ICES WGHANSA REPORT 2012

ICES ADVISORY COMMITTEE

ICES CM 2012/ACOM:16

Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)

23 – 28 June 2012

Azores (Horta), Portugal

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2012. Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 23 - 28 June 2012, Azores (Horta), Portugal. ICES CM 2012/ACOM:16. 544pp.

Contents

Executive Summary WGHANSA 2012

The Working Group on Anchovy and Sardine (WGANSA) met at Horta, Azores (Portugarl) 23-28 June 2012, chaired by Andrés Uriarte, Spain. There were 11 participants from France, Portugal and Spain. The main task was to assess the status and to provide short term predictions for the stocks of Anchovy in Subarea VIII and in Division IXa, for Sardine in Divisions VIIIc and IXa, and in Divisions VIIIab and subarea VII, and for horse mackerel (*T. trachurus*) in Division IXa and Jack Marckerel (*T. pictoratus*) in X (Azores). Most assessments were updates assessments according to the stock annexes, except for Anchovy in Division IXa Jack mackerel in Azores which do not have any:

The Anchovy in Subarea VIII was estimated to be at 68 200 t (   ) in May 2012, well above Blim, with a 100% certainty, according to the Bayesian modelling of the population. This SSB is about 34 % below the 2011 levels. As usual two spring surveys were used as inputs for the Bayesian assessment of the population. However this year they diverged largely; While the acoustic (PELGAS) survey estimated a biomass around 183 000 t with 40% of this biomass corresponding to individuals of age 1, the DEPM (BIOMAN) estimated a biomass of 36 200 t, being 30% of age 1. The decrease in biomass between 2011 and 2012 resulting in the assessment was related to the relative agreement of both surveys in pointing that the percentage of age 1 was less than at age 2, as this imply not sufficient regeneration of the population in 2012 as to maintain the 2011 biomass.

As in previous years, the WG collected the available data on the fisheries of anchovy in northern areas (Subareas VI, VII and IV), although no assessment is so far required for the anchovy in those regions.

Anchovy in division IXa, demands separate analysis and advice for the western Iberian Atlantic coasts (i.e. Subdivisions IXa North, Central- North and Central-South) from the southern regions (Algarve and Gulf of Cadiz, i.e. Subdivision IXa South), due to the independent dynamics and genetic differentiation of the populations in these regions. In the western areas catches are generally low, in rare occasion exceeding a thousand tonnes (as in 1995/96). In 2011, after several years of almost null detections, the acoustic PELAGO survey estimated a Biomass of 27,000 t, in that area, and catches raised up to 3780 t. In the subdivision IXa South, where the bulk of the population is usually concentrated and supports a rather stable fishery, the acoustic Portuguese and Spanish surveys show a declining stock between 2008 up to 2010, but the DEPM survey in 2011 pointed to a recovery of the biomass levels at similar values as in 2008. So neither the fishery nor the populations (assessed by surveys) show any long trend for the anchovy in IXa south. Exploratory evaluations of current harvest rates in the context of Yield per recruit analysis suggest that current exploitation levels in the IXa seem sustainable. The absence of any survey in 2012 prevents any outlook on this populations or fisheries for 2013.

The Iberian Sardine was benchmarked in February 2012 adopting a new assessment model (SS3, Method). In addition the assessment included the fishery data for 2011 and a new DEPM survey in 2011. According to the assessment the biomass has declined since 2006 due to the lack of any strong recruitments remaining in 2011 at similar levels as in 2010 around 340 thousand tonnes. Current SSB levels are is assessed around historical minimum, being 37% below the long-term average, while fishing mortality seems to around the historical average. The stock is expected to decline unless a new strong year class appears. The new assessment model has rescaled up-

ward the biomass estimates compared to last year assessment outputs. The lack of the Portuguese PELAGO survey in 2012 makes more uncertain the projections for 2013.

The WG was asked to assess by the first time the Sardine in divisions VIIIabd and subarea VII However several issues prevented a single unified assessment of the sardine in these regions: while some fisheries occur in close regions and time (between VIIIb and VIIh,e in the fourth quarter) some other fisheries occur quite distant in space and time. In addition, for sardine in the Bay of Biscay (VIIIab) the collection of catch numbers at age and annual acoustic surveys estimates allow some exploratory assessment since 2000 with TASACS (data rich stock category 2), however there is little information from subarea VII: no survey index is available and catches are not monitored for biological sampling, so little can be done in terms of assessing the population and the fishery in this subarea, though some exploration of methods suggested in WGLIFE were essayed for data poor stock (category 4), and some others will be pursued in next future. The stock is foreseen for benchmarking in 2013.

For the southern Horse mackerel (Division IXa) no new assessment was carried out this year, due to inconsistencies between the official reported catches and those used in previous years by the WG. The Spanish official data was not disaggregated into DCF métiers (the basic sampling unit for length distributions) and this fact made impossible the estimation of catches at length and age according to DCF standards and there were obvious changes in the relative catches by gears compared to those estimated in previous years by the WG. For these reasons, the WG used the past year assessment as the basis for the current advice, making use of last year's population estimates to conduct a F-constrained short-term forecast up to 2014. The projections were of increasing uncertainty as the number of new year classes presumed to occur at the historical geometric mean increase, affecting particularly to the outlook for 2013.

For the Jack marckerel (*Trachurus picturatus)* in the waters of the Azores the WG continue the collation of data and performed some exploratory assessments. The landings of horse mackerel in recent years averaged to about 1800 tonnes. The fish is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990. The horse mackerel is also the main species used as live bait by the local bait boat fleet, that targets on tuna species. Finally, the demersal long line fleet also catch horse mackerel of big sizes compared to the other fisheries. Standardized catch per unit effort were reported to the group: There was no tendency in the cpue of the small artisanal purse seine fishery, whilst the cpue of longliners has some increasing tendency since 2010. Surplus production models were explored with ASPIC on the cpue of the artisanal purse seine fishery, suggesting that harvest rates were sustainable for the last 10 years. An analysis of yield per recruit was also available but without a propose assessment of current F it was insufficient to assess the fishery. Nevertheless the general results indicate that current fishing levels seem not detrimental to the stock given the stability of the catches and cpue indexes.

In addition the WG was asked to report on the advance of the preparation of the benchmarking for Anchovy in Subarea VIII and sardine in Divisions VIIIab and subarea VII. This was reported at the end of the respective stock sections (in sections 3.8 y 3.6). Finally the WG was asked to report on the potential use of the acoustic JUVENA surveys of juveniles in the Bay of Biscay (subarea VIII) to improve management advice and the implications it will have in the time frame for the provision of the advice and the management of the fishery. The WG concluded (section 3.9) according to the good performance of this juvenile index series in tracking the oscillations of recruitment at age 1 arising from the ICES assessment in the following year, that the index is valid to improve the basis for forecasts. Regarding the implications for the formulation of management advice and management time framework this would imply reopening the advice in November for including proper forecasts of the population either to review the catch options nowadays going from July to June next year, or to give catch options for a new management year going from January to December.

1 Introduction

1.1 Terms of reference

The **Working Group on Southern Horse Mackerel, Anchovy and Sardine** (WGHANSA), chaired by Andres Uriarte, Spain,met in Azores (Horta), Portugal, 23–28 June 2011 to:

a) address generic ToRs for Fish Stock Assessment Working Groups (see table below);

b) assess the progress on the benchmark preparation of Anchovy in Subarea VIII (Bay of Biscay) and sardine in Divisions VIIIabd and subarea VII

c) indicate, without pre-empting on actually using the new JUVENA survey as input to the Bay of Biscay anchovy assessment, if the group considers this survey will be useful in describing the state of the stock and improving the forecast. If this is the case, the group should indicate what alternative advice time-frame(s) could be put forward to ask clients if they would consider aligning the management cycle with a modified advice schedule*.

The assessments were carried out on the basis of the stock annex during the meeting (not prior to it) and coordinated as indicated in the table below:

Fish Stock	Stock Name	Stock Coord.	Assess. Coord. 1	Assess. Coord. 2	Advice
ane-pore	Anchovy in Division IXa	Spain	Spain	Spain	Update
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	Spain	Spain	France	Update
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)	Portugal	Portugal	Spain	Update
sar-soth	Sardine in Divisions VIIIc and IXa	Portugal	Portugal	Spain	Update
sar-bisc	Sardine in Divisions VIIIabd and subarea VII	France	UK	Spain	-
jaa-10**	Jack mackerel (Trachurus picturatus) in the waters of the Azores	Portugal	Portugal	Portugal	Update

*If the survey would be an improvement for the assessment, ACOM intends to ask clients how the management procedure could be adapted to the advice time-frame(s) put forward by the group. If clients agree with the possibility of updated advice during the fishing season, a benchmark should be arranged to follow up on this

**Depending on the outcome of WGNEW, WGNEW may be able to define stocks in this area and draft summary sheets. In this case those summary sheets should be considered within this ecoregion.

1.2 Report structure

Ad hoc and Generic TOR relative to the stocks for which advice is required are dealt stock by stock in the following chapters of the report.

Specific TOR b on the benchmark preparation of Anchovy in Subarea VIII (Bay of Biscay) and sardine in Divisions VIIIabd and subarea VII was addressed in sections 3.8 and 6.6 respectively, at the end of the respective stocks chapters.

Specific TOR c on the potential use of JUVENA and implications for the advice time-frame goes in section 3.9.

The generic TORs c (Overview of the sampling activities on a national basis for 2010) is dealt in this introduction section (below section 1.5).

Finally in annexes the remaining requests were appended: such as the Relevant WDs; List of data available for the fish stock assessments (submitted to ICES, with specification of the data used as input) (Generic TOR.b); Stock Annexes and a table with the suggestions and timing for Future benchmarks (table).

1.3 Comments to the new WG structure and working schedule and workload

For this year 2012 the WGHANSA benefit for an additional day of work in comparison to previous years. So the meeting took place for a total 6 working days. Such addition was a demand of the WG in 2011 to have sufficient time to

a) On the one hand to finish the processing of the acoustic and DEPM surveys usually carried out in May which serve as input for the anchovy in subarea VIII.
b) To deal with the new stocks for assessments: the southern horse mackerel stock (Division IXa), Jack mackerel in Azores Islands and the further request for sardine in VIIIab and VII.

The amount of days is seen nowadays as a minimum for this Working Group.

1.4 Quality of the fishery input

Spanish Official catches were provided to the WG this year by the Secretaría General de Pesca (SGP), the Spanish official national administration responsible for fishery statistics. The data were made available on the 21st of June and was sent directly to ICES. The official Spanish catch statistics were provided for all the stocks assessed in WGHANSA (Iberian sardine, Bay of Biscay and IXa anchovy and southern horse mackerel). In all cases, except horse mackerel, the scientific data obtained by the Spanish fisheries research institutes (IEO and AZTI) via their sampling network were used in the assessment, following the procedure applied in previous assessments. For horse mackerel, the data from the Spanish institutes was not made available to the WG, instead only the Spanish official catches were available. Strong inconsistencies were found between this data and the previous data series (see Section 8.1 for further explanations).

1.5 Overview of the sampling activities on a national basis for 2011 based on the INTERCATCH database

The Working Group again carried out a brief review of the sampling data and the level of sampling on the commercial fisheries. However this was not made on the basis of InterCatch as this has not been the usual procedure for collecting the national catch data inputting the assessments. The actual use of InterCatch is reflected here below, and further down the level of sampling on National basis by stocks is reported.

Table of Use and Acceptance of InterCatch				
Stock code for each stock of the expert group	InterCatchused as the: 'Only tool' 'In parallel with another tool' 'Partly used' 'Not used'	If InterCatch have not been used what is the reason? Is there a reason why InterCatch cannot be used? Please specify it shortly. For a more detailed description please write it in the 'The use of InterCatch' section.	Discrepancy between output from InterCatch and the so far used tool: Non or insignificant Small and acceptable significant and not acceptable Comparison not made	Acceptance test. InterCatch has been fully tested with at full data set, and the discrepancy between the output from InterCatch and the so far used system is acceptable. ThereforeInterCatch can be used in thefuture.
Example sai-3a46	*Onlytool*	*InterCatchwasused*	*Non orinsignificant*	*Can be used*
ane-bisc	Notused.	Shortage of manpower. Intention of been implemented interseasonally.	Comparisonnotmade	Test notperformedyet.
ane-pore	Notused.	Shortage of manpower. Intention of been implemented intersessionally.	Comparison not made.	No acceptance test has been done so far.
Sar-soth	Notused.	Shortage of manpower. Intention of been implemented intersessionally.	Comparison not made.	No acceptance test has been done so far.
Sar-north	Notused.	Shortage of manpower. Intention of been implemented interseasonally.	Comparisonnotmade	Test notperformedyet.
Hom-south	Notused	Shortage of manpower. Intention of been implemented intersessionally.	Comparison not made.	Test notperformedyet.
Jaa-10	Notused	Shortage of manpower. Intention of been implemented intersessionally.	Comparison not made.	Test notperformedyet.

The sampling summary by stocks on national basis is the following:

a) Anchovy Other areas

Country	Official Catch IV	No measured	Official Catch VI	No measured	Official Catch VII	No measured
UK	0	n/a	0	0	320	?
France	0.28	7	0	0	1130	2478
Total	0.28	7	0	0	1450	2478

b) Anchovy VIII

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	10 402	100%	200	20 432	2 926
France	3 615	100%	18	1 947	358
Total	14 017	100%	218	22 379	3 284

c) Anchovy IXa

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	6 758	100%	68	8 946	2 599
Portugal	3 318	100%	*815	*377	*377 645
Total	10 076	100%	83	8 946	3 244

(*): Anchovy is a group 3 species in the Portuguese sampling plan for DCF. Samples were funded by IPIMAR and age readings were carried out following a IPIMAR-IEO age reading and otolith exchange with 2011 samples (see Soares et al., WD 2012).

d) Sardine North

e) Sardine IXa and VIIIc

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	**57 223**	**100%**	**145**	**18 700**	**4 732**
Spain	**19 858**	**100%**	**189**	**15 924**	**3 605**
Total	**77 081**	**100%**	**334**	**34 624**	**8 337**

f) Southern Horse Mackerel (Division IXa) (A. Murta)

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	1 842	100%	288	14 552	129
Total	1 842	100%	288	14 552	129

g) Horse Mackerel (*T. picturatus*) in the waters of Azores

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	1 842	100%	288	14 552	129
Total	1 842	100%	288	14 552	129

1.6 Review of the Generic categorization of stocks of WGHANSA by WKLIFE

(by stock coordinators)

The WG review the categorization made by WKLIFE of the populations being assessed in the WGHANSA as follows:

Fish Stock	**Stock Name**	**Category**	**Comments**
ane-pore	Anchovy in Division IXa	3	Category 3 with a monitoring system for catches at length and ages and by direct surveys
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)	1	Good monitoring of catches and direct surveying of the stock
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)	1	Good monitoring of catches and direct surveying of the stock
sar-soth	Sardine in Divisions VIIIabd and subarea VII	2 in VIIIab 4 in VII	VIIIab: Good monitoring of catches and direct surveying of the stock in VIIIab, only preliminary assessment was given for orientative purposes. VIII: no monitoring system of catches or by surveys (though a survey may start this year in autumn)
sar-bisc	Sardine in Divisions VIIIc and IXa	1	Good monitoring of catches and direct surveying of the stock
jaa-10**	Jack mackerel (Trachurus picturatus) in the waters of the Azores	3	Good monitoring of catches and cpue but no direct surveying of the stock.

2 Anchovy in Northern areas

Both species, sardine and anchovy, exist outside the areas for which assessments are requested by ICES and made. In previous years, some work has been done on the sardine in other areas. Contributions on the occurrence of sardine and anchovy and historical records outside the core areas are useful to build up an understanding of the distribution dynamics of these species as well as potential effect from climate change on spatial expansion of fish stocks.

Anchovy is generally considered to be found in small amounts in other areas, typically associated with river outlets.

The WG reviewed available information on anchovy populations in ICES division IV, VI and VII. Division VII is connected to the Bay of Biscay area where local stock is assessed by this working group. Anchovy populations in ICES division IV (North Sea), VI (West of Scotland) and VII (Celtic Sea and English Channel) are not assessed and not regulated, as those populations have not been considered so far to be locally substantial even if they sometimes represent enough biomass for a small or opportunistic fishery .

2.1 Connectivity between North Sea, Bay of Biscay and Western channel.

In 2010, an ICES Workshop on Anchovy, Sardine and Climate Variability in the North Sea and Adjacent Areas (WKANSARNS) was held to investigate the phenomena of increased catches in anchovy and sardine since the mid-1990s in the North Sea and adjacent areas. The workshop attempted to increase our understanding by considering the phenomenon in terms of the processes controlling the life cycle of anchovy and sardine. It considered the historical context and synthesized across the scientific disciplines of oceanography, climatology, genetics, ecology, biophysical individual-based modeling and analysis of empirical time series.

WKANSARNS concluded that the recent increase of anchovy in the North Sea is probably due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations. There has always been anchovy, at a low abundance, in the North Sea (spawning along the Dutch coast, Wadden Sea and estuaries). The expansion of anchovy in the North Sea is thought to be driven by pulses of successful recruitment that are controlled by relatively high summer temperature of sufficient duration followed (or preceded) by favorable winter conditions. There is probably a balance between high enough summer temperature allowing sufficient growth and winter conditions allowing sufficient survival at length. Variability in the length of these periods or in spatial extent where such conditions can be found may have a strong influence on the recruitment success. Whilst this workshop primarily considered driving processes related to temperature, other potential mechanisms, or mechanisms that co-vary with temperature, may be important in the dynamics of North Sea anchovy. The conclusion of the workshop, although preliminary, was that climate-driven changes in water temperature appear to mediate the productivity of anchovy in the North Sea.

On stock definition, the European anchovy shows large amounts of genetic differentiation between populations. An initial analysis has been carried out on the genetic structure of anchovy populations over the whole distributional range of the species by a research group of the genetics laboratory of the University of the Basque Country and Azti-Tecnalia. This study analyses 50 nuclear neutral SNP (Single

Nucleotide polymorphism) markers on 790 individuals covering an extensive regions: North Sea, English Channel, Bay of Biscay, South East Atlantic coast, Canary Islands, South Africa, Alboran, West Mediterranean and East Mediterranean (Adriatic and Aegean seas).

Nei standard (Ds) distance based neighbor-joining tree, pair-wise FST comparisons and the Bayesian approach clustering method suggest that North Sea and English Channel samples are genetically homogenous, exhibiting significant genetic differences with the Bay of Biscay samples. Moreover, Bay of Biscay samples appeared to be genetically more similar to the West Mediterranean samples than to the North sea-English channel samples. These results support that the recent increase of anchovy in the North Sea is likely due to the development of local North Sea populations, rather than a northward movement of Bay of Biscay populations.

In looking for explanations for the recent expansion of anchovy in the North Sea, two main hypothesis arise: sympatry and allopatry. Allopatry could either be due to further adult migration to the north, or increase of larval and juvenile survival into the English Channel and southern North Sea for individuals originating from Biscay spawning. The second hypothesis was tested using a particle tracking model and showed that anchovy eggs spawned in the Bay of Biscay could be transported to the Channel, but no attempt was made to quantify the strength of that potential connectivity. It was also reported that, considering the seasonal shift in the circulation from northward to southward during the anchovy spawning season, and the northward progression of spawning during the season as the temperature increase, retention of eggs in the Bay of Biscay was much more likely compared to transport to the English Channel. The fraction of eggs arriving in the English Channel was low, from ~0% for spawning grounds 1 to 3, to 10% for spawning ground 5 in the north of the Bay (2.11% when averaged over the 5 spawning grounds). 87% of the particles lost from the Bay are entering the Channel, the rest remaining in the Celtic Sea. Results showed that the potential connectivity fraction of the Bay of Biscay to the north of 48°N is only 2%, essentially due to northern spawning in the Bay. Considering the observed spatio-temporal spawning pattern (shift to the north as the season progress), it was concluded that connectivity may be considered as negligible.

In the context of climate change, Bay of Biscay surface temperature has already been observed to increase, which will likely continue. This could advance the spawning season with earlier spawning in the north of the Bay. Under the hypothesis of no other change than temperature increase (e.g. circulation patterns), this would increase the potential for connectivity with the English Channel. From climate change scenarios (temperature increase, wind change) run over the Bay of Biscay, Lett *et al.* (2010) have suggested modification of the circulation with further impact on the dispersal kernel for Bay of Biscay anchovy, among them further distance dispersed under increased stratification.

2.2 Data Exploration from fishery statistics.

Landings and effort data are scarcely available from France and United Kingdom. Length distributions were available in VII from the French observer program at sea (OBSMER).

2.2.1 Catch in divisions IV and VI.

In division IV, landings are very scarce (table 2.2.1) with data available only past 1999 and ranging from 2 kgs to 4 tons (in 2002). Landings in 2010 were 280 kgs. In division

VI, 83 kgs were reported by the French fleets in 2000 and 1875 kgs in 2011.

2.2.2 Catch in division VII.

In division VII, landings from both French and British fleets have been scarce until 1996 with up to 25t of landed fish (table 2.2.2). The 1997-2010 period has shown a rise of landings up to 244 tons in 2003 followed by a decrease 5 tons over the period 2004-2006 and then strong landings especially in 2009 and 2010 where the strongest landings of the time series were recorded (940 and 1450 tons respectively).

The proportion of France and UK landings in the total catch has been highly variable between years. Over the last three years, French landings have accounted for at least 62% of the total landings of anchovy in that division. It is unknown if the increase of landings in 2009-2010 were a consequence of the expansion of stock of anchovy in the Bay of Biscay. In 2011, only France reported landings (77 tons) for that division.

Most of the French landings occur during the second semester (Q3-Q4) in statistical rectangles 25E4, 25E5 which are adjacent to the VIIIa division (figure 2.2.1). There have been evidences that the Bay of Biscay stock sometimes expand further north the VIIIa division therefore an undefined portion of the catch of anchovy in VII is likely to consist of individuals from the Bay of Biscay stock. A minor portion of the French catch is also made in 26E8 mainly during the summer (quarters 2-3). UK landings are located in the coastal rectangles of north-western part of the Channel (29E4-29E7) and are mainly made during the winter months (quarter 4 and 1).

Most of the landings by the UK fleets have been in the last 5 years by ring nets (77% of UK landings in 2010) and purse seiners and midwater trawlers. French catches are mainly made by purse seiners (46%) and midwater pair trawlers (39%) (table 2.2.3).

Data from length distribution of catch anchovy are scarce (figure 2.2.2). In ICES division IVc and VIIe, less than 10 fishes were sampled. In divisions VIIc, VIId, VIIg, the level of sampling was high enough to provide information on length distribution. The retained samples were collected in September, October and were compared against distribution in VIIIa for the same periods. All the distributions in VII have only a single mode but the mode differs between areas. 17cm is the mode of the Bay of Biscay and VIIc length distribution while in VIId and VIIg, the mode is at 16cm. Considering the low level of sampling (few stations), it is difficult to give any meaning to those results.

Table 2.2.1: UK and French landings (kg) of anchovy in divisions IV and VI.

	FR-IV	UK-IV	Landings in kg
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
1997			
1998			
1999	1.6		1.6
2000	3.1		3.1
2001			
2002	4029	2	4031
2003	0		0
2004	12.1		12.1
2005			
2006	10.8	0	10.8
2007	50	0	50
2008		2	2
2009	28	127	155
2010	280		280
2011			

	FR-VI	UK-VI	Landings in kg
1983			
1984			
1985			
1986			
1987			
1988			
1989			
1990			
1991			
1992			
1993			
1994			
1995			
1996			
1997			
1998			
1999			
2000	82.6		82.6
2001			
2002			
2003			
2004			
2005			
2006			
2007			
2008			
2009			
2010			
2011	1875		1875

Table 2.2.2 UK and French landings (tons) of anchovy in division VII.

	Landings in tons			Portion of landings in	Portion of landings in
	FR-VII	UK-VII	Total	25E4-5 in FR landings	29E4-7 in UK landings
1983					
1984		25.0	25.0		?
1985					
1986	0.0		0.0	?	
1987		5.0	5.0		?
1988		3.9	3.9		?
1989	0.2	16.6	16.8	?	?
1990					
1991		12.0	12.0		?
1992			0.0		
1993	1.7		1.7	?	
1994	0.0		0.0	?	
1995					
1996	0.0			0.0%	
1997	56.0		56.0	84.7%	
1998	0.8	39.0	39.8	0.0%	?
1999	6.0		6.0	0.0%	
2000	51.1	0.0	51.1	71.6%	?
2001	141.0	0.9	141.9	92.3%	?
2002	109.8	0.3	110.1	39.8%	?
2003	220.2	23.8	244.0	50.0%	?
2004	18.2	67.6	85.8	90.9%	?
2005	7.5	7.7	15.2	99.3%	?
2006	5.2	0.2	5.4	61.7%	?
2007	0.3	763.2	763.4	0.0%	?
2008	0.7	175.8	176.5	0.0%	?
2009	585.1	353.5	938.6	85.0%	?
2010	1157.1	319.6	1449.2	84.2%	97.0%
2011	77.0		77.0	52.5%	

Table 2.2.3 Landings (tons) of anchovy per fleets per year in ICES division VII.

UK Fleets

Gear	2005	2006	2007	2008	2009	2010
MIDWATER TRAWL	5814		619021	10126	98056	10840
RING NET			92560	132294	235788	244935
MIDWATER PAIR TRAWL	1665	200	28103	12600	4286	1100
PURSE SEINE						47056
DRIFT NET			5241	17838	1	15613
UNSPECIFIED OTTER TRAWL			18216	1	270	22
TRIPLE NEPHROPS OTTER					15080	
OTHER OR MIXED POTS				2688		
BOTTOM PAIR TRAWL	245					
BEAM TRAWL				199		
UNSPECIFIED GILL NET			11	27		58
GILL NET (NOT 52 OR 53)				8		7
WHELK POTS			1			
Total	**7724**	**200**	**763153**	**175781**	**353481**	**319631**

French Fleets

Gear	2005	2006	2007	2008	2009	2010	2011
PURSE SEINE					392150	517940	39692
MIDWATER PAIR TRAWL		1500			51460	437720	34582
MIDWATER OTTER TRAWL				0.5	78994	68294	
SCOTISH SEINE					53400	33500	137
BOAT DREDGES				1.7		37200	
NOT KNOWN					9000	26330	
PURSE SEINE 1 BOAT	7415.2	1720					1050
BOTTOM OTTER TRAWL	54.7	2002	270	19.7	80	4720	601
OTTER TWIN TRAWL						2150	21
GILL NETS				400		1730	936
TRAMMEL NETS				320			
Total	**7469.9**	**5222**	**270**	**741.9**	**585084**	**1129584**	**77019**

1)

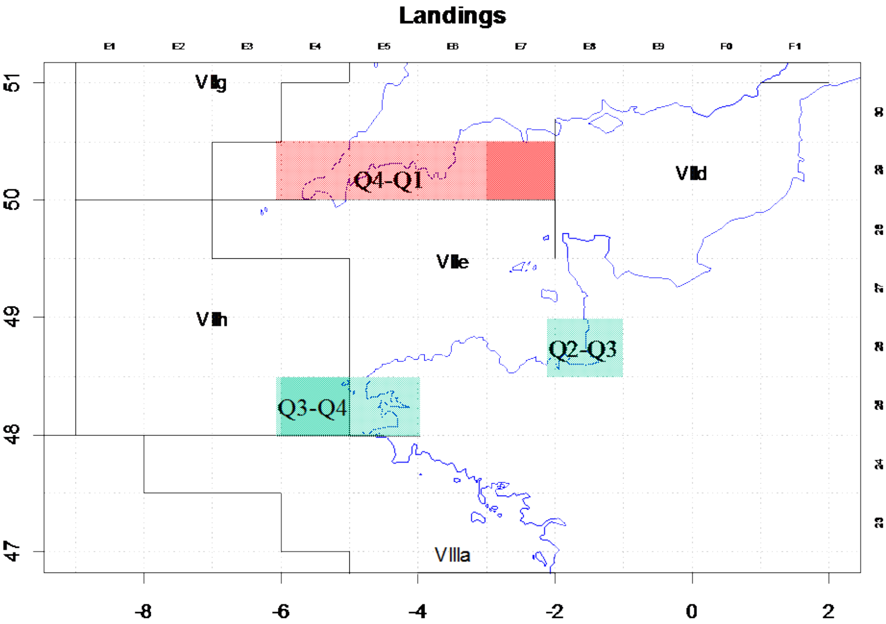


Figure 2.2.1. Map of the statistical rectangles where most of the catches of anchovy occur in ICES division VII for France (Green) and UK (Red).

2)

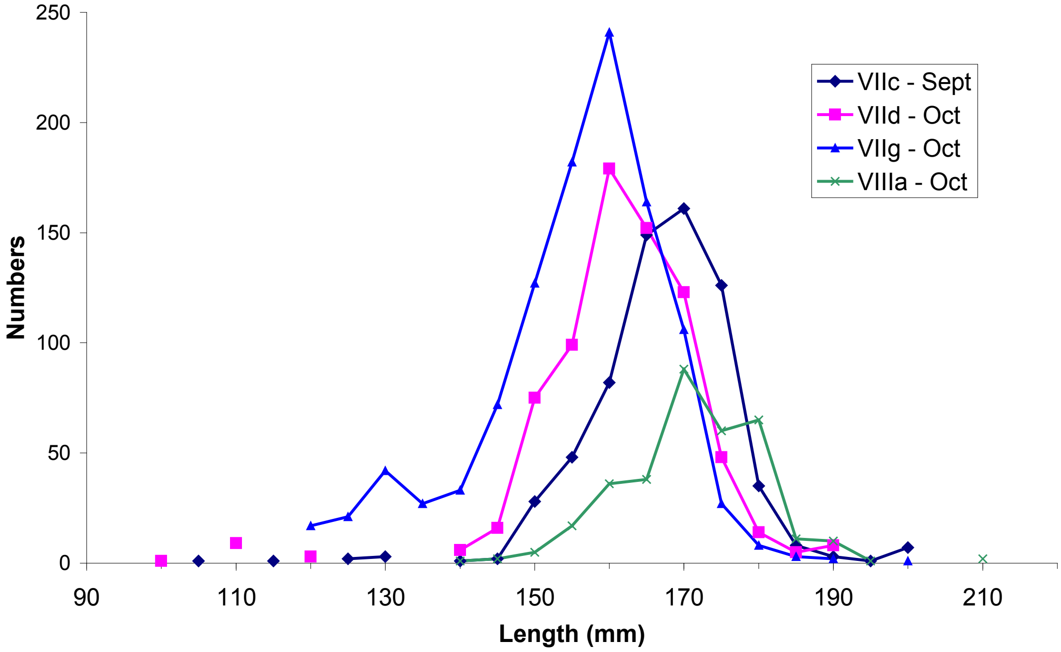


Figure 2.2.2. Length distributions of catch of anchovy in ICES divisionsVIIc, VIId, VIIg and VIIIa.

3 Anchovy in the Bay of Biscay (Subarea VIII)

3.1 ACOM advice for 2011 and 2012

The closure of the anchovy fishery in July 2005 and July 2006, due to the low levels of biomass of the anchovy population and the failure of the fishery, was sustained until December 2009. In January 2010 the fishery was reopened with a TAC of 7000 t. In July 2010 the Council established the TAC for the fishing season running from 1 July 2010 to 30 June 2011 at 15 600 tonnes (Council Regulation No 685/2010) based on the European Commission long-term management plan proposal. This proposal was presented on 29 July 2009 and at present is subject to revision and agreement between the EC, the Council and the Parliament, according to the procedures established in the Lisbon treaty.

In June 2011, ICES estimated the median SSB at 98 450 t which is above B_{lim} with a 100% probability. This was the fourth highest SSB since 1987, indicating a recovery from low SSBs between 2002 and 2009. On the basis of the precautionary approach ICES advised that assuming an undetermined recruitment scenario for 2012, *"to reduce the risk to less than 5% of the SSB in 2012 falling below B_{lim}, catches in the period 1 July 2011–30 June 2012 should be less than 47 000 t"*.

In July 2011 the Council established the TAC for the fishing season running from 1 July 2011 to 30 June 2012 at 29 700 tonnes (Council Regulation No 716/2011) based on the European Commission long-term management plan proposal. The regulation established that from this TAC 90% corresponded to Spain and 10% to France. However, due to a bilateral agreement, the final TAC allocation between the member states was 80% of the TAC for Spain and 20% for France. In addition, 100 t were transferred from Spain to France, resulting finally in 23 660t for Spain and 6 040 t for France. The agreement included a fishing ban from December 2011 to February 2012. The purse-seine fishery started in March 2012 and the pelagic trawl fishery in June 2012.

3.2 The fishery in 2010 and 2011

3.2.1 Fishing fleets

For the period July 2006 and December 2009, there was no commercial fishery for anchovy in the Bay of Biscay, due to the closure of the fishery.

Two fleets used to operate on anchovy in the Bay of Biscay before the closure: Spanish purse seines (operating mainly during spring) and the French fleet constituted of purse seiners (the Basque ones operating mainly in spring and the Breton in autumn) and pelagic trawlers (mainly during the second half of the year). A more complete description of the fisheries is made in the stock annex.

With the reopening of the fishery, in January 2010, the total number of fishing licences for anchovy in Spain was 168. In 2011 the number of fishing licences increased to 175 but in 2012 decreased again to 159. The distribution of the fishing licences by regions in 2012 was as follows:

GALICIA	ASTURIAS	CANTABRIA	PAIS VASCO	TOTAL
50	7	40	62	159

For France the number of purse seiners able to catch anchovy in 2011 is around 27. The exact number of vessels is not fixed, due to important movements in this fleet. Most of them are based in Brittany. The number of Basque purse seiners decreases progressively and some of them joined the North of the Bay of Biscay since two years. The real target specie of these vessels is sardine, and anchovy is more opportunistic.

The number of French pelagic trawlers decreased drastically during the last 4 years because they were targeting mainly anchovy and tuna. Currently 10 pairs of trawlers (20 vessels) target anchovy.

3.2.2 Catches

In July 2010 a TAC of 15 600 t was established for the period July 2010-June 2011. Overall around 4200 t were caught in the second half of 2010 and 10 900 t in the first half of 2011. The French fishery was closed in January 2011 due to quota exhaustion. In July 2011 a TAC of 29 700 t was established for the period July 2011-June 2012. In the second half of 2011 around 3600 t were caught. The Spanish catches up to the end of May 2012 were around 6700 t.

Historical catches by countries are presented in Table 3.2.2.1 and Figure 3.2.2.1. The series of monthly catches by country are shown in Table 3.2.2.2.

The quarterly catches by country and division in 2011 are given in Table 3.2.2.3. Most of the Spanish catches took place in the second quarter (85%), whereas the major French catches occurred in quarter 4 (73%). Regarding fishing areas, the Spanish catches corresponded to ICES Divisions VIIIb and VIIIc (43 and 57% respectively) and French catches were all taken in ICES Division VIIIa. Some catches occurred at the border between VIIIa and VIIe-h and around 50 tons of anchovy were reported northern than this border, and we assumed these VIIe-h catches in VIIIa, as last year.

3.2.3 Catch numbers at age and length

Catch numbers at age by quarter and country in 2011 are given in Table 3.2.3.1. Age 1 individuals were predominant in all quarters for the French catches, whereas age 2 individuals were the most abundant ones in the Spanish catches.

Table 3.2.3.2 records the age composition of the international catches since 1987, on a half-yearly basis. One year old anchovies have dominated in the catches during both halves of most of the years, except in some years with recruitment failure. In 2011, age 2 individuals predominated in the first half and age 1 individuals in the second half.

Catch at length data (by 0.5 cm classes) by quarter and country are given in Table 3.2.3.3. During the first and second quarters the modal length was around 16 cm. For the third quarters the individuals landed by the French fleet were larger than the ones landed by the Spanish fleet (modal length at 15 and 13 cm respectively). The modal length of the French landings in the fourth quarter was 14 cm. The Spanish catches in the fourth quarter were very few and with a length range between 14 and 17.5 cm.

See the stock annex for methodological issues.

3.2.4 Weights and lengths at age in the catch

The series of mean weight at age in the fishery by half year, from 1987 to 2011, is shown in Table 3.2.4.1. See the stock annex for methodological issues.

3.3 Fishery independent data

3.3.1 DEPM survey 2012 (BIOMAN2012)

All the methodology for the survey and the estimates performance are described in the stock annex - Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey and results 2012 is attached as **Santos. M *et al.* – WD 2012.**

3.3.1.1 Survey description

The 2012 anchovy DEPM survey was carried out in the Bay of Biscay from 10th to the 30th of May, covering the whole spawning area of the species, following the procedures described in the stock annex- Bay of Biscay Anchovy (Subarea VIII). Two vessels were used at the same time and place: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. Sample specifications are given in **Table 3.3.1.1.**

No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45′N in the French platform and the northern limit was found at 47º15′N. The eggs in the French platform where encountered between Adour and Arcachon and in the area of influence of Le Gironde (**Figure 3.3.1.1**).

In relation with the adult samples, most of the hauls consisted of anchovy, sardine, horse mackerel and mackerel. The fishing hauls from the pelagic trawler are summarized in **WD – Santos. M *et al.* 2012**. From 42 pelagic trawl hauls obtained with the research pelagic trawler, 28 had anchovy, and 24 were used for the analysis. In general, the small individuals were all along the coast and the big ones were offshore. The spatial distribution of the samples and their species composition is showed in **Figure 3.3.1.2**; the adults mean weight in **Figure 3.3.1.3**. **Figure 3.3.1.4** shows the age composition by haul.

The salinity data obtained during the survey showed clearly the effect of the river discharges of Adour and Gironde and the dispersion of their plumes. This year the mean sea surface salinity (34.77 UPS) was at the same levels of last year (35.25 UPS). The mean sea surface temperature of the survey (14.9ºC) was lower than last year's (16.8ºC). **Figure 3.3.1.5** shows the maps of surface salinity and temperature found during the survey.

3.3.1.2 Total daily egg production estimate

The estimates of daily egg production, daily egg mortality rates and total egg production are given in **Table 3.3.1.2** and the mortality curve model used is shown in **Figure 3.3.1.6.** Total egg production in 2012 was estimated at 2.16 E+12 with a coefficient of variation of 0.18.

3.3.1.3 Daily fecundity

In previous years the adult samples were not fully processed by the end of June and the preliminary SSB estimate for June was based on the average daily fecundity of the historical series (see the stock annex). This year a first analysis of the adult samples was available at the time of the working group and a preliminary daily fecundity was estimated from the sex ratio, the mean weight of females and a preliminary estimate of the batch fecundity. Until the histological analysis of the samples is finished, the spawning frequency was set equal to the historical mean.

Sex ratio and mean weight of females were directly measured on board from each sample. The sex ratio and the female mean weight estimates are given in **Table 3.3.1.3**. For the batch fecundity (F) the hydrated egg method was followed. Only the hydrated females showing a CV of the number of oocytes per ovary gram between the three pieces of ovary less than 15% were retained. Given that by the time being it was not possible to check histologically that these retained females did not start ovulation, the number of females allowed entering the batch fecundity regression was reduced following the procedure explained in **WD – Santos. M *et al.* 2012.** Then, a linear model was fitted between the number of hydrated oocytes and the female gonad free weight to the retained females (**Figure 3.3.1.7**). The average of the batch fecundity for the females of each sample was derived by applying the former relationship to the average gonad free weight of females per sample. The overall batch fecundity estimated is shown in Table 3.3.1.3. The spawning fraction was set at the historical mean (0.25). The resulting daily fecundity estimate is given in Table 3.3.1.3.

3.3.1.4 Preliminary Spawning Stock Biomass estimate and population at age

In 2012 the preliminary SSB estimated was 36,200 t with a CV of 20%, (**Table 3.3.1.4)**. This points out a decrease from last year spawning stock biomass (**Figure 3.3.1.8**) that was one of the highest of the historical series.

In order to estimate the numbers at age, 6 strata were defined (**Figure 3.3.1.9**). 44% of the anchovy in numbers are individuals of age 1(31%in mass) and 55% of the individuals (in numbers) are of age 2 (**Table 3.3.1.4**). The time series of the age structure of the population is shown in **Figure 3.3.1.10**.

3.3.2 The Pelgas 12 spring acoustic survey

Acoustic surveys are carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2011). The protocol for acoustics has been described during WGACEGG in 2009 (*Doray et. Al, 2009*):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 3.3.2.1.). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).
- acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo sounder between the surface and 8 m depth.

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage in the Douarnenez bay, in the West of Brittany, in optimum meteorological conditions at the end of the survey (another calibration was done during PELACUS some weeks before).

Acoustic data were collected by R/V Thalassa along a total amount of 6500 nautical miles from which 2025 nautical miles on one way transect were used for assessment. A total of 27155 fishes were measured onboard Thalassa (including 10205 anchovies and 5228 sardines) and 3124 otoliths were collected for age determinations (1811 anchovy and 1313 sardine).

A consort survey is routinely organized since 2007 with French pair trawlers during the 18 first days. This approach, in the continuity of last year survey, and the commercial vessels hauls were used for echo identification and biological parameters at the same level than Thalassa ones. A total of 108 hauls were carried out during the assessment coverage including 59 hauls by Thalassa and 49 hauls by commercial vessels (fig 3.3.2.2.).

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 2.2. shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area (fig 3.3.2.3.).

Biomass indices are gathered in Tables 2.3.1. and 2.3.2. No estimate has been provided for mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is totally scattered and mixed with soft plankton echoes.

The main observation in 2012 is that anchovy is very well present in the centre of the bay of Biscay, from the South until the Yeu island, and from coastal waters (very small anchovies, particularly at the Gironde) to the shelf break (bigger individuals, but in lower quantity than last year).

On the platform, anchovy echo-traces were most of the time vertically distributed between 15 m above the bottom until 50 to 70 m above, as in 2010 and 2011. It was in some areas very dense, providing very high values of SA. These echoes were systematically identified on each transect and revealed most of the time pure anchovy or at least a majority of anchovy. Their geographic distribution showed a rather continuous layer along about 200 nm from south to north between the 80 to100 m bottom depth. . A particular dense concentration of very small anchovies was observed close to the coast in front of the Gironde.(fig 3.3.2.4.).

Looking at the numbers at age since 2000 (fig 3.3.2.5.), the number of 1 year old anchovies this year seems to be the strongest observed along the whole time series (22 417 millions of fish against 9 770 millions fish last year and 4 100 millions in 2010). They represent 40 % of the biomass (74% in numbers). The 1 year old class this year is the best recruitment never observed since 2000 and 2 years old are still present, in agreement with the high abundance of age 1 last year.

Figure 3.3.2.6. shows that the abundance of anchovy eggs and abundance of adults are not always situated on the same place : close to the coast (in the Gironde plume but also southern and Northwestern), the most important anchovy biomass per ESDU is observed, while numbers of eggs are poor. In that coastal zone, anchovies of age 1 were really predominant. Biological parameters showed that the most part of theses anchovies were immature or starting their maturation. This delay in the spawning period of age 1 anchovies could be explained by the very particular hydrological conditions this year (*see WD Duhamel et al, 2012*). This was not observed during previous years surveys, when almost each anchovy was mature.

3.3.3 Cross discussion about the results of spring surveys

This year the results from the Acoustic (PELGAS) and DEPM (BIOMAN) spring surveys diverge largely one from the other. While the former estimates a biomass around 183 000 t with 75% of the population (in numbers) at age 1, the latter estimates the spawning stock biomass at 36 200 t with 55% of the population (in numbers) at age 1. It has to be noted that the DEPM biomass estimate is preliminary until the histological analysis are completed. The current estimate is based on a preliminary estimate of the batch fecundity and on the spawning fraction set equal to its historical average (section 3.3.1).

This is not the first time that these two surveys diverge remarkably in the historical series. It also happened in 1991, 2000 and 2002, but this year the differences are the largest in the series.

The discrepancy in biomass derives from the amount of anchovy abundance indicators recorded by each survey. PELGAS recorded big amount of acoustic energy over many transect radials (15), of almost pure anchovy according to the fishing hauls in the region. On the contrary the amount of egg sampled by BIOMAN was not substantial and supposed a large decrease in comparison with previous year. During PELGAS survey low temperatures were recorded (SST = 13.5ºC, whilst in last years they were around 15.5ºC) and part of the small anchovies (one year old) detected in the nursery area around the Gironde were in an earlier phase of maturation, not having yet arrived to spawning (according to the macroscopic maturity scales). The total number of eggs sampled by CUFES during the PELGAS survey indicated an overall decrease in comparison with last year. In particular no eggs were found in the zone where small maturing anchovies were found (Figure 3.3.2.6). This pointed to the possibility that a part of the population was yet immature or with abnormally low spawning rates at the time of PELGAS. During the BIOMAN survey mean SST reached 16.8 ºC. The egg sampling in the Gironde area took place around 12 days later, encountering a rather typical egg distribution. When the adult samples were taken for the DEPM, 17 days after the acoustic coverage in that area, the smallest anchovies were all mature according to the normal values of the IGS encountered (around 6%). However, this does not exclude the possibility that this year and in this particular area the spawning frequency is smaller than the average of previous years and hence might affect the final estimates. If this was the case, some upward correction of the DEPM biomass might occur in November, when the final DEPM estimates are reported to WGACEGG.

The spatial distribution of the proportion of anchovy by ages arising from the available fishing hauls was similar for both surveys. Therefore the reasons for the discrepancy in the age structure of the population, derives from a different relative spatial distribution of the anchovy according to the respective abundance indicators of the two methods (echo energy and eggs). The acoustic detected very dense schools (and a lot of energy) in very coastal areas around the Gironde plume of partly immature and very small fish. Along 40 nautical miles (9% of the area where anchovy was encountered during the survey) in front of the Gironde 66 000 tons of anchovy were estimated by acoustics. The acoustic energies were well identified by 6 pelagic hauls, revealing always at least 75% of anchovy. This added quite much abundance and supposed a big contribution of the individuals at age 1, which is not followed by a similar relative high egg production during the DEPM. This explains why even though a similar spatial distribution of ages by fishing hauls is obtained from the two surveys, the PELGAS survey reveals a higher proportion of age 1 (in numbers) than the DEPM survey.

In terms of the biomass percentage at age (which are used to fit the assessment model), there are almost no discrepancies between the two surveys estimates (40% age 1 in mass from PELGAS and 30% from BIOMAN). This was attributed to the fact that the high age 1 proportion in numbers encountered by the acoustic survey around the Gironde coastal areas corresponded to very small fish with small weight.

3.3.4 Autumn juvenile acoustic survey 2011 (JUVENA 2011)

The JUVENA survey series, including the last survey in autumn 2011, was reported and discussed in WGACEGG (ICES, 2011). JUVENA2011 took place on board two vessels equipped with scientific acoustic equipment and with two different fishing gears: purse seiner Itsas Lagunak and pelagic trawler Emma Bardan (**Figure 3.3.4.1**). The survey took place during 30 days in September, sampling 4,000 nmi to reach an effective sampling of 2,500 nmi. that provided a coverage of about 37,500 nmi.[2] along the continental shelf and shelf break of the Bay of Biscay, from the 7º40′ W in the Cantabrian area up to 47º 30′ N at the French coast. 77 hauls were done during the survey to identify the species detected by the acoustic equipment, 64 of which were positive for anchovy (**Figure 3.3.4.2**).

Anchovy was found distributed along two different strata: an external stratum and a coastal stratum. In the external stratum anchovy was located in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy, mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. In the coastal stratum adult and juveniles were mixed and was detected in schools close to the bottom, mixed also with superior proportions of other species, mainly small sardine in the most coastal area, and horse mackerel on the mid continental shelf (**Figures 3.3.4.3 and 3.3.4.4**).

The biomass of juveniles estimated for this year 2011 is 207,625 t. This value, although is the second in the temporal series (Table 3.3.4.1), represents only 35% of the maximum value, obtained last year, which caused the recovery of the resource. This year estimate is of about the same range (slightly higher) as the estimate of year 2009. The area of distribution of juvenile anchovy this year was similar to the area observed last year (which was the highest one in the temporal series,). But the lesser mean density of the observed anchovy schools and the smaller size of the juveniles caused the considerably lower estimated biomass of juvenile anchovy.

3.4 Biological data

3.4.1 Maturity at age

As reported in previous year reports, anchovies are fully mature as soon as they reach their first year of life, in the spring the year after the hatch. See stock annex - Bay of Biscay Anchovy (Subarea VIII) for details.

3.4.2 Natural mortality and weight at age in the stock

Natural mortality is fixed at 1.2, see stock annex - Bay of Biscay Anchovy (Subarea VIII) for further information.

In the Bayesian Biomass Model the parameter *g* describes the annual change in mass of the population by encapsulating the growth in weight (G) and the natural mortality (M) of the population as G-M (0.52-1.2=-0.68).

There are evidences that this parameter *g* is not constant across age groups. An extension of the current assessment method separating the growth in weight and the natural mortality parameters and splitting each of them by age class (Ibaibarriaga *et al.* 2011) suggests larger growth and smaller natural mortality of the age 1 class than the 2+ age class. Previous works by Petitgas *et al.* and Uriarte *et al.* (WDs in WGANSA 2010) also indicated lower natural mortalities than the one currently assumed. The working group considers necessary a revision of the natural mortality parameter for this stock. The inclusion of a new value(s) of natural mortality in the assessment of this fishery will be subject to the approval of the next Benchmark for this species.

3.5 State of the stock

3.5.1 Stock assessment

The update assessment for the Bay of Biscay anchovy population is based on a two-stage biomass-based model (BBM) (Ibaibarriaga *et al*. 2008) and it is described in the stock annex. This method was approved in the Benchmark Workshop on Short-lived species (WKSHORT) that took place in August 2009.

The input data entering into the assessment of the anchovy stock consist of:

- total biomass estimated by DEPM and acoustics surveys
- proportion of the biomass at age 1 estimated by the DEPM and acoustic surveys
- total catch during the first period (from 1st January to 15th May)
- total catch during the second period (from 15th May to 31st December)
- catch at age 1 (in mass) during the first period (from 1st January to 15th May)

The historical series of spawning stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 3.5.1.1. The trends in biomass from both surveys are similar. In particular, from 2003 to 2010 a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. This year both surveys give completely different estimates. The acoustic biomass estimate is the largest of their historical series, indicating an increase with respect to last year's biomass. In contrast, the DEPM biomass estimate decreases significantly with respect to last year. Possible causes of the discrepancies found are discussed in section 3.3.3. Similar discrepancies between DEPM and acoustic surveys (though of smaller magnitude) occurred in 1991, 2000 and 2002. The agreement between both surveys is higher when estimating the age structure of the population. Figure 3.5.1.2 compares the historical series of the proportion of age 1 biomass of DEPM and acoustic surveys. However, it should be noted that this year the age 1 proportion in numbers from the DEPM and acoustic survey are rather different (see section 3.3.3).

Figure 3.5.1.3 shows the historical series of age 1 and total catches in the first period (1st January-15th May) and of the total catches in the second period (15th May-31st December), which are used in BBM. In the past catches in the second period were larger than in the first period and most of the catches in the first period corresponded to age 1. In the last two years (2010 and 2011) catches in the first period are larger than in the second period and the majority of the catches in the first period corresponded to age 2 and older individuals. After various fishery closures due to the low level of the population, in 2010 the fishery was re-opened. In 2012 the total catch in the first period was approximately 3900t.

The data used for the assessment are given in Table 3.5.1.1.

Figures 3.5.1.4 and 3.5.1.5 compare prior and posterior distribution of the parameters. Summary statistics (median and 95% probability intervals) of the posterior distributions of recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15th May) and harvest rates (catch/SSB) are shown in Table 3.5.1.2 and Figure 3.5.1.6. The largest probability intervals correspond to the period in which some data are missing. In general recruitment is highly variable from year to year. Recruitment in 2012 is at levels similar to 2006, though with larger uncertainty. The median SSB has decreased from last year to intermediate levels in the historical series. The harvest rates in 2010 and 2011 are smaller than the levels observed before the fishery closure in 2005. In order to analyse the biomass trends in relative terms, median and 95% posterior probability intervals of the ratio of spawning stock biomass with respect to 1989 spawning stock biomass, in which Blim is based (ICES 2003), are given in Table 3.5.1.2.

Figure 3.5.1.7 shows the posterior distribution of current level of spawning stock biomass in 2012. Current state of the population is summarized in Table 3.5.1.3. Recruitment (age 1 biomass in January) in 2012 is 29 300 tones and 95% probability interval between 19 000 and 45 400 tones. The estimated level of biomass in 2012 is 68 200 tones and the 95% probability interval is 46 300 and 99 800 tones. In relative terms the median of the ratio of SSB in 2012 with respect to 1989 biomass (used for defining Blim) is 3.9 (with a 95% interval between 2.5 and 6.0) indicating that current level of the population is well above the biomass in 1989. The biological risk, defined as the probability of SSB in 2012 being below Blim (21 000 tones), is 0.

3.5.2 Reliability of the assessment and uncertainty of the estimation

Compared to commonly used assessment methods in ICES, the Bayesian two-stage biomass-based model (BBM) entails changes in both the methodology used for projecting the population forward and establishing catch options and in the terminology in which the assessment and consequent advice is given. Concepts such as fishing mortality or selectivity at age are not used in the model. Alternatively, harvest rates, defined as the ratio between total annual catches and spawning stock biomass, are used. The state of the stock is given in terms of spawning biomass, recruitment is understood as biomass at age 1 at the beginning of the year and management options may be given in terms of catches. Due to the Bayesian framework, all the results are given in stochastic terms and deterministic points estimates are replaced by summary statistics of the posterior distributions of the parameters, such as medians and percentiles.

The observation equations of the model refer just to the age 1 biomass proportion and total biomass indices from the research surveys (DEPM and acoustics). Figure 3.5.2.1 shows the posterior distribution of spawning stock biomass from BBM in comparison to the estimates from the DEPM and acoustic surveys (corrected by their catchability, which is assumed to be 1 for the DEPM and estimated as 1.16 for the acoustic survey). In most of the years the SSB estimates of the surveys taking into account their standard errors fall within the 95% posterior probability intervals from the assessment. In this last year both estimates are outside this interval. Figure 3.5.2.2 shows the posterior distribution of age 1 proportion in mass from BBM in comparison to the estimates from the DEPM and acoustic surveys. In all the years the age 1 biomass proportion estimates of the surveys are within the 95% probability intervals from the assessment. Pearson residuals of the four indices do not reveal any clear pattern (Figure 3.5.2.3).

Despite the fact that this year the biomass indices from both surveys point out to distinct situations, the last year Pearson residuals for biomass shows that the model estimate for this year is a compromise between both survey estimates (negative residuals for the DEPM and positive for acoustics). The WG considers that the main reason for assessment model results to indicate a drop in the spawning biomass in 2012 compared to 2011 is the consistent low percentages at age 1 in biomass from the two surveys. The lower percentage of age 1 compared to age 2 to the final biomass estimate is an indicator of a drop in the biomass and this is probably guiding the final SSB estimate in 2012. The discrepancy between the two biomass indices results in a larger uncertainty, with wider probability intervals in comparison to other years at similar biomass levels. See section 3.3.3 for a discussion on the discrepancies between the two spring surveys. Nevertheless, the abundance index of anchovy juveniles in 2011 (from JUVENA) pointed towards a drop in the recruitment level at age 1 expected in 2012 compared to those in 2011, and hence in the same direction of the outcome from the assessment (see section 3.9 and figure 3.9.1). This gives some independent support to the latest tendency shown by the assessment.

It has to be noted that the DEPM estimates provided in June are preliminary, given that the adult samples have not been fully processed. The final estimates will be made available to WGACEGG in November. As a result the stock assessment has to be considered also as preliminary.

In this model catch data are accounted for in the development of the dynamics of the population. Therefore, it is necessary to continue the collection of total landings and catch at age data.

The assessment is scaled by the assumption of absolute catchability of DEPM surveys. The current perception of the population in relative terms (SSB/SSB1989) is insensitive to the use of the DEPM survey as absolute or relative. It is the absolute level of the assessment results (i.e. the mass in tonnes corresponding to the spawning population) that is dependent on the catchability assumptions of the assessment. This implies that the absolute level of the harvest rate, defined as the ratio between total annual catches and spawning stock biomass, is also dependent on the catchability assumption. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomasses or harvest rates even under the assumption of DEPM being an absolute abundance estimate.

Other important assumptions of the current assessment are that the natural mortality and growth rates are constant across ages and from year to year and that the catchability of the surveys is constant across ages. This may imply some artificial reduction of the posterior probabilities profiles of the outputs from the assessment. In addition, the value assumed for g (natural mortality and growth) could be another source of uncertainty in the current assessment. The 5 years fishery closure has allowed new studies on the natural mortality (see section 3.4.2) indicating that it might be different by age and lower than the currently assumed rate. Using a new vector of natural mortality at age would change the trends in biomass even in relative terms (SSB with respect to SSB in 1989).

The DEPM series of biomass are under revision due to changes in the procedures for spawning frequency estimates (WGACEGG ICES 2009). This will affect the assessment results and may imply the revision of the current precautionary reference points for management.

The methodology is the same as described in Ibaibarriaga *et al*. (2008) and in the stock annex. The only change is that, as in the last year, longer runs (500 000 draws) with longer burn-in period (100 000 draws) and higher thinning (1 out of 40 draws was kept) were conducted to ensure convergence.

Figure 3.5.2.4 compares the SSB estimates from the assessment conducted in WGANSA 2011 and the updated assessments. The results are almost identical.

3.6 Short Term Prediction

3.6.1 Recruitment prediction

The prediction of the population for next year in order to explore catch options requires predicting recruitment entering the population.

At the time of the Working Group meeting, there are no indications about next incoming recruitment. Since the population seems to have recovered from the period of low levels of recruitment (2002-2009), the WG decided to make the projections under an undetermined recruitment scenario, where all the past recruitments are equally likely. The resulting recruitment distribution, with median at 45 560 t, is shown in Figure 3.6.1.1.

The construction of alternative recruitment scenarios based on the recruitment indices from juvenile acoustic surveys and from environmental variables is discussed in sections 3.9 and 3.7.

3.6.2 Method

The method for predicting the population is based on the Bayesian two-stage biomass-based model and it is described in detail in the stock annex. This method was approved in the Benchmark Workshop on Short-lived species (WKSHORT) that took place in August 2009.

3.6.3 Results

Starting from the posterior distribution of SSB in 2012 the population was projected one year forward under the undetermined recruitment scenario.

Under the assumption that this year the percentage of the catch taken until mid May with respect to the catch taken during the first semester will be equal to the historical average (0.585), the catches from the 15th May to the end of June in 2012 were assumed to be equal around 2 800 t. Total allowable catch between 1st July 2012 and 30th June 2013 were explored from 0 (fishery closure) to 33 000 tonnes with a step of 1 000 tonnes. In addition, the effect of the percentage of those total allowable catches corresponding to the second half of 2012 was also studied by considering percentages from 0 to 100% with a step of 5%. The timing within the year in which the catches in the second half of 2012 and the first half of 2013 were assumed to occur were computed as the average time points from the historical series from 1987 to 2011 excluding the years 2005-2009 in which the fishery was closed during all or some part of the year. Similarly, the percentage of catches in the first half of 2013 taken before the 15th May, when SSB is estimated, was assumed to be equal to the average from the historical series between 1987 and 2011 excluding the years 2005-2009 (58.5%). Probability of SSB in 2013 being below B_{lim} was derived for each of the catch options and for the percentages of catch corresponding to the second half of 2012.

Figure 3.6.3.1 shows the distribution of SSB in 2013 in the absence of fishing from 1st July 2012 to 15th May 2013. Under this condition the probability that SSB in 2013 is below B_{lim} is 0.

The probability of SSB in 2013 being below B_{lim} is given in Figure 3.6.3.2 (upper panel) and Table 3.6.3.1. The probability of SSB being below B_{lim} is 0 up to catches of 5 000 t and it increases above 0.05 for catches of 30 000t. The probability of falling below B_{lim} is almost insensitive to the allocation into semesters, but it increases slightly for larger percentages of the TAC taken in the second semester of 2012. The corresponding predicted median SSB values in 2013 are shown in Table 3.6.3.2. According to the harvest control rule included in the long term management plan proposal launched by the European Commission on 29 July 2009, the TAC for the fishing season running from 1 July 2012 to 30 June 2013 should be established at 20 700 t. The corresponding probability of SSB in 2013 being below B_{lim} under different allocation into semesters is shown in Figure 3.6.3.2 (lower panel).

3.7 Reference points and management considerations

3.7.1 Reference points

The precautionary reference points and their definitions are found in the Stock annex. Precautionary reference points were not revised by the WG this year.

The precautionary reference points were set according to stock estimates with ICA and within the standard framework related to deterministic stock assessments. For the anchovy, a Bayesian assessment is now well established, and the reference points may need to be revisited within that conceptual framework.

Because the assessment provides the probability distributions for the SSB, the rationale to maintain a B_{pa} under the assumption that being at B_{pa} would imply a low risk to B_{lim} becomes irrelevant. Furthermore, under the MSY framework for advice, B_{pa} is in principle redundant, and will be substituted by a $B_{trigger}$ below which fishing mortality should be reduced below F_{MSY}.

B_{lim} is defined by ICES as the SSB below which recruitment becomes impaired (ICES 2003). For stocks with a clear plateau in the S/R scatter plot (a wide dynamic range of SSB, but no evidence that recruitment is impaired) it was recommended to identify B_{loss} as a candidate value of B_{lim}, below which the dynamics of the stock is unknown. When defining the reference points for anchovy -in 2003 -, it was considered that “the dynamic range in SSB and R has been relatively large, but there is no clear signal in the S/R relationship. Furthermore, the assessment time-series is relatively short. B_{loss} should be maintained as B_{lim}.” Hence B_{lim} was set equal to B_{loss} = 21 000 t, which was the lowest spawning biomass (SSB) in the ICA 2003 assessment (corresponding to year 1989).

The B_{lim} is set with reference to a particular year where a normal recruitment occurred at the historical low SSB. The assessment provides a probability distribution of SSB_{1989} which is updated every year. An alternative would therefore be to consider the current SSB relative to SSB_{1989} in probabilistic terms. This is now done routinely by considering the distribution of the ratio SSB_y/SSB_{1989}. The median and 95% probability intervals of such ratio for the current assessment is presented in **Table 3.5.1.2** and the distribution for 2012 indicates that there is a 0 probability of being below B_{lim} (21 000 t).

3.7.2 MSY and the precautionary approach

According to the recent advisory practice (ICES advice 2010, Book1, Section 1.2 General context of ICES advice), the ICES MSY approach for short-lived stocks is aimed at achieving a target escapement (BMSY-escapement, the amount of biomass left to spawn), which is more robust against low SSB and recruitment failure than a fishing mortality approach.

This applies to the Bay of Biscay anchovy. Hence, defining an F_{MSY} is irrelevant, and advice aiming at MSY is equivalent to the precautionary approach advice.

3.7.3 Short term advice

Providing a risk adverse advice according to the precautionary approach has two separate aspects, and the anchovy requires special considerations on both.

1. For *tactical advice* in the short term perspective, where the risk to B_{lim} is calculated as part of the short term prediction, this translates into recommending a TAC which implies a low risk of leading below B_{lim}, for selected scenario(s) of recruitment.
2. When *evaluating a harvest control rule* or management strategy, one will consider a plausible range of future natural variations (recruitment, weight, maturity) and require that the rule should imply a low probability that the modelled 'real' stock falls into an unwanted state of reduced productivity, when the rule is practised based on uncertain observations of the state of the stock. Low probability is usually interpreted as SSB < B_{lim} at least once over a time period in less than 5% of the cases (ICES 2008).

With respect to tactical advice on the anchovy in the absence of a harvest rule, the Bayesian assessment model provide estimates of the uncertainty which are expressed as posterior distributions of the interest parameters. The posterior distributions express the uncertainty of the results given the uncertainty of the data and the prior assumptions, and presumably represent more realistic estimates of the uncertainty than the assumptions underlying the distance between B_{lim} and B_{pa} in the common deterministic framework. The distribution, and in particular the outer percentiles are sensitive to the "a priori" assumptions. The distribution of the predicted biomass after the TAC is taken is also broadened by the uncertainty in future recruitments.

In June, at the time when the short term prediction is made, there is nothing to indicate the strength of the incoming year class. Recently there has been a period (2002-2009) with successive recruitment failures, the reasons for which are poorly known. Therefore an undetermined scenario was assumed based on a mixture distribution of all the past recruitments.

The JUVENA survey now has been conducted for 9 years (2003-2011). Last year ICES *emphasized the possibility of revising the June advice if the JUVENA 2011 survey indicates a new low incoming recruitment. In any case, if managers decide on a revision of the advice for 2012, this could be done once results from the autumn acoustic survey are available*. However, in July the EC established the TAC from 1st July 2011 to 30th June 2012 according to the long term management plan proposal and ICES did not reviewed its June advice according to the JUVENA results. This year WGHANSA had a specific ToR regarding the usefulness of the JUVENA surveys and the most appropriate time-frame for its potential use for management advice. This issue is covered in detail in section 3.9.

To base the advice routinely on the 5-percentile of the SSB distribution relative to B_{lim} may not be adequate both because the distribution represents a broader range of uncertainty, because of the additional recruitment uncertainty and because the 5 - percentile is poorly estimated and highly sensitive to assumptions. Uncritical use of the 5-percentile as a criterion may lead to an advice to close the fishery far more often than necessary if the distribution is broad enough. For small pelagics, which are inherently highly variable, the 5% of risk may be unnecessarily high. Instead of looking for a reference risk, the increased risk due to fishing should be evaluated.

3.7.4 Management plans

A draft management plan was proposed by the EC in 2009 in cooperation between science (STECF) and stakeholders (South Western RAC). This plan has not yet been formally adopted by the EU, and it has not been presented to ICES for evaluation. However, the plan has been used in the last two years (2010 and 2011) for establishing the TAC for the period between 1st July and 30th June. The plan is based on a constant harvest rate (30%), and sets a TAC as a percentage of the point estimate of the SSB as assessed at the start of the TAC period which runs from 1st July to 30th June, but with an upper bound on the TAC (of 33 000 t), and with a minimum TAC level (of 7 000 t) applicable at SSB estimates between 24 000 tonnes and 33 000 tonnes. It is understood that the TAC this year will again be set according to this draft plan.

The draft plan has a clause to revise it within 3 years after it has been accepted, and WGHANSA assumes that future revisions will take recent scientific developments into account. It is not a task for ICES in general and WGHANSA in particular to develop a revised plan. ICES has been open to assist in such development by providing scientific insight on opportunities and limitations, in a dialogue process with managers and stakeholders, as outlined by SGMAS (ICES 2008) and practised for a number of stocks.

3.7.5 Management considerations for the development of future management plans

There is an ongoing revision of the method to compute the stock abundance from the DEPM data. The procedures for the estimation of the Spawning frequency (S) for the Bay of Biscay anchovy have been revised due to a better understanding of the POF degeneration cycle (Alday *et al*. 2008) and its application to the estimation of S (Uriarte *et al*. 2012). This will affect the past Spawning Biomass estimates of anchovy by the DEPM leading to a reduction of those estimates. This may lead to a re-scaling of the historical series of SSB and recruitments from the assessment as well. This will have implications for reference points that are set in absolute terms, including the reference points embedded in the draft management plan. Implementing this change in methodology, which from a scientific perspective is a clear improvement, will therefore have implications for future management plans.

Recruitment indicators, such as the JUVENA juvenile abundance index, may open opportunities to consider future management plans with half-yearly decisions and/or revisions of the TAC. This year WGHANSA had a specific ToR regarding the most appropriate time-frame for its potential use for management advice, in case the survey is considered useful for the assessment and forecast of the stock. That issue is covered in detail in section 3.9.

An extension of the Bayesian Biomass method currently used to assess the stock (Ibaibarriaga et al., 2011) is currently available. The WGHANSA considers this a promising development, which will improve at least some theoretical shortcomings. The assessment will be conducted with the current method until a new method has been formally approved, e.g. through a new Benchmark assessment. The new method may lead to revision of growth- and or natural mortality parameters, which will have implications for simulations of future management plans.

Bay of Biscay anchovy is one of the few stocks considered by ICES where uncertainties are considered explicitly in the assessment. Hence, there is information available not only on the point estimates of biomasses, but also on their distributions. This opens for opportunities to properly evaluate risks in terms of the combination of likelihood and costs, which may give a firmer basis for rational decisions about management plans. This would facilitate managers finding the probabilities of an unacceptable low stock abundance which imply the best counterbalance between the biological, economic and social concerns.

A rational basis for deciding on management plans is to simulate its performance under a variety of likely scenarios. This field has developed rapidly in recent years, and there is a good deal experience both within and outside ICES, on methods as well as on critical conditions for reaching management objectives (SGMAS - ICES 2008). Such simulations were made for the current draft plan, but will need to be extended and adapted to the new developments outlined above when revising the plan. This implies a considerable amount of work. The WGHANSA has no views on how this work should be organized, but notes that ICES on some occasions has assisted in such processes, and that an assessment working group sometimes can be a good forum for coordination and exchange of ideas on the scientific aspects of the process.

3.7.6 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and also for cetaceans and birds. Recruitment depends strongly on environmental factors, and several recruitment predictions have been proposed in the past based on environmental variables. Approaches like the one presented in Fernandes *et al* (2010) look promising, but its prediction capacity is still being tested.

3.7.7 Ecosystem effects of fisheries

These effects are not quantified.

3.8 Benchmark preparation

The last benchmark for anchovy in the Bay of Biscay took place in 2009. A new benchmark for this stock is planned for 2013. The list of issues to be discussed at the benchmark is the following:

1) Tuning series:
    a. The DEPM historical series of spawning stock biomass are being revised within WGACEGG due to changes in the procedure for estimating spawning frequency.
    b. There is a potential new index on biomass arising from egg abundances collected with CUFES from the acoustic PELGAS survey. This index will be presented and discussed in WGACEGG.
    c. This working group considered the juvenile abundance index from the JUVENA surveys useful for describing the state of the stock, given its re-

lationship with recruitment (age 1 biomass next year). In the benchmark the potential of including this index into the assessment as an index of recruitment could be evaluated.

d. Currently the assessment is scaled by the assumption of absolute catchability of DEPM surveys. Although the perception of the stock in relative terms is insensitive to the use of the DEPM as absolute and relative, the absolute level of the biomass and the absolute level of the harvest rates are dependent on this catchability assumption. In the benchmark the assumptions on survey's catchability should be evaluated.

2) Biological parameters:
   a. In the current assessment model mortality and growth rates are assumed to be constant across ages and from year to year. There are evidences that these assumptions might not be appropriate. The possibility of estimating these parameters by age class using an extension of the BBM assessment model or any other assessment model should be investigated.
3) Assessment method:
   a. The current assessment method presents some shortcoming, as the strong assumptions on natural mortality and growth rate parameters explained above. There is an extension available of the BBM that allows the growth and natural mortality rates to be estimated and to vary across age groups. In addition, the catches are modelled and included into the observation equations. This model seems to be more adequate, but also more data and computer-time demanding. The possibility of changing the assessment method to this extended version or to any other assessment model considered more appropriate should be studied in the benchmark.
4) Forecast method:
   a. The current forecast methodology is considered appropriate as a complementary tool for the assessment model (BBM). However, if the assessment model is changed, the most appropriate forecast method should also be revised.
   b. In June when the short term forecast is done there are no indications on the next year recruitment. However, the JUVENA juvenile abundance index has proven its potential in forecasting recruitment. In the last years ICES did not revise its advice based on the JUVENA results, but new projections based on a log-linear model between the juvenile abundance index and recruitment were available under request. The best use of the JUVENA juvenile abundance index to improve the forecast once the results of the survey are available in November should be discussed in the benchmark.
5) Biological reference points
   a. Any changes into the above points might imply a revision of the biological reference points.

3.9 On the potential use of JUVENA and implications (TOR c)

ICES advice on anchovy delivered in June each year is made without any indication of the next year recruitment, despite the fact that for short-lived species recruitment typically supposes the major part of the population. Therefore, the risk assessment for any catch option is of poor reliability given the uncertainties on the level of next coming recruitment.

Since 2003, an autumn juvenile acoustic survey called JUVENA (Boyra *et al*. 2012) has been conducted annually. The main objective of the survey is to estimate the juvenile abundance in order to provide an index of recruitment for the following year and its results are reported and discussed annually in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG) (ICES CM 2011/SSGESST:20). In December 2009, the European Commission agreed the temporary re-opening of the anchovy fishery (closed since July 2005) with a TAC of 7 000 t based on the results of JUVENA 2009. In June 2010 and 2011, the advice provided in June by ICES admitted "*the possibility to review the current advice once indications of the next incoming recruitment become available from the autumn survey*". In 2010 and 2011, the European Commission established the TAC for the Bay of Biscay anchovy stock from July to June in next year based on the harvest control rule of the draft long-term management plan proposal (COM 2009) and the juvenile abundance indices from JUVENA in 2010 and 2011 were not used neither to revise the June scientific advice nor to change the TAC established.

Under these circumstances WGHANSA this year has a term of reference (ToR c) asking to "*indicate, without pre-empting on actually using the new JUVENA survey as input to the Bay of Biscay anchovy assessment, if the group considers this survey will be useful in describing the state of the stock and improving the forecast. If this is the case, the group should indicate what alternative advice time-frame(s) could be put forward to ask clients if they would consider aligning the management cycle with a modified advice schedule*".

The WG examined a working document on this subject (Ibaibarriaga *et al*. WD) and looked at the relationship of the juvenile index with the next coming recruitment as estimated in the current assessment.

Regarding the first issue about the usefulness of the JUVENA index on juveniles, the WG notes that the relationship between the JUVENA's juvenile abundance index and the recruitment next year (age 1 biomass in January, as estimated by the Bayesian two-stage biomass-based assessment model -BBM) has been statistically significant since 2009 (then at alpha of 6%). Figure 3.9.1 compares the times series of the JUVENA anchovy juveniles abundance index with the estimates of biomass at age 1 (median values) from this year assessment (section 3.5), when each of the series is standardised according to their mean and variance. The high estimate of anchovy juveniles in JUVENA2010 has been followed by strong anchovy recruitment at age 1 in 2011. In addition, the low juvenile abundance indices of 2004, 2007 and 2008 are associated with the lowest recruitments estimated by the assessment since 2003. The Spearman rank correlation between the JUVENA series and the assessment estimates of recruitment at age 1 is 0.81, which is statistically significant with p-value=0.01, and the Pearson correlation is 0.94, which is statistically significant with p-value=0.000163. This is above the minimums required (around 50%) for recruitment indicators to suppose an improvement in case of using it for the provision of management advice (De Oliveira and Butterworth 2005, De Oliveira et al. 2005). Among several candidate models the best fitting was achieved with a log-linear model (Figure 3.9.2). The model was significant (p-value= 1.6E-04) with R^2=0.89%. Therefore the WG considers that the JUVENA acoustic index of juveniles is a valid indicator of the strength of the incoming recruitment and hence useful improving the forecast of the population and potentially its assessment. Nevertheless, the best use of this survey index should be established in the framework of next coming benchmark foreseen for next year.

The current time framework of formulation of advice and management decision taking is summarised in Figure 3.9.3. WGHANSA meets in June to assess the stock status and ACOM delivers its advice at the beginning of July. Then, the European Commission and the Council set the TAC from July to June next year based on the long-term management plan for this fishery. This plan was proposed in 2009 by the EC (COM 2009) and even if it has not yet been formally adopted by the EU, it has been used to set the TAC from 1st July to 30th June in the last two years (2010 and 2011). The harvest control rule in this long-term management plan sets the TAC as the 30% of the spawning stock biomass (SSB) estimated in the assessment, which makes use of the most up-to-date estimates from the spring surveys (DEPM and acoustics). The rule was designed to be robust to the unknown levels of recruitments occurring during the management year from July to June next year.

The inclusion of JUVENA as a tool to forecast the population in next year, should serve to either review the TAC set currently from July to June according to the tendency of the forecasted population in relation to last assessment, or to generate an advice for a TAC going from January to December according to a sustainable harvest rate on the forecasted population over the management year. Certainly, this management advice based on JUVENA index should be generated in late November, once the results from the survey become available (Figure 3.9.3). Depending on the final management calendar year adopted, this would involve a first assessment in June to set the initial TAC with a revision in November, or a first assessment in November with a revision in June.

However, it is worth noting that the inclusion of this update advice according to expected level of incoming recruitment to change the TAC based on the HCR of the current management plan implies changing the basis upon which the HCR was designed. It is not evident how the TAC set in June could be changed in January according to the expected forecasted population levels and it would require some developing and evaluating a set of alternative options in the framework of the management objectives for this stock. On the other hand, moving to a management year from January to December cannot be done just borrowing the current HCR with the same harvest rate. The current HCR applies a harvest rate on the latest SSB estimates while a new HCR from January to December would apply a harvest rate on a forecasted SSB estimate (informed by the recruitment index). In the impact assessment of the proposal for the long term management plan of anchovy it is stated that the management calendar should be moved to January-December once the JUVENA juvenile abundance index is ready to be used in management (COM 2009 -399 final SEC(2009)1077). This type of harvest control rule has been already evaluated by management strategy evaluation in the past. However, for the above reasons, moving from the current HCR of the draft management plan to a HCR setting TAC from January to December, based on the JUVENA recruitment index, requires a re-evaluation of the risk levels associated to different harvest control rules, and in particular their harvest rate, in order to define the best rule according to the management objectives for this fishery. This re-evaluation could be carried out either by the STCEF or, if requested, by ICES.

Table 3.2.2.1: Bay of Biscay anchovy: Annual catches (in tonnes) as estimated by the Working Group members.

COUNTRY	FRANCE	SPAIN	SPAIN	INTERNATIONAL
YEAR	VIIIab	VIIIbc, Landings	Live Bait Catches	VIII
1960	1,085	57,000	n/a	58,085
1961	1,494	74,000	n/a	75,494
1962	1,123	58,000	n/a	59,123
1963	652	48,000	n/a	48,652
1964	1,973	75,000	n/a	76,973
1965	2,615	81,000	n/a	83,615
1966	839	47,519	n/a	48,358
1967	1,812	39,363	n/a	41,175
1968	1,190	38,429	n/a	39,619
1969	2,991	33,092	n/a	36,083
1970	3,665	19,820	n/a	23,485
1971	4,825	23,787	n/a	28,612
1972	6,150	26,917	n/a	33,067
1973	4,395	23,614	n/a	28,009
1974	3,835	27,282	n/a	31,117
1975	2,913	23,389	n/a	26,302
1976	1,095	36,166	n/a	37,261
1977	3,807	44,384	n/a	48,191
1978	3,683	41,536	n/a	45,219
1979	1,349	25,000	n/a	26,349
1980	1,564	20,538	n/a	22,102
1981	1,021	9,794	n/a	10,815
1982	381	4,610	n/a	4,991
1983	1,911	12,242	n/a	14,153
1984	1,711	33,468	n/a	35,179
1985	3,005	8,481	n/a	11,486
1986	2,311	5,612	n/a	7,923
1987	4,899	9,863	546	15,308
1988	6,822	8,266	493	15,581
1989	2,255	8,174	185	10,614
1990	10,598	23,258	416	34,272
1991	9,708	9,573	353	19,634
1992	15,217	22,468	200	37,885
1993	20,914	19,173	306	40,393
1994	16,934	17,554	143	34,631
1995	10,892	18,950	273	30,115
1996	15,238	18,937	198	34,373
1997	12,020	9,939	378	22,337
1998	22,987	8,455	176	31,617
1999	13,649	13,145	465	27,259
2000	17,765	19,230	n/a	36,994
2001	17,097	23,052	n/a	40,149
2002	10,988	6,519	n/a	17,507
2003	7,593	3,002	n/a	10,595
2004	8,781	7,580	n/a	16,361
2005	952	176	0	1,128
2006	913	840	0	1,753
2007	140 **	1.2 **	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	4,573	5,744	n/a	10,317
2011	3,615	10,916	n/a	14,530
2012 (Up end May)	0	6,697	n/a	6,697
AVERAGE (1960-2004)	6,394	26,337	318	32,824

** : Experimental fishery

Table 3.2.2.2: **Bay of Biscay anchovy : Monthly catches by country (Sub-area VIII) (without live bait catches)**

COUNTRY: FRANCE

Units: t.

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1987	0	0	0	1,113	1,560	268	148	582	679	355	107	87	4,899
1988	0	0	14	872	1,386	776	291	1,156	2,002	326	0	0	6,822
1989	704	71	11	331	648	11	43	56	70	273	9	28	2,255
1990	0	0	16	1,331	1,511	127	269	1,905	3,275	1,447	636	82	10,598
1991	1,318	2,135	603	808	1,622	195	124	419	1,587	557	54	285	9,708
1992	2,062	1,480	942	783	57	11	335	1,202	2,786	3,165	2,395	0	15,217
1993	1,636	1,805	1,537	91	343	1,439	1,315	2,640	4,057	3,277	2,727	47	20,914
1994	1,972	1,908	1,442	172	770	1,730	663	2,125	3,276	2,652	223	0	16,934
1995	620	958	807	260	844	1,669	389	1,089	2,150	1,231	855	22	10,892
1996	1,084	630	614	206	150	1,568	1,243	2,377	3,352	2,666	1,349	0	15,238
1997	2,235	687	24	36	90	1,108	1,579	1,815	1,680	2,050	718		12,022
1998	1,523	2,128	783	0	237	1,427	2,425	4,995	4,250	2,637	2,477	103	22,987
1999	2,080	1,333	574	55	68	948	1,015	922	3,138	1,923	1,592	0	13,649
2000	2,200	948	825	5	58	1,412	2,190	2,720	3,629	2,649	1,127	0	17,765
2001	717	517	143	46	47	1,311	1,078	3,401	4,309	2,795	2,732	0	17,097
2002	1,435	2,561	1,560	1	30	758	350	979	1,957	771	578	0	10,978
2003	39	2	0	32	123	1,031	284	2,284	1,478	1,319	983	19	7,593
2004	210	106	3	13	145	1,625	853	1,995	2,464	555	813	0	8,781
2005	363	15	33	0	16	525	0	0	0	0	0	0	952
2006	1	0	29	0	0	795	88	0	0	0	0	0	913
2007	0	0	0	39	56	45	0	0	0	0	0	0	140
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	592	75	630	2,202	862	213	0	4,573
2011	0	0	0	1	0	12	0	167	817	1,322	1,262	47	3,627
2012	0	0	0	0	0								0

COUNTRY: SPAIN

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1987	0	0	454	4,133	3,677	514	81	54	28	457	202	265	9,864
1988	6	0	28	786	2,931	3,204	292	98	421	118	136	246	8,266
1989	2	2	25	258	4,295	795	90	510	116	198	1,610	273	8,173
1990	79	6	2,085	1,328	9,947	2,957	1,202	3,227	2,278	123	16	10	23,258
1991	100	40	23	1,228	5,291	1,663	91	60	34	265	184	596	9,573
1992	360	384	340	3,458	13,068	3,437	384	286	505	63	94	89	22,468
1993	102	59	1,825	3,169	7,564	4,488	795	340	198	65	546	23	19,173
1994	0	9	149	5,569	3,991	5,501	1,133	181	106	643	198	74	17,554
1995	0	0	35	5,707	11,485	1,094	50	9	6	152	48	365	18,951
1996	48	17	138	1,628	9,613	5,329	1,206	298	266	152	225	17	18,937
1997	43	1	81	2,746	2,672	877	316	585	1,898	331	203	185	9,939
1998	35	235	493	371	4,602	1,083	1,518	44	47	3	22	1	8,455
1999	8	26	52	4,626	4,214	1,396	1,037	26	911	207	615	27	13,144
2000	18	0	99	1,952	11,864	3,153	958	342	413	346	83	0	19,230
2001	243	48	337	2,203	14,381	3,102	1,436	1	126	1,055	120	1	23,052
2002	1	0	13	914	2,476	1,340	323	56	1,013	381	1	0	6,519
2003	0	0	0	1,709	767	373	10	12	124	4	3	0	3,002
2004	0	0	0	2,364	3,102	1,616	50	22	423	1	1	2	7,580
2005	0	2	2	4	167	0	0	0	0	0	0	0	176
2006	0	0	4	124	630	75	7	0	0	0	0	0	840
2007	0	0	0	0	1	0	0	0	0	0	0	0	1
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	299	1,324	2,955	940	0	2	223	1	0	0	5,744
2011	0	0	1,586	4,483	4,492	339	2	10	1	2	0	0	10,916
2012	0	0	10	1,058	5,629								6,697

COUNTRY: INTERNATIONAL

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1987	0	0	454	5246	5237	782	229	636	707	812	309	352	14763
1988	6	0	42	1657	4317	3979	584	1253	2423	445	136	246	15088
1989	706	73	36	588	4943	806	132	566	186	472	1619	301	10429
1990	80	6	2101	2658	11459	3083	1471	5132	5553	1570	652	92	33856
1991	1418	2175	626	2036	6913	1858	215	479	1621	822	238	882	19282
1992	2422	1864	1282	4241	13125	3448	719	1488	3291	3228	2489	89	37685
1993	1738	1864	3362	3260	7906	5927	2110	2979	4254	3342	3273	70	40086
1994	1972	1917	1591	5741	4761	7231	1796	2306	3382	3295	421	74	34487
1995	620	958	842	5967	12329	2764	439	1098	2155	1382	903	387	29843
1996	1132	647	752	1834	9763	6897	2449	2675	3617	2818	1575	17	34176
1997	2278	688	105	2782	2762	1985	1895	2400	3578	2381	921	185	21961
1998	1558	2363	1276	371	4839	2510	3943	5039	4298	2640	2500	104	31442
1999	2088	1360	626	4681	4282	2345	2052	948	4049	2130	2207	27	26794
2000	2219	948	925	1957	11922	4565	3148	3063	4043	2995	1210	0	36994
2001	960	565	479	2249	14428	4413	2514	3403	4435	3850	2852	1	40149
2002	1436	2561	1573	915	2506	2098	673	1034	2970	1152	578	0	17497
2003	39	2	0	1740	890	1403	294	2297	1602	1322	986	20	10595
2004	210	106	3	2377	3247	3241	902	2017	2886	557	813	2	16360
2005	363	17	35	4	183	525	0	0	0	0	0	0	1127
2006	1	0	33	124	630	870	95	0	0	0	0	0	1753
2007	0	0	0	39	57	45	0	0	0	0	0	0	141
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	299	1324	2955	1532	75	632	2425	863	213	0	10317
2011	0	0	1586	4483	4492	351	2	177	818	1324	1262	47	14543
2012	0	0	10	1058	5629	0	0	0	0	0	0	0	6697

Table 3.2.2.3: Bay of Biscay anchovy: Catches in the Bay of Biscay by country and divisions in 2011 (without live bait catches)

		QUARTERS				CATCH (t)	
COUNTRIES	DIVISIONS	1	2	3	4	ANNUAL	%
SPAIN	VIIIa	0	0	0	0	0	0.0%
	VIIIb	1371	3278	0	0	4649	42.6%
	VIIIc	215	6037	13	2	6266	57.4%
	TOTAL	1586	9315	13	2	10916	100.0%
	%	14.5%	85.3%	0.1%	0.0%	100.0%	
FRANCE	VIIIa	0	0	983	2631	3614	100.0%
	VIIIb	0	0	0	0	0	0.0%
	VIIIc	0	0	0	0	0	0.0%
	TOTAL	0	0	984	2631	3615	100.0%
	%	0.0%	0.0%	27.2%	72.8%	100.0%	
INTERNATIONAL	VIIIa	0	0	983	2631	3614	24.9%
	VIIIb	1371	3278	0	0	4650	32.0%
	VIIIc	215	6037	13	2	6266	43.1%
	TOTAL	1586	9315	997	2633	14530	100.0%
	%	10.9%	64.1%	6.9%	18.1%	100.0%	

Table 3.2.3.1: Bay of Biscay anchovy: catch at age in thousands for 2011 by country and quarter (without the catches from the live bait tuna fishing boats).

2011 units: thousands

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIbc	VIIIbc	VIIIbc	VIIIbc	VIIIbc
	0	0	0	522	0	522
	1	15113	148949	634	51	164,747
	2	39440	175014	3	2	214,459
	3	1669	5492	0	0	7,161
SPAIN	4	0	0	0	0	0
	5	0	0	0	0	0
	TOTAL(n)	56,221	329,455	1,160	53	386,889
	W MED.	28.21	28.27	11.27	29.36	28.21
	CATCH. (t)	1586	9315	13	2	10,915.6
	SOP	1586	9315	13	2	10,915.7
	VAR. %	100.00%	100.00%	99.98%	100.19%	100.00%

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIab	VIIIab	VIIIab	VIIIab	VIIIab
	0	0	0	122	4012	4,134
	1	0	0	38498	120492	158,990
	2	0	0	3689	7385	11,075
	3	0	0	224	278	503
FRANCE	4	0	0	0	0	0
	5	0	0	0	0	0
	TOTAL(n)	0	0	42,533	132,168	174,701
	W MED.	0.00	0.00	23.13	19.91	20.69
	CATCH. (t)	0	0	984	2631	3,614.8
	SOP	0	0	984	2631	3,614.8
	VAR. %	0.00%	0.00%	100.00%	100.00%	100.00%

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIabc	VIIIabc	VIIIabc	VIIIabc	VIIIabc
	0	0	0	644	4,012	4,656
	1	15,113	148,949	39,132	120,543	323,737
	2	39,440	175,014	3,693	7,387	225,534
	3	1,669	5,492	224	278	7,664
TOTAL	4	0	0	0	0	0
Sub-area VIII	5	0	0	0	0	0
	TOTAL(n)	56,221	329,455	43,693	132,221	561,590
	W MED.	28.21	28.27	22.82	19.91	25.87
	CATCH. (t)	1586	9315	997	2633	14530
	SOP	1586	9315	997	2633	14530
	VAR. %	100.00%	100.00%	100.00%	100.00%	100.00%

Table 3.2.3.2: Bay of Biscay anchovy: Catches at age of anchovy of the fishery in the Bay of Biscay on half year basis (including live bait catches up to 1999)

Units: Thousands

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	38,140	0	150,338	0	180,085	0	16,984	0	86,647	0	38,434	0	63,499	0	59,934	0	49,771
1	218,670	120,098	318,181	190,113	152,612	27,085	847,627	517,690	323,877	116,290	1,001,551	440,134	794,055	611,047	494,610	355,663	522,361	189,081
2	157,665	13,534	92,621	13,334	123,683	10,771	59,482	75,999	310,620	12,581	193,137	31,446	439,655	91,977	493,437	54,867	282,301	21,771
3	31,362	1,664	9,954	596	18,096	1,986	8,175	4,999	29,179	61	16,960	1	5,336	0	61,667	1,325	76,525	90
4	14,831	58	1,356	0	54	0	0	0	0	0	0	0	0	0	0	0	4,096	7
5	8,920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	431,448	173,494	398,971	529,130	294,445	219,927	915,283	615,671	663,677	215,579	1,211,647	510,015	1,239,046	766,523	1,049,714	471,789	885,283	260,719

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	109,173	0	133,232	0	4,075	0	54,357	0	5,298	0	749	0	267	0	7,530	0	11,184
1	683,009	456,164	471,370	439,888	443,818	598,139	220,067	243,306	559,934	396,961	460,346	507,678	103,210	129,392	50,327	133,083	254,504	252,887
2	233,095	53,156	138,183	40,014	128,854	123,225	380,012	142,904	268,354	64,712	374,424	98,117	217,218	77,128	44,546	87,142	85,679	20,072
3	31,092	499	5,580	195	5,596	3,398	17,761	525	84,437	18,613	19,698	5,095	37,886	3,045	34,133	11,459	12,444	1,153
4	2,213	42	0	0	155	0	108	0	0	0	4,948	0	76	0	887	1,152	4,598	16
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	949,408	619,034	615,133	613,329	578,423	728,837	617,948	441,092	912,725	485,584	859,417	611,639	358,390	209,832	129,893	240,366	357,225	285,312

YEAR	2005		2006		2007		2008		2009		2010		2011	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	0	0	0	0	0	0	0	0	0	0	16,287	0	4,656
1	7,818	0	48,718	3,894	0	0	0	0	0	0	125,198	135,570	164,061	159,675
2	32,911	0	17,172	991	0	0	0	0	0	0	77,342	13,864	214,454	11,080
3	6,935	0	6,465	320	0	0	0	0	0	0	10,897	815	7,161	503
4	586	0	49	2	0	0	0	0	0	0	1,711	189	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total #	48,250	0	72,405	5,207	0	0	0	0	0	0	215,149	166,725	385,677	175,914

SPAIN

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	35,452	0	141,918	0	174,803	0	11,999	0	81,536	0	13,121	0	63,499	0	59,022	0	31,101
1	134,390	40,172	210,641	47,480	110,276	13,165	719,678	234,021	210,686	21,113	751,056	72,154	578,219	75,865	257,050	47,065	367,924	17,611
2	119,503	7,787	61,609	2,690	92,707	9,481	47,266	43,204	139,327	1,715	131,221	5,916	266,612	11,904	315,022	24,971	206,387	1,333
3	27,336	1,664	7,710	596	8,232	1,986	8,139	4,999	2,657	61	10,067	1	967	0	44,622	1,325	57,214	90
4	14,831	58	1,356	0	54	0	0	0	0	0	0	0	0	0	0	0	4,096	7
5	8,920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	304,980	85,134	281,414	192,684	211,270	199,435	775,083	294,222	352,670	104,425	892,344	91,192	845,798	151,268	616,694	132,383	635,621	50,142

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd haf	1st half	2nd half	1st half	2nd half
0	0	52,238	0	91,400	0	4,075	0	29,057	0	439	0	748	0	239	0	49	0	115
1	542,127	72,763	296,261	123,011	217,711	57,847	134,411	87,191	389,515	71,547	378,136	54,151	31,347	40,149	11,761	4,895	183,853	18,994
2	163,010	12,403	74,856	9,435	41,171	9,515	231,384	37,644	199,233	8,640	327,090	43,487	98,700	22,621	32,566	1,068	71,589	482
3	14,461	499	1,927	195	4,002	9	10,051	525	50,834	2,085	18,854	464	13,702	2,041	28,809	272	7,461	23
4	2,213	42	0	0	155	0	108	0	0	0	4,948	0	0	0	434	0	4,340	16
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total #	721,810	137,945	373,044	224,041	263,039	71,445	375,954	154,416	639,583	82,711	729,029	98,851	143748.2	65049.3	73,569	6,285	267,243	19,630

YEAR	2005		2006		2007		2008		2009		2010		2011	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	0	0	0	0	0	0	0	0	0	0	66	0	522
1	1,096	0	21,276	355	0	0	0	0	0	0	109,881	10,580	164,061	686
2	4,631	0	7,708	25	0	0	0	0	0	0	71,862	0	214,454	5
3	266	0	3,587	7	0	0	0	0	0	0	10,109	0	7,161	0
4	16	0	0	0	0	0	0	0	0	0	1,578	0	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total #	6,009	0	32,571	387	0	0	0	0	0	0	193,431	10,646	385,677	1,213

FRANCE

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	2,688	0	8,419	0	5,282	0	4,985	0	5,111	0	25,313	0	0	0	912	0	18,670
1	84,280	79,925	107,540	142,634	42,336	13,919	127,949	283,669	113,191	95,177	250,495	367,980	215,836	535,182	237,560	308,598	154,437	171,470
2	38,162	5,747	31,012	10,644	30,976	1,290	12,216	32,795	171,293	10,866	61,916	25,530	173,043	80,073	178,415	29,896	75,914	20,438
3	4,026	0	2,245	0	9,863	0	36	0	26,522	0	6,893	0	4,369	0	17,045	0	19,311	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	126,468	88,360	140,797	161,697	83,175	20,492	140,200	321,449	311,007	111,154	319,303	418,823	393,248	615,255	433,020	339,406	249,662	210,578

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd haf	1st half	2nd half	1st half	2nd half
0	0	56,936	0	41,832	0	0	0	25,300	0	4,859	0	1	0	29	0	7,481	0	11,069
1	140,882	383,401	175,109	316,877	226,107	540,293	85,656	156,115	170,418	325,413	82,210	453,527	71,864	89,243	38,567	128,188	70,651	233,893
2	70,085	40,753	63,327	30,579	87,683	113,710	148,628	105,260	69,121	56,072	47,334	54,630	118,518	54,507	11,981	86,074	14,091	19,590
3	16,631	0	3,653	0	1,594	3,389	7,710	0	33,603	16,528	844	4,631	24,184	1,005	5,324	11,187	4,983	1,130
4	0	0	0	0	0	0	0	0	0	0	0	0	76	0	453	1,152	258	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Total #	227,598	481,089	242,089	389,288	315,384	657,392	241,994	286,676	273,142	402,873	130,388	512,789	214641	144783	56,325	234,082	89,982	265,683

YEAR	2005		2006		2007		2008		2009		2010		2011	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	0	0	0	0	0	0	0	0	0	0	16,221	0	4,134
1	6722	0	27,442	3,539	0	0	0	0	0	0	15,316	124,989	0	158,990
2	28281	0	9,464	966	0	0	0	0	0	0	5,480	13,864	0	11,075
3	6669	0	2,878	313	0	0	0	0	0	0	788	815	0	503
4	570	0	49	2	0	0	0	0	0	0	133	189	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total #	42,242	0	39,833	4,820	0	0	0	0	0	0	21,719	156,079	0	174,701

Table 3.2.3.3: Bay of Biscay anchovy: Catch numbers at length by country and quarters in 2011

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4	
Length (half cm)	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc
3.5								
4								
4.5								
5								
5.5								
6								
6.5								
7								
7.5						1		
8						3		
8.5								
9						2		
9.5						3		
10		68		132		4	168	
10.5		122		245		7	458	
11		248		438		12	933	
11.5		290		626		50	2,050	
12		545		1,526	168	174	2,392	
12.5		760		2,636	798	371	5,203	
13		1,180		5,015	2,147	394	7,257	
13.5		2,299		11,007	2,057	99	14,950	
14		2,765		20,028	3,374	18	24,381	
14.5		4,823		36,636	5,952	8	21,891	1
15		5,811		41,620	8,134	6	19,303	5
15.5		7,046		46,088	6,790	2	13,429	7
16		7,182		44,979	5,064	1	7,829	10
16.5		8,012		40,412	4,635	1	6,141	7
17		7,088		34,542	2,003	1	3,535	10
17.5		4,974		24,132	914	0	1,243	9
18		2,154		13,022	259	0	563	2
18.5		723		5,241	238		260	1
19		85		1,224			181	
19.5		47		100				
20								
20.5								
21								
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
Total ('000)		56,221		329,650	42,533	1,160	132,168	53
Catch (t)		1,586		9,315	984	13	2,631	2
Mean Length(cm)		15.74		15.73	15.17	12.64	14.48	16.45

Table 3.2.4.1: Bay of Biscay anchovy: Mean weight at age (grammes) in the international catches on half year basis
nits: grams

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Sources	Anon. (1989 & 1991)		Anon. (1989)		Anon. (1991)		Anon. (1991)		Anon. (1992)		Anon. (1993)		Anon. (1995)		Anon. (1996)		Anon. (1997)	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	11.7	na	5.1	na	12.7	na	7.4	na	14.4	na	12.6	na	12.3	na	14.7	na	15.1
1	21.0	21.9	20.8	23.6	19.5	24.9	20.6	23.8	18.5	25.1	19.6	23.0	15.5	20.9	16.8	25.3	22.5	26.9
2	32.0	34.2	30.3	30.4	28.5	35.2	28.5	27.7	25.2	29.0	30.9	28.8	27.0	29.4	26.8	28.1	32.3	31.3
3	37.7	39.2	34.5	44.5	29.7	42.7	44.8	40.8	28.2	39.0	37.7	27.4	30.5	na	30.7	30.0	36.4	36.4
4	41.0	40.0	37.6	na	27.1	na	na	na	na	na	na	na	na	na	na	na	37.3	29.1
5	42.0	0.0	48.5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	27.3	20.8	24.6	10.7	23.9	15.6	21.3	24.0	22.1	21.1	21.7	22.5	19.6	21.2	22.3	24.3	26.9	25.0

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Sources:	Anon. (1998)		Anon. (1999)		Anon (2000)		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	12.0	na	11.6	na	10.2	na	15.7	na	19.3	na	14.3	na	9.5	na	15.4	na	15.5
1	19.1	23.2	14.4	20.3	21.8	23.7	17.1	27.0	21.7	28.2	22.7	27.5	25.0	28.8	21.0	25.4	21.7	24.9
2	29.3	27.7	26.9	30.1	24.3	27.7	29.8	33.5	29.1	33.0	31.8	31.1	31.6	33.4	36.2	29.5	35.7	33.5
3	35.0	35.7	32.0	29.7	31.9	28.7	34.7	38.9	32.8	36.9	36.3	38.6	42.8	36.5	40.3	36.4	39.3	40.7
4	46.1	39.7	na	na	31.9	na	55.9	na	na	na	40.7	na	45.6	na	36.9	37.9	44.0	42.8
5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	22.2	21.6	17.3	19.1	22.5	24.3	25.4	27.7	24.9	29.0	27.1	28.2	30.9	30.6	31.4	27.1	26.0	25.2

YEAR	2005		2006		2007		2008		2009		2010		2011	
Sources:	WG data		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	na	na	na	na	na	na	na	na	na	na	14.4	na	8.9
1	19.3	na	20.3	17.8	na	na	na	na	na	na	25.0	25.9	22.5	20.5
2	24.5	na	27.7	19.7	na	na	na	na	na	na	32.1	27.4	32.4	27.3
3	27.6	na	31.3	19.7	na	na	na	na	na	na	43.7	43.2	36.4	34.8
4	24.5	na	37.3	34.3	na	na	na	na	na	na	43.0	44.4	na	na
5	na	na	na	na	na	na	na	na	na	na	55.7	na	na	na
Total	24.1	na	23.0	18.2	na	na	na	na	na	na	28.6	25.0	28.3	20.6

Table 3.3.1.1: Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2012.

Parameters	Anchovy DEPM survey
Surveyed area	(43º17' to 47º23'N & 4º14' to 1º30' W)
R/V	*Ramón Margalef* & *Emma Bardán*
Date	10-30/05/12
Eggs	R/V INVESTIGADOR
Total egg stations	529
% st with anchovy eggs	51%
Anchovy egg average by st	12 eggs/0.1m^2
Max. anchovy eggs in a St	273 eggs/0.1m^2
Total anchovy egg collected	6,377 eggs
North spawning limit	47º15'N
West spawning limit	4ºW
Total area surveyed	80,440 Km^2
Spawning area	39,989 Km^2
CUFES stations	1,156
Adults	R/V EMMA BARDAN
Pelag. trawls	42
With anchovy	28
Selected for analysis	24

Table 3.3.1.2: Bay of Biscay anchovy: Daily egg production (P_0), daily egg mortality rates (z) and total egg production (P_{tot}) estimates with their correspondent standard error (s.e.) and coefficient of variation (CV) for 2012.

Parameter	Value	S.e.	CV
P_0	55.54	10.59	0.1908
z	0.18	0.094	0.5222
Ptot	2.16.E+12	4.1.E+11	0.1908

Table: 3.3.1.3: Bay of Biscay anchovy: Preliminary biomass estimate (SSB) from BIOMAN 2012.

Parameter	estimate	S.e.	CV
Ptot	2.16E+12	4.13E+11	0.1908
R'	0.53	0.0048	0.0090
S	0.25	0.0087	0.0353
F	9,447	856	0.0906
Wf	20.64	1.59	0.0769
DF	59.79	3.47	0.0580
BIOMASS	**36,200**	7,217	0.1994

Table: 3.3.1.4: Bay of Biscay anchovy: SSB, percentage at age, numbers at age, mean weight by age class, SSB at age in mass and percentage at age in mass and the correspondent standard error (s.e.) and coefficient of variation (CV) from BIOMAN 2012.

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**36,200**	7,217	0.1994
Tot. Mean W (g)	18.15	1.77	0.0974
Population (millions)	2,014	448	0.2225
Percent. age 1	0.44	0.07	0.1467
Percent. age 2	0.55	0.06	0.1169
Percent. age 3	0.00	0.00	0.6269
Numbers at age 1	906	281	0.3103
Numbers at age 2	1,104	229	0.2076
Numbers at age 3	4	3	0.6375
W age 1 (g)	12.4		
W age 2 (g)	22.9		
W age 3 (g)	27.8		
SSB at age 1 (Tons)	11,127		
SSB at age 2 (Tons)	24,959		
SSB at age 3 (Tons)	113		

Table 3.3.2.1 : Acoustic biomass index for sardine and anchovy by strata during PELGAS12

	strata	area	anchovy	sardine
SURFACE	1	12 847	704	14 035
	2	4 906	27 700	1 846
	3	-	0	0
CLASSIC	4	2 016	13 620	39 961
	5	4 912	139 741	35 239
	6	3 301	2 488	9 637
	7	7 622	1 343	0
	8	3 160	1 268	104 909
	SUM		186 865	205 627

Table 3.3.2.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*		
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*		
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*		
Horse mackerel	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*		
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*		

Table 3.3.4.1: Bay of Biscay anchovy: Synthesis of the JUVENA surveys on anchovy juveniles from 2003 to 2011.

YEAR	Sampled area (nmi)	Posit area (nmi)	Size juvenile (cm)	Biomass Juvenile (year y)
2003	16,829	3,476	7.9	98,601
2004	12,736	1,907	10.6	2,406
2005	25,176	7,790	6.7	134,131
2006	27,125	7,063	8.1	78,298
2007	23,116	5,677	5.4	13,121
2008	23,325	6,895	7.5	20,879
2009	34,585	12,984	9.1	178,028
2010	40,500	21,110	8.3	599,990
2011	37,500	21,025	6	207,625

Table 3.5.1.1: Bay of Biscay anchovy: Input data for BBM.

			CATCH DATA			DEPM		ACOUSTICS	
Year	h1	h2	C(y,1,1)	C(y,1,1+)	C(y,2,1+)	B(y,1)	B(y,1+)	B(y,1)	B(y,1+)
1987	0.3068	0.1940	2711	8318	6543	14235	29365	NA	NA
1988	0.3253	0.1774	2602	3864	10954	53087	63500	NA	NA
1989	0.2820	0.2328	1723	3876	4442	7282	16720	6476	15500
1990	0.3070	0.2057	9314	10573	23574	90650	97239	NA	NA
1991	0.2347	0.1984	3903	10191	8196	11271	19276	28322	64000
1992	0.2542	0.2184	11933	16366	21026	85571	90720	84439	89000
1993	0.2368	0.2378	6414	14177	25431	NA	NA	NA	NA
1994	0.2331	0.2050	3795	13602	20150	34674	60062	NA	35000
1995	0.2917	0.1751	5718	14550	14815	42906	54700	NA	NA
1996	0.2756	0.1978	4570	9246	23833	NA	39545	NA	NA
1997	0.2078	0.2624	4323	7235	13256	38536	51176	38498	63000
1998	0.1992	0.2567	5898	7988	23588	80357	101976	NA	57000
1999	0.2304	0.2626	2067	10895	15511	NA	69074	NA	NA
2000	0.2569	0.1999	6298	12010	24882	NA	44973	89363	113120
2001	0.2984	0.2195	5481	11468	28671	69110	120403	67110	105801
2002	0.1833	0.2389	1962	7738	9754	6352	30697	27642	110566
2003	0.2997	0.2795	625	2379	8101	16575	23962	18687	30632
2004	0.2989	0.2126	2754	4623	11657	14649	19498	33995	45965
2005	0.1138	0.0741	102	790	372	2063	8002	2467	14643
2006	0.3266	0.0741	484	815	947	15064	21436	18282	30877
2007	0.3181	0.0590	20	67	73	16030	25973	26230	40876
2008	0.2610	0.1991	0	0	0	7579	25377	10400	37574
2009	0.2610	0.1994	0	0	0	9295	24846	11429	34855
2010	0.3134	0.2221	1723	3447	6655	33725	42979	64564	86355
2011	0.2927	0.2575	2747	8307	6182	140555	172223	115379	142601
2012	0.3368	NA	557	3882	NA	11127	36200	73843	186865

h1 and h2 denote the fractions of year to the time point w ithin each period w hen commercial catch is assumed to take place

Table 3.5.1.2: Bay of Biscay anchovy: Median and 95% probability intervals for recruitment, spawning stock biomass, harvest rates (Catch/SSB) and the ratio of SSB with respect to SSB in 1989 as resulted from BBM.

	R (tonnes)			SSB (tonnes)			Harvest rate			SSB/SSB_{1989}		
Year	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%
1987	14300	17020	21900	18430	21860	28600	0.520	0.680	0.806	0.937	1.269	1.596
1988	36250	41385	51020	31430	35700	44530	0.333	0.415	0.471	1.754	2.066	2.327
1989	9485	11730	16220	13860	17280	24630	0.338	0.481	0.600	1.000	1.000	1.000
1990	79710	88570	105003	57840	64825	79100	0.432	0.527	0.590	2.759	3.752	4.782
1991	20510	26250	35670	23210	30230	43670	0.421	0.608	0.792	1.190	1.742	2.458
1992	79879	136200	231900	54710	100900	180300	0.207	0.371	0.683	2.965	5.818	10.459
1993	42180	94060	133300	85990	98410	119500	0.331	0.402	0.461	3.851	5.700	7.621
1994	40740	50050	66470	50620	61060	82020	0.412	0.553	0.667	2.344	3.504	5.097
1995	35100	60415	108303	27720	52580	98391	0.298	0.558	1.059	1.505	2.962	5.749
1996	38269	64740	86783	51710	59490	74252	0.445	0.556	0.640	2.460	3.423	4.547
1997	40680	52900	71391	39100	50990	69920	0.293	0.402	0.524	1.926	2.916	4.255
1998	54560	83240	131200	47960	75130	119700	0.264	0.420	0.658	2.540	4.304	6.991
1999	37889	77960	120603	50759	75340	105400	0.251	0.350	0.520	2.624	4.281	6.689
2000	106300	131600	154900	102300	120600	134300	0.275	0.306	0.361	4.617	6.951	8.894
2001	74120	83535	98601	91520	100400	111900	0.359	0.400	0.439	4.031	5.828	7.386
2002	10440	12780	17160	32200	37170	44680	0.391	0.471	0.543	1.487	2.154	2.808
2003	24370	31130	37700	28560	34910	42340	0.248	0.300	0.367	1.328	2.021	2.657
2004	35510	45660	57090	34000	43660	55160	0.295	0.373	0.479	1.593	2.517	3.410
2005	3941	6523	9038	13160	19690	27010	0.043	0.059	0.088	0.650	1.131	1.647
2006	20120	28960	38811	21910	31455	41800	0.042	0.056	0.080	1.060	1.808	2.596
2007	26040	34925	47841	32400	42390	56680	0.002	0.003	0.004	1.552	2.440	3.444
2008	8921	12440	17510	24160	31010	41201	0.000	0.000	0.000	1.153	1.789	2.515
2009	9464	12580	17210	20220	25475	33420	0.000	0.000	0.000	0.968	1.471	2.049
2010	44320	57370	75021	42340	54180	70170	0.144	0.186	0.239	2.067	3.110	4.331
2011	81570	113900	161203	74990	104200	146200	0.099	0.139	0.193	3.843	5.918	8.903
2012	19010	29280	45400	46310	68180	99841	NA	NA	NA	2.475	3.865	6.041

Table 3.5.1.3: Bay of Biscay anchovy: Summary table of the current state of the stock from BBM.

R_{2012}	Median	29 280
	95 % C.I.	(19 010, 45 400)
SSB_{2012}	Median	68 180
	95 % C.I.	(46 310, 99 841)
SSB_{2012} / SSB_{1989}	Median	3.865
	95 % C.I.	(2.475, 6.041)
P(SSB_{2012} < 21 000)		0

Table 3.6.3.1: Bay of Biscay anchovy: Probability of SSB in 2012 of being below B_{lim} under the undetermined recruitment scenario under different catch options from 1st July 2012 to 30th June 2013 and alternative catch allocation by semesters.

P(SSB<B_{lim})			% CATCHES IN THE 2nd SEMESTER 2012										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH (July 2012 - June 2013)	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		5000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
		10000	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
		15000	0.005	0.005	0.005	0.005	0.006	0.006	0.007	0.007	0.007	0.008	0.009
		20000	0.013	0.013	0.014	0.016	0.017	0.018	0.020	0.020	0.022	0.023	0.025
		25000	0.028	0.031	0.034	0.036	0.038	0.041	0.044	0.046	0.049	0.052	0.055
		30000	0.053	0.057	0.060	0.064	0.068	0.072	0.077	0.082	0.086	0.091	0.095
		33000	0.071	0.076	0.081	0.086	0.091	0.096	0.101	0.106	0.110	0.115	0.119

Table 3.6.3.2: Bay of Biscay anchovy: Median SSB in 2013 under the undetermined recruitment scenario under different catch options from 1st July 2011 to 30th June 2012 and alternative catch allocation by semesters.

SSBmedian			% CATCHES IN THE 2nd SEMESTER 2012										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R undetermined	TOTAL CATCH (July 2012 - June 2013)	0	69393	69393	69393	69393	69393	69393	69393	69393	69393	69393	69393
		5000	66677	66618	66560	66502	66444	66386	66328	66270	66212	66154	66095
		10000	63960	63844	63727	63611	63495	63379	63262	63146	63030	62914	62798
		15000	61243	61069	60894	60720	60546	60371	60197	60023	59848	59674	59500
		20000	58526	58294	58061	57829	57596	57364	57132	56899	56667	56434	56202
		25000	55809	55519	55228	54938	54647	54357	54066	53776	53485	53194	52904
		30000	53093	52744	52395	52047	51698	51349	51001	50652	50303	49955	49606
		33000	51463	51079	50696	50312	49929	49545	49161	48778	48394	48011	47627

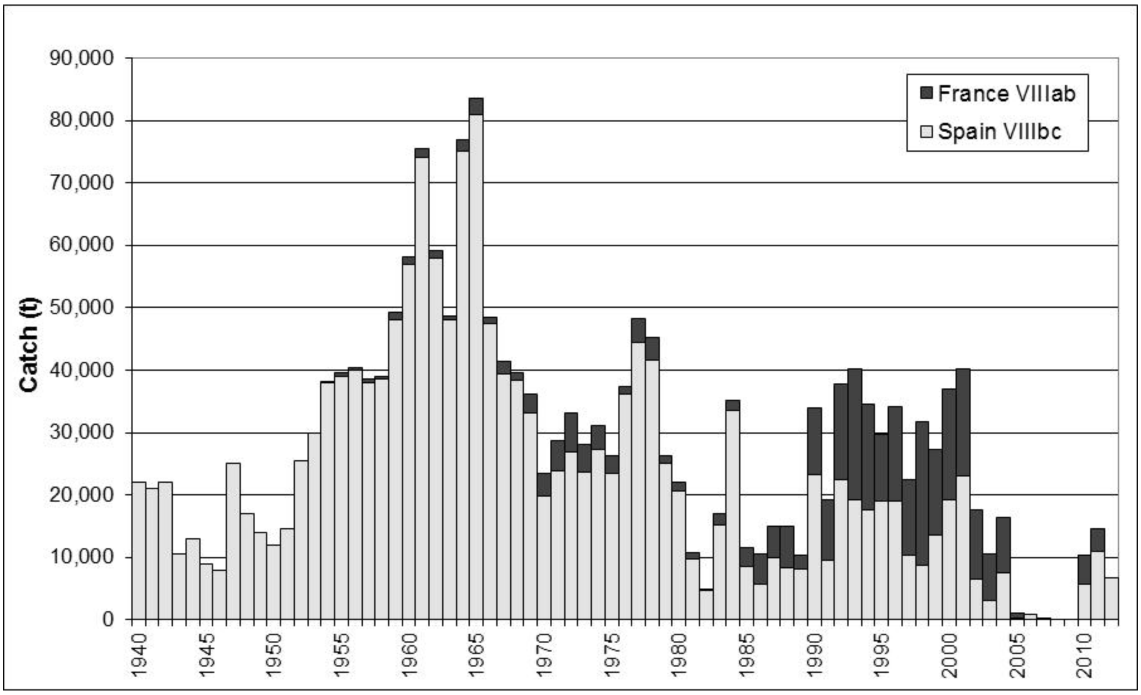


Figure 3.2.2.1: Bay of Biscay anchovy: Historical evolution of catches in division VIII by countries. Catches in the last year (2012) correspond only to the period until end of May.

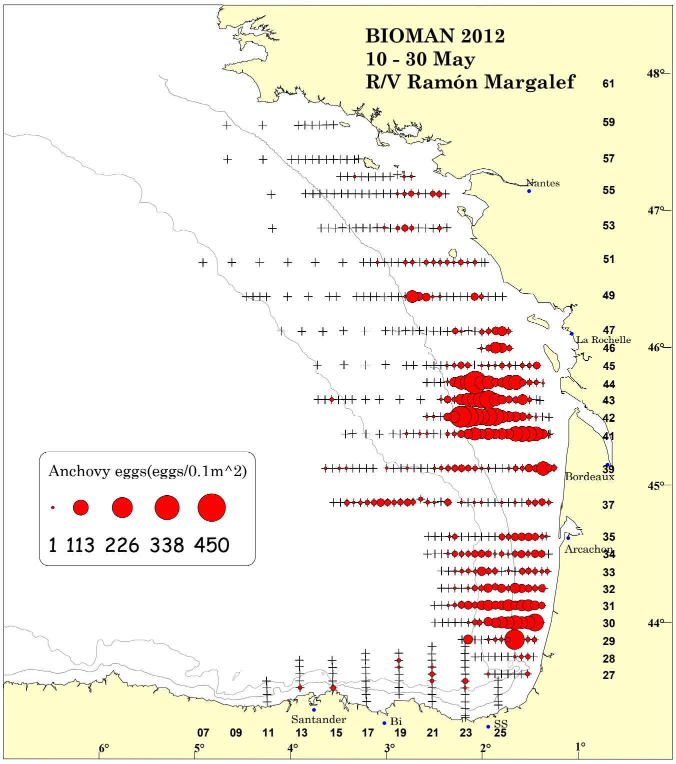


Figure 3.3.1.1: Bay of Biscay anchovy: Distribution of egg abundance (eggs per m²) from the DEPM survey BIOMAN2012 obtained with PairoVET.

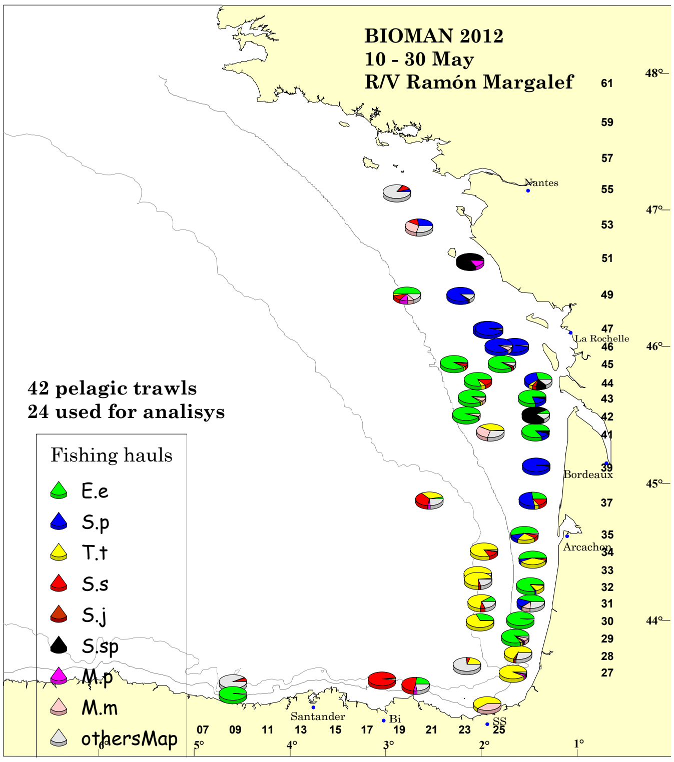


Figure 3.3.1.2: Bay of Biscay anchovy: Species composition of the 42 pelagic trawls from the R/V Emma Bardán during BIOMAN2012.

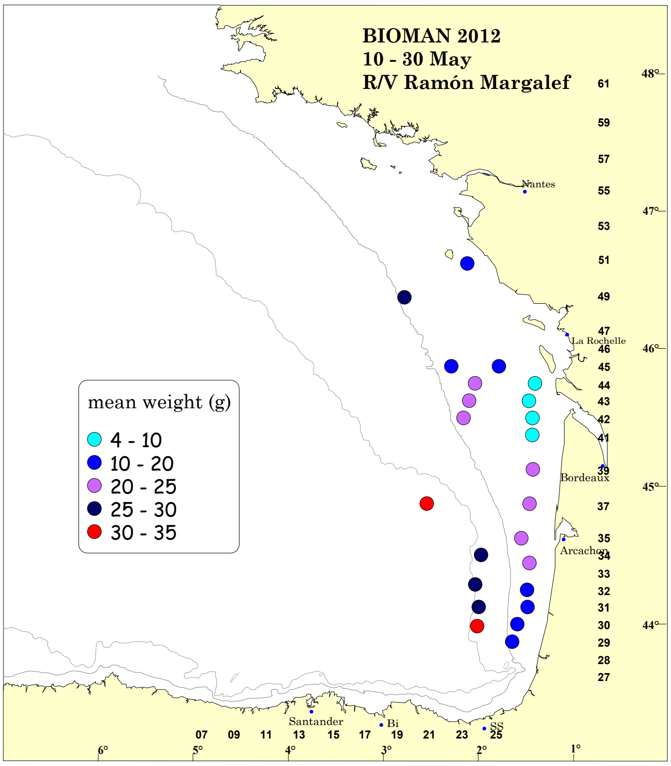


Figure 3.3.1.3: Bay of Biscay anchovy: Spatial distribution of the mean weight (males and females) per haul in BIOMAN2012.

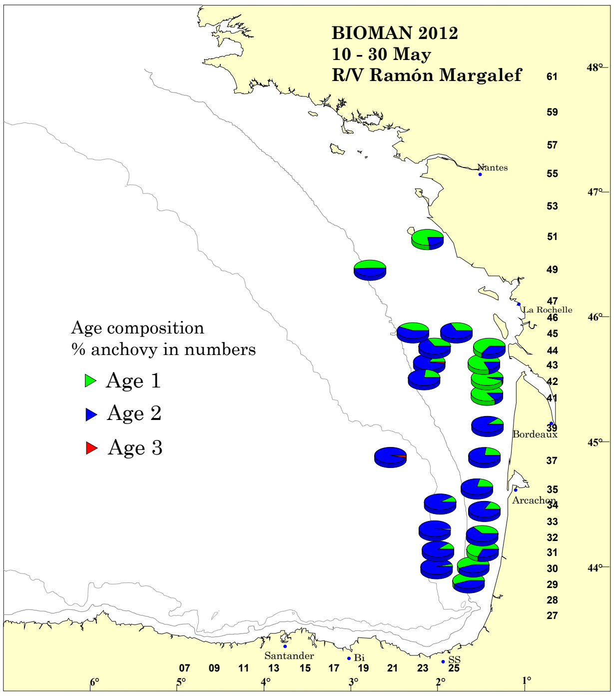


Figure 3.3.1.4: Bay of Biscay anchovy: Age composition per haul in BIOMAN2012.

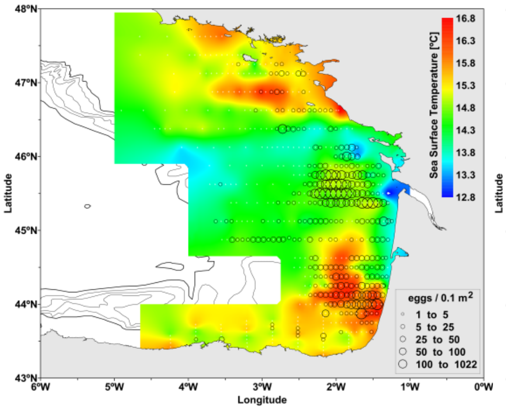


Figure 3.3.1.5: Bay of Biscay anchovy: From left to right spatial distribution of SST and SSS in BIOMAN 2012. The bubbles represent the anchovy egg abundance.

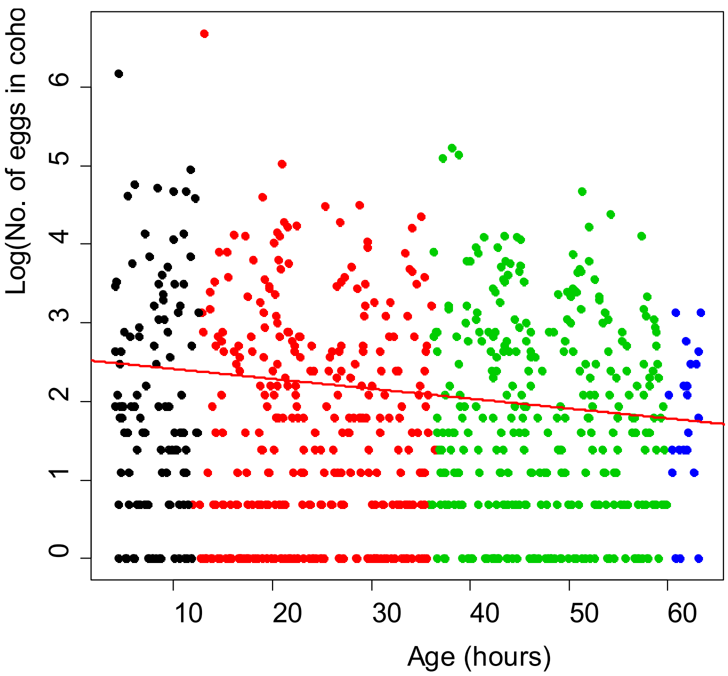


Figure 3.3.1.6: Bay of Biscay anchovy: Exponential mortality model adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak assumed to be at 23:00h).The red line is the adjusted line. The point colours represent the different cohorts.

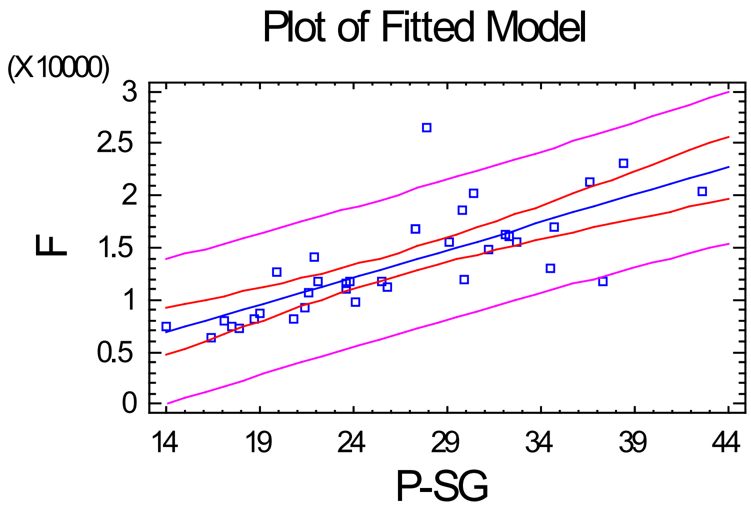


Figure 3.3.1.7: Bay of Biscay anchovy: Fitted linear model (in blue) between the batch fecundity and the gonad-free weight of the females. The red and pink lines represent the confidence and prediction intervals.

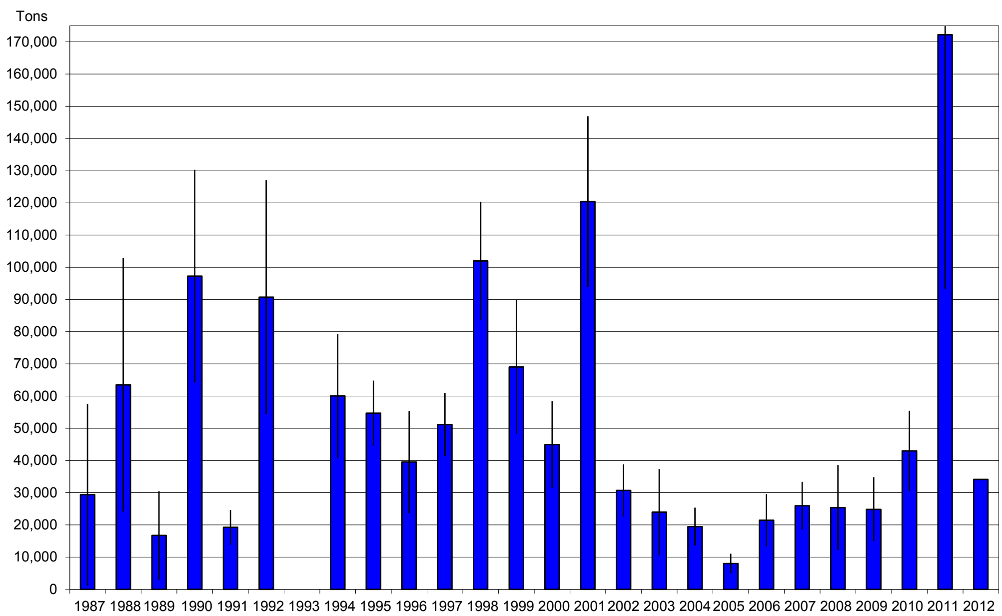


Figure 3.3.1.8: Bay of Biscay anchovy: Series of biomass estimates (in tonnes) obtained from the DEPM. In 1996, 1999, 2000, 2007, 2008, 2009, 2010 and 2011 the spawning fraction was deduced indirectly.

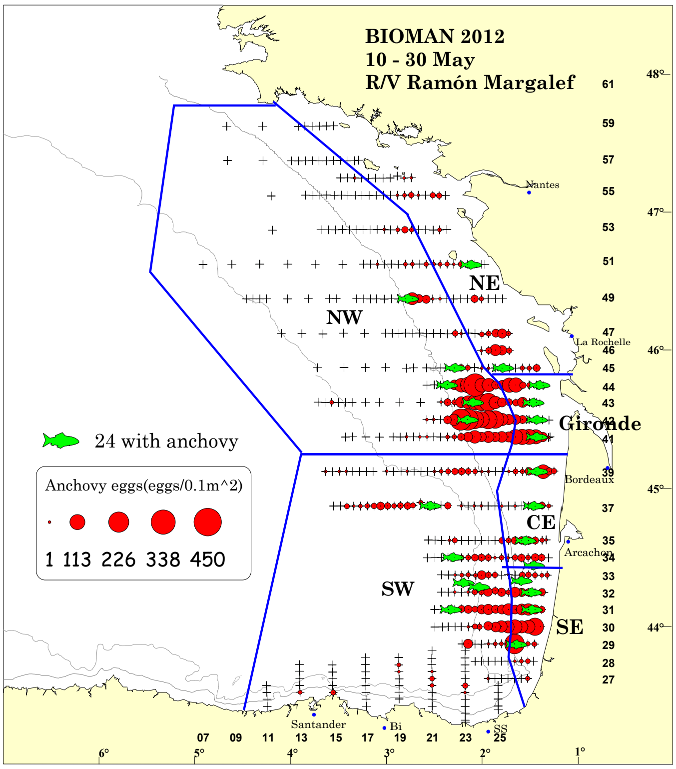


Figure 3.3.1.9: Bay of Biscay anchovy: Spatial strata to estimate the numbers at age in BIOMAN2012.

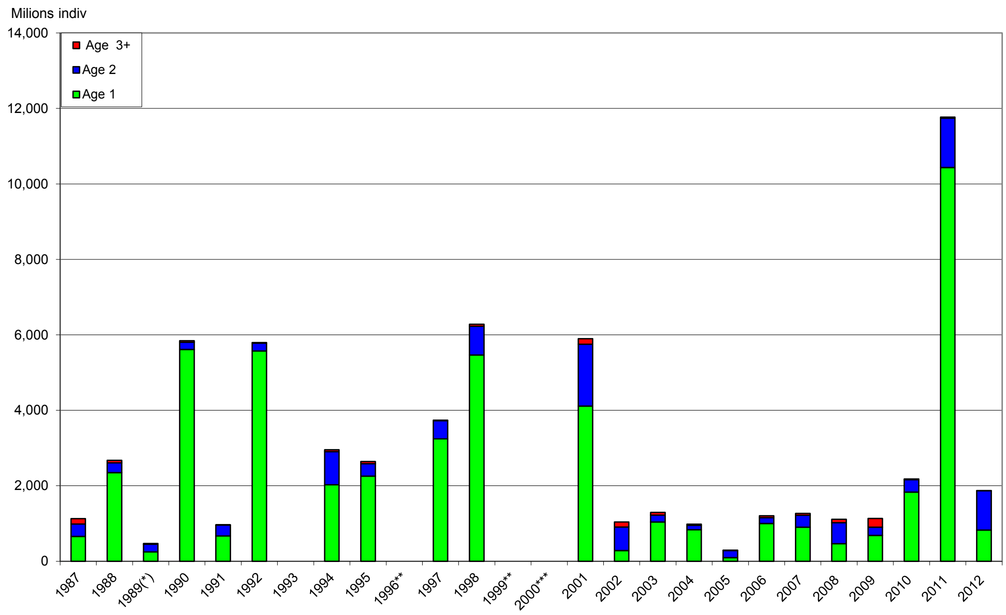


Figure 3.3.1.10: Bay of Biscay anchovy: Historical series of numbers at age from 1987 to 2012 from BIOMAN surveys.

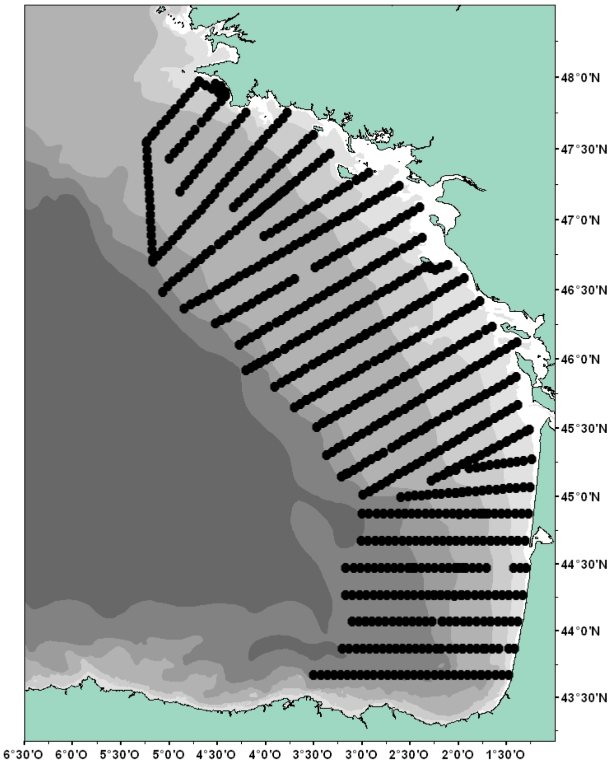


Figure 3.3.2.1. Acoustic transects network during PELGAS12 survey

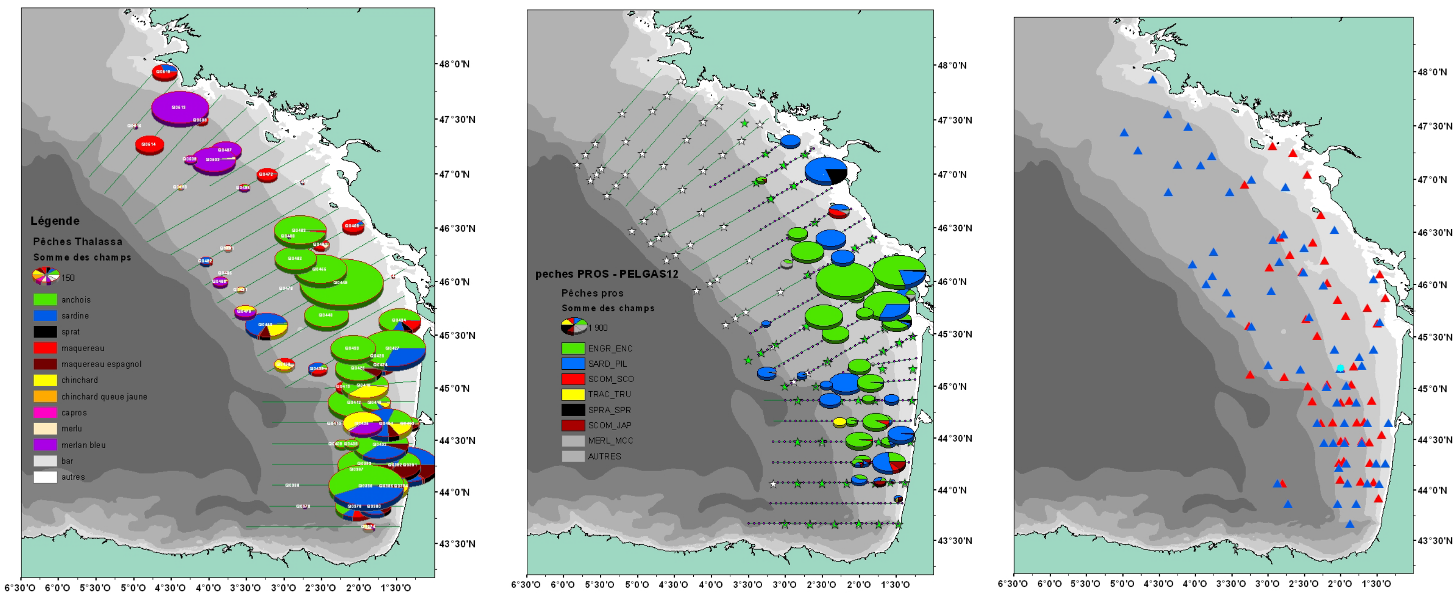
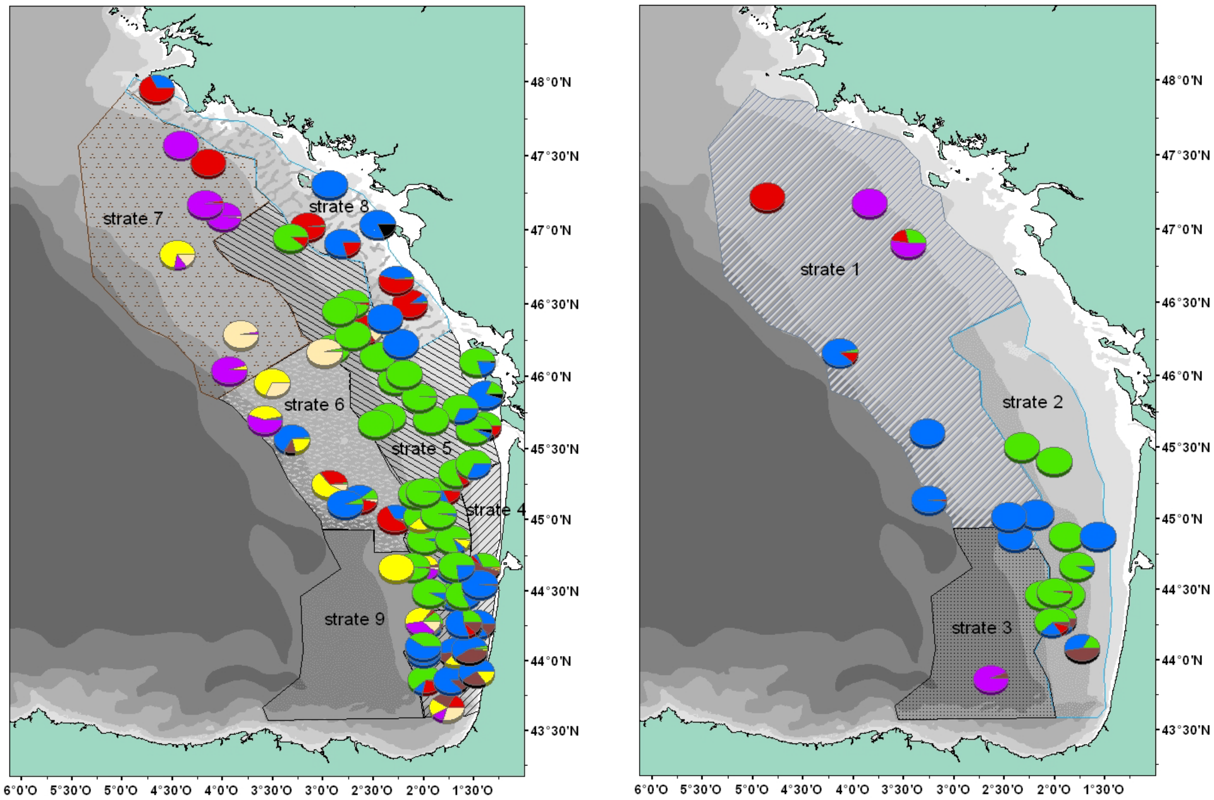


Figure 3.3.2.2 fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS12



Classic strata Surface strata

Figure 3.3.2.3. Coherent strata (for classic and surface echotraces) according to species distributions for abundance indices estimates.

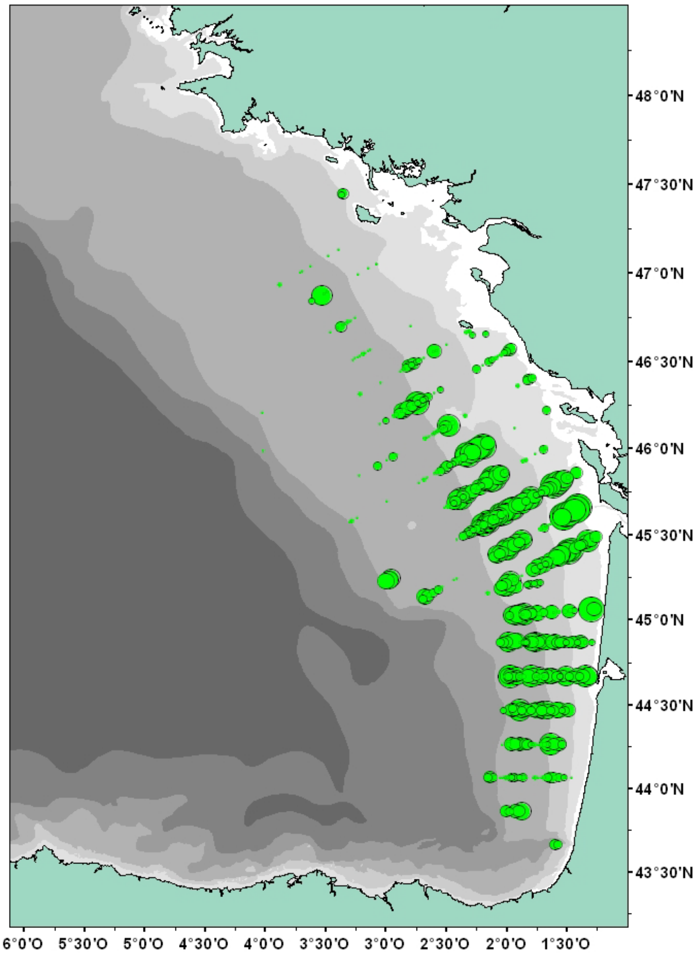


Figure 3.3.2.4. Adult anchovy distribution (density / ESDU)

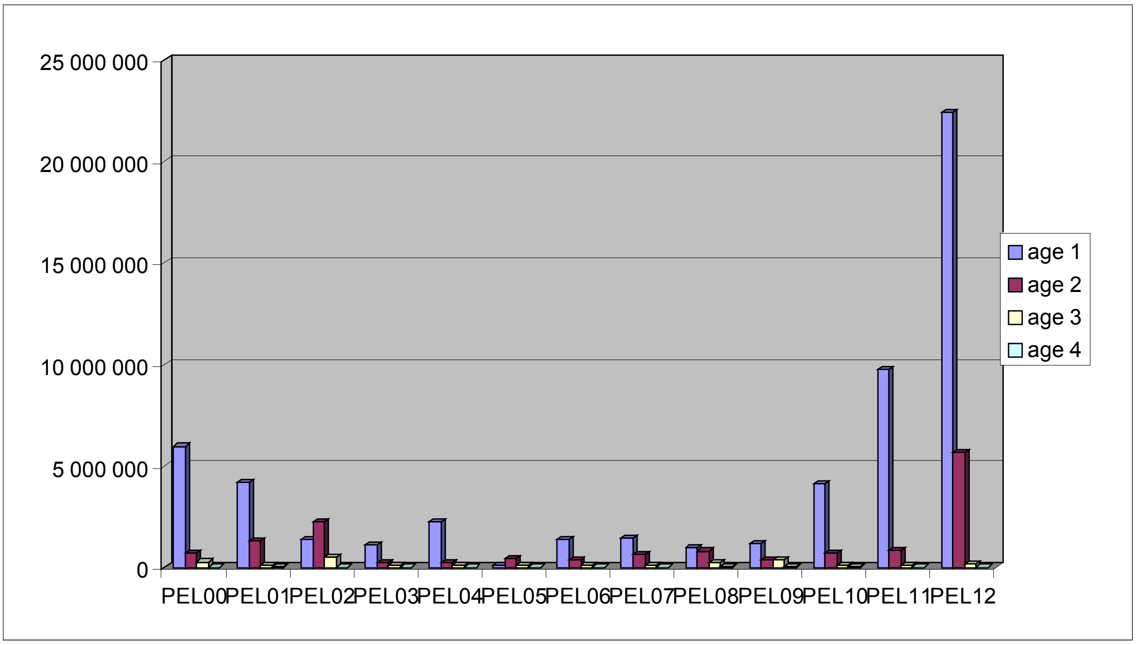


Figure 3.3.2.5. Age distribution of anchovy along PELGAS series.

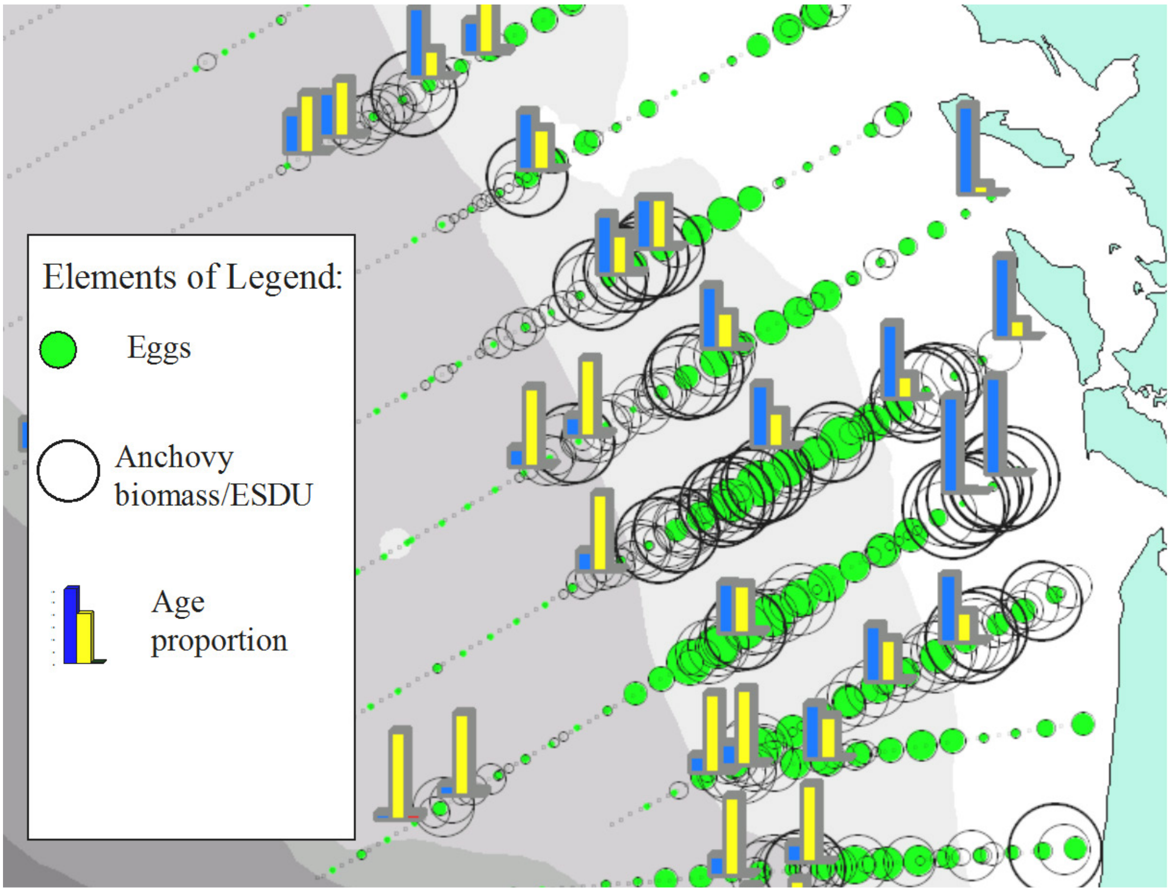


Figure 3.3.2.6. – Eggs, adults and age structure of anchovy – zoom in the Gironde area

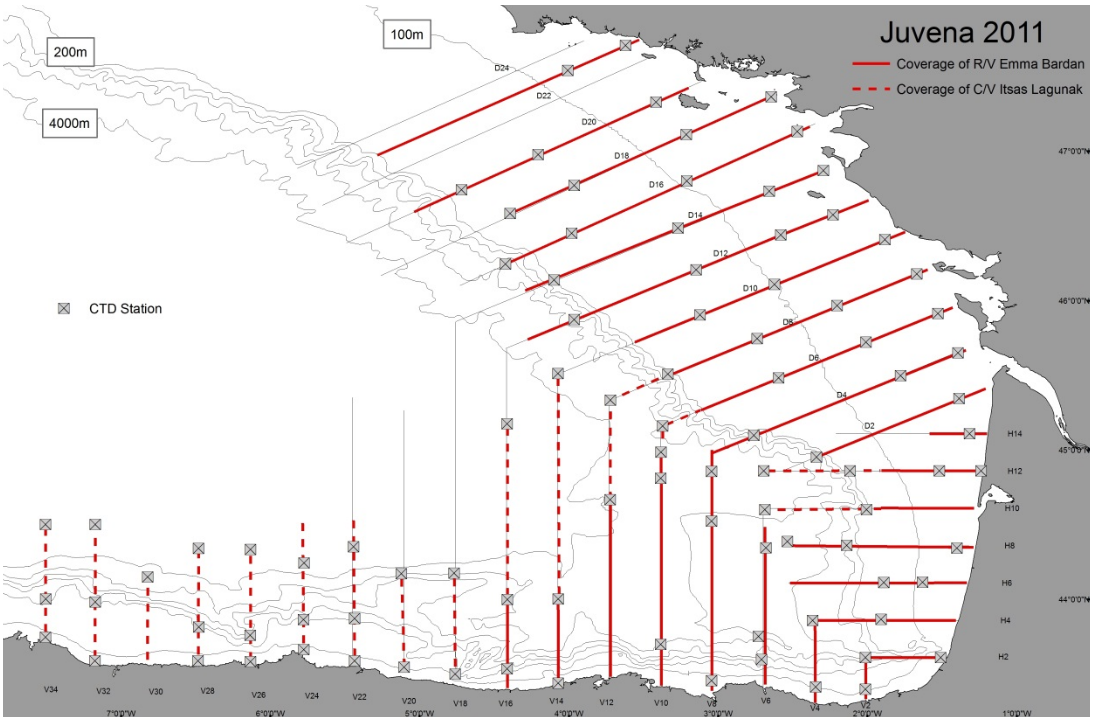


Figure 3.3.4.1: Bay of Biscay anchovy: Planned (soft grey line) and actual transects (red solid line for the EB and dashed line for the IL). The CTD stations are also shown (solid squares).

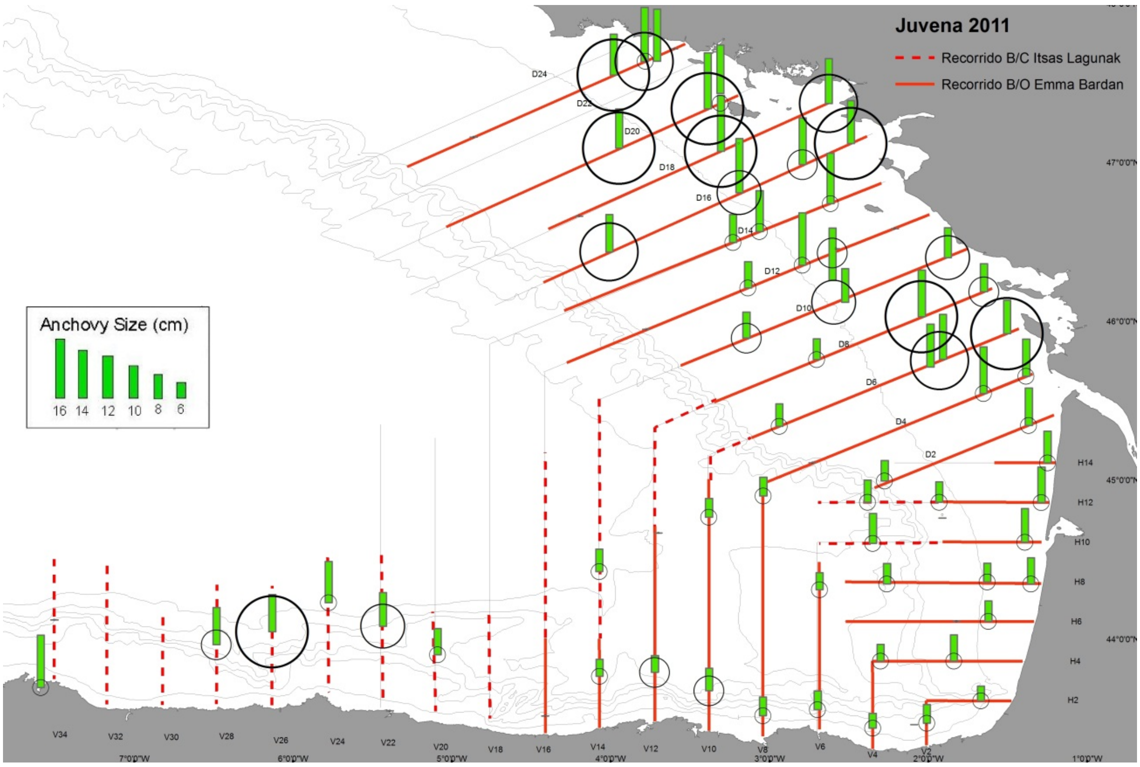


Figure 3.3.4.2: Bay of Biscay anchovy: The circles represent the positive anchovy hauls. The diameter of the circles is proportional to the captured weight of anchovy. The length of the bars is proportional to the mode of the size (standard length) of the captured anchovy.

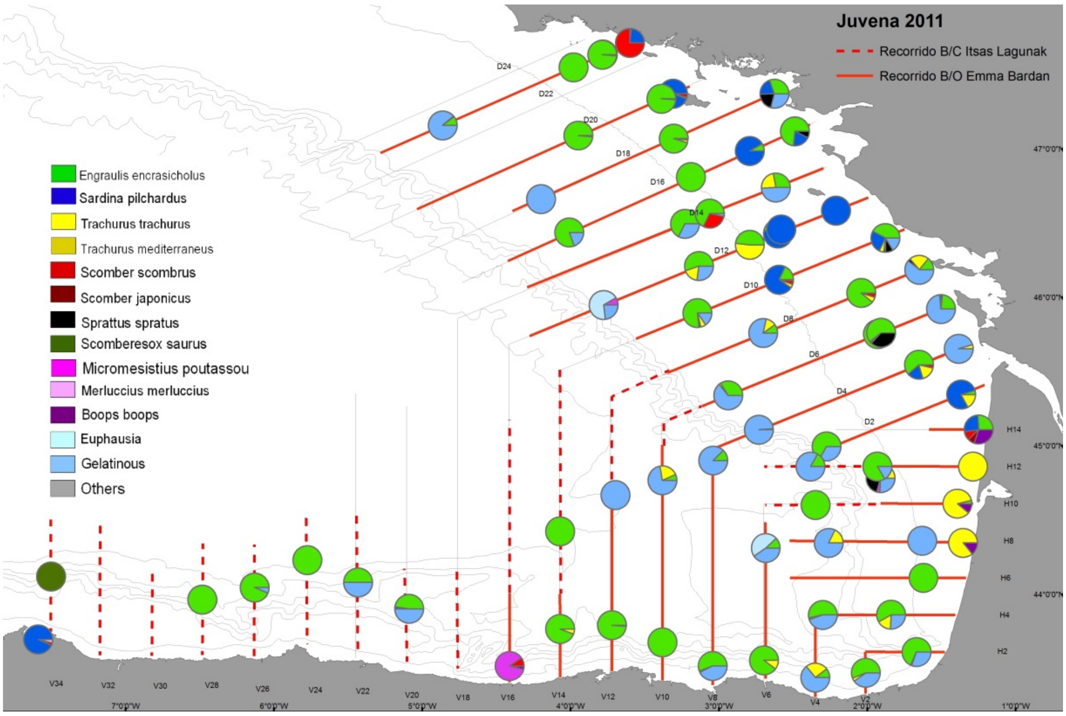


Figure 3.3.4.3: Bay of Biscay anchovy: Species composition of the hauls in JUVENA 2011.

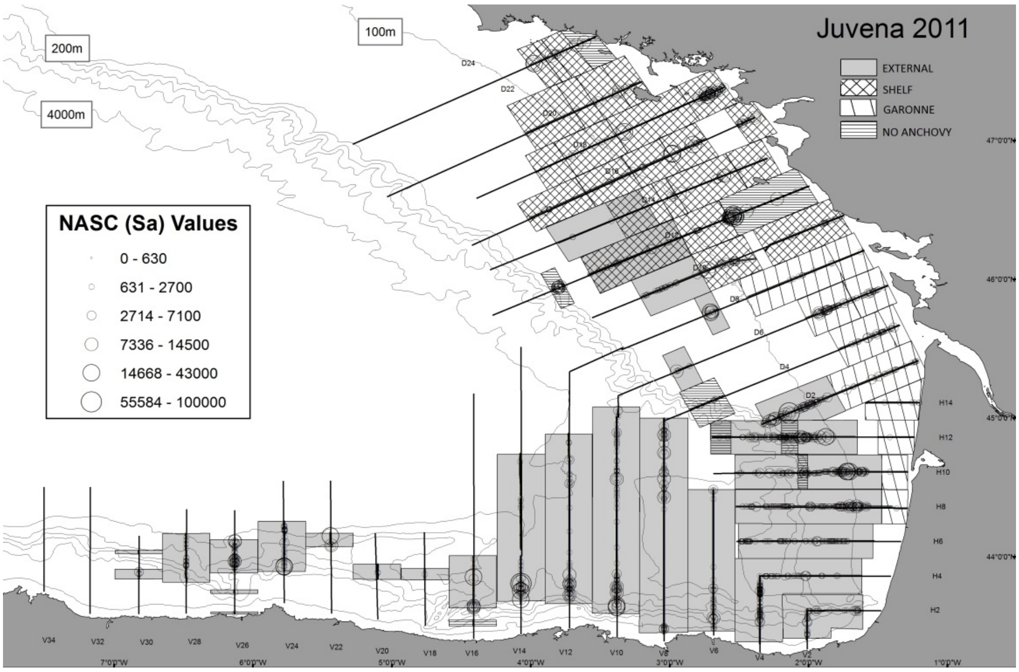


Figure 3.3.4.4: Bay of Biscay anchovy: Total acoustic energy (NASC) of all the identified species and the three subareas of the positive area for anchovy.

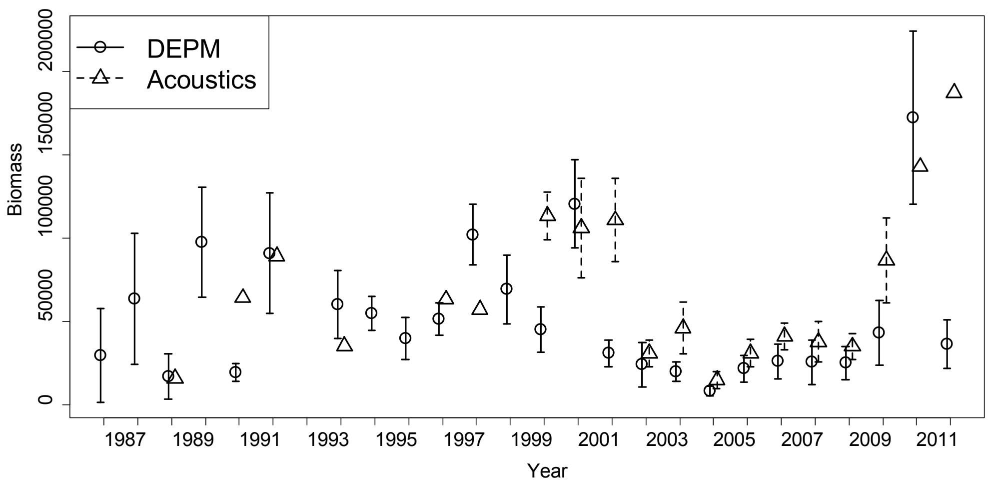


Figure 3.5.1.1: Bay of Biscay anchovy: Historical series of spawning stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

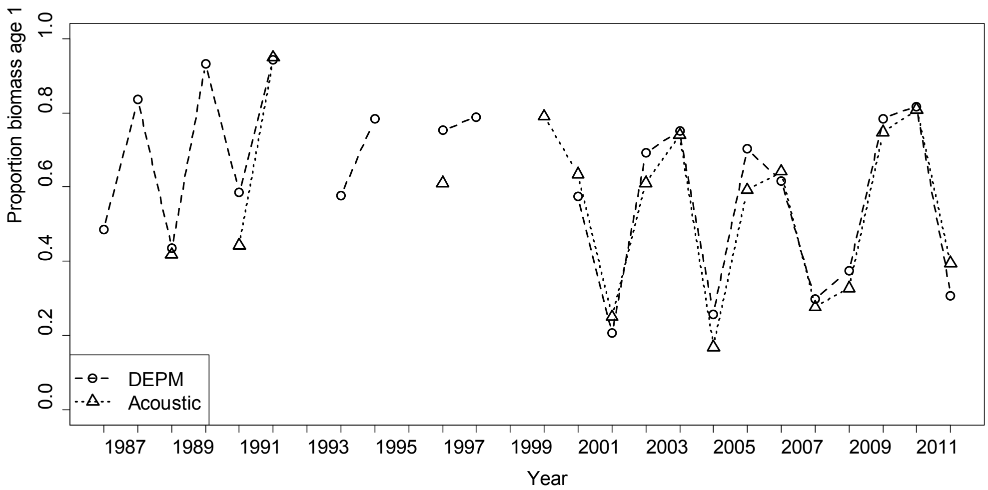


Figure 3.5.1.2: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

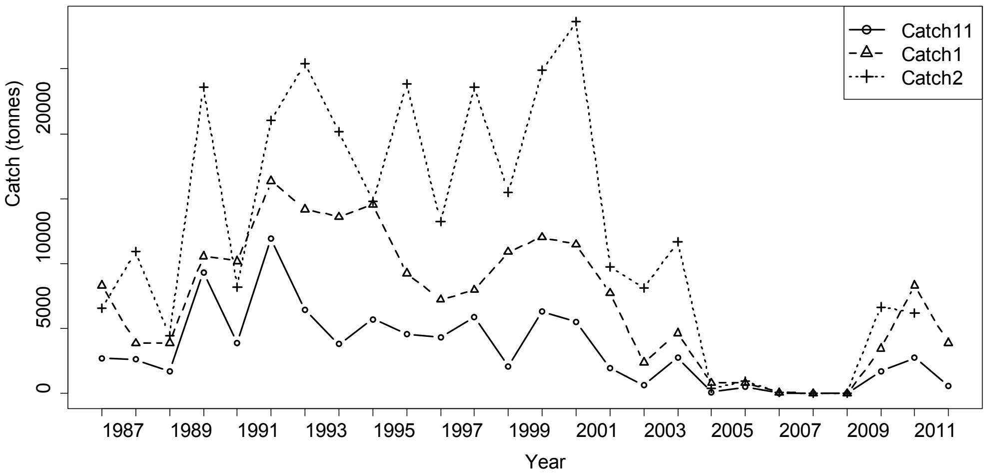


Figure 3.5.1.3: Bay of Biscay anchovy: Historical series of age 1 and total catch in the first period (1st January-15th May) (solid line and open circle and dashed line and triangle respectively) and of total catch in the second period (15th May-31st December) (dotted line and cross).

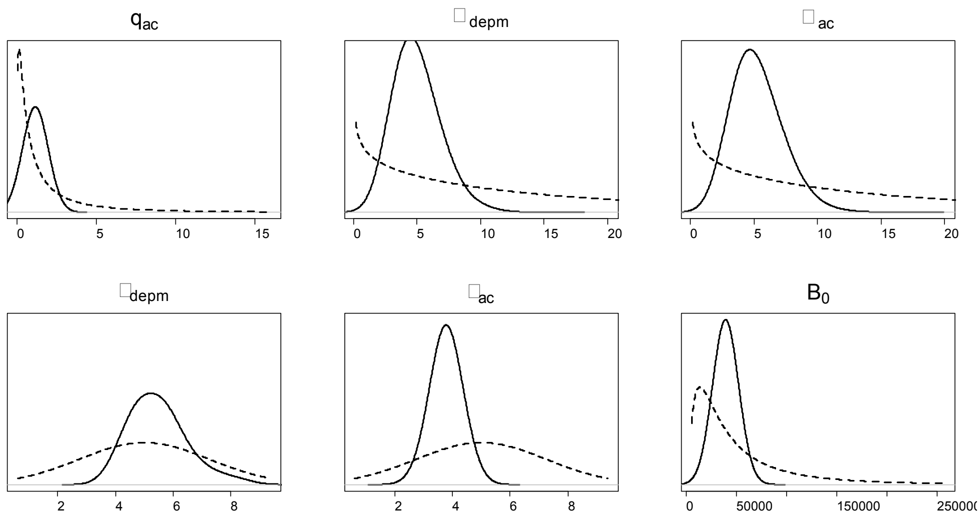


Figure 3.5.1.4: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of BBM.

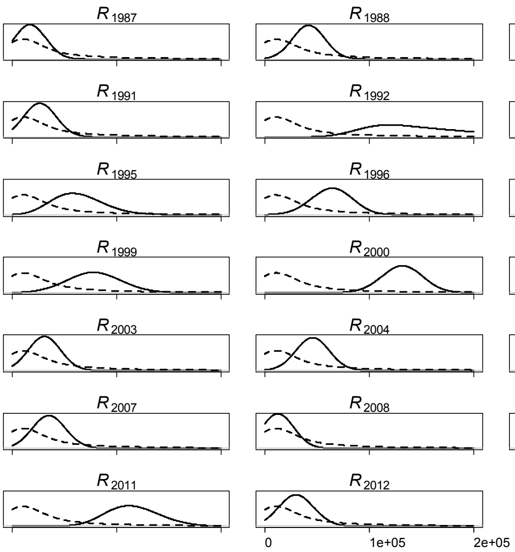


Figure 3.5.1.5: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for recruitment in BBM.

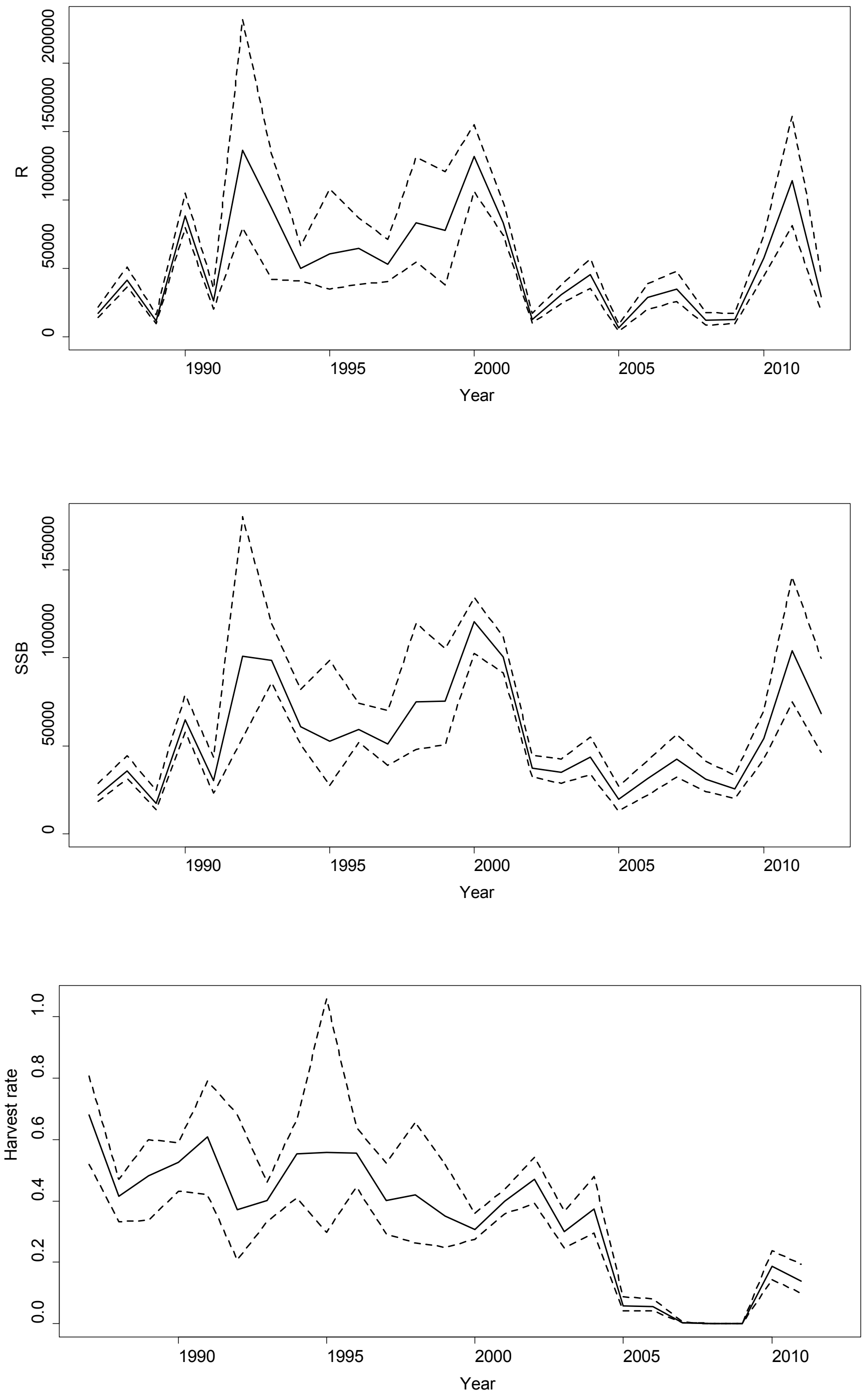


Figure 3.5.1.6: Bay of Biscay anchovy: Posterior median (solid line) and 95% probability intervals (dashed lines) for the recruitment (age 1 in mass in January), the spawning stock biomass and the harvest rates (Catch/SSB) from the BBM.

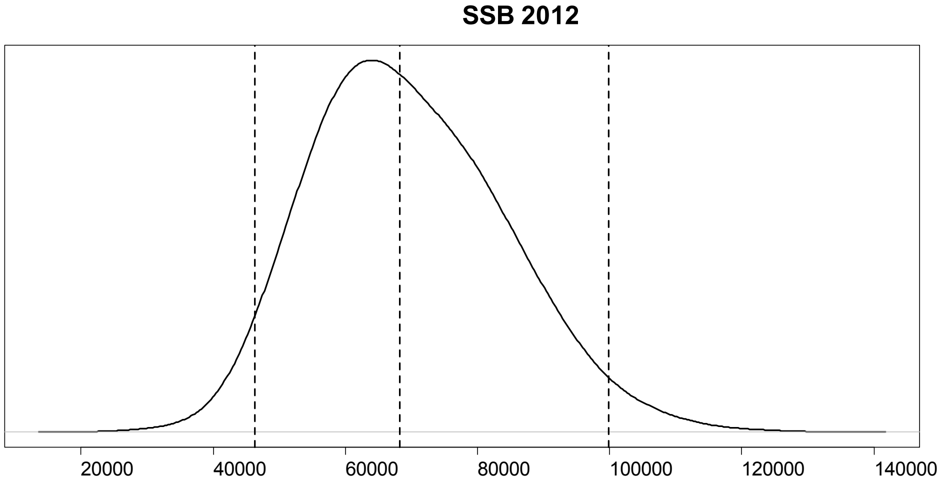


Figure 3.5.1.7: Bay of Biscay anchovy: Posterior distribution of spawning biomass in 2012 from BBM. Vertical dashed lines correspond to posterior median and 95% probability intervals.

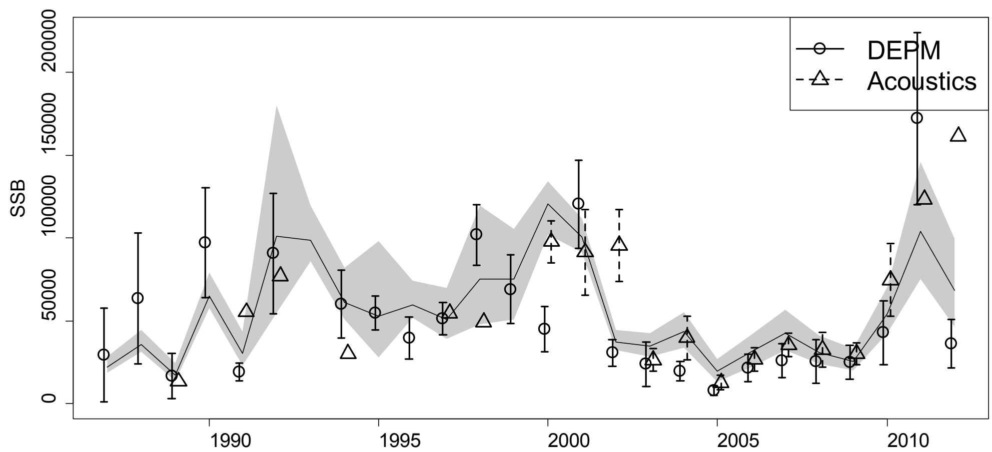


Figure 3.5.2.1: Bay of Biscay anchovy: Comparison of the SSB posterior 95% probability intervals from the BBM (grey area) and the SSB indices corrected by their catchability with the corresponding confidence intervals from DEPM (open circle and solid line) and Acoustics (triangle and dashed line).

