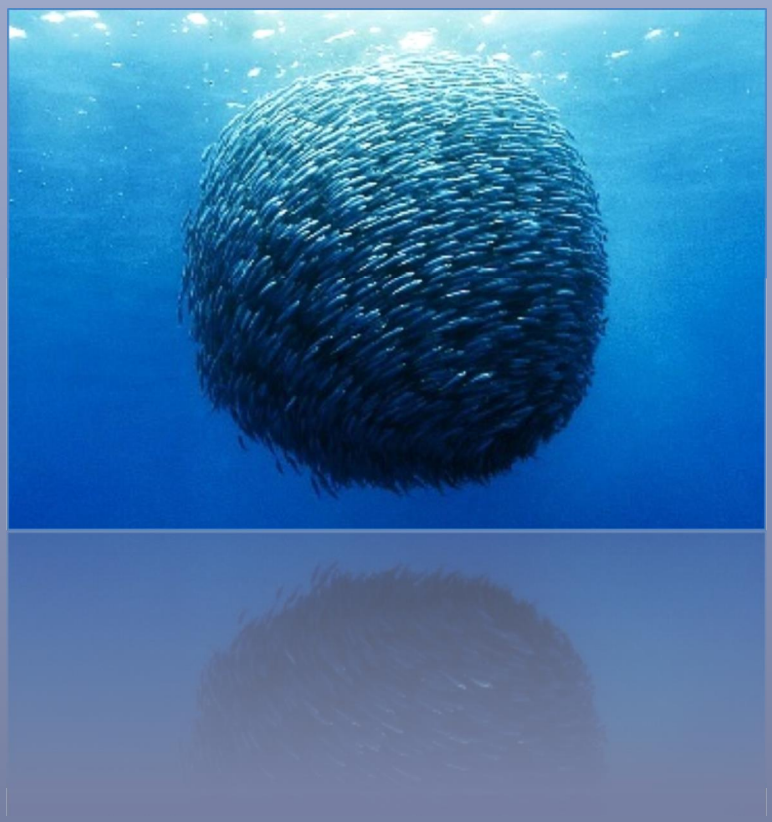


Stock Assessment Form

Small Pelagics

Reference Year: 2016

Reporting Year: 2017

Data from 2003 to 2016 in GSA01 have been pooled and XSA model has been run. The stock of sardine is in over exploitation.

Stock Assessment Form version 1.0 (November 2014)

Sardine GSA01 (Northern Alboran Sea)

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:**
1		
1st Country	**2nd Country**	**3rd Country**
Spain		
Stock assessment method: (direct, indirect, combined, none)		
Indirect: : XSA, Surplus production model (Biodyn package; FAO, 2004), VIT		
Authors:		
Torres, P., A. Giráldez, M. Iglesias, M. González, M.J. Meléndez and A. Ventero		
Affiliation:		
IEO. Instituto Español de Oceanografía		

2 Stock identification and biological information

2.1 Stock unit

The General Fisheries Commission for the Mediterranean (GFCM) stress the importance of making common assessments of shared stocks of priority species. The joint stock assessment of the main shared stocks in the Mediterranean Sea is considered as an important step to contribute reinforcing the subregional collaboration, and to promote agreed management recommendations for fisheries in the GFCM area.

Sponsored by Copemed II there have been two joint assessments between Spain and Morocco for the Alboran Sea sardine. These have been submitted to the WG of assessment of small pelagic GFCM, however it is necessary to promote other studies to determine if 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)			**LT**	**Units**	cm
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	Autumn-Winter
Maximum size observed			22.6 (2016) 25 (2004-2015)	**Recruitment season**	Spring-summer
Size at first maturity			12.24 (2016) 12.95 (2003-2015)	**Spawning area**	All the coast
Recruitment size to the fishery			11.5 (2016)	**Nursery area**	Bays

Table 2-2.2: M vector and proportion of matures by age 2004- 2016.

Size/Age	Natural mortality *	Proportion of matures
Edad 0	1.17	0.46
Edad 1	0.44	0.94
Edad 2	0.32	0.99
Edad 3	0.27	1.00
Edad 4	0.25	1.00
Edad 5+	0.24	1.00

* The vector was estimated using the ProdBiom Method (Abella et al, 1997) (En Quintanilla et al. 2009) Stocks Assesment sardine in GSA01. SCSA Working Group on stock assessment of Small Pelagic species Ancona, Italy, 26-30 October 2009

Table 2-3: Growth and length weight model parameters 2003-2016

			Sex			
		Units	female	male	Combined	Years
Growth model	L_D				22.6	2003-2016
	K				-1.7507	2003-2016
	t_0				0.39	2003-2016
	Data source	DCF 2003-2016				
Length weight relationship	a				0.0062	2003-2016
	b				3.1091	2003-2016
	sex ratio (% females/total)	53.8				

3 Fisheries information

3.1 Description of the fleet

The current fleet in GSA 01 the Northern Alboran Sea is composed by 87 units, characterised by small vessels, average TJB 24.7. 16% of them are smaller than 12 m (operational Unit 1), 84% > 12 m (operational Unit 2), and no one bigger than 24 m. The purse seine fleet has been continuously decreasing in the last two decades, from more than 230 vessels in 1980 to 87 in 2015. 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 is an important support to the fishery as it is the most fished species. Catches in the period 1990-2016 in the South Mediterranean Region (85% of the total landing) has been highly variable, with a minimum of 3000 tons in 1997. Higher catches occurred in

1992 (11000 tons). The whole period mean is around 6000 t. In 2016 landings were 3800 t, very close to the historical minimum of 3200 t in 1997.

The two operational units fish the same species, there are no major differences, sardine is the most fished species in their both. Although there is 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 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. In the case of mackerel is exported to Portugal.

Data used in the assessment correspond to DCF. Unit of effort has been effective fishing night by species. Series of CPUE shows a very similar profile to catches (Fig. 3.2.1.)

