Stock Assessment Form

Small Pelagics

Reference Year: 2017

Reporting Year: 2018

Stock Assessment Form version 1.0 (January 2014)

Uploader: Tarek Hattab

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:**
[GSA 07 Gulf of Lions]	[GSA_2]	[GSA_3]
4th Geographical sub-area:	**5th Geographical sub-area:**	**6th Geographical sub-area:**
[GSA_4]		
1st Country	**2nd Country**	**3rd Country**
[France]	[Country_2]	[Country_3]
4th Country	**5th Country**	**6th Country**
Stock assessment method: (direct, indirect, combined, none)		
Direct (acoustic survey)		
Authors:		
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Affiliation:		
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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
- SURBA
- Other (please specify)

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 (please specify)

2 Stock identification and biological information

2.1 Stock unit

The assessment covers the whole GSA07 area corresponding to the Gulf of Lions. However, the Gulf of Lions may not correspond to a complete stock unit. Indeed, hydrological exchanges between the Gulf of Lions and the Catalan Sea for instance are well known, which should at least affect larval transport (see Ospina-Alvarez et al. 2013) and then recruitment of juvenile sardines in both areas. Similarly, part of the young recruited in the Gulf of Lions sardine population may come from larval transport from spawners of the Ligurian Sea. Further, preliminary genetic analyses have shown no differences between Spanish and French stocks of sardines in the North-Western Mediterranean Sea. Because of these questions about the stock unit, further investigations have been conducted combining French and Spanish landing data in order to see whether the disappearance of large individuals from the Gulf of Lions might result from a migration towards Spanish waters. This does not seem to be the case (see below) and we believe the two GSA may be assessed independently.

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**	
Sex	**Fem**	**Mal**	**Combined**	**Reproduction season**	Winter
Maximum size observed	20.5	19		**Recruitment season**	
Size at first maturity			10.5	**Spawning area**	Offshore Rhone river
Recruitment size to the fishery			7	**Nursery area**	Coastal and lagoons

*Maximum size observed corresponds to the maximum size ever observed in PELMED (1993-2018)

**Size at first maturity was calculated based on samplings in Novembre, Decembre and January (peak of reproduction) from 2009 onwards (as a change in size at first maturity was observed around 2008).

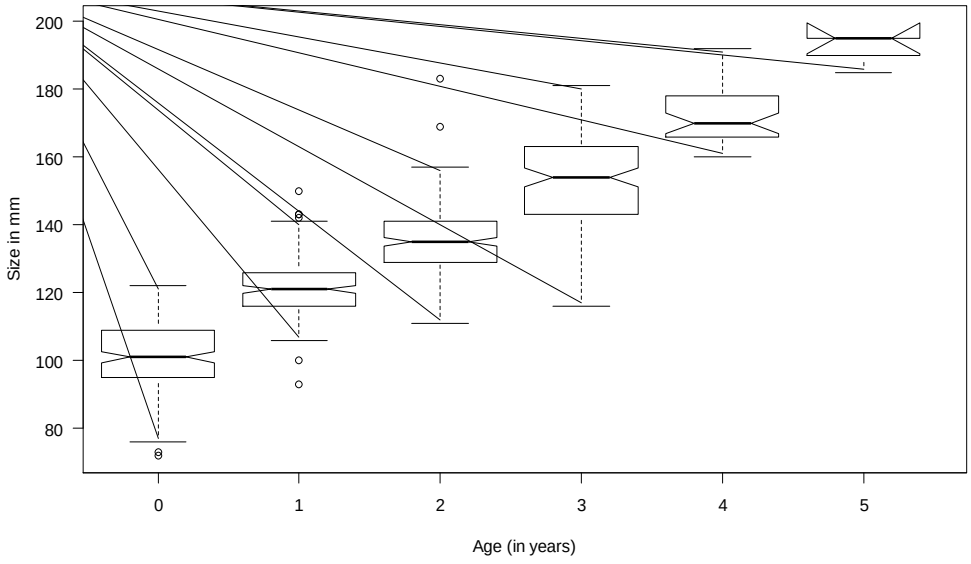
Table 2-2.2: Proportion of matures by size

Size/Age	Proportion of matures (Males)	Proportion of matures (Females)
7cm	*0.0599*	*0.0237*
8cm	*0.1206*	*0.0638*
9cm	*0.2279*	*0.1607*
10cm	*0.3884*	*0.3498*
11cm	*0.5775*	*0.6018*
12cm	*0.7463*	*0.8094*
13 cm	*0.8636*	*0.9227*
14 cm	*0.9316*	*0.9710*
15 cm	*0.9670*	*0.9895*
16 cm	*0.9844*	*0.9962*
17 cm	*0.9927*	*0.9987*

Table 2-3: Growth and length weight model parameters

			Sex			
		Units	**female**	**male**	**Combined**	**Years**
Growth model	**L_∞**				Due to the disappearance of old individuals and the slow growth since 2008, we were unable to fit a Von Bertalanffy curve, as the size age relationship appears linear (LM: $P < 0.001$, $R^2 = 0.68$, $a = 1.75 \pm 0.27$ cm.yr^{-1}; see Figure below)	2008-2014
	K					
	t_0					
	Data source					
Length weight relationship	**a**				0.0063	2018
	b				3.09	2018
	M (scalar)					
	sex ratio (% females/total)					

Length-weight relationship parameters are derived from data collected during the 2018 PELMED survey only.



