SAC GFCM
Sub-Committee on Stock Assessment

Date*	5	October	2009	Code*	PIL0109Qui

Authors*

Quintanilla, L.F.1*, Bellido, J.M.2, Torres, P.1, Giráldez, A.1, Ceruso, C.2, Alemany, F.3, Iglesias, M.3

Affiliation*

1 Instituto Español de Oceanografía. Centro Oceanográfico de Málaga. Puerto Pesquero S/N. Fuengirola. 29640. Málaga. Spain.

Species Scientific name*

1 ***Sardina pilchardus - PIL***
Source: GFCM Priority Species

2
Source: -

3
Source: -

Geographical area*

Western Mediterranean (FAO Subarea 37.1.)

Geographical Sub-Area (GSA)*

01 - Northern Alboran Sea

Combination of GSAs 1

2

3

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Assessment form — **Sheet #0** — **Basic data on the assessment**

Code: PIL0109Qui

Date*	5	Oct	2009	Authors*	Quintanilla, L.F.1*, Bellido, J.M.2, Torres, P.1, Giráldez, A.1, Ceruso, C.2, Alemany, F.3, Iglesias, M.3

Species Scientific name*	Sardina pilchardus - PIL	Species common name*	Sardine, Sardina

Data Source

GSA*	01 - Northern Alboran Sea	Period of time*	2000-2008

Description of the analysis

Type of data*	Landings, Length and biological samplings. Tuning from Purse seiners	Data source*	Official Statistics, IEO Sampling Network, Acoustic Survey
Method of assessment*	XSA - Extended Survivor Analysis	Software used*	VPA Suite. Lowestoft. 1995

Sheets filled out

B	P1	P2a	P2b	G	A1	A2	A3	Y	Other	D	Z	C
1	1	1	1	---	1	1	1	---	1	1	1	1

Comments, bibliography, etc.

Fishery assessment by VPA methods of the Spanish sardine stock GSA01 is reported. VPA Lowestoft software suite was used and XSA was the assessment method. A separable VPA was also run as exploratory analysis for both stocks. Stochastic short term projections were also produced.

Comments, bibliography, etc.

Bibliography (Published papers and books):

Abella A., Caddy J.F., Serena F. (1997) Declining natural mortality with age and fisheries on juveniles: a Mediterranean demersal fishery yield paradigm illustrated for Merluccius merluccius. Aquatic Living Resources 10: 257–269.

Caddy, J.F. (1991). Death rates and time intervals: Is there an alternative to the constant natural mortality axiom? Rev. Fish Bio/. Fisheries, 1: 109-13 8.

De Oliveira, J.A.A., Uriante, A., and Roel, B., 2005. Potential improvements in the management of Bay of Biscay anchovy by incorporating enviromental indices as recruitmen predictors. Fisheries Research, 75: 2-14.

Freon, P. and Misund, O.A., 1999. Dynamics of Pelagic Fish Distribution and Behaviour: Effects on Fisheries and Stock Assessment. Fishing News Books, UK, 348 pp.

Hilborn, R. and Walters C.J., 1992. quantitative Fisheries Stock Assessment; Choice, Dynamics and Uncertainty. New York: Chapman and Hall, 570 pp.

Lleonard, J. and Maynou, F., 2003. Fish Stock Assessment in the Mediterranean: state of the art. Scientia Marina, 67: 37-49.

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

Ramon M.M and Castro, J.A., 1997. Genetic variation in natural stocks of Sardina pilchardus (Sardines) from the western Mediterranean Sea. Heredity, 78: 520-528.

Sheperd, J.G., 1999. Extended Survivors Analysis: An improved method for the analysis of catch-at-age data and abundance indices. Journal of Marine Science, 56: 584-591.

Bibliography (Technical Reports and grey literature):

Darby, C.D. and Flatman, S., 1994. Virtual Population Analysis, version 3.1 (Windows/DOS) user guide. Information Technology Series 1. CEFAS, Lowestoft, UK.

Reports from the SCSA and SAC of the General Fisheries Commission for the Mediterranean (GFCM), available at http://www.fao.org/fi/body/rfb/GFCM/gfcm_home.htm and/or ftp://cucafera.icm.csic.es/pub/scsa/

Reports from the Assessment Working Groups of the International Council for the Explorration of the Seas (ICES), particularly the small pelagics assessment working group WGMHSA. Available at www.ices.dk

Reports from the SGMED Working Groups on the Mediterranean of the Scientific, Technical and Economic Committee for Fisheries (STECF). Available at http://fishnet.jrc.it/web/stecf.

