Stock Assessment Form

Small Pelagics

Reference Year: 2014

Reporting Year: 2015

[A brief abstract may be added here]

Stock Assessment Form version 1.0 (November 2014)

Sardine in GSA06 (Northern Spain)

Stock assessment form

1 Basic Identification Data

Scientific name:	Common name:	ISCAAP Group:
Sardina pilchardus	Sardine	35
1st Geographical sub-area:	2nd Geographical sub-area:	3rd Geographical sub-area:
6		
Spain		
Stock assessment method: (direct, indirect, combined, none)		
Direct: Acoustic survey **Indirect:** : Surplus production model (BioDyn package; FAO, 2004) and CMSY		
Authors:		
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2 Stock identification and biological information

2.1 Stock unit

The assessment of anchovy corresponds to the GSA06 (Northern Spain), but it is not known yet if this is a shared Mediterranean French stock or a complete stock unit. Studies of larvae transport from the Golf of Lion to Spanish waters suggest that this is a shared stock.

2.2 Growth and maturity

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

Somatic magnitude measured (LT, LC, etc)				Units	cm
Sex	Fem	Mal	Combined	Reproduction season	Autumn-winter
Maximum size observed			21.5 (2014) 23.5 (2004-2013)	Recruitment season	Spring-summer
Size at first maturity			9.78 (2014) 11.34 (2007-2013)	Spawning area	Continental shelf
Recruitment size to the fishery			10	Nursery area	Bays and Delta Ebro

Table 2-2.2: M vector and proportion of matures by size or age.

Size/Age	Natural mortality	Proportion of matures
Edad 0		0.64
Edad 1		0.96
Edad 2		1.00
Edad 3		1.00
Edad 5		1.00

Table 2-3: Growth and length weight model parameters

			Sex			
		Units	female	male	Combined	Years
Growth model	L_∞	cm			25	2014
	K				0.1903	2014
	t_0				-2.8213	2014
	Data source	CFD 2014				
Length weight relationship	a				0.0030	2014
	b				3.3249	2014
	M (scalar)	0.49			Pauly (1980). Temp.=16,2*	
	sex ratio (% females/total)	48.6				

* Average temperature of the last 50 years to 100 m deep. Removed the surface temperature. MEDAR Group, 2002 - MEDATLAS/2002 database Mediterranean and Black Sea database of temperature salinity and bio-chemical parameters. Climatological Atlas

3 Fisheries information

3.1 Description of the fleet

The current fleet in GSA 06 the Northern Spain is composed by 118 units (average GT 39.5), 2% of them are smaller than 12 m (operational Unit 1), 98% > 12 m (operational Unit 2) and 16% are over 24m. The purse seine fleet has been continuously decreasing in the last two decades, from 222 vessels in 1990 to 118 in 2014. They have lost the smallest units.

Sardine although 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 1990-2014 sardine landings show a negative trend, between 53000 t in 1994 to 9700 t in 2014. The whole period average is 28000 t.

The catches evolution is consistent with result of acoustic assessments.

Data used in the assessment correspond to DCF. Unit of effort has been effective fishing day for the species.

Table 3-1: Description of operational units exploiting the stock

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	Spain	6	G-Purse Seine (6-12 m)	02-Seine Nets	31- Small gregarious pelagic	PIL
Operational Unit 2	Spain	6	H-Purse Seine (>12)	02-Seine Nets	31- Small gregarious pelagic	PIL

Table 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year

Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed) Tons	Other species caught (names and weight) Tons	Discards (species assessed)	Discards (other species caught)	Effort (units)
ESP 06 G 02 31-PIL	2	120	Anchovy: 27 Trachurus spp: 2 Scomber spp: 4 Sardinella: 1 Otros: 9 Total: 43	negligible	negligible	Effective fishing day for the species
ESP 06 H 02 31-PIL	116	9533	Anchovy: 16821 Trachurus spp: 368 Scomber spp: 850 Sardinella: 1454 Otros: 726 Total: 20219	negligible	negligible	Effective fishing day for the species
Total	118	9653	20262	negligible	negligible	Effective fishing day for the species

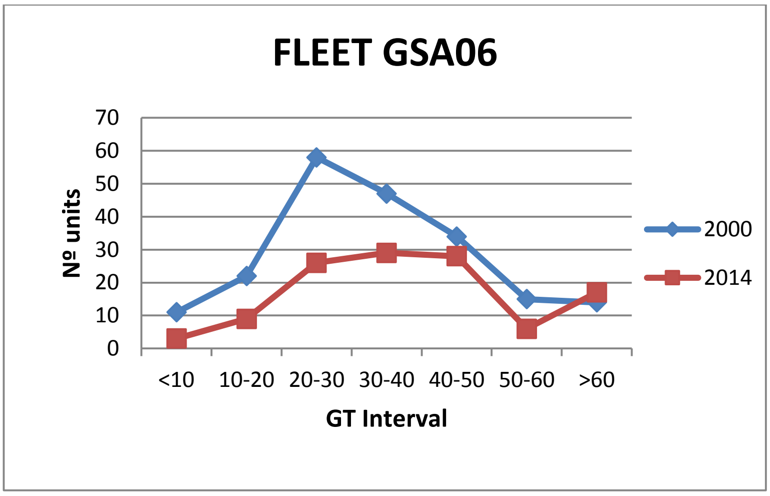


Fig. 3.1.1. Fleet GSA06 in years 2000 and 2014.

Table 3.1-3: Sardine catches and acoustic biomass estimate 1996-2014.

YEAR	Catch (tons)	ACOUSTIC (tons)	Date
1996	44966	95915	Nov-dc
1997	38210	92192	Nov-dc
1998	34339	68975	Nov-dc
1999	38837	66099	Nov-dc
2000	38607	53633	Nov-dc
2001	32831		Nov-dc
2002	20277		Nov-dc
2003	22506	65679	Nov-dc
2004	22252	30997	Nov-dc
2005	20985	35277	Nov-dc
2006	29609	47114	Nov-dc
2007	24379		Nov-dc
2008	16952	28767	Nov-dc
2009	9190	25609	Jn-Jul
2010	8752	19022	Jn-Jul
2011	12218	31746	Jn-Jul
2012	9193	43296	Jn-Jul
2013	9734	41871	Jn-Jul
2014	9659	6215	Jn-Jul
Average	23217	47025	

