# 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: |
|---|---|---|
| *Engraulis encrasicolus* | Anchovy | |
| 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: | | |
| Patti B., Quinci E.M., Bonanno A., Basilone G., Mazzola S. | | |
| 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 anchovy stock in GSA 16 is mainly based on information collected over the last decade on the fishery grounds off the southern Sicilian coast (GSA 16, South of Sicily), and specifically using biomass estimates obtained by hydro-acoustic surveys and catch/effort data from local small pelagic fisheries. The main distribution area of the anchovy 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). Daily Egg Production Method (DEPM) surveys were also carried out starting from 1998, giving also information on spawning areas distribution.

## *2.2 Growth and maturity*

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

<table>
<tr><th colspan="3">Somatic magnitude measured (LH, LC, etc)*</th><th colspan="2">LT</th><th>Units*</th><th>cm</th></tr>
<tr><th>Sex</th><th>Fem</th><th>Mal</th><th>Both</th><th>Unsexed</th><th></th><th></th></tr>
<tr><td>Maximum size observed</td><td></td><td></td><td>18</td><td></td><td>Reproduction season</td><td>Spring-Summer</td></tr>
<tr><td>Size at first maturity</td><td></td><td></td><td>11.2</td><td></td><td>Reproduction areas</td><td>South Sicilian Shelf</td></tr>
<tr><td>Recruitment size</td><td></td><td></td><td>9</td><td></td><td>Nursery areas</td><td>Cape Passero area</td></tr>
</table>

*Table 2.2-2: Growth and length weight model parameters*

| | | | Sex | | | |
|---|---|---|---|---|---|---|
| | | Units | female | male | both | unsexed |
| Growth model | $L_\infty$ | cm | | | 19.83 | |
| | K | y-1 | | | 0.31 | |
| | $t_0$ | year | | | -1.95 | |
| | Data source | DCF 2007-2009 | | | | |
| Length weight relationship | a | | | | | |
| | b | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **M** (vector by length or age) | 0.66 | | | Pauly (1980) relationship. Ref. Temp=13.5 °C | |

| | |
|---|---|
| **sex ratio** (% females/total; 2010 data) | 55% |
| | |

# 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: 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 1998-2011 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, ranged from a minimum of 3,100 tons in 2008 to a maximum of 23,000 tons in 2001. Current (2011) acoustic biomass estimate is below the average over the considered period (5,070 vs. 11,105).

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 | ANE |
| **Operational Unit 2** | ITA | 16 | J - Pelagic Trawl (12-24 metres) | 03 - Trawls | 31 - Small gregarious pelagic | ANE |
| **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 - ANE | 17 | Tons | 824 | sardine | negligible | negligible | fishing day |
| ITA 16 J 03 31 - ANE | 30 | Tons | 1243 | sardine | negligible | negligible | fishing day |
| | * Dec 2006 , census data | | ave 1998-2011 | | | | |
| Total | 47 | | 2067 | | | | |

*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<br>YEAR | Catch (tn) |
|---|---|
| 1998 | 781 |
| 1999 | 2043 |
| 2000 | 190 |
| 2001 | 1627 |
| 2002 | 3467 |
| 2003 | 2218 |
| 2004 | 1554 |
| 2005 | 2390 |
| 2006 | 4262 |
| 2007 | 4812 |
| 2008 | 1062 |
| 2009 | 4302 |
| 2010 | 5124 |
| 2011 | 4374 |
| | |
| Average 1998-2011 | 3100 |

