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

20–25 June 2014

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Executive summary

The Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), met at ICES headquarter (Copenhagen, Denmark), 20–25 June 2014, chaired by Lionel Pawlowski. There were 12 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 Blue Jack Mackerel (*T. pictoratus*) in X (Azores). Assessments were updated assessments according to the stock annexes. A new stock annex was added for Blue Jack Mackerel.

The Anchovy in Subarea VIII was estimated to be at 66 158t in May 2014(within a range 46 981-92 833t), well above Blim, according to the Bayesian modelling of the population. Two spring and one autumn surveysproviding biomass and age structure (spring) and recruitment indices (autumn) were used as inputs for the Bayesian assessment of the population. Catch options were provided on the basis of undetermined recruitment in 2015.

As in previous years, the WG collected the few 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. This a data poor stock category for which trend based assessment from surveys is provided. In 2014, the acoustic PELAGO+PELACUS surveys estimated a Biomass of 30 864 t, well above the average 2007-2013 (26 771t). In the western areas, catches are generally low (392t in 2013), in rare occasion exceeding a thousand tonnes (as in 1995/96). PELACUS in IXaNorth estimated in 2014 biomass to be 1947t which is below the average 2007-13 (2011 excluded), 3007t. In the Subdivision IXa South, where the bulk of the population is usually concentrated and supports a rather stable fishery (5240t), the 2014 biomass index from the acoustic PELAGO survey is estimated to be 28 917t which is well above the historical mean (22 767t). However neither the fishery nor the population indices (assessed by surveys) show any long-term 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 South seem sustainable. There is no information on recruitment that will form the bulk of the catches in the following year.

For the Iberian Sardine, an updated analytic assessment of the population was carried out this year. Catches were 46kt in 2013 which is the lowest historical value. The biomass of age 1 and older fish in 2013, 149 thousand tonnes, is 69% below the historical mean. This is a small increase of 14% compared with 2012. Fishing mortality decreased by 25% from 2011 to 2012 and 15% from 2012 to 2013 and is still above (21%) the long-term average. Recruitment is 44% lower than the historical geometric mean but this estimate is slightly above the geometric mean of the recent low recruitments. The estimate of the recruitment in the last year of the assessment (2013 in the present assessment) is supported by the 2014 Iberian acoustic survey index. As already stated last year by the working group, the stock is expected to decline unless a new strong

year class appears. Catch options were provided including one based on a multi-annual management plan that has been evaluated by ICES in 2013.

The WG assessed in 2013 for the first time the Sardine in Divisions VIIIa,b,d and Sub-area VII, by analysing survey trends according to the benchmark carried out in February 2013 (WKPELA). Surveys, restricted to subarea VIII (acoustic-Pelgas- and eggs-Bioman- surveys), show no neat trend in biomass indices since 2000, though marked fluctuations are recorded. The last big cycle peaked in 2009-2010. Following years were lower but in the middle of the range of biomass for the period 2000-2011. Pelgas survey pointed to the highest recruitment in 2013 in subarea VIII. Biomass is estimated to be 343 206t in 2014. The advice is biennal and was not reopened this year. 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, except assuming trends would be similar to subarea VIII. No assessment were carried out this year except attempt to derive natural mortality from cohort analysis. There is no international TAC for these fisheries. Catch are mainly taken by France and Spain in VIIIa,b,d and by France, Netherlands and United Kingdom in VII.

For the southern Horse mackerel (Division IXa) a new analytical assessment was carried out following the stock annex. Catches are around 30kt in 2013. The estimated SSB in 2013 from the assessment is 344 974 t. The SSB decreased gradually from 2007 to 2011, increasing in 2012 and 2013 to around the long-term average. Fishing mortality (0.044) has decreased since 2010 being at present around 60% below the long-term average. Recruitment is estimated to be well above long-term average in 2011 due to two good recruitments events spotted by the surveys in 2011 and 2012 (the strongest of the time-series). The latter is however uncertain. Catch options were provided under the assumption of historical geometric mean recruitment.

For the Blue Jack Mackerel (*Trachurus picturatus*) in the waters of the Azores, the advice is biennial and is valid for 2015 and 2016.The WG continue the collation of data. The assessment is currently based on commercial abundance indices from the purse-seiners and tuna baitboat, used as an indicator of stock trends. It was noted that catches in 2012 and 2013 were reduced compared to previous years despite no regulation in force.

In addition the WG was asked to report on the advance of the preparation of the benchmarking for Anchovy in Subarea IXa; the WG recommended to delay the benchmarking to 2016, basically due to limited man power. Additional benchmarks are also requested for both IXa, VIIIc and VIIIa, b, d, VII Sardine stocks and Southern Horse Mackerel in IXa in 2017. Sardine stock should be benchmarked simultaneously.

Finally the WG proposes in Annex 4 specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection), as requested to the group.

1 Introduction

1.1 Terms of reference

The **Working Group on Southern Horse Mackerel, Anchovy and Sardine** (WGHANSA), chaired by Lionel Pawlowski, France, met in in ICES HQ, Denmark, 20-25 June 2014 to:

1) address generic ToRs for Regional and Species Working Groups (see table below);

2) assess the progress on the benchmark preparation of Anchovy in Division IXa.

The assessments were carried out on the basis of the stock annexes 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)	Spain	Portugal	Spain	Update
sar-soth	Sardine in Divisions VIIIc and IXa	Portugal	Portugal	Spain	Update
sar-bisc	Sardine in Divisions VIIIa, b, d and subarea VII	France	UK	Spain	Update
jaa-10	Blue jack mackerel (Trachurus picturatus) in the waters of the Azores	Portugal	Portugal	Portugal	Update

WGHANSA reported by 2 July 2014 for the attention of ACOM.

1.2 Report structure

Ad hoc and Generic TOR relative to the stocks for which assessment is required are dealt stock by stock in respective chapters of the report: Anchovy VIII (Chapter 3), Anchovy IXa (Chapter 4), Sardine VIIIa, b, d and VII (Chapter 6), Sardine in IXa (Chapter 7), Southern Horse Mackerel (Chapter 8) and Blue jack mackerel (*Trachurus picturatus*) in the waters of the Azores (Chapter 9).

Specific TOR b (And generic g) on the benchmark preparation of Anchovy in Division IXa was briefly addressed in sections 4.10, asking for a delay of this benchmarking to 2016.

Answer to generic TORs are dealt as follows:

Generic TOR c)*If no stock annex is available this should be prepared prior to the meeting, based on the previous year'sassessment and forecast method used for the advice, including analytical and data-limited methods.*A stock annex was added for the Blue Horse Mackerel in the waters of the Azores.

Generic TOR d) *Audit the assessments and forecasts carried out for each stock under consideration by the Working Group and write a short report.*Audits were carried out for each stock. Each stock has followed the proper procedure as described in their respective stock annex.

Generic TOR e) *Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).* Feedback on data issues to the RCMs and PGCCDBS are provided in the table "STOCK DATA PROBLEMS RELEVANT TO DATA COLLECTION" which is annexed to the report (in Annex 4). Further comments are reported in for each stock in their chapters, and a general comment on the quality of catch data is addressed in section 1.4.

Generic TOR f) *Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis*. This was dealt on stock by stock basis in the last section of their respective chapters. Though for short living species like anchovy the advice should always be revised annually.

Generic TOR g) *Prepare planning for benchmarks next year, and put forward proposals for benchmarks of integrated ecosystem, multi or single species for 2016.*

Generic TOR i) *In autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA (2008 report)*. This is dealt on stock by stock basis within last section of their respective chapters.

Generic TOR j)*Take into account new guidance on giving catch advice (ACOM, December 2013)*. This is dealt on stock by stock basis within the fishery information of their respective chapters.

The generic TORs l (Overview of the sampling activities on a national basis for 2012) is dealt in the following introductory section 1.5.

Generic TOR: o) *On basis of the outcomes of WKMSYREF2 for the specific stocks of the EG. Calculate reference points for stocks where the information exists but the calculations have not been done yet and resolve inconsistencies between MSY and precautionary reference points and if possible.*Due to lack of time, the group was unable to investigate this TOR. This work requires some extensive time and therefore can only be carried out in intersession.

Finally several annexes contain the remaining issues such as

- Relevant WDs (Annex 4);
- Annexes (Annex 5)
- Timing for Future benchmarks (Annex 6).
- Internal Technical minutes (Audit Reviewers Templates; Annex 7)

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

Since 2012 the WGHANSA benefits for a total 6 working days (instead of 5), as a result of the stocks added to the WG for assessment (the southern horse mackerel stock (Division IXa), Jack mackerel in Azores Islands and the further request for sardine in VIIIab and VII).

The WG has noticed that there is a continuously increasing amount of demands to the WGs for reporting data issues, availability and transmission issues, data deficiencies, future needs, interactions with RACs etc. (See Generic TORs etc.), indicators and criteria for reopening the advice, recommendations, etc. which certainly make difficult giving due responses to all these individual requests.

In 2013, it was certainly difficult to make the Internal Review Audit of the quality of the stock assessments, and this was only achieved after the WG with little (or none) time for the WG members to properly make the audit and to trigger any amendment in the report. The feedback from the various WGs regarding internal audits lead ICES to some clarifications and more accurate guidelines.

The group also points that the workload during the WG is also dependant on the availability and quality of the data ahead before the meeting. Data calls are expected to overcome this problem but will not solve the fact that some of the spring surveys ends only a few weeks before the meeting and in that case, any problem in the processing may be critical. Another issue is the proper qualification of datasets. New data points labelled as "uncertain" or "unexplained" when provided to the working group tends to bring additional exploratory assessments or forecast assumptions to consider which requires extra times in an already tight schedule.

The amount of days available for the meeting is currently seen as a minimum for this Working Group, with the perception that the group is becoming unable of providing satisfactory replies for all the increasing “extra” demands.

1.4 Quality of the fishery input

In 2014 (2013 catch data), the differences between the WG estimates and official data were minimal, and as is the usual procedure, estimates of the working group were used to perform the assessment in all cases.

1.5 Overview of the sampling activities on a national basis for 2013 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	InterCatch used 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 dataset, 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

Table of Use and Acceptance of InterCatch				
ane-bisc	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test not performed yet.
ane-pore	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	No acceptance test has been done so far.
Sar-soth	Used		Comparison not made.	No acceptance test has been done so far.
Sar-north	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test not performed yet.
Hom-south	Notused	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.
Jaa-10	Notused	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.

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						
France						
Total						

b) Anchovy VIII

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	11 801	100%	339	33 806	3 979
France	2 392	100%	35	2 252	1 522
Total	14 193	100%	374	36 058	5 501

c) Anchovy IXa

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	5 241	100%	54	6 458	2 087
Portugal	390	100%	4	294	78

Total	5 631	100%	58	6 758	2 165

d) Sardine North

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
France	20 066	100%	70	4 897	1 658
Spain	12 423	100%	126	9 206	450
Total	32489	100%	196	14 103	2 108

e) Sardine IXa and VIIIc

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

f) Southern Horse Mackerel (Division IXa)

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	15 944	100%	214	25 207	2 223
Spain	8 878	100%	124	7 887	805
Total	24 822	100%	338	33 094	3 028

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

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	1 153	100 %	254	16 962	123
Total	1 153	100%	254	16 962	123

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

(by stock coordinators)

The WG reviewed in 2013 the categorization made by WKLIFE of the populations being assessed in the WGHANSA as follows. Given that no new type of information were available and assessment methods have not changed, the perception of the group is that the following categorization still applies in 2014.

Table of Use and Acceptance of InterCatch

Stock code for each stock of the expert group	InterCatch used 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 dataset, 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	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test not performed yet.
ane-pore	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	No acceptance test has been done so far.
Sar-soth	Used		Comparison not made.	No acceptance test has been done so far.
Sar-north	Not used.	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made	Test not performed yet.
Hom-south	Notused	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.
Jaa-10	Notused	Shortage of manpower. Intention of being implemented interseasonally.	Comparison not made.	Test not performed yet.

1.7 Data requirements and needs for future for RACs and DC-MAP input

The WG has addressed the reporting of data issues, such as availability and transmission issues, data deficiencies, future needs, interactions with RACs etc. (Generic TORs c, e, J.ii etc). For it the WG fulfilled the required tables for reporting. All of them are included in Annex 4 of this report:

- "*STOCK DATA PROBLEMS RELEVANT TO DATA COLLECTION*"
    - Where the monitoring needs currently relevant to be passed to DC-MAP are listed
- Data table with indications of research needs for assessments for DLS as requested by RACs
    - Where major weakness or lack of information for future improvement are identified for the stocks of this WG.

1.8 Date and venue for WGHANSA in 2015

In order to allow more time for the data processing from the spring surveys, the Working Group proposes the meeting to be scheduled 24-29 June 2015. It is also proposed the meeting to be held at IPMA, Lisbon, Portugal in 2015.

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 of 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 modelling 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 favourable winter conditions. There is probably a balance between high enough summer temperature allowing sufficient growth and winter conditions allowing sufficient survival at length. Variability of the length of these periods or in spatial extent where such conditions can be found may have a strong influence on the recruitment success. Whereas 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, Southeast Atlantic coast, Canary Islands, South Africa, Alboran, West Mediterranean and East Mediterranean (Adriatic and Aegean seas).

Nei standard (Ds) distance based neighbour-joining tree, pairwise 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 in 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. No landings were reported in those divisions in 2012 and 2013.

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 1997-2013 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 with the majority of the landings over the last decade made by French vessels. 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. In 2012, landings were 788t for France and 51t for UK. In 2013, 10.3t were reported by UK vessels only.

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 summer (quarters 2-3). UK landings are located in the coastal rectangles of northwestern part of the Channel (29E4-29E7) and are mainly made during winter months (quarter 4 and 1). In 2013, 61% of the landings occured in 30E6.

The landings by the UK fleets are made by ringnets, purse-seiners and midwater trawlers. French catches are mainly made by purse-seiners (56%) and midwater pairtrawlers (44%; table 2.2.3).

Data from length distribution of catch anchovy are almost non existing. . No data were available in 2013. In previous years, the level of sampling in VII was on some occasion enough to provide comparable length distributions to other areas. All distributions had different modes. Considering the low level of sampling (few stations), it was 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		FR-VI	UK-VI	Landings in kg
1983				1983			
1984				1984			
1985				1985			
1986				1986			
1987				1987			
1988				1988			
1989				1989			
1990				1990			
1991				1991			
1992				1992			
1993				1993			
1994				1994			
1995				1995			
1996				1996			
1997				1997			
1998				1998			
1999	1.6		1.6	1999			
2000	3.1		3.1	2000	82.6		82.6
2001				2001			
2002	4029	2	4031	2002			
2003	0		0	2003			
2004	12.1		12.1	2004			
2005				2005			
2006	10.8	0	10.8	2006			
2007	50	0	50	2007			
2008		2	2	2008			
2009	28	127	155	2009			
2010	280		280	2010			
2011				2011	1875		1875
2012				2012			
2013				2013			

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%	
2012	788.3	50.9	839.2	91.2%	96.1%
2013		10.4	10.4	0.0%	39.5%

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

UK Fleets									
Gear	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
MIDWATER TRAWL	5814		619021	10126	98056	10840		34936	10307
RINGNET			92560	132294	235788	244935		12220	
MIDWATER PAIR TRAWL	1665	200	28103	12600	4286	1100			
PURSE-SEINE						47056			

UK Fleets									
Gear	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
DRIFTNET			5241	17 838	1	15 613			
UNSPECIFIED OTTER TRAWL			18 216	1	270	22		3622	
TRIPLE NEPHROPS OTTER					15 080				
OTHER OR MIXED POTS				2 688					
BOTTOM PAIR TRAWL	245								
BEAM TRAWL				199					
UNSPECIFIED GILLNET			11	27		58			
GILLNET (NOT 52 OR 53)				8		7			
WHELK POTS			1						
Total	**7724**	**200**	**763 153**	**175 781**	**353 481**	**319 631**	**0**	**50 778**	**10 307**

French Fleets									
Gear	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
PURSE-SEINE					392 150	517 940	39 692	445 778	
MIDWATER PAIR TRAWL		1500			51 460	437 720	34 582	208 593	
MIDWATER OTTER TRAWL				0.5	78 994	68 294			
SCOTISH SEINE					53 400	33 500	137		
BOAT DREDGES				1.7		37 200		100	
NOT KNOWN					9000	26 330		132 283	
PURSE-SEINE 1 BOAT	7415	1720					1050		
BOTTOM OTTER TRAWL	54.7	2002	270	19.7	80	4720	601	47	
OTTER TWIN TRAWL						2150	21		
GILLNETS				400		1730	936		
TRAMMELNETS				320				1470	
Total	**7470**	**5222**	**270**	**741.9**	**585 084**	**1 129 584**	**77 019**	**788 272**	

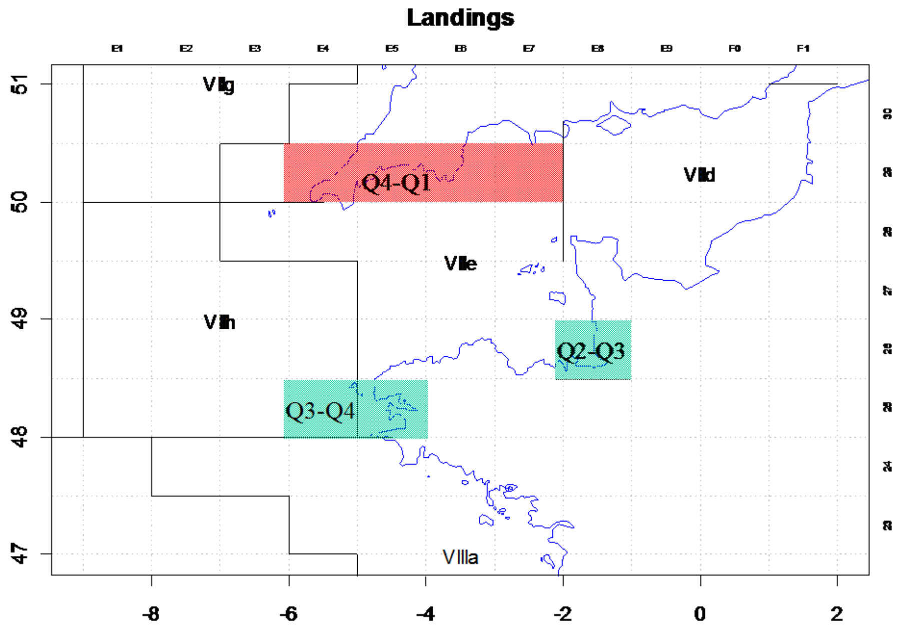


Figure 2.2.1. Map of the statistical rectangles where most of the catches of anchovy occur in ICES division VII for France (Green) and UK (Red).