3.2 Historical trends

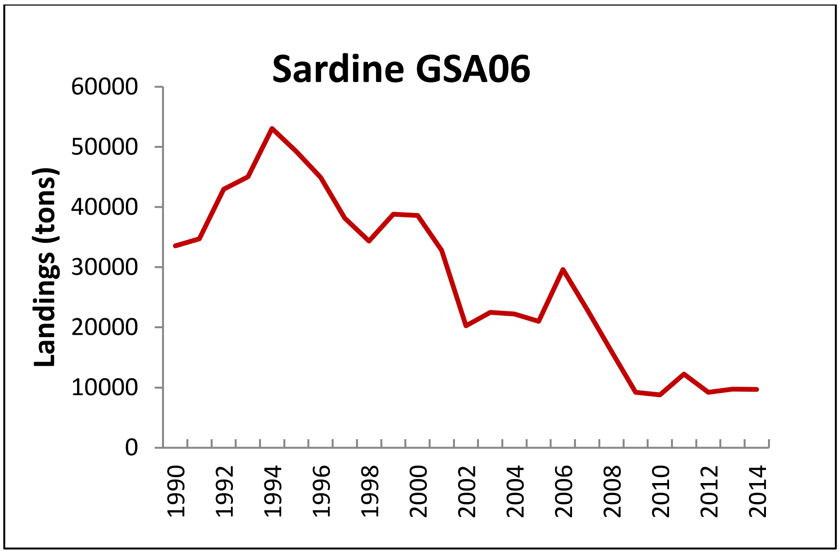
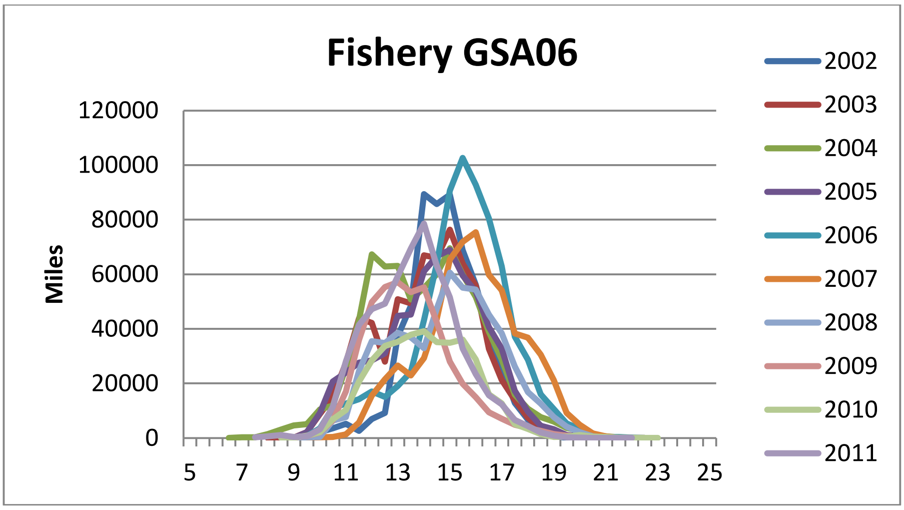
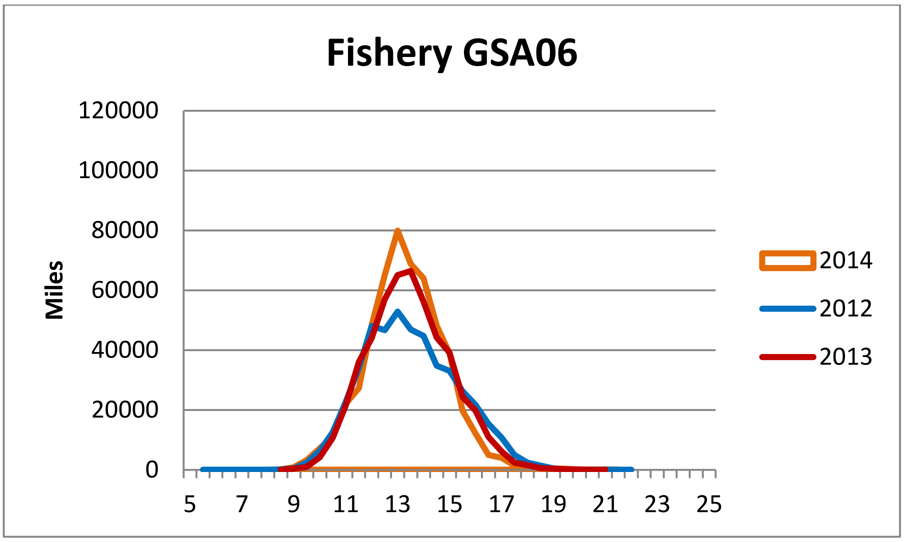


Figure 3.2.1. Trends in sardine landings 1996-2014.

Negative trend in catches since 1994

3.3 Length distribution fishery





Figures 3.3.1 y 3.3.2. Length distribution fishery 2002-2011 (up) and 2012-2014 down).

During the last 3 years there is a decreasing trend in the landing average length (Fig. 3.3.2). Only ages 0-4, age 3 and 4 are less than 1%.

3.4 Cohorts fishery

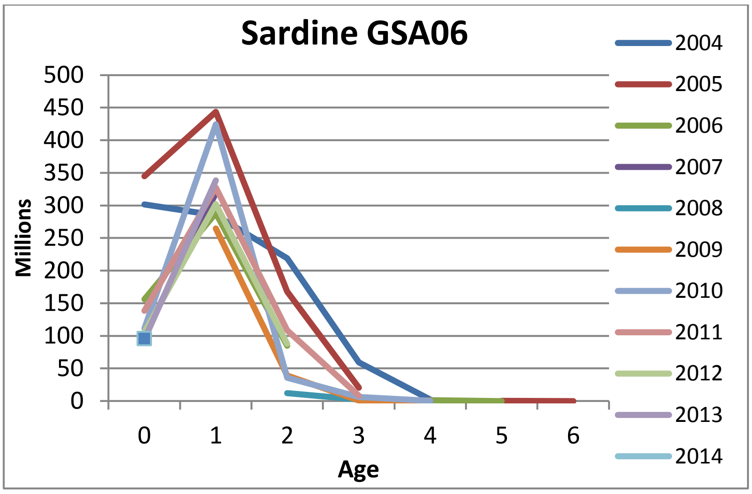
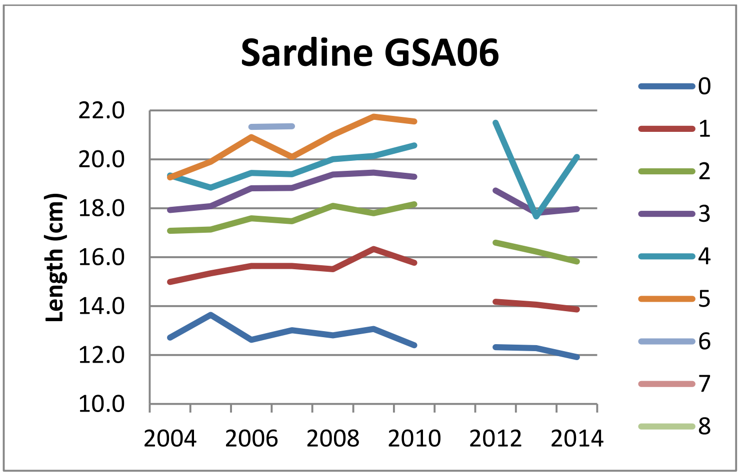
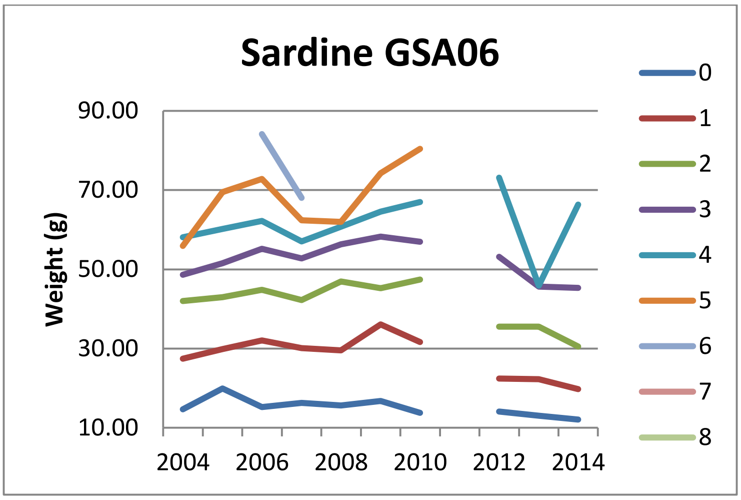


Figure 3.4.1. Sardine cohorts can be followed.

