GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

COMMISSION GÉNÉRALE DES PÊCHES POUR LA MÉDITERRANÉE

SCIENTIFIC ADVISORY COMMITTEE (SAC)

Fourteenth Session

Sofia, Bulgaria, 20-24 February 2012

Report of the Working Group on Stock Assessment of Small Pelagic Species Chania (Crete), Greece, 24-29 October 2011

INTRODUCTION

1. The meeting of the SCSA Working Group on Small Pelagic species (WG) was held in Chania (Crete) Greece, from 24 to 29 October 2011 at the Thales and Heraclitus conference rooms of the Mediterranean Agronomic Institute of Chania (MAICh). It was attended by 21 participants from GFCM Member Countries, FAO Regional Projects as well as representatives of the GFCM Secretariat (see list of participants in Appendix B).

2. Pilar Hernández, GFCM Secretariat, welcomed the participants and thanked them for attending this meeting, as well as the Greek Authorities for their kindness in hosting and arranging the meeting

3. Dr. Miguel Bernal, Spanish scientist working at the Instituto de Ciencias del Mar in Barcelona was the Moderator. The terms of reference of the meeting are presented in Appendix C.

4. The moderator highlighted that the main objective of the meeting is to give advice on the management of fisheries/stocks, based on assessments supported by data, biological parameters and methods agreed by the participants. Such assessments must have quality and consistency to provide relevant information for management. In the case of assessments that, for some reason, were considered to be preliminary, no advice is given but a strong effort will be done to identify paths to sort out problems with the aim of having agreed assessments on the near future (1 or 2 years).

5. Piera Carpi for sardine session, Milica Mandic for anchovy, Encarna Garcia for the methods session, and Lofti Ben Abdallah for the general conclusions and recommendations sessions were appointed as reporters.

6. With some minor amendments and the inclusion of two presentations: one on acoustic surveys and one on “bianchetto” fishery both in the Adriatic, the agenda was adopted (see Agenda in Appendix A).

PROGRESS ON LAST YEAR RECOMMENDATIONS

7. The moderator introduced some slides with the summary of the recommendations on research from the previous year meeting and recall the participants to provide inputs, and insights on the progress done if any and on their opinion on either adopting and go forward with them, or change the approach according to suitability of methods and means. The topics addressed were:

- Understanding stock identity and migrations
- Biological sampling
- Surveys
- Processes across the Mediterranean
- Assessment methods

Some participants raised also the issue of the recommendation on using a combination of direct and indirect methods. In the south East Adriatic direct methods can be very acceptable as a good estimation for biomass since the fleet is very small and the exploitation rate might be close to zero. The group agreed nevertheless that to draw some management advice, we need to know also how much is caught, and hence some data on landings are also necessary.

The need for more area-based studies on growth parameters and age/length keys and the convenience of sharing them throughout different areas was also raised. Differences are commonly found in population dynamic parameters when we move from one area to other even in close areas (N/S Adriatic).

The question on suitability of age structured based methods even when data are reliable was raised. Common agreement on importance of having good information on recruitment was highlighted. To this goal, one of things to be recommended is to try to find good indicators of recruitment. However, it was also pointed out that currently reliable recruitment indexes are difficult to obtain, and direct estimation of recruitment, for example based on juvenile surveys is expensive and still poses some methodological challenges.

The utility of risk-based methods to attain some management advice based on probabilistic estimations of recruitment was also stressed. With the fluctuations in recruitment experienced by these species the discussion focused on the need to move towards a more probabilistic approach in the way to define different scenarios according to the knowledge on recruitment and on its waivers.

JUSTIFICATION OF THIS YEAR PROCEDURES

8. Based on the approach suggested by the Scientific Advisory Committee (SAC), the group discussed a common guideline to provide a coherent advice across the different stocks evaluated. The following issues were discussed and agreed by the group:

9. The group endorsed separating the assessment of stock status into two different questions: status of the biomass and fishing mortality levels, following the usual procedure for stock assessment and the guidelines of the SAC.

10. No limit or precautionary reference point for biomass was available for any of the stocks evaluated, and few have precautionary reference points for fishing mortality, usually based on Patterson's criterium (F/Z = 0.4). When existing, reference points for fishing mortality were not always considered adequate.

11. In the absence of reliable reference points for most of the stocks, and following the precautionary approach to provide advice with the available data, the group took the following approach:

a. When long time series of estimates were available, the status of the biomass and the evaluation of current fishing mortality levels were done in relation to the abundance and fishing mortality levels observed in the time series. Main criteria to assess the status of both stock and fishing mortality using the time series were i) the stability of stock biomass levels, ii) signals of changes in growth and/or age/length composition, iii) signals of recruitment impairment and iv) on changes in fishing mortality levels.

b. When analyzing time series of stock status, the group adopted a Regime-Specific Harvest Rate (RSHR - Polovina, 2005; King et al., 2010) conceptual approach; it was recognized that small pelagic fish may show medium term fluctuations in productivity, due to environmental control. Therefore, the possibility for each stock to have different equilibrium biomass levels (and therefore surplus biomass and Maximum Sustainable Yield) at different ecosystem status was adopted. In case various productivity phases are identified, stability as defined in a) above was evaluated in relation to each phase.

c. When no extra information was available to evaluate the productivity of the stock in each of the potential high or low abundance phases, the stability of stock characteristics in the time series was used as a guideline.

d. When no long time series of estimates or reference points were available, harvest rates (proportion of catches to biomass) and comparison with biomass levels of other stocks of the same species across the Mediterranean, as well as rough estimates of stock unit area were used to provide a rough evaluation of stock status.

12. The group considered that the current assessment forms did not include all required information for small pelagic fish (see discussion in section recommendations in Section 4.2), as it was difficult to include an assessment of stock biomass and fishing mortality under a variable equilibrium situation. The group decided to use the forms to evaluate the stock status in relation to its believed current phase state, but an explanation of the full perspective for each stock is provided in the stock summaries and in each individual stock report.

OVERVIEW OF ASSESSMENTS PERFORMED AND STOCK STATUS

13. A total of 14 stocks or stock units analysis have been presented to this year WG, from which a total of 11 stocks are formally assessed (a stock status assessment is provided; see Table below). All assessments had been done before the meeting, although some extra analysis in some of the stocks was carried out during the meeting.

14. In terms of GSA areas, 11 GSA areas were covered, from which 6 areas are formally assessed. Sardine and anchovy are the two species analyzed in most of the areas, while for some areas some data on sardinella and mackerel was also presented.

15. Fishery independent methods are used in 9 of the formally assessed stocks, either as a tuning index for analytical assessment or else as the only biomass estimator. Acoustics is the most used method (8 out of 9 of these assessments) while Daily Egg Production Method SSB estimator is used only in 2 of these assessments. For the stocks without formal assessment (GSA 01, 4, 12, 13, 14), 3 of the areas (GSA 12, 13, 14) are covered by a single acoustic survey, and acoustic surveys have also been previously used in GSA01. A first acoustic survey was carried out in GSA04 this year.

16. In relation to the assessment model, most stocks with analytical assessment were analysed using either length or (most commonly) age based cohort analysis. Two stocks (sardine and anchovy

in GSA 16) were analysed using a biomass (Surplus) model, allowing for an external index of ecosystem productivity.

17. Overall, most stocks show a somehow linear stock-recruitment signal, stronger than in other small pelagic stocks outside the Mediterranean. No clear hockey-stick stock-recruitment relationships were shown, therefore preventing using this information to set up a clear limit biomass reference point based on recruitment impairment observations.

18. All formally assessed stocks were either classified as fully exploited (7) or overexploited (2), with the exception of the sardine and anchovy stocks in southern Adriatic Sea (GSA18) for which the status is considered moderately exploited, although exact situation is not fully known due to poor information on exploitation rates.

19. In accordance to the previous results, the recommendation in the different stocks is either to reduce or maintain current fishing effort. Some room for local increase of fishing effort is only recognized for the eastern part of southern Adriatic Sea.

GSA	Species	Assessed by	Exploitation rate	Biomass level	Status	Recommendation
03	Sardine	VIT	Moderate in East, high in west	Lower than previous years	Fully exploited	Maintain current F, protect spawners (temporal ban)
06	Sardine	XSA tuned with acoustic	High	The lowest value in the time series	Overexploited	Reduce fishing effort until recruitment levels increase
07	Sardine	Acoustic and CPUE	Very Low	Low, decreasing trend. Close to collapse	Fully exploited, without room for potential expansion	The system is not controlled by human activity. Not to increase fishing effort until the system stabilizes or show signals of recovery.
16	Sardine	Surplus production model, BIODYN	Moderate	Lower than BMSY	Fully exploited with low abundance and moderate fishing	Not to increase fishing effort
17	Sardine	VPA, ICA and acoustic survey	Moderate	Low	Fully exploited	Not to increase fishing effort
18	Sardine	Acoustic survey	Moderate	Low	Considered Moderately exploited, but exploitation rate is uncertain	An exploitation rate for the whole area should be estimated. Not to increase fishing effort in the western part.

GSA	Species	Assessed by	Exploitation rate	Biomass level	Status	Recommendation
06	Anchovy	XSA tuned with acoustic	It is difficult to assess. (between moderate to high) It is constant.	Intermediate but within a low range for the area	Fully exploited	Not to increase fishing effort. Despite F has been constant, there are fluctuations in biomass.
07	Anchovy	Acoustic and CPUE	Moderate	Low	Fully exploited	Not to increase fishing effort.
16	Anchovy	Surplus production model, BIODYN	High	Intermediate	Overexploited	Fishing effort should be reduced by means of a multi-annual management plan until there is evidence for stock recovery
17	Anchovy	VPA, ICA and acoustic survey	Moderate	Intermediate	Fully exploited	Not to increase fishing effort
18	Anchovy	Acoustic and DEPM	Moderate	Intermediate	Moderately exploited but biomass may be in a decreasing trend	Not to increase fishing effort, specially in the West

STOCK ASSESSMENTS BY AREA AND SPECIES

20. This year, some preliminary combined assessment on neighbourhood areas were presented. In order to accommodate this, and taking into account that in the future other areas that share stocks may be assessed in common, the individual stock assessments were first organised by areas and then by species. Whenever a combined area exercise and/or assessment was carried out, the results of the combined exercise are presented first, and then the individual assessment of each subarea is included.

21. The WG congratulated the ADRIAMED team and the involved Institutes for the successful application of an integrated survey that covers all the Adriatic Sea, as well as COPEMED II and the Moroccan and Spanish Institutes that participated in a first attempt to jointly analyse the stocks in the Alborán Sea. The WG recommends that these and other similar initiatives be fully supported by required parties, and encourages the participant Institutes and Countries to perform joint analysis of the available data, especially when evidence of connectivity of stocks, populations or stock units across areas/countries exists. The WG also encourages testing the potential of performing unique joint assessments on shared stocks, and recognises the importance of spatial issues both for assessment and management of small pelagic fish stocks (see Section 4.1 and recommendations in Section 5)

22. Also, the WG acknowledged the importance of strengthening the scientific cooperation towards standardization of echo-survey activities in Mediterranean. This cooperation, which involves North African and European countries, especially those conducting MEDIAS, is going to be facilitated by the FAO Sub-Regional Projects CopeMed II, MedSudMed and EastMed in the ambit of SAC-GFCM activities.

Combined GSA 01 and 03 – Alboran Sea

Authors: Omar Kada; F. Álvarez; A. Giráldez; P. Torres; M. Najih; I.L. Fernández; M. Bernardon and J.A. Camiñas

Within the context of the FAO project COPEMEDII, a first attempt of analysis with the data from Morocco and Spain in Alboran Sea (GSA 03 and 01), considering the series of landings and biological samplings, was carried out. A joint comparative analysis of the length-frequency distribution of sardine landings in Morocco and Spain was performed, in order to achieve a first approximation to the pattern of exploitation of both fleets. Also a common database between the two countries was prepared, in order to perform a joint preliminary assessment based on Length Cohort Analysis (LCA). The two analyses were carried out with data from the period 2003-2010.

The comparative analysis of the landing size distributions showed that both countries catch a large range of sizes with different annual modes. In GSA03, Moroccan fleet exploit regularly a range of sizes between 13 and 22 cm while in GSA01 two major ranges of sizes are exploited by the Spanish fleets, including juveniles/annual recruitment (in high demand for local consumption) and adults. These large ranges of sizes of sardine landed in GSA01 from 2008 represent a new fishing strategy of the fleet as a consequence of the high demand of sardine for feeding -fattening- bluefin tuna kept in captivity in Spain before commercialization. From 2006-07 the larger sizes in Spain are substantially higher than the maximum sizes in Morocco.

From this preliminary analysis it is inferred that the pattern of exploitation in both sub-areas (GSAs 01 and 03) is different but the total length-frequency distribution of sardine exploited in both GSAs appears to be similar. It was concluded and recommended the length-frequency distribution analysis of the catches from Morocco and Spain by month for the total period (2003-2010) that could provide better and accurate information on the exploitation pattern of both fleets in order to analyze possible similarities.

