Stock Assessment Form

Small Pelagics

2012

[A brief abstract may be added here]

Stock Assessment Form version 0.9

Uploader: Miguel Bernal

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Sardina pilchardus	Sardine	
1st Geographical sub-area:	2nd Geographical sub-area:	3rd Geographical sub-area:
16		
1st Country	2nd Country	3rd Country
Italy		
Stock assessment method: (direct, indirect, combined, none)		
combined		
Authors:		
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Affiliation:		
CNR-IAMC		

The ISSCAAP code is assigned according to the FAO 'International Standard Statistical Classification for Aquatic Animals and Plants' (ISSCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. This can be provided by the GFCM secretariat if needed. A list of groups can be found here:

http://www.fao.org/fishery/collection/asfis/en

Direct methods (you can choose more than one):

- Acoustics survey
- Egg production survey
- Trawl survey

Indirect method (you can choose more than one):

- ICA
- VPA
- LCA
- AMCI
- XSA
- Biomass models
- Length based models
- Other (please specify)

Combined method: you can choose both a direct and an indirect method and the name of the combined method (if it does exist)

2 Stock identification and biological information

2.1 Stock unit

This assessment of the sardine stock in GSA 16 is mainly based on information collected over the last decade on fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically on biomass estimates obtained by hydroacoustic surveys and catch-effort data from local small pelagic fisheries. The main distribution area of the sardine stock in GSA 16 is the narrow continental shelf area between Mazara del Vallo and the southernmost tip of Sicily, Cape Passero (Patti *et al*., 2004).

2.2 Growth and maturity

Table 2.2-1: Maximum size, size at first maturity and size at recruitment.

Somatic magnitude measured (LH, LC, etc)*			LT		**Units***	cm
Sex	**Fem**	**Mal**	**Both**	**Unsexed**		
Maximum size observed				20.0	**Reproduction season**	Autumn - Winter
Size at first maturity	11.5	11.6	11.5		**Reproduction areas**	South Sicily
Recruitment size					**Nursery areas**	South Sicily

Table 2.2-2: Growth and length weight model parameters

		Units	Sex			
			female	male	both	unsexed
Growth model	**L_∞**	cm			21,41	
	K	y-1			0.40	
	t_0	year			-1.83	
	Data source	DCF 2007-2008				
Length weight relationship	**a**				0,0028	
	b				3.37	

M (vector by length or age)	0.77			Pauly (1980) relationship. Ref. Temp=13.5 °C	

sex ratio (% females/total)	

3 Fisheries information

3.1 Description of the fleet

In GSA 16, the two operational units fishing for small pelagic are present, mainly based in Sciacca port (accounting for about 2/3 of total landings): purse seiners (lampara vessels, locally known as "Ciancioli") and midwaters pair trawlers ("Volanti a coppia"). Midwaters trawlers are based in Sciacca port only, and receive a special permission from Sicilian Authorities on an annual basis. In both OUs, anchovy represents the main target species due to the higher market price. Another fleet fishing on small pelagic fish species, based in some northern Sicilian ports, was used to target on juvenile stages (mainly sardines). However this fishery, which in the past was allowed for a limited period (usually one or two months in the winter season) by a special Regional law renewed year by year, was no more authorized starting from 2010 and it is presently stopped.

Average sardine landings in Sciacca port over the period 1998-2011 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. 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 (2011) 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 (1998-2011) compared to the official data for the whole GSA 16 (2004-2011).

Table 3.1-1: Description of operational units in the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ITA	16	H - Purse Seine (12-24 metres)	01 - Surrounding Nets	31 - Small gregarious pelagic	PIL
Operational Unit 2	ITA	16	J - Pelagic Trawl (12-24 metres)	03 - Trawls	31 - Small gregarious pelagic	PIL
Operational Unit 3						
Operational Unit 4						
Operational Unit 5						

Table 3.1-2: Catch, bycatch, discards and effort by operational unit (Sciacca port only)

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
ITA 16 H 01 31 - PIL	17	Tons	680	anchovy	negligible	negligible	fishing day
ITA 16 J 03 31 - PIL	30	Tons	720	anchovy	negligible	negligible	fishing day
	* Dec 2006, census data		ave 1998-2011				
Total	47		1400				

Table 3.1-3: Catches as used in the assessment (aggregated data from the two operational units; values estimated for the whole GSA 16 extrapolated from Sciacca port fishery)

Classification YEAR	Catch (tn)
1998	2994
1999	1850
2000	3119
2001	2484
2002	2430
2003	1739
2004	2011
2005	1798
2006	1856
2007	1585
2008	2448
2009	1874
2010	565
2011	2665
Average 1998-2011	2101