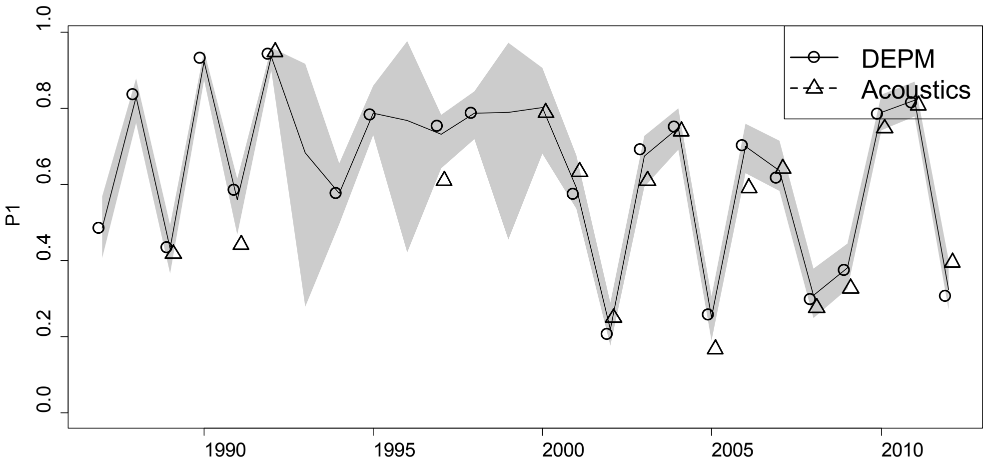


Figure 3.5.2.2: Bay of Biscay anchovy: Comparison of the age 1 biomass proportion posterior 95% probability intervals from the BBM (grey area) and the point estimates from DEPM (open circle) and Acoustics (triangle).

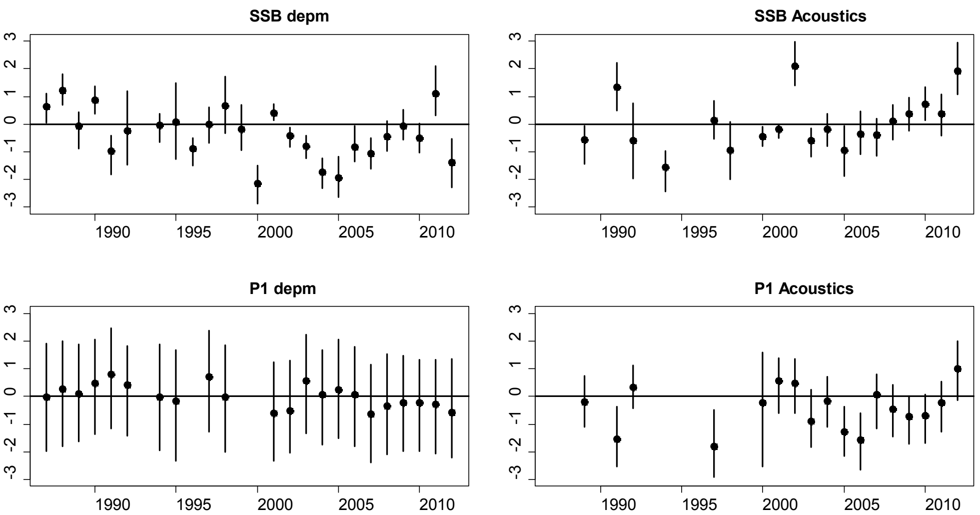


Figure 3.5.2.3: Bay of Biscay anchovy: Pearson residual medians and 95% probability intervals to the four indices used in the BBM.

Figure 3.5.2.4: Bay of Biscay anchovy: Comparison between last (in red) and updated (in black) assessment. Solid and lines represent the SSB medians and the 95% probability intervals respectively.

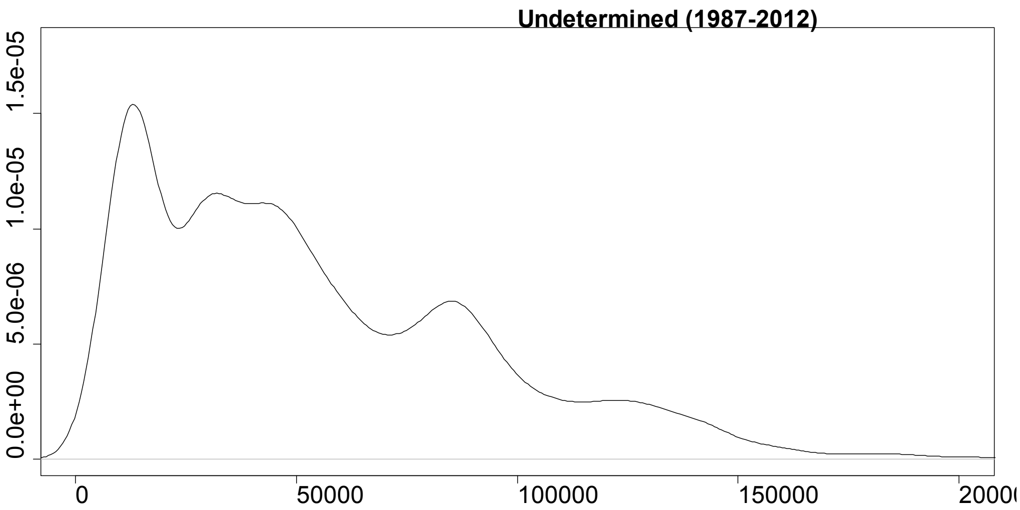


Figure 3.6.1.1: Bay of Biscay anchovy: Undetermined recruitment (age 1 mass in January) scenario for 2013.

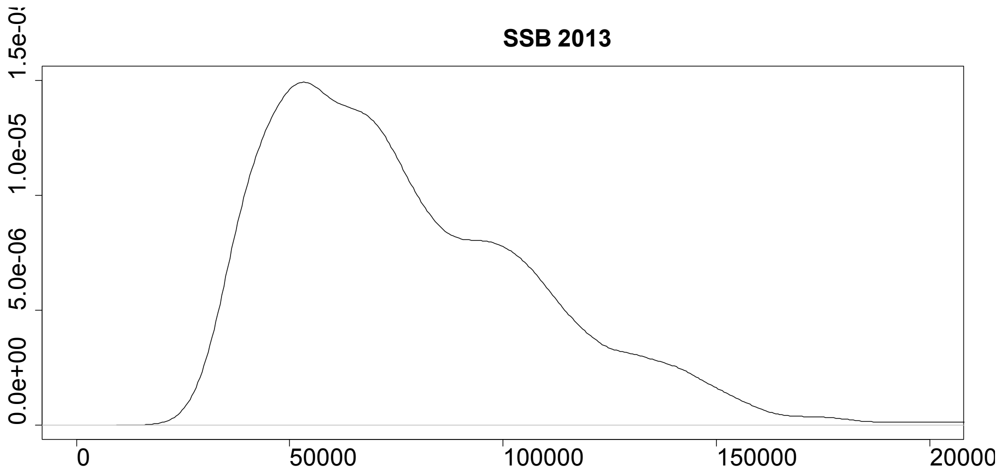


Figure 3.6.3.1: Bay of Biscay anchovy: Distribution of SSB in 2013 constructed from the posterior distribution of SSB in 2012 and the undetermined recruitment scenario in the absence of fishing.

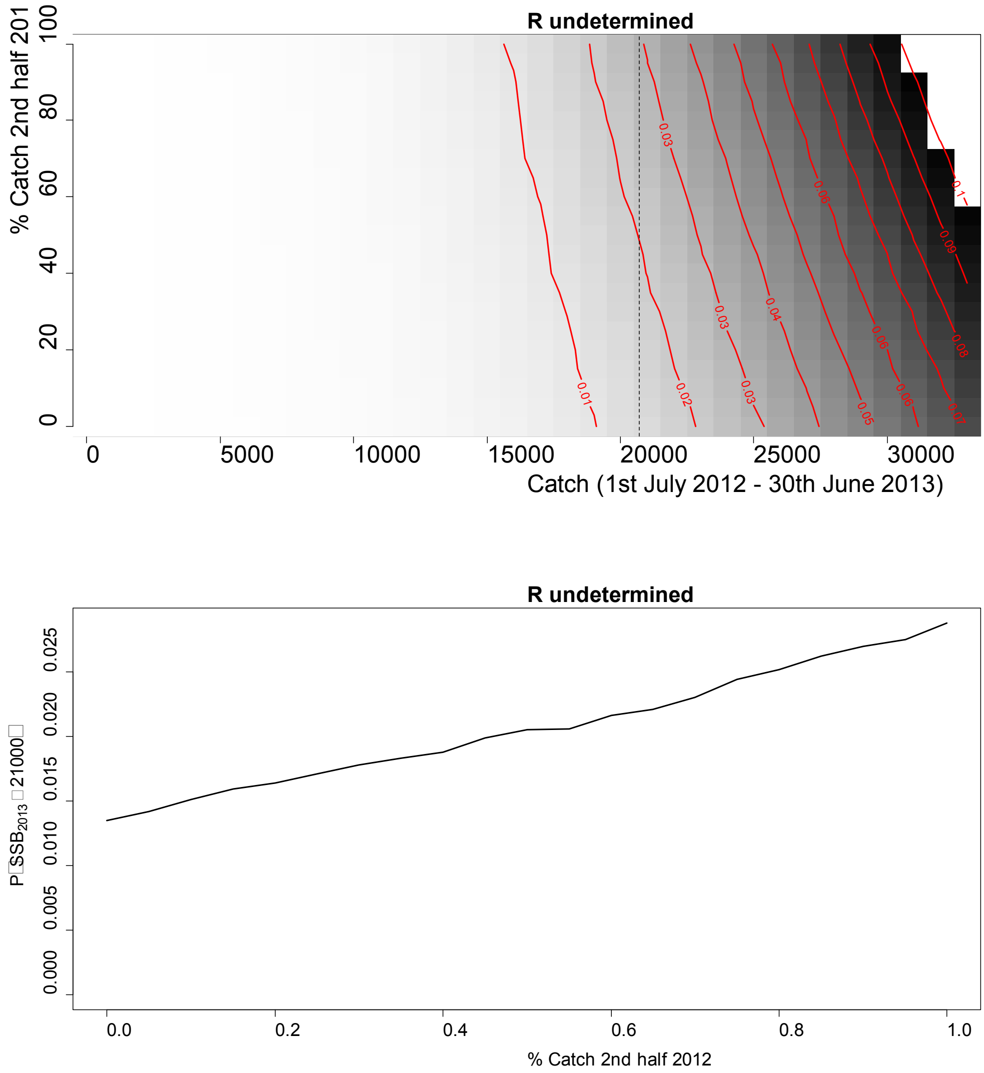


Figure 3.6.3.2: Bay of Biscay anchovy: In the top panel contour plots of probability of SSB in 2013 of falling below B_{lim} depending on the total catch from 1st July 2012 to 30th June 2013 (x-axis) and the percentage of catch corresponding to the second half of 2012 (y-axis) under the undetermined recruitment scenario (top panel). The vertical dashed line represents the TAC of 20 700 t for 2012-2013 under the long term management proposal. In the bottom panel probability of SSB in 2013 of falling below B_{lim} (y-axis) for catch levels equal to 29 700 t depending on the percentage of catch corresponding to the second half of 2011 (x-axis).

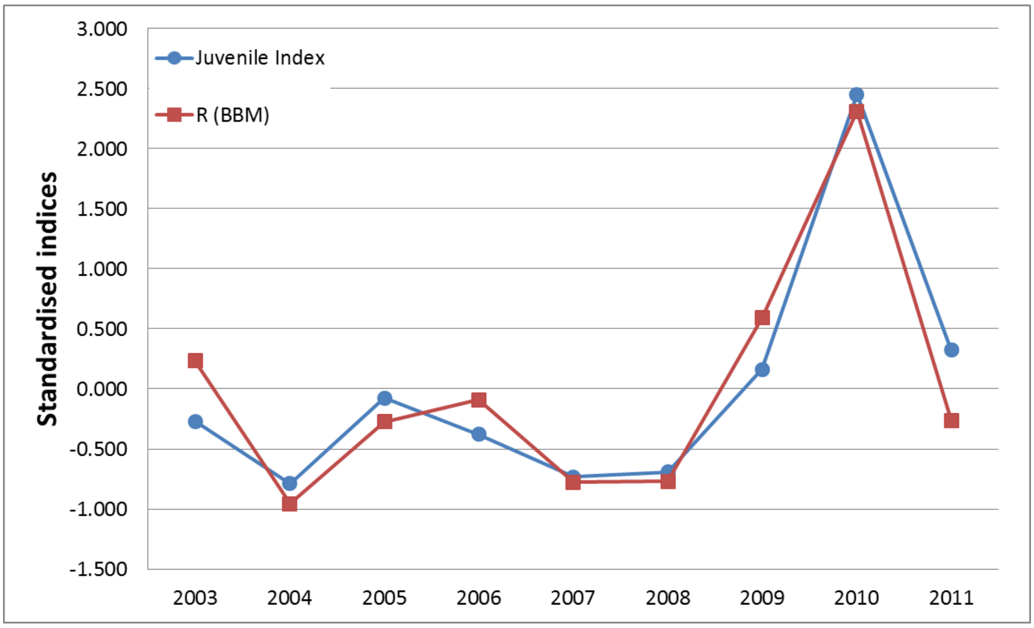


Figure 3.9.1: Bay of Biscay anchovy: Times series of the JUVENA anchovy juveniles abundance index (in blue) and of the recruitment (median of the age 1 biomass at the beginning of the next year) as estimated by BBM. Each of the series is standardized according to its mean and its variance.

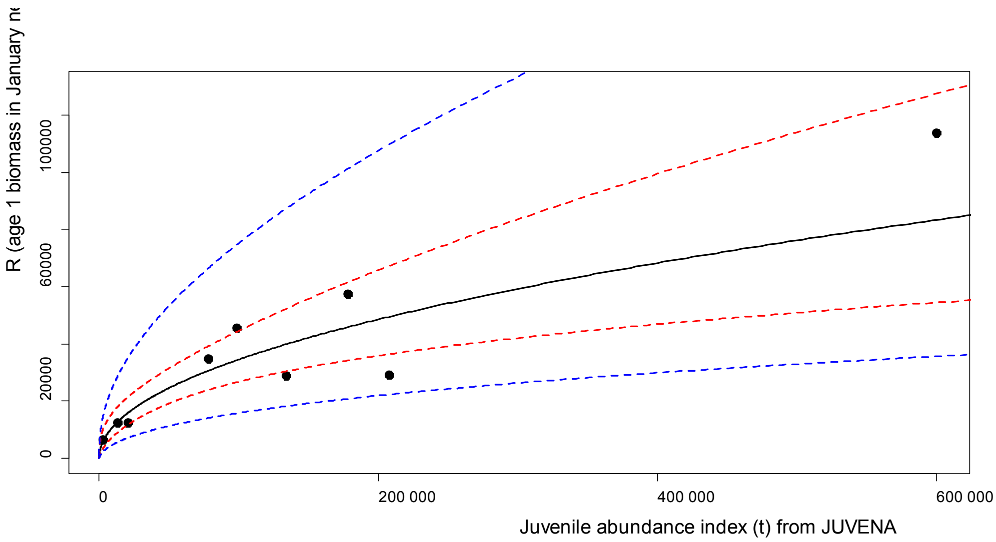


Figure 3.9.2: Bay of Biscay anchovy: Log linear model fitted to the recruitment (median of the age 1 biomass at the beginning of the next year, y-axis) as estimated by BBM and the juvenile abundance index from the JUVENA surveys (x-axis, in tones). The bullets represent the observed points from 2003 to 2010. The solid black line is the fitted model, whereas the red and blue dashed lines are the 95% confidence and prediction intervals.

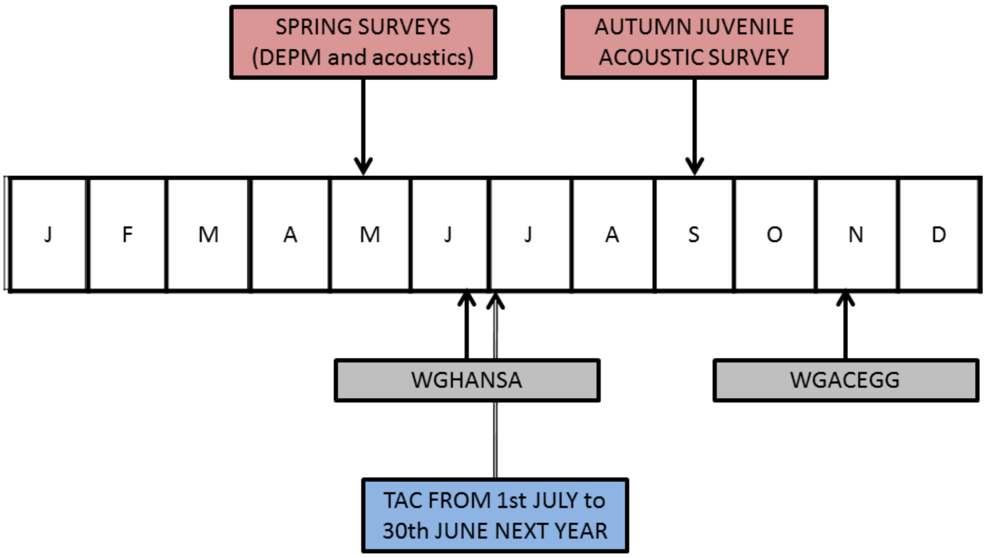


Figure 3.9.3: Bay of Biscay anchovy: Calendar with the main events related to the current assessment and management of the Bay of Biscay anchovy.

4 Anchovy in Division IXa

4.1 ACOM Advice Applicable to 2011 and 2012

ICES advice from recommendations from the former ACFM in December 2005 (ICES, 2005 a) firstly stated that the state of the anchovy stock in Division IXa was unknown because of the inadequacy of the available information to evaluate the spawning stock or fishing mortality relative to risk (precautionary limits). So far, these shortcomings are still preventing from the provision of explicit management objectives for this stock and the estimation of appropriate reference points. Accordingly, ICES advice in relation to the exploitation boundaries of this stock stated in that year that catches since 2007 should be restricted to 4 800 t (mean catches from the period 1988-2005, excluding 1995, 1998, 2001, and 2002, the years when catches were probably influenced by exceptionally high recruitment), and that this catch level should be maintained until the response of the stock to the fishery is known. Such an advice was repeatedly provided until 2010. Nevertheless, the agreed TAC for anchovy from 2002 to 2010 (for ICES Subareas IX and X and EC waters of the CECAF Sub-area 34.1.1) was of 8 000 t.

The above advice was revised in 2010 since both the most recent survey biomass index for the Portuguese acoustic survey and the disappearance of 0- group fish in the landings indicated a declining stock in the Subdivision IXa-South, where the bulk of the fishery takes place. Under the MSY approach the facts of a stock showing signs of decrease and the absence of reliable indicators for exploitation status implied that catches should be reduced from recent levels at a rate greater than the rate of stock decrease. In light of the EU policy paper on fisheries management (17 May 2010, COM(2010) 241) this stock can be classified under category 5 because it is a short lived species. However, because no advice based on a biomass escapement strategy is available, the stock was classified under category 9 because the state of the stock is not known precisely, but there were indications of a declining stock. Using the maximum 15% reduction in TAC for this category, the resulting TAC would be 6 800 t. However, TAC agreed for 2011 was set at 7 600 t, with national catch quotas being established at 3 635 t for Spain and 3 965 t for Portugal. In any case, ACOM notes that TACs have not been restrictive to the fishery. Thus, as described in the present report, anchovy catches in Division IXa in 2011 (10 076 t) accounted for a three-fold increase in relation to the value recorded in 2010 (3 013 t), after a period of three years with catch levels amongst the lowest ones recorded in the recent years.

ICES advice in 2011, based on precautionary considerations, established that catches in 2012 should be reduced. These precautionary considerations were an uncertain but decreased stock trend for anchovy in the southern area in the most recent years (2009 and 2010) and a steep increase in biomass in spring 2011 in the northern part of Division IXa, although the effect on the population for 2012 cannot be predicted. For 2012 the TAC has been agreed in 8 360 t, with national catch quotas being established at 3 998 t for Spain and 4 362 t for Portugal.

Given the high natural mortality experienced by this stock, its high dependence upon recruitment (the fishery depends largely on the incoming year class, the abundance of which cannot be properly estimated before it has entered the fishery), and the large inter-annual fluctuations observed in the spawning stock, ICES is aware that the state of this resource can change quickly. Therefore an in-year monitoring and management, or alternative management measures should be considered. However, such measures should take into account the data limitation on the stock and the need for a reliable index of recruitment strength.

4.2 The Fishery in 2011

4.2.1 Fishing fleets

Anchovy harvesting throughout the Division IXa is at present carried out by the following fleets:

- Portuguese purse-seine fleet.
- Portuguese polyvalent fleet (although fishing with artisanal purse-seines).
- Portuguese trawl fleet for demersal fish species.
- Spanish purse-seine fleet.
- Spanish trawl fleet for demersal fish, crustaceans and cephalopods (in Subarea IXa-South (Cadiz)).

Technical characteristics of the Portuguese fleets fishing anchovy in 2011 in Division IXa are described in the sardine section of this report.

A total of 26 purse-seine vessels operated by Spain were authorized for fishing anchovy in the Sub-division IXa north in 2010. Their average technical characteristics were 22 m length, 49 GRT and 325 HP. No updating of this information for 2011 has been provided to this WG.

Number and technical characteristics of the purse-seine vessels operated by Spain in their national waters off Gulf of Cadiz (Sub-division IXa south), differentiated between total operative fleet and fleet targeting anchovy are summarised in **Table 4.2.1.1** and **Figure 4.2.1.1**. In 2011, the entire Spanish purse-seine fleet fishing in the Gulf of Cadiz was composed by 90 vessels, with 81 vessels dedicated in a greater or lesser extent to the anchovy fishing. Details of the dynamics of this fleet in terms of number of operative vessels over time in recent years are given in the Stock Annex and in previous WG reports.

4.2.2 Catches by fleet and area

4.2.2.1 Catches in Division IXa

The WG estimates of landings are shown in **Table 4.2.2.1.1**. These estimates may differ from the official figures supplied to ICES, because as a result of a crossing of the auction sales, available logbooks and data communicated to the administrations, some unallocated catches were estimated to have occurred, although by an amount of only 0.6% of total estimated catches. Therefore the WG decided to maintain the WG estimates in the subsequent reporting of catches all throughout the tables and figures.

Anchovy total landings in 2011 were 10,076 t, the third highest record in the recent historical series, which represented a 214% increase with regard to the 2010 landings (3,210 t). It should be noted that annual landings for the period 2008-2010 were amongst the lowest annual levels ever recorded in the most recent historical series (**Table 4.2.2.1.1**, **Figure 4.2.2.1.1**). The contribution by each sub-division to the total catch was characterized in 2011 by strong increases in landings both in the northernmost sub-divisions (mainly the IXa Central-North, accounting for 32% of the whole anchovy landed in the Division) and in the Spanish part of the Sub-division IXa-S (IXa S (Cádiz)), accounting for 62% of total landings).

As usual, the anchovy fishery in 2011 was almost exclusively harvested by purse seine fleets (99.8% of total catches; **Table 4.2.2.1.2**). However, unlike the Spanish fleet fishing in the Gulf of Cadiz, the remaining purse-seine fleets in the Division (targeting sardine and fishing anchovy as a commercial by-catch) only target anchovy when its abundance is high, as occurred in 2011.

4.2.2.2 Landings by Subdivision

The updated historical series of anchovy landings by Sub-division are shown in **Table 4.2.2.1.1** and **Figure 4.2.2.1.1**. **Table 4.2.2.1.2** shows the contribution of each fleet in the total annual landings by Sub-division. The seasonal distribution of 2011 landings by Sub-division is shown in **Table 4.2.2.2.1**.

Portuguese landings by sub-division in the first quarter in 2012 has also been provided to this WG.

Subdivision IXa North

Anchovy landings in 2011 increased notably up to 541 t from the 179 t recorded in 2010. Landings from this Sub-division accounted for 5% of total landings in the whole Division IXa and occurred mainly during the third quarter.

Subdivision IXa Central- North

Anchovy landings in 2011 (3,239 t) outburst abruptly in relation to the catch levels recorded in 2010 (100 t). As commented above, landings from this Sub-division represented 32% of the total anchovy fishery in the Division. The 2011 anchovy fishery in this sub-division was concentrated in the second semester.

During the first quarter in 2011 have been landed 95 t.

Subdivision IXa Central-South

Anchovy fishery in this Sub-division in 2011 was almost inexistent, as it is occurring since 2005 on. However, in the first quarter of 2012 were landed a total of 210 t.

Subdivision IXa South

Landings in 2011 (6,294 t) experienced a two-fold increase in relation to the levels recorded in 2010 (2,929 t). As described above, the sub-division contributed in 2011 with 62% of total catches landed in the Division. As usual, the Spanish waters of the Sub-division yielded the bulk of the fishery in these southernmost areas (6,216 t). In these waters the fishery in 2011 mainly developed through the second and third quarters.

Anchovy landings in the Portuguese part of the sub-division during the first quarter in 2012 were 31 t.

4.2.3 Discards

See the Stock Annex for previous available information on discards.

General guidelines on appropriate discard sampling strategies and methodologies were established during the ICES Workshop on Discard Sampling Methodology and Raising Procedures (ICES, 2003).

Data on anchovy discarding in the Spanish purse-seine fishery operating in the Gulf of Cádiz (Sub-division IXa South) are being gathered on a quarterly basis since the fourth quarter in 2009 on, within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR). In 2011 a total of 7 fishing trips (2 trips in the second quarter, 4 in the third quarter, and 1 in the fourth one) were sampled for the above purpose. Neither anchovy discarding nor slipping practices were observed in those sampled trips, although the low sample size makes these results not conclusive.

4.2.4 Effort and Catch per Unit Effort

Annual and half-year standardised CPUE series for the whole Spanish purse-seine fleet fishing Gulf of Cadiz anchovy (Sub-division IXa-South) are routinely provided to this WG. However, no updating (with 2011 data) of the available series (1988-2010) has been provided this year to this WG. Details of data availability and the standardisation process are commented in the Stock Annex. The recent dynamics of fishing effort and CPUE until 2010 is described in the last year's WG report. In the last years was observed a relative decrease in fishing effort which was coupled to a relative stable trend in the CPUE (at around 0.7 t/fishing day). A combination of fishing closures, both in the beginning and in the end of the year, bad weather at the start and/or the end of the fishing season, and the displacement of a part of the fleet to the Moroccan fishing grounds (under the EC-Morocco Fishery Agreement) at the same time of the re-opening of the Gulf of Cadiz fishery (usually in February), may be the causes responsible for the observed decrease in the fishing effort since 2008. Regarding CPUE, it was suggested last year a probable overestimation of the annual estimates computed so far because of a probable underestimation of the true exerted fishing effort on anchovy, since fishing trips targeting anchovy with zero anchovy catches are not considered in the effort measure. The available historical series of effort and CPUE estimates are shown in **Table 4.2.4.1** and **Figure 4.2.4.1**.

4.2.5 Catches by length and catches at age by Sub-division

Size composition of landings and catch-at-age data from the whole Division IXa have been routinely provided to this WG only from the Spanish Gulf of Cadiz fishery (Sub-division IXa South) since the anchovy fishery in the Division has traditionally concentrated there. Data from the Spanish fishery in Sub-division IXa North were not available since commercial landings used to be negligible. The same reason was also valid for the Portuguese sub-divisions (included the Portuguese part of the IXa South), although in this case anchovy is also a group 3 species in its national sampling program for DCF. Nevertheless, the local outbursts of anchovy in Subdivisions IXa North and Central North recorded in 2011 led to a circumstantial exploitation of the species by the fleets operating in those areas. The respective national sampling programs accounted for this event last year. Thus, new additional information about this subject from these sub-divisions is now available, at least for 2011.

4.2.5.1 Length distributions

Subdivision IXa North

Quarterly and annual size composition of anchovy landings in the Sub-division IXa North in 2011 are shown in **Table 4.2.5.1.1** and **Figure 4.2.5.1.1**. Annual mean size in landings in 2011 was estimated at 15.0 cm. The smallest anchovy mean size was recorded in the fourth quarter as a result of the incoming recruitment to the fishery.

Subdivision IXa Central- North

Size composition of anchovy landings in this Sub-division is described in **Table 4.2.5.1.2** and **Figure 4.2.5.1.2**. Length frequency distributions are only available for the third and fourth quarter in 2011. Mean lengths for each of these quarters were estimated at 14.4 cm and 16.5 cm. No clear evidences of an incoming recruitment to the fishery were detected through the second half in the year.

Subdivision IXa Central-South

No estimates from this sub-division are available since catches in 2011 were negligible.

Subdivision IXa South

Gulf of Cadiz anchovy quarterly length distributions from the Spanish fishery in 2011 are shown in **Table 4.2.5.1.3** and **Figure 4.2.5.1.3**. Length frequency distributions of Portuguese landings in the Sub-division are not available for the reasons described above.

Anchovy mean length and weight in the Spanish 2011 annual catch (11.5 cm and 10.0 g) were amongst the highest ones ever recorded in the historical series, as it is observed since 2008. However, a persistent recruitment to the fishery was detected since the second quarter on. In any case, Subdivision IXa South showed the smallest mean size in landings from the whole Division.

4.2.5.2 Catch numbers at age

Sub-division IXa North

Quarterly and annual catch at age of anchovy in IXa North in 2011 are shown in **Table 4.2.5.2.1** and **Figure 4.2.5.2.1**. Total catch in this Sub-division in 2011 was estimated at 27 million fish. Landings were composed by anchovies belonging to 0, 1 and 2 age group anchovies, with 1 age-group anchovies being the dominant age group.

Sub-division IXa Central- North

Soares *et al*. (WD 2012) describe the age reading results from anchovies collected during 2011 from research surveys and commercial samples by IPIMAR (with limited experience on the ageing of anchovy otoliths) as well as the results from an otolith exchange and age reading exercise with IEO (with experienced readers). Results from this exercise showed that age readings by IPIMAR were clearly improved after this exchange.

Catches at age of anchovy in third and fourth quarter in 2011 are shown in **Table 4.2.5.2.2**. A total of about 50 million fish were captured during the second half in 2011. Catches were composed by anchovies belonging to 0, 1, 2 and 3 age groups, with 1 and 2 years old anchovies accounting for the bulk of the fishery.

Subdivision IXa Central-South

No estimate from this sub-division is available since catches in 2011 were negligible.

Subdivision IXa South

Problems with ageing/reading Gulf of Cadiz anchovy otoliths were revisited in 2009 during the *Workshop on Age reading of European anchovy* (WKARA; ICES, 2010a), although such problems still persist.

The historical series of quarterly and annual catch at age of anchovy in the Spanish fishery in IXa South are shown in **Table 4.2.5.2.3** and **Figure 4.2.5.2.2**. No data are available from the Portuguese fishery in this Sub-division.

Description of annual trends of catch-at-age data from the Spanish fishery through the available data series is given in the Stock Annex.

Total catch in the Spanish fishery in 2011 was estimated at 466 million fish, which represents an 82% overall increase in numbers with respect to 2010 (256 million).

In relation to the previous year, the aforementioned landed numbers in 2011 are the result of the relative increase in landings of the 0 and 1 age-groups, and in a lesser extent the 2 age group. Three year old anchovies were absent in the fishery.

4.2.6 Mean length and mean weight at age in the catch

Subdivision IXa North

Annual mean length and weight at age of anchovy catches are shown in **Tables 4.2.6.1** and **4.2.6.2**, and **Figure 4.2.6.1**. Annual total mean size and weight were estimated at 15.0 cm and 20 g respectively. The lowest mean size and weight was recorded in the fourth quarter.

Subdivision IXa Central- North

Mean length and weight at age of anchovy catches for the second semester of 2011 are shown in **Tables 4.2.6.3** and **4.2.6.4.** Total mean size and weight in the second half in 2011 were estimated at 16.0 cm and 30 g respectively. Highest sizes and weights were recorded in the fourth quarter.

Sub-division IXa Central-South

No estimate from this sub-division is available since catches in 2011 were negligible.

Subdivision IXa South

Annual mean length and weight at age of Gulf of Cadiz anchovy catches are shown in **Tables 4.2.6.5** and **4.2.6.6**, and **Figure 4.2.6.2**. As described above anchovy mean length and weight in the Spanish 2011 annual catch were estimated at 11.5 cm and 10.0 g respectively.

Age 0 and age 1 anchovies have showed a noticeable increasing trend in both estimates in the most recent years, with the 2008-2011 estimates of mean size in landings being between the highest ones in the historical series. Conversely, from 2002 to 2010 age 2 anchovies experienced a remarkable decreasing trend in mean size and weight of landed fish, showing in 2011 a new relative increase. Three year olds were firstly recorded in the sampled landings in 1992. New occurrences of these anchovies have been observed from 2008 to 2010.

Seasonally, 0 age-group anchovies off the Gulf of Cadiz are larger (and usually also heavier) in the fourth quarter. This general pattern was apparent in 2006 – 2009 period, but it was not so in 2004 and 2005, when weights in the fourth quarter were rather similar to those estimated in the third quarter. The 1 and 2 year-old anchovies exhibit a clear and persistent pattern through the years, showing the larger mean length and heavier mean weight in the second half in the year. Three year olds occurred in a more or less constant way only through 2009. In that year, these eldest anchovies in the fishery showed larger sizes and weights between the second and fourth quarters, mainly in the second quarter.

4.3 Fishery-Independent Information

4.3.1 DEPM-based SSB estimates

Anchovy DEPM surveys in the Division are only conducted by IEO for the SSB estimation of Gulf of Cadiz anchovy (Sub-division IXa-South, *BOCADEVA* survey series, see text table below). The series started in 2005 and their surveys are conducted with a triennial periodicity. The methods adopted for both the conduction of these surveys and the estimation of parameters are described in the Stock Annex and in ICES (2009 a,b). This series is not financed by DCF. **The WG recommends that this survey series is maintained to scale properly the assessment of anchovy in Sub-division IXa South**.

BOCADEVA 0711 Survey

The last survey in the series, *BOCADEVA 0711*, was conducted in July 2011, one month after the 2011 WGHANSA meeting. The last year's Working Group considered the results from this survey as determinant to confirm or reject the null estimate of anchovy abundance and biomass in Sub-division IXa provided by the *PELAGO 11* spring survey about 3 months before (see section 4.3.2 below). In this context, a preliminary SSB estimate from the *BOCADEVA 0711* survey (computed by using only a sub-sample of the collected adult samples for batch fecundity, *F*, and the 2008 estimate for the spawning fraction, *S*) was presented during the 2011 WGACEEG (ICES, 2011). This preliminary SSB estimate was of about 30 kt. Final estimates from this survey based on the whole set of adult samples has been provided to this WG. A detailed report of the survey, containing their results and these final estimates, is attached as Jiménez *et al*. (WD 2012).

*BOCADEVA 0711 su*rvey was carried out on board R/V *Cornide of Saavedra* (IEO) from 22st July to 2nd August 2011, one month later than the dates of the previous survey in 2008, following the procedures described in the Stock Annex. Sampling and samples specifications are shown in **Table 4.3.1.1**.

Anchovy eggs occurred in 71 from a total of 124 PairoVET stations (57% of the total; **Table 4.3.1.2**). No sardine eggs were caught during the survey. About 60% of the sampled anchovy eggs were distributed in the Portuguese Algarve waters located between Carvoeiro and the Guadiana river mouth (**Figure 4.3.1.1**). A secondary nucleus of egg abundance was also observed in the Spanish waters close to the Guadalquivir river mouth. In both locations, eggs occurred in waters shallower than 100 m depth with a SST ranging between 18.9 and 21.7°C (mean 20.4°C).

As for the adult samples, anchovy showed a high frequency of occurrence in the pelagic hauls (91%, i.e., in 20 from 22 valid hauls), which were carried out between 6:52 and 20:18 hrs GMT and in a bathymetric range between 39 and 121 m depth. In these hauls anchovy was mainly captured together with sardine and chub mackerel (**Figure 4.3.1.2**). Anchovy mean cpue was estimated at 311 kg/h, a higher estimate than the one obtained in previous *BOCADEVA* surveys. Highest yields were recorded in the middle-outer shelf waters (90-120 m depth) located between Doñana National Park and Guadiana river mouth. Nineteen samples fulfilled the criterion of minimum sample size (60 anchovies). The characteristics of the samples used for the estimation of the adult parameters are described in **Table 4.3.1.3**.

The estimates of daily egg production, daily egg mortality rate and total egg production are given in **Table 4.3.1.4** and the mortality curve model used is shown in **Figure 4.3.1.3.** The total spawning area (*A*+) in 2011 was 6770 Km^2. Total egg production in 2011 (1.87 E+12egg/day) was relatively close to the one estimated in the previous survey in 2008 (2.11 E+12egg/day) (ICES, 2009b).

The spatial mapping of the single mean estimates of adult parameters evidenced a certain spatial structure for the mature female mean weight and batch fecundity (**Figure 4.3.1.4**), in agreement with the distribution pattern previously described in the area: an east-west size (-age) gradient, with the largest (and oldest) anchovies being more abundant in the westernmost limit of their distribution. Although this spatial pattern highlighted the convenience of a post-stratification to estimate both egg and adult parameters, as it was done in 2005 (ICES, 2006), the post-stratified estimates not showed a gain in precision and hence the not-stratified estimates were retained instead (**Table 4.3.1.4**).

The 2011 SSB estimate was 32,757 t with a CV of 40% (**Table 4.3.1.4, Figure 4.3.1.5**). This estimate is quite similar to the 2008 DEPM-based SSB estimate (31,527 t; CV= 32%) and indicates a rather stable adult population.

4.3.2 Spring/summer acoustic surveys

General

A description of the available acoustic surveys providing estimates for anchovy in Division IXa is given in the Stock Annex (see also ICES, 2007 b). Survey's methodologies deployed by the respective national Institutes (IPIMAR and IEO) are also thoroughly described in ICES (2008 c, 2009 b).

A summary list of the available acoustic and DEPM surveys providing direct estimates for anchovy in IXa is given in **Table 4.3.2.1**. **The WG considers each of these survey series as an essential tool for the direct assessment of the population in their respective survey areas (Sub-divisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history**.

Results from the Spring Portuguese (*PELAGO 11*) and Spanish (*PELACUS 0411*) acoustic surveys in 2011 were previously described in the last year's WGHANSA and WGACEEG reports (ICES, 2011 a, b). Detailed information in the present section will be provided for only those surveys carried out during the elapsed time between 2011 and 2012 WGHANSA meetings.

PELACUS04 series

This Spanish spring acoustic survey series is the only one that samples yearly the waters off the Sub-divisions IXa-North and Sub-area VIIIc since 1983. This series is currently financed by DCF.

PELACUS 0412

Figure 4.3.2.1 summarises the main results from the April 2012 survey (*PELACUS 0412*) surveying the Sub-division IXa North. A more detailed description of the survey is given by Santos *et al*. (WD 2012).

The spring 2012 survey, *PELACUS 0412*, was carried out between 27th March and 22th April on board the RV *Thalassa*. In the Sub-division IXa North, anchovy was found in 2 hauls from the 8 ones carried out in this area, and mainly distributed inside the Arousa and Pontevedra rías. Anchovy biomass and abundance were estimated at only 45 tonnes and 1.5 million fish, respectively. Anchovy size composition ranged between 13.5 and 19 cm size classes with a mode at 15.5 cm (**Figure 4.3.2.1**). The population in this area (southern rías) was dominated by age 1 and 2 fish.

Age-structured estimates from the *PELACUS04* series for the period 2007-2012 have been provided to this year's WG (**Figures 4.3.2.2** and **4.3.2.3).** Such estimates evidence that from 2007 to 2010 the anchovy population in IXa N showed very low abundance levels, although supported by a relatively well structured population (age groups 1 to 5+ were present). In 2011 and 2012 the population has been sustained only by the 1 and 2 year age groups, evidencing a high dependence on the recruitment strength. These two young age groups were the only ones that contributed to the high peak in abundance recorded in 2011, suggesting a relatively strong recruitment in 2009 and 2010, but with a complete absence of older anchovies in the population. The situation worsens even more in 2012 as the population returns to the usual very low population levels, but this time supported by a weak age structure.

Table 4.3.2.2 and **Figure 4.3.2.4** describe the available estimates from this survey series.

PELAGO series

The *PELAGO* survey series (spring Portuguese acoustic survey, until 2006 it was called *SAR*) is carried out every year surveying the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Sub-divisions IXa Central-North, Central-South, and South), between 20 and 200 m depth. This survey series is currently financed by DCF.

There has been no *PELAGO* survey during the elapsed time between the 2011-2012 WGHANSA meetings due to the RV *Noruega* was not operative for the survey season. Therefore, the most recent *PELAGO* estimate available is the one from the *PELAGO 11* survey. It should be noted (see ICES, 2011 a) that this survey estimated a total biomass of 27 thousand tonnes (1,558 million fish) for the whole surveyed area, within the average value for the entire time series, but only distributed in the IXa Central-North and, as stated above, without no anchovy at all in the IXa Central-South and IXa South (this last sub-area is the one where the bulk of the anchovy population mainly concentrates). Age structure of this estimate has been provided this year to the WG: in the IXa Central-North age 0 was the dominant age group in the population (70% in number), followed by age 1 (20%) and age 2 (1%) anchovies.

During the last WGACEEG meeting and in the present WG were recognised the difficulties found both in the species' identification and the realization of the pelagic hauls during the *PELAGO 11* just in the Gulf of Cádiz waters as the main causes for the probable underestimation of the anchovy population in this area. CUFES during this survey in addition pointed out to a significant amount of spawning (at a level above previous years records of egg abundances). Therefore anchovies were spawning in the area but the acoustic couldn`t catch or see them. As described above, the results from the *BOCADEVA 0711* DEPM survey also contradicted the perception given by PELAGO 2011 of an exhausted population in the IXa South. Therefore the WG concluded that the PELAGO2011 anchovy estimates in IXa South resulted in a strong understima of the actual biomass levels in the region. For this reason the estimates of PELAGO 2011 for anchovy in this area will be disregarded for the stock trend and harvest rates assessments which follow.

Table 4.3.2.3 and **Figure 4.3.2.5** track the historical series of anchovy acoustic estimates from *PELAGO* surveys in the Division IXa. Size composition and age structure of the population estimate in IXa South through the series was described in the last year's report.

ECOCÁDIZ series

The *ECOCÁDIZ* survey series acoustically samples the shelf waters off the Subdivision IXa-South during early summer (June-July).

No *ECOCÁDIZ* survey has been conducted neither in 2011 (ship time invested in the *BOCADEVA 0711* DEPM survey) nor 2012 (no ship-time available). The last estimate from this survey series dates back to 2010 (*ECOCÁDIZ 0710*). Results and estimates from this survey were shown in the last year's WGHANSA (ICES, 2011 a)

Figure 4.3.2.6 and **Table 4.3.2.4** track the historical series of anchovy acoustic estimates from *ECOCÁDIZ* surveys in the Sub-division IXa South.

The size composition and age structure of the population in IXa South through the series were described in the last year's report. Some additional comments explaining the recent trends exhibited by the acoustic estimates of anchovy in IXa-South from both the *PELAGO* and *ECOCÁDIZ* series were also thoroughly described in that report (ICES, 2011 a).

4.3.3 Recruitment surveys

SAR autumn survey series

The last survey in this series (aimed to cover the sardine early spawning and recruitment season in the Division IXa, but also covering the anchovy recruitment season) providing anchovy estimates was carried out in 2007 (see **Table 4.3.2.1**). **Table 4.3.2.5** show the historical series of anchovy acoustic estimates derived from this survey series in the Division IXa available so far. The series of point estimates is at present scattered and scarce for this autumn survey series and they are not used in the qualitative trend-based assessment.

The (so far failed) attempts of planning new sardine/anchovy recruitment surveys in the Division were described in the last year's WG report (ICES, 2011 a).

4.4 Biological Data

4.4.1 Weight at age in the stock

Weights at age in the stock are shown in **Table 4.4.1.1**. See the Stock Annex for comments on computation and trends.

4.4.2 Maturity at Age

Annual maturity ogives for Gulf of Cadiz anchovy are shown in **Table 4.4.2.1**. See the Stock Annex for comments on computation and trends in the maturity ogives of Gulf of Cádiz anchovy.

Maturity stage assignment criteria were agreed between national institutes involved in the biological study of the species during the *Workshop on Small Pelagics (Sardina pilchardus, Engraulis encrasicolus) maturity stages* (WKSPMAT; ICES, 2008 a).

4.4.3 Natural Mortality

Natural mortality is unknown for this stock. By analogy with anchovy in Sub-area VIII, natural mortality is probably high (a half-year M=0.6 has been used in previous years for the data exploration, see Stock Annex).

4.5 Assessment of the state of the stock

4.5.1 Previous data explorations

Data availability and some fishery (recent catch trajectories) and biological evidences have been the basis for a data exploration of anchovy in Sub-division IXa South (Algarve and Gulf of Cadiz) (Ramos *et al*., 2001; ICES, 2002).

For the time being, no analytical assessment model has been successfully applied. An *ad hoc* seasonal (half-year) separable model implemented and run on a spreadsheet has been used in the last years for data exploration of anchovy catch-at-age data in Subdivision IXa-South since 1995 onwards. The separable model was fitted to the updated half-year catch-at-age data until the year before the WG and to the available acoustic estimates of anchovy aggregated biomass from the *PELAGO* spring Portuguese surveys series only (including the acoustic estimate one year ahead of the assessment's last year). The exploratory assessments performed so far with this *ad hoc* model have not been recommended as a basis for predictions or advice due to they have not provided any reliable information about the true levels of the stock, F and Catch/SSB ratios since the assessment is not still properly scaled. For the above reasons since 2009 it was preferred not to perform any exploratory assessment with this model. More details on the model settings and assumptions and its performance are described in the Stock Annex.

Trends of biomass indices in the Subdivision IXa South.

The provision of advice since 2009 has been traditionally restricted to Sub-division IXa south as this is the only area showing a persistent population and fishery. It relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (2008 & 2009 RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data for the Sub-division IXa South, both fishery-dependent and –independent information (*i.e.*, landings, fishing effort, cpue, survey estimates). A summary of these trends for the Sub-division IXa South is shown in the **Figure 4.5.2.1**. They indicate a relatively stable stock status with little changes until 2009, without any evidence of serious problems: the drop of landings in 2008 and 2009 was caused by a parallel fall in the fishing effort. In fact, cpue is maintained relatively stable, and survey estimates, although variable did not show marked trends until 2009. The DEPM estimates, although uncertain, matched reasonable well with acoustic estimates. The relative levels of catches to biomass indexes (taken as absolute) suggested relatively acceptable levels of harvest rates until 2009 (of about ¼ the SSB index) (see an evaluation in sections 4.5.2 and 4.7)

Since 2008 the acoustic estimates of biomass show a continuous declining trend which seems to reach an extreme situation in spring 2011, when no anchovy was detected in the *PELAGO* acoustic survey. However anchovy eggs sampled by CUFES during that survey were found at comparable or even higher levels than in the previous year 2010 during that acoustic survey, which is not consistent with the null detection of biomass with acoustics. The Fishery maintained its normal activity throughout 2010 and 2011. Up to 2010 the cpue indices of the fleet did not show any declining trend, although the validity of this CPUE index may be questionable given that the unit effort does not take into account neither the searching time nor the occurrence of fishing trips with zero catches.

For these reasons the working group was reluctant last year to accept that the fall in biomass in 2011 was so pronounced as the *PELAGO* acoustic survey suggested and questioned the validity of this very last point of the series. The *BOCADEVA* DEPM survey, conducted in July 2011, has provided a new indication about the state of the anchovy biomass in 2011. Its SSB estimate (32,757 t) indicated a recovery of the biomass in 2011 up to levels above the average. Unfortunately, there is no indication about the state of the anchovy biomass in 2012 since no survey index is available, but the most recent estimates suggest a rather stable situation.

Trend of biomass indices in the western Iberian shores (IXa North, Central-North and Central-South).

According to *PELAGO* survey in 2011 an outburst of anchovy biomass has happened in this area, with an estimation of 27,000 t (**Figure 4.5.2.2**). This can come from recruitment in that area (as modal lengths range between 13-15 cm). This is the highest record in biomass in this area. The second highest estimate in the area was recorded in 2008 (5,500t). A former outburst of biomass might have happened in the mid nineties, as a high record of catches appeared in 1995 (but acoustic surveys did only provide by then estimates of sardine (and not of anchovy)). The uncertainty about this phenomenon is its duration in time, as in the past these sudden outbursts have not been sustained in the following year.

Trend of biomass indices in the whole Division IXa.

Figure 4.5.2.3 shows a synoptic representation of the acoustic index from *PELAGO* and *PELACUS 04* over the total Division IXa. Over the whole Division there is a recovery of the anchovy in 2011 to the levels recorded in 2007 and 2008 and at the beginning of the series. So a perception of a fluctuating resource without a neat trend will be inferred from the figure. However, we know that such perception is erroneous as the behaviour of the population is being quite different in the different Sub-divisions of the region. This puts in doubt the stock unit of the anchovy populations inhabiting this area and the suitability of the unified management applied to the fisheries on anchovy in the different Sub-divisions of Division IXa (see management considerations about the definition of stocks in this area below).

4.5.2 Assessment of the potential fishery Harvest Rates (HR) on anchovy in Subdivision IXa South

A range of a likely potential Harvest Rates (HR) applied for the fishery on the anchovy in Subdivision IXa south was directly tried through the estimation of the quotient between total Catch (tons) and Survey Biomasses for a range of potential catchability of the surveys. Given the rather consistent levels of biomass estimates provided by the acoustic and DEPM surveys applied in this area, the HR evaluation assumed equal catchability for all surveys, something coherent with the results from the assessment of anchovy in VIII, which assumes q=1 to the DEPM and estimates q=1.15 (aprox.) for the acoustic. In addition the range of catchabilities explored went from 0.6 to 1.4. The results assuming catchability =1 are shown by years in **Table 4.5.2.1**. On average for a catchability = 1 HR = 23.5% (CV of 0.4) and a maximum individual HR happens in 2002 with a HR of 39%. The sensitivity analysis for the range of selected catchabilities are in **Table 4.5.2.2**. If catchabilities are higher than 1, the actual Biomasses at sea would be lower and hence the HR higher than for catchabilities = 1, in proportion equal to the catchability raising factor. As such for a catchability = 1.4 the average HR would be around 33% (CV of 0.4) and the maximum individual year value would rise up to 54.2%.

In the context of the Yield per recruit analysis for Harvest rates shown in section 4.7, all the range of HR resulting from the former sensitivity analysis are well below the HR corresponding to the 50% SBR per recruit (= 0.77), thus the stock seems to be exploited sustainable. This sustainability of the current exploitation seems to be valid for any potential catchability value below 1.8.

For the western Sub-divisions (IXa North to IXa Central South) a harvest ratio of about 13% in 2011 may be derived from the merged acoustic estimates in these sub-divisions (28 558 t) in relation to 3 782 t of anchovy landings, a rate even at a lower level than those ones estimated in the Sub-division IXa South.

4.6 Predictions

There is no basis to predict the status of the anchovy population in 2012.

4.7 Yield per Recruit analysis and Reference Point on Harvest Rates

Although the current fishing pattern is uncertain, the matrix of catches at age allow to estimate the selectivities at age (relative fishing mortalities at age), which for an assumed natural mortality (M=1.2) would equal the relative catches at age (in percentages). For a given selectivity at age the Yield per recruits can computed straightforward. This section contains a sensitivity analysis of a Yield per recruit analysis in terms of reference points for fishing mortality and Harvest rates:

Two vectors of relative catches at age were generated from the catch statistics: A first vector correspond to the average age composition in the period 1999-2011. A second vector correspond with the catches in the earlier period and 2011 (years 1996, 97, 98 and 2011) when catches at age 0 were more abundant. These two vectors are summarised in the text table below:

Mean Catches at age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1999-2011	87.078	414.957	15.022	0.273	517.330
Percentage at age	16.8%	80.2%	2.9%	0.1%	
Mean 1996, 97, 98 & 2011	374.93	479.57	19.24	0.00	873.745
Percentage at age	42.9%	54.9%	2.2%	0.0%	

Mean weights at age in the catches since 1999 were used for both the catches and the population. Maturity was assumed to be knife edge like, full maturity and reproductive capacity at age 1 (as estimated to happen here at least during the recent years and consistent with the biology of the anchovy in the Bay of Biscay as well).

As the selectivities required to reproduce the relative catches at age can slightly change according to the actual level of fishing mortality (unknown) then selectivities were fitted for a vector of potential F values at age 1 (the age of reference) going from 0.2 to 1.4 in steps of 0.2. For each fitted selectivity at age a Yield per recruit analysis was made in terms of % of Spawning biomass per recruit (%SBR) for different levels of F multipliers and corresponding Harvest Rates (HR) (the quotient between catches in tonnes and Spawning Biomass). Spawning and surveying times were set to occur at the middle of the year. For the acoustic ECOCADIZ and DEPM BOCADEVA survey this is correct, as they are made in June-July, though acoustic PELAGO survey is made in March- April.

Sensitivity to the vector of natural mortality was not made, as alternative vectors would be of the type of decreasing M with Age (Gislanson *et al*. 2010) but resulting in M at age 0 and 1 probably higher than the ones considered here. Those types of vectors would imply less risk for the same relative age composition in the catches. Hence the current Y/R analysis is risk averse over other alternative vectors of Natural mortality.

The Y/R assessment was made with an Excel spread sheet, which is laid down in the software folder of the Share point. The selectivities at different F at age 1 levels were fitted with the Solver function. And the subsequent associated Y/R analysis is run with visual Basic macro in Excel.

Results for the first vector of relative catches at age are shown in T**able 4.7.1**. Sensitivity of the selectivity at age pattern to the concrete guessed level of F at age 1 for which the selectivity was fitted is minor. Thus, all reference points were rather similar across the potential alternative selectivities at age (**Table 4.7.1a**). A plot with the reference points for F and HR corresponding to the selectivity at age fitted with a presumed F at age 1 = 0.6 are shown in **Figure 4.7.1**. Not surprisingly F_0.1 is rather similar to assumed M, but F_35%(SBR) and F_50%(SBR) fall to 0.53 and 0.34. The value of F_0.1 at 1.23 will certainly be not sustainable as it corresponds with a %SBR of about 11%. In terms of Harvest Rates, HR_35%(SBR) and HR_50%(SBR) are around 1.44 and 0.78. The potential for HR to exceed 1 comes from the fact that part of the catches are made on age 0 or age 1 prior to the spawning and first observations of the cohort at survey time. For the potential range of HR assessed for this fishery (section 4.5.2), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 12 years are below HR_50%(SBR), so at sustainable levels.

For the second vector of catches at age the sensitivity analysis did not differ much from the first analysis (**table 4.7.1 b**). Results were again not much sensitive to the actual selectivity at age of the fleet matching the 43% of age 0. The value of F_0.1 was not sustainable, as it resulted in 9% of %SBR. Results in terms of Harvest rates were all rather coincident: HR_35%(SBR) and HR_50%(SBR) are around 1.5 and 0.79. As before, for the potential range of HR assessed for this fishery (section 4.5.2), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 12 years are below HR_50%(SBR), so at sustainable levels.

For both selectivities at age patters and for the levels of Harvest rates induced by the Fishery, under the assumption of a catchability equal to 1 for the surveys, the expected min, mean and max values of %SBR corresponding to those HR would be around 67%, 77% and 89% respectively. And if catchability would be equal to 1.4 then HR would be 59%, 71% and 81% respectively. Therefore, for the potential range of HR assessed for this fishery (section 4.5.2), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 12 years are below HR_50%(SBR), so at sustainable levels.

4.8 Management considerations

4.8.1 Definition of stock units

A summarised description of the distribution of the main anchovy populations in NE Atlantic European waters is given in the Stock Annex. Traditionally, the distribution of anchovy in the Division IXa has been concentrated in the Sub-division IXa South (**Figure 4.8.1.1.a**), where about 99% of the population is usually encountered during the acoustic surveys, mainly in the Spanish waters of the Gulf of Cadiz. Outside the main nucleus of the Gulf of Cadiz, resilient anchovy populations were usually detected in all fishery independent surveys (ICES, 2007 b, **Figure 4.8.1.1.b**). Occasionally large catches are produced in ICES areas IXa North and Central-North coincident with a sporadic raise up of the anchovy abundance in those areas, as for instance in 1995/96 and in 2011. The Working Group has traditionally concentrated its exploratory analysis of the anchovy in Sub-division IXa South, because it was the only persistent population in the area. The perception of the anchovy in other areas of IXa is that they are marginal populations of independent dynamics from the anchovy population in IXa South. As such the advice was based solely on the information coming from the anchovy in IXa South (Algarve and Cadiz).

In 2011 the acoustic detection of anchovy biomass by *PELAGO* spring survey in Sub-division IXa Central-North raised up from 0 t in 2010 to 27,000 t in 2011. Contrary to this, the acoustic estimates in subdivision IXa South passed from about 7,400 t in 2010 to 0 t (**Figure 4.8.1.1.c**). Beyond the noise behind these estimates, these data demonstrates the independent dynamics of the anchovy in the northern part of the IXa from the dynamics of the population in IXa south (with examples in the period 1995/96 and in 2011).

This has a direct implication: there is no firm basis to consider the anchovy in Division IXa as a single stock, given that the dynamics of the population (via their recruitment pulses) in the different areas are independent.

Recent studies by Zarraonandía (2011) on the genetic structure of the European anchovy populations using single nucleotide polymorphisms (SNP) indicate that the Gulf of Cádiz anchovy (Subdivision IXa South) is genetically different to the other samples in the Ibero-Atlantic coast, while is genetically similar to that of Alborán Sea (Spanish SW Mediterranean) (**Figure 4.8.1.2**). This genetic subdivision observed in Ibero-Atlantic coasts is in concordance with the morphological segregation pattern described by Caneco *et al*. (2004). That study suggests that the differences between areas could reflect slight adaptive reactions to small environmental differences.

From all of this it follows that there is no reason to provide a single management advice for the anchovy in all the Division IXa, given that the fishery and the exploited populations are spatially separated and with independent dynamics and different genetic structure. At the contrary, it would be better to provide separate advice for the well identified population in Sub-division IXa South, from the rest of the anchovy in the Division (occupying the western waters of the Iberian peninsula: IXa North, Central-North and Central-South). This would demand a separate management of the fisheries on anchovy in these two regions of the Division IXa.

This issue will be translated to the formulation of the advice this year: as an advice provided at the level of the Division IXa, it will be based on the perception of the rather sustainable population based on the acoustic surveys. The advice restricted to the Subdivision IXa South will also be based on a perceived stable population in that area.

4.8.2 Current management situation

No EU management plan exists for the fisheries in Division IXa.

Portuguese producers organisations traditionally agree a voluntary closure of the purse-seine fishery in the northern part (north of the 39º 42" North) of the Portuguese coast (IXa Central-North). This closure usually lasts two months in the first quarter in the year. Since 2006 half of the fleet stops one month and the remaining vessels stop the other month. Effects of these closures in the anchovy landings in the IXa Central-North area have not been analysed although they should be low since no targeted fishery to anchovy is presently developed there.

The regulatory measures in force for the Spanish anchovy purse-seine fishing in the Division are the same as for the previous years and are summarised as follows:

- Minimum landing size: 12 cm total length in VIIIc and IXa North, 10 cm in Gulf of Cadiz (IXa South).
- Minimum vessel tonnage of 20 GRT with temporary exemption.
- Maximum engine power: 450 h.p.
- Purse-seine maximum length: 450 m.
- Purse-seine maximum height: 80 m.
- Minimum mesh size: 14 mm
- Fishing time limited to 5 days per week, from Monday to Friday.
- Cessation of fishing activities from Saturday 00:00 h to Sunday 12:00 h.
- Fishing prohibition inside bays and estuaries.

In the Gulf of Cadiz (Subdivision IXa South) the Spanish purse-seine fleet was performing a voluntary closure of three months (December to February) until 1997. Since 2004 two complementary sets of management measures affecting directly to the Gulf of Cadiz fishery have been implemented and are still in force. The first one was the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months since October the 30th and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid February 2008, 1st December 2008 to 28th February 2009), which is accompanied by a subsidized tie-up scheme for the purse-seine fleet. The expected subsidized 3-month closure from mid-autumn in 2009 to mid-winter in 2010 was restricted to one month only, in December 2009, although the fishery was practically closed since November 2009 until February 2010 for persistent bad sea conditions during all those months. During the 2010 autumn-2001 winter the fishery was again officially closed one month, in December 2010, but the purse seine fleet did not start to fish until February 2011. The fishery was closed in the period of 2011 autumn-2012 winter in December 2011 and January 2012.

The plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (3000 kg of sardine, 3000 kg of anchovy, 6000 kg of sardine-anchovy mixing but in no case each of these species can exceed 3000 kg). A new regulation approved in October

2006 establishes that up to 10% of the total catch weight could be constituted by fish below the established minimum landing size (10 cm) but fish must always be ≥9 cm.

Impacts of the autumn fishery closures in landings and fishing effort by the Spanish Gulf of Cadiz purse-seine fishery has been described in previous reports and, although not formally evaluated, indicate that such closures did not cause serious effects in the reduction of the exerted fishing effort, at least in the last years, but only halting the possibility of expanding even more the fishing capacity of the fleets up to the recent maxima reached in the 1999-2007 period.

The second management action in force since 15th of July 2004 in Spanish gulf of Cadiz is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure 4.8.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA.

The effects of such closures and MPA in the Gulf of Cadiz anchovy recruitment are not still possible to be directly assessed. In any case, the implementation of both of these measures should benefit the stock.

Results from the qualitative assessment described in Section 4.5 suggest that the anchovy population in the Sub-division IXa South is rather stable without any neat tendencies. Despite the likely drop of biomass in 2010 (according to the acoustic survey PELAGO), the DEPM estimates in 2011 and high levels of catches in this year suggest a recovery to normal levels in 2011. Therefore it seems that catches can be allowed to remain at current mean levels.

In the absence of any recruitment index, neither for the anchovy in subdivision IXa South nor for the populations in the remaining Sub-divisions of IXa there is sufficient information as to outline what the situation in 2012 will be.

4.8.3 Scientific advice and contributions

An in-depth evaluation of the possibilities of handling the above problems on the performance and suitability of the analytical model for the Sub-division IXa South by other kinds of assessment models was out of reach for the WGHANSA. In that context, it may be productive to consider before any benchmark process a wide range of assessment approaches in an open-minded way. It is noted that most of the signals in the data are found in the catches at age 1 in both semesters and at age 0 in the second semester, in addition to the trends in the survey biomass measurements. It might be worth exploring the time signal in these data. Production models should also be explored, but large fluctuations of the catches over time give some doubts about the stability of the carrying capacity.

The analyses of the data should also be viewed in the context of the management strategies that might be applied. The surveys have improved greatly in recent years, both through improvements of the acoustic surveys and the initiation of a DEPM survey. In addition, recent scientific efforts have improved the understanding of the biology of the stock. As stated in previous WG, these sources of information might become the core of a knowledge base for future management, which may not necessarily need to be dependent on analytic assessments. Alternative management regimes, like harvest rate rules based on survey information, could be examined by simulations.

The WG recommends a benchmarking for the anchovy in these areas for 2014 to address the best way to assess this resource.

In order to scale the assessment, additional DEPM estimates will also be required.

4.8.4 Species interaction effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and sea-birds.

The anchovy population in Subdivision IXa-South appears to be well established and relatively independent of populations in other parts of the Division. These other populations seem to be abundant only when suitable environmental conditions occur, while during unfavorable conditions they seem to be restricted to the river and "rías" estuaries (Ribeiro *et al*., 1996).

The recruitment depends strongly on environmental factors. Ruíz *et al*. (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the northeastern sector of the Gulf of Cadiz (IXa-South). The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favor the existence of warm and chlorophyll-rich waters in the area, thus offering a favorable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favorable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

In this context, Ruíz *et al*. (2009) recently implemented the Bayesian approach for a state-space model of Gulf of Cadiz anchovy life stages. The model is used to infer 17 years (1988-2004) of stock size in the Gulf of Cadiz. Its population dynamics was modeled under the influence of the physical environment and connected to available observations of sea surface temperature, river discharge, wind, catches, catch per unit effort, and acoustic records, as available. The model diagnosed values that are consistent with independent observations of anchovy early life stages in the Gulf of Cadiz. It was also able to explain the main crises historically recorded for this fishery in the region (*e.g*., in 1995-1996).

As previously described, the Gulf of Cádiz anchovy population has also experienced a noticeable decreasing trend during the period 2008-2010 as a probable consequence of successive failures in the recruitment strength in those years (ICES, 2011). A man-induced alteration of the nursery function of the Guadalquivir estuary, caused by episodes of highly persistent turbidity events (HPTE; González-Ortegón *et al*., 2010), during the anchovy recruitment seasons in 2008, 2009 and 2010 could be one plausible explanation. Thus, the control of the Guadalquivir River flow, from a dam 110 km upstream, has an immediate effect on the estuarine salinity gradient, displacing it either seaward (reduction) or upstream (enlargement of the estuarine area used as nursery). This also affects the input of nutrients to the estuary and adjacent coastal areas. The abovementioned HPTEs used to start with strong and sudden freshwater discharges after relatively long periods of very low freshwater inflow and caused significant decreases in abundances of anchovy recruits and the mysid *Mesopodopsis slabberi*, its main prey.

All of these evidences confirm that the Gulf of Cádiz anchovy population relies on recruits to persist and, therefore, is highly vulnerable to ocean processes and totally controlled by environment fluctuations.

4.8.5 Ecosystem effects of fisheries

The purse seine fishery is highly mono-specific, with a low level of reported by-catch of non-commercial species. Information gathered from observers' at sea sampling programs and interview-based surveys indicate, at least for the western waters of the Iberian Peninsula façade, a low impact on the common dolphin population (Wise *et al*., 2007), but less data are available on seabird and turtle by-catch. Other species such as pelagic crabs are released alive and it is likely that the inflicted mortality is low.

Table 4.2.1.1. Anchovy in División IXa. Sub-division IXa South. Spanish purse-seine fleet composition in the Gulf of Cadiz (Sub-division IXa-South) in 2011. The fleet is differentiated into total fleet and vessels targeting anchovy. The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels). Storage: catches are dry hold with ice (1 fishing trip equals to 1 fishing day). Similar tables for yearly data since 1999 are shown in the Stock Annex and previous WG reports.

2011	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10						
11-15	2	11	6	1		20
16-20		5	32	16		53
>20			2	13	2	17
Total	2	16	40	30	2	90

2011	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10						
11-15	2	12	6	1		21
16-20		5	29	13		47
>20			2	10	1	13
Total	2	17	37	24	1	81

Table 4.2.2.1.1. Anchovy in Division IXa. Historical series of total annual landings and by Sub-division (t). Landings in Sub-division IXa South are also differentiated between "Algarve" (A; Portuguese waters) and "Cádiz" (C; Spanish waters). (-) data not available; (0) less than 1 tonne (from Pestana, 1989 and 1996, and WGMHSA, WGANC, WGANSA and WGHANSA members).

Year	IXa N	IXa C-N	IXa C-S	IXa S (A)	IXa S (C)	IXa S (Total)	Total Division
1943	-	7121	355	2499	-	-	-
1944	-	1220	55	5376	-	-	-
1945	-	781	15	7983	-	-	-
1946	-	0	335	5515	-	-	-
1947	-	0	79	3313	-	-	-
1948	-	0	75	4863	-	-	-
1949	-	0	34	2684	-	-	-
1950	-	31	30	3316	-	-	-
1951	-	21	6	3567	-	-	-
1952	-	1537	1	2877	-	-	-
1953	-	1627	15	2710	-	-	-
1954	-	328	18	3573	-	-	-
1955	-	83	53	4387	-	-	-
1956	-	12	164	7722	-	-	-
1957	-	96	13	12501	-	-	-
1958	-	1858	63	1109	-	-	-
1959	-	12	1	3775	-	-	-
1960	-	990	129	8384	-	-	-
1961	-	1351	81	1060	-	-	-
1962	-	542	137	3767	-	-	-
1963	-	140	9	5565	-	-	-
1964	-	0	0	4118	-	-	-
1965	-	7	0	4452	-	-	-
1966	-	23	35	4402	-	-	-
1967	-	153	34	3631	-	-	-
1968	-	518	5	447	-	-	-
1969	-	782	10	582	-	-	-
1970	-	323	0	839	-	-	-
1971	-	257	2	67	-	-	-
1972	-	-	-	-	-	-	-
1973	-	6	0	120	-	-	-
1974	-	113	1	124	-	-	-
1975	-	8	24	340	-	-	-
1976	-	32	38	18	-	-	-
1977	-	3027	1	233	-	-	-
1978	-	640	17	354	-	-	-
1979	-	194	8	453	-	-	-
1980	-	21	24	935	-	-	-
1981	-	426	117	435	-	-	-
1982	-	48	96	512	-	-	-
1983	-	283	58	332	-	-	-
1984	-	214	94	84	-	-	-
1985	-	1893	146	83	-	-	-
1986	-	1892	194	95	-	-	-
1987	-	84	17	11	-	-	-

Table 4.2.2.1.1. (Cont'd).

Year	IXa N	IXa C-N	IXa C-S	IXa S (A)	IXa S (C)	IXa S (Total)	Total Division
1988	-	338	77	43	4263	4306	4721
1989	118	389	85	22	5330	5352	5944
1990	220	424	93	24	5726	5750	6487
1991	15	187	3	20	5697	5717	5922
1992	33	92	46	0	2995	2995	3166
1993	1	20	3	0	1960	1960	1984
1994	117	231	5	0	3035	3035	3388
1995	5329	6724	332	0	571	571	12956
1996	44	2707	13	51	1780	1831	4595
1997	63	610	8	13	4600	4613	5295
1998	371	894	153	566	8977	9543	10962
1999	413	957	96	355	5587	5942	7409
2000	10	71	61	178	2182	2360	2502
2001	27	397	19	439	8216	8655	9098
2002	21	433	90	393	7870	8262	8806
2003	23	211	67	200	4768	4968	5269
2004	4	83	139	434	5183	5617	5844
2005	4	82	6	38	4385	4423	4515
2006	15	79	15	14	4368	4381	4491
2007	4	833	7	34	5576	5610	6454
2008	5	211	87	37	3168	3204	3508
2009	19	35	5	32	2922	2954	3013
2010	179	100	2	28	2901	2929	3210
2011	541	3239	1	78	6216	6294	10076

Table 4.2.2.1.2. Anchovy in Division IXa. Catches (t) by gear and Sub-division in 1988-2011. Landings by gear in Sub-divisions IXa C-N to S (Algarve) until 2009 are not available by Sub-division.

Sub-area	Gear	1988	1989	1990	1991	1992	1993	1994	1995*	1996	1997	1998	1999	2000
IXa N	Artisanal	-	0	0	0	0	0	0	0	0	0	0	0	0
	Purse seine	-	118	220	15	33	1	117	5329	44	63	371	413	10
IXa C-N to IXa S (A)	Demersal Trawl	-	-	-	-	4	9	1	-	56	46	37	43	6
	P. seine polyvalent	-	-	-	-	1	1	3	-	94	7	35	20	7
	Purse seine	-	-	-	-	270	14	233	-	2621	579	1541	1346	297
	Not different. By gear	458	496	541	210	-	-	-	7056	-	-	-	-	-
IXa S (C)	Demersal Trawl	0	0	0	0	0	330	152	75	224	190	1148	993	104
	Purse seine	4263	5336	5911	5696	2995	1630	2884	496	1556	4410	7830	4594	2078

Sub-area	Gear	2001	2002	2003	2004	2005	2006	2007	2008	2009
IXa N	Artisanal	0	0	4	1	0	0	0	1	0,1
	Purse seine	27	21	19	2	4	15	4	4	18
IXa C-N to IXa S (A)	Demersal Trawl	16	13	7	5	7	27	14	9	4
	P. seine polyvalent	32	13	184	197	57	24	376	141	38
	Purse seine	806	888	287	455	62	57	484	185	30
	Not different. By gear	-	-	-	-	-	-	-	-	-
IXa S (C)	Demersal Trawl	36	23	14	6	0,2	0,4	0,3	0,1	0,02
	Purse seine	8180	7847	4754	5177	4385	4367	5575	3168	2922

Sub-area	Gear	2010	2011
IXa N	Artisanal	4	0
	Purse seine	175	541
IXa C-N	Demersal Trawl	5	4
	P. seine polyvalent	45	1116
	Purse seine	50	2119
IXa C-S	Demersal Trawl	1	0,9
	P. seine polyvalent	0	0,1
	Purse seine	0,7	0,4
IXa S (A)	Demersal Trawl	8	13
	P. seine polyvalent	4	33
	Purse seine	17	33
IXa S (C)	Demersal Trawl	0	0
	Purse seine	2901	6216

Table 4.2.2.2.1. Anchovy in Division IXa. Quarterly anchovy catches (t) by Sub-division in 2011.

SUBDIVISION	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2011)	
	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
IXa North	5	1,0	2	0,3	444	82,0	91	16,8	541	5,4
IXa Central North	16	0,5	262	8,1	1668	51,5	1293	39,9	3239	32,1
IXa Central South	0,1	4,1	0,6	46,7	0,6	43,2	0,1	6,0	1	0,0
IXa South (Algarve)	20	25,0	3	3,6	50	64,0	6	7,4	78	0,8
IXa South (Cádiz)	1308	21,0	2340	37,6	2003	32,2	566	9,1	6216	61,7
IXa South	1327	21,1	2343	37,2	2053	32,6	571	9,1	6294	62,5
TOTAL	1349	13,4	2607	25,9	4166	41,3	1955	19,4	10076	100,0

Table 4.2.4.1. Anchovy in Division IXa. Sub-division IXa South. Standardised effort (no. of standardised fishing trips fishing anchovy) and CPUE (t/fishing trip) data for Spanish fleets operating in the Gulf of Cadiz (1988-2010; no updated with 2011 data). Colour intensities denote increasing problems in sampling coverage of fishing effort. (SP: single purpose; MP: multipurpose; HT: heavy GRT; LT: light GRT).

	SUB-DIVISION IXa SOUTH (Gulf of Cadiz)															
	PURSE SEINE															
FLEET	BARBATE			SANLÚCAR		P.UMBRÍA		I. CRISTINA			MEDIT.	SUBTOTAL	SUBTOTAL	TOTAL	TOTAL	OVERALL
	(SP-HT)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-HT)	(SP-LT)	(MP)	(SP-HT)	SP-HT	SP-LT	SP	MP	EFFORT
Year	No. fishing trips															
1988	3873	-	58	-	587	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	3873	?	3873	644	**4517**
1989	4567	-	179	-	933	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4567	?	4567	1112	**5679**
1990	4724	-	162	-	1431	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4724	?	4724	1593	**6317**
1991	4428	-	96	-	3147	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	4428	?	4428	3244	**7672**
1992	3985	-	206	-	1432	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	3985	?	3985	1639	**5623**
1993	2359	-	13	-	606	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	2359	?	2359	619	**2978**
1994	2177	-	114	-	1030	*n.a.*	*n.a.*	0	225	46	-	2177	225	2402	1191	**3593**
1995	1406	-	13	-	381	*n.a.*	*n.a.*	0	14	25	-	1406	14	1420	419	**1839**
1996	3491	-	100	-	1920	*n.a.*	*n.a.*	0	85	67	-	3491	85	3576	2087	**5664**
1997	2246	39	118	-	1900	*n.a.*	*n.a.*	0	79	16	-	2246	118	2364	2034	**4399**
1998	2165	82	0	2450	0	*n.a.*	*n.a.*	0	192	37	-	2165	2723	4888	37	**4925**
1999	1772	136	8	2264	0	665	587	0	285	248	-	1772	3350	5122	843	**5965**
2000	256	824	1,6	2234	0	1857	182	0	613	0	-	256	5528	5784	183	**5967**
2001	177	1039	142	1474	0	2329	52	96	1097	30	267	540	5939	6479	224	**6703**
2002	2967	590	47	1140	0	2160	13	17	464	0	125	3109	4355	7464	60	**7524**
2003	2505	439	16	1217	0	1381	0	76	735	0	0	2582	3771	6353	16	**6369**
2004	3037	519	17	734	0	1615	48	191	853	19	0	3228	3721	6949	84	**7033**
2005	2480	656	0	500	0	1223	0	175	525	0	0	2655	2904	5559	0	**5559**
2006	3247	437	0	498	0	1480	0	267	1298	0	0	3513	3713	7226	0	**7226**
2007	1652	676	15	944	0	1692	0	303	1620	0	0	1955	4933	6887	15	**6902**
2008	1318	446	0	625	0	1136	0	184	852	0	0	1502	3059	4561	0	**4561**
2009	1440	449	0	522	0	1287	0	153	808	0	0	1593	3065	4659	0	**4659**
2010	1329	438	0	545	0	1094	0	250	698	0	0	1579	2775	4355	0	**4355**

	SUB-DIVISION IXa SOUTH (Gulf of Cadiz)															
	PURSE SEINE															
FLEET	BARBATE			SANLÚCAR		P.UMBRÍA		I. CRISTINA			MEDIT.	SUBTOTAL	SUBTOTAL	TOTAL	TOTAL	OVERALL
	(SP-HT)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-LT)	(MP)	(SP-HT)	(SP-LT)	(MP)	(SP-HT)	SP-HT	SP-LT	SP	MP	CPUE
Year	Tonnes/fishing trip															
1988	1,070	-	0,136	-	0,150	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1,070	?	1,070	0,149	**0,939**
1989	1,101	-	0,116	-	0,236	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1,101	?	1,101	0,217	**0,928**
1990	1,104	-	0,163	-	0,296	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1,104	?	1,104	0,283	**0,897**
1991	1,180	-	0,141	-	0,126	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	1,180	?	1,180	0,126	**0,734**
1992	0,709	-	0,097	-	0,122	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	0,709	?	0,709	0,119	**0,537**
1993	0,582	-	0,102	-	0,095	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	-	0,582	?	0,582	0,096	**0,481**
1994	0,990	-	0,158	-	0,347	*n.a.*	*n.a.*	0	0,177	0,106	-	0,990	0,177	0,914	0,320	**0,717**
1995	0,142	-	0,169	-	0,165	*n.a.*	*n.a.*	0	0,082	0,017	-	0,142	0,082	0,141	0,156	**0,145**
1996	0,227	-	0,279	-	0,213	*n.a.*	*n.a.*	0	0,123	0,128	-	0,227	0,123	0,225	0,213	**0,221**
1997	1,549	0,180	0,298	-	0,263	*n.a.*	*n.a.*	0	0,100	0,100	-	1,549	0,126	1,478	0,264	**0,916**
1998	3,107	0,430	0	0,202	0	*n.a.*	*n.a.*	0	0,224	0,158	-	3,107	0,210	1,493	0,158	**1,483**
1999	2,126	0,267	0,237	0,230	0	0,141	0,145	0	0,155	0,156	-	2,126	0,208	0,871	0,149	**0,769**
2000	0,247	1,223	0,094	0,205	0	0,162	0,132	0	0,365	0	-	0,247	0,360	0,355	0,132	**0,348**
2001	3,408	2,287	0,941	0,225	0	0,964	0,142	2,271	1,561	0,109	2,055	2,538	1,122	1,240	0,646	**1,220**
2002	1,786	1,056	0,416	0,198	0	0,577	0,164	0,412	0,657	0	0,932	1,744	0,552	1,048	0,362	**1,043**
2003	1,366	0,629	0,163	0,313	0	0,291	0	0,529	0,313	0	0	1,341	0,342	0,748	0,163	**0,747**
2004	1,220	0,687	0,055	0,253	0	0,329	0,132	0,386	0,360	0,071	0	1,171	0,371	0,743	0,103	**0,735**
2005	1,130	0,634	0	0,503	0	0,453	0	0,588	0,493	0	0	1,094	0,510	0,789	0	**0,789**
2006	0,669	0,577	0	0,807	0	0,489	0	0,678	0,490	0	0	0,670	0,542	0,604	0	**0,604**
2007	1,214	0,946	0,026	0,772	0	0,589	0	1,100	0,537	0	0	1,196	0,656	0,809	0,026	**0,808**
2008	0,949	0,758	0	0,577	0	0,473	0	1,018	0,579	0	0	0,957	0,565	0,694	0	**0,694**
2009	0,922	0,483	0	0,976	0	0,434	0	0,314	0,323	0	0	0,864	0,504	0,627	0	**0,627**
2010	1,133	0,460	0	0,391	0	0,696	0	0,116	0,274	0	0	0,972	0,492	0,666	0	**0,666**

Table 4.2.5.1.1. Anchovy in Division IXa. Sub-division IXa North. Seasonal and annual length distributions ('000) of Spanish anchovy landings in 2011.

2011	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa N	IXa N	IXa N	IXa N	IXa N
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5	0	0	0	63	63
11	0	0	0	253	253
11.5	0	0	0	569	569
12	7	2	627	379	1015
12.5	5	1	419	442	867
13	6	2	532	758	1298
13.5	5	2	539	127	672
14	37	11	3642	0	3690
14.5	35	10	3357	53	3456
15	44	13	3857	213	4127
15.5	42	12	3572	267	3893
16	51	15	3908	1119	5093
16.5	16	5	1012	587	1619
17	3	1	174	160	338
17.5	0	0	0	53	54
18					
18.5					
19					
19.5					
20					
20.5					
21					
21.5					
22					
Total N	250	74	21638	5046	27008
Catch (T)	5	2	444	91	541
L avg (cm)	15.2	15.2	15.1	14.3	15.0
W avg (g)	25.0	25.0	20.5	18.0	20.1

Table 4.2.5.1.2. Anchovy in Division IXa. Sub-division IXa Central North. Seasonal and annual length distributions ('000) of Portuguese anchovy landings in 2011 (only data available for the second semester).

2011	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa C-N	IXa C-N	IXa C-N	IXa C-N	IXa C-N
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5					
11					
11.5					
12			107	0	
12.5			214	0	
13			1495	58	
13.5			2135	350	
14			2135	374	
14.5			2455	1414	
15			1280	7826	
15.5			853	14263	
16			575	15614	
16.5			299	15438	
17			64	15380	
17.5			0	7748	
18			0	389	
18.5			0	1542	
19			0	1168	
19.5			0	389	
20					
20.5					
21					
21.5					
22					
Total N	na	na	11612	81954	na
Catch (T)	16	262	1668	1293	3239
L avg (cm)	na	na	14,4	16,5	na
W avg (g)	na	na	22,2	32,6	na

Table 4.2.5.1.3. Anchovy in Division IXa. Sub-division IXa South (Cádiz). Seasonal and annual length distributions ('000) of Spanish anchovy landings in 2011.

2011	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa S (C)	IXa S (C)	IXa S (C)	IXa S (C)	IXa S (C)
3.5					
4					
4.5					
5					
5.5					
6					
6.5	0	0	195	0	195
7	0	438	97	152	687
7.5	0	659	605	152	1417
8	0	1819	2562	461	4843
8.5	393	4135	4761	766	10055
9	2325	7393	11177	1971	22867
9.5	7544	9995	16573	4127	38238
10	17223	9822	25379	6026	58449
10.5	25309	11445	29587	8793	75134
11	31428	27831	34919	7635	101812
11.5	21244	40533	32989	7839	102605
12	10826	39242	17941	7395	75404
12.5	6906	31235	12180	6667	56988
13	4081	19304	5893	2427	31704
13.5	2559	6805	1618	1943	12925
14	2793	3541	1957	544	8836
14.5	1597	1915	4231	436	8180
15	1189	1012	4208	218	6626
15.5	694	153	2303	0	3150
16	409	154	589	0	1152
16.5	35	0	192	0	227
17	0	0	185	0	185
17.5					
18					
18.5					
19					
19.5					
20					
20.5					
21					
21.5					
22					
Total N	136555	217430	210143	57551	621679
Catch (T)	1308	2340	2003	566	6216
L avg (cm)	11.4	11.8	11.3	11.4	11.5
W avg (g)	9.5	10.7	9.5	9.8	10.0

Table 4.2.5.2.1. Anchovy in Division IXa. Sub-division IXa North. Spanish catch in numbers ('000) at age of anchovy on a quarterly (Q), half-year (HY) and annual basis (only data available for 2011).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0	2725	0	2725	2725
	1	102	30	21636	2135	132	23771	23903
	2	148	44	2	185	192	188	380
	3	0	0	0	0	0	0	0
	Total (n)	250	74	21638	5046	324	26684	27008
	Catch (t)	5	2	444	91	7	535	541
	SOP	6	2	444	91	8	534	542
	VAR.%	84	84	100	100	84	100	100

Table 4.2.5.2.2. Anchovy in Division IXa. Sub-division IXa Central North. Portuguese catch in numbers ('000) at age of anchovy on a quarterly (Q), half-year (HY) and annual basis (only data available for the second semester in 2011).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			3516	1481		4998	
	1			6110	18949		25060	
	2			1868	17901		19769	
	3			117	0		117	
	Total (n)			11612	38331		49943	
	Catch (t)	16	262	1668	1293	278	2961	3239
	SOP			258	1249		1507	
	VAR.%			647	104		197	

Table 4.2.5.2.3. Anchovy in Division IXa. Sub-division IXa South. Spanish catch in numbers ('000) at age of Gulf of Cadiz anchovy (1995-2011) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	11256	23241	0	34497	34497
	1	19579	6928	6851	602	26508	7453	33961
	2	189	0	0	0	189	0	189
	3	0	0	0	0	0	0	0
	Total (n)	19769	6928	18107	23843	26697	41950	68647
	Catch (t)	185	80	148	157	265	305	571
	SOP	184	79	148	157	264	305	568
	VAR.%	101	101	100	100	101	100	100
1996	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	413465	71074	0	484540	484540
	1	12772	130880	11550	7281	143652	18832	162483
	2	13	882	826	333	894	1159	2053
	3	0	0	0	0	0	0	0
	Total (n)	12785	131761	425842	78688	144546	504530	649076
	Catch (t)	41	807	585	348	848	933	1780
	SOP	36	743	621	306	779	926	1706
	VAR.%	114	109	94	113	109	101	104
1997	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	237283	96475	0	333758	333758
	1	67055	123878	69278	19430	190933	88708	279641

1999	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	40549	84234	0	124784	124784
	1	249922	115218	86931	20276	365140	107207	472348
	2	10982	18701	2450	146	29683	2596	32279
	3	0	0	0	0	0	0	0
	Total (n)	260904	133919	129931	104656	394823	234587	629410
	Catch (t)	1335	1983	1582	687	3318	2269	5587
	SOP	1330	1756	1391	673	3087	2064	5150
	VAR.%	100	113	114	102	107	110	108
2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	41028	77780	0	118808	118808
	1	75141	65947	46460	9949	141088	56409	197497
	2	638	2670	523	14	3307	537	3844
	3	0	0	0	0	0	0	0
	Total (n)	75779	68617	88011	87743	144395	175755	320150
	Catch (t)	329	660	655	537	989	1193	2182
	SOP	327	659	666	535	986	1201	2187
	VAR.%	101	100	98	100	100	99	100
2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	30987	127140	0	158126	158126
	1	98687	227388	177264	37992	326075	215256	541331

	2	22601	9828	11649	745	32429	12394	44823
	3	0	0	0	0	0	0	0
	Total (n)	89656	133706	318211	116650	223362	434860	658223
	Catch (t)	906	1110	2006	578	2016	2584	4600
	SOP	844	1273	1923	596	2117	2519	4635
	VAR.%	107	87	104	97	95	103	99
1998	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	75708	360599	0	436307	436307
	1	325407	384529	220869	84729	709936	305599	1015535
	2	11066	879	1316	0	11944	1316	13260
	3	0	0	0	0	0	0	0
	Total (n)	336473	385408	297893	445329	721881	743221	1465102
	Catch (t)	1773	2113	2514	2579	3885	5092	8977
	SOP	1923	2127	2599	2654	4050	5254	9304
	VAR.%	92	99	97	97	96	97	96

	2	4155	14028	4535	624	18183	5159	23342
	3	0	0	0	0	0	0	0
	Total (n)	102842	241416	212785	165756	344258	378541	722800
	Catch (t)	924	3031	3195	1066	3955	4261	8216
	SOP	908	3014	3145	1065	3922	4210	8132
	VAR.%	102	101	102	100	101	101	101
2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	45129	29271	0	74399	74399
	1	218090	304295	149120	36565	522385	185685	708070
	2	2004	6083	8808	620	8087	9428	17515
	3	0	0	0	0	0	0	0
	Total (n)	220094	310378	203057	66456	530471	269512	799984
	Catch (t)	1700	2814	2566	789	4515	3355	7870
	SOP	1617	2778	2524	818	3937	3342	7737
	VAR.%	105	101	102	96	115	100	102

Table 4.2.5.2.3. (Cont'd).

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	26034	45813	0	71847	71847
	1	96135	229184	49058	7028	325320	56087	381407
	2	10041	2587	481	0	12628	481	13109
	3	0	0	0	0	0	0	0
	Total (n)	106176	231772	75574	52841	337948	128415	466363
	Catch (t)	1025	2533	798	413	3557	1211	4768
	SOP	1031	2398	759	378	3430	1137	4567
	VAR.%	99	106	105	109	96	94	104

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	31680	74278	0	105958	105958
	1	157200	165738	69542	6383	322937	75924	398862
	2	388	1419	248	534	1808	782	2590
	3	0	0	0	0	0	0	0
	Total (n)	157588	167157	101470	81195	324745	182665	507410
	Catch (t)	1382	1975	1192	634	3357	1826	5183
	SOP	1284	1844	1194	593	3129	1788	4916
	VAR.%	108	107	100	107	107	102	105

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	24163	13743		37906	37906
	1	195482	249404	36999	371	444886	37370	482256
	2	2716	445	334	0	3161	334	3495

2007	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	41020	20672	0	61692	61692
	1	222366	230200	89173	17477	452567	106650	559217
	2	1696	5016	594	35	6712	629	7342
	3	0	0	0	0	0	0	0
	Total (n)	224063	235216	130787	38185	459279	168971	628250
	Catch (t)	1572	2233	1418	351	3806	1770	5576
	SOP	1443	2061	1290	335	3504	1624	5128
	VAR.%	109	108	110	105	109	109	109

2008	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	38173	19304	0	57477	57477
	1	38742	51510	30608	17435	90251	48043	138295
	2	10220	13400	5137	2214	23620	7351	30970
	3	245	149	0	0	394	0	394
	Total (n)	49206	65059	73918	38953	114266	112871	227137
	Catch (t)	590	1117	909	552	1707	1461	3168
	SOP	552	1056	852	518	1608	1369	2978
	VAR.%	107	106	107	107	106	107	106

2009	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	1143	8552	0	9695	9695
	1	24402	93317	64150	3072	117719	67222	184941
	2	11236	6842	1944	28	18079	1972	20051

	3	0	0	0	0	0	0	0		3	1463	364	846	1	1827	846	2673
	Total (n)	198198	249848	61496	14114	448046	75610	523656		Total (n)	37101	100523	68084	11652	137624	79736	217360
	Catch (t)	1361	2241	705	77	3602	783	4385		Catch (t)	530	1279	1006	107	1809	1113	2922
	SOP	1302	2098	665	67	3401	732	4132		SOP	486	1194	937	100	1680	1037	2717
	VAR.%	105	107	106	115	106	107	106		VAR.%	109	107	107	107	108	107	108
2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL	2010	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	9552	1751	0	11303	11303		0	0	0	16924	17538	0	34462	34462
	1	152978	296608	41515	206	449586	41721	491307		1	6154	148182	46697	9351	154336	56048	210384
	2	2944	2317	0	0	5261	0	5261		2	144	5690	5285	0	5833	5285	11118
	3	0	0	0	0	0	0	0		3	0	102	155	0	102	155	257
	Total (n)	155922	298925	51068	1957	454847	53024	507871		Total (n)	6297	153973	69061	26889	160271	95950	256221
	Catch (t)	1289	2655	414	9	3944	424	4368		Catch (t)	67	1698	907	229	1765	1136	2901
	SOP	1206	2474	387	8	3680	395	4075		SOP	60	1664	907	229	1724	1136	2859
	VAR.%	107	107	107	108	107	107	107		VAR.%	112	102	100	100	102	100	102

Table 4.2.5.2.3. (Cont'd).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	26034	45813	0	71847	71847
	1	96135	229184	49058	7028	325320	56087	381407
	2	10041	2587	481	0	12628	481	13109
	3	0	0	0	0	0	0	0
	Total (n)	106176	231772	75574	52841	337948	128415	466363
	Catch (t)	1025	2533	798	413	3557	1211	4768
	SOP	1031	2398	759	378	3430	1137	4567
	VAR.%	99	106	105	109	96	94	104

Table 4.2.6.1. Anchovy in Division IXa. Sub-division IXa North. Mean length (TL, in cm) at age in the Spanish catches of anchovy on a quarterly (Q), half-year (HY) and annual basis in 2011.

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0				12,6		12,6	12,6
	1	14,3	14,3	15,1	16,3	14,3	15,2	15,2
	2	15,8	15,8	17,3	16,5	15,8	16,5	16,2
	3							
	Total	15,2	15,2	15,1	14,3	15,2	15,0	15,0

Table 4.2.6.2. Anchovy in Division IXa. Sub-division IXa North. Mean weight (in kg) at age in the Spanish catches of anchovy on a quarterly (Q), half-year (HY) and annual basis in 2011.

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0				0,010		0,010	0,010
	1	0,020	0,020	0,020	0,027	0,020	0,021	0,021
	2	0,028	0,028	0,033	0,028	0,028	0,028	0,028
	3							
	Total	0,025	0,025	0,020	0,018	0,025	0,020	0,020

Table 4.2.6.3. Anchovy in Division IXa. Sub-division IXa Central North. Mean length (TL, in cm) at age in the Portuguese catches of anchovy on a quarterly (Q), half-year (HY) and annual basis in 2011 (only data available for the second semester).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			13,8	15,8		14,4	
	1			14,4	16,3		15,8	
	2			15,4	16,7		16,5	
	3			15,4			15,4	
	Total			14,4	16,5		16,0	

Table 4.2.6.4. Anchovy in Division IXa. Sub-division IXa Central North. Mean weight (in kg) at age in the Portuguese catches of anchovy on a quarterly (Q), half-year (HY) and annual basis in 2011 (only data available for the second semester).

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,019	0,029		0,022	
	1			0,022	0,032		0,029	
	2			0,028	0,034		0,033	
	3			0,028			0,028	
	Total			0,022	0,033		0,030	

Table 4.2.6.5. Anchovy in Division IXa. Sub-division IXa South. Mean length (TL, in cm) at age in the Spanish catches of Gulf of Cadiz anchovy (1995-2011) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm. Data from 1988 to 1994 has been previously reported in WGMHSA reports.

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,3	10,2		10,2	10,2
	1	11,3	11,8	11,4	13,0	11,5	11,6	11,5
	2	14,7				14,7		14,7
	3							
	Total	11,4	11,8	10,7	10,2	11,5	10,4	10,9

1996	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			5,6	7,3		5,8	5,8
	1	7,4	8,5	12,9	13,7	8,4	13,2	8,9
	2	14,0	13,9	15,2	15,6	13,9	15,3	14,7
	3							
	Total	7,4	8,5	5,8	7,9	8,4	6,1	6,6

1997	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,1	8,1		7,4	7,4
	1	10,0	10,5	13,1	13,0	10,3	13,0	11,2
	2	13,4	14,0	15,0	15,1	13,6	15,0	14,0
	3							
	Total	10,9	10,8	8,7	8,9	10,8	8,8	9,5

1998	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,1	8,8		8,5	8,5
	1	9,5	9,2	11,9	12,2	9,3	12,0	10,1
	2	13,2	14,0	15,0		13,3	15,0	13,5
	3							
	Total	9,6	9,2	10,7	9,5	9,4	10,0	9,7

1999	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,7	9,3		8,8	8,8
	1	8,2	12,2	12,7	12,5	9,5	12,7	10,2
	2	13,4	14,1	15,2	14,9	13,8	15,2	13,9
	3							
	Total	8,4	12,5	11,2	10,0	9,8	10,6	10,1

2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,7	9,5		8,9	8,9
	1	8,2	10,9	11,9	12,5	9,4	12,0	10,2
	2	14,1	15,0	15,4	16,1	14,9	15,5	15,0
	3							
	Total	8,2	11,1	10,0	9,8	9,6	9,9	9,8

2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,9	8,4		8,7	8,7
	1	10,7	11,4	13,2	13,0	11,2	13,1	12,0
	2	15,5	16,2	16,3	16,2	16,0	16,3	16,1
	3							
	Total	10,9	11,7	12,8	9,5	11,4	11,3	11,4

2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			7,9	10,2		8,8	8,8
	1	10,7	10,6	12,8	13,6	10,6	12,9	11,2
	2	15,0	15,1	15,6	15,7	15,1	15,6	15,4
	3							
	Total	10,7	10,7	11,8	12,1	10,7	11,9	11,1

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,6	10,1		9,9	9,9
	1	10,8	11,3	12,1	12,6	11,1	12,2	11,3
	2	15,1	15,4	16,5		15,1	16,5	15,2
	3							
	Total	11,2	11,3	11,3	10,4	11,3	10,9	11,2

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,9	10,1		10,0	10,0
	1	10,9	11,8	12,7	13,3	11,4	12,8	11,6
	2	15,8	14,5	15,9	15,2	14,8	15,4	15,0
	3							
	Total	10,9	11,8	11,8	10,4	11,4	11,2	11,3

Table 4.2.6.5. (Cont'd).

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,0	9,4		9,1	9,1
	1	10,1	10,8	12,7	11,8	10,5	12,7	10,7
	2	13,9	14,3	15,2		14,0	15,2	14,1
	3							
	Total	10,2	10,8	11,3	9,4	10,5	10,9	10,6

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			8,6	9,1		8,7	8,7
	1	10,7	10,8	11,1	10,2	10,8	11,1	10,8
	2	13,5	14,8			14,1		14,1
	3							
	Total	10,8	10,9	10,6	9,2	10,8	10,6	10,8

2007	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			9,5	10,4		9,8	9,8
	1	10,2	10,6	12,1	12,1	10,4	12,1	10,7
	2	13,2	14,3	14,7	14,4	14,0	14,7	14,1
	3							
	Total	10,2	10,7	11,3	11,2	10,5	11,3	10,7

2008	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,3	11,3		10,6	10,6
	1	11,2	12,7	13,1	13,7	12,1	13,3	12,5
	2	13,8	14,6	14,5	14,5	14,2	14,5	14,3
	3	15,7	14,9			15,4		15,4
	Total	11,8	13,1	11,7	12,6	12,5	12,0	12,3

2009	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			8,5	10,4		10,2	10,2
	1	12,3	11,7	12,6	12,0	11,8	12,6	12,1
	2	13,5	14,1	14,4	14,4	13,8	14,4	13,8
	3	14,6	15,3	15,2	15,5	14,7	15,2	14,9
	Total	12,7	11,9	12,6	10,8	12,1	12,3	12,2

2010	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,2	10,7		10,5	10,5
	1	11,4	11,6	13,1	12,3	11,6	12,9	12,0
	2	14,4	13,9	14,1		13,9	14,1	14,0
	3		14,8	15,4		14,8	15,4	15,2
	Total	11,5	11,7	12,5	11,3	11,7	12,1	11,8

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			10,7	11,3		10,9	10,9
	1	11,3	11,8	12,1	13,8	11,6	12,2	11,7
	2	14,8	13,8	15,3	13,8	14,7	15,3	15,1
	3							
	Total	11,4	11,8	11,3	11,4	11,6	11,3	11,5

Table 4.2.6.6. Anchovy in Division IXa. Sub-division IXa South. Mean weight (in kg) at age in the Spanish catches of Gulf of Cadiz anchovy (1995-2011) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm. Data from 1988 to 1994 has been previously reported in WGMHSA reports.

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,007	0,006		0,007	0,007
	1	0,009	0,011	0,010	0,014	0,010	0,010	0,010
	2	0,021				0,021		0,021
	3							
	Total	0,009	0,011	0,008	0,007	0,010	0,007	0,008

1996	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,001	0,003		0,001	0,001
	1	0,003	0,006	0,014	0,015	0,005	0,015	0,006
	2	0,018	0,017	0,023	0,023	0,017	0,023	0,020
	3							
	Total	0,003	0,006	0,001	0,004	0,005	0,002	0,003

1997	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,003		0,003	0,003
	1	0,007	0,009	0,015	0,013	0,008	0,015	0,010
	2	0,016	0,019	0,023	0,021	0,017	0,023	0,018
	3							
	Total	0,009	0,010	0,006	0,005	0,009	0,006	0,007

1998	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,005		0,004	0,004
	1	0,005	0,005	0,011	0,011	0,005	0,011	0,007
	2	0,014	0,019	0,022		0,014	0,022	0,015
	3							
	Total	0,006	0,006	0,009	0,006	0,006	0,007	0,006

1999	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,005		0,005	0,004
	1	0,005	0,012	0,014	0,012	0,007	0,013	0,008
	2	0,015	0,020	0,023	0,020	0,018	0,023	0,018
	3							
	Total	0,005	0,013	0,011	0,006	0,008	0,009	0,008

2000	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,005		0,005	0,005
	1	0,004	0,009	0,011	0,012	0,006	0,011	0,008
	2	0,018	0,024	0,025	0,027	0,023	0,025	0,023
	3							
	Total	0,004	0,010	0,008	0,006	0,007	0,007	0,007

2001	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,006	0,004		0,005	0,005
	1	0,008	0,011	0,016	0,014	0,010	0,015	0,012
	2	0,025	0,032	0,031	0,028	0,030	0,031	0,030
	3							
	Total	0,009	0,012	0,015	0,006	0,011	0,011	0,011

2002	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,003	0,007		0,005	0,005
	1	0,007	0,009	0,014	0,016	0,008	0,015	0,010
	2	0,019	0,025	0,027	0,026	0,024	0,027	0,025
	3							
	Total	0,007	0,009	0,012	0,012	0,008	0,012	0,010

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,006	0,006		0,006	0,006
	1	0,008	0,010	0,012	0,012	0,010	0,012	0,010
	2	0,022	0,026	0,030		0,023	0,030	0,023
	3							
	Total	0,010	0,010	0,010	0,007	0,010	0,009	0,010

2004	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,007	0,007		0,007	0,007
	1	0,008	0,011	0,014	0,015	0,010	0,014	0,010
	2	0,026	0,021	0,028	0,023	0,022	0,024	0,023
	3							
	Total	0,008	0,011	0,012	0,007	0,010	0,010	0,010

Table 4.2.6.6. (Cont'd).

2005	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,005	0,005		0,005	0,005
	1	0,006	0,008	0,015	0,009	0,008	0,008	0,008
	2	0,017	0,021	0,025		0,018	0,019	0,019
	3							
	Total	0,007	0,008	0,011	0,005	0,008	0,010	0,008

2006	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,004	0,004		0,004	0,004
	1	0,008	0,008	0,008	0,006	0,008	0,008	0,008
	2	0,015	0,021			0,017		0,017
	3							
	Total	0,008	0,008	0,008	0,004	0,008	0,007	0,008

2007	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,005	0,007		0,006	0,006
	1	0,006	0,009	0,012	0,011	0,007	0,012	0,008
	2	0,015	0,020	0,022	0,018	0,019	0,021	0,019
	3							
	Total	0,006	0,009	0,010	0,009	0,008	0,010	0,008

2008	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,007	0,009		0,008	0,008
	1	0,009	0,015	0,015	0,017	0,012	0,016	0,014
	2	0,018	0,022	0,021	0,021	0,020	0,021	0,020
	3	0,027	0,023			0,026		0,026
	Total	0,011	0,016	0,012	0,013	0,014	0,012	0,013

2009	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,004	0,008		0,007	0,007
	1	0,012	0,011	0,014	0,011	0,011	0,014	0,012
	2	0,015	0,020	0,020	0,019	0,017	0,020	0,018
	3	0,019	0,026	0,023	0,023	0,021	0,023	0,022
	Total	0,013	0,012	0,014	0,009	0,012	0,013	0,012

2010	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	0,007	0,007		0,007	0,007
	1	0,009	0,010	0,015	0,011	0,010	0,014	0,011
	2	0,019	0,019	0,019		0,019	0,019	0,019
	3		0,022	0,025		0,022	0,025	0,024
	Total	0,009	0,011	0,013	0,009	0,011	0,012	0,011

2011	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0			0,008	0,009		0,008	0,008
	1	0,009	0,011	0,011	0,017	0,010	0,012	0,010
	2	0,022	0,017	0,023	0,017	0,021	0,023	0,023
	3							
	Total	0,010	0,011	0,010	0,010	0,010	0,010	0,010

Table 4.3.1.1. Anchovy in Division IXa. *BOCADEVA 0711* survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). General sampling and samples specifications.

Parameters	Anchovy DEPM survey *BOCADEVA0711*
Surveyed area	(36º11'- 36º47'N – 6º12'- 8º54'W)
R/V	*Cornide de Saavedra*
Dates	22/07-02/08/2011
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	124
Sampling maximum depth (m)	100
Hydrographical sensor	CTD SBE25 and CTD SBE37
Flowmeter	Yes
CUFES stations	114
CUFES (335µm)	3 n miles (sample unit)
Environmental data	Temperature and Salinity
Adults	
Gears	Pelagic trawl
Trawls	24 (2 null; 21 positive for anchovy)
Trawling time	From 07:15 to 20:08 hrs GMT
Biological sampling	On fresh material, on board of the R/V
Sample size	At least 60 individuals, randomly picked; up to 120 (adding
Fixation	4% Phosphate buffered Formaldehyde
Preservation	4% Phosphate buffered Formaldehyde

Table 4.3.1.2. Anchovy in Division IXa. *BOCADEVA 0711* survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Number and density of anchovy eggs sampled by the PairoVET net during the survey.

By Pairovet	Anchovy eggs
N stations	124
N positive stations	71
N total eggs	2387
N medium eggs	19
N maximum eggs	191
Total density (egg/m^2)	24722
Mean density	199
Maximum density	2195

Table 4.3.1.3. Anchovy in Division IXa. *BOCADEVA 0711* survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Catch by haul in number and weight, number of sampled individuals (in biological and size samplings) and number of preserved ovaries.

Fishing station	Total catch		Size sampling		Biological sampling				
	Weight (kg)	N	Weight (kg)	n	n	Mature females			Pairs of otoliths
						Non hydrated gonads	Hydrated gonads	Total	
02	3,386	264	1,980	154	60	35		35	60
03	54,273	8677	0,663	136	60	43		43	60
04	63,100	11310	0,809	145	70	28		28	70
05	65,560	5802	1,559	138	63	41		41	63
06*					43	29		29	43
07	149,080	10888	1,698	124	60	48		48	60
08	142,056	15714	0,904	100	100	28	3	31	100
09	7,839	655	1,604	134	60	39		39	60
10	654,430	50496	1,296	100	60	45		45	60
11	36,580	3078	1,367	115	60	35		35	60
12	139,000	6794	2,374	116	60	47		47	60
13	832,628	69184	1,372	114	70	31		31	70
14	246,500	19328	1,760	138	60	35	1	36	60
15	81,260	4944	2,317	141	90	32		32	90
17	51,860	1787	4,610	159	90	69		69	80
18	17,301	650	4,846	182	60	30		30	60
19	4,314	147	1,246	43	43	17	6	23	43
20	63,469	5709	1,679	151	70	31		31	70
21	4,202	379	1,144	103	131	18	21	39	131
23	122,200	16366	0,881	118	120	13	8	21	120
24	57,180	6495	1,030	117	378	13	264	277	378
TOTAL	**2796,218**	**238667**	**35,139**	**2528**	**1808**	**707**	**303**	**1010**	**1798**

* Null fishing station. Sampled especimens were only the few ones still occurring inside the codend once retrieved the gear on the deck.

Table 4.3.1.4. Anchovy in Division IXa. *BOCADEVA 0711* survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Summary of estimates of eggs and adult parameters and SSB.

Parameters	Gulf of Cádiz 2011
Eggs	
P_0 (eggs/m^2/day) (CV)	276.4 (0.32)
Z (day^{-1}) (CV)	-0.294 (1.14)
P_{tot} (eggs/day) (x10^{12}) (CV)	1.87 (0.36)
Positive area (Km^2)	6770.2
Adults	
Female Weight (g) (CV)	15.2 (0.11)
Batch Fecundity (CV)	7486 (0.12)
Sex Ratio (CV)	0.531 (0.007)
Spawning Fraction (CV)	0.276 (0.036)
SSB 2011	
Spawning Biomass –tons (CV)	32757.2 (0.40)

Table 4.3.2.1. Acoustic and DEPM surveys providing direct estimates for anchovy in Division IXa. (1): surveys used until 2008 as tuning series in the exploratory analytical assessment of anchovy in Sub-division IXa South (Algarve and Gulf of Cádiz) (see Section 4.5.1); (2): surveys used since 2008 in the trends-based qualitative assessment; (3): *ECOCÁDIZ-COSTA 0709*, (pilot) Spanish survey surveying shallow waters <20 m depth and complementary to the standard survey; ((Month)): surveys that were carried out but did not provide any Gulf of Cádiz anchovy acoustic estimate because of its very low presence and/or for an incomplete geographical coverage (some areas were not covered: either the Spanish or the Portuguese part of the Gulf).

Method	Acoustics							DEPM	
Survey	PELACUS 04	PELAGO		SAR	ECOCÁDIZ		ECOCÁDIZ-RECLUTAS	BOCADEVA	
Institute (Country)	IEO (Spain)	IPIMAR (Portugal)		IPIMAR (Portugal)	IEO (Spain)		IEO (Spain)	IEO (Spain)	
Subareas	IXa N	IXa CN-IXa S		IXa CN-IXa S	IXa S		IXa S	IXa S	
Year/Quarter	Q2	Q1	Q2	Q4	Q2	Q3	Q4	Q2	Q3
1998				Nov					
1999		Mar (1,2)							
2000				Nov					
2001		Mar (1,2)		Nov					
2002		Mar (1,2)							
2003		Feb (1,2)		(Nov)					
2004			(Jun)		Jun (2)				
2005			Apr (1,2)	(Nov)				Jun (2)	
2006			Apr (1,2)	(Nov)	Jun (2)				
2007			Apr (1,2)	Nov		Jul (2)			
2008	Apr (2)		Apr (1,2)	(Nov)				Jun (2)	
2009	Apr (2)		Apr (2)		Jun (2)	(Jul) (3)	(Oct)		
2010	Apr (2)		Apr (2)			(Jul)(2)			
2011	Apr (2)		Apr (2)						Jul (2)
2012	Apr (2)								

Table 4.3.2.2. Anchovy in Division IXa. *PELACUS 04* survey series (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c). Historical series of acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes) in Sub-division IXa North..

Survey	Estimate	IXa North
Apr. 08	N	10
	B	306
Apr. 09	N	0.7
	B	26
Apr. 10	N	0.03
	B	90
Apr. 11	N	73
	B	1650
Apr. 12	N	1
	B	45

Table 4.3.2.3. Anchovy in Division IXa. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Mar. 99	N	22	15	*	37	2079	2079	2116
	B	190	406	*	596	24763	24763	25359
Mar. 00	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Mar. 01	N	25	13	285	324	2415	2700	2738
	B	281	87	2561	2929	22352	24913	25281
Mar. 02	N	22	156	92	270	3731 **	3823 **	4001 **
	B	472	1070	1706	3248	19629 **	21335 **	22877 **
Feb. 03	N	0	14	*	14	2314	2314	2328
	B	0	112	*	112	24565	24565	24677
Mar. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 05	N	-	59	-	59	1306	1306	1364
	B	-	1062	-	1062	14041	14041	15103
Apr. 06	N	-	-	319	319	1928	2246	2246
	B	-	-	4490	4490	19592	24082	24082
Apr. 07	N	0	103	284	387	2860	3144	3247
	B	0	1945	4607	6552	33413	38020	39965
Apr.08	N	69	252	213	534	1819	2032	2353
	B	3000	2505	4661	10166	29501	34162	39667
Apr.09	N	127	0****	159	286	1910	2069	2196
	B	2089	0****	3759	5848	20986	24745	26834
Apr. 10	N	0	62	0	62	963	963	1026
	B	0	1188	0	1188	7395	7395	8583
Apr. 11	N	1558	0	0	1558	0	0	1558
	B	27050	0	0	27050	0	0	27050
Apr. 12	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz.** Corrected estimates after detection of errors in the sA values attributed to the Cadiz area (Marques & Morais, 2003). ****Possible underestimation: although no echo-traces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming directly this.

Table 4.3.2.4. Anchovy in Division IXa. *ECOCÁDIZ* survey series (summer Spanish acoustic survey in Sub-division IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal	Spain	TOTAL
		S(A)	S(C)	S(Total)
Jun. 04***	N	125	1109	1235
	B	2474	15703	18177
Jun. 05	N	-	-	-
	B	-	-	-
Jun. 06	N	363	2801	3163
	B	6477	30043	36521
Jul. 07	N	558	1232	1790
	B	11639	17243	28882
Jul. 08	N	-	-	-
	B	-	-	-
Jul. 09	N	35	1102	1137
	B	1075	20506	21580
Jul. 10	N	?	954+	954 +
	B	?	12339 +	12339 +
Jul. 11	N	-	-	-
	B	-	-	-
Jul. 12	N	-	-	-
	B	-	-	-

***Possible underestimation: shallow waters between 20 and 30 m depth were not acoustically sampled+ Partial estimate due to an incomplete coverage of the sub-division (only the Spanish part).

Table 4.3.2.5. Anchovy in Division IXa. *SAR* autumn survey series (autumn Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Nov. 98	N	30	122	50	203	2346	2396	2549
	B	313	1951	603	2867	30092	30695	32959
Nov. 99	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 00	N	4	20	*	23	4970	4970	4994
	B	98	241	*	339	33909	33909	34248
Nov. 01	N	35	94	-	129	3322	3322	3451
	B	1028	2276	-	3304	25578	25578	28882
Nov. 02	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 03	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 05	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 06	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 07	N	0	59	475	534	1386	1862	1921
	B	0	1120	7632	8752	16091	23723	24843

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz

Table 4.4.1.1. Anchovy in Division IXa. Sub-division IXa South. Mean weight at age in the stock (in g).

Year	Age 0	Age 1	Age 2	Age 3
1995	7.030	10.720	22.550	
1996	1.056	6.256	19.983	
1997	2.574	11.061	20.900	
1998	2.646	7.404	20.449	
1999	3.187	12.839	19.988	
2000	3.137	9.963	23.817	
2001	6.210	13.288	31.765	
2002	3.319	10.500	26.286	
2003	5.982	10.566	26.789	
2004	6.644	12.009	21.875	
2005	4.936	9.166	22.619	
2006	3.651	8.214	20.970	
2007	5.358	9.442	20.385	
2008	7.181	14.934	21.768	23.093
2009	4.120	12.194	20.261	24.207
2010	6.911	11.309	19.088	22.987
2011	8.230	10.323	22.731	

Table 4.4.2.1. Anchovy in Division IXa. Sub-division IXa South. Maturity ogives (ratio of mature fish at age) for Gulf of Cadiz anchovy.

Year	Age		
	0	1	2+
1988	0	0.82	1
1989	0	0.53	1
1990	0	0.65	1
1991	0	0.76	1
1992	0	0.53	1
1993	0	0.77	1
1994	0	0.60	1
1995	0	0.76	1
1996	0	0.49	1
1997	0	0.63	1
1998	0	0.55	1
1999	0	0.74	1
2000	0	0.70	1
2001	0	0.76	1
2002	0	0.72	1
2003	0	0.69	1
2004	0	0.95	1
2005	0	0.95	1
2006	0	0.77	1
2007	0	0.91	1
2008	0	0.97	1
2009	0	0.99	1
2010	0	0.97	1
2011	0	0.97	1

Table 4.5.2.1. Anchovy in Division IXa. Sub-division IXa South. Assessment of yearly harvest rates on anchovy in the Gulf of Cadiz (IXa South) with the assumption of catchability equal 1 for all surveys (and averaging annual estimates).

EXPLOITATION STATUS QUO OF ANCHOVY IN IXA South

Biomass (tonnes)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
PELAGO (Acoustic)	24.763		24.913	21.335	24.565		14.041	24.082	38.020	34.162	24.745	7.395	0	
ECOCADIZ (Acoustic)						18.177		36.521	28.882		21.580	12.339		
BOCADEVA (DEPM)							14.637			31.527			32.757	
Mean Biomas (For q=1)	24.763		24.913	21.335	24.565	18.177	14.339	30.301	33.451	32.845	23.163	9.867	32.757	290.476
Catches	5.942	2.360	8.655	8.262	4.968	5.617	4.423	4.381	5.610	3.204	2.954	2.929	6.294	63.240
Harvest Rate	24%		35%	39%	20%	31%	31%	14%	17%	10%	13%	30%	19%	22%

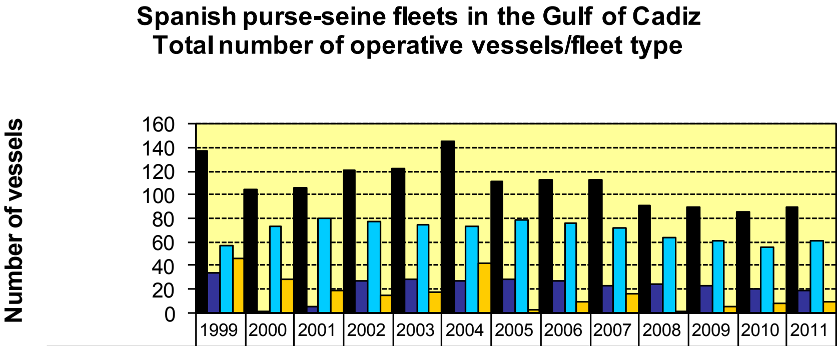
Q														Mean	Desvest	CV	MAX	min
0.6	0.14398		0.20844	0.23236	0.12134	0.18542	0.18506	0.08676	0.10062	0.05854	0.07652	0.1781	0.11529	0.14104	0.0562	0.3986	23.2%	5.9%
0.8	0.19197		0.27792	0.30981	0.16178	0.24723	0.24675	0.11568	0.13416	0.07805	0.10203	0.23747	0.15372	0.18805	0.0750	0.3986	31.0%	7.8%
1	0.23996		0.3474	0.38726	0.20223	0.30904	0.30844	0.1446	0.1677	0.09756	0.12754	0.29683	0.19216	0.23506	0.0937	0.3986	38.7%	9.8%
1.2	0.28795		0.41688	0.46471	0.24267	0.37084	0.37012	0.17351	0.20124	0.11708	0.15304	0.3562	0.23059	0.28207	0.1124	0.3986	46.5%	11.7%
1.4	0.33595		0.48636	0.54216	0.28312	0.43265	0.43181	0.20243	0.23478	0.13659	0.17855	0.41557	0.26902	0.32908	0.1312	0.3986	54.2%	13.7%

Table 4.5.2.2. Anchovy in Division IXa. Sub-division IXa South. Sensitivity of the Status Quo exploitation of Anchovy in IXa South to different levels of average catchability of surveys.

Sensitivity Assessment	0.6	0.8	1	1.2	1.4	1.6	1.8	2
Catchability of Surveys	q = 0.6	q = 0.8	q = 1	q = 1.20	q = 1.40			
Mean Harvest Rate (HR)	14.1%	18.8%	23.5%	28.2%	32.9%			
HR standard Deviation	5.62%	7.50%	9.37%	11.24%	13.12%			
CV	0.399	0.399	0.399	0.399	0.399			
MIN (HR)	5.9%	7.8%	9.8%	11.7%	13.7%			
MAX (HR)	23.2%	31.0%	38.7%	46.5%	54.2%	62.0%	69.7%	77.5%

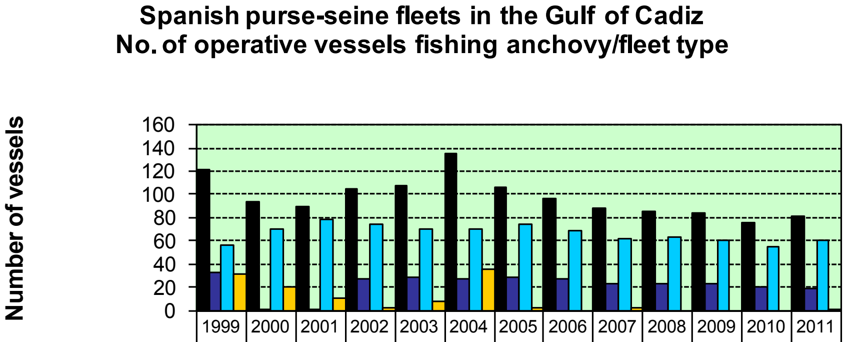
Table 4.7.1. Anchovy in Division IXa. Sub-division IXa South. Fishing mortaltity (F) and Harvest Rate (HR) reference points for a) the average age composition of the catches (1999-2011) and b) years with high presence of age 0 (1996, 97, 98 and 2011). Note: F reference points in terms of Fbar(ages 1-3).

a) First set of % of catches at age (Average % of age 0 in catches = 17%)							**F Reference Points**				**HR reference points**			
ANALISIS	**Fitted selectivity**	S_0	S_1	S_2	S_3	S_4+	**F_SBR50%**	**F_SBR40%**	**F_SBR35%**	**F_0.1**	**HR_SBR50%**	**HR_SBR40%**	**HR_SBR35%**	**HR_0.1**
Fitted at F (age 1)	0.02	0.0627	1.0000	0.1218	0.0074	0.0000	**0.32**	**0.44**	**0.50**	**1.19**	**0.78**	**1.18**	**1.44**	**7.09**
Fitted at F (age 1)	0.20	0.0580	1.0000	0.1372	0.0084	0.0000	**0.33**	**0.44**	**0.51**	**1.20**	**0.77**	**1.17**	**1.44**	**6.94**
Fitted at F (age 1)	0.40	0.0535	1.0000	0.1575	0.0099	0.0000	**0.33**	**0.45**	**0.52**	**1.21**	**0.77**	**1.17**	**1.43**	**6.71**
Fitted at F (age 1)	0.60	0.0494	1.0000	0.1822	0.0118	0.0000	**0.34**	**0.46**	**0.53**	**1.23**	**0.78**	**1.17**	**1.44**	**6.51**
Fitted at F (age 1)	0.80	0.0459	1.0000	0.2124	0.0143	0.0000	**0.35**	**0.47**	**0.54**	**1.24**	**0.78**	**1.17**	**1.44**	**6.25**
Fitted at F (age 1)	1.00	0.0428	1.0000	0.2502	0.0179	0.0000	**0.36**	**0.48**	**0.56**	**1.26**	**0.78**	**1.16**	**1.46**	**6.02**
Fitted at F (age 1)	1.20	0.0400	1.0000	0.2984	0.0225	0.0000	**0.37**	**0.50**	**0.58**	**1.28**	**0.78**	**1.18**	**1.44**	**5.69**
Fitted at F (age 1)	1.40	0.0374	1.0000	0.3618	0.0303	0.0000	**0.39**	**0.52**	**0.60**	**1.30**	**0.79**	**1.18**	**1.45**	**5.36**
b) Second set of Catches at age (Average % of age 0 in catches = 43%)							**F Reference Points**				**HR reference points**			
ANALISIS	**for a selectivity**	S_0	S_1	S_2	S_3	S_4+	**F_SBR50%**	**F_SBR40%**	**F_SBR35%**	**F_0.1**	**HR_SBR50%**	**HR_SBR40%**	**HR_SBR35%**	**HR_0.1**
Fitted at F (age 1)	0.20	0.2121	1.0000	0.1522	0.0000	0.0000	**0.27**	**0.37**	**0.42**	**1.10**	**0.79**	**1.21**	**1.49**	**9.97**
Fitted at F (age 1)	0.60	0.1760	1.0000	0.2029	0.0000	0.0000	**0.29**	**0.39**	**0.46**	**1.14**	**0.79**	**1.19**	**1.50**	**8.67**
Fitted at F (age 1)	1.00	0.1493	1.0000	0.2805	0.0000	0.0000	**0.32**	**0.43**	**0.49**	**1.19**	**0.79**	**1.21**	**1.48**	**7.65**
Fitted at F (age 1)	1.40	0.1291	1.0000	0.4112	0.0000	0.0000	**0.34**	**0.46**	**0.54**	**1.24**	**0.79**	**1.18**	**1.49**	**6.54**



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total	137	104	106	121	122	145	111	113	112	91	90	86	90
SP Heavy Tonn.	34	2	6	28	29	28	29	27	23	25	23	21	19
SP Light Tonn.	57	73	80	78	75	74	79	76	72	64	61	56	61
Multipurpose	46	29	20	15	18	43	3	10	17	2	6	9	10

Year



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total	121	94	90	105	107	135	106	96	88	86	84	76	81
SP Heavy Tonn.	33	2	2	28	29	28	29	27	23	23	23	21	19
SP Light Tonn.	57	71	78	75	70	71	75	69	62	63	61	55	61
Multipurpose	32	21	10	2	8	36	2	0	3	0	0	0	1

Year

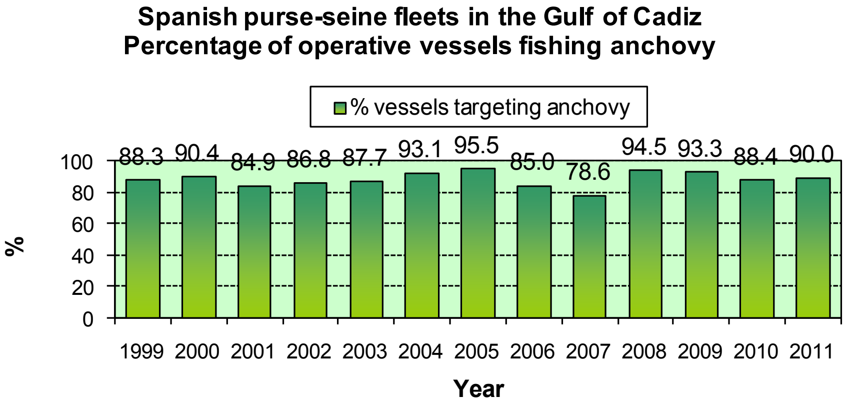


Figure 4.2.1.1. Anchovy in División IXa. Sub-division IXa South. Spanish purse-seine fishery. Fleet composition operating in the Gulf of Cadiz fishery since 1999. The fleet is differentiated into total fleet and vessels targeting anchovy. The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels).

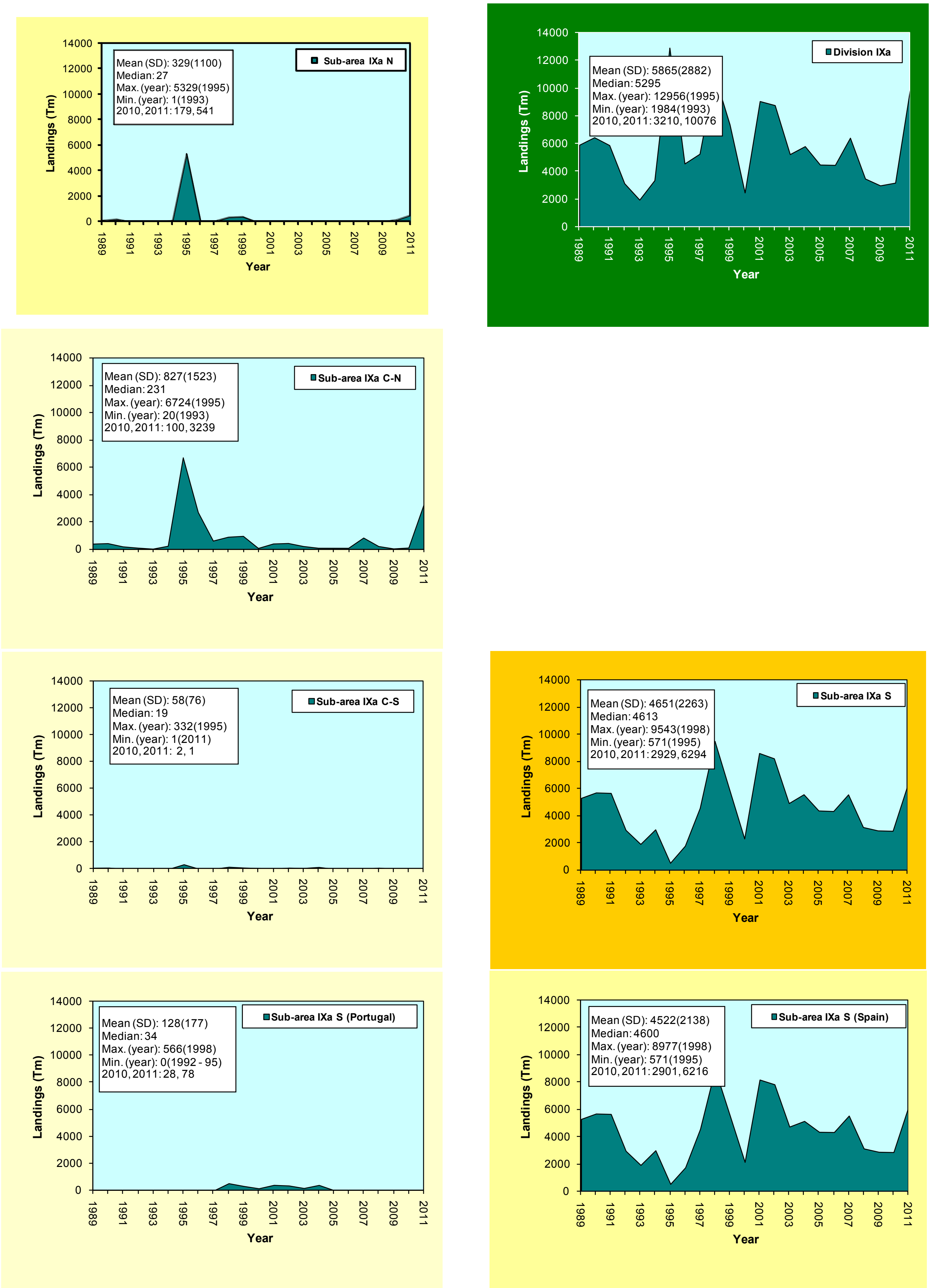


Figure 4.2.2.1.1. Anchovy in Division IXa. Recent series of Portuguese and Spanish anchovy landings in Division IXa (1989-2011, the period with data for all the Sub-divisions). Sub-areas arranged according to its geographical location along the Atlantic Iberian Peninsula. Series for the whole Division and for the whole Sub-area IXa-South are also shown.

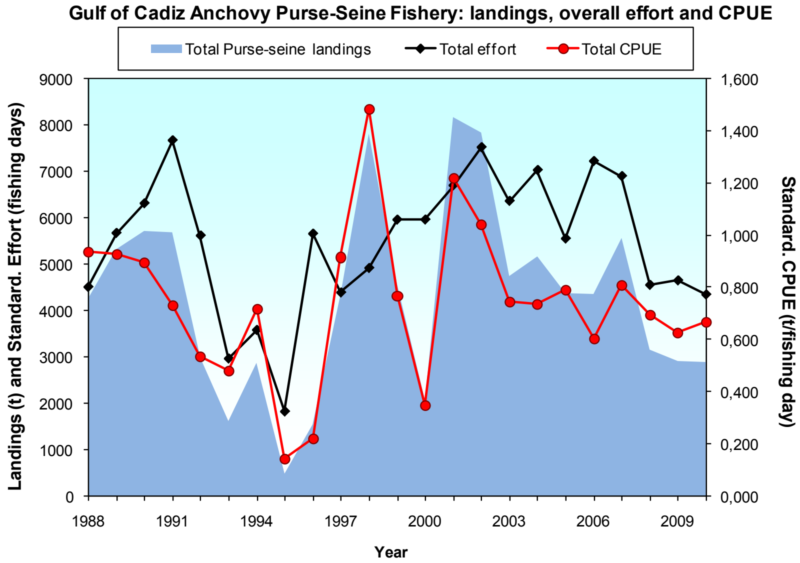


Figure 4.2.4.1. Anchovy in Division IXa. Sub-division IXa South. Spanish purse-seine fishery. Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and CPUE (1988-2010; graphs not updated with 2011 data; the figure is the same that the one showed in the last year's report and it is included here to show the available recent trends in standardised effort and CPUE).

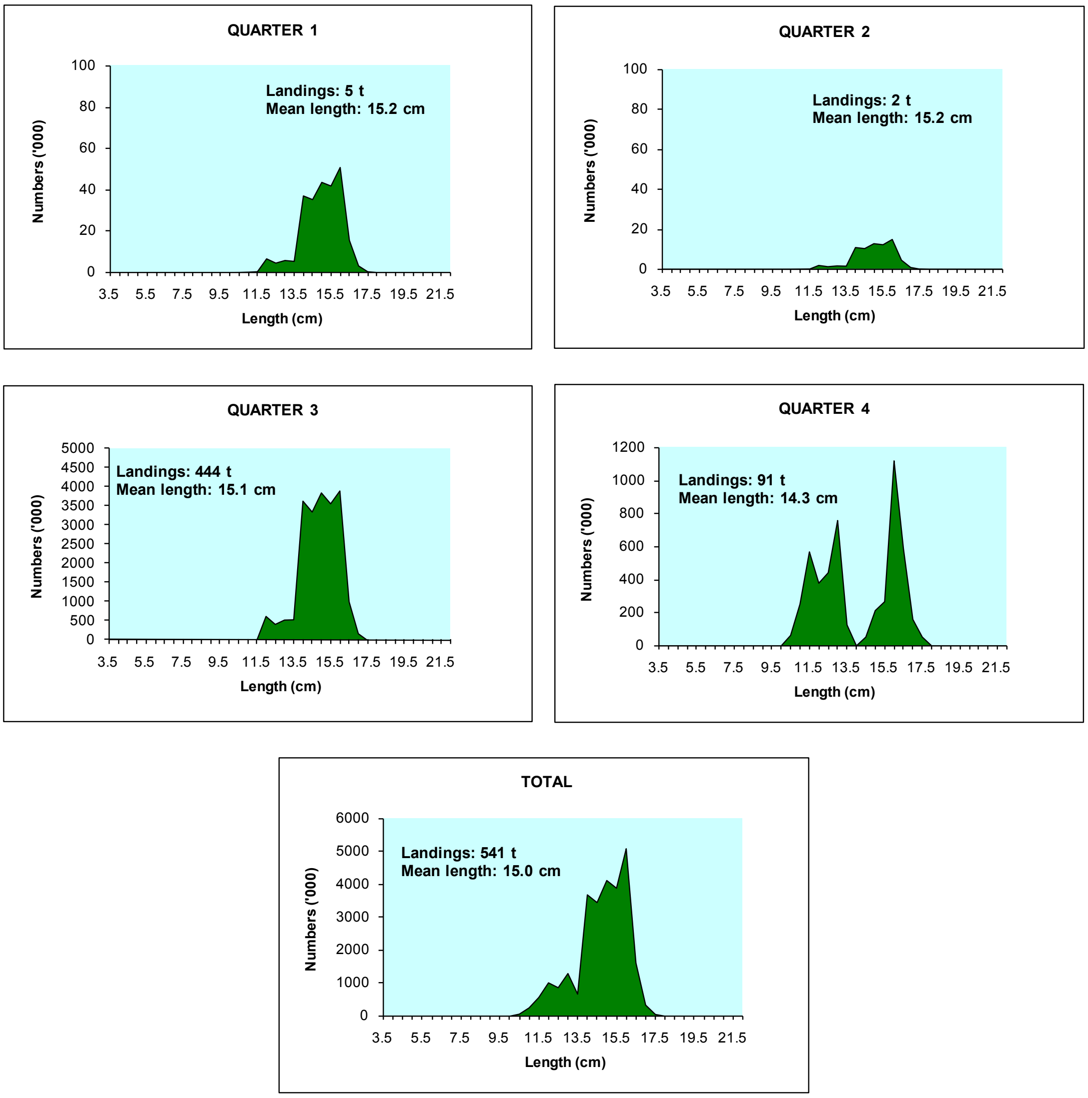


Figure 4.2.5.1.1. Anchovy in Division IXa. Sub-division IXa North. Spanish fishery (all fleets). Quarterly and annual length distributions ('000) of Spanish landings of Western Galicia anchovy in 2011.

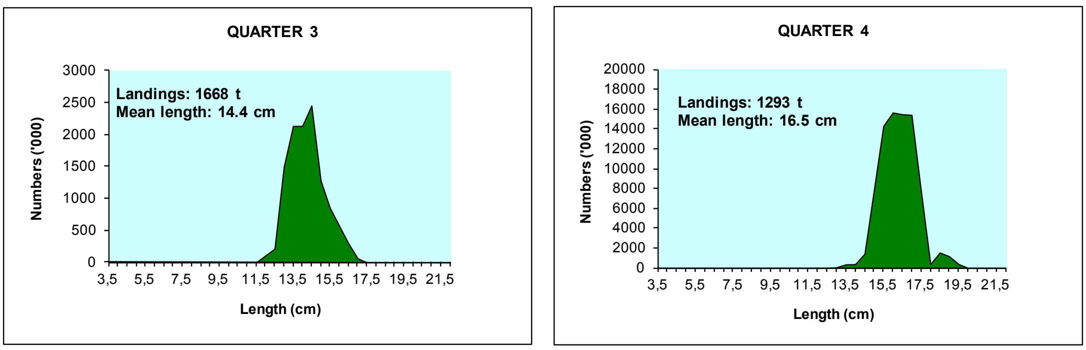


Figure 4.2.5.1.2. Anchovy in Division IXa. Sub-division IXa Central-North. Portuguese fishery (all fleets). Quarterly and annual length distributions ('000) of Portuguese landings in 2011 (only data available for the second semester).

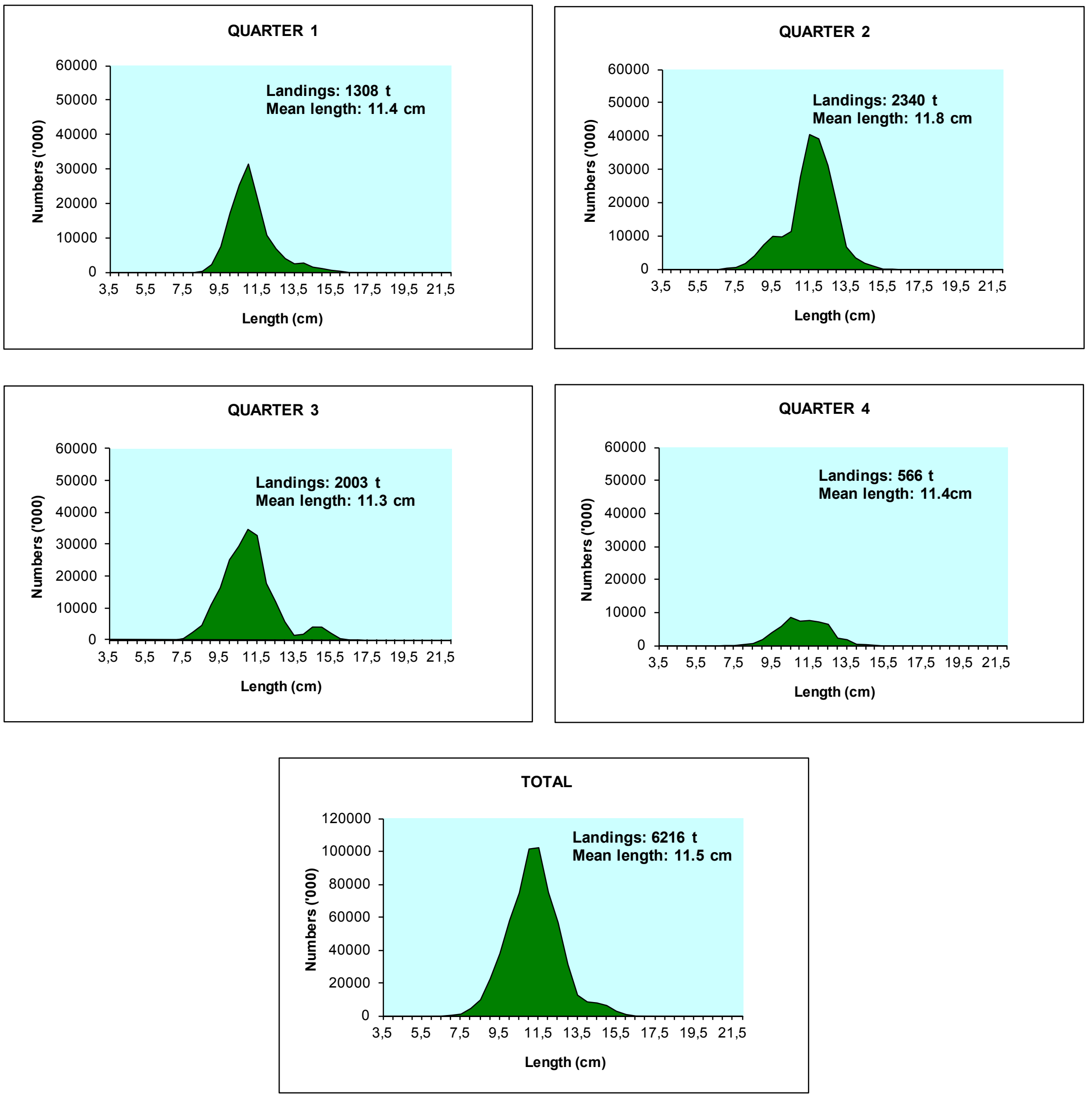


Figure 4.2.5.1.3. Anchovy in Division IXa. Sub-division IXa South. Spanish fishery (all fleets). Quarterly and annual length distributions ('000) of Spanish landings of Gulf of Cadiz anchovy in 2011.

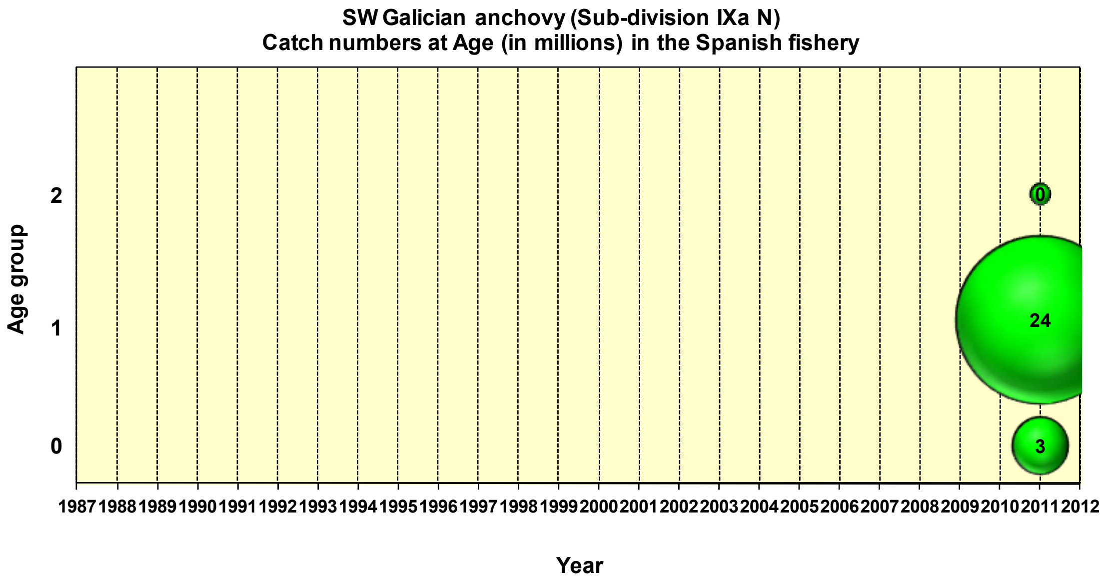


Figure 4.2.5.2.1. Anchovy in Division IXa. Sub-division IXa North. Spanish fishery (all fleets). Age composition in Spanish landings of SW Galician anchovy (only 2011 data available).

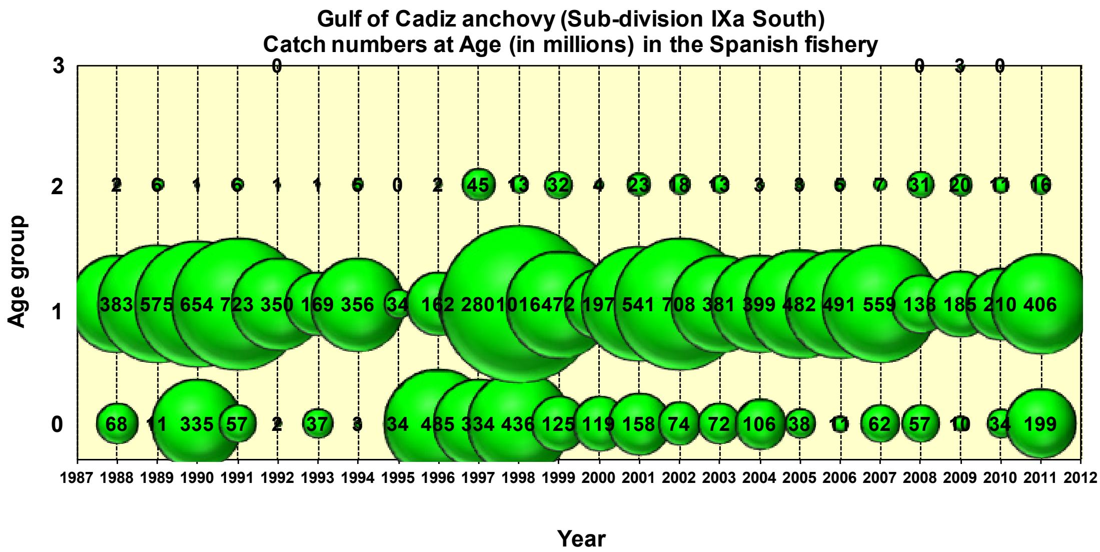
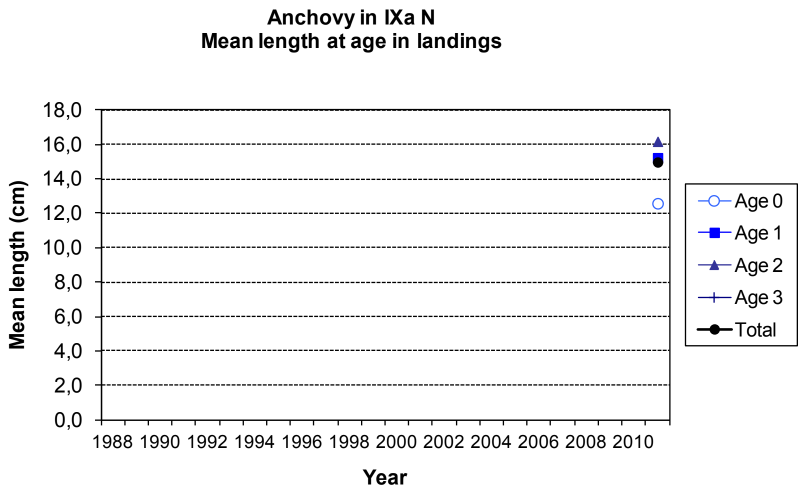


Figure 4.2.5.2.2. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Age composition in Spanish landings of Gulf of Cadiz anchovy (1988-2011). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.



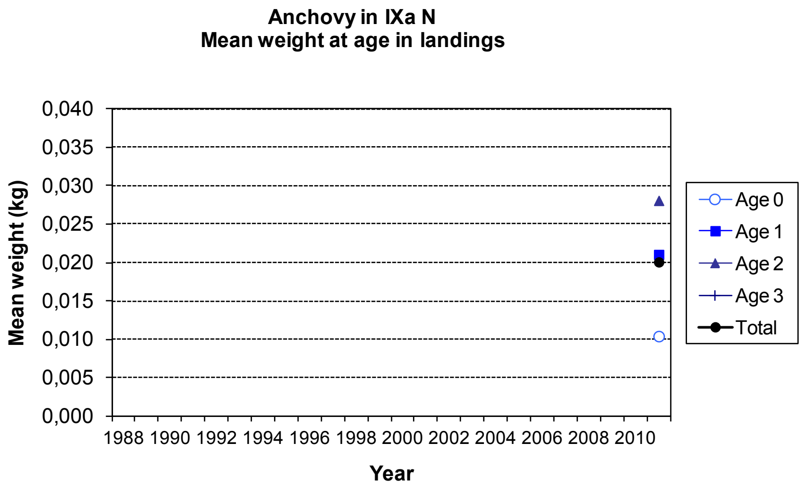
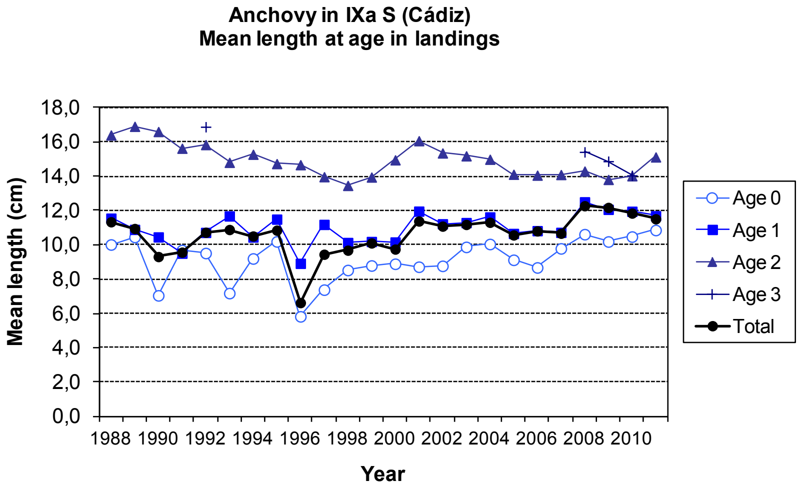


Figure 4.2.6.1. Anchovy in Division IXa. Sub-division IXa North. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Western Galicia anchovy in 2011.



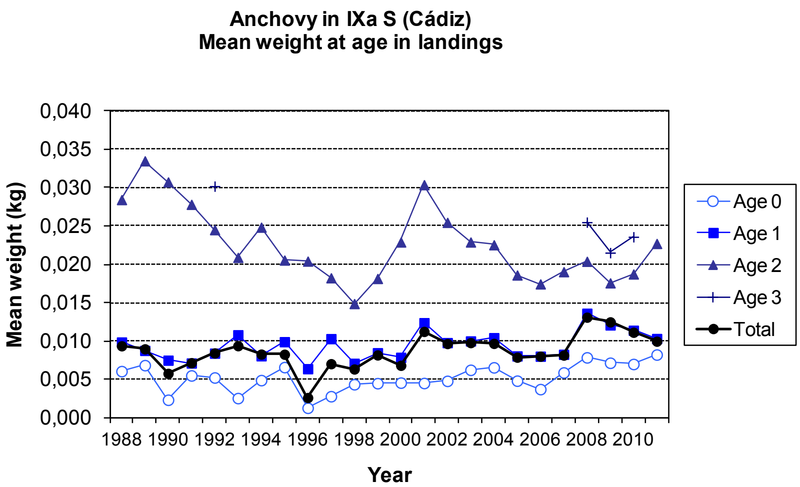


Figure 4.2.6.2. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Gulf of Cadiz anchovy (1988-2011). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

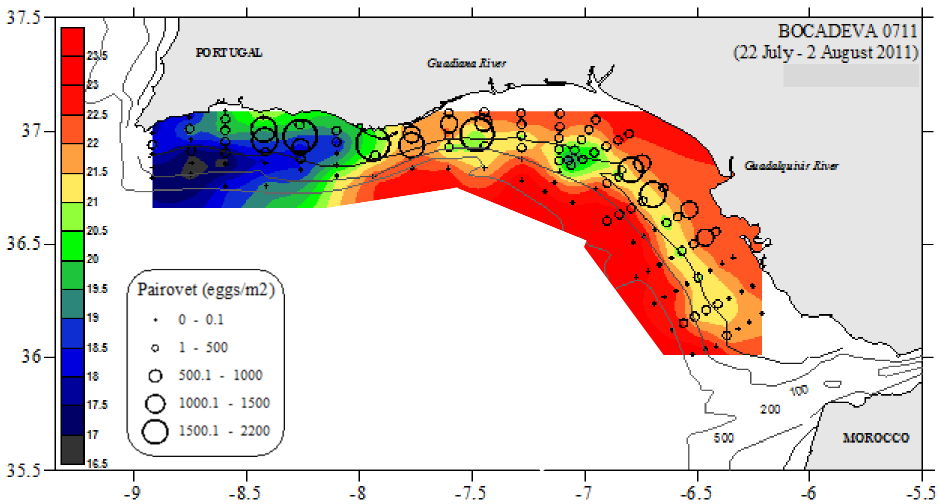


Figure 4.3.1.1. Anchovy in Division IXa. *BOCADEVA 0711* survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Distribution of anchovy egg densities sampled by PairoVET and SST.

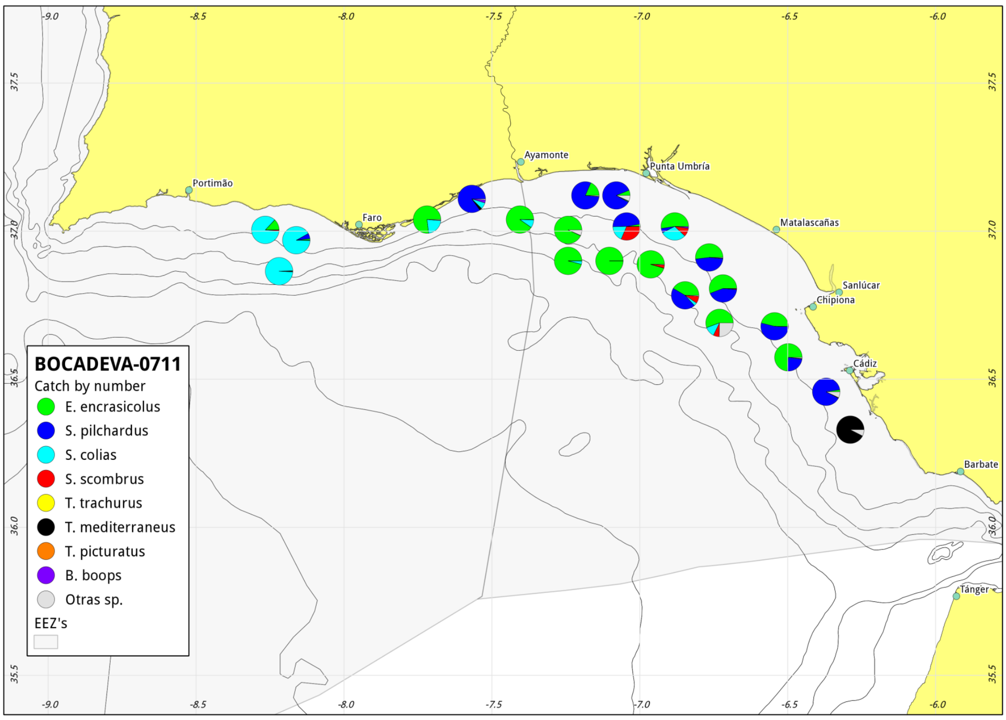


Figure 4.3.1.2. Anchovy in Division IXa. *BOCADEVA 0711* survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Distribution and species composition (% in numbers) of the valid pelagic hauls.

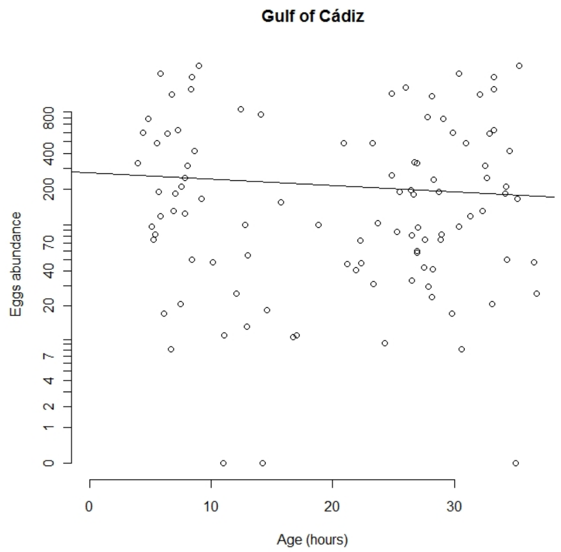


Figure 4.3.1.3. Anchovy in Division IXa. ***BOCADEVA 0711*** **survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Exponential mortality model fitted, by applying a GLM (with negative binomial distribution), to the egg abundance by cohorts and corresponding mean age.**

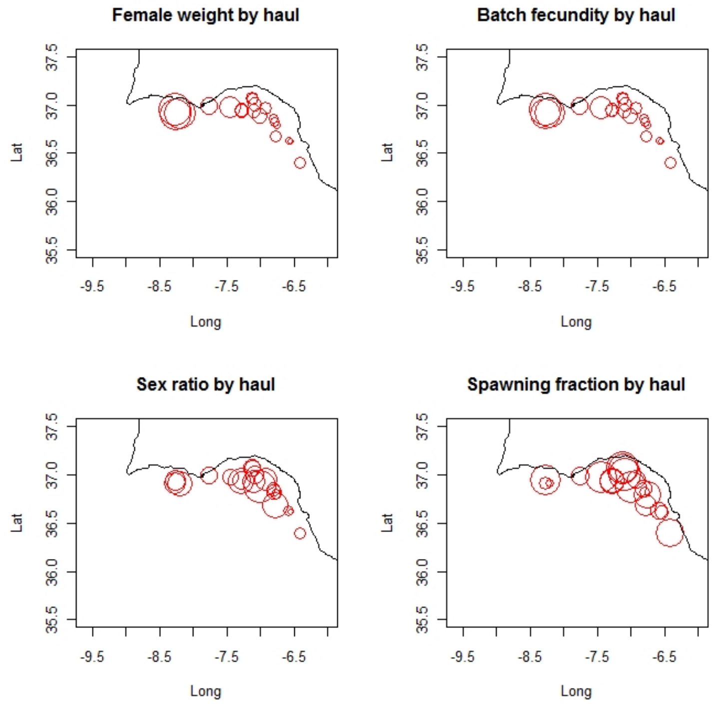


Figure 4.3.1.4. Anchovy in Division IXa. ***BOCADEVA 0711*** **survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Spatial distribution of single mean estimates of adult parameters.**

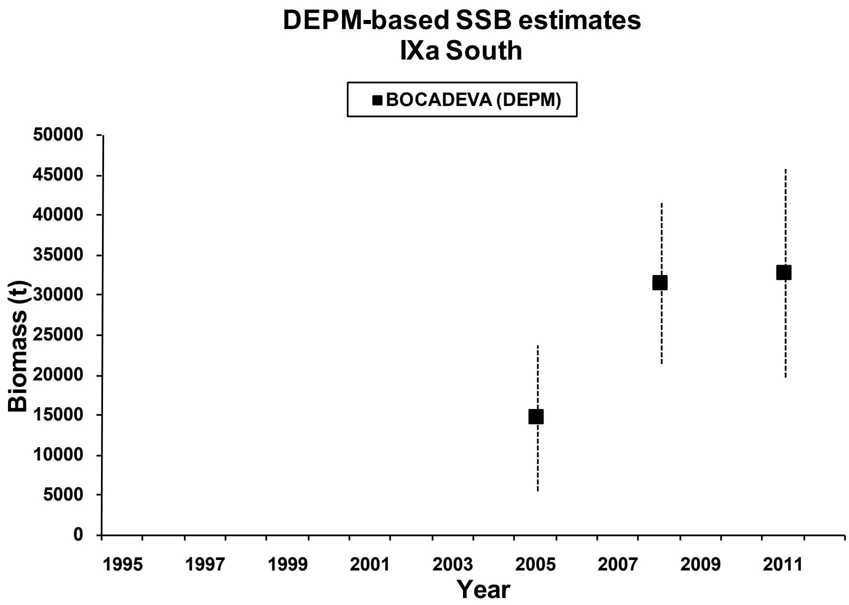
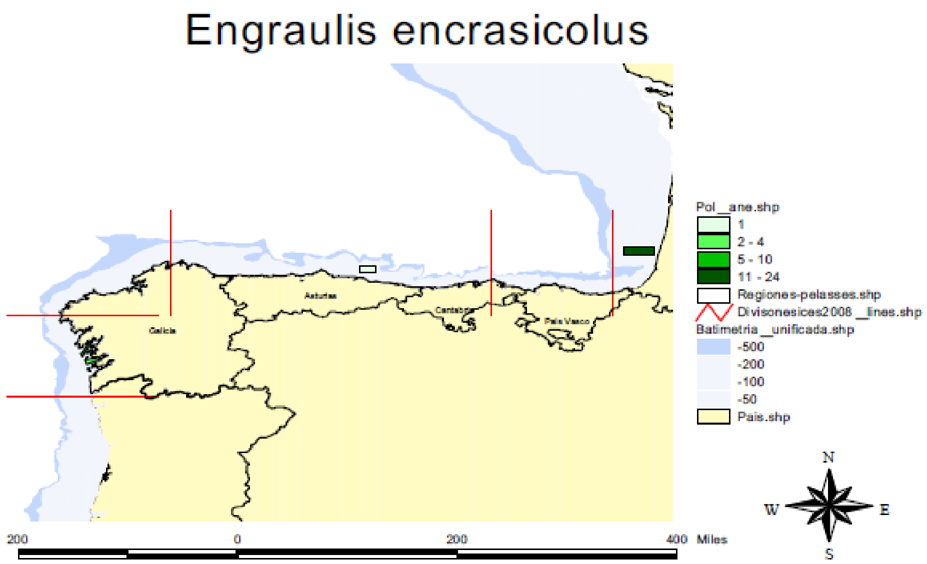


Figure 4.3.1.5. Anchovy in Division IXa. Sub-division IXa South. *BOCADEVA 0711* survey (summer Spanish DEPM survey in Sub-division IXa South in 2011). Series of SSB estimates (±SD) obtained from the *BOCADEVA* survey series.



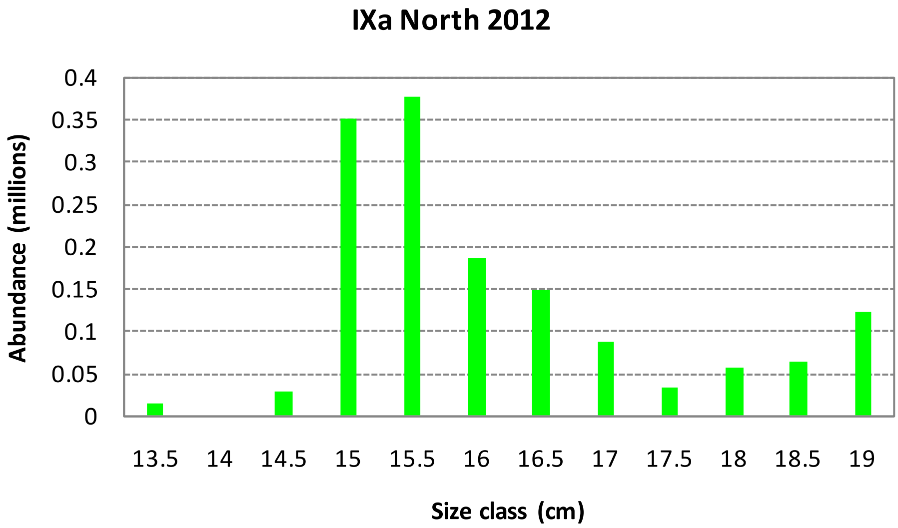


Figure 4.3.2.1. Anchovy in Division IXa. Sub-division IXa North. *PELACUS 0411* survey (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c in 2011). Top: distribution of the NASC coefficients (m2/mn2) attributed to anchovy. Sub-division IXa North corresponds to the south westernmost geographical stratum. Polygons (i.e., coherent post-strata) encompass the observed echoes and homogenous size composition, and polygon colour indicates the mean value of NASC coefficients inside each polygon. Bottom: size composition of the estimated anchovy population in the Sub-division IXa North during the survey.

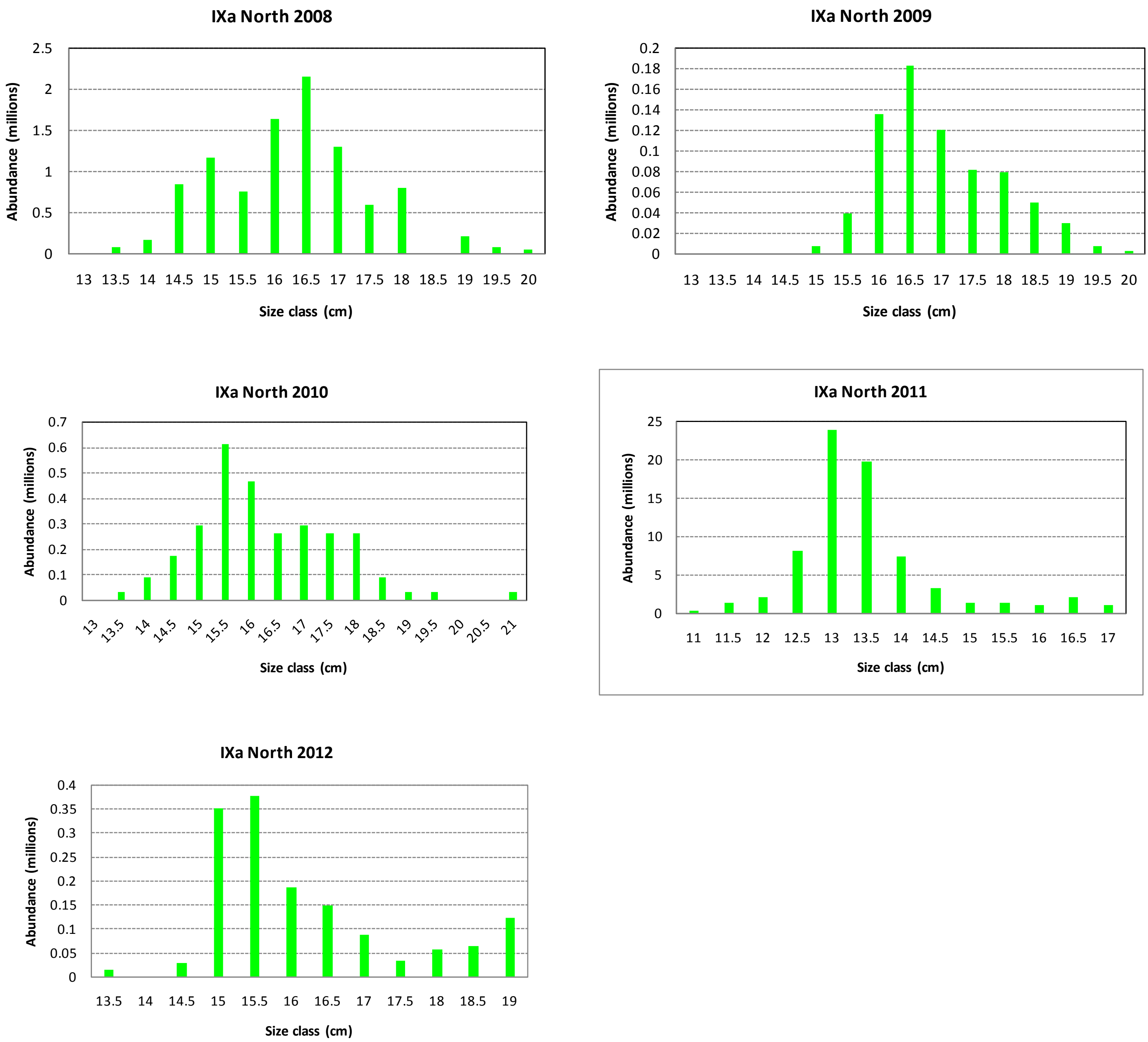


Figure 4.3.2.2. Anchovy in Division IXa. Sub-division IXa North. ***PELACUS 04*** **survey series (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c). Size composition of the estimated population during the survey series (2008-2012).**

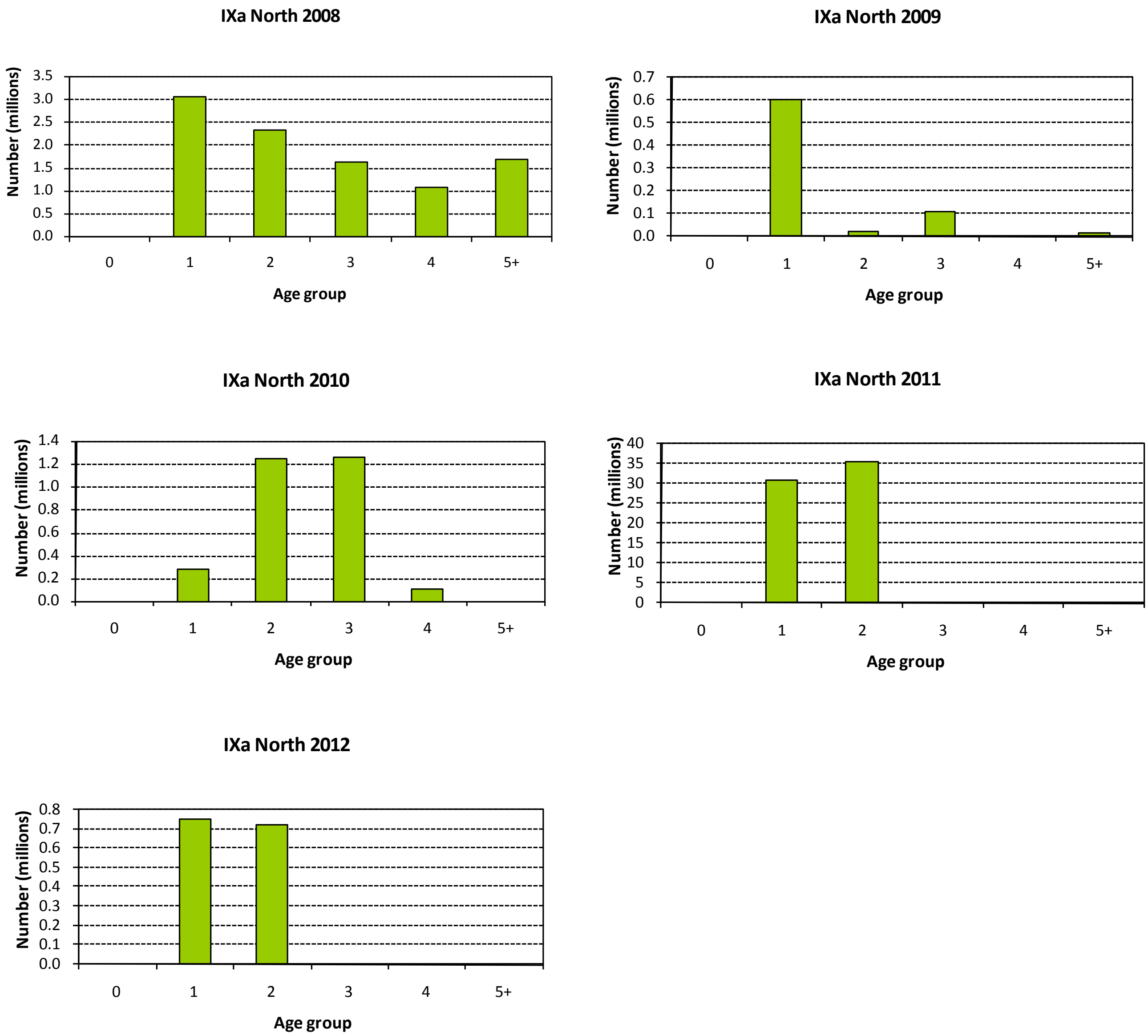


Figure 4.3.2.3. Anchovy in Division IXa. Sub-division IXa North. *PELACUS 04* survey series (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c). Age structure of the estimated population during the survey series (2008-2012).

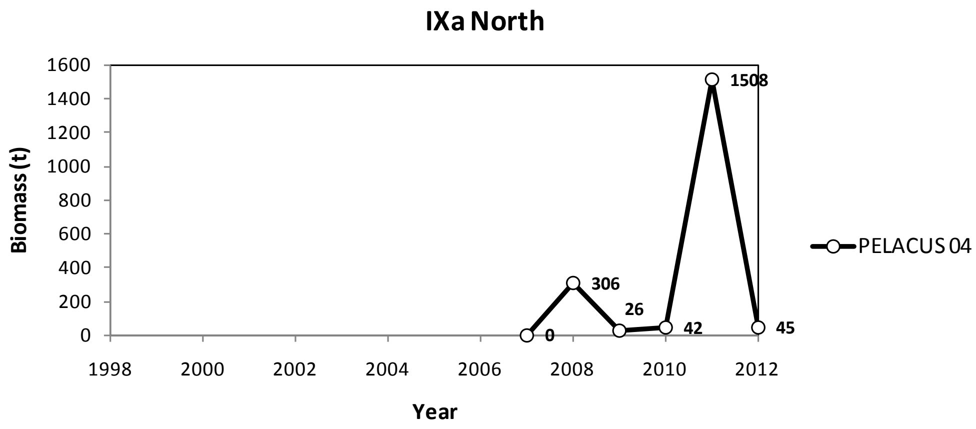


Figure 4.3.2.4. Anchovy in Division IXa. Sub-division IXa North. *PELACUS 04* survey series (spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c). Historical series of acoustic estimates of anchovy biomass (t) for the Sub-division IXa North.