3 Fisheries information

3.1 Description of the fleet

Identification of Operational Units exploiting this stock. Use as many rows as needed

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*	FRA	[07]	E – Trawl (12-24 m)	03 - Trawls	35 – Small gregarious pelagic	PIL
Operational Unit 2	FRA	07	H – Purse Seine (0-24 m)	02 – Seine Nets	35-Small gregarious pelagic	PIL

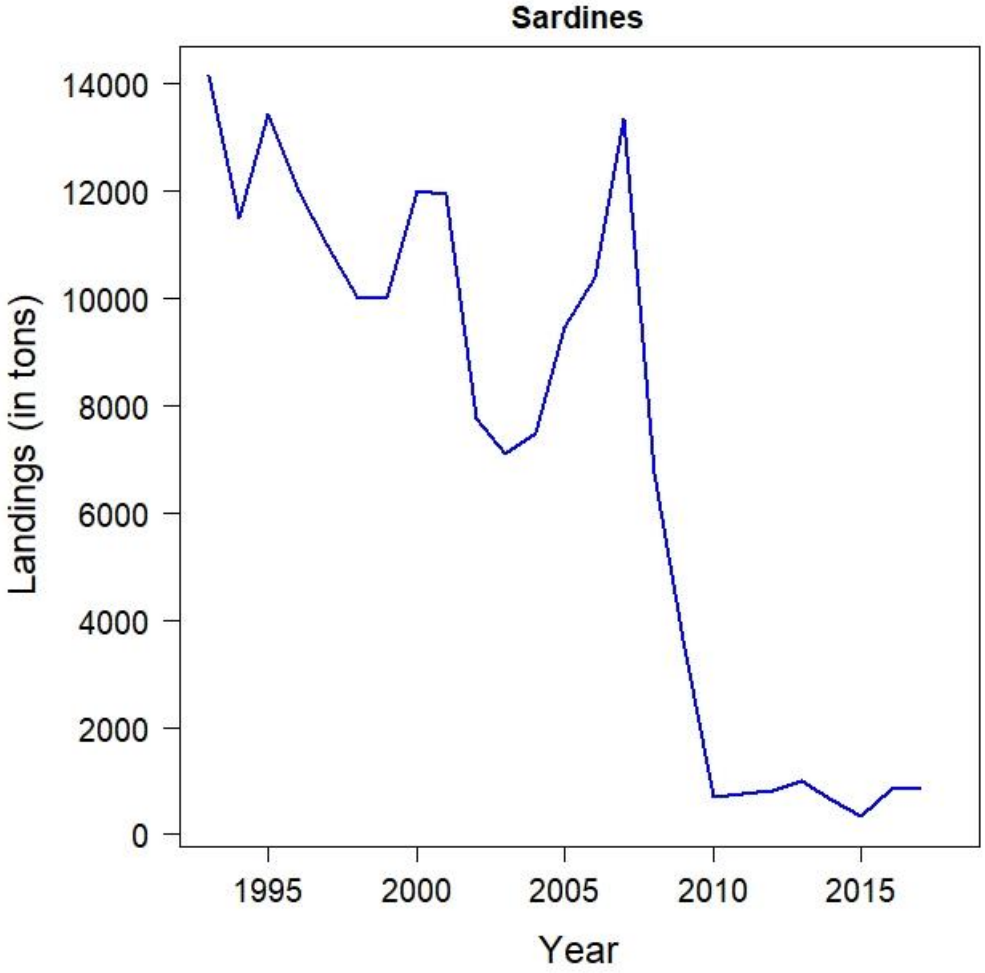
Table 3.1-2: Catch, bycatch, discards and effort by operational unit in the reference year

Operational Units*	Fleet (n° of boats)*	Catch (T or kg of the species assessed)	Other species caught (names and weight)	Discards (species assessed)	Discards (other species caught)	Effort (units)
FRA 07 E 03 31 -PIL		86				
FRA 07 H 02 31 -PIL		725				
Total		876				

Trawlers landed very few sardines, which are not targeted anymore, and appear more as by-catch of demersal fisheries. The activity of purse-seiners is very opportunistic and none of these boats are focusing on sardines all throughout the year. The landings of the purse seines are in fact very seasonal, one season offshore Marseille from January to April and one season of Port-Vendres in July-September.