3.2 Historical trends

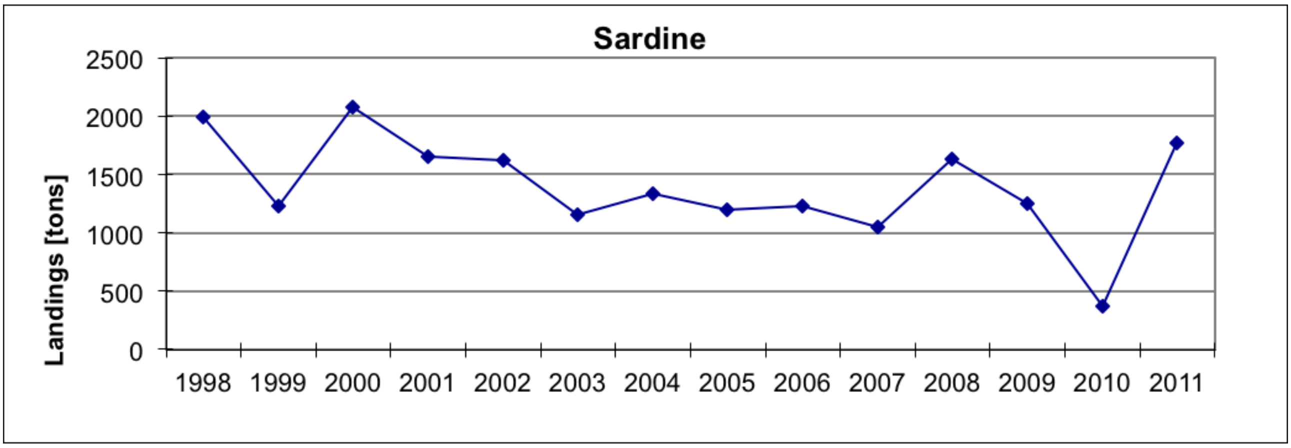

Fig. 3.2-1: Trends in sardine landings, years 1998-2011

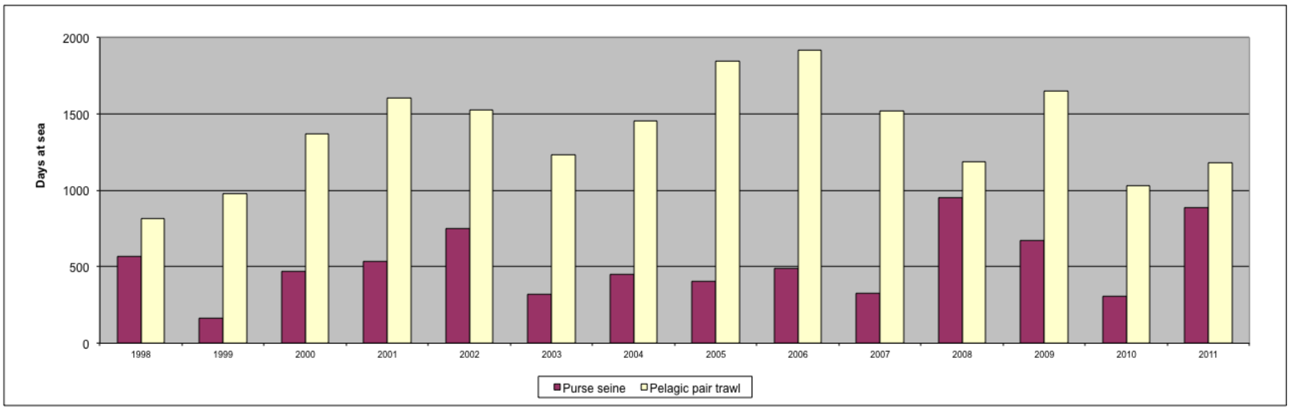

Fig. 3.2-2: Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2011

3.3 Management regulations

Fisheries practices are affected by EU regulations through the Common Fisheries Policy (CFP), based on the following principles: protection of resources; adjustment of (structure) facilities to the available resources; market organization and definition of relationships with other countries.

The main technical measures regulating fishing concern minimum landing size (11 cm for sardine), mesh regulations (20 mm for pelagic pair trawlers, 14 mm for purse seiners) and restrictions on the use of fishing gear. Towed fishing gears are not allowed in the coastal area in less than 50 m depth, or within a distance of 3 nautical miles from the coastline. A seasonal closure for trawling, generally during summer-autumn, has been established since 1993. In GSA 16, two operational units fishing for small pelagic fish are present, mainly based in Sciacca port: 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. 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.

3.4 Reference points

Table 3.4-1: List of reference points

Criterion	Current value	Units	Reference Point	Trend	Comments
B					
SSB					
F					
Y					
CPUE					

4 Fisheries independent information

4.1 Acoustics

4.1.1 Brief description of the chosen method and assumptions used

Steps for biomass estimation

- Collection of acoustic and biological data during surveys at sea;
- Extraction of $NASC_{Fish}$ (Fishes Nautical Area Scattering Coefficient [$m^2/n.mi^2$]) by means of Echoview (Sonar Data) post-processing software;
- Link of NASC values to control catches;
- Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data;
- Production of ρ distribution maps for different fish species and size classes;
- Integration of density areas for biomass estimation.

Collection of acoustic and biological data

Since 1998 the IAMC-CNR has been collecting acoustic data for evaluating abundance and distribution pattern of small pelagic fish species (mainly anchovy and sardine) in the Strait of Sicily (GSA 16). The scientific echosounder Kongsberg Simrad EK500 was used for acquiring acoustic data until summer 2005; for the echosurvey in the period 2006-2011 the EK60 echosounder was used. In both cases the echosounder was equipped with three split beam transducers pulsing at 38, 120 and 200 kHz. During the period 1998-2008 acoustic data were collected continuously during day and night time; since the 2009 echosurvey acoustic data are collected during daytime, according to the MEDIAS protocol.

Before or after acoustic data collection a standard procedure for calibrating the three transducers was carried out by adopting the standard sphere method (Johannesson & Mitson, 1983).

Biological data were collected by a pelagic trawl net with the following characteristics: total length 78 m, horizontal mouth opening 13-15 m, vertical mouth opening 6-8 m, mesh size in the cod-end 10 mm. The net was equipped with two doors with weight 340 kg. During each trawl the monitoring system SIMRAD ITI equipped with trawl-eye and temp-depth sensors was adopted.

Extraction of $NASC_{Fish}$ by means of Echoview (Sonar Data) post-processing software

The evaluation of the $NASC_{Fish}$ (Fishes Nautical Area Scattering Coeffcient [$m^2/n.mi^2$]) and the total NASC for each nautical mile of the survey track was performed by means of the SonarData Echoview software v3.50, taking into account the day and night collection periods.

Link of NASC values to control catches

For the echo trace classification the nearest haul method was applied, taking into account only representative fishing stations along transects.