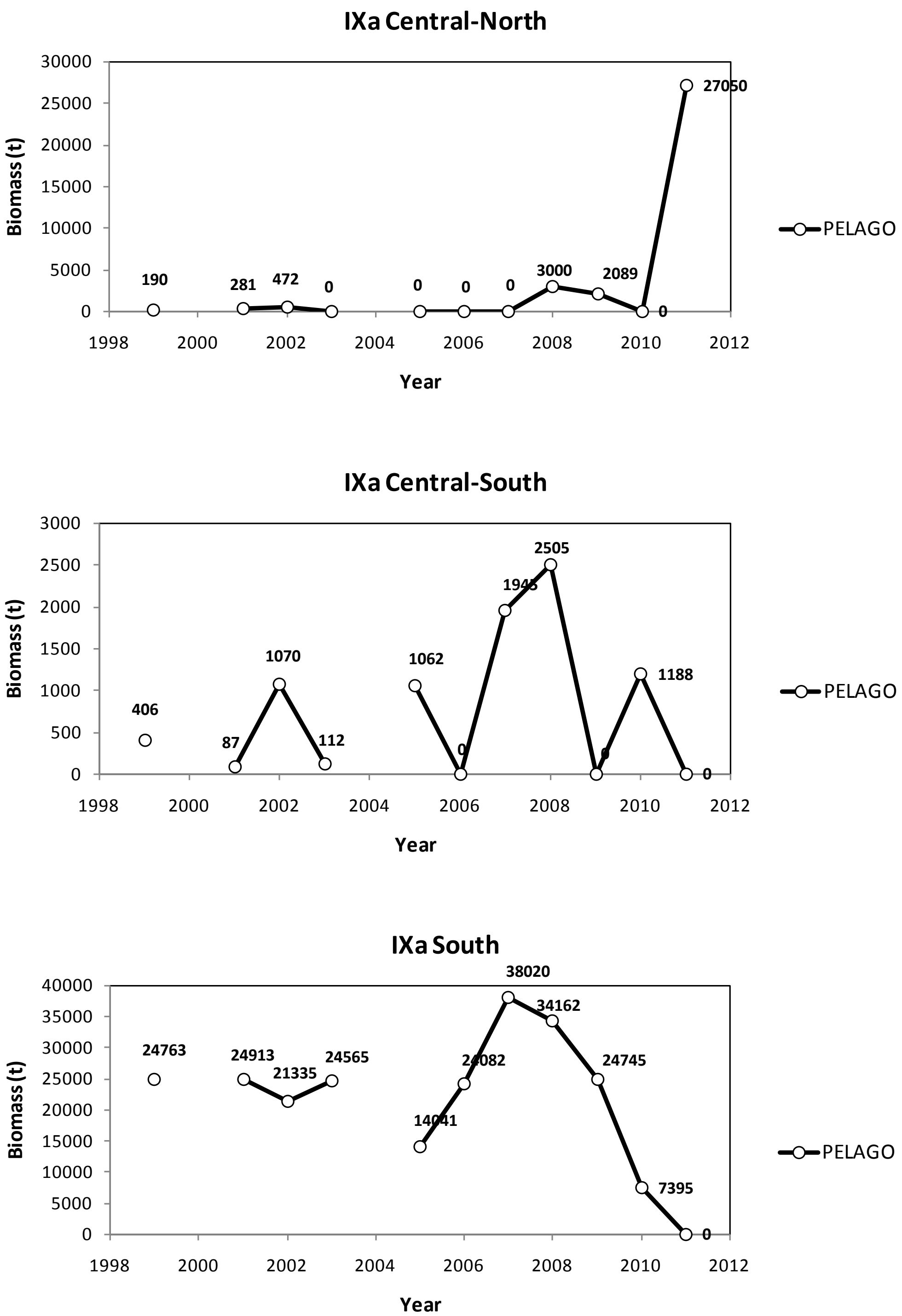
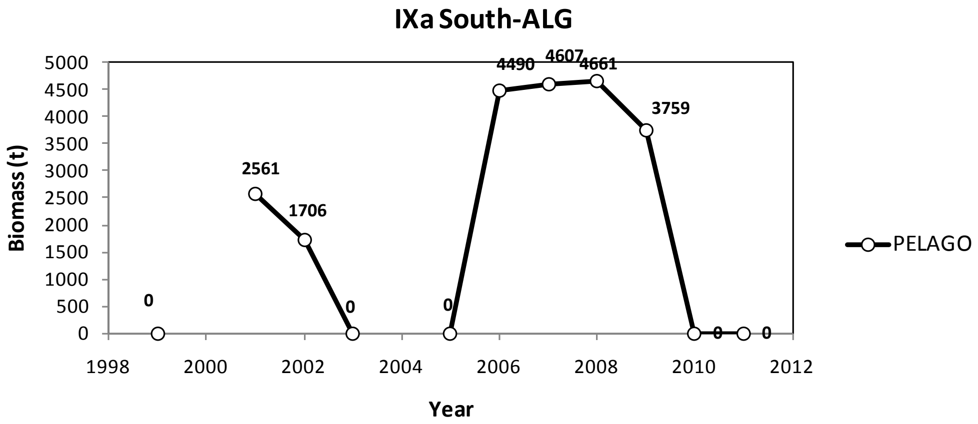


Figure 4.3.2.5. Anchovy in Division IXa. Sub-divisions IXa Central-North to IXa South. *PELAGO* survey series (spring Portuguese acoustic survey in Sub-divisions IXa Central-North to IXa South). Historical series of overall and regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.



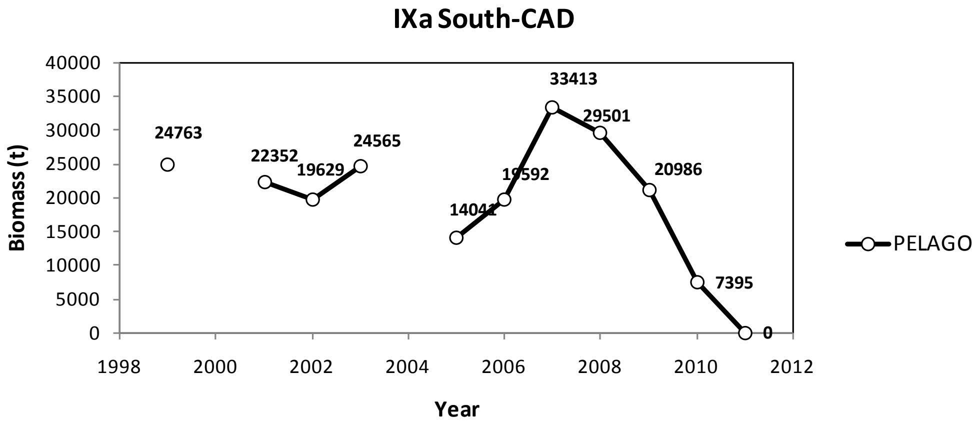


Figure 4.3.2.5 (cont'd). Acoustic estimates in the IXa South differentiated by Algarve (ALG) and Spanish waters of the Gulf of Cádiz (CAD). Note the different scale of the y-axis. Although estimates from Subdivision IXa-South in 2010 were not separately provided for Algarve and Cadiz to this WG, the total estimated for the Sub-division was assigned (by assuming some overestimation) to the Cadiz area according to the observed acoustic energy distribution in the area.

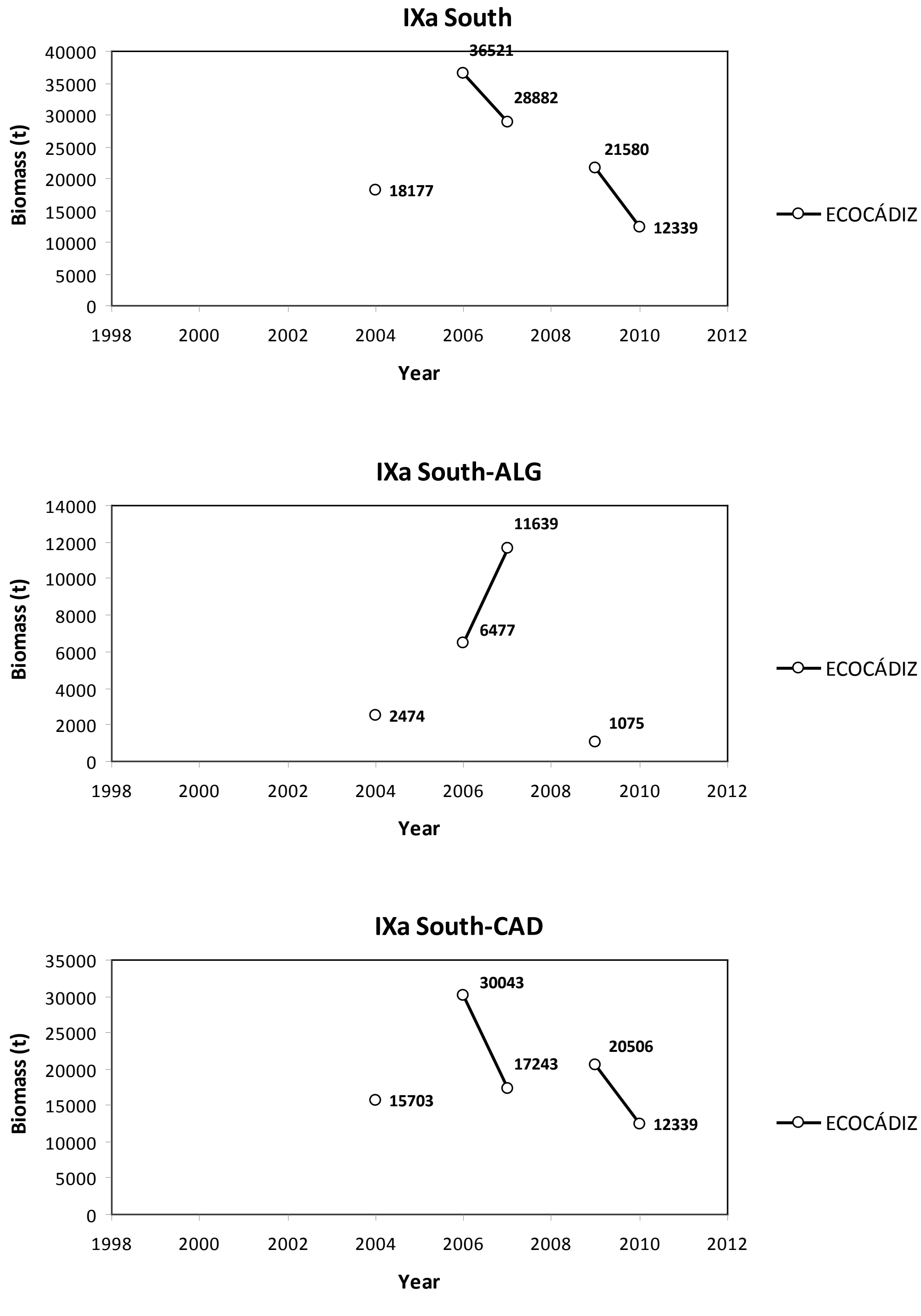
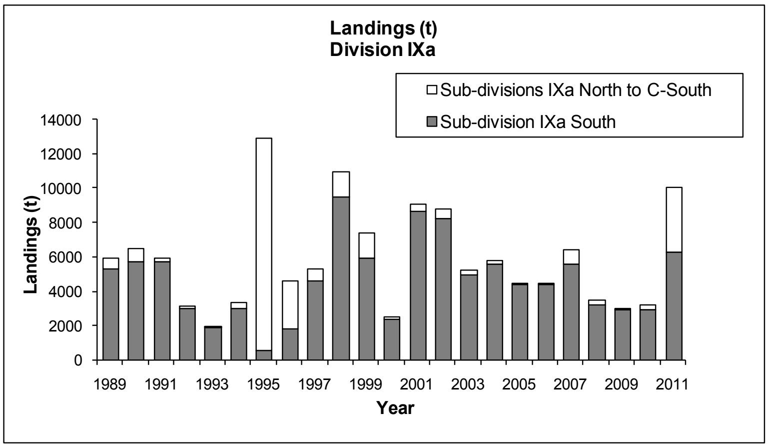
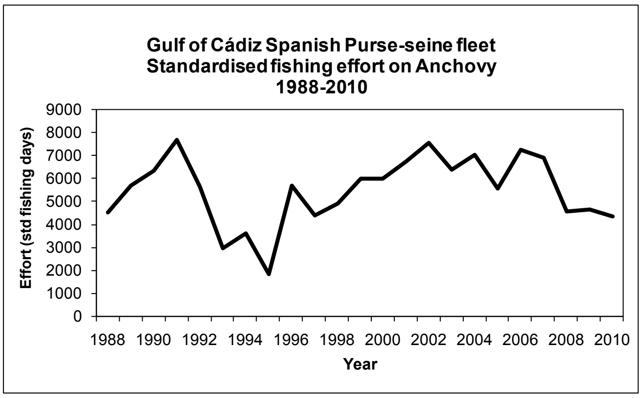
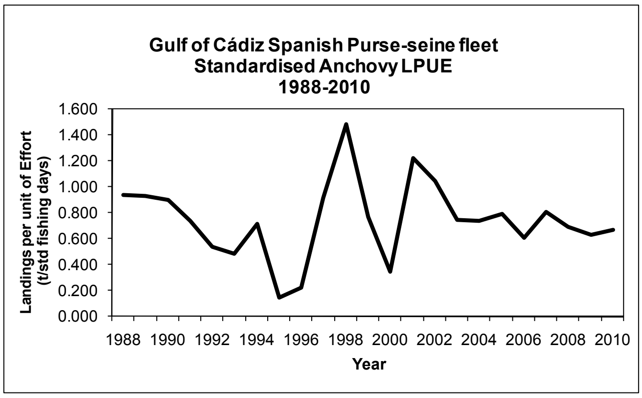


Figure 4.3.2.6. Anchovy in Division IXa. Sub-divisions IXa Central-North to IXa South. *ECOCÁDIZ* survey series (summer Spanish acoustic survey in Sub-division IXa South). Historical series of overall and regional (Algarve, ALG, and Spanish waters of the Gulf of Cádiz, CAD) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.







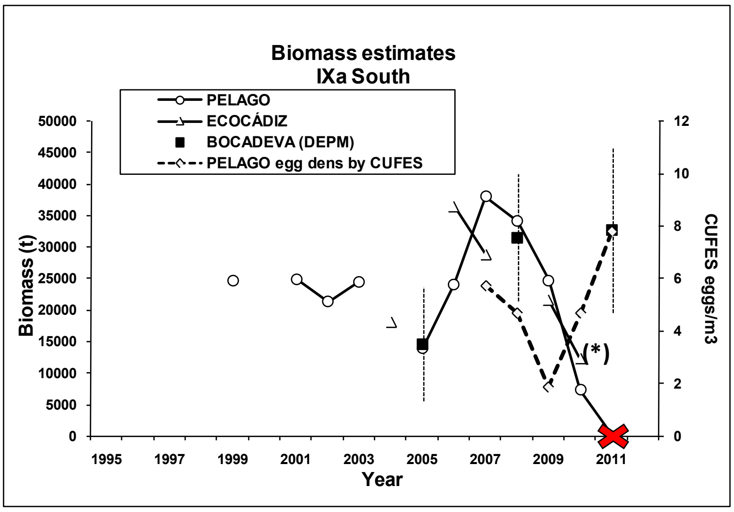


Figure 4.5.2.1. Anchovy in División IXa. Anchovy in Sub-division IXa-South. Information used in the Qualitative (Updated) Assessment. Upper row: total annual landings in Division IXa differentiated between Sub-division IXa South (Algarve + Gulf of Cádiz) and remaining Sub-divisions. Middle row: standardised fishing effort (fishing days) and CPUE (tonnes/fishing day) exerted by the Spanish purse-seine fleet in the Sub-division (not updated with 2011 data). Bottom row: available biomass estimates from research surveys series sampling the Sub-division used for comparative purposes. Anchovy egg densities sampled by CUFES during the most recent *PELAGO* surveys are also shown for comparison with their respective population biomass acoustic estimates (by chance this value is overlaid with the DEPM estimates for this year despite of having independent axis for reference). Asterisk denotes that the 2010 *ECOCÁDIZ* survey only partially explored the whole survey area. The red cross denotes that the 2011 *PELAGO* survey estimate is eliminated from the trend-based assessment. There are no available estimates in 2012.

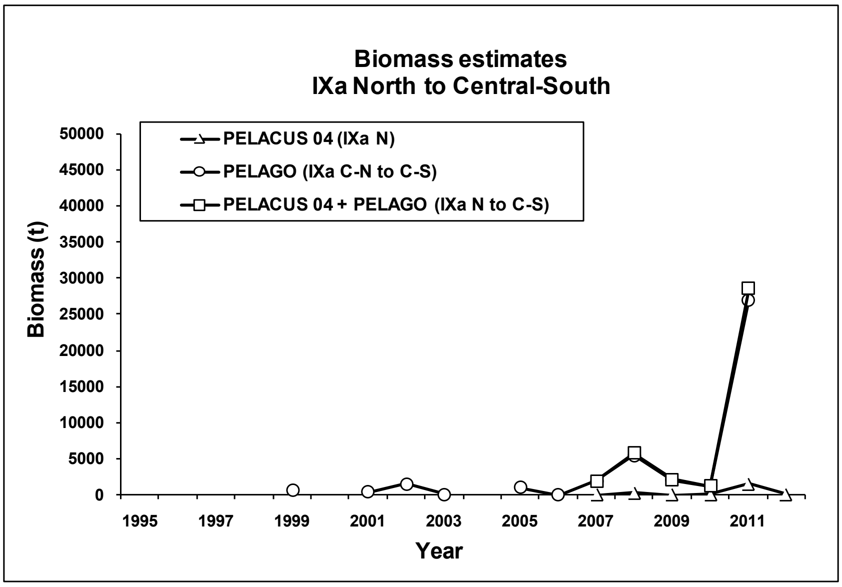


Figure 4.5.2.2. Anchovy in División IXa. Anchovy in Sub-divisions IXa-North to Central-South (Western Iberian Atlantic façade). Information used in the Qualitative (Updated) Assessment: total annual landings from Sub-divisions and the whole region (see Figure 4.5.2.1), and available biomass estimates from research surveys series sampling the Sub-divisions used for comparative purposes. For 2012 the only available estimates is the one from the *PELACUS 04* survey for IXa North.

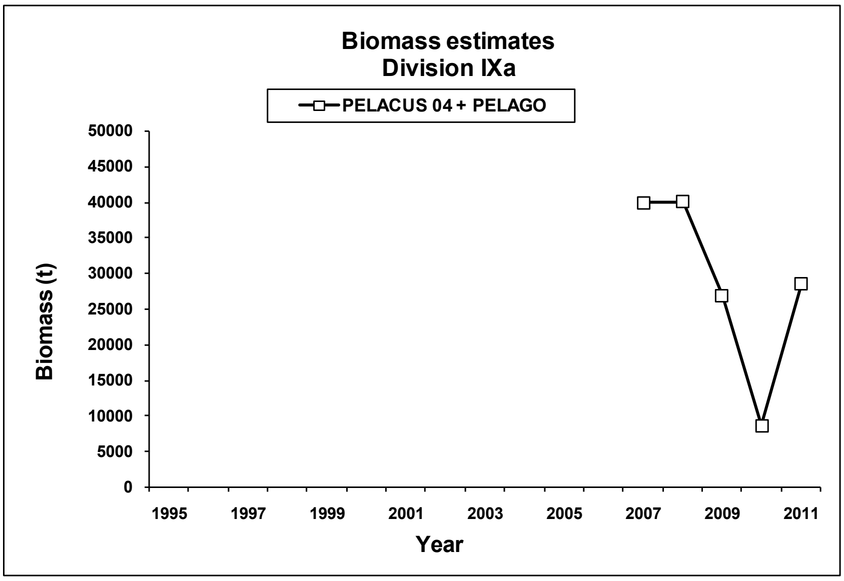
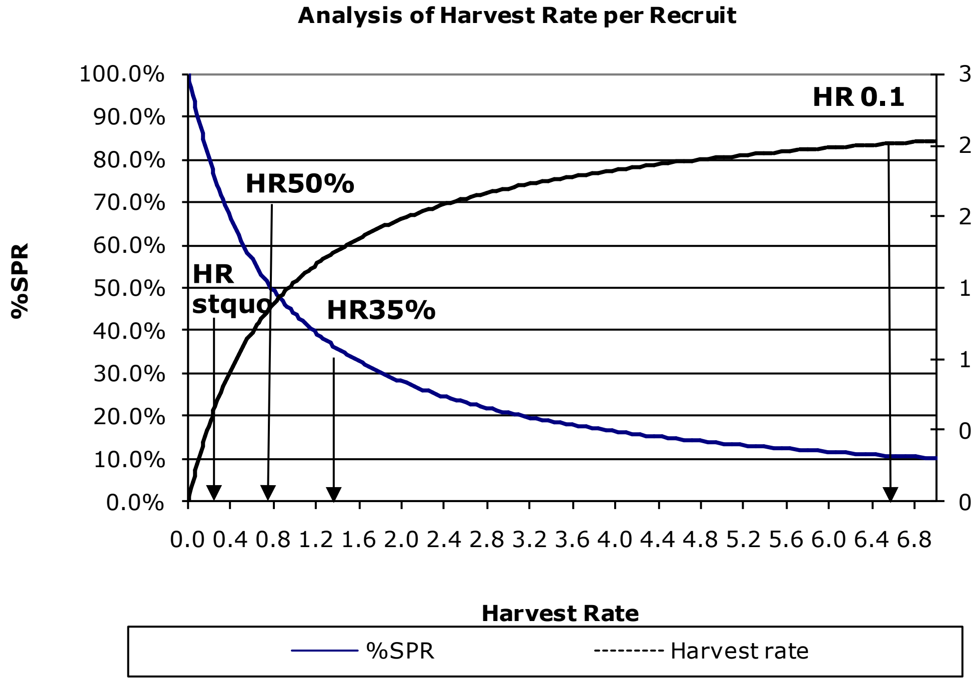


Figure 4.5.2.3. Anchovy in División IXa. Information used in the Qualitative (Updated) Assessment of the whole Division: total annual landings (see Figure 4.5.2.1) and available biomass estimates from research surveys series sampling the Division. For consistency, when merging estimates for the whole Division, only spring surveys (both *PELACUS 04* and *PELAGO*) have been considered.



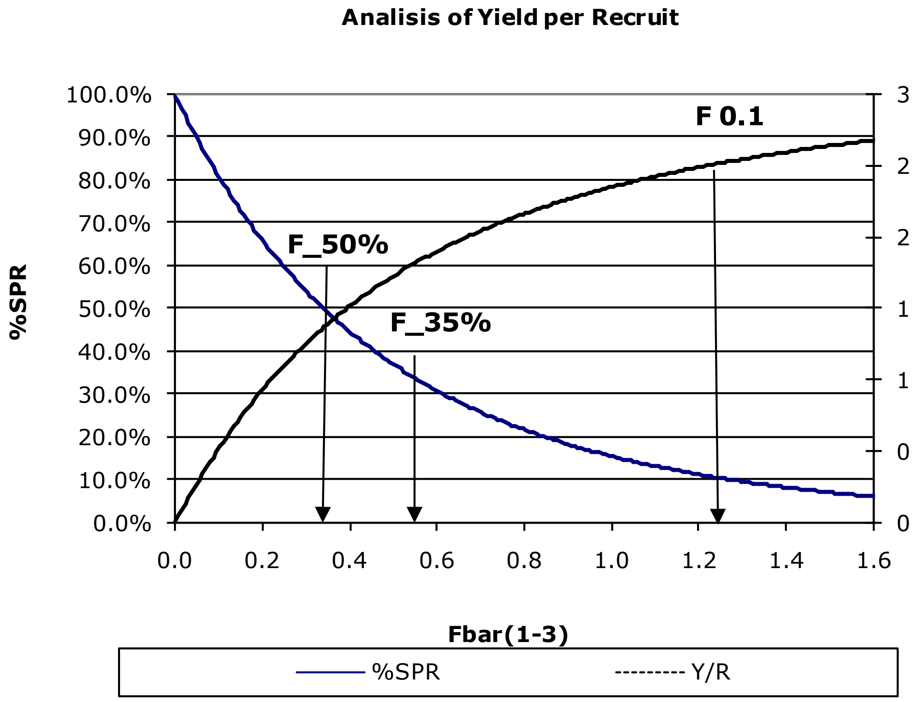


Figure 4.7.1. Anchovy in División IXa. Sub-division IXa South. Plots with the reference points for F and HR corresponding to the selectivity at age fitted with a presumed F at age 1 = 0.6

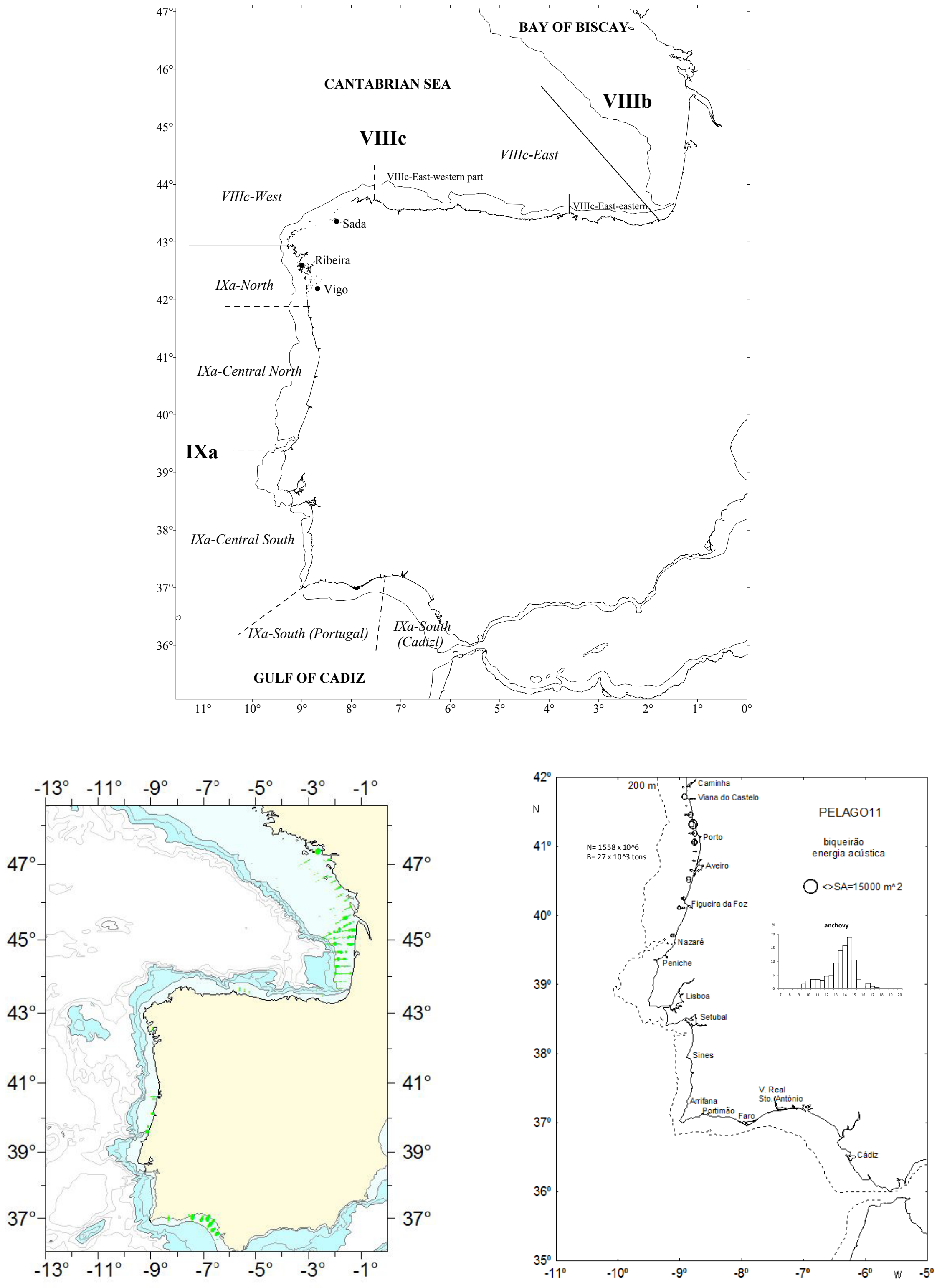


Figure 4.8.1.1. Anchovy in División IXa. A) Geographical distribution of Sub-divisions. B) Usual distribution of the anchovy populations throughout the Division as derived from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b). C) Current spatial pattern of the anchovy abundance in the Division from the 2011 spring Portuguese acoustic survey.

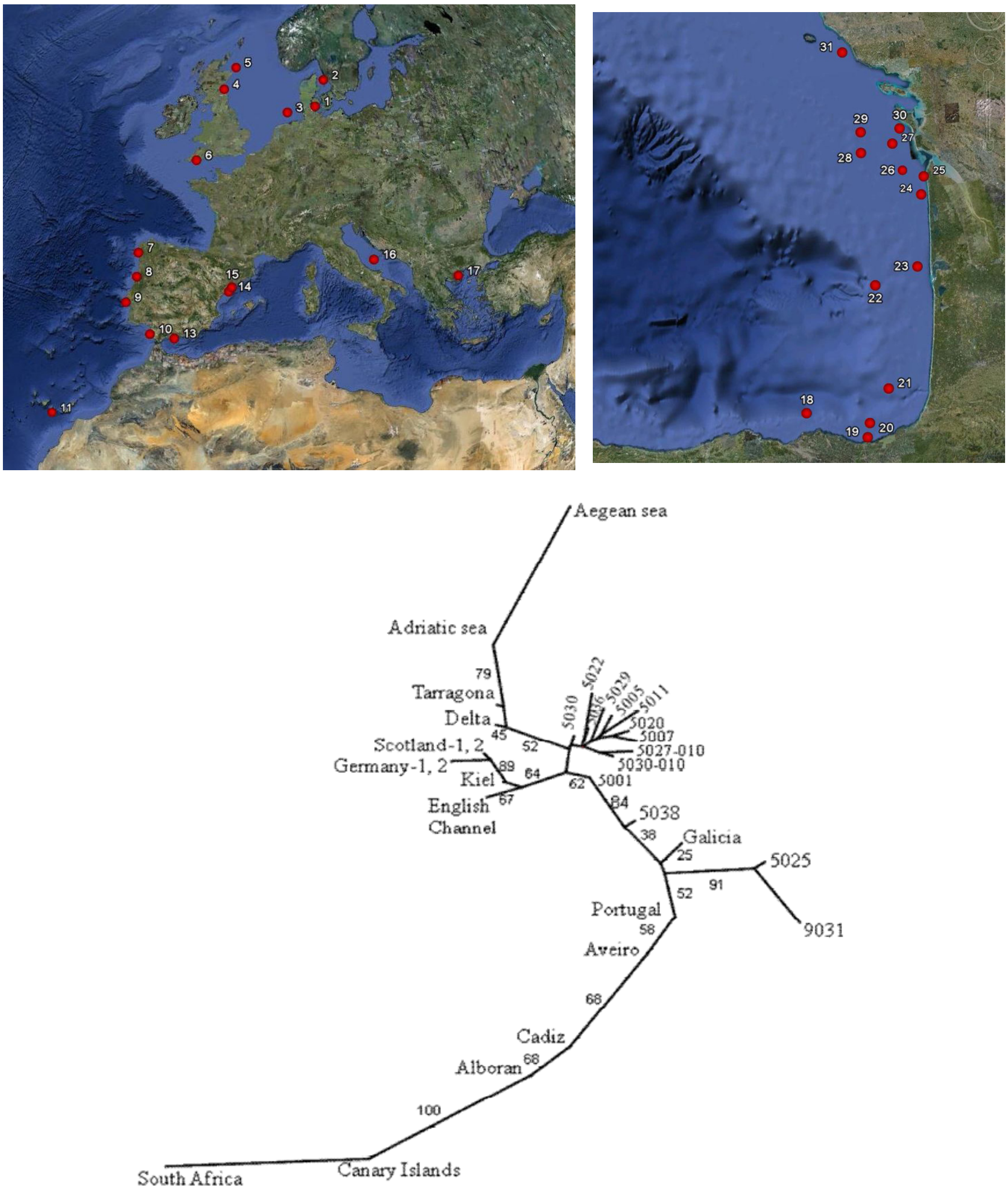


Figure 4.8.1.2. Anchovy in División IXa. Results from Zarraonandía's (2011) studies on genetic structure of European anchovy populations using single nucleotide polymorphisms (SNP). Upper row: geographical location of the analysed samples. Lower figure: Neighbour-Joining (NJ) dendrogram based on Reynolds distances among all the analyzed localities. Topological confidence obtained by 1,000 bootstrap replicates.

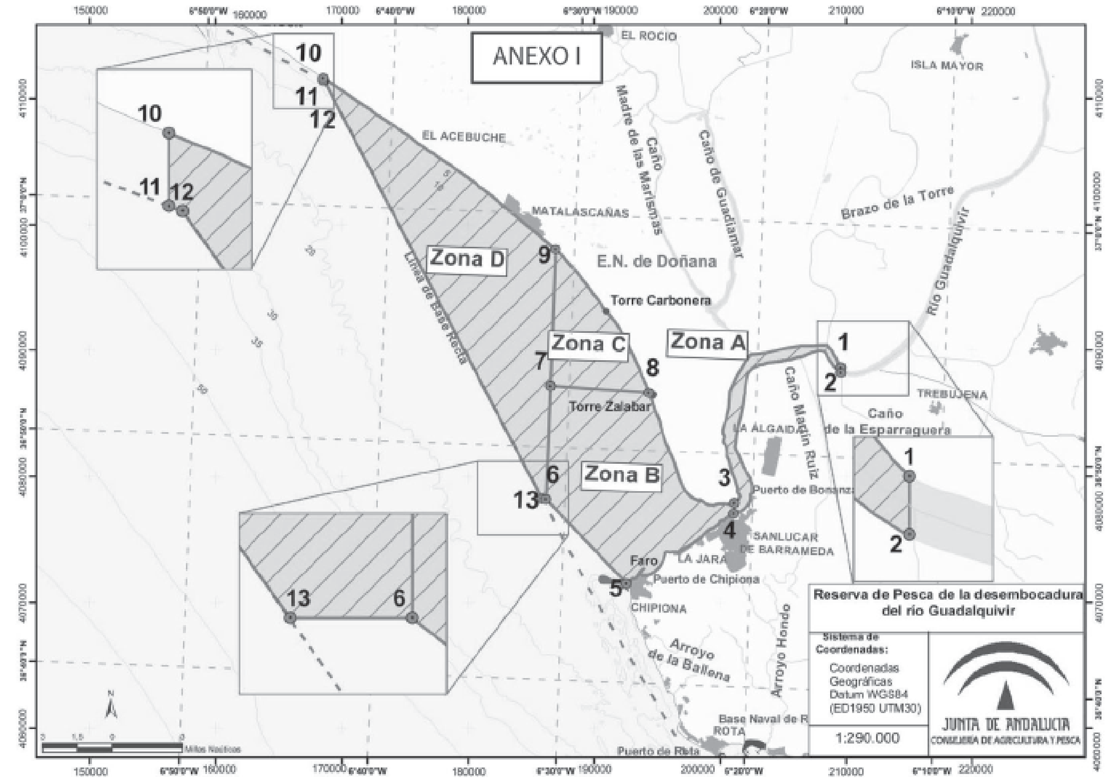


Figure 4.8.2.1. Anchovy in Division IXa. Sub-division IXa-South. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish waters of the Gulf of Cadiz).

5 Sardine general

5.1 The fisheries for sardine in the ICES area

5.1.1 Catches for sardine in the ICES area

Commercial catch data for 2011 were provided by Portugal, Spain, France, Netherlands and UK (England and Wales) (**Table 5.1.1.1**). Total reported catch was 105 442 tonnes, divided as follows: 54% of the catches by Portugal, 27% by Spain and 18% by France. The remaining 1% of catches are reported by Netherlands, England and Wales. Catches in VIIIc and IXa amount to 76% of the total sardine catches (although it should be taken into account that not data were provided to the WG by Ireland and Germany this year). It should be noted that fishing activities are limited in both Spain and Portugal, while there are no catch regulations in place in the other countries. In 2011, there was a 6% decrease with respect to the total 2010 sardine catches reported in European waters. Portugal showed a 10% decrease while Spain showed a 7% increase in catches with respect to 2010. Landings in France showed a 1% decrease and catches from England, Wales and Netherlands respectively decreased by 70% and 92% in 2011.

Table 5.1.1.1: Sardine general: 2011 commercial catch data from the ICES area, available to the Working Group.

Unit Tonnes.

Divisions	UK (Engl&Wal)	France	Spain	Portugal	Netherlands	Total
IVa						0
IVb		89				89
IVc		62				62
VIa						0
VIIa						0
VIIb						0
VIIc						0
VIId		294			437	731
VIIe	470	99			33	602
VIIf	261				44	305
VIIg						0
VIIh	7	19				26
VIIi						0
VIIj						0
VIIIa		17917				17917
VIIIb			5283		5	5288
VIIIc		10	8536			8546
VIIId		8				8
VIIIe						0
IXaN			5621			5621
IXaCN				37152		37152
IXaCS				13685		13685
IXaS-Alg				6387		6387
IXaS-Cad			9023			9023
Total	738	18498	28463	57224	519	105442

6 Sardine in divisions VIIIabd and subarea VII

6.1 Population structure and stock identity

It is unclear if populations in VII and VIIIabd could be treated as a single stock. There are evidence from landings that some fish coming from VIIIa are caught in VIIh and VIIe and vice versa. Dutch vessels which operates in the English Channel and North sea sometimes declare catches in VIIIa. Major landings occurs in both VIIIabd and English Channel (VIId, VIIe, VIIf, VIIh) area. Few landings occur in other VII areas therefore two major fishing regions appears: the English Channel and the Bay of Biscay.

Information are scarce regarding biological sampling of sardine in the English Channel and this is a key problem to define if sardine from both VIIIabd and VI should be treated as a single stock or not. From the small amount of information available, it appears that the caught sardines tend to be bigger in the Channel.

From the modelling point of view, the lack of sampling in the Channel, survey, biological information in contrast to the richness of the datasets available for the Bay of Biscay does not allow the use of a single assessment method for the whole area.

Therefore, while the members of the working group assume sardines in VIIIabd and VII belong to the same stock, it was decided to divide this stock in two "substock": VIIIabd and VII. As data are abundant in VIIIabd, the sardine of the Bay of Biscay can be assessed with various tools and attempts have been made with TASACS while other methods are needed for the sardines in English Channel. This year an attempt was made to use the WKLIFE framework to classify the sardine "substock" belonging to that region.

6.2 Input data in VIIIabd and VII

6.2.1 Catch data

Divisions VIIIabd

An update of the French and Spanish catch data series in Divisions VIIIa and VIIIb (from 1983 and 1996 for France and Spain, respectively) including 2011 catches was presented to this year´s WG (**Table 6.2.1.1**). Spanish catches are taken by purse seines from the Basque Country operating only in division VIIIb. Spanish landings peaked in 1998 and 1999 with almost 8 thousand tonnes but have decreased until 2010 to below 1 thousand tonnes. In 2011, 5283 tonnes were landed. The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year.

French catches have increased along the series, with values ranging from 4 367 tonnes in 1983 to 21 104 tonnes in 2008 with some small fluctuations; 17 925 tonnes were landed in 2010.

A total of 90% of the catches are taken by purse seiners while the remaining 10% is reported by pelagic trawlers (mainly pair trawlers). A substantial part of the French catches originates in divisions VIIh and VIIe, but these catches have been assigned to division VIIIa due to their very concentrated location at the boundary between VIIIa, VIIh and VIIe.

Both purse seiners and pelagic trawlers target sardine in French waters. Average vessel length is about 18 m. Purse seiners operate mainly in coastal areas (<10 nautical miles) while trawlers are allowed to fish within 3 nautical miles from the coast. Both pair trawlers and purse seiners operate close to their base harbour when targeting sardine. The highest catches are taken in the summer months. Almost all the catches are taken in south-west Brittany.

Numbers by length-class for divisions VIIIa,b by quarter are shown in **Tables 6.2.1.2** and **6.2.1.3** for France and Spain (only VIIIb), respectively. While French catches in divisions VIIIa and VIIIb are constituted by fish of a wide range of sizes with a peak at 20 cm length, sardine taken by Spanish vessels show a narrower range of sizes but with a peak at similar length size.

Subarea VII

Most of the catches are concentrated close to or in the English Channel (VIId, VIIe, VIIf, VIIh) with major landings from France and Netherlands, other catches being taken by England & Wales. No information was available from other countries operating in that subarea. Catches have substantially oscillated with time and between countries (**Table 6.2.1.4**) from 12000 to 3800 tons. In 2011, the catches were 3757t with France catching most of it (2506t).

No additional information was available such numbers by length-class due to lack of monitoring of the fisheries operating in that subarea.

As part of the preparation of the benchmark of sardine in 2013. Additional historical information on the various fleets operating in VII will be collected.

6.2.2 Surveys in Divisions VIIIabd

DEPM survey in in Divisions VIIIabd

The Daily Egg Production Method (DEPM) for sardine in Divisions VIIIab in the Bay of Biscay, beyond the boundaries of Atlanto-Iberian sardine stock has been covered by the IEO in the inner part of the Bay of Biscay (VIIIb in April of 1997, 1999, 2002 and 2008, up to a maximum of 45°N) and by AZTI (Divisions VIIIabc in several years from 1999 to 2010 in May, up to a maximum of 48ºN, including the estimates of egg production in 1999, 2002 and 2008). The egg coverage of these areas VIIIab by AZTI and IEO were planned for 2011 within the framework of WGACEGG (ICES 2010) and their results were reported in the report of WGACEGGS (ICES CM 2011/SSGESST:20).

Only preliminary estimates of the DEPM survey were provided to WGACEGG as several adult samples were still waiting for laboratory processing. The provisional *SSB* estimate from the application of the DEPM was 136.56 t with a CV of 43.2, lower than the acoustic PELGAS estimates in 2011 around 340 thousand tonnes. The coordinated work of AZTI and IEO allowed achieving a complete coverage of the spawning area. However it seems evident that the major problem might have come from the lag in time of the southern and northern coverage of the areas. In this application the lag in time between the SAREVA (IEO) and BIOMAN (AZTI) surveys was longer than in former years, lasting in total an entire month and this has produced a major change in sea surface temperature in the area. In addition it seems that spawning may have suffered changes during such inner period as to apparently reduce the amount of spawning. So improvements in the coordination of these two coverage will be required for the next survey foreseen for 2014.

Definitive estimates of the DEPM 2011 for sardine in Subarea VIII are expected by November this year to be submitted to WGACEGG 2012.

In the meanwhile the WG decided not making use of the preliminary estimates in the assessment, not only for being preliminary estimates but also because it is the first SSB DEPM estimate for subarea, so it would suppose an isolated value index not a series.

Further results on the application of this DEPM survey are reported in WGACEGGS 2001 report (ICES CM 2011/SSGESST:20).

PELGAS acoustic survey in Divisions VIIIabd

The French acoustic survey PELGAS takes place every spring in the Bay of Biscay on board the R/V Thalassa with the main objective of studying the abundance and distribution of pelagic fish in the Bay of Biscay and to study the pelagic ecosystem as a whole. In 2012, PELGAS took place from the 26th April to 5th June and detailed objectives, methodology and sampling strategy are described in the WD- Duhamel et al (2012) presented in this group.

Target species were anchovy and sardine but both species were considered in a multi-species context.

Sardine was distributed mixed with anchovy in two small areas: front of Arcachon and front of the Gironde. Then, they appeared pure in surface at the shelfbreak and close to the coast, between La Rochelle and Belle-Ile.(see figure 6.2.2.2.1) .

As usual, sardine shows a bimodal length distribution (Figure 6.2.2.2.2), the first one (about 14 cm, corresponding to the age1, and almost well present this year) and the second about 19.5 cm, where mainly is constituted by the 2, 3 and 4 years old, in the same proportions.

The series of age distribution in numbers since 2000 are shown in figure 6.2.2.2.3. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or high 2004 age class). 2003 was an atypical year in terms of environmental conditions and therefore fish distributions.

It must be noticed that the number of age 4 individuals this year is still important (17% in number of total fishes), and confirms one more time the good recruitment of the 2008 year class. The relative high abundance of age 1 (47% and 2 billions fishes) gives the impression that a good recruitment occurred.

The biomass estimate of sardine observed during PELGAS12 is 205 627 tons, which is a little bit less than the average level of the PELGAS series, and constitutes the third year of decrease (figure 6.2.2.2.4).

6.2.3 Biological data

6.2.3.1 Catch numbers at length and age

Tables 6.2.3.1.1 and 6.2.3.1.2 shows the catch-at-age in numbers for each quarter of 2011 for French and Spanish landings respectively in VIIIabd. Both for France and Spain, fish of age 2 and 3 dominated the fishery in 2011.

No data were available for VII.

6.2.3.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter in 2011 are shown in **Tables 6.2.3.2.1-6.2.3.2.4** for both French and Spanish landings in VIIIabd.

No data were available for VII.

6.2.4 Exploratory assessments

6.2.4.1 Exploratory assessment in VIIIabd using TASACS.

An exploratory assessment using the separable model part of the TASACS implementation was performed this year. The population model was fit to the PELGAS survey numbers at age. Input data consisted of catch at age from the Spanish and French fisheries and weights at age in the catch and the survey. The survey sampling CVs were used to weight the survey data. The 2003 survey was excluded given very low survey estimates linked to unusual high temperatures. Mortality at age was fixed as for the Iberian data (M=0.33 constant across years and ages); maturity at age was based on data collected in the acoustic survey. All input data are shown on **Table 6.3.1**.

The model time framework is from 2000 to 2012. However, although survey coverage with PELGAS goes from 2000 to 2012, catch at age data are only available from 2002 to 2011 so, fishing mortality was fixed in 2000 and 2001 at the same as the estimated for 2002. Survey catchability was fixed = 1. Recruitment in 2012 was fixed equal to the arithmetic average of the historic series.

Results from the base run: time series of recruitment, SSB, average F for ages 2 – 6 are shown in **Figure 6.3.1.**

The model suggests an increasing SSB peaking in 2010 and a decline after that. Recruitments have been strong in years 2007 and 2008 followed by a declining recruitment and another event of strong recruitment in 2010. Fishing mortality is very low (0.065) suggesting that the fishery is making little impact on the stock. However, caution needs to be exercised because the catch is likely to be an underestimate (e.g discards are unknown). Fleets other than the Spanish and French are fishing in VIIIabd and discarding sardine, but the amounts are not reported. Further, the catchability of the French surveys is not known.

Quality of the assessment

Residuals from the model fit to the catch and the survey data are shown in **Figures 6.3.2 and 6.3.3**. The fit to the catch at age is reasonable suggesting that the separable assumption is sensible however, there are strong negative residuals in the plus group and that may be related to the way the plus groups were set for the survey and for the catch; setting the plus group at age 8 for both the survey and the catch data may be advisable. Year effects are apparent in the survey residuals. Possible cause of those year effects are discussed above. An exploration of the mortality signal provided by the catch and survey data is illustrated in **Figure 6.3.4** which also highlights the year effects in the survey data.

Figure 6.3.7 explores the retrospective patterns of the model where SSB and recruits estimates tend to be underestimated. No pattern is distinguishable for fishing mortality.

Further work on data exploration is encouraged including for example the use of DEPM indices. This model is however not suitable for subarea VII as it requires age structured information which is currently lacking in that area. Therefore the use of this model cannot be extended for the moment to subarea VII.

6.2.4.2 Exploratory assessment in subarea VII based on the WKLIFE framework

As only catch and few efforts information are available for subarea VII, the range of assessment model usable is limited for the time being. Provided CPUE could be assumed as a good indicator of abundance for sardine, a surplus production model could be a good candidate in the future. This possibility will be scrutinized at the next benchmark. WKLIFE (2012) proposed alternate solution for data-limited stocks. Since the working group had readily only catch data, this substock could be temporarily considered as a category 4 stock (catch only). Category 4 stock requires the use of DCAC (Depletion Corrected Average Catch Model) from the NOAA NMFS toolbox. The following input parameters were used:

1) Number of Years = 12

			Value	STD	Distribution
2)	Sum of Catch	=	117123	0.0000	Normal
3)	Natural Mortality	=	0.2000	0.5000	Lognormal
4)	FMSY to M	=	1.0000	0.2000	Lognormal
5)	Depletion Delta	=	0.5000	0.1000	Beta
6)	BMSY / B0	=	0.4000	0.1000	Beta

This resulted in a average DCAC of 5978t (median 6094t) . Given the average catch of 9760t, this would advise to reduce catches. However, it is unclear how good or wrong this result is for several reasons:

- The natural mortality was set to 0.2. The DCAC manual advises not to increase M at values higher than 0.2. The assessment with TASACS in VIIIabd assumes M=0.33. An additional run with M set to 0.33 shows a substantial increase in the results (Average 6978t, median 7152t).
- The depletion rate was set arbitrary to 0.5. This parameter is supposed to show the decline of the catch. In the case of VII, there are no clear trends in landings. Some years have high landings above 10000 tons, some other are less than 5000t. A depletion rate set to 0.25 would lead to an average DCAC of 16770t (median 17281t). This is a sensitive parameter and the time series of catches does not bring any clue to its value.

For those reason, it is impossible to propose any advice in VII based on this preliminary approach. Further approaches will be tried during the benchmark in 2013.

6.2.5 Short term predictions

Due to the exploratory nature of the assessment, no predictions have been carried out. This stock is due for benchmark in 2013 and a proper prediction procedure will be established.

6.2.6 Reference points and harvest control rules for management purposes

No reference points, TACs and no harvest control rules are currently implemented for this stock. Reference points should be defined during the upcoming benchmark.

6.2.7 Management considerations

There are no management objectives for these fisheries and there is no international TAC. Catch are mainly taken by France and Spain in VIIIabd and by France and Netherlands in VII. The lack of sampling program in VII makes any attempt to assess this stock as a single unit complicated. It is recommended that a proper sampling program should be implemented to monitor the sardine fishery in subarea VII.

6.2.8 Benchmark preparation

The sardine stock in VIIIabd and VII is due for benchmark early 2013. The major issues are:

- Stock identity: should fish population VIIIabd and VII belong to the same stock and should they be treated the same way ?
- The level of discards is an unknown parameter. Could it substantially affect the assessment of sardine ?
- Lack of biological data, sampling program, survey indices in VII. This is not relevant of the benchmark but the choice of assessment in VII is directly affected by the limited nature of datasets in that region.
- Tuning series. a) Could the DEPM indices in the Bay of Biscay be used in a modelling approach for that area ? b) In VII, it is necessary to collect any historical information on fleet activity and effort from all countries fishing sardine in that area. The actual level of landings and efforts remain quite unknown.
- Data rich vs data limited areas: the Bay of Biscay is a data rich area allowing use of various assessment models while subarea VII is data limited allowing only models such as surplus production model or indicators of biomass.
- Reference points and advisory procedure need to be set after taking account of all the previous points.

Table 6.2.1.1: Sardine general: Landings by France (1983-2011) and Spain (1996-2011) in ICES divisions VIIIa, VIIIb and VIIId

Year	Catch (tonnes)	
	France	Spain*
1983	4,367	n/a
1984	4,844	n/a
1985	6,059	n/a
1986	7,411	n/a
1987	5,972	n/a
1988	6,994	n/a
1989	6,219	n/a
1990	9,764	n/a
1991	13,965	n/a
1992	10,231	n/a
1993	9,837	n/a
1994	9,724	n/a
1995	11,258	n/a
1996	9,554	2,053
1997	12,088	1,608
1998	10,772	7,749
1999	14,361	7,864
2000	11,939	3,158
2001	11,285	3,720
2002	13,849	4,428
2003	15,494	1,113
2004	13,855	342
2005	15,462	898
2006	15,916	825
2007	16,060	1,263
2008	21,104	717
2009	20,627	228
2010	19,485	642
2011	17,925	5283

* all landings from division VIIIb

n/a = not available

Table 6.2.1.2: Sardine general: French catch length composition (thousands) by ICES divisions VIIIa,b in 2011.

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
10					
10.5					
11			21	5	26
11.5	6	32	4	1	42
12	14	80	9	3	106
12.5	17	96	52	13	178
13	48	271	114	29	462
13.5	73	415	192	49	730
14	99	636	351	87	1 173
14.5	110	858	457	130	1 555
15	94	1 196	641	153	2 084
15.5	66	1 156	773	193	2 187
16	99	1 235	2 006	293	3 632
16.5	116	949	3 487	532	5 083
17	195	1 004	4 754	698	6 652
17.5	247	1 450	3 408	611	5 717
18	441	2 293	3 431	1 341	7 506
18.5	530	2 446	4 547	1 194	8 716
19	301	3 229	6 427	1 981	11 938
19.5	549	3 552	11 722	1 907	17 731
20	1 340	3 296	22 079	3 022	29 736
20.5	1 686	4 773	18 894	2 776	28 128
21	1 719	4 562	15 885	3 541	25 707
21.5	2 132	6 616	21 063	3 227	33 037
22	1 593	5 960	9 867	3 997	21 416
22.5	1 003	4 974	6 771	2 194	14 942
23	649	3 741	3 501	2 440	10 330
23.5	236	2 508	2 286	1 605	6 634
24	118	2 383	1 707	654	4 862
24.5	59	699	1 215	409	2 381
25		329	174		503
25.5				82	82
26		41			41
26.5					
27					
27.5					
28					
28.5					
29				82	82
29.5					
30					
30.5					
31					
Total	13 539	60 778	145 835	33 168	253 319
Average length	20.6	20.4	20.3	20.8	20.4
Catch (t)	986	4362	10113	2464	17925

Table 6.2.1.3: Sardine general: Spanish catch length composition (thousands) by ICES divisions VIIIb in 2011.

Length * (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
10					
10.5					
11					
11.5					
12					
12.5					
13					
13.5	8 869				8 869
14	11 638				11 638
14.5	92 243				92 243
15	5 819				5 819
15.5	55 709	5 490	2	28 863	90 064
16	58 409		3	49 645	108 057
16.5	53 586		2	29 052	82 640
17	171 977		11	166 089	338 077
17.5	389 309		25	395 084	784 419
18	740 097	5 490	23	366 031	1111 641
18.5	917 231	38 432	65	1016 226	1971 955
19	1081 497	21 961	93	1444 427	2547 978
19.5	1316 124	38 432	161	2520 613	3875 332
20	1183 182	60 394	392	6122 758	7366 726
20.5	1321 909	38 432	732	11441 397	12802 471
21	1167 215	10 981	760	11875 993	13054 948
21.5	1042 567	16 471	670	10470 845	11530 553
22	784 229	5 490	385	6013 839	6803 943
22.5	570 471		204	3183 971	3754 645
23	307 540		91	1430 107	1737 739
23.5	119 070		39	602 229	721 337
24	34 745		15	241 079	275 839
24.5	32 728		9	136 018	168 755
25	8 138				8 138
25.5	17 017				17 017
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
Total	11491 320	241 575	3 682	57534 266	69270 843
Average length	20.1	19.7	20.9	20.9	20.8
Catch (t)	792	16	0.29	4476	5283

Table 6.2.1.4: Sardine landings (tons) in ICES subarea VII in 2011.

Year	France	Netherlands	UK	Total
1997		1		1
1998		77		77
1999	119	5166		5285
2000	1593	6586		8179
2001	1629	6608		8237
2002	2228	1905		4134
2003	5318	6897		12215
2004	3264	2187		5451
2005	4278	2231		6509
2006	5104	2287		7391
2007	4371	1106		5477
2008	5150	2073		7223
2009	6421	3406		9827
2010	2787	6645	2521	11954
2011	2506	513	738	3757

Table 6.2.3.1.1: French 2011 landings in ICES division VIIIb:
Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			2851	657	657
1	1105	8911	24627	5045	39688
2	1123	6174	38168	7557	53023
3	4569	16436	47797	9599	78400
4	4504	15640	20001	5091	45236
5	945	3928	1522	415	6810
6	662	3502	6502	3096	13763
7	278	1339	2552	809	4978
8	187	3151	1203	622	5163
9	97	890	554	358	1899
10	69	809	58		
11					
12					
13					
Total	13539	60778	145835	33249	249615
Catch (Tons)	978	4372	10113	2464	17927

Table 6.2.3.1.2: Spanish 2011 landings in ICES division VIIIb:

Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0				431	431
1	634	6	0	2247	2887
2	1483	27	1	8132	9643
3	4932	144	2	35047	40126
4	2552	49	1	8996	11598
5	827	11	0	914	1752
6	724	3	0	1082	1809
7	192	1		228	422
8	127			228	355
9	19			228	248
10					
11					
12					
13					
Total	11491	242	4	57534	69271
Catch (Tons)	791	16	0	4476	5283

Table 6.2.3.2.1: French 2011 landings in divisions VIIIa and VIIIb:

Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			14.8	14.6	14.8
1	15.4	15.4	17.5	17.6	17.0
2	18.1	18.1	19.6	19.6	19.4
3	19.8	19.6	20.1	20.3	20.0
4	20.7	20.9	20.6	21.0	20.7
5	21.2	21.4	21.2	21.6	21.4
6	21.5	21.8	21.8	22.0	21.8
7	21.4	21.7	22.2	22.5	22.1
8	23.0	23.0	22.8	22.6	22.9
9	22.1	22.8	22.9	23.9	23.0
10	22.9	23.1	23.9		23.1
11					
12					
13					
14					

Table 6.2.3.2.2: Spanish 2011 landings in ICES division VIIIb:
Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			17.5	17.5	17.5
1	16.7	15.9	18.7	18.7	18.2
2	18.6	18.9	20.4	20.4	20.1
3	20.1	20.0	21.2	21.2	21.1
4	21.1	20.5	22.0	22.0	21.8
5	21.7	20.9	22.6	22.6	22.1
6	22.6	21.9	22.9	22.9	22.8
7	22.7	21.8	23.9	23.9	23.4
8	23.9		23.9	23.9	23.9
9	23.5		23.9	23.9	23.9
10					
11					
12					
13					
14					

Table 6.2.3.2.3: Sardine general: French 2011 landings in divisions VIIIa and VIIIb:
mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			0.027	0.025	0.026
1	0.031	0.030	0.046	0.047	0.042
2	0.052	0.052	0.068	0.067	0.066
3	0.069	0.068	0.073	0.076	0.072
4	0.080	0.083	0.079	0.084	0.081
5	0.087	0.091	0.088	0.093	0.090
6	0.091	0.096	0.096	0.098	0.096
7	0.091	0.094	0.102	0.106	0.100
8	0.114	0.114	0.111	0.109	0.113
9	0.100	0.111	0.112	0.130	0.114
10	0.113	0.116	0.130		0.116
11					
12					
13					
14					

Table 6.2.3.2.4: Sardine general: Spanish 2011 landings in ICES division VIIIb: mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			0.042	0.042	0.042
1	0.037	0.031	0.052	0.052	0.048
2	0.050	0.053	0.069	0.069	0.066
3	0.066	0.064	0.078	0.078	0.076
4	0.077	0.070	0.087	0.087	0.084
5	0.083	0.074	0.095	0.095	0.089
6	0.095	0.086	0.099	0.099	0.097
7	0.097	0.084	0.114	0.114	0.106
8	0.114		0.114	0.114	0.114
9	0.107		0.114	0.114	0.114
10					
11					
12					
13					
14					

Table 6.3.1: Input tables for the exploratory assessment on Sardine in VIIIabd.

CATON	Landings
2000	15097
2001	15005
2002	18277
2003	16607
2004	14197
2005	16360
2006	16741
2007	17323
2008	21821
2009	20855
2010	20127
2011	23208

CANUM	0	1	2	3	4	5	6	7	8	9
2002	3703.33	162938	67783.2	25016.3	15759.5	11126.9	7444.36	2156.67	1170	823.576
2003	4381.71	89475.4	62145.4	27446.6	16544.5	9656.77	6206.69	3333.87	1646.63	736.523
2004	22283.4	88305.7	50183.7	36191.3	15109.6	9387.93	2795.98	1328.2	632.331	305.648
2005	4114.1	91371.1	41479.2	29104.7	22997.9	17983.2	9190.1	5114.8	3167.25	1804.78
2006	8895.82	35588.4	84755.4	30337.3	21007.8	15203.7	9519.41	6946.06	3558.31	2806.92
2007	24017.4	66813.2	25930.2	59416.2	13094.7	14185.5	12177.6	7468.42	3582.31	2906.63
2008	3845.38	162408	71483.8	26645.2	42044.1	13223.2	11590	10817.6	5354.45	5061.74
2009	8535.45	117821	139899	50134.2	25635.8	24240.4	12464.9	9281.81	5516.68	1915.84
2010	1907.26	37904.9	107444	59131	18718.6	14836.9	22904.4	7452.21	8526.83	4811.31
2011	3938.2	42575.0	62665.7	118526.1	56833.2	8561.8	15571.5	5399.7	5518.4	3082.4

WECA	0	1	2	3	4	5	6	7	8	9
2002	0.0178	0.0444	0.0692	0.0804	0.0876	0.0998	0.1116	0.1150	0.1299	0.1332
2003	0.0188	0.0540	0.0802	0.0913	0.1008	0.1108	0.1169	0.1293	0.1317	0.1243
2004	0.0197	0.0398	0.0798	0.0902	0.0948	0.1013	0.1110	0.1198	0.1299	0.1254
2005	0.0184	0.0470	0.0806	0.0886	0.0936	0.0972	0.1053	0.1098	0.1190	0.1333
2006	0.0236	0.0390	0.0740	0.0881	0.0941	0.1013	0.1095	0.1153	0.1176	0.1330
2007	0.0318	0.0525	0.0805	0.0870	0.0986	0.1035	0.1090	0.1195	0.1228	0.1305
2008	0.0179	0.0438	0.0626	0.0759	0.0782	0.0908	0.1003	0.0950	0.1034	0.1101
2009	0.0318	0.0379	0.0623	0.0733	0.0861	0.0869	0.0959	0.0982	0.0997	0.1149
2010	0.0231	0.0378	0.0605	0.0742	0.0808	0.0898	0.0924	0.1023	0.1028	0.1105
2011	0.0280	0.0427	0.0656	0.0737	0.0817	0.0895	0.0963	0.1004	0.1129	0.1149

WEST	1	2	3	4	5	6	7	8
2000	0.0351	0.0547	0.0692	0.0765	0.0848	0.0899	0.0988	0.1084
2001	0.0413	0.0589	0.0768	0.0838	0.0937	0.0969	0.1034	0.1118
2002	0.0405	0.0602	0.0749	0.0817	0.0923	0.0994	0.1067	0.1181
2003	0.0382	0.068	0.0732	0.0781	0.086	0.0933	0.0887	0.0961
2004	0.0359	0.0647	0.0765	0.0844	0.0959	0.0988	0.1043	0.1084

2005	0.0344	0.0635	0.0733	0.0796	0.0849	0.089	0.09	0.106
2006	0.0392	0.0584	0.0708	0.0812	0.0864	0.0825	0.0913	0.1021
2007	0.0376	0.066	0.0718	0.0791	0.084	0.0945	0.1004	0.0991
2008	0.0334	0.0603	0.0711	0.0752	0.0838	0.0928	0.0905	0.0978
2009	0.0295	0.0571	0.0736	0.0813	0.0833	0.0884	0.0957	0.0934
2010	0.0303	0.0505	0.064	0.0731	0.0784	0.0876	0.0932	0.1069
2011	0.0274	0.0501	0.0587	0.0698	0.0783	0.0830	0.0843	0.1075
2012	0.0229	0.0447	0.0574	0.0654	0.0784	0.0878	0.0953	0.0923

MAT	1	2	3	4	5	6	7	8	9
2000	0.465	0.915	0.96	0.972	0.98	0.984	1	1	1
2001	0.43	0.816	0.942	0.971	0.971	0.978	1	1	1
2002	0.586	0.932	0.981	0.993	0.997	0.997	1	1	1
2003	0.5	0.936	0.973	0.985	0.99	0.987	1	1	1
2004	0.489	0.936	0.974	0.983	0.985	1	1	1	1
2005	0.193	0.854	0.968	0.986	0.992	1	1	1	1
2006	0.885	0.985	0.997	0.999	0.999	0.999	1	1	1
2007	0.75	0.976	0.99	0.996	0.998	0.999	1	1	1
2008	0.75	0.976	0.99	0.996	0.998	0.999	1	1	1
2009	0.509	0.993	0.989	1	0.969	0.935	0.958	0.938	1
2010	0.576	0.998	1	1	1	1	1	1	1
2011	0.763	1	1	0.996	1	1	1	1	1
2012	0.3744	0.987	0.9955	0.9898	0.9935	1	0.9545	1	1

FLEET	1	2	3	4	5	6	7	8+
2000	1276312	1559347	1083847	721738	551465	218657	152984	132676
2001	1280080	1367856	819203	751576	353970	466190	175124	277453
2002	3458311	3585189	1115098	566798	162725	85013	38003	9120
2003	160136	528081	463812	165696	55940	2234	5426	1090
2004	2997203	2029661	1606397	706117	467766	283692	95817	61324
2005	2613794	1807043	824020	822188	610585	383260	230492	174773
2006	605847	2819592	274996	90287	42056	38918	13436	16260
2007	631471	296092	761271	131707	57856	64658	27165	35554
2008	3432039	1549493	383747	1478305	301616	223603	241521	373181
2009	6111475	3286964	707700	301305	737098	215647	148810	157875
2010	1511640	5227578	1558567	267859	125992	122739	27877	41082
2011	1435411	1504792	2516162	794842	106115	64749	23433	33899
2012	3257929	1129668	833824	1158709	340656	77427	54120	43030

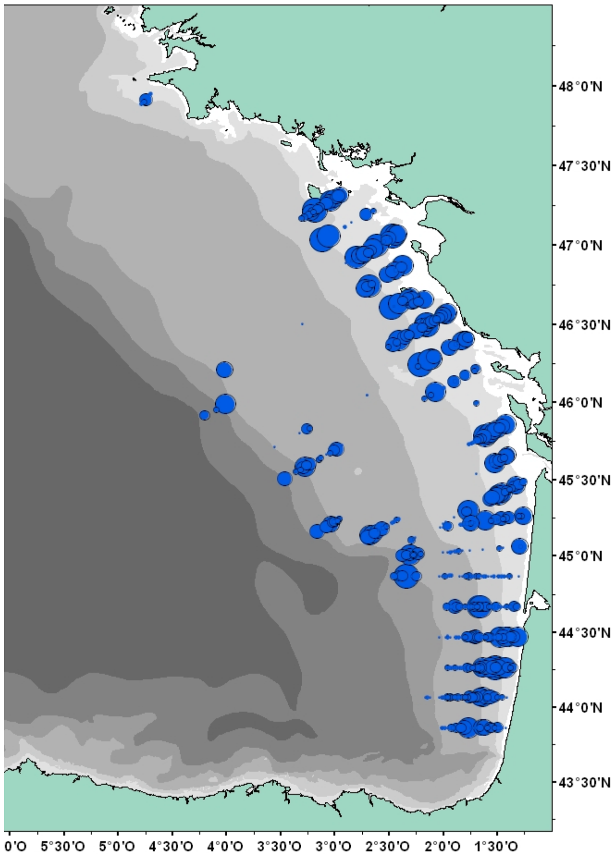


Figure. 6.2.2.2.1 : Adult sardine distribution (density / ESDU) during PELGAS12

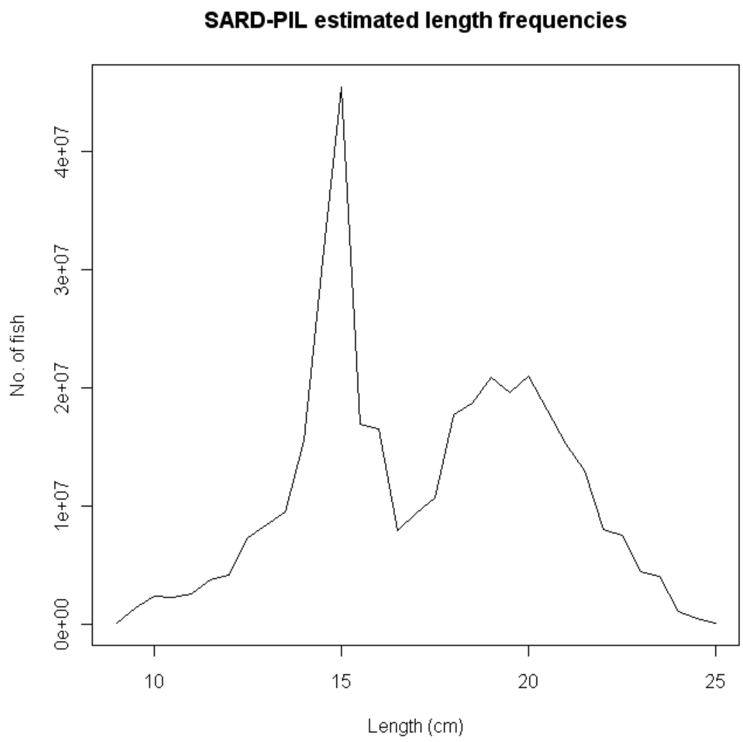
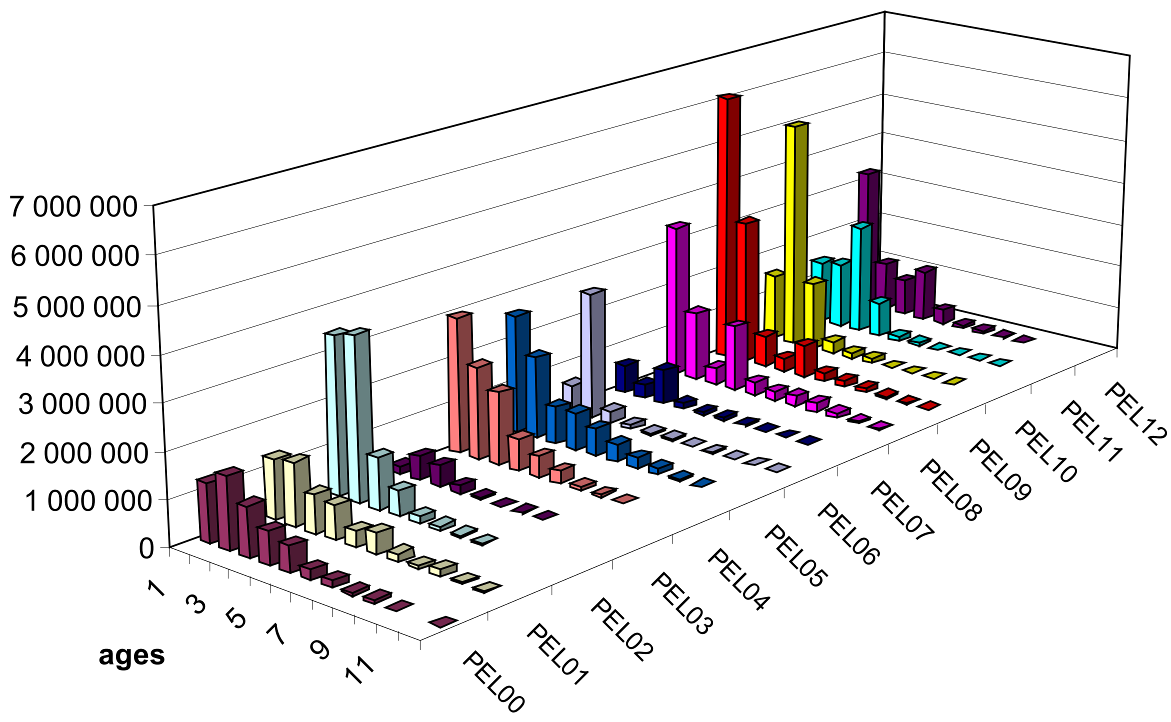


Figure 6.2.2.2.2 : Sardine length distribution during PELGAS12



/Figure 6.2.2.2.3 : sardine age distribution along the PELGAS surveys

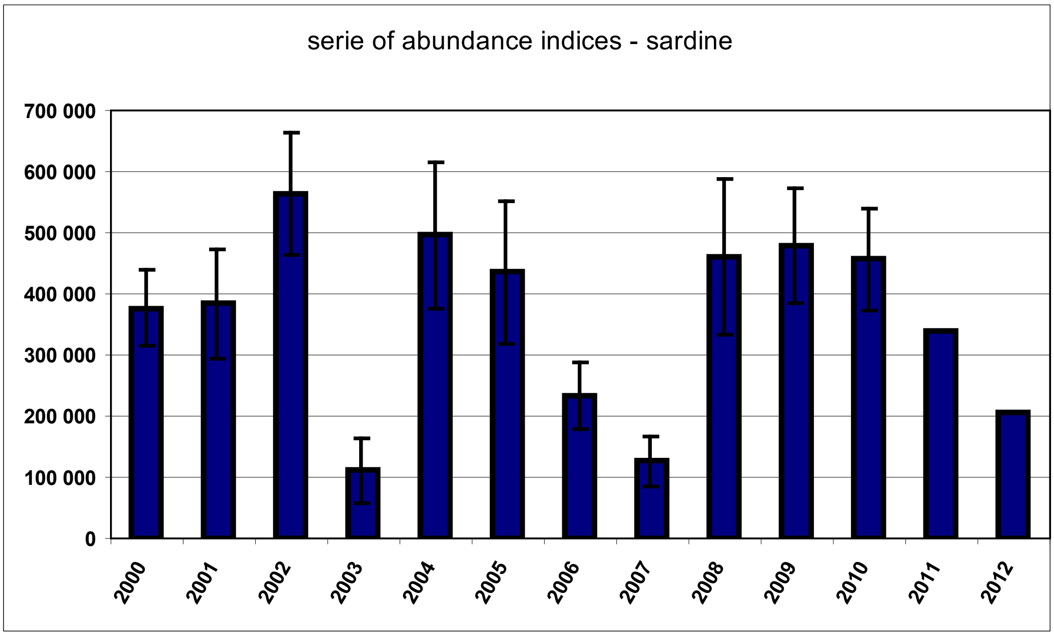


Figure 6.2.2.2.4 : sardine abundance indices along the PELGAS surveys

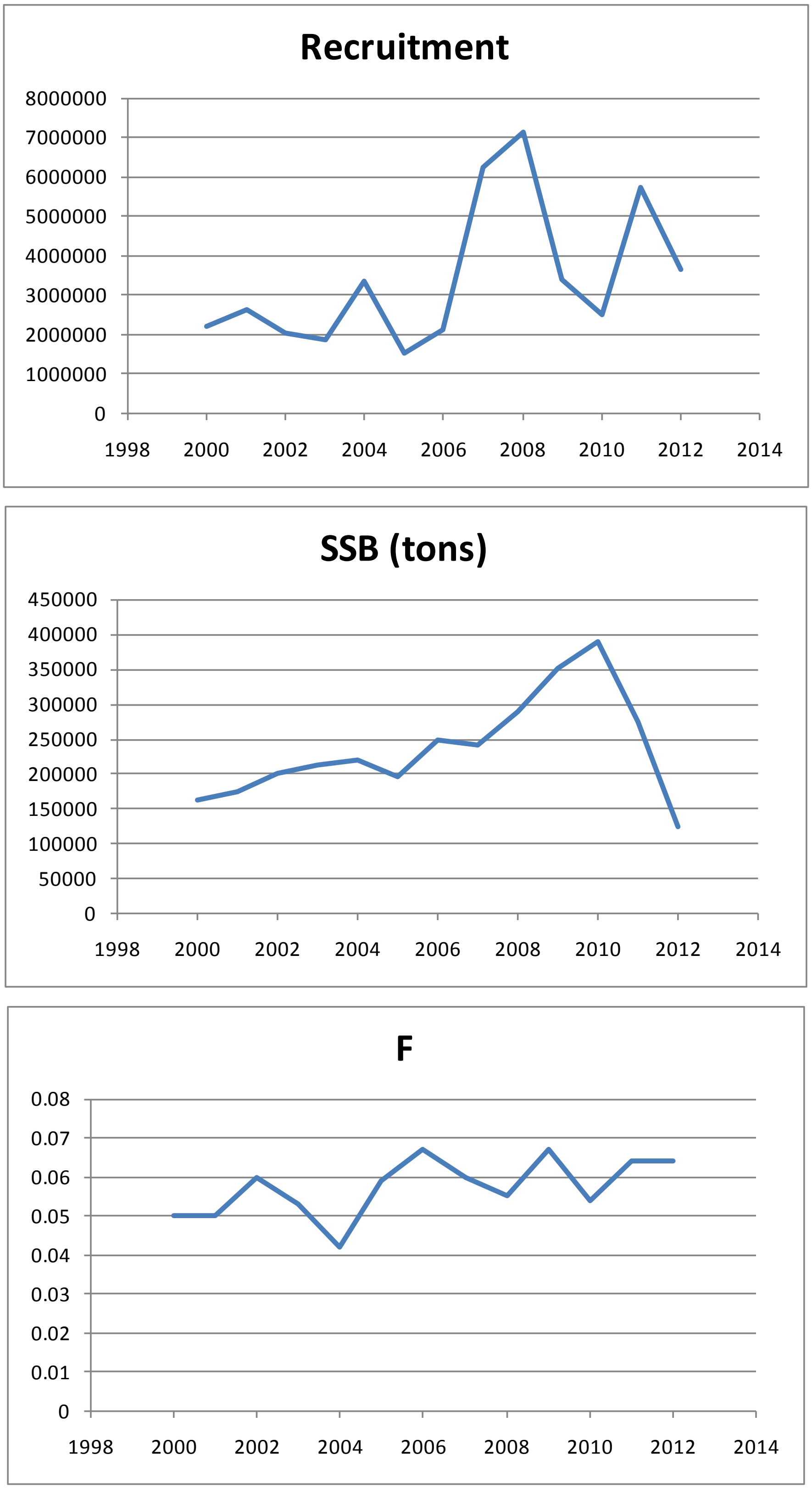


Figure 6.3.1: Sardine in VIIIabd. Summary plots from the exploratory assessment.

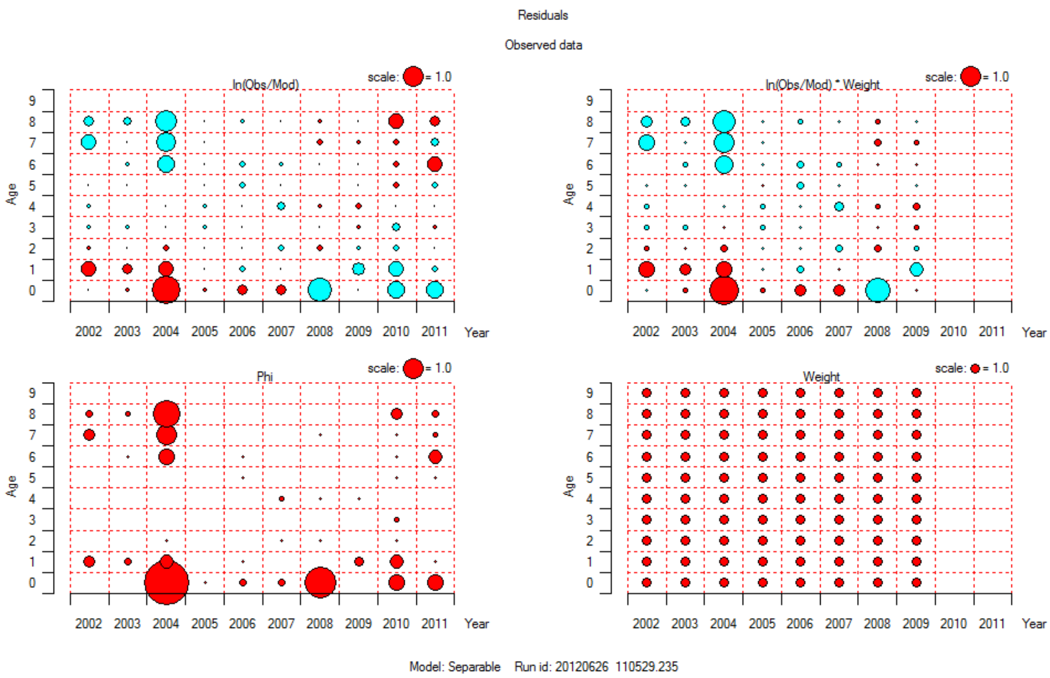


Figure 6.3.2. Sardine in VIIIabd. Separable VPA, base run. Residuals from catch at age. Upper panels: Log residuals: Left: unweighted, Right: weighted. Lower left: Individual contributions to the objective function. Lower right: Display of the applied weightings.

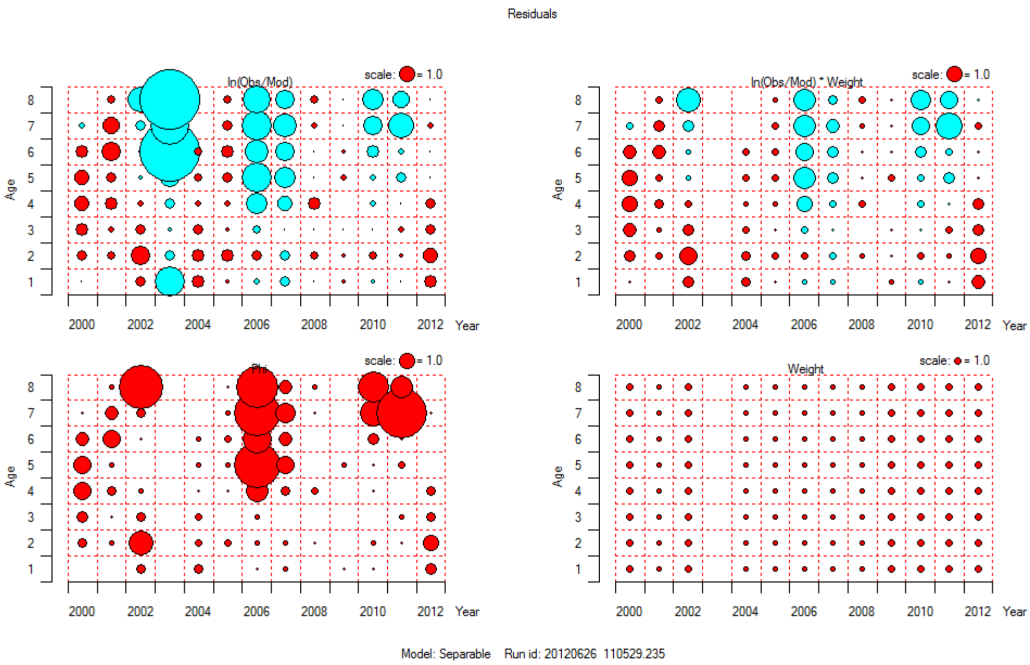


Figure 6.3.3. Sardine in VIIIabd. Separable VPA, base run. Residuals from survey numbers at age. Upper panels: Log residuals: Left: unweighted, Right: weighted. Lower left: Individual contributions to the objective function. Lower right: Display of the applied weightings.

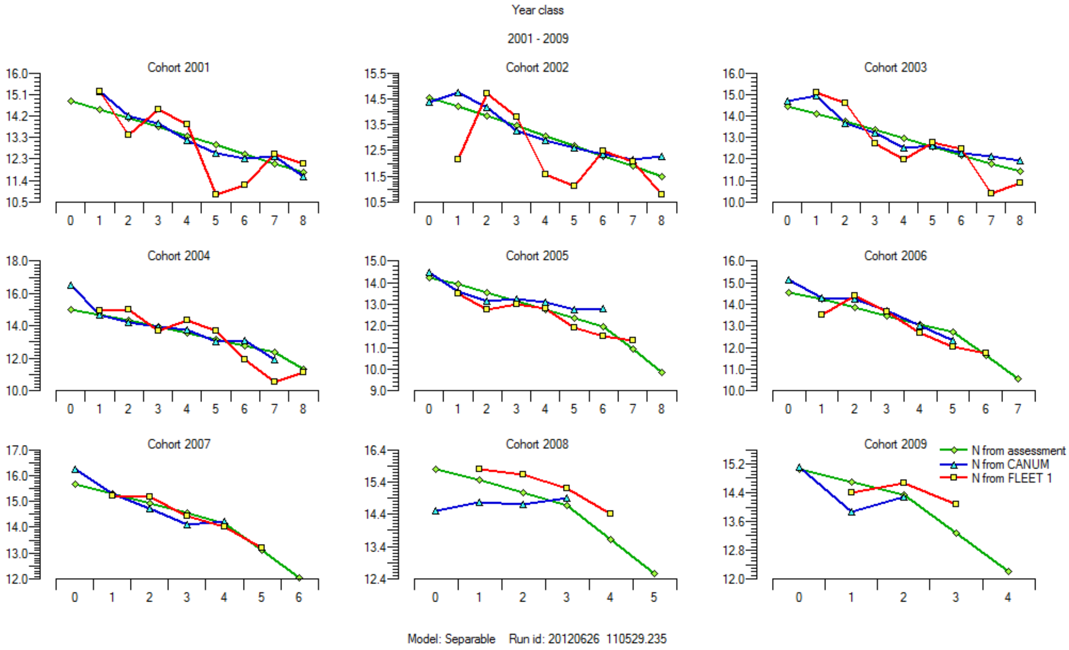


Figure 6.3.4. Sardine in VIIIabd. Separable VPA, base run. Cohort curves (2001 – 2009) from catch and survey data and estimated by the assessment.

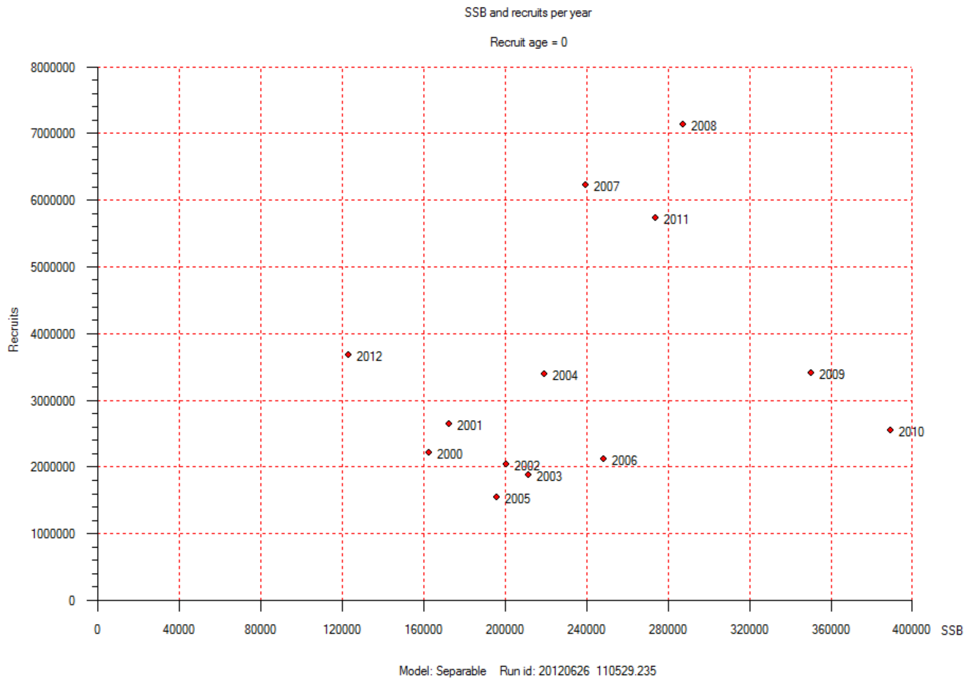


Figure 6.3.6. Sardine in VIIIabd. SSB and recruitment pairs as estimated by TASACS model.

Figure 6.3.7. Sardine in VIIIabd. Retrospective plots.

7 Sardine in VIIIc and IXa

7.1 ACOM Advice Applicable to 2012, STECF advice and Political decisions

ICES advised on the basis of precautionary considerations that landings in 2012 should be no more than 36 000 t.

7.2 The fishery in 2011

7.2.1 Fishing Fleets in 2011

Details about the vessels operated by both Spain and Portugal targeting sardine are given in Table 7.2.1.1.

Sardine is taken in purse seine fisheries throughout the stock area.

In northern Spain, data from 2010 indicates that the total number of vessels with license for this gear was 289, with mean vessel length and power of 21m and 305 HP, respectively. In the Gulf of Cadiz, purse seiners taking sardine are generally targeting anchovy (n = 73) and range in size from 8 to 34 m with a mean vessel length of 16 m (horse power between 27 and 800 with a mean of 182).

In Portuguese waters, fleet data (INE, 2012) indicate that, in 2011, 118 vessels were licensed for purse seining, with a global tonnage of 5 251 GT (mean= 44.5) and a total vessel engine power of 26 455 (mean = 224).

7.2.2 Catches by fleet and area

The WG estimates of landings and catches are shown in Tables 7.2.2.1 and 7.2.2.2.

The WG landing estimates differ from the official figures supplied to ICES, because as a result of a crossing of the auction sales, available logbooks and data communicated to the administrations, some unallocated catches were estimated to have occurred by an amount of 4% of total estimated catches. Therefore the WG decide to make use of both the official and unallocated catches in the subsequent reporting of catches all throughout the tables and figures.

As estimated by the Working Group, sardine landings in 2011 have slightly decreased in comparison with those of 2010 (Tables 7.2.2.1 and 7.2.2.2, Figure 7.2.2.1). Total 2011 landings in divisions VIIIc and IXa were 80 403 t, i.e. a decrease of 10% with respect to the 2010 values (89 571). The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine, 23 180 tonnes, showed a 10% decrease in relation to values from 2010 (25 843 tonnes). Both ICES subdivisions VIIIc and IXaN showed a substantial decrease in catches (24% in subdivision IXaN and 38% in VIIIc) while subdivision IXaS-Cadiz showed a 94% increase. In Portugal, landings in 2011 (57 223tonnes) were 10% lower than the landings in 2010 (63 727 tonnes, see also Section 7.8). This decrease in landings originated in all subdivisions (9% decrease in catches in IXaCN and a 22% decrease in IXaCS), with the exception of IXaS-Algarve that have a 23% increase.

Table 7.2.2.1 summarises the quarterly landings and their relative distribution by ICES Subdivision. Fifty-nine percent of the catches were landed in the second semester and 46% of the landings took place off the northern Portuguese coast (IXaCN), showing the same pattern than last year. The percentage of catches in the northern area of the stock (VIIIc and IXaN) (17%) has decreased from last year value (24%).

The southern areas (IXaS Algarve and IXaS Cadiz) account for 19% of the total values in 2011, moderately above the value in 2010 (11%).

7.2.3 Effort and catch per unit effort

No new information on fishing effort has been presented to the WG.

7.2.4 Catches by length and catches at age

Tables 7.2.4.1a,b,c,d show the quarterly length distributions of landings from each subdivision. Annual length distributions (Table 7.2.4.1.) were bimodal in Spain in subdivisions VIIIcE with modes at 16.5 and 24 cm. Sardine in subdivisions VIIIcW, IXaN and IXaS-Cádiz showed single modes at 21, 19.5 and 13.5 cm respectively. For Portugal, single modes were observed for IXaCS at 20.5 cm and at 21 cm while sardine in IXaCN showed a bimodal length distribution (at 12 and 19 cm).

Table 7.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision. In Table 7.2.4.3, the relative contribution of each age group in each Subdivision is shown as well as their relative contribution to the catches. Age 2 fish (2009 cohort) are only apparent in IXaN and IXaCN. The cohort of 2007 (which was strong in French waters) dominates the catches in VIIIcE. No clear pattern of ages was observed in IXaS-Algarve. Ages 0 and 1 dominate in IXaS-Cádiz.

0-group catches are concentrated in Subdivision IXaCN. Older fish (age groups 5 and 6+) concentrate in IXaCS and IXaS-Algarve.

7.2.5 Mean length and mean weight at age in the catch

Mean length and mean weight at age by quarter and Subdivision are shown in Tables 7.2.5.1 and 7.2.5.2.

7.3 Fishery independent information

Figures 7.3.1 and 7.3.2. show the time series of fishery independent information for the sardine stock.

7.3.1 Iberian DEPM survey (PT-DEPM-PIL+SAREVA)

As part of the Iberian DEPM survey, surveys are carried out every three years by Portugal (IPIMAR) and Spain (IEO). In 2011, the Portuguese survey took place in February-March covering the western and southern distribution area of the stock, and the Spanish survey took place in March-April covering the northern area. As described in the Stock Annex, the total spawning biomass from the two surveys is used in the assessment.

The DEPM survey is planned and discussed within WGACEGG (e.g WGACEGG, 2011). As happened in past years, the results presented to this WG (WD2012, Angélico *et al.*) have not been fully discussed by WGACEGG (meeting in November 2012) and should be considered provisional. Nevertheless, no major changes of the estimates are anticipated.

The 2011 winter/early spring season was characterized by very unstable oceanographic conditions, however, the ocean temperature values and distribution patterns were similar to observations from other years. Unrealistic observations for spawning fraction and batch fecundity in the south (S) and west (W) strata required the use of alternative information for the estimation of these parameters. Batch fecundity was calculated, using non-hydrated ovaries (using the oocytes at the migratory nucleus stage, Ganias *et al.* 2010) while for the spawning fraction mean historic values per strata, were taken on.. SSB estimate (S+W+N strata) was 465 thousand t. This estimate is 30% lower than the 2008 value, but is the second highest biomass estimate of the historical series for the Iberian stock. The 2011 results lead to the following remarks:

- the spawning area for 2011 was smaller than in 2008 in all strata but particularly in the W and N shores, around 75 and 50 % respectively; on the whole, the total positive area was reduced to about 55%.
- total egg production estimates were lower than in 2008 in all areas; mortality for S and W was higher than in previous years; the highest daily egg production per m2 (eggs/m2/day) was obtained for the southern coast
- mean female weights for all strata were similar to the 2008 estimates; the values calculated for the N strata (N and NW coasts of Spain) being higher than for the W and S strata
- mean batch fecundity considerably higher for the N than for the W and S strata; W and S estimates obtained by alternative methodology (MN oocytes), values in line with previous values
- the spawning fraction for the N strata in 2011 was higher than in the two previous surveys; for S and W, mean historic values were used
- the SSB estimate for 2011 is lower than in 2008; the decrease was more accentuated for the W and N strata while for the S the value was close to the previous estimate
- the unusual observations concerning some of the adult parameters during the survey in areas S and W are under investigation and will be further discussed; results suggest an eventual temporary interruption of spawning in the S and SW (skipped full maturation and ovulation of one batch of oocytes).

Discussion on the preliminary estimates here presented, and options taken for SSB estimation will be addressed at the WGACEGG in November 2012

7.3.2 Iberian acoustic survey (PELACUS04+PELAGO)

As part of the Iberian acoustic survey, surveys are carried out each year by Portugal and Spain to estimate small pelagic fish abundance in IXa and VIIIc. The Iberian acoustic survey is planned and discussed within WGACEGG (e.g WGACEGG, 2011). As described in the Stock Annex, the total numbers-at-age from the two surveys are used as input to the assessment.

7.3.2.1 PELAGO Portuguese spring acoustic survey

The Portuguese acoustic spring survey PELAGO normally takes place on board the R/V Noruega in April-May, covering the Portuguese and Gulf of Cádiz waters from 20 to 200 m depth.

In 2012, due to technical problems of the vessel, this survey was not carried.

7.3.2.2 PELACUS04 Spanish spring acoustic survey

The Spanish survey took place onboard the RV "Thalassa" from the 27th March to 20th April. The area covered extended from the Galician-Portugal border to southern French waters and from 30 to 200 m depth. The methodology applied was agreed and revised at the WGACEGG. Detailed objectives, methodology and sampling strategy are described in the WD-Santos *et al*. (2012) presented in this group.

The results of the PELACUS04 survey in 2012 were used qualitatively, as an indicator of the abundance of the sardine population.

Sardine abundance was estimated as 217 million individuals, while biomass was estimated to be 17.3 thousand tonnes (Figure 7.3.2.2.1, Table 7.3.2.2.1). Fish were mainly found in Galicia (ICES sub-areas IXa-N and VIIIcW, representing the 94% of the abundance and 93 % of the total biomass estimated in Spanish surveyed area) and was almost absent from the rest of the surveyed area with only a few low detections found in Asturias (ICES sub-area VIIIcE-w) and in the Basque country (ICES sub-area VIIIcE-e). These figures represent an increase of 48% in biomass and 44% in abundance in relation to the estimated values in 2011, but still at the lowest levels of the time series (the lower value was the 2011 estimation with 15.1 millions of individuals and 11.8 thousand tons).

Sardine ranged in length from 15 to 25 cm, with a mode at 20.5 cm which corresponds to quite large fish (Figure 7.3.2.2.2). Most fish (39% of the abundance and 37% of the biomass) in the entire surveyed area were assigned as belonging to the age class 3 (2009 year class). By sub-area, age 3 fish predominated in southern Galician waters (ICES subarea IXa-N), while age 4 fish predominated in western Cantabrian waters (38% of both abundance and biomass in VIIIcE-w). The age composition in southern Galicia, where recruits occur typically, provided no indication of a strong 2011 recruitment.

The distribution of sardine eggs (obtained from the analysis of 291 CUFES stations in Spanish waters, total number of stations was 303) indicates a very coastal distribution with whole areas, e.g. Asturias (ICES sub-area VIIcE-w) and northern Galicia devoid of eggs (Figure 7.3.2.2.3). The number of sardine eggs during the PELACUS0412 survey was one order of magnitude lower than the number obtained in the 2011 and the number of positive stations was very low comparing with the previous years. This scarcity of sardine eggs during the PELACUS survey in 2012 could be partly a consequence of the meteorological conditions during the survey period, with bad weather conditions, with very strong westerly winds (in some cases reaching up to 50 knots), rain, hail and very low surface water temperature dominating most of the survey and in particular during the second half, where subdivision VIIIcE was sampled.

7.4 Biological data

7.4.1 Mean weight at age in the stock and in the catch

Mean weight at age in the catch are shown in Table 7.4.1a.

Mean weight at age in the stock are obtained from samples collected in the acoustic surveys (Table 7.4.1b).

7.4.2 7.4.2 Maturity at age

Following the Stock Annex (WKPELA 2012), in DEPM years maturity at age is obtained from the survey samples. For 2011, maturity at age is:

Age	0	1	2	3	4	5	6+
Proportion mature	0.00	0.99	1.00	1.00	1.00	1.00	1.00

7.4.3 Natural mortality

Following the Stock Annex (WKPELA 2012), natural mortality is:

	M, year^{-1}
Age 0	0.8
Age 1	0.5
Age 2	0.4
Age 3	0.3
Age 4	0.3
Age 5	0.3
Age 6	0.3
Mean (2-5)	0.3

7.5 Assessment Data of the state of the stock

7.5.1 Stock assessment

The assessment follows the Stock Annex as reviewed in WKPELA 2012 with a single deviation regarding the use of the Iberian acoustic survey (PELACUS04+PELAGOS). Since the PELAGOS survey was not carried out in 2012 (Section 7.3.2.1), the joint acoustic index is not available for 2012 and cannot be used in the assessment as indicated in the Stock Annex. Therefore, years up to 2011 of this survey were used in the assessment.

Table 7.5.1.1 shows the parameters estimated by the assessment model. Estimates of fishing mortality at age are presented in Table 7.5.1.2. Figures 7.5.1.1 and 7.5.1.2 show the fit of the model to the acoustic and DEPM survey indices (total number of fish and spawning biomass by year, respectively). As in the benchmark assessment , the model fits poorly to the 1996 and 2011 acoustic surveys. Regarding the DEPM, the fit is poor to the 2011 survey and, as already noted in the benchmark to the 2002 and 2008 surveys as well.

Figure 7.5.1.3 shows the model residuals from the fit to the catch-at-age composition (a) and the acoustic survey age composition (b). The residuals from the present assessment are comparable to those from benchmark assessment. Catch residuals show some clustering being generally larger at age 0. Acoustic survey residuals shift from mostly positive to mostly negative around 2000, reflecting some conflict between the DEPM and acoustic signals.

The fishery and survey selectivity patterns are comparable to those obtained in the benchmark (Figure 7.5.1.4).

The assessment estimates of B1+, recruitment and fishing mortality are presented in Table 7.5.1.3 and Figure 7.5.1.5). The model estimates standard errors of SSB, recruitment and ApicalF (maximum F over age within years). We assume the CVs of SSB and ApicalF apply to B1+ and F(2-5). B1+ in 2011=330 thousand t (CV=22%) is 40% below the historical mean 1978 – 2010. B1+ shows an increase of 5% from 2010 to 2011. F in 2011 is estimated to be 0.27 year^{-1}(CV=25%), 6% below the historical mean. F decreased 16% from 2010 to 2011.

The series of historical recruitments 1978 – 2010 shows a significant linear downward trend (r^2=0.30, p<0.001, n=33). The 2009 recruitment (11431 millions, CV=18%), is estimated to be slightly above the level of recruitments in 2005 -2010. The moderate strength of this yearclass is noticeable in the survey numbers-at-age (Figure 7.5.1.5.) and in a smaller extent in the catch-at-age data (Figure 7.5.1.6.)

The R2011 estimate, 11627 billions, is 10% lower than the historical geometric mean. Although it is well above (+73%) the geometric mean of the recent low recruitments in 2005 – 2010, it is far below the last strong recruitments in 2000 and 2004. Furthermore, the estimate of the recruitment in the last year of the assessment (2011 in the present assessment) is more uncertain this year than in previous years (CV=31% compared to 26% of R2010 in the benchmark) due to lack of the 2012 Iberian acoustic survey index.

7.5.2 Reliability of the assessment

The results from this year's assessment are comparable to those of the benchmark assessment (Figure 7.5.2.1).

Compared to the benchmark assessment, B1+ in 2010 is revised upwards 6%, F2010 is revised downwards 9% and R2010 is revised upwards 52%. These revisions are considered to be small. They are mainly due to the addition of the 2011 DEPM survey which estimates a smaller stock decline than the acoustic survey from 2008 to 2011. There is indication that the 2011 acoustic survey may have provided an underestimation of sardine in some of the stock areas (WGANSA 2011).

As noted in past assessments (e.g. WGANSA 2010, 2011), the DEPM and the acoustic survey show discrepant signals in some years. Nevertheless, from 2008 to 2011, both surveys agree in a substantial decrease of the stock. The assessment tends to accommodate the signals from the two surveys by providing broadly an average perspective, as shown by the model fit to each survey (Figures 7.5.1.1 and 7.5.1.2) and by the comparison of biomass estimates (Figure 7.5.2.2).

This year's assessment is affected by the lack of the 2012 Iberian acoustic survey index (see section 7.5.1.). In particular, the estimate of the recruitment in the last year of the assessment (2011) is more uncertain than in previous years since it has no support from the survey estimate at age 1 in the interim year.

7.6 Short term predictions (Divisions VIIIc and IXa)

Catch predictions are carried out following the Stock Annex, apart from the assumptions about recruitment.

Recruitment (Age 0) estimated in the final year of the assessment, 2011, was not accepted for the projection since there is no data from the acoustic survey in the interim year to support this estimate.

Input values for 2011, 2012 and 2013 recruitments (Age0) were set equal to the geometric mean of the period 2005-2010, RGM(05-10) = 6720 million individuals, instead of using a geometric mean of the recruitments of the last 15 years, as indicated in the Stock Annex. This year's assumption is equal to that adopted in last year's assessment. As argued last year, the assessment indicates the last strong recruitment was in 2004. Since then, no strong recruitments were observed. The last five recruitment estimates, 2006 – 2010, are at a low level. There is a declining trend in the recruitment time series (Figure 7.5.2.1.). The WG considers that the possibility that low recruitments continue in the near future should be taken into account in the short term predictions. Therefore, a low recruitment, corresponding to the geometric mean of the period 2005 – 2010 is assumed for 2012 – 2013. The 2011 recruitment was not included in the geometric mean since it has no support from an acoustic survey in 2012. Numbers-at-age 1 in the beginning of 2012 were obtained projecting from the RGM(05-10) = 6720 million individuals in 2011 with $F_{0,2011}$ and $M_{0,2011}$.

As indicated in the Stock annex, predictions were carried out with an $F_{multiplier}$ assuming an F_{sq} equal to the average estimates of the last three years in the assessment (F_{sq}=0.29). Two options are presented regarding the interim year (2012): (a) Catches in the interim year were constrained to correspond to the average level of F in 2002-2007 (0.22); (b) catches in the interim year were assumed to correspond to the F_{sq} (0.29). The average F2002-2007 has been used as a basis for the ICES advice in 2011. Option (a) takes into account the regulations in place in 2012 for the Portuguese fishery (Section 7.8). These include the possibility of a in-year revision of the annual quota according to the ICES 2012 Advice. The Portuguese fishery takes ca. 70% of the total stock catches.

Input values are shown in Table 7.6.1 and results are shown in Tables 7.6.2 a-b.

7.7 Reference points and harvest control rules for management purposes

Reference points for this stock were proposed at the benchmark (WKPELA 2012): Fmsy=0.35 $year^{-1}$ and Blim=307 thousand t. These have been accepted by the WG. WKPELA decided not to propose a $B_{MSYtrigger}$, since this reference point is only relevant in a management context. The application of the expression Bpa=Blim*exp(1.645*sigma) assuming a sigma of 0.20, to derive a Bpa from Blim provided 427 thousand t. This value does not appear to be a reasonable proxy for $B_{MSYtrigger}$ since it is close to the equilibrium biomass (with a Ricker SR model) corresponding to F50%BPR (Fmsy proxy), 466 thousand t (WKPELA 2012).

A harvest control rule, developed within a MSE framework with the objective to rebuild the stock above Blim in 2015 with 80% probability, has been implemented recently in the Portuguese sardine fishery. This HCR is part of a national management plan which includes effort limitations too (see section 8.7) (http://www.dgrm.min-agricu-
lura.pt/xportal/xmain?xpid=dgrm&selectedmenu=107304&xpgid=genericPage&conteudoDetalhe=209429). The management plan has not been evaluated by ICES.

7.8 Management considerations

No specific management objectives are known to ICES. The stock is managed by Portugal and Spain through minimum landing size, maximum daily catch, days fishing limitations, and closed areas (see Stock Annex). Since 2010, annual catch limits are set for the Portuguese fishery by the Portuguese authorities. Catch limits are set for the civil year and admit a in-year revision following the publication of the ICES Advice. In 2010 and 2011, the catch limit was 55 thousand t and landings were 63 and 57 thousand t, respectively. In 2012 the catch limit was set at 36 thousand t and catch of sardine was banned for 45 days during the first quarter of the year (Despacho n.º 1517/2012, DR 2.ª série, 23, 1 February 2012; Despacho n.º 7509/2012, DR 2.ª série, 106, 31 May 2012).

B1+ at the beginning of 2011, 330 thousand t is 7% above Blim (307 thousand t). Fsq=0.29 is 16% below Fmsy. The assessment indicates a 5% increase in B1+ and a 16% decrease of F from 2010 to 2011. Given the uncertainty in the assessment estimates (CV=21 and 22% for B1+ in 2010 and 2011 and CV=23 and 25% for F in 2010 and

2011, respectively) these changes broadly indicate stable biomass and fishing mortality in those years. The moderate 2009 year class has contributed to this stability.

The stock biomass shows a declining trend since 2006 due to the lack of strong recruitments. According to the short term predictions, assuming recruitment is confirmed to be at a low level in 2011 and remains low in 2012, the stock will continue to decline. If catches in 2012 do not exceed the value corresponding to F=0.22, and the 2012 recruitment continues to be at a low level (RGM(05-10) = 6720 million individuals) B1+ in 2013 is estimated to be 289 thousand t. F in 2013 should be set as low as possible to prevent further decline of the stock.

It is noted that, at present, the development of the stock is mainly dependent on the strength of the incoming recruitment. In the recent past, large recruitments were produced by very low spawning biomasses (e.g. in 2000). Catch levels have been broadly stable in the past decade such that F fluctuates inversely to the stock biomass. Fsq is close to the historical mean level (0.28).

Table 7.2.1.1. Sardine in VIIIc and IXa: Spanish and Portuguese composition of the fleet licensed to catch sardine in 2011. Dimensions average (units), Engine power average in HP.

Country	Details given	DIMENSIONS	Engine power (Horse Power)	Gear	Storage	Discard estimates	No vessels
Spain (northern)	yes	22 (meters)	464	Purse seine	Dry hold with ice	No	339
Spain (Gulf of Cadiz)	yes	16 (meters)	182	Purse seine	Dry hold with ice	No	73
Portugal	yes	44.5 (GT)	224	Purse seine	Dry hold with ice	No	118

Table 7.2.2.1. Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2011 by ICES Sub-Division. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	2614	410	174	664	3862
VIIIc-W	871	1039	2064	701	4674
IXa-N	238	1625	1663	2094	5621
IXa-CN	4207	9718	10055	13172	37152
IXa-CS	3950	2578	4477	2680	13685
IXa-S (A)	911	1779	2112	1585	6387
IXa-S (C)	1547	1814	3516	2146	9023
Total	14337	18963	24061	23042	80403

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	3.25	0.51	0.22	0.83	4.80
VIIIc-W	1.08	1.29	2.57	0.87	5.81
IXa-N	0.30	2.02	2.07	2.60	6.99
IXa-CN	5.23	12.09	12.51	16.38	46.21
IXa-CS	4.91	3.21	5.57	3.33	17.02
IXa-S (A)	1.13	2.21	2.63	1.97	7.94
IXa-S (C)	1.92	2.26	4.37	2.67	11.22
Total	17.83	23.59	29.92	28.66	

Table 7.2.2.2. WG Estimates. Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by sub-area and total for the period 1940-2011.

			Sub-area					
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All sub-areas	Div. IXa
1940	66816		42132	33275	23724		**165947**	**99131**
1941	27801		26599	34423	9391		**98214**	**70413**
1942	47208		40969	31957	8739		**128873**	**81665**
1943	46348		85692	31362	15871		**179273**	**132925**
1944	76147		88643	31135	8450		**204375**	**128228**
1945	67998		64313	37289	7426		**177026**	**109028**
1946	32280		68787	26430	12237		**139734**	**107454**
1947	43459	21855	55407	25003	15667		**161391**	**117932**
1948	10945	17320	50288	17060	10674		**106287**	**95342**
1949	11519	19504	37868	12077	8952		**89920**	**78401**
1950	13201	27121	47388	17025	17963		**122698**	**109497**
1951	12713	27959	43906	15056	19269		**118903**	**106190**
1952	7765	30485	40938	22687	25331		**127206**	**119441**
1953	4969	27569	68145	16969	12051		**129703**	**124734**
1954	8836	28816	62467	25736	24084		**149939**	**141103**
1955	6851	30804	55618	15191	21150		**129614**	**122763**
1956	12074	29614	58128	24069	14475		**138360**	**126286**
1957	15624	37170	75896	20231	15010		**163931**	**148307**
1958	29743	41143	92790	33937	12554		**210167**	**180424**
1959	42005	36055	87845	23754	11680		**201339**	**159334**
1960	38244	60713	83331	24384	24062		**230734**	**192490**
1961	51212	59570	96105	22872	16528		**246287**	**195075**
1962	28891	46381	77701	29643	23528		**206144**	**177253**
1963	33796	51979	86859	17595	12397		**202626**	**168830**
1964	36390	40897	108065	27636	22035		**235023**	**198633**
1965	31732	47036	82354	35003	18797		**214922**	**183190**
1966	32196	44154	66929	34153	20855		**198287**	**166091**
1967	23480	45595	64210	31576	16635		**181496**	**158016**
1968	24690	51828	46215	16671	14993		**154397**	**129707**
1969	38254	40732	37782	13852	9350		**139970**	**101716**
1970	28934	32306	37608	12989	14257		**126094**	**97160**
1971	41691	48637	36728	16917	16534		**160507**	**118816**
1972	33800	45275	34889	18007	19200		**151171**	**117371**
1973	44768	18523	46984	27688	19570		**157533**	**112765**
1974	34536	13894	36339	18717	14244		**117730**	**83194**
1975	50260	12236	54819	19295	16714		**153324**	**103064**
1976	51901	10140	43435	16548	12538		**134562**	**82661**
1977	36149	9782	37064	17496	20745		**121236**	**85087**
1978	43522	12915	34246	25974	23333	5619	**145609**	**102087**
1979	18271	43876	39651	27532	24111	3800	**157241**	**138970**
1980	35787	49593	59290	29433	17579	3120	**194802**	**159015**
1981	35550	65330	61150	37054	15048	2384	**216517**	**180967**
1982	31756	71889	45865	38082	16912	2442	**206946**	**175190**
1983	32374	62843	33163	31163	21607	2688	**183837**	**151463**
1984	27970	79606	42798	35032	17280	3319	**206005**	**178035**
1985	25907	66491	61755	31535	18418	4333	**208439**	**182532**
1986	39195	37960	57360	31737	14354	6757	**187363**	**148168**
1987	36377	42234	44806	27795	17613	8870	**177696**	**141319**
1988	40944	24005	52779	27420	13393	2990	**161531**	**120587**
1989	29856	16179	52585	26783	11723	3835	**140961**	**111105**
1990	27500	19253	52212	24723	19238	6503	**149429**	**121929**
1991	20735	14383	44379	26150	22106	4834	**132587**	**111852**
1992	26160	16579	41681	29968	11666	4196	**130250**	**104090**
1993	24486	23905	47284	29995	13160	3664	**142495**	**118009**
1994	22181	16151	49136	30390	14942	3782	**136582**	**114401**
1995	19538	13928	41444	27270	19104	3996	**125280**	**105742**
1996	14423	11251	34761	31117	19880	5304	**116736**	**102313**
1997	15587	12291	34156	25863	21137	6780	**115814**	**100227**
1998	16177	3263	32584	29564	20743	6594	**108924**	**92747**
1999	11862	2563	31574	21747	18499	7846	**94091**	**82229**
2000	11697	2866	23311	23701	19129	5081	**85786**	**74089**
2001	16798	8398	32726	25619	13350	5066	**101957**	**85159**
2002	15885	4562	33585	22969	10982	11689	**99673**	**83787**
2003	16436	6383	33293	24635	8600	8484	**97831**	**81395**
2004	18306	8573	29488	24370	8107	9176	**98020**	**79714**
2005	19800	11663	25696	24619	7175	8391	**97345**	**77545**
2006	15377	10856	30152	19061	5798	5779	**87023**	**71646**
2007	13380	12402	41090	19142	4266	6188	**96469**	**83088**
2008	13636	9409	45210	20858	4928	7423	**101464**	**87828**
2009	11963	7226	36212	20838	4785	6716	**87740**	**75777**
2010	13772	7409	40923	17623	5181	4662	**89571**	**75798**
2011	8536	5621	37152	13685	6387	9023	**80403**	**71867**

Table 7.2.4.1: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2011.

				Total				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10				132				132
10.5		12		395	17		330	754
11		36	47	7 483			6 561	14 128
11.5		54	95	11 616			25 241	37 006
12	9	96	131	22 922	17	17	35 385	58 577
12.5	74	78	239	20 206		8	35 418	56 023
13	109	174	328	20 147	101	17	34 877	55 751
13.5	243	84	468	9 130	366	105	26 363	36 760
14	106	80	986	7 230	339	114	30 165	39 021
14.5	149	40	1 324	6 430	628	231	27 157	35 960
15	101	47	2 285	10 612	532	536	25 594	39 706
15.5	515	33	2 136	12 540	600	933	24 046	40 802
16	683	17	3 756	17 311	1 409	994	20 433	44 603
16.5	720	185	4 928	19 290	1 579	1 283	18 360	46 345
17	657	602	5 219	21 272	3 066	2 450	17 014	50 280
17.5	223	1 866	4 219	29 316	7 293	3 075	14 848	60 841
18	291	4 209	5 085	45 445	9 507	2 627	8 532	75 697
18.5	85	5 801	6 495	65 264	10 281	3 301	6 688	97 916
19	80	5 312	8 060	86 999	11 042	6 669	5 883	124 045
19.5	410	5 892	10 384	80 788	16 706	12 991	5 453	132 624
20	446	4 676	10 200	72 695	24 327	17 714	3 594	133 652
20.5	975	5 171	7 693	43 108	34 072	18 195	1 718	110 931
21	974	6 409	4 767	31 836	33 669	14 469	1 102	93 227
21.5	1 199	6 092	3 150	14 214	24 907	7 109	334	57 006
22	1 794	5 780	3 221	6 742	12 418	2 721		32 677
22.5	3 369	3 677	1 856	2 190	4 453	808		16 353
23	5 670	2 481	1 359	911	1 609	243		12 273
23.5	7 045	1 392	446	215	807	23		9 928
24	7 907	694	282	167	42			9 092
24.5	6 878	211	37					7 126
25	5 021	39			104			5 164
25.5	2 330							2 330
26	1 419	3						1 421
26.5	720							720
27	163							163
27.5	39							39
28	6							6
28.5								
29								
Total	50 408	61 244	89 197	666 608	199 894	96 633	375 095	1 539 079
Mean L	23.3	20.5	0.0	18.2	20.4	20.1	14.7	18.1
sd	2.48	1.86	11871.00	2.74	1.54	1.45	2.24	3.23
Catch	**3862**	**4674**	**5621**	**37152**	**13685**	**6387**	**9023**	**80403**

Table 7.2.4.1a: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the first quarter of 2011.

			First Quarter					
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6.5								
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5	7	12			17		416	453
11	21	36					5 255	5 312
11.5	32	54					9 975	10 061
12	56	96			17		8 934	9 103
12.5	46	78					6 946	7 070
13	263	174	11		101		7 035	7 584
13.5	286	84	22	82	172	48	6 319	7 012
14	368	78	100	1 195	69	69	5 402	7 281
14.5	591	36	106	2 385	288	78	3 153	6 637
15	213	24	61	5 074	134	134	3 191	8 831
15.5	288	18	45	5 881	515	111	3 977	10 834
16	75		6	5 392	1 101	72	3 870	10 517
16.5	38		160	4 051	1 084	99	1 938	7 369
17	356		137	2 450	2 224	46	2 754	7 967
17.5	277		222	2 990	4 466	11	1 717	9 683
18	621	7	376	4 834	3 959	10	1 039	10 846
18.5	335	11	248	6 782	3 289	44	198	10 907
19	540	91	373	12 165	3 075	359	336	16 938
19.5	788	73	515	8 810	4 476	1 034	434	16 130
20	2 065	254	301	5 748	9 140	2 079	336	19 922
20.5	3 992	778	321	6 001	11 607	2 871	28	25 599
21	4 772	1 690	242	5 234	10 265	3 410		25 613
21.5	5 891	1 965	265	2 725	6 806	1 583		19 236
22	4 585	2 048	247	1 754	3 530	766		12 930
22.5	3 781	1 341	128	819	1 371	198		7 639
23	1 757	1 198	92	588	332	103		4 071
23.5	1 193	556	34	215	281	17		2 297
24	638	258	26	50	22			994
24.5	131	88	4					224
25	38	4			104			146
25.5	6							6
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	34 049	11 054	4 044	85 224	68 445	13 141	73 254	289 212
Mean L	21.1	21.6	19.5	18.6	20.1	20.7	13.8	18.3
sd	2.23	2.39	2.23	2.16	1.73	1.43	2.03	3.40
Catch	**2 614**	**871**	**238**	**4 207**	**3 950**	**911**	**1 547**	**14 337**

Table 7.2.4.1b: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdi-

Second Quarter								
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10				132				132
10.5				395				395
11			47	1 184				1 232
11.5			95	658			45	798
12			71	395		17	529	1 011
12.5			83			8	912	1 004
13	2		71			17	1 812	1 901
13.5			36			50	4 496	4 581
14			83			30	6 212	6 325
14.5	2		107	360	79	121	9 425	10 094
15	10		213	291	59	240	9 616	10 429
15.5	3		254	1 578	20	380	5 236	7 470
16	10		726	4 647	72	577	3 584	9 616
16.5	17	59	1 450	7 307	59	369	2 143	11 404
17	33	198	1 714	10 097	65	421	2 647	15 175
17.5	70	444	2 073	14 329	382	704	1 513	19 516
18	136	788	2 740	18 303	753	490	1 845	25 053
18.5	353	1 308	2 412	21 216	988	749	2 496	29 522
19	359	1 585	2 044	25 647	1 846	2 529	3 069	37 080
19.5	646	2 220	1 978	22 655	3 009	5 534	1 254	37 296
20	663	1 872	2 180	19 553	5 863	6 425	575	37 132
20.5	855	1 940	2 056	14 104	8 868	4 848	341	33 012
21	618	1 598	1 446	9 992	9 711	2 790	114	26 269
21.5	606	1 267	984	4 850	5 008	1 629		14 345
22	496	890	961	1 929	2 054	732		7 062
22.5	393	493	819	822	330	230		3 086
23	205	196	974	180	143	71		1 769
23.5	83	114	348					545
24	29	12	208	117	20			387
24.5	5	14	32					51
25	2	16						17
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	5 595	15 015	26 203	180 742	39 329	28 961	57 865	353 710
Mean L	20.8	20.3	19.3	19.0	20.7	20.	15.8	18.9
sd	1.46	1.39	2.20	1.73	1.05	1.47	1.86	2.25
Catch	**410**	**1 039**	**1 625**	**9 718**	**2 578**	**1 779**	**1 814**	**18 963**

vision in the second quarter of 2011.

Table 7.2.4.1c: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter of 2011.

				Third Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6.5								
7								
7.5								
8								
8.5								
9								
9.5	9							9
10	74						330	404
10.5	102						6 145	6 246
11	222			6 299			19 582	26 102
11.5	74			10 348			21 783	32 205
12	92			20 696			19 197	39 985
12.5	55		31	15 747			22 987	38 820
13	250			13 497			16 450	30 196
13.5	398			5 399	135	8	18 372	24 312
14	351			2 699	271	16	13 380	16 716
14.5	65		125	450	203	31	9 814	10 688
15			94		338	132	6 992	7 556
15.5			94		8	419	4 381	4 902
16	1	8	34	11	44	220	4 024	4 341
16.5	25	119	187	582	266	563	8 308	10 051
17	22	399	95	2 427	347	1 776	4 554	9 620
17.5	97	1 418	304	6 105	912	1 988	744	11 569
18	199	3 399	427	12 119	1 762	1 434	738	20 076
18.5	245	4 451	1 054	18 724	1 899	1 408	488	28 269
19	205	3 561	2 843	21 446	2 531	2 421		33 007
19.5	211	3 489	3 800	22 264	3 053	4 090		36 908
20	137	2 172	5 156	16 723	5 255	6 112		35 555
20.5	128	1 900	5 429	7 808	8 429	5 950		29 644
21	156	1 924	2 800	4 828	10 052	4 008		23 768
21.5	139	1 786	825	1 621	9 746	1 469		15 586
22	103	1 323	139	114	6 015	232		7 926
22.5	76	916	107	162	2 109			3 370
23	37	476	32		723			1 268
23.5	24	357			395			776
24	9	141						150
24.5	1	17						18
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	3 507	27 857	23 576	190 069	54 493	32 276	178 269	510 046
Mean L	16.6	19.9	20.1	16.7	20.8	19.8	13.3	16.5
sd	3.84	1.55	1.13	3.46	1.51	1.44	1.75	3.69
Catch	**174**	**2 064**	**1 663**	**10 055**	**4 477**	**2 112**	**3 516**	**24 061**

Table7.2.4.1d: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter of 2011.

Fourth Quarter

Length	VIIIc E	VIIIc W	IXa N	IXa CN	IXa CS	IXa S	IXa S (Ca)	Total
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11							404	404
11.5				611			3 581	4 192
12			29	1 832			6 758	8 619
12.5			156	4 460			4 031	8 646
13			246	6 649			1 067	7 962
13.5			411	3 649	59		978	5 097
14		2	678	3 336			2 164	6 180
14.5		4	1 018	3 236	59		3 201	7 517
15		23	1 917	5 247		29	4 247	11 463
15.5		15	1 804	5 082	58	22	6 839	13 819
16		9	2 837	7 261	192	124	6 881	17 305
16.5		6	3 223	7 350	170	253	4 624	15 627
17		5	3 064	6 298	429	208	4 893	14 897
17.5	1	4	1 497	5 891	1 533	372	4 557	13 856
18	20	16	915	10 190	3 034	694	3 066	17 935
18.5	41	31	992	18 542	4 106	1 100	2 700	27 512
19	95	75	1 843	27 741	3 591	1 360	2 049	36 754
19.5	148	109	2 736	27 059	6 168	2 332	1 907	40 459
20	503	379	2 290	30 671	4 068	3 098	807	41 815
20.5	695	552	2 515	15 194	5 168	4 526	733	29 384
21	1 499	1 197	2 253	11 782	3 641	4 262	220	24 855
21.5	1 270	1 074	1 762	5 019	3 347	2 428		14 900
22	1 695	1 519	1 907	2 944	819	992		9 876
22.5	771	927	877	387	643	380		3 985
23	331	612	293	143	411	69		1 858
23.5	119	364	64		131	6		683
24	44	281	47					372
24.5	25	92						117
25		20						20
25.5								
26		3						3
26.5								
27								
27.5								
28								
28.5								
29								
Total	7 258	7 319	35 374	210 573	37 626	22 255	65 707	386 112
Mean L	21.7	22.	18.5	18.6	20.	20.5	15.7	18.4
sd	.98	1.29	2.53	2.39	1.39	1.25	2.41	2.68
Catch	**664**	**701**	**2 094**	**13 172**	**2 680**	**1 585**	**2 146**	**23 042**

Table 7.2.4.2: Sardine in VIIIc and IXa: Catch in numbers (thousands) at age by quarter and by subdivision in 2011.

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
							First Quarter	
0								
1	3 094	839	1 402	26 640	4 761	693	63 827	101 258
2	1 662	2 357	1 473	39 265	19 371	82	7 387	71 597
3	8 449	2 224	432	4 784	12 721	963	1 596	31 169
4	14 357	2 009	234	2 747	13 138	1 808	381	34 673
5	3 153	1 038	198	2 171	4 278	3 557	61	14 457
6	1 768	1 481	163	3 931	9 150	2 247	2	18 742
7	903	816	100	5 077	3 393	2 615		12 903
8	663	184	23	466	1 299	1 176		3 813
9		79	19	143				241
10		27			333			360
11								
12								
Total	34 049	11 054	4 044	85 224	68 445	13 141	73 254	289 212
Catch (Tons)	2 614	871	238	4 207	3 950	911	1 547	14 337

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
							Second Quarter	
0								
1	254	4 926	10 694	49 842	314	1 369	41 066	108 464
2	675	5 799	8 724	97 372	7 388	1 941	11 021	132 920
3	1 908	1 731	2 401	11 886	7 730	5 348	4 612	35 617
4	2 113	1 085	1 298	4 765	8 278	5 101	817	23 457
5	358	441	1 056	1 250	5 023	3 267	311	11 706
6	165	562	1 092	5 934	4 797	5 032	38	17 619
7	76	384	627	9 556	4 440	3 822		18 905
8	45	64	155		1 141	1 470		2 875
9		17	157		129	1 106		1 408
10		7			30	242		279
11					30	96		126
12					29	167		
Total	5 595	15 015	26 203	180 605	39 329	28 961	57 865	353 377
Catch (Tons)	410	1 039	1 625	9 718	2 578	1 779	1 814	18 963

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
							Third Quarter	
0	1 793	11 379	3 174	75 830	1 303	456	146 970	240 906
1	842	7 883	6 189	70 752	5 852	6 267	29 929	127 715
2	240	4 598	13 344	37 745	9 459	6 755	1 266	73 408
3	330	2 146	575	2 538	13 363	11 912	103	30 967
4	239	758	99	340	10 583	4 279		16 298
5	24	486	126	241	4 529	1 575		6 980
6	14	482	65	1 793	3 658	851		6 864
7	5	95	4	517	3 367	180		4 168
8	10	21			997			1 028
9	10	8			1 382			1 400
10				313				313
11								
12								
Total	3 507	27 857	23 576	190 069	54 493	32 276	178 269	510 046
Catch (Tons)	174	2 064	1 663	10 055	4 477	2 112	3 516	24 061

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
							Fourth Quarter	
0	4	157	16 438	57 040	596	39	26 355	100 629
1	862	764	4 723	62 813	13 595	1 424	30 642	114 821
2	1 319	2 573	9 965	71 092	11 984	2 608	5 888	105 428
3	2 565	1 745	1 907	8 087	3 867	3 909	2 303	24 384
4	1 960	829	587	2 818	3 170	3 663	519	13 548
5	285	445	830	989	1 414	3 843		7 806
6	102	592	720	3 863	1 919	3 137		10 332
7	30	130	113	3 131	736	2 291		6 431
8	65	53	30		107	717		972
9	65	27	30	741		460		1 322
10		5	30		238	165		438
11								
12								
Total	7 258	7 319	35 374	210 573	37 626	22 255	65 707	386 112
Catch (Tons)	664	701	2 094	13 172	2 680	1 585	2 146	23 042

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
							Whole Year	
0	1 798	11 535	19 612	132 870	1 899	495	173 325	341 535
1	5 052	14 412	23 007	210 047	24 523	9 753	165 464	452 259
2	3 896	15 327	33 507	245 473	48 202	11 386	25 562	383 352
3	13 253	7 847	5 315	27 294	37 681	22 131	8 614	122 136
4	18 669	4 681	2 218	10 670	35 169	14 851	1 718	87 976
5	3 820	2 409	2 209	4 652	15 243	12 243	372	40 949
6	2 049	3 116	2 040	15 520	19 525	11 267	40	53 557
7	1 014	1 425	844	18 281	11 936	8 908		42 407
8	783	322	208	466	3 545	3 364		8 688
9	75	131	206	884	1 510	1 566		4 371
10		39	30	313	601	407		1 389
11					30	96		126
12					29	167		
Total	50 408	61 244	89 197	666 471	199 894	96 633	375 095	1 538 747
Catch (Tons)	3 862	4 674	5 621	37 152	13 685	6 387	9 023	80 403

Table 7.2.4.3: Sardine in VIIIc and IXa: Relative distribution of sardine catches. Upper pannel, relative contribution of each group within each subdivision. Lower pannel, relative contribution of each subdivision within each Age Group.

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	4%	19%	22%	20%	1%	1%	46%	22%
1	10%	24%	26%	32%	12%	10%	44%	29%
2	8%	25%	38%	37%	24%	12%	7%	25%
3	26%	13%	6%	4%	19%	23%	2%	8%
4	37%	8%	2%	2%	18%	15%	0%	6%
5	8%	4%	2%	1%	8%	13%	0%	3%
6+	8%	8%	4%	5%	19%	27%	0%	7%
	100%	100%	100%	100%	100%	100%	100%	100%

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	1%	3%	6%	39%	1%	0%	51%	100%
1	1%	3%	5%	46%	5%	2%	37%	100%
2	1%	4%	9%	64%	13%	3%	7%	100%
3	11%	6%	4%	22%	31%	18%	7%	100%
4	21%	5%	3%	12%	40%	17%	2%	100%
5	9%	6%	5%	11%	37%	30%	1%	100%
6+	4%	5%	3%	32%	34%	23%	0%	100%

Table 7.2.5.1: Sardine VIIIc and IXa: Sardine Mean length (cm) at age by quarter and by subdivision in 2011.

	First Quarter						
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	15.3	14.3	17.2	15.9	16.4	15.8	13.3
2	19.5	21.3	19.9	19.2	18.7	18.8	16.9
3	21.2	22.0	20.8	20.4	20.6	20.0	18.5
4	21.7	22.3	21.8	21.3	21.0	20.5	18.3
5	22.2	22.7	22.0	21.0	21.1	20.8	20.0
6	23.1	22.8	22.7	21.2	21.6	21.1	20.8
7	23.6	22.6	22.7	21.8	21.4	21.2	
8	24.0	22.9	22.9	21.5	22.1	22.0	
9		23.8	23.2	23.0			
10		24.3			23.5		
11							
12							

	Second Quarter						
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	17.8	18.9	17.4	17.2	16.3	15.7	14.9
2	19.3	20.3	19.7	19.3	19.5	17.6	17.5
3	20.5	21.4	20.8	20.8	20.7	19.5	19.1
4	21.3	21.8	21.9	21.0	21.0	20.1	18.9
5	22.0	22.1	22.0	21.0	21.2	20.4	20.1
6	23.0	22.2	23.0	21.1	21.1	20.5	20.9
7	23.5	22.0	22.9	21.2	21.3	21.0	
8	23.7	22.5	23.1		21.7	21.0	
9		23.8	23.3		22.1	21.2	
10		24.7			22.8	22.1	
11					22.8	21.8	
12					23.3	22.4	

	Third Quarter						
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	13.2	18.5	17.8	12.6	15.2	15.6	12.7
1	19.0	19.8	19.4	19.0	18.7	17.7	15.9
2	20.5	21.3	20.0	19.9	20.0	19.8	17.4
3	21.3	22.0	21.0	20.6	21.2	20.4	18.6
4	21.3	22.8	21.2	21.4	21.3	21.2	
5	22.7	22.4	21.3	21.4	21.6	20.4	
6	23.3	22.9	21.7	21.2	21.9	20.5	
7	23.5	23.1	22.4	21.2	21.8	20.3	
8	23.9	24.1			22.6		
9	23.9	24.3			22.9		
10				22.0			
11							
12							

	Fourth Quarter						
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	18.4	17.7	16.3	15.2	16.5	16.8	13.5
1	20.6	20.6	18.8	19.2	18.8	18.0	16.8
2	21.2	21.6	20.6	20.0	20.1	18.9	18.6
3	21.9	22.4	21.8	21.0	21.0	20.3	19.6
4	21.8	22.8	22.2	21.8	21.5	20.7	20.6
5	22.5	22.7	22.1	21.4	21.1	21.0	
6	23.2	23.1	22.2	21.1	21.9	21.0	
7	23.4	23.3	22.8	21.6	21.6	21.5	
8	24.0	24.5	23.6		21.3	21.7	
9	24.0	24.6	23.6	21.4		22.0	
10		25.4	23.6		23.3	21.1	
11							
12							

	Whole Year						
Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	13.2	18.5	16.5	13.7	15.6	15.7	12.9
1	17.0	19.2	18.2	18.2	18.3	17.3	14.8
2	20.1	21.0	20.1	19.6	19.4	19.2	17.6
3	21.2	21.9	21.2	20.7	20.8	20.1	19.1
4	21.7	22.4	21.9	21.3	21.1	20.6	19.3
5	22.2	22.5	22.0	21.1	21.3	20.7	20.1
6	23.1	22.8	22.6	21.1	21.6	20.8	20.9
7	23.6	22.5	22.9	21.5	21.5	21.2	
8	23.9	23.2	23.2	21.5	22.1	21.5	
9	24.0	24.0	23.3	21.7	22.8	21.5	
10		24.5	23.6	22.0	23.4	21.7	
11					22.8	21.8	
12					23.3	22.4	

Table 7.2.5.2: Sardine VIIIc and IXa: Sardine Mean weight (kg) at age by quarter and by subdivision in 2011.

							First Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	0.029	0.025	0.041	0.030	0.032	0.032	0.019
2	0.059	0.074	0.061	0.052	0.046	0.053	0.036
3	0.076	0.081	0.070	0.062	0.061	0.062	0.047
4	0.082	0.085	0.080	0.071	0.065	0.067	0.045
5	0.087	0.089	0.081	0.068	0.066	0.070	0.058
6	0.097	0.090	0.089	0.069	0.070	0.073	0.064
7	0.103	0.088	0.089	0.076	0.068	0.074	
8	0.108	0.092	0.092	0.073	0.075	0.082	
9		0.102	0.095	0.088	0.000		
10		0.108			0.091		
11							
12							

							Second Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	0.047	0.057	0.046	0.040	0.034	0.034	0.025
2	0.059	0.069	0.064	0.055	0.056	0.045	0.042
3	0.070	0.079	0.073	0.067	0.065	0.057	0.054
4	0.079	0.083	0.084	0.069	0.068	0.062	0.052
5	0.086	0.086	0.085	0.069	0.069	0.064	0.063
6	0.096	0.088	0.095	0.070	0.069	0.065	0.070
7	0.102	0.085	0.095	0.072	0.071	0.069	
8	0.105	0.091	0.097		0.074	0.069	
9		0.105	0.099		0.078	0.071	
10		0.116			0.084	0.1	
11					0.1	0.1	
12					0.1	0.1	

							Third Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0.023	0.059	0.053	0.022	0.037	0.039	0.017
1	0.065	0.072	0.068	0.069	0.062	0.051	0.035
2	0.080	0.089	0.075	0.079	0.074	0.065	0.046
3	0.090	0.098	0.086	0.088	0.085	0.069	0.057
4	0.089	0.108	0.088	0.097	0.087	0.075	
5	0.107	0.103	0.089	0.097	0.090	0.069	
6	0.116	0.110	0.093	0.095	0.093	0.071	
7	0.118	0.112	0.103	0.094	0.092	0.069	
8	0.124	0.128		0.000	0.100		
9	0.1	0.131		0.000	0.104		
10				0.106			
11							
12							

							Fourth Quarter
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0.055	0.050	0.038	0.032	0.040	0.044	0.020
1	0.078	0.078	0.060	0.066	0.059	0.053	0.038
2	0.085	0.090	0.078	0.076	0.072	0.058	0.052
3	0.095	0.100	0.093	0.088	0.082	0.069	0.061
4	0.093	0.107	0.098	0.100	0.088	0.073	0.070
5	0.102	0.105	0.097	0.094	0.083	0.075	
6	0.112	0.111	0.098	0.089	0.093	0.076	
7	0.115	0.114	0.105	0.097	0.089	0.080	
8	0.124	0.132	0.117	0.000	0.1	0.081	
9	0.1	0.134	0.117	0.095	0.0	0.085	
10		0.1	0.1		0.1	0.077	
11							
12							

							Whole Year
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0.023	0.059	0.041	0.026	0.038	0.039	0.017
1	0.044	0.065	0.055	0.056	0.054	0.048	0.027
2	0.069	0.079	0.072	0.064	0.060	0.060	0.042
3	0.079	0.090	0.081	0.075	0.073	0.066	0.054
4	0.083	0.092	0.088	0.079	0.074	0.069	0.056
5	0.088	0.094	0.090	0.075	0.076	0.070	0.062
6	0.098	0.097	0.096	0.078	0.076	0.070	0.070
7	0.103	0.092	0.096	0.078	0.077	0.073	
8	0.109	0.101	0.099	0.073	0.082	0.076	
9	0.124	0.111	0.101	0.094	0.101	0.075	
10		0.115	0.1	0.106	0.099	0.077	
11					0.1	0.1	
12					0.1	0.1	

Table 7.3.2.2.1. Sardine in VIIIc and IXa: Sardine abundance in number (thousands of fish) and

AREA VIIIcE east					AGE						
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	5	4	1	1	1	0	0	0	0	0	13
% Biomass	39,1	30,0	5,2	11,7	9,7	2,5	1,8	0,0	0,0	0,0	100
Abundance (Numbers in '000)	134	80	9	18	14	3	2	0	0	0	262
% Abundance	51,2	30,7	3,6	6,8	5,5	1,3	0,9	0,0	0,0	0,0	100
Medium Weight (gr)	36,7	47,0	69,7	83,3	84,2	91,4	93,2	0,0	0,0	0,0	52,1
Medium Length (cm)	16,8	18,2	20,7	21,9	22,0	22,6	22,8	0,0	0,0	0,0	14,2

AREA VIIIcE west											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	0	29	55	429	348	124	147	0	0	0	1131
% Biomass	0,0	2,5	4,8	37,9	30,8	10,9	13,0	0,0	0,0	0,0	100
Abundance (Numbers in '000)	0	420	696	4717	3715	1294	1432	0	0	0	12274
% Abundance	0,0	3,4	5,7	38,4	30,3	10,5	11,7	0,0	0,0	0,0	100
Medium Weight (gr)	0,0	68,1	78,7	90,9	93,7	95,5	102,9	0,0	0,0	0,0	58,9
Medium Length (cm)	0,0	20,5	21,5	22,6	22,8	22,9	23,5	0,0	0,0	0,0	14,9

AREA VIIIcW											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	0	722	690	442	910	587	642	550	0	0	4543
% Biomass	0,0	15,9	15,2	9,7	20,0	12,9	14,1	12,1	0,0	0,0	100
Abundance (Numbers in '000)	0	10084	7802	4662	8908	5707	6190	5134	0	0	48489
% Abundance	0,0	20,8	16,1	9,6	18,4	11,8	12,8	10,6	0,0	0,0	100
Medium Weight (gr)	0,0	71,6	88,4	94,8	102,2	102,9	103,7	107,2	0,0	0,0	83,8
Medium Length (cm)	0,0	20,9	22,4	22,9	23,4	23,5	23,5	23,8	0,0	0,0	20,0

AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	521	1975	5646	1543	540	412	534	521	0	0	11690
% Biomass	4,5	16,9	48,3	13,2	4,6	3,5	4,6	4,5	0,0	0,0	100
Abundance (Numbers in '000)	10149	29083	76816	18061	6188	4493	5846	5559	0	0	156197
% Abundance	6,5	18,6	49,2	11,6	4,0	2,9	3,7	3,6	0,0	0,0	100
Medium Weight (gr)	51,3	67,9	73,5	85,4	87,2	91,7	91,3	93,7	0,0	0,0	76,2
Medium Length (cm)	18,7	20,5	21,1	22,1	22,2	22,6	22,6	22,8	0,0	0,0	21,2

TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	525	2729	6391	2415	1799	1123	1323	1071	0	0	17377
% Biomass	3,0	15,7	36,8	13,9	10,4	6,5	7,6	6,2	0,0	0,0	100
Abundance (Numbers in '000)	10284	39667	85324	27458	18826	11497	13471	10693	0	0	217221
% Abundance	4,7	18,3	39,3	12,6	8,7	5,3	6,2	4,9	0,0	0,0	100
Medium Weight (gr)	51,1	68,8	74,9	87,9	95,6	97,7	98,2	100,2	0,0	0,0	67,4
Medium Length (cm)	18,7	20,6	21,2	22,3	22,9	23,1	23,1	23,3			21,9

biomass (tons) by age groups and ICES subdivision in PELACUS0412.

Table 7.4.1a. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the catch.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1979	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1980	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1981	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1982	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1983	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1984	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1985	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1986	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1987	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1988	0.017	0.034	0.052	0.060	0.068	0.072	0.100
1989	0.013	0.035	0.052	0.059	0.066	0.071	0.100
1990	0.024	0.032	0.047	0.057	0.061	0.067	0.100
1991	0.020	0.031	0.058	0.063	0.073	0.074	0.100
1992	0.018	0.045	0.055	0.066	0.070	0.079	0.100
1993	0.017	0.037	0.051	0.058	0.066	0.071	0.100
1994	0.020	0.036	0.058	0.062	0.070	0.076	0.100
1995	0.025	0.047	0.059	0.066	0.071	0.082	0.100
1996	0.019	0.038	0.051	0.058	0.061	0.071	0.100
1997	0.022	0.033	0.052	0.062	0.069	0.073	0.100
1998	0.024	0.040	0.055	0.061	0.064	0.067	0.100
1999	0.025	0.042	0.056	0.065	0.070	0.073	0.100
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.100
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.100
2002	0.028	0.045	0.057	0.069	0.075	0.079	0.100
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.100
2004	0.020	0.040	0.056	0.066	0.072	0.082	0.100
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.100
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.100
2007	0.028	0.054	0.071	0.074	0.085	0.086	0.100
2008	0.025	0.043	0.066	0.074	0.075	0.083	0.100
2009	0.020	0.041	0.065	0.075	0.079	0.083	0.100
2010	0.026	0.046	0.061	0.075	0.082	0.084	0.100
2011	0.024	0.045	0.064	0.073	0.077	0.077	0.100

Table 7.4.1b. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the stock.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0	0.015	0.038	0.050	0.064	0.067	0.100
1979	0	0.015	0.038	0.050	0.064	0.067	0.100
1980	0	0.015	0.038	0.050	0.064	0.067	0.100
1981	0	0.015	0.038	0.050	0.064	0.067	0.100
1982	0	0.015	0.038	0.050	0.064	0.067	0.100
1983	0	0.015	0.038	0.050	0.064	0.067	0.100
1984	0	0.015	0.038	0.050	0.064	0.067	0.100
1985	0	0.015	0.038	0.050	0.064	0.067	0.100
1986	0	0.015	0.038	0.050	0.064	0.067	0.100
1987	0	0.015	0.038	0.050	0.064	0.067	0.100
1988	0	0.015	0.038	0.050	0.064	0.067	0.100
1989	0	0.015	0.038	0.050	0.064	0.067	0.100
1990	0	0.015	0.038	0.050	0.064	0.067	0.100
1991	0	0.019	0.042	0.050	0.064	0.071	0.100
1992	0	0.027	0.036	0.050	0.062	0.069	0.100
1993	0	0.022	0.045	0.057	0.064	0.073	0.100
1994	0	0.031	0.040	0.049	0.060	0.067	0.100
1995	0	0.029	0.050	0.062	0.072	0.079	0.100
1996	0	0.021	0.042	0.050	0.057	0.065	0.077
1997	0	0.024	0.032	0.052	0.059	0.064	0.072
1998	0	0.029	0.037	0.048	0.054	0.059	0.066
1999	0	0.024	0.040	0.052	0.059	0.067	0.073
2000	0	0.017	0.043	0.056	0.061	0.067	0.067
2001	0	0.021	0.041	0.060	0.071	0.072	0.074
2002	0	0.024	0.040	0.055	0.068	0.074	0.074
2003	0	0.019	0.043	0.053	0.065	0.070	0.076
2004	0	0.020	0.045	0.061	0.069	0.076	0.100
2005	0	0.019	0.045	0.059	0.068	0.073	0.079
2006	0	0.030	0.042	0.060	0.068	0.068	0.075
2007	0	0.039	0.054	0.062	0.070	0.076	0.077
2008	0	0.017	0.052	0.065	0.070	0.080	0.087
2009	0	0.020	0.053	0.060	0.065	0.069	0.076
2010	0	0.018	0.042	0.058	0.064	0.064	0.071
2011	0	0.026	0.048	0.058	0.065	0.066	0.067

Table 7.5.1.1. Sardine in VIIIc and IXa: Parameters and asymptotic standard deviations estimated in the final assessment model.

Parameter	Phase	Min	Max	Initial value	Final Value	Std Dev
SR_LN(R0)	1	1	12	8.9	9.46	0.071
Main_RecrDev_1978	_	_	_	_	0.62	0.149
Main_RecrDev_1979	_	_	_	_	0.76	0.147
Main_RecrDev_1980	_	_	_	_	0.90	0.141
Main_RecrDev_1981	_	_	_	_	0.43	0.170
Main_RecrDev_1982	_	_	_	_	-0.16	0.226
Main_RecrDev_1983	_	_	_	_	1.34	0.113
Main_RecrDev_1984	_	_	_	_	0.18	0.183
Main_RecrDev_1985	_	_	_	_	0.10	0.177
Main_RecrDev_1986	_	_	_	_	-0.10	0.185
Main_RecrDev_1987	_	_	_	_	0.61	0.126
Main_RecrDev_1988	_	_	_	_	0.02	0.158
Main_RecrDev_1989	_	_	_	_	-0.01	0.157
Main_RecrDev_1990	_	_	_	_	0.02	0.153
Main_RecrDev_1991	_	_	_	_	1.04	0.089
Main_RecrDev_1992	_	_	_	_	0.71	0.097
Main_RecrDev_1993	_	_	_	_	-0.09	0.131
Main_RecrDev_1994	_	_	_	_	-0.25	0.123
Main_RecrDev_1995	_	_	_	_	-0.56	0.124
Main_RecrDev_1996	_	_	_	_	-0.11	0.098
Main_RecrDev_1997	_	_	_	_	-0.63	0.121
Main_RecrDev_1998	_	_	_	_	-0.35	0.107
Main_RecrDev_1999	_	_	_	_	-0.55	0.122
Main_RecrDev_2000	_	_	_	_	0.58	0.081
Main_RecrDev_2001	_	_	_	_	0.08	0.100
Main_RecrDev_2002	_	_	_	_	-0.51	0.128
Main_RecrDev_2003	_	_	_	_	-0.78	0.155
Main_RecrDev_2004	_	_	_	_	0.71	0.072
Main_RecrDev_2005	_	_	_	_	-0.28	0.105
Main_RecrDev_2006	_	_	_	_	-1.35	0.159
Main_RecrDev_2007	_	_	_	_	-0.83	0.129
Main_RecrDev_2008	_	_	_	_	-0.54	0.129
Main_RecrDev_2009	_	_	_	_	-0.12	0.136
Main_RecrDev_2010	_	_	_	_	-0.78	0.189
Main_RecrDev_2011	_	_	_	_	-0.10	0.281
InitF_1purse_seine	1	0	2	0.3	0.33	0.057
Q_base_3_DEPM_survey	1	-7	5	0	-0.07	0.190
AgeSel_1P_2_purse_seine	2	-5	5	0.9	1.11	0.091
AgeSel_1P_3_purse_seine	2	-5	5	0.4	0.63	0.088
AgeSel_1P_4_purse_seine	2	-5	5	0.1	0.41	0.099
AgeSel_1P_7_purse_seine	2	-5	5	-0.5	-1.01	0.266
AgeSel_2P_3_Acoustic_survey	2	-5	9	-0.3	-0.22	0.094
AgeSel_2P_7_Acoustic_survey	2	-5	9	-0.8	-0.73	0.297

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model

Parameter	Phase	Min	Max	Initial value	Final Value	Std Dev
AgeSel_1P_2_purse_seine_BLK1delta_1978	2	-5	5	0.9	0.58	0.237
AgeSel_1P_3_purse_seine_BLK1delta_1978	2	-5	5	0.4	0.00	0.226
AgeSel_1P_4_purse_seine_BLK1delta_1978	2	-5	5	0.1	-0.74	0.251
AgeSel_1P_7_purse_seine_BLK1delta_1978	2	-5	5	-0.5	0.45	0.458
AgeSel_1P_2_purse_seine_DEVrwalk_1978	_	_	_	_	0.00	0.100
AgeSel_1P_2_purse_seine_DEVrwalk_1979	_	_	_	_	-0.02	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1980	_	_	_	_	-0.03	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1981	_	_	_	_	-0.04	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1982	_	_	_	_	-0.01	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1983	_	_	_	_	-0.03	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1984	_	_	_	_	-0.03	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1985	_	_	_	_	-0.06	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1986	_	_	_	_	-0.07	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1987	_	_	_	_	-0.07	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1988	_	_	_	_	0.00	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1989	_	_	_	_	0.02	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1990	_	_	_	_	0.01	0.098
AgeSel_1P_3_purse_seine_DEVrwalk_1978	_	_	_	_	0.00	0.100
AgeSel_1P_3_purse_seine_DEVrwalk_1979	_	_	_	_	0.06	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1980	_	_	_	_	0.03	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1981	_	_	_	_	0.03	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1982	_	_	_	_	0.04	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1983	_	_	_	_	-0.01	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1984	_	_	_	_	-0.02	0.093
AgeSel_1P_3_purse_seine_DEVrwalk_1985	_	_	_	_	0.01	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1986	_	_	_	_	-0.02	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1987	_	_	_	_	-0.03	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1988	_	_	_	_	0.03	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1989	_	_	_	_	0.03	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1990	_	_	_	_	0.02	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1978	_	_	_	_	0.00	0.100
AgeSel_1P_4_purse_seine_DEVrwalk_1979	_	_	_	_	0.04	0.098
AgeSel_1P_4_purse_seine_DEVrwalk_1980	_	_	_	_	0.04	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1981	_	_	_	_	0.05	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1982	_	_	_	_	0.06	0.096
AgeSel_1P_4_purse_seine_DEVrwalk_1983	_	_	_	_	0.03	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1984	_	_	_	_	0.01	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1985	_	_	_	_	0.03	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1986	_	_	_	_	0.02	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1987	_	_	_	_	0.03	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1988	_	_	_	_	0.06	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1989	_	_	_	_	0.06	0.096
AgeSel_1P_4_purse_seine_DEVrwalk_1990	_	_	_	_	0.04	0.097

Table 7.5.1.1. (cont.) Parameters and asymptotic standard deviations estimated in the final assessment model

Parameter	Phase	Min	Max	Initial value	Final Value	Std Dev
AgeSel_1P_7_purse_seine_DEVrwalk_1978	_	_	_	_	0.00	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1979	_	_	_	_	0.01	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1980	_	_	_	_	0.02	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1981	_	_	_	_	0.03	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1982	_	_	_	_	0.03	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1983	_	_	_	_	0.03	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1984	_	_	_	_	0.02	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1985	_	_	_	_	0.02	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1986	_	_	_	_	0.02	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1987	_	_	_	_	0.02	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1988	_	_	_	_	0.02	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1989	_	_	_	_	0.02	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1990	_	_	_	_	0.01	0.099

Table 7.5.1.2. Sardine in VIIIc and IXa: Fishing mortality-at-age estimated in the assessment. F(2-5) is the reference fishing mortality, corresponding to the average F of ages 2 to 5 years.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	F(2-5)
1978	0.05	0.25	0.46	0.33	0.33	0.24	0.19	0.34
1979	0.04	0.22	0.44	0.33	0.33	0.24	0.19	0.33
1980	0.04	0.21	0.43	0.33	0.33	0.25	0.20	0.33
1981	0.04	0.19	0.41	0.34	0.34	0.25	0.21	0.33
1982	0.04	0.17	0.38	0.33	0.33	0.25	0.21	0.32
1983	0.04	0.17	0.36	0.33	0.33	0.27	0.21	0.32
1984	0.04	0.17	0.36	0.32	0.32	0.27	0.21	0.32
1985	0.03	0.14	0.30	0.28	0.28	0.24	0.19	0.28
1986	0.04	0.16	0.33	0.32	0.32	0.25	0.22	0.31
1987	0.05	0.17	0.36	0.35	0.35	0.27	0.25	0.33
1988	0.04	0.16	0.34	0.36	0.36	0.33	0.25	0.35
1989	0.04	0.14	0.29	0.33	0.33	0.26	0.24	0.30
1990	0.04	0.16	0.35	0.41	0.41	0.33	0.30	0.38
1991	0.04	0.13	0.25	0.37	0.37	0.20	0.14	0.30
1992	0.03	0.10	0.18	0.27	0.27	0.18	0.10	0.23
1993	0.03	0.10	0.18	0.28	0.28	0.16	0.10	0.22
1994	0.03	0.08	0.16	0.24	0.24	0.14	0.09	0.19
1995	0.03	0.08	0.15	0.23	0.23	0.14	0.08	0.18
1996	0.03	0.10	0.20	0.30	0.30	0.23	0.11	0.25
1997	0.04	0.13	0.25	0.37	0.37	0.23	0.14	0.30
1998	0.05	0.15	0.28	0.42	0.42	0.21	0.16	0.33
1999	0.05	0.14	0.26	0.40	0.40	0.19	0.14	0.31
2000	0.04	0.12	0.23	0.35	0.35	0.17	0.13	0.27
2001	0.04	0.12	0.22	0.34	0.34	0.19	0.12	0.27
2002	0.03	0.10	0.19	0.28	0.28	0.14	0.10	0.22
2003	0.03	0.09	0.18	0.27	0.27	0.16	0.10	0.22
2004	0.03	0.10	0.19	0.29	0.29	0.16	0.11	0.23
2005	0.03	0.10	0.19	0.28	0.28	0.21	0.10	0.24
2006	0.03	0.08	0.16	0.24	0.24	0.14	0.09	0.19
2007	0.03	0.08	0.16	0.24	0.24	0.12	0.09	0.19
2008	0.04	0.12	0.22	0.34	0.34	0.17	0.12	0.27
2009	0.04	0.12	0.23	0.35	0.35	0.26	0.13	0.30
2010	0.05	0.14	0.26	0.40	0.40	0.21	0.15	0.32
2011	0.04	0.12	0.23	0.34	0.34	0.15	0.13	0.27

Table 7.5.1.3. Sardine in VIIIc and IXa: Summary table of the final WGHANSA 2012 assessment. CVs, in %, are presented for SSB, recruitment and Apical F (maximum F-at-age by year); biomass and landings in thousand t, recruits in millions of individuals, F in year^{-1}.

Year	Biomass 1+	SSB	CV_{SSB}	Recruits	CV_R	F (2-5)	Apical F	$CV_{apicalF}$	Landings
1978	424	407	0	23921	0	0.34	0.00	0	146
1979	464	433	0	27481	0	0.33	0.00	0	157
1980	560	525	0	31471	0	0.33	0.00	0	195
1981	659	618	0	19690	0	0.33	0.00	0	217
1982	667	642	0	10956	0	0.32	0.00	0	207
1983	572	558	0	49222	0	0.32	0.00	0	184
1984	734	669	0	15381	0	0.32	0.00	0	206
1985	781	761	0	14228	0	0.28	0.00	0	208
1986	677	659	0	11676	0	0.31	0.00	0	187
1987	584	569	0	23745	0	0.33	0.00	0	178
1988	555	524	0	13148	0	0.35	0.00	0	162
1989	545	528	0	12676	0	0.30	0.00	0	141
1990	492	475	0	13119	0	0.38	0.00	0	149
1991	475	453	0	36404	0	0.30	0.00	0	133
1992	759	680	0	26193	0	0.23	0.00	0	130
1993	898	853	0	11694	0	0.22	0.00	0	142
1994	809	778	0	10038	0	0.19	0.00	0	137
1995	818	792	0	7366	0	0.18	0.00	0	125
1996	549	537	0	11478	0	0.25	0.00	0	117
1997	483	458	0	6864	0	0.30	0.00	0	116
1998	397	379	0	9057	0	0.33	0.00	0	109
1999	363	343	0	7427	0	0.31	0.00	0	94
2000	306	297	0	22968	0	0.27	0.00	0	86
2001	453	413	0	13861	0	0.27	0.00	0	102
2002	513	471	0	7685	0	0.22	0.00	0	100
2003	462	448	0	5871	0	0.22	0.00	0	98
2004	442	432	0	26221	0	0.23	0.00	0	98
2005	520	407	0	9707	0	0.24	0.00	0	97
2006	581	556	0	3341	0	0.19	0.00	0	87
2007	537	525	0	5594	0	0.19	0.00	0	96
2008	412	405	0	7511	0	0.27	0.00	0	101
2009	336	323	0	11431	0	0.30	0.00	0	87
2010	314	294	0	5910	0	0.32	0.00	0	90
2011	330	330	0	11627	0	0.27	0.00	0	80

Table 7.6.1 - Sardine in VIIIc and IXa: Input data for short term catch predictions applied for 2012 and 2013. Input values of natural mortality (M), Maturity (Mat), proportion of F (PF), proportion of M (PM), stock weights (SWt), Selectivity (Sel) and catch weights (CWt) in each age, apply to 2012 and 2013.

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	6720	0.8	0	0	0	0.000	0.042	0.023
1	2901	0.5	0.8	0	0	0.021	0.128	0.044
2	1363	0.4	1	0	0	0.048	0.241	0.063
3	1390	0.3	1	0	0	0.059	0.363	0.074
4	472	0.3	1	0	0	0.065	0.363	0.079
5	184	0.3	1	0	0	0.066	0.205	0.081
6	612	0.3	1	0	0	0.071	0.133	0.100

Table 7.6.2 - Sardine in VIIIc and IXa: Output data for short term catch predictions. The shaded cells shows predictions with F2013=average F(2002-2007)=0.22. (a) Prediction assuming F2012= average F(2002-2007)=0.22. (b) Prediction assuming F2012=Fsq=0.29.

(a)

2012				
Biomass	SSB	FMult	FBar	Landings
295	282	0.76	0.22	61

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
289	276	0	0.00	0	329	316
.	276	0.1	0.03	8	322	310
.	276	0.2	0.06	17	316	304
.	276	0.3	0.09	24	311	298
.	276	0.4	0.12	32	305	292
.	276	0.5	0.15	40	299	287
.	276	0.6	0.18	47	294	281
.	276	0.75	0.22	58	286	273
.	276	0.7	0.21	55	289	276
.	276	0.8	0.23	62	283	271
.	276	0.9	0.26	69	278	266
.	276	1	0.29	75	273	261
.	276	1.1	0.32	82	269	256
.	276	1.2	0.35	88	264	252
.	276	1.3	0.38	95	259	247
.	276	1.4	0.41	101	255	243
.	276	1.5	0.44	107	251	239
.	276	1.6	0.47	113	246	234
.	276	1.7	0.50	119	242	230
.	276	1.8	0.53	124	238	226
.	276	1.9	0.56	130	234	222
.	276	2	0.59	135	230	219

Input units are millions and kg - output in kilotonnes

(b)

2012				
Biomass	SSB	FMult	FBar	Landings
295	282	1	0.29	78

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
276	264	0	0.00	0	318	305
.	264	0.1	0.03	8	312	300
.	264	0.2	0.06	16	307	294
.	264	0.3	0.09	23	301	288
.	264	0.4	0.12	31	296	283
.	264	0.5	0.15	38	290	278
.	264	0.6	0.18	45	285	273
.	264	0.7	0.21	52	280	268
.	264	0.75	0.22	55	278	265
.	264	0.8	0.23	59	275	263
.	264	0.9	0.26	65	270	258
.	264	1	0.29	72	266	253
.	264	1.1	0.32	78	261	249
.	264	1.2	0.35	84	257	244
.	264	1.3	0.38	90	252	240
.	264	1.4	0.41	96	248	236
.	264	1.5	0.44	102	244	232
.	264	1.6	0.47	108	240	228
.	264	1.7	0.50	113	236	224
.	264	1.8	0.53	119	232	220
.	264	1.9	0.56	124	228	216
.	264	2	0.59	129	224	213

Input units are millions and kg - output in kilotonnes

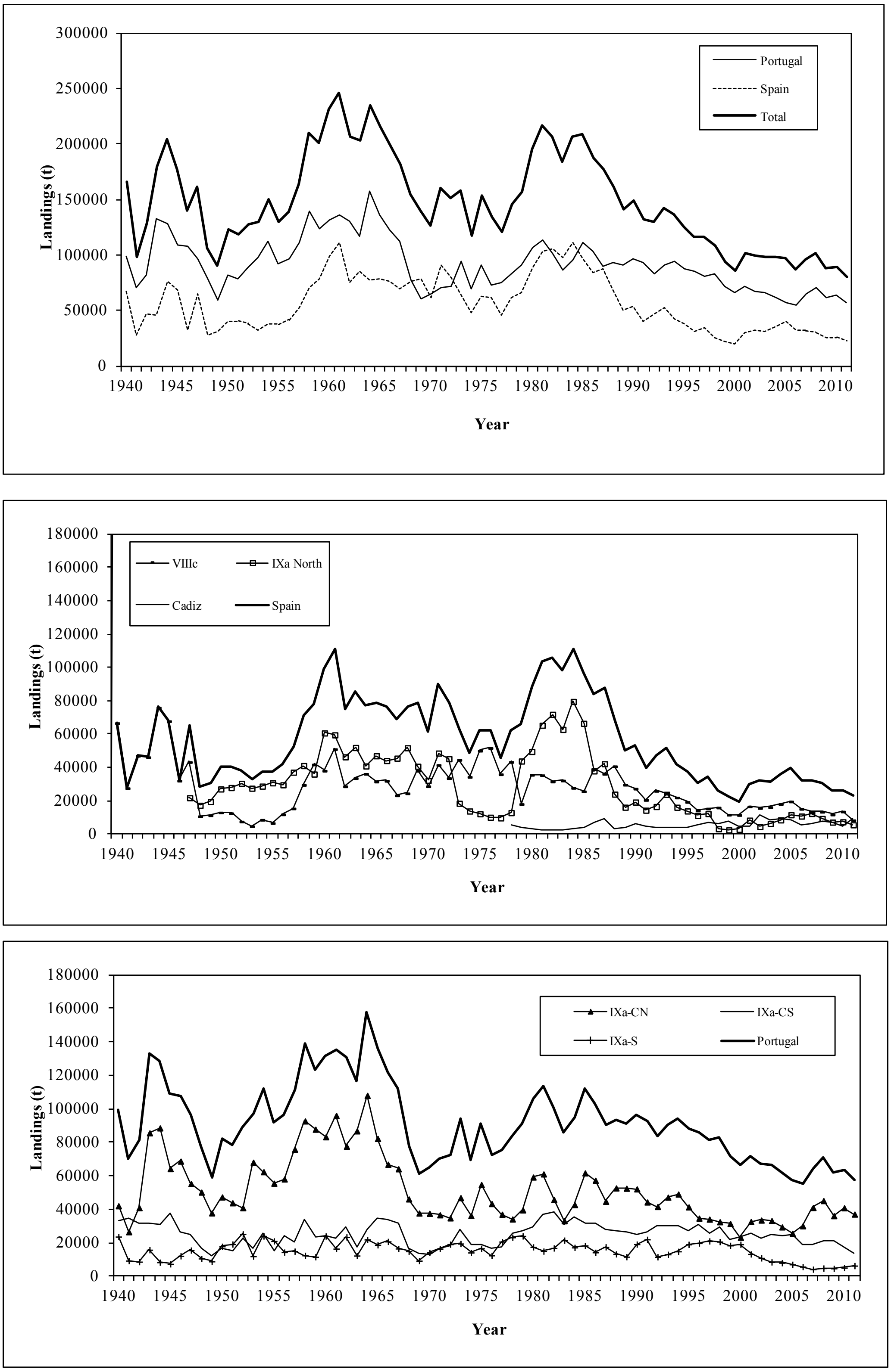


Figure 7.2.2.1: Sardine in VIIIc and IXa: Annual landings of sardine, by country (upper pannel) and by ICES subdivision and country

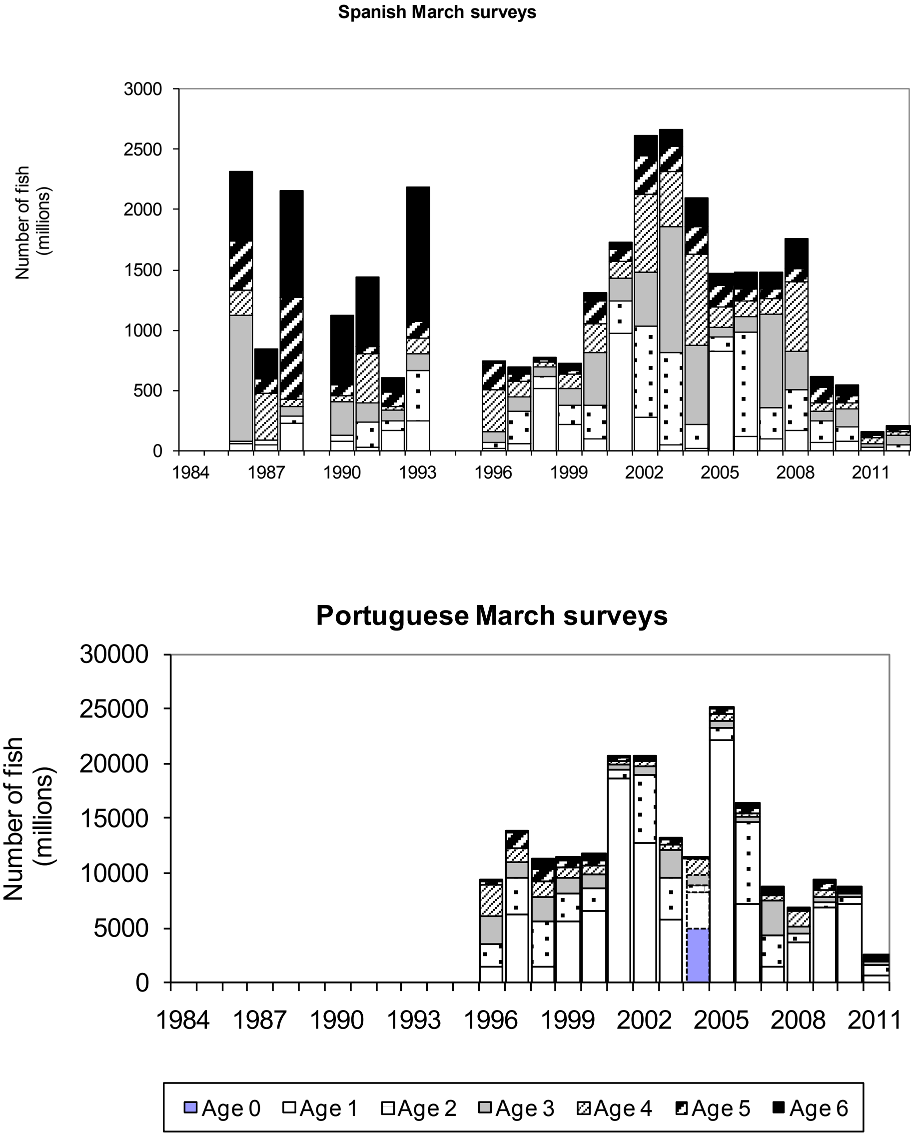


Figure 7.3.1: Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area VIIIc and IXa-N (Galicia) and the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz). Portuguese acoustic surveys in June 2004 was considered as indications of the population abundance and is not included in assessment. Estimates from Portuguese acoustic surveys are not available for 2012.

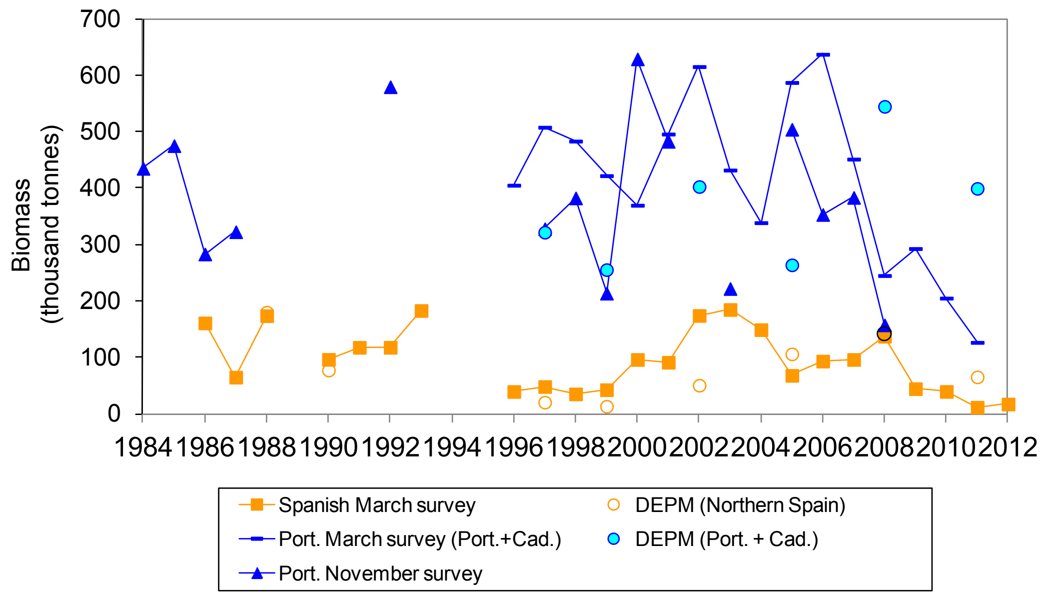


Figure 7.3.2: Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

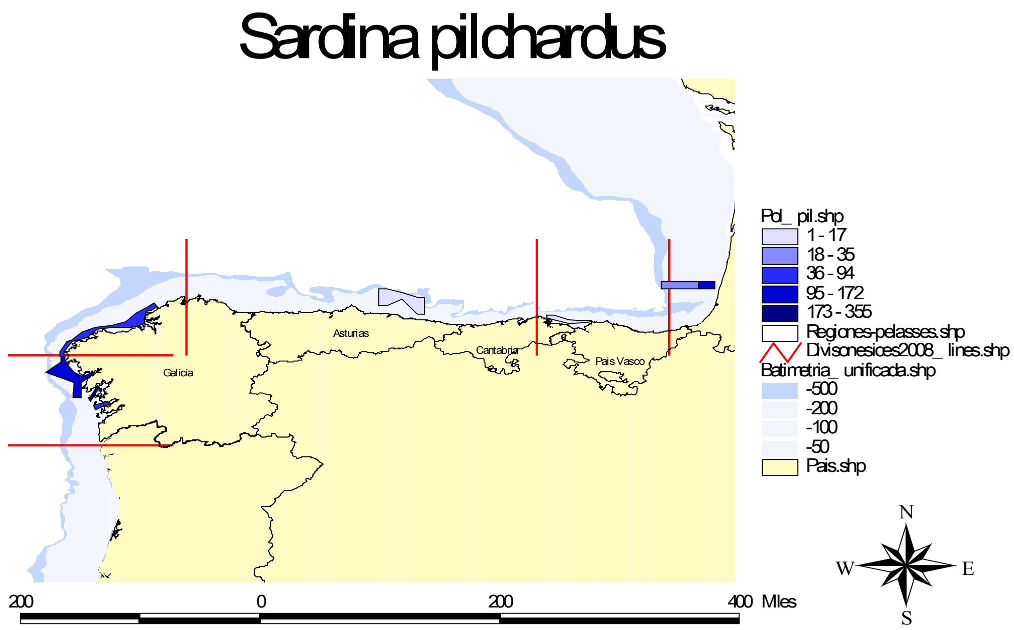
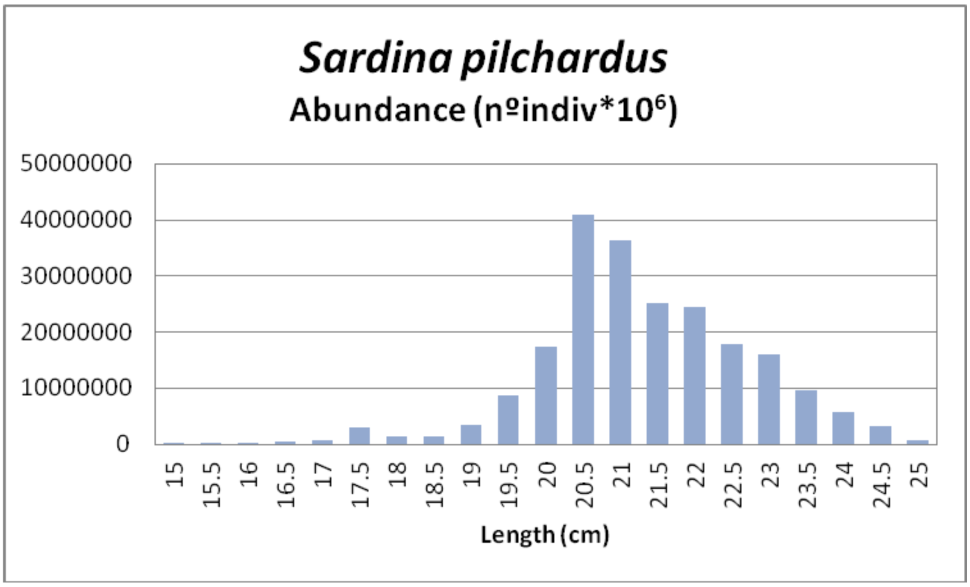


Figure 7.3.2.2.1: Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0412 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m^2 within each polygon.



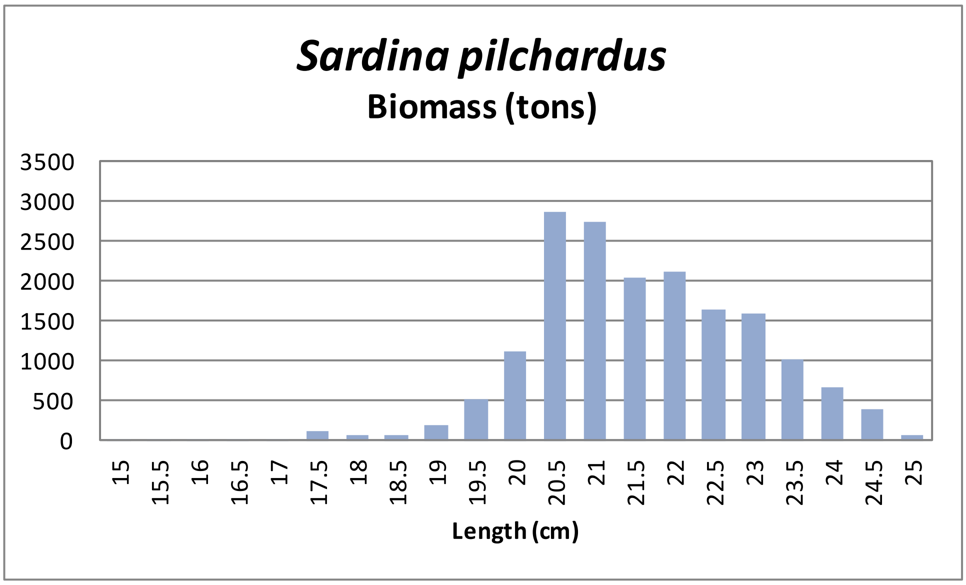


Figure 7.3.2.2.2. Sardine length distribution (cm) in numbers (top) and biomass in tonnes (bottom) during the PELACUS0412 survey.

