GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

COMMISSION GÉNÉRALE DES PÊCHES POUR LA MÉDITERRANÉE

Scientific Advisory Committee (SAC)
Subcommittee on Stock Assessment (SCSA)
Report of the Working Group on Stock Assessment of Small Pelagic species (WGSASP)
Bar, Montenegro, 28 January – 1 February 2014

OPENING OF THE WORKING GROUPS ON STOCK ASSESSMENT (WGSAs)

1. The meetings of the SCSA Working Groups on Stock Assessment of Demersal (WGSAD) and Small Pelagic Species (WGSASP) were held in Bar, Montenegro from 28 January to 1 February 2014. The first day was dedicated to a joint Workshop on the definition and estimation of reference points for Mediterranean and Black Sea fisheries.

2. Ms. Pilar Hernandez and Mr. Miguel Bernal, GFCM Secretariat, welcomed participants. They thanked the Ministry of Agriculture and Rural Development of Montenegro, together with the Institute of Marine Biology of Kotor, for their warm welcome and for the hosting and organization of the meetings. They then provided background information to the WGSAs and explained the new structure of the Stock Assessment forms, informing on how to upload them online and inviting participants to use SharePoint for this purpose.

WORKSHOP ON THE DEFINITION AND ESTIMATION OF REFERENCE POINTS FOR MEDITERRANEAN AND BLACK SEA FISHERIES (joint session for the two WGSAS)

3. Mr. Miguel Bernal opened the Workshop on the definition and estimation of reference points for Mediterranean and Black Sea fisheries and gave the floor for three presentations, as follows:

- Reference points and advice in the SAC and in other relevant organizations *(Miguel Bernal*)

An introductory presentation describing the current framework of reference points in use in the GFCM and comparisons with other frameworks was delivered. Mr Bernal highlighted that reference points are crucial elements for the provision of advice for fisheries management, and that their role was defined in the GFCM Guidelines for management plans, approved at the 36th session of the Commission. He pointed out however, that some inconsistencies in the definition of reference points regularly used in the GFCM existed, and that there was room for harmonization on how the Working Groups provided advice to the SAC. He also introduced some the approaches being used by the EU and UNEP on the definition of Good Environmental Status by highlighting that indicators based on the status of stocks were the most developed. He stressed the importance to increase the number of stocks assessed in the Mediterranean and Black Sea, and therefore to extend the assessment methods to fisheries for which information is limited.

4. Participants agreed on the relevance of reference points and the need to better define and harmonize their use in the different stocks, as well as the importance to try to incorporate biological and ecological considerations on the definition and estimation of reference points. Also, the importance of incorporating appropriate Stock-Recruitment relationships (when apparent from the information on specific stocks) and incorporate uncertainty into the reference point framework was stressed.

- Review of reference points for demersal stocks in the Mediterranean and Black Sea (*Francesco Colloca*)

An overview of the demersal stocks assessed by GFCM and STECF since 2007 and the reference points more commonly used to produce an advice on the status of the stocks. Mr Colloca highlighted that under the UN Fish Stock Agreement, Fmsy should be the Limit Reference point. He also underlined the great variability observed on the values obtained for F0.1 in the different GSAs and pointed out to the different values of biological parameters used as the possible cause and ask for an effort to standardized these values. The need i) to find ways to assess also data poor stocks (e.g. catch-MSY model, by Martell and Froese, 2013), to have reference levels based on biomass and ii) to define priority lists of stocks to be assessed in the next years was stressed.

5. Some participants suggested that stock units' identification, migration rates and stock boundaries should be among priorities for the SAC. The group was informed that StockMed Project was trying to address this issue in the Mediterranean using different sources of standardised information.

6. The use of catch or landings as well as the different ways of calculating biological parameters were pinpointed as possible causes of the observed differences in estimated reference points for neighbor stocks of the same species, and a general request to standardize the estimators and to improve documentation of the basic information used in the analysis was highlighted.

- Review of reference points for small pelagics in the Mediterranean and Black Sea *(Piera Carpi)*

The presentation reviewed the management strategies developed for small pelagics stocks worldwide, e.g. empirical reference points, reference points from stock assessment and reference points based on the potential biological removal principles. The more common reference points used inside the ICES framework and in the Mediterranean and Black sea were presented.

7. Some doubts were expressed about the applicability of approaches designed in upwelling ecosystems to the estuarine-type (input runoff) ecosystems predominant in the Mediterranean and the Black Sea, and participants agreed on the need to use approaches suitable for non-upwelling ecosystems. Also, participants agreed that for the Mediterranean, the use of simulations (e.g. as in some of the approaches done at ICES), could be a complimentary option to the exclusively use of analytical models or empirical analysis to estimate reference points.

8. Participants stressed the need to account for the biological characteristics of small pelagic fisheries that fluctuate not only due to the fishing activity but also on the base of natural causes. In this regard, the analysis of time series was considered crucial to understand the dynamics of small pelagics in the ecosystem, and management should take into consideration that different phases (e.g. regime shifts) that show different productivity are common for these species.

9. The general conclusions and recommendations of the Workshop on the definition and estimation of reference points for Mediterranean and Black Sea as agreed among the two WGSAs are included in Appendix D.

OPENING AND ARRANGEMENTS OF THE WORKING GROUP ON STOCK ASSESSMENT OF SMALL PELAGIC SPECIES

10. The meeting of the SCSA Working Group on Small Pelagic species (WGSASP) was held in Bar, Montenegro, from 29 of January to 1 February 2014. It was attended by 25 participants from GFCM Member Countries, FAO Regional Projects as well as representatives of the GFCM Secretariat (see list of participants in Appendix B).

11. The WGSASP was chaired by Ms Piera Carpi, who introduced the agenda that was adopted with some changes, i.e. the inclusion of a presentation on *Changes in growth, condition, size and age of small pelagic fish in the Gulf of Lion,* a presentation on anchovy assessment in GSA03, and a presentation on anchovy and sardine assessment in GSA16 (Appendix A).

12. Ms Claire Seraux was appointed rapporteur.

13. All stock assessment forms presented and prepared during the WGSASP are available on the GFCM website (www.gfcm.org).

PROGRESS ON PREVIOUS YEAR RECOMMENDATIONS

14. The chair summarized the 2012 conclusions and recommendations, as well as the assessments presented that year during the WGSASP.

15. The GFCM Secretariat presented the improvements to the Stock Assessment Forms implemented for the WGSAs, namely:

a) A word document, with the detailed assessment and the main results;

b) An excel file, including all the input data used for the assessment;

c) An online library of metadata, available for each stock assessment form uploaded on the SharePoint page of the stock assessment working groups: whenever a file would be uploaded on SharePoint, the user would be requested to provide the main information concerning the stock, such as the data available, some details on the assessments carried out and information on reference points and stock status.

16. The GFCM Secretariat proposed, in line with the previous year recommendations, to dedicate time to the estimation of empirical biomass RPs for all the stocks that were being presented. Also, the GFCM Secretariat briefly presented the outcomes of the exercise on RPs that was carried out during the Sub-regional Groupon Stock Assessment in the Black Sea (SGSABS), and proposed a similar exercise for the stocks for which a long time series of absolute estimate of biomass was not available.

JUSTIFICATION OF WGSASP 2014 PROCEDURES

17. Based on the approach suggested by the SAC and on the results of the Working Group on Reference Points, 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:

- The group provided a draft comprehensive table to define the stock status based on the available reference points. The draft was to be further discussed at the Subcommittee on Stock Assessment and was expected to provide a standard procedure to produce advice in the stock assessment working groups.

- The precautionary fishing mortality reference point based on Patterson’s criterion ($F/Z = 0.4$), together with empirical biomass reference points (B_{lim} and $B_{threshold}$) based on the analysis of time series of biomass estimates, were the most commonly used reference points in the stocks assessed by the group.

- Consistently with the previous year guidelines, B_{loss} was used as a proxy for B_{lim}; the definition of B_{loss} was refined, so as to be the lowest biomass from which a recovery had been confirmed. B_{loss} was estimated from an analysis of time series of biomass estimates. Time series should be sufficiently long and only if the analysis provides consistent perspective in the historical and the recent part of the time series, this reference point could be considered. Whenever similar minima that meet the required criteria (recovery) exist in the time series, the upper value should be chosen as a precautionary approach. On the other hand, the estimation of the threshold reference point (or precautionary reference point, referred in this report as B_{pa}) proposed the year before was disregarded because it was too close to B_{lim}. The WGSASP proposed a more precautionary estimation of B_{pa}: B_{pa} be defined as a point at which the probability to be below B_{lim} is lower than 5%. In order to estimate it, a lognormal distribution of B_{lim} was assumed, with a coefficient of variation of 40%. This approximately resulted in $B_{pa} = 2 * B_{lim}$.

18. For those stocks for which reference points were not available, and following the precautionary approach which requires to provide advice with the available data, the group continued with the approach proposed the previous year, i.e. :

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) 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 and McFarlane, 2006) 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 SustainableYield) at different ecosystem status was adopted. In case various productivity phases were identified, stability as defined in point 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, were used to provide a rough evaluation of stock status.

19. The group also proposed that environmental variables deemed important for stock dynamics should be incorporated in the Stock Assessment form, in order to be able to support potential future implementation of environmental variables into stock assessment models and/or in the definition of reference points.

OVERVIEW OF ASSESSMENTS PERFORMED AND STOCK STATUS

20. A total of 12 stocks were presented, from which a total of ten stocks were formally assessed (a stock status was provided; see Table below). One of these ten assessments was rejected due to uncertainties in the model. Nine assessments were validated by the group. All assessments had been done before the meeting although some extra analyses in some of the stocks were carried out during the meeting.

21. In terms of GSA areas, seven GSAs were covered, from which five areas were formally assessed while two only have a preliminary assessment.

22. Sardine and anchovy were the two species analysed in all areas.

23. Fishery independent methods were used in six of the formally assessed stocks, either as a tuning index for analytical assessment or else as the only biomass estimator. Acoustics was the most used method (6 out of 6 of these assessments); non-standardized CPUE data were used as tuning index for four of the formally assessed stocks. Daily Egg Production Method SSB estimator was used for a preliminary estimation of the SSB for the anchovy stock in GSA 18.

24. In relation to the assessment model, the stocks with analytical assessment were analysed using age based cohort analysis. Six stocks (sardine and anchovy in GSA01, GSA06 and GSA 16) were analysed using a biomass (Surplus) model, allowing for an external index of ecosystem productivity.

25. Two of the analytical assessments presented, namely anchovy in GSA01 and anchovy in GSA16, were rejected from the WGSASP due to uncertainty in the assessment: in particular, contradictory signals between the catch and the survey data were pointed out, as well as some methodological problems in the application of the surplus production model for anchovy in GSA01. Stock status and advice were provided anyway for anchovy in GSA16 based on the acoustic estimates.

26. Sardine stock in the Northern Alboran Sea (GSA01) and anchovy stock in Northern Spain (GSA06) were considered sustainably exploited. Sardine in the North Adriatic Sea (GSA17) was classified as “in an increased risk of overexploitation: , while anchovy off the Southern Sicilian cost (GSA 16) was considered “in overexploitation”. Sardine off the Northern Spanish coast (GSA01), sardine off the Southern Sicilian coast (GSA 16), and anchovy stock in the North Adriatic Sea (GSA17) were classified as “Overexploited and in overexploitation”. Anchovy and sardine in the Gulf of Lions (GSA07) were considered respectively depleted, with low exploitation rate and low biomass, and unbalanced, with high recruitment but fish small and in poor conditions. The status of anchovy in the Northern Alboran Sea was considered uncertain.

27. In light of the above mentioned status of stocks, the recommendations were either to reduce or maintain current fishing effort, and to implement a recovery plan or to apply management plan currently in force.

28. Ms Claire Saraux delivered a presentation on *Changes in growth, condition, size and age of small pelagic fish in the Gulf of Lions.* She provided insights on the dynamics of the pelagic ecosystem in the Gulf of Lions, summarizing the knowledge available on the current situation of anchovy, sardine and sprat. The main point addressed the decrease in sardine and anchovy biomass, associated with a decrease in fish size and mean weight, with disappearance of bigger (and older) fish and a drop in body condition. Several hypotheses (bottom-up processes due to changes lower in the food chain, increase in predators, virus, changes in reproductive behaviour) to explain the phenomena were proposed, but none were confirmed. The WGSASP highlighted some similarities with other areas (i.e. GSA06).

GSA	Species	Assessed by	Exploitation rate	Biomass level	Status	Recommendation
01	Sardine	Surplus production model (BioDyn)	Low (E=0.36 - $F_{curr}/F_{0.1}$=0.66)	Higher than B_{MSY} (B_{cur}/B_{MSY}=1.31)	Sustainably exploited	Not to increase fishing mortality.
03	Sardine	LCA	High (E=0.56)	-	-	Preliminary assessment: no advices can be provided.
06	Sardine	Surplus production model (BioDyn)	High (E=0.46 - $F_{curr}/F_{0.1}$=1.68)	Lower than B_{MSY} (B_{curr}/B_{MSY}=0.37)	Overexploited and in Overexploitation	Reduce fishing mortality. Apply a multiannual management plan.
07	Sardine	Acoustics and harvest rate from catches/acoustic	Low fishing mortality	Intermediate	Unbalanced	Fishing mortality should not be allowed to increase, monitoring of changes in the fishing effort/gears required.
16	Sardine	Harvest Rate and Surplus production model (BioDyn)	High (F_{Curr}/F_{MSY}=1.11)	Lower than B_{MSY} (B_{curr}/B_{MSY}=0.5). B_{curr} below B_{pa} and above B_{lim}	Overexploited and in overexploitation	Fishing mortality should be reduced by means of a multi-annual management plan.
17	Sardine	SAM tuned by acoustic	High (E=0.42)	Intermediate, above B_{pa}	Increased risk of overexploitation	Do not increase fishing mortality and revise stock advice next year.
01	Anchovy	Surplus production model (BioDyn)	-	-	-	The assessment was rejected.
06	Anchovy	Surplus production model (BioDyn)	Low (E=0.24 - F_{Curr}/F_{MSY}=0.72)	Higher than B_{MSY} (B_{cur}/B_{MSY}=1.34)	Sustainably exploited	Not to increase fishing mortality.
07	Anchovy	Acoustics and harvest rate from catches/acoustic	Low exploitation rate	Low biomass (B_{curr} below B_{lim})	Depleted	Implement a recovery plan (including monitoring on biological parameters and limits on effort).
16*	Anchovy	Harvest Rate and Surplus production model (BioDyn)	High (E=0.42)	Uncertain	In overexploitation	Fishing mortality should be reduced by means of a multi-annual management plan.
17	Anchovy	ICA and SAM tuned by acoustic	High (E=0.48-0.57)	Low (12-19 percentile)	Overexploited and in overexploitation	Fishing mortality should be reduced and the existing management plan should be applied.
18	Anchovy	DEPM	-	-	-	Preliminary assessment: no advices can be provided.

*The stock status and the recommendation are based on the harvest rate calculated on acoustic data, since the analytical assessment was rejected.