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	1	G-Purse Seine (6-12 m)	02-Seine Nets	31- Small gregarious pelagic	PIL
Operational Unit 2	Spain	1	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 in GSA01

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 01 G 02 31-PIL	14	342	Anchovy: 70 Trachurus spp: 300 Scomber spp: 133 Sardinella: 93 Otros: 161	negligible	negligible	Effective fishing day for species
ESP 01 H 02 31-PIL	73	3829	Anchovy: 1108 Trachurus spp: 1376 Scomber spp: 815 Sardinella: 895 Otros: 988	negligible	negligible	Effective fishing day for species
Total	87	4171	5939			

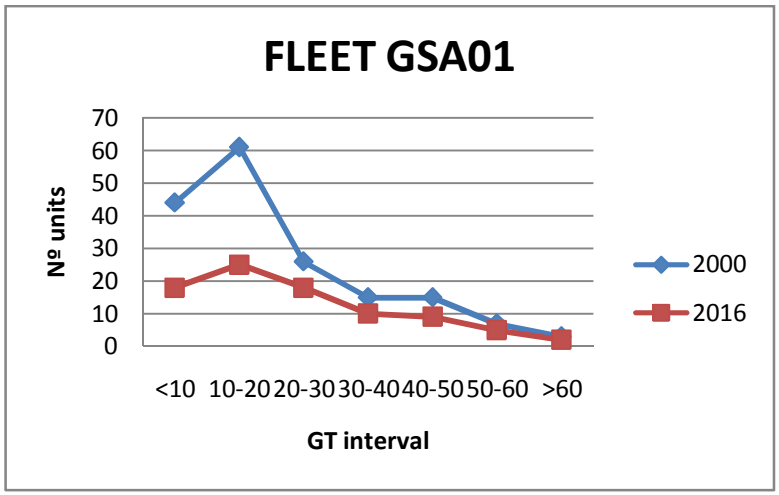


Fig. 3.2.1. Fleet GSA01 in years 2000 and 2016.

A great decrease in the smallest units (Fig. 3.2.1).

*Table 3.1-3: Catches used in the assessment 2003-2016 in GSA01. RSM: landings correspond to the **Southern Mediterranean Region (RSM)**, around 95% of catches of GSA01 1990-2016.*

YEAR	Catch (tons) RSM	CPUE Kg/fishing day	Catch (tons GSA01
1990	6439	921	
1991	9599	1328	
1992	10826	1308	
1993	5782	1095	
1994	5220	926	
1995	4316	756	

1996	3589	612	
1997	3263	726	
1998	3982	839	
1999	5146	1143	
2000	8697	1369	
2001	6817	1255	
2002	5237	1019	5275
2003	7817	1189	8087
2004	3904	792	3957
2005	7066	1272	7516
2006	9376	1478	9971
2007	5683	1116	6139
2008	4329	1069	4468
2009	5896	1313	5972
2010	7164	1270	7328
2011	6065	1139	6293
2012	5431	1112	6214
2013	4456	956	4983
2014	4782	932	5174
2015	5058	977	5248
2016	3844	911	4171
Average 1990-2016	5921	1067	6053

3.2 Historical trends

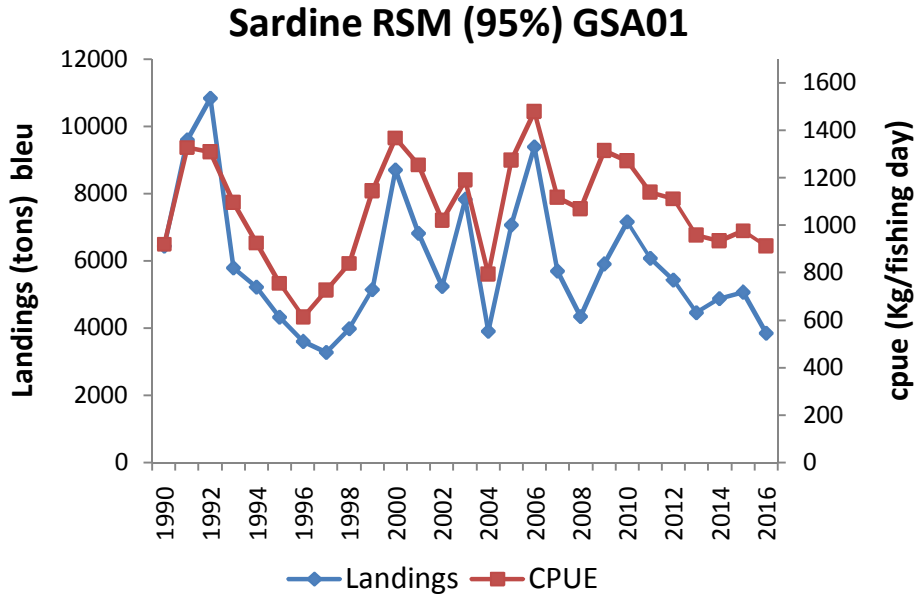
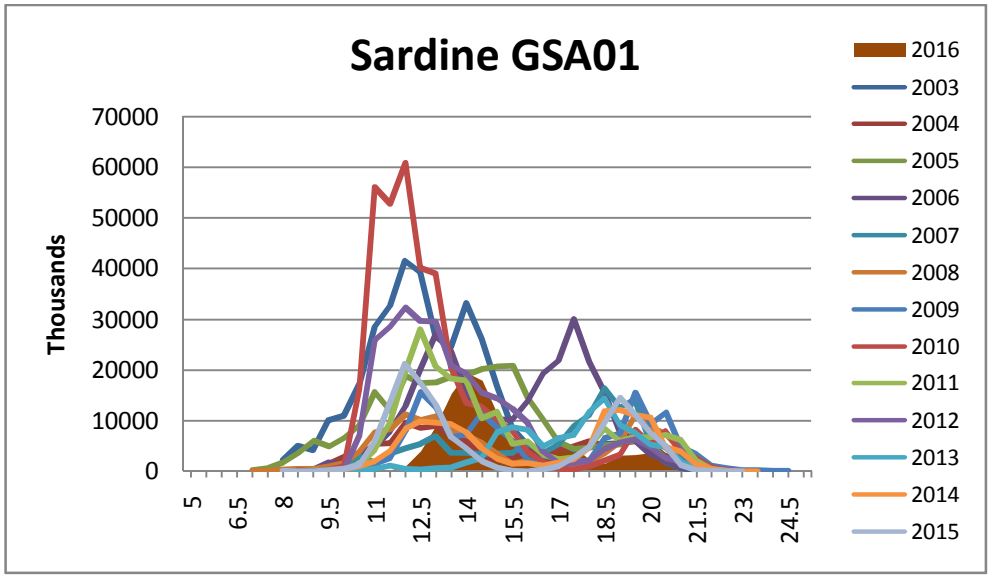
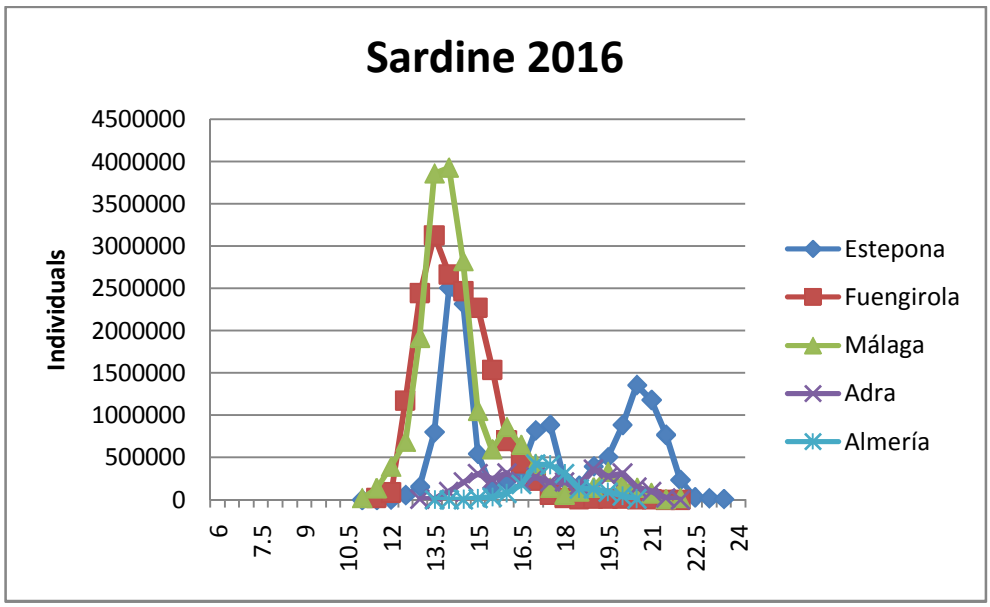


