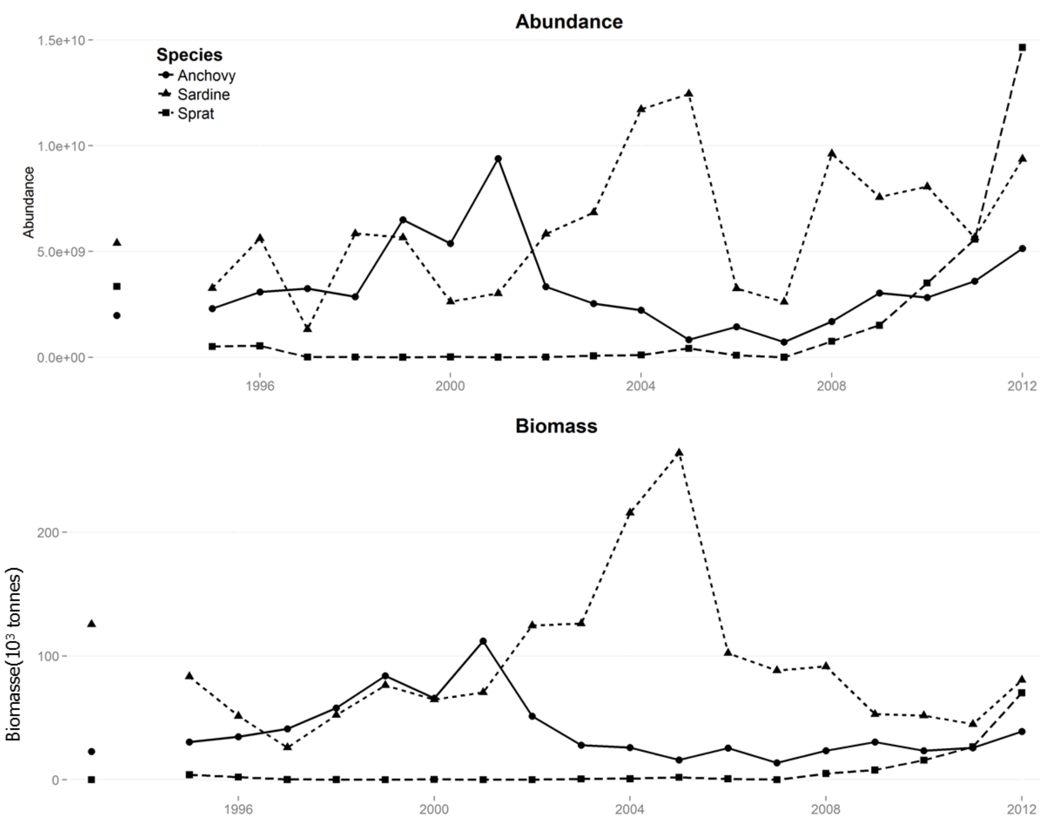



Figure 6.5.3.3.1. Trends in abundance and biomass of the three main small pelagic species.

Trends in abundance by length or age

Recruitment values are high in the last years, while older age classes almost disappeared from the population.

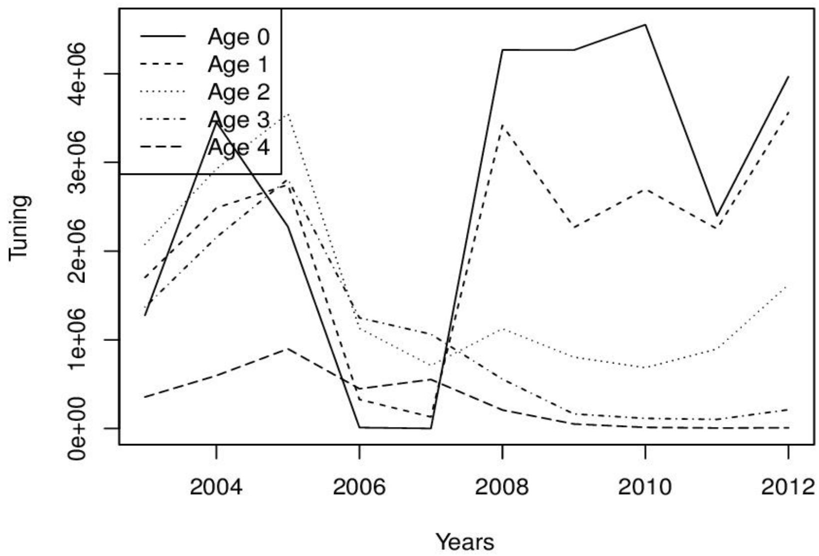



Figure 6.5.3.4.1. Sardines GSA7. Trends in abundance for each age class (Age 4 is Age4+).

### 6.6.3.5 Trends in growth

See 6.5.1.2.

### 6.6.3.6 Trends in maturity

See 6.5.1.3.

## 6.5.4. **Assessments of historic stock parameters**

### 6.5.4.1Method 1: XSA

#### *6.5.4.1.1 Justification*

An attempt of assessment using XSA was made over the period 1994-2012 for age classes from 0 to 4+.

#### *6.5.4.1.2 Input parameters*

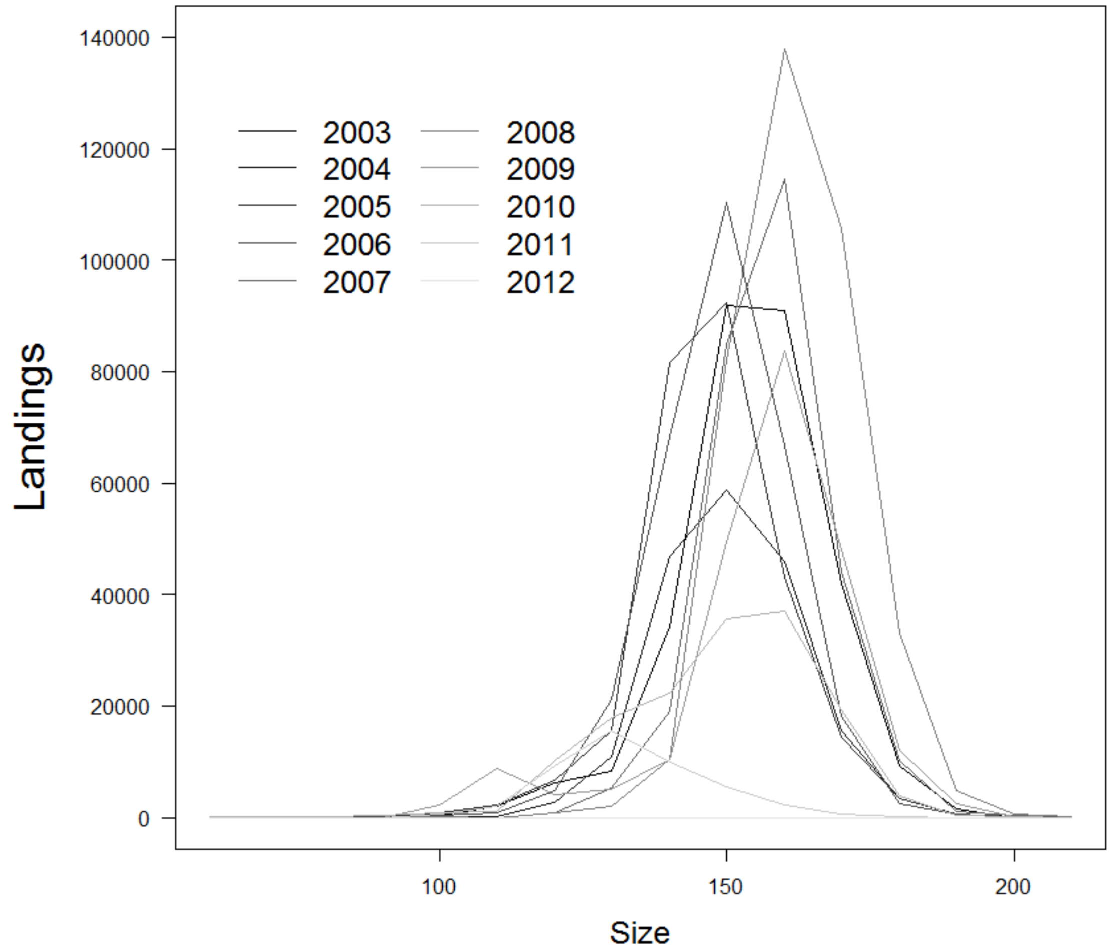



Fig. 6.5.4.1.2.1.Sardine GSA 7. Length distributions of total landings 2003-2012 (all gears combined).

Table 6.5.4.1.2.1. Catch at age for Sardine in GSA 7.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 1332.46 | 5740.64 | 3306.89 | 783.57 | 719.1 | 11456.44 | 1116.62 | 790.46 | 818.14 | 796.32 |
| **1** | 28059.87 | 47810.34 | 44953.02 | 51465.64 | 48447.8 | 37360.82 | 12465.65 | 9782.08 | 7926.17 | 6445.97 |
| **2** | 69513.89 | 105553.92 | 116084.75 | 118791.68 | 151580.28 | 86312.17 | 43822.81 | 21932 | 18970.11 | 17457.52 |
| **3** | 62843.47 | 79647.87 | 101081.12 | 61795.8 | 93447.68 | 49612.44 | 64525.08 | 11189.87 | 8728.78 | 7677.08 |
| **4** | 22679.89 | 21993.04 | 28262.11 | 47369.58 | 83506.75 | 41740.99 | 26687.75 | 1829.86 | 1104.96 | 619.53 |

Table 6.5.4.1.2.2 Weight at age for sardine in GSA 7.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0.0129 | 0.0115 | 0.0134 | 0.0203 | 0.0157 | 0.0099 | 0.0078 | 0.0111 | 0.0089 | 0.0078 |
| **1** | 0.0207 | 0.0227 | 0.0244 | 0.0322 | 0.0305 | 0.0249 | 0.0157 | 0.0159 | 0.0162 | 0.0168 |
| **2** | 0.0256 | 0.0275 | 0.0306 | 0.0365 | 0.0343 | 0.0305 | 0.0202 | 0.0190 | 0.0195 | 0.0193 |
| **3** | 0.0299 | 0.0318 | 0.0352 | 0.0389 | 0.0363 | 0.0325 | 0.0263 | 0.0242 | 0.0242 | 0.0219 |
| **4** | 0.0372 | 0.0409 | 0.0434 | 0.0415 | 0.0390 | 0.0347 | 0.0311 | 0.0296 | 0.0288 | 0.0260 |

Table 6.5.4.1.2.3. Maturity at age for sardine in GSA 7.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0.12261 | 0.12261 | 0.12261 | 0.12261 | 0.12261 | 0.12261 | 0.72864 | 0.72864 | 0.72864 | 0.15741 |
| **1** | 0.8491 | 0.8491 | 0.8491 | 0.8491 | 0.8491 | 0.8491 | 0.91845 | 0.91845 | 0.91845 | 0.96907 |
| **2** | 0.95929 | 0.95929 | 0.95929 | 0.95929 | 0.95929 | 0.95929 | 0.95929 | 0.95929 | 0.95929 | 0.95929 |
| **3** | 0.99214 | 0.99214 | 0.99214 | 0.99214 | 0.99214 | 0.99214 | 0.99214 | 0.99214 | 0.99214 | 0.99214 |
| **4** | 0.99799 | 0.99799 | 0.99799 | 0.99799 | 0.99799 | 0.99799 | 0.99799 | 0.99799 | 0.99799 | 0.99799 |

Table 6.5.4.1.2.4. Natural mortality for sardine in GSA 7 (obtained from Lorenz 1996).

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0.58 | 0.64 | 0.63 | 0.57 | 0.63 | 0.65 | 0.65 | 0.62 | 0.65 | 0.68 |
| **1** | 0.5 | 0.51 | 0.5 | 0.48 | 0.47 | 0.52 | 0.52 | 0.55 | 0.54 | 0.55 |
| **2** | 0.49 | 0.49 | 0.49 | 0.47 | 0.46 | 0.47 | 0.49 | 0.53 | 0.52 | 0.53 |
| **3** | 0.47 | 0.48 | 0.47 | 0.46 | 0.45 | 0.46 | 0.47 | 0.5 | 0.49 | 0.52 |
| **4** | 0.45 | 0.46 | 0.46 | 0.45 | 0.44 | 0.44 | 0.45 | 0.47 | 0.47 | 0.49 |

Table 6.5.4.1.2.5. Tuning indices from PELMED.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 2393522790 | 4980602128 | 4076386494 | 44562838 | 3296651 | 7838230646 | 3731225645 | 3912620736 | 1976326810 | 3311635326 |
| **1** | 1132580363 | 1559453564 | 1711494802 | 731943126 | 308531892 | 705254608 | 2678605038 | 3194769034 | 2522713374 | 3949108824 |
| **2** | 1749315799 | 2614742266 | 2957676756 | 1400846006 | 1050737876 | 588260354 | 869811434 | 791465212 | 1019206736 | 1833934045 |
| **3** | 1156136699 | 1885874985 | 2604082935 | 633436274 | 653484505 | 278294804 | 203671032 | 148835034 | 128144114 | 264767200 |
| **4** | 382162996 | 643228372 | 998040865 | 309385034 | 385628623 | 144881502 | 71665205 | 17631153 | 8939076 | 11217114 |

### *6.5.4.1.3 Results*

The present analysis is the first attempt of an age-structured assessment for sardine in GSA 7. Catch at age was available from age 0 to age 8, but given the small number of individuals in the older age classes towards the end of the series, ages 4 to 8 were aggregated to build a 4+ age class. Sensitivity analyses were carried out to explore which parameter values for shrinkage, years shrinked, ages shrinked and age after which catchability is no longer estimated, were the most suitable. Shrinkage values below 2 were shown to be associated to unrealistically high SSB estimates and were thus ignored, the sensitivity analysis was run on a range of shrinkage values varying from 2 to 5. A shrinkage of 3 was selected as results were stable around this value and SSB estimates were consistent with the direct acoustic estimate for the stock biomass (Figure 6.5.4.1.3.1). However, F estimates were rather low. The years-shrinked parameter was assigned values ranging from 1 to 6 and results showed a low sensitivity to this parameter (Figure 6.5.4.1.3.2). An intermediate value of 3 was selected. Similarly, a reduced sensitivity was found for the ages shrinked that was then set to 3 (Figure 6.5.4.1.3.3). Finally, the age after which catchability is no longer estimated was set at 3, as strong changes were found when this parameter was set at age 2 (Figure 6.5.4.1.3.4). The residuals were overall acceptable as no strong pattern could be detected (Figure 6.5.4.1.3.5) and were very similar regardless of the parameter values for shrinkage, years shrinked; ages shrinked and age after which catchability is no longer estimated (Figure 6.5.4.1.3.6). Finally the retrospective analysis displayed a very strong instability for SSB, mean F and recruitment (Figure 6.5.4.1.3.7). Given the high sensitivity of the results to parameter values, this attempt of XSA analysis will remain an exploratory work to serve as a basis for future assessment.

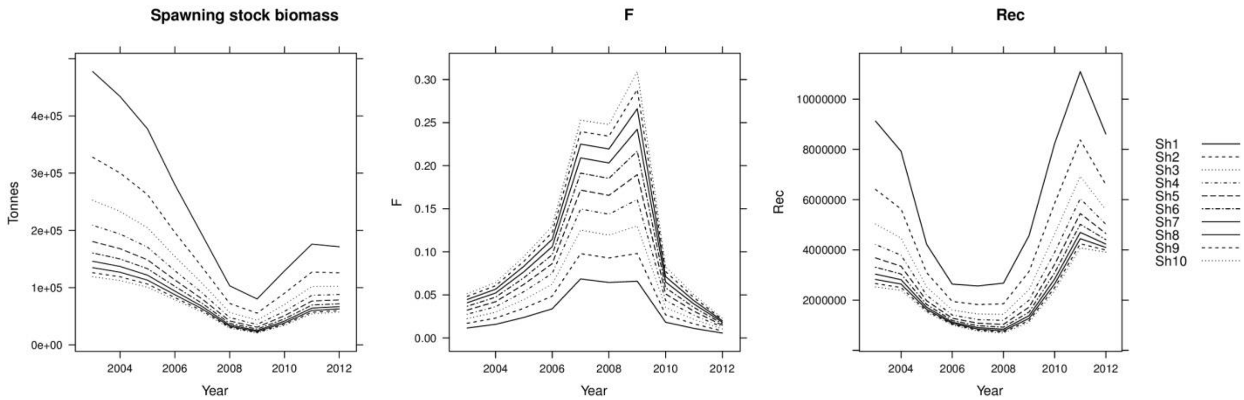



Figure 6.5.4.1.3.1.Sardines GSA7. Sensitivity of spawning stock biomass, fishing mortality and recruitment to shrinkage. Shrinkage values ranged from 2 to 5.

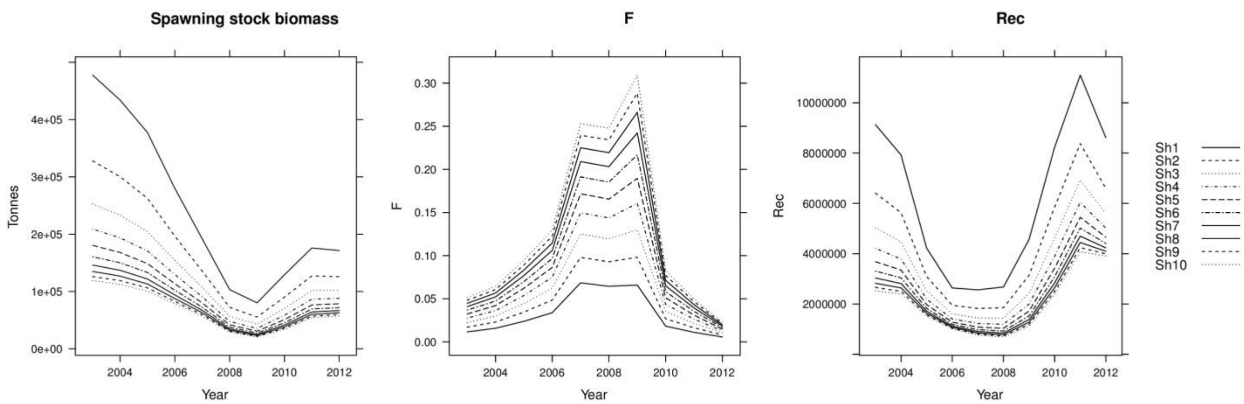



Figure 6.5.4.1.3.2.Sardines GSA7. Sensitivity of spawning stock biomass, fishing mortality and recruitment to the ages shrinked that ranged from 1 to 4.

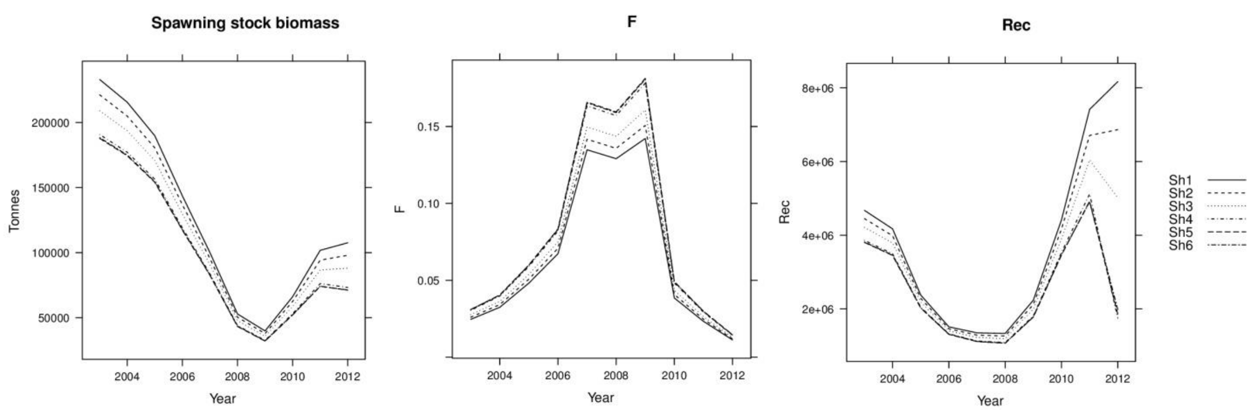



Figure 6.5.4.1.3.3.Sardines GSA7. Sensitivity of spawning stock biomass, fishing mortality and recruitment to the number of years shrinked that ranged from 1 to 6.

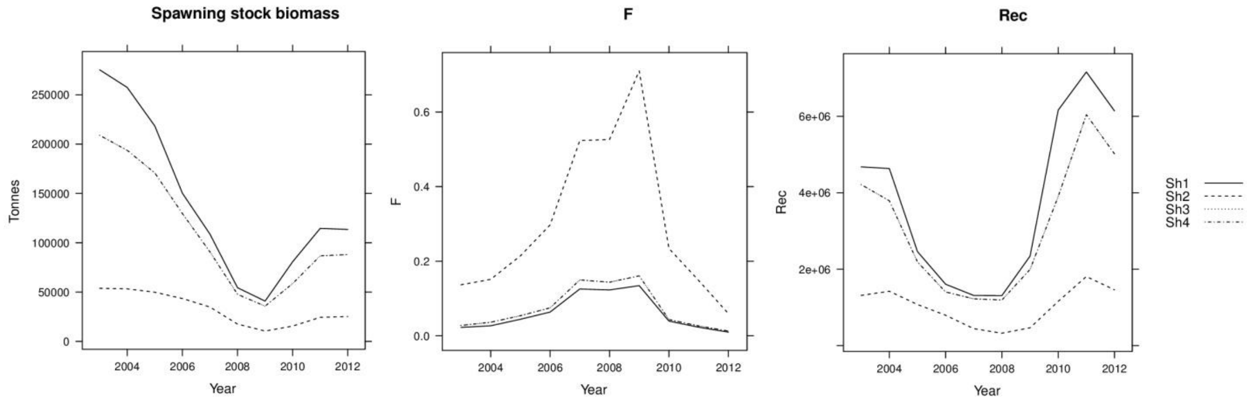



Figure 6.5.4.1.3.4.Sardines GSA7. Sensitivity of spawning stock biomass, fishing mortality and recruitment to the age after which catchability is no longer estimated that ranged from 1 to 4.

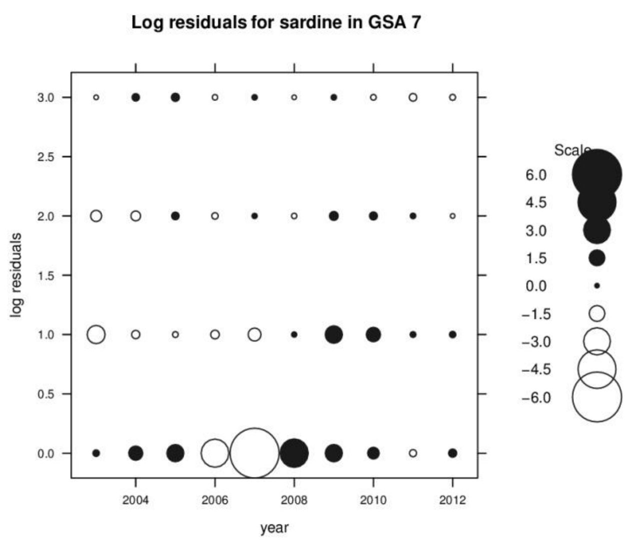



Figure 6.5.4.1.3.5.Sardines GSA7. Log catchability residual plots.

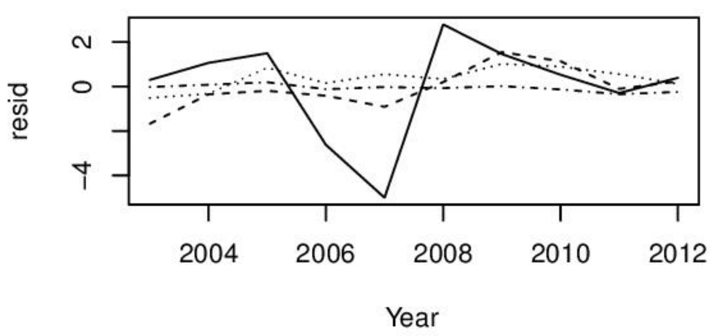



Fig. 6.5.4.1.3.6.Sardines GSA7. General shape of the time series of residuals obtained by age. Only very little departures from these series were observed across the parameter space tested through sensitivity analyzes.

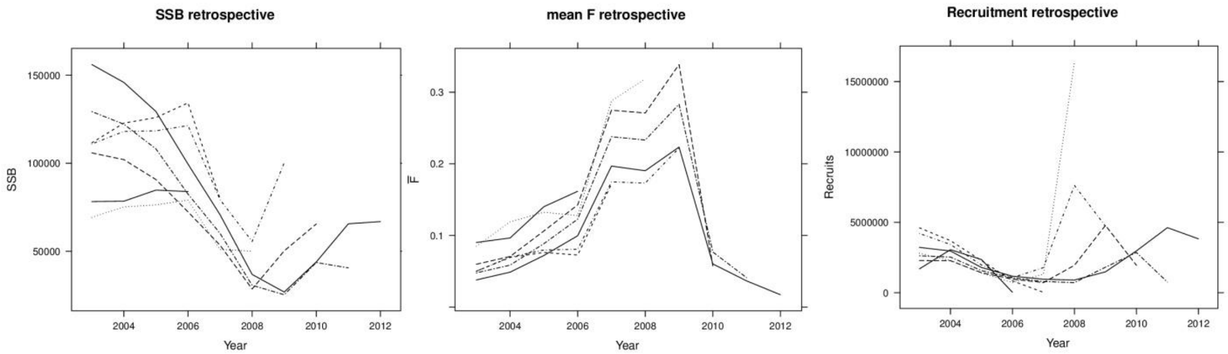



Fig. 6.5.4.1.3.7.Sardines GSA7. Retrospective analysis for SSB, mean F and recruitment.

### 6.5.5.**Long term prediction**

No predictions were carried out due to the instability of the model results.

### 6.5.6.**Short-term prediction 2013-2014**

No predictions were carried out due to the instability of the model results.

### 6.5.7.**Data quality**

In order to compute the VPA, a lot of assumptions had to be done.

1 Age-length keys: Age-length keys were used for the age structure of both the tuning series and the Landings. Age slicing had to be redone to take into account changes in age-length keys over the last years. Therefore, we tested for 2 different scenarios: 1 with a constant age length-key for the entire 10-yr period and another scenario with three different periods. These periods come from Van Beveren et al. in prep, which assessed the demographic structure and condition of sardines from 1993 to 2012.

2 Mean weight of catches: Because revised age-length keys were used in this model, we had to redo the age slicing and mean weight of catches per age computed in the DCF dataset. As we had no access to original individual weights of fishes sampled in landings, we used another biological dataset from IFREMER Sète combining samples from PELMED and MEDITS surveys as well as on individual fish from fishermen. Two different scenarios were tested: 1 global for the entire 10-yr period and 1 with 3 periods (2003-2005/2006-2008/2009-2012). Again, these periods come from Van Beveren et al. in prep, and are the same as the ones used for the age-length keys.

3 Maturity at age: Maturity data were missing in 2008 and scarce in 2005, preventing the use of annual maturity ogives. Yet, looking at available annual maturity data, we observed high inter-annual variability. In particular for the % of age 0 fish mature. The decrease in size observed in sardines seems to have led to a decrease at size at first maturity. Therefore, we tested for 2 different scenarios, one with constant maturity data over years and one with 3 different periods (2003-2008/2009-2011/2012).

4. Discards: No data on discards were available, so that the model was run without taking discards into account (i.e., catches = landings)

5. Natural mortality: According to Lorenzen paper (1996), we estimated natural mortality depending on fish body mass (mean weight at age in catches).

6. Terminal fishing mortality: Similarly, no information was available. We tested different scenario of terminal fishing mortality and ran sensitivity analysis to see how this affected the results.

7. 2012: As stated above in 2012, 93% of the landings were from purse seine. Yet, most samples used to calculate landing size distribution came from trawlers. We had to assume that the size distribution of the catches done by purse seine was similar to those of trawlers.

8. 2011: In 2011, only 4 samples of the landings were available. They were all done in June. This appears to be too scarce to be used, so that no size structure (and no age structure) was estimated for this year. The age structure of the landings was estimated from the mean of the age structure of the 2 adjacent years 2010 and 2012, as both were very similar. Similarly, we had no mean weight per age of catches for 2011. In this case, we used the average of mean weights per age of the catches in 2009-2010 and 2012, as 2009 to 2012 were pooled together in a single period for weight-length relationships.

### 6.5.8. Scientific advice

No advice could be given on the present basis.

## 6.6. **Stock assessment of Sardine in GSA 9**

### 6.6.1. **Stock identification and biological features**

Stock Identification

Due to a lack of information about the stock structure of the sardine population in the western Mediterranean, this stock was assumed to be confined within the GSA 9 boundaries. Studies are needed on the biological stock identification of this species in the Mediterranean Sea.

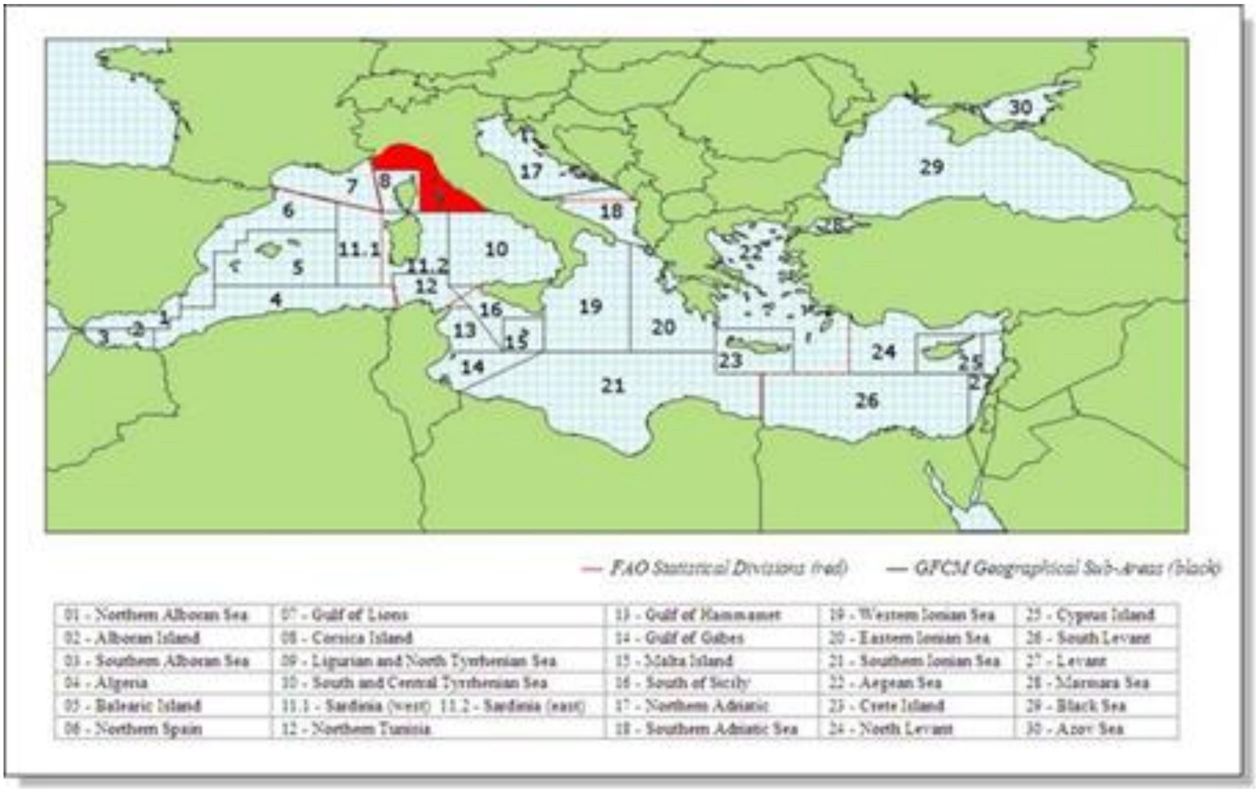



Figure 6.6.1.1.1.Sardine GSA9. Geographical location of the study area (Ligurian and Northern Tyrrhenian seas).

6.6.1.2. Growth

This species can reach the size of 25 cm TL, with a relatively short life cycle (8-12 years), although in the Mediterranean seems more plausible to a maximum age of 8 years (Sinovčić, 2000). This species has a very fast initial growth, reaching sexual maturity at the end of the first year of life (Sinovčić, 1984).

Growth parameters were estimated using data collected within the Data Collection Framework (DCF). The method applied was the von Bertalanffy equation fit to the age (otolith readings) and growth data using nonlinear estimation with minimum least squares.

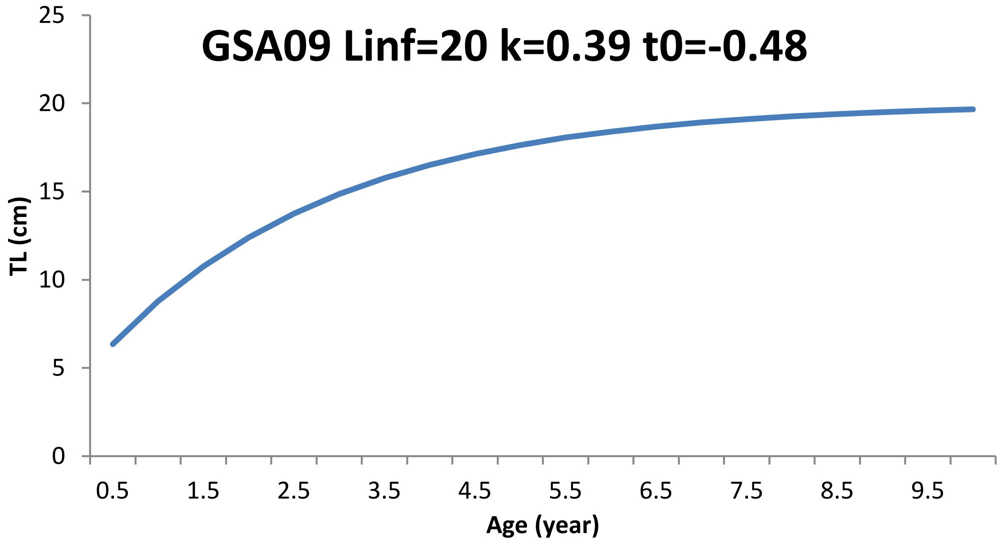



Figure 6.6.1.2.1.Sardine GSA 9. Von Bertalanffy growth function.

6.6.1.3Maturity

Sardines, as most of the clupeidae, is a batch-spawner: females emit groups of pelagic eggs asynchronously, with different ovulations during the breeding season (autumn-winter) (Ganias et al., 2004). In the Mediterranean the breeding season is between October and April (Muzinić, 1954; 1984, Morello and Arneri 2009) and the size of first sexual maturity is 12.5 cm (MedSudMed, 2004).

Reproduction occurs both in the open sea and close to shoreline, producing 50000-60000 eggs with a diameter of 1.5 mm. The larval (so called “bianchetto”) and post larval forms are present in the period between January and March close to the coast.

The hatching of eggs depends strongly on the temperature. In the peak of the breeding season each female lays from 11337 to 12667 eggs (Sinovčić, 1983).

## 6.6.2. **Fisheries**

### 6.6.2.1 General description of fisheries

In the GSA9, sardine is mainly exploited by purse seiners. Due to its low economic value, however, sardine does not represent the main target species for this fleet, while anchovy (*Engraulis encrasicolus*) is the most important species exploited by this fishery. The fishing season starts in spring (March) and ends in autumn (October). Favorable weather conditions and abundance in the catches can extend the fishing activity to the end of November. However, the maximum activity of the fleet is normally observed in the summer. Sardine is also a by-catch in the bottom trawl fisheries. However, the landings yielded by these metiers are very low (about 1%) in comparison to those by purse seiners. Pelagic trawling is not carried out in the GSA9.

Table 6.6.2.1.1. Sardine in GSA9. Contribution of the different fleets (PS Purse Seine and OTB Otter Trawler) to the total landing in tonnes (2006-2012).

| | PS | OTB | Total | % by PS | % by OTB |
|---|---|---|---|---|---|
| 2006 | 4344 | | 4344 | 100.0 | 0.0 |
| 2007 | 5112 | | 5112 | 100.0 | 0.0 |
| 2008 | 2288 | | 2288 | 100.0 | 0.0 |
| 2009 | 5674 | | 5674 | 100.0 | 0.0 |
| 2010 | 4476 | | 4476 | 100.0 | 0.0 |
| 2011 | 2543 | 28 | 2572 | 98.9 | 1.1 |
| 2012 | 1705 | 29 | 1734 | 98.3 | 1.7 |

6.6.2.2. Management regulations applicable in 2012

In Italy, the legal minimum size for sardine is 11 cm (Reg. (CE) 1967/2006), while 14 mm is the minimum mesh size allowed for purse seine and 40 mm squared or 50 mm diamond cod end mesh size for bottom trawl.

6.6.2.3.Catches

6.6.2.3.1.Landings

Sardine landing showed large variation in the study period with a maximum in the 2007 with about 5000 tonnes and a minimum in the last year of about 1700 tonnes. Landings of the trawler were very low about 30 tonnes and were observed only in the last two years (Table 6.6.2.3.1.1 and figure 6.6.2.3.1.1).

Table 6.6.2.3.1.1. Sardine GSA 9. Annual landings (t) by gear (data source: DCR and DCF).

| COUNTRY | AREA | YEAR | GEAR | FISHERY | SPECIES | LANDINGS |
|---|---|---|---|---|---|---|
| ITA | SA9 | 2006 | PS | SPF | PIL | 4344 |
| ITA | SA9 | 2007 | PS | SPF | PIL | 5112 |
| ITA | SA9 | 2008 | PS | SPF | PIL | 2288 |
| ITA | SA9 | 2009 | PS | SPF | PIL | 5674 |
| ITA | SA9 | 2010 | PS | SPF | PIL | 4476 |
| ITA | SA9 | 2011 | OTB | DEMSP | PIL | 28 |
| ITA | SA9 | 2011 | PS | SPF | PIL | 2543 |
| ITA | SA9 | 2012 | OTB | DEMSP | PIL | 29 |
| ITA | SA9 | 2012 | PS | SPF | PIL | 1705 |

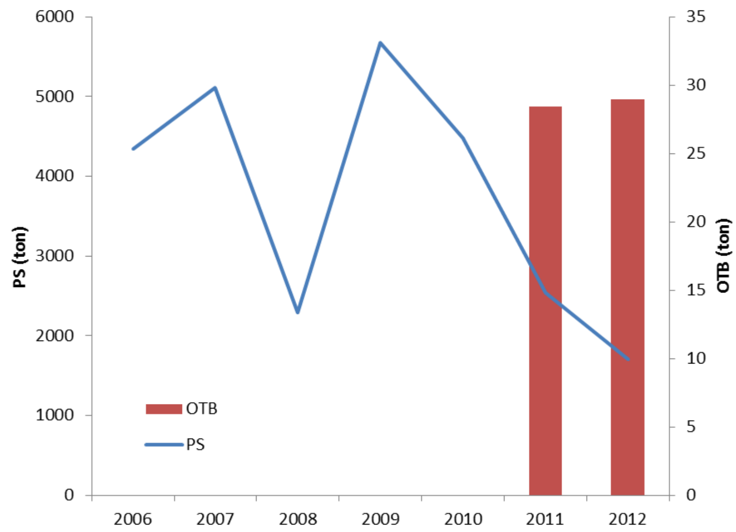



Figure 6.6.2.3.1.1. Sardine GSA 9. Annual landings (t) by gear (data source: DCR and DCF).

In figure 6.6.2.3.1.2 are showed the length frequency distributions by year (all fleets). In 2012 was possible detect in the catch the presence of a large amount of juvenile.

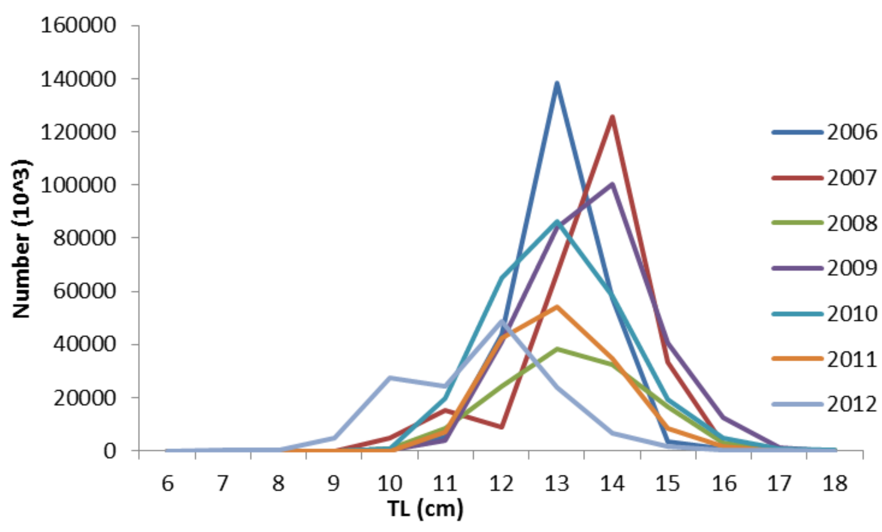



Fig. 6.6.2.3.1.2. Sardine in GSA9. Catch in numbers by length and year (2006-2012).

6.6.2.3.2 Discards

Studies carried out in the framework of the DCF in 2011 showed that discards of sardine by the commercial fleet in GSA9 can be considered as negligible. According to the DCF investigation, in 2011 the discards at sea of sardine in the GSA9 were in term of maximum value by gear around 3 tons by purse seine fishery and 123 tons by demersal otter trawl fishery (Table 6.6.2.3.2.1)

Table 6.6.2.3.1.1. Sardine annual discards (t) by gear (data source: DCR and DCF).

| COUNTRY | AREA | YEAR | GEAR | FISHERY | SPECIES | DISCARDS |
|---|---|---|---|---|---|---|
| ITA | SA9 | 2006 | OTB | DEMSP | PIL | 88 |
| ITA | SA9 | 2010 | OTB | DEMSP | PIL | 22 |
| ITA | SA9 | 2011 | OTB | DEMSP | PIL | 123 |
| ITA | SA9 | 2011 | PS | SPF | PIL | 3 |
| ITA | SA9 | 2012 | OTB | DEMSP | PIL | 11 |

6.6.2.3.3. Fishing effort

The fishing effort, expressed as GT · fishing days, remained quite constant during the investigated period(2006-2012). However, it is worth to recognize that this estimate of fishing effort is relative to the entire purse seine fleet in the GSA9, without any information about the specific targeting effort for sardine.

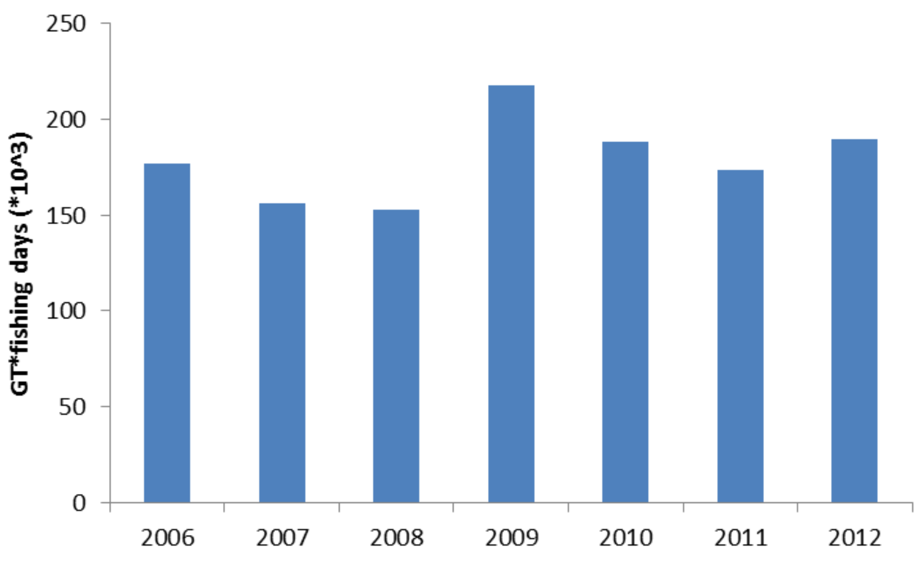


Fig. 6.6.2.3.3.1. Sardine GSA9. Annual total fishing effort (GT · fishing days) of purse seine vessels.

## 6.6.3. **Scientific surveys**

### 6.6.3.1. MEDITS

#### 6.6.3.1.1. Methods

MEDITS surveys were carried out from late spring to mid-summer and the sampling design was always random depth-stratified in respect on five depth strata: 10–50, 50–100, 100–200, 200–500 and 500–800 m. GOC 73 trawl net was used during the surveys. The cod-end mesh size was of 20 mm in MEDITS surveys. Hauls duration was of 0.5 h for the hauls carried out on the shelf (10–200m depth) and 1 h for the hauls carried out on the slope (200–800m depth) fishing grounds. Details of sampling protocol can be found in Bertrand *et al*. (2002).

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA9 the following number of hauls was reported per depth stratum (Tab. 6.6.3.1.1.1).

Tab. 6.6.3.1.1.1. Number of hauls per year and depth stratum in GSA9, 1994-2012.

| STRATUM | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *GSA09_010-050* | *21* | *20* | *20* | *20* | *21* | *20* | *20* | *19* | *15* | *14* | *15* | *16* | *15* | *15* | *16* | *16* | *15* | *15* | *15* |
| *GSA09_050-100* | *21* | *21* | *20* | *20* | *20* | *21* | *22* | *23* | *17* | *18* | *17* | *16* | *18* | *18* | *16* | *16* | *19* | *19* | *19* |
| *GSA09_100-200* | *38* | *40* | *40* | *40* | *39* | *39* | *38* | *38* | *30* | *30* | *30* | *31* | *29* | *30* | *31* | *31* | *29* | *29* | *29* |
| *GSA09_200-500* | *40* | *40* | *42* | *42* | *41* | *41* | *42* | *41* | *32* | *33* | *36* | *35* | *36* | *37* | *34* | *34* | *35* | *35* | *35* |
| *GSA09_500-800* | *33* | *32* | *31* | *31* | *32* | *32* | *31* | *32* | *26* | *25* | *22* | *22* | *22* | *20* | *23* | *23* | *22* | *22* | *22* |
| Total | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to swept area. The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$
$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$
Where:
A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean
The variation of the stratified mean is then expressed as standard deviation:
Confidence interval = Yst ± V(Yst)

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per square kilometers) over the stations of each stratum.

6.6.3.1.2. Geographical distribution patterns

No analyses were conducted during EWG-13-19.

6.6.3.1.3. Trends in abundance and biomass

Fishery independent information regarding the state of sardine in GSA9 was derived from the international survey MEDITS. Figure 6.6.3.1.3.1. displays the estimated trend in *S. pilchardus* density and biomass in GSA9. The estimated biomass indices reveal a clear decreasing trend.

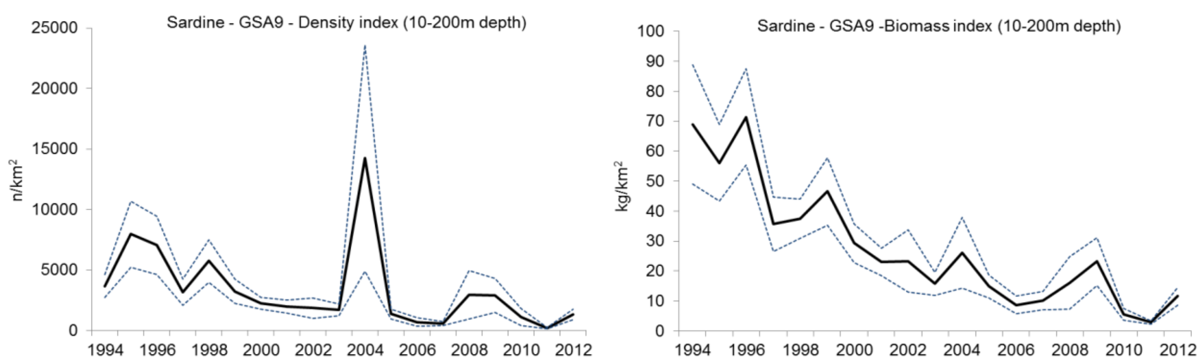



Figure. 6.6.3.1.3. Sardine GSA9. Medits survey trends in density and biomass indexes.

6.6.3.1.4. Trends in abundance by length or age

No analyses were conducted during EWG-13-19.

6.6.3.1.5.Trends in growth

No analyses were conducted during EWG-13-19.

6.6.3.1.6. Trends in maturity

No analyses were conducted during EWG-13-19.

### 6.6.4. **Assessments of historic stock parameters**

6.6.4.1. Method 1: Separable VPA

6.6.4.1.1.Justification

Data provided from DCF at the EWG 13-19 with information on total landings and catch at age of sardine in GSA9 for the years 2006-2012 were used. Despite data available were enough to perform an Extended Survivor Analysis (XSA) the lack of corresponding abundance indexes for the same period, useful for model tuning, led to the decision of consider the opportunity to assess the species using a Separable VPA approach.

6.6.4.1.2. Input parameters

Data from DCF provided at EWG-13-19 containing information on sardine landings and the respective age structure for 2006-2012 were used. A vector of natural mortality value by age was obtained using Gislason method (Gislason et al.,2010).Catch at age, weight at age, mortality at age and maturity at age data for the 2006-2012 period were compiled for age classes 0 to 4+ and used as input data for the Separable VPA. Figure 6.6.4.1.2.1. showed that the catches belonged mainly to age 1 class. Separable VPA was computed for three different scenarios of $F_{terminal}$: 0.3, 0.5 and 0.7 considering as $F_{terminal}$ value 1 and a *Reference age for unit selection*, the first age at which the selection pattern may be regarded as fully recruited and subsequently flat equal to 2. The computation was made by R-project software and the FLR libraries.

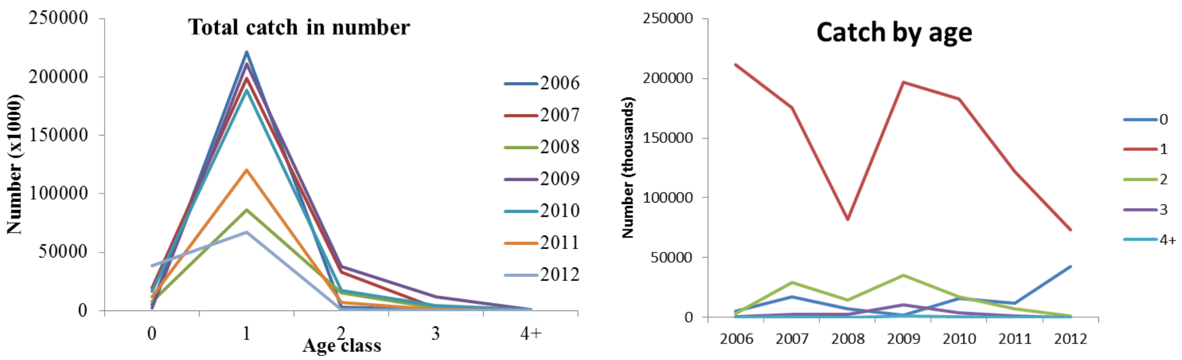



Fig. 6.6.4.1.2.1. Sardine GSA9. Catch in numbers by age and year (2006-2012).

Inputs are reported in the tables below:

Table 6.6.4.1.2.1 Sardine GSA9. Catch in numbers by age per year used in Separable VPA and SOP correction factor.

| | Age | | | | | |
|---|---|---|---|---|---|---|
| Catch in numbers (thousands) by year | 0 | 1 | 2 | 3 | 4+ | SOP |
| 2006 | 5159 | 211466 | 3039 | 785 | 0 | 0.980 |
| 2007 | 16900 | 175344 | 29116 | 2337 | 256 | 1.000 |
| 2008 | 7540 | 82068 | 14514 | 2585 | 52 | 1.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2009 | 2128 | 196406 | 35464 | 10844 | 1041 | 1.000 |
| 2010 | 16059 | 182939 | 16982 | 4072 | 731 | 0.995 |
| 2011 | 11731 | 121757 | 7389 | 1250 | 0 | 0.996 |
| 2012 | 42548 | 73368 | 1367 | 117 | 47 | 0.996 |

Table 6.6.4.1.2.2. Sardine GSA9. Mean weights at age used in Separable VPA (both in catch and stock).

| | Age | | | | |
|---|---|---|---|---|---|
| Weight at age (kg) by year | 0 | 1 | 2 | 3 | 4+ |
| 2006 | 0.0118 | 0.0201 | 0.0300 | 0.0363 | 0.0444 |
| 2007 | 0.0114 | 0.0225 | 0.0300 | 0.0363 | 0.0435 |
| 2008 | 0.0120 | 0.0203 | 0.0300 | 0.0363 | 0.0474 |
| 2009 | 0.0120 | 0.0211 | 0.0300 | 0.0363 | 0.0435 |
| 2010 | 0.0120 | 0.0198 | 0.0300 | 0.0363 | 0.0444 |
| 2011 | 0.0117 | 0.0189 | 0.0295 | 0.0359 | 0.0444 |
| 2012 | 0.0106 | 0.0170 | 0.0295 | 0.0359 | 0.0431 |

Table 6.6.4.1.2.4. Sardine GSA9. Proportion of matures ate age used in Separable VPA.

| Proportion of matures | | | | |
|---|---|---|---|---|
| Age0 | Age1 | Age2 | Age3 | Age4+ |
| 0.5 | 1 | 1 | 1 | 1 |

Table 6.6.4.1.2.5. Sardine GSA9. Vector of natural mortality at age used in Separable VPA.

| Natural mortality | | | | |
|---|---|---|---|---|
| Age0 | Age1 | Age2 | Age3 | Age4+ |
| 2.57 | 1.10 | 0.74 | 0.60 | 0.52 |

Table 6.6.4.1.2.6. Sardine GSA9. Growth and length weight relationships parameters used.

| | Female |
|---|---|
| Linf | 20 |
| K | 0.39 |
| t0 | -0.48 |
| a | 0.007 |

| | |
|---|---|
| b | 3.046 |

6.6.4.1.3. Results

Separable VPA was run setting three different scenarios for *Fterminal*0.3, 0.5 and 0.7. In the following figures are showed the main results.

*Scenario 1: Fterminal 0.7*

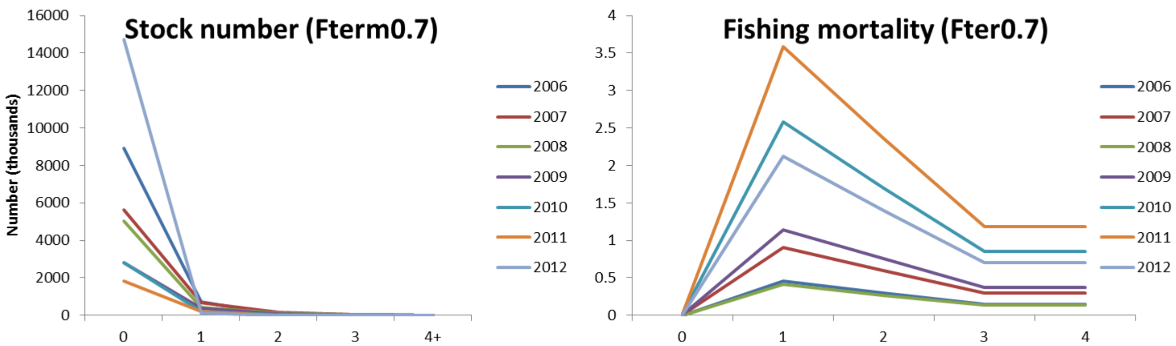



Figure 6.6.4.1.3.1. Sardine GSA9. Stock number and fishing mortality by age (*F terminal* 0.7).

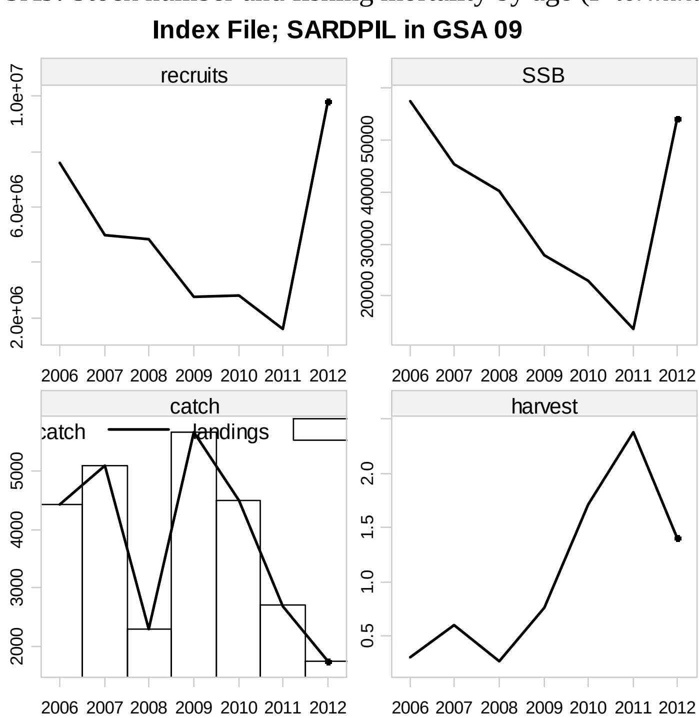



Figure 6.6.4.1.3.2. Sardine GSA9. Main output of the Separable VPA analysis (*F terminal* 0.7).

*Scenario 2: Fterminal 0.5*

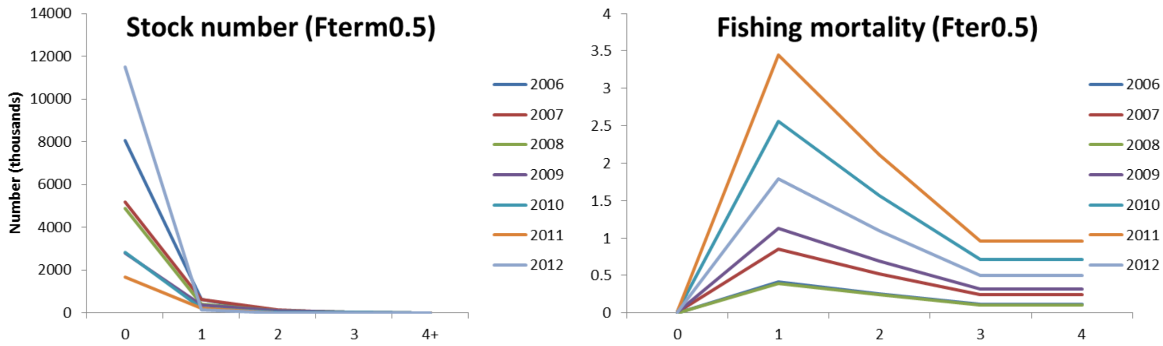



Figure 6.6.4.1.3.3. Sardine GSA9. Stock number and fishing mortality by age (*F terminal* 0.5).

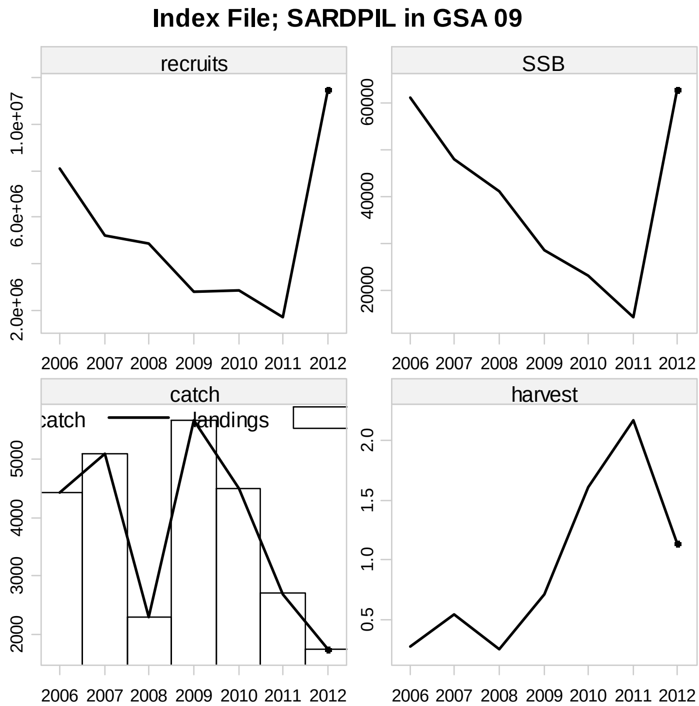



Figure 6.6.4.1.3.4. Sardine GSA9. Main output of the Separable VPA analysis (*F terminal* 0.5).

*Scenario 3: Fterminal 0.3*

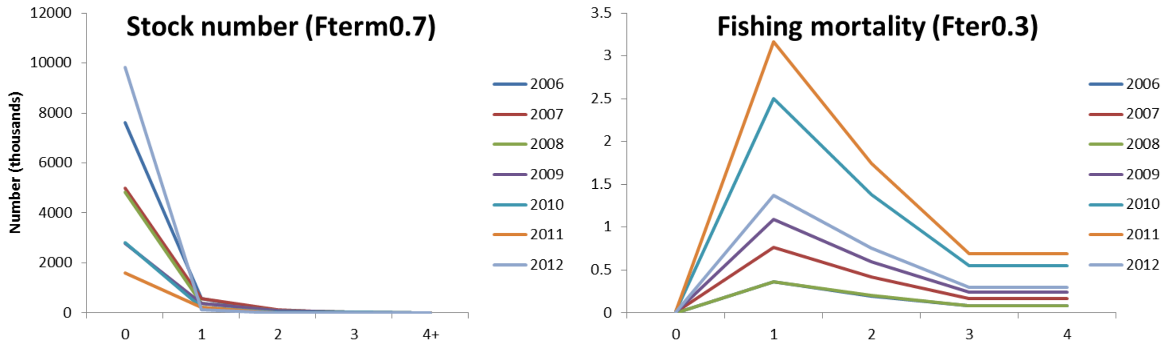



Figure 6.6.4.1.3.4. Sardine GSA9. Stock number and fishing mortality by age (*F terminal* 0.3).

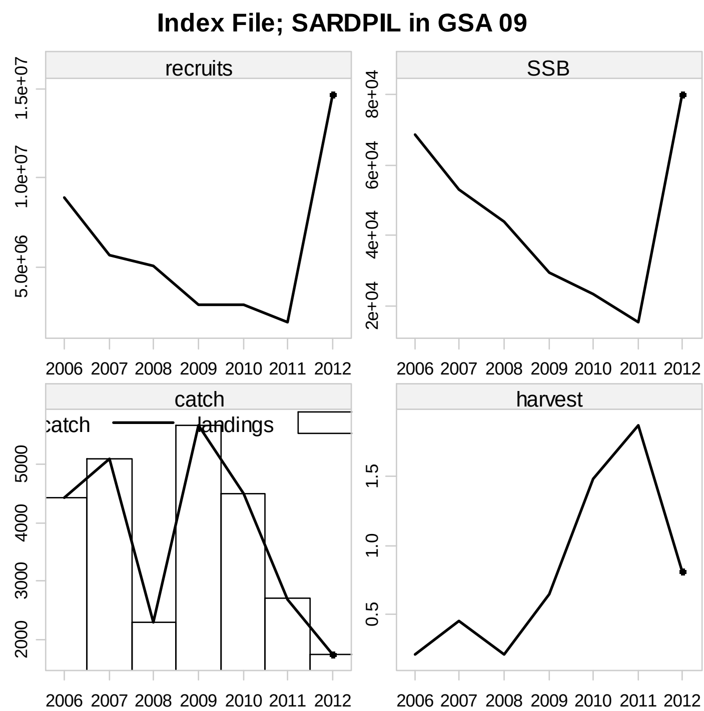



Figure 6.6.4.1.3.6. Sardine GSA9. Main output of the Separable VPA analysis (*F terminal* 0.3).

The three scenarios gave very similar results showing a decreasing trend both in term of recruits than in term of spawners. In 2012 was observed an inversion in the tendency. Harvest, instead, showed a specular trend with an increasing trend followed in the last year of an inversion. Separable VPA outputs can be considered valid only for the estimates of the harvest level while they must be considered only as trend in term of recruits and SSB. The mainly exploited ages were from 1 to 3and for this age range were estimated the corresponding mean $F_{1\text{-}3}$ for each scenarios. These values were used to computed a corresponding value of exploitation rate (E) to compare with Small Pelagics Reference Point E=0.4 proposed by Patterson (1992) (Fig. 6.6.4.1.3.7)

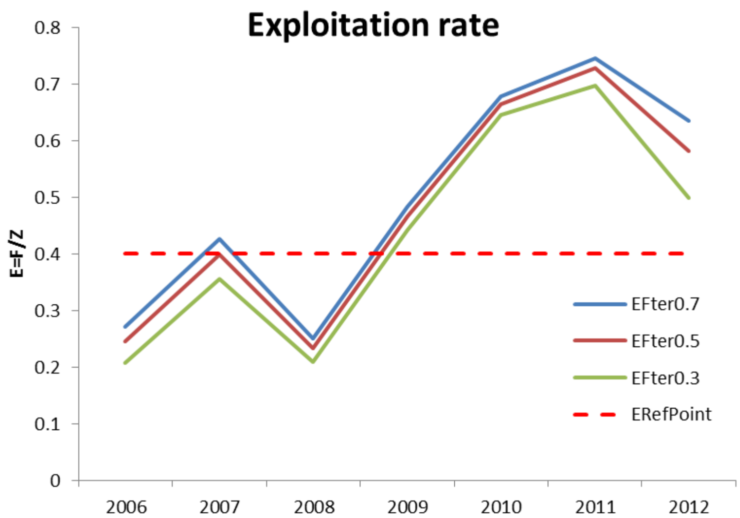



Figure 6.6.4.1.3.7. Sardine GSA9. Trend in the exploitation rate obtained for the three scenarios compare to E=0.4.

### 6.6.5. **Short term prediction 2013-2014**

No analyses were conducted during EWG-13-19.

### 6.6.6. **Medium term prediction**

No analyses were conducted during EWG-13-19.

### 6.6.7. **Data quality**

Data provided from DCF at the EWG 13-19 contained information on total landings and catch at age of sardine in GSA9 for the years 2006-2012. Despite data available were enough to perform an Extended Survivor Analysis (XSA) the lack of corresponding abundance indexes for the same period, useful for model tuning, led to the decision of consider the opportunity to assess the species using a Separable VPA approach.

Tuning data should be derived from the data collected during surveys at sea and in the case of small pelagic species especially with the acoustic survey. It would therefore be wise to plan campaigns also in the GSA9 along the lines of those currently made in other Italian areas (i.e. MEDIAS surveys in the Adriatic Sea and Strait of Sicily).

### 6.6.8. **Scientific advice**

6.6.8.1. Short term considerations

6.6.8.1.1. State of the stock size

Fishery independent information regarding the state of sardine in GSA 9 was derived from the international survey MEDITS in term of estimated trend in density and biomass. The estimated biomass indices reveal a clear decreasing trend. The outputs of Separable VPA confirm this trend also if in the last year the tendency was reversed.

6.6.8.1.2. State of recruitment

Also for the recruits the outputs of Separable VPA showed a decreasing trend from 2006 until 2011. In the 2012 the trend was reversed.

6.6.8.1.3. State of exploitation

Considering E=0.4 as limit management reference point consistent with high long term yields for small pelagic species. The exploitation rate for sardine in GSA9 was higher than the reference point so the stock was considered in overfishing situation. Anyway without an independent source of information especially coming from Echo-survey the results of the present assessment should be considered indicative but not reliable as absolute estimates.

6.6.8.2. Management recommendations

For the relevant fleets'effort exploitation rate should be reduced until fishing mortality is below or at the same level of proposed management reference, in order to avoid future loss in stock productivity and landings.

## Reference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## 6.7. **Stock assessment of striped red mullet in GSA 11**

### 6.7.1. **Stock identification and biological features**

This stock was assumed to be confined within the GSA boundaries (Figure 6.7.1.1.1), but no scientific evidence is available to confirm this hypothesis. Under a management point of view, in the frame of GFCM, it has been decided that, when the lack of any evidence does not allow suggesting an alternative hypothesis, inside each one of the GSAs boundaries inhabits a single, homogeneous stock that behaves as a single well-mixed and self-perpetuating population.

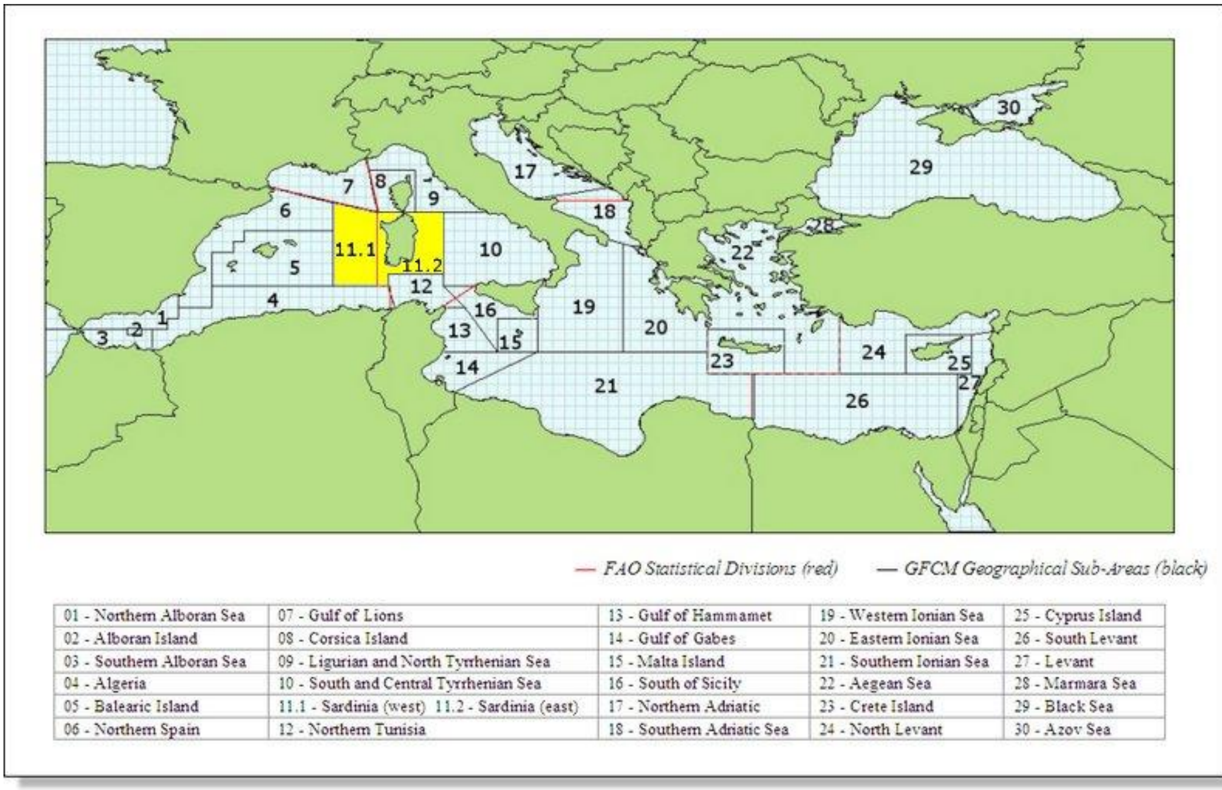



Figure 6.7.1.1.1 Geographical localization of GSA 11.

Striped red mullet (*Mullus surmuletus*) is a demersal species living on a wide bathymetric range, abundant over the coastal stripe, but can be found over and sometime beyond the continental shelf. In GSA11 it is distributed between 0 and 600 m of depth, even though is generally found on shelf bottoms. Generally bigger individuals are found at greater depths, mainly in summer and winter, while smaller ones are found in shallow waters where in summer, after the pelagic phase, they recruit to the bottom becoming very concentrated close to the coast, as the congeneric species *Mullus surmuletus*. In GSA 11 the stock is mainly exploited by the local fishing fleet, both with trawl and net gears. Juveniles showed a patchy distribution with some main density hot spots (nurseries) showing a high spatio-temporal persistence in western and southern areas.

Growth

The striped red mullet shows different growth rates by sex. Females grow faster and can reach a maximum of 40 cm of total length (Tortonese, 1975), while males do not exceed 30 cm. For this specie were observed differences in growth rates depending on geographic areas in some cases due to the use of different methodologies for the estimation of growth parameters (length-frequency analysis or direct reading of scales or otoliths). Recently was held an ICES workshop of reading exercises based on images exchange (ICES, 2009; Mahé et al., 2012) but the results indicated that identification of rings was already difficult.

The Von Bertalanffy Growth Function (VBGF) parameters available for this species in the GSA 11 are presented below (table 6.7.1.2.1) and the growth curve is illustrated on Figure 6.7.1.2.1.

Tab. 6.7.1.2.1. References of the Von Bertalanffy growth function parameters of *Mullus surmuletus* in the GSA 11.

| method | sex | Linf | k | $t_0$ | reference |
|---|---|---|---|---|---|
| Length frequency | F | 38.71 | 0.21 | -1.57 | Pesci (2006) |
| Length frequency | M | 31.91 | 0.25 | -1.67 | Pesci (2006) |

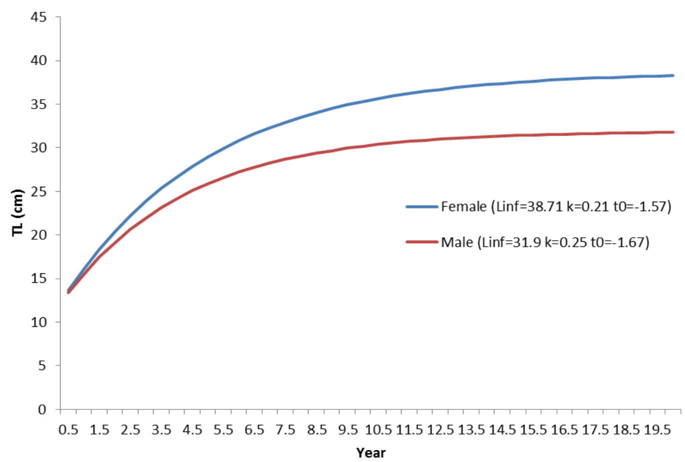



Figure 6.7.1.2.1. Striped red mullet GSA11. Von Bertalanffy growth function by sex.

The asymptotic length estimated from LFDA confirm that females growth bigger and faster than males. Using these parameters the species reaches 50% of its total size within one year and half, thus for the assessment it should be treated as fast growing.

Maturity

Larvae and post-larvae are pelagic until a maximum of 65 mm of total length, when they acquire the characteristic adult color pattern (Lo Bianco, 1909). Reproduction occurs from April to June (Lo Bianco, 1909, Desbrosses, 1935; Morales-Nin, 1991; Vassilopoulou e Papaconstantinou, 1992), but some authors have hypothesized an extension of this period (Arnaldi, 1990). The size at first maturity was between 13 and 15 cm of total length for males and from 15 to 18 for females (Gharby & Ktari, 1981b; Arnaldi, 1990; Carbonell *et al*., 1995; Reñones *et al*., 1995).

### 6.7.2. **Fisheries**

General description of the fisheries

Striped red mullet (*Mullus surmuletus*) is one of the most important demersal target species for the commercial fisheries in Sardinia (GFCM-GSA11). In this area striped red mullet is exploited by trawlers and gillnetters, which operate near shore. Particularly, during the period of post-recruitment (August-October), small trawlers target this species on shallower waters, near the cost.

According to official statistics the total annual landings for all species during the period 2011-2012 was on average around 3700 tons of which *Mullus surmuletus* constituted about the 9.8 %.

In the GSA 11, the trawling-fleet has remarkably changed from 1994 to 2004. The change has mostly consisted of a general increase of the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA a decrease of 20% for the smaller boats (<30 GRT), which principally exploit this species, has been observed.

Management regulations

As in other areas of the Mediterranean, the stock management is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06).

Two small closed areas were also established along the mainland (west and east coast respectively), although these are finalized to protected mainly lobsters.

Since 1991, a fishing ban for trawling 45 day was have been almost every year enforced in different periods for the small scale fishery (march, TSL<=15 m) and for the larger vessels, mostly trawlers (September, TSL<15 m).

Furthermore, (2006) the closure was recently differentiate also considering the different coasts (west and east mainly) with a shift of 15 day of the fishing ban period. Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

Catches

Landings

It is worth of note that no landing information are available before 2011. For *M. surmuletus* in the majority of the Mediterranean GSAs landings records are available regularly at least from 2006, and in some areas since 2002 (Figure 6.7.2.3.1.1). The EWG 13-19 was not able to know if the lack of information in GSA11 is due a problem on the data collection program or due to a misreporting.

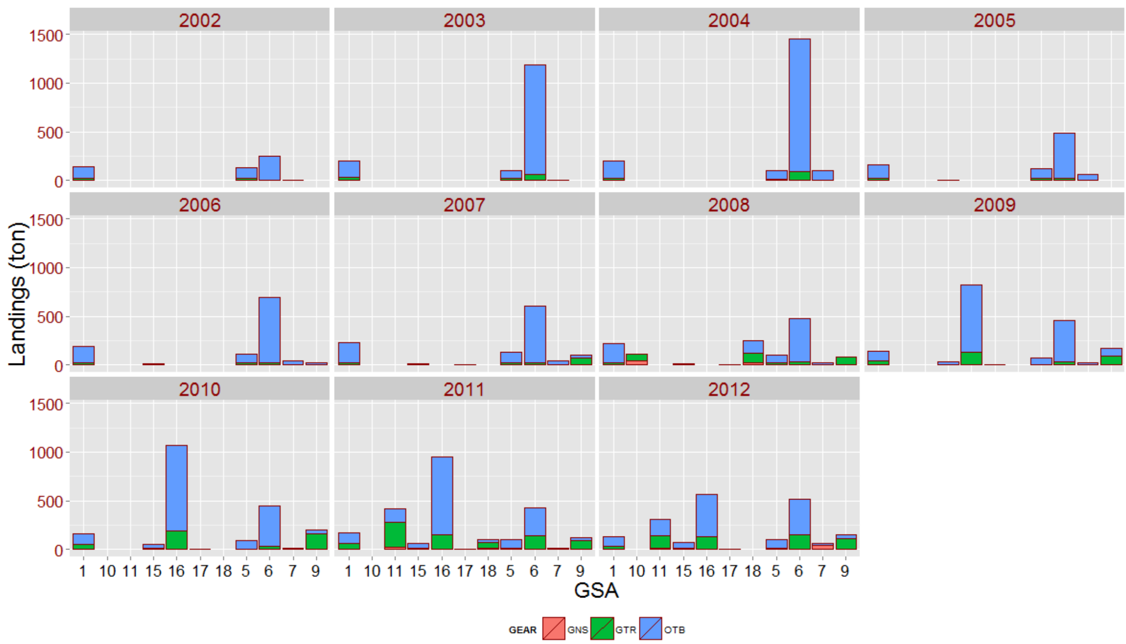


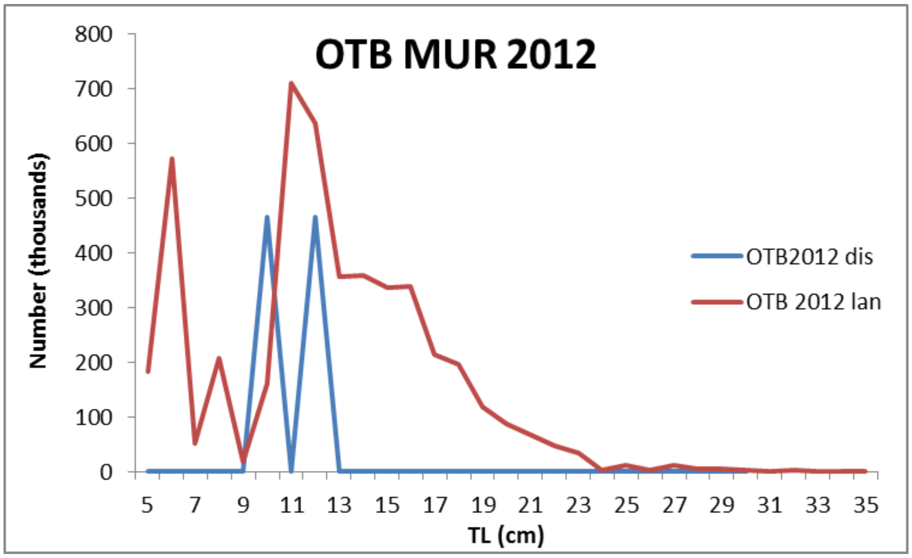

Figure 6.7.2.3.1.1. Striped red mullet. GSA's comparison of landings (OTB, GTR and GNS).

From the available information (DCF data, 2013) striped red mullet landings of GSA 11 come mostly exclusively from bottom trawlers (OTB) and trammel nets (GTR). The OTB fleet landed around the 33% and the 54% in 2011 and 2012 respectively. The gill nets (GNS) landings account yearly for about the 5% of the total.

The following table shows the annual landings (t) by gear (DCF data, 2013):

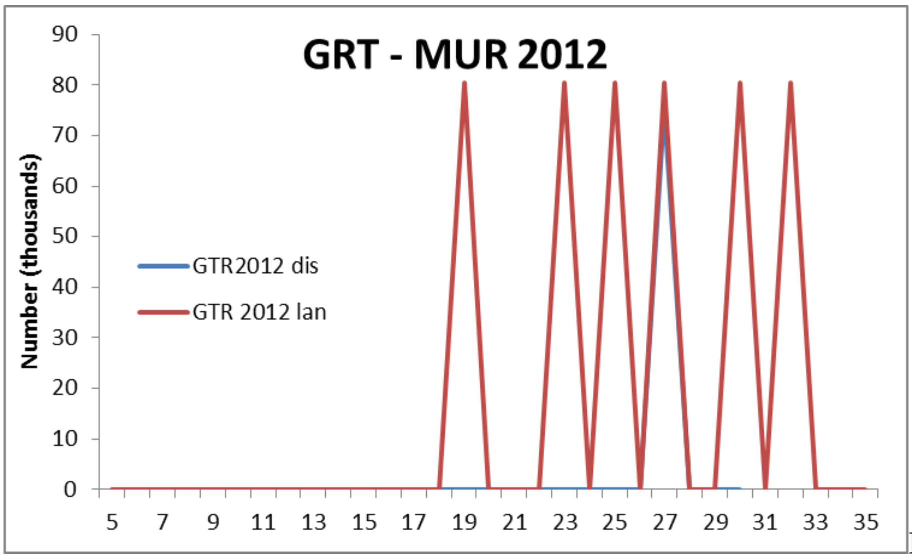
| Gear | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| **OTB** | | | | | | | 136.0 | 165.9 |
| **GTR** | | | | | | | 257.5 | 128.1 |
| **GNS** | | | | | | | 22.7 | 15.6 |

Catch data at length clearly shows issues in the raising procedure particularly for GTR and GNS (Figure 6.7.2.3.1.2).