STOCK ASSESSMENTS BY AREA AND SPECIES

29. The WGSASP critically analysed each one of the stock assessments presented, also reviewing the input data and the basic assumptions. The rationale behind every new model was demanded, and a scrupulous inspection of the results and the diagnostics was carried out.

30. The WGSASP welcomed the presentation of an assessment of sardine in Moroccan waters (GSA03). Some questions on the assessment model used were raised during the WGSASP and it was unclear whether the assessment was presented as an exercise (as in previous years) or as a final assessment. The authors of the assessment were unfortunately not present and therefore the assessment was considered preliminary. The WGSASP encouraged that this assessment be presented for validation next year, and suggested to consider the use of acoustic data as a tuning index.

31. The group welcomed the presentation of assessments for sardine and anchovy in GSA01 and GSA06 by Spanish experts, which met recommendations proposed in previous years of the WGSA to overcome some of the problems detected for these stocks. The WGSASP encouraged such effort to be continued and suggested to test alternative production models.

32. The WGSASP noticed some inconsistencies in the data used for the assessment, such as lack of signals in the cohorts for anchovy and sardine stock in GSA17, in particular concerning the acoustic data. The exercise of revising the ALKs used for both species in GSA17 was carried out during the group and some major differences between the Eastern and the Western age reading were identified for sardine.

33. Two models were presented for anchovy stock in GSA17, namely ICA and a statistical catch at age (SAM). The two models showed some inconsistencies in the historical part of the time series (both minimum and maximum level), turned more coherent in the last 15 years, and then diverged again in the last couple of years. Besides, both models showed some problems in the diagnostics and an unusual drop in F from 2011 to 2012. Given the above considerations, the WGSASP did not find enough scientific evidence to support the choice of one model with respect to the other, therefore both were taken into account to provide management advice.

34. The WGSASP expressed concerns on the use of CPUE data as the only index of tuning in the assessment of small pelagic stocks. The issue rised with regard to the assessment carried out for anchovy and sardine in both GSA01 and GSA06: for some of these stocks an acoustic based index of abundance was available, however model results incorporating acoustic indexes were not satisfactory. Therefore, the final models chosen relied on CPUE data only, which showed a very similar trend to the landings, and therefore provided very little additional information to the model. The group expressed doubts on the reliability of those models, and suggested to: i) investigate the problems in the model fitting caused by the inclusion of acoustic indexes, and if necessary test alternative biomass models (e.g. Bayesian biomass delay models) which allow the inclusion of those indices; b) evaluate the trend in effort data to understand the relation between catches and CPUE; and c) evaluate the most appropriate CPUE estimate, independently to the performance of the assessment model with the different CPUE estimators.

35. The WGSASP appreciated the work done by the AdriaMed team and the involved Institutes for the successful application of an integrated survey that covered the entire Adriatic Sea and for the effort in the improvement of the DEPM method for GSA 18; nevertheless, it encouraged that the results are regularly presented at the WGSAs, since no data for the acoustic survey in GSA18 were available for the consideration of the ongoing meeting.

36. The WGSASP acknowledged the importance of strengthening the scientific cooperation towards standardization of echo-survey activities in Mediterranean. Such cooperation, which involved North African and European countries, especially those conducting MEDIAS, could be facilitated by the FAO Regional Projects CopeMed II, MedSudMed and EastMed within GFCM-SAC activities.

GSA 01 – Northern Alboran Sea

Sardine (*Sardina pilchardus*)

Authors: Torres, P., A. Giráldez, M. Iglesias, M. González

Fishery

The current fleet in GSA 01 (Northern Alborán Sea) is composed by 91 units, characterised by small vessels, average TJB 23.8. 16% of them are smaller than 12 m (operational Unit 1), 84% > 12 m (operational Unit 2), and no one bigger than 24m. The purse seine fleet has been continuously decreasing in the last two decades, from more than 230 vessels in 1980 to 91 in 2012. A strong reduction of larger vessels occurred from 1985 onwards, possibly linked to a decreasing in anchovy catches in Northern Morocco, where a part of that fleet fished under agreement between the countries. Subsequently the fleet continued to decline but more slowly.

Although sardine has a lower price than anchovy, it is an important support to the fishery as it is the most fished species. Catches in the period 1990-2012 has been highly variable, with a minimum of 3000 tons in 1997. Higher catches occurred in 1992 (11000 tons). All period average is about 6000 tons.

The two operational units fish the same species with no major differences, being sardine the most fished species in both. There is a slight difference only in the percentage of mackerel catches, since bigger ships are able to fish species with more swimming ability.

Species with a lower economical value are also captured, sometimes representing a high percentage of landings: horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.), and gilt sardine (*Sardinella aurita*). The interest about some of these species has been increasing because there is a new market for them; gilt sardine and mackerel, especially the first, are sold for tuna farming. A requirement for such sales is a high yield by fishing day, due to its low economic value.

Series of CPUE shows a very similar profile to catches.

Data and parameters

The input data used for the adopted modelling approach was total yearly catch (tons) and as an abundance index CPUE (Catch per unit effort, kg fished considering all trips of the gear) over the period (2003-2012), assuming that CPUE is an indicator of the stock abundance.
Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated with DCF data collected in GSA01 in 2012, running the last version of the program INBIO 2.0 (Sampedro *et al*., 2005, up dated 2012 pers. Comm.). Natural mortality was estimated following Pauly (1980) and a reference exploitation rate E=0.4 following Patterson (1992).

Assessment method

A modelling approach based on the fitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indexes, allowing for the optional incorporation of an environmental index, so that the r and/or K parameters of each year can be considered to depend on the corresponding value of the applied index. In the actual case two different environmental indexes were tested: average chlorophyll-a concentration over the continental shelf and North Atlantic Oscillation (NAO), but neither of them showed any improvement in the model fit.

Model performance

The quality of input data is excellent and the obtained output is satisfactory. Hence the results of the adopted modeling approach are consistent with the trend of the longer landing series.

The goodness of the best fit obtained using the surplus production modeling approach is also satisfactory ($R_{pearson}$ Index=0.53). Pearson linear regression coefficient will not detect a non-linear relation, but will measure how closely the predicted abundance indices follow the observed ones.

Results

The results based on the implementation of a non-equilibrium logistic surplus production model are consistent with the previous considerations about trends observed in the landings, showing a current stock of 16314 tons for 2012. The fishery would be at a sustainably exploited situation. Furthermore, the exploitation rate corresponding to F=0.33 and M=0.59, estimated with Pauly (1980) empirical equation, is E= 0.36 which is a lower than the reference point for the exploitation rate of 0.4 suggested by Patterson (1992), so this stock could be considered as being sustainably exploited.

Table 1. Reference points 2012

MSY	B_{MSY}	F_{MSY}	$F_{0.1}$	F_{Cur}	B_{Cur}/B_{MSY}	F_{cur}/FSY_{Cur}	F_{cur}/F_{MSY}
6961	12409	0.56	0.50	0.33	1.31	0.87	0.59

Diagnose of stock status

Sustainable exploited. Trend in landings is stable. Exploitation rate is lower than the Patterson's reference point (E=0.36). B_{Cur}/B_{MSY}=1.31, Fcurrent (0.33) is below $F_{0.1}$(0.5).

Exploitation rate		Stock Abundance	
1990-2012		199-2012	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
X	Sustainable Fishing Mortality	**X**	Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Advices and recommendations

Not to increase fishing mortality.

GSA 01 – Northern Alboran Sea

Anchovy (*Engraulis encrasiclous*)

Authors: Giráldez A., P. Torres, M. Iglesias, M. González

Fishery

The current fleet in GSA 01 (Northern Alborán Sea) is composed by 91 units, characterised by small vessels, average GT 23.8. 16% of them are smaller than 12 m (operational Unit 1), 84% > 12 m (operational Unit 2), and no one bigger than 24m. The purse seine fleet has been continuously decreasing in the last two decades, from more than 230 vessels in 1980 to 91 in 2012. A strong reduction of larger vessels occurred from 1985 onwards, possibly linked to a decreasing in anchovy catches in Northern Morocco, where a part of that fleet fished under agreement between the countries. Subsequently the fleet continued to decline but more slowly.

Anchovy is the main target species of the purse seine fleet in Northern Alboran Sea, due to its high economic value, although its abundance is low and very local. Catches in the period 1990-2012 has been highly variable, with a minimum of 157 tons in 1993. Higher catches occurred in 1996 and in 2001-02, when were caught between 2000 and 3200 tons of anchovy. The whole period average is 855 tons. In the early twenties of the last century, anchovy was fished all around the Alboran Sea, but currently Málaga Bay is the only area where anchovy is fished throughout all the year and where more than 80% of catches are located. The fishery of anchovy in the Malaga Bay is exclusively focused on individuals from early age classes because older age classes are not found: almost all the catch correspond to class 0 and 1. Years with higher catches are usually correlated with a successful and high recruitment period, while unsuccessful recruitment in a given year is correlated with a low level of catch.

The two operational units fish the same species with no major differences, being sardine the most fished species in both. There is only a slight difference in the percentage of mackerel catches, as bigger ships are able to fish species with more swimming ability.

Species with a lower economical value are also fished, sometimes representing a high percentage of landings: horse mackerel (*Trachurus* spp.), mackerel (*Scomber* spp.), and gilt sardine (*Sardinella aurita*). The interest about some of these species has been increasing as there is a new market for them; gilt sardine and mackerel, especially the first, are sold for tuna farming. A requirement for such sales is a high yield by fishing day, due to its low economic value.

Data and parameters

The input data used for the adopted modelling approach was total yearly catch (tons) and as an abundance index CPUE (Catch per unit effort, kg fished considering all trips of the gear) over the period (2003-2012), assuming that CPUE is an indicator of the stock abundance.

Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated with DCF data collected in GSA01 in 2012, running the last version of the program INBIO 2.0 (Sampedro *et al*., 2005, up dated 2012 pers. Comm.). Natural mortality was estimated following Pauly (1980) and a reference exploitation rate E=0.4 following Patterson (1992).

Assessment method

A modelling approach based on the fitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indexes, allowing for the optional incorporation of an environmental index, so that the r and/or K parameters of each year can be considered to depend on the corresponding value of the applied index. In the actual case were tested two different environmental indexes: average chlorophyll-a concentration over the continental shelf and North Atlantic Oscillation (NAO), neither of them showed any improvement in the model fit.

Model performance

The quality of input data is excellent, but the output obtained with Biodyn is inconsistent with the exploitation rate.

The goodness of the best fit obtained using the surplus production modeling approach is satisfactory ($R_{pearson}$ Index=0.57). Pearson linear regression coefficient will not detect a non-linear relation, but will measure how closely the predicted abundance indices follow the observed ones.

Results

The diagnostics of fit provided by Byodin shows a satisfactory result ($R_{pearson}$ Index=0.57) and a current stock of 980 tons. The reference points provided from the Byodin model indicate a situation of <u>overexploited</u>. Nevertheless, the exploitation rate F/Z corresponding to F=0.28 and M=0.92, estimated with Pauly (1980) empirical equation, is E=0.23 which is lower than the reference point for the exploitation rate of 0.4 suggested by Patterson (1992), meaning this stock should be considered as being sustainably exploited. In this case exploitation rate do not coincide with the Biodyn result. Due to the inconsistency results obtained it was tested the same series of data with ASPIC (A Stock-Production Model Incorporating Covariates ver. 5, Michael H. Prager, 2005) obtaining F=0.54 and E=0.37, once again it should be a sustainable exploited stock. According to the landing longer series there is not any clear trend. Preliminary landings data from 2013 shows a great increase (1660 tons), around 6 times greater than 2012 landing. Furthermore the average biomass assessed in ECOMED surveys, regardless of the exceptional year of 2001, is about 1000 tons in the Málaga Bay.

Table 1. Reference points 2012

MSY	B_{MSY}	F_{MSY}	$F_{0.1}$	F_{Cur}	B_{Cur}/B_{MSY}	F_{cur}/FSY_{Cur}	F_{cur}/F_{MSY}
414	1249	0.33	0.30	0.28	0.78	0.70	0.85

Diagnose of stock status
Uncertain, with high fluctuations and population concentrated on first age classes.

Exploitation rate		Stock Abundance	
2003-2012		2003-2012	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality		Low abundance
x	Uncertain/Not assessed		Depleted
		x	Uncertain / Not assessed

Advices and recommendations
The population may have a high pressure on juveniles, and this decrease the probability to reconstruct the adult population.

GSA 03 – Southern Alboran Sea

Sardine (*Sardina pilchardus*)

Authors: I. My Hachem and O. Kada

The landings of sardine in the Moroccan Mediterranean Sea are of primary importance compared to other species, with an average annual production of 12000 tonnes in the last 10 years. Exploitation of sardine is practiced essentially by purse seiners belonging to seven ports.
The evaluation of the state of sardine stock is carried out with a Length Frequency Analysis (LCA) using the VIT software (Lleonart et Salat, 1997), based on data from 2012.
The intensity of fishing during this year was especially important on juveniles (between 10 and 11 cm) and adult individuals (between 18 and 20 cm).
Given the yield per recruit analysis of data relating to the year 2012, it appears that the sardine stock in the Moroccan Mediterranean is fully exploited.

The average exploitation rate E is estimated equal to 0.56 (upper threshold value F/Z = 0.4 suggested as a biological reference point for small pelagics (Patterson, 1992)). Therefore, the exploitation rate may be considered high.
Given the current state of the stock and in order to ensure a sustainable exploitation of the sardine stock, it is recommended to:

- Not increase fishing effort;
- Reduce fishing mortality on spawning stock by introducing a biological rest period in January, which coincides with the peak of spawning;
- Prohibit fishing during the month of May near Ras Kebdana to preserve juveniles.

GSA 06 – Northern Spain

Sardine (*Sardina pilchardus*)

Authors: Torres, P., A. Giráldez, M. Iglesias, M. González, A. Ventero and N. Díaz

Fishery
The current fleet in GSA 06 (Northern Spain) is composed by 130 units (average GT 38.9), 3% of them are smaller than 12 m (operational Unit 1), 97% > 12 m (operational Unit 2) and 13% are over 24m. The purse seine fleet has been continuously decreasing in the last two decades, from 222 vessels in 1990 to 130 in 2012. They have lost the smallest units.
Sardine, even if with a lower price than anchovy, was an important support to the fishery until 2009 as it was the most fished species. In the period 1990-2012 sardine landings show a negative trend, between 53000 t in 1994 to 9000 t in 2012. The whole period average is 30000 t.
The catches evolution is consistent with result of acoustic assessments.

Data and parameters
The input data used for the adopted modelling approach was total yearly catch (Tons) and as an abundance index CPUE (Catch per unit effort, kg fished considering only trips of the gear with landing of the specie) over the period (2003-2012), assuming that CPUE is an indicator of the stock abundance.
Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated with DCF data collected in GSA06 in 2012, running the last version of the program INBIO 2.0 (Sampedro *et al*., 2005, last update 2012 pers. Comm.). Natural mortality was estimated following Pauly (1980) and a reference exploitation rate E=0.4 following Patterson (1992).
Biomass data series of acoustic surveys Medias and Ecomed.