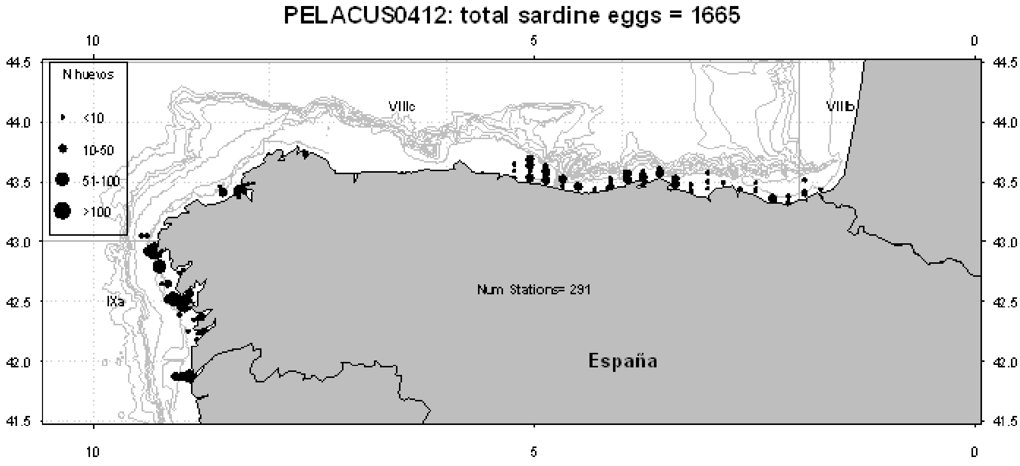


Figure 7.3.2.2.3: Sardine in VIIIc and IXa: Total number of sardine eggs obtained during the PELACUS0412 survey. Diameter of circles is proportional to egg abundance.

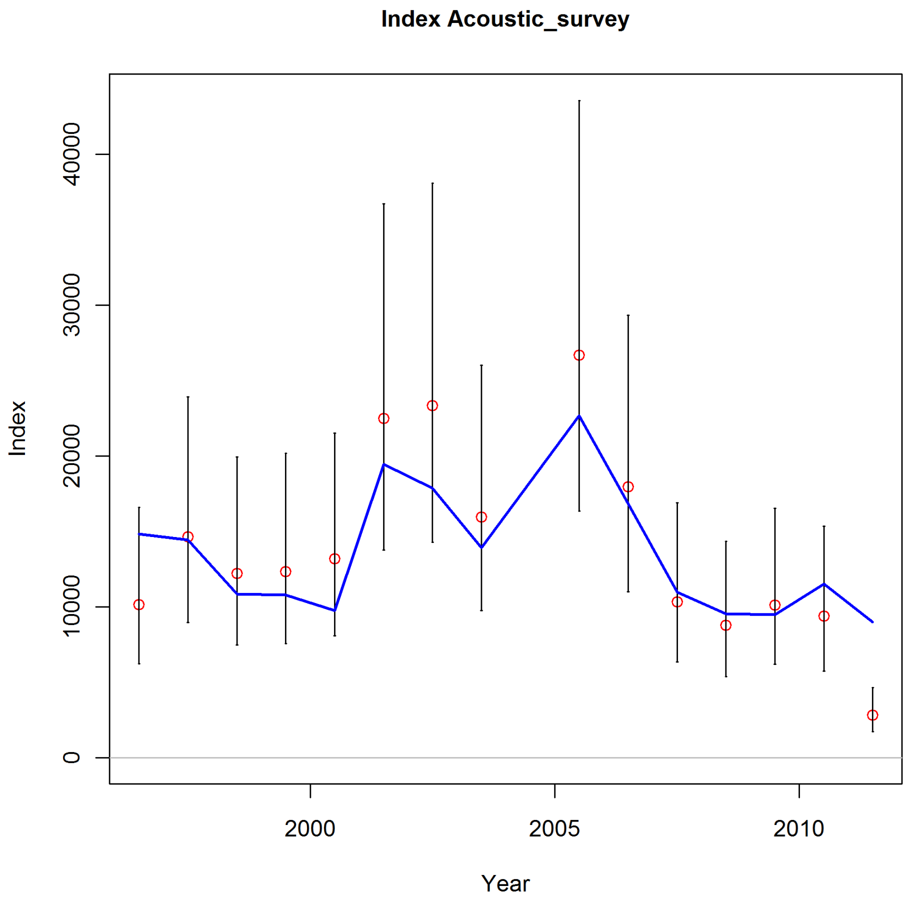


Figure 7.5.1.1. Sardine in VIIIc and IXa: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors re-transformed from the log scale.

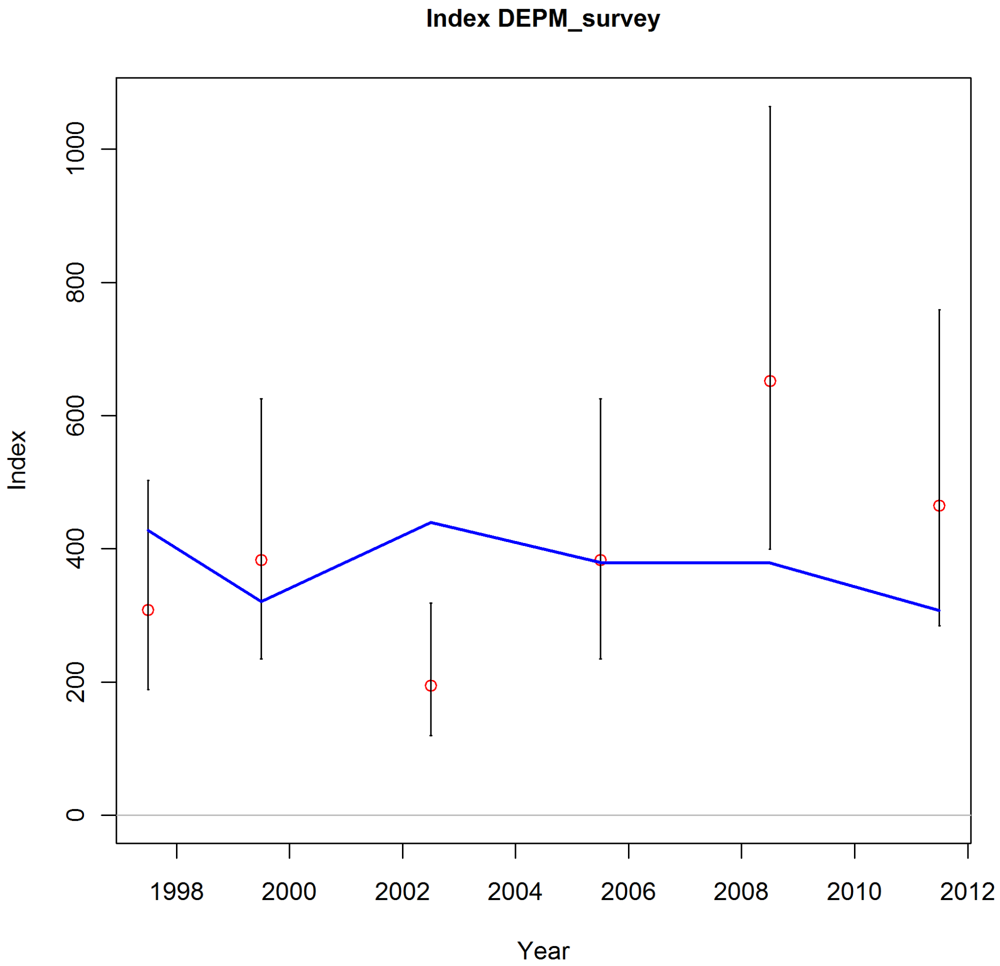
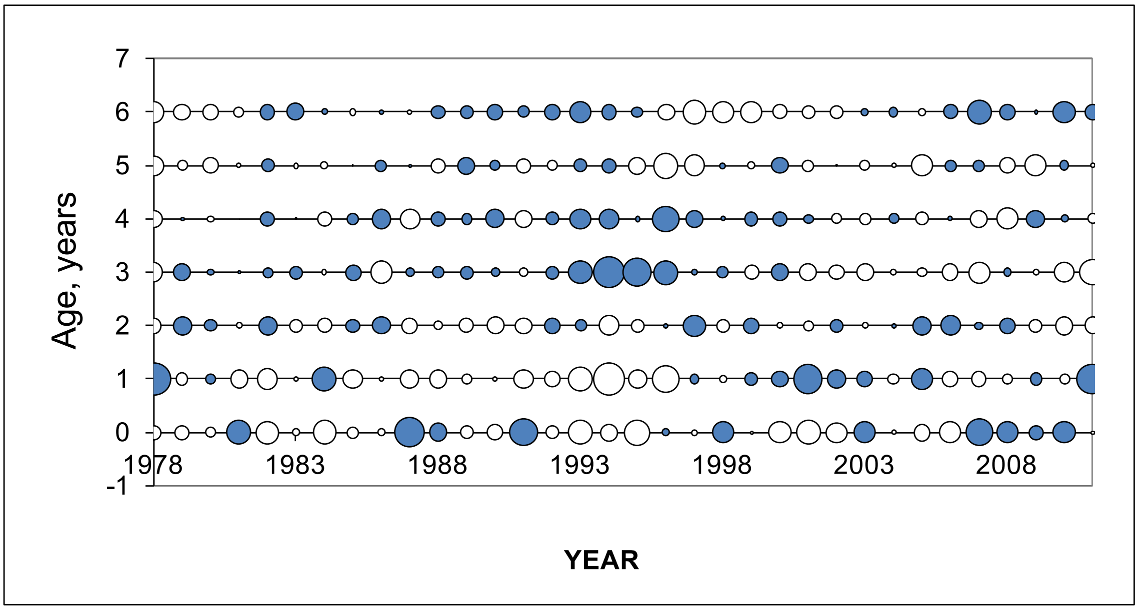


Figure 7.5.1.2: Sardine in VIIIc and IXa: Model fit to the DEPM survey series. The index is SSB (in thousand tons). Bars are standard errors re-transformed from the log scale.



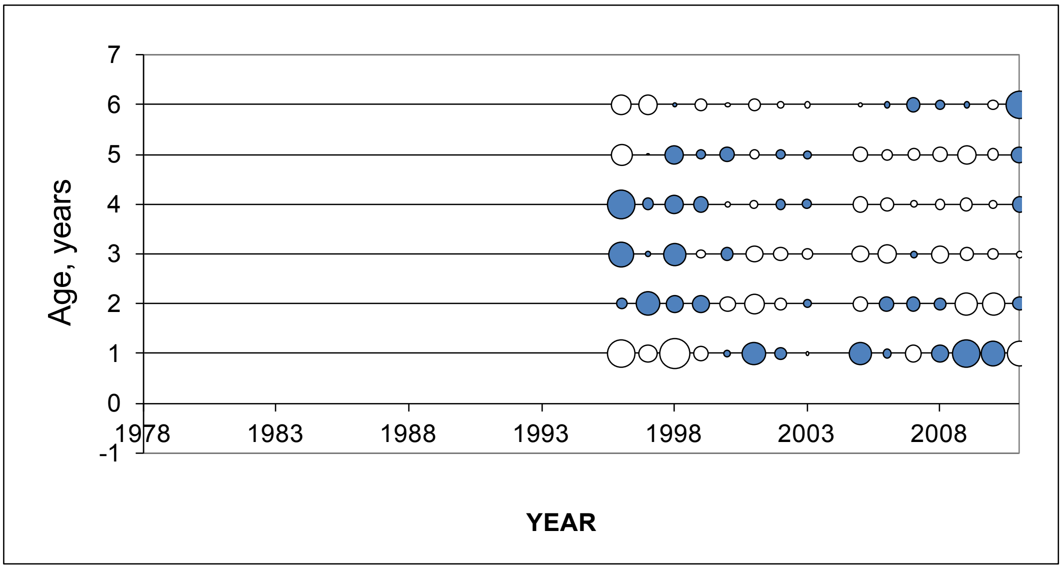


Figure 7.5.1.3. Sardine in VIIIc and IXa: Model residuals from the fit to the catch-at-age composition (a) and the acoustic survey age composition (b). Solid symbols correspond to positive residuals. Residuals are in the range [-2.9,3.1] for catch and in the range [-3.4, 2.9] for survey age compositions.

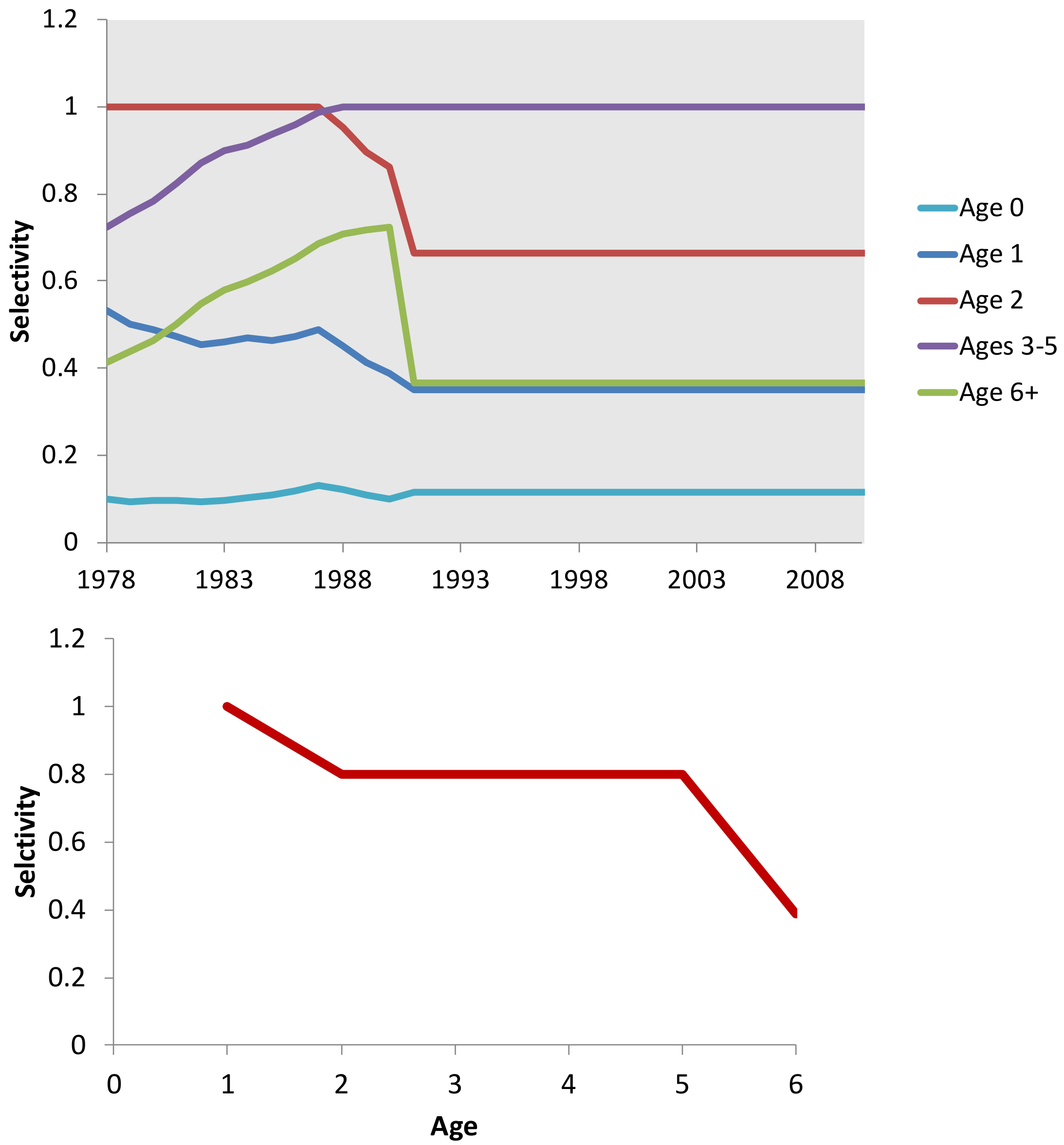


Figure 7.5.1.4. Sardine in VIIIc and IXa: Selectivity-at-age in the fishery (a) and in the acoustic survey (b).

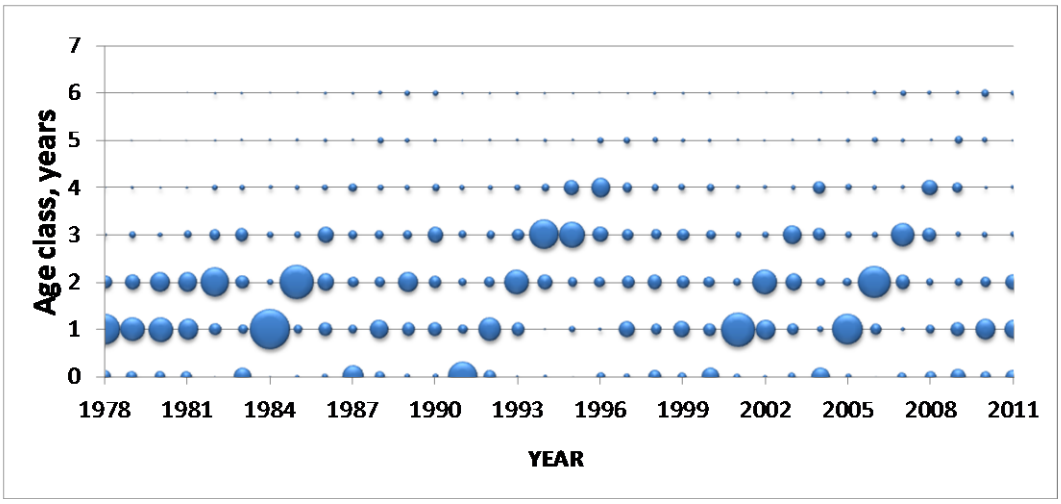


Figure 7.5.1.5. Sardine in VIIIc and IXa: Catches-at-age for 1978-2011.

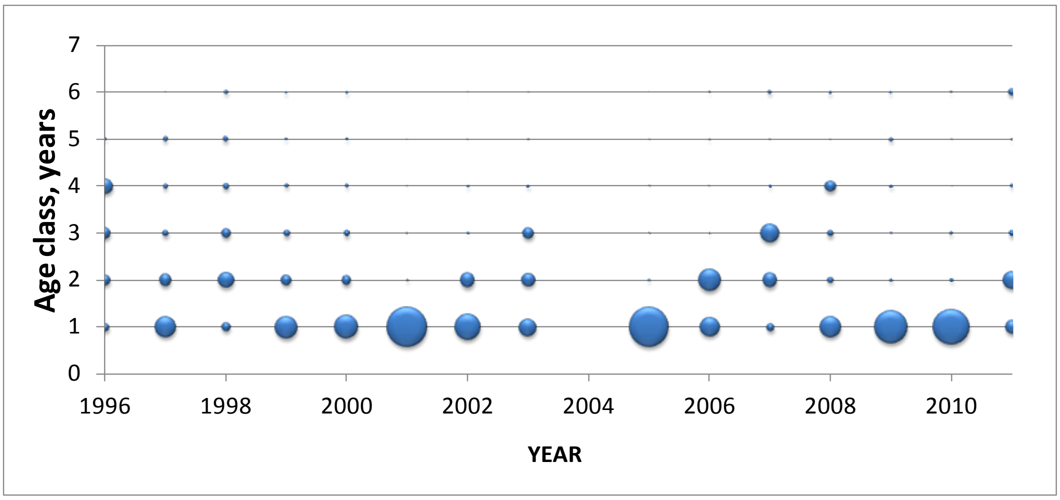


Figure 7.5.1.6. Sardine in VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996-2011.

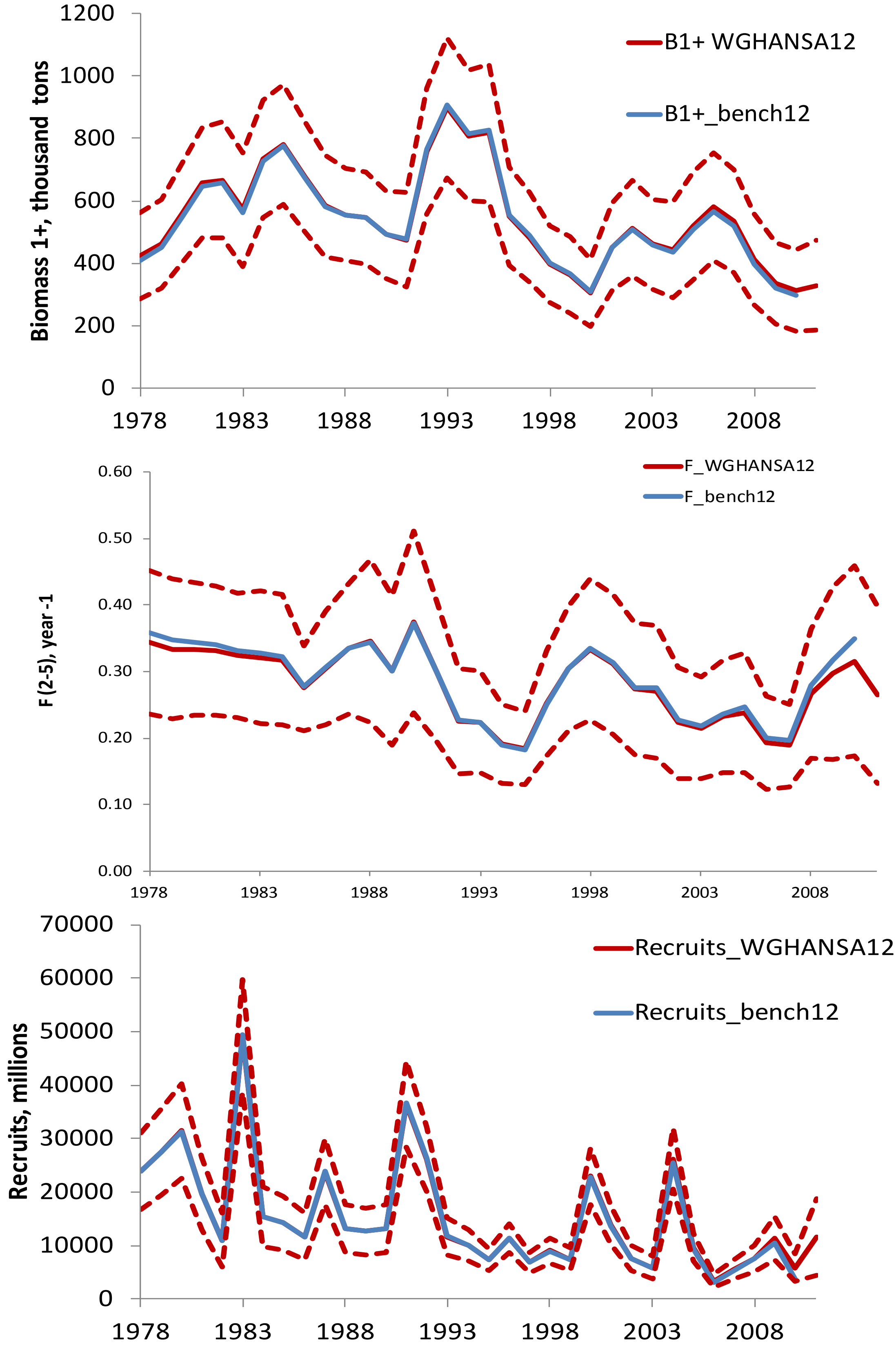


Figure 7.5.2.1. Sardine VIIIc and IXa: Historical B1+ (top), F (middle) and recruitment (bottom) trajectories in the period 1978 – 2011. The WKPELA 2012 assessment is shown for comparison.

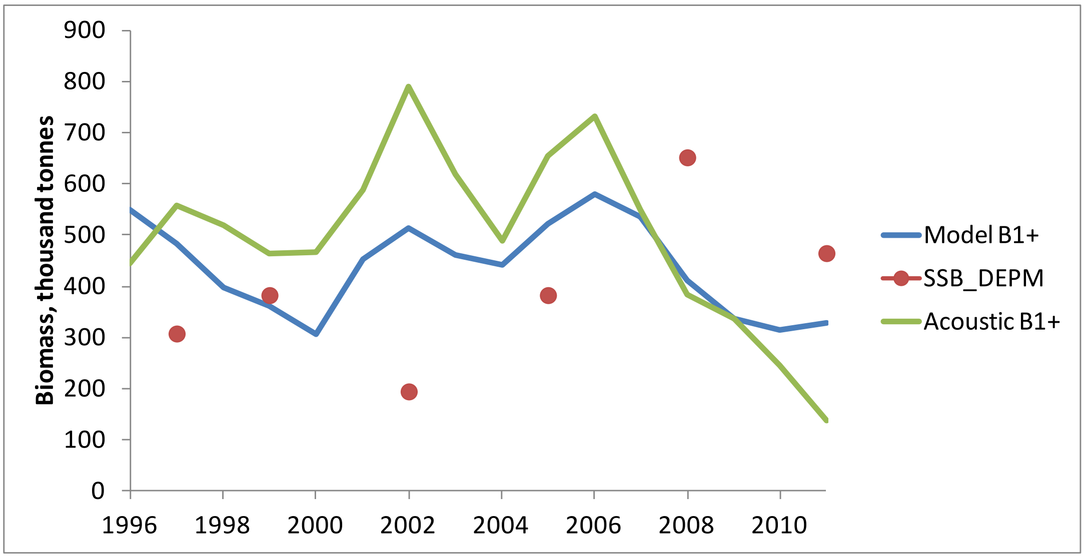


Figure 7.5.2.2. Sardine VIIIc and IXa: Biomass estimates by the acoustic survey, the DEPM survey and the assessment model in 1996 – 2011.

8 Southern Horse Mackerel (Division IXa)

8.1 ACOM Advice Applicable to 2011, STECF advice and Political decisions

In 2011 ICES considered that in absence of precautionary reference points the stock status cannot be evaluated in reference to those. The current fishing mortality does not seem to be detrimental to the stock. The wide confidence intervals indicate high uncertainty in the assessment estimates and particularly in the current trends of the stock. Therefore, based on precautionary considerations, ICES recommended that fishing mortality should not be allowed to increase from the present level. This would imply landings of less than 30 800 t.

The TAC finally accepted by the European Commission was of 30 800 t.

8.2 The fishery in 2011

8.2.1 Quality of the fishery input data

In previous years, Spanish landings and effort data have been estimated by the WG based on the scientific data obtained at fishing harbours and from the ship owners. However, in this year, the 2011 Spanish landing data have been provided by the Secretaría General de Pesca (SGP), the official national administration responsible for fishery statistics in Spain. The data were submitted on the 21st of June, just two days before the WGHANSA meeting was due to start. These data (obtained using several sources including log-books) did not include effort data, thus no discards could be estimated for 2011. Furthermore, data provided were not disaggregated into DCF métiers (the basic sampling unit for length distributions) and this fact made impossible the estimation of catches at length and age according to DCF standards. To solve this limitation, WG members tried to apply a proxy for obtaining length and age distribution from those landings by gear. Unfortunately, the complex calculations needed were too time consuming for the limited time available during the WG. The official reported catches by gears do not match the relative contributions by each gear estimated in recent years by the WG, especially in the case of trawl data (Figure 8.2.1.1). Official Spanish landings for 2011 are 7659 ton., less than half the estimated 2010 landings (15490 ton.) (Figure 8.2.1.1). The relative changes in landings by gears and the strong reduction in overall landings should be explained by a strong reduction on effort and/or abundance, or a strong increase on discards. WG members were not aware of any major changes in the fishery, and survey indexes in 2011 were very similar to the previous year indexes. Given the fact that information on effort and discards was not made available to the WG, the former hypotheses cannot be verified. Therefore, it seems that this change in methodology could not be consistent with the time series of estimated landings obtained by the sampling network run by the Spanish research institutes. The observed differences in catches and in the relative contribution by gears, are likely to result in a different age composition of catches, and may be strongly incoherent with the previous catch at age series, raising further doubts on the quality of any stock assessment performed with such time series (Figure 8.2.1.2). A comparison and quality control between the two data sources has not been carried out yet. If the scientific estimation procedure to obtain landing data use in the past would not be adequate for southern horse mackerel, then a complete time series of landings, obtained from a different source, must be provided and an assessment benchmark of this stock must be scheduled to adapt the assessment procedure to the new data. In case that the procedure used in the past for obtaining landings estimates are considered scientifically sound, then new estimates for 2011 and 2012 should be made available next year following past estimation procedures. This year, just an exploratory assessment was conducted by the group using the catch at age proxy estimates derived in the WG for the official catches in 2011. Given the current doubts about the quality and consistency of Spanish landings data series, this assessment was not considered reliable. Therefore the WG used the past year assessment as the basis for the current advice, making use of last year's population estimates to conduct a F-constrained short-term forecast up to 2014.

8.2.2 Fishing Fleets in 2011

Six fleets exploit the southern horse mackerel stock in ICES division IXa. These fleets are considered defined by the gear type (bottom trawl, purse seine and artisanal) and country (Portugal and Spain). Portuguese bottom trawl fleet, Portuguese purse seine fleet and Spanish purse seine fleet show a similar exploitation pattern with a great presence of juveniles and lower abundance of adults. On the other hand the Portuguese artisanal fleet, and the Spanish bottom trawl and artisanal fleets show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible. Description of the Portuguese and Spanish fleets is available in Stock Annex.

8.2.3 Catches by fleet and area

Catch allocation between Subdivisions for this stock is described in the Stock Annex. The definition of the ICES Subdivisions was set in 1992 and some of the previous catch statistics came from an area that comprises more than one Subdivision. This is the case of the Galician coasts where the Subdivisions VIIIc West and Subdivision IXa North are located. Further work is necessary to collect the catches by port and to distribute them by Subdivision. At the moment it has been collected the required information for the period 1992–2010, and it is expected to go back in time during the next years. The catch time series during the assessment period does not show a clear trend, with a peak reached in 1998 and a minimum in 2003 (Table 8.2.3.1). The different fleets targeting Southern horse mackerel are described in the Stock Annex. The relative contribution of each gear to the total catch is given in Table 8.2.3.2.

In general discards of southern horse mackerel are considered scarce. Spain did provided discards scaled to 1000 individuals for 2011 (Table 8.2.3.3). Because there was no raising factor (oficial effort) estimates of discards have not been calculated for the moment. The Portuguese discards of horse mackerel are usually very low and not frequent. Discards have been estimated for 2005 for the bottom-trawl fleet targeting finfish as 61 tons. For other years, estimates were not obtained because the frequency of occurrence of discards was too low, and therefore estimates could be highly biased (see Prista et al., 2012 WD in Annex).

8.2.4 Effort and catch per unit effort

No series of catch-per-unit-effort is currently available to be used for stock assessment.

8.2.5 Catches by length and catches at age

The procedure to estimate numbers at age in the catch is described in the Stock Annex. Landings age distribution by fleet are presented scaled to sum 1000, given that the 2011 official catches from Spain were not accepted for the assessment (Table

8.2.5.1). In the time series of the catch in numbers at age, the 1994 year class showed high catches at ages 11 and 12 and the 1996 year class appears to be conspicuous at juvenile ages (0, 1 and 2) and reappearing again at ages 8 and 10 (Table 8.2.5.1). In general, catches are dominated by juveniles and young adults, although in recent years there is an increment of catch of older ages.

8.2.6 Mean weight at age in the catch

Detailed information on the way to calculate mean weight at age values is included in the Stock Annex.

Table 8.2.6.1 shows the mean weight at age in the catch. These mean weights increased significantly in 2004 for the ages above 3 years old, being for some of these ages the highest of the historical series (Figure 8.2.6.1).

8.3 Fishery independent information

8.3.1 DEPM-based SSB estimates

The methods to obtain egg abundance estimates and adult parameters are under revision within ICES WGMEGS. Therefore, at present there are no reliable SSB estimates from the DEPM to be used in the assessment of the stock.

8.3.2 Bottom-trawl surveys

The Spanish and Portuguese surveys from Division IXa are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawl gears. The indexes from these surveys are shown in Table 8.3.2.1. The catchability of these vessels (BO Cornide de Saavedra and NI Noruega) and fishing gears were compared for different fish species during project SESITS and no significant differences were found for horse mackerel. Thus, the raw data (number per hour and age in each haul, including zeros) of the two data sets were merged and treated as a single data set. The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals.

There are two very clear features in this data set: a strong variability of age 0 and strong year-effects (some years with higher abundance of all ages than others) (Figure 8.3.2.1). The first feature may be explained by the greater aggregation tendency of these small fish in dense shoals and by their typically pelagic behaviour which makes them less available to the bottom-trawl. The apparent year-effects in the data are more difficult to explain, and are likely due to natural variations in the availability of the fish in that time of the year and small variations in sampling effort (e.g. due to bad weather). Both the variability in age 0 and the apparent year-effects must be accounted for in the assessment model to be fitted to these data.

In the fourth quarter, every year, a bottom trawl survey is carried out in the Gulf of Cadiz (Spanish part of div. IXa south). A time series of those abundance-at-age indices has been made available, but exploratory work must be carried out in order to decide the possible inclusion of these data in next year’s assessment. The inclusion of another data series may have a significant influence in the outcome of the stock assessment.

8.4 Biological data

8.4.1 Mean length and mean weight at age in the stock

Taking in consideration that the spawning season is very long, spawning is almost from September to June, and that the whole length range of the species has commercial interest in the Iberian Peninsula, with scarce discards, there is no reason to consider that the mean-weight in the catch may be significantly different from the mean weight in the stock.

8.4.2 Maturity at age

Maturity ogive estimation procedures are detailed in Stock Annex. In WGANSA 2011 a working document has been presented (Murta, Costa, and Gonçalves, WD to WGANSA 2011) showing the possible variation in SSB caused by poor coverage of the ages range when sampling for the maturity ogive. The Grop has discussed this problem, and it has been decided to use a single maturity ogive for the whole assessment period, which is an average of all maturity ogives estimated in the past, with the values for each age weighted by the corresponding number of samples that were used to estimate it. The resulting maturity ogive is described below. It was also decided to only make drastic changes to the maturity ogive in the case that strong evidence arises, based on as appropriate number of samples, showing that the proportion of fish mature at age has changed.

Age	0	1	2	3	4	5	6	7	8	9	10
Prop. mature	0	0	0.36	0.82	0.95	0.97	0.99	1.0	1.0	1.0	1.0

8.4.3 Natural mortality

The procedure in estimation of natural mortality rate is detailed in Stock Annex. The natural mortality used in the assessment is:

Age	0	1	2	3	4	5	6	7	8	9	10
M	0.90	0.60	0.40	0.30	0.20	0.15	0.15	0.15	0.15	0.15	0.15

8.5 Assessment of the state of the stock

8.5.1 Stock assessment

The most recent stock assessment available was carried out last year in WGANSA 2011, given that this year, due to inconsistencies in the Spanish official estimates, no updte assessment was carried out. Tha last assessment has been performed as agreed during the latest benchmark, with the settings and method as described in the Stock Annex. For further details see the Stock Annex and last year's report (WGANSA 2011). The summarised results of last year's stock assessment are shown in Table 8.5.1.1.

8.5.2 Reliability of the assessment

Given the high fluctuations in total biomass from year to year as measured by the survey, and the fact that horse mackerel can be considered a long-lived species (living more than 30 years), it is unlikely that the large fluctuations observed correspond to actual fluctuations of biomass (see Figure 8.3.2.1). A more probable hypothesis is that they are due to fluctuations in availability due to natural causes.

Therefore, to force the model to fit well to the biomass index would result in a poor fit to other data sources and could make the model to provide spurious results. Thus, the biomass index is mainly helping the model to estimate an overall level of biomass, and the fitted values can be seen as a rough smoother for the variable values of the index.

The landings of this stock are believed to be fairly accurate, given the good sampling coverage, few discards and the existence of well-defined ageing criteria. Therefore, a higher weight was given to the data series of landings in weight, which was very well fitted by the model (Figure 8.5.2.1).

A good fit was also obtained for the proportions at age of catch in numbers (Figure 8.5.2.2) and for the proportions at age of the abundance indices in number/hour from the bottom-trawl surveys, although the fit of this latter data series was slightly poorer (Figure 8.5.2.3).

The optimization process for the fitting of the model converged quickly, and the correlation matrix of the parameter estimates (118 parameters in total) showed little correlation between them, therefore suggesting that the model was not overparameterised.

8.6 Short Term predictions

Last year an analytical assessment was presented which allowed for a forecast of catch options. This year, the official Spanish data was found to be inconsistent with the existing time series, hence an update assessment was not carried out. Short-term forecasts with two intermediate years, based on F status-quo (F 2010) were performed, based on the assessment performed in 2011. Given that recent catches have been below the TAC, and catches in 2011 are unreliable, this option seemed more adequate than catch constrained forecasts.

The short-term forecasts were made assuming a constant recruitment corresponding to the geometric mean of all estimated recruitments, except the one for the last year in the assessment (2010). For the forecasts, the recruitment estimated for 2010 was also replaced by that geometric mean recruitment. The fishing mortalities used for the forecasts were those of the last assessment year (F status quo) of the assessment performed in 2011 (WGANSA 2011). Table 8.6.1 shows the management options table obtained from the deterministic short-term forecasts.

8.7 Reference points and harvest control rules for management purposes

Reference points to be used for management were never proposed for this stock since the revision of the stock boundaries was made. Given the apparent stability in the exploitation and dynamics of this stock during the assessment time period (lack of contrast in the data), and the lack of a well-defined stock-recruitment relationship, the calculation of MSY reference points for fishery management would have to be based on proxies calculated in equilibrium conditions, which is an approach far from being satisfactory. Any points that could be calculated in these conditions could only be seen as provisory, and subject to revision as soon as an acceptable stock-recruitment relationship was available (e.g. when the time series of catch data can be extended in the past).

A yield-per-recruit analysis was carried out last year using identical options and input data files to the ones used for the short-term forecasts. An estimate for Fmax, which is commonly used as a proxy for Fmsy, could not be obtained.

8.8 Management considerations

The recent history of the stock has been of stability, both in catch and SSB levels, which may indicate that for the current productivity regime, the stock may be exploited close to or below MSY. Several estimates obtained during the last assessment of this stock show no signs of depletion and indicate an exploitation level that seems sustainable. The level of the fishing mortality rates is low, although that is also a cause of the high values for natural mortality that were adopted during the latest benchmark assessment. Also, the lowest observed stock biomass originated the second highest recruitment estimate in the series.

Nevertheless, all these indicators of the condition and state of exploitation of the stock are based on estimates that have a very high level of uncertainty associated, which is clear from the large asymptotic confidence intervals for F and SSB obtained in last year's assessment. Also, the fact that no update assessment was made this year adds to the uncertainty regarding the current state of the stock. However, for long-lived species, such as horse mackerel, that should not be a major factor of uncertainty, and the possibility of carrying out an assessment only every two years has been discussed in the Group before, being considered an option to take into account in the future (motivated by an increasing number of stocks requiring analytical stock assessments).

Therefore, and from a precautionary point of view, a too optimistic advice for stock exploitation should be avoided. The catches of horse mackerel are currently mainly limited by effort limitations of the bottom-trawl fleets, due to management plans for other species caught in the same mixed-fisheries (e.g. hake), and to a low demand of this species in the market, which makes its price to drop sometimes to levels unsustainable to fishermen. The TACs of the latest years were not achieved, and according to the short-term forecasts performed, a status-quo F will result in higher catches. Thus, a TAC for 2013 of 25 500 ton., corresponding to an F status-quo, identical to the one of 2011 would keep the stock at a sustainable level, and would maintain the same fishing opportunities for the industry, while taking into account the uncertainty related to the state of the stock.

Table 8.2.3.1 Time series of southern horse mackerel historical catches (in tonnes).

Year	Division IXa
1991	21.772
1992	284.111
1993	31.945
1994	284.411
1995	25.147
1996	204.001
1997	27.642
1998	41.564
1999	27.733
2000	27.16
2001	24.91
2002	22.506 // (23.663)*
2003	18.887 // (19.566)*
2004	23.252 // (23.577)*
2005	22.695 // (23.111)*
2006	23.902 // (24.558)*
2007	22.790 // (23.424)*
2008	22.993 // (23.593)*
2009	25.737 // (26.497)*
2010	26.556// (27.216)*
2011	NA

(*) In parenthesis: the Spanish catches from Subdivision IXa south are also included.
These catches are only available since 2002 and they will not be considered in the assessment data until the rest of the time series be completed.
(1) These figures have been revised in 2008.

Table 8.2.3.2. Southern horse mackerel. Landings by gear with indication of the percentage that represent those landings in each gear.

Year	Bottom trawl	Purse seine	Artisanal
1992	14651	9762	3445
	53.0%	35.0%	12.0%
1993	20660	7004	3841
	65.6%	22.2%	12.2%
1994	13121	12093	3202
	46.2%	42.6%	11.3%
1995	15611	7387	2137
	62.1%	29.4%	8.5%
1996	13379	5727	1228
	65.8%	28.2%	6.0%
1997	14576	13161	1800
	49.3%	44.6%	6.1%
1998	16943	22359	2287
	40.7%	53.8%	5.5%
1999	10106	15781	1855
	36.4%	56.9%	6.7%
2000	12697	11237	2227
	48.5%	43.0%	8.5%
2001	12226	11048	1637
	49.1%	44.3%	6.6%
2002	12307	8230	1969
	54.7%	36.6%	8.7%
2003	10116	6523	2248
	53.6%	34.5%	11.9%
2004	16126	5700	2658
	65.9%	23.3%	10.9%
2005	14029	6040	2621
	61.8%	26.6%	11.6%
2006	15019	5430	3445
	62.9%	22.7%	14.4%
2007	13705	6775	2308
	60.1%	29.7%	10.1%
2008	12380	7670	2949
	53.8%	33.3%	12.8%
2009	15075	6669	3984
	58.6%	25.9%	15.5%
2010	16062	6847	4308
	59.0%	25.2%	15.8%
2011			

Table 8.2.3.3 Length distributions of Spanish discards scaled to 1000 individuals.

	IXa-North		IXa-South	
Length (cr	1 sem	2 sem	1 sem	2 sem
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	22	0
11	0	0	4	0
12	0	0	26	3
13	0	0	17	36
14	0	0	17	228
15	0	0	87	91
16	0	0	126	300
17	0	0	61	26
18	0	0	35	23
19	0	0	9	17
20	0	0	52	29
21	0	0	91	16
22	85	0	190	31
23	85	0	147	3
24	85	0	61	10
25	85	0	30	49
26	0	0	13	44
27	170	0	4	44
28	0	0	0	44
29	0	0	4	0
30	51	0	0	5
31	0	0	4	0
32	216	0	0	0
33	187	0	0	0
34	36	1000	0	0
35	0	0	0	0
36	0	0	0	0
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	0	0
41	0	0	0	0
42	0	0	0	0
43	0	0	0	0
44	0	0	0	0

Table 8.2.5.1 Southern horse mackerel. Relative catch in number by gear. Numbers in 2011 are scaled to 1000 individuals.

Bottom trawl

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	4707.05	43326.11	72194.25	19569.14	7265.44	6348.91	3562.48	4339.08	3125.41	2623.12	7008.34	6134.39
1993	97.76	8738.5	40093.93	78016.34	28660.49	10904.01	10400.79	8174.25	5166.31	3923.08	3319.43	9412.2
1994	3412.82	16252.48	37678.58	55078.88	16322.45	3926.2	2137.95	1558.66	2529.65	2200.13	2207.39	5222.62
1995	3917.25	12983.03	18291.91	22806.75	11447.43	5374.74	2541.26	2279.85	2299.3	2738.58	2137.75	25610.26
1996	30762.58	10340.41	10122.96	19244.57	23331.28	6326.33	4523.88	3062.99	2771.73	3245.2	2210.72	8611.4
1997	2828.41	180542.9	68330.29	15054.79	7846.12	4536.37	2087.14	1216.47	811.07	801.23	608.13	4360.45
1998	4443.62	36543.97	205608.9	32993.63	7151.09	3427.44	2487.36	3562.46	3100.11	2418.08	2723.86	7225.36
1999	28176.24	11491.6	16059.47	23744.8	8653.09	2914.39	3642.93	2569.57	1649.8	1932.31	1613.52	5524.64
2000	1105.57	35946.3	13684.5	18085.39	10763.35	7889.82	9179.88	7656.75	5545.72	4146.45	2544.11	2515.97
2001	39871.24	25244.64	10860.78	9400.82	8291.37	6329.16	8685.69	10261.44	7644.28	2630.24	1555.58	2605.62
2002	3572.46	59040.68	49401.95	12287.83	4796.12	4460.87	5100.07	7280.17	6067.87	5196.9	2670.59	3156.42
2003	14580.53	2076.54	18079.15	12555.77	13024.53	7525.29	7410.01	6939.91	6045.19	3965.89	2255.06	1525.53
2004	1352.22	77528.98	44171.02	12649.31	4757.52	9114.09	7786.59	9616.08	6875.28	2365.8	3822.7	3958.41
2005	2955.61	50642.5	30389.23	15099.7	12245.94	6636.29	6996.7	6190.15	7046.81	5545.53	3709.81	6704.72
2006	1665.8	59477.44	61175.35	14914.81	3798.31	9822.3	9492.03	3762.3	3871.14	4302.14	4908.3	9981.32
2007	18.58	2443.62	14852.78	31470.37	10967.35	2931.65	1983.42	1461.08	2680.81	2643.67	3135.4	21375.26
2008	5511.93	12786.96	21077.56	21827.86	10408.11	2984.47	1695.29	1166.04	1917.94	1678.05	2373.44	16881.17
2009	4552.29	19630.46	14557.8	5032.93	4757.95	4462.57	1581.28	1069.57	1183.17	1830.2	2578.7	27992.71
2010	10832.13	46074.36	15193.36	11434.33	6888.26	3660.68	1723.29	1728.34	1416.89	1531.05	1896.88	25218.07
2011	91	53	144	143	102	46	29	25	22	52	44	249

Purse seine

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	6977.19	51859.45	73537	21162.34	4860.34	2676.8	1362.14	1972.6	1298.68	1203.62	2571.77	2401.67
1993	6293.44	51337.32	83235.83	16596.54	4355.04	794.74	512.34	819.1	544.33	862.06	666.99	1842.48
1994	7634.29	45428.5	45987.42	39235.54	11267.49	2838.3	1378.8	1035.85	1640.18	1691.41	2550.09	3530.4
1995	3310.67	42110.68	12456.83	27030.2	14822.27	4224.44	854.13	444.89	162.62	361.62	217	2247.44
1996	38888.11	3446.49	3801.24	8189.23	8954.56	2916.79	1621.34	1107.19	1022.29	2003.31	890.55	4300.91
1997	2210.97	114183.6	42908.21	9796.93	6407.37	5775.21	4380.18	5300.14	2706.54	2830.83	1538.75	3672.16
1998	18293.56	59225.15	112386.1	34393.06	9892.78	6028.45	5838.14	15381.1	8920.24	3621.16	2759.54	2041.41
1999	23481.18	18236.69	9440.14	41031.88	31470.56	10684.28	7777.14	3834.73	2092.48	2464.64	763.64	1327.96
2000	11067.63	35860.95	8831.79	22508.38	23778.88	9644.94	5889.53	2291.06	875.66	337.92	171.9	231.01
2001	65468.04	51105.04	20259.83	14164.16	14393.94	9020.05	5034.97	3007.54	1169.54	289.54	227.45	643.76
2002	13660.19	32185.05	34515.54	13603.53	7894.59	6040.66	3804.18	3509.72	2435.42	1140.64	358.7	116.29
2003	22915.24	4609.12	17092.97	15337.87	7464.11	3944.1	5188.38	3784.32	2553.92	1447.47	674.92	260.09
2004	5258.08	42113.9	12331.61	5136.57	2673.37	3042.25	2600.15	2602.88	958.08	488.9	979.68	928.57
2005	17856.16	56689.91	18512.24	8881.42	5272.27	3365.35	2538.81	798.8	903.73	848.18	599.68	1026.4
2006	1637.2	27295.38	29845.03	7133.4	2102.74	2209.91	1506.14	1225.44	1638.33	1803.79	2037.21	1514.46
2007	2863.02	13802.45	12416.43	11230.97	8018.66	3799.79	1912.47	1712.39	2798.8	1666.91	1322.53	4185.91
2008	42867.98	41050.17	9765.85	4672.49	3728.88	2223	2138.25	1918.42	2062.61	1877.06	1707.38	3544.46
2009	18016.34	65130.36	17156.7	2736.23	3550.52	2078.36	1139.21	1205.66	1040.7	1167.96	1136.06	3199.7
2010	70205.84	41432.82	11571.34	2766.44	2057.9	1530.87	1037.6	904.42	446.33	376.8	560.56	1597.52
2011	604	147	84	63	41	15	12	6	2	6	6	15

Artisanal

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	0	0.01	0.82	4.81	45.03	76.3	92.91	552.71	730.7	934.66	4392.87	5817.74
1993	88.86	6135.44	13759.73	5902.2	2402.22	1668.42	2024.98	1501.3	886.31	766.48	510.56	3186.89
1994	1666.04	1549.41	3051.5	1938.66	1171.16	863.08	881.66	838.63	1038.78	942.9	1289.55	3511.03
1995	1.7	286.28	516.34	2192.88	1929.1	1410.34	607.97	414.72	258	252.22	174.8	3485.47
1996	0.02	10.82	96.85	691.61	1650.7	617.61	465.28	330.6	370.35	255.12	205.05	1330.19
1997	17.06	602.43	971.82	1383.97	2914.79	2574.61	1312.94	652.85	419.92	234.82	277.97	814.1
1998	179.63	180.77	2725.58	1050.99	1725.7	1861.45	1386.54	1683.82	739.55	646.53	728.26	2056.32
1999	1.67	66.61	731.02	1927.08	2836.18	2101.82	2420.11	1150.52	433.12	393.53	97.59	564.02
2000	73.15	1129.13	1030.33	1023.97	1425.34	1108.27	2184.09	2170.64	1493.66	742.66	407.66	809.63
2001	419.97	1014.13	140.1	538.96	1036.17	1445.04	1670.83	1695	981.24	389.86	239.71	739.49
2002	1211.5	3175.99	461.26	590.73	470.56	894.69	1358.37	1710.75	1653.14	1187.16	578.11	1160.72
2003	2536.83	143.84	1581.49	665.2	1442.11	1320.49	2152.27	2857.63	2031.8	1078.73	600.8	547.11
2004	491.05	7153.66	1551.62	456.64	896.63	1429.46	1449.12	2659.1	2708.64	1021.41	455.22	431.49
2005	203.3	737.84	295.24	307.68	359.22	1332.39	1643.21	938.18	1173.81	1050.92	1192.73	3688.57
2006	26.06	5790.06	1875.44	617.03	836.97	1143.93	893.78	1040.89	1793.38	1964.49	2001.77	3826.05
2007	3.42	173.38	398.23	1655.9	1548.03	1455.84	563.36	389.71	495.61	437.89	485.5	4439.76
2008	0.05	330.31	1107.6	1557.49	2479.45	1986.52	948.11	575.64	598.77	419.83	455.69	4563.98
2009	49.31	653.72	701.09	712.89	1465.21	620.79	568.8	585.22	567.06	581.29	520.84	7902.97
2010	10.42	14509.02	7141.2	3295.3	3033.15	2377.82	1086.58	1309.07	588.86	763.08	519.2	5468.57
2011	167	54	44	80	140	100	41	50	51	50	46	175

Table 8.2.6.1.- Southern horse mackerel. Mean weight (kg) at age in the catch.

YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	0.03	0.03	0.04	0.07	0.1	0.13	0.15	0.17	0.19	0.2	0.23	0.3
1993	0.02	0.03	0.04	0.07	0.09	0.13	0.17	0.21	0.24	0.24	0.25	0.3
1994	0.04	0.04	0.06	0.07	0.09	0.13	0.16	0.19	0.23	0.25	0.27	0.34
1995	0.04	0.03	0.06	0.08	0.1	0.12	0.16	0.17	0.2	0.22	0.23	0.31
1996	0.02	0.05	0.07	0.09	0.11	0.14	0.17	0.19	0.22	0.24	0.26	0.31
1997	0.03	0.03	0.05	0.07	0.11	0.14	0.17	0.2	0.24	0.26	0.26	0.36
1998	0.03	0.03	0.04	0.07	0.1	0.13	0.17	0.21	0.17	0.24	0.25	0.35
1999	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.19	0.22	0.25	0.27	0.36
2000	0.02	0.03	0.05	0.09	0.11	0.13	0.16	0.19	0.22	0.24	0.25	0.31
2001	0.02	0.03	0.07	0.08	0.09	0.13	0.16	0.18	0.2	0.23	0.24	0.31
2002	0.03	0.03	0.04	0.07	0.1	0.12	0.15	0.17	0.2	0.23	0.25	0.31
2003	0.02	0.03	0.05	0.06	0.09	0.12	0.15	0.18	0.2	0.23	0.25	0.31
2004	0.04	0.03	0.05	0.08	0.12	0.16	0.18	0.21	0.23	0.25	0.27	0.33
2005	0.02	0.03	0.04	0.07	0.12	0.15	0.17	0.18	0.22	0.24	0.25	0.3
2006	0.03	0.03	0.05	0.06	0.09	0.13	0.14	0.17	0.19	0.23	0.25	0.33
2007	0.03	0.05	0.06	0.07	0.09	0.11	0.16	0.19	0.23	0.22	0.24	0.3
2008	0.02	0.05	0.06	0.08	0.1	0.13	0.15	0.17	0.2	0.21	0.23	0.32
2009	0.02	0.03	0.06	0.09	0.11	0.13	0.15	0.17	0.18	0.21	0.24	0.36
2010	0.02	0.04	0.06	0.08	0.11	0.14	0.16	0.18	0.19	0.2	0.24	0.38
2011												

Table 8.3.2.1 Time series of CPUE at age from Portuguese and Spanish combined bottom trawl.

YEAR\AGE	0	1	2	3	4	5	6	7	8	9	10	11+
1992	329.8	355.18	113.91	39.86	18.19	7.23	4.94	5.21	2.75	2.34	4.71	5.14
1993	1451.63	190.41	192.85	119	27.93	3.65	2.64	3.64	3.34	4.83	2.91	9.42
1994	2.92	7.19	49.85	45.43	18.91	4.67	2.11	1.51	0.9	0.9	1.2	13.08
1995	16.63	65.59	93.95	56.94	25.36	4.82	1	1.17	0.49	0.24	0.47	8.86
1996	1144.25	7.94	12.92	20.88	20.98	3.98	1.72	0.79	0.63	1.32	0.29	4.74
1997	844.41	59.49	98.25	29.31	47.69	27.66	5.71	4.97	2.42	2.95	1.18	3.49
1998	77.56	32.6	91.63	13.27	4.92	2.73	1.52	1.76	0.4	0.13	0.07	0.21
1999	104.54	22.23	41.79	49.25	4.13	1.42	0.83	0.31	0.34	0.99	1.16	3.65
2000	2.53	15.45	20.78	23.35	11.36	6.34	3.4	2.01	1.88	1.29	0.31	1.05
2001	545.08	1.88	3.5	2.75	3.8	5.48	6.72	11.52	7.62	3.66	2.43	2.64
2002	32.48	2.05	6.87	11.31	9	4.63	1.75	1.58	3.96	3.51	4.56	9.9
2003	63.14	7.62	7.64	14.79	13.16	3.77	2.06	1.33	0.84	0.75	0.52	0.67
2004	82.37	31.8	113.13	49.83	11.15	5.61	2.49	5.18	6.38	1.08	0.48	0.23
2005	1451.28	1188.35	191.08	65.29	32.23	14.03	16.4	16.68	12.89	6.78	4.08	11.82
2006	84.21	76.75	204.14	50.9	3.05	9.78	7.06	5.8	2.37	1.32	0.65	0.5
2007	34.22	0.72	23.34	37.79	28.39	7.16	2.68	1.8	0.65	0.71	1.54	3.25
2008	48.47	21.67	33.39	19.25	24.72	17.12	2.39	0.82	1.23	1.76	1.24	4.43
2009	1436.39	66.51	98.83	36.26	29.36	8.13	2.21	1.26	0.94	0.58	0.55	4.6
2010	62.23	24.76	44.67	36.77	41.74	16.23	7.47	5.28	4.33	3.29	3.17	9.48
2011	71.57	28.56	27.61	45.53	43	10.65	4.83	6.8	3.43	4.5	5.01	6.52

Table 8.5.1.1 Summary of the stock assessment performed in 2011.

Year	Recruits('	SSB(ton)	Fmult	mean F(2-	Landings
1992	3749400	137260	0.097267	0.11	27858
1993	2667100	136840	0.10389	0.12	31521
1994	2633700	135770	0.085548	0.1	28450
1995	3492900	132920	0.082079	0.09	25132
1996	9075200	135090	0.059677	0.07	20360
1997	3027600	147200	0.083142	0.09	29491
1998	1941100	150090	0.11874	0.13	41661
1999	2907900	149930	0.074345	0.08	27768
2000	2641600	149790	0.077849	0.08	26160
2001	3163500	149130	0.076936	0.08	24911
2002	1750800	147480	0.074906	0.08	22506
2003	3591500	143240	0.063262	0.07	18887
2004	3921200	140670	0.069268	0.07	24485
2005	2326400	144620	0.070805	0.08	22689
2006	1097500	148690	0.079057	0.08	23895
2007	1678400	140110	0.077152	0.08	22787
2008	3043400	129550	0.081287	0.09	22993
2009	3037400	123210	0.092689	0.1	25726
2010	6057700	120700	0.088125	0.09	27217

Table 8.6.1 Management options table obtained from the deterministic short-term forecasts.

Basis: F (2010) = 0.088 = Fsq; SSB (2012) = 233; Landings (2011) = 26.1; F(2012) = Fsq; SSB (2013) = 242; Landings (2012) = 26.4; R = Geom. Mean (1992-2009) = 2806 millions.

Rationale	Landings (	Basis	F (2013)	SSB (2014)	%SSB char	%TAC change (2)
No catch	0	0 x Fsq	0	267.9	13	-100
	5.3	0.2 x Fsq	0.018	262.7	10	-83
	10.5	0.4 x Fsq	0.035	257.6	8	-66
	15.6	0.6 x Fsq	0.053	252.6	6	-49
	20.6	0.8 x Fsq	0.07	247.7	4	-33
F status qu	25.5	1.0 x Fsq	0.088	242.9	2	-17
Current T/	30.3	1.2 x Fsq	0.106	238.2	0	-2
	35	1.4 x Fsq	0.123	233.6	-2	14
	39.6	1.6 x Fsq	0.141	229.1	-4	29
	44.1	1.8 x Fsq	0.158	224.7	-6	43
Double F s	48.6	2.0 x Fsq	0.176	220.4	-7	58

Weights in thousand tonnes.

(1) SSB 2014 relative to SSB 2011 (last assessment estimate).

(2) Landings 2013 relative to TAC 2012.

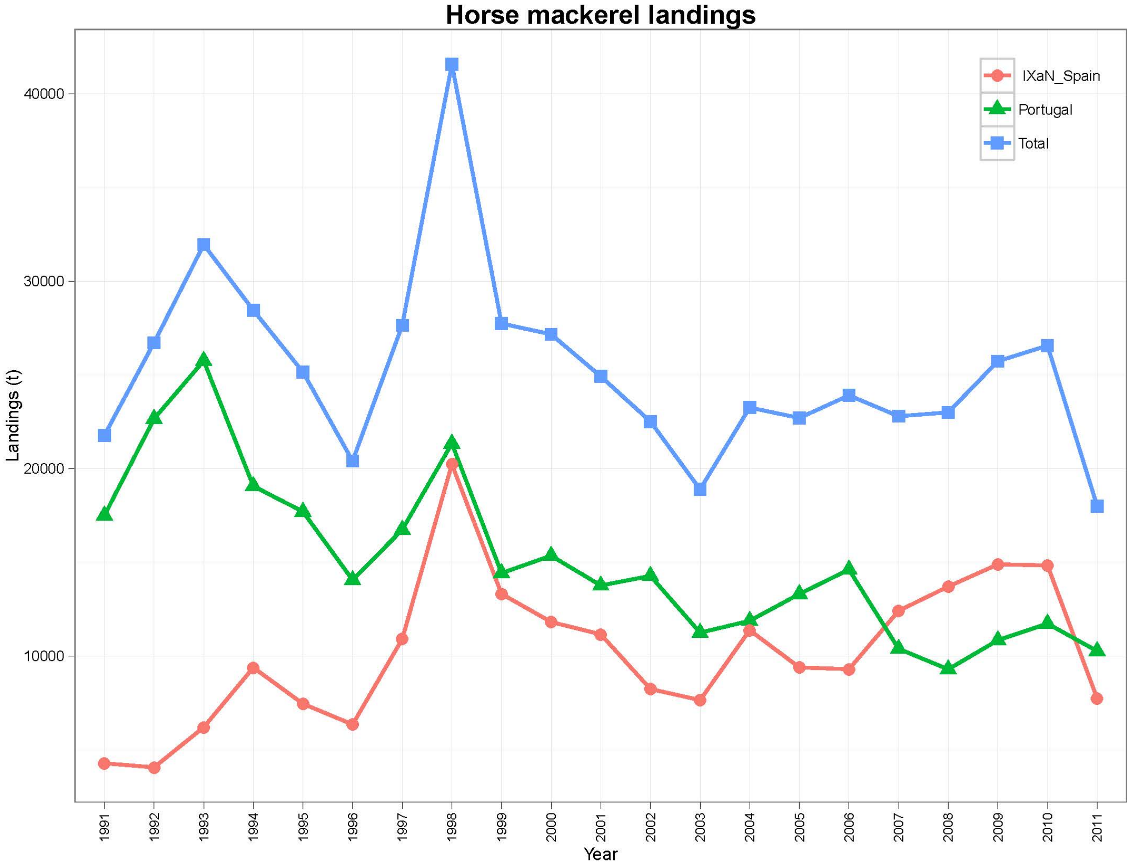


Figure 8.2.1.1 Horse Mackerel landings

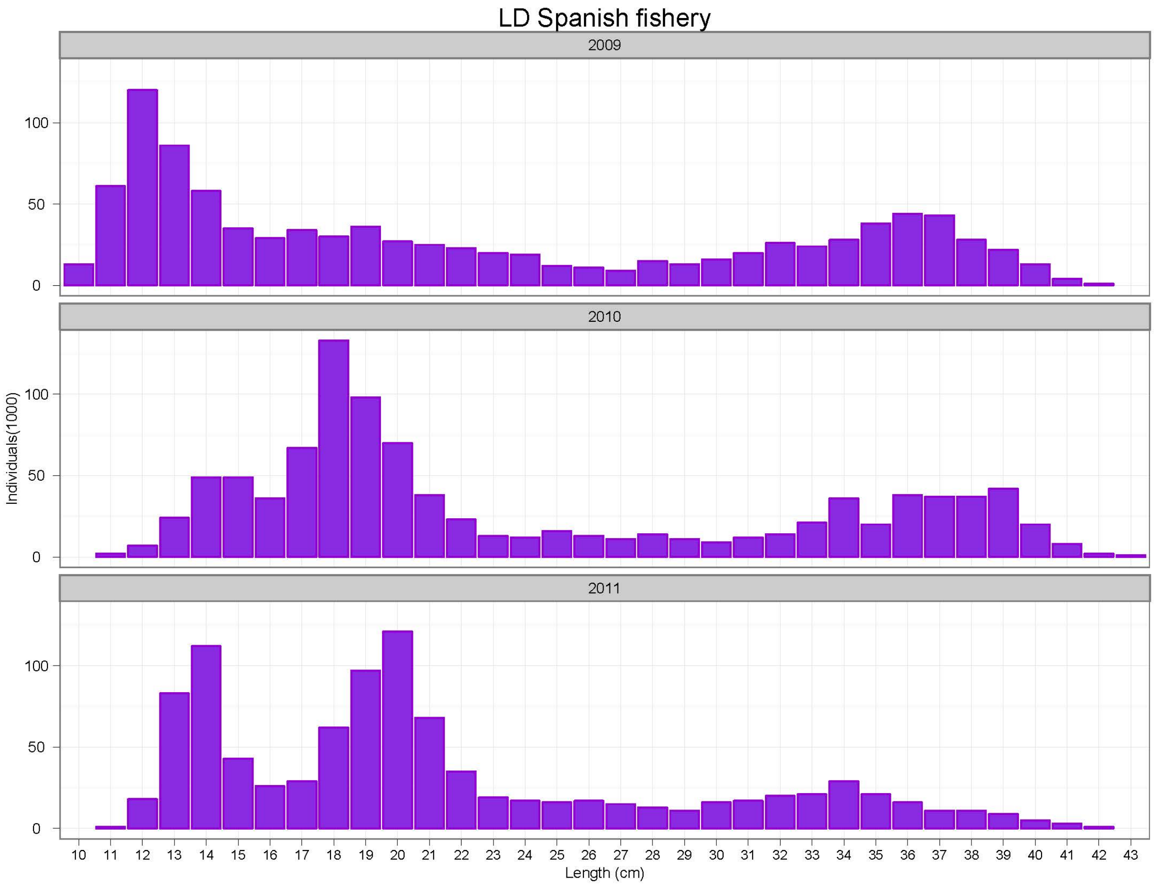


Figure 8.2.1.2 LD Spanish fishery

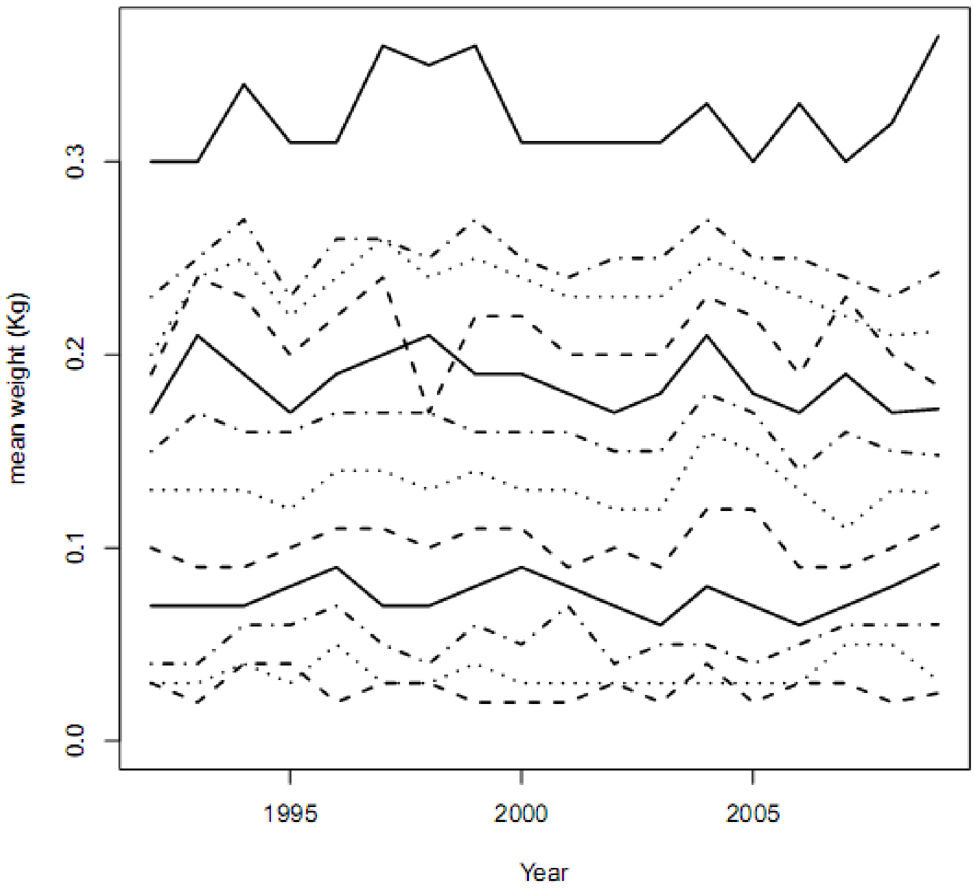


Figure 8.2.6.1. Southern horse mackerel. Time series of mean weight at age in the catch (from age 1 to 11).

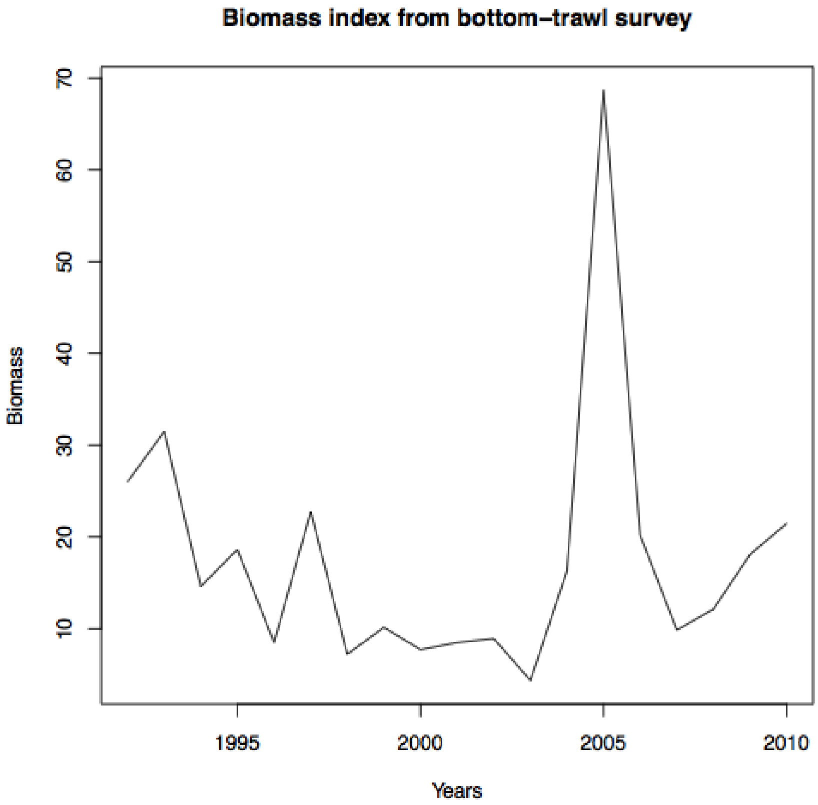


Figure 8.3.2.1 - Evolution of the biomass index of the bottom-trawl surveys.

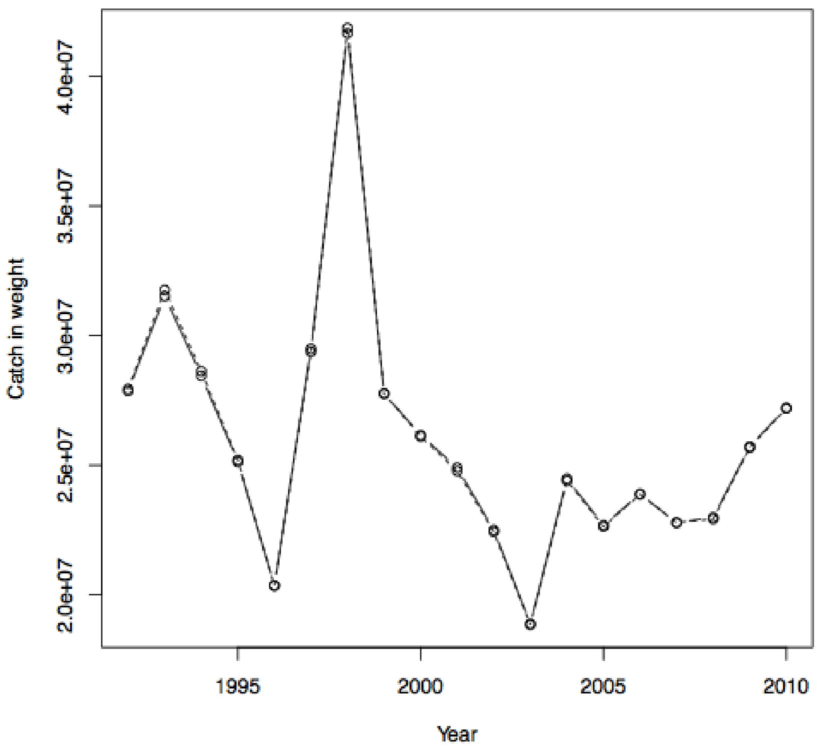


Figure 8.5.2.1 - Southern horse mackerel. Historical series of stock landings (solid line) and estimated landings by the assessment model (dashed line).

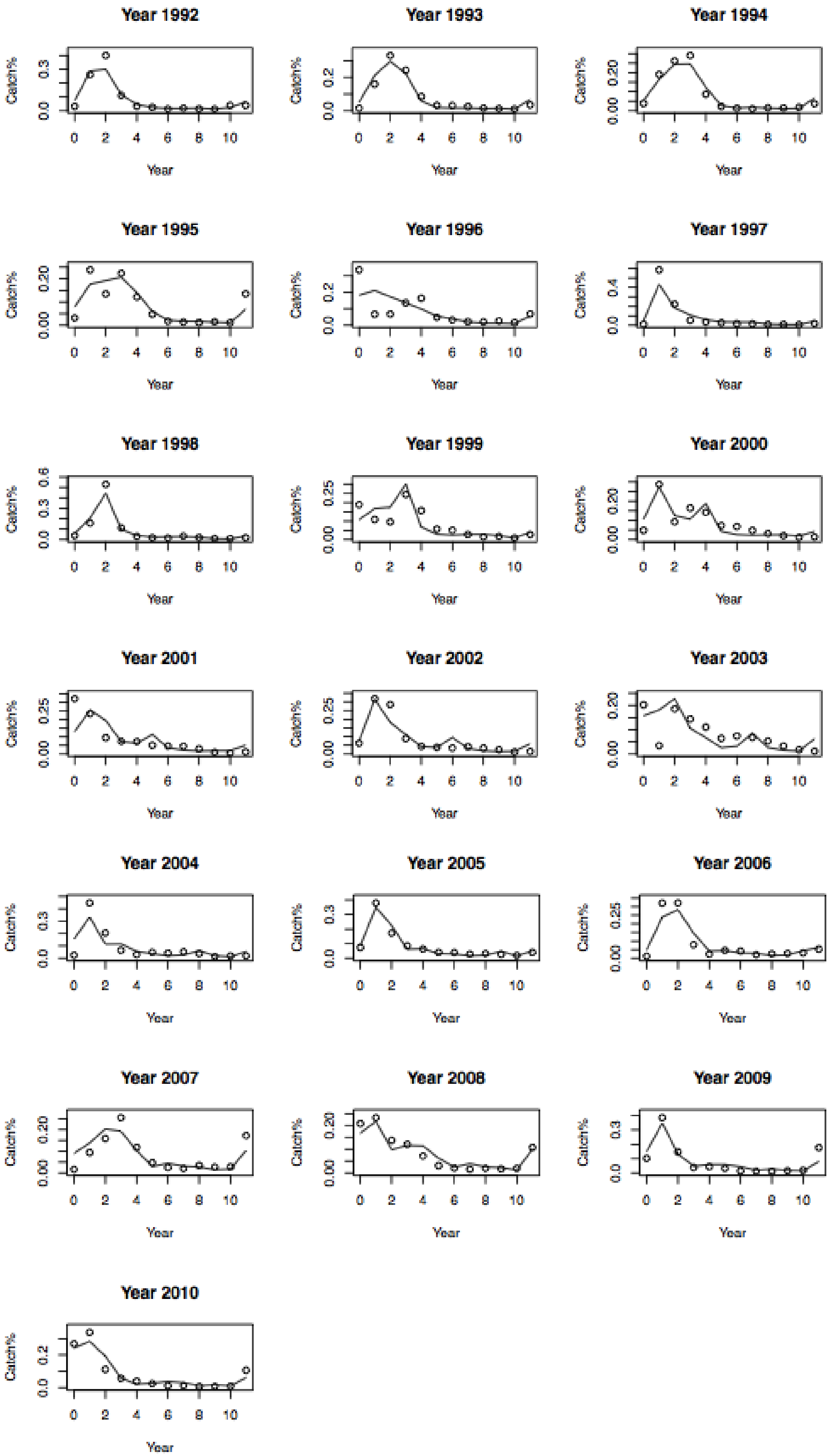


Figure 8.5.2.2 - Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

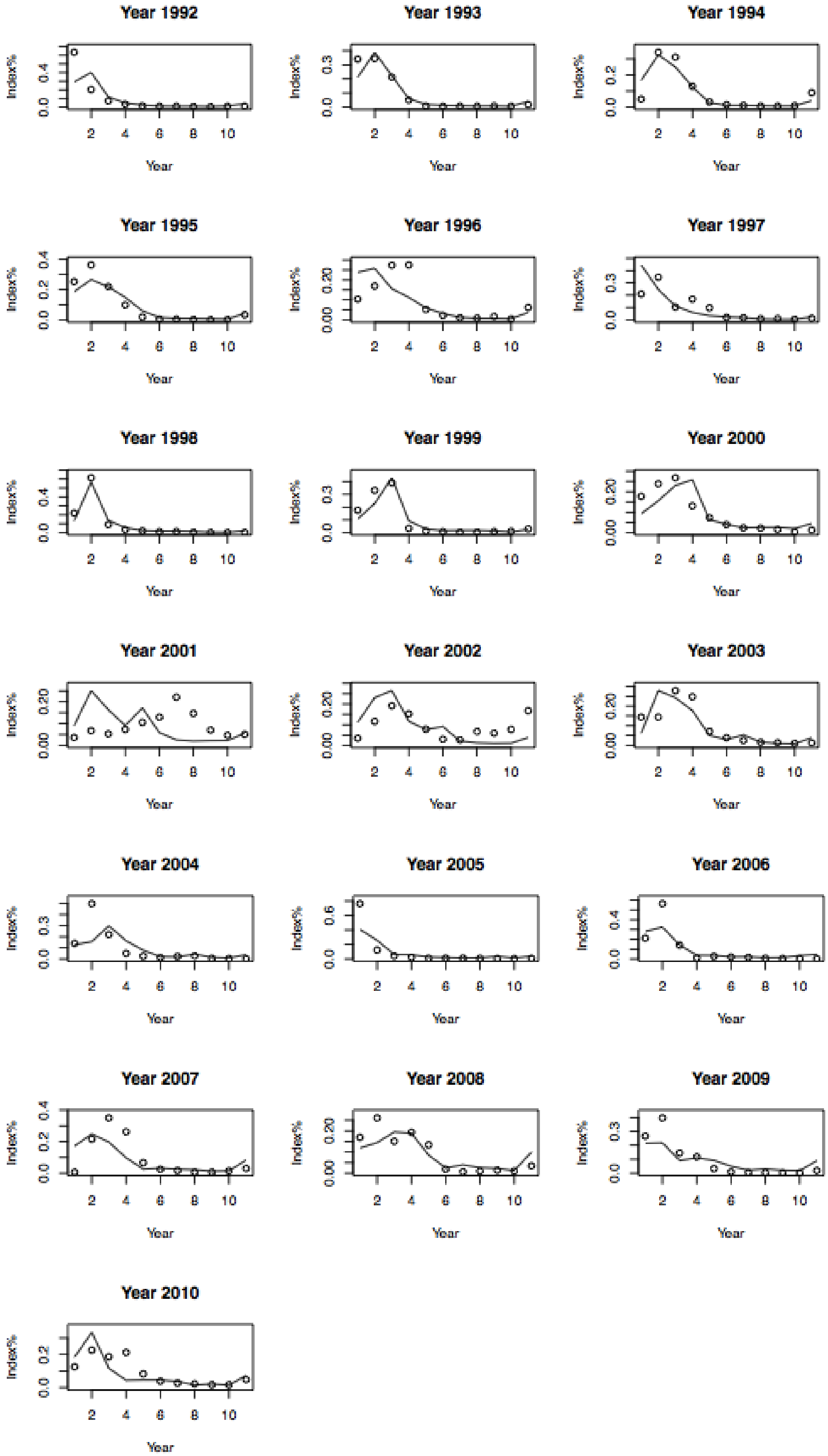


Figure 8.5.2.3 - Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in bottom trawl survey and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

9 Jack Mackerel T. picturatus in the waters of the Azores

9.1 General Jack Mackerel

The jack mackerel, Trachurus picturatus Bowdich, 1825 (Carangidae) is a pelagic fish species distributed through the Northeast Atlantic, Eastern Central Atlantic, Mediterranean and the Black Sea. Its characteristic habitat includes the neritic zones of islands shelves, banks and seamounts (Smith-Vaniz, 1986). It has a schooling behaviour and prey mainly on crustaceans, being common in the islands of Madeira, Azores, and Canaries and Portuguese continental waters.

No studies specifically addressing the existence of distinct populations in the distribution range of this species have been attempted so far. Some studies on growth and biological characteristics from Madeira and Azores (Isidro, 1990; Jesus, 1992; Gouveia, 1993) indicated differences in growth rates, age at first maturity and reproductive season, which could be correlated with water temperatures. According to Shaboneyev & Ryazantseva (1977) biological differences seem to exist between individuals from the Azores compared with those from the Canary islands, and adjacent waters of western Europe. Although there is a lack of morphometric studies on T. picturatus, some variation was found in some of the meristic characteristics in individuals collected from different geographic areas, concerning the soft spines of the second dorsal fin (Shaboneyev & Kotlyar 1979; Smith-Vaniz, 1986). However, meristic characters are heavily influenced by the environmental conditions experienced by the fish while in the larval stages, therefore in the case of migratory oceanic species, such as T. picturatus, are usually considered of reduced utility for the identification of stock units.

A number of studies have successfully used parasites as biological markers. Gaevskaya and Kovaleva (1985) conducted a survey of the parasites of T. picturatus from the Azores and western Sahara. Their study identified a number of protozoan and helminth parasites showing differences in prevalence. The myxosporean Kudoa nova was found in samples from the western Sahara, but not from banks of the Azores archipelago. Similarly, some species of digeneans (Platyhelminths: Digenea) found in the banks of the Azores, were not observed in the samples from the western Sahara and vice-versa. The apicomplexan, Goussia cruciata which is common in T. picturatus from the Mediterranean (Kalfa-Papaioannou & Athanassopoulou-Raptopoulou, 1984) and more recently from Madeira waters (Gonçalves, 1996), was not found in the Azores or from the western Sahara. These variations in the occurrence of parasites could be indicative of the existence of different populations of T. picturatus. Further studies concentrating the occurrence of helminth parasites indicate some differences in both species diversity and parasitic infections levels (Costa et al. 2000, 2003).

The jack mackerel is an economically important resource, especially in the Macaronesian islands of Azores and Madeira, where is the main pelagic fish species being caught in the local fisheries. The landings of this species in the Portuguese mainland have suffered strong fluctuations, which may be related, at least partially to fluctuations in abundance or availability. From 2005 to 2007 the landings have tripled, being 2007 the year with the highest landings recorded. In the Azores archipelago the landings have also fluctuated, while in Madeira the average of the landings from 1986 to 1991 was three times higher than the average landings from 1992 to 2007. The hypothesis that the fluctuations in landings can be due to changes in availability or abundance, and not just by changes in fishing effort, is supported for the Portuguese mainland by the observation of fluctuations in the abundance indices obtained from research surveys.

9.2 ACOM Advice Applicable to 2010

No advice has ever been given to this stock.

9.3 The fishery in 2011

The jack mackerel (*Trachurus picturatus*) is the only species of genus *Trachurus* that occurs in the Azores, where it's exploited by different fleets and métiers. The main catches are those of the artisanal fleet that operates with several types of surface nets, the most important being the purse seines. Purse seines are also used by the tuna bait boat fleet, which targets the jack mackerel as live bait for tuna. The artisanal purse seine fleet that operates in the vicinity of the islands (Figure 9.3.1) with purse seines is responsible for the main share of the catches and is composed by small open deck vessels, mostly with less than 12 meters of length overall.

The demersal fleet, composed of vessels using longlines and a variety of handlines catch jack mackerel, mostly as bycatch, in the multi-specific demersal fishery. Only a portion of those catches are landed, a large percentage is used as bait or discarded at sea. In recent years the amounts of jack mackerel used as bait in the demersal fishery have been increasing. The main fishing areas of the bottom longline fleet are located in the Azores seamounts but also close to shore (Figure 9.3.2). One other important component of the surface fishery are the catches made by the tuna baitboat fleet that also uses purse seines to catches jack mackerel to be used as live bait for tuna. Their catches are estimated from data collected from logbooks and by an observer program. The variability of the catches from these fleets reflects also the availability of tuna in the Azorean area in each year. The geographical distribution of the catches of jack mackerel by tuna baitboat fleet in the Azores is showed in figure 9.3.2. The jack mackerel is also a very popular species among the recreational fisherman that fish along the coast of all islands.

During the past 5 years, the total estimated catches of jack mackerel in the Azores are around 1850 tonnes (figure 9.3.3. and table 9.3.1) while the landings in recent years average 1200 tonnes. The horse mackerel is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman associations due to market restrictions. This stability of the catches is mostly observed in S. Miguel Island, where around 75% of the annual catches occur (figure 9.3.4). Continuous reductions in the demands from the consumers lead to the catch limits auto adopted by the fleet, which explains the reduction observed in the catches along the recent years.

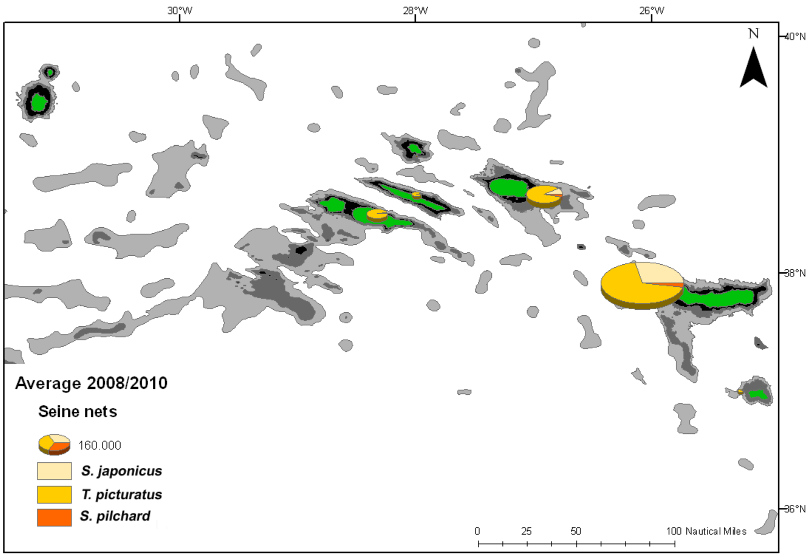


Figure 9.3.1. Geographical distribution of the catches of small pelagics by the artisanal purse seine fleet in the Azores (average 2008-2010).

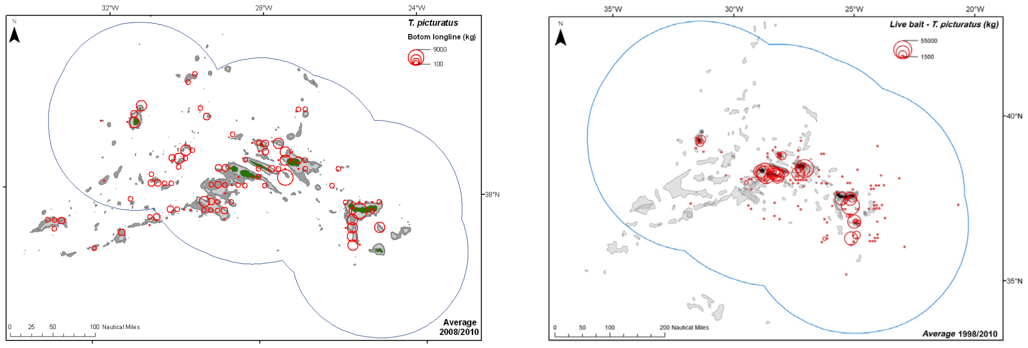


Figure 9.3.2. Geographical distribution of the catches of horse mackerel by the longline fleet (left panel) and the tuna baitboat fleet (right panel) in the Azores (average 2008-2010).

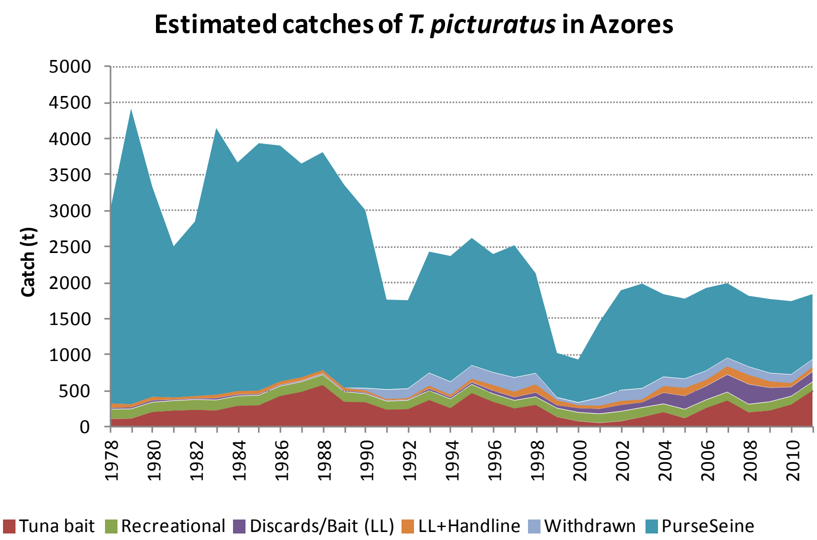


Figure 9.3.3. - Estimated catches of jack mackerel (*T. picturatus*) in the Azores (ICES area X) from 1978 to 2011.

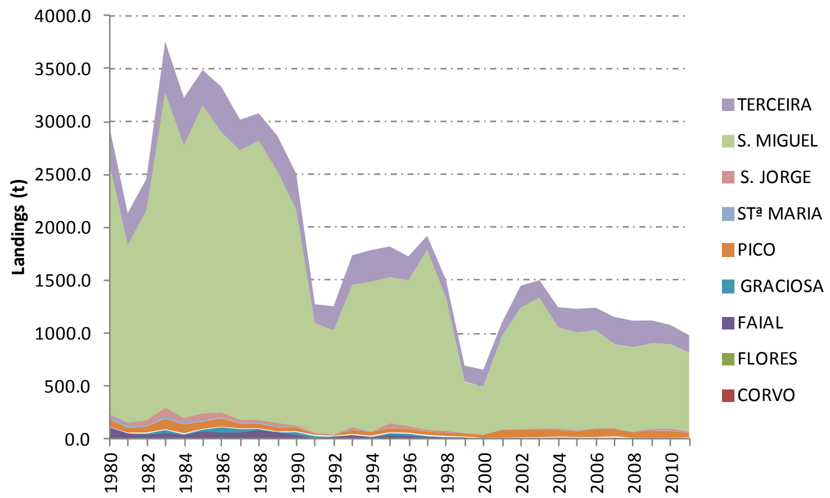


Figure 9.3.4. Landings of horse mackerel in the Azores, by island (1980-2011).

9.3.1 Fishing Fleets in 2011

The jack mackerel is mostly landed by the artisanal fleet, using purse seines. The fleet segments that use hand lines and bottom longlines also catches jack mackerel, but the catches are only partially landed, since an important part of their catches is used for bait in the demersal species fishery. The catches made by the tuna bait boat fleet, for use as live bait for tuna, are not landed. Those catches are estimated by the tuna observer program and from information in the logbooks.

The artisanal purse seines fleet is composed by small open deck vessels, mostly with less than 12 meters of length overall. The composition of this fleet, classified in three length categories (LOA) as showed in figure 9.3.5, presented a sharp decrease in the number of vessels during the exploitation period considered and has remained stable in the recent years. The contribution to the landings of the vessels of each size category is showed in figure 9.3.6

The fleet segments that use hand lines and bottom longlines also catches horse mackerel, but the catches are only partially landed, since an important part of their catches is used for bait in the demersal fishery or discarded. Figure 9.3.7 shows the percentage of horse mackerel discarded or used as bait by the longline fleet, from 2004 to 2011, representing an average of 68% since 2007. The catches also made with purse seines by the tuna baitboat fleet, for use as live bait for tuna, are not landed. Two sources of data are used to estimate the jack mackerel catches from the tuna fleet: information from the logbooks and by the tuna observer program. The tuna observer program targets a minimum annual coverage of 50% of the tuna trips and of the tuna catches.

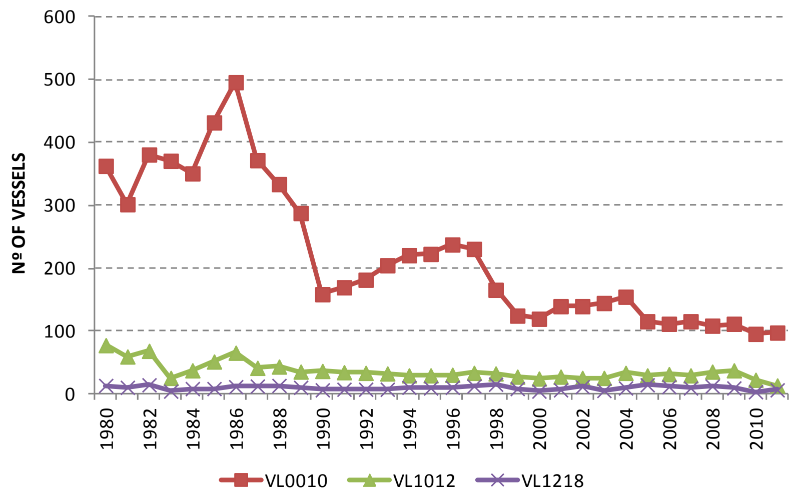


Figure 9.3.5. Number of vessels, by size category, using purse seines for jack mackerel in the Azores, from 1890 to 2011.

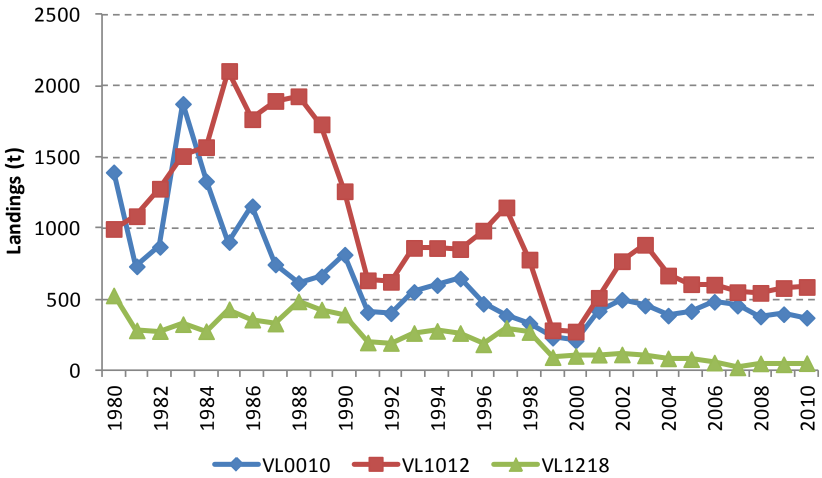


Figure 9.3.6. Landings of jack mackerel by size category of vessels using purse seines in the Azores, from 1890 to 2011.

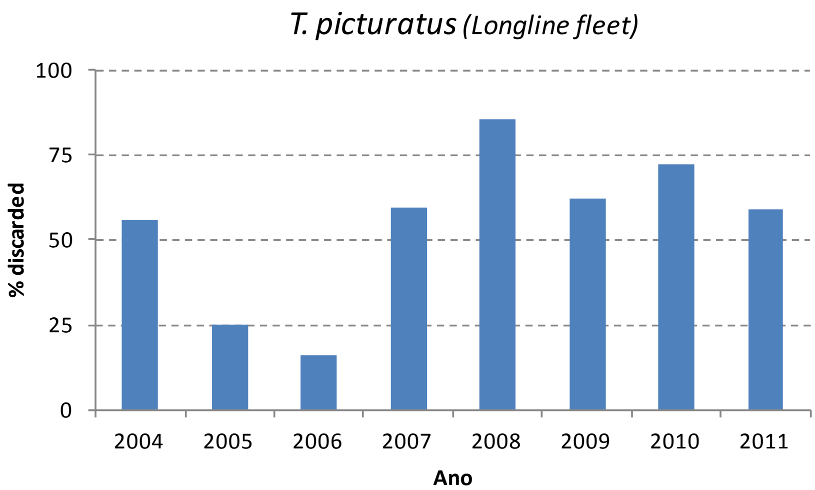


Figure 9.3.7. Percentage of the catches of jack mackerel discarded or used as bait by the Azores longline fleet.

9.3.2 Catches

After a period of large catches until the end of the 1980's, changes in the local markets lead to a strong reduction in the catches. This reduction was also accompanied by a sharp decrease in the small pelagics fleet (figure 9.3.5). The catches of this fleet had since been maintained at a low level due a voluntary auto regulation adopted by the fisherman associations, each vessel can only land a maximum of 400kg per day. The estimated catches of jack mackerel by fishery, from 1978 to 2011, is presented in Table 9.3.1 and Figure 9.3.3.

Table 9.3.1. Estimated catches of jack mackerel (*T. picturatus*) by fishery, in the Azores (ICES area X) from 1978 to 2011.

Year	Tuna bait	Recreational	Discards/Bait (LL)	Withdrawn	PS	LL+Hand	Total
1978	115	129	15	0	2657	63	2980
1979	118	130	15	0	4114	46	4424
1980	210	132	22	0	2920	48	3333
1981	229	135	9	0	2104	30	2507
1982	239	142	10	0	2429	33	2852
1983	231	142	21	0	3711	46	4152
1984	295	135	17	0	3180	46	3673
1985	303	136	11	0	3442	49	3941
1986	433	135	9	0	3282	48	3908
1987	491	139	8	0	2974	45	3658
1988	586	143	8	0	3032	47	3816
1989	352	138	9	0	2824	42	3365
1990	345	117	11	27	2472	37	3010
1991	242	115	6	127	1247	27	1765
1992	249	121	6	126	1226	29	1756
1993	375	130	22	173	1684	48	2432
1994	264	125	18	179	1745	41	2371
1995	474	119	24	182	1769	54	2623
1996	351	110	38	173	1642	85	2399
1997	259	110	39	192	1836	86	2521
1998	308	111	54	151	1387	120	2131
1999	141	119	36	35	614	79	1023
2000	83	117	55	32	594	50	932
2001	59	121	64	110	1047	54	1455
2002	82	132	85	145	1385	65	1894
2003	140	128	68	150	1453	49	1987
2004	208	111	150	125	1146	100	1840
2005	124	120	180	123	1110	120	1778
2006	264	111	186	124	1149	93	1927
2007	370	115	239	115	1035	119	1994
2008	205	110	273	111	982	137	1818
2009	230	119	190	112	1026	95	1773
2010	313	114	122	116	1017	61	1744
2011	510	118	136	105	904	68	1842

9.3.3 Effort and catch per unit effort

The data on catch and effort collected includes fleet characteristics, quantities caught and landed, fishing effort, gears used and fishing grounds, that are obtained through interviews to the fisherman at the landing sites, logbooks and by observers on board the fishing vessels. Two observer programs are currently operating, one on the demersal logline fleet, collecting detailed information on fishing operations and the amount and size composition of the catches, including data on discards and one other observer program that collects information on board of the tuna vessels, including the fishing for bait species, among which the horse mackerel is the major species.

Standardized CPUE are available for 3 of the fisheries catching jack mackerel, the small purse seine fleet, the tuna baitboat catches of jack mackerel for use as live bait for tuna and the catches of the bottom longline fleet.

9.3.3.1 Standardized CPUE for small purse seines

Large purse seines (over 12 m LOA) show higher nominal catch rates of horse mackerel, and were observed also higher catch rates in Sao Miguel Island. There were no major differences in catch rates by season.

Standardized CPUE series for jack mackerel are shown in Table 9..3.2 and figure 9.3.8. Estimated coefficients of variation average 18%. The standardized CPUE series show that the relative abundance of horse mackerel varied in the early part of the series (1980-98) followed by a large increase in 1998/99, followed by an stable trend since 1993 in the latest years of the series. Although, in recent years the average catch rates are slight below compare to the earlier years.

Table 9.3.2. Estimated standardized relative index of abundance for horse mackerel from the Azorean small purse seine fishery fleet.

Year	N Obs	Nominal CPUE	Standard CPUE	95% Low CI	95% Upp CI	CV	Std error
1980	643	250.33	227.57	159.18	325.34	18.0%	41.00
1981	795	277.86	234.12	164.46	333.29	17.8%	41.67
1982	878	270.40	216.83	152.75	307.81	17.7%	38.28
1983	763	253.05	283.05	199.73	401.12	17.6%	49.72
1984	882	243.73	252.66	178.30	358.04	17.6%	44.37
1985	1046	292.03	259.85	183.54	367.88	17.5%	45.51
1986	1205	277.22	251.76	177.98	356.12	17.5%	43.98
1987	1043	304.44	252.27	178.41	356.71	17.5%	44.03
1988	938	684.35	517.20	365.23	732.41	17.5%	90.65
1989	850	699.00	582.47	411.40	824.66	17.5%	102.03
1990	550	336.66	207.78	141.34	305.46	19.4%	40.41
1991	427	250.80	150.47	101.66	222.71	19.8%	29.79
1992							
1993	890	218.89	192.14	135.80	271.86	17.5%	33.59
1994	932	203.59	147.65	104.51	208.58	17.4%	25.70
1995	944	189.03	193.15	136.60	273.09	17.4%	33.70
1996	876	200.49	175.31	123.87	248.12	17.5%	30.68
1997	770	214.30	154.88	108.57	220.95	17.9%	27.73
1998	630	206.77	171.71	120.79	244.10	17.7%	30.44
1999	493	162.67	171.80	120.53	244.90	17.9%	30.69
2000	455	150.99	143.16	99.87	205.24	18.2%	25.99
2001	467	204.54	190.90	132.74	274.54	18.3%	34.97
2002	578	216.06	191.42	134.65	272.11	17.7%	33.93
2003	607	222.16	225.52	159.00	319.87	17.6%	39.72
2004	592	183.23	180.33	126.97	256.10	17.7%	31.88

2005	517	201.70	169.43	119.26	240.69	17.7%	29.97
2006	509	198.75	203.50	143.38	288.85	17.6%	35.91
2007	503	186.73	197.51	139.16	280.33	17.6%	34.85
2008	399	195.71	193.07	135.57	274.95	17.8%	34.40
2009	406	176.54	171.49	120.45	244.15	17.8%	30.53
2010	352	187.60	178.97	125.43	255.37	17.9%	32.07

In Figure 9.3.8, the standardized cpue (kg/day fishing) is presented for the juvenile stock, caught by the small purse seine fleet.

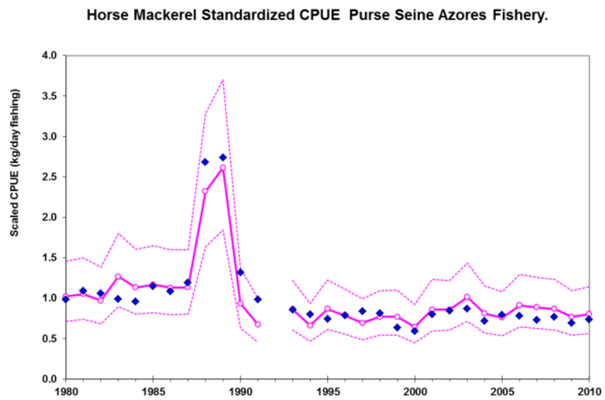


Figure 9.3.8 - Standardized (solid line) and nominal CPUE horse mackerel from the Azores small purse seine fishery 1980 – 2010. Broken lines indicated 95% confidence intervals

9.3.3.2 Standardized CPUE for tuna baitboat fleet

Standardized CPUE series for jack mackerel from the Azorean bait catch of the tuna baitboat fishery are shown in Table 9.3.3 and figure 9.3.9. Estimated coefficients of variation average 46%. The standardized CPUE series show that the relative abundance of horse mackerel varied in the early part of the series (1980-98) followed by an increase since 2006. In recent years the average catch rates are above the overall average.

Table 9.3.3. Estimated standardized relative index of abundance for jack mackerel from the Azorean tuna baitboat fishery fleet.

Year	N Obs	Nominal CPUE	Standard CPUE	95% Low CI	95% Upp CI	CV	Std error
1998	275	238.52	276.22	154.21	494.79	29.8%	82.25
1999	266	114.01	124.02	57.68	266.67	39.7%	49.27
2000	303	93.96	89.09	30.66	258.85	57.4%	51.10
2001	180	117.27	180.53	70.78	460.45	49.5%	89.37
2002	163	59.66	129.10	44.13	377.69	57.8%	74.60
2003	205	52.39	61.89	18.49	207.11	66.3%	41.06
2004	260	84.30	117.05	42.41	323.04	54.2%	63.45
2005	209	94.64	124.25	57.31	269.40	40.2%	49.94

2006	261	45.44	103.51	36.38	294.49	56.1%	58.03
2007	371	113.82	228.87	117.74	444.88	34.2%	78.21
2008	404	78.86	134.16	46.14	390.09	57.4%	77.01
2009	256	229.89	408.79	202.66	824.60	36.2%	147.95
2010	408	187.71	289.69	147.17	570.21	34.9%	100.97
2011	386	280.68	474.52	256.36	878.33	31.5%	149.62

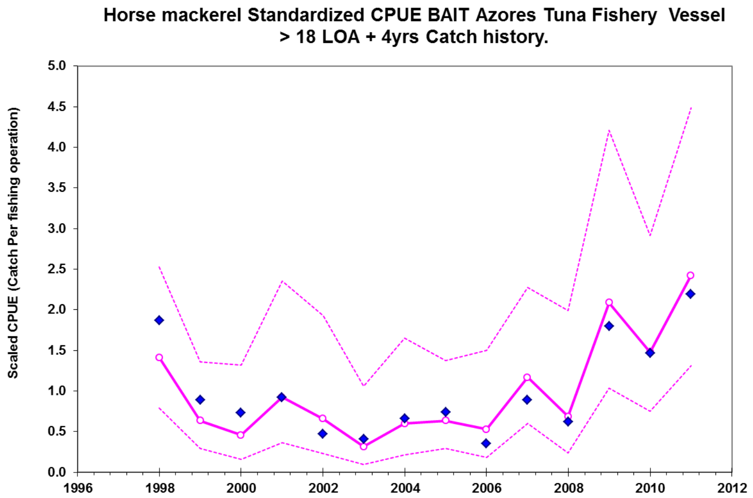


Figure 9.3.9. Nominal and standardized catch rates of horse mackerel from the Azorean baitboat tuna fishery 1998-2011.

9.3.3.3 Standardized CPUE for longline fleet

Standardized CPUE series for jack mackerel from the Azorean longline fishery are shown in Table 9.3.4 and figure 9.3.10. Estimated coefficients of variation are large, as indicated by the wide confidence intervals. The standardized CPUE series show that the relative abundance of horse mackerel varied in the early part of the series (1990-98) followed by an increase from 2000 until 2008 with the highest catch rates in 2008, followed by a decline in the latest years of the series.

The decline observed in the latest years can be explained by the current practice of the bottom longline fleet to land only part of the catches of jack mackerel and discards and retains on board an important part of the fish caught to be used for bait in the demersal fishery (figure 9.3.7). This practice is explained by the low market value of horse mackerel. Figure 9.x shows the percentage of horse mackerel caught and discarded or used as bait by the longline fleet, from 2004 to 2010, representing an average of 68% since 2007.

Table 9.3.4. Estimated standardized relative index of abundance for horse mackerel from the Azorean longline fishery fleet.

Year	N obs	Nominal Cpue	Standard CPUE	95 % Low CI	95% Upp CI	CV	std error	Nominal	Estimated
1990	36	0.187	0.173	0.04	0.79	88%	0.249	0.61	0.28
1991	95	0.433	0.281	0.06	1.33	91%	0.419	1.42	0.46
1992	85	1.764	1.531	0.39	6.03	77%	1.934	5.77	2.50
1993	210	1.046	0.679	0.20	2.32	68%	0.751	3.42	1.11
1994	141	0.321	0.500	0.16	1.56	62%	0.504	1.05	0.82
1995	198	0.457	0.372	0.11	1.20	64%	0.389	1.49	0.61
1996	275	1.201	1.870	0.70	4.98	52%	1.587	3.93	3.05
1997	249	0.532	0.703	0.23	2.17	61%	0.701	1.74	1.15
1998	188	0.545	0.638	0.17	2.36	73%	0.760	1.78	1.04
1999	69	0.620	0.543	0.12	2.48	88%	0.783	2.03	0.89
2000	97	0.230	0.287	0.07	1.17	80%	0.375	0.75	0.47
2001	38	0.416	0.727	0.24	2.20	60%	0.712	1.36	1.19
2002	29	0.715	1.039	0.33	3.22	61%	1.040	2.34	1.69
2003	45	1.233	1.693	0.49	5.89	69%	1.902	4.03	2.76
2004	70	0.721	1.654	0.63	4.33	51%	1.375	2.36	2.70
2005	77	1.175	0.617	0.20	1.90	61%	0.613	3.85	1.01
2006	47	1.889	1.290	0.40	4.13	63%	1.334	6.18	2.10
2007	40	1.523	1.433	0.46	4.49	62%	1.451	4.98	2.34
2008	77	3.670	2.700	1.03	7.10	51%	2.259	12.01	4.40
2009	88	1.506	1.224	0.38	3.96	64%	1.282	4.93	2.00
2010	129	0.815	1.049	0.38	2.91	55%	0.933	2.67	1.71

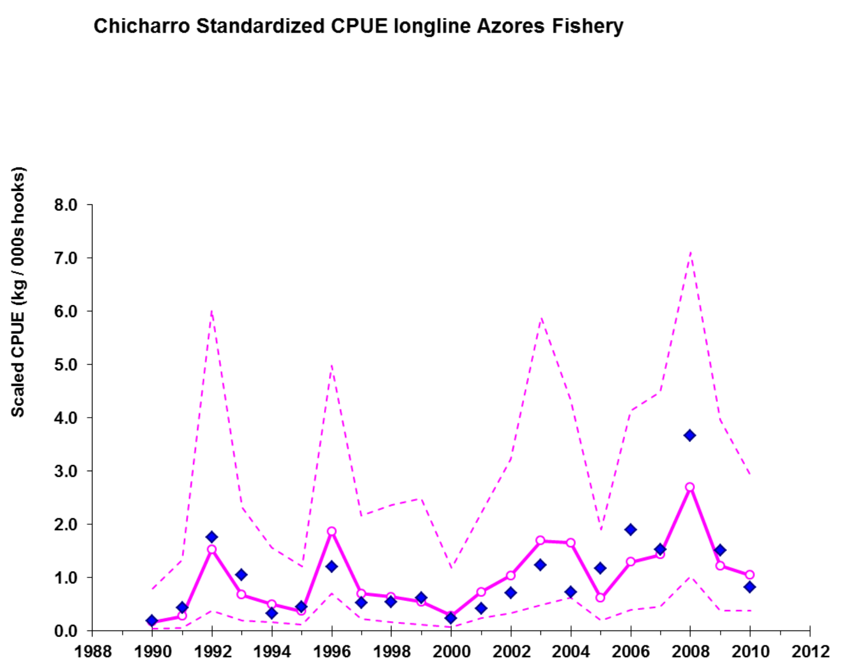


Figure 9.3.10. Standardized relative catch rates of jack mackerel from the longline Azores fishery. Solid line represents standardized index, broken lines the estimated 90% Confidence bounds, and the filled diamonds the nominal CPUEs.

9.3.4 Catches by length

Size frequencies for the jack mackerel caught in the Azores are available since 1980. In Figure 9.3.11, is presented the size distribution of the landings (catch at size) for the years 2001 to 2010. The size distribution (catch at size) of the landings of jack mackerel caught by two of the main métiers involved in the fishery, artisanal purse seiners and longliners, is presented in Figure 9.3.12.

The two main fisheries target on different size categories, the surface fleets catches the juvenile fraction of the population while the longliners target the adult stock.

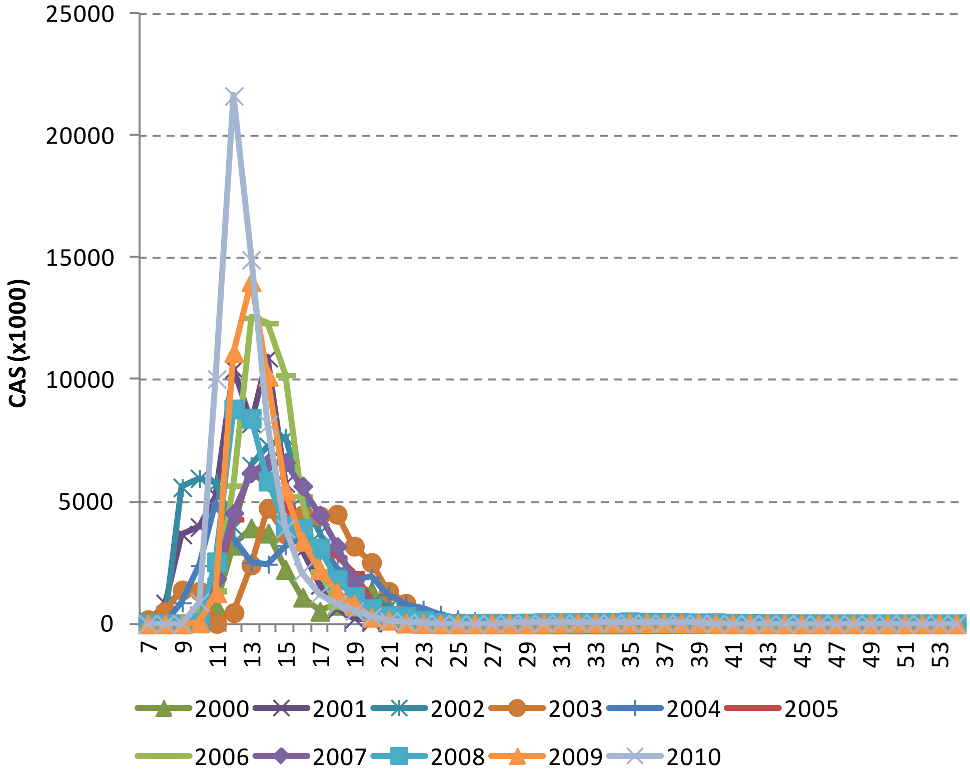


Figure 9.3.11 - Size frequencies of the catches of jack mackerel (*T. picturatus*) in the Azores fishery, from 2000 to 2010.

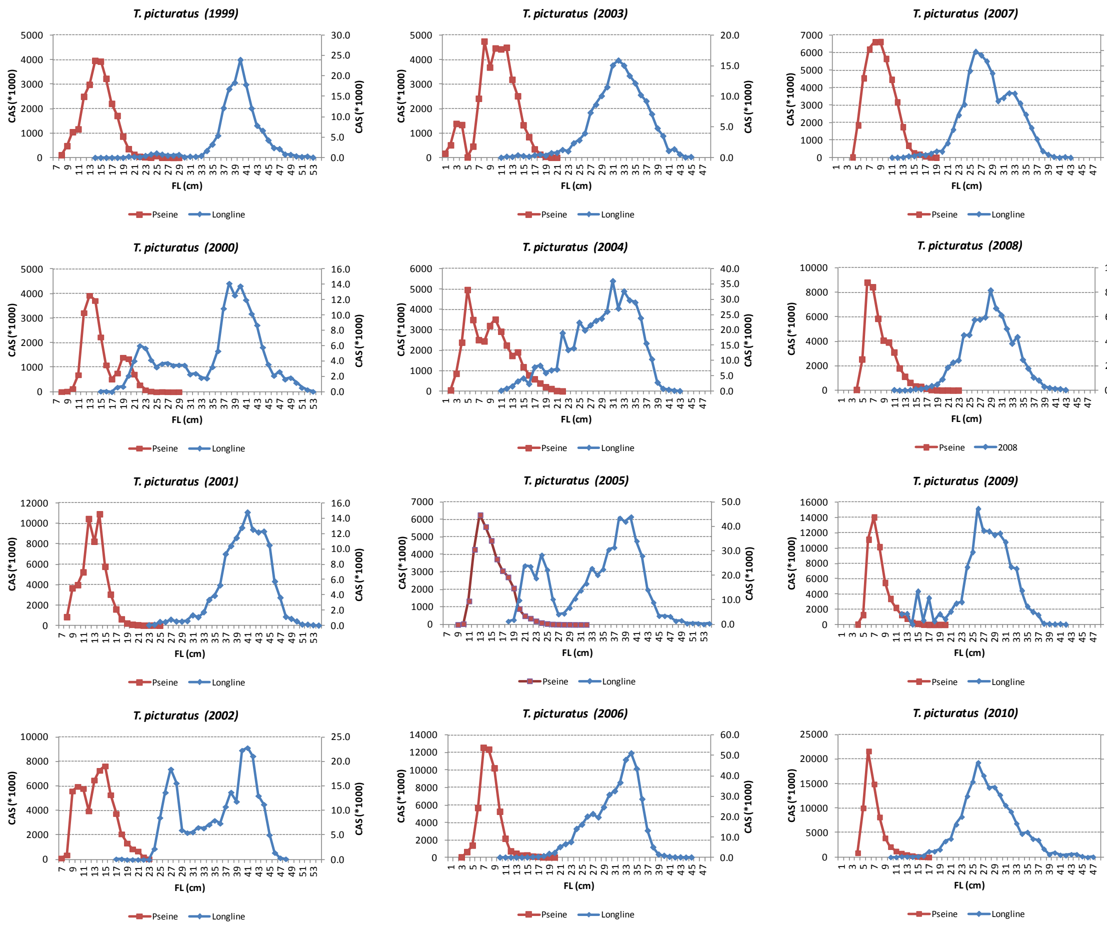


Figure 9.3.12 - Size frequencies of jack mackerel (*T. picturatus*) caught in the Azores by purse seine and longlines, from 1999 to 2010.

9.3.5 Mean weights in the catch

The analysis of the sizes caught shows stability along the analyzed period, which is also confirmed by the stability in the average weights (figure 9.3.13) of the fish caught by the different métiers involved in the fishery.

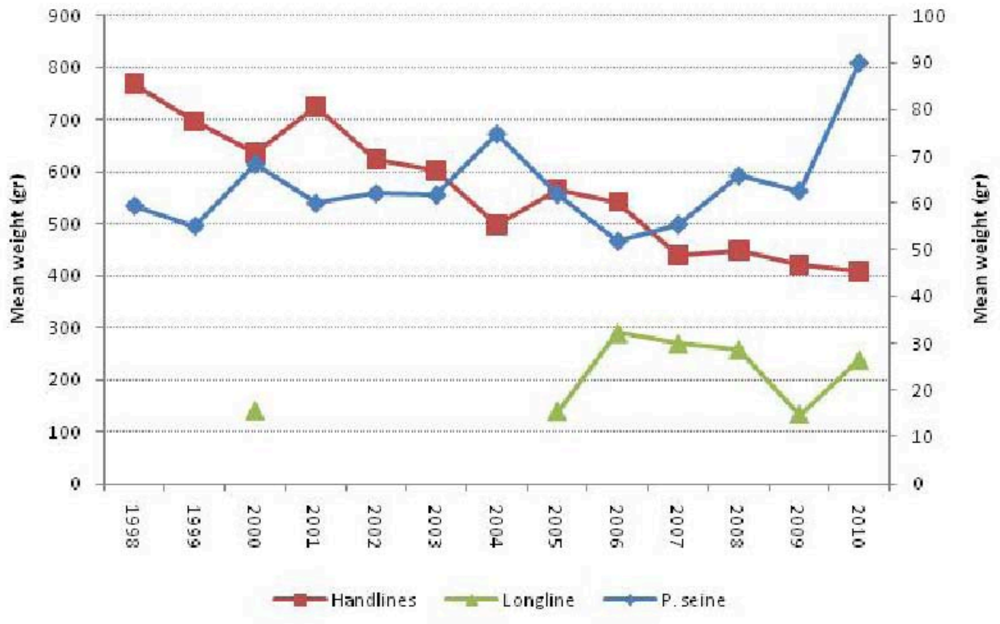


Figure 9.3.13 - Annual mean weights of the Jack mackerel caught in the Azores by different métiers.

9.3.6 Catch at age

The conversion of the catch at size to catch at age of the jack mackerel caught in the Azores by the two main metiers, purse seines and hook and line, shows a distribution of the catches characteristic of each metier, the purse seines catching mostly juvenile fish, ages 1 and 2) and the longliners catching the adult fish (figures 9.3.14. and 9.3.15).

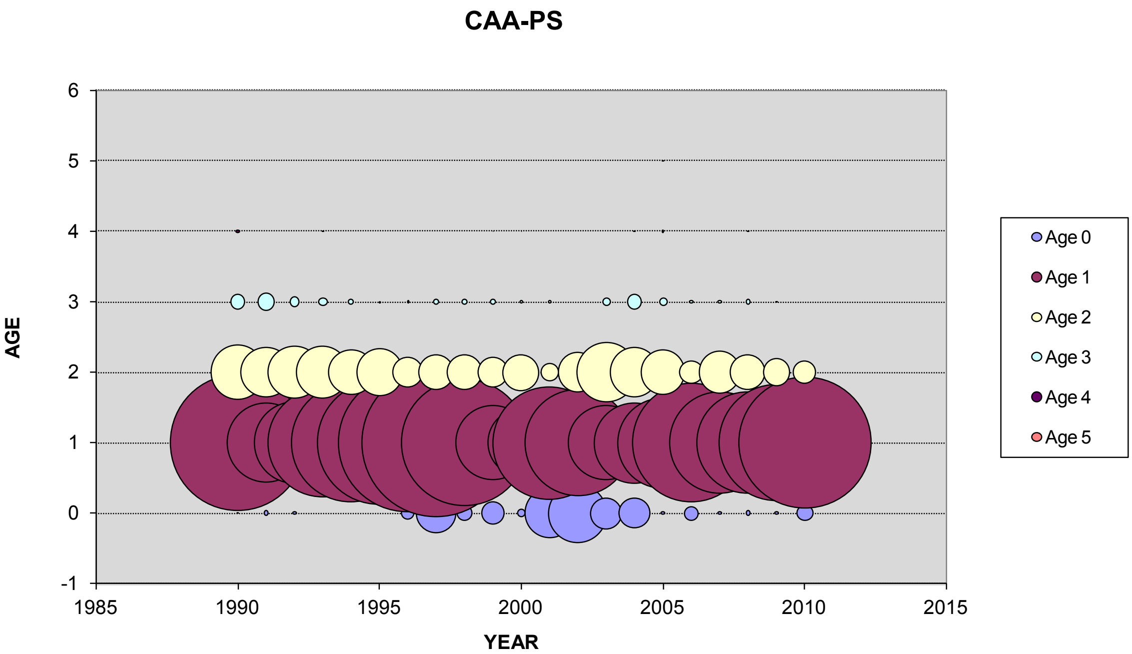


Figure 9.3.14. Catch at age of jack mackerel caught by the purse seiners in the Azores.

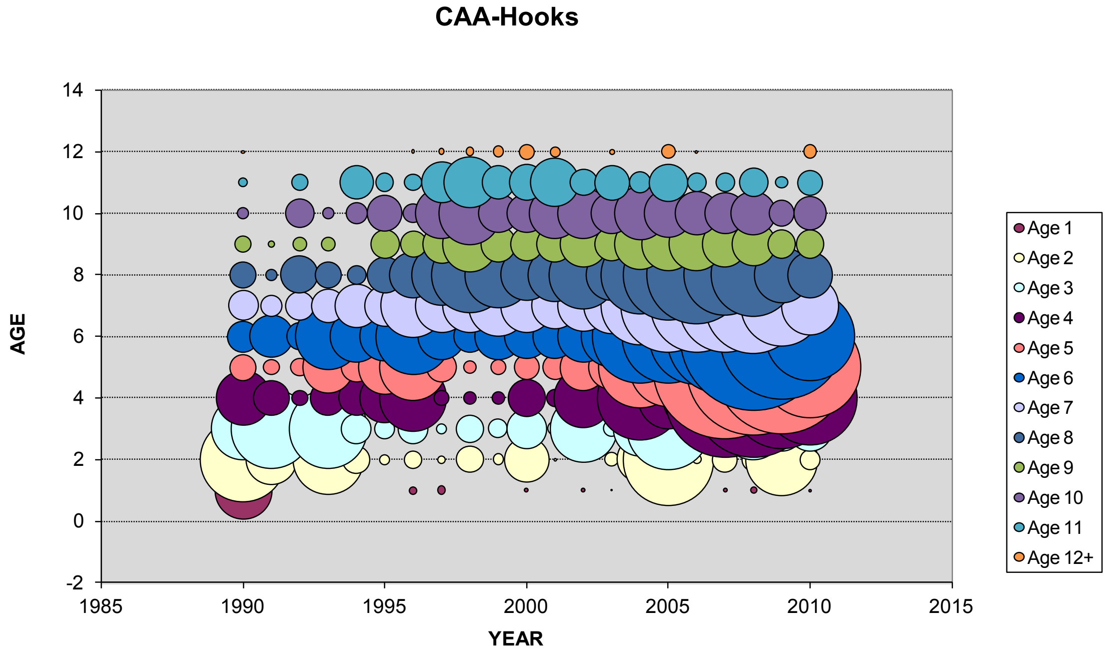


Figure 9.3.15. Catch at age of jack mackerel caught by longlines and handlines in the Azores.

9.4 Biological data

The jack mackerel (*Trachurus picturatus*) is one of the species included in the data collection in Azores and consequently its landings are subject to regular sampling for biological data. The biological data available includes samples from 1998 to 2011, for a total of 3434 fish.

9.4.1 Length-weight relationship

A total of 3372 specimens of jack mackerel were sampled for weight and length, and the length-weight relationships were calculate separately for males and females and for both sexes together. The parameters of the fork length to total weight relationships are given in Figure 9.4.1

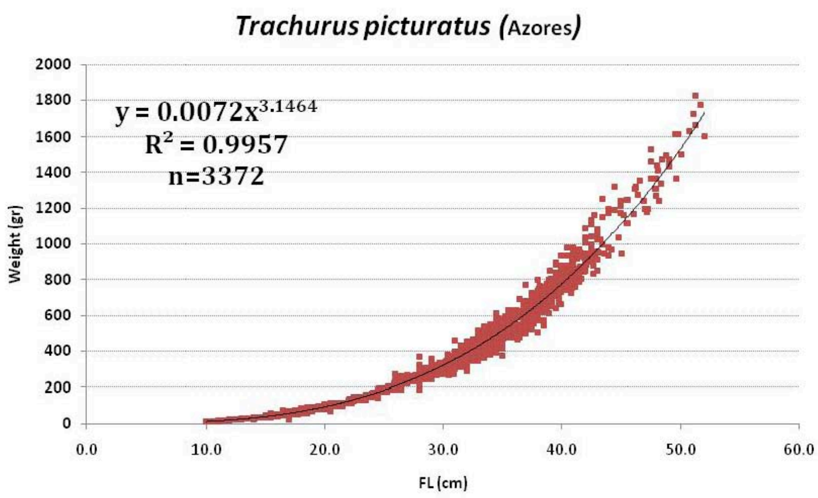


Figure 9.4.1 - Length-weight relationship for the jack mackerel (*T. picturatus*) from the Azores.

9.4.2 Maturity at length

The logistic curve fitted to the proportion of sexually mature jack mackerel estimated the mean length at sexual maturity at 28.5 cm of fork length, as showed in figure 9.4.2

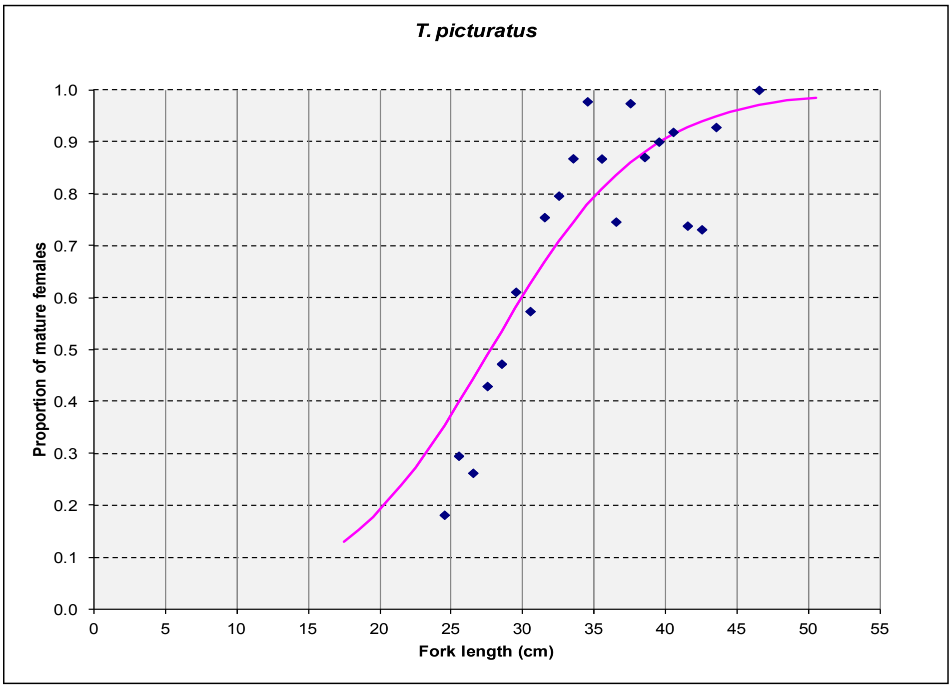


Figure 9.4.2 - Size at sexual maturity (FL50) for the jack mackerel from the Azores.

9.4.3 Age and growth

For the determination of age and growth, otoliths collected from 405 specimens where used. The smallest estimated age was 0+ and the highest 18+ (sexes pooled). Age groups 6, 7 and 8 were the dominant in the whole sample, accounting for approximately 31%. Plots of the fitted von Bertalanffy growth function are shown in Figure 9.4.3 and the estimated parameters are: L_∞=62.65 cm; k=0.08 year^{-1} e t_0=-2.82 year.

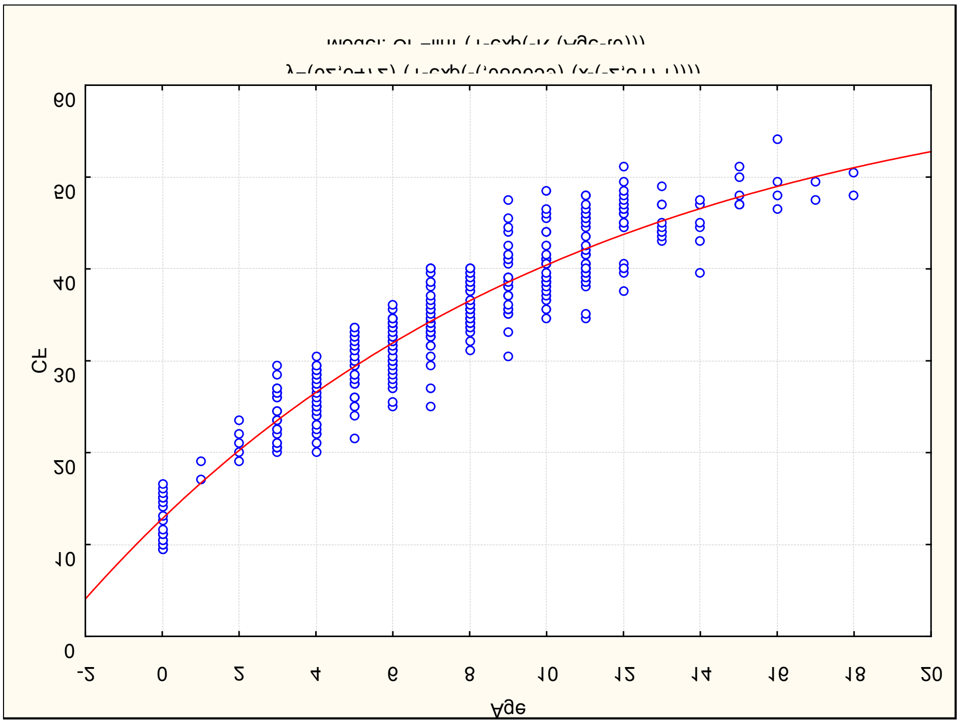


Figure 9.4.3. von Bertalanffy growth curve for *T. picturatus* from the Azores.

9.5 Assessment of the state of the stock

The jack mackerel stock from Azores is assessed for the first time. Some of the analyses were conducted during the WG meeting, with limited time. For this reason results are presented in a unique section, Data analysis.

9.5.1 Data analysis

The available information for this stock was resumed and presented to the working group on a structure for a formal stock assessment procedure. This includes: time series of landings and standardized cpue, catch at size and catch at age for the three components of the fleet. So, this stock should be classified in category 2. However, no analytical assessment using age structure models was performed because of the structure of the available data. Catch-at-age includes the age structure of juveniles and an incomplete structure of the adults. The lengths of preadults (20-30cm LF), are almost not presented on the fishery. There is no survey data available for any component of the stock. Production models were explored.

9.5.2 Trend analysis of time series

Total catches followed the artisanal seiner's decrease trend on the catches with a reduction of about 50% from the early eighties to 2002 and maintained stable thereafter around 1860 t (Fig. 9.3.3). These decrease trend observed on the artisanal purse seiner are related with voluntary management measures implemented by the industry due to market reasons.

Length compositions reflect the two different components of the exploitation: juveniles from surface fisheries and adults from benthopelagic fisheries (Fig. 9.3.12). Both time series present a stable structure with a mode around 14cm on the juveniles and 35cm on the adults suggesting equilibrium size distribution. Mean weight in the catch are stable along time (Fig. 9.3.13). Decrease observed on the hook and line mean weight is due to the discard effects (only small individuals are landed).

Standardized cpue for the main fishery (artisanal seiners) shows a decrease trend until 1987 followed by two high peaks on 1988 and 1989 and a stable trend onward. Hook and line cpue presents an increase trend with high variability along time. The cpue from the bait boat tuna vessels present high values for the last 3 years, suggesting an abundance increase on individual's age 1-2. However, the last two indices present high variability.

9.5.3 Production models

Standardized cpue from the different fisheries are available. Exploratory runs using production models (ASPIC 5.0) were made (Table 9.5.1). Data from the mixed demersal hook and line fishery were not used on the analysed because it comes from a bycatch fishery where most of the fish are discarded. So, data from the surface fisheries were explored. The model could not to estimate the three parameters at the same time, probably due to the lack of contrast on the data. Analyse with the two surface indices shows a slight negative correlations and more research is needed to review these indices and access how appropriate they are. Influential points of 1988 and 1989 were removed from purse seine cpue time series because the model was not able to interpret this suddenly high variability on the abundance. Sensitivity analysis was made for different input parameters (see a resume on Table 9.5.1). A final trial was attempted using only the purse seine abundance index as a base case (Run4).

The model converged and shows a reasonable fitting of the cpue series (figure 9.5.1). Results show that the stock is currently inside the safe biological limits (figure 9.5.2), with 79% of probability of getting a biomass level above Bmsy (B/Bmsy>1) and a Fishing mortality lower than Fmsy (F/Fmsy<1) (Table 9.5.1 and Fig 9.5.3).

Table 9.5.1. Exploratory runs using production models (ASPIC 5.0) made for jack mackerel

Model, parameter	Base case for assessment		Sensitivity without 1988 and 1989 years	Sensitivity without Bait boats	Sensitivity without Bait boats and 1988, 1989 years	Sensitivity without Bait boats	Sensitivity without 1988 and 1989 years	Sensitivity without Bait boats	Sensitivity without 1988 and 1989 years	Sensitivity Run 04 for B1/K=1	Sensitivity Using Bait boat index only
Run number	Run04	Run01	Run02	Run03	Run04	Run05	Run06	Run07	Run08	Run09	Run10
Model	Fox	Fox	Fox	Fox	Fox	Logistic	Logistic	Logistic	Logistic	Fox	Fox
Index	PS	PS, BB	PS, BB	PS	PS	PS, BB	PS, BB	PS	PS	PS	BB
Year of data	1978-2011	1978-2011	1978-2011	1978-2011	1978-2011	1978-2012	1978-2013	1978-2011	1978-2011	1978-2012	1978-2013
Weighting of fishery		Equal	Equal			Equal	Equal	Equal			
Objecyive function	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV	LAV
Removed points	1988, 1989		1988, 1989		1988, 1989		1988, 1989		1988, 1989	1988, 1990	1988, 1990
MSY (t)	1,839	1,929	1,981	1,769	1,839	1,987	1,994	1,871	1,854	1,980	3,036
K (t)	83,280	69,280	73,400	93,450	83,280	63,670	68,340	70,860	77,300	73,930	86,850
B_{MSY} (t)	30,640	25,490	27,300	34,380	30,640	31,830	34,170	35,430	38,650	27,200	31,950
F_{MSY}	0.060	0.0756	0.0733	0.051	0.060	0.062	0.058	0.052	0.048	0.073	0.095
$B_{current}/B_{MSY}$	1.139	1.1	1.192	1.560	1.139	0.830	0.905	0.790	0.852	1.456	1.907
$F_{current}/F_{MSY}$	0.879	0.868	0.781	0.899	0.879	1.110	1.022	1.240	1.160	0.638	0.3188
phi	0.368	0.3679	0.3679	0.368	0.368	0.500	0.500	0.500	0.500	0.368	0.368
Equilibrium yield (t)	1,822	1,919	1,946	1,748	1,822	1,930	1,976	1,790	1,813	1,800	2,052
Convergence	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful	Successful
Bootstrap analysis	Successful										Successful

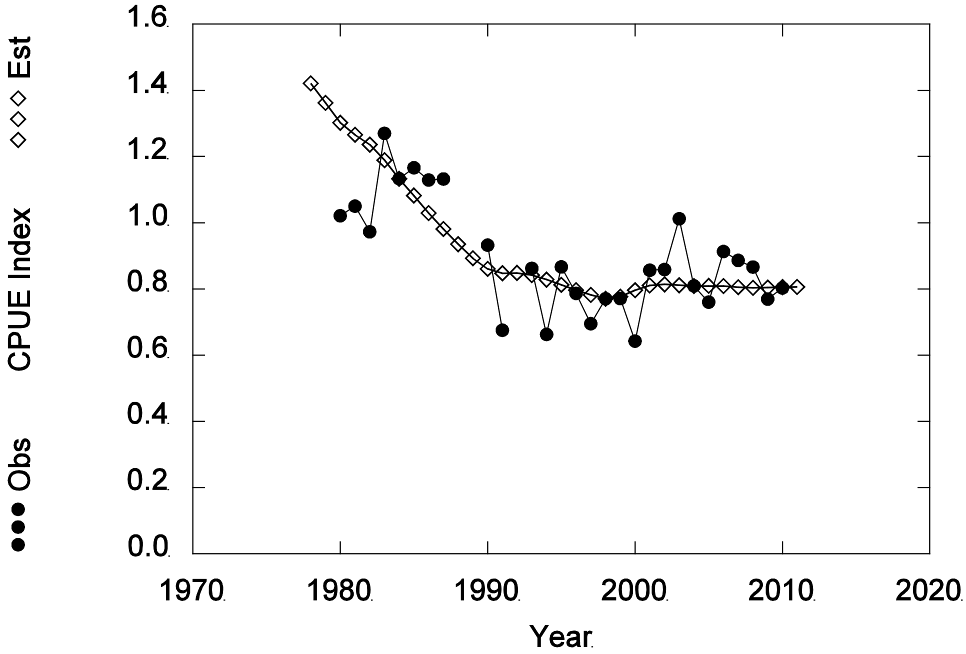


Figure 9.5.1. Trends of observed and estimated cpue in the base case production model for the Azores jack mackerel.

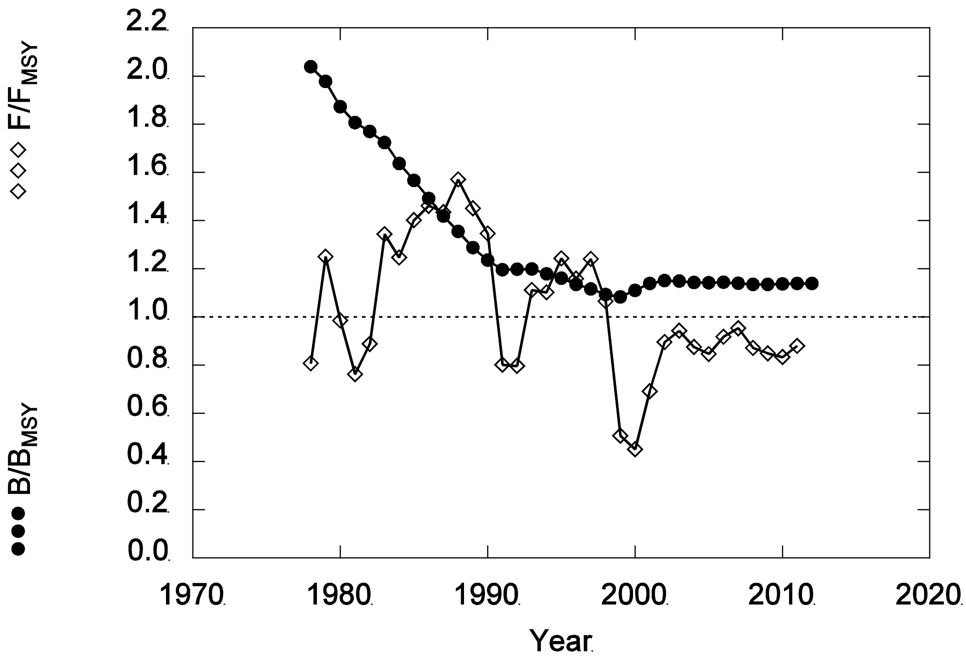


Figure 9.5.2. Relative biomass (B/Bmsy) and relative fishing mortality (F/Fmsy) trajectories estimated by the base case production model for the Azores jack mackerel.

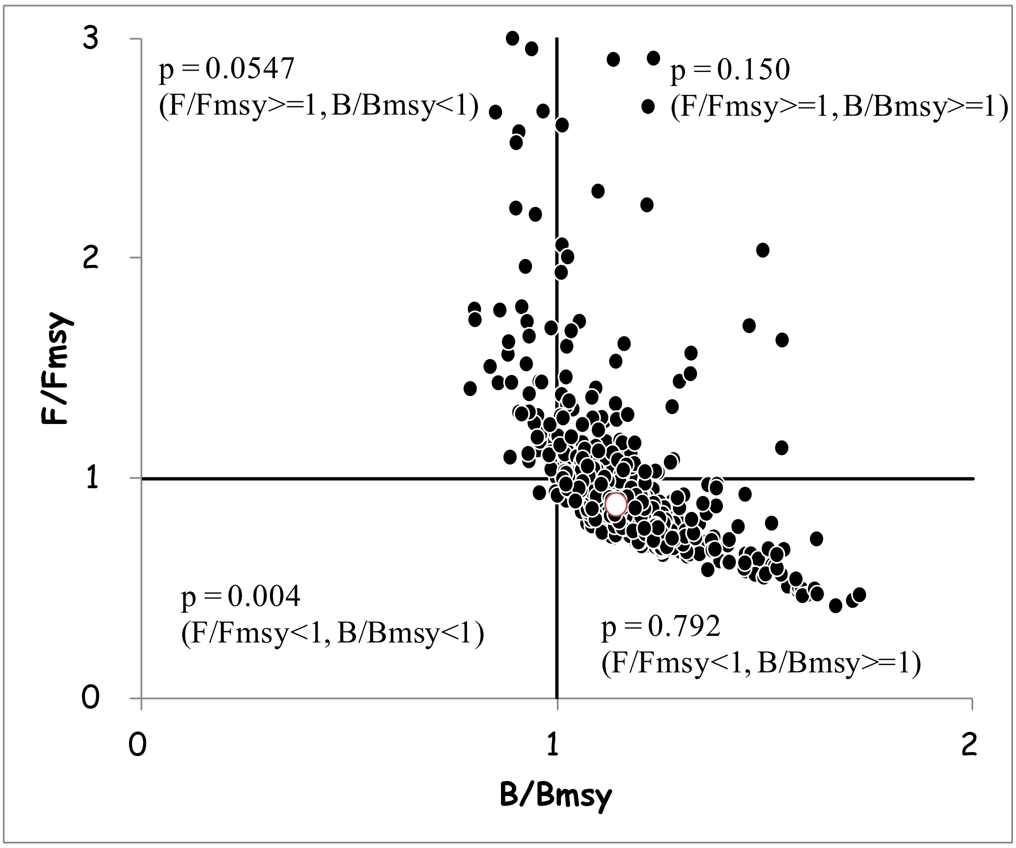


Figure 9.5.3. Results of bootstrap examination from the base case production model for the Azores jack mackerel. Biomass ratios and fishing mortality ratios for most recent year of assessment (2011). The model estimates a probability of 0.79 that the stock is not overfished and it is not undergoing overfishing. Points represent 1000 bootstraps, large circle correspond to median.

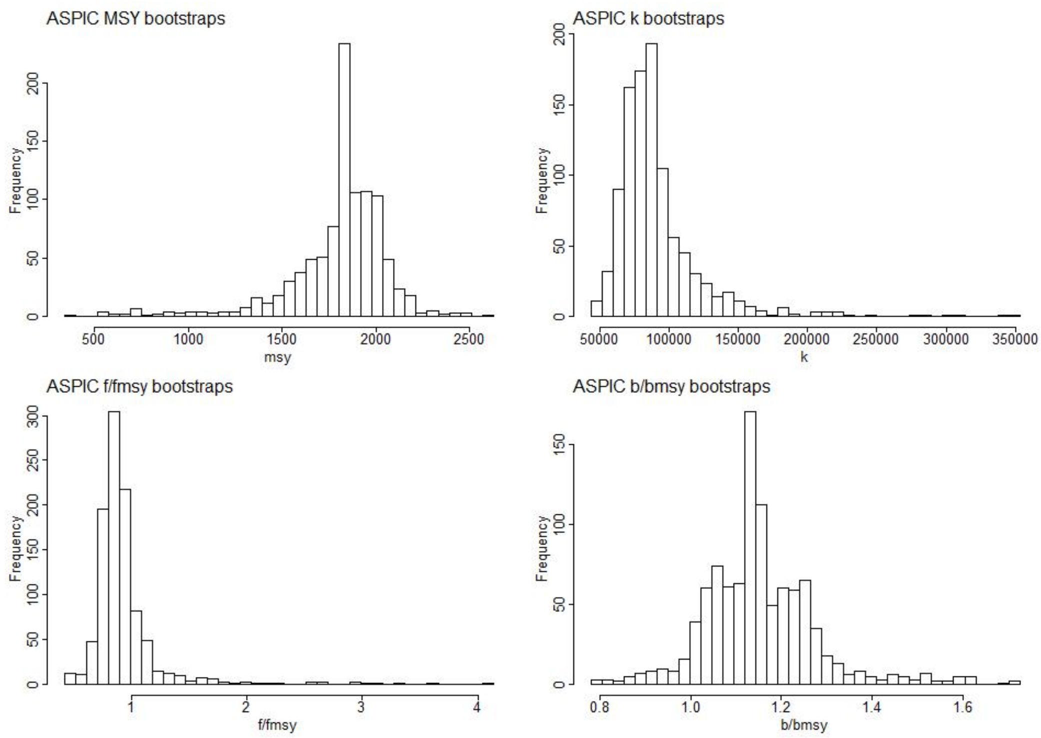


Figure 9.5.4. Histogram distribution of bootstrap results from the base case production model for the Azores jack mackerel.

9.5.4 Yield per recruit analysis

A YPR analysis was performed. The input parameters Loo=62,6 , K=0,08 To=-2,82, M=0,2, cm(L_{mat}/L_{inf})=0,44 and c(Lc/L_{inf})=0,22) were adopted.

An attempted was made to estimate total mortality (Z) from the catch curve applied to the fishery length frequency or age data. Length composition shows a clear differentiated mortality for juveniles (surface fisheries) and adults (hook and line fisheries). The estimated values were probably overestimated for the juveniles (Z= 2-4 $year^{-1}$) and adults (Z=0.4-0.7 $year^{-1}$), because of the gear selection effects. YPR results suggest that $F_{0.1}$ seems to be the appropriate target reference point for the species corresponding to a long term fishing mortality of F=0.11 $year^{-1}$.

	Fmax	**F0.1**	**$F_{20\%BPR}$**	**$F_{30\%BPR}$**	**$F_{35\%BPR}$**	**$F_{40\%BPR}$**
F	0,18	0,11	0,22	0,15	0,13	0,11
%BPR	0,25	0,40	0,20	0,30	0,35	0,40
%SPR	0,17	0,32	0,12	0,22	0,27	0,33

9.6 Management considerations

The catches of jack mackerel in recent years average 1850 tonnes. The jack mackerel is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman association, due to market restrictions. This stability of the catches is mostly observed in S. Miguel Island, where around 70% of the annual catches occur. Continuous reductions in the demands from the consumers lead to the catch limits auto adopted by the fleet, which explains the reduction observed in the catches along the recent years

Standardized cpue for the small purse seiners fishery shows that the relative abundance of jack mackerel as a stable trend in during the exploitation period. Standardized cpue for tuna bait boat fishery shows an increasing trend in the relative abundance of jack mackerel since 2006. In the case of the longliners, the decrease observed in the last 2 years is explained by the fact that the cpue is based on landings and the fleet has reduced its landings of 70% in recent years.

The production model estimates a probability of 0.79 that the stock is not overfished and it is not undergoing overfishing.

Considering the status of the stock and that the catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman association, there is no reason to make any changes to the current management measures.

10 Recommendations

WGANSA 2012 General Recommendations	to
The WGHANSA recommends that the BOCADEVA survey series (Anchovy in IXa DEPM survey) is maintained to scale properly the assessment of anchovy in Sub-division IXa South.	PGCCDBS
The WGHANSA considers PELACUS, PELAGO and ECOCÁDIZ surveys series as essential tools for the direct assessment of the population in their respective survey areas (Sub-divisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history.	PGCCDBS, RCM's
The WGHANSA recommends that the age composition of anchovy in Division IXa from the PELAGO survey continues to be reported to the WG.	PGCCDBS, RCM's
The WGHANSA recommends that anchovy catches in the western part of Division IXa are sampled whenever an outburst of the population in the area is detected.	PGCCDBS, RCM's
The WG demands that the Monitoring of sardine catches in VIIIab is assured as for subarea VII. This a requirement to achieve an assessment of the sardine populations in this areas.	PGCCDBS, RCM's
Priodicity of assessment for Jack Mackerel (every 2 o 3 years given the stability of the fishery and the workload associated to this species), Horse Mackerel (the same every two years). Even though catches and LPUE could be looked and updated every year.	ICES secretariat
The WGHANSA supports the realisation of a Portuguese Autumn survey in 2012 as a substiture of the PELAGO 2012 spring survey. An autumn survey will confirm the abundance of the 2011 yearclass and provide an estimate of the 2012 recruitment to support the assumption made in the 2012 WG short term forecast. Given the current low abundance of the stock, data on the 2012 recruitment is essential to evaluate the recovery of the spawning biomass in the short term,	PGCCDBS, RCM's
A Benchmark for anchovy in IXa is recommended for 2014.	ICES secretariat
The WGHANSA recommends that, unless proven inadequate, the data needed for calculation by the WG of horse mackerel landings continues to be submitted, including those missing this year regarding the year 2011. In case the calculation methods used in the past are considered to be not correct, a new time series of landings, from 1985 to present, calculated with a improved method, should be submitted to the WG.	PGCCDBS, RCM's, National Administrations
The WGHANSA recommends that the monitoring of the Bay of Biscay anchovy is continued and support by national administrations and EC throught the DCF, this refers to the French PELGAS acoustic survey (with the support provided by the consortium with fishermen) and the Spanish DEPM BIOMAN and acoustic JUVENA surveys	DCF & National Administrations

Data Problems Relevant to Data Collection

Stock	Data Problem	How to be addressed in DCR	By who
Stock name	***Data problem identification***	***Description of data problem and recommend solution***	***Who should take care of the recommended solution and who should be notified on this data issue.***
Anchovy in IXa South.	*Spanish surveys on anchovy in Cadiz (acoustic survey ECOCADIZ and DEPM BOCADEVA) which are one of the pillars for the trend assessment are not guarantee by Spanish administration and ot funded within the DCF.*	*Now that advise is required separately for the Souhern area (Cadiz) from the rest of Division IXa these survey need to be re-evaluated and funded by the EC through the DCF*	*PGCCDBS*
Anchovy in IXa South.	*Anchovy catches in Subdivisions IXa North, Central north and Central south are not routinely monitored for length or ages.*	*The WGHANSA recommends that anchovy catches in the western part of Division IXa are sampled by Spain and Portugal whenever an outburst of the population in the area is detected*	*PGCCDBS, RCM's*
Sardine in VIIIc and IXa ***Anchovy in IXa.***	*Both for sardine and anchovy in the area, an indication of the strength of incoming year classes would improve the advice on management.*	***The WG recommends DCR to economically support an autumn acoustic survey for provision of recruitment indices for sardine and anchovy. This could be addressed by a coordinated survey between IPIMAR and IEO, covering the NW of Portugal and Cadiz where major recruitment of sardine and anchovy occur.***	*ICES ACOM, SSGESST and PGCCDBS should support the idea of such a Survey and communicate to RCM and to relevant bodies accordingly* *The same idea was recommended by WGANSA and WGACEGG in 2009 and 2010*
Sardine in VIIIc and IXa and Anchovy in IXa.	*PELAGO acoustic survey do not always provide information on the age composition of anchovy encountered in division IXa*	*The WG recommends DCR to economically support the collection of otoliths and age reading for anchovy in this area*	*PGCCDBS*
Sardine in VIIIc and IXa	This year the acoustic survey PELAGO did not take place due to logistic problems. This increased the uncertainties surrounding the outlook for 2013	An autumn acoustic survey is recommended to assess the most recent levels of sardine recruitments.	*PGCCDBS should support the idea of such a Survey and communicate to RCM and to relevant bodies accordingly*

Stock	Data Problem	How to be addressed in DCR	By who
Sardine in subarea VII	The WG noticed that there is no monitoring program of sardine catches in subarea VII. This hampers assessment and provision of advice for this region	The WG demands that a Monitoring of sardine catches in subarea VII is requested and assured by countries involved in the fishery.	*PGCCDBS should support the idea and pass to RCM for inclusion in the DCF.*
Anchovy in Subarea VIII	JUVENA For the future management of this stock, a continuation of surveys to monitor anchovy juveniles in autumn is mandatory in order to provide indications of the incoming recruitment for the next year. JUVENA survey has proved its validity as indicator of next coming recruitment after 9 years of consecutive applications.	***DCR to economically support the continuation of the acoustic assessment of juveniles in the Bay of Biscay (JUVENA survey)***	*PGCCDBS should support the idea of continuation of such a Survey and communicate to RCM and to relevant bodies accordingly for its inclusion in DCF.*
Anchovy in Subarea VIII	Since 2007, the collaboration between the R/V Thalassa and commercial vessels has increased considerably the reliability of the abundance index estimate, particularly in terms of echoe determination (on average	The WG recommends the continuation through DCR or national fundings.	*PGCCDBS*

11 References:

Alday A., Uriarte A., Santos M., Martín I., Martinez de Murguia A., Motos L. 2008: Degeneration of postovulatory follicles of the Bay of Biscay anchovy (*Engraulis encrasicolus L.*). Sci. Mar., 72(3), September 2008, 565-575.

Caneco, B., Silva, A., Morais, A., 2004. Morphometric variation among anchovy (*Engraulis encrasicholus*, L.) populations from the Bay of Biscay and Iberian waters. ICES CM 2004/EE:24.

COM. 2009. Proposal for a council regulation establishing a long-term plan for the anchovy stock in the Bay of Biscay and the fisheries exploiting that stock.

Costa G, Pontes T, Mattiucci S, D'Amelio S (2003). The occurrence and infection dynamics of Anisakis larvae in the black-scabbard fish Aphanopus carbo, chub mackerel, Scomber japonicus and oceanic horse mackerel Trachurus picturatus from Madeira, Portugal. J. Helminthol. 77: 163-166.

Costa, G, Chubb, JC, Veltkamp, CJ (2000). Cystacanths of Bolbosoma vasculosum in the black scabbard fish Aphanopus carbo, oceanic horse mackerel Trachurus picturatus and common dolphin Delphinus delphis from Madeira, Portugal. Journal of Helminthology 74: 113-120.

De Oliveira, J.A.A., and Butterworth, D.S. 2005. Limits to the use of environmental indices to reduce risk and/or increase yield in the South African anchovy fishery. Afr. J. Mar. Sci. 27(1): 191-203.

De Oliveira, J.A.A., Uriarte, A., and Roel, B. 2005. Potential improvements in the management of Bay of Biscay anchovy by incorporating environmental indices as recruitment predictors. Fisheries Research 75(1-3): 2-14.

Fernandes, J. A., Irigoien, X., Goikoetxea, N., Lozano, J. A., Inza, I., Pérez, A., Bode, A. 2010. Fish recruitment prediction, using robust supervised classification methods. Ecological modelling 221: 338-352.

Gaevskaya, AV, Kovaleva, AA (1985). The parasite fauna of the oceanic horse-mackerel, Trachurus picturatus picturatus and eco-geographical characteristics of its formation. Ekologiya moray 20: 80-84 (translated from Russian).

Ganias, M. Rakka, T. Vavalidis, C. Nunes. 2010. Measuring batch fecundity using automated particle counting. Fisheries Research 106(3): 570-574

Gislason, H., Daan, N., Rice, J. & Pope, J. (2010) Size, growth, temperature and the natural mortality of marine fish. Fish and Fisheries, 11, 149-158.

González-Ortegón, E., M. D. Subida, J. A. Cuesta , A. M. Arias, C. Fernández-Delgado, P. Drake. 2010. The impact of extreme turbidity events on the nursery function of a temperate European estuary with regulated freshwater inflow. *Estuarine, Coastal and Shelf Science* 87: 311–324.

Gonçalves, MCB (1996). Parasitas internos do chicharro, Trachurus picturatus (Bowdich, 1825) da Madeira. Histopatologia e Prevalência. Diplom Thesis, Universidade da Madeira: 42pp.

Gouveia, MEP (1993). Aspectos da biologia do chicharro, Trachurus picturatus (Bowdich, 1825) da Madeira. Diplom thesis, University of Lisbon, Science Faculty: 153 pp.

Ibaibarriaga, L., Fernandez, C., Uriarte, A and Roel, B.A. 2008. A two-stage biomass dynamic model for the Bay of Biscay anchovy: A Bayesian Approach. ICES Journal of Marine Science, 65: 191 – 205.

Ibaibarriaga, L., Fernández, C., and Uriarte, A. 2011. Gaining information from commercial catch for a Bayesian two-stage biomass dynamic model: application to Bay of Biscay anchovy. – ICES Journal of Marine Science, 68: 1435–1446.

ICES, 2003. Report of the Workshop on Discard Sampling Methodology and Raising Procedures. Charlottenlund, Denmark, 2-4 September 2003.

ICES. 2003. Report of the Study Group on precautionary reference points for advice on fishery management. ICES CM 2003/ACFM:15.

ICES, 2006. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 27 November - 1 December 2006, Lisbon, Portugal. ICES C.M. 2007/LRC:18. 169 pp.

ICES. 2008 a. Report of the Workshop on Small Pelagics (*Sardina pilchardus*, *Engraulis encrasicolus*) maturity stages (WKSPMAT), 10–14 November 2008, Mazara del Vallo, Italy. ICES CM 2008/ACOM:40. 82 pp.

ICES. 2008 b. Report of the Working Group on Anchovy (WGANC), 13 - 16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

ICES. 2008 c. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17. 183 pp.

ICES. 2008. Report of the Study Group on Management Strategies (SGMAS), 17 - 21 November 2008, Lisbon, Portugal. ICES CM 2008/ACOM: 24. 74 pp.

ICES. 2009 a. Report of the Working Group on Anchovy and Sardine (WGANSA), 15 - 20 June 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:13. 354 pp.

ICES. 2009 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 16–20 November 2009, Lisbon, Portugal. ICES CM 2009/LRC:20. 181 pp.

ICES. 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT), 31 August–4 September 2009, Bergen, Norway. ICES CM 2009/ACOM:34. 166 pp.

ICES. 2010 a. Report of the Workshop on Age reading of European anchovy (WKARA), 9-13 November 2009, Sicily, Italy. ICES CM 2009/ACOM:43. 122 pp.

ICES, 2010 b. Report of the Working Group on Anchovy and Sardine (WGANSA), 24 -28 June 2010, Lisbon, Portugal. ICES CM 2010/ACOM: 16. 285 pp.

ICES, 2010 c. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 22-26 November 2010. ICES CM 2010/SSGESST:24. 210 pp.

ICES. 2010. Report of the Workshop on Implementing the ICES Fmsy framework (WKFRAME), 22-26 March 2010, Copenhagen, Denmark. ICES CM 2010/ACOM:54. 83 pp.

ICES, 2011 a. Report of the Working Group on Anchovy and Sardine (WGANSA), 24 -28 June 2011, Vigo, Spain. ICES CM 2011/ACOM: 16. 462 pp.

ICES, 2011 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 21-25 November 2011. ICES CM 2011/SSGESST: 20. 157 pp.

ICES. 2011. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks (WKBENCH 2011). ICES CM 2011/ACFM:38.

ICES. 2012. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2012), 13–17 February 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:47. 572 pp

ICES. 2012. Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE), 13–17 February 2012, Lisbon, Portugal . ICES CM 2012/ACOM:36. 122 pp.

INE 2012. Estatísticas da Pesca 2011. Instituto Nacional de Estatística, I.P. www.ine.pt.

Isidro, HA (1990). Age and growth of T. picturatus from the Azores. Arquipelago 8: 45-54.

Jesus, GT (1992). Estudo do crescimento e reprodução da espécie Trachurus picturatus (Bowdich, 1825) da Madeira. Direcção Regional das Pescas, Direcção de Serviços de Estudos e Investigação das Pescas: 66pp.

Kalfa-Papaioannou, AM, Athanassopoulou-Raptopoulou, F (1984). Incidence of coccidiosis in horse-mackerel (Trachurus trachurus, T. mediterraneus, T. picturatus) and sardines (Clupea pilchardus) from the North-Aegean Sea. Zbl. Vet. Med. B 31: 530-536.

Petitgas, P., Massé, J, Grellier, P. and Duhamel, E. 2010. Has the fishery closure affected anchovy mortality? Working document to WGANSA 2010.

Ramos F., Uriarte A., Millán M. and Villamor B., 2001. Trial analytical assessment for anchovy (*Engraulis encrasicolus*, L.) in ICES Subdivision IXa-South. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2002/ACFM:06

Ribeiro, R., Reis, J., Santos, C, Gonçalves, F., Soares, A.M.V.M., 1996. Spawning of anchovy *Engraulis encrasicolus* in the Mondego estuary, Portugal. Estuarine, Coastal and Shelf Science 42(4): 467-482.

Ruíz, J., García-Isarch, E., Huertas, I.E. *et al.* (2006) Meteorological forcing and ocean dynamics controlling *Engraulis encrasicolus* early life stages and catches in the Gulf of Cadiz. *Deep-Sea Res*. II 53:1363–1376.

Ruíz, J., González-Quirós, R., Prieto, L. and García-Lafuente, J., 2007. Anchovy in the Gulf of Cadiz: a case of BOTTOP control. GLOBEC International Newsletter 13:10–12.

Ruíz, J., González-Quirós, R., Prieto, L., Navarro, G., 2009. A Bayesian model for anchovy (*Engraulis encrasicolus*): the combined forcing of man and environment *Fish. Oceanogr*. 18:1, 62–76.

Shaboneyev, I Ye, Ryazantseva, I, Ye (1977). Population structure of the oceanic horse mackerel (Trachurus picturatus picturatus). J. Ichthyology 17 (6): 954-958.

Shaboneyev, I. Ye; Kotlyar, AN (1979). A comparative morphoecological analysis of the eastern pacific forms of Trachurus symmetricus and the Atlantic oceanic horse mackerel Trachurus picturatus picturatus. J. Ichthyology 19 (2): 24-29.

Smith-Vaniz, WF (1986). Carangidae. In "Whitehead, PJP, Bauchot, ML, Hureau, JC, Nielsen, J, Tortonese, E. Fishes of the northeastern Atlantic and the Mediterranean. Vol. II, Unesco, UK: 815-844.

Uriarte, A., Ibaibarriaga, L., Abaunza, P., Pawlosky, L., Massé, J., Petitgas, P., Santos, M. and D. Skagen. 2010. Assessing natural mortality of anchovy from survey's population and biomass estimates. Working document to WGANSA 2010.

Uriarte, A., Alday A., Santos M., Motos L. 2012. A re-evaluation of the spawning fraction estimation procedures for Bay of Biscay anchovy, a species with short interspawning intervals. Fisheries research 117-118: 96-111.

Wise, L., Silva, A., Ferreira, M., Silva, M.A., Siqueira, M., 2007. Interactions between small cetaceans and the purse-seine fishery in western Portuguese waters. *Scientia Marina* 71(2): 405-412.

Zarraonandía, I., 2011. Estudio genético poblacional de la anchoa europea (*Engraulis encrasicolus*). Tesis doctoral. Universidad del País Vasco. 282 pp.

Annex 1 List of Participants

Working Group on Anchovy, Sardine and Horse Mackerel

(WGHANSA)

23 - 28 June 2012

Horta, Azores, Portugal

LIST OF PARTICIPANTS

Name	Address	Phone/Fax	Email
Alberto Murta	IPIMAR Avenida de Brasilia 1449 – 006 Lisbon Portugal	+ 351 21 301 59 48	amurta@ipimar.pt
Alexanda (Xana) Silva	IPIMAR Avenida de Brasilia 1449 – 006 Lisbon Portugal	+ 351 21 301 59 48	asilva@ipimar.pt
Andres Uriarte	AZTI Herrera Kaia Portualde Z/G 20110 Pasaia Spain	+34 943004816 / 800	auriarte@azti.es
Erwan Duhamel	IFREMER 8 Rue Francois Toullec 56100 Lorient France	+	Erwan.Duhamel@ifremer.fr
Fernando Ramos	IEO Puerto Pesquero Mulle de Levante E 11006, Cadiz Spain	+34 956016290	fernando.ramos@cd.ieo.es
Gersom Costas	IEO Cabo Estai Canido 36200 PO BOX 1552 Vigo Spain	+ 34 986492111	gersom.costas@vi.ieo.es
Isabel Rivero	IEO Cabo Estai Canido 36200 PO BOX 1552 Vigo Spain	+ 34	isabel.riveiro@vi.ieo.es

Name	Address	Phone/Fax	Email
Leire Ibaibarriaga	AZTI Herrera Kaia Portualde Z/G 20110 Pasaia Spain	+ 34 943004800	libaibarriaga@azti.es
Lionel Pawlowski	IFREMER 8 Rue Francois Toullec 56100 Lorient France	+33 2 97 87 38 46	lionel.pawlowski@ifremer.fr
João Gil Pereira	Universidade dos Açores Departamento de Oceanografia e Pescas 9901-862 HORTA - PORTUGAL	Tel. (+351) 292 207 800, Fax: (+351) 292 207 811	pereira@uac.pt
Mario Rui Pinho	Universidade dos Açores Departamento de Oceanografia e Pescas 9901-862 HORTA - PORTUGAL	Tel. (+351) 292 207 810, Fax: (+351) 292 207 811	maiuka@uac.pt
Alexandra Garcia Guerreiro	Universidade dos Açores Departamento de Oceanografia e Pescas 9901-862 HORTA - PORTUGAL	Tel. (+351) 292 207 800, Fax: (+351) 292 207 811	agarcia@uac.pt

Annex 2 List of Working Documents and Presentations

Angélico, M. M., Díaz, P., Franco, C., Lago de Lanzós, A., Nunes, C., Pérez, J. R. WD 2012. Sardine 2011 DEPM – ICES areas IXa and VIIIc.

Abstract: The triennial DEPM for estimation of sardine spawning biomass for the Atlanto-Iberian stock areas IXa and VIIIc took place in the S and W (IPIMAR) from 10th February to 8th March and in the N (Galicia and Cantabrian Sea, IEO) between 26th March and 22th April. The 2011 winter/early spring season was characterized by very unstable oceanographic conditions with frequent events of gale force winds and periods of heavy rain. However, the ocean temperature values and distribution patterns were similar to observations from other years. Sampling was conducted according to planned despite the fact of a few interruptions due to adverse weather; the number of fishing samples was maintained at the levels from previous years but it was very clear that sardine schools were much less available than during the previous DEPM survey, in 2008. Unusual (unrealistic) observations for spawning fraction and batch fecundity in the S and W strata required the use of alternative information for the estimation of these parameters. Batch fecundity was achieved, using non-hydrated ovaries (using the oocytes at the migratory nucleus stage) while for the spawning fraction mean historic values per strata, were taken on. Spawning stock biomass (SSB) estimates were presented using 3 strata for all adult and egg parameters (P0 GLM model with 3 slopes, mortality, and 3 intercepts, P0). SSB estimate (S+W+N strata) was 465 x103 tons. This estimate is 30% lower than the 2008 value, but is the second highest biomass estimate of the historical series for the whole Iberian stock. The 2011 results lead to the following remarks:

- the spawning area for 2011 was smaller than in 2008 in all strata but particularly in the W and N shores, around 75 and 50 % respectively; on the whole, the total positive area was reduced to about 55%.
- total egg production estimates in all areas were lower than in 2008 when estimates are based in a model with 3 mortalities and 3 P0 values; mortality for S and W was higher than in previous years; the highest daily egg production per m2 (eggs/m2/day) was obtained for the southern coast
- mean female weights for all strata were similar to the 2008 estimates; the values calculated for the N strata (N and NW coasts of Spain) being higher than for the W and S strata
- mean batch fecundity considerably higher for the N than for the W and S strata; W and S estimates obtained by alternative methodology (MN oocytes), values in line with previous values
- the spawning fraction for the N strata in 2011 was higher than in the two previous surveys; for S and W, mean historic values were used
- the SSB estimate for 2011 using 3 strata for egg and adult parameter is lower than in 2008; the decrease was more accentuated for the W and N strata while for the S the value was close to the previous estimate
- the unusual observations concerning some of the adult parameters during the survey in areas S and W are under investigation and will be further discussed; results suggest an eventual temporary interruption of spawning in the S and SW (skipped full maturation and ovulation of one batch of oocytes)

- discussion on the preliminary estimates here presented and options taken for SSB estimation will be addressed at the WGACEGG in November 2012.

Duhamel, E., Massé, M., Doray, M., Baudiniere, E. WD 2012. Direct assessment of small pelagic fish by the PELGAS12 acoustic survey. PELGAS12 Survey Report.

Abstract: An acoustic survey was carried out in the Bay of Biscay from April 25st to June 5th on board the French research vessel Thalassa. The objective of PELGAS12 survey was to study the abundance and distribution of pelagic fish in the Bay of Biscay. The target species were mainly anchovy and sardine and were considered in a multi-specific context. To assess an optimum horizontal and vertical description of the area, two types of actions were combined: i) Continuous acquisition by storing acoustic data from five different frequencies and counting the number of fish eggs using CUFES system, and discrete sampling at stations. Commercial vessels were accompanying Thalassa for most of the time, such as to double the number of identifications hauls and increase the reliability of identification of echoes. This WD report acoustic assessments and length distributions of main species, age distribution for anchovy and sardine and some environmental data. Anchovy recruitment appears as one of the best one in the time series, with an index of abundance of 186 865 tons. Concerning sardine, the recruitment appears as a good level, and the biomass has been calculated at a level of 205 627 tons, which constitute a decrease from the three previous years.

Gil Pereira, J. and Ortiz, M. WD 2012. Standardized catch rates for jack mackerel (Trachurus picturatus) from the Azorean bait catch for the tuna fishery 1998-2011.

Abstract: Indices of abundance of jack mackerel (Trachurus picturatus) were estimated from the Azorean baitboat tuna fishery that catches this species as bait for their tuna operations for the period 1998-2011. The index of catch (kg) of fish per day of fishing operation was estimated from data collected by scientific observers and through the interview program. The standardization analysis procedure included the following variables; year, season, vessel class and area. The purse seine fleet operates primarily on the juvenile age groups of jack mackerel. The standardized index was estimated using Generalized Linear Mixed Models under a delta lognormal model approach. The standardized CPUE series shows a rather stable trend since the 1980's with the exception of 2008 and 2009 when the highest catch rates were observed. In recent years, the average catch rates are slight below compare to the earlier years.

Gil Pereira, J. and Ortiz, M. WD 2012. Standardized catch rates for jack mackerel (*Trachurus picturatus*) from the Azorean purse seine fishery 1980-2010.

Abstract: Indices of abundance of jack mackerel (Trachurus picturatus) from the Azorean purse seine fishery are presented for the period 1980-2010. The index of catch (kg) of fish per day of fishing operation was estimated from data collected by scientific observers through the interview program and from logbooks. The standardization analysis procedure included the following variables; year, season, vessel class and area. The purse seine fleet operates primarily on the juvenile age groups of jack mackerel. The standardized index was estimated using Generalized Linear Mixed Models under a delta lognormal model approach. The standardized CPUE series shows a rather stable trend since the 1980's with the exception of 2008 and 2009 when the highest catch rates were observed. In recent years, the average catch rates are slight below compare to the earlier years.

Gil Pereira, J., Reis, D., Canha, Â., Garcia, A. WD 2012. Biological data on jack mackerel (*Trachurus picturatus*) from the Azores.

Abstract: Biological data is presented for jack mackerel (*Trachurus picturatus*) caught in the Azores. Length weight relationships are given for the all population and for separate sexes. Biological data includes information on sex ratio, sexual maturity, reproduction and growth.

Ibaibarriaga, L., Uriarte, A., Sánchez, S. and G. Boyra. WD 2012. Potential use of the JUVENA survey for the assessment and management advice of anchovy in the Bay of Biscay.

Abstract: Since 2003 an autumn acoustic survey called JUVENA has been conducted annually to estimate the abundance of the juvenile anchovy. One of the terms of reference of the ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine in 2012 is to comment on the usefulness of the JUVENA juvenile abundance index for the assessment and for improving the forecast. This working document reviews the evaluation of the JUVENA juvenile abundance index as an indicator of recruitment strength and summarises previous work on the potential use of this index for management purposes. The log-linear model between this juvenile abundance index and recruitment as estimated in the assessment has shown to be significant with a coefficient of determination (R^2 = 93%), above the minimum level necessary to improve the provision of management advice. Recruitment forecasts based on the log-linear model have shown a reasonable good performance over the last three years. These forecasts could be used in the short or long term management advice. In both cases, this could imply a change on the management calendar from January to December, with a revision in June based on the most up-to-date assessment using information from the spring surveys (DEPM and acoustic).