OTB MUR 2012
Number (thousands)
800
700
600
500
400
300
200
100
0
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
TL (cm)
OTB2012 dis
OTB 2012 lan


A



GRT - MUR 2012
Number (thousands)
90
80
70
60
50
40
30
20
10
0
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
GTR2012 dis
GTR 2012 lan


B

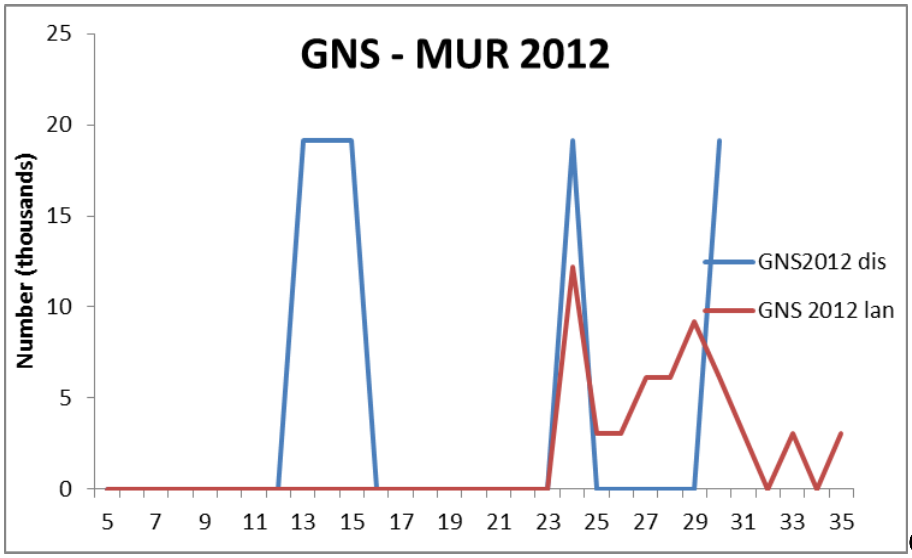


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Figure 6.7.2.3.1.2. Striped red mullet GSA 11. Length frequency distributions of landings and discards (OTB, GTR and GNS).

Discards

The table 6.7.2.3.2.1 report the annual discards (t) by gear (DCF data, 2013). It shows that discards data was not available since 2011.

Table 6.7.2.3.2.1. Striped red mullet GSA 11. Discard data (t) by fishing gear as reported through the DCF data call.

| Gear | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| OTB | | | | | | | 367.5 | 15.7 |
| GTR | | | | | | | 106.2 | 20.7 |
| GNS | | | | | | | 0 | 12.7 |

In 2011 the percentage of discards was incredibly high for this specie, which generally has low discards (Table 6.7.2.3.2.2, Figure 6.7.2.3.2.1). In 2012 discards were less than 14% for the GTR and OTB fleets, but around 45 % for the gillnets (0% in the 2011).

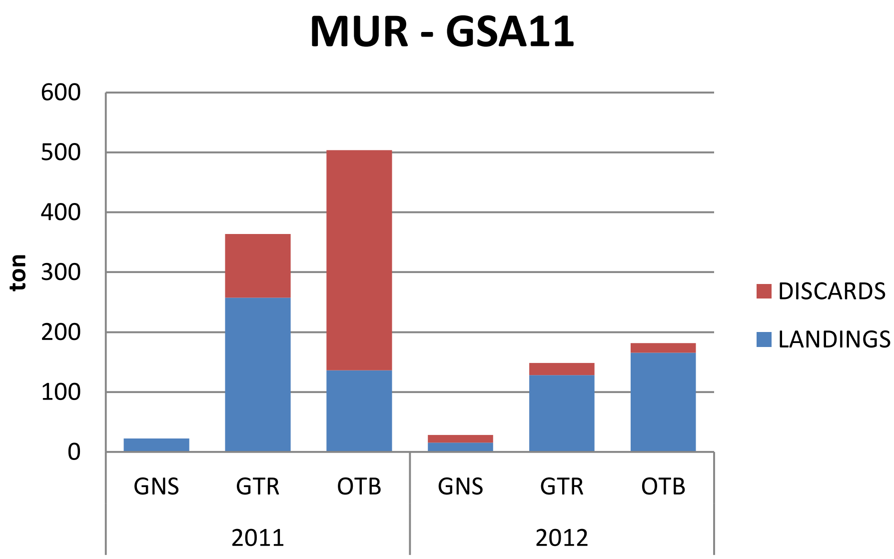



Figure 6.7.2.3.2.1. Striped red mullet GSA 11, catch composition by gear.

Table 6.7.2.3.2.2. Striped red mullet GSA 11, percentage of discard in catches (by gear).

| | % discard | | |
|---|---|---|---|
| **YEAR/GEAR** | **GNS** | **GTR** | **OTB** |
| 2011 | 0.0 | 29.2 | 73.0 |
| 2012 | 45.3 | 13.9 | 8.6 |

The EWG 13-19 compare discards of *M. surmuletus* among the Mediterranean GSAs and note that GSA11 values are much higher than the other GSAs (Figure 6.11.2.3.2.2). Having no access to raw data it is difficult to evaluate if this information is real or represent factual mistakes.

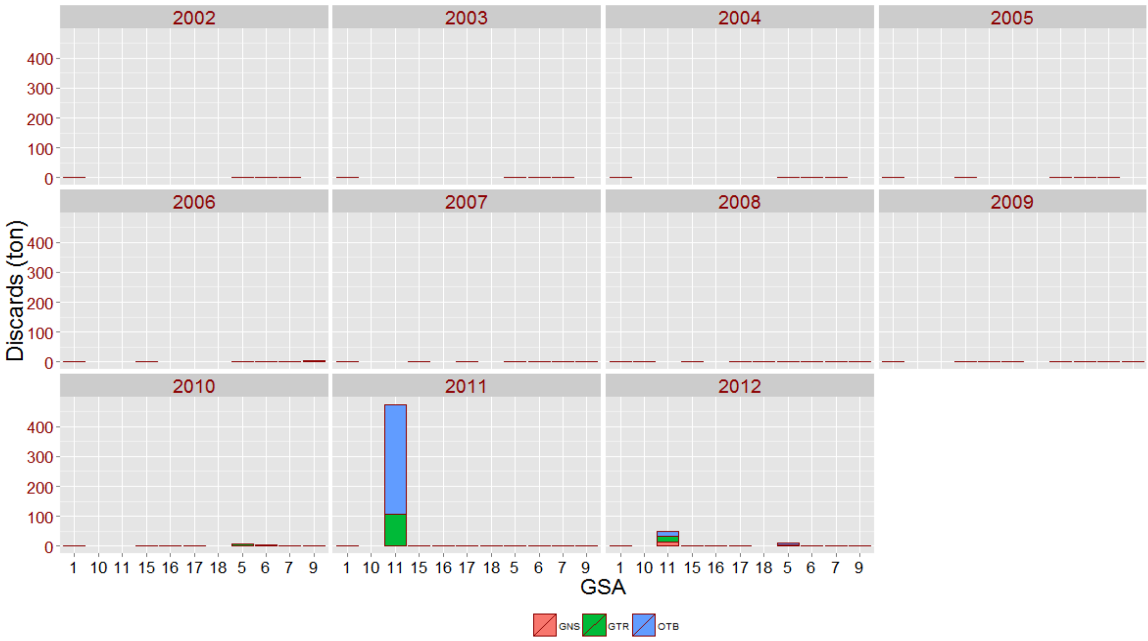



Figure 6.7.2.3.2.2. Striped red mullet: GSA's comparison of discards (OTB, GTR and GNS)

Checks of discards at length shows that samples seem to be insufficient and raised improperly (see Figure 6.7.2.3.2.1). Also these data stress the need of improving data collection in GSA 11.

Finally the comparison between the length structure of OTB commercial catches and survey highlights that landing and discards seems to be unreliable (Figure 6.7.2.3.2.3).

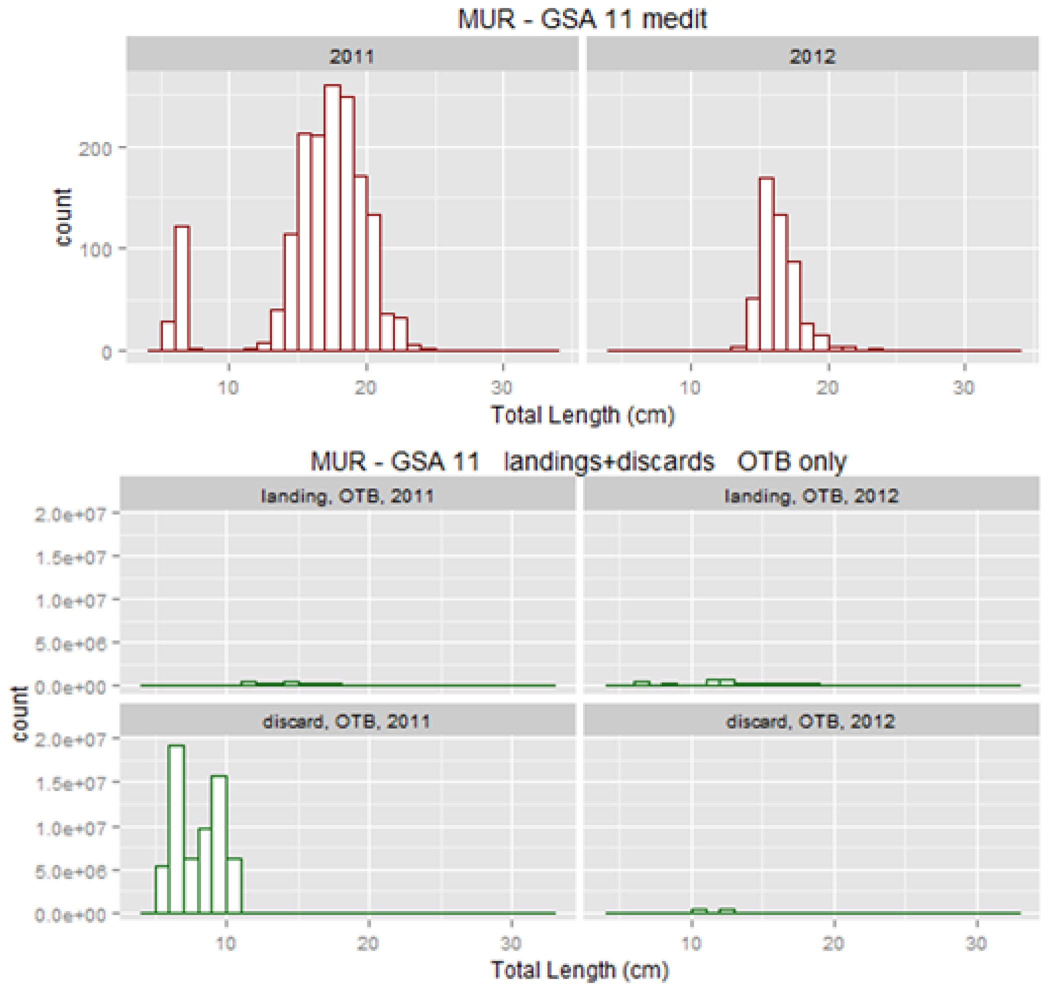



Figure 6.7.2.3.2.3. Striped red mullet GSA 11: Comparison of Length frequency distributions of commercial data (OTB) and independent data (MEDITS survey).

Fishing effort

Using data available to EGW-13-19, the fishing effort by year and major gear type was calculated (Figure 6.7.2.3.3.1).

The analysis shows a major drop of total fishing effort from 2007 onwards, when effort decrease both for trawlers and small scale fishery (reduction of 25 and 31 % respectively). In the last three years, the total effort was almost stable, even if a minor increase in the small scale fishery did occur.

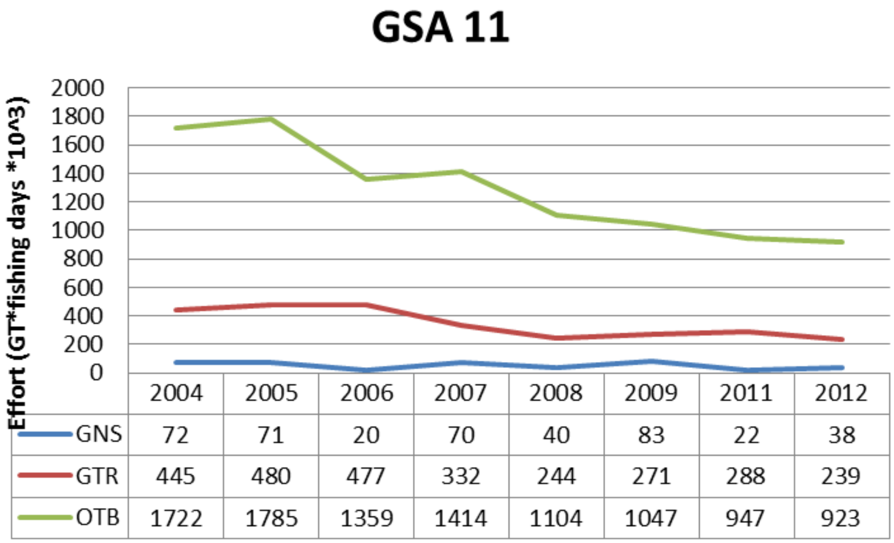



Figure 6.7.2.3.3.1. Trend in fishing effort (kW·days) for the Italian fleet in GSA 11 for the major gear types in 2004-2012.

## 6.7.3. **Scientific surveys**

MEDITS

Methods

Since 1994, MEDITS trawl surveys has been regularly carried out each year during the spring season. In GSA 11 the following number of hauls was reported per depth stratum (Table 6.7.3.1.1.1).

Table 6.7.3.1.1.1. Number of hauls per year and depth stratum in GSA11, 1994-2012.

| GSA 11 STRATUM | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 17 | 19 | 21 | 21 | 21 | 21 | 19 | 18 | 20 | 18 | 17 | 17 | 19 | 19 | 17 | 18 | 19 | 20 | 20 |
| 050-100 | 28 | 21 | 23 | 23 | 21 | 22 | 22 | 24 | 19 | 19 | 18 | 22 | 19 | 20 | 19 | 20 | 19 | 19 | 19 |
| 100-200 | 22 | 23 | 30 | 31 | 31 | 30 | 31 | 30 | 24 | 24 | 24 | 24 | 24 | 24 | 22 | 24 | 24 | 24 | 24 |
| 200-500 | 35 | 29 | 29 | 26 | 25 | 27 | 24 | 25 | 20 | 24 | 21 | 20 | 20 | 20 | 21 | 19 | 20 | 21 | 21 |
| 500-800 | 23 | 16 | 22 | 25 | 25 | 24 | 27 | 26 | 16 | 14 | 15 | 14 | 16 | 17 | 16 | 16 | 17 | 17 | 17 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

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

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval:

Confidence interval = Yst ± t(student distribution) * V(Yst) / n

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations in each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of the low numbers in most strata) and finally aggregated (sum) over the strata of the entire GSA.

Geographical distribution patterns

The spatial structure of striped red mullet have been achieved by modeling the spatial correlation structure of the abundance indices through geostatistical techniques (i.e. kriging), showing clear areas of persistence in the south (Gulf of Cagliari) and western coasts (Carloforte and coast between Bosa Marina and Capo Mannu).

Trends in abundance and biomass

Fishery independent information regarding the state of striped red mullet in GSA11 was derived from the international survey MEDITS. Figure 6.7.3.1.3.1 displays the estimated trend in *M. surmuletus* abundance and biomass in GSA 11. The estimated abundance and biomass indices do not reveal a clear trend but a series of peaks particularly in the last part of the time series.

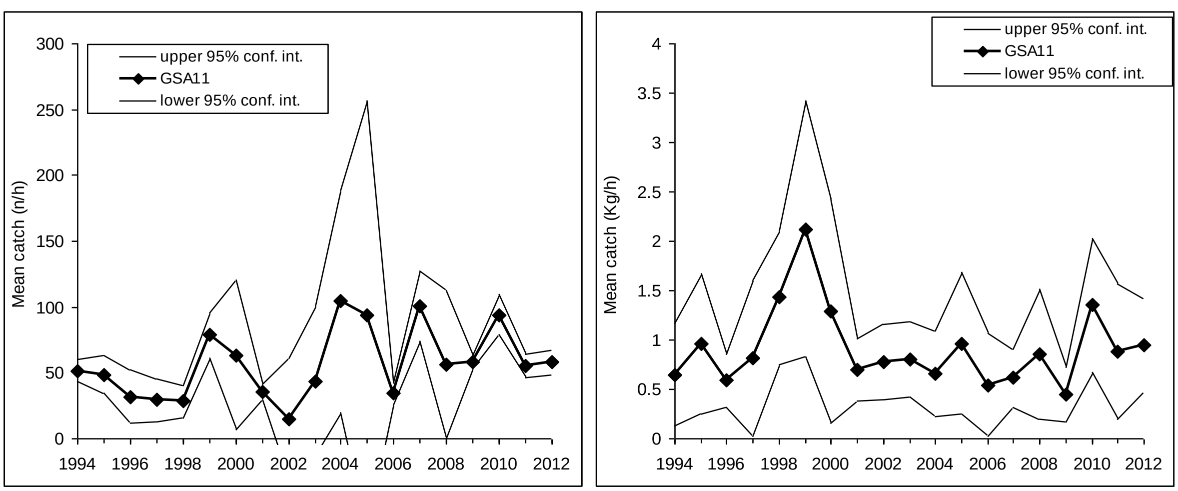



Figure 6.7.3.1.3.1 *M. surmuletus* GSA 11. MEDITS trends in density and biomass indexes from 1994 to 2012.

Trends in abundance by length or age

Boxplots and histograms of the MEDITS standardized length frequencies distributions (LFD) are shown in Figure 6.7.3.1.4.1 and 6.7.3.1.4.2.

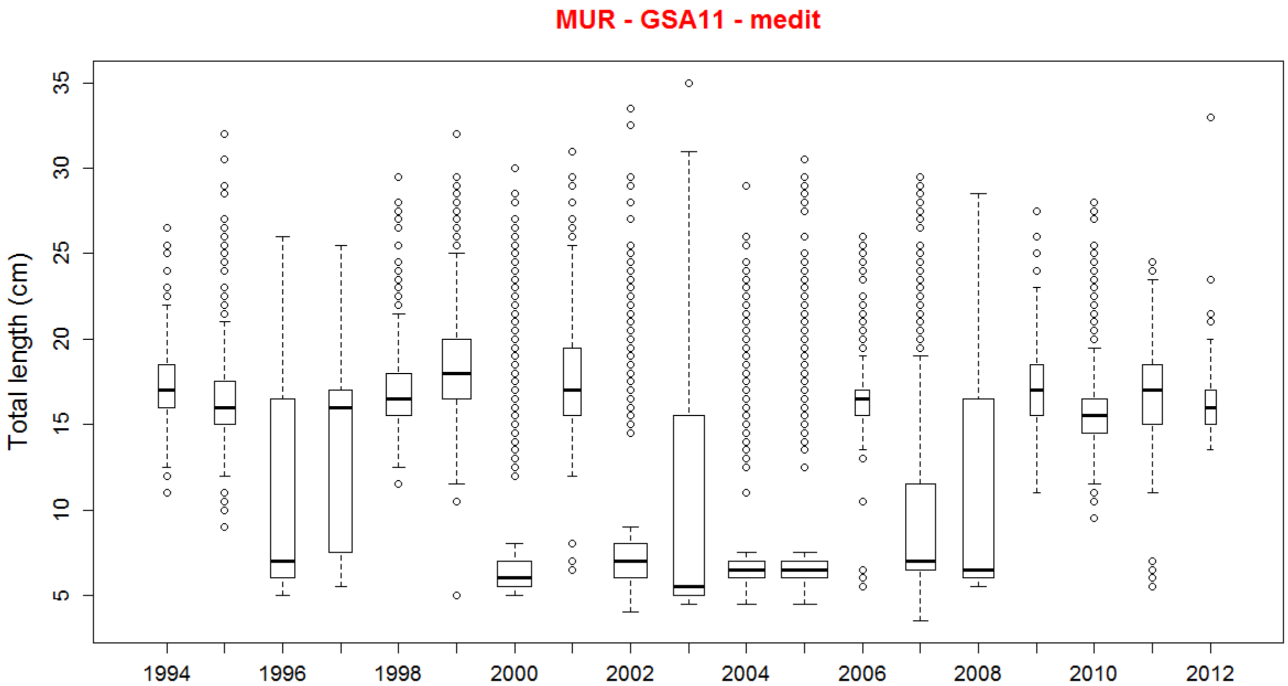



Figure 6.7.3.1.4.1.*Striped red mullet* GSA 11. Boxplot of the stratified length frequency distributions (MEDITS).

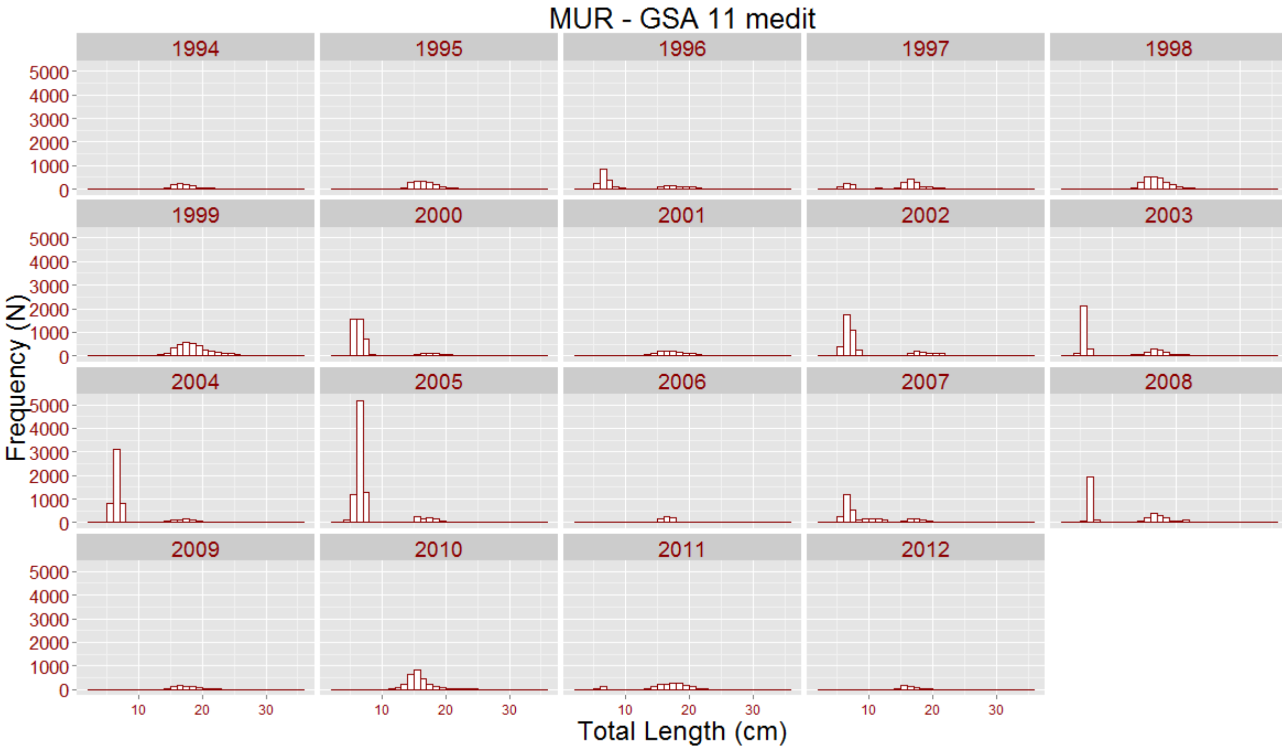



Figure 6.7.3.1.4.2. *Striped red mullet* GSA 11, stratified abundance indices by size, 1994-2012.

The length structure is extremely variable along the years due to peak of juveniles. As a matter of fact using the central tendency measures (median) two scenario are detectable: years when the survey is able to catch the recruitment process (mean of medians length 6.5 cm) and years when the survey do not (mean of medians length 16.6 cm) (Figure 6.7.3.1.4.3).

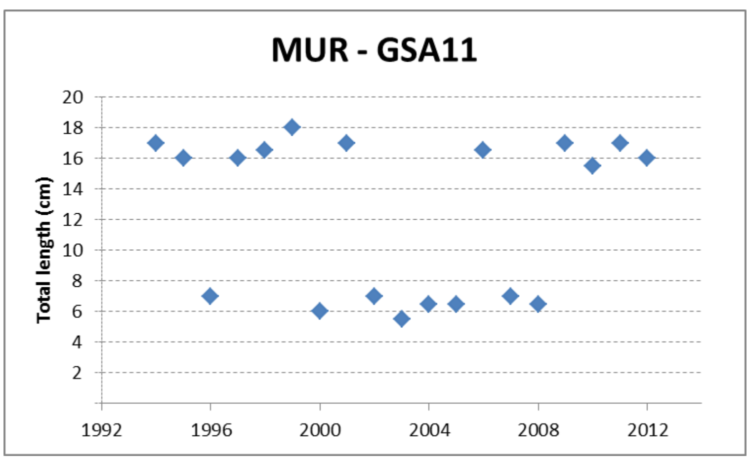



Figure 6.7.3.1.4.3.*Striped red mullet* GSA 11: Median of length sizes by year (MEDITS).

The second quartile (median) of the LFD is observed along the time series, the degree of dispersion and the total abundances (box are proportional) is more variable in the years. Moreover, in 2004, a peak of recruitment is evident.

The length structure by sex of *Mullus surmuletus* in GSA 11 shows that male and female slightly differ in terms of range and mean length (Figure 6.7.3.1.4.4).

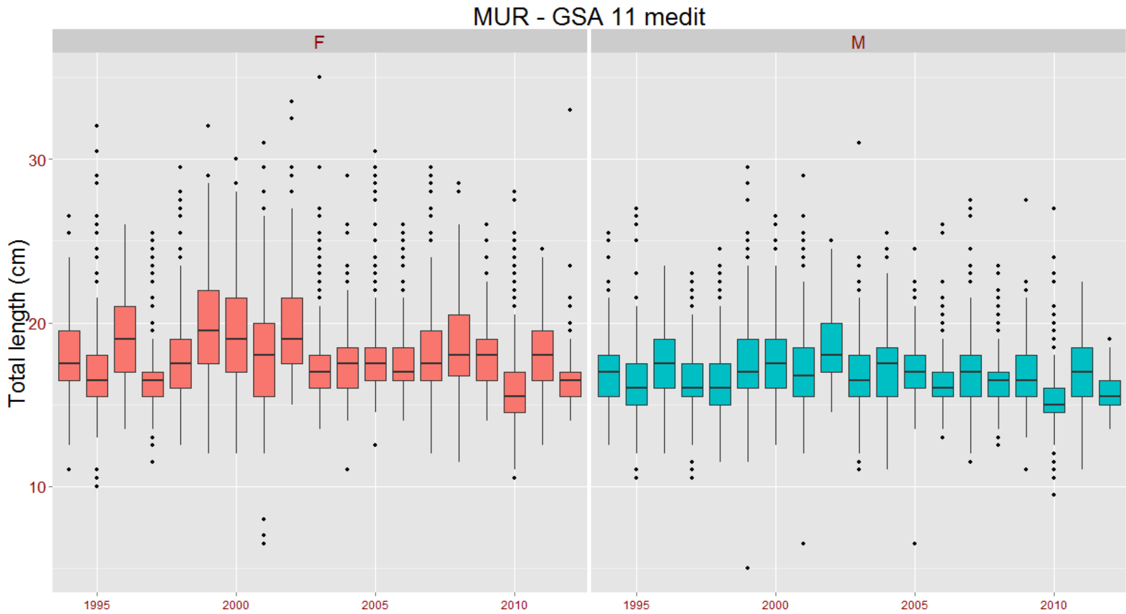



Figure 6.7.3.1.4.3.*Striped red mullet*: Boxplot of the stratified length frequency distributions by sex (Female and Male) in GSA 11 (MEDITS).

Trends in growth

No analyses were conducted during EWG 13-19 meeting.

Trends in maturity

No analyses were conducted during EWG 13-19 meeting.

### 6.7.4. **Assessment of historic stock parameters**

No analyses were conducted during EWG 13-19 meeting.

### 6.7.5. **Short term prediction 2013-2015**

No analyses were conducted during EWG 13-19 meeting.

### 6.7.6. **Data quality**

The MEDITS survey (1994 to 2012) is a much longer data series than the catch (2011 and 2012) data series for *Mullus surmuletus* in GSA 11. The lack of a continuous and long data series of commercial landings and discards data prevents the application of a VPA type of approach to assess the status of the stock.

Although the EWG 13-19 preform several analyses, the preliminary checks of data quality did not allow to progress in the assessment of the stock due to the unreliable information provided through the DCF data call.

EWG 13-19 reiterates that the situation with fisheries data in GSA 11 is of concerns and that an exhaustive review of the data and the data collection process is urgent.

Since it is unclear the sampling level in GSA 11 and how the raising is performed, the EWG 13-19 considers necessary to access the raw sampling data to verify the raising procedures in order to evaluate the accuracy of the fisheries data.

### 6.7.7. Scientific advice

Short term considerations

State of the stock size

No analyses were conducted during EWG 13-19 meeting.

State of the recruitment

No analyses were conducted during EWG 13-19 meeting.

State of exploitation

No analyses were conducted during EWG 13-19 meeting.

Management recommendations

The EWG 13-19 group considers that to evaluate properly the fisheries data and allow for a proper assessment of this stock and of the other stocks in GSA 11 in general, a thorough evaluation of the sampling data and a revision of the raising procedures is urgently needed.

## 6.8. **Stock assessment of red mullet in GSA 11**

### 6.8.1. **Stock identification and biological features**

Stock Identification

This stock was assumed to be confined within the GSA boundaries (Figure 6.8.1.1.1), but no scientific evidence is available to confirm this hypothesis. Under a management point of view, in the frame of GFCM, it has been decided that, when the lack of any evidence does not allow suggesting an alternative hypothesis, inside each one of the GSAs boundaries inhabits a single, homogeneous stock that behaves as a single well-mixed and self-perpetuating population.

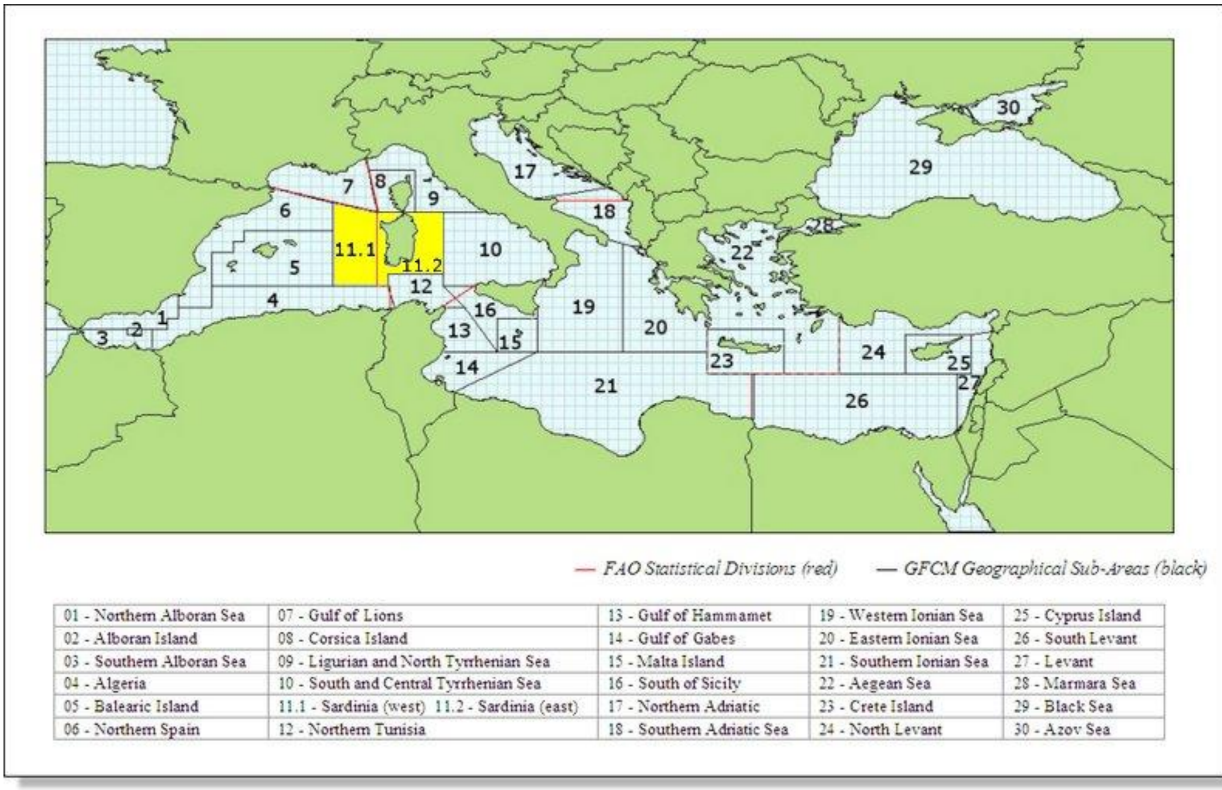



Figure 6.8.1.1.1.Geographical localization of GSA 11.

In the GSA11, red mullet (*Mullus barbatus*) is distributed between 0 and 300 m of depth, even though is generally found on shelf bottoms (within 200m of depths) where the bulk of abundance and biomass is up to 100 m. The stock is mainly exploited by the local fishing fleet only, both with trawl and net gears. Juveniles showed a patchy distribution with some main density hot spots (nurseries) showing a high spatio-temporal persistence in western and southern areas.

Growth

The Von Bertalanffy Growth Function (VBGF) parameters available for this species in the GSA 11 are presented below (Table 6.8.1.2.1).

The asymptotic length estimated from LFDA (Samed, 2002) and otoliths readings (Sabatini et al., 2002) showed that females growth bigger than males, and that males approach to L∞ faster. However using these parameters in the growth function the differences of the growth pattern by sex is much bigger for the data coming from the otoliths readings.

Tab. 6.8.1.2.1. References of the Von Bertalanffy growth function parameters of *M. barbatus* in the GSA 11.

| method | sex | Linf | k | $t_o$ | reference |
|---|---|---|---|---|---|
| otoliths reading | F | 29.96 | 0.23 | -1.54 | Sabatini et al ., 2002 |
| otoliths reading | M | 21.8 | 0.62 | -0.7 | Sabatini et al ., 2002 |
| Length frequency | F | 28.7 | 0.53 | -0.80 | SAMED, 2003 |
| Length frequency | M | 23.8 | 0.55 | -0.20 | SAMED, 2003 |

The growth parameters used during the EWG 13-19 were the same used for SGMED-12-19 (sex combined):

| sex | Linf | k | $t_o$ | reference |
|---|---|---|---|---|
| F+M | 29.1 | 0.41 | -0.39 | SAMED, 2003 |

Using these parameters the species reaches 50% of its total size within one year and half, thus for the assessment it has been treated here as fast growing.

Maturity

The species reaches massively the sexual maturity at one year old. Observations of proportion of mature individuals by size and analysis with the standard procedure show the bulk of the females spawn at a size of about 10 cm. Data on spawning (DCR) confirm that is taking place in spring (April-June), with a peak during May.

The maturity at age utilized in the assessment is reported in Table 6.8.1.3.1.

Table 6.8.1.3.1. Red mullet GSA 11, maturity and natural mortality vector utilized in the assessment.

| PERIOD | Age | 0 | 1 | 2 | 3+ |
|---|---|---|---|---|---|
| 1994-2012 | Prop. matures | 0 | 1 | 1 | 1 |
| 1994-2012 | M | 1.3 | 0.45 | 0.27 | 0.24 |

## 6.8.2. **Fisheries**

General description of the fisheries

Red mullet (*Mullus barbatus*) is one of the most important demersal target species for the commercial fisheries in Sardinia (GFCM-GSA11). In this area red mullet is exploited by trawlers and gillnetters, which operate near shore. Particularly, during the period of post-recruitment (September-October), small trawlers target this species on shallower waters, near the cost.

According to official statistics the total annual landings for all species during the period 2005-2012 were on average around 1800 tons of which *Mullus barbatus* constituted about 13.1 %.

In the GSA 11, the trawling-fleet has remarkably changed from 1994 to 2004. The change has mostly consisted of a general increase of the number of vessels and by the replacement of the old, low tonnage wooden boats by larger steel boats. For the entire GSA a decrease of 20% for the smaller boats (<30 GRT), which principally exploit this species, has been observed.

Management regulations

As in other areas of the Mediterranean, the stock management is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area closures), and minimum landing sizes (EC 1967/06).

Two small closed areas were also established along the mainland (west and east coast respectively), although these are finalized to protected mainly lobsters.

Since 1991, a fishing ban for trawling 45 day was have been almost every year enforced in different periods for the small scale fishery (march, TSL<=15 m) and for the larger vessels, mostly trawlers (September, TSL<15 m).

Furthermore, (2006) the closure was recently differentiate also considering the different coasts (west and east mainly) with a shift of 15 day of the fishing ban period. Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

Catches

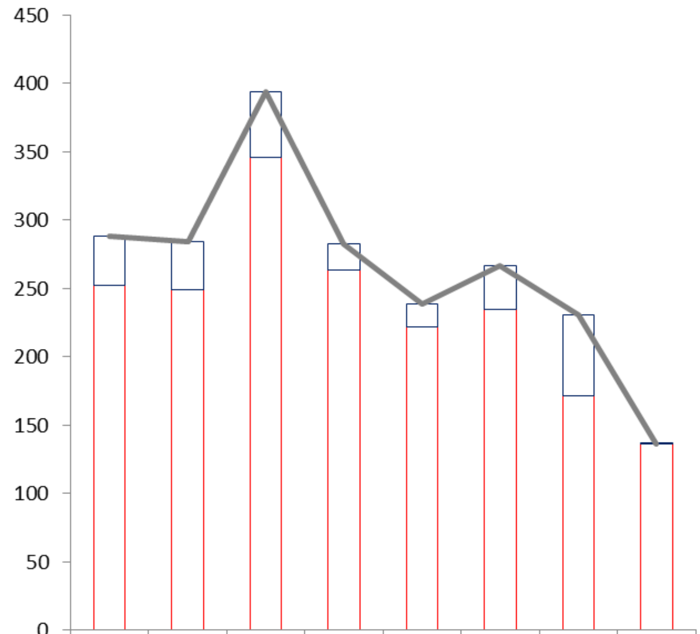
Landings

Red mullet landings came mostly exclusively from bottom trawlers (OTB) in GSA 11. In 2008 and 2012 less than 0.3 % of landings came from trammel nets (GTR) and gill nets (GNS) respectively (Table 6.8.2.3.1). It is worth of note that no landing for trammel nets (GTR) is reported in 2010 but discards account for 5% of the total discards (all gears, OTB and GTR) in weight.

The following table (Table 6.8.2.3.1) shows the annual landings (t) by gear (DCF data, 2013):

| Gear | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| OTB | 253 | 249 | 346 | 263 | 222 | 235 | 171 | 136 |
| GTR | | | | 1 | | | | |
| GNS | | | | | | | | 0.2 |

The catches show a strong negative trend from 2007 (Figure 6.8.2.3.1.1).



| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| DISCARDS | 35 | 35 | 48 | 20 | 17 | 32 | 59 | 00 |
| LANDINGS | 253 | 249 | 346 | 263 | 222 | 235 | 171 | 136 |
| TOTAL | 288 | 284 | 394 | 283 | 239 | 267 | 230 | 136 |

Figure 6.8.2.3.1.1. Red mullet GSA 11, trend of catches from DCR-DCF (2005-2012).

Catch data at length clearly show issues in the raising procedure for GTR and GNS (Figure 6.8.2.3.1.2).

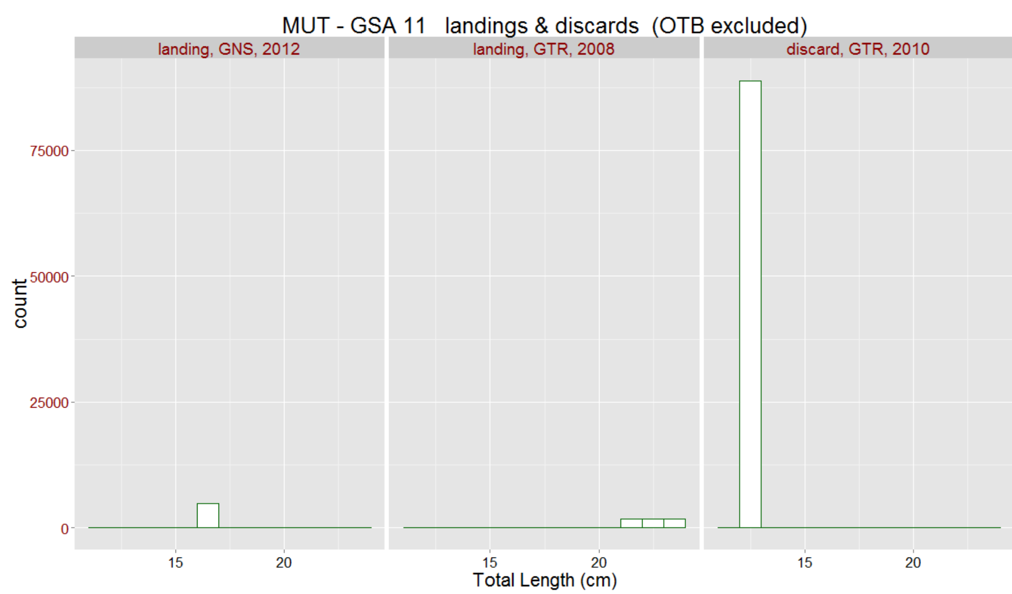



Figure 6.8.2.3.1.2. Red mullet GSA 11, length frequency distributions of landings (GTR and GNS).

However, a better quality of the data was observed for the OTB landing at length (Figure 6.8.2.3.1.3).

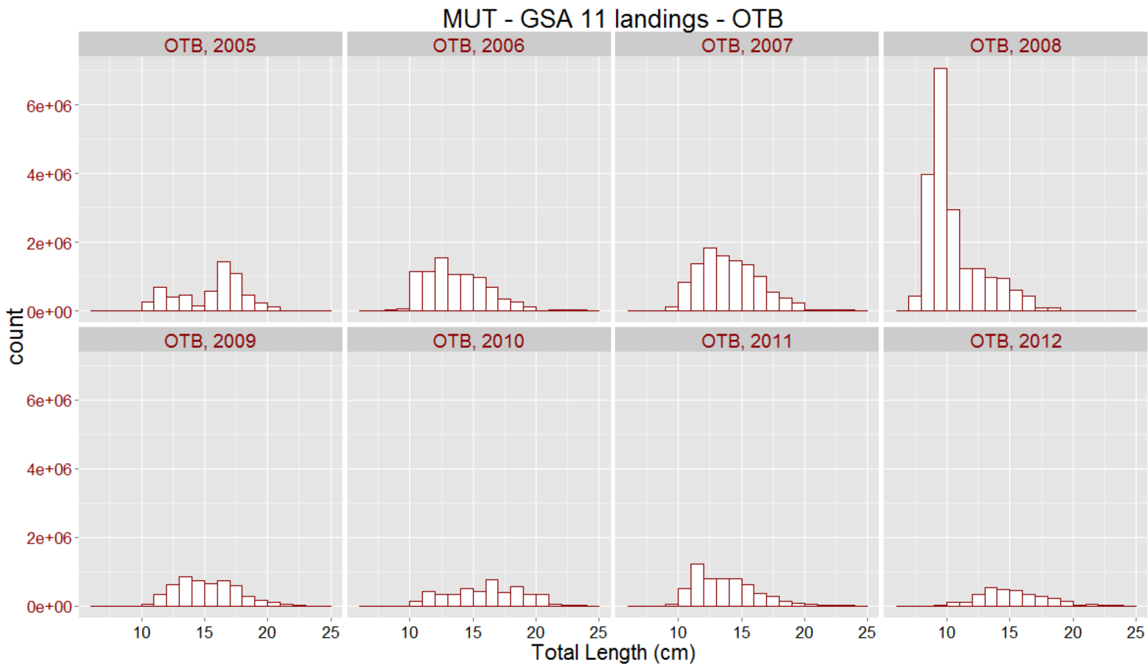



Figure 6.8.2.3.1.3. Red mullet GSA 11, length frequency distributions of landings (OTB).

Discards

The table 6.8.2.3.2.1 report the annual discards (t) by gear (DCF data, 2013). It shows that no discards data was available for 2005, 2007 and 2008.

Table 6.8.2.3.2.1. Red mullet GSA 11, discard data (t) by fishing gear as reported through the DCF data call.

| Gear | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| OTB | | 35 | | | 17 | 32 | 59 | 0.1 |
| GTR | | | | | | | | |
| GNS | | | | | | | | |

The percentage of discards shows an increasing trend in the last period (table 6.10.2.3.2.2). In 2009 discard were around the 7% of the OTB's catches but this percentage rise up to 26% in 2011. Moreover discard almost disappear in 2012, here again probably due to some problem in the sampling design of data collection.

Table 6.8.2.3.2.2. Red mullet GSA 11, percentage of discard in the OTB catches

| 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| | 12.3 % | | | 6.9 % | 12.0 % | 25.7 % | 0.1 % |

Data of discards at length for OTB stresses about the need of improving the data collection (Figure 6.8.2.3.2.1). Once again the impression is that information the insufficient samples are improperly used in the raising procedure.

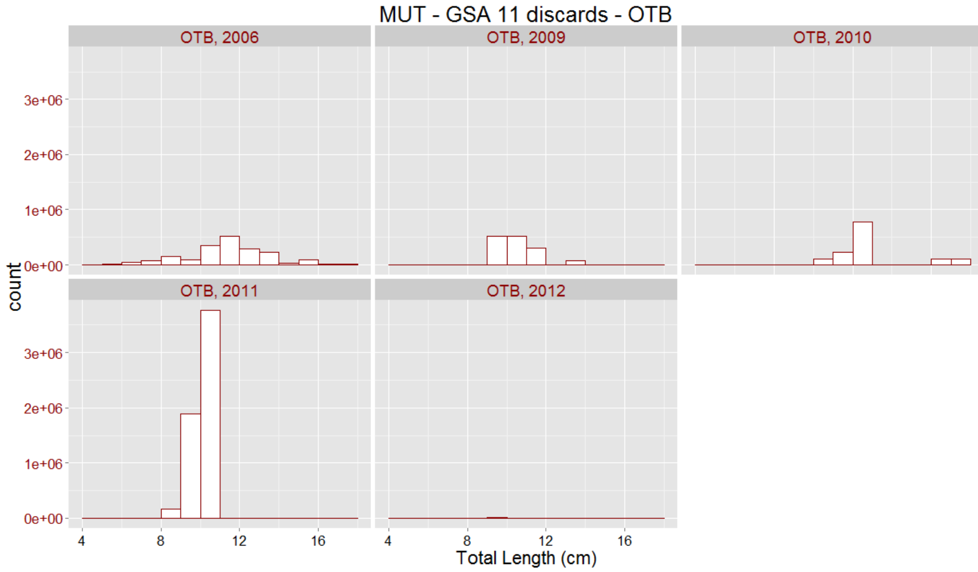



Figure 6.8.2.3.2.1. Red mullet GSA 11, length frequency distributions of discards (OTB).

The comparison between the length structure of commercial catches (landing + discard) and survey highlights some differences in the tails of the LFD (Figure 6.8.2.3.2.2).

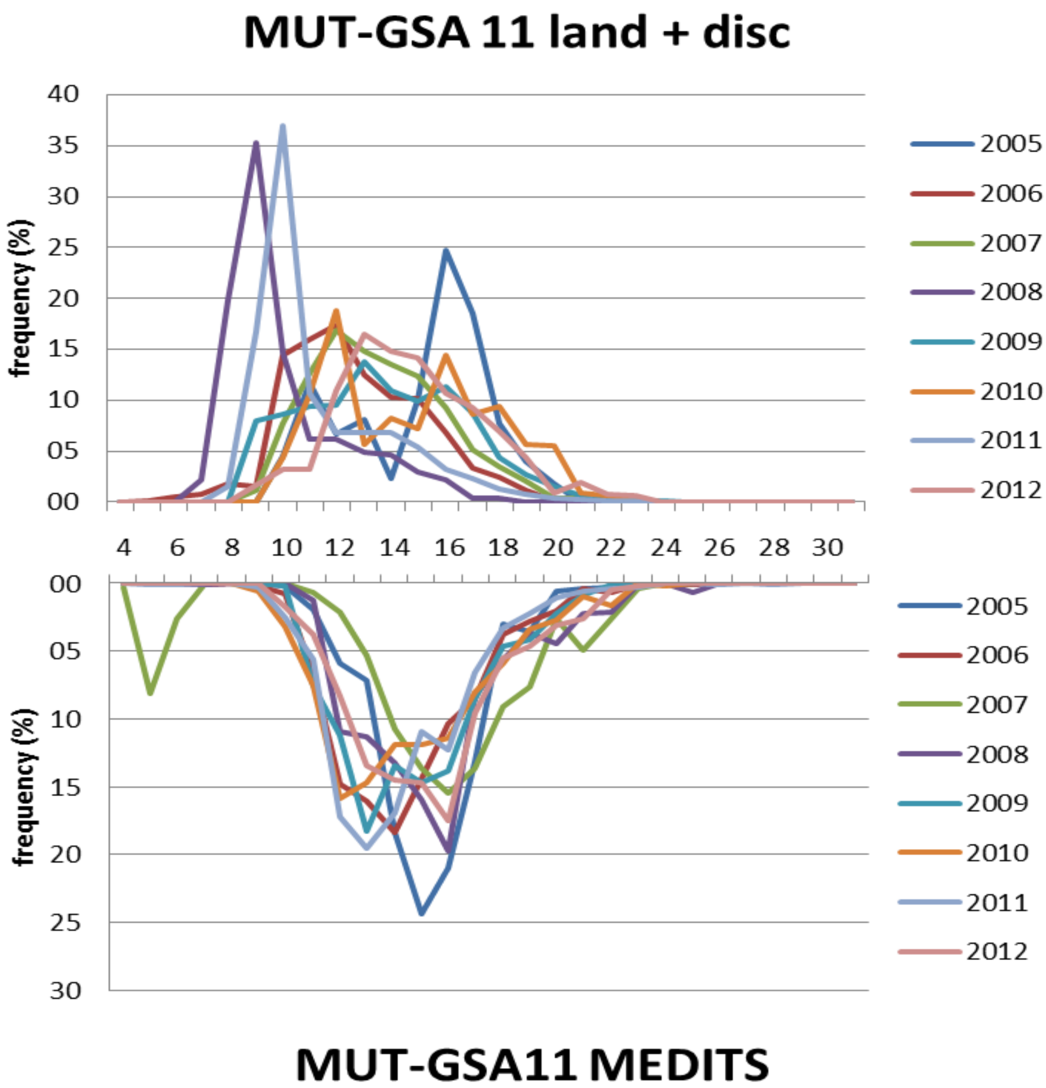



Figure 6.8.2.3.2.2. Red mullet GSA 11, comparison of Length frequency distributions of commercial data (OTB) and independent data (MEDITS survey).

Fishing effort

Using data available to EGW-13-19, the fishing effort by year and major gear type was calculated (Figure 6.8.2.3.3.1).

The analysis shows a major drop of total fishing effort from 2007 onwards, when effort decrease both for trawlers and small scale fishery (reduction of respectively 25% and 31%). In the last three years, the total effort was almost stable, even if a minor increase in the small scale fishery did occur.

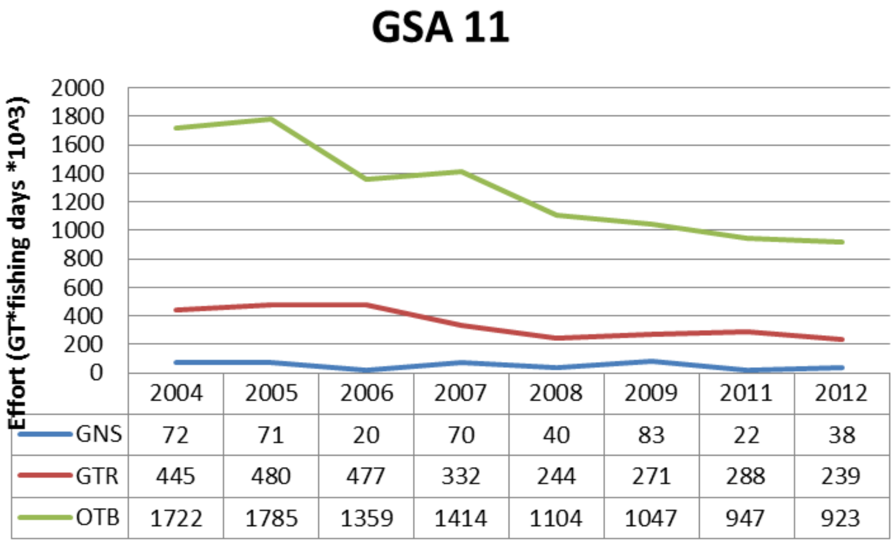



Figure 6.8.2.3.3.1. Trend in fishing effort (kW·days) for the Italian fleet in GSA 11 for the major gear types in 2004-2012.

### 6.8.3. Scientific surveys

MEDITS

Methods

Since 1994, MEDITS trawl surveys has been regularly carried out each year during the spring season. In GSA 11 the following number of hauls was reported per depth stratum (Table 6.8.3.1.1.1).

Table 6.8.3.1.1.1. Number of hauls per year and depth stratum in GSA11, 1994-2012.

| GSA 11 STRATUM | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 010-050 | 17 | 19 | 21 | 21 | 21 | 21 | 19 | 18 | 20 | 18 | 17 | 17 | 19 | 19 | 17 | 18 | 19 | 20 | 20 |
| 050-100 | 28 | 21 | 23 | 23 | 21 | 22 | 22 | 24 | 19 | 19 | 18 | 22 | 19 | 20 | 19 | 20 | 19 | 19 | 19 |
| 100-200 | 22 | 23 | 30 | 31 | 31 | 30 | 31 | 30 | 24 | 24 | 24 | 24 | 24 | 24 | 22 | 24 | 24 | 24 | 24 |
| 200-500 | 35 | 29 | 29 | 26 | 25 | 27 | 24 | 25 | 20 | 24 | 21 | 20 | 20 | 20 | 21 | 19 | 20 | 21 | 21 |
| 500-800 | 23 | 16 | 22 | 25 | 25 | 24 | 27 | 26 | 16 | 14 | 15 | 14 | 16 | 17 | 16 | 16 | 17 | 17 | 17 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

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

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

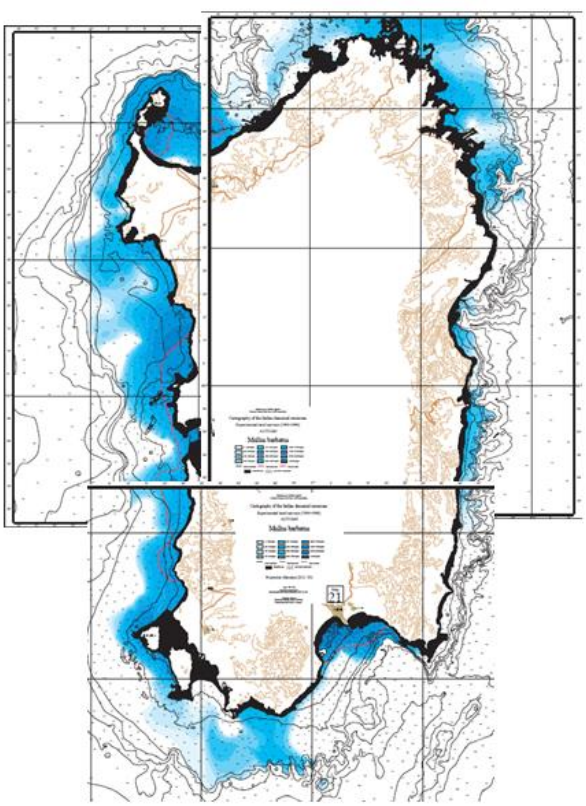
The variation of the stratified mean is then expressed as the 95 % confidence interval:

Confidence interval = Yst ± t(student distribution) * V(Yst) / n

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations in each stratum. Aggregated length frequencies were then raised to stratum abundance per 100 (because of the low numbers in most strata) and finally aggregated (sum) over the strata of the entire GSA.

Geographical distribution patterns

The stock is present in the whole area but is more abundant in the western and southern part of the GSA 11 as showed in Figures 6.8.3.1.2.1 (Ardizzone e Corsi, 1997, Eds. CD-ROM Version).



Figures 6.8.3.1.2.1. Mean biomass index of *Mullus barbatus* in GSA 11 (Autumn, 1994-1996, modified from Ardizzone e Corsi, 1997).

The spatial structure of red mullet have been achieved by modeling the spatial correlation structure of the abundance indices through geostatistical techniques (i.e. kriging), showing clear areas of persistence in the south (Gulf of Cagliari) and western coasts (Carloforte and coast between Bosa Marina and Capo Mannu). Main results and maps are reported in the "nursery section" of the SGMED-09-02 report.

Trends in abundance and biomass

Fishery independent information regarding the state of red mullet in GSA11 was derived from the international survey MEDITS. Figure 6.8.3.1.3.1 displays the estimated trend in *M. barbatus* abundance and biomass in GSA 11. The estimated abundance and biomass indices do not reveal a clear trend but a series of peaks particularly in the last part of the time series.

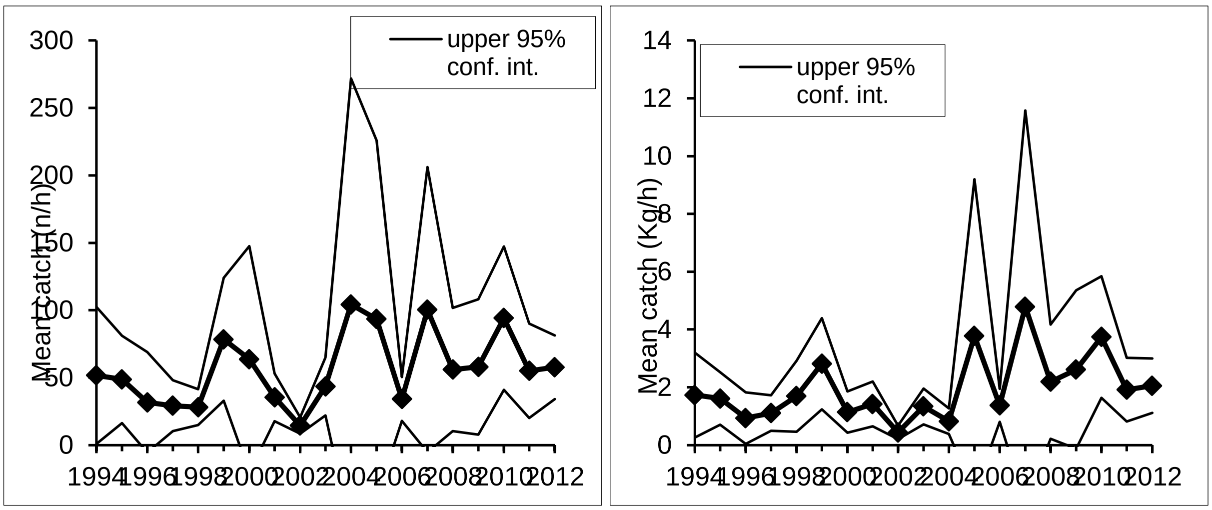



Figure 6.8.3.1.3.1 *M. barbatus* GSA 11. MEDITS trends in density and biomass indexes from 1994 to 2012 in GSA11.

Trends in abundance by length or age

Boxplots and histograms of the MEDITS standardized length frequencies distributions (LFD) are shown in Figure 6.8.3.1.4.1. Whereas a low variability in the second quartile (median) of the LFD is observed along the time series, the degree of dispersion and the total abundances (box are proportional) is more variable in the years. Moreover, in 2004, a peak of recruitment is evident.

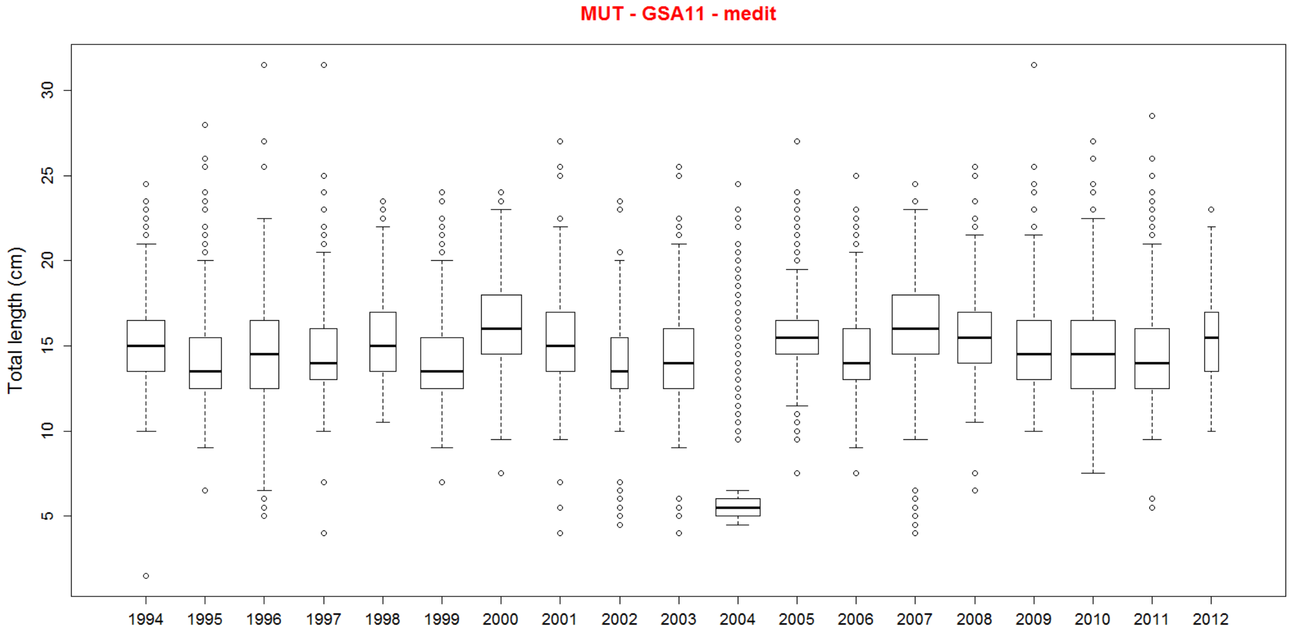



Figure 6.8.3.1.4.1.*Red mullet* in GSA 11. Boxplot of the stratified length frequency distributions in GSA 11 (MEDITS).

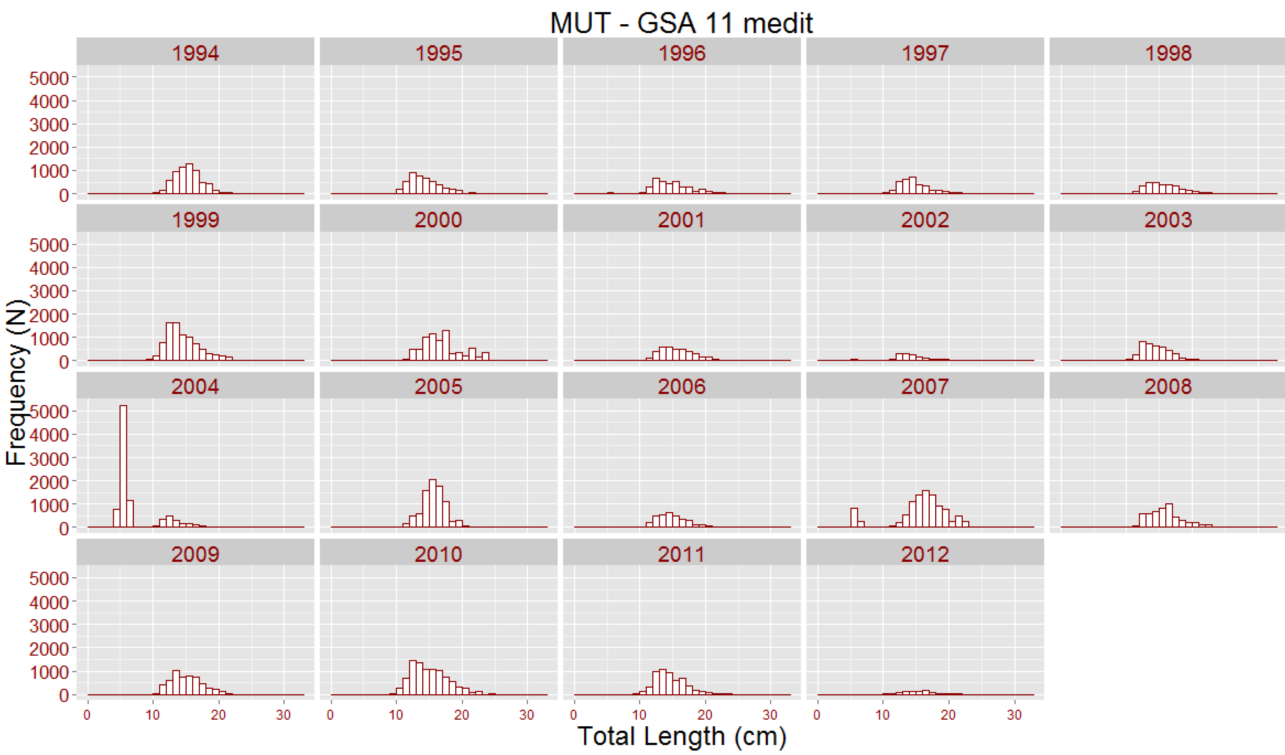


Figure 6.8.3.1.4.2. Stratified abundance indices by size, 1994-2012.

In accordance with the bibliography of this species, the length structure by sex of *Mullus barbatus* in GSA 11 confirm that males have a smaller range and a smaller mean length of females (Figure 6.8.3.1.4.3).

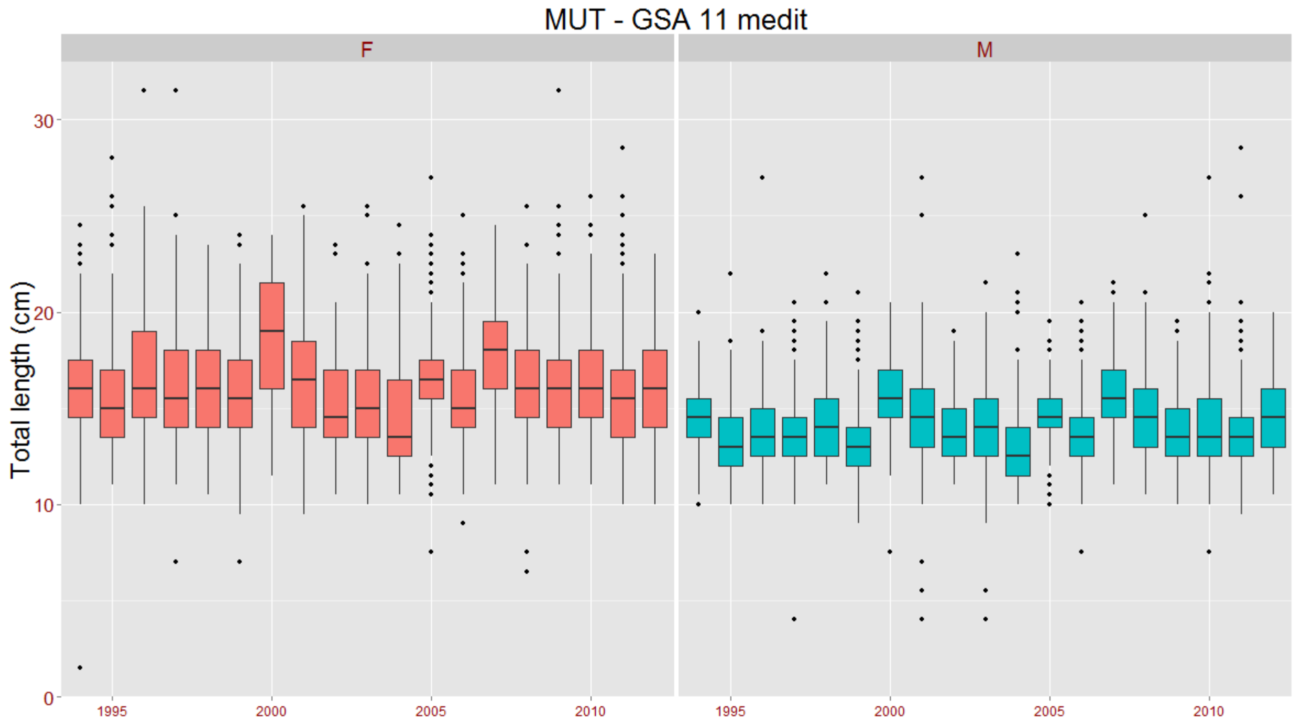



Figure 6.8.3.1.4.3.Red mullet GSA 11, boxplot of the stratified length frequency distributions by sex in GSA 11 (MEDITS).

Trends in growth

No analyses were conducted during EWG13-19.

Trends in maturity

No analyses were conducted during EWG-13-19.

### 6.8.4. Assessment of historic stock parameters

Method 1: XSA

Justification

An Extended Survivor Analysis (XSA, Darby and Flatman 1994) was performed employing the FLR libraries and, as input, data (2005 to 2012) from the DCF tuned with fishery independent data, i.e. the MEDITS survey abundance indices for GSA 11.

Input parameters

As mentioned in the landing section (6.8.2.3.1) catch at length data (DCR, 2012) were available respectively for 2005-2012 while data on discard at length were available only for the last three years (2009-2012). Moreover these are mainly derived from the trawling fleet (OTB).

Using the landing information from 2005 to 2008 EWG 13-19 calculate the mean landing/discards ratio for all the years when both information were reported in order to fill the gap of years when discard information were not collected and to obtain the necessary input data to run the XSA. Moreover, due to the discrepancy between catch at age and landings EWG 13-19 apply a SOP correction to catch data.

This aspect underlines both the need of some improvements of the data collection, paying particular attention to the sampling design and the importance of routinely check of the official data made by experts.

LFD of OTB catches (Figure 6.8.2.3.1.2) and MEDITS survey (Figure 6.8.3.1.4.2) were split in age classes using the statistical slicing procedure developed by Scott et al. (2011).

The analysis was performed by sex combined using the VBGF parameters. As shown below the best mixtures (minimum chi-square) are reported for each year separately for commercial catches and MEDIT data (Figures 6.8.4.3.1 and 6.8.4.3.2).

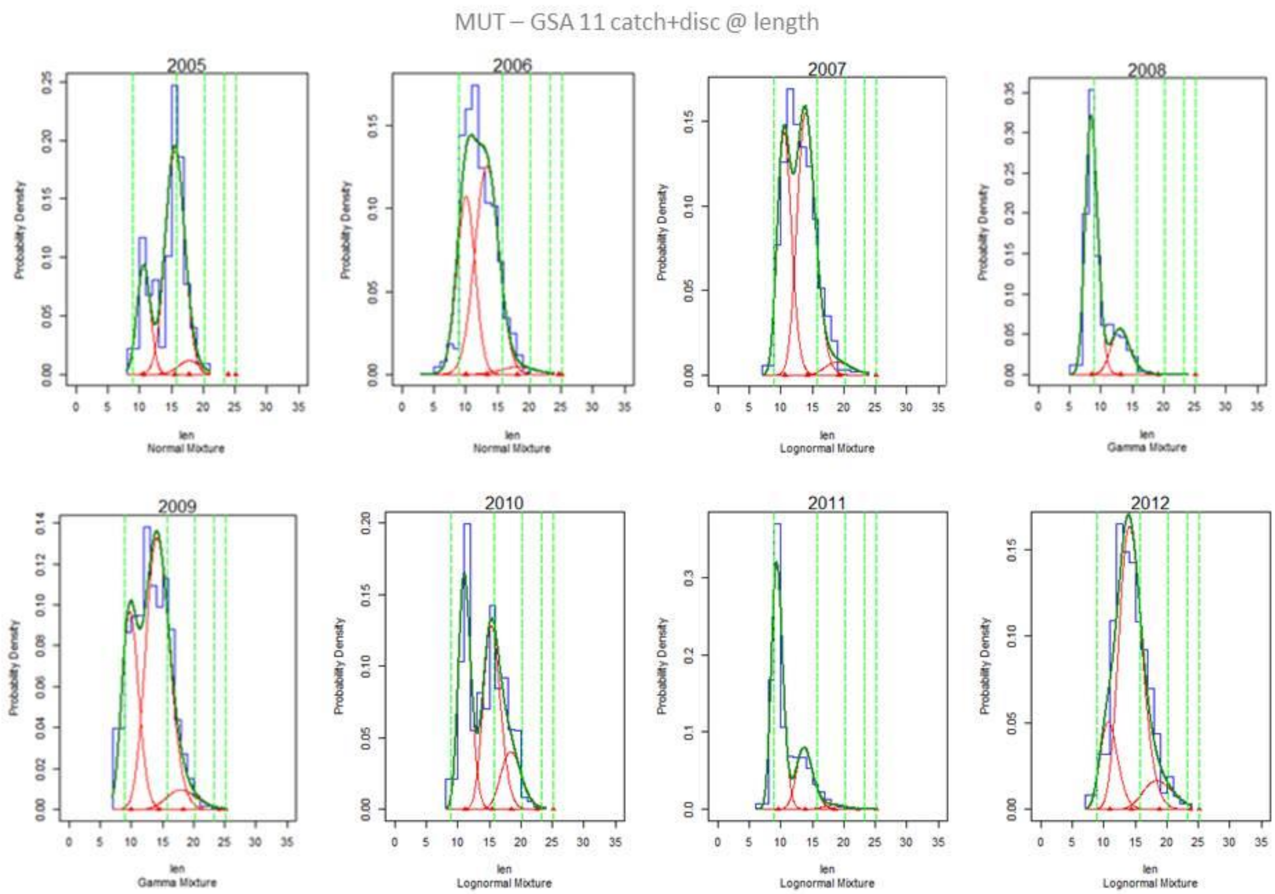


Figure 6.8.4.3.1. Red mullet GSA 11, statistical age slicing of the catch at length frequency distribution (OTB, 2005-2012).

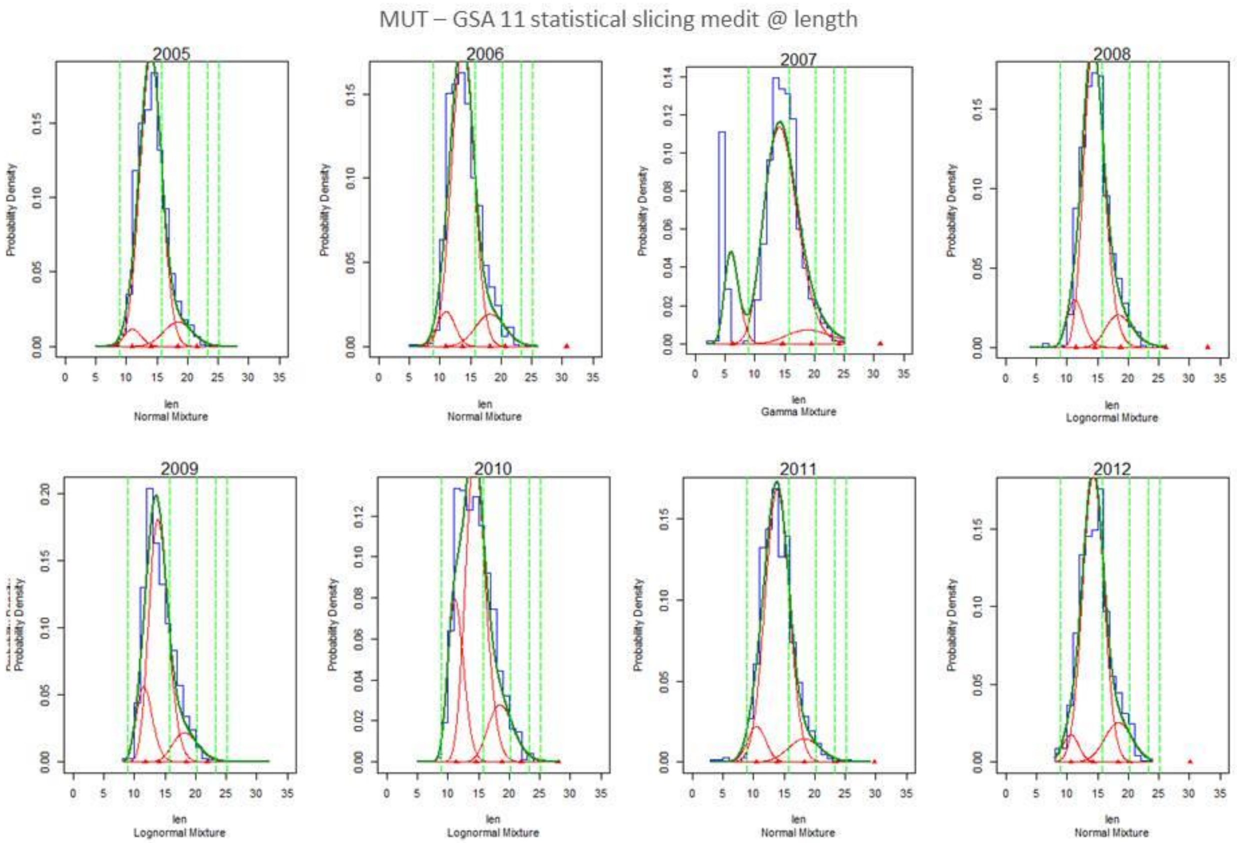



Figure 6.8.4.3.2. Red mullet GSA 11. Statistical age slicing of the length frequency distribution of survey data (MEDITS, 2005-2012).

For the XSA the data and parameter used are reported below (Table 6.8.4.3.1) together with the abundances by age in n/km$^2$ from the MEDITS survey used as tuning fleet.

Table 6.8.4.3.1. Input data and parameters used for the XSA

*Maturity and M vectors*

| **PERIOD** | **Age** | **0** | **1** | **2** | **3** |
|---|---|---|---|---|---|
| 2005-2011 | Prop. Matures | 0.0 | 1.0 | 1.0 | 1.0 |

| **PERIOD** | **Age** | **0** | **1** | **2** | **3** |
|---|---|---|---|---|---|
| 2005-2011 | M | 1.3 | 0.45 | 0.27 | 0.24 |

Catch in numbers by year

| age | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| all | 288 | 284 | 394 | 283 | 239 | 267 | 230 | 136 |

Mean weight in catch at age (kg)

| age | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.013 | 0.011 | 0.013 | 0.007 | 0.010 | 0.015 | 0.009 | 0.014 |
| 1 | 0.040 | 0.025 | 0.030 | 0.025 | 0.031 | 0.039 | 0.028 | 0.032 |
| 2 | 0.060 | 0.063 | 0.076 | 0.075 | 0.065 | 0.068 | 0.068 | 0.071 |
| 3 | 0.147 | 0.160 | 0.170 | 0.170 | 0.150 | 0.124 | 0.117 | 0.143 |

Mean weight in stock at age (kg)

| age | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.014 | 0.015 | 0.002 | 0.013 | 0.017 | 0.016 | 0.012 | 0.013 |
| 1 | 0.029 | 0.029 | 0.035 | 0.031 | 0.029 | 0.033 | 0.028 | 0.031 |
| 2 | 0.066 | 0.067 | 0.082 | 0.066 | 0.067 | 0.071 | 0.065 | 0.066 |
| 3 | 0.109 | 0.098 | 0.162 | 0.205 | 0.119 | 0.115 | 0.136 | 0.089 |

Number at age in the catch (thousands)

| age | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| 0 | 1989 | 5244 | 6189 | 21139 | 2832 | 3147 | 10609 | 725 |
| 1 | 5957 | 8102 | 8869 | 5720 | 5596 | 3389 | 3875 | 3071 |
| 2 | 418 | 385 | 593 | 8 | 521 | 1278 | 344 | 410 |
| 3 | 2 | 8 | 14 | 1 | 4 | 2 | 4 | 4 |

Tuning (MEDITS)

| age | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| 0 | 8.5 | 45.6 | 31.4 | 3.5 | 43.8 | 73.6 | 21.5 | 6.6 |
| 1 | 183.3 | 195.0 | 175.1 | 174.2 | 168.8 | 178.8 | 216.0 | 92.4 |
| 2 | 20.4 | 28.8 | 13.1 | 25.1 | 26.9 | 43.1 | 24.4 | 16.4 |
| 3+ | 0.4 | 0.1 | 0.2 | 0.5 | 0.3 | 0.2 | 0.5 | 0.05 |

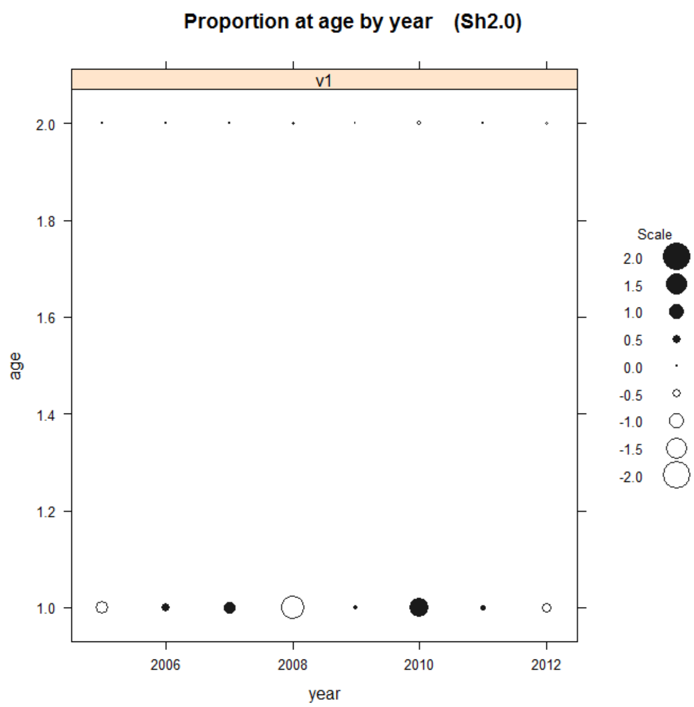
Before the final run a sensitivity analysis was employed taking in to account different settings. In particular several combinations of shrinkage values and ages for catchability and $F_{bar}$ were compared in term of residuals and final results.

The best combination of parameters’ settings finally used was:

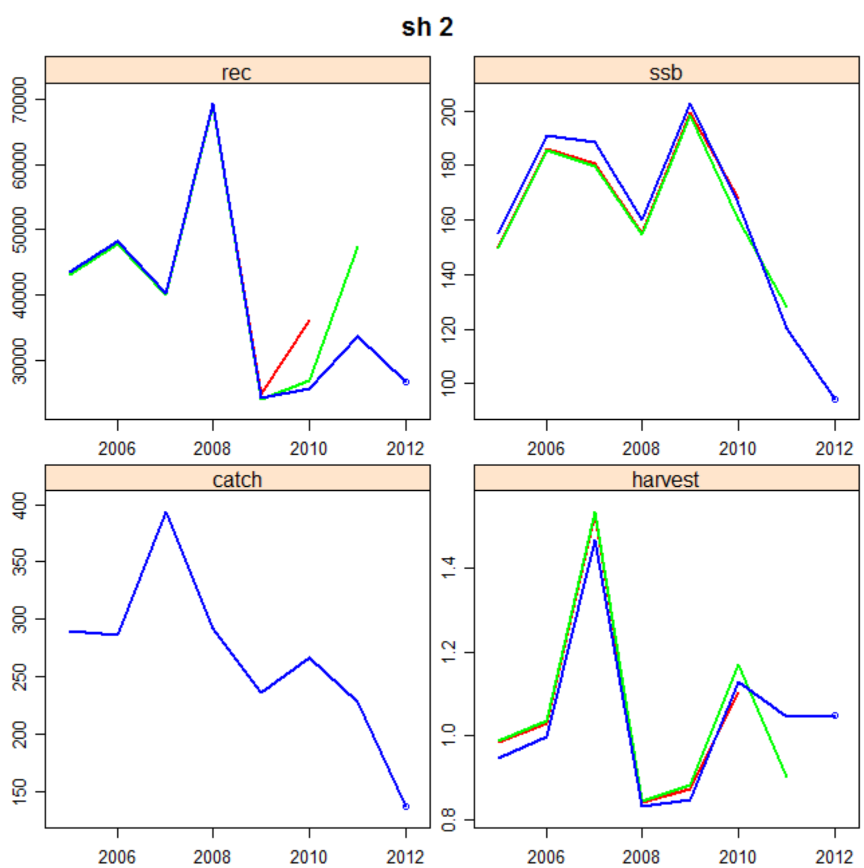
**$F_{bar}$ 1-3, fse=0.5, rage=0, qage=2, shk.yrs= 3, shk.ages=2, min.nse=0.3**

Results

Residuals from the survey do not show any particular trend (Figure 6.8.4.3.1.A) as well as the retrospective analysis (Figure 6.8.4.3.1.B).


