OPENING OF THE WORKING GROUPS ON STOCK ASSESSMENT (WGSAs)

1. The meetings of the SCSA Working Group on Stock Assessment of Demersal Species (WGSAD) and Small Pelagic Species (WGSASP) were held at the GFCM headquarters in Rome, Italy, from 24 to 27 November 2014. The first day was dedicated to a joint session on methodologies for data-limited stocks.

2. Ms Pilar Hernandez and Mr Miguel Bernal, GFCM Secretariat, welcomed the participants to both Working Groups on Stock Assessment of Demersal (WGSAD) and Small Pelagic Species (WGSASP) and provided background information on the meetings and related logistics. They also acknowledged the presence of the Scientific Technical and Economic Committee for Fisheries (STECF) Secretariat and of the European Commission (EC) at the working groups.

SESSION ON METHODOLOGIES FOR DATA-LIMITED STOCKS

3. The GFCM Secretariat opened the session “Methodologies for data-limited stocks” which was a joint session for the two working groups. They then introduced Mr Giacomo Chato Osio from the EC Joint Research Centre (JRC).

4. The GFCM Secretariat reviewed the status of the Mediterranean stocks, highlighting the need to increase the number of stocks assessed in the Mediterranean and Black Sea, and therefore to extend the assessment methods to fisheries for which information is limited. It was pointed out that most of the stocks were overexploited and that it was important to have some indicators on the health of the stock (either based on age or, most likely, on length).

5. A discussion was raised on the urgent need to integrate the information coming from other independent working groups (e.g. STECF) and participants underlined the need to optimize the use of experts’ time and effort. However, a final conclusion on how to take advantage of the work undertaken by the various external working groups was not reached.

6. Mr Chato Osio delivered a presentation entitled “Assessment of limited or data limited stocks in the Mediterranean: what to do?”. He described the productivity and susceptibility analysis” (PSA)
methodology that was recently applied at the Mediterranean level. He suggested that this analysis would allow for the prioritization of stocks in term of vulnerability. He also presented some of the outcomes from a FAO working group on catch-only models, where simulations were carried out to test the performances of four different methods, i.e., the modified panel regression model (mPRM), the catch-MSY (CMSY) model, the catch-only model – sampling importance resampling (COM-SIR), and state-space catch-only model (SSCOM) (Rooseberg et al., 2014).

7. The GFCM Secretariat presented the GFCM framework for providing advice on stock status and related management actions. Specific reference was made to promoting the use, whenever possible, of both biomass and fishing mortality reference points. Participants were also introduced to the GFCM Data Collection Reference Framework (DCRF). The presentation emphasized the minimum set of indicators of ‘good environmental status’ agreed upon during the MedSuit Regional Workshop (FAO headquarters, November 2014) i.e., total landings, SSB, fishing mortality, effort, bycatch of vulnerable species. Tentative indicators to be further tested were biomass index, the large fish indicator, optimal length and mean trophic level.

8. Mr Chato Osio, in the capacity of STECF Secretariat, presented a summary of the stock assessment results of the last Expert Working Group -14-09-SGMED. Of the 13 stocks assessed, 11 were defined as overexploited, while for two, there was insufficient data to be able to carry out a reliable assessment. The presentation was followed by a discussion on how to link information provided by STECF working groups to GFCM procedures. The WGSASP acknowledged the opportunity presented by the presence of the STECF Secretariat at the meeting to start a common discussion on the issue. One major concern raised by the scientists was that not all GFCM experts also take part in the STECF-EWG. As such, participants suggested establishing a clear procedure on how to use STECF results.

9. Participants of both the WGSAD and WGSASP agreed on a set of general conclusions and recommendations from the session on “Methodologies for data-limited stocks”. This is included in the conclusions section of this report.

OPENING AND ARRANGEMENTS OF THE WORKING GROUP ON STOCK ASSESSMENT OF DEMERSAL SPECIES (WGSAD)

10. The WGSAD meeting was held at the GFCM headquarters in Rome, Italy, from 24 to 27 November 2014. It was attended by 33 fisheries experts from thirteen GFCM Member States, together with representatives of the FAO regional projects, the STECF Secretariat, the European Commission and the GFCM Secretariat (the full list of participants is provided in Appendix B).

11. The GFCM Secretariat welcomed participants and thanked them for attending and contributing to the meeting. Participants were encouraged to make use of SharePoint in submitting the three components of the stock assessments, they had completed; in particular, participants were reminded of the importance of providing the requested metadata so that the content of the SharePoint libraries will conform databases with the assessments of each session.

12. The agenda was adopted with minor amendments and is included as Appendix A. The generic terms of reference of the WGSAD were reviewed and are included in Appendix C.

13. Participants unanimously elected Ms Beatriz Guijarro as coordinator of the WGSAD. Ms Angélique Jadaud was designated as rapporteur for the session on hake (Merluccius merluccius), Mr José Luís Pérez was designated as rapporteur for the session on other demersal fishes and Ms Isabella Bitteto was designated as rapporteur for the sessions on crustaceans.

14. The chair recapped the main conclusions and recommendations from the previous meeting with the aim of reviewing the progress achieved by national experts and by the GFCM Secretariat.
SESSION ON THE ASSESSMENT OF RED CORAL

15. A dedicated session on red coral was carried out in parallel to the WGSAs. This session reviewed four case studies with different models that were applied to the assessment of red coral, two in the same fishery in GSA 11.1, northwest Sardinia (Shaeffer, and Beverton and Holt), one in GSA 06 north Spain and one in GSA 09 in the eastern Ligurian sea (Leslie-Lewis Matrix).

16. A preliminary exercise previously undertaken (Follesa et al. 2013) in GSA 11.1 was revised during the session. The Schaeffer model was applied to a series of data from 1990 to 2012 taken from red coral fishery logbooks. The results showed that the current biomass level was higher than $B_{\text{MSY}}$, therefore indicating that the resource would be in a sustainable status. However, these results were subject to much discussion. The time series for effort and landings data showed a flat curve without significant fluctuations, maybe due to a possible bias introduced by the logbook data (i.e. the total quantity registered daily by the fishermen is always close to the imposed daily quota (2.5 kg per fisherman) even if it is not always true) and therefore, landings values are very steady. Consequently, participants decided that unless that additional fishery-independent data can be provided these results could not be relied upon for issuing advice.

17. The Beverton and Holt model was used to estimate size at MSY in the same fishery. The Y/R curve showed that the harvest of red coral in the north-western coast of Sardinia would reach its maximum yield at an age of 20 years of first capture; such an age is significantly lower than the average age of 30 years at which colonies are currently being harvested. The group noted that if confirmed this would mean that that the current management measures in place in Sardinia (i.e. minimum size 10 mm) are very conservative prioritizing protection of the resource against economical profitability.

18. A previous study in GSA 06 (Spain), which also used the Beverton & Holt model, reported a size at first capture of 98 years. It was noted that the growth rates and the length/weight relationships used in Spain were very different from those used in Sardinia. This discrepancy put in evidence two drawbacks of the model outputs: on one hand the high sensitivity of the model to variations in the growth and mortality coefficients and on the other hand the high variability of population dynamics in different areas and the importance of estimating these parameters on a stock by stock basis. Consequently, the group decided to wait for some more testing of this model before using these results for advice.

19. The Leslie-Lewis matrix models were applied to two red coral populations in Calafuria and Marseille. The model simulated behaviour of year classes under different types of mortality events. Participants agreed that such type of methods as applied up to now provided description of population dynamics, but in order to obtain a diagnosis of the stock status, they should be coupled with catch-at-age data.

20. Another indicator of population status of red coral was assessed: ‘percentage of colonies over the legal size at sea’ by comparing its value in different areas as presented in table 1.
Table 1. Values of percentages of colonies larger than 7 mm in different areas

<table>
<thead>
<tr>
<th>Population</th>
<th>Depth (m)</th>
<th>Reference</th>
<th>% &gt; 7mm</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sardinia (Italy)</td>
<td>80 - 119</td>
<td>Follesa et al. 2013</td>
<td>38</td>
<td>Fishing ground</td>
</tr>
<tr>
<td>Cap de Creus (Spain)</td>
<td>7 - 49</td>
<td>Tsounis et al. 2006</td>
<td>15</td>
<td>Fishing ground</td>
</tr>
<tr>
<td>Cap de Creus (Spain)</td>
<td>30- 35</td>
<td>Bramanti et al. 2014</td>
<td>2.1</td>
<td>Fishing ground</td>
</tr>
<tr>
<td>Calafuria (Italy)</td>
<td>20 - 45</td>
<td>Santangelo et al. 2007</td>
<td>42.1</td>
<td>Fishing ground</td>
</tr>
<tr>
<td>Costa Brava (Montgri and Begur), Spain</td>
<td>13 - 32</td>
<td>Tsounis et al. 2006</td>
<td>15</td>
<td>Fishing ground</td>
</tr>
<tr>
<td>Marseille (France)</td>
<td>20 - 40</td>
<td>Bianchimani 2005; Garrabou et al. 2001</td>
<td>2.8</td>
<td>Fishing ground</td>
</tr>
<tr>
<td>Portofino (Italy)</td>
<td>30 - 35</td>
<td>Bramanti et al. 2014</td>
<td>6.7</td>
<td>MPA</td>
</tr>
<tr>
<td>Banyuls sur mer (France)</td>
<td>23 - 25</td>
<td>Linares et al. 2010</td>
<td>30.3</td>
<td>MPA</td>
</tr>
<tr>
<td>Scandola (Corsica)</td>
<td>19 - 22</td>
<td>Linares et al. 2010</td>
<td>54.2</td>
<td>MPA</td>
</tr>
<tr>
<td>Medes Islands (Spain)</td>
<td>15 - 48</td>
<td>Tsounis et al. 2006</td>
<td>53</td>
<td>MPA</td>
</tr>
</tbody>
</table>

21. Amongst those populations analysed, the lowest percentage was found in Spain Costa Brava, (Bramanti et al. 2014) with 2% of colonies above minimum size of 7 mm in basal diameter in 30 – 35 m depth. A previous study by Tsounis et al. (2006) reported 15% of colonies between 11 – 49 m depth which indicated an increased and continuous pressure on this shallow water stock which is at its limit of overexploitation.

22. In Sardinian waters, where a management plan was in place, the stocks at 80 – 119 m depth featured 38% of colonies above the local legal size of 10 mm (Follesa et al. 2013). A continuous shift of all coral fisheries towards deeper stocks was observed over recent decades, and shallow water stocks were recognized as overexploited. Recommendation GFCM/35/2011/2 protects red corals up to 50 m. Member states are urged to comply with this and all other relevant recommendations.

23. Studies undertaken in marine protected areas reported significantly larger coral sizes. These studies also revealed very slow recovery times, on the scale of decades.

OVERVIEW OF ASSESSMENTS CARRIED OUT AND STOCKS’ STATUS

24. Overall, 25 assessments were presented of which 18 referred to stocks of five fish species and seven to stocks of three crustacean species. Of the 18 assessments on fish stocks, eight referred to Merluccius merluccius, three to Mullus barbatus, two to Mullus surmuletus and two assessments to of Solea solea and Saurida undosquamis. From the seven assessments on crustaceans, three stocks referred to Parapenaeus longirostris, three to Aristaeus antennatus and one to Aristaeomorpha foliacea.

25. With respect to assessments by GFCM geographical sub-area, 23 assessments were confined within one subarea (one assessment referred to GSA 01, two to GSA 03, three to GSA 05, three to
GSA 06, two to GSA 07, three to GSA 10, two to GSA 17, two to GSA 18, one to GSA 19, one to GSA 24, one to GSA 25 and two to GSA 26 and two assessments spanned GSAs 12–16.

26. Regarding methodologies, different models were used for the assessments (i.e. VPA, LCA, XSA, Y/R, production models, SS3, and predictive models) in relation to the different characteristics of the stocks assessed and the availability of data.

27. During the session, the general aspects of the assessments carried out, including the methods and data used, the stock status and a summary of the resulting scientific advice were revised in detail. In some cases, new analyses were carried out. The comments on the modifications made by the WGSAD to each stock are summarized in a table in Appendix D.

28. Overall, 23 of the stocks were “in overexploitation”, one was considered to be sustainably exploited (red mullet in GSA 10) and one was considered preliminary. The individual stock assessment summaries are presented below whilst all stock assessment forms presented and finalized during the WG are available on the GFCM SharePoint page of the Expert Groups (https://gfcm.sharepoint.com/EG).

29. Two assessment-related works were also presented: one on red mullet (*Mullus barbatus*) in Algeria and one on striped venus clam (*Chamalea gallina*) in Egypt.

30. In the context of technical advice on the management measures in GSAs 12–16 (following the request of the thirty-eighth session of the Commission), two stocks were assessed: hake and deep-sea pink shrimp and two presentations were delivered on the application of bio-economic tools.

**INDIVIDUAL STOCK SUMMARIES**

1. **Stock**: European hake, *Merluccius merluccius*

**GSA**: 03

**Author(s)**: El Ouamari N. & J. Bensbai

**Fishery**: Among the demersal species exploited in the GFCM-GSA03, the hake *Merlucius merluccius* is one of the most targeted by trawling fleet composed by 117 units. The average of the annual production of this species is about 168 tonnes. During the 2003–2013 period, the fishing effort applied by trawlers to catch hake have ranged between 7277 and 11100 fishing days.

**Data and parameters**: The stock of *Merluccius merluccius* of the GFCM-GSA 03 has been assessed using data from the trawl fishery on a time series covering 11years (2003–2013). This data concerns annual landings and abundance indices coming from trawl surveys.

**Assessment method**: This assessment has been carried out by applying the production model. The software used was the CECAF Schaeffer model (CECAF dynamic Schaeffer model, 2007).
Results:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>MSY</td>
<td>187</td>
</tr>
<tr>
<td>B_{MSY}</td>
<td>115</td>
</tr>
<tr>
<td>B_{0.1}</td>
<td>127</td>
</tr>
<tr>
<td>B_{current}</td>
<td>145</td>
</tr>
<tr>
<td>B_{current}/ B_{MSY}</td>
<td>1.26</td>
</tr>
<tr>
<td>B_{current}/ B_{0.1}</td>
<td>1.15</td>
</tr>
<tr>
<td>Cur_SustProd</td>
<td>174</td>
</tr>
<tr>
<td>Cur_percProd</td>
<td>93%</td>
</tr>
<tr>
<td>CurY</td>
<td>148</td>
</tr>
<tr>
<td>F_{MSY}</td>
<td>1.62</td>
</tr>
<tr>
<td>F_{0.1}</td>
<td>1.46</td>
</tr>
<tr>
<td>F_{current}</td>
<td>1.02</td>
</tr>
<tr>
<td>F_{current}/ F_{MSY}</td>
<td>0.63</td>
</tr>
<tr>
<td>F_{current}/ F_{0.1}</td>
<td>0.7</td>
</tr>
<tr>
<td>FSYCur</td>
<td>1.20</td>
</tr>
<tr>
<td>F_{current}/ FSYCur</td>
<td>0.85</td>
</tr>
<tr>
<td>DBCur</td>
<td>26</td>
</tr>
<tr>
<td>DBCur/Bcur</td>
<td>0.18</td>
</tr>
<tr>
<td>CurY/MSY</td>
<td>0.79</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:** Results indicate that the status of stock is in sustainable exploitation with relative high biomass.

**Advice and recommendation:** Do not increase fishing mortality

**Discussion:** Given the extremely high value of F_{MSY}, the group agreed to request a second trial with other models if possible to be provided for the consideration of the next SCSA before formulating a final advice. The status and advice were therefore considered preliminary.

2. **Stock:** European hake, *Merluccius merluccius*

**GSA:** 05

**Author(s):** Beatriz Guijarro, Vanessa Rubio, Natalia González, Francesc Ordines and Enric Massutí

**Fishery:** In the Balearic Isles, commercial bottom trawlers use a mixture of four different fishing tactics associated with the shallow shelf, deep shelf, upper slope and middle slope habitats. These tactics mainly target: (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 significant bycatch of big *Merluccius merluccius, Lepidorhombus* spp., *Lophius* spp. and *Micromesistius poutassou* on the upper slope (350–600 m) and (iv) *Aristeus antennatus* on the middle slope (600-750 m). The European hake (*M. merluccius*) which is a target species for this fishery, is mainly exploited on the deep shelf and upper slope, with annual landings fluctuating between 50 and 190 tonnes during the last decades. All catches of hake in this area are caught exclusively by bottom trawlers.

**Data and parameters:** Size composition of commercial trawl catches and official landings (1980–2013), CPUE data from bottom trawl surveys (2001–2013) and from commercial fleet (2000–2013). Growth parameters from Mellon-Duval et al. (2010), maturity ogive based on data from Spanish National Data Collection Programme, M vector from PRODBIOM.
Assessment method: Extended Survivor Analysis (XSA), yield-per-recruit analysis and short-term forecast.

Model performance: XSA residuals did not show any trend.

Results: Stock abundance, stock biomass and recruitment showed oscillations for the entire data series, without any clear trend.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>F_{current}</strong> (mean 2011-2013, ages 0-2)</td>
<td>1.15</td>
</tr>
<tr>
<td><strong>F_{0.1}</strong></td>
<td>0.15</td>
</tr>
<tr>
<td><strong>F_{current}/F_{0.1}</strong></td>
<td>7.7</td>
</tr>
<tr>
<td>Current survey biomass (tonnes)</td>
<td>227</td>
</tr>
<tr>
<td>33^{rd} percentile biomass (tonnes)</td>
<td>181</td>
</tr>
<tr>
<td>66^{th} percentile biomass (tonnes)</td>
<td>244</td>
</tr>
</tbody>
</table>

Diagnosis of stock status: The stock is ‘in overexploitation’ with relative intermediate biomass.

Advice and recommendation: To reduce fishing mortality

Discussion: No particular discussion on this stock.

3. Stock: European hake, *Merluccius merluccius*

GSA: 06

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

Fishery: European hake is a target demersal species of the Mediterranean fishing fleets. It is largely exploited in GSA 06, mainly by trawlers on the shelf and slope (91% landings), but also by small-scale fisheries using long lines (6%) and gillnets and trammel nets (3%) (averages estimated between 2009 and 2013). According to official statistics, around 1 000 boats are involved in this fishery, with total annual landings oscillating around an average value of 3 798 tonnes for the period 2003–2013 (3256 tonnes in 2013). The trawler fleet is the largest in number of boats and landings (472 trawlers and 2966 tonnes in 2013).