3.2 Historical trends

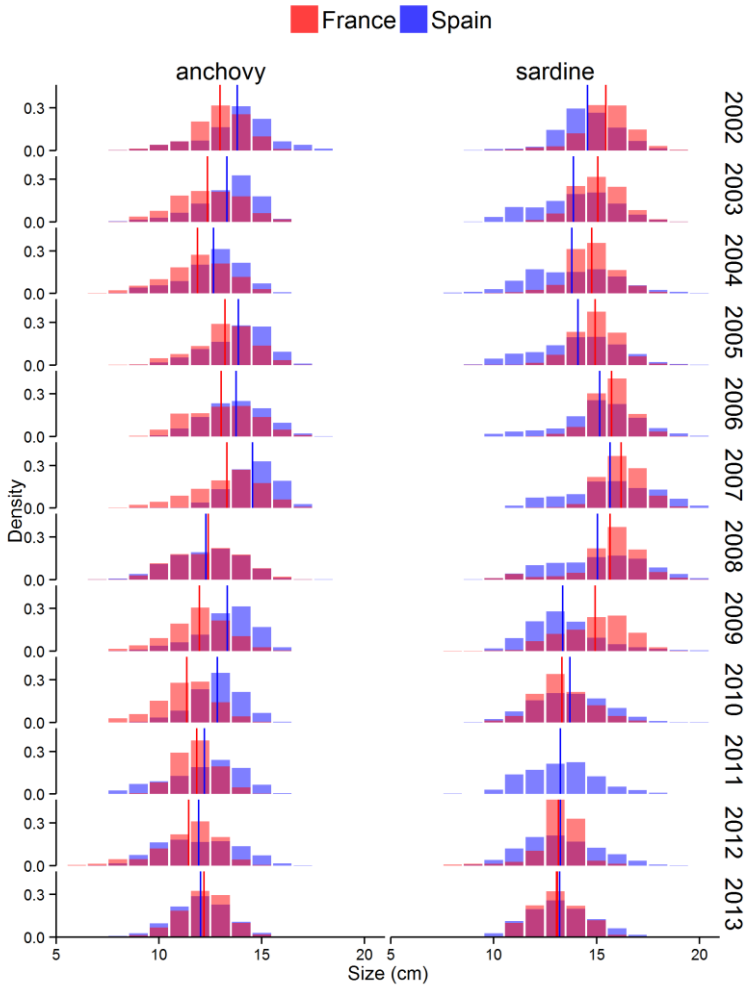
Landings have strongly decreased to reach very low values presently: between 10 and 14 000t were landed annually between 1993 and 2008, while less than 1 000t have been landed each year since 2010. Also, while pelagic trawlers represented the main float targeting sardines (> ¾ until 2010), it is now purse seines that lands the most sardines (~ ¾ in 2011-2018).



Further, the mean size of the landings has strongly decreased as well. From a main peak at 15-16cm until 2010, it decreased to 13/14cm in 2011-2013 and has reached even lower sizes (12-13cm) since then. This led to an important decrease in the commercial value of the landings and a decrease in the market, explaining the current very low fishing effort.

Questions about the disappearance of large and old small pelagic fish have been raised during the last years. As small pelagic fish population dynamics governed by adult mortality is very unusual, one question concerns the possibility of a displacement of these fish rather than mortality. In such a case, they would have likely moved towards the Spanish coast, especially as there is a general strong south-westward circulation in the GOL (Millot 1990; Nicolle, Garreau & Liorzou 2009) and the continental shelf is broader than the one of the Ligurian coast (Italy). As French and Spanish acoustic surveys have taken place at the same season only for a few years, it is difficult to compare abundance, size distribution… between regions based on these data. Nevertheless, the annual size distribution of the landings can still be paralleled. For France, the landing sizes follow roughly the same trend as the size distribution observed during July surveys. Thus, landed size distributions are

a reasonably proxy for the size distributions of the wild populations. Only the frequencies of the smallest fish are perhaps biased because of the used mesh sizes, but given that we are primarily interested in the larger fish, this does not pose a problem. From a comparative analysis, it becomes clear that Spanish landed pelagic fish were also smaller during recent years. The converging of the size distributions of both areas for both species might stress similarities between the French and Spanish populations, or a close connection between both. As we found evidence that sardine and anchovy in Spain are also smaller, there might have been a driver that acted on a larger scale, that is, the NW Mediterranean basin rather than just the Gulf of Lions. Hence, without excluding migration between areas itself, it can still be concluded that large individuals did not move to Spain.



3.3 Management regulations

- Exclusive licence for trawling, with a given number each year (both for small pelagics and demersals) - fully respected
- Limited engine power for trawlers to 318 kW or 430 hp - not respected
- Length of fishing trawlers inferior to 25 meters - fully respected
- Fishing effort limitation :
    - No fishing on Saturdays and Sundays, authorised hours trip: 3.00am to 8.00pm - fully respected
    - Trawling forbidden from coast to 3NM - not fully respected
    - Professional organisation regulations: Additional holidays: on average 40 days/year - fully respected

National management plans have also been established for trawlers (2014) and purse seines (2015) in the Gulf of Lions. Objectives in terms of harvest rate and age selectivity have been fixed. The current situation compared to these objectives is assessed each year, affecting the number of licences delivered the following year or the number of allowed fishing days.

3.4 Reference points

No reference point has been defined for this stock.