3.5 Length and Weight by age Fisher





Figures 3.5.1 y 3.5.2. Length and weight by age 2004-2014.

Length and weight by age are decreasing since 2012. During the last years there are only age 0 to 4 in landings (Fig. 3.5.1 and 3.5.2).

3.6 Body Condition

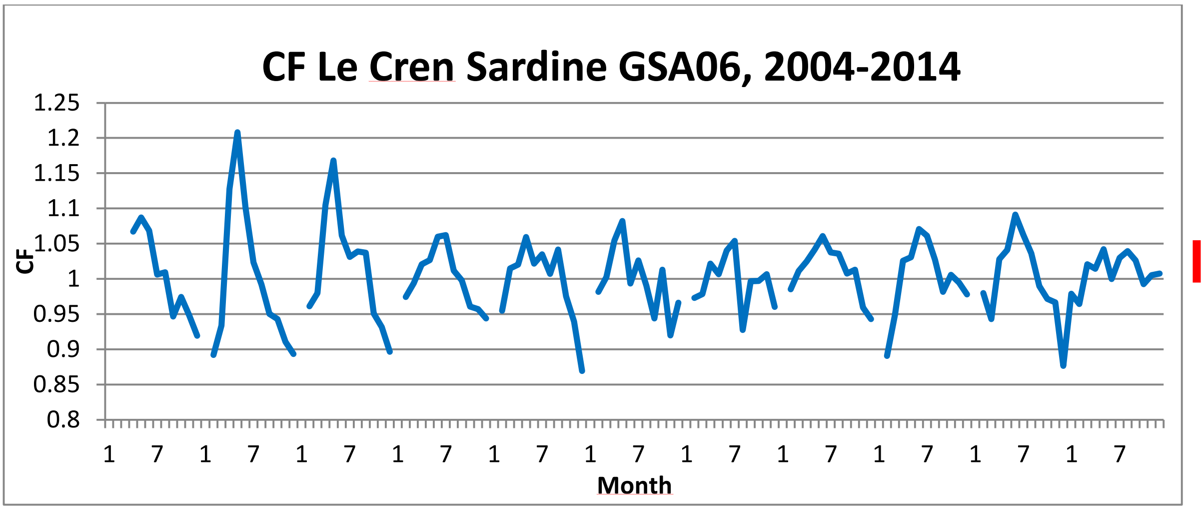


Figure 3.6.1. Monthly evolution of the Condition Factor from 2004 to 2014.

The formula used for the calculation of the Condition Factor was Le Cren (1951). Monthly evolution of this factor in sardine (Fig. 3.6.1) shows in the early years a good nutritional status at certain times of the year; monthly differences are decreasing so that in 2014 the range of values of this factor is the smallest of the entire series since 2004 (red line). Sardine condition is poor being the smaller size and weight in the series.

3.7 Management regulations

Regulated by Fishery European regulations REGULATION (EC) Nº 1967/2006 of December 21, 2006, with a more restrictive Spanish regulations.

Features gear: Minimum aperture of 14 mm mesh, The height of the purse seine shall not exceed 82 m and the use of purse seines is not allowed at a depth less than 70 percent of the net length, Length net will not exceed more than 300 m except for Alboran Sea which may be up to 450 m.

Characteristics of vessels: No less than 9 m long, maximum power 450 hp, only one auxiliary boat and there is a Regulating for its power lights. **Fishing areas:** prohibited fishing less than 35 m deep, although at a distance of 300 m offshore it is permitted at a lower depth than 50m. There are forbidden areas to safe anchovy recruitment. **Fishing effort:** No fishing on weekend, restricted fishing areas and seasonal closures in some regions. **Minimum sizes:** Minimum legal landing size 11 cm. **List of species authorized** to be fished by the gear. There is a margin of 2% of others species.

4 Fisheries independent information

4.1 Acoustic survey: MEDIAS 2013

4.1.1 Brief description of the chosen method and assumptions used

In the Spanish Mediterranean waters an acoustic survey has been annually carried out since the 90'. Until 2009 the survey (ECOMED)was carried out in late autumn focusing on the anchovy (*Engraulis encrasicolus*) recruitment; since 2009 the acoustic survey season changed to summer in order to standardize with the rest of acoustic surveys carried out by the European countries in Mediterranean Sea and to start the MEDIAS (Mediterranean acoustic surveys) series. The pelagic community is nowadays assessed, focusing on the spawning stock biomass (SSB) for anchovy and the recruitment of sardine. The GFCM Geographical Sub-Area covered are the GSA 06 (Northern Spain) and 01 (Northern Alboran Sea), prospecting the continental shelf (20 to 200 m depth) by means of a scientific echosounder EK60 (Simrad), equipped with 5 frequencies (18, 38, 70, 120 and 200 kHz).

Acoustic data are recorded continuously at a constant ship speed of 10 knots from sunrise to sunset, along parallel equidistant transects lying perpendicular to the bathymetry. The echosounder is calibrated before each survey following standard techniques (Foote et al., 1987).

Midwater pelagic trawls were deployed to determine the species proportions present in the area. Acoustic data are processed using Echoview (Miryax Ltd.) software and PESMA (VisualBasic) software. Echo trace classification is based on echogram visual scrutinisation, usually the allocation is allocation on account of representative fishing station and very few times on direct allocation. Results of biomass (tons) and abundance (nº individuals) are presented by species, length and age.

Direct methods: acoustics

- Specify if numbers are per km^2 or raised to the area, assuming the same catchability .
- Specify the ageing method or the age slicing procedure applied, specify the maturity scale used.
- In case maturity ogive has not been estimated by year, report information for groups of years.

Table 4.1-1: Acoustic cruise information.

Date	29 June – 31 July		
Cruise	MEDIAS 2014	**R/V**	Miguel Oliver
Target species	Anchovy and sardine		
Sampling strategy	66 tracks normal to the coast. Inter-transect distance: 4 or 8 nautical miles		
Sampling season	Summer (29 June - 18 July)		
Investigated depth range (m)	20-200 m depth		
Echo-sounder	Scientific Echo-sounder EK60 equipped with 5 frequencies (18, 38, 70, 120 & 200 kHz)		

Fish sampler	Pelagic trawls with 10, 16 & 18 m vertical opening
Cod –end mesh size as opening (mm)	20 mm
ESDU (i.e. 1 nautical mile)	Elementary Distance Sampling Unit: 1 nautical mile
TS (Target Strength)/species	-72.6 dB for anchovy and sardine
Software used in the post-processing	SonarData Echoview, PESMA (Visual Basic)
Samples (gear used)	Pelagic trawl
Biological data obtained	Length-weight relationship, age, sex, maturity
Age slicing method	Otolith
Maturity ogive used	