### 3.2 Historical trends

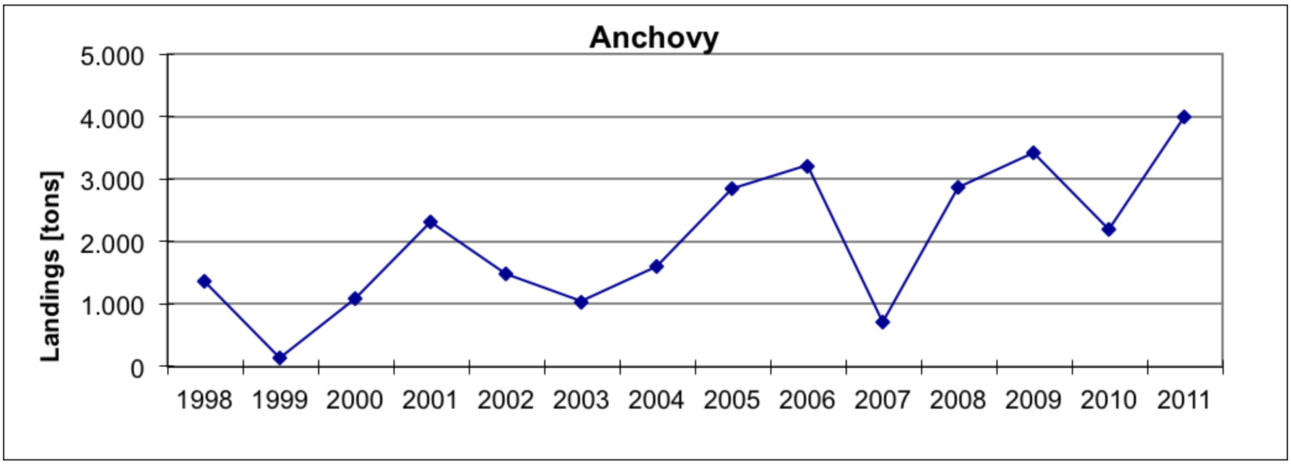


*Fig. 3.2-1: Trends in anchovy landings, years 1998-2011*

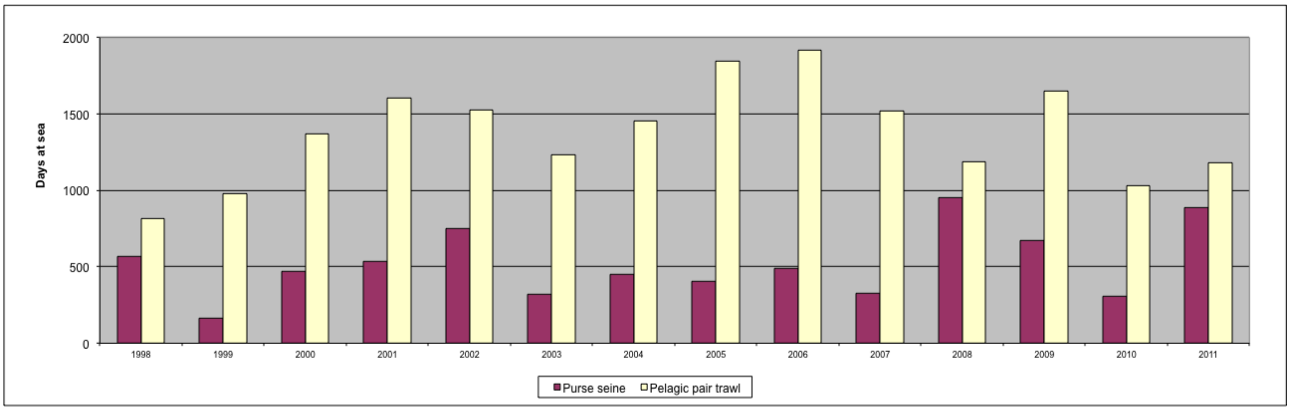


*Fig. 3.2-2: Effort data regarding the purse seine and pelagic pair trawl fleets in Sciacca port (GSA 16), 1998-2011*

### 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 (9 cm for anchovy), 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 ($\rho$) from $NASC_{Fish}$ values and biological data;
- Production of $\rho$ 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 ($\nu_j$) 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 $\sigma_{jk}$ is the scattering cross section of the *k*-th length class in the *j*-th species. $\sigma_{jk}$ *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<br><br>Inter-transect distance: 5 nmi | | |
| **Sampling season** | Summer | | |
| **Investigated depth range (m)** | 0-200 m | | |
| **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 – 75.10 | | |
| **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 … |
|---|---|---|---|---|---|
| **Anchovy** | 5070 | | 17.0 | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