Fig. 3.2.1. Trends in sardine landings and CPUE in South Mediterranean Region (RSM), years 1990-2016.

Series of CPUEs from 1990-2016 show the same profile of landings without a clear trend (Fig. 3.2.1). Catches in 2016 were very low, similar to 2004 and 1997.

3.3 Length distribution fishery

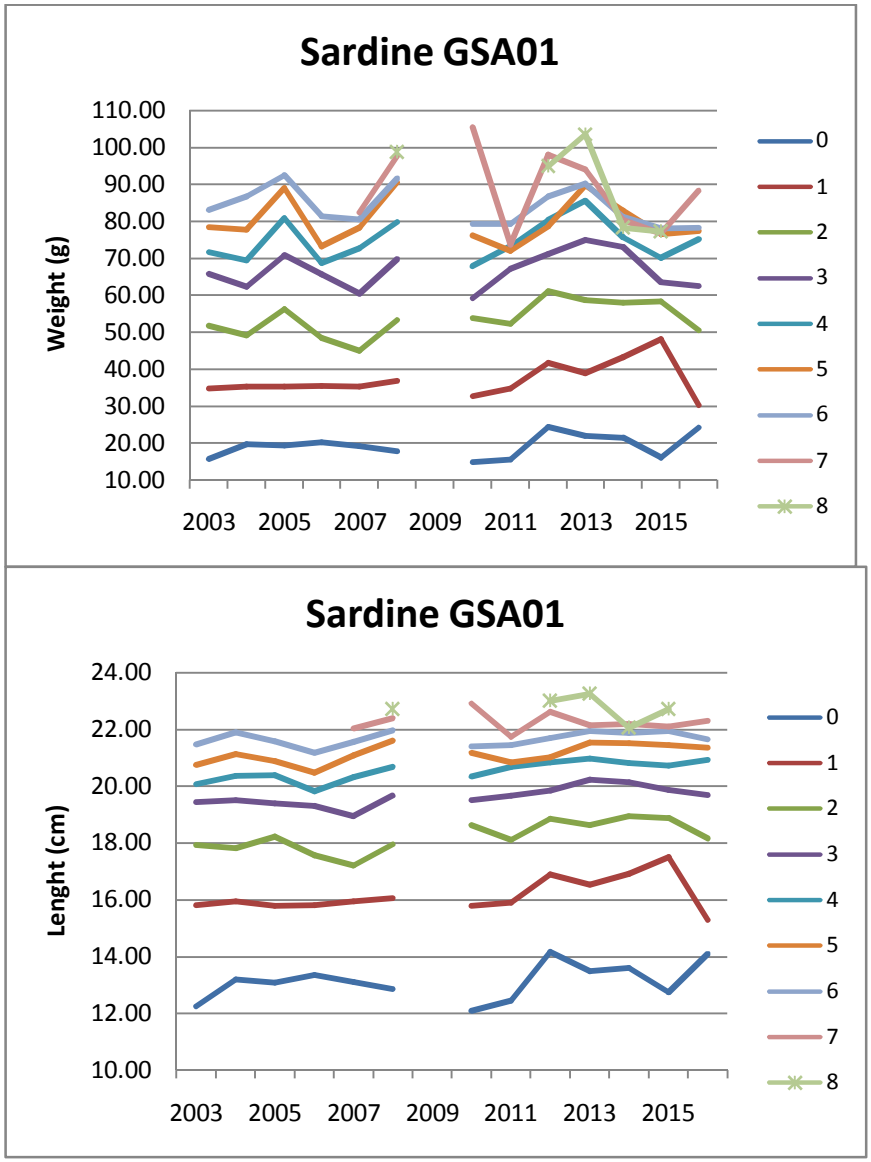




Figures 3.3.1 y 3.3.2. Length distribution sardine fishery 2003-2016 (above) and 2016 by ports (below).