Calculation of Fish density (ρ) from $NASC_{Fish}$ values and biological data

For each trawl haul the frequency distribution of the *j*-th species (ν_j) and for the *k*-th length class (f_{jk}) are estimated as

$$\nu_j = \frac{n_j}{N} \qquad \text{and} \qquad f_{jk} = \frac{n_{jk}}{n_j}$$

where n_j is the total number of specimens of the *j*-th species, n_{jk} is the total number of specimens of the *k*-th length class in the *j*-th species, and *N* is the total number of specimens in the sample.

For each nautical mile the densities for each size class and for each fish species are estimated as

$$\rho_{jk} = \frac{NASC_{FISH} * n_{jk}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(number of fishes / n.mi}^2\text{)}$$

$$\rho_{jk} = \frac{NASC_{FISH} * W_{jk} * 10^{-6}}{\sum_{j=1}^{n}\sum_{k=1}^{m} n_{jk} * \sigma_{jk}} \qquad \text{(t / n.mi}^2\text{)}$$

where W_{jk} is the total weight of the *k*-th length class in the *j*-th species, and σ_{jk} is the scattering cross section of the *k*-th length class in the *j*-th species. σ_{jk} *is given by*

$$\sigma_{spjk} = 4\pi * 10^{\frac{TS_{jk}}{10}}$$

where the target strenght (TS) is

$$TS_{jk} = a_j Log_{10}(L_k) + b_j$$

L_k is the length of the *k*-th length class while the a_j and b_j coefficient are linked to the fish species.

For anchovy, sardine and trachurus we adopted respectively the following relationships:

TS = 20 log L_k 76.1 [*dB*]
TS = 20 log L_k 70.51 [*dB*]
TS = 20 log L_k 72 [*dB*]

Integration of density areas for biomass estimation

The abundance of each species was estimated by integrating the density surfaces for each species.

Direct methods: acoustics

Table 4.1-1: Acoustic cruise information

Date	1998-2011		
Cruise	ANCHEVA series	**R/V**	Dallaporta
Target species	Anchovy and sardine		
Sampling strategy	Systematic, perperdicular to bathymetry Inter-transect distance: 5 nmi		
Sampling season	Summer		
Investigated depth range (m)	0-200m		
Echo-sounder	EK500, Ek-60		
Fish sampler	Pelagic trawl, vertical opening 10 m, horizontal opening 13 m. Trawling speed: 4 knots		
Cod –end mesh size as opening (mm)	18 mm		
ESDU (i.e. 1 nautical mile)	1		
TS (Target Strength)/species	TSdB = 20LogL – 70.51		
Software used in the post-processing	Echoview		
Biological data obtained	Length, weight, maturity, age		
Age slicing method			
Maturity ogive used			

Table 4.1-2: Acoustic results (July 2011)

	Biomass in metric tons	fish numbers	Nautical Area Scattering Coefficient (average value)	Indicator …	Indicator …
Sardine	14977		82.7		