4 Fisheries independent information

4.1 {Direct acoustic method}

4.1.1 Brief description of the chosen method and assumptions used

Sampling was performed along 9 parallel and regularly spaced transects (inter-transect distance = 12 nautical miles, see map below). Acoustic data were obtained by means of echosounders (Simrad ER60) and recorded at constant speed of 8 $nm.h^{-1}$. A 3D-echosounder (Simrad ME70) is also now installed and used onboard to help discriminating schools. The size of the elementary distance sampling unit (EDSU) is 1 nautical mile. Discrimination between species was done both by echo trace classification and trawls output (Simmons & MacLennan 2005). Indeed, each time a fish trace was observed for at least 2 nm on the echogram, the boat turned around to conduct a ≥30 min-trawl at 4 $nm.h^{-1}$ in order to evaluate the proportion of each species (by random sampling of the catch and sorting before counting and weighing per species). While all frequencies were visualized during sampling and helped deciding when to conduct a trawl, only the energies from the 38kHz channel were used to estimate fish biomass. Acoustic data were preliminary treated with Movies 3D software in order to perform bottom corrections and to attribute to each echotrace one of the 5 different echotypes previously defined. Acoustic data analyses (stock estimation, length-weight relationships, etc.) were later performed using R scripts.

Table 4.1-1: Acoustic cruise information.

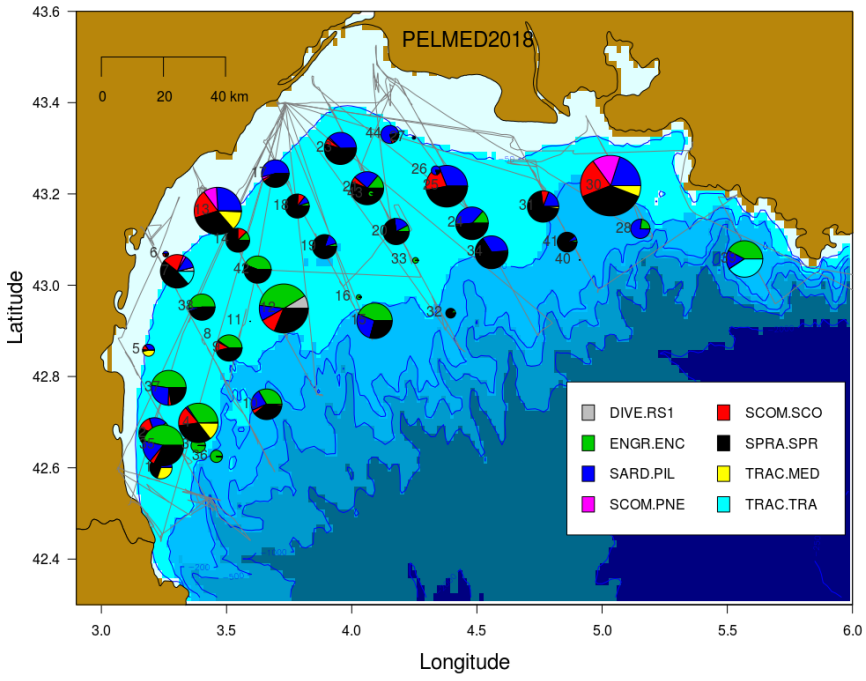
Date	27/06/2018 –31/07/2018		
Cruise	PELMED 18	**R/V**	L'Europe
Target species	Anchovy - Sardine		
Sampling strategy	9 // transects spaced 12Nm		
Sampling season	Summer		
Investigated depth range (m)	20-200m		
Echo-sounder	ER60 38 KHz for assessment 70, 120, 200 and 333 used as complementary frequency ME70 (3D echosounder) as support for echotype definitions		
Fish sampler	Pelagic trawls: 4FF176 with 7 m of vertical opening 4PM159 with 16 m of vertical opening		
Cod –end mesh size as opening (mm)	9 mm of mesh side; 18 mm of mesh size		
ESDU (i.e. 1 nautical mile)	1 Nm		
TS (Target Strength)/species	- 71.2 for anchovy and sardine		
Software used in the post-processing	Movies3D and R scripts		
Samples (gear used)	Pelagic trawl		
Biological data obtained	Length-Weight relationship, Age, Sex, Maturity, Fat content		
Age slicing method	Otolith		
Maturity ogive used	L50		