Table 4.1-2: Acoustic results, if available by age or length class

	Biomass in metric tons	**fish numbers**	**Nautical Area Scattering Coefficient**	**Indicator …**	**Indicator …**
2009	26640	3696millions			
2010	19022	2180 millions			
2011	31746	4323 millions			
2012	43296	5945 millions			
2013	41871	6651 millions			
2014	6215	789 millions			

4.1.2 Spatial distribution of the resources

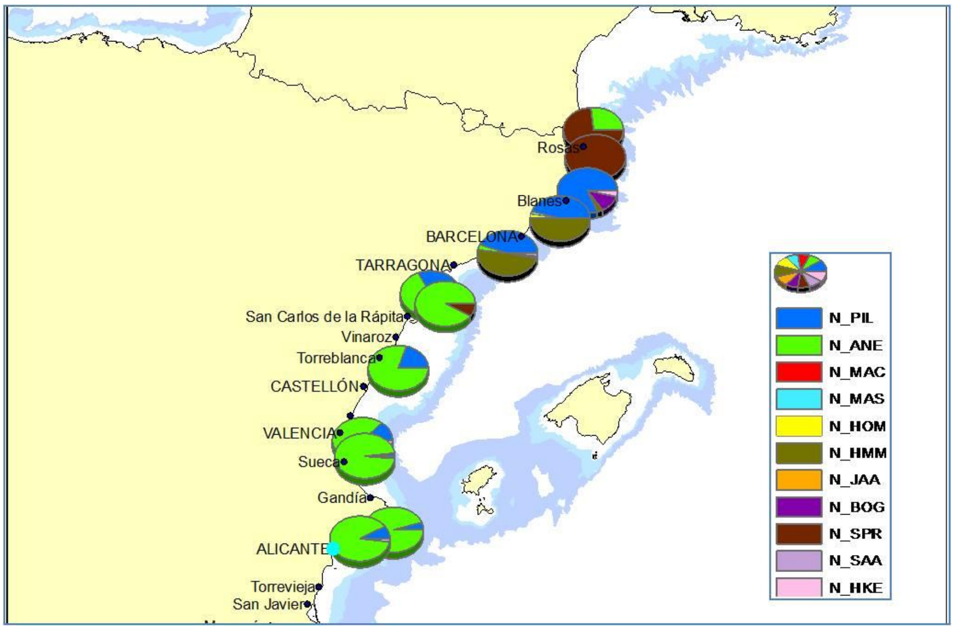


Fig. 4.1.2.1. Proportion of species in MEDIAS hauls 2014.

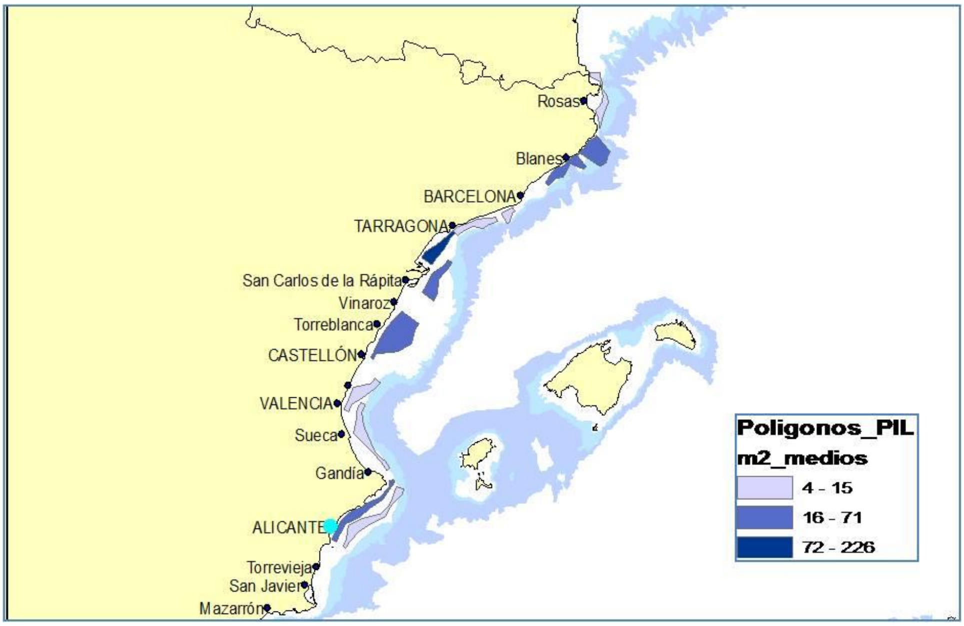


Fig. 4.1.2.2. Medias 2014: Sardine distribution map.

The figure 4.1.2.1 shows the proportion of species in the catches in MEDIAS survey 2014. Sardine (blue) appears only in a few hauls, while anchovy (green) increases, especially in the southern part of the area. In 2014 sardine distribution area has decreased greatly, appearing large "empty" areas (Fig. *4.1.2.).* Sprat (brown) was increasing from north to south over the past few years and now has dropped from 29500 to 4045 in 2014 and being restrain to the north

4.1.3 Historical trends

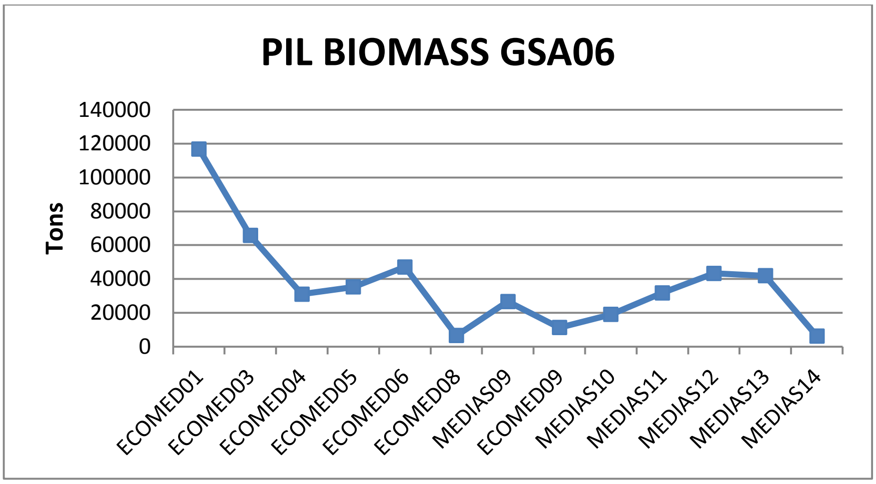


Fig. 4.1.3.1. Biomass estimates for sardine in GSA06 since 2001. Steady biomass.