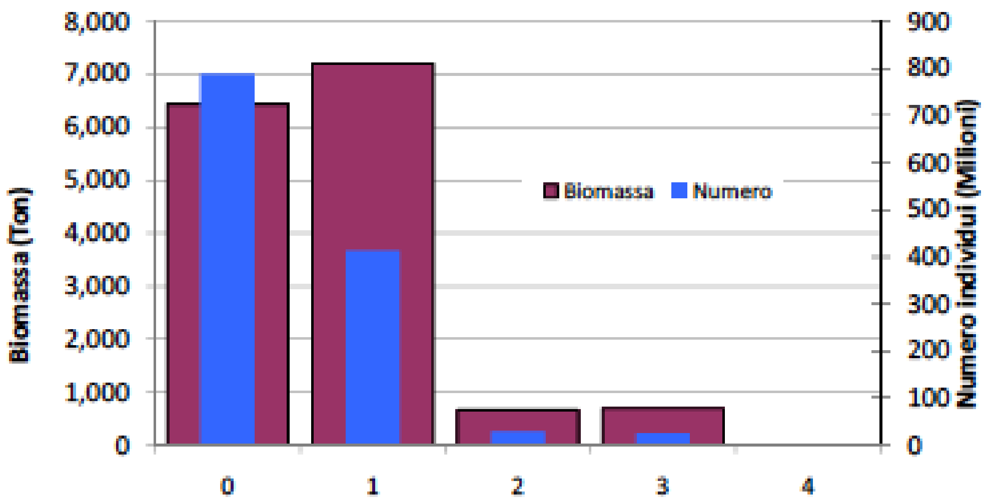

Fig. 4.1-1: Sardine distribution by age(years), 2011 survey

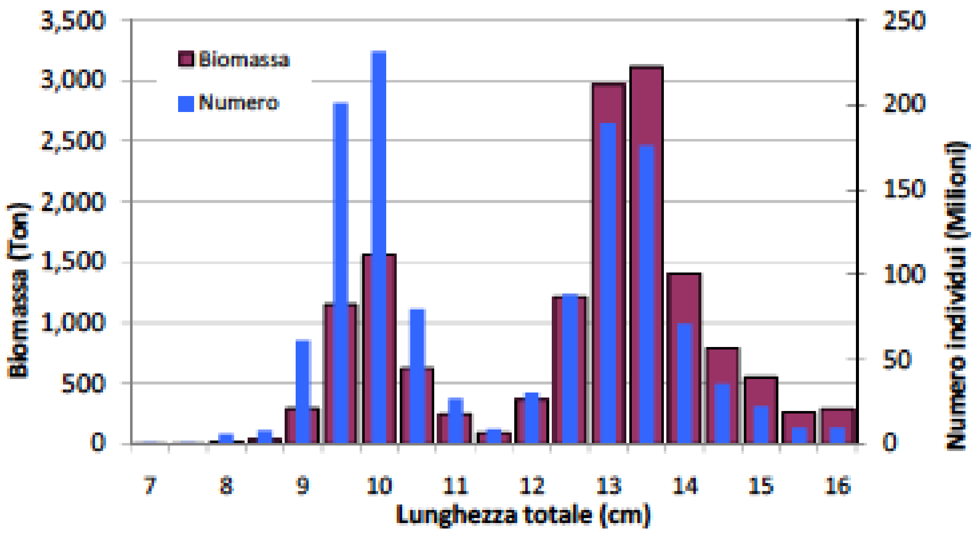

Fig. 4.1-2: Sardine distribution by length, 2011 survey

4.1.2 Spatial distribution of the resources

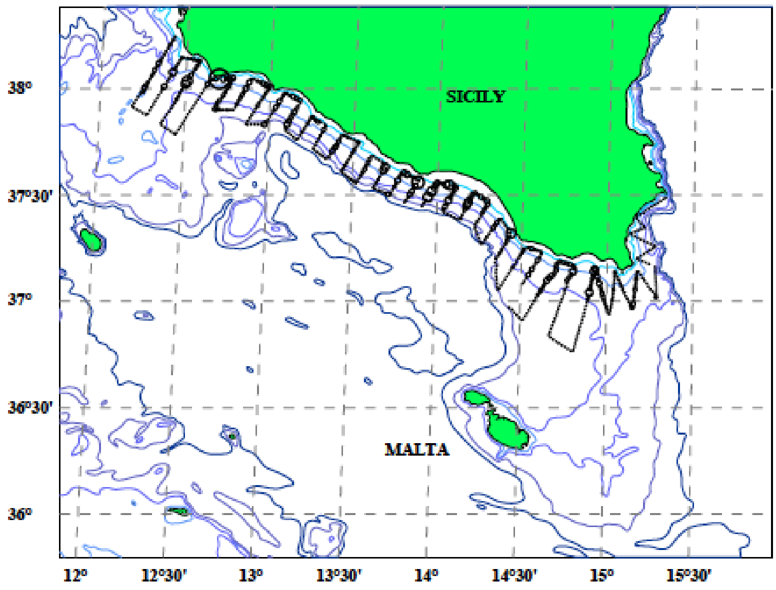

Fig. 4.1.2-1: Survey Ancheva 2009. Sardine density spatial distribution (t/nm^2)

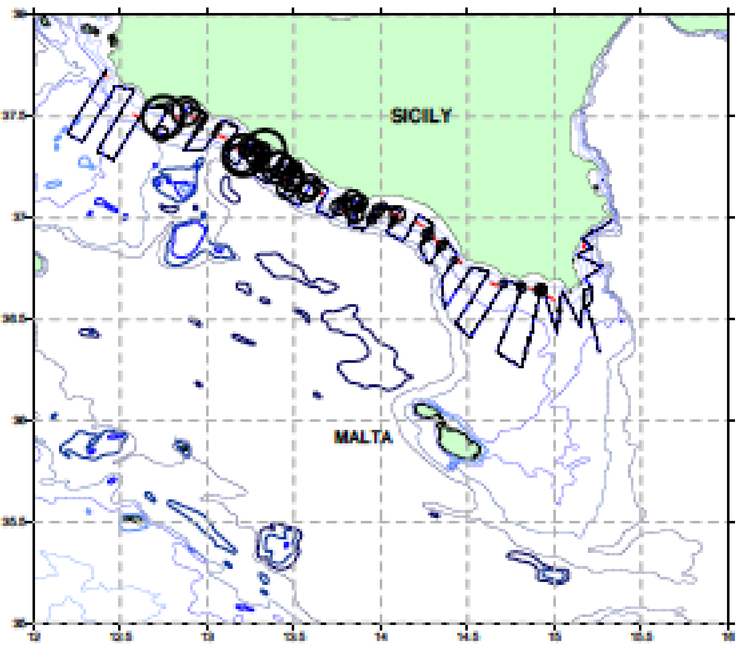

Fig. 4.1.2-2: Survey Ancheva 2010. Sardine density spatial distribution (t/nm^2)

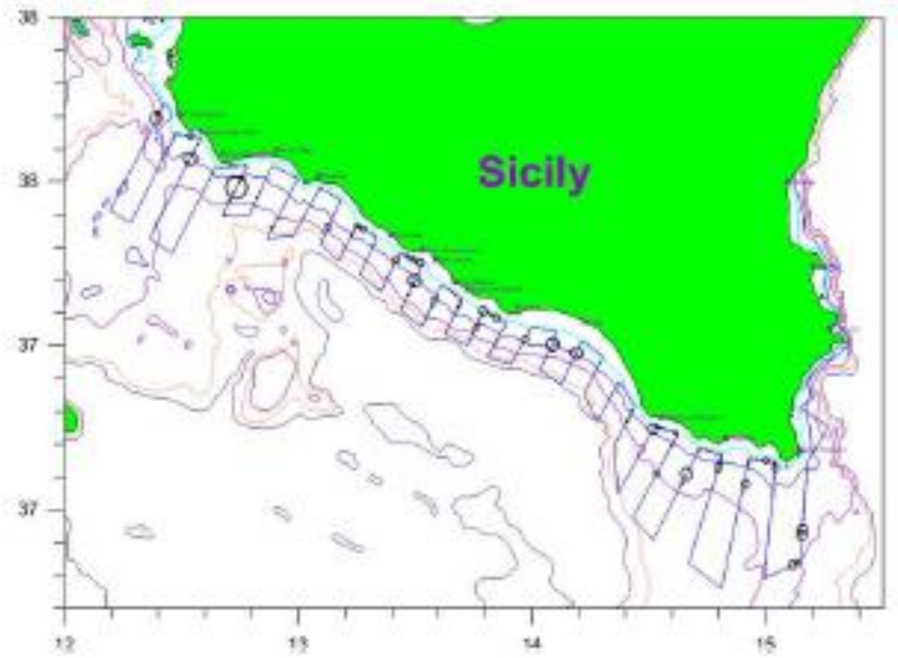

Fig. 4.1.2-3: Survey Ancheva 2011. Sardine density spatial distribution (t/nm^2)