Data and parameters: The assessment was carried out using official landings and data on the size composition of trawl and set gillnet catches for the years 2003-2013. Catch-at-length data were converted into catch-at-age data by cohort slicing procedures. Length-weight relationship and maturity ogive comes from Spanish DCF and the vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella et al., 1997).

Assessment method: The state of exploitation of this stock was assessed by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999). The software used was the Lowestoft suite (Darby and Flatman 1994) and FLR (Fisheries Libraries in R). The XSA tuning was performed using abundance index series from MEDITIS trawl surveys and CPUEs from commercial fleet. Yield-per-Recruit (Y/R) and Spawning-per-Recruit (SSB/R) analyses was conducted based on the exploitation pattern resulting from XSA model and population parameters. Several reference points were estimated based on this Y/R analysis. Stochastic short term projections assuming equilibrium conditions were also produced.

Model performance: Sensitivity and retrospective analyses were applied in the XSA model in order to check the robustness of the assessment. Results showed no particular retrospective bias in spawning biomass (SSB), fishing mortality (F) or recruitment (R).
**Results:** XSA results show that total biomass (B) fluctuates around 8 000 t. Spawning stock biomass (SSB) and yield (Y) show a decreasing trend from 2006 to 2010. After this decrease, yield (Y) stabilizes with slight fluctuations over the last 4 years (2010–2013). Recruitment (R) showed a drastic decline from the maximum observed in 2008 but seems to have stabilized during the last three years (around 120 000 thousands).

Fishing mortality (F<sub>bart0.3</sub>) shows an increasing trend from 2008 to 2012 and a slight decrease in the last year (1.4).

Y/R analysis shows that the F<sub>ref</sub> = F<sub>current</sub> (1.4) exceeds the Y/R F<sub>0.1</sub> reference point (0.18).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F&lt;sub&gt;current&lt;/sub&gt; (mean 6 last years, ages 1-3)</td>
<td>1.4</td>
</tr>
<tr>
<td>F 33&lt;sup&gt;rd&lt;/sup&gt; percentile (ages 1-3)</td>
<td>1.32</td>
</tr>
<tr>
<td>F 66&lt;sup&gt;th&lt;/sup&gt; percentile (ages 1-3)</td>
<td>1.45</td>
</tr>
<tr>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;</td>
<td>0.18</td>
</tr>
<tr>
<td>F&lt;sub&gt;current&lt;/sub&gt;/F&lt;sub&gt;0.1&lt;/sub&gt;</td>
<td>7.8</td>
</tr>
<tr>
<td>B&lt;sub&gt;current&lt;/sub&gt; (mean 6 last years)</td>
<td>7986 (t)</td>
</tr>
<tr>
<td>Biomass 33&lt;sup&gt;rd&lt;/sup&gt; percentile</td>
<td>7666 (t)</td>
</tr>
<tr>
<td>Biomass 66&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>8451(t)</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:**
- In overexploitation (F<sub>current</sub> > F<sub>0.1</sub>)
- Relative intermediate biomass; B<sub>current</sub> = 7986 (t); Biomass at 33<sup>rd</sup> percentile = 7666(t)

**Advice and recommendations:**
- Reduce F<sub>current</sub> towards F<sub>0.1</sub>
- Progressive reduction of the fishing effort

**Discussion:** No particular discussion on this stock.

4. **Stock:** European hake, *Merluccius merluccius*

**GSA:** 07

**Author(s):** Rouyer T., Jadaud A., Guijarro B., Massuti E.

**Fishery:** Hake is one of the most important demersal target species for the commercial fisheries in the Gulf of Lions (GSA 07). In this area, hake is exploited by French trawlers, French gillnetters, Spanish trawlers and Spanish longliners. Since 1998, an average of 243 boats are involved in this fishery and, according to official statistics, the total annual landings for the period 1998–2013 have oscillated around an average value of 2008 tonnes (1 736 tonnes in 2013). In 2009, because of the large decline of small pelagic fish species in the area, the trawlers fishing small pelagic have diverted their effort on demersal species. Between 1998 and 2013, the number of French trawlers operating in the GSA 07 has decreased by 39%, while it decreased by more than 30% between 2010 and 2013. This follows management measures to reduce the number of boats. The French trawler fleet is the largest both for the number of boats and the catch realized (41% and 72%, respectively). The length of hake in the trawler catches ranges between 3 and 92 cm total length (TL), with an average size of 21 cm TL. The second largest fleet is the French gillnetters (41 and 14% respectively, range 13–86 cm TL and average size 39 cm TL), followed by the Spanish trawlers (11 and 8%, respectively, range 5–88 cm TL, and average size 24 cm TL), and the Spanish longliners (6 and 6%, respectively, range 22–96 cm TL and average size 52 cm TL).

The hake trawlers exploit a highly diversified species assemblage: Striped red mullet (*Mullus surmuletus*), red mullet (*Mullus barbatus*), angler fish (*Lophius piscatorius*), black-bellied angler fish
(Lophius budegassa), European conger (Conger conger), poor-cod (Trisopterus minutus capelanus), four-spotted megrim (Lepidorhombus boscii), soles (Solea spp.), horned octopus (Eledone cirrhosa), squids (Illex coindetii), gilt-head seabream (Sparus aurata), European seabass (Dicentrarchus labrax), seabreams (Pagellus spp.), blue whiting (Micromesistius poutassou) and tub gurnard (Chelidonichthys lucerna).

**Data and parameters:** The information used for the assessment of the stock consisted of annual size composition of catches (estimated from monthly or quarterly sampling in the main landing ports), official landings and biological parameters estimated from data collected in the GSA 7 (1998–2013) by IFREMER and for the DCF from 2002 to 2013). These parameters are length-weight relationship, sex-ratio and maturity ogive. They were computed using inbio (R scripts developed by IEO). From 1998 to 2012, the length-weight relationship was used to compute the mean weight at age. For 2013, we used the weight estimates produced by COST tools. The mean weights at age were computed as the average of males and females abundance weighted by the catch numbers and the weights were adjusted by sop correction. The growth parameters come from tagging experiments developed by IFREMER in the area (Mellon-Duval et al., 2010). The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella et al., 1997).

**Assessment method:** The stock assessment was performed over the period 1998-2013 using the a4a model (developed by the Joint Research Center) and the MEDITS index, over age classes ranging from 0 to 5+, as tuning fleet, instead of XSA for assessing the stock. A4a is a statistical catch at age model, which its flexibility allows fitting a wide range of models to the data. Compared to XSA, a4a runs forward and allows reaching a better stability for last year’s estimates. As it is the first year this method was used, the results were compared to an XSA run, following the classically approach used for this model, involving sensitivity analyses on parameters to select the best run. The comparison of the a4a results with those from the XSA run displayed a good consistency as the trends for the various variables were found to be the same. The only notable differences were observed for the two last years of the fishing mortality time series, but that is likely to be linked to the well-known instability of the last years XSA estimates and to the better estimation of fishing mortality with a4a (no back-calculation in contrary to XSA). Consequently, the WG validated the use of the a4a for this assessment. The reference point $F_{0.1}$ had to be estimated due to the use of a new model. These methods were applied using the FLR libraries in the statistical software R.

**Model performance:** XSA retrospective analysis did not show any trend.

**Results:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_{current}$ (mean last 3 years, ages 0-3)</td>
<td>1.671</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.174</td>
</tr>
<tr>
<td>Biomass current (2011-2013) (tonnes)</td>
<td>2836</td>
</tr>
<tr>
<td>Biomass (33rd)</td>
<td>3369</td>
</tr>
<tr>
<td>Biomass (66th)</td>
<td>4382</td>
</tr>
<tr>
<td>Current Recruitment (Thousands) 2011-2013</td>
<td>30224</td>
</tr>
<tr>
<td>$F_{current}/F_{0.1}$</td>
<td>9.6</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:** The stock is in an overexploitation status with a relative low abundance with periodically higher recruitments (1998, 2001–2002 and 2007) which ensured the sustainability of the stock at the lower level of abundance of the series. Since 2007, the recruitment has reached the lowest level of the historical series 1998–2013. After reaching very high values in 2010 and 2011, the trend in fishing mortality seems to be a decreasing one. However, the spawning stock biomass and the recruitment are still at low levels, with little signs of improvement. The current exploitation level is well above the level estimated to be sustainable. The important decrease in number of the French trawler fleet since 1998, reducing the number of boats by 39%, is likely to start to have a positive effect on the stock.
**Advice and recommendation**: Reduce fishing mortality

- Improve the fishing pattern of the trawlers so that the minimum length of catches is consistent with the minimum legal landing size
- Freezing of the effort in the Fishery Restricted Area

It is important to note that some management measures have been taken since 2011 (reduction from 2010 to 2013 by more than 30% of the number of trawlers). This measure was over at the end of 2013.

**Discussion**: The WG recommended incorporating a comparison of trends for fishing effort and F.

5. **Stock**: European hake, *M. merluccius*

**GSA**: 10

**Author(s)**: Bitetto I., Carbonara P., Casciaro L., Facchini M. T., Lembo G. and Spedicato M. T.

**Fishery**: In the central-southern Tyrrenian Sea (GSA 10), the main demersal resources on the continental shelf are European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), pandora (particularly *Pagellus erythrinus*) and, among cephalopods, squids (e.g., *Todarodes sagittatus*, *Illex coindetii*) and octopus (*Octopus vulgaris*). European hake is mostly targeted by trawlers, but also by small-scale fisheries using nets and bottom long-lines. Fishing grounds are located on the soft bottoms of continental shelves and the upper part of continental slope along the coasts of the whole GSA.

**Data and parameters**: The commercial landing and discard time series (2006-2013) and the LFDs by fleet segment from DCF has been used for the assessment. MEDITS trawl survey data from 1994 to 2013 have been used in the analysis. The biological parameters estimated within DFC for the area have been also used (growth parameters, length-weight relationship, sex ratio and maturity. The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella *et al.*, 1997).

**Assessment method**: Given that the time series covers the total number of age classes in landing (0 to 6+) at least one time was possible to carry out an assessment using XSA (Extended Survivors Analysis) on the times series 2006-2013.

**Model performance**: The log-catchability residuals and the retrospective analysis did not show any trend.

**Results**:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F&lt;sub&gt;current&lt;/sub&gt;</td>
<td>0.74</td>
</tr>
<tr>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;</td>
<td>0.16</td>
</tr>
<tr>
<td>MEDITS biomass index 33&lt;sup&gt;rd&lt;/sup&gt; percentile (kg/km&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>14</td>
</tr>
<tr>
<td>MEDITS biomass index 66&lt;sup&gt;th&lt;/sup&gt; percentile (kg/km&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>21</td>
</tr>
<tr>
<td>Current MEDITS biomass index (2013) (kg/km&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>20.4</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status**: Given the results of the present analysis, the stock seems in overexploitation, being exploited at level of F (0.74) higher than the reference point (0.16) with an intermediate level of biomass according to MEDITS survey data.
**Advice and recommendation:** It is recommended to reduce the fishing mortality in order to achieve the estimated $F_{0.1}$ levels that can be gradually achieved by multi-annual management plans that foresee a reduction of fishing mortality through fishing restrictions.

**Discussion:** No particular discussion on this stock.

**6. Stock:** European hake, *Merluccius merluccius*

**GSA:** 12-13-14-15-16

**Author(s):** V. Gancitano, S. Ben Meriem, F. Colloca, E. Arneri, L. Ceriola, R. Micallef, R. Mifsud and F. Fiorentino

**Fishery:** European hake, *Merluccius merluccius*, is an important demersal target species for commercial fisheries in the Strait of Sicily (GFCM-GSAs 12-16, south-central Mediterranean Sea). In this area, European hake is exploited by 5 main fishing fleet segments: Italian coastal trawlers, Italian distant trawlers, Tunisian trawlers and nets, Maltese trawlers and Italian artisanal vessel but catch from this fleet segment in negligible. Average annual landings of European hake for the period 2012–2013 is about 1 500 tonnes. Trawlers landing hake also exploit a diversified species assemblage including *inter alia:* deep-sea rose shrimp, striped mullet (*Mullus surmuletus*), red mullet (*Mullus barbatus*), angler (*Lophius piscatorius*), black-bellied angler (*Lophius budegassa*) and European conger (*Conger conger*). The catch of hake comprises a wide range of size classes, between 8 and 68 cm total length (TL), with an average size of 20 cm TL. To assess the state of the stock in the MedSudMed area analytical and global models were applied: extended survivors analysis (XSA) and Schaefer and Fox models respectively.

**Data and parameters:**
- The data used for the stock assessment were: i) Catch composition and total catch according to official national data from Tunisia, Italy and Malta; ii) tuning data from MEDITs surveys from GSA 15 and 16 (2007–2013) and iii) biological parameters (sex combined) estimated by experts from Tunisia, Italy and Malta such as: $L_\infty = 100.0$ cm, $k = 0.116$, $t_0 = -0.6$, $a = 0.004$, $b = 3.15$.
- The natural mortality as vector by age group was estimated through the Prodbiom model (Abella et al., 1997).
- General comments - The definition of the most appropriate growth parameters for this species is still a matter of active debate (Bouhlal, 1975; Aldebert 1981; Aldebert and Carries, 1988; Relini Orsi et al., 1989; Recasens, 1992; Aldebert and Morales-Nin, 1992; Morales-Nin and Aldebert, 1997, Morales-Nin et al., 1998; Morales-Nin and Moranta, 2004; Courbin et al., 2007). The set of biological parameters used for the stock assessment of European hake was chosen in coherence with the previous stock assessment exercises carried out in the area (2010, 2011, 2012, 2013), and according to a precautionary approach.

**Assessment method:** The assessment was performed using extended survivor analysis (XSA) as implemented in the FLR (fisheries libraries in R) and using Global model to estimate MSY and FMSY. According to the recommendations of the GFCM WG, current F was estimated as average of the last three years of the time series considered (i.e. 2011-2013) and equal to 0.63. $F_{0.1}$ was estimated through FLR with XSA data and results and considering M and F at age and equal to 0.14. The results obtained through the Global models further confirm the results of the XSA. The results obtained in terms of stock status are reported in the following table.
Results:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_{\text{current}}$</td>
<td>0.63</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.14</td>
</tr>
<tr>
<td>Current B/R</td>
<td>54.3</td>
</tr>
<tr>
<td>$F_{\text{curr}}/F_{0.1}$</td>
<td>4.5</td>
</tr>
<tr>
<td>Maximum exploitable production $_{\text{Schaefer Model}}$</td>
<td>4007</td>
</tr>
<tr>
<td>Maximum exploitable production $_{\text{Fox Model}}$</td>
<td>3023</td>
</tr>
<tr>
<td>Effort at Maximum exploitable production $_{\text{Schaefer Model}}$</td>
<td>36550</td>
</tr>
<tr>
<td>Effort at Maximum exploitable production $_{\text{Fox Model}}$</td>
<td>33333</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:** $F$ showed a decreasing trend in the study period (2007-2013). The results of the assessment revealed the stock is in overexploitation ($F_{0.1} > F_{\text{curr}}$). The survey data (MEDITS) indicated a relative high abundance of the stock.

**Advice and recommendation:** Considering the estimated values of $F$, to reach $F_{0.1}$ the current level of fishing mortality should be reduced by about 77% of current level of $F$. The reduction of fishing mortality to move toward $F_{0.1}$, should take into account the different contribution to the catch by fleet segment and GSA.

According to the stock assessment carried out, the fisheries are essentially oriented to juveniles, resulting in growth overfishing. A reduction of the impact of trawlers targeting the juvenile portion of the stock could result in an improved stock status. In particular, an improvement of the spatial fishing pattern and selectivity of trawlers would result in a reduction of pressure on juveniles, increasing of minimum length of catch and reduction of growth overfishing. Also, the possibility of the hake stock in the Strait of Sicily being exploited by fisheries from subareas not considered in this stock assessment cannot be excluded. Therefore, it is advisable to evaluate the possibility of integrating data from adjacent GSAs in to a comprehensive analysis.

**Discussion:** No particular discussion on this stock.

### 7. Stock: European hake, *Merluccius merluccius*

**GSA:** 17

**Author(s):** Angelini S., Scarcella G., Bitetto I., Martinelli M., Carpi P., Colella S., Donato F., Panfili M., Belardinelli A., Croci C., Domenichetti F., Tesauro C., Manfredi C., Isajlović I., Piccinetti C., Vrgoč N., Santojanni A.

**Fishery:** European hake, *Merluccius merluccius*, is one of the most important demersal species for the Adriatic Sea. In this area, hake is exploited mainly by bottom trawlers and in Croatian waters, longliners are also used. Landings present a fluctuating trend all over the time series considered accounting for the highest value in 1993 and the lowest value in 2011. Italy is the country that mainly exploits this species representing more than 70% of the total landings of GSA 17. Bottom trawl catches are mainly composed by age 0 and 1 individuals while longliners exploit mainly age 2 and 3 individuals.

**Data and parameters:** The information used for the stock assessment comes from the annual size composition of Italian and Croatia catches from 2008 to 2013 obtained from the DCF. According to the fast growth, the von Bertalanffy growth factor used in this assessment are $L_{\text{inf}}$ 104, k 0.2 and $t_0$ - 0.01 and length weight parameters are $a$ 0.0043 and $b$ 3.2. These parameters have been also used in the age slicing performed by LFDA 5.0. The vector of natural mortality by age has been calculated using Prodbiom (Abella *et al.* 1997). Abundance and biomass indexes come from GRUND and
MEDITS survey and they are computed using ATrIS software, which also allows drawing GIS maps of the spatial distribution of the stock, spawners and juveniles.

**Assessment method:** Statistical Catch at Age (SCAA) using SS3 assessment has been applied. Input data were provided by the Italian and Croatian DCF official data call. Tuning data were collected during the GRUND and MEDITS survey. SCAA with SS3 permits to model the selectivity of each fleet and survey and use data sources with different time series. The $F_{\text{current}}$ is equal to 0.53 and it comes to the mean of the last 3 years (2011-2013). The reference point, $F_{0.1}$ as a proxy of $F_{\text{MSY}}$, is equal to 0.26 and was estimated using the yield per recruit analysis.