Proportion at age by year (Sh2.0)
v1
age
year
2.0
1.8
1.6
1.4
1.2
1.0
2006
2008
2010
2012
Scale
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0

A


sh 2
rec
ssb
catch
harvest
2006
2008
2010
2012

B

Figure 6.8.4.3.1. Red mullet GSA 11, log transformed catchability residuals by age (A) and retrospective analysis (B).

From the results of the XSA (Figure 6.8.4.3.2), SSB oscillated between 155 and 202 t during the first period (2005-2009), then progressively drop down to the minimum value of 95 t in the last year (2012).

Recruitment as well shows a strong decrease in the last 4 years. Estimates ranged between about 2.4 x$10^7$ (2009) and 6.9 x $10^7$ (2008).

Mean $F_{1\text{-}3}$ ranged between 0.8-1.5 from 2005 to 2012.

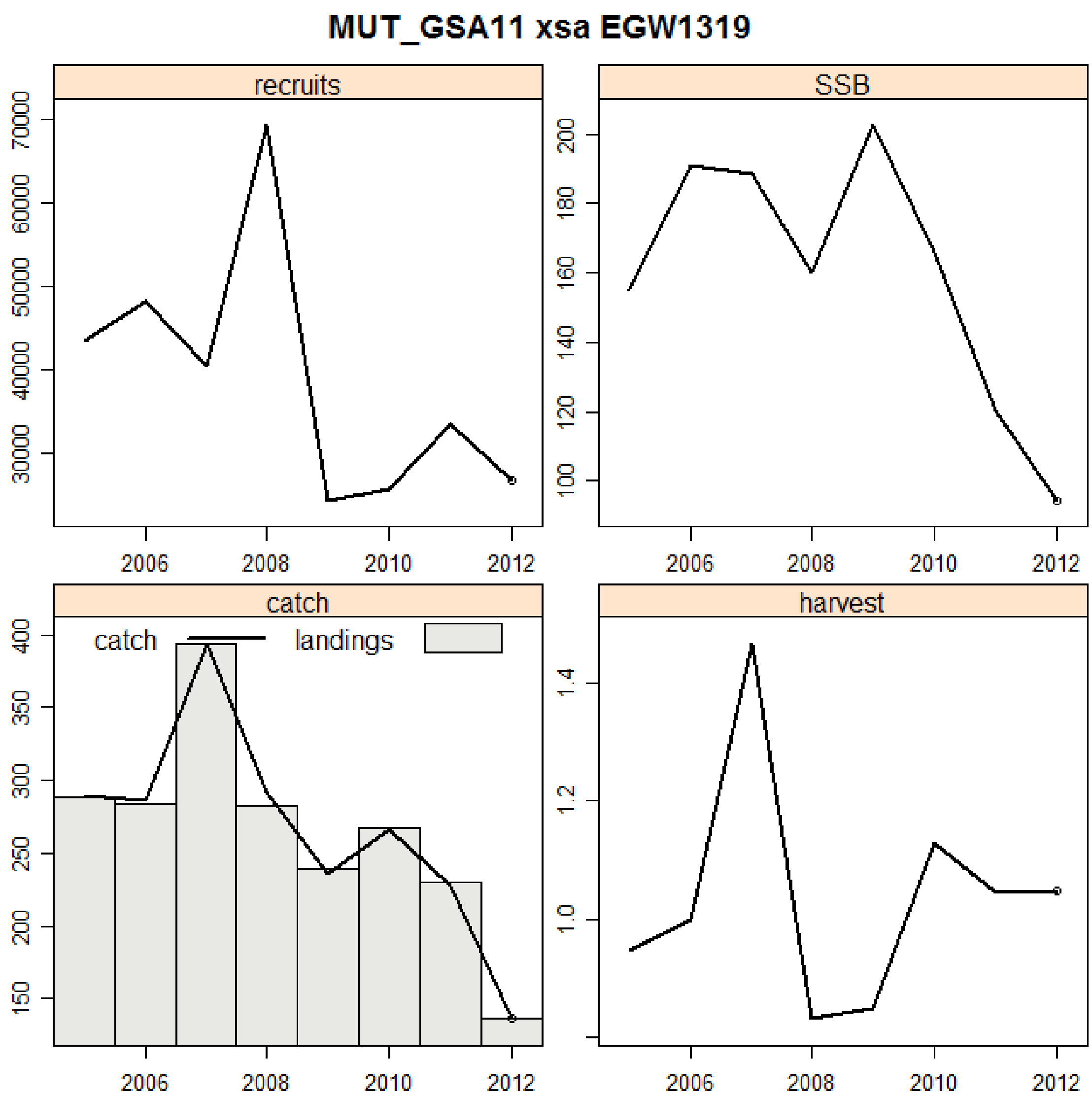



Figure 6.8.4.3.2. Red mullet GSA 11, summary of XSA estimation of stock parameters.

The shortness of the time series did not allow estimation of stock recruitment relationship, thus the biological reference point were estimated using the Yield per Recruits approach.

Considering the main results from XSA the Yield per Recruits Analysis was performed by means of the NOAA Fishery Toolbox. The resulting yield per recruit plot (Figure 6.8.4.3.3) and the reference point $F_{0.1}$ used as a proxy of $F_{MSY}$ are reported below (Table 6.8.4.3.1).

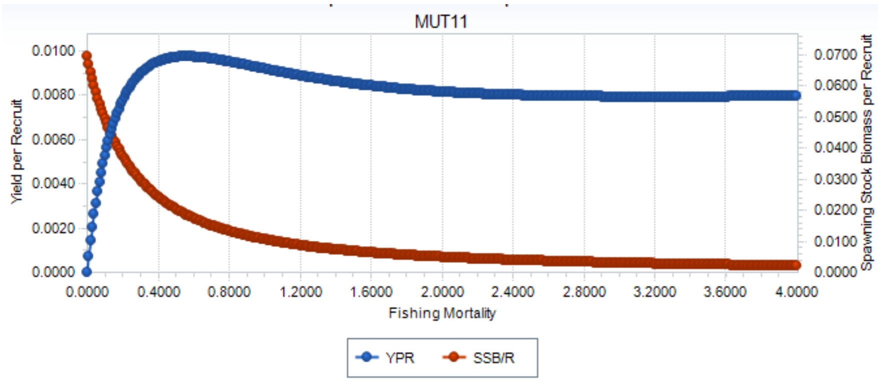



Figure 6.8.4.3.3. *Mullus barbatus* GSA 11, Yield per recruit.

Table 6.8.4.3.1. *Mullus barbatus* GSA 11. Results of the Yield per Recruits Analysis.

| Reference Point | F | YPR | SSB/R | TSB/R | Mean Age | Mean Gen Time | Exp Spawnings |
|---|---|---|---|---|---|---|---|
| F-Zero | 0.000000 | 0.000000 | 0.069447 | 0.088250 | 2.310056 | 4.531715 | 0.976888 |
| F-01 | 0.320000 | 0.009112 | 0.028598 | 0.046848 | 0.887477 | 2.450587 | 0.488618 |
| F-Max | 0.560000 | 0.009749 | 0.018562 | 0.036563 | 0.589770 | 1.909664 | 0.357991 |
| F at 10% of MSP | 1.470000 | 0.008554 | 0.006945 | 0.024729 | 0.289219 | 1.247994 | 0.180052 |

### 6.8.5. **Short term prediction 2013-2015**

Justification

Short term predictions were implemented in R (www.r-project.org) using the FLR libraries and based on catch and landings in numbers and weight, discards and the results of the Extended Survivor Analyses (XSA. Darby and Flatman, 1994) presented in the previous paragraph.

Input parameters

The same input parameters utilized for the XSA were used for the short term prediction. The $F_{curr}$ ($F_{bar}$ ages 1-3) has been considered as the mean of the last 3 years $F_{bar}$, as well as the catch weight at age used in the analysis. Recruitment has been estimated as the geometric mean of the last 3 years of the numbers estimated with FLR for the class 0.

Results

A short term projection (Table 6.8.2.3.1), assuming an $F_{stq}$ of 1.07 in 2012 and a recruitment of 28,366 (thousand) individuals show that:

Fishing at the $F_{stq}$ (1.07) generates an increase of the catch of 71% from 2012 to 2014 and a decrease in SSB of 1% between from 2014 and 2015.

Fishing at $F_{0.1}$ (0.11) generates a decrease of the catch of 73% from 2012 to 2014 along with the SSB increase by 113% from 2014 to 2015.

EWG 13-19 recommends that catch in 2014 should not exceed 37 tons corresponding to $F_{0.1}$ = 0.11.

Table 6.8.5.3.1 *M. barbatus* GSA 11: short term forecast in different F scenarios.

| **Rationale** | **Ffactor** | **Fbar** | **Catch_ 2014** | **Catch_ 2015** | **SSB_ 2015** | **Change SSB 2014-2015 (%)** | **Change Catch 2012-2014 (%)** |
|---|---|---|---|---|---|---|---|
| zero catch | 0.0 | 0.00 | 0.0 | 0.0 | 503.5 | 136 | -100 |
| High long-term yield ($F_{0.1}$) | 0.1 | 0.11 | 36.7 | 66.7 | 435.6 | 113 | -73 |
| Status quo | 1.0 | 1.07 | 233.0 | 232.3 | 233.0 | -1 | 71 |
| Different scenarios | 0.2 | 0.21 | 69.2 | 115.9 | 377.9 | 94 | -49 |
| | 0.3 | 0.32 | 98.1 | 151.9 | 328.8 | 76 | -28 |
| | 0.4 | 0.43 | 124.0 | 178.0 | 286.9 | 61 | -9 |
| | 0.5 | 0.54 | 147.1 | 196.8 | 251.1 | 47 | 8 |
| | 0.6 | 0.64 | 167.9 | 210.1 | 220.5 | 35 | 23 |
| | 0.7 | 0.75 | 186.6 | 219.3 | 194.1 | 25 | 37 |
| | 0.8 | 0.86 | 203.6 | 225.6 | 171.3 | 15 | 49 |
| | 0.9 | 0.97 | 219.0 | 229.7 | 151.6 | 7 | 60 |
| | 1.0 | 1.07 | 233.0 | 232.3 | 134.6 | -1 | 71 |
| | 1.1 | 1.18 | 245.8 | 233.8 | 119.7 | -8 | 80 |
| | 1.2 | 1.29 | 257.6 | 234.4 | 106.8 | -14 | 89 |
| | 1.3 | 1.40 | 268.4 | 234.6 | 95.4 | -20 | 97 |
| | 1.4 | 1.50 | 278.5 | 234.4 | 85.5 | -25 | 104 |
| | 1.5 | 1.61 | 287.8 | 233.9 | 76.7 | -29 | 111 |
| | 1.6 | 1.72 | 296.4 | 233.4 | 69.0 | -33 | 117 |
| | 1.7 | 1.83 | 304.5 | 232.8 | 62.2 | -37 | 123 |
| | 1.8 | 1.93 | 312.0 | 232.2 | 56.1 | -41 | 129 |
| | 1.9 | 2.04 | 319.1 | 231.6 | 50.7 | -44 | 134 |
| | 2.0 | 2.15 | 325.8 | 231.1 | 45.9 | -47 | 139 |

Weights in t. Basis: F(2013) = mean ($F_{bar}$ 1-3, 2010-2012)=1.07; R (2012, geometric mean 2010-2012) = 28366 (thousands); SSB (2012) = 94.4 t; Catch (2012)= 136.5 t.

### 6.8.6. Data quality

The MEDITS survey data series (1994 to 2012) in comparison to landing and discard is much longer and has been improved in quality in the last years. The landing data series is continuous from 2005 while discards are more discontinuous.

Data quality of landing and of discard remain the main issue for improving the evaluation of the state of the red mullet stock in GSA 11.

Landings seems to be mostly derived from the OTB fleet. However in some years small amount of catches are reported for GTR and GNS and it is not clear if these information are real or if data are erroneously reported. Moreover it is worth of note that for trammel nets (GTR) no landings are reported in 2010 although in the same year discards account for 5% of the total catches in weight.

The quality of data at length or age coming from the DCF of GSA 11 is also poor and shows a deficit in sampling design and data collection. The length structures of commercial catches and survey show the lack of small and big sizes from samples of discards and landings respectively. The length distribution of GTR discards in 2010 and of GTR landings in 2008 have an unrealistic length structure based on one single or very few classes. The same situation was noted for some years of the OTB DCR data at length.

Finally length structures of discards as well as their year total values are very variable along the time series, which seems to be unrealistic.

The lack of discard information implies lack of information on the recruits component of the stock. The EWG 13-19 group considers that to evaluate properly the fisheries data and improve the assessment a careful check of raw sampling data and a revision of raising procedures is urgently needed.

### 6.8.7. Scientific advice

Short term considerations

State of the stock size

The spawning stock biomass estimated by XSA shows a clear decreasing trend. The level of SSB oscillated between 155 and 203 t from 2005 to 2009, then constantly decline to the minimum of 94 t in 2012.

Since no biomass reference are proposed or agreed, EWG 13-19 is unable to fully evaluate the state of the stock size in respect to biomass.

State of the recruitment

No clear trend was identified for R, with oscillations along the entire data series and an isolated peak in 2008.

State of exploitation

The current F (1.07) is larger than the values of $F_{0.1}$considered as a proxy of $F_{MSY}$ (0.11), which indicates that red mullet in GSA 11 is exploited unsustainably.

Management recommendations

STECF EWG 13-19 suggests that catch in 2014 should not exceed 37 t, corresponding to $F_{0.1}$=0.11.

The lack of information do not compromise the main signal of an overfishing status of the stock but the estimation of reference points and F values would be improved using a better quality of input data for the assessment.

It is worthy of note that the species seems to be harvested on continental shelf mainly from otter trawls targeting to an assemblage of coastal species. A multispecies approach should be considered for the management of this stock.

## 6.9. **Stock assessment of striped red mullet in GSA 15 and 16**

### 6.9.1. **Stock Identification**

Striped red mullet (*Mullus surmuletus*) is an important demersal target species in the Strait of Sicily (GSA 15 and 16), mostly found on the continental shelf up to depths of 200 m; the highest concentration of individuals is usually found in the 0-150 m depth range. Striped red mullet generally inhabits mixed sediment as well as rocky and detritic bottoms, with a preference for patchy habitats made up of sand, rocks, coralligenous benthic communities. In coastal areas the species is often found in *Posidonia oceanica* seagrass meadows.

Due to a lack of information about the structure of the striped red mullet population in the central Mediterranean, this stock was assumed to be confined within the boundaries of GSAs 15 and 16 (Figure 6.9.1).

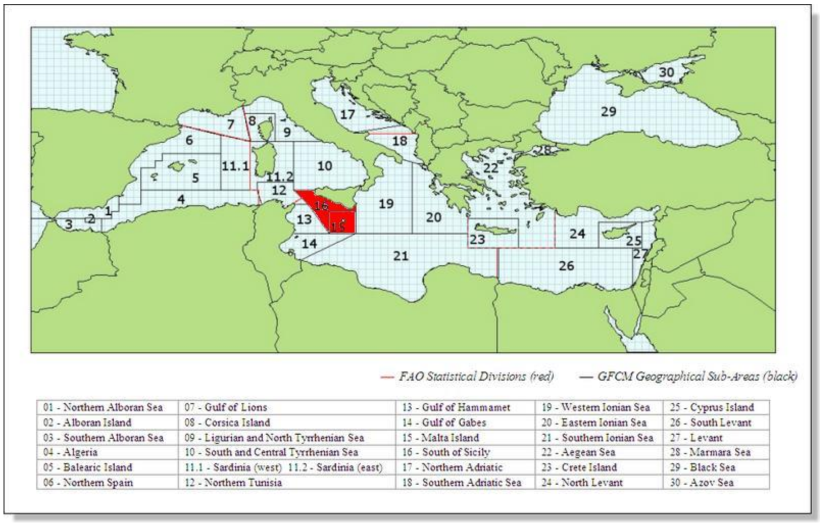



Figure 6.9.1.1.Geographical location of GSA 15 and 16.

Growth

Striped red mullet growth parameters which have been estimated based on otolith readings in several areas of the Mediterranean Sea, including in the Balearic Islands (GSA 5), the Ligurian and North Tyrrhenian Sea (GSA 9) and the Strait of Sicily (GSA 16), are summarized in Table 6.9.1.2.1 below.

Tab. 6.9.1.2.1.Striped red mullet in GSA 15 and 16, Von Bertalanffy growth function estimates and length-weight parameters in the Mediterranean; $L_\infty$, k and $t_0$ refer to the asymptotic total length (cm), the curvature coefficient ($year^{-1}$) and the theoretical age at size 0 respectively.

| Author | Area | Method | Sex | $L_\infty$ | k | $t_0$ | a | b |
|---|---|---|---|---|---|---|---|---|
| Andaloro and Giarritta (1985) | GSA 16 | Otolith readings | F | 29.75 | 0.49 | -0.31 | 0.0093 | 3.07 |
| | | | M | 26.25 | 0.41 | -0.23 | | |
| Renones (1995) | GSA 5 | Otolith readings | M&F | 31.28 | 0.211 | -2.348 | - | - |
| Machias et al. (1998) | GSA 23 | Scale annuli readings & LFD analysis | M&F | 35.4 | 0.225 | -1.194 | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Voliani et al. (1998) | GSA 9 | LFD analysis | M&F | 26.4 | 0.69 | -0.47 | 0.0084 | 3.118 |
| Ragonese et al. (2002) | GSA 16 | Otolith readings & LFD analysis | F | 29.0 | 0.48 | -0.84 | 0.0195 - 0.0093 | 2.90 - 3.04 |
| | | | M | 25.0 | 0.5 | -0.2 | 0.01758 - 0.007097 | 2.94 - 3.11 |
| STECF EWG 11-12 (2012) | GSA 9 | Otolith readings | F | 32.0 | 0.44 | -0.8 | - | - |
| | | | M | 28.0 | 0.44 | -0.9 | - | - |
| | | | M&F | 32.0 | 0.43 | -0.7 | 0.01 | 3.103 |
| Guijarro et al. (2012) | GSA 5 | Otolith readings | M&F | 40.05 | 0.164 | -1.883 | 0.0084 | 3.118 |

Maturity

The period of reproductive activity of striped red mullet is in spring until early summer, with subsequent recruitment taking place in summer (Fig. 6.9.1.3.1.). Length at maturity of females has ranged between 14.1 and 19.1 cm total length in the period 2008-2012 (DCF data, Fig. 6.9.1.3.2.).

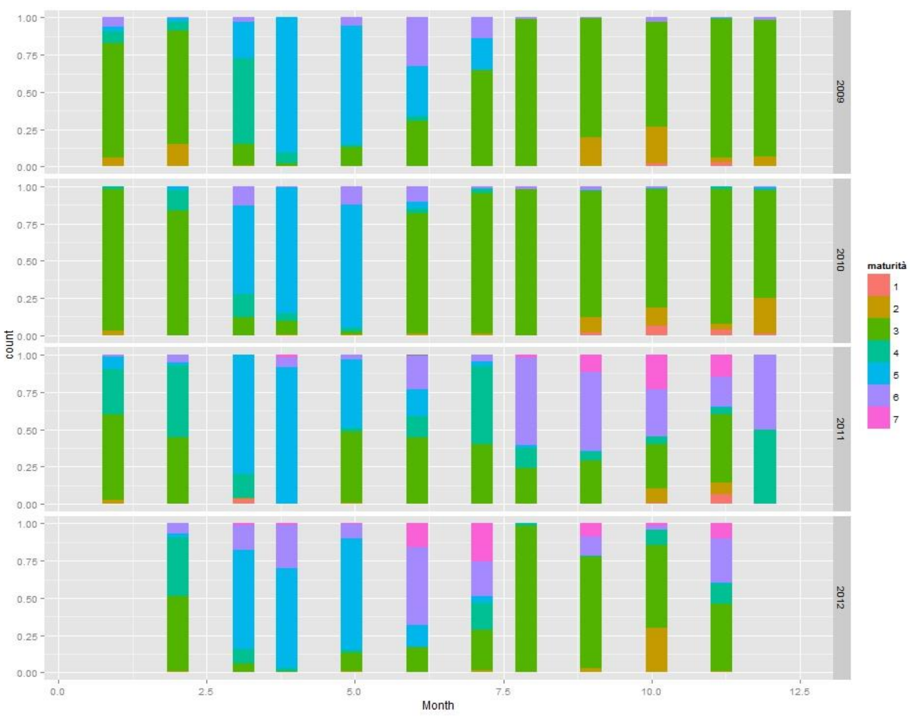



Figure 6.9.1.3.1. Striped red mullet GSA 16. Proportion of individuals in the 7 maturity stages of the fish maturity scale by month from DCF data, in the years 2009-2012. The maturity stages refer to the following: 1 = immature (virgin), 2-4 = maturing (virgin developing / recovering / maturing), 5 = mature spawner, 6-7 = spent and resting.

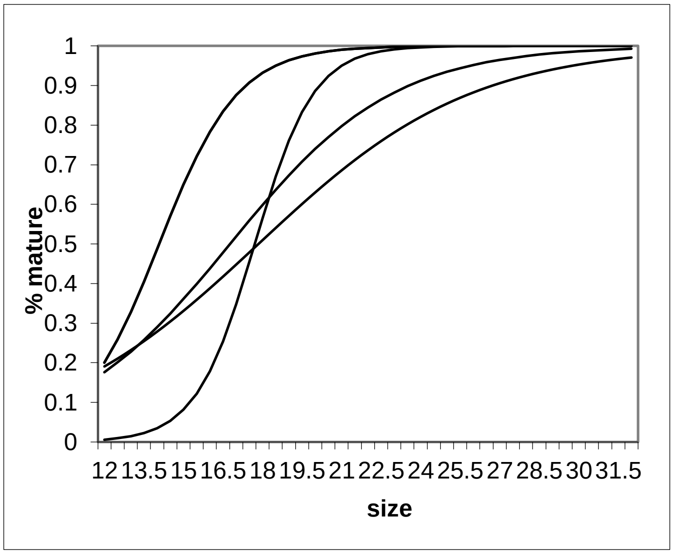



Figure 6.9.1.3.2.Striped red mullet in GSAs 16. Maturity ogives of females in the period 2008-2012.

Spawning grounds of striped red mullet are mainly located in the northern part of the Strait of Sicily, in shallow waters up to 80 m of depth. Spawning aggregations are found on both the Adventure and the Malta Bank, but the highest concentration of spawners is found on the Adventure Bank, where a large and persistent spawning area is located on the western side of the Adventure Bank on coastal detritic bottoms which are characterized by *Laminaria rodriguezii*. A smaller concentration of spawners is located to the east of the Maltese Islands within the 25 nautical mile Maltese Fisheries Management Zone; however this area has a much lower level of temporal persistence (Fig. 6.9.1.3.3).

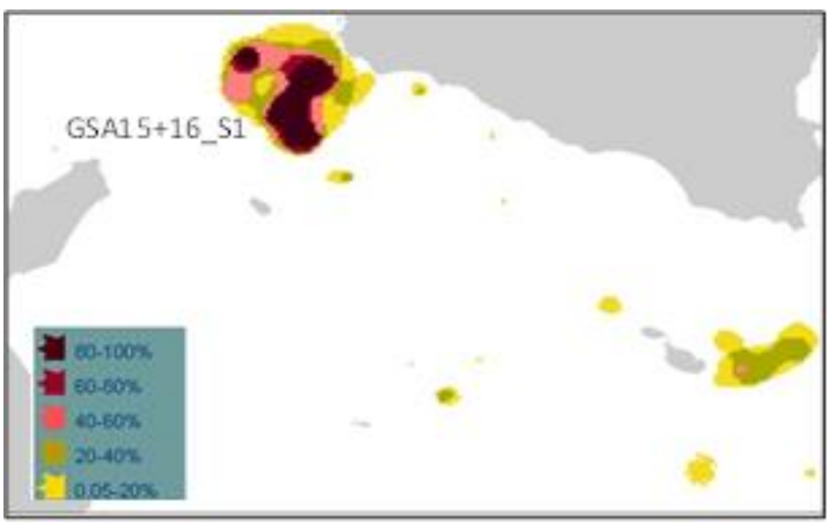



Fig. 6.9.1.3.3. Striped red mullet in GSA 15 and 16. Position of persistent spawning areas in GSA 15 and 16 (from MAREA-MEDISEH project).

### 6.9.2. **Fisheries**

General description of fisheries

Striped red mullet is mainly targeted by bottom otter trawlers in the Strait of Sicily. On average 73% of total striped red mullet landings in GSA 15 came from trawlers in 2007-2012; in GSA 16 the proportion of landings coming from bottom otter trawlers was 88% in 2004-2012. The great majority of remaining catches come from gillnet fisheries, although small amounts of striped red mullet are landed as by-catch from set gillnets (less than 0.5% of catches in both GSAs for during the analysed time period).

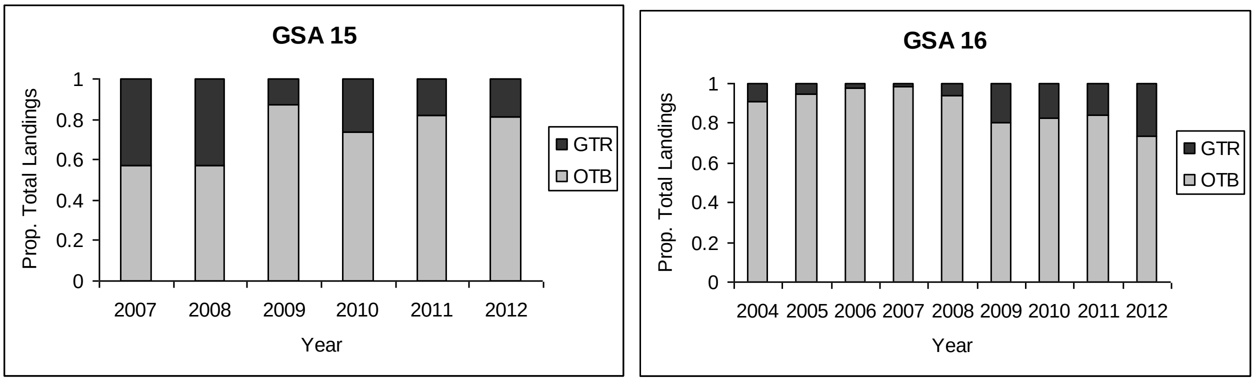



Figure 6.9.2.1.1. Striped red mullet GSA 15 and 16. Proportion of total landings coming from vessels using bottom otter trawl (OTB) gear and from vessels using trammel nets (GTR)

In GSA 15 the main fishing grounds for striped red mullet are located on the continental shelf of the Malta Bank to the south east of the Maltese Islands, within the 25 nautical mile Fisheries Management Zone. In GSA 16 the main fishing grounds of artisanal fisheries are located on soft bottoms between 20 and 60 m depth either inshore and offshore (i.e. Adventure Bank). Catch from trawlers came mostly from the continental shelf.

Management regulations applicable in 2010 and 2011

At present there are no formal management objectives for striped red mullet fisheries in the Strait of Sicily. As in other areas of the Mediterranean, the stock management in Italy and Malta is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area/season closures).

In order to limit the over-capacity of the fishing fleet, no new fishing licenses have been assigned in Italy since 1989 and a progressive reduction of the trawl fleet capacity is currently underway. Maltese fishing capacity licenses had been fixed at a total of 16 trawlers since 2000, but eight new licenses were issued in 2008 and one in 2011, a move made possible by capacity reductions in other segment of the Maltese fishing fleet.

A compulsive fishing ban for 30 days in August-September was recently adopted by Sicilian Government. There is no closed season in place in Malta, but the Maltese Islands are surrounded by a 25 nautical miles fisheries management zone where fishing effort and capacity are being managed by limiting vessel sizes, as well as total vessel engine powers (EC 813/04; EC 1967/06). Trawling is allowed within this designated conservation area, however only by vessels not exceeding an overall length of 24 m and only within designated areas. Vessels fishing in the management zone hold a special fishing permit in accordance with Regulation EC 1627/94. Moreover, the overall capacity of the trawlers allowed to fish in the 25nm zone cannot exceed 4 800 kW, and the total fishing effort of all vessels is not allowed to exceed an overall engine power and tonnage of 83 000 kW and 4 035 GT respectively. The fishing capacity of any single vessel with a license to operate at less than 200m depth cannot exceed 185 kW.

In order to protect coastal habitats the use of towed gears is prohibited within 3 nm of the coast or within the 50 m isobath if the latter is reached closer to the coast in both Malta and Italy (EC 1967/2006; Res. GFCM 36/2012/3).

In terms of technical measures, EC 1967/2006 fixed a minimum mesh size of 40 mm for bottom trawling of EU fishing vessels. Mesh size had to be modified to square 40 mm square or at the duly justified request of the ship owner a 50 mm diamond mesh in July 2008; derogations were only possible up to 2010. Moreover diamond mesh panels can only be used if it is demonstrated that size selectivity is of equivalent or higher than using 40 mm square mesh panels (EC 1343/2011).

The minimum landing size for red mullets (*Mullus* spp.) is 11 cm in European legislation (EC 1967/2006).

Catches

Landings

Total striped red mullet landings for Italian and Maltese fleets combined in the period 2002-2012 decreased from 2616 tonnes in 2002 to 753 tonnes in 2012; landings recorded in 2012 were at the lowest level recorded in the time series. A similar pattern was observed for *Mullus barbatus* (red mullet) in the same area.

The Maltese landings have however increased ten fold in 2005-2012, from 7.4 tonnes in 2005 to 75 tonnes in 2012. The average of striped red mullet landings in 2010 – 2012 was 937 tonnes from Sicilian vessels and 63 tonnes from Maltese vessels in 2009-2012; the average annual contribution of Maltese catches to the total catch in this period was 6.3%.

Table 6.9.2.3.1.1.Striped red mullet GSA 15 and 16. Total annual landings (t) in 2002-2012 for GSA 16 and 2005-2012 in GSA 15 as reported through the EU DCF data call.

| Area | Country | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GSA 15 | Malta | - | - | - | 7 | 10 | 15 | 16 | 37 | 51 | 64 | 75 |
| GSA 16 | Italy | 2616 | 1657 | 2092 | 1008 | 1853 | 2330 | 1456 | 870 | 1118 | 1016 | 678 |
| GSA 15&16 | Italy & Malta | 2616 | 1657 | 2092 | 1016 | 1863 | 2344 | 1472 | 907 | 1169 | 1080 | 753 |

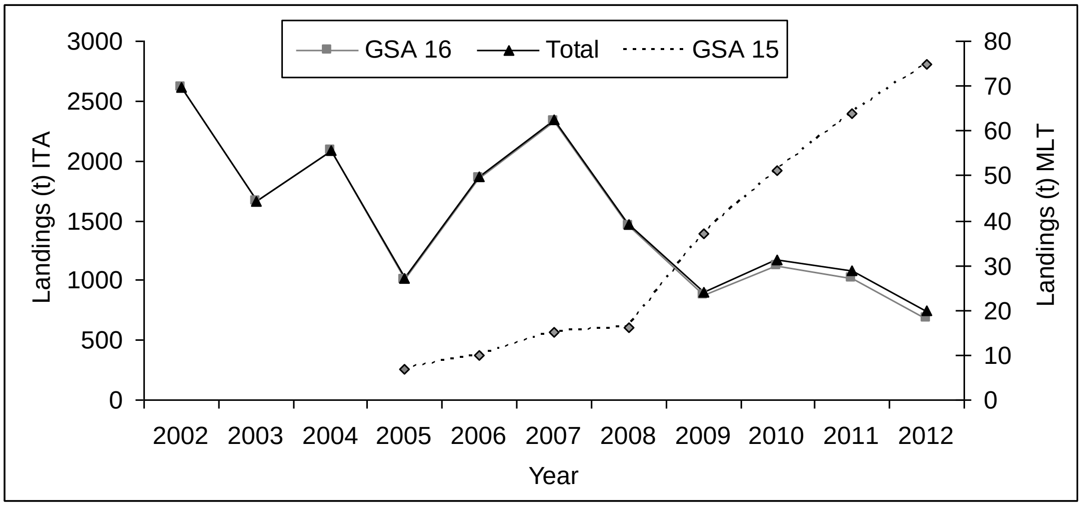



Fig. 6.9.2.3.1.1. Striped red mullet GSA 15 and 16. Evolution of total landings in 2002-2012 for Italian fleet (left axis) and Maltese fleet (right axis).

Length frequencies of total landings from the Strait of Sicily (Italian and Maltese landings data combined), are shown in Figure 6.9.2.3.1.2 below. Landings are dominated by specimens between 14-22 cm length.

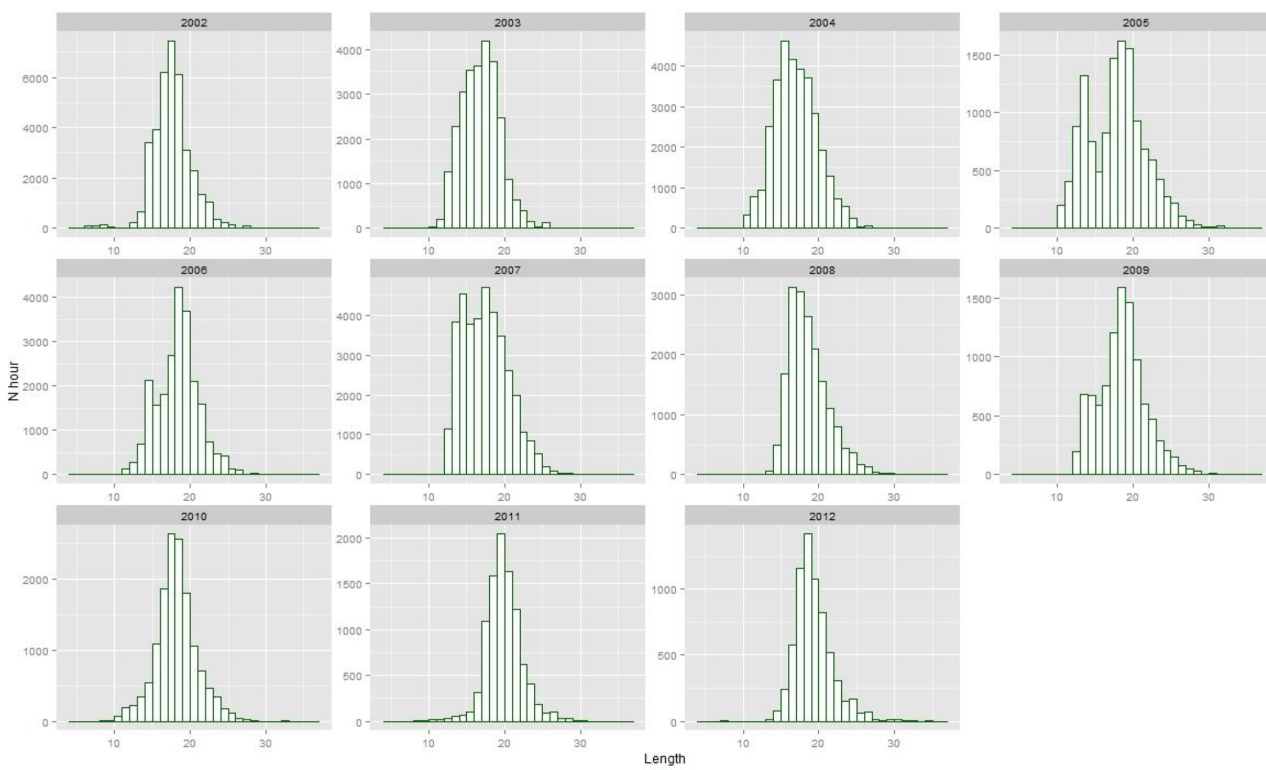



Fig. 6.9.2.3.1.2. Striped red mullet GSA 15 and 16. Length frequency of landings in 2002-2012; numbers are in thousands.

Discards

According to official data submitted by Italian authorities in response to the DCF data call, an estimated 1.4 tonnes of striped red mullet were discarded by the Italian fleet in 2012, with 1.2 tonnes coming from small vessels (6 – 12 m LOA) engaged in the trammel net fishery. The discards were evaluated in 2010-2011 to be between 0.14 and 0.17% of the total catch (Tab. 6.9.2.3.2.1).

Discarded specimens ranged mostly between 9 and 14 cm TL (Fig. 6.9.2.3.2.1).

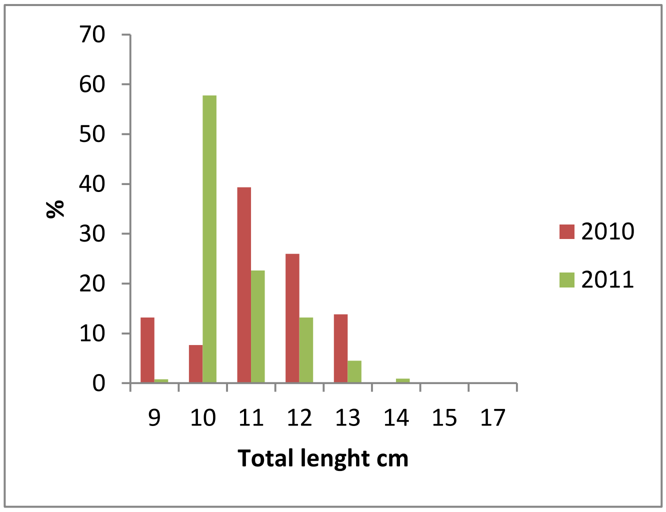


Fig. 6.9.2.3.2.1. Striped red mullet GSA 15 and 16. Length frequency composition of discards

Tab. 6.9.2.3.2.1Striped red mullet in GSA 15 and 16. Discard estimates for the Italian fleet in 2010-2012.

| Year | Vessel Length (m) | Gear | Discards (t) |
|---|---|---|---|
| 2010 | VL1224 | OTB | 0.30 |
| | VL2440 | OTB | 0.02 |
| 2011 | VL1824 | OTB | 1.52 |
| | VL2440 | OTB | 0.06 |
| 2012 | VL0612 | GTR | 1.21 |
| | VL1824 | GTR | 0.10 |
| | VL2440 | OTB | 0.10 |

No information on total discards or discarded sizes was available for the Maltese fleet in the official data.

Fishing effort

In 2011 the Italian trawlers measuring 12-24 m, operating mainly on short-distance fishing trips and fishing on the outer shelf and upper slope, were 250. In addition 140 Italian trawlers measuring over 24m in length carrying out longer fishing trips (up to 4 weeks) were active in both the Italian and the international waters of the Central Mediterranean. In the Maltese Islands 14 trawlers measuring 12-24 m and 8 measuring over 24 m in length were active in 2011, 11 of which had a license to operate within the 25 nm Maltese Fisheries Management Zone.

With regards to fishing effort, data submitted by Italy and Malta in response to the annual EU fisheries Data Collection Framework (DCF) data-call in 2013 revealed a 40% decrease in fishing effort for Italian bottom otter trawl vessels larger than 24 m in the period 2004-2012. Maltese vessels were only responsible for 3.5% of total trawling effort in GSAs 15 and 16 in 2012, however the total nominal effort of Maltese trawlers increased by 78% in 2005-2012 and fishing effort exerted by Maltese trawlers increased by 27% in 2011-2012 (Fig. 6.9.2.4.1).

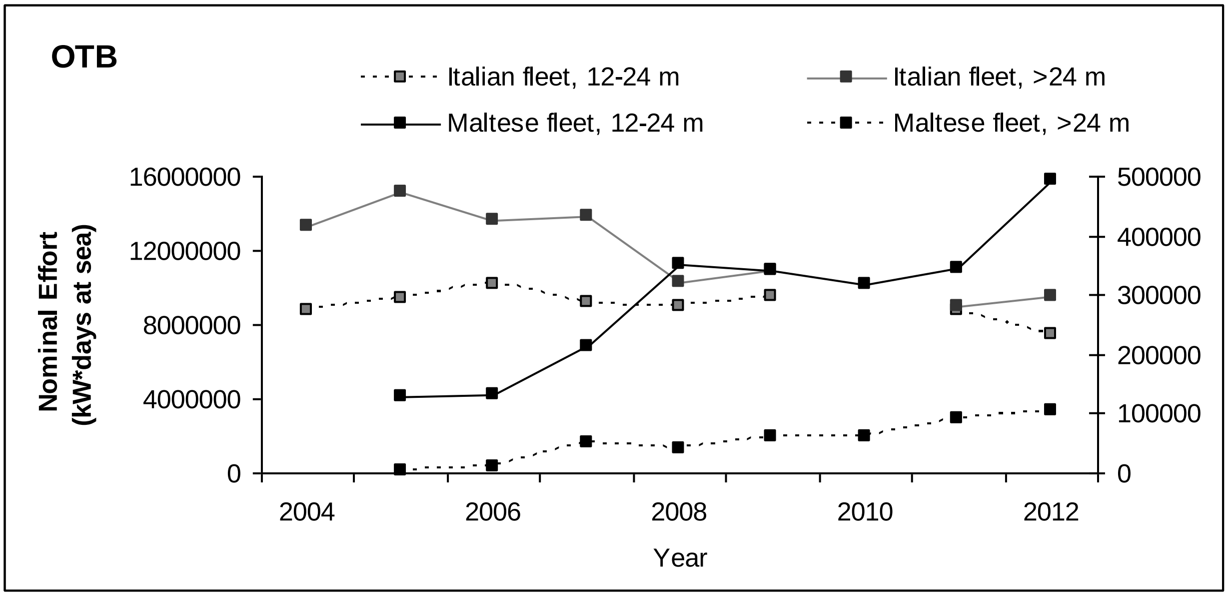



Fig. 6.9.2.4.1 Nominal effort (kW*days at sea) trends of trawlers (OTB) by Italian (left y-axis) and Maltese (right y-axis) 12-24 m and over 24 m LOA fleet segments

With regards to vessels fishing with trammel nets, DCF data show a 33% decline in fishing effort for Italian artisanal vessels measuring 6-12 m in length, and a 42% increase in fishing effort for vessels measuring 12-24 m in the period 2004-2012. For the Maltese fleet, fishing effort for vessels fishing with trammel nets overall declined by 70% in the period 2006-2012 (Table 6.9.2.4.2.).

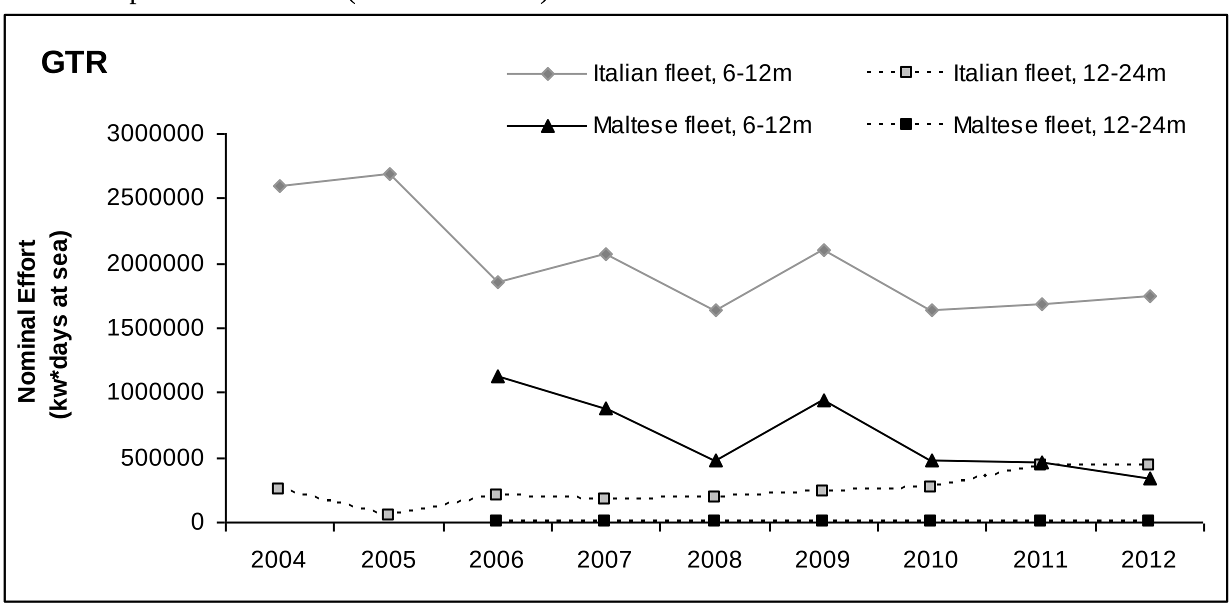


Fig. 6.9.2.4.2. Nominal effort (kW*days at sea) trends of trammel nets (GTR) by Italian and Maltese 6-12 m and 12-24 m LOA fleet segments

## 6.9.3. **Scientific surveys**

MEDITS

Methods

In order to collect fisheries independent data, which is a requirement of the EU DCF (Council Regulation 199/2008, Commission Regulation 665/2008, Commission Decision EC 949/2008 and Commission Decision 93/2010); the MEDITS international trawl survey is carried out in GSAs 15 and 16 on an annual basis. The number of hauls was reported per depth stratum in 1994-2012 (GSA 16) and 2002-2012 (GSA 15) is reported in Tables 6.9.3.1.1.1 and 6.9.3.1.1.2.

Tab. 6.9.3.1.1.1 Number of hauls per year and depth stratum in GSA 16, 1994-2012.

| Depth (m) | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10-50 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 7 | 7 |
| 50-100 | 8 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 11 | 12 |
| 100-200 | 4 | 4 | 4 | 4 | 5 | 5 | 6 | 5 | 10 | 8 |
| 200-500 | 10 | 11 | 11 | 12 | 11 | 11 | 11 | 11 | 19 | 18 |
| 500-800 | 10 | 14 | 14 | 13 | 14 | 14 | 14 | 14 | 19 | 20 |

| Depth (m) | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|
| 10-50 | 7 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 11 |
| 50-100 | 12 | 20 | 22 | 23 | 23 | 23 | 23 | 23 | 23 |
| 100-200 | 9 | 18 | 19 | 21 | 21 | 21 | 21 | 21 | 21 |
| 200-500 | 19 | 28 | 31 | 27 | 27 | 27 | 27 | 27 | 27 |
| 500-800 | 19 | 32 | 33 | 38 | 38 | 38 | 38 | 38 | 38 |

Tab. 6.9.3.1.1.2 Number of hauls per year and depth stratum in GSA 15, 2002-2012.

| Depth (m) | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-50 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50-100 | 5 | 5 | 4 | 5 | 5 | 12 | 6 | 6 | 6 | 6 | 6 |
| 100-200 | 13 | 13 | 13 | 13 | 13 | 12 | 13 | 14 | 14 | 14 | 14 |
| 200-500 | 10 | 10 | 10 | 9 | 10 | 4 | 9 | 10 | 10 | 10 | 10 |
| 500-800 | 16 | 16 | 15 | 17 | 16 | 17 | 17 | 15 | 15 | 15 | 14 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). A limited number of obvious data errors were corrected and catches by haul were standardized to 60 minutes haul duration. Only hauls noted as valid were used, including stations with no catches of hake, red mullet or pink shrimp (i.e. zero catches were included).

The abundance and biomass indices were subsequently calculated by stratified means (Cochran, 1953; Saville, 1977). This implies weighing average values of the individual standardized catches as well as the variation of each stratum by the respective stratum area:

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

Where:

A = total survey area
Ai = area of the i-th stratum
si = standard deviation of the i-th stratum
ni = number of valid hauls of the i-th stratum
n = number of hauls in the GSA
Yi = mean of the i-th stratum
Yst = stratified mean abundance
V(Yst) = variance of the stratified mean

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

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

Geographical distribution patterns

The distribution of striped red mullet spawners was analysed as part of the Mediseh project, and results showed localized off-shore spawning areas (see section on maturity above). In particular, a large and persistent spawning area is located in the west side of the Adventure Bank. Another concentration of spawners, which however doesn't attain temporal persistency, is located on the area off the east of Malta within the 25 nautical mile FMZ

Since the MEDITS survey is carried out before the recruitment period of the species (summer-autumn), the MEDITS data cannot be used to identify nursery grounds. In addition, due the preference of *M. surmuletus* for coastal habitats and rocky bottoms, trawl survey cannot appropriately sample the species.

Trends in abundance and biomass

Fishery independent information regarding the state of the striped red mullet stock in GSAs 15 and 16 can be derived from the international bottom trawl survey MEDITS, which has been carried out in GSA 15 since 2002 and in GSA 16 since 1994.

The patterns recorded in GSA 15 and GSA 16 in 2002-2012 were generally similar, however total abundance and total biomass recorded in GSA 15 in 2002-2012 were considerably higher than in GSA 16 (Figs. 6.9.3.1.3.1 and 6.9.3.1.3.2). Moreover in 2010 a decline in abundance was recorded in GSA 15 although an increase in abundance was recorded in GSA 16. In the longer time series available from GSA 16, fluctuations in abundance (min 37 N/km2 in 2006, max 234 and 181 n/km2 in 1996 and 181 respectively) and biomass (min 1.4 kg/km$^2$ in 2003 and max 15 kg/km$^2$ in 1996) are evident.

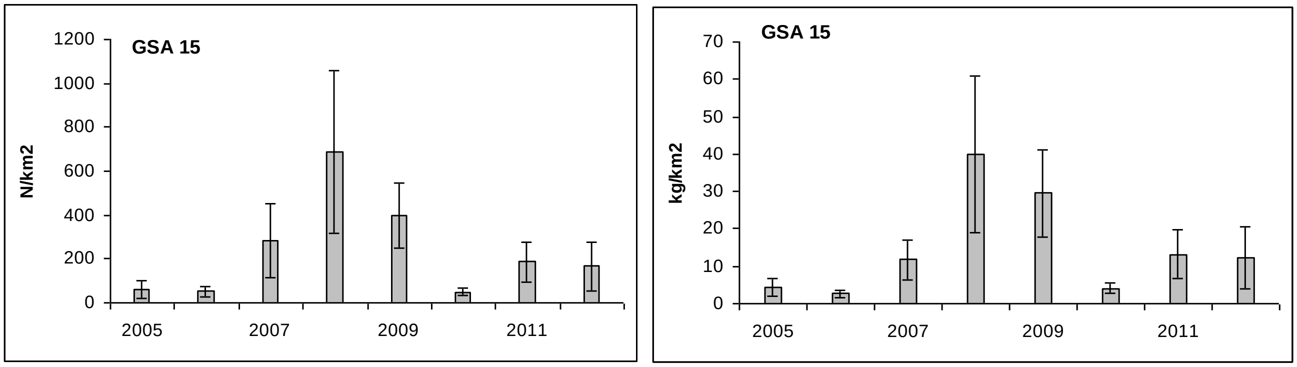



Fig. 6.9.3.1.3.1. Striped red mullet GSA 15. Abundance and biomass indices of *Mullus surmuletus* for the years 2002-2011 in GSA 15.

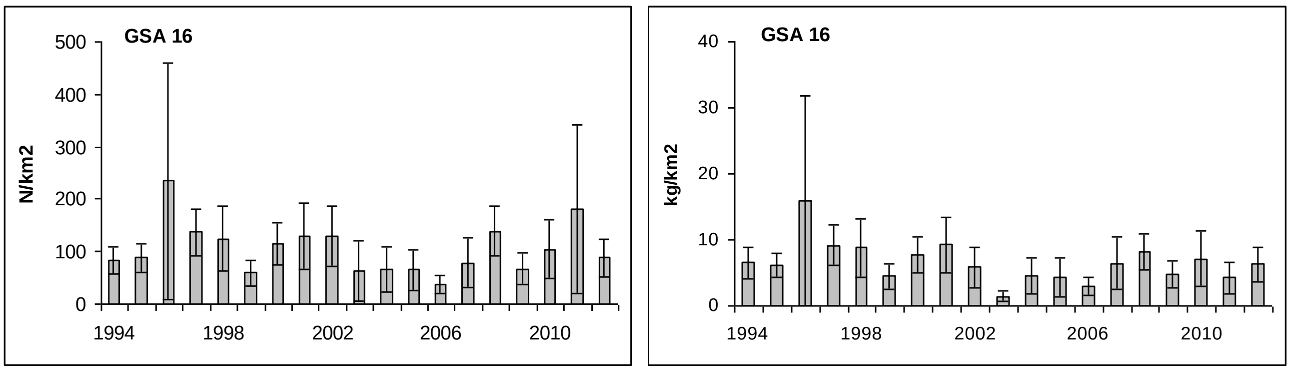



Fig. 6.9.3.1.3.2. Striped red mullet GSA 16. Abundance and biomass indices of *Mullus surmuletus* for the years 1994-2011 in GSA 16.

Trends in abundance by length or age

The following Figures 6.9.3.1.4.1 and 6.9.3.1.4.2 display the standardized length frequency distributions (LFDS) of striped red mullet in GSA 16 (2002-2012) and 15 (2005-2012).

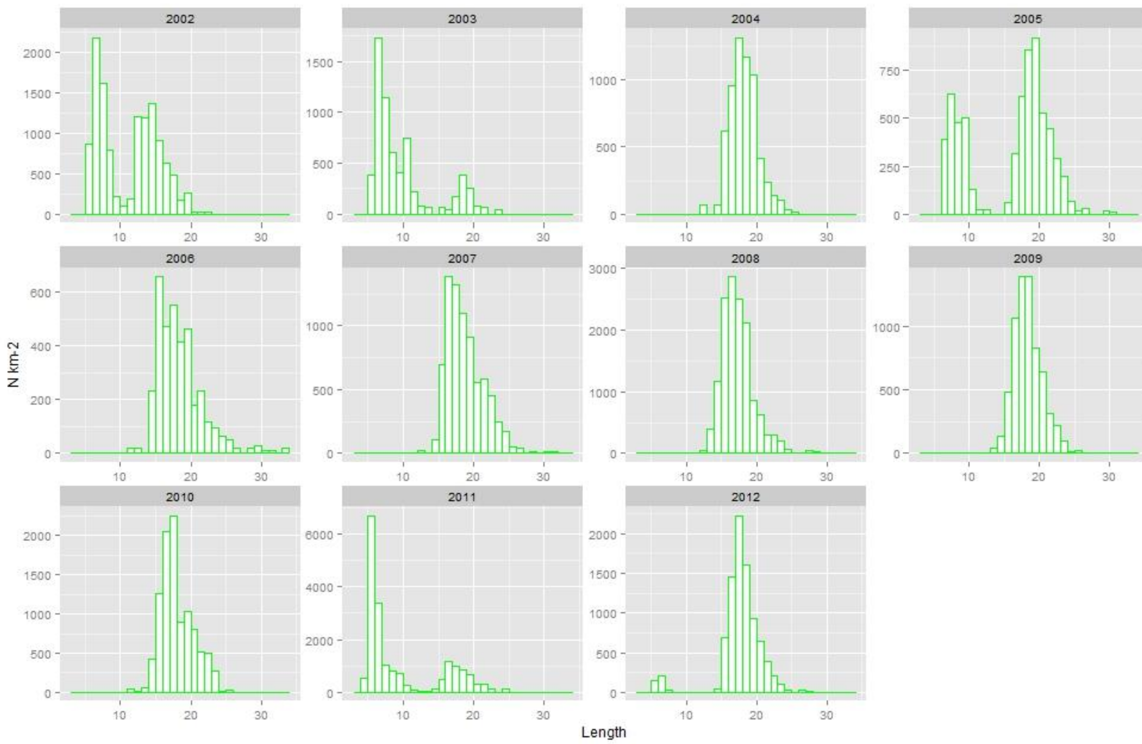



Fig. 6.9.3.1.4.1 Striped red mullet GSA 16. Stratified abundance indices by size class in GSA 16, 2002-2012. Numbers are in thousands.

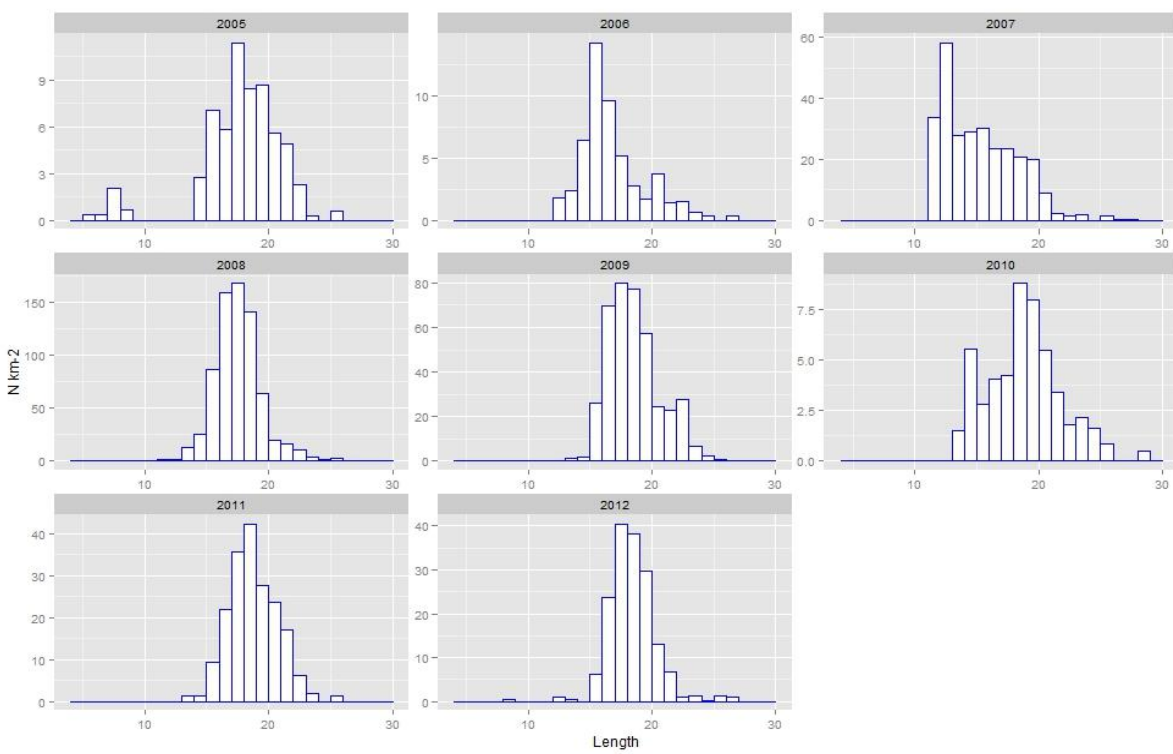



Fig. 6.9.3.1.4.2 Striped red mullet GSA 15. Length frequency of MEDITS in 2002-2012; numbers are in thousands.

Trends in growth

No analyses were conducted during EWG 13-19.

Trends in maturity

No analyses were conducted during EWG 13-19.

### 6.9.4. **Assessments of historic stock parameters**

Method 1: XSA

Justification

An XSA assessment was run using the Italian and Maltese annual landings data of the GSAs 15-16 for the period 2002 to 2012 and calibrated with MEDITS survey data for the same period 2002-2012. The Maltese landings (GSA 15), corresponding to a proportion that has increased from 0.53 % in 2005 to 12% in 2012 of the Italian landings, were available for the period 2005-2012. An average proportion of 0.6% was added to the Italian landings for the period 2002-2004.

Input parameters

The annual size distributions (LFDs) of the catch as well as of the surveys (MEDITS) were converted in numbers at ages classes 1-6+ using the slicing statistical approach developed during STECF-EWG 11-12 (Scott et al., 2011).LFDs were sliced according to two different set of growth parameters corresponding to a slow growth ($L_{inf}$=36.00, k=0.22, to=-0.7) and fast growth pattern (Linf=38.00, k=0.31, to=-0.4) respectively. The pattern produced by the fast growth parameters appeared more consistent and was therefore adopted to compile the catch-at age matrix as well as to split the MEDITS length frequency distributions from 2002 to 2012. These were used as tuning data. The XSA input data are listed in Table 6.9.4.1.2.2.

Table 6.9.4.1.2.1. Striped red mullet GSA 15-16. Results of the statistical slicing applied according to two different sets of growth parameters corresponding to slow and fast growth rate.

Slow growth

| Age group | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 450.31 | 14.07 | 312.16 | 0.00 | 0.03 | 0.03 | 0.05 | 8.38 | 125.75 | 29.12 | 1.87 |
| 1 | 13580.22 | 12331.94 | 15480.93 | 3760.27 | 5794.80 | 15749.78 | 6003.81 | 2109.23 | 3471.56 | 439.86 | 0.00 |
| 2 | 19996.21 | 13556.40 | 14330.13 | 6953.10 | 14315.13 | 17057.04 | 8805.99 | 6173.44 | 9061.53 | 7045.69 | 5655.86 |
| 3 | 2887.87 | 924.64 | 2197.07 | 2032.63 | 2542.68 | 3852.43 | 2695.94 | 1520.58 | 1549.98 | 1931.30 | 960.34 |
| 4 | 209.49 | 17.00 | 0.00 | 36.05 | 203.72 | 185.67 | 270.94 | 185.25 | 0.01 | 196.22 | 8.97 |
| 5+ | 0.02 | 0.04 | 17.69 | 111.20 | 0.01 | 49.76 | 61.85 | 24.28 | 6.81 | 0.01 | 65.77 |

Fast growth

| Age group | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 469.49 | 368.28 | 703.75 | 585.43 | 295.38 | 379.16 | 178.08 | 103.58 | 334.22 | 158.53 | 68.2 |
| 1 | 31366.37 | 24625.72 | 26524.55 | 8785.92 | 17402.15 | 28761.09 | 13160.54 | 7175.17 | 11223.85 | 5638.7 | 4783.86 |
| 2 | 5150.57 | 2113.67 | 5081.4 | 3383.7 | 5300.49 | 8023.5 | 4462.44 | 2727.86 | 2643.26 | 3739.6 | 1767.12 |
| 3 | 136.53 | 4.4 | 26.27 | 136.11 | 85.38 | 92.47 | 209.54 | 111.31 | 38.3 | 204.86 | 123.8 |
| 4 | 1.14 | 0.01 | 1.97 | 0.02 | 0.95 | 7.45 | 5.98 | 3.24 | 1.98 | 0.49 | 15.79 |
| 5+ | 0.01 | 0.01 | 0.04 | 2.08 | 0.03 | 0.04 | 0 | 0.01 | 0.03 | 0.01 | 0.01 |

The XSA settings adopted for the analyses were the followings: shrinkage (Fse): 0.5, 1.0, 2.0 ; Rage: 2; Qage: 2; shk.yrs: 3; shk.ages: 3. Table 6.9.4.1.2.2 lists the XSA input data.

Table 6.9.4.1.2.2. Striped red mullet GSA 15 and 16. XSA input data.

Catch at Age (thousands)

| age | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 469.49 | 368.28 | 703.75 | 585.43 | 295.38 | 379.16 | 178.08 | 103.58 | 334.22 | 158.53 | 68.2 |
| 2 | 31366.37 | 24625.72 | 26524.55 | 8785.92 | 17402.15 | 28761.09 | 13160.54 | 7175.17 | 11223.85 | 5638.7 | 4783.86 |
| 3 | 5150.57 | 2113.67 | 5081.4 | 3383.7 | 5300.49 | 8023.5 | 4462.44 | 2727.86 | 2643.26 | 3739.6 | 1767.12 |
| 4 | 136.53 | 4.4 | 26.27 | 136.11 | 85.38 | 92.47 | 209.54 | 111.31 | 38.3 | 204.86 | 123.8 |
| 5 | 1.14 | 0.01 | 1.97 | 0.02 | 0.95 | 7.45 | 5.98 | 3.24 | 1.98 | 0.49 | 15.79 |
| 6 | 0.01 | 0.01 | 0.04 | 2.08 | 0.03 | 0.04 | 0 | 0.01 | 0.03 | 0.01 | 0.01 |

Natural Mortality (M) at age (PROBIOM)

| age | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| 2 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 | 0.34 |
| 3 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 | 0.27 |
| 4 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| 5 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 | 0.21 |
| 6 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Maturity at age

| age | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| 2 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

MEDITS index (2002-2012)

| age | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5959.825 | 5205.705 | 71.422 | 2152.421 | 32.875 | 19.532 | 44.665 | 35.068 | 62.402 | 13200 | 391.460 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 6354.118 | 1170.754 | 5301.065 | 3138.234 | 2787.440 | 5521.404 | 12546.580 | 5463.021 | 7805.385 | 5158.085 | 7668.145 |
| 3 | 22.624 | 154.901 | 797.889 | 1224.415 | 749.701 | 2064.139 | 1375.138 | 1115.435 | 2295.272 | 474.199 | 685.558 |
| 4 | 0.001 | 0.005 | 0.087 | 19.112 | 51.856 | 40.324 | 69.682 | 0.067 | 0.065 | 0.042 | 2.220 |
| 5 | 0.000 | 0.000 | 0.003 | 2.596 | 29.211 | 21.179 | 1.561 | 0.002 | 0.002 | 0.000 | 0.002 |
| 6 | 0.000 | 0.000 | 0.005 | 0.134 | 16.673 | 2.894 | 0.043 | 0.004 | 0.003 | 0.000 | 0.000 |

Results

As showed in Figure 6.9.4.1.3.1, XSA run with shrinkage at 2.0diverged from runs with the other two settings in particular for SSB and recruitment (Fig. 6.9.4.1.3.1).Model with 2.0 shrinkage was adopted as final model based on both residuals and retrospective analysis (Figs. 6.9.4.1.3.2 and 6.9.4.1.3.3). Furthermore, it also kept the high recruitment peak showed by the MEDITS survey in 2011.

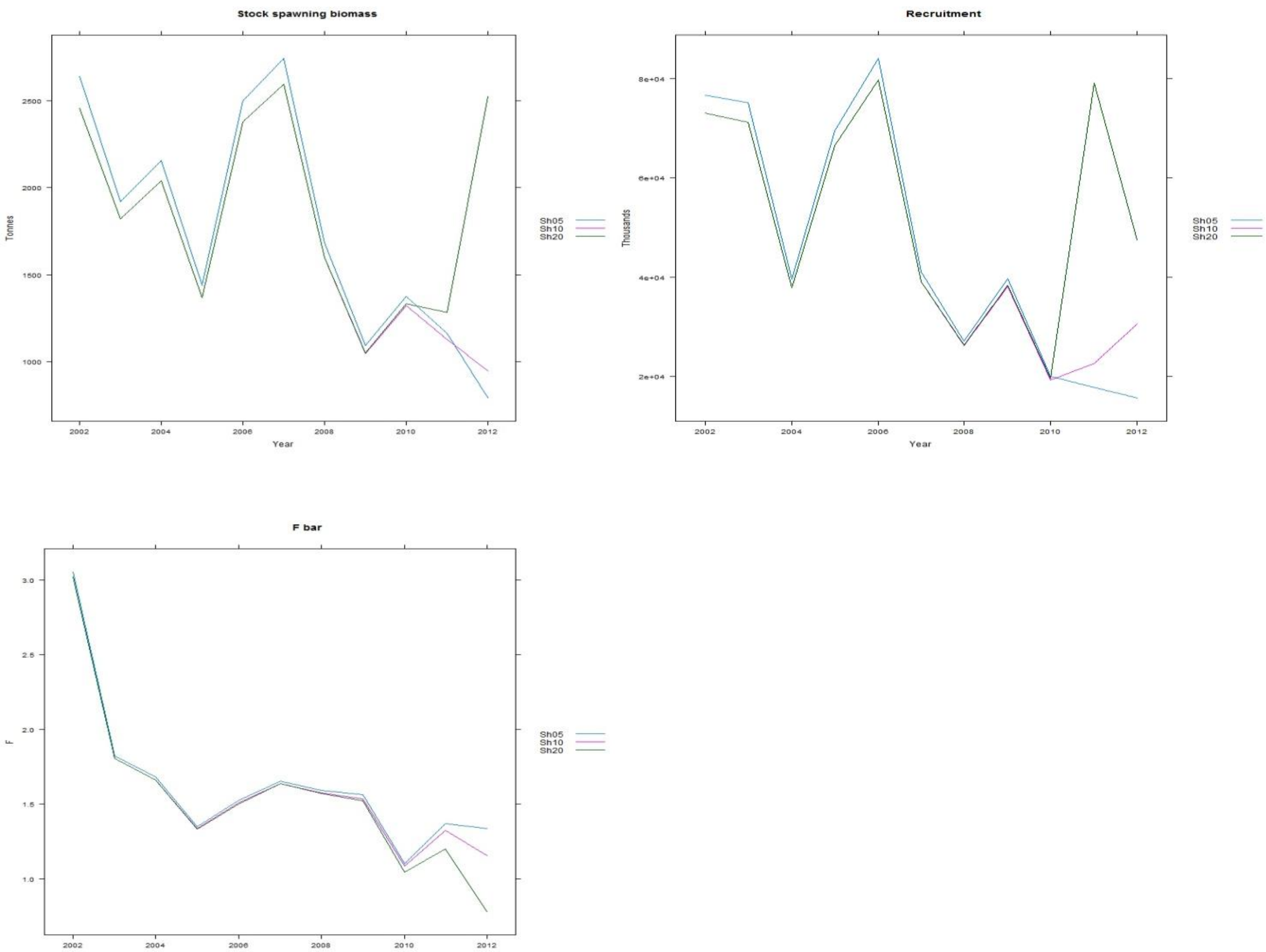
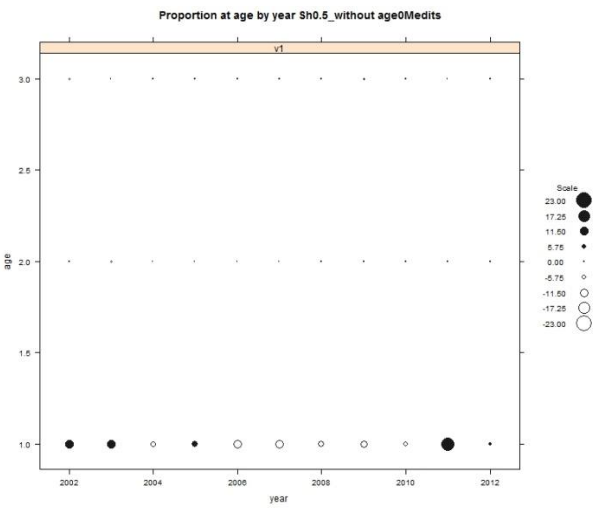
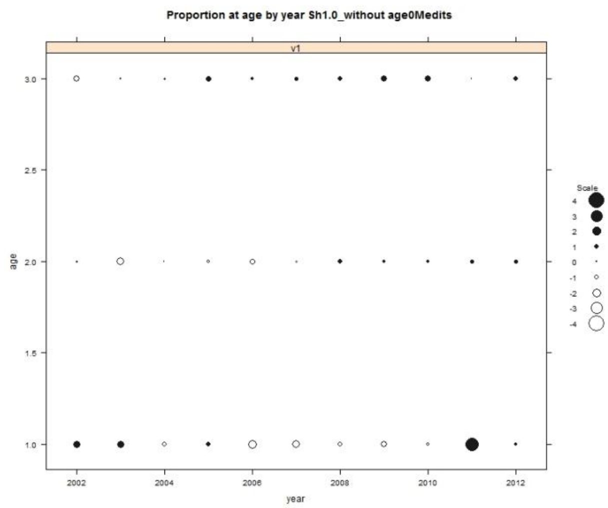



Fig. 6.9.4.1.3.1. Striped red mullet GSA 15 and 16. Estimates of SSB, recruitment and F according to different values of shrinkage.

Shrinkage=0.5




Shrinkage=1.0




Shrinkage=2.0

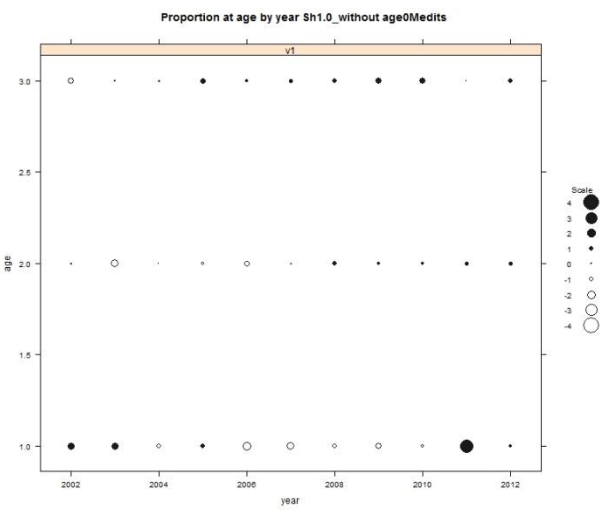
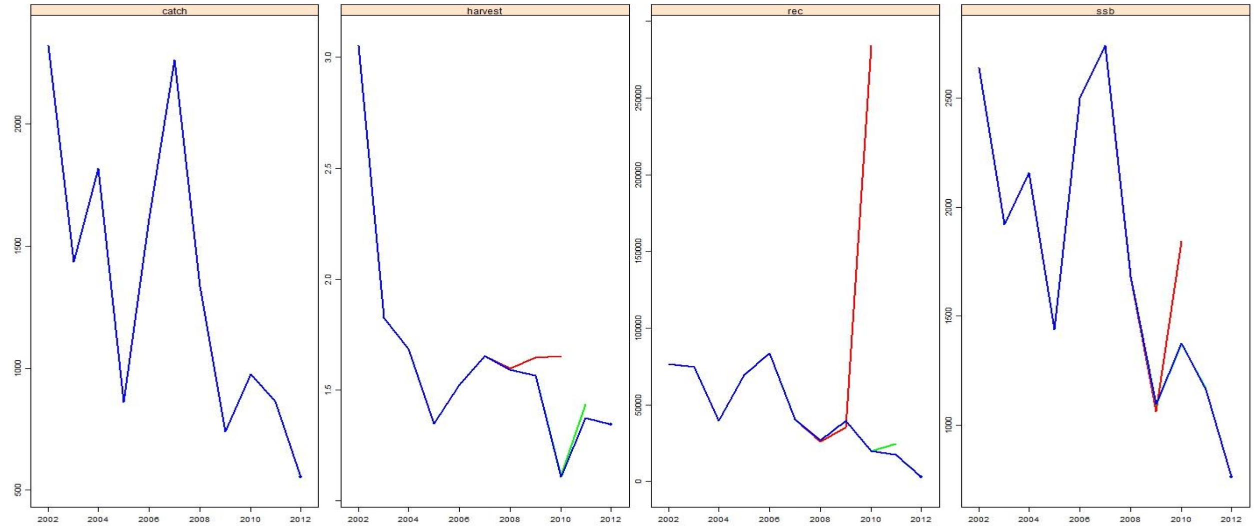
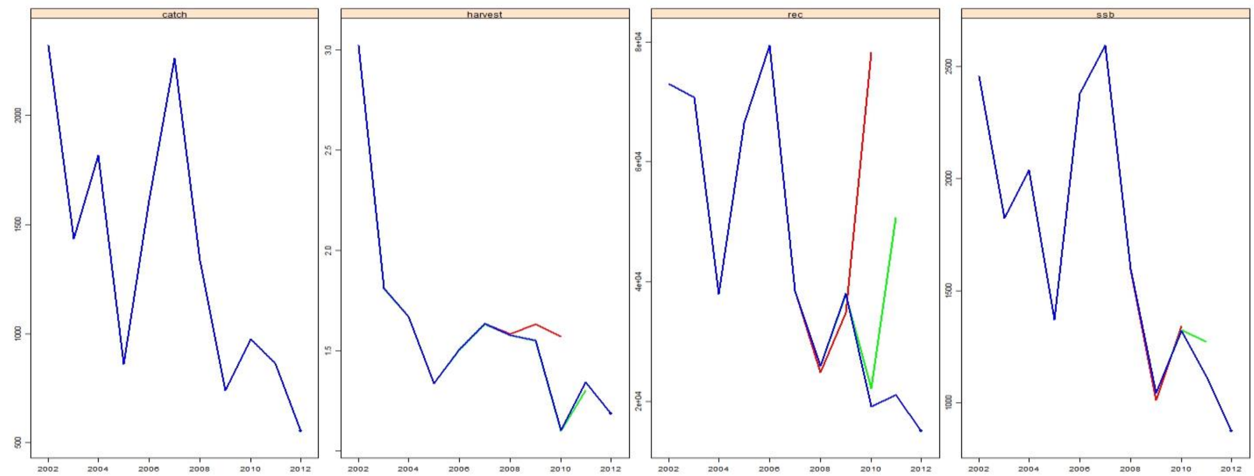



Fig. 6.9.4.1.3.2. Striped red mullet GSA 15 and 16. Residuals at age of XSA with shrinkage set at 0.5, 1.0 and 2.0.

Shrinkage 0.5




Shrinkage 1.0




Shrinkage 2.0

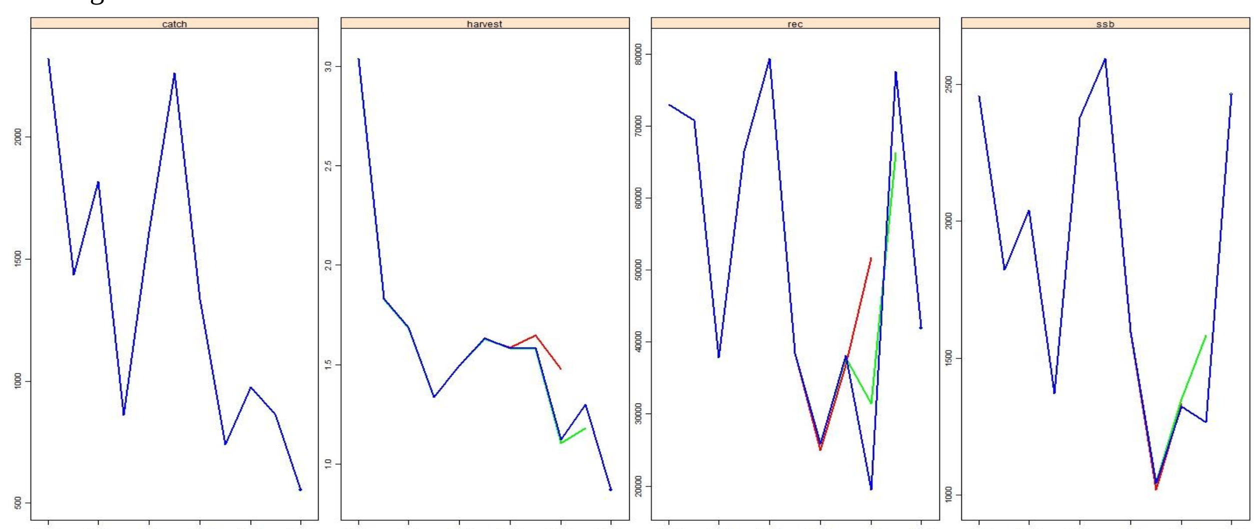


Fig. 6.9.4.1.3.3. Striped red mullet in GSA 15 and 16. Retrospective analysis with three different values of shrinkage.

The final model is showed in Fig. 6.9.4.1.3.4. In 2002-2012, the SSB ranged between about 1,043 and 2,462t. In the same period recruitment at age 1 fluctuated widely between 19.4 and 77.6 million (Table 6.9.4.1.3.1). $Fbar_{1-4+}$showed a declining temporal trend from 3.0 in 2002 to 0.78 in 2012 (Table 6.9.4.1.3 2). Fishing mortality was generally higher for age classes 3-4.

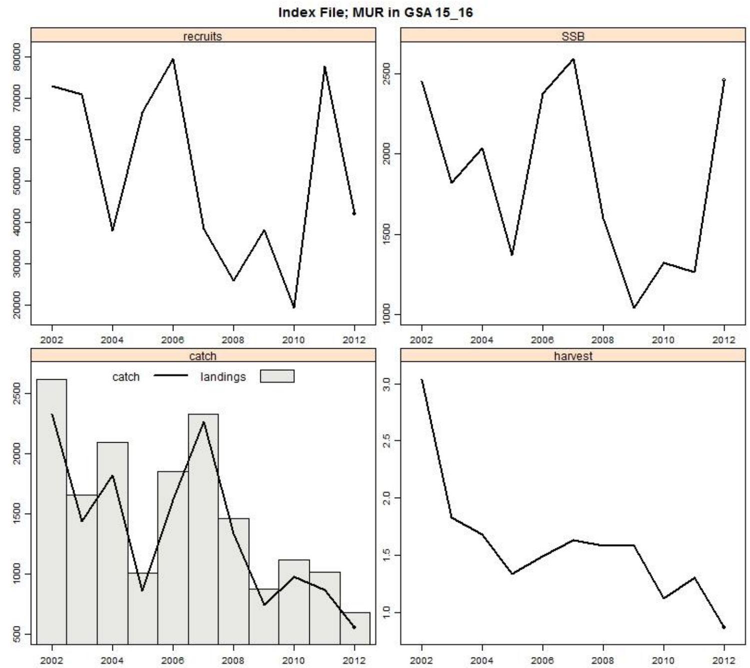



Fig. 6.9.4.1.3.4. Striped red mullet in GSA 15 and 16. XSA results: F, Recruitment, SSB and Yield.

Table 6.9.4.1.3.1. Spawning stock biomass (SSB), and recruitment estimates by XSA for Striped red mullet in GSA 15 and 16 from 2006 to 2011.

| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SSB** (tons) | 2456 | 1821.5 | 2038.6 | 1370.3 | 2378.4 | 2593.4 | 1595.9 | 1043 | 1323.9 | 1264.1 | 2462.3 |
| **Recruitment** (millions) | 73.037 | 70.823 | 37.868 | 66.524 | 79.440 | 38.484 | 25.852 | 38.113 | 19.406 | 77.618 | 41.971 |

Table 6.9.4.1.3.2. Fishing mortality and numbers at age at age as estimated by XSA.

| **F-at-age** | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.01 | 0.01 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 |
| 2 | 2.47 | 1.50 | 1.89 | 0.81 | 0.95 | 1.73 | 1.51 | 1.01 | 1.13 | 1.14 | 0.15 |
| 3 | 6.58 | 3.91 | 3.08 | 3.18 | 3.58 | 3.17 | 3.20 | 3.56 | 2.01 | 2.60 | 2.18 |
| 4 | 3.02 | 1.81 | 1.66 | 1.33 | 1.48 | 1.64 | 1.56 | 1.52 | 1.02 | 1.07 | 0.79 |
| **Fbar(1-4)** | **3.02** | **1.80** | **1.66** | **1.33** | **1.50** | **1.64** | **1.57** | **1.52** | **1.05** | **1.20** | **0.78** |

### 6.9.5. **Long term prediction**

Justification

A yield per recruits model (YPR) under the equilibrium assumption was run using FLR.