4.1.3 Historical trends

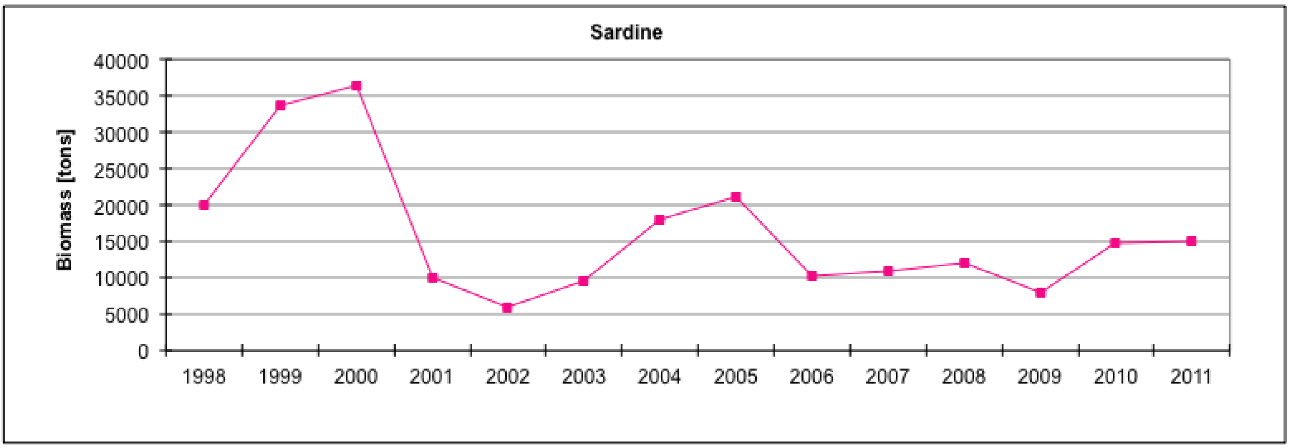

Fig. 4.1.3-1: Trends in sardine biomass, years 1998-2011.

Table 4.1-3: Estimated acoustic biomass values for sardine stock as used in the assessment

Classification YEAR	Sardine biomass (tons)
1998	20000
1999	33700
2000	36370
2001	10054
2002	6000
2003	9510
2004	17960
2005	21219
2006	10220
2007	11043
2008	12152
2009	8028
2010	14771
2011	14977
Average 1998-2011	16143

5 Ecological information

5.1 Protected species potentially affected by the fisheries

Dolphins' species: bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*).

Dolphins are reported to typically interact with fishing operations. However, by-catches occur only occasionally, as dolphins are usually able to prevent to be entangled.

5.2 Environmental indexes

The environmental index adopted and included in the modeling approach was the yearly average satellite-based (SeaWiFS and MODIS-Aqua) chlorophyll-a concentration estimate, calculated over the continental shelf of the study area.

Specifically, chl-a data NASA Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) and MODIS-Aqua projects, distributed as a Level 3 Standard Mapped Image product (Feldman and McClain, 2006), were used. Yearly composite images for the period 1998 to 2010 were downloaded from the http://oceancolor.gsfc.nasa.gov/cgi/l3 website in Hierarchical Data Format (HDF). These images have 2160 by 4320 pixels and a resolution of about 9 × 9 km^2.

6 Stock Assessment

Assessment methods:

Two separate approaches were adopted:

- An empirical approach based on estimation of yearly and average (2008-2011) 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.

6.1 Estimation of exploitation rates from harvest rates

6.1.1 Input data and model assumptions

The first approach for the evaluation of stock status, used in the present assessment, 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.

Landings data for GSA16 were obtained from DCF for the years 2006-2011 and from census information (on deck interviews) in Sciacca port (1998-2011). Acoustic data were used for fish biomass evaluations over the period 1998-2011. 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 1998-2011. Available data were used to estimate yearly and average (2007-2011) exploitation rates starting from the estimation of harvest ratios (catches/biomass from survey).

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.

6.1.2 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 2011) harvest rate is 11.9% (DCF data were used for landings). The estimated average value over the years 2008-2011 is 13.7%.

The exploitation rate corresponding to F=0.137 is E=0.15, if M=0.77, estimated with Pauly (1980) empirical equation, is assumed, and E=0.16 if M=0.72, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. In relation to the above considerations on the possible overestimation of mean stock size in harvest rate calculation, it is worth noting that, even if the harvest rates were twice the estimated values, the exploitation rates would continue to be lower than the reference point (0.4) suggested by Patterson (1992). Thus, using the exploitation rate as a target reference point, the stock of sardine in GSA 16 would be considered as being sustainably exploited.

6.2 Non-equilibrium surplus production model

The sardine stock in the area was also assessed using a non-equilibrium surplus production model based on the Schaefer (logistic) population growth model.

The model was implemented in an MS Excel spreadsheet, modified from the spreadsheets distributed by FAO under the BioDyn package (P. Barros, pers. comm.). Details about the implementation of the applied logistic modelling approach can be found in a FAO report on the Assessment of Small Pelagic Fish off Northwest Africa (FAO, 2004).

The report is available at the web site http://www.fao.org/docrep/007/y5823b/y5823b00.htm.

6.2.1 Input data and model assumptions

The input data used for the adopted modelling approach was total yearly catch estimates, and a series of abundance indices (acoustic biomass estimates) over the period 1998-2011. Specifically, the time series of estimated total yearly sardine landings for GSA 16 between 1998 and 2011 was used as input data for the model, together with the abundance indices from acoustic surveys from the same set of years.