4.1.4 Length distribution Surveys

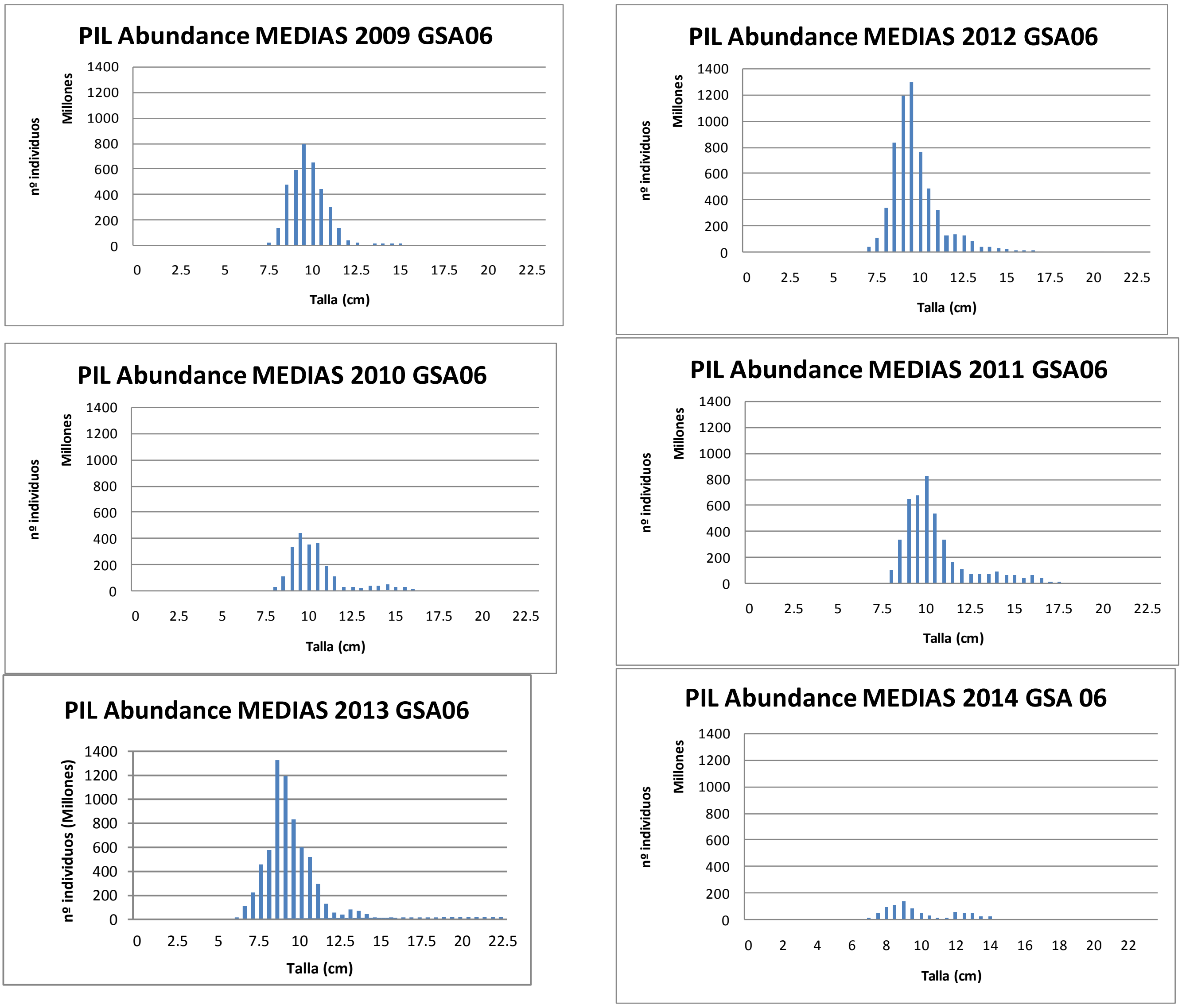


Fig. 4.1.3.2. Sardine abundance by length class by year.

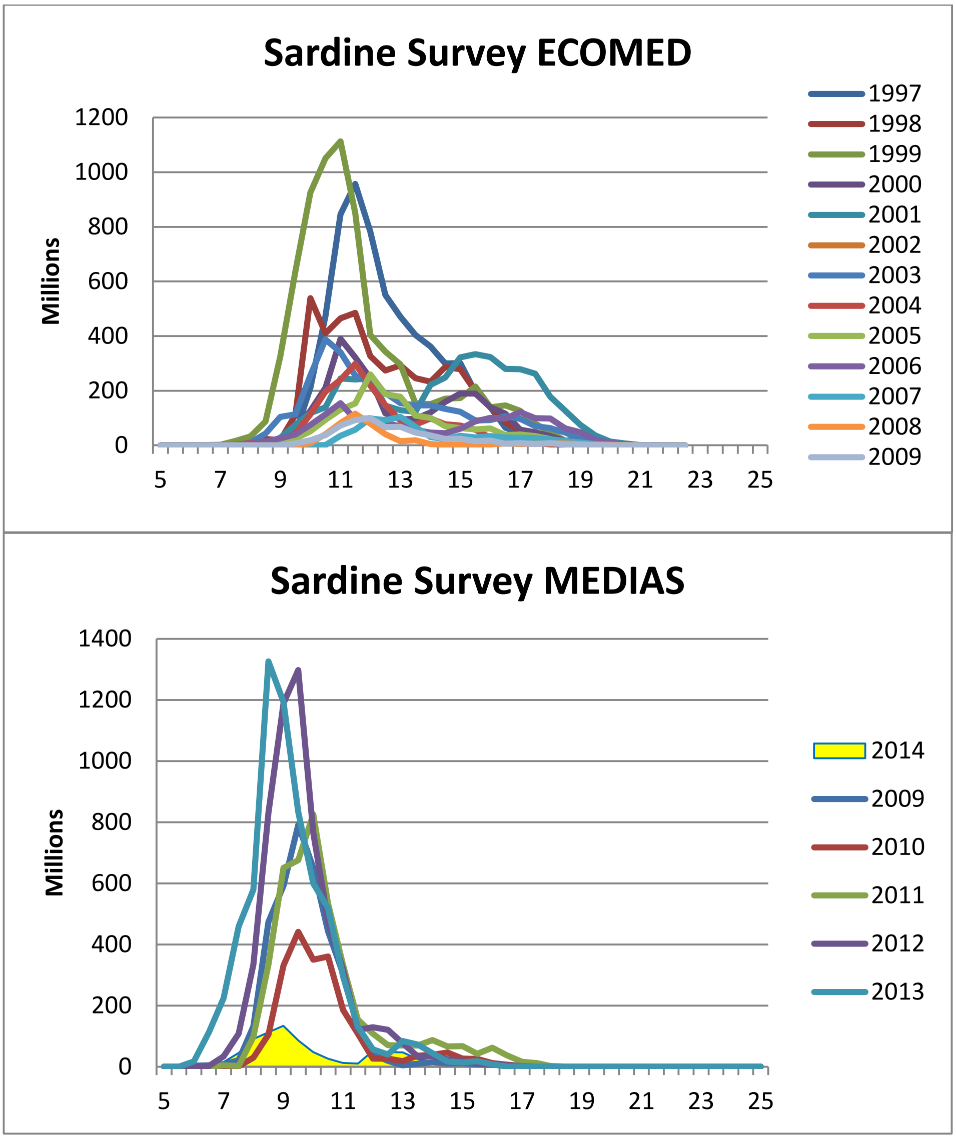


Fig. 4.1.3-4. Sardine abundance by length class by year and surveys ECOMED and MEDIAS.

In this figure is shown ECOMED assessed the spawning biomass and MEDIAS the recruitment biomass.