**Model performance:** Residuals don’t show particular discrepancies.

**Results:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_{\text{current}}$ (age 0-4)</td>
<td>0.53</td>
</tr>
<tr>
<td>$F_{\text{max}}$</td>
<td>0.46</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.26</td>
</tr>
<tr>
<td>$F_{\text{current}}/F_{0.1}$</td>
<td>2.04</td>
</tr>
<tr>
<td>Biomass MEDITS</td>
<td>33.093</td>
</tr>
<tr>
<td>Biomass 33rd percentile MEDITS</td>
<td>29.612</td>
</tr>
<tr>
<td>Biomass 66rd percentile MEDITS</td>
<td>40.639</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:** Stock is in overexploitation status, with intermediate values of biomass (estimates on the MEDITS time series). The stock is in overfishing as $F_{\text{current}}$ exceeds the $F_{0.1}$ level, thus a reduction of fishing mortality is necessary to approach the reference point.

**Advice and recommendation:** Considering the overexploitation status and the intermediate biomass estimated by MEDITS survey, a reduction of fishing mortality and an improvement in exploitation pattern is advisable, especially for bottom trawlers, which mainly exploit juveniles. Particular management measure can be considered for the Pomo area since it constitutes a nursery area for hake, supporting the entire Adriatic hake stock, and in the eastern part a persistency area for spawners has been revealed from the MEDISEH project.

**Discussion:** No particular discussion on this stock.

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8. **Stock:** European hake, *Merluccius merluccius*

**GSA:** 18

**Author(s):** Bitetto I., Carbonara P., Casciaro L., Ceriola L., Đurović M., Facchini M. T., Ikica Z., Joksimović A., Kolitari J., Kroqi G., Lembo G., Marković O., Milone N. and Spedicato M. T.

**Fishery:**
Trawling represents the most important fishery activity in the southern Adriatic Sea and a yearly catch of around 30,000 tonnes could be estimated for the last decades. Hake is also caught by off-shore bottom long-lines, but these gears are utilised by a low number of boats (less than 5% of the whole South-western Adriatic fleet). Fishing grounds are located on the soft bottoms of continental shelves and the upper part of continental slope along the coasts of the whole GSA. Catches from trawlers are from a depth range between 50–60 and 500 m and hake occurs with other important commercial species as *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone spp.*, *Todaropsis eblanae*, *Lophius spp.*, *Pagellus spp.*, *P. blennoides*, *N. norvegicus*. 
Data and parameters: Standardized LFD abundance indices (N/km$^2$) for the whole GSA18 from MEDITS trawl survey data from 1996 to 2013 have been used for the analysis. The length structure of landings and production by fishing segment from DCF has been used for west side, while for the east side data collected within a pilot study in the framework of AdriaMed project and biological sampling supported by AdriaMed (Montenegro) and from National Statistics Bureau (Albania). The biological parameters estimated within DFC for the area have been also used (growth parameters, length-weight relationship, sex ratio and maturity. The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella et al., 1997).

Assessment method: Previous assessments were performed with VIT (from 2008 to 2011). The update of XSA stock assessment of last year has been made, given that the time series covers the total number of age classes in landing (0 to 6+) at least one time, taking into account the data of the western and eastern side of GSA; in particular the LFDs of commercial catches for Albania has been used for the first time. The stock assessment has been performed also using a4a statistical catch at age, to overcome the hypothesis of flat selectivity in the oldest ages. The advice is based on the a4a method. Also ALADYM simulation model, providing a multi-fleet approach, has been applied and used to forecast the effects of different management strategies. The scenarios that have been modelled are:
- Status quo until 2021;
- Change in mesh size since 2014 for all the fleet segments;
- Fishing ban of one month since 2014 for all fleet segments;
- Reduction of F towards F$_{0.1}$ in 2020.

Model performance: About XSA analysis, the log-catchability residuals and the retrospective analysis did not show any trend. About a4a analysis, the residuals do not show any trend and the fitting of the survey and commercial catches seem reconstructed in a quite satisfactory way. A satisfactory fit has been obtained with ALADYM simulation model for all the fleet segments between simulated and observed landing. The hind-casting approach used for this assessment was accomplished to supporting the validity of the combined assessment.

Results:
In the table below are reported the Fcurrent and F0.1 according to a4a results:

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F$_{\text{current}}$</td>
<td>0.8</td>
</tr>
<tr>
<td>F$_{0.1}$</td>
<td>0.2</td>
</tr>
<tr>
<td>MEDITS biomass index 33$^{\text{rd}}$ percentile (kg/km$^2$)</td>
<td>20</td>
</tr>
<tr>
<td>MEDITS biomass index 66$^{\text{rd}}$ percentile (kg/km$^2$)</td>
<td>29</td>
</tr>
<tr>
<td>Current MEDITS biomass index (2013) (kg/km$^2$)</td>
<td>27.6</td>
</tr>
</tbody>
</table>

The ALADYM projections show that in medium term the best performances for catches of the different fleet segments are given by the mesh size increase scenario, followed by the fishing ban and the reduction towards F$_{0.1}$ in 2020, while the better effect to SSB is given by the scenario based on the gradual reduction of F towards F$_{0.1}$ in 2020.

Diagnosis of stock status: The stock is in overexploitation with low biomass levels, as current fishing mortality exceeds F$_{0.1}$ levels (0.8 vs. 0.2) and thus it is necessary to consider a considerable reduction of the fishing mortality to allow the achievement of F$_{0.1}$.

Advice and recommendation: The reference point F$_{0.1}$ can be gradually achieved by multiannual management plans. As observed in 2013, the production of hake in GSA 18 is split in 6% caught by Italian longlines, 82% by Italian trawlers, about 1% by Montenegrin trawlers, about 1% by Montenegrin gillnets and trammel nets and about 10% by Albanian trawlers.
Discussion: The WG suggested to use an average of the last three years for the recruitment in the projections.

9. Stock: Common sole, *Solea solea*

GSA: 17


Fishery: The common sole is a very important commercial species in the Northern Adriatic Sea (GSA 17). The Italian fleets exploit common sole by rapid trawl and set nets, while only trawl net is commonly used in the countries of the eastern coast. The main fleets operating with rapid trawl in GSA 17 are from Ancona, Chioggia and Rimini. More than 90% of catches come from the Italian side, whereas the eastern part of the basin contributes for about the 10% of the total landings, with on average 8 t from Slovenia and 200 t from Croatia. Rapido trawl landings are traditionally dominated by small sized specimens; they are basically composed by 0+, 1 and 2 year old individuals. Italian set net fishery lands mostly the same portion of the population. In the eastern part of the basin the catch composition is dominated by adults.

Data and parameters: The information used for stock assessment consisted of common sole landings coming from the FAO Capture Production (GFCM Area; 1970-2005) database and from the Italian, Slovenian and Croatian data collected under DCF and submitted in 2014 data call (period 2006-2013), biological parameters were estimated from data collected in the GSA 17 during SoleMon project. Abundance and biomass indexes from SoleMon rapid trawl survey were also utilised and computed using ATrIS software, which also allowed drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles. The natural mortality was estimated as a vector using the Prodbiom approach.

Assessment method: XSA, and Statistical Catch at Age (SCAA) using SS3 and a4a assessments were applied. Input data were provided by the Italian, Slovenian and Croatian DCF 2014. Tuning data were collected during the SoleMon survey. Considering the longer data series employed and the possibility to model the selectivity of fleets and survey, has been decided that the SCAA using SS3 provides more accurate results on the status of the stock, thus such analysis have been used to draft the scientific advices. Moreover, due to the different approach used to estimate the fishing mortality it was decided to use the 2013 value of F, instead of the mean of the last 3 years (0.8).

Model performance: The residuals and retrospective analyses did not show particular discrepancies.

Results:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F\text{current} (2013, ages 0-4)</td>
<td>0.46</td>
</tr>
<tr>
<td>F\text{0.1}</td>
<td>0.31</td>
</tr>
<tr>
<td>Biomass current (tonnes)</td>
<td>3150</td>
</tr>
<tr>
<td>Biomass (33\text{rd} tonnes)</td>
<td></td>
</tr>
<tr>
<td>Biomass (66\text{rd} tonnes)</td>
<td></td>
</tr>
<tr>
<td>Current recruitment</td>
<td></td>
</tr>
<tr>
<td>F\text{current}/ F\text{unique}</td>
<td>1.48</td>
</tr>
</tbody>
</table>

Diagnosis of stock status: Considering the results of the analyses carried out, the common sole stock in GSA 17 is in overexploitation, being the current F (2013) estimated with SCAA model equal to 0.46 (SCAA) and higher than the proposed reference point F\text{0.1} (F\text{0.1} SCAA = 0.31 as a proxy of F\text{MSY}).
**Advices and recommendation:** A reduction of fishing mortality is advised towards the proposed reference point \(F_{MSY}\). Considering the overexploited situation and the low values of SSB and biomass of the sole stock in GSA 17 a reduction of fishing effort and an improvement in the exploitation pattern is advisable. These enhancements could be reached introducing a closure for rapido trawling within 17 Km (9 nm) of the Italian coast during summer – fall period, as observed in the spatial simulation presented in the stock assessment form. In addition, it was noted that in the last years some Italian artisanal fleets fish with gill nets in the main spawning area. Additional measures to restrict exploitation of sole in the spawning area are desirable, to prevent a dramatic increase of the fishing pressure both of rapido trawlers and set netters. Finally, to have a more accurate estimation of the tuning data, would be necessary the expansion of SoleMon survey inside Croatians waters.

**Discussion:** The group considered the use of the SS3 method as a good initiative. The WG appreciated the comparison between the models provided, as requested by last year’s WG.

**10. Stock:** Red mullet, *Mullus barbatus*

**GSA:** 03

**Author(s):** El Ouamari N. & J. Bensbai

**Fishery:** Red mullet (*Mullus barbatus*) is one of most important target species of trawlers in GSA03. According to official statistics, around 111 boats are involved in the fishery. The average of the annual landings of this species were situated around 375 tonnes. The fishing effort applied by trawlers shows a clear decrease since 2010 and reach his minimal value in 2013 which is about 10600 fishing days. During the period 2010–2013, trawl catches range between 5 and 29 cm fork length (FL).

**Data and parameters:** The analyses were performed using monthly size composition of catches, official landings. Other biological parameters (growth parameters, length-weight relationships, oogive of maturity) were obtained within the framework of the Moroccan data collection programme. The natural mortality was calculated from Dabali et al, 1994. The terminal fishing mortality adopted was 0.5. The production model was carried out using a time series of landing and CPUEs data covering a period 2004-2013 by the CECAF Schaeffer model (FAO CECAF Dynamic Schaeffer model, 2007).

**Assessment method:** The stock of *Mullus barbatus* of the GSA03 has been assessed using both analytical methods and production model. The first one has been carried out using the VIT program (Lleonart and Salat, 1997) using data from the trawl fishery on a time series covering five years (2010-2013). A VPA and a Y/R analysis on a mean pseudo-cohort from that period has been applied.
Results:

- **Analytical model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_{cur}$</td>
<td>1.09</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.48</td>
</tr>
<tr>
<td>$F_{max}$</td>
<td>0.87</td>
</tr>
<tr>
<td>$F_{cur}/F_{0.1}$</td>
<td>2.27</td>
</tr>
</tbody>
</table>

- **Production model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSY</td>
<td>763</td>
</tr>
<tr>
<td>$B_{MSY}$</td>
<td>1756</td>
</tr>
<tr>
<td>$B_{0.1}$</td>
<td>1932</td>
</tr>
<tr>
<td>$B_{current}$</td>
<td>670</td>
</tr>
<tr>
<td>$B_{current}/B_{MSY}$</td>
<td>0.38</td>
</tr>
<tr>
<td>$B_{current}/B_{0.1}$</td>
<td>0.35</td>
</tr>
<tr>
<td>$Cur_SustProd$</td>
<td>471</td>
</tr>
<tr>
<td>$Cur_percProd$</td>
<td>62%</td>
</tr>
<tr>
<td>$CurY$</td>
<td>320</td>
</tr>
<tr>
<td>$F_{MSY}$</td>
<td>0.43</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.39</td>
</tr>
<tr>
<td>$F_{current}$</td>
<td>0.48</td>
</tr>
<tr>
<td>$F_{current}/F_{MSY}$</td>
<td>1.10</td>
</tr>
<tr>
<td>$F_{current}/F_{0.1}$</td>
<td>1.22</td>
</tr>
<tr>
<td>$FSY_{Cur}$</td>
<td>0.70</td>
</tr>
<tr>
<td>$F_{current}/FSY_{Cur}$</td>
<td>0.68</td>
</tr>
<tr>
<td>$DBC_{Cur}$</td>
<td>152</td>
</tr>
<tr>
<td>$DBC_{Cur}/B_{cur}$</td>
<td>0.23</td>
</tr>
<tr>
<td>$CurY/MSY$</td>
<td>0.42</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status**: The results obtained by the two assessment methods applied on this species indicate that the stock is in overexploitation status with relative low biomass.

Advice and recommendation: *Reduce the fishing mortality.*

**Discussion**: The WG encouraged the continuity of the sampling in order to achieve longer data series and improve the robustness of the assessment.

11. **Stock**: Red mullet, *Mullus barbatus*

**GSA**: 06

**Author(s)**: Fernández, A. M; A. Esteban, A & Pérez Gil, J. L.

**Fishery**: Both species of red mullet, *Mullus surmuletus* and *M. barbatus*, are exploited by trawl and artisanal fleets in GSA 06, although small gears (trammel nets and gillnets) account only for 5% of the total landings of these species (Demestre et al., 1997). Trawl fisheries developed along the continental shelf and upper slope are multi-specific. Small vessels (12–16m length) operate mainly on the shallow shelf targeting on red mullets, octopus, cuttlefish and sea breams. Medium and large vessels usually operates on deep continental shelf and slope areas targeting on hake and crustaceans, but some of these units can also operate on the shallow shelf depending on weather conditions or
market prices. Red mullet is more intensively exploited from September to November coinciding with the recruitment period of this species (Martín et al., 1999). The total trawl fleet in the GSA 06 has declined from 810 boats in 1998 to 478 boats in 2012; around 30% of these boats regularly operate in sallow shelf.

According to official statistics, the fishery developed quickly during the seventies reaching a maximum of 1984 tonnes in the year 1984. Since then landings have widely oscillated around a mean value of 1174 tonnes (1995–2013) although a decreasing trend is observed. Catches in the period 1995-2010 were composed mainly by individuals of age groups 0 and 1. After the enforcement of the new mesh type in 2010 (40mm square or alternatively 50mm diamond) catches in 2011–2013 are composed mainly by individuals of age groups 1 and 2.

**Data and parameters:** The information used for the assessment are the total annual landings from official statistics, the annual catch in number by size class estimated by monthly port sampling and on board observers and the abundance index from commercial fleet and MEDITS surveys. Growth parameters are those used in previous assessments by STECF and GFCM for GSA 06 (Demestre et al, 1997). Length-weight relationship and maturity ogive comes from Spanish DCF and the vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella et al., 1997). Selectivity experiences carried out by the IEO with 40 mm diamond and square mesh in the cod-end were also used.

**Assessment method:** Tuned VPA applying the XSA method (Darby & Flatman, 1994) and Yield per recruit (YPR software, NOOA Fisheries Tools) for the estimation of reference points.

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

**Results:**

<table>
<thead>
<tr>
<th></th>
<th>Fcurrent (mean FBAR ages 1-2 in 2011-2012)</th>
<th>0.692 (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F&lt;sub&gt;0.1&lt;/sub&gt; (present assessment)</td>
<td>0.508</td>
<td></td>
</tr>
<tr>
<td>SSB&lt;sub&gt;current&lt;/sub&gt; (2013) (tonnes)</td>
<td>1110</td>
<td></td>
</tr>
<tr>
<td>Biomass (33th)</td>
<td>811</td>
<td></td>
</tr>
<tr>
<td>Biomass (66th)</td>
<td>947</td>
<td></td>
</tr>
<tr>
<td>Current Recruitment (Thousands)</td>
<td>104641</td>
<td></td>
</tr>
<tr>
<td>Fcurrent/F0.1</td>
<td>1.36</td>
<td></td>
</tr>
</tbody>
</table>

(*) Fishing mortality is overestimated for the last year in the analysis. Consequently, it is not considered in the estimation of Fcurrent.

**Diagnosis of stock status:**
- In overexploitation (F<sub>current</sub> > F<sub>0.1</sub>)
- Relative high biomass (SSB<sub>current</sub> > SSBiomass at 66<sup>rd</sup> percentile)

**Advice and recommendation:**
- Reduce F<sub>current</sub> towards F<sub>0.1</sub>
- Progressive reduction of the fishing effort

**Discussion:** The retrospective analysis showed an overestimation of F in the last year and for that reason, it was not considered for F<sub>current</sub>-
12. Stock: red mullet *Mullus barbatus*

GSA: 07

Author(s): Jadaud A., Rouyer T., Guijarro B., Massuti E.

Fishery: In the Gulf of Lions (GSA 7), red mullet is exploited by both French and Spanish trawlers. Information on French gillnetters is only available for 2011 and 2013, but although it is suspected that they have been fishing red mullet in the past, no data is available to quantify their catches. Between 2004 and 2013, around 100 boats have been involved in the fishery. According to official statistics, during this period the total annual landings have oscillated around an average value of 200 tonnes and the French trawlers have been dominating the fishery, as they represent 73% of the catches (165 tonnes) on the period. After 2009, because of the large decline of small pelagic fish species in the area, the trawlers fishing small pelagic have diverted their effort on demersal species, this can explain the high catches of 2010. Between 1998 and 2013, the number of French trawlers operating in the GSA 07 has decreased by 39%, while it decreased by more than 30% between 2010 and 2013. From a maximum number of 123 trawlers in 2004, the French fleet catching red mullet is nowadays composed by 61 units. This follows management measures to reduce the number of boats. The mean modal lengths in the catches of the French and Spanish trawlers were 13.9 and 14.9 cm, respectively and the length at first capture is about 6 cm. Catch is mainly composed by individuals of age 0, 1 and 2 (Figure 3.1.2.), while the oldest age class (4+ group) is poorly represented. In GSA 07, the trawl fishery is a multi-specific fishery. In addition to *M. barbatus*, the following species can be considered important by-catches: *Merluccius merluccius*, *Lophius sp.*, *Pagellus sp.*, *Trachurus sp.*, *Mullus surmuletus*, *Octopus vulgaris*, *Eledone sp.*, *Scyliorhinus canicula*, *G. melastomus*, *Trachinus sp.*, *Triglidae*, *Scorpaena sp.*

Data and parameters: The information used for the assessment of the stock consisted in annual size composition of catches (estimated from monthly or quarterly sampling in the main landing ports), official landings and biological parameters estimated from data collected in the GSA 7 (2004–2013) by IFREMER for the DCF. These parameters are length-weight relationship, sex-ratio and maturity ogive. They were computed using inbio (R scripts developed by IEO). From 2004 to 2012, the length-weight relationship was used to compute the mean weight at age. For 2013 we used the weight estimates produced by COST tools. The mean weights at age were computed as the average of males and females abundance weighted by the catch numbers and the weights were adjusted by sop correction. Size compositions were converted from number at length to number at age by knife edge slicing (deriving the growth from DCF data) from 2004 to 2012, whereas in 2012 and 2013 age-length key from otolith readings were used. Natural mortality was estimated using PROBIOM (Abella *et al.*, 1997).