Input parameters
YPR was run using the XSA input values for ages 1 to 5+ and XSA estimates of F at age, recruitment and SSB.

Results

$F_{01}$ was estimated to be 0.19 (Tab. 6.9.5.1.2.1).

Table 6.9.5.1.2.1 Striped red mullet in GSAs 15 and 16. Results of yield per recruit analysis

| Ref. Points | Harvest | Yield | Rec | SSB | Biomass |
|---|---|---|---|---|---|
| virgin | 0 | 0 | 1 | 0.48 | 0.50 |
| $F_{0.1}$ | 0.19 | 0.03 | 1 | 0.20 | 0.21 |
| $F_{max}$ | 0.34 | 0.04 | 1 | 0.12 | 0.14 |
| spr.30 | 0.27 | 0.04 | 1 | 0.15 | 0.16 |

### 6.9.6. **Short term prediction 2013-2014**

Input parameters

An average of the last three years has been used for weight at age, maturity at age and F at age of the last year (2012). Mortality at age was the same as used as input data in the XSA.

*Recruitment*

Recruitment (class 0+) in 2013 has been estimated as the geometric mean (2010-2012), taken from XSA results = 41944 (thousands).

A short term projection table (Table 6.9.6.1.1) assuming a *status-quo* F of $F_{stq}$=0.78 in 2013 and a recruitment of 41944 thousand individuals shows that:

- Fishing at $F_{stq}$ from 2012 to 2014 would produce an increase in catches of 156.4% and a decrease in SSB of 4.5% between 2014 and 2015.
- Fishing at $F_{0.1}$ (0.19) from 2012 to 2014 would generate a decrease of 8.1% of the catches and an increase of 46.2% in SSB.
- STECF EWG 13-19 considers that catch in 2014 does not exceed 600 t, corresponding to $F_{0.1.}$= 0.19.

Table 6.9.6.1.1. Striped red mullet GSA 15 and 16. Short term forecast for different F scenarios computed for *Mullus surmuletus* in GSA 15 and 16. Basis: F(2012) =0.78; R(2010-2012): 41944 (thousands); SSB(2012)= 2525 t; landings(2012)= 653 t.

| | F Fact. | Fbar | Catch 2012 | Catch 2013 | Catch 2014 | Catch 2015 | SSB 2014 | SSB 2015 | Change in SSB 2014 - 2015(%) | Change in Catch 2012 - 2014(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.0 | 652.8 | 2684.3 | 0.0 | 0.0 | 3008.3 | 5287.0 | 75.7 | -100.0 |
| 2 | 0.1 | 0.1 | 652.8 | 2684.3 | 260.1 | 420.8 | 3008.3 | 4899.0 | 62.8 | -60.2 |
| 3 | 0.2 | 0.2 | 652.8 | 2684.3 | 491.8 | 742.0 | 3008.3 | 4556.5 | 51.5 | -24.7 |
| 4 | 0.3 | 0.2 | 652.8 | 2684.3 | 698.8 | 985.6 | 3008.3 | 4253.3 | 41.4 | 7.0 |
| 5 | 0.4 | 0.3 | 652.8 | 2684.3 | 884.3 | 1168.7 | 3008.3 | 3984.1 | 32.4 | 35.4 |
| 6 | 0.5 | 0.4 | 652.8 | 2684.3 | 1051.0 | 1305.0 | 3008.3 | 3744.5 | 24.5 | 61.0 |
| 7 | 0.6 | 0.5 | 652.8 | 2684.3 | 1201.2 | 1404.9 | 3008.3 | 3530.5 | 17.4 | 84.0 |
| 8 | 0.7 | 0.5 | 652.8 | 2684.3 | 1337.1 | 1476.7 | 3008.3 | 3339.0 | 11.0 | 104.8 |
| 9 | 0.8 | 0.6 | 652.8 | 2684.3 | 1460.2 | 1526.8 | 3008.3 | 3167.0 | 5.3 | 123.7 |
| 10 | 0.9 | 0.7 | 652.8 | 2684.3 | 1572.1 | 1560.4 | 3008.3 | 3012.2 | 0.1 | 140.8 |
| 11 | 1 | 0.8 | 652.8 | 2684.3 | 1674.0 | 1581.3 | 3008.3 | 2872.4 | -4.5 | 156.4 |
| 12 | 1.1 | 0.8 | 652.8 | 2684.3 | 1767.2 | 1592.6 | 3008.3 | 2745.9 | -8.7 | 170.7 |
| 13 | 1.2 | 0.9 | 652.8 | 2684.3 | 1852.5 | 1596.7 | 3008.3 | 2631.1 | -12.5 | 183.8 |
| 14 | 1.3 | 1.0 | 652.8 | 2684.3 | 1930.8 | 1595.5 | 3008.3 | 2526.7 | -16.0 | 195.7 |
| 15 | 1.4 | 1.1 | 652.8 | 2684.3 | 2002.8 | 1590.3 | 3008.3 | 2431.5 | -19.2 | 206.8 |
| 16 | 1.5 | 1.1 | 652.8 | 2684.3 | 2069.2 | 1582.4 | 3008.3 | 2344.5 | -22.1 | 217.0 |
| 17 | 1.6 | 1.2 | 652.8 | 2684.3 | 2130.6 | 1572.5 | 3008.3 | 2264.9 | -24.7 | 226.4 |
| 18 | 1.7 | 1.3 | 652.8 | 2684.3 | 2187.4 | 1561.3 | 3008.3 | 2191.8 | -27.1 | 235.0 |
| 19 | 1.8 | 1.4 | 652.8 | 2684.3 | 2240.0 | 1549.3 | 3008.3 | 2124.7 | -29.4 | 243.1 |
| 20 | 1.9 | 1.4 | 652.8 | 2684.3 | 2288.9 | 1536.9 | 3008.3 | 2062.8 | -31.4 | 250.6 |
| 21 | 2 | 1.5 | 652.8 | 2684.3 | 2334.4 | 1524.3 | 3008.3 | 2005.8 | -33.3 | 257.6 |
| 22 | 0.25 | 0.19 | 652.8 | 2684.3 | 599.8 | 874.2 | 3008.3 | 4398.0 | 46.2 | -8.1 |

### 6.9.7. **Data quality**

There was no information on striped red mullet discards for GSA 15 and from GSA 16 information from discards was only available for 2010 and 2011.

Information on fishing effort from GSA 16 was lacking for 2010.

### 6.9.8. **Scientific advice**

Short term considerations

State of the stock size
Based in the results of the XSA analysis, SSB is fluctuating around a mean level of 1850 tonnes, with levels recorded in 2012 (2462 tonnes) similar to levels estimated for 2007 and 2002. The lowest levels estimated for the time series were 1043 tonnes in 2009. In the absence of proposed and agreed precautionary management references, EWG 13-19 is unable to fully evaluate the status of the spawning stock biomass.

State of recruitment
Based in the results of the XSA analysis, recruitment is fluctuating around a mean level of 52 000 thousands, with levels recorded in 2012 (42 000 thousands) almost half of levels estimated for 2011 (78 000 thousands) but higher than levels recorded in 2010 (19 000 thousands), which were the lowest recorded during the time series (2002-2012).

State of exploitation
From yield per recruit analysis, STECF EWG 13-19 proposes $F_{0.1} \leq 0.19$ as a limit management reference point consistent with high long term yields ($F_{MSY}$ proxy). Given the results of the present analysis (mean $F_{cur}(2012) = 0.78$), the stock is considered to be exploited unsustainably in 2012.

Management recommendations

STECF EWG 13-19 suggests that catch in 2014 should not exceed 600 t, corresponding to $F_{0.1}$=0.19.

EWG 13-19 recommends the relevant fleets' effort and / or catches to be reduced to reach the proposed $F_{MSY,}$ in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan.

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## 6.10. **Stock assessment of common dolphinfish in the Mediterranean Sea**

### 6.10.1. **Stock Identification**

Common dolphinfish (*Coryphaena hippurus*) is an epipelagic, fast swimming oceanic species known to migrate over considerable distances, although the species is generally restricted by the 18-20°C isotherm (Gibbs and Collette, 1959; Brandhorst, 1977 as quoted by Zaouali and Missaoui, 1999). As a circum-tropical oceanic pelagic species it is common in waters of the Mediterranean Sea as well as the Atlantic, Pacific and Indian Oceans (Briggs, 1960).

Traditional small-scale fisheries for dolphinfish are carried out in the Central Mediterranean (Sicily, Malta, Tunisia, Libya) and the western Mediterranean (Balearic Islands). Although there is no documented information for other areas in the Mediterranean it is likely that for instance Algerian artisanal fishermen also target *C.* hippurus (Morales-Nin et al., 2000).

Information on the biology, migratory patterns and population structure is limited; however it is very likely that the Italian, Tunisian, Maltese, Spanish and Libyan fisheries are exploiting a single, shared stock. Pla and Pujolar (1999) used protein electrophoresis to study the population genetic structure of dolphinfish in the Mediterranean and eastern Atlantic. Genetic variability characteristic of highly migratory species was found, and the authors conclude that it is likely that dolphinfish form one large panmictic population across the Mediterranean.

Based on EU DCF data, the EU fishing fleet is targeting *C. hippurus* in GSA 5 and 6 (Spain), GSA 10, 16, 19 (Italy) and GSA 15 (Malta). Minor quantities of dolphinfish are also caught as by-catch in other countries, including in Cyprus (GSA 25) and Slovenia (GSA 17).

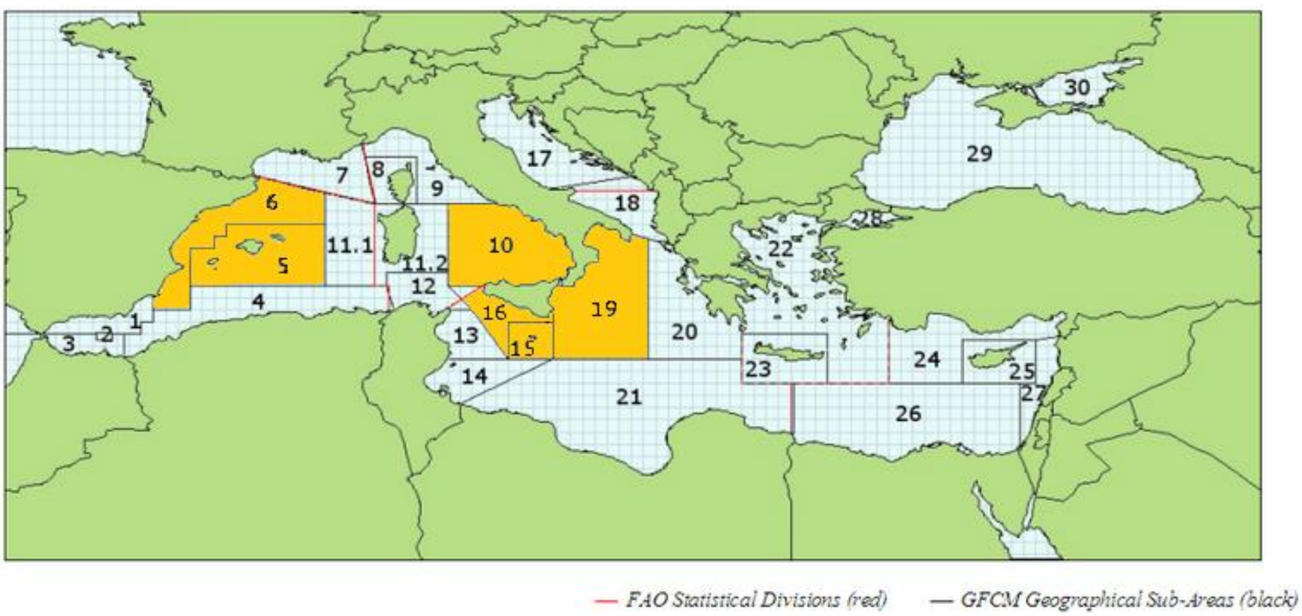


Figure 6.10.1.1. Geographical location of GSAs where common dolphinfish is targeted by the EU fishing fleet.

Growth

The limited studies performed in the Mediterranean on individual growth of common dolphinfish suggest a very fast growth rate and a short life span of up to four years with maximum lengths of about 1 m (see Table 6.10.1.2.1).

Samples of commercial size frequencies are inadequate for observing modes suitable for the derivation of growth parameters since the gears in use mainly catch juveniles and a smaller proportion of individuals of intermediate sizes or ages.

Tab. 6.10.1.2.1. Common dolphinfish in the Mediterranean Sea. Von Bertalanffy growth function estimates and length-weight parameters in the Mediterranean; $L_\infty$, k and $t_0$ refer to the asymptotic total length (cm), the curvature coefficient ($year^{-1}$) and the theoretical age at size 0 respectively.

| **Author** | **Area** | **Method** | **Sex** | **L∞** | **k** | **$t_0$** | **a** | **b** |
|---|---|---|---|---|---|---|---|---|
| Massuti et al. (1999) | Western Mediterranean | Scales and otoliths | F | 110 | 1.56 | 0.08 | 0.0139 | 2.8983 |
| | | | M | 98.7 | 2.06 | 0.024 | 0.0092 | 3.0187 |
| | | | M&F | 102.4 | 1.90 | 0.023 | 0.0113 | 2.9605 |
| Besbes Denseddik et al. (2011) | Tunisia | Otoliths | F | 97.5 | 1.499 | 0.046 | 0.0091 | 3.0281 |
| | | | M | 100.5 | 1.430 | 0.042 | 0.0077 | 3.0893 |
| | | | F&M | 100.5 | 1.418 | 0.048 | 0.0081 | 3.0669 |

As a result there are no reliable estimates of age-specific natural mortality rates; calculations of M based on von Bertalanffy's growth parameters using Pauly's (1980) procedure, and assuming a mean water temperature during the year of 17ºC, results as 1.74 $yr^{-1}$ assumed constant for all ages (Lleonart et al., 1999).

Maturity

The period of reproductive activity of common dolphinfish lasts several months over the summer – autumn period (June-September), and it has been suggested that the Mediterranean is an important spawning area for this species (Massuti and Morales-Nin, 1997; Potoschi et al., 1999).

Massuti and Morales-Nin (1997) studied reproductive aspects of *Coryphaena hippurus* individuals sampled by long line (60 – 120 cm fork length) and surrounding net (14.4–66 cm fork length) in the Balearic Islands and observed sexual dimorphism; fish smaller than 25 cm fork length were predominantly females, while males were more abundant over 115 cm fork length. Size at 50% maturity was estimated at 54.5 cm fork length in females and 61.8 cm fork length in males. At least two groups of mature oocytes were found in the ovaries of females suggesting an extended spawning season with multiple spawning events.

## 6.10.2. **Fisheries**

General description of fisheries

The main commercial fishing gear for *C. hippurus* in the Mediterranean is based on the use of Fish Aggregating Devices (FADs), where the aggregatory behaviour of common dolphinfish under floating materials is used to exploit this seasonally abundant resource (Morales-Nin et al., 2000). The individuals targeted by the FAD fishery are in fact juvenile specimens in the age group 0, which have been spawned in late spring and early summer during the spawning speak of this species in the Mediterranean (Massuti and Morales-Nin, 1995). The fishing season extends from August to December, when juveniles are the most abundant around the Balearic Islands, Tunisia, Sicily and the Maltese Islands. The earliest records of this fishery dates back to the 14th century in the Balearic Islands (Massuti and Morales-Nin, 1997), and the 18th century in the Maltese Islands (Farrugia-Randon, 1995).

Traditional FADs used in the Balearic Islands (*capcer*), Malta (*cima*), Sicily (*cannizzi*) are generally made up of cheap floating materials such as floating cork, empty plastic bottles, or polystyrene, with tied palm fronds to increase the surface area of floating materials, which fish use as shelter. In Tunisia a V-shaped wooden frame is used, with palm fronds or plastic sheets covering the frame to create the traditional FAD (*ghanatsi* or *jrid*) (Morales-Nin et al. 2000). The float is moored to the bottom by a stretch of nylon rope attached to a 30 – 50 kg anchor block such as limestone slabs. Different mooring patterns exist depending on the area, with the most common pattern being a series of FADs deployed along transects.

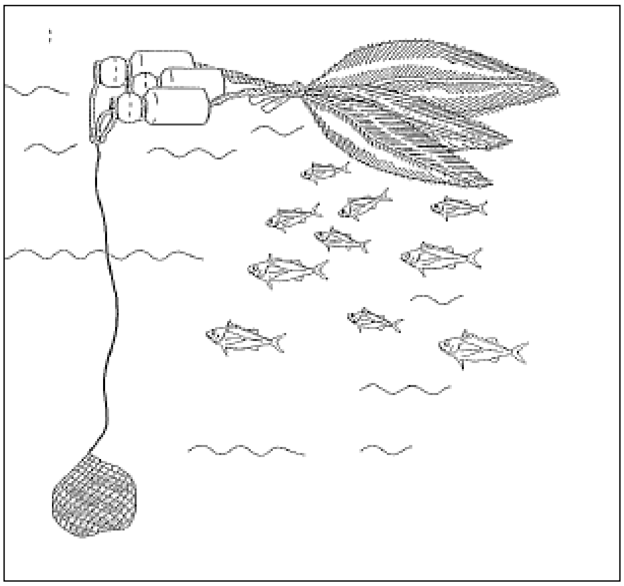

Figure 6.10.2.1.1.*Coryphaena hippurus*. Traditional Fish Aggregating Device used in the Mediterranean Sea. Source: Morales-Nin et al. (2000).

The net used to catch the dolphinfish which have aggregated under the FAD is a special surrounding net similar to a purse seine, however lacking a purse-line; the net is not closed at the bottom. This net is only deployed once the presence of fish under a FAD is detected.

FADs may be visited only once during a fishing trip if a high abundance of fish is detected, or several times; hence the success of the first fishing operations of the clay determines the number of FADs which are visited. Moreover fishermen may choose only a part of the mooring area for fishing, depending on wind and current conditions, or on their estimate of the place with best chance of a catch (Morales-Nin, 2000). These characteristics of the FAD fishery have important implications for estimating fishing effort accurately (see below).

In addition to catches from traditional FAD fisheries, *C. hippurus* is caught in much smaller amounts by trolling lines and as by-catch by drifting longlines, gill- and trammel nets (see section on landings below).

Management regulations applicable in 2010 and 2011

GFCM recommendation 2006/2 on ‘The establishment of a closed season for the dolphinfish fisheries using fish aggregation devices (FADs)’ recommends that ‘fisheries exploiting dolphin fish (*Coryphaena hippurus*) and using fish aggregating devices (FADs), can operate, in all geographical sub-areas (GSAs), only between 15 August and

31 December of each year'. The same GFCM Recommendation also states that 'By way of derogation, if a Member can demonstrate that due to bad weather, fishermen of this Member were unable to use their normal fishing days (notified in advance to the Executive Secretary), then the Member can carry over days lost by this fleet in FAD fisheries until 31 January of the following year.

The only country in the Mediterranean with additional regulations targeted specifically at managing common dolphinfish fisheries is Malta. Based on the provisions set out in Article 27 of EC 1967/2006, it is prohibited to fish for dolphinfish in the 25 nautical mile Fisheries Management Zone surrounding the Maltese Islands from 1st January till 5th of August each year. All vessels fishing for dolphinfish have to be in possession of a special fishing permit, and the number of vessels participating in the dolphinfish fishery within the zone shall not exceed 130. The fishing effort has to be controlled in order to safeguard the sustainability of the fishery in the Maltese Fisheries Management Zone, and system of transects has to be established every year by the 30th of June to manage the spatial deployment of FADs. A management plan for the dolphinfish fishery in the Maltese FMZ was recently submitted to the European Commission, but the plan is still being finalised since several issues were raised during its evaluation by STECF.

Catches

Landings

Based on catch data available from the GFCM Capture Production database for the last decade (2000-2010), Italy was responsible for 42%, Tunisia for 36%, Malta for 14%, Spain for 6% and Libya for 2% of landings. Malta clearly has a long history of targeting dolphinfish, and Malta and Spain seem to be the only countries which did not increase their total dolphinfish landings. Italian landings on the other hand seem to have increased dramatically since 2005 but considering that FAD fisheries are a traditional activity in some parts of Italy, it is likely that such increase can be linked to an improvement of the official statistics. Tunisian landings have increased steadily since the 1980s, and Libyan fishermen for the first time harvested as many dolphinfish as Malta in 2009. Considering the period 2005-2010, Italy was responsible for 56%, Tunisia for 27%, Malta for 10%, Spain for 6% and Libya for 3% of landings.

Whilst the data are likely to give a reliable idea of the trend in landings, earlier reports of dolphinfish being harvested by the Sicilian fleet do exist despite the lack of data on Italian landings prior to 2005. According to Cannizzaro (2011), about 300 Sicilian, 200 Tunisian and 50 Majorcan artisanal vessels were fishing for dolphinfish in the 1990s.

DCF data for the years 2011 and 2012 indicate a decreasing trend in overall catches; however it is not possible to confirm this trend without data for the Tunisian fleet in recent years.

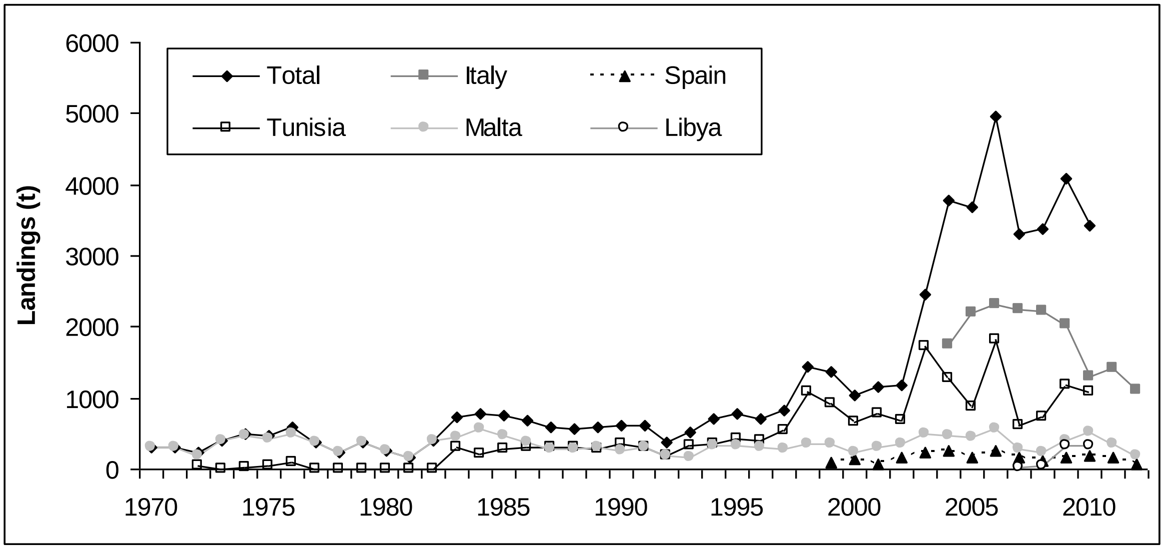


Fig. 6.10.2.3.1.1.Evolution of dolphinfish landings in 1970-2012; data for 1970-2010 was taken from the FAO-GFCM capture production database, data for 2011-2012 for European countries was obtained through the DCF data call.

For the European fishing fleets (Spain, Malta and Italy), 67% of catches recorded in 2012 came from fishing vessels using surrounding nets (i.e. the FAD fishery), 28% came from longlines (drifting and set longlines; most of such catches are likely to be by-catch, e.g. from the longline fisheries targeting swordfish), 2% from gill and trammel nets and the remaining percentage from trolling lines and 'mixed gears' reported for Italian GSAs. In the Maltese Islands by-catch of common dolphinfish in longlines and gill and trammel nets were the lowest when compared to other GSAs; 97% of catches came from the traditional FAD fishery.

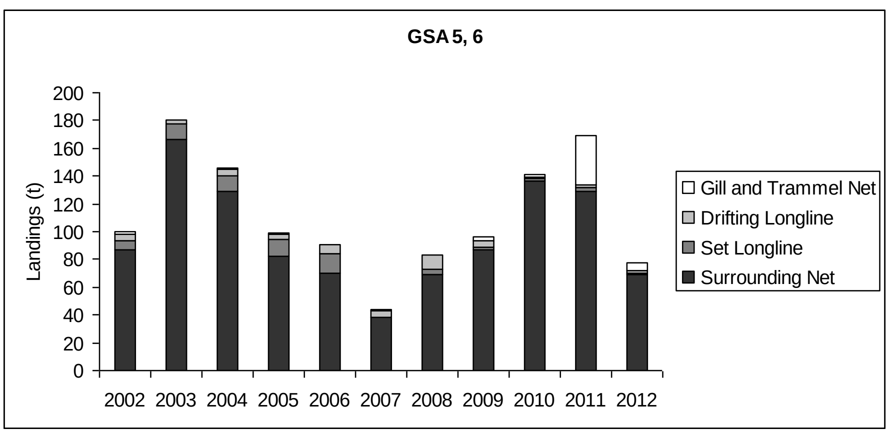


Fig. 6.10.2.3.1.2.*Coryphaena hippurus*. Common dolphinfish catch data as reported in the official DCF data call for GSAs 5 and 6.

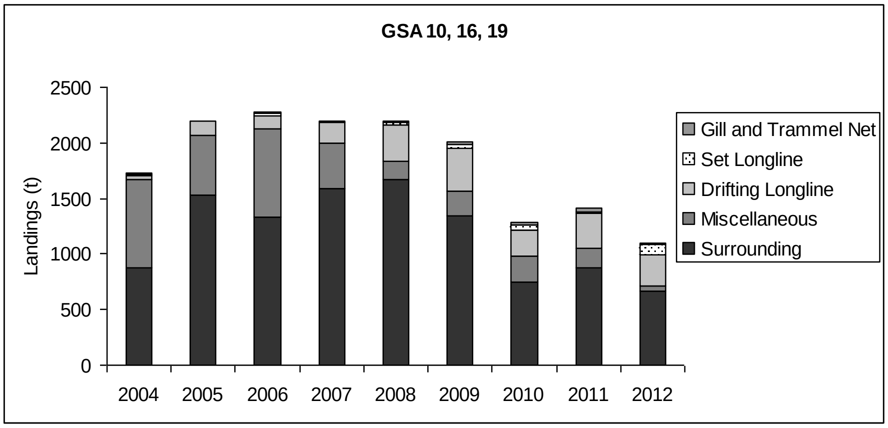


Fig. 6.10.2.3.1.3.*Coryphaena hippurus*. Common dolphinfish catch data as reported in the official DCF data call for GSAs 10, 16 and 19.

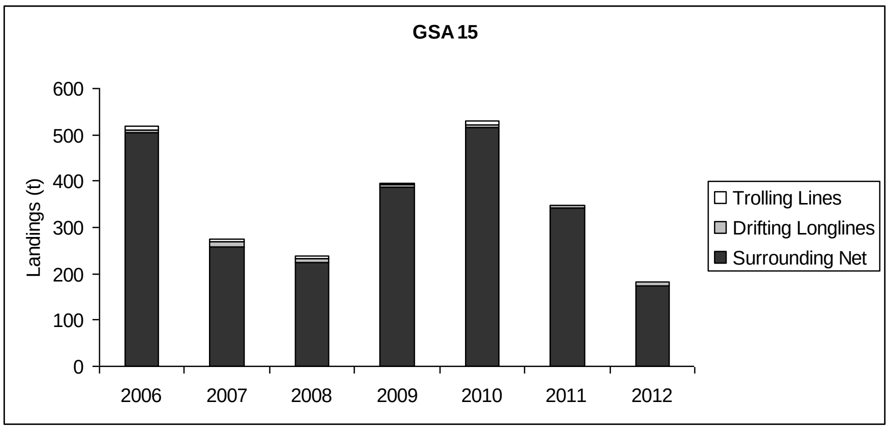


Fig. 6.10.2.3.1.4.*Coryphaena hippurus*. Common dolphinfish catch data as reported in the official DCF data call for GSA 15.

Catches reported by Slovenia through the DCF for 2012 were negligible (0.06 tonnes); no data on catches or by-catches from longline fleets in Greece or Cyprus were available.

DCF data on catch length frequency distributions were only available from the Maltese Islands since this is the only country where this fishery is selected for DCF sampling due to its local importance. As illustrated in Figure 6.10.2.3.1.5 below, individuals measuring 35-45 cm fork length were the most abundant in catches in 2005-20012. Individuals measuring up to 1 m in length were caught by surrounding nets in areas were FADs were deployed, however the overwhelming majority of individuals caught by this fishery in the Maltese Islands are juveniles below the size of first maturity.

From scientific literature it is clear that a similar exploitation pattern exists in the Italian and Spanish FAD fisheries, which also target juveniles in the 20-60 cm size range (Lleonart et al., 1999; Morales-Nin et al., 2000).

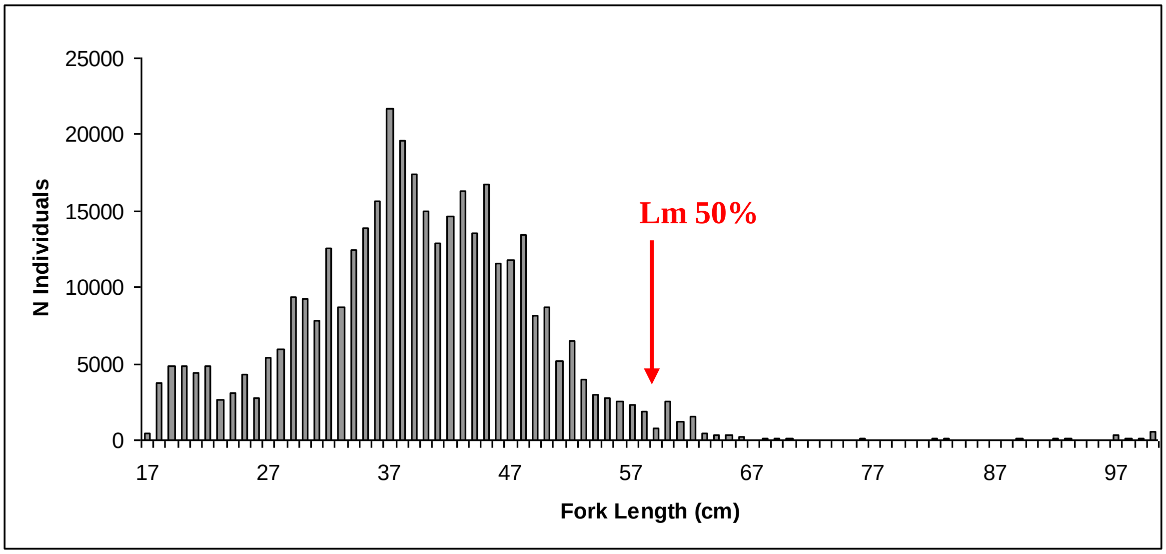


Fig. 6.10.2.3.1.5.*Coryphaena hippurus*. Average catch length frequency distributions from the Maltese Islands FAD fishery in 2005-2012

Discards

Since there is no minimum legal landing size for this species and the fishery targets juvenile individuals of a particular size range, there are no discards of the target species. Pilotfish (*Naucrates ductor*) and greater amberjack (*Seriola dumerili*) are caught as by-catch (Morales-Nin, 2000; Pipitone et al., 2000).

Fishing effort

As illustrated in section 6.10.2.3, 67% of common dolphinfish landings reported through the EU DCF in 2012 came from surrounding nets, i.e. fisheries using Fish Aggregation Devices. In order to assess the fishing effort of fishing vessels using FADs accurately, the following parameters would be required: (i) number of vessels engaged in this seasonal fishing activity, (ii) days at sea, (iii) nominal effort kW·days at sea and / or effort in terms of GT·days at sea (iv) number of FADs deployed per vessel, (v) number of FADs visited per fishing trip.

Since 'number of FADs' is not an effort unit included in the EU DCF the latter two parameters are not currently available through the DCF. Some countries have such data through targeted studies, and there is an optional field in the GFCM dolphinfish reporting forms which countries using FAD fisheries are obliged to submit on an annual basis, however only outdated data from literature was available to the EWG 13-19 (see Table 6.10.2.4.1 below). This data showed that both the total number of FADs used and the number of FADs targeted per vessel varies considerably between fishing areas.

In addition information on number of vessels, days at sea and nominal effort is only available for DCF gear categories in general, not for the dolphinfish fishery as such (for instance in Italy the surrounding nets used to catch *C. hippurus* are classed as purse seines, and the lowest level of aggregation is that of the fishing metiers for small and large pelagic fish, which may include fisheries for several species.

Table 6.10.2.4.1. Summary of available data on vessel length and FADs used in Mediterranean dolphinfish fisheries. Source: Morales-Nin (2000).

| Area | Mean Vessel Length | Total Number of | Number of FADs / |
|---|---|---|---|

| | (m) | FADs | Vessel |
|---|---|---|---|
| Balearic Islands | 8 | 1156 | 30-40 |
| Sicily | 11 | 21920 | 10-110 |
| Malta | 6-15 | 15000 | > 35 |
| Tunisia | 11 | 273000 | 17-75 |

The evolution of total fishing effort data available through the DCF for the most important gears in the available time series (these fleet segments together contributed 88% of total catches in 2012), GT*days at sea for vessels using surrounding nets in Italy, Spain and Malta, and GT·days at sea for vessels using drifting longlines in Italy, is shown in Figure 6.10.2.4.1 below.

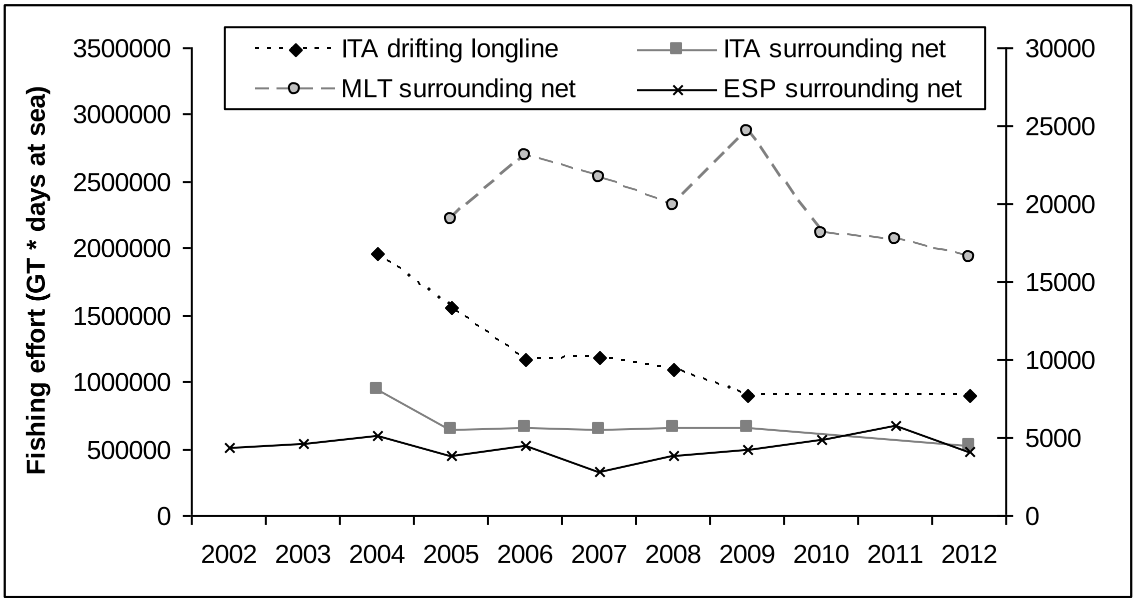


Fig. 6.10.2.4.1.*Coryphaena hippurus*. Fishing effort (GT·days at sea) trends of vessels using surrounding nets in Italy, Spain and Malta, and GT* days at sea for vessels using drifting longlines in Italy. Maltese and Spanish fleet segments are shown on the right y-axis. Fishing effort data for Italy in 2010 and 2011 produced erroneous outliers and were therefore excluded from the graph.

Catch per unit effort was estimated for vessels using surrounding nets (i.e. engaged in the FAD fishery), which in total accounted for 72% of total landings over the time series. Other gears were excluded since *C. hippurus* is not a target species for other gears. Although there are limitations in effort data as described above, the overall pattern seems to indicate a decrease in CPUE. Moreover this data is based on information from the European fishing fleet which has not been completely standardised and no effort data was available for Tunisian fisheries.

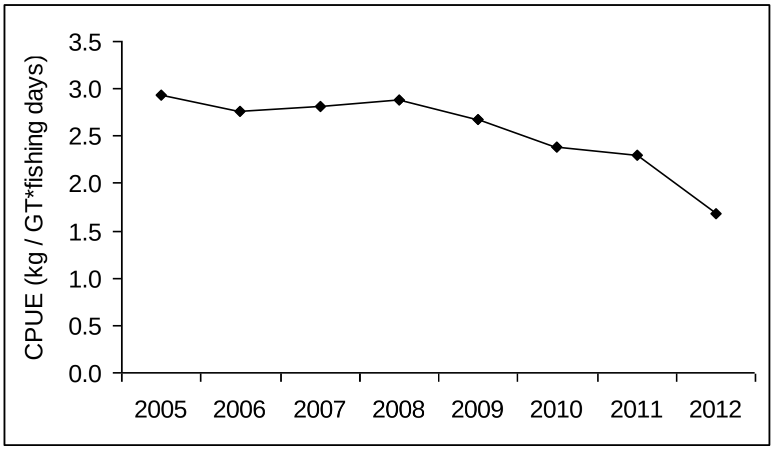


Fig. 6.10.2.4.2.*Coryphaena hippurus*. Catch per unit effort (CPUE) in terms of total landings (kg) / fishing effort (GT·days at sea) trends of vessels using surrounding nets in Italy, Spain and Malta combined. Fishing effort data for Italy in 2010 and 2011 was estimated based on average values of 2009 and 2012.

### 6.10.3. **Stock assessment and management**

As for other stocks, the management objective for dolphin fish in the Mediterranean Sea is to keep stocks at the appropriate levels in order to produce maximum sustainable yields. The estimation of the various reference points linked to this management objective requires information regarding biological features such as estimates of natural mortality rates, individual growth, stock-recruitment relationships, and fisheries dependent information including catches by fishery and country, age structure of the commercial catches and selectivity.

Only the availability of such information allows estimating variables such as biomass at sea and of exploitation rates. The information needed is however not available or incomplete, precluding the use of formal stock assessment approaches.

Moreover, there are additional factors which render the assessment of the *Coryphaena hippurus* stock status difficult. The species high and variable productivity makes difficult to quantify the effect of fishing on the population using fisheries data and traditional stock assessment methods.

There are some alternative approaches that can be tested in the near future considering the data poor situation that preclude the use of formal stock assessment methods. Some methods which may be appropriate once the required data is available are:

The Delury depletion model

The Delury depletion model can be used for the estimation of fishing mortality. The model (Hilborn and Walters, 1992, Rosenberg et al, 1990) considers the population as a homogenous assemblage of individuals that are equally exposed to fishing and natural mortality events. With the Delury model, the goal is the estimation of the recruitment and population size that must have occurred in order to produce the observed pattern in catches.

An Index Method (AIM)

The AIM method, which is included in the NOAA Fisheries Toolbox, allows the user to fit a relationship between time series of relative stock abundance indices and catch data in order to estimate sustainable levels of F. Underlying the methodology is a linear model of population growth, which characterizes the population response to varying levels of fishing mortality. If the underlying model is valid, AIM can be used to estimate the level of relative fishing mortality (catch / stock abundance indices) at which the population is likely to be stable. The index methodology can used to construct reference points based on relative abundance indices and catches, and to perform deterministic or stochastic projections to achieve a target stock size. The data needed are yearly catches.

Depletion-Adjusted Average Catch (DCAC)

DCAC, which is also included in the NOAA Fisheries Toolbox (see MacCall, 2007; 2009), is a simple method for estimating sustainable catch levels when the data available are little more than a time series of catches. A robust evidence for a sustainable yield can be a prolonged period over which yield has been taken, without indication of a reduction in the stock abundance. In such cases, a sustainable yield would simply be the long-term average annual catch during such a period. Whenever the resource declines in abundance, a portion of the associated catch is derived from that one-time decline, and will not further represent potential future yield supported by sustainable production. Such parts should be removed in the averaging procedure, in order to avoid the overestimation of a sustainable yield.

### 6.10.4. **Data quality**

Data quality for *C. hippurus* overall at this point in time is too poor to allow for a formal assessment of stock status to be carried out. This is due to several reasons, including (i) poor quality of some of the available DCF data (effort data in particular), (ii) the lack of effort data parameters important for this species (number of FADs deployed per vessel, number of FADs targeted per fishing trip) in the DCF regulation, and (iii) the lack of biological data including length-frequency distributions of commercial catches and (iv) the wide regional distribution of this medium-sized pelagic migratory species and the resulting overlap in the remit of several entities involved in the provision of fisheries data collection and the provision of fisheries management advice (STECF, GFCM and ICCAT).

Landings Data
Data on landings by gear, fishing métier and quarter were available for surrounding nets as well as several gears catching *C. hippurus* as by-catch in Italy, Malta, Spain and Slovenia (although the number of individuals caught by the latter was negligible). It was noted that not all countries classify dolphinfish catches from surrounding nets in the same gear category, with Malta and Spain using the category ‘LA’ – *lampara* gear and Italy using the category ‘PS’ – purse seines, which however is most likely due to differences in net characteristics. No landings data was available for by-catch of dolphinfish in Greece or Cyprus.

Effort Data
In order to assess the fishing effort of fishing vessels using FADs accurately, the following parameters would be required: (i) number of vessels engaged in this seasonal fishing activity, (ii) days at sea, (iii) nominal effort kW*days at sea and / or effort in terms of GT* days at sea (iv) number of FADs deployed per vessel, (v) number of FADs visited per fishing trip. Moreover for a proper standardization of the effort using information on the FADs, a good knowledge on local characteristics and ways of using FADs is necessary since several additional factors can also affect catchability in this fishery, including FADs design, technology, fisher’s skill in using FADs, and FAD deployment patterns (high density may means proximity, and this may reduce catchability through the competition among attraction devices).

Since ‘number of FADs’ is not an effort unit included in the EU DCF the latter two parameters are not currently available through the DCF. Some countries have such data through targeted studies, and there is an optional field in the GFCM dolphinfish reporting forms which countries using FAD fisheries are obliged to submit on an annual basis; however such data was not available to the EWG 13-19. In addition information on number of vessels, days at sea and nominal effort is only available for DCF gear categories in general, not for the dolphinfish fishery as such (for instance in Italy the surrounding nets used to catch *C. hippurus* are classed as purse seines, and the lowest level of aggregation is that of the fishing metiers for small and large pelagic fish, which may include fisheries for several species.

Problems were also encountered in the quality of the limited effort data available, with a lack of effort data for Italian vessels in 2010 and erroneous data for 2011. Since Italian vessels in these years were responsible for on 63% and 77% of total catches in 2010 and 2011 respectively, and the time series is already very short (too short for instance for a surplus production method), the poor quality of Italian effort data in these years further limited the use of models to interpret the available data.

Abundance Indices

One of the major uncertainties when assessing this fishery is whether the catch per unit of effort (CPUE) calculated for the various fisheries targeting this stock are appropriate indexes of abundance, especially when the fish are associated with fish-aggregating devices (FADs), and bearing in mind FADs are targeting juveniles.

For FADs, it is likely that an appropriate combination of number of FADs, yearly activity and soaking time can be useful. However these variables do not necessarily have the same weight and are not necessarily directly linked with the gear's fishing power; local FAD density (and spatial distribution) is also important, since this may influence the accumulation rate of fish at the FADs.

A more suitable method of estimating abundance indices may be monitoring of CPUE for adult specimens, since this would give information on spawning stock biomass (SSB). Dedicated studies may be necessary since most adult specimens are currently caught as by-catch in fisheries which are not directly targeting *Coryphaena hippurus.*

Moreover, considering the wide area over which the stock is distributed and the numerous variables conditioning fishing performance, data standardization will be necessary before combining information from several fisheries and regions. In order to standardize CPUEs, GLM or other statistical methods can be used, however the availability of some independent estimate of abundance indices, for instance from scientific survey would be required. Moreover, the use of oceanographic variables in the CPUE models can be informative whenever the spatial and temporal resolution of these data is adequate to represent the prevailing oceanographic conditions at the scale of the fishing operations targeting *Coryphaena hippurus*.

Biological Data

Biological data (including length frequency data, sex ratios, and age length keys) were only available from Maltese data since the *C. hippurus* fishery is only selected in the DCF ranking system in this country. The lack of biological stock-related data further limits the potential stock assessment methods which can be used for this species. The definition of the unit of stock and management boundaries is another important issue to be solved.

### 6.10.5. **Scientific advice**

Due to a lack of suitable data to assess this species, EWG 13-19 is not in a position to formulate any scientific advice for common dolphinfish.

EWG 13-19 proposes that the issue of data quality for this species should be addressed by (i) including the relevant effort parameters (total number of FADs and number of FADs targeted per fishing trip) in the DC-MAP for future monitoring (ii) collecting information on additional variables required for a sound standardization of CPUEs through a series of targeted studies in the EU Member States concerned. In addition a series of targeted studies aimed at gathering up to date / historical information on fishing effort, and variables required for standardising CPUE should be conducted in third countries (notably Tunisia and Libya) fishing C. hippurus, possibly by involving the FAO regional projects.

Moreover, given the problems associated with standardising CPUE for FAD fisheries targeting juveniles EWG 13-19 further considers studies characterizing CPUE for adult specimens in order to estimate abundance indices for SSB, and/or scientific surveys will need to be carried out in order to assess the species using formal stock assessment methods to estimate maximum sustainable yield and relevant reference points.

Due to the biology of the species as well as the nature of the fishery EWG 13-19 considers that *Coryphaena hippurus* should in future be assessed by the RFMOs GFCM and/or ICCAT.

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## 6.11. **Stock assessment of anchovy in GSA 17**

### 6.11.1. **Stock identification and biological features**

Stock Identification

Anchovy (*Engraulis encrasicolus*) stock is shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia, Figure 6.11.1.) and it constitutes a unique stock. Many studies have been carried out regarding the presence of a unique stock or the presence of different sub populations living in the Adriatic Sea (GSA 17 and GSA 18). This has several implications for the management, i.e. differences in the growth features between subpopulations imply the necessity of *ad hoc* strategies in the management. The hypothesis of two distinct populations claims the evidence of morphometric differences between northern and southern Adriatic anchovy, such as colour and length, and some variability in their genetic structure (Bembo *et al*., 1996). Nevertheless, many authors warn against the use of morphological data in studies on population structure (Tudela, 1999) and, a recent study from Magoulas *et al.* (2006), revealed the presence of two different clades in the Mediterranean, one of those is characterized by a high frequency in the Adriatic Sea (higher than 85%) with a low nucleotide diversity (around 1%).

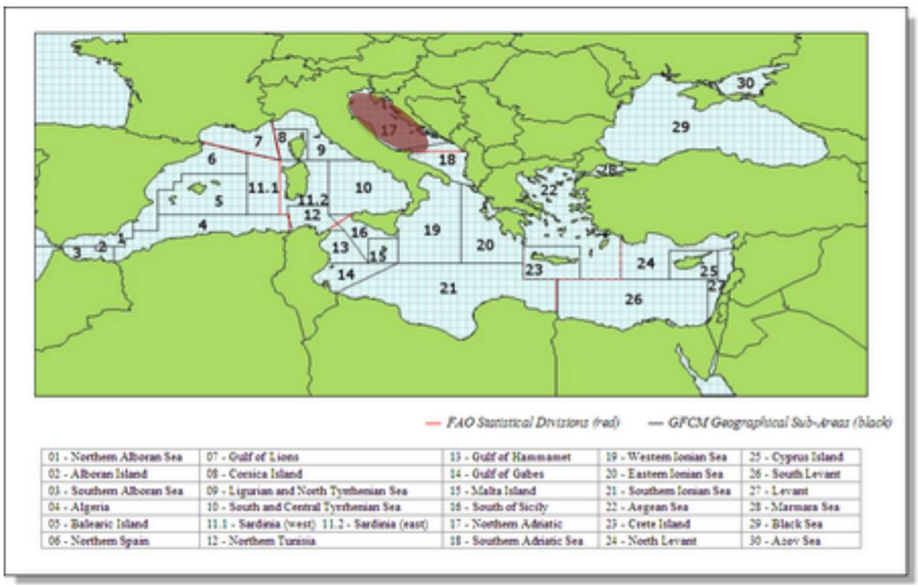



Figure 6.11.1. Geographical location of GSA 17.

Growth

The growth of anchovy in Adriatic Sea was assessed using the historical growth parameters (Sinovčić, 2000). Age-length and age-weight keys were produced using the otolith reading and actual length-weight parameters. The growth parameters used during the EWG 13-19 were:

Table 6.11.1. Anchovy GSA 17. Von Bertalanffy growth parameters used in the assessment.

| Growth parameters | $L_{inf}$ | k | $t_0$ |
|---|---|---|---|
| Both sexes | 19.4 | 0.57 | -0.5 |

Maturity

Table 6.11.2. Anchovy GSA 17. Proportion of mature specimens at age.

| PERIOD | Age | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1975-2011 | Prop. Matures | 0.75 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Natural mortality

Table 6.11.3. Anchovy GSA 17. Natural mortality vector by age from Gislason et al. (2010) used in the assessment.

| PERIOD | Age | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1975-2011 | M | 2.36 | 1.10 | 0.81 | 0.69 | 0.64 | 0.61 |

### 6.11.2. **Fisheries**

General description of the fisheries

Anchovy is commercially very important in Adriatic Sea. It is targeted by pelagic trawlers (Italy) and purse seiners (Croatia, Slovenia, Italy). The number of vessels targeting this species is around 300 units.

Management regulations applicable in 2012

A multi–annual management plan for small pelagic fisheries in the Adriatic Sea has been established by the General Fisheries Commission for the Mediterranean (GFCM) in 2012. Besides, Italy has been enforcing for years a general regulation concerning the fishing gears and since 1988 a suspension (about one month) of fishing activity of pelagic trawlers in summer. A closure period is observed from 15th December to 15th January from the Croatian purse seiners. In 2011 and 2012 a closure period of 60 days (August and September) was endorsed by the Italian fleet.

Catches

Landings

In Figure 6.11.2 the trends in landings for Italy and Croatia are shown. From 1988 the trend is increasing with a maximum of 47055 tons in 2007. The Slovenian catches are included in the total landings but are not shown here since the quantities are really low (less than 150 tons in 2011).

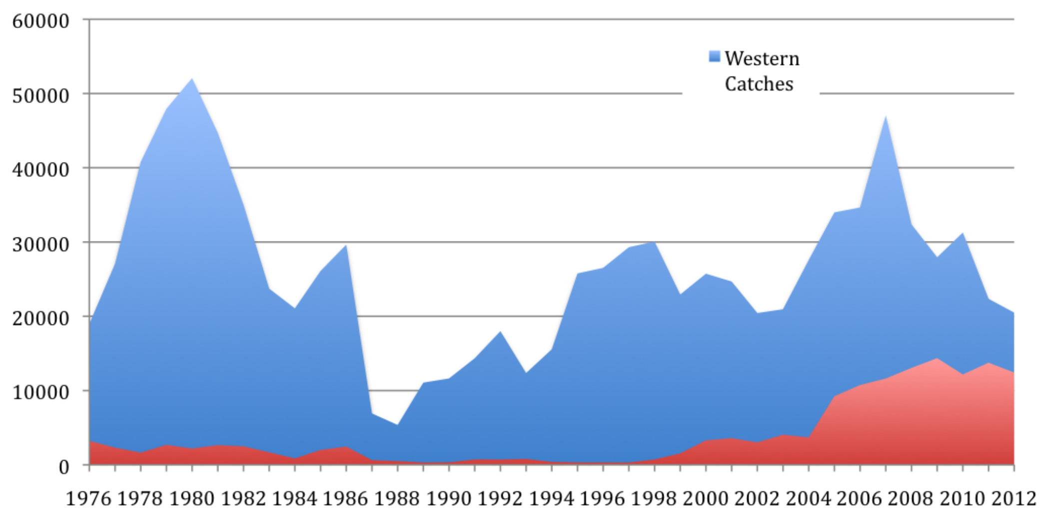



Figure 6.11.2. Anchovy GSA 17. Total landings (in tons) of anchovy by country from 1976 to 2012.

The following table (Table 6.11.4.) shows the annual landings (t).

Table 6.11.4. Anchovy GSA 17. Total landings (tons) by year.

| Year | Catch | Year | Catch | Year | Catch | Year | Catch |
|---|---|---|---|---|---|---|---|
| 1976 | 22215 | 1986 | 32110 | 1996 | 26844 | 2006 | 45401 |
| 1977 | 29400 | 1987 | 7558 | 1997 | 29611 | 2007 | 58674 |
| 1978 | 42422 | 1988 | 5875 | 1998 | 30792 | 2008 | 45433 |
| 1979 | 50633 | 1989 | 11390 | 1999 | 24484 | 2009 | 42313 |
| 1980 | 54279 | 1990 | 11967 | 2000 | 29036 | 2010 | 43453 |
| 1981 | 47346 | 1991 | 15088 | 2001 | 28280 | 2011 | 36110 |
| 1982 | 37525 | 1992 | 18726 | 2002 | 23467 | 2012 | 32924 |
| 1983 | 25418 | 1993 | 13160 | 2003 | 25016 | | |
| 1984 | 21930 | 1994 | 15960 | 2004 | 31280 | | |
| 1985 | 28113 | 1995 | 26103 | 2005 | 43233 | | |

The trend of the cohorts in the catches is shown in figure 6.11.3. Each plot represents the number of fish of each age born in the same year. Age 1 can be identified as the first fully recruited age.

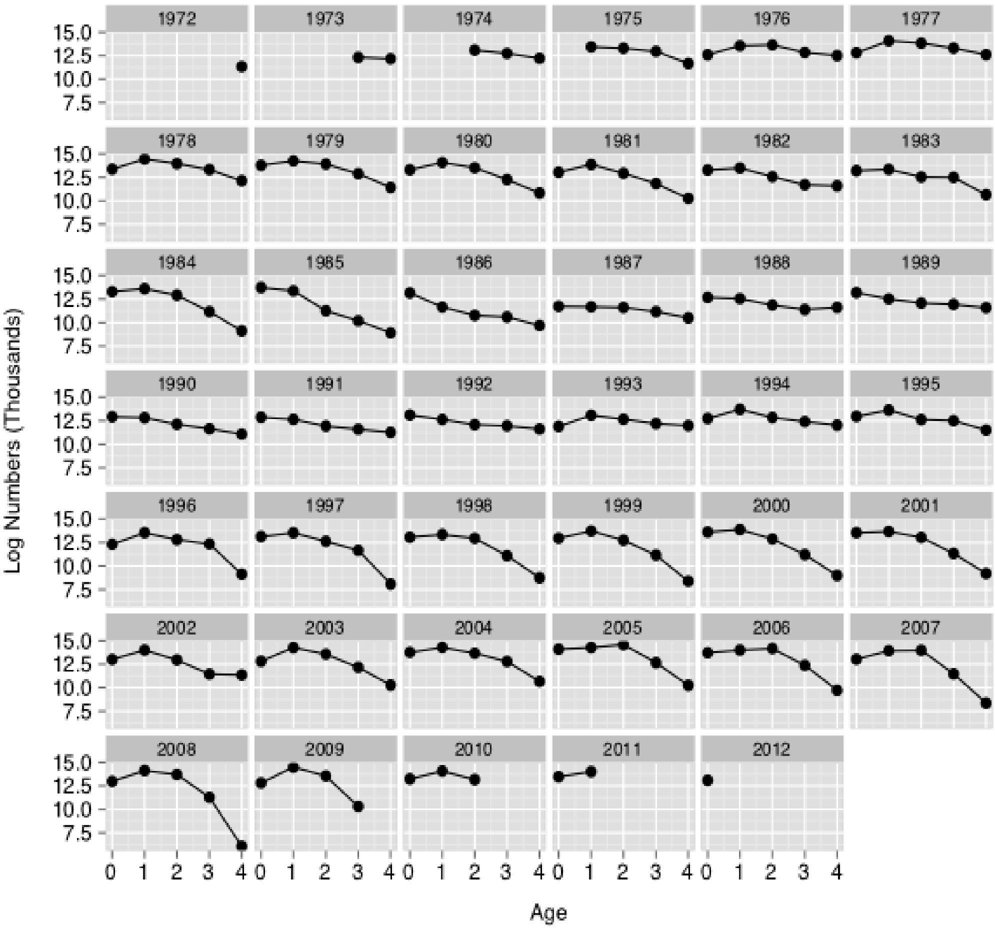


Figure 6.11.3. Anchovy GSA 17. Log numbers at age (thousands) of the catch used in the assessment.

Discards

Discards were not included in the catches because landings were almost equal to catches as very few fishes are usually discarded.

### 6.11.3. Scientific surveys

MEDIAS

Methods

Echo-surveys were carried out from 2004 to 2012 for the entire GSA 17. In the western part the acoustic survey was carried out since 1976 in the Northern Adriatic (2/3 of the area) and since 1987 also in the Mid Adriatic (1/3 of the area), and it is in the MEDIAS framework since 2009. The eastern part was covered by Croatian national pelagic monitoring program PELMON. The data from both the surveys have been combined to provide an overall estimate of numbers-at-age.

The survey methods for MEDIAS are given in the MEDIAS handbook (MEDIAS, March 2012).

Western Echo-survey:

- Length frequencies distribution available from 2004 onward (no LFD for Mid Adriatic in 2004, so the biomass at length in 2004 was assumed equal to the proportion of biomass at length in the 2005 Mid Adriatic survey).
- ALKs available for 2009-2010-2011-2012;
- Numbers at age for 2004 to 2008 were obtained applying the sum of the 2009-2010-2011 ALKs to the numbers at length.

Eastern Echo-survey:

- Length frequencies distribution available from 2009.
- No ALKs available.
- Numbers at length from 2004 to 2008 were obtained applying the length frequency distribution from the 2009 survey to the total biomass.
- Numbers at age were obtained applying commercial ALK from the eastern catches to the eastern echosurvey length distribution.
- 2011-2012 surveys covered only the Northern part of the area (about 52% of the total area), so the estimated biomass was raised to the total using an average percentage from previous years (2004-2010).

Geographical distribution patterns

Acoustic sampling transects and the total area covered is shown in figure 6.1.4.

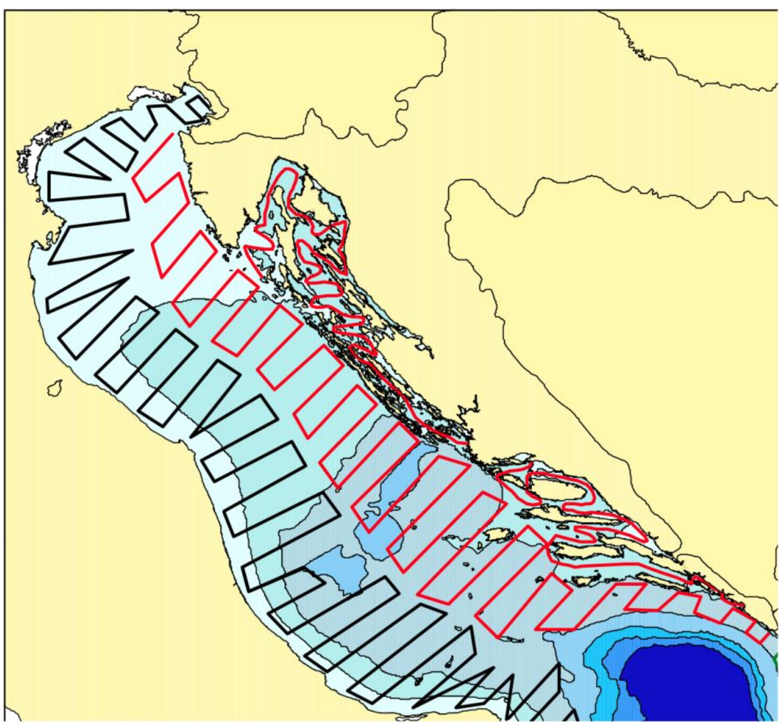


Figure 6.11.4. Anchovy, GSA 17, Acoustic transects for the western echo-survey (to the left) and the eastern echo-survey (to the right).

Trends in abundance and biomass

Biomass estimates from the two surveys show a much higher occurrence of anchovy on the western side of the Adriatic. In 2008 the western survey contributed to more than 85% of the total estimated biomass. For 2012 the acoustic estimates for the eastern side were really low (about 2% of the total).

Pooled total biomass in tons from eastern and western echo-survey (2004-2012) is given in table 6.11.5 and it is shown in Figure 6.11.5.

Table 6.11.5. Anchovy GSA 17. Total biomass (tons) of anchovy estimated by the acoustic surveys.

| | Tons |
|---|---|
| 2004 | 302130 |
| 2005 | 335312 |
| 2006 | 627226 |
| 2007 | 533525 |
| 2008 | 858497 |
| 2009 | 486373 |
| 2010 | 642184 |
| 2011 | 474920 |
| 2012 | 540434 |

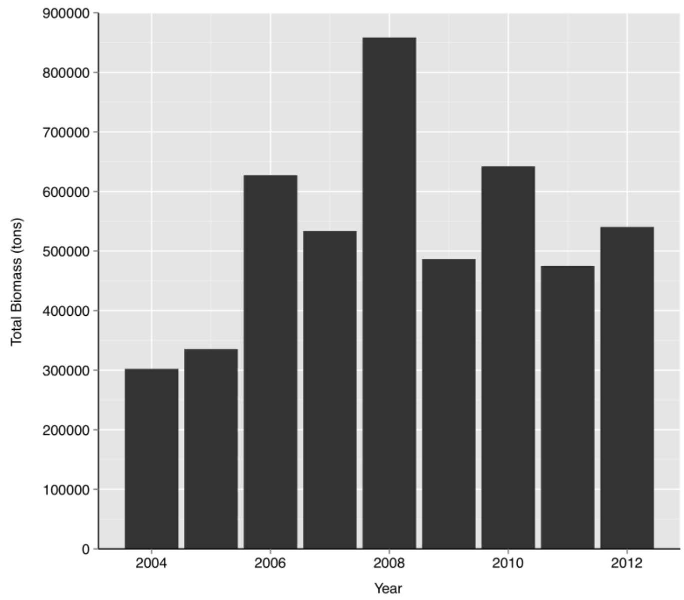



Figure 6.11.5. Anchovy GSA 17. Total biomass (tons) of anchovy estimated from the eastern and western echo-survey.

Figure 6.1.6 illustrates the proportion by year of each age class from the surveys. In 2008 and 2012 a higher percentage of age 0 occurred. Age 3 and age 4 are scarcely represented in the surveys.

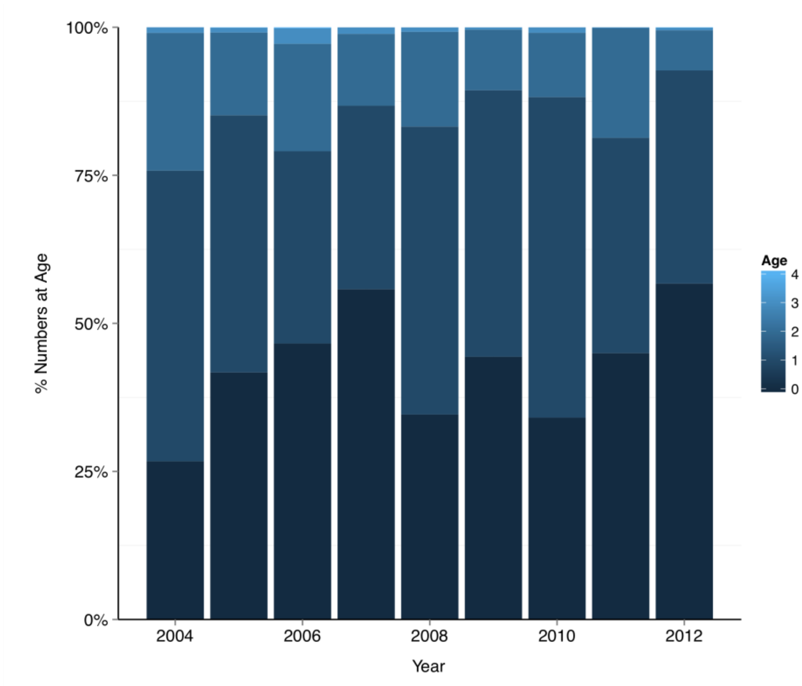



Figure 6.11.6. Anchovy, GSA 17, Total proportion of age classes of anchovy from the acoustic survey carried out in GSA 17.

Trends in abundance by length or age
No analyses were conducted during EWG-13-19.

Trends in growth
No analyses were conducted during EWG-13-19.

Trends in maturity
No analyses were conducted during EWG-13-19.

### 6.11.4. **Assessment of historic stock parameters**

Method: SAM

Justification

The stock of anchovy was assessed using the State-space Assessment Model (SAM) (Nielsen *et al*., 2012) in FLR environment with data from 1975 to 2012. The SAM environment is encapsulated into the Fisheries Library in R (FLR) (Kell *et al*., 2007) in the form of the package "FLSAM". The state-space assessment model (SAM) is an assessment model which is used for several assessments within ICES. The model allows selectivity to evolve gradually over time. It has fewer model parameters than full parametric statistical assessment models, with quantities such as recruitment and fishing mortality modelled as random effects. One tuning index (acoustic survey covering the entire GSA 17) from 2004 to 2012 was used in the assessment. Since the spawning takes place mostly in spring-summer (Zorica *et al*., 2013), the assessment was carried out taking into account a conventional birth date on the first of June (split-year), as in Santojanni *et al*. (2003). Consequently, all data were shifted by 6 months in order to have each year compounded by the time interval ranging from the first of June, up to May 31$^{st}$ of the following year. All assessments are performed with version 0.99-3 of FLSAM, together with version 2.5 of the FLR library (FLCore).

Input parameters

Input data type and characteristics are given in the following tables and figures.

Table 6.11.6. Anchovy, GSA 17, Catch at age data (numbers, $10^3$).

| | Age0 | Age1 | Age2 | Age3 | Age4+ |
|---|---|---|---|---|---|
| 1976 | 296691 | 686091 | 480224 | 221629 | 83577 |
| 1977 | 362899 | 768650 | 587692 | 339326 | 190485 |
| 1978 | 629137 | 1303524 | 843825 | 418961 | 201054 |
| 1979 | 962994 | 1868703 | 1025407 | 376911 | 117188 |

| | | | | | |
|---|---|---|---|---|---|
| 1980 | 594600 | 1524697 | 1153558 | 595074 | 270313 |
| 1981 | 460310 | 1294987 | 1092606 | 600133 | 299005 |
| 1982 | 581166 | 1045453 | 736400 | 392667 | 186551 |
| 1983 | 538138 | 719903 | 413727 | 211638 | 91843 |
| 1984 | 585801 | 626031 | 285235 | 137334 | 50293 |
| 1985 | 903238 | 803134 | 277163 | 120871 | 28520 |
| 1986 | 507957 | 638687 | 401614 | 266062 | 108615 |
| 1987 | 123399 | 114640 | 77416 | 70299 | 42427 |
| 1988 | 316468 | 117550 | 47454 | 26896 | 9133 |
| 1989 | 525159 | 279251 | 109436 | 40112 | 7356 |
| 1990 | 404575 | 268710 | 140347 | 70441 | 16149 |
| 1991 | 386111 | 371134 | 174825 | 88455 | 36519 |
| 1992 | 489542 | 310754 | 183858 | 150916 | 110267 |
| 1993 | 147249 | 308002 | 151684 | 114463 | 106191 |
| 1994 | 341049 | 478188 | 177472 | 108763 | 65023 |
| 1995 | 422169 | 892358 | 316490 | 154855 | 78699 |
| 1996 | 217939 | 834866 | 377253 | 197706 | 111294 |
| 1997 | 500532 | 751743 | 305104 | 245281 | 158812 |
| 1998 | 472876 | 747334 | 360525 | 271427 | 169079 |
| 1999 | 422169 | 622278 | 302634 | 226727 | 98775 |
| 2000 | 813325 | 906112 | 416398 | 115379 | 9098 |
| 2001 | 754071 | 1050164 | 340092 | 65643 | 3235 |
| 2002 | 440144 | 862964 | 387591 | 69170 | 6216 |
| 2003 | 361837 | 1184318 | 460288 | 72766 | 4342 |
| 2004 | 937742 | 1566232 | 414941 | 82271 | 7881 |
| 2005 | 1313601 | 1590677 | 771420 | 92198 | 9803 |
| 2006 | 900119 | 1574148 | 855572 | 189103 | 85002 |
| 2007 | 450965 | 1196270 | 2144804 | 351479 | 29007 |
| 2008 | 432509 | 1108561 | 1400440 | 310553 | 42896 |
| 2009 | 363194 | 1338074 | 1158175 | 234816 | 28397 |
| 2010 | 555113 | 1950086 | 888299 | 96184 | 16669 |
| 2011 | 701515 | 1275961 | 759953 | 79200 | 4314 |
| 2012 | 483869 | 1204246 | 517493 | 30078 | 431 |

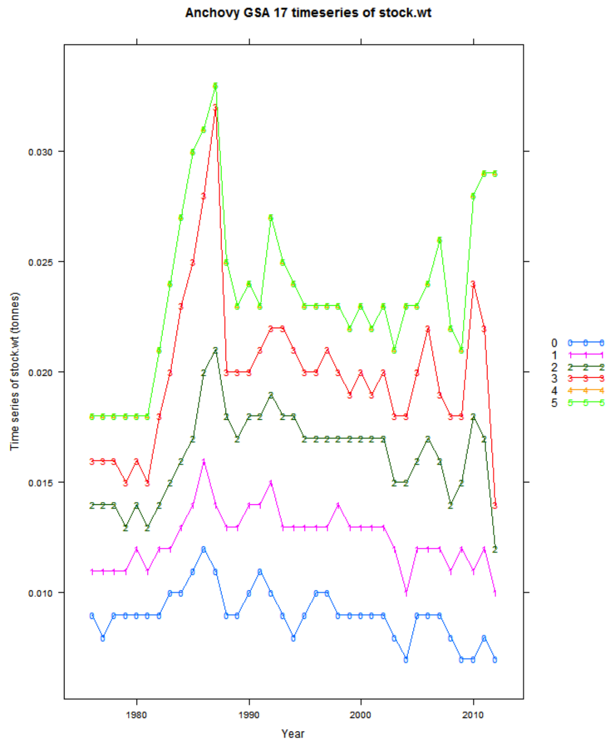



Figure 6.11.7. Anchovy GSA 17.Mean weight at age in the catches for the whole time series (1976-2012).

Internal consistency plot was used to explore the survey data and age classes within survey to be used in the SAM model. Even if the data show a weak internal consistency, they were used to tune the assessment (Figure 6.11.8.).

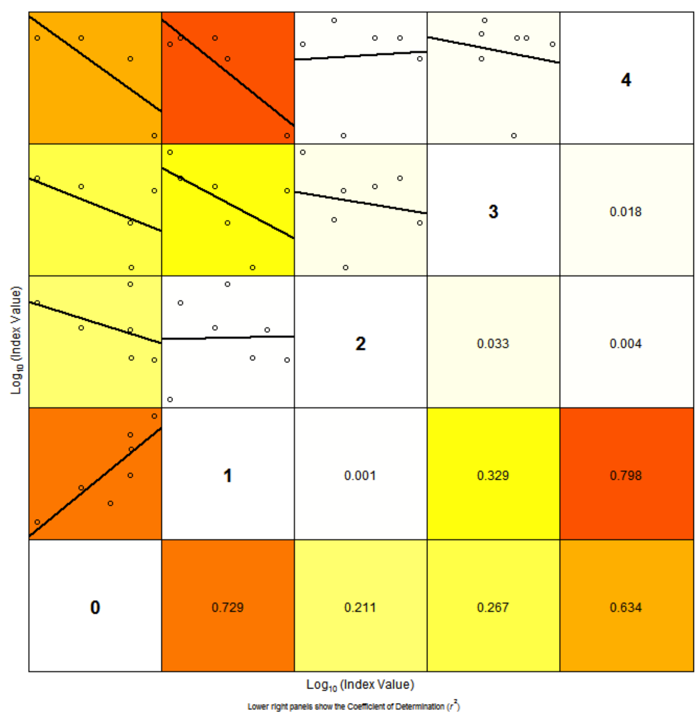



Figure 6.11.8. Anchovy GSA 17. Internal consistency plot of the echo-survey data used to tune anchovy assessment.

All the configuration setting used in the SAM model are presented in the Table 6.11.7.

Table 6.1.7. Anchovy GSA 17.SAM configuration settings for stock assessment.

| name | Final | Assessment | | | | | |
|---|---|---|---|---|---|---|---|
| range | min | max | plusgroup | minyear | maxyear | minfbar | maxfbar |
| | 0 | 5 | 5 | 1976 | 2012 | 1 | 2 |
| fleets | Acoustic Survey for the entire GSA 17 from 2004 to 2012 | | | | | | |
| plus.group | TRUE | | | | | | |
| logN.vars | | 0 | 1 | 1 | 1 | 1 | |
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| catchabilities | fleet | 2 | 3 | 4 | 5 | 6 | 7 |
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| f.vars | catch | 1 | 2 | 2 | 2 | 2 | |
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| obs.vars | fleet | 1 | 1 | 2 | 3 | 3 | |
| obs.vars | catch | 1 | 2 | 2 | 2 | 3 | 3 |

Results

SAM outputs are listed in Table 6.11.8.

Table 6.11.8. Anchovy GSA 17.Results of the assessment obtained from the SAM model.

| Year | Recruits Age 0 (Thousands) Mean | Recruits Age 0 (Thousands) Low | Recruits Age 0 (Thousands) High | Total biomass (tonnes) Mean | Total biomass (tonnes) Low | Total biomass (tonnes) High | Spawing biomass (tonnes) Mean | Spawing biomass (tonnes) Low | Spawing biomass (tonnes) High | Landings (tonnes) Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 136386047 | 103714117 | 179350258 | 1419762 | 1104155 | 1825582 | 389259 | 306688 | 494061 | 22607 |
| 1977 | 163610637 | 126083784 | 212306767 | 1522707 | 1198576 | 1934492 | 418738 | 333731 | 525397 | 27945 |
| 1978 | 167752460 | 133999255 | 210007794 | 1760309 | 1432884 | 2162553 | 480701 | 394964 | 585049 | 41606 |
| 1979 | 130515167 | 108630807 | 156808269 | 1432598 | 1219064 | 1683534 | 404335 | 346900 | 471281 | 49911 |
| 1980 | 86443363 | 72220938 | 103466603 | 1013581 | 872591 | 1177351 | 298045 | 258658 | 343430 | 53051 |
| 1981 | 60490688 | 49920267 | 73299354 | 698716 | 594564 | 821113 | 198392 | 170019 | 231499 | 45570 |
| 1982 | 48206287 | 38350863 | 60594361 | 547436 | 450823 | 664752 | 151146 | 125545 | 181967 | 38101 |
| 1983 | 52378146 | 38744261 | 70809717 | 607435 | 466735 | 790549 | 159054 | 125168 | 202115 | 27584 |
| 1984 | 41574602 | 33659638 | 51350745 | 505347 | 415875 | 614067 | 139107 | 114446 | 169082 | 24125 |
| 1985 | 22908074 | 16721803 | 31382972 | 337055 | 264705 | 429179 | 97538 | 79349 | 119897 | 27778 |
| 1986 | 15934546 | 10760076 | 23597393 | 253723 | 183274 | 351253 | 66769 | 47599 | 93661 | 31508 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 22499418 | 16415458 | 30838239 | 279568 | 208920 | 374106 | 72403 | 54678 | 95874 | 8868 |
| 1988 | 35250843 | 26352076 | 47154613 | 353982 | 268714 | 466305 | 92503 | 70850 | 120774 | 6380 |
| 1989 | 44500011 | 33300295 | 59466471 | 457714 | 349482 | 599466 | 122027 | 94250 | 157990 | 10856 |
| 1990 | 45626534 | 34393151 | 60528931 | 536059 | 412903 | 695950 | 148153 | 115352 | 190280 | 12428 |
| 1991 | 44366711 | 32915453 | 59801853 | 577810 | 439625 | 759429 | 160653 | 123853 | 208387 | 15125 |
| 1992 | 52064818 | 38795080 | 69873429 | 617849 | 471187 | 810162 | 171613 | 132202 | 222774 | 16956 |
| 1993 | 61098630 | 44709367 | 83495759 | 646288 | 484456 | 862179 | 179333 | 136229 | 236076 | 13222 |
| 1994 | 73221526 | 56167632 | 95453407 | 698716 | 546342 | 893588 | 196614 | 154729 | 249839 | 16394 |
| 1995 | 61898097 | 51220695 | 74801298 | 690382 | 581625 | 819475 | 197402 | 166150 | 234534 | 25286 |
| 1996 | 50223821 | 41675732 | 60525205 | 623435 | 530942 | 732042 | 177549 | 152328 | 206945 | 26370 |
| 1997 | 38919268 | 31984591 | 47357473 | 491885 | 422384 | 572821 | 139944 | 123275 | 158867 | 26876 |
| 1998 | 36397112 | 31546429 | 41993653 | 409626 | 363523 | 461577 | 111413 | 99705 | 124495 | 28681 |
| 1999 | 38263232 | 33382319 | 43857796 | 407583 | 362487 | 458289 | 105873 | 94999 | 117992 | 23017 |
| 2000 | 46455248 | 40332428 | 53507567 | 479740 | 423445 | 543519 | 119731 | 106444 | 134676 | 27723 |
| 2001 | 49525587 | 42279476 | 58013580 | 514011 | 446837 | 591283 | 130353 | 114250 | 148725 | 26742 |
| 2002 | 54515739 | 45994335 | 64615908 | 565237 | 486208 | 657111 | 146093 | 126939 | 168138 | 23553 |
| 2003 | 79717524 | 66453696 | 95628748 | 716404 | 608591 | 843316 | 180773 | 155328 | 210387 | 26318 |
| 2004 | 103388056 | 89553757 | 119359483 | 818313 | 718973 | 931378 | 208981 | 185070 | 235982 | 29614 |
| 2005 | 142094090 | 98969393 | 204009843 | 1424028 | 1025610 | 1977219 | 360771 | 266456 | 488471 | 44712 |
| 2006 | 104845668 | 90247979 | 121804546 | 1151988 | 1004460 | 1321185 | 319656 | 278215 | 367269 | 46028 |
| 2007 | 77904946 | 67883538 | 89405779 | 888242 | 796123 | 991021 | 243045 | 220630 | 267736 | 59516 |
| 2008 | 68134892 | 58812026 | 78935615 | 669308 | 592847 | 755631 | 178975 | 160592 | 199461 | 41523 |
| 2009 | 65791420 | 58023696 | 74599022 | 569207 | 513599 | 630837 | 149194 | 135812 | 163894 | 41151 |
| 2010 | 56683856 | 42882501 | 74927055 | 492377 | 392129 | 618254 | 125242 | 101492 | 154549 | 43695 |
| 2011 | 60249209 | 38985627 | 93110396 | 564107 | 383004 | 830845 | 140927 | 96342 | 206146 | 35207 |
| 2012 | 58585630 | 31910919 | 107558044 | 478303 | 273535 | 836361 | 123871 | 71052 | 215957 | 22427 |
| NA | 58585630 | 31910919 | 107558044 | NA | NA | NA | 2271364 | NA | NA | NA |

| | Landings (tonnes) Low | Landings (tonnes) High | Yield / SSB (ratio) Mean | Yield / SSB (ratio) Low | Yield / SSB (ratio) High | Mean F ages 1-2 Mean | Mean F ages 1-2 Low | Mean F ages 1-2 High | Mean F ages 0-1 | SoP (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1976 | 19901 | 25680 | 0.058 | 0.065 | 0.052 | 0.175 | 0.123 | 0.250 | 0.053 | 0.989 |
| 1977 | 25143 | 31059 | 0.067 | 0.075 | 0.059 | 0.188 | 0.138 | 0.256 | 0.055 | 0.965 |
| 1978 | 37811 | 45782 | 0.087 | 0.096 | 0.078 | 0.262 | 0.197 | 0.347 | 0.079 | 0.992 |
| 1979 | 45085 | 55254 | 0.123 | 0.130 | 0.117 | 0.301 | 0.241 | 0.375 | 0.113 | 0.993 |
| 1980 | 48872 | 57587 | 0.178 | 0.189 | 0.168 | 0.352 | 0.288 | 0.431 | 0.123 | 0.997 |
| 1981 | 41739 | 49752 | 0.230 | 0.245 | 0.215 | 0.471 | 0.386 | 0.574 | 0.161 | 0.991 |
| 1982 | 34398 | 42203 | 0.252 | 0.274 | 0.232 | 0.544 | 0.440 | 0.673 | 0.192 | 1.041 |
| 1983 | 24094 | 31580 | 0.173 | 0.192 | 0.156 | 0.453 | 0.358 | 0.572 | 0.169 | 1.049 |
| 1984 | 20910 | 27833 | 0.173 | 0.183 | 0.165 | 0.359 | 0.280 | 0.462 | 0.138 | 1.052 |
| 1985 | 22286 | 34623 | 0.285 | 0.281 | 0.289 | 0.382 | 0.320 | 0.456 | 0.240 | 1.059 |
| 1986 | 27903 | 35578 | 0.472 | 0.586 | 0.380 | 0.838 | 0.622 | 1.130 | 0.379 | 1.095 |
| 1987 | 6921 | 11363 | 0.122 | 0.127 | 0.119 | 0.290 | 0.192 | 0.439 | 0.086 | 1.090 |
| 1988 | 5012 | 8122 | 0.069 | 0.071 | 0.067 | 0.148 | 0.105 | 0.208 | 0.060 | 1.021 |
| 1989 | 8993 | 13106 | 0.089 | 0.095 | 0.083 | 0.211 | 0.158 | 0.280 | 0.088 | 0.982 |
| 1990 | 10637 | 14520 | 0.084 | 0.092 | 0.076 | 0.178 | 0.131 | 0.241 | 0.069 | 1.014 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | 13197 | 17335 | 0.094 | 0.107 | 0.083 | 0.191 | 0.144 | 0.253 | 0.088 | 1.013 |
| 1992 | 14663 | 19608 | 0.099 | 0.111 | 0.088 | 0.190 | 0.139 | 0.260 | 0.076 | 1.033 |
| 1993 | 11234 | 15560 | 0.074 | 0.082 | 0.066 | 0.159 | 0.115 | 0.219 | 0.061 | 0.990 |
| 1994 | 14499 | 18537 | 0.083 | 0.094 | 0.074 | 0.172 | 0.128 | 0.232 | 0.078 | 0.999 |
| 1995 | 23001 | 27798 | 0.128 | 0.138 | 0.119 | 0.270 | 0.210 | 0.349 | 0.124 | 0.982 |
| 1996 | 23895 | 29103 | 0.149 | 0.157 | 0.141 | 0.306 | 0.245 | 0.384 | 0.141 | 0.965 |
| 1997 | 23970 | 30135 | 0.192 | 0.194 | 0.190 | 0.325 | 0.274 | 0.386 | 0.161 | 0.970 |
| 1998 | 25796 | 31890 | 0.257 | 0.259 | 0.256 | 0.483 | 0.428 | 0.545 | 0.222 | 0.977 |
| 1999 | 20744 | 25540 | 0.217 | 0.218 | 0.216 | 0.580 | 0.517 | 0.650 | 0.196 | 0.960 |
| 2000 | 24352 | 31560 | 0.232 | 0.229 | 0.234 | 0.907 | 0.813 | 1.012 | 0.281 | 0.988 |
| 2001 | 23586 | 30321 | 0.205 | 0.206 | 0.204 | 0.812 | 0.718 | 0.919 | 0.267 | 0.974 |
| 2002 | 21384 | 25941 | 0.161 | 0.168 | 0.154 | 0.677 | 0.573 | 0.799 | 0.196 | 0.993 |
| 2003 | 23576 | 29379 | 0.146 | 0.152 | 0.140 | 0.706 | 0.589 | 0.847 | 0.243 | 1.016 |
| 2004 | 26639 | 32921 | 0.142 | 0.144 | 0.140 | 0.613 | 0.511 | 0.736 | 0.211 | 0.963 |
| 2005 | 39388 | 50756 | 0.124 | 0.148 | 0.104 | 0.640 | 0.557 | 0.734 | 0.167 | 1.048 |
| 2006 | 42046 | 50387 | 0.144 | 0.151 | 0.137 | 0.471 | 0.400 | 0.553 | 0.115 | 1.051 |
| 2007 | 55483 | 63842 | 0.245 | 0.251 | 0.238 | 0.789 | 0.708 | 0.881 | 0.120 | 1.025 |
| 2008 | 38782 | 44458 | 0.232 | 0.241 | 0.223 | 0.786 | 0.709 | 0.871 | 0.151 | 0.920 |
| 2009 | 38466 | 44023 | 0.276 | 0.283 | 0.269 | 1.124 | 1.037 | 1.219 | 0.216 | 0.964 |
| 2010 | 40703 | 46908 | 0.349 | 0.401 | 0.304 | 1.278 | 1.197 | 1.365 | 0.347 | 1.015 |
| 2011 | 32191 | 38506 | 0.250 | 0.334 | 0.187 | 1.518 | 1.379 | 1.672 | 0.263 | 0.989 |
| 2012 | 20301 | 24774 | 0.181 | 0.286 | 0.115 | 0.796 | 0.442 | 1.433 | 0.224 | 0.670 |

Table 6.1.9. and 6.1.10. show fishing mortality at age by year and stock numbers at age by year (in thousand).