Available data were used as input for the fitting of a non-equilibrium surplus production model to abundance indices, assuming an observation error 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, as expected because pelagic stocks are known to be significantly affected by environmental variability.

The model 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. Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the 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.

Values of F_{Cur}/FSY_{Cur} below 100% indicate that the catch currently taken is lower than the natural production of the stock, and thus that so stock biomass is expected to increase the following year, while values above 100% indicate a situation where fishing mortality exceeds the stock natural production, and thus where stock biomass will decline next year. For comparison purposes, also the series of F_{Cur}/F_{MSY} was evaluated and reported.

6.2.2 Results

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 = 0.35) if no environmental effect is incorporated in the model. The best fit with the inclusion of the selected environmental factor (R^2 = 0.76; Fig. 6.2.2-1) 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 2011) fishing mortality is below the sustainable fishing mortality at current biomass levels (F_{Cur}/FSY_{Cur}=0.69) but slightly above F_{MSY} (F_{MSY}=0.16; F_{Cur}/F_{MSY}=1.05) (Table 6.2.2-1), and fishing mortality experienced high values during the considered period, sometimes above sustainability (F_{Cur}/FSY_{Cur}>1; Fig. 6.2.2-2). In addition abundance was low over the last decade (B/B_{MSY} < 50%; B_{MSY} = 32527; B_{Cur}/B_{MSY} = 0.48; Fig. 6.2.2-3). However, the average production of the last three years (1400 tons) is well below the estimated MSY (5307 tons).

Table 6.2.2-1: Reference points

MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
5307	32527	0.16	48%	69%	105%

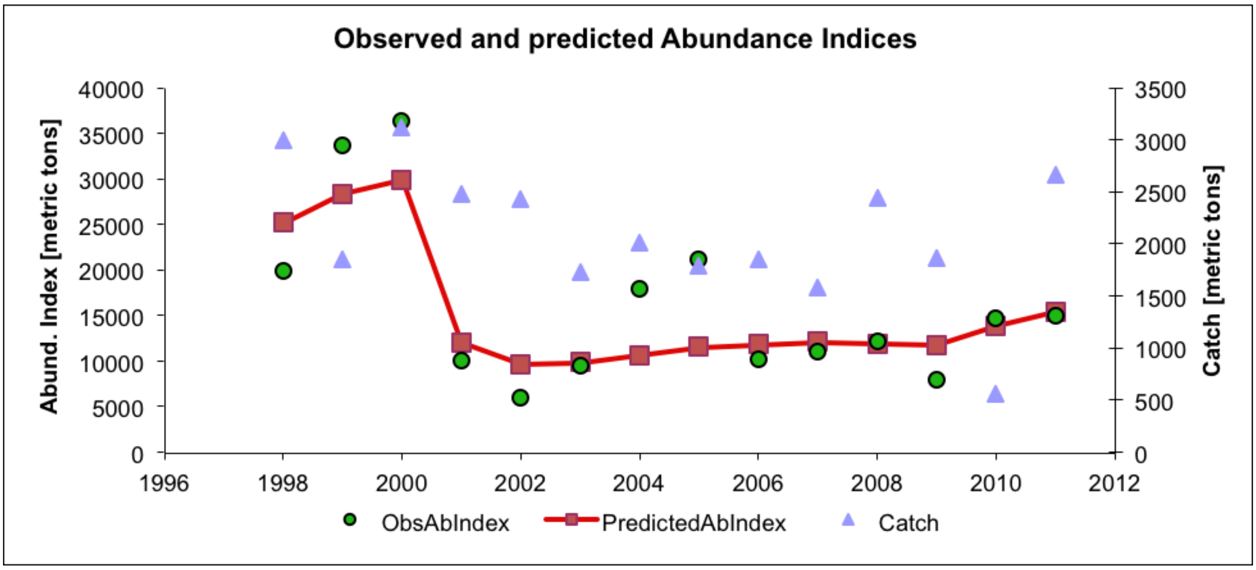

Figure 6.2.2-1: Best fit obtained with a flexible current capacity “K”, modulated by chl-a concentration at sea.

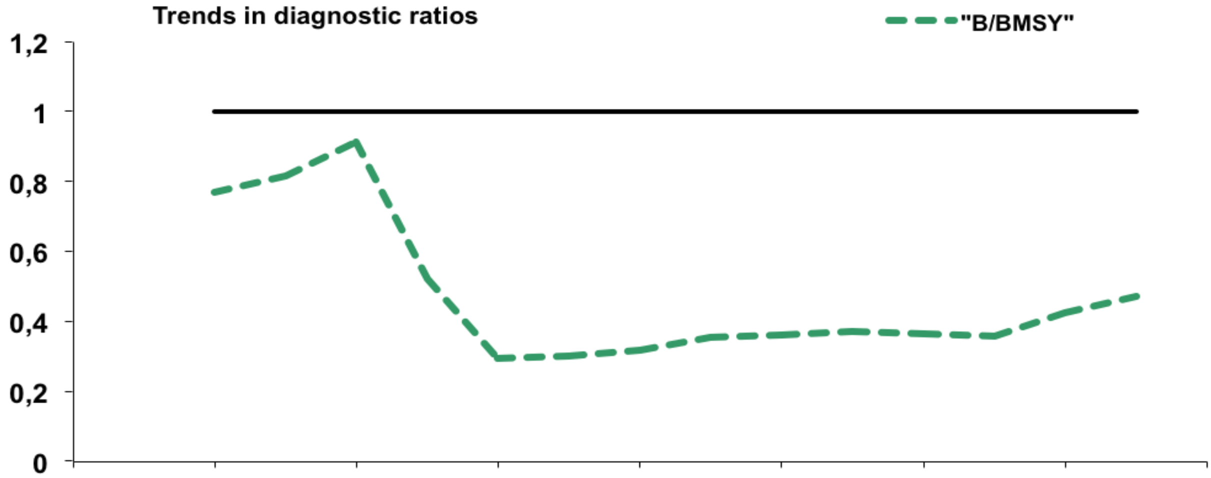

Figure 6.2.2-2: Trend in ratio between current biomass (B) and B_{MSY} over 1998-2011.