Landing ports are split in 2 types: the ones catching bigger sardines (capes) and those catching the smaller ones (bays).

3.4 Length and Weight by age in the fishery.



Figures 3.4.1 y 3.4.2. Length and weight by age 2003-2016.

A very different situation compared with GSA06. Length and weight by age are a bit higher in the last years.

3.5 Body Condition

The formula used for the calculation of the Condition Factor was Le Cren (1951). Monthly evolution of this factor in sardine (Fig. 3.5.1) shows a good nutritional status at certain times of the year with no trend over the years.

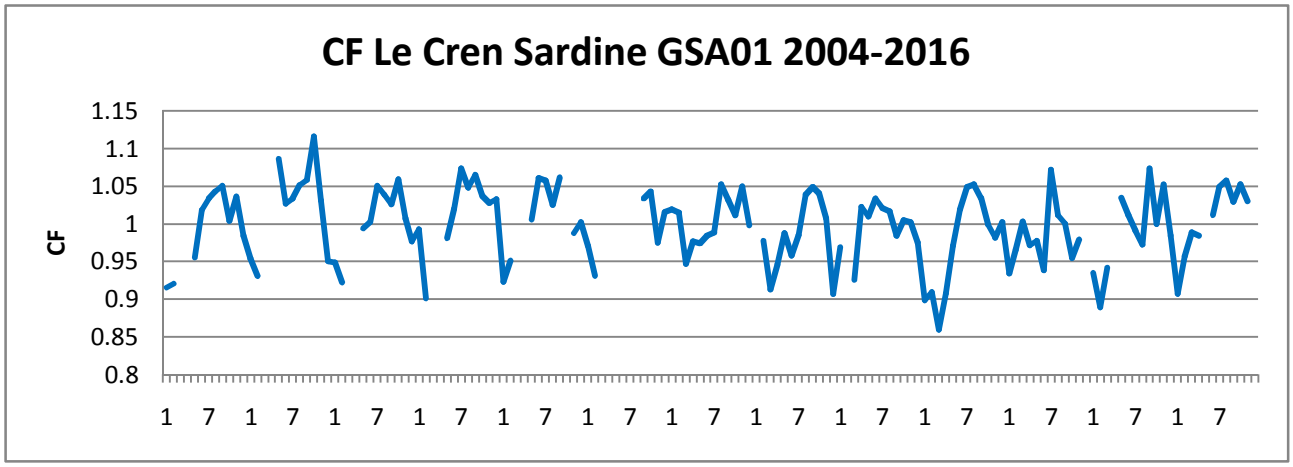


Figure 3.5.1. Monthly evolution of the condition factor 2004-2016. There are not any differences between years.

3.6 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 9 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: ECOMED and MEDIAS

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 (30 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 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

Table 4.1-1: Acoustic cruise information.

Date	MEDIAS: June-July; ECOMED: November-December		
Cruise	ECOMED and MEDIAS	**R/V**	Cornide de Saavedra 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	MEDIAS: June-July; ECOMED: November-December		
Investigated depth range (m)	30-200 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 …**
2013	2677	46 millions			
2014	8500	148 millions			
2015	10442	335 millions			
2016	1710	52 millions			

4.1.2 Spatial distribution of the resources

Fig. 4.1.2.1. Proportion of sardine in MEDIAS hauls in 2015.

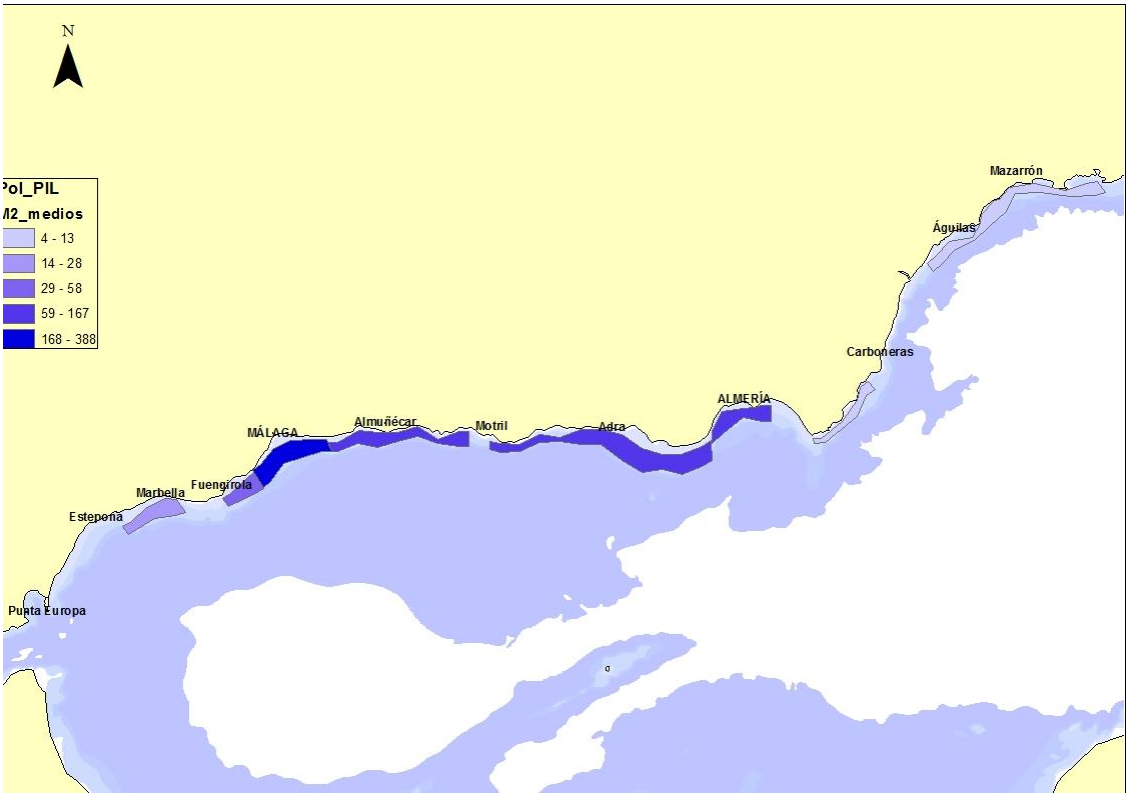


Fig. 4.1.2.1. Densities distribution of sardine *Medias 2015.*

The western area, between Marbella and Estepona ports, used to be the one with a greater biomass of sardine and mainly large sizes. The acoustic assessment in 2015 of this area has been rather low.