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

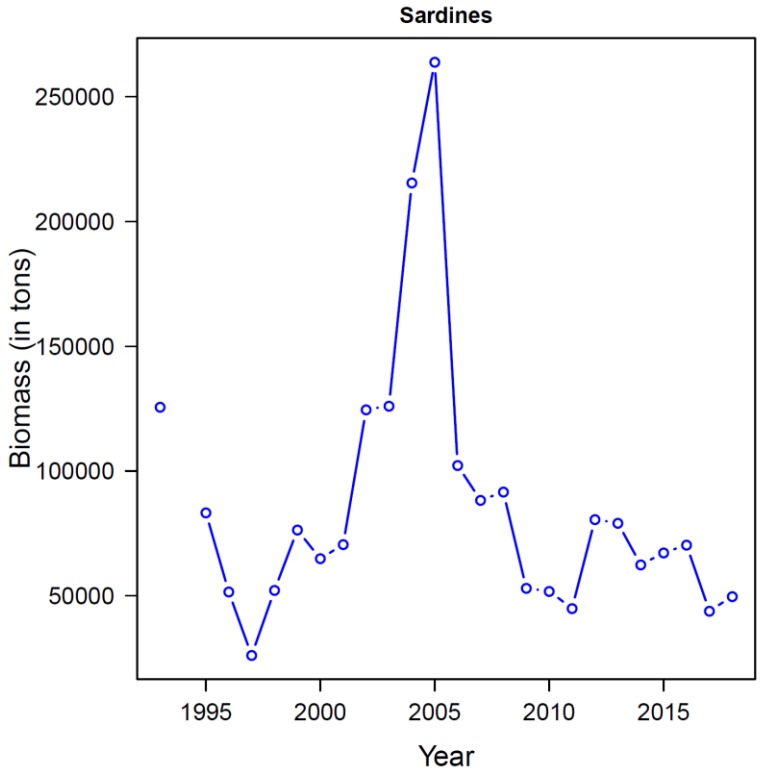
	Biomass in metric tons	fish numbers	Nautical Area Scattering Coefficient	Indicator …	Indicator …
Sardines	49748	5636644209			
Anchovies	32342	4228741331			
Sprats	96783	22947499092			

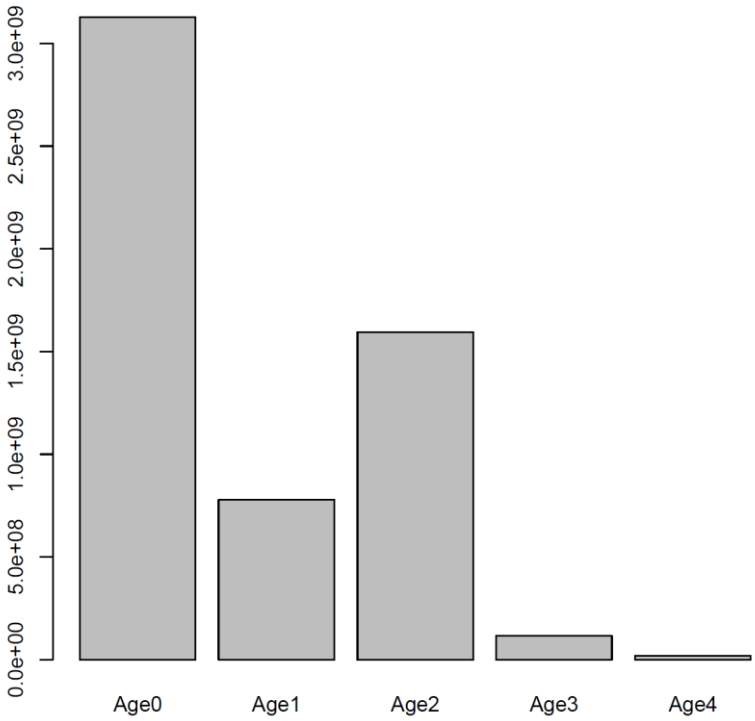
This corresponds to the abundance and biomass of the whole sampled area.

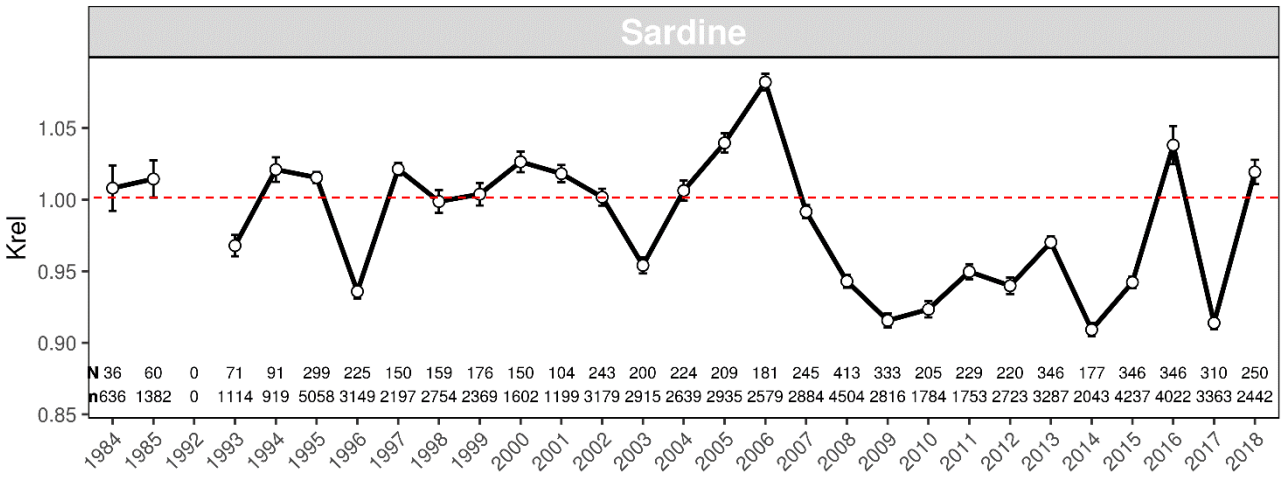
4.1.2 Spatial distribution of the resources