A joint stock assessment of sardine, based on the length-frequency distribution of landings data in both sub-areas for the period 2003-2008, applying the software VIT (Lleonart and Salat, 19927) was

undertaken. This assessment was considered preliminary and further work was concluded necessary to provide a final joint assessment of Alboran Sea. A number of recommendations were given to the COPEMED II, stressing the interest of performing this joint assessment and addressing the prerequisites to gather the data, create the common database and successfully applied a joint analytical assessment method. Also, a recommendation to explore the possibility of having a joint echo-survey in the area was put forward to the Spanish and Moroccan authorities. A new meeting to continue with this efforts is expected by 2012.

Discussion: This WG congratulated the Institutes and researchers involved in this analysis, as well as COPEMED II for promoting the initiative. The WG endorses the recommendations passed to COPEMED II, the involved Institutes and the National Authorities and expressed in the WD presented here. The WG supports the efforts to jointly analyse the data in the area and test the possibility of providing a combined assessment of all Alboran Sea. The group also suggest to try to do the assessment using ages instead of lengths since this information is available for some of the years, and there may be some spatial differences in growth and other biological parameters which may difficult the combined analysis.

GSA 03 - Southern Alboran Sea

Sardine (*Sardina pilchardus*)

Author: Omar Kada

Fishery: The small pelagic fishery in the area includes a fleet composed of about 144 units, 20% of the fleet operating in the Mediterranean coast of Morocco. These boats are technically modest (on average, 47 gross tons, 320 hp and 19m LOA), which is why their activity is limited to the coastal fringe, close to their homeports. The sardine of the Mediterranean are based mainly M'diq (35%), Nador (27%) and Al Hoceima (25%). It should be noted that these units can make trips to the Atlantic ports, namely the port of Larache. The sardine fishery is carried on throughout the year and for a frequency of 6 days a week. Vessels fish at night and returning to ports of landing after a sea of 12 to 15 hours, during which two to three fishing operations are conducted. The effort has grown rapidly since the 80s due to an increase in the number of boats operating in the region and this, after a period of stagnation in this effort during the 70's. Currently, the average number of outputs produced by the sardine is estimated at more than 10,000 trips per year. Landings of small pelagics in the Mediterranean are composed of sardines, sardinella, anchovy, horse mackerel, mackerel and the bug. The sardine and anchovy are the target species which is oriented on the fishing effort of the sardine, sardines remarkable for its abundance relative to other species and anchovy for its high commercial value. For over a decade, the production of sardines in the Mediterranean, Moroccan, varies between 10000 and 25000 tonnes / year. Between the years 2000 to 2010, the average annual production of sardines is about 12400 tons. The analysis of time series of catches of sardines since 2000 shows important fluctuations, with a stable overall trend. A progressive reduction in catches between 2000 and 2003 is noted, followed by a recovery between 2004 and 2006, a further decline in 2007 and 2008, and an increase in 2009. The latter is due to the acquisition of statistics from all points of landing of sardines in the Mediterranean in particular that of Sidi H'ssain. In 2010, landings declined by 19% over the previous year. The general trend of the sardine catches between 2004 and 2010 tended to decline. Al Hoceima port alone produces 42% of total landings in the Mediterranean, while the port of Nador is in second place with 19% and 12% Kebdana Ras. Other ports have less than 10%. Catches are taken during all months of the year. However, a decline of fishing activity is noted in winter because of weather conditions that limit the activity of boats. The best catches are taken mainly in spring and summer. In terms of fishing days, the active fleet in the Mediterranean sardine carries an average 10,000 fishing days per year. This effort is exerted mainly by active purse seine vessels from the three major ports namely those of Al Hoceima, Nador and M'diq. Fishing effort varies from one year to another, linked to climatic conditions and abundance of the resource. The catch per unit effort CPUE is generally between 0.03 and 0015 but up to 0.05 observed in 2001 and 2009

Data and parameters: Statistics of sardine landings by weight and fishing effort of purse seiners in the number of outputs is obtained monthly from the delegations of the National Office of Fisheries (ONP).

The biological data used to measure the state of exploitation of the sardine are those of the years 2007 to 2010 at the ports of Nador, Ras Kebdana and Al Hoceima and landings data and effort fishing from the Mediterranean ports of Tangier Moroccan except that since the capture of the port are carried out in the Atlantic. The value of natural mortality used is 0.5. It was calculated by the formula TANAKA 5% of survivors. It is assumed constant for all size classes. The value of terminal fishing mortality chosen to start the calculations is FTERM = 0.4.

Assessment method: Pseudo-cohort analysis on the average size frequency of the sardine weighted to the entire area of the Moroccan Mediterranean during the last three years in 2007 to 2010, using VIT (Lleonart and Salat, 2000). The level of exploitation of the sardine stock is determined by analyzing the curve of yield per recruit and the calculation of biological reference points F0.1 and / or Fmax.3.

Results: Large differences in relation to the size frequency distributions of the catches in the time series are observed between the E and the W of the Mediterranean Moroccan coast. In the East, represented by the ports of Nador and Ras Kebdana, two size modes are usually apparent, a lower one with a peack around 11 cm and a larger one with a peack at around 17 cm, which is similar to the mode of the West area, represented by the port of Al Hoceima. In some years, the second (large) mode is not present in the east part. Fishing mortality show a clear ascendent trend in relation to size, with a maximum mortality around 0.8 at sizes between 17 and 18 cm. The yield per recruit curve has no maximum corresponding to Fmax, hence the need to seek other biological reference point that is $F_{0.1}$. The value of $F_{0.1}$ is obtained by maximizing the function $V = (Y / R) i - (0.1 * Bo * F_i)$. (Cadima, 2003). The curve of the function V gives us the benchmark $F_{0.1}/F_{act}$ 0.99. The value of F_{act} (F current) being located at the value 1; hence the stock can be classified as fully exploited.

Diagnose of Stock status: Fully exploited

Advice and recommendations: The results show that the fishing effort is exercised essentially on adult individuals (between 16 and 19 cm). The analysis of the yield by recruit indicates a state of full exploitation on this resource. It is therefore recommended not to increase the fishing effort. Given the current state of the stock and to ensure a rational and sustainable exploitation of the stock of sardine GSA03, the following recommendations are made:

- To maintain the overall current fishing effort;
- To reduce the fishing mortality exerted on the spawning stock of the sardine. In order to do that it is proposed to establish a closed season during the breeding season of this species, especially during the month of January to coincide with the peak spawning;
- Due to the presence of significant numbers of small sardines in the landings of this species, especially in the Eastern part of GSA Region 03, it is proposed to prohibit fishing during the month of May in the vicinity of Ras Kebdana to preserve the stock of juveniles.

Discussion: The increase in fishing mortality for larger sizes was attributed to the coincidence of the mode of the catches in the west area with a second mode of larger sizes in the east area. This has occur previously in the time series presented, and for those years fishing mortality is higher around the peak of the coincident mode in the East and West side. It is unclear whether the level of fishing mortality at those sizes may affect the reproductive potential, so the WG endorses the recommendation to create a temporal ban on spawning season as a way to reduce some pressure when the large individuals may concentrate, and also to reduce pressure on the juveniles. There is no clear reason to suggest that the stock in overfished, therefore the WG also endorses the recommendation to maintain overall current fishing effort.

GSA 04 - Algeria

Author: Bennoui Azeddine,

Fishery: In GSA 04, small pelagic are primarily caught by seiners using the purse seine and to lesser extent by pelagic and mid-water trawlers. Catches of seiners are essentially on the contours of 20 to 80 m depth, area of high concentration of banks of small pelagic. The particularity of small pelagic requires us to identify periodically the biological and exploitation parameters. Landings are dominance of small pelagic (87%). *Sardina pilchardus* and *Sardinella aurita* represent respectively 58% and 22% of the total landings of small pelagic.

Data and parameters: Length structure, length-weight relationships, maturity and natural mortality estimates are available for sardina and sardinella.

Assessment method: Analytic assessment, using length cohort analysis (LCA) and pseudocohorts.

Model performance:

Results: The assessment of the stocks of these species, using the LCA in pseudocohort method, gives the mean biomass of *Sardina pilchardus* 149 716 tones where more than 80% is the parental stock biomass (SSB). For *Sardinella aurita*, the mean biomass is 36400 tones with 83.7% represent the SSB. The determination of the reference points shows that the two stocks are in an optimum exploitation rate.

Sardine
The results of the VPA in number and weight of sardines in the GSA 04 area show a stock mainly constituted of young individuals by reason of its average age (2 years) for a mean length of 14 cm. Also, the stock is characterized by a mean biomass of 149 716 tones more than 80% of which is the biomass of the parental stock (SSB).

Total Biomass balance (D): 151578 tones		
---	Biomass (T)	Percentage
Recruitment	56451	37.24
Growth	95127	62.76
Natural death	77876	51.38
Fishing	73702	48.62
Turnover : D/B(mean)		101.21

Sardine exploited-stock in GSA 04 area, is located in under-exploited phase if F_{actual} is compared with F_{limite} and in a phase of fully exploited if it is compared to $F_{0.1}$.

Sardinella aurita
The *Sardinella aurita's* stock in numbers and weight by size class is characterized by a mean length of 14.76 cm and an age of 2.1 years. The biomass of the parental stock reaches 30 475 tones representing thus 83.7% of the total mean biomass of 36400 tones.

Total Biomass balance (D): 35780 Tones		
---	Biomass (T)	Percentage
Recruitment	6713	18.76
Growth	29067	81.24
Natural death	18928	52.9
Fishing	16852	47.1
Turnover : D/B(mean)		98.3

The same state is observed for the exploited-stock of *Sardinella aurita* in the area of coast of Algeria. The situation shows a State of as if factual operation is compared with F_{limite} and in a phase fully exploited if it is compared to $F_{0.1}$.

Diagnose of Stock status: Research has shown for the case of sardines and sardinellas, representing respectively 58% and 22% of catches of small pelagic, a optimum exploitation state in relation to biological reference points ($F_{0.1}$, F_{MSY}). Also, the area covered by the national fishing fleet reached less than 1/3 of the range of small pelagic. Fully exploited for both sardine and sardinella species

Advice and recommendations:

- Impose a spatial control on fishing effort in spawning areas at spawning time, redirecting fishing effort to other areas.
- Combine data from surveys to those from the sampling of landings to complement the length structure;
- An analysis of the VPA structured by age for clarity;
- Integrate the environment parameters in the analysis of changes in biomass and to situate the amplitude of the fluctuations;

Discussion: The assessment of stocks by the indirect method (analytical models) was the only approach used so far. The first acoustic campaign took place in September-October 2011, thus reinforcing the means of investigation in the GSA04 area. This will allow establishing maps of distribution how to facilitate the orientation of the national fishing effort. The WG endorses the recommendations and support the continuation of the echo-surveys and the combination of fishery, survey and environmental data towards an integrated assessment of the status of the stock.

GSA 06 – Tramontana and Levantine coast

Sardine (*Sardina pilchardus*)

Author: Encarnación García

Fishery: Sardine (*Sardina pilchardus*) and Anchovy (*Engraulis encrasicolus*) are the main target species of the purse seine fleet operating in GSA 06, but other species with lower economical importance are also captured, sometimes representing a high percentage of the capture as horse mackerel (*Trachurus spp*.), mackerel (*Scomber spp*.) and gilt sardine (*Sardinella aurita*). Fishing is carried out 5 days a week and the time at sea is 12 hours per day. No fishing is allowed at weekend. The minimum landing size is 11 cm, although some landings are under minimum size in some specific ports. There are several technical measures regulations (gear and mesh size, engine, GTR, etc.) Temporary fishing closures (from 1st December to 31st January). From official data, the total purse seine fleet of the whole geographical sub-area 06 (Northern Spain) is made up by 130 units: 3% are smaller than 12 m in length, 83% between 12 and 24 m and 13% larger than 24 m. The fleet continuously decreased in the last decade, from more than 222 vessels in 1995 to 130 in 2010. This strong reduction is possibly linked to a continuous decline of small pelagic catches.

Data and parameters: Landings, length and biological samplings are obtained from Official Statistics, IEO Sampling Network and Acoustic Surveys.

Assessment method: VPA Lowestoft software suite and FLR was used and XSA was the assessment method.

Model performance: Several potential problems were suggested for the analytical assessment of sardine in this area. First, the age length key used is a combined age length key for a number of years, as data is scarce in some of the years. Also, little information for ages 4 and more is available in the catches or surveys, but the model use age classes up to 6+. The analytical model diagnosis show some year and age class effects that should be further investigated.

Results: Landings decrease in 2010, reaching up 7475 t, which represents the lowest landings of the assessed time series. Fishing mortality is at a moderate-high level (F10 = 1.14) lower to that of 2008 (2.55). Recruitment in 2010 (1268 millions) is higher to 2008 (746) the lower value of the time series, following the decreasing trend from 2003 onwards.The trend of the recruitments is as important as they can affect seriously to the stock health. Total Biomass (TB = 31689 t) is the lowest value of the time series and Spawning Stock Biomass (SSB = 16917 t) is the second lower value of the time series.