Assessment method: The assessment was carried out by means of Extended Survivor Analysis (XSA) over the period 2004-2013, and calibrated with indices from the scientific survey MEDITS, and yield-per-recruit (Y/R) for the period 2011–2013. These methods were applied using the FLR libraries in the statistical software R.

Model performance: No concern was raised about that issue.

Results:

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<table>
<thead>
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<tbody>
<tr>
<td>Fcurrent (average last 3 years, ages 0-3)</td>
<td>0.45</td>
</tr>
<tr>
<td>F0.1 (estimated in 2012)</td>
<td>0.14</td>
</tr>
<tr>
<td>Biomass current (tonnes) 2011-2013</td>
<td>1022</td>
</tr>
<tr>
<td>Biomass (33th)</td>
<td>597</td>
</tr>
<tr>
<td>Biomass (66th)</td>
<td>690</td>
</tr>
<tr>
<td>Current Recruitment (thousands) 2011-2013</td>
<td>35077</td>
</tr>
<tr>
<td>Fcurrent/F0.1</td>
<td>3.21</td>
</tr>
</tbody>
</table>
**Diagnosis of stock status:** The stock is in an overexploitation status with a relative high abundance and punctually higher recruitments (2005, 2006 and 2013). This diagnostic is based upon analytical results based on fishing mortality. The exploitation level is currently above the level estimated to be sustainable since the referent point $F_{0.1}$ is equal to 0.14 and current fishing mortality ($F_{\text{current}}$) is equal to 0.45. The current fishing mortality is the lowest of the series and the spawning stock biomass currently follows an upward trend. The exploitation is mainly concentrated on young individuals (age 0-2), moreover 60% of the recruitment (age 0) is mature. The current biomass (2011–2013) is above the 66th percentile.

However computed over a relatively short time-period (2004–2013), the increase in spawning stock biomass and the decrease in fishing mortality have to be noticed. The important decrease in numbers of French trawler fleet since 1998, reducing the number of boats by 39%, is likely to start to have a positive effect on the stock.

**Advice and recommendation:** Reduce fishing mortality.

- Improve the fishing pattern of the trawlers so that the minimum length of catches is consistent with the minimum legal landing size
- Freezing of the effort in the Fishery Restricted Area

It is important to notice that some management measures have been taken since 2011 (reduction from 2010 to 2013 by more than 30% of the number of trawlers). This measure was over at the end of 2013.

**Discussion:** No particular discussion on this stock.

13. **Stock:** Red mullet, *Mullus barbatus*

**GSA:** 10

**Author(s):** Bitetto I., Carbonara P., Casciaro L., Facchini M. T., Lembo G. and Spedicato M. T.

**Fishery:** In the central-southern Tyrrhenian Sea (GSA 10) the main demersal resources on the continental shelf are European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), pandora (particularly *Pagellus erythrinus*) and, among cephalopods, squids (e.g. *Todarodes sagittatus, Illex coindetii*) and octopus (*Octopus vulgaris*). Red mullet is an important species in the area, targeted by trawlers and small scale fisheries using mainly gillnet and trammel nets. Fishing grounds are located along the coasts of the whole GSA within the continental shelves. During late summer-early autumn (September-October), the species is intensely fished. About three-four months after settlement, red mullet has spread up to depths of about 100 m.

**Data and parameters:** The commercial landing time series (2006–2013) and the LFDs by fleet segment from DCF has been used for the assessment. MEDITS trawl survey data from 1994 to 2013 have been used in the analysis. The biological parameters estimated within DFC for the area have been also used (growth parameters, length-weight relationship, sex ratio and maturity. The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella et al., 1997).

**Assessment method:** Given that the time series covers the total number of age classes in landing (0 to 3+) at least one time was possible to make perform assessment using XSA (Extended Survivors Analysis) on the times series 2006–2013.

**Model performance:** The log-catchability residuals and the retrospective analysis did not show any trend.
Results:

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>$F_{current}$ (average 2011-2013)</td>
<td>0.5</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.5</td>
</tr>
<tr>
<td>MEDITS biomass index 33rd percentile (kg/km$^2$)</td>
<td>14.1</td>
</tr>
<tr>
<td>MEDITS biomass index 33rd percentile (kg/km$^2$)</td>
<td>25.5</td>
</tr>
<tr>
<td>Current MEDITS biomass index (2013) (kg/km$^2$)</td>
<td>21.8</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:** Given the results of the present analysis, the stock seems sustainably exploited, being exploited at level of $F$ (0.5) equal to the reference point (0.5). The level of biomass in intermediate according to MEDITS survey data.

**Advice and recommendation:** It is recommended to not increase the relevant fleets’ effort and/or catches to maintain fishing mortality in line with the agreed reference point.

**Discussion:** No particular discussion on this stock.

**14. Stock:** Red mullet, *Mullus barbatus*

**GSA:** 24

**Author(s):** Guççu A.C., Ok M.

**Fishery:** GSA 24 is characterized by quite large continental shelf in the east and very narrow and steep shelf on the west. This topographic difference determines the fleet size and type of fishery targeting red mullet in the area. The stock in the eastern side is mainly exploited by bottom trawls, whereas in the west bottom trawling is very limited due to 3 miles trawl exclusion zone where red mullet is mainly fished by artisanal fishers in negligible quantities. In between there exists a 16 miles long fisheries restricted zone (covering Turkish territorial waters).

**Data and parameters:**

Data used in the assessment comprises official landing statistics of red mullet published initially by the State Statistical Institute and later by TurkStat. The size composition was obtained monthly from a trawl representing the fleet operated throughout the fishing season (September-April). In addition, experimental survey data conducted monthly all year round was used as abundance index. The number of trawlers officially reported by the statistical institutions of Turkey is assumed to represent the effort. Monthly length frequency distribution is converted to age using seasonally oscillating VBGF.

**Assessment method:** Extended Survivor Analysis (FLXSA) was used to assess the red mullet stock in the area. Due to lack of length composition data, the stock is assessed for the period 2007-2013. Two sets of index file were used, as well as an abundance index from the survey data and CPUE of the trawl fleet.

**Model performance:** Various tests on model parameters were performed to assess the sensitivity of the model to the input parameters; which includes shrinkage, taper, selectivity. The best model was chosen based on residual distribution and the retrospective analysis.
Results:

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<table>
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<tbody>
<tr>
<td>( F_{\text{current}} ) (average last 3 years, ages 0-3)</td>
<td>0.60</td>
</tr>
<tr>
<td>( F_{0.1} ) (estimated in 2012)</td>
<td>0.47</td>
</tr>
<tr>
<td>SSB current (tonnes) 2011-2013</td>
<td>1850</td>
</tr>
<tr>
<td>Current Recruitment (Thousands) 2011-2013</td>
<td>145</td>
</tr>
<tr>
<td>( F_{\text{current}}/F_{0.1} )</td>
<td>1.28</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:**
The stock is in overexploitation when the reference value of \( F_{0.1} = 0.47 \) is compared to the fisheries mortality of the last three years \( (F_{\text{curr}}=0.60) \). The F, on the other hand, displays a cyclic pattern over the years in question with a maximum in 2010. The fluctuations in the number of trawlers are well reflected in the F estimates with a year of delay which, in essence, displays the impact of fishing pressure on the stock. On the other hand, the model suggests a sharp decline in the number of recruits in 2013, which is a rather unexpected situation when at the same time spawning stock biomass increases and fishing effort is reduced through a buyback program.

**Advice and recommendation:** Reduce fishing mortality
It is very likely in the area that the Lessepsian predators and competitors, sharing the same habitat and nursery ground in particular, have significant impacts on the red mullet. Therefore the regulations to be enforced to reduce the fishing mortality should take this issue into consideration. For instance, exotic mulloids which are smaller in size and hence attain maturity at a smaller size, would gain more benefit than does the red mullet when the mesh size of the trawl nets are increased.

**Discussion:** No particular discussion on this stock.

**15. Stock:** Red mullet, *Mullus barbatus*

**GSA:** 25

**Authors:** Josephides M., Charilaou C.

**Fishery:** Red mullet in GSA 25 is exploited by the artisanal fleet using set nets (basically trammel nets - GTR) and by the bottom otter trawlers - OTB. In both fisheries the species is exploited with a number of other demersal species, including *Sparisoma cretense*, *Octopus vulgaris*, *Sepia officinalis*, *Serranus cabrilla*, *Scorpaena* spp., *Labridae*, *Diplodus* spp., *Boops boops*, *Pagellus erythrinus*, *Siganus* spp. (Charilaou, 2011).

On average 51% of total red mullet landings in GSA 25 came from bottom otter trawlers in 2005-2013. The remaining catches came from small-scale vessels measuring up to a maximum length overall (LOA) of 12 m using trammel nets (gear code GTR).

Total red mullet landings in the period 2005–2013 decreased from 43.52 tonnes in 2005 to 23.7 tonnes in 2013. Landings of red mullet recorded in 2012 were at the lowest level recorded in the time series with 15.18 tonnes. The decrease in catches until 2012 was observed both for vessels using trammel nets (from 25.28 tonnes in 2005 to 8.54 tonnes in 2012) and for vessels using bottom otter trawlers (from 18.25 tonnes in 2005 to 6.65 tonnes in 2012). For both fishing categories an increase in landings was observed in 2013 (12 tonnes using trammel nets and 11.7 tonnes using bottom otter trawlers) compared to 2012 with 8.54 tonnes and 6.65 tonnes respectively.

**Data and parameters:** Official DCF data (Data Collection Framework (DCF) of the EU Regulation 199/2008) of commercial catches and MEDITS survey data were used; the analysis was carried out using sex-combined data. The annual size distributions of GSA 25 catches at age (from age reading) were used as well as the von Bertalanffy growth function estimates given in Charilaou (2011). Maturity at age data was based on the information given in Charilaou (2011) and natural mortality at
age was calculated with the PRODBIOM method. Weight at age information for catches was based on available official data for the years 2005-2013.
The abundance indices of red mullet (thousands at age), derived from the MEDITS survey were used as tuning data from 2006 to 2013. The year of 2005 was excluded because the survey was conducted in August while from 2006 and beyond was in June-early July.

Assessment method: Considering the variability observed in the catches and effort, the assessment is based on non-equilibrium method. Fisheries Library in R statistical language was used to implement Extended Survivor Analysis (XSA) as an assessment method. For the XSA model, a shrinkage coefficient of variation (CV) was supplied in order to weight the fishing mortality (F) shrinkage by testing three values of 0.5, 1 and 2. The best model was chosen according to the diagnostics of the residuals. A plus age group was set in the assessment. Biological reference points of \( F_{0.1} \) and \( F_{\text{max}} \) were estimated from the FLBRP library in R using the Yield per Recruit analysis. The biomass reference points \( B_{0.33} \) and \( B_{0.66} \) from the 33rd and 66th percentile were calculated to observe the status of current biomass.

Model performance: Diagnostic plots of XSA show an adequate fitting of the models and did not show any trends in the residuals that were observed. The best model chosen was with shrinkage 1, because of the lower values of the residuals.
Retrospective analysis generally showed a good agreement in the trend of recruitment, spawning stock biomass (SSB) and harvest, indicating that the assessment was consistent.

Results: The results of XSA showed an increase in spawning stock biomass and recruitment from 2010 to 2013. However, recruitment showed a slight decrease from 2012 to 2013. Regarding the exploitation, there is a remarkable decrease of harvest since 2010. Catch shows a decreasing trend in the time series with a slight increase occurring from 2012 to 2013. Total biomass indicates a decreasing trend from 2005 to 2010, and a remarkable increasing trend from 2010 to 2013.
Yield-per-recruit analysis showed that reference point of \( F_{0.1} \) has value of 0.23 with the current value \( F_c \) of the analysis being 0.34, while biomass of 33rd and 66th percentile have values of 83.67 and 117.78 tonnes respectively. The current biomass \( B_{\text{curr}} \) is estimated to be 124.99 tonnes.
A short term prediction was applied to the model, using 22 scenarios of fishing mortality with the assumption that recruitment is constant for the next 3 years (2014, 2015 and 2016).
In the case of reducing the fishing mortality close to the value of reference point \( F_{0.1} \) (0.228) [scenario 7 with \( F = 0.244 \)], catch will reach the value of 31.5 tonnes in 2014 while for the years 2015 and 2016 will be 21 and 25.3 tonnes respectively. SSB will increase to 81.3 and 97.2 tonnes for 2015 and 2016 respectively.

Diagnosis of stock status: Considering the results, it can be concluded that the resource is in overexploitation, with a relatively high level of biomass.

Advice and recommendation: Based on the above diagnosis, it is recommended that fishing mortality is reduced. It is noted that cessation schemes have already been implemented recently for both fleet segments concerned, and possibly the positive effects on the fishery have not been shown yet. Cyprus is planning to continue the cessation of small scale vessels in 2015-2016; in total, with the completion of the measure of permanent cessation, a reduction of at least 30% of the small scale inshore fleet is expected.
Following the completion of the measure, and based on the annual evaluations, possible inclusion of further management measures will be considered.

Discussion: No particular discussion on this stock.
16. **Stock:** Striped red mullet, *Mullus surmuletus*

**GSA:** 05

**Author(s):** Beatriz Guijarro, Natalia González, Vanessa Rubio, Francesc Ordines and Antoni Quetglas

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

**Data and parameters:** Size composition of commercial trawl catches and official landings (2000-2013), CPUE data from bottom trawl surveys (2001–2013) and from commercial fleet (2000–2013). Growth parameters, length-weight relationship and maturity ogive obtained in the area from monthly biological samplings in the Spanish National Data Collection Programme. M vector from PRODBIOM.

**Assessment method:** Extended Survivor Analysis (XSA), Yield per recruit analysis and short-term forecast.

**Model performance:** XSA residuals did not show any trend.

**Results:** Stock abundance, stock biomass, recruitment and spawning stock biomass showed a clear decreasing trend for the last years, although they cannot explained by changes in F as it has fluctuated around 0.5 along the data series, without a clear trend.

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<table>
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<tbody>
<tr>
<td>$F_{\text{current}}$ (mean 2011-2013, ages 0-2)</td>
<td>0.17</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.51</td>
</tr>
<tr>
<td>$F_{\text{current}}/F_{0.1}$</td>
<td>3.00</td>
</tr>
<tr>
<td>Current biomass (tonnes)</td>
<td>300</td>
</tr>
<tr>
<td>33rd percentile biomass (tonnes)</td>
<td>401</td>
</tr>
<tr>
<td>66th percentile biomass (tonnes)</td>
<td>459</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:** The stock is in overexploitation with relative low biomass.

**Advice and recommendation:** To reduce fishing mortality.

**Discussion:** The WG recommended assessing the stock again next year, as it seems to be at risk.
17. **Stock:** striped red mullet, *Mullus surmuletus*

**GSA:** 26

**Authors:** Mahmoud, H.H., EL Haweet, A.A.K. and Dimech M.

**Fishery:** The red mullet *Mullus surmuletus* is one of the most important commercial species in the eastern Mediterranean coast of Egypt (GSA 26). Its landings were 2268 tonnes during 2011, 1442 tonnes during 2012 and 1058 tonnes during 2013. Four species (*Mullus surmuletus, Mullus barbatus, Upeneus moluccensis* and *Upeneus asymmetricus*) of Mullidae were recorded in the catches of the eastern Mediterranean (GSA 26). The bulk of the landed catch of red mullet came from the trawl vessels while there is a minor percentage of the landed catch from the small-scale fisheries sector so it was negligible. *Mullus surmuletus* constituted about 55% of red mullets in GSA 26.

**Data and parameters:** Monthly samples were collected from landings during the period from January 2011 to December 2012. During 2013, samples were collected on a bimonthly basis within a fisheries data collection system supported by the FAO EastMed project. The length-frequency was analyzed by the Bhattacharya method in order to estimate the growth parameters by Ford & Walford method for sex combined. Length-weight relationship, maturity ogive with L₅₀% and sex ratio were estimated. The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet, LFDA was used for age slice. Yield-per-recruit, biomass-per-recruit and biological reference points were estimated annually for the three years. Moreover, samples of the three years were combined together and the previous parameters were estimated.

**Assessment method:** VIT software was used for pseudo-cohort analysis. In addition, the Y/R analysis implemented in the VIT was applied for the calculation of the reference point F₀₁.

**Model performance:** The methods were used in a complementary and integrated way. Consistency between results and inputs and life history parameters was cross-checked among methods and with inputs.

**Results:** Sex ratio (% females / total) was 0.52 during study period. The stock of each year was assessed separately for result comparison. Age-composition analysis indicates that, the majority of the catch of this species is represented by the young ages, especially in 2012. The Y/R analysis indicates a current level of fishing mortality 0.395 during 2011, 0.464 during 2012 and 0.485 during 2013 while the target reference points F₀₁ were 0.217, 0.223 and 0.228 during 2011, 2012 and 2013 respectively. The fishing mortality of the three years together was 0.482 and F₀₁ was 0.188. The length at first capture is smaller than length at first maturity in the three years.

**Diagnose of stock status:** The ratios between Fₑₑₑₑ and F₀₁ (1.82, 2.08 & 2.126 for 2011, 2012 & 2013 respectively and for the merged data of the three years, it was 2.56) indicate that, the stock of *Mullus surmuletus* is in overexploitation.