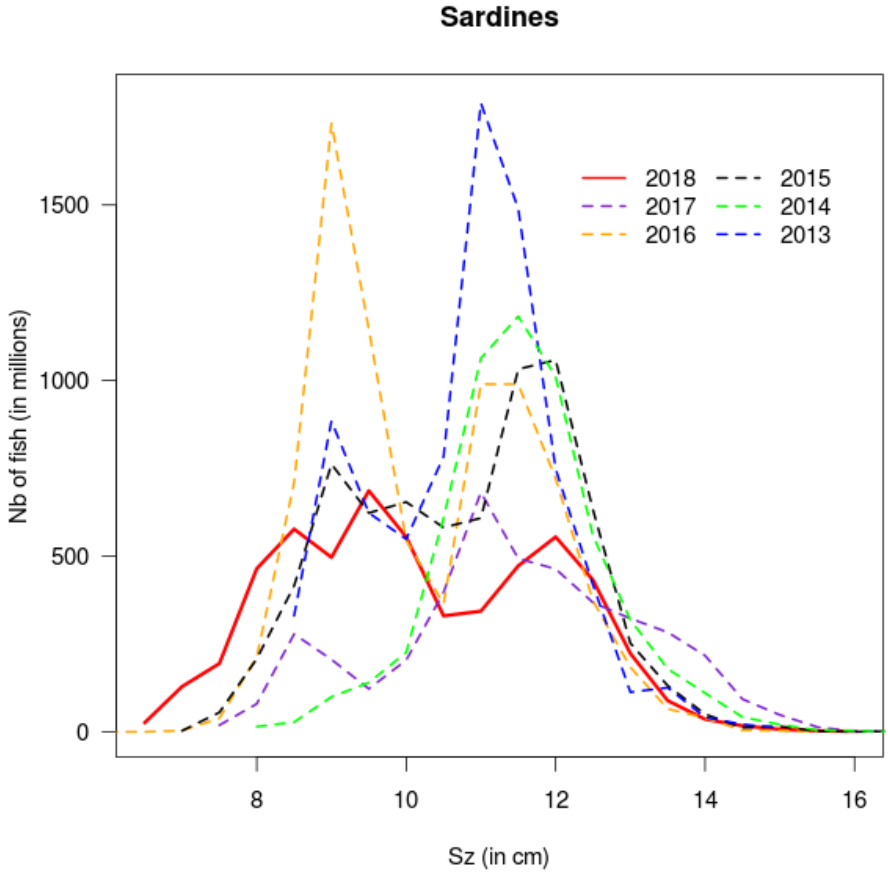


4.1.3 Historical trends






Sardine
Krel
1.05
1.00
0.95
0.90
0.85
N 36 60 0 71 91 299 225 150 159 176 150 104 243 200 224 209 181 245 413 333 205 229 220 346 177 346 346 310 250
n 636 1382 0 1114 919 5058 3149 2197 2754 2369 1602 1199 3179 2915 2639 2935 2579 2884 4504 2816 1784 1753 2723 3287 2043 4237 4022 3363 2442
1984 1985 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018


Sardines
Nb of fish (in millions)
1500
1000
500
0
2018
2017
2016
2015
2014
2013
8
10
12
14
16
Sz (in cm)

5 Ecological information

5.1 Protected species potentially affected by the fisheries

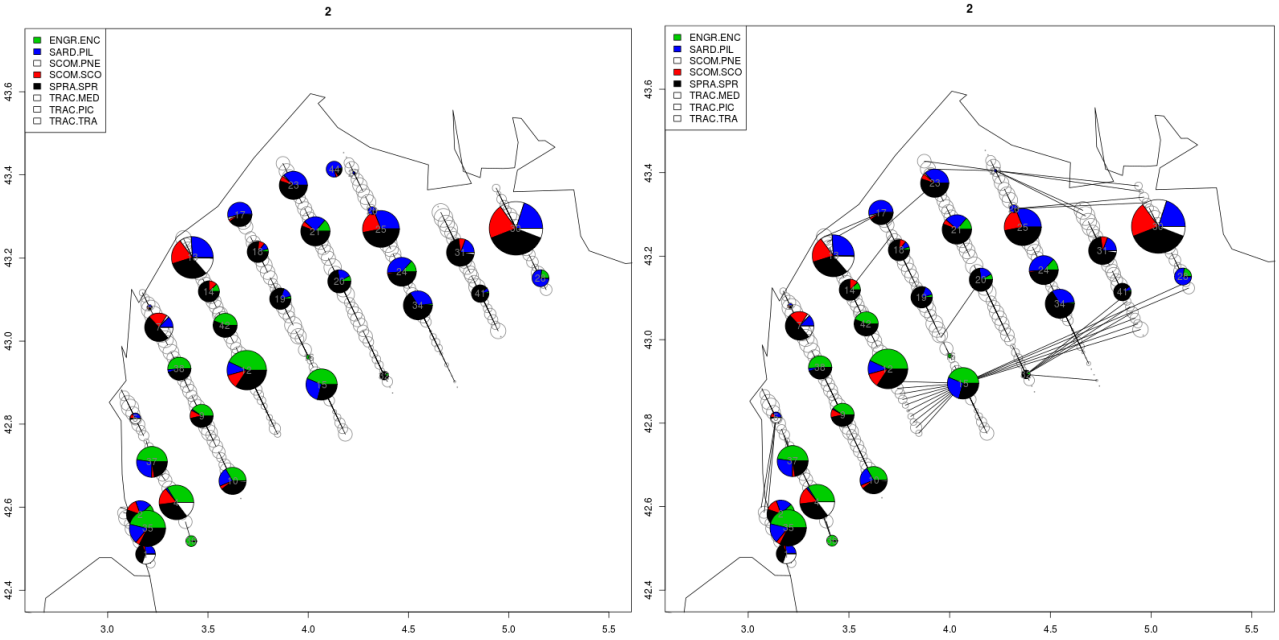
No protected species should be affected by small pelagic fisheries