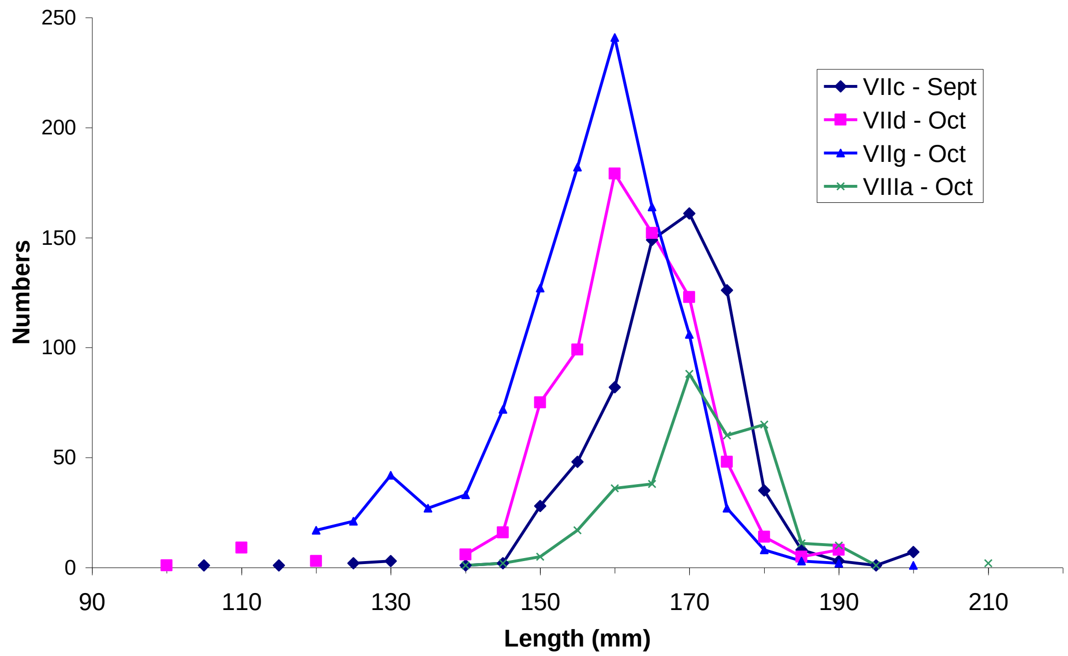


Figure 2.2.2. Length distributions of catch of anchovy in ICES divisionsVIIc, VIId, VIIg and VIIIa in 2010.

3 Anchovy in the Bay of Biscay (Subarea VIII)

3.1 ACOM advice for 2013 and 2014

In June 2013, ICES estimated the median SSB at 56 055 t which is above B_{lim} with a 100% probability. On the basis of the precautionary approach ICES advised that assuming an undetermined recruitment scenario for 2014, *"to reduce the risk to less than 5% of the SSB in 2014 falling below B_{lim}, catches in the period 1 July 2013-30 June 2014 should be less than 18 000 t"*.

In July 2013 the Council established the TAC for the fishing season running from 1 July 2013 to 30 June 2014 at 17 100 tonnes (Council Regulation No 713/2013) based on the European Commission long-term management plan proposal. This proposal was presented on 29 July 2009 but it has not been formally accepted yet. It is subject to revision and agreement between the EC, the Council and the Parliament, according to the procedures established in the Lisbon treaty. However, the plan proposal has been used since 2010 for establishing the TAC for the period between 1st July and 30th June next year, after the period of consecutive fishery closures from July 2005 to December 2009.

The Council Regulation No 713/2013 also established that 90% of the TAC corresponded to Spain and 10% to France. However, due to a bilateral agreement, Spain transferred 10% of their corresponding TAC plus 100 t to France in exchange of access to certain areas for live-bait. This agreement included a fishing ban from December 2013 to February 2014. So, the purse-seine fishery started in March 2013 and the pelagic trawl fishery in June 2013.

In October 2013 the European Commission increased the 2013-2014 fishing quota for anchovy in the Bay of Biscay allocated to France by 70.9 tonnes and to Spain by 1646 tonnes (Regulation No 1007/2013) based on Regulation (EC) No 847/96 according to which Member States may ask the Commission, before 31 October of the year of application of a fishing quota allocated to them, to withhold a maximum of 10 % of that quota to be transferred to the following year.

In March 2013 the European Commission established deductions from certain fishing quotas allocated to Spain in 2013 and subsequent years on account of overfishing of the mackerel quota in 2009 (Regulation No. 185/2013). In particular, 3696 tonnes will be deduced from the anchovy annual quota from 2016 to 2022 and 180 tonnes in 2023.

3.2 The fishery in 2013 and 2014

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 ones 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.

The total number of fishing licences for anchovy in Spain in 2013 was 176. The number of fishing licenses in 2014 until mid-June was 149, with the following distribution by regions:

PAIS VASCO	CANTABRIA	ASTURIAS	GALICIA	TOTAL
52	30	7	60	149

For France the number of purse-seiners able to catch anchovy in 2013 was 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 three years. The real target species of these vessels is sardine, and anchovy is more opportunistic.

The number of French pelagic trawlers decreased drastically during last years because they were targeting mainly anchovy and tuna. Currently 10 pairs of trawlers (20 vessels) are able to target anchovy. In 2013, a small shift occurred on the French anchovy fishery. Pair pelagic trawlers mainly target tuna between July and October, and single pelagic trawlers caught anchovy particularly in September and October.

3.2.2 Catches

In July 2012 a TAC of 20 700 t was established for the period July 2012-June 2013. Overall 5802 t were caught in the second half of 2012 and 10 935 t in the first half of 2013. In July 2013 a TAC of 17 100 t was established for the period July 2013-June 2014. In the second half of 2013 around 3300 t were caught. The Spanish catches up to mid June 2014 were around 13 460 t.

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

Table 3.2.2.1 Bay of Biscay anchovy: Annual catches (in tonnes). The catches up to 2011 are estimated by the Working Group members and the catches from 2012 correspond to official records.

COUNTRY	FRANCE	SPAIN	SPAIN	UNALLOCATED	INTERNATIONAL
YEAR	VIIIab	VIIIbc, Landings	Live Bait Catches		VIII
1960	1085	57 000	n/a		58 085
1961	1494	74 000	n/a		75 494
1962	1123	58 000	n/a		59 123
1963	652	48 000	n/a		48 652
1964	1973	75 000	n/a		76 973
1965	2615	81 000	n/a		83 615
1966	839	47 519	n/a		48 358
1967	1812	39 363	n/a		41 175
1968	1190	38 429	n/a		39 619
1969	2991	33 092	n/a		36 083
1970	3665	19 820	n/a		23 485
1971	4825	23 787	n/a		28 612
1972	6150	26 917	n/a		33 067
1973	4395	23 614	n/a		28 009
1974	3835	27 282	n/a		31 117
1975	2913	23 389	n/a		26 302
1976	1095	36 166	n/a		37 261

COUNTRY	FRANCE	SPAIN	SPAIN	UNALLOCATED	INTERNATIONAL
YEAR	VIIIab	VIIIbc, Landings	Live Bait Catches		VIII
1977	3807	44 384	n/a		48 191
1978	3683	41 536	n/a		45 219
1979	1349	25 000	n/a		26 349
1980	1564	20 538	n/a		22 102
1981	1021	9794	n/a		10 815
1982	381	4610	n/a		4991
1983	1911	12 242	n/a		14 153
1984	1711	33 468	n/a		35 179
1985	3005	8481	n/a		11 486
1986	2311	5612	n/a		7923
1987	4899	9863	546		15 308
1988	6822	8266	493		15 581
1989	2255	8174	185		10 614
1990	10 598	23 258	416		34 272
1991	9708	9573	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	9939	378		22 337
1998	22 987	8455	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	6519	n/a		17 507
2003	7593	3002	n/a		10 595
2004	8781	7580	n/a		16 361
2005	952	176	0		1128
2006	913	840	0		1753
2007	140 **	1.2**	0		0
2008	0	0	0		0
2009	0	0	0		0
2010	4573	5744	n/a		10 317
2011	3615	10 916	n/a		14 530
2012	5975	7896	n/a	531	14 402
2013	2392	11 801	n/a		14 192
2014 (Up 15th June)	0	13 459	n/a		13 459
AVERAGE	6394	26 337.33401	317.816173		32 823.62357
(1960-2004)					

**** Experimental fishery**

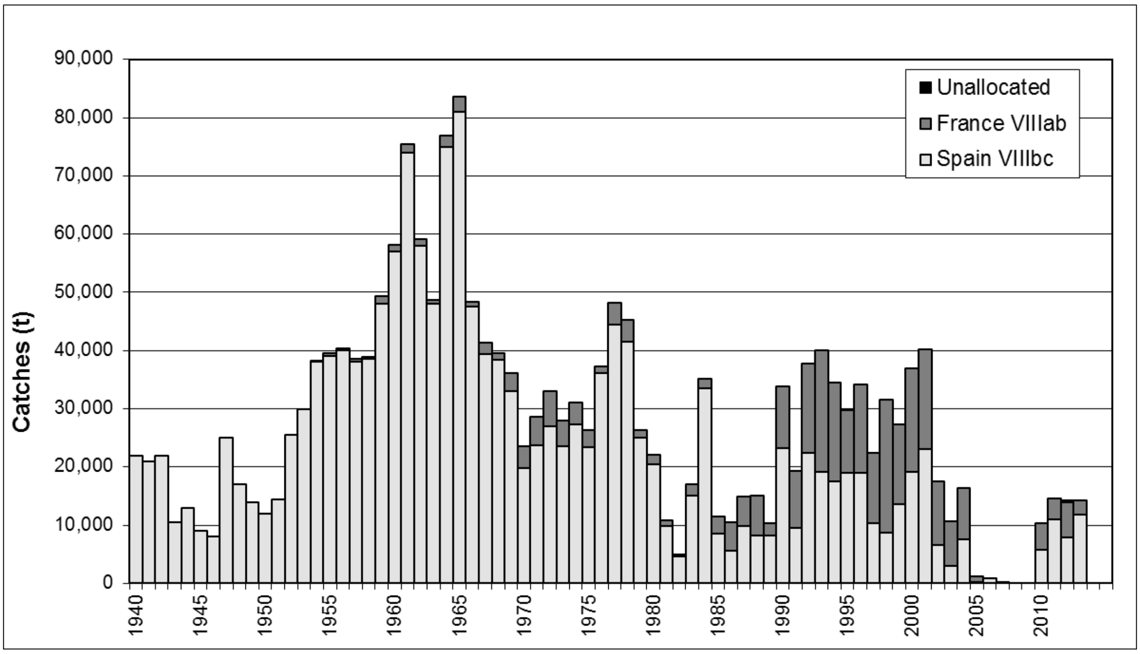


Figure 3.2.2.1: Bay of Biscay anchovy: Historical evolution of catches in division VIII by countries. Catches until 2011 are working group estimates.

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

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	14 763
1988	6	0	42	1657	4317	3979	584	1253	2423	445	136	246	15 088
1989	706	73	36	588	4943	806	132	566	186	472	1619	301	10 429
1990	80	6	2101	2658	11 459	3083	1471	5132	5553	1570	652	92	33 856
1991	1418	2175	626	2036	6913	1858	215	479	1621	822	238	882	19 282
1992	2422	1864	1282	4241	13 125	3448	719	1488	3291	3228	2489	89	37 685
1993	1738	1864	3362	3260	7906	5927	2110	2979	4254	3342	3273	70	40 086
1994	1972	1917	1591	5741	4761	7231	1796	2306	3382	3295	421	74	34 487
1995	620	958	842	5967	12 329	2764	439	1098	2155	1382	903	387	29 843
1996	1132	647	752	1834	9763	6897	2449	2675	3617	2818	1575	17	34 176
1997	2278	688	105	2782	2762	1985	1895	2400	3578	2381	921	185	21 961
1998	1558	2363	1276	371	4839	2510	3943	5039	4298	2640	2500	104	31 442
1999	2088	1360	626	4681	4282	2345	2052	948	4049	2130	2207	27	26 794
2000	2219	948	925	1957	11 922	4565	3148	3063	4043	2995	1210	0	36 994

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
2001	960	565	479	2249	14 428	4413	2514	3403	4435	3850	2852	1	40 149
2002	1436	2561	1573	915	2506	2098	673	1034	2970	1152	578	0	17 497
2003	39	2	0	1740	890	1403	294	2297	1602	1322	986	20	10 595
2004	210	106	3	2377	3247	3241	902	2017	2886	557	813	2	16 360
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	10 317
2011	0	0	1586	4483	4492	351	2	176	815	1319	1258	47	14 530
2012	0	0	68	1060	5663	1809	354	868	2352	1940	288	0	14 402
2013	0	3	272	2226	5166	3269	312	316	1375	1069	185	1	14 192

The quarterly catches by division in 2013 are given in Table 3.2.2.3. Most of the catches took place in the second quarter (75.1%) corresponding to the major fishing activity of the Spanish fleet. Regarding fishing areas, the catches in the second quarter corresponded to ICES Divisions VIIIb and VIIIc (57 and 43% respectively). More than 80% of the catches in the second semester were taken in ICES Division VIIIb by the Spanish fleet, while French catches are almost exclusively coming from the VIIIa.

Table 3.2.2.3 Bay of Biscay anchovy: Catches by divisions in 2013 (without live bait catches)

	QUARTERS				CATCH (t)	
DIVISIONS	**1**	**2**	**3**	**4**	**ANNUAL**	**%**
VIIIa	0	0	0	0	0	0.0%
VIIIb	204	6049	1628	1075	8956	63.1%
VIIIc	70	4605	381	180	5236	36.9%
TOTAL	274	10 654	2009	1255	14 192	100.0%
%	1.9%	75.1%	14.2%	8.8%	100.0%	

Discards are not measured and hence not included in the assessment, but nowadays they are considered not relevant to the two fleets exploiting this stock.

3.2.3 Catch numbers-at-age and length

Catch numbers-at-age by quarter in 2013 are given in Table 3.2.3.1. Age 2 individuals were predominant in the first and second quarters, whereas age 1 individuals were the most abundant ones in the third and fourth quarters.

Table 3.2.3.1 Bay of Biscay anchovy: catch-at-age in thousands for 2013 by quarter (without the catches from the live bait tuna fishing boats).

	QUARTERS	1	2	3	4	Annual total
	AGE	**VIIIabc**	**VIIIabc**	**VIIIabc**	**VIIIabc**	**VIIIabc**
TOTAL Subarea VIII	0	0	0	2294	8049	10 343
	1	2750	82 113	58 991	22 401	166 255
	2	6630	217 328	26 239	18 938	269 135
	3	2144	85 349	3168	2392	93 053
	4	0	0	0	0	0
	5	0	0	0	0	0
	TOTAL(n)	11 524	384 790	90 692	51 779	538 785
	W MED.	23.78	27.80	22.91	25.19	26.64
	CATCH. (t)	274	10 654	2009	1255	14 192
	SOP	274	10 698	2078	1304	14 354
	VAR. %	100.00%	100.41%	103.42%	103.90%	101.14%

Year 2013; Units: thousands

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 2013, age 2 individuals predominated in the first half and age 1 individuals in the second half.

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)

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	1664	9 954	596	18 096	1 986	8 175	4999	29 179	61	16 960	1	5336	0	61 667	1 325	76 525	90
4	14 831	58	1356	0	54	0	0	0	0	0	0	0	0	0	0	0	4 096	7
5	8920	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	5580	195	5596	3398	17 761	525	84 437	18 613	19 698	5095	37 886	3045	34 133	11 459	12 444	1153
4	2213	42	0	0	155	0	108	0	0	0	4948	0	76	0	887	1152	4598	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		2012		2013	
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	0	0	0	0	0	0	0	0	0	0	16 287	0	4656	0	3761	0	10 343
1	7 818	0	48 718	3894	0	0	0	0	0	0	125 198	135 570	164 061	159 675	56 013	167 935	84 863	81 392
2	32 911	0	17 172	991	0	0	0	0	0	0	77 342	13 864	214 454	11 080	254 863	69 396	223 958	45 177
3	6 935	0	6465	320	0	0	0	0	0	0	10 897	815	7161	503	5055	1 115	87 493	5559
4	586	0	49	2	0	0	0	0	0	0	1711	189	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0				
Total #	48 250	0	72 405	5207	0	0	0	0	0	0	215 149	166 725	385 677	175 914	315 932	242 207	396 315	142 471

Units: thousands

Catch at length data (by 0.5 cm classes) by quarter are given in Table 3.2.3.3. The length range was between 9.5 and 19.5 cm. During the first three quarters the modal length was between 15 and 16 cm, whereas the fourth quarter showed a length distribution with two modes at 12 and 16 cm.

See the stock annex for methodological issues.