**Advice and recommendations:** A more sustainable harvest strategy is advised, which can be achieved by the reduction of the fishing mortality. Such a reduction can be taken by fishing activity limitations. Such limitations to consider can include reducing the number of working days, improving the selection pattern of the trawl fishery, enforcing of the closed season, and applying the minimum fish size at landing.

**Discussion:** No particular discussion on this stock.
18. Stock: Brushtooth lizardfish, *Saurida undosquamis*

GSA: 26

Authors: Mahmoud, H.H., EL Haweet, A.A.K. and Dimech M.

Fishery: Family Synodontidae is represented in the Egyptian Mediterranean waters (GSA 26) by two species: *Saurida undosquamis* and *Synodus saurus*. Brushtooth lizardfish, *Saurida undosquamis* is considered one of the most important demersal target species of the commercial fishery in Egypt. It represented about 70% (575 tonnes) of the total landing of the family Synodontidae during 2013, which is nearly equal to 1% of the total Egyptian Mediterranean landed catch. The bulk of the landed catch of *Saurida undosquamis* came from the trawl vessels while there is a minor percentage of the landed catch from the artisanal so it was negligible. The demersal fishes of Egypt are exploited by 1084 fishing trawlers vessels (GAFRD, 2014). The size of the fish samples ranged between 11 and 32 cm and the mean length was 19.06 cm.

Data and parameters: The information used for the assessment of the stock consisted of catch length structure, length-weight relationship, total length at the end of each year of life, Von Bertalanffy growth parameters, sex ratio, length at first sexual maturity, the values of total (Z) and fishing mortalities (F). The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet.

Assessment method: For the period of study (2013), the methodology applied indirect methods: length cohort analysis and Beverton & Holt yield per recruit analysis were performed in order to estimate the limit and target reference points (FiSAT, LFDA, Vit 4 win & ProdBiom, 2009).

Results: Length at first capture is smaller than length at first maturity in the three years (2011, 2012 & 2013). The same conclusion came when samples of the three years were pooled together and the previous parameters were estimated. The reference points from Yield-per-recruit analysis (2013) are summarized in the following table.

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Y/R</td>
<td>10.236</td>
<td></td>
</tr>
<tr>
<td>Maximum Y/R</td>
<td>10.677</td>
<td></td>
</tr>
<tr>
<td>Y/R₀.₁</td>
<td>10.243</td>
<td></td>
</tr>
<tr>
<td>Fₗ₅₀ current</td>
<td>0.659</td>
<td></td>
</tr>
<tr>
<td>Fₗ₅₀ max</td>
<td>0.442</td>
<td></td>
</tr>
<tr>
<td>F₀.₁</td>
<td>0.297</td>
<td></td>
</tr>
<tr>
<td>Current B/R</td>
<td>15.514</td>
<td></td>
</tr>
<tr>
<td>Maximum B/R</td>
<td>21.851</td>
<td></td>
</tr>
<tr>
<td>B/R₀.₁</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>Fₗ₅₀ current / F₀.₁</td>
<td>2.22</td>
<td></td>
</tr>
</tbody>
</table>

Diagnosis of stock status: According to the results obtained of the three years (2011, 2012 & 2013) and of the three years together, the current fishing level of the lizardfish is higher than the biological reference points (F₀.₁ & Fₗ₅₀) and the ratio between Fₗ₅₀ current and F₀.₁ (2.02, 2.17 & 2.22 during 2011, 2012 and 2013 respectively and 2.326 for the three years together) shows that the lizardfish (*Saurida undosquamis*) resources in GSA 26 is in overexploitation. Based on the fact that the length at first capture (Lₗ₅₀ = 14.25 cm) is almost equal with the length at first maturity (L₅₀ = 15 cm), it seems that fishery is focused on spawning fish.
Advice and recommendation:
- Reduce the fishing mortality to $F_{0.1}$ by limitation of trawl fishing activities.
- Improvement of the selection pattern of the trawl fishery
- Enforcement of the closed fishing season.

**Discussion:** No particular discussion on this stock.

**19. Stock:** Blue and red shrimp, *Aristeus antennatus*

**GSA:** 01

**Author(s):** Pérez Gil, J. González, M. Torres, P. García, T. Meléndez, M. Esteban, A. Serna-Quintero, J.M. and Ciércoles, C.

**Fishery:** The red shrimp (*Aristeus antennatus*) is the most important resource of slope bottom trawling in the GSA 01 (Northern Alboran Sea) and is targeted by the largest vessels of the deep water trawl fleet segment. The trawlers catch red shrimp on the slope on muddy bottoms between depths of 400 to 800 m. A total of 49 vessels (average 2011-2013) had fishing activities directed towards the pink shrimp in the GSA 01 fishing ground. This segment fleet, catches about 135 tonnes of red shrimp per year (average 2011-2013). The most important landings port in 2013 was Garrucha with 42 tonnes landed, followed by Aguilas (24 t) and Almería (19 t). The pattern of this fishery can be considered monospecific, where the discard is practically zero for this species

**Data and parameters:** The assessment was carried out using official landings and data on the size composition of trawl catches for the years 2002-2013. Catch-at-length data were converted into catch-at-age data by cohort slicing procedures. Length-weight relationship and maturity ogive comes from Spanish DCF and the vector of natural mortality by age was calculated from Djabali formule computing for the GSA01 area (Djabali et al, 1993).

**Assessment method:** The state of exploitation of this stock was assessed by means of VPA Extended Survivor Analysis (XSA) (Shepherd, 1999). The software used was the Lowestoft suite (Darby and Flatman 1994) and FLR (Fisheries Libraries in R). The assessment was carried out using official landings and data on the size composition of trawl catches for the years 2002-2013. Catch-at-length data were converted into catch-at-age data by cohort slicing procedures. The XSA tuning was performed using abundance index series from MEDITS trawl surveys and CPUEs from commercial fleet. Yield-per-Recruit (Y/R) and Spawning-per-Recruit (SSB/R) analyses was conducted based on the exploitation pattern resulting from XSA model and population parameters. Several reference points were estimated based on this Y/R analysis. Stochastic short term projections assuming equilibrium conditions were also produced.

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

**Results:** Spawning Stock Biomass (SSB) and Recruitment (R), declined until 2007 and have been relatively stable over the 2008-2013 period.

Fishing mortality ($F_{bar 1-2}$) shows decreasing trend until 2007 with a drastically decline during this years and has been stable over the last six years. Since 2003, when the maximum was observed, the pink shrimp stock in GSA01 has suffered a fairly strong decrease in landings, spawning biomass and total biomass. Current indicators represent respectively 35% (Y), 46% (SSB) and 49% (B) of the values observed ten years ago. Y/R analysis shows that the $F_{ref} = F_{current}$ (0.82) exceeds the Y/R $F_{0.1}$ reference point (0.41).
## Diagnosis of stock status:
- In overexploitation ($F_{\text{current}} > F_{0.1}$)
- Relative intermediate biomass; $B_{\text{current}} = 423 \text{ (t)}$; Biomass at 33rd percentile = 419(t)

## Advice and recommendations:
- Reduce $F_{\text{current}}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort

## Discussion:
No particular discussion on this stock.

### 20. Stock: Blue and red shrimp, *Aristeus antennatus*

GSA: 05

**Author(s):** Aina Carbonell, Beatriz Guijarro and Magdalena Gazá

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

**Data and parameters:** Size composition of commercial trawl catches and official landings (1992-2013), CPUE data from bottom trawl surveys (2001-2013) and from commercial fleet (1992-2013). Growth parameters, length-weight relationship and maturity ogive obtained in the study area (Carbonell *et al*., 1999).

**Assessment method:** Separable VPA and Extended Survivor Analysis (XSA) for 1992-2013 and Yield per Recruit (Y/P). Analysis were performed by sex, combining the results, and for both sexes.

**Model performance:** Recruitment fluctuated around similar values for the entire TS. SSB showed a slightly over-estimation in relationship to the actual assessment (2013), whereas $F_{\text{bar}}$ 0-4 was underestimated. In general terms assessment set correctly trends, and not big or erratic trends are observed overall of the past and present analysis.

| $F_{\text{current}}$ (mean 6 last years, ages 1-2) | 0.82 |
| $F_{33\%}$ percentile (ages 1-2) | 0.78 |
| $F_{66\%}$ percentile (ages 1-2) | 0.85 |
| $F_{0.1}$ | 0.41 |
| $F_{\text{current}}/F_{0.1}$ | 1.9 |
| $B_{\text{current}}$ (mean 6 last years) | 423 (t) |
| $B_{33\%}$ percentile | 419 (t) |
| $B_{66\%}$ percentile | 430(t) |
Results:

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<table>
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<tbody>
<tr>
<td>F&lt;sub&gt;current&lt;/sub&gt; (mean 2011-2013, ages 0-4)</td>
<td>0.42</td>
</tr>
<tr>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;</td>
<td>0.24</td>
</tr>
<tr>
<td>F&lt;sub&gt;current&lt;/sub&gt;/F&lt;sub&gt;0.1&lt;/sub&gt;</td>
<td>1.75</td>
</tr>
<tr>
<td>Biomass (tonnes)</td>
<td>447</td>
</tr>
<tr>
<td>33&lt;sup&gt;rd&lt;/sup&gt; percentile biomass (tonnes)</td>
<td>380</td>
</tr>
<tr>
<td>66&lt;sup&gt;th&lt;/sup&gt; percentile biomass (tonnes)</td>
<td>421</td>
</tr>
</tbody>
</table>

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

**Advice and recommendation:** To reduce fishing mortality

**Discussion:** No particular discussion on this stock.

**21. Stock:** Blue and red shrimp, *Aristeus antennatus*

GSA: 06.

**Authors:** Esteban, A; Fernandez, A. & Perez Gil, J.L.

**Fishery:** Trawl fleets fishing effort in the four ports were quite stable for the period studied with small variations of the number of vessels in the recent years. Vessels length was between 12-24 m. The gears used corresponded to a trawl net 60 and 100 longest rope. The vertical opening was between 1-3 m. The cod end mesh size used was a squared 40 mm of mesh opening. The net was rigged two doors between 500-800 kg. Trawl fleet in the four ports do daily trips with a unique haul directed to the red shrimp, with a duration between 5-7 hours. The number of harbours with red shrimp fleets is 22 for the whole area, and the number of boats in this area is 241. Discards of the red shrimp are zero.

Total landings in GSA 06 (1996-2013) were around 10887 tonnes and were produced by a total effort of 332908 fishing days*vessel (number of days*vessel). For this period, landings reached approximately 605 tonnes and total effort over 18495 fishing days by year and CPUE medium, 34.28 kg/day.

**Data and parameters:** Size composition of commercial trawl catches and official landings, CPUE data from MEDITS surveys and commercial fleet.

Growth parameters from L/W and Age/L relationships from Data Collection Framework (2012).

**Assessment method:** VPA- Separable Virtual Analysis, XSA- Extended Survivor Analysis (Darby & Flatman, 1994), Sensitivity and Retrospective Analysis and Y/R (NOAA Fisheries Toolbox).

The male and female length distributions for year (1996-2013) were split using L2Age, slicing ICES package to ages. It was run by a tuned VPA, an XSA and a Y/R analysis for combined sex. Effort in days represents effort by trip. Tuning data series was made using the Palamos, Tarragona, Villajoyosa and Santa Pola harbours like a reference fleet and MEDITS GSA 06 trawl surveys.

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

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<tbody>
<tr>
<td>$F_{\text{current}}$ (mean FBAR ages 1-4 in 2011-2013)</td>
<td>0.94</td>
</tr>
<tr>
<td>$F_{0.1}$ (present assessment)</td>
<td>0.47</td>
</tr>
<tr>
<td>$\text{SSB}_{\text{current}}$ (2013) (tonnes)</td>
<td>1850</td>
</tr>
<tr>
<td>$\text{SSB}_{\text{biomass}}$ (33rd)</td>
<td>1359</td>
</tr>
<tr>
<td>$\text{SSB}_{\text{biomass}}$ (66th)</td>
<td>1659</td>
</tr>
<tr>
<td>Current Recruitment (thousands)</td>
<td>134893</td>
</tr>
<tr>
<td>$F_{\text{current}}/F_{0.1}$</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Diagnosis of stock status:
- In overexploitation ($F_{\text{current}}>F_{0.1}$)
- Relative high level of biomass ($\text{SSB}_{\text{current}}>\text{SSB}_{\text{biomass}}$ at 66th percentile)

Advice and recommendation:
- Reduce $F_{\text{current}}$ towards $F_{0.1}$
- Progressive reduction of the fishing effort

Discussion: No particular discussion on this stock.

22. Stock: Deep-water pink shrimp, *Parapenaeus longirostris*

GSA: 10

Author(s): Bitetto I., Carbonara P., Casciaro L., Facchini M. T., Lembo G. and Spedicato M. T.

Fishery: In the central-southern Tyrrhenian Sea (GSA 10) the main demersal resources on the continental shelf are European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), pandora (particularly *Pagellus erythrinus*) and, among cephalopods, squids (e.g. *Todarodes sagittatus*, *Illex coindetii*) and octopus (*Octopus vulgaris*). The pink shrimp is almost exclusively targeted by trawlers and fishing grounds are located on the soft bottoms of continental shelves and the continental slope along the coasts of the whole GSA.

Data and parameters: The commercial landing and discard time series (2006–2013) and the LFDs by fleet segment from DCF has been used for the assessment. MEDITS trawl survey data from 1994 to 2013 have been used in the analysis. The biological parameters estimated within DFC for the area have been also used (growth parameters, length-weight relationship, sex ratio and maturity. The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella et al., 1997).

Assessment method: Given that the time series covers the total number of age classes in landing (0 to 3+) at least one time was possible to perform an assessment using XSA (Extended Survivors Analysis) on the times series 2006–2013.

Model performance: The log-catchability residuals and the retrospective analysis did not show any trend.
Results:

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<tbody>
<tr>
<td>$F_{\text{current}}$ (average 2011-2013)</td>
<td>1.6</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.92</td>
</tr>
<tr>
<td>MEDITS biomass index 33rd percentile (kg/km$^2$)</td>
<td>2.7</td>
</tr>
<tr>
<td>MEDITS biomass index 66th percentile (kg/km$^2$)</td>
<td>4.4</td>
</tr>
<tr>
<td>Current MEDITS biomass index (2013) (kg/km$^2$)</td>
<td>9</td>
</tr>
</tbody>
</table>

**Diagnosis of stock status:** Given the results of the present analysis, the stock seems in overexploitation, being exploited at level of $F$ (1.6) higher than the reference point (0.92) with a relative high level of biomass according to MEDITS survey data.

**Advice and recommendation:** It is recommended to reduce the fishing mortality in order to achieve the estimated $F_{0.1}$ levels that can be gradually achieved by multiannual management plans foreseeing a reduction of fishing mortality through fishing limitations.

**Discussion:** No particular discussion on this stock.

**22. Stock:** Deep-water rose shrimp, *Parapenaeus longirostris*

**GSA:** 12-13-14-15-16

**Author(s):** V. Gancitano, S. Ben Meriem, F. Colloca, A. Vinci, A. Arneri, L. Ceriola, O. Jarboui, R. Micallef, R. Mifsud, F. Fiorentino.

**Fishery:** *Parapenaeus longirostris*, is caught by bottom otter trawling in the Strait of Sicily together with Norway lobster (*N. norvegicus*), giant red shrimp (*A. foliacea*), hake (*M. merluccius*), violet shrimp (*A. antennatus*), scorpionfish (*H. dactylopterus*), grater forkearbd (*P. blennioides*), red Pandora (*P. bogaraveo*) and monkfish (*Lophius spp.*). Scientific data available indicates that exploitation by the fishing fleets of Tunisia, Malta, Libya and Italy is targeting a single shared stock of deep water rose shrimp. Accordingly, 4 fishing segments were considered in the stock assessment: Italian coastal trawlers, Italian distant trawlers, Tunisian trawlers and Maltese trawlers. Sicilian coastal trawlers (LOA between 12 and 24 m) targeting deep water rose shrimp are based in seven harbours along the southern coasts of Sicily. These trawlers operate mainly on short-distance fishing trips, which range from 1 to 2 days at sea. Sicilian distant trawlers (LOA > 24 m) carry out longer fishing trips, which may last up to 4 weeks. Sicilian distant trawlers operate offshore, in both Italian and international waters of the Central Mediterranean. In the Maltese Islands, small vessels measuring 12 to 24 m in length, target rose shrimp at depths of about 600 m. Fishing grounds are located to the north and north-west of Gozo. Tunisian trawl vessels which target rose shrimp measure around 24 m in LOA. Tunisian vessels operate primarily in Northern Tunisia where 90% of the country’s total *P. longirostris* catches originate. The vast majority of these catches are landed in the ports of Bizerte and Kelibia. To assess the state of the stock in MedSudMed area analytical and global models were applied: extended survivors analysis (XSA) and Schaefer and Fox models respectively.

**Data and parameters:** Catch at age and landing data matrices from Italy (OTB 12-24 m and OTB >24), Malta and Tunisia for 2005, 2007, 2008, 2009, 2010, 2012 and 2013 were performed. Also, the tuning data at age from MEDITS survey in GSAs 15 and 16 were used. The parameters used were an average of growth parameters and length-weight relationships from SAMED (2002) and Ben Meriem (unpublished). Females: $L_x = 42.705$, $k = 0.67$, $t_0 = -0.208$, $a = 0.0029$, $b = 2.48185$. Male: $L_x = 33.56$, $k = 0.73$, $t_0 = -0.13$, $a = 0.00345$, $b = 2.4096$. The natural mortality $M$ was estimated by Prodbiom’s method.
Assessment method: The assessment was carried out using extended survivor analysis (XSA) as implemented in the FLR (fisheries libraries in R) and using Global model for to estimate MSY and FMSY. Current mean F was obtained as average three previous years (2011–2013), $F_{0.1}$ was estimated using FLR with XSA data and results and considering M and F at age.

Model performance: According to the recommendations of the GFCM WG, current F was estimated as average of the last three years of the time series considered (i.e. 2011-2013) and equal to 0.88. $F_{0.1}$ was estimated using FLR with XSA data and results and considering M and F at age and equal to 0.7. The results obtained through the Global models further confirm the results of the XSA. The results obtained in terms of stock status are reported in the table below.