Table 6.11.9. Anchovy GSA 17. F at age estimated from 1976 to 2012.

| age \ year | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.006 | 0.007 | 0.010 | 0.016 | 0.018 | 0.021 | 0.029 | 0.030 | 0.041 | 0.078 |
| 1 | 0.100 | 0.104 | 0.147 | 0.211 | 0.228 | 0.301 | 0.355 | 0.309 | 0.234 | 0.403 |
| 2 | 0.250 | 0.272 | 0.377 | 0.391 | 0.476 | 0.641 | 0.733 | 0.596 | 0.485 | 0.361 |
| 3 | 0.455 | 0.548 | 0.621 | 0.575 | 0.852 | 1.062 | 1.127 | 1.079 | 0.855 | 0.830 |
| 4 | 0.580 | 0.692 | 0.759 | 0.732 | 0.914 | 1.179 | 1.471 | 1.781 | 2.149 | 1.816 |
| 5 | 0.580 | 0.692 | 0.759 | 0.732 | 0.914 | 1.179 | 1.471 | 1.781 | 2.149 | 1.816 |

| age \ year | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.064 | 0.023 | 0.024 | 0.028 | 0.024 | 0.022 | 0.019 | 0.009 | 0.012 | 0.016 |
| 1 | 0.694 | 0.150 | 0.097 | 0.148 | 0.114 | 0.154 | 0.133 | 0.112 | 0.144 | 0.232 |
| 2 | 0.982 | 0.430 | 0.199 | 0.273 | 0.242 | 0.228 | 0.247 | 0.206 | 0.199 | 0.308 |
| 3 | 1.555 | 1.045 | 0.522 | 0.491 | 0.548 | 0.454 | 0.607 | 0.467 | 0.428 | 0.511 |
| 4 | 2.629 | 2.696 | 2.633 | 1.606 | 1.046 | 0.938 | 1.059 | 1.193 | 1.128 | 1.089 |
| 5 | 2.629 | 2.696 | 2.633 | 1.606 | 1.046 | 0.938 | 1.059 | 1.193 | 1.128 | 1.089 |

| age \ year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.015 | 0.028 | 0.032 | 0.032 | 0.040 | 0.035 | 0.022 | 0.016 | 0.021 | 0.023 |
| 1 | 0.267 | 0.295 | 0.411 | 0.360 | 0.523 | 0.498 | 0.370 | 0.470 | 0.400 | 0.312 |
| 2 | 0.346 | 0.356 | 0.555 | 0.799 | 1.291 | 1.126 | 0.984 | 0.942 | 0.826 | 0.967 |
| 3 | 0.640 | 0.821 | 1.434 | 2.393 | 2.573 | 2.083 | 2.050 | 1.117 | 0.927 | 0.940 |
| 4 | 1.159 | 1.546 | 2.762 | 9.830 | 8.824 | 7.989 | 7.915 | 7.153 | 1.850 | 1.285 |
| 5 | 1.159 | 1.546 | 2.762 | 9.830 | 8.824 | 7.989 | 7.915 | 7.153 | 1.850 | 1.285 |

| age \ year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 0 | 0.021 | 0.017 | 0.017 | 0.017 | 0.024 | 0.027 | 0.023 |
| 1 | 0.209 | 0.223 | 0.285 | 0.415 | 0.670 | 0.499 | 0.426 |
| 2 | 0.732 | 1.356 | 1.287 | 1.834 | 1.887 | 2.537 | 1.166 |
| 3 | 1.767 | 2.030 | 2.136 | 2.285 | 2.579 | 4.331 | 3.732 |
| 4 | 2.235 | 8.739 | 9.598 | 9.317 | 8.822 | 8.132 | 17.893 |
| 5 | 2.235 | 8.739 | 9.598 | 9.317 | 8.822 | 8.132 | 17.893 |

Table 6.11.10. Anchovy GSA 17. Stock numbers at age from 1976 to 2012.

| age \ year | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.36E+08 | 1.64E+08 | 1.68E+08 | 1.31E+08 | 8.64E+07 | 6.05E+07 | 4.82E+07 | 5.24E+07 | 4.16E+07 | 2.29E+07 |
| 1 | 1.18E+07 | 1.27E+07 | 1.55E+07 | 1.59E+07 | 1.21E+07 | 8.00E+06 | 5.58E+06 | 4.36E+06 | 4.87E+06 | 3.83E+06 |
| 2 | 3.11E+06 | 3.55E+06 | 3.82E+06 | 4.50E+06 | 4.30E+06 | 3.22E+06 | 1.97E+06 | 1.30E+06 | 1.05E+06 | 1.31E+06 |
| 3 | 8.19E+05 | 1.08E+06 | 1.21E+06 | 1.16E+06 | 1.36E+06 | 1.19E+06 | 7.55E+05 | 4.19E+05 | 3.16E+05 | 2.86E+05 |
| 4 | 2.58E+05 | 2.61E+05 | 3.13E+05 | 3.25E+05 | 3.28E+05 | 2.92E+05 | 2.07E+05 | 1.23E+05 | 7.13E+04 | 6.74E+04 |
| 5 | 6.91E+04 | 9.74E+04 | 9.55E+04 | 1.01E+05 | 1.09E+05 | 9.34E+04 | 6.31E+04 | 3.29E+04 | 1.39E+04 | 5.25E+03 |

| age | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.59E+07 | 2.25E+07 | 3.53E+07 | 4.45E+07 | 4.56E+07 | 4.44E+07 | 5.21E+07 | 6.11E+07 | 7.32E+07 | 6.19E+07 |
| 1 | 1.96E+06 | 1.36E+06 | 2.10E+06 | 3.28E+06 | 4.10E+06 | 4.22E+06 | 4.07E+06 | 4.79E+06 | 5.79E+06 | 6.91E+06 |
| 2 | 8.62E+05 | 3.17E+05 | 3.83E+05 | 6.50E+05 | 9.39E+05 | 1.23E+06 | 1.20E+06 | 1.18E+06 | 1.42E+06 | 1.69E+06 |
| 3 | 4.19E+05 | 1.42E+05 | 9.00E+04 | 1.40E+05 | 2.22E+05 | 3.28E+05 | 4.40E+05 | 4.15E+05 | 4.24E+05 | 5.20E+05 |
| 4 | 6.26E+04 | 4.44E+04 | 2.49E+04 | 2.67E+04 | 4.29E+04 | 6.47E+04 | 1.05E+05 | 1.20E+05 | 1.30E+05 | 1.39E+05 |
| 5 | 6.27E+03 | 2.63E+03 | 1.67E+03 | 1.01E+03 | 2.93E+03 | 8.52E+03 | 1.52E+04 | 2.22E+04 | 2.29E+04 | 2.63E+04 |

| age | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5.02E+07 | 3.89E+07 | 3.64E+07 | 3.83E+07 | 4.65E+07 | 4.95E+07 | 5.45E+07 | 7.97E+07 | 1.03E+08 | 1.42E+08 |
| 1 | 5.74E+06 | 4.73E+06 | 3.53E+06 | 3.31E+06 | 3.49E+06 | 4.21E+06 | 4.49E+06 | 4.99E+06 | 7.52E+06 | 9.50E+06 |
| 2 | 1.84E+06 | 1.46E+06 | 1.18E+06 | 7.68E+05 | 7.68E+05 | 6.86E+05 | 8.50E+05 | 1.03E+06 | 1.03E+06 | 1.69E+06 |
| 3 | 5.57E+05 | 5.80E+05 | 4.56E+05 | 3.04E+05 | 1.53E+05 | 9.36E+04 | 9.87E+04 | 1.41E+05 | 1.79E+05 | 2.00E+05 |
| 4 | 1.57E+05 | 1.48E+05 | 1.29E+05 | 5.45E+04 | 1.39E+04 | 5.83E+03 | 5.85E+03 | 6.35E+03 | 2.33E+04 | 3.56E+04 |
| 5 | 2.94E+04 | 3.10E+04 | 2.03E+04 | 5.00E+03 | 1.69E+00 | 1.08E+00 | 1.04E+00 | 1.13E+00 | 2.62E+00 | 1.94E+03 |

| age | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 0 | 1.05E+08 | 7.79E+07 | 6.81E+07 | 6.58E+07 | 5.67E+07 | 6.02E+07 | 5.86E+07 |
| 1 | 1.35E+07 | 9.70E+06 | 7.20E+06 | 6.28E+06 | 6.15E+06 | 5.16E+06 | 5.53E+06 |
| 2 | 2.31E+06 | 3.77E+06 | 2.60E+06 | 1.80E+06 | 1.37E+06 | 1.04E+06 | 1.03E+06 |
| 3 | 2.86E+05 | 5.00E+05 | 4.35E+05 | 3.21E+05 | 1.27E+05 | 9.24E+04 | 3.64E+04 |
| 4 | 3.93E+04 | 2.45E+04 | 3.30E+04 | 2.58E+04 | 1.64E+04 | 4.85E+03 | 6.08E+02 |
| 5 | 5.55E+03 | 2.56E+03 | 2.28E+00 | 1.18E+00 | 1.22E+00 | 1.27E+00 | 7.54E-01 |

The average fishing mortality for ages 1-2 (presented in figure 6.11.9., middle panel) started increasing in 1995, reaching the maximum value of 1.518 in 2011. The estimate for 2012 is equal to 0.796.

The mid-year spawning stock biomass (figure 6.1.9., top panel) fluctuated from the highest values in the late 70th (about 480701 tons) to a first drop in the 1986 with a biomass of 66769 tons. After that the stock recovered to about 197402 tons in 1995 and then decreased again to a minimum of 105,873 tons in 1998. A third phase saw a new recovery up to 360771 tons in 2005. In 2012 the estimated SSB is around 123871 tons.

The recruitment (age 0, figure 6.1.9., bottom panel) fluctuates around a minimum value of 15934546 thousands specimen in 1986, to a maximum value of 167752460 in 1978. A second peak was registered in 2005, with a value of 142094090 thousand specimen.

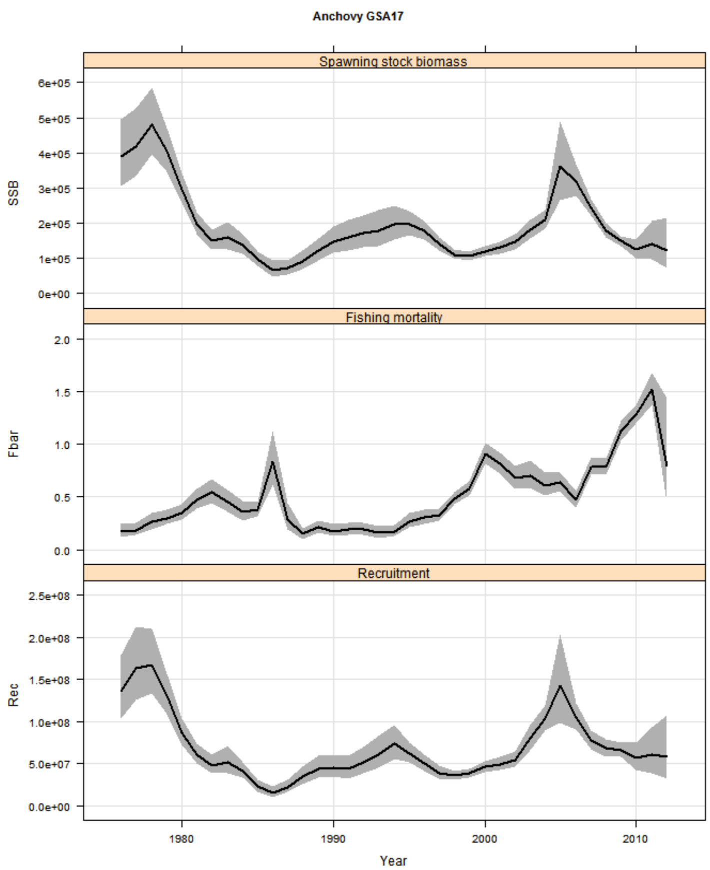
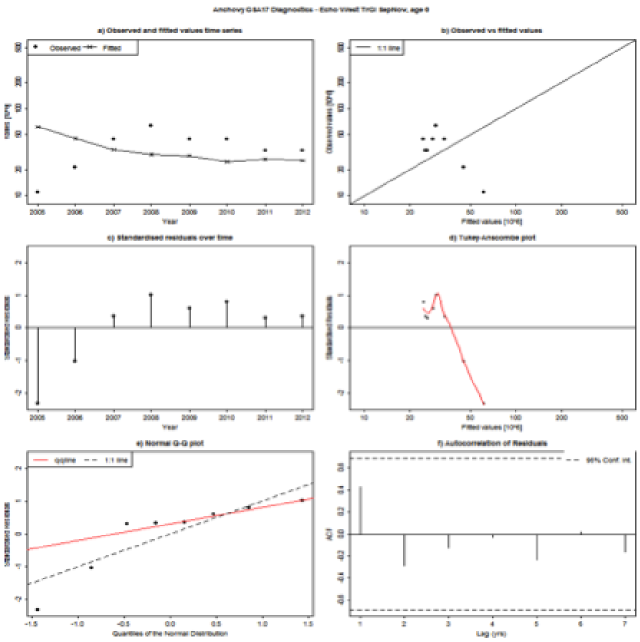
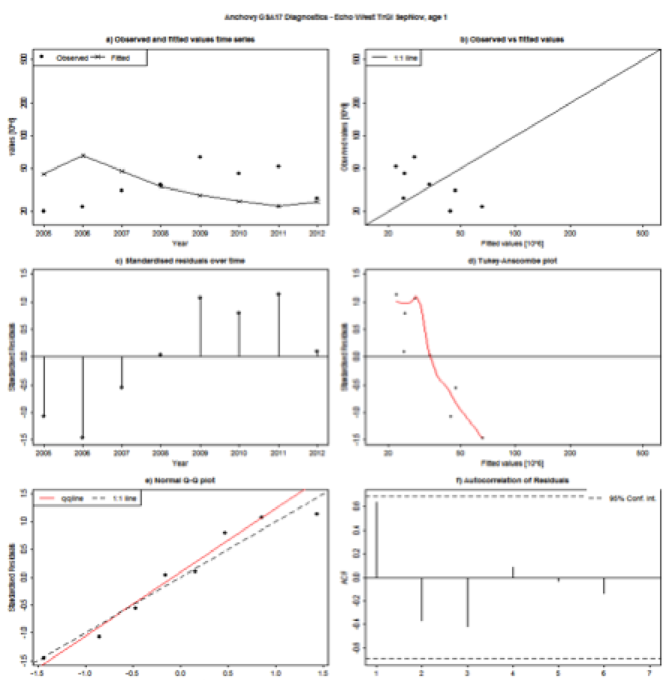



Figure 6.11.9. Anchovy GSA 17. Mid-year spawning stock biomass (in tons, top), reference F (mean F 1-2, middle) and recruitment (in thousands individuals, bottom), with the 95% confidence intervals.

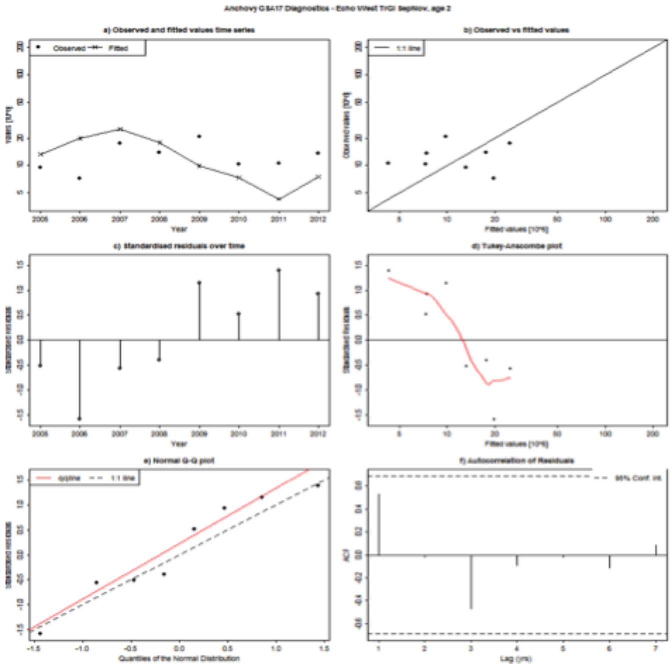
Catch residuals did not show any trend. On the other hand, survey data showed some patterns for the most important ages (figure 6.11.10.).


a) Observed and fitted values time series
Observed
Fitted
b) Observed vs fitted values
1:1 line
c) Standardised residuals over time
d) Tukey-Anscombe plot
e) Normal Q-Q plot
qqline
1:1 line
f) Autocorrelation of Residuals
95% Conf. Int.

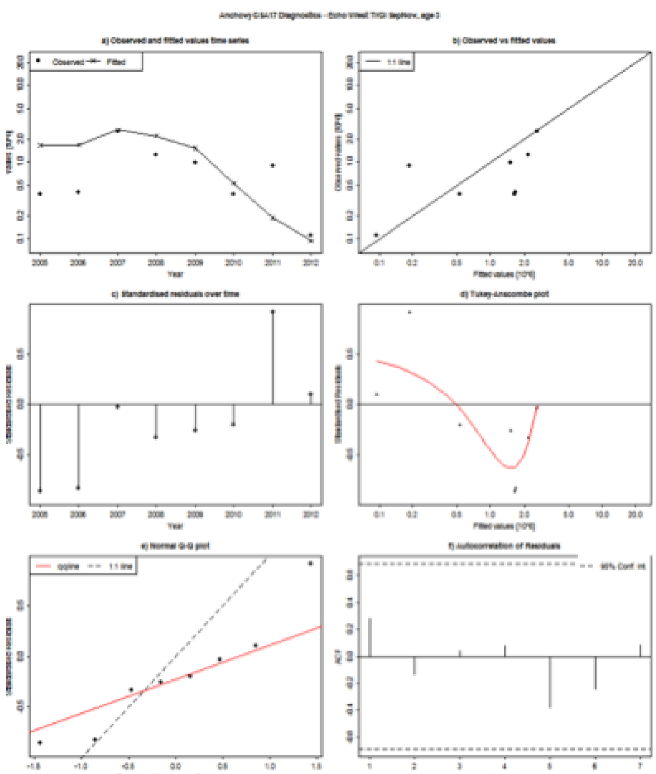
a)


a) Observed and fitted values time series
Observed
Fitted
b) Observed vs fitted values
1:1 line
c) Standardised residuals over time
d) Tukey-Anscombe plot
e) Normal Q-Q plot
qqline
1:1 line
f) Autocorrelation of Residuals
95% Conf. Int.

b)



c)



d)

Figure 6.11.10.Anchovy GSA 17. Diagnostics: trend in residuals and fitted values for the acoustic index at age from age 0 (a) to age 3 (d).

The annual exploitation rate E = F/(F+M) or F/Z was calculated and plotted over the years for the ages 1-2. The values obtained were compared with the threshold F/Z = 0.4 adopted as biological reference point for small pelagics (Patterson, 1992). The trends in values of F/Z were plotted in Figure 6.1.11. It is evident that E from 2009 shown values above threshold limit, but in 2012 values are rather close to the reference once again (E=0.43).

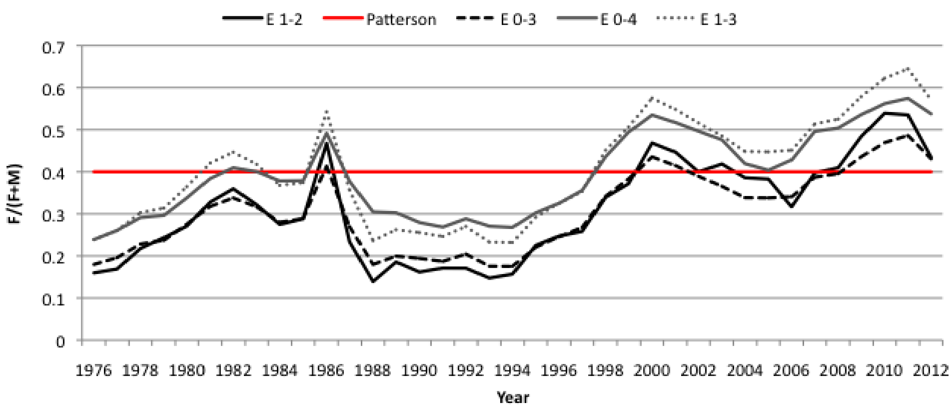



Figure 6.11.11.Anchovy GSA 17. Exploitation rate compared to the Patterson' reference point of 0.4.

## 6.11.5.**Short term predictions 2014-2015**

Method and justification

Short term prediction for 2014 and 2015 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using SAM (Nielsen *et al*., 2012) that was conducted in the framework of the EWG 13-19.

Input parameters

A short term projection for 2013 to 2015 was performed using the R-routine and was and based on the results of the SAM, assuming an $F_{stq}$ of 1.156 and a recruitment of 58488068thousands (geometric mean of the last 3 years).

Results

A short term projection (Table 6.11.1), assuming an $F_{stq}$ of 1.15in 2013 and a recruitment of 58488068(thousands) individuals, shows that:

- Fishing at the $F_{stq}$ (1.15) from 2012 to 2014 generates an increase of the catch of41.8 % and a decrease of the spawning stock biomass of 0.03% from 2014 to 2015.

- Fishing at $F_{MSY}$ (0.38) from 2012 to 2014 generates a decrease of the catch of 39.1% and a spawning stock biomass increase of 3.8 % from 2014 to 2015.

- A 30% reduction of the $F_{stq}$ (F=0.81) generates an increase of catch of 10% in 2014 and an increase of spawning stock biomass of about 1% from 2014 to 2015, indicating that this level of reduction could generate an increase in both catches and spawning stock biomass.

EWG 13-19 considers that fishing mortality in 2014 should not exceed $F_{MSY}$ (F=0.38) corresponding to catches of 13432 tons.

**Outlook for 2014-2015**

Table 6.11.1. Anchovy GSA 17.Short term forecast for the different F scenarios computed.

| | **Ffactor** | **Fbar** | **Catch_2012** | **Catch_2013** | **Catch_2014** | **Catch_2015** | **SSB_2014** | **SSB_2015** | **Change_SSB_2014-2015(%)** | **Change_Catch_2012-2014(%)** |
|---|---|---|---|---|---|---|---|---|---|---|
| Zero catch | 0.00 | 0.00 | 22073 | 33415 | 0 | 0 | 145624 | 160386 | 10.14 | -100.00 |
| Fmsy | 0.33 | 0.38 | 22073 | 33415 | 13432 | 17834 | 138937 | 144260 | 3.83 | -39.15 |
| Status quo | 1.00 | 1.16 | 22073 | 33415 | 31290 | 31090 | 128957 | 128923 | -0.03 | 41.76 |
| Different scenarios | 0.10 | 0.12 | 22073 | 33415 | 4539 | 7481 | 143453 | 154249 | 7.53 | -79.43 |
| | 0.20 | 0.23 | 22073 | 33415 | 8610 | 12737 | 141428 | 149403 | 5.64 | -60.99 |
| | 0.30 | 0.35 | 22073 | 33415 | 12298 | 16723 | 139531 | 145419 | 4.22 | -44.28 |
| | 0.40 | 0.46 | 22073 | 33415 | 15666 | 19890 | 137750 | 142056 | 3.13 | -29.03 |
| | 0.50 | 0.58 | 22073 | 33415 | 18761 | 22491 | 136074 | 139160 | 2.27 | -15.01 |
| | 0.60 | 0.69 | 22073 | 33415 | 21622 | 24686 | 134492 | 136628 | 1.59 | -2.04 |
| | 0.70 | 0.81 | 22073 | 33415 | 24282 | 26581 | 132996 | 134387 | 1.05 | 10.01 |
| | 0.80 | 0.92 | 22073 | 33415 | 26766 | 28248 | 131579 | 132381 | 0.61 | 21.26 |
| | 0.90 | 1.04 | 22073 | 33415 | 29096 | 29739 | 130235 | 130571 | 0.26 | 31.82 |
| | 1.10 | 1.27 | 22073 | 33415 | 33363 | 32330 | 127741 | 127413 | -0.26 | 51.15 |
| | 1.20 | 1.39 | 22073 | 33415 | 35328 | 33478 | 126581 | 126020 | -0.44 | 60.05 |
| | 1.30 | 1.50 | 22073 | 33415 | 37196 | 34551 | 125473 | 124728 | -0.59 | 68.51 |
| | 1.40 | 1.62 | 22073 | 33415 | 38976 | 35560 | 124414 | 123525 | -0.72 | 76.58 |
| | 1.50 | 1.73 | 22073 | 33415 | 40677 | 36516 | 123400 | 122398 | -0.81 | 84.29 |
| | 1.60 | 1.85 | 22073 | 33415 | 42307 | 37425 | 122429 | 121338 | -0.89 | 91.67 |
| | 1.70 | 1.97 | 22073 | 33415 | 43870 | 38295 | 121496 | 120339 | -0.95 | 98.75 |
| | 1.80 | 2.08 | 22073 | 33415 | 45372 | 39129 | 120599 | 119393 | -1.00 | 105.55 |
| | 1.90 | 2.20 | 22073 | 33415 | 46819 | 39933 | 119737 | 118495 | -1.04 | 112.11 |
| | 2.00 | 2.31 | 22073 | 33415 | 48214 | 40708 | 118907 | 117640 | -1.07 | 118.43 |

### 6.11.6. **Data quality**

The available data for anchovy stock in GSA 17 are considered good enough in order to perform a reliable assessment of the stock status. Nevertheless, the acoustic numbers at age should be carefully examined since it seems that the data do not follow the cohorts properly. Besides, MEDIAS Eastern sampling coverage was incomplete in 2011-2012 due to logistic problems so the observed biomass was raised to the total area using the average abundance percentage in the previous years. No data were provided by countries regarding the discards.

### 6.11.7. **Scientific advice**

Short term considerations

State of the spawning stock size

The SAM analyses indicate that the anchovy stock size fluctuated over the time period examined. Namely, maximum values of the SSB were obtained in 1978 (around 480,000 t; estimated for age 0-5). After that, the stock started to decline reaching a minimum level in 1986 (around 67,000 t). In the following years the stock started recovering until 2005, when the biomass reached its second maximum (SSB at 360,000 tons). From 2005, the stock started to decline again, reaching in 2012 a SSB biomass level of around 124,000 tons.

It should be considered that this assessment is based on a long time series of data and that the oldest years of catch data in the time series can be not correctly reported. Moreover, anchovy is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

The level of anchovy SSB in 2012 estimated for age 1 to 5 only (i.e. excluding age 0; 30431 t) is lower than the estimated reference point for both $B_{lim}$ (3,8791 tons) and $B_{pa}$ (54,307 t) estimated by EWG 13-19. Also, spawning biomass in 2012 (estimated using all age classes, 0-5; 123,871 t) is below both the biomass reference points $B_{pa}$ (250,600 t) and $B_{lim}$ (179,000 t) established by the GFCM-SAC in 2012.

State of recruitment

SAM model estimates show fluctuations in the number of recruits since the beginning of the time series, similar to those observed for the SSB. The recruitment (age 0, figure 6.1.9, bottom panel) fluctuates around a minimum value of 15934546 thousands specimen in 1986, to a maximum value of 167752460 in 1978. A second peak was registered in 2005, with a value of 142094090 thousand specimen.

State of exploitation

Based on SAM results, the F of ages 1 and 2 was strongly fluctuating in the observed time series. Fbar (1-2) reached high levels in the 2009-2011 period (1.518 in 2011), but in 2012 lower values were estimated (0.80).

The exploitation rate in 1986, between 2000 and 2003, and in the last 5 years, is above the reference point limit estimated from Patterson for small pelagics (E=0.4). Nevertheless, in 2012, exploitation rate shows a decreasing trend, reaching the value of 0.43, just slightly above the proposed reference value of 0.4.

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## 6.12. **Stock assessment of sardine in GSA 17**

### 6.12.1. **Stock identification and biological features**

Stock Identification

Sardine (*Sardine pilchardus*) stock is shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia) and constitutes a unique stock.

Although there is some evidence of differences on a series of morphometric, meristic, serological and ecological characteristics, the lack of genetic heterogeneity in the Adriatic stock has been demonstrated through allozymic and mitochondrial DNA (mtDNA) surveys (Carvalho *et al.*, 1994) and through sequence variation analysis of a 307-bp cytochrome b gene (Tinti *et al*., 2002). The results of the genetic analyses imply that the different trophic and environmental conditions found in the northern and central Adriatic, may cause differences in growth rates.

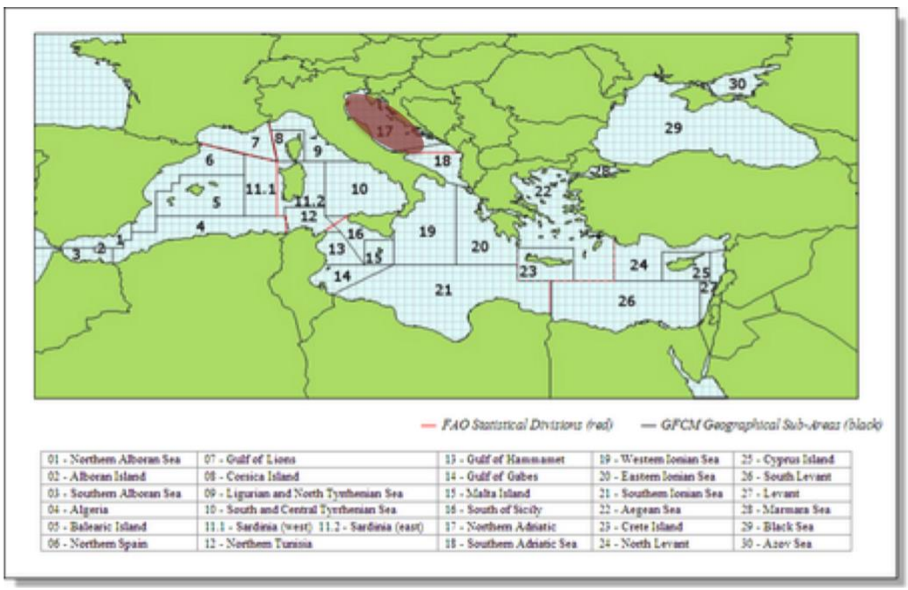



Figure 6.11.2. Geographical location of GSA 17.

Growth

The growth of sardine in the Adriatic Sea was assessed using historical growth parameters (Sinovčić, 1984). Age-length and age-weight keys were produced using otolith readings and actual length-weight parameters. The growth parameters used during the EWG 13-19 were:

Table 6.12.1. Sardine, GSA 17. Von Bertalanffy growth parameters used in the assessment.

| Growth parameters | $L_{inf}$ | k | $t_0$ |
|---|---|---|---|
| Both sexes | 20.5 | 0.46 | -0.5 |

Maturity

Table 6.12.3. Sardine, GSA 17. Proportion of mature specimens at age.

| PERIOD | Age | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1975-2011 | Prop. Matures | 0.75 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Natural mortality

Table 6.12.4. Sardine, GSA 17. Natural mortality vector by age from Gislason et al. (2010) used in the assessment.

| PERIOD | Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| 1975-2011 | M | 2.51 | 1.10 | 0.76 | 0.62 | 0.56 | 0.52 | 0.50 |

### 6.12.2. **Fisheries**

General description of the fisheries

Sardine is commercially very important in the Adriatic Sea: it is targeted by pelagic trawlers (Italy) and purse seiners (Croatia, Slovenia, Italy). Number of vessels targeting this species is around 300.

Management regulations applicable in 2012

A multi–annual management plan for small pelagic fisheries in the Adriatic Sea has been established by the General Fisheries Commission for the Mediterranean (GFCM) in 2012. Besides, Italy has been enforcing for years a general regulation concerning the fishing gears and since 1988 a suspension (about one month) of fishing activity of pelagic trawlers in summer. A closure period is observed from 15th December to 15th January from the Croatian purse seiners. In 2011-2012 a closure period of 60 days (August and September) was endorsed by the Italian fleet.

Catches

Landings

In Figure 6.12.2 the trends in landings for Italy and Croatia are shown. The trend started decreasing in the late eighties reaching a minimum in 2005 with 19000 tons. In the last 8 years the Croatian catches grew high, reaching the maximum of the entire time series in 2011 with about 46000 tons (almost 90% of the overall catches). The Slovenian catches are included in the total landings but are not shown here since the quantities are really low (18 tons in 2012):

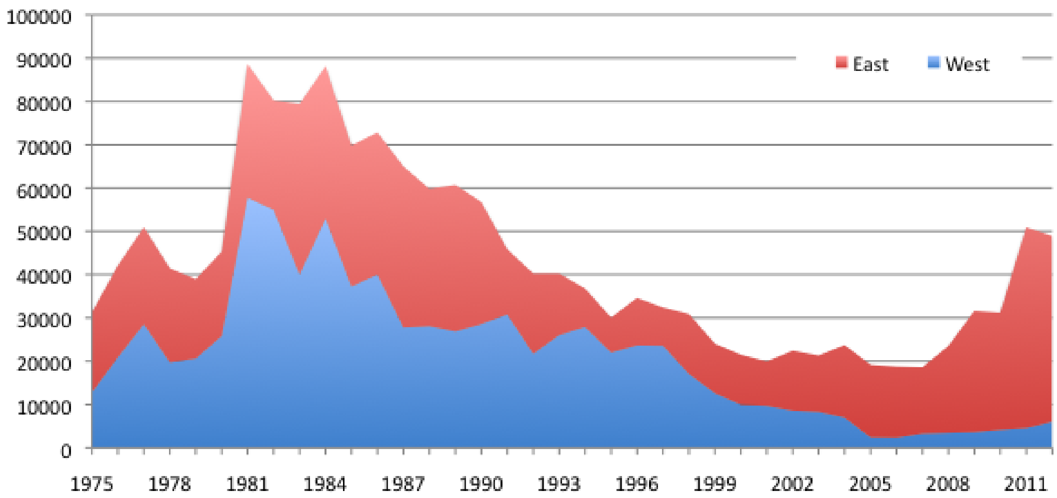



Figure 6.12.2. Sardine, GSA 17. Total landings (in tons) of sardine by country for GSA 17 from 1975 to 2011.

The following table shows the annual landings (t):

Table 6.1.4. Sardine GSA 17. Total landings (tons) of sardine by year.

| Year | Catch | Year | Catch | Year | Catch | Year | Catch |
|---|---|---|---|---|---|---|---|
| 1975 | 31263 | 1985 | 69838 | 1995 | 30047 | 2005 | 19866 |
| 1976 | 42095 | 1986 | 72839 | 1996 | 34622 | 2006 | 20227 |
| 1977 | 50952 | 1987 | 64989 | 1997 | 32391 | 2007 | 21015 |
| 1978 | 41439 | 1988 | 59812 | 1998 | 30893 | 2008 | 26002 |
| 1979 | 38954 | 1989 | 60736 | 1999 | 24029 | 2009 | 33256 |
| 1980 | 45297 | 1990 | 56758 | 2000 | 21495 | 2010 | 32926 |
| 1981 | 88587 | 1991 | 45845 | 2001 | 19941 | 2011 | 53611 |
| 1982 | 80227 | 1992 | 40256 | 2002 | 22431 | 2012 | 57588 |
| 1983 | 79404 | 1993 | 40243 | 2003 | 21333 | | |
| 1984 | 88105 | 1994 | 36765 | 2004 | 23713 | | |

The trend of the cohorts in the catches is shown in figure 6.12.3. Each plot represents the number of fish of each age born in the same year. Age 2 can be identified as the first fully recruited age in most of the years.

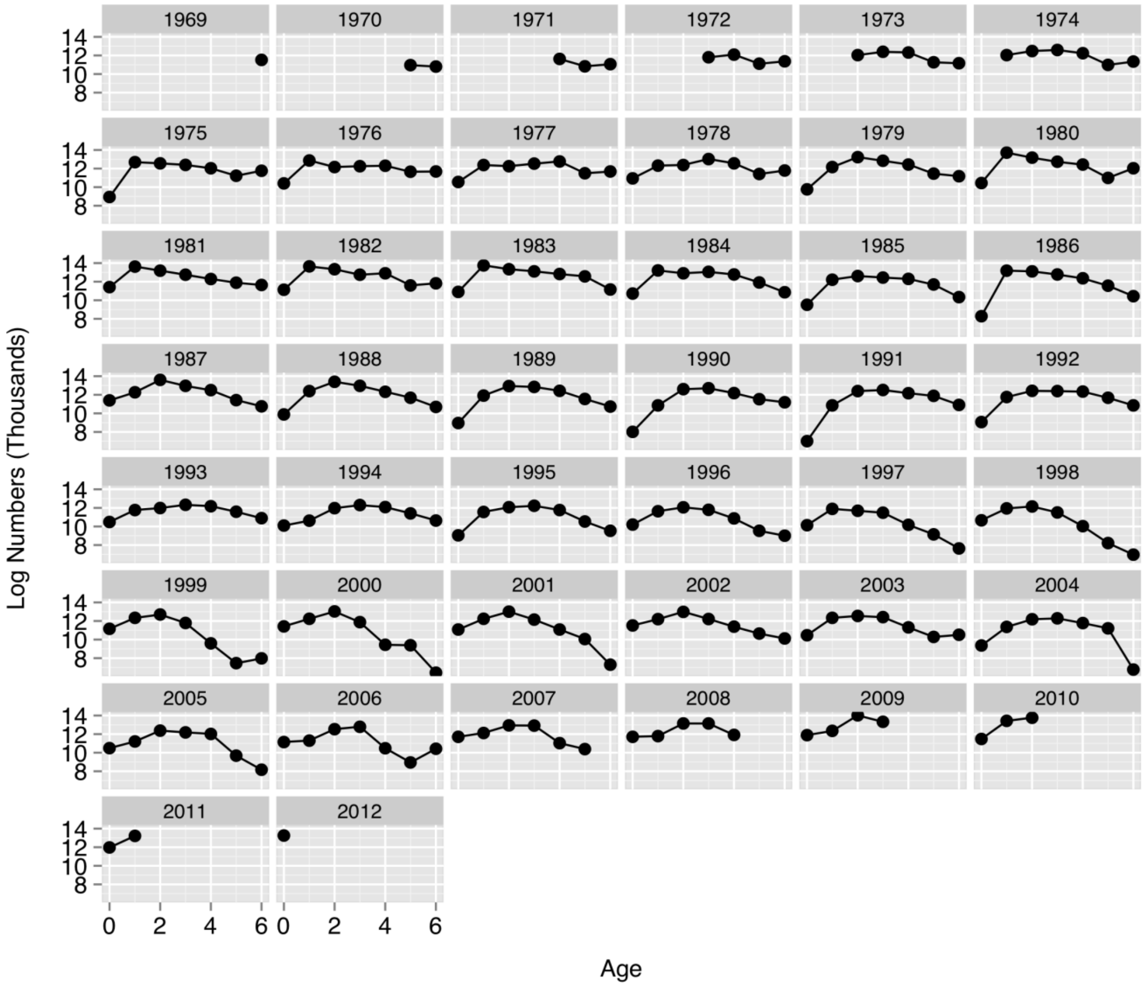



Figure 6.12.3. Sardine GSA 17. Log numbers at age (thousands) of the catch at age used in the assessment.

Discards

Discards were considered to be close ot 0, since very few sardine are usually discarded in GSA 17.

### 6.12.3. Scientific surveys

MEDIAS

Methods

Echosurveys were carried out from 2004 to 2012 for the entire GSA 17. In the western part the acoustic survey was carried out since 1976 in the Northern Adriatic (2/3 of the area) and since 1987 also in the Mid Adriatic (1/3 of the area), and it is in the MEDIAS framework since 2009. The eastern part was covered by Croatian national pelagic monitoring program PELMON. The data from both the surveys have been combined to provide an overall estimate of numbers-at-age.

The survey methods for MEDIAS are given in the MEDIAS handbook (MEDIAS, March 2012).

Western Echosurvey:

- Length frequencies distribution available from 2004 onward (no LFD for Mid Adriatic in 2004, so the biomass at length in 2004 was assumed equal to the proportion of biomass at length in the 2005 Mid Adriatic survey).
- ALKs available for 2009-2010-2011-2012;
- Numbers at age for 2004 to 2008 were obtained applying the sum of the 2009-2010-2011 ALKs to the numbers at length.

Eastern Echosurvey:

- Length frequencies distribution available from 2009.
- No ALKs available.
- Numbers at length from 2004 to 2008 were obtained applying the length frequency distribution from the 2009 survey to the total biomass.
- Numbers at age were obtained applying commercial ALK from the eastern catches to the eastern echosurvey length distribution.
- 2011-2012 surveys covered only the Northern part of the area (about 52% of the total area), so the estimated biomass was raised to the total using an average percentage from previous years (2004-2010).

Geographical distribution patterns

Acoustic sampling transects and the total area covered is shown in figure 6.12.4.

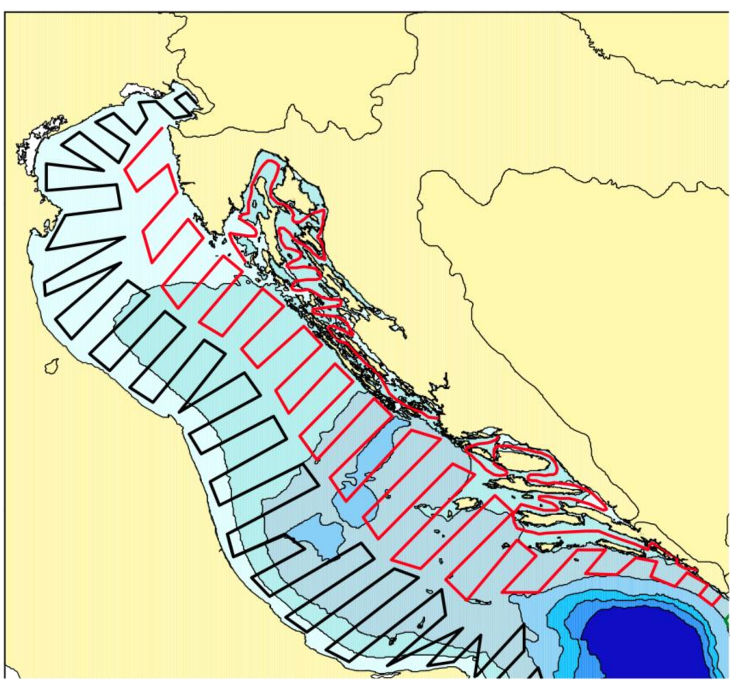


Figure 6.12.4. Sardine GSA 17. Acoustic transects for the western echosurvey (black tracks) and the eastern echosurvey (red tracks).

Trends in abundance and biomass

Biomass estimates from the two surveys show a constant increase of the occurrence of sardine on the western side of the Adriatic: in the first years, the western survey was contributing to about 23% of the biomass estimated from acoustic, while in 2011 and 2012 the contribution was respectively of 83% and 65%.

Pooled total biomass in tons from eastern and western echosurvey (2004-2011) is given in table 6.12.5 and it is shown in figure 6.12.5.

Table 6.12.5. Sardine GSA 17. Total biomass (tons) estimated by the acoustic surveys.

| | Tons |
|---|---|
| 2004 | 287675 |
| 2005 | 140082 |
| 2006 | 312793 |
| 2007 | 217897 |
| 2008 | 272370 |
| 2009 | 365939 |
| 2010 | 258130 |
| 2011 | 483224 |
| 2012 | 207637 |

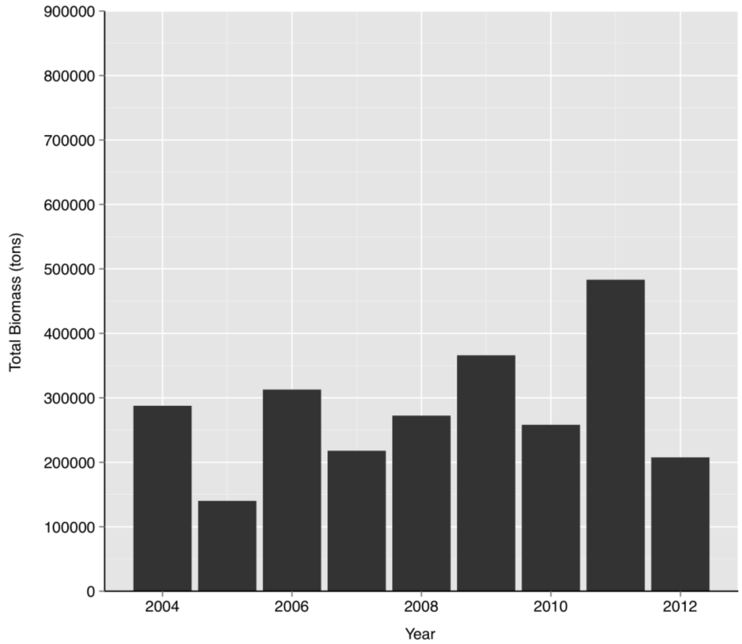



Figure 6.12.5. Sardine, GSA 17. Total biomass (tons) estimated from the eastern and western echosurvey.

Figure 6.12.6 illustrates the proportion by year of each age class from the surveys. In 2009, 2011and 2012 a higher percentage of age 0 has occurred. Age 5 and age 6 are scarcely represented.

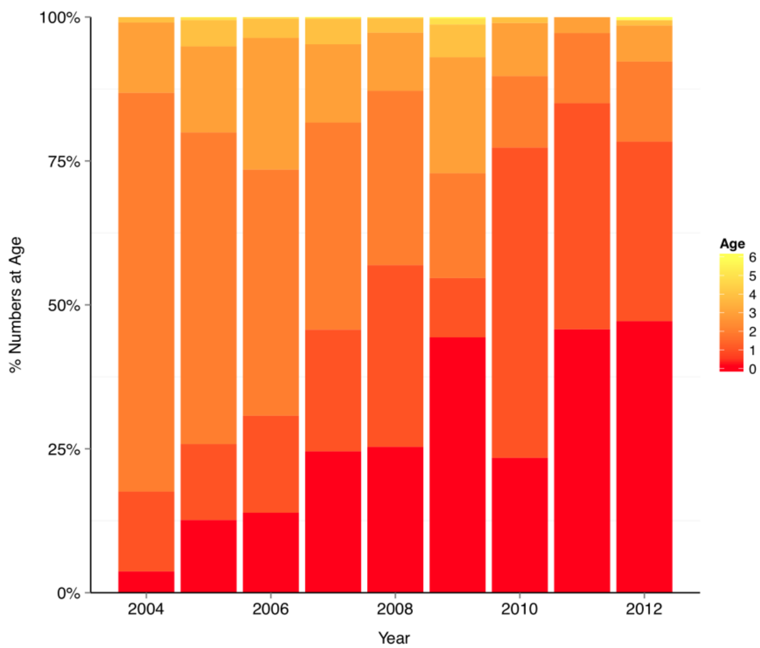


Figure 6.12.6. Sardine GSA 17. Total proportion of age classes from the acoustic surveys.

Trends in abundance by length or age
No analyses were conducted during EWG-13-19.

Trends in growth
No analyses were conducted during EWG-13-19.

Trends in maturity
No analyses were conducted during EWG-13-19.

### 6.12.4. **Assessment of historic stock parameters**

State-space Assessment Model (SAM) has been performed from 1975 to 2012. Acoustic survey was available for the assessment of sardine in GSA 17.

Age 0 was not included in the model: the high natural mortality, in fact, drives the biomass to really high and quite unrealistic values. Since age 0 is not largely represented in the catches, the EWG decided not to include it in the assessment.

Method 1: SAM

Justification

The stock of anchovy was assessed using the State-space Assessment Model (SAM) (Nielsen et al., 2012) in FLR environment with data from 1975 to 2012. The SAM environment is encapsulated into the Fisheries Library in R (FLR) (Kell et al., 2007) in the form of the package “FLSAM”. The state-space assessment model (SAM) is an assessment model which is used for several assessments within ICES. The model allows selectivity to evolve gradually over time. It has fewer model parameters than full parametric statistical assessment models, with quantities such as recruitment and fishing mortality modelled as random effects. One tuning index (acoustic survey covering the entire GSA 17) from 2004 to 2012 was used in the assessment. All assessments are performed with version 0.99-3 of FLSAM, together with version 2.5 of the FLR library (FLCore).

Input parameters

Input data types and characteristics are given in Table 6.12.6.

Table 6.12.6. Sardine GSA 17.Input data for SAM assessment.

Catch at age data (numbers, $10^3$)

| | Age0 | Age1 | Age2 | Age3 | Age4 | Age5 | Age6+ |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1975 | 7585 | 169567 | 168809 | 133637 | 111767 | 57349 | 101185 |
| 1976 | 32674 | 325425 | 262716 | 240229 | 178982 | 50674 | 49174 |
| 1977 | 38311 | 390846 | 286255 | 293502 | 225872 | 66399 | 63126 |
| 1978 | 56203 | 237503 | 191355 | 241149 | 206344 | 77865 | 86317 |
| 1979 | 17371 | 223353 | 211007 | 210192 | 167858 | 58922 | 70146 |
| 1980 | 34213 | 191096 | 239748 | 274783 | 220395 | 74540 | 83558 |
| 1981 | 90126 | 900152 | 558533 | 455718 | 351636 | 115444 | 129101 |
| 1982 | 67953 | 830415 | 523066 | 375817 | 286187 | 98067 | 118146 |
| 1983 | 54307 | 835931 | 533989 | 337134 | 252708 | 90895 | 117826 |
| 1984 | 45549 | 944959 | 619572 | 342244 | 248612 | 94093 | 130938 |
| 1985 | 13544 | 542745 | 622565 | 343080 | 217535 | 59584 | 71576 |
| 1986 | 3982 | 202553 | 402509 | 497431 | 404964 | 145442 | 168290 |
| 1987 | 88835 | 533147 | 298747 | 465766 | 368575 | 109178 | 113598 |
| 1988 | 19605 | 211508 | 492882 | 253874 | 354199 | 289823 | 136351 |
| 1989 | 7739 | 242067 | 806193 | 351688 | 219265 | 149582 | 70539 |
| 1990 | 3004 | 149813 | 661602 | 422933 | 231691 | 118764 | 52015 |
| 1991 | 1109 | 51418 | 417914 | 427739 | 266029 | 104863 | 30532 |
| 1992 | 8577 | 52194 | 295811 | 379281 | 225554 | 92045 | 34310 |
| 1993 | 35680 | 127134 | 242700 | 327819 | 249316 | 119111 | 47053 |
| 1994 | 24216 | 129380 | 247673 | 272042 | 195019 | 103236 | 44028 |
| 1995 | 8404 | 41136 | 160331 | 241258 | 193086 | 101514 | 46134 |
| 1996 | 27103 | 105687 | 157413 | 225860 | 227896 | 144333 | 72568 |
| 1997 | 25272 | 114328 | 174086 | 218736 | 195818 | 117145 | 55102 |
| 1998 | 42932 | 146871 | 173147 | 202282 | 177559 | 107280 | 51867 |
| 1999 | 70321 | 153580 | 119382 | 132549 | 129604 | 90379 | 53378 |
| 2000 | 91446 | 227543 | 189318 | 96714 | 52050 | 37405 | 41908 |
| 2001 | 64787 | 206423 | 324603 | 99569 | 26133 | 13715 | 13810 |
| 2002 | 100550 | 205041 | 453768 | 131496 | 22790 | 9400 | 8138 |
| 2003 | 35091 | 198099 | 444112 | 142622 | 14551 | 3676 | 2080 |
| 2004 | 11544 | 229349 | 437905 | 188641 | 12553 | 1724 | 1063 |
| 2005 | 35892 | 85638 | 280877 | 202058 | 65245 | 11977 | 2894 |
| 2006 | 69646 | 73662 | 195892 | 244272 | 87628 | 23472 | 630 |
| 2007 | 121581 | 81354 | 237378 | 215712 | 81796 | 41821 | 1474 |
| 2008 | 122615 | 184382 | 277499 | 195388 | 129852 | 29246 | 24790 |
| 2009 | 146575 | 131653 | 415049 | 359983 | 166506 | 74164 | 36709 |
| 2010 | 95963 | 228932 | 510678 | 408577 | 35650 | 15970 | 876 |
| 2011 | 156872 | 673342 | 1224725 | 508855 | 61584 | 7706 | 3508 |
| 2012 | 577690 | 551149 | 956569 | 607865 | 148432 | 32401 | 33304 |

Mean weight at age in the catches is shown in figure 6.12.7.

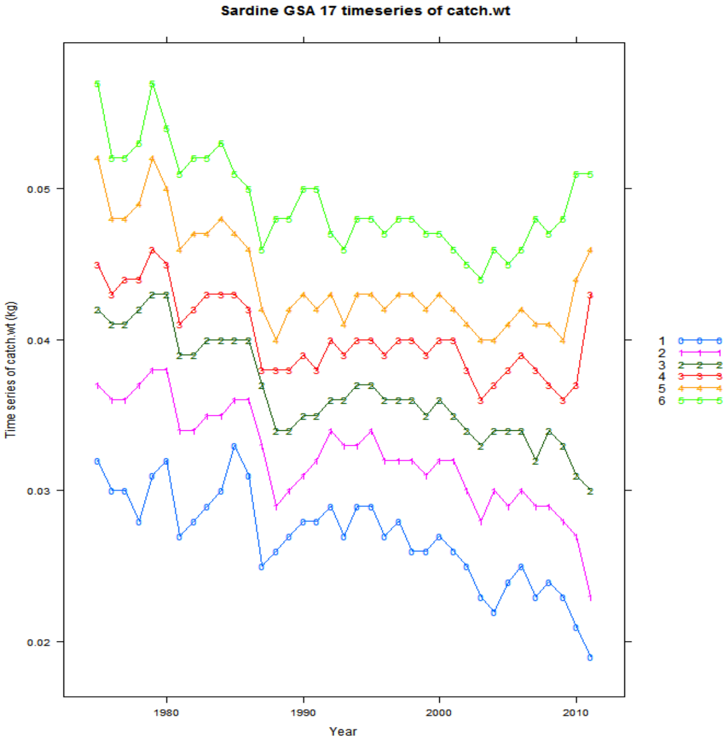



Figure 6.12.7. Sardine GSA 17. Mean weight at age in the catches for the whole time series (1975-2012).

Internal consistency plot was used to explore the survey data and age classes within survey to be used in the SAM model. Even if the data showed a weak internal consistencies, they were used to tune the assessment.

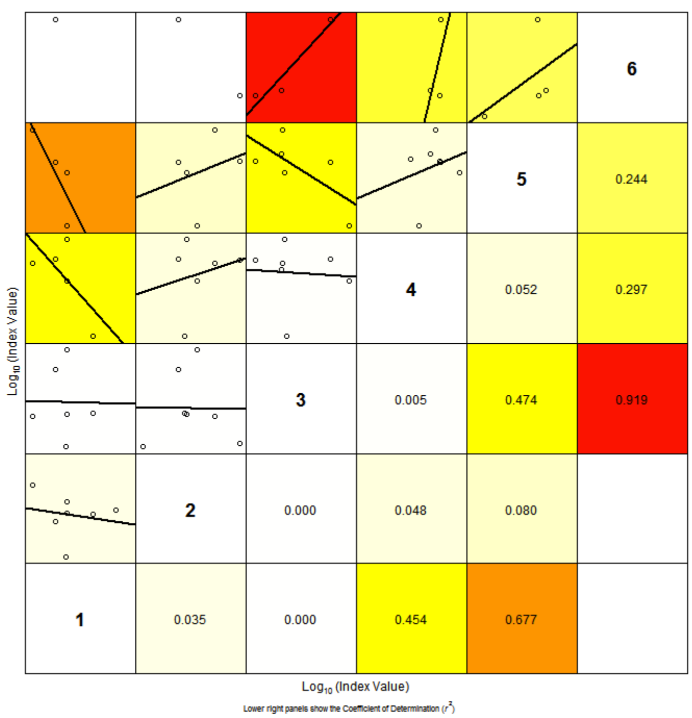



Figure 6.12.8. Sardine GSA 17. Internal consistency plot of the echo-survey data used to tune assessment.

All the configuration setting used in the SAM model this year are presented in the Table 6.12.7.

Table 6.12.7.Sardine GSA 17.Configuration settings for SAM model.

| name | Final | Assessment | | | | | |
|---|---|---|---|---|---|---|---|
| range | min | max | plusgroup | minyear | maxyear | minfbar | maxfbar |
| | 1 | 6 | 6 | 1975 | 2012 | 2 | 5 |
| fleets | | Acoustic Survey for the entire GSA 17 from 2004 to 2012 | | | | | |
| plus.group | TRUE | | | | | | |
| age | | 1 | 2 | 3 | 4 | 5 | 6 |
| logN.vars | | 1 | 1 | 1 | 1 | 1 | 1 |
| catchabilities | fleet | 1 | 2 | 2 | 3 | 3 | 4 |
| f.vars | catch | 1 | 1 | 1 | 2 | 2 | 2 |
| obs.vars | fleet | 1 | 1 | 1 | 2 | 3 | 4 |
| obs.vars | catch | 1 | 2 | 2 | 3 | 3 | 4 |

Results

SAM outputs are listed in table 6.12.8.

Table 6.12.8. Sardine GSA 17. Main results of sardine assessment by the means of SAM model.

| Year | Recruits Age 0 (Thousands) Mean | Recruits Age 0 (Thousands) Low | Recruits Age 0 (Thousands) High | Total biomass (tonnes) Mean | Total biomass (tonnes) Low | Total biomass (tonnes) High | Spawing biomass (tonnes) Mean | Spawing biomass (tonnes) Low | Spawing biomass (tonnes) High | Landings (tonnes) Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 12298649 | 9424952 | 16048546 | 573206 | 460960 | 712783 | 339762 | 271692 | 424886 | 33190 |
| 1976 | 12572218 | 9766165 | 16184517 | 615999 | 498178 | 761684 | 365858 | 293881 | 455463 | 39419 |
| 1977 | 12274077 | 9532699 | 15803810 | 622812 | 505429 | 767457 | 369165 | 297207 | 458546 | 45342 |
| 1978 | 13269782 | 10384283 | 16957080 | 630961 | 514315 | 774063 | 376623 | 305011 | 465048 | 41069 |
| 1979 | 14447038 | 11466221 | 18202764 | 733073 | 603785 | 890044 | 437136 | 358143 | 533552 | 44091 |
| 1980 | 15603409 | 12433861 | 19580916 | 808552 | 671369 | 973765 | 480701 | 397346 | 581541 | 50312 |
| 1981 | 15998412 | 12747626 | 20078184 | 735275 | 613044 | 881877 | 427197 | 352889 | 517151 | 70474 |
| 1982 | 17348212 | 13851903 | 21727011 | 783088 | 651473 | 941292 | 453613 | 374137 | 549972 | 71970 |
| 1983 | 19268843 | 15402956 | 24105004 | 876770 | 729502 | 1053768 | 508388 | 419899 | 615524 | 74832 |
| 1984 | 22053900 | 17610946 | 27617738 | 1008526 | 838955 | 1212369 | 585956 | 484528 | 708616 | 79459 |
| 1985 | 17698669 | 14173894 | 22099987 | 987567 | 827059 | 1179225 | 582451 | 484767 | 699818 | 74682 |
| 1986 | 12434681 | 9853219 | 15692465 | 766048 | 644908 | 909943 | 457714 | 382435 | 547811 | 66769 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 14606833 | 11765184 | 18134827 | 647582 | 547399 | 766099 | 380789 | 319461 | 453890 | 60476 |
| 1988 | 16110793 | 13103328 | 19808530 | 665970 | 564831 | 785219 | 388870 | 327961 | 461091 | 53423 |
| 1989 | 15494567 | 12590531 | 19068425 | 684196 | 581661 | 804806 | 396329 | 334439 | 469672 | 61145 |
| 1990 | 13322968 | 10763102 | 16491664 | 640497 | 543995 | 754119 | 373622 | 314982 | 443179 | 57011 |
| 1991 | 11353084 | 9125091 | 14125067 | 565802 | 479689 | 667374 | 333701 | 281037 | 396233 | 47524 |
| 1992 | 10702629 | 8548165 | 13400101 | 543617 | 458706 | 644246 | 321258 | 269524 | 382922 | 43347 |
| 1993 | 10756276 | 8541985 | 13544566 | 502324 | 421463 | 598698 | 297152 | 247983 | 356071 | 38871 |
| 1994 | 8957485 | 7108754 | 11287002 | 468832 | 392814 | 559562 | 278452 | 231911 | 334333 | 36680 |
| 1995 | 7102803 | 5715962 | 8826126 | 395933 | 334749 | 468299 | 236807 | 198864 | 281989 | 31761 |
| 1996 | 5531668 | 4526913 | 6759431 | 305590 | 262236 | 356112 | 180954 | 154011 | 212611 | 30946 |
| 1997 | 3569728 | 2972933 | 4286326 | 225709 | 197156 | 258397 | 131137 | 113351 | 151714 | 30546 |
| 1998 | 2383308 | 2004731 | 2833377 | 149194 | 131865 | 168799 | 83533 | 72865 | 95763 | 27364 |
| 1999 | 2366683 | 2045475 | 2738331 | 114462 | 102614 | 127678 | 62505 | 55509 | 70383 | 20109 |
| 2000 | 3035844 | 2669988 | 3451831 | 122762 | 111401 | 135281 | 65775 | 59366 | 72877 | 19334 |
| 2001 | 3929411 | 3446630 | 4479816 | 143057 | 129562 | 157959 | 75811 | 68268 | 84187 | 21558 |
| 2002 | 5178365 | 4450588 | 6025151 | 175255 | 155882 | 197036 | 93060 | 82093 | 105492 | 24539 |
| 2003 | 6261936 | 5292746 | 7408602 | 199786 | 175061 | 228002 | 109645 | 95338 | 126098 | 22675 |
| 2004 | 6205832 | 5190030 | 7420448 | 214486 | 187306 | 245610 | 120211 | 104062 | 138866 | 24270 |
| 2005 | 5542743 | 4587898 | 6696312 | 217510 | 188641 | 250797 | 125744 | 108363 | 145912 | 19589 |
| 2006 | 5060622 | 4231361 | 6052401 | 215346 | 187947 | 246739 | 124742 | 108106 | 143937 | 20554 |
| 2007 | 5734436 | 4890125 | 6724523 | 213844 | 189476 | 241345 | 123007 | 108335 | 139666 | 20848 |
| 2008 | 7534477 | 6431663 | 8826387 | 267266 | 236612 | 301892 | 152360 | 134308 | 172838 | 24149 |
| 2009 | 8921726 | 7521367 | 10582809 | 305590 | 268503 | 347800 | 171271 | 149430 | 196303 | 32209 |
| 2010 | 12019009 | 9908007 | 14579781 | 363669 | 312200 | 423624 | 204025 | 173712 | 239629 | 36279 |
| 2011 | 13150890 | 9432967 | 18334201 | 380028 | 297170 | 485989 | 205048 | 156678 | 268350 | 55826 |
| 2012 | 15157409 | 9297302 | 24711152 | 405550 | 274850 | 598404 | 220577 | 144177 | 337460 | 54502 |

| Year | Landings (tonnes) Low | Landings (tonnes) High | Yield / SSB (ratio) Mean | Yield / SSB (ratio) Low | Yield / SSB (ratio) High | Mean F ages 2-5Mean | Mean F ages 2-5Low | Mean F ages 2-5High | Mean F ages 0-1 | SoP (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 24156 | 45602 | 0.098 | 0.089 | 0.107 | 0.324 | 0.234 | 0.45 | 0.246 | 0.994 |
| 1976 | 34196 | 45440 | 0.108 | 0.116 | 0.1 | 0.346 | 0.256 | 0.468 | 0.276 | 0.992 |
| 1977 | 39741 | 51734 | 0.123 | 0.134 | 0.113 | 0.356 | 0.267 | 0.475 | 0.29 | 0.991 |
| 1978 | 35810 | 47099 | 0.109 | 0.117 | 0.101 | 0.337 | 0.252 | 0.45 | 0.264 | 0.997 |
| 1979 | 38163 | 50939 | 0.101 | 0.107 | 0.095 | 0.328 | 0.245 | 0.439 | 0.253 | 0.995 |
| 1980 | 43851 | 57725 | 0.105 | 0.11 | 0.099 | 0.341 | 0.259 | 0.45 | 0.268 | 0.998 |
| 1981 | 61982 | 80130 | 0.165 | 0.176 | 0.155 | 0.4 | 0.314 | 0.51 | 0.341 | 0.986 |
| 1982 | 61999 | 83544 | 0.159 | 0.166 | 0.152 | 0.391 | 0.306 | 0.498 | 0.325 | 0.978 |
| 1983 | 64037 | 87446 | 0.147 | 0.153 | 0.142 | 0.386 | 0.303 | 0.491 | 0.314 | 0.978 |
| 1984 | 68124 | 92681 | 0.136 | 0.141 | 0.131 | 0.385 | 0.304 | 0.489 | 0.309 | 0.975 |
| 1985 | 65525 | 85120 | 0.128 | 0.135 | 0.122 | 0.377 | 0.297 | 0.479 | 0.292 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1986 | 59616 | 74781 | 0.146 | 0.156 | 0.137 | 0.394 | 0.315 | 0.493 | 0.3 | 0.999 |
| 1987 | 53285 | 68638 | 0.159 | 0.167 | 0.151 | 0.415 | 0.334 | 0.514 | 0.315 | 0.988 |
| 1988 | 47137 | 60547 | 0.137 | 0.144 | 0.131 | 0.429 | 0.348 | 0.528 | 0.315 | 1.004 |
| 1989 | 55451 | 67424 | 0.154 | 0.166 | 0.144 | 0.471 | 0.386 | 0.577 | 0.36 | 0.999 |
| 1990 | 51873 | 62658 | 0.153 | 0.165 | 0.141 | 0.484 | 0.396 | 0.592 | 0.367 | 0.991 |
| 1991 | 42870 | 52684 | 0.142 | 0.153 | 0.133 | 0.479 | 0.391 | 0.587 | 0.353 | 1 |
| 1992 | 38684 | 48572 | 0.135 | 0.144 | 0.127 | 0.474 | 0.387 | 0.581 | 0.34 | 0.989 |
| 1993 | 34619 | 43645 | 0.131 | 0.14 | 0.123 | 0.475 | 0.388 | 0.581 | 0.332 | 0.994 |
| 1994 | 32664 | 41191 | 0.132 | 0.141 | 0.123 | 0.469 | 0.384 | 0.574 | 0.317 | 0.989 |
| 1995 | 28019 | 36003 | 0.134 | 0.141 | 0.128 | 0.464 | 0.379 | 0.568 | 0.301 | 0.994 |
| 1996 | 27155 | 35266 | 0.171 | 0.176 | 0.166 | 0.488 | 0.401 | 0.594 | 0.323 | 0.993 |
| 1997 | 26881 | 34712 | 0.233 | 0.237 | 0.229 | 0.527 | 0.437 | 0.636 | 0.369 | 0.993 |
| 1998 | 24139 | 31021 | 0.328 | 0.331 | 0.324 | 0.592 | 0.496 | 0.707 | 0.449 | 0.998 |
| 1999 | 17532 | 23064 | 0.322 | 0.316 | 0.328 | 0.642 | 0.538 | 0.766 | 0.511 | 0.986 |
| 2000 | 16821 | 22222 | 0.294 | 0.283 | 0.305 | 0.74 | 0.627 | 0.873 | 0.64 | 0.993 |
| 2001 | 19073 | 24367 | 0.284 | 0.279 | 0.289 | 0.875 | 0.75 | 1.021 | 0.82 | 1.078 |
| 2002 | 21959 | 27421 | 0.264 | 0.267 | 0.26 | 1.013 | 0.869 | 1.182 | 0.997 | 1.107 |
| 2003 | 20329 | 25291 | 0.207 | 0.213 | 0.201 | 0.875 | 0.739 | 1.036 | 0.808 | 1.053 |
| 2004 | 22129 | 26618 | 0.202 | 0.213 | 0.192 | 0.746 | 0.624 | 0.891 | 0.629 | 1.171 |
| 2005 | 17948 | 21379 | 0.156 | 0.166 | 0.147 | 0.673 | 0.549 | 0.824 | 0.507 | 1.058 |
| 2006 | 18742 | 22541 | 0.165 | 0.173 | 0.157 | 0.675 | 0.55 | 0.827 | 0.502 | 1.099 |
| 2007 | 18939 | 22949 | 0.169 | 0.175 | 0.164 | 0.669 | 0.548 | 0.817 | 0.5 | 1.108 |
| 2008 | 21808 | 26741 | 0.159 | 0.162 | 0.155 | 0.698 | 0.571 | 0.854 | 0.542 | 1.135 |
| 2009 | 29621 | 35024 | 0.188 | 0.198 | 0.178 | 0.86 | 0.7 | 1.057 | 0.75 | 1.172 |
| 2010 | 33036 | 39841 | 0.178 | 0.19 | 0.166 | 0.812 | 0.657 | 1.003 | 0.704 | 1.065 |
| 2011 | 50747 | 61414 | 0.272 | 0.324 | 0.229 | 0.887 | 0.714 | 1.101 | 0.816 | 1.17 |
| 2012 | 48588 | 61137 | 0.247 | 0.337 | 0.181 | 0.924 | 0.696 | 1.227 | 0.858 | 1.023 |

Table 6.12.9 and 6.12.10. show the fishing mortality at age by year and the stock numbers at age by year (in thousand).

Table 6.12.9. Sardine GSA 17. F at age estimated from 1975 to 2012.

| | year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| age | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
| 1 | 0.029 | 0.037 | 0.040 | 0.034 | 0.031 | 0.034 | 0.061 | 0.069 | 0.068 | 0.061 |
| 2 | 0.071 | 0.097 | 0.105 | 0.073 | 0.073 | 0.077 | 0.165 | 0.162 | 0.152 | 0.158 |
| 3 | 0.172 | 0.230 | 0.259 | 0.212 | 0.183 | 0.218 | 0.336 | 0.286 | 0.261 | 0.237 |
| 4 | 0.495 | 0.500 | 0.505 | 0.506 | 0.504 | 0.509 | 0.522 | 0.528 | 0.530 | 0.532 |
| 5 | 0.558 | 0.558 | 0.557 | 0.555 | 0.553 | 0.562 | 0.577 | 0.587 | 0.599 | 0.615 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 6.278 | 6.278 | 6.279 | 6.278 | 6.273 | 6.269 | 6.265 | 6.257 | 6.247 | 6.235 |

year

| age | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.049 | 0.038 | 0.040 | 0.027 | 0.023 | 0.017 | 0.011 | 0.012 | 0.016 | 0.019 |
| | 0.134 | 0.107 | 0.116 | 0.163 | 0.238 | 0.203 | 0.146 | 0.119 | 0.103 | 0.104 |
| | 0.215 | 0.257 | 0.293 | 0.237 | 0.292 | 0.338 | 0.346 | 0.334 | 0.322 | 0.274 |
| | 0.527 | 0.536 | 0.535 | 0.545 | 0.551 | 0.560 | 0.568 | 0.568 | 0.572 | 0.573 |
| | 0.633 | 0.675 | 0.715 | 0.770 | 0.805 | 0.836 | 0.856 | 0.875 | 0.902 | 0.926 |
| | 6.220 | 6.207 | 6.188 | 6.168 | 6.145 | 6.125 | 6.106 | 6.092 | 6.080 | 6.069 |

year

| age | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.018 | 0.031 | 0.052 | 0.084 | 0.101 | 0.104 | 0.086 | 0.068 | 0.055 | 0.047 |
| 2 | 0.082 | 0.100 | 0.147 | 0.242 | 0.273 | 0.470 | 0.672 | 0.721 | 0.479 | 0.363 |
| 3 | 0.242 | 0.270 | 0.334 | 0.446 | 0.552 | 0.700 | 1.000 | 1.445 | 1.116 | 0.728 |
| 4 | 0.579 | 0.600 | 0.625 | 0.661 | 0.709 | 0.751 | 0.787 | 0.825 | 0.829 | 0.795 |
| 5 | 0.952 | 0.984 | 1.004 | 1.021 | 1.035 | 1.039 | 1.043 | 1.063 | 1.075 | 1.098 |
| 6 | 6.059 | 6.051 | 6.038 | 6.024 | 6.009 | 5.991 | 5.969 | 5.947 | 5.923 | 5.902 |

year

| age | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.031 | 0.027 | 0.027 | 0.032 | 0.031 | 0.039 | 0.057 | 0.059 |
| 2 | 0.219 | 0.167 | 0.218 | 0.237 | 0.271 | 0.292 | 0.543 | 0.401 |
| 3 | 0.507 | 0.554 | 0.479 | 0.549 | 1.088 | 0.929 | 1.013 | 1.250 |
| 4 | 0.794 | 0.787 | 0.804 | 0.840 | 0.891 | 0.889 | 0.893 | 0.922 |
| 5 | 1.169 | 1.191 | 1.174 | 1.167 | 1.191 | 1.137 | 1.098 | 1.122 |
| 6 | 5.886 | 5.833 | 5.833 | 5.803 | 5.804 | 5.828 | 5.916 | 5.969 |

Table 6.1.10. Sardine GSA 17. Stock numbers at age for sardine stock from 1976 to 2012.

year

| age | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12298649 | 12572218 | 12274077 | 13269782 | 14447039 | 15603409 | 15998412 | 17348212 | 19268843 | 22053900 |
| 2 | 3516582 | 3992787 | 4028884 | 3882540 | 4278016 | 4685579 | 5085989 | 4950504 | 5362817 | 5974435 |
| 3 | 1129177 | 1542631 | 1691286 | 1679489 | 1682851 | 1867292 | 2069878 | 2006696 | 1947389 | 2150046 |
| 4 | 406362 | 514011 | 660664 | 696623 | 725053 | 757668 | 813418 | 797311 | 809361 | 798907 |
| 5 | 166043 | 141776 | 178617 | 227749 | 238470 | 249946 | 261974 | 275957 | 268875 | 271577 |
| 6 | 109316 | 56613 | 48388 | 61023 | 77808 | 81634 | 84966 | 87641 | 91400 | 88080 |

year

| age | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17698669 | 12434681 | 14606833 | 16110793 | 15494567 | 13322968 | 11353084 | 10702629 | 10756277 | 8957485 |
| 2 | 7004056 | 5643415 | 3909813 | 4643598 | 5277695 | 5055564 | 4351364 | 3749001 | 3534209 | 3541284 |
| 3 | 2371421 | 2896460 | 2397651 | 1612022 | 1837653 | 1941556 | 1928012 | 1760309 | 1565945 | 1503040 |
| 4 | 911640 | 1028899 | 1213477 | 964148 | 684196 | 735275 | 741922 | 732340 | 678066 | 611090 |
| 5 | 266199 | 308970 | 342833 | 409626 | 319017 | 225483 | 239187 | 238948 | 237044 | 218382 |
| 6 | 87378 | 84373 | 93714 | 100008 | 112758 | 84881 | 58105 | 60355 | 59278 | 57182 |

| age | year 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7102803 | 5531668 | 3569728 | 2383308 | 2366683 | 3035844 | 3929411 | 5178365 | 6261936 | 6205832 |
| 2 | 2916807 | 2354879 | 1801265 | 1125795 | 711407 | 702219 | 906186 | 1197804 | 1618483 | 1992698 |
| 3 | 1492555 | 1265528 | 1013581 | 734540 | 409626 | 250697 | 202805 | 214701 | 270222 | 471182 |
| 4 | 619086 | 632225 | 523871 | 395933 | 254231 | 126248 | 66703 | 39935 | 26984 | 47382 |
| 5 | 197205 | 199786 | 198988 | 161297 | 117948 | 71396 | 33827 | 17335 | 9907 | 6638 |
| 6 | 51483 | 45433 | 44534 | 43478 | 34683 | 25034 | 15066 | 7120 | 3566 | 2011 |

| age | year 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| 1 | 5542743 | 5060622 | 5734436 | 7534477 | 8921726 | 12019009 |
| 2 | 1968928 | 1799465 | 1636385 | 1852414 | 2433887 | 2867640 |
| 3 | 650177 | 739700 | 725778 | 610480 | 682829 | 868915 |
| 4 | 122885 | 212564 | 228433 | 244752 | 190232 | 121905 |
| 5 | 12282 | 31729 | 55882 | 58513 | 60840 | 44135 |
| 6 | 1324 | 2260 | 5706 | 10318 | 10913 | 10918 |

The average fishing mortality for ages 2-5 (presented in Figure 6.12.9., middle panel) starts increasing in 1995, reaching the maximum value of 1.013 in 2002. The estimate for 2012 is equal to 0.924.

The mid-year spawning stock biomass (Figure 6.12.9., top panel) fluctuates from the highest values in 1984 (about 586,000 tons) to a minimum in 1999 of 62,500 tons. After that the stock is constantly increasing: in 2012 reach the highest value registered in the last decade (220,577 tons).

The recruitment (age 1, Figure 6.12.9., bottom panel) fluctuates around a minimum value of 2,366,683 thousands specimen in 1999, to a maximum value of 22,053,900 in 1984. From 1999 the estimated recruitment is constantly increasing: the value for 2012 is equal to 15,157,409 thousands specimen.

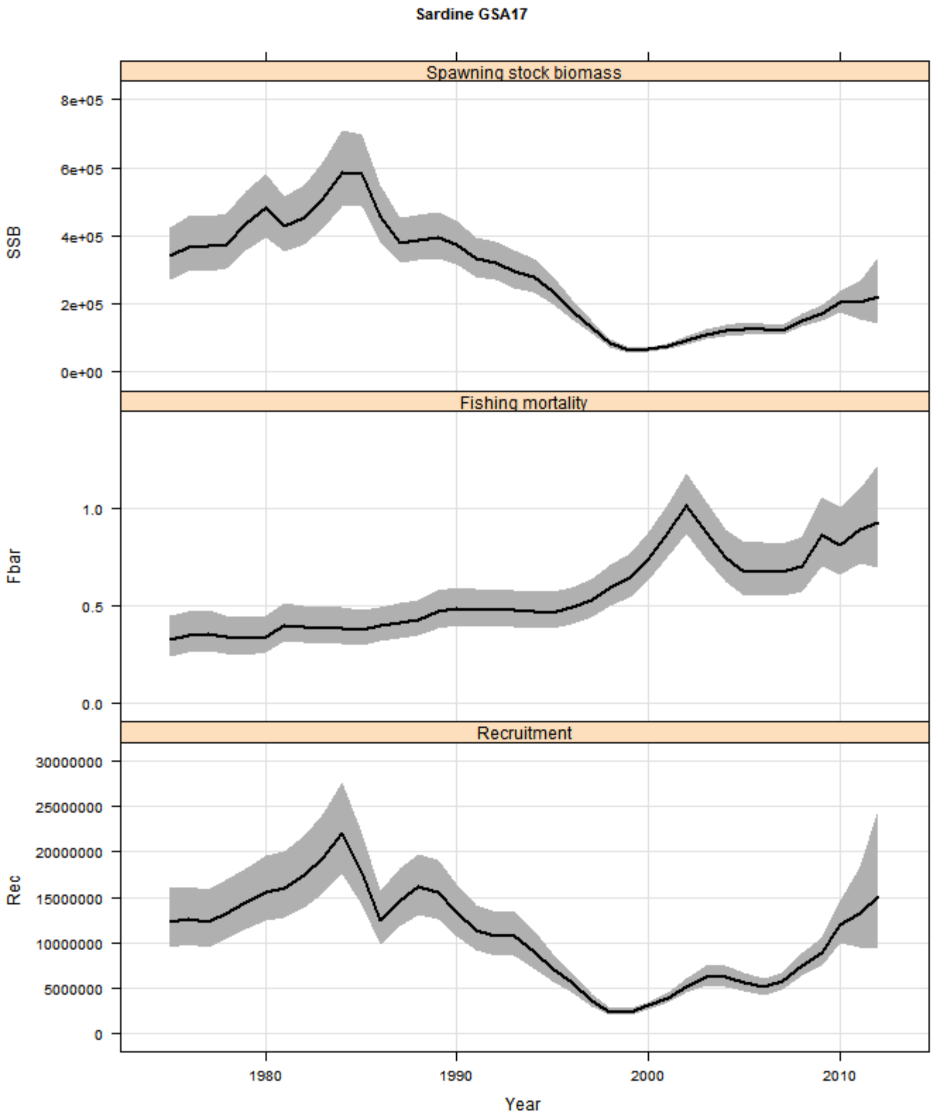
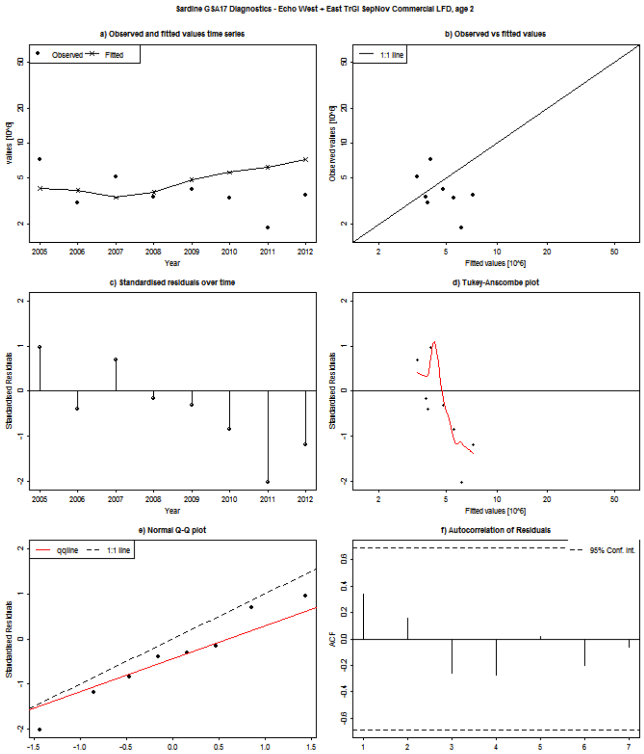
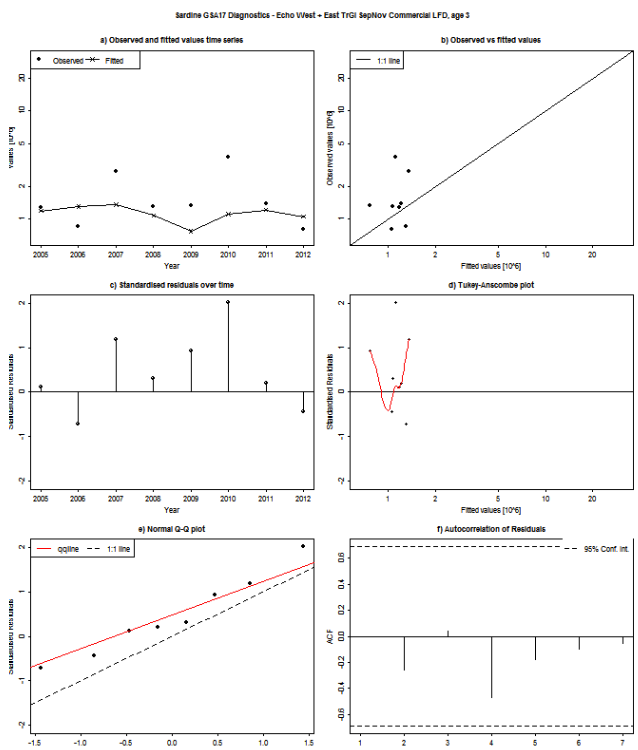



Figure 6.12.9. Sardine, GSA 17. Mid-year Spawning Stock Biomass (SSB) in tons (top panel). $F_{bar}$ (age 2 to 5) (middle panel); recruitment (as thousands individuals)(bottom panel); 95% confidence intervals are shown.