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Assessment form	**Sheet B** **Biology of the species**

Code: PIL0109Qui

Biology

Somatic magnitude measured (LH, LC, etc)*	Total Length	Units*	1/2 centimeter

Sex	Fem	Mal	Both	Unsexed		
Maximum size observed			23.2		Reproduction season	Oct-Mar
Size at first maturity			13.6		Reproduction areas	All the coast
Recruitment size			10		Nursery areas	Bays

Parameters used (state units and information sources)

			Sex			
		Units	female	male	both	unsexed
Growth model	L∞	cm			23.0844	
	K	year-1			0.31274	
	t0	year			-2.22053	
	Data source	Otoliths				
Length weight relationship	a				0.00522	
	b				3.17746	

M			M vector (see comments)

sex ratio (mal/fem)	44/56

Comments

ALKs 2003-2008, combined ALK for 2000-2002. Length Distributions 2003-2008, combined for 2000-2002.

Biological sampling 2005-2008 for Maturity at age and Weight-Length relationships.

Natural Mortality value (M) - Following the recommendation from the Workshop on Mediterranean Stock Assessment Standardization (SG-ECA/RST/MED 09-01), a vector (declining value of M with age) instead of a constant value was used. The vector was estimated using the ProdBiom method (Abella et al., 1997) based on Caddy (1991).

Age	M
0	1.17
1	0.44
2	0.32
3	0.27
4	0.25
5+	0.24

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Assessment form

Sheet P1
General information about the fishery

Code: PIL0109Qui

Data source*	Official Statistics, IEO Sampling Network, Acoustic	Year (s)*	2000-2008
Data aggregation (by year, average figures between years, etc.)*	By year 2000-2008		

Fleet and catches (please state units)

	Country	GSA	Fleet Segment	Fishing Gear Class	Group of Target Species	Species
Operational Unit 1*	ESP	01	G - Purse Seine (6-12 metres)	02 - Seine Nets	31 - Small gregarious pelagic	PIL
Operational Unit 2	ESP	01	H - Purse Seine (12-24 metres)	02 - Seine Nets	31 - Small gregarious pelagic	PIL
Operational Unit 3						
Operational Unit 4						
Operational Unit 5						

Operational Units*	Fleet (n° of boats)*	Kilos or Tons	Catch (species assessed)	Other species caught	Discards (species assessed)	Discards (other species caught)	Effort units
ESP 01 G 02 31 - PIL	28	Tons	4423				
ESP 01 H 02 31 - PIL	103	Tons					
Total	131		4423				

Legal minimum size	11 cm TL

Comments

The catch (landings) is not split by Fleet segments. It comprises 4423 Tons in 2008 for the two Operational Units. Although landings are not still separated by Fleet segments we can provide a segmentation of the pelagic fleet in GSA01, with number of boats for every fleet segment:

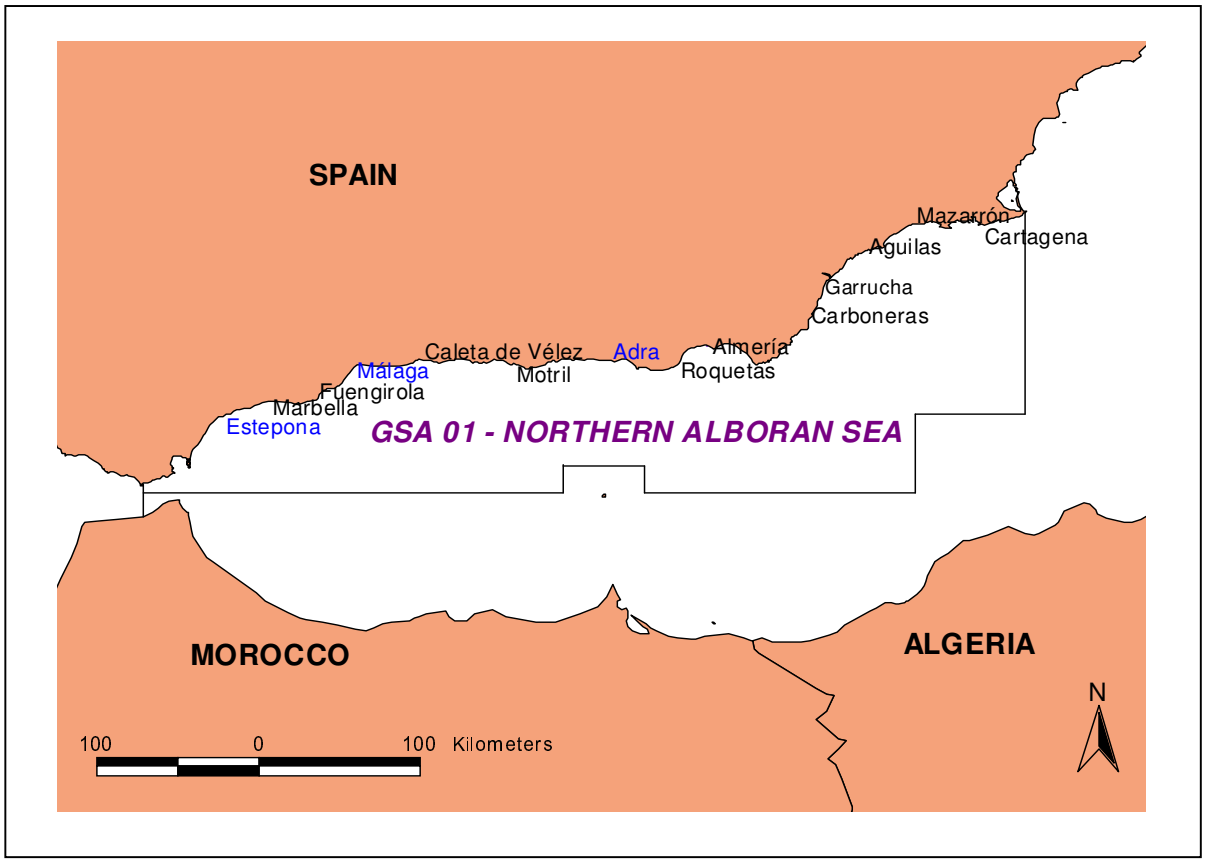
The Fleet Segment G - Purse Seine (6-12 metres) comprises 28 boats in GSA01 in 2008
The Fleet Segment H - Purse Seine (12-24 metres) comprises 103 boats in GSA01 in 2008