Results:

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>$F_{current}$</td>
<td>0.88</td>
</tr>
<tr>
<td>$F_{0.1}$</td>
<td>0.7</td>
</tr>
<tr>
<td>Current B/R</td>
<td>21.8</td>
</tr>
<tr>
<td>$F_{current}/F_{0.1}$</td>
<td>1.26</td>
</tr>
<tr>
<td>Maximum exploitable production Schaefer Model</td>
<td>1423712</td>
</tr>
<tr>
<td>Effort at Maximum exploitable production Schaefer Model</td>
<td>8749</td>
</tr>
</tbody>
</table>

Diagnosis of stock status: F showed a decreasing trend in the study period (2005–2013). Also, the results of the assessment revealed a low overfishing status and relative high abundance of the stock. The results of the assessment revealed that the stock is in overexploitation ($F_{0.1} > F_{current}$). The survey data (MEDITS) indicated a relative high abundance of the stock.

Advice and recommendation: To move toward $F_{0.1}$ taking into account the different contribution to the catch by GSA. Considering the estimated values of F, to reach $F_{0.1}$ the current level of fishing mortality should be reduced by about 20%. The protection of the juvenile fraction of the population and the recruitment generally is also advisable. To this extent, an improvement of the exploitation pattern of trawlers targeting juveniles, and the protection of nursery areas are suggested.

Discussion: No particular discussion on this stock.


GSA: GSA: 18

Author(s): Bitetto I., Carbonara P., Casiaro L., Ceriola L., Durović M., Facchini M. T., Ikica Z., Joksimović A., Kolitari J., Kroqi G., Lembo G., Marković O., Milone N. and Spedicato M. T.

Fishery: The deep-water pink shrimp, is one of the target species of the central and southern Adriatic multispecies trawl catches and is an epi-benthic short-lived species, inhabiting preferably muddy sediments (Karlovac, 1949). Pink shrimp is only targeted by trawlers and fishing grounds are located along the coasts of the whole GSA. Catches are from a depth range between 50–60 and 500 m and the species may co-occur with other important commercial species as *Merluccius merluccius*, *Illex coindetii*, *Eledone cirrhosa*, *Lophius spp.*, *Lepidorhombus boscii*, *N. norvegicus*.

Data and parameters: Standardized LFD abundance indices ($N/km^2$) for the whole GSA 18 from MEDITS trawl survey data from 1996 to 2013 have been used for the analysis. The length structure of landings and production by fishing segment from DCF has been used for west side, while for the east side data collected within a
pilot study in the framework of AdriaMed project and biological sampling supported by AdriaMed (Montenegro) and from National Statistics Bureau (Albania).
The biological parameters estimated within DFC for the area have been also used (growth parameters, length-weight relationship, sex ratio and maturity. The vector of natural mortality by age was calculated from Caddy’s formula, using the PROBIOM Excel spreadsheet (Abella et al., 1997).

**Assessment method:** Previous assessments were performed with VIT (from 2008 to 2011). The update of XSA stock assessment of last year has been made, given that the time series covers the total number of age classes in landing (0 to 3+) more than one time, taking into account the data of the western and eastern side of GSA; in particular the LFDs of commercial catches for Albania has been used for the first time. As comparison, also ALADYM simulation model, providing a multi-fleet approach, has been applied and used also to forecast effects of different management strategies.

The scenarios that have been performed are:
- Status quo until 2021;
- Change in mesh size since 2014 for all the fleet segments;
- Fishing ban of one month since 2014 for all fleet segments;
- Reduction of F towards F$_{0.1}$ in 2020.

**Model performance:** About XSA analysis, the log-catchability residuals and the retrospective analysis did not show any trend.
A satisfactory fit has been obtained with ALADYM simulation model for all the fleet segments between simulated and observed landing. The hind-casting approach used for this assessment was accomplished to support the validity of the combined assessment.

**Results:**
In the table below are reported the F current and F$_{0.1}$ from the XSA results:

<table>
<thead>
<tr>
<th>F$_{current}$</th>
<th>1.62</th>
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<tbody>
<tr>
<td>F$_{0.1}$</td>
<td>0.74</td>
</tr>
<tr>
<td>MEDITS biomass index 33$^{rd}$ percentile (kg/km$^2$)</td>
<td>4.2</td>
</tr>
<tr>
<td>MEDITS biomass index 66$^{th}$ percentile(kg/km$^2$)</td>
<td>5.7</td>
</tr>
<tr>
<td>Current MEDITS biomass index (2013) (kg/km$^2$)</td>
<td>2.1</td>
</tr>
</tbody>
</table>

ALADYM projections show that increasing the mesh size (to 60 mm diamond mesh size for Italy and Albania and 50 mm diamond mesh size for Montenegro) could lead to increased landings in the entire GSA, under the assumption of total survival of all the escaped individuals from the codend. The better effect to SSB is given instead by the scenario based on the gradual reduction of F towards F$_{0.1}$ in 2020.

**Diagnosis of stock status:** The stock is in overexploitation with low biomass levels, as current fishing mortality exceeds F$_{0.1}$ levels (1.62 vs. 0.74) and thus it is necessary to consider a considerable reduction of the fishing mortality to allow the achievement of F$_{0.1}$.

**Advice and recommendation** (in terms of research and, when possible in terms of management):
The reference point F$_{0.1}$ can be gradually achieved by multiannual management plans which foresee a reduction of fishing mortality through fishing limitations. As observed in 2013, the contribution of each country to the total production of _P. longirostris_ in the GSA18 is: Italy 67%, Albania 30%, and Montenegro 3%.

**Discussion:** No particular discussion on this stock.
25. Stock: Giant red shrimp, *Aristaeomorpha foliacea*

GSA: 19

Author(s): Carlucci R., Scarcella G., Sion L., Maiorano P., Tursi A., D’Onghia G.

Fishery: The giant red shrimp, *Aristaeomorpha foliacea*, is one of the most important target species of the mixed demersal deep-water trawling carried out on the upper-middle continental slope of the GSA19. The highest trawl fishing pressure occurs along the Calabrian and Apulian coasts. In fact, National official statistics (IREPA, 2009), showed as the trawling fleet along the Calabrian and Apulian coasts counted 225 vessels for a total amount of 4000 GT and 30000 kW. During the 2004-2011 the monthly fishing effort in GSA19 fluctuated around a mean value of \(482470\pm217862\) GT*days. Similarly, the monthly engine power fluctuated around a mean value of \(1481178\pm497910\) kW*days. During spring and summer a higher number of working days were recorded for trawling in GSA19, whilst during autumn and winter the bad sea-weather conditions could influence the displacement of the fishing effort on very coastal areas rather than on deep water grounds. The mean annual values fluctuated between \(63167\pm21505\) GT*days (2004) and \(582576\pm198435\) GT*days (2006) and between \(476270\pm163906\) kW*days (2004) and \(1892829\pm305992\) kW*days (2005), without indicating any temporal trend.

The total catches of *A. foliacea* in the GSA19 derived exclusively from trawling. In the framework of the trawl surveys carried out in the GSA19 the giant red shrimp was caught at a minimum and maximum sizes of 8.0 and 69.0 mm CL, respectively. Generally, the majority of the sampled specimens in both the experimental surveys as well in landing catches, were from 0 to age 3. Discard was considered negligible being the species marketable whatever the size.

Data and parameters: An Extended Survivors Analysis (XSA) and a Steady state Virtual Population Analysis (VPA) were applied. The XSA and VPA used the catch-at-age in numbers matrix of the giant red shrimp derived from the landings data by length collected in the framework of DCF (time series 2008-2013) and the growth parameters estimated for females in the GSA19 (\(L_\infty=69.78\) mm CL, \(k=0.45\) and \(t_0=-0.18\)) (Maiorano et al., 2010). The weights at age in the landings was obtained including the length-weight relationship parameters \(a =0.0013, b= 2.64\). The tuning was run using the supplementary stock abundance indices collected in the framework of the MEDITS surveys (time series 2008-2013). The vector of natural mortality \(M\) was estimated using ProdBiom model, assuming values equal to 1.119 in age 0, to 0.498 in age 1, to 0.374 in age 2, to 0.321 in age 3 and to 0.291 in age 4. The F terminal (0.291) was set equal to M at age 4. Due to the length at maturity equal to 39.3 mm CL and the growth parameters adopted for sex combined, the proportion of mature was set as equal to 0.0 in age 0, to 0.50 in age 1, to 0.75 in age 2 and 1 in the other age classes.

Assessment method: An Extended Survivors Analysis (XSA) and a Steady state Virtual Population Analysis (VPA) were applied using FLR and software VIT4win, respectively. In addition, the biomass and density index values derived from trawl surveys (Medit time series 1994–2013) were also observed throughout indicating an empirical relative condition in the stock biomass.

Model performance: Although consistency between the reconstructing total catches from both XSA and steady state VPA models and the landings recorded in the framework of the DCF during 2013 was achieved, the scientific advice was only derived from XSA since the main assumption of a steady state condition in the stock seems to be not satisfied. In addition, the sharp decreasing trend observed from XSA analysis in the \(F_{bar0.3}\) values during 2011-2013 as well as in the recruitment from 2012 to 2013 indicated the need to revise the assessment in the next 1 or 2 years in order to incorporate possible trends.

Results: Different XSA simulations were tested taking into account the increasing shrinkage weight values 0.5, 1.0 and 2.0. However, the best results were obtained using the shrinkage 2.0 on the base of the residuals and retrospective analysis. In particular, a good overlapping between reconstructed
catches and landings was observed during the 2008-2013 period. In fact, as in the landings the reconstructed catches highly fluctuated throughout the investigated period and F values decreased mostly from 2010 (F_{bar0-3}=1.019) and 2011 (F_{bar0-3}=1.068) to 2013 (F_{bar0-3}=0.418). The recruitment slightly increased from 2008 to 2012 and sharply decreased during 2013. Differently, the SSB seems to increase mostly from 2011 (about 150 t) to 2013 (about 450 t). The Y/R analysis from XSA provided a brp F_{0.1} equal to 0.294 (F_{unique}). The current F = 0.657 was calculated over the period 2011-2013 as the mean F_{bar0-3}.

The Biomass Empirical Reference showed a relative high biomass condition (B_{curr}= 9.56 is higher than B_{66th}= 3.58). However, the decreasing trends observed for recruitment have to be taken into consideration as a potential stress of the stock.

**Diagnosis of stock status:** In overexploitation with relative high biomass.

**Advice and recommendation:**
A reduction of fishing mortality below or at the proposed reference level (F_{0.1} = 0.294) would be recommended in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan.

**Discussion:** The assessment and scientific advice were endorsed. However, the WG recommended to revise the assessment in the next 1 or 2 years in order to better address outliers in the model outputs.

### CONCLUSIONS AND RECOMMENDATIONS – JOINT WGSAs SESSION ON DATA-LIMITED STOCKS

31. At the joint session on data-limited stocks, the WGSAs agreed on the importance of continuing to pursue a strategy for increasing the percentage of the catches being assessed in the Mediterranean and Black Sea. The session also voiced a desire to have stock assessments covering the various sub-regions in a more even fashion. In line with these stated objectives the WGSAs concluded the following:

- a. Attempts should be made at conducting a productivity susceptibility analysis (PSA) for various fisheries (in particular, artisanal fisheries, small pelagic fisheries and crustacean-oriented fisheries). The aim of this is to provide additional useful information which can assist in identifying priorities for stock assessment and management;
- b. For stocks where there is only catch data (“catch-only data”) available, methods for providing advice are still being tested; therefore, these methods may not yet be reliable. Similarly, simple harvest control rules pertaining to indicators of stock health are also being tested. It is possible that the indicators being developed by the SAC could be used for this purpose;
- c. There are a number of stocks in the Mediterranean for which information on catch, length/age structure, fishing effort and some indicator of biomass (from surveys or CPUE) may be available. For those stocks, VPA-based methods or the statistical catch-at-age approach could be applied.

32. The WGSAs encouraged taking the following steps: a) carrying out a PSA for select fisheries, with the possibility of jointly developing them in collaboration with the European Commission.
Joint Research Centre; b) adding more stocks for which VPA or statistical catch-at-age models could be applied; and c) investigating management measures and harvest control rules that could be applied together with indicators of stock health as defined by the SAC.

33. The WGSAs warmly welcomed the presence of a representative of the STECF Secretariat and his presentation on the work deployed by the STECF Expert Working Group on stock assessment for the Mediterranean Sea (STECF-14-09). The representative summarized the advice issued by the STECF on those stocks not included in the agenda for the WGSAs (the complete report of the STECF meetings on the Mediterranean and Black Sea is available at http://stecf.jrc.ec.europa.eu/reports/medbs). Previous requests made by a number of experts in the WGs (who are also members of the STECF-EWGs) were touched upon with a view to improving coordination between the SAC and the STECF and optimizing the overall efficiency of the stock assessments carried out in the Mediterranean and Black Sea.

34. Members of the WGs expressed concern with the sizeable workload currently facing the WGSAs. WG members also echoed the wish to increase the area covered by stock assessments in the Mediterranean Sea through improved cooperation and coordination amongst experts. The WGSAs suggested focusing their intersessional work on a series of ‘priority stocks’, whilst striving to establish a procedure for presenting, discussing and eventually incorporating the advice provided by other expert groups on Mediterranean stocks (including the STECF). The WGSAs agreed that this procedure should include clear indications on the information that needs to be reported (e.g., final reports, databases used, scripts, etc.), the format to be followed, the deadline for submission of information and any other aspect that can help experts to fully understand the stock assessments carried out by an external scientific body.

35. In order to implement the procedure discussed in the point above, the WGSAs could propose draft terms of reference (ToRs) which would include a list of priority stocks, for finalization and endorsement by the SCSA and the SAC. In turn, the agendas of the WGSAs would focus on the ToRs provided by the SAC. Such agendas could include a brief dedicated session for revising and eventually incorporating the advice provided by other expert groups into the draft advice to be provided to the SCSA and the SAC. To facilitate this task, the WGSAs agreed to explore ways of harmonizing the existing tools for reporting to the WG and the STECF EWGs.

CONCLUSIONS AND RECOMMENDATIONS OF WGSAD

36. Twenty-five stock assessments were revised by the WGSAD. Only one of the stocks was considered to be in a state of sustainable exploitation, 23 of them were assessed as ‘in overexploitation’ and another was considered “preliminary”. For the stock assessed as preliminary, it was recommended, if possible, to carry out a second trial with a different model before submitting it to the SCSA. A summary table with stock status and management advice for each stock is available in Appendix D of this report. In addition, two assessment related works were presented and two presentations on the application of bio-economic tools were delivered.

37. In the absence of reference points based on biomass, the WG used the Empirical Reference Framework for the relative level of stock biomass (as agreed at the WGSAD meeting in 2012 and as collected in the SAF template approved by the fifteenth session of the SAC). Given the sensitivity of this framework to the length of the data time series used, the longest dataset available was used (provided it was deemed to be reliable).

38. As a general rule, input data used in the assessment were provided through the SAFs and were made available to the WG during the session. For instance, for those models where a stock-recruitment relationship was generated, experts were asked to present a figure of the values and its fit to the group. Similarly, where sensitivity tests had been carried out, their results had to be reviewed by the WG as well as the final settings considered for the selected model. In addition, a
full description of the input data, parameters and assumptions for the stock assessment needed to be included in the SAF.

39. For medium- and long-term forecasts, stock-recruitment relationships needed to be reliable. In cases where an appropriate stock-recruitment relationship did not exist, results of the long-term forecast were used as an exercise and not for issuing advice. In these cases, it was recommended to generate at least a short term forecast.

40. Where different methods were applied to the same stock, the WG compared contrasting results in order to validate the conclusions achieved.

41. On the selection of input parameters, it was agreed that the use of different methods and models, estimation of reference points for F and computation of biological parameters, the recommendations approved by the WGSAD 2014 Session 1 and adopted by the SCSA 2014 would still apply.

42. Given their relevance to fisheries population dynamics the WGSAD agreed to explore ways of incorporating the effects of environmental and ecological factors into the stock assessments.

43. Where a stock is exploited by more than one fleet, the WGSAD recommended calculating the value of F by fleet, as it would facilitate decision-making on management measures designed to improve stock status.

44. The utilization of the GFCM SharePoint tool for the third year proved to be a very useful tool for transmitting information from the participants to the coordinator and vice-versa. More efforts should be made to improve the quality of the data that would become a part of this new information portal.

45. The WGSAD recommended including a session on the estimation of biomass reference points within the next session of the WGSAD. A background document with methodologies and some examples to be discussed should be prepared in advance; this would be coordinated by the chair and the GFCM Secretariat.

46. The fact that the WGSAD session this year had to be shortened by one day imposed considerable time constraints on the WG, which still had to evaluate a sizeable number of stocks. As such, the WGSAD recommended that the duration of future sessions be at least 5 days.

**Technical advice related to the management measures in GSAs 12-16**

47. The WGSAD reviewed two stock assessments carried out in the Strait of Sicily (*M. merluccius* and *P. longirostris*). Both stocks were in a state of overexploitation. However, the WGSAD also noted a decreasing trend in fishing mortality (F) for the two stocks reviewed. This was attributed to the reduction of fishing capacity and the relocation of some fleets to deeper waters that were further offshore. The WGSAD also noted a decrease in recent years of length at first maturity for *P. longirostris*. This was considered as a warning sign and as such the WG recommended continuing to assess this stock in the future.

48. The WGSAD also reviewed the results of the spatially-explicit bio-economic model (SMART) applied in this area and was informed about the potential uses of the bio-economic model (BEMTOOL) through different examples already applied throughout the Mediterranean.

49. With regards to the testing of possible management measures in GSAs 12-16, both the SMART and BEMTOOL models were considered very useful tools for the completion of this task. In particular, the ability of the SMART model to consider the spatial dimension of fishing effort and
to encompass economic variables was considered crucial for the assessment of management measures. The results of the different scenarios tested using the SMART model in the Strait of Sicily demonstrated that even if the overall fishing effort in the area is maintained at the current level, the closure of three identified nursery grounds for hake, red mullet and deep-sea rose shrimp may lead to an improvement in the condition of these resource. Moreover, these closures could generate sustainable economic returns for fishers if the three nursery grounds were closed at different times.