6 Stock Assessment

The stock assessment relies on 1) the direct acoustic method and 2) a 2-stage biomass model.

6.1 Direct acoustic estimates

Concerning the acoustic estimates, different trawl allocations to echotraces have been tested. Trawl allocation has been done in two different ways: 1) closest trawl allocation, where each echotrace is attributed the closest trawl under the condition that the trawl is in the correct stratum (surface vs. pelagic), 2) expert allocations. In allocation 2, each echotrace was allocated a trawl according to the form and intensity of the echotrace. This also enables to put more importance on depth strata than the closest trawl allocation. Indeed, depth has been shown to be an important factor of the spatial distribution of these species and of the size structuration (sardines are more coastal than anchovies and small individuals are also more coastal regardless of the species). The 2 allocations for bottom energy are shown below (near trawl on the left and expert allocation on the right).



The uncertainty associated with trawl allocation was higher than usual for sardines (biomass CV due to different allocations -up to 4 allocations tested- = 16.5%), while it equaled 6% for anchovies. This was due to very high acoustic density in mid-water, which were associated to sardines on expert view, but to sprats when using the nearest trawl method.

6.2 2-stage biomass model

6.2.1 Model assumptions

A 2-stage biomass model requires a series of catch as well as 2 independent tuning series (an index of recruitment and an index of adult biomass). Both tuning indices were obtained from the PELMED acoustic survey, which occurs in July, so that it was assumed to detect recruitment quite well. In order to separate between juvenile and adult sardines, we used a cutting length that comes from previous analyses on age slicing (see Van Beveren et al. 2014). However, as growth has

changed quite substantially during the 25-yr period of the survey, this length was not constant. The cutting length was taken as 12.5cm until 2008 and 11cm afterwards.

As the series need to be concomitant and without missing data, the model was run from 1995 to 2016.

6.2.2 Scripts

The model was run using an R script. This script has been made available on the sharepoint of the working group

6.2.3 Input data and Parameters

Input data are shown below

year	SurvA_7	SurvR_7	landings
1995	82565,2676	777,732375	13450
1996	47469,6815	4066,26668	12000
1997	19043,4957	7010,50429	11000
1998	10185,4254	42020,5746	10000
1999	20268,9626	56102,0375	10000
2000	57338,9392	7480,06083	12000
2001	67132,1626	3414,8374	11948
2002	61484,5676	63064,4324	7764
2003	59813,4003	66306,5997	7111
2004	145190,321	70369,679	7493
2005	140558,359	123465,641	9472
2006	93853,3286	8422,67137	10384
2007	58294,2202	30002,7798	13340
2008	20951,7424	70594,2576	6740
2009	15485,6303	37491,3697	3620
2010	26510,3277	25308,6723	693
2011	23349,5459	21576,4541	757,364
2012	21979,3746	58557,6254	836
2013	45591,4245	33589,6125	989
2014	54101,2662	8355,73378	633
2015	47799,34	19340,57	342
2016	43474,47	26912,51	846
2017	40485,34	7637,072	876

Regarding the model parameters,

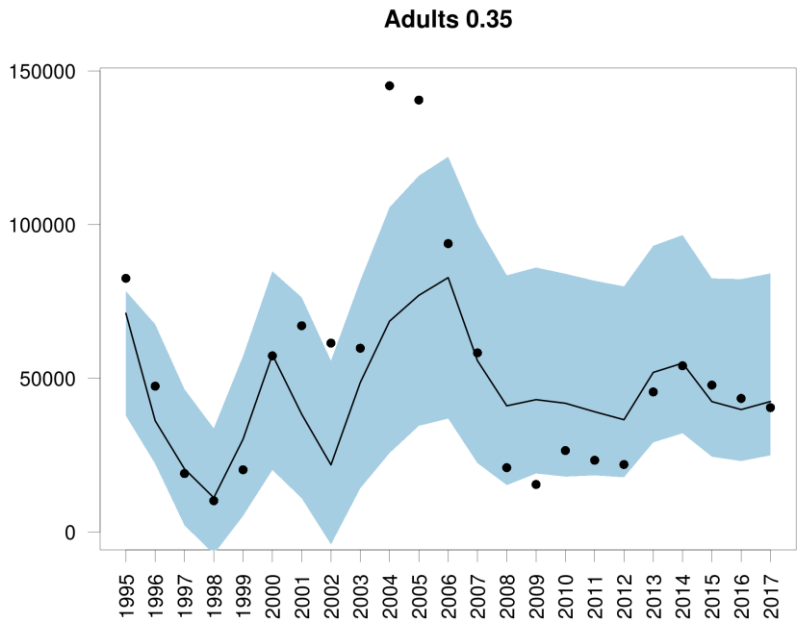
- the timing of pulse was set to 0.5 (sardines spawning peak is in January), while the survey (from which the recruitment index is derived) occurs in July).
- The initial estimate of recruits each year was set to 36 000 (roughly the average along the period)
- The initial estimate of adults in the first year was set to 83 000 (about the adult biomass from the survey in the first year).
- The growth parameter was set to 0.35.