Beacuse that landing aggregation we prefer to fill pages P2a and P2b considering the two fleet segments as an unique pelagic fleet. We aim to split landings by Fleet segment in a near future.

Landing Ports are shown in the attached Figure. Sampling ports are highlighted in blue.

Tuning data from acoustic survey ECOMED and Commercial Fleet off Estepona, Málaga and Adra for years 2003 to 2008.

Comments


SPAIN
Mazarrón
Aguilas
Cartagena
Garrucha
Carboneras
Almería
Roquetas
Adra
Caleta de Vélez
Motril
Málaga
Fuengirola
Marbella
Estepona
GSA 01 - NORTHERN ALBORAN SEA
MOROCCO
ALGERIA
N
100 0 100 Kilometers

Data source*	Official Statistics, IEO Sampling Network	OpUnit 1*	ESP 01 G 02 31 - PIL

Time series

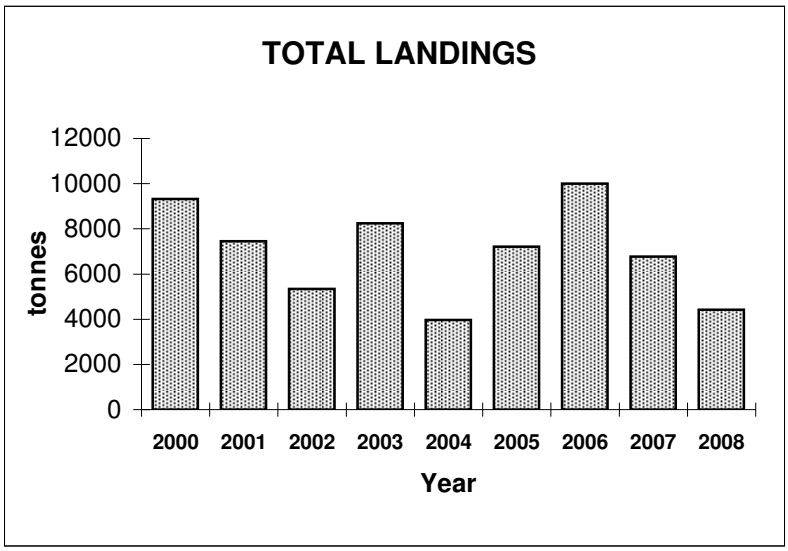
Year*	2000	2001	2002	2003	2004	2005
Catch	9325 t	7457 t	5348 t	8244 t	3964 t	7208 t
Minimum size	6 cm	6 cm	6 cm	8 cm	6 cm	6 cm
Average size Lc	18.12 cm	18.12 cm	18.12 cm	18.09 cm	18.57 cm	18.16 cm
Maximum size	24 cm	24 cm	24 cm	22 cm	23.5 cm	24 cm
Fleet	187	184	168	167	160	149

Year	2006	2007	2008			
Catch	10002 t	6766 t	4423 t			
Minimum size	10.5 cm	9.5 cm	7.0 cm			
Average size Lc	18.13 cm	18.79 cm	17.37			
Maximum size	22 cm	22.5 cm	23.0 cm			
Fleet	135	136	136			