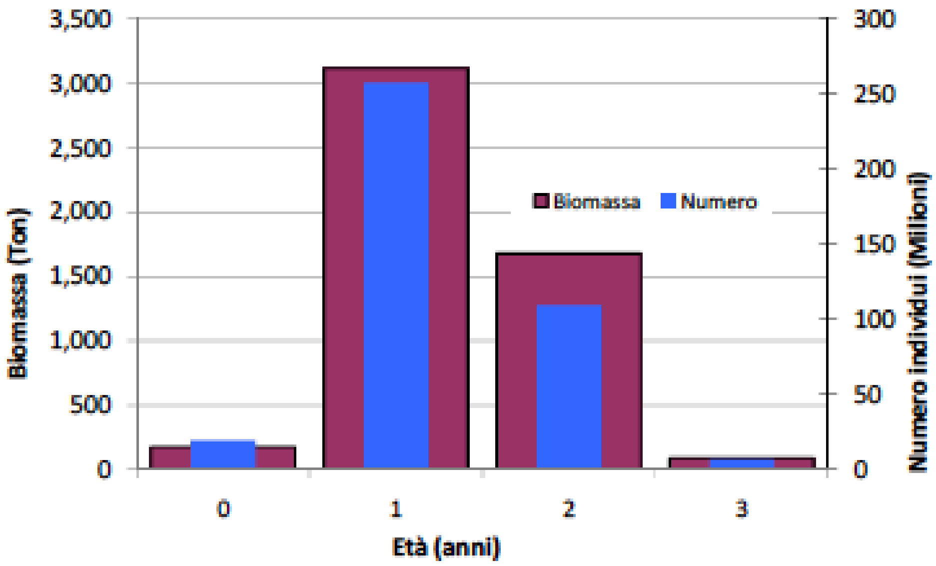


*Fig. 4.1-1: Anchovy distribution by age (years), 2011 survey*

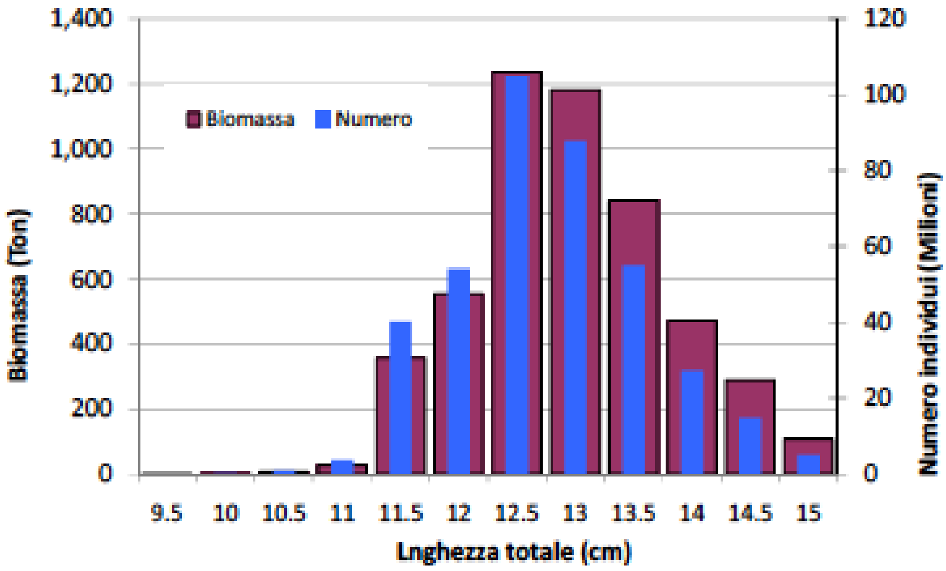


*Fig. 4.1-2: Anchovy distribution by length, 2011 survey*

## 4.1.2 Spatial distribution of the resources

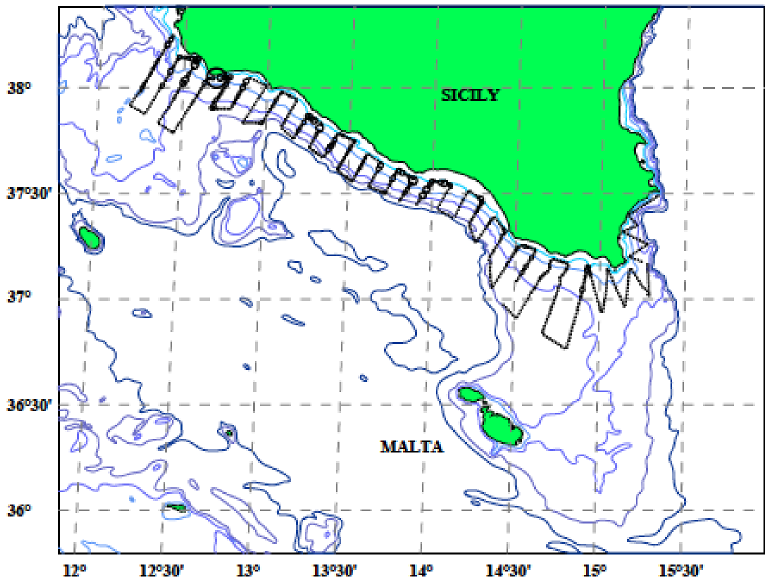


*Fig. 4.1.2-1: Survey Ancheva 2009. Anchovy density spatial distribution (t/nm²)*