Table 3.2.3.3 Bay of Biscay anchovy: Catch numbers at length quarters in 2013

	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								
8								
8.5								
9								
9.5		6		13				
10		10		13		4	83	2
10.5		9		192		42		12
11		35		301		220	578	33
11.5		58		863	99	779	1155	213
12		149	27	2015	764	2222	2433	412
12.5		343	148	4288	561	2718	1971	754
13		510	386	7090	955	4031	1023	984
13.5		925	513	11 073	1329	4847	774	1398
14		1231	636	18 744	5179	4010	1226	1134
14.5		1772	512	25 818	8661	3619	1230	764
15		2064	463	44 608	11 573	3617	3937	890
15.5		1707	331	61 913	10 989	4073	4985	1620
16		1336	139	76 251	9516	2284	7435	2011
16.5		793	59	58 095	4439	1547	5854	1994
17		435	30	37 502	2653	618	4413	1105
17.5		146	5	16 513	1213	256	838	637
18		73		6494	588	28	838	210
18.5		27		1725	347	2	413	27
19		5		483	211			10
19.5		7		33	53			
20								
20.5								
21								

	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
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
Total ('000)		11 641	3249	374 026	59 128	34 917	39 186	14 210
Catch (t)		274	58	10 596	1 395	614	938	317
Mean Length(cm)		15.16	14.23	15.92	15.28	14.33	15.24	15.29

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 2013, is shown in Table 3.2.4.1. See the stock annex for methodological issues.

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

INTERNATIONAL																		
YEAR	**1987**		**1988**		**1989**		**1990**		**1991**		**1992**		**1993**		**1994**		**1995**	
Sources	**Anon. (1989 and 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		2012		2013	
Sources:	**WG data**		**WG data**		**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**	**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	na	12.6	na	12.0
1	19.3	na	20.3	17.8	na	na	na	na	na	na	25.0	25.9	22.5	20.5	16.7	22.3	20.8	21.9
2	24.5	na	27.7	19.7	na	na	na	na	na	na	32.1	27.4	32.4	27.3	28.9	25.9	28.8	28.7
3	27.6	na	31.3	19.7	na	na	na	na	na	na	43.7	43.2	36.4	34.8	38.7	26.5	31.5	31.6
4	24.5	na	37.3	34.3	na	na	na	na	na	na	43.0	44.4	na	na	na	na	na	na
5	na	na	na	na	na	na	na	na	na	na	55.7	na	na	na	na	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	26.9	23.2	27.7	23.7

Units: grammes

3.3 Fishery-independent data

3.3.1 BIOMAN DEPM survey 2014

All the methodology for the survey and the estimates performance are described in detail in the Annex A.5_stock annex-Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey and results 2014 is attached as Annex A3.2_ WD_DEPM_BIOMAN (Santos. M *et al*. WD 2014).

3.3.1.1 Survey description

The 2014 anchovy DEPM survey was carried out in the Bay of Biscay from 5th to the 24th of May, covering the whole spawning area of the species, following the procedures described in the Annex A.5_stock annex- Bay of Biscay Anchovy (Subarea VIII). Two vessels were used at the same time and place: the RV Ramón Margalef to collect the plankton samples and the pelagic trawler RV Emma Bardán to collect the adult samples. Sample specifications are given in Table 3.3.1.1.1

Table 3.3.1.1.1 Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2014.

Parameters	Anchovy DEPM survey
Surveyed area	(43º19' to 47º53′N and 7º47′ to 1º14' W)
RV	*Ramón Margalef and Emma Bardán*
Date	5-24/05/14
Eggs	RV RAMON MARGALEF
Total egg stations	767
% st with anchovy eggs	45%
Anchovy egg average by st	29 eggs/0.1m^2
Max. anchovy eggs in a St	634 eggs/0.1m^2
Total anchovy egg collected	22 310 eggs
North spawning limit	47º′N
South spawning limit	43º37′N
Total area surveyed	104 115 Km^2
Spawning area	35 317 Km^2
CUFES stations	1719
Adults	RV EMMA BARDAN
Pelagic trawls	51
With anchovy	42
Selected for analysis	41
Hauls from purse-seines	6
Total adult samples for analisis	47

Total number of PairoVET samples obtained was 767. From those, 348 had anchovy eggs (45%) with an average of 29 eggs 0.1m-2 per station and a maximum of 634 eggs 0.1m-2 in a station. A total of 22 310 anchovy eggs were encountered and classified. The number of CUFES samples obtained was 1719 with 88 711 anchovy eggs in total (9056eggm-3) with a mean of 5 egg m-3 per station. No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º37′N in the French platform and the northern limit was found at 47º N. The eggs in the French platform where encountered in the historical common places: Between Adour and Arcachon passed the 200m depth from the coast and in the area of influence of Le Gironde, from the coast to the 100m depth line. (Figure 3.3.1.1.1).

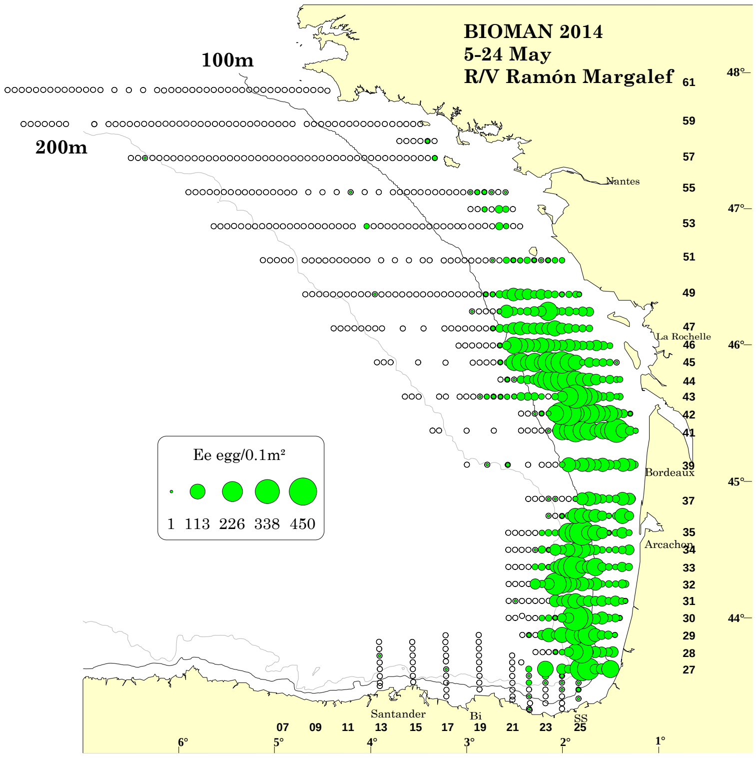


Figure 3.3.1.1.1: Bay of Biscay anchovy: Distribution of anchovy egg abundance (eggs per 0.1 m2) from the DEPM survey BIOMAN2014 obtained with PairoVET.

In relation with the adult samples, 51 pelagic trawls were performed, of these, 42 provide anchovy and 41 were selected for the analysis. Moreover, 6 hauls from the commercial fleet, purse-seines, were added for the analysis. In total there were 47 adult anchovy samples for the estimation of the adult parameters. The spatial distribution of the samples and their species composition is shown in Figure 3.3.1.1.2. The most abundant species in the trawls ware: anchovy, sardine, mackerel, blue whiting and sprat. Spatial distribution of mean weight and mean Length (males and females) is shown in Figure 3.3.1.1.3. Less weight individuals were found near the coast inside the 100 m depth isoline and in the influence of the Gironde estuary while heavier anchovies were found offshore, once passed the isoline of 100m depth. Figure 3.3.1.1.4 shows the age composition by haul.

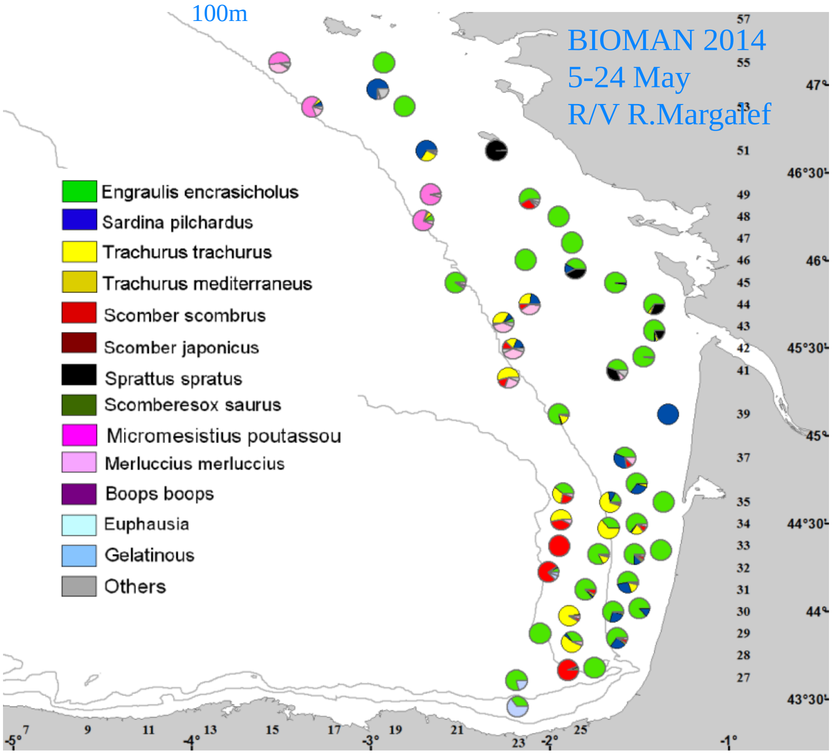


Figure 3.3.1.1.2 Bay of Biscay anchovy: Species composition of the 47 pelagic trawls from the RV Emma Bardán during BIOMAN2014.

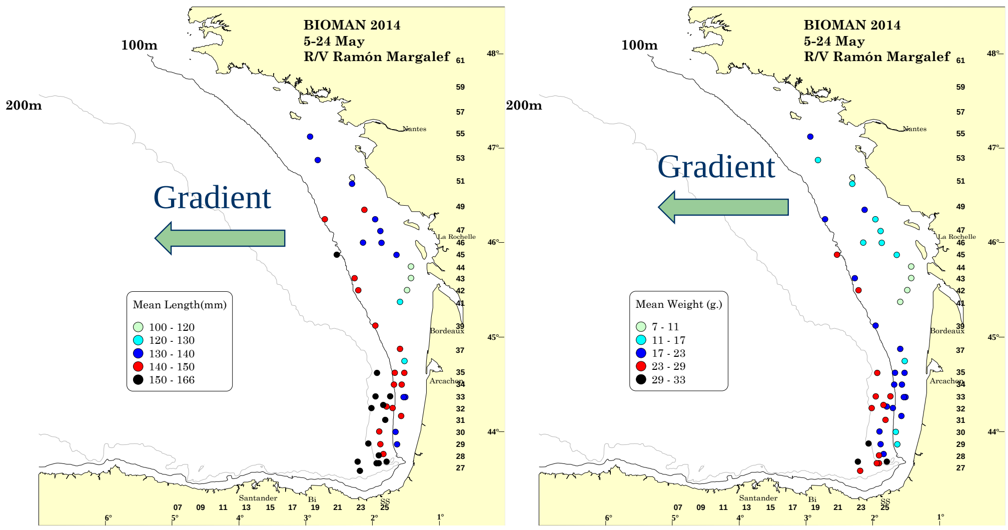


Figure 3.3.1.1.3 Bay of Biscay anchovy: Spatial distribution of anchovy mean size (left) and mean weight (right) (males and females) per haul in BIOMAN2014.

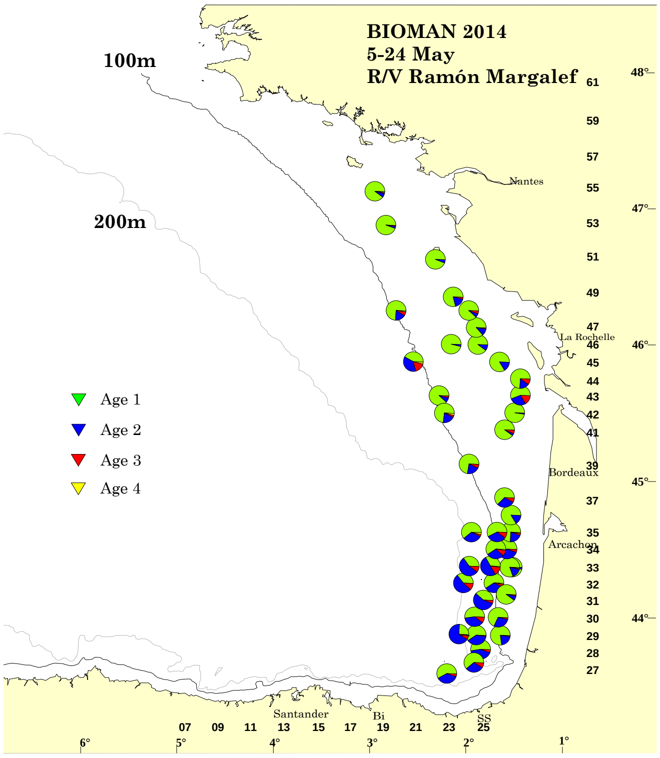


Figure 3.3.1.1.4 Bay of Biscay anchovy: Anchovy age composition per haul in BIOMAN2014.

The weather conditions during the survey were good in general with a mean Sea Surface Temperature of 14.8ºC. This year the salinity with a mean of 34 is wide spread over the area more than in previous years and is under 32 in the area of the Gironde and Adour. Comparing with the last 3 years this year appears to be wormer than last but not as wormer as 2011. Figure 3.3.1.1.5 shows the maps of surface salinity and temperature found during the survey.

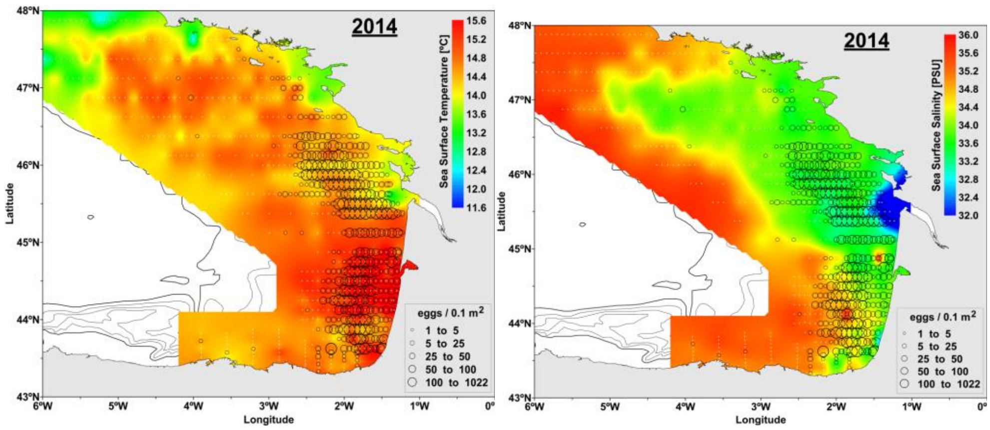


Figure 3.3.1.1.5 Bay of Biscay anchovy: From left to right spatial distribution of SST and SSS in BIOMAN 2014. The bubbles represent the anchovy egg abundance per 0.1m².

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 inTable 3.3.1.2.1 and the mortality curve model adjusted is shown in

Figure 3.3.1.2.1 Total egg production in 2014 was estimated at 6.76 E+12 with a CV of 0.11, two times last year estimate.

Table 3.3.1.2.1 Bay of Biscay anchovy: Anchovy daily egg production (P0), daily egg mortality rates (z) and total egg production (Ptot) estimates with their correspondent standard error (s.e.) and coefficient of variation (CV) for 2014.

Parameter	Value	S.e.	CV
P0	191.37	21.70	0.1134
z	0.17	0.056	0.3367
Ptot	6.76.E+12	7.7.E+11	0.1134

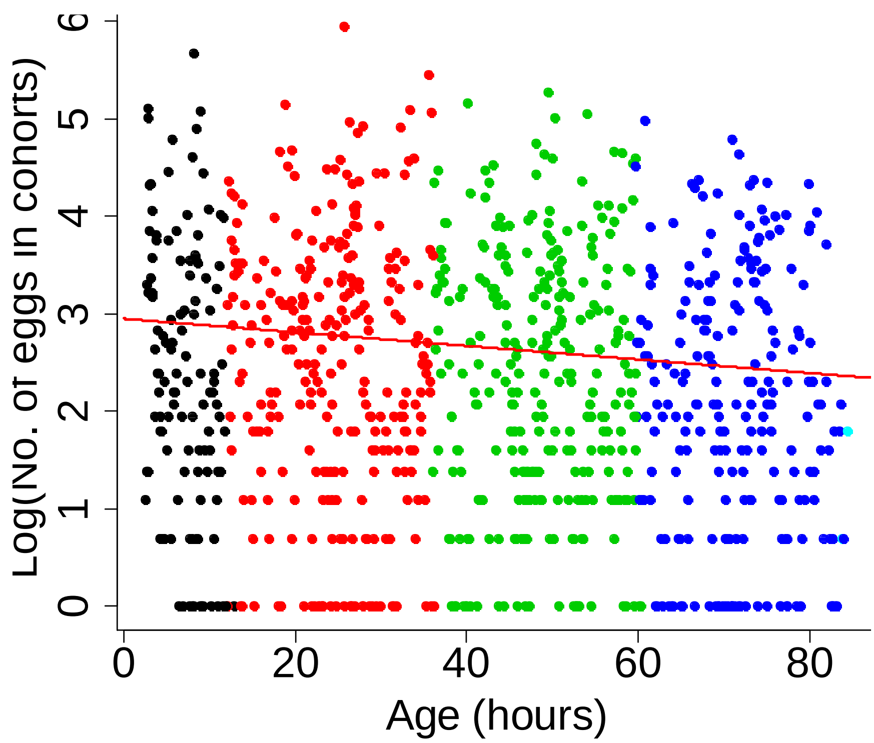


Figure 3.3.1.2.1 Bay of Biscay anchovy: Exponential mortality model adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak assumed to be at 23:00h).The red line is the adjusted line. The point colours represent the different cohorts.