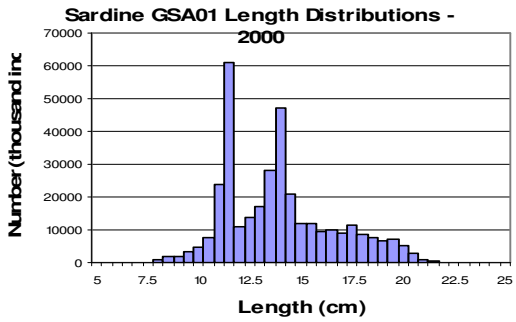
Selectivity **Remarks**

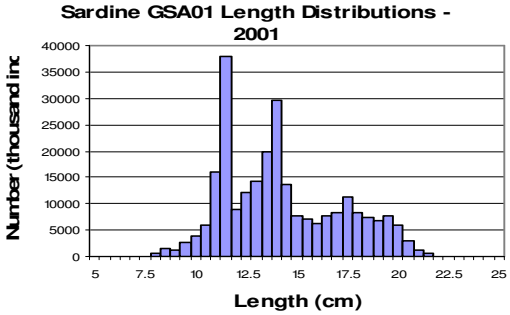
L25	
L50	
L75	
Selection factor	

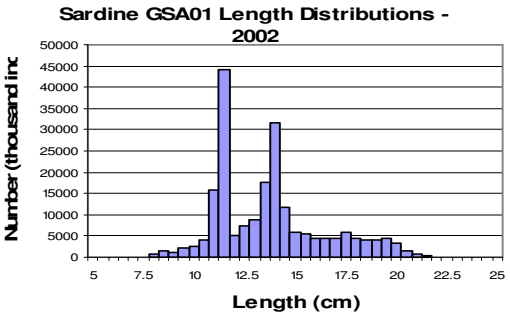
Structure by size or age

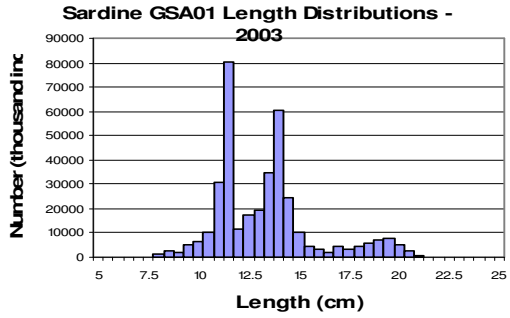


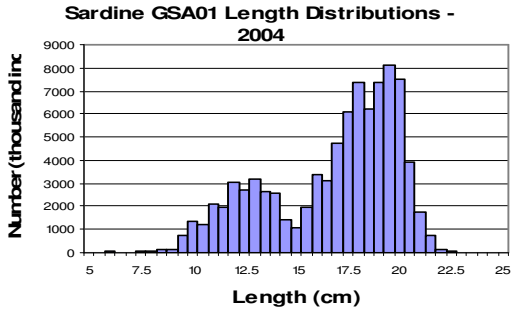
Structure by size or age

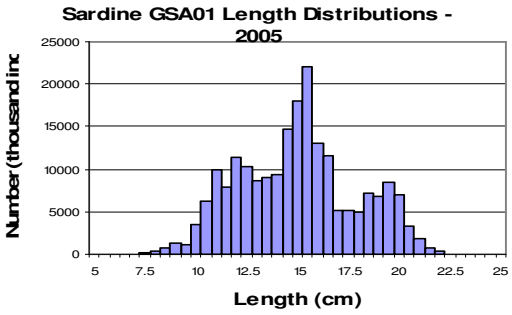


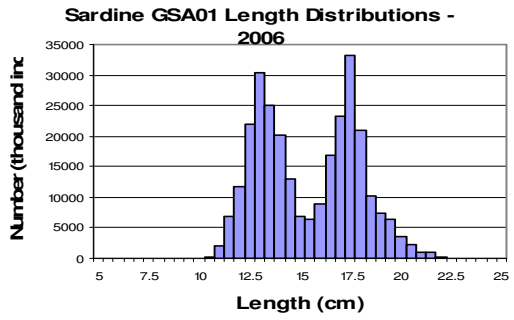


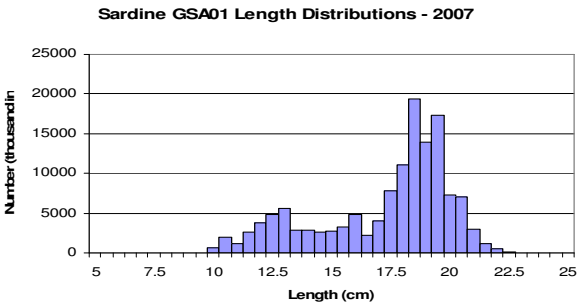


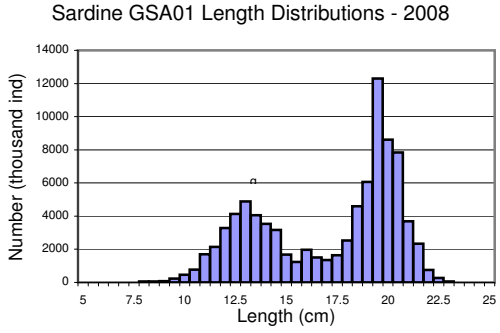












Data source*	Official Statistics, IEO Sampling Network	OpUnit 1*	ESP 01 G 02 31 - PIL