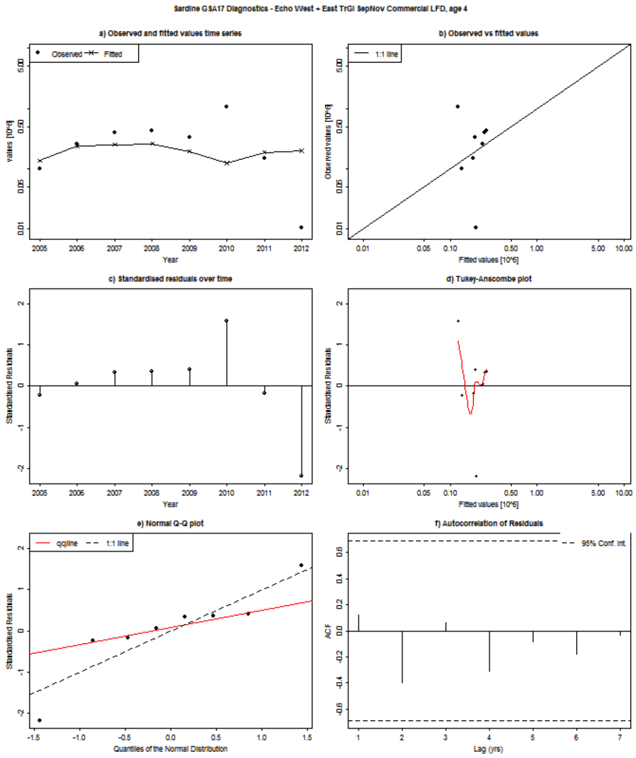
Catch residuals did not show any particular trend. On the other hand, survey data showed some patterns in the residuals for ages 2, 3 and 4 (see figures below).


Sardine GSA17 Diagnostics - Echo West + East TrGI SepNov Commercial LFD, age 2
a) Observed and fitted values time series
b) Observed vs fitted values
c) Standardised residuals over time
d) Tukey-Anscombe plot
e) Normal Q-Q plot
f) Autocorrelation of Residuals
Observed
Fitted
1:1 line
qqline
95% Conf. Int.
Year
Fitted values [10^6]

a)


Sardine GSA17 Diagnostics - Echo West + East TrGI SepNov Commercial LFD, age 3
a) Observed and fitted values time series
b) Observed vs fitted values
c) Standardised residuals over time
d) Tukey-Anscombe plot
e) Normal Q-Q plot
f) Autocorrelation of Residuals
Observed
Fitted
1:1 line
qqline
95% Conf. Int.
Year
Fitted values [10^6]
Quantiles of the Normal Distribution
Lag (yrs)

b)




c)

Figure 6.12.10. Sardine GSA 17. Diagnostics: Trend in residuals and fitted values for the acoustic index at age from age 2 (a) to age 4 (c).

The annual exploitation rate E = F/(F+M) or F/Z was calculated and plotted over the years for the ages 2-5. The values obtained were compared with the threshold F/Z = 0.4 adopted as biological reference point for small pelagics (Patterson, 1992). The trends in values of F/Z were plotted in Fig. 6.12.11.

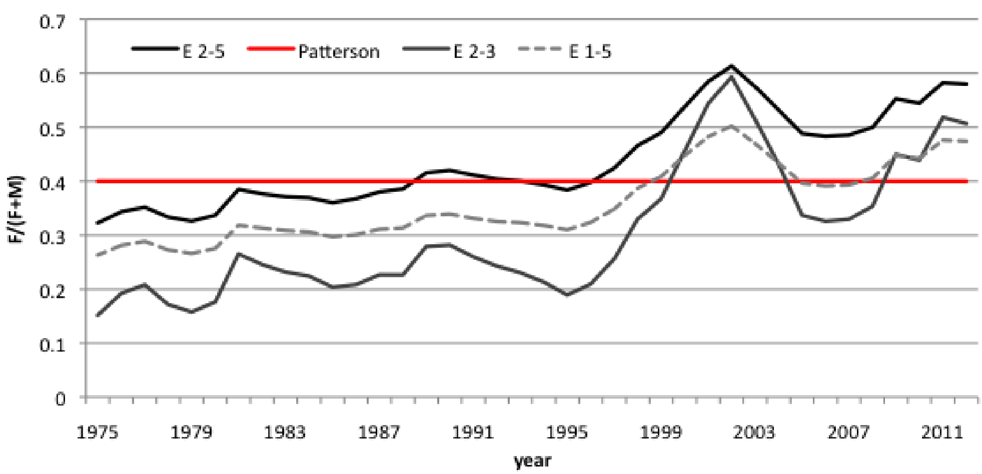



Figure 6.12.11. Sardine GSA 17. Exploitation rate compared to the Patterson' reference point of 0.4.

### 6.12.5. **Short term predictions 2014-2015**

Method and justification

Short term prediction for 2014 and 2015 was implemented in R (www.r-project.org) using the FLR libraries and based on the results of the stock assessment performed using SAM (Nielsen *et al*., 2012) that was conducted in the framework of the EWG 13-19.

Input parameters

A short term projection for 2013 to 2015 was performed using the R-routine and was and based on the results of the SAM, assuming an $F_{stq}$ of 0.87and a recruitment of 13380826 thousands (geometric mean of the last 3 years).

Results

A short term projection (Table 6.12.1), assuming an $F_{stq}$ of 0.87in 2013 and a recruitment of 13380826(thousands) individuals, shows that:

- Fishing at the $F_{stq}$ (0.87) from 2012 to 2014 generates an increase of the catch of 4.42 % and a decrease of the spawning stock biomass of 0.47% from 2014 to 2015.
- Fishing at $F_{MSY}$ (0.46) from 2012 to 2014 generates a decrease of the catch of 37.2 % and a spawning stock biomass increase of 4.2 % from 2014 to 2015.
- A 30% reduction of the $F_{stq}$ (F=0.61) generates a decrease of catch of 20.9% in 2014 and an increase of spawning stock biomass of about 2.2% from 2014 to 2015, indicating that this level of reduction could generate a significant decrease of catches and just a small increase of the spawning stock biomass.

EWG 13-19 considers that fishing mortality in 2014 should not exceed $F_{MSY}$= 0.46 corresponding to catches of 36962 tons in 2014.

## Outlook for 2014-2015

Table 6.12.1. Sardine GSA 17.Short term forecast in different F scenarios computed.

| | Ffactor | Fbar | Catch_2012 | Catch_2013 | Catch_2014 | Catch_2015 | SSB_2014 | SSB_2015 | Change_ SSB_2014 -2015(%) | Change_Catch_ 2012-2014(%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Zero Catch | 0.00 | 0.00 | 58921 | 60213 | 0 | 0 | 260569 | 296991 | 13.98 | -100.00 |
| High long-term yield (FMSY) | 0.53 | 0.46 | 58921 | 60213 | 36962 | 42031 | 241173 | 251201 | 4.16 | -37.27 |
| F status quo | 1.00 | 0.87 | 58921 | 60213 | 61525 | 60060 | 226754 | 225691 | -0.47 | 4.42 |
| Different scenarios | 0.10 | 0.09 | 58921 | 60213 | 8013 | 11011 | 256586 | 286243 | 11.56 | -86.40 |
| | 0.20 | 0.17 | 58921 | 60213 | 15484 | 20226 | 252761 | 276649 | 9.45 | -73.72 |
| | 0.30 | 0.26 | 58921 | 60213 | 22482 | 28048 | 249084 | 268019 | 7.60 | -61.84 |
| | 0.40 | 0.35 | 58921 | 60213 | 29056 | 34746 | 245543 | 260212 | 5.97 | -50.69 |
| | 0.50 | 0.44 | 58921 | 60213 | 35248 | 40520 | 242131 | 253120 | 4.54 | -40.18 |
| | 0.60 | 0.52 | 58921 | 60213 | 41092 | 45526 | 238839 | 246653 | 3.27 | -30.26 |
| | 0.70 | 0.61 | 58921 | 60213 | 46617 | 49888 | 235661 | 240736 | 2.15 | -20.88 |
| | 0.80 | 0.70 | 58921 | 60213 | 51849 | 53710 | 232591 | 235306 | 1.17 | -12.00 |
| | 0.90 | 0.79 | 58921 | 60213 | 56812 | 57077 | 229624 | 230306 | 0.30 | -3.58 |
| | 1.10 | 0.96 | 58921 | 60213 | 66009 | 62717 | 223977 | 221417 | -1.14 | 12.03 |
| | 1.20 | 1.05 | 58921 | 60213 | 70279 | 65098 | 221288 | 217449 | -1.73 | 19.28 |
| | 1.30 | 1.13 | 58921 | 60213 | 74351 | 67245 | 218684 | 213755 | -2.25 | 26.19 |
| | 1.40 | 1.22 | 58921 | 60213 | 78240 | 69193 | 216162 | 210307 | -2.71 | 32.79 |
| | 1.50 | 1.31 | 58921 | 60213 | 81958 | 70970 | 213716 | 207080 | -3.10 | 39.10 |
| | 1.60 | 1.40 | 58921 | 60213 | 85517 | 72601 | 211345 | 204053 | -3.45 | 45.14 |
| | 1.70 | 1.48 | 58921 | 60213 | 88929 | 74107 | 209044 | 201206 | -3.75 | 50.93 |
| | 1.80 | 1.57 | 58921 | 60213 | 92202 | 75506 | 206812 | 198522 | -4.01 | 56.48 |
| | 1.90 | 1.66 | 58921 | 60213 | 95346 | 76811 | 204644 | 195986 | -4.23 | 61.82 |
| | 2.00 | 1.75 | 58921 | 60213 | 98369 | 78036 | 202539 | 193584 | -4.42 | 66.95 |

### 6.12.6. **Data quality**

The available data for sardine stock in GSA 17 are considered good enough in order to perform a reliable assessment of the stock status. Nevertheless, the acoustic numbers at age should be carefully examined since it seems that the data do not follow the cohorts properly. Besides, MEDIAS Eastern sampling coverage was incomplete in 2011-2012 due to logistic problems so the observed biomass was raised to the total area using the average abundance percentage in the previous years. Very few data were provided by countries regarding the discards.

### 6.12.7. **Scientific advice**

Short term considerations

State of the spawning stock size

Estimates of fishery independent surveys for sardine in GSA 17 indicated a peak in 2011 respect to other years; in 2012 the biomass estimated from acoustic survey is around 200000 tons. Results of the state-space assessment model (SAM) indicated a constant increase in total biomass starting in the late nineties, being the 2012 the highest, with 405550 tons. The same trend is reflected in the Spawning stock biomass mid-year estimate, that is estimated at 220577 tons in 2012. Biomass reference points were estimated from the SAM results using the approach of a typical medium term projection, but including uncertainty in the choice of the stock recruitment model. Besides, the estimated biomass has been related to the reference points enforced from the GFCM regulations in 2012. The biomass of sardine in 2012 (220577 t) is above both the biomass reference points $B_{lim}$ (78000 t) and $B_{pa}$ (109200 t), and it is above the limit biomass reference point $B_{lim}$ (167383 tons) and slightly below the precautionary reference points $B_{pa}$ (234336 t) estimated by EWG 13-19.It should be considered that sardine is a short lived species characterized by high fluctuations in abundance and recruitment strongly depends on environmental conditions.

State of recruitment

The recruitment level (corresponding to age 1 in the model) is constantly increasing since the drop in recruitment occurred from 1985 to 1998. In 2012 recruitment reaches the highest value after the peak in 1984, with 15157409 thousands specimen.

State of exploitation

Based on SAM results, the F of age 3, differently from the other ages, is strongly fluctuating, increasing since 1997 to 2002, reaching the highest value of 1.45. After that, new but milder increasing trends start in 2010.

The $F_{bar}$ (2-5) shows the highest value in 2005 equal to 1.01 and then decrease; the estimated value for 2012 is 0.92. The exploitation rate (ages 2 to 5) in the last 3 years is above the reference point of 0.4, being equal in 2012 to 0.58.

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## 6.13. **Stock assessment of red mullet in GSA 17**

### 6.13.1. **Stock identification and biological features**

Red mullet (*Mullus barbatus*) is uniformly distributed in the whole Adriatic and the isolation of the Adriatic population was assessed by molecular and Bayesian analysis (Maggio *et al.*, 2009). This study proved a limited gene flow attributable to really low adult migration and a reduced passive drift of pelagic larvae from and to the Adriatic Sea (Fig. 6.13.1.1.1). A previous study from Garoia *et al.* (2004) developed a set of dinucleotide microsatellite markers and revealed a significant overall heterogeneity within the red mullet Adriatic stock: this result indicate that this species may constitute local subpopulations that remain partly isolated from each other. However, the randomness of genetic differences among samples indicated that red mullet in the Adriatic likely belongs to a single population. Besides, no correlation between geographic distance and genetic differentiation has been detected. The observed genetic fragmentation could be explained by a passive dispersion of larvae due to marine currents, from random changes in allele frequencies or from fishing pressure. No information are available regarding the separation of the stock from the GSA 18. Although the red mullet is distributed in the entire Adriatic, the density of the population is not the same in space. For example, Arneri and Jukić (1986) found that the biomass index between Italian and Croatian waters is about 1:4.

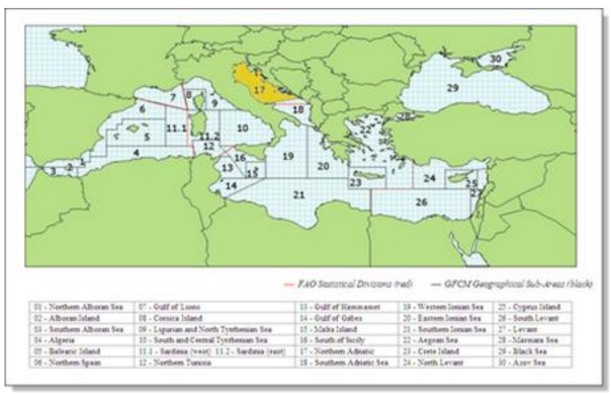


Fig. 6.13.1.1.1. Red mullet GSA 17. GFCM division in Geographical Sub-Areas (GSAs), in yellow (GSA17).

Growth

According to Jardas (1996), red mullet grow up to 30 cm, with females growing faster and bigger than males. The Von Bertalanffy Growth Function parameters available for this species are presented in table 6.13.1.2.1.

Tab. 6.13.1.2.1. Red mullet GSA 17. Summary of the Von Bertalanffy growth function parameters of *M. barbatus* the Adriatic Sea (the references of the table are from Vrgoc *et al.*,2004)

| **Author** | **Sex** | **$L_\infty$ (cm)** | **K (yr$^{-1}$)** | **$t_0$ (yr)** | **Φ'** |
|---|---|---|---|---|---|
| Scaccini (in Levi *et al*., 1994) | M+F | 27.49 | 0.5 | -0.25 | 5.93 |
| Jukić and Piccinetti, 1988 | M+F | 27.0 | 1.8 | | 7.18 |
| Marano, 1994; Ungaro *et al*., 1994 | M+F | 19.70 | 0.360 | -1.18 | 4.94 |
| Vrgoč, 1995 ("Hvar") | M+F | 27.75 | 0.274 | -0.616 | 5.35 |
| Marano, 1996; Marano *et al*., 1998b, c | M | 27 | 0.184 | -1.92 | 4.90 |
| | F | 34.5 | 0.156 | -1.53 | 5.22 |
| | M+F | 31.5 | 0.182 | -1.45 | 5.19 |
| | M+F (Bhatt) | 26.3 | 0.45 | | 5.74 |
| Ardizzone, 1998 | M+F | 27.50 | 0.50 | | 5.93 |
| Marano, 1998b, c | M | 22.5 | 0.24 | -1.29 | 4.80 |
| | F | 26.2 | 0.23 | -1.41 | 5.06 |
| | M+F | 22.5 | 0.38 | -0.63 | 5.26 |
| | M+F (Bhatt) | 25.4 | 0.25 | | 5.08 |
| | M+F (Surf.) | 23 | 0.52 | | 5.62 |
| Vrgoč, 2000 | M+F | 26.86 | 0.295 | | 5.36 |
| EC XIV/298/96-EN, Ionian and Southern Adriatic | M+F | 21.72 | 0.31 | | 4.99 |
| EC XIV/298/96-EN, Adriatic Sea | M+F | 27.5 | 0.50 | | 5.94 |

Length frequency distributions from the Croatian fleet as well as from survey data were converted into catch at age according to slicing using the growth parameters obtained independently for males and females reported in table 2 (Vrgoc et al., 2009: PHARE 2005 *EuropeAid/123624/D/SER/HR).*

The parameters of the length-weight relationship used for the present assessment are the ones suggested by Marano et al. (1994) and Ungaro et al. (1994) and reported in table 6.13.1.2.2.

Tab. 6.13.1.2.2. Red mullet GSA 17. Growth and L-W parameter for GSA 17 utilized in the present assessment.

| Parameters | $L_\infty$ | K | $t_0$ | a | b |
|---|---|---|---|---|---|
| | 26.86 cm | 0.295 y$^{-1}$ | -1.1 | 0.009 | 3.076 |

Maturity

Red mullet reproduction in GSA 17 occurs in late spring and summer. Specimens reach sexual maturity during the first year of life, at length between 10 and 14 cm (Županović, 1963; Haidar, 1970; Jukić and Piccinetti, 1981; Marano *et al*., 1998; Vrgoč, 2000). The maturity at age utilized in the assessment is reported in Table 6.13.1.3.1.

Tab. 6.13.1.3.1. Red mullet GSA 17. Maturity vector for GSA 17 utilized in the present assessment.

| Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Maturity | 0.1 | 0.9 | 1 | 1 | 1 | 1 | 1 |

### 6.13.2. **Fisheries**

General description of fisheries

In the Adriatic, red mullet is mainly fished by bottom trawl nets. Smaller quantities are also caught with trammel-nets and gill nets.

Fishing closure for Italian trawlers: 45 days in late summer have been enforced in 2011-2012 for the Italian fleet. Before 2011 the closure period was 30 days in summer. Minimum landing sizes: EC regulation 1967/2006 defined 11 cm TL as minimum legal landing size for red mullet.

Along Croatian coast bottom trawl fisheries is mainly regulated by spatial and temporal fisheries regulation measures, and about 1/3 of territorial sea is closed for bottom trawl fisheries over whole year. Also bottom trawl fishery is closed half year in the majority of the inner sea. Minimum landing size for red mullet is the same like in the EC regulation.

Mannini and Massa (2000) analyzed trends of the red mullet landings in the Adriatic from 1972 to 1997. In that period, the landings showed an overall increase. This positive trend was constant in the Western Adriatic, while in the Eastern Adriatic landings decreased during the second half of the 1990s.

Management regulations applicable in 2011 and 2012

Italy and Slovenia :

- In Italy and Slovenia the main rules in force are based on the applicable EU regulations (mainly EC regulation 1967/206):
- Minimum landing sizes: 11 cm TL for red mullet (valid also for Croatia).
- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.
- Set net minimum mesh size: 16 mm stretched.
- Set net maximum length x vessel x day: 5,000 m

Croatia

Since the accession of Croatia to the EU the 1st if July 2013, the same regulations of Italy and Slovenia are implemented. Furthermore the following regulation for OTB are applied, especially in specific areas (Fig. 6.13.2.2.1):

1. Ordinance on Commercial Fishing at Sea (Official Journal no. 63/2010, 141/2010, 148/2010, 52/2011 and 144/2011) in parts which remain in force after the Croatian entry into the European Union:

- Article 3, paragraph 1 (minimum size of cod-end in the inner sea)
- Article 4 (spatial regulation considering the power of propelling engine)
- Article 5, paragraph 1 (permanent ban for certain zones)
- Article 6 and 7 (spatial-temporal ban to protect immature fish and other marine organisms)
- Article 8 and 9 – regulation in E zone
- Article 10 – regulation in F zone
- Article 11 – regulation in G zone
- Article 32 - ban on the issuance of new licences and entry of new types of fishing (fishing tools and equipment) to the valid licences.

2. Ordinance on fishing gear and equipment for commercial fishing in the sea (Official Journal, no. 148/2010, 25/2010) in parts which provide design and technical characteristics of the fishing gear and equipment, and the amount of gear that can be used in fishing (if it is not regulated by EC Regulations).

3. Ordinance on privileges for commercial fishing at the sea and the register of issued privileges (Official Journal no. 144/2010, 123/2011, 53/2012 and 98/2012.) which defines the conditions for transfer of rights from one valid licence to another valid licence and the terms of transfer of licences from one fishing vessel to another.

4. Ordinance on special habitats of fish and other marine organisms, and regulation of fishing in the Velebit Channel, Novigrad and Karin Sea, Prokljan Lake, Marina Bay and Neretva Channel (Official Journal, no. 148/2004, 152/2004, 55/2005, 96/2006, 123/2009 and 130/2009) which prohibits fishing by bottom trawling tools in specific habitats and in areas of the fishing sea with a special fishing regulation (Velebit Channel, Novigrad and Karin Sea, Prokljan Lake, Marina Bay and the Neretva Channel).


Figure 6.13.2.2.1. Red mullet GSA 17. Administrative classification of the fishing sea in the Republic of Croatia.

Catches

Landings

Landings data for the Italian and Slovenia fleet were reported through the Data Collection Framework, while Croatian data comes from official statistics of Fisheries Department and data were collected through logbooks. The Italian catches remained above the 3000 t from 2006 to 2009 and then started to decrease, reaching the minimum in 2012 with less than 2000 t (Table 6.13.2.3.1.1).The Croatian catches remain lower than 1000 tons for all the time series except in 2011, in which the increase to a value around 1000 tons.

Tab. 6.13.2.3.1.1.Red mullet GSA 17.Annual landings (t) by fishing gear as reported through the DCF data call for Italy and Slovenia, and official statistic data from Croatian Fisheries Department.

| Country | Gear | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| ITA | OTB | 3100 | 3299 | 3158 | 2433 | 1797 | 2619 | 1646 |
| ITA | GNS | n/a | n/a | n/a | n/a | n/a | 31.225 | 18 |
| ITA | TBB | n/a | n/a | n/a | n/a | n/a | 36 | 43 |
| CRO | OTB | 805 | 950 | 742 | 800 | 750 | 1100 | 1318 |
| SLO | OTB | 1.9 | 6.4 | 2 | 2.6 | 1.4 | 6 | 3.5 |

The length and age distributions of Italian and Croatian catches are showed in figures 6.13.3.2.1.1 and 6.13.3.2.1.2.

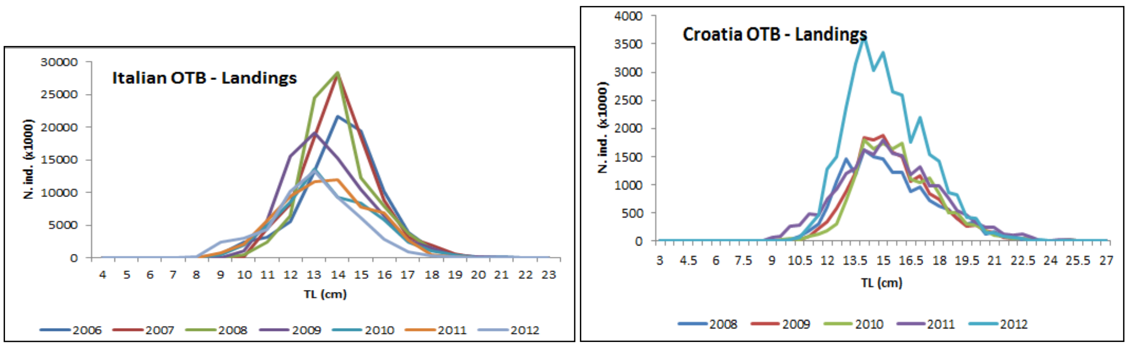


Figure 6.13.3.2.1.1 Red mullet GSA 17 - Length frequency distributions of Italian and Croatian landings.

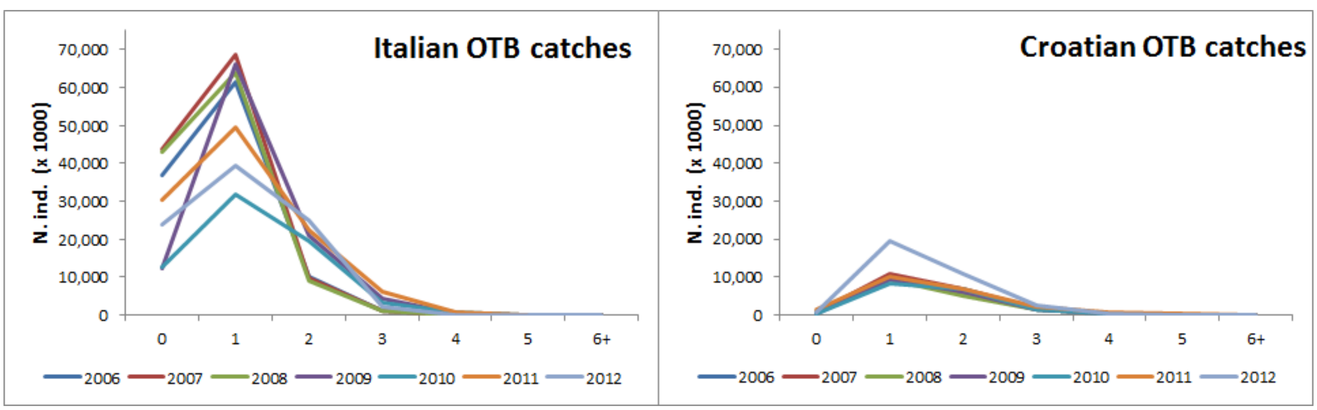


Figure 6.13.3.2.1.2 Red mullet GSA 17. Age frequency distributions of Italian and Croatian catches.

Discards

Discard data for the Italian fleet are available for the period 2010-2012 (Table 6.13.2.3.2.1). The amount of discard for the Croatian bottom trawl fisheries is negligible due to the fact that the minimum size in the catches is bigger than the minimum landing size allowed (i.e. there are no juveniles in the catches).

Table 6.13.2.3.2.1. Red mullet GSA 17. Discard data (t) by fishing gear as reported through the DCF data call.

| Country | Gear | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| ITA | OTB | n/a | n/a | n/a | n/a | 183 | 796 | 680 |
| ITA | TBB | n/a | n/a | n/a | n/a | n/a | 7.39 | 0 |
| SLO | OTB | 0.012 | 0.14 | 0.018 | 0.03 | 0 | 0.121 | 0.05 |

In the Italian catches the discard proportion varied between 9 and 30% in the period 2010-2012. The total length of the discards ranged between 4 and 16 cm (Fig. 6.13.2.3.2.1). For the years without discard data the Italian data has been modified assuming the discard proportion reported in table 6.13.2.3.2.2.

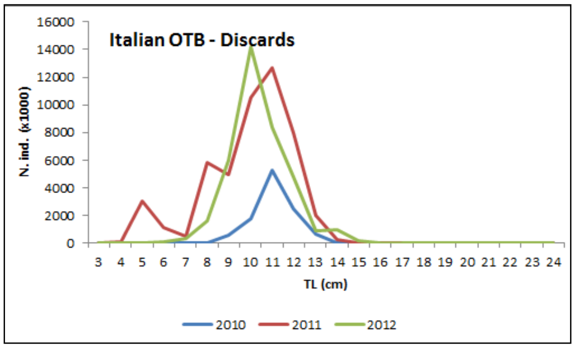


Figure 6.13.2.3.2.1. Red mullet GSA 17. Length frequency distributions of Italian discard.

Tab. 6.13.2.3.2.2. Red mullet GSA 17. Discard proportion applied to the overall Italian catches and to the Italian catch at age distribution from 2006 to 2012.

| Overall Catch | Age0 | Age1 | Age2 | Age3 | Age4 |
|---|---|---|---|---|---|
| 0.24 | 0.58 | 0.29 | 0.02 | 0.00 | 0.00 |

Fishing effort

Effort data from the 2013 DCF data call are listed in the tables below respectively for Italy and Slovenia (Tables 6.13.2.4.1 and 6.13.2.4.2) and shown in Figure 6.13.2.4.1 It is possible to observe a remarkable decrease of the OTB effort in Italy, while the other gears show a generally constant trend in fishing effort. Conversely, Slovenian effort data shows a clear increasing trend for all the gear categories.

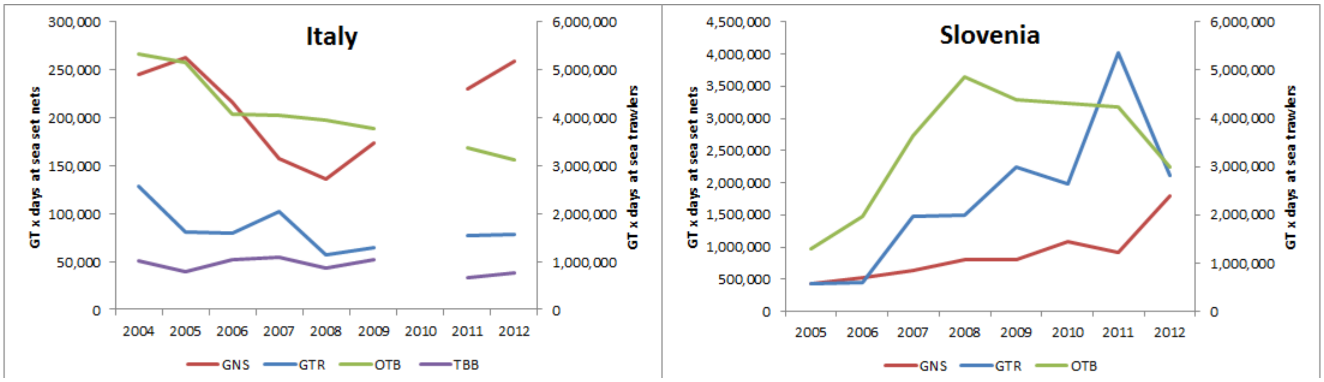


Figure 6.13.2.4.1Red mullet GSA 17. Effort data from Italian and Slovenia DCF 2013 expressed in GT per working days.

Table 6.13.2.4.1.Red mullet GSA 17. Italian effort from 2013 DCF data.

| Year | Gear | NOMINAL EFFORT | GT DAYS AT SEA |
|---|---|---|---|
| 2004 | GNS | 4,476,609 | 245,401 |
| 2004 | GTR | 1,790,055 | 129,028 |
| 2004 | OTB | 27,823,853 | 5,324,756 |
| 2004 | TBB | 4,232,537 | 1,003,129 |
| 2005 | GNS | 4,980,544 | 262,674 |
| 2005 | GTR | 1,275,558 | 80,535 |
| 2005 | OTB | 24,094,431 | 5,165,331 |
| 2005 | TBB | 3,812,915 | 785,589 |
| 2006 | GNS | 4,315,531 | 216,424 |
| 2006 | GTR | 1,157,336 | 79,544 |
| 2006 | OTB | 19,896,811 | 4,079,669 |
| 2006 | TBB | 4,946,237 | 1,052,912 |
| 2007 | GNS | 2,538,855 | 156,782 |
| 2007 | GTR | 1,463,360 | 101,669 |
| 2007 | OTB | 19,409,042 | 4,056,776 |
| 2007 | TBB | 5,231,834 | 1,096,364 |
| 2008 | GNS | 2,456,661 | 135,755 |
| 2008 | GTR | 890,098 | 56,449 |
| 2008 | OTB | 19,141,918 | 3,961,550 |
| 2008 | TBB | 4,256,290 | 875,295 |
| 2009 | GNS | 3,278,725 | 173,251 |
| 2009 | GTR | 1,068,830 | 64,168 |
| 2009 | OTB | 18,598,084 | 3,777,751 |
| 2009 | TBB | 4,340,202 | 1,035,663 |
| 2011 | GNS | 4,524,279 | 229,986 |
| 2011 | GTR | 1,475,946 | 77,291 |
| 2011 | OTB | 16,050,252 | 3,378,533 |
| 2011 | TBB | 2,625,526 | 670,632 |
| 2012 | GNS | 5,314,329 | 259,488 |
| 2012 | GTR | 1,505,889 | 78,308 |
| 2012 | OTB | 14,020,762 | 3,130,643 |
| 2012 | TBB | 3,254,187 | 772,706 |
| Total | | 234,247,486 | 42,514,052 |

Table 6.13.2.4.2.Red mullet GSA 17. Slovenian effort from 2013 DCF data.

| Year | Gear | NOMINAL EFFORT | GT DAYS AT SEA |
|---|---|---|---|
| 2005 | GNS | 5,288,929 | 433,333 |
| 2005 | GTR | 7,479,684 | 436,343 |
| 2005 | OTB | 14,824,767 | 1,306,298 |
| 2006 | GNS | 7,026,978 | 525,500 |
| 2006 | GTR | 8,357,902 | 449,787 |
| 2006 | OTB | 21,946,724 | 1,963,964 |
| 2007 | GNS | 7,612,145 | 637,539 |
| 2007 | GTR | 29,085,357 | 1,482,231 |
| 2007 | OTB | 36,475,949 | 3,631,210 |
| 2008 | GNS | 13,548,520 | 812,959 |
| 2008 | GTR | 27,493,876 | 1,493,514 |
| 2008 | OTB | 47,504,644 | 4,857,259 |
| 2009 | GNS | 14,910,574 | 807,833 |
| 2009 | GTR | 39,439,838 | 2,241,223 |
| 2009 | OTB | 45,029,312 | 4,399,362 |
| 2010 | GNS | 20,414,817 | 1,082,202 |
| 2010 | GTR | 37,830,757 | 1,986,779 |
| 2010 | OTB | 45,322,719 | 4,306,395 |
| 2011 | GNS | 17,643,895 | 916,959 |
| 2011 | GTR | 80,413,417 | 4,011,741 |
| 2011 | OTB | 41,135,645 | 4,227,010 |
| 2012 | GNS | 38,271,483 | 1,791,291 |
| 2012 | GTR | 42,487,120 | 2,115,613 |
| 2012 | OTB | 28,317,034 | 2,978,721 |
| Total | | 677,862,086 | 48,895,066 |

The mean spatial distribution of Italian OTB has been observed interpolation VMS data as shown in figure 6.13.2.4.2.

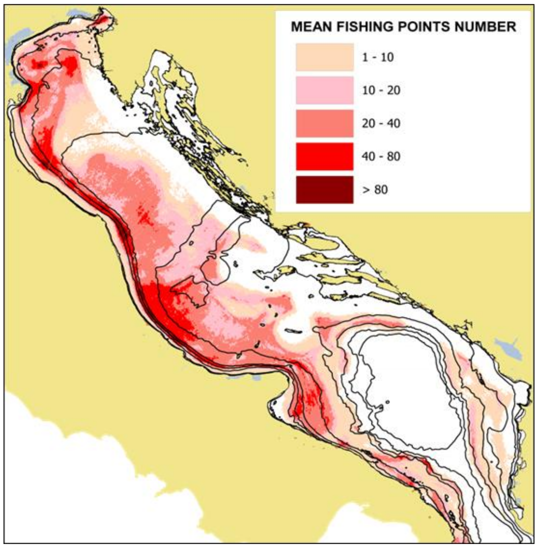


Figure 6.13.2.4.2. Red mullet GSA 17. Spatial distribution of Italian OTB

## 6.13.3. **Scientific surveys**

Medits

Methods

In order to collect fisheries independent data, which is a requirement of the EU DCF (Council Regulation 199/2008, Commission Regulation 665/2008, Commission Decision EC 949/2008 and Commission Decision 93/2010); the MEDITS international trawl survey is carried out in GSA 17 on an annual basis. The number of hauls was reported per depth stratum in 2000-2012 (GSA 17) is reported below in table 6.13.3.1.1.1.

Tab. 6.13.3.1.1.1.Red mullet GSA 17. Number of hauls per year and depth stratum in GSA 17, 2000-2012.

| **Depth (m)** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-50 | 39 | 40 | 54 | 55 | 56 | 57 | 58 | 61 | 60 | 59 | 58 | 59 | 58 |
| 50-100 | 45 | 46 | 59 | 60 | 69 | 68 | 67 | 72 | 66 | 67 | 64 | 64 | 64 |
| 100-200 | 38 | 39 | 53 | 50 | 50 | 45 | 43 | 45 | 44 | 44 | 49 | 49 | 49 |
| 200-500 | 8 | 8 | 11 | 13 | 12 | 10 | 11 | 10 | 10 | 10 | 9 | 9 | 9 |
| Total | 130 | 133 | 177 | 178 | 178 | 180 | 179 | 188 | 180 | 181 | 180 | 181 | 180 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).

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

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

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

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

Geographical distribution patterns

In figures 6.13.3.1.2.1-3 are presented the spatial distributions of red mullet in GSA 17 from different fishery independent sources.

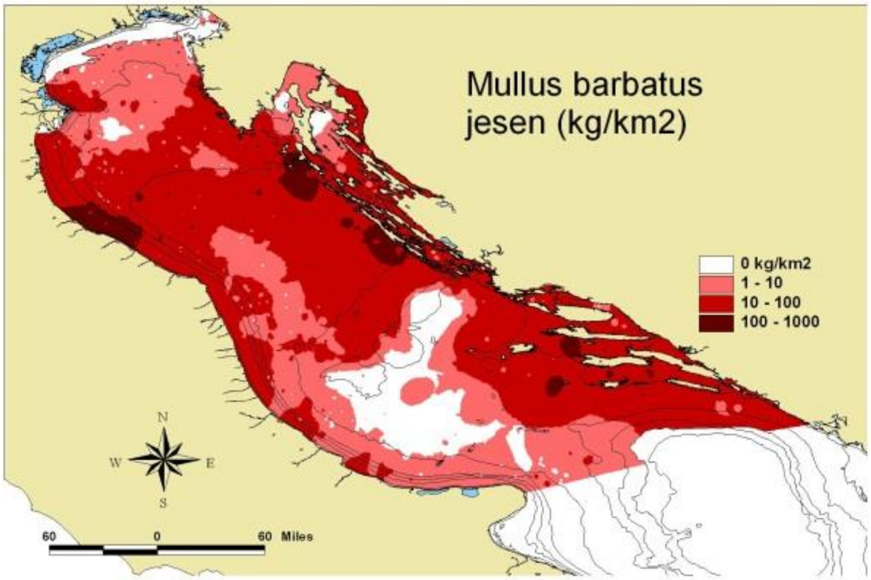


Fig. 6.13.3.1.2.1. Red mullet GSA 17. Distribution of red mullet in the autumn –winter period (AdriaMed Trawl Survey + GRUND).

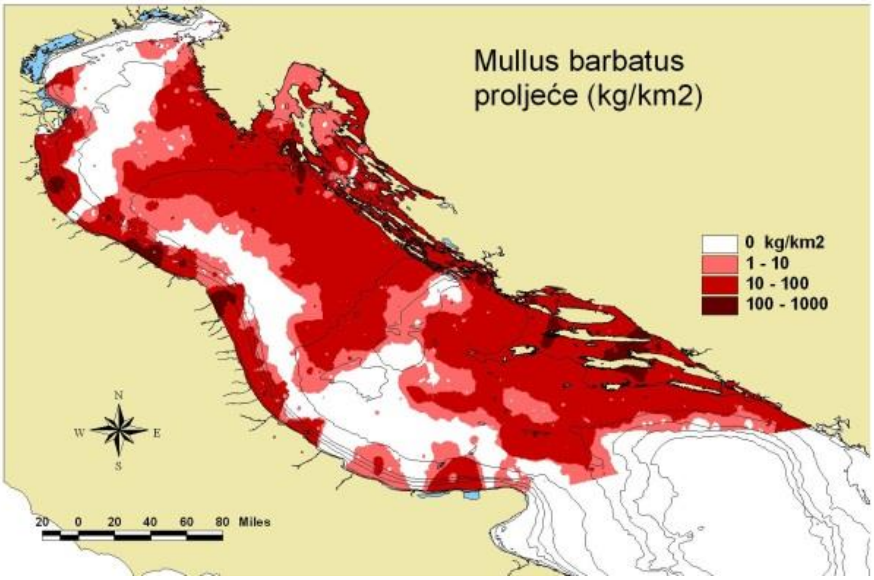


Fig. 6.13.3.1.2.2. Red mullet GSA 17. Distribution of red mullet in the spring-summer period (Medits Trawl Survey)

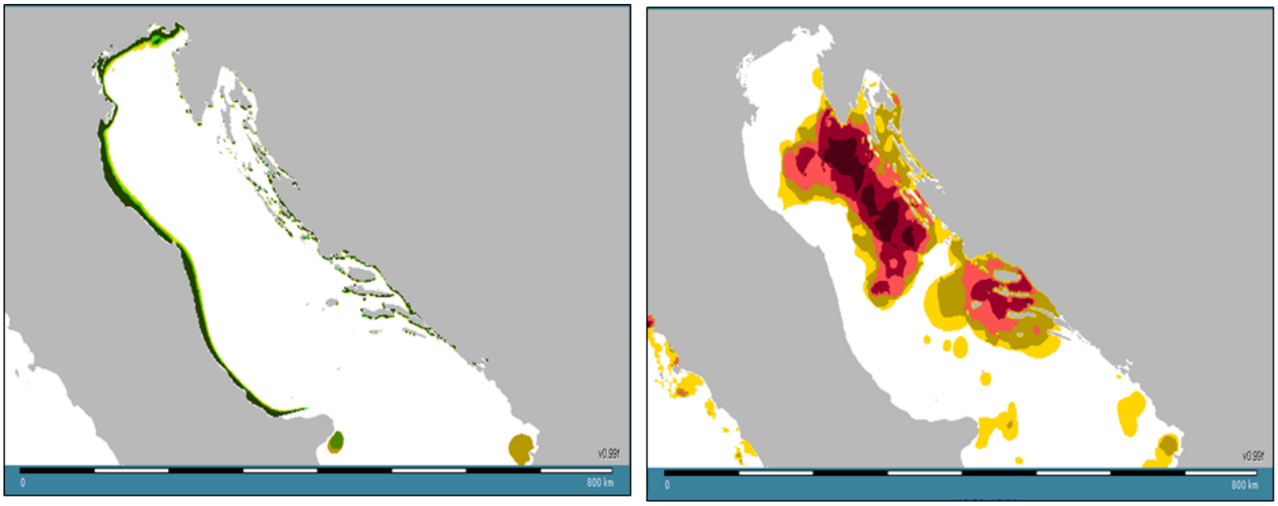

Fig. 6.13.3.1.2.3. Red mullet GSA 17. Distribution of red mullet recruits persistency areas (left graph) and spawners (right graph) in the spring summer period. Darker colors represent higher percentage of persistency (MEDITS SURVEY, from MEDISEH MAREA project).

Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 17 was derived from the international survey MEDITS. Figure 6.13.3.1.3.1 shows the estimated trend in red mullet abundance and biomass in GSA 17. The stock seems stable with some fluctuations. The lowest values of the last 10 years were reached in 2007, but since then the indices are increasing.

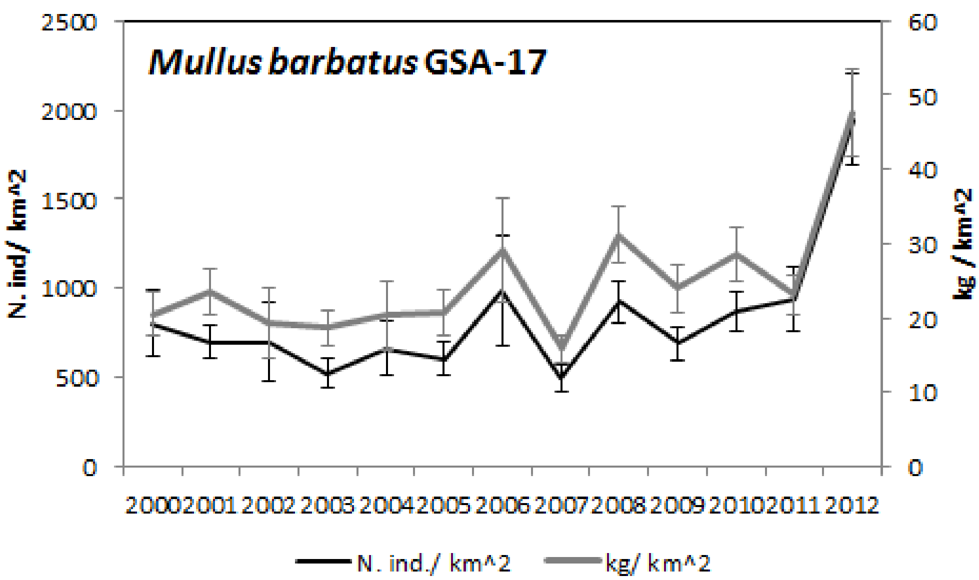


Figure 6.13.3.1.3.1. Red mullet GSA 17. Abundance and biomass indices from MEDITS.

Trends in abundance by length

Figures 6.13.3.1.4.1 and 2 show the length frequency distributions of red mullet in GSA 17 from MEDITS data.

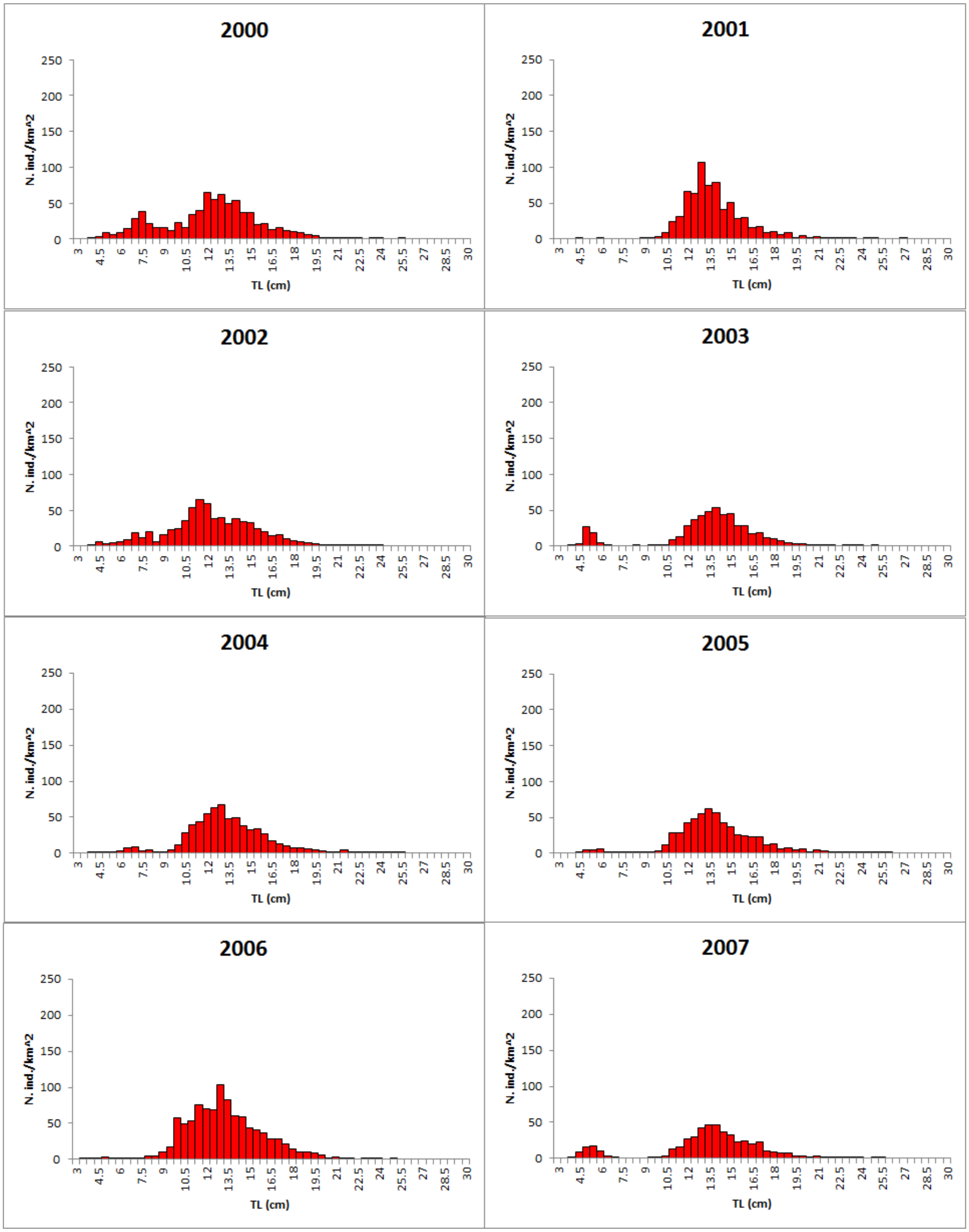


Fig. 6.13.3.1.4.1. Red mullet GSA 17. Stratified abundance indices by size, 2000-2007.

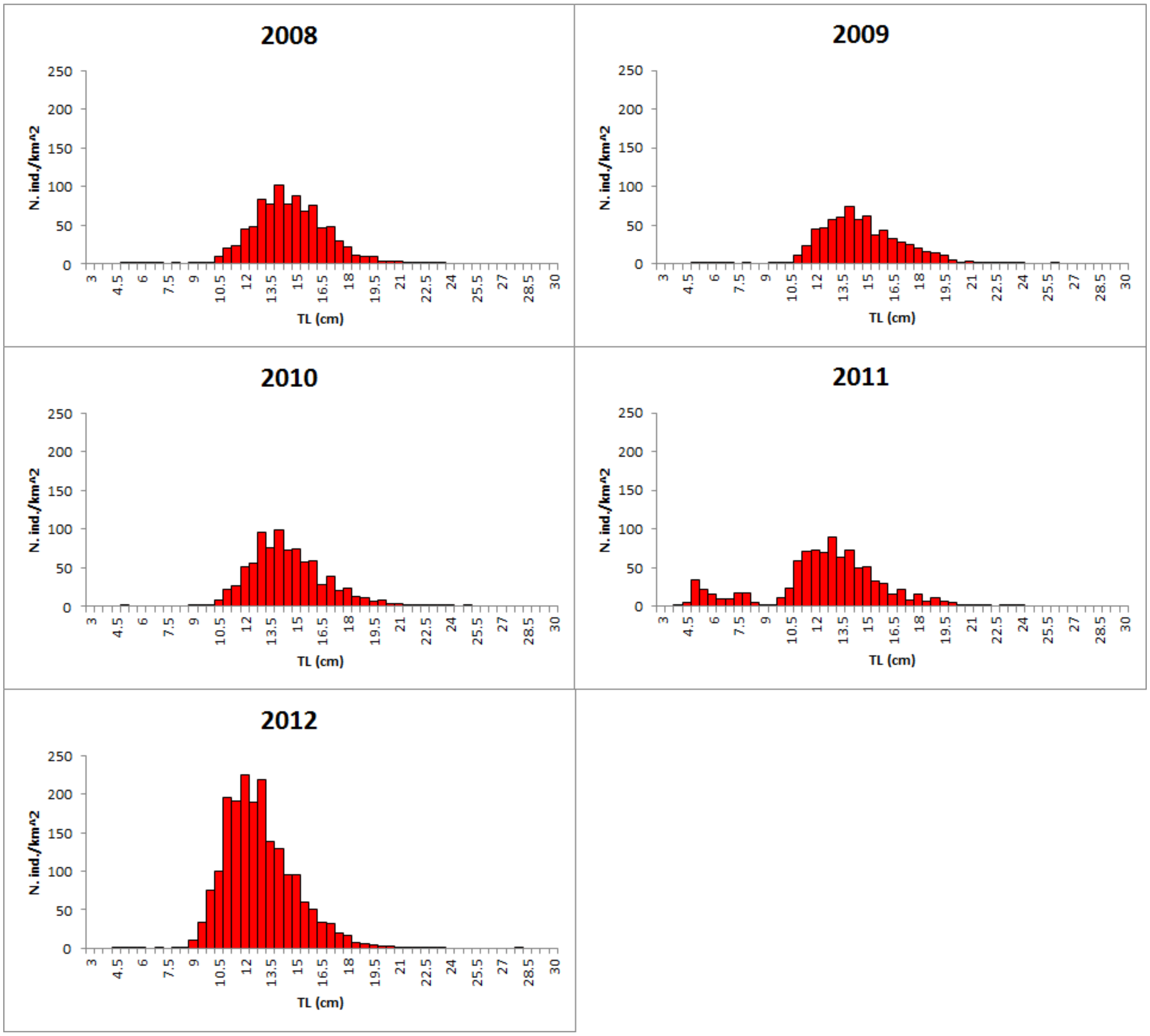


Fig. 6.13.3.1.4.1. Red mullet GSA 17. Stratified abundance indices by size, 2008-2012.

Trends in growth

No assessment of trend in growth has been carried out.

Trends in maturity

No assessment of trend in maturity has been carried out.

SoleMon

Methods

Ten *rapido* trawl fishing surveys were carried out in GSA 17 from 2005 to 2012: two systematic “pre-surveys” (spring and fall 2005) and four random surveys (spring and fall 2006, fall 2007-2012) stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). Hauls were carried out by day using 2-4 *rapido* trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83). The following number of hauls was reported per depth stratum (Tab. 6.13.3.2.1.1).

Tab. 6.13.3.2.1.1. Number of hauls per year and depth stratum in GSA 17, 2005-2012.

| Depth strata | Spring 2005 | Fall 2005 | Spring 2006 | Fall 2006 | Fall 2007 | Fall 2008-2012 |
|---|---|---|---|---|---|---|
| 0-30 | 30 | 30 | 20 | 35 | 32 | 39 |
| 30-50 | 14 | 12 | 10 | 20 | 19 | 17 |
| 50-100 | 24 | 15 | 8 | 8 | 11 | 11 |
| HR islands | 0 | 5 | 4 | 4 | 0 | 0 |
| TOTAL | 68 | 62 | 42 | 67 | 62 | 67 |

Abundance and biomass indexes from *rapido* trawl surveys were computed using ATrIS software (Gramolini *et al*., 2005) which also allowed drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles. Underestimation of small specimens in catches due to gear selectivity was corrected using the selective parameters given by Ferretti and Froglia (1975).

The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

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

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

Where:

- A=total survey area
- Ai=area of the i-th stratum
- si=standard deviation of the i-th stratum
- ni=number of valid hauls of the i-th stratum
- n=number of hauls in the GSA
- Yi=mean of the i-th stratum
- Yst=stratified mean abundance
- V(Yst)=variance of the stratified mean

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

Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

Geographical distribution patterns

Figure 6.13.3.3.2.1 shows the spatial distribution of red mullet in GSA 17 from SoleMon survey.

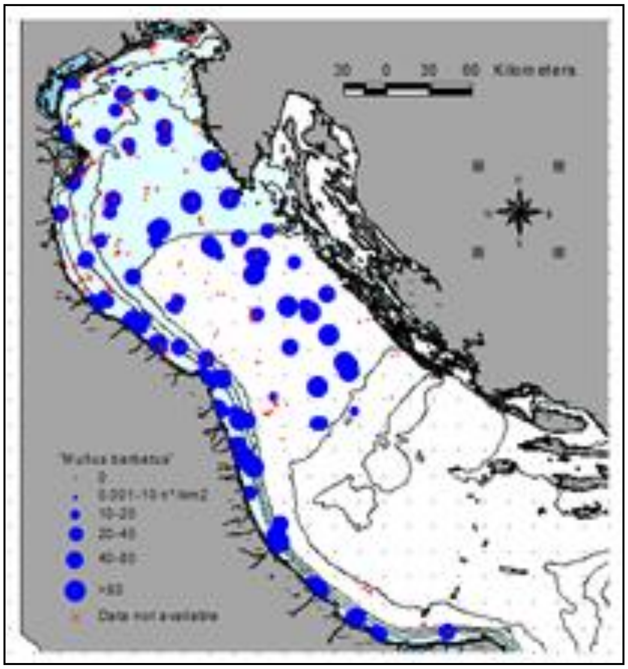


Fig. 6.13.3.3.2.1. Red mullet GSA 17. Distribution of red mullet from SoleMon data.

Trends in abundance and biomass

Figure 6.13.3.3.3.1 shows the abundance and biomass indices of red mullet obtained from 2005 to 2012.

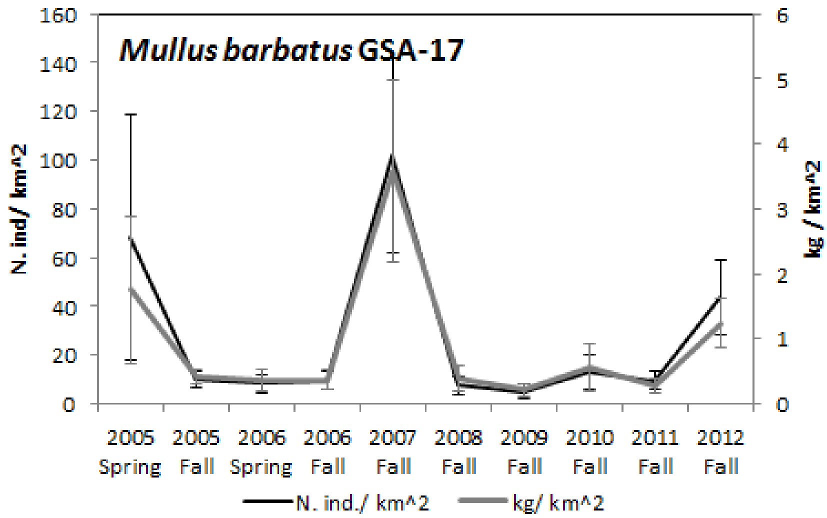


Fig. 6.13.3.3.3.1. Red mullet GSA 17. Abundance and biomass indices of red mullet obtained from SoleMon surveys.

Trends in abundance by length

Figure 6.13.3.3.4.1 displays the stratified abundance indices obtained in the GSA 17 in the years 2005-2012 in fall.

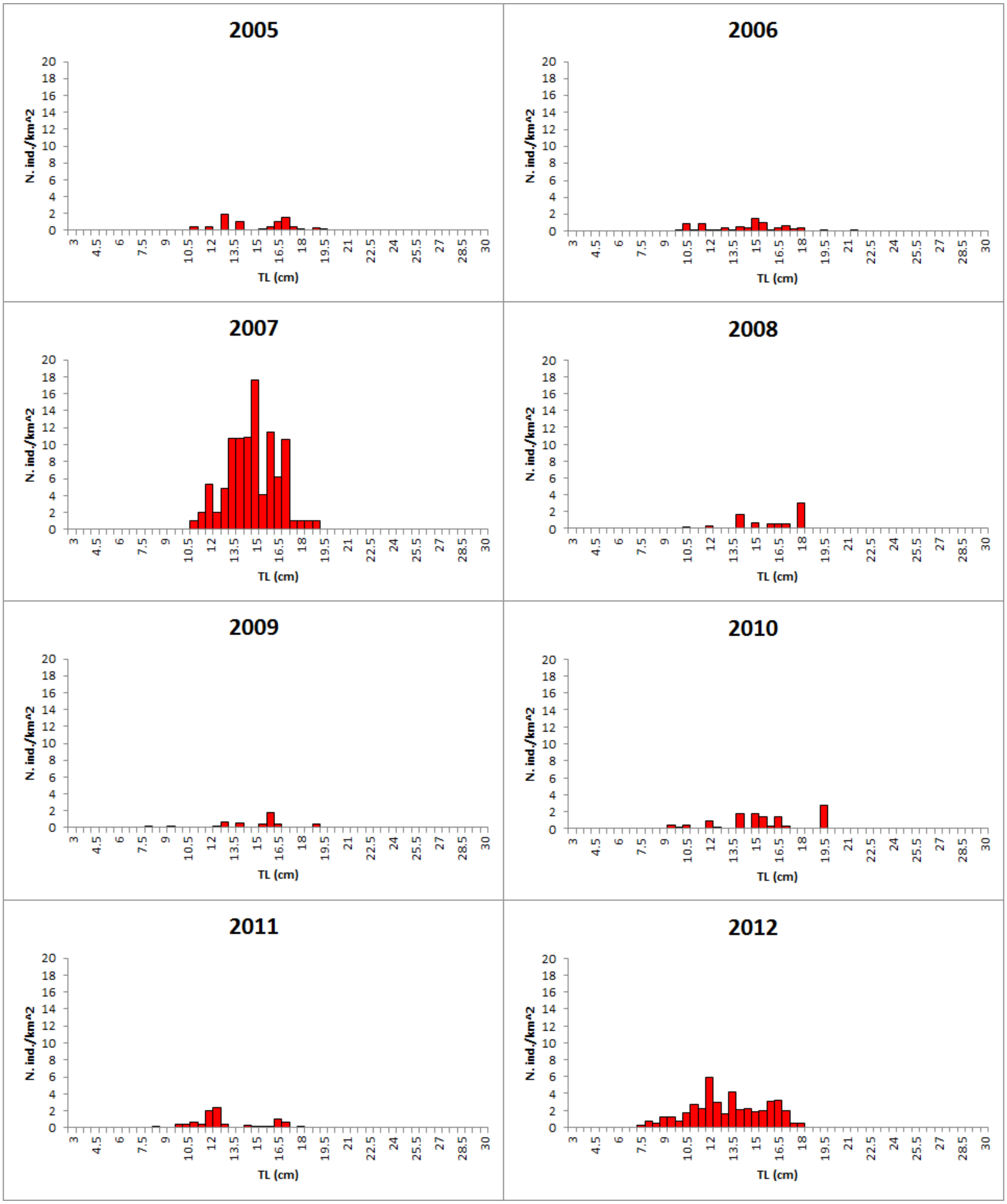


Fig. 6.13.3.3.4.1.Red mullet GSA 17. Stratified abundance indices by size, 2005-2012.

Trends in growth
No assessment of trend in growth has been carried out.

Trends in maturity
No assessment of trend in growth has been carried out.

### 6.13.4. **Assessments of historic stock parameters**

Red mullet has been the object of stock assessments in GSA17 during STECF EWG 12-10 and EWG 12-19 and in both case stock was considered exploited unsustainably.

Method 1: Statistical catch at age using SS3 model

Justification

Stock Synthesis 3 provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. It is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analysed. It uses forward projection of population in the "statistical catch-at-age" (hereafter SCAA) approach. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity. Differently from VPA based approaches (e.g. by XSA) SCAA calculates abundance forward in time and allows for errors in the catch at age matrices. Selectivity has been generated as age-specific by fleet, with the ability to capture the major effect of age-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Some SS features include ageing error, growth estimation, spawner-recruitment relationship, movement between areas; in the present assessment such features are not summarized in the results. The ADMB C++ software in which SS is written searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian methods.

In the present assessment the variance is not shown for fishing mortality results, because the model outputs provide F values (called continuous F) within a year as standardized into selection coefficients by dividing each F value by the maximum value observed for any age class in the year (e.g., Derio et al., 1985; Sampson and Scott, 2011). For a better comparison with the results of previous assessments carried out both in the framework of STECF-EWGs and GFCM-WGs and with the outputs of the XSA carried out in the present assessment, the F values are standardized by dividing by the average (called $F_{bar}$) of the F values observed over a defined range of age classes (in the present case from 1 to 5; Darby and Flatman, 1994; Sampson and Scott, 2011).

Input data and parameters

The SS3 analyses has been carried out considering the following three fleets:

1. Italian otter trawlers (ITA OTB)
2. Croatian otter trawlers (CRO OTB)
3. Slovenian otter trawlers (SLO OTB)

The catch at age for the Italian and Croatian fleets are summarized in figure 6.13.3.2.3.1.2. Data from Italian gill netters and rapido trawlers were not employed because were absent in some years, however they represent a really low amount of the catches.  A SOP correction has been applied at the catch data. Moreover tuning data were available from two fishery independent sources:

1. Medits trawl survey carried out in the whole GSA 17 in summer in the period 2000-2012
2. SoleMon rapido trawl survey carried out in the Italian side of the basin until the Croatian territorial waters in the period 2005-2012.

For both surveys the catch at age data has been estimated with the slicing of length frequency using the growth parameters reported in table 5. The selectivity of the three fleets and the 2 surveys have been modelled and different attempts were carried out in order to find out the best model which minimize the log likelihood and the final convergence values (Fig. 6.13.4.1.2.1, Table 6.13.4.1.2.1). Moreover the choice of the best model have been taken considering also the absence of parameters close to the bounds, the agreement between observed and reconstructed data of the surveys and the randomness distribution of the residuals of the 3 fleets and the 2 surveys.

The catch at age data from 2006 to 2012 for Italian and Slovenia OTB has been provided in the framework of European DCF data call. Discard data for the period 2010-2012 were used. The proportion of discard for each age class averaged between 2010 to 2012 has been applied to the previous years, to include a discard estimate in the catch at age matrix. This procedure has been applied only to the Italian data since no relevant discard is reported for the Croatian fleet. Croatian catch at age data has been estimated using the same slicing approach employed for survey data for length frequency distributions of landings data available for the period 2008-2012, for the year 2006 and 2007 the average length frequency distribution of the period 2008-2012 has been assumed and the total landings have been reconstructed on the base of it. In the case of Slovenia and Croatian series discard data have been considered negligible. The model allowed to specify the different source of data, providing different uncertainties estimates for each data set.

Total catches from 1970 to 2012 has been employed in the model, for Italy in the case discard data were absent a proportion of 24% of the landings has been assumed. The ISTAT-IREPA databases have been utilized in order to estimate the Italian data series of landings data before the begin of the EC DCF. Slovenian total catch data before the begin of the EC DCF has been assumed as equal to 3 tons. Croatian total catches data have been available from 1997 to 2012 from Croatian authorities. In the period 1992-1996, in concomitance with the conflicts in the ex-Jugoslavia an amount of 10 tons has been assumed, while in the period before a total catches of 300 tons have been assumed each year. Also in this case the model considered the different sources of the data sets and treated the error separately for each period. In order to facilitate the convergence of the model a higher number of ages (until 10) has been employed for natural mortality, fecundity and weight at age. Moreover, for the same reason, the initial catch before 1970 has been assumed to be null.

Table 6.13.4.1.2.1. Red mullet GSA 17. Input data and parameters for SS3 model.

| Catch at age in numbers (x 1000) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Italian OTB | 0 | 1 | 2 | 3 | 4 | 5 | 6+ |
| 2006 | 36722.82 | 61410.26 | 10054.76 | 1036.77 | 0 | 0 | 0 |
| 2007 | 43865.7 | 68464.1 | 9886.86 | 1197.66 | 0 | 0 | 0 |
| 2008 | 43044.38 | 63926.95 | 8971.26 | 1140.95 | 0 | 0 | 0 |
| 2009 | 12242.89 | 66019.71 | 20874.36 | 4325.52 | 375.18 | 0 | 0 |
| 2010 | 12713.16 | 31835.2 | 19428.81 | 3161.88 | 659.68 | 0 | 0 |
| 2011 | 30190.8 | 49478.83 | 22503.75 | 6155.74 | 746.97 | 0 | 0 |
| 2012 | 23847.59 | 39258.1 | 25053.45 | 2113.56 | 140.05 | 0 | 0 |
| Croatian OTB | 0 | 1 | 2 | 3 | 4 | 5 | 6+ |
| 2006 | 566.58 | 9239.35 | 5842.35 | 1479.88 | 316.06 | 89.29 | 28.23 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2007 | 668.63 | 10903.58 | 6894.7 | 1746.44 | 372.99 | 105.37 | 33.31 |
| 2008 | 553.6 | 9522.91 | 5135.32 | 1570.79 | 377.8 | 76.83 | 13.71 |
| 2009 | 344.42 | 9333.56 | 6203.9 | 1459.2 | 331.96 | 97.87 | 26 |
| 2010 | 280.12 | 8391.11 | 6755.13 | 1593.06 | 315.41 | 75.73 | 37.67 |
| 2011 | 1575.45 | 9927.12 | 6877.19 | 2067.53 | 576.93 | 216.82 | 67.66 |
| 2012 | 732.44 | 19673.12 | 10975.27 | 2414.82 | 342.56 | 82.15 | 28.62 |
| Slovenian OTB | 0 | 1 | 2 | 3 | 4 | 5 | 6+ |
| 2006 | 1.37 | 22.31 | 14.11 | 3.57 | 0.76 | 0.22 | 0.07 |
| 2007 | 4.6 | 75.09 | 47.48 | 12.03 | 2.57 | 0.73 | 0.23 |
| 2008 | 1.42 | 23.23 | 14.69 | 3.72 | 0.79 | 0.22 | 0.07 |
| 2009 | 1.9 | 31 | 19.6 | 4.97 | 1.06 | 0.3 | 0.09 |
| 2010 | 0.9 | 14.67 | 9.28 | 2.35 | 0.5 | 0.14 | 0.04 |
| 2011 | 4.35 | 70.87 | 44.82 | 11.35 | 2.42 | 0.68 | 0.22 |
| 2012 | 2.55 | 41.59 | 26.3 | 6.66 | 1.42 | 0.4 | 0.13 |

| Mean weight in catches (kg) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PERIOD | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2006-2012 | 0.018 | 0.026 | 0.043 | 0.072 | 0.100 | 0.125 | 0.147 | 0.165 | 0.179 | 0.189 | 0.198 |
| Mean weight in stock (kg) | | | | | | | | | | | |
| PERIOD | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2006-2012 | 0.01 | 0.018 | 0.043 | 0.072 | 0.100 | 0.125 | 0.147 | 0.165 | 0.179 | 0.189 | 0.198 |

| Abundance index at age (ind/km$^2$) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Medits | 0 | 1 | 2 | 3 | 4 | 5 | 6+ |
| 2000 | 35.9 | 245.64 | 373.5 | 85.53 | 21.45 | 2.69 | 1.06 |
| 2001 | 0.34 | 64.04 | 501.34 | 99.69 | 22.49 | 5.68 | 1.24 |
| 2002 | 26.46 | 269.18 | 295.36 | 82.06 | 16.48 | 3.45 | 1.59 |
| 2003 | 53.73 | 24.93 | 314.79 | 102.57 | 19.29 | 3.91 | 1.39 |
| 2004 | 11.08 | 145.41 | 376.6 | 93.91 | 20.36 | 8.09 | 4.46 |
| 2005 | 20.12 | 72.44 | 360.64 | 110.88 | 24.4 | 10.28 | 5.12 |
| 2006 | 8.32 | 264.11 | 519.99 | 151.97 | 34.14 | 6.73 | 1.72 |
| 2007 | 54.95 | 36.27 | 274.03 | 100.93 | 21.1 | 5.54 | 1.96 |
| 2008 | 2.69 | 54.25 | 559.26 | 259.77 | 36.31 | 8.09 | 1.77 |
| 2009 | 0.38 | 36.31 | 425.73 | 171.79 | 46.81 | 6.59 | 1.09 |
| 2010 | 0.11 | 57.98 | 555.8 | 204 | 39.74 | 7.86 | 1.47 |
| 2011 | 85.03 | 212.34 | 495.63 | 110.1 | 30.25 | 3.3 | 1.19 |
| 2012 | 1.66 | 580.35 | 1147.16 | 187.73 | 20.36 | 3.3 | 1.61 |
| SoleMon | 0 | 1 | 2 | 3 | 4 | | |
| 2005 | 1.517 | 4.975 | 1.339 | 0.001 | | | |
| 2006 | 2.778 | 5.513 | 1.18 | 0.12 | | | |
| 2007 | 11.856 | 82.762 | 7.392 | 0.001 | | | |
| 2008 | 0.6 | 3.914 | 3.256 | 0.001 | | | |
| 2009 | 0.898 | 3.472 | 0.38 | 0.001 | | | |
| 2010 | 2.31 | 6.973 | 2.827 | 0.001 | | | |
| 2011 | 6.55 | 2.717 | 0.402 | 0.001 | | | |
| 2012 | 20.66 | 21.147 | 1.593 | 0.001 | | | |

| Fecundity at Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PERIOD | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2006-2012 | 0 | 0.017 | 0.043 | 0.072 | 0.100 | 0.125 | 0.147 | 0.165 | 0.179 | 0.189 | 0.198 |

| Natural mortality (M) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PERIOD | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2006-2012 | 1.6 | 0.84 | 0.37 | 0.29 | 0.26 | 0.25 | 0.22 | 0.21 | 0.2 | 0.2 | 0.2 |

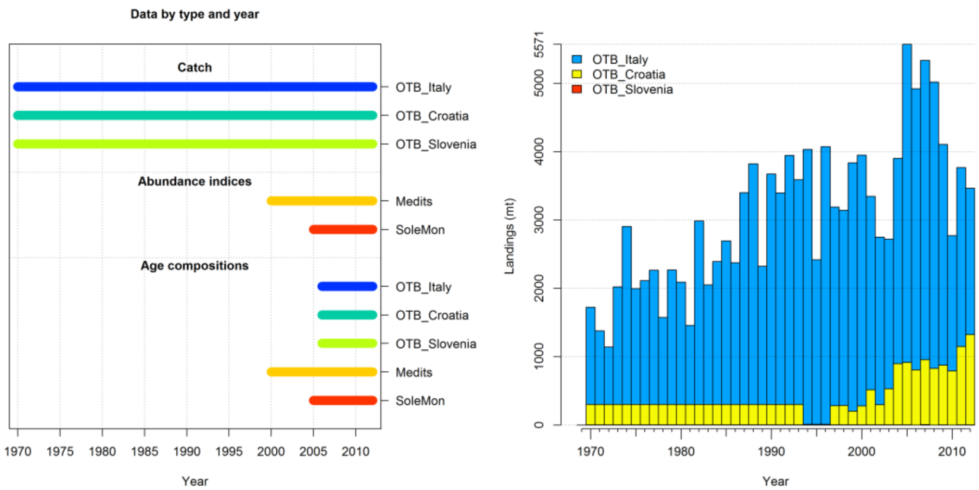


Fig. 6.13.4.1.2.1. Red mullet GSA 17.Input data and landings imputed in the SS3 model.

Considering the information provided in figures 6.13.2.4.1 and 6.13.3.1.2 the selectivity patterns of the fleets and the survey have been rescaled as in the Fig. 6.13.4.1.2.2.

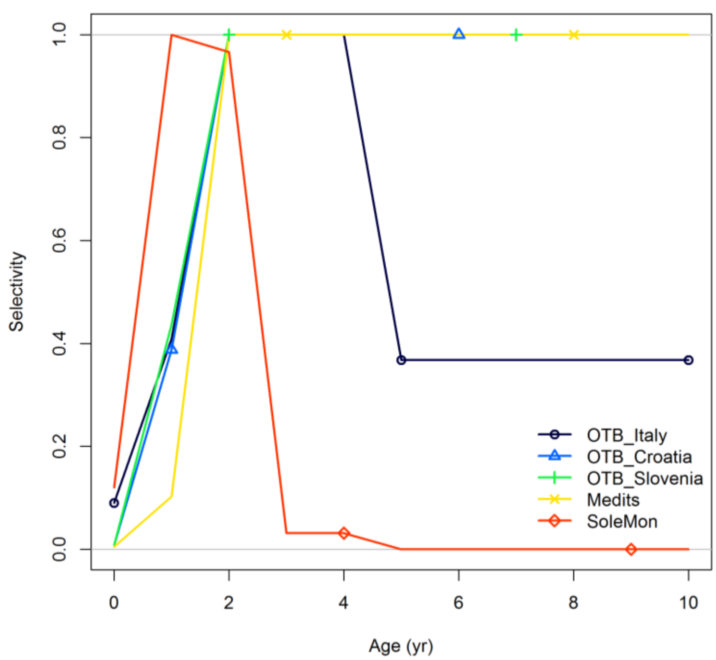


Fig. 6.13.4.1.2.2. Red mullet GSA 17. Selectivity estimated by the SS3 model.

Results

SCAA Diagnostics in the form of residuals by survey and fleet data are shown in Fig. 6.13.4.1.3.1. Moreover in table 6.13.4.1.3.1 are summarized the main results in terms of diagnostics of the different model attempts carried out changing the selectivity assumption for the fleets and the surveys. The model number 5 has been selected as the best model.

Tab.6.13.4.1.3.1. Red mullet GSA 17. Model diagnostics of SS3 using different selectivity assumptions.

| **Model** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **Selectivity assumptions** | Flat selectivity for all fleets and Medits. Dome-shaped for SoleMon | Flat selectivity for Croatia and Slovenia fleets and Medits. Dome-shaped for SoleMon and Italian OTB. | Dome shaped for all. SoleMon dome-shaped and higher level after age 2. | Dome shaped for all. Fleets and surveys. | Flat selectivity for Croatian, Slovenia fleets and Medits survey. Dome shaped for Italian fleet and SoleMon. |
| **log Likelhood** | -81.02 | -79.837 | -56.99 | -55.043 | **-77.94** |
| **Number of parameters** | 33 | 33 | 39 | 39 | 33 |
| **BIC** | 361.6033 | 359.2373 | 349.8275 | 345.9335 | **355.4433** |
| **Convergence** | 0.00055 | 0.00027 | 0.0013 | 0.0017 | **0.00013** |
| **N. of paremeters close to bound** | 0 | 0 | 1 | 1 | 0 |
| **Fitting in Medits data** | good | good | fair | fair | good |
| **Fitting in SoleMon data** | good | good | fair | fair | good |
| **Max residual Italian fleet** | 1.9 | 1.9 | 1.9 | 1.56 | 1.56 |
| **Max residual Croatian fleet** | 0.78 | 0.78 | 0.78 | 0.79 | 0.79 |
| **Max residual Slovenia fleet** | 0.37 | 0.38 | 0.38 | 0.35 | 0.36 |
| **Max residual Medits** | 3.58 | 3.4 | 3.4 | 3.12 | 3.1 |
| **Max residual SoleMon** | 2.34 | 2.24 | 2.24 | 2.3 | 2.12 |

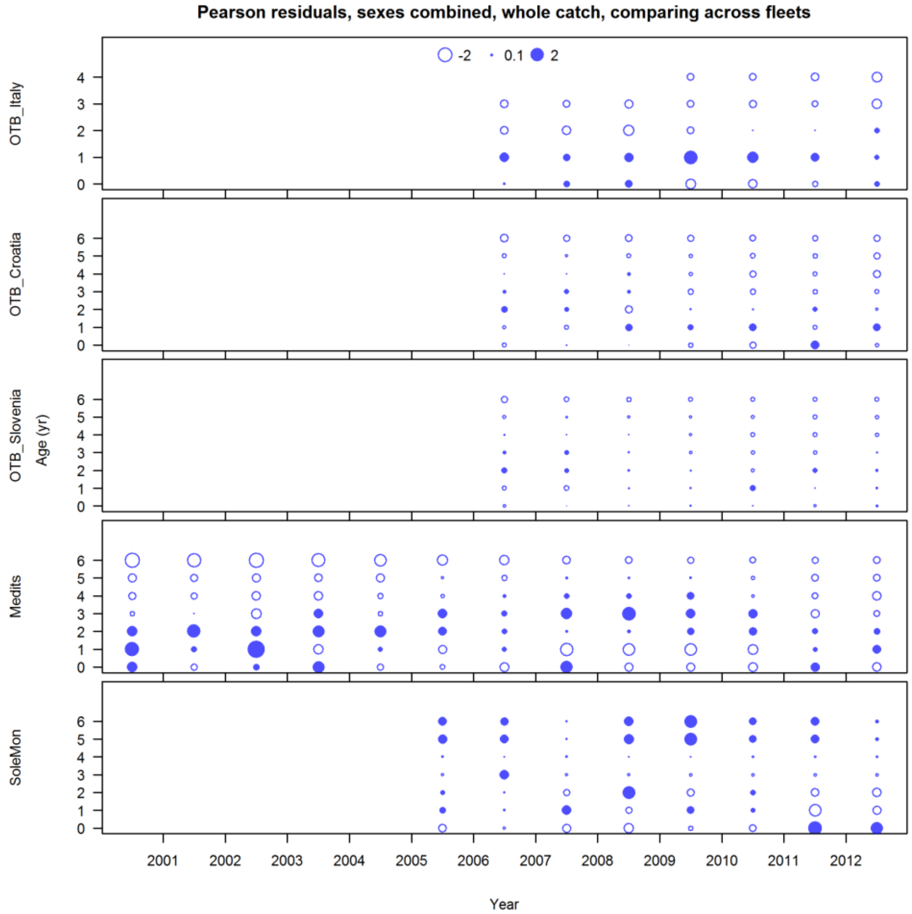


Fig. 6.13.4.1.3.1.Red mullet GSA 17. Pearson residuals for surveys and the fleets.

No particular trends in the residuals were observed.

Figure 6.13.4.1.3.2 presents the main results from the SCAA run of Model 5: fishing mortality ($F_{bar1-5}$ and by fleet), total biomass, spawning stock biomass (SSB) and recruitment.

State of exploitation: Exploitation increased from the beginning of the time-series, with a more pronounced increase after 2003. In the period 2006-2012 the $F_{bar}$ showed important oscillations around a value of 0.7. The most recent estimate of fishing mortality ($F_{bar}$ 0-5) is 0.55, the partial F for each fleet is 0.33 for the Italian trawlers, 0.23 for the Croatian trawlers and 0.001 for the Slovenian trawlers.