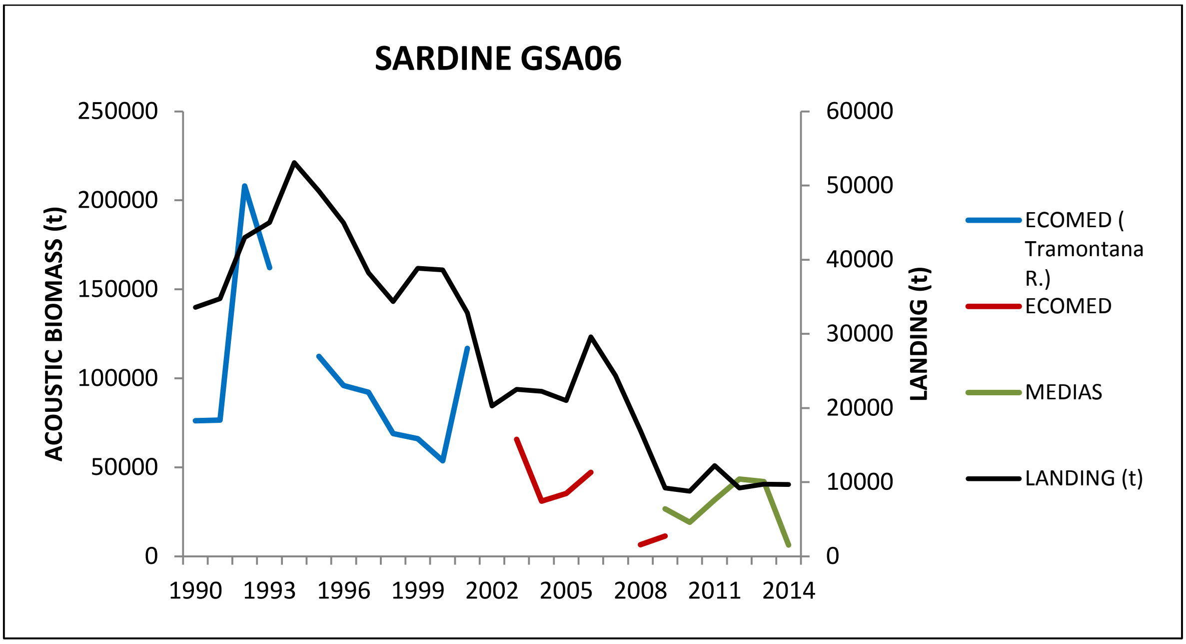


Fig. 4.1.3.3. Biomass estimates for sardine in GSA06 since 1990-2014. Surveys ECOMED 1990-2009, MEDIAS 2009-2014 and landings.

There is a decreasing trend in abundance since 1992. The biomass assessed in 2014 is the lowest in the time series (Fig. 4.1.3.3). Landing shows the same trend from 53,000 t landed in 1994 to 9700 t in 2014, one of the lowest cacht for the whole series. The evolution of catches is consistent with the result of acoustic assessments.

5 Ecological information

5.1 Protected species potentially affected by the fisheries

A list of protected species that can be potentially affected by the fishery should be incorporated here. This should also be completed with the potential effect and if available an associated value (e.g. bycatch of these species in T)

5.2 Environmental indexes

If any environmental index is used as i) a proxy for recruitment strength, ii) a proxy for carrying capacity, or any other index that is incorporated in the assessment, then it should be included here.

Other environmental indexes that are considered important for the fishery (e.g. Chla or other that may affect catchability, etc.) can be reported here.

6 Stock Assessment

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.

6.1.1 Non-equilibrium surplus production model

The sardine stock in the area was 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. 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.

The model uses four base parameters:

–virgin biomass K
–intrinsic growth rate of the population r
–initial rate of reduction D (initial biomass related to K)
–catchability q
–All other estimated parameters derive from these four.

6.1.2 Model assumptions

Basic Assumptions:

• Stock can be described solely by its biomass
• “Natural” Rate of change in biomass depends on current biomass only
• There is a maximum biomass that the system can support (K)
• The relative rate of increase of biomass is maximum when the biomass is close to zero, and zero when the biomass is at the maximum level
• Simplest model: Logistic (Schaefer) model

6.1.3 Input data and Parameters

The model uses four base parameters:

– Carrying capacity (or virgin biomass) K
–Population Intrinsic growth rate r
–Initial depletion BI/K (or rate of reduction D), starting biomass related to K.
–Catchability q

Environmental effect is also estimated if included in the model. Given the best parameter estimates, the model calculates the MSY, BMSY and FMSY reference points.

Given the best parameter estimates, the model calculates the MSY, BMSY and FMSY reference points. It also calculates the reference points BRatio, B CurB/ B MSY (the ratio between the estimated biomass for the last year in the data series and BMSY), and FRatio, F Cur/F SYCur (the ratio between the effort actually exerted on the stock in the last year of the data series and the effort that would have produced the sustainable yield in the same year).

BRatio, BCur/BMSY indicates the current status of the stock biomass in the last year of the data series BCur, relative to the biomass that would produce MSY, BMSY. Values smaller than 100% indicate a stock abundance below BMSY, while values larger than 100% indicate a stock abundance larger than BMSY.

FRatio, FCur/FSYCur measures the fishing effort in the last year of data available, as a proportion of the fishing effort that would have been necessary to extract the sustainable catch at the Biomass levels estimated for the same year. The value of this ratio is the same as the Yield ratio YRatio, the current yield as a proportion of the sustainable yield at the current stock biomass level, YCur/SYCur. Values below 100% indicate that the catch currently being extracted is lower than the natural production of the stock, and so stock biomass can be expected to increase, while values above 100% suggest that the catch exceeds the production from the stock and so this will decrease next year.

Trends of these ratios and whether or not they are above/below 100% provide useful information for management purposes.

The input data used for the adopted modelling approach was total yearly catch (tons) and a series of abundance indices (acoustic biomass estimates) over the period (1996-2013).

Von-Bertalanffy growth parameters, necessary for the calculation of natural mortality, were estimated with DCF data collected in GSA06 in 2013, 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).

Table 6.13.1. Parameters limits to minimization, tolerance ratio and parameters calculated by Biodyn. (K in tons).

Parameter	Initial Value	Tolerance Ratio	Min Value	Max Value	Calculated by Biodyn
R	1.0	5	0.2	5	0.47
K	116839	5	23367	584195	282123
BI/K	40%		25%	95%	40%

6.1.4 Results

The fishery would be at an depleted situation (BCur/BMSY=0.15). This stock is at lowest historical levels of biomass. As Fcur/F0.1 = 2.14 and it is above to 1.66 the stock is in High overfishing.