3.3.1.3 Daily fecundity and preliminary index of biomass

A preliminary daily fecundity was estimated from the sex ratio, the mean weight of females, a preliminary estimate of the batch fecundity and the spawning frequency as an historical mean.

Sex ratio (*R*) and mean weight of females (W_f) were directly measured on board from each sample. For batch fecundity (*F*) the hydrated egg method was followed. 155 hydrated females were selected *a visu*, 32 of them were excluded due to the suspected of started the ovulation. By the time being it was not possible to check histologically that these retained females did not start ovulation, so the batch fecundity is considered preliminary (seeAnnex A3.2_ WD_DEPM_BIOMAN (Santos. M *et al*. WD 2014).

The average of the historical series of S was 0.4. The index of biomass estimate resulted in 87 225 t with a coefficient of variation of 16%. (Figure 3.3.1.3.1).

The resulting estimate of the adult parameters and index of biomass are given in Table 3.3.1.3.1.

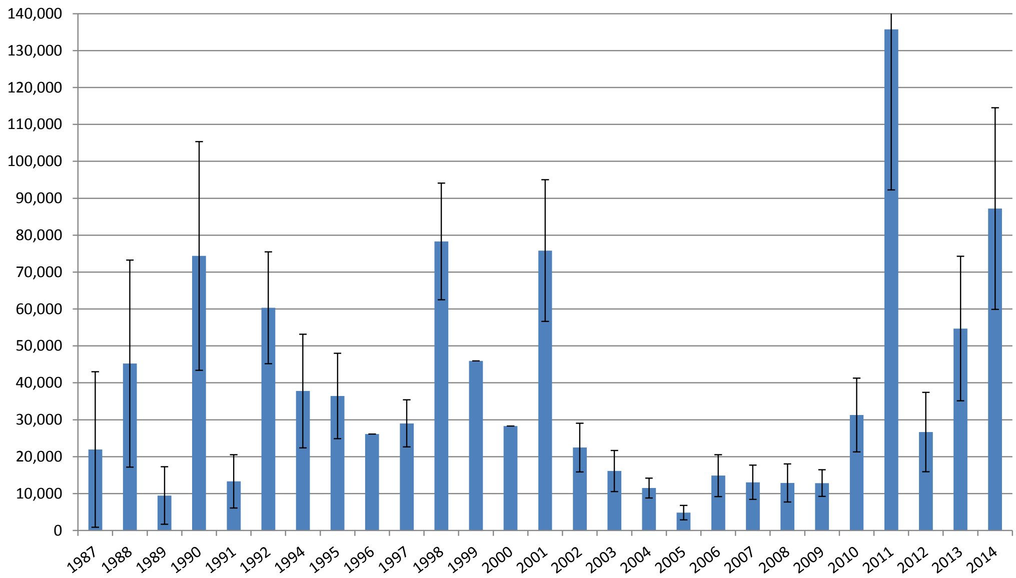


Figure 3.3.1.3.1 Bay of Biscay anchovy: Series of anchovy biomass estimates (in tonnes) obtained from the DEPM.

Table: 3.3.1.3.1 Bay of Biscay anchovy: All the parameters to estimate de index of biomass using the Daily Egg Production Method (DEPM) for 2014: Ptot (total egg production), R (sex ratio), S (Spawning frequency), F (batch fecundity), W_f (female mean weight), DF (daily fecundity) and Wt (total mean weight (female and male) with correspondent Standard errors (S.e.) and coefficients of variation (CV).

Parameter	estimate	S.e.	CV
Ptot	6.76E+12	7.67E+11	0.1134
R'	0.54	0.0108	0.0199
S	0.40	0.0396	0.1000
F	7,594	464	0.0611
Wf	21.09	0.87	0.0412
DF	77.48	8.36	0.1079
BIOMASS	87,225	13,655	0.1566
Wt	17.07	1.17	0.0685

3.3.1.4 Population at age

In order to estimate the numbers-at-age, 2 strata were defined: North (N) and South (S) (Figure 3.3.1.4.1). 73% of the anchovy are individuals of age 1(65%in mass) and 21% of the individuals are of age 2 (27%in mass) (Table 3.3.1.4.1). The time-series of the age structure of the population is shown in Figure 3.3.1.4.2.

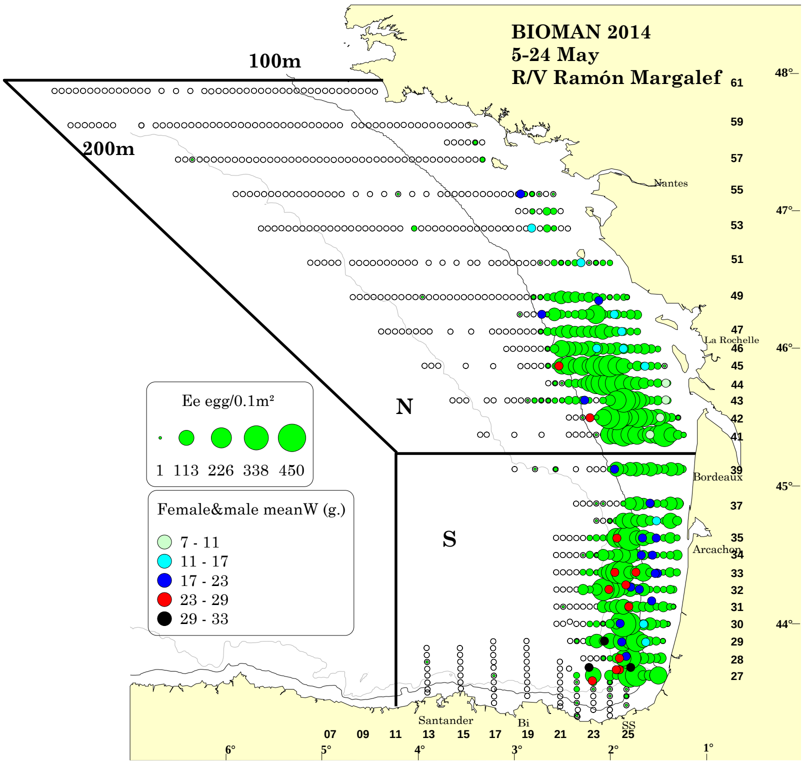


Figure 3.3.1.4.1 Bay of Biscay anchovy: Spatial strata to estimate anchovy numbers-at-age in BIOMAN2014.

Table: 3.3.1.4.1 Bay of Biscay anchovy: Anchovy index of biomass, percentage at age, numbers-at-age, mean weight at age, biomass at age in mass and percentage at age in mass and the correspondent standard error (s.e.) and coefficient of variation (CV) from BIOMAN 2014.

Parameter	estimate	S.e.	CV
Biomass (Tons)	87 225	13 655	0.1566
Tot. Mean W (g)	17.07	1.17	0.0685
Population (millions)	5136	893	0.1739
Percentage at age 1	0.73	0.03	0.0464
Percentage at age 2	0.21	0.03	0.1286
Percentage at age 3	0.06	0.01	0.1819
Numbers-at-age 1	3781	717	0.1895
Numbers-at-age 2	1087	202	0.1857
Numbers-at-age 3	289	72	0.2492
Weight at age 1 (g)	15.3		
Weight at age 2 (g)	22.3		
Weight at age 3 (g)	22.7		
SSB at age 1 (Tons)	56 873		
SSB at age 2 (Tons)	23 903		
SSB at age 3 (Tons)	6450		
Percentage at age 1 in mass	65.2		
Percentage at age 2 in mass	27.4		
Percentage at age 3 in mass	7.4		

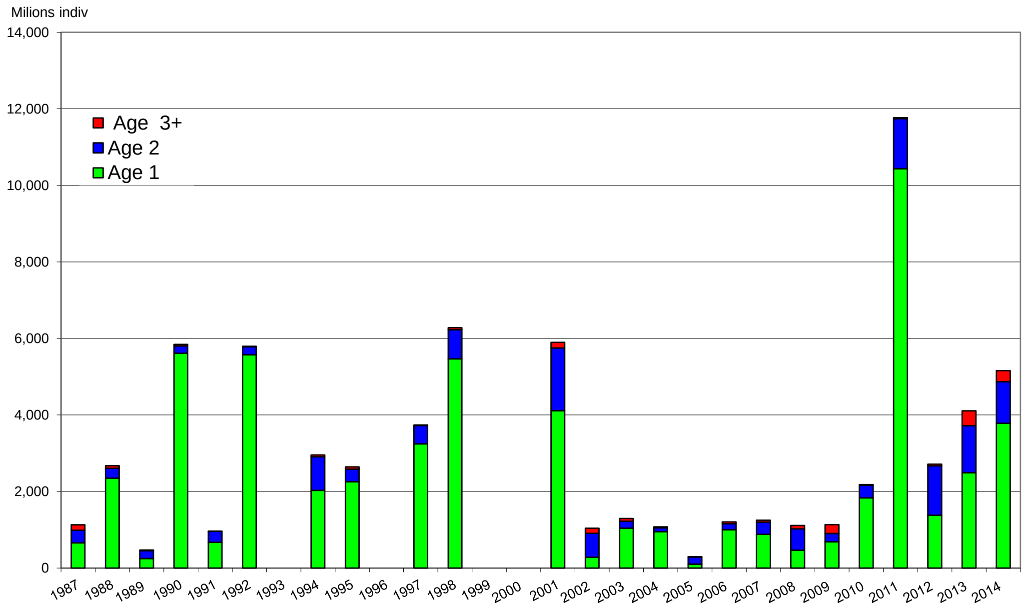


Figure 3.3.1.4.2 Bay of Biscay anchovy: Anchovy historical series of numbers-at-age from 1987 to 2014 from BIOMAN surveys.

3.3.2 The PELGAS 14 spring acoustic survey

For more details, see WD Duhamel et al.,2014, presented to this group

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 are anchovy and sardine but they are considered in a multispecific context and within an ecosystemic approach as they are located in the centre of pelagic ecosystem.

The strategy this year was the identical with previous surveys (2000 to 2013). 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 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 of the echosounder between the surface and 8 m depth.

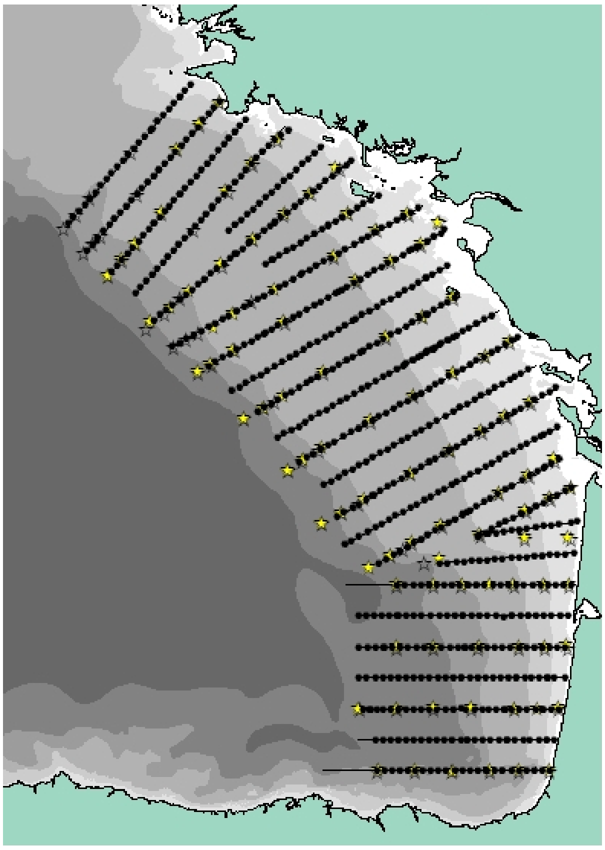
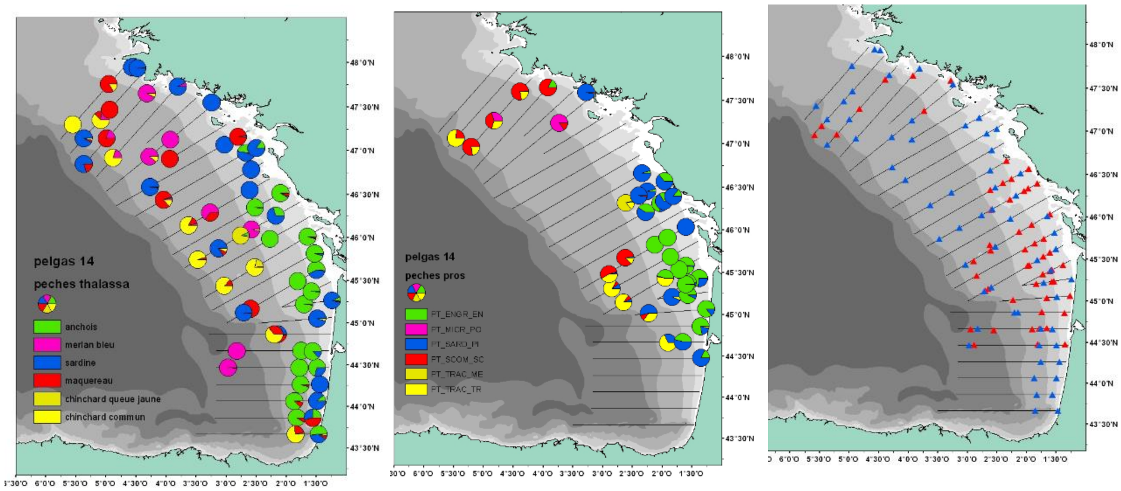


Figure 3.3.2.1. Acoustic transects network during PELGAS14 survey

Acoustic data were collected by RV Thalassa along a total amount of 6230 nautical miles from which 2011 nautical miles on one way transect were used for assessment. A total of 28 352 fish were measured (including 9038 anchovies and 8129 sardines) and 2458 otoliths were collected for age determination (1197 of anchovy and 1261 of sardine).

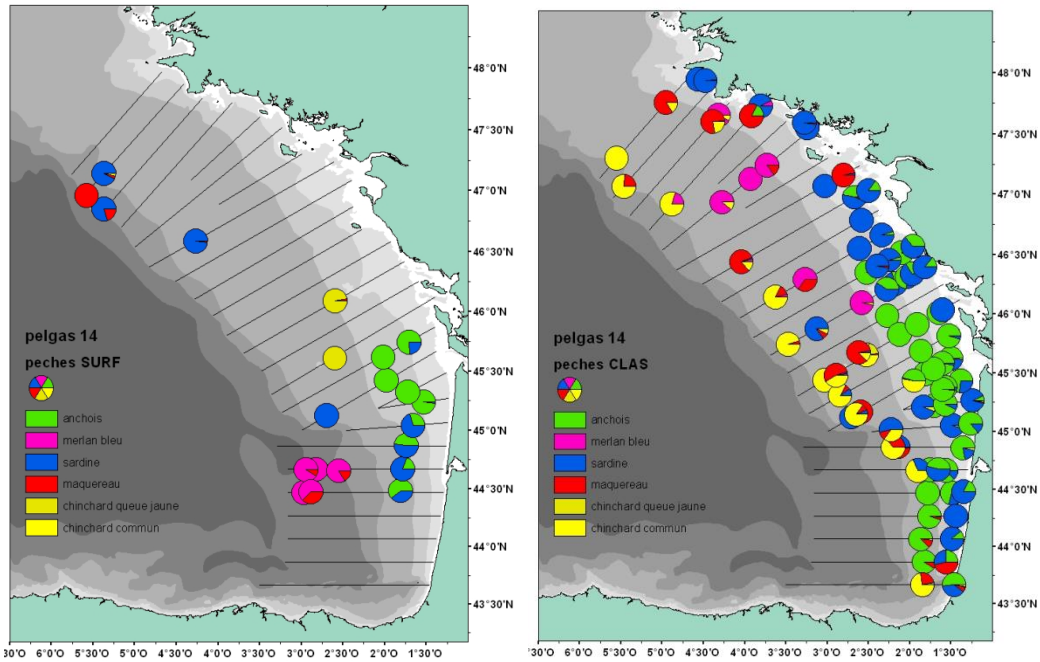
A consort survey is routinely organized since 2007 with French pairtrawlers during 18 days. This approach, in the continuity of last year survey, and the commercial vessels hauls were used for echo identification and biological parameters at the same level than Thalassa ones. A total of 116 hauls were carried out during the assessment coverage including 62 hauls by Thalassa and 54 hauls by commercial vessels. (Figure 3.3.2.2).



a) Thalassa (nb :62) *b) Commercial vessels (nb : 54)* *c) all fishing hauls (nb :116) Thalassa in blue and commercial in red*

Figure 3.3.2.2 Fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS14

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 minimize the variability due to the variable mixing of species. Figure 3.3.2.3. 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.



Classic strata | Surface strata

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

The biomass estimate of anchovy observed during PELGAS14 is 125 427 tons. (Table 3.3.2.1.), which is at a high level on the PELGAS series, and constituting a new increase of this biomass in the Bay of Biscay. Biomass indices are gathered in Table 3.3.2.2.