State of the juveniles (recruits): Recruitment varied without any trend in the years 1970-2012, reaching a minimum in 2000, followed by a general increase until 2012.

State of the adult biomass: The total biomass and SSB showed a strong decrease since the begin of the series. The last estimate of SSB in 2012 is around 4,700 tons.

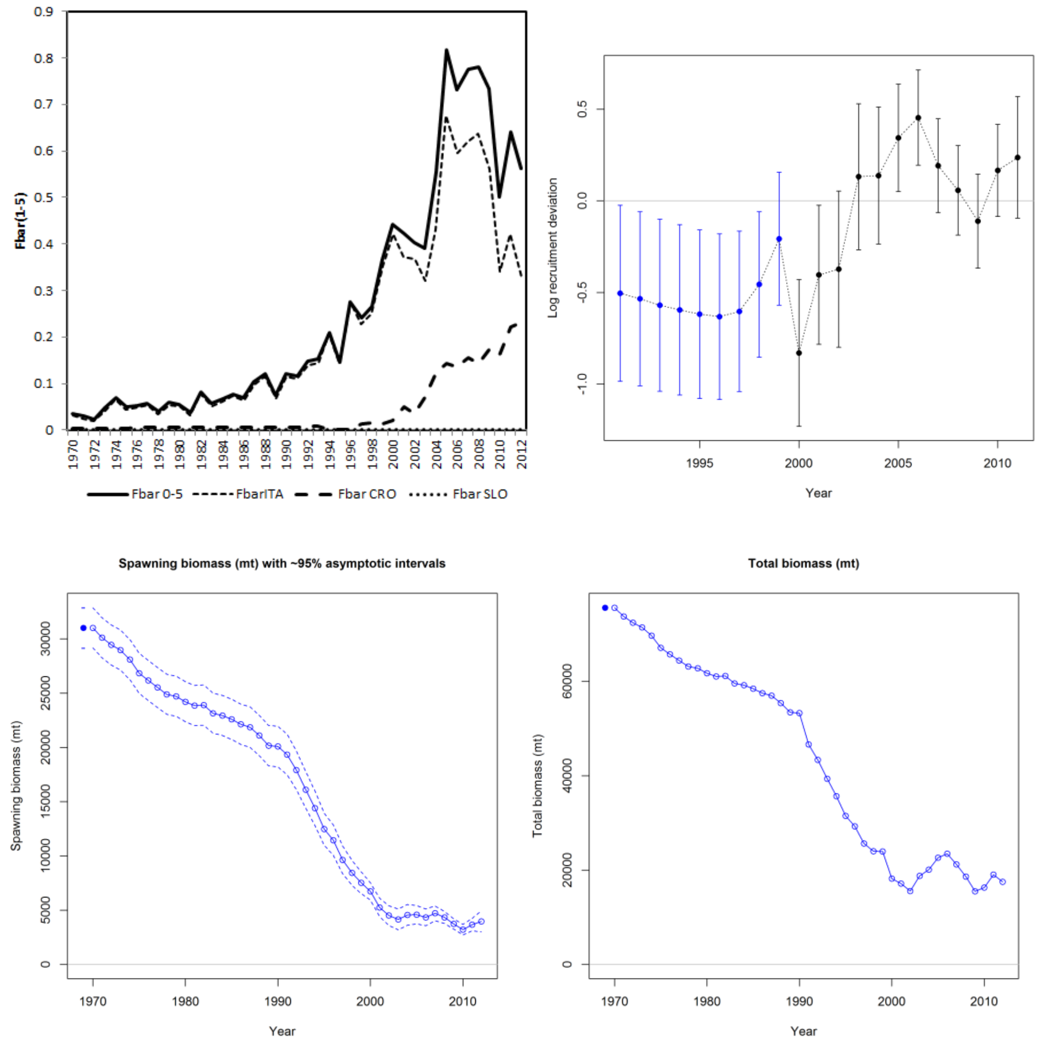


Figure 6.13.4.1.3.2. Red mullet GSA 17. Final assessment results SCAA run with SS3.

Method 2: Extended Survivor Analyses (XSA)

Justification

Considering the variability observed in the recruitment, the assessment is based on non-equilibrium method. FLR libraries were used in order to perform an XSA (Darby and Flatman 1994).

Input parameters

The same data employed in the SCAA have been utilized also for XSA. A SOP correction has been applied at the catch data. Data coming from DCF and Croatian Fisheries Department for the period 2006-2012 were used to perform an Extended Survivor Analysis (XSA) calibrated with fishery independent data (i.e. MEDITS and SoleMon abundance indices by age class for 2006-2012) and using FLR (www.r-project.org). Data included information on total landings and catch at age of *M. barbatus* in GSA 17 for both the Italian, Croatian and Slovenia OTB fleets. Discard data from the Italian fleet (available for 2010-2012) were also included in the analyses.

The XSA runs were made using the following settings:

- Catchability dependent on stock size for ages = 0
- Catchability independent of age for ages >= 4
- S.E. of the mean to which the estimates are shrunk = 1
- Minimum standard error for population estimates derived from each fleet = 0.300
- The number of ages used for the shrinkage mean: 5
- $F_{bar}$: 0-5

Results

XSA Diagnostics in the form of residuals by survey data are shown in Figure 6.13.4.2.3.1. No particular. trends are evidenced. The summary results are showed in figure 6.13.4.2.3.2.

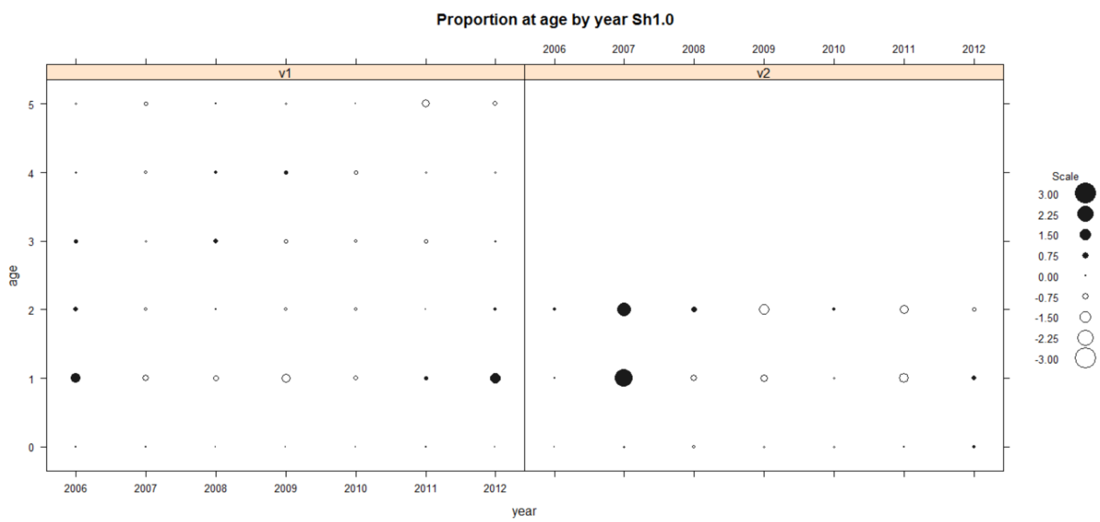


Figure 6.13.4.2.3.1. Red mullet GSA 17. Log transformed catchability residuals by age.

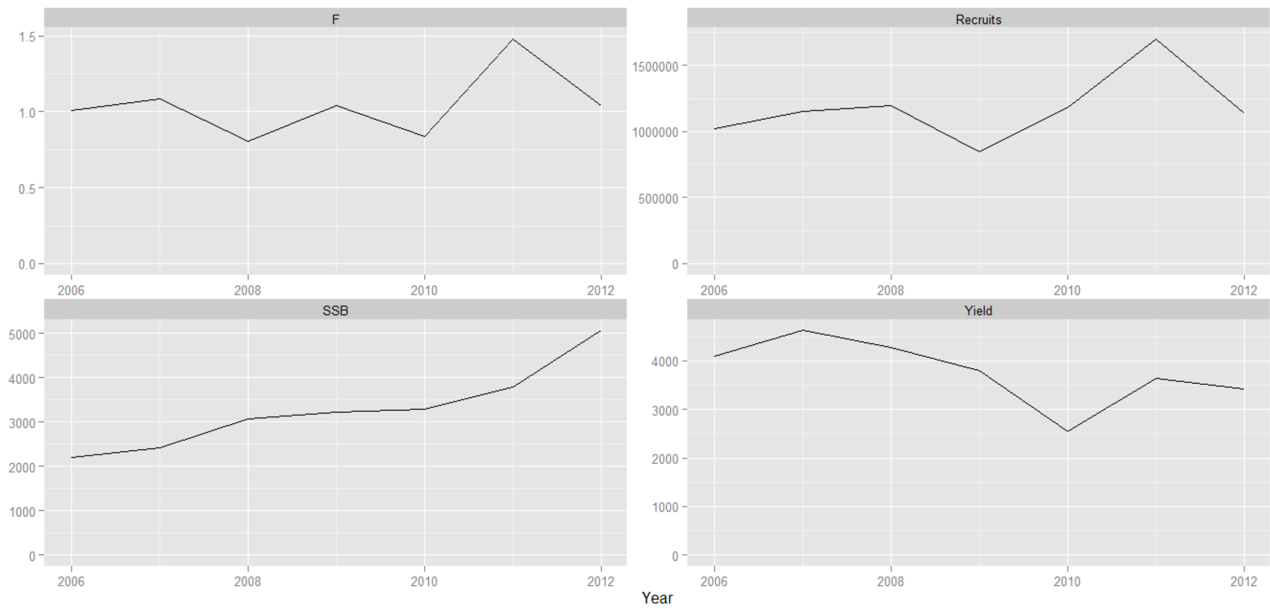


Figure 6.13.4.2.3.2. Red mullet GSA 17**.** Summary of stock parameters (recruitment, SSB, Yield, F mean forages 1-5) as estimated by XSA

State of exploitation

Exploitation fluctuated from the beginning of the time-series, with a more pronounced increase in 2011. The most recent estimate of fishing mortality ($F_{bar}$ 1-5) is 1.09.

State of the juveniles (recruits)

Recruitment varied without any trend in the years 2006-2012, reaching a minimum in 2009, followed by an increase until 2011.

State of the adult biomass:

The SSB showed an increasing trend from 2006 to 2012. The last estimate of SSB in 2012 is around 3,900 tons.

### 6.13.5.**Long term prediction**

Justification

Due to the short time series it was not possible to estimate a stock recruitment relationship. As a consequence the biological reference point has been estimated using the Yield per Recruits approach, where $F_{0.1}$ is considered a proxy of $F_{MSY}$.

Input parameters

Biological reference points have been estimated using the XSA and SCAA input data and selectivity patterns.

Results

The results presented here suggest an overfishing situation for the red mullet stock both for the XSA and SCAA results (Figure 6.13.5.1.2; Table 6.13.5.1.2.1).

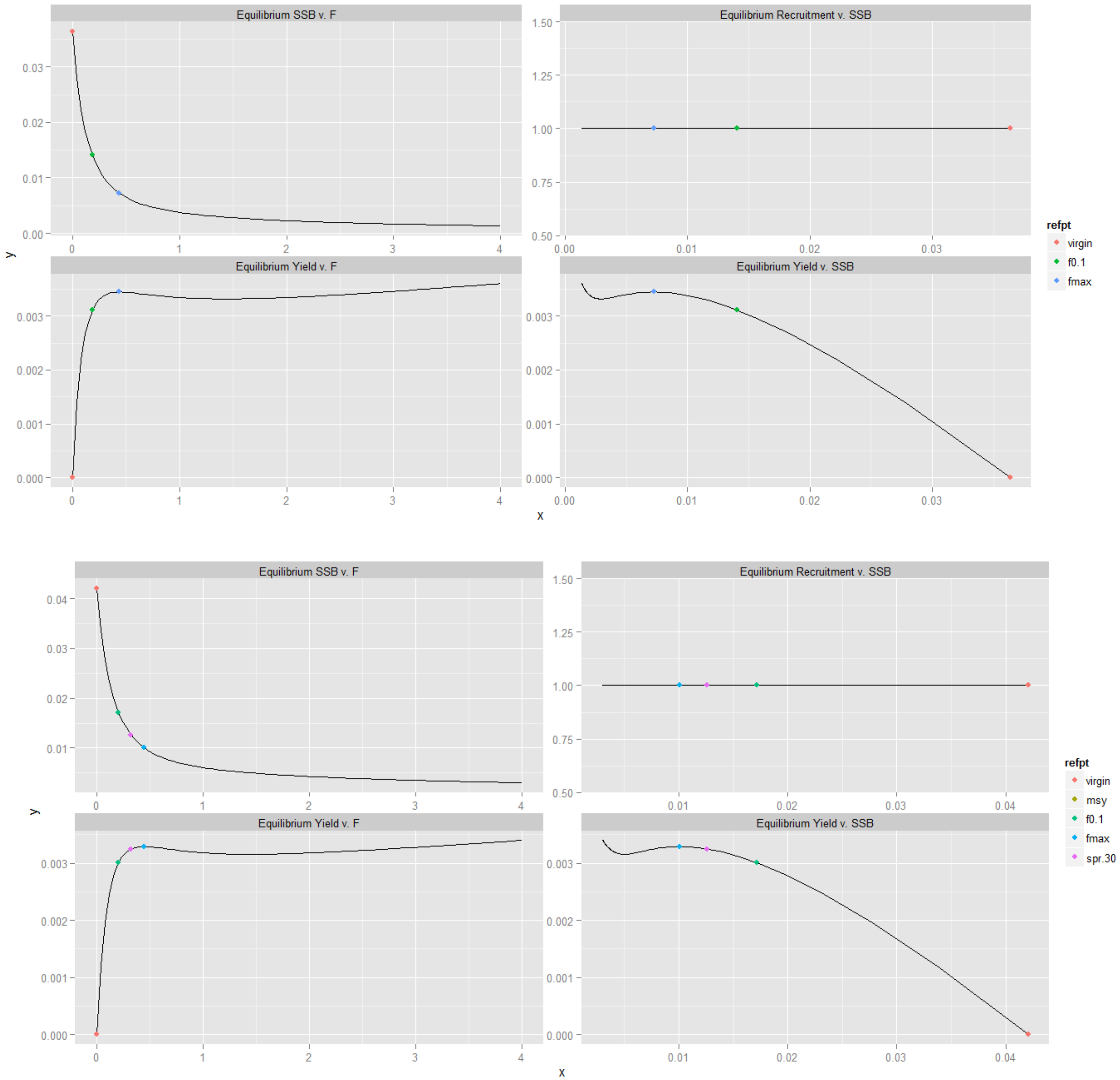


Figure 6.13.5.1.2. Yield per Recruit analyses for XSA (above) and SCAA (below).

Table 6.13.5.1.2.1.Yield per Recruit outputs for XSA and SCAA.

| | Current F ($F_{BAR\ 1\text{-}5}$) | Reference Points | Harvest | Yield/R |
|---|---|---|---|---|
| XSA | 1.09 | $F_{0.1}$ | 0.19 | 0.0031 |
| | | $F_{max}$ | 0.44 | 0.0034 |
| SCAA | 0.55 | $F_{0.1}$ | 0.21 | 0.0030 |

| | | |
|---|---|---|
| $F_{max}$ | 0.45 | 0.0032 |

The SS3 model allows the assumption of a dome-shaped population selection curve, which determines more reliable values of SSB and F if compared with the historical yields. Thus EWG 13-19 believes that the more accurate methodology to assess the stock is the SCAA carried out with SS3 model. EWG 13-19 proposes $F \leq 0.21$ as proxy for $F_{MSY}$. Given the results of the present analysis (current F is around 0.56), the stock appeared to be subject to overfishing.

### 6.13.6. **Short term prediction 2013-2014**

Input parameters

An average of the last three years has been used for weight at age, maturity at age and F at age. Mortality at age was the same as used as input data in the SCAA.

*Recruitment*

Recruitment (class 0+) in 2013 has been estimated as the geometric mean (2010-2012), taken from SCAA results = 925976(thousands).

A short term projection table (Table 6.13.5.1). assuming a *statu-quo* F of $F_{stq}$=0.55 in 2013 and a recruitment of 925976thousand individuals shows that:

- Fishing at $F_{stq}$ from 2013 to 2014 would produce an decrease in catches of 8.2% and an increase in SSB of 0.2% between 2014 and 2015.

- Fishing at $F_{0.1}$ (0.21) from 2013 to 2014 would generate a decrease of 58% of the catches and an increase of 23.7% in SSB.

- STECF EWG 13-19 recommends that catch in 2014 does not exceed 1441t, corresponding to $F_{0.1.}$=0.21.

Table 6.13.5.1. Red mullet GSA 17.Short term forecast for different F scenarios computed for *Mullus barbatus* in GSA 17 from SCAA results. Basis: F(2013) =0.55; R(2013-2015): 925976(thousands); SSB(2012)= 8543t; landings(2012)= 3429t.

| Rationale | F scenario | F factor | Catch 2014 | Catch 2015 | SSB 2015 | Change SSB 2014-2015 (%) | Change catch 2012-2014 (%) |
|---|---|---|---|---|---|---|---|
| zero catch | 0.00 | 0 | 0.0 | 0.0 | 12296.0 | 43.9 | -100.0 |
| High long-term yield (F0.1) | 0.21 | 0.3895 | 1441.1 | 1890.8 | 10546.5 | 23.5 | -58.0 |
| Status quo | 0.55 | 1 | 3147.8 | 3168.2 | 8556.3 | 0.2 | -8.2 |
| Different scenarios | 0.06 | 0.1 | 402.2 | 610.1 | 11802.7 | 38.2 | -88.3 |
| | 0.11 | 0.2 | 781.2 | 1125.4 | 11341.3 | 32.8 | -77.2 |
| | 0.17 | 0.3 | 1138.5 | 1560.2 | 10909.5 | 27.7 | -66.8 |
| | 0.22 | 0.4 | 1475.6 | 1926.4 | 10505.2 | 23.0 | -57.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0.28 | 0.5 | 1794.1 | 2234.4 | 10126.5 | 18.5 | -47.7 |
| | 0.33 | 0.6 | 2095.1 | 2493.0 | 9771.4 | 14.4 | -38.9 |
| | 0.39 | 0.7 | 2379.9 | 2709.8 | 9438.4 | 10.5 | -30.6 |
| | 0.44 | 0.8 | 2649.6 | 2891.0 | 9125.8 | 6.8 | -22.7 |
| | 0.50 | 0.9 | 2905.3 | 3042.3 | 8832.2 | 3.4 | -15.3 |
| | 0.61 | 1.1 | 3378.1 | 3272.8 | 8296.8 | -2.9 | -1.5 |
| | 0.66 | 1.2 | 3597.0 | 3359.5 | 8052.7 | -5.7 | 4.9 |
| | 0.72 | 1.3 | 3805.2 | 3431.1 | 7822.7 | -8.4 | 11.0 |
| | 0.77 | 1.4 | 4003.5 | 3490.0 | 7606.0 | -11.0 | 16.7 |
| | 0.83 | 1.5 | 4192.5 | 3538.5 | 7401.6 | -13.4 | 22.2 |
| | 0.88 | 1.6 | 4372.9 | 3578.2 | 7208.7 | -15.6 | 27.5 |
| | 0.94 | 1.7 | 4545.1 | 3610.7 | 7026.6 | -17.7 | 32.5 |
| | 0.99 | 1.8 | 4709.8 | 3637.3 | 6854.4 | -19.8 | 37.3 |
| | 1.05 | 1.9 | 4867.3 | 3658.9 | 6691.5 | -21.7 | 41.9 |
| | 1.10 | 2 | 5018.2 | 3676.6 | 6537.4 | -23.5 | 46.3 |

### 6.13.7. **Data quality**

Red mullet DCF data in GSA17 are delivered by Italy and Slovenia, but because the latter contribute for less than 1%, data quality analyses focused only on the Italian data.

In GSA17 landings at age and at length were available only for otter trawl from 2006 to 2012; no data from gillnet and beam trawls were available with continuity for the same time period. Similarly also discard data were complete for the whole period and fleets.

The comparison between total landings and landings reconstructed as the sum of the landings at age evidenced differences from 3 to 50% of the total landings by gear and year (Figure 6.13.7.1).

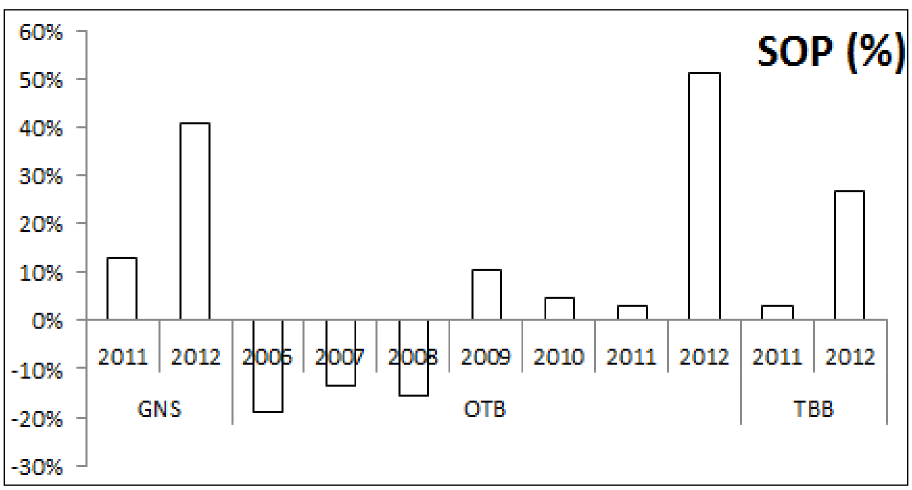


Figure. 6.13.7.1. Red mullet GSA 17. Differences in percentage between the declared landings and the reconstructed landings as sum of products (2013 DCF data).

6.13.8.**Scientific advice**

Short term considerations

State of the stock size

According to SCAA analyses the SSB trend was constant in the period 2006-2012. However the estimates made by the SS3 model with SCAA show a critical situation, because the population is characterized by an SSB which is less than 20% of the 90s, and demonstrates a clear decreasing pattern of the older ages (Fig. 6.13.8.1.1.1). Nevertheless, is not possible to fully evaluate the state of the spawning stock due to the absence of proposed or agreed management reference points for the SSB.

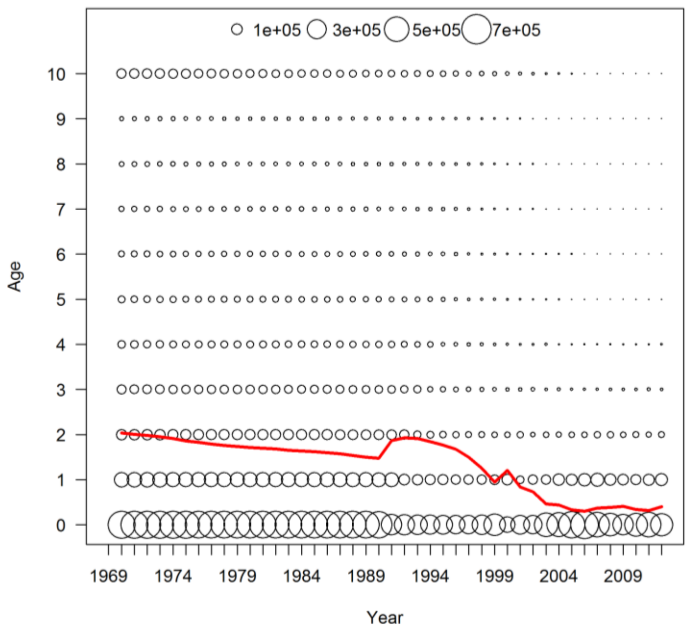


Figure 6.13.8.1.1.1. Red mullet GSA 17. Bubble plot showing the middle of year expected numbers at age in thousands (max bubble = 35,345) from SS3 model. Red line represents the mean age of the population.

State of recruitment

The analyses carried out with SS3 model for the period 1970-2012 show that recruitment has been stable with a minimum observed in 2009.

State of exploitation

The estimates from SS3 model show that in 2012 the fishing mortality appears higher than the respective estimates of $F_{0.1}$ (2.5 times in the SCAA) and, hence, it can be concluded that the resource is overexploited.

Management recommendations

Considering the overfishing status and the low values of SSB of the red mullet stock in GSA 17 a reduction of fishing effort, especially of Italian otter trawl is advisable. It should also be taken into account that, differently from the Croatian fleet, the exploitation of Italian trawlers is mainly orientated towards juveniles, creating a situation of growth overfishing that can directly affect the Croatian catches.

References

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## 6.14. **Stock assessment of Anchovy in GSA 18**

See section 6.19.

## 6.15. **Stock assessment of Anchovy in GSA 19**

### 6.15.1.**Stock identification and biological features**

Due to a lack of information on the structure of anchovy population in the GSA19 (Western Ionian sea), this stock was assumed to be confined within the boundaries of this Geographical Sub-Area.

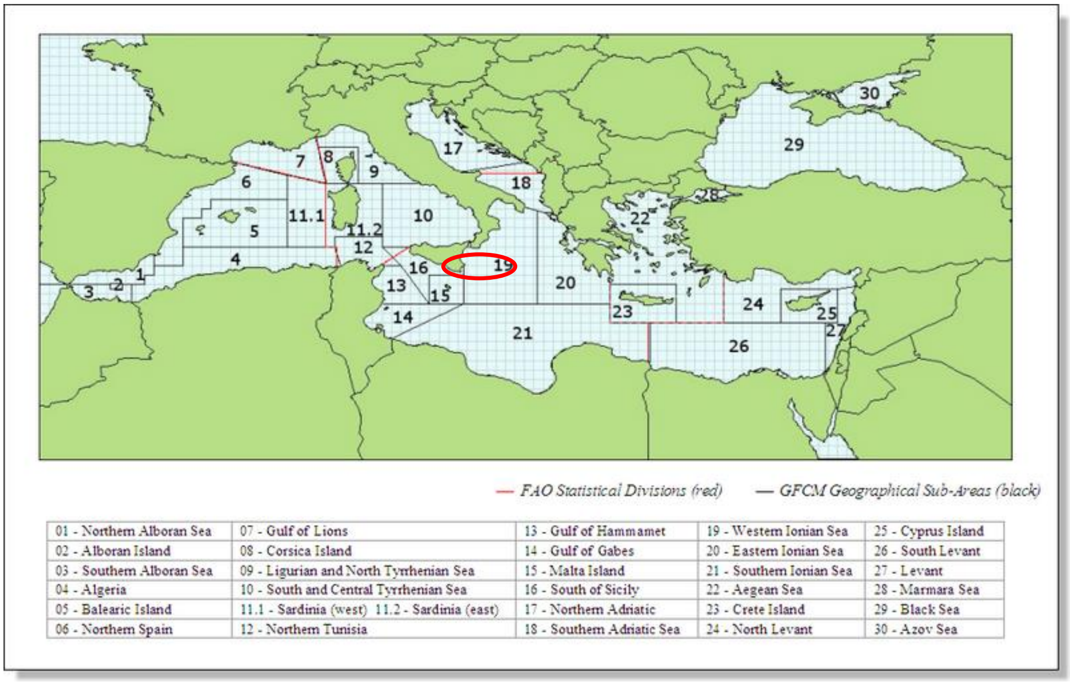



Figure 6.15.2.1. Geographical location of GSA 19.

### 6.15.2.**Growth**

In GSA 19 growth of anchovy has been studied using DCF data and ageing fish by otolith readings (whole sagitta; Intini *et al.*, 2011). According to the ageing criteria the birthday was set at the first of July (Giannetti and Donato, 2003) and consequently the age assigned to the fish sampled before this date was equal to the observed number of hyaline ring (excluding the edge) plus 0.5, whereas the age corresponded to the number of hyaline ring for the fishes caught during the second part of the year. Thus). ALK information (Table 6.15.3.1) was used to estimate the growth parameters for males and females according to a von Bertalanffy growth function (VBGF). The two VBGFs were compared by the Chen-Test (Chen et al., 1992). The growth parameters, estimated for females and males, are respectively: $L_\infty$ = 17.705 cm, k = 0.312 and t0 = -1.694 for females; $L_\infty$ =17.187 cm, k =0.302 and t0 = -1.827 for males. The two VBGCs of female and males were not significantly different (p>0.05) ,a combined curve was derived with the following parameters $L_\infty$ = 17.413, k = 0.308, t0 = -1.764 (Fig. 6.15.3.1).

Table 6.15.3.1. Anchovy GSA 19. ALK (Age-Length Key) for sex combined estimated within DCF.

|  | Age |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| **Length class** | **0** | **1** | **2** | **3** | **4** | **5** | **Total** |
| 7 | 5 |  |  |  |  |  | 5 |
| 7.5 | 16 |  |  |  |  |  | 16 |
| 8 | 36 | 4 |  |  |  |  | 40 |
| 8.5 | 41 | 25 |  |  |  |  | 66 |
| 9 | 21 | 50 |  |  |  |  | 71 |
| 9.5 | 25 | 102 |  |  |  |  | 127 |
| 10 | 25 | 128 | 9 |  |  |  | 162 |
| 10.5 | 12 | 182 | 37 |  |  |  | 231 |
| 11 | 2 | 134 | 107 |  |  |  | 243 |
| 11.5 |  | 101 | 121 | 9 |  |  | 231 |
| 12 |  | 55 | 151 | 46 |  |  | 252 |
| 12.5 |  | 31 | 144 | 70 |  |  | 245 |
| 13 |  | 5 | 122 | 80 | 7 |  | 214 |
| 13.5 |  | 1 | 84 | 87 | 17 |  | 189 |
| 14 |  |  | 26 | 84 | 56 | 1 | 167 |
| 14.5 |  |  | 12 | 68 | 42 | 12 | 134 |
| 15 |  |  | 1 | 33 | 39 | 15 | 88 |
| 15.5 |  |  |  | 10 | 29 | 16 | 55 |
| 16 |  |  |  | 2 | 15 | 12 | 29 |
| 16.5 |  |  |  | 2 | 10 | 6 | 18 |
| 17 |  |  |  |  | 3 | 5 | 8 |
| 17.5 |  |  |  |  |  | 1 | 1 |
| **Total** | 183 | 818 | 814 | 491 | 218 | 68 | 2592 |

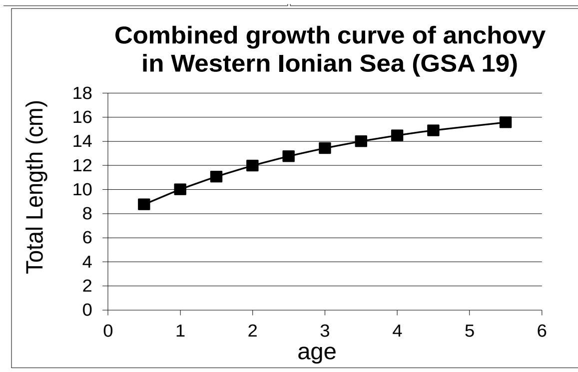



Fig. 6.15.3.1.Anchovy GSA 19. Von Bertalanffy growth functions for sex combined.

The length-weight relationship coefficients estimated using DCF data are reported in table 6.15.3.2.:

Table 6.15.3.2.Anchovy GSA 19. Length-weight relationship coefficients estimated from DCF data.

| Sex | a | b |
|---|---|---|
| C | 0.0035 | 3.28 |
| F | 0.0032 | 3.3 |
| M | 0.0035 | 3.29 |

### 6.15.3. **Maturity**

The size at first maturity ($L_{m50}$= 9.6 cm) and the maturity range MR ($L_{m75}$-$L_{m25}$=1.09 cm) for anchovy in GSA19 are reported in the Figure 6.15.4.1 for sex combined, as the two ogives of females and males were not significantly different (Chen test; p>0.05).

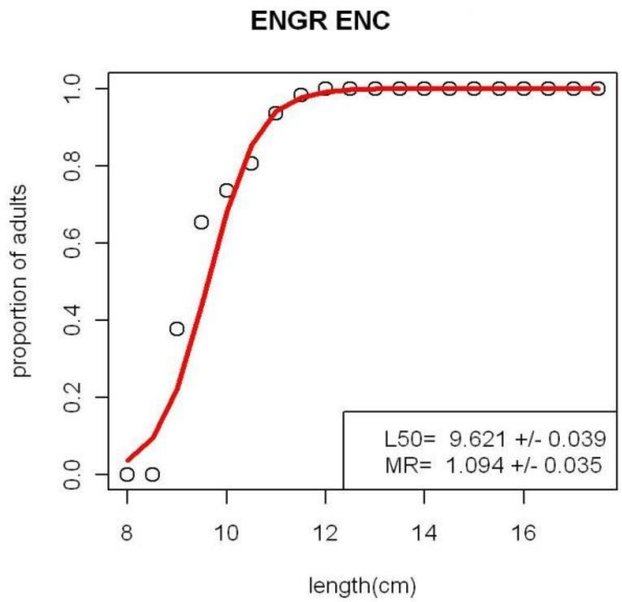



Fig. 6.15.4.1.Anchovy GSA 19. Maturity ogive (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

These estimates were obtained by monthly samples (years: 2009-2010) of anchovy from commercial landings (biological sampling from DCF). Specimens were considered adult when classified as 2b (recovering), 2c (maturing), 3 (mature/spawner), 4a (spent) and 4b (resting), while immature/juvenile ones were classified as 1 (immature virgin) and 2a (virgin developing) (MEDITS maturity scale). Binomial generalized linear models (GLMs) with logistic link has been used to model the proportion of adult individuals on the length as independent variable (ICES, 2008).

The sex ratio is about 1:1 up to the size of 14 cm, after females are prevailing (Fig. 6.15.4.2).

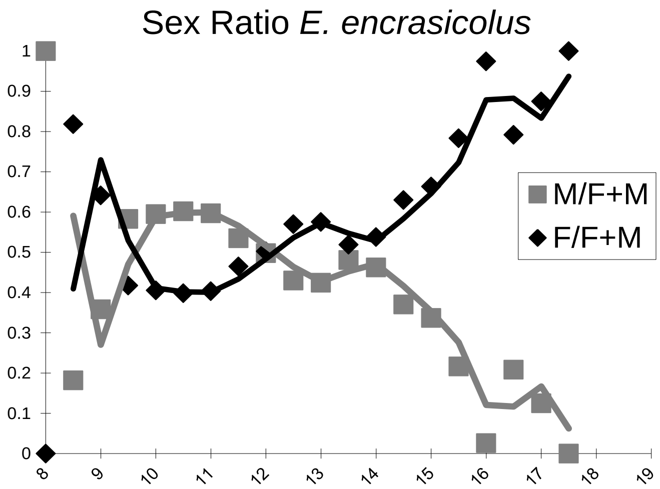



Fig. 6.15.4.2.Anchovy GSA 19. Sex ratio for females and males by length (cm).

The percentage of mature specimens by month (Fig. 6.15.4.3) suggests a long reproductive period with the presence of spawners from March to September and a peak in summer. Post-spawning and recovering specimens occur mostly after summer, while the maturing specimens more frequent in spring and summer.

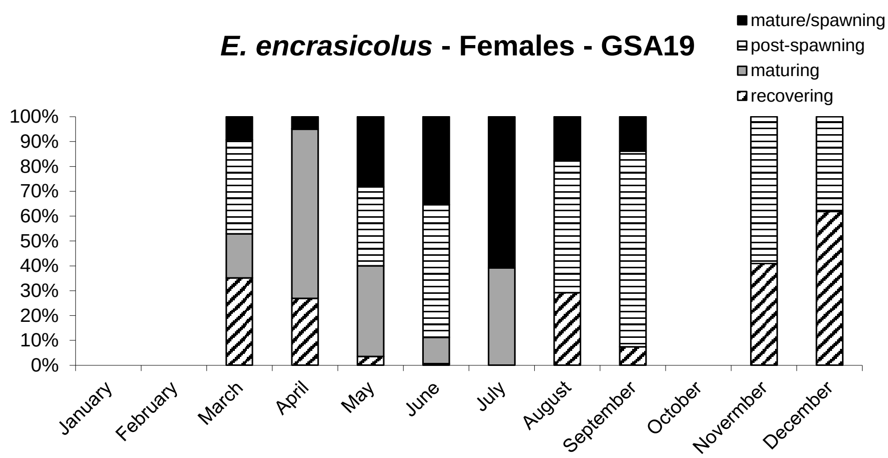



Fig. 6.15.4.3. Anchovy GSA 19.Monthly percentage of maturity stage for females (n=2934).

### 6.15.4.**Fisheries**

General description of fisheries

In GSA19 anchovy is mostly targeted by Purse seine, but also by small scale driftnets (GND) (Fig. 6.15.5.1), which represents a fraction not negligible ranging between 22% in 2007 and 38% in 2012 of the total landing in the GSA 19.

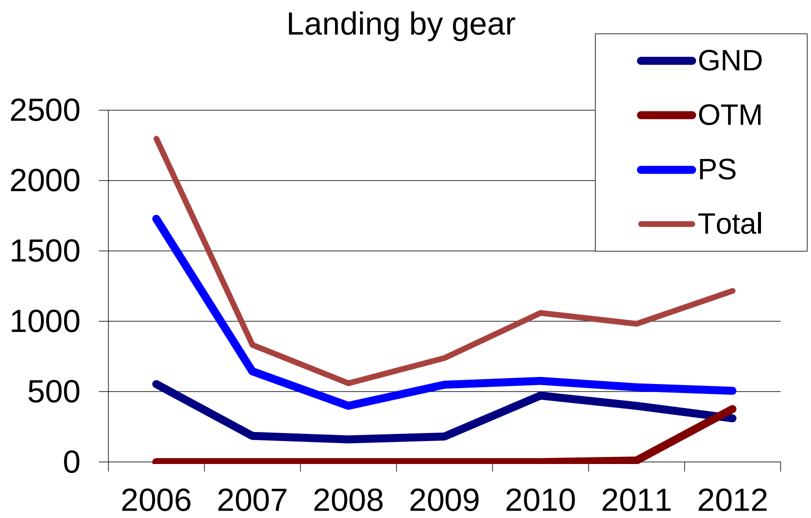



Fig. 6.15.5.1. Anchovy GSA 19. Landings by year and fisheries (Purse seine, Small scale driftnet and Midwater otter trawl).

In the GSA 19 the activity of the Purse seine for small pelagic fish (PS_SPF_>=14_0_0) and driftnet for small pelagic fish (GND_SPF_0_0_0) is more concentrated along the coasts of the Eastern Sicily. The operations of both metiers are characterized by a seasonality linked to the water temperature and the sea conditions. So in the winter time the fishing activity is reduced. Catches are mainly from a depth range between 50-200 m and anchovy co-occurs with other important commercial species as *S. pilchardus, B. boops, Trachurus sp and Scomber sp*.

Management regulations applicable in 2010 and 2011

There are no formal management objectives for anchovy in GSA19. As in other areas of the Mediterranean, the stock management in Italy is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area/season closures). The minimum landing size (Reg. EC 1967/06) is 9 cm.
In order to limit the over-capacity of fishing fleet, no new fishing licenses have been assigned in Italy since 1989 and a progressive reduction of the trawl fleet capacity is currently underway.

In the GSA 19 the fishing ban has not been mandatory along the time, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it was mandatory.

Porto Cesareo MPA was permanently established in 1997 (Decree of Ministry of Environment of 12.12.1997; G.U. n. 45 del 24/02/1998). Porto Cesareo MPA is delimited by Punta Prosciutto and Torre dell'Inserraglio and its surface is 0.16654 $km^2$. The MPA is divided in three zones with different level of protection, from total to partial.

Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

6.15.5.3 Catches

Landings

Table 6.1.5.3.1.1. Annual landings (tons) of Anchovy by gear from DCF.

| YEAR | GND | PS | Total |
|---|---|---|---|
| 2006 | 554 | 1729 | 2284 |
| 2007 | 186 | 645 | 831 |
| 2008 | 160 | 400 | 560 |
| 2009 | 182 | 550 | 731 |
| 2010 | 472 | 576 | 1048 |
| 2011 | 400 | 531 | 931 |
| 2012 | 311 | 506 | 817 |

The data from 2006 to 2012 from Data call shows a sharp decrease in landings from 2006 to 2007 and then values varying from a minimum of 560 tons in 2008 and 1048 tons in 2010.

Discards

According to the data from DCF, discard for GND is reported as null in 2011 and 2012; in the previous years the discard is not reported. For PS the discard is reported as null in 2012; in 2011 the discard is not reported (it is related to 10 measured individuals). In the previous year the discard is not reported.

Fishing effort

Data of fishing effort in GSA 19 are available on a quarterly basis from 2006 to 2012, but are not reported for 2010. The annual values are in table 6.15.5.3.3.1.

Table 6.15.5.3.3.1. Annual fishing effort (GT*days at sea) in GSA 19. 2006- 2012.

| Nominal effort | GND | PS | Total |
|---|---|---|---|
| 2006 | 5,052,770 | 8,969,240 | 14,022,010 |
| 2007 | 2,703,960 | 8,973,980 | 11,677,940 |
| 2008 | 2,565,630 | 12,223,180 | 14,788,810 |
| 2009 | 2,564,860 | 8,877,750 | 11,442,610 |
| 2011 | 4,980,790 | 7,247,950 | 12,228,740 |
| 2012 | 5,595,900 | 10,088,230 | 15,684,130 |

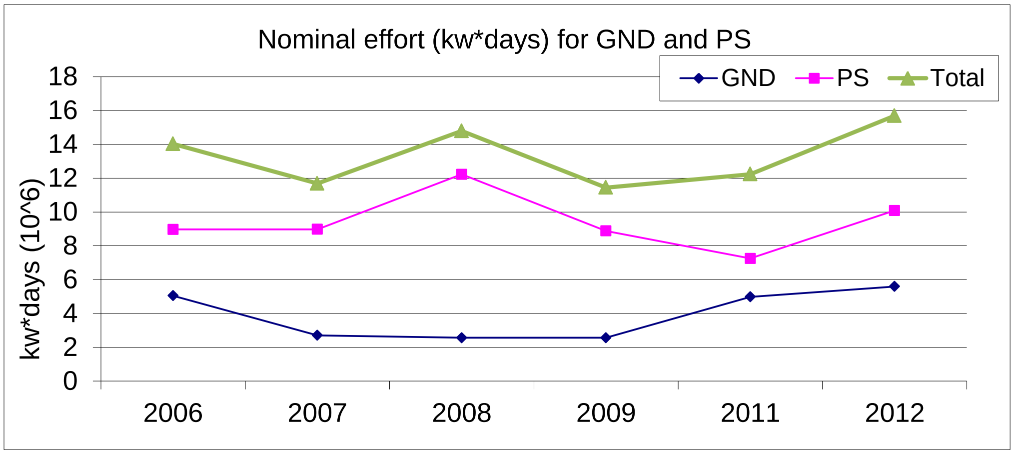



Fig. 6.15.5.3.3.1. Annual fishing effort (GT*days at sea) for GND and PS in GSA19 from 2006 to 2012.

## 6.15.5. **Scientific surveys**

MEDITS

Methods

The number of hauls per depth stratum in GSA 19 is reported in the Tab. 6.15.6.1.1.1.

Table 6.15.6.1.1.1. Number of hauls per year and depth stratum in SA19, 1996-2012.

| STRATUM | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GSA19_010-050 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 9 | 9 |
| GSA19_050-100 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 8 | 8 | 8 | 8 | 8 |
| GSA19_100-200 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| GSA19_200-500 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| GSA19_500-800 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 29 | 29 | 29 | 28 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to the square kilometer. Hauls noted as valid were only used, including stations with no catches (zero catches are included).

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

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

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

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

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

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution or quasi-Poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Based on the DCF data call, abundance and biomass indices were recalculated. Density and biomass indices represent the number of individuals per $km^2$ and kg of biomass per $km^2$ (Cochran, 1977).

Geographical distribution patterns

According to MEDITS data of this species (DCF), the species is distributed on the whole Calabria costs, along the coasts of the Eastern Sicily and in the southern part of Puglia cost (Figure 6.15.6.1.2.1). It should be however underlined that the MEDITS trawl survey cannot be considered an accurate source of information of anchovy abundance, given that the acoustic technology is the more suitable approach for small pelagics.

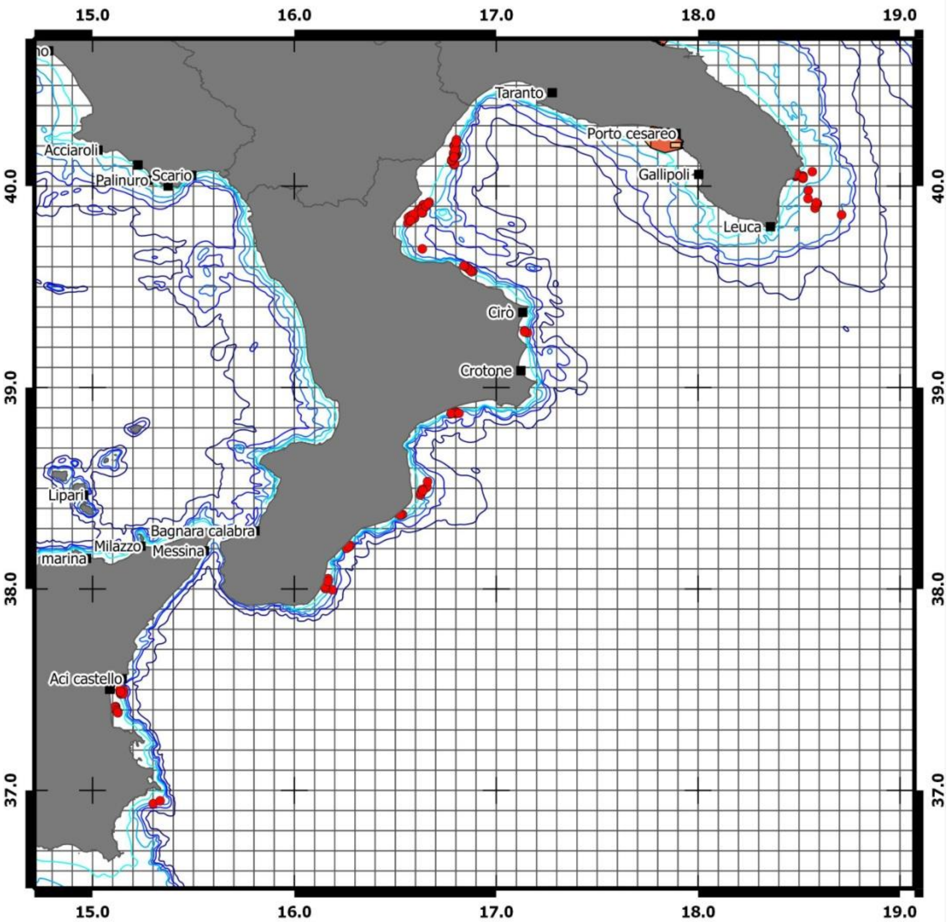
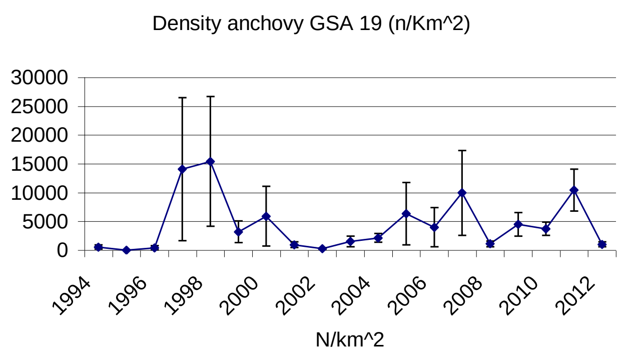



Figure 6.15.6.1.2.1. MEDITS hauls of GSA19 where anchovy occurs.

Trends in abundance and biomass

Fishery independent information regarding the state of anchovy in GSA 19 was derived from the international survey MEDITS and was computed during STECF 13-19. Fig. 6.15.6.1.3.1 displays the estimated trend in anchovy density and biomass in SA 19. It should be again underlined that the MEDITS cannot be considered an accurate source of information of small pelagic species abundance.



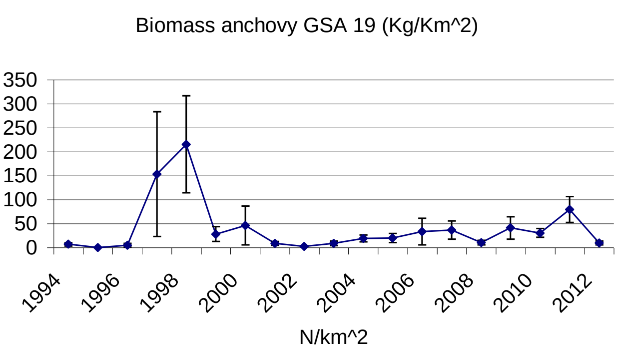




Figure 6.15.6.1.3.1. Density and biomass indices of anchovy in GSA19 (50-200 m).

Trends in abundance by length or age

Length frequency distribution

Length frequency distribution for this species from MEDITS is available only for 2012, when the species was considered as target in the MEDITS protocol.

Trends in growth

No analyses were conducted during EWG 13-19 meeting.

Trends in maturity

No analyses were conducted during EWG 13-19 meeting.

### 6.15.6. **Assessments of historic stock parameters**

Due to the lack of information from eco-survey data, EWG 13-19 applied separable VPA method to evaluate the status of this stock.

Method 1: Separable VPA

Justification

This is the first assessment of anchovy in the GSA19. In the last data call 2013 the landing data in weight, by age and by length from 2006 to 2012 have been provided by gear and fishery; the analysis has been performed considering the data from 2007 to 2012, because the sharp decrease of landing from 2006 to 2007 is not supported by a decrease in effort and by abundance indices from MEDITS.

Input parameters

For the assessment of anchovy stock in GSA19 the DCF official data of commercial catch have been used. A sex combined analysis has been carried out.

For GND fleet segment in 2009 and 2010 annual production data from IREPA have been used. The LFDs for these years have been estimated raising the average LFDs of 2008 and 2011 to the corresponding productions of 2009 and 2010, this because in 2009 and 2010 the GND métier was not selected in the ranking system of DCF

Catch numbers at age (Figure 6.15.7.1.2.2) were derived from the DCF annual size distributions (Figure 6.14.4.1.2.1) using the ALK (age-length key) from DCF to slice the LFDs. The following length-weight relationship (cm-g): a =0.0035, b =3.28 was used.

The maturity at age has been derived by the maturity at length age sliced using the ALK.

The natural mortality by age has been calculated using Gislason method (Gislason et al., 2010).

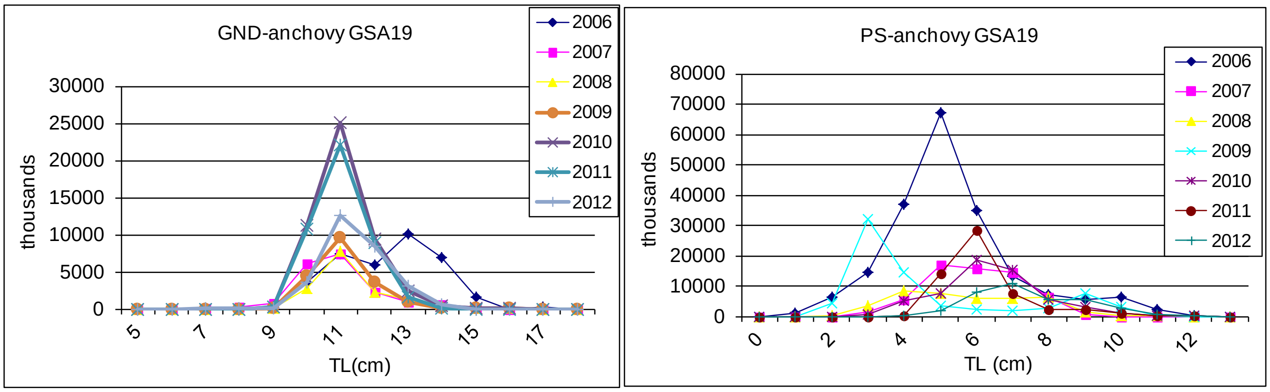



Figure 6.15.7.1.2.1.Anchovy GSA 19. Catch in numbers by length.

Table 6.15.7.1.2.1.Anchovy GSA 19. Catch in numbers by age (thousands).

| Year | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|
| 2007 | 2272 | 40314 | 27081 | 8150 | 838 |
| 2008 | 5251 | 23477 | 16447 | 7277 | 1670 |
| 2009 | 44134 | 20407 | 11898 | 8335 | 5587 |
| 2010 | 2647 | 42430 | 42941 | 14022 | 3550 |
| 2011 | 4889 | 42427 | 41882 | 7376 | 2108 |
| 2012 | 252 | 23165 | 29871 | 8413 | 1807 |

Table 6.15.7.1.2.2.Anchovy GSA 19. Individual weight in catch by age (kg).

| Year | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|
| 2007 | 0.005 | 0.008 | 0.013 | 0.017 | 0.02 |
| 2008 | 0.006 | 0.009 | 0.011 | 0.016 | 0.022 |
| 2009 | 0.005 | 0.008 | 0.011 | 0.017 | 0.02 |
| 2010 | 0.004 | 0.008 | 0.01 | 0.014 | 0.018 |
| 2011 | 0.007 | 0.009 | 0.01 | 0.013 | 0.019 |
| 2012 | 0.005 | 0.011 | 0.013 | 0.016 | 0.023 |

Table 6.15.7.1.2.3.Anchovy GSA 19. Maturity by age.

| Age | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|
| 2007-2012 | 0.27 | 0.81 | 1 | 1 | 1 |

Table 6.15.7.1.2.4.Anchovy GSA 19. Natural mortality by age (Gislason et al., 2010).

| Age | 0 | 1 | 2 | 3 | 4+ |
|---|---|---|---|---|---|
| 2007-2012 | 1.332 | 0.99 | 0.665 | 0.517 | 0.436 |

The reference age chosen to run the separable VPA is the one most represented in the catch (age 1). A sensitivity analysis on the results with Fterminal values 0.2, 0.4 and 0.6 has been performed.

The $F_{current}$ has been calculated on age 1-3 that are the most represented in the catches.

Results

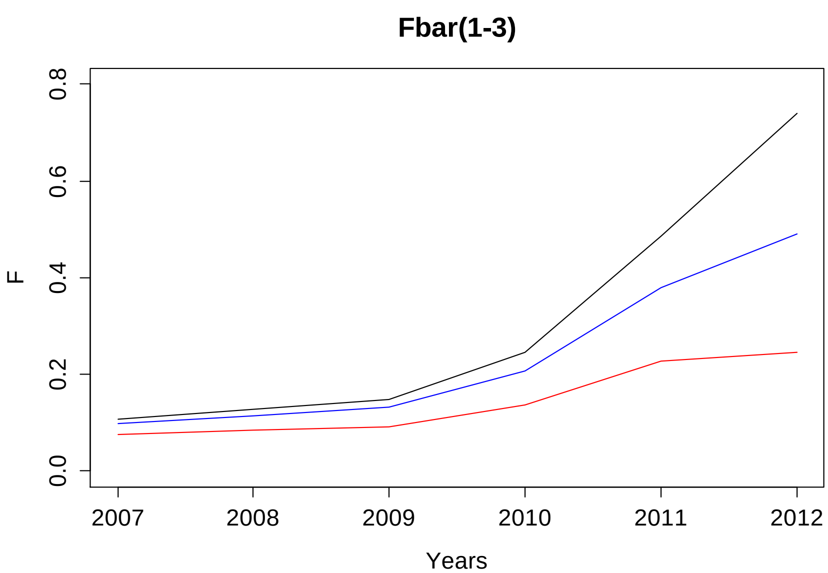



Figure 6.15.7.1.3.1.Anchovy GSA 19. Sensitivity of $F_{bar}$ with Fterminal 0.2 (red), 0.4 (blue) and 0.6 (black).

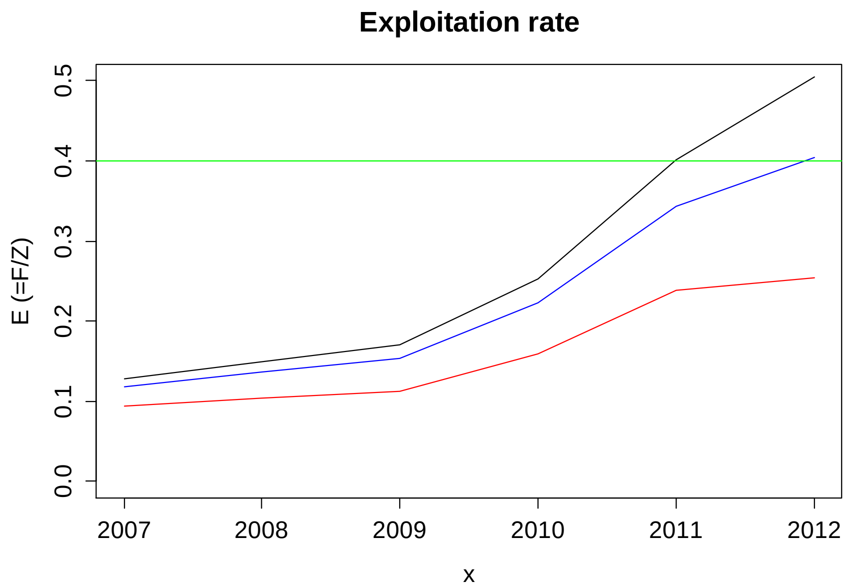



Figure 6.15.7.1.3.2.Anchovy GSA 19. Sensitivity of Exploitation Rate (F/Z) with $F_{termina}$l 0.2 (red), 0.4 (blue) and 0.6 (black).

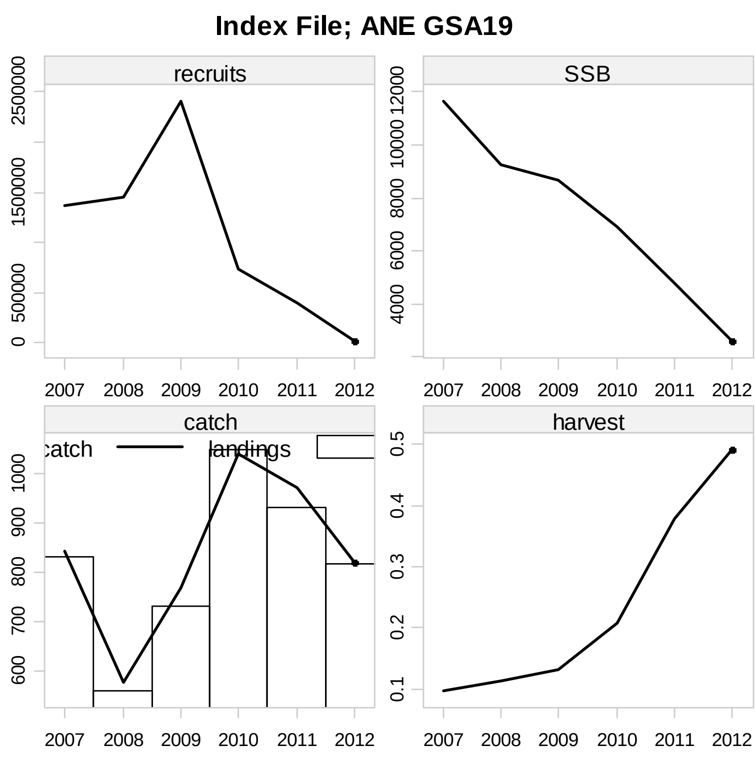



Figure 6.15.7.1.3.3 Summary of results ($F_{terminal}$=0.4).

The estimated fishing mortality shows a sharp increase in 2011, probably due to the decrease in recruitment from 2009 to 2010. The exploitation rate increases from about 0.12 in 2007 to a range from 0.25 to 0.5 in 2012, according to the different terminal F values. The value of the exploitation rate for two terminal F (0.2 and 0.4) among the three tested is lower than or equal to the reference point selected for small pelagic stocks (E=0.4). Given the level of M in the last age class (4+; 0.436) a terminal F=0.4 seems more plausible.

However, there is uncertainty in the last year estimates, also because of the lack of eco-survey data that would represent a more reliable and independent source of information especially for better understanding the recruitment pattern along the time. Thus, the results of the present assessment can be only considered indicative of trends and should be taken with caution.

### 6.15.7. Long term prediction

As the assessment is only indicative of trend for SSB and R, EWG 13-19 was not able to provide long term forecast for this stock.

### 6.15.8. Short term prediction 2013-2014

As the assessment is only indicative of trend for SSB and R, EWG 13-19 was not able to provide short term forecast for this stock.

### 6.15.9. Data quality

Data from DCF 2013 were used. Assessments were performed using the submitted time series. The difference observed in the sum of products of submitted age and length data compared to submitted landings are less than 10%. Discards data of 2011 and 2012 were available. Information on number of samples for landings, discards and catches, as well as the number of measurements by length for landings, discards and catches were also available. MEDITS raw data have been provided by JRC; the abundance indices have been calculated by the experts using ELASMOSTAT R routine (Facchini et al.) given some difficulties in getting outputs from the JRC database.

Eco-survey data were not available because there is not a monitoring program in place in this GSA. For this reason, tuned assessment models as XSA could not be used during EWG 13-19. It is suggested to perform eco-survey in this area to obtain suitable survey abundance indices that would assist a the evaluation on the state of this stock.

The effort data of PS and GND fleet segments were lacking for 2010 in SA19. The landing for GND fleet segment was lacking in 2009 and 2010 because the metier was not selected by the ranking system of DCF in the area.

### 6.15.10. Scientific advice

Short term considerations

State of the stock size

In the absence of proposed and agreed precautionary management references, EWG 13-19 is unable to fully evaluate the status of SSB. However the results of the separable VPA show a decline of the SSB from 2007 to 2012.

State of recruitment

In the absence of eco-survey data for this area it was not possible to evaluate the state of recruitment. However, the separable VPA showed a sharp decrease of recruitment in the last year.

State of exploitation

EWG 13-19 proposes E<=0.4 as limit management reference point of exploitation consistent with high long term yield. However, as the assessment is only indicative of trend for SSB and R, the state of the stock cannot be defined and thus EWG 13-19 was not able to provide short term forecast for this stock.

Management recommendations

Based on the F estimates from a separable VPA the values of the exploitation rate E are in 2 of the 3 tested scenarios using 3 different Fterminal below the proposed E<=0.4 as limit management reference point of exploitation consistent with high long term yield. However, as the assessment is only indicative of trend for SSB and R, EWG 13-19 was not able to provide short term forecast for this stock.

## References

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## 6.16. **Stock assessment of Anchovy in GSA 22**

The stock of anchovy in GSA 22 has been previously assessed (SGMED 08-04) by means of Integrated Catch at Age analysis in the framework of SGMED 09-02. Following the suggestion of EWG 11-20, in the EWG 12-03 a further assessment of the stock was performed on the same data set following a different analytical methodology. EWG 13-19 has been requested to verify the possibility to update the assessment of anchovy in GSA 22. However, due to the fact that no data were made available for anchovy stock in GSA 22 between 2008 and 2012, EWG 13-19 was not able to provide an updated assessment of anchovy stock in GSA 22.

## 6.17. **ToR C 2 Estimate of reference points of Anchovy and Sardine in GSA 17**

### 6.17.1. **Introduction**

Reference points (fishing mortality and biomass) were estimated for two stocks, namely anchovy and sardine of GSA 17, whose stock assessment are included in section 6.11 and 6.12.Estimation of reference points was done based on the methodology described in Simmonds *et al*., (2011) which originated as a working document to the 2010 WKFRAME meeting (Anon., 2010): the same procedure was applied to the same stocks during the EWG 12-19 (STECF, 2012).The framework uses computer intensive methods to estimate MSY (Maximum Sustainable Yield) reference points and calculates for a given value of $B_{lim}$ corresponding $F_{lim}$ reference points with a probabilistic interpretation (for further methodological details, see STECF 2012).

### 6.17.2. **Anchovy**

The fits of the stock recruitment model are shown in figure 6.17.2.1 and the results of the simulations are given in figure 6.17.2.1.1. A hockey-stick model was applied to the anchovy stock. The SSB considered in the model included 30% of age 0, and from age 1 to 4+.

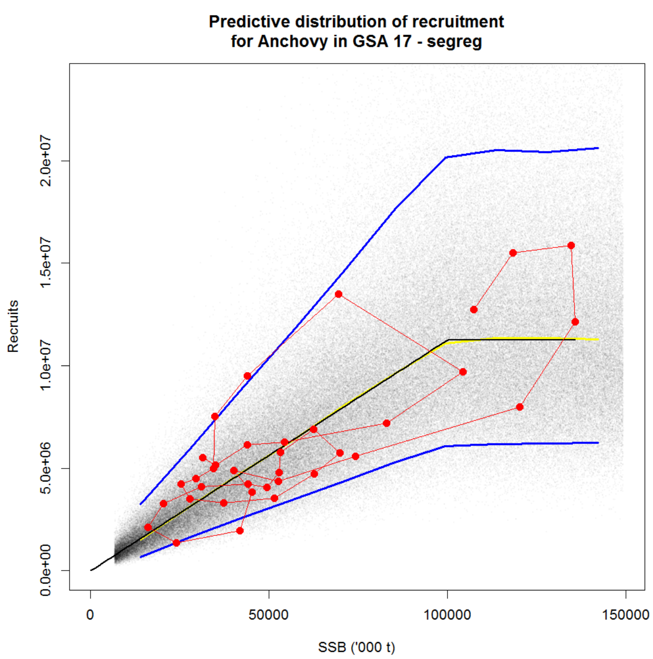


Figure 6.17.2.1. Hockey-stick stock-recruitment model fits showing the data (red), the median (yellow) and the 5$^{th}$ and 95$^{th}$ percentiles for anchovy in GSA 17.

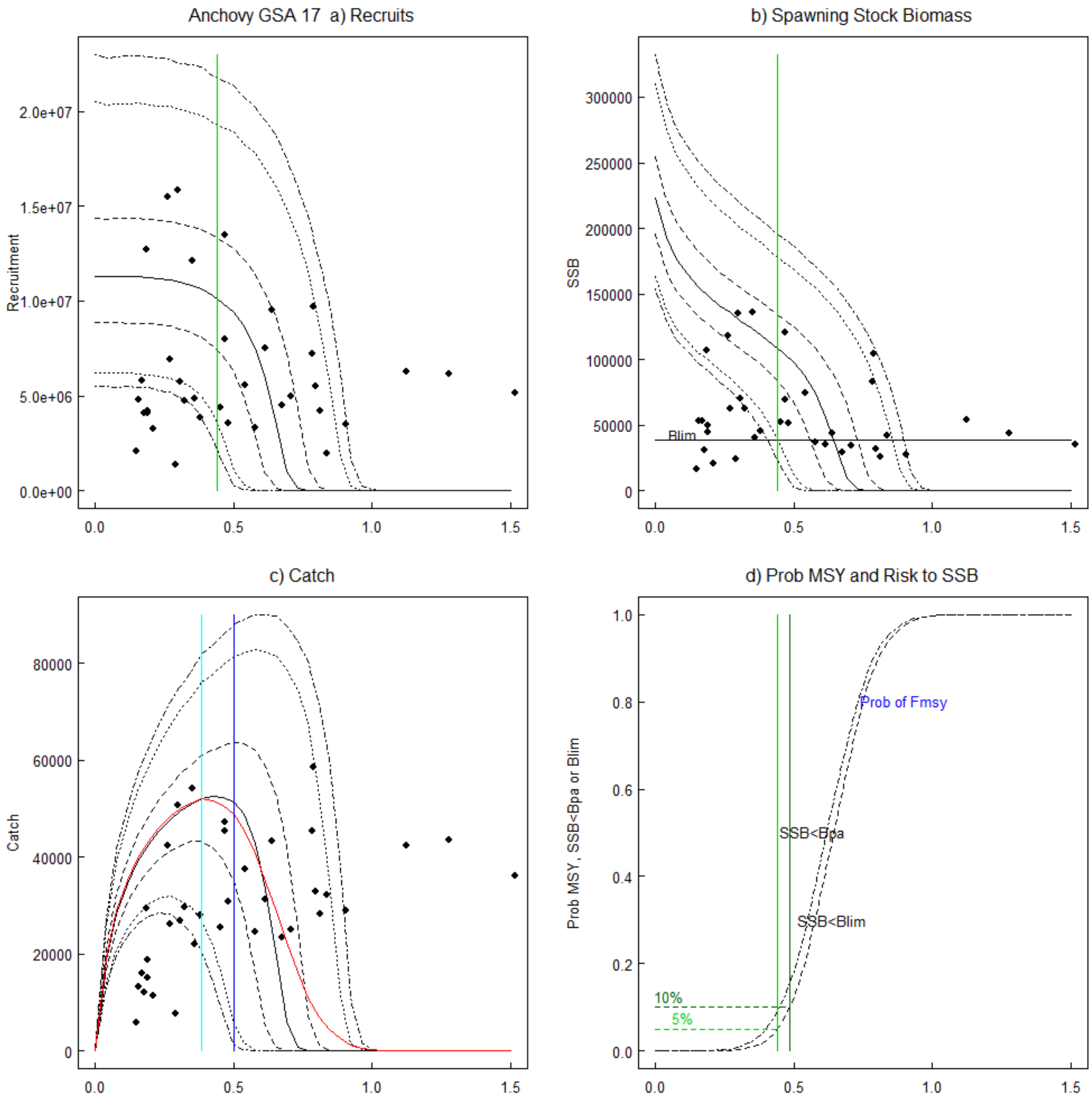


Figure 6.17.2.2. A summary of the state of the equilibrium stock under different fishing mortalities for anchovy in GSA 17. The points show the recent state of the stock. Panel a) shows the distribution of recruitment against $F_{bar}$, the solid line is the median, with the remaining dotted lines showing the $25^{th}$ and $75^{th}$, $5^{th}$ and $95^{th}$, and $2.5^{th}$ and $97.5^{th}$ quantiles. The vertical green bar shows the position of $F_{lim5}$. Panel b) show the same for SSB against F with a solid horizontal line representing $B_{lim}$ highlighting the definition of $F_{lim5}$. Panel c) shows catch against $F_{bar}$, here a red line shows average equilibrium catch, which is maximised at $F_{max\ catch}$ indicated by a vertical light blue line. In the final panel (d), $F_{lim5}$ (green) and $F_{lim10}$ (dark green) are shown as vertical lines.

### 6.17.3. **Sardine**

The fits of the stock recruitment model are shown in figure 6.17.3.1 and the results of the simulations are given in figure 6.17.3.2. A hockey-stick model was applied to the sardine stock.

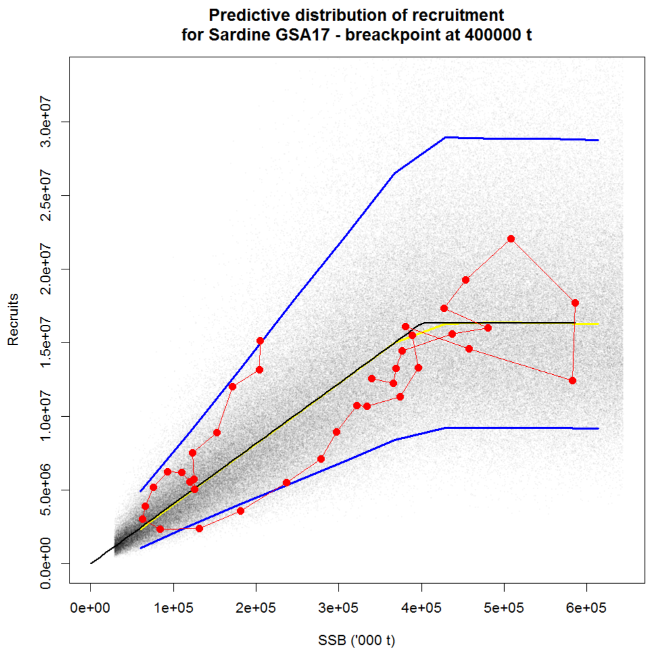


Figure 6.17.3.1. Hockey-stick stock-recruitment model fits showing the data (red), the median (yellow) and the 5th and 95th percentiles for sardine in GSA 17.

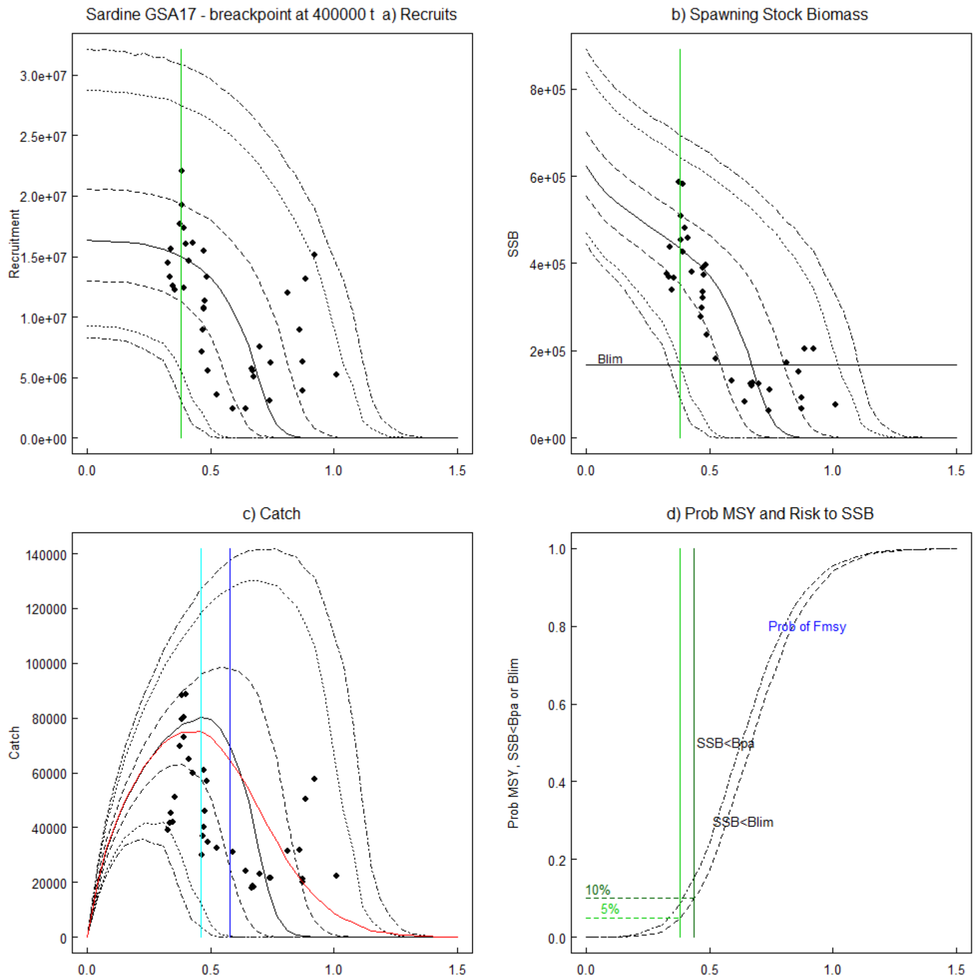


Figure 6.17.3.2. A summary of the state of the equilibrium stock under different fishing mortalities for sardine in GSA 17. The points show the recent state of the stock. Panel a) shows the distribution of recruitment against $F_{bar}$, the solid line is the median, with the remaining dotted lines showing the 25th and 75th, 5th and 95th, and 2.5th and 97.5th quantiles. The vertical green bar shows the position of $F_{lim5}$. Panel b) show the same for SSB against F with a solid horizontal line representing $B_{lim}$ highlighting the definition of $F_{lim5}$. Panel c) shows catch against $F_{bar}$, here a red line shows average equilibrium catch, which is maximised at $F_{max\ catch}$ indicated by a vertical light blue line. In the final panel (d), $F_{lim5}$ (green) and $F_{lim10}$ (dark green) are shown as vertical lines.

### 6.17.4. **Summary and recommendations**

EWG 13-19 suggest to adopt the following reference points for sardine and anchovy in GSA 17 (i.e Table 6.17.4.1):

Table 6.17.4.1.Estimated reference point sfor sardine and anchovy in GSA 17. $F_{lim5}$, and $F_{lim10}$ are the F values that give a 5% and 10% probability of SSB falling below $B_{lim}$. $F_{MSY}$ is the median F that gives maximum sustainable yield and $F_{max\ catch}$ maximises average catch. $B_{lim}$ was defined as 30% of maximum observed SSB.

| Reference point | Sardine | Anchovy |
|---|---|---|
| $B_{lim}$ | 167383 | 38791 |
| $B_{pa}$ | 234336 | 54307 |
| $F_{lim5}$ | 0.38 | 0.44 |
| $F_{lim10}$ | 0.44 | 0.48 |
| $F_{MSY}$ | 0.58 | 0.50 |
| $F_{maxCatch}$ | 0.46 | 0.38 |
| SSB at $F_{MSY}$ | 300069 | 97611 |
| SSB at $F_{maxCatch}$ | 396025 | 118311 |

The EWG 13-19 adopted the F that maximises the average catches ($F_{maxCatch}$)as proxy of $F_{MSY}$. The estimated values were 0.46 and 0.38 for sardine and anchovy, respectively.

References

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STECF (2012) Report of the Scientific, Technical and Economic Committee for Fisheries (STECF 12-19) on Assessment of Mediterranean Sea Stocks part II (SGMED). Ancona, 03– 08 December 2012.

## 6.18. **TOR C.3 Short-term forecasts by fisheries/métier**

The EWG 13-19 discussed the request made by DGMARE in the framework of ToR C3. The EWG 13-19 decided that the calculations of partial fishing mortality using the Fcube approach, which considers the average F ($F_{bar}$) levels and catch rates by fisheries/métier in tonnage, assuming identical selectivity at age across fisheries/métier, as a consequence of limitations in the available data, is not appropriate for most of the Mediterranean exploited resources, especially demersal species. Moreover, Fcube is largely dependent on catchability (q) and effort share. If the estimates of these parameters deviate far from the actual ones, great inconsistencies may arise in the effort and catch estimates, especially for fleets with very dissimilar exploitation patterns. This makes the application of the Fcube methodology, that is heavily dependent on effort measurements, more difficult. In addition, the old version of the software is designed for short term forecasts (for the running of one future year) and is not age specific. Thus, medium term and selection effects cannot be simulated and short term advice might be biased in cases of recruitment events. Moreover, the relationship between fishing mortality and fishing effort is not necessarily proportional and it has been rarely investigated for Mediterranena fisheries.

In the case of Mediterranean stocks, the main weakness of calculating partial F from the catch ratios is mainly related to the evidence that the same stock is usually exploited by different fisheries with completely different population selectivity. The estimation of partial F in such cases should be carried out with more complex approaches, not assuming a steady state situation (as VIT model) and allowing the possibility to modulate the selectivity of each fleet. In the case of common sole in GSA 17 (STECF EWG 13-09) the estimation of partial F for each of the main three fleets has been carried out employing SS3 model assuming different selectivity for each fleet. Common sole in GSA 17 has been utilized as an example in order to calculate short-term forecasts by fleet using AlaDym software. However due the uncertainty in the relationship between fishing mortality and fishing effort was not possible to further analyse the implications of the proposed changes in fishing mortality on the fishing effort exerted by the relevant fleets.