Jiménez, M. P., Tornero, J., Solla, A. and F. Ramos. WD 2012. Gulf of Cádiz anchovy spawning stock biomass estimation through the application of DEPM in 2011.

Abstract: The DEPM to estimate the anchovy spawning-stock biomass (SSB) in the Gulf of Cádiz (ICES, Subdivision IXa South) is conducted every three years by IEO (Spain). The *BOCADEVA-0711* survey is the third in the series. The survey has been carried out on board RV *Cornide of Saavedra* (IEO) from 22st July to 2 August 2011. The surveyed area (13106.83 km^2) extends from Cape Trafalgar (Spain) to Cape San Vicente (Portugal), from 36º 11′ - 36º 47 N – 6º 12′ - –8º 54′ W). The sampling grid was established on the continental shelf with 21 transects perpendicular to the coast (8x3). Vertical hauls of plankton were carried out with a PairoVET (150 µm of mesh size), up to a maximum depth of 100 m. Sampling depth and temperature and salinity of the water column were recorded using a CTD SBE 37 fitted to the net. Flowmeters were used to calculate the volume of filtered water. Adult anchovy samples were obtained from pelagic trawl hauls. The location of the fishing stations was opportunistic, according to the echogram information. Except for searching anchovy females with hydrated gonads, fishing stations were mostly conducted during daylight hours. A total of 124 PairoVET stations were carried out. In 71 stations (57.3%) there was presence of anchovy eggs. A total of 2387 anchovy eggs were caught, and a mean density (in number/m^2) of 199 was obtained. No sardine eggs were caught. A total of 24 fishing operations were carried out during the survey, of which 22 were valid. Anchovy showed a high frequency of presence, with catches in 20 fishing stations. The mean yield per haul of anchovy (kg/h) was about 311 kg/h, a value much higher than the obtained in previous surveys. The total spawning area (*A*+) was 6770 Km^2 and the total egg production (P_{total}) was 1.87x10^{12} eggs/day. A total of 32757 tons (CV = 0.40) has been estimated for the whole Gulf of Cadiz. This value of biomass is very close to the average biomass estimated for this species in the area throughout the time-series of surveys (both acoustic and DEPM) carried out by the IEO since 2004.

Ortiz, M. and J. Gil Pereira. WD 2012. Standardized catch rates for Jack mackerel (*Trachurus picturatus*) from the Azorean longline fishery 1990-2010.

Abstract: Indices of abundance of jack mackerel (Trachurus picturatus) from the Azorean fishery are presented for the period 1990-2010. The index of catch (kg) of fish per number of hooks (thousand) was estimated from data collected by scientific observers through the interview program. The standardization analysis procedure included the following variables; year, season, vessel group and port of operation. Because the longline fleet operates over a wide range of species and habitats, a procedure was used to select fishing trips with a likelihood of catching jack mackerel. This procedure is based in a multispecies logistic regression based on the concurrence of species commonly caught in the same habitat. Once a subset of trips was selected, the standardized index was estimated using Generalized Linear Mixed Models under a delta lognormal model approach. The standardized CPUE series show that the relative abundance of jack mackerel varied in the early part of the series (1990-98) followed by an increase from 2000 until 2008 with the highest catch rates in 2008, followed by a decline in the latest years of the series.

Prista, N., Fernandes, A.C., Murta, A.G. and E. Soares. WD 2012. Discards of horse mackerel, anchovy and sardine by the Portuguese bottom otter trawl fleet operating in the Portuguese ICES Division IXa.

Abstract: We compile the information available on the discards of horse mackerel (Trachurus trachurus), anchovy (Engraulis encrasicolus) and sardine (Sardina pilchardus) produced by Portuguese vessels operating with bottom otter trawl (OTB) within the Portuguese reaches of ICES Division IXa. The data was collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2011. We present an overview of the on-board sampling programme, estimation algorithms, and data quality assurance procedures and provide results for two fisheries: the crustacean fishery (OTB_CRU) and the demersal fish fishery (OTB_DEF). The frequency of occurrence of anchovy, horse mackerel and sardine in discards of the OTB_CRU fishery is low and in the case of horse mackerel mostly related to by-catch limits imposed on this fishery. In what concerns the OTB_DEF fishery, discarding of these species was more frequent and mainly motivated by minimum landing size regulations (horse mackerel) and market forces (low commercial value of trawl-caught sardine and anchovy). In 2005, the annual estimate of horse mackerel discards produced by the OTB_DEF fishery was 61 tonnes (CV: 30%). The annual estimates of sardine discards produced by the OTB_DEF fishery were 588 (CV: 29%), 295 (CV: 22%), 434 (CV: 28%), 119 (CV: 36%) tonnes in 2004, 2005, 2010 and 2011, respectively. Details on the length structure and age composition of these annual discard estimates are given. Discards of anchovy (and discards of horse mackerel and sardine in other fishery × year combinations) were not estimated due difficulties in raising data when frequency of occurrence is low.

Santos, M. B., Iglesias, M., Miquel, J., Oñate, D., Villamor, B. and I. Riveiro. WD 2012. PELACUS0412 estimates of sardine and anchovy in Galicia and Cantabrian waters.

Abstract: A total of 17,377 tons of sardine (217 million fish) was estimated to be present in northwest and northern Spanish waters by the Spanish spring acoustic survey PELACUS0412 carried out from 27th March to 21th April 2012. Fish were mainly found in Galicia (ICES sub-areas IXa-N and VIIIcW) and was almost absent from the

rest of the surveyed area. Most fish were 3-year old (born in 2009), although age 4 fish predominated in western Cantabrian waters (ICES sub-area VIIIcE-w). The 2012 estimates represent an increase of 7.7% in biomass and 43.7 in abundance with respect the values obtained in 2011 but the current figures are still among the lowest of the time series. Anchovy showed a marked reduction in biomass, abundance and distribution in the area prospected by the survey with only 52 tons estimated this year compared with the 2701 tons detected during the 2011 survey.

Results from the CUFES data indicated an order of magnitude decrease in the number of sardine eggs (only 1665 were determined in Spanish waters) and number of positive stations has continued to decrease since 2010 with gaps now apparent in egg distribution (mainly located in northern Galicia and Asturias). For anchovy, eggs were almost absent from the survey (only found in some numbers in the Galician rias) in contrast with the situation in 2011.

Santos, M., Ibaibarriaga, L. and A. Uriarte. WD 2012. Preliminary Spawning Stock Biomass estimates for the Bay of Biscay anchovy (*Engraulis encrasicolus, L.*) applying the DEPM.

Abstract: The research survey BIOMAN 2012 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy was conducted in May 2012 from the 10th to the 30th covering the whole spawning area of the species. Two vessels were used: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 80,381Km2 and the spawning area was 38,974Km2. During the survey 529 plankton samples were obtained and 42 pelagic trawls were performed, from which 28 contained anchovy and 24 of them were selected for the analysis. No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45′N in the French platform and the northern limit was found at 47º15′N. The eggs in the French platform were encountered in the historical common places: Between Adour and Arcachon and in the area of influence of Le Gironde. The sampling was stopped for 12 hours due to bad weather at 47º23′N after 22 days of survey. The conditions of the survey were in general wintry, with a mean SST of 14.9. Two preliminary estimates are presented: A preliminary SSB estimate is obtained, as in previous years, as the ratio between the total daily egg production (Ptot) and the mean historical daily fecundity (DF). Ptot is calculated as the product of the spawning area and the daily egg production rate (P0), which is obtained from the exponential mortality model fitted as a Generalized Linear Model (GLM) to the abundance of the daily egg cohorts obtained from the plankton survey. As the adults samples are not fully processed yet, the DF is taken as a mean of the historical DF series. This results in a preliminary biomass estimate of 34,144 t, with a coefficient of variation of 27%. A second estimate was based on a first analysis of the adult samples to derive the parameters defining the Daily Fecundity, with the exception of the spawning frequency, i.e, sex ratio, mean weight of females and preliminary estimates of Batch Fecundity. For the spawning frequency the historical mean was adopted. This estimate results in a biomass of 36,200 t, with a CV of 20%. We suggest to adopt this second estimate to input the assessment, given that make the major use of the data collected during the survey, and should be quite similar to the final one expected by November 2012. Both estimates are very similar and around the same level as recorded in 2010. Approximately 56% of the anchovy were individuals of age 2 (70% in mass) and 44% of age 1 (30% in mass).

Soares, E., Silva, A., Villamor, B. and C. Dueñas Liaño. WD 2012. Age determination of the anchovy (*Engraulis encrasicolus*, L. 1758) off the Portuguese coast in 2011.

Abstract: This document presents the age reading results from the analysis of 645 anchovy otoliths sampled in 2011 during acoustic research surveys undertaken in Spring and Autumn and also collected from biological sampling in the fishing harbours of Matosinhos (Portuguese Northern West coast) and Portimão (Southern Coast). A sub-sample of 60 otoliths sampled in an IPIMAR acoustic survey in spring 2011 was exchanged with IEO (Santander), which readings were taken as reference. A first reading of this sample without knowing the IEO results was undertaken by both IPIMAR readers independently. A second reading was then held after a discussion having the IEO readings as a reference. There was a clear and considerable improvement of age reading both between IPIMAR readers as between these and the IEO reader (Table IV) from the first to the second reading of these otoliths. From the results and although the IPIMAR readers have still limited experience on the ageing of anchovy otoliths, it can be considered that the final consensual readings are nevertheless reliable.

Ramos, F.: Qualitative assessment of Anchovy in Division IXa: Data & Trends.

Ramos, F.: Qualitative assessment of Anchovy in Division IXa: Qualitative assessment.

Riveiro, I., Santos, B. and A. Silva. Results from the 2011/2012 surveys, overview of 2011 landings and preliminary assessment.

Abstract: This presentation summarises the surveys results and catch data to update the assessment and shows the results of the preliminary assessment.

Silva, A. Portuguese regulations for sardine.

Abstract: This presentation summarises the 2011 and 2012 regulations applicable to the Portuguese sardine fishery by the Portuguese management authorities. Since 2010, annual catch limits are set for the Portuguese fishery by the Portuguese authorities. Catch limits are set for the civil year and admit a in-year revision following the publication of the ICES Advice. In 2010 and 2011, the catch limit was 55 thousand t and landings were 63 and 57 thousand t, respectively. In 2012 the catch limit was set at 36 thousand t and catch of sardine was banned for 45 days during the first quarter of the year (Despacho n.º 1517/2012, DR 2.ª série, 23, 1 February 2012; Despacho n.º 7509/2012, DR 2.ª série, 106, 31 May 2012). Catch and effort limitations, as well as a harvest control rule, have recently been integrated in a management plan for the fishery (http://www.dgrm.min-agricultura.pt/xportal/xmain?xpid=dgrm&selectedmenu=107304&xpgid=genericPage&conteudoDetalhe=209429). The HCR was developed within a MSE framework. The HCR is catch-based, considers a target catch of 86 thousand t, and takes into account the reference points proposed in the benchmark assessment. The output catch is based on B1+ estimate for the interim year, as estimated in the ICES assessment. The evaluation of the HCR (assuming no implementation error) was shown to allow B1+ to increase in the short term so that the probability that B1+<Blim in 2015 is less than 18% while F remains below Fmsy=0.35. This management plan has not been evaluated by ICES.

Silva, A., Riveiro, I., Santos, B. and A. Uriarte. SARDINE IN VIIIc and IXa: Benchmark Results.

Abstract: This presentation summarises the work done and main conclusions taken on the benchmark assessment (WKPELA 2012) regarding: stock identity, revision of DEPM, acoustic surveys intercalibration, uncertainty of acoustic surveys, predation by marine mammals,maturity ogive and natural mortality, assumptions of fishery and survey selectivity. The results of the assessment, reference points and short term forecasts are presented, as well as a list of topics for future research and data requirements. Finally, the major comments of external reviewers are presented.

Soares, E., A. Silva, B. Villamor, C. Dueñas Liaño: Age determination of the anchovy (*Engraulis encrasicolus*, L. 1758) off the Portuguese coast in 2011.

Annex 3 Appending Relevant Working Documents

Working Document for WGHANSA (Horta, June. 2012)

Direct assessment of small pelagic fish by the PELGAS12 acoustic survey

, Erwan Duhamel[1], Jacques Massé[2], Mathieu Doray[2], Estelle Baudiniere[3]

Special thanks to, Martin Huret[1], Florence Sanchez[4], Pierre Petitgas[2],Lionel Pawlowsk[1]

(1) IFREMER, lab. Fisheries Research, 8 rue François Toullec 56100 Lorient, France.
[tel: +33 297 87 38 37, fax: +33 297 87 38 36, e-mail: Erwan.Duhamel@ifremer.fr
(2) IFREMER, lab. Fisheries Ecology, BP 21105, F- 44311, Nantes, France.
[tel: +33 240 374000, fax: +33 240 374075, e-mail: Jacques.Masse@ifremer.fr]
(3) CNPMEM, 134 avenue de Malakoff, 75116 PARIS
(4) IFREMER, lab Fisheries Research, UFR Côte Basque, 1 allée du Parc Montaury, 64600 Anglet, France, e-mail : Florence.Sanchez@ifremer.fr

1. Material and method

1.1. PELGAS survey on board Thalassa

Acoustic surveys are carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area covered from Gibraltar to Brest with the same protocol regarding sampling strategy. . Data are available for the ICES working groups WGHANSA, WGWIDE and WGACEGG.

In the spirit of the ecosystemic approach, the pelagic ecosystem is characterized at each trophic level. To achieve this and to assess an optimum horizontal and vertical description of the area, two types of actions are combined :

1) Continuous acquisition of acoustic data from six different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler)), and
2) discrete sampling at stations (by trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modeling have been also used before and during the cruise to recognise the main physical and biological structures and to improve the

sampling strategy. Concurrently, a visual counting and identification of cetaceans and birds (from board) carried out in order to characterise the higher level predators of the pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2011). The protocol for acoustics has been described during WGACEGG in 2009 (*Doray et. Al, 2009*):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).

-acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo sounder between the surface and 8 m depth.

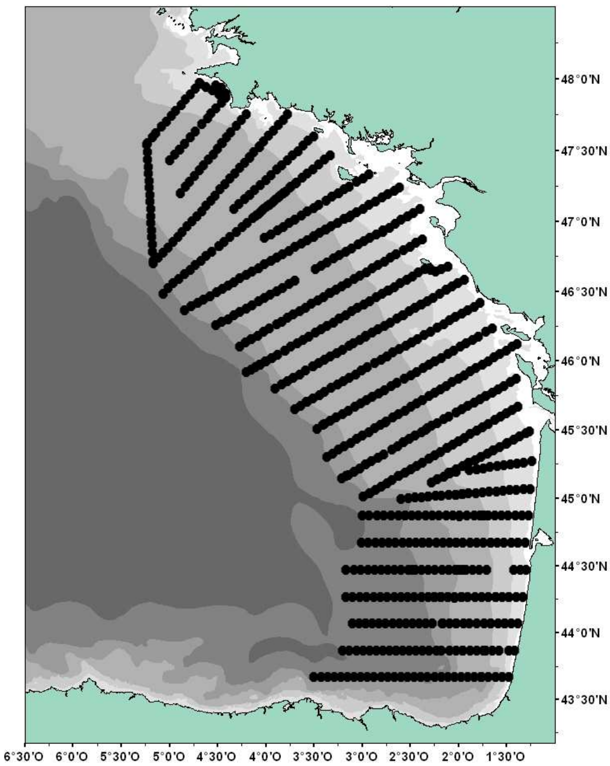


Fig. 1.1.1 - Transects prospected during PELGAS12 by Thalassa.

Three different echosouders were used during the survey :

In 2012, as in previous surveys (since 2009), three modes of acoustic observations were used :

- 6 split beam vertical echosounders (EK60), 6 frequencies, 18, 38, 70, 120, 200 and 333 kHz
- 1 horizontal echosounder on the starboard side for surface echo-traces
- 1 SIMRAD ME70 multi-beam echosounder (32 x 2°beams, from 70 to 120 kHz) used essentially for visualisation to observe the behaviour and shapes of fish schools during

the whole survey.. Nevertheless, only echoes stored on the vertical echosounder were used for abundance index calculation.

Energies and samples provided by all sounders were simultaneously visualised and stored using the MOVIES+ and MOVIES3D software and stored at the same standard HAC format.

The calibration method was the same that the one described for the previous years (see WD 2001) and was performed at anchorage in the Douarnenez bay, in the West of Brittany, in optimum meteorological conditions at the end of the survey (another calibration was done during PELACUS some weeks before).

Acoustic data were collected by R/V Thalassa along a total amount of 6500 nautical miles from which 2025 nautical miles on one way transect were used for assessment. A total of 27155 fishes were measured onboard Thalassa (including 10205 anchovies and 5228 sardines) and 3124 otoliths were collected for age determinations (1811 anchovy and 1313 sardine).

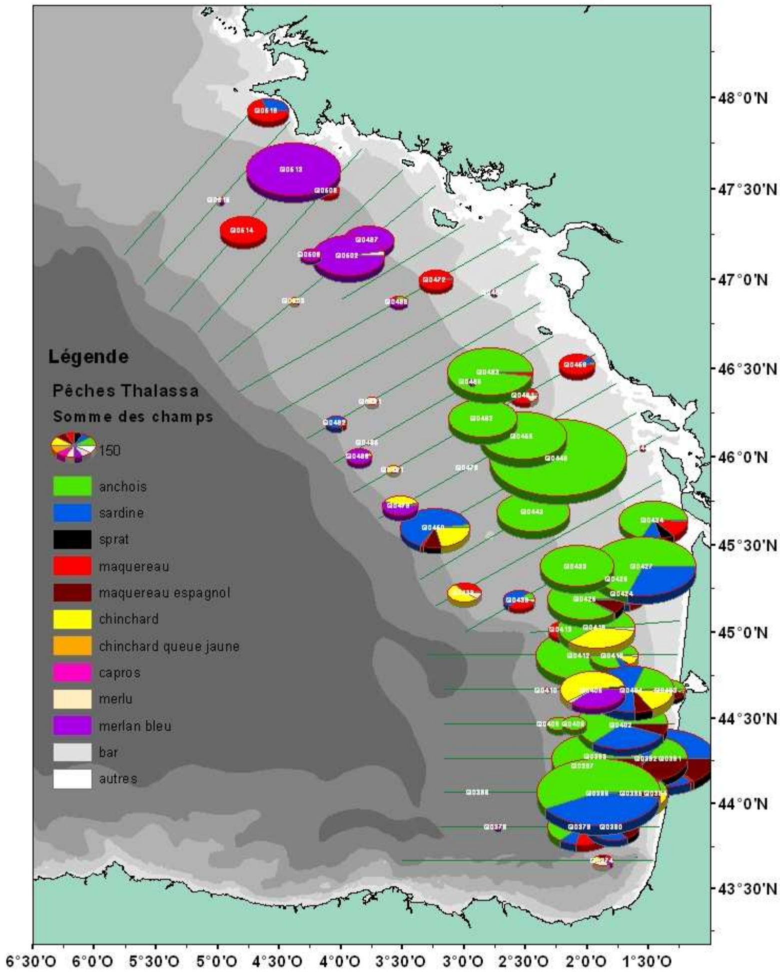


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2. The consort survey

A consort survey is routinely organized since 2007 with French pair trawlers during the 18 first days. This approach, in the continuity of last year survey, and the commercial vessels hauls were used for echo identification and biological parameters at the same level than Thalassa ones.

Four commercial vessels (two pairs of pelagic trawlers) participated to PELGAS12 survey:

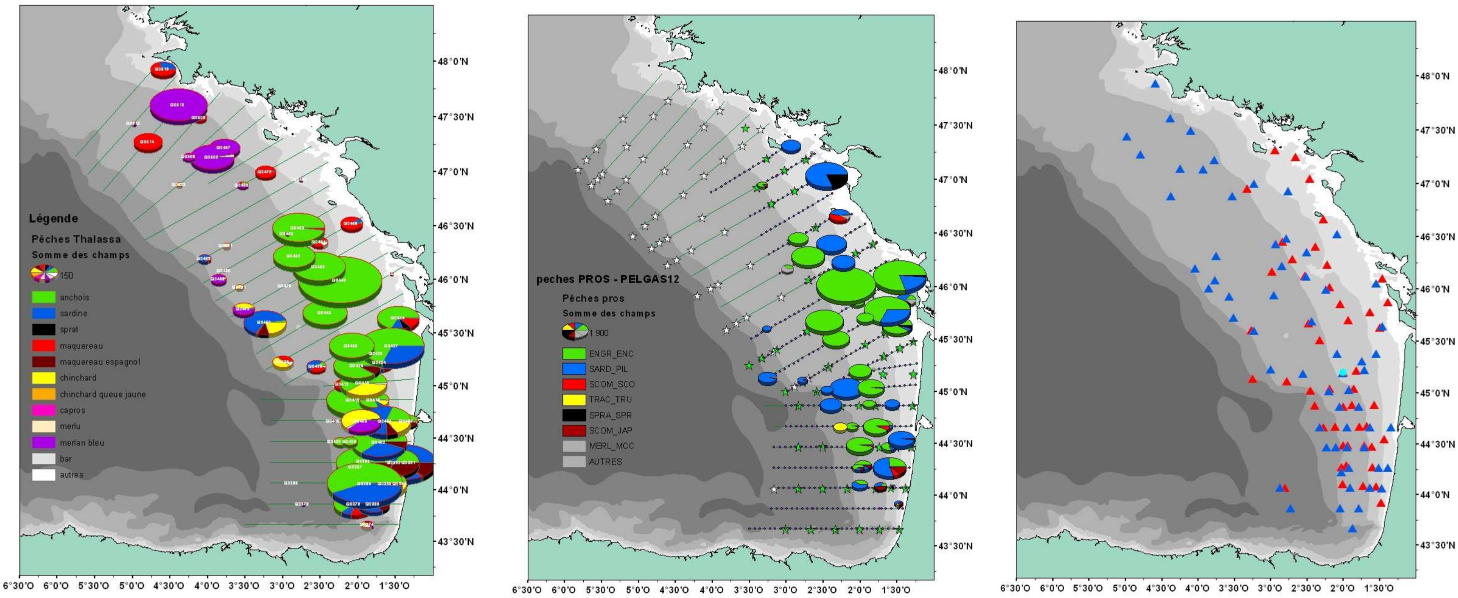
Vessel	gear	Period	Days at sea
Jérémi-Simon / Prométhée	Pelagic pair trawl	27/04 to 05/05/2011	9
Joker / Ar Raok	Pelagic pair trawl	05/05 to 13/05/2011	9

The transects network agreed for several years for Thalassa is 12 miles separated parallel transects. Commercial vessels worked between standard transects and 4 NM northern. Sometimes, they carried out fishing operations on request (complementary to Thalassa, particularly for surface hauls or in very coastal areas) Their pelagic trawl was until 25 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).

A scientific observer was onboard to control every operation, and to collect biological data. The fishing operations were systematically agreed after a radio contact with Thalassa in order to confirm their usefulness. In some occasions, the use was to check the spatial extension of species already observed and identified by Thalassa (and therefore the spatial distribution), in others the objective was to enlarge the vertical distribution description by stratified catches. Globally, a great attention was given on a good distribution of samples to avoid over-sampling on some situations. Regularly a biological sample was provided by commercial vessels to Thalassa to improve otoliths collection and sexual maturity (14 samples of sardine, 15 of anchovy). A total of 7279 fishes were measured onboard commercial vessels, including 2968 anchovies and 2671 sardines.

The catches and biological data have been directly used with the same consideration than Thalassa ones for identification and biological characterisation.

A total of 108 hauls were carried out during the assessment coverage including 59 hauls by Thalassa and 49 hauls by commercial vessels.



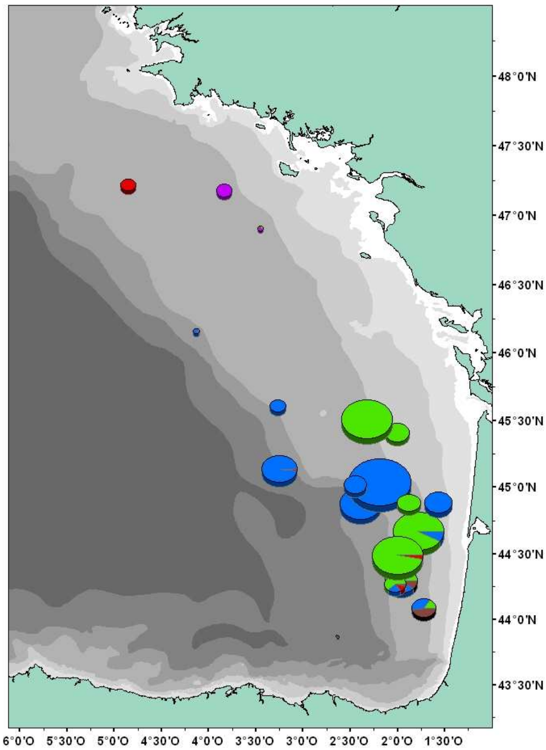
a) Thalassa (nb :59) *b) Commercial vessels (nb : 49)* *c) all fishing hauls (nb :108)*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS12

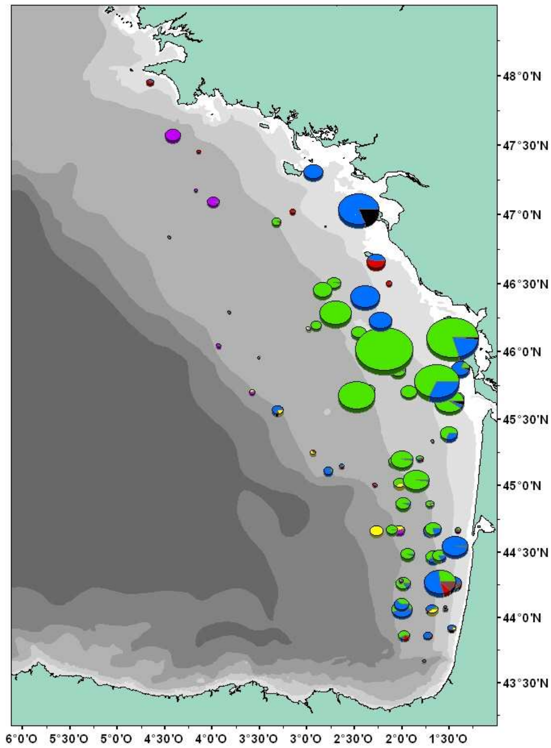
The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and furthermore, to verify that both scientists and fishermen observe the same types of echo-traces and have similar interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check if the catches were well comparable (in proportion of species and, most of the time, in quantity as well). As last year, the fishing operations by commercial vessels were carried out only during day time (as for Thalassa) each time it was necessary and preferentially at the surface or in mid-water, since the pair trawlers are more efficient at surface than single back trawlers.

	R/V Thalassa	Commercial vessels	Total
Surface Hauls	8	13	21
Classic Hauls	45	30	75
Valid	53	43	96
Null	6	6	12
Total	59	49	108

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS12



a) Hauls carried out at surface or in mid-water levels (Thalassa & commercial vessels)



b) classic Hauls carried out closed to the bottom and 50m upper (Thalassa + commercial vessels)

Figure 1.2.4 : Vertical localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS12

2. Acoustics data processing

2.1. Echo-traces classification

All the acoustic data along the transects were processed and scrutinised by the date of the meeting (figure 2.2.1). Acoustic energies (Sa) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 5 categories of echo-traces :

D1 – energies attributed to mackerel, horse mackerel, blue whiting, various demersal fish, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sprat, sardine and herring corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well defined, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometimes more offshore.

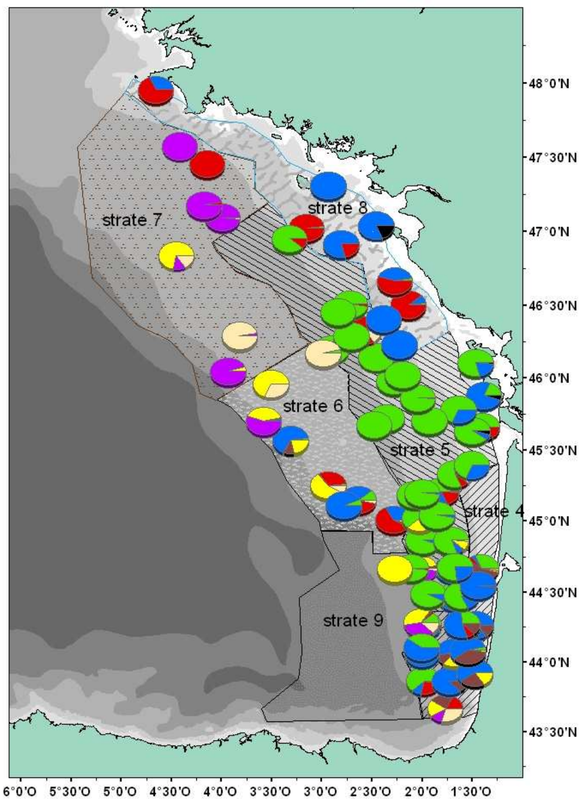
D3 – energies attributed to blue whiting, myctophids and capros aper offshore, just closed to the shelf-break and on the platform in the north.

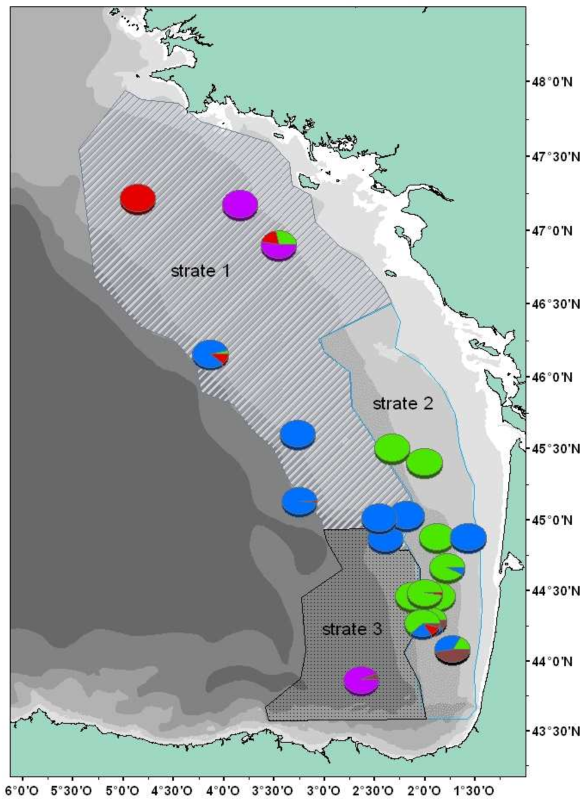
D4 – energies attributed to sardine, mackerel and anchovy corresponding to small and dense echoes, very close to the surface.

D8 – energies attributed exclusively to sardine (big and very dense schools).

2.2. Splitting of energies into species

As for previous years (except in 2003, see WD-2003), the global area has been split into several strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species. Figure 2.2. shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.





Coherent classic strata   Coherent surface strata

Fig. 2.2. – Coherent strata (classic and surface), in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS12 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to profit of the best efficiency of each vessel and maximise the number of samples (in term of identification and biological parameters as well). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fish preferably in the bottom layer. According to previous strata, using both Thalassa and consort fishing operations, biomass estimates have been calculated for each main pelagic species in the surveyed area.

Biomass indices are gathered in table 2.3.1. and 2.3.2. and figure 2.3.1.. No estimate has been provided for mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is totally scattered and mixed with soft plankton echoes.

Anchovy was present this year upon 15 consecutive transects as a thich layer of dense schools, from the Spanish coast to the Loire river. 45 hauls identified this species most of the time as single species from the bottom to the surface. The calculated abundance index for anchovy is therefore very high and appears a the maximum abundance observed since the 80s. A particularly dense concentration was observed close to the coast in Gironde river plume (acoustic energies were up to 10 times more than anywhere else on the platform) which revealed from 3 different hauls more than 90% of immature age 1 (length about 10cm).

Sardine was less present than in previous years and mostly in coastal waters in South of Brittany. It was also spotted offshore, in low quantities, close to the surface.

About other species, the main characteristic of this year is that mackerel and horse mackerel were very rare, scattered along the shelf. Another particularity of this year is the presence of very dense schools of blue whiting on the platform in the northern area . This behaviour for this species is very unusual, but several hauls confirmed this situation during the last week of surveying.

	strata	**area**	**anchovy**	**sardine**
SURFACE	1	12 847	704	14 035
	2	4 906	27 700	1 846
	3	-	0	0
CLASSIC	4	2 016	13 620	39 961
	5	4 912	139 741	35 239
	6	3 301	2 488	9 637
	7	7 622	1 343	0
	8	3 160	1 268	104 909
	SUM		186 865	205 627

Table 2.3.1. Acoustic biomass index for sardine and anchovy by strata during PELGAS12

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
anchovy	**113 120**	**105 801**	**110 566**	**30 632**	**45 965**	**14 643**	**30 877**	**40 876**	**37 574**	**34 855**	**86 354**	**142 601**	**186 865**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*		
Sardine	**376 442**	**383 515**	**563 880**	**111 234**	**496 371**	**435 287**	**234 128**	**126 237**	**460 727**	**479 684**	**457 081**	**338 468**	**205 627**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*		
Sprat	**30 034**	**137 908**	**77 812**	**23 994**	**15 807**	**72 684**	**30 009**	**17 312**	**50 092**	**112 497**	**67 046**	**34 726**	**6 417**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*		
Horse mackerel	**230 530**	**149 053**	**191 258**	**198 528**	**186 046**	**181 448**	**156 300**	**45 098**	**100 406**	**56 593**	**11 662**	**61 237**	**7 435**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*		
Blue Whiting	**-**	**-**	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**
CV BW	*-*	*-*	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*		

Table 2.3.2. Acoustic biomass index for the five main pelagic species since the beginning of PELGAS surveys (2000)

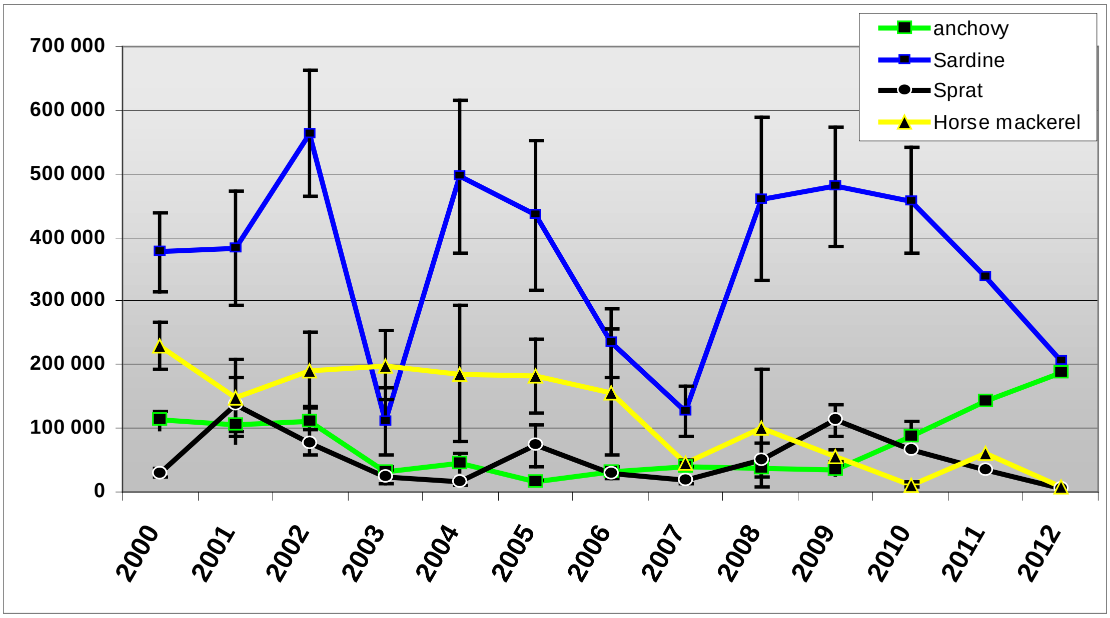


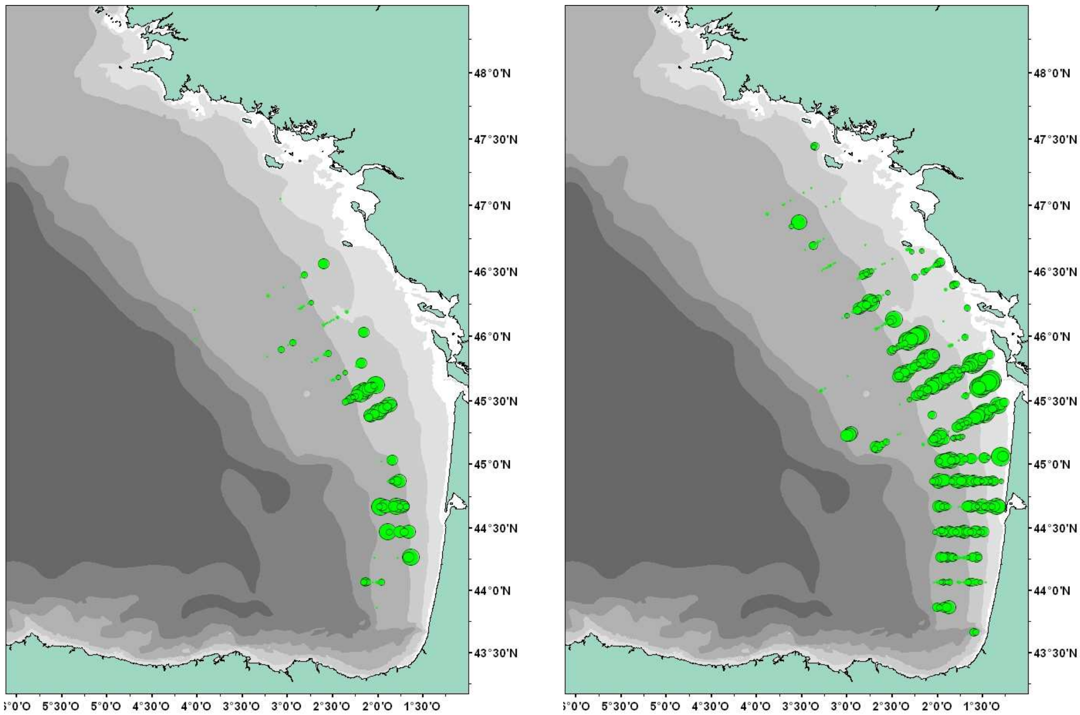
figure 2.3.1. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + pair trawlers) and coefficients of variation associated.

3. Anchovy data

3.1. anchovy biomass

The main observation in 2012 is that anchovy is very well present in the centre of the bay of Biscay, from the South until the Yeu island, and from coastal waters (very small anchovies, particularly at the Gironde) to the shelf break (bigger individuals, but in lower quantity than last year).

On the platform, anchovy echo-traces were most of the time vertically distributed between 15 m above the bottom until 50 to 70 m above, as in 2010 and 2011. It was in some areas very dense, providing very high values of SA. These echoes were systematically identified on each transect and revealed most of the time pure anchovy or at least a majority of anchovy. Their geographic distribution showed a rather continuous layer along about 200 nm from south to north betwen the 80 to100 m bottom depth. . A particular dense concentration of very small anchovies was observed close to the coast in front of the Gironde.



Surface distribution

Classic distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS12 survey.

3.2. Anchovy length structure

Length distribution in the trawl haul were estimated from random samples. The population length distributions (figures 3.2.1 and 3.2.2) has been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul.

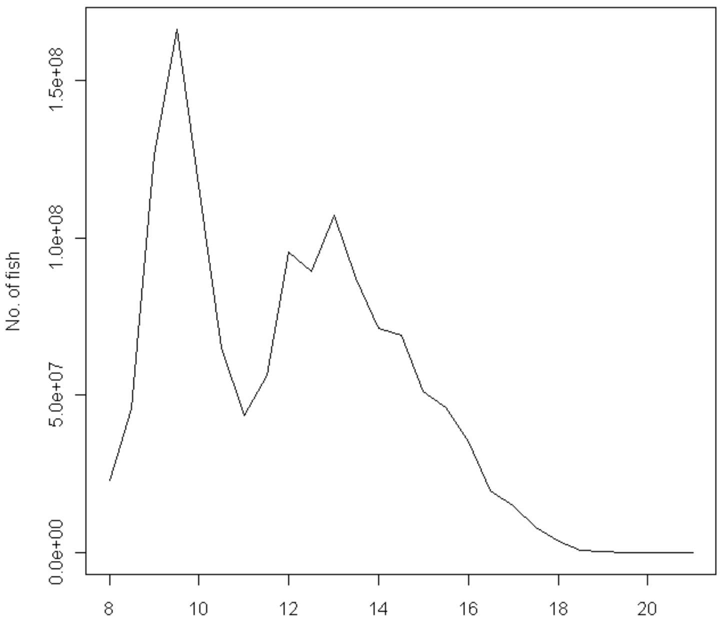


Figure 3.2.1: length distribution of global anchovy as observed during PELGAS12 survey

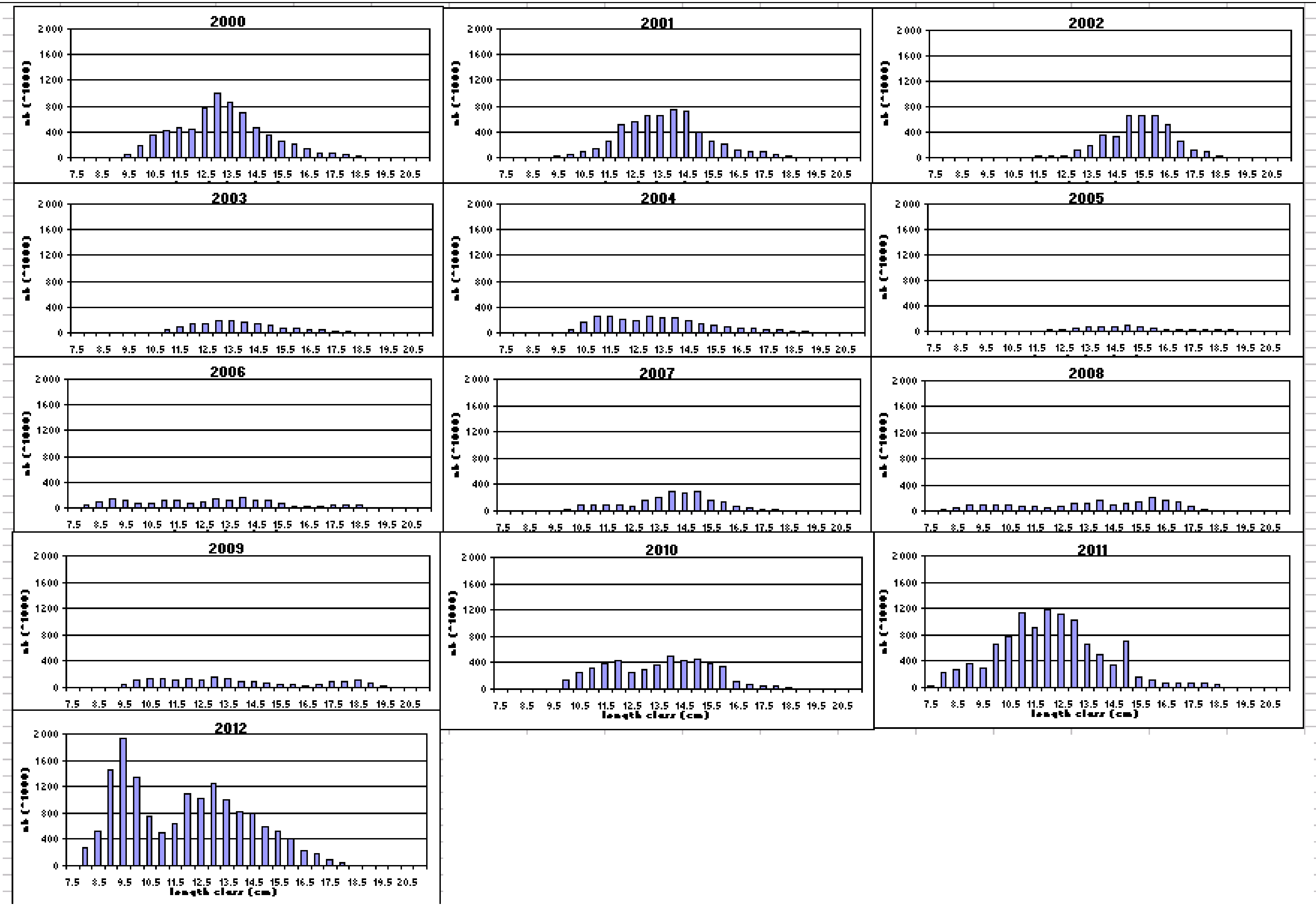


Figure 3.2.2. – length composition of anchovy as estimated by acoustics since 2000

.

3.3. Demographic structure

An age length key was built for anchovy from the trawl catches (Thalassa hauls) and samples from commercial vessels. We took the otoliths from a set number of fishes per length class (4 to 6 /half-cm), for a total amount of around 50 fish per haul. As there was a lot of fishing operations where anchovy was present, the number of otoliths we took during the survey was more or less the same as last year, and the double of each previous years (1764 anchovies aged in 2012).

The population length distributions were estimated by a weighted use of length distributions in the hauls Weighted as decribed in section 3.2. .

NB Age	Age				
Length (mm)	1	2	3	4	Total
75	100.00%	0.00%	0.00%	0.00%	100.00%
80	100.00%	0.00%	0.00%	0.00%	100.00%
85	100.00%	0.00%	0.00%	0.00%	100.00%
90	100.00%	0.00%	0.00%	0.00%	100.00%
95	100.00%	0.00%	0.00%	0.00%	100.00%
100	100.00%	0.00%	0.00%	0.00%	100.00%
105	95.45%	4.55%	0.00%	0.00%	100.00%
110	92.68%	4.88%	2.44%	0.00%	100.00%
115	93.75%	6.25%	0.00%	0.00%	100.00%
120	90.79%	9.21%	0.00%	0.00%	100.00%
125	84.62%	14.42%	0.96%	0.00%	100.00%
130	70.07%	29.20%	0.73%	0.00%	100.00%
135	57.14%	40.60%	2.26%	0.00%	100.00%
140	41.29%	58.71%	0.00%	0.00%	100.00%
145	33.58%	64.96%	1.46%	0.00%	100.00%
150	22.66%	77.34%	0.00%	0.00%	100.00%
155	12.61%	85.71%	1.68%	0.00%	100.00%
160	7.09%	90.55%	2.36%	0.00%	100.00%
165	3.67%	92.66%	3.67%	0.00%	100.00%
170	1.75%	89.47%	8.77%	0.00%	100.00%
175	0.98%	91.18%	6.86%	0.98%	100.00%
180	0.00%	89.74%	10.26%	0.00%	100.00%
185	0.00%	69.70%	30.30%	0.00%	100.00%
190	0.00%	23.08%	76.92%	0.00%	100.00%
195	0.00%	50.00%	50.00%	0.00%	100.00%
200	0.00%	100.00%	0.00%	0.00%	100.00%
210	0.00%	0.00%	100.00%	0.00%	100.00%
Total	38.58%	57.67%	3.69%	0.06%	100.00%

Table 3.3.1. PELGAS12 anchovy age/Length key.

Applying the age distributions to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated. The total biomass used here has been updated with the value obtained from the previous method based on strata.

Age distribution is shown in figures 3.3.2. The age distributions compared from 2000 to 2012 are shown in figure 3.3.3.

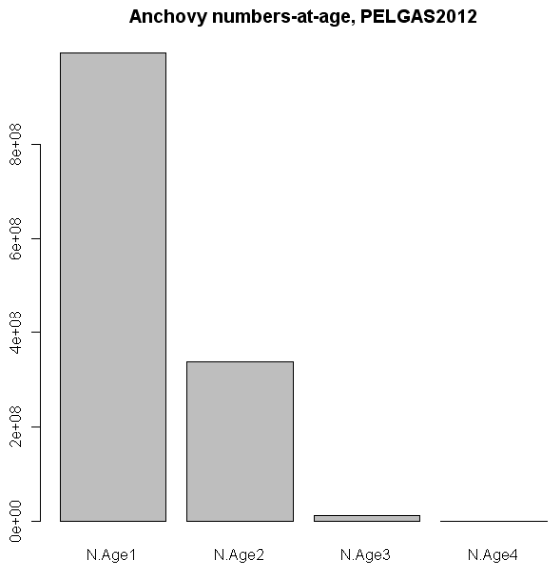


Figure 3.3.2– global age composition of anchovy as observed during PELGAS12 survey

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year seems to be the strongest observed along the whole time series (22 417 millions of fish against 9 770 millions fish last year and 4 100 millions in 2010). They represent 40 % of the biomass (74% in numbers). The 1 year old class this year is the best recruitment never observed since 2000 and 2 years old are still present, in agreement with the high abundance of age 1 last year.

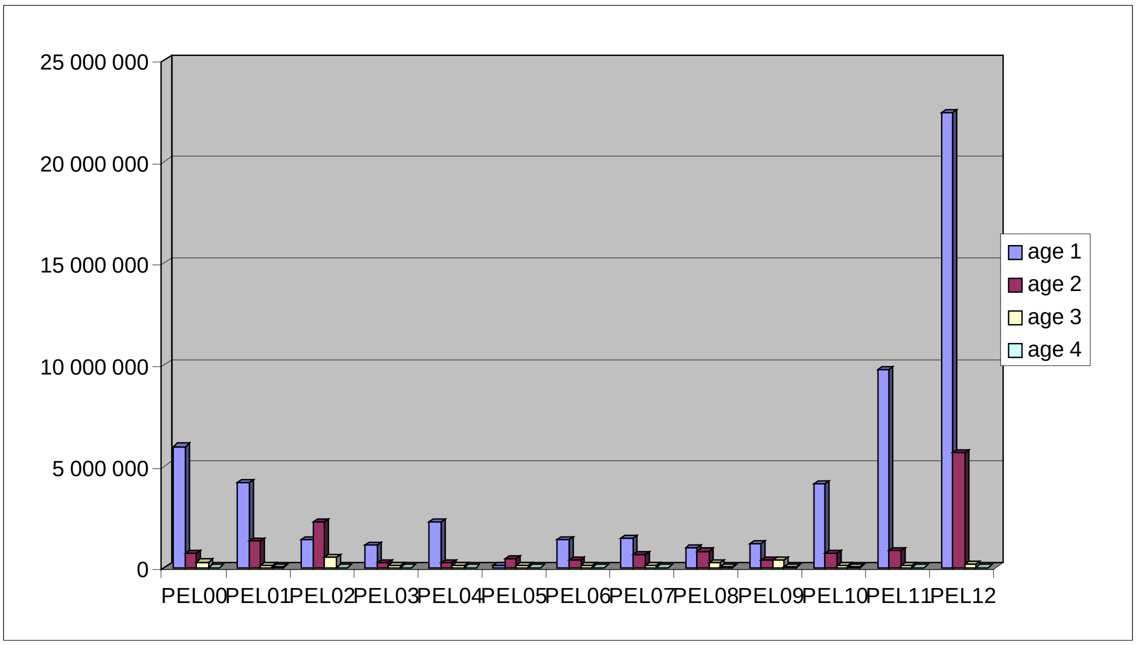


Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

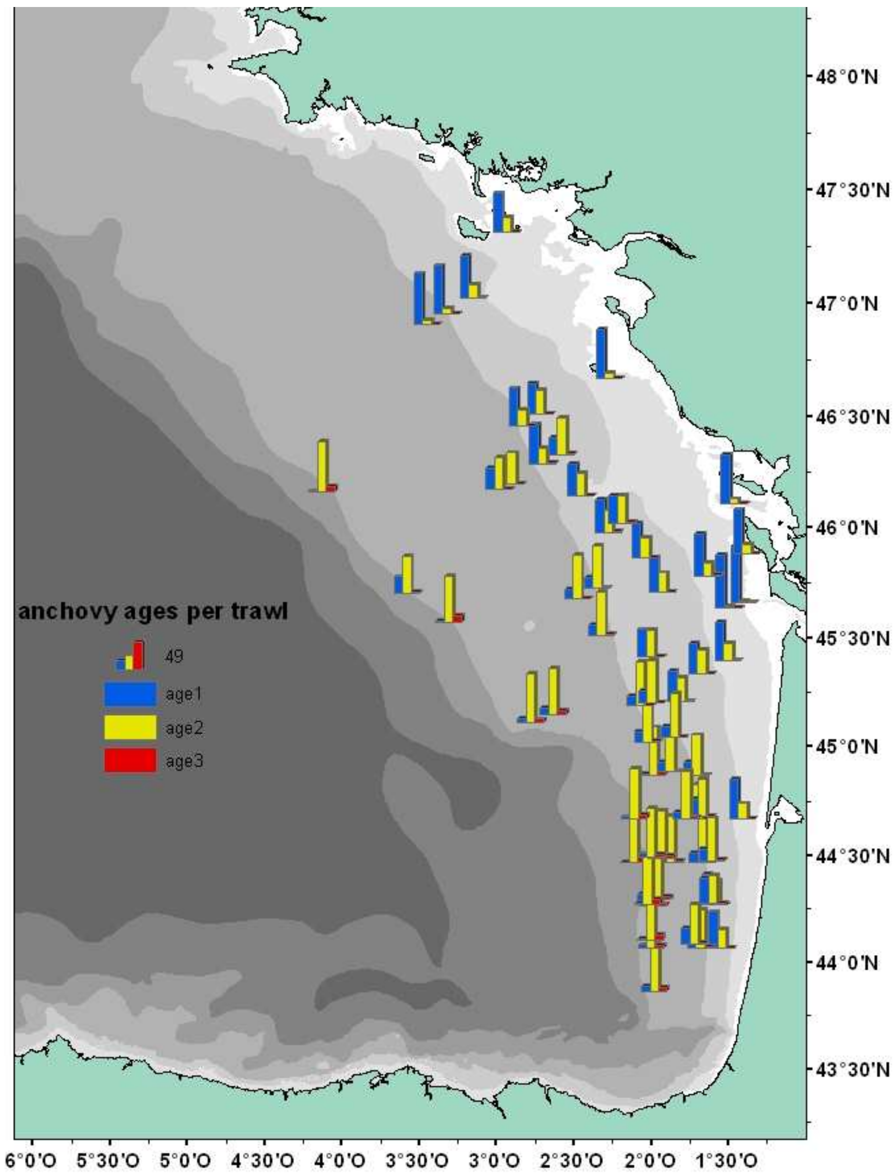


Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS12 survey.

During previous surveys, anchovy was well geographically stratified depending on the age (*see WD 2010, Direct assessment of small pelagic fish by the PELGAS10 acoustic survey, Masse J and Duhamel E.*). It is less true this year as age2 were often predominant in the centre of the shelf. In the Gironde area, from 45°30N to 46°30, age 1 appeared in a almost exclusive way, as the smallest anchovies never observed before at this period.

3.4. Weight/Length key

Based on 1811 weights of individual fishes, the following weight/length key was established (figure 4.5.) :

$W = 2E\text{-}06L^{3.2311}$ with R2 = 0.9713

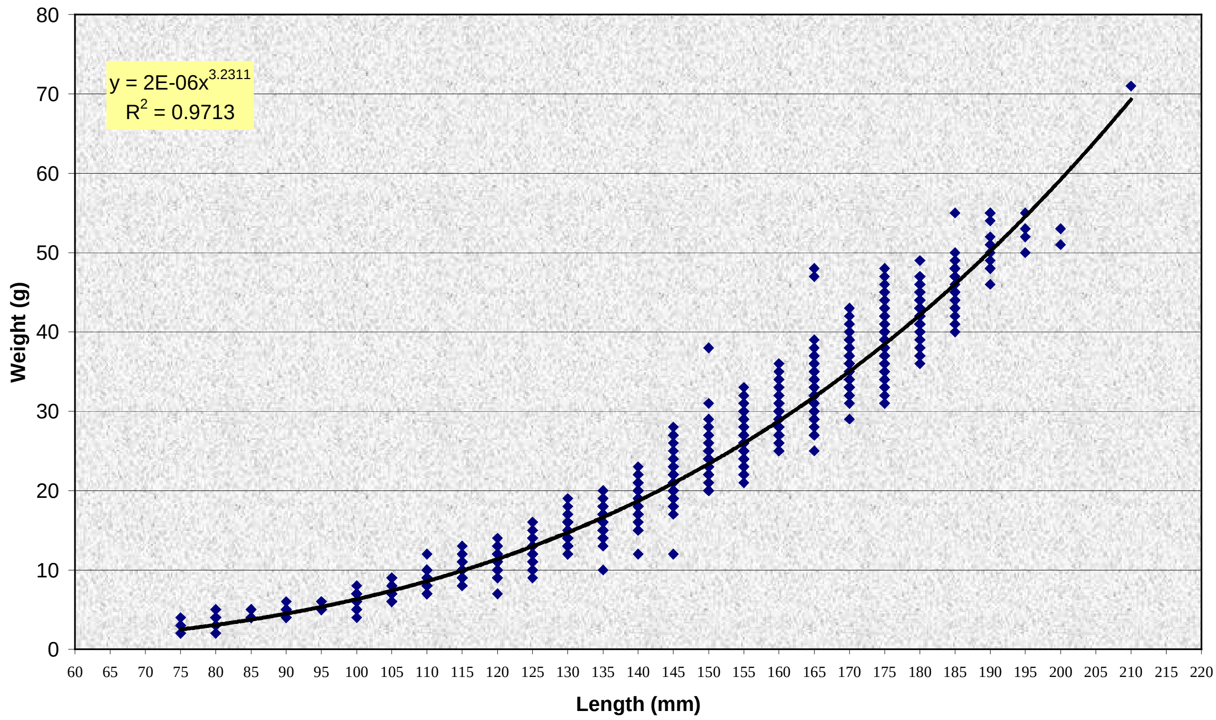


Fig. 3.4. – Weight/length key of anchovy established during PELGAS12

3.5. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 795 CUFES samples were collected and counted, 76 vertical plankton hauls and 87 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

Looking at the time series from 2000 to 2011 (Figure 3.5.2. and 3.5.3.), anchovy eggs abundance is in the average of the time series since 2000, far away from the last year's strong peak.

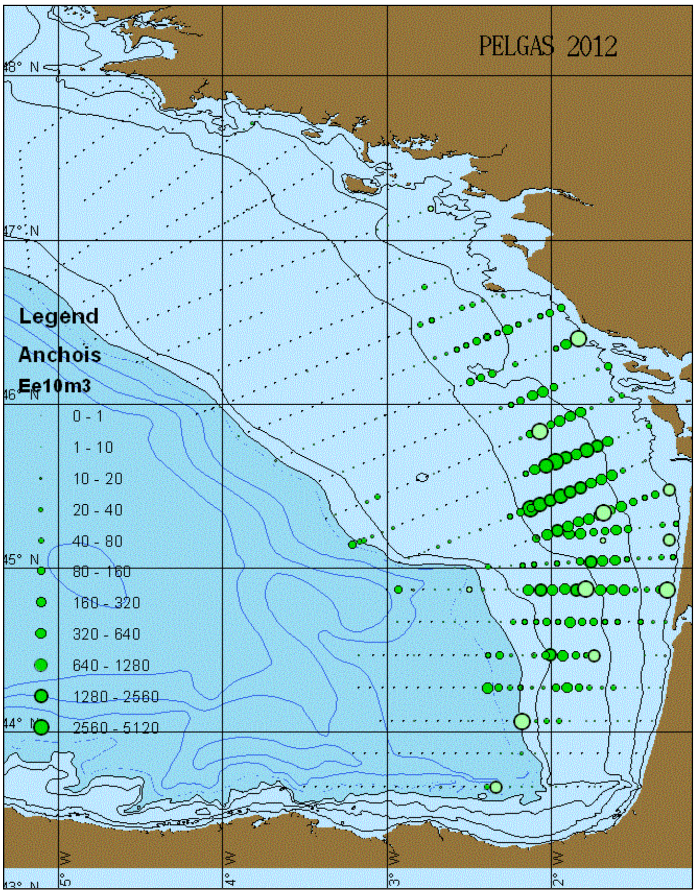


Figure 3.5.1 – Distribution of anchovy eggs observed with CUFES during PELGAS12.

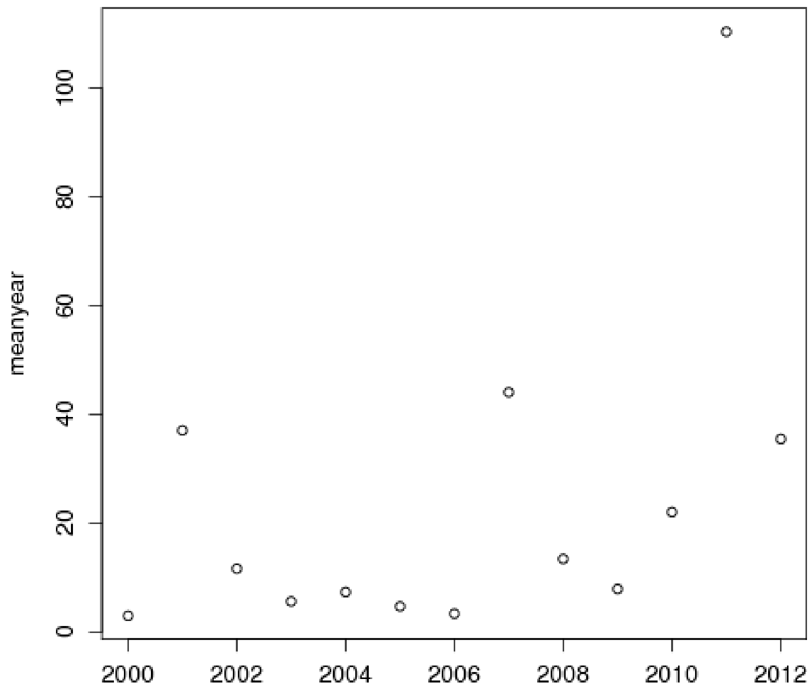


Figure 3.5.2 – Number of eggs observed during PELGAS surveys from 2000 to 2012

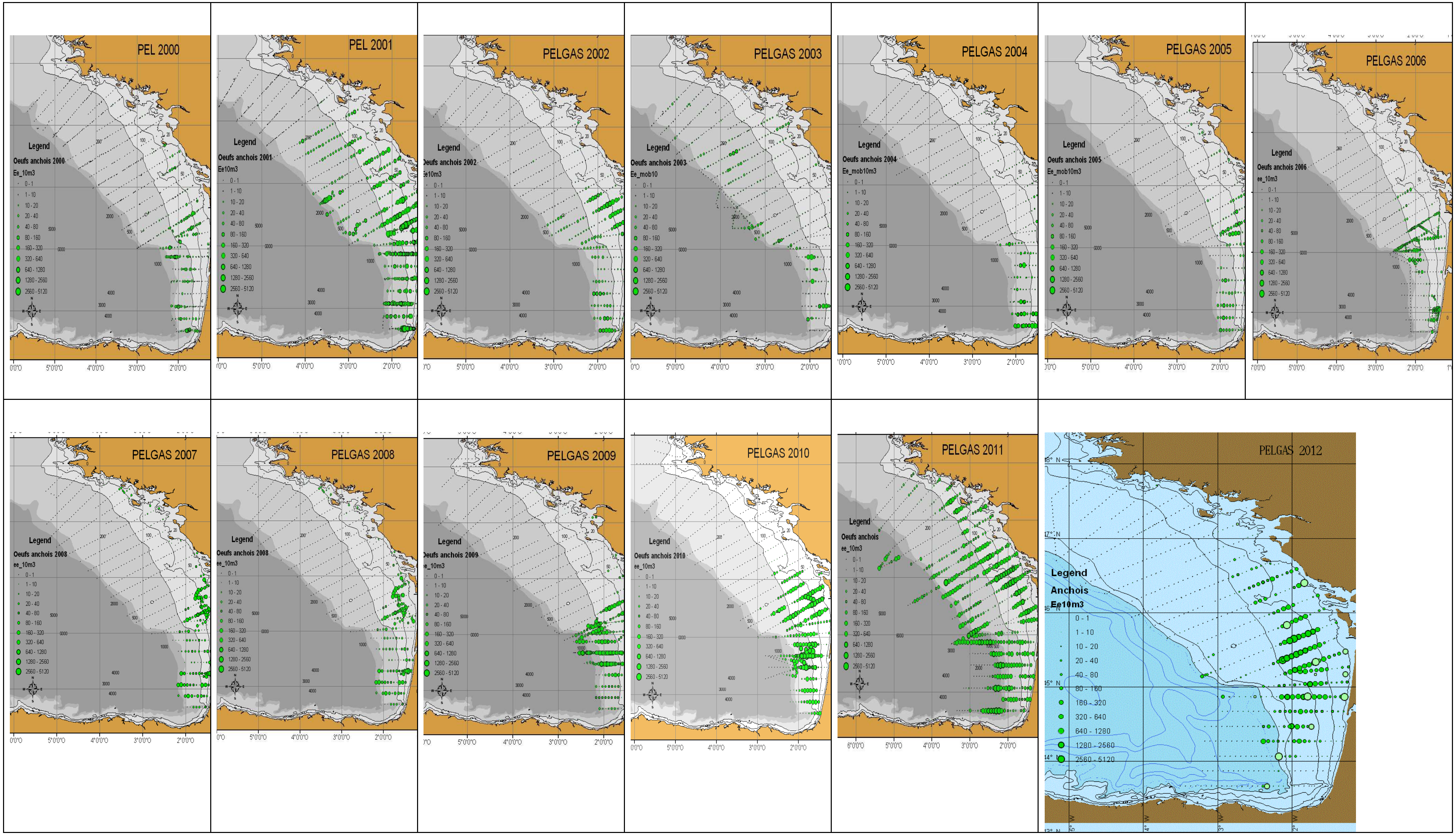


Figure 3.5.3 – distribution of anchovy eggs observed with CUFES during PELGAS from 2000 to 2012 (number for $10m^3$).

3.6. coherence in the eggs and adults distributions.

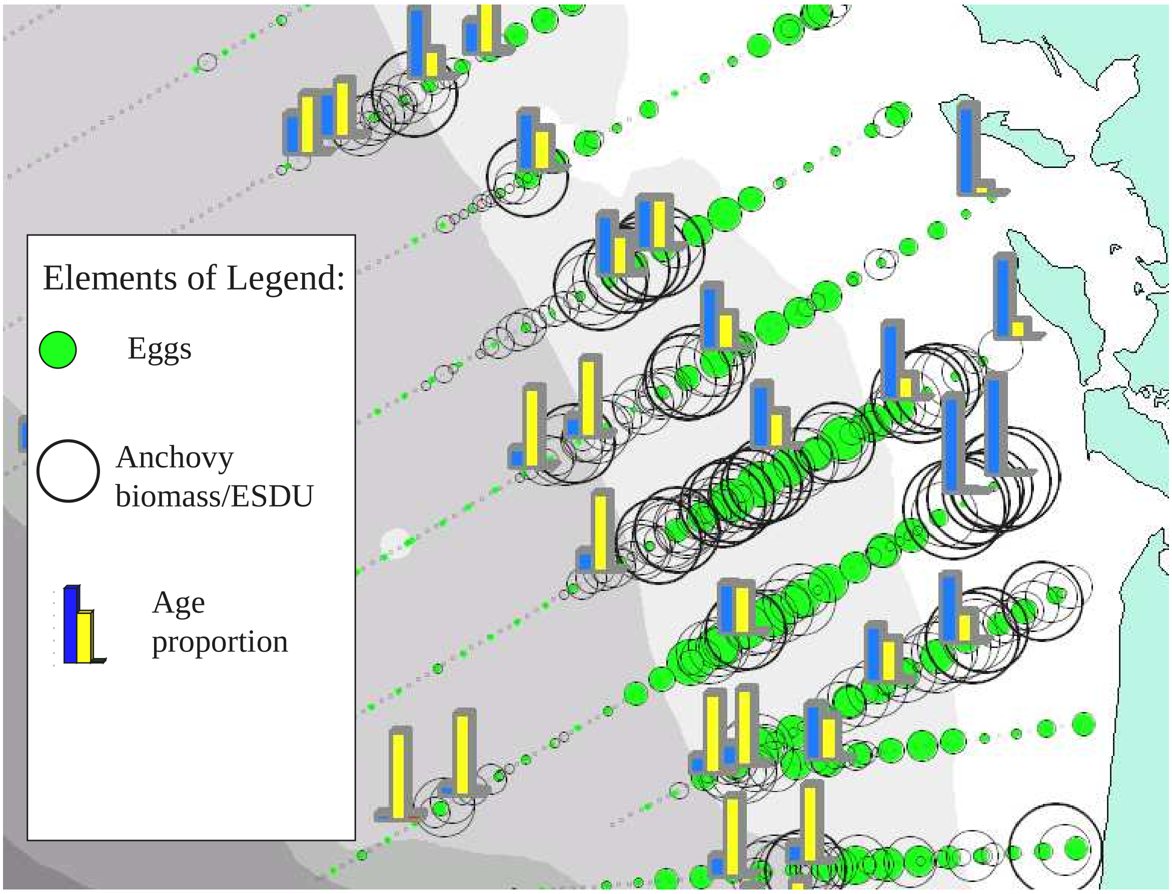


Figure 3.6.1 – Eggs, adults and age structure of anchovy – zoom in the Gironde area

We can observe on that map that abundance of anchovy eggs and abundance of adults are not always situated on the same place : close to the coast (in the Gironde plume but also southern and Northwestern), the most important anchovy biomass per ESDU is observed, while numbers of eggs are poor. In that coastal zone, anchovies of age 1 were really predominant. Biological parameters showed that the most part of theses anchovies were immature or starting their maturation. This delay in the spawning period of age 1 anchovies could be explained by the very particular hydrological conditions this year (*see chapter 6*). This was not observed during previous years surveys, when almost each anchovy was mature.

Eggs were particularly met this year in the area where age 2 (mature fish) were significantly present.

4. Sardine

4.1. Adults

The biomass estimate of sardine observed during PELGAS12 is **205 627** tons (table 2.3.), which is a little bit less than the average level of the PELGAS series, but constituting the third year of decrease. It must be enhance that these surveys don't cover the total area of potential presence of sardine. It is possible that some years, this specie could be present up to the north, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, apparently more and more. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed mixed with anchovy in two small areas : front of Arcachon and front of the Gironde. Then, they appeared pure in surface at the shelfbreak and close to the coast, between La Rochelle and Belle-Ile.

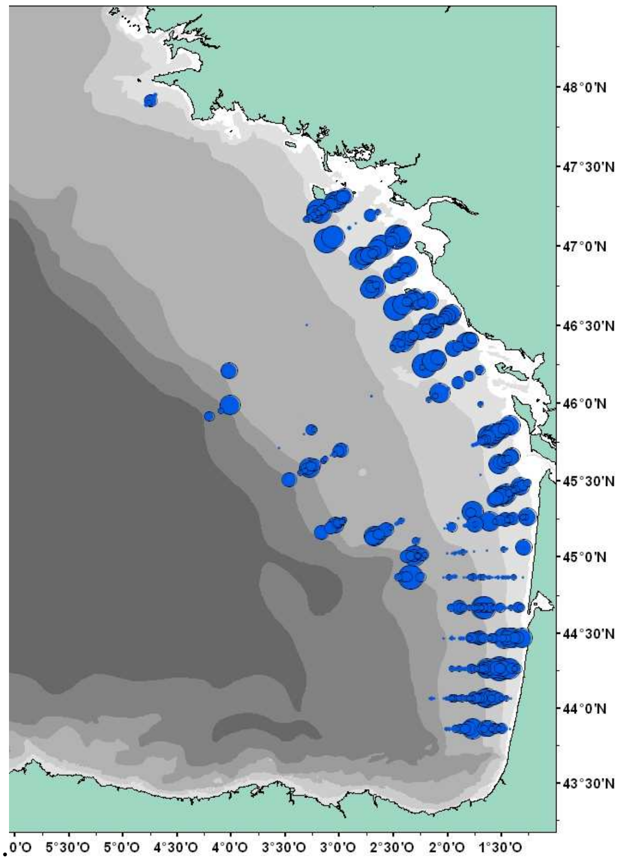


Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS12

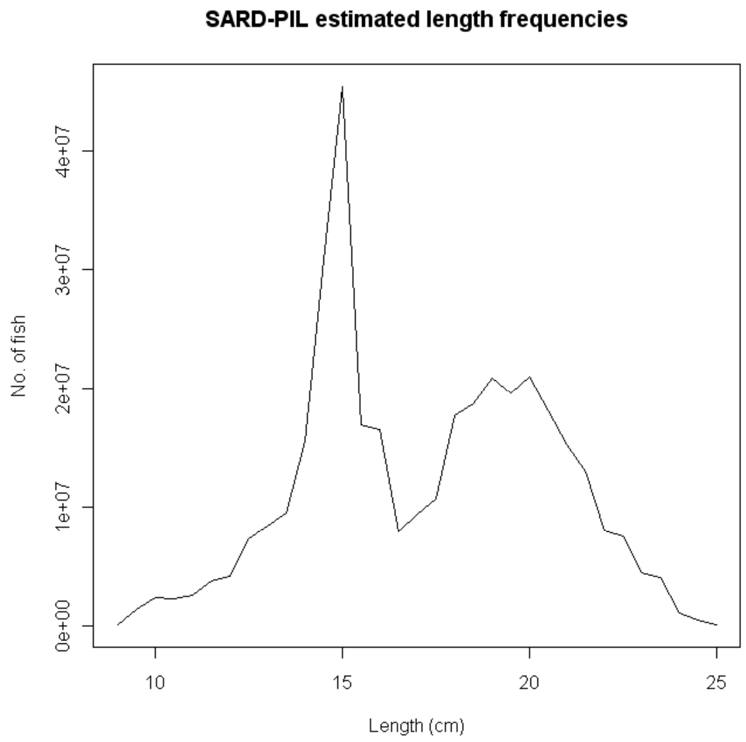


Figure 4.1.2. – length distribution of sardine as observed during PELGAS12.

Length distributions in the trawl hauls were estimated from random samples. The population length distributions have been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

As usual, sardine shows a bimodal length distribution, the first one (about 14 cm, corresponding to the age1, and almost well present this year) and the second about 19.5 cm, where mainly is constituted by the 2, 3 and 4 years old, in the same proportions.

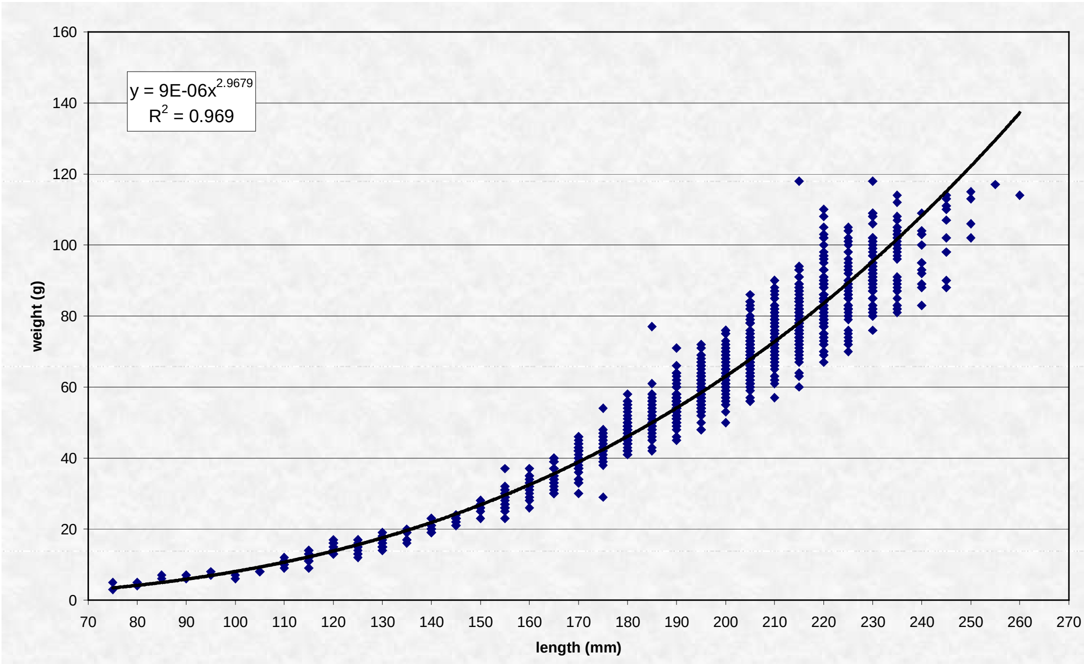


Figure 4.1.3 – Weight/length key of sardine established during PELGAS12

longueur (mm)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
50																	0%
55																	0%
60																	0%
65																	0%
70																	0%
75		100%															100%
80		100%															100%
85		100%															100%
90		100%															100%
95		100%															100%
100		100%															100%
105		100%															100%
110		100%															100%
115		100%															100%
120		100%															100%
125		100%															100%
130		100%															100%
135		100%															100%
140		100%															100%
145		100%															100%
150		100%															100%
155		100%															100%
160		77%	23%														100%
165		73%	27%														100%
170		33%	67%														100%
175		11%	86%	2%													100%
180		2%	84%	14%													100%
185		3%	55%	26%	16%												100%
190			31%	43%	24%	1%											100%
195			25%	43%	31%	1%											100%
200			7%	30%	60%	3%											100%
205			2%	37%	50%	10%	1%										100%
210				22%	62%	14%	2%		1%								100%
215			1%	7%	61%	27%	3%		1%								100%
220			1%	3%	44%	42%	7%	1%		1%							100%
225				4%	33%	40%	10%	6%	6%								100%
230				4%	23%	34%	21%	8%	11%								100%
235					9%	28%	25%	22%	9%	6%							100%
240						8%	23%	23%	31%	15%							100%
245						30%	10%	20%	20%	20%							100%
250							25%	25%	25%	25%							100%
255							100%										100%
260									100%								100%
265																	0%
270																	0%
275																	0%
280																	0%
285																	0%
290																	0%
295																	0%
300																	0%

Table 4.1.4 : sardine age/length key from PELGAS12 samples (based on 1321 otoliths)

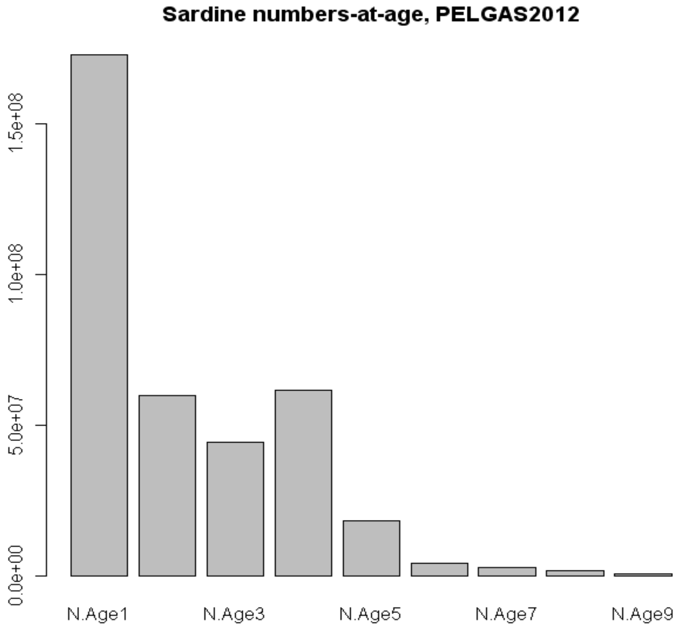


Figure 4.1.5.- Global age composition of sardine as observed during PELGAS 12

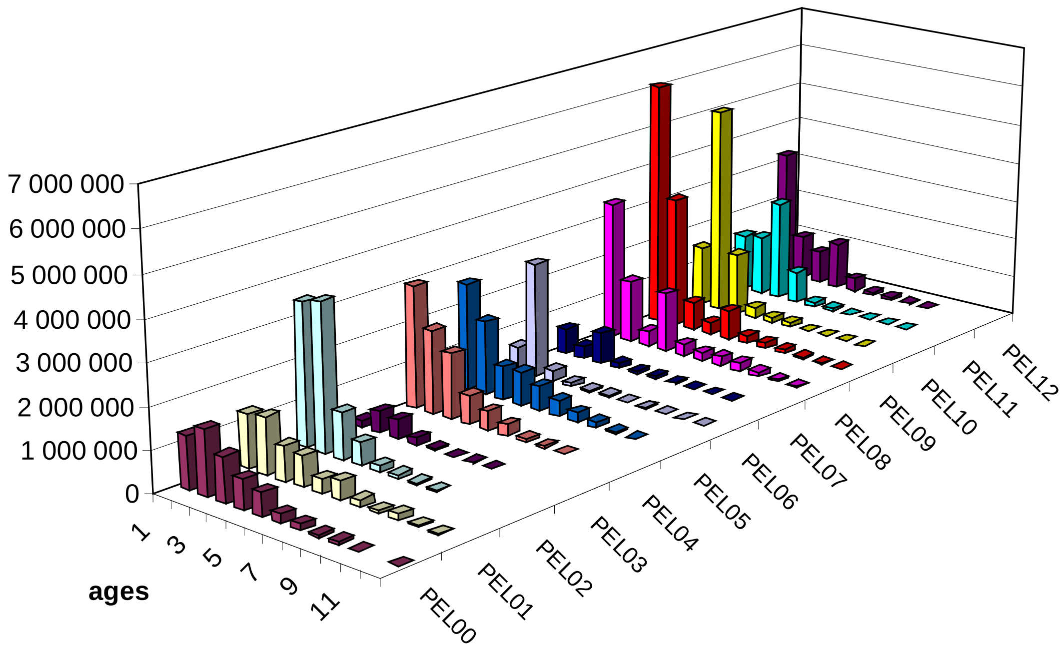


Figure 4.1.6- Age composition of sardine as estimated by acoustics since 2000

The series of age distribution in numbers since 2000 are shown in figure 5.1.6. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or high 2004 age class). 2003 was an atypical year in terms of environmental conditions and therefore fish distributions.

It must be noticed that the number of age 4 individuals this year is still important (17% in number of total fishes), and confirms one more time the good recruitment of the 2008 year class. The relative high abundance of age 1 (47% and 2 billions fishes) gives the impression that a good recruitment occurred.

4.2. Eggs

Sardine eggs were observed mainly along the coast between the 50 and the 100m isobaths, from the south of the bay of Biscay to the south of Brittany. Then, another lower concentration was visible along the end of the continental slope, northern than the "fer à cheval", according to the presence of adults in surface.

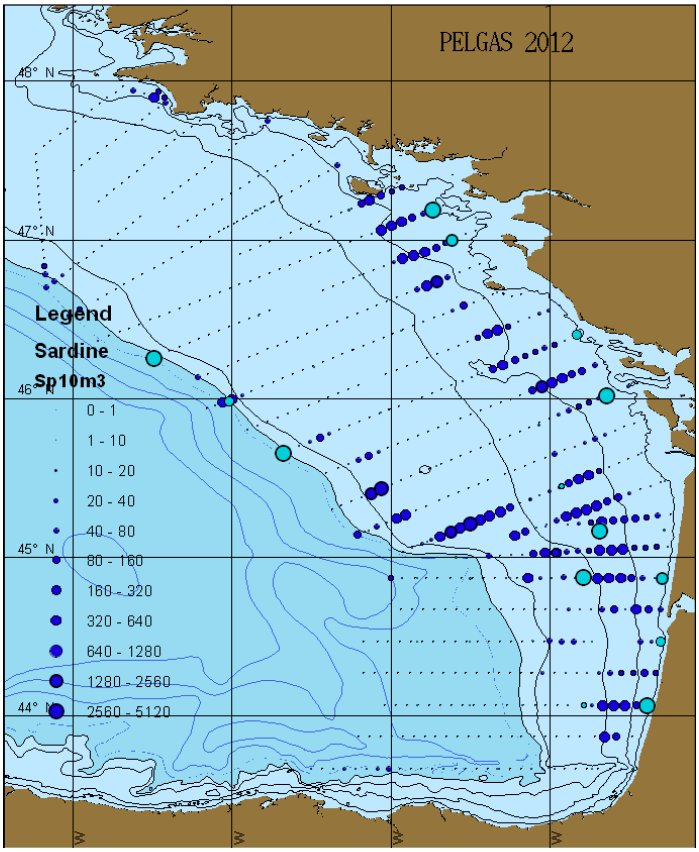


Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS12.

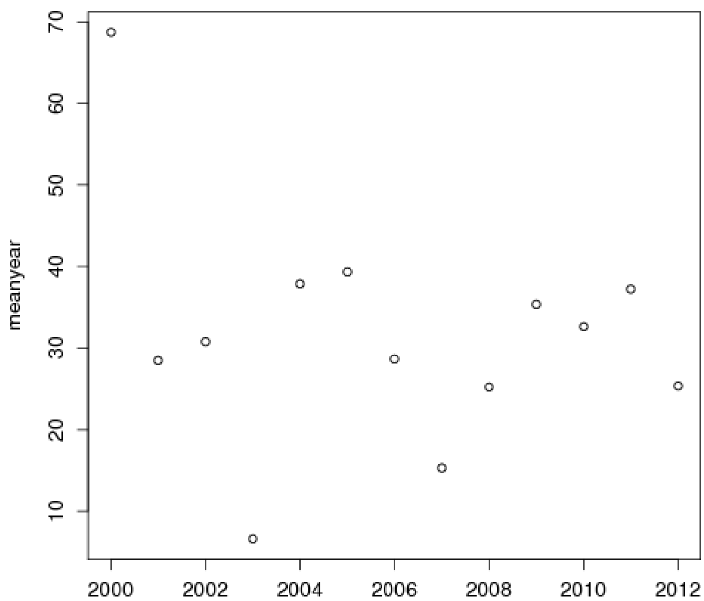


Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2012

The number of eggs collected by CUFES during the PELGAS12 survey was comparable to previous years but still far below the maximum observed in 2000.

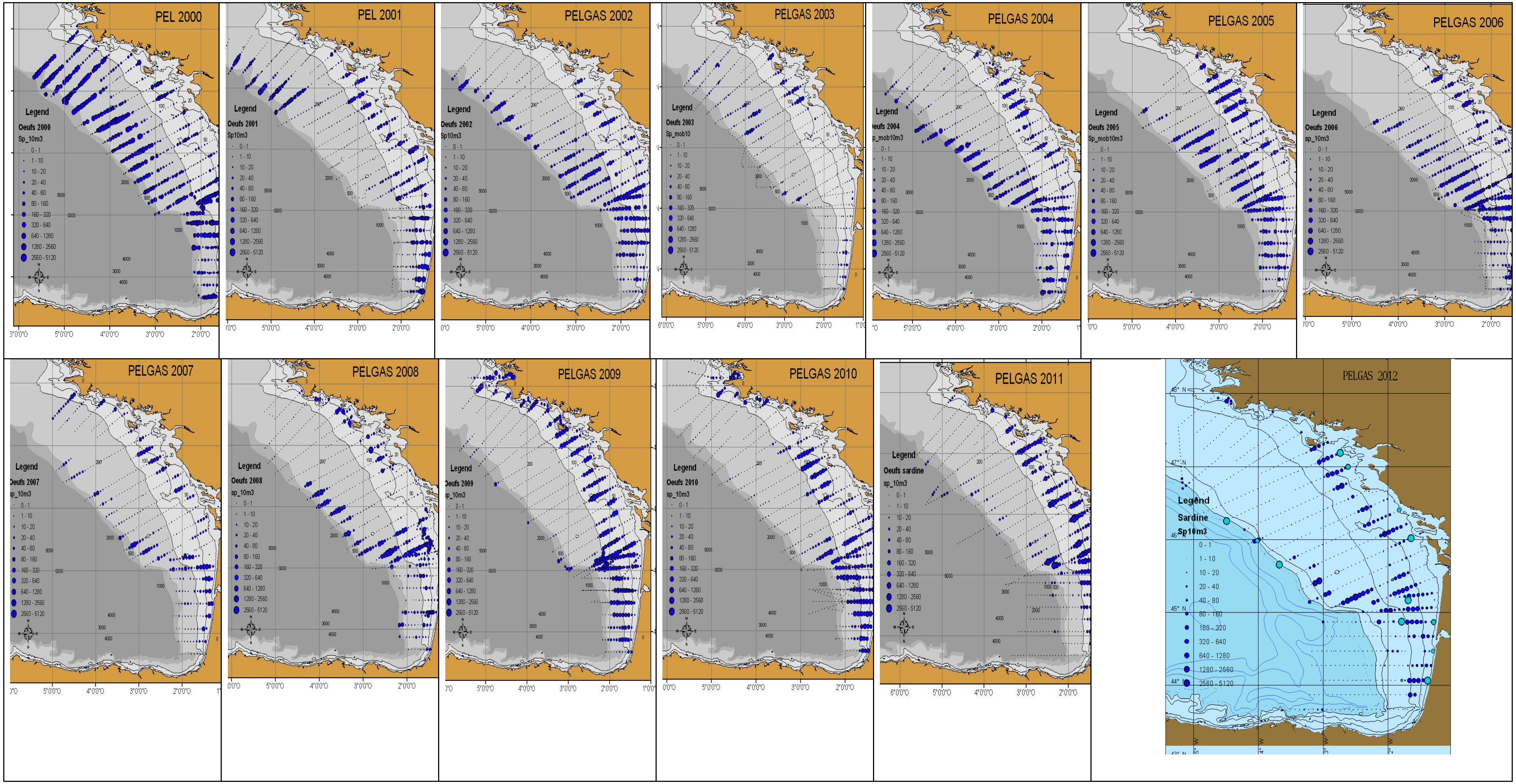


Figure 4.2.3 – distribution of sardine eggs observed with CUFES during PELGAS from 2000 to 2012 (number for $10m^3$).

5. Top predators

5.1 – Birds

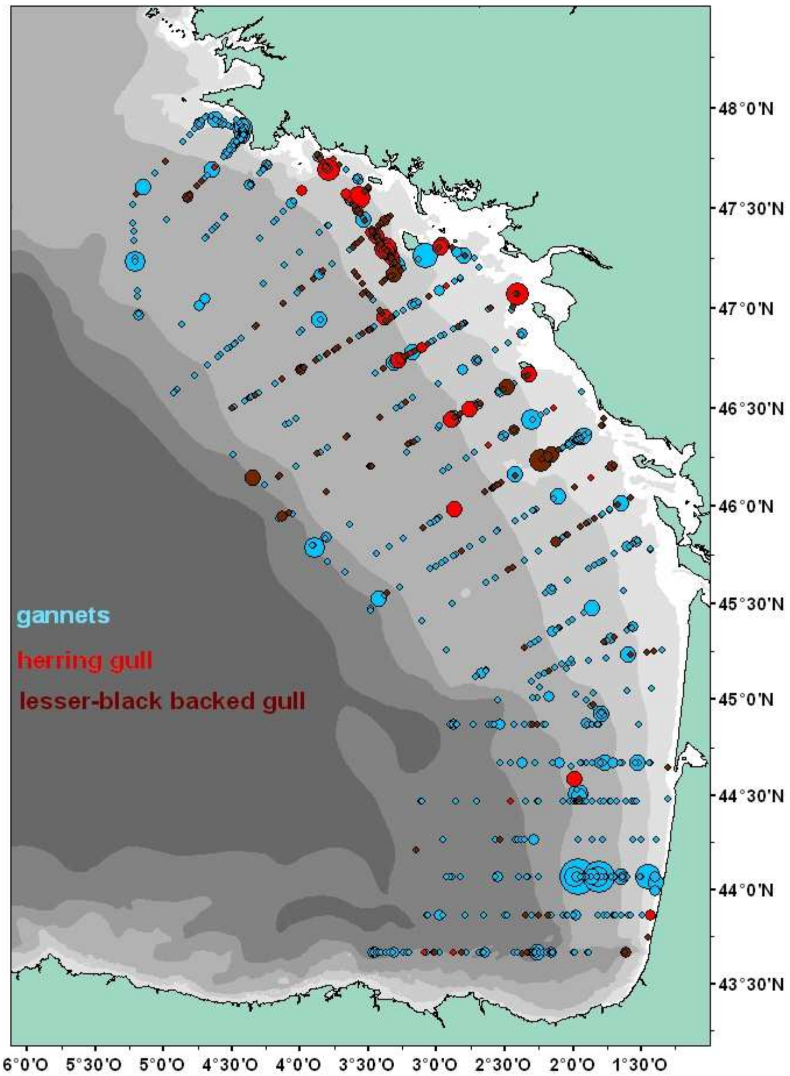


Figure 5.1.1 Distribution of marine birds observed during the PELGAS12 survey

The gannet is the species that accumulates the highest number of sightings (Appendix 2). It presents a homogeneous distribution across the Bay of Biscay, but with a larger number of individuals in the south where many hunts as a group were found (Figure 4)

Lesser Black-backed gull is the second most present species with large groups and mostly seen in areas where there is a fishing activity. The majority of sightings were focused on the northern half of the area, with aggregations nevertheless more pronounced near the Gironde estuary and the middle of the shelf in the south of Brittany.

5.2 – Mammals

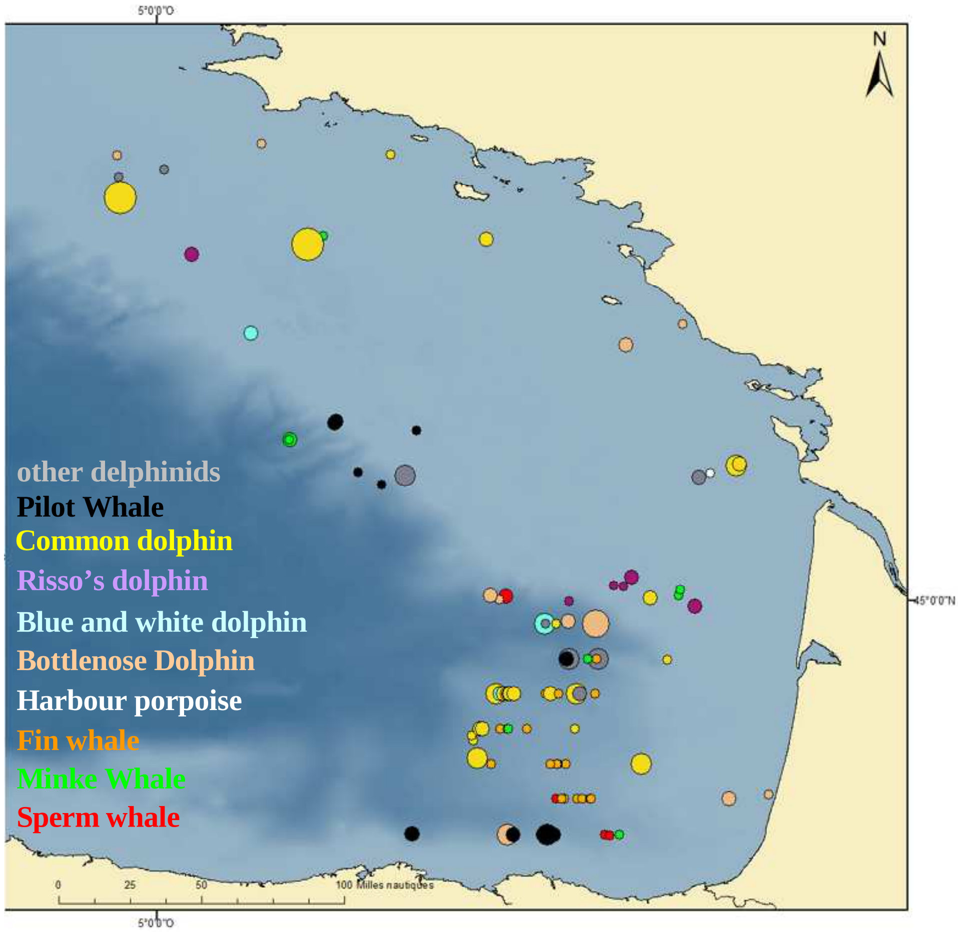


Figure 5.2.1 Distribution of mammals during the PELGAS12 survey.

The most observed species was the common dolphin (23% of Cetacean). Its distribution on the continental shelf differs from the previous nine years with a much lower number of sightings. In addition, numerous sightings were carried on the shelf offshore to the southern Bay of Biscay (Figure 2). Group size varies from 1 to 200 individuals.

Bottlenose dolphins sightings are less regular and correspond to groups mainly located on the slope. It is the same for sightings of rare striped dolphins encountered this year only in the southern Bay of Biscay. For the Risso's dolphin, the distribution is well marked upstream slope, with funds close to 150 meters. Groups of pilot whales, very present to the south of the area and on the slopes or canyons, have also been many sightings. Unidentified small dolphins formally relate mostly distant groups, it is highly probable that it is common or striped dolphin.

Note this year observation of harbour porpoise is the third carried on this campaign. It is like the others a few miles from the Gironde estuary.

Larges whales have been rebranded with the fin whale (15% of sightings) very confined beyond the south slope, such as the sperm whale. The minke whale was also contacted several times with such an exceptional case of ten individuals.

6. Hydrological conditions

After a relatively warm and dry winter, especially in March, conditions have changed from early April to bad weather. We started the survey with cold and bad weather, and these conditions have lasted until the survey break on 24th of May.

The weather conditions of April and May seem to have resulted in a delay of the Spring season, with cold Sea Surface Temperature (often 2°C below the climatology whereas it was above in March), weak stratification and phytoplanktonic concentrations, the latter only at surface without subsurface maximum.
First transects in the south did not show any stratification at all, after a strong wind event just before the start of the survey.
The low river discharges durong the winter did not help in the stratification process of surface waters, the plumes being restricted to a narrow coastal strip to the north of the estuaries. Precipitations of April and May have compensated these deficits, and the Gironde plume extension was larger when we came back in the south at the end of May.

The phytoplanktonic production is highest in the plumes and along the shelf break in the north, with apparently a succession of limited bloom events in space and time under succeding calm and small wind events. But the production is mostly limited to the surface with absence of well established stratification.

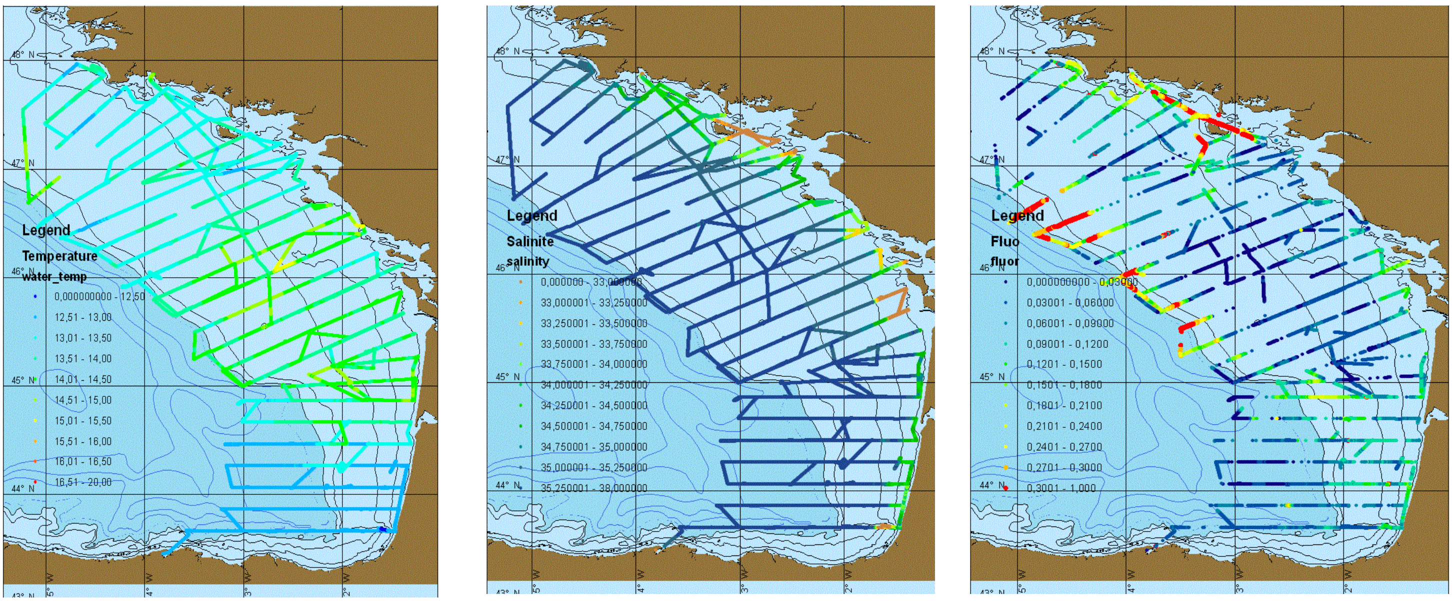


Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS12.

8. Conclusion

The Pelgas12 acoustic survey has been carried out with relative bad weather conditions (wind, cold temperatures) for the whole area, from the south of the bay of Biscay to the west of Brittany. The help of commercial vessels (two pair of trawlers) during most of the survey provided about 110 identification hauls as a whole instead of about 50 before 2007 when Thalassa was alone to identify echo traces. Their participation increased the precision of identification of echoes and some double hauls permitted to confirm that results provided by the two types of vessels (R/V and Fishing boats) were comparable and usable for biomass estimate purposes. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration, with the financial help of "France Filière Pêche" which is a groupment of French fishing organisations.

Temperature and salinity recorded during PELGAS12 were affected by rather bad weather conditions before and during the survey. During the whole survey, water column showed a lack of stratification, with a very low surface temperature (often 2°C below last year's SST).

The PELGAS12 survey observed a very high abundance of anchovy, at the highest level observed on the time series (186 865 tons). Anchovy was mostly concentrated in a long area between 80 and 100 m depth during 15 conscutive transects . It was particularly dense in and around the Gironde plume, where very high densities of age 1 were detected at a level which was never observed in the past. The good recruitment of age 1 this year is particularly clear, representing 75% of the total number of anchovies (40 % in mass), mainly in front of the Gironde as very small immature fish. Comparativly, few eggs were observed compared to 2011, this can be explained by the very low temperture of sea water which can be assimilated to a late spring season and therefore to a low level of spawning. This is also related to the very small and immature anchovies concentrated close to the coast in front of the Gironde.

The biomass estimate of sardine observed during PELGAS12 is 205 627 tons, which is a little bit less than the average level of the PELGAS series, and constitutes the third year of decrease. Distribution looks as usual, with maximum again in the Centre of the bay, with extension to the north both along the coast and along the slope. Recruitment seems to be good (47% of the total number of fish), at the same level than the 2007 and the 2004 years class. It must be noticed that the number of age 4 individuals this year is still important (17% in number of total fishes), and confirms one more time the very good recruitment of the 2008 year class.

Concerning the other species, mackerel was dispersed on the platform and not abundant compared to the average on the whole PELGAS series, while horse mackerel and sprat were rather absent this year, contrary to the blue whiting, detected as sometimes enormous and dense schools in the North part of the bay of Biscay.

Working Document to WGHANSA, 23-28 June 2012, Azores (Horta), Portugal

Preliminary Spawning Stock Biomass estimates for the Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) applying the DEPM

by

M. Santos[1], L.Ibaibarriaga[1] and A.Uriarte[1]

[1] AZTI-Tecnalia, Instituto Tecnológico Pesquero y Alimentario, Pasaia, SPAIN.
msantos@azti.es; auriarte@azti.es; libaibarriaga@azti.es

ABSTRACT

The research survey BIOMAN 2012 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy was conducted in May 2012 from the 10th to the 30th covering the whole spawning area of the species. Two vessels were used: the R/V Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 80,381Km^2 and the spawning area was 38,974Km^2. During the survey 529 plankton samples were obtained and 42 pelagic trawls were performed, from which 28 contained anchovy and 24 of them were selected for the analysis.

No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45'N in the French platform and the northern limit was found at 47º15'N. The eggs in the French platform were encountered in the historical common places: Between Adour and Arcachon and in the area of influence of Le Gironde. The sampling was stopped for 12 hours due to bad weather at 47º23'N after 22 days of survey. The conditions of the survey were in general wintry, with a mean SST of 14.9.

Two preliminary estimates are presented: A preliminary SSB estimate is obtained, as in previous years, as the ratio between the total daily egg production (P_{tot}) and the mean historical daily fecundity (DF). P_{tot} is calculated as the product of the spawning area and the daily egg production rate (P_0), which is obtained from the exponential mortality model fitted as a Generalized Linear Model (GLM) to the abundance of the daily egg cohorts obtained from the plankton survey. As the adults samples are not fully processed yet, the DF is taken as a mean of the historical DF series. This results in a preliminary biomass estimate of 34,144 t, with a coefficient of variation of 27%. A second estimate was based on a first analysis of the adult samples to derive the parameters defining the Daily Fecundity, with the exception of the spawning frequency, i.e, sex ratio, mean weight of females and preliminary estimates of Batch Fecundity. For the spawning frequency the historical mean was adopted. This estimate results in a biomass of 36,200 t, with a CV of 20%. We suggest to adopt this second estimate to input the assessment, given that make the major use of the data collected during the survey, and should be quite similar to the final one expected by November 2012. Both estimates are very similar and around the same level as recorded in 2010.
Approximately 56% of the anchovy were individuals of age 2 (70% in mass) and 44% of age 1 (30% in mass).

1. INTRODUCTION

Anchovy (*Engraulis encrasicolus*) is one of the commercial species of high economic importance in the Bay of Biscay. The economy of the Spanish purse seine fleets (primarily from the Basque Country, Cantabria and Galicia) and the French fleet rely greatly on this resource (Uriarte *et al.*, 1996 and Arregi *et al.*, 2004). In order to provide proper advice on the fishery management, it is necessary to conduct annually a monitoring of the population. Thanks to that monitoring, ICES (International Council for the Exploration of the Sea) recommended a limited TAC of 29,700 t for 2012, 26,730t for Spain and 2,970 for France. This year scientific advice from this DEPM survey and the Acoustic one performed by IFREMER (France) will become available at this WGANSA 2012.

Anchovy is a short-lived species, for which the evaluation of its biomass has to be conducted by direct assessment methods as the daily egg production method (DEPM) (Barange *et al*, 2009). This method consists of estimating the spawning stock biomass (SSB) as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (DF) estimates. It requires a survey to collect anchovy eggs (plankton sampling) for estimating the total daily egg production and to collect anchovy adults (adult sampling) for estimating the adult parameters. Since 1987, AZTI-Tecnalia (Marine and Food Technological Centre, Basque country, Spain), either alone or in collaboration with other institutes, has conducted annually specific surveys to obtain anchovy biomass indices (Somarakis *et al.*, 2004; Motos *et al.*, 2005, Santos *et al,* 2010). In addition, the Basque fishery on anchovy has been continuously monitored. This information has been submitted annually to ICES, to advice on the exploitation of the fishery (ICES, 2011).

The survey for the application of the DEPM to estimate the Bay of Biscay anchovy biomass is one of the two surveys which give information about the anchovy population. The other one carried out at the same time in May is the acoustic French survey. The biomass indices provided by the acoustic and DEPM surveys together with the information supplied by the fleet are used as input variables for a two stage biomass model used to assess the Bay of Biscay anchovy population (Ibaibarriaga *et al.*, 2008). Apart from the anchovy SSB estimates the DEPM survey in the Bay of Biscay gives information on the distribution and abundance of sardine eggs and environmental conditions.

This working document describes the BIOMAN2012 survey for the application of the DEPM for the Bay of Biscay anchovy in 2012. First, the data collection and the estimation of the egg production are described in detail. Next the processing of the adults samples is described up to define the sex ratio, mean weight of females and batch fecundity. Then, a preliminary SSB indices based on the ratio between the total daily egg production (P_{tot}) estimate and a preliminary daily fecundity (DF) estimate derived from the mean historical series and the age structure indices are given. And finally a second preliminary estimate based on the adults parameters obtained so far and assuming historical average of the spawning frequency is also presented, and proposed to be used as input for the assessment of this stock. Finally the historical trajectory of the population is showed.

2. MATERIAL AND METHODS

2.1 Survey description

The BIOMAN2012 survey was carried out at the spawning peak of the species covering the whole spawning area of the anchovy in the Bay of Biscay. During the survey, icthyoplankton and adult samples were obtained for the estimation of the total daily egg production and the total daily fecundity respectively. The age structure of the population was also estimated.

The collection of plankton samples was carried out on board R/V Ramón Margalef from the 10^{th} to the 30^{th} May. The area covered was the southeast of the Bay of Biscay (**Fig. 1**), which corresponds to the main spawning area and spawning season of anchovy. The strategy of egg sampling was identical to that used in previous years (Uriarte *et al.*, 1999), i.e. a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found. Stations were located every 3 miles, along 15-mile-apart transects perpendicular to the coast. The sampling strategy was adaptive. The survey started from the West (transect 11, at 4º14'W), and covered the Cantabrian Coast eastwards up to Pasajes (transect 25, approx. 1º50'W) (**Fig. 1**) looking for the western limit of the spawning area. Then, the survey continued to the north, in order to find the Northern limit of the spawning area. The spawning was stopped during10 hours due to bad weather at 47º23'N. Moreover the cufes was broken and the spawning was stopped for 9 hours. Another cufes was then used at 4m instead to 3m. At La Rochelle on the 23th at 8:00h, the vessel stopped to take gasoleo for 12 hours. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were completed. This occurred from the Adour until Arcachon inside the 100m depth and the area of influence of Gironde. This year the survey was restricted to survey further west of 5ºW by the French authorities from 1st to 27 May and outside of continental shelf between 20-27 May.

At each station a vertical plankton haul was performed using a PairoVET net (2-Calvet nets, Smith *et al.*, 1985 in Lasker, 1985) with a net mesh size of 150µm for a total retention of the anchovy eggs under all likely conditions. The net was lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the surface and at maximum depth for stabilisation, the net was retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to detect sequential clogging of the net during a series of tows.
Immediately after the haul, the net was washed and the samples obtained were fixed in formaldehyde 4% buffered with sodium tetraborate in sea water. After six hours of fixing, anchovy, sardine and other eggs species were identified, sorted out and counted onboard. Afterwards, in the laboratory, a percentage of the samples were checked to assess the quality of the sorting made at sea. According to that, a portion of the samples were sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy eggs were classified into morphological stages (Moser and Alshtrom, 1985). This year half of the samples were staged as well on board.

Sample depth, temperature, salinity and fluorescence profiles were obtained at each sampling station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity were recorded in each station with a CTD RBR and with a manual termosalinometer WTW LF197. At some points determinate before the survey, water was filtered from the surface to obtain chlorophyll samples to calibrate the chlorophyll data.

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al.*, 1997) was used to record the eggs found at 3m depth with a net mesh size of 350µm. The samples obtained were immediately checked under the microscope so that the presence/absence of anchovy eggs was detected in real time. When anchovy eggs were not found in six consecutive CUFES samples in the oceanic area transect was abandoned. The CUFES system had a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data were registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

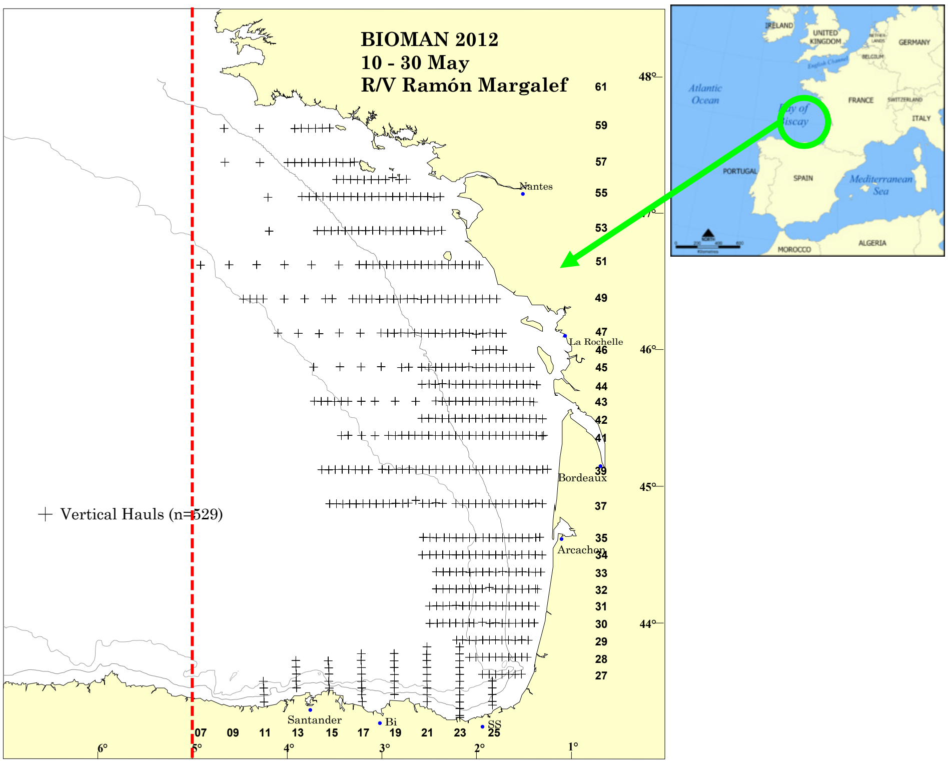


Figure 1: Plankton stations during BIOMAN 2012. The red line represents the longitude where the survey was restricted to survey further west by the French authorities from 1st to 27 May. The work was also restricted to survey outside of continental shelf between 20-27 May.

The adult samples were obtained on board R/V Emma Bardán (pelagic trawler) from the 9th to the 30th May coinciding in space and time with the plankton sampling. When the plankton vessel encountered areas with anchovy eggs, the R/V Emma Bardán was directed to those areas to fish. In each haul, immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of two kg was selected at random. A minimum of one kg or 60 anchovies were weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) were preserved. If the target of 25 NHF was not completed 10 more anchovies were taken at random and processed in the same manner. Sampling was stopped when more than 120 anchovies had to be sexed to achieve the target of 25 NHF. Otoliths were extracted onboard and read in the laboratory to obtain the age composition per sample. In addition, a piece of each anchovy was frozen to do genetic analysis afterwards on land. In each haul 100 individuals of each species were measured. Extra anchovy samples were frozen to obtain morphometric measurements.

This year no additional anchovy adult samples were obtained from the commercial Basque purse seine fleet due to bad weather the week when the egg sampling was crossing the area of Cap Breton where the purse seiners were operating.
The spatial distribution of the pelagic hauls with anchovy is shown in **Figure 2**.

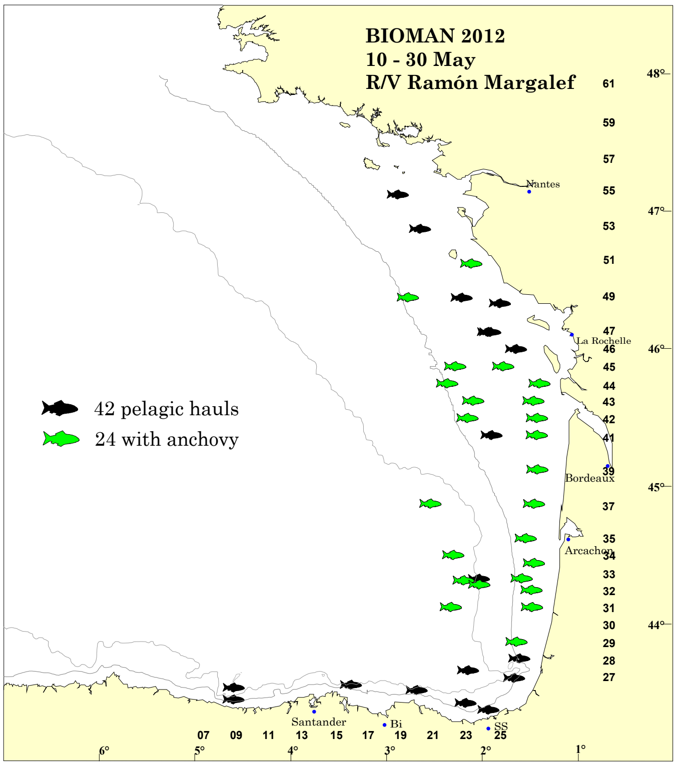


Figure 2: Spatial distribution of fishing hauls from R/V Emma Bardán in 2012.

2.2 Total daily egg production

Total daily egg production (P_{tot}) was calculated as the product between the spawning area (SA) and the daily egg production (P_0) estimates:

(1)
$$P_{tot} = P_0 \, SA \, .$$

A standard PairoVET sampling station represented a surface of 45 Nm^2 (i.e. 154 km^2). Since the sampling was adaptive, the area represented by each station was corrected according to the sampling intensity and the cut of the coast. The total area was calculated as the sum of the area represented by each station. The spawning area (SA) was delimited with the outer zero anchovy egg stations although it could contain some inner zero anchovy egg stations embedded. The spawning area was computed as the sum of the area represented by the stations within the spawning area.
The daily egg production per area unit (P_0) was estimated together with the daily mortality rate (Z) from a general exponential decay mortality model of the form:

(2)
$$P_{i,j} = P_0 \exp\left(- Z \, a_{i,j}\right),$$

where $P_{i,j}$ and $a_{i,j}$ denote respectively the number of eggs per unit area in cohort j in station i and their corresponding mean age. Let the density of eggs in cohort j in station i, $P_{i,j,}$ be the ratio between the number of eggs $N_{i,j}$ and the effective sea area sampled R_i (*i.e.* $P_{i,j}$ =

$N_{i,j}$ / R_i). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

(3) $$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log(P_0) - Z\, a_{i,j} \ ,$$

where the number of eggs of daily cohort *j* in station *i* (N_{ij}) was assumed to follow a negative binomial distribution. The logarithm of the effective sea surface area sampled (log(R_i)) was an offset accounting for differences in the sea surface area sampled and the logarithm of the daily egg production log(P_0) and the daily mortality *Z* rates were the parameters to be estimated.
The eggs collected at sea and sorted into morphological stages had to be transformed into daily cohort frequencies and their mean age calculated in order to fit the above model. For that purpose the Bayesian ageing method described in ICES (2004), Stratoudakis *et al*., (2006) and Bernal *et al.,* (2011) was used. This ageing method is based on the probability density function (pdf) of the age of an egg *f(age | stage, temp)*, which is constructed as:

(4) $$f(age \mid stage, temp) \propto f(stage \mid age, temp)\, f(age)\,.$$

The first term *f(stage | age, temp)* is the pdf of stages given age and temperature. It represents the temperature dependent egg development, which is obtained by fitting a multinomial model like extended continuation ratio models (Agresti, 1990) to data from temperature dependent incubation experiments (Ibaibarriaga *et al.,* 2007, Bernal *et al.,* 2008). The second term is the prior distribution of age. A priori the probability of an egg that was sampled at time τ of having an age *age* is the product of the probability of an egg being spawned at time τ - *age* and the probability of that egg surviving since then (*exp(-Z age)*):

(5) $$f(age) \propto f(spawn = \tau - age)\exp(-Z\, age) \ .$$

The pdf of spawning time *f(spawn=*τ *- age)* allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al* (2011).
Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the *Z* estimates was used (Bernal *et al*., 2001; ICES, 2004; Stratoudakis *et al.,* 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value
Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age.
Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate.
Step 4. Repeat steps (1)-(3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, eggs younger than 4 hours and older than 90% of the survey incubation time (Motos, 1994) were removed.

The incubation temperature was taken as the temperature obtained with the CTD at 10m depth.

Once the final model estimates were obtained the coefficient of variation of P_0 was given by the standard error of the model intercept ($\log(P_0)$) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.

The analysis was conducted in R (www.r-project.org). The "MASS" library was used for fitting the GLM with negative binomial distribution and the "egg" library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm .

2.3 Daily fecundity

The daily fecundity (DF) is usually estimated as follows:

(6)
$$DF = \frac{R \cdot F \cdot S}{W_f} ,$$

where R is the sex ratio in weight, F is the batch fecundity (eggs per batch per female weight), S is the spawning frequency (percentage of females spawning per day) and W_f is the female mean weight.

In previous years, as the adult samples were not processed by the time WGANSA met, DF was derived from the past historical series, using the procedure accorded in WGACEGG 2009, i.e taking the mean of the historical DF series. The historical mean is produced excluding a June survey because of the mismatch with the current dates of BIOMAN; in addition the last seven years are excluded too, because the Spawning Frequency was not fully estimated. An extimate of SSB based on this historical mean will be presented in this WD for the purposes of historical comparison with the preliminary estimates produced in June in the same manner.

This year adult samples were processed as to derive the parameters defining the Daily Fecundity, with the exception of the spawning frequency, i.e, sex ratio, mean weight of females and preliminary estimates of Batch Fecundity, while for the spawning frequency the historical mean was adopted.

Sex ratio and mean weight of females were directly measured on sample basis on board by the biological sampling of the random sample of fishes, as described formerly.

For the batch fecundity (F) the hydrated egg method was followed (Hunter and Macewicz., 1985). The number of hydrated oocytes in gonads of a set of 82 hydrated females was counted. This F by individual female was deduced from a sub-sampling of the hydrated ovary. Three pieces of approximately 50 mg were removed from the extremes and the centre of one of the ovary lobule of each hydrated anchovy. Those were weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Finally, the number of hydrated oocytes in the sub-sample was raised to the gonad weight of the female according to the ratio between the weights of the gonad and the weight of the sub-samples. From these hydrated females, only those showing a CV les than 15% of the number of oocytes per ovary gram between the three pieces of ovary were retained.

As such only 52 females were retained for the fitting of the linear model between the between the number of hydrated oocytes and the female gonad free weight. This model was fitted by ordinary least squares under the assumption of normal distribution and

homocedasticty. A posterior histological checking of these retained females is due to assure that ovulation has not started, as that would bias downwards their individual F estimates. As this can not be done in such a short time after the survey, a some further reduction of the number of females allowed entering the batch fecundity regression was applied, on the following basis:

a) Assuming that the percentages of females which may have already starting ovulation in 2012 would be similar to that in previous years. As such the last 3 years were examined to outline the expected percentage of withdrawal of hydrated females due to on-going ovulation:

Rejected hydrated females		2011	2011	2010	2010	2009	2009			Option 1	Option 2
due to the onset of ovulation		total	Rjected %	total	Rjected %	total	Rjected %		Mean (%)	Females # 2012	Females # 2012
Or before	De 19 a 20			23	0%				0%	14	14
	De 20 a 21	20	0%	19	0%	22	14%		5%		
	De 21 a 22	48	4%			17	6%		5%		
	De 22 a 23	34	26%			44	25%		26%	30	18
	De 23 a 24	62	32%	17	35%	35	49%		39%	8	20
	De 00 a 01	32	59%			27	78%		69%		
									Total	52	52
							Expected Mean rejection%			21%	24%

Certainly the close to mid night the larger is the expected % of rejection of hydrated females due to ovulation. Following this table we decided to withdraw 30% of females (as a percentage a bit higher than the one expected according to the distribution of hydrated females in 2012 across sampling times (the Expected Mean rejection would be around 24%). In this way we try to be a bit conservative in terms of avoiding …

b) We simulated the withdrawal of 30% of the hydrated females (i.e. about 16 females out of the 52), among the females captured between 22:00 and 24:00 hours, a period for which some ovulation was typically observed, while those females caught before 20:00 hours were excluded from the withdrawal procedure. The criteria for selection of the withdrawn16 females was that of having the lowest F/W ratio, as the expectations is that ovulation would lead to a drop in this ratio compared to those not having started ovulation.

Later on, by November the proper histological checking of ovulation will be available and the batch fecundity regression will be based on the definitive subset of valid hydrated females.

The adjusted regression was: F = 525.952*P-SG -450.387 (with P-SG meaning the gonad free weight of females), which is significant with a P<0.0000 for n=36.

and it is shown in the graph below:

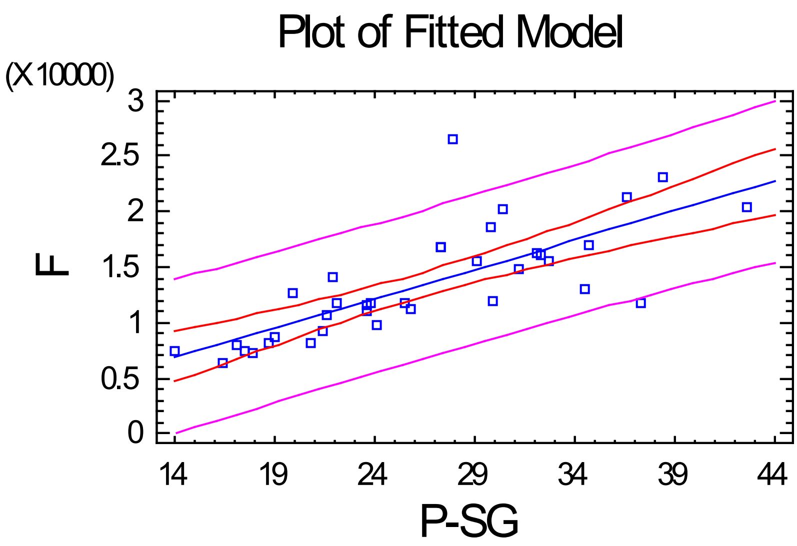


Figure 3: Fitting of a linear model to the eggs per batch of individual females (F) versus the gonad free weight (P-SG) for the selected set of hydrated females from BIOMAN 2012

The average of the batch fecundity for the females of each sample was derived by applying the former relationship to the average gonad free weight of females per sample.

2.3 Spawning stock biomass and numbers at age

The Spawning Stock Biomass (*SSB*) was estimated as the ratio between the total egg production (P_{tot}) and daily fecundity (*DF*) estimates and its variance was computed using the Delta method (Seber, *1982*). For the DF the two approaches mentioned above were followed, either using the historical mean DF or just using the average historical spawning frequency while including the estimates of the remaining adult parameters (R, W and F).

To deduce the numbers at age 6 regions, Northeast (NE), Centereast (CE), Southeast (SE), Northwest (NW), and Southwest (SW) and Gironde (G) were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs (**Figure 4**). Mean and variance of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples (Picquelle and Stauffer 1985) where the weights were proportional to the population (in numbers) in each region. In particular, the weighting factors were proportional to the egg abundance divided by the numbers of adult samples in the region and the mean weight of anchovy per sample.

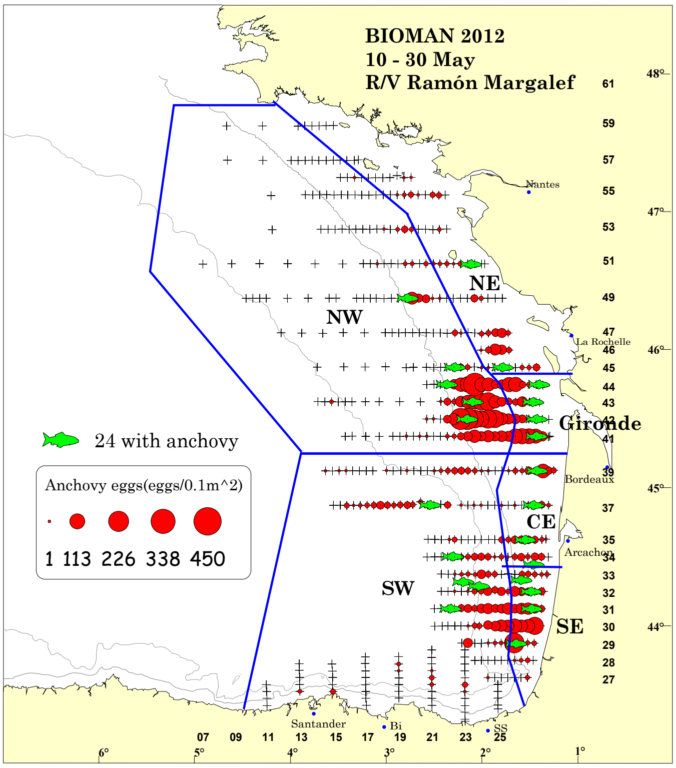


Figure 4: Six regions defined to estimate the numbers at age.

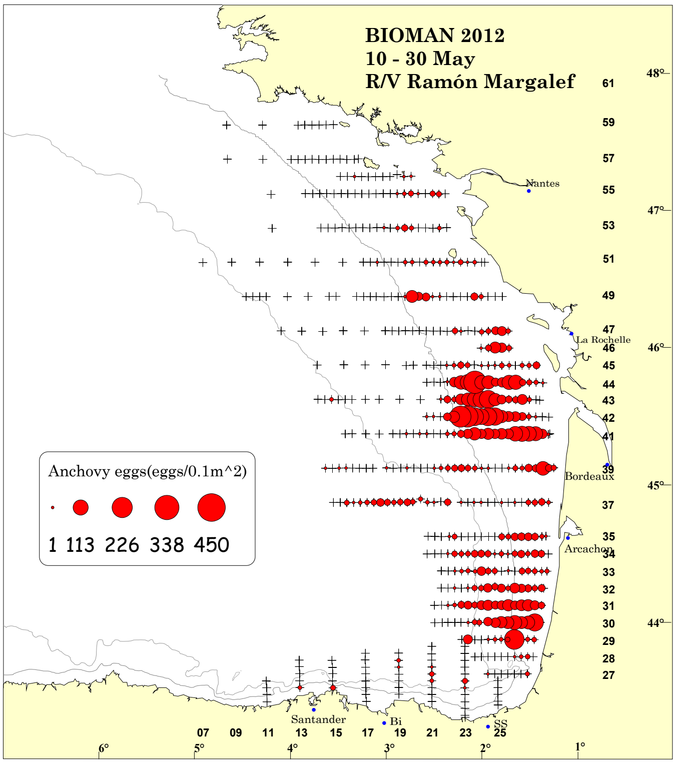
3. RESULTS

3.1 Survey description

This year no anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45'N in the French platform and the northern limit was found at 47º 15'N. The total number of PairoVET samples obtained was 529. The number of CUFES samples obtained was 1,156. The total area surveyed was 80,440 km^2 and the spawning area was 39,989 km^2. From 529 PairoVET samples, 270 had anchovy eggs (51%) with an average of 12 eggs $0.1m^{-2}$ per station and a maximum of 273 eggs $0.1m^{-2}$ in a station. A total of 6,377 anchovy eggs were encountered and classified.

No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º45'N in the French platform and the northern limit was found at 47º15'N. The eggs in the French platform where encountered in the historical common places: Between Adour and Arcachon and in the area of influence of Le Gironde (**Figure 5**). The abundance of sardine was scarce in relation with the historical series, all the eggs where inside the 100m depth.

Physical variables such as Temperature, Salinity and Wind at the sea surface are indicators of the currents that control the water mass movements. The salinity field obtained during the survey shows clearly the effect of the river discharges of Adour and Gironde and the dispersion of their plumes. The temperature field only shows the effect of river discharges in the Gironde (values between 12.8 and 14 ºC,) and close to the coast.



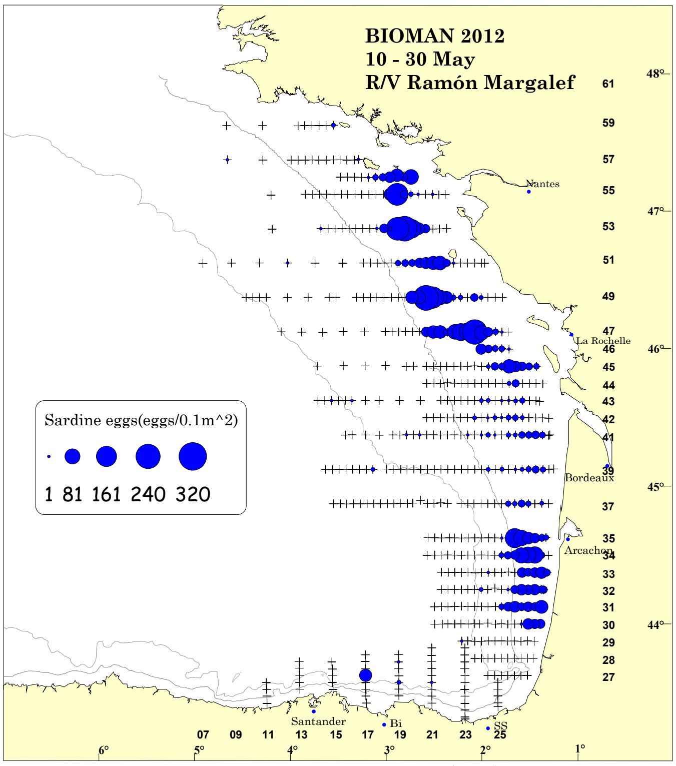


Figure 5: Distribution of anchovy (red) and sardine (blue) egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN2012 obtained with PairoVET.

Figure 6 shows the sea surface temperature and sea surface salinity maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2012 survey. This year the mean SST of the survey (14.9ºC) was lower than last year's (16.8ºC). The mean SSS (34.77 UPS) was at the same levels of last year (35.25 UPS).

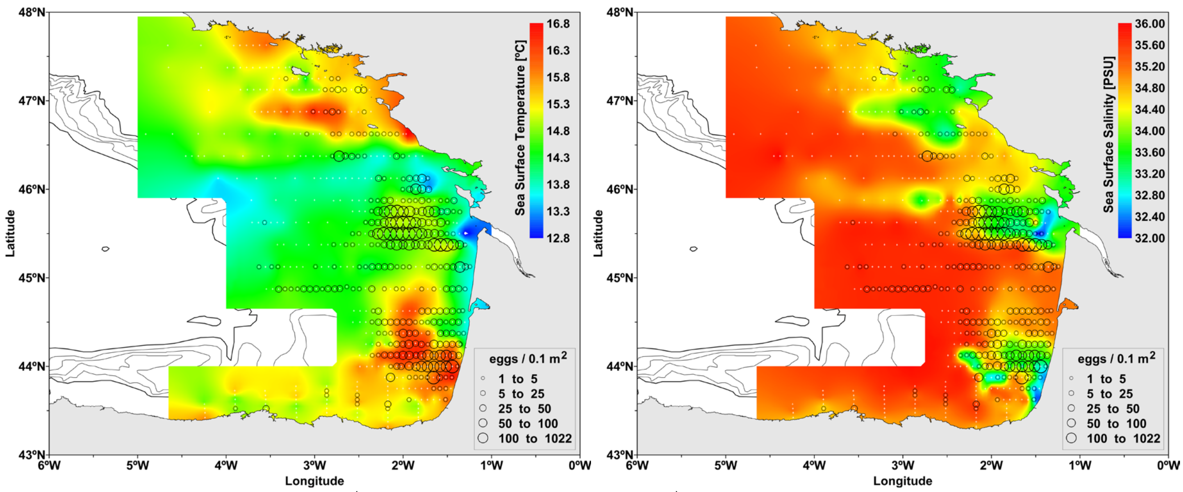


Fig.6: SST and SSS maps (left and right respectively) with anchovy egg distribution.

In relation with the adult samples, most of the hauls consisted of anchovy, horse mackerel, sardine and some mackerel (**Annex I**). 42 pelagic trawls were performed, of these, 28 provide anchovy and 24 were selected for the analysis. The spatial distribution of the samples and their composition is showed in **figure 7. Figure 8** shows the mean weight. Part of the adult parameter are in process, they will be available at WGACEGG that will take place from 26th to 30th of November 2012.

3.2 Total daily egg production

As a result of the adjusted GLM (**Figure 9**) the daily egg production (P_0) was 55.54 egg m^{-2} day^{-1} with a standard error of 10.59 and a CV of 0.19. The daily mortality z was 0.18 with a standard error of 0.0938 and a CV of 0.52. Then, the total daily egg production as the product of spawning area and daily egg production was 2.16 E+12 with a standard error of 4.13 E+11 and a CV of 0.1808.

3.3 Daily fecundity

The Daily Fecundity obtained as a mean of the historical series was 63.39 eggs/g. with a variance of 139 (CV=18.6)

The use of the ad hoc parameters from the BIOMAN 2012 adult sampling, plus the historic Spawning frequency mean of 0.25 with a CV of 3.5%, led to 59.90 eggs/g. with a CV of 6%.

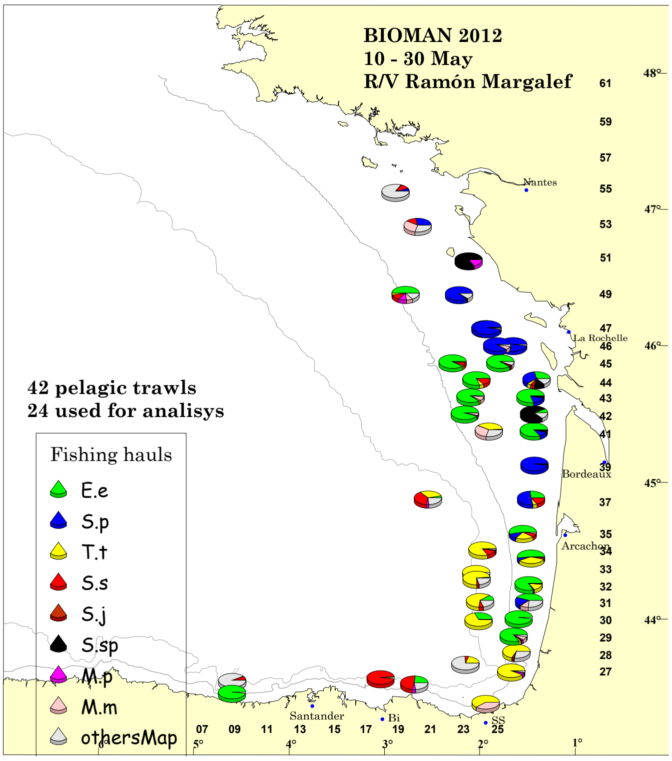


Figure 7: Species composition of the 42 pelagic trawls from the R/V Emma Bardán during BIOMAN12

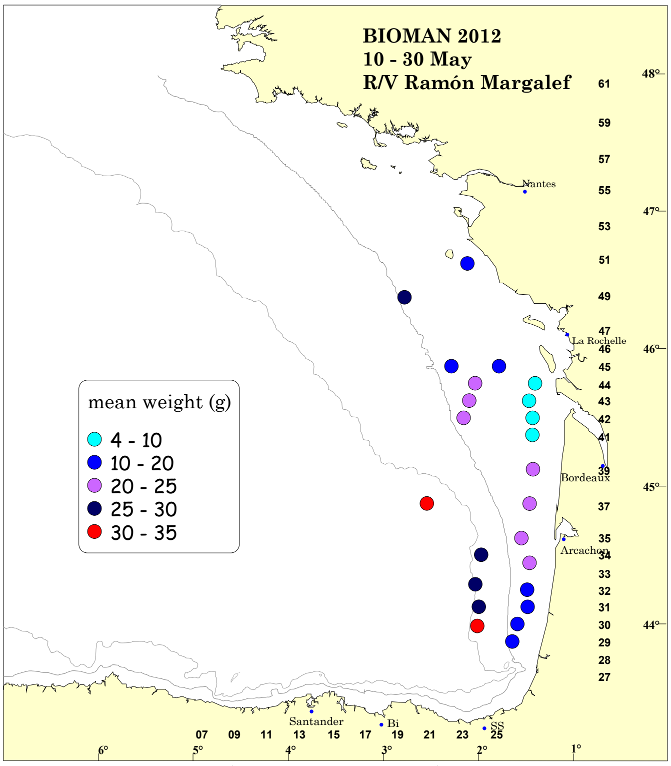


Figure 8: Anchovy (male and female) mean weight per haul

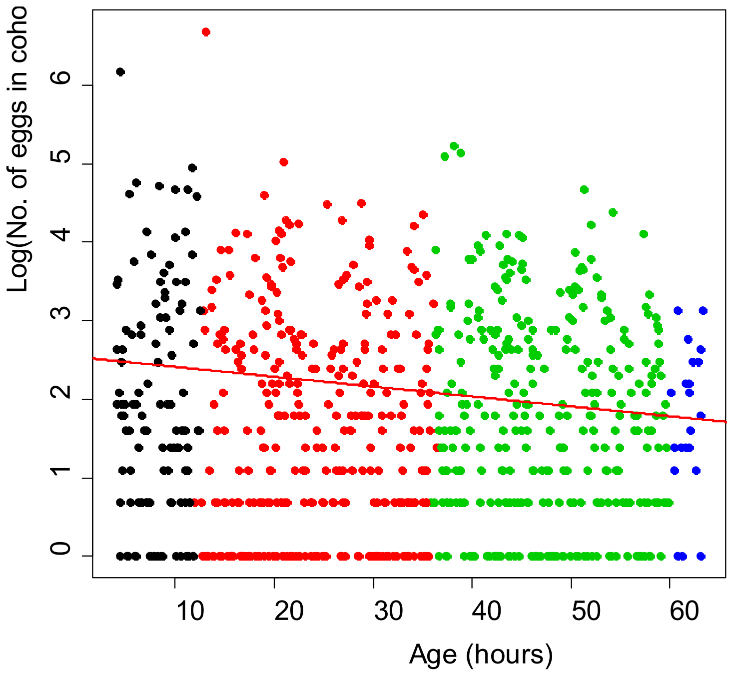


Figure 9: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale.

3.4. Preliminary SSB and numbers at age

A) Based on the historical Mean Daily Fecundity (DF)

Preliminary spawning stock biomass indices resulted in 34,144t with a CV of 27%, obtained as the ratio between the estimates of P_{tot} derived from the GLM and the mean DF. These results are showed in **table 1** below.

Ptot (eggs)			DF (eggs/gramme)			SSB (Ton.)		
Model	**Estimate**	**Var**	**Predic.Model**	**Estimate**	**Var.Pred.**	**Estimate**	**Var**	**Cv**
GLM	2.16E+12	1.7E+23	df = histor. mean	63.39	139.01	34,144	8.3.E+07	0.2664

For the purposes of producing population at age estimates, the age readings based on 1,679 otoliths from 24 samples were available. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents. Given that mean weights of anchovies change between different regions (**Figure 4**) proportionality between the amount of samples and approximate biomass indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance by areas (assuming equal daily fecundity at each area) (**Table 2**). According to that table, the 24 samples selected cannot be considered to be balanced between these regions and differential weighting factors were applied to each sample coming from one or the other region for the purposes of the number at age estimates. The proportion by age, numbers by age, weight at age and biomass by age estimates are given in **Table 3, Figure 12**.

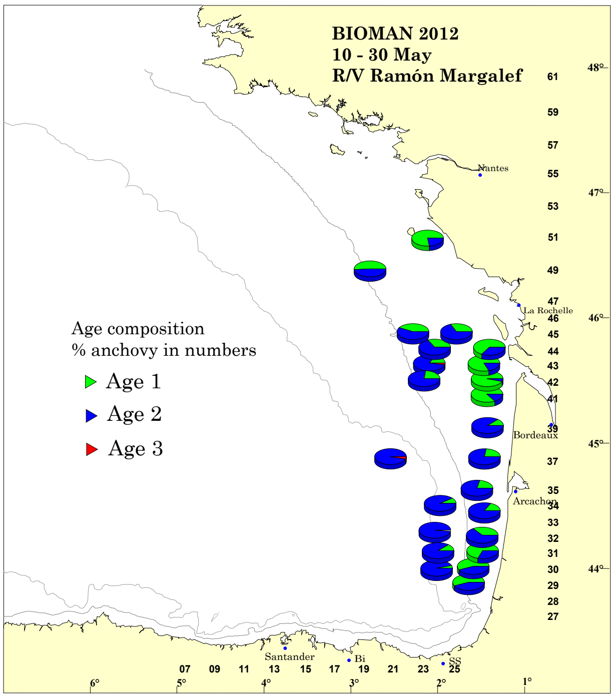


Figure 10: Anchovy age composition per haul

Table 2: Balance of the adult sampling to egg abundance by 6 regions in the Bay of Biscay (see **figure 4**). The row of the table above the mean weights corresponds to the weighting factor of each of the samples by region to obtain the preliminary population structure. Mean weight by region arises from the 24 adult samples selected for the analysis.

Estrata	NE	SE	CE	G	SW	NW	Addition
Total egg abundance	2.7E+11	7.25E+11	4.21E+11	8.22E+11	7.86E+11	2.71E+12	5.74E+12
% egg abundance	5%	13%	7%	14%	14%	47%	100%
Nº of adult samples	**2**	**4**	**4**	**4**	**5**	**5**	24
%Egg/sample	0.02	0.03	0.02	0.04	0.03	0.09	
Proportion of SSB relative to estrata NW	0.25	0.33	0.19	0.38	0.29	1.00	
W. factor proportional to the population	0.25/wi	0.33/wi	0.19/wi	0.38/wi	0.29/wi	1/wi	
Mean weight of anchovies by region	17.8	16.4	22.4	6.8	29.4	22.4	

Table 3: SSB 2012 estimates and the correspondent standard error (S.e.) and coefficient of variation (CV) of the percentage by age and numbers at age estimates, with the mean weight by age class.

Parameter	**Estimate**	**S.e.**	**CV**
Biomass (Tons)	34,144	9,097	0.2664
Tot.mean W (g)	18.27	1.73	0.0947
Population (millions)	1,869	528.5	0.2827
Percent age 1	0.4428	0.0645	0.1457
Percent age 2	0.5557	0.0640	0.1152
Percent age 3+	0.0016	0.0012	0.7725
Numbers at age 1	828	263.3	0.3181
Numbers at age 2	1,039	317.1	0.3053
Numbers at age 3+	3	2.4	0.8227
Weight at age 1	12.4		
Weight at age 2	22.9		
Weight at age 3+	36.0		
SSB at age 1 in mass	10,284		
SSB at age 2 in mass	23,755		
SSB at age 3+ in mass	105		
Percent age 1 in mass	0.3012		
Percent age 2 in mass	0.6957		
Percent age 3+ in mass	0.0031		

B) SSB and Population at age estimates using DF based on the ad hoc adult parameters for R, W and F in 2012

The application of the same procedures described above, with the exception of making use of the DF from the R, W and F obtained from the 2012 adult samples and the mean historical spawning frequency results in the following Biomass estimates:

Parameter	**estimate**	**S.e.**	**CV**
Ptot	2.16E+12	4.13E+11	0.1908
R'	0.53	0.0048	0.0090
S	0.25	0.0087	0.0353
F	9,447	856	0.0906
Wf	20.64	1.59	0.0769
DF	59.79	3.47	0.0580
BIOMASS	**36,200**	7,217	0.1994

And in the following Population at age estimates:

Parameter	estimate	S.e.	CV
BIOMASS (Tons)	**36,200**	7,217	0.1994
Tot. Mean W (g)	18.15	1.77	0.0974
Population (millions)	2,014	448	0.2225
Percent. age 1	0.44	0.07	0.1467
Percent. age 2	0.55	0.06	0.1169
Percent. age 3	0.00	0.00	0.6269
Numbers at age 1	906	281	0.3103
Numbers at age 2	1,104	229	0.2076
Numbers at age 3	4	3	0.6375
W age 1 (g)	12.4		
W age 2 (g)	22.9		
W age 3 (g)	27.8		
SSB at age 1 (Tons)	11,127		
SSB at age 2 (Tons)	24,959		
SSB at age 3 (Tons)	113		

We consider that this result based on ad hoc estimates of adult parameters from BIOMAN2012 survey are preferable for inputing the assessment of anchovy in the Bay of Biscay, simply because they are based on better guess of the final adult parameter estimates than the former estimate based just on the historical mean DF. The inclusion of the alternative A based on the historical mean DF is made as this has been the usual approach for delivering provisional estimates in June in previous years. Differences are minor but SSB from option B seems better for the reason mentioned before.

3.5. Historical perspective

The whole series of biomass estimates from the DEPM, including the current preliminary estimate for 2012, are presented in **figure 11**. The historical series of numbers at age in numbers is shown in **figure 12.** In order to provide a broader point of view for the interpretation of current survey results, distribution maps of the anchovy egg abundances in the last 18 DEPM surveys were compiled (**Fig 13**).

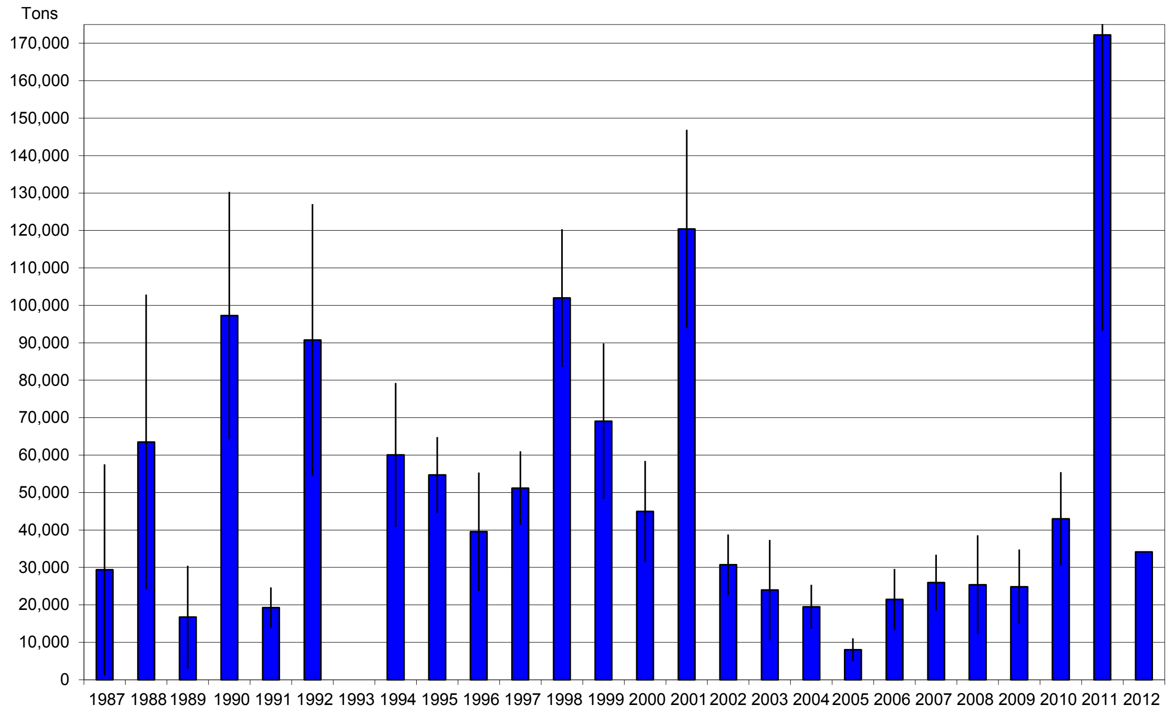


Figure 11: Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. In 1996, 1999, 2000, 2007, 2008, 2009, 2010 and 2011 S was deduced indirectly.

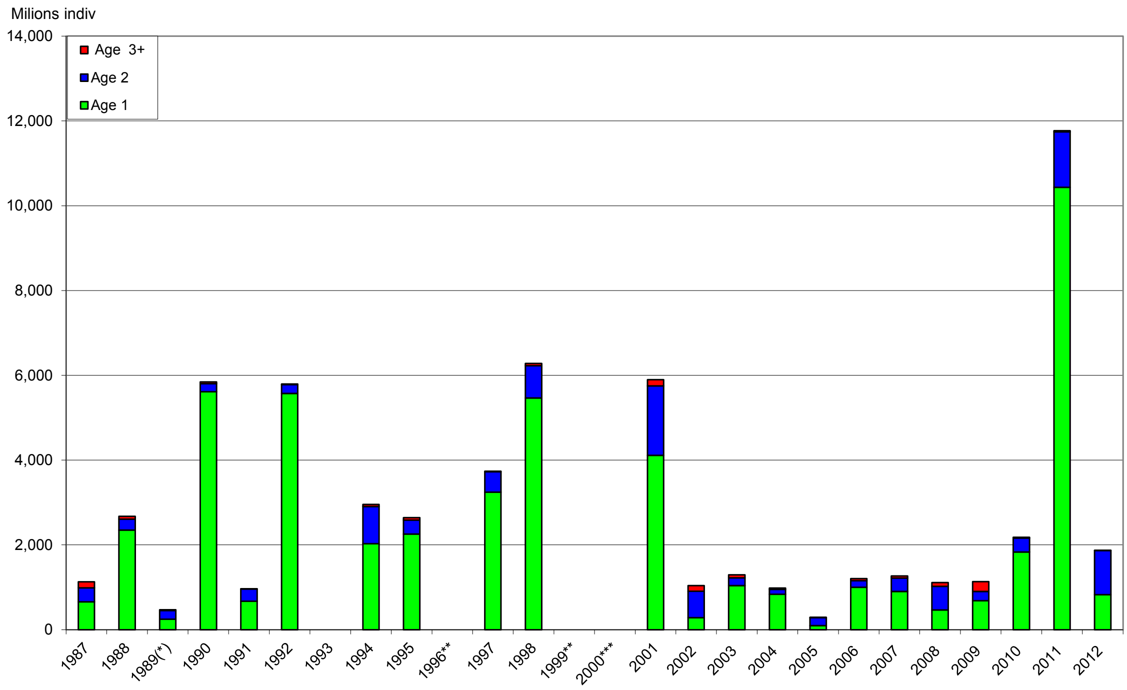


Figure 12: Historical series of numbers at age from 1987 to 2012. This year 56% of the biomass in numbers was year two.

4. CONCLUSIONS

The survey BIOMAN2012 has covered the spawning area satisfactorily and the total egg production has been estimated in the distribution area of the population. Moreover there were obtained 52 pelagic trawls, from those 28 were positive for anchovy and 24 were selected for the analysis. Those were obtained simultaneously to the egg sampling.

To estimate the total egg production an exponential mortality model was applied. The adjustment of the model was satisfactory. Two estimates of daily Fecundity DF were made available: the first one was the mean of the DF historical series, following the procedure was agreed during ICES WGACEGG 2009. The second one made use of the processing of the adults samples from BIOMAN2012 for sex ratio, mean weight and batch fecundity (based on 36 females), which jointly with an historical mean spawning fraction, led to an ad hoc estimate of DF for 2012, considered to be close to the final expected estimate for this survey than the former. Both estimates of DF and of corresponding SSB were in any case very similar.

The spawning area, the total egg production and the preliminary SSB of anchovy in 2012 are at levels similar to those recorded in 2010, with a final SSB around 36,000 t.

Approximately 44% of the anchovy are individuals of age 1 acounting for 30% of the biomass, while 56% of the anchovies are of age 2, accounting for 70% of the biomass. This denotes a moderate level of recruitment, compared to the historical maximum at age 1 recorded in 2011.

The complete estimate of the anchovy biomass and the confirmation of the level of recruitment will be obtained taking into account both the BIOMAN survey (DEPM) index (carried out by AZTI) and the PELGAS Acoustic index (carried out by IFREMER), including the commercial catch by the fleet. This analysis will take place during this ICES WGHANSA meeting.

5. ACKNOWLEDGEMENTS

We thank all the crew of the R/V Ramón Margalef and Emma Bardán and all the personal that participated in BIOMAN 2012 for their excellent job and collaborative support. This work has been founded by the Agriculture, Fisheries and Food Technology Department of the Basque Government and by the European Commission within the frame of the National Sampling Programme. The General Secretariat of Sea also collaborated providing the R/V Emma Bardán.

6. REFERENCES

Agresti, A. 1990. *Categorical data analysis*. John Wiley & Sons, Inc. New York

Arregi, L., Puente, E., Lucio, P., Sagarminaga, Y., Castro and Uriarte, An. Costal fisheries and demersal estuarine fauna. In: Oceanography and marine environment of the Basque Country. (ed. A. Borja and M. Collins) Elsevier oceanography series.

Barange, M., Bernal, M., Cercole, M.C., Cubillos, L.A., Cunningham, C.L., Daskalov, G.M., De Oliveira, J.A.A., Dickey-Collas, M., Hill, K., Jacobson, L.D., Köster, F.W., Masse, J., Nishida, H., Ñiquen, M., Oozeki, Y., Palomera, I., Saccardo, S.A., Santojanni, A., Serra, R., Somarakis, S., Stratoudakis, Y., van der Lingen, C.D., Uriarte, A. and Yatsu, A. 2009. Current trends in the assessment and management of small pelagic fish stocks. Chapter 10 in: Checkley, D.M. Jr, Roy, C., Oozeki, Y. and Alheit J. (Eds.) Climate Change and Small Pelagic Fish. Cambridge University Press.

Bernal, M., Ibaibarriaga, L., Lago de Lanzós, A., Lonergan, M., Hernández, C., Franco, C., Rasines, I., et al. 2008. Using multinomial models to analyse data from sardine egg incubation experiments; a review of advances in fish egg incubation analysis techniques. *ICES Journal of Marine Science*, 65: 51–59.

Bernal, M., Borchers, D. L., Valde´s, L., Lago de Lanzo´ s, A., and Buckland, S. T. 2001. A new ageing method for eggs of fish species with daily spawning synchronicity. *Canadian Journal of Fisheries and Aquatic Sciences*, 58: 2330–2340.

Checkely D.M., Ortner P.B., Settle L.R., S.R. Cummings (1997). A continuous, underway fish egg sampler. *Fisheries Oceanography* 6: 58–73.

Ferrer, L., Fontán, A., Chust, G., Mader, J., González, M., Valencia, V., Uriarte, Ad., Collins, M.B., 2009. Low salinity plumes in the oceanic region of the Basque Country. Cont. Shelf Res., 29 (8), 970-984.

Hunter, J.R. and Macewicz, B.J. (1985) Measurement of spawning frequency in multiple spawning fishes. In: *An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, Engraulis mordax* (ed. R. Lasker), NOAA Technical Report NMFS, US Department of Commerce, Springfield, VA, USA, 79–93.

Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D. L.,Lonergan, M., and Wood, S. 2007. Estimation of development properties of stage-classified biological processes using multinomial models: a case study of Bay of Biscay anchovy (*Engraulis encrasicolus* L.) egg development. *Canadian Journal of Fisheries and Aquatic Sciences*, 64: 539–553.

ICES. 2010. Report of the Working Group on Anchovy and Sardine (WGANSA), 24–28 June 2010, Lisbon, Portugal. ICES CM 2010/ACOM:16. 290 pp.

ICES. 2004. The DEPM estimation of spawning-stock biomass for sardine and anchovy. *ICES Cooperative Research Report*, 268.91 pp.

Lasker, R., 1985. *An Egg Production Method for Estimating Spawning Biomass of pelagic fish: Application to the Northern Anchovy, Engraulis mordax*. NOAA Technical report NMFS 36:100p.

Lo, N.C.H. (1985a). A model for temperature-dependent northern anchovy egg development and an automated procedure for the assignment of age to staged eggs. In: *An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, Engraulis mordax* (ed. R. Lasker), NOAA Technical Report NMFS, US Department of Commerce, Springfield, VA, USA, 43–50.

McCullagh, P., and Nelder, J.A. 1989. Generalised linear models. Chapman & Hall, London.

Moser HG, Ahlstrom EH (1985). Staging anchovy eggs. In: Lasker R. (ed.) *An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application to the Northern Anchovy, Engraulis mordax*. pp 99–101. NOAA Technical Report 36: 37–41.

Motos, L., Uriarte, A., Prouzet, P., Santos, M., Alvarez, P., Sagarminaga, Y., 2005. *Assessing the Bay of Biscay anchovy population by DEPM: a review 1989–2001.* In: Castro, L.R., P. Freón, C. D. van der Lingen and A. Uriarte, editors, Report of the SPACC Meeting on Small Pelagic Fish Spawning Habitat Dynamics and the Daily Egg Production Method (DEPM). GLOBEC Report 22, xiv, pp. 88-90.

Motos, L., 1994. Estimación de la biomasa desovante de la población de anchoa del Golfo de Vizcaya *Engraulis encrasicolus* a partir de su producción de huevos. Bases metodológicas y aplicación. Ph. D. thesis UPV/EHU, Leioa.

Parker, K., 1980. A direct method for estimating northern anchovy, *Engraulis mordax*, spawning biomass. *Fisheries. Bulletin.*, 78: 541-544

Picquelle, S and G. Stauffer. 1985. Parameter estimation for an egg production method of anchovy biomass assessment. In: R. Lasker (ed.). *An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, Engraulis mordax*, pp. 7-16. U.S. Dep. Commer.,NOAA Tech. Rep. NMFS 36.

Sanz, A. and A. Uriarte. 1989. Reproductive cycle and batch fecundity of the Bay of Biscay anchovy (*Engraulis encrasicholus*) in 1987. CalCOFI Rep., 30: 127-135

Seber, G.A.F. *The estimation of animal abundance and related parameters*. Charles Griffin and Co., London, 2nd edition, 1982.

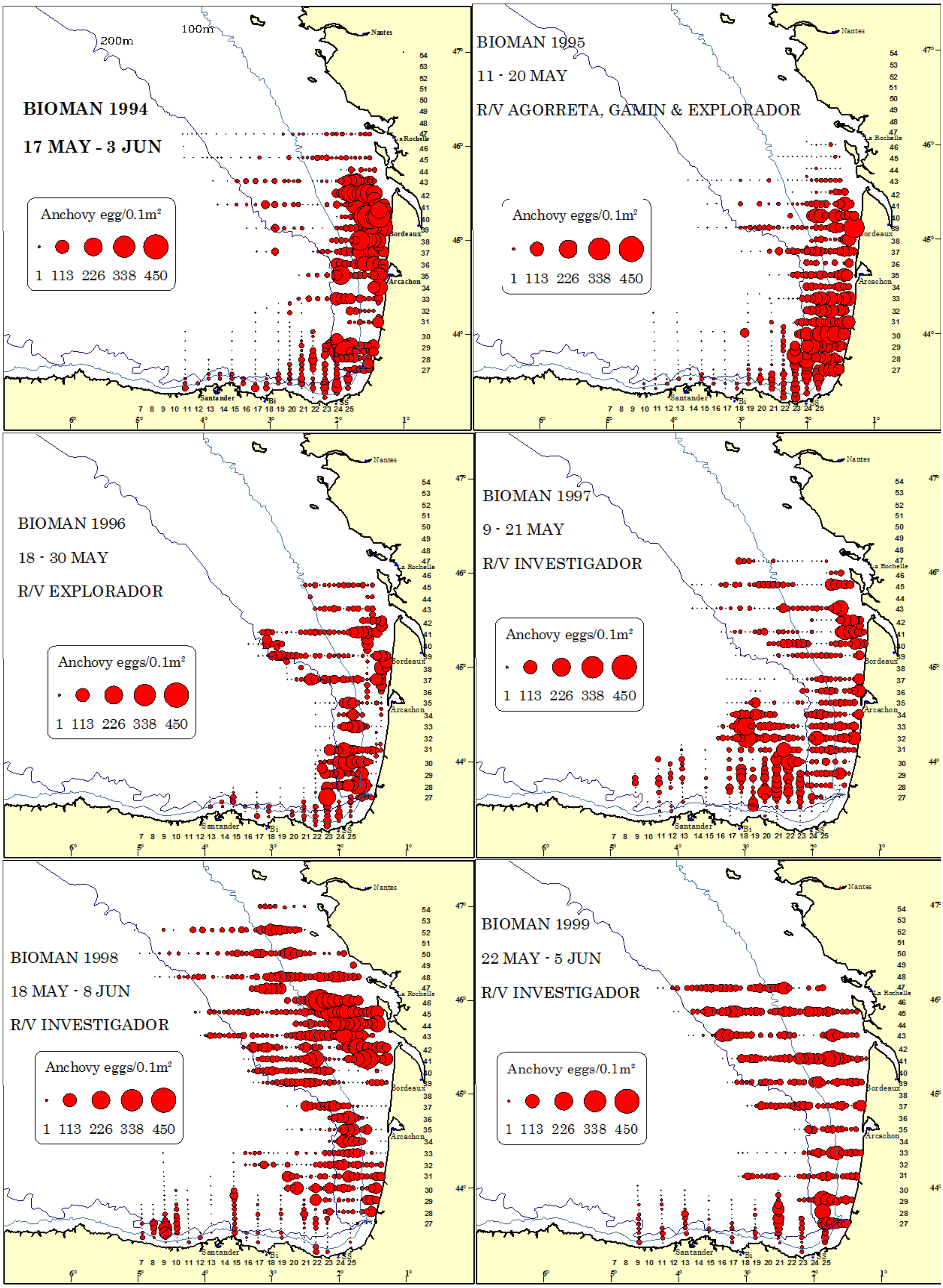
Shchepetkin, A.F., McWilliams, J.C., 2005. The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model. Ocean Model., 9, 347-404.

Somarakis, S., Palomera, I., García, A., Quintanilla, L., Koutsikopoulos, C., Uriarte, A., Motos, L., 2004. Daily egg production of anchovy in European waters. *ICES Journal Marine Science*. 61, 944-958.

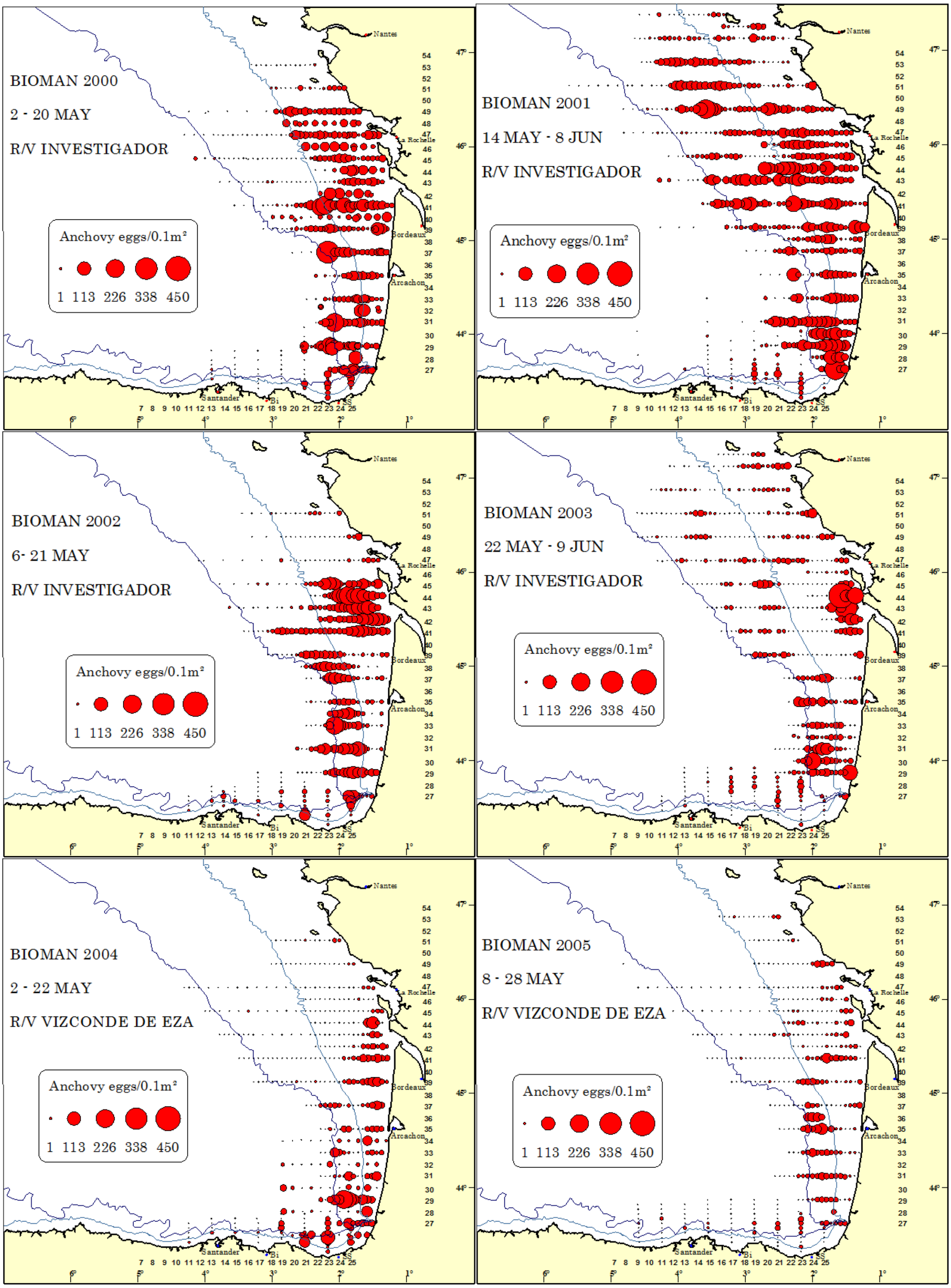
Smith, P.E., W. Flerx and R.H. Hewitt, 1985. The CalCOFI Vertical Egg Tow (CalVET) Net. In R. Lasker (editor), *An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, Engraulis mordax,* p. 27-32. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 36.

Stratoudakis, Y., Bernal, M., Ganias, K., and Uriarte, A. 2006. The daily egg production methods: recent advances, current applications and future challenges. *Fish and Fisheries*, 7: 35–57.

Uriarte A., Prouzet, P. Villamor B. 1996. Bay of Biscay and Ibero-Atlantic anchovy populations and their fisheries. *Scientia Marina*, 60 (Supl.2): 237-255.



BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1998
18 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1999
22 MAY - 5 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
200m
100m
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS


BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS

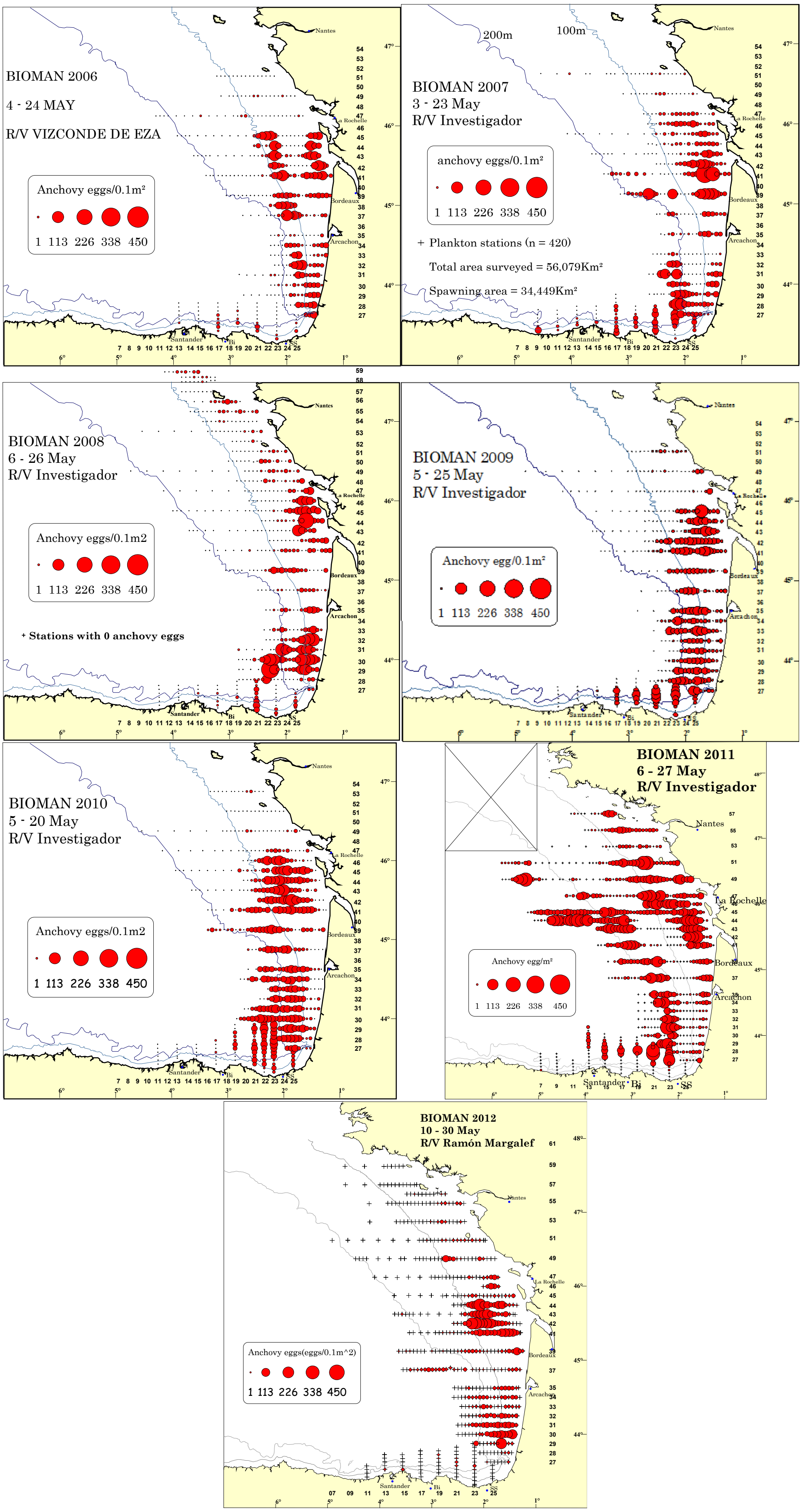


Figure 13: Anchovy egg distribution and abundance from 1994 to 2012.

Working Document presented to the ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). Horta, Faial Island, Azores Islands (Portugal), 23-28 June 2012.

Gulf of Cádiz Anchovy Spawning Stock Biomass estimation through the application of DEPM in 2011.

M.P. Jiménez (*1), J. Tornero (1), A. Solla (2) and F. Ramos (1)

(*) Corresponding autor.
(1) Instituto Español de Oceanografía. Centro Oceanográfico de Cádiz. Puerto Pesquero, Muelle de Levante s/n. 11006 (Cádiz, Spain).
(2) Instituto Español de Oceanografía. Centro Oceanográfico de Vigo. Subida a Radio Faro, 50. 36390 (Vigo, Pontevedra, Spain).

Introduction

The IEO (Spain) conducts every three years a Daily Egg Production Method (DEPM) survey to estimate the Gulf of Cádiz Anchovy Spawning Stock Biomass (SSB) (ICES Subdivision IXa South). The *BOCADEVA-0711* DEPM survey (the third survey in its series) is one of the research activities developed in 2011 under the project ICTIOEVA09 (*Métodos de Producción de Huevos, Estimación de la biomasa de especies pelágicas de interés comercial: sardina, anchoa, caballa y jurel*). The survey was carried out on board R/V *Cornide of Saavedra* (IEO) from 22st July to 2nd August 2011, one month later than the previous survey in 2008. The survey dates are determined by the reproductive cycle of the species in the study area, and they should coincide with the peak spawning.

The surveyed area extends from the Strait of Gibraltar to Cape San Vicente (Spanish and Portuguese waters off the Gulf of Cadiz). Plankton samples, along a grid of parallel transects perpendicular to the coast, are obtained for the spawning area delimitation and density estimation of the daily egg production; concurrently, fishing hauls are undertaken for the estimation of adult parameters (sex ratio, female mean weight, batch fecundity and spawning fraction) within the mature component of the population. The survey objectives also include obtaining the length distributions and the biological parameters for other important commercial fish species in the area as well as to characterize the oceanographic and meteorological conditions in the study area during the survey.