Table 3.3.2.1 Acoustic biomass index for sardine and anchovy by strata during PELGAS14

	Classic	Surface	Total
Anchovy	110 343	15 084	**125 427**
Sardine	308 759	30 848	**339 607**
Sprat	33 894		**33 894**
Mackerel	110 174	300 006	**410 181**
Horse Mackerel	53 154		**53 154**
Blue whiting	25 015		**25 015**

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	2013	2014
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**	**93 854**	**125 427**
CV anchovy	*0.064*	*0.141*	*0.113*	*0.132*	*0.167*	*0.171*	*0.136*	*0.100*	*0.162*	*0.112*	*0.147*	*0.07741*	*0.04665*	*0.12821*	*0.062928*
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**	**407 740**	**339 607**
CV sardine	*0.083*	*0.117*	*0.088*	*0.241*	*0.121*	*0.135*	*0.117*	*0.159*	*0.139*	*0.098*	*0.091*	*0.06991*	*0.07668*	*0.07382*	*0.065212*
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**	**44 651**	**33 894**
CV sprat	*0.098*	*0.155*	*0.120*	*0.198*	*0.178*	*0.228*	*0.162*	*0.132*	*0.268*	*0.108*	*0.108*			*0.19922*	*0.241009*
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**	**33 471**	**53 154**
CV HM	*0.079*	*0.204*	*0.156*	*0.137*	*0.287*	*0.160*	*0.316*	*0.065*	*0.455*	*0.09*	*0.188*			*0.30067*	*0.227089*
Blue Whiting	-	-	**35 518**	**1 953**	**12 267**	**26 099**	**1 766**	**3 545**	**576**	**4 333**	**48 141**	**11 823**	**68 533**	**25 715**	**25 015**
CV BW	-	-	*0.386*	*0.131*	*0.202*	*0.593*	*0.210*	*0.147*	*0.253*	*0.219*	*0.074*			*0.15422*	*0.337606*

In the Gironde area (Figure 3.3.2.4), we found a configuration more classic (in size and in Sa), with an acoustic energy attributed to anchovy about the average, and far away from the very high energies from 2012. Nevertheless, anchovy was predominant in this area. The most part of the age 1 of anchovy was there, in size class comparable with a "normal" year (all, except 2012 where the fish was much smaller).

In the South part of the Bay of Biscay, anchovy was also well present in the middle of the platform, in the whole water column (close to the bottom until the surface).

On the South coast of Brittany, sightings of anchovy occurred around the Loire River and in much lower quantities in the southwest of Brittany, still along the coast.

One thing must be noticed this year, the absence of anchovy along the shelf break, neither at the surface, nor at the bottom.

Looking at the numbers-at-age since 2000 (Figure 3.3.2.5.), the number of 1 year old anchovies this year seems to be around the average of the serie, but far away from 2011 or 2012 levels of recruitment, but nevertheless at a good level of recruitment.

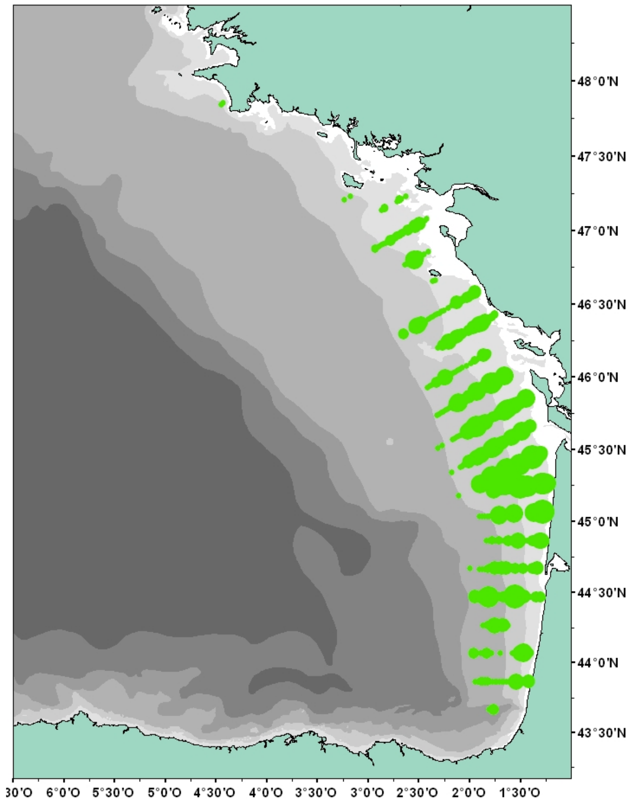


Figure 3.3.2.4. Adult anchovy distribution (density / ESDU)

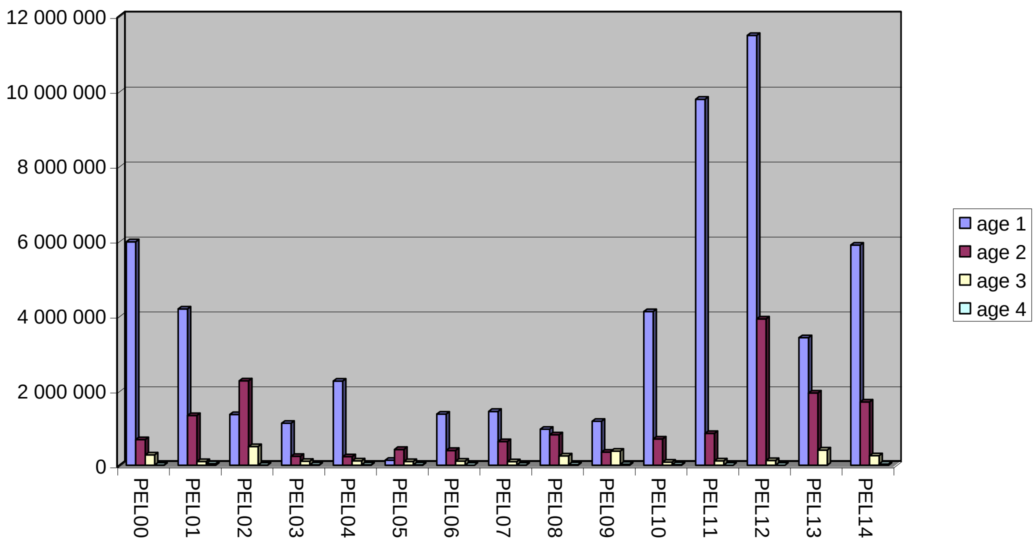


Figure 3.3.2.5. Age distribution of anchovy along PELGAS series.

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 age1 were as usual predominant in the Gironde area, but also dispersed on the platform, mixed with age 2.

3.3.3 Autumn juvenile acoustic survey 2013 (JUVENA 2013)

The JUVENA survey series (Boyra *et al.*, 2013), including the last survey in autumn 2013, was reported and discussed in WGACEGG (ICES, 2013 in November 2013) and an update of the estimates of this survey and the historical perspective was reported to this WG (Working Document Boyra and Martinez, 2014). Here below follow a summary of all this.

In year 2013 the survey was coordinated between AZTI and IEO. AZTI leaded the assessment studies of the JUVENA series and IEO leaded the ecological studies.The survey JUVENA 2013 took place between the 1st and 30th of September with two Vessels the RV Ramon Margalef (RM) of the IEO and the RV Enma Bardán (EM). For the 30 days of work a sampling cruise track of 2250 nautical miles was made which provided a coverage of about 32 500 nautical mile^2 along the continental shelf and shelf break of the Bay of Biscay, from the 7º10′ W in the Cantabrian area up to 47º 30′ N at the French coast (Figure 3.3.3.1). A total of 69 hauls were done during the survey to identify the species detected by the acoustic equipment, 47 of which were positive of anchovy. The survey was covered by both vessels in coordination, concentrating the sampling effort of each vessel in the most appropriate areas according to their efficiency: this is, oceanic and slope waters for the RM and continental shelf for the smaller pelagic trawler EB.

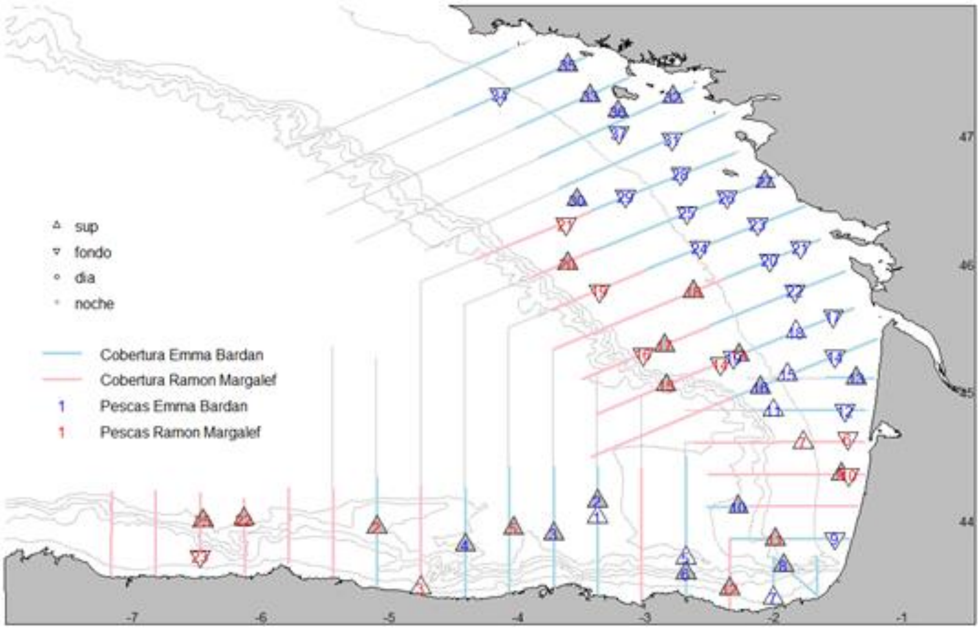


Figure 3.3.3.1 Bay of Biscay anchovy: JUVENA 2013 Coverage and fishing hauls by surveys: Position of the fishing stations (Triangles). Hauls performed by RV Emma Bardán (EB) are numbered in blue from 9001 to 9030 and the transects are marked with solid blue lines; hauls performed in the RV Ramón Margalef (RM) are numbered in red from 9201 to 9235 and the transects are marked with solid red lines.

This year, as usual, anchovy was found distributed along three different strata: a pure juvenile anchovy stratum, located at the outer part of the continental shelf and slope waters, and a mixed juvenile-adult stratum located at the inner part of the continental shelf and coastal waters and the Garonne (Figures 3.3.3.2, 3.3.3.3 and 3.3.3.4, Table 3.3.3.1).

- **Pure juvenile stratum**: In this stratum, anchovy was located in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy (Figures 3.3.3.2 and 3.3.3.4), mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill.
- **Mixed stratum**: Anchovy size in this stratum was bigger, between 11 and 15 cm, a mix of adult and juvenile (Figure 3.3.3.2), and was detected in schools close to the bottom, mixed also with larger proportions of other species, mainly small sardine in the most coastal area, and horse mackerel and blue whiting on the mid continental shelf. This year, the mixed stratum was located closer to the shore than usual.
- **Garonne:** Around the plume of the Gironde River, a positive area was found extending from the coast to about 50 m isobath. Here, anchovy included both adults and juveniles, and was found mixed with sardine, sprat, horse mackerel and other species, distributing along the whole water column. The hauls provided typical examples of the so called "beach anchovy" by the Spanish fishermen, that shows some morphologic differences with the rest. The sizes ranged from 8 to 13 cm (Figure 3.3.3.2).

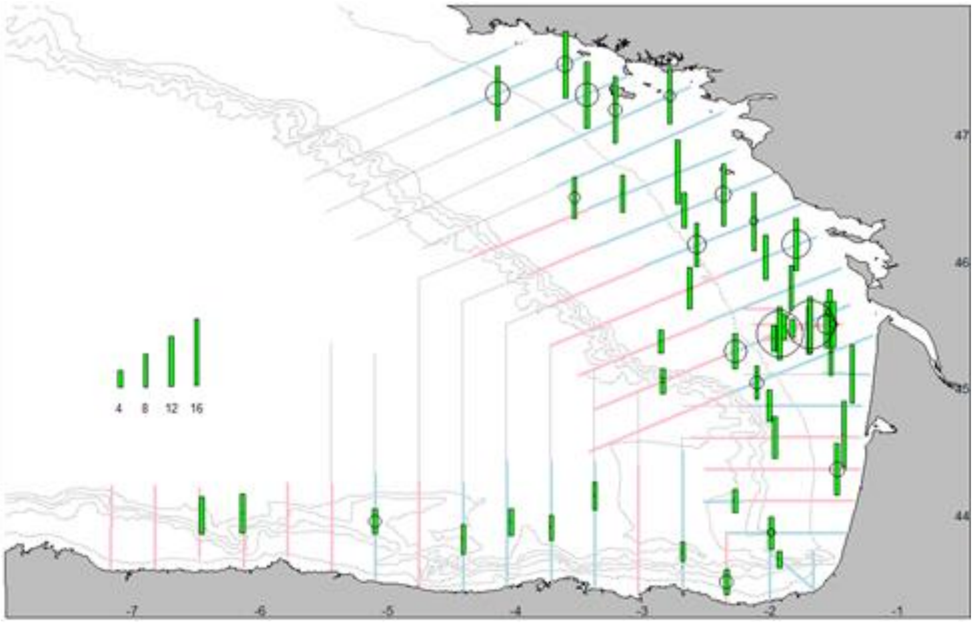


Figure 3.3.3.2 Bay of Biscay anchovy: The circles represent the positive anchovy hauls. The diameter of the circles is proportional to the captured weight of anchovy. The length of the bars is proportional to the mode of the size (standard length) of the captured anchovy.

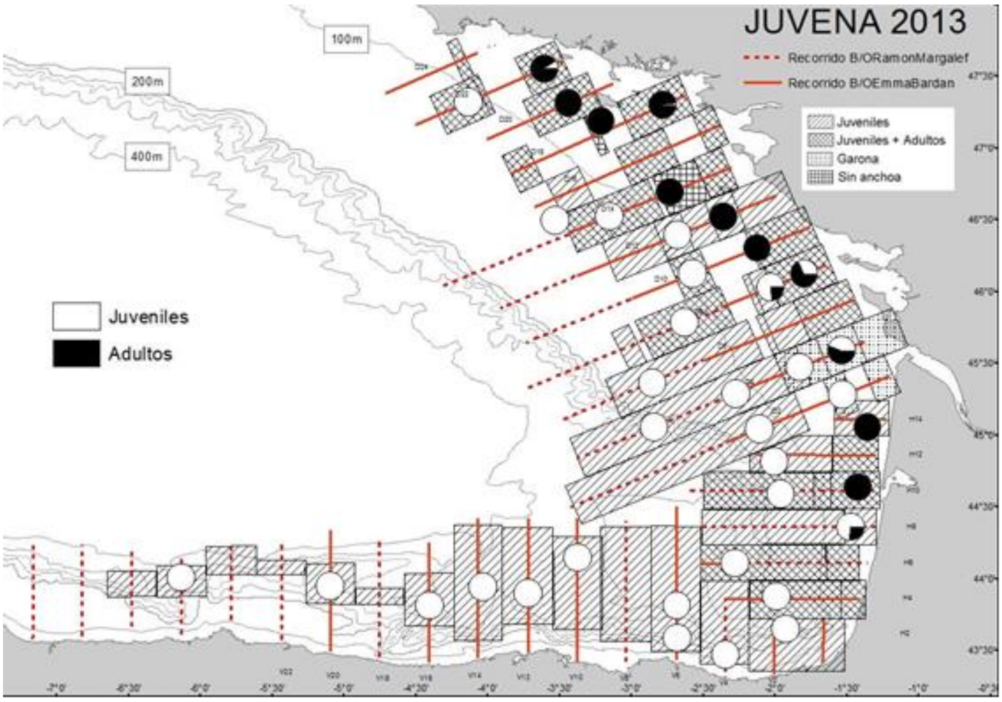


Figure 3.3.3.3 JUVENA 2013 results: positive area of distribution of anchovy and proportion of juveniles (white) and adults by fishing hauls (black) (pie charts).

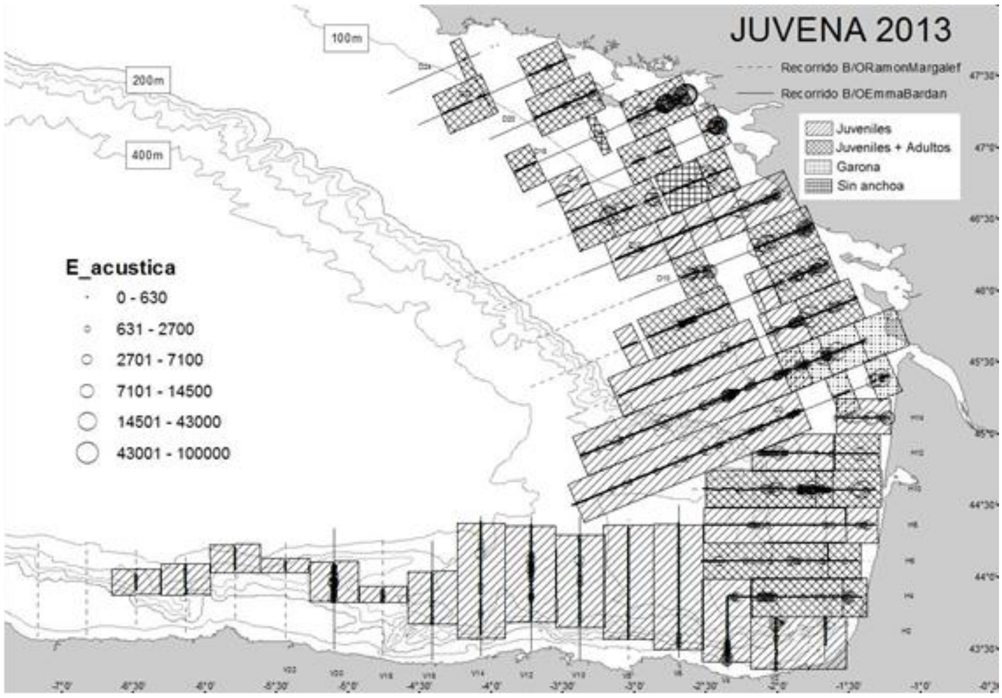


Figure 3.3.3.4 Bay of Biscay anchovy: Total acoustic energy (NASC) of all the identified species and the three subareas of the positive area for anchovy.