Stock status: This fishery is considered overexploited. Although the exploitation rate (fishing mortality) is at a moderate high level, the stock abundance in 2010 remains at low levels, though it has increased from 2008 to the lowest value of the entire series.
Advice and recommendation: Unless the recruitment levels increase in the near future, this fishery will be exploited above the level that is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse.

Discussion: It is important to point that the stock is in danger of recruitment overexploitation due to the decreasing trend in recruitment and very low levels of the spawning stock. The WG endorses the advice and recommendation given for this stock. The WG also recommend that a series of test are carried out for future assessment of the assessment robustness:

- The performance of the model using different assumptions have to be evaluated, using model diagnosis such as residuals, etc. For example, different weighting factors for age 1 and a reduced influence of ages 3 or 4+ in the models should be tested. A preliminary analysis of the effects of using a separated ALK (with some missing years) versus the combined ALK was performed this year; the WG recommends performing that analysis again when testing the selectivity assumptions discussed above, and also with different options to fill in missing years.
- Due to some of the residual trends in the model used and the problems in some of the age-length keys used, the WG also recommend to explore the possibility to use biomass models as an alternative to virtual population - like assessment models.

The WG also recommends including some of the suggested data and model diagnosis for analytical assessments included in Section 4.2.

Anchovy (*Engraulis encrasicolus*)

Author: Encarnación García

Fishery: Anchovy (*Engraulis encrasicolus*) and Sardine (*Sardina pilchardus*) are the main target species of the purse seine fleet operating in GSA 06, but other species with lower economical importance are also captured, sometimes representing a high percentage of the capture as horse mackerel (*Trachurus spp*.), mackerel (*Scomber spp*.) and gilt sardine (*Sardinella aurita*). Fishing is carried out 5 days a week and the time at sea is 12 hours per day. No fishing is allowed at weekend. The minimum landing size is 11 cm, although some landings are under minimum size in some specific ports. There are several technical measures regulations (gear and mesh size, engine, GTR, etc.) There is also a temporary fishing closure (from 1st December to 31st January). From official data, the total purse seine fleet of the whole geographical sub-area 06 (Northern Spain) is made up by 130 units: 3% are smaller than 12 m in length, 83% between 12 and 24 m and 13% larger than 24 m. The fleet continuously decreased in the last decade, from more than 222 vessels in 1995 to 130 in 2010. This strong reduction is possibly linked to a continuous decline of small pelagic catches.

Data and parameters: Landings, length and biological samplings were obtained from Official Statistics, IEO Sampling Network and dedicated Acoustic Surveys.

Assessment method: VPA Lowestoft software suite and FLR were used with XSA was the assessment method.

Model performance: Several potential problems, similar to the ones found for sardine, were suggested for the analytical assessment of anchovy in this area. First, the age length key used is a combined age length key for a number of years and obtained with data from a different area, as regular age readings for anchovy in GSA 06 are not available. Also, little information for ages 4 and more is available in the catches or surveys, but the model use age classes up to 6+. The time series used for the analysis is very short (2002-2010), as the authors do not have access to a complete record of catches previous to that date. The analytical model diagnosis show some year and age class effects that should be further investigated.

Results: Landings in 2010 were 8399 t, showing a slight decrease from 2009 (9814 t). The time series shows a soft increasing trend because this is the second high value from 2008 (the lowest one). There is no very much variability in the fishing mortality in the last few years so is is necessary to have a longer time series to compare. Recruitment in 2010 (R = 2013 millions) is similar to 2009 (2021 millions). The trend of the recruitments is as important as they can affect seriously to the stock health. Both Total Biomass (37039 t) and Spawning Stock Biomass (22980 t) in 2010 show a slight decrease.

Stock status: This fishery is considered as fully exploited with a low abundance compared with the extent of the area.

Advice and recommendation:

- A longer time series for landings or length distributions should be used.
- A specific ALK for the stock is necessary.
- An ecological analysis is suggested to validate the similarity of the nearest stock (GSA01) to use a common ALK for both areas.
- If production models can be applied, a simplified ALK could be used.

The assessment is based in estimated values of biomass from the survey and for fourteen years the biomass have been stable, with small fluctuations which do not seem to follow the same trend as the fishing mortality. A formal reference point is not available and the time series used in the assessment is short. However, when comparing with published data on biomass estimates for anchovy in GSA06, the biomass seem to be fairly stable, although at a low overall biomass level in relation to some high biomass estimates obtained early in the 90's. Following a precautionary approach, the final recommendation is not to increase current fishing mortality levels until a clear indication of a higher stable biomass that can sustain higher exploitation rates is observed.

Discussion: The WG endorses the advice and recommendation for this stock. The WG encourages improving the quality of data used for the analysis in terms of the length of the time series and the biological data used (age – length keys). An analysis of biological variability of the parameters between areas 01 and 06 will be desirable, as well as an analysis of robustness of the model to use common assumptions for those areas. In case a common ALK or any other common assumption is taken across these areas, the WG recommends that it is based on samples that cover both areas.

GSA 07 – Gulf of Lion

Sardine (*Sardina pilchardus*)

Author: Jean Louis Bigot

Fishery: In 2010, fishery effort on sardine was limited to an exploratory activity. Catches were characterized by low CPUE, small sardines mixed with a lot of small sprat. The landings had low commercial values. Two fleets are described, trawlers and purse seiners.
Trawl (12-24 m) Small gregarious pelagic

Average from 2005 to 2010: 6000 MT # **80%** of total landing. There are a total of 20 boats targeting sardine. Ratio Landing/Biomass: 0.12 %

YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Catch	7850	9650	10337	7036	6106	6825	7435	8301	11000	5740	2720	600
Fleet	(113)	(113)	(113)	56	50	50	50	50	50	30	15	10-3

During the 1st part of the year 2010, about 10 boats catch sardine. At the end of the year 2010 only 3 boats catch sardine

National regulations include:

- Exclusive licence for trawling, with *numerus closus* (both small pelagics and demersals) - fully observed
- Engine power limited for trawlers to 318 kW or 430 hp - not observed
- Length of fishing trawlers less 25 meters - fully observed
- Fishing effort limitation: no fishing saturday and sunday, autorised hours trip : 3.00am – 8.00pm - fully observed
- Trawling forbidden from coast until 3NM - not fully observed

Professional organisations regulations:

- Additionnal hollydays days : in average 40 days/year - fully observed

Purse Seiners (12-24 m) Small gregarious pelagic
Average from 2005 to 2010: 1400 MT # **20%** of total landing. 10 boats targeting sardine

YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Catch	2150	2530	1611	727	1005	668	2037	2083	2340	1000	900	93
Fleet						(16)	(18)	(19)	14 (16)	11 (23)	10 (23)	4 (23)

During the 1st part of the year 2010, about 10 boats catch sardine. At the end of the year 2010 only 3 boats catch sardine

Accompanying species:
Main accompanying species are:

- Sprat (*Sprattus sprattus*) **since 2008**
- European anchovy (*Engraulis encrasicolus*)
- Atlantic mackerel (*Scomber scombrus*)
- Chub mackerel (*Scomber japonicus*)
- Atlantic horse mackerel (*Trachurus trachurus*)
- Mediterranean horse mackerel (*Trachurus mediterraneus*)
- European hake (*Merluccius merluccius*)

Occasional accompanying species include:

- Round sardinella (*Sardinella aurita*)
- Seabreams (*Pagellus spp*.)
- Blue whiting (*Micromesistius poutassou*)

Data and parameters: Condition index, growth rate, and size at first maturity decrease sensitively and quickly these 3 last years. Very low and depleted biomass of adult (age 1+) wasn't in accordance with high recruitments levels observed in this stock since 2008, suggesting an important external spawning biomass contribution to GFL stock.

Assessment method: Direct: Acoustic Biomass estimates

Model performance: *Not provided, see discussion*

Results: The stock seems to be highly unbalanced in 2009, 2010 and 2011, with a very low abundance (less than 10% of the total biomass) of commercial-sized sardines (groups 1+). Even if total biomass was not very much lower than the average level of the last decade, most of the recorded biomass consisted of 0-group sardines, and even these showed a mean size and condition factor appreciably below the values usually found for this stock. Besides, for three years in a row, these recruits have almost completely disappeared from the stock, with very few survivors the following year. The system of the Gulf of Lyons show important signs of disequilibrium since 2008, with important changes in structure of the stocks of sardine and anchovy, and an unusually high abundance of sprat. This one began to appear in 2008, and his biomass have a very positive trend with 5, 8, 14, 25 000 MT from 2008 to 2011. The same patterns are found in the commercial activity. The fleet does not manage to capture any significant amounts of sardine, and the commercial activity has almost stopped since the end of 2009. All these signs indicate that the production capacity of the stock, and its potential to sustain an economic activity, is severely hampered, and it is essential to allow it to recover, by preventing the addition of additional sources of mortality to this already depleted population.

Diagnose of Stock status:

- Fully exploited
- No or low fishing
- Low abundance

The assessment provided here is entirely dependent on the assumption of Acoustic biomass providing unbiased estimates of the absolute level of biomass at sea.

Conclusion: Catches in the time series (smooth decreasing trend) are mainly independent from abundance trends (variable abundance shown). Also the fishery is currently no targeting sardine and there is a problem of mixing with sprat (decrease interest). The system is not controlled by human activity. However, even with relative high recruitments in recent years, there is an indication of a change (decrease) in growth rates. There is no certainly that the system is able to maintain current levels of biomass (carrying capacity), they may continue decreasing even if recruitment continues moderately high. Therefore, fishing effort cannot be increased (no surplus for the stock) until the system stabilise or show signals of recovery.

Advices and recommendations: Fishing effort cannot be increased until the system stabilise or show signals of recovery.

Discussion: The WG endorses the conclusions and recommendations made. The WG also suggest to analyse the lack of cohort signals in the catch and acoustic data with apparent “natality” in some year classes (e.g. instead of a mortality signal apparent in the decrease of abundance in a given year class from one year to the next one, an increase in abundance for that year class from one year to the next one), which may suggest some selectivity issues or migration of fish in and out of the area. Also, the increase in recent recruitments with a clear decrease in spawning stock biomass should be investigated. The WG also acknowledges that there is evidences on changes in the pelagic ecosystem of this area, and suggest that further ecological studies are conducted to clarify the ecosystem status. The WG also recommends that further research in non-local effort in this area is made to improve the historical perspective (i.e. landings and boats operating in the area but not reporting to GSA07).

Anchovy (*Engraulis encrasicolus*)

Author: Jean Louis Bigot

Fishery: Two fleets are described, trawlers and purse seiners.

Trawl (12-24 m) Small gregarious pelagic

- Average from 2005 to 2010: 2960 MT
- 20 boats targeting anchovy
- Ratio F/B: 0.12 %

YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Catch	5000	6000	4769	6941	7073	4497	2249	2605	4133	4003	2460	2307
Fleet	(113)	(113)	(113)	56	50	50	50	50	50	30	20	20

National regulations include:

- Exclusive licence for trawling, with numerus closus (both small pelagics and demersals) - fully observed
- Engine power limited for trawlers to 318 kW or 430 hp - not observed
- Length of fishing trawlers less 25 meters - fully observed
- Fishing effort limitation: no fishing Saturday and Sunday, authorized hours trip: 3.00am – 8.00pm - fully observed
- Trawling forbidden from coast until 3NM - not fully observed

Professional organisations regulations:

- Additional holydays: in average 40 days/year - fully observed

Accompanying *species*:
Main accompanying species are:

- Sprat (*Sprattus sprattus*) **since 2008**
- European pilchard (*Sardina pilchardus*)
- Atlantic mackerel (*Scomber scombrus*)
- Chub mackerel (*Scomber japonicus*)
- Atlantic horse mackerel (*Trachurus trachurus*)
- Mediterranean horse mackerel (*Trachurus mediterraneus*)
- European hake (*Merluccius merluccius*)

Occasional accompanying species include:

- Round sardinella (*Sardinella aurita*)
- Seabreams (*Pagellus* spp.)
- Blue whiting (*Micromesistius poutassou*)

Data and parameters:

Assessment method: Direct: Acoustic Biomass estimates

Model performance: *Not provided, see discussion*

Results: The stock seems to be highly unbalanced in 2009, 2010 and 2011, with a very low abundance of commercial-sized anchovy (groups 2+). Even if total biomass was not very much lower than the average level of the last six years (20, 25000 MT), most of the recorded biomass consisted of 1-group anchovy, and even these showed a mean size and condition factors appreciably below the values usually found for this stock. However, in comparison with sardine, the biomass trend in recent years seems to be stable, with a small increasing trend. The system of the Gulf of Lyons show important signs of disequilibrium since 2008, with important changes in structure of the stocks of sardine and anchovy, and an unusually high abundance of sprat. This one began to appear in 2008, and his biomass have a very positive trend with 5, 8, 14, 25 000 MT from 2008 to 2011.

Diagnose of Stock status:

- Fully exploited
- Moderate fishing
- Low abundance

Advices and recommendations: Not to increase fishing effort

Discussion: The WG endorses the diagnose and recommendation for this stock. The WG also acknowledges that there is evidences on changes in the pelagic ecosystem of this area, and suggest that further ecological studies are conducted to clarify the ecosystem status. The WG also recommends that further research in non-local effort in this area is made to improve the historical perspective (i.e. landings and boats operating in the area but not reporting to GSA07).