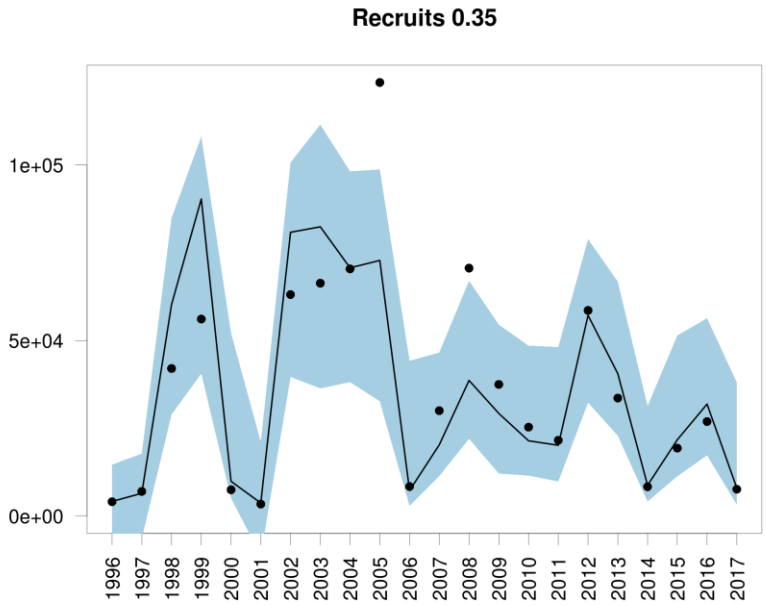
- The number of bootstrap iterations used in the model was set to 50 (in order to have realistic confidence interval).

Sensitivity analyses were conducted on these parameters, and the results were shown mostly unsensitive to the initial estimates of recruits and adults.

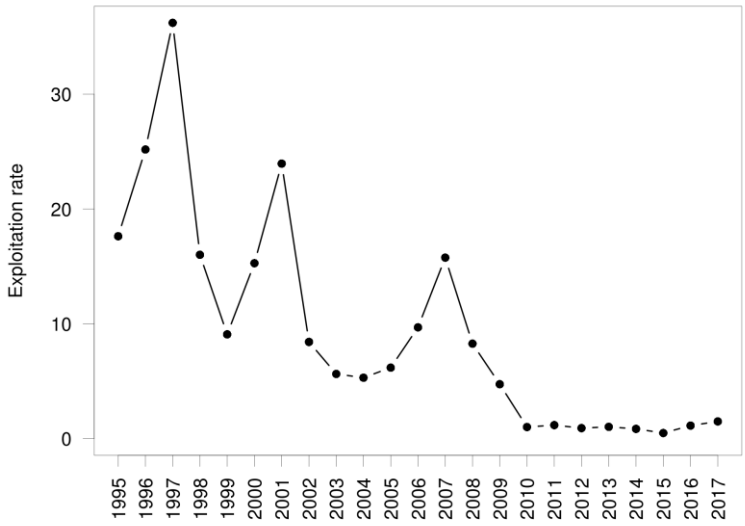
6.2.4 Results

The predicted versus fitted adult biomass and recruitment are shown below. Despite the inability of the model to reproduce very high adult biomass values in 2004/2005 or extremely high recruitment in 2005 and 2008, the trends are quite satisfactory.





The model then returns the time series of exploitation rate (see below). Despite variability and cycle a clear decreasing trend has occurred along the time series. Exploitation rate has been extremely low since 2010 and currently equals 0.01.



7 Stock predictions

As no statistical assessment exists, no stock predictions are done.

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	Exploitation rate E = 0.4 from Patterson	0.01		D	Low fishing mortality
	Fishing effort					
	Catch				D	
Stock abundance	Biomass		49748			Low
	SSB					
Recruitment						
Final Diagnosis		Unbalanced				

The stock is judged ecologically unbalanced due to its lack of old individuals and problems of growth. The exploitation level was extremely low in 2017 (E = 0.01), and the biomass in 2018 is still low despite a slight increase. As the low fishing effort is mostly linked to the low commercial value of small and lean fish, management measures need to ensure that if size and condition increase again the fishing activity would not increase too much to allow the stock for a recovery.

The working group recommends not to increase fishing mortality.

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)*