This working document provides a brief description of the survey, laboratory analysis and the estimation procedures used to obtain the Anchovy SSB by DEPM in 2011 for the Southern component of the Anchovy stock in the ICES Division IXa.

Methodology

Table I presents a summarised description of the methodology used to obtain eggs and adults samples during the survey. The sampling grid was composed by 21 transects perpendicular to the coast, interspaced 8 nm between transects and 3 nm between stations (following the standards by the *Study Group on Spawning Biomass of Sardine and Anchovy*, ICES 2003).

Table I. *BOCADEVA 0711*. Gulf of Cádiz Anchovy DEPM survey. General sampling.

Parameters	**Anchovy DEPM survey *BOCADEVA0711***
Surveyed area	(36º11’- 36º47’N – 6º12’- 8º54’W)
R/V	*Cornide de Saavedra*
Dates	22/07-02/08/2011
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 μm)	124
Sampling maximum depth (m)	100
Hydrographical sensor	CTD SBE25 and CTD SBE37
Flowmeter	Yes
CUFES stations	114
CUFES (335μm)	3 n miles (sample unit)
Environmental data	Temperature and Salinity
Adults	
Gears	Pelagic trawl
Trawls	24 (2 null; 21 positive for anchovy)
Trawling time	From 07:15 to 20:08 hrs GMT
Biological sampling	On fresh material, on board of the R/V
Sample size	At least 60 individuals, randomly picked; up to 120
Fixation	4% Phosphate buffered Formaldehyde
Preservation	4% Phosphate buffered Formaldehyde

<u>Egg sampling and processing</u>

The strategy of egg sampling was identical that the one used in previous *BOCADEVA* surveys. An adaptive sampling was carried out in the E-W direction using a PairoVET net in fixed stations as main sampler and a continuous sampling with CUFES (Continuous Underwater Fish Egg Sampler) as a secondary sampler.

- *Vertical sampling (PairoVET)*

The sampling grid was sampled over the continental shelf following a systematic sampling scheme, with transects being perpendicular to the coast and equally spaced 8 nm. Egg samples were always taken every 3 nm in the inner shelf, up to 100m depth in the water column (ICES, 2003). The inshore limit of transects was determined by the bottom depth (as close to the shore as possible), while the offshore extension was decided adaptively depending on the results of the most recent CUFES sample.

Vertical hauls of plankton were carried out with a PairoVET sampler equipped with nets of 150 µm mesh size. Hauls were carried out up to a maximum depth of 100 m or of 5 m above the bottom in shallower depths, with a speed of about 1 m/s. Sampling depth and temperature of the water column were recorded using a CTD SBE 37 fitted to the net. Flowmeters were used to calculate the volume of filtered water during each haul. Egg samples were analysed onboard.

A preliminary identification and counting of anchovy eggs and larvae, as well as other commercial species were carried out. Samples were sorted, counted and preserved in a 4 % buffered formaldehyde solution. In the laboratory, anchovy eggs were classified in 11 developmental stages, according to the key proposed by Moser and Ahlstrom (1985).

- *Continuous sampling (CUFES)*

During the CUFES sampling (Checkley *et al.*, 2000) the volume of filtered water (600 l/min, approximately) was also integrated each 3 nm (at a fixed depth of 5 m). The CUFES collector was arranged with a 335 µm net. Anchovy eggs were classified in three stages: No-Embryo (I-III), Early Embryo (IV-VI) and Late Embryo (VII-XI).

<u>Adult sampling and processing</u>

Adult anchovy samples for DEPM purposes were obtained during the survey from pelagic trawl hauls. Initially was used the *Pedreira* pelagic trawl (12-13 m true vertical opening, 20 mm mesh size in the cod-end). However, a gear hooking during the fishing haul P06, which resulted in the breaking of the net, forced to replace this gear by the *Tuneado* pelagic trawl (17-18 m vertical opening). In both cases, the performance and geometry of the gears as well as the entrance of fish in the net were monitored by a *Simrad Mesotech FS20/25* net sonar (working frequencies: 120-200 kHz).

The location of the fishing stations was opportunistic, according to the echogram information on the expected anchovy presence (by visual scrutiny based on expertise) recorded with a *Simrad® EK60* echo-sounder working in a multi-frequency fashion (18, 38, 70, 120 and 200 kHz).

Except for searching anchovy females with hydrated gonads, fishing stations were mostly conducted during daylight hours and carried out over the isobath, once echotraces supposedly belonging to anchovy were detected by echo-sounder. In such situations, and depending on the survey logistics, either the ichthyoplancton sampling was interrupted for doing the fishing stations or these ones were carried out once the eggs sampling over transect was finished.

For the estimation of spawning fraction (S), a minimum of 30 mature, non-hydrated females per sample was sought, so a minimum of 60 random anchovies were sampled, adding batches of 10 random individuals to the sampling until the goal was achieved or a maximum of 120 anchovies were sampled. Sex-ratio (R), along with other parameters used in the DEPM was also obtained from this random sampling.

When hydrated females (HF) appeared, an additional sampling was done in order to obtain a minimum of 150 HF for the whole area prospected. These females were sampled as described above. Gonads from both hydrated and non-hydrated females were preserved in 4% buffered formaldehyde.

Mean female weight (*W*) was estimated after correction for the increase in weight due to the hydration in hydrated females. Sex ratio (*R*) was estimated as the weight ratio of females in the mature population.

The individual batch fecundity (*Fobs*) was estimated by the hydrated oocyte method (Hunter *et al*., 1985). The spawning fraction (*S*) is currently being determined by histological analysis of the post-ovulatory follicles, POFs. Post-ovulatory follicles (POF's) were assigned to stages according to the Alday *et al*., 2010 classification, and the correspondence en days by Hunter and Macewicz (1985): (Day-0 POFs (estages 1 and 2); Day-1 POFs (stages 3 and 4); Day-2 POFs (stages 5 and 6); Day-2+ POFs (stage 7), although considering as the peak spawning time the species-specific for the study area.

<u>Data analysis and estimation</u>

Anchovy biomass estimation was based on procedures and software adapted and developed during the WKRESTIM (Madrid, 2009).

- *Egg Production estimation (z, P_0 and P_{tot}) and area calculation*

All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages *geofun, eggsplore and shachar* available at *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis).

The surveyed area (*A*) was calculated as the sum of the area represented by each station. The spawning area (*A+*) was delimited with the outer zero Anchovy egg stations, and was calculated as the sum of the area represented by those stations. The model of egg development with temperature was derived from the incubation experiment carried out in Cádiz in July 2007 (Bernal *et al*., 2011). A multinomial model was applied (Ibaibarriaga *et al.,* 2007, Bernal *et al.,* 2008) considering only the interaction Age*Temp (other interactions were not significant).

$$N_{i,t} \sim \text{Mult}(N, p_{i,t})$$

$$p_{i,t} = f(\text{Age}, \text{Temp})$$

Egg ageing was performed by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST; a normal probability distribution was used with peak spawning assumed to be at 22:00 h with 2 h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution).

p(age | stage, temp, time) a p (stage | age, temp) p (age | time)

ageing development model synchronicity

Daily egg production (P_0) and mortality (*z*) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of *z* converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z = 0.01].

$$P_{age} = P_0 \, e^{-z\,age}$$

$$\log\left(\frac{N_{age}}{area}\right) = \log(P_0) - z\,age \;\rightarrow\; \log(N_{age}) = \log(area) + \log(P_0) - z\,age$$

Finally, the total egg production was calculated as: $P_{tot} = P_0\,A+$

- *Adult parameters*

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data).

Before the estimation of the mean female weight per haul (W), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (*Wnov*). The sex ratio in weight per haul (*R*) was obtained as the quotient between the total weight of females and the total weight of males and females. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (*Fobs*) in the sampled hydrated females and their gonad-free weight (*Wnov*) by a GLM. The fraction of females spawning per day (*S*) was determined for each haul as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF is corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females are not included).

The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology proposed by Picquelle and Stauffer (1985; *i.e.*, weighted means and variances). All the estimations and statistical analyses were performed using the R software.

- *Spawning Stock Biomass*

The spawning Stock Biomass was computed according to: $SSB = \frac{P_{total} * W}{F * S * R}$

Results

The surveyed area (13106.83 km^2) extends from Cape Trafalgar (Spain) to Cape San Vicente (Portugal), from 36º 11' - 36º 47 N – 6º 12' - –8º 54' W. This area includes the continental shelf of the Gulf of Cádiz. The survey was carried out from East to West, starting in the radial 1- station 1, located close the Strait of Gibraltar. **Fig. 1** shows the track sailed by the R/V *Cornide de Saavedra* during the survey, with indication of the date.

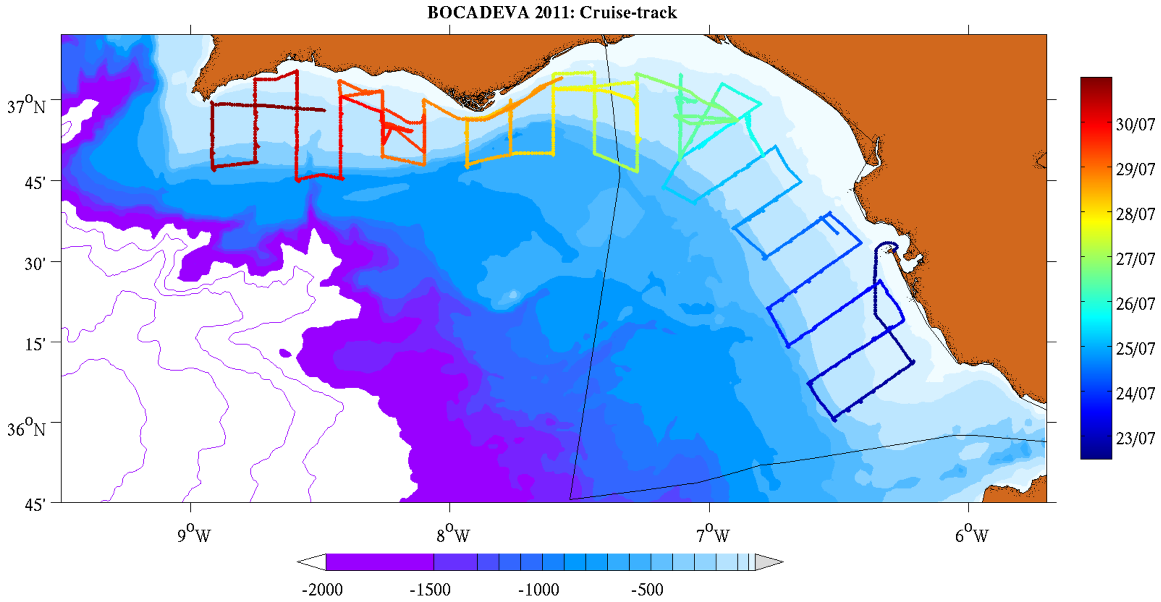


Figure 1. ***BOCADEVA 0711*. Track of the route sailed by the R/V *Cornide of Saavedra* during the survey.**

<u>Distribution and abundance of anchovy eggs</u>

The icthyoplankton sampling almost covered the whole 24 hours' day-time period, except for small intervals of time, when the fishing hauls were carried out in order to obtain anchovy adults. A total of 124 PairoVET stations were carried out. In 71 stations (57.3%) there was presence of anchovy eggs (positive stations). A total of 2387 anchovy eggs were caught, and a maximum density (in number/m^2) of 2195 was obtained (**Table II**). No sardine eggs were caught.

Anchovy eggs were caught mainly (59 % in number) in the coastal area located between the radial 12 (close to the Guadiana River mouth) and the radial 18, in Portuguese waters (**Fig. 2**). High abundances were also found in stations located close to the Guadalquivir River mouth. In these stations (all of them with a density > 1000 eggs/m^2 and located inside isobaths of the 100 m) the temperature (SST) ranged between 18.9 and 21.7 ºC (mean 20.4 ºC). In the total area, the SST ranged between 16.8 and 23.5 ºC (mean 21 ºC) (**Fig. 2**).

Table II. *BOCADEVA-0711*. Number and density of anchovy eggs sampled by the PairoVET net during the survey.

By Pairovet	Anchovy eggs
N stations	124
N positive stations	71
N total eggs	2387
N medium eggs	19
N maximum eggs	191
Total density (egg/m2)	24722
Mean density	199
Maximum density	2195

93.6% of the anchovy eggs have been classified into 11 stages according to the degree of embryonic development. It has been found anchovy eggs in all the described stages. The most abundant development stages were II, VI and VII (35.6, 16.5 and 15%, respectively). 30 eggs were found in stage I whereas XI stage eggs, right before the hatching, represented 0.6%.

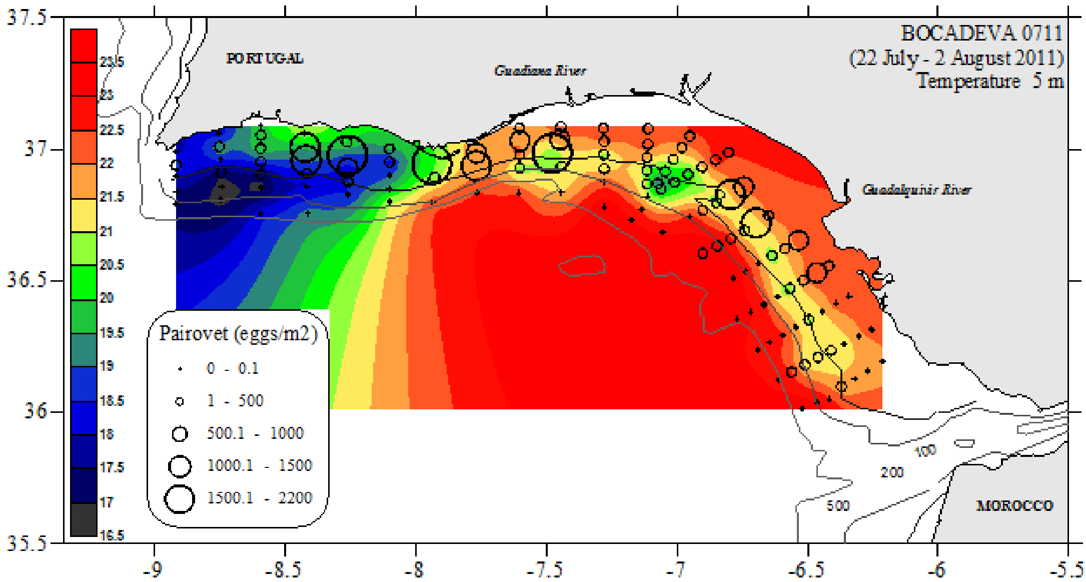


Figure 2. *BOCADEVA 0711*. Abundance distribution of anchovy eggs sampled by PairoVET and SST.

The total number of anchovy eggs obtained by CUFES was 37 831 (92.6% of the total of sampled eggs), with a mean estimated at of 332 eggs, and a maximum value of 3952 eggs. The spatial distribution of the abundance of anchovy eggs (number/m^3) as sampled by CUFES showed a similar spatial distribution than the one sampled by PairoVET (**Fig. 3**), with maximum values between the Guadiana River and Portimão, in Portuguese waters. The stations with higher abundances (> 200 eggs/m^3) were close to the coast (45 – 80m depth). As described for the vertical sampling, sardine eggs were not found by CUFES.

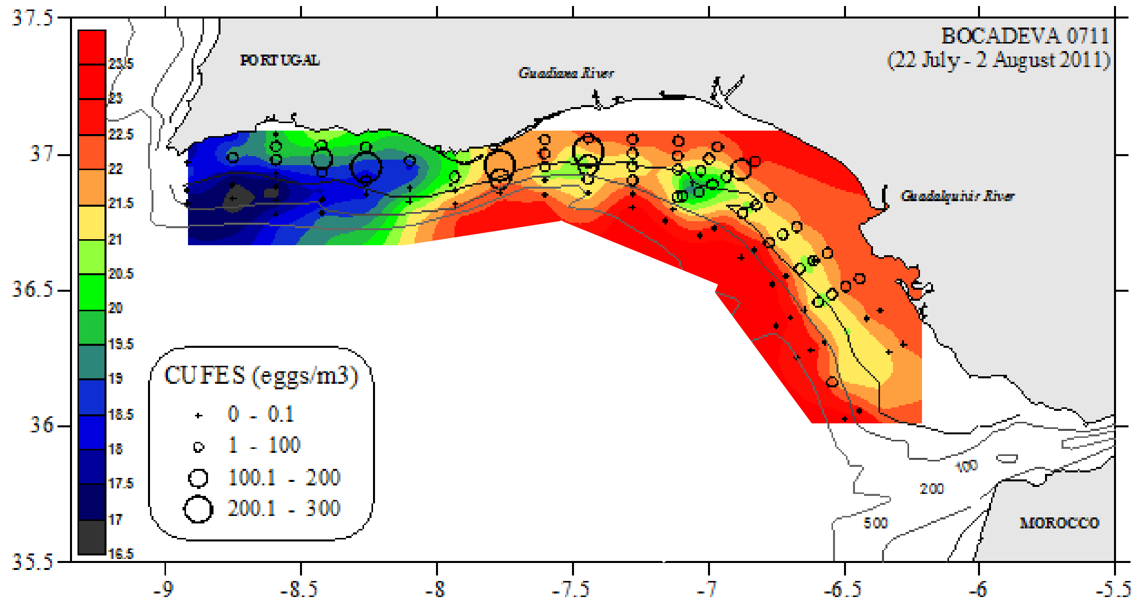


Figure 3. *BOCADEVA 0711*. Abundance distribution of anchovy eggs sampled by CUFES and SST.

<u>Adults. Results of the pelagic hauls</u>

A total of 24 fishing operations were carried out during the survey, of which 22 were valid, 5 in Portuguese waters and the remaining 17 fishing hauls in Spanish waters. Anchovy showed a high frequency of occurrence in the fishing stations throughout the surveyed area, with positive catches in 20 fishing stations from the 22 valid ones. These positive stations were carried out between 6:52 and 20:18 hrs GMT and in a bathymetric range between 39 and 121 m depth (**Table III, Fig. 4**).

Table III. *BOCADEVA 0711*. General characteristics of the fishing hauls (null hauls highlighted in orange; in yellow those night hauls, aimed at the capture of hydrated females, that were a repetition of previous ones).

Fishing station	Dates	Transect	Zone	Start		Retrieval		GMT time		Depth (m)		Effec. Traw. (min)	Gear	Validity
				Latitude	Longitude	Latitude	Longitude	Start	Retr.	Start	Retr.			
01	23/07/11	R02	Sancti-Petri	36°17,292' N	6°18,418' W	36°15,711' N	6°21,392' W	08:40	09:36	41,0	48,6	56	Pedreira	Y
02	23/07/11	R03	Cádiz	36°23,058' N	6°26,109' W	36°24,713' N	6°23,300' W	12:08	12:50	56,3	48,0	42	Pedreira	Y
03	24/07/11	R05	Chipiona	36°38,004' N	6°33,897' W	36°36,845' N	6°35,999' W	06:52	07:38	40,8	53,6	46	Pedreira	Y
04	24/07/11	R04-R05	Rota-Chipiona	36°35,758' N	6°30,992' W	36°37,792' N	6°33,572' W	08:31	09:15	43,7	40,7	44	Pedreira	Y
05	24/07/11	R06	Doñana	36°41,663' N	6°44,579' W	36°39,981' N	6°47,647' W	16:42	17:28	74,5	102,4	46	Pedreira	Y
06	25/07/11	R08	Mazagón	36°53,200' N	6°59,109' W	36°51,562' N	7°02,118' W	11:37	12:22	92,4	110,7	45	Pedreira	N
07	25/07/11	R08	Mazagón	36°53,132' N	6°59,253' W	36°51,983' N	7°01,302' W	14:17	14:47	92,5	104,5	30	Tuneado	Y
08	25/07/11	R07-R08	Matalascañas-Mazagón	36°50,571' N	6°48,077' W	36°52,318' N	6°49,316' W	18:59	19:29	50,0	49,5	30	Tuneado	Y
09	26/07/11	R09-R10	Punta Umbría – El Rompido	37°00,368' N	7°06,684' W	36°59,745' N	7°03,992' W	07:42	08:15	57,4	57,4	33	Tuneado	Y
10	26/07/11	R10-R09	El Rompido – Punta Umbría	36°56,357' N	7°06,357' W	36°55,803' N	7°04,967' W	15:19	15:37	92,9	93,0	18	Tuneado	Y
11	26/07/11	R08-R09	Mazagón – Punta Umbría	36°56,612' N	6°54,023' W	36°58,162' N	6°56,816' W	18:04	18:43	49,8	50,6	39	Tuneado	Y
12	27/07/11	R11	Isla Cristina	36°59,706' N	7°26,509' W	36°57,354' N	7°26,529' W	08:05	08:40	97,4	119,3	35	Tuneado	Y
13	27/07/11	R11	Isla Cristina	36°55,162' N	7°16,692' W	36°57,251' N	7°16,719' W	16:44	17:16	121,2	99,8	32	Tuneado	Y
14	27/07/11	R11	Isla Cristina	36°55,200' N	7°16,683' W	36°58,681' N	7°16,696' W	19:08	19:59	120,7	91,7	51	Tuneado	Y
15	28/07/11	R13-R14	Tavira – Fuzeta	36°59,462' N	7°44,276' W	36°58,620' N	7°46,604' W	12:50	13:20	73,7	70,8	30	Tuneado	Y
16	28/07/11	R13	Tavira	37°03,652' N	7°35,309' W	37°02,859' N	7°37,642' W	15:36	16:05	36,7	40,3	29	Tuneado	Y
17	29/07/11	R17	Albufeira	36°58,077' N	8°15,499' W	36°55,679' N	8°15,512' W	08:29	09:08	103,1	79,5	39	Tuneado	Y
18	29/07/11	R16-R17	Cuarteira – Albufeira	36°54,376' N	8°10,544' W	36°54,747' N	8°13,062' W	16:23	16:53	70,6	80,8	30	Tuneado	Y
19	29/07/11	R17	Albufeira	36°52,737' N	8°15,470' W	36°56,192' N	8°15,670' W	19:00	19:52	105,0	68,5	52	Tuneado	Y
20	31/07/11	R10-R11	El Rompido – Isla Cristina	37°03,490' N	7°05,924' W	37°04,329' N	7°09,283' W	16:31	17:11	41,3	40,8	40	Tuneado	Y
21	31/07/11	R10-R11	El Rompido – Isla Cristina	37°03,489' N	7°05,864' W	37°04,294' N	7°09,183' W	19:08	19:48	39,5	38,7	40	Tuneado	Y
22	01/08/11	R07-R06	Matalascañas – Doñana	36°49,606' N	6°47,443' W	36°49,125' N	6°47,082' W	17:56	18:03	51,2	50,7	7	Tuneado	N
23	01/08/11	R06-R07	Doñana – Matalascañas	36°47,157' N	6°45,424' W	36°47,992' N	6°46,122' W	18:55	19:10	48,0	48,9	15	Tuneado	Y
24	01/08/11	R07-R06	Matalascañas – Doñana	36°49,716' N	6°47,478' W	36°48,678' N	6°46,662' W	19:58	20:18	49,0	48,0	20	Tuneado	Y

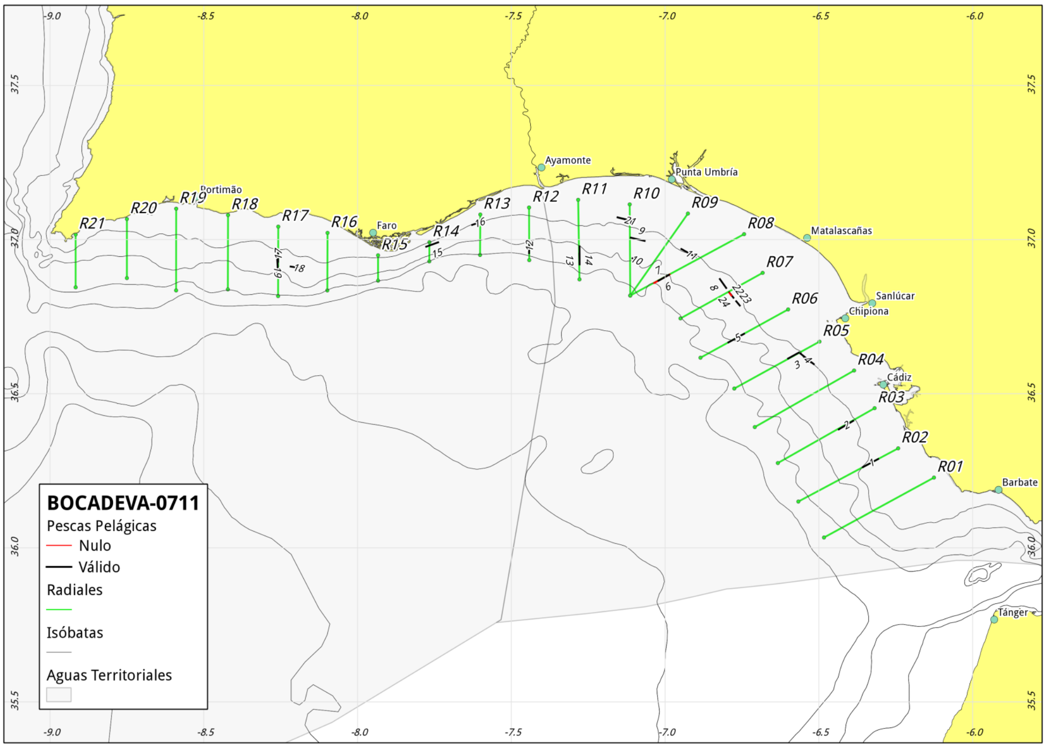


Figure 4. *BOCADEVA-0711*. Position of the fishing hauls.

The mean yield per haul of anchovy (kg/h) during the survey was about 311 kg/h, a value much higher than the obtained in previous surveys (70 kg/h in 2008, 46 kg/h in 2005). The highest yields obtained during BOCADEVA-0711 were registered in those fishing hauls located in the Doñana-Isla Cristina zone, mainly the hauls P10 (2181 kg/h, close to El Rompido-Punta Umbría, at 93 m depth) and P13 (1561 kg/h in front of Isla Cristina, between 100 - 121 m depth). In Portuguese waters the maximum yield (163 kg/h) was obtained in front of Tavira-Fuzeta, in 71-74 m depth.

From the 20 anchovy samples, 19 fulfilled the criterion of minimum sample size (60 anchovies). The characteristics of the samples used for the estimation of the adult parameters are described in the **Table IV**.

Table IV. *BOCADEVA 0711*. *E. encrasicolus*. Catch by haul in number and weight, number of individuals sampled (biological and length distribution sampling) and number of preserved ovaries. Note: In the table both individuals coming from random sampling and those coming from non-random are taken into account

Fishing station	Total catch		Size sampling		Biological sampling				
						Mature females			
	Weight (kg)	N	Weight (kg)	n	n	Non hydrated gonads	Hydrated gonads	Total	Pairs of otoliths
02	3,386	264	1,980	154	60	35		35	60
03	54,273	8677	0,663	136	60	43		43	60
04	63,100	11310	0,809	145	70	28		28	70
05	65,560	5802	1,559	138	63	41		41	63
06*					43	29		29	43
07	149,080	10888	1,698	124	60	48		48	60
08	142,056	15714	0,904	100	100	28	3	31	100
09	7,839	655	1,604	134	60	39		39	60
10	654,430	50496	1,296	100	60	45		45	60
11	36,580	3078	1,367	115	60	35		35	60
12	139,000	6794	2,374	116	60	47		47	60
13	832,628	69184	1,372	114	70	31		31	70
14	246,500	19328	1,760	138	60	35	1	36	60
15	81,260	4944	2,317	141	90	32		32	90
17	51,860	1787	4,610	159	90	69		69	80
18	17,301	650	4,846	182	60	30		30	60
19	4,314	147	1,246	43	43	17	6	23	43
20	63,469	5709	1,679	151	70	31		31	70
21	4,202	379	1,144	103	131	18	21	39	131
23	122,200	16366	0,881	118	120	13	8	21	120
24	57,180	6495	1,030	117	378	13	264	277	378
TOTAL	**2796,218**	**238667**	**35,139**	**2528**	**1808**	**707**	**303**	**1010**	**1798**

* Null fishing station. Sampled especimens were only the few ones still occurring inside the codend once retrieved the gear on the deck.

- *Estimation of eggs parameters*

Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age (**Fig. 5**). The model was fitted using a generalized linear model (GLM) with negative binomial distribution (**Table V, Fig. 6**). The ageing process and the GLM fitting were iterative until the value of z converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z = 0.01].

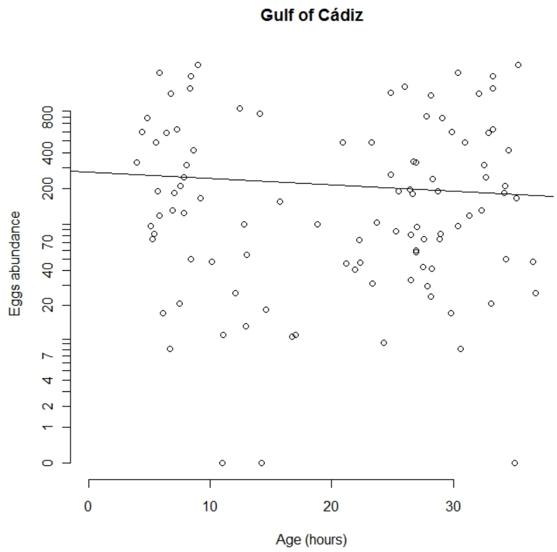


Figure 5. Gulf of Cádiz Anchovy DEPM 2011 survey. Egg exponential mortality model.

Table V. Gulf of Cádiz Anchovy DEPM 2011 survey. Egg production and mortality. Selected Generalized lineal model (GLM).

```
glm.nb(formula = cohort ~ offset(log(Efarea)) + age, data = aged.data,
    weights = Rel.area, init.theta = 0.416148912500272, link = log)

Deviance Residuals:
  Min        1Q       Median      3Q       Max
-2.25174  -1.15789  -0.60953   0.04461   2.00544

Coefficients:
             Estimate    Std. Error   t value      Pr(>|t|)
(Intercept) 5.62181      0.32103      17.512       <2e-16 ***
age        -0.01227   0.01397   -0.878        0.382
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.4161) family taken to be
0.7790106)

Null deviance: 105.81  on 102  degrees of freedom
Residual deviance: 105.18  on 101  degrees of freedom
AIC: 688.3

Number of Fisher Scoring iterations: 1
```

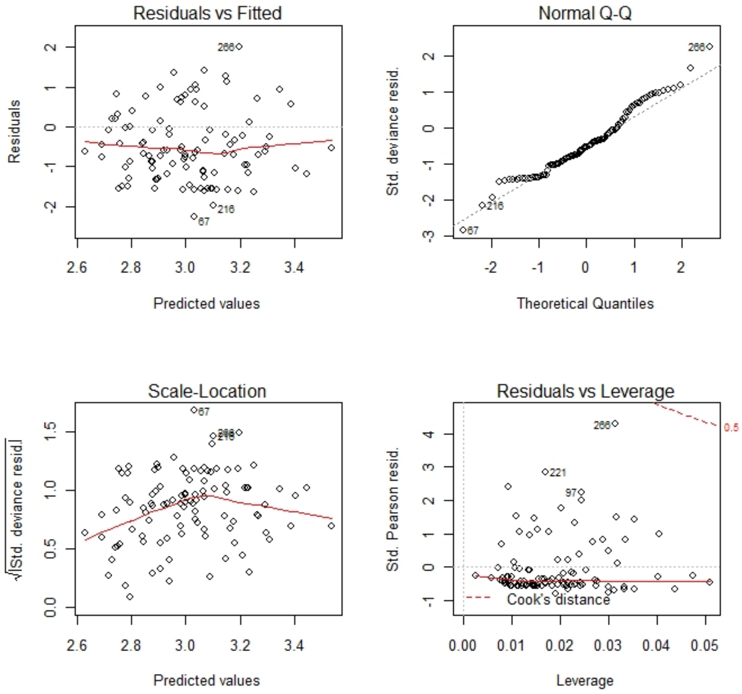


Figure 6. Gulf of Cádiz Anchovy DEPM 2011 survey. Residual inspection plots for the Generalized Linear Model fitted to Anchovy egg production data.

- *Estimation of adult parameters by haul*

The total weight of hydrated females was corrected for the increase of weight due to the hydration process by a linear regression model between individual data of gonad-free-weight (*Wnov*) and its corresponding total weight (*Wt*) from non-hydrated females (**Fig. 7**).

Wt = -0.23662+ 1.07656Wnov, R^2 = 0.998, n = 634

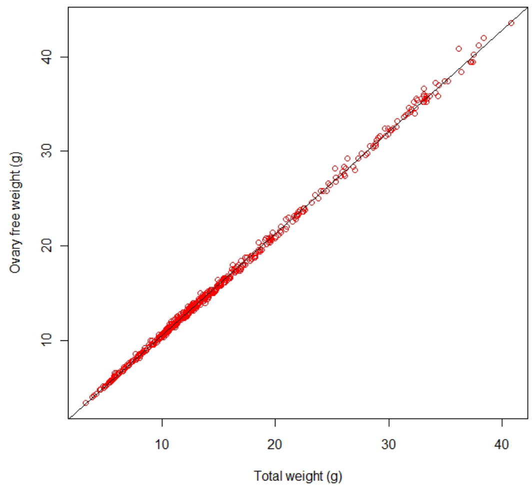


Figure 7. Gulf of Cadiz anchovy DEPM 2011 survey. Linear regression model for the relationship between non-hydrated females total weight (Wt) and ovary-free weight (Wnov).

The expected female weight (*Wexp*) for all mature females was also estimated using this linear regression model.

The expected batch fecundity for all mature females (*Fexp*) was estimated by modelling the observed individual batch fecundity (*Fobs*) in hydrated females in function of their gonad-free-weights (*Wnov*) by a GLM model (**Fig. 8**). Results of this model and the residual inspection plots are shown in **Table VI** and **Fig. 9**.

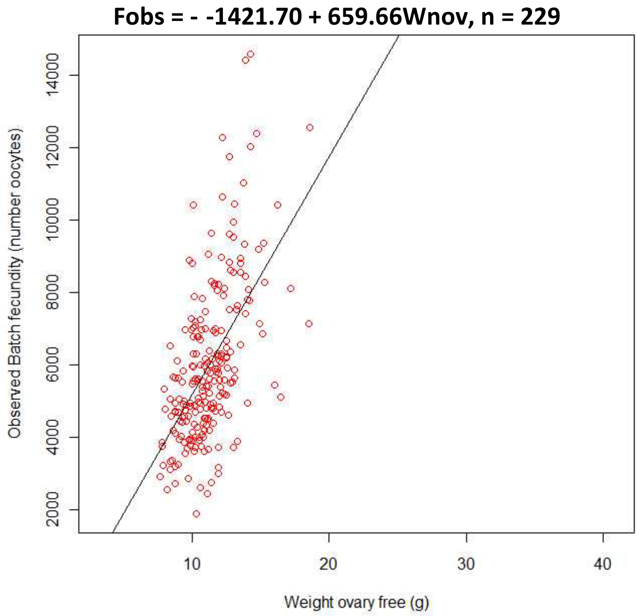


Figure 8. Gulf of Cadiz anchovy DEPM 2011 survey. Generalized linear model for the relationship between observed individual batch fecundity (Fobs) and ovary-free weight (Wnov).

Table VI. Gulf of Cadiz anchovy DEPM 2011 survey. Batch fecundity. Selected Generalized lineal model (GLM).

```
glm.nb(formula = Fobs ~ Wnov, data = adults.dat, na.action = "na.omit",
    link = identity, init.theta = 12.3453261476099)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.1448  -0.8131  -0.1565   0.6011   2.7182

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1421.70     668.84  -2.126   0.0335 *
Wnov          659.66      62.69  10.522   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(12.3453) family taken to be 1)

    Null deviance: 353.28  on 229  degrees of freedom
Residual deviance: 233.09  on 228  degrees of freedom
  (1501 observations deleted due to missingness)
AIC: 4060.2

Number of Fisher Scoring iterations: 1
```

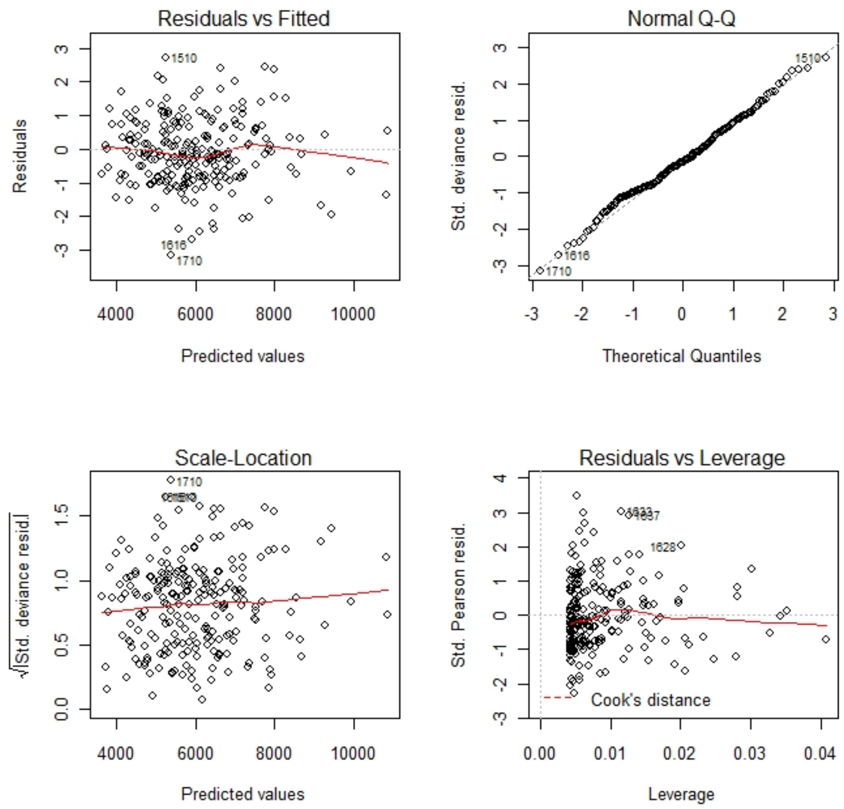


Figure 9. Gulf of Cadiz anchovy DEPM 2011 survey. Residual inspection plots for the Generalized Linear Model fitted to the anchovy batch fecundity data.

Spatial mapping of the estimates of the adult parameters by haul

The spatial mapping of the mean estimates per haul evidenced a certain structure for the mature female mean weight and batch fecundity (**Fig. 10**), in agreement with the distribution pattern previously described in the area: an east-west size (-age) gradient, with the largest (and oldest) anchovies being more abundant in the westernmost limit of their distribution.

This spatial pattern in adult parameters suggests the convenience of a post-stratification to estimate data from adults and eggs, in the same way as was done in 2005 (ICES, 2006). The estimation with post-stratification has been made, but we consider that the results obtained are not much better, because both P_0 and *SSB* are quite similar and the associated CVs are even higher. Also, we have been found a low number of hydrated females in the Algarve.

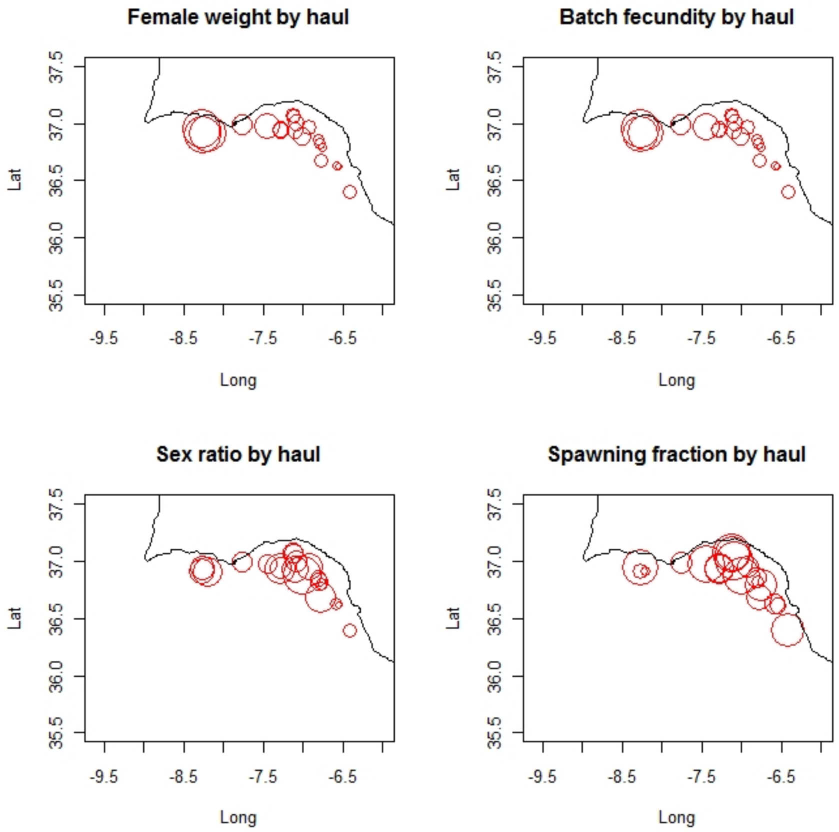


Figure 10. Gulf of Cádiz anchovy DEPM 2011 survey. Spatial distribution of mean estimates of the adult parameters per haul.

<u>SSB estimates</u>

The total spawning area (*A+*) was 6770 Km^2. The values of the mean estimates and their associated variances for the egg and adult parameters and the *SSB* are summarized in the **Table VII**. A total of 32757 tons have been estimated for the whole Gulf of Cadiz. This value of biomass is very close to the average biomass estimated for this species in the area throughout the time series of surveys carried out by the IEO since 2004 (**Figure 11**). These surveys are conducted in order to evaluate this stock, both by acoustic methods (in 2004, 2006, 2007, 2009 and 2010) and by the DEPM (in 2005, 2008 and 2011). Note that all these surveys have been conducted with the same research vessel and following the same sampling scheme. It should also be noted that during the 2010 survey (*ECOCADIZ-0710*) it was not possible to cover the whole Gulf of Cadiz because the shortening of the ship-time available, the westernmost limit being located just to the west of the Cape Santa María.

Table VII. Gulf of Cadiz anchovy DEPM 2011 survey. Summary of the results for eggs, adults and SSB estimates.

Parameters	Gulf of Cádiz 2011
Eggs	
P_0 (eggs/m^2/day) (CV)	276.4 (0.32)
Z (day^{-1}) (CV)	-0.294 (1.14)
P_{tot} (eggs/day) (x10^{12}) (CV)	1.87 (0.36)
Positive area (Km^2)	6770.2
Adults	
Female Weight (g) (CV)	15.2 (0.11)
Batch Fecundity (CV)	7486 (0.12)
Sex Ratio (CV)	0.531 (0.007)
Spawning Fraction (CV)	0.276 (0.036)
SSB 2011	
Spawning Biomass –tons (CV)	32757.2 (0.40)

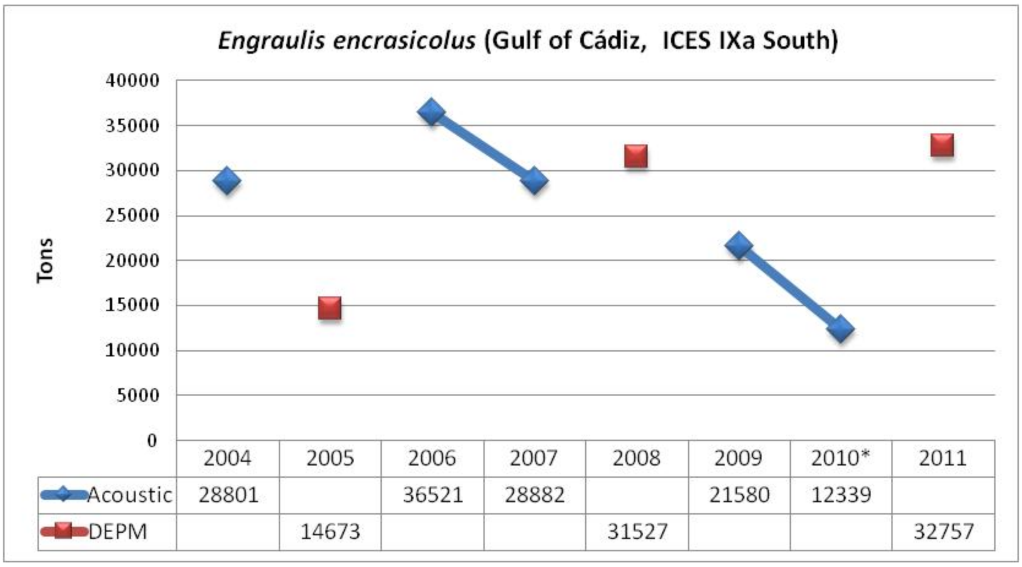


Figure 11. Historical series of Anchovy biomass (tons) estimates of the Gulf of Cadiz obtained in IEO Spanish surveys by acoustic methods (years 2004, 2006, 2007, 2009 and 2010) and DEPM (years 2005, 2008 and 2011). During the 2010 acoustic survey (*ECOCADIZ-0710*) it was not possible to cover the whole Gulf of Cadiz, the western most limit of the surveyed area being located just to the west of the Cape of SantaMaria.

Acknowledgements

Our sincere thanks to the crew and scientific personnel who participated in the survey *BOCADEVA-0711*. First author (M.P.J.) would also like to thank to her colleague Gersom Costas for being there to help me whenever I need.

REFERENCES

Alday, A., Santos, M., Uriarte, A., Martín, I., Martínez, U., Motos, L., 2010. Revision of criteria for the classification of postovulatory follicles degeneration, for the Bay of Biscay anchovy (Engraulis encrasicolus L.) *Revista de Investigación Marina*. 17(8): 165-171.

Bernal, M., M.P. Jiménez and J. Duarte, 2011. Anchovy egg development in the Gulf of Cádiz and its comparison with development rates in the Bay of Biscay. *Fisheries Research*.

Bernal, M., Ibaibarriaga, L., Lago de Lanzos, A., Lonergan, M.E., Hernandez, C., Franco, C., Rasines, I., Valdes, L. and Borchers, D.L., 2008. Using multinomial models to analyse data from Iberian sardine egg incubation experiments: a comparison with traditional techniques. *ICES J. Mar. Sci*., 65:51–59.

Hunter, J.R., B.J. Macewicz, 1985. Measurement of spawning frequency in multiple spawning fishes. *In* : Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern Anchovy, *Engraulis mordax*. *NOAA Tech. Rep. NMFS* 36: 7-16 pp.

Hunter, J.R., N.C.H. Lo, R.J.H. Leong, 1985. Batch fecundity in multiple spawning fishes. *In*: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern Anchovy, *Engraulis mordax*. *NOAA Tech. Rep. NMFS* 36: 66-77 pp.

Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D.L., Lonergan, M.E., and Wood, S.N. 2007. Characterization of stage-classified biological processes using multinomial models: a case study of Anchovy (*Engraulis encrasicolus*) eggs in the Bay of Biscay. Canadian Journal of Fisheries and Aquatic Sciences, 64:539–553.

ICES, 2003. Report of the Study Group on the Estimation of Spawning Stock Biomass of Sardine and Anchovy (SGSBSA),

ICES 2006. Report of the Working Group on Acoustic and Eggs Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). ICES Living Resources Committee. ICES CM 2006/LCR:18. Ref.ACFM.

Jiménez, M.P., M. Millán, M. Bernal, G. Costas, 2005. Estimación de la biomasa de reproductores del stock de *Engraulis encrasicolus* del Golfo de Cádiz por el Método de Producción Diaria de Huevos (MPDH). Informe de incidencias y resultados preliminares. Documento interno IEO. 62 pp.

Moser H.G, E.H Ahlstrom, 1985 Staging Anchovy EggsIn: R. Lasker (editor), An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application t o theNorthern Anchovy, Engraulis mordax. NOAA Tech. Rep. NMFS 36. US. Dep. Commer., Wash., D.C., 99 p.

Picquelle, S., Stauffer, G., 1985. Parameter estimation for an egg production method of northern Anchovy biomass assessment. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern Anchovy, *Engraulis mordax*. NNAA Tech. Rep. NMFS 36: 43-50 pp.

Sardine 2011 DEPM – ICES areas IXa and VIIIc

Maria Manuel Angélico[1], Paz Díaz[2] , Concha Franco[2], Ana Lago de Lanzós[2], Cristina Nunes[1], Jose Ramón Pérez[2]

[1] IPMA (IPIMAR), Instituto Português do Mar e da Atmosfera, Av. de Brasília 1449-006, Lisboa, Portugal.
[2] Instituto Español de Oceanografía, Centros Oceanográficos de Vigo y Madrid.

Summary

The triennial DEPM for estimation of sardine spawning biomass for the Atlanto-Iberian stock areas IXa and VIIIc took place in the S and W (IPIMAR) from 10th February to 8th March and in the N (Galicia and Cantabrian Sea, IEO) between 26th March and 22th April. The 2011 winter/early spring season was characterized by very unstable oceanographic conditions with frequent events of gale force winds and periods of heavy rain. However, the ocean temperature values and distribution patterns were similar to observations from other years. Sampling was conducted according to planned despite the fact of a few interruptions due to adverse weather; the number of fishing samples was maintained at the levels from previous years but it was very clear that sardine schools were much less available than during the previous DEPM survey, in 2008. Unusual (unrealistic) observations for spawning fraction and batch fecundity in the S and W strata required the use of alternative information for the estimation of these parameters. Batch fecundity was achieved, using non-hydrated ovaries (using the oocytes at the migratory nucleus stage) while for the spawning fraction mean historic values per strata, were taken on. Spawning stock biomass (SSB) estimates were presented using 3 strata for all adult and egg parameters (P0 GLM model with 3 slopes, mortality, and 3 intercepts, P0). SSB estimate (S+W+N strata) was 465 x10^3 tons. This estimate is 30% lower than the 2008 value, but is the second highest biomass estimate of the historical series for the whole Iberian stock. The 2011 results lead to the following remarks:

- the spawning area for 2011 was smaller than in 2008 in all strata but particularly in the W and N shores, around 75 and 50 % respectively; on the whole, the total positive area was reduced to about 55%.
- total egg production estimates in all areas were lower than in 2008 when estimates are based in a model with 3 mortalities and 3 P0 values; mortality for S and W was higher than in previous years; the highest daily egg production per m2 (eggs/m2/day) was obtained for the southern coast
- mean female weights for all strata were similar to the 2008 estimates; the values calculated for the N strata (N and NW coasts of Spain) being higher than for the W and S strata
- mean batch fecundity considerably higher for the N than for the W and S strata; W and S estimates obtained by alternative methodology (MN oocytes), values in line with previous values
- the spawning fraction for the N strata in 2011 was higher than in the two previous surveys; for S and W, mean historic values were used
- the SSB estimate for 2011 using 3 strata for egg and adult parameter is lower than in 2008; the decrease was more accentuated for the W and N strata while for the S the value was close to the previous estimate
- the unusual observations concerning some of the adult parameters during the survey in areas S and W are under investigation and will be further discussed; results suggest an eventual temporary interruption of spawning in the S and SW (skipped full maturation and ovulation of one batch of oocytes)
- discussion on the preliminary estimates here presented and options taken for SSB estimation will be addressed at the WGACEGG in November 2012

1. Background

The DEPM for estimation of sardine spawning biomass within the Atlanto-Iberian stock area is conducted every three years by IPIMAR (Instituto de Investigação das Pescas e do Mar, Portugal) and IEO (Instituto Español de Oceanografía, Spain) in an internationally coordinated survey. In 2011, the Portuguese survey took place in February/March covering the Atlantic waters from the entrance of the Strait of Gibraltar to the northern border of Portugal, while the Spanish survey took place in March/April covering the northern stock area from the river Minho to the south of the Armorican shelf (in French waters). The Portuguese DEPM survey was carried out from the 10th February to the 08th March onboard RV Noruega, while the Spanish survey was undertaken using two vessels, from the 25th March to the 10th of April onboard RV Cornide de Saavedra (for plankton sampling mainly) and from 26 March to 22 April using RV Thalassa to carry out the fishing hauls (Table 1).

2. Environmental data, SST distribution

In the Portuguese survey, records of water temperature, salinity and fluorescence were obtained for surface waters by the CTF probes associated with the CUFES system; the CTDF profiler usually used together with the vertical nets was not operational for the 2011 survey. A CTD (Sea Bird 37) profiler (Temperature and Salinity) was carried out at each CalVET station in the Spanish survey. Morover a CTD (Sea Bird-25, higher resolution and accuracy) was used in each transect head and in alternate stations along the transects.

Surface temperature and salinity distributions are presented in figure 3. Temperature values ranged from 12.5 to 16.9 ºC and the distribution patterns were similar to observations from previous years; the highest temperature values were observed in the southern area and the lowest values registered for the Cantabrian Sea. The winter/spring conditions in the Atlanto-Iberian region were very unstable and much severe than in 2008. During the first quarter of 2011 heavy rain and strong winds were frequent.

For the area covered by the Portuguese survey the temperature data used for egg ageing was registered underway at 3m depth (CTF probes). During the Spanish survey the data were extracted from the SBE-25 and SBE-37 records.

3. Egg data

During surveying vertical plankton hauls were carried out following a pre-defined grid of sampling stations along transects perpendicular to the coast and spaced 8 nmiles (Figure 1). The inshore limit of the transects was dependent on bottom depth (as close to the shore as possible), while the offshore extension was decided adaptively. The main sampler for the DEPM is the PairoVET net that collects eggs through the water column at point stations. The PairoVET sampler (=double CalVET) includes 2 nets (Ø 25cm) with 150 µm mesh size and a CTDF probe; sampling covered the water column from bottom, or 150m (100 m for IEO) (beyond the 150 isobath) depth, to the surface. PairoVET samples were taken every 3 nm in the inner shelf (up to 200 m depth or 100 m where the platform is wider) and every 3 or 6 nmiles beyond the inner shelf, depending on egg presence in CUFES samples.CUFES was used as the auxiliary egg sampler, helping in defining vertical hauls density and offshore extension of the transects. The outer limit of a transect was reached when two consecutive CUFES samples were negative beyond the 200 m depth.

All plankton samples were preserved in formalin at 4% in distilled water and the 2 samples from each net stored in separate containers. For IPIMAR both nets were used for egg density estimates while IEO used 1 net (the other being used for plankton dried mass calculations) (Table 2). IEO counted total number of eggs from the CUFES onboard in order to obtain a preliminary data of sardine egg abundance and distribution. In the laboratory, all sardine eggs were sorted from PairoVET and CUFES samples. The eggs from the vertical hauls (2 nets – IPIMAR, 1 net –IEO) were all counted and staged according to the 11 stages of development classification (adapted from Gamulin and Hure, 1955). For IPIMAR, the eggs from the CUFES sampler were all counted and a sub-sample, of a minimum of 100, was staged per sample.

All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available within the open source project *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). Some routines of the R packages used were updated since the 2008 versions. To avoid high and low extreme values in the area represented by each of the sampled stations, this values were forced to the minimum and maximum values of 25 and 175 respectively (the extreme values usually occur on the borders of the survey area and therefore do not affect the estimation of the positive area). The range 25-175 was selected to be a mean interval suitable according to the distance between transect and stations (fixed to be 8 nmiles between transects and 3 between stations along the transects).

The model of egg development with temperature was derived from the incubation experiment data available within the *egg* R library. Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST. Distribution of the daily spawning cycle was assumed as a normal (Gaussian) distribution, with a peak at 21:00 h GMT and a standard deviation of 3 h (spawning period from 21-6 h to 21+6 hours). It is assumed that 0 time is at midnight and days are 24 hours long. The upper age cutting limit was determined using a maximum age for the strata considered and it is not dependent on the individual stations (upper.age=F). Older cohorts are dropped if their mean age plus 2* stdev hours is over the critical age at which less than 5% of the eggs are expected to be still unhatched (how.complete=95%). The lower age cutting excluded the first cohort of stations in which the sampling time is included within the daily spawning period (lower.age=T).

Three different sets of strata were used in the analysis; some based on previous analyses and others reorganized in order to estimate mortality and/or egg production. The strata were defined according to biological/ecological (geographical) reasons (see Bernal *et al*., 2007) and also to consider timing of survey (IPIMAR and IEO surveys are on average 1 month apart)

- No strata: unique strata for all Atlanto-Iberia, from the strait of Gibraltar to the Spanish-French Atlantic limit.
- Three strata (Stratum); **South**, encompassing from the strait of Gibraltar to Cape St. Vicente, **West**, from Cape St. Vicente to the northern limit between the Spain and Portugal, and **North**, between the Spanish-Portuguese northern limit and the Spanish-French Atlantic limit.
- Two strata (StratumI); **South-West**, encompassing the Gulf of Cádiz and the Western Iberian coast up to the northern Portuguese Spanish limit (stratum south and west above), which includes the area covered by the Portuguese survey, and **North**, which coincides with the northern stratum defined above, the Spanish survey.

The second set of strata represent the current view of the different nuclei of the stock (Bernal *et al.*, 2007, Silva, 2007), while the third set of strata represent the area covered by the Portuguese and Spanish survey respectively, which were carried out with seventeen days difference. Then, a series of tests were carried out in which estimates of mortality and/or egg production were aggregated first into the two strata of the third set and then into a unique estimate for all Atlanto-Iberia. The final model was selected using a combination of significance of the mortality estimates.

The maximun age and temperature was calculated for the different strata described previously. Estimates of egg production and mortality were initially estimated for the entire area (no strata), for each stratum of the second set and for the two strata of the third stratum set.

The exponential model: $E[P] = P0\ e^{-Z\ age}$ was fitted by a Generalized Linear Model (GLM), assuming a negative binomial distribution. Finally, the total egg production was calculated multiplying the daily egg production by the positive area (area with eggs defined by an automated procedure using the spatstat library)

The models used to estimate mortality and egg production were:

Model 1
1 strata and 1 mortality

glm.nb(cohort ~ offset(log(Efarea)) + age, weights=Rel.area, data=aged.data)

Model 2
3 strata (Stratum) and 3 mortalites (Stratum:age)
glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ Stratum:age, weights=Rel.area, data=aged.data)

Model 3
3 strata P0 (Stratum) and 1 mortality (age)
glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ age, weights=Rel.area, data=aged.data)

Model 4
3 strata P0 (Stratum) and 2 mortalities (StratumI:age) (1z for IPIMAR, 1z for IEO)
glm.nb(cohort ~ offset(log(Efarea)) -1 + Stratum+ StratumI:age, weights=Rel.area, data=aged.data)

Model 5
2 strata (StratumI) e 2 mortalidade (StratumI:age)
glm.nb(cohort ~ offset(log(Efarea)) -1 + StratumI+ StratumI:age, weights=Rel.area, data=aged.data)

Details on the methodologies used on board, during laboratorial work and for data analyses are summarized in Table 1.

In total 224 PairoVET hauls and 829 CUFES samples were obtained (Table 1), during the Portuguese survey the number of CUFES stations was reduced in circa 20% due to irreparable damage to the system. The percentage of stations with sardine eggs was 27% for the vertical tows and 33% for the surface samples. Considering only one of the PairoVET nets 3300 sardine eggs were gathered in total, of which more than half came from the northern region, around a third from the south and less than 15% from W Portugal. In the positive stratum, the highest egg abundance per haul was 4950 (egg/m^2) reached in the South (Cadiz), while in the West coast the maximum density per haul was 2970 (egg/m^2) and in the Northern stratum 1537 (egg/m^2). Sardine egg distribution, obtained from the PairoVET and CUFES systems, for the whole area are presented in Figure 1. The egg distribution pattern derived from the observations from the two samplers is similar and it is evident that the area occupied by eggs was much smaller than in 2008, this is particularly clear for the West coast of Portugal. Spots of higher egg densities were observed in the eastern regions of the Gulf of Cadiz, south of Cabo Carvoeiro, off Cabo Mondego and in the Cantabrian Sea.

The surveys covered a total area of 83508 km2 of which 23745 km^2 (28.4 %) were considered the spawning area (Table 3). The northern stratum represented 52.5 % of the spawning area while 27.5 % were in the southern coast and 20.3 % in the western shores

Table 3 shows the mortality values obtained using geographical stratification (no strata, 3 strata and two strata) as described above. Mortality values for the southern and western regions are much higher than for the northern stratum. Mortality calculated for each one of the three strata defined shows negative and significantly different from zero values and was considered acceptable for egg production estimation. Egg mortality is very much dependent on water temperature. When mortality is considered by geographic stratum the values estimated decrease from south to north, higher temperatures shorten egg duration and usually give rise to an increase in the estimates of mortality. Conversely, lower temperatures, more common in the north, originate slower egg development and lower mortality. Therefore choice of GLM model, with one, two or three slopes (mortality), may give distinct results for the egg production (intercept) by stratum.

Final egg production models (Table 3. and Figure 4.) include individual egg production estimates for the Southern, Western and Northern areas, with three independent mortality estimates (Model 2), three egg productions with a common slope for the the whole Atlanto Iberian stock (Model 3) and two separate mortality estimates (one for the South and West combined, and one for the Northern area- Model 4). With model 5 estimates of egg production and mortality are obtained for the two surveys

(IPIMAR and IEO) and finally, egg production with a single mortality, estimated for the whole Atlanto Iberian stock, is considered using Model 1.

Although the results from different GLM models could be considered an option for the final egg production estimation (negative and statistically significant mortality), large differences in the estimates by areas are introduced due to the choice of model used.

The final model to estimate egg production should be selected according to a combination of the following criteria:

- obtainment of a negative (and significant) value for mortality estimates
- P0s estimates for 3 strata (to improve detail for the P0, that may allow better description of processes than when considering only one strata for all the Atlanto-Iberian stock)
- knowledge on the biology/ecology of the species and system in the distinct areas surveyed

For all models, daily egg production per m^2 (eggs/m2/day) is highest for the southern region.

Total egg production (eggs/day) estimated for the Atlanto Iberian stock varies from $7.33 x10^{12}$ (model 1) to $8.79 x10^{12}$ (model 4). Using three P0s and three mortality estimates (Model 2), the added total egg production estimate was $7.59 x10^{12}$; $4.03 x10^{12}$ corresponding to the south, $1.83 x10^{12}$ to the west and $1.73 x10^{12}$ to the north.

Further discussion on the choice of GLM model, and other options for obtainment of a coherent mortality estimate per stratum are also presented in the WGACEGG 2011 report (ICES, 2011b). However since the issue of mortality estimate is still being addressed further developments will be presented at the next WGACEGG meeting. It should be mentioned that in order to consider comparable estimates to the previous reported DEPM survey (2008), the egg production results to consider are the ones from model 4. For the years of the series prior to 2008, the analyses were considered independently for the Portuguese and Spanish strata and diverse options were implemented in order to get coherent mortalities. A revision document, that will include a discussion on the comparison of historic results, is being prepared and will be presented at the 2012 WGACEGG meeting.

4. Adult data

Fishing hauls were conducted by either pelagic or bottom trawling following sardine schools detection by the echo-sounder. The number of samples and its spatial distribution was organized to ensure good and homogeneous coverage of the survey area (Figure 2). In the Portuguese survey, the samples collected by the RV were complemented with samples obtained from commercial purse-seiners at Olhão, Portimão, Sines Setúbal, Peniche, Figueira da Foz and Matosinhos. Samples from the fishing fleet were acquired within 1-2 weeks of the surveying by RV Noruega in each area, except for 5 trawls: 2 samples from Matosinhos collected with 4 weeks lag and 1 sample from Portimão collected with 3 weeks lag, both during the survey period; 1 sample from Portimão and 1 sample from Peniche obtained 2 and 3 weeks after the survey was ended, respectively. The fish from the 3 first samples were included in the calculation of the estimates whereas the 2 last ones were used only for the measures of batch fecundity with hydrated females.

Onboard the RV, and for each haul, a minimum of 60 sardines were randomly selected and biologically sampled. These were, in some occasions, also complemented by additional fish in order to achieve a minimum of 30 females per haul for histology, and/or to obtain extra hydrated females for the fecundity estimations. Individual biological information (length, total weight, sex, maturity state, gonad weight) was recorded for all fish, the ovaries were preserved for histology (with a 4% formaldehyde solution diluted in distilled water and buffered with sodium phosphate) and the otoliths removed (only from females for IPIMAR) for age determination. The biological sampling and ovaries preservation were always carried out in fresh material, with the exception of 5 commercial samples for which the ovaries were removed from the fish body and preserved immediately after the fish were landed, while the remaining body of the fish was frozen for posterior biological sampling in laboratory.

The preserved ovaries were weighed in laboratory and the obtained weights corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries were then processed for histology: they were embedded in either resin (IEO) or paraffin (IPIMAR), the histological sections were stained with haematoxylin and eosin, and the slides examined and scored for their maturity state (most advanced oocyte batch) and POF presence and age (Hunter and Macewicz 1985, Pérez et al. 1992a, Ganias et al. 2004, Ganias et al. 2007). Prior to fecundity estimation, hydrated ovaries were also processed histologically in order to check for POF presence and thus avoid underestimating fecundity (Pérez et al. 1992b). The individual batch fecundity was then measured, by means of the gravimetric method applied to the hydrated oocytes, on 1-3 whole mount sub-samples per ovary, weighing on average 50-150 mg (Hunter et al. 1985). Additional batch fecundity measures (IPIMAR) were obtained by means of the methodology developed by Ganias et al. (2010) which applies the gravimetric method also to non hydrated ovaries (oocytes at the migratory nucleus stage) using automatic particle counting.

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data) and was based on the biological data collected from both surveys and commercial samples. Before the estimation of the mean female weight per haul (W), the individual total weight (Wt) of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (R) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females. The expected individual batch fecundity (Fexp) for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (Fobs) in the sampled females and their gonad-free weight (Wnov) by a GLM (Normal errors distribution and identity link). In case a geographical variability was observed in individual batch fecundity, a posterior post-stratification was carried out, Fobs being modelled against the Wnov and the Stratum (second and third sets of strata used for the egg data analysis). The fraction of females spawning per day (S) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included) (Pérez et al. 1992a, Ganias et al. 2007). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer 1985 (weighted means and variances). All estimations and statistical analysis were performed using the R software. Final adult parameters include individual estimates for the Southern, Western and Northern areas, with three independent estimates.

Details on the methodologies used on board, during laboratorial work and for data analyses are summarized in Table 2.

For the 2011 survey an effort was made to guarantee the level of sampling already achieved in the 2002, 2005 and 2008 surveys, however a high percentage of fishing hauls (48 %) over the total, resulted negative for sardine. On the whole, 34 fishing hauls which caught sardines were performed during the surveys covering the whole area, complemented by 24 samples obtained from the Portuguese purse-seine fleet (Figure 2**.** On the whole, around 3760 sardines were sampled (Table 1), more than 1450 ovaries were collected, preserved and analysed histologically and *ca.* 1070 otoliths were removed for age determination. A total of 72 hydrated females were caught for batch fecundity estimation (much lower than in 2008), with final 61 being effectively used (see also discussion ahead on batch fecundity for S and W)

All laboratory tasks are completed for the samples collected during IEO's survey whereas for the Portuguese samples, the histological processing and microscopical analysis are still in progress. Therefore, for the South and West strata, the parameters W, R and F were calculated based on all samples whereas the S was obtained from the microscopical analysis of a subset of 24 samples (selected in view of a good geographical coverage) and is thus a preliminary estimate.

Data were analysed and the parameters estimated for the two surveys jointly:

- The same linear regression between the non-hydrated females Wt and their corresponding Wnov was used for the whole surveyed area (Wt = 1.073 * Wnov - 1.571, R^2 = 0.995).

- The geographical distribution of female weight (Figure 5) and mean batch fecundity (F = 15977, 10570 and 40844 eggs/female, respectively, for South, West and North strata, Table 3) suggest the need for a spatial stratification in view of the parameters estimation. The above estimates were obtained by modelling Fobs against the Wnov and the Stratum, and though a relatively small number of hydrated females were collected per stratum (n = 11, 19 and 31), the model considering the three strata separately was statistically significant and thus selected to estimate F for the three areas.

The minimum mean weights by haul were observed in the North of Portugal and in the Gulf of Cadiz (Figure 5). Mean female weight (W) was similar for the whole Portuguese and Cadiz coasts (54.3 and 50.1 g for strata 1 and 2, respectively) and considerably higher for the Northern Spanish coast (85.8 g for stratum 3). Compared to previous surveys, mean female weight for the whole area surveyed was similar to the values estimated for the 2008 survey, the two latest surveys presenting the highest values of the historical series.

The mode of individuals age distribution off the Northern Spanish coast is 3 years-old, these fish representing almost half of the individuals for which otoliths were sampled. On the contrary, female age distribution is bimodal off the Western Portuguese and Southern coasts, with sardines aged 1 and 6 and over being the most abundant in the samples representing respectively, about one third and one quarter of the females for which otoliths were collected (the latter likely still corresponding to the 2004 strong recruitment) (Figure 5).

Mean batch fecundity estimates (F) were considerably lower (one third) off the Portuguese and Cadiz than off the Northern Spanish coasts (Table 3). The latter presented the highest estimate of the historical series, though similar to the ones obtained for the 2005 and 2008 surveys. On the contrary, for the Southern and Western strata, although mean female weights were similar to the ones obtained during the 2008 survey, F estimates were the lowest of the time series, only comparable to the batch fecundities obtained for the 2002 survey (especially for the West coast).

This unexpected result for F estimates off the South and West coasts, the fact that for these areas most of the hydrated (H) females used in the model were obtained 2-3 weeks after the completion of the survey, and when batch fecundity is known to vary during the spawning season (Zwolinski et al. 2011), made it necessary to investigate this issue further. An additional set of Fobs data (n=63) was obtained from non-hydrated females (at the oocyte migratory nucleus stage, MN; Ganias et al. 2010) collected during the survey, and modelled against Wnov. The results of the comparison between H- and MN-based Fobs (which corresponds mostly to compare between data obtained inside and outside the survey period) show that for the same female weights, batch fecundity was significantly higher for the females collected during the survey period (in particular, relative fecundity off the West coast, almost doubled from outside to inside the survey period).

This investigation is still in progress, but at present it was considered more reliable to use the observations obtained during the survey period, and therefore it was decided that F be estimated using the GLM model (Fobs ~ -1 + Wnov: factor(Stratum)) which includes the H females data collected in the North stratum during IEO's survey, and the H and MN females data collected in the West and South strata during IPIMAR's survey period (Figure 6). These alternative F estimates are presented in Table 3 (F = 19052, 19416, and 40844 eggs for the S, W and N strata, respectively).

Regarding spawning fraction (S), estimate for the Northern Spanish coast was higher than the one obtained during the 2005 and 2008 surveys (0.114 *vs.* 0.078 and 0.090, respectively). For the South and West strata, the S estimates obtained from the microscopic analysis of the subset of 24 hauls are unrealistic (< 0.01), and cannot be reliably included in the estimation of the SSB. It is not expected that the S final estimates off the S and W strata to be substantially modified after the histological analysis of the remaining samples, therefore alternative reliable estimates for this parameter should undoubtedly be considered in view of the calculation of the 2011 SSB. It was at present decided to use the historical mean values of the spawning fractions obtained in these two areas (Table 3).

5. SSB estimate

Spawning stock biomass was estimated taking into consideration the options discussed in the previous sections, the exceptions to the traditional method being:

- spawning fraction estimates for S and W – historical mean values;
- batch fecundity for S and W – using hydrated and MN females from the survey period
- P0 – for assessment usage results from GLM model 2 (3 P0, 3 z) (however other estimates are provided).

Using the option highlighted in table 3 the SSB estimate was 465 x10^3 tons. This estimate is lower than the one obtained in 2008, but is the second highest biomass estimate of the historical series for the whole Iberian stock. The SSB estimate for the S area in 2011 was similar to the one in 2008, whereas the SSBs off the W and N coasts decreased substantially.

6. Results summary

Despite the fact that the 2008 DEPM results for egg production and SSB were the highest of the historical series no strong recruitment has been identified in the past six years. In fact other sources such as acoustics surveying have been noticing a decline in the Iberian sardine since 2006 (ICES, 2011). During the 2011 survey the difficulty in obtaining positive hauls for sardine, even though considerable fishing effort was undertaken, suggests that the species was much less available than it was in 2008.

The spawning area estimates for 2011 were lower in all the strata compared to 2008 (ICES, 2009). The spawning area of sardine in the western and northern areas was much smaller than in 2008, around 75 and 50 % respectively. On the whole the total positive area was reduced to about 55%.

Total egg production estimates in all areas are lower than in 2008 when estimates are based in a model with three different mortalities values (one mortality value for each area, Model 2). When egg production estimates are compared with those obtained using the same procedure carried out in 2008 (Model 4, three egg production and two mortalities values, one for southern and western areas and one for northern area), northern area egg production is higher than in 2008, but southern and specially western area egg production values are much lower than in 2008.

Mean female weights obtained for all strata were similar to the ones estimated in 2008, the values calculated for the N and NW coasts of Spain being higher than for the West and South strata.

As in previous years, batch fecundity estimates in 2011 were considerably higher for the North than for the West and South strata. Moreover, mean batch fecundity for the West and South strata showed the lowest values from the whole historical series, though mean female weights in these areas were among the highest. The fact that these estimates were based on hydrated females collected a few weeks after the end of the survey, and knowing that batch fecundity varies intra-seasonally, it was considered more reliable to rather obtain F estimates based on an additional set of non-hydrated females sampled within the survey period. These alternative F estimates are still about half the values obtained off the Northern Spanish coast, but are more in line with previous estimates for the Cadiz and Portuguese waters.

The spawning fraction for the North strata in 2011 was higher than in the two previous surveys. As for the West and South coasts, the obtained S estimates were considered unrealistic, and can thus not be reliably included in the calculation of the SSB; it was decided to use as an alternative the historical mean values of the spawning fractions obtained for these two areas. Furthermore, these unexpected estimates are indicative that spawning activity during the 2011 survey period may have presented some unusual features, which deserve being further investigated.

The SSB estimate for 2011 using 3 strata for egg and adult parameter (highlighted in table 3; P0 model 2 and batch fecundity model 2) is lower than the one obtained in 2008. The decrease was more accentuated for the W and N strata while for the S the value was close to the previous estimate.

In short :

- spawning area in 2011 reduced compared to 2008
- spawning area in the western area much smaller than in 2008 (only around 20% of the

- total spawning area in 2011)
- the southern region showed the highest daily egg production per m2 (eggs/m2/day)
- total egg production in all regions lower than in 2008 but higher than in 2002
- total egg production for 2011 was higher than in 2005 for S but lower for W and N
- main differences in total egg production between 2011 and 2008 were related to spawning area differences; reduced in all regions
- mortality values for S and W much higher than for N and higher than in 2008
- mean female weights similar to the ones obtained in 2008, higher for the North than for the West and South strata
- mean batch fecundity considerably higher for the North than for the West and South strata in 2011
- mean batch fecundity first estimated for the West and South strata among the lowest of the historical series, but alternative estimates recommended for these 2 areas more in line with previous values
- spawning fraction for the North strata in 2011 higher than in the two previous surveys; estimates obtained for the South and West strata in 2011 considered unrealistic and replaced by historical mean values as alternative
- depending on the model of the egg production, variable SSBs are obtained; the option selected indicate a decrease of ca. 30% of the SSB compared to 2008 for the whole Iberian stock, this decrease being considerably marked for the West and North coasts.
- the unexpected values obtained for some of the adult parameters in the S and W coasts suggest that spawning activity during the 2011 survey period may have presented some unusual features (cf. section 7).

7. The 2010-2011 reproductive season in the south and western strata

On account of the uncommon estimates obtained for the spawning fraction off the South and West strata, it was decided to explore all biological data available attempting to identify any unusual pattern in the sardine reproductive dynamics during the 2010-2011 spawning season, and in particular during the survey period. This section includes preliminary results of this exploratory analysis.

Seasonal data from the commercial fleet

First, macroscopic data obtained from the samples collected regularly (monthly) within the framework of the Data Collection Regulation off the Portuguese Northwest (NW: Matosinhos, Póvoa de Varzim), Southwest (SW: Peniche), and South (S: Portimão) coasts were used. These included gonads macroscopic maturity stage, gonado-somatic index (GSI) and condition factor (relative weight).

The females' macroscopic maturity stages during the 2010-2011 reproductive season showed a common seasonal pattern (active females being present in the samples from September until April or June, depending on the areas). During the survey period, these macroscopic data were globally in line with the observations obtained during the survey. In February 2011, all females sampled were at maturity stage 3 (active) (exception: ~90% for the SW area). No females were available in March for the NW and S (temporary closure of the purse-seine activity), in the SW about 1/4 of the females were in March at maturity stage 5 (post-spawning). In the whole area considered, there is no evidence from the available information that reproductive season might have ended for most of the individuals during and/or soon after the DEPM survey (Figure 7). Similarly, the seasonal pattern observed for the GSI of mature females during the 2010-2011 spawning season was not uncommon, compared to other recent years (maximum values in December-January, minimum values in July-August). During the 2011 survey period, the data showed a slight increase of the GSI in February 2011 in the NW, whereas the GSI in the SW started decreasing from February 2011 onwards and the GSI in the S remained stable in January and February 2011 (Figure 8). The seasonal pattern observed for the condition factor during the 2010-2011 spawning season was also similar to the one obtained in other recent years (maximum values in August-October, minimum values in February-March). Minimum values were observed in January for the NW and in February for the SW and S areas (Figure 9).

Survey data: spawning activity

The adult data include all the samples obtained within the context of the 2011 DEPM survey, i.e. the samples collected onboard the RV as well as the samples provided by the commercial fleet during that period. The analyses were carried out taking into account both spatial and temporal factors. Four areas were considered: Cadiz (Spanish waters), South (Algarve), Southwest (from Sagres to Nazaré), and Northwest (from Nazaré to Caminha). The studied period was divided into weeks:
week 1: 8-14 Fev 2011, period during which most Cadiz area was covered by the survey;
week 2: 15-21 Fev 2011, period during which most Algarve area was covered by the survey;
week 3: 22-28 Fev 2011, period during which most SW area was covered by the survey;
week 4: 1-7 Mar 2011, period during which most NW area was covered by the survey.
week 5: 8-14 Mar 2011, just after the survey, only commercial samples
The macroscopic data (proportion of active females) were obtained from all samples collected (48 hauls, n = 1260) whereas histological information (proportion of females with vitellogenic oocytes, proportion of mature females with POFs or with massive atresia) was based on the microscopical analysis of 24 hauls (n = 676, available at present and selected to have a homogeneous sub-sample for areas and gears).

The reproductive activity was evaluated both macroscopically (active females with mature stages 3 and 4) and microscopically (females with oocytes at stage >= 3). (except for SW area in weeks 1 and 4 and for S in week 5, still not confirmed histologically). Globally, macroscopic and histological data were in accordance (Figure 10). In the south, Cadiz and Algarve, activity was maximal at the beginning of the survey, then it seems to have decreased during weeks 2 to 4, and increased again after the survey was ended (week 5). In the SW, the pattern is more difficult to assess from the available information, whereas in the NW activity seems to have decreased from week 3 onward, although again the data do not provide any evidence that reproductive season might have ended for most of the individuals towards the end or soon after the DEPM survey. Namely, 2 to 3 weeks after the end of the survey, hydrated females were obtained from commercial samples off both S and W coasts (hydrated ovaries used to model batch fecundity, see previously).

The prevalence of mature females with ovaries containing more than 50% of vitellogenic atretic oocytes (alpha atresia) was assessed based on the histological analysis (the percentage of atretic oocytes was not measured accurately but evaluated roughly from visual observation of the histological slide). Massive atresia increased in weeks 2 and 3 in S and W coasts to about 10% of the mature females; however, its prevalence decreased again in the S and SW at the end of the survey while it kept on increasing in the NW (Figure 11).

Females with signs of recent spawning activity (POFs) were observed during the first week of the survey (at least, in the areas sampled during that period, i.e., Cadiz and the NW coast) (Figure 12). Plankton sampling during the survey collected eggs of all ages in the Cadiz area; egg abundances were high in that area; eggs were also found all along the southern Spanish coast (no fishing was possible in the region between the Guadalquivir and Cabo St^{a} Maria) (Figure 13). Following an interruption of 3 days, due to bad weather, the survey resumed off

Cabo St[a] Maria (week 2); few (older) eggs were collected at the restart however further to the west, in the region off Portimão-Sagres eggs of all stages were again observed. Egg production per unit area was higher in the south than in the west and northern strata (similar results had occurred in previous DEPM surveys). Several fishing hauls were undertaken but in general sardine schools were scarce and in some hauls none were caught. From the microscopic ovary observations there was any or nearly any signs of spawning activity during weeks 2 and 3 in both S and W coasts. Egg abundance in the W coast south of Lisbon was nearly zero with only a small patch of eggs over Setubal canyon (weeks 2-3). However spawning activity was noted in commercial samples in the region Lisbon-Sines 2 weeks after surveying. POFs were again present in ovaries sampled in weeks 4 and 5 (at least, in the areas sampled during that period, i.e., the S and SW coasts). On the contrary, POFs were very scarce in the samples from the NW area, simultaneously with the survey coverage of that area, and only a few hydrated females were collected by the RV in the N during week 4. But recently spawned eggs and subsequent ages were obtained in the region from Porto to Cabo Mondego in particular over the middle and outer shelf (due to the wind regime a the time advection offshore may account for the apparent unmatch between sardine schools and egg distributions). Fishing for sardine in the NW coast was more successful than in other areas, however sardine distribution was quite patchy and the RV operated mainly in the same areas where the purse-seiners were fishing.

During the 2011 survey the CTDF profiler that operates together with the CalVET net was not operational and therefore no data on the water column structure is available. However, in situ SST showed that the temperature distribution patterns were the typical for a late winter situation. Despite the fact that the temperature was slightly lower than in 2008, it was, for all areas, within the range registered for the DEPM surveying series and can not therefore explain the uncommon biological observations discussed.

Summary and work in progress

The above preliminary results, as well as the information on the size/age composition of the samples collected suggest:

- <u>Cadiz area</u>: the area was sampled only during the first week of the survey, there is no information for the remaining weeks. During week 1, nearly all females were active and actively spawning, though the presence of POFs in the ovaries is likely lower than in other years. Egg abundances were in accordance to results from other years, although lower than in 2008. Recently spawned eggs as well as eggs from days 1, 2 and 3 cohorts, were collected.

- <u>Off the South and Southwest coasts</u>: the macroscopic data (from both surveys and regular DCF sampling) do not indicate that the reproductive season had ended or been interrupted during the period considered, since most females had active ovaries with vitellogenic oocytes. Eggs of all ages were observed in the Algarve during week 2. But only very few were collected in the west region south of Lisbon (weeks 2/3) and even over Promontório da Estremadura (Cabo Raso-Cabo Carvoeiro), where abundances are regularly high. Adults collected during weeks 2 and 3 of the survey did not present evidence of spawning activity (presence of POFs). The prevalence of massive atresia was slightly higher (~10%) than observed in other years at the same period, it was observed mainly in females aged 3 and above, but atresia could difficultly be considered the main cause for the nearly absence of spawning during that period. The above observations leads to the hypothesis that for reasons not yet identified (environmental, physiological) during a period of *ca.* 2-3 weeks, the sardines of the S and SW coasts could have skipped the full maturation and ovulation of one batch of oocytes.

- In the Northwest area: Though the available information does not allow a full understanding of what happened in this area, both macroscopic and histological data seem to indicate that the scenario might have been in part different than in the S and SW. Most females sampled in this area were young individuals (~60% sized under 16 cm, ~ 70% aged 1 and 2), the prevalence of 17% of massive atresia in week 4 corresponded exclusively to fish aged 1 or 2, and in weeks 4 and 5, spawning activity (presence of POFs) kept on being nearly inexistent in the NW area. However the egg results indicate spawning activity, eggs of all ages, including very young ones (< 8h), were collected in the NW area, though not at the coastal stations.. It is known that the duration of the reproductive season is shorter for younger sardines (Silva et al. 2006, Stratoudakis et al. 2007). The working hypothesis concerning the NW area is that perhaps a considerable fraction of the individuals (young first-time spawners) in this area would have been ending their reproductive season during the last week of the survey.

- The investigation on the eventual causes for the unusual observations related to the spawning activity during part (temporal or spatial) of the survey period is still in progress. Further analyses on the biological information will be undertaken and additionally, environmental data, from remote sources and operational models, will be explored in order to assess potential relationships between the biological observations and the environmental scenario.

References

Bernal, M., Stratoudakis, Y., Coombs, S., Angelico, M., Lago de Lanzós, A., Porteiro, C., Sagarminaga, Y., Santos, M., Uriarte, A., Cunha, E., Valdes, L. and Borchers, D. 2007. Sardine spawning off the European Atlantic coast: Characterization of and spatio-temporal variability in spawning habitat. Progress in Oceanography, 74: 210-227.

Bernal, M 2008 Modelling the abundance, distribution and production of sardine (Sardina pilchardus, Walb.) eggs in the Iberian Peninsula. PhD thesis, Universida de Cádiz. 240 pp.

Gamulin, T., and Hure, T. 1955. Contribution a la connaissance de l'ecologie de la ponte de la

sardine, Sardina pilchardus (Walb.) dans l'Adriatique. Acta Adriat. 7(8): 1-22.

Ganias K., Somarakis S., Machias A., Theodorou A. 2004. Pattern of oocyte development and batch fecundity in the Mediterranean sardine. Fish. Res. 67: 13–23.

Ganias K., C. Nunes, Y. Stratoudakis 2007. Degeneration of postovulatory follicles in the Iberian sardine *Sardina pilchardus*: structural changes and factors affecting resorption. Fish. Bull. 105:131–139.

Ganias, M. Rakka, T. Vavalidis, C. Nunes. 2010. Measuring batch fecundity using automated particle counting. Fisheries Research 106(3): 570-574

Hunter, J.R., B.J. Macewicz 1985. Measurement of spawning frequency in multiple spawning fishes. In: Lasker (ed.) An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*. NOAA Tech. Rep. NMFS 36: 79−93.

Hunter J.R., N.C.H. Lo, R.J.H. Leong 1985. Batch fecundity in multiple spawning fishes. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. NOAA Tech. Rep. NMFS 36: 66-77.

ICES 2008. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 26_30 November 2008, Nantes, France. ICES CM 2008/LRC:17. 181 pp.

ICES. 2009. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 16 ‐ 20 November 2009, Lisbon, Portugal. ICES CM 2009/LRC:20. 181 pp.

ICESa. 2011. Report of the Working Group on Anchovy and Sardine (WGANSA), 24-28 June 2011, Vigo, Spain. ICES CM 2011/ACOM:16 . 8 pp.

ICESb. 2011. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 21–25 November 2011, Barcelona, Spain. ICES CM 2011/SSGESST:20, 164 pp.

Pérez N., I. Figueiredo, B.J. Macewicz 1992a. The spawning frequency of sardine, *Sardina pilchardus* (Walb.), off the Atlantic Iberian coast. Bol. Inst. Esp. Oceanogr. 8:175−189.

Pérez N, Figueiredo I, Lo NCH 1992b Batch fecundity of sardine, *Sardina pilchardus* (Walb.), off the Atlantic Iberian coast. Boletin del Instituto Español de Oceanografia **8**: 155-162.

Silva, A., Santos, M.B., Caneco, B., Pestana, G., Porteiro, C., Carrera, P., Stratoudakis, Y. 2006. Temporal and geographic variability of sardine maturity at length in the north-eastern Atlantic and the western Mediterranean. ICES Journal of Marine Science 63: 663 - 676.

Silva, A. 2007. Geographic variation in sardine population traits: implications for stock assessment. PhD thesis, Universidad do Algarve. 235 pp.

Stratoudakis, Y., Bernal, M., Ganias, K. and Uriarte A. 2006. The daily egg production methods: recent advances, current applications and future challenges. Fish and Fisheries, 7: 35-57.

Stratoudakis, Y., Coombs, S., Lago de Lanzós, A., Halliday, N., Costas, G., Caneco, B., Franco, C., Conway, D., Santos, M.B., Silva, A., Bernal, M. 2007. Sardine (*Sardina pilchardus*) spawning seasonality in European waters of the northeast Atlantic. Marine Biology 152: 201 - 212.

Zwolinski, J., Stratoudakis, Y., Soares, E. 2001. Intra-annual variation in the batch fecundity of sardine off Portugal. Journal of Fish Biology 58: 1633-1645.

Table 1. General Sampling DEPM 2011

Institute	IPIMAR	IPIMAR	IEO
Survey area	**South**	**West**	**NW & N Spain**
SURVEY EGGS			
R/V	Noruega	Noruega	Cornide de Saavedra
Date	10/02-20/02	20/02-08/03	25/03-10/04
Transects	21	36	56
PairoVET stations	170	309	337
Positive stations	54	40	130
Tot. Eggs	2208	803	1794 (1 net)
Max eggs/m2	4950	2970	1537
Temp (ºC) min/mean/max	14.6/16/16.9	13.5/14.7/16.1	12.5/13.4/14.6
Max age	56.8	66	70.9
CUFES stations	183	309	337
Positive CUFES stations	60	54	163
Tot. Eggs CUFES	4607	479 (inc. area)	34438
Max eggs/m3	81.73	22.13	97.26
Hydrographic stations	NA	NA	337
SURVEY ADULTS			
Number Hauls R/V (total)	11	23	53
- Pelagic Trawls	10	20	53
- Bottom trawls	1	3	-
Numer Hauls Commercial vessel	7	17	-
Number (+) trawls	16	32	10
Date	10.02-20.02	20.02-08.03	12/04-20/04
Depth range (m)	33-107	25-116	61-185
Time range	During the whole day		07:00-20:00
Total sardine sampled	975	2065	718
Length range (mm)	115-266	120-246	162-256
Weight range (g)	11-89	12-98	26.8-130.8
Female for histology	397	827	230
Hydrated females	11	30	31
Otoliths	235	429	409
Female Ages Range	1-10	1-10	1-11

Table 2. Surveying, processing and analyses for eggs and adults

DEPM Surveys	Portugal (IPIMAR)	Spain (IEO)
Survey	**PT-DEPM11-PIL**	**SAREVA0411**
Survey area	South-West	NW & N Spain
SURVEY EGGS		
Sampling grid	8 (transect) x 3(station)	8 (transect) x 3(station)
PairofVET Eggs staged (n egg) (stages from Gamulin and Hure, 1955)	All (2 nets)	All (1 net)
Sampling maximum depth (m)	150	100
Temperature for egg ageing	10 m	
Peak spawning hour	(PDF 21 ± 2 * 3)	
Egg ageing	Bayesian (Bernal et al, 2008)	
Strata	No strata/Stratum (South,West,North)/StratumI (South+West/North)	
Egg production	GLM	
CUFES, mesh 335	3nm (sample unit)	3 nm (sample unit)
CUFES Eggs counted	All	All
CUFES Eggs staged (stages from Gamulin and Hure, 1955)	Subsampled of a minimun of 100	No
Hydrographic sensor	CTDF (FSI)	CTD (SBE 37) CTD SBE 25
Flowmeter	Y	Y
Clinometer	Y	Y
Environmental data	Fluorescence, Temperature, Salinity	Fluorescence (surface only), Temperature, Salinity
SURVEY ADULTS		
Biological sampling:	On fresh material, onboard the R/V or in laboratory; on frozen material for certain commercial samples (ovaries removed before)	On fresh material, on board of the R/V
Sample size	60 indiv randomly ; extra if needed (30 females min for histology) and if hydrated females found	60 indiv randomly (30 mature female); extra if needed and if hydrated found
Sampling for age	Otoliths from the same females sampled for histology	Otoliths from random males and females
Fixation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin	Formalin
Histology:		
- Embedding material	Paraffin	Resin
- Stain	Haematoxilin-Eosin	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez et al. 1992b and Ganias et al. 2010	On hydrated females (without POFs), according to Pérez et al. 1992b

Table 3. Results DEPM 2011

Institute	**IPIMAR**	**IPIMAR**	**IEO**	**TOTAL**
Area	**South**	**West**	**NW & N Spain**	
Survey area (Km^2)	17578	32098	33832	83508
Positive area (Km^2)	6524	4817	12405	23746
Z (hour^{-1})(CV%)				
Model 1	-0.046***(14)			
Model 2	-0.058***(19)	-0.073***(16)	-0.020**(28)	
Model 3	-0.047***(13)			
Model 4	-0.068***(13)		-0.021***(28)	
Model 5	-0.064*** (13)		-0.021***(28)	
P0 (eggs/m2/day)(CV%)				
Model 1	308.8 (23)			
Model 2	617.6(39)	380.2 (43)	139.2(25)	
Model 3	438.9(27)	174.4(29)	326.0(24)	
Model 4	851.5(32)	312.3(34)	140.0(25)	
Model 5	546.1(30)		140.0(26)	
Daily mortality rate (%)				
Model 2	75.3	82.7	38.7	
Model 3	67.8			
Model 4	80.5		39	
Model 5	78.7		39	
P0 tot (eggs/day) (x10^{12}) (CV%)				
Model 1	7.33(23)			
Model 2	4.03(39)	1.83(43)	1.73(25)	7.59
Model 3	2.86(27)	0.84(29)	4.04(24)	7.75
Model 4	5.55(32)	1.50(34)	1.74(25)	8.79
Model 5	6.19(30)		1.74(26)	7.93
Female Weight (g) (CV%)	54.250 (7.1)	50.070 (6.4)	85.850 (3.0)	
Batch Fecundity (CV%)				
Model F1 (hydr. females)	15977 (12.4)		10570 (10.0)	40844 (5.0)
Model F2 (hydr. and MN females from survey)	19052 (12.3)	19416 (9.7)	40844 (5.0)	
Sex Ratio (CV%)	0.498 (9.1)	0.496 (4.4)	0.487 (12.0)	
Spawning Fraction (CV%)	0.083 (8.7)	0.078 (6.5)	0.114 (26.0)	
Spawning Biomass (thousand tons) (CV%)				
Model 2 P0 – Model F1	331056 (43.4)	224067 (45.3)	65497 (28.4)	620621 (28.5)
Model 2 P0 – Model F2	277624 (43.4)	121981 (45.2)	65497 (28.4)	465102 (28.8)
Model 3 P0 – Model F1	234943 (33.1)	102850 (32.3)	152954 (27.5)	490747 (19.2)
Model 3 P0 – Model F2	197023 (33.0)	55991 (32.2)	152954 (27.5)	405968 (28.4)

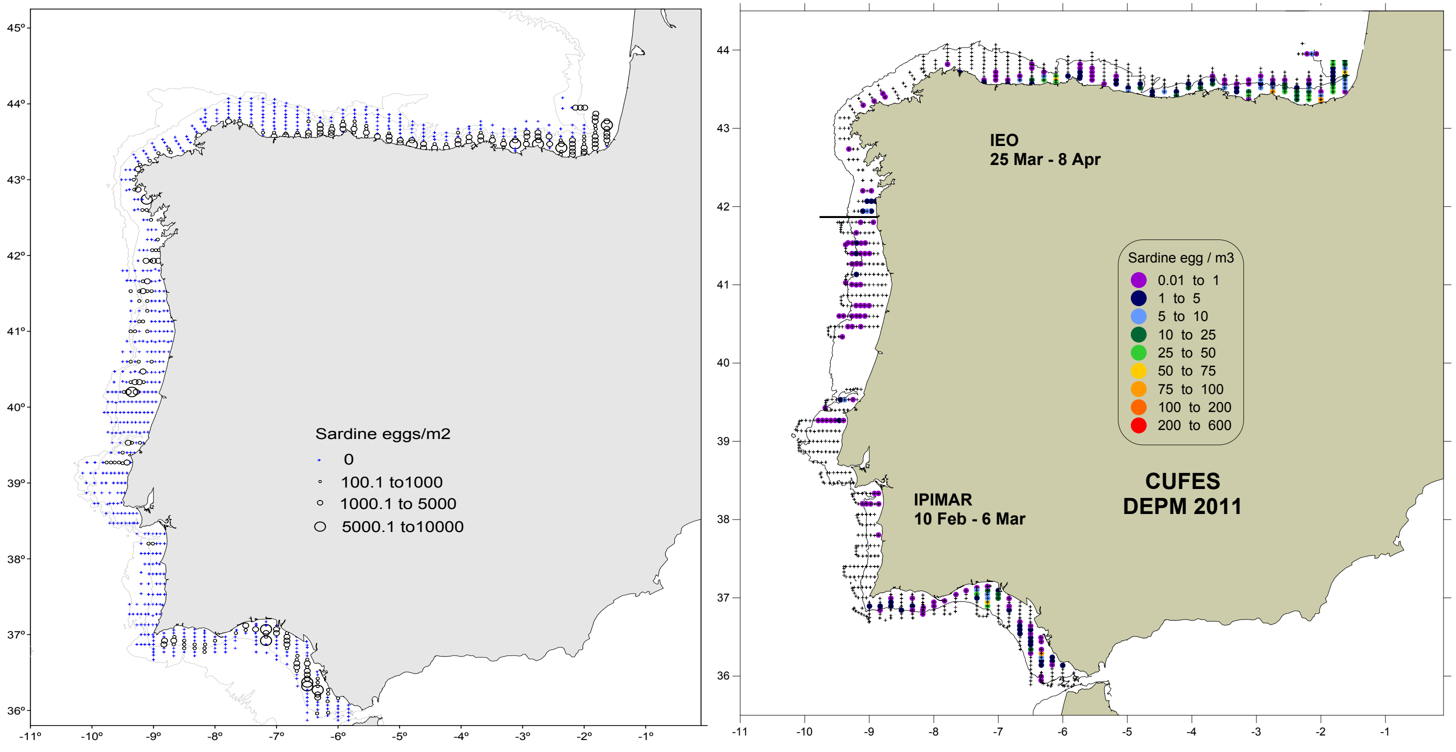


Figure 1. Sardine egg distribution. Left panel: Egg/m^2 from PairoVET sampling; Right panel: Egg/m^3 from CUFES sampling; (+, egg absence).

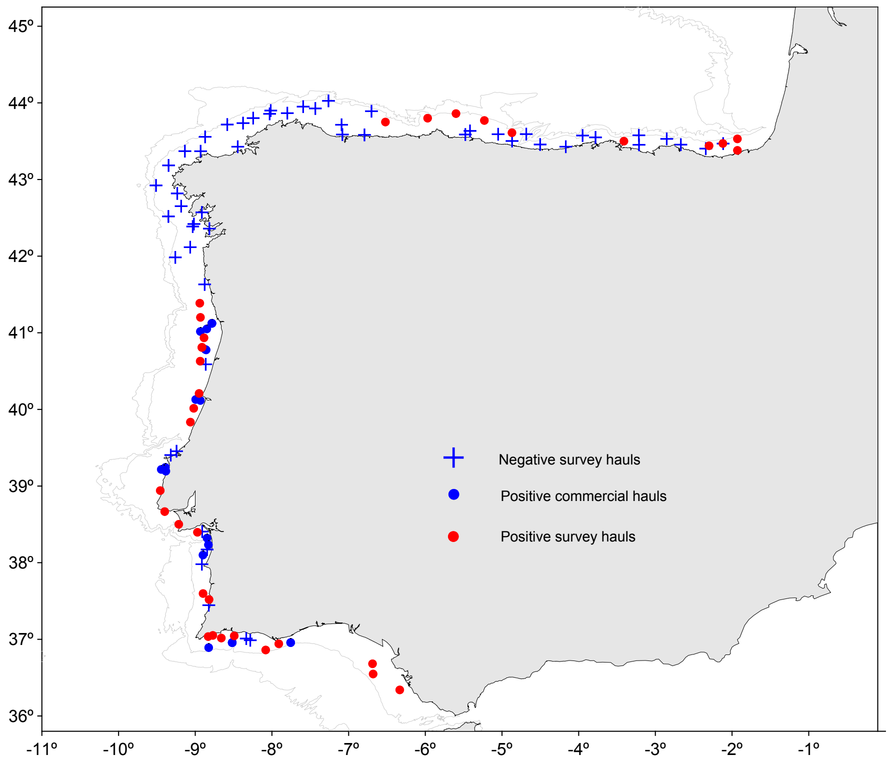


Figure 2. Spatial distribution of fishing hauls (+, hauls without sardine presence)

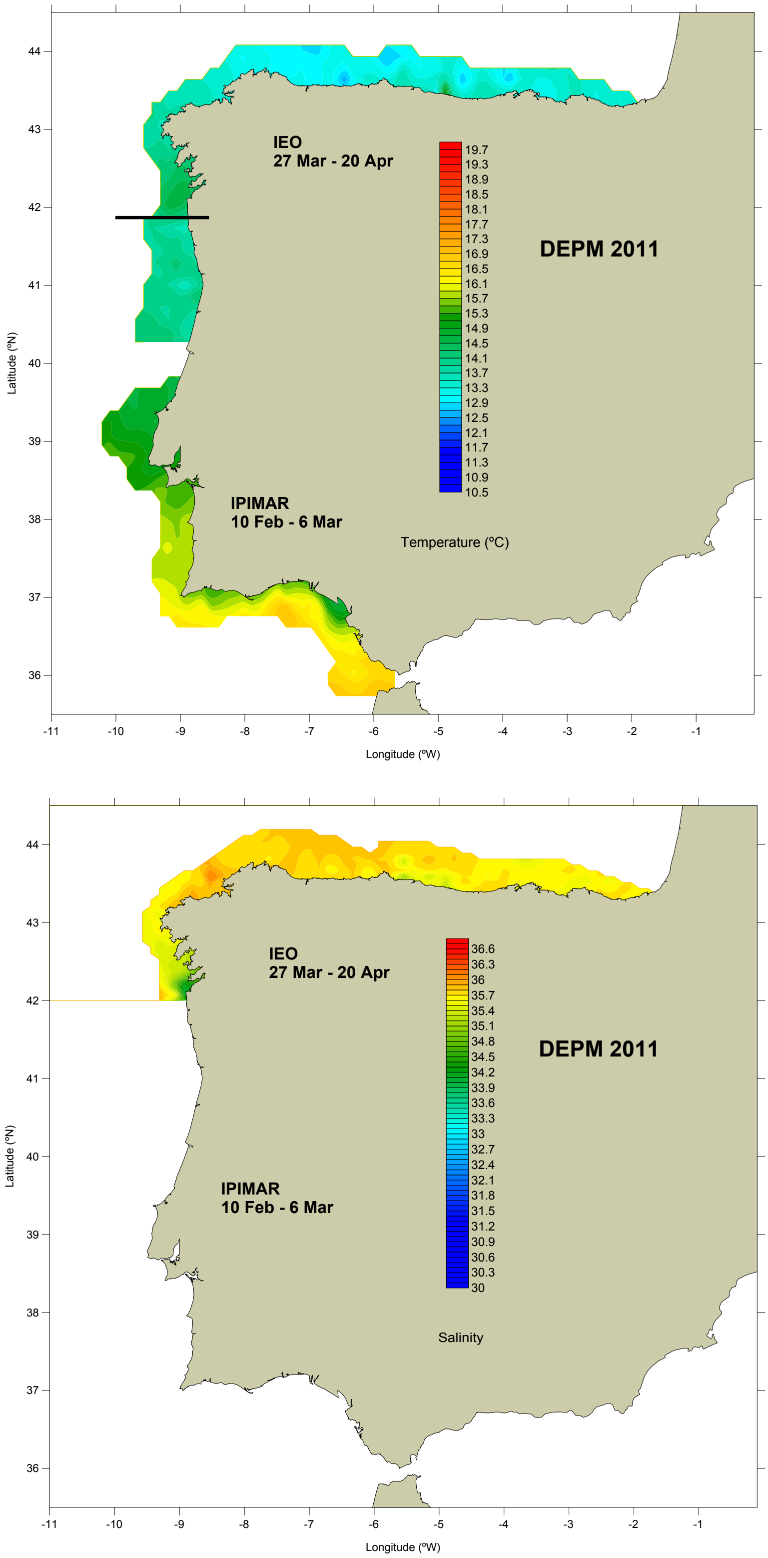


Figure 3. Distribution of sea surface temperature (above) and salinity (below).

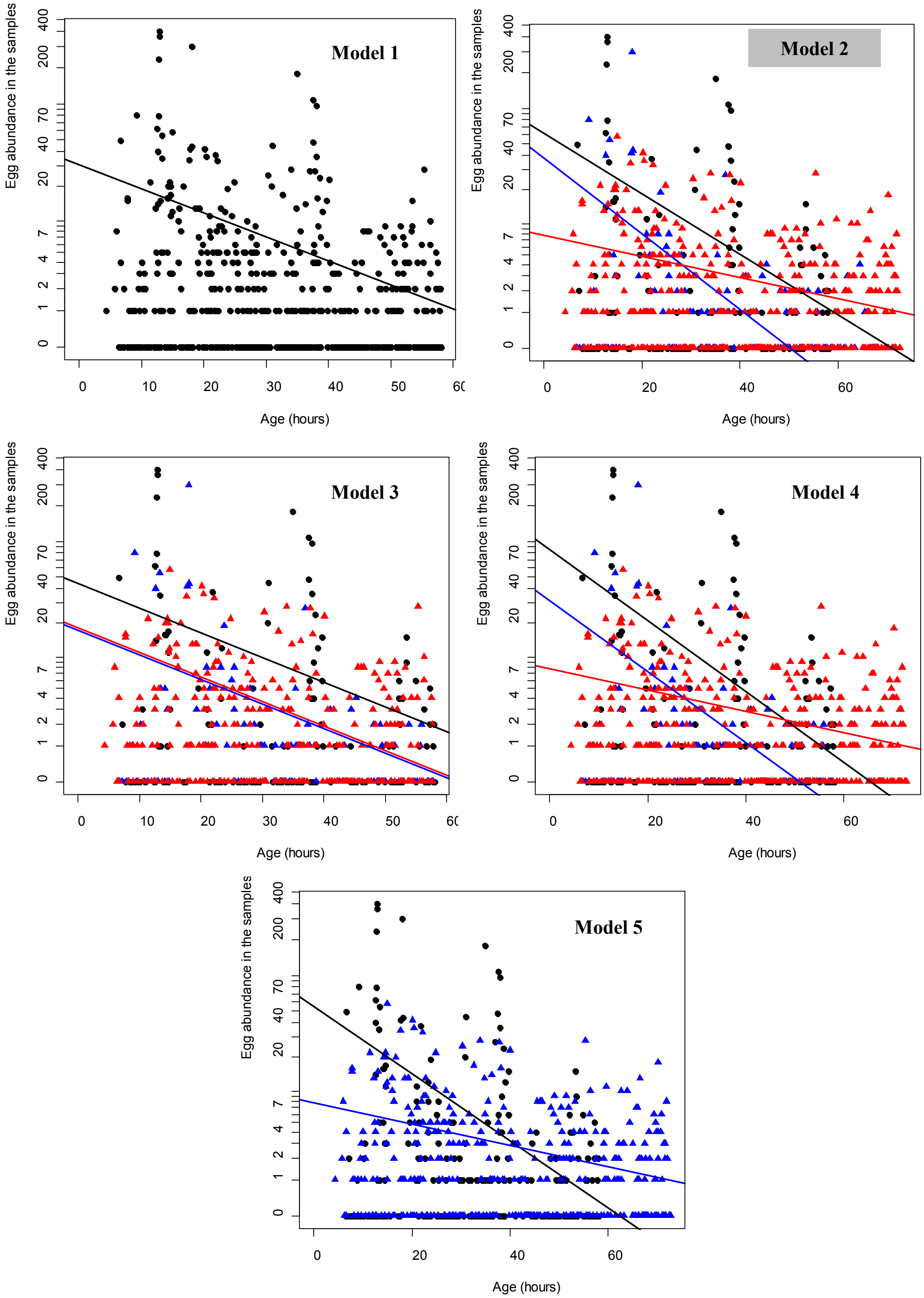


Figure 4. Abundance by age of eggs in the different spatial strata (black = south, blue = west, red = north) and its corresponding fitted mortality curve. Note that southern, western and northern mortality curves were forced to have a common slope (mortality) in Model 3. In Model 4, southern and western mortality curves were forced to have a common slope and that duration of the egg phase is larger in the northern stratum, due to lower temperatures. Below abundance by age of eggs in model 5 (black= south and west, blue= north) and the resultant fitted mortality curve.

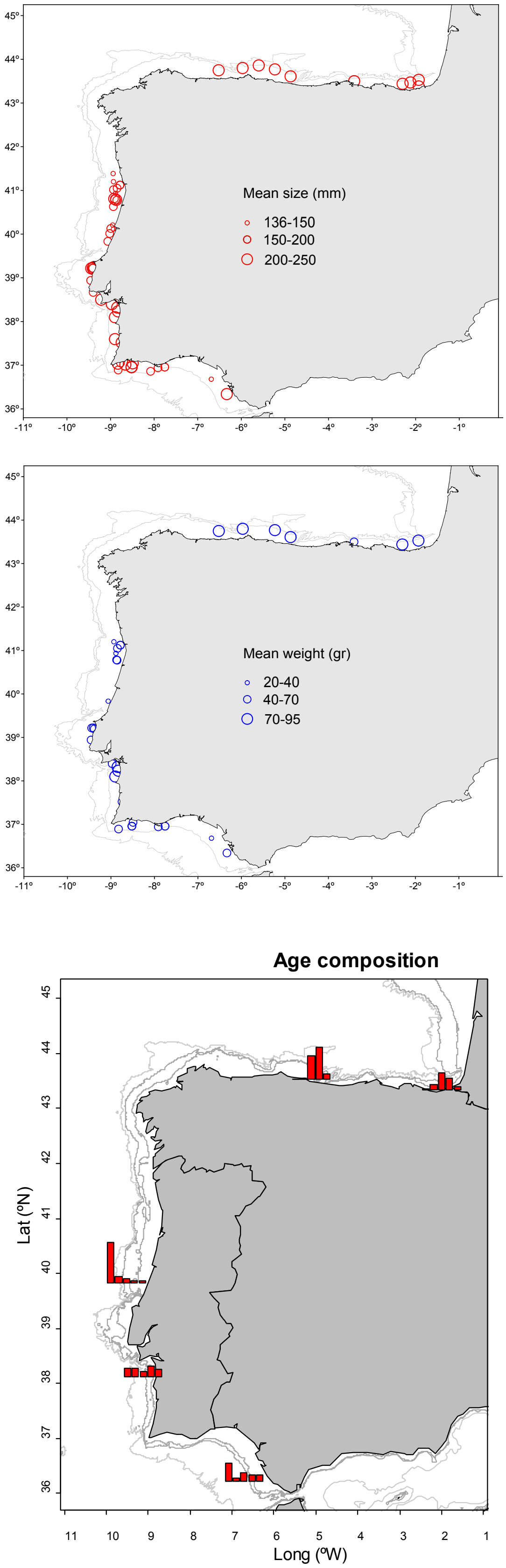


Figure 5. Spatial distribution of the mean size (above), mean weight for mature females, and age composition for the South, West and North areas.

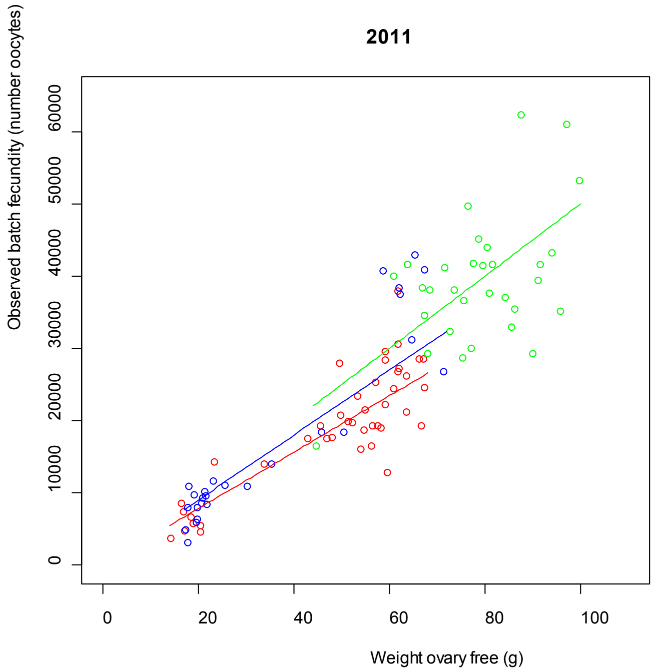


Figure 6. Observed batch fecundity vs. gonad free weight of the hydrated females and regression line of the corresponding model for the three geographical areas (red: South stratum, green: West stratum, blue: North stratum). The model includes includes data from the hydrated females collected in the North stratum during IEO's survey and the data from both hydrated and non-hydrated (migratory nucleus stage) females collected in the West and South strata during IPIMAR's survey period.

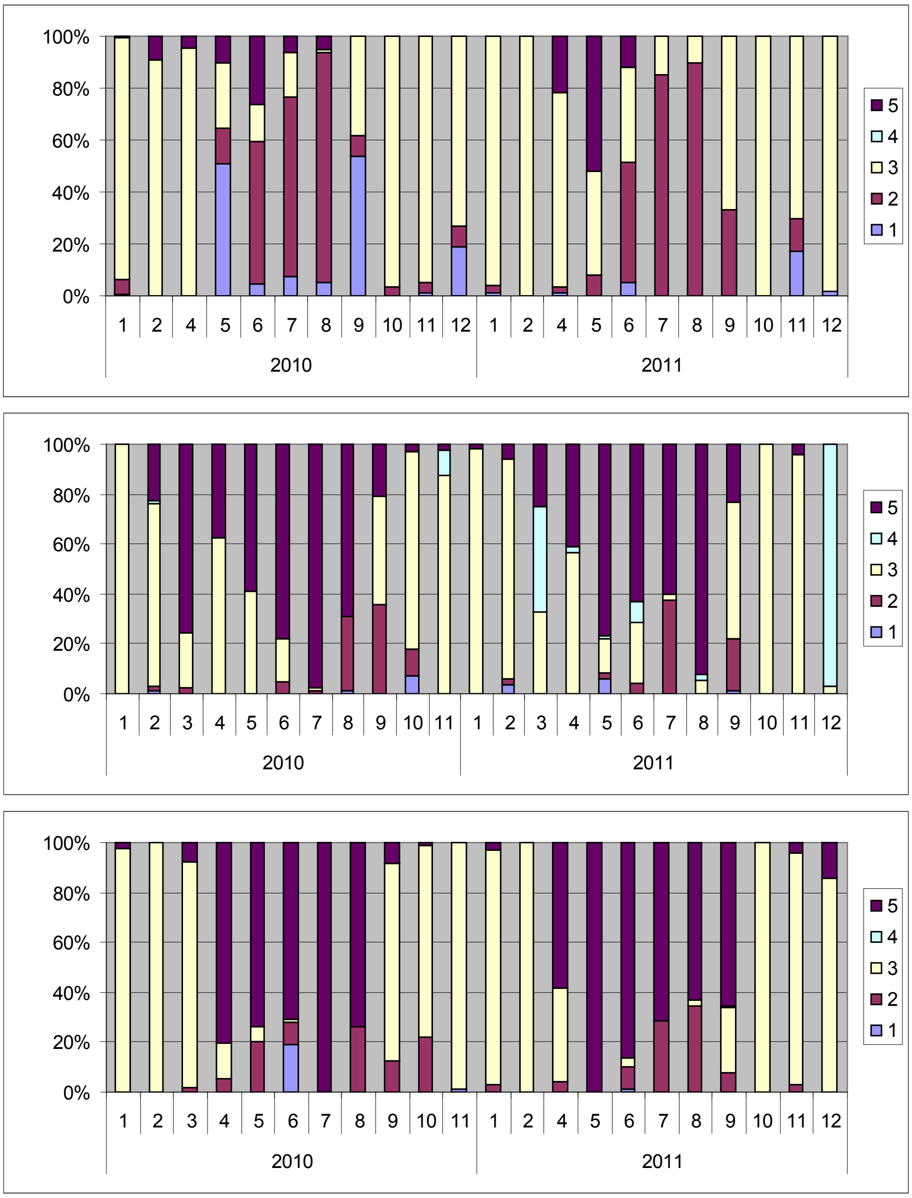


Figure 7: Monthly evolution of the relative proportion of female gonad macroscopic maturity stages (1 to 5) in the samples obtained regularly from the commercial fleet within the framework of the Data Collection Regulation off the Portuguese Northwest (upper panel), Southwest (middle panel) and South (lower panel) coasts during the period January 2010-December 2011.

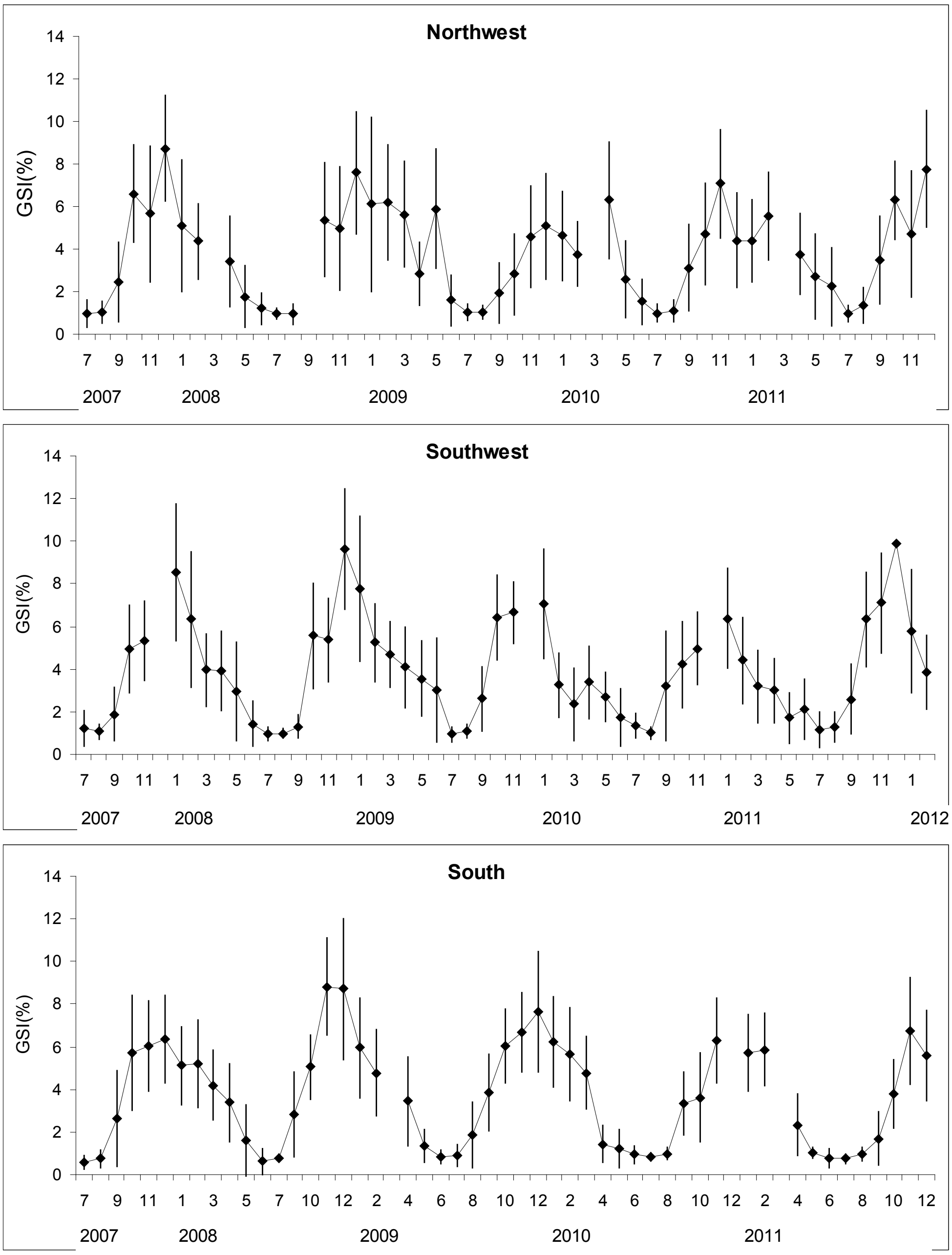


Figure 8: Monthly evolution of the mean (± standard-deviation) gonado-somatic index (GSI) of mature females from the samples obtained regularly from the commercial fleet within the framework of the Data Collection Regulation off the Portuguese Northwest (upper panel), Southwest (middle panel) and South (lower panel) coasts during the period July 2007-December 2011.

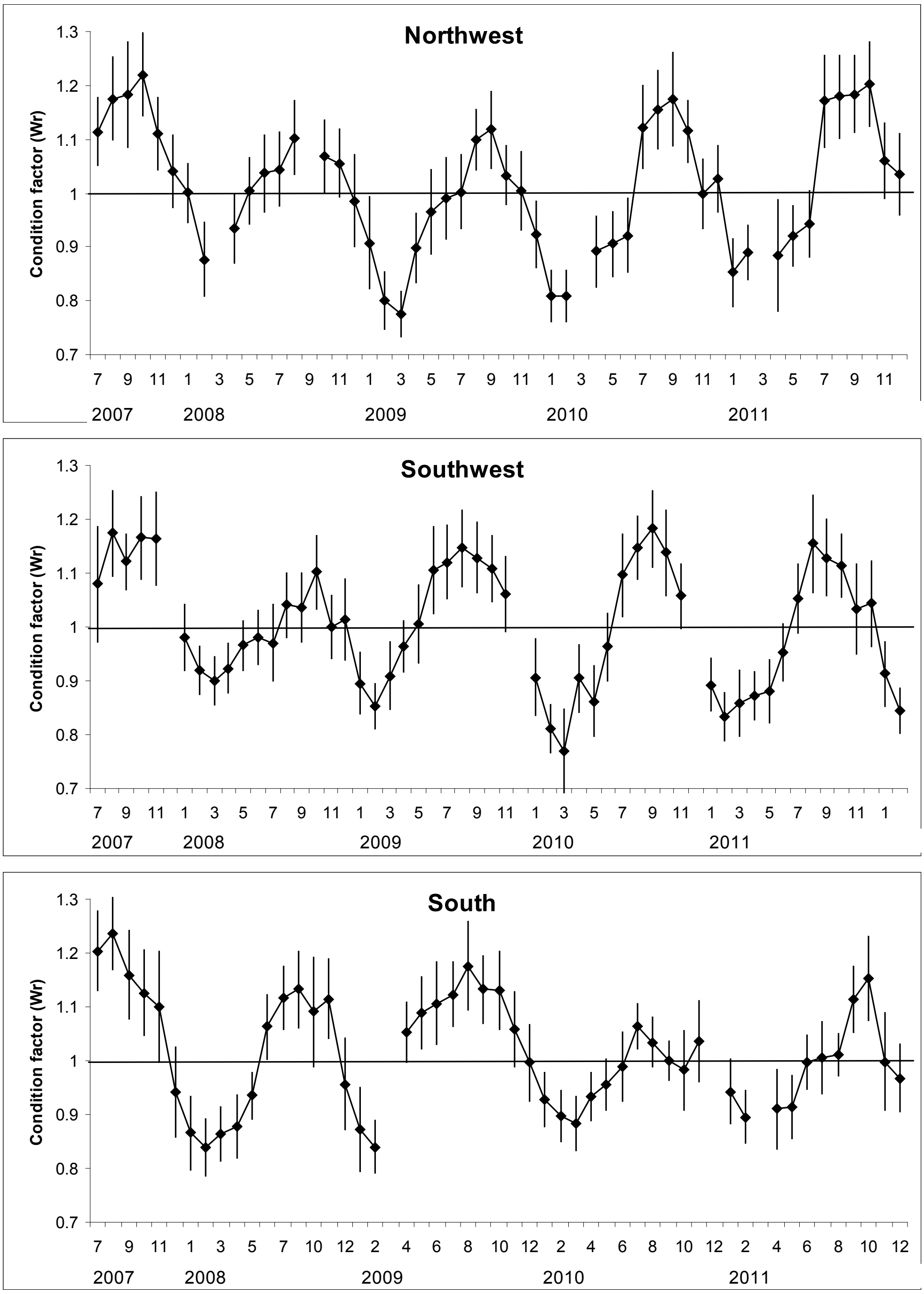


Figure 9: Monthly evolution of the mean (± standard-deviation) condition factor (relative weight Wr) of mature females from the samples obtained regularly from the commercial fleet within the framework of the Data Collection Regulation off the Portuguese Northwest (upper panel), Southwest (middle panel) and South (lower panel) coasts during the period July 2007-December 2011.

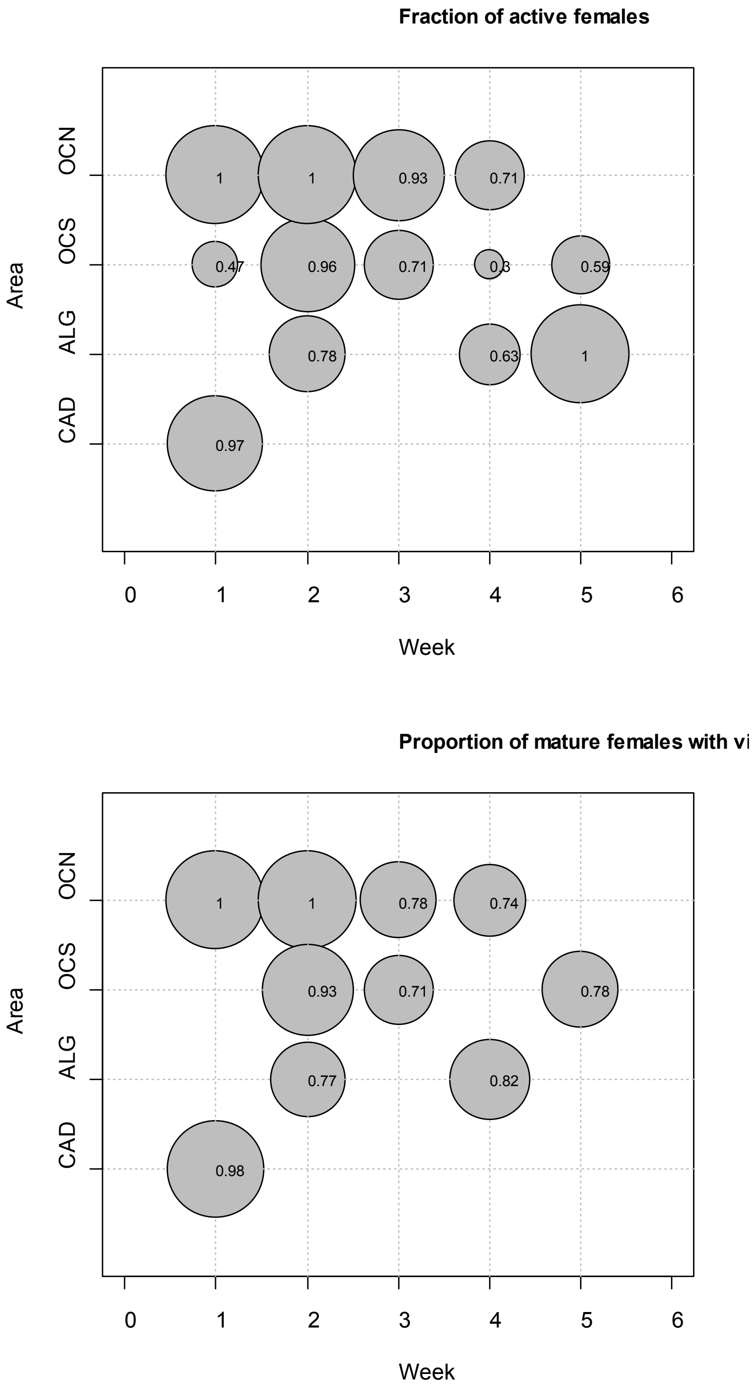


Figure 10: Bubble plots representing the proportion of active females (i.e., the females with ovary macroscopical mature stages 3 and 4) (upper panel) and the proportion of mature females with ovaries containing vitellogenic oocytes (i.e., oocyte stages ≥ 3) (lower panel) sampled in each geographical area (CAD: Cadiz Spanish waters, ALG: Portuguese South, OCS: Portuguese Southwest, and OCN: Portuguese Northwest coasts) and for each week (weeks 1 to 4: period of the DEPM survey coverage, corresponding to samples collected by both R/V and the commercial fleet; week 5: the week after the completion of the survey, corresponding only to adult commercial samples); the figures inside the bullets indicate the corresponding proportion values.

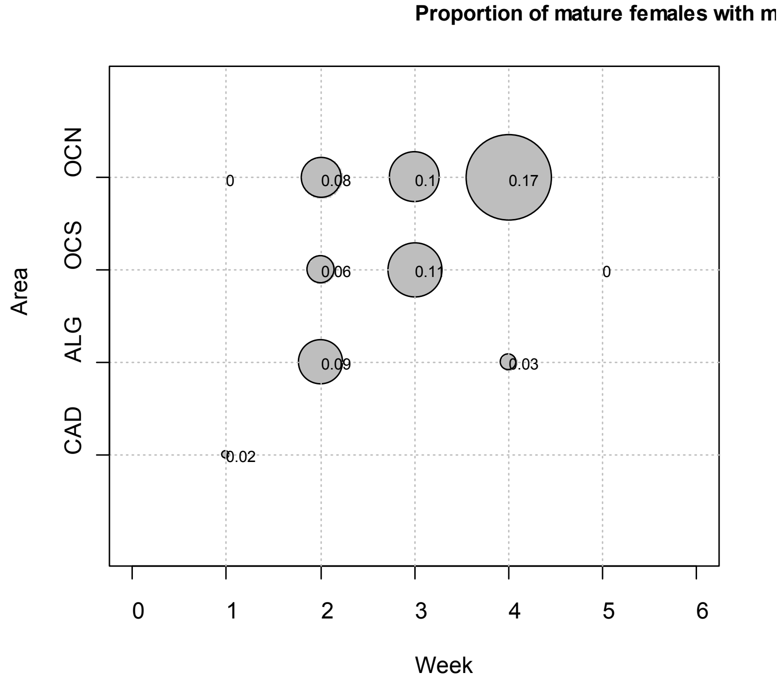


Figure 11: Bubble plot representing the proportion of mature females with ovaries containing more than 50% of the vitellogenic oocytes with alpha atresia, sampled in each geographical area (CAD: Cadiz Spanish waters, ALG: Portuguese South, OCS: Portuguese Southwest, and OCN: Portuguese Northwest coasts) and for each week (weeks 1 to 4: period of the DEPM survey coverage, corresponding to samples collected by both R/V and the commercial fleet; week 5: the week after the completion of the survey, corresponding only to adult commercial samples); the figures inside the bullets indicate the corresponding proportion values.

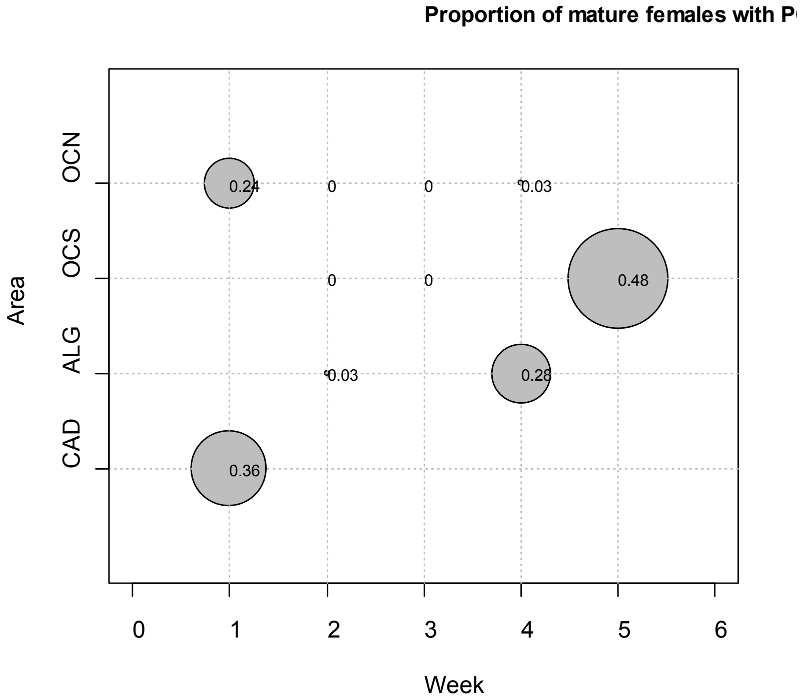


Figure 12: Bubble plot representing the proportion of mature females with ovaries containing post-ovulatory follicles (POFs), sampled in each geographical area (CAD: Cadiz Spanish waters, ALG: Portuguese South, OCS: Portuguese Southwest, and OCN: Portuguese Northwest coasts) and for each week (weeks 1 to 4: period of the DEPM survey coverage, corresponding to samples collected by both R/V and the commercial fleet; week 5: the week after the completion of the survey, corresponding only to adult commercial samples); the figures inside the bullets indicate the corresponding proportion values.

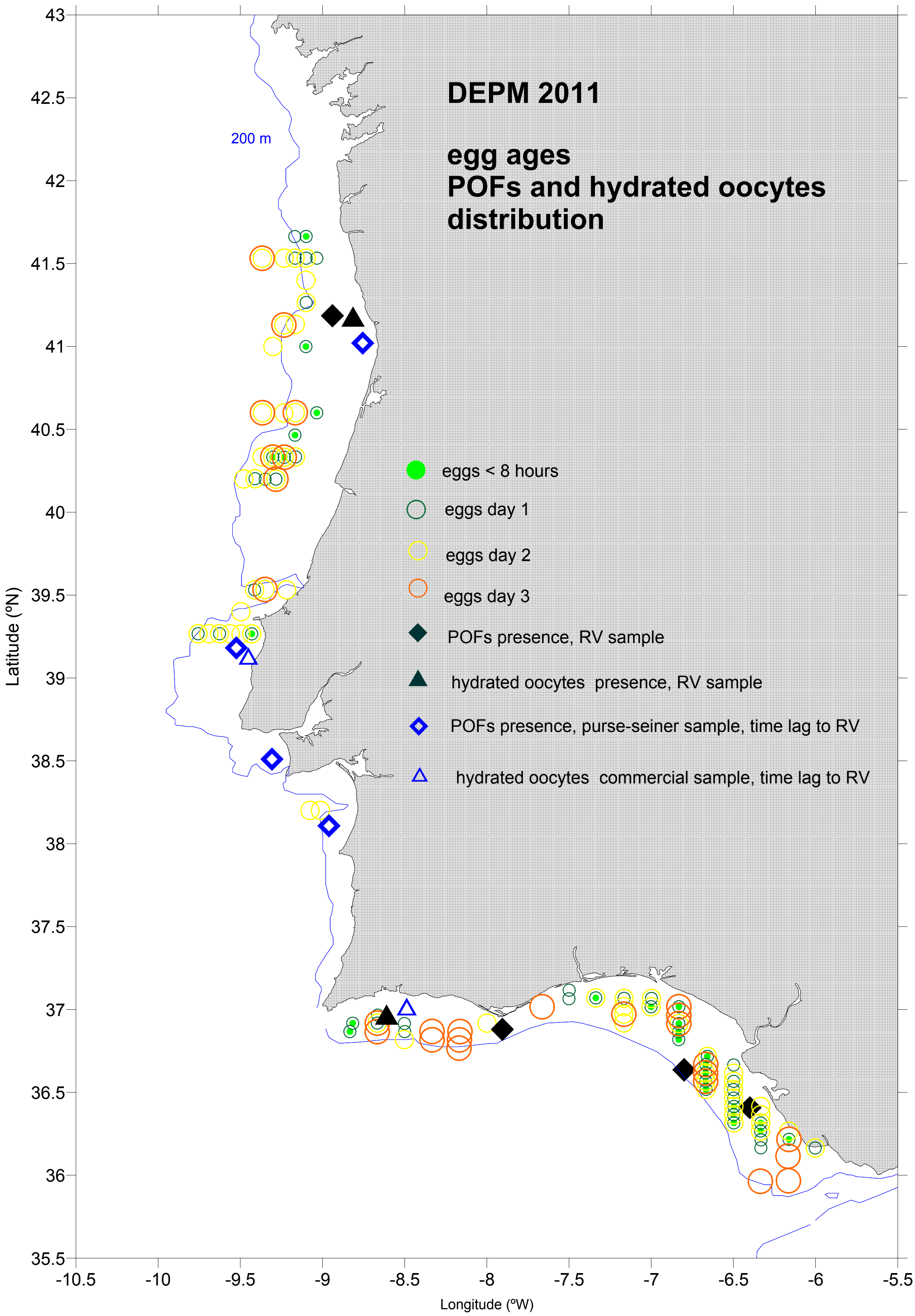


Figure 13: Geographical distribution of eggs (of different ages) from the plankton samples, and of females with signs of spawning activity (hydrated ovaries and ovaries with pots-ovulatory follicles, POFs) collected by both the R/V and the commercial vessels (some fishing hauls were not taken simultaneous to the plankton surveying).

Discards of horse mackerel, anchovy and sardine by the Portuguese bottom otter trawl fleet operating in the Portuguese ICES Division IXa

Nuno Prista <nmprista@ipimar.pt>
Ana Cláudia Fernandes <acfernandes@ipimar.pt>
Alberto Murta <amurta@ipimar.pt>
Eduardo Soares<esoares@ipimar.pt>

IPIMAR - INRB I.P., Avenida de Brasília, 1449-006 Lisboa, Portugal

Abstract

We compile the information available on the discards of horse mackerel (*Trachurus trachurus*), anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) produced by Portuguese vessels operating with bottom otter trawl (OTB) within the Portuguese reaches of ICES Division IXa. The data was collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2011. We present an overview of the on-board sampling programme, estimation algorithms, and data quality assurance procedures and provide results for two fisheries: the crustacean fishery (OTB_CRU) and the demersal fish fishery (OTB_DEF). The frequency of occurrence of anchovy, horse mackerel and sardine in discards of the OTB_CRU fishery is low and in the case of horse mackerel mostly related to by-catch limits imposed on this fishery. In what concerns the OTB_DEF fishery, discarding of these species was more frequent and mainly motivated by minimum landing size regulations (horse mackerel) and market forces (low commercial value of trawl-caught sardine and anchovy). In 2005, the annual estimate of horse mackerel discards produced by the OTB_DEF fishery was 61 tonnes (CV: 30%). The annual estimates of sardine discards produced by the OTB_DEF fishery were 588 (CV: 29%), 295 (CV: 22%), 434 (CV: 28%), 119 (CV: 36%) tonnes in 2004, 2005, 2010 and 2011, respectively. Details on the length structure and age composition of these annual discard estimates are given. Discards of anchovy (and discards of horse mackerel and sardine in other fishery × year combinations) were not estimated due difficulties in raising data when frequency of occurrence is low.

1 Introduction

This working document compiles the information available on the discards of horse mackerel (*Trachurus trachurus*), anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) produced by the Portuguese bottom otter trawl fleet (OTB) operating in the Portuguese reaches of ICES Division IXa. The data was collected by the Portuguese on-board sampling programme (EU DCR/NP) between 2004 and 2011. The document starts with a description of the on-board sampling programme and details of the estimation algorithms and data quality assurance procedures (Section 2). Then, results on species' annual frequency of occurrence in discards, total discard estimates and length composition of discards are presented (Section 3).

2 On-board sampling and data analysis

The Portuguese on-board sampling program, included in the EU DCR/NP, is based on a quasi-random sampling of cooperative commercial vessels between 12 and 40 meters long. The programme started in late 2003 and involves on-board sampling of several fishing métiers. These include, amongst other, bottom otter trawl, deep-water set longlines, gill and trammel nets (of various mesh sizes) and purse seines. From these, the bottom otter trawl fleet (OTB) constitutes the most comprehensively sampled fleet. For sampling purposes the OTB fleet is split into two components: a crustacean fishery (OTB_CRU) that operates cod-end mesh sizes 55-59mm and >70mm targeting deep-water rose shrimp, Norway lobster and blue whiting and a demersal fish fishery (OTB_DEF) that operates cod-end mesh size 65-69mm and >70mm and targets horse-mackerel, cephalopods and other finfish. A detailed account of the characteristics in these fisheries is found in Castro et al. (2007). The procedures used to collect data on board and raise discard data from samples to fleet level discards produced by each fishery have been previously described in Fernandes et al. (2010) and Prista et al. (2011), amongst other. A brief account follows.

2.1 Trip selection

The EU DCR/NP (CR (EC) 199/2008; CD 2010/93/EU) establishes fishing trip as the sampling unit to be used by at-sea discard sampling programmes. The Portuguese on-board sampling programme targeting the bottom otter trawl fleet is based on a quasi-random sampling of trips from a set of cooperative vessels known to operate in each fishery. Annual sampling targets are fixed for each fishery, namely 12 trips in the OTB_CRU fishery and 27 trips in the OTB_DEF fishery. Sampling levels attained in the 2004-2011 period are presented in Table 1. In most years sampling attained or surpassed the annual sampling targets in both fisheries.

Table 1: Discard sampling levels of the Portuguese on-board sampling programme per fishery (2004-2011).

	Trips		Hauls		Hours fished	
Year	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF	OTB_CRU	OTB_DEF
2004	17	24	111	125	479	315
2005	15	39	74	159	372	349
2006	7	42	30	194	133	376
2007	12	38	73	162	260	287
2008	12	34	66	128	267	250
2009	16	38	84	135	299	264
2010	16	31	103	116	372	192
2011	13	30	56	83	217	161

2.2 Catch sampling

The sampling protocols used in Portuguese on-board sampling of the OTB fisheries are detailed in Prista et al. (2011). Briefly, two observers are deployed in each trip and on each selected haul they take a sample from catch, sort the specimens into retained and discarded fraction and register the weight and length composition of each species fraction. Concurrently, observers also collect fishing effort information (hours fished) and register environmental information (GPS coordinates, depth, bottom type, etc.). The sampling protocol suffered only minor changes and adaptations between 2004 and 2010. In 2011 the size of samples was increased from 1 to 2 boxes (of catch) and the number of hauls sampled in each trip was standardized to “at least, every other haul”.

2.3 Estimates of discards (haul level)

Total volume discarded (in kg) in each haul is estimated by multiplying the ratio of discard and retained sample weights (all species combined) by the total retained weight in the haul (all species combined). The volume of discards of individual species in each haul is calculated *a posteriori* by multiplying the proportion (in weight) of species discards in the catch sample by the total catch volume estimated for each haul (total volume discarded + total volume landed).

2.4 Estimates of discards (fleet level)

The procedure generally used to raise discards from haul to fleet level in the Portuguese trawl fisheries is adapted from Fernandes et al. (2010) (Jardim and Fernandes*, in prep.*). Using this procedure, species with low frequency of occurrence or abundance in discards (i.e., a large number of zeros in the data set) cannot be reliably estimated at fleet level (Jardim et al., 2011). As a consequence, annual discard volumes at fleet level were only estimated for horse mackerel and sardine in some specific years (see Section 3.3). The length structure of discards at fleet level are estimated using the same raising methodology as Fernandes et al. (2010) but applied to discarded numbers per length class. The age composition of discards is obtained from the length composition through an age-length key. The age compositions of horse mackerel and sardine discards were obtained from length compositions, through the application of an age-length key for each year. The age-length keys contained data obtained from otolith readings of horse mackerel collected in research surveys and market sampling. The age-length keys contained data obtained from otolith readings of sardines collected in market sampling. The information on fleet effort (in hours and days) used in discard raising was provided by the Portuguese Administration (DGPA) based on vessel’s logbooks and auction market sale records.

2.5 Quality assurance procedures

The Portuguese on-board database is programmed in Oracle and contains internal routines for the detection of basic errors (e.g., errors in dates). The database contains general trip information (vessel information, date, location, haul number, retained weight by species), along with sample information by fraction (retained, discarded) and species, namely weight, number of specimens and length composition. Quality checks involving the manual checking of (at least) 10% of annual trawl records have been routinely carried out since the beginning of the on-board sampling programme. In 2010-2011 a semi-automated R quality assurance procedure was designed and the entire trawl database was checked for additional undetected errors. Minor updates and data reviews have been performed since then. The data used in the current estimates were extracted from the database in 04/06/2012.

2.6 Note on species identification

The Portuguese on-board observers are trained in using the FAO 3-alpha code list (ASFIS List of Species for Fishery Statistics Purposes: available at http://www.fao.org/fishery/collection/asfis/en, date: February 2011) to identify species and species groups during field observations. General training in species identification is provided to observers during demersal surveys and/or market sampling. When on board a commercial fishing trip, observers are requested to record data at the most appropriate taxonomic level based on the specimen's conservation status, on field logistics, and on their own identification expertise. Practice shows that Portuguese on-board observers are accurate in the identification of the three species involved in the current report.

3 Species discards

3.1 Frequency of occurrence

The annual frequency of occurrence of horse mackerel, anchovy and sardine in the discards of hauls sampled from the Portuguese OTB fleet ranged 0% to 25% in OTB_CRU and 4% and 46% in OTB_DEF. The frequency of occurrence of anchovy discards remained below 20% in all fisheries and years sampled, with few individuals sampled (Tables 2 and 3). In what concerns horse mackerel, the number of individuals sampled in discards was higher but the only fishery × year combination where this species was frequently discarded was the OTB_DEF fishery in 2005 (32%). The frequency of occurrence of sardine discards in the OTB_DEF fishery was higher, remaining above 30% in two time periods: 2004-2005 and 2010-2011 (Tables 2 and 3). In OTB_CRU, however, a single individual was found in the more than 500 haul samples collected between 2004 and 2011.

Table 2: Frequency of occurrence (%) of anchovy (ANE), horse mackerel (HOM) and sardine (PIL) in the discards of hauls sampled in the OTB_CRU fishery (2004-2011). "—" = no occurrence; "Total" = frequency of occurrence over the entire period; "n" = total number of fish sampled in discards; "w" = total weight of fish sampled in discards (in kg)

YEAR	ANE	HOM	PIL
2004	—	2	1
2005	—	8	—
2006	13	7	—
2007	4	8	—
2008	—	11	—
2009	—	17	—
2010	—	24	—
2011	7	25	—
Total	2	13	0
n	47	460	1
w	0.964	87.348	0.090

Table 3: Frequency of occurrence (%) of anchovy (ANE), horse mackerel (HOM) and sardine (PIL) in the discards of hauls sampled in the OTB_DEF fishery (2004-2011). "—" = no occurrence; "Total" = frequency of occurrence over the entire period; "n" = total number of fish sampled in discards; "w" = total weight of fish sampled in discards (in kg)

YEAR	ANE	HOM	PIL
2004	9	8	46
2005	10	32	43
2006	10	13	27
2007	16	4	20
2008	9	10	24
2009	10	11	20
2010	8	16	41
2011	17	5	30
Total	11	13	31
n	459	3195	6767
w	11.390	36.252	368.152

3.2 Total weight of discards

To accurately estimate the discard weight of rare species (i.e., species with low abundance and low frequency of occurrence in the sampled hauls) a large number of observations is required. The current fleet-level discard estimation algorithm is considered sensitive to large numbers of zeros in the data set (Jardim et al., 2011) and discard estimates are deemed not reliable when the frequency of occurrence of species is 30% or lower. Anchovy and sardine discards were rare in the OTB_CRU fishery indicating null or negligible discards in these fisheries (see section 3.1). In what concerns the OTB_DEF fishery, the frequency of occurrence of the three species was slightly higher, but still <30% in most years. Consequently, estimates of annual discards are, for the moment, only provided for horse mackerel in 2005 and sardine in 2004-2005 and 2010-2011 (Tables 4 and 5).

Table 4: Volume (in metric tons) and CVs (%, in brackets) of anchovy (ANE), horse mackerel (HOM) and sardine (PIL) discards in the Portuguese OTB_CRU fishery (2004-2011). "—" = no occurrence, "(a)" = low frequency of occurrence

YEAR	ANE	HOM	PIL
2004	—	(a)	(a)
2005	—	(a)	—
2006	(a)	(a)	—
2007	(a)	(a)	—
2008	—	(a)	—
2009	—	(a)	—
2010	—	(a)	—
2011	(a)	(a)	—

Table 5: Volume (in metric tons) and CVs (%, in brackets) of anchovy (ANE), horse mackerel (HOM) and sardine (PIL) discards in the Portuguese OTB_DEF fishery (2004-2011). "—" = no occurrence, "(a)" = low frequency of occurrence

YEAR	ANE	HOM	PIL
2004	(a)	(a)	588 (29%)
2005	(a)	61 (30%)	295 (22%)
2006	(a)	(a)	(a)
2007	(a)	(a)	(a)
2008	(a)	(a)	(a)
2009	(a)	(a)	(a)
2010	(a)	(a)	434 (28%)
2011	(a)	(a)	119 (36%)

3.3 Length composition of discards

The length distributions of sampled discards are provided in Figure 1 with some additional data provided in Annex. In OTB_DEF, discards of horse mackerel are mostly undersized fish (i.e., fish smaller than the minimum landing size for the species); in OTB_CRU the main motiv for discarding is a limit on by-catch species (minimum 30% target species in mesh-size 55-59mm). Discards of sardine and anchovy in both fleets were mostly related with poor fish condition (and consequent low commercial value) of trawl-caught fish when compared to fish from other fisheries (namely purse seine). Length composition raised to fleet level indicated an average size of 10.7 cm in the horse mackerel discarded in OTB_DEF (2005) and 18.4 cm, 17.6 cm, 19.4 cm, 18.4 cm average size in sardine in 2004, 2005, 2010 and 2011, respectively (Table 6 and 7).

Figure 1: Length distribution of anchovy (ANE), horse mackerel (HOM) and sardine (PIL) discards sampled in the OTB_CRU and OTB_DEF fisheries between 2004 and 2011. “red line” = minimum landing size. See Table 2 and Table 3 for sample size

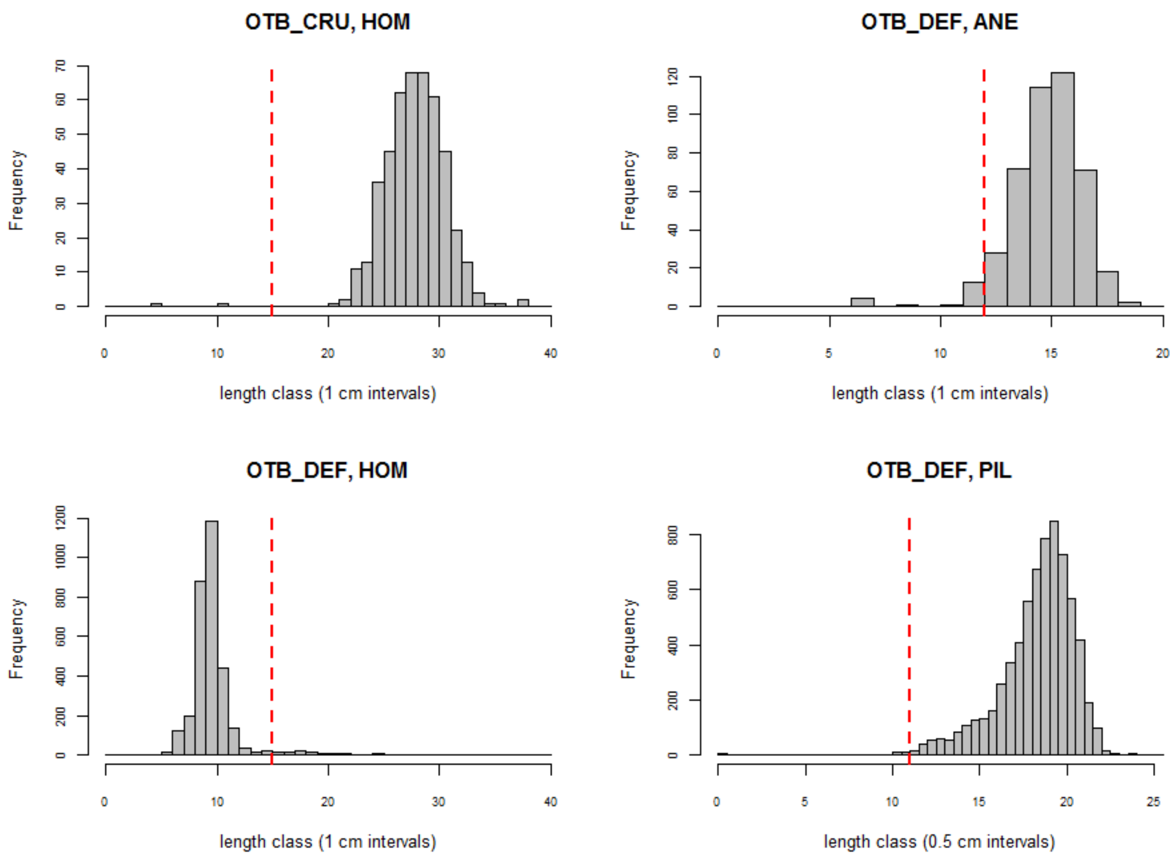


Table 6: Length composition of discards (no.x1000) of horse mackerel discarded by the Portuguese OTB_DEF fishery (2005)

Class (cm)	OTB_DEF, 2005
5	4
6	0
7	64
8	259
9	827
10	838
11	1455
12	702
13	272
14	45
15	63
16	23
17	16
18	0
19	8
20	4
21	0
22	0
23	7
24	0
25	15
26	0
27	0
28	0
29	0
30	0
31	0
32	0
33	0
34	0
35	0
36	0
37	0
38	0

Table 7: Length composition of discards (no.x1000) of sardine discarded by the Portuguese OTB_DEF fishery (2004, 2005, 2010, 2011)

Class (0.5 cm)	OTB_DEF, 2004	OTB_DEF, 2005	OTB_DEF, 2010	OTB_DEF, 2011
9.0	0	0	0	0
9.5	0	2	0	0
10.0	0	5	0	0
10.5	28	11	0	0
11.0	19	34	0	0
11.5	6	176	0	0
12.0	157	146	0	0
12.5	331	165	0	0
13.0	303	173	0	18
13.5	237	132	0	0
14.0	179	238	0	76
14.5	188	220	52	100
15.0	179	383	19	77
15.5	107	452	136	126
16.0	60	200	74	190
16.5	12	256	0	52
17.0	58	147	177	145
17.5	351	204	168	75
18.0	904	276	371	146
18.5	1421	243	546	97
19.0	1986	379	1001	72
19.5	1492	376	1130	295
20.0	1306	799	944	282
20.5	654	523	1130	181
21.0	574	520	582	249
21.5	359	278	169	99
22.0	236	88	89	20
22.5	0	35	0	24
23.0	0	0	34	0
23.5	0	0	0	17
24.0	0	0	0	4
24.5	0	0	0	0
25.0	0	0	0	0

3.4 Age composition of discards

The fleet level age compositions of horse mackerel and sardine discards (in numbers) are displayed in Table 8.

Table 8: Age composition of horse mackerel and sardine discards (no.x1000) of the Portuguese OTB_DEF fishery (2005)

age class	HOM, 2005	PIL, 2004	PIL, 2005	PIL, 2010	PIL, 2011
0	1653	891	341	184	147
1	5852	1388	2766	1373	843
2	63	1856	704	1781	569
3	10	3057	781	953	245
4	11	3228	953	502	176
5	9	398	708	789	103
6	3	214	123	753	127
7	3	80	52	136	102
8	0	24	22	90	20
9	0	10	9	47	8
10	0	2	2	14	3
11+	0	0	0	0	1

References

Castro, J., Abad, E., Artetxe, I., Cardador, F., Duarte, R., Garcia, D., Hernandez, C., Marin, M., Murta, A., Punzon, A., Quincoces, I., Santurtun, M., Silva, C., Silva, L., 2007. Identification and segmentation of mixed-species fisheries operating in the Atlantic Iberian Peninsula waters (IBERMIX project). Final report (Contract ref.: FISH/2004/03-33), 220 pp.

Fernandes, A., Jardim, E., Pestana, G., 2010. Discards raising procedures for Portuguese trawl fleet - revision of methodologies applied in previous years. Working document presented at Benchmark Workshop on Roundfish (WKROUND), 9 - 16 February 2010, Copenhagen, Denmark. ICES CM 2010/ACOM:36, 183 pp.

Jardim, E., Alpoim, R., Silva, C., Fernandes, A. C., Chaves, C., Dias, M., Prista, N., Costa, A. M., 2011b. Portuguese data of sole, plaice, whiting and pollock provided to WGHMM in 2011. Working Document presented at the ICES Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM), 5-11 May 2011, ICES Headquarters, Copenhagen, Denmark. ICES CM 2011/ACOM: 11, 625 pp.

Prista, N., Jardim, E., Fernandes, A. C., 2011. Portuguese onboard sampling protocols: contribution to the standartization of bottom otter trawl and set gears. Presentation to the Study Group on Practical Implementation of Discard Sampling Plans (SGPIDS) , 27 June - 1 July 2011, ICES Headquarters, Copenhagen, Denmark. ICES CM 2011/ACOM: 50, 116 pp.

Annex

Lengths of anchovy (ANE) and sardine (PIL) sampled in the discards of the OTB_CRU fisheries. "Size Class" refers to total length to the lowest 0.5 cm

Species	Fishery	Year	Quarter	Size Class	No.
ANE	OTB_CRU	2006	Q4	12.0	1
ANE	OTB_CRU	2006	Q4	13.0	1
ANE	OTB_CRU	2006	Q4	13.5	6
ANE	OTB_CRU	2006	Q4	14.0	3
ANE	OTB_CRU	2006	Q4	14.5	5
ANE	OTB_CRU	2006	Q4	15.0	3
ANE	OTB_CRU	2007	Q3	15.5	2
ANE	OTB_CRU	2007	Q3	16.0	2
ANE	OTB_CRU	2007	Q4	13.0	1
ANE	OTB_CRU	2007	Q4	14.5	2
ANE	OTB_CRU	2007	Q4	15.0	2
ANE	OTB_CRU	2007	Q4	15.5	2
ANE	OTB_CRU	2007	Q4	16.0	2
ANE	OTB_CRU	2011	Q4	14.0	2
ANE	OTB_CRU	2011	Q4	14.5	2
ANE	OTB_CRU	2011	Q4	15.0	1
ANE	OTB_CRU	2011	Q4	16.0	3
ANE	OTB_CRU	2011	Q4	16.5	1
ANE	OTB_CRU	2011	Q4	17.0	4
ANE	OTB_CRU	2011	Q4	17.5	2
PIL	OTB_CRU	2004	Q4	20.0	1

STANDARDIZED CATCH RATES FOR JACK MACKEREL (*Trachurus picturatus*) FROM THE AZOREAN PURSE SEINE FISHERY 1980 2010

João Gil Pereira[1] &Mauricio Ortiz[2]

SUMMARY

Indices of abundance of jack mackerel (Trachurus picturatus) from the Azorean purse-seine fishery are presented for the period 1980-2010. The index of catch (kg) of fish per day of fishing operation was estimated from data collected by scientific observers through the interview program and from logbooks. The standardization analysis procedure included the following variables; year, season, vessel class and area. The purse seine fleet operates primarily on the juvenile age groups of jack mackerel. The standardized index was estimated using Generalized Linear Mixed Models under a delta lognormal model approach. The standardized CPUE series shows a rather stable trend since the 1980's with the exception of 2008 and 2009 when the highest catch rates were observed. In recent years, the average catch rates are slight below compare to the earlier years.

KEYWORDS: jack mackerel, Catch rates, Azorean Sea, Azorean purse seine fishery

[1] Universidade dos Açores, 9901-862 Horta, Portugal (pereira@uac.pt)
[2] ICCAT Secretariat, Corazón de María, 8. 28002 Madrid, Spain. (mauricio.ortiz@iccat.int)

1. INTRODUCTION

The jack mackerel (*Trachurus picturatus*) has traditionally been one of the favourite species of the Azorean population and is targeted by several fleets and gears. The purse seine fleet catches primarily jack mackerel juveniles**.** This document presents standardized catch rates of jack mackerel from the purse seine fleet 1980 - 2010, using a Generalized Linear Random Mixed Model.

2. MATERIALS AND METHODS

The jack mackerel is one of the species included in the fisheries data collection in the Azores. Several types of statistical and biological information are collected at the main fishing harbours and on board of the fishing vessels. The data collected includes fleet characteristics, quantities caught and landed, fishing effort, gears used and fishing grounds, that are obtained through interviews to the fisherman at the landing sites. The data used in this analysis comes from the interview program and logbooks, over the period 1980-2010.

The purse seine Azorean fishery operates over a wide range islands around the Azores archipelago, however the main fleet is located in Sao Miguel and Terceira, with over 95% to total catch landed in these two islands. (Fig 1). Since 1980 there has been registered 1996 different vessels with purse seine gear that have catch jack mackerel as part of the Azorean fleet. However, some vessels are opportunistic in nature, and only target jack mackerel in response to economic factors primarily. On the other hand, there are vessels that have been operated throughout the whole time period having jack mackerel as main target species. A preliminary analysis was performed to identify these main purse seine vessels. It was concluded that vessels with at least 8 years of reported catches of jack mackerel represented this main fleet. These selected vessels accounted for over 87% of the total annual catch on average (Fig 2). It is believed that this fleet represents a more consistent sampling unit in terms of the stock trends, removing noisy catch rates from learning or inexperience vessels or skippers. Figure 3 shows the annual number of active purse seine vessels and the number of PS vessels that were selected (i.e. at least 8 years of catch in 1980-2010).

Nominal catch rates of jack mackerel (CPUE) were estimated as kilograms of fish per day of fishing operation. The list of potential factors included in the analyses of catch rates included: Island as proxy for the geographical area of fishing operations, Trimester of year defined to account for seasonal fishery distribution through the year (*i.e.*, Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec). Vessel type, a classification of vessels based on their size (LOA) that grouped vessels less than 12 m, and vessels equal or greater than 12 m LOA. Over 90% of PS vessels are less than 12 m in this fleet. Figure 4 shows the nominal log transformed catch rates by each of the main factors considered.

For the Azorean purse seine fishery data, relative indices of abundance for jack mackerel were estimated by Generalized Linear Modeling approach (GLM) assuming a delta lognormal model distribution. The delta distribution was selected due to the proportion of zero catch trips in the dataset. From 1980 through 2010, the proportion of observations that reported positive catches of jack mackerel varied between 78% a 98%. The delta model estimates the predicted catch rates as the result of two processes: i) the probability of catching at least one jack mackerel (proportion of positive catch) and, ii) the mean catch rate given that a positive catch has been realized (conditional predicted catch rate) (Lo *et al.*, 1992). Then the estimated catch rates overall is the product of these two processes.

Statistically, a step-wise regression procedure was used to determine the set of explanatory factors and interactions that significantly explained the observed variability. For this, deviance analysis tables were created for the proportion of positive observations (e.g., positive sets/total sets), and for the positive catch rates. Final selection of explanatory factors was conditional to: a) the relative percent of deviance explained by adding the factor in evaluation, normally factors that explained more than 5 % of deviance were included, and b) The Chi-square significance test. Interactions among factors were also evaluated, if an interaction was statically significant, including the year factor in particular, it was then consider as a random interaction(s) within the final model (Maunder and Punt 2004).

The selection of the final mixed model was based on the Akaike's Information Criterion (AIC), the Bayesian Information Criterion (BIC), and a Chi-square (χ^2) test of the difference between the log-likelihood statistics of two nested model formulations (Littell et al., 1996). Once having a final model selected, the relative indices for the delta model formulation were calculated as the product of the year effect least square means (LSmeans) from the binomial and the lognormal model components (Ortiz and Arocha 2004, Punt et al. 2000). These LSmeans estimates use a weighted factor of the proportional observed margins in the input data to account for the non-balance characteristics of the data. The LSMeans of the lognormal positive trips component were bias corrected for the logarithm transformation using Lo et al., (1992) algorithms. All analyses were done using the Glimmix and Mixed procedures from the SAS® statistical computer software (SAS Institute Inc. 1997).

3. RESULTS AND DISCUSSION

The frequency distribution of log-transformed nominal CPUE kg jack mackerel per fishing day is presented in figure 5 for positive trips, with a mean overall nominal catch rate of 5.0 kg per day. Large purse seines (over 12 m LOA) show higher nominal catch rates of jack mackerel, and were observed also higher catch rates in Sao Miguel. There were no major differences in catch rates by season.

The deviance analysis for jack mackerel from the Azorean PS fishery data analyses are presented in Table 1. For the proportion of positive/total sets; *year*, *season*, *vessel class* and *Area*; and the interactions: *year*×*Area*, *year*×*season* were the major factors that explained whether or not a set caught at least one jack mackerel. For the mean catch rate given that it is a positive set, the factors: *year*, *Area* and the interactions *year*×*season*, *year*×*area* were significant. Once a set of fixed factors were selected, we evaluated first level random interaction between the year and other effects. Table 2 shows the results from the random test evaluation for interactions that included the *year* factor. For the proportion of positive sub model, the interaction *year*×*area* and *year*×*season* were significant, while for the positive observations sub model the interaction *year*×*area* and *year*×*season* were also significant and included in the final model. Diagnostic plots indicated some departure particularly for the low catch rates (Fig 6).

Standardized CPUE series for jack mackerel are shown in Table 3 and figure 7. Estimated coefficients of variation average 18%. The standardized CPUE series show that the relative abundance of jack mackerel varied in the early part of the series (1980-98) followed by a large increase in 1998/99, followed by an stable trend since 1993 in the latest years of the series. Although, in recent years the average catch rates are slight below compare to the earlier years.

4. REFERENCES

LITTELL, R.C., G.A. Milliken, W.W. Stroup, and R.D Wolfinger. 1996. SAS® System for Mixed Models, Cary NC:SAS Institute Inc., 1996. 663 pp.

LO, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

MAUNDER N. M., and A. E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fish. Res. 70:141:159.

SAS Institute Inc. 1997, SAS/STAT® Software: Changes and Enhancements through Release 6.12. Cary, NC: SAS Institute Inc., 1997. 1167 pp.

Table 1. Deviance analysis table for the catch rates of jack mackerel from the Azorean purse seine fishery 1980-2010. Highlighted rows indicated main factor and interactions considered significant for the final model.

Horse mackerel Azores PS CPUE Index

Model factors positive catch rates values	d.f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	30403.4			
Year	29	28312.7	2090.7	15.0%	< 0.001
Year Area	2	17306.6	11006.1	78.8%	< 0.001
Year Area Qtr	3	17112.3	194.3	1.4%	< 0.001
Year Area Qtr Vessclass	1	17026.2	86.1	0.6%	< 0.001
Year Area Qtr Vessclass Area*Vessclass	2	17018.1	8.1	0.1%	0.018
Year Area Qtr Vessclass Qtr*Vessclass	3	17007.8	18.3	0.1%	< 0.001
Year Area Qtr Vessclass Area*Qtr	6	16983.5	42.7	0.3%	< 0.001
Year Area Qtr Vessclass Year*Vessclass	29	16828.6	197.5	1.4%	< 0.001
Year Area Qtr Vessclass Year*Area	58	16516.4	509.7	3.7%	< 0.001
Year Area Qtr Vessclass Year*Qtr	87	16438.8	587.4	4.2%	< 0.001

Model factors proportion positives	d.f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	2190.1			
Year	29	1646.7	543.4	38%	< 0.001
Year Area	2	1603.0	43.7	3%	< 0.001
Year Area Qtr	3	1267.4	335.6	24%	< 0.001
Year Area Qtr Vessclass	1	1195.6	71.8	5%	< 0.001
Year Area Qtr Vessclass Qtr*Vessclass	3	1195.1	0.5	0%	0.925
Year Area Qtr Vessclass Area*Vessclass	2	1176.0	19.5	1%	< 0.001
Year Area Qtr Vessclass Area*Qtr	6	1146.7	48.8	3%	< 0.001
Year Area Qtr Vessclass Year*Vessclass	29	1146.4	49.1	3%	0.011
Year Area Qtr Vessclass Year*Area	58	931.8	263.8	19%	< 0.001
Year Area Qtr Vessclass Year*Qtr	87	770.2	425.4	30%	< 0.001

Table 2. Random interaction(s) evaluation table for selected model of the delta-lognormal standardization analysis. * indicates final model selected for each sub-component.

Model Catch (kg) per day fishing CPUE

	GLMixed Model	-2 REM Log likelihood	Akaike's Information Criterion	Bayesian Information Criterion	Likelihood Ratio Test	
	Proportion Positives					
	Year Area Qtr VessClass	2189.3	2191.3	2195.4		
	Year Area Qtr VessClass *Year*Area*	2180.6	2184.6	2189.6	8.7	0.0032
*	Year Area Qtr VessClass *Year*Area Year*Qtr*	2114.6	2120.6	2128.1	66	0.0000
	Positives catch rates					
	Year Area Qtr VessClass	52114.6	52116.6	52124.5		
	Year Area Qtr VessClass *Year*Area*	51726.3	51730.2	51735.2	388.3	0.0000
*	Year Area Qtr VessClass *Year*Area Year*Qtr*	51311.6	51317.6	51325.1	414.7	0.0000

Table 3. Estimated standardized relative index of abundance for jack mackerel from the Azorean purse seine fishery fleet.

Year	N Obs	Nominal CPUE	Standard CPUE	95% Low CI	95% Upp CI	CV	Std error
1980	643	250.33	227.57	159.18	325.34	18.0%	41.00
1981	795	277.86	234.12	164.46	333.29	17.8%	41.67
1982	878	270.40	216.83	152.75	307.81	17.7%	38.28
1983	763	253.05	283.05	199.73	401.12	17.6%	49.72
1984	882	243.73	252.66	178.30	358.04	17.6%	44.37
1985	1046	292.03	259.85	183.54	367.88	17.5%	45.51
1986	1205	277.22	251.76	177.98	356.12	17.5%	43.98
1987	1043	304.44	252.27	178.41	356.71	17.5%	44.03
1988	938	684.35	517.20	365.23	732.41	17.5%	90.65
1989	850	699.00	582.47	411.40	824.66	17.5%	102.03
1990	550	336.66	207.78	141.34	305.46	19.4%	40.41
1991	427	250.80	150.47	101.66	222.71	19.8%	29.79
1992							
1993	890	218.89	192.14	135.80	271.86	17.5%	33.59
1994	932	203.59	147.65	104.51	208.58	17.4%	25.70
1995	944	189.03	193.15	136.60	273.09	17.4%	33.70
1996	876	200.49	175.31	123.87	248.12	17.5%	30.68
1997	770	214.30	154.88	108.57	220.95	17.9%	27.73
1998	630	206.77	171.71	120.79	244.10	17.7%	30.44
1999	493	162.67	171.80	120.53	244.90	17.9%	30.69
2000	455	150.99	143.16	99.87	205.24	18.2%	25.99
2001	467	204.54	190.90	132.74	274.54	18.3%	34.97
2002	578	216.06	191.42	134.65	272.11	17.7%	33.93
2003	607	222.16	225.52	159.00	319.87	17.6%	39.72
2004	592	183.23	180.33	126.97	256.10	17.7%	31.88
2005	517	201.70	169.43	119.26	240.69	17.7%	29.97
2006	509	198.75	203.50	143.38	288.85	17.6%	35.91
2007	503	186.73	197.51	139.16	280.33	17.6%	34.85
2008	399	195.71	193.07	135.57	274.95	17.8%	34.40
2009	406	176.54	171.49	120.45	244.15	17.8%	30.53
2010	352	187.60	178.97	125.43	255.37	17.9%	32.07

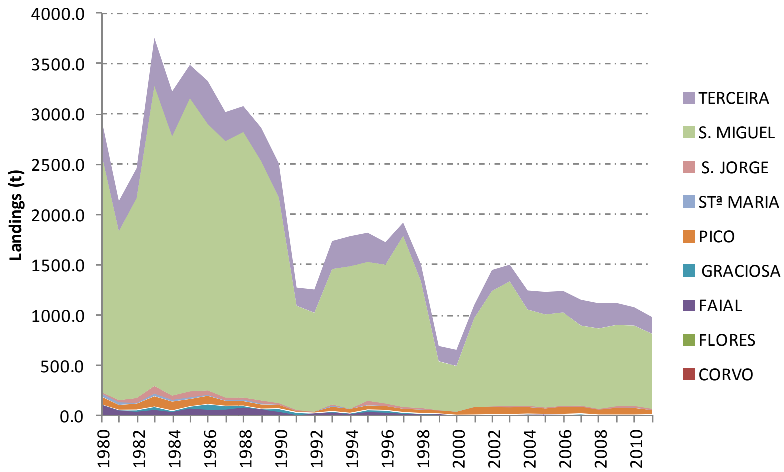


Figure 1. Catch (tones) of jack mackerel by island from the Azorean purse seine fleet 1980-2011.

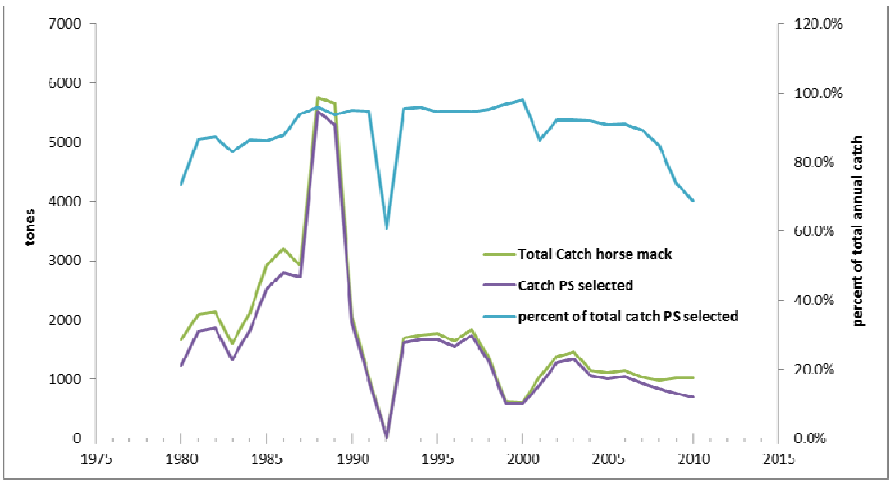


Figure 2. Annual total catch of jack mackerel (tons, green line) by the Azorean PS fleet in the database used for analysis and the selected vessels (PS selected, purple line). The right axis represents the equivalent annual percent of the catch by the selected vessels. Annual number of Azorean purse seine vessels active (green line) and number of PS vessels that have consistently targeted jack mackerel, with at least 8 years of reported catches throughout the 1980-2010 period.

Figure 3. Annual number of Azorean purse seine vessels active (green line) and number of PS vessels that have consistently targeted jack mackerel, with at least 8 years of reported catches throughout the 1980-2010 period.