Combined GSAs 12-13-14 - Tunisian coast

Author: Ben Abdallah Lotfi

Fishery: Small pelagic species are an important resource in Tunisia. Indeed, they represent 50% of the total landings and the fisheries targeting these species accounts for more than 6500 direct jobs. Due to this economic and social importance and biological characteristics of species, including their movements and their short lives, and in order to ensure regular monitoring of the resource, INSTM organizes, regularly since 1998, acoustic surveys and experimental fishing in a well-defined protocol. Related to the morphology of the Tunisian coasts we distinguished five sectors: North sector, Sector of Gulf of Tunis, Sector of Gulf of Hammamet, Sector of Sahel (from Sousse to Sfax) and South sector: Gulf of Gabes.

Data and parameters: Since 1998, we regularly carry out acoustic survey for the biomass evaluation of small pelagic species of commercial interest. For each sector of the area, a sampling design was adapted to be perpendicular to the bathymetry and the shoreline. Transects start at the depth of 20 m and end at 200 m depth. The total distance on transects for each survey is almost 1600 Nmi that needed forty five sea-days working in summer period as prospecting and biological sampling are done only at day time. The prospecting is done with the echosounder Simrad EK 500 within the frequency 38 kHz while the speed of the vessel is around 9 Knots. The biological sampling is done with a midwater trawl (4FF) within 7 m vertical opening. The protocol respected in our survey, compared to that of EU MEDIAS (CE 665/2008) revealed some gaps specially related to the distribution of NASC by species. This gap will be filled as soon as the survey of 2011, thanks to PESMA software we got from IEO Palma de Mallorca (Spain).

Assessment method: Biomass is evaluated by direct methods (acoustic surveys). Catches or exploitation rates are not estimated, analytical assessment therefore not available.

Model performance: Some methodological issues exist in relation with the acoustic estimates. Methodology is being fully standardised against MEDIAS criteria. Standardisation is expected to be completed by the 2011 survey.

Results: The available data show fluctuations, which appear to be cyclical. Sardine and horse mackerel are the most abundant species (70%). For the period 1998-2009 we note that the total Exploitable Potential (EP) fluctuate between 80 Ktn and 140 Ktn and the mean value is 110 Ktn. For **GSA 12**, the Exploitable Potential (EP) for sardine and anchovy are varying in cyclic but opposite way. A decrease in anchovy abundance the last years is also attributed to a parasite (*Peroderma cylindricum*) infecting

the medium size (mature) individuals. The parasite consume all the fat of the animals and do not allow them to reproduce..

Stock status: Not available

Advices and recommendations: Not available

Discussion: The WG recommends that a full time series of acoustic estimates for the areas 12, 13, and 14 is used to assess the variability of sardine and anchovy biomass in the area. Also, the WG recommends that some estimate of landings for these species be obtained, in order to be able to obtain an estimate of exploitation rates and provide an advice on this area.

GSA 16 - South Sicilian coast

Sardine (*Sardina pilchardus*)

Authors: Patti B., Quinci E.M., Bonanno A., Basilone G., Mazzola S.

Fishery: In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port (accounting for about 2/3 of total landings): purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. In both OUs, anchovy represents the main target species due to the higher market price. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped. Average sardine landings in Sciacca port over the period 1998-2010 were about 1,400 metric tons, with a general decreasing trend. The production dramatically decreased in 2010 (-70%). Fishing effort remained quite stable over the last decade. Sardine biomass, estimated by acoustic methods, ranged from a minimum of 6,000 tons in 2002 to a maximum of 39,000 tons in 2005. Current acoustic biomass is at intermediate level.

Data and parameters: Landings data for GSA16 were obtained from DCF for the years 2006-2010 and from census information (on deck interviews) in Sciacca port (1998-2010). Acoustic data were used for fish biomass evaluations over the period 1998-2010. Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2008. Natural mortality was estimated following Pauly (1980) and by the Beverton & Holt's Invariants (BHI) method (Jensen, 1996). For the BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and $k = 0.40$. The input data used for the stock was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2010. Available data were used to estimate yearly and average (2007-2010) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey), and as input for the fitting of a non-equilibrium surplus production model. The scientific surveys, mainly carried during early summer of each year, were considered to represent the stock abundance the same year including part of the recruitment. In addition, an enviromental index, the satellite-based estimate of yearly average chlorophyll-a concentration over the continental shelf off the southern sicilian coast, was used in the attempt of improving the performance of the model fitting.

Assessment method:
Two separate approaches were adopted:

- An empirical approach bassed on estimation of yearly and average (2007-2010) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey);
- A modelling approach based on thefitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indeces, allowing for the optional incorporation of environmental indices, so that the *r* and/or *K* parameters of each year can be considered to depend on the corresponding value of the applied index.

The modellig approach uses four basic parameters: Carring capacity (or Virgin Biomass) K, population intrinsic growth rate r, initial depletion BI/K (starting biomass relative to K) and catchability q (fixed). Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the overall MSY, B_{MSY} and F_{MSY} reference points. Derived reference points were also evaluated: B_{Cur}/B_{MSY}, indicating whether the estimated stock biomass, in any given year, is above or below the biomass producing the MSY, and F_{Cur}/FSY_{Cur} (the ratio between the fishing effort in the last year of the data series and the effort that would have produced the sustainable yield at the biomass levels estimated in the same year), indicating whether the estimated fishing mortality, in any given year, is above or below the fishing mortality producing the sustainable (in relation to natural production) yield in that year.

Model performance: Quite poor (R^2 = 0.35) without incorporating the environmental effects, quite good (R^2 = 0.76) when adopting in the model formulation a variable carrying capacity, considered to be positively affected by chlorophyll-a concentration at sea.

Results: The first approach for the evaluation of stock status is based on the analysis of the harvest rates experienced in the available time series over the last years and on the related estimate of the current exploitation rate. Annual harvest rates, as estimated by the ratio between total landings and stock sizes, indicated relatively low fishing mortality during the last decade. Actually, as long as this estimate of harvest rate can be considered as a proxy of F obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can also be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given. Sardine biomass estimates are based on acoustic surveys carried out during the summer and, as in general they would include the effect of the annual recruitment of the population, they are possibly higher than the average annual stock sizes. This in turn could determine in an underestimation of the harvest rates and of the corresponding exploitation rates. The current (year 2010) harvest rate is unusually low (0.04) compared to the estimated average value over the years 2007-2010 (0.15). The very low harvest rate for 2010, due to the combination of increased biomass and decreased production, appears to be the result of a change in the fishing pattern in favour of anchovy, as the fishing effort remained relatively stable. The exploitation rate corresponding to F=0.15 is E=0.16, if M=0.77, estimated with Pauly (1980) empirical equation, is assumed, and E=0.17 if M=0.72, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. In relation to the above considerations on the possible overestimation of mean stock size in harvest rate calculation, it is worth noting that, even if the harvest rates were twice the estimated values, the exploitation rates would continue to be lower than the reference point (0.4) suggested by Patterson (1992). Thus, using the exploitation rate as a target reference point, the stock of sardine in GSA 16 would be considered as being sustainably exploited. The results of the second assessment approach, which is based on the implementation of a non-equilibrium logistic surplus production model, are consistent with the previous considerations. The fluctuations in stock biomass cannot be explained solely by the observed fishing pattern. This was an expected result, as pelagic stocks are known to be significantly affected by environmental variability. The incorporation of an environmental index in the model, significantly improved the fitting of the model, allowing the stock to grow more or less than average depending on the state of the environment in each year. In the current adopted formulation of the model, satellite-based data on chlorophyll concentration showed to have a positive effect on the yearly carrying capacity. Though current (year 2010) fishing mortality is far below the sustainable fishing mortality at current biomass levels (F_{Cur}/FSY_{Cur}=0.14; F_{MSY}=0.17; F_{Cur}/F_{MSY}=0.22), fishing mortality experienced high values during the considered period, sometimes above sustainability (F_{Cur}/FSY_{Cur}>1). In addition B/B_{MSY} values were low over last decade (B_{MSY} = 32476; B_{Cur}/B_{MSY} = 0.48). However, current biomass estimate (about 14700 tons) is somewhat above a precautionary level (Blim), fixed as the 40% of B_{MSY}, and the average production of the last three years (1494 tons) is well below the estimated MSY (5430 tons).

Diagnose of Stock status: Results of the adopted modelling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels (mostly due to

recruitment success) and indicate that the stock status was well below the B_{MSY} during the considered period, although the current biomass estimate is above a tentative precautionary Blim fixed as the 40% of B_{MSY}. However, the stock in 2010 only partially recovered from the high decrease in biomass occurred in 2006 (-52% from July 2005 to June 2006), and this fact, along with the general decreasing trend in landings over the last decade, also suggests questioning about the sustainability of current levels of fishing effort. In relation to the fishing mortality levels, the stock can be considered as fully exploited. Exploitation rate (ratio between total landings and biomass estimates): moderate fishing mortality. Stock abundance (acoustic biomass estimate): low abundance.

Advices and recommendations: Given that the stock biomass over the last years appears to be in a stable low abundance phase and considering the fishing mortality pattern observed throughout the time series, fishing effort should not be allowed to increase and consistent catches should be determined. However, as the small pelagic fishery is generally multispecies, any management of fishing effort targeting the sardine stock would also have effects on anchovy. Local small pelagic fishery appears to be able to adapt at resource availability and market constraints, targeting the fishing effort mainly on anchovy. But due to the generally low biomass levels experienced by the anchovy stock over the last years (see related assessment), measures should be taken to prevent a possible further shift of effort back from anchovy to sardine.

Discussion: The WG endorses the advice and recommendation given for this stock. No specific limit or precautionary reference point have been yet adopted for small pelagic fish species in the framework of GFCM. However, the present assessment, based on the analysis of the abundance and fishing mortality levels observed in the available time series, implied the tentative precautionary evaluation of sustainable levels for current exploitation rates and for current biomass, also taking into the relative low (even stable) abundance phase together with a signal of increasing in the last year of the series. The WG also recommend trying to estimate a B-Lim reference point, as it will facilitate taking advise in relation to the current stock status. The use of this global (in contrast with age or length based methods) method is suitable for small pelagic fish, due to their short life and low number of predominant age-classes. However, this kind of methods have not been previously used for the assessment of Mediterranean small pelagic stocks, neither have them being used to assess much other small pelagic stocks worldwide (but see Ibaibarriaga et al., 2008 for a successful application to Bay of Biscay anchovy). The inclusion of the environmental factor improves the fitting of the production model. Especially for sardine, for which the acoustic survey is carried out in summer, including also most of recruits, the Chl-a concentrations have been proved to be linked to the success of recruitment.

Anchovy (*Engraulis encrasicolus*)

Authors: Patti B., Quinci E.M., Bonanno A., Basilone G., Mazzola S.

Fishery: In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port (accounting for about 2/3 of total landings): purse seiners (lampara vessels, locally known as “Ciancioli”) and midwaters pair trawlers (“Volanti a coppia”). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. In both OUs, anchovy represents the main target species due to the higher market price. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped. Average anchovy landings over the period 1998-2010 were about 1,900 metric tons, with large interannual fluctuations. Fishing effort remained quite stable over the last decade. Anchovy biomass, estimated by acoustic methods, ranged from a minimum of 3,100 tons in 2008 to a maximum of 23,000 tons in 2001. Current acoustic biomass estimate is above the average (15,880 vs. 11,550).

Data and parameters: Landings data for GSA16 were obtained from DCF for the years 2006-2010 and from census information (on deck interviews) in Sciacca port (1998-2010). Acoustic data were used for fish biomass evaluations over the period 1998-2010. Von-Bertalanffy growth parameters, necessary for

the calculation of natural mortality, were estimated by FISAT with DCF data collected in GSA16 over the period 2007-2009. Natural mortality was estimated following Pauly (1980) and by the Beverton & Holt's Invariants (BHI) method (Jensen, 1996). For the BHI method, the equation $M = \beta * k$ was applied, with β set to 1.8 and $k = 0.31$. The input data used for the stock was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2010. Available data were used to estimate yearly and average (2007-2010) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey), and as input for the fitting of a non-equilibrium surplus production model. The scientific surveys, mainly carried during early summer of each year, were considered to represent the stock abundance the same year. In addition an enviromental index, the satellite based estimate of yearly average chlorophyll-a concentration over the continental shelf off the southern sicilian coast, was used in the attempt of improving the performance of the model fitting.

Assessment method:
Two separate approaches were adopted:

- An empirical approach bassed on estimation of yearly and average (2007-2010) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey);
- A modelling approach based on thefitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indeces, allowing for the optional incorporation of environmental indices, so that the *r* and/or *K* parameters of each year can be considered to depend on the corresponding value of the applied index.