4.1.3 Historical trends

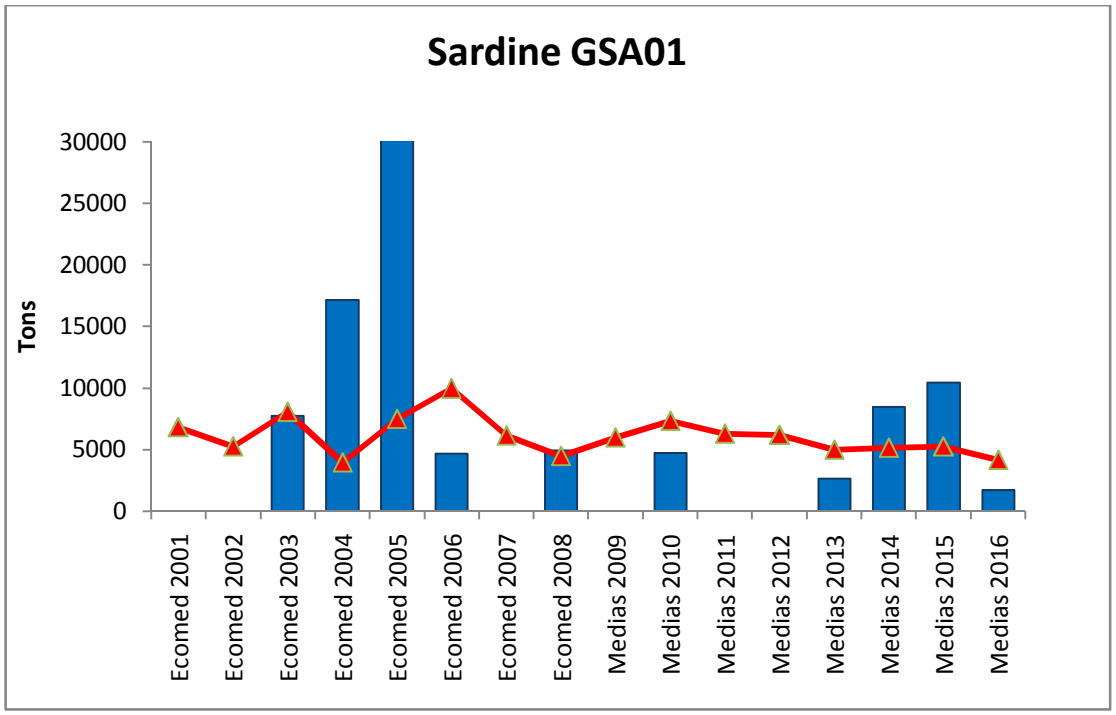


Figure 4.1.3.1. Evolution of biomass assessed in the Alboran Sea for surveys ECOMED and MEDIAS. The area was partly assessed in 2003, 2006, 2008 and 2010, these years are estimated in the graph.

There are inconsistencies between landings and surveys assessments. The acoustic assessment in the area is not feasible with the actual methods. The resource is close to the shore (less than 30 m deep) where there are plenty of artificial reefs and the artisanal fleet set its gears doing unfeasible fishing with the survey net. It was consulted to experts about carrying out eggs production methods (EPM) in the area, but apparently it is not possible at such a low level of biomass.

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. by catch of these species in T)

5.2 Environmental indexes

6 Stock Assessment

6.1 {Extended Survivor analysis (XSA)}

Ad hoc methods for tuning single species VPA's to fleet catch per unit effort (CPUE) data are sensitive to observation errors in the final year because they make the assumption that the data for that year are exact. In addition, the methods fail to utilize all of the year class strength information contained within the catches taken from a cohort by the tuning fleets. Extended Survivors Analysis (XSA), (Shepherd, 1992, 1999), an extension of Survivors Analysis (Doubleday, 1981), is an alternative approach which overcomes these deficiencies. In general, the algorithms used within the *ad hoc* tuning procedures, exploit the relationship between fishing effort and fishing mortality. XSA focuses on the relationship between catch per unit effort and population abundance, allowing the use of a more complicated model for the relationship between CPUE and year class strength at the youngest ages. (Darby and Flatman, 1994).

Input Parameters

- Landings time series 2003-2016 of GSA1.
- Length distributions 2003-2016 (monthly port sampling).
- Catch-at-Length data transform into Catch-at-Age data using cohort slicing. It was also tested using age length key but the model fit was not good enough.
- Growth Parameters DCF 2003-2016.
- M vector by age using ProdBiom.
- Tuning data: CPUE index from 2003 to 2016. It is the only possibility of tuning; there is not a long enough and trustful series of acoustic surveys in the area.

Main Settings

- Ages 0 to 5+ (Ag 5 is a Plus Group).
- Fbar 0-3.
- Fse=0.1
- Shk.ages=1
- rage=0
- qage=3

6.1.1 Scripts

The script has been provided to the sharepoint

6.1.2 Input data and Parameters

For analytical models: **catch matrix** in lengths or ages (see the example below for age). Specify if catch includes discards.

Catch numbers at age (in thousands)

Catch numbers at age (in thousands).