Assessment method
A modelling approach based on the fitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indexes, allowing for the optional incorporation of an environmental index, so that the r and/or K parameters of each year can be considered to depend on the corresponding value of the applied index. In the actual case were tested two different environmental indexes: average chlorophyll-a concentration over the continental shelf and North Atlantic Oscillation (NAO), but neither of them showed any improvement in the model fit.

Model performance
The quality of input data is excellent and the obtained output is satisfactory.
The goodness of the best fit obtained using the surplus production modeling approach is also satisfactory ($R_{pearson}$ Index=0.71). Pearson linear regression coefficient will not detect a non-linear relation, but will measure how closely the predicted abundance indices follow the observed ones.

Results

The results based on the implementation of a non-equilibrium logistic surplus production model, are consistent with the previous considerations about trends observed in the acoustic surveys. Although the model predict a current stock of 21684 tons and the acoustic survey 43296 tons both for 2012. Hence the fishery would be at an overexploited situation, although not at such a low level (B_{Cur}/B_{MSY}=0.37) as the MEDIAS acoustic survey shows (B_{Cur}/B_{MSY}=0.73). Furthermore, the exploitation rate F/Z corresponding to F=0.42 and M=0.49, estimated with Pauly (1980) empirical equation, is E= 0.46 which is a little bit higher than the reference point for the exploitation rate of 0.4 suggested by Patterson (1992), so this stock could be considered as being slightly overexploited.

Table 1. Reference points 2012

MSY	B_{MSY}	F_{MSY}	$F_{0.1}$	F_{Cur}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
16307	59298	0.28	0.25	0.42	0.37	0.93	1.5

Diagnose of stock status

Overexploited and in overexploitation. Both landings and CPUE decreasing. Exploitation rate is higher than the Patterson's reference point (E = 0.46). Fcurrent (0.42) is higher than the $F_{0.1}$ reference point (0.25). Bcurrent is below BMSY (B_{curr}/B_{MSY}=0.37).

Exploitation rate		Stock Abundance	
1990-2012		1990-2012	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
x	High fishing mortality	**x**	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1990-2012		1990-2012	
[Range]		[Range]	
	Stable		Stable
	Increasing		Increasing
x	Decreasing		Decreasing

Advices and recommendations:

Reduce fishing mortality. Apply a multiannual management plan.

GSA 06 – Northern Spain

Anchovy (*Engraulis encrasiclous*)

Authors: Giráldez A., P. Torres, M. Iglesias, M. González, A. Ventero and N. Díaz

Fishery

The current fleet in GSA 06 (Northern Spain) is composed by 130 units, average GB is 38.9. About 3% of them are smaller than 12 m (operational Unit 1), 97% > 12 m (operational Unit 2) and 13% are over 24m. The purse seine fleet has been continuously decreasing in the last two decades, from 222 vessels in 1990 to 130 in 2012. They have lost the smallest units.

Anchovy is the main target species of the purse seine fleet in Northern Spain due to its high economic value. Catches in the period 1990-2012 has been highly variable, with a minimum of 2800 tons in 2007 and an average of 11500 tons. Higher catches occurred in the period 1990-94, they were caught between 17000 and 22000 tons. Thereafter it has been continuously decreasing with three recoveries in 2002, 2009 and 2012. In 2012 shows higher catches, but still half of the landings occurred between 1990 and 1994. Years with higher landings are usually correlated with a successful and high recruitment period, while unsuccessful recruitment in a given year is correlated with a low level of landings.

The catches evolution is consistent with the result of acoustic assessments.

Data and parameters

The input data used for the adopted modelling approach was total yearly catch (tons) and as an abundance index CPUE (Catch per unit of effort, kg fished considering all trips of the gear) over the period (1990-2012), assuming that CPUE is an indicator of the stock abundance.

Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated with DCF data collected in GSA06 in 2012, running the last version of the program INBIO 2.0 (Sampedro *et al*., 2005, last update 2012 pers. Comm.). Natural mortality was estimated following Pauly (1980) and a reference exploitation rate E=0.4 following Patterson (1992).

A biomass data series of acoustic surveys Medias was available as well.

Assessment method

A modelling approach based on the fitting of a non-equilibrium surplus production model (BioDyn package; FAO, 2004) on the series of observed abundance indexes, allowing for the optional incorporation of an environmental index, so that the r and/or K parameters of each year can be considered to depend on the corresponding value of the applied index. In the actual case were tested two different environmental indexes: average chlorophyll-a concentration over the continental shelf and North Atlantic Oscillation (NAO), neither of them showed any improvement in the model fit.

Scientific surveys are not incorporated in the assessment model, but results of the assessment model are compared with absolute estimates from the acoustic survey for comparation/validation purposes.

Model performance

The quality of input data is excellent and the obtained output is satisfactory. Hence the results of the adopted modeling approach are consistent with those ones obtained from the acoustic surveys series.

The goodness of the best fit obtained using the surplus production modeling approach is also satisfactory ($R_{pearson}$ Index=0.61). Pearson linear regression coefficient will not detect a non-linear relation, but will measure how closely the predicted abundance indices follow the observed ones.

Results

The results based on the implementation of a non-equilibrium logistic surplus production model, are consistent with the previous considerations about trends observed in the acoustic surveys. Biodyn shows a current stock of 63053 tons and the acoustic survey 66948 tons both for 2012. The fishery would be at a sustainably exploited situation. Furthermore, the exploitation rate F/Z corresponding to F=0.18 and M=0.58, estimated with Pauly (1980) empirical equation, is E= 0.24 which is a lower than the reference point for the exploitation rate of 0.4 suggested by Patterson (1992), so this stock would be considered as being sustainably exploited.

Table 1. Reference points 2012

MSY	B_{MSY}	F_{MSY}	$F_{0.1}$	F_{Cur}	B_{Cur}/B_{MSY}	F_{cur}/FSY_{Cur}	F_{cur}/F_{MSY}
11854	47209	0.25	0.23	0.18	1.34	1.09	0.72

Diagnose of stock status

Sustainable exploited. Increasing trend in landings and biomass from acoustic survey. $F_{current}$ (0.18) is lower than F_{msy} reference point (0.25). Exploitation rate is lower than the Patterson's reference point (E=0.24). Current biomass is above B_{MSY}.

Exploitation rate		Stock Abundance	
1990-2012		1990-2012	
	No fishing mortality		Virgin
	Low fishing mortality	x	High abundance
x	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1990-2012		1990-2012	
[Range]		[Range]	
	Stable		Stable
x	Increasing		Increasing
	Decreasing		Decreasing

Advices and recommendations

Not to increase fishing mortality.

GSA 07 - *Changes in growth, condition, size and age of small pelagic fish in the Gulf of Lions*

Authors: C. Saraux, E. Van Beveren, P. Brosset, J-L Bigot, S. Bonhommeau, J-M Fromentin

Since 2007 the Gulf of Lions shifted to a different regime, characterised by a decreased anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) biomass and the explosion of sprats (*Sprattus sprattus*). We developed the EcoPelGol program in order to better understand these changes and the population dynamics of these species. First, we investigated the magnitude and the timing of changes in growth, body condition and size and age structure of anchovy, sardine and sprat over the last 20 years, using PELMED data. The decrease in sardine and anchovy biomass has been associated with a decrease in fish size and mean weight due to a combination of growth problems and disappearance of the oldest fish. On top of this, all 3 species are in poorer body condition than they were 10 years ago. Following these results, we investigated the determinants of body condition in more details and found that the relationship between condition and age has been reversed in these past years, older fish being in poorer condition. Finally, we will adapt the algorithm PHYSAT to a regional scale in order to track potential changes in phytoplankton community over the past 15 years to test for a bottom-up hypothesis.

GSA 07 - Gulf of Lions

Sardine (*Sardina pilchardus*)

Authors: J-L. Bigot, J-H. Bourdeix, C. Saraux
IFREMER BP171 Av. Jean Monnet 34203 SETE CEDEX (France)

Fisheries

The fishing effort has changed, as most sardines were landed by purse seines instead of trawlers this year. Fishing effort and landings from trawlers kept decreasing, while the number of purse-seiner landing sardines increased. The total catch is similar to that of 2011. Most regulations (no fishing activity during the week-end, length of trawlers, etc.) are fully respected, the limitation of engine power for trawlers being the only one not to.

Biological data and parameters

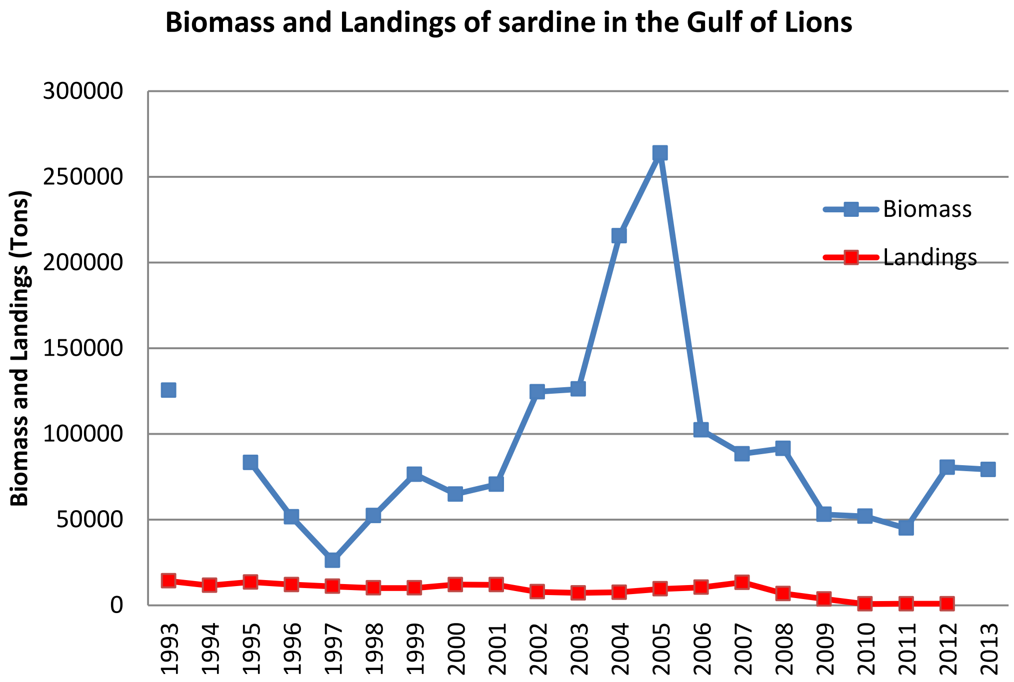
Morphometric parameters were obtained directly onboard during the scientific survey, while samples were taken back to the lab for age determination and reproductive parameter analysis. Length-weight relationships were thus obtained. Important trends have been detected in sardine biological parameters. The current situation shows small individuals, as a result of a lower growth and the disappearance of old individuals. Individuals are also in a poor body condition (i.e. low reserves).

Assessment method: Direct method by acoustics.

Sampling was performed in July along 9 parallel and regularly interspaced transects (inter-transect distance = 12 nautical miles). Acoustic data were obtained by means of echosounders (Simrad ER60) and recorded at constant speed of 8 nm.h-1. The size of the elementary distance sampling unit (EDSU) is 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output. Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a 30 min-trawl at 4 nm.h-1 in order to evaluate the proportion of each species (by randomly sampling and sorting of the catch before counting and weighing each individual species). A total of 33 trawls were conducted. While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminarily treated with Movies + software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts. A combination of two methodologies (assessment by mean weight and length or by size class) and 3 echotrace allocation scenarios have been tested, resulting in 6 biomass estimates. Sardine biomass estimate was judged reliable as the coefficient of variation associated with it equals 3.2%. Biomass could be slightly underestimated as more energy than usual was detected close to the surface and that surface energy is not well estimated due to the small angle of the acoustic sounder.

Results

	Biomass in metric tons	fish numbers	Blim	Bpa	
Sardine	79 181	7927.861 millions			
Anchovy	18 366	2685.862 millions	22 889	45 778	
Sprat	46 977	9969.930 millions			



Biomass stabilized at a similar level as last year. Yet, this level is still low compared to what had been observed in the past. Further, a retrospective work on biological parameters (from 93 to 2012) showed that sardines were presently smaller, younger, grew less and were in poorer condition than before (Van Beveren *et al*. submitted). In particular, the population is now composed almost only by age 0 and 1 individuals. High recruitment levels for the last years have enabled the biomass to stabilize at intermediate levels. However, the truncation of the age structure and problems in growth and body condition indicate a stock in a poor state. A similar signal has been detected in anchovies suggesting that it may translate changes in the whole ecosystem coming from the environment.

Diagnose of Stock status

Exploitation rate		Stock Abundance	
1993-2012		1993-2012	
	No fishing mortality		Virgin
x	Low fishing mortality		High abundance
	Sustainable Fishing Mortality	**x**	Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1993-2012		1993-2012	
[Range]		[Range]	
x	Stable	x	Stable
	Increasing		Increasing
	Decreasing		Decreasing

The stock is judged unbalanced. The biomass has stabilized at intermediate values for the last two years and recruitments are still high. Yet, biological parameters indicate important problems in the population age structure (disappearance of fish older than 1), as well as poor growth and low body condition. The small size of the fish is preventing fishermen to target sardines and landings continued decreasing.

Advice and recommendation
All the biological 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 additional sources of mortality to this already depleted population, even if the system is not controlled by human activity. Therefore, fishing mortality should not be allowed to increase. Further, the change observed in the effort of purse-seiner needs to be closely monitored.

GSA 07 - Gulf of Lions

Authors: Jean-Louis Bigot, Jean-Hervé Bourdeix, Claire Saraux
IFREMER BP171 Av. Jean Monnet 34203 SETE CEDEX (France)

Fisheries:
Both pelagic trawlers and purse seines are present in the Gulf of Lions. However, the number of boats has been decreasing these last few years and the fleet now contains 7 trawlers targeting anchovies and sardines at the same time and 3 purse-seines targeting mostly sardines but also landing a few anchovies. As a consequence, the total catches have also been decreasing with less than 2000 T caught. Most regulations (no fishing activity during the week-end, length of trawlers, etc.) are fully respected, the limitation of engine power for trawlers being the only one not to.