The modellig approach uses four basic parameters: Carring capacity (or Virgin Biomass) K, population intrinsic growth rate r, initial depletion BI/K (starting biomass relative to K) and catchability q (fixed). Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the overall MSY, B_{MSY} and F_{MSY} reference points. Derived reference points were also evaluated: B_{Cur}/B_{MSY}, indicating whether the estimated stock biomass, in any given year, is above or below the biomass producing the MSY, and F_{Cur}/FSY_{Cur} (the ratio between the fishing effort in the last year of the data series and the effort that would have produced the sustainable yield at the biomass levels estimated in the same year), indicating whether the estimated fishing mortality, in any given year, is above or below the fishing mortality producing the sustainable (in relation to natural production) yield in that year.

Model performance: Very poor ($R^2 = 0.04$) without incorporating the environmental effects, significantly higher ($R^2 = 0.48$) when adopting in the model formulation a variable population intrinsic growth rate *r*, considered to be positively affected by chlorophyll-a concentration at sea.

Results: The first approach used herewith for the evaluation of stock status is based on the analysis of the harvest rates experienced in the available time series over the last years and on the related estimate of the current exploitation rate. The high and increasing yearly harvest rates, as estimated by the ratio between total landings and stock sizes, indicate high fishing mortality levels. Actually, as long as this estimate of harvest rate can be considered as a proxy of F estimate obtained from the fitting of standard stock assessment models (assuming survey biomass estimate as a proxy of mean stock size), this index can be used to assess the corresponding exploitation rate E=F/Z, provided that an estimate of natural mortality is given. The current (2010) harvest rate is 0.28, whereas the estimated average value over the years 2007-2010 is 0.67. The exploitation rate corresponding to F=0.67 is E=0.50, if M=0.66, estimated with Pauly (1980) empirical equation, is assumed, and E=0.54 if M=0.56, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. Using the exploitation rate as a reference point, this stock should be considered as being overexploited. The results of the second assessment approach, based on the implementation of a logistic surplus production model, are consistent with the previous considerations. The fluctuations in stock biomass cannot be explained solely by the observed fishing pattern. This was an expected result, as pelagic stocks are known to be significantly affected by environmental variability. The incorporation of an environmental index in the model significantly improved the fitting of the model. In the current adopted formulation, satellite-based data on chlorophyll concentration showed to have a positive effect on the yearly population intrinsic growth rate. Current

(year 2010) fishing mortality is far above the sustainable fishing mortality at current biomass levels (F_{Cur}/FSY_{Cur}=1.53; F_{MSY}=0.13; F_{Cur}/F_{MSY}=1.76). Fishing mortality experienced very high values during the considered period; frequently well above sustainability (F_{Cur}/FSY_{Cur}>1). In addition, B_i/B_{MSY} values were below 100% over the entire time series (B_{MSY} = 17584 tons; B_{Cur}/B_{MSY} = 0.85), and estimated average production of the last three years (4455 tons) is well above the MSY (2198 tons). However, current biomass (about 16000 tons) is more than double compared to a tentative precautionary a tentative B_{lim}, fixed as the 40% of B_{MSY}.

Diagnose of Stock status: Results of the adopted modelling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels (mostly based on recruitment success) and indicate that the stock status was below the B_{MSY} during the considered period, although the current biomass estimate is well above a tentative precautionary B_{lim} fixed as the 40% of B_{MSY}. Though in 2010 the stock biomass increased significantly from the low biomass levels experienced during the period 2006-2009, fishing levels over the last years are higher then those required for extracting the MSY of the resource. In relation to the fishing mortality levels, the stock can be considered as overexploited. Exploitation rate (ratio between total landings and biomass estimates): high fishing mortality. Stock abundance (acoustic biomass estimate): intermediate abundance.

Advices and recommendations: Given that the stock is currently overexploited, fishing effort should be_reduced by means of a multi-annual management plan until there is evidence for stock recovery. Consistent catch reductions along with effort reductions should be determined. However, the mixed fisheries effects, mainly the interaction with sardine, need to be taken into account when managing the anchovy fishery. As the small pelagic fishery is generally multispecies, any management of fishing effort targeting the anchovy stock would also have effects on sardine. Local small pelagic fishery appears to be able to adapt at resource availability and market constraints, targeting the fishing effort mainly on anchovy. But due to the low biomass levels experienced by the anchovy stock over the last years, measures should be taken to prevent a possible further shift of effort back from anchovy to sardine.

Discussion: The WG endorses the advice and recommendation given for this stock. No specific limit or precautionary reference point have been yet endorsed for small pelagic fish species in the framework of GFCM. However, the present assessment, based on the analysis of the abundance and fishing mortality levels observed in the available time series, implied the tentative precautionary evaluation of sustainable levels for current exploitation rates and for current biomass, also taking into the contrasting perspective between the model output, showing a relative stable trend, and the raw data.

Combined GSAs 17 and 18 – Adriatic Sea

The Adriatic Sea is a semi-enclosed basin, which encompasses two different GSA areas, 17 and 18. Notwithstanding this administrative separation, both the north and the south regions show various connectivity features, and small pelagic fish stocks in the Adriatic are considered as shared stocks. Fish stock assessment work within the Adriatic is coordinated within the FAO project ADRIAMED.

Until now, all the involved countries in the Adriatic have performed a joined assessment for each GSA separately, however, this year, a joined assessment of the small pelagic stocks distributed in both GSAs was attempted. Also, some results of the recently finished EU project SARDONE on the impact of a sardine juvenile – *fry* - fishery ("Bianchetto") in the Adriatic sardine stock were presented.

As stated before, this WG encourages both joint assessment and also combined assessment of stocks shared between GSA areas. The WG therefore congratulates ADRIAMED and the institutes involved for their advances in coordination and combination of data required for the understanding of the dynamics of small pelagic fish stocks in the area.

In this section, first a summary of the combined areas assessment exercise is presented, together with the main results found in the analysis of the *Bianchetto* fisheries and a summary of the discussion that

took place in the group. Then, the formal assessment of sardine and anchovy in each GSA area is also presented.

Acoustic assessment of small pelagic stocks in the whole Adriatic.

Authors: I. Leonori, V. Ticina and A. De Felice

An acoustic assessment for 2010 was carried out for GSA 17 and 18 together and presented to the working group. However, due to logistic reasons (ship availability and very long survey duration) and historical series continuity, acoustic surveys are conducted in July for GSA 18 and September for GSA 17. The study area was covered following systematic parallel grids perpendicular to coastline / bathymetry covering all the continental shelf of the Adriatic Sea. Inter transect distance was 10 nm, slightly lower (8 nm) only in areas where the continental shelf or the political boundaries allow short ranged transects or in case of relatively new study areas (Montenegro and Albania). The acoustic survey was performed 24 hours a day stopping only in case of bad weather conditions. The research vessels used were "G. Dallaporta" and BIOS DVA, with the same methodology in terms of acquisition of acoustic data. Hydrographic and plankton stations were also performed in both the east and the west part of the Adriatic. Results obtained indicate that dominant species in the Adriatic Sea during 2010 was anchovy with estimated biomass of approx. 709,439t; estimated biomass of sardine was approx. 329,053t. Anchovy and sardine biomass spatial distributions were very heterogeneous in all parts of the Adriatic Sea, with a variable relative importance of sardine and anchovy across the East and West parts of northern Adriatic, as well as between the North and South Adriatic. Standardization in acoustic data collection among Croatian and Italian research vessels enable comparable estimates of fish distribution and abundance. However, further efforts are still needed in standardization of auxiliary equipment (i.e. multifrequency echosounder, net sondes) and results presentation (GIS software used to prepare maps and graphs).

In terms of combined analytic assessment of sardine and anchovy in the whole Adriatic Sea, some work has still to be done. First of all, the catch data available from the GSA 18 are not realistic: a great number of boats licensed in the GSA 18 fish actually in the GSA 17, and there is a completely lack of data for some ports. Besides that, there are great differences in the fleets between the countries involved.

New models (i.e. biomass model and AMCI, an assessment model combining information from various sources) should be implemented to take into account differences in fleet and in regional management procedures. In particular, biomass models can be explored to have a first general assessment.

Discussion: In relation to this presentation and others attempts to have a common assessment on stocks that show a clear spatial heterogeneity and also spatial heterogeneity on the fleets, a discussion took place on what will be the requirements for an assessment model to be applied on those circumstances. Some flexibility to treat different spatial units would be desirable in the assessment model used, to accommodate spatial variability in fleets and biological characteristics of the stock, but also to allow for some regional management of a shared stock (See Recommendations section)

Impact of fry fishery for sardine in Adriatic, results of the project SARDONE

Authors: Elisabetta Betulla Morello, Andres Uriarte, Leire Ibaibarriaga, Alberto Santojanni, Piera Carpi and Enrico Arneri

In the ambit of the SARDONE project (FP6 – 44294-Improving assessment and management of small pelagic species in the Mediterranean), a study of Mediterranean fry fisheries was conducted with the aim of assembling and summarizing all available data on these fisheries; the ultimate scope being that of testing various population dynamics tools with respect to their capability of assessing the impact of fry fisheries on the dynamics of the stocks. According to Council Regulation (EC) No 1967/2006 the application of a minimum landing size to marine organisms fished commercially does not apply to fries

of sardine landed for human consumption if caught by boat seines or shore seines and authorised in accordance with a management plan, and provided that the stock of sardine concerned is within safe biological limits. The main fry fishery in the Adriatic sea is located in the Gulf of Manfredonia, and a vast amount of information on this fishery was collected and used, in particular: 1) Commercial data from the Manfredonia fish market; 2) Length – frequency distributions and growth data from the SARDONE project; and 3) Abundance of Age 1 estimates from Laurec Shepherd tuned VPA from adult stock assessment. As estimates of natural mortality of larvae and juveniles are of crucial importance in the results, four possible models were chosen: (i) Pepin (1991): based on growth rate and length, (ii) Jung et al. (2008) based on length, (iii) McGurk (1986) based on weight: two functions were predicted by McGurk (1987), one for juveniles and one for eggs and larvae and both were tested in these trials, and (iv) an empirical Pareto function modified to take into account known (from literature) values of initial and final (Age 1, in this case) natural mortality estimates. Different bianchetto catch scenarios (official catches and official catches multiplied by 5 as well as different stock size scenarios were tested along with the different natural mortality functions. Results showed that the bianchetto fishery in the Gulf of Manfredonia impacts the overall adult stocks to variable extents depending, mainly on the natural mortality function used. The use of the most plausible one (Pepin, 1991) indicated impact levels on the adult stock ranging between 0.3 and 3.7%. But assuming other mortality models the impact could be as high as 13% or, rather unrealistically, up to 40%.

Given a reasonable set of assumptions on larval mortalities, and given a decent stock assessment providing an estimate of year one sardines (the first caught by the adult fishery), it could be possible to tune the fry fishery controlling catches and/or effort (i.e. fishing mortality of larvae) in order to maintain the impact of this fishery within "safe" limits. In order to do this an assessment of the adults is needed and the possibility of controlling larval fishing mortality (i.e. a yearly quota) must be foreseen as mandatory.

Discussion: The WG welcomes this kind of work and congratulate the authors for the thoughtful analysis of such a complex issue. The WG also acknowledges the difficulty on obtaining precise estimates of the potential impact of these activities. The WG recognises that indication of impact from 1 to 13% are not very helpful under a management point of view, because they range in practice from null effect to heavy impact. Some indication was done to check the natural mortality values assumed for the first part of life (eggs), as they could be lower than what is currently estimated in literature. In terms of numbers, the low weight of sardine late larvae means that the numbers being taken from the stock do not look negligible (approximately 10,000 individuals in 1 kg). However, the group also recognized that currently it is difficult to set up a limit for what is a realistic maximum mortality that this kind of fishery imposes. There is also a necessity to evaluate the extent of other nursery areas for sardine in the Adriatic. Some simulations of the potential effect of various scenarios regarding fishing of sardine late larvae/juvenile in the stock will be desirable. This group will like to see a continuation of this work, and we foresee several potential scientific lines that will be of interest for assessment; to incorporate this knowledge together with hydrodynamic and connectivity models, and to devise simple simulation models that can incorporate the effect of a variety of larvae mortality estimates into biomass. Also, the Group concludes that information on catches (not restricted only to official landings) from these kind of fisheries, along the Adriatic Sea, have to be monitored, and if possible included in assessment.

GSA 17 – North Adriatic

Sardine (*Sardina pilchardus*)

Authors: Santojanni A., Leonori I., Carpi P., De Felice A., Angelini S., Belardinelli A., Biagiotti I., Canduci G., Cikes Kec V., Cingolani N., Colella S., Donato F., Marceta B., Modic T., Panfili M., Pengal P., Ticina V., Zorica B.

Fishery: Sardines are fished by purse seiners (attracting fish by light) and pelagic trawlers belonging to Italy, Croatia and Slovenia. The fishery takes place all year round: a closure period is observed from the Italian pelagic trawlers on August, while from 15th December to 15th January in Croatia. Exploitation is based on all the age classes from 0 to 6+. The Croatian catches of sardine represent the great part of the total catches, while the Italian small pelagic fishery concentrate mainly on anchovy (though high amounts of sardine were also caught by the Italian fleet in the past). The Italian fleet is composed of about 65 pairs of mid-water trawlers and about 45 purse seiners (with quite different tonnage), with the former being predominant on the latter ones. In Croatia, small pelagic (mainly sardine) are fished by purse seiners. On the other hand, in Slovenia, mid-water trawlers gradually caused the disappearance of purse seiners since 1991.