Class Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	301620	62248	172145	130499	36489	75314	65903	313542	131172	208690	8538	56997	86530	67192
1	38088	16994	71986	75042	21510	9232	18432	24409	28611	41424	36094	8505	2301	32840
2	14849	15755	14162	67134	36489	6571	10488	3591	16101	7902	33394	18979	17208	8618
3	15830	16888	16500	16932	32485	25310	32223	16755	19168	16499	22090	33846	33299	10086
4	2196	4048	4138	2680	7408	11248	16282	11746	13334	4365	6669	8777	6313	6831
5+	77	659	1151	594	1012	3005	5153	3733	2917	1769	1196	2078	463	2560

6.1.3 Tuning data

Tuning commercial fleet (thousands by successful fishing day).

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
0	39.6	11.4	31.0	14.6	6.6	17.7	13.9	51.2	21.4	48.3	2.6	11.4	16.4	10.2
1	12.0	5.2	11.7	18.4	3.2	2.9	4.6	8.7	8.3	3.4	10.5	2.0	1.9	10.1
2	2.1	2.4	3.8	8.9	5.0	1.7	2.2	1.3	4.1	2.1	6.1	6.9	1.6	1.9
3	1.9	2.9	2.3	2.8	8.7	6.4	8.0	1.0	2.4	2.2	2.7	2.5	5.3	2.1
4	0.7	1.3	1.2	0.9	2.6	2.4	2.8	1.9	1.3	0.6	0.8	1.0	2.0	1.3
5+	0.2	0.5	0.4	0.6	0.6	1.1	1.5	2.1	2.1	0.8	0.4	0.8	0.9	0.6

6.1.4 Results

Fig. 6.1.4-1: Age structure of sardine in GSA01&03

In alboran sea, the exploited stock is mostly composed by ages 0 and 1-3.

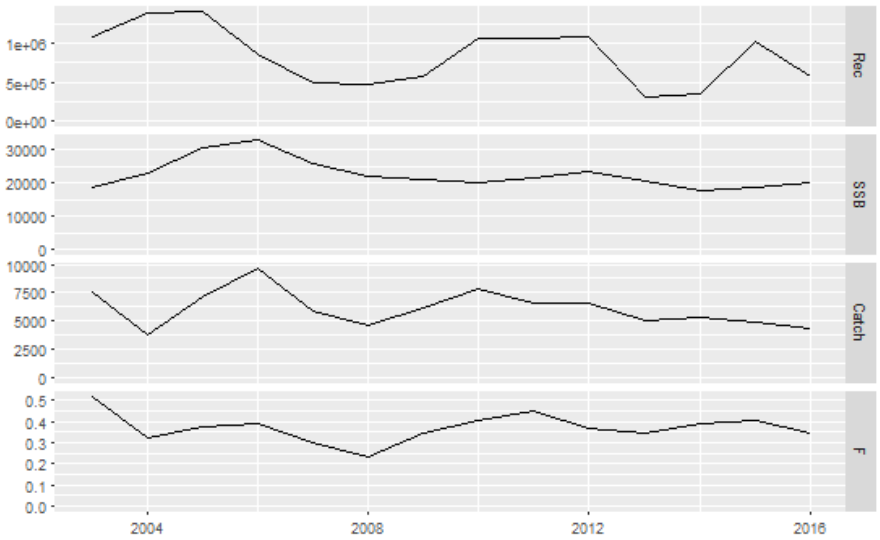


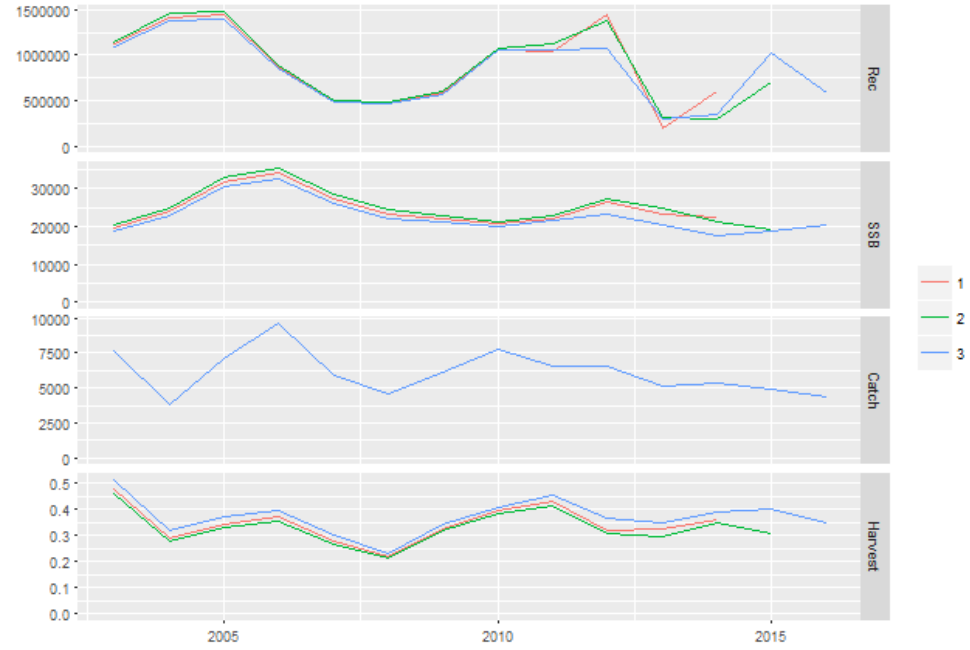
Fig. 6.1.4-2: main results obtained by XSA model

Recruitment is different from one year to another with decline in 2010 and pick in 2012. It shows decrease in the last three years. Spawning Stock Biomass (SSB) is quite similar to recruitment. It shows decrease trend since 2014. Average fishing mortality in ages 1-2, (Fbar 1-2) fluctuates between 0.15 and 0.87. It's quite stable in the last four years in low level.