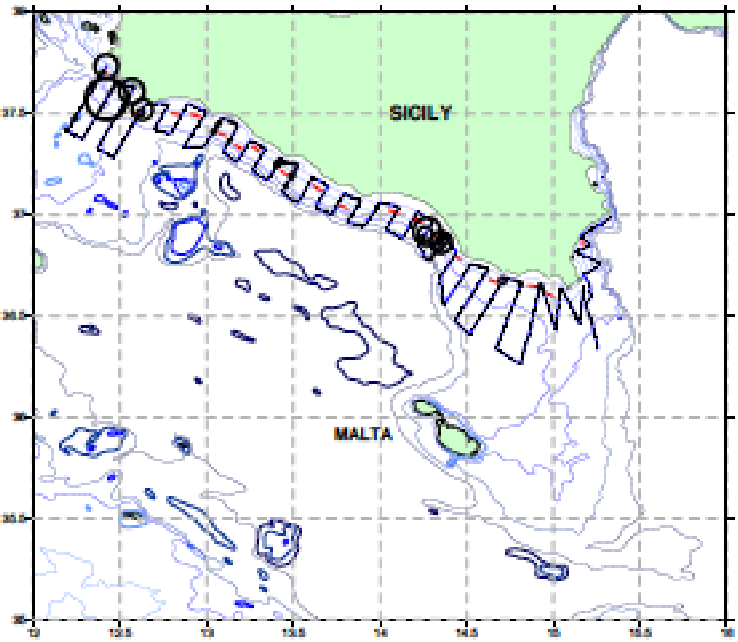


*Fig. 4.1.2-2: Survey Ancheva 2010. Anchovy density spatial distribution (t/nm²)*

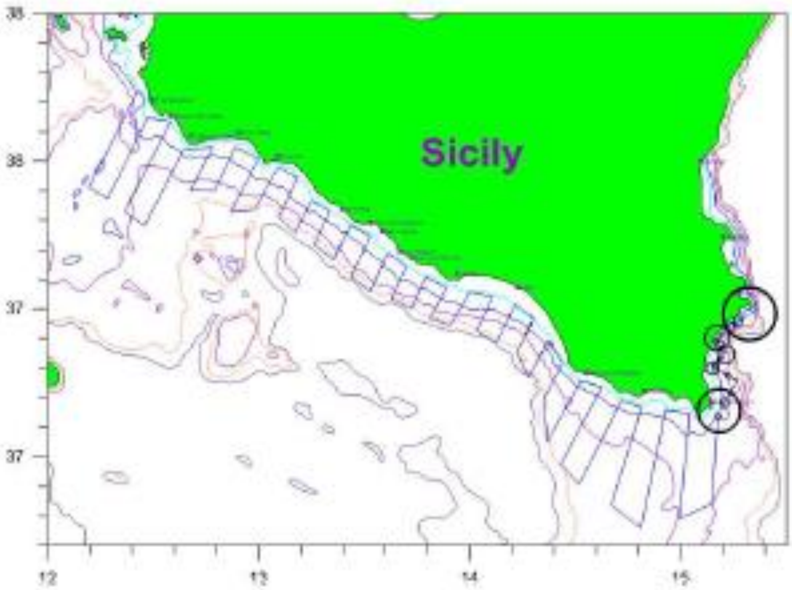


*Fig. 4.1.2-3: Survey Ancheva 2011. Anchovy density spatial distribution (t/nm²)*

### 4.1.3 Historical trends


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

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

| Classification<br>YEAR | Anchovy biomass (tons) |
|---|---|
| 1998 | 7100 |
| 1999 | 20200 |
| 2000 | 11000 |
| 2001 | 22950 |
| 2002 | 11500 |
| 2003 | 9200 |
| 2004 | 9820 |
| 2005 | 20702 |
| 2006 | 6370 |
| 2007 | 6725 |
| 2008 | 3130 |
| 2009 | 5833 |
| 2010 | 15880 |
| 2011 | 5070 |
| | |
| Average 1998-2011 | 11106 |

# 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 2007-2009. 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 $\beta$ 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 1998-2011. 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.