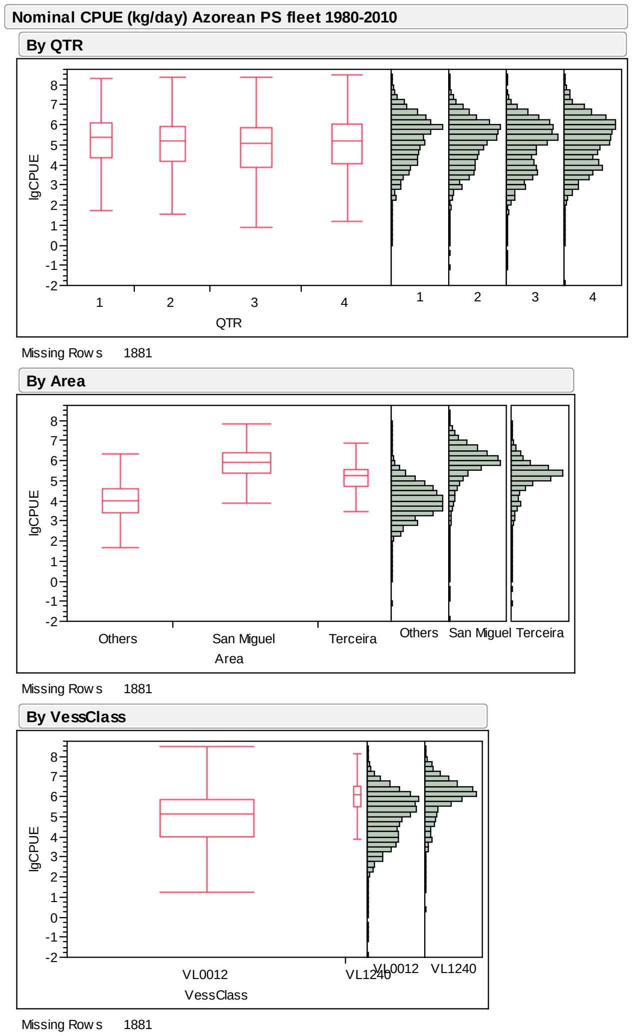


Figure 4. Boxplot and histograms of jack mackerel nominal log transformed CPUE (kg /day) of PS Azorean fleet by season (Qtr), area and vessel class. Size of boxplot is proportional to the number of observations per group.

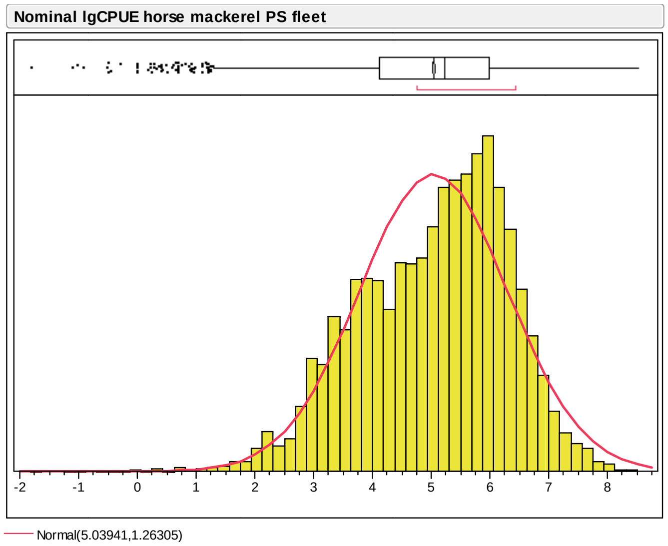


Figure 5. Distribution of the nominal logCPUE for jack mackerel PS fleet 1980-2010 positive observations.

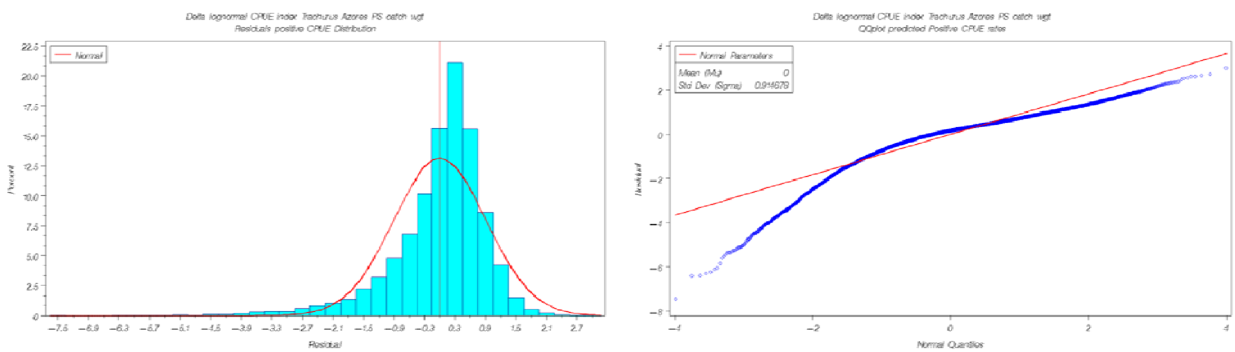


Figure 6. Diagnostic plots positive lognormal standardization model, residuals distribution (left) and normalized qq plot.

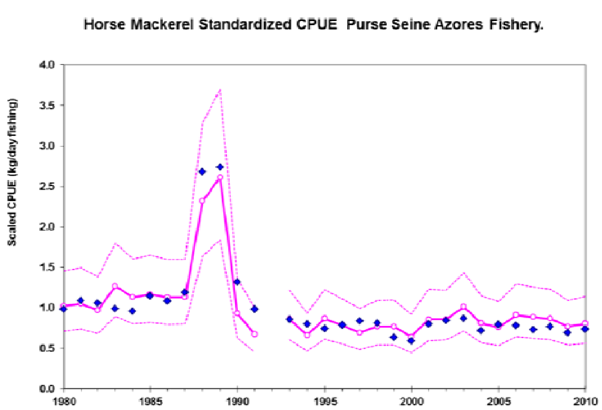


Figure 7. Standardized (solid line) and nominal CPUE jack mackerel from the Azores purse seine fishery 1980 – 2010. Broken lines indicated 95% confidence intervals.

STANDARDIZED CATCH RATES FOR JACK MACKEREL (*Trachurus picturatus*) FROM THE AZOREAN LONGLINE FISHERY 1990 2010

Mauricio Ortiz[1] & João Gil Pereira[2]

SUMMARY

Indices of abundance of jack mackerel (Trachurus picturatus) from the Azorean fishery are presented for the period 1990-2010. The index of catch (kg) of fish per number of hooks (thousand) was estimated from data collected by scientific observers through the interview program. The standardization analysis procedure included the following variables; year, season, vessel group and port of operation. Because the longline fleet operates over a wide range of species and habitats, a procedure was used to select fishing trips with a likelihood of catching jack mackerel. This procedure is based in a multispecies logistic regression based on the concurrence of species commonly caught in the same habitat. Once a subset of trips was selected, the standardized index was estimated using Generalized Linear Mixed Models under a delta lognormal model approach. The standardized CPUE series show that the relative abundance of jack mackerel varied in the early part of the series (1990-98) followed by an increase from 2000 until 2008 with the highest catch rates in 2008, followed by a decline in the latest years of the series.

KEYWORDS: jack mackerel, Catch rates, Azorean Sea, Azorean longline fishery

[1] ICCAT Secretariat, Corazón de María, 8. 28002 Madrid, Spain. (mauricio.ortiz@iccat.int)
[2] Universidade dos Açores, 9901-862 Horta, Portugal (pereira@uac.pt)

1. INTRODUCTION

The jack mackerel (*Trachurus picturatus*) has traditionally been one of the favourite species of the Azorean population and is targeted by several fleets and gears. The demersal fleet catches jack mackerel, usually large specimens, in the multi-specific fishery for deep water species, where several types of hooks and lines gears are used. Those gears vary from hand lines, using one to several hundred hooks, to the bottom longlines**.** This document presents standardized catch rates of jack mackerel from the longline fleet, using a Generalized Linear Random Mixed Model.

2. MATERIALS AND METHODS

The jack mackerel is one of the species included in the fisheries data collection in the Azores. Several types of statistical and biological information are collected at the main fishing harbours and on board of the fishing vessels. The data collected includes fleet characteristics, quantities caught and landed, fishing effort, gears used and fishing grounds, that are obtained through interviews to the fisherman at the landing sites. The data used in this analysis comes from this interview program, over the period 1990-2010.

The longline Azorean fishery operates over a wide range of species and habitats around the Azores archipelago, because of the diversity of fishery operations and target species, an initial step involved identifying the trips that were considered relevant for the catch rate trends of jack mackerel (*Trachurus picturatus*). An objective procedure proposed by Stephens and MacCall (2004) was used to subset trip-interviews with a positive probability of catching jack mackerel based on their catch composition. This procedure uses a multispecies logistic regression to estimate a probability of a given target species, in our case jack mackerel, based on the concurrence presence of species in the catch. Figure 1 shows a distribution histogram of the number of species reported per trip in the interview database. Clearly this fishery is a multispecies type with over 80% of the trips catching 3 or more species. In the case of jack mackerel, Figure 2 shows the pair-wise correlation of species present or not in fishing trips that reported catches of jack mackerel. The most common associated species with catches of jack mackerel are chub mackerel (*Scomber japonicus*) 40%, silver scabbard fish (*Lepidopus caudatus*) 21%, moray (*Muraena helena*), john dory (*Zeus faber*), alfonsino (*Beryx splendens*), scorpionfish (*Scorpaena scrofa*) and comber (*Serranus cabrilla*). This plot also shows those species that are not commonly associated with catches of jack mackerel.

Once the subset of trip-interviews with a positive probability for catching jack mackerel was created, this was used as input for the standardization of nominal catch rates of jack mackerel (CPUE) estimated as kilograms of fish per thousand hooks deployed. The list of potential factors included in the analyses of catch rates included: Port of operation as proxy for the geographical area of fishing, Trimester of year defined to account for seasonal fishery distribution through the year (*i.e.*, Jan-Mar, Apr-Jun, Jul-Sep and Oct-Dec). Class vessel, a classification of vessels based on their size (LOA) that grouped vessels less than 12 m, group 2 vessels between 12 and 24 m. LOA, and group 3 vessels greater than 24 m. LOA.

For the Azorean longline fishery data, relative indices of abundance for jack mackerel were estimated by Generalized Linear Modeling approach (GLM) assuming a delta lognormal model distribution. The delta distribution was selected due to the high proportion of zero catch trips in the dataset. From 1990 through 2010, the proportion of trips from those selected based on the species composition, and reported positive catches of jack mackerel varied between 24% a 70% (Fig 3). The delta model estimates the predicted catch rates as the result of two processes: i) the probability of catching at least one jack mackerel (proportion of positive catch) and, ii) the mean catch rate given that a positive catch has been realized (conditional predicted catch rate) (Lo *et al*., 1992). Then the estimated catch rates overall is the product of these two processes.

Statistically, a step-wise regression procedure was used to determine the set of explanatory factors and interactions that significantly explained the observed variability. For this, deviance analysis tables were created for the proportion of positive observations (e.g., positive sets/total sets), and for the positive catch rates. Final selection of explanatory factors was conditional to: a) the relative percent of deviance explained by adding the factor in evaluation, normally factors that explained more than 5 % of deviance were included, and b) The Chi-square significance test. Interactions among factors were also evaluated, if an interaction was statically significant, including the year factor in particular, it was then consider as a random interaction(s) within the final model (Maunder and Punt 2004).

The selection of the final mixed model was based on the Akaike's Information Criterion (AIC), the Bayesian Information Criterion (BIC), and a Chi-square (χ^2) test of the difference between the log-likelihood statistics of two nested model formulations (Littell et al., 1996). Once having a final model selected, the relative indices for the delta model formulation were calculated as the product of the year effect least square means (LSmeans) from the binomial and the lognormal model components (Ortiz and Arocha 2004, Punt *et al*. 2000). These LSmeans estimates use a weighted factor of the proportional observed margins in the input data to account for the non-balance characteristics of the data. The LSMeans of the lognormal positive trips component were bias corrected for the logarithm transformation using Lo et al., (1992) algorithms. All analyses were done using the Glimmix and Mixed procedures from the SAS® statistical computer software (SAS Institute Inc. 1997).

3. RESULTS AND DISCUSSION

The frequency distribution of log-transformed nominal CPUE kg horse mackerel per thousand hooks is presented in figure 4 for positive trips with longline gear only, with a mean overall nominal catch rate of 0.9 kg per 1000 hooks. The distribution follows closely the assumed error lognormal assumption of the delta model. Figure 5 shows the nominal catch rates boxplots for the main factors evaluated. Small vessels (Less than 12 m LOA) show higher nominal catch rates of horse mackerel, there were however no main differences among seasons or ports of operation.

The deviance analysis for horse mackerel from the Azorean longline fishery data analyses are presented in Table 1 for the analysis based on catch rates. For the proportion of positive/total sets; *year*, *vessel group*, and *Port of operation*; and the interactions: *year*×*Port*, *year*×*season*, *year*×*vessel group* and *Port*×*vessel group* were the major factors that explained whether or not a set caught at least one horse mackerel. For the mean catch rate given that it is a positive set, the factors: *year, Port* and *vessel group*; and the interactions *year*×*season*, *year*×*Port* and *year*×*vessel group*, were more significant. Once a set of fixed factors were selected, we evaluated first level random interaction between the year and other effects. Table 2 shows the results from the random test evaluation for interactions that included the *year* factor. For the proportion of positive sub model, the interaction *year*×*Port* was significant, while for the positive observations sub model the interaction *year*×*vessel group* and *year*×*Port* were significant, and included in the final model. Diagnostic plots indicated no major departure from model assumptions (Fig 6).

Standardized CPUE series for horse mackerel are shown in Table 3 and figure 7. Estimated coefficients of variation are large, as indicated by the wide confidence intervals. The standardized CPUE series show that the relative abundance of horse mackerel varied in the early part of the series (1990-98) followed by an increase from 2000 until 2008 with the highest catch rates in 2008, followed by a decline in the latest years of the series.

The decline observed in the latest years can be explained by the current practice of the bottom longline fleet that land only part of the catches of horse mackerel, discards and retains on board an important part of the fish caught to be used for bait in the demersal fishery. This practice is explained by the low market value of horse mackerel. Figure 8 shows the percentage of horse mackerel caught and discarded or used as bait by the longline fleet, from 2004 to 2010, representing an average of 68% since 2007.

4. REFERENCES

LITTELL, R.C., G.A. Milliken, W.W. Stroup, and R.D Wolfinger. 1996. SAS® System for Mixed Models, Cary NC:SAS Institute Inc., 1996. 663 pp.

LO, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

MAUNDER N. M., and A. E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fish. Res. 70:141:159.

ORTIZ, M. and F. Arocha. 2004. Alternative error distribution models for standardization of catch rates of non-target species from pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery. Fish. Res., 70:275-297.

PUNT, A.E., T.I. Walker, B.L. Taylor and F. Pribac. 2000. Standardization of catch and effort data in a spatially-structured shark fishery. Fish. Res. 45:129-145.

SAS Institute Inc. 1997, SAS/STAT® Software: Changes and Enhancements through Release 6.12. Cary, NC: SAS Institute Inc., 1997. 1167 pp.

STEPHENS, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70: 299:310.

Table 1. Deviance analysis table for the catch rates of jack mackerel from the Azorean longline fishery database 1990-2010. Highlighted rows indicated main factor and interactions considered significant for the final model.

Chicharro Azores Palangre CPUE Index

Model factors positive catch rates values	d.f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	1	2068.0702			
Year	20	1802.6992	265.37	42.4%	< 0.001
Year Season	3	1795.4918	7.21	1.2%	0.066
Year Season Portc	3	1742.3696	53.12	8.5%	< 0.001
Year Season Portc Vesscat	2	1643.4976	98.87	15.8%	< 0.001
Year Season Portc Vesscat Season*Vesscat	6	1634.6492	8.85	1.4%	0.182
Year Season Portc Vesscat Season*Portc	9	1630.6886	12.81	2.0%	0.171
Year Season Portc Vesscat Portc*Vesscat	5	1544.1892	99.31	15.9%	< 0.001
Year Season Portc Vesscat Year*Season	59	1525.8764	117.62	18.8%	< 0.001
Year Season Portc Vesscat Year*Vesscat	32	1519.4208	124.08	19.8%	< 0.001
Year Season Portc Vesscat Year*Portc	33	1442.2958	201.20	32.2%	< 0.001

Model factors proportion positives	d.f.	Residual deviance	Change in deviance	% of total deviance	*p*
1	.	852.082			
Year	20	733.233	118.85	30%	< 0.001
Year Season	3	723.842	9.39	2%	0.025
Year Season Portc	3	701.061	22.78	6%	< 0.001
Year Season Portc Vesscat	2	673.904	27.16	7%	< 0.001
Year Season Portc Vesscat Season*Vesscat	6	663.681	10.22	3%	0.116
Year Season Portc Vesscat Season*Portc	9	655.317	18.59	5%	0.029
Year Season Portc Vesscat Portc*Vesscat	6	612.988	60.92	15%	< 0.001
Year Season Portc Vesscat Year*Season	60	591.019	82.89	21%	0.027
Year Season Portc Vesscat Year*Vesscat	38	539.072	134.83	34%	< 0.001
Year Season Portc Vesscat Year*Portc	46	454.942	218.96	55%	< 0.001

Table 2. Random interaction(s) evaluation table for selected model of the delta-lognormal standardization analysis. * indicates final model selected for each sub-component.

Chicharro Random effects evaluation table

	GLMixed Model	-2 REM Log likelihood	Akaike's Information Criterion	Bayesian Information Criterion	Likelihood Ratio Test		Dispersion
	Proportion Positives						
	Year Season VessCat Port	1415.7	1417.7	1421.6			
*	Year Season VessCat Port Year*PortC	1410.6	1414.6	1419.1	5.1	0.0239	1.1559
	Year Season VessCat Port Year*PortC Year*VessCat	1410.3	1416.3	1423	0.3	0.5839	1.0344
	Year Season VessCat Port Year*PortC Year*VessCat Year*Season	1415.6	1423.9	14332.8	-5.3	N/A	0.9649
	Positives catch rates Vessel Size Category						
	Year Season VessCat Port	3595.9	3597.9	3602.9			
	Year Season VessCat Port Year*Port	3528.8	3532.8	3536.9	67.1	0.0000	
*	Year Season VessCat Port Year*Port Year*VesseCat	3512.6	3518.6	3524.7	16.2	0.0001	
	Year Season VessCat Port Year*Port Year*Season Year*VessCat	3510.5	3518.5	3526.7	2.1	0.1473	

Table 3. Estimated standardized relative index of abundance for jack mackerel from the Azorean longline fishery fleet.

Year	N obs	Nominal Cpue	Standard CPUE	95 % Low CI	95% Upp CI	CV	std error	Nominal	Estimated
1990	36	0.187	0.173	0.04	0.79	88%	0.249	0.61	0.28
1991	95	0.433	0.281	0.06	1.33	91%	0.419	1.42	0.46
1992	85	1.764	1.531	0.39	6.03	77%	1.934	5.77	2.50
1993	210	1.046	0.679	0.20	2.32	68%	0.751	3.42	1.11
1994	141	0.321	0.500	0.16	1.56	62%	0.504	1.05	0.82
1995	198	0.457	0.372	0.11	1.20	64%	0.389	1.49	0.61
1996	275	1.201	1.870	0.70	4.98	52%	1.587	3.93	3.05
1997	249	0.532	0.703	0.23	2.17	61%	0.701	1.74	1.15
1998	188	0.545	0.638	0.17	2.36	73%	0.760	1.78	1.04
1999	69	0.620	0.543	0.12	2.48	88%	0.783	2.03	0.89
2000	97	0.230	0.287	0.07	1.17	80%	0.375	0.75	0.47
2001	38	0.416	0.727	0.24	2.20	60%	0.712	1.36	1.19
2002	29	0.715	1.039	0.33	3.22	61%	1.040	2.34	1.69
2003	45	1.233	1.693	0.49	5.89	69%	1.902	4.03	2.76
2004	70	0.721	1.654	0.63	4.33	51%	1.375	2.36	2.70
2005	77	1.175	0.617	0.20	1.90	61%	0.613	3.85	1.01
2006	47	1.889	1.290	0.40	4.13	63%	1.334	6.18	2.10
2007	40	1.523	1.433	0.46	4.49	62%	1.451	4.98	2.34
2008	77	3.670	2.700	1.03	7.10	51%	2.259	12.01	4.40
2009	88	1.506	1.224	0.38	3.96	64%	1.282	4.93	2.00
2010	129	0.815	1.049	0.38	2.91	55%	0.933	2.67	1.71

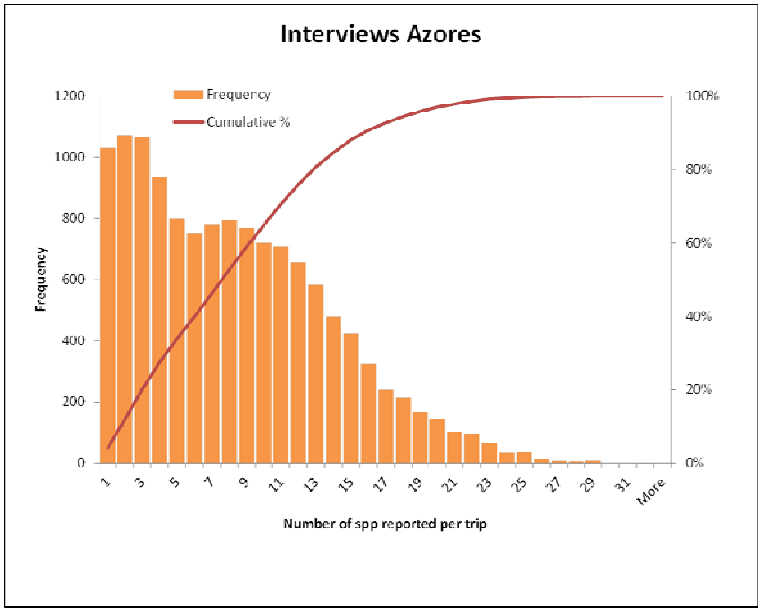


Figure 1. Frequency distribution of the number of species reported by fishing trip-interview in the Azorean fishery database 1990-2007.

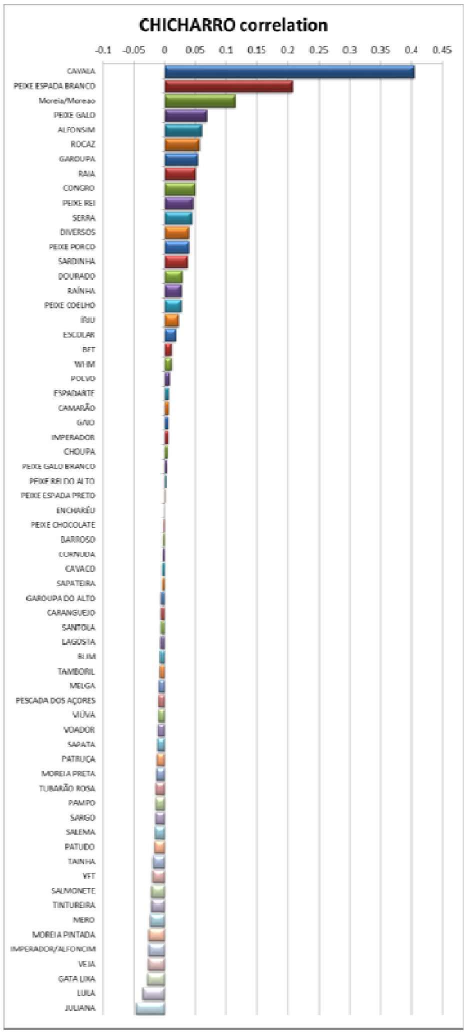


Figure 2. Pairwise correlation between catches of jack mackerel and catches of other species from the interview-trip Azorean fishery database.

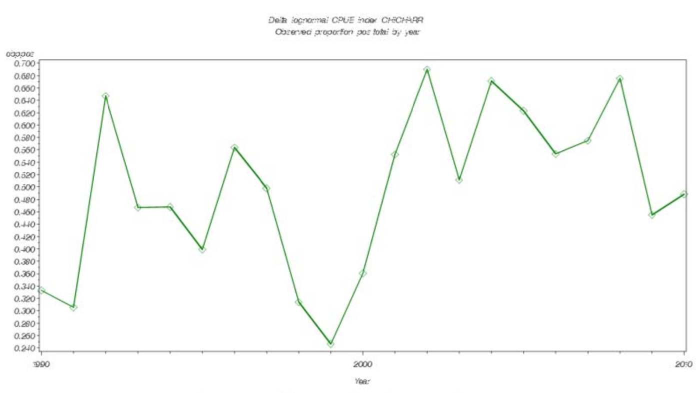


Figure 3. Observed mean annual proportion of positive catch trips for jack mackerel from the interview-trip Azorean fishery database 1990 to 2010.

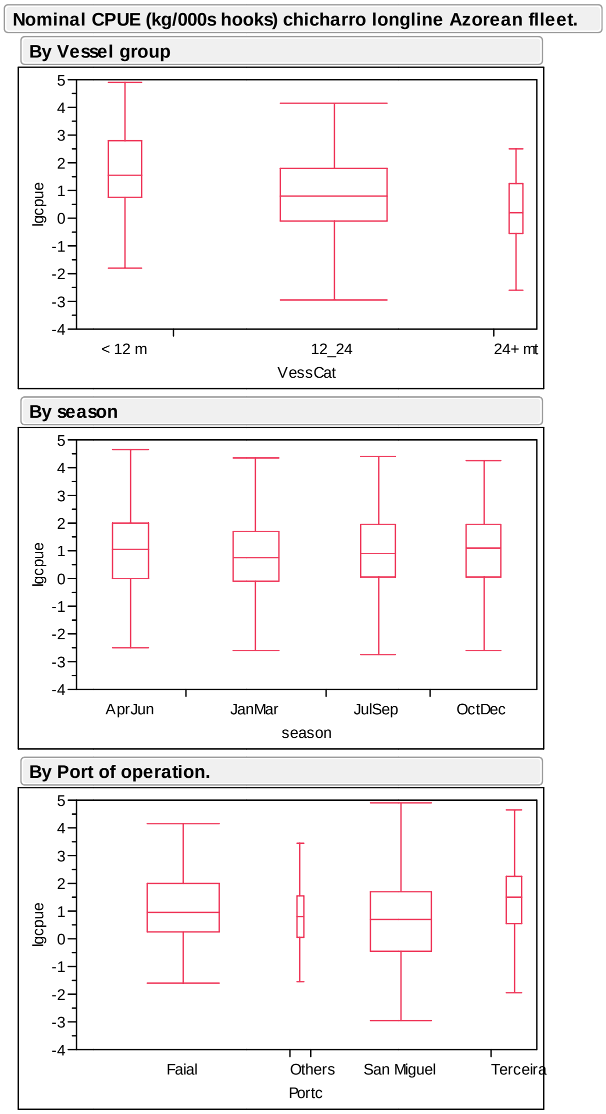


Figure 4. Boxplots of nominal catch rates of jack mackerel for the longline Azorean fishing fleet.

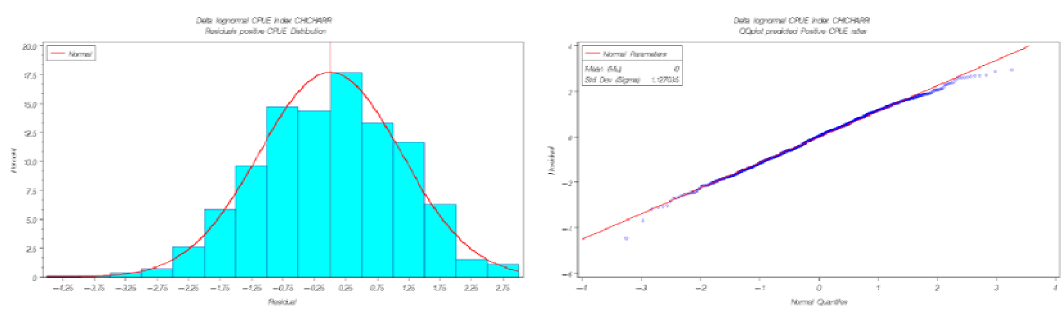


Figure 5. Diagnostics plots standardized CPUEs of jack mackerel for the longline Azorean fishing fleet.

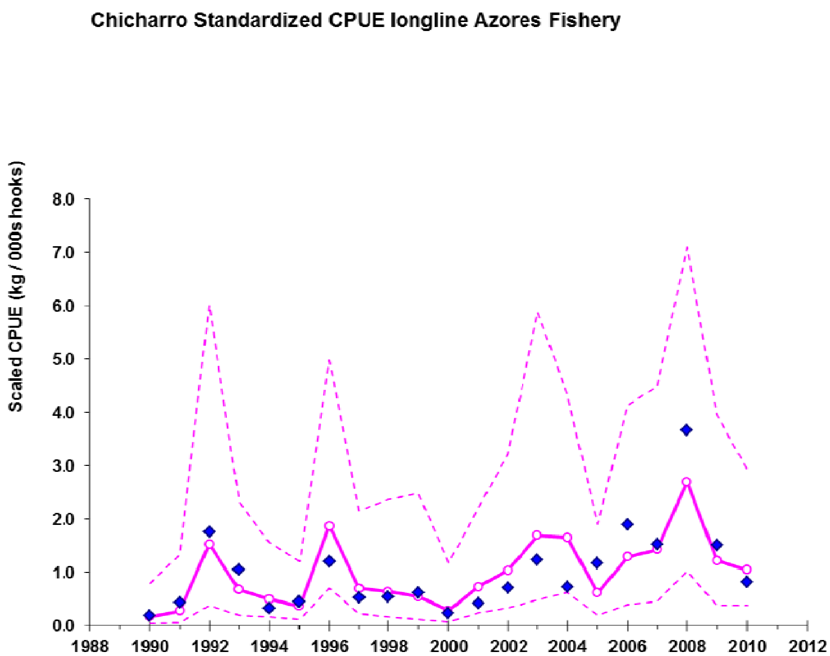


Figure 6. Standardized relative catch rates of jack mackerel from the longline Azores fishery. Solid line represents standardized index, broken lines the estimated 90% Confidence bounds, and the filled diamonds the nominal CPUEs.

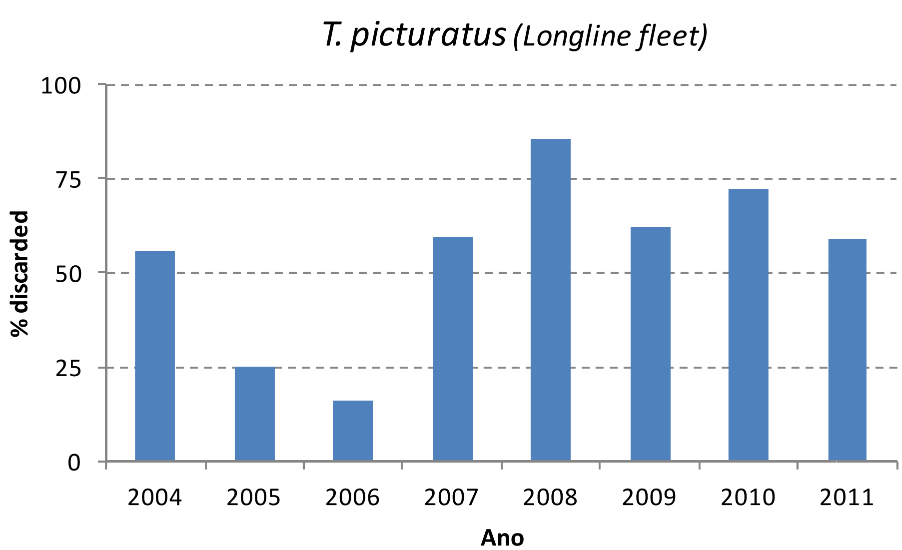


Figure 7. Percentage of jack mackerel discarded or used as bait by the Azores longline fleet.

Working document to ICES WGHANSA, 23-28 June 2012, Azores (Portugal)

Potential use of the JUVENA survey for the assessment and management advice of anchovy in the Bay of Biscay

by

L. Ibaibarriaga, A. Uriarte, S. Sánchez and G. Boyra

Abstract

Since 2003 an autumn acoustic survey called JUVENA has been conducted annually to estimate the abundance of the juvenile anchovy. One of the terms of reference of the ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine in 2012 is to comment on the usefulness of the JUVENA juvenile abundance index for the assessment and for improving the forecast. This working document reviews the evaluation of the JUVENA juvenile abundance index as an indicator of recruitment strength and summarises previous work on the potential use of this index for management purposes. The log-linear model between this juvenile abundance index and recruitment as estimated in the assessment has shown to be significant with a coefficient of determination (R^2 = 93%), above the minimum level necessary to improve the provision of management advice. Recruitment forecasts based on the log-linear model have shown a reasonable good performance over the last three years. These forecasts could be used in the short or long term management advice. In both cases, this could imply a change on the management calendar from January to December, with a revision in June based on the most up-to-date assessment using information from the spring surveys (DEPM and acoustic).

1. Introduction

One of the major sources of uncertainty when managing small pelagic fish is the level of next incoming recruitment, which is highly variable and dependent on environmental conditions. This is usually addressed either trying to reduce the uncertainty when forecasting recruitment or promoting the development of management procedures robust to that uncertainty (Barange et al. 2009).

Both approaches have been tried for the Bay of Biscay anchovy. On the one hand, several methods relating recruitment with various environmental indices have been developed (Allain et al. 2001, Borja et al. 2008, Borja et al. 1998, Fernandes et al. 2010, Huret et al. 2007). However, their low reliability has prevented their actual use with management purposes. On the other hand, the long term management plan for this stock proposed by the European Commission (EC) in 2009 (COM 2009) was selected with the aim of being robust to the unknown level of recruitment entering the population in January. According to the harvest control rule (HCR), in that proposal, the Total Allowable Catch (TAC) is set from June to July next year based on the spawning stock biomass estimate available in June, once the recruits have been fully incorporated into the spawning population.

Since 2003, an autumn juvenile acoustic survey called JUVENA (Boyra et al. 2012) has been conducted annually. The main objective of the survey is to estimate the juvenile abundance in order to provide an index of recruitment for the following year and its results are reported and discussed annually in the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG) (ICES 2010). In the last years the survey methodology has been consolidated and the protocol has been endorsed by WGACEGG. Until 2009, the time series of JUVENA survey was short and restricted to a range of years with low recruitment. By that time, ICES Working Group on Anchovy (WGANC) in 2008 and Working Group on Anchovy and Sardine (WGANSA) in 2009 considered JUVENA as a promising tool. But they specified that the capacity of the survey to predict the age 1 entering the population and the fishery could not be properly evaluated until at least one medium or strong year class has been both measured in the survey and confirmed in the subsequent assessment. The 2009 JUVENA survey gave the largest juvenile abundance estimate since 2003 pointing out to a strong incoming recruitment. In December 2009, despite the fact that both ICES and STECF were reluctant to use the juvenile index as an indicator of recruitment for management purposes, the Council and the European Commission agreed the temporary re-opening of the anchovy fishery (closed since July 2005) with a TAC of 7 000 t based on the results of JUVENA 2009. In June 2010, the spring surveys confirmed a strong year class and ICES started to consider "*the possibility to review the current advice once indications of the next incoming recruitment become available from the autumn survey*". In June 2011, ICES stated that "*despite the fact that the predictive power of the survey may be limited, the correlation between survey index and recruitment appears to be quite strong and is statistically significant. This year ICES emphasized the possibility of revising the June advice if the JUVENA 2011 survey indicates a new low incoming recruitment. In any case, if managers decide on a revision of the advice for 2012, this could be done once results from the autumn acoustic survey are available*". In 2010 and 2011, the European Commission established the TAC for the Bay of Biscay anchovy stock from July to June in next year based on the long-term management plan proposal and the juvenile abundance indices from JUVENA in 2010 and 2011 were not used neither to revise the June scientific advice nor to change the TAC established.

Under these circumstances one of the terms of reference of the ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA) in 2012 is to "*indicate, without pre-empting on actually using the new JUVENA survey as input to the Bay of Biscay anchovy assessment, if the group considers this survey will be useful in describing the state of the stock and improving the forecast. If this is the case, the group should indicate what alternative advice time-frame(s) could be put forward to ask clients if they would consider aligning the management cycle with a modified advice schedule*". Further specifying that "*If the survey would be an improvement for the assessment, ACOM intends to ask clients how the management procedure could be adapted to the advice time-frame(s) put forward by the group. If clients agree with the possibility of updated advice during the fishing season, a benchmark should be arranged to follow up on this.*"

This working document describes the current assessment and management of anchovy in the Bay of Biscay, reviews the evaluation of JUVENA's juvenile abundance index as an indicator of recruitment strength and summarises previous work on the potential use of this index for management purposes. Finally, an advice time-frame for a management procedure including JUVENA's juvenile abundance index is proposed.

2. Current assessment and management of anchovy in the Bay of Biscay

The most effective monitoring programs for small pelagic fish are based on fishery-independent surveys (Barange et al. 2009). Two direct surveys are conducted in spring every year to provide total and age-structured abundance indices of the Bay of Biscay anchovy population. One (BIOMAN) samples anchovy eggs and spawning adults for application of the Daily Egg Production Method (DEPM) (Lasker 1985) whereas the other one (PELGAS) is an acoustic survey (Simmonds and MacLennan 2005). This information together with the commercial catch data gathered regularly throughout the year by Spain and France is compiled and analysed annually in June in the ICES Working Group on Anchovy and Sardine (WGANSA; formerly WGANC and from 2012 onwards WGHANSA) (ICES 2011). As at the time the assessment is conducted the adult samples for the DEPM are not processed yet, the DEPM spawning stock biomass estimates are preliminary based on an average of the daily fecundity from the historical series. The definitive estimates are presented in WGACEGG in November (ICES 2010). The catches in the first semester of the assessment year are also preliminary.

In June, ICES provides its advice based on the precautionary approach principle. The population estimated in the assessment is projected one year forward under different levels of catches and a selected recruitment scenario. Then, the advised catch level from July to June should reduce the probability of next year spawning stock biomass being below B_{lim} (21 000 t) at levels lower than 0.05. Given that in June there is no indication of next year recruitment, usually an undetermined recruitment scenario constructed as a mixture distribution of past recruitments is considered.

The long-term management plan for this fishery was proposed in 2009 by the EC in cooperation between STECF and the South Western RAC. This plan has not yet been formally adopted by the EU, but has been used to set the TAC from 1st July to 30th June in 2010 and 2011. The harvest control rule within proposal sets the TAC as the 30% of the point estimate of the spawning stock biomass (SSB) but with an upper bound on the TAC (of 33 000 t), and with a minimum TAC level (of 7 000 t) applicable at spawning stock biomass estimates between 24 000 t and 33 000 t.

$$TAC_{Jul_{y-1}-Jun_y} = \begin{cases} 0 & \text{if } \widehat{SSB}_{y-1} \leq 24\,000 \\ 7000 & \text{if } 24\,000 < \widehat{SSB}_{y-1} \leq 33\,000 \\ \min(33000,\ 0.3 * \widehat{SSB}_{y-1}) & \text{if } \widehat{SSB}_{y-1} \geq 33\,000 \end{cases}$$

In the absence of a reliable index of recruitment, this rule sets the TAC once the recruits have consolidated as spawning fish in spring. The management decisions apply from July of a given year to June of the following year based on the most up-to-date assessment. According to the STECF evaluation, this rule is robust to the unknown level of recruitment which will enter the population in the following year in conformity with a selected risk (0.05) level in a long term (10 years) perspective (STECF 2008a, b).

Since 2003, the JUVENA acoustic survey on anchovy juveniles is conducted annually in autumn (September). Currently, these results are not used by ICES in the assessment and the management advice and they are not considered within the EC long-term management plan proposal.

See Figure 1 for a diagram on the main events for the assessment and management advice of anchovy in the Bay of Biscay.

3. Is JUVENA survey a good indicator of recruitment strength?

The relationship between the JUVENA's juvenile abundance index and the recruitment next year (age 1 biomass in January, as estimated by the Bayesian two-stage biomass-based assessment model -BBM) was analysed last year in WGANSA (ICES 2011). The comparison of the two time series (each standardised according to its mean and variance) is shown in Figure 2. The log-linear model fitted to the recruitment age 1 estimated from the assessment and the juvenile abundance index was significant (p-value=7.1E-05) with R^2=93%. This level of the coefficient of determination is above the minimum required (around 50%) to suppose an improvement in case of using it for the provision of management advice (De Oliveira and Butterworth 2005, De Oliveira et al. 2005). Figure 3 shows the fitted model and the corresponding 95% confidence and prediction intervals.

The JUVENA 2011 survey estimated the juvenile biomass at 207 625 acoustic tonnes. This estimate is the second highest in the time series and it is similar to that observed in 2009. Based on the log-linear model this would correspond to a recruitment value of 48 000 t, which is close to the historical recruitment median. The actual recruitment strength should be confirmed with the results of the assessment conducted in WGHANSA 2012. In addition, the assessment results should be used to revisit the relationship between the age 1 recruitment estimated in the assessment and the juvenile abundance index. This year there will be 9 pair of observations and the juvenile abundance estimates will cover a broader range of values than in previous years.

4. Potential use of JUVENA into management advice and implications

The potential use of the JUVENA juvenile abundance index for management was discussed in a working document to WGANSA in 2010 (Ibaibarriaga et al. 2010). Basically, two types of management advice were considered: short and long term.

4.1. Short term management advice

If management advice is given in the short term, the juvenile abundance index can be used to reduce the uncertainty of the prediction. Nowadays an undetermined recruitment distribution, in which any recruitment observed in the past is equally likely, is considered. This leads to a wide probability density function for recruitment and biomass of next year. Given the dependence of the anchovy population on the assumed recruitment value, any information on next incoming recruitment will help to reduce the uncertainty and therefore obtaining a more reliable estimate of the probability of the population being below B_{lim} for a given level of catches. Once the JUVENA survey results are available in November the predictive distribution of recruitment according to the log-linear model (which relates the recruitment and the juvenile abundance index from JUVENA) can be used as the probability density function of recruitment in the probabilistic short term projection. These projections have been performed routinely since 2009 for the Spanish government. The results in 2009 were used by the EC to re-open the fishery, but they haven't been used in 2010 and 2011. The highest juvenile abundance index obtained in 2010 was followed in 2011 by one of the highest recruitments at age 1 in the assessment series (figure 2). If a more qualitative use is preferred, the short term advise could be revisited only when the JUVENA juvenile abundance index points to a low recruitment. In which case, the next year recruitment probability density function could be constructed as a mixture of the low recruitment distributions in the past.

4.2. Long term management advice

Regarding the long-term advice, in the impact assessment accompanying the regulation proposal for the long-term management plan of the stock, it is stated that *DG MARE supports the views expressed by the SWWRAC and believes that the results of the autumn recruitment survey should be incorporated into the decision-making process to ensure that TAC set in early winter takes into account the natural mortality exerted on the newly recruits during the rest of the season and thus, can predict the available biomass for the next year. The proposal for a long-term plan would set the rule whereby fishing would be permitted from July of year N to June of the year N+1 depending on the biomass available in June, which is estimated following the spring scientific research trips. Once the JUVENA survey of juvenile fish commences, the TAC would once again be set every year, for a calendar year (from January to December).*

According to this change in the calendar, the HCR in the long-term management plan would set the TAC from January to December based on the expected spawning biomass estimate for that year:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & \text{if } \widehat{SSB}_y \leq 24\,000 \\ 7000 & \text{if } 24\,000 < \widehat{SSB}_y \leq 33\,000 \\ \min(33000,\ 0.3 * \widehat{SSB}_y) & \text{if } \widehat{SSB}_y \geq 33\,000 \end{cases}$$

At the end of year when the TAC from January to December is established, the spawning biomass $\widehat{SSB}_y$ has not yet been observed. Therefore, it should be calculated as the sum of the recruitment entering the population and the projection forward from the previous year spawning biomass estimate. The JUVENA juvenile abundance index can be used to obtain an estimate of the recruitment entering the population and the fishery in that year. The established TAC could be revised in June, based on the spawning stock biomass $\widehat{SSB}_y$ from the most up-to-date assessment of the stock based on the two spring surveys (DEPM and acoustics). See Figure 4 for an schematic display of this management time-frame.

In contrast with the long term management plan proposal that establishes the TAC from July to June next year as a proportion of the most recent estimate of SSB in May, the incorporation of JUVENA in the management formulation would establish the TAC from January to December as a proportion of the SSB forecasted.

The performance of this type of rules setting the TAC from January to December, based on a forecasted population with a possible revision in June, have already been analyzed by management strategy evaluation under various operating models and initial conditions (see for instance Bastardie et al. (2009)). Ibaibarriaga et al. (2010) showed that for the harvest control rule in the current long term management plan proposal, when no recruitment index is available, the management cycle from July to June performs better (lower probability of biomass being below B_{lim}) than from January to December. But when a recruitment index can be used the harvest control rule from January to December, it results in less biological risk for the same levels of catch. Furthermore, if a midyear TAC revision takes place, catches can be higher for the same levels of harvest rates.

The implications of selecting a certain harvest rate cannot be the same for a harvest control rule setting the TAC from July to June or for a harvest control rule setting the TAC from January to December which incorporates a recruitment forecast. Therefore, the harvest rate of 0.3 selected in the draft management plan cannot be directly adopted for any alternative harvest control rule in a new time-frame. Moving from the harvest control rule in the management plan proposal to any alternative HCR using JUVENA would require a new evaluation in terms of biological risks and catches associated to different harvest rates.

Nowadays there are more observations on how the JUVENA juvenile abundance index relates to next year recruitment. This should help on the parameterization of the operating model and on the assumptions for management strategy evaluation of harvest control rules including the juvenile abundance index.

Any change to the harvest control rule in the current long term management plan proposal regarding a change in the time-frame or the inclusion of JUVENA juvenile abundance index, requires an evaluation of its performance with respect to the management objectives for this fishery. This would imply to select the most appropriate level of exploitation under biological and economic considerations. This evaluation could be carried out either by the STECF or, if requested, by ICES. The results should be presented and discussed with interested stake-holders.

The alternative use of JUVENA index just to revise the TAC from July to June, at the end of the year once the results of the survey are available is less clear, as it breaks the basis of the current management cycle which operates in the absence of information on the next coming recruitment level. The difficulty relates with the degree of TAC revision allowed to take place in January according to the forecasted SSB for next May. Notice that if the revision would simply set a revised TAC equal to the application of the same harvest rate to the forecasted SSB, then this will equal to moving in practice the calendar management year to January to December with a revision in June, as described and discussed above. Then, a move of the management cycle from January to December seems more reasonable.

5. Conclusions

- One of the major sources of uncertainty when managing small pelagic fish is the level of next incoming recruitment. Management plans based on acoustic monitoring of both adults and recruits have been implemented successfully in the the South African multispecies pelagic fisheries (De Oliveira and Butterworth 2004).
- Currently no indication of next incoming recruitment for anchovy in the Bay of Biscay is taken into account for the provision of management advice. The harvest control rule in the draft long term management plan was developed to overcome the lack of a forecasting tool.
- In June 2012, once the assessment of Bay of Biscay anchovy stock is finalised, there will be 9 pairs of observations for the juvenile abundance estimate in autumn and its subsequent estimate in spring after the assessment covering a wider range of recruitment cases. In addition, this can be the third consecutive year in which the long-term management plan proposal is applied. Although this proposal has not been officially adopted, it includes a provision for a re-evaluation of the plan each three years from the date of entry into force of the Regulation. Given the significant relationships of this index with the assessed recruitment at age 1 by the assessment, the potential use of JUVENA index as indicator of the next incoming recruitment should be discussed and considered as a source of information to help in the provision of a new management advice.
- JUVENA's juvenile abundance index has been successful detecting low and high recruitments. Therefore, it could be used at least in qualitative terms. However, a more quantitative use based on the log-linear model between the juvenile abundance index and recruitment looks plausible. The coefficient of determination of this model (R^2 = 93%) is above the minimum R^2 level required to improve the provision of management advice. Although the best model could be further discussed.
- If advice is given in the short term, the predictive distribution of recruitment according to the log-linear model between the recruitment and the juvenile abundance index from JUVENA can be used as the probability density function of recruitment. This will reduce the uncertainty with respect to the current advice based on an undetermined recruitment scenario.

- In the additional considerations of the long term management plan proposal it is stated that the management calendar should be moved to January-December once the JUVENA juvenile abundance index is ready to be used in management. And this type of harvest control rule has been already evaluated by management strategy evaluation in the past. However, moving from the current HCR of the draft management plan to a HCR setting TAC from January to December, based on the JUVENA recruitment index, requires a revaluation of the risk levels associated to different harvest rates in order to define the best harvest rate in agreement with the management objectives for this fishery. This re-evaluation could be carried out either by the STCEF or, if requested, by ICES.
- The JUVENA juvenile abundance index is available by the end of the year. The practical implications of moving to a management making use of this index would be:
    - The management cycle year could be moved from July-June to January-December.
    - The management advice should be generated in late November, once the results from JUVENA become available. This will provide the scientific basis for managers to set the TAC from January to December.
    - The TAC could be revised in July every year based on the stock assessment carried out in WGHANSA using the spring surveys (DEPM and acoustic) population estimates.

6. References

Allain, G., Petitgas, P., and Lazure, P. 2001. The influence of mesoscale ocean processes on anchovy (Engraulis encrasicolus) recruitment in the Bay of Biscay estimated with a three-dimensional hydrodynamic mode. Fish. Oceanogr. **10**(2): 151-163.

Barange, M., Bernal, M., Cercole, M.C., Cubillos, L.A., Cunningham, C.L., Daskalov, G.M., De Oliveira, J.A.A., Dickey-Collas, M., Hill, K., Jacobson, L.D., Köster, F.W., Masse, J., Nishida, H., Ñiquen, M., Oozeki, Y., Palomera, I., Saccardo, S.A., Santojanni, A., Serra, R., Somarakis, S., Stratoudakis, Y., van der Lingen, C.D., Uriarte, A., and Yatsu, A. 2009. Current trends in the assessment and management of small pelagic fish stocks. *In* Climate change and small pelagic fish. *Edited by* D.M. Checkley, C. Roy, Y. Oozeki and J. Alheit. Cambridge University Press, Cambridge, UK. pp. 191-255.

Bastardie, F., Baudron, A., Bilocca, R., Boje, J., Bult, T.P., García, D., Hintzen, N.T., Nielsen, J.R., Petursdottir, G., Sanchez, S., and Ulrich, C. 2009. Evaluating biological robustness of innovative management alternatives. *In* Comparative evaluations of innovative fisheries management. *Edited by* K.H. Hauge and D.C. Wilson. Springer. p. 272.

Borja, A., Fontán, A., Sáenz, J., and Valencia, V. 2008. Climate, oceanography, and recruitment: the case of the Bay of Biscay anchovy (Engraulis encrasicolus). Fish. Oceanogr. **17**(6): 477-493.

Borja, A., Uriarte, A., Egaña, J., Motos, L., and Valencia, V. 1998. Relationships between anchovy (Engraulis encrasicolus) recruitment and environment in the Bay of Biscay. Fish. Oceanogr. **7**(3/4): 375-380.

Boyra, G., Martínez, U., Cotano, U., Santos, M., Irigoien, X., and Uriarte, A. 2012. Acoustic abundance estimates of juvenile anchovy (Engraulis encrasicholus) in the of Bay of Biscay as a tool for predicting recruitment. Submitted.

COM. 2009. Proposal for a council regulation establishing a long-term plan for the anchovy stock in the Bay of Biscay and the fisheries exploiting that stock.

De Oliveira, J.A.A., and Butterworth, D.S. 2004. Developing and refining a joint management procedure for the multispecies South African pelagic fishery. ICES J. Mar. Sci. **61**(8): 1432-1442.

De Oliveira, J.A.A., and Butterworth, D.S. 2005. Limits to the use of environmental indices to reduce risk and/or increase yield in the South African anchovy fishery. Afr. J. Mar. Sci. **27**(1): 191-203.

De Oliveira, J.A.A., Uriarte, A., and Roel, B. 2005. Potential improvements in the management of Bay of Biscay anchovy by incorporating environmental indices as recruitment predictors. Fish. Res. **75**(1-3): 2-14.

Fernandes, J.A., Irigoien, X., Goikoetxea, N., Lozano, J.A., Inza, I., Pérez, A., and Bode, A. 2010. Fish recruitment prediction, using robust supervised classification methods. Ecol. Model. **221**(2): 338-352.

Huret, M., Petitgas, P., Planque, B., Schrum, C., Saulquin, B., Pau, C., and Gohin, F. 2007. Linking anchovy and sprat distributions with bio-physical ocenaographic features: a Bay of Biscay - North Sea comparison. ICES C. M. **2007/G:14**.

Ibaibarriaga, L., Uriarte, A., Sánchez, S., Fernandes, J.A., and Irigoien, X. 2010. Use of juvenile abundance indices for the management of the Bay of Biscay anchovy. Working document to WGANSA.

ICES. 2010. Report of the Working Group on acoustic and egg surveys for sardine and anchovy in ICES areas VIII and IX (WGACEGG). 22-26 November 2010. Palma de Mallorca, Spain. ICES CM 2010/SSGESST:24. 210 pp.

ICES. 2011. Report of the Working Group on Anchovy and Sardine (WGANSA). 24-28 June 2011. Vigo, Spain. ICES CM 2011/ACOM:16. 462 pp.

Lasker, R. 1985. An egg production method for estimating spawning biomass of pelagic fish: application to the Northern anchovy, Engraulis mordax. US Department of Commerce, Springfield, VA, USA.

Simmonds, E.J., and MacLennan, D.N. 2005. Fisheries acoustics: fisheries and practice. Blackwell publishing.

STECF. 2008a. Report of the working group on a long-term management plan for the stock of anchovy in the Bay of Biscay. 14-18 April 2008. Hamburg, Germany. 119 pp.

STECF. 2008b. Report of the working group on the long term management of Bay of Biscay anchovy. 2-6 June 2008. San Sebastián, Spain. 100 pp.

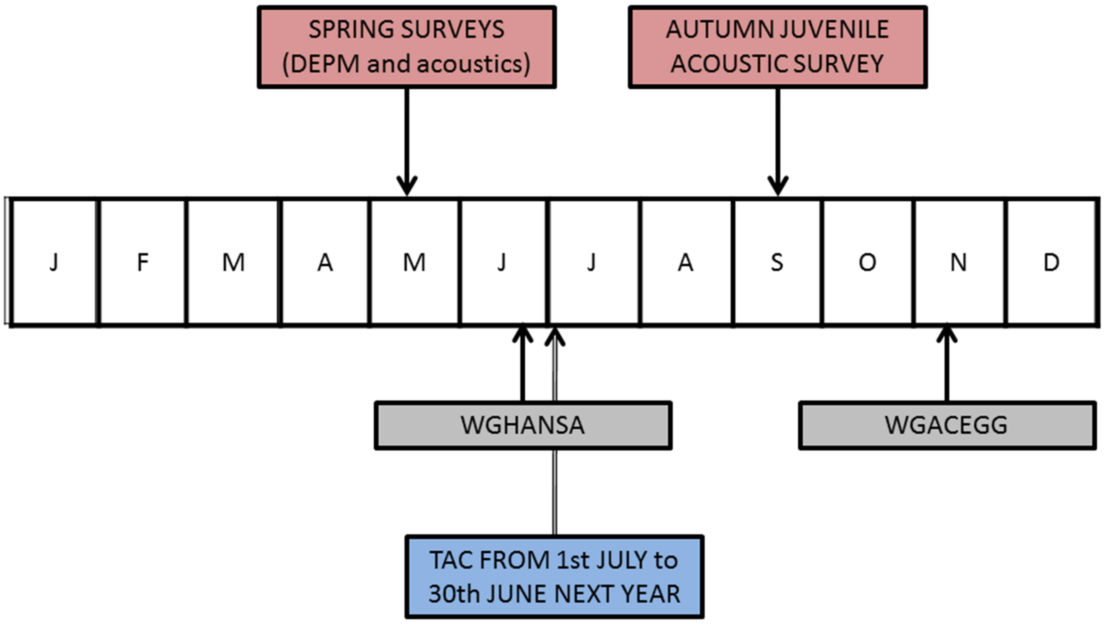


Figure 1: Calendar with the main events related to the current assessment and management of the Bay of Biscay anchovy.

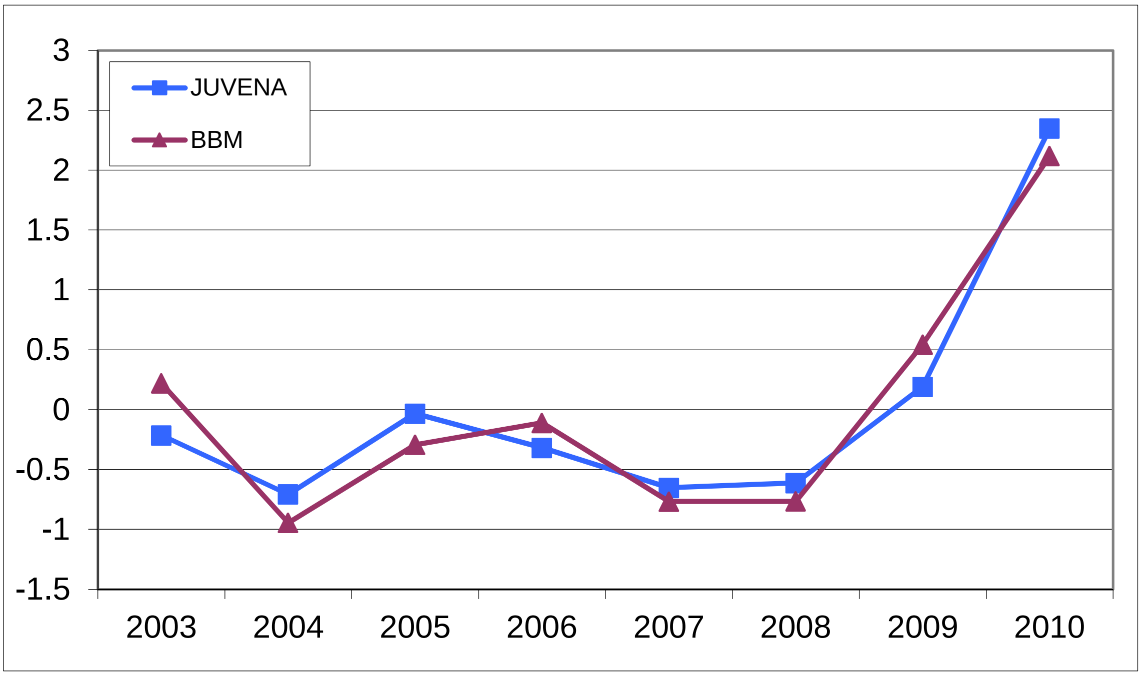


Figure 2: Time series of the JUVENA juvenile abundance index (in blue) and recruitment as estimated by BBM (in red). Each time series is standardized with respect to its mean and variance. Figure from WGANSA 2011.

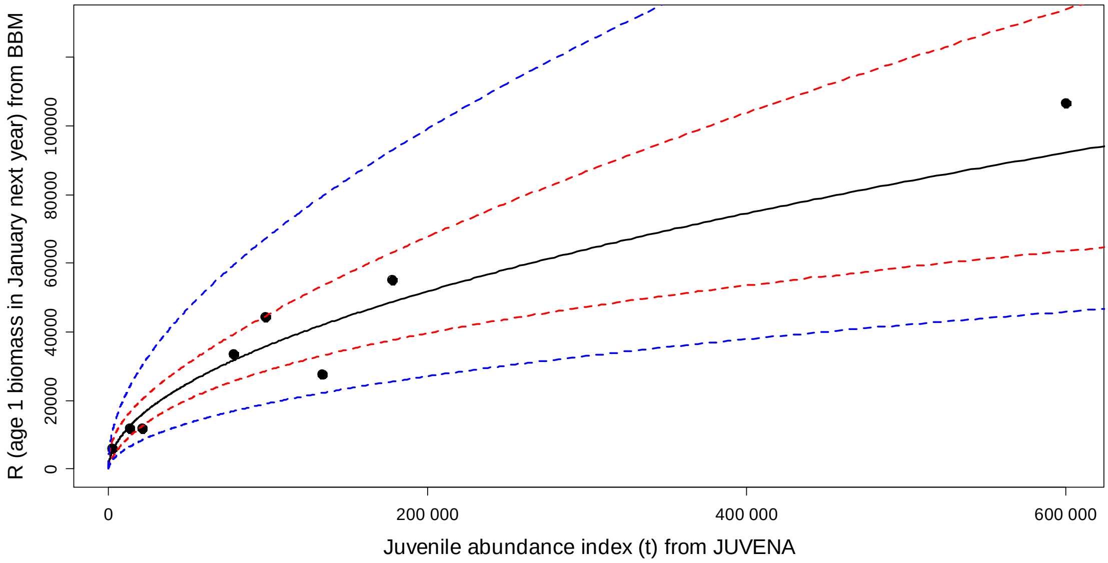


Figure 3: Log linear model fitted to the recruitment as estimated by BBM and the juvenile abundance index from the JUVENA surveys. The solid black line is the fitted model, whereas the red and blue dashed lines are the 95% confidence and prediction intervals. Figure from WGANSA 2011.

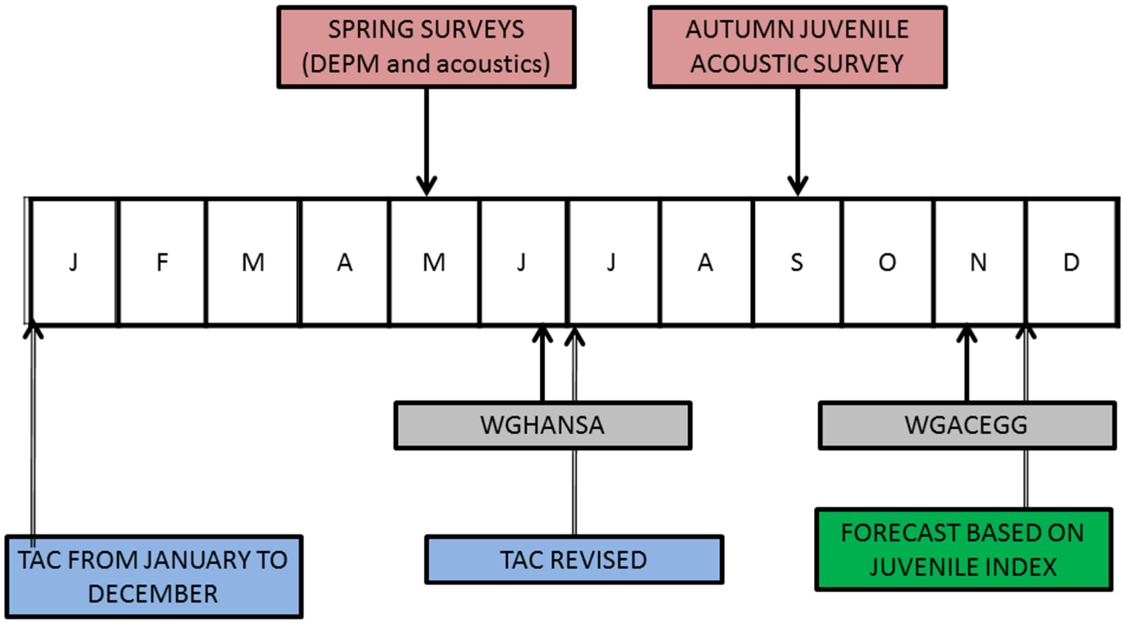


Figure 4: Proposed time-frame for the management of the Bay of Biscay anchovy including the JUVENA juvenile abundance index.

Annex 4 – Stock Annexes

Stock Annex – Bay of Biscay Anchovy (Subarea VIII)

Quality Handbook **Annex:A.4.1**

Stock specific documentation of standard assessment procedures used by ICES

Stock: Bay of Biscay Anchovy (Subarea VIII)

Working Group: WGANSA (working group on the assessment of anchovy and sardine)

Date: 15th to 20th of June, 2009

Revised at: WGANSA2009, WKSHORT2009 and WGANSA2010

Authors by alphabetic order: E. Duhamel, L. Ibaibarriaga, J. Massé, L. Pawlowski, M. Santos and A. Uriarte.

A. General

A.1. Stock definition

Anchovy (*Engrulis encrasicolus, L*) stock in Subarea VIII (Bay of Biscay) is considered to be isolated from a small population in the English Channel and from the population in the area IXa. No subpopulations have been defined, although morfometrics and meristic studies suggest some heterogeneity at least in morphotipes (*Prouzet and Metuzals, 1994*; *Junquera and Perez-Gandaras, 1993*). Some genetic heterogeneity based on proteins allocime loci have been found between the Garonne spawning regions and southern regions in the Bay of Biscay (Adour and Cantabrian shores) (*Sanz et al., 2008*). Nevertheless, the evident inter connection of fisheries and rather homogenous recruitment pulses occurring in the Bay of Biscay lead ICES to consider that the anchovy in this area should be dealt as a single stock for assessment and management (ICES 2007).

A.2. Fishery

The fisheries were closed since June 2006 to December 2009 due to poor condition of the stock. It was reopened in January 2010 with a TAC of 7,000t. The fisheries for anchovy are targeted by purse-seiners and pelagic trawlers. The Spanish and French fleets fishing for anchovy in Subarea VIII are spatially and temporally quite well separated. The Spanish fleet (purse seine fleet) operates mainly in Divisions VIIIc and VIIIb in spring, while the French fleet (mainly pelagic trawlers) operates in Division VIIIa in summer and autumn and in Division VIIIb in winter and summer. A small fleet of French purse seiners operates in the South of the Bay of Biscay (VIIIb) in spring and in the North (VIIIa) during the autumn. An overview of the history of the fishery until the mid nineties and its spatial behaviour is found in Junquera (1986) and Uriarte *et al.* (1996) and for more recent perspective see ICES 2007 & 2008 or STECF 2008 for the international fishery and Uriarte *et al.* (2008) Villamor *et al.* (2008) for the Spanish fishery and Duhamel (2004) and Vermard *et al.* (2008) for the French pelagic trawlers. A recent updated information (2009) provided by the SWW RAC shows a 18% decrease in the fleet size operating on anchovy since the closure of the fishery (2005). This decrease is much more important for the pelagic trawlers' fleet (-39%) than for the purse seiners (-11%). Since the fishery closure, the fleets have redeployed their effort mainly towards other small pelagic species (57%) and tunas (29%) (Table A.2.2).

Table A.2.1: Evolution of the French and Spanish fleets on anchovy in Sub-area VIII. Fishery closed in 2006, 2007 and 2008. Units: numbers of boats.

	France				Spain *	
Year	**P. seiner**	**P. trawl**		**Total**	**P. seiner**	**Total**
1960	-	-			571	571
1972	-	-			492	492
1976	-	-			354	354
1980	-	-			293	293
1984	-	-			306	306
1987	-	-			282	282
1988	-	-			278	278
1989	18	6	(1,2)	24	215	239
1990	25	48	(1,2)	73	266	339
1991	19	53	(1,2)	72	250	322
1992	21	85	(1,2)	106	244	350
1993	34	108	(1,2)	142	253	395
1994	34	77	(1,2)	111	257	368
1995	33	44	(1,2)	77	257	334
1996	30	60	(1,2)	90	251	341
1997	27	52	(1,2)	79	267	346
1998	29	44	(1,2,3)	73	266	339
1999	30	49	(1,2)	79	250	329
2000	32	57	(1,2)	89	238	327
2001	34	60	(1,2)	94	220	314
2002	32	47	(1,2)	79	215	294
2003	19	47	(1,2)	66	208	274
2004	31	54	(1,2)	85	201	286
2005	8	41	(1,2,4)	49	197	246
2006	1 **	6 **	(1,2,4)	7 **	0	7
2007	0	0		0	0	0
2008	0	0		0	0	0
2009						
2010	2	30	(2)	32		

*** Spanish purse seiners are those with licences that landed anchovy**

(1) Only purse seiners having catch anchovy at least once a year but fishing sardine most of the time

(2) only trawlers that targeted anchovy (annual catch > 50 t)

(3) doubtful in terms of separation between gears because of misreporting

(4) Provisional estimate

**** French number of boats involved in the experimental fishery; not the actual size of the fleet**

Table A.2.2. Approximate figures for the anchovy fleet and fishing effort displacement for the the period 2005-2009 (based on reports from stakeholders 28th August 2009, provided by the SWW RAC). Report vers = report to add; bolincheurs sud bretagne = purse seiners in southern Brittany; chinchard = horse mackerel; maquerau = mackerel; thon rouge = bluefin tuna; thon blanc = albacore; Autres = others

Fishing ports	Seiners		Pelagic trawlers		report vers												number of targeted species
					sardine		chinchard		maquereau		thon rouge		thon blanc		autres		
	2005	2009	2005	2009													
Galice	67	61			1	15,3	1	15,3	1	15,3					1	15,3	4
Asturies	10	6			1	3,0	1	3,0									2
Cantabrie	54	47			1	9,4	1	9,4	1	9,4	1	9,4	1	9,4			5
Vizcaya	25	25			1	5,0	1	5,0	1	5,0	1	5	1	5			5
Guipuzkoa	52	44			1	8,8	1	8,8			1	8,8	1	8,8	1	8,8	5
StJean de Luz	8	8	4	4			1	12,0									1
la Turballe			39	23									1	11,5	1	11,5	2
St Gilles			24	14	1	0,0					1	0					2
Bolincheurs sud bretagne	8	8			1	2,7	1	2,7							1	2,7	3

2010 St jena de luz 2 Lorient 2 La Turbballe 20 St Gilles 6 (15 pairs of pair pelagic trawlers)

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species in the Bay of Biscay, and also for cetaceans and birds.

The recruitment depends strongly on environmental factors. Two environmental recruitment indices have been considered during the last 10 years: i) Borja's *et al.* (1998) index, which is an upwelling index, and ii) Allain's *et al.* (2001) index, which is a combination of upwelling and stratification breakdown. Allain's model was reviewed by Huret & Petitgas (WD 2007 in ICES2008) including a) the previous "upwelling" index, plus a new "stratification" index according to a new hydrodynamic model and b) an adult spatial indicator. The role of the Eastern Atlantic pattern in relation to the Upwelling index and the recruitment of anchovy have also been recently pointed out (Borja *et al.*, 2008). Other approaches based on coupling spawning habitat with hydrodynamic and production models are being tried for this anchovy population with promising results (Allain *et al.*, 2007).

The significance and reliability of all these indices is considered still insufficient for their consideration in the provision of management advice and no update was provided on their performance for the meeting in 2010 of WGANSA. Recent reviews have suggested that comparison with global indexes and correlation analysis may not be the best approach to understand and consequently predict recruitment in small pelagic fish (Barange *et al.*, 2009).

Fernandes et al (2010) presents an alternative to attempt to relate environmental indices with recruitment by means of linear models. It uses machine-learning techniques to obtain the probability of having a recruitment discretized into low, medium and high classes depending on environmental variables. The proposed methodology consists of performing supervised predictors discretization, carrying out supervised predictors selection and learning a 'naive Bayes' classifier. The approach can be applied to a dataset where the values of the recruitment have been discretized by the end-user, or the recruitment discretization can be part of the proposed model-building process in a bootstrap scheme. The results up to now are promising.

B. Data

B.1. Commercial catches:

Fishery closed from July 2006 to December 2009. reopened with 7,000t the 1st of March 2010

Annual Landings are available since 1940. The fishing statistics are considered accurate. Discards are not measured and hence not included in the assessment, but nowadays they are considered not relevant for the two fleets. In the past (late eighties and early nineties for the French Pelagic trawlers and sixties and seventies for the Spanish Purse seine fleet) they seemed to be more relevant (according to disputes among fishermen), but were never quantified.

B.2. Biological

- Catches at length and catches at age are known since 1984 for Spain and since 1987 for France. They are obtained by applying to the monthly Length distributions half year or quarterly ALKs (and when possible monthly ALKs, as for the Spanish fishery in spring). Biological sampling of the catches has been generally sufficient, except for 2000 and 2001, when an increase of the sampling effort seemed useful to have a better knowledge of the age structure of the catches during the second semester in the North of the Bay of Biscay. Complete age composition and mean weight at age on half year basis, were reported in ICES (2008- WGANC report).
- Age reading is considered accurate. The most recent cross reading exchanges and workshop between Spain and France took place in 2005 and 2006 respectively (Uriarte *et al.*, 2006 and 2007). The overall level of agreement and precision in anchovy age reading determinations seems to be satisfactory: Most of the anchovy otoliths were well classified by most of the readers during the 2006 workshop (with an average agreement of 92.7 % and a CV of 9.2%). CVs were on average smaller than 15% for any age, although individual CVs for ages or readers might be 30-35%. A new otolith exchange and age reading workshop took place in November 2009.
- Anchovies are mature at their 1st year of life.
- Growth in weight and length are well known from Surveys and from the monitoring of the fishery (Uriarte *et al.*, 1996).
- Natural mortality is fixed at 1.2 as an average of varying values obtained under the assumption of past DEPM providing absolute estimates of the population in numbers at age (*Uriarte et al.*, 1996). This parameter is considered to vary between years, but it is assumed to be constant for the assessment of the stock.
- In the Bayesian Biomass Model, the parameter *g* describes the annual change in mass of the population by encapsulating the growth in weight (G) and the natural Mortality (M) of the population as G-M (0.52-1.2=-0.68)

B.3. Surveys

Spring surveys: series of DEPM(Daily egg production method) and acoustic surveys in Spring every year.

The population is monitored by the two annual surveys carried out in spring on the spawning stock, namely, the Daily Egg Production Method (since 1987 with a gap in 1993) (Santiago and Sanz, 1992; Motos *et al.*, 2005) and the Acoustics surveys (regularly since 1989, although surveys were also conducted in 1983, 1984 and some in the seventies) (Massé 1988, 1994, 1996). Both surveys provide spawning biomass and population at age estimates. The surveys have shown pronounced inter-annual variability of biomass according to the pulse of recruitments, since one year old anchovies can conform up to more than 75% of the spawning population. Spawning area and biomass are positive and closely related, revealing expansion of the area occupied by the population when SSB increases (Uriarte *et al.*, 1996, Somarakis *et al.*, 2004).

This survey based monitoring system provides population estimates by the middle of the year, when about half of the annual catches have been already taken; and provide very little information about the anchovy population in the next year, since the bulk of it will consist of 1 year old anchovies being born at the time the surveys take place. Spawning Biomass in spring equals total stock biomass since all anchovies are mature (the youngest being 1 year old by then).

B.3.1 Anchovy Daily Egg Production Method

B.3.1.1 The DEPM model

The anchovy spawning stock biomass estimates is derived according to Parker (1980) and Stauffer & Picquelle (1980) from the ratio between daily production of eggs in the sea and the daily specific fecundity of the adult population:

Equation 1
$$SSB = {P_{tot}}/{DF} = \frac{P_0 \cdot A+}{k \cdot R \cdot F \cdot S / W}$$

Where,

SSB = Spawning stock biomass in metric tons

P_{tot} = Total daily egg production in the sampled area

P_0 = daily egg production per surface unit in the sampled area

A+ = Spawning area, in sampling units

DF = Daily specific fecundity. $DF = \frac{k \cdot R \cdot F \cdot S}{W}$

W = Average weight of mature females in grams,

R = Sex ratio, fraction of population that are mature females, by weight.

F = Batch fecundity, numbers of eggs spawned per mature females per batch

S = Fraction of mature females spawning per day

k = Conversion factor from gram to metric tons (10^6)

An estimate of an approximate variance and bias for the biomass estimator derived using the *delta* method (Seber, 1982, *in* Stauffer & Picquelle, *op. cit.*) was also developed by the latter authors.

Population estimates of numbers at age are derived as follows:

Equation 2
$$N_a = N \cdot E_a = \frac{SSB}{W_t} \cdot E_a$$

Where,

Na = Population estimate of numbers at age *a*.

N = Total spawning stock estimate in numbers. $N = \frac{SSB}{W_t}$

B = spawning stock biomass estimate.

Wt = average weight of anchovies in the population.

Ea = Relative frequency (in numbers) of age *a* in the population.

Variance estimate of the anchovy stock in numbers at age and total is derived applying the delta method.

B.3.1.2 Collection of plankton samples

Every year the area covered to collect the plankton samples is the southeast of the Bay of Biscay which corresponds to the main spawning area and season of anchovy.

Predetermined distributions of the vertical hauls that will be performed with the PairoVET net are shown in **Figure B.3.1.2.1**. The strategy of egg sampling is as follow: a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found. Stations are located every 3 miles, along 15-mile-apart transects perpendicular to the coast. The sampling strategy is adaptive. When the egg abundances found are relatively high, additional transects separated by 7.5 nm are completed.

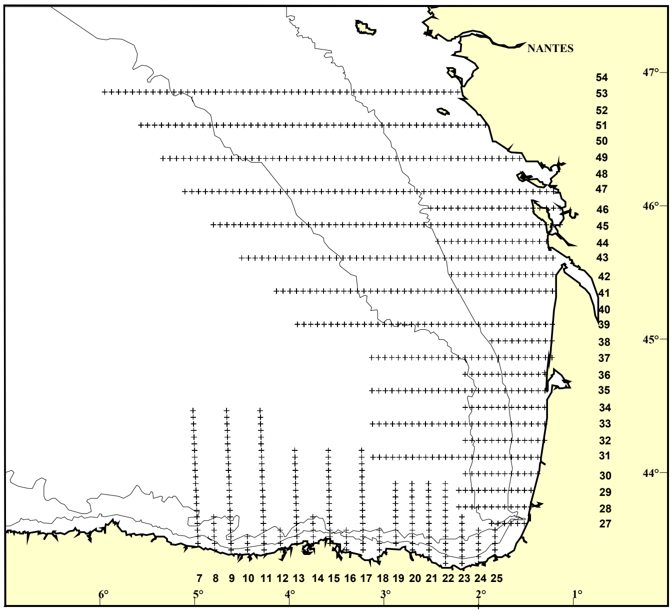


Figure B.3.1.2.1: Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey

The Continuous Underway Fish Egg Sampler (CUFES) is also used to record the eggs found at 3m depth. The samples obtained are immediately checked under the microscope so that presence/absence of anchovy eggs is detected in real time. This allowed knowing whether there were anchovy eggs in the area. When anchovy eggs are not found in 6 consecutive CUFES samples in the oceanic area, transect is left.

A vertical plankton haul is performed in each sampling station, using a PairoVET net (2-Calvet nets, Smith *et al.*, 1985 in Lasker, 1985) with a mouth aperture of 0.05 m^2 each CalVET. The frame was equipped with nets of 150 µm. The net is lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net is retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to know the amount of water filtered during the tow.

Immediately after the haul, the net is washed and the samples obtained are fixed in formaldehyde 4% buffered with sodium tetra borate in sea water. After 6h of fixing, anchovy, sardine and other species eggs are identified and sorted out on board. Afterwards, in the laboratory a percentage of the samples are checked to assess the quality of the sorting made at sea. According to that a portion of the samples are sorted again to assure no eggs are left. In the laboratory the anchovy eggs are staged (Moser and Alshtrom, 1985).

During the survey, the presence/absence of eggs was recorded per PairoVET station and the area where anchovy eggs occurred was quantified. The spawning area was delimited with the outer zero anchovy egg stations. It contains some inner zero egg stations embedded on it (Picquelle and Stauffer, 1985). Following the systematic central sampling scheme (Cochran, 1977) each station was located in the centre of a rectangle. Egg Abundance found at a particular station was assumed to represent the abundance in the whole rectangle. The area represented by each station was measured. A standard station has a surface of 45 squared nautical miles (154 km^2) = 3 (distance between two consecutive stations) x 15 (distance between tow consecutive transects) nautical miles. Since sampling was adaptive, station area changed according to sampling intensity.

Real depth, temperature, salinity and chlorophyll profiles are obtained in every station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity is recorded in each station with a manual termosalinometer WTW LF197.Moreover current data are obtained all along the survey with an ADCP(Acoustic Doppler Current Profiles).In some point determinate previously to the survey, water is filtered from the surface to obtain chlorophyll samples.

B.3.1.3 Collection of adult samples

In 1987 and 1988 the samples were obtained from commercial purse seines, the adult sampling was opportunistic. From years 1989 to 2005 the adult samples were obtained both from commercial purse seines and a research vessel with pelagic trawl so the adult sampling was both opportunistic and directed. Since 2006 the samples are obtained from a research vessel with pelagic trawl but not from the purse seines due to the closure of the fishery so the adult sampling is only directed not opportunistic. Since the reopening of the fisheries in March 2010 the commercial purse seines are providing again samples for the analysis apart from the ones from the research vessels.

The research vessel pelagic trawler covers the same area as the plankton vessel. When the plankton vessel encountered areas with anchovy eggs, the pelagic trawler is directed to those areas to fish. In each haul 100 individuals of each species are measure. Immediately after fishing, anchovy is sorted from the bulk of the catch and a sample of near 2 Kg is selected at random. Sampling finished as soon as a minimum of 1 kg or 60 anchovies are sexed, and from those, 25 non-hydrated females (NHF) are preserved. Sampling is also stopped when more than 120 anchovies have to be sexed to achieve the target of 25 NHF. Moreover, otoliths are extracted to obtain the age composition per sample.

In the case the sample are obtained from the purse seines a sample of near 2kg is selected from the fishing and are directly kept in 4% formaldehyde. Afterwards, in the laboratory the samples are process in the same way as explained above.

B.3.1.4 Total daily egg production estimates

When all the anchovy eggs are sorted and staged, it is possible to estimate total daily egg production (P_{tot}). This is calculated as the product between the daily egg production (P_0) and the spawning area (SA)

$$P_{tot} = P_0 \, SA$$

A standard sampling station represents a surface of 45 nm^2 (i.e. 154 km^2). Since the sampling was adaptive, area per station changes according to the sampling intensity and the cut of the coast. The total area is calculated as the sum of the area represented by each station. The spawning area (SA) is delimited with the outer zero anchovy egg stations but it can contain some inner zero stations embedded. The spawning area is computed as the sum of the area represented by the stations within the spawning area.

The staged eggs are transformed into daily cohort abundances using the Bayesian ageing method (ICES 2004) Daily egg production (P_0) and daily mortality rates (Z) are estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age.

The model is fitted as a Generalised Linear Model (GLM) with Negative Binomial distribution and log link.

The ageing process and the model fitting are repeated until convergence. Eggs younger than 4 hours and older than 90% of the incubation time are removed from the model fitting to avoid any possible bias.

B3.1.5 Adult parameters and Daily Fecundity estimates

The DF estimate for this WGANSA in June is obtained from a linear regression model between DF and sea surface temperature (SST). Two weeks after arriving from the survey the adult parameters are not processed yet, uniquely the anchovies were weighted, measured, sexed and the otoliths were extracted, consequently Daly Fecundity has to be derived from the past historical series. Afterwards in the ICES WGACEGG in November the complete DEPM with all the adult parameters estimates is presented and approval. This occurred since 2005 when the advice started demanding SSB estimates in June, however the historical series of DF is being revised within WGACEGG (ICES 2009). Until DF is fully revised and its relationship with temperature corroborated by WGACEGG, the WGANSA decided to use the historical mean of DF (63.39 egg/ g per day) to obtain the preliminary SSB estimate for June.

From the whole set of adult samples gathered during the survey, a subset is chosen for final processing with the criterion of collection within ±5 days of the egg sampling in the same particular area. In the last years the samples are collected within the same day as the egg sampling. These samples are used to obtain adult parameters estimates leading to the estimate of Daily Fecundity, i.e. batch fecundity, spawning fraction, average female weight and sex ratio. These adult parameters are estimates for November as follows:

Sex Ratio (R): Given the large variability among samples of the sex ratio and taking into account that for most of the years when the DEPM has been applied to this population the final estimate has come out to be not significantly different from 50 % for each sex (in numbers), since 1994 the proportion of mature females per sample is being assumed to be equal to 1:1 in numbers. This leads to adopt as R the value of the average sample ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

Total weight of hydrated females is corrected for the increase of weight due to hydration. Data on gonad-free-weight (Wgf) and correspondent total weight (W) of non hydrated females is fitted by a linear regression model. Gonad-free-weight of hydrated anchovies is then transformed to total weight by applying the following equation:

$$W = -a + b * W_{gf}$$

For the **Batch fecundity (F)** estimates i.e. number of eggs laid per batch and female, the hydrated egg method was followed (Hunter et al, 1985). The number of hydrated oocytes in gonads of a set of hydrated females is counted. This number is deduced from a sub-sampling of the hydrated ovary: Three pieces of approximately 50 mg are removed from different parts of each ovary, weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Sanz & Uriarte (1989) showed that 3 tissue samples per ovary are adequate to get good precision in the final batch fecundity estimate and the location of sub-samples within the ovary do not affect it. Finally the number of hydrated oocytes in the sub-sample is raised to the total gonad of the female according to the ratio between the weights of the gonad and the weight sub-sampled.

A linear regression between female weight and batch fecundity is established for the subset of hydrated females and used to calculate the batch fecundity of all mature females. The average of the batch fecundity estimates for the females of each sample as derived from the gonad free weight – eggs per batch relationship is then used as the sample estimate of batch fecundity.

Moreover, an analysis is conducted to verify if there are differences in the batch fecundity if strata are defined to estimate SSB.

To estimate **Spawning Frequency (S)**, i.e. the proportion of females spawning per day, until the new series of spawning frequency (S) is accepted a model based on the historical series was considered. This model relates S linearly with Sea Surface Temperature (SST).

Mean and variance of the adult parameters are estimated following equations for cluster sampling (as suggested by Picquelle & Stauffer, 1985):

Equation 3
$$Y = \frac{\sum_{i=1}^{n} M_i \, y_i}{\sum_{i=1}^{n} M_i}$$

Equation 4 $$Var(Y)=\frac{\sum_{i=1}^{n} M_i^2 (y_i - Y)^2}{\overline{M}^2 n(n-1)}$$

Where,

Y_i is an estimate of whatever adult parameter from sample *i* and M_i is the size of the cluster corresponding to sample *i.* occasionally a station produced a very small catch, resulting in a small sub-sample size. To reflect the actual size of the station and its lower reliability, small samples were given less weight in the estimate. For the estimation of W, F and S, a weighting factor was used, which equalled to 1 when the number of mature females in station *i* (M_i) was 20 or greater and it equalled to $M_i/20$ otherwise. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to total weight of the sample divided by 800g, otherwise it was set equal to 1. In summary for the estimation of the parameters of the Daily Fecundity we are using a threshold-weighting factor (TWF) under the assumption of homogeneous fecundity parameters within each stratum.

B.3.1.6 SSB estimates

In the WGANSA during June the Spawning Stock Biomass is preliminary estimates as the ratio between the total egg production (P_{tot}) and Daily Fecundity (DF) estimates and its variance is computed using the Delta method (Seber, *1982*):

$$V\hat{a}r[SSB]=\frac{V\hat{a}r[Ptot]}{DF^2}+\frac{P_{tot}^{\ 2}V\hat{a}r[DF]}{DF^4}$$

The definitive SSB estimate with all the adult parameters is presented and approval at the WGACEGG during November.

B.3.1.7 Numbers at age

For the purposes of producing population at age estimates, the age readings based on otoliths from the adult samples collected were available. Estimates of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples where the weights were proportional to the population (in numbers) in each stratum. These weighting factors are proportional to the egg abundance per stratum divided by the numbers of samples in the stratum and the mean weight of anchovy per sample. Weighting factors were allocated according to the relative egg abundance and to the amount of samples in the strata defined for the proposed of the estimation of the numbers at age. These strata are defined each year depending on the distribution of the adult samples i.e. size, weight, age and the distribution of the anchovy eggs.

Mean and variance of the adult parameters of the Population in numbers at age and the Population length distribution (total weight, proportion by ages and length distribution) are estimated following equations 4 and 5 for cluster sampling.

B.3.2. Anchovy acoustic indices

Acoustic surveys are carried out every year in the Bay of Biscay in spring on board the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species is anchovy but it will be considered in a multi-specific context as species located in the centre of ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area to be covered from Gibraltar to Brest with the same protocol for sampling strategy. Data are available for the ICES working groups WGANSA, WGWIDE and WGACEGG.

B.3.2.1. Method and sampling strategy

In the frame of an ecosystemic approach, the pelagic ecosystem is characterized at each trophic level. In this objective, to assess an optimum horizontal and vertical description of the area, two types of actions are combined:

- Continuous acquisition by storing acoustic data from five different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler), and
- Discrete sampling at stations (by trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modelisation will be also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans (from board) and of birds (by plane) will be carried out in order to characterise the higher level predators of the pelagic ecosystem.

Satellite imagery (temperature and sea colour) and modelisation are also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy.

Concurrently, a visual counting and identification of cetaceans and of birds (from board) is carried out in order to characterise the top predators of the pelagic ecosystem.

The strategy was the identical to previous surveys (2000 to 2009):

- Acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20 m depth to the shelf break.

- Acoustic data were collected only during the day because of pelagic fish behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer for the echo sounder between the surface and 8 m depth.

Two echo-sounders are usually used during surveys (SIMRAD EK60 for vertical echo-sounding and OSSIAN 500 on the pelagic trawl). In 2009 the SIMRAD ME70 has been used for multi-beam visualisation. Energies and samples provided by split beam transducers (5 frequencies EK60, 18, 38, 70, 120 and 200 kHz), simple beam (OSSIAN 49 kHz) and multibeam echo-sounder were simultaneously visualised, stored using the MOVIES+ software and at the same standard HAC format.

The calibration method is the same that the one described for the previous years (see W.D. 2001) with a tungsten sphere hanged up 20 m below the transducer and is generally performed at anchorage in front of Machichaco cap or in the Douarnenez bay, in the west side of Brittany, in optimum meteorological conditions.

Acoustic data are collected by Thalassa along the totality of the daylight route from which about 2000 nautical miles on one way transect are usable for assessment. Fish are measured on board (for all species) and otoliths (for anchovy and sardine) are collected for age determinations.

B.3.2.2. Echoes scrutinizing

Most of the acoustic data along the transects are processed and scrutinised during the survey and are generally available one week after the end of the survey (figure 2.2.1). Acoustic energies (Sa) are cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into several categories of echo-traces according to the year fish (species) structures.

Some categories are standard such as:

D1 – energies attributed to mackerel, horse mackerel, blue whiting, divers demersal fish, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sprat, sardine corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well designed, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometime more offshore.

D3 – energies attributed to blue whiting and myctophids offshore, just closed to the shelf-break.

D4 – energies attributed to sardine, mackerel or anchovy corresponding to small and dense echoes, very close to the surface.

D6 – energies attributed to a mix, usually between 50 and 100 m depth when D1 and D2 were not separable

Some particular categories are usually specifically designed according to several identifications during the survey (when Thalassa and/or commercial vessels hauls are available), such as:

D7 – energies attributed exclusively to sardine (big and very dense schools).

D5 – energies attributed to small horse mackerel only when they are gathered in very dense schools this category is usually used for typical echoes which occur along particular surveys. In the case of 2010, it was used to gather energies which occurred all along the transects in the. northern platform where a continuous cover of mainly blue whiting was observed.

B.3.2.3. Data processing

The global area is split into several strata where coherent communities are observed (species associations) in order to minimise the variability due to the variable mixing of species. For each stratum, a mean energy is calculated for each type of echoes and the area measured. A mean haul for the strata is calculated to get the proportion of species into the strata. This is obtained by estimating the average of species proportions weighted by the energy surrounding haul positions. Energies are therefore converted into biomass by applying catch ratio, length distributions and TS relationships. The calculation procedure for biomass estimate and variance is described in Petitgas et.al 2003.

The TS relationships used since 2000 are still the same and as following:

Sardine, anchovy & sprat : TS = 20 Log L – 71.2

Horse-mackerel : TS = 20 Log L – 68.7

Blue whiting : TS = 20 Log L – 67.0

Mackerel : TS = 20 Log L – 86.0

The mean abundance per species in a stratum (tons m.n.$^{-2}$) is calculated as:

$$M_e(k)=\sum_D \overline{s}_A(D,k)\overline{X}_e(D,k)$$

and total biomass (tons) by : $B_e=\sum_k A(k)Me(k)$

where,

k : strata index
D : echo type
e : species

S_A : Average S_A (NASC) in the strata (m2/n.mi.2)
X_e : species proportion coefficient (weighted by energy around each haul) (tons m^{-2})
A : area of the strata (m.n.^{2})
Then variance estimate is:

$$Var.M_e(k)=\sum_D \overline{s}_A^{\,2}(D,k)Var[X_e(D,k)]/n.cha(k)+\overline{X}_e^{\,2}\,\mathrm{var}[s_A(D,k)]/n.esu(D,k)$$

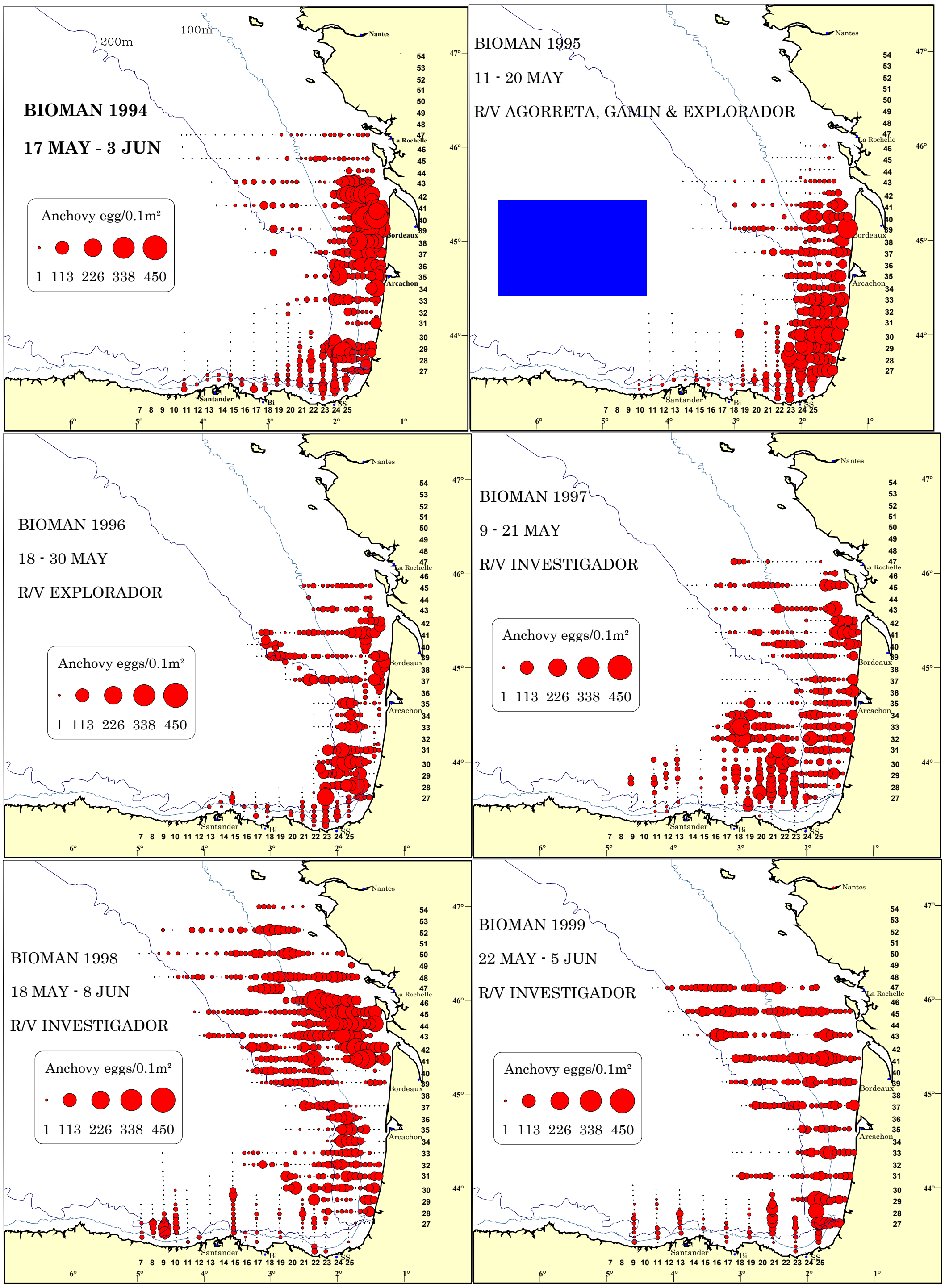
$$Var.B_e=\sum_k A^2(k)Var.Me(k)$$

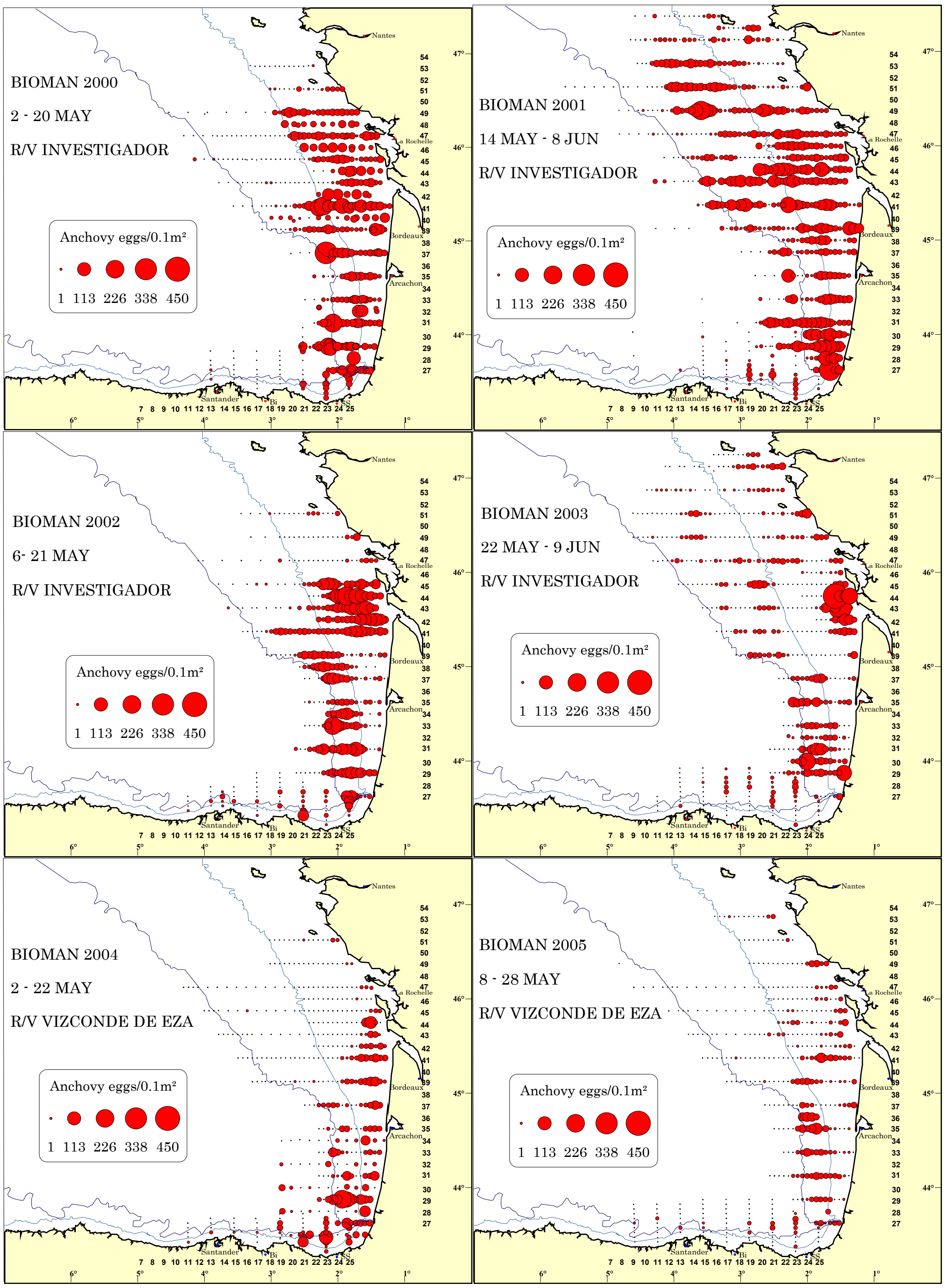
$$cv=\sqrt{Var.Be}\Big/Be$$

At the end, density in numbers and biomass by length and age are calculated for each species in each ESDU according to the nearest haul length composition. These numbers and biomass are weighted by the biomass in each stratum and data are used for spatial distributions by length and age.

The detailed protocol for these surveys (strategy and processing) is described in annex 6 of WGACEGG report in 2009

B.3.3 Historical series DEPM and acoustic surveys




BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450

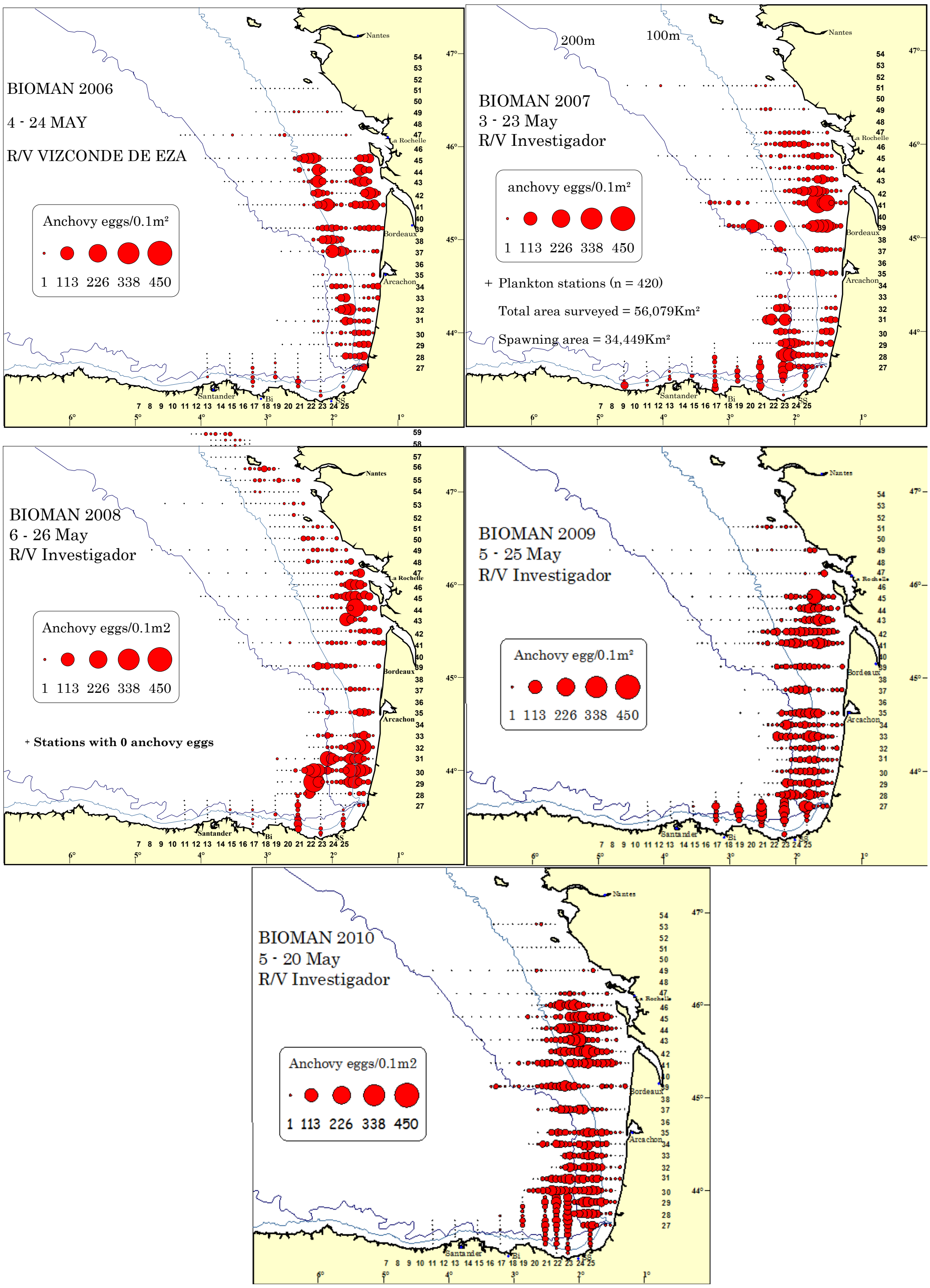
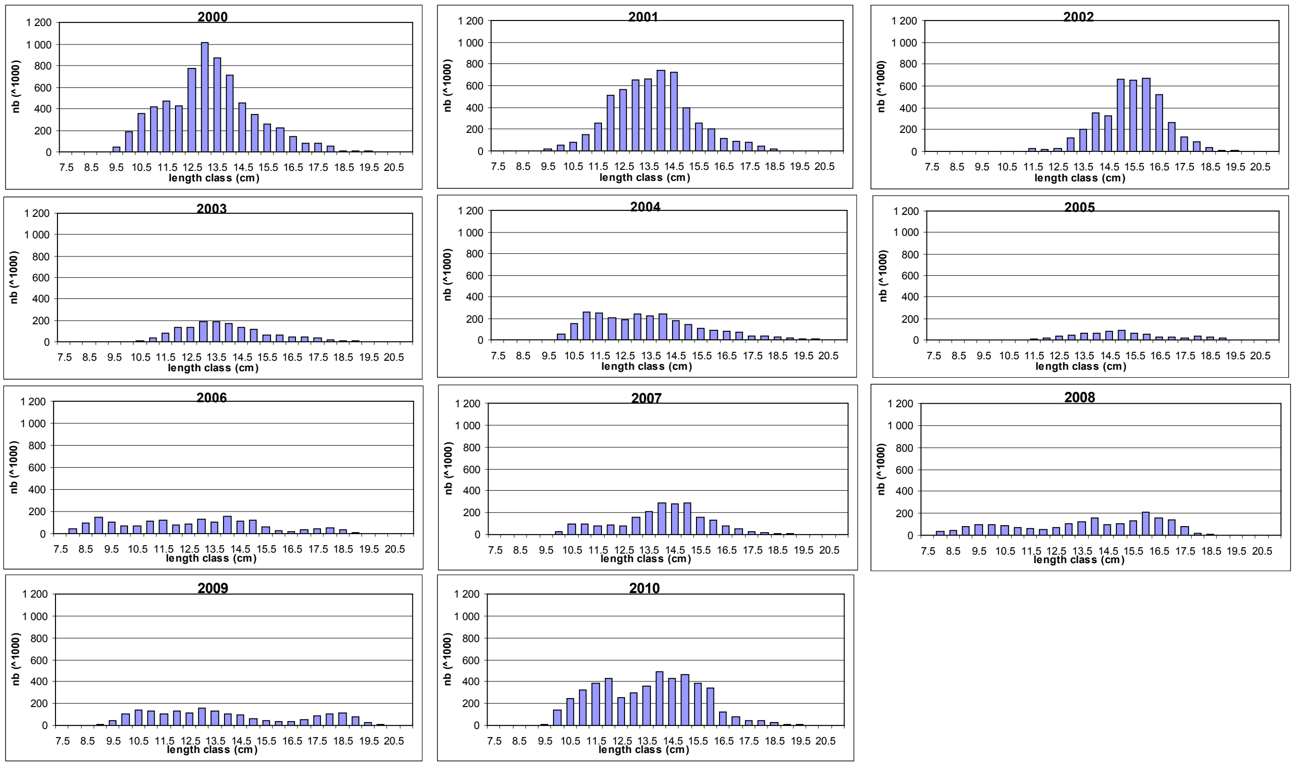
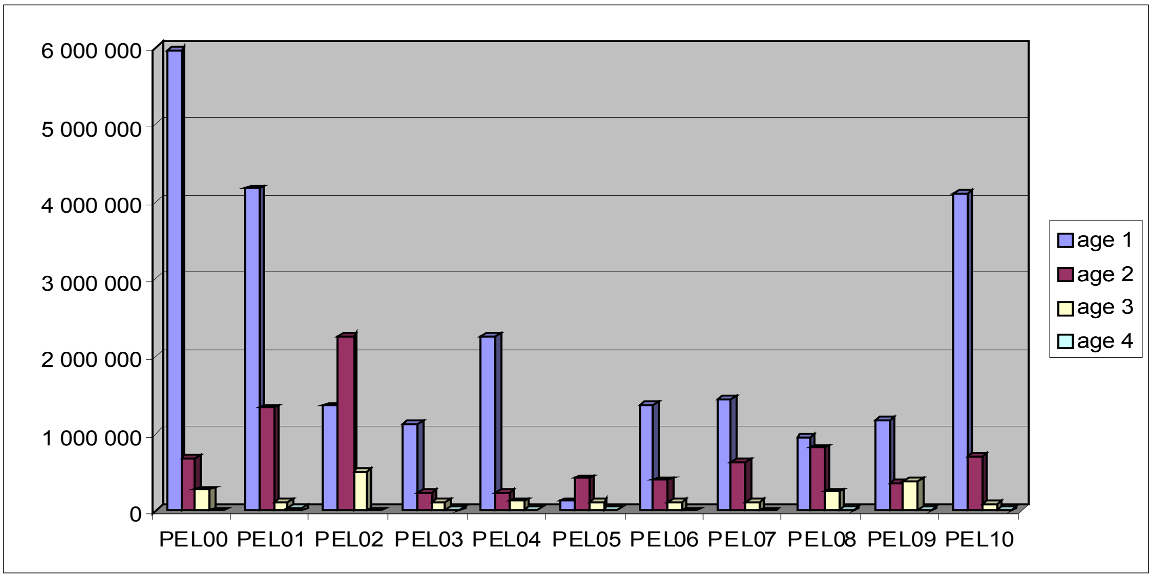


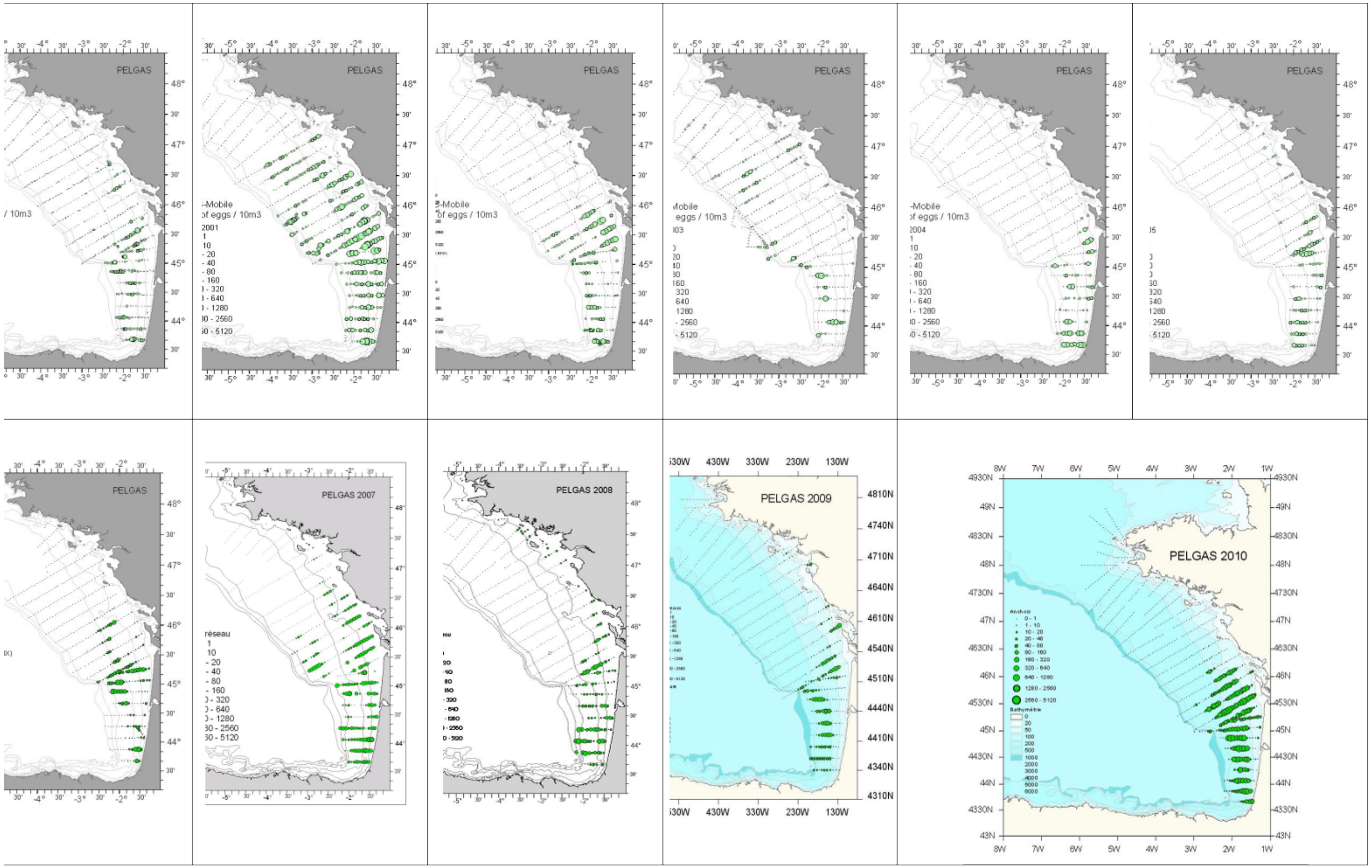
Figure B.3.3.1: Anchovy egg distribution from 1998 to 2009.The circles represent the anchovy egg abundance /0.1m² encountered in each plankton station.



Length composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.



Number of eggs observed during PELGAS surveys with CUFES from 2000 to 2010



Distribution of anchovy eggs observed with CUFES during PELGAS surveys from 2000 to 2010 (number for 10m³).

B.3.4 Autumn surveys on Juveniles, still under testing period

In recent years two series of acoustic surveys on juvenile anchovy (JUVENA and PELACUS10) have been launched in September-October, expecting that in the future the estimates can allow forecasting the strength of the anchovy recruitment which will enter the fishery the next year (ICES 2008 – WGACEGG report). Both surveys were coordinated with WGACEGG and are being merged nowadays. These surveys are expected to provide further insights on the recruitment process and additional knowledge on the biology and ecology of the juveniles Despite the encouraging results obtained with the series of 6 years of data available, the lack of sufficient contrast in the recent levels of recruitments prevents a proper evaluation of its performance as a predictor and the series are therefore not yet used for improving the management advice for the population (ICES 2008 - WGANC report).

B.3.4.1 Juvena survey

B.3.4.1.1 Data acquisition

JUVENA surveys take place annually since 2003, around September. In the period 2003 to 2005, the area was covered onboard commercial purse seiners. Since 2006 in addition to purse seiners, an oceanographic vessel, the R/V Emma Bardán, was incorporated to the survey. The abundance estimation is obtained by means of acoustic methodology (MacLennan and Simmonds, 1992). The acoustic equipment includes split beam echo sounders Simrad EK60 (Kongsberg Simrad AS, Kongsberg, Norway). The transducers of 38 kHz and 120 kHz (and 200kHz since 2006) were installed looking vertically downwards, about 2.5 m deep, at the end of a tube attached to the side of the purse seiners and at the hull in the case of the R/V Emma Bardan. The transducers were calibrated using standard procedures (Foote *et al.* 1987). Fishing was based on purse seining up to 2005 but since then onwards both pelagic trawling and purse seines are being used for species identification and biological sampling, along with hydrological recordings. In addition, the spatial distribution of the juvenile population is studied along with their growth condition. Two boats have been used since 2005 and therefore some extension of the northern limits of the surveys thus facilitated.

The water column was sampled to depths of 200 m. A threshold of -100 dB was applied for data collection. Acoustic back-scattered energy by surface unit (S_A, MacLennan *et al.* 2002) was recorded for each geo-referenced ESDU (Echointegration Sampling Distance Unit) of 0.1 nautical mile (185.2 m). Fish identity and population size structure was obtained from fishing hauls and echotrace characteristics. The commercial vessels used a purse seine of about 400 m of perimeter and 75 m height to fish the samples to depths of 50 m and the R/V Emma Bardan used a pelagic trawl. Acoustic data, thresholded to -60 dB, was processed using Movies+ software (Ifremer) for biomass estimation and the processed data was represented in maps using Surfer (Golden Software Inc., CO, USA) and ArcView GIS. Hydrographic recording was made with CTD casts.

B.3.4.1.2 Sampling strategy

The sampling area covered the waters of the Bay of Biscay (being 5º W and 47º45′ N the limits). Sampling was started from the Southern part of the sampling area, the Cantabrian Sea, moving gradually to the North to cover the waters in front of the French Coast. The acoustic sampling was performed during the daytime, when the juveniles are supposed to aggregate in schools (Uriarte 2002 FAIR CT 97-3374) and can be distinguished from plankton structures.

The vessels followed parallel transects, spaced 15 nm., perpendicular to the coast along the sampling area, taking into account the expected spatial distribution of anchovy juveniles for these dates, that is, crossing the continental shelf in their way to the coast from offshore waters (Uriarte et al. 2001).

B.3.4.1.3 Other sources of information

During the summer, information from the commercial live bait tuna fishery was collected, in order to have knowledge about the spatial distribution and relative abundance of anchovy previous to the beginning of the survey. We continued collecting this information about the captures of the fleet during the survey itself. In addition we maintained a constant communication with the responsible of the survey Pelacus-10, conducted by the IEO and Ifremer, survey performed onboard R/V Thalassa with a double objective: juvenile abundance estimation and ecologic studies.

B.3.4.1.4 Biological processing

Each fishing haul was classified to species and a random sample of each species was measured to produce size frequencies of the communities under study. A complete biological sampling of the anchovy juveniles collected is performed in order to analyze biological parameters of the anchovy juvenile population, as the age, size or size-weight ratio. Using these and other environmental parameters we will try to obtain, in a long term, indexes of the state of condition of the juvenile population, in order to be able to improve the prediction of the strength of the recruitment.

B.3.4.1.5 Acoustic data processing

Acoustic data processing was performed by layer echo-integration by 0.1 nautical mile (s_A) of the first 65 m of the water column with Movies+ software, after noise filtering and bottom correction, increasing or decreasing this range when the vertical distribution of juveniles made it necessary.

The hauls were grouped by strata of homogeneous species and size composition. Inside each of these homogeneous strata, the echo-integrated acoustic energy s_A was assigned to species according to the composition of the hauls. Afterwards, the energy corresponding to each specie-size was converted to biomass using their corresponding conversion factor.

Each fish species has a different acoustic response, defined by its scattering cross section that measures the amount of the acoustic energy incident to the target that is scattered backwards. This scattering cross section depends upon specie *i* and the size of the target *j*, according to:

$$\sigma_{ij} = 10^{TS_j/10} = 10^{\{(a_i + b_i \log L_j)/10\}}$$

Here, L_j represents the size class, and the constants a_i and b_i are determined empirically for each species. For anchovy, we have used the following TS to length relationship:

$$TS_j = -72.6 + 20 \log L_j$$

The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in its vicinity (2 nm of diameter). Thus, given a homogeneous stratum with M hauls, if E_k is the mean acoustic energy in the vicinity of the haul *k*, w_i, the proportion of species *i* in the total capture of the stratum, is calculated as follows:

$$w_i = \sum_j w_{ij} = \sum_j \left(\frac{\sum_{k=1}^{M} \left(q_{ijk} \cdot E_k \big/ Q_k \right)}{\sum_{k=1}^{M} E_k} \right).$$

Being q_{ijk} the quantity (in mass) of species *i* and length *j* in the haul *k*; and Q_k, the total quantity of any species and size in the haul *k*.

In order to distinguish their own contribution, anchovy juveniles and adults were separated and treated as different species. Thus, the proportion of anchovy in the hauls of each stratum (w_{ij}) was multiplied by a age-length key to separate the proportion of adults and juveniles. Then, separated w_i were obtained for each.

Inside each homogeneous stratum, we calculated a mean scattering cross section for each species, by means of the size distribution of such specie obtained in the hauls of the stratum:

$$\langle \sigma_i \rangle = \frac{\sum_j w_{ij} \sigma_{ij}}{w_i}.$$

Let s_A be the calibration-corrected, echo-integrated energy by ESDU (0.1 nautical mile). The mean energy in each homogeneous stratum, $E_m =< s_A >$, is divided in terms of the size-species composition of the haul of the stratum. Thus, the energy for each species, E_i, is calculated as:

$$E_i = \frac{w_i \langle \sigma_i \rangle E_m}{\left(\sum_i w_i \langle \sigma_i \rangle \right)}$$

Here, the term inside the parenthesis sums over all the species in the stratum. Finally, the number of individuals F_i of each species is calculated as:

$$F_i = H \cdot l \frac{E_i}{\langle \sigma_i \rangle}$$

Where *l* is the length of the transect or semi-transect under the influence of the stratum and *H* is the distance between transect (about 15 nm.). To convert the number of juveniles to biomass, the size-length ratio obtained in each stratum is applied to obtain the average weight of the juveniles in the stratum:

$$< W_i >= a \cdot < L_i >^b$$

Thus, the biomass is obtained by multiplying F_i times $< W_i >$.

B.3.4.1.6 Commercial CPUE

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). Current series of CPUE available for the Spanish Purse seine are not considered of utility for the monitoring of the fishery (Uriarte *et al.*, 2008).

C. Stock assessment method

Model used:

The assessment for the Bay of Biscay anchovy population is a Bayesian two-stage biomass-based model (BBM) (Ibaibarriaga *et al*., 2008), where the population dynamics are described in terms of biomass with two distinct age groups, recruits or fish aged 1 year, and fish that are 2 or more years old. The biomass decreases exponentially on time by a factor g accounting for intrinsic rates of growth (G) and natural mortality (M) which are assumed year- and age-invariant.

Two periods are distinguished within each year. The first begins on 1 January, when it is assumed that age incrementing occurs and age 1 recruit enter the exploitable population, and runs to the date when the monitoring research surveys (acoustics and DEPM) take place. The second period covers the rest of the year (from 15th May to 31st December). Catch is assumed to be taken instantaneously within each of these periods.

The observation equations consist on log-normally distributed spawning stock biomass from the acoustics and DEPM surveys, where the biomass observed is proportional to the true population biomass by the catchability coefficient of each of the surveys, and the beta distributed age 1 biomass proportion from the acoustics and DEPM surveys, with mean given by the true age 1 biomass proportion in the population.

The model unknowns are the initial population biomass (in 1987), the recruitment each year, the catchability of the surveys and the variance related parameters of the observation equations. The model can be cast into a Bayesian state-space model framework where inference on the unknowns is done using Markov Chain Monte Carlo (MCMC).

Software used:

The model is implemented in BUGS (www.mrc-bsu.cam.ac.uk/bugs/) and it is run from R (www.r-project.org) using the package R2WinBUGS.

Model Options chosen:

Catchability for the DEPM SSB is set to 1 because it is assumed to be an absolute indicator of Biomass and for consistency with the past practice in the assessment of this stock. Catchability of the acoustic SSB is estimated. DEPM and acoustic surveys are assumed to provide unbiased proportion of age 1 biomass estimates in the stock. The first set of priors as defined in Ibaibarriaga et al. 2008 is used. The length of the MCMC run, the burn-in period (removal of the first draws to avoid dependency on the initial values) and the thinning to diminish autocorrelation should be enough to ensure convergence and obtain a representative joint posterior distribution of the parameters.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year. Yes/No
Caton	Catch in tonnes by periods	1987-2010	1 to 2+	Yes
Canum	Catch at age in numbers by periods	1987-2010	1 & 2+	Yes
Weca	Weight at age in the commercial catch by periods	1987-2010	1 to 2+	Yes
Mprop	Proportion of natural mortality before spawning	Not applicable		
Fprop	Proportion of fishing mortality before spawning	Not applicable		
Matprop	Proportion mature at age	Not applicable		
Natmor	Natural mortality M=1.2	1987-2010	1 to 2+	No
G	Intrinsic growth rate G= 0.52	1987-2010	1 to 2+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	DEPM SSB spring series	1987-2010 (with gap in 1993)	
Tuning fleet 2	Acoustic SSB spring series	1989-2010 (with gaps)	
Tuning fleet 3	DEPM P1 (B1/SSB) spring series	1987-2010 (with gaps)	
Tuning fleet 4	Acoustic P1 (B1/SSB) spring series	1989-2010 (with gaps)	

Prior distributions of the parameters:

The current prior distributions (see table below) are described and justified in Ibaibarriaga *et al.* (2008) and ICES WGANC (2008)

Parameter	Prior 1	
	Hyper-parameters	Median (95% CI)
q_{surv}	$\mu_{q_{surv}} = 0$	1 (0.1, 16.0)
	$\psi_{q_{surv}} = 0.5$	
ψ_{surv}	$a_{\psi_{surv}} = 0.8$	10 (0.2, 65.1)
	$b_{\psi_{surv}} = 0.05$	
ξ_{surv}	$\mu_{\xi_{surv}} = 5$	5 (0.6, 9.4)
	$\psi_{\xi_{surv}} = 0.2$	
B_0	$\mu_{B_0} = 10.5$	36 316 (5 116, 257 806)
	$\psi_{B_0} = 1.0$	
μ_R	$\mu_{\mu_R} = 9.8$	9.8 (7.0, 12.6)
	$\psi_{\mu_R} = 0.5$	
ψ_R	$a_{\psi_R} = 4$	1.8 (0.5, 4. 4)
	$b_{\psi_R} = 2$	
g	$\mu_g = \log(0.7)$	0.7 (0.1, 5.0)
	$\psi_g = 1$	

The benchmark workshop recommended to conduct some sensitivity analysis on the prior distributions. In particular, to test the effect of having more informative priors on the surveys' catchability and precision and on the g parameter. If this is done, any changes in the prior distributions of the parameters should be documented and justified in the ICES anchovy assessment working group report (WGANSA).

D. Short-Term Projection

Model used:

The Bayesian two-stage biomass-based model (Ibaibarriaga *et al.* 2008) used for the assessment of the stock is used to project the population one year forward from the current state and to analyse the probability of the population in the next year of being below the biological reference point Blim (21 000 tonnes) under a recruitment scenario based on the past recruitment series and under alternative catch options for the second half of the current year and the first half of next year.

The predictive distribution of recruitment at age 1 (in mass) in January next year is defined as a mixture of the past series of posterior distributions of recruitments as follows:

$$R_{2008} = \sum_{y=1987}^{2007} w_y \; p(R_y|\cdot) \,,$$

where $p(R_y\,|\cdot)$ denotes the posterior distribution of recruitment in year y and w_y are the weights of the mixture distribution, such that $\sum w_y = 1$. These weights can be based on information about incoming recruitment or on assumptions regarding different scenarios.

Software used:

The projections are implemented in R (www.r-project.org)

Projection period:

One year ahead from the spawning period (15th May) in the last assessment year

Initial stock size:

Posterior distribution of SSB in the last assessment year

Maturity: NA

F and M before spawning: NA

Weight at age in the stock: NA

Weight at age in the catch: NA

Intrinsic growth rate (G):

Assumed constant same as in the assessment (G=0.52)

Natural mortality rate (M):

Assumed constant same as in the assessment (M=1.2)

Exploitation pattern:

Alternative options for splitting catches by periods are tested

Intermediate year assumptions: NA

Stock recruitment model used:

No implicit S/R model is used. Recruitment is sampled from the posterior distributions of past series recruitments. Different recruitment scenarios are constructed by giving different weights to the past series recruitments.

Procedures used for splitting projected catches: NA

E. Medium-Term Projections

No Medium term projections are applied to this fishery for the provision of advice by ICES. Long term projections (10 years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC, based on a Ricker stock recruitment relationship.

F. Long-Term Projections

No Long term projections are applied to this fishery for the provision of advice by ICES. Long term projections (10 years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC, based on a Ricker stock recruitment relationship.

G. Biological Reference Points

A stock/recruitment relationship is not explicitly used.

Current biological reference points for the Bay of Biscay anchovy were defined by ICES ACFM in October 2003 as follows:

	ICES considers that:	**ICES proposes that:**
Limits reference points	**B_{lim}** is 21,000 t, the lowest observed biomass in 2003 assessment.	B_{pa}= 33,000 t.
	There is no biological basis for defining F_{lim}.	F_{pa} be established between 1.0-1.2.
Target reference points		

Technical basis:

$B_{lim} = B_{loss} = 21{,}000$ t.	$B_{pa} = B_{loss} * 1.645$.
	F_{pa}= F for 50% spawning potential ratio, i.e., the F at which the SSB/R is half of what it would have been in the absence of fishing

H. Other Issues

I. References

Allain, G., Petitgas, P. and Lazure, P. 2001. The influence of mesoscale ocean processes on anchovy (*Engraulis encrasicolus*) recruitment in the Bay of Biscay estimated with a three-dimensional hydrodynamic model. Fisheries Oceanography, 10: 151-163.

Allain, G., Petitgas, P., Lazure, P. and Grellier, P., 2007. Biophysical modelling of larval drift, growth and survival for the prediction of anchovy recruitment in the Bay of Biscay (NE Atlantic). Fisheries Oceanography, 16(6), 489-505.

Barange, M., Bernal, M., Cercole, M.C., Cubillos, L.A., Cunningham, C.L., Daskalov, G.M., De Oliveira, J.A.A., Dickey-Collas, M., Hill, K., Jacobson, L.D., Köster, F.W., Masse, J., Nishida, H., Ñiquen, M., Oozeki, Y., Palomera, I., Saccardo, S.A., Santojanni, A., Serra, R., Somarakis, S., Stratoudakis, Y., van der Lingen, C.D., Uriarte, A. and Yatsu, A. (2009). Current trends in the assessment and management of small pelagic fish stocks. Chapter 10 in: Checkley, D.M. Jr, Roy, C., Oozeki, Y. and Alheit J. (Eds.) Climate Change and Small Pelagic Fish. Cambridge University Press.

Borja, A. Uriarte, A., Egana, J., Motos, L. and Valencia, V. 1998. Relationships between anchovy (*Engraulis encrasicolus*) recruitment and environment in the Bay of Biscay (1967-1996). Fisheries Oceanography, 7(3-4), 375-380.

Borja, A. Fontán, A., Saez, J. and Valencia, V. 2008: Climate, oceanography, and recruitment: the case of the Bay of Biscay anchovy (*Engraulis encrasicolus*). Fish. Oceanogr. 17:6, 477–493, 2008

Cochran, W.G., 1977. Sampling techniques. John Wiley and sons (ed,.) 428 pp, N.Y.

Csirke J. 1988. Small shoaling pelagic fish stocks. In Fish Population Dynamics (Second Edition). Edited by J.A. Gulland. John Wiley & Sons Ltd.

Duhamel, E., Biseau, A., Massé, J. and Villalobos, H. 2004. The French fishery. Working document to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), 7-16 September 2004, ICES Headquarters, ICES CM 2005/ACFM:08.

Fernandes, J. A., Irigoien, X., Goikoetxea, N., Lozano, J. A., Inza, I., Pérez, A., Bode, A. 2010. Fish recruitment prediction, using robust supervised classification methods. Ecological modelling, 221: 338-352.

Hunter, J. R., et al. Batch fecundity in multiple spawning fishes, R. Lasker (ed.), p. 67-77. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 36.

Huret, M., and Petitgas, P. 2007. Anchovy recruitment forecasting and environment. Working document to ICES WGMHMSA 2007.

Ibaibarriaga, L., Fernández, C., Uriarte, A., and Roel, B. A. 2008. A two-stage biomass dynamic model for Bay of Biscay anchovy: a Bayesian approach. – ICES Journal of Marine Science, 65: 191–205

ICES. 2007. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), 4 - 13 September 2007, ICES Headquarters. ICES CM 2007/ACFM:31. 712 pp.

ICES. 2008a. Report of the Working Group on Anchovy (WGANC), 13 - 16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

ICES. 2008b. Report of the ICES Advisory Committee, 2008. ICES Advice, 2008. Book 7, 122 pp.

Junquera, S., 1986. Pêche de l'anchois (*Engraulis encrasicholus*) dans le golfe de Gascogne et sur le littoral atlantique de Galice depuis 1920. Variations quantitatives. Rev. Trav. Inst. Pêches Marit., 483-4: 133-142.

Junquera, S. and Perez-Gandaras, G. 1993. Population diversity in Bay of Biscay anchovy (*Engraulis engrasicholus*, L. 1758) as revealed by multivariate analisis of morphometric and meristic characters. ICES J. mar. Sci., 50:383:396.

Lasker, R., 1985. An Egg Production Method for Estimating Spawning Biomass of pelagic fish: Application to the Northen Anchovy, *Engraulis Mordax*. NOAA Technical report NMFS 36:100p.

Mackinson, S., Sumaila, U. R. and T. J. Pitcher. 1997. Bioeconomics and catchability: fish and fishers behaviour during stock collapse. Fisheries Research 31: 11-17.

Massé, J. 1988. Utilisation de l'echo-integration en recherche halieutique (analyse des campagnes effectuées dans le Golfe de Gascogne de 1983 à 1987). Direction des Ressources Vivantes, IFREMER.

Massé J. 1994. Acoustic Surveys DAAG 90, DAAG 91, DAAG 92. Annex to: Orestes (editor): Improvement of stock assessment by direct methods, its application to the anchovy (*Engraulis encrasicholus*) in the Bay of Biscay. Report of the EC FAR Project (1991-1993) (Contract No. MA 2495 EF), 90 pp. + annexes.

Massé, J. (1996). "Acoustics observation in the Bay of Biscay: schooling, vertical distribution, species assemblages and behaviour." Scientia Marina 60(Suppl. 2): 227-234.

Moser, H.G. and E. H. Ahlstrom, 1985. Staging anchovy eggs. In: "An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, *Engraulis mordax*, R. Lasker (ed.), p. 7-16. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 36.

Motos L., A. Uriarte, P. Prouzet, M. Santos, P. Alvarez and Y. Sagarminaga. 2005: Assessing the Bay of Biscay anchovy population by DEPM: a review 1989-2001. In Castro, LR, P. Fréon , C.D.

Petitgas, P., Massé, J., Beillois, P., Lebarbier, E. and Le Cann, A. (2003) Sampling variance of species identification in fisheries acoustic surveys based on automated procedures associating acoustic images and trawl hauls ICES Journal of Marine Science 60: 437-445 (1)

Pitcher, T. J., 1995 : The impact of pelagic fish behaviour on fisheries. Sci. Mar., 59 (3-4): 295-306.

Prouzet, P. and Metuzals, K. 1994. Phenotypic and genetic studies on the Bay of Biscay anchovy. InCendrero (Eds) 1994. Final report of the EC FAR project (1991–1993).

Santiago, J. and A. Sanz, 1992. Egg production estimates of the Bay of Biscay anchovy, Engraulis encrasicolus (L.), spawning stock in 1987 and 1988 (Estimaciones de la producción de huevos de l stock reproductor de anchoa, *Engraulis encrasicolus* (L.), del Golfo de Vizcaya en 1987 y 1988). Bol. Inst. Esp. Oceanogr. 8 (1):225-230

Sanz, N., García-Marín, J-L., Viñas, J., Roldán, M., and Pla, C. 2008. Spawning groups of European anchovy: population structure and management implications. – ICES Journal of Marine Science, 65.

Sanz, A. & A. Uriarte, 1989. Reproductive cycle and batch fecundity of the Bay of Biscay anchovy (*Engraulis encrasicholus* L.) in 1987. CalCOFI Rep., vol. 30: 127-135.

Stauffer, G. and S. J. Picquelle, 1980. Estimates of the 1980spawning biomass of the of the central subpopulation of northern anchovy. Natl. Mar. Fish. Serv. , NOAA. Southw. Fish . Cent. Admin. Rep. LJ-80-09, 41 p.

Picquelle, S. J. and G. Stauffer, 1985. Parameter estimation for an egg production method of anchovy biomass assessment. In R. Lasker (editor), An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, *Engraulis mordax*, p. 7-16. U.S. Dep. Commer., NOAA Tech. Rep. NMFS36.

STECF-SGRST 2008: Report of the Meeting to inform the Commission on a long-term management plan for the stock of anchovy in the Bay of Biscay (ICES Sub-area VIII). Held in Hamburg, 14-18 April 2008

STECF/SGBRE-08-01: Working Group Report on the long term management of Bay of Biscay anchovy. San Sebastian, 2-6 June

Seber, G.A.F., 1982. Estimation of animal abundance and related parameters. Macmillan, New York.

Somarakis, S., Palomera, I., Garcia, A., Quintanilla, L., Koutsikopoulos, C. Uriarte, A. and L. Motos, 2004: Daily egg production of anchovy in European waters. ICES Journal of Marine Science, 61: 944-958

Ulltang, O. 1980. Factors affecting the reaction of pelagic fish stocks to exploitation and requiring a new approach to assessment and management, Rapp. Procès-Verb. Réun. Cons. Int. Explor. Mer 177. 489-504.

Uriarte, A. 2005: Assessment of the Bay of Biscay anchovy by means of a seasonal separable VPA. Working Document to the ICES Working Group on the assessment of mackerel, horse mackerel, sardine and anchovy, held in Vigo from 06 to 15 September 2005.

Uriarte, A., Prellezo, R., Punzón, A., Aranda, M. and Villamor, B. 2008. The Spanish fishery on anchovy in the Bay of Biscay: Analysis of the relationship between fishing Capacity, Effort and mortality. ICES CM 2008/I:18.

Uriarte A. Prouzet, P. and B. Villamor 1996: Bay of Biscay and Ibero atlantic anchovy populations and their fisheries. Sci. Mar. 60 (Supl.2): 237-255

Uriarte A (Coordinator), M. Blanco, E. Duhamel, P. Grellier, I. Rico, B. Villamor 2006: 2005 Anchovy otolith exchange programme from subarea VIII: Working Document to the 2006 ICES Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) 24 February 2006

Uriarte, A. C. Dueñas, E. Duhamel, P. Grellier, I. Rico, B. Villamor, 2007: 2006 Anchovy Otolith Workshop. Working Document to the 2007 ICES Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) (5-9 March)

Vermard, Y., Marchal, P., Mahevas, S. and Thebaud, O. 2008. A dynamic model of the Bay of Biscay pelagic fleet simulating fishing trip choice: the response to the closure of the European anchovy (Engraulis encrasicolus) fishery in 2005. Can. J. Fish. Aquat. Sci. 65: 2444–2453.

Villamor B., Aranda M., Punzón A., Uriarte A., Báez J. C., (2008): The Anchovy fishery in the Bay of Biscay I: Description and Analysis of the Spanish Fleet (2000-2005). ICES CM 2008/ I:30 (Theme session I).

Stock Annex Anchovy in Division IXa

Quality Handbook	ANNEX: A.5.2

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Anchovy in Division IXa
Working Group:	WGANSA (Working Group on the Assessment of Anchovy and Sardine)
Date:	24th June 2011
Revised by	Fernando Ramos

A. General

A.1. Stock definition

The distribution of anchovy in the Division IXa is nowadays mainly concentrated in the Spanish waters of the Gulf of Cádiz (Sub-division IXa-South, **Figure A.1.1**). Outside the main nucleus of the Gulf of Cádiz, resilient anchovy populations have been detected in all fishery independent surveys (ICES, 2007 b) and previous records on large catches in ICES areas IXa North, Central North and South (Algarve) suggest that abundance in those areas have been high in early years of the time series. In the south, outside the Gulf of Cádiz anchovy is abundant to the East of the Strait of Gibraltar, in the Mediterranean Sea (GFCM, 2002) as well as in northern Africa, where a combined Spanish-Morocco fishery produces landings of up to 12000 tn (Millán, 1992; García-Isarch *et al*., 2008).

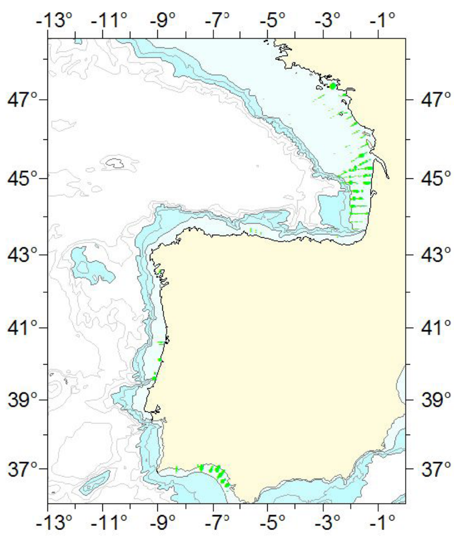


Figure A.1.1. Distribution of acoustic energy allocated to anchovy from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b).

A.2. Fishery

Anchovy harvesting along the Division IXa is at present carried out by the following fleets:

- o Portuguese purse-seine fleet
- o Portuguese trawl fleet
- o Portuguese artisanal fleet (although fishing with artisanal purse-seines)
- o Spanish purse-seine fleet
- o Spanish trawl fleet (in Subarea IXa-South (Cádiz))

Purse-seine fleets are the main responsibles for the anchovy fishery in the Division (usually more than 90% of total annual landings in the Division). Spanish fleets operate in Sub-divisions IXa-North (Southern Galicia) and IXa-South (Gulf of Cadiz), and the Portuguese ones along its national peninsular fishing grounds (Sub-divisions IXa-Central North, -Central South and South (Algarve)). Most of the fishery for this anchovy stock in the Division takes place in Sub-division IXa-South (C), where anchovy is the target species. The fleets in the northern part of Division IXa (targeting sardine) occasionally target anchovy when abundant, as occurred in 1995.

Data on number and technical characteristics for the Portuguese fleets are available for 2006 (ICES, 2007 a). The Portuguese purse- seine fleet (n =121 in 2006) presently ranges in size from 10.5 to 27 m (mean vessel length = 20 m) and between 71 to 447 HP (mean = 249) in vessel engine power. Portuguese producers organisations traditionally agree a voluntary closure of the purse-seine fishery in the northern part (north of the 39º 42" North) of the Portuguese coast. This closure usually lasted from the 1st of February to 31 of March. Since 2006, the closure, also lasting 2 months, may however be selected between 1st of February and 30th of April (*i.e.* boats stopped fishing in February to March or in March to April).

Since 1999 the number of Gulf of Cadiz purse-seiners operated by Spain has oscillated between 145 (in 2004) and 84 (in 2010) vessels, and the vessels within this fleet targeting anchovy between 76 (2010) and 135 (2004) vessels. As it has been previously reported (ICES, 2007 a), the observed fluctuations during this period were mainly motivated by the ending of the fifth EU-Morocco Fishery Agreement (in 1999, which affected the heavy-tonnage fleet in the following two years: acceptation of tie-up scheme in 2000 and 2001), the rising of the light-tonnage purse seiners on those dates, and the fluctuations showed by the multipurpose vessels. These vessels fishing for anchovy account for more than 85% of the whole fleet during the available series, evidencing the importance of anchovy as a target species in the Gulf of Cadiz purse-seine fishery. Since 2008 the EU–Morocco Fishery Agreement was renewed, and part of the fleet (the heavier/larger vessels) devoted to the anchovy fishing in the Moroccan grounds, which entailed an important reduction of the fishing effort in the Gulf of Cadiz.

A first attempt of identifying *métiers* in this last fleet/fishery was presented in the 2007 WGMHSA meeting (ICES, 2007 a). This study (see also Silva *et al*., 2007, for details) focused on the application of a non-hierarchical clustering data-mining technique (*CLARA*, *C*lustering *LAR*ge *A*pplications) for classifying the fishing trips from 2003 to 2005. The classification of individual trips was only based on the species composition of landings from logbooks, hence the preliminary character of this study. Up to four clusters (catch profiles) were identified from each of the annual datasets according to the targeted species: 1) trips targeting anchovy, 2) trips targeting sardine; 3) trips targeting a mackerel (*Scomber* spp.) species mixture; and 4) trips targeting an anchovy and sardine mixture. The first three groupings were considered as clearly identifiable *métiers* according to the knowledge on the fishery. At present no comparable information on Portuguese *métiers* is available.

The regulatory measures in place for the Spanish anchovy purse-seine fishing in this Division were the same as for the previous years and are summarized as follows:

- Minimum landing size: 10 cm total length;
- Minimum vessel tonnage of 20 GRT with temporary exemption;
- Maximum engine power: 450 h.p;
- Purse-seine maximum length: 450 m;
- Purse-seine maximum depth: 80 m;
- Minimum mesh size: 14 mm;
- Fishing time limited to 5 days per week, from Monday to Friday;
- Cessation of fishing activities from Saturday 00:00 hrs to Sunday 12:00 hrs;
- Fishing prohibition inside bays and estuaries.

Until 1997, the Spanish purse-seine fleet voluntary closed the fishery each year from December to February in the Gulf of Cadiz (Sub-division IXa-South(C)). Since 2004, two complementary sets of management measures have been in force in this part of the Sub-division. The first one is the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months from 30th October and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid February 2008; 1st December 2008 to 28th February 2009), accompanied by a subsidized tie-up scheme for the purse-seine fleet. The expected subsidized 3-month closure from 2009 mid-autumn to the 2010 mid-winter was restricted to one month only, in December 2009, although the fishery was practically closed since November 2009 until February 2010 for persistent bad sea conditions during all these months. This same scheme was accomplished for the 2010-2011 autumn/winter closure. This plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (6000 kg of sardine-anchovy mixing, but the catch of each of these species cannot exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight may contain fish below the established minimum landing size (10 cm), but fish must always be ≥9 cm.

The effort exerted by the entire purse-seine fleet since 1997 has been high (even with the fishing closures since 2004 on). While the effects of the fishery closures have not been formally evaluated, it appears that they have limited a further expansion of effort.

The second management action in force since 15th of July 2004 is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure A.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA. The effects of such closures and MPA in the Gulf of Cádiz anchovy recruitment are not still possible to be directly assessed. In any case, the implementation of both of these measures should benefit the stock.

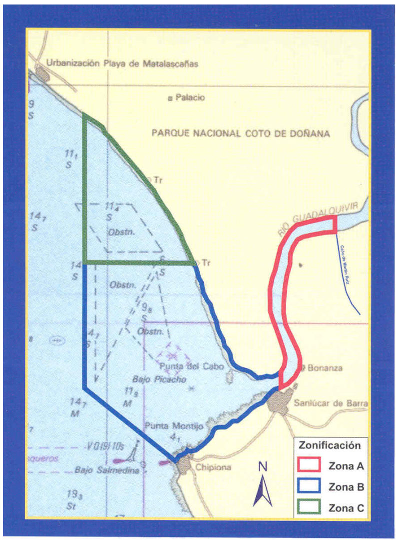


Figure A.2.1. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Sub-division IXa South).

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and sea-birds. The recruitment depends strongly on environmental factors. Ruíz *et al.* (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the north-eastern sector of the Gulf of Cadiz. The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favor the existence of warm and chlorophyll-rich waters in the area, thus offering a favorable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favorable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

The anchovy population in Subdivision IXa-South appears to be well established and relatively independent of populations in other parts of the Division. These other populations seem to be abundant only when suitable environmental conditions occur.

B. Data

B.1. Commercial catch

Portuguese annual landings from their respective Sub-divisions are available since 1943. Spanish landings started to be available since 1989.

No information on anchovy discarding in the Division IXa has been available until 2005. That year several pilot surveys for estimating discards in the Gulf of Cadiz Spanish fisheries (trawl, purse-seine and artisanal) were conducted by an IEO observer's programme onboard commercial vessels lasting five months and covering the whole study area. Preliminary results (average estimates from 6 purse-seine trips – 13 hauls –, not raised to total annual landings) from these pilot surveys were described in ICES (2006 a) although there were concerns about the reliability of such estimates and the ratios derived from them due to their extremely high associated CVs. On the other hand, discarded anchovies were of commercial and legal size, between 10 and 15 cm (mode at 12.5 cm), but reasons for discarding anchovy were not reported to that WG. Anchovy catches in sampled trips from the bottom otter-trawl fleet were negligible. Slipping practices are probable but not directly evidenced by sampling onboard. New data on anchovy discarding have started to be gathered since 2009 on within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR).

B.2. Biological

Annual and quarterly length compositions of anchovy landings in Division IXa are routinely provided by Spain for its Sub-division IXa-South(C). This series dates back to 1988. Length distributions for the Spanish fishery in Sub-division IXa-North are only available for the 1995-1999 period and they were characterized, with the exception of 1998, by fish larger than 12.5 cm (ICES, 2007 a). At present, Portugal does not provide either length distributions or catches at age of their anchovy landings in Division IXa due to their scarce catches.

Catches at age from the whole Division IXa are only available from the Spanish Gulf of Cadiz fishery (Sub-division IXa South (C)). Problems with ageing/reading Gulf of Cádiz anchovy otoliths still persist.

The age composition of the Gulf of Cadiz anchovy in Spanish landings is available since 1988 (see ICES, 2007 a, for tabulated data from years not shown in this report). The catch-at-age series shows that 0, 1 and 2 age groups support the Gulf of Cadiz anchovy fishery and that the success of this fishery largely depends on the abundance of 1 year-old anchovies. The contribution of age-2 anchovies usually accounts for less than 1% of the total annual catch (except in 1997, 1999, the 2001-2003 period and since 2008 on, with contributions oscillating between 2% and 14%). Likewise, age-3 anchovies only occurred in the first quarter in 1992 and since 2008 on, but the importance of this age class in the total annual catch those years was insignificant. Inter-annual variations in the contribution of each age group in landings throughout the historical series are described in ICES (2007 a, 2008 a). Weights at age in the stock for the Gulf of Cádiz anchovy correspond to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (throughout the spawning season).

Catches at age from the Spanish fishery in Sub-division IXa North are presently not available since commercial landings used to be negligible. Mean length- and mean weight-at-age data are only available for Gulf of Cadiz anchovy catches. The analysis of small samples of otoliths from Subdivision IXa North in 1998 and 1999 rendered estimates of mean sizes at ages 1, 2 and 3 of 15.5 cm, 17.6 cm and 17.9 cm respectively (ICES, 2000, 2001). A sample of 78 otoliths from the same area was collected during the *PELACUS 0402* acoustic survey. Mean lengths at age 1 and 2+ were 13.7 cm and 17.0 cm (Begoña Villamor, pers. comm.). Comparisons of these estimates with the ones from the Gulf of Cadiz anchovy indicate that southern anchovies attain smaller sizes at age.

Previous biological studies based on commercial samples of Gulf of Cadiz anchovy (Millán, 1999) indicate that its spawning season extends from late winter to early autumn with a peak spawning time for the whole population occurring from June to August. Length at maturity was estimated in that study at 11.09 cm in males and 11.20 cm in females. However, it was evidenced that size at maturity may vary between years, suggesting a high plasticity in the reproductive process in response to environmental changes. Annual maturity ogives for Gulf of Cadiz anchovy are routinely provided to ICES. They represent the estimated proportion of mature fish at age in the total catch during the spawning period (second and third quarters) after raising the ratio of mature-at-age by size class in monthly samples to the monthly catch numbers-at-age by size class.

Natural mortality is unknown for this stock. By analogy with anchovy in Sub-area VIII, natural mortality is probably high (M=1.2 is used for the data exploration).

B.3. Surveys

B.3.1. Acoustic surveys

The IPIMAR's Portuguese surveys series (*SAR* and *SARNOV* series, carried mainly out with the R/V *Noruega*) correspond to those ones routinely performed for the acoustic estimation of the sardine abundance in Division IXa off the Portuguese continental shelf and Gulf of Cadiz, during March-April (sardine late spawning season) and November (early spawning and recruitment season). Since 2007 on, the Spring surveys are being planned as 'pelagic community' surveys. This shift in planning mainly entailed, as compared with previous years, a substantial increase in the number of fishing stations in the Sub-division IXa-South, where the species diversity is higher, changing the series its former name by the one of *PELAGO* surveys. Anchovy estimates from these survey series started to be available since November 1998.

Spanish 'pelagic community' acoustic surveys have been conducted by IEO in Sub-division IXa North and Division VIIIc since 1983 (the spring *PELACUS* series with the R/V *Thalassa*). Results from these surveys for the Sub-division IXa North have shown the scarce presence or even the absence of anchovy in this area (Carrera, 1999, 2001; Carrera *et al*., 1999). This situation still continues in the most recent years (surveys in the 2003-2010 period, see Porteiro *et al*., 2005; Iglesias *et al*., 2007).

Spanish acoustic surveys in the Gulf of Cadiz waters (Sub-division IXa-South) have been sporadically conducted by IEO from 1993 to 2003. A consistent yearly series of early summer acoustic surveys (*ECOCÁDIZ* series) estimating the anchovy abundance in the Subdivision IXa South (Algarve and Gulf of Cadiz) started in 2004. Surveys in this new series are also planned under the 'pelagic community' approach. Unfortunately, this series may show some gaps in those years coinciding (same dates and surveyed area) with the conduction of the (initially triennial) anchovy DEPM survey because of the available ship time (R/V *Cornide de Saavedra*). In 2009 two additional surveys to the conventional one were also conducted, but mainly restricted to the Spanish waters. So, in July 2009 a complementary and almost synchronous survey to the *ECOCÁDIZ 0609* conventional survey was carried out with a small-draught vessel, R/V *Francisco de Paula Navarro*, aiming to survey shallower waters than 20 m depth not sampled by no vessel, either Spanish or Portuguese, routinely surveying the study area (*ECOCÁDIZ-COSTA 0709* survey). The acoustic estimates from this survey were separately given in the 2010 WG report from its conventional survey awaiting an intercalibration of data for a further merging of estimates if possible.

In October 2009 a new autumn survey (*ECOCÁDIZ-RECLUTAS 1009*, R/V *Emma Bardán*), aimed to acoustically estimate the abundance and biomass of Gulf of Cádiz anchovy recruits, was planned to be conducted throughout the easternmost Portuguese waters and those waters off the central part of the Spanish Gulf of Cádiz, waters that supposedly include the main Gulf of Cádiz anchovy recruitment area. Unfortunately, the shortness of the available ship-time to cover a more intensive acoustic sampling grid (*i.e.* 4 nm spaced transects from 100 to 7-10 m depth) than the conventionally planned in standard surveys and some other unforeseen circumstances (e.g., a one-day technical stop for crew replacement, 2-day military manoeuvres just in the middle of both the survey area and calendar) prevented finally from covering the whole survey area. For the above reasons, the surveyed area was restricted to a relatively small central area in front the Guadalquivir river mouth rendering a very probable underestimation of the recruits abundance. Continuity of this survey in following years will necessarily depend on external (EC) funding.

All these surveys followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Subareas VIII and IX (ICES, 1986; 1998) and recommendations given by the WGACEGG (ICES, 2006 b,c). The methodological differences between these recent surveys are not considered by the WGACEGG as important as to prevent from any comparison between their results, such differences being basically due to:

- The echo-sounder and working frequencies used (IPIMAR surveys: Simrad EK 500 working at 38 and 120 KHz; IEO surveys since 2007 onwards: Simrad EK 60 working at 18, 38, 70, 120, and 200 KHz).
- The fishing gear used as sampler for echo-trace identification/confirmation and gathering biological data (IPIMAR surveys: bottom and pelagic trawl gears; IEO surveys: pelagic trawl).
- The software used for data storage and post-processing (IPIMAR surveys: Movies+ software; IEO surveys: SonarData EchoView software).
- The set of species-specific TS-length relationships: at present, the new IPIMAR spring survey series, *PELAGOS*, takes into account the same agreed species-specific TS values than the IEO surveys, but for mackerel (b_{20} IPIMAR= – 82.0 vs b_{20} IEO= – 84.9).

Regarding their respective objectives, the *SAR* Portuguese November surveys, as presently planned, are mainly aimed at the mapping of the spatial distribution of sardine *Sardina pilchardus*, and anchovy *Engraulis encrasicolus*, and the provision of acoustic estimates of their abundance and biomass by length class and age groups, speciallly the computation of a sardine recruitment index (for the time being age-structured estimates are only available for sardine).

Although the main objective of the *ECOCÁDIZ* Spanish surveys was formerly the mapping and the size-based and age-structured acoustic assessment of the anchovy

SSB, and hence the survey's dates, mapping and acoustic estimates of all of those species susceptible of being assessed (according to their occurrence frequency and abundance levels in fishing stations) are also obtained. This same 'multi-species' or 'pelagic community' approach has also been adopted in the new *PELAGO* Spring Portuguese survey series, at least, for the time being, for the southern area (Subarea IXa South), which has involved a substantial increase in the number of fishing stations as compared with previous surveys. In any case, the progressive inclusion of alternative (continuous and discrete) samplers for collecting ancillary information on the physical and biological environment (including top predators) are shaping these surveys as true 'pelagic ecosystem surveys'.

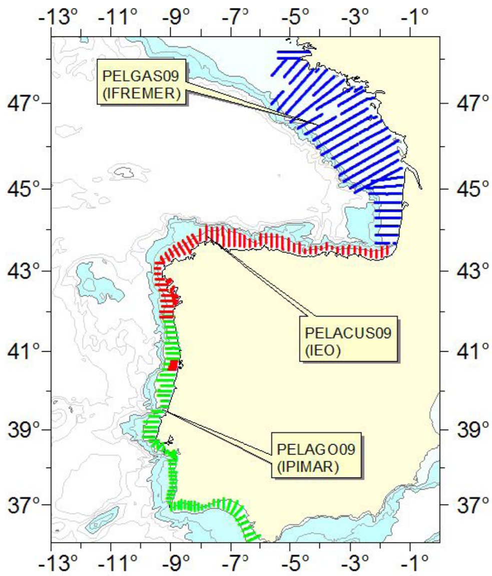


Figure B.3.1.1. Transects surveyed by the Spring *PELAGO*, *PELACUS* and *PELGAS* surveys. The early Summer *ECOCÁDIZ* surveys samples the same area that the *PELAGO* one in the Gulf of Cádiz waters (from Cape San Vicente to Cape Trafalgar).

B.3.2. DEPM Surveys

The Daily Egg Production Method (DEPM) for estimation of anchovy spawning biomass of the Gulf of Cádiz (South-Atlantic Iberian waters) is conducted every three years by IEO (Spain) since 2005. The first survey of this series was in 2005 (*BOCADEVA 0605*) and the second one in 2008 (*BOCADEVA 0608*). As described for the acoustic surveys, methods adopted for Gulf of Cádiz anchovy DEPM surveys follow the standards and recommendations given. **Figure B.3.2.1** shows the grid of egg sampling with the PairoVET sampler. **Table B.3.2.1** summarises the methodology used in these surveys (*BOCADEVA 0608* used as example) in order to obtain the eggs and adults samples.

Table B.3.2.1 ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. General sampling.**

Parameters	**Anchovy DEPM survey** ***BOCADEVA0608***
Survey area	(36º18'- 36º75'N – 6º22'- 8º92'W)
R/V	*Cornide de Saavedra*
Date	21/06-03/07
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	127
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25 and CTD SBE37
Flowmeter	Yes
CUFES stations	121
CUFES (335µm)	3 nmiles (sample unit)
Environmental data	Fluorescence(surface only),Temperature, Salinity
Adults	
Gears	Pelagic trawl
Trawls	26
Trawls time	During the daylight hours
Biological sampling:	On fresh material, on board of the R/V
Sample size	60 indiv randomly (30 female minimum); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin

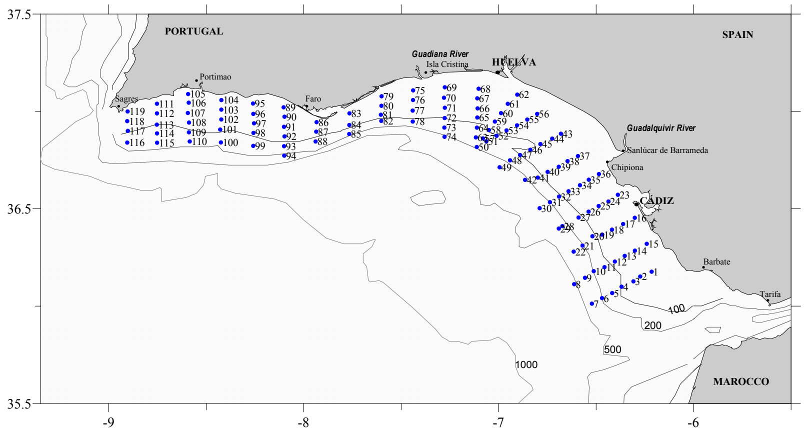


Figure B.3.2.1. Sampling grid adopted in the ***BOCADEVA*** **anchovy DEPM surveys series.**

Anchovy biomass estimation from these surveys was based on procedures and software adapted and developed during the WKRESTIM that took place between 27-30/04/2009 in Madrid (with e-participation of IPIMAR members from Lisbon), and validated by the WGACEGG. All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available at *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). The surveyed area (*A*) was calculated as the sum of the area represented by each station. The spawning area (*A*+) was delimited with the outer zero anchovy egg stations, and was calculated as the sum of the area represented by those stations. The model of egg development with temperature was derived from the incubation experiment carried out in Cádiz in July 2007

(Duarte *et al.*, 2007). A multinomial model was applied (Ibaibarriaga *et al.*, 2007, Bernal *et al.* 2008) considering only the interaction Age*Temp (other interactions were not significant). Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al.* (2008) and using *in situ* SST; a normal probability distribution was used with peak spawning assumed to be at 22:00h with 2h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution). Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. Finally, the total egg production was calculated as: $P_{tot} = P_0\ A+$

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (*W*), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (*Wnov*). The sex ratio (*R*) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (*Fobs*) in the sampled hydrated females and their gonad-free weight (*Wnov*) by a GLM. The fraction of females spawning per day (*S*) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985; i.e., weighted means and variances). All estimations and statistical analysis were performed using the R software. The spawning biomass was computed according to:

$$SSB = \frac{P_0 * Area+}{(F * S * R)/W}$$

The high uncertainty associated to the estimates (especially to those ones related to the egg sampling in the 2005 survey) was matter of concern for the 2009 WGANSA and it was recommended that the appropriateness of the egg sampling scheme were revised in the 2009 WGACEGG. It was concluded by this last working group that reducing the variance in future surveys can probably be attained by increasing the number of stations in the actual positive spawning areas (adaptive sampling) and perhaps by applying GAM based estimators.

B.4. Commercial CPUE

The annual series of both nominal fishing effort (number of fishing trips) and CPUE indices of anchovy in Division IXa are available for the Gulf of Cadiz Spanish purse-seine fishery since 1988. The data series from the Spanish purse-seine fishery off southern Galician waters (Sub-division IXa North) only comprise the 1995-1999 period whereas no data from the Portuguese purse-seine fisheries along the Division are available. Causes for this scarcity or even absence of data from the later fisheries must be found in their low anchovy annual catches during the last 3-4 decades and mainly by the fact that these fisheries target sardine.

Regarding the Gulf of Cadiz anchovy Spanish fishery, data on annual values of nominal effort (fishing trips targeting on anchovy) and CPUE by fleet type have routinely been provided to ICES. The series of effective effort and CPUE from all of the Spanish fleets exploiting the Gulf of Cadiz anchovy were provided for the first time to the WGMHSA in 2004. For such a purpose, vessels from single-purpose fleets were additionally differentiated according to their tonnage in heavy- (≥30 GRT) and light- (<30 GRT) tonnage vessels, rendering a total of 11 fleet types.

The standardisation procedure was performed in the last years by fitting quarterly log-transformed CPUE's from fleet types composing the fishery to a GLM (Robson, 1966; Gavaris, 1980) which only included the effects of quarter and fleet type (without any interaction), (ICES, 2007 a). Since 2008 the GLM fitting is performed with the following modifications to the original version: (a) the effect of missing values in the nominal CPUE data was smoothed by adding a constant value to data before their log-transformation (ICES, 2008 b). In this case, this constant was computed as the 10% of the average value for the whole nominal CPUE series resulting in log(CPUE adjusted) data. (b) the model includes year, quarter, fleet type and first order interaction effects. Reference fleet (*métier* or fleet type), year and season used in the standardisation were the Barbate's single-purpose high-tonnage fleet, the first year in the series, 1988, and the first quarter in the year, respectively. The updated series of standardised effort and CPUE from all of the fleets exploiting the fishery is provided to the WG each year. Annual and half-year standardised CPUE series for the whole fleet are computed from the quotient between the sum of raw quarterly catches and that of standardised quarterly efforts within each of the respective time periods.

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). At present, the series of CPUE indices is only used for interpreting the fleet's dynamics.

B.5. Other relevant data

C. Historical Stock Development

Model used:

For the time being, no analytical assessment model has been successfully applied. An exploratory assessment was under development until 2008. This exploratory assessment carried out so far was only performed for the anchovy population nucleus in the Gulf of Cádiz (Sub-division IXa-South: Algarve + Cádiz zones), the remaining resilient anchovy populations along the Atlantic Iberian façade of the Division being out of the scope of this assessment. The model used was an *ad hoc* seasonal separable model implemented and run on a spreadsheet for data exploration of anchovy catch-at-age data in IXa South since 1995 onwards. Given the nature of stock, short-lived, data in this model were analysed by half-year-periods, those from the Algarvian anchovy being previously compiled by applying Gulf of Cadiz ALKs. Weights at age in the catches were estimated as usual, whereas weights at age in the stock corresponded to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (reproductive season). The model was fitted to the updated half-year catch-at-age data until the assessment's last year and to the available acoustic estimates of anchovy aggregated biomass from the spring Portuguese surveys series only (including the acoustic estimate one year ahead of the assessment's last year).

Reasons for the choice of the above tuning index were: (a) the Spanish acoustic survey series (2004, 2006, 2007), was not used as a tuning index because of its shortness; (b) neither the DEPM-based anchovy SSB was considered since it has only 1 data point until the last year, but it was provided for comparison with the acoustic and model-predicted biomass estimates; (c) both Portuguese acoustic surveys series (spring and autumn surveys) were used as tuning indices in the past, assuming the same catchability coefficient. However, each survey series cover different fractions of the population so, the assumption of same catchability is probably inappropriate. Given that the model is unlikely to be able to estimate the extra parameter and that the spring survey series has a better coverage both in space and time, only this survey series was recently used.

The exploratory runs were recently performed under the following assumptions:

–Assessment only tuned by Spring Portuguese acoustic surveys (for the reasons above).

–Catches at age are assumed by the model to be linked by the Baranov catch equations.

–The relationship between the index series and the stock sizes is assumed linear.

–A constant selection pattern is assumed for the whole period.

–F values for 1995 (assessment's first year) are computed as an average of the Fs in subsequent years.

–F in the 2nd half-year in the assessment's last year estimated as a ratio of the F estimated in the 1st half by applying the ratio of seasonal Fs in the previous year (affected by a closure as well in the last years).

–No available Cages for the first half in the year ahead of the assessment's last year: assumed as the same ones that in first half in the assessment's last year.

–Wagesstock in the year ahead of the assessment's last year: average of the estimates in the 3 last years in the assessment.

–F in the 1st half year of the assessment's last year: average of estimated 1st half-year Fs counterparts for the same period of years.

– Log-residuals of Cages in the year ahead of the assessment's last year excluded from the minimisation routine whereas the residuals from the biomass acoustic estimate in the year ahead of the assessment's last year are included in the model fitting.

Runs explored last years consisted in:

- **RUN 1**: Acoustic surveys as a relative tuning index and a weighting factor= 1.
- **RUN 2**: Acoustic surveys as a relative tuning index and a weighting factor= 6.
- **RUN 3**: Acoustic surveys as an absolute tuning index and a weighting factor= 1.

An upweighting factor of 6 for the acoustic estimates in RUN 2 was selected in order to balance the influence of their annual residuals in relation to those from catches at age (3 age groups x 2 semesters in a year). The rational for RUN 3 is the similarity between the estimates by the Portuguese survey and the Spanish DEPM in 2005 (around 14,000 tonnes).

Parameters estimated are selectivity at age for both half-year-periods in relation to the reference age (age 1), recruitment, an average SSB, survey catchability (Q) and annual F values per half-year-period. Parameters are estimated by minimising the sum of squares of the log-residuals from the catch-at-age and the acoustics biomass data.

The exploratory assessments performed so far with this *ad hoc* model have not been recommended as a basis for predictions or advice. The immediate reason is that it usually estimated a large drop in fishing mortality and rapid increase in stock abundance in recent years, which is not supported by the data or the development of the fishery. The residuals showed large clusters over time, indicating that the selection may not be constant, one of the model's assumptions. Migration between the main nucleus in the Gulf of Cádiz and adjacent areas might be one of the causes explaining the discrepancies found in the assessment and it should be properly studied. The exploratory model utilised so far does not provide any reliable information about the true levels of both the stock, F and Catch/SSB ratios since the assessment is not still properly scaled.

For all the above reasons in 2009 was preferred to do not perform any exploratory assessment with this model. Instead of this, the provision of advice relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data, both fishery-dependent and –independent information (*i.e.*, landings, fishing effort, cpue, survey estimates).

Advice is framed in a precautionary manner to limit exploitation and, accordingly, the basis for advice is average catches over a reference period.

Software used: the exploratory model was implemented and run in a MicroSoft Excel spreadshet.

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes			
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1			
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1. Initial stock size:
2. Natural mortality:
3. Maturity:
4. F and M before spawning:
5. Weight at age in the stock:
6. Weight at age in the catch:
7. Exploitation pattern:
8. Intermediate year assumptions:
9. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

H. Other Issues

I. References

Bernal, M., Ibaibarriaga, L., Lago de Lanzos, A., Lonergan, M.E., Hernandez, C., Franco, C., Rasines, I., Valdes, L. and Borchers, D.L., 2008. Using multinomial models to analyse data from Iberian sardine egg incubation experiments: a comparison with traditional techniques. *ICES J. Mar. S*ci., 65:51–59.

Carrera, P. 1999. Acoustic survey JUVESU 0899: preliminary results. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2000/ACFM:05.

Carrera, P. 2001. Acoustic abundance estimates from the multidisciplinary survey PELACUS 0401. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2002/ACFM:06.

Carrera, P., Villamor, B., Abaunza, P. 1999. Report of the acoustic survey PELACUS 0399: results on sardine, mackerel, horse mackerel and anchovy. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2000/ACFM:05.

Duarte, J, M. Bernal, M.P. Jiménez, J. Canoura, E. García, A. Juárez, I. Muñoz, 2007. Egg development model for anchovy (Engraulis encrasicolus) in the Gulf of Cádiz. ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG).

García-Isarch, E., Millán, M., Ramos, F., García-Santamaría, T and Burgos, C. 2008. Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa. Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa, available at http://www.smallpelagics2008.org/index.html

Gavaris, S., 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. *Can. J. Fish. Aquat. Sci*., 37: 2272-2275.

Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D.L., Lonergan, M.E., and Wood, S.N. 2007. Characterization of stage-classified biological processes using multinomial models: a case study of anchovy (*Engraulis encrasicolus*) eggs in the Bay of Biscay. *Canadian Journal of Fisheries and Aquatic Sciences*, 64:539–553.

ICES, 1986. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. Lisbon, 1-4 April 1986. ICES CM 1986/H:27. 7 pp.

ICES, 1998. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. A Coruña, 30-31 January 1998. ICES CM 1998/G:2. 17 pp.

ICES. 2000. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES, C.M. 2000/ACFM:05.

ICES. 2001. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES, C.M. 2001/ACFM:06.

ICES, 2006 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy. ICES CM 2006/ ACFM: 36.

ICES, 2006 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG), 24-28 October 2005, Vigo, Spain. ICES, C.M. 2006/LRC: 01. 126 pp.

ICES, 2006 c. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 27 November-1 December 2006, Lisbon, Portugal. ICES C.M. 2006/LRC:18. 169 pp.

ICES 2007 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES CM 2007/ACFM:31

ICES 2007 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovyin ICES areas VIII and IX (WGACEGG). ICES CM 2007/LRC:16

ICES. 2008 a. Report of the Working Group on Anchovy (WGANC), 13 - 16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

ICES. 2008 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17. 183 pp.

ICES. 2009 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 16–20 November 2009, Lisboa, Portugal. ICES CM 2009/LRC:20. 181 pp.

Millán, M., 1992. Descripción de la pesquería de cerco en la Región Sur-atlántica Española y Atlántico-Norte Marroquí. *Informes Técnicos Instituto Español Oceanografía* 136, 70pp.

Millán, M. 1999. Reproductive characteristics and condition status of anchovy *(Engraulis encrasicolus*, L.) from the Bay of Cadiz (S.W. Spain). *Fish. Res*., 41: 73-86.

Picquelle, S., Stauffer, G., 1985. Parameter estimation for an egg production method of northern anchovy biomass assessment. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. *NOAA Tech. Rep.* NMFS 36: 43-50 pp.

Robson, D.S., 1966. Estimation of the relative fishing power of individual ships. *ICNAF Research Bulletin*, 3:5-14.

Silva, L., Castro J., Ramos, F. and Punzón A., 2007. Identification of métiers in the Gulf of Cadiz Spanish purse-seine fishery (ICES Subdivision IXa-South). Working document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2007/ACFM:31.

Stock Annex Anchovy in Division IXa

Quality Handbook ANNEX: A.5.2

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Anchovy in Division IXa
Working Group:	WGANSA (Working Group on the Assessment of Anchovy and Sardine)
Date:	24th June 2011
Revised by	Fernando Ramos

A. General

A.1. Stock definition

The distribution of anchovy in the Division IXa is nowadays mainly concentrated in the Spanish waters of the Gulf of Cádiz (Sub-division IXa-South, **Figure A.1.1**). Outside the main nucleus of the Gulf of Cádiz, resilient anchovy populations have been detected in all fishery independent surveys (ICES, 2007 b) and previous records on large catches in ICES areas IXa North, Central North and South (Algarve) suggest that abundance in those areas have been high in early years of the time series. In the south, outside the Gulf of Cádiz anchovy is abundant to the East of the Strait of Gibraltar, in the Mediterranean Sea (GFCM, 2002) as well as in northern Africa, where a combined Spanish-Morocco fishery produces landings of up to 12000 tn (Millán, 1992; García-Isarch *et al*., 2008).

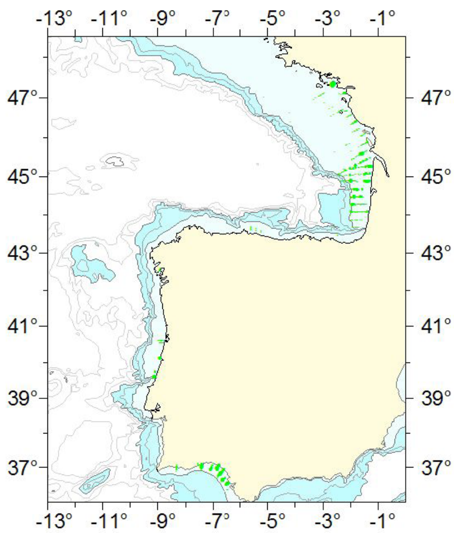


Figure A.1.1. Distribution of acoustic energy allocated to anchovy from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b).