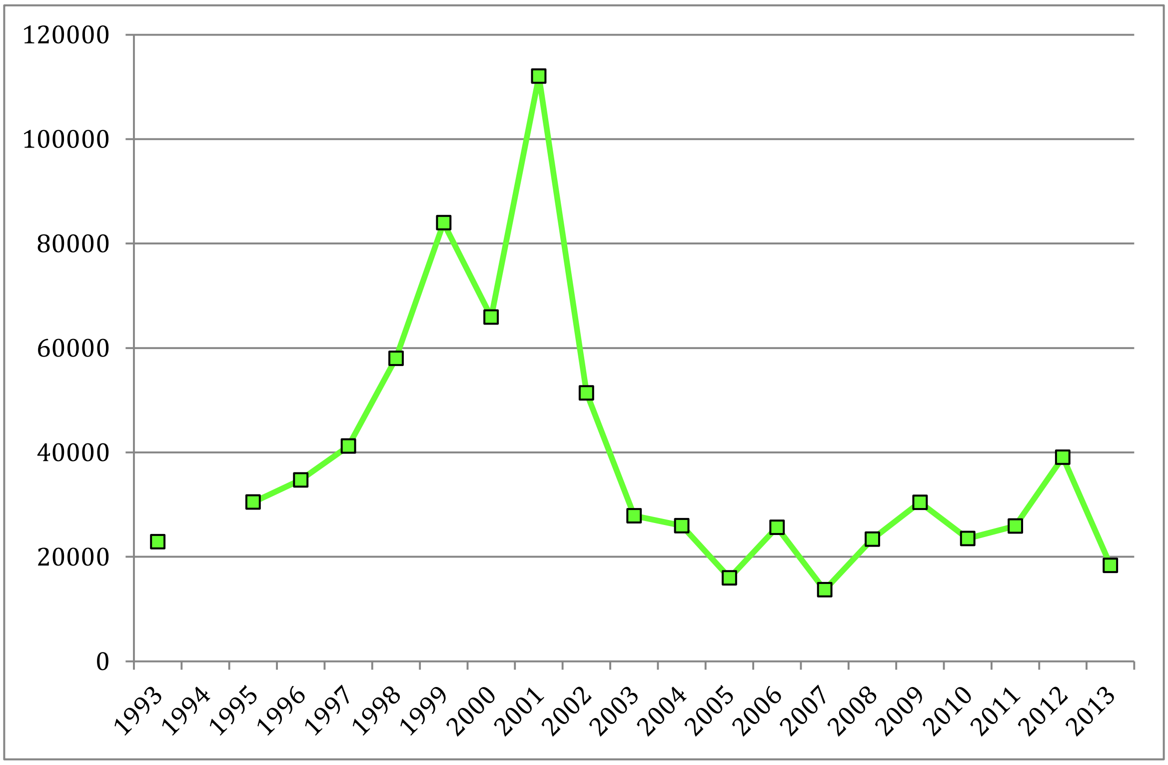
Biological parameters
Morphometric parameters were obtained directly onboard during the scientific survey, while samples were taken back to the lab for age determination and reproductive parameter analysis. Length-weight relationships were thus obtained. A retrospective work on biological parameters (from 93 to 2012) showed that anchovies were presently smaller, grew less and were in poorer condition than before (Van Beveren et al. submitted)

Assessment method: Direct method by acoustics
Sampling was performed in July along 9 parallel and regularly interspaced transects (inter-transect distance = 12 nautical miles). Acoustic data were obtained by means of echosounders (Simrad ER60) and recorded at constant speed of 8 nm.h-1. The size of the elementary distance sampling unit (EDSU) is 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output. Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a 30 min-trawl at 4 nm.h-1 in order to evaluate the proportion of each species (by randomly sampling and sorting of the catch before counting and

weighing each individual species). A total of 33 trawls were conducted. While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminarily treated with Movies + software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts. A combination of two methodologies (assessment by mean weight and length or by size class) and 3 echotrace allocation scenarios have been tested, resulting in 6 biomass estimates. Anchovy biomass estimate was judged reliable as the coefficient of variation associated with it equals 5.8%. Biomass could be slightly underestimated as more energy than usual was detected close to the surface and that surface energy is not well estimated due to the small angle of the acoustic sounder.

Results

	Biomass in metric tons	fish numbers	Blim	Bpa	
Anchovy	18 366	2685.862 millions	22 889	45 778	
Sardine	79 181	7927.861 millions			
Sprat	46 977	9969.930 millions			



Biomass is almost at its lowest, as are the landings. The fishing effort has again been decreasing, but this had not enabled the stock to recover yet. Further, similar changes in anchovy and sardine biological parameters suggest that it may translate changes in the whole ecosystem coming from the environment. All these negative signs indicate that the stock is doing poorly.

Diagnose of Stock status:

Exploitation rate		Stock Abundance	
1993-2012		1993-2012	
	No fishing mortality		Virgin
X	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
	High fishing mortality		Low abundance
	Uncertain/Not assessed	X	Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1993-2012		1993-2012	
[Range]		[Range]	
	Stable		Stable
	Increasing		Increasing
x	Decreasing		Decreasing

The stock is judged depleted due to its very low biomass and low commercial-sized anchovy abundance. Current biomass is below Blim (22889). The exploitation level is low and the declining trend in biomass and landings is supposed to be driven mainly by exogenous environmental factors.

Advice and recommendation:
The working group recommends to implement a recovery plan, which could include pursuing the monitoring of biological parameters and limiting fishery effort to allow recovery.

GSA 16 – Southern Sicily

Sardine (*Sardina pilchardus*)

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

Fisheries: Purse seiners, pelagic pair trawlers

In GSA 16, the two operational units (OU) 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 1998-2012 were about 1,400 metric tons, with a general decreasing trend. The production dramatically decreased in 2010 (-70%), but increased again above the average in 2011 and 2012. 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 (2012) acoustic biomass is at intermediate level.

Landings data from Sciacca port were used for the stock assessment because of their importance (they accounts for about 2/3 of total landings; Patti *et al.*, 2007) in GSA 16 and the availability of a longer time series (1998-2012) compared to the official DCF data for the whole GSA 16 (2004-2012).

Biological parameters

Landings data for GSA16 were obtained from DCF for the years 2006-2012 and from census information (on deck interviews) in Sciacca port (1998-2012). Acoustic data were used for fish biomass evaluations over the period 1998-2012. 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 1998-2012. Available data were used to estimate yearly and average (2009-2012) 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 based on estimation of yearly and average (2008-2012) 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 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. 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 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.

Results

Annual harvest rates, as estimated by the ratio between total landings and stock sizes, indicated relatively low fishing mortality during the last decade.

The current (year 2012) harvest rate is 14.0% (DCF data were used for landings). The estimated average value over the years 2009-2012 is 10.4%.

The exploitation rate (E) corresponding to F=0.104 is E=0.12, if M=0.77, estimated with Pauly (1980) empirical equation, is assumed, and E=0.13 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 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 about trends in harvest rates and in estimated exploitation rates.

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.

Model performance was quite poor (R^2 = 0.31) if no environmental effect is incorporated in the model. The best fit with the inclusion of the selected environmental factor (R^2 = 0.75) was obtained when assuming in the model formulation a flexible carrying capacity, which was found to be positively affected by chlorophyll-a concentration at sea (exponential effect).

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. The current (year 2012) fishing mortality (F_{Cur}= 0.18) is below the sustainable fishing mortality at current biomass levels (FSY_{Cur}=0.24; F_{Cur}/FSY_{Cur}=0.74) but above F_{MSY} (F_{MSY}=0.16; F_{Cur}/F_{MSY}=1.11) (Table 1). Fishing mortality experienced quite high values during the considered period, sometimes above sustainability (F_i/ F_{MSY} >1). In addition, abundance was low over the last decade (B_{MSY} = 32,830; B_{Cur}/B_{MSY} = 0.50). However, the average production of the last three years (1,437 tons) is well below the estimated MSY (5,300 tons).

Table 1: Reference points, 2012 data.

MSY	**B_{MSY}**	**F_{MSY}**	**B_{Cur}/B_{MSY}**	**F_{Cur}/FSY_{Cur}**	**F_{Cur}/F_{MSY}**
5,300	32,830	0.16	50%	74%	111%

	Biomass in metric tons (MEDIAS 2012 data)	**fish numbers (MEDIAS 2012 data)**	**B_{lim}**	**B_{pa}**	**B_{MSY}**
Sardine	13,407	817,500,018	7,274	18,185	32,830

Diagnose of Stock status

The present diagnosis of stock status is based on the evaluation of current exploitation pattern, on the results of the appplication of a non-equilibrium surplus prodoction models and on estimated biomass levels. The adopted reference points (RP) for fishing mortality were E=0.4 (Patterson) and F_{MSY}, whereas for biomass level the WG proposed the use of both B_{MSY} and a new set of RP (B_{lim} and B_{pa}) as defined below.

Results of the adopted modeling 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 from year 2000 onward the stock status was well below the B_{MSY}.

In addition, the stock in 2012 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.

A tentative B_{lim} was discussed and adopted by the WG as 0.2*Bvirgin (Serchuck *et al.*, 1999 – also FAO; STECF 2012). Similarly, B_{pa} was established as 0.5*Bvirgin. Bvirgin was fixed as the maximum biomass values observed in the series (B_{y2000}=36,370 tons).

Using the above reported RPs, the current biomass estimate (13,407 tons, 2012 value) is well below B_{MSY} (32,830 tons), and even below B_{pa} (18,185 tons), but above the estimated B_{lim} (7,274 tons) (Figure 1).

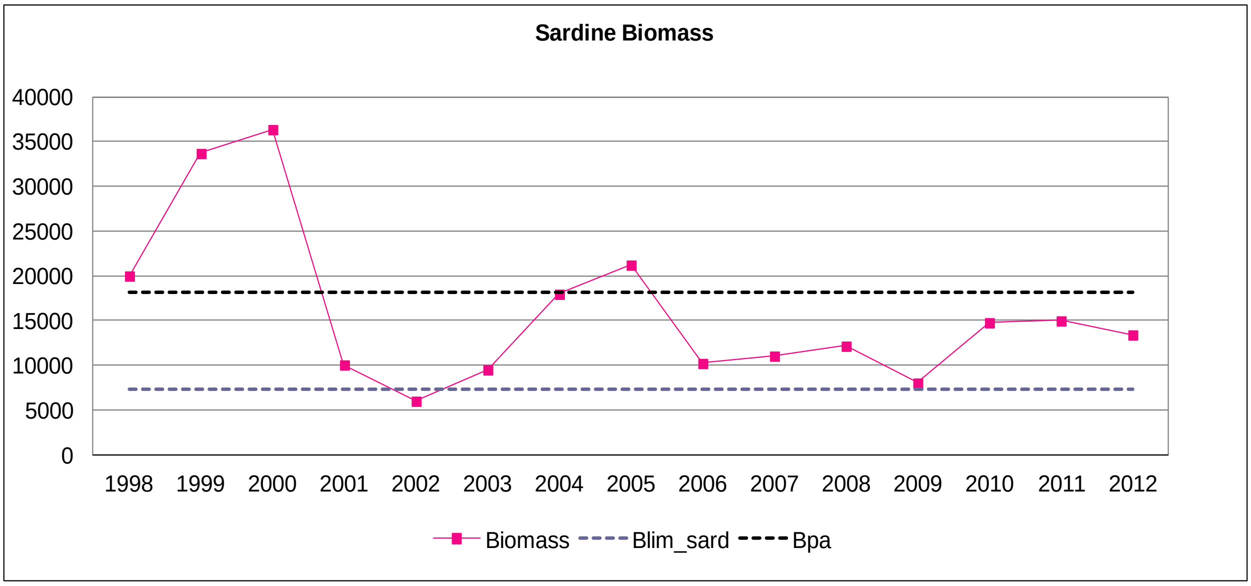


*Figure 1: Trends in sardine biomass (tons), years 1998-2012. Blim=0.2*Bvirgin and Bpa=0.5*Bvirgin are also indicated.*

Exploitation rate		Stock Abundance	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
x	High fishing mortality	**x**	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1998-2012		N.A.	
6000-36370 tons		[Range]	
	Stable		Stable
	Increasing		Increasing
x	Decreasing		Decreasing

Based on the above consideration, the stock is to be considered as overexploited (overfished) and in overexploitation (subject to overfishing).

Advice and recommendation

Fishing mortality should be reduced by means of a multi-annual management plan.

GSA 16 – Southern Sicily

Anchovy (*Engraulis encrasicolus*)

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

Fisheries: Purse seiners, pelagic pair trawlers

In GSA 16, two operational units (OU) 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 in Sciacca port over the period 1998-2012 were about 2,000 metric tons, with large interannual fluctuations. Fishing effort remained quite stable over the last decade. Anchovy biomass, estimated by acoustic methods, experienced large interannual fluctuations, ranging from a minimum of 3,100 tons in 2008 to a maximum of 23,000 tons in 2001. Current (2012) acoustic biomass estimate is above the average over the considered period (14,319 vs. 11,320), with an increase of +182% respect to 2011 biomass estimate.

Landings data from Sciacca port were used for the stock assessment because of their importance (they accounts for about 2/3 of total landings; Patti *et al*., 2007) in GSA 16 and the availability of a longer time series (1998-2012) compared to the official DCF data for the whole GSA 16 (2004-2012).

Biological parameters

Landings data for GSA16 were obtained from DCF for the years 2006-2012 and from census information (on deck interviews) in Sciacca port (1998-2012). Acoustic data were used for fish biomass evaluations over the period 1998-2012. 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 1998-2012. Available data were used to estimate yearly and average (2009-2012) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey).

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 based on estimation of yearly and average (2008-2012) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey);
- A modelling approach based on the fitting 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 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. 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. As anchovy biomass estimates are based on acoustic surveys carried out during the summer and, they in general would not include the effect of the annual recruitment of the population.

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.

Results

The high and increasing yearly harvest rates, as estimated by the ratio between total landings and stock sizes, indicate high fishing mortality levels.

However the current (year 2012) harvest rate is 18.3% (DCF data), much lower compared the 2011 estimate (79.3%). The estimated average value over the years 2009-2012 is 41.4%.

The exploitation rate (E) corresponding to F=0.41 is E=0.38, if M=0.66, estimated with Pauly (1980) empirical equation, is assumed, and E=0.42 if M=0.56, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. Consequently, considering as reference point for the exploitation rate the 0.4 value suggested by Patterson (1992), this stock could be considered as subjected to overfishing.

The results of the second assessment approach, which is based on the implementation of a non-equilibrium logistic surplus production model, are not satisfactory in terms of model fitting but consistent with the previous considerations about trends in harvest rates and in estimated exploitation rates.

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.

Model performance was very poor (R^2 = 0.05) without incorporating the environmental effect, significantly higher (R^2 = 0.33) when adopting in the model formulation a variable population intrinsic growth rate *r*, considered to be positively affected by chlorophyll-a concentration at sea (exponential effect).

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 2012) fishing mortality (F_{Cur}= 0.17) is above the sustainable fishing mortality at current biomass levels (FSY_{Cur}=0.09; F_{Cur}/FSY_{Cur}=191%) and above F_{MSY} (F_{MSY} =0.07; F_{Cur}/F_{MSY}=260%; see Table 1). Fishing mortality experienced very high values during the considered period, frequently well above sustainability (F_i/ F_{MSY} >1; Fig. 6.2.2-2). In addition, B_i/B_{MSY} values were below 100% over the entire time series (B_{MSY} = 21,908 tons; B_{Cur}/B_{MSY} = 64%), and estimated average production of the period 2010-2012 (3,617 tons; DCR data) is well above the MSY (1,449 tons).

Table 1: Reference points, 2012.

MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
1,449	21,908	0.07	64%	191%	260%

	Biomass in metric tons (MEDIAS 2012 data)	fish numbers (MEDIAS 2012 data)	B_{lim}	B_{pa}	B_{MSY}
Anchovy	14,319	913,387,428	4,950	11,475	21,908

Diagnose of Stock status

The present diagnosis of stock status is based on the evaluation of current exploitation pattern and biomass levels. The adopted reference points (RP) for fishing mortality were E=0.4 (Patterson) and F_{MSY}, whereas for biomass level the WG proposed the use of both B_{MSY} and a new set of RPs (B_{lim} and B_{pa}) as defined below.

Results of the adopted modeling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels and indicate that the stock abundance was below the B_{MSY} during the last years.

In addition, fishing levels over the last years are increasing and higher than those required for extracting the MSY of the resource.

A tentative B_{lim} was discussed and adopted by the WG as 0.2*Bvirgin (Serchuck *et al.*, 1999 – also FAO; STECF 2012). Similarly, B_{pa} was established as 0.5*Bvirgin. Bvirgin was fixed as the maximum biomass values observed in the series (B_{y2001}=22,950 tons).

Using the above reported RP, the current biomass estimate (14,319 tons, 2012 value) is below B_{MSY} (21,908 tons), but it is well above the adopted estimated B_{lim} (4,950 tons) and also above B_{pa} (11,475 tons) (Fig. 1).

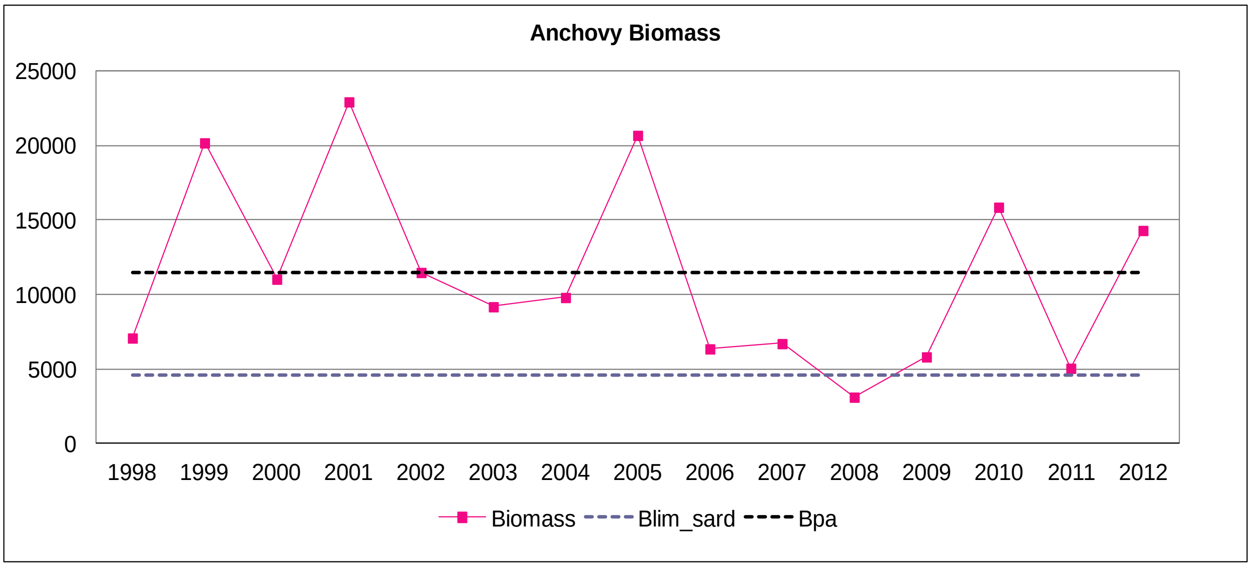


*Fig. 7-1: Trends in anchovy biomass (tons), years 1998-2012. Blim=0.3*Bvirgin and Bpa=0.5*Bvirgin are also indicated.*

Exploitation rate		Stock Abundance	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
x	High fishing mortality	**x**	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1998-2012		N.A.	
3,100-23,000 tons		[Range]	
	Stable		Stable
	Increasing		Increasing
x	Decreasing		Decreasing

Based on the above consideration, the stock is to be considered in overexploitation (subject to overfishing).

Advice and recommendation

Fishing mortality should be reduced by means of a multi-annual management plan.

GSA 17 – Northern Adriatic Sea

Sardine (*Sardina pilchardus*)

Authors: Carpi P., Angelini S., Belardinelli A., Biagiotti I., Campanella F., Canduci G., Cingolani N., Čikeš Keč V., Colella S., Croci C., De Felice A., Donato F., Leonori I., Martinelli M., Malavolti S., Modic T., Panfili M., Pengal P., Santojanni A., Ticina V., Vasapollo C., Zorica B., Arneri E.

Fishery

Sardines are fished by purse seiners 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 for purse seiners in Croatia. In 2011 the closure season for the Italian fleet was extended to 60 days (August and September).

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 were 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. In 2011 Slovenia had 5 actively fishing purse seiners and one active pair of pelagic trawlers.

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 2012. 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. The period covered by the present assessment goes from 1975 to 2012.

Echo-survey abundance index was used to tune the models. The echo-surveys were carried out for both the western and eastern side from 2004 onwards. Western echo-survey abundances were split into age classes by the means of length frequency distribution and age-length key coming from the western echo-survey. On the other hand, eastern echo-survey biomass was distributed into age classes by the means of proportion at length from the 2009 eastern echosurvey and age-length keys from the Croatian commercial fleet.

The 2011-2012 eastern echo-survey covered only about 50% of the total area: for this reason, an average percentage of the biomass in that area from the previous years (2004-2010) was estimated, and by that raised to the whole eastern area.

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 (Gislason, 2009). The growth parameters required by this method were derived from Sinovcic (1984).

Assessment method: State-Space Assessment Model (SAM).

Model performance

The diagnostics of the model did not show any problems: only acoustic residuals for ages 2 and 4 display some trends.

Results

The average fishing mortality for ages 2-5 starts increasing in 1995, reaching the maximum value of 1.013 in 2002. The estimate for 2012 is equal to 0.924.

The mid year spawning stock biomass fluctuates from the highest values in 1984 (about 586,000 tons) to a minimum in 1999 of 62,500 tons. After that the stock is constantly increasing: in 2012 reach the highest value registered in the last decade (220,577 tons).

The recruitment (age 1) fluctuates around a minimum value of 2,366,683 thousands specimen in 1999, to a maximum value of 22,053,900 in 1984. From 1999 the estimated recruitment is constantly increasing: the value for 2012 is equal to 15,157,409 thousands specimen.

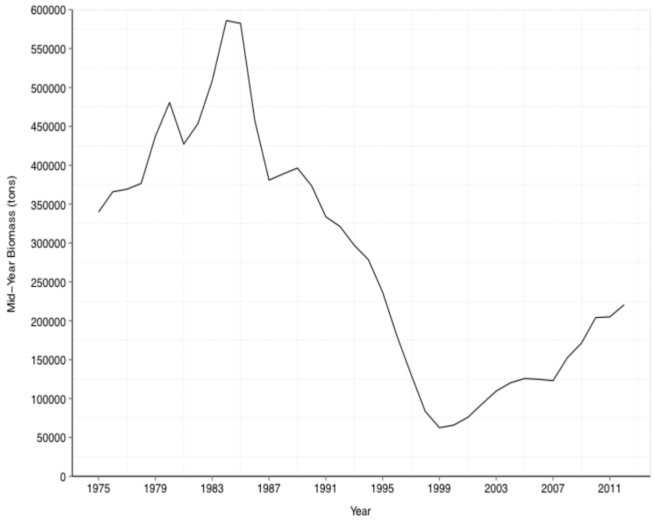


Figure 1: Mid-Year biomass from 1975 to 2012 for sardine in GSA17.

Diagnose of Stock status

The estimated biomass (B_{curr}=220,577 tons) is above both B_{lim} (78,000 tons) and B_{pa} (109,200 tons) estimated in 2012, and B_{lim} (62,505 tons) and B_{pa} (125,010 tons) based on the results of the assessment presented above, and the trend is constantly increasing. Nevertheless, since the exploitation rate $E_{(1-4)}$ is slightly higher than the empirical reference point of 0.4, the stock is to be considered “in high risk of overexploitation”.

Exploitation rate		Stock Abundance	
1975-2012		1975-2012	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality	**x**	Intermediate abundance
x	High fishing mortality		Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1975-2012		1975-2012	
[2010-2012]		[2010-2012]	
	Stable		Stable
x	Increasing	**x**	Increasing
	Decreasing		Decreasing

Advices and recommendations

The advice for sardine stock in GSA17 is not to increase the fishing mortality.

Small pelagic species, such as anchovy and sardine, are strongly dependent from massive recruitment event, often environmental driven, which exposes these stocks to wide fluctuations. Therefore, it is strongly recommended to continue explore the relationship between these species and the environment.

The WG recommend investigating the age-length structure and the age-length keys from both the eastern and western side since they showed some inconsistencies, possibly due to methodological differences.

GSA 17 – Northern Adriatic Sea

Anchovy (*Engraulis encrasicolus*)

Authors: Carpi P., Angelini S., Belardinelli A., Biagiotti I., Campanella F., Canduci G., Cingolani N., Čikeš Keč V., Colella S., Croci C., De Felice A., Donato F., Leonori I., Martinelli M., Malavolti S., Modic T., Panfili M., Pengal P., Santojanni A., Ticina V., Vasapollo C., Zorica B., Arneri E.

Fishery

Anchovies are fished by purse seiners 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 Croatian purse seiners. In 2011 the closure season for the Italian fleet was extended to 60 days (August and September).

Exploitation is based on all the age classes from 0 to 3+.

The Italian small pelagic fishery concentrates mainly on anchovy, while the Croatian catches mainly represent 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. In 2012 Slovenia had 5 actively fishing purse seiners and one active pair of pelagic trawlers.

Data and parameters

The data used for the present assessment derive from the catch recorded for the fleets of Italy, Croatia and Slovenia, from 1976 to 2012. The biological data of the species (available since 1976 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 and ALK coming from the western echo-survey. On the other hand, eastern echo-survey biomass was distributed into age classes by the means of proportion at length from the 2009 eastern echosurvey and age-length keys from the Croatian commercial fleet.

The 2011 and 2012 eastern echo-survey covered only about 50% of the total area: for this reason, an average percentage of the biomass in that area from the previous years (2004-2010) was estimated and by that raised to the whole eastern area.

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 (Gislason, 2010). The growth parameters required by this method were derived from Sinovcic *et al.* (2000).

Assessment method: Integrated Catch Analysis (ICA) and State-Space Assessment Model (SAM).

Model performance

The two models used for the assessment show several inconsistencies. Namely, ICA and SAM show some differences in the historical part of the time series (both minimum and maximum levels). Nevertheless, from 1997 the two models give the same results, with just a small discrepancy in the last couple of year.

Both the models showed some problems in the diagnostics: ICA partial residuals show a clear yearly trend; nevertheless, SAM shows strong trends in the residuals for the acoustic fitting for the ages 1 to 3 and a high Confidence Interval (CI) in the last year's estimations. Besides, both the models register an unusual drop in F in 2012.

The harvest rate seems consistent between the two models.

Given all the above considerations, we did not find enough scientific evidences to support the choice of one model respect to the other, therefore were both taken into account for management advises. Consequently, due to the uncertainty in the historical estimates, it was not possible to evaluate new reference points. Nevertheless, the percentile level of the current biomass was computed respect to the overall time series: from the ICA model, current biomass is in the 12th percentile, while from SAM model is in the 19th percentile.

Results

In ICA the total biomass shows fluctuations between higher and lower values since the beginning of the time series: the average stock biomass from 1976 to 2012 is 838,888 tons and the estimation for 2012 is 652,074 tons. The SSB estimation for 2012 is of 212,291 tons. The fishing mortality (Fbar1-3) remains at low values until the late nineties, and the sharply increases to higher values, reaching the maximum value in 2011 and dropping again in 2012. The recruitment is quite stable, with fluctuations between 27,349,890 and 194,091,020 thousands individuals. The trend in 2012 is positive.

In SAM, the mid year spawning stock biomass fluctuated from the highest values in the late 70th (about 480,701 tons) to a first drop in the 1986 with a biomass of 66,769 tons. After that the stock recovered to about 197,402 tons in 1995 and then decreased again to a minimum of 105,873 tons in 1998. A third phase saw a new recovery up to 360,771 tons in 2005. In 2012 the estimated SSB is around 123,871 tons. The average fishing mortality for ages 1-2 started increasing in 1995, reaching the maximum value of 1.518 in 2011. The estimate for 2012 dropped to 0.796. The recruitment fluctuates around a minimum value of 15,934,546 thousands specimen in 1986, to a maximum value of 167,752,460 in 1978. A second peak was registered in 2005, with a value of 142,094,090 thousand specimen.

The harvest rate is about 22 and 26%.

Figure 2: Mid-Year biomass from 1976 to 2012 for anchovy in GSA17

Diagnose of Stock status

Due to the uncertainties in the stock assessment models, the biomass for 2012 is the average between the estimated 2012 biomass from ICA and SAM: the same principle has been applied to F and E. At the present the stock can be considered as "overexploited and in overexploitation": in fact, the biomass is low (between 12th and 19th percentile for respectively ICA and SAM) and $E_{(1-3)}$ is higher than the reference point of 0.4. Besides, the total biomass is slightly higher than the limit biomass reference point estimated during the last GFCM-WGSASP (B_{lim}=179,000 tons) and lower than B_{pa} (250,000 tons).

Exploitation rate		Stock Abundance	
1976-2012		1976-2012	
	No fishing mortality		Virgin
	Low fishing mortality		High abundance
	Sustainable Fishing Mortality		Intermediate abundance
x	High fishing mortality	**x**	Low abundance
	Uncertain/Not assessed		Depleted
			Uncertain / Not assessed

Biomass trends		Recruitment trends	
1976-2012		1976-2012	
[2010-2012]		[2010-2012]	
	Stable		Stable
x	Increasing	**x**	Increasing
	Decreasing		Decreasing

Advices and recommendations

The advice for anchovy stock in GSA17 is to reduce fishing mortality and to apply the in act management plan. Nevertheless, since the two models presented show some internal inconsistencies, some differences in the historical estimates, and strong changes in the historical perspective respect to the assessment conducted in 2012 on which the reference points have been based, it is suggested to revise the entire assessment next year and to take this estimation with caution. This year it was not possible to estimate biomass RPs due to the uncertainty in the assessment: besides, given the incoherencies between the current and the past assessment, the reference points estimated in 2012 should be revised as well.

Small pelagic species, such as anchovy and sardine, are strongly dependent from massive recruitment event, often environmental driven, which exposes these stocks to wide fluctuations. Therefore, it is strongly recommended to continue explore the relationship between these species and the environment.