6.1.5 Robustness analysis

6.1.6 Retrospective analysis, comparison between model runs, sensitivity

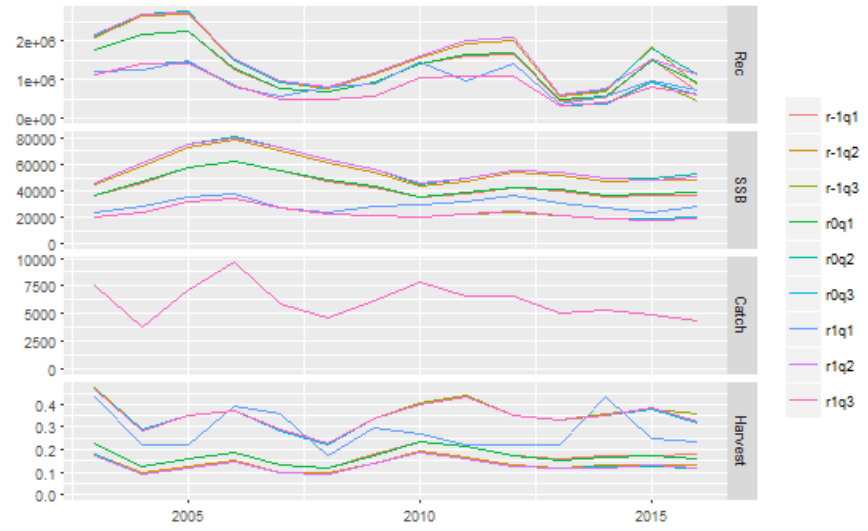
Retrospective analysis

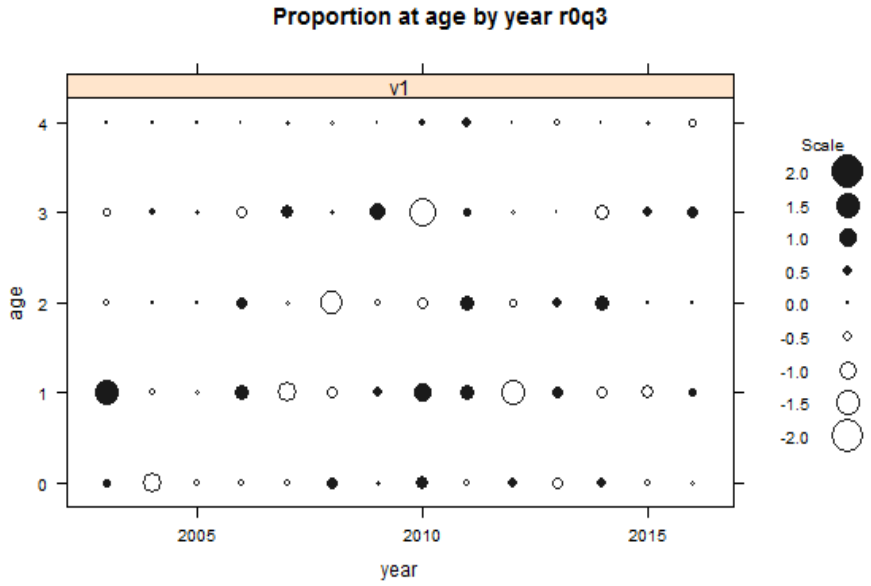


Retrospective *analysis on different stock parameters.*

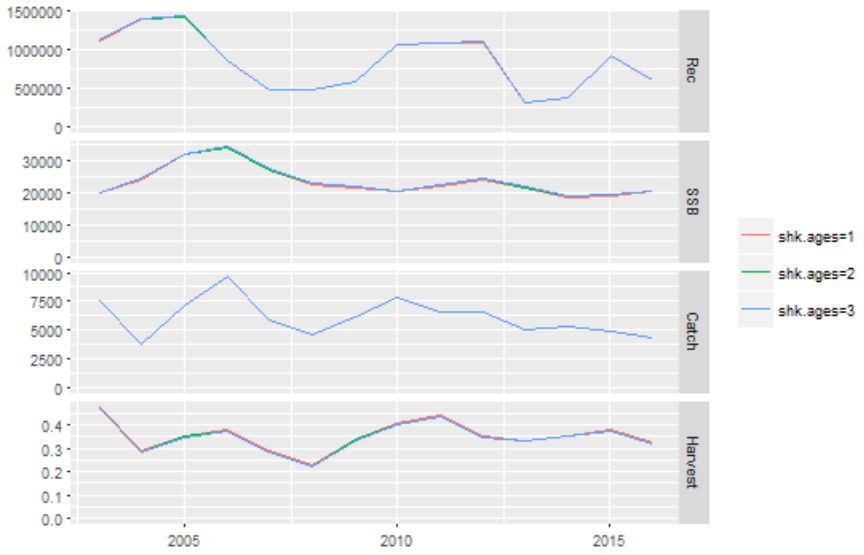
6.1.7 Sensitivity analysis

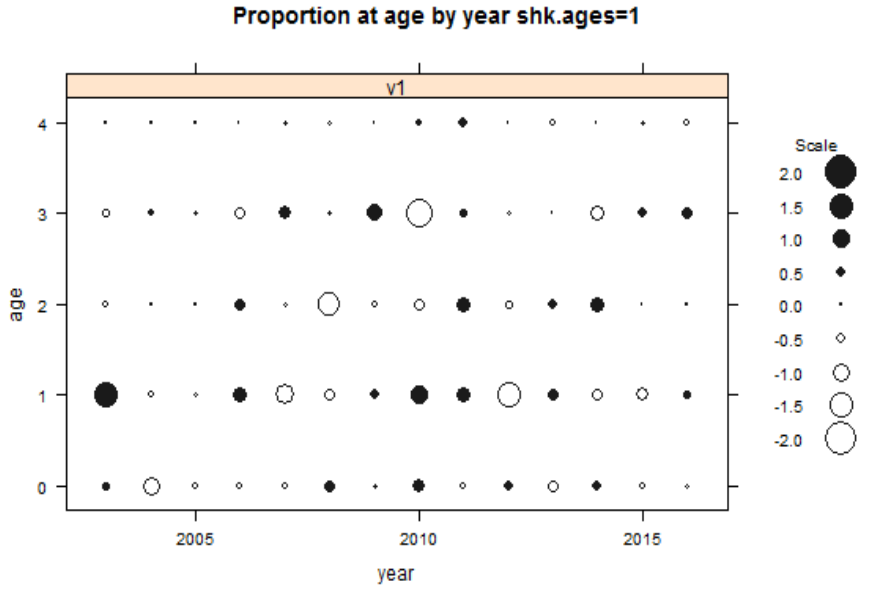
Sensitivity analysis on catchability independent of age "rage" and "qage"