### 6.1.2 Results

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

The current (year 2011) harvest rate is 79.3% (DCF data were used for landings). The estimated average value over the years 2008-2011 is again 79.3%.

The exploitation rate corresponding to F=0.79 is E=0.55, if M=0.66, estimated with Pauly (1980) empirical equation, is assumed, and E=0.59 if M=0.56, estimated with Beverton & Holt's Invariants method (Jensen, 1996), is used instead. Consequently, sing as reference point for the exploitation rate the 0.4 value suggested by Patterson (1992), this stock should be considered as being overexploited.

## *6.2 Non-equilibrium surplus production model*

The anchovy 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 anchovy 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. 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 ($R^2$ = 0.11) without incorporating the environmental effect, significantly higher ($R^2$ = 0.45; Fig. 6.2.2-1) 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 2011) fishing mortality is far above the sustainable fishing mortality at current biomass levels_($F_{Cur}/FSY_{Cur}$=3.15; $F_{MSY}$=0.17; $F_{Cur}/F_{MSY}$=4.54; see Table 6.2.2-1). Fishing mortality experienced very high values during the considered period, frequently well above sustainability ($F_{Cur}/FSY_{Cur}$>1; Fig. 6.2.2-2). In addition, $B_i/B_{MSY}$ values were below 100% over the entire time series ($B_{MSY}$ = 14152 tons; $B_{Cur}/B_{MSY}$ = 0.56; Fig. 6.2.2-3), and estimated average production of the last three years (5160 tons) is well above the MSY (2359 tons).

*Table 6.2.2-1: Reference points*

| MSY | $B_{MSY}$ | $F_{MSY}$ | $B_{Cur}/B_{MSY}$ | $F_{Cur}/FSY_{Cur}$ | $F_{Cur}/F_{MSY}$ |
|---|---|---|---|---|---|
| 2359 | 14152 | 0.17 | 56% | 315% | 454% |

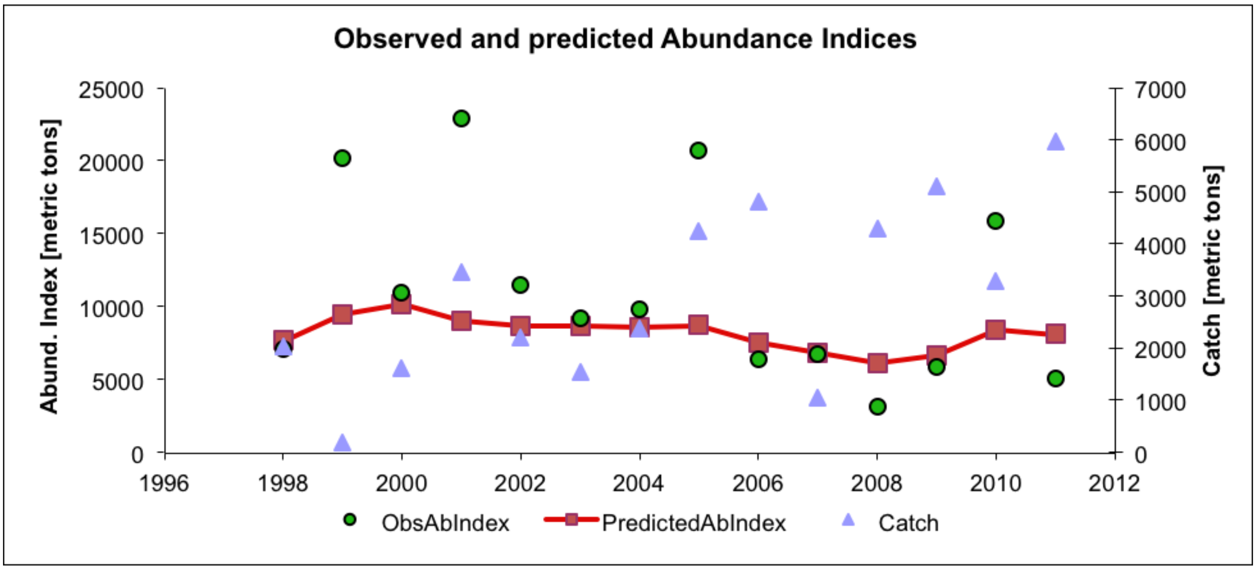


*Figure 6.2.2-1: Best fit obtained with a flexible intrinsic growth rate "r", modulated by chl-a concentration at sea.*