Regulations in force and degree of observance of regulations

Fishing license: fully observed
Minimum landing size 11cm: not fully observed (Some landings under minimum size in some specific ports).
No fishing allowed on weekend. Time at sea 12 hours per day and 5 days a week: fully observed
Several technical measures regulations (gear and mesh size, engine, GRT, etc...): not fully observed
Temporary fishing closures (March and April): fully observed.

Accompanying species

The most important are:
Anchovy (*Engraulis encrasicolus*)
Mediterranean Horse Mackerel (*Trachurus mediterraneus*)
Other Horse Mackerels (*Trachurus trachurus* and *Tachurus picturatus*)
Mackerel (*Scomber scombrus*)
Chub Mackerel (*Scomber japonicus*)
Round sardinella (*Sardinella aurita*)
Bogue (*Boops boops*)

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Assessment form — **Sheet A1** — **Indirect methods: VPA, LCA**

Code: PIL0109Qui

Sex*	Both

Analysis # *	XSA

Time series

Data	Size	Age
(mark with X)	X	X

Model	Cohorts	Pseudocohorts
(mark with X)	X	

Equation used	VPA	Tunig method	XSA
# of gears	Purse seiners	Software	VPA95. Lowestoft suite
$F_{terminal}$	Not relevant to XSA		

Population results (please state units)

	Sizes	Ages		Amount	Biomass
Minimum	7	0	Recruitment	347 millions	
Average	See page 2a		Average population	See coments below	
Maximum	23	5+	Virgin population		
Critical			Turnover		

Average mortality

		Gear					
	Total						
F_1	Fbar=0.25						
F_2							
Z	See Comments						

(F1 and F2 represent different possible calculations. Please state them)

Comments

Reference F is Fbar1-3 (average of ages 1 to 3 are considered the reference ages). Following the SG-ECA/RST/MED 09-01 recommendation, a vector instead of a constant value was used. The vector was estimated using the ProdBiom method (Abella et al., 1997) based on Caddy (1991).

Age	0	1	2	3	4	5+
F	0.15	0.13	0.20	0.43	0.36	0.36
M	1.17	0.44	0.32	0.27	0.25	0.24

Separable VPA results show the pattern of Log catchability residuals. Some conflict between ages seem to appear. Fleet behaviour and fishery movements could affect the catchability pattern. XSA main settings were Fbar 1-3; Age 2 for q stock-size independent and age 3 for q independent of age. Landings decrease in 2008, reaching up 4423 t. The time series shows a rather fluctuating trend, with the lowest value in 2004 (3960 t) and the greatest in 2006 (10000 t). Fishing mortality is at a moderate level (F08=0.25), showing a decreasing trend. Recruitment in 2008 is similar to 2007 but decreases from that of previous years (R08=347 millions), showing the second lowest value of the time series. The time series recruitment shows a decreasing pattern. Both Total biomass in 2008 (TB=23,871 t) and Spawning Stock Biomass in 2008 (SSB=18,950 t) decrease with respect to previous years showing the lowest values of the time series. See also figures in page VPA