Data and parameters: The data used for the present assessment derive from the catch recorded for the fleets of Italy, Croatia and Slovenia, from 1975 to 2010. The biological data of the species (available since 1975 for the western and from the 2001 for the eastern side) were used to obtain the age distribution in the catches. Echo-survey abundance index was used to tune the models. The echo-surveys were carried out for both the western and eastern sides from 2004 onwards. Western echo-survey abundances were split into age classes by the means of length frequency distribution coming from the western echo-survey and age-length key coming from the Italian commercial fleet. On the other hand, eastern echo-survey abundance was distributed into age classes by the means of length frequencies and age-length key coming from the Croatian commercial fleet. Calendar year was used, by fixing the birthday date on the first of January, according to the biology of this species in the Adriatic Sea. The natural mortality rate M was taken as variable over age and was calculated using the Gislason's equation. The growth parameters required by this method were derived from the biological sampling of the Croatian catches.

Assessment method: Virtual Population Analysis (VPA) with Laurec-Shepherd tuning and preliminary Integrated Catch Analysis (ICA).

Model performance: The VPA assumption of constant catchability at age over time was respected. Shrinkage for F was applied in the VPA, to smooth an unreliable increase in the F value. The age class 0 was not included into the analysis since the value of M = 2.51 obtained for this age class would have implied too high and thus not conservative estimates of abundance at sea; also, the age class 0 is not substantial in the total catch at age.

Results: The trend in biomass of sardine obtained by both VPA and ICA method fluctuated over the time interval examined, with a high peak in the middle of the 1980s. From the mentioned peak onwards biomass of sardine continuously decreased due to a drop in the recruitment, which most likely was caused by environmental influence. A slow but continuous recovery has started since 2000. This trend is also reflected in the biomass estimated by the echo-survey from both the west and east part of the Adriatic. The fishing mortality shows a peak for the oldest ages in 2009 (unweighted mean F for age 1 to 5 = 1) in both models: a possible explanation is the increase in the catch of all the ages respect to age 1. This effect is smoothed in the ICA model. Despite this value, since 2004 the F remains below 0.5, increasing to 0.6 only in 2010. The recent exploitation rate F/Z is slightly under the Patterson's threshold 0.4. However, the picture of F/Z over years is too "negative" due to the effects of some high estimates of F in the oldest age 3 and 4; this is evident if the corresponding F/Zs weighted on abundance at sea are taken into account. Besides that, the ratio between total catch and stock biomass remain stable at low level (0.2).

Diagnose of Stock status: The present status of the stock up to 2010 can be considered as fully exploited.

Advices and recommendations: Since this stock can display large fluctuations associated with analogous fluctuations in recruitment, the advice is not to increase the fishing effort. Nevertheless, since numerous studies have shown that the dynamics of anchovy and sardine populations are strongly influenced by success in the recruitment, which is, on the other hand, strongly influenced by environmental conditions, the working group suggests continuing to explore the relationships between these species and the environment.

Discussion: The WG endorses the conclusion and recommendations for this stock. The biomass estimated by the echosurvey has approximately the same level of the VPA results, without including age 0 in the VPA calculation; therefore there are some differences in absolute levels between the VPA and the acoustic echo-surveys. The working group is awarded that this trend should be investigated: some attempts to include age 0, for example down-weighting their influence in the model, are recommended. Besides that, the working group will like to see an evaluation of the use of some more flexible models that allow including spatial information both in the inputs and in the outputs. Clearly sardine is suffering from a lower fishing mortality with the respect to anchovy and the trend is increasing. Nevertheless the level is still much lower than the highest biomass estimated for the 70s and 80s: the working group agreed that there is no room for an increasing in F. However, it should be taken into account that the higher biomass in the time series could be overestimated even if this high biomass have been observed also by the western acoustic estimates: further study will be carried out to address this issue. It should be noted that Adriatic small pelagic fishery is multispecies and effort on sardine stock cannot be separated from effort on stock of anchovy. Hence, management decisions have to be taken considering both species. The approach used in this assessment was to maintain the independence of the dataset during the preparation of the input data in order to reduce the statistical dependence (Cotter et al., 2004): the working group tried, whenever possible, to treat echo-survey data as more independent as possible from the commercial data. WG recognised that spatial distribution of shared stock of sardine is not limited to GSA17 area only, but it is extended in GSA18 area also. Therefore, the WG suggest that future assessments take into account combined data from these two GSAs. Moreover, an important nursery area of this stock is located in Gulf of Manfredonia (GSA18) where the sardine stock is exploited by fry fishery.

Anchovy (*Engraulis encrasicolus*)

Authors: Santojanni A., Leonori I., Carpi P., De Felice A., Angelini S., Belardinelli A., Biagiotti I., Canduci G., Cikes Kec V., Cingolani N., Colella S., Donato F., Marceta B., Modic T., Panfili M., Pengal P., Ticina V., Zorica B.

Fishery: Anchovies are fished by purse seiners (attracting fish by light) and pelagic trawlers belonging to Italy, Croatia and Slovenia. The fishery takes place all year round: a closure period is observed from the Italian pelagic trawlers on August, while from 15th December to 15th January in Croatia. Exploitation is based on all the age classes from 0 to 4+. The Italian catches of anchovy represent the great part of the total catches, while the Croatian small pelagic fishery concentrate mainly on sardine. The Italian fleet is composed of about 65 pairs of mid-water trawlers and about 45 purse seiners (with quite different tonnage), with the former being predominant on the latter ones. In Croatia, small pelagic (mainly sardine) are fished by purse seiners. On the other hand, in Slovenia, mid-water trawlers gradually caused the disappearance of purse seiners since 1991.

Data and parameters: The data used for the present assessment derive from the catch recorded for the fleets of Italy, Croatia and Slovenia, from 1975 to 2010. The biological data of the species (available since 1975 for the western and from the 2001 for the eastern side) were used to obtain the age distribution in the catches. Echo-survey abundance index was used to tune the models. The echo-surveys were carried out for both the western and eastern sides from 2004 onwards. Western echo-survey abundances were split into age classes by the means of length frequency distribution coming from the western echo-survey and age-length key coming from the Italian commercial fleet. On the

other hand, eastern echo-survey abundance was distributed into age classes by the means of length frequencies distribution coming from the 2009-2010 eastern echo-surveys and age-length key coming from the Croatian commercial fleet. Split year was used, by fixing the birthday date on the first of June, according to the biology of this species in the Adriatic Sea. The natural mortality rate M was taken as variable over age and was calculated using the Gislason's equation. The growth parameters required by this method were derived from the biological sampling of the Italian catches.

Assessment method: Virtual Population Analysis (VPA) with Laurec-Shepherd tuning and preliminary Integrated Catch Analysis (ICA).

Model performance: The VPA assumption of constant catchability at age over time was respected. In ICA age 0, 3 and 4+ were down-weighted because poor representation in the catch data.

Results: The trend in biomass resulted from the performed VPA and ICA put in evidence the collapse that took place in the 1987 with consequent crisis of the Italian fishery. Another decrease occurred from 1999 up to 2001 and is clear from both models even if there is no evidence of this collapse from the echo-survey estimates and from the recorded catches. After the true collapse in 1987, the biomass shows a slow but constant recovery, increasing to 200.000 tonnes in 2005. Since then, the stock is experiencing a slight decrease reaching around 150.000 tonnes in 2010. The fishing mortality shows strong fluctuations since the 2000 in both the models. In 2009 the F raises sharply to the value of 1.8 for age 2 and 3, probably an overestimation of the backward calculation; this peak is not so evident in the F at age resulting from the ICA, which fits statistically the data to the tuning index. Despite this high value, since 2004 the F remains below 0.5, increasing to 0.6 only in 2010. The recent exploitation rate F/Z is slightly above the Patterson's threshold 0.4. However, the picture of F/Z over years is too "negative" due to the effects of the above-mentioned high estimate of F in the age 2 and 3; this is evident if the corresponding F/Zs weighted on abundance at sea are taken into account. Besides that, the ratio between total catch and stock biomass remain stable at relatively low level (0.3).

Diagnose of Stock status: The present status of the stock up to 2010 can be considered as fully exploited.

Advices and recommendations: Since this stock can display large fluctuations associated with analogous fluctuations in recruitment, and since the exploitation rate is close to our precautionary threshold of 0.4, the advice is not to increase the fishing effort. Nevertheless, since numerous studies have shown that the dynamics of anchovy and sardine populations are strongly influenced by success in the recruitment that is, on the other hand, strongly influenced by environmental conditions, the working group suggests continuing to explore the relationships between these species and the environment.

Discussion: The WG endorses the conclusions and recommendations. The biomass estimated by means of echo-surveys data is higher than the VPA results. Besides that, compared to the past assessment, the picture is slighter negative. These changes in the estimation are probably due to the new data that entered in the analysis for the present assessment (LFD from eastern echo-survey) and to the fact that fixed terminal Fs were not used in the present assessment. Also, retrospective VPA gave some degree of pattern in the estimated abundance, with each year being overestimated when taken as the last one of the series. For these reasons the picture gave from the present assessment is probably more negative than what the reality is. It should be noted that Adriatic small pelagic fishery is multispecies and effort on sardine stock cannot be separated from effort on stock of anchovy. Hence, management decisions have to be taken considering both species. The approach used in this assessment was to maintain the independence of the dataset during the preparation of the input data in order to reduce the statistical dependence (Cotter et al., 2004): the working group tried, whenever possible, to treat echo-survey data as more independent as possible from the commercial data. The WG recognised that spatial distribution of shared stock of anchovy is not limited to GSA17 area only, but it is extended in GSA18 area also. Therefore, WG suggest that future assessments take into account combined data from these two GSAs. Moreover, an important nursery area of this stock is located in Gulf of Manfredonia (GSA18) where the sardine stock is exploited by fry fishery.

Sardine (*Sardina pilchardus*)

Authors: I. Leonori, A. De Felice, I. Biagiotti, G. Canduci, M. Mandić, A. Pešić, A. Joksimović, S. Regner and J. Kolitari

Fishery:

Italy

Sardine is exploited by pelagic trawl, purse seine and to a lower level by bottom trawl (bycatch of small pelagics). Highest landings in weight are those of pelagic trawling followed by purse seine. Fishing is carried out five days a week. Exploitation is mainly based on age classes 1 and 2. Purse seiners during most of the fishing season operate in GSA 17. Pelagic trawlers fishing mainly small individuals (bianchetto) are no longer allowed to operate. From official data, the pelagic trawl and purse seine fleet of the geographical sub-area 18 (South-Western Adriatic Sea) is made up by 41 boats, but not all of them are operating all over the year.

Montenegro

Since 2004 there was no commercial catching of small pelagic fishes in Montenegro so it wasn't possible to estimate biomass or MSY from commercial landings data. At present time, there is only one active vessel (purse seine) that is exploiting these resources in Montenegro but the catches are poor, probably because of lack of experience of the crew and some technical problems. Even when catches are accomplished there is a big problem in its sale because of unorganized market. Sardine is targeted mostly by small-scale fisheries. Fishing grounds are located along the coast, and also in the Boka Kotorska Bay. In small-scale fishery almost all types of nets are used (gillnet, purse seines, trammel net etc. and long lines). With this type of fishery, a lot of economically important fishes are caught but there are no precise data about their amounts.

Albania

At present there are 4 pelagic vessels in Albania, which are active for 3 - 5 months during the year. There are three main exploitation areas: Shengjin, Durres and Valona. The catch goes to market or is used by the local conservation industry. There are three conservation industries in Shengjin; most of the product for these industries is imported.

Data and parameters: Data concerning Italian official commercial landings come from ISTAT (1987-2003) and IREPA (2004-2010). Sardine biomass was assessed by means of acoustic methodology, in the framework of MEDIAS and AdriaMed projects in both sides of GSA 18. Survey period was during the month of July. Biomass estimate is derived from the elaboration of acoustic data logged at three frequencies (38, 120 and 200 kHz) to calculate raw density of small pelagic fish in the study area converted into biomass per species on the base of percentage in weight of the different species and their mean size from the outcome of pelagic trawls made during the survey. Biomass per age class is also estimated using age length keys derived by biological samples collected during the survey.

Assessment method: Acoustics

Model performance: The estimation of the exploitation rate has to be done each year using a proper method. There is the need to improve landings data related to western side (part of the fleet go to fish in GSA 17) and start collecting landings data in eastern side.

Results:

Western GSA 18

Acoustics: The average value of sardine biomass density estimations for the studied period (1987-2010) is 16.8 t/nm^2. Sardine stock presents strong fluctuations in the first years of the studied period until the peak in 1996 (72.9 t/nm^2), after which we assist to a sudden decline with minor fluctuations around the mean value of the entire period. After that sardine showed very low levels of biomass; even if in the last 5 years there was a recovery, current biomass level is slightly below the mean value of the series. In 2010 sardine density biomass was 10.9 t/nm^2, equal to 27,359 t for an area of 2510 nm^2 (from the coastline to the isobath of 200 m).