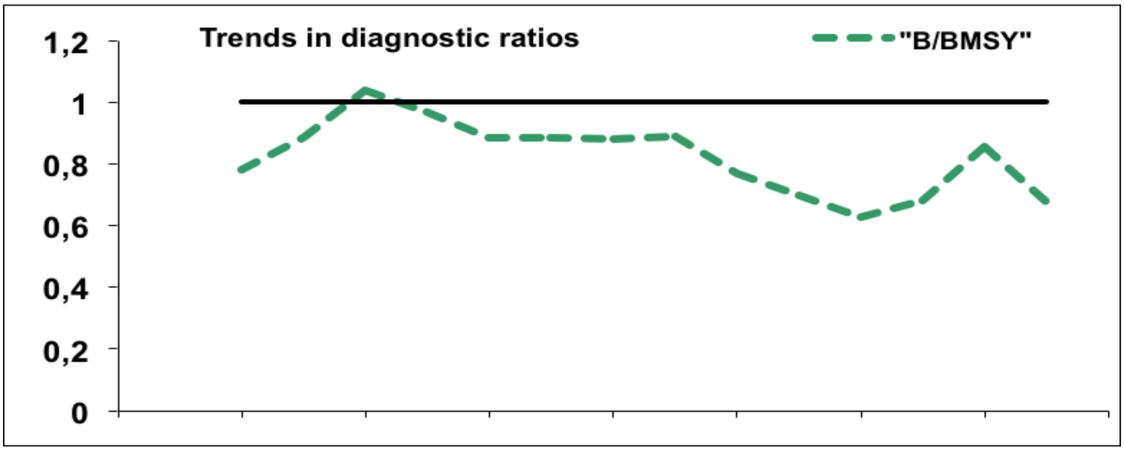


*Figure 6.2.2-2: Trend in ratio between current biomass (B) and $B_{MSY}$ over 1998-2011.*

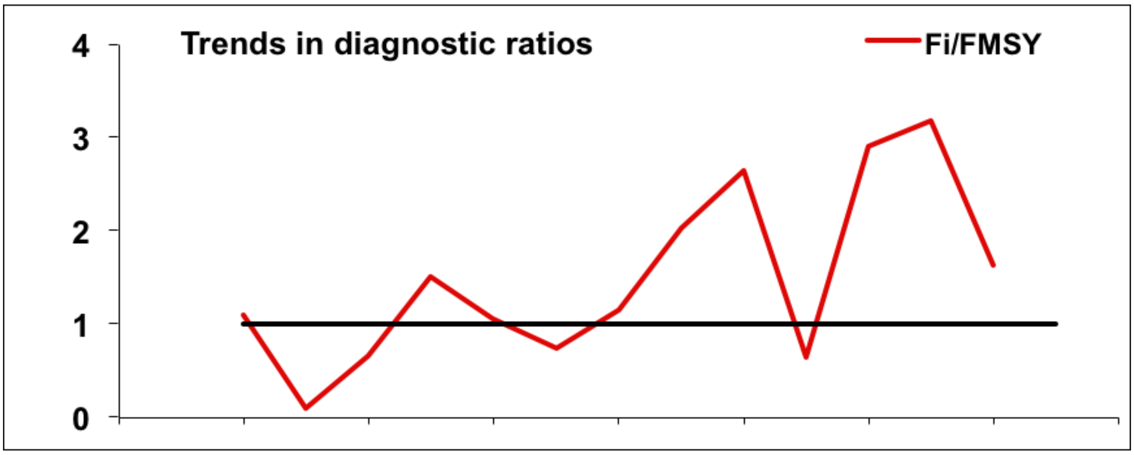


*Figure 6.2.2-3: Trend in ratio between current fishing mortality (F) and $F_{MSY}$ over 1998-2011.*