Table 6.1.4.1. Reference points

MSY	BMSY	FMSY	F0.1	FCur	BCur/BMSY	Fcur/FSYCur	Fcur/FMSY	FCur/F0.1
33156	141061	0.24	0.21	0.45	0.15	1.04	1.93	2.14

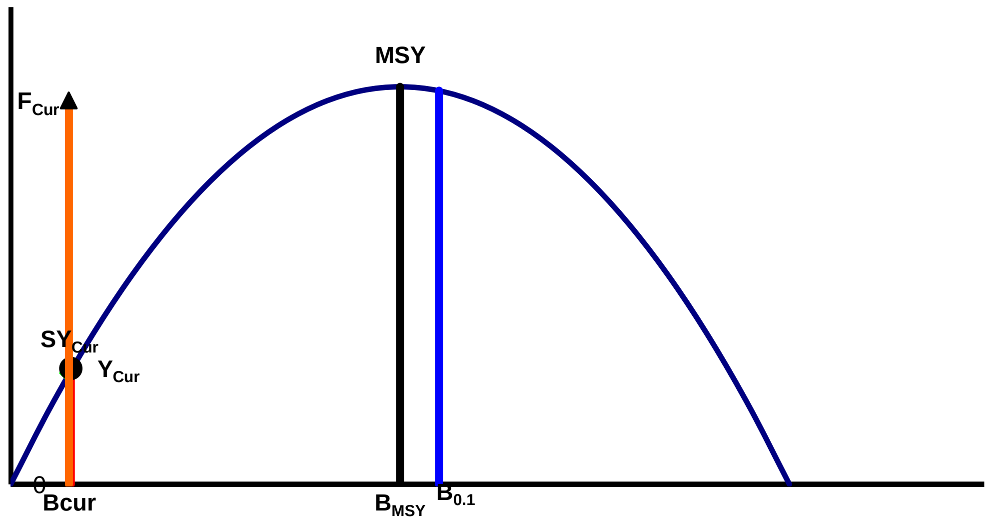


Figure 6.1.4.1. Stock current situation

6.1.5 Assessment quality

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 (RpearsonIndex=0.89). Pearson linear regression coefficient will not detect a non-linear relation, but will measure how closely the predicted abundance indices follow the observed ones. This plot presents, in a graphical way, the relation between the Abundance Index observed (or given to the model) and the Abundance index estimated by the model, on the basis of the estimated biomass. The desirable characteristic for this plot is a linear relation between the predicted and observed indices, with slope 1.

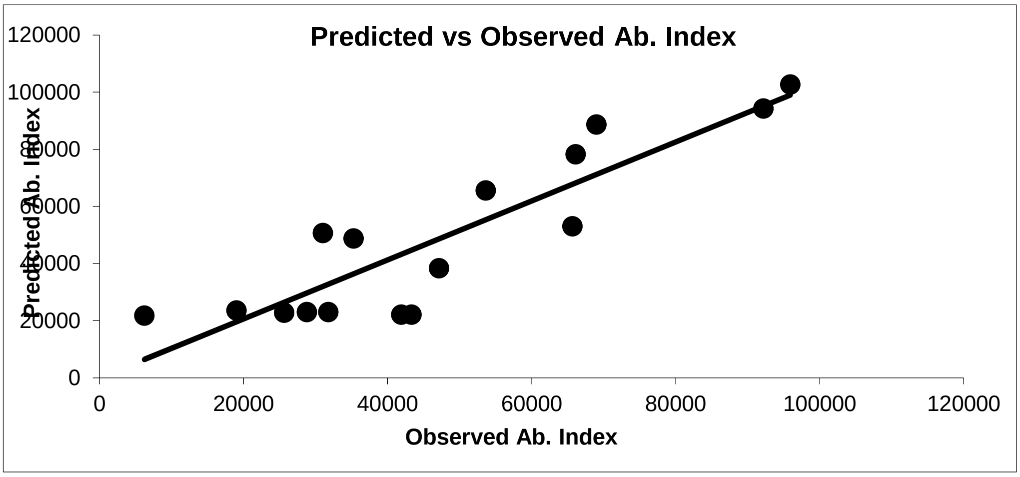


Figure 6.1.5.1. Plot of the relation between the predicted and the observed abundance indices. This plot can be used to detect severe deviations from the linear relationship between the observed abundance indices and those predicted by the model.