50. The WG questioned the fact that the SMART model only used a reduced dataset (i.e., MEDIT data) and voiced concerns on the bias that such a practice has potentially to introduce. In this regard, the WG put forward a recommendation to complement the survey data with data from the fishery, and to test the use of different temporal scales for the closures. It will be necessary to make concerted efforts to acquire the data demanded by this model in order to apply this tool to other areas of the Mediterranean where a management intervention is required.

Data Collection Reference Framework (DCRF)

51. With regards the new framework for data collection and submission proposed by the GFCM through the DCRF, the WGSAD welcomed the proposal and added the following remarks and recommendations:

- It will be important to establish official data calls with a calendar of frequency and deadlines and to ensure the correct compliance by members.
- The criteria for the annual selection of stocks by the SAC should be defined in advance, taking into account, inter alia, the outcomes of the WGSAD sessions.
- If a priority arises in a given area, the possibility of including stocks for which data was already collected during the intersessional period should be considered.
- The participation of experts from the geographical areas concerned in the different activities related to the DCRF (meetings, training etc.) should be facilitated.
- Despite the need to increase the currently low number of stocks assessed in some GSAs, alternative options should be considered, including but not limited to selecting certain species to represent the entire target community, or combining data from various GSAs where supporting evidence of shared stocks exist.

Indicators of Good Environmental Status

52. With regards to the indicators of good environmental status, the WGSAD recommended elaborating on the assessment of the performance of some of the proposed “tentative” indicators (e.g., the large fish indicator) which had exhibited a number of limitations in their performance in other areas (North Sea). In addition, some concern was raised about the limited data available to estimate those indicators that require survey data, since surveys are only available in certain areas and periods across the Mediterranean and Black Seas.

Session on red coral

53. Given the life history characteristics of red coral, a sessile and very slow growing species, and given the scarcity of data available both from fishery-dependent and fishery-dependent sources, the Schaeffer, and the Beverton and Holt models were not considered appropriate for its assessment. The WG recommended conducting trials using the Leslie matrix coupled with catch-at-age data. The participation of modelling experts from the WGSAD in the red coral session in the future was strongly recommended.

54. Given the current lack of the necessary data for modelling, sampling programmes for red coral should be established in the relevant countries, in the same way that they are for the rest of the
species fished. In this regard, the WGSAD suggested including red coral in Group 3 of the priority species within the DCRF.

55. The session discussed the unit of effort to be used and proposed a change from the “number of dives” to the “number of days at sea” in order to take into account the time spent exploring, with or without effective harvest.

56. The current data submission template developed by the GFCM Secretariat proved to be a useful tool for systematically submitting data on catches, effort, depth and landings size distribution. Compliance with Recommendation GFCM/35/2011/2 by the Member States should be ensured.

57. Data from fishery-independent surveys are indispensable in obtaining reliable assessments of the status of red coral populations. Standard protocols for carrying out scientific surveys using remotely-operated vehicles (ROVs) should be developed and put in to place. The first phase of this standardization could be completed within the context of a Mediterranean-wide research programme, as per the request of the thirty-eighth session of the Commission.

58. The concept note entitled “Research Programme on Stock Evaluation and Management Tools for the Mediterranean Red Coral” (reproduced under Appendix E) was presented to the WG and discussions on this concept note took place. The WG agreed with the contents of the concept note and supported its development.

ADOPTION OF THE REPORT AND ITS ASSOCIATED RECOMMENDATIONS

59. All conclusions and recommendations were adopted by the WGSAD on 27 November 2014. The entire report was adopted on 28 January 2015 after revisions and amendments by electronic correspondence.
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Caddy J.F. and Abella A.J. (1999) Reconstructing reciprocal M vectors from length cohort analysis (LCA) of commercial size frequencies of hake, and fine mesh trawl surveys over the same grounds. Fish. Res. 41: 169–175


WGSAD agenda

1. Opening session

2. Workshop on methodologies for data-limited stocks
   2.1. Introduction of GFCM strategy towards wider advice on status of Mediterranean and Black Sea stocks (GFCM Secretariat)
   2.2. Stock assessment methods for data-limited stocks (JRC)
   2.3. Discussion on a roadmap for the implementation of DLS methods in the GFCM area of competence

3. Common session on proceedings for this year’s WGs
   3.1. Summary of the SAC framework for advice and introduction of procedures for this year’s WGs (GFCM Secretariat)
   3.2. Summary of stock assessments discussed in the STECF (STECF)
   3.3. Overview of the new structure of DCRF and proposed indicators of good environmental status of exploited populations (GFCM Secretariat)

4. Introductory session for the WG on demersal species
   4.1. Adoption of the agenda
   4.2. Nomination of WG coordinator and rapporteur(s)
   4.3. Review of previous year conclusions and recommendations
   4.4. Review of terms of reference provided by the SAC and the Commission

5. Presentation and discussion of draft assessments
   - Assessments of sole (1) and hake (6)
   - Assessments of hake (1) and red mullet (4)
   - Assessment-related work on red mullet (GSA4)
   - Assessments of red mullet (2), striped red mullet (2) and lizardfish (1)
   - Assessments of blue and red shrimps (3)
   - Assessment-related work on striped Venus clam (GSA26)
   - Assessments of deep-sea rose shrimp (4) and giant red shrimp (1)

6. General discussion on the advice to SAC from the demersal WG
   - Review of conclusions and recommendations from the red coral session
   - Technical advice in relation to the management measures in GSAs 12-16
   - Comments on the DCRF
   - Comments on the proposal for indicators of good environmental status
   - Comments on the relationship between the GFCM WG and other WGs on stock assessment (STECF)
   - Proposal to create a framework for reference points on biomass
   - Priority species

7. Formulation of conclusions, recommendations and management advice to be transmitted for the consideration by the SCSA and the SAC (preparation of draft report)

8. Closing session
Red coral session agenda

1. Overview of available methods for the assessment of red coral stocks
2. Hands-on exercise with some of the models
3. Comments to the draft concept note “Research programme on stock evaluation and management tools for the Mediterranean red coral”.
4. Comments on the data requirements for red coral within the DCRF
5. Formulation of conclusions, recommendations and management advice to be transmitted for the consideration by the SCSA and SAC
Appendix B

List of participants

Marco ABBIATI
University of Bologna
Via S Alberto 163, 48123 Ravenna
Italy
E-mail: marco.abbiati@unibo.it

Benoit ARCHAMBAULT
Ministère de l’écologie, du développement durable et de l’énergie
Direction des pêches maritimes et de l'aquaculture.
Tour Voltaire – 1 place des Degrés – 92055 La Défense cedex
France
E-mail: benoit.archambault@developpement-durable.gouv.fr

Lorenzo BRAMANTI
LECOB UPMC Observatoire Oceanologique
Banyuls sur mer
18 Avenue Fontaulè
France
E-mail: philebo@gmail.com

Silvia ANGELINI
CNR - ISMAR Ancona
Largo Fiera della Pesca, 2, 60125 Ancona
Italy
E-mail: silvia.angelini@an.ismar.cnr.it

Sadok BEN MERIEM
Director of Agriculture Research
INSTM, Centre La Goulette
2060 La Goulette
Tunisia
E-mail: sadokbm@yahoo.fr

Isabella BITETTO
COISPA Tecnologia & Ricerca
Via dei Trulli, 18/20
Bari
Italy
E-mail: bitetto@coispa.it

Roberto CARLUCCI
Department of Biology - University of Bari
via Orabona 4 – 70125
Bari
Italy
E-mail: roberto.carlucci@uniba.it

Rita CANNAS
University of Cagliari
Dept Life and Environmental Sciences
via T. Fiorelli, 1
Cagliari
Italy
E-mail: rcannas@unica.it

Angelo CAU
University of Cagliari - Dept Life and Environmental Sciences
via T. Fiorelli, 1, Cagliari, Italy
E-mail: cau@unica.it

Alessandro CAU
University of Cagliari
Dept Life and Environmental Sciences
via T. Fiorelli, 1
Cagliari
Italy
E-mail: alessandrocau@unica.it

Maria Cristina FOLLESA
University of Cagliari
Dept Life and Environmental Sciences
via T. Fiorelli, 1
Cagliari
Italy
E-mail: follesac@unica.it

Francesco COLLOCA
Istituto per l’Ambiente Marino Costiero
Consiglio Nazionale delle Ricerche (CNR)
Via Luigi Vaccara 61
91026 Mazara del Vallo (TP)
Italy
Tel: +39 0923948966
E-mail: francesco.colloca@iamc.cnr.it
Lorenzo D’ANDREA  
University of Tor Vergata  
Via Orazio Raimondo, 18 – 00173 Roma  
Italy  
E-mail: dandrea.lorenzo@gmail.com

Najib EL OUAMARI  
Institut National de Recherche Halieutique  
13, Bd Zerktouni, BP 493  
Nador  
Morocco  
E-mail: azir46@hotmail.com

Antonio ESTEBAN  
I.E.O. Centro Oceanográfico de Murcia  
C/ Varadero nº 1, San Pedro del Pinatar.  
30740-Murcia  
Spain  
E-mail: antonio.esteban@mu.ieo.es

Angel M. FERNÁNDEZ  
Instituto Español de Oceanografía. Centro  
Oceanográfico de Murcia  
C/Varadero, 1. 30740 S. Pedro del Pinatar.  
Murcia  
Spain  
E-mail: angel.fernandez@mu.ieo.es

Vita GANCITANO  
IAMC-CNR UOS  
Mazara del Vallo  
via L. Vaccara,61  
Italy  
E-mail: vita.gancitano@iamc.cnr.it

Jean Philippe GIORDANO  
Corailleur  
Place Montepagano  
France  
E-mail: info@corailrouge.com

Ali Cemal GUCU  
Middle East Technical University  
Institute of Marine Science  
E-mail :gucu@ims.metu.edu.tr

Beatriz GUIJARRO  
Spanish Institute of Oceanography (IEO)  
Moll de Ponent, s/n. 07015 Palma de Mallorca  
Spain  
E-mail: beatriz@ba.ieo.es

Zdravko IKICA  
Institute of Marine Biology  
University of Montenegro  
Dobrota b.b., PO Box 69, 85330 Kotor  
Montenegro  
E-mail: zdikica@ac.me

Igor ISAJLOVIC  
Institute of Oceanography and Fisheries  
Set. I. Mestovica 63  
Croatia  
E-mail: igor@izor.hr

Angélique JADAUD  
IFREMER  
1, Bd Jean Monnet  
34200 Sète  
France  
E-mail: ajadaud@ifremer.fr

Othman JARBOUI  
Institut National des Sciences et Technologies de la Mer  
BP 1035, 3018 Sfax  
Tunisia  
E-mail: othman.jarboui@instm.rnrt.tn

Jerina KOLITARI  
Agricultural University of Tirana , Aquaculture and Fishery Laboratory  
Albania  
E-mail: j.kolitari@gmail.com

Simone LEONI  
ISMAR - CNR Ancona  
Largo Fiera della Pesca 1  
60125, Ancona  
Italy  
E-mail: s.leoni1985@gmail.com

Hatem MAHMOUD  
College of Fisheries Technology and Aquaculture  
Arab Academy for Science, Technology and Maritime Transport  
Abu Qir, Alexandria  
Egypt  
E-mail: hatemhanafy@hotmail.com
Moussa MENNAD  
Centre National de Recherche et du Développement de la Pêche et de l’Aquaculture  
11 Boulevard Colonel Amirouche, Bou-Ismail, W. Tipasa  
Algeria  
E-mail: mennen.moussa@gmail.com

Reno MICALLEF  
Department of Fisheries and Aquaculture, Ministry for Sustainable Development, the Environment and Climate Change  
Department of Fisheries and Aquaculture, MSDEC, Ngiered Road  
Marsa  
Malta  
E-mail: reno.micallef@gov.mt

Marco PANI  
IWMC World Conservation Trust  
Piazza dei Mercanti 2 00153  
Roma  
Italy  
E-mail: panimarco@gmail.com

José Luis PÉREZ GIL  
IEO  
Puerto Pesquero S/N Fuenígola 29640  
Málaga  
Spain  
E-mail: joseluis.perez@ma.ieu.es

Tommaso RUSSO  
University of Rome Tor Vergata  
via della Ricerca Scientifica snc  
Italy  
E-mail: Tommaso.Russo@uniroma2.it

Giovanni SANTANGELO  
University of Pisa  
Dep. Biology Via Volta 6 56126  
Pisa Italy  
E-mail: giovanni@santangelo.unipi.it

Paolo SARTOR  
Centro Interuniversitario di Biologia Marina  
Viale Nazario Sauro 4  
Livorno  
Italy  
E-mail: psartor@cibm.it

Mario SBRANA  
Centro Interuniversitario di Biologia Marina  
Viale Nazario Sauro 4  
Livorno  
Italy  
E-mail: msbrana@cibm.it

Maria Teresa SPEDICATO  
COISPA Tecnologia & Ricerca  
Via dei Trulli, 18  
Italy  
E-mail: spedicato@coispa.it

Georgios TSOUNIS  
California State University Northridge  
18111 Nordhoff Street, CA91330  
USA  
E-mail: georgios.tsounis@uni-bremen.de

Nedo VRGOC  
Institute of oceanography and fisheries  
Set. I. Mestovica 63  
Croatia  
E-mail: vrgoc@izor.hr

FAO Regional Projects

Luca CERIOLA  
FAO Ceriola  
Fisheries and Aquaculture Resources Use and Conservation Division (FIRF)  
Fisheries and Aquaculture Department  
Viale delle Terme di Caracalla  
00153 Rome, Italy  
Ph.: +39 346229179  
E-mail: luca.ceriola@fao.org

Mark DIMECH  
FAO MedSudMed  
Project Coordinator  
Fisheries and Aquaculture Resources Use and Conservation Division (FIRF)  
Fisheries and Aquaculture Department  
Androu 1, 112 57 Athens, Greece  
Ph: +30 2108847960  
E-mail: Mark.Dimech@fao.org
EC Joint Research Centre (JRC)

**Giacomo Chato, Osio**
Institute for Protection and Security of the Citizen (IPSC) Maritime Affairs Unit G.04, TP 051 Via Enrico Fermi 2749 21027 Ispra (Va) Italy
E-mail: giacomo-chato.osio@jrc.ec.europa.eu

European Commission

**Amanda PEREZ PERERA**
European Commission
Rue Joseph II 99, 1000 Brussels Belgium
E-mail: Amanda.PEREZ-PERERA@ec.europa.eu

GFCM Secretariat

**Miguel BERNAL**
Fisheries Officer
GFCM Secretariat
Food and Agriculture Organisation of the United Nations (FAO)
Via Vittoria Colonna 1 00193 Rome, Italy
Tel: +39 0657056437
E-mail: miguel.bernal@fao.org

**Pilar HERNÁNDEZ**
Information Management Officer
GFCM Secretariat
Food and Agriculture Organisation of the United Nations (FAO)
Via Vittoria Colonna 1 00193 Rome, Italy
Tel: +39 0657054617
E-mail: pilar.hernandez@fao.org
Appendix C

Terms of reference for the SCSA Working Groups on Stock Assessment for demersal and small pelagic species

One of the objectives of the Sub-Committee on Stock Assessment (SCSA) is to make progress on the enhancement of joint practical stock assessments. “Joint” refers to the participation of scientists from different countries providing their data and sharing them with their colleagues, using a standard method and analyzing together the results and options for fisheries management.

The main objective of the annual meetings of the two working groups is to give advice on those stocks that are well assessed. “Well” meaning agreed by the group on the type of data, on the parameters used and on the methodology applied. Specifically, the group will, on a stock by stock basis:

1. Analyze the data sets provided by the participants (sampling frequency, time series, age-structured, commercial vs survey data, etc.)
2. Check parameters used and methodology applied on the assessments already done ‘at home’.
3. Resume the performance of the methods through sensitivity tests and residuals analysis.
4. Run stock assessments on the cases not previously done with the data sets available and with the agreed methodology on a practical session.
5. Get the actual values of the biological reference points (BRP) and compare with those agreed at the 13th SAC meeting, namely $F_{MSY}$ or its proxy $F_{0.1}$ as the Target Reference Point and $F_{max}$ as provisional Limit Reference Point.
6. In cases where BRP cannot be obtained use an empirical approach based on standing stock as stock status indicator, the harvest ratio (catch/biomass from survey) as fishing impact, and some indicators (SST, Chlorophyll, condition factor, etc.) of environmental stress.
7. Produce diagnoses on the status of the stocks.
8. Present and discuss assessment related works.
9. Complete the filling up of the SCSA stock assessment forms including, when available, those for direct methods.
10. Evaluate the new assessment forms provided this year, in relation to the recommendations provided by the 2011 Assessment Working Groups and the SAC.
11. Suggest management advice to the SAC considering different alternatives.
## Appendix D