GSA 18 – Southern Adriatic Sea

Anchovy (*Engraulis encrasicolus*)

Authors: Mandić M[1]., Pešić A[1]., Joksimović A[1]., Kolitari J.[2]
[1]Institute of Marine Biology, University of Montenegro, Montenegro
[2]Laboratory of Fisheries and Aquaculture, Agricultural University of Tirane, Albania

Anchovy stock biomass in Southern Adriatic Sea was estimated with the application of the Daily Egg Production Method (DEPM) and acoustic method during peak spawning period of anchovy. Those surveys were conducted in the frame of FAO AdriaMed and EU-MEDIAS projects. The survey has been carried out using R/V “G. Dallaporta” from 29th of July to the 4th of August 2012 in Montenegrin and Albanian territorial waters, in the eastern side of the Adriatic Sea that is part of GSA 18. During the survey total of 62 plankton station and 45 stations for hydrographic sampling was performed. Plankton samples were taken with WP2 plankton net, with a mesh size of 0.200 mm and mouth opening of 0.57 cm. Sampling of adult individuals was done using mid-water sampling trawl and total of 14 trawls were performed in the surveyed area.

During the meetings that were held in the frame of AdriaMed project (AdriaMed DEPM Study Group) throughout 2012 and 2013, several changes in traditional DEP methodology were made in order to standardize sampling procedure and methodology that will be used in Adriatic Sea and following the indication of the GFCM SCSA Working Group of Small Pelagic Species. The Study Group agreed to use WP2 plankton net for all further DEPM application. In order to standardize DEP methodology, several steps were added to the traditional DEP methodology that was developed for northern anchovy SSB estimation (Lasker, 1985). Based on the back-calculation of anchovy egg ages, peak spawning time was changed and 10PM was accepted as peak spawning time of anchovy in Adriatic Sea. High temperatures and upwelling area caused problems in attempt to use traditional model. Temperature/stage/age key is used for prediction of anchovy egg stages, however in the Adriatic Sea, the definition of fixed temperature (at 5 m depth) generally resulted in discrepancies between observed and predicted stages . In order to overcome this problem and to increase the compatibility of observed and predicted stages it was decided to use different temperature for every station, depending on the observed stages in the samples. One more improvement was added to the traditional methodology, ageing of anchovy eggs was done using formula by Regner (1996) which gives more precise calculation of anchovy egg ages.

Preliminary result of anchovy SSB in SE Adriatic Sea is 1486,68 tons, while acoustic estimation of anchovy biomass in the same area is 13310,6 tons. Revision of all data from previous surveys is planned, based on the improved DEP methodology.

Anchovy fisheries in GSA 18 is shared between Montenegro, Italy and Albania, but the Montenegrin and Albanian influence on anchovy stock is negligible compared to Italian one. Further challenges are to collect consistent information on landings from eastern part and to continue with application of two direct methods for biomass estimation in the entire GSA 18, in order to provide valuable data for future stock assessment that will ensure sustainable development of pelagic fisheries in the Eastern part of GSA 18.

GENERAL DISCUSSION

Exercise on reference points

37. The estimation of reference points for small pelagic was one of the main issues being discussed, as a follow up on a similar exercise carried out in the previous year. The WGSASP defined general rules and guidelines to specify the stock status and to give appropriate management advice (see Appendix D), which should be further refined and adopted by the SCSA and the SAC.

38. The WGSASP proposed, as an exercise, to estimate two sets of reference points (B_{lim} and B_{pa}), one based on B_{virgin} and the other based on B_{loss}. In the former approach, B_{virgin} was assumed as the highest biomass estimate in the time series, and B_{lim} and B_{pa} were related to that, namely B_{lim} was equal to 20% of B_{virgin} and Bpa was equal to 50% of B_{virgin} (B_{virgin} approach - Serchuck et al., 1999). The second approach followed the guidelines proposed during the current and previous year WGSA, where B_{lim} was equal to the lowest value from which recovery had been confirmed (B_{loss}), while Bpa was twice B_{lim} (see paragraph 17 of this report).

39. The WGSASP estimated the reference points for all the stocks for which a long enough time series was available, using both the B_{virgin} and the B_{loss} approach: whenever the time series in biomass was short or uncertain and a longer time series in catches was available, a proxy for biomass was derived from the catches themselves: in particular, an average harvest rate for the data available (H=C/B) was estimated, then the catches were rised from this value to obtain a proxy for total biomass (B=C/H). Such option was used for the stocks of anchovy and sardine in GSA01 and GSA06.

40. The two sets of reference points were compared among each other and with the previous year RPs (whenever available).

41. The WGSASP analysed all the estimations and agreed that, whenever the estimated biomass was characterized by a high uncertainty, the reference points should be discarded.

42. Overall, the exercise was carried out on all ten stocks, but the group agreed that for some stocks reference points for biomass could not be proposed due to:

- Anchovy and sardine stocks in GSA01 and GSA06 did not have any reliable long time series of biomass, and the exercise was performed using the proxy derived from the catch data: the estimate was not considered reliable enough to base empirical reference point on it.

- The assessment of anchovy of both GSA16 and GSA17 was considered highly uncertain, with changes in the historical perspective of biomass and fishing mortality trends between different assessment models. Therefore the time series of model based biomass estimates were not considered to be reliable.
- The current situation of sardine in GSA07 could be potentially related to changes in the ecosystem (e.g. regime shifts) or to biological characteristics of the population, and therefore reference points based on the historical series may not be applicable to the current ecological situation of the stock.

43. For the other three stocks analysed (anchovy in GSA07 and sardine in GSAs 16 and 17), the WGSASP concluded that the time series allowed for a definition of reference points useful for the management of these stocks. The group favoured the choice of the B_{loss} approach over B_{virgin} based on a qualitative assessment of the reliability of these two estimates. In fact, estimates of B_{virgin} often come from early years in the time series, where only catches (and no direct estimates of abundance) are available. Different assessment models or even different model set-ups often provide estimates of B_{virgin} of different magnitude, and furthermore some of these estimates were deemed unrealistic (e.g. total combined biomass of anchovy and sardine in the Adriatic reached about 3 million tonnes). In addition to this, the concept of virgin biomass for small pelagics, due to its low trophic level and also to the top-down control that predators impose on them, is tightly coupled with changes in ecosystem, and this implied that management based on achieving past B_{virgin} biomasses under current ecosystem characteristics could be unrealistic. On the other hand, B_{loss} may be a risky limit reference point due to uncertainties, therefore the group decided to establish a more conservative threshold reference point that minimized the risk to fall below B_{lim} (see paragraph 17 of this report).

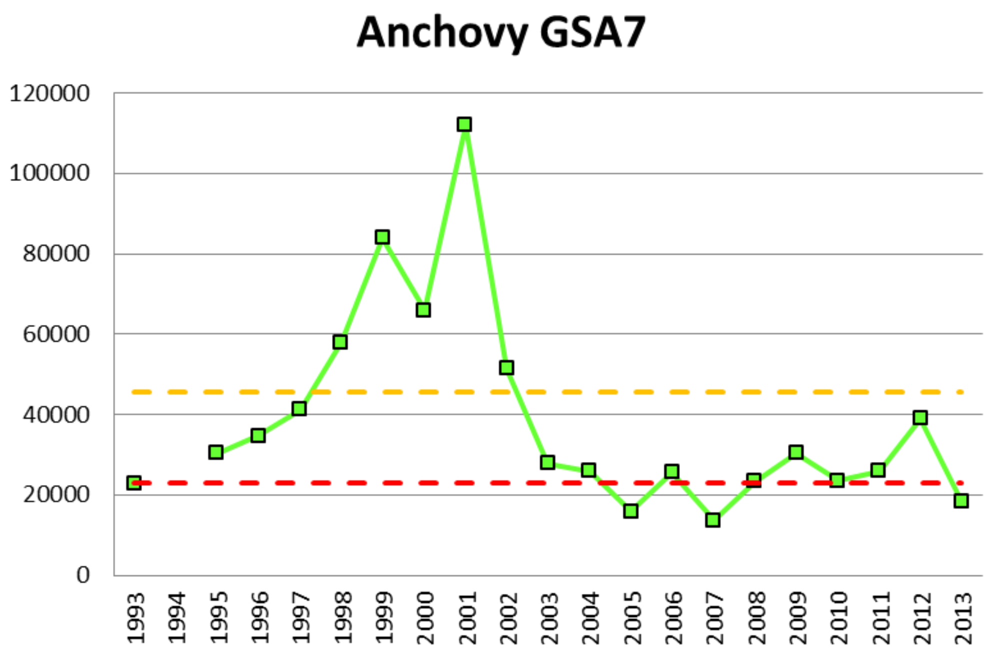


Figure 3: Biomass and reference points (B_{loss} approach) for anchovy in GSA07: red line represents B_{lim}, orange line represents B_{pa}.

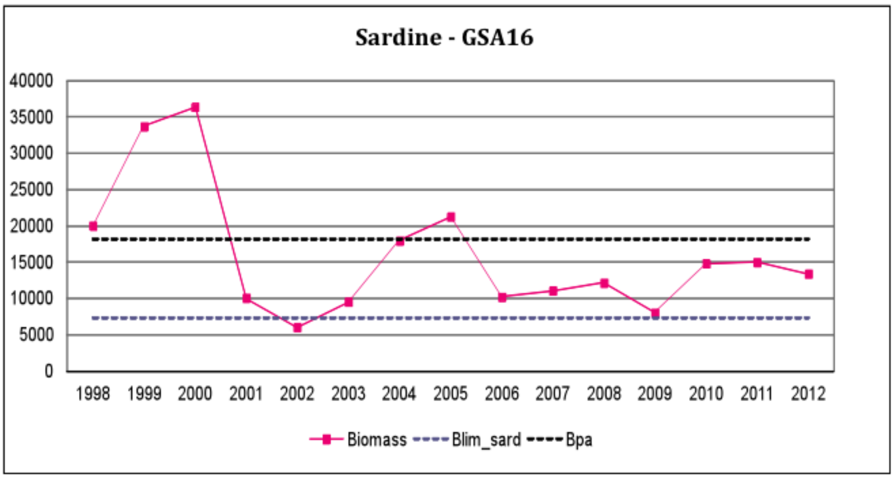


Figure 4: Biomass and reference points (B_{loss} approach) for sardine in GSA16: purple line represents B_{lim}, black line represents B_{pa}.

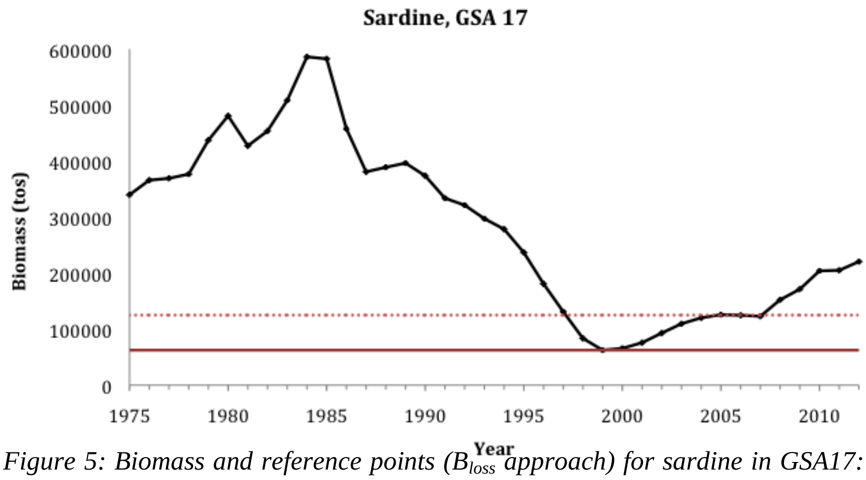


Figure 5: Biomass and reference points (B_{loss} approach) for sardine in GSA17: red full line represents B_{lim}, red dashed line represents B_{pa}.

44. In addition to the exercise to define reference points, the WG pointed out an inconsistency between the reference points estimated in the 2012 WG for anchovy in GSA 17 and the reference points used in the management plan for small pelagic stocks included in Recommendation GFCM/37/2013/1. Reference points proposed in the 2012 WG relate to reference points for mid-year Total Biomass (TB), while the same values proposed in the 2012 WG are used as reference points for mid-year Spawning Stock Biomass (SSB) in the above mentioned recommendation. Although for sardine both TB and SSB are identical, as the assessment is not including age 0 and therefore all individuals considered are mature, for anchovy the assessment includes age 0 and therefore mid-year SSB is only a fraction of mid-year TB (see Figure 7.1.3.1 and Table 7.1.3.3 within the Stock Assessment Form for anchovy in 2012 also included in pages 200 and 201 of the 2012 WG report). Therefore the Group suggests that the reference points included in GFCM/37/2013/1 should refer to mid-year Total Biomass.

45. Overall, empirical RPs for biomass were estimated for three stocks, while model based reference points for Biomass and for F were estimated for four stocks. The empirical reference point for F (E=0.4) was considered valid for all the ten stocks.

Biomass reference points		Empirical Reference points				Model Based reference points		Current Total Biomass
GSA	Species	B_{lim}	B_{pa}	B_{lim} 2012	B_{pa} 2012	B_{MSY}	B_{MSY} 2012	
1	Sardine	--	--	--	--	12409	--	13650
1	Anchovy	--	--	--	--	--	--	--
6	Sardine	--	--	--	--	59298	--	21608
6	Anchovy	--	--	--	--	47209	--	63000
7	Sardine	--	--	--	--	--	--	79181
7	Anchovy	22889	45778	--	--	--	--	18366
16	Sardine	7274	18185	8028	11239	32830	32527	16415
16	Anchovy	--	--	3130	4382	--	14152	14319*
17	Sardine	62505	125010	78000	109200	--	--	220577
17	Anchovy	--	--	179000	250600	--	--	183644**

*Estimate of biomass used in advice comes from the Acoustic survey
**Average of the Mid-Year Total Biomass from ICA and SAM models

Exploitation reference points		Empirical Reference points	Model Based reference points		Current E	Current F
GSA	Species	E	F_{MSY}	F_{MSY} 2012		
1	Sardine	0.4	0.56	--	0.36	0.33
1	Anchovy	0.4	--	--	--	--
6	Sardine	0.4	0.28	--	0.46	0.42
6	Anchovy	0.4	0.25	--	0.24	0.18
7	Sardine	0.4	--	--	--	--
7	Anchovy	0.4	--	--	--	--
16	Sardine	0.4	0.16	0.16	0.13	0.18
16	Anchovy	0.4	--	0.17	0.42*	--
17	Sardine	0.4	--	--	0.42	0.66
17	Anchovy	0.4	--	--	0.52**	1.35**

*Estimated using catches and acoustic abundance plus an assumption on natural mortality
**Average of the current value (age range 1 to 3) from ICA and SAM models

46. The WGSASP agreed that a regular revision of the reference points should be established. On the one hand the Group recommended the RP to stay stable for some years unless a severe criticism arose, in order to avoid incorporating too much uncertainty from the assessment models themselves and to correspond to multiannual management plan. On the other hand, the WGSASP also recommended the reference points to be revised on dedicated meetings, or on regular meetings in which the revision of the reference points would be incorporated in the terms of reference.