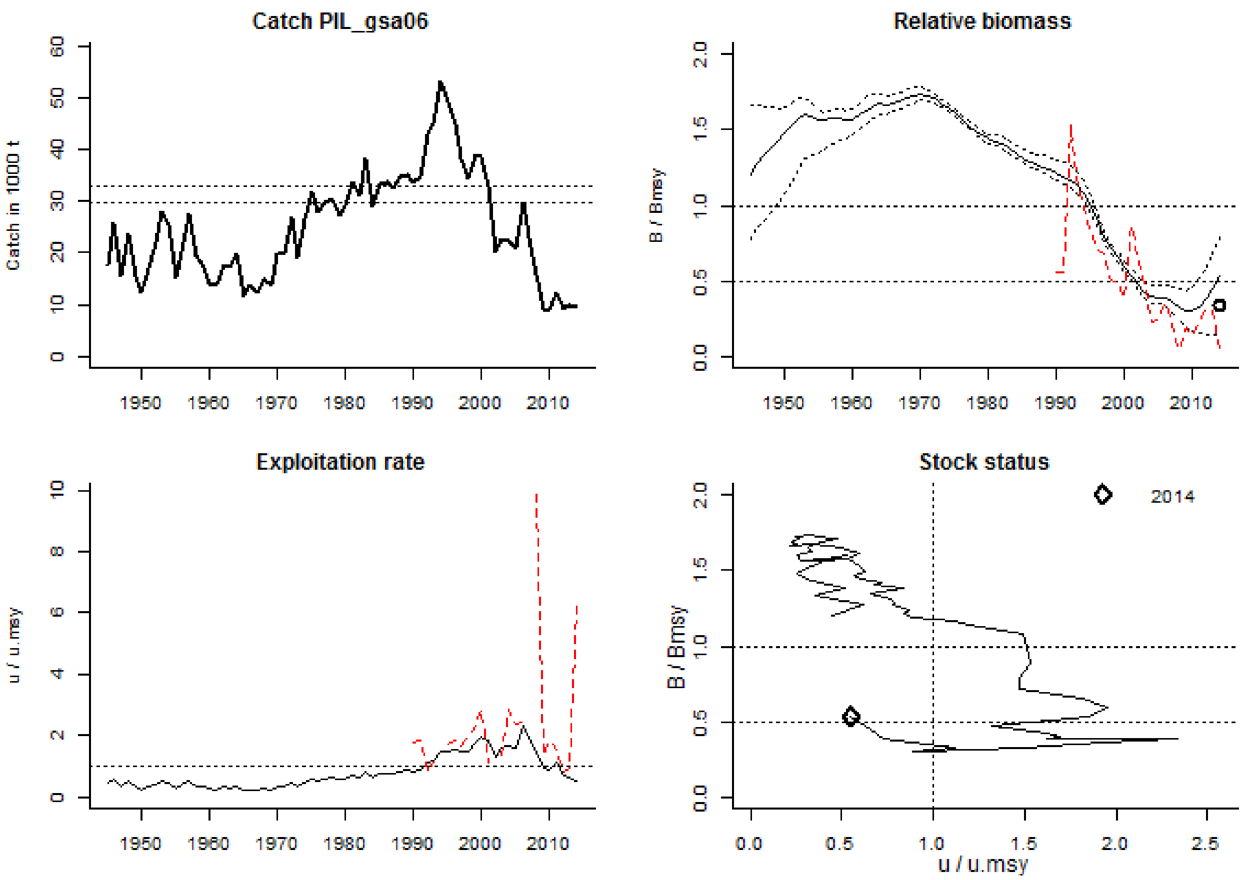
6.1.6 2-stage biomass model

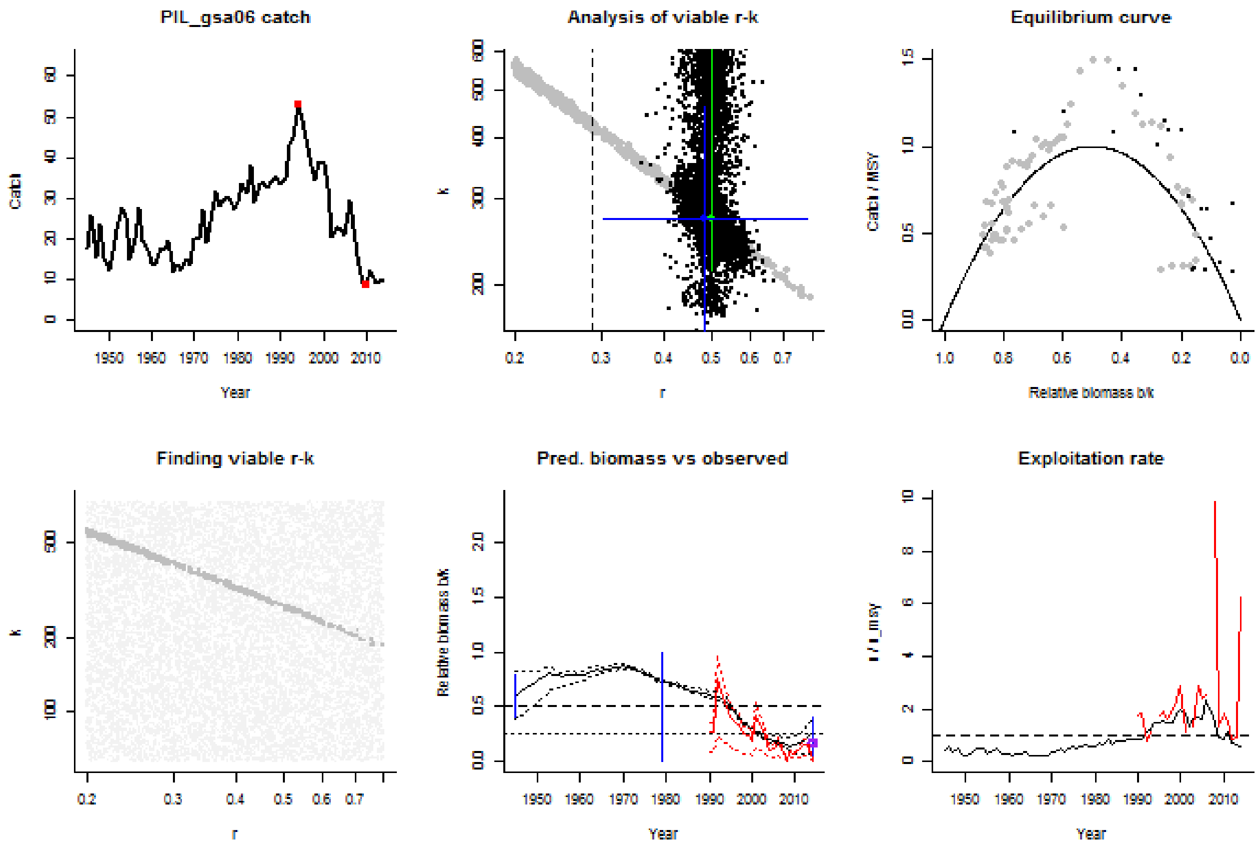
This model was tested combining the two surveys (Ecomed and Medias), but the result was not consistent as the two surveys take place in different seasons, MEDIAS assesses the recruitment and ECOMED the spawning biomass of sardine.

6.1.7 Catch-MSY

Others tests were done during the meeting sessions with the model CMSY. Catches and acoustic estimates were used. In the table below, we compare results between two methods. See figures below.

Reference points	BioDyn	CMSY Schaeffer	CMSY bayesian
Bcur/Bmsy	0.15	0.50	0.54
FCur/F0.1	2.14		
Years	1996-2014	1945-2014	1996-2014





7 Stock predictions

When an analytical assessment exists, predictions should be attempted. All scenarios tested (recruitment and/or fishing mortality) should be reported. The source of information/model used to predict recruitment should be documented.

7.1 Short term predictions

7.2 Medium term predictions

7.3 Long term predictions

8 Draft scientific advice

(Examples in blue)

Based on	Indicator	Analytic al reference point (name and value)	Current value from the analysis (name and value)	Empirical reference value (name and value)	Trend (time period)	Status
Fishing mortality	Fishing mortality	$F_{0.1}$, =			N	IO_L
	Fishing effort	F=			D	
	Catch		CPUE			
Stock abundance	Biomass			33_{th} percentile		O_L
	SSB					
Recruitment					D	
Final Diagnosis		Depleted				

State the rationale behind that diagnoses, explaining if it is based on analytical or on empirical references

8.1 Explanation of codes

Trend categories

1) N - No trend
2) I - Increasing
3) D – Decreasing
4) C - Cyclic

Stock Status

Based on Fishing mortality related indicators

1) **N - Not known or uncertain** – Not much information is available to make a judgment;
2) **U - undeveloped or new fishery** - Believed to have a significant potential for expansion in total production;
3) **S - Sustainable exploitation**- fishing mortality or effort below an agreed fishing mortality or effort based Reference Point;
4) **IO –In Overfishing status**– fishing mortality or effort above the value of the agreed fishing mortality or effort based Reference Point. An agreed range of overfishing levels is provided;

Range of Overfishing levels based on fishery reference points

In order to assess the level of overfishing status when $F_{0.1}$ from a Y/R model is used as LRP, the following operational approach is proposed:

- If $Fc^*/F_{0.1}$ is below or equal to 1.33 the stock is in **(O_L): Low overfishing**
- If the $Fc/F_{0.1}$ is between 1.33 and 1.66 the stock is in **(O_I): Intermediate overfishing**
- If the $Fc/F_{0.1}$ is equal or above to 1.66 the stock is in **(O_H): High overfishing**

*Fc is current level of F

5) **C- Collapsed**- no or very few catches;

Based on Stock related indicators

1) **N - Not known or uncertain:** Not much information is available to make a judgment
2) **S - Sustainably exploited:** Standing stock above an agreed biomass based Reference Point;
3) **O - Overexploited**: Standing stock below the value of the agreed biomass based Reference Point. An agreed range of overexploited status is provided;

Empirical Reference framework for the relative level of stock biomass index

- **Relative low biomass:** Values lower than or equal to 33rd percentile of biomass index in the time series **(O_L)**
- **Relative intermediate biomass:**Values falling within this limit and 66th percentile **(O_I)**

- **Relative high biomass:**Values higher than the 66th percentile **(O_H)**

4) **D–Depleted**: Standing stock is at lowest historical levels, irrespective of the amount of fishing effort exerted;
5) **R –Recovering:** Biomass are increasing after having been depleted from a previous period;

Agreed definitions as per SAC Glossary

Overfished (or overexploited) *- A stock is considered to be overfished when its abundance is below an agreed biomass based reference target point, like B0.1 or BMSY. To apply this denomination, it should be assumed that the current state of the stock (in biomass) arises from the application of excessive fishing pressure in previous years. This classification is independent of the current level of fishing mortality.*

Stock subjected to overfishing (or overexploitation) - *A stock is subjected to overfishing if the fishing mortality applied to it exceeds the one it can sustainably stand, for a longer period. In other words, the current fishing mortality exceeds the fishing mortality that, if applied during a long period, under stable conditions, would lead the stock abundance to the reference point of the target abundance (either in terms of biomass or numbers)*

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