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Assessment form

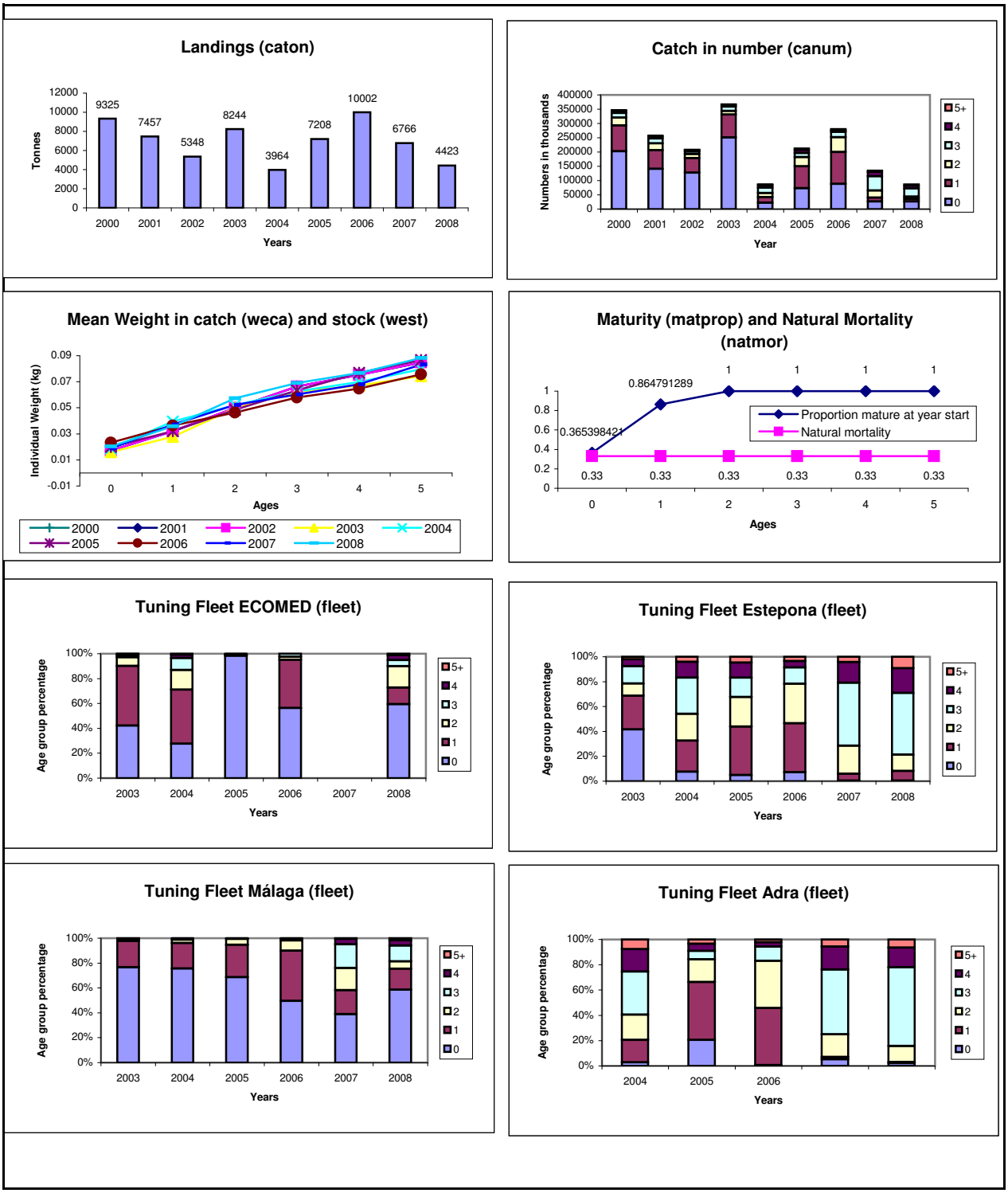
Sheet A2
Indirect methods: data

Code: PIL0109Qui

Sex*	Both	Gear*	Purse seiners	Analysis # *	XSA

Data	Input data for XSA

Data

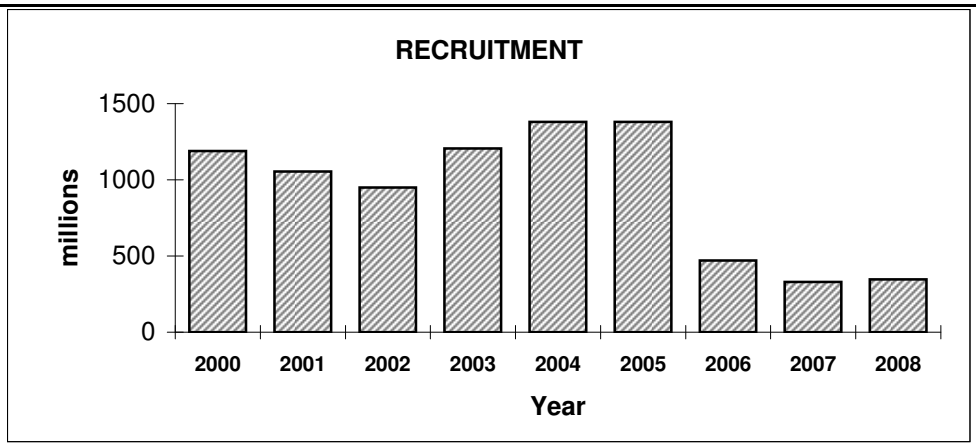


SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	**Sheet A3** **Indirect methods: VPA results**