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

47. As in previous years, the problem of using only age or length-based model in short living species with a variable growth was raised. Six applications of biomass models were presented (BioDyn) and the group encouraged, whenever possible, some comparative analysis between the performance of existing biomass models and analytical models.

Long-term management of small pelagic fish stocks

48. The need to establish some indicators of environmental stress was highlighted and a recommendation to progress in this direction was made, also in coherence with the proposed use of a "traffic light approach" recommended by SAC.

DISCUSSION ON STOCK ASSESSMENT FORMS AND INDIVIDUAL REPORT TEMPLATES

49. Over the years, the WGSAs had evolved from "hands on" sessions in which the participants provided data to run the assessments, towards a revision type sessions in which the assessments were previously done and the groups discussed the assumptions taken and the results found. In fact, scientists would, within sub-regional ad hoc working groups or back in their own Institutes, meet together and elaborate their assessments to present results in the WGSAs. Hence, the objectives of the working groups and consequently those of the stock assessment forms adapted to this evolution.

50. Under such new working procedures, the assessment forms should make sure that participants can:

- Have more flexibility in including as much information as possible.
- Evaluate the assumptions taken as well as the preliminary analysis that allows making those assumptions.
- Evaluate the results obtained in the assessment and therefore discuss on the conclusions and recommendations proposed.

51. The stock assessment form file would be integrated with an excel file containing all the input data for the assessment: therefore, the tables would be removed from the word file and only figures would be included.

52. The WGBS agreed with the new table in the "Draft Scientific Advice" section of the stock assessment form proposed by the Secretariat in place of the old tables.

53. The section about direct methods, historical trends, input data and results 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 would also be desirable.

54. In addition to the stock assessment forms, it was also suggested 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 were 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 CONCLUSIONS

55. The WGSASP analysed stock assessment information for a total of 12 stocks, and decided to provide advice on ten of these stocks: sardine and anchovy in GSA 01, 06, 07, 16 and 17. Advice for anchovy and sardine in GSA07 was based on direct assessment of the biomass (acoustic survey), advice on anchovy stocks in GSA01 and GSA16 was based on a precautionary approach using empirical observations on the status of the stocks, and advice for anchovy stock in GSA17 was based on an empirical analysis of two different assessment models. Advice for the rest of the stocks was based on validated analytical assessment models.

56. The WGSASP analysed potential biomass reference points for the ten stocks for which advice was provided, following the guidelines discussed in the Workshop on Reference points and also taking into account biomass reference points proposed in the previous year. The WGSASP decided to continue using B_{loss} (see definition adopted by the WGSASP in Appendix D) as a proxy for B_{lim}, in accordance with previously proposed biomass reference points, but to modify the definition of B_{pa} to be 2 * B_{lim} (see rationale for the modification), providing a more precautionary reference point for the management of fisheries.

57. The WGSASP agreed on B_{lim} and B_{pa} biomass reference points for three of the stocks analysed: Anchovy GSA07 and Sardine GSA16 and GSA17. The new reference points proposed are shown in paragraph 44, together with references to previous reference points when available.

58. Stocks of Sardine in GSA01 and Anchovy in GSA06 were considered sustainably exploited, while all other stocks were considered under some threats.

59. The WGSASP advice on the status of the stocks analyzed, including WGSASP comments and recommendations, are included in Appendix E.

GENERAL RECOMMENDATIONS

60. The WGSASP recommended to continue the effort of increasing the number of stocks analysed in the group. It encouraged that existing information on the status of small pelagic stocks collected in different GSAs through the Mediterranean be presented to the group.

61. The WGSASP recommended adopting the conceptual framework for reference points and scientific advice discussed in the Workshop of Reference points and included in Appendix D.

62. The WGSASP recommended that the experts participating in the group provide all information required to perform advice using the new stock assessment forms (metadata information, word document with the description of the analysis, and excel file with the input data required to recreate the analysis). In addition, participants were encouraged to have all biological data related to the stock available for discussion during the group. Those participants using scripts to perform analysis (e.g. R scripts) were encouraged to share their scripts using the software library incorporated in the WGSASP SharePoint workspace.

63. The WGSASP recommended that the following year all interested participants would come with all the required data to run production models and that a practical session on the application of production models be incorporated in the agenda of the following WGSASP.

64. The WGSASP recommended that a timeframe for the adoption/revision of reference points be decided once the definition and methodology to estimate reference points would be adopted by the SAC.

65. The WGSASP encouraged holding the meeting between the end of October and beginning of December in Rome. It suggested to have it separated from the meeting of the SCSA.

66. The WGSASP had not received any updated TORs from the SCSA for its meeting. Therefore, it recommended that newly revised TORs would be provided for the following year WGSASP.

ADOPTION OF THE REPORT AND OF THE RECOMMENDATIONS FROM THE WGSASP

67. The Conclusions and Recommendations were adopted by the WGSASP on 1th of February 2014. The whole report was adopted after revisions and amendments by electronic correspondence.

References:

Gislason, H., Daan, N., Rice, J. C., & Pope, J. G. (2010). Size, growth, temperature and the natural mortality of marine fish. *Fish and Fisheries*, *11*(2), 149–158. doi:10.1111/j.1467-2979.2009.00350.x

Jensen, A. L. (1996). Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. *Canadian Journal of Fisheries and Aquatic Sciences*, *53*(4), 820–822. doi:10.1139/f95-233.

King, JR, and GA McFarlane. (2006). A Framework for Incorporating Climate Regime Shifts into the Management of Marine Resources. *Fisheries Management and Ecology* 13 (2): 93–102.

Lleonart J. & Salat J., (1997). VIT: Software for fishery analysis,. User's manual. FAO Computerised Information, Ser. Fish. 11.

Martell, S., & Froese, R. (2013). A simple method for estimating MSY from catch and resilience. *Fish and Fisheries*, *14*(4), 504–514. doi:10.1111/j.1467-2979.2012.00485.x

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. Journal du Conseil International pour l'Exploration de la Mer, 39: 175–192.

Patterson, K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. *Reviews in Fish Biology and Fisheries*, *2*, 321–338.

Polovina, J. J. (2005). Climate variation, regime shifts, and implications for sustainable fisheries. *Bulletin of Marine Science*, *76*(2), 233–244.

Prager M. (2005). Users Manual for ASPIC: A Stock-Production Model Incorporating Covariates (vers.5), NMFS, Beaufort Lab. Doc. BL-2004-01.

Sampedro, P., Sainza, M. and Trujillo, V., (2005). A simple tool to calculate biological parameters'uncertainty. Working Document, In: Workshop on Sampling Desing for Fisheries Data (WKSDFD), Pasajes, Spain.

Serchuk, F.M., Rivard, D., Casey, J. & Mayo, R.K. (1999). A Conceptual Framework for the Implementation of the Precautionary Approach to Fisheries Management Within the Northwest Atlantic Fisheries Organization (NAFO). In V. R. Restrepo (Editor), Proceedings of the Fifth National NMFS Stock Assessment Workshop: Providing Scientific Advice to Implement the Precautionary Approach Under the Magnusson- Stevens Fishery Conservation and Management Act, p. 103-119. U.S. Dep. Commer., *NOAA Tech. Memo*. NMFS-F/SPO-40. Shankar,

Sinovčić, G. (2000). Anchovy, *Engraulis encrasicolus* (Linnaeus, 1758): biology, population dynamics and fisheries case study. *Acta Adriatica*, *41*(1), 3–53.

Sinovcic, G. (1984) Summary of biological parameters of sardine (*Sardina pilchardus*,Walb.) from the Central Adriatic. *FAO Fish. Rep*., 290: 147-148. STCF.

Appendix A

Agenda

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

2. **Workshop on the definition and estimation of reference points for Mediterranean and Black Sea fisheries (joint session for the two Working Groups on Demersal and Small Pelagic Species)**

   2.1. Introduction

   2.1.1. Reference points and advice in the SAC and in other relevant organization

   2.1.2. Review of reference points for small pelagics in the Mediterranean and Black Sea

   2.1.3. Review of reference points for demersal stocks in the Mediterranean and Black Sea

   2.2. Discussion on reference points for small pelagics and demersal stocks:

   - Discussion on conceptual reference points in agreement with GFCM guidelines for management plans
   - Discussion on already adopted or proposed reference points
   - Discussion on alternatives for data-poor stocks

3. **Conclusions and recommendations of the Workshop on reference points**

4. **Introductory session for the WGSASP**

5. **Presentation and discussion on preliminary assessments and assessment related information**

6. **Presentation and discussion of draft assessments**

6. **Practical session on time series analysis for small pelagics**

7. **Discussion on the mechanism of advice from the WGSASP**
   - Submission of information for the assessment of small pelagics
   - Classification of stocks status based on existing information and precision of the advice
   - Summary sheet with stock advice
   - Stock Assessment forms

8. **Practical session to finalize individual reports and SAFs**

9. **Review and adoption of recommendations from the Workshop on Reference points**

10. **Review of the advice for the stocks assessed**

11. **Formulation of conclusions, recommendations and management advice to be transmitted for the consideration by the SCSA and SAC**

12. **Closing Session**

Appendix B

List of Participants

Nikol BAJCETA
Ministry of Agriculture and Rural Development
Rimski trg 46
81 000 Podgorica, Montenegro
E-mail: ulamanikol@yahoo.com

Jean Louis BIGOT
IFREMER
BP171 Av. Jean Monnet 34203
Sete, Cedex
France
E-mail: jean.louis.bigot@ifremer.fr

Piera CARPI
CNR-ISMAR
Largo Fiera della Pesca, 2 - 60125
Ancona, Italy
E-mail: piera.carpi@an.ismar.cnr.it

Vanja ČIKEŠ KEČ
Institute of oceanography and fisheries
Šet.I.Meštrovića 63,
21000 Split, Croatia
E-mail: cikes@izor.hr

Francesco COLLOCA
Istituto per l'Ambiente Marino Costiero
Consiglio Nazionale delle Ricerche (CNR)
Via Luigi Vaccara 61
91026 Mazara del Vallo (TP), Italy
Tel: +39 0923948966
E-mail: francesco.colloca@iamc.cnr.it

Ana GIRALDEZ NAVA
Spanish Institute of Oceanography
C.O. de Malaga
Puerto Pesquero S/N
29640 Fuengirola, Spain
E-mail: agiraldez@ma.ieo.es

Nada LAKICEVIC
Ministry of Agriculture and Rural Development
Rimski trg 46,
81 000 Podgorica, Montenegro
E-mail: nada.lakicevic@mpr.gov.me

Milica MANDIC
Institute of Marine Biology
Dobrota bb
85 330 Kotor, Montenegro
E-mail: mamilica@ac.me

Tomaz MODIC
Zavod za ribistvo Slovenije
Fisheries Research Institute of Slovenia
Spodnje Gameljne 61a
SI-1211 Ljubljana, Šmartno, Slovenia
E-mail: Tomaz.modic@zzrs.si

Bernardo PATTI
Researcher
Consiglio Nazionale delle Ricerche - Istituto per l'Ambiente Marino Costiero (CNR-IAMC)
Via del Mare 3, 91021 Torretta Granitola,
Fraz. di Campobello di Mazara (TP), Italy
E-mail: bernardo.patti@cnr.it

Polona PENGAL
Zavod za ribistvo Slovenije
Fisheries Research Institute of Slovenia
Spodnje Gameljne 61a
SI-1211 Ljubljana, Šmartno, Slovenia
E-mail: polona.pengal@zzrs.si

Ana PESIC
Institute of Marine Biology
Dobrota bb
85 330 Kotor, Montenegro
E-mail: pesica@ac.me

Claire SARAUX
IFREMER
BP171 Av. Jean Monnet 34203
Sete, Cedex, France
E-mail: claire.saraux@ifremer.fr

Vjekoslav TIČINA
Institute of oceanography and fisheries
Šet.I.Meštrovića 63,
21000 Split, Croatia
E-mail: ticina@izor.hr

Pedro TORRES CUTILLAS
Spanish Institute of Oceanography
C.O. de Malaga
Puerto Pesquero S/N
29640 Fuengirola, Spain
E-mail: pedro.torres@ma.ieo.es

Barbara ZORICA
Institute of oceanography and fisheries
Šet.I.Meštrovića 63,
21000 Split, Croatia
E-mail: zorica@izor.hr

FAO Regional Projects

Juan Antonio CAMIÑAS
FAO CopeMed II
Project Coordinator
Fisheries and Aquaculture Resources Use and Conservation Division (FIRF)
Subdelegación del Gobierno en Malaga
Paseo de Sancha 64
29071 Malaga, Spain
Ph: +34 695797666
E-mail: juanantonio.caminas@fao.org

Matthieu BERNARDON
FAO CopeMed II
Fisheries and Aquaculture Resources Use and Conservation Division (FIRF)
Subdelegación del Gobierno en Malaga
Paseo de Sancha 64
29071 Malaga, Spain
E-mail: matthieu.bernardon@fao.org

Konstantina KARLOU-RIGA
FAO EastMed
Project Coordinator
Fisheries and Aquaculture Resources Use and Conservation Division (FIRF)
Fisheries and Aquaculture Department
Androu 1,
112 57 Athens, Greece
Ph: +30 2108847960
E-mail: Konstantina.Riga@fao.org

Enrico ARNERI
FAO AdriaMed/MedSudMed
Project Coordinator
Fisheries and Aquaculture Resources Use and Conservation Division (FIRF)
Fisheries and Aquaculture Department
Viale delle Terme di Caracalla
00153 Rome, Italy
Ph.: + 39 06 57056092
E-mail: enrico.arneri@fao.org

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

Nicoletta MILONE
FAO AdriaMed
Fisheries and Aquaculture Resources Use and Conservation Division (FIRF)
Fisheries and Aquaculture Department
Viale delle Terme di Caracalla
00153 Rome, Italy
Ph.: +39 06 57055467
E-mail: nicoletta.milone@fao.org

GFCM Secretariat

Miguel BERNAL
Fisheries Officer
GFCM Secretariat
Food and Agriculture Organisation of the United Nations (FAO)
Via Vittoria Colonna1
00193 Rome, Italy
Tel: +39 0657056437
E-mail: miguel.bernal@fao.org

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

Appendix C

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

One of the objectives of the Sub-Committee on Stock Assessment (SCSA) is to progress in the enhancement of joint practical stock assessment. "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. Analyse 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 FMSY 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. Evaluate the new assessment forms provided this year, in relation to the recommendations provided by the 2011 Assessment Working Groups and the SAC.
11. Suggest management advice to the SAC considering different alternatives

Appendix D

General conclusions and recommendations of the *Workshop on the definition and estimation of reference points for Mediterranean and Black Sea fisheries* (WGREF)

Specific recommendations for reference points for stocks with analytical assessment	
Clarify the role of $F_{0.1}$ as a reference point	- $F_{0.1}$ is a proxy for F_{MSY} - $F_{0.1}$ is in principle lower than F_{pa} and F_{lim}. If not, estimation of reference points should be revised - If possible $F_{0.1}$ should be complemented with an additional estimate of F_{lim} (e.g. from an independent B_{lim} estimate) and F_{pa} should be defined in relation to F_{lim}. If that is achieved, then there is a full framework in place for fishing mortality and advice can be provided in relation to MSY and precautionary frameworks - If only $F_{0.1}$ is available, then F_{lim} should be defined in relation to $F_{0.1}$ (a percentage or identical) and advice should be provided based on these two points.
Requirements for advice in small pelagics	- A threshold for Biomass, based on reproductive capacity should be established to maximize probability of obtaining good recruitments. Advice should be based if possible on both Biomass (priority) and fishing mortality (or some proxy such as exploitation rate) reference points. - In the absence of a precise stock recruitment relationship, limit biomass reference points and associated precautionary should be obtained from analysis of temporal series of Biomass estimates. - Estimates of maximum observed biomass (as a proxy for B_{virgin}) or minimum observed biomass from which the stock recovered (as a proxy for B_{loss}) could be used as reference to estimate limit and threshold reference points. - Due to the fluctuating nature of small pelagics and the existence of regime shifts that alter the ecosystem productivity, the concept of B_{virgin} is not expected to represent the potential maximum biomass on a range of possible ecosystem status. - The combination of B_{loss} as a limit reference point and a precautionary threshold that minimizes the probability to reach it, is therefore considered the most appropriate option. - B_{lim} is defined as the lowest biomass from which a recovery has been confirmed. B_{lim} is estimated from an analysis of time series of biomass estimates. Time series should be sufficiently long and only if the analysis provides consistent perspective in the historical and the recent part of the time series this reference points is to be considered. Whenever similar minima that meet the required criteria (recovery) exist in the time series the upper value should be chosen as a precautionary approach. - B_{pa} is defined as a point at which the probability to be below B_{lim} is lower than 5%. In order to estimate it, a lognormal distribution of B_{lim} is assumed, with a coefficient of variation of 40%. This approximately results in $B_{pa} = 2 * B_{lim}$.