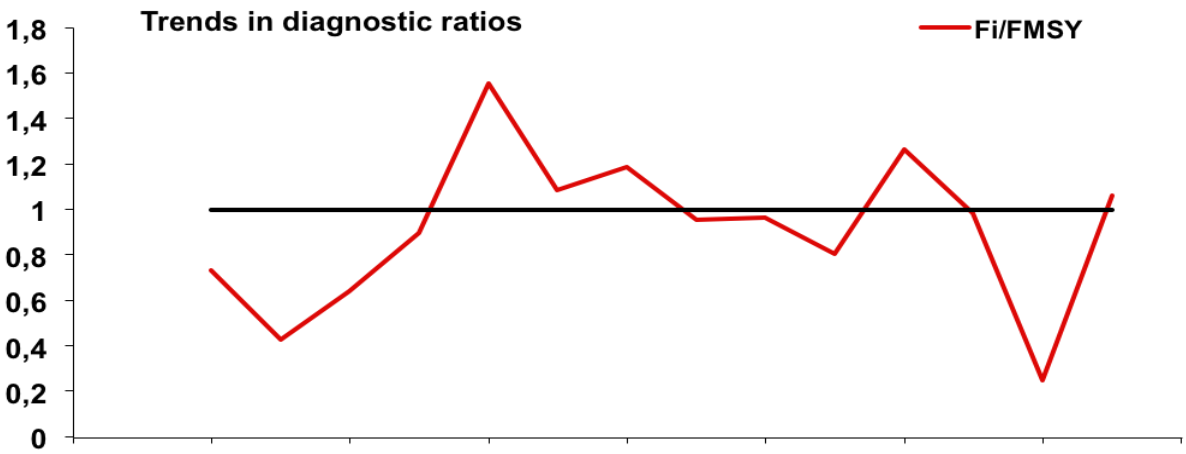

Figure 6.2.2-3: Trend in ratio between current fishing mortality (F) and F_{MSY} over 1998-2011.

6.3 Robustness analysis

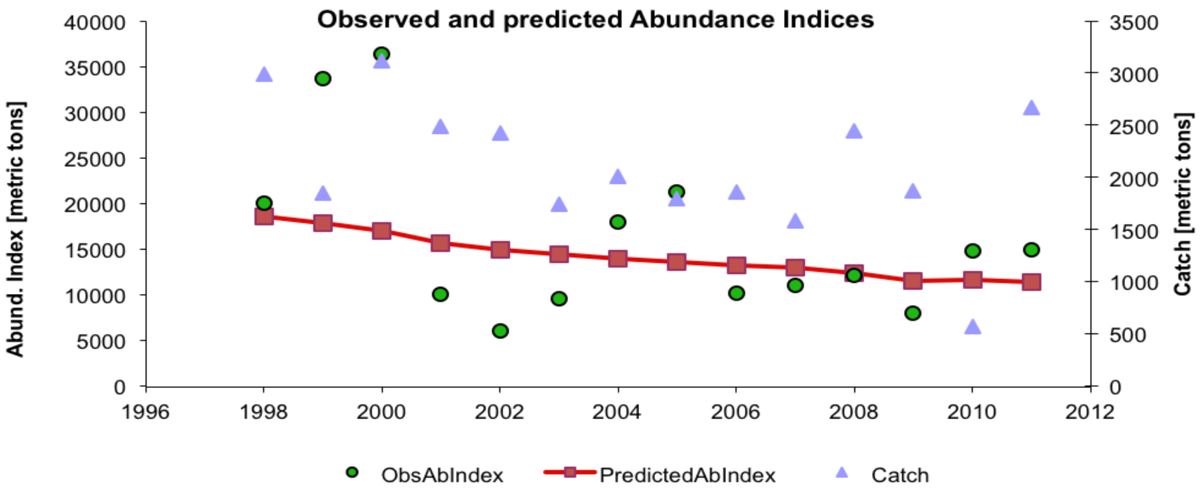

Figure 6.3-1: Best fit obtained without incorporating the environmental. Data 1998-2011.