### Advice on the status of the stocks assessed, including WGSAD comments and recommendations

<table>
<thead>
<tr>
<th>GSA</th>
<th>Species</th>
<th>Methodology used</th>
<th>Current values</th>
<th>Reference points</th>
<th>F&lt;sub&gt;curr&lt;/sub&gt;/F&lt;sub&gt;0.1&lt;/sub&gt;</th>
<th>Stock status</th>
<th>Management advice</th>
<th>WGSAD comments</th>
</tr>
</thead>
</table>
| GSA  | European hake *Merluccius merluccius* | Dynamic Schaeffer model         | F<sub>curr</sub>=1.02  
B<sub>curr</sub>= 145 | F<sub>MSY</sub>= 1.62  
B<sub>MSY</sub>=115 | 0.6                      | Sustainable exploitation with sustainable biomass | Do not increase fishing mortality               | The estimated value of F<sub>MSY</sub> is considered too high, and therefore the assessment is not considered reliable. Alternative assessment models are recommended. The status and advice is therefore considered preliminary. |
<p>| GSA  | European hake <em>Merluccius merluccius</em> | XSA, Y/R, short-term forecast | F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 1.15 | F&lt;sub&gt;0.1&lt;/sub&gt;= 0.15 | 7.7                      | In overexploitation with relative intermediate biomass | Reduce fishing mortality                   | No specific comments on this stock. |
| GSA  | European hake <em>Merluccius merluccius</em> | XSA, Y/R, short-term forecast | F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 1.4 | F&lt;sub&gt;0.1&lt;/sub&gt;= 0.18 | 7.8                      | In overexploitation with relative intermediate biomass | Reduce fishing mortality                   | No specific comments on this stock. |
| GSA  | European hake <em>Merluccius merluccius</em> | a4a, Y/R, short-term forecast | F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 1.67 | F&lt;sub&gt;0.1&lt;/sub&gt;= 0.17 | 9.8                      | In overexploitation with relative low biomass | Reduce fishing mortality                   | The WGSAD recommended incorporating a comparison of trends for fishing effort versus F. |
| GSA  | European hake <em>Merluccius merluccius</em> | XSA, Y/R                          | F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 0.74 | F&lt;sub&gt;0.1&lt;/sub&gt;= 0.16 | 4.6                      | In overexploitation with relative intermediate biomass. | Reduce fishing mortality                   | No specific comments on this stock. |
| GSA  | European hake <em>Merluccius merluccius</em> | XSA, global model                 | F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 0.63 | F&lt;sub&gt;0.1&lt;/sub&gt;= 0.14 | 4.5                      | In overexploitation with relative high biomass | Reduce fishing mortality                   | No specific comments on this stock. |</p>
<table>
<thead>
<tr>
<th>GSA</th>
<th>Species</th>
<th>Methodology used</th>
<th>Current values</th>
<th>Reference points</th>
<th>F&lt;sub&gt;curr&lt;/sub&gt;/F&lt;sub&gt;0.1&lt;/sub&gt;</th>
<th>Stock status</th>
<th>Management advice</th>
<th>WGSAD comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSA 17</td>
<td>European hake <em>Merluccius merluccius</em></td>
<td>SCAA (SS3), Y/R</td>
<td>F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 0.53</td>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;=0.26</td>
<td>2.0</td>
<td>In overexploitation with intermediate biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>GSA 18</td>
<td>European hake <em>Merluccius merluccius</em></td>
<td>XSA, a4a SCA, ALADYM, Y/R</td>
<td>F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 0.8</td>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;= 0.2</td>
<td>4.0</td>
<td>In overexploitation with relative intermediate biomass</td>
<td>Reduce fishing mortality</td>
<td>The WGSAD suggested using an average of the last three years for the recruitment in the projections. This suggestion has been applied in the last version of the stock assessment form.</td>
</tr>
<tr>
<td>GSA 17</td>
<td>Common sole <em>Solea solea</em></td>
<td>SS3, Y/R, short-term forecast</td>
<td>F&lt;sub&gt;(2013)&lt;/sub&gt; = 0.46</td>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;= 0.31</td>
<td>1.5</td>
<td>In overexploitation with relative low biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>GSA 03</td>
<td>Red mullet <em>Mullus barbatus</em></td>
<td>VIT (LCA, VPA, Y-R) Biodyn</td>
<td>F&lt;sub&gt;cur&lt;/sub&gt;(VIT)= 1.09</td>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;(VIT)= 0.48</td>
<td>2.3</td>
<td>In overexploitation</td>
<td>Reduce fishing mortality</td>
<td>The WGSAD encouraged the continuation of sampling in order to achieve a longer data time series and improve the robustness of the assessment.</td>
</tr>
<tr>
<td>GSA 06</td>
<td>Red mullet <em>Mullus barbatus</em></td>
<td>XSA, Y/R</td>
<td>F&lt;sub&gt;(2011-2012)&lt;/sub&gt;= 0.69</td>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;= 0.51</td>
<td>1.3</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>The retrospective analysis showed an overestimation of F in the last year and for that reason, it was not considered for F&lt;sub&gt;current&lt;/sub&gt;.</td>
</tr>
<tr>
<td>GSA 07</td>
<td>Red mullet <em>Mullus barbatus</em></td>
<td>XSA, Y/R, short-term forecast</td>
<td>F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 0.45</td>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;= 0.14</td>
<td>3.2</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>GSA 10</td>
<td>Red mullet, <em>Mullus barbatus</em></td>
<td>XSA, Y/R</td>
<td>F&lt;sub&gt;(2011-2013)&lt;/sub&gt;= 0.5</td>
<td>F&lt;sub&gt;0.1&lt;/sub&gt;= 0.5</td>
<td>1.0</td>
<td>Sustainable exploitation with relative intermediate biomass.</td>
<td>Do not increase fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>GSA</td>
<td>Species</td>
<td>Methodology used</td>
<td>Current values</td>
<td>Reference points</td>
<td>F_{curr}/F_{0.1}</td>
<td>Stock status</td>
<td>Management advice</td>
<td>WGSAD comments</td>
</tr>
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</tr>
<tr>
<td>24</td>
<td>Red mullet, <em>Mullus barbatus</em></td>
<td>XSA</td>
<td>F_{(2011-2013)} = 0.60</td>
<td>F_{0.1} = 0.47</td>
<td>1.3</td>
<td>In overexploitation</td>
<td>Reduce fishing mortality considering the possible side effects of management measures to be enforced on the Lessepsian competitors and predators</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>25</td>
<td>Red mullet, <em>Mullus barbatus</em></td>
<td>XSA</td>
<td>F_{curr} = 0.34</td>
<td>F_{0.1} = 0.23</td>
<td>1.5</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>05</td>
<td>Striped red mullet, <em>Mullus surmuletus</em></td>
<td>XSA, Y/R, short term forecast</td>
<td>F_{(2011-2013)} = 0.51</td>
<td>F_{0.1} = 0.17</td>
<td>3.0</td>
<td>In overexploitation with relative low biomass</td>
<td>Reduce fishing mortality</td>
<td>This stock should be closely monitored as it has been consistently in overexploitation and with relative low biomass for a number of years.</td>
</tr>
<tr>
<td>26</td>
<td>Striped red mullet, <em>Mullus surmuletus</em></td>
<td>VIT (LCA,VPA, Y/R)</td>
<td>F_{(2011-2013)} = 0.48</td>
<td>F_{0.1} = 0.19</td>
<td>2.5</td>
<td>In overexploitation</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>26</td>
<td>Brush tooth lizard fish, <em>Saurida undosquamis</em></td>
<td>VIT (LCA,VPA, Y/R)</td>
<td>F_{(2011-2013)} = 0.58</td>
<td>F_{0.1} = 0.25</td>
<td>2.3</td>
<td>In overexploitation</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>01</td>
<td>Red shrimp, <em>Aristeus antennatus</em></td>
<td>XSA, Y/R, short term forecast</td>
<td>F_{(2011-2013)} = 0.82</td>
<td>F_{0.1} = 0.41</td>
<td>2.0</td>
<td>In overexploitation with relative intermediate biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>05</td>
<td>Red shrimp, <em>Aristeus antennatus</em></td>
<td>XSA, Y/R, short term forecast</td>
<td>F_{(2011-2013)} = 0.42</td>
<td>F_{0.1} = 0.24</td>
<td>1.8</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>GSA</td>
<td>Species</td>
<td>Methodology used</td>
<td>Current values</td>
<td>Reference points</td>
<td>$F_{curr}/F_{0.1}$</td>
<td>Stock status</td>
<td>Management advice</td>
<td>WGSAD comments</td>
</tr>
<tr>
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</tr>
<tr>
<td>06</td>
<td>Red shrimp, <em>Aristeus antennatus</em></td>
<td>XSA, Y/R</td>
<td>$F_{(2011-2013)} = 0.94$</td>
<td>$F_{0.1}= 0.47$</td>
<td>2.0</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>10</td>
<td>Deep-water pink shrimp, <em>Parapeneaus longirostris</em></td>
<td>XSA, Y/R</td>
<td>$F_{(2011-2013)} = 1.60$</td>
<td>$F_{0.1}= 0.92$</td>
<td>1.7</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>12, 14, 15, 16</td>
<td>Deep-water pink shrimp, <em>Parapeneaus longirostris</em></td>
<td>XSA, Global model</td>
<td>$F_{(2011-2013)} = 0.88$</td>
<td>$F_{0.1}= 0.70$</td>
<td>1.3</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>18</td>
<td>Deep-water pink shrimp, <em>Parapeneaus longirostris</em></td>
<td>XSA, ALADYM, Y/R</td>
<td>$F_{(2011-2013)} = 1.62$</td>
<td>$F_{0.1}= 0.74$</td>
<td>2.2</td>
<td>In overexploitation with relative low biomass</td>
<td>Reduce fishing mortality.</td>
<td>No specific comments on this stock.</td>
</tr>
<tr>
<td>19</td>
<td>Giant red shrimp, <em>Aristaeomorpha foliacea</em></td>
<td>XSA &amp; Y/R, tuning with Medits MEDITS data</td>
<td>$F_{(2011-2013)} = 0.66$</td>
<td>$F_{0.1}= 0.29$</td>
<td>2.3</td>
<td>In overexploitation with relative high biomass</td>
<td>Reduce fishing mortality</td>
<td>The WGSAD recommended updating the assessment in the next year in order to better address outliers in the model outputs.</td>
</tr>
</tbody>
</table>
INTRODUCTION

Status quo of red coral fishery management in the Mediterranean region

The Mediterranean red coral (*Corallium rubrum*) is one of the most valuable marine living resources as larger specimens of this gorgonian can be prized several thousand euro/kg. The fishery follows a historic tradition including an artisanal industry specialized on carving and trading artistic objects and jewellery made from the red calcium carbonate skeleton of red coral. Several centuries of intense commercial harvesting led to a decline of yield before more stringent management rules were set up in the 1980s.

Fishery management began considering coral ecology in the 1870s, yet measures have been arbitrary and inconsequent in a fragmented landscape of scientific expertise and policy instruments. Most coral fisheries followed a mining strategy where one stock was depleted, before moving on to explore new areas and harvest new stocks (Tsounis et al. 2010). Declining fishing yields of the highly valuable Mediterranean red coral indicated overexploitation by the 1980s. In response, the General Fisheries Commission for the Mediterranean (GFCM) of the UN Food and Agriculture Organization (FAO) organised several technical consultations that produced guidelines and recommendations for management and highlighted the difficulties posed by this species (sessile and slow growing) to the application of regular models for the evaluation of its stocks. The need to further investigate its biology and distributional range was also put forward, (GFCM 1983, 1988). In 1994 dredging gears for coral harvesting were totally banned in the Mediterranean by several national and EU Laws. However, recent data led to new concerns about the sustainability of coral harvest by highlighting previous and ongoing overexploitation. The US and EU reacted in 2007 and 2009 by proposing to include the family Corallidae in CITES Appendix II to regulate trade (Tsounis et al. 2010). However, the proposals did not receive majority votes, due in part to the hope and promise that local management would provide a less obtrusive solution.

In 2014 the GFCM adopted at its thirty-eighth session “Guidelines for the management of Mediterranean red coral populations” agreed by all its members (GFCM 2014b). These Guidelines are based on conclusions of three technical workshops in 2010, 2011 and 2014 and aim to promote the implementation of two binding recommendations adopted in 2011 and 2012 which prohibit harvesting over 50 m depth, gear other than manual hammer by scuba divers and established a minimum size of 7 mm diameter in all its competence area. These preliminary measures are based on the existing knowledge of red coral populations, but what the process put forward was a peremptory need of undertaking formal assessments of the red coral stocks in the whole basin.

Limited resources and insufficient interdisciplinary work have so far limited the research needed to improve management guidelines, while a lack of human and financial resources hinders local management and efficient enforcement (Tsounis et al. 2013).

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1 Rec. GFCM/35/2011/2 On the exploitation of red coral in the GFCM Competence Area
2 Rec. GFCM/36/2012/1 on further measures for the exploitation of red coral in the GFCM area
Current challenges

Many meetings and workshops have been held about the ecology of Corallium rubrum, yet less than a handful of studies propose sustainable management guidelines in practical terms. Analyzing the workshop proceedings regarding Corallidae management, it becomes apparent that criteria for sustainability in line with fishery biology are rarely mentioned. For example, the “survival of the species” is often mistaken for the final objective, in order to avoid extinction. But this point of view has unfortunately permitted the continuation of the "boom and bust“ mining exploitation that depletes one stock after the other.

Recent data revealed that most stocks are overharvested to an extent where debates about extinction of the species arose (Bussoletti et al. 2010, Bruckner 2009 and 2014). While the risk of global species extinction is debatable, the industry certainly faces the threat of local or even economic extinction of its resource.

Industry representatives petitioned for the legalization of remote operated vehicles (ROVs) to harvest coral without exposing humans to the depths where large corals remain (GFCM 2014). ROV were previously used for prospecting only during limited time windows. While SCUBA diving at 100 – 130 m depth imposes a drastic physiological limitation on diving time, ROV harvest would provide access to the corals without any limitation of depth or time. Furthermore, it is known that harvesting deep populations without any physiological limitation as the one imposed nowadays to the divers, would mean that > 99% of the world’s C. rubrum populations would be subjected to fishing pressure (i.e. except < 1 % that are protected areas), so that overharvesting these last viable stocks would lead to economic extinction. Therefore, the use of such type of devices would need the development of a reliable management system, through an experimental period to test how limitations of time and depth can be applied and controlled, as well as to assess their impact not only on the red coral colonies, but also on the fragile ecosystem that they inhabit.

A sustainable fishery shall provide by definition the same amount of yield perpetually from any stock, and the scientific community is challenged with providing managers with the diagnostic tools to steer the fishery accordingly (Cau et al. 2014). This will require an interdisciplinary approach joining coral ecology with fishery and demographic modelling. Furthermore, the holistic concept of ecosystem approach to manage single species in consideration of the impact on nursery services and overall system productivity and biodiversity is of outmost importance.

This emphasizes the urgent need for improved coral fishery management. Clearly, an adequately funded group of experts combining backgrounds from international policy, management, coral ecology, fishery, is required to improve the fishery management of a species that provides structure to Mediterranean ecosystems.

The GFCM continues to unite Mediterranean researchers, leading the collection of data and development of management guidelines of this resource through the organization of expert workshops (GFCM 2014a). The challenge of funding a project on Mediterranean red coral consists in identifying funding agencies that feel responsible for a conservation oriented program that contributes to the sustainable management of this fishery. Possibilities include an array of in-kind funding by the GFCM, funding by the EU Commission through various programmes, some of which can include non-European participants in the Mediterranean basin. In addition, foundations are likely to play a crucial role. Close collaboration under single leadership is important, therefore networked programmes are ideal. The GFCM Secretariat will coordinate this effort by acting as the focal point for the information gathering, supervising work packages tasks of the different participants and fostering the transfer of results into management guidelines for the Mediterranean.

THE PROGRAMME FOR RED CORAL FISHERY MANAGEMENT
General structure

In accordance with the previous workshop's recommendations (GFCM 1988, 2010, 2011, 2014) the Programme will be articulated around the following five thematic/strategic areas as identified by the workshops:

1. Surveys at sea on unexplored red coral stocks, notably along the North-African coast as well as deep areas in the whole basin to evaluate their role as either reserves or future stocks
2. Compilation of biological data to support modelling of red coral populations
3. Development and/or adaptation of stock assessment models for red coral
4. Evaluation of the concept of robotic remote (ROV) harvesting
5. Socioeconomic analysis with focus on future development of the industry

The activities are grouped into 4 work packages (WP) as described below.

General objectives

The overall focus of the red coral programme is to promote the successful management of red coral fisheries in the Mediterranean Sea, delivering on the ecosystem approach to fisheries (EAF) while improving livelihoods and economies of coastal communities.

Strategy

During the first year of the programme, a series of surveys and case studies on fisheries will be undertaken to address gaps of knowledge. An analytical framework to analyze the data is being developed by the GFCM, and shall be improved and expanded upon in the second year.

Specific objectives

Provisional identified specific objectives are summarized in the following suggested work packages:

Work packages

WP1: Surveys at sea in selected areas of the Mediterranean basin

The red coral stocks are being harvested, but little is known about its current abundance along Mediterranean coasts. It is crucial to determine the extension of stocks, identify new stocks, and quantify the abundance of coral in those stocks. Socioeconomic analysis of the fisheries is also required, e.g. with respect to currently used technology and potential for capacity building.

Surveys in offshore waters as well as in seamounts shall explore pristine populations or remote stocks that have been recovering for decades (e.g. Scerchi channel), in order to obtain a case study for comparison and baseline data to be used in production models. In this context, radioisotope analysis shall be used to resolve the maximum age of red coral in pristine habitats.

WP2: Coral abundance and population structure in stocks
In established fisheries, the areal extension of stocks needs to be precisely quantified with coordinates by local regional fishery management bodies and communicated to the Secretariat. Surveys need to be undertaken in all fisheries to actually assess and monitor the abundance and size structure of red coral in the stocks.

WP3: Resilience of deep stocks and connectivity

Research programmes on the resilience of especially deep stocks are required for imminent policy decisions: Growth rates have been measured, but there is a need for a better understanding of pan-geographical variability and growth rates of deep sea red coral below 100 m depth.

The resilience of shallow and deep stocks depends on their connectivity, as it determines their risk of extinction in case they are overharvested (adult corals do not migrate and dispersal capacities of larvae are unknown). Genetic tools as well as numerical simulations of ocean circulation integrated with data on larval behavior can address gaps of knowledge concerning connectivity.

WP4: New generation fishery models

At present, red coral fisheries are managed based on considerations for minimum size according to age at full maturity, but production models are required to specify maximum sustainable yield. Two types of models have been applied to assess two fisheries so far: The Beverton Holt Model in Spain and the Schaefer Model in Sardinia. The development of better models is required for precise yield predictions, e.g., a matrix models. Furthermore, economic models to determine optimum yield are required.

WP5: Economical development of the red coral fishery

An analysis of the socioeconomic structure of industry is required to identify adequate management options. For example the income distribution and potential earnings need to be considered in light of the cost of alternative types of harvesting (including ROV). The analysis might for example lead to the establishment of fishery cooperatives as a management institution, if the amortisation of harvesting robots appears unfeasible.

Solutions for monitoring need to be identified, including estimates of monitoring and enforcement costs. Finally, research on alternative business models is required to consider scenarios of reduced raw material availability).

Implementation

GFCM Secretariat and relevant partner organizations.

Programme duration

2015–2016: 2 years

Funding

The implementation of the regional programme will be subject to available extra budgetary resources. It will be supported by ad hoc funding mechanisms (e.g., through multilateral trust-funds settings). Potential donors include GFCM Members, non-Members, international organizations and private foundations/entities.
Bibliography

Bruckner AW (2009) Rate and extent of decline in Corallium (pink and red coral) populations: existing data meet the requirements for a CITES Appendix II listing. MEPS 397: 319-332