Specific recommendations for reference points for stocks with analytical assessment	
	- Advice for small pelagics: ○ If only fishing mortality/explotaition rate reference points (e.g. Patterson) is used, then use the overexploitation ranking proposed in WG demersal. ○ If you have both fishing mortality/exploitation rate and Biomass: ▪ If $B > B_{pa}$ and $E <$ Patterson / $F < F_{MSY}$: sustainable ▪ If $E >$ Patterson or $F > F_{MSY}$ and $B > B_{pa}$, increased risk of overexploitation ▪ If $B_{lim} < B < B_{pa}$ and $F > F_{MSY}$ or $E >$ Patterson: overexploited and in overexploitation ▪ If $B_{lim} < B < B_{pa}$ and $F < F_{MSY}$ or $E <$ Patterson: overexploited and/or ecologically unbalanced ▪ $B < B_{lim}$: depleted / collapsed ○ If you have only Biomass reference points, then: ▪ $B > B_{pa}$: sustainable ▪ $B_{lim} < B < B_{pa}$: overexploited / ecologically unbalanced ▪ $B < B_{lim}$: depleted / collapsed
Clarify the term "in overexploitation" in relation to reference points	- The proposal from the Demersal WG last year should be revised taking into account the definition of $F_{0.1}$ and F_{lim} above: - If you have the three (Target, threshold, limit): ○ $F_{target} < F < F_{pa}$: increased risk of overexploitation ○ $F_{pa} < F < F_{lim}$: in overexploitation ○ $F > F_{lim}$: Severe overexploitation - If you have only $F_{0.1}$ (and an associated F_{lim}) ○ $F > F_{0.1}$: Use the percentile proposal from WG (copy)
How should the advice be provided? (replace for the definitions on the status of stock defined above)	- $F_{target} < F < F_{pa}$ and $B > B_{pa}$. Do not increase fishing mortality and revise stock advice next year. - $F_{lim} > F > F_{pa}$: reduce F - $F > F_{lim}$: Immediate measures to minimize risk of collapse - If both F_{target} and B_{pa} exist, then if $B > B_{pa}$ and $F <= F_{target}$ then keep fishing mortality - If $B_{lim} < B < B_{pa}$ then F has to be reduced - If $B < B_{lim}$: recovery plan - In case there are signs of stock unbalance or stock is not able to recover even if low fishing mortality, then a recovery plan could be suggested.
Incorporate these conclusions to the Individual stock summary	

Specific recommendations for data limited stocks	
SCSA should aim to extend the advice on the status of stocks to those Mediterranean and Black Sea stocks consider important and not yet being assessed. In order to do the following steps should be performed:	- Review existing information for the most important stocks which are not yet assessed - Define a set of methods to apply to all these stocks - Collate the data and perform a benchmark assessment of those stocks - Organize a dedicated Workshop to analyse the data with the countries and report back to the SCSA.
General recommendations	
Compare the estimates of $F_{0.1}$ for selected species across the different GSAs, making use of the incipient library of stocks assessments being developed at the GFCM.	- Evaluate ecosystem considerations and differences in parameter estimation that could led to these differences, and propose potential harmonization of methodologies/reference points.
Incorporate environmental issues in the reference points framework	- Environmental issues should be incorporated into the estimation of reference points (both target and threshold), especially for small pelagics

Appendix E

Advice on the status of the stocks analyzed, including WGSASP comments and recommendations

GSA	Species	Methodology used	Stock status	Management advice	WGSASP comments
GSA 01	Anchovy, *Engraulis encrasiclous*	Indirect method: BioDyn (Surplus production Model)	Uncertain, with high fluctuations and population concentrated on first age classes.	The population may have a high pressure on juveniles, and this decrease the probability to reconstruct the adult population .	The assessment was not accepted as there were contradictory signals between the survey, catches, trial test with the ASPIC surplus production model, and independent estimates of exploitation rate. There was uncertainty in the assessment and methodological problems in incorporating acoustic time series in the production model, so the model only relies on CPUE, which is very similar to the landings. The fishery mainly depends on recruitment: the possibility to have an index of recruitment to manage the stock should be considered. The WGSASP suggested to evaluate the trend in effort data and that CPUE be evaluated independently to its performance in the production model. The WGSASP recommended the use of available time series both for CPUE and acoustic abundance indices. In the case of fitting problems, alternative production model should be tested.
GSA 01	Sardine, *Sardina pilchardus*	Indirect method: BioDyn (Surplus production Model)	Sustainably exploited Trend in landings is stable. Exploitation rate is lower than the Patterson's reference point (E=0.36). B_{cur}/B_{MSY}=1.31 $F_{current}$ (0.33) is below $F_{0.1}$ (0.5).	Not to increase fishing mortality	Uncertainty in the assessment and methodological problems in incorporating acoustic time series in the production model, so the model only relies on CPUE, which is very similar to the landings. The WGSASP suggested to evaluate the trend in effort data and that CPUE is evaluated independently to its performance in the production model. The WGSASP recommended the use of available time series both for CPUE and acoustic abundance indices. In the case of fitting problems, alternative production model should be tested. The area should be covered yearly with an independent survey.
GSA 03	Sardine, *Sardina pilchardus*	Direct method: CPUE analysis. Indirect method: LCA	Uncertain (preliminary assessment) Decreasing trend in landings from 2000. Effort is slightly increasing. Exploitation rate is higher than the Patterson's reference point (E=0.56).	No advice is provided	The WGSASP encouraged that this assessment is presented for validation next year, and suggested to consider the use of acoustic data as a tuning index. Fishing mortality is high for small sizes and in 2012 a low percentage of large individuals was found in the landings. A reduction in fishing mortality should be considered to allow for the recovery of adults population.
GSA 06	Anchovy, *Engraulis encrasiclous*	Indirect method: BioDyn (Surplus production Model)	Sustainably exploited Increasing trend in landings and biomass from acoustic $F_{current}$ (0.18) is lower than F_{MSY} reference point (0.25). Exploitation rate is lower than the Patterson's reference point (E=0.24). Current biomass is above B_{MSY}.	Not to increase fishing mortality	Uncertainty in the assessment and methodological problems in incorporating acoustic time series in the production model, so the model only relies on CPUE which in this case is very similar to the landings. The WGSASP suggested that CPUE is evaluated independently to its performance in the production model. The WGSASP recommended the use of available time series both for CPUE and acoustic abundance indices. In the case of fitting problems, alternative production model should be tested. Empirical RP not reliable since an historical maximum or minimum is not obvious in the time series available.

GSA	Species	Methodology used	Stock status	Management advice	WGSASP comments
GSA 06	Sardine, *Sardina pilchardus*	Indirect method: BioDyn (Surplus production Model)	Overexploited and in Overexploitation. Both landings and CPUE decreasing. Exploitation rate is higher than the Patterson's reference point (E = 0.46). $F_{current}$ (0.42) is higher than the $F_{0.1}$ reference point (0.25). $B_{current}$ is below B_{MSY} (B_{curr}/B_{MSY}=0.37).	Reduce fishing mortality. Apply a multiannual management plan.	Uncertainty in the assessment and methodological problems in incorporating acoustic time series in the production model, so the model only relies on CPUE, which in this case is very similar to the landings. The WGSASP suggested that CPUE is evaluated independently to its performance in the production model. The WGSASP recommended the use of available time series both for CPUE and acoustic abundance indices. In the case of fitting problems, alternative production model should be tested. The declining trend is clear and in accordance with the acoustic. The exercise on reconstructed time series of biomass based on harvest rate seems to be coeherent with acoustic estimates and point out for low biomass.
GSA 07	Anchovy, *Engraulis encrasiclous*	Direct method by acoustics and harvest rate from catches/acoustic	Depleted Low exploitation rate and very low biomass, low commercial-sized anchovy abundance. Declining trend in landings and biomass. Current biomass is below B_{lim} (22,889).	Implement a recovery plan (including monitoring on biological parameters and limits on effort)	Biomass is more or less stable in this stock since 2005, with a slight increasing trend noted in 2012, but in 2013 the stock estimate decreased. Average size and condition of anchovy remains low. Unusual high acoustic energy close to the surface in all the area in 2013: extra uncertainty on the estimates due to difficulties in catch the signal and lower success in trawling.
GSA 07	Sardine, *Sardina pilchardus*	Direct method by acoustics and harvest rate from catches/acoustic	Unbalanced Landings continue decreasing, the biomass is stable, high recruitments, but the fish are small, young and in poor conditions.	Fishing mortality should not be allowed to increase, monitoring of changes in the fishing effort/gears required.	This year the juvenile-adult partition was not done (disappearance of the two modes and changes in growth). There is a change in the fishery: in 2012 purse seiners contribute to 95% of the catch of sardine (previously around 20%). Measures of effort should be improved (e.g. number of "fishing sets" for purse seiners).
GSA 16	Sardine, *Sardina pilchardus*	Harvest Rate and Surplus production model (BioDyn)	Overexploited and in overexploitation $F_{Current}$ (0.18) is below the sustainable fishing mortality at current biomass levels (F_{cur}/F_{SYCur}=0.74) but above F_{MSY} (F_{MSY}=0.16; F_{cur}/F_{MSY}=1.11). B (16415) < B_{MSY} (32830) $B_{current}$ is above B_{lim} but below B_{pa}.	Fishing mortality should be reduced by means of a multi-annual management plan.	The role of the environmental index in the population and in the model fitting procedure is unclear. Further analysis in the model fitting behaviour should be investigated (e.g. testing other environmental factors, sensitivity analysis on seed values…). The WGSASP suggested to look at the monthly catches and the LFD of the catches.
GSA 16	Anchovy, *Engraulis encrasiclous*	Harvest Rate and Surplus production model (BioDyn)	In overexploitation Exploitation rate is higher than the Patterson's reference point (E=0.42) Model trial provides a high exploitation rate.	Fishing mortality should be reduced by means of a multi-annual management plan.	The assessment is uncertain. The catches and the biomass estimates provide opposite trends and the performances of the model are low. The WGSASP suggested to look at the monthly catches and the LFD of the catches. The overall picture shows a decreasing trend in biomass, a harvest rate that is fluctuating up to really high values (in 2011 was about 80%) and an increase in F. Empirical RP not reliable since an historical maximum or minimum is not obvious in the time series available.

GSA	Species	Methodology used	Stock status	Management advice	WGSASP comments
GSA 17	Sardine, *Sardina pilchardus*	SAM tuned by acoustic Tests with ICA and ASAP tuned by acoustic	Increased risk of overexploitation. Exploitation rate is higher than the Patterson's reference point (E=0.42). $B_{current}$ is above both limit and precautionary reference point. Positive trend. Harvest rate is equal to 26%.	Do not increase fishing mortality and revise stock advice next year.	The WGSASP chose the SAM model as the final assessment due to better performance. All models tested provide similar estimates in the recent years, nevertheless there are discrepancies in the historical perspective. Catch data and acoustic data show some inconsistencies in the abundance by age trend (cohorts signal). Partial coverage of the eastern acoustic survey in the last two years: analysis of spatial variability should be desirable. Some differences in the ALK between the eastern and western data were identified. The WGSASP recommended a revision of the input-basic data (e.g. age structure) including testing the use of recent biological data (length structure and ALKs) from the Eastern area in the older part of the eastern landings time series, instead of data from the Western area.
GSA 17	Anchovy, *Engraulis encrasiclous*	Both ICA and SAM with acoustic tuning are considered for the advice.	Overexploited and in overexploitation Exploitation rate is higher than the Patterson's reference point (E=0.48-0.57). Biomass level is at a low level (between 12-19 percentile of the biomass estimates)	Fishing mortality should be reduced and the existing management plan should be applied.	Both models were retained to provide a comprehensive advice. The recent perspective is consistent, but models provide a different historical perspective; ICA 2012, ICA 2013 and SAM all give a different perspective in both maximum and minimum biomass and some variability in F for the more recent years. Terminal F shows a large drop (probably unreliable) with a large CI. Due to unclear historical perspective, previously adopted reference points were considered not reliable. Advice was therefore provided on a precautionary basis (exploitation rate and biomass percentiles). The WGSASP recommended that the discrepancies of the different models should be further investigated. Partial coverage of the Eastern acoustic survey in the last two years: analysis of spatial variability should be desirable. Some differences in the ALK between the Eastern and Western data were identified. The WG recommended a revision of the input-basic data (e.g. age structure) including testing the use of recent biological data (length structure and ALKs) from the eastern area in the older part of the Eastern landings time series, instead of data from the Western area.
GSA 18	Anchovy, *Engraulis encrasiclous*	DEPM	Uncertain (preliminary assessment) Since this is just a preliminary estimation it is not possible to diagnose the status of the anchovy stock in GSA 18 based on the DEPM investigation.	No advice is provided This stock is not considered to be formally assessed	Data of only eastern GSA18 were considered. Low fishing pressure in Eastern GSA 18, especially in Montenegro. Higher fishing pressure in the Western GSA18, although part of the fleet also operates in GSA17. The WGSASP recommended to continue improving and standardizing the DEPM methods and comparing both acoustic and DEPM independent estimates, while improving the quality of the landings data in order to obtain an estimate of exploitation rate.