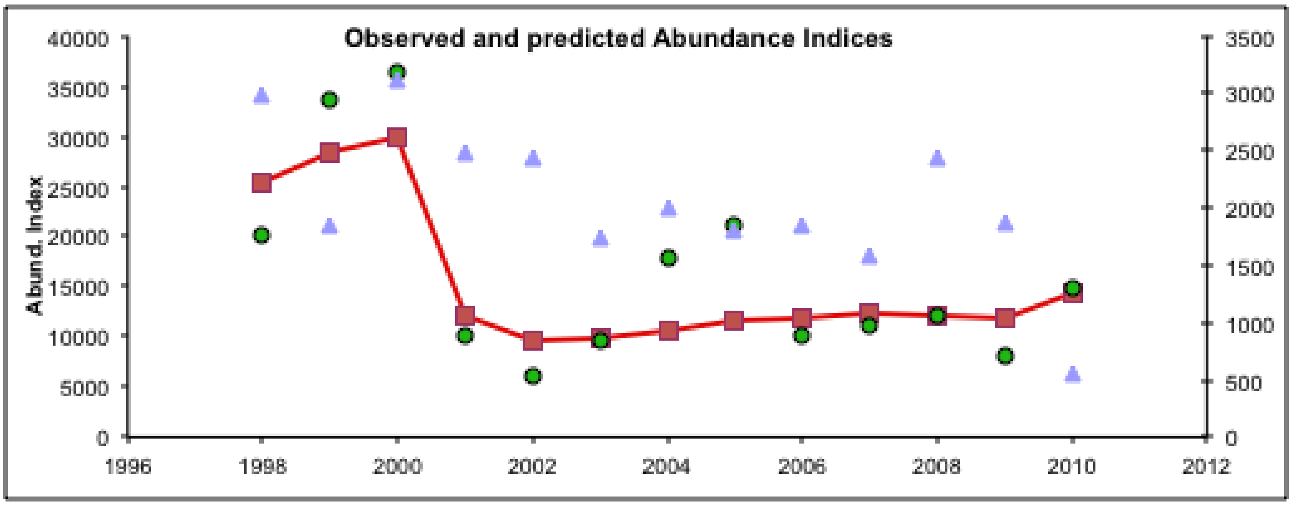

Figure 6.3-2. Results of the retrospective analysis run, obtained using data from 1998 to 2010. Best fit with a flexible current capacity "K", modulated by chl-a concentration at sea.

Table 6.3.2-1: Reference points for the retrospective analysis run and for the best fit obtained including updated data (2011) .

Year	MSY	B_{MSY}	F_{MSY}	B_{Cur}/B_{MSY}	F_{Cur}/FSY_{Cur}	F_{Cur}/F_{MSY}
2010	5430	32476	0.17	48%	14%	22%
2011	5307	32527	0.16	48%	69%	105%

6.4 *Assessment quality*

The quality of input data is good and the obtained output is reasonable.

The current biomass level is estimated to be quite low compared to B_{MSY}, however it should be considered that the obtained results are always strictly linked to the choice of model formulation. In this case in particular, the carrying capacity has been considered to be variable depending on the environmental level of each year, and this will affect the estimated B_{MSY}.

Results of the retrospective analysis are satisfactory.

7 Draft scientific advice

Diagnosis 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 FMSY, 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 modelling approach suggest that the environmental factors can be very important in explaining the variability in yearly biomass levels (mostly due to recruitment success) and indicate that from year 2000 onward the stock status was well below the B_{MSY}.

In addition, the stock in 2010-2011 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 the lowest value observed in the last year of the series. Similarly, B_{pa} was established as B_{lim}*1.4.

Using the above reported RP, the current biomass estimate (14977 tons, 2011 value) is well below B_{MSY} (32527 tons), but above the adopted estimated B_{lim} (8028 tons) and also above B_{pa} (11239 tons) (Fig. 7-1).

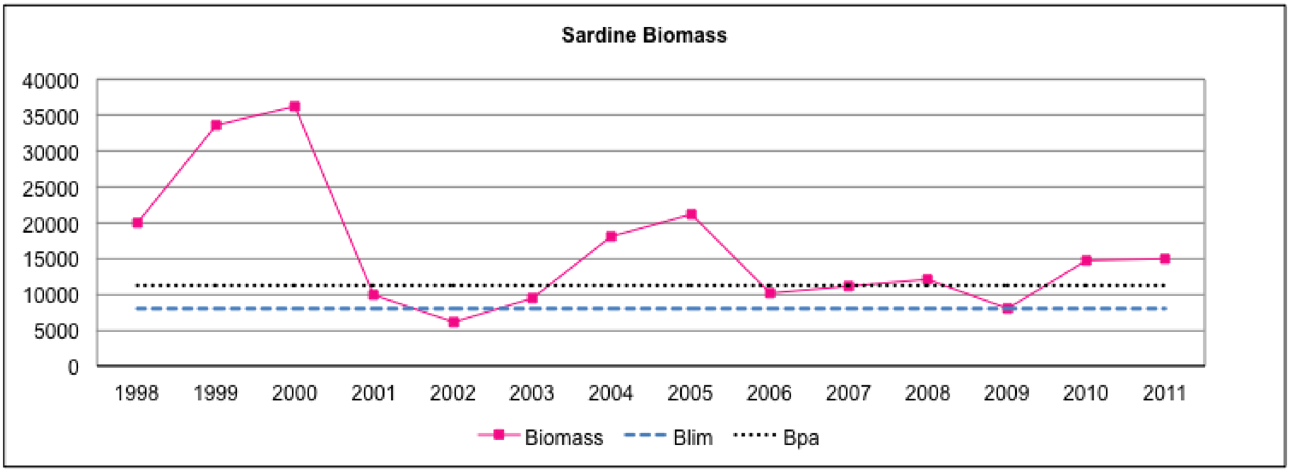

Fig. 7-1: Trends in sardine biomass (tons), years 1998-2011. Blim and Bpa are also indicated

Advices and recommendations

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

Discussion:

The present assessment, based on the analysis of the abundance and fishing mortality levels observed in the available time series, implied the tentative precautionary evaluation of sustainable levels for current exploitation rates and for current biomass, also taking into the relative low (even stable) abundance phase together with a signal of increasing in the last years of the series.

References

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Table 2: Bidimensional stock advice summary; Exploitation rate and Stock Abundance.

Exploitation rate		Stock Abundance	
1998-2011		1998-2011	
	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

Complete explanation: Conceptual reference point refers to the period in the table. The two variables are being assessed independently. The values are related to conceptual reference points. Sustainable Fishing Mortality: refers to fishing mortality alone and to the conceptual reference point used (FMSY, or Fpa or Flim). If MSY then is the F that is expected to produce sustainable maximum yields in the future, if PA then that B is not expected to drop below BPA in the future.

Table 3: Stock advice summary; Historical trends in biomass and recruitment.

Biomass trends		Recruitment trends	
1998-2011		N.A.	
6000-36370 tons		[Range]	
	Stable		Stable
	Increasing		Increasing
X	Decreasing		Decreasing