A.2. Fishery

Anchovy harvesting along the Division IXa is at present carried out by the following fleets:

- Portuguese purse-seine fleet
- Portuguese trawl fleet
- Portuguese artisanal fleet (although fishing with artisanal purse-seines)
- Spanish purse-seine fleet
- Spanish trawl fleet (in Subarea IXa-South (Cádiz))

Purse-seine fleets are the main responsibles for the anchovy fishery in the Division (usually more than 90% of total annual landings in the Division). Spanish fleets operate in Sub-divisions IXa-North (Southern Galicia) and IXa-South (Gulf of Cadiz), and the Portuguese ones along its national peninsular fishing grounds (Sub-divisions IXa-Central North, -Central South and South (Algarve)). Most of the fishery for this anchovy stock in the Division takes place in Sub-division IXa-South (C), where anchovy is the target species. The fleets in the northern part of Division IXa (targeting sardine) occasionally target anchovy when abundant, as occurred in 1995.

Data on number and technical characteristics for the Portuguese fleets are available for 2006 (ICES, 2007 a). The Portuguese purse- seine fleet (n =121 in 2006) presently ranges in size from 10.5 to 27 m (mean vessel length = 20 m) and between 71 to 447 HP (mean = 249) in vessel engine power. Portuguese producers organisations traditionally agree a voluntary closure of the purse-seine fishery in the northern part (north of the 39º 42” North) of the Portuguese coast. This closure usually lasted from the 1st of February to 31 of March. Since 2006, the closure, also lasting 2 months, may however be selected between 1st of February and 30th of April (*i.e.* boats stopped fishing in February to March or in March to April).

Since 1999 the number of Gulf of Cadiz purse-seiners operated by Spain has oscillated between 145 (in 2004) and 84 (in 2010) vessels, and the vessels within this fleet targeting anchovy between 76 (2010) and 135 (2004) vessels. As it has been previously reported (ICES, 2007 a), the observed fluctuations during this period were mainly motivated by the ending of the fifth EU-Morocco Fishery Agreement (in 1999, which affected the heavy-tonnage fleet in the following two years: acceptation of tie-up scheme in 2000 and 2001), the rising of the light-tonnage purse seiners on those dates, and the fluctuations showed by the multipurpose vessels. These vessels fishing for anchovy account for more than 85% of the whole fleet during the available series, evidencing the importance of anchovy as a target species in the Gulf of Cadiz purse-seine fishery. Since 2008 the EU–Morocco Fishery Agreement was renewed, and part of the fleet (the heavier/larger vessels) devoted to the anchovy fishing in the Moroccan grounds, which entailed an important reduction of the fishing effort in the Gulf of Cadiz.

A first attempt of identifying *métiers* in this last fleet/fishery was presented in the 2007 WGMHSA meeting (ICES, 2007 a). This study (see also Silva *et al*., 2007, for details) focused on the application of a non-hierarchical clustering data-mining technique (*CLARA*, *C*lustering *LAR*ge *A*pplications) for classifying the fishing trips from 2003 to 2005. The classification of individual trips was only based on the species composition of landings from logbooks, hence the preliminary character of this study. Up to four clusters (catch profiles) were identified from each of the annual datasets according to the targeted species: 1) trips targeting anchovy, 2) trips targeting sardine; 3) trips targeting a mackerel (*Scomber* spp.) species mixture; and 4) trips targeting an anchovy and sardine mixture. The first three groupings were considered as clearly identifiable *métiers* according to the knowledge on the fishery. At present no comparable information on Portuguese *métiers* is available.

The regulatory measures in place for the Spanish anchovy purse-seine fishing in this Division were the same as for the previous years and are summarized as follows:

- Minimum landing size: 10 cm total length;
- Minimum vessel tonnage of 20 GRT with temporary exemption;
- Maximum engine power: 450 h.p;
- Purse-seine maximum length: 450 m;
- Purse-seine maximum depth: 80 m;
- Minimum mesh size: 14 mm;
- Fishing time limited to 5 days per week, from Monday to Friday;
- Cessation of fishing activities from Saturday 00:00 hrs to Sunday 12:00 hrs;
- Fishing prohibition inside bays and estuaries.

Until 1997, the Spanish purse-seine fleet voluntary closed the fishery each year from December to February in the Gulf of Cadiz (Sub-division IXa-South(C)). Since 2004, two complementary sets of management measures have been in force in this part of the Sub-division. The first one is the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months from 30th October and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid February 2008; 1st December 2008 to 28th February 2009), accompanied by a subsidized tie-up scheme for the purse-seine fleet. The expected subsidized 3-month closure from 2009 mid-autumn to the 2010 mid-winter was restricted to one month only, in December 2009, although the fishery was practically closed since November 2009 until February 2010 for persistent bad sea conditions during all these months. This same scheme was accomplished for the 2010-2011 autumn/winter closure. This plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (6000 kg of sardine-anchovy mixing, but the catch of each of these species cannot exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight may contain fish below the established minimum landing size (10 cm), but fish must always be ≥9 cm.

The effort exerted by the entire purse-seine fleet since 1997 has been high (even with the fishing closures since 2004 on). While the effects of the fishery closures have not been formally evaluated, it appears that they have limited a further expansion of effort.

The second management action in force since 15th of July 2004 is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure A.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA. The effects of such closures and MPA in the Gulf of Cádiz anchovy recruitment are not still possible to be directly assessed. In any case, the implementation of both of these measures should benefit the stock.

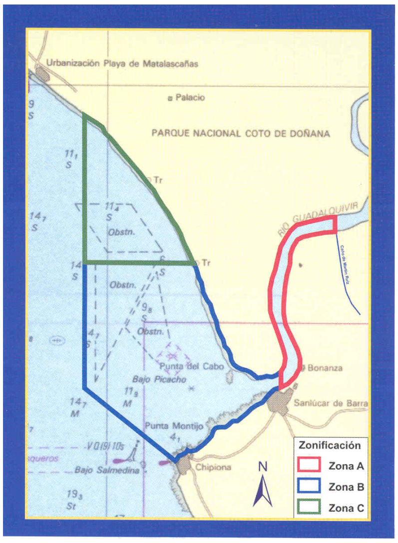


Figure A.2.1. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Sub-division IXa South).

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species, and for cetaceans and sea-birds. The recruitment depends strongly on environmental factors. Ruíz *et al*. (2006, 2007) evidenced the clear influence that meteorological and oceanographic factors have on the distribution of anchovy early life stages in shelf waters of the north-eastern sector of the Gulf of Cadiz. The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favor the existence of warm and chlorophyll-rich waters in the area, thus offering a favorable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favorable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

The anchovy population in Subdivision IXa-South appears to be well established and relatively independent of populations in other parts of the Division. These other populations seem to be abundant only when suitable environmental conditions occur.

B. Data

B.1. Commercial catch

Portuguese annual landings from their respective Sub-divisions are available since 1943. Spanish landings started to be available since 1989.

No information on anchovy discarding in the Division IXa has been available until 2005. That year several pilot surveys for estimating discards in the Gulf of Cadiz Spanish fisheries (trawl, purse-seine and artisanal) were conducted by an IEO observer's programme onboard commercial vessels lasting five months and covering the whole study area. Preliminary results (average estimates from 6 purse-seine trips – 13 hauls –, not raised to total annual landings) from these pilot surveys were described in ICES (2006 a) although there were concerns about the reliability of such estimates and the ratios derived from them due to their extremely high associated CVs. On the other hand, discarded anchovies were of commercial and legal size, between 10 and 15 cm (mode at 12.5 cm), but reasons for discarding anchovy were not reported to that WG. Anchovy catches in sampled trips from the bottom otter-trawl fleet were negligible. Slipping practices are probable but not directly evidenced by sampling onboard. New data on anchovy discarding have started to be gathered since 2009 on within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR).

B.2. Biological

Annual and quarterly length compositions of anchovy landings in Division IXa are routinely provided by Spain for its Sub-division IXa-South(C). This series dates back to 1988. Length distributions for the Spanish fishery in Sub-division IXa-North are only available for the 1995-1999 period and they were characterized, with the exception of 1998, by fish larger than 12.5 cm (ICES, 2007 a). At present, Portugal does not provide either length distributions or catches at age of their anchovy landings in Division IXa due to their scarce catches.

Catches at age from the whole Division IXa are only available from the Spanish Gulf of Cadiz fishery (Sub-division IXa South (C)). Problems with ageing/reading Gulf of Cádiz anchovy otoliths still persist.

The age composition of the Gulf of Cadiz anchovy in Spanish landings is available since 1988 (see ICES, 2007 a, for tabulated data from years not shown in this report). The catch-at-age series shows that 0, 1 and 2 age groups support the Gulf of Cadiz anchovy fishery and that the success of this fishery largely depends on the abundance of 1 year-old anchovies. The contribution of age-2 anchovies usually accounts for less than 1% of the total annual catch (except in 1997, 1999, the 2001-2003 period and since 2008 on, with contributions oscillating between 2% and 14%). Likewise, age-3 anchovies only occurred in the first quarter in 1992 and since 2008 on, but the importance of this age class in the total annual catch those years was insignificant. Inter-annual variations in the contribution of each age group in landings throughout the historical series are described in ICES (2007 a, 2008 a). Weights at age in the stock for the Gulf of Cádiz anchovy correspond to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (throughout the spawning season).

Catches at age from the Spanish fishery in Sub-division IXa North are presently not available since commercial landings used to be negligible. Mean length- and mean weight-at-age data are only available for Gulf of Cadiz anchovy catches. The analysis of small samples of otoliths from Subdivision IXa North in 1998 and 1999 rendered estimates of mean sizes at ages 1, 2 and 3 of 15.5 cm, 17.6 cm and 17.9 cm respectively (ICES, 2000, 2001). A sample of 78 otoliths from the same area was collected during the *PELACUS 0402* acoustic survey. Mean lengths at age 1 and 2+ were 13.7 cm and 17.0 cm (Begoña Villamor, pers. comm.). Comparisons of these estimates with the ones from the Gulf of Cadiz anchovy indicate that southern anchovies attain smaller sizes at age.

Previous biological studies based on commercial samples of Gulf of Cadiz anchovy (Millán, 1999) indicate that its spawning season extends from late winter to early autumn with a peak spawning time for the whole population occurring from June to August. Length at maturity was estimated in that study at 11.09 cm in males and 11.20 cm in females. However, it was evidenced that size at maturity may vary between years, suggesting a high plasticity in the reproductive process in response to environmental changes. Annual maturity ogives for Gulf of Cadiz anchovy are routinely provided to ICES. They represent the estimated proportion of mature fish at age in the total catch during the spawning period (second and third quarters) after raising the ratio of mature-at-age by size class in monthly samples to the monthly catch numbers-at-age by size class.

Natural mortality is unknown for this stock. By analogy with anchovy in Sub-area VIII, natural mortality is probably high (M=1.2 is used for the data exploration).

B.3. Surveys

B.3.1. Acoustic surveys

The IPIMAR's Portuguese surveys series (*SAR* and *SARNOV* series, carried mainly out with the R/V *Noruega*) correspond to those ones routinely performed for the acoustic estimation of the sardine abundance in Division IXa off the Portuguese continental shelf and Gulf of Cadiz, during March-April (sardine late spawning season) and November (early spawning and recruitment season). Since 2007 on, the Spring surveys are being planned as 'pelagic community' surveys. This shift in planning mainly entailed, as compared with previous years, a substantial increase in the number of fishing stations in the Sub-division IXa-South, where the species diversity is higher, changing the series its former name by the one of *PELAGO* surveys. Anchovy estimates from these survey series started to be available since November 1998.

Spanish 'pelagic community' acoustic surveys have been conducted by IEO in Subdivision IXa North and Division VIIIc since 1983 (the spring *PELACUS* series with the R/V *Thalassa*). Results from these surveys for the Sub-division IXa North have shown the scarce presence or even the absence of anchovy in this area (Carrera, 1999, 2001; Carrera *et al.*, 1999). This situation still continues in the most recent years (surveys in the 2003-2010 period, see Porteiro *et al.*, 2005; Iglesias *et al.*, 2007).

Spanish acoustic surveys in the Gulf of Cadiz waters (Sub-division IXa-South) have been sporadically conducted by IEO from 1993 to 2003. A consistent yearly series of early summer acoustic surveys (*ECOCÁDIZ* series) estimating the anchovy abundance in the Subdivision IXa South (Algarve and Gulf of Cadiz) started in 2004. Surveys in this new series are also planned under the 'pelagic community' approach. Unfortunately, this series may show some gaps in those years coinciding (same dates and surveyed area) with the conduction of the (initially triennial) anchovy DEPM survey because of the available ship time (R/V *Cornide de Saavedra*). In 2009 two additional surveys to the conventional one were also conducted, but mainly restricted to the Spanish waters. So, in July 2009 a complementary and almost synchronous survey to the *ECOCÁDIZ 0609* conventional survey was carried out with a small-draught vessel, R/V *Francisco de Paula Navarro*, aiming to survey shallower waters than 20 m depth not sampled by no vessel, either Spanish or Portuguese, routinely surveying the study area (*ECOCÁDIZ-COSTA 0709* survey). The acoustic estimates from this survey were separately given in the 2010 WG report from its conventional survey awaiting an intercalibration of data for a further merging of estimates if possible.

In October 2009 a new autumn survey (*ECOCÁDIZ-RECLUTAS 1009*, R/V *Emma Bardán*), aimed to acoustically estimate the abundance and biomass of Gulf of Cádiz anchovy recruits, was planned to be conducted throughout the easternmost Portuguese waters and those waters off the central part of the Spanish Gulf of Cádiz, waters that supposedly include the main Gulf of Cádiz anchovy recruitment area. Unfortunately, the shortness of the available ship-time to cover a more intensive acoustic sampling grid (*i.e.* 4 nm spaced transects from 100 to 7-10 m depth) than the conventionally planned in standard surveys and some other unforeseen circumstances (e.g., a one-day technical stop for crew replacement, 2-day military manoeuvres just in the middle of both the survey area and calendar) prevented finally from covering the whole survey area. For the above reasons, the surveyed area was restricted to a relatively small central area in front the Guadalquivir river mouth rendering a very probable underestimation of the recruits abundance. Continuity of this survey in following years will necessarily depend on external (EC) funding.

All these surveys followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Subareas VIII and IX (ICES, 1986; 1998) and recommendations given by the WGACEGG (ICES, 2006 b,c). The methodological differences between these recent surveys are not considered by the WGACEGG as important as to prevent from any comparison between their results, such differences being basically due to:

- The echo-sounder and working frequencies used (IPIMAR surveys: Simrad EK 500 working at 38 and 120 KHz; IEO surveys since 2007 onwards: Simrad EK 60 working at 18, 38, 70, 120, and 200 KHz).
- The fishing gear used as sampler for echo-trace identification/confirmation and gathering biological data (IPIMAR surveys: bottom and pelagic trawl gears; IEO surveys: pelagic trawl).
- The software used for data storage and post-processing (IPIMAR surveys: Movies+ software; IEO surveys: SonarData EchoView software).
- The set of species-specific TS-length relationships: at present, the new IPIMAR spring survey series, *PELAGOS*, takes into account the same agreed species-specific TS values than the IEO surveys, but for mackerel (b_{20} IPIMAR= – 82.0 vs b_{20} IEO= – 84.9).

Regarding their respective objectives, the *SAR* Portuguese November surveys, as presently planned, are mainly aimed at the mapping of the spatial distribution of sardine *Sardina pilchardus*, and anchovy *Engraulis encrasicolus*, and the provision of acoustic estimates of their abundance and biomass by length class and age groups, speciallly the computation of a sardine recruitment index (for the time being age-structured estimates are only available for sardine).

Although the main objective of the *ECOCÁDIZ* Spanish surveys was formerly the mapping and the size-based and age-structured acoustic assessment of the anchovy

SSB, and hence the survey's dates, mapping and acoustic estimates of all of those species susceptible of being assessed (according to their occurrence frequency and abundance levels in fishing stations) are also obtained. This same 'multi-species' or 'pelagic community' approach has also been adopted in the new *PELAGO* Spring Portuguese survey series, at least, for the time being, for the southern area (Subarea IXa South), which has involved a substantial increase in the number of fishing stations as compared with previous surveys. In any case, the progressive inclusion of alternative (continuous and discrete) samplers for collecting ancillary information on the physical and biological environment (including top predators) are shaping these surveys as true 'pelagic ecosystem surveys'.

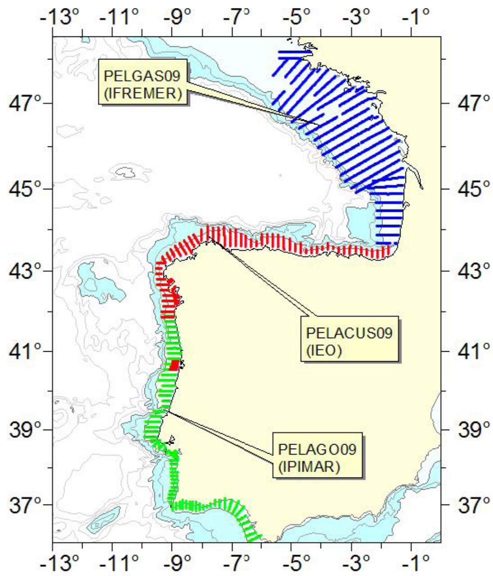


Figure B.3.1.1. Transects surveyed by the Spring *PELAGO*, *PELACUS* and *PELGAS* surveys. The early Summer *ECOCÁDIZ* surveys samples the same area that the *PELAGO* one in the Gulf of Cádiz waters (from Cape San Vicente to Cape Trafalgar).

B.3.2. DEPM Surveys

The Daily Egg Production Method (DEPM) for estimation of anchovy spawning biomass of the Gulf of Cádiz (South-Atlantic Iberian waters) is conducted every three years by IEO (Spain) since 2005. The first survey of this series was in 2005 (*BOCADEVA 0605*) and the second one in 2008 (*BOCADEVA 0608*). As described for the acoustic surveys, methods adopted for Gulf of Cádiz anchovy DEPM surveys follow the standards and recommendations given. **Figure B.3.2.1** shows the grid of egg sampling with the PairoVET sampler. **Table B.3.2.1** summarises the methodology used in these surveys (*BOCADEVA 0608* used as example) in order to obtain the eggs and adults samples.

Table B.3.2.1 *BOCADEVA 0608* Gulf of Cádiz anchovy DEPM survey. General sampling.

Parameters	**Anchovy DEPM survey** ***BOCADEVA0608***
Survey area	(36º18'- 36º75'N – 6º22'- 8º92'W)
R/V	*Cornide de Saavedra*
Date	21/06-03/07
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	127
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25 and CTD SBE37
Flowmeter	Yes
CUFES stations	121
CUFES (335µm)	3 nmiles (sample unit)
Environmental data	Fluorescence(surface only),Temperature, Salinity
Adults	
Gears	Pelagic trawl
Trawls	26
Trawls time	During the daylight hours
Biological sampling:	On fresh material, on board of the R/V
Sample size	60 indiv randomly (30 female minimum); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin

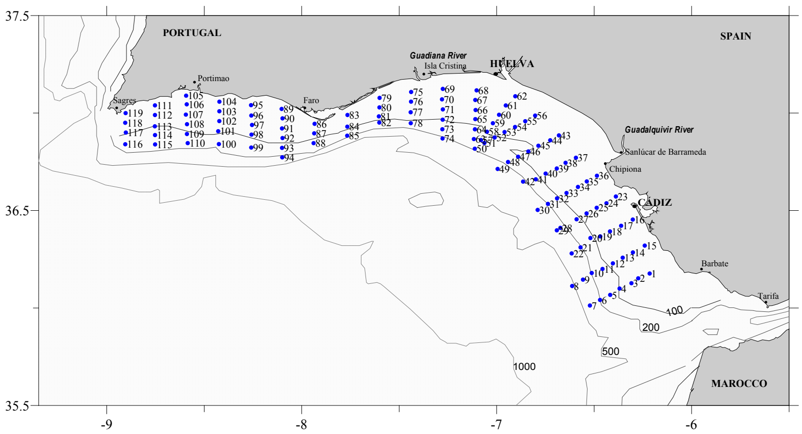


Figure B.3.2.1. Sampling grid adopted in the *BOCADEVA* anchovy DEPM surveys series.

Anchovy biomass estimation from these surveys was based on procedures and software adapted and developed during the WKRESTIM that took place between 27-30/04/2009 in Madrid (with e-participation of IPIMAR members from Lisbon), and validated by the WGACEGG. All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available at *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). The surveyed area (*A*) was calculated as the sum of the area represented by each station. The spawning area (*A+*) was delimited with the outer zero anchovy egg stations, and was calculated as the sum of the area represented by those stations. The model of egg development with temperature was derived from the incubation experiment carried out in Cádiz in July 2007

(Duarte *et al*., 2007). A multinomial model was applied (Ibaibarriaga *et al*., 2007, Bernal *et al*. 2008) considering only the interaction Age*Temp (other interactions were not significant). Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST; a normal probability distribution was used with peak spawning assumed to be at 22:00h with 2h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution). Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. Finally, the total egg production was calculated as: $P_{tot} = P_0 A+$

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (*W*), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (*Wnov*). The sex ratio (*R*) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (*Fobs*) in the sampled hydrated females and their gonad-free weight (*Wnov*) by a GLM. The fraction of females spawning per day (*S*) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985; i.e., weighted means and variances). All estimations and statistical analysis were performed using the R software. The spawning biomass was computed according to:

$$SSB = \frac{P_0 * Area+}{(F * S * R)/W}$$

The high uncertainty associated to the estimates (especially to those ones related to the egg sampling in the 2005 survey) was matter of concern for the 2009 WGANSA and it was recommended that the appropriateness of the egg sampling scheme were revised in the 2009 WGACEGG. It was concluded by this last working group that reducing the variance in future surveys can probably be attained by increasing the number of stations in the actual positive spawning areas (adaptive sampling) and perhaps by applying GAM based estimators.

B.4. Commercial CPUE

The annual series of both nominal fishing effort (number of fishing trips) and CPUE indices of anchovy in Division IXa are available for the Gulf of Cadiz Spanish purse-seine fishery since 1988. The data series from the Spanish purse-seine fishery off southern Galician waters (Sub-division IXa North) only comprise the 1995-1999 period whereas no data from the Portuguese purse-seine fisheries along the Division are available. Causes for this scarcity or even absence of data from the later fisheries must be found in their low anchovy annual catches during the last 3-4 decades and mainly by the fact that these fisheries target sardine.

Regarding the Gulf of Cadiz anchovy Spanish fishery, data on annual values of nominal effort (fishing trips targeting on anchovy) and CPUE by fleet type have routinely been provided to ICES. The series of effective effort and CPUE from all of the Spanish fleets exploiting the Gulf of Cadiz anchovy were provided for the first time to the WGMHSA in 2004. For such a purpose, vessels from single-purpose fleets were additionally differentiated according to their tonnage in heavy- (≥30 GRT) and light- (<30 GRT) tonnage vessels, rendering a total of 11 fleet types.

The standardisation procedure was performed in the last years by fitting quarterly log-transformed CPUE's from fleet types composing the fishery to a GLM (Robson, 1966; Gavaris, 1980) which only included the effects of quarter and fleet type (without any interaction), (ICES, 2007 a). Since 2008 the GLM fitting is performed with the following modifications to the original version: (a) the effect of missing values in the nominal CPUE data was smoothed by adding a constant value to data before their log-transformation (ICES, 2008 b). In this case, this constant was computed as the 10% of the average value for the whole nominal CPUE series resulting in log(CPUE adjusted) data. (b) the model includes year, quarter, fleet type and first order interaction effects. Reference fleet (*métier* or fleet type), year and season used in the standardisation were the Barbate's single-purpose high-tonnage fleet, the first year in the series, 1988, and the first quarter in the year, respectively. The updated series of standardised effort and CPUE from all of the fleets exploiting the fishery is provided to the WG each year. Annual and half-year standardised CPUE series for the whole fleet are computed from the quotient between the sum of raw quarterly catches and that of standardised quarterly efforts within each of the respective time periods.

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). At present, the series of CPUE indices is only used for interpreting the fleet's dynamics.

B.5. Other relevant data

C. Historical Stock Development

Model used:

For the time being, no analytical assessment model has been successfully applied. An exploratory assessment was under development until 2008. This exploratory assessment carried out so far was only performed for the anchovy population nucleus in the Gulf of Cádiz (Sub-division IXa-South: Algarve + Cádiz zones), the remaining resilient anchovy populations along the Atlantic Iberian façade of the Division being out of the scope of this assessment. The model used was an *ad hoc* seasonal separable model implemented and run on a spreadsheet for data exploration of anchovy catch-at-age data in IXa South since 1995 onwards. Given the nature of stock, short-lived, data in this model were analysed by half-year-periods, those from the Algarvian anchovy being previously compiled by applying Gulf of Cadiz ALKs. Weights at age in the catches were estimated as usual, whereas weights at age in the stock corresponded to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (reproductive season). The model was fitted to the updated half-year catch-at-age data until the assessment's last year and to the available acoustic estimates of anchovy aggregated biomass from the spring Portuguese surveys series only (including the acoustic estimate one year ahead of the assessment's last year).

Reasons for the choice of the above tuning index were: (a) the Spanish acoustic survey series (2004, 2006, 2007), was not used as a tuning index because of its shortness; (b) neither the DEPM-based anchovy SSB was considered since it has only 1 data point until the last year, but it was provided for comparison with the acoustic and model-predicted biomass estimates; (c) both Portuguese acoustic surveys series (spring and autumn surveys) were used as tuning indices in the past, assuming the same catchability coefficient. However, each survey series cover different fractions of the population so, the assumption of same catchability is probably inappropriate. Given that the model is unlikely to be able to estimate the extra parameter and that the spring survey series has a better coverage both in space and time, only this survey series was recently used.

The exploratory runs were recently performed under the following assumptions:

–Assessment only tuned by Spring Portuguese acoustic surveys (for the reasons above).

–Catches at age are assumed by the model to be linked by the Baranov catch equations.

–The relationship between the index series and the stock sizes is assumed linear.

–A constant selection pattern is assumed for the whole period.

–F values for 1995 (assessment's first year) are computed as an average of the Fs in subsequent years.

–F in the 2nd half-year in the assessment's last year estimated as a ratio of the F estimated in the 1st half by applying the ratio of seasonal Fs in the previous year (affected by a closure as well in the last years).

–No available Cages for the first half in the year ahead of the assessment's last year: assumed as the same ones that in first half in the assessment's last year.

–Wagesstock in the year ahead of the assessment's last year: average of the estimates in the 3 last years in the assessment.

–F in the 1st half year of the assessment's last year: average of estimated 1st half-year Fs counterparts for the same period of years.

– Log-residuals of Cages in the year ahead of the assessment's last year excluded from the minimisation routine whereas the residuals from the biomass acoustic estimate in the year ahead of the assessment's last year are included in the model fitting.

Runs explored last years consisted in:

- **RUN 1**: Acoustic surveys as a relative tuning index and a weighting factor= 1.
- **RUN 2**: Acoustic surveys as a relative tuning index and a weighting factor= 6.
- **RUN 3**: Acoustic surveys as an absolute tuning index and a weighting factor= 1.

An upweighting factor of 6 for the acoustic estimates in RUN 2 was selected in order to balance the influence of their annual residuals in relation to those from catches at age (3 age groups x 2 semesters in a year). The rational for RUN 3 is the similarity between the estimates by the Portuguese survey and the Spanish DEPM in 2005 (around 14,000 tonnes).

Parameters estimated are selectivity at age for both half-year-periods in relation to the reference age (age 1), recruitment, an average SSB, survey catchability (Q) and annual F values per half-year-period. Parameters are estimated by minimising the sum of squares of the log-residuals from the catch-at-age and the acoustics biomass data.

The exploratory assessments performed so far with this *ad hoc* model have not been recommended as a basis for predictions or advice. The immediate reason is that it usually estimated a large drop in fishing mortality and rapid increase in stock abundance in recent years, which is not supported by the data or the development of the fishery. The residuals showed large clusters over time, indicating that the selection may not be constant, one of the model's assumptions. Migration between the main nucleus in the Gulf of Cádiz and adjacent areas might be one of the causes explaining the discrepancies found in the assessment and it should be properly studied. The exploratory model utilised so far does not provide any reliable information about the true levels of both the stock, F and Catch/SSB ratios since the assessment is not still properly scaled.

For all the above reasons in 2009 was preferred to do not perform any exploratory assessment with this model. Instead of this, the provision of advice relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data, both fishery-dependent and –independent information (*i.e.*, landings, fishing effort, cpue, survey estimates).

Advice is framed in a precautionary manner to limit exploitation and, accordingly, the basis for advice is average catches over a reference period.

Software used: the exploratory model was implemented and run in a MicroSoft Excel spreadshet.

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes			
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1			
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

10. Initial stock size:

11. Natural mortality:

12. Maturity:

13. F and M before spawning:

14. Weight at age in the stock:

15. Weight at age in the catch:

16. Exploitation pattern:

17. Intermediate year assumptions:
18. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

H. Other Issues

I. References

Bernal, M., Ibaibarriaga, L., Lago de Lanzos, A., Lonergan, M.E., Hernandez, C., Franco, C., Rasines, I., Valdes, L. and Borchers, D.L., 2008. Using multinomial models to analyse data from Iberian sardine egg incubation experiments: a comparison with traditional techniques. *ICES J. Mar. S*ci., 65:51–59.

Carrera, P. 1999. Acoustic survey JUVESU 0899: preliminary results. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2000/ACFM:05.

Carrera, P. 2001. Acoustic abundance estimates from the multidisciplinary survey PELACUS 0401. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2002/ACFM:06.

Carrera, P., Villamor, B., Abaunza, P. 1999. Report of the acoustic survey PELACUS 0399: results on sardine, mackerel, horse mackerel and anchovy. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2000/ACFM:05.

Duarte, J, M. Bernal, M.P. Jiménez, J. Canoura, E. García, A. Juárez, I. Muñoz, 2007. Egg development model for anchovy (Engraulis encrasicolus) in the Gulf of Cádiz. ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG).

García-Isarch, E., Millán, M., Ramos, F., García-Santamaría, T and Burgos, C. 2008. Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa. Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa, available at http://www.smallpelagics2008.org/index.html

Gavaris, S., 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. *Can. J. Fish. Aquat. Sci*., 37: 2272-2275.

Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D.L., Lonergan, M.E., and Wood, S.N. 2007. Characterization of stage-classified biological processes using multinomial models: a case study of anchovy (*Engraulis encrasicolus*) eggs in the Bay of Biscay. *Canadian Journal of Fisheries and Aquatic Sciences*, 64:539–553.

ICES, 1986. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. Lisbon, 1-4 April 1986. ICES CM 1986/H:27. 7 pp.

ICES, 1998. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. A Coruña, 30-31 January 1998. ICES CM 1998/G:2. 17 pp.

ICES. 2000. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES, C.M. 2000/ACFM:05.

ICES. 2001. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES, C.M. 2001/ACFM:06.

ICES, 2006 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy. ICES CM 2006/ ACFM: 36.

ICES, 2006 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG), 24-28 October 2005, Vigo, Spain. ICES, C.M. 2006/LRC: 01. 126 pp.

ICES, 2006 c. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 27 November-1 December 2006, Lisbon, Portugal. ICES C.M. 2006/LRC:18. 169 pp.

ICES 2007 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES CM 2007/ACFM:31

ICES 2007 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovyin ICES areas VIII and IX (WGACEGG). ICES CM 2007/LRC:16

ICES. 2008 a. Report of the Working Group on Anchovy (WGANC), 13 - 16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

ICES. 2008 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17. 183 pp.

ICES. 2009 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 16–20 November 2009, Lisboa, Portugal. ICES CM 2009/LRC:20. 181 pp.

Millán, M., 1992. Descripción de la pesquería de cerco en la Región Sur-atlántica Española y Atlántico-Norte Marroquí. *Informes Técnicos Instituto Español Oceanografía* 136, 70pp.

Millán, M. 1999. Reproductive characteristics and condition status of anchovy *(Engraulis encrasicolus*, L.) from the Bay of Cadiz (S.W. Spain). *Fish. Res*., 41: 73-86.

Picquelle, S., Stauffer, G., 1985. Parameter estimation for an egg production method of northern anchovy biomass assessment. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. *NOAA Tech. Rep.* NMFS 36: 43-50 pp.

Robson, D.S., 1966. Estimation of the relative fishing power of individual ships. *ICNAF Research Bulletin*, 3:5-14.

Silva, L., Castro J., Ramos, F. and Punzón A., 2007. Identification of métiers in the Gulf of Cadiz Spanish purse-seine fishery (ICES Subdivision IXa-South). Working document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2007/ACFM:31.

Stock Annex – Sardine in Division VIIIc and IXa (Sar-Soth)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sardine in Divisions VIIIc and IXa (sar-soth).
Working Group:	**WGHANSA**
Date:	February 2012
Revised by:	WKPELA 2012

A. General

A.1. Stock definition

European sardine (*Sardine pilchardus* Walbaum, 1792) has a wide distribution extending in the Northeast Atlantic from the Celtic Sea and North Sea in the north to Mauritania in the south. Populations of Madeira, the Azores and the Canary Islands are at the western limit of the distribution (Parrish *et al*., 1989). Sardine is also found in the Mediterranean and the Black Seas. Changing environmental conditions affect sardine distribution, with fish having been found as far south as Senegal during episodes of low water temperature (Corten and van Kamp, 1996; Binet *et al*., 1998).

The sardine stock assessed by ICES covers the Atlantic waters of the Iberian Peninsula (ICES Areas VIIIc and IXa), extending from the Strait of Gibraltar in the south to the border with France in the Inner Bay of Biscay in the north. These limits are somewhat arbitrary in that they were set for management purposes (Figure A.1).

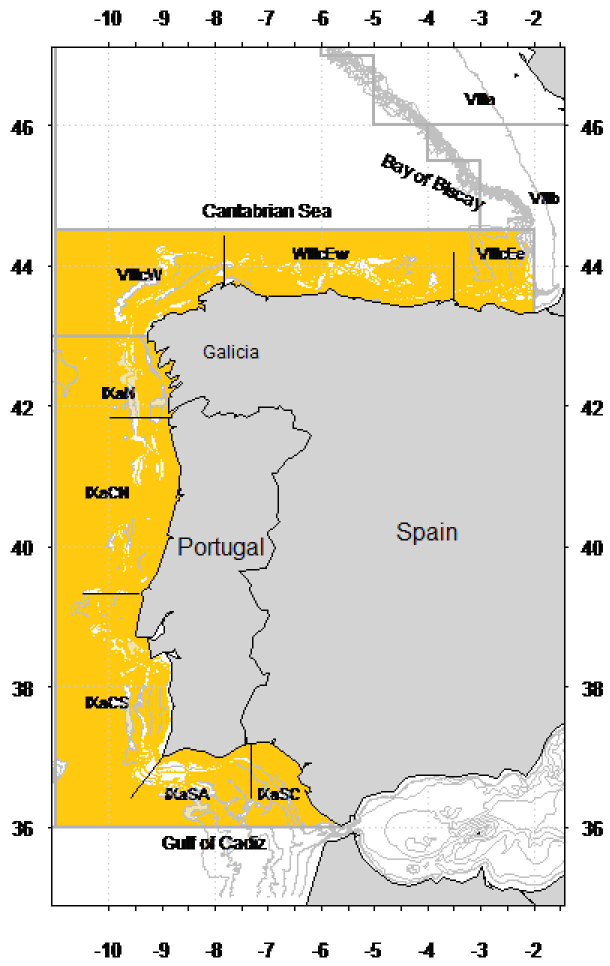


Figure A.1. Map of the current Iberian sardine stock area showing (in orange) the ICES Divisions and subdivisions currently considered in the assessment of the stock.

Because sardine distribution is continuous in the Northeast Atlantic (from the Agadir area in north Morocco to the North Sea) it is likely that there could be movement of fish to and from the stock area and it is the level and impact of this movement which is relevant for the assessment of sardine in Iberian waters. Several genetic studies have failed to demonstrate population differentiation inside the area, with only weak population structure being found using allozymes (Laurent *et al*., 2007, Figure 2) and microsatellite DNA (Kasapidis *et al*., 2012). These studies also reported that sardine taken from Azores and Madeira was genetically closer to Mediterranean samples than to those sampled in other areas of the Northeast Atlantic.

Common genetic and life-history characters provide indication of the possibility of some mixing across the southern Iberian stock limit (Gulf of Cádiz) with sardine populations from southwest Mediterranean and northern Morocco. However, the absence of large sardine populations in these areas would limit the influence of such movements in the dynamics of the Iberian stock.

There are also indications of spatial population substructuring across Iberian waters. Although sardine shows a nearly continuous spawning ground distribution along the Iberian and French Atlantic coasts (Bernal *et al*., 2007), there some evidence of distinct recruitment pulses off the two main recruitment areas in some years (northern Portugal and the Gulf of Cádiz) and observation that these mainly influence the demography of adjacent populations but not that of distant ones (Silva *et al*., 2009; Riveiro *et al*., 2012 WD). Persistent spatial differences in growth (Silva *et al*., 2008) and spawning temperature tolerance have also been found (Stratoudakis *et al*., 2007) and these together with the existence of a persistent gap (Bernal *et al*., 2007) in the spawning area corroborate the hypothesis of spatial heterogeneity of sardine populations. However, indirect evidence of movements from otolith chemistry (Castro, 2007) and cohort analyses (Sardyn project report) suggest that sardines recruiting on the western area move gradually north or south as they grow, crossing the above potential discontinuities.

Catch and survey-at-age data appear to indicate that some strong year classes in the Cantabrian Sea (VIIIc East) originated from recruitment areas in the Gulf of Biscay (VIIIa,b) (Riveiro *et al*., 2012WD). Furthermore, the northern extent of this homogeneous population is still unclear. Sardine maturity-at-length seems to decline substantially in northern France while growth might increase in the English Channel (Silva *et al*., 2008a). Young sardine are not usually observed in this northern area (although juveniles have been recently sampled in the North Sea), suggesting that older (2+) spawning individuals from the English Channel possibly originate in the French coast. Microsatellite analyses revealed no significant genetic differentiation among sardines in Subarea VII and VIII (Shaw *et al.*, 2012). The inner Bay of Biscay does not represent a barrier for other small pelagic fish populations either; as horse mackerel, anchovy and mackerel stocks are also considered to distribute across the Cantabrian Sea and Gulf of Biscay (Abaunza *et al*., 2008; Uriarte *et al*., 1996, 2001). No other barriers were evidenced within French Atlantic waters for any of these species.

In recent years there has been an increase of sardine in both the commercial landings and in fishery-independent surveys in the Celtic Sea and western Channel (VIIe–j) (Beare *et al*., 2004) and is forming the basis of a locally important fishery (Cornish sardine) (ICES, 2010).

Further efforts should help to clarify sardine population structure in this area and their relationship with fish in the Bay of Biscay and the Iberian sardine stock, in order to take into account regional dynamics in the context of an area based assessment.

A.2. Fishery

The bulk of the landings in both Spain and Portugal (99%) are made by purse-seiners.

The Spanish purse-seine fleet targets anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*) and sardine, (which occur seasonally in the area) and horse-mackerel (*Trachurus trachurus*) which is available all year-round (Uriarte *et al*., 1996; Villamor *et al*., 1997; Carrera and Porteiro, 2003). In summer, part of the fleet switches to trolling lines or bait boat for tuna fishing, a resource with a marked seasonal character. Since 2004, Spanish legislation requires that purse-seiners must have, at least, a length of 11 m in the Atlantic coast of Spain. Moreover, the gear must have a maximum length of 600 m, a maximum height of 130 m and minimum mesh size of 14 mm (see Table A.2.1). Because of this regulation, most of the effort and catches are registered in logbooks (which are mandatory for boats larger than 10 m). Analysis of these logbook data from 2003 to 2005 (Abad *et al.*, 2008) showed that currently, sardine and horse-mackerel represent 75% of the total landings of the purse-seine fleet, which is in accordance with the values observed in historical series of purse-seine catch statistics, especially when the anchovy is scarce (ICES, 2007). Sardine catches show the highest values in summer and autumn and effort concentrates in southern Galician and western Bay of Biscay waters. Vessels can be characterized by 21 m length overall, 296 HP, and 57 gross tonnage.

In Portugal, sardine is the main target species of the purse-seine fleet comprising 98% of the landings. The sardine fishery is of great social-economical importance for the fishing community and industry since it represents an important part of the fish production and a relevant supply for the canning sector. Other pelagic species such as chub mackerel (*Scomber japonicus*), horse mackerel and anchovy are also landed by the purse-seine fishery. Currently, purse-seiners in Portuguese waters have a length of about 20 m; an engine horsepower between 100 and 500 HP and use a minimum mesh size of 16 mm (see Table A.2.1). According to Stratoudakis and Marçalo (2002), fishing is usually close to the home port, on short (daily) trips where the net is set once or twice, usually around dawn. A large part of a typical fishing trip is spent searching for schools with echosounders and sonars. Once schools of pelagic fish have been detected, large nets (up to 800 m long and 150 m deep) are set rapidly with the help of an auxiliary small vessel, and hauled in a largely manual operation involving all members of the crew (usually between 15–20 people) (Mesquita, 2008).

Table B.2.1. Summary of the major existing regulatory mechanism for sardine.

Species	Technical measure	National/European level	Specification	Note	Source/date of implementation
Sardine	Minimum size	European	11 cm	10% undersized allowed	EU Reg 850/98 amended 1999, 2000, 2001, 2004
Sardine/Anchovy	Effort limitations	National (ES)	VIIIc,IXa: minimum vessel tonnage 20 GRT, maximum engine power 450 hp, max length purse-seine 450 m, max height purse-seine 80 m, minimum mesh size 14 mm, max number of fishing days/week: 5, fishing prohibited in bays and estuaries Gulf of Cádiz: Maximum net length 450 m. Maximum net high 80 m.		1997
Sardine	Catch limitation	National (ES)	Max 7000 kg/day/boat fish >15 cm, max 2000 kg/day/boat fish between 11 and 15 cm. IXaS Cádiz: 3000 kg/vessel day(<10% of small sardine (<9 cm))		1997
Sardine/anchovy	Area closure	National (ES)	IXaS Cádiz: fishing closures implemented annually between November–February		2008
Sardine/Anchovy	Effort limitations	National (PT)	IXa: max length of purse-seine 800 m, max height of purse-seine 150 m, max number of fishing days/week: 5, max number of fishing days/year: 180	Portaria n.o 1102-G/2000 de 22 de Novembro	1997

Species	Technical measure	National/European level	Specification	Note	Source/date of implementation
Sardine/Anchovy	Area closure	National (PT)	No purse-seine fishing at depths lower than 20 m. For 2012, there is a 45 day fishing ban for sardine for all regional PO, in alternate periods between 15 February and 30 April.	Despacho n.º 1521/2012, 1 February 2012	1997
Sardine	Catch limitation	National (PT)	55 thousand tons January–May 2012: 9 thousand tons	Applicable to vessels associated under PO (Producer Organization) which make 96% of the landings. Non-associated vessels have equivalent restrictions.	2010
All species	Mesh sizes	European	different specifications acc. to catch compositions	In Portugal, >16 mm, Portaria n.o 1102-G/2000 de 22 de Novembro	EU Reg 850/98 amended 1999, 2000, 2001, 2004
All species	Mesh openings	European	different specifications acc. to catch compositions		EU Reg 850/98 amended 1999, 2000, 2001, 2004

A.3. Ecosystem aspects

There are a number of studies investigating the role of sardine in the ecosystem both as predator and prey. Sardine is widely distributed all along the Atlantic Iberian shelf in waters ranging from 10 to 100 m (e.g. Porteiro *et al*., 1996). Analysis of its stomach contents and stable isotope signature indicate an omnivorous feeding behaviour, related to its ability to feed by particle-feeding and filter-feeding (more common as fish grow older, Bode *et al.*, 2003), and its exploitation of a wide range of prey (both phytoplankton and zooplankton have been found in its diet, e.g. Bode *et al*., 2004). In addition, sardines have been found to ingest their own eggs (and probably those of other species) and this cannibalism may act as a density control mechanism (Garrido *et al.*, 2007).

The composition of nitrogen isotopes in the muscle of sardine integrates fish diet over seasonal periods and reflects the composition of plankton over large shelf areas. A differential isotopic signature in high and low upwelling zones reflects low mobility of sardines during periods of low population size (Bode *et al.*, 2007).

Sardine is prey of a range of fish and marine mammal species which take advantage of its schooling behaviour and availability. Sardine has been found to be important in the diet of common dolphins (*Delphinus delphis*) in Galicia (NW Spain) (Santos *et al.*, 2004), Portugal (Silva, 2003) and the Atlantic French coast (Meynier, 2004). Recent studies of consumption of common dolphins in Galician (Santos *et al.*, 2011b) waters give figures ranging from almost 6000 tons to more than 9000 tons of sardine, which represents a rather small proportion of the combined Spanish and Portuguese annual landings of sardine from ICES Areas VIIIc and IXa (6–7%).There are also other species feeding on sardine, although to a lesser extent, such as: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), and white-sided dolphin (*Lagenorhynchus acutus*) (e.g. Santos *et al.*, 2007).

Habitat modelling studies aim to identify which environmental processes could be defining the habitat of a species and eventually to be able to predict fish distribution. Zwolinski *et al*. (2008) analysed the relationship between data on sardine distribution obtained by the Portuguese acoustic surveys and four environmental variables (subsurface salinity, temperature, chlorophyll concentration and plankton presence). Sardine showed a preference for waters with low temperature and salinity, high chlorophyll content and low planktonic backscattering energy.

Populations of planktivorous fish, such as the sardine, show large fluctuations in size and distribution over the Atlantic Iberian shelf (Carrera and Porteiro, 2003). Periods of good recruitments have helped develop new industries and led to the social and economic changes while periods of continuous low recruitments have brought economic hardship in many areas. This was the case of the Iberian sardine at the end of the 1990s, when several successive poor recruitments led to an all time low of the stock biomass. Sardine is a batch spawner producing batches of eggs over an extended period of time (October to May) in Iberian waters with different peaks between southern and northern regions. Although the survival of offspring is highly dependent on favourable environmental conditions (concentrations of egg/larvae in suitable areas), sardine appears to show a wide range of temperature tolerance for both habitat and spawning distribution (Bernal, 1998). Even more, the presence of sardine larvae has been recorded by a recent study (Morais *et al*., 2009) inside the Guadiana estuary. The authors suggest that this is not an accidental occurrence but that in order to migrate to that location and remain in the estuary, counteracting river inflow, these late larvae must have employed active migration and retention strategies.

Upwelling intensity was shown to affect both positively and negatively sardine recruitment (Dickson *et al.*, 1988; Roy *et al.*, 1995) but the main direct effect was due to the transport of eggs and larvae offshore by northern winds (Guisande *et al.*, 2001). In this way, strong upwelling during the recruitment season would decrease the probability of survival of sardine larvae as they are dispersed to outer shelf and oceanic zones. In contrast, southerly winds favour the progress of the poleward current, and tend to accumulate fish larvae near the coast where plankton biomass and production are high. At high population sizes, sardine spawning and distribution areas extend over the whole continental shelf and the adults display feeding migrations to the upwelling area off Galicia, while at low population sizes a reduction in the mobility of adult sardines between the Cantabrian Sea and Galicia is expected (Carrera and Porteiro, 2003).

Santos *et al*. (2011a) analysed previous studies, on relationships between recruitment and environmental variables for the sardine around the Iberian Peninsula and carried out a new analysis of empirical relationships with environmental series, using dynamic factor analysis, generalized additive models, and mixed models. Relationships were identified between recruitment and global (number of sunspots), regional (NAOAutumn), and local winter wind strength, sea surface temperature (SST), and upwelling environmental variables. Separating these series into trend and noise components permitted further investigation of the nature of the relationships. Whereas the other three environmental variables were related to the trend in recruitment, SST was related to residual variation around the trend, providing stronger evidence for a causal link. After removal of trend and cyclic components, residual variation in recruitment was also weakly related to the previous year's spawning–stock biomass.

B. Data

B.1. Commercial catch

Commercial catch data are obtained from the national laboratories of both Spain and Portugal. Annual landings are available since 1940 (see Figure B.1). Landings are not considered to be significantly underreported.

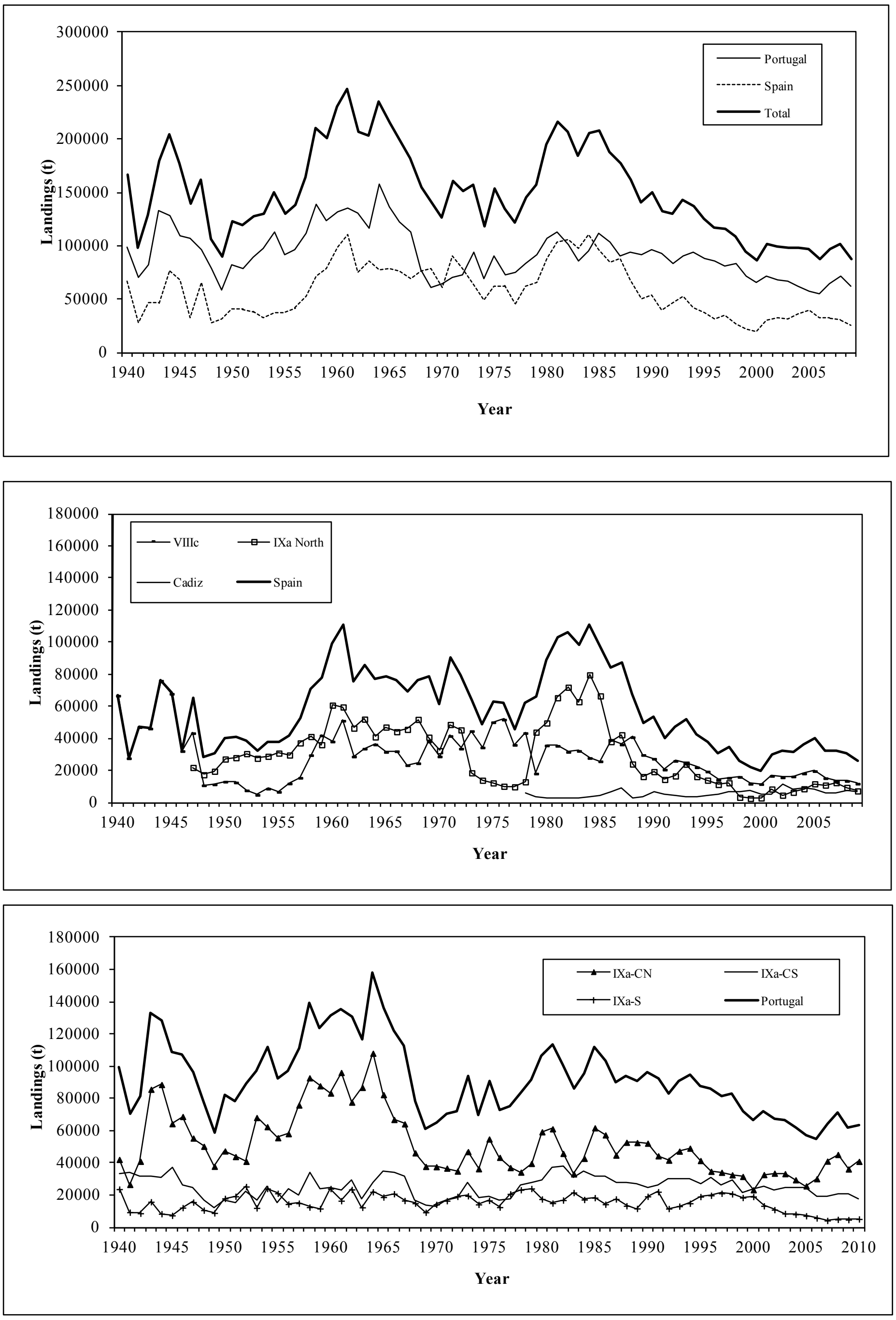


Figure B.1. Annual landings of sardine, by country and area.

Discards data on the fishery are not available and it is very difficult to measure. As with other pelagic fisheries that exploit schooling fish discarding occurs in a sporadic way and with often extreme fluctuation in discard rates (100% or null discards). Extreme discards occur especially when the entire catch is released (“slippage”) which tend to be related to quota limitations, illegal size and mixture with unmarketable bycatch. Quantifying such discards at a population level is extremely difficult because they vary considerably between years, seasons, species targeted and geographical region.

A discard programme, sampling purse-seine vessels, has started in Portugal. Nevertheless, discard estimates are still not available. There is some slipping in northern

Portugal (Division IXa) but mostly in years with high recruitment. During a twelve week lasting study, the sampled fleet (nine vessels) landed 2196 t and released an estimated 4979 t (CV 33.6%) (Stratoudakis and Marcalo, 2002). More than 95% of the total catch was sardine.

Sardine constituted 97% of the landings in the trips observed and >99% of the total for the whole fleet, and some of the bycatch species caught in small quantities during the trips observed never reached the market.

Since 1999 (catch data 1998), both Spanish and Portuguese laboratories have used a common spreadsheet to provide all necessary landing and sampling data developed originally for the Mackerel Working Group (WGMHSA). The stock co-ordinators collates data using the latest version of SALLOCL (Patterson, 1998) which produces a standard output file (Sam.out). However it should be noted that only sampled, official, WG catch and discards are available in this file.

In addition, commercial catch and sampling data were stored and processed using the InterCatch software for the first time during the WGHMHSA in 2007. Comparisons were made between the SALLOCL and the InterCatch routines and a very good agreement was found (<0.3% discrepancies). These discrepancies are likely the results of the fact that for stocks where no allocations are required (as is the case of sardine), the SALLOCL application requires a 'dummy' allocation to be made in order for the program to run successfully. While a very small value is used for the allocation, it is likely to have some impact on the results and so will have added to the discrepancy when compared with the InterCatch output.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures routinely provided by both Spain and Portugal. These data are obtained either by market sampling or by on-board observers. In Spain, samples for age–length keys are pooled on a half year basis for each subdivision while length–weight relationships are calculated quarterly. In Portugal, both age–length keys and length–weight relationships are compiled on a quarterly and subdivision basis.

Mean weights-at-age in the stock are derived from March/April acoustic surveys and maturity ogive comes from DEPM surveys, whilst for the years without DEPM surveys, a constant value of 80% full maturity-at-age 1 and a 100% for ages 2 and older is adopted. The 80% maturity-at-age 1 is about a median of former DEPM estimates.

Table B.2.1. Summary of the overall sampling intensity over recent years on the catches of the sardine stock in VIIIc and IXa.

Year	Total catch	N° samples	N° fish measured	N° fish aged
1992	164 000	788	66 346	4086
1993	149 600	813	68 225	4821
1994	162 900	748	63 788	4253
1995	138 200	716	59 444	4991
1996	126 900	833	73 220	4830
1997	134 800	796	79 969	5133
1998	209 422	1372	123 754	12 163
1999	101 302	849	91 060	8399
2000	91 718	777	92 517	7753
2001	110 276	874	115 738	8058
2002	99 673	814	96 968	10 231
2003	97 831	756	93 102	10 629
2004	98 020	932	112 218	9268
2005	97 345	925	116 400	9753
2006	87 023	927	122 185	9165
2007	96 469	797	97 187	8607
2008	101 464	821	91 847	7950
2009	87 740	465	52 821	8216
2010	89 572	327	35 615	7890

B.3. Surveys

At present, the surveys used in the sardine assessment are the Spanish and Portuguese DEPM surveys and the spring acoustic surveys which jointly provide a full coverage of the stock area (ICES Areas VIIIc and IXa). Surveys not used in the assessment, which cover parts of the stock area or Areas VIIIa,b (considered to be a different stock unit) are also described below for completeness.

B.3.1. DEPM surveys

The Daily Egg Production Method started being applied to sardine in the Iberian Peninsula during the 1980s but surveys were interrupted for almost ten years. Current DEPM surveys started in 1997 for both Spain and Portugal and have been carried out triennially since 1999. Sampling design and methodology have been further standardized in 2002 in order to guarantee good coordination of the surveys and analyses of the data collected Since 2011 the coordinated surveys between Spain (IEO and AZTI) and Portugal (IPIMAR) do also cover the Bay of Biscay (Divisions VIIIa, b).

The extension of the surveyed area almost up to Southern Brittany results in a complete coverage of the species over most of its European Atlantic distribution (Subareas IX and VIII), except for the top Northwestern limits. The methodology adopted for the processing of sardine adults data followed the general plan agreed for previous surveys (cf. ICES, 2005, 2006 and 2007) and a summary is presented in Table B.3.1.

Table B.3.1. Processing and analysis for eggs and adults (The surveys carried out by IEO and AZTI cover Areas VIIIb and VIIIa,b, respectively).

DEPM	Portugal (IPIMAR)	Spain (IEO)	Spain (AZTI)
EGGS			
PairoVET eggs staged sardine (Gamulin & Hure, 1955)	All	All	Sample size 50/75 or all eggs
CUFES egg staged sardine (Gamulin & Hure, 1955)	In the lab, all or subsample if more than 100 per sample	No	No
Temperature for egg ageing	Surface (continuous underway CTF at 3 m)	10 m	10 m
Peak spawning hour	21:00 (Sd=3 hh)	21:00 (Sd=3 hh)	21:00 (Sd=3 hh)
Egg ageing	Bayesian (Bernal *et al*., 2008)	Bayesian (Bernal *et al*., 2008)	Bayesian (Bernal *et al*., 2008)
Egg production	GLM (and GAMs available)	GLM (and GAMs available)	GLM (and GAMs available)
ADULTS			
Histology -Embedding material	Paraffin	Resin	Resin
-Stain	Haematoxilin-Eosin	Haematoxilin-Eosin	Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez *et al*., 1992a and Ganias *et al*., 2007)	Day 1 and Day 2 POFs (according to Pérez *et al*., 1992a and Ganias *et al*., 2007)	Day 1 and Day 2 POFs (according to Pérez *et al*., 1992a and Ganias *et al*., 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez *et al*., 1992b	On hydrated females (without POFs), according to Pérez *et al*., 1992b	On hydrated females (without POFs), according to Pérez *et al*., 1992b

B.3.2. Acoustic surveys

B.3.2.1 Spring acoustic Surveys

Portuguese and Spanish acoustic surveys are coordinated within WGACEGG (ICES, 2011). Surveys are undertaken within the framework of the EU DG XIV project "Data Directive". There are two spring annual surveys (one Portuguese and one Spanish) used in the assessment as a single index of abundance of the stock. During the benchmark assessment carried out in 2006, a joint survey dataseries was made as a weighted sum of the two spring surveys and results from the exploration of survey data provided some indication of similar catchabilities. In addition, preliminary runs with a range of weighting factors the Spanish surveys indicated that the actual catchability ratio made little difference to the final outcome of the assessment. Therefore, the stock was assessed with a joint spring survey derived by just adding the Spanish and the Portuguese results. In spite of this, the merging of data from these surveys remains an outstanding issue in the current assessment and in order to address this, two calibration exercises between the Spanish and Portuguese acoustic surveys have taken place in spring 2008 and again in 2009 with the simultaneous coverage of several transects by the RVs Thalassa (Spanish survey) and Noruega (Portuguese survey) off northern Portugal. Results from these exercises were inconclusive and therefore a new intercalibration is planned in 2012. Conclusions will be analysed within WGACEGG.

In addition to the spring surveys, between 1984 and 2008 (gaps in 1988–1991 and 1993–1996) there was a Portuguese acoustic survey carried out in November and covering the Portuguese waters and, since 1997, the Gulf of Cádiz. This survey follows the same methodology as the spring surveys and is also coordinated by WGACEGG. Since it covers only part of the stock area and may not take into account changes in distribution between years, it is currently not used in the assessment model. However, it covers the main recruitment areas of the stock and is therefore used as additional information on recruitment strength. This survey-series could be potentially useful in the context of a future area-based assessment.

Outside the assessed stock area, the spring acoustic survey PELGAS (run by Ifremer) covers the area from the south of the Bay of Biscay to south of Brittany (Figure B.3.2.1.3).

B.3.2.1.1. Portuguese spring acoustic survey: PELAGOS

The Portuguese acoustic surveys (on board the RV "Noruega") are mainly directed to sardine and anchovy.

The survey track follow a parallel grid, with transects perpendicular to the coastline. The acoustic energy in the inter-transect track is not taken into account. The transects are spaced by 8 nautical miles in the West Coast, 6 nautical miles in Algarve and around 10 nautical miles in the Cádiz area. Acoustic data from 38 kHz is stored with MOVIES+ software as standard HAC files along the transects. Trawl hauls are performed whenever significant amounts of fish are found but mainly targeting sardine and anchovy. Trawl data are used to:

- Identify the echotraces
- Obtain the length structure of the population
- Obtain the species proportion
- Get biologic samples

The identification of the echotraces is made by eye, with the aid of the trawl hauls. If it is not possible to separate the species schools by eye, the energy of the ESDUs (Elementary Sampling Distance Unit) is split using the haul species proportion, in number, and taking into account the target strength and the species length compositions.

The weight of the hauls is always the same, since a post stratification is made and the overall area is divided into small homogeneous areas, with similar length composition. To partition the acoustic energy by species, using the trawl species proportion, the hauls are not weighted by the energy around the haul, assuming that the species mixture is independent of the acoustic energy density. The acoustic energy is extracted from the EK500 echograms, school by school, using MOVIES+ software. Plankton and very small schools are rejected.

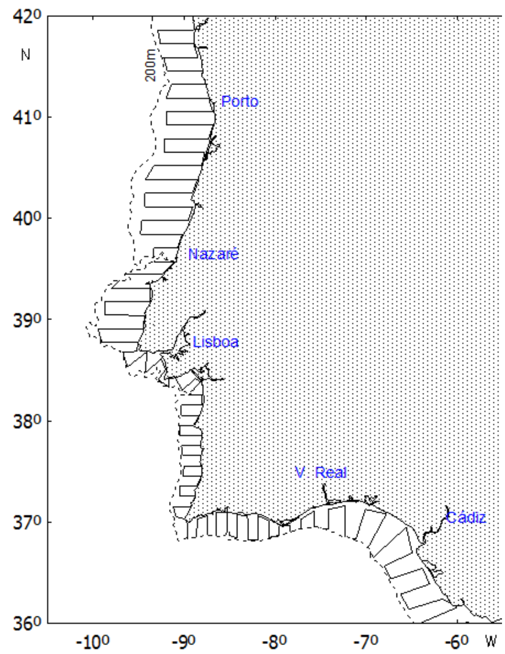


Figure B.3.2.1.1. Acoustic transects sampled during the PELAGOS acoustic survey in 2011.

For each species, the acoustic energy is also partitioned by length classes according to the length structure found in the trawl hauls. The biomass is derived from the number of individuals, applying the weight–length relationship obtained from the haul samples.

B.3.2.1.2. Spanish spring acoustic survey: PELACUS

The spring acoustic survey PELACUS (on board the RV "Thalassa") covers the area between northern Portuguese waters and southern French waters. Acoustic sampling takes place during the day, over a grid of parallel transects separated by 8 nm and perpendicular to the coastline. The area covered by the survey extends from 30 to 200 m depth. The EDSU is fixed at 1 nm. Fish abundance estimation is only carried out with the 38 kHz frequency of a Simrad EK60 scientific echosounder, although echograms from 120 kHz are also used to help discrimination. No threshold is set for integration.

Backscattering energy is allocated to fish species by visual scrutiny of the echograms and based on the information provided by the fishing trawls. Fishing stations are analysed and grouped according to depth and proximity criteria and their representativeness is assessed based on the continuity in the probability density function of the length distribution for all fish species in the haul.

The main differences between surveys are related to the sampling strategy and the type of gear used. Noruega's main objective is estimating sardine and anchovy abundance while Thalassa samples all fish aggregations. Noruega's net is smaller than Thalassa's, which allows Noruega to carry out trawls closer to the shore while Thalassa can take advantage of a bigger pelagic trawl to sample schools in more offshore areas.

Figure B.3.2.1.2. Acoustic transects sampled during the PELACUS acoustic survey in 2011.

B.3.2.1.3 French spring acoustic survey: PELGAS

The French acoustic survey (PELGAS) is routinely carried out each year in spring in the Bay of Biscay (on board the RV Thalassa) and information on pelagic fish species distribution and abundance is available since 2000. The main species targeted is anchovy but the survey is part of the Ifremer programmes on data collection for monitoring and management of fisheries with an ecosystemic approach for fisheries and information is therefore also collected on other pelagic species, on egg presence and abundance, on top predators abundance and distribution and on environmental variables such as temperature, salinity, plankton, etc. The survey is planned with Spain and Portugal in order to have most of the potential area to be covered from Gibraltar to Brest with the same protocol for sampling strategy. Data are made available to the ICES working groups WGHANSA, WGWIDE and WGACEGG.

Acoustic data are collected along systematic parallel transects perpendicular to the French coast. The length of the ESDU (Elementary Sampling Distance Unit) was one mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20 m depth to the shelf break. Acoustic data are collected only during the day because of pelagic fish behaviour in the area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer for the echosounder between the surface and 8 m depth.

Since 2008, PELGAS survey has been accompanied by pelagic pairtrawlers that follow the RV Thalassa transects. Identification hauls were carried out both by the RV Thalassa and the commercial vessels being preferentially carried out by pairtrawlers which are more efficient (less avoidance to the vessels) and hauls close to the bottom being preferentially carried out by the RV Thalassa.

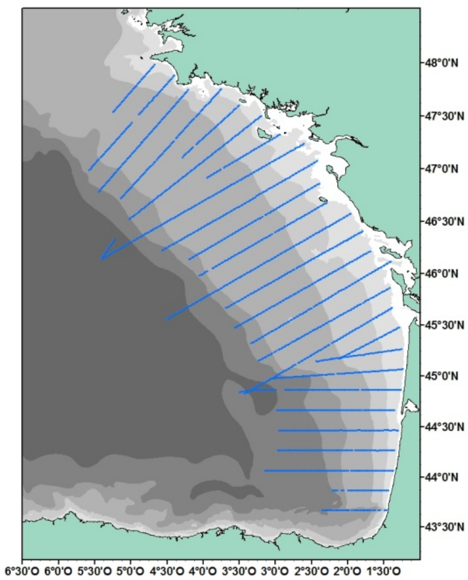


Figure B.3.2.1.3. Acoustic transects sampled during the PELGAS acoustic survey in 2011.

B.4. Commercial cpue

Cpue indices are not considered reliable indicators of abundance for small pelagic fish (Ulltang, 1982; Csirke, 1988; Mackinson *et al.*, 1997) and are not used.

B.5. Other relevant data

C. Assessment: data and method

Model used: Stock Synthesis (SS, Methot, 1990, 2005). SS is a generalized age- and length-based model that is very flexible with regard to the types of data that may be included, the functional forms that are used for various biological processes, the level of complexity and number of parameters that may be estimated. A description and discussion of the model can be found in ICES (2010).

The sardine assessment is an age-based assessment assuming a single area, a single fishery, a yearly season and genders combined. Input data include catch (in biomass), age composition of the catch, total abundance (in numbers) and age composition from an annual acoustic survey and spawning–stock biomass (SSB) from a triennial DEPM survey. Considering the current assessment calendar (annual assessment WG in June in year *y+1*), the assessment includes fishery data up to year *y* and acoustic data up to year *y+1*. According to the ICES terminology, year *y* is the final year of the assessment and year *y+1* is termed the interim year.

Software used:

Stock Synthesis (SS) version 3.21d (Methot, 2011)

Model Options chosen:

The main model options are described below. A copy of the control file (sardine.ctl) including all model options is appended to the bottom of this section.

Natural mortality are age specific input values as listed in the table below.

Age 0	0.8
Age 1	0.5
Age 2	0.4
Age 3	0.3
Age 4	0.3
Age 5	0.3
Age 6+	0.3

Growth is not modelled explicitly. Weights-at-age in the beginning and mid of the year are input values and fecundity-at-age are input values, corresponding to the proportion mature-at-age * weight-at-age at the beginning of the year.

Annual recruitments are parameters, defined as lognormal deviations from a constant mean value penalized by a sigma of 0.55 (the standard deviation of log(recruits) estimated in the 2011 assessment, ICES, 2011a). Recruitment for the interim year of the assessment is assumed to be the historic geometric mean.

Fishing mortality is applied as the hybrid method. This method does a Pope's approximation to provide initial values for iterative adjustment of the continuous F values to closely approximate the observed catch.

Total catch biomass by year is assumed to be accurate and precise. The F values are tuned to match this catch.

Total catch biomass by year is assumed to be a median unbiased index of abundance.

Both the acoustic survey and the DEPM survey are assumed to be relative indices of abundance. The corresponding catchability coefficients are considered to be mean unbiased.

Age selectivity in the fishery and in the acoustic survey is such that the parameter for each age is estimated as a random walk from the previous age (however, this applies only to ages 1, 2, 3 and 6+ in the fishery and 2 and 6+ in the survey). In the fishery, selectivity-at-age 0 is not estimated and is used as the reference age against which subsequent changes occur. A similar assumption is considered for age 1 in the survey, the first observed age. Selectivities at ages 3 to 5 years in the fishery are bound, meaning that parameters for ages 4 and 5 are not estimated but assumed to be equal to the parameter estimated for age 3. A similar assumption is accepted for ages 2 to 5 years in the survey. The initial values for the fishery and survey selectivities mimic dome-shaped patterns with a decline at the 6+ group. However, the range of initial values is wide and almost any pattern can be estimated.

The fishery selectivity is allowed to vary over time in part of the assessment period. Two periods are considered: 1978–1990 with selectivity-at-age varying as a random walk and 1991–2010 for which selectivity-at-age is fixed over time. In the random walk, log(Sy) = log(Sy-1 + delta(y)), with SD=0.1 as the penalty on the deltas, y being the year). The transition between periods is done as a random walk as well.

In the interim year of the assessment, there is data from the acoustic survey but not from the fishery (catch and age composition). The model requires input fishery data for all assessment years. Catch biomass for the interim year is assumed to be equal to the ICES advised catch (75 000 tons in 2011). Age composition data for the fishery in the interim year is included in the calculation of expected values but excluded from the objective function. Catch numbers-at-age in the interim year are derived from numbers-at-age in the previous year assuming the same fishing mortality, selectivity pattern and biological parameters. An arbitrary value of 4 000 000 individuals was assumed as the interim recruitment.

The objective function is a log likelihood combining components for:

- Catch biomass (lognormal);
- acoustic survey abundance index (lognormal);
- DEPM survey SSB (lognormal);
- fishery age composition (multinomial);
- survey age composition (multinomial);
- recruitment deviations (lognormal);
- random walk selectivity parameters (normal);
- initial equilibrium catch (normal).

Estimates of data precision are included in the likelihood components for the abundance indices and age composition data as follows:

- a standard error of 0.25 is assumed for all years both for the acoustic index (total number of fish) and the DEPM index (SSB). In the likelihood components of each survey, annual log residuals are divided by the corresponding standard errors. Therefore, the two surveys and the years within each survey have equivalent weight in the objective function. The assumed standard error corresponds to a CV of 25% which is consistent with the average level of CVs estimated for the acoustic survey by geostatistics (range 12–43%, mean=23%) and GAM methods (Zwolinski *et al.*, 2009) and with CVs estimated for the DEPM survey (range 14–32%, mean =22%).
- assumed sample sizes for annual age compositions in the fishery and acoustic survey are:

Fishery			
1978-1990	50	1996-2011	50
1991-2010	75		

  Sample size sets the precision of the age composition data. It should correspond to the actual number of fish in the age samples if the multinomial error model was strictly correct (i.e. the number of independent observations in a sample). In general, the levels of age sampling for the sardine stock are high in both the fishery and the acoustic survey (see Table B.1.2). Although input values for sample size can be calculated from the sampling data, it is difficult to obtain real values since there is often autocorrelation within age samples. Therefore, sample sizes were calculated approximately taking into account the harmonic mean of expected sample sizes provided by the model. The sample size for fishery age compositions was assumed to be lower in the period 1978–1990 than afterwards to reflect the poorer regional coverage of stock landings (ICES, 2012; WKPELA Report);

- indices of ageing imprecision were obtained from the most recent age reading workshop (ICES, 2011b). Three sets of otoliths from different stock regions were aged by readers implicated in the preparation of ALKs. Standard deviations by age and reader were calculated relative to the modal age for each regional otolith set. These SDs were averaged over all readers and a weighted average for the three sets was calculated assuming the weights in the table below. Ageing imprecision was assumed to be constant over time and to be the same in the fishery and in the survey. Within the model, a transition matrix defines the expected distribution of observed ages for each true age assuming a normal distribution with mean equal to the true age and standard deviations as given in the table below.

Age	Portuguese coast	Cantabrian Sea	Gulf of Cadiz	Weighted Average
0	0.13	0.08	0.26	0.1
1	0.17	0.19	0.16	0.2
2	0.30	0.24	0.24	0.3
3	0.23	0.26	0.30	0.2
4	0.24	0.26	0.45	0.3
5	0.27	0.19	0.45	0.3
6	0.40	0.40	0.53	0.4
7	0.25	0.33	0.48	0.3
Weights	0.60	0.30	0.10	

The initial equilibrium catch was set at 100 000 tons, the recent level of catches. The model uses the initial equilibrium catch to derive an initial fishing mortality. The population numbers-at-age in the initial year (the year before the first year of the assessment period) are calculated from the mean recruitment, the initial equilibrium catch and the selectivity in the first year. Numbers-at-age in the first year of the assessment are derived from those in the initial year assuming the mean recruitment.

Minimization of the likelihood is implemented in phases using standard ADMB process. The phases in which estimation will begin for each parameter is shown in the control file appended to this section.

Variance estimates for all estimated parameters are calculated from the Hessian matrix.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978 forward	Ages 0–6+	
Canum	Catch-at-age in numbers	1978 forward	Ages 0–6+	
Weca	Weight-at-age in the commercial catch	1978 forward	Ages 0–6+	1978–1991 No 1992 forward Yes
West	Weight-at-age of the spawning stock at spawning time.	1978 forward	Ages 0–6+	1978–1990 No 1991 forward Yes
Matprop	Proportion mature-at-age	1978 forward	Ages 0–6+	Estimated in DEPM years, else assumed constant
Natmor	Natural mortality	1978 forward	Ages 0–6+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Joint SP+PT Acoustics	1996 onwards	Ages 1–6+
Tuning fleet 2	Joint SP+PT DEPM	1997, 1999, 2002, 2005, triennal	Not age structured

The model estimates spawning–stock biomass (SSB) and summary biomass (B1+, biomass of age 1 and older) at the beginning of the year. The reference age range for output fishing mortality is 2–5 years.

```
#C Sardine in VIIIc and IXa : Benchmark assessment

#C growth parameters are estimated spawner-recruitment bias adjustment Not tuned For optimality

#_data_and_control_files: sardine.dat // sardine.ctl

1 #_N_Growth_Patterns

1 #_N_Morphs_Within_GrowthPattern

1 #_Nblock_Patterns

1 #_blocks_per_pattern

# begin and end years of blocks

 1978 1990

#

0.5 #_fracfemale

3 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate

0.8 0.5 0.4 0.3 0.3 0.3 0.3 #_no additional input for selected M option; read 1P per morph

1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_speciific_K; 4=not implemented

0 #_Growth_Age_for_L1
```

6 #_Growth_Age_for_L2 (999 to use as Linf)

0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)

0 #_CV_Growth_Pattern: 0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)

5 #_maturity_option: 1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-fecundity; 5=read fec and wt from wtatage.ss

#_placeholder for empirical age-maturity by growth pattern

1 #_First_Mature_Age

1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L; (5)eggs=a+b*W

0 #_hermaphroditism option: 0=none; 1=age-specific fxn

1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)

2 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no bound check)

#

#_growth_parms

```
#_LO     HI     INIT   PRIOR  PR_type  SD    PHASE  env-var  use_dev  dev_minyr dev_maxyr dev_stddev    Block
   Block_Fxn
8   18     14     0      -1     0      -2     0      0      0      0      0      0      0      #
   L_at_Amin_Fem_GP_1
20  25     23     0      -1     0      -4     0      0      0      0      0      0      0      #
   L_at_Amax_Fem_GP_1
0.2 0.8    0.4    0      -1     0      -4     0      0      0      0      0      0      0      #
   VonBert_K_Fem_GP_1
0.05       0.25   0.1    0      -1     0      -3     0      0      0      0      0      0      0      #
   CV_young_Fem_GP_1
0.05       0.25   0.1    0      -1     0      -3     0      0      0      0      0      0      0      #
   CV_old_Fem_GP_1
-3  3      2      0      -1     0      -3     0      0      0      0      0      0      0      #
   Wtlen_1_Fem
-3  4      3      0      -1     0      -3     0      0      0      0      0      0      0      #
   Wtlen_2_Fem
50  60     55     0      -1     0      -3     0      0      0      0      0      0      0      #
   Mat50%_Fem
-3  3      -0.25  0      -1     0      -3     0      0      0      0      0      0      0      #
   Mat_slope_Fem
-3  3      1      0      -1     0      -3     0      0      0      0      0      0      0      #
   Eggs/kg_inter_Fem
-3  3      0      0      -1     0      -3     0      0      0      0      0      0      0      #
   Eggs/kg_slope_wt_Fem
0   0      0      0      -1     0      -4     0      0      0      0      0      0      0      #
   RecrDist_GP_1
0   0      0      0      -1     0      -4     0      0      0      0      0      0      0      #
   RecrDist_Area_1
0   0      0      0      -1     0      -4     0      0      0      0      0      0      0      #
   RecrDist_Seas_1
0   0      0      0      -1     0      -4     0      0      0      0      0      0      0      #
   CohortGrowDev
```

```
#_Spawner-Recruitment
4 #_SR_function: 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop; 7=survival_3Parm
#_LO    HI     INIT   PRIOR  PR_type  SD     PHASE
1   12     8.9    4.5    -1     5      1      #      SR_LN(R0)
0.2 1      0.9    0.7    -1     0.05   -5     #      SR_SCAA_null
0   4      0.55   0.6    -1     0.8    -4     #      SR_sigmaR
-5  5      0.1    0      -1     1      -3     #      SR_envlink
-5  5      0      0      -1     1      -4     #      SR_R1_offset
0   0      0      0      -1     0      -99    #      SR_autocorr
```

```
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
1 #do_recdev: 0=none; 1=devvector; 2=simple deviations
1978 # first year of main recr_devs; early devs can preceed this era
2010 # last year of main recr_devs; forecast devs start in following year
2 #_recdev phase
1 # (0/1) to read 13 advanced options
 0 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 -4 #_recdev_early_phase
 -1 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 1 #_lambda for Fcast_recr_like occurring before endyr+1
 1900 #_last_early_yr_nobias_adj_in_MPD
 1900 #_first_yr_fullbias_adj_in_MPD
 1900 #_last_yr_fullbias_adj_in_MPD
 1900 #_first_recent_yr_nobias_adj_in_MPD
 1 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
```

```
 0 #_period of cycles in recruitment (N parms read below)
 -5 #min rec_dev
 5 #max rec_dev
 0 #_read_recdevs
#_end of advanced SR options

#Fishing Mortality info
0.3 # F ballpark for tuning early phases
-2001 # F ballpark year (neg value to disable)
3 # F_Method: 1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
2 # max F or harvest rate, depends on F_Method
4 # N iterations for tuning F in hybrid method (recommend 3 to 7)
#
#_initial_F_parms
#_LO HI INIT PRIOR PR_type SD PHASE
 0 2 0.3 0.3 -1 0.2 1 # InitF_1purse_seine
#
#_Q_setup
 #     Q_type     options:     <0=mirror,     0=median_float,     1=mean_float,     2=parameter,     3=parm_w_random_dev,     4=parm_w_randwalk,
5=mean_unbiased_float_assign_to_parm
#_for_env-var:_enter_index_of_the_env-var_to_be_linked
#_Den-dep env-var extra_se Q_type
 0 0 0 0 # 1 purse_seine
 0 0 0 1 # 2 Acoustic_survey
 0 0 0 2 # 3 DEPM_survey
#
#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q; 1=read a parm for each year of index
#_Q_parms(if_any)
# LO HI INIT PRIOR PR_type SD PHASE
 -7 5 0 0 -1 1 1 # Q_base_3_DEPM_survey

#_age_selex_types
#_Pattern ___ Male Special
 17 0 0 0 # 1 purse_seine
 17 0 0 0 # 2 Acoustic_survey
 10 0 0 0 # 3 DEPM_survey

#_LO       HI       INIT     PRIOR    PR_type  SD       PHASE    env-var  use_dev  dev_minyr dev_maxyr dev_stddev      Block
   Block_Fxn
-5  5      0        0        -1       0.01     -2       0        0        0        0        0.1      0        0        #
   AgeSel_1P_1_purse_seine
-5  5      0.9      0.5      -1       0.01     2        0        3        1978     1990     0.1      1        3        #
   AgeSel_1P_2_purse_seine
-5  5      0.4      0.5      -1       0.01     2        0        3        1978     1990     0.1      1        3        #
   AgeSel_1P_3_purse_seine
-5  5      0.1      0.3      -1       0.01     2        0        3        1978     1990     0.1      1        3        #
   AgeSel_1P_4_purse_seine
-5  5      0        0.1      -1       0.01     -2       0        0        0        0        0.1      0        0        #
   AgeSel_1P_5_purse_seine
-5  5      0        0.1      -1       0.01     -2       0        0        0        0        0.1      0        0        #
   AgeSel_1P_6_purse_seine
-5  5      -0.5     0.5      -1       0.01     2        0        3        1978     1990     0.1      1        3        #
   AgeSel_1P_7_purse_seine
-1000      -1000    -1000    -6       -1       0.01     -2       0        0        0        0        0        0        0        #
AgeSel_2P_1_Acoustic_survey
-5  5      0        0.5      -1       0.01     -2       0        0        0        0        0        0        0#       Age-
Sel_2P_2_Acoustic_survey
-5  9      -0.3     0        -1       0.01     2        0        0        0        0        0        0        0#       Age-
Sel_2P_3_Acoustic_survey
-5  9      0        0        -1       0.01     -2       0        0        0        0        0        0        0#       Age-
Sel_2P_4_Acoustic_survey
-5  9      0        0        -1       0.01     -2       0        0        0        0        0        0        0#       Age-
Sel_2P_5_Acoustic_survey
-5  9      0        0        -1       0.01     -2       0        0        0        0        0        0        0#       Age-
Sel_2P_6_Acoustic_survey
-5  9      -0.8     -1       -1       0.01     2        0        0        0        0        0        0        0#       Age-
Sel_2P_7_Acoustic_survey

1 #_custom_sel-blk_setup (0/1)
 -5 5 0.9 1 -1 0.01 2 # AgeSel_1P_2_purse_seine_BLK1delta_1978
 -5 5 0.4 1 -1 0.01 2 # AgeSel_1P_3_purse_seine_BLK1delta_1978
 -5 5 0.1 1 -1 0.01 2 # AgeSel_1P_4_purse_seine_BLK1delta_1978
 -5 5 -0.5 1 -1 0.01 2 # AgeSel_1P_7_purse_seine_BLK1delta_1978

4 #_selparmdev-phase
1 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)

1 #_Variance_adjustments_to_input_values
#_fleet: 1 2 3
 0 0 0 #_add_to_survey_CV
 0 0 0 #_add_to_discard_stddev
 0 0 0 #_add_to_bodywt_CV
 0 0 0 #_mult_by_lencomp_N
 1 1 1 #_mult_by_agecomp_N
 1 1 1 #_mult_by_size-at-age_N

4 #_maxlambdaphase
1 #_sd_offset

3 # number of changes to make to default Lambdas (default value is 1.0)
# Like_comp codes: 1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;
# 9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin
# like_comp fleet/survey phase value sizefreq_method
 9 1 1 1 1
 4 2 2 1 1
 4 2 3 1 1
```

D. Short-term projection

Model and software used: Multi Fleet Deterministic Projection (MFDP)

The initial stock size corresponds to the assessment estimates for ages 1–6+ at the final year. Recruitment (Age 0) estimated in the final year of the assessment is accepted for the projection since it is supported by data from the acoustic survey in the interim year. Recruitment in the interim year and forecast year will be set equal to a pre-agreed level of recruitment according to the update assessment. This level corresponds to the geometric mean recruitment of the last 15 years. The period selected does not cover the entire assessment period because there is a decreasing trend in recruitment throughout the historical period. A 15 year period will integrate some bad and good recruitments without being too much dependent to the most recent recruits estimated by the model.

The maturity ogive corresponds to the ogive used in the assessment (in years with no DEPM survey), i.e. 0% mature at age 0, 80% mature at age 1 and 100% mature at age 2+.

Input values for the proportion of F and M before spawning are zero, which correspond to the beginning of the year when the SSB is estimated by the model.

Weights-at-age in the stock and in the catch are calculated as the arithmetic mean value of the last three years of the assessment.

Natural mortality-at-age is equal to that used in the assessment.

The exploitation pattern is the average of the last three years of the assessment.

Predictions are carried out with an $F_{multiplier}$ (usually ranging from 0 to 2) assuming an F_{sq} equal to the average estimates of the last three years in the assessment. In the interim year, catches are constrained to be an agreed expected level (since data in not yet available), usually those corresponding to F_{sq} (0.36) or alternatively as duly justified by stock assessment scientists. Predicted population at the beginning and end of the forecast year will be shown according to preselected levels of fishing mortality in consonance with defined precautionary and target reference points.

E. Medium-term projections

Not carried out.

F. Long-term projections

Not carried out.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Undefined
Approach	F_{MSY}	0.35	$F_{BPR50\%}$, F at which the B1+/R is half of what it would have been in the absence of fishing
	B_{lim}	307 000 t	B_{lim}=B_{loss} (2000 B1+), B_{loss} being the lowest historical biomass which produced good recruitments
Precautionary	B_{pa}	xxx t	Undefined
Approach	F_{lim}	Xxx	Undefined
	F_{pa}	Xxx	Undefined

Reference points are expressed in terms of B_{1+}, the biomass of age 1 and older individuals. B_{1+} corresponds to total-stock biomass at the beginning of the year.

H. Other issues

H.1. Historical overview of previous assessment methods

From 2003 to the current benchmark, the sardine stock was assessed using the age structured model AMCI (Assessment Model Combining Information from various sources, Skagen, 2005). Because the program is not going to be maintained in the future, alternative programs have been explored. Stock Synthesis (SS3) has been chosen as the final assessment model in the 2012 benchmark since it offers the same level of flexibility of AMCI and additional features, such as the possibility to incorporate uncertainty of input data in the variance of final estimates. Other SS3 abilities which were not explored due to time limitation but might be useful in the future are: link to environmental data (e.g. to recruitment), include several fleets and areas (explain spatial differences in sardine demography) and use of the forecast module.

Summary of data ranges used in recent assessments:

Data	2006 assessment	2007 assessment	2008 assessment	2009 assessment
Catch data	Years: 1978–(AY-1) Ages: 1–8+	Years: 1978–(AY-1) Ages: 1–8+	Years: 1978–(AY-1) Ages: 1–8+	Years: 1978–(AY-1) Ages: 1–8+
Survey: A_Q1	Years: 1985–AY Ages: 1–7	Years: 1985–AY Ages 1–7	Years: 1985– AY Ages 1–7	Years: 1985–AY Ages 1–7
Survey: B_Q4	Years: 1996–(AY-1) Ages: 1–5	Years: 1996– AY-1) Ages 1–7	Years: 1996– AY-1) Ages 1–7	Years: 1996–AY-1) Ages 1–7
Survey: C	Not used	Not used	Not used	Not used

AY – Assessment year

I. References

Abad, E., Castro, J., Punzón, A. and Abaunza, P. 2008. Métiers of the Northern Spanish coastal fleet using purse-seine gears. WD presented to the ICES WGWIDE 2008 meeting.

Abaunza *et al*. 2008. Stock identity of horse mackerel (*Trachurus trachurus*) in the Northeast Atlantic and Mediterranean Sea: Integrating the results from different stock identification approaches. Fisheries Research 89, 196–209.

Beare DJ, Burns F, Greig A, Jones EG, Peach K, Kienzle M, McKenzie E, Reid DG. 2004. Long-term increases in prevalence of North Sea fishes having southern biogeographic affinities. Mar Ecol Prog Ser 284: 269–278.

Bernal M, Stratoudakis Y, Coombs S, Angelico M, de Lanzos A, Porteiro C, Sagarminaga Y, Santos M, Uriarte A, Cunha E, Valdes L, Borchers D. 2007. Sardine spawning off the European Atlantic coast: Characterization of and spatio-temporal variability in spawning habitat. Progress In Oceanography 74: 210–227.

Bernal, M. 2008. Modelling the abundance, distribution and production of sardine (*Sardina pilchardus*, Walb.) eggs in the Iberian Peninsula. PhD Thesis, Universidad de Cádiz, Cádiz, Spain, 262pp.

Binet D, Samb B, Sidi MT, Levenez JJ, Servain J. 1998. Sardine and other pelagic fisheries associated with multi-year trade wind increases, pp. 212–233. Paris: ORSTOM.

Bode, A., Alvarez-Ossorio, M.Y., Carreara, P. and Lorenzo, J. 2004. Reconstruction of trophic pathways between plankton and the North Iberian sardine (*Sardina pilchardus*) using stable isotopes. Scientia Marina 68:175–178.

Bode, A., Carrera, P. and Lens, S. 2003. The pelagic foodweb in the upwelling ecosystem of Galicia (NW Spain) during spring: natural abundance of stable carbon and nitrogen isotopes. ICES Journal of Marine Science 60:11–22.

Bode, A., Alvarez-Ossorio M.T., Cunha, M.E., Garrido, S., Peleteiro, J.B., Porteiro, C., Valdés, L. and Varela, M. 2007. Stable nitrogen isotope studies of the pelagic food web on the Atlantic shelf of the Iberian Peninsula. Progress in Oceanography 74:115–131.Carrera and Porteiro, 2003.

Corten A, van de Kamp G. 1996. Variation in the abundance of southern fish species in the southern North Sea in relation to hydrography and wind. ICES J Mar Sci 53:1113–1119.

Csirke, J. 1988. Small shoaling pelagic fish stocks. In: Fish population dynamics, J.A. Gulland (Ed.), John Wiley y Sons., New York, 271–302.

Dickson, R.R., Kelly, P.M., Colebrook, J.M., Wooster, W.S. and Cushing, D.H. 1988. North winds and production in the eastern North Atlantic. J. Plankton Res. 10: 151–169.Gamulin and Hure, 1955.

Ganias K., Nunes C., Stratoudakis Y. 2007. Degeneration of sardine (*Sardina pilchardus*) post-ovulatory follicles: structural changes and factors affecting resorption. Fishery Bulletin, 105:131–139.

Garrido S., Marçalo A., Zwolinski J. and van der Lingen C.D. 2007. Laboratory investigations on the effect of prey size and concentration on the feeding behaviour of *Sardina pilchardus*. Marine Ecology Progress Series. 330:189–199.

Guisande, C., Cabanas, J.M., Vergara, A.R., Riveiro, I. 2001. Effect of climate on recruitment success of Atlantic Iberian sardine *Sardina pilchardus.* Marine Ecology Progress Series. 223: 243–250.

ICES. 2007. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES CM 2007/ACFM: 31.

ICES. 2010. Report of the Workshop on Reviews of Recent Advances in Stock Assessment Models World-wide: "Around the World in AD Models" (WKADSAM). ICES CM 2010/SSGSUE:10.

ICES. 2011a. Report of the Working Group on Anchovy and Sardine (WGANSA). ICES CM 2011/ACOM:16.

ICES. 2011b. Report of the Workshop on Age Reading of European Atlantic Sardine (WKARAS). ICES CM 2011/ACOM:42.

ICES. 2012. WKPELA Report.

Kasapidis P, Magoulas A, Silva A, Zampicinini G. 2012. Evidence for microsatellite hitchhiking selection in European sardine (*Sardina pilchardus*) and implications in inferring stock structure. Scientia Marina, 76.

Laurent V, Magoulas A, Caneco B, Planes S. 2007. Isolation by distance and selection effects on genetic structure of sardines *Sardina pilchardus* Walbaum. Journal of Fish Biology 2007; 71:1–17.

Mackinson, S., Vasconcellos, M. C., Pitcher, T. and Walters, C. J. 1997. Ecosystem impacts of harvesting small pelagic fish in upwelling systems using a dynamic mass-balance model. Proceedings Forage Fishes in Marine Ecosystems. Fairbanks: Anchorage, Alaska. Alaska Sea Grant College Program. AK9701: 15–30.

Mesquita, C. 2008. Application of Linear Mixed Models in the study of LPUE patterns in the Portuguese purse-seine fishery for sardine (*Sardina pilchardus* Walbaum, 1792). PhD Thesis. School of Biological Sciences, University of Aberdeen.

Methot, R.D. 1990. Synthesis model: an adaptable framework for the analysis of diverse stock assessment data. International North Pacific Fisheries Commission, Bulletin Number 50.

Methot, R.D. 2005. Technical description of the Stock Synthesis II Assessment program. Available with SS3 download at http://nft.nefsc.noaa.gov.

Methot, R.D. 2011. User Manual for Stock Synthesis. Available with SS3 download at http://nft.nefsc.noaa.gov.

Meynier, L. 2004. Food and feeding ecology of the common dolphin, *Delphinus delphis*, in the Bay of Biscay: intraspecific dietary variation and food transfer modelling. MSc report, University of Aberdeen, Aberdeen, 84 pp.

Morais, P., Faria, A., Chícharo, M.A., Chícharo, L. 2009. The unexpected occurrence of late *Sardina pilchardus* (Walbaum, 1792) (Osteichthyes: Clupeidae) larvae in a temperate estuary. Cahiers de Biologie Marine 50 (1), pp. 79–89.

Parrish RH, Serra R, Grant WS. 1989. The monotypic sardines, *Sardina* and *Sardinops*: their taxonomy, stock structure, and zoogeography. Can. J. Fish. Aquat. Sci. 46: 2019–2036.

Patterson, K.R. 1998. A programme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Pérez, N., I. Figueiredo, and B. J. Macewicz. 1992. The spawning frequency of sardine, *Sardina pilchardus* (Walb.), off the Atlantic Iberian coast. Bol. Inst. Esp. Oceanogr. 8:175−189.

Perez N Figueredo, I Lon C H. 1992. Batch fecundity of *Sardina pilchardus* Walb., of the Atlantic Iberian Coast. Bol Inst Esp Oceanogr 8(1): 155–162.

Porteiro C., Carrera P., Miquel J. 1996. Analysis of Spanish acoustic surveys for sardine, 1991–1993: abundance estimates and interannual variability. ICES Journal of Marine Science 53:429–433.

Riveiro, I., Santos MB., Silva A. 2012. Current knowledge on Iberian sardine (*Sardine pilchardus*) stock identity. Working Document to WKPELA (ICES Benchmark Workshop on Pelagic Stocks. February 2012).

Roy C, Porteiro C, Cabanas J. 1995. The optimal environmental window hypothesis in the ICES Area: the example of the Iberian sardine. ICES Cooperative Research Report , 206:57–65.

Santos, M.B, Pierce, G.J., López, A., Martínez, J.A., Fernández, M.T., Ieno, E., Mente, E., Porteiro, C., Carrera, P. and Meixide M. 2004. Variability in the diet of common dolphins (*Delphinus delphis*) in Galician waters 1991–2003 and relationship with prey abundance. ICES CM 2004/Q:09.

Santos, A.M.P., Chícharo, A., Dos Santos, A., Miota, T., Oliveira, P.B., Peliz, A., and Ré, P. 2007. Physical-biological interactions in the life history of small pelagic fish in the Western Iberia Upwelling Ecosystem. Progress in Oceanography, 74: 192–209.

Santos MB, German I, Correia D, Martinez J, Caldas M, López A, Pierce GJ. 2011a. Predation on sardine by common dolphins (*Delphinus delphis*) in Galician waters (NW Spain) dolphins. Working Document for WKPELA, 25–26/10/2011 Copenhagen.

Santos M B, González-Quirós R, Riveiro I, Cabanas J M, Porteiro C, Pierce G J. 2011b. Cycles, trends, and residual variation in the Iberian sardine (*Sardina pilchardus*) recruitment series and their relationship with the environment. ICES Journal of Marine Science, doi:10.1093/icesjms/fsr186.

Shaw P, McKeown N, Van der Kooij J. 2012. Analysis of genetic population structuring of Sardine (*Sardina pilchardus*) in Eastern Atlantic waters using nuclear microsatellite DNA markers Working Document for WKPELA, 13–17/02/2012 Copenhagen.

Silva A. 2003. Morphometric variation among sardine (*Sardina pilchardus*) populations from the northeastern Atlantic and the western Mediterranean. ICES J. Mar. Sci. 60 (6): 1352–1360.

Silva, A., Carrera, P., Massé, J., Uriarte, A. D., Santos, M. B., Oliveira, P. B., Soares, E., *et al*. 2008. Geographic variability of sardine growth across the northeastern Atlantic and the Mediterranean Sea. Fisheries Research, 90: 56–69.

Silva A. 2008a. Geographic variation in sardine population traits: implications for stock assessment. PhD Thesis. Faro, Portugal. 243 pp.

Silva A, Kasapidis P, Laurent V, Caneco B, Planes S, Magoulas A. 2008b. Integrating genetic and morphometric variation in the sardine (*Sardina pilchardus*, walb.) from the northeastern Atlantic and the Mediterranean Sea. Symposium "Science and the challenge of managing small pelagic fisheries on shared stocks in Northwest Africa", Casablanca, Morocco, 11–14 March 2008. Available at www.smallpelagics2008.org.

Silva, A., Skagen, D. W., Uriarte, A., Masse´, J., Santos, M. B., Marques, V., Carrera, P., Beillois, P., Pestana, G., Porteiro, C., and Stratoudakis, Y. 2009. Geographic variability of sardine dynamics in the Iberian Biscay region. ICES Journal of Marine Science, 66: 495–508.

Stratoudakis Y, Coombs S, Lanzós AL, Halliday N, Costas G, Caneco B, Franco C, Conway D, Santos MB, Silva A, Bernal M. 2007. Sardine (*Sardina pilchardus*) spawning seasonality in European waters of the Northeast Atlantic. Marine Biology 152 (1): 201–212.Stratoudakis Y, Marçalo A (2002) Sardine slipping during purse-seining off northern Portugal. ICES Journal of Marine Science 59:1256–1262.

Uriarte, A., Prouzet, P. and Villamor, B. 1996. Bay of Biscay and Ibero Atlantic anchovy populations and their fisheries. Scientia Marina, 60 (Suppl. 2): 237–255.

Uriarte A, Alvarez P, Iversen S, Molloy J, Villamor B, Martíns MM, Myklevoll S. 2001. Spatial pattern of migration and recruitment of Northeast Atlantic mackerel. ICES CM 2001/O: 17.

Villamor, B., Abaunza, P., Lucio, P. and Porteiro, C. 1997. Distribution and age structure of mackerel (*Scomber scombrus* L.) and horse mackerel (*Trachurus trachurus* L.) in the north coast of Spain. Scientia Marina. 61: 345–366.

Zwolinski, J., Fernandes, P., Marques, V. And Stratoudakis, Y. 2009. Estimating fish abundance from acoustic surveys: calculating variance due to acoustic backscatter and length distribution error. Can. J. Fish. Aquat. Sci, 66:2081–2095.

Stock Annex: Southern Horse Mackerel

Stock	Horse Mackerel in Division IXa (Southern horse mackerel)
Working Group:	WGANSA
Date:	30 January 2011
Revised by	Alberto Murta, Pablo Abaunza, Jim Ianelli (WKBENCH, 2011)

A. General

A.1. Stock definition

Stock units

For many years the Working Group has considered the horse mackerel in the northeast Atlantic as separated into three stocks: the North Sea, the Southern and the Western stocks (ICES, 1990; ICES 1991). Until the results from the EU project (HOMSIR, QLK5-Ct1999-01438), were available, the separation into stocks was based on the observed egg distributions and the temporal and spatial distribution of the fishery. The extremely strong 1982 year class appeared for the first time in the eastern part of the North Sea in 1987, during the third and mainly the fourth quarter. This year class was the basis for the start of the Norwegian horse mackerel fishery in the eastern part of North Sea during the third and mainly the fourth quarter. Since Western horse mackerel are assumed to have broadly similar migration patterns as NEA mackerel the Norwegian catches have been considered to be fish of western origin migrating to this area to feed. In addition, there is a fishery further south in the North Sea which is considered to be fish of North Sea origin. These views were supported by results from the mentioned EU project which was reviewed in ICES (2004) which also concluded to include Division VIIIc as part of the distribution area of the western horse mackerel stock (see also Abaunza *et al.*, 2008 for a comprehensive discussion of the results from the HOMSIR project). Horse mackerel off the west coast of the Iberian Peninsula have characteristics (morphometry, parasites, distribution and migratory circuit) that distinguish them from the rest of the samples collected in the northeast Atlantic. The border between southern and western horse mackerel stocks may therefore lie at the level of Cape Finisterre on the coasts of Galicia at 43°N, which is also the limit between Division VIIIc and IXa. The southern limit of the southern horse mackerel stock is not as evident due to the lack of samples from the north of Africa. Based on morphometric studies, Murta (2000) showed that the horse mackerel of the Portuguese coast was closer to the northwest coast of Morocco than to the Gulf of Cadiz in the south of Spain. However, the respective parasite composition suggests that the populations off the north of Africa and the west of the Iberian Peninsula are not part of a continuous stock.

Data from bottom-trawl surveys carried out throughout the Atlantic waters of the Iberian Peninsula during the autumn supported the existence of ontogenic migrations (Murta *et al.*, 2008). Analysis of the proportion of each year class in each area off the Portuguese coast indicated that most year classes recruit to the northwest area (close to Area 8) and then move progressively southwards. After six years of age, they return to the north.

Allocation of catches to stocks

Based on spatial and temporal distribution of the horse mackerel fishery, the catches were allocated to the three stocks as follows:

Western stock: Divisions IIa, IIIa (western part), Vb, IVa (third and fourth quarter), VIa, VIIa–c,e–k and VIIIa–e. Although it seems strange that only catches from western part of Division IIIa are allocated to this stock, the catches in the western part of this Division taken in the fourth quarter often are taken in neighbouring area of catches of western fish in Division IVa. The Working Group is not sure if catches in Divisions IIIa and IVa during the first two quarters are of western or North Sea origin. Usually this is a minor problem because the catches here during this period are small. However, in 2006 relatively larger catches were taken in this area during the first half of the year (3600 tons) and these catches were allocated to the North Sea stock. In 2007, 2100 tons were caught during the two first quarters in Divisions IVa and IIIa and were allocated to the North Sea stock.

North Sea stock: Divisions IIIa (eastern part), IVa (first and second quarter), IVb,c and VIId. The catches in 3–4 quarters of Divisions IVa and IIIa and 1–4 quarters from Divisions IVb,c and VIId were allocated to the North Sea stock. In 2007, some small catches were reported from Divisions IIIb (4 tons) and IIIc (21.5 tons) and were allocated to the North Sea stock.

Southern stock: Division IXa. All catches from these areas are allocated to the southern stock.

A.2. Fishery

The catches of horse mackerel in Division IXa (Subdivision IXa North, Subdivision IXa Central-North, Subdivision IXa Central-South and Subdivision IXa South) are allocated to the Southern horse mackerel stock. In the years before 2004 the catches from Subdivisions VIIIc West and VIIIc East, were also considered to belong to the southern horse mackerel stock.

The Spanish catches in Subdivision IXa South (Gulf of Cádiz) are available since 2002. They will not be included in the assessment data until they are available for all assessment years, to avoid a possible bias in the assessment results. On the other hand, the total catches from the Gulf of Cádiz are scarce and represent less than the 5% of the total catch. Therefore, their exclusion should not affect the reliability of the assessment.

The “Prestige” oil spill had also an effect on the fishery activities in the Spanish area (Division IXa North) in 2003. The Spanish catches increased markedly from 1991 until 1998, whereas the Portuguese catches were more stable, showing a smooth decreasing trend since the peak observed in 1992 (with a secondary peak in 1998).

Catches in Subdivisions IXa Central-North showed a decreasing trend whereas in Subdivision IXa North they increased markedly until 1998, and since then, the catches always have been higher than 7000 t. The catches from bottom trawlers are the majority in both countries. The rest of the catches are taken by purse seiners, especially in the Spanish area and by the artisanal fleet which is much more important in the Portuguese area.

Description of the Portuguese fishing fleets operating in Division IXa (data provided by the Portuguese Fisheries Directorate) and catch horse mackerel (only trawlers and purse seiners):

Gear	Length	Storage	Number of boats
Trawl	10-20	Freezer	2
Trawl	20-30	Freezer	7
Trawl	30-40	Freezer	5
Trawl	0-10	Other	259
Trawl	10-20	Other	68
Trawl	20-30	Other	60
Trawl	30-40	Other	29
Purse seine	0-10	Other	79
Purse seine	10-20	Other	103
Purse seine	20-30	Other	79

Note that horse mackerel is also caught in all polyvalent and most small scale fisheries.

Description of the Spanish fishing fleets operating in Division IXa including the Gulf of Cádiz (Southern stock) and Division VIIIc (Western stock) (Hernández, 2008):

Gear	Bottom trawl	Purse seine	Lgline Bottom	Lgline surface	Gillnet (big mesh size)	Gillnet	Other artisanal
Number	282	410	100	67	35	57	5379
Construction year (mean)	1996	1992	1990	1995	1990	1993	1982
Length	9–35 (22.9)	8–38 (21)	6–28 (15.1)	18–38 (27.6)	4–28.6 (14)	12–27 (17.2)	3–27 (7)
Power	66–800 (322.3)	24–1100 (302.5)	12–476 (150.3)	175–780 (418.9)	10–500 (141.8)	50–408 (164.9)	2–450 (32.6)
Tonnage	6–228 (81.2)	4–221 (56.6)	2–118 (26)	37–206 (116)	1–110 (23.7)	10–99 (27.6)	0.3–83 (3.5)

It is indicated the range and the arithmetic mean (in parenthesis). Data from official census (Hernández, 2008). Note that horse mackerel in the Spanish area is mainly fished by bottom trawlers and purse seiners.

The Spanish bottom-trawl fleet operating in ICES Divisions VIIIc (Western stock) and Subdivision IXa north (Southern stock), historically relatively homogeneous, has evolved in the last decade (approximately since 1995) to incorporate several new fishing strategies. A classification analysis for this fleet between the years 2002 and 2004 was made based on the species composition of the individual trips (Castro and Punzón, 2005). The analysis resulted in the identification of five catch profiles in the bottom otter trawl fleet: 1) targeting horse mackerel (>70% in landings), 2) targeting mackerel (>73% in landings); 3) targeting blue whiting (>40% in landings); 4) targeting demersal species; and 5) a mixed "métier". In the bottom pair trawl fleet the classification analysis showed two métiers: 1) targeting blue whiting; and 2) targeting hake. These results should help in obtaining standardized and more coherent cpue series from fishing fleets.

In the Portuguese area (Division IXa) Silva and Murta (2007) classified trawl fleet in two main types: those targeting fish and cephalopods species and those fishing crustaceans. Looking at the fishing trips of those that catch fish and cephalopods, they identified three main clusters: 1) targeting horse mackerel, 2) targeting cephalopods, and 3) a poorly defined mixed cluster.

In 2005, the landings of blue whiting increased, probably due to increased market demand and consequent reduction of discards, resulting in a fourth specific cluster. The Crustacean trawl clusters do not follow the same pattern every year, depending on the abundance of the two main target crustacean species, which are Norway lobster and deep-water rose shrimp. There can be one target species by cluster or mixed clusters with different percentages of these two species.

A.3. Ecosystem aspects

Influence of environmental drivers on the stock dynamic

The southern horse mackerel stock is distributed along the western and southern Atlantic coasts of the Iberian Peninsula, which is an area subject to upwelling events. There is already evidence in the literature that horse mackerel recruitment is influenced by environmental drivers. The analysis carried out under the IN EX Fish project (Frid *et al*., 2009) showed that non-linear combinations of NAO and upwelling indices were able to explain the strength of past recruitments. The rise and fall of this horse mackerel stock was probably caused by a complex interaction of different factors, both human and natural. However, it is very likely that changes in recruitment due to upwelling and NAO events may have played an important role.

Role of multispecies interactions

Horse mackerel is a schooling species and often close to the sea floor. Shelf attachment is a predominant distributional pattern for this stock. Therefore, horse mackerel is in relation with other fish and invertebrate species that are usually caught during the bottom-trawl surveys and share the same habitat. These species are mainly: snipefish, boarfish, blue whiting, European hake, sardine, blue jack mackerel, squid and pelagic crabs (Sousa *et al*., 2006).

Trophic interactions

Young horse mackerel is a feeding resource consumed by several demersal, benthic and pelagic predators present in the distribution area like: hake, monkfish, John Dory, bluefin tuna and dolphins.

Horse mackerel is mainly a zooplanktivorous species. Diet variations with fish length and water depth are correlated: small fish are closely associated with coastal areas where they feed on copepods and decapod larvae (Cabral and Murta, 2002). However, they can prey on fish as they grow. They become *Ichthyophagous* when they reach large sizes.

B. Data

B.1. Commercial catch

Mean length-at-age and mean weight-at-age

Both mean length-at-age and mean weight-at-age values are calculated by applying the mean, weighted by the catch, over the mean weights or mean lengths-at-age obtained by Subdivision.

Taking in consideration that the spawning season is very long, from September to June, and that the whole length range of the species has commercial interest in the

Iberian Peninsula, with probably very scarce discards, there is no special reason to consider that the mean weight in the catch is significantly different from the mean weight in the stock.

Catch in numbers-at-age

The sampling scheme is believed to achieve a good coverage of the fishery (above 95% of the total catch). The number of fish aged seems also to be sufficient through the historical series. Catch in numbers-at-age have been obtained by applying a quarterly ALK to each of the catch length distribution estimated from the samples of each subdivision. In the case of Subdivision IXa north, the catch in number estimates before 2003 have changed. In previous years the age–length key applied to the length distributions from Subdivision IXa north had included otoliths from Division VIIIc, which has been defined recently as part of the western stock. Since 2003, the catch in numbers-at-age from Subdivision IXa north were estimated using age–length keys which included only otoliths from Division IXa.

B.2. Biological

Maturity-at-age

For multiple spawners, such as horse mackerel, macroscopical analysis of the gonads cannot provide a correct and precise means to follow the development of both ovaries and testes. Histological analysis has to be included because it provides precise information on oocyte developmental stages and it can distinguish between immature gonads and regressing ones, or those partly spawned (Abaunza *et al.*, 2008). The HOMSIR project provided microscopical maturity ogives from the different IXa subdivisions. The maturity ogive from Subdivision IXa South is adopted here as the maturity-at-age for all years until 2006 of the southern stock, since it was based on a better sampling than in the others subdivisions. The percentage of mature female individuals per age group was adjusted to a logistic model.

In 2007 a new estimate of maturity proportion by age was available for Division IXa for the application of the Daily Egg Production Method (DEPM). This maturity ogive was then adopted since 2007 and will be revised with new data collected in the DEPM to be carried out in 2010.

Natural mortality

Natural mortality has been considered to be 0.15. This level of natural mortality was adopted for all horse mackerel stocks since 1992. However, the presence of very old horse mackerel specimens in the southern stock is much scarcer than in the western or North Sea stocks. On the other hand, the available references on natural mortality estimates for other *Trachurus* species (e.g. *Trachurus capensis, Trachurus japonicus* and *Trachurus murphyi*) show higher natural mortality values, being higher than 0.3 in the majority of cases (range from 0.1 to 0.5) (Cubillos *et al.*, 2008; MFMR, 2006; Zhang, 2001). Also, the assumption that natural mortality is the same for all ages is highly unrealistic, given that the chances of a 10 cm fish of being predated are much higher than those of a 30 cm fish.

As a conclusion, it is considered that the value of natural mortality (0.15) is an underestimation for southern horse mackerel stock. It is generally accepted that natural mortality is very high during larval stages and decreases as the age of the fish increases, approaching a steady rate (Jennings *et al.*, 2001). The natural mortality adopted in the assessment (mean = 0.3) is dependent on age, being higher for younger ages. The adopted values are the following and are based in the estimates for other similar pelagic species, observed diet composition of fish predators in the area and taking into account the observed mean life span in southern horse mackerel.

Age	0	1	2	3	4	5	6	7	8	9	10
Nat Mor	0.9	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

B.3. Surveys

The only survey datasets currently available for the assessment of southern horse mackerel are those from the bottom-trawl surveys carried out in the 4th quarter (October) by Portugal (Pt-GFS-WIBTS-Q4) and Spain (Sp-GFS-WIBTS-Q4) in ICES Division IXa. These surveys cover contiguous areas at the same time but do not cover the southern part of the stock distribution area, corresponding to the Spanish part of the Gulf of Cadiz. In that area another bottom-trawl survey is carried out Sp-GFS-caut-WIBTS-Q4), usually in November, but the raw data were unavailable in time for this workshop to investigate the effect of merging it with the datasets from the other areas. This work is expected to be completed in time for the next assessment working group, in June 2011.

As suggested in previous reviews of the assessment of this stock, the Spanish survey from Subdivision IXa North (Sp-GFS-WIBTS-Q4) and the Portuguese survey (Pt-GFS-WIBTS-Q4) are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawls. The catchability of these vessels (BO Cornide de Saavedra and NI Noruega) and fishing gears were compared for different fish species during project SESITS (EU Study Contract 96-029) and no significant differences were found for horse mackerel. Thus, the raw data (number per hour and age in each haul, including zeros) of the two datasets were merged and treated as a single dataset.

The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals. Therefore, it is questionable whether a simple average of the number-per-hour, by age and year, is an adequate abundance index for tuning the stock assessment. Different ways of obtaining an abundance index by age and year were explored, all of them based on the smoothing of the data assuming probability distributions other than the Normal one. For this, we fitted Generalized Additive Models (GAM) to the raw data using the package "mgcv" (Wood, 2006) in the R statistical computing language (R Core Development Team, 2010). Data smoothing was tried with four different strategies: by year class (one GAM for each year-class, with age as covariate), by age (one GAM by age with year as covariate), by year (one GAM by year with age as covariate), and by age and year (one GAM using a bi-dimensional smoother by age and year). A log link function was used in all cases, and the error was modelled with a binomial negative distribution. Other distributions and transformations of the data were tried, but with worse fittings than with these settings.

An example of the GAM fitting diagnostics with each of these four strategies showed in all cases a poor fitting, with the residuals showing undesirable patterns. Looking at the differences between the indices matrix obtained with each of these strategies and the one obtained by a simple average of the raw data, it is clear that most of the attempted strategies to smooth the data would result in strong differences, especially for the youngest ages. Given that an acceptable fit could not be achieved with these GAMs, it was decided to use the simple averaged data as abundance indices for tuning the assessment. Further work must be carried out in the future to better address this problem.

Two very clear features can be observed in the abundance indices dataset: a strong variability of age 0 and strong year effects (some years with higher abundance of all ages than others). The first feature may be explained by the greater aggregation tendency of these small fish in dense shoals and by their typically pelagic behaviour, which makes them less available to the bottom trawl. When, by chance, one or a few of those shoals are captured by the bottom trawl (e.g. at the end of a haul when the trawl is being towed at mid-water), it contributes to a high abundance estimate of that age class. The apparent year effects in the data are more difficult to explain, and are likely due to natural variations in the availability of the fish in that time of the year and small variations in sampling effort (e.g. due to bad weather). Both the variability in age 0 and the apparent year effects must be accounted for in the assessment model to be fitted to these data.

Recent work suggests that horse mackerel has indeterminate fecundity (Gordo *et al.*, 2008), which makes the Annual Egg Production Method (AEPM) unsuitable to estimate SSB for this species. For species with indeterminate fecundity, the Daily Egg Production Method (DEPM) must be used instead. The existence of different series of data from egg surveys covering the whole area of the southern horse mackerel stock makes it possible to obtain egg production estimates using DEPM.

For this stock, a total of three SSB estimates, for the years 2002, 2005 and 2007, were made available. The SSB estimate and variance for 2007 was obtained from a DEPM egg survey directed at horse mackerel. Details of the sampling procedure, data obtained and methods followed are available from the 2008 report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (ICES, 2008. ICES CM 2008/LRC:09). However, some details were corrected after the WGMEGS report, namely the total egg distribution area (which was corrected from 1.7e11 sq.meter to 7.1e11 sq.meter) and the fitting of the mortality curve to the egg abundance data, which was done using a GLM with a log link and assuming a Poisson distribution for the variance, instead of the non-linear regression described in the WGMEGS report. This resulted in a change of egg production from 13 eggs/sq.meter to 17 eggs/sq.meter.

The 2002 and 2005 estimates were obtained with egg abundance data collected during the surveys directed at sardine in 2002 and 2005 and from horse mackerel adult samples collected at the same time of those surveys. The methodology followed to estimate SSB was the same as the one for 2007, although the area covered in the egg sampling, which corresponded to the sampling grid for sardine, was smaller than in 2007.

There are different criteria that can be used to estimate the spawning fraction, such as the presence of migratory nucleus, hydrated oocytes or post-ovulatory follicles (POF). Estimates of SSB were obtained for the three years with all these criteria, and the obtained trends in SSB were parallel but with different levels. The POF criteria, assuming POF last for two days as in other species at similar temperatures (Ganias *et al.*, 2003; Hunter and Macewicz, 1985) was the one providing the lowest CV, being therefore adopted to use in the assessment. However, given the uncertainty in the absolute value of SSB, partly due to the choice of the criteria for the spawning fraction, the SSB index for the assessment must be treated as relative and a corresponding catchability parameter has to be estimated.

Still another source of uncertainty is the egg distribution area, which was roughly defined and kept fixed for the three years. In all these egg surveys, there are several transects with the presence of eggs in the most offshore station, which indicates that the area with egg presence must, in some cases, be extended further away from the coast. However, a good approximation of that area is impossible to obtain with the available data.

B.4. Commercial cpue

No commercial cpue data is used in the stock assessment.

B.5. Other relevant data

There were no other data considered at this time.

C. Assessment: data and method

Model used: AMISH (Assessment Method for the Ibero-Atlantic Stock of Horse-Mackerel).

A model similar to the one adopted by the South Pacific Regional Fishery Management Organization (SPRFMO) for the assessment of Chilean jack mackerel (*Trachurus murphyi*) was modified for application with horse mackerel. This method (Lowe *et al*., 2009) models the population numbers-at-age as projections forward based on recruitment estimates leading up the initial population numbers-at-age (in 1992 for this case) and subsequent annual recruitment and fishing mortalities parameters. These underlying population numbers-at-age are fit through an observation model for parameter estimation via a penalized likelihood applied to a quasi-Newton minimisation routine with partial derivatives calculated by automatic differentiation (Griewank and Corliss, 1991). The automatic differentiation and minimisation routines are those from the package AD Model Builder (ADMB). A similar model is currently used in many stock assessments in North American waters (e.g., Atka mackerel, eastern Bering Sea pollock, Pacific Ocean perch). It is a simple, well tested, and widely used methodology. The population equations, model fitting components, and model settings are listed in Tables 1–4.

The approach differs from the XSA methods in that:

- calculations proceed from the initial conditions to the present and into the future,
- the catch-at-age is not assumed to be known exactly,
- the inclusion of annual estimates of sampling variability (for both age composition and survey index precision) is allowed,
- fishing mortality is separable but selection-at-age is allowed to change gradually over time,
- separate components of the fishery are treated independently,
- some parameters, which are assumed constant in XSA, such as the catchability coefficients associated with tuning indices, may be allowed to change over time,
- statistical basis allows for careful consideration of data quality and the impact on the uncertainty of estimates.

The model begins in the first year of available data with an estimate of the population abundance-at-age. Recruitments are estimated for each year. In subsequent ages and years the abundance-at-age is reduced by the total mortality rate. This projection continues until the terminal year specified. If data are unavailable to estimate recruitment, the model will use the geometric mean value and hence can be projected to any arbitrary year (assuming specified catches).

The fishing mortality rates for each sector in the fishery are assumed to be separable into an age component (called selectivity) and a year component (called the F multiplier). The selectivity patterns are allowed to change over time. Expected catches are computed according to the usual catch equation using the determined fishing mortality rate, the assumed natural mortality rate, and the estimated population abundance described above. The statistical fitting procedure used with the model will try to match the indices and the catch-at-age. The emphasis of each of these sources of information depends on the values of the relative weights assigned to each component by the user.

The minimization processes proceeds in phases, in which groups of parameters are estimated simultaneously, while the remaining parameters are maintained at their initially assigned values. Once the objective function is minimized for a particular phase, more parameters are treated as unknown and added to those being estimated. This process of estimation in phases continues until all parameters to be estimated contribute to the objective function and the best set of all parameters that minimize the objective function value is determined.

The software code and input files is available on request.

Model Options chosen:

The objective function is the sum of a number of negative log-likelihoods generally following two types of error distributions: the lognormal and multinomial and details are listed in Table 3. The specifications of input sampling levels (in terms of sample size or variance term) are provided in Table 4.

The separability in the fishing mortality was allowed to vary according to a shift in fleet composition. An F multiplier was estimated for the first year, and was allowed to change in time by estimating deviations to this parameter for each year. The fishing mortality at each age, year and fleet resulted from the product of the F multipliers by the selectivity parameter at each age and fleet. Three selectivity vectors were estimated, corresponding to blocks of fleets sharing a similar selectivity-at-age. This is a useful feature of the model that helps to avoid overparameterisation. By looking at the plots of catch-at-age by fleet, it was decided to have a common selectivity for the purse-seine fleets, together with the Portuguese bottom-trawl fleet, another one for the artisanal fleets and a third one just for the Spanish bottom-trawl fleet. One catchability parameter for the abundance index was kept fixed over time.

The model fitting is affected by statistical weights (lambdas or inverse variance functions) as part of the objective function. Specified input variance assumptions can influence the fitting of the model, by attributing a lower or higher importance to different data sources that contribute to the objective function. The variance assumption assumed the highest precision for landings data by year and fleet. The fishery proportions-at-age for the moment were assumed to have an "effective sample size" of 100 compared to the value of ten specified for the survey estimates of age composition. The survey index data was fit assuming that the coefficient of variation was 30%. These values are typical for this type of information and diagnostic plots of model fits confirmed that they are reasonable. As more data become available, these assumptions can be modified to more appropriate and potentially time-varying values.

D. Short-term projection

Model used: Apropos designed function, named *mff*, to perform deterministic forecast, only with catch constraints (allowing the introduction of variability in the assumed recruitment values). Having the initial numbers-at-age at the beginning of the year, the total F at age in the assessment year y-1 and the assumptions we want to make on the weight-at-age, the selectivity-at-age by fleet, the maturity ogive, the natural mortality rate and the recruitment. We can project forward the population given a level of catches for the intermediate year y and for the protection year y+1. It is also possible to add some variability to the recruitments, by including a standard deviation value.

The method starts projecting the population numbers-at-age from the last assessment year with the estimated the fishing mortality rates by fleet,

$$N_0 = rec \cdot e^{\varepsilon}, \quad \varepsilon \sim N(0, \sigma)$$
$$N_1 = N_0 \cdot e^{-(M_0 + F_0) p}$$
$$N_a = N_{a-1} e^{-(M_{a-1} + F_{a-1})}, \quad a \text{ in } 2, \dots, \text{A-1}$$
$$N_A = N_{A-1} e^{-(M_{A-1} + F_{A-1})} + N_A e^{-(M_A + F_A)}$$

where rec corresponds to the assumed recruitment level, N_a are the numbers-at-age a, M_a is the natural mortality-at-age a, F_a is the fishing mortality-at-age a, σ is the standard deviation of the recruitment and p is the proportion of the year from the recruitment time to the end of the year.

For the intermediate year in the short-term projections, the population numbers-at-age are calculated assuming catch constraints by fleet, using Pope's approximation forward,

$$\lambda = \frac{catch}{\sum_a S_a \cdot N_a \cdot W_a}, \quad proportion to the \max imum that could be captured$$
$$C_a = \sum_a S_a \cdot N_a \cdot \lambda$$
$$N_0 = rec \cdot e^{\varepsilon}, \quad \varepsilon \sim N(0, \sigma)$$
$$N_1 = \left(N_0 - C_0 \cdot e^{M_0 \cdot p/2}\right) e^{-M_0 \cdot p}$$
$$N_a = \left(N_{a-1} - C_{a-1} e^{M_{a-1}/2}\right) e^{-M_{a-1}}, \quad a \text{ in } 2, \dots, \text{A-1}$$
$$N_A = \left(N_{A-1} - C_{A-1} e^{M_{A-1}/2}\right) e^{-M_{A-1}} + \left(N_A - C_A e^{M_A/2}\right) e^{-M_A}$$

where λ is the proportion to the maximum catch that could be captured, rec corresponds to the assumed recruitment, N_a are the numbers-at-age a, M_a is the natural mortality-at-age a, F_a is the fishing mortality-at-age, S_a is the selectivity-at-age, a and p is the proportion of the year from the recruitment time to the end of the year.

The source code is available on request.

Software used: R (www.r-project.org)

Initial stock size: the one estimated by the assessment model

Maturity: the same as in the previous year of the assessment

F and M before spawning: both of them are 0

Weight-at-age in the stock: the same as in the previous year of the assessment

Weight-at-age in the catch: assumed equal to the weight-at-age in the stock

Exploitation pattern: the one estimated in the assessment model

Intermediate year assumptions: the catches by fleet are assumed to be exactly the same as the ones in the previous year

Stock–recruitment model used: no stock–recruitment model is used, the recruitment is assumed to be stochastic in all the years (the assessment year, the intermediate and the projection year), around the geometric mean of the historical values with the same variability as the one observed in the series.

Procedures used for splitting projected catches:

E. Medium–term projections

No medium-term projection has been performed for this stock

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

F. Long-term projections

No long-term projection has been performed for this stock.

Model used:

Software used*:*

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

Reference points have not been defined for this stock.

H. Other issues

I. References

ASTT. 2010. Report from the assessment simulation task team on Chilean jack mackerel stock assessments, April 6–9th 2010, IMARPE, Lima, Peru. http://www.southpacificrfmo.org

Abaunza, P., Gordo, L.S., García Santamaría, M.T., Iversen, S.A., Murta, A.G., Gallo, E. 2008. Life history parameters as an important basis for the initial recognition of stock management units in horse mackerel (*Trachurus trachurus*). Fisheries Research 89: 167–180.

Abaunza, P., Murta, A.G., Campbell, N., Cimmaruta, R., Comesaña, A.S., Dahle, G., García Santamaría, M.T., Gordo, L.S., Iversen, S.A., MacKenzie, K., Magoulas, A., Mattiucci, S., Molloy, J., Pinto, A.L., Quinta, R., Ramos, P., Sanjuan, A., Santos, A.T., Stransky, C., Zimmermman, C. 2008b. Stock identity of horse mackerel (*Trachurus trachurus*) in the Northeast Atlantic and Mediterranean Sea: integrating the results from different stock identification approaches. Fisheries Research. 89, 196–209.

Cabral, H.N., Murta, A. G. 2002. The diet of blue whiting, hake, horse mackerel and mackerel off Portugal. J. Appl. Ichthyiol. 18: 14–23.

Castro, J., Punzón, A. 2005. Pelágic métiers of the Northern Spanish coastal bottom trawl fleet. Working Document to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (September, Vigo, Spain). Included in the W.G. report: ICES C.M. 2006/ACFM: 08.

Cubillos, L., Gatica, C., Serra, R. 2008. Short review of natural mortality and size at first maturity on jack mackerel (*Trachurus murphyi*) in the southeastern Pacific. Working Document Nº 14 to the Chilean Jack Mackerel Workshop, Santiago, Chile, 30 June–4 July 2008. In: Report of the South Pacific Regional Fishery Management Organization. Chilean Jack Mackerel Workshop.

Frid, C.L.J. (coord.). 2009. The Synthesis of the EU funded INEXFISH project. Final report of the project IN-EX Fish - Incorporating extrinsic drivers into fisheries management (**FP6-022710**). 156 pp.

Ganias, K. Somapakis, S. Machias, A. Theodorau, A. J. 2003. Evaluation of spawning frequency in a Mediterranean sardine population (*Sardina pilchardus*) Marine biology, 142:1169–1179.

Gordo, L. S., Costa, A., Abaunza, P., Lucio, P., Eltink, A. T. G. W., Figueiredo, I. 2008. Determinate versus indeterminate fecundity in horse mackerel. Fish. Res., 89: 181–185.

Griewank, A., Corliss, G. F. (Editors). 1991. Automatic Differentiation of Algorithms: Theory, Implementation, and Application. SIAM, Philadelphia.

Hernández, 2008. "Report of the census fishing fleets operating in Northeast Atlantic waters in 2007." Authors: Carmen Hernández. Internal Report IEO nº 15, 32p. (SAP Project). June 13, 2008. In Spanish.

Hunter, J. R., Macewicz, B. J. 1985. Rates of atresia in in the ovary of captive and wild northern anchovy, *Engraulis mordax*. Fish. Bull., U.S. 83: 119–136.

ICES. 1990. Report of the Working Group on the assessment of the stocks of sardine, horse mackerel and anchovy. 20–29 June 1990, ICES Headquarters, Copenhagen. ICES CM 1990/Assess:24: 169pp.

ICES. 1991. Report of the Working Group on the assessment of the stocks of sardine, horse mackerel and anchovy. 18–27 June 1991, ICES Headquarters, Copenhagen. ICES CM 1991/Assess:22: 138pp.

ICES. 2004. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES CM 2005/ACFM:08.

ICES. 1992. Report of the Working Group on the assessment of mackerel, horse mackerel, sardine and anchovy. 22–30 June 1992, ICES Headquarters, Copenhagen. ICES CM 1992/Assess:17: 207pp.

ICES. 2008. Report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). ICES CM 2008/LRC:09.

Jennings, S., Kaiser, M.J., Reynolds, J.D. 2001. Marine Fisheries Ecology. Blackwell Science, Ltd. London.

Lowe, S., J. Ianelli, M. Wilkins, K. Aydin, R. Lauth, and I. Spies. 2009. Stock assessment of Aleutian Islands Atka mackerel. In Stock Assessment and Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, Alaska, 99510.

MFMR. 2006. Ministry of fisheries and marine resources. Horse mackerel, rock lobster and deep-sea crab geological state of the stock. <http://www.thefishsite.com/articles>

Murta, A.G. 2000. Morphological variation of horse mackerel (*Trachurus trachurus*) in the Iberian and North African Atlantic: implication for stock identification. ICES J. Mar. Sci. 27: 1240–1248.

Murta, A.G., Abaunza, P. 2000. Has horse mackerel been more abundant than it is now in Iberian waters? Working Document to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, sardine and Anchovy (Copenhagen, 2000). Document included in the Working Group Report: ICES C.M. 2000/ACFM: 5.

Murta, A.G., Abaunza, P., Cardador, F., Sánchez, F. 2008. Ontogenic migrations of horse mackerel (*Trachurus trachurus*) along the Iberian coast: implications for stock identification. Fish. Res. 89: 186–195.

Silva, C. and Murta, A. Classification of the Trawl and Purse Seine fishing trips in the Portuguese Continental Waters. Working Document to be presented at the Meeting of the Working Group on the Assessment of Hake, Monk and Megrim, (WGHMM). 8–17 May 2007. Vigo.

Sousa, P., Azevedo, M., Gomes, M.C. 2006. Species-richness patterns in space, depth, and time (1989–1999) of the Portuguese fauna sampled by bottom trawl. Aquat. Living Resour. 19: 93–103.

Wood S.N. 2006. Generalized additive models: an introduction with R. Chapman & Hall/CRC. 391 pp.

Zhang, C.I., Lee, J.B. 2001. Stock assessment and management implications of horse mackerel (*Trachurus japonicus*) in Korean waters, based on the relationships between recruitment and the ocean enviroment. Progress in Oceanography, 49: 513–537.

Table 5. Symbols definitions used for model equations.

General Definitions	Symbol/Value	Use in Catch at Age Model
Year index: i = {1992, …., 2010}	i	
Age index: j = { 0,1,2, …, 11+}	j	
Mean weight in year t by age j	Wt,j	
Maximum age beyond which selectivity is constant	Maxage	Selectivity parameterization
Instantaneous Natural Mortality	Mj	Fixed M=0.8,0.5,0.3,0.2,0.1…0.1, for j=0,1,2…11
Proportion females mature at age j	pj	Definition of spawning biomass
Sample size for proportion in year i	T_i	Scales multinomial assumption about estimates of proportion at age
Survey catchability coefficient	q^s	Prior distribution = lognormal(μ_q^s , σ_q^2)
Stock-recruitment parameters	R_0 h σ_R^2	Unfished equilibrium recruitment, steepness, variance
Virginal biomass	ϕ	Spawning biomass per recruit when there is not fishing
Estimated parameters		
φ_i $R_0, h, \varepsilon_i, \mu^f, \mu^s, M, \eta_j^s, \eta_j^f, q^s$		

Note that the number of selectivity parameters estimated depends on the model configuration.

Table 6. Variables and equations describing implementation of the horse mackerel assessment model.

Eq	Description	Symbol/Constraints	Key Equation(s)
1)	Survey abundance index (s) by year (Δ^s represents the fraction of the year when the survey occurs)	I_i^s	$I_i^s = q^s \sum_{j=0}^{11} N_{ij} W_{ij} S_j^s e^{-\Delta^s Z_{ij}}$
2)	Catch biomass by year	C_i	$\hat{C}_{ij}^f = \sum_{j=0}^{11} N_{ij} W_{ij} \frac{F_{ij}^f}{Z_{ij}} (1 - e^{-Z_{ij}})$
3)	Proportion at age j, in year i	$P_{ij}, \sum_{j=0}^{11} P_{ij} = 1.0$	$p_{ij}^f = \frac{\hat{C}_{ij}^f}{\sum_j \hat{C}_{ij}^f}$
4)	Initial numbers at age	j = 0	$N_{1992,j} = e^{\mu_R + \varepsilon_{1992}}$
5)		0 < j < 10	$N_{1992,j} = e^{\mu_R + \varepsilon_{1993-j}} \prod_{j=1}^{j} e^{-M}$
6)		j = 11+	$N_{1992,11} = N_{1992,10} \left(1 - e^{-M}\right)^{-1}$
7)	Subsequent years (i >1992)	j = 0	$N_{i,2} = e^{\mu_R + \varepsilon_i}$
8)		0 < j < 10	
9)		j = 11+	$N_{i,11} = N_{i-1,10} e^{-Z_{i-1,10}} + N_{i-1,11} e^{-Z_{i-1,11}}$
10)	Year effect and individuals at age 2 and i = 1981, …, 2010	$\varepsilon_i, \sum_{i=1981}^{2010} \varepsilon_i = 0$	$N_{i,0} = e^{\mu_R + \varepsilon_i}$
11)	Index catchability Mean effect Age effect	μ^s, μ^f $\eta_{ij}, \sum_{j=0}^{11} \eta_{ij} = 0$	$q_i^s = e^{\mu^s}$ $s_j^s = e^{\eta_j^s}$ $j \le$ maxage $s_j^s = e^{\eta_{\text{maxage}}^s}$ $j >$ maxage
12)	Instantaneous fishing mortality		$F_{ij}^f = e^{\mu^f + \eta_j^f + \varphi_i}$
13)	Mean fishing effect	μ^f	
14)	Annual effect of fishing mortality in year i	$\varphi_i, \sum_{i=1992}^{2010} \varphi_i = 0$	
15)	age effect of fishing (regularized) In year time variation allowed In years where selectivity is constant over time	η_{ij}^f, $\sum_{j=2}^{12^+} \eta_{ij} = 0$ $\eta_{i,j}^f = \eta_{i-1,j}^f$	$s_{ij}^f = e^{\eta_j^f}$, $j \le$ maxage $s_{ij}^f = e^{\eta_{\text{maxage}}^f}$ $j >$ maxage $i \ne$ change year
16)	Natural Mortality vector	Mj	0.8 0.5 0.3 0.2,0.1…0.1 for ages 0 - 11
17)	Total mortality		$Z_{ij} = \sum_f F_{ij}^f + M$
17)	Spawning biomass (note spawning taken to occur at mid of January)	Bi	$B_i = \sum_{j=0}^{11} N_{ij} e^{-\frac{0.5}{12} Z_{ij}} W_{ij} p_j$
18)	Recruitments (Beverton-Holt form) at age 0.	$\tilde{R}_i$	$\tilde{R}_i = \frac{\alpha B_i}{\beta + B_i}$, $\alpha = \frac{4hR_0}{5h-1}$ and $\beta = \frac{B_0(1-h)}{5h-1}$ where $B_0 = R_0 \varphi$ $\varphi = \sum_{j=2}^{12} e^{-M(j-1)} W_j p_j + \frac{e^{-12M} W_{12} p_{12}}{1 - e^{-M}}$ h=0.8

Table 7. Specification of objective function that is minimized (i.e., the penalized negative of the log-likelihood).

	Likelihood /penalty component		Description / notes
44)	Catch biomass likelihood	$L_1 = \sum_f \lambda_4^f \sum_{i=1992}^{2010} \ln\left(\frac{C_i^f}{\hat{C}_i^f}\right)^2$	Fit to catch biomass in each year
19)	Abundance indices	$L_2 = \sum_s \lambda_1^s \sum_i \ln\left(\frac{I_i^s}{\hat{I}_i^s}\right)^2$	Survey abundances
20)	Proportion at age likelihood	$L_k = \sum_{k,i,j} \tau_i^k P_{ij}^k \ln\left(\hat{P}_{ij}^k\right) \qquad k = 3,4$	k=3 for the fishery, k=4 for the survey
21)	Penalty on smoothness for selectivities	$L_k = \sum_k \lambda_k \sum_{j=0}^{11} \left(\eta_{j+2}^l + \eta_j^l - 2\eta_{j+1}^l\right)^2 \; k = 6,9$	Smoothness (second differencing), Note: k=6 for the fishery, k=9 for the survey
22)	Penalty on recruitment regularity	$L_{11} = \lambda_{11} \sum_{i=1981}^{2010} \varepsilon_i^2$	Influences estimates where data are lacking (e.g., if no signal of recruitment strength is available, then the recruitment estimate will converge to median value).
23)	Recruitment curve penalty	$L_6 = \lambda_6 \sum_{i=1992}^{2010} \ln\left(\frac{N_{i,0}}{\tilde{R}_i}\right)^2$	Conditioning on stock-recruitment curve over period 1992–2007 (but reduced to have negligible effect on estimation).
24)	Overall objective function to be minimized	$\dot{L} = \sum_k L_k$	

Table 8. Input variance □ or sample size (τ □ assumptions and corresponding penalties (□ used on log-likelihood functions in the base model.

L	Abundance index	□	τ	□L
1	Landings	0.05	-	200
2	Combined index	0.3	-	5.556
3	Fishery age composition	-	100	-
4	Survey age composition	-	10	-
5	Time-change in fishery selectivities	0.8		0.78
6	Fishery age-specific penalties	1.0	-	0.5
7	Fishery descending selectivity-with-age penalty	10	-	0.1
8	Time-change in survey selectivities	0.8		0.78
9	Survey age-specific penalties	1.0	-	0.5
10	Survey descending selectivity-with-age penalty	10	-	0.1
11	Recruitment regularity	10	-	0.1
12	S-Recruitment curve fit (for period 1992–2007, scale only)	1.9	-	0.14

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1992–2008	0–11+	Si
Canum	Catch-at-age in numbers	1992–2008	0–11+	Si
Weca	Weight-at-age in the commercial catch	1992–2008	0–11+	Si
West	Weight-at-age of the spawning stock at spawning time.	1992–2008	0–11+	Si
Mprop	Proportion of natural mortality before spawning	1992–2008	0–11+	Si
Fprop	Proportion of fishing mortality before spawning	1992–2008	0–11+	No
Matprop	Proportion mature-at-age	1992–2008	0–11+	No
Natmor	Natural mortality	1992–2008	0–11+	No
	Spanish-Portuguese bottom-trawl survey	1992–2009	0–11+	

Annex 5 Benchmark preparation

X.1 Latest benchmark results

X.2 Planning future benchmarks

Stock	Ass status	Latest benchmark	Benchmark agreed	Planning in future	Further planning	Comments
example	*Update OK,* *Update deviating from bench-mark*	*Year*	*If Agreed by ACOM* *Update X.3!!*	*Proposal to ACOM* *Fill in X.3!!*	*Future proposals for internal use*	*Data deteriorating, new method available, etc*
ane-pore	???? Qualitative assessment based on trends (surveys and fishery).	No benchmark has been carried out before		2014	A preparatory meeting might be needed. This would take place….?	New studies on genetic structure of anchovy populations suggest genetic differences between southern and western anchovies in Division IXa. Assessment is of a qualitative nature based on surveys and fishery trends.
ane-bisc	Update OK New datasets and methods available for evaluation	2009		2013	A preparatory meeting might be needed. This would take place once the revision of the DEPM estimates is finalised by WGACEGG.	New development available on the assessment model. Incorporation of data from the Juvena survey into the advice needs to be evaluated. DEPM data are being revised by WGACEGG which might change substantially the biomass estimates. There are

						evidences that the current mortality rates might not be appropriate. All the above changes will require the revision of the biological reference points.
sar-soth			2012 agreed			
hom-soth						
jaa-10						

X.3 Issue lists for stocks with upcoming benchmarks [Mind: describe in short ***both the problem and the proposed solution***. It helps if it is clear the solution can be brought about at the proposed time]

Issue list template:

Stock	Ane-bisc	
Benchmark	Year:	Planned by EG /Agreed by ACOM
Stock coordinator	Name:	Email:
Stock assessor	Name:	Email:
Data contact	Name:	Email:

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark
Tuning series				Who, what type of expertise
Discards				
Biological Parameters				
Ecosystem/mixed fisheries considerations				

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark
Assessment method				
Forecast method				
Biological Reference Points				

Benchmark information per stock

To be filled in by the stock coordinator

Stock	Anchovy in IXa......................			
Stock coordinator	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Stock assessor	Name: Fernando Ramos & Andrés Uriarte	Email: fernando.ramos@cd.ieo.es; auriarte@azti.es		
Data contact	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Issue	**Problem/Aim**	**Work needed /** **possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark** **type of expertise / proposed names**

Stock	Anchovy in IXa......................			
Stock coordinator	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Stock assessor	Name: Fernando Ramos & Andrés Uriarte	Email: fernando.ramos@cd.ieo.es; auriarte@azti.es		
Data contact	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Stock identity	Providing one management advice for the anchovy in the whole of Division IXa may be inadequate, since survey results and the fishery demonstrate independent dynamics of the anchovy in the northwestern part of Division IXa from the dynamics of the population in Division IXa South. Recent genetic studies suggest separated stocks for anchovy in IXa South (which show more genetic similarities with the Alborán Sea anchovy) from anchovy in the remaining waters in the Division.	To compile information from anchovy in all sub-divisions and in close areas to the boundaries of the Division, such as morphometrics, genetics, parasites, distribution and, any modelling assessing migration taking place between areas will be examined in the benchmark (and summarised prior to it)	Published and unpublished information.	????

Stock	Anchovy in IXa........................			
Stock coordinator	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Stock assessor	Name: Fernando Ramos & Andrés Uriarte	Email: fernando.ramos@cd.ieo.es; auriarte@azti.es		
Data contact	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Issue	**Problem/Aim**	**Work needed /** **possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark** **type of expertise / proposed names**
Tuning series	1. Portuguese (PELAGO) and Spanish (PELACUS) spring acoustic surveys are combined in a single index of abundance in the qualitative assessment for the whole Division. Spanish (ECOCÁDIZ) summer surveys are used for comparison for the IXa South. 2. The survey relative catchability and implications for their joint or separate use in tuning the assessment should be investigated.	1. To explore and analyze the results applicable to anchovy from the inter-calibration exercises between the PELACUS/PELAGO surveys in 2008, 2009 and 2011; a dedicated session to discuss the results was a 2011 ToR of WGACEGG. To explore what is the situation for ECOCÁDIZ surveys. 2. To investigate the influence of changes in methodology (e.g. echosounder, vessel, fishing gear) and anchovy behaviour and/or depth distribution changes along the survey historical series.	1. Results from 2008, 2009, and 2011 intercalibrations are available from IPIMAR and IEO and have been reported to WGACEGG. 2. Information on survey methodology and data on anchovy distribution are available from IPIMAR and IEO databases.	????

Stock	Anchovy in IXa......................			
Stock coordinator	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Stock assessor	Name: Fernando Ramos & Andrés Uriarte	Email: fernando.ramos@cd.ieo.es; auriarte@azti.es		
Data contact	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Biological Parameters	1. Catches at age are only available from the Spanish fishery in IXa South (only in 2011 has been provided this kind of data from other sub-divisions, i.e., only when the anchovy abundance was high). 2. Biological parameters (Maturity ogives, weight at age in the stock, etc, are only available for the Spanish part of the IXa South). 3. Natural Mortality is assumed to be equal to the one estimated for Bay of Biscay Anchovy.	1. Investigate availability of these data to obtain a consistent data series allowing a further (analytical) assessment. 2. Ditto. 3. Explore different approaches (empirical, etc.) to derive the estimate of Natural Mortality.	1. Data available (IPIMAR, IEO data bases), but their availability has to be explored. 2. Ditto. 3. Ditto.	????

Stock	Anchovy in IXa……………………			
Stock coordinator	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Stock assessor	Name: Fernando Ramos & Andrés Uriarte	Email: fernando.ramos@cd.ieo.es; auriarte@azti.es		
Data contact	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Assessment method	Alternatives to the current assessment model (qualitative, not analytical) need to be explored.	Test both age-structured and generalised models as well as those ones based on survey data only and for data limited stocks.	Data from WGHANSA. Models available from assessment tools repositories	????
Biological Reference Points	Reference points are not defined for this stock and need to be considered.	Investigate reference points, together with proposals of harvest control rules	Data from WGHANSA.	????

Stock	Anchovy in IXa......................			
Stock coordinator	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Stock assessor	Name: Fernando Ramos & Andrés Uriarte	Email: fernando.ramos@cd.ieo.es; auriarte@azti.es		
Data contact	Name: Fernando Ramos	Email: fernando.ramos@cd.ieo.es		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Other issues	1. Compile information on the role of anchovy as a forage fish in the pelagic ecosystem. 2. Understand what environmental issues may drive the fluctuations and intensity of the recruitment pulses in IXa South and western sub-divisions.	1. Review results from studies on the diet of anchovy predators, including inter-annual, seasonal and geographic variation in anchovy importance in their diets. 2. Review results from studies on the impact of the environmental forcing in anchovy recruitment	1. Published and unpublished information. 2. Published and unpublished information.	????

Annex 6 Technical Minutes WGHANSA

Review of ICES WGHANSA Report 2012.

3-5 July 2012

Reviewers:	Einar Hjörleifsson (chair)
	Margit Eero
	Alexander Kempf
Chair WG:	Andres Uriarte
Secretariat:	Barbara Schoute / Henrik Sparholt

General

The RG acknowledges the intense effort expended by the working group to produce the report.

The Review Group considered the following stocks:

ane-pore	Anchovy in Division IXa
ane-bisc	Anchovy in Subarea VIII (Bay of Biscay)
hom-soth	Horse mackerel (*Trachurus trachurus*) in Division IXa (Southern stock)
sar-soth	Sardine in Divisions VIIIc and IXa
sar-bisc	Sardine in Divisions VIIIabd and subarea VII
jaa-10**	Jack mackerel (Trachurus picturatus) in the waters of the Azores

For advice other than stock summary style fisheries advice:

Section …

Comments per section

Short description

Comments

The introductory chapters of this report were clear and very useful.

Section xxx may have been a little too long and complex,

Anchovy in Division IXa

The assessment is qualitative, based on trends from surveys.

Assessment type: update

1) **Assessment**: trends
2) **Forecast**: not presented
3) **Assessment model**: qualitative analyses of surveys and commercial CPUE
4) **Consistency**: Low acoustic estimate in IXa South in PELAGO survey in 2011 was disregarded in this year's assessment by the WG
5) **Stock status**: Stock status in Subdivision IXa South is stable, given the 2011 estimate of SSB based on DEPM, at a similar level as in 2008. In the area IXa North, Central North and Central-South, an anchovy outburst was registered in 2011, with the highest biomass recorded in this area since 1995. No information is available for 2012.
6) **Man. Plan.**: no EU management plan exists for Division IXa.

General comments

New information:

i) Catches in 2011

ii) DEPM survey estimate for July 2011for IXa South

iii) PELACUS spring survey in 2012 in IXa North. Due to generally very low abundance in this area compared to the other areas in IXa, this information for 2012 is of little use for determining stock status in IXa in 2012.

- Strong increase in landings both in IXa South (Cadiz) and IXa Central-North in 2011 compared to previous 3 years. Thus, the catches support that the stock in IXa South has not been as low as estimated from PELAGO acoustic survey in 2011.
- Is there any explanation for the doubling of landings in IXa South in 2011 compared to earlier years (also in 2008 when stock estimate from DEPM was at a similar level as in 2011), any change in fisheries?
- Catches in 2011 much higher than TAC, is TAC practically not effective? This could be discussed in the report.
- Commercial cpue is used as an indicator for stock trends. It is doubtful, whether this is valid for purse seine fisheries, e.g. the commercial cpue did not react to the decline in stock in 2009-2010 indicated from surveys.
- The population in Central North is considered to have independent dynamics from the population in the south. This is not supported by the age structure of catches in Central North in 2011, in the year of sudden outburst of anchovy in this area. The catch in 2011 consisted of equal proportions of age 1 and age 2, which cannot be explained by one year of strong recruitment in the area.

- The low acoustic estimate from PELAGO survey in spring 2011 was disregarded this year by the WG, as the estimate was not supported by egg abundances at the survey time and the new estimate of SSB based on DEPM from 3 month later. In earlier years (2005 and 2008), the correspondence between PELAGO and DEPM estimates has been good.

  The decision by the WG to disregard the PELAGO estimate for the South for 2011 is not consistently followed throughout the report as Figure 4.5.2.3 presents a combined index for IXa, where the estimate for 2011 is based on the assumption of a very low abundance in IXa South.

- Yield per Recruit analyses are conducted to estimate reference points on harvest rates. 50% SBR is used as a criteria for sustainable fisheries. On which basis?

Technical comments

i) in Section 4.2.2.2 the landings in first quarter of a year at 95 t in Central-North are presumably for 2012, not 2011?

ii) Figure 4.5.2.3. Figure caption does not match with what is presumably shown on the figure (reference to landings information, etc??)

Conclusions

Stock status in 2012 (and 2013) is unknown as no information is available on the year-classes forming the bulk of the stock in these years.

****

Conclusions from the Advice Drafting Group:

- The ADG decided to keep all survey information in Figures, thus not to delete the low value estimated in acoustic survey for IXa South in 2011.
- Different dynamics in the biomass in the areas of IXa North and Central-North and in the area of IXa South is recognized.
- The historical level of fisheries and management measures in IXa seem to have been sustainable and not detrimental for the stock. However, this cannot be translated into catch advice for 2013, due to lack of information on year-classes constituting the biomass and catches in 2013.

Anchovy in Subarea VIII (Bay of Biscay)

The update assessment for the Bay of Biscay anchovy is based on a two-stage biomass-based model (BBM), described in Stock Annex.

1) Assessment type: update
2) Assessment: analytical
3) Forecast: presented
4) Assessment model: Bayesian two-stage biomass-based model, tuning by two series of surveys, i.e. Daily Egg Production method (DEPM) and spring acoustic survey
5) Consistency: Consistent with previous assessment.
6) Stock status: The median SSB increased substantially in 2011 but declined again in 2012. Median SSB in 2012 estimated at 68180 t, which is, with 100% probability, above B_{lim}. Recruitment in 2012 is below the long term average, and lower than in 2010-2011.
7) Man. Plan.: A draft plan proposed by the EC in 2009. The plan is based on a constant harvest rate (30%) , and sets a TAC as a percentage of the point estimate of the SSB at the start of TAC period (1st July) with an upper bound on the TAC (33000 t), and a minimum TAC (7000 t) applicable at SSB estimates between 24000-33000 t. The plan is not formally adopted or evaluated. However, the plan was used for establishing TAC for 1 July 2010-30th June 2012.

General comments

- The report is well structured and easy to follow. The material and analyses are generally well described.
- New information from two spring surveys (DEPM and acoustic survey) since last assessment was available and included in the update of the assessment in 2012.
- In addition, juvenile abundance from JUVENA survey in autumn 2011 was available, though not used in the assessment.
- The major issue in the assessment for 2012 is the discrepancy in the biomass estimates for 2012 from DEPM and spring acoustic surveys. This discrepancy is discussed in the report, however there is no clear explanation for it. Both surveys were used in the assessment as in previous years.
- It was not possible to judge which one of the two survey estimates would be more appropriate. Discrepancies between the two surveys have occurred also in earlier years, e.g. in 2000 and 2002. In 2000, the estimate from the assessment was closer to the acoustic estimate, while the opposite was the case in 2002, when the final estimate was close to the estimate from DEPM (Figure 3.5.2.1). Therefore, there is no basis to select one survey above the other. The biomass from the assessment in 2012 lies somewhere in between the estimates from DEPM and acoustic, like has been the case in some earlier years (e.g. 1998).
- The estimate for recruitment (age 1) from the assessment for 2012 (which combines the information from spring acoustics and DEPM) is in line with the index for juveniles (age 0) from autumn acoustic JUVENA survey in 2011. This supports the combined estimate from the two surveys.

- The decline in biomass in 2012 compared to 2011 is supported by a relatively low proportion of age 1 in the stock in both surveys (Fig. 3.5.1.2 in the report). Such low proportion of age 1 has in previous years has been associated with a decline in SSB (e.g. 2002, 2005, 2008, 2009).
- TAC corresponding to the proposed management plan is the only management option provided in the report. The other options, especially the one chosen as a basis for the advice (Precautionary approach) should be given as well.
- Concerning future improvement of the assessment the WG provides a clear list of valid issues to look into in the upcoming benchmark. A comment concerning the growth rate that is currently assumed constant across ages and years: in the list of tasks planned for benchmark, growth is planned to be modeled by age. What about changes in growth over the years? Data on weight at age in catches by year are available. Could these be used to include changes in growth over the years to the model?

Technical comments

i) The total French catch in 2001 in Table 3.2.2.2 is different from the values in Tables 3.2.2.1and 3.2.2.3.

ii) Figure 3.3.1.2 Please specify species codes in figure label.

iii) Table 3.3.1.3.Please specify the abbreviations used in the first column

iv) Table 3.3.1.4 Is the biomass in the first row actually SSB? These terms should be used precisely and consistently.

v) the legend in Figure 3.3.2.2 insufficient, e.g what is the difference between the first and second panel; or what are the triangles on third panel showing.

vi) section 3.3.2 in the report refers to tables 2.3.1 and 2.3.2, presumably should be 3.3.2.1 and 3.3.2.2 instead

vii) Table 3.6.3.3, the years in table heading are incorrect, should be 2012 and 2013

viii) Section 3.5.1 says that in 2010 and 2011 the catches in the first period of a year are larger than in the 2nd period. From Figure 3.5.1.3, this is the case for 2011 but not for 2010.

ix) In Figure 3.6.3.2. label, the last line, shouldn't it be 2012 instead of 2011.

x) Define clearly the "juveniles". Presumably it is age 0, but it is not stated anywhere in the report

Conclusions

Although the two surveys included in the assessment give very different biomass estimates individually, the assessment combining both estimates seems to be a reasonable option. The resulting recruitment estimates for 2012 are supported by independent estimate from autumn JUVENA survey in 2011.

In light of recent strong recruitment, after a series of weak year-classes, the assumption of undetermined recruitment in short-term forecast (where all past recruitments are equally likely) seems reasonable.

JUVENA autumn survey for juveniles is proven to provide valuable information for the new year-class entering the fishery and it is therefore recommended that the information from these surveys is used in the management process in future.

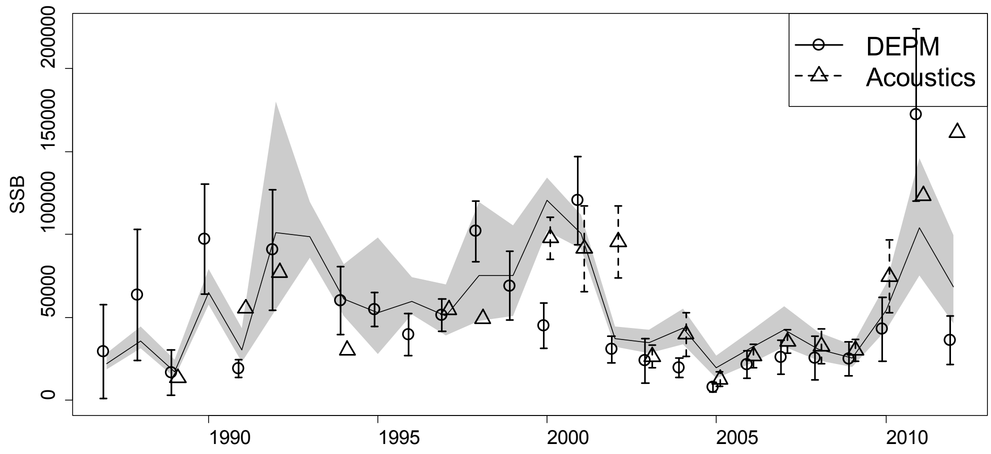


Figure 3.5.2.1: Bay of Biscay anchovy: Comparison of the SSB posterior 95% probability intervals from the BBM (grey area) and the SSB indices corrected by their catchability with the corresponding confidence intervals from DEPM (open circle and solid line) and Acoustics (triangle and dashed line).

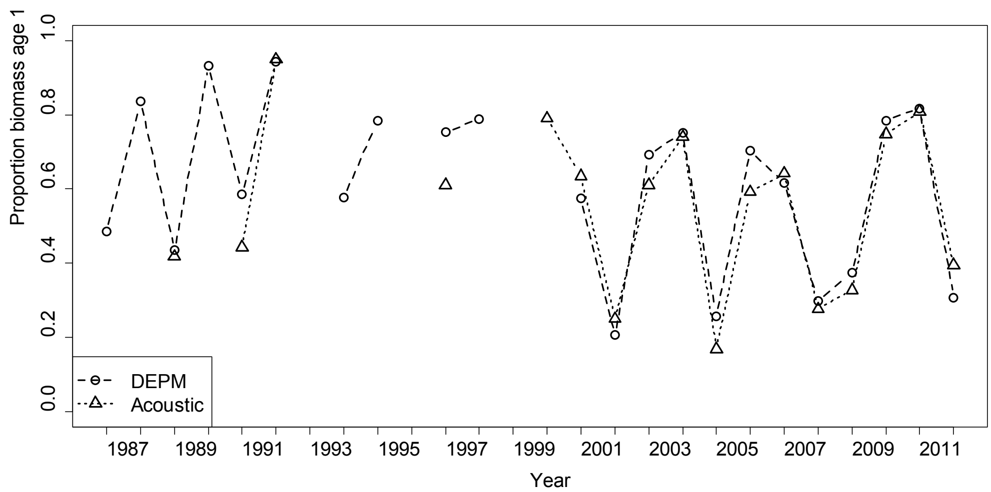


Figure 3.5.1.2: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

Southern horse mackerel (WGHANSA 2012 section 8))

Assessment not updated with new data, since Spanish catch data for 2011 that are comparable with that used in the time series not available. Prediction and advice for 2013 based on projection from the 2011 assessment.

1) **Assessment type: SALY**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: AMISH – tuning by 1 survey
5) **Consistency**: Not relevant since assessment not updated.
6) **Stock status**: Unknown because no reference points defined. However given the low fishing mortality (lower than M) it has mostly likely been below any candidate MSY or PA reference points.
7) **Man. Plan.**: None

General comments

Document this year fit for purpose given that in the end only the short term predictions were updated.

Technical comments

Predictions done by using a Fsq (using 2010 value) constraint, stock annex describes using catch constraint. Under the circumstances where catches in 2011 and 2012 cannot be predicted using a Fsq constraint is the only way foreward. The TAC constraint used in last years advice gave similar F in the prediction as Fsq.

Conclusions

The predictions have been performed correctly and are considered an appropriate base advice.

Jack Mackerel T. picturatus in the waters of the Azores Stock
(WGHANSA 2012 section 9)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type: update**
2) **Assessment**: trends
3) **Forecast**: not presented
4) **Assessment model**: Trend based assesment
5) **Consistency**: Last year assessment accepted, this year as well
6) **Stock status**: Biomass indices stable since 1990's (purse seine fisheries on juveniles) or increasing since early 2000's (long line fisheries on adults). The stock is exploited mostly by the artisanal purse seine fishing fleet. Landings in the past decade average 1.2kt being lower than observed in the early mid 1990's (around 1.5 kt) and earlier (1980+s catches around 3 kt). The decline in catches is in part due to decline in consumer demand. Decline in catches and stable/increasing cpue over the period hence imply that the derived effort (catch/cpue) my be lower at present than in the 1990's.
7) **Man. Plan.**: none

General comments

The WG put a lot of effort into exploring various approaches to estimate historical stock dynamics (e.g. biomass production models, estimates of Z from catch curves) and reference points (e.g. Y/R analysis, F/Fmsy, B/Bmsy). The RG encourages further work along this avenue but considered premature to base the advice on the current analysis.

There were questions raised with regards to the Stock production model exercise. Although not explicitly stated in the document it was apparent that the assumption of B1 was that it was at K. This may not be an appropriate assumption if the fishery has taken place for a long time prior to the first data year used in the assessment. Secondly, it was questioned if it is appropriate to use a juvenile index (which ones assumes reflects recruitment more that stock index) as an indicator of biomass in the stock production framework since the surplus production is by definition the sum of the new recruitment and the growth of individuals already in the population minus those dying naturally. This in the addition to the usually caveat that applies to stock production methods (need for a contrast in biomass and the fishing effort) should be carefully considered/explored before this framework can be used as a basis for advice for this stock.

Some very limited information were presented on estimates of Z in the report. Numerical results for both age based and length based estimates of Z were reported without further elaborations or presentation of the results. E.g. with regards to the discrepancy between these values depending on the age or length based approach used. Further work/documentation is encourage along these line because this may be a potential advisory tool, given that reasonable reference points can be derived (via Y/R and/or simply via Fadvice=Fmsy=M analogy). It is however acknowledge that this may be a little tricky/potentially not successful approach, given that the Z estimates has to come from that part of the size group of the population were the selectivity is assumed constant. In the case for this fishery that would presumably be the older age groups of the stock which does not constitute the bulk of the fishery.

The trends based description are based on cpue and landings (Cy). If cpue is supposed to constitute biomass trajectory (By) we have here two out of three parameters of the fundamental catch equation: Cy = Fy*By. Hence, once could simply calculate a proxy of the fishing mortality as Fy=Cy/By, assuming that q=1 in the Fy=qEy relationship. Using this approach may given some indication about a sensible empirical advisory Fproxy to be used to derive advice on catch for the next year(s) based on the most recent biomass index (Cadviced=advisoryFproxy * By). Potential candidate Fproxy could e.g. be derived from comparison with historical Z from catch curves. Some precautionary Btrigger may be proposed to be used in such a decision rule, whereupon the multiplier on the By is reduced linearly when the biomass index is below the Btrigger. Although this kind of an approach is not currently adopted by ICES in its default approach (although one may argue that it is mathematically implicit in the equation) it should be kept in mind that the approach is expected to develop with time and other alternative to the default approach have already been adopted as a basis for advice. An example of the approach described above can be found in Va ling and Va Blue ling advice this year, albeit based on survey indices and with no definition of Btrigger.

Technical comments

No minor ones, see general comments.

Conclusions

The ADG concluded that the advice should be the same as last year given stable (juveniles) and increasing cpue (adults) in recent years and that it is likely that the derived effort is lower at present than in the early part of the time series.

Stock Sardine VIIIc and IX (report section 7))

Short description of the assessment: extremely useful for reference of ACOM!

1) Assessment type: update after benchmark in 2012
2) Assessment: analytical
3) Forecast:presented
4) Assessment model: Stock synthesis 3, two surveys (Acoustic + DEPM survey (combined PT and SP))
5) Consistency: Last years assessment accepted, Benchmark 2012, new model (SS III) + changes in settings and input (e.g., M at age and selectivity changes over time) + new reference points ➔ changes in stock status (higher SSB and lower F, F below reference points, B above Blim).
6) Stock status: According to newest assessment: B above Blim since 1978, now close to Blim. R uncertain but currently on low level compared to previous years. F below Fmsy.
7) Man. Plan.: no international one (only a national Portuguese plan)

General comments

The section was in general good to understand but some important information is missing:

- There was no section on comments from former review groups or the benchmark decisions
- Landings at age time series (or proportions at age) are missing. *SOP values should be tabulated to get an indication on quality of landings at age data*
- No overview table on model settings is presented.
- No detailed assessment output is tabulated (numbers at age, F at age, diagnostics)
- No retrospective analysis and no single fleet runs are presented

The describtion of the fishery was difficult to read. Length frequencies may be better presented as figures instead of tables.

Technical comments

There is a mis-match between Table 5.1.1.1 (sardine general) and table 7.2.2.2 (WG estimates landings) While in table 5.1.1.1 Spanish landings are 30800 tonnes for the assessment area, the working group estimates are only 23200. This discrepancy makes the description of trends in the fishery contradicting between report section 5 and 7. ➔ *most probably difference between official and WG estimates. WG estimates were used in the assessment.*

The 2011 DEPM survey is missing in Figure 7.3.2. Spawning fraction and batch fecundity could not be used from the 2011 survey for the S and W component. Is the 2011 survey estimate reliable?

Overall trends between DEPM and acoustic surveys are contradicting. The acoustic survey alone would indicate a collapse of the stock.

For 2012 no Portuguese spring acoustic survey was carried out leading to additional uncertainties in the assessment.

According to the heading, table 7.5.2.1 should also show geometric mean recruitment 2005-2010 but does not.

Assumptions on recruitment in the forecast were changed due to higher uncertainties for the 2011 recruitment estimate. To use the geometric mean from 2005 to 2010 seems reasonable given the series of low recruitment in recent years. However, it is unclear whether also the recruitment estimate for 2011(last assessment year) has been changed for the forecast. Unclear description in the report text: "Input values for 2011, 2012 and 2013 recruitments (Age0) were set equal…." compared to "Therefore, a low recruitment, corresponding to the geometric mean of the period 2005 – 2010 is assumed for 2012 – 2013". Page 7

Forecast input table with wrong heading: N should be only input for 2012, weight and selectivity etc…for 2012 and 2013

The selectivity pattern seems to be wrong in the forecast input table. Selectivity should be constant between ages 3-5 but selectivity is lower for age 5 in the forecast input table. As there was no F at age table it could not be found out whether only the forecast input table was wrong or the model settings in the assessment in general. The figure presented in the report on selectivity over ages suggests that the selectivity was chosen to be constant for ages 3-5 as in the final benchmark assessment.

Fsq for the forecast should be defined exactly in the text. I assumed mean age 2-5 as in the assessment output.

Forecast output table does not include information on intermediate year (SSB, resulting catch from Fsq assumption etc…). No rationales behind options in the forecast table are given.

Conclusions

Based on the tables and figures available in the WG report and from a comparison with the assessment from WKPELA (benchmark group), it seems that the assessment has been performed correctly and according to benchmark settings. However, there is doubt whether the right selectivity over ages has been applied. The F at age output table was missing so this could not be checked directly. *The 2012 index from the acoustic survey was not available leading to a deviation from benchmark settings and a higher uncertainty for the recruitment estimates in 2011. In general, the two contrasting trends in DEPM and the acoustic surveys are a serious concern.*

It was not possible to fully judge whether the forecast was performed correctly. Tables as F at age and N at age from the assessment output were missing to check forecast input. Also no data were uploaded to the sharepoint. It is unclear from the report what recruitment estimate has been used for 2011.There is an issue with selectivity over ages in the forecast input table.

Report:

The report could be improved by adding information as outlined under general comments. Also a description of larger changes during the benchmark and their impact on assessment results would help to increase the readability of the report. A retrospective analysis would help to judge on the consistency of the assessment.

Future Benchmark:

The discrepancies between acoustic and DEPM estimates are serious. To give both information an equal weight is a preliminary solution but should be not the final one.

Exact stock structure is unknown. This could bias the assessment if migration in and out of the assessment area takes place.

Reasons for differences in final results between different assessment methods and model settings should be further investigated

To choose a Fmsy that is close to the all time high needs further investigation given the current low recruitment regime and the stock being already close to the chosen Blim when fished below Fmsy.

R/ADG notes on proposed reference points and basis for next years advice

The benchmark (WKPELA) and subsequently the WG proposed that the candidate for Blim was Bloss (307 kt) and that the appropriate Fmsy was BPR50% (0.36) based on biomass of B1+. This relatively conservative percentage of the BPR (almost equivalent to SPR, since maturity at age 1 is 0.8 and maturity of older fish 1.0) was justified based on the logic that sardine was an important prey species for other components of the ecosystem. The ADG was unaware of any ICES guiding reports were reference points for prey species should be established based on such a relatively conservative basis.

In the benchmark and the wg report no deliberation was made in relation to that the historical fishing mortality has in almost all cases been below the proposed Fmsy but that this has resulted in the stock being close to the proposed Blim. Methodologically speaking, if the advice catches are based on the Fmsy being a target fishing mortality there should be low probability that the consequence of such a removal should result in the stock going below Blim. In the case of the sardine we have empirical evidence that this is not the case, the average realized fishing mortality over the whole time period (0.28) being lower than the proposed Fmsy but still resulting in the stock being currently at Blim. The reason for this lies in the recruitment time series (see figure). So although fishing at the proposed Fmsy should lead to SSB to be around 600 kt (i.e. well above Blim) if we assume average recruitment around (12 billions) it would result lead to a SSB around Blim when the average recruitment is at the current level (around 7 billions).

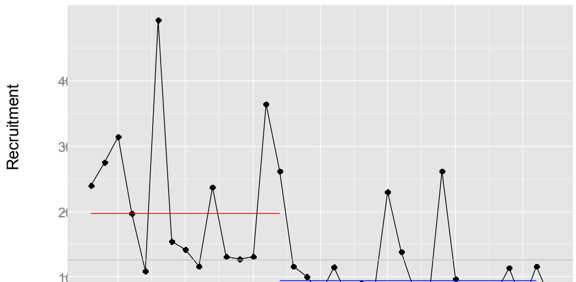


Figure. Recruitment pattern. Red line: mean for the early period, Blue mean: mean for the later period, Grey line: Mean for the whole period.

Hence, because of the apparent mismatch between the proposed Blim and Fmsy, given the historical dynamics in the stock (in particular the autocorrelation/time pattern in recruitment) the ADG was reluctant to adopt these proposed reference points as the basis for advice. Additional considerations were that in the WG draft proposal for the catch advice next year were not based on the Fmsy that the WG itself proposed, but on using the same base as was used last year (F=0.22). The R/ADG suggest that the WG takes a second look at the proposed reference points given the above.

Given a lack of a reasonable alternative the ADG concluded that the basis of the ICES advice for next year should be the same as that used in recent year.

R/ADG recommendation for establishing reference points for Sardine

For a stock like the sardine, that apparently has been relatively lightly exploited (historical F are equal/below the WG assumed/estimated M in older age groups) it may be questionable if the Bloss is a natural candidate for Blim. In such cases we have in the past sometimes used Bloss as a candidate for Bpa. The latter currently being the default candidate for Btrigger in the absence of other alternatives. Note that plausible higher values for Btrigger may also need to be considered. And for that matter that there may have been a regime shift in productivity of the stock.

The knowledge base for the sardine falls under the category of data rich stock. For these stocks the methodology for deriving advisory reference points are well established, using a stochastic simulation framework which take into account the stock recruitment relationship, autocorrelation in recruitment, uncertainty in assessment, etc. (see e.g. WKFRAME I). The R/ADG is of the opinion that such a methodology should hence be used to define potential fishing mortalities upon which annual advice for the sardine stock can be based.

Stock Sardine VII and VIII(abd) (report section 7))

Short description of the assessment: extremely useful for reference of ACOM!

1) Assessment type: exploratory assessment
2) Assessment: only exploratory
3) Forecast:not presented
4) Assessment model: TASACS (catch at age (French and Spanish data) + Acoustic survey (PELGAS)) only applied to VIIIabd
5) Consistency: new
6) Stock status: no reference points defined
7) Man. Plan.: no management plan

General comments

The section was in general good to understand and pointed out data deficiencies well. Input data to the assessment for VIIabd were described well and all input data are tabulated. Some information could be included in addition for next year:

- SOP values should be tabulated to get an indication on quality of landings at age data
- No overview table on model settings is presented.
- No detailed assessment output is tabulated (F at age, N at age, summary, diagnostics)

Technical comments

The same M as for the stock in VIIc and IX should have been used in the assessment for VIIabd according to the report. However, according to the text in the report a constant M of 0.33 over all ages was used. This is different for the stock in VIIIc and IX where for younger ages a higher natural mortality is assumed

Time series of catches is shorter than for the survey. Therefore, assumptions on F in the first two years had to be made. At the benchmark either data become available or influence of different assumptions on assessment results should be tested.

Catch data are incomplete also for VIIIabd. Discard estimates are missing for both area.s

Year effects in the survey need further investigation. Different assumptions on changes in catchability over time should be tested.

Because for area VII no discard data are available sardine is more likely a category 5 stock (only landings available) then a category 4 stock.

Catches are often confused with landings in the text

The result of the preliminary assessment of sardine in VII according to WKLIFE suggestions are highly uncertain and completely depend on expert judgment.

Conclusions

Based on the results presented it is encouraging that a first assessment has been carried out for sardine in VIIIabd. However, it is too preliminary to base advice for sardine in VIIIabd and VII on the results. *Input data have to be completed and further sensitivity analysis on different assumptions and maybe also assessment approaches are needed during the benchmark. For area VII currently not enough data and knowledge is available to carry out a robust assessment.*

Report:

The report could be improved by adding information as outlined under general comments.

Future Benchmark:

The review group agrees with the suggestions from the working group for the benchmark in 2013. In addition, alternative assessments should be tested allowing for more flexible treatment of catchabilities and selectivity patterns over time. For area VII a robust assessment method has to be found that does not depend on uncertain assumptions as DCAC. However, if it turns out that sardine in VIIIabd and VII are one stock it will be difficult to conduct an assessment for both areas combined.

Annex 2

Checklist for review process

General aspects

- Has the WG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- Is general ecosystem information provided and is it used in the individual stock sections.
- Has the group carried out evaluations of management plans?
- Has the group collected and analyzed mixed fisheries data?

For stocks where management plans or recovery plans have been agreed

- Has the management plan been evaluated in earlier reports?
- If the management plans has been evaluated during this WG:
    - Is the evaluation credible and understandable
    - Are the basic assumptions, the data and the methods (software) appropriate and available?

For update assessments

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

For overview sections

- Are the main conclusions in accordance with the WG report?
- Verify that tables and figures been updated and are correct (except for the advice table)