Eastern GSA 18
Acoustics: Apart from the first surveys that took place in Montenegro waters only, the results of two surveys covering the whole area (Montenegro and Albania) are available by now. While in 2008 sardine biomass was 91,211 t, in 2010 it resulted 43,727 t in an area of 2597 nm^2 (from the coastline to the isobath of 200 m); sardine stock resulted half the quantity of two years before.

Diagnose of Stock status: Sardine stock in GSA 18 slightly decreased respect to 2008-2009 levels in the western side. The biomass in the western side is at a rather low level looking at the historical series but fishing effort is also very low in this area. The stock could be considered moderately exploited. For what concerns the eastern side even if sardine biomass showed a decrease respect to 2008 the fishing effort is very low here and again the stock could be considered moderately exploited.

Advice and recommendation:
Eastern GSA 18
Due to the fact that there is a lack of consistent fishery effort here the stock could be considered moderately exploited. In any case if an increase in fishing effort is foreseen in eastern GSA 18 for a precautionary approach it has to be introduced slowly and step by step, also because biomass estimations through acoustics indicated a decrease for sardine stock in 2010.

Western GSA 18
Sardine is targeted mainly by purse seiners and pelagic trawls; fishing effort is bigger than in the eastern side. Biomass in the western side is at a rather low level looking at the historical series; anyway the fishery effort is not entirely directed in GSA 18 and fishing pressure is rather low. The stock could be considered moderately exploited.

There is the need to keep investigation of all GSA 18 by acoustic surveys and also the need to try to improve the quality and availability of landings data.

Discussion: The WG endorses the conclusions and recommendations for this stock. Nevertheless, the assessment is considered uncertain, as it is difficult to assess the relation between current stock levels and catches in the area. An effort should be made to improve the quality and availability of landings data. Exploitation rate should be calculated each year on the base of survey and landings data.

Anchovy (*Engraulis encrasicolus*)

Authors: De Felice A., Leonori I., Biagiotti I., Canduci G., Donato F. - for acoustic method.
M. Mandić, A. Pešić, A. Joksimović, S. Regner and J. Kolitari - for DEPM.

Fishery:
Italy
Anchovy is exploited by pelagic trawl, purse seine and to a lower level by bottom trawl (bycatch of small pelagics). Highest landings in weight are those of pelagic trawling followed by purse seine. Fishing is carried out five days a week. Exploitation is mainly based on age classes 1 and 2. Purse seiners during most of the fishing season operate in GSA 17. From official data, the pelagic trawl and purse seine fleet of the geographical sub-area 18 (South-Western Adriatic Sea) is made up by 41 boats, but not all of them are operating all over the year.

Montenegro
Since 2004 there was no commercial catching of small pelagic fishes in Montenegro so it wasn't possible to estimate biomass or MSY from commercial landings data. At present time, there is only one active vessel (purse seine) that is exploiting these resources in Montenegro but the catches are poor, probably because of lack of experience of the crew and some technical problems. Even when catches are accomplished there is a big problem in its sale because of unorganized market. As for the case of sardine, anchovy is targeted mostly by small-scale fisheries. Fishing grounds are located along the coast, and also in the Boka Kotorska Bay. In small-scale fishery almost all types of nets are used

(gillnet, purse seines, trammel net etc. and long lines). With this type of fishery, a lot of economically important fishes are caught but there are no precise data about their amounts.

Albania
At present there are 4 pelagic vessels in Albania, which are active for 3 - 5 months during the year. There are three main exploitation areas: Shengjin, Durres and Valona. The catch goes to market or is used by the local conservation industry. There are three conservation industries in Shengjin; most of the product for these industries is imported.

Data and parameters: Data concerning Italian official commercial landings come from ISTAT (1987-2003) and IREPA (2004-2010). Anchovy biomass was assessed by two direct methods, acoustics and DEPM, in the frameworks of MEDIAS and AdriaMed project in both sides of GSA 18. Survey period was July. Reproductive parameters of adult population were processed directly onboard (total length, weight with and without gonads, sex ratio and maturity stages), while relative batch fecundity (Frb) and spawning frequencies (f) were analysed in lab. Plankton samples were processed in lab using methodology given by Regner (1985). Developmental time from fertilization to hatching (D) was analyzed and also instantaneous mortality rates of eggs, average and total daily egg production and spawning areas. Biomass estimate is derived from the elaboration of acoustic data logged at three frequencies (38, 120 and 200 kHz) to calculate raw density of small pelagic fish in the study area converted into biomass per species on the base of percentage in weight of the different species and their mean size from the outcome of pelagic trawls made during the survey. Biomass per age class is also estimated using age length keys derived by biological samples collected during the survey.

Assessment method:
- Acoustics
- DEPM

Model performance: The estimation of the exploitation rate has to be done each year using a proper method. There is the need to improve landings data related to western side (part of the fleet go to fish in GSA 17) and start collecting landings data in eastern side. The reliability of spawning frequency for anchovy obtained through eggs and larvae surveys has to be checked. There is the need to continue conducting the two direct methods simultaneously in order to have a reciprocal control of the results.

A comparison of abundance estimated by the two direct methods is presented. The use of a larger time series is suggested for more reliable comparisons, since variability among years is very high.

The low value of spawning frequency may indicate that very small number of females are spawning and a very slow spawning rate (one spawn every 25 days) which is very low for this species, an r-strategist that show spawning frequencies around one per week. The group suggests investigating why estimates of spawning fraction are so low, and if it relates to biological conditions, or to potential bias in the estimation of development rates of ovary structures (e.g. POFs).

Results:
Western GSA 18
Acoustics: The average value of anchovy biomass density estimations for the studied period (1987-2010) is 26.7 t/nm^2. From the very low levels of abundance at the beginning of the historical series we assist to a recovery since 1994; after that the stock maintained good levels of abundance from 1997 to 2002. In these last years anchovy biomass in this area presents strong fluctuations with two minima (2005, 2008) and two maxima (2006, 2009). In 2010 biomass density was estimated in 20.2 t/nm^2 equal to 50,692 t for an area of 2510 nm^2, a value slightly below the mean.
DEPM: the only estimate available is for 2010; biomass resulted 81,904 t. This estimation resulted higher than the acoustic one but comparing the estimates in SW GSA 18 with those of SE GSA 18 they are in agreement seeing much lower biomasses in SE. Using the historical series of biomass estimates by acoustics and the relative landings from ISTAT & IREPA the harvest rate was estimated. Using the mean value for the last 4 years and considering it in good approximation equal to fishing mortality F the exploitation rate E was calculated assuming natural mortality M equal to 0.82. The value of natural

mortality used refers to that indicated in the stock assessment of GSA 17 for age class 1, being this age class the most represented in 2009 and 2010 in survey samples. The value of E resulted 0.17, well below the reference point of 0.4.

Eastern GSA 18
Acoustics: Apart from the first surveys that took place in Montenegro waters only, the results of two surveys covering the whole area (Montenegro and Albania) are available by now. While in 2008 anchovy biomass was 31,606 t, in 2010 it resulted only 13,081 t over an area of 2597 nm^2.
DEPM: The available estimates for the whole area made in 2008 and 2010 gave respectively 21,524 t and 18,448 t.

In 2008 acoustic estimation was higher while in 2010 it was lower than DEPM one; anyway the decrease in anchovy biomass from 2008 to 2010 is seen by both methods even if at different extents.

Diagnose of Stock status: Anchovy stock in GSA 18 shows a decrease respect to 2009 in the western side and also respect to 2008 in the eastern side (no survey here in 2009). Due to the fact that the biomass in the western side is at an intermediate level looking at the historical series and that the fishing effort is not entirely directed in GSA 18 the stock could be considered moderately exploited. Moreover the exploitation rate estimated with western side data gave a value of 0.17, well below the Patterson's Reference Point of 0.4. For what concerns the eastern side even if anchovy biomass resulted at a low level the fishing effort is very low, so the stock could be considered moderately exploited.

Advice and recommendation:
Eastern GSA 18
Due to the fact that there is a lack of consistent fishery effort here the stock could be considered moderately exploited. In any case if an increase in fishing effort is foreseen in eastern GSA 18 for a precautionary approach it has to be introduced slowly and step by step, also due to the fact that biomass estimations through two direct methods indicated a decrease for anchovy stock in 2010.

Western GSA 18
Anchovy is targeted mainly by purse seiners and pelagic trawls; fishing effort is bigger than in the eastern side. The exploitation rate E estimated through the harvest rate over the historical series of biomass estimates by acoustics and the landings data resulted 0.17 (0.4 Patterson's Reference Point), then the stock could be considered moderately exploited also due to the fact that part of the fleet operates in GSA 17.

There is the need to keep investigation of all GSA 18 using two independent methods simultaneously. Another suggestion is to try to improve the quality and availability of landings data.

Discussion: The WG endorses the conclusions and recommendations for this stock. Estimates of landings in the area allowed estimating a harvest rate for this species in the area, however the precision of the catch estimates is difficult to assess. The WG recommends to continue with the two direct assessments of anchovy biomass, checking the reliability of spawning frequency for anchovy obtained through eggs and larvae surveys and cross-comparing the final estimates from the two methods. Also the WG recommends obtaining yearly estimates of the harvest rate.

GENERAL DISCUSSION

Discussion on stock assessment methods

23. The moderator introduced a summary presentation of current methods available for fishery dependent as well as independent data sources. He highlighted pros and cons, data requirements and main constraints. He also outlined the process of management advice, introduced some software and stressed the importance of considering environmental stressors into the system.

In relation to estimates coming from Direct Methods

24. Direct methods (specially acoustics) are widely used in this WG and are considered as one of the best available tools to obtain an estimate of the overall biomass levels and observe changes in the biomass levels across the time series. However, all of the underlying assumptions should be investigated to validate the final estimates. Also, if direct methods are the only analytical tool used to obtain biomass estimates, then some estimate of Harvest Rate (proxy of F): Catch/Survey through catch analysis or other means are necessary to be able to provide some management advice.

25. Some questions were raised on the possibility to use direct estimates of biomass only for a portion of the stock as tuning indexes for the whole stock assessment, when using analytical methods with tuning indexes. The moderator explained that it would be possible to use the values of parameters of one area to an extended area of the same ecosystem if the biomass estimate of that area is a good index of the overall biomass of the stock. However, spatio-temporal variability of the relative importance of an area in the overall stock should be well understood before this can be done.

26. Other issue discussed is the importance of trying to provide biomass estimate by age classes, in order to have also information on the age structure and ideally of recruitment (if estimates of young ages are reliable). If separation by length or age classes is not available, at least the total biomass could be divided into age 0 and the rest. Information of fleet and estimations of biomass and recruitment are also very recommendable.

Common problems shared by all methods:

27. Several common problems shared by all methods presented in this year WG were discussed. Most methods have problems with age 0, which come from selectivity issues in the surveys and/or in the catches. Therefore, estimates of age 0 abundances are often unreliable. The question is then how to incorporate this age in any analytical assessment. Solutions range from excluding this age from the assessment, which leads to estimating only a partial biomass (in comparison with total biomass) of the stock, to try to reduce the impact of this age class in the model (either by using a correct selectivity curve, or by down weighting the effect of age 0 residuals in the model, or by a combination of both). Differences in the final estimate by using different assumptions should be investigated, both as a way to explore the effect of this age class in the model and to have a notion on the robustness of the final estimates.

28. Other common issue that affects most of the assessment models presented here is the precision and bias of the growth models used. For length-based models, growth models become crucial to understand differences in the length distribution along the time series, and to perform a cohort analysis. Also, for most stocks presented in this WG, natural mortality is estimated based on the growth model for the stock. The reliability of the growth models should therefore be continuously investigated. Furthermore, alternative estimates or at least a review of mortality estimates for sardine and anchovy in the Mediterranean should be pursued.

29. Finally, a common issue for all age-based models is the necessity to have a good Age-Length-Key (ALK), representative of the age-length distribution of the stock that is being assessed. Cross-areas or cross years (combined) ALK should be avoided whenever possible. Comparison of ALK between neighbor areas is also an interesting exercise, but combination should also be done after a careful analysis. Whenever an ALK should be obtained by combining areas, then the sampling should at least represent all included areas.

Assessment models to-do-list and potential alternative assessment models

30. A discussion on what would be the characteristics the WG will like to see in an assessment model, as well as which other assessment methods apart from the ones presented in the group can be potentially interesting took also place. The WG concluded that a good assessment model of small pelagic fish in the Mediterranean should be able to incorporate some spatial heterogeneity on the stock properties (age structure, growth, maturity, etc.) as well as in some fishery properties (composition of the fleet, selectivity of the different fleets, different tuning indexes, etc.). This was also seen as a way to be able to test different sub-regional management measures, and to provide some sub-regional advice.

31. Some of these issues are available in existing age-based models; for example "Assessment Model Combining Information" (AMCI) provides more flexibility than other existing models to incorporate spatial and temporal changes in selectivity, a variety of fleets, etc.

32. Another issue discussed is the general well-known problems of using age or length-based model in short living species with a variable growth. An example of a successful application of a biomass model was presented in this WG, and the WG encourages some comparative analysis of various existing biomass models to the stocks assessed in the WG. However, the WG also recognized that most of these models have to be developed explicitly for each stock, and are not available as out-of-the-selves methods. Examples of successful application of biomass or two stage biomass models exist in various small pelagic stocks, and the WG encourages attempting those models in the Mediterranean stocks.