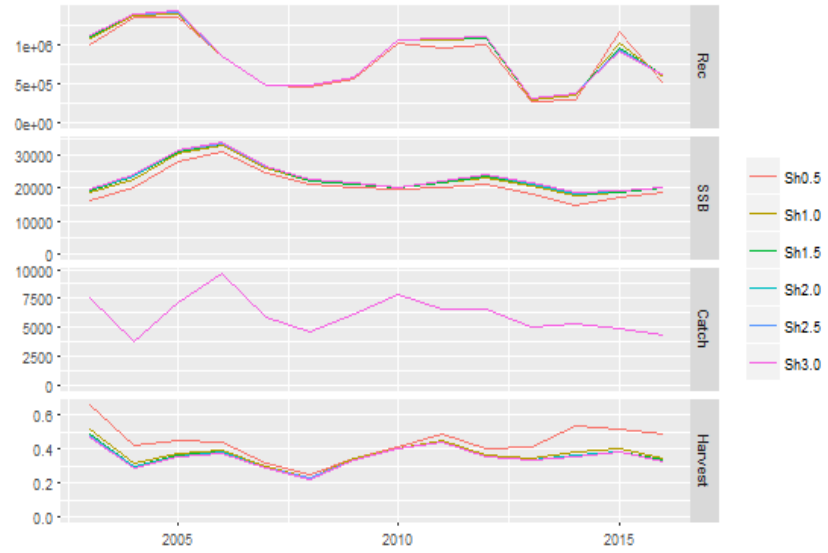


Sensitivity analysis on shrinkage ages "shk.ages"

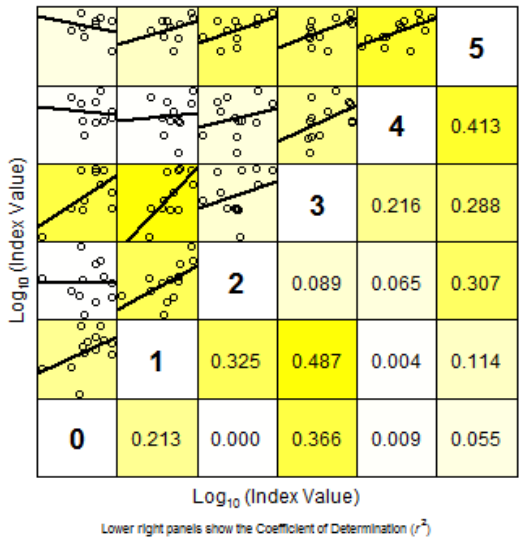


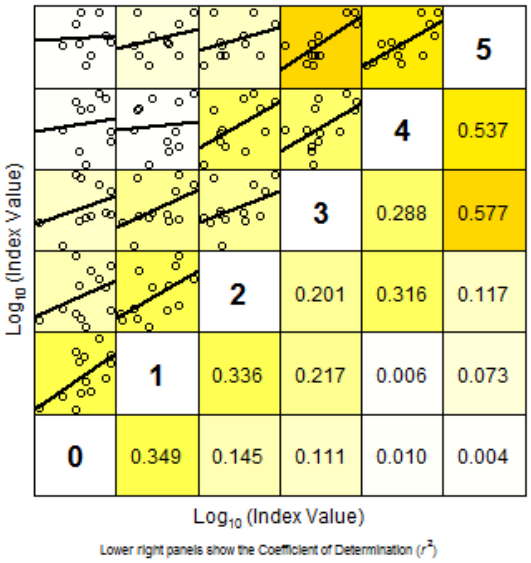


Sensitivity analysis on shrinkage weight "fse"



Consistency of catches and surveys.





Consistency of catches and surveys

6.1.8 Assessment quality

The selection of the suitable parameters for the final XSA run was performed by running sensitivity and retrospective analyses, to ensure the robustness of the final estimates. For instance a value of 3.0 for the shrinkage weight was found inappropriate as it induced great differences from the general pattern as in harvest. In all the cases residuals are lower than two.

6.1.9 Reference points

Biomass is at an intermediate level. Furthermore F0.1= 0.24 and Fcur= 0.33 being the ratio Fcur/F0.1 = 1.38; so the fishing effort is high.

Sardine stock in GSA01 is in overexploitation.

6.1.10 Reference points

Reference points	XSA
Fcur	0.33
F0.1	0.24
F/F0.1	1.38
E	0.47

The exploitation rate E = Fbar(0-3) / Z is greater than 0.4 (threshold suggested as a biological reference point for small pelagic (Patterson, 1992). Also, the ratio F/F0.1 is greater than 1. So, the sardine stock is considered overexploited.

Comparing different models reference points.

	XSA	BioDyn*	VIT*
Tun	CPUE	CPUE	
Fcur	0.33 (0-3)	0.054	0.27 (1-2)
F0.1	0.24	0.045	0.14
Fcur/F0.1	1.38	1.2	1.92

* los análisis en las SAF GSA03 y 04

7 Stock predictions

7.1 Short term predictions

7.2 Medium term predictions

7.3 Long term predictions

8 Draft scientific advice

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	F0.1=0.33	Fc=0.24		2003-2016	IO –In Overfishing status
	Fishing effort					
	Catch					
Stock abundance	Biomass					
	SSB					
Recruitment						
Final Diagnosis		Over exploited (in over exploitation)				

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)*

9.1 Explanation of codes

Trend categories

5) N - No trend
6) I - Increasing
7) D – Decreasing
8) C - Cyclic

Stock Status

Based on Fishing mortality related indicators

6) **N - Not known or uncertain** – Not much information is available to make a judgment;
7) **U - undeveloped or new fishery** - Believed to have a significant potential for expansion in total production;
8) **S - Sustainable exploitation**- fishing mortality or effort below an agreed fishing mortality or effort based Reference Point;
9) **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:

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- 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

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

Based on Stock related indicators

6) **N - Not known or uncertain:** Not much information is available to make a judgment
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10 BIBLIOGRAFIA

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