Table 3.3.3.1 Synthesis of the abundance estimation (acoustic index of biomass) for Juvena 2012 for each of the main strata

	NASC (m2/ n.m.2)	Area (n.m.2)	Mean length (cm)	Biomass (t)
Pure Juvenile	151	12 824	7.2	90 862.00
Shelf	678	4778	9.3	9284.63
Garonne	455	588	11.0	5124.79

The biomass of juveniles estimated for year 2013 is 105 300 tones (Table 3.3.3.2). This value is about 25% less than the average of the biomasses of the temporal series (Figure 3.3.3.5). The area of distribution of juvenile anchovy this year was considerably large (among the highest ones in the temporal series), but the densities were low. Almost the 85% of this biomass was located off-the-shelf or in the outer part of the shelf (Table 3.3.3.1) in surface waters (5-25 m).

Table 3.3.3.2 Synthesis of the abundance estimation (acoustic index of biomass) for the ten years of surveys.

Year	Sampled area (mn2)	Posit area (mn2)	Size juv (cm)	Biom Juvenile (year y)
2003	16 829	3476	7.9	98 601
2004	12 736	1907	10.6	2406
2005	25 176	7790	6.7	134 131
2006	27 125	7063	8.1	78 298
2007	23 116	5677	5.4	13 121
2008	23 325	6895	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	21 063	6.0	207 625
2012	31 724	14 271	6.4	142 083
2013	32 500	18 189	7.4	105 271

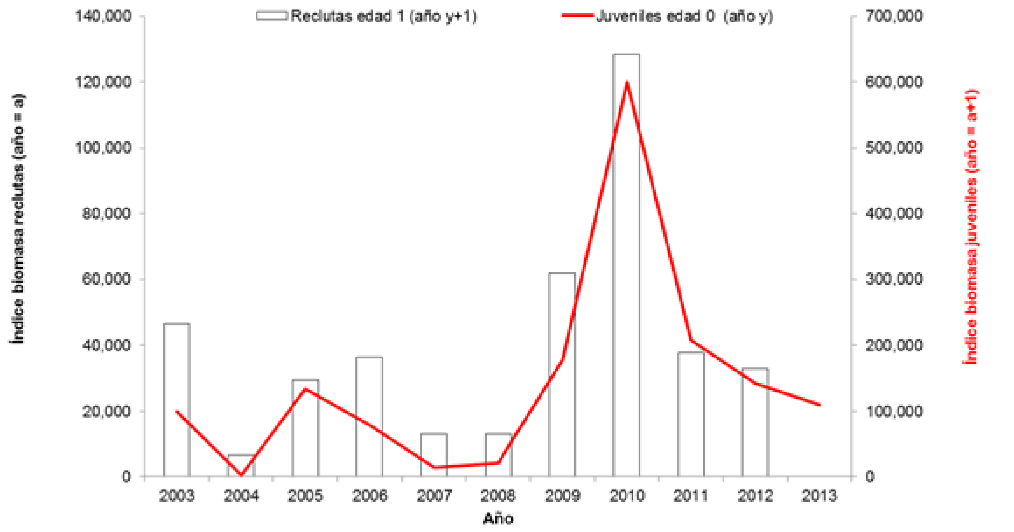


Figure 3.3.3.5 Temporal series of the estimated abundances of anchovy juveniles (blue) against the Bayesian Based Model synthetic estimated abundances of age 1 anchovy next spring (red), based on PELGAS and BIOMAN surveys plus the catches.

Due to an extremely close-to-surface distribution of juvenile anchovy in the oceanic area, part of the stock was outside the 38 kHz detection range (inside the nearfield). Therefore, in some oceanic transects, the abundance in the layer 5-10 m depth was calculated based on the 120 kHz frequency data. In these layers, the 120 kHz was echointegrated instead of the 38 kHz one. The use of the 120 kHz transducer, thanks to its shallow deployment and short nearfield range, allowed to echo-integrate from depths of 5 meters depth. With the aid of this transducer, it's not considered that a significant part of the stock was missed in the first layers. In absence of a consistent TS value for anchovy at 120 kHz, it was decided to convert 120 kHz echointegrals to biomass: For it, a 38/120 NASC conversion ratio was calculated over regions with common juveniles detections in both transducers; and this conversion ratio was applied to the 120 kHz data corresponding to the blind layer of the 38 Khz transducer. In this way the 38 kHz energy was re-scaled as to be comparable with the 38 kHz data. Then the TS of anchovy at 38 kHz was applied to all the echointegrals (38 kHz and re-scaled 120 kHz in the blind zone of the 38 Khz transducer) to obtain the biomass using the standard acoustic-trawl survey methodology. Given the extra processing step introduced with the conversion of the 120 Khz to 38 kHz energy, it must be taken into account that it will introduce some additional potential uncertainty in this year's estimate.

In the preliminary estimation of abundance of the survey, reported in November 2013 to ICES WGACEGG, a high biomass of adult anchovy in the North was estimated. A large part of this biomass was located in a few coastal strata of small size and high density. These strata were very shallow and with a combination of rough bottom and presence of commercial nets in the area. In these conditions, it was not possible to fish and the identification of the high acoustic energy found in these strata was uncertain. This acoustic energy was originally attributed to adult anchovy, based on the catches of the available nearby fishing operations. Other possible candidate species to attribute this biomass, based on the acoustic typology and the usual species composition in this area, were sardine and sprat.

In a revision of the preliminary abundance estimate, the acoustic energy from these poorly identifiable strata was removed, resulting in a reduction of the estimated biomass, especially of adult anchovy (from 180 000 to 78 000 t). The biomass of juvenile anchovy was also changed from 109 700 to 105 300 t.

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 checked and validated during WKPELA 2013 process (Figure 3.3.3.5). Among several candidate models the best relationship was achieved applying a log-linear regression model (i.e. a power relationship) (Figure 3.3.3.6). The model was significant (p-value=3.00e-05, with n=10) with R^2=0.89. As WKPELA decided to make use of this juvenile index as an input for the assessment of the age 1 in the population at the beginning of the year. The 2013 index pointed out towards a medium recruitment level for 2014 (Figure 3.3.3.6).

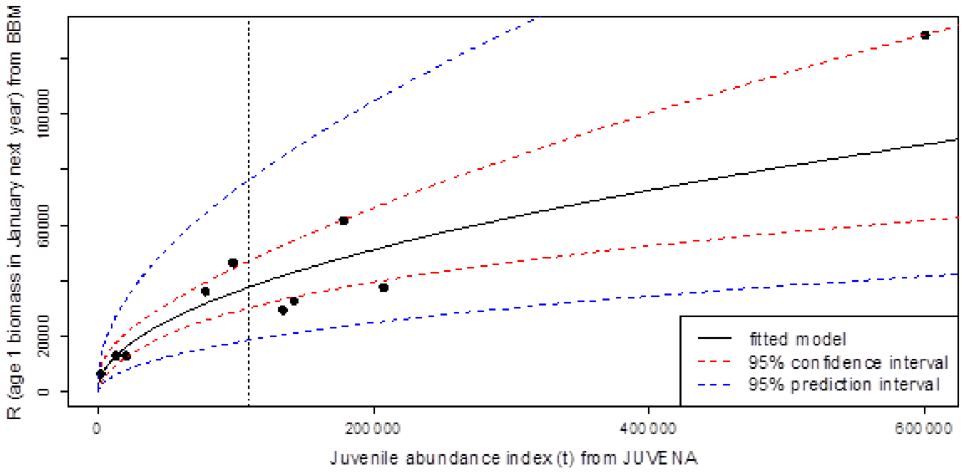


Figure 3.3.3.6 Bay of Biscay anchovy: Log linear model fitted to the recruitment (median of the age 1 biomass at the beginning of the next year, y-axis) as estimated by BBM (in past ICES assessment in 2013) and the juvenile abundance index from the JUVENA surveys (x-axis, in tonnes) plotted on natural scale. The discontinuous line shows the 95 % confidence interval of the linear regression and the discontinuous blue line shows the 95% confidence interval of each single prediction.

3.3.4 Exploratory comparison between spring indices

3.3.4.1 Comparison between PELGAS and BIOMAN spring surveys

A quick exploratory analysis comparing the indices obtained in the DEPM and acoustic surveys was led last year and presented in two working documents (Petitgas, P., Huret, M., Doray, M. Coherence between CUFES and Acoustic PELGAS survey indices, 2013 and Petitgas, P., Duhamel, E., M., Doray, M. Coherence between Egg (BIOMAN) and Acoustic (PELGAS), 2013).

2014 points (acoustic abundance index, P_{tot} from DEPM, P_{tot} from CUFES) were added to the serie to update this study. The first step was to compare the following indices: the total daily egg production (P_{tot}) from PELGAS (based on CUFES data following the method described in Petitgas *et al.*, 2009) *vs.* acoustic biomass from PELGAS (Figure 3.3.4.1), and the total daily egg production (P_{tot}) from BIOMAN(DEPM survey) vs. acoustic biomass from PELGAS (Figure 3.3.4.2). It should be noticed however that the series in terms of CUFES P_{tot} estimates can be inconsistent as in 2004 there was a change in the mesh size of the egg collector from 500 to 315 microns which has not been corrected.

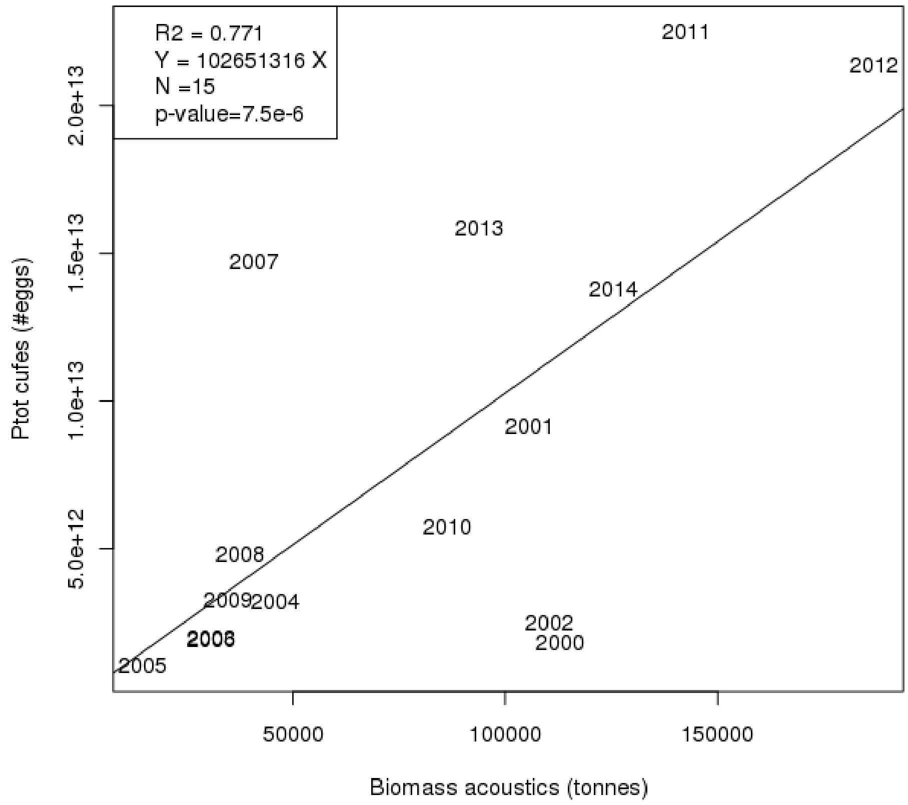


Figure 3.3.4.1 Relationship between total daily egg production Ptot as estimated from CUFES surveys and spawning biomass as estimated from acoustics. The regression line is forced to pass by the origin. Slope= DF= 102.6 eggs g^{-1}. R-squared= 0.771.

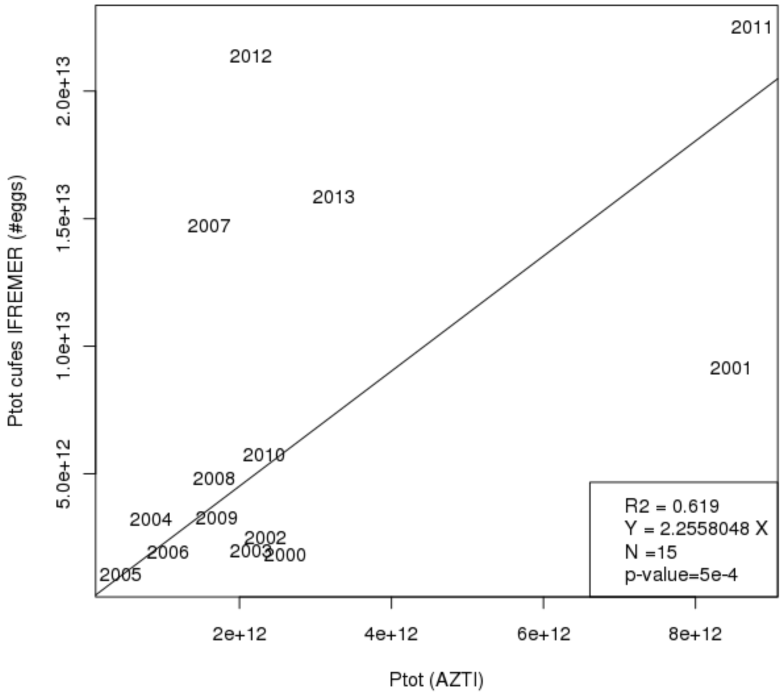


Figure 3.3.4.2. Relationship between total daily egg production Ptot as estimated from BIOMAN surveys and from PELGAS surveys. R-squared= 0.62

Assuming that the total daily egg production (P_{tot}) and the acoustic biomass (B) provide unbiased estimates, we can simply estimate the daily fecundity (DF: # eggs g-1 d-1) by the ratio P_{tot}/B. Note that here, DF is the egg production by gramme of stock (i.e. both females and males). This allows investigating the coherence between the egg and the acoustic survey indices of PELGAS.

Fig 3.3.4.1 shows the relationship between total daily egg production P_{tot} as estimated from CUFES data in PELGAS and acoustic biomass from PELGAS. The value of the slope was 102.6 eggs g-1 and the R-squared of the fitted model was equal to 0.77. The fitted regression model (forced to pass through the origin) is not sensitive to the addition of year 2014. The present analysis shows coherence between CUFES and acoustic. The CUFES index was presented in the last Benchmark Workshop on Pelagic Stocks (WKPELA ICES 2013). The benchmark workshop considered this as a promising approach. However the potential inclusion of this index into future assessments was postponed until the CUFES series is complete (two years were lacking), and until the series is verified and supported by WGACEGG as a reliable index of anchovy egg production. The CUFES series is now complete (two years were lacking in 2013) and the authors plan to propose the series as a reliable index of anchovy egg production to the next WGACEGG.

A similar analysis was done comparing P_{tot} from BIOMAN DEPM survey series of AZTI and P_{tot} from the PELGAS CUFES index of Ifremer (Fig 3.3.4.2). The 2014 P_{tot} AZTI estimate was not included. On average the P_{tot} of CUFES from PELGAS is about twice (slope = 2.25) the P_{tot} provided by BIOMAN which uses the standards for the Daily Egg Production estimates (both in terms of vertical egg sampling and estimating methods). Overall the R-squared is equal to 0.62, with some years showing high discrepancies, particularly 2001, 2007, 2012 and 2013. More investigation should be carried out to explain these discrepancies.

3.3.4.2 Comparison between autumn and spring surveys

There are 3 surveys targeting anchovy in the Bay of Biscay, at different period of the year and with different methodologies:

- See above a short discussion crossing the results of the two spring surveys. One of these surveys is BIOMAN, carried out in May, producing a biomass index based on the egg production (DEPM – Daily Egg Production method for anchovy). The other one is PELGAS, acoustic survey carried out at the same time (spring, between end of April and beginning of June), giving abundance indices for all small pelagics in an ecosystemic approach.
- An autumn acoustic survey, JUVENA, is carried out by AZTI in the Bay of Biscay to calculate and abundance index on juveniles to assess the strength of the incoming recruitment.

The correlation between JUVENA index and the amount of recruits the year after has been good (r=0.95 up to 2013 -n=10- see WGHANSA 2013 report, WGACEGG 2013 report, or WKPELA 2013 report).

But in 2013, a significant part of the juvenile anchovy was occupying layers close to the surface partly within the blind layer of the 38 kHz echosounder). Therefore, in some oceanic transects, the abundance in the layer 5-10 m depth was calculated based on the 120 kHz frequency data which had a shallower deployment and shorter near-field range than the 38 kHz, and as such allowed to echo-integrate from depths of 5 meters depth onwards. A 38/120 NASC conversion ratio was calculated over regions with common juveniles detections in both transducers; and this conversion ratio was applied to the 120 kHz data corresponding to the 5-10 m layer (blind to the 38 kHz transducer). Thanks to the aid of this 120 kHz transducer, the authors of the survey considered that the fraction of juveniles which might have been was missed in the first depth layers was minimized.

The trend of the estimates given by spring 2014 and autumn 2013 survey estimates of the incoming recruitment (age 1 in 2014) is opposite:

Both spring surveys estimated (with two different methods - acoustic and DEPM) a better recruitment in 2014 than in 2013 (see chapters 3.3.1. and 3.3.2.). In relative terms, both spring surveys observed about two times better recruitment in 2014 than in 2013.

JUVENA observed a slight decrease of this recruitment compared to the previous one, with a lower biomass of juveniles in 2013 than in 2012 (see chapter 3.3.3.).

Due to the corrections required for the use of the 120 kHz estimates in the most surficial layers (blind zone of the 38 kHz) the authors admitted that the uncertainty in this index is probably some higher than the previous ones. See last ACEGG 2013 report, ICES CM 2013/SSGESST:20, page 62 : "*However, given the extra processing step introduced with the 120 to 38 kHz scale conversion, it must be taken into account that it will introduce some additional potential uncertainty in this year's estimate*".

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 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 0.8 for age 1 and 1.2 for older individuals (age 2+).