Short-term management of small pelagic fish stocks

33. The WG discussed the current difficulties when trying to use short-term stock projections to help in providing management advice. All populations assessed show a strong dependence with recruitment, due to the short life cycle of these species. Therefore, the short-term projections will largely depend on the assumption taken in terms of next years' recruitment. Two options were discussed;

a) Try to predict the most realistic scenario for next year' recruitment, and perform the short-term projection based on this prediction
b) Perform a risk analysis of the future state of the stock using all possible recruitment scenarios (good, medium, bad)

34. In the first case, next year' recruitment is predicted based either on a recruitment model or on some informed decision on what the next year recruitment level will be. Recruitment models based on environmental indexes with or without an embedded stock-recruitment relationships have been used in other stocks worldwide, although problems have also been found with those indexes (see a review of their utility in De Oliveira et al. 2005). Informed decision on next year recruitment level have also been used for example in the management of small pelagic fish in ICES areas, where an average or geometric mean of previous years' recruitment is used as an indication of next year' recruitment. The WG also acknowledges that for Mediterranean small pelagic fish, stock-recruitment signals were stronger than in some other stocks, opening the possibility to try to use an improved (e.g. including some kind of environmental indexes) stock recruitment index to perform short term projections.

35. Another statistical sound approach also used in some ICES small pelagic fish assessments (see for example Ibaibarriaga et al. 2008) is to classify the observed recruitments in the time series into classes (low, medium, high) and perform a probabilistic risk analysis of what will be the state of the stock under different management options (e.g. fishing mortality) given next year' recruitment belongs to any of the three recruitment classes. In this way, management decisions can be taken assuming different risk levels for each stock.

Long-term management of small pelagic fish stocks

36. The need to establish some indicator of environmental stress was highlighted and a recommendation to progress in this direction is done, also in coherence with the proposed use of a "traffic light approach" recommended by SAC. The first attempts to use primary productivity (Chl. a) in the Straits of Sicily and hydrodynamics and plankton abundance in northern Adriatic were commented. The convenience of getting information on oceanographic parameters while doing the surveys was also highlighted as well as providing results of studies on biological and oceanographic factors performed within other running projects.

37. Various alternatives to account for regime shifts and climate effects were discussed:

- Assessment based on ecosystem approach to fisheries; incorporate environmental, biological and human effects on the stock.
- Adaptive management based on productivity cycles; regime-specific harvest rates (RSHR) (Polovina, 2005; King and McFarlane, 2006), combination of short-term adaptive management with long-term fleet capacity control (Fréon et al., 2005).

38. This year, the WG tentatively took into account the potential for regime shift and different sustainable small pelagic fish biomass levels for the assessed stocks. The WG recommends that this approach is further developed in the future, and the required information regarding regime productivity and medium to long-term trends in stock abundance is incorporated into the routine information provided to the group (e.g. in the stock assessment forms).

DISCUSSION ON STOCK ASSESSMENT FORMS AND INDIVIDUAL REPORT TEMPLATES

39. The participants provided their suggestions to improve the structure, the contents and the utility of the current Stock Assessment Forms, as well as some suggestions to use the individual report templates.

40. During the last years, the working groups have evolved from "hands on" sessions in which the participants provided data to run the assessments, towards a revision type sessions in which the assessments are previously done and the WG discuss the assumptions taken and the results found. In sub regional *Ad hoc* working groups or in their own Institutes the scientists meet together and elaborate their assessments which results are finally addressed to the SCSA Working Groups. Hence, the objectives, of the working groups and consequently those of the stock assessment forms must be adapted to this evolution.

41. Under the new working procedures, the assessment forms must make sure that the participants can:

- Evaluate the assumptions taken as well as the preliminary analysis that allows to make those assumptions
- Evaluate the results obtained in the assessment and therefore discuss on the conclusions and recommendations proposed.

42. The WG envisages a new system that consists in two separate modules, one for inputs, which includes the data and metadata used, and one for assumptions and outcomes of the model. Both modules should include standard ways of presenting the data and outcomes, independently of the method used (e.g. abundance by age bubble plots from catches and surveys to evaluate cohort signals, estimates of abundance by age by year by the model, plots of F, SSB and Recruitment, etc.). Some automatic routines will also be desirable.

43. The WG therefore recommends that the SAC take the required actions to design a new system to replace current stock assessment forms in order to ensure the new WG requirements. A potential way to do this will be to create a specific expert group (task force or working group) to deal with this requirement.

44. In addition to the stock assessment forms, the moderator also suggests that some clarifications on the use of the individual report template provided to the participants and used to compile the information required for the final report are needed:

- Under the section on "Model performance", participants should include an own critical evaluation of the model used, including an evaluation of the model diagnostic plots provided by most analytical assessment (e.g. residual plots by age, survey, etc.) as well as (when available) an evaluation of agreement between direct estimates and catches (e.g. showing the catchability and selectivity of surveys) and a critical evaluation on the suitability of the assumptions taken.
- Under the section on "Discussion", the discussion taken place on the WG should be included, as well as whether or not the WG arrived to an agreement on the conclusions and recommendations for that stock

GENERAL RECOMMENDATIONS

- The WG recommends continuing current efforts to provide combined analysis for stocks that span through more than one GSA area, as well as coordination between Institutes and nations involved in the assessment of shared pelagic fish stocks.

- The WG recommends that the stock assessment forms should be revised to accommodate the current WG functioning and the small pelagic fish characteristics.

- For short-term management, the WG recommends to perform risk analysis of stock projections using different probabilistic scenarios based in possible levels of recruitment. The evaluation of the use of stock recruitment relationship, if necessary with some extra environmental index, is also recommended, due to the good correlations observed in some of the stocks.

- For long-term management, the WG recommends to undertake a basin-wide analysis to identify climate signals that can be coherent at the Mediterranean Sea spatial level, in order to identify potential phases or regime shifts that can control stock productivity. An analysis of basin-wide signals versus local effects on recruitment is encouraged.

- In relation to the previous recommendation, the WG also recommends to investigate the possibility to incorporate some indication of environmental stress on the stock productivity into the traffic light approach recommended by SAC. The convenience of getting information on oceanographic parameters while doing the surveys was also highlighted as well as providing results of studies on biological and oceanographic factors performed within other running projects.

- The WG recommends that a specific workshop on assessment methods for small pelagic fish is carried out. Potential issues to be covered by the workshop include i) the use of aggregated or disaggregated (recruitment and spawning stock) Biomass models to evaluate small pelagic fish stocks, ii) Bayesian techniques to incorporate assumptions, prior distribution of the unknown parameters and/or external information such as environmental indexes and tuning indexes, iii) analysis of time series to identify changes in the ecosystem, and iv) management options for variable carrying capacity small pelagic fish stocks.

ADOPTION OF THE REPORT AND OF THE RECOMMENDATIONS FROM THE GROUP

45. The Conclusions and Recommendations were adopted by the Working Group on 29th of October 2011. The whole report was adopted after revisions and amendments by electronic correspondence within the following two weeks.

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Appendix A

Agenda

1. Opening session (joint session for the two Working Groups on Demersal and Small Pelagic Species)

2. Introductory session

3. Presentation of assessment and review of available data on *Sardina pilchardus*
(presentations by national experts)

4. Presentation of assessment and review of available data on *Engraulis encrasicolus*
(presentations by national experts)

5. Review of Monday/Tuesday discussion

6. Stocks without complete assessment: review of existing data and procedures to provide advice

7. Overview on small pelagic stock assessment methods (Bernal, M.) to introduce joint discussion on:

Available fishery independent methods:
- EPM; discussion of problems in the different stocks
- Acoustics; discussion of problems in the different stocks

Available assessment models:
- Available assessment models, pros & cons
- Basic biological data from landings; report on problems and recommendations
- Integration of fishery independent methods (tuning)

8. Review of Wednesday discussion

9. Formulation of conclusions, recommendations and management advices to be transmitted for the consideration by the SCSA and SAC

10. Summary of the conclusions and recommendations: (joint session for the two Working Groups on Demersal and Small Pelagic Species)

11. Closing session:

Appendix B

List of Participants

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

Enrico **ARNERI**
FAO AdriaMed and
MedSudMed Projects
Viale delle Terme di Caracalla1
00153 Rome Italy
Tel: +39 0657056092
Fax: +39 0657056500
Email: enrico.arneri@fao.org

Pedro **BARROS**
FAO
Viale delle Terme di Caracalla1
00153 Rome Italy
Tel: +39 0657056469
Email: pedro.barros@fao.org

Lotfi **BEN ABDALLAH**
Institut National des Sciences
et Technologies de la Mer (INSTM),
Centre de la Goulette
La Goulette Port, Tunisia
Email: lotfi.benabdallah@instm.rnrt.tn

Azeddine **BENNOUI**
Centre National de Recherche et Développement
de la Pêche et l'Aquaculture
Bd Colonel Amirouche, BP 54,
Bou Ismail, Tipaza, Algerie
Email: bennoui_azeddine@yahoo.fr

Jean Louis **BIGOT**
IFREMER
BP 171 Av. Jean Monnet
Piera **CARPI**
CNR - ISMAR
Largo Fiera della Pesca
60125 Ancona, Italy
Email: piera.carpi@an.ismar.cnr.it

Vanja **ČIKEŠ KEČ**
Institute of Oceanography and Fisheries
Set. I Mestrovica 63,
Split, Croatia
Email: cikes@izor.hr
Andrea **DE FELICE**
CNR - ISMAR
Largo Fiera della Pesca
60125 Ancona, Italy
Email: a.defelice@ismar.cnr.it

Fabio **FIORENTINO**
SCSA Coordinator
CNR - IAMC
via L. Vaccara 61
91026 Mazara del Vallo (TP), Italy
Email: fabio.fiorentino@iamc.cnr.it

Encarnación **GARCÍA RODRÍGUEZ**
I.E.O. Instituto Español de Oceanografía
C/Varadero 1 San Pedro del Pinatar, Murcia, C.P.
30740, Spain
Email: encarnacion.garcia@mu.ieo.es34203 Sete
Cedex, France
Email: jean.louis.bigot@ifremer.fr

Omar **KADA**
Institut National de Recherche Halieutique
(INRH), Centre Régional de Nador
BP 143 Boulevard Zerktoni
Nador, Maroc
Email: inrhomarkada@yahoo.fr

Jerina **KOLTARI**
Head of Aquaculture and Fishery
Laboratory Durres,
Agricultural University Tirana
Lagjia 4, Rruga "Skenderbeg"
Durres, Albania
Email: jerina_juka@yahoo.com

Milica **MANDIĆ**
Institute of Marine Biology (IBM)
Dobrota bb, 85330
Kotor, Montenegro
Email: mamilica@ac.me

Bernardo **PATTI**
CNR - IAMC
Via del Mare 3, 91021 Campobello di Mazara
(TP), Italy
Email: bernardo.patti@cnr.it

Alberto **SANTOJANNI**
CNR - ISMAR
Largo Fiera della Pesca
60125 Ancona, Italy
Email: alberto.santojanni@an.ismar.cnr.it

Vjekoslav **TIČINA**
Institute of Oceanography and Fisheries
Šet. I. Meštrovića 63,
21000 Split, Croatia
Email: ticina@izor.hr

Barbara **ZORICA**
Institute of Oceanography and Fisheries
Šet. I. Meštrovića 63,
21000 Split, Croatia
Email: zorica@izor.hr

Moderator

Miguel **BERNAL**
Current address:
Institut de Ciències del Mar
(CMIMA-CSIC)
P. Maritim de la Barceloneta, 37-49
08003 Barcelona, Spain
Tel: +34 932309569
Fax: +34 932309555
Email: mbernal@icm.csic.es
Permanent address:
Instituto Español de Oceanografía
Centro Oceanográfico de Cádiz
Puerto Pesquero,
Muelle de Levante, s/n
Apdo. 2609, 11006 Cádiz, Spain
Tel: +34 956 294189
Fax: +34 956 294232
Email: miguel.bernal@cd.ieo.es

GFCM Secretariat

Pilar **HERNANDEZ**
GFCM Coordinator
Information Management Officer
GFCM Secretariat, Via Vittoria Colonna1
00193 Rome Italy
Tel: +39 0657054617
Fax: +39 0657056500
Email: pilar.hernandez@fao.org

Federico **DE ROSSI**
GFCM Secretariat
Via Vittoria Colonna1
00193 Rome Italy
Tel: +39 0657053481
Fax: +39 0657056500
Email: federico.derossi@gao.org

Appendix C

TERMS OF REFERENCE

One of the objectives of the Sub-Committee on Stock Assessment (SCSA) is to progress in the enhancement of joint practical stock assessment on small pelagic and demersal species. "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. surveys data, …).
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,…) of environmental stress.
7. Produce diagnoses on the status of the stocks.
8. Present and discuss assessment related woks.
9. Complete the filling up of the SCSA stock assessment forms including, when available, those for direct methods.
10. Suggest management advice to the SAC considering different alternatives.