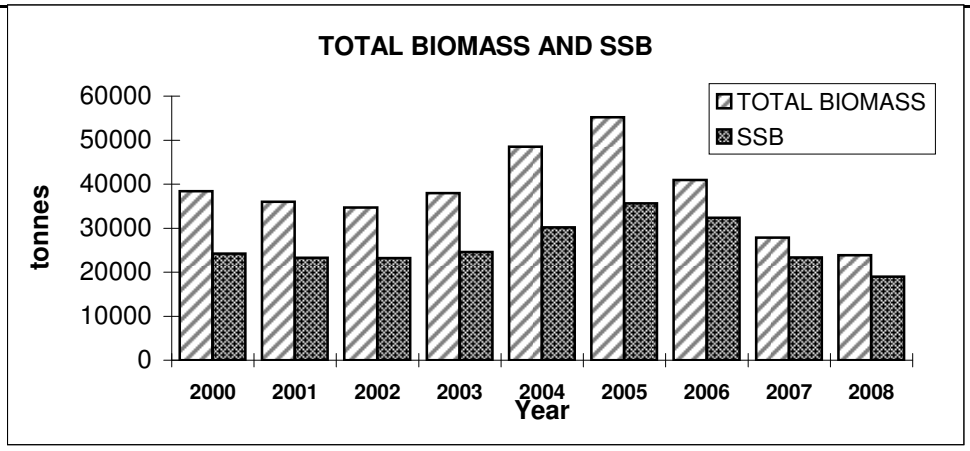
Code: PIL0109Qui

Sex*	Both	Gear*	Purse Seiners	Analysis #*	XSA

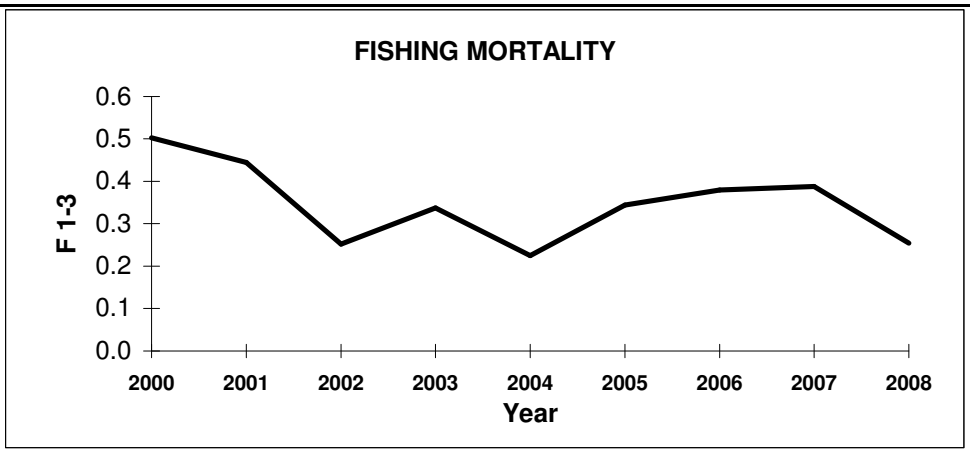
Population in figures



Population in biomass



Fishing mortality rates



SAC GFCM - Sub-Committee on Stock Assessment (SCSA)	
Assessment form	**Sheet Y** **Indirect methods: Y/R**

Code: PIL0109Qui

Sex		Analysis #	

# of gears		Software	

Parameters used

Vector F	
Vector M	
Vector N	

Model characteristics

Results

	Total	Gear			
Current YR					
Maximum Y/R					
Y/R 0.1					
F_{max}					
$F_{0.1}$					
Current B/R					
Maximum B/R					
B/R 0.1					

Comments

Other assessment methods

Short Terms Deterministic Projections for three years (2009 to 2011).

MFDP software (Multi-Fleet Deterministic Projections).

Table below shows the management options from the short term catch prediction. Assuming statu quo F (Fbar06-06=0.34) and the recruitment is similar to the recruitment observed in 2007 and 2008 (Rlow=347 millions). We realise this option is more conservative but the most realistic and robust as recruitment has been continuously decreasing reaching their lowest values in last two years. Landings are predicted to be 4600 t in 2009 and 3900 t in 2010. Total biomass will decrease from 20700 t in 2009 to 17100 t in 2011 and SSB will also decrease from 16000 t in 2009 to 12000 t in 2011.

Hence this exploitation pattern of maintaining F statu quo 2009-11 with scenarios of low recruitment rates, will produce a slight loss and continuing decreasing trend which could prompt a decline of the fishery.

In this situation it is particularly important to pay special attention to recruitment levels as they could prompt sudden increases or drops in a near future.