In the CBBM assessment model the parameters G_1 and G_{2+} representing the annual intrinsic growth of the population by age class are assumed constant along years and are estimated based on the weight-at-age data from the surveys.

See stock annex - Bay of Biscay Anchovy (Subarea VIII) for further information.

3.5 State of the stock

3.5.1 Stock assessment

The assessment for this stock follows the stock annex approved in October 2013 (Annex A.5), once the discussion after the Benchmark Workshop on Pelagic Stocks (WKPELA; ICES, 2013) and WGHANSA (ICES, 2013) concluded with agreement.

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

- total biomass estimated by DEPM and acoustics surveys with their corresponding coefficients of variation (CV);
- proportion of the biomass at age 1 estimated by the DEPM and acoustic surveys;
- juvenile abundance index from JUVENA;
- total catch by semester;
- proportion (in mass) of the age 1 in the catch by semester;
- growth rates by age estimated from the weights at age of the stock.

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 a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. The largest discrepancy between the SSB estimates from the DEPM and acoustic surveys occurred in 2012. The 2012 acoustic biomass estimate is the largest of their historical series, whereas the 2012 DEPM biomass estimate decreased significantly with respect to 2011. Other discrepancies between DEPM and acoustic surveys (though of smaller magnitude) occurred in 1991, 2000 and 2002. In 2014 both surveys point to high SSB levels, with the acoustic survey providing a larger estimate. The agreement between both surveys is higher when estimating the relative age composition of the population. Figure 3.5.1.2 compares the historical series of the proportion of age 1 biomass of DEPM and acoustic surveys.

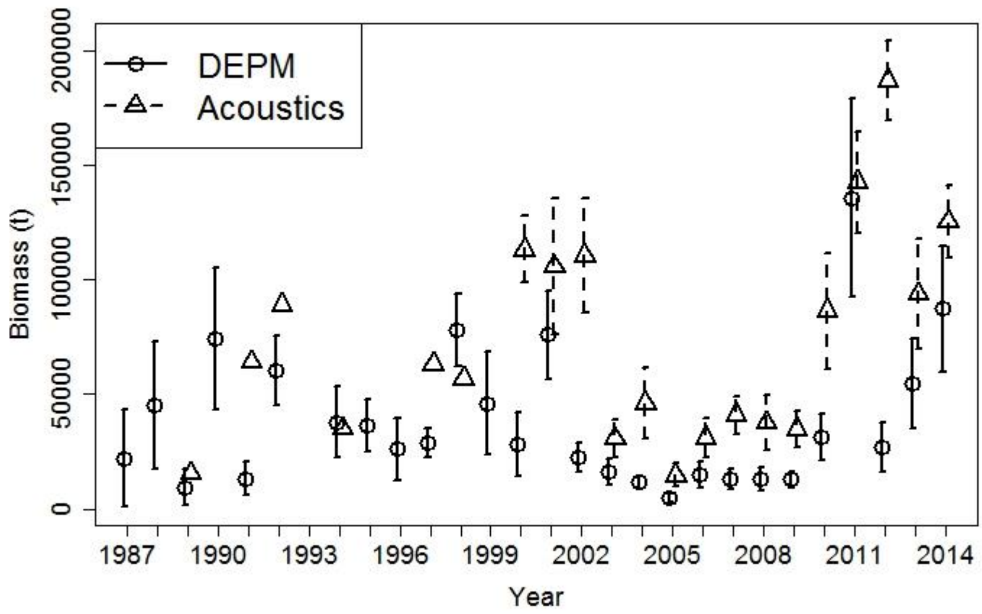


Figure 3.5.1.1 Bay of Biscay anchovy: Historical series of spawning-stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

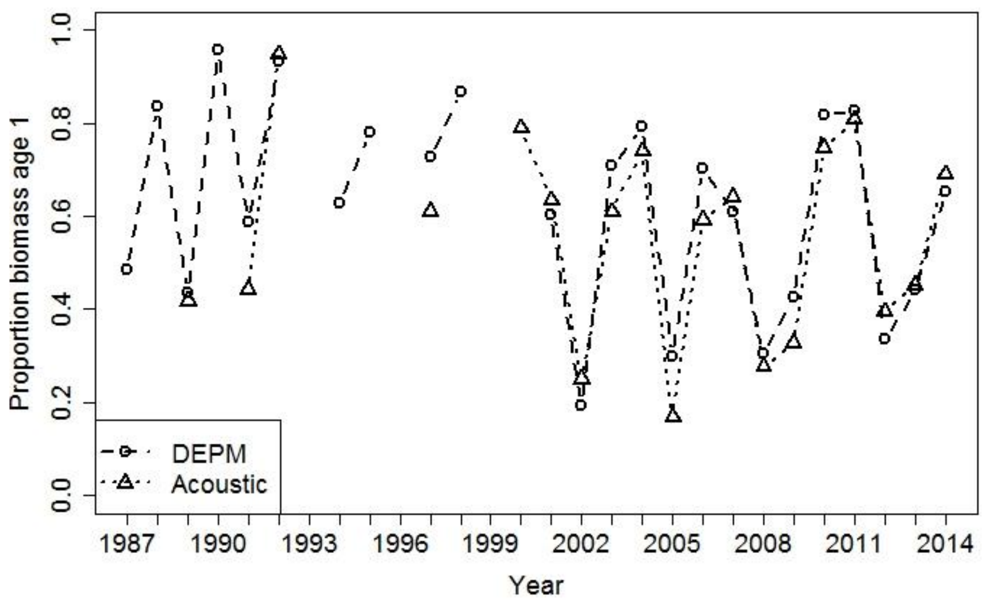


Figure 3.5.1.2 Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

The historical series of the juvenile abundance index from the autumn acoustic survey JUVENA is shown in Figure 3.5.1.3. The 2013 survey index points to a medium recruitment level for 2014, lower than the previous year.

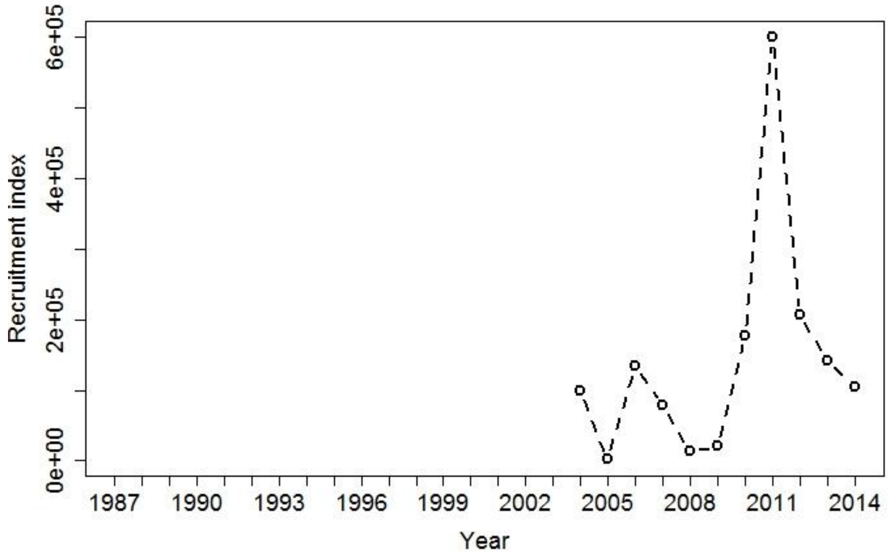


Figure 3.5.1.3 Bay of Biscay anchovy: Historical series of the juvenile abundance index from the autumn acoustic survey JUVENA that is related to recruitment (age 1) next year.

Figure 3.5.1.4 shows the historical series of total catches by semester. In general catches in the first semester are larger than in the second semester. The absence of catches from 2005 to 2009 corresponds to various consecutive fishery closures due to the low level of the population. The fishery was reopened in March 2010. In 2014 the provisional total catch in the first period was around 13 500t. Most of the catches correspond to age 1, especially during the second semester (Figure 3.5.1.5).

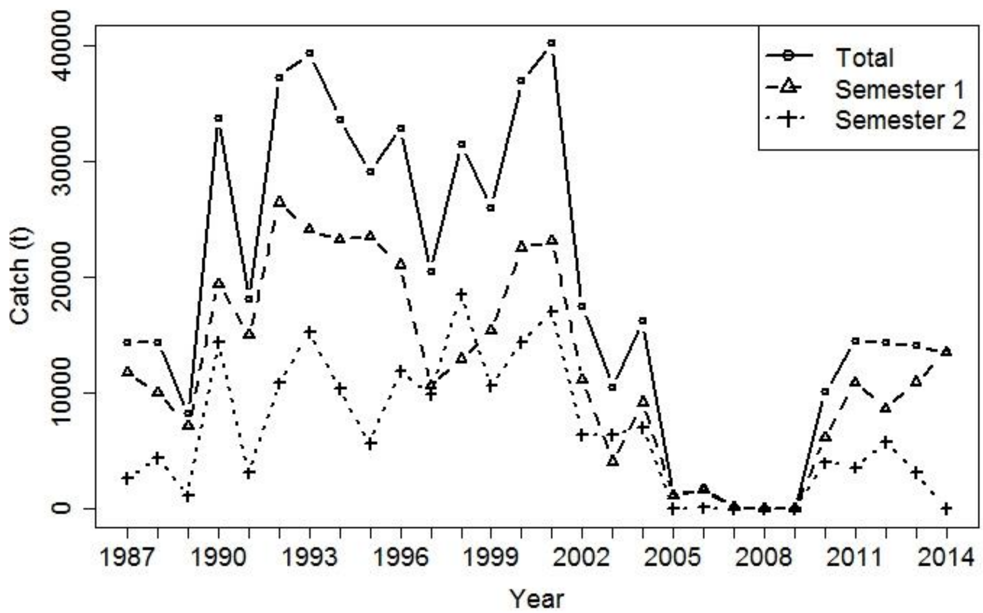


Figure 3.5.1.4 Bay of Biscay anchovy: Historical series of total catch (solid line) and catch by semesters (dashed and dotted lines for the first and second semester respectively). Note that the catch in 2014 is provisional.

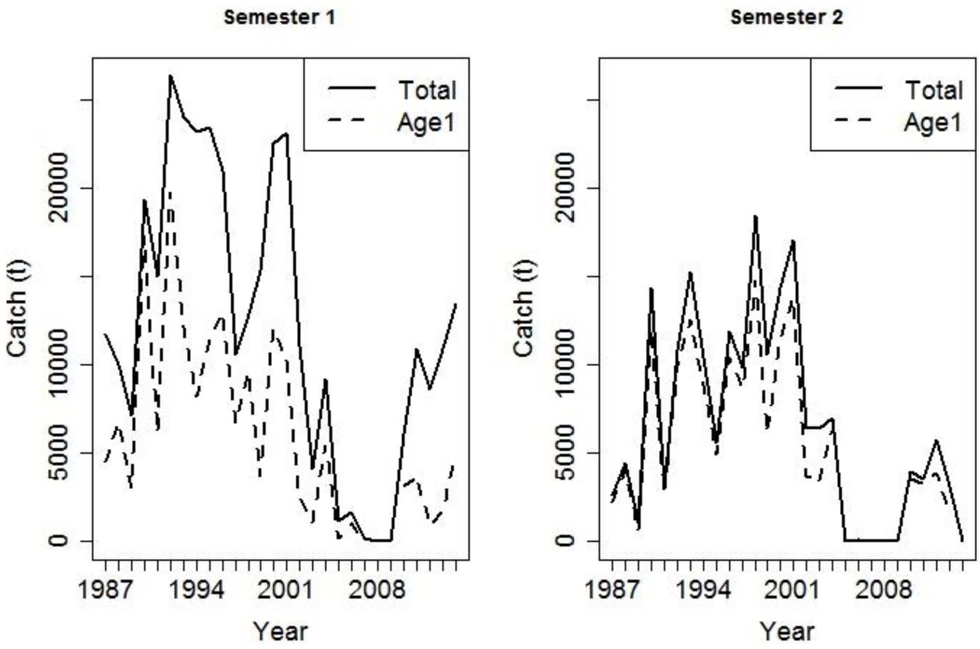


Figure 3.5.1.5 Bay of Biscay anchovy: Historical series of total (solid line) and age 1 (dashed line) catch (in tonnes). The left panel corresponds to the first semester and the right panel to the second semester. Note that the catch in 2014 is provisional.

Historical series of intrinsic growth rates by age (computed from the weights at age of the stock) suggest a larger growth at age 1 than at age 2+ (Figure 3.5.1.6).

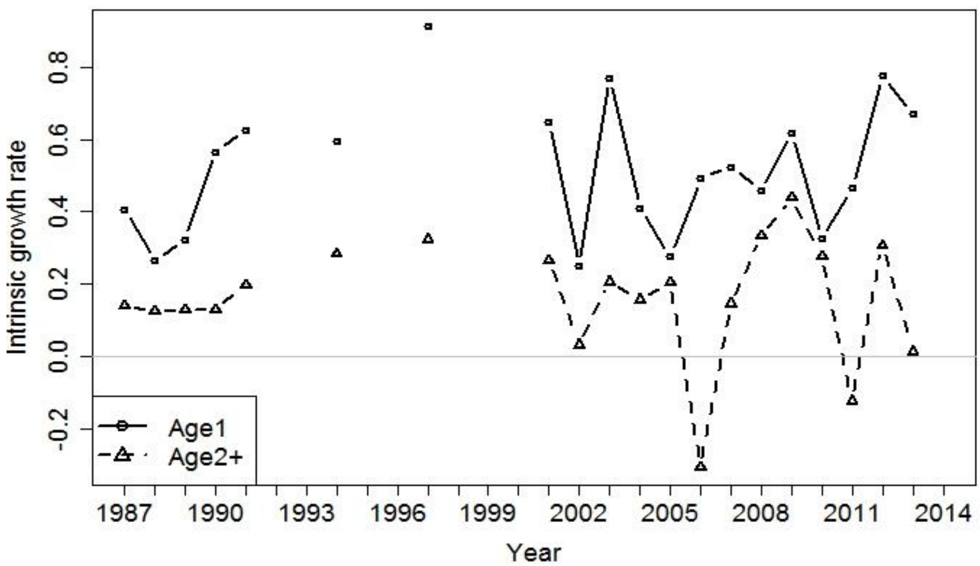


Figure 3.5.1.6 Bay of Biscay anchovy: Historical series of intrinsic growth rates by age as estimated from the mean weights at age of the stock.

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

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

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
	DEPM survey			Acoustic survey			Acoustic	Semester1		Semester2		G1	G2+
Year	**Age1**	**Total**	**cv**	**Age1**	**Total**	**cv**	**Age0 previous year**	**Age1**	**Total**	**Age1**	**Total**	**Age1**	**Age2+**
1987	10637	21943	0.480	NA	NA	NA	NA	4561	11719	2219	2666	0.405	0.141
1988	37813	45230	0.310	NA	NA	NA	NA	6739	10002	4018	4404	0.266	0.125
1989	4128	9477	0.410	6476	15500	NA	NA	3026	7153	643	1086	0.323	0.129
1990	71142	74371	0.208	NA	NA	NA	NA	17337	19386	12080	14347	0.566	0.130
1991	7821	13295	0.271	28322	64000	NA	NA	6150	15025	2743	3087	0.626	0.198
1992	56202	60332	0.125	84439	89000	NA	NA	19737	26381	9939	10829	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	12152	24058	12589	15255	NA	NA
1994	23739	37777	0.204	NA	35000	NA	NA	8236	23214	8849	10408	0.594	0.283
1995	28416	36432	0.159	NA	NA	NA	NA	11600	23479	4961	5629	NA	NA
1996	NA	26148	0.260	NA	NA	NA	NA	13007	21024	10397	11864	NA	NA
1997	21098	29022	0.110	38498	63000	NA	NA	6730	10600	8675	9852	0.911	0.324
1998	68015	78277	0.101	NA	57000	NA	NA	9620	12918	14811	18481	NA	NA
1999	NA	45932	0.244	NA	NA	NA	NA	3681	15381	6136	10617	NA	NA
2000	NA	28321	0.245	89363	113120	0.064	NA	12036	22536	11463	14354	NA	NA
2001	45779	75826	0.126	67110	105801	0.141	NA	10379	23095	13828	17043	0.649	0.266
2002	4330	22462	0.147	27642	110566	0.113	NA	2585	11089	3720	6405	0.249	0.032
2003	11401	16109	0.173	18687	30632	0.132	NA	1055	4074	3376	6405	0.769	0.206
2004	9121	11496	0.117	33995	45965	0.167	98601	5467	9183	6285	7004	0.410	0.157
2005	1441	4832	0.202	2467	14643	0.171	2406	146	1127	0	0	0.277	0.205
2006	10451	14872	0.191	18282	30877	0.136	134131	982	1659	69	95	0.493	-0.307

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
	DEPM survey			**Acoustic survey**			**Acoustic**	**Semester1**		**Semester2**		**G1**	**G2+**
Year	**Age1**	**Total**	**cv**	**Age1**	**Total**	**cv**	**Age0 previous year**	**Age1**	**Total**	**Age1**	**Total**	**Age1**	**Age2+**
2007	7946	13060	0.178	26230	40876	0.1	78298	42	140	0	0	0.524	0.146
2008	3940	12898	0.200	10400	37574	0.162	13121	0	0	0	0	0.458	0.333
2009	5460	12832	0.140	11429	34855	0.112	20879	0	0	0	0	0.618	0.439
2010	25543	31277	0.159	64564	86355	0.147	178028	3099	6111	3544	3971	0.325	0.276
2011	112202	135732	0.160	115379	142601	0.077	599990	3701	10913	3256	3576	0.465	-0.123
2012	8936	26663	0.202	73843	186865	0.046	207625	948	8600	3869	5753	0.777	0.307
2013	24090	54686	0.179	42508	93854	0.128	142083	1759	10928	1722	3144	0.670	0.013
2014	56873	87225	0.157	86670	125427	0.063	105271	4941	13459	0	0	NA	NA

Figure 3.5.1.7 compares prior and posterior distribution of some of the parameters estimated. Summary statistics (median and 90% probability intervals) of the posterior distributions of the parameters estimated are given in Table 3.5.1.2 and Table 3.5.1.3. Recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15thMay) and fishing mortality by semester are shown in Figure 3.5.1.8. The largest probability intervals correspond to the period in which some data are missing or the observations give contradictory information. In general recruitment is highly variable from year-to-year. Recruitment in 2014 is slightly higher than in 2013, whereas the median SSB is at similar level than in last year. The fishing mortality during the first semester in 2014 has increased in the last two years, while the fishing mortality during the second semester in 2013 is lower than in 2012. Overall, the harvest rates are smaller after the fishery reopening in 2010 than the levels observed before in 2005.