### 6.18.1. Short-term forecasts by fleet exploiting common sole in GSA 17

Due to the availability of partial F estimations of different fleets for common sole in GSA 17, during EWG 13-19 short-term forecasts have been carried out for each fleet using AlaDym software by hindcast approach (Lembo et al., 2009). The reference point estimated from the common sole stock during EWG 13-09 was the value of $F_{0.1}$ (0.31) estimated with the Y/R model. The forecasts have been conducted using AlaDym in Z mode changing the fishing coefficient in 2014 and 2015 as reported in the following table 6.18.1.1, in order to reach the $F_{0.1}$ in 2014:

Table 6.18.1.1. Common sole GSA 17. Input data for Aladym forecast.

| year | Z | Recruitment | Selectivity | | | | |
|---|---|---|---|---|---|---|---|
| 2006 | 2.16 | 38118 | **Fleet segment** | **Type** | **SL50** | **SR** | **DSL50** |
| 2007 | 2.03 | 33309 | Beam trawl ITA | ogive deselection | 170 | 15 | 250 |
| 2008 | 1.79 | 38878 | Set netters ITA | gaussian | 210 | 30 | |
| 2009 | 2.31 | 43143 | Set netters CRO+SLO | ogive deselection | 260 | 20 | 340 |
| 2010 | 1.85 | 35989 | | | | | |
| 2011 | 1.74 | 40228 | | | | | |
| 2012 | 1.85 | 44255 | | | | | |
| 2013 | 1.85 | 44255 | | | | | |
| 2014 | 1.85 | 44255 | | | | | |
| 2015 | 1.85 | 44255 | | | | | |

| Year | Month | F coeff. | Fleet segmentt | Year | Month | F coeff | fleet_segment | Year | Month | F coeff | Fleet segmentt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | Jan | 1.09 | Beam trawl ITA | 2013 | Jan | 0 | Set netters ITA | 2013 | Jan | 0 | Set netters CRO+SLO |
| 2013 | Feb | 1.09 | Beam trawl ITA | 2013 | Feb | 0 | Set netters ITA | 2013 | Feb | 0 | Set netters CRO+SLO |
| 2013 | Mar | 1.09 | Beam trawl I\TA | 2013 | Mar | 0 | Set netters ITA | 2013 | Mar | 0 | Set netters CRO+SLO |
| 2013 | Apr | 1.09 | Beam trawl ITA | 2013 | Apr | 0 | Set netters ITA | 2013 | Apr | 0 | Set netters CRO+SLO |
| 2013 | May | 1.09 | Beam trawl ITA | 2013 | May | 0 | Set netters ITA | 2013 | May | 0 | Set netters CRO+SLO |
| 2013 | Jun | 1.09 | Beam trawl ITA | 2013 | Jun | 0 | Set netters ITA | 2013 | Jun | 0 | Set netters CRO+SLO |
| 2013 | Jul | 1.09 | Beam trawl ITA | 2013 | Jul | 2 | Set netters ITA | 2013 | Jul | 2 | Set netters CRO+SLO |
| 2013 | Aug | 0.00 | Beam trawl ITA | 2013 | Aug | 2 | Set netters ITA | 2013 | Aug | 2 | Set netters CRO+SLO |
| 2013 | Sep | 1.09 | Beam trawl ITA | 2013 | Sep | 2 | Set netters ITA | 2013 | Sep | 2 | Set netters CRO+SLO |
| 2013 | Oct | 1.09 | Beam trawl ITA | 2013 | Oct | 2 | Set netters ITA | 2013 | Oct | 2 | Set netters CRO+SLO |
| 2013 | Nov | 1.09 | Beam trawl ITA | 2013 | Nov | 2 | Set netters ITA | 2013 | Nov | 2 | Set netters CRO+SLO |
| 2013 | Dec | 1.09 | Beam trawl ITA | 2013 | Dec | 2 | Set netters ITA | 2013 | Dec | 2 | Set netters CRO+SLO |
| 2014 | Jan | 0.40 | Beam trawl ITA | 2014 | Jan | 0 | Set netters ITA | 2014 | Jan | 0 | Set netters CRO+SLO |
| 2014 | Feb | 0.40 | Beam trawl ITA | 2014 | Feb | 0 | Set netters ITA | 2014 | Feb | 0 | Set netters CRO+SLO |
| 2014 | Mar | 0.40 | Beam trawl ITA | 2014 | Mar | 0 | Set netters ITA | 2014 | Mar | 0 | Set netters CRO+SLO |
| 2014 | Apr | 0.40 | Beam trawl ITA | 2014 | Apr | 0 | Set netters ITA | 2014 | Apr | 0 | Set netters CRO+SLO |
| 2014 | May | 0.40 | Beam trawl ITA | 2014 | May | 0 | Set netters ITA | 2014 | May | 0 | Set netters CRO+SLO |
| 2014 | Jun | 0.40 | Beam trawl ITA | 2014 | Jun | 0 | Set netters ITA | 2014 | Jun | 0 | Set netters CRO+SLO |
| 2014 | Jul | 0.40 | Beam trawl ITA | 2014 | Jul | 0.74 | Set netters ITA | 2014 | Jul | 0.74 | Set netters CRO+SLO |

| | | | |
|---|---|---|---|
| 2014 | Aug | 0.00 | Beam trawl ITA |
| 2014 | Sep | 0.40 | Beam trawl ITA |
| 2014 | Oct | 0.40 | Beam trawl ITA |
| 2014 | Nov | 0.40 | Beam trawl ITA |
| 2014 | Dec | 0.40 | Beam trawl ITA |
| 2015 | Jan | 0.40 | Beam trawl ITA |
| 2015 | Feb | 0.40 | Beam trawl ITA |
| 2015 | Mar | 0.40 | Beam trawl ITA |
| 2015 | Apr | 0.40 | Beam trawl ITA |
| 2015 | May | 0.40 | Beam trawl ITA |
| 2015 | Jun | 0.40 | Beam trawl ITA |
| 2015 | Jul | 0.40 | Beam trawl ITA |
| 2015 | Aug | 0.00 | Beam trawl ITA |
| 2015 | Sep | 0.40 | Beam trawl ITA |
| 2015 | Oct | 0.40 | Beam trawl ITA |
| 2015 | Nov | 0.40 | Beam trawl ITA |
| 2015 | Dec | 0.40 | Beam trawl ITA |

| | | | |
|---|---|---|---|
| 2014 | Aug | 0.74 | Set netters ITA |
| 2014 | Sep | 0.74 | Set netters ITA |
| 2014 | Oct | 0.74 | Set netters ITA |
| 2014 | Nov | 0.74 | Set netters ITA |
| 2014 | Dec | 0.74 | Set netters ITA |
| 2015 | Jan | 0 | Set netters ITA |
| 2015 | Feb | 0 | Set netters ITA |
| 2015 | Mar | 0 | Set netters ITA |
| 2015 | Apr | 0 | Set netters ITA |
| 2015 | May | 0 | Set netters ITA |
| 2015 | Jun | 0 | Set netters ITA |
| 2015 | Jul | 0.74 | Set netters ITA |
| 2015 | Aug | 0.74 | Set netters ITA |
| 2015 | Sep | 0.74 | Set netters ITA |
| 2015 | Oct | 0.74 | Set netters ITA |
| 2015 | Nov | 0.74 | Set netters ITA |
| 2015 | Dec | 0.74 | Set netters ITA |

| | | | |
|---|---|---|---|
| 2014 | Aug | 0.74 | Set netters CRO+SLO |
| 2014 | Sep | 0.74 | Set netters CRO+SLO |
| 2014 | Oct | 0.74 | Set netters CRO+SLO |
| 2014 | Nov | 0.74 | Set netters CRO+SLO |
| 2014 | Dec | 0.74 | Set netters CRO+SLO |
| 2015 | Jan | 0 | Set netters CRO+SLO |
| 2015 | Feb | 0 | Set netters CRO+SLO |
| 2015 | Mar | 0 | Set netters CRO+SLO |
| 2015 | Apr | 0 | Set netters CRO+SLO |
| 2015 | May | 0 | Set netters CRO+SLO |
| 2015 | Jun | 0 | Set netters CRO+SLO |
| 2015 | Jul | 0.74 | Set netters CRO+SLO |
| 2015 | Aug | 0.74 | Set netters CRO+SLO |
| 2015 | Sep | 0.74 | Set netters CRO+SLO |
| 2015 | Oct | 0.74 | Set netters CRO+SLO |
| 2015 | Nov | 0.74 | Set netters CRO+SLO |
| 2015 | Dec | 0.74 | Set netters CRO+SLO |

When ALADYM operates in Z mode every month of the simulation the fishing mortality by fleet segment is calculated modulating the maximum F by means of selectivity functions and the proportions of production of the different fleet, following the formula below:

$$F_f(a) = (Z_{inp} - mean(M)) * Sel_f(a) * f_{act,f} * p_f$$

where $f_{act,f}$ is the F coefficient of fleet *f* as reported in table 17.1.1, $Sel_f(a)$ the selectivity of fleet *f* in the age class *a*, $Z_{inp}$ the total mortality in input, *mean(M)* the average natural mortality on all the age classes and the production coefficient $p_f$ is an estimate of the proportion of *F* due to fleet segment *f*. The fishing coefficient $f_{act,f}$ in the simulation phase (past/present years) and at month scale is calculated as:

$$f_{act,f} = \frac{FD_f * Nb\_vessels_f * GT_f}{annual\_mean(FD_f * Nb\_vessels_f * GT_f)}$$

while in the forecast phase is calculated as:

$$f_{act,f} = \frac{FD_f * Nb\_vessels_f * GT_f}{baseline\_annual\_mean(FD_f * Nb\_vessels_f * GT_f)}$$

The production coefficient in the simulation phase (past/present years) and at month scale is calculated as:

$$p_f = \frac{Production_f}{\sum_{i=1}^{N} Production_i}$$

where *N* is the total number of fleet segments. In the forecast phase the production ratio is set equal to the average of the production ratio of the last n years, as set by the user. Only the fishing coefficient modulates the monthly differences.

The forecast results evidenced that reducing the partial F of each fleet toward the reference point in 2014 a 48% increment of SSB is observed from 2014 to 2015, while a 48% reduction of the overall catches is observed from 2012 to 2014, such reduction is less strong for the Italian set netters exploiting the juvenile portion of the population. However in 2015 there is an increase of the production if compared with 2014 for all fleets, in particular the increase of SSB will lead to a recover of Croatian and Slovenian set netters yields toward values observed in the period before the F reduction of 2014 (Fig. 6.18.1.1).

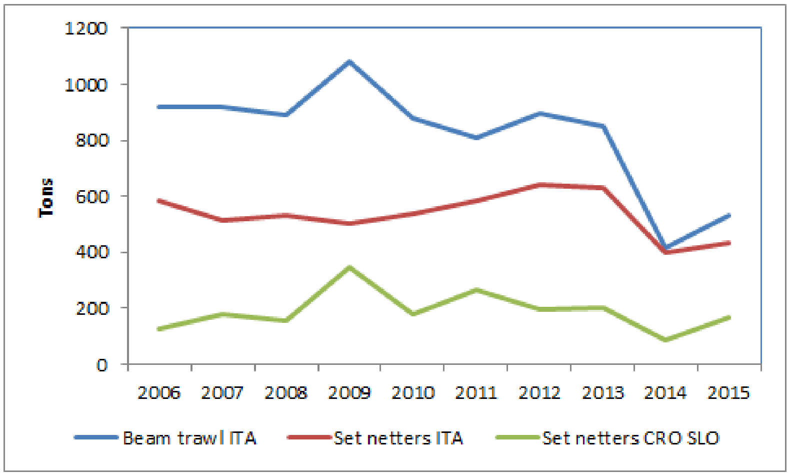



Fig. 6.18.1.1. Common sole production in GSA 17 simulated with AlaDym software.

Medium term forecasts have not be conducted due the unavailability of an appropriate stock-recruitment relationship.

### 6.18.2. **Conclusions**

The calculation of partial F by fleet/metiers should be carried out with appropriate models allowing the possibility of assuming different population selection curves. One of the major issues with methodologies employed until now in the assessment of Mediterranean stocks is that the methods usually do not allow the use of different functional form of selectivity than the and it do not allow the estimation of selectivity. Such shortcoming restricts the number of selectivity scenarios that can be modelled for each stock assessment. Mediterranean demersal fisheries are often characterized by an intense exploitation of juveniles, while older individuals are less available to the gears, especially trawls, as they are more abundant in non trawlable areas as for example is the case for hake, and for sole in GSA 17. Moreover, often different gears exploit different age classes within the population. This implies that using a single logistic selectivity as assumed in the XSA might tend to overestimate F and underestimate SSB. Nowadays, more complex models exists (e.g. statistical catch at age), which can actually estimate or use different selectivity functions but these models are more complex and have been limited tested in the Mediterranean: only for 4 stocks during EWG 13-09 and EWG 13-19, sole and red mullet in GSA 17 with SS3 and Norway lobster in GSA 15 and 16 and Hake in GSA 07 with FLa4a. EWG 13-19 consider that it would be crucial to evaluate the possibility of using statistical catch at age models in the future with different assumption on selectivity by fleet, especially to estimate partial F by fisheries/metiers. Furthermore, simulation models could be used to compare the results of the fleet based assessment with simulated ones; the hind casting approach could be used, as made in this exercise using ALADYM, which provides a set of different selectivity function allowing to support a number of assumptions on selectivity of the fleet.However the use of more complex approaches needs the availability of longer time series of fishery dependent and independent data in order to run the model and the availability other sources of data (e.g. VMS or AIS) in order to operate with appropriate assumptions. Furthermore the availability of such information has to be supported by a scientific community having a deep knowledge of the stock dynamic and connectivity as well as the capacity in using complex statistical frameworks for calibration of population dynamics models. In order to have a wider use of such models a process of capacity building of the scientific community involved in stock assessment needs to be taken into consideration for the future, also considering that such approaches are quite time consuming and needs an higher computation power.

In summary the EWG 13-19 is not able to fully address the ToR C-3 mainly due to the following reasons:

- the calculation of partial F by fleet/metiers should be carried out with appropriate and more complex models than used within the EWG and which currently are not commonly utilized, allowing the possibility of assuming different population selection curves;
- the lack of long time series of fishery dependent and independent data and lack of knowledge on stock dynamics and connectivity for most of the exploited resources of the Mediterranean, allowing the possibility of use more complex approaches (AlaDym, SS3, ASAP, Fla4a, etc.). In such context, a simulation exercise using a virtual stock with simulated data and parameters would be an appropriate test in order to confirm the outputs of more complex methods;
- time constraints and lack of expertise in the use of complex multi-fleet models. Such drawback can be solved with the promotion of a capacity building process in the scientific community involved in stock assessment for example through ad-hoc courses.

## 6.19. **ToR D, Scientific advice for small pelagics in GSA 17 and 18**

GFCM Recommendation 37/2013/1 establishes a multiannual management plan for fisheries on small pelagic stocks in the GFCM-GSA 17 (Northern Adriatic Sea) and transitional conservation measures for fisheries on small pelagic stocks in GSA 18 (Southern Adriatic Sea). The plan for GSA 17 is based on the exploitation rate E lower than 0.4 and on mid-year spawning biomass precautionary and limit reference points respectively of 250,600 tonnes and 179,000 tonnes for anchovy and of 109,200 tonnes and 78,000 tonnes for sardine.

The GFCM-SAC is expected to provide on annual basis as from 2014 advice on the status of the small pelagic stocks, including catch forecasts in line with precautionary approach and the MSY, in GSA 17 and GSA 18. The STECF EWG is requested to prepare the ground in support of the forthcoming GFCM-SAC working group and to advise on:

- the relative position of the mid-year spawning stock biomass with respect to the precautionary and limit reference points both for anchovy and sardine (**TOR D1**)

- the level of exploitation rate with respect to the reference point of E = 0.4 (**TOR D2**)

- the uniqueness or separation of the anchovy and sardine stocks between the two GSA 17 and 18 (**TOR D3**).

-the areas of aggregation of anchovy and sardine juveniles in their first year of life. To this end it is advisable to use the statistical grids of 30'x30' as established by the GFCM/35/2011/1 concerning the establishment of a GFCM logbook (**TOR D4**).

### 6.19.1. **TOR D1**

To calculate the relative position of the mid-year spawning stock biomass with respect to the precautionary and limit reference points both for anchovy and sardine in GSA 17 and GSA 18, stock assessments for the two stocks were performed.

### 6.19.2. **Assessment of GSA 18**

EWG 13-19 attempted to assess the state of both anchovy and sardine stocks of GSA 18: the models used were Extended Survivors Analysis (XSA) and State-space assessment model(SAM). The data used were:

- Italian landings data from 2004 to 2012 from DCF
- Italian catch at age data from 2006 to 2012 from DCF
- Italian mean weight at age data from 2006 to 2012 from DCF
- Landings data for Albania and Montenegro from GFCM statistics (2004-2010)
- Acoustic survey data for the entire GSA 18 from 2005 to 2012 from DCF
- Natural mortality M and maturity at age: assumed equal to the vectors used for anchovy and sardine stocks of GSA 17

Results from both the models were not satisfactory: the log-catchability residuals at age calculated by XSA ranged between -100 and +100. Moreover, estimates for $F_{bar}$ reached in 2011 a value of 4, really high considering the fleet composition of GSA 18. Several attempts have been made in the parameterization of SAM, changing the aggregations of the age classes for the calculation of fishing mortality, but the model seemed to have convergence problems, probably due to the shortness of the time series.

It is important to highlight that Albanian and Montenegrin catches are really low respect to the Italian catches (less than 1% for anchovy and about 11% for sardine). Besides, the Italian boats registered in GSA 18 most probably fish in GSA 17 (this should be confirmed having access to VMS data). For these reasons, it seemed quite reasonable to join the data from GSA 18 to GSA 17. Nevertheless, the landings data from GSA 18 span only from 2004 to 2012, while data from GSA 17 date back to 1975. An attempt to reconstruct the time series for GSA 18 from other sources (GFCM statistics) has been made but the total production for the Italian side GSA 17 and GSA 18 in GFCM statistics in several years was lower than the data available from 1975 and collected for GSA 17 from the CNR-ISMAR of Ancona. The EWG 13-19 considers that could be useful to explore more options in order to reconstruct the time series of the landings for GSA 18, in order to join the two GSAs to produce future more robust assessments. After these preliminary attempts to assess the stocks for GSA 18, the assessment of anchovy and sardine stocks have been performed/updated only for GSA 17, in order to answer, at least partially, this ToR.

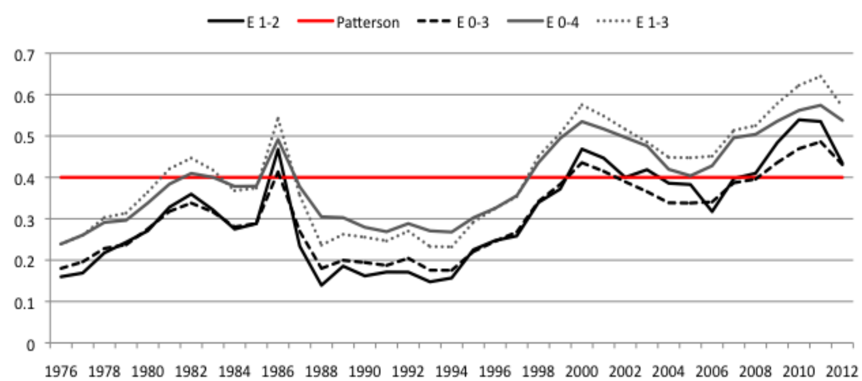
### 6.19.3. **Assessment of GSA17**

During EWG 13-19 the stock of anchovy and sardine in GSA 17 was assessed by the means of SAM. The spawning stock biomass estimated for anchovy for 2012 is equal to 123,000 tons, with 95% confidence intervals of (71,052, 215,957). The GFCM-SAC limit and precautionary biomass reference points for this stock are equal to respectively $B_{lim}$=179,000 tons and $B_{pa}$=250,600 tons, so anchovy stock biomass in the Adriatic Sea is below the limit reference points of 179,000 tons. Nevertheless, since those reference points are based on the values in biomass time series estimated with ICA method, which are quite higher than the ones estimated by SAM, the EWG considers that would be reasonable to re-estimate them on the basis of SAM results, in order to have a coherent comparison between the estimated biomass and the reference points.

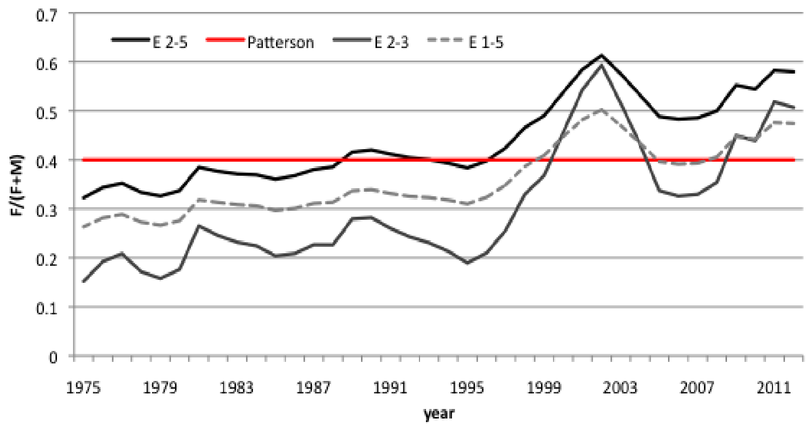
The spawning stock biomass estimated for sardine for 2012 estimated during EWG 13-19 is equal to 220,577tons, with 95% confidence intervals of (144,177, 337,460). The GFCM-SAC limit and precautionary biomass reference points for this stock are equal to respectively $B_{lim}$=78,000 tons and $B_{pa}$=109,200 tons, thus sardine stock biomass in the Adriatic Sea is well above both the limit and precautionary reference points. Same considerations made for anchovy stock about reference points and stock assessment methods are valid also for this stock.

### 6.19.4. **TOR D2.** The level of exploitation rate with respect to the reference point of E = 0.4

Respect to the exploitation rate reference point of 0.4 for small pelagics (Patterson, 1994), according to the SAM results, anchovy stock is slightly above it, with a value of 0.43 (estimated using age 1-2).




For sardine stock in GSA17, the exploitation rate estimated by SAM for 2012 is higher than the reference point and equals 0.57 (estimated using age 2-5).




6.19.5.**TOR D3.** The uniqueness or separation of the anchovy and sardine stocks between the two GSA 17 and 18.

Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) stocks are commercially shared among the countries belonging to GSA 17 (Italy, Croatia and Slovenia) and GSA 18 (Italy, Montenegro and Albania). Uniqueness or separation of the anchovy and sardine stocks between the two GSAs (17 and 18) can be considered throughout different views:

Biological point of view

Hypothesis of two distinct populations of anchovy, one in the North and one in the South Adriatic, was formulated due to evidences in morphometric differences, such as color and length, and due to some variability in their genetic structure (Bembo *et al*., 1996), though many authors point out disadvantages in using morphological data in studies on population structure (Tudela, 1999). A recent paper from Magoulas *et al*. (2006), revealed the presence of two different *clades* in the Mediterranean, one of those characterized by a high frequency (higher than 85%) with low nucleotide diversity (around 1%) present in part of the Mediterranean including Adriatic Sea: nevertheless, this study included only one sample from the Adriatic Sea and it did not solve the debate.

As far as sardine is concerned, there are evidence of no differences between northern and southern stock, based on a series of morphometric, meristic, serological and ecological characteristics, as well as the lack of genetic heterogeneity in the Adriatic stock demonstrated through genetic analyses (Carvalho *et al*. 1994, Tinti *et al*. 2002a,b, Ruggeri *et al*. 2013). Ruggeri *et al*. (2013), even if supporting the hypothesis of one stock on the basis of microsatellites DNA, suggest that some of the genetic homogeneity observed could be apparent and the identification of a subtle structuring in sardine population could be limited by technical difficulties and by the incomplete knowledge of molecular mechanisms: other molecular markers, such as single nucleotide polymorphisms, may solve definitively the debate.

Data availability

Data from GSA 17 (both sides) date back to 1975. On the other hand, data for GSA 18 are poor respect to GSA17 data. In fact, commercial landings for the western side of GSA 18 date back only to 2004; besides, these data are probably coming from GSA 17, since most of the boat registered in GSA 18 goes fishing in GSA 17 (this should be confirmed with VMS data). Moreover, commercial landings for the eastern side of GSA 18 are rather uncertain.

The conclusions made during EWG 13-19 are listed below:

- Sardine in GSA 17 and GSA 18 probably belong to the same stock, but further scientific confirmation is needed
- Anchovy in GSA 17 and GSA 18 probably belong to the same stock, but further scientific confirmation is needed
- In the future, it will be advisable to merge both GSAs for sardine and anchovy. However, data revision and building up for the GSA 18 is needed to avoid to break down the long times series of GSA 17. This is especially important when considering the fact that GSA 17 constitutes by far the largest part of the stock for both species.

6.19.6.**TOR D4.** The areas of aggregation of anchovy and sardine juveniles in their first year of life. To this end it is advisable to use the statistical grids of 30'x30' as established by the GFCM/35/2011/1 concerning the establishment of a GFCM logbook.

Although some investigations on the spawning and nursery grounds of sardine and anchovy have been done, they were spatially constrained. Namely, some data exist on juveniles of both the species on the western side of the GSA 17 and GSA 18, and some investigations are conducted on eggs and larvae in the eastern side.

Nevertheless, these data are not comparable between each other since they have been acquired at different times of the year; the comparison could be misleading since juveniles distribution can change during the recruitment season in relation to environmental forcing such as currents.

Both sardines and anchovy are shared stocks in GSA 17, and are distributed throughout the entire area (MEDIAS data): a detailed study on their nursery grounds have been conducted on the western part of Adriatic Sea (GSA 17 and GSA 18) during the SARDONE project (2008-2010). Nevertheless, would be necessary to join the findings of SARDONE to information available for the eastern part of the Adriatic, to have a general overview.

Moreover, in GSA 18, ichthyoplanktonic surveys were conducted recently to identify anchovy eggs and larvae distribution: some of the results were included into the last SAC-SCSA GFCM report (2012) for this area.

References

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Carvalho, G.R., D. Bembo, A. Carone, G. Giesbrecht, N. Cingolani, D., D. Levi and T.J. Pitcher (1994). Stock discrimination in relation to the assessment of Adriatic anchovy and sardine fisheries. *Final Project Report on European Community Funded Project* EC XIV1/MED/ 91/001/A, 172 pp.

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Tudela, S. (1999). Morphological variability in a Mediterranean, genetically homogeneous population of the European anchovy, *Engraulis encrasicolus*. *Fisheries Research*, *42*, 229–243.

## 6.20. **ToR E Review of data quality from DCF Mediterranean data call**

Review the quality and completeness of all data resulting from the official Mediterranean DCF data call issued on April 2013. STECF is requested to summarize and concisely describe in detail all data quality deficiencies of relevance for the assessment of stocks and fisheries. Such review and description are to be based the data format of the official DCF data calls for the Mediterranean issued on April 2013. Particular attentions should be devoted to assessing the quality of MEDITS survey for which inconsistencies had emerged during previous EWG meetings.

### 6.20.1.**DCF data**

Data quality was scrutinized by JRC data collection team at the time of data upload and database compilation and during the STECF EWG 13-19 by the experts. A general overview of the data is given below while detailed data issues are reported in each stock assessment in a specific data section.

In Tables 6.20.1 and 6.20.2 are summarized the data availability of fish landings and discards at age form Table A of the April 2013 data call, the number of records is the number of species for which data was submitted, by GSA and Year.

Table 6.20.1. Number of species for which landings at age have been reported in the 2013 Data Call for the available years.

| Number of Species for which are collected Numbers at Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTRY | AREA | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| ESP | SA 1 | 1 | 9 | 9 | 9 | 9 | 9 | 9 | 13 | 13 | 13 | 13 |
| ESP | SA 2 | | | | | | | | 1 | 1 | 1 | 1 |
| ESP | SA 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 8 | 8 | 8 | 9 |
| ESP | SA 6 | 7 | 8 | 8 | 8 | 7 | 7 | 8 | 12 | 12 | 12 | 12 |
| ESP | SA 7 | 1 | 1 | 4 | 4 | 4 | 4 | 4 | 10 | 10 | 7 | 10 |
| FRA | SA 7 | 2 | 2 | | 1 | 4 | 4 | 4 | 4 | 4 | 3 | 3 |
| ITA | SA 10 | | | | | 7 | 9 | 11 | 10 | 12 | 11 | 11 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITA | SA 11 | | | | 5 | 5 | 5 | 5 | 7 | 7 | 27 | 27 |
| ITA | SA 16 | | | | | | | 7 | 9 | 9 | | 9 |
| ITA | SA 17 | | | | 4 | 8 | 6 | 5 | 5 | 5 | 6 | 6 |
| ITA | SA 18 | | | | | 2 | 7 | 8 | 9 | 10 | 15 | 13 |
| ITA | SA 19 | | | | | 7 | 8 | 10 | 11 | 11 | 11 | 11 |
| ITA | SA 9 | | | | | 21 | 17 | 14 | 25 | 27 | 28 | 27 |
| MLT | SA 15 | | | | | 1 | 1 | 1 | 1 | 1 | | |
| BUL | SA 29 | | | | | | | | | | | |
| ROM | SA 29 | | | | | | | 5 | 5 | 5 | 5 | 6 |
| SVN | SA 17 | | | | | 2 | 2 | 2 | | 2 | 2 | 2 |

Table 6.20.2. Number of species for which **discards at age** in tons have been reported in the 2013 Data Call for the available years and GSAs (AREA).

| Number of Species for which are collected Discards at Age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| COUNTRY | AREA | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| FRA | SA 7 | | | | | | | | 1 |
| ITA | SA 10 | | 4 | | | 4 | 6 | 8 | 6 |
| ITA | SA 11 | 1 | 2 | | | 3 | 5 | 18 | 17 |
| ITA | SA 17 | | | | | | | 2 | |
| ITA | SA 18 | | | | | 7 | 6 | 10 | 8 |
| ITA | SA 19 | | 2 | | | 8 | 4 | 6 | 8 |
| ITA | SA 9 | | 9 | | | 19 | 21 | 25 | 21 |
| ROM | SA 29 | | | | 2 | 2 | 4 | 3 | 4 |

Details of the other DCF fisheries data table are not reported here but can be found on the 2012 Data Coverage Report published by JRC. The main data issues are summarized here: the quality of the fisheries data from GSA 11 (Italy) has impeded the EWG to conduct an assessments of striped red mullet in GSA 11. Also, lack of catch data for GSA 8 did not allow the EWG to conduct an assessment for any of the species in the area. Thus, EWG 13-19 reiterates that the situation with fisheries data in GSA 8 and 11 is of concerns. While for GSA 8 data should be provided, for GSA 11 a thorough review of the data and the data collection process is deemed necessary to be able to perform proper stock assessments. Since it is unclear the sampling level in GSA 11 and how the raising is performed, the EWG 13-19 considers necessary to access the raw sampling data to verify the raising procedures to evaluate properly the fisheries data.

### 6.20.2. MEDITS data quality

Since December 2012 JRC has developed quality checks with SQL routines in the MEDITS Postgres database of JRC to do cross table consistency tests and conformity to the survey manual checks. In total 26 routines where developed, these share a similar philosophy to the ROME routines (Spedicato and Bitetto 2012) and when ROME is used before data upload the JRC routines correctly show no error patterns.

A reduced number of quality check reports (number of erroneous records by year) are plotted for the data call of 2012 and the 2 data calls in 2013 (labelled as 7_2013 for the July 2013 call and 12_2013 for the December 2013 call) to identify changes in error patterns or corrections of previously identified errors. The checks has been run on the data in December 2013 and, in the case of upload of incomplete time series, the data from the previous data call was used to complete the time series.

The check of the vertical opening equal to zero in case of valid hauls (Figure 6.20.1) returns several errors in GSA 7 and GSA 8 in 2004, while it shows that in GSA 16 the data where corrected compared to the 2012 data call.

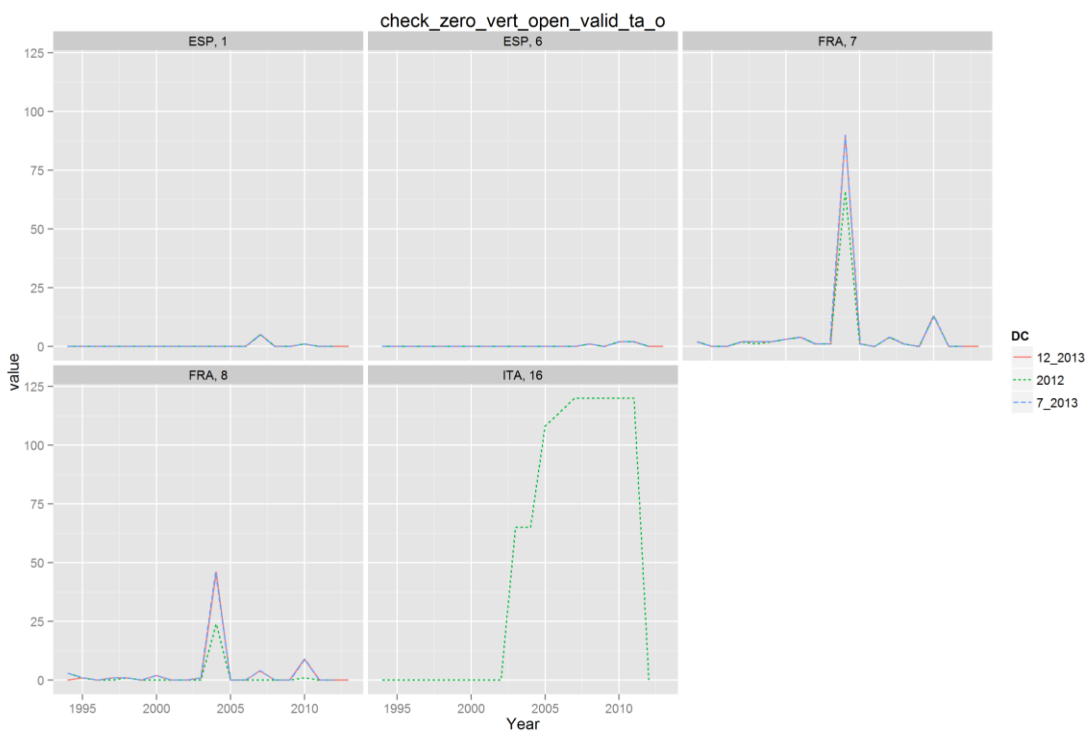


Figure 6.20.1. Check of valid hauls where vertical opening is declared as zero. The value is the number of errors by year, the columns indicate the GSA and the rows the country. In red the report from the December 2013 data call, in

blue from the June 2013 data call and in dashed green from 2012. As an example the lack of a red line in GSA 16 indicates that all the erroneous records where corrected in 2013. In case of overlapping lines there was no change or correction of the records.

A similar check is implemented for the wing opening equal to zero and hauls declared valid (Figure 6.20.2). Here the only errors pertain Spain but these were not corrected during the last two data calls.

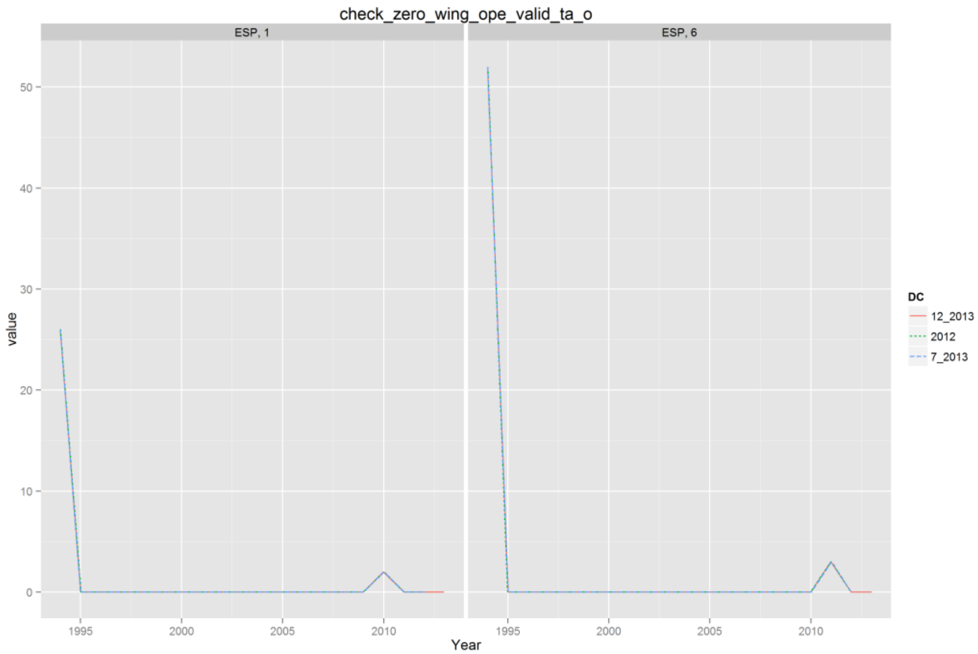


Figure 6.20.2. Erroneous records when wing opening is zero but the hauls are declared valid in the new and old data calls (2012 and 2013).In red the report from the December 2013 data call, in blue from the June 2013 data call and in dashed green from 2012.

The consistency of the haul duration was evaluated against haul start time and end time (Figure 6.20.3). In the case of GSA 9 all erroneous records where corrected compared to the 2012 data call, while very few errors remain for the other GSAs.

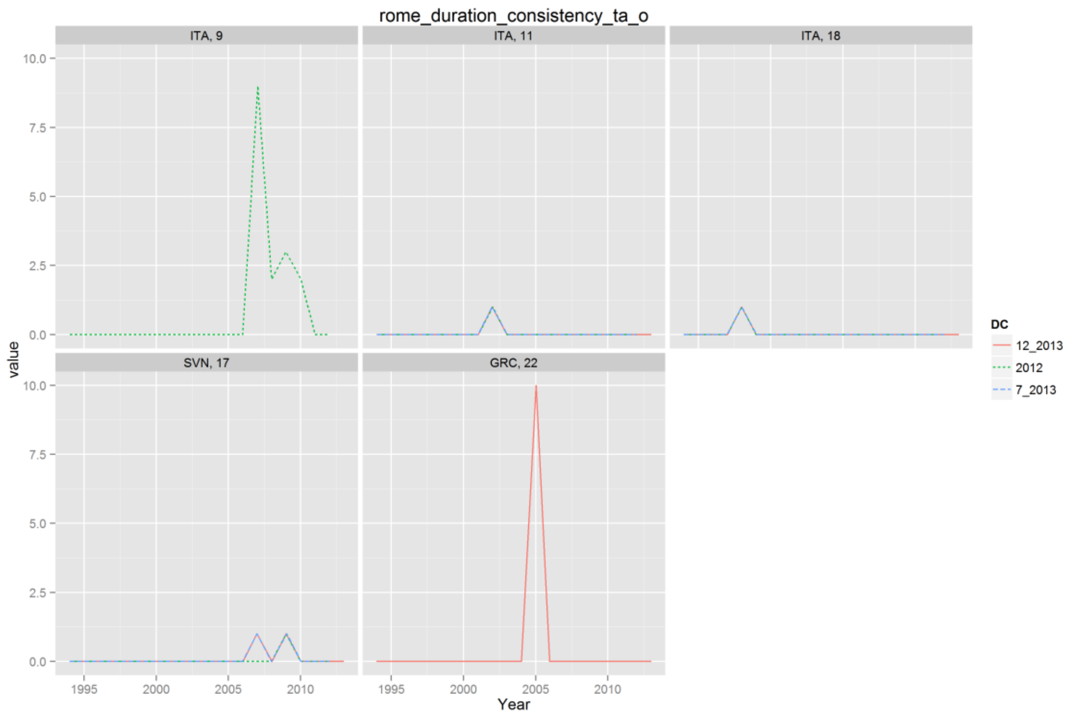


Figure 6.20.3. Erroneous records identifying inconsistent haul duration when compared to haul start and end time in the new and old data calls (2012 and 2013).In red the report from the December 2013 data call, in blue from the June 2013 data call and in dashed green from 2012.

A check of the consistency of the bridle length and the haul mean depth was performed according to the MEDITS manual (Figure 6.20.4). Violations of the protocol emerge in different areas, in GSA 9,16,11 the newest submitted records have been corrected.

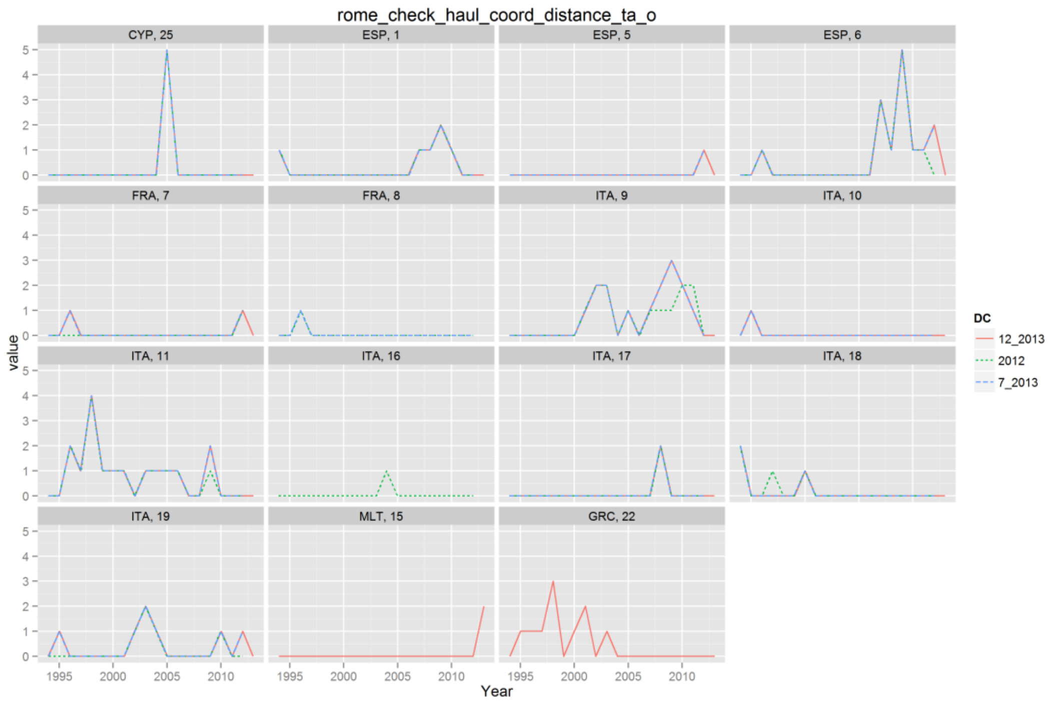


Figure 6.20.4. Consistency of the bridle length and the haul mean depth according to the MEDITS manual in new and old data calls (2012 and 2013). The values correspond to the number of hauls presenting violations.

A check on the total number of individual and the corresponding numbers of females, males and indetermined individuals was done for TB file (Figure 6.20.5). Corrections were performed in the latest data call by GSA 9 and GSA 17 while some errors remain for the other GSAs.

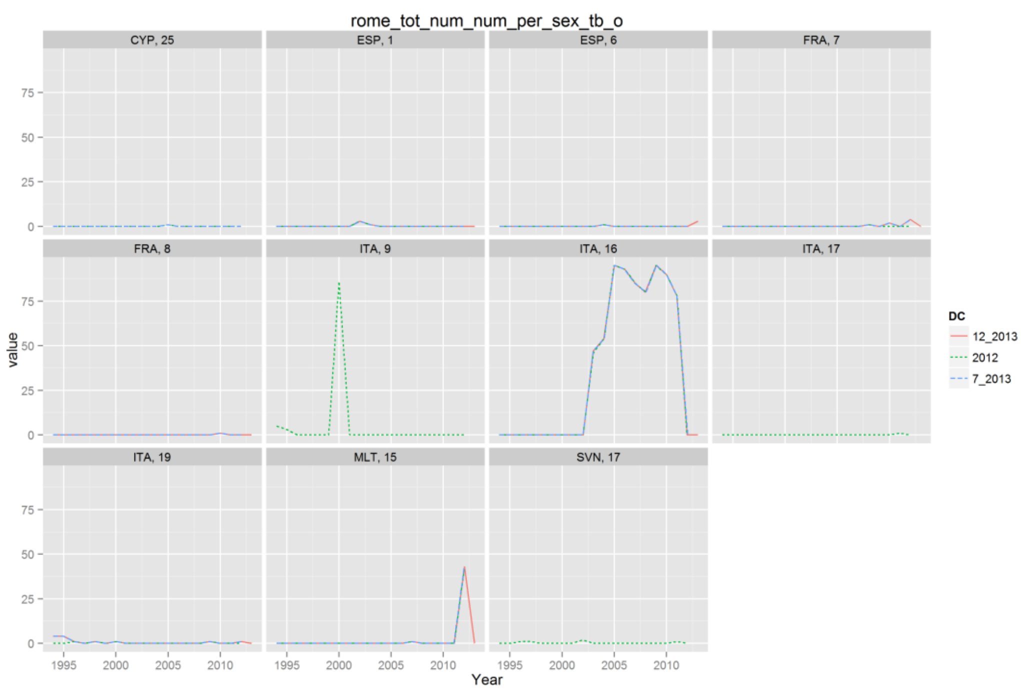

Figure 6.20.5. Consistency between the total number of individual and the corresponding numbers of females, males and indetermined individuals in the new and old data calls (2012 and 2013).

Another check was performed to verify that in the case of subsampling in TC the numbers per sex in Tb are raised correctly (Figure 6.20.6). For this check few corrections are noticeable but new errors emerged in particular in the last year of the survey in GSA 16. The reason for this is unclear and will be investigated.


Figure 6.20.7. Check that in case of subsampling in TC the numbers per sex in Tb are raised correctly in new and old data calls (2012 and 2013).

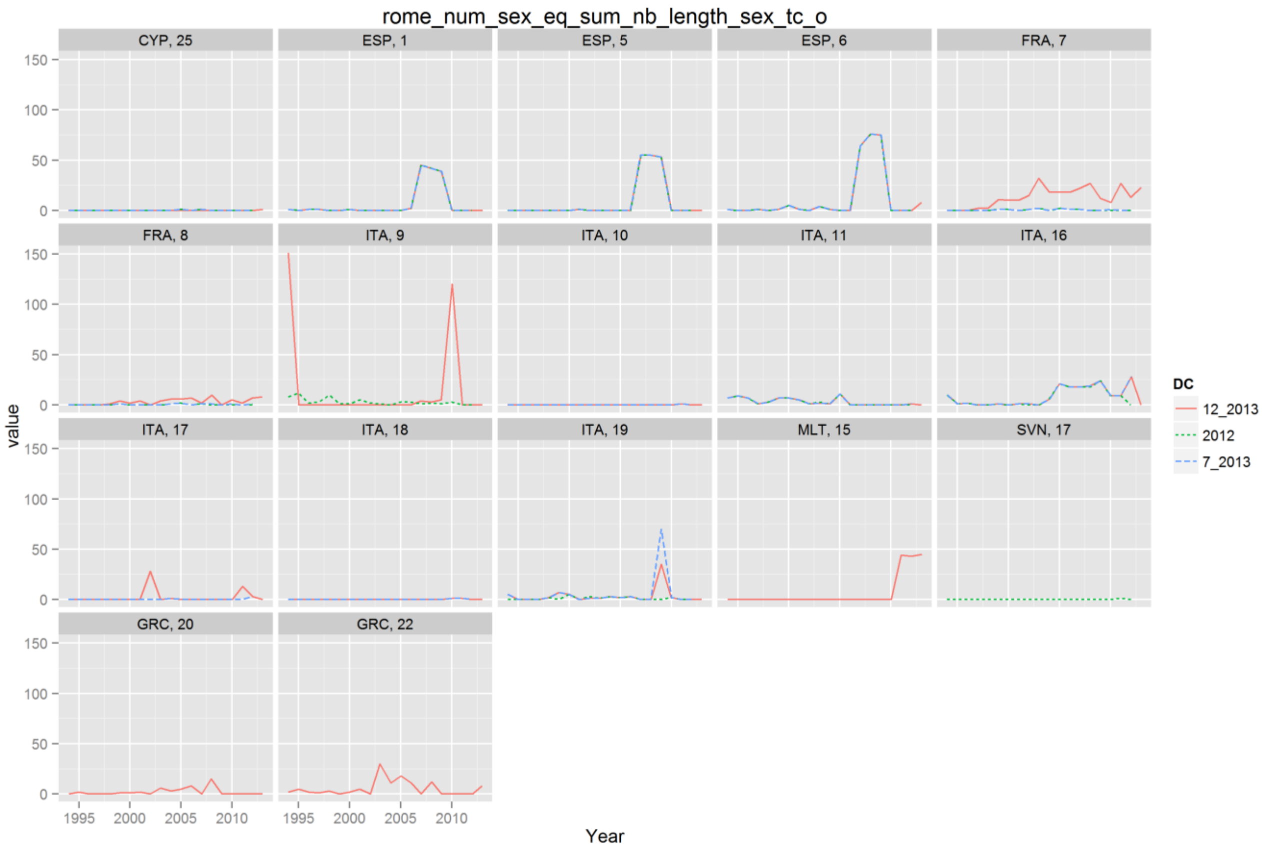


Figure 6.20.7. Internal check  in TC, the number per sex must be equal to the sum of numbers per length per sex, in new and old data calls (2012 and 2013).

This subset of quality check shows how over time the quality of the MEDITS data submitte has been improving and experts in the Member States have been putting a remarkable effort in identifying erroneous records and correcting them. The EWG 13-19 streesses the value of the use of the ROME routines for data correction and advices to use them as much as possible.

## 6.21. **ToR F Revision of R scripts**

EWG 13-19 was requested to review, update and consolidate the R scripts developed by EWG-MED and JRC over the period 2008-2013 to: perform deterministic and statistical age slicing on DCF catch at length and MEDITS data, extract and standardize MEDITS indexes of biomass and abundance, R plotting functions to produce standard plots for STECF reports.

During EWG 19-09 an effort to update and improve the R scripts in use of the Mediterranean Working group was started. This effort continued during EWG 13-19 tanks to contributions from JRC experts and IFREMER.

The MEDITS R scripts previously developed where updated to correctly incorporate the changes in the format of the MEDITS DB. The original functionality was updated and improved. Details on the updates and new implementations are in the following sections.

### 6.21.1. **Slicing methods**

Two deterministic slicing methods were implemented in R during the meeting: “knife-edge” and “proportional”. Both of the methods rely on using the von Bertalanffy growth equation to relate age to length. This requires values of the von Bertalanffy growth equation to be provided. These methods can be used even with limited data. The “knife-edge” slicing is the simplest method where the lengths of each sample are converted to ages using the von Bertalanaffy equation, and the ages then rounded down to the nearest integer value. The “proportional” method calculates what proportion of abundances in each length class go into which age class (Sparre  and Venema, 1998).

An R script was written that implemented these methods as functions (“length_slicing_funcs.R”). An example script demonstrating how the the “knife-edge” function can be used with landings data, including extraction of the landings data from the database, was written (“length_slicing_landings.R”). This script also includes a preliminary example of the “proportional” method.

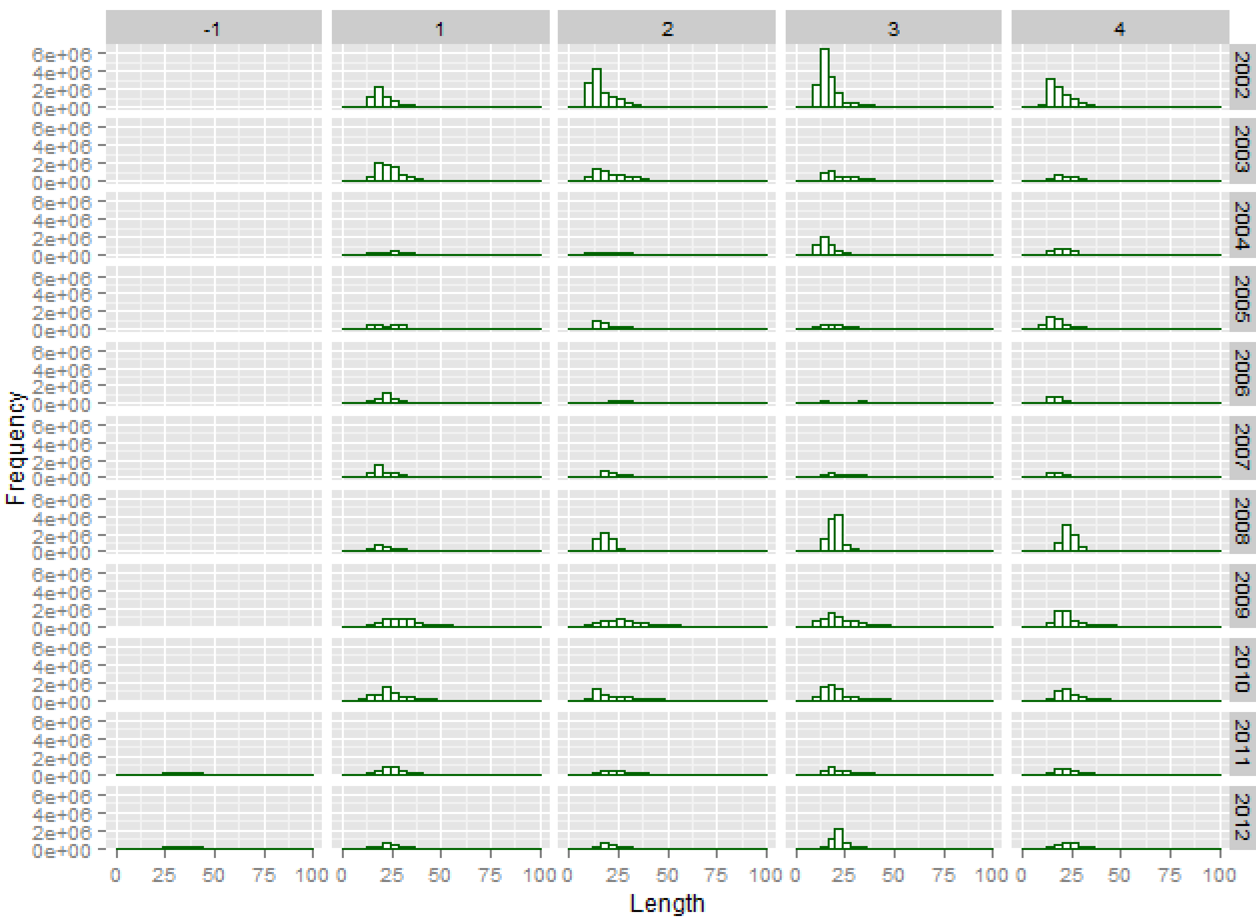


Figure 6.21.1 Example of the length histogram plot using Hake in GSA 7.

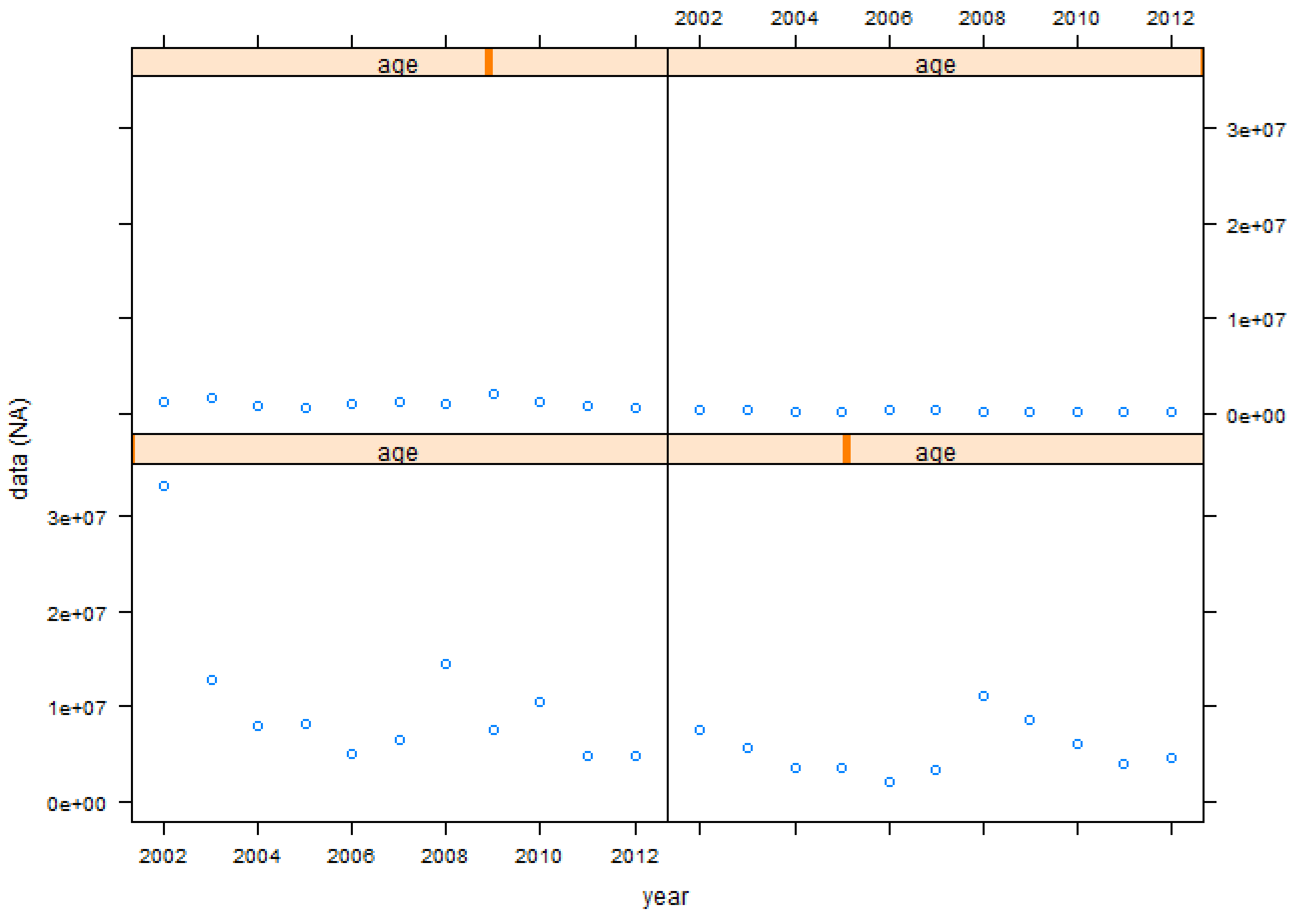


Figure 6.21.2. Results of the “knife-edge” slicing method using Hake in GSA 7.

The scripts make use of the FLR library (FLCore 2.5.0) so that the resulting R objects can be immediately used with the stock assessment and forecasting methods implemented using FLR. It was recommended that the latest version of R (3.0.2) is used.

Investigations were made into generalising the use of the statistical slicing method using the *mixdist* package for R (Macdonald, 2011). It is a more sophisticated method than the deterministic methods described above. The distributions of lengths at age are estimated rather than fixed by the von Bertalanffy growth equation. The statistical slicing has many different options that can strongly affect the results, including the shape of the model and which combinations of variances and modes should be fixed or estimated. As such it is not possible to generalise the method. Additionally, the statistical slicing method has strong data requirements. For example, for the model to effectively fit there needs to be strong modes in the length based data. This is not always the case. Consequently, the statistical slicing method should be used only by those who understand what the method is doing, and with suitable data. An example script demonstrating its uses and drawbacks is planned for the next meeting.

### 6.21.2. **MEDITS stratified numbers at length**

During EWG 13-19 it was outlined the need of implementing in R routines that would allow the calculation of a MEDITS stratified index of numbers of fish at length standardized by area or time. Such index is meant to replace old MS Access functions in the JRC MEDITS database and be linked with the MEDITS database for fast processing of the data. The new scrit (stratifiedmeans.R) builds on prexisting functions that extract data from TA and TC files and perform the raisings for the subsampling (db_connection.R).

The R script in the current implementation produces an abundance indices by GSA and Year through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA according to the standard formula:

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

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

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

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

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

In the current implementation the stratified variance (V(YsT) is still not developed. Once this last part is finished and the code clean it will be pushed to the Github repository where the R scripts of the STECF Meditereanan EWG are stored for public access and distribution.

### 6.21.3. **Repository**

A code repository was created on GitHub to store R scripts and example data sets that can be used by the Mediterranean working group. The repository, R4Med, can be found at: https://github.com/drfinlayscott/R4Med. There are several advantages to using a repository instead of passing scripts between users during the meetings. It is possible for multiple developers to collaborate on further development of the scripts. All changes are tracked thus ensuring consistency. Users will have easy access to the latest versions of the scripts, even outside of the meetings. All of the scripts are published under an open source GPL license.

The repository currently hosts the slicing scripts described above and also scripts used for performing forecasts. Example data objects are included.

### 6.21.4. **Future**

The GitHub repository will be further developed for forthcoming Mediterranean meetings. All future additional scripts and modifications to existing scripts, including more methods, tests and documentation, will be added to the repository.

References

Macdonald, P., 2011, Finite Mixture Distribution Models – mixdist package for R. available on CRAN (http://cran.r-project.org/).

Sparre, P. and Venema, S. C., 1998, Introduction to Tropical Fish Stock Assessment, FAO Fisheries Technical Paper 306/1 Rev. 2, Food and Agriculture Organisation of the United Nations, Rome.

## 6.22. **ToR G Review of 2013 DCF data call and discussion for the 2014 one**

The EWG 13-19 was requested to review the DCF data call in 2013 for Mediterranean stocks, fisheries and surveys and where necessary suggest adjustments on data needs and quality of data to be requested in the DCF call in 2014.

The structure of the Data Call has been stable since 2010, with the exception of small adjustments, and should not be changed. For the time being all institutes involved in DCF have ad hoc procedures to produce the standard tables and a change would cause unnecessary instability in the data collection process.

- At upload time, the lack of a file naming convention for the different data tables can and has created problems to JRC data collection facilities and database processing (see EWG 13-09). In many instances files containing the same data or partially overlapping data where uploaded with different names thus generating duplicate records. For the 2014 DCF data call, guidance and clear naming conventions should be indicated and implemented in JRC upload facility.

- Based on the number of files uploaded with errors on the JRC upload facility, it appears that the templates, distributed by JRC, containing the Data Validation Tool are used by only few Member States. The DV tool allows data checks for validity and can prepare and split large file for a clean transmission to JRC upload facilities. The DV tool should be used as much as possible to correct the files before data upload, the user manual can be downloaded from the JRC web site (http://datacollection.jrc.ec.europa.eu/c/document_library/get_file?uuid=2fb35342-db52-4c97-ba9a-d104dced6e3c&groupId=10213).

- JRC should move to progressively more restrictive checks at the time of upload to ensure conformity of the data with the most important data formatting specifications (e.g. alphabetic or numeric field, number of digits allowed in the field, strict enforcement of decimal separator).

- Future data calls should aim at a stabilization of the historical series uploaded by member states. A proposal would be that for the June 2014 data call data series (Catch, Landings, Discards, Effort and Acoustic and Demersal surveys) from 1994or earlier up to 2013 will be requested. In December 2014 Medits and acoustic surveys will be requested only for 2014 data. In June 2015 data call for 2014 data only will be requested. Revision of the time series will be allowed in case MS find and correct errors. Such approach should reduce on the long run the number of files that are re-uploaded over time and should improve the efficiency of the data transmission from MS to JRC databases.

-Harmonization of deadlines for data submissions in the National Data Plans so that all MS can comply with unique deadlines for data upload to JRC facilities.

## 6.23. **ToR H Ranking of stocks suitable for future stock assessment**

## Introduction

EWG 13-19 was requested to rank the stocks for which DCF data is suitable for assessment and for establishment of long term management plans. And additional request was to rank the stocks based on productivity/vulnerability and other life history parameters and complete the list with the MSY reference points where available.

The first step of this task was to retrieve the necessary data to build up the requested table. Fisheries data provided in Microsoft Office (MO) Access format through the last data call about landings, discards and fishing effort, updated to 2012 and made available for the previous EWG 13-09 meeting held in Ispra (15-19 July 2013), was used.

Information about catch was retrieved from the MO Access file named “A Fisheries landings and discards at age data MED 2002-2011-2013”. Information about fishing effort was retrieved from the MO Access file named “D Fisheries effort data MED 2002-2011 2013”. For the sake of data analysis, MO Access data files were firstly exported into MO Excel data files.

The template adopted for the table is essentially the same included in ToR h), modified in order to include auxiliary information such as “Total catch”, “Period covered by the last assessment”, “FMSY” (“E” for small pelagics)”, “F0.1”, “M” and “BMSY” (for small pelagics only). In addition, a separate table was build in order to account for the shared (and joined) stocks contained in the list of ToR a), and specifically for Striped red mullet (MUR) in GSAs 15&16, Common dolphinfish in GSAs 5 and 15 and Anchovy and Sardine in GSA 17.

As requested by the ToR, sub-totals by Country, GSA, Species and Gear were evaluated in order to calculate the corresponding % of catches. Whenever discard information was available, catch was evaluated summing landings and discards. As index of fishing effort the Nominal Effort (expressed in kW·days) was used instead of the number of vessels, in order to avoid the problem of duplications when summing information from quarterly data.

### Discussion

The EWG agreed about limiting the present analysis to the stocks listed in ToR a) of the present EWG 13-19 – part II meeting. This last decision was due to the quite large number of stocks assessed so far within the STECF EWG MED meetings, and also to the difficulty of establishing an unique criterion for the ranking of the fish stocks on the basis of their vulnerability. A more complete (and ranked) list could be delivered in one of the next meetings, provided that an agreement is achieved about the criteria to be applied for the ranking of the assessed stocks. A possible approach would be to run a PSA analysis, to be performed on a set of parameters representing for each stock proxies of “their production potentials /productivity/vulnerability based on growth, longevity and size/age at first maturity”. The extra columns added in the table about fishing exploitation patterns aim at giving a contribution in this direction. An alternative approach would be to use for the ranking an unique index that best represents the vulnerability of fish stocks, such as the ratio between current exploitation pattern (current F or average F of the last three estimates) and a reference point (FMSY or F0.1).

## 6.24. **ToR i Review of references points Errata corrige**

Amongst the stocks so far assessed since 2008 some show quite big short term differences in the value of fishing mortality and/or different Fmsy reference values; the table below reports the different cases where one or both situations occur. Explanations shall be provided to corroborate such changes and/or to detect possible errors.

| **Species** | **GSAs** |
|---|---|
| Giant red shrimp | 15-16 |
| Anchovy | 1, 6, 9 |
| European hake | 5, 6, 7, 10, 11, 17 |
| Red mullet | 6, 7, 9, 10, 15-16 |
| Striped red mullet | 5 |
| Common pandora | 9 |
| Blue and red shrimp | 6 |
| Deep-water rose shrimp | 6, 9, 10, 15-16 |

The STECF EWG 13-19 addressed the ToRi to review differences in values of Fmsy refrences values and fishing mortality. The ToR did not specify the years to be examined and the threshold levels to accept the differences in values.

The ToRs provided did not give specific detailed information on the way to assess the observed differences. For example no information was provided regarding the years to be examined, the acceptable threshold levels and which information to be checked.

The EWG 13-19 examined all the assessments carried out for the relevant stocks and provided explanations for the observed differences in $F_{curr}$ and $F_{MSY}$ values. Overall, the latest assessments are considered more reliable as these were performed with improved quality data and methods. The experts reported that the differences were mainly due to either a change in the assessment methodologies or in the input parameters of the models (e.g. growth parameters, catch data). In several occasions the short term differences in the value of fishing mortality and/or different $F_{MSY}$ reference values were not considered significant.

The EWG 13-19 noted only one remarkable difference in $F_{MSY}$ in the case the Hake stock in GSA 11. This was explained by the poor quality of the catch data that also let the EWG 13-09 to not accept the stock assessment.

The resulting table include the exaustive list of reviewed stocks and comments and it is available at http://stecf.jrc.ec.europa.eu.

Table 6.24.1Summary table with the revision of the stock assessments relevant for ToR i Errata corrige.

| GSAs | Species | Common names | Issues | Stock Assessment Methods | Comments | Conclusions | Reports |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 15-16 | *Aristaeomorpha foliacea* | Giant red shrimp | Fcurr(2009)= 0.73<br>Fcurr(2010)= 0.7<br>Fcurr(2011)= 1.09 | SURBA | Differences were observed in the input parameters: Maturity, w-at-age, catchability between 2010 and 2011. In 2010 Italy didn't submit data so the assessment was based on 2006-08 data (2009 Maltese data were not used). In 2011 the assessment used all the data from 2006-10. | No significant problems | 09-06 SG-MED 09-02 10-05 SG-MED 10-02 2011-11 STECF 11-14 |
| 1 | *Engraulis encrasicolus* | Anchovy | Fcurr(2008)= 1.82<br>Fcurr(2010)= 1.051 | XSA | Input parameters were the same both in 2008 and 2010. The resulting differences could be due to reported lower biomass and landings values. | No significant problems | 08-10 SG-MED 08-04<br>10-05 SG-MED 10-02 |
| 6 | *Engraulis encrasicolus* | Anchovy | Fcurr(2008)= 1.17<br>Fcurr(2010)= 0.89 | XSA | The same methodologies were applied. | No significant problems | 08-10 SG-MED 08-04<br>10-05 SG-MED 10-02 |
| 9 | *Engraulis encrasicolus* | Anchovy | Fcurr(2010)= 0.75<br>Fcurr(2011)= 1 | LCA | The same methodologies and input biological parameters were used. The slight increase is probably due to the observed increase in biomass and landings during the last years. | No significant problems | 10-05 SG-MED 10-02<br>2011-11 STECF 11-14 |
| 5 | *Merluccius merluccius* | European hake | Fcurr(2010)= 0.84<br>Fcurr(2011)= 1.21 | XSA | Different growth parameters used in the 2011 assessment derived from tagging data (i.e. from Mellon-Duval et al. (2009) (Linf= 110, K= 0.178). | No significant problems | 10-05 SG-MED 10-02<br>2012-04 STECF 12-03 |
| 6 | *Merluccius merluccius* | European hake | Fcurr(2008)= 0.7<br>Fcurr(2009)= 1.5<br>Fcurr(2010)= 0.99<br>Fcurr(2011)= 1.3 | XSA | The sources of these discrepancies are due to the growth hypothesis assumed in each assessment and, to some extent, to the age classes used in computing Fbar. More specifically in 2008 hake was not assessed in SGMED 08-04; the reported values derived from GFCM assessment carried out in 2007. The slow growth hypothesis was assumed. The Fbar included 0-4 age classes. In 2009 the species was assessed assuming a fast growth hypothesis with Fbar over 0-2 age classes. In 2010 the hake was assessed assuming a slow growth hypothesis with Fbar over 0-2 age classes. In 2011 hake was assessed following a fast growth hypothesis assumption and a Fbar over 0-3 age classes. | No significant problems | 08-10 SG-MED 08-04<br>09-06 SG-MED 09-02 10-12 SGMED 10-03<br>2011-11 STECF 11-14 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7 | *Merluccius merluccius* | European hake | Fcurr(2010)= 0.92 Fcurr(2011)= 1.43 Fcurr(2012)= 1.6 | XSA | There were different maturity at age values used in 2010 and 2011. In 2011 the growth parameters, especially the estimations of K, came from tagging experiments developed by IFREMER Sète in the Gulf of Lions ( Mellon-Duval et al., 2010). These were different than the corresponding values used in 2010. The catch values were also different between those two years. | No significant problems | 10-05 SG-MED 10-02 2012-04 STECF 12-03 2012-11 STECF 12-19 |
| 10 | *Merluccius merluccius* | European hake | Fcurr(2009)= 0.55 Fcurr(2010)= 0.72 Fcurr(2011)= 0.63 Fcurr(2013)= 1 | VIT (2009-11), XSA (2013) | The differences are caused by the use of discard in 2013 and by the different assessment methods. | No significant problems | 09-06 SG-MED 09-02 10-05 SG-MED 10-02 2012-04 STECF 12-03 2013-11 STECF 13-22 |
| 11 | *Merluccius merluccius* | European hake | Fcurr(2009)= 2.3 Fcurr(2010)= 0.89 Fcurr(2011)= 0.37 Fcurr(2012a) =1.16 Fcurr(2012b) =2.5 | SURBA (2009), LCA (2010-12), XSA (2012) | F in 2009 is estimated using SURBA, in 2010-12 using LCA, in 2012 was also estimated using an XSA. In 2013 the assessment was not accepted because of the poor data quality. | Data problems | 09-06 SG-MED 09-02 10-12 SGMED 10-03 2012-04 STECF 12-03 2012-11 STECF 12-19 2013-04 STECF 13-05 2013-11 STECF 13-22 |
| 17 | *Merluccius merluccius* | European hake | Fcurr(2008)= 1.22 Fcurr(2010)= 0.6 Fcurr(2012)= 2.02 | LCA (2008), VPA (2010), XSA (2012) | In 2008 LCA was used, in 2010 VPA and in 2012 XSA. In 2010 discards and Croatian data were not used. | No significant problems | 08-10 SG-MED 08-04 10-05 SG-MED 10-02 2013-04 STECF 13-05 |
| 6 | *Mullus barbatus* | Red mullet | Fcurr(2008)= 0.7 Fcurr(2010)= 1.08 Fcurr(2011)= 1.9 Fmsy(2008)= 0.86 Fmsy(2010)= 0.74 Fmsy(2011)= 0.38 | XSA | The 2008 values come from a GFCM assessment. In 2010 growth parameters from GSA 9 were used while in 2011 from GSA 6. | No significant problems | 08-10 SG-MED 08-04 10-05 SG-MED 10-02 2011-11 STECF 11-14 |
| 7 | *Mullus barbatus* | Red mullet | Fcurr(2010)= 0.69 Fcurr(2011)= 0.94 Fcurr(2012)= | VIT (2010), XSA (2011-12) | From 2011 the growth parameters changed. In 2010 VIT was used while in the following years XSA. In 2011 the assessment was presented at GFCM so not all | No significant problems | 10-05 SG-MED 10-02 2012-04 STECF 12-03 2012-11 STECF |

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|---|---|---|---|---|---|---|---|
| | | | 1.26 | | input files were available to EWG 13-19. Still the differences seem plausible. | | 12-19 |
| 9 | *Mullus barbatus* | Red mullet | Fcurr(2008)= 0.86 Fcurr(2009)= 0.97 Fcurr(2010)= 0.73 Fcurr(2011)= 0.59 Fcurr(2013)= 0.68 | ASPIC | In 2008 the growth parameters were different. The same methodologies were applied (ASPIC). | No significant problems | 08-10 SG-MED 08-04 09-06 SG-MED 09-02 10-05 SG-MED 10-02 2011-11 STECF 11-14 2013-04 STECF 13-05 |
| 10 | *Mullus barbatus* | Red mullet | Fcurr(2008)= 0.65 Fcurr(2010)= 0.57 Fcurr(2011)= 1.01 | VIT | The differences in the fishing mortality are due to the use of different growth parameters to split the length-frequency distribution. | No significant problems | 08-10 SG-MED 08-04 10-05 SG-MED 10-02 2012-04 STECF 12-03 |
| 15-16 | *Mullus barbatus* | Red mullet | Fcurr(2011)= 0.8 Fcurr(2012)= 1.3 | LCA (2011), XSA (2012) | In 2011 LCA was used while in 2012 XSA. | No significant problems | 2011-11 STECF 11-14 2012-11 STECF 12-19 |
| 5 | *Mullus surmuletus* | Striped red mullet | Fcurr(2010)= 0,76 Fcurr(2012)= 0.55 | XSA | Natural mortality was different (higher in 2010 and lower in 2011). It is difficult to further investigate since the assessment in 2011 was done by GFCM but the differences seem plausible. | No significant problems | 10-05 SG-MED 10-02 2012-04 STECF 12-03 |
| 9 | *Pagellus erythrinus* | Common pandora | Fcurr(2010)= 0.26 Fcurr(2011)= 0.63 Fmsy(2010)= 0.13 Fmsy(2011)= 0.48 | SEINE (2010), LCA (2011) | In 2010 the Fcurr was estimated using the model SEINE while in 2011 the LCA. | No significant problems | 10-05 SG-MED 10-02 2011-11 STECF 11-14 |
| 6 | *Aristeus antennatus* | Blue and red shrimp | Fcurr(2009)= 1.3 Fcurr(2010)= 1.3 Fcurr(2012)= 1.05 | XSA | In 2009-10 just OTB landings were considered. The 2009 and 2010 are the same assessment (data from 2002-2008) with some minor updates. All the input parameters of the 2011 assessment are different and the data are from 2002-2011. | No significant problems | 09-06 SG-MED 09-02 10-05 SG-MED 10-02 2012-11 STECF 12-19 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | *Parapenaeus longirostris* | Deep-water rose shrimp | Fcurr(2008)= 0.2 Fcurr(2009)= 0.5 Fcurr(2010)= 0.43 Fcurr(2011)= 1 Fcurr(2013)= 1.48 | XSA | The 2008 value comes from a GFCM assessment.The 2009 and 2010 are the same assessment with some minor update. The imput parameters were changed a lot from 2011 on. The biggest changes were in the catch at age matrix, weight at age and natural mortality. In 2013 the length weight parameters (a, b) were changed. | No significant problems | 08-10 SG-MED 08-04 09-06 SG-MED 09-02 10-05 SG-MED 10-02 2011-11 STECF 11-14 2013-11 STEC 13-22 |
| 9 | *Parapenaeus longirostris* | Deep-water rose shrimp | Fcurr(2008)= 0.6 Fcurr(2009)= 0.5 Fcurr(2010)= 0.5 Fcurr(2011)= 0.29 Fmsy(2008)= 1.3 Fmsy(2009)= 0.6 Fmsy(2010)= 0.6 Fmsy(2011)= 0.6 | LCA (2008-10), XSA (2011) | The different Fmsy in 2008 is probably due to a short time series. In 2009 the Natural mortality was changed. In 2011 XSA was used instead of LCA. | No significant problems | 08-10 SG-MED 08-04 09-06 SG-MED 09-02 10-05 SG-MED 10-02 2011-11 STECF 11-14 |
| 10 | *Parapenaeus longirostris* | Deep-water rose shrimp | Fcurr(2010)= 1.33 Fcurr(2011)= 1.11 Fcurr(2013)= 1.24 Fmsy(2010)= 0.58 Fmsy(2011)= 0.6 Fmsy(2013)= 0.93 | VIT (2010-11), XSA (2013) | The differences in the fishing mortality estimates and in the reference points are due to the different assessment methods used. VIT until 2011 and XSA in 2013. | No significant problems | 10-05 SG-MED 10-02 2012-04 STECF 12-03 2013-11 STEC 13-22 |
| 15-16 | *Parapenaeus longirostris* | Deep-water rose shrimp | Fcurr(2008)= 1.2 Fcurr(2010)= 0.98 | VIT | There is a change in the growth parameters between 2008 and 2010. In 2008 only the female part of the stock was assessed. The maturity and natural mortality values changed in 2010. | No significant problems | 08-10 SG-MED 08-04 10-05 SG-MED 10-02 |

# 8 Annex I. Contact details of STECF members and EWG-13-19 List of Participants

[1] - Information on STECF members and invited experts' affiliations is displayed for information only. In some instances the details given below for STECF members may differ from that provided in Commission COMMISSION DECISION of 27 October 2010 on the appointment of members of the STECF (2010/C 292/04) as some members' employment details may have changed or have been subject to organisational changes in their main place of employment. In any case, as outlined in Article 13 of the Commission Decision (2005/629/EU and 2010/74/EU) on STECF, Members of the STECF, invited experts, and JRC experts shall act independently of Member States or stakeholders. In the context of the STECF work, the committee members and other experts do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members and invited experts make declarations of commitment (yearly for STECF members) to act independently in the public interest of the European Union. STECF members and experts also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

Experts declarations are displayed here: http://stecf.jrc.ec.europa.eu/web/stecf/ewg1319

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# 9 Annex II. Summary of stock status

Summary of stock status for the 16 stocks assessed by the EWG 13-19. In the case of small pelagic stocks the ratio $F/F_{MSY}$ refers to $E/E_{0.4}$.

| GSA | Common name | Species | Presentation | Assessment | Comment | Status | $F/F_{MSY}$ |
|---|---|---|---|---|---|---|---|
| 1 | Sardine | *Sardina pilchardus* | Yes | SepVPA | Trends only | Exploited sustainably | < 1 |
| 5 | Striped red mullet | *Mullus surmuletus* | Yes | XSA | Accepted | Overexploited | 3.0 |
| 5 | Red mullet | *Mullus barbatus* | Yes | XSA | Accepted | Overexploited | 6.2 |
| 6 | Red mullet | *Mullus barbatus* | Yes | XSA | Accepted | Overexploited | 3.8 |
| 7 | Sardine | *Sardina pilchardus* | Yes | XSA | Not accepted | Unknown | |
| 9 | Sardine | *Sardina pilchardus* | Yes | SepVPA | Trends only | Overexploited | > 1 |
| 11 | Striped red mullet | *Mullus surmuletus* | Yes | | Data quality issues | Unknown | |
| 11 | Red mullet | *Mullus barbatus* | Yes | XSA | Accepted | Overexploited | 9.7 |
| 15-16 | Striped red mullet | *Mullus surmuletus* | Yes | XSA | Accepted | Overexploited | 4.1 |
| 4,5,11-16 | Common dolphinfish | *Coryphaena hippurus* | Yes | | Data quality issues | Unknown | |
| 17 | Anchovy | *Engraulis encrasicolus* | Yes | SAM | Accepted | Overexploited | 2.1 |
| 17 | Sardine | *Sardina pilchardus* | Yes | SAM | Accepted | Overexploited | 2.0 |
| 17 | Red mullet | *Mullus barbatus* | Yes | SS3 | Accepted | Overexploited | 2.6 |
| 18 | Anchovy | *Engraulis encrasicolus* | Yes | | Data quality issues | Unknown | |
| 19 | Anchovy | *Engraulis encrasicolus* | Yes | SepVPA | Trends only | Unknown | |
| 22-23 | Anchovy | *Engraulis encrasicolus* | Yes | | Data not collected | Unknown | |

# 10 Annex III. Summary table for the stocks to be assessed in 2014 as proposed by EWG 13-19.

| GSA | CODE | Common name | Species | 2013 (1) | 2013 (2) | 2014 (1) | 2014 (2) |
|---|---|---|---|---|---|---|---|
| 1 | PIL | Sardine | *Sardina pilchardus* | | 1 | | |
| 1 | ARA | Blue and red shrimp | *Aristeus antennatus* | | | 1 | |
| 1 | HKE | Hake | *Merluccius merluccius* | 1 | | | |
| 1 | DPS | Deepwater Pink shrimp | *Parapenaeus longirostris* | 1 | | | |
| 1 | MUT | Red mullet | *Mullus barbatus* | | | | 1 |
| | | | | | | | |
| 5 | ARA | Blue and red shrimp | *Aristeus antennatus* | | | 1 | |
| 5 | MUR | Striped red mullet | *Mullus surmuletus* | | 1 | | |
| 5 | HKE | Hake | *Merluccius merluccius* | | | | 1 |
| 5 | NEP | Norway lobster | *Nephrops norvegicus* | | | 1 | |
| 5 | DPS | Deepwater Pink shrimp | *Parapenaeus longirostris* | 1 | | | |
| 5 | MUT | Red mullet | *Mullus barbatus* | | 1 | | |
| | | | | | | | |
| 6 | PIL | Sardine | *Sardina pilchardus* | | | 1 | |
| 6 | HKE | Hake | *Merluccius merluccius* | | | | |
| 6 | ANK | Black-bellied angler | *Lophius budegassa* | | | | 1 |
| 6 | DPS | Deepwater Pink shrimp | *Parapenaeus longirostris* | 1 | | | |
| 6 | MUT | Red mullet | *Mullus barbatus* | | 1 | | |
| 6 | ARA | Blue and red shrimp | *Aristeus antennatus* | | | 1 | |
| | | | | | | | |
| 7 | PIL | Sardine | *Sardina pilchardus* | | 1 | | |
| 7 | ANE | Anchovy | *Engraulis encrasicolus* | | | | |
| 7 | HKE | Hake | *Merluccius merluccius* | 1 | | | 1 |
| 7 | ANK | Black-bellied angler | *Lophius budegassa* | | | 1 | |
| 7 | MUT | Red mullet | *Mullus barbatus* | | | | 1 |
| | | | | | | | |
| 9 | PIL | Sardine | *Sardina pilchardus* | | 1 | | |
| 9 | HKE | Hake | *Merluccius merluccius* | | | | 1 |
| 9 | MUT | Red mullet | *Mullus barbatus* | | | | 1 |
| 9 | DPS | Deepwater Pink shrimp | *Parapenaeus longirostris* | | | 1 | |
| 9 | NEP | Norway lobster | *Nephrops norvegicus* | | | 1 | |
| 9 | ARS | Giant red shrimp | *Aristaeomorpha foliacea* | 1 | | | |
| | | | | | | | |
| 10 | HKE | Hake | *Merluccius merluccius* | 1 | | | |
| 10 | DPS | Deepwater Pink shrimp | *Parapenaeus longirostris* | 1 | | | |
| 10 | MTS | Spottail mantis | *Squilla mantis* | | | 1 | |
| 10 | MUT | Red mullet | *Mullusbarbatus* | | | | 1 |
| | | | | | | | |
| 11 | HKE | Hake | *Merluccius merluccius* | 1 | | | |
| 11 | MUR | Striped red mullet | *Mullus surmuletus* | | 1 | | |
| 11 | MUT | Red mullet | *Mullus barbatus* | | 1 | | |
| 11 | ARS | Giant red shrimp | *Aristaeomorpha foliacea* | | | 1 | |
| 11 | DPS | Deepwater Pink shrimp | *Parapenaeus longirostris* | | | 1 | |
| | | | | | | | |
| 15&16 | ANE | Anchovy | *Engraulis encrasicolus* | | | | |
| 15&16 | PIL | Sardine | *Sardina pilchardus* | | | | |
| 15&16 | ARS | Giant red shrimp | *Aristaeomorpha foliacea* | | | 1 | |
| 12&16 | DPS | Deepwater Pink shrimp | *Parapenaeus longirostris* | | | 1 | |
| 15&16 | NEP | Norway lobster | *Nephrops norvegicus* | 1 | | | |
| 15&16 | ARA | Blue and red shrimp | *Aristeus antennatus* | 1 | | | |
| 15&16 | PAC | Common Pandora | *Pagellus erythrinus* | | | | |
| 15&16 | HKE | Hake | *Merluccius merluccius* | | | | 1 |
| 15&16 | MUT | Red mullet | *Mullus barbatus* | | | | 1 |
| 15&16 | MUR | Striped red mullet | *Mullus surmuletus* | | 1 | | |

# 11 Annex IV Stocks ranking table

Table with ranked the stocks for which DCF data are suitable for stock assessment and for the establishment of long term management plans and also ranked their vulnerability according to their productivity, susceptibility and other criteria based on life history parameters. Such rankings are available at:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg1319

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Abstract

The Expert Working Group meeting of the Scientific, Technical and Economic Committee for Fisheries EWG 13-19 was held from 9 – 13 December 2013 in Brussels, Belgium to assess the status of demersal and small pelagic stocks in the Mediterranean Sea against the proposed FMSY reference point. The report was reviewed by the STECF during its spring plenary held from 24 to 28 March 2014 in Brussels (Belgium).

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