2009							
Biomass	SSB	FMult	FBar	Landings			
20688	15595	1	0.3407	4572			
2010					2011		
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB	
18459	13397	0	0	0	20819	15670	
.	13397	0.1	0.0341	452	20381	15241	
.	13397	0.2	0.0681	889	19957	14827	
.	13397	0.3	0.1022	1311	19549	14429	
.	13397	0.4	0.1363	1719	19155	14044	
.	13397	0.5	0.1704	2114	18775	13673	
.	13397	0.6	0.2044	2496	18408	13315	
.	13397	0.7	0.2385	2865	18054	12970	
.	13397	0.8	0.2726	3223	17712	12636	
.	13397	0.9	0.3067	3569	17382	12315	
.	13397	1	0.3407	3904	17064	12004	
.	13397	1.1	0.3748	4228	16756	11705	
.	13397	1.2	0.4089	4542	16459	11415	
.	13397	1.3	0.4429	4846	16173	11136	
.	13397	1.4	0.477	5141	15896	10866	
.	13397	1.5	0.5111	5426	15628	10606	
.	13397	1.6	0.5452	5703	15369	10354	
.	13397	1.7	0.5792	5971	15119	10111	
.	13397	1.8	0.6133	6231	14878	9876	
.	13397	1.9	0.6474	6483	14644	9649	
.	13397	2	0.6814	6727	14419	9429	

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Assessment form	**Sheet D** **Diagnosis**

Code: PIL0109Qui

Indicators and reference points

Criterion	Current value	Units	Reference Point	Trend	Comments
B					Not Reference Point defined yet
SSB					Not Reference Point defined yet
F					Not Reference Point defined yet
Y					Not Reference Point defined yet
CPUE					Not Reference Point defined yet

Stock Status* Use one (or both) of the following two systems for the stock assessment status description

Unidimensional		
	☐	? - (or blank) Not known or uncertain. Not much information is available to make a judgment;
	☐	U - Underexploited, undeveloped or new fishery. Believed to have a significant potential for expansion in total production;
	☐	M - Moderately exploited, exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production;
	☐	F - Fully exploited. The fishery is operating at or close to an optimal yield level, with no expected room for further expansion;
	☉	O - Overexploited. The fishery is being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse;
	☐	D - Depleted. Catches are well below historical levels, irrespective of the amount of fishing effort exerted;
	☐	R - Recovering. Catches are again increasing after having been depleted or a collapse from a previous;

Bidimensional

Exploitation rate

☐	No or low fishing
☉	Moderate fishing
☐	High fishing mortality
☐	Uncertain / Not assessed

Stock abundance

☐	Virgin or high abundance
☐	Intermediate abundance
☉	Low abundance

☐	Depleted
☐	Uncertain / Not assessed

Comments

No reference points for sardine can be suggested at this point.Further years will come a Time series extension suitable to suggest relevant Reference Points as well as Harvest Control Rules for this fishery.

Code: PIL0109Qui

Management advice and recommendations*

Regarding suggestion for management options, this fishery is considered overexploited. Although the exploitation rate (fishing mortality) is at a moderate level, the stock abundance in 2008 remains at low levels (the lowest of the time series 2002-2008) and continues the decreasing trend observed from 2005 onwards. Unless the recruitment levels increase in the near future, this fishery will be being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse.

Advice for scientific research*

No reference points for sardine can be suggested at this point. Further years will come a Time series extension suitable to suggest relevant Reference Points as well as Harvest Control Rules for this fishery.

Comments*

Conclussions - Assessment:

Landings in 2008 were 4423 t, showing a decrease from that of previous years (6766 t in 2007 and 10002 t in 2006). The time series shows an irregular pattern with landings in 2008 close to the lowest levels observed in the assessed time series (3964 t in 2004).

Fishing mortality is at a moderate level (F08=0.25), which represents one of the lowest values of the assessed time series.

Recruitment in 2008 (R08=347 millions) is on the same level than recruitment in 2007 (329 millions) and slightly lower than recruitment in 2006 (470 millions). The recruitments in these last three years are the lowest of the assessed time series and represent less than the half of that estimated un previous years. The trend of the recruitments is so important as they can affect seriously to the stock health.

Both Total Biomass in 2008 (TB=23871 t) and Spawning Stock Biomass in 2008 (SSB= 18950 t) also show a decreasing trend and the lowest levels of the assessed time series.

Conclusions – Catch Forecasting

Assuming Statu quo F (Fbar06-08=0.34) and conservative recruitment levels (the lowest of the assessed time series Rlow= 347 millions):

- Landings are predicted to be 4600 t in 2009 and 3900 t in 2010.
- Total biomass will decrease from 20700 t in 2009 to 17100 t in 2011.
- SSB will also decrease from 16000 t in 2009 to 12000 t in 2011.

.
Hence this exploitation pattern of maintaining F statu quo 2009-11 with scenarios of low recruitment rates, will produce a slight loss and continuing decreasing trend which could prompt a decline of the fishery.

In this situation it is particularly important to pay special attention to recruitment levels as they could prompt sudden increases or drops in a near future.

Conclusions - Management considerations:

This fishery is considered overexploited. Unless the recruitment levels increase in the near future, this fishery will be being exploited at above a level which is believed to be sustainable in the long term, with no potential room for further expansion and a higher risk of stock depletion/collapse.

Further work:

Reference points.
Harvest Control Rules.