## 6.3 Robustness analysis

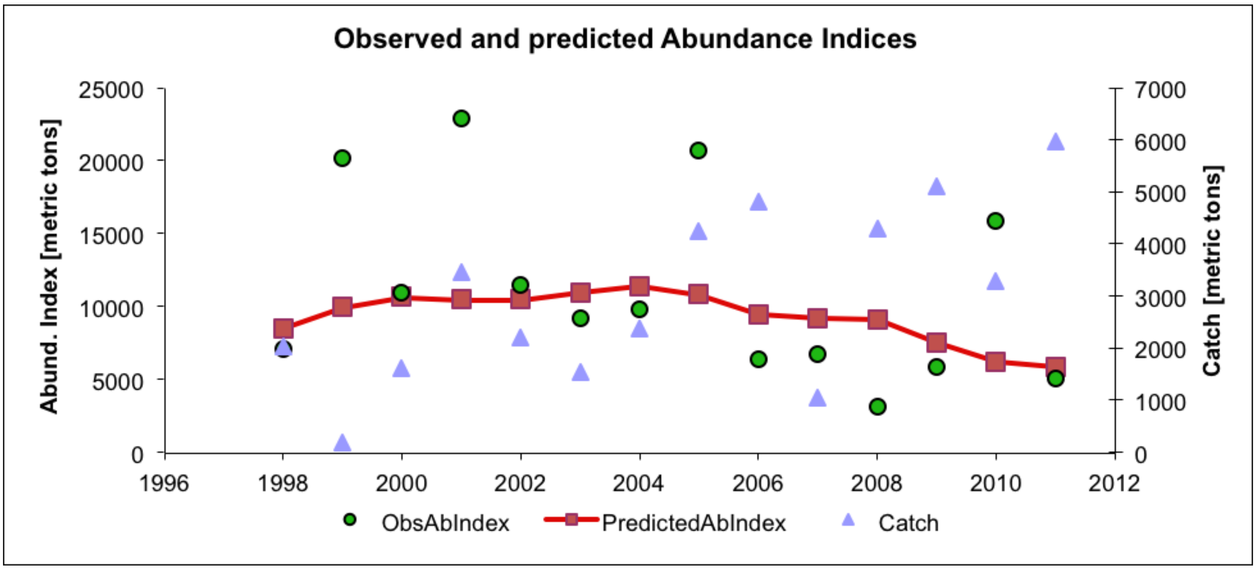


*Figure 6.3.3-1: Best fit obtained without incorporating the environmental.*

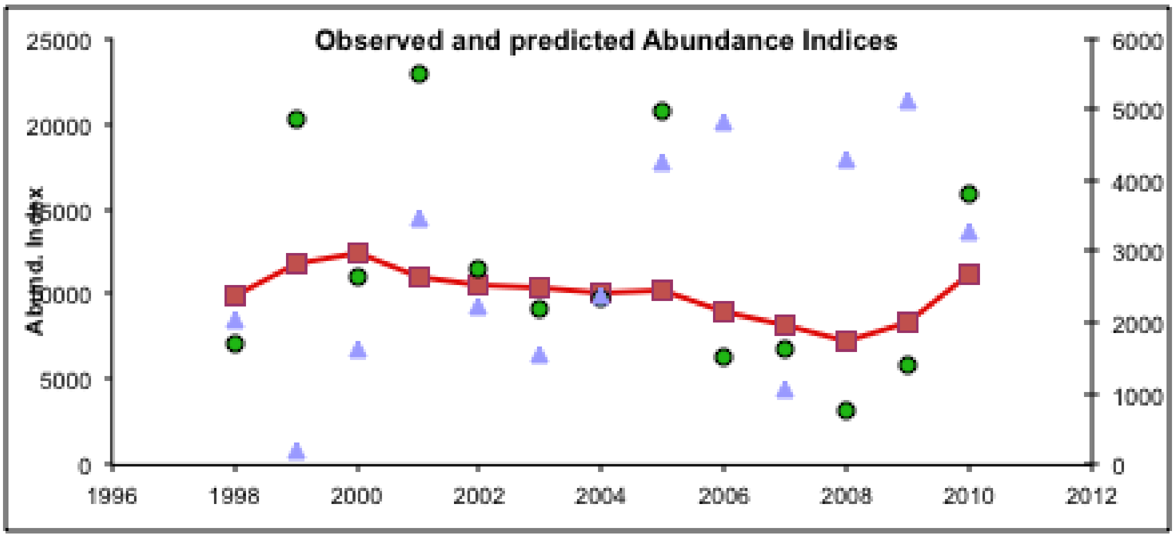


*Figure 6.3-2. Results of the retrospective analysis run, obtained using data from 1998 to 2010. Best fit with a flexible intrinsic growth rate "r", modulated by chl-a concentration at sea.*

*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 | 2198 | 17584 | 0.13 | 85% | 153% | 176% |
| 2011 | 2359 | 14152 | 0.17 | 56% | 315% | 454% |

## 6.4 *Assessment quality*

The quality of input data is good and the obtained output is reasonable, even though the goodness of the best fit obtained using the surplus production modeling approach is limited.

The results of the adopted modeling approach are consistent with those ones obtained from the estimation of exploitation rates based on the analysis of harvest rate time series, as in both cases the current fishing mortality levels are estimated to be above sustainability.

Results of the retrospective analysis are also 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 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 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 (5070 tons, 2011 value) is well below $B_{MSY}$ (14152 tons), but it is above the adopted estimated $B_{lim}$ (3130 tons) and also slightly, even not significantly, above $B_{pa}$ (4382 tons) (Fig.7-1).

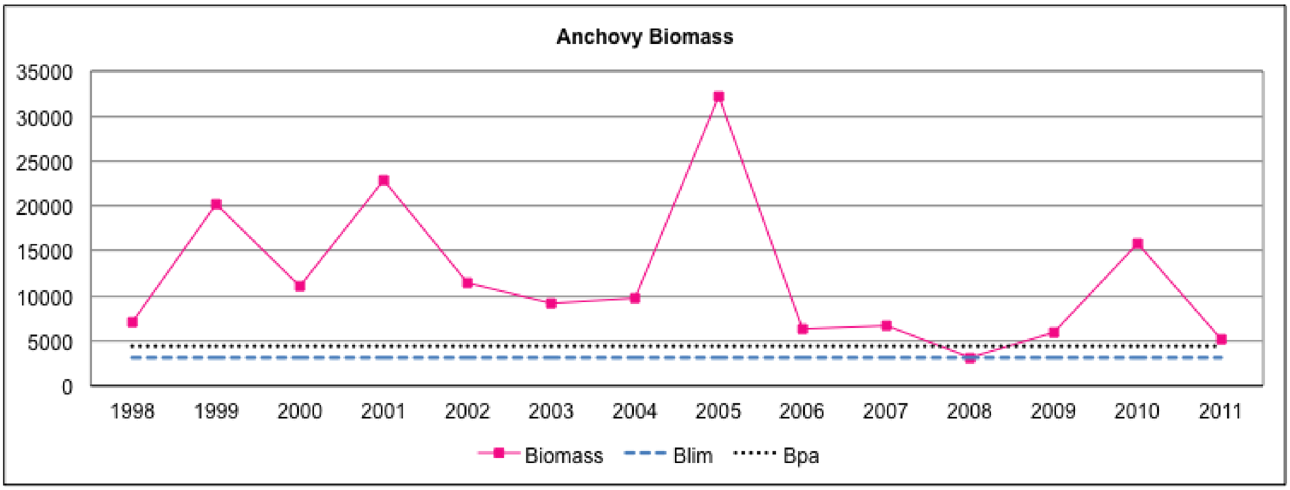


*Fig. 7-1: Trends in anchovy biomass (tons), years 1998-2011. Blim and Bpa are also indicated*

## Advices and recommendations

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

## Discussion

The present assessment, based on the analysis of the abundance and fishing mortality levels observed in the available time series, implied the tentative precautionary evaluation of sustainable levels for current exploitation rates and for current biomass, also taking into the contrasting perspective between the model output, showing a relative stable trend, and the raw data.

## References


Jensen, A.L. (1996). Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can. J. Fish. Aquat. Sci., 53: 820-822.

Patterson, K. (1992). Fisheries for small pelagic species: an empirical approach to management targets. Review of Fish Biology and Fisheries, 2: 321-338.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer, 39 (3): 175-192.


*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 |
| | Sustainable Fishing Mortality | | Intermediate abundance |
| X | High fishing mortality | X | 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 |