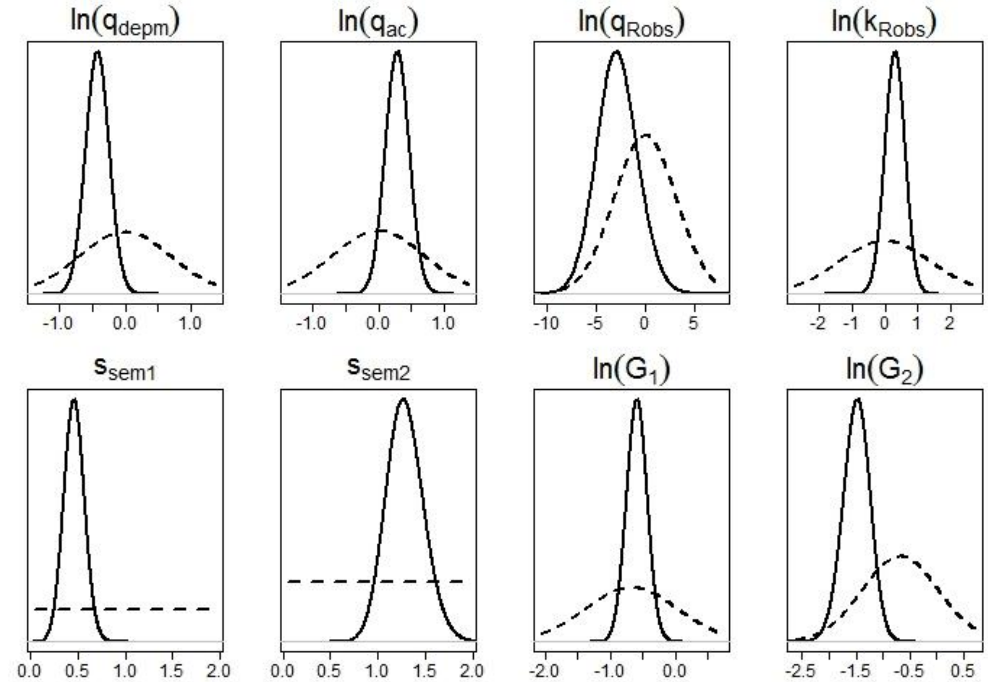


Figure 3.5.1.7 Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of CBBM.

Table 3.5.1.2 Bay of Biscay anchovy: Median and 90% probability intervals for some of the parameters estimated in the CBBM.

	5.00%	Median	95.00%
qdepm	0.5435	0.6580	0.7973
qac	1.1011	1.3445	1.6337
qrobs	0.0028	0.0561	1.4622
krobs	1.0683	1.3914	1.6853
psidepm	3.4660	6.4965	12.4572
psiac	4.1399	8.1377	15.5327
psirobs	1.3729	3.5048	8.4151
xidepm	3.3886	4.2132	5.2236
xiac	2.8784	3.5729	4.2420
xicatch	2.4106	2.8042	3.1886
B0	16983	21901	27640
mur	10.0662	10.3694	10.6789
psir	0.7549	1.1975	1.8037
sage1sem1	0.3904	0.4651	0.5559
sage1sem2	1.0182	1.2792	1.5904
G1	0.4876	0.5563	0.6276
G2	0.1628	0.2286	0.3009
psig	17.7643	26.8058	38.4098

Table 3.5.1.3 Bay of Biscay anchovy: Median and 90% probability intervals for recruitment, spawning-stock biomass, fishing mortalities by semester and harvest rates (Catch/SSB) as resulted from CBBM.

	R (tonnes)			SSB (tonnes)			fsem1			fsem2			Harvest rate		
Year	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**
1987	11869	15591	20992	16408	21254	27759	0.926	1.216	1.548	0.224	0.318	0.448	0.224	0.318	0.448
1988	26246	31259	38259	24171	29354	36583	0.794	1.027	1.289	0.242	0.328	0.444	0.242	0.328	0.444
1989	6467	8978	12673	11237	15644	21935	0.697	0.953	1.290	0.118	0.174	0.260	0.118	0.174	0.260
1990	59483	68106	79549	46496	54107	64456	0.978	1.227	1.515	0.452	0.607	0.813	0.452	0.607	0.813
1991	17405	22852	30154	22495	30183	40039	0.861	1.136	1.480	0.175	0.248	0.362	0.175	0.248	0.362
1992	72826	90705	115802	58198	75688	99541	0.857	1.154	1.531	0.206	0.302	0.442	0.206	0.302	0.442
1993	50438	63904	79198	63245	75028	89491	0.664	0.838	1.045	0.371	0.490	0.653	0.371	0.490	0.653
1994	33946	41828	51591	40136	49202	60615	0.908	1.142	1.420	0.395	0.536	0.741	0.395	0.536	0.741
1995	35374	46402	60728	30746	42515	57585	1.090	1.491	2.025	0.200	0.304	0.475	0.200	0.304	0.475
1996	40709	50411	62345	39896	48241	59492	0.929	1.211	1.559	0.431	0.599	0.819	0.431	0.599	0.819
1997	31672	40511	52730	36040	46412	60717	0.478	0.638	0.834	0.345	0.497	0.721	0.345	0.497	0.721
1998	74860	97156	126285	74745	96887	125651	0.328	0.438	0.587	0.276	0.401	0.596	0.276	0.401	0.596
1999	28997	43049	61485	54233	70519	91100	0.383	0.511	0.680	0.265	0.370	0.522	0.265	0.370	0.522
2000	75332	91600	110908	78906	94621	112755	0.569	0.708	0.881	0.249	0.328	0.437	0.249	0.328	0.437
2001	61999	73513	88136	79669	91472	106448	0.545	0.658	0.786	0.342	0.440	0.558	0.342	0.440	0.558
2002	8805	12479	18136	31804	38818	47953	0.444	0.549	0.672	0.361	0.475	0.622	0.361	0.475	0.622
2003	15665	19715	24470	22641	27537	33744	0.301	0.384	0.482	0.430	0.570	0.761	0.430	0.570	0.761
2004	24734	30429	37867	24820	30877	39072	0.661	0.865	1.099	0.377	0.527	0.737	0.377	0.527	0.737
2005	2719	4086	5937	10567	14488	19595	0.113	0.157	0.219	0.000	0.000	0.000	0.000	0.000	0.000
2006	13235	18049	24788	16232	21579	28691	0.169	0.229	0.309	0.006	0.009	0.012	0.006	0.009	0.012

	R (tonnes)			SSB (tonnes)			fsem1			fsem2			Harvest rate		
Year	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**	**5.00%**	**Median**	**95.00%**
2007	16775	22545	30544	24637	31993	41620	0.009	0.012	0.016	0.000	0.000	0.000	0.000	0.000	0.000
2008	6599	9205	12946	19634	25111	32200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	7475	10216	14336	16380	20752	26531	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2010	36935	47374	62193	38421	48980	63226	0.308	0.404	0.521	0.114	0.161	0.226	0.114	0.161	0.226
2011	86651	110008	139766	93217	116770	146590	0.232	0.301	0.388	0.044	0.059	0.081	0.044	0.059	0.081
2012	32328	42433	56614	76088	94405	118261	0.159	0.202	0.255	0.110	0.145	0.189	0.110	0.145	0.189
2013	25530	34198	45906	49171	63477	82018	0.301	0.391	0.502	0.085	0.115	0.158	0.085	0.115	0.158
2014	36806	52344	75508	46981	66158	92833	0.393	0.541	0.754	NA	NA	NA	NA	NA	NA

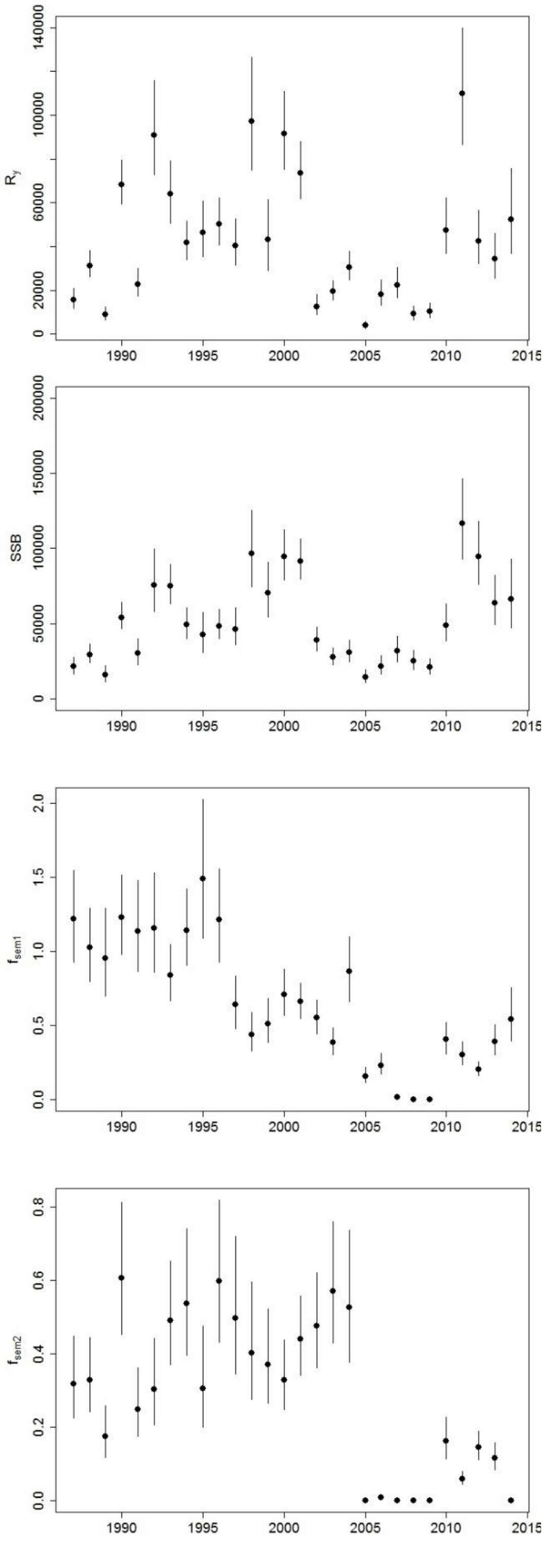


Figure 3.5.1.8 Bay of Biscay anchovy: Posterior median (bullet points) and 90% probability intervals (solid lines) for the recruitment (age 1 in mass in January), the spawning-stock biomass and the fishing mortality for the first and second semesters from the CBBM.

Figure 3.5.1.9 shows the posterior distribution of spawning-stock biomass in 2014. The estimated level of biomass in 2014 is 66 158 tonnes and the 90% probability interval is 46 981 and 92 833 tonnes. The biological risk, defined as the probability of SSB in 2014 being below B_{lim} (21 000 tonnes), is 0.

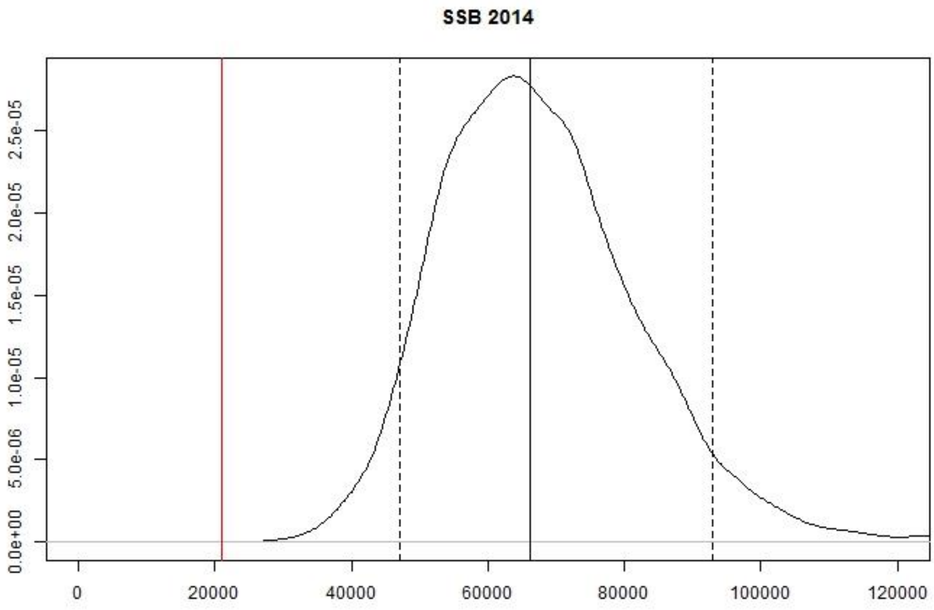


Figure 3.5.1.9 Bay of Biscay anchovy: Posterior distribution of spawning biomass in 2014 from CBBM. Vertical black solid and dashed lines correspond to posterior median and 90% probability intervals respectively. The vertical red solid line is B_{lim} (21 000t).

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 (CBBM) 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. 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.

Figure 3.5.2.1 shows Pearson residuals for the survey and catch, the data used in the observation equations. In most of the cases the residuals are within-2 and 2, showing no major discrepancies between the observed and modelled quantities.

This year the biomass indices from DEPM and acoustics point out to an increase of 60% and 34% with respect to 2013 indices and the age 1 biomass proportion estimated from both surveys suggest a good recruitment (high age 1 biomass proportion). However the juvenile abundance index from JUVENA indicated recruitment in 2014 being 26% lower than in 2013. See also section 3.3.4 on cross-discussion of the surveys result. From the assessment results, recruitment in 2014 is 53% higher than in 2013 and biomass is 4% higher than in 2013. Therefore, the JUVENA index has a negative residual and the final assessed biomass is below the biomass estimated in the DEPM and acoustics surveys (i.e. they have positive residuals). Overall, the Pearson residuals for all the observations used in the assessment (Figure 3.5.2.1) show that the model estimate for this year is a compromise between all surveys inputs and catch estimates and all along the time-series.

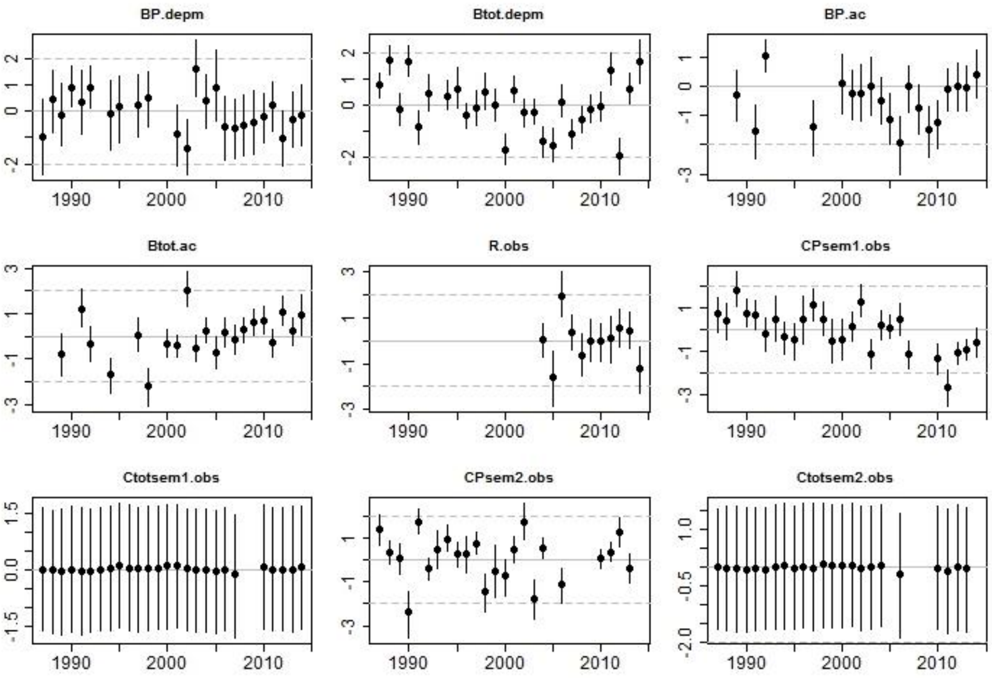


Figure 3.5.2.1 Bay of Biscay anchovy: Pearson residual medians and 90% probability intervals to the survey and catch observations used in the CBBM.

In order to test the sensitivity of the assessment to the apparently discrepant recruitment signal from spring (DEPM and acoustics) and autumn (juvenile acoustic) surveys in the last year, the assessment was re-run omitting the 2013 juvenile abundance index from JUVENA. Figure 3.5.2.2 shows the recruitment and the SSB when omitting the 2013 juvenile abundance index compared with the updated assessment run this year. Without the 2013 juvenile abundance index the recruitment and the SSB increase about 8000 t in 2014. The recruitment and biomass for the rest years are almost the same and other parameters do not change by the inclusion or not of this point. Therefore, the WG considers that the main reason for assessment model results to indicate an increase in the spawning biomass in 2014 lower than the one observed in spring surveys compared to 2013 is due not only to the latest JUVENA index but also for additional information provided by the catches and the age structure of the surveys and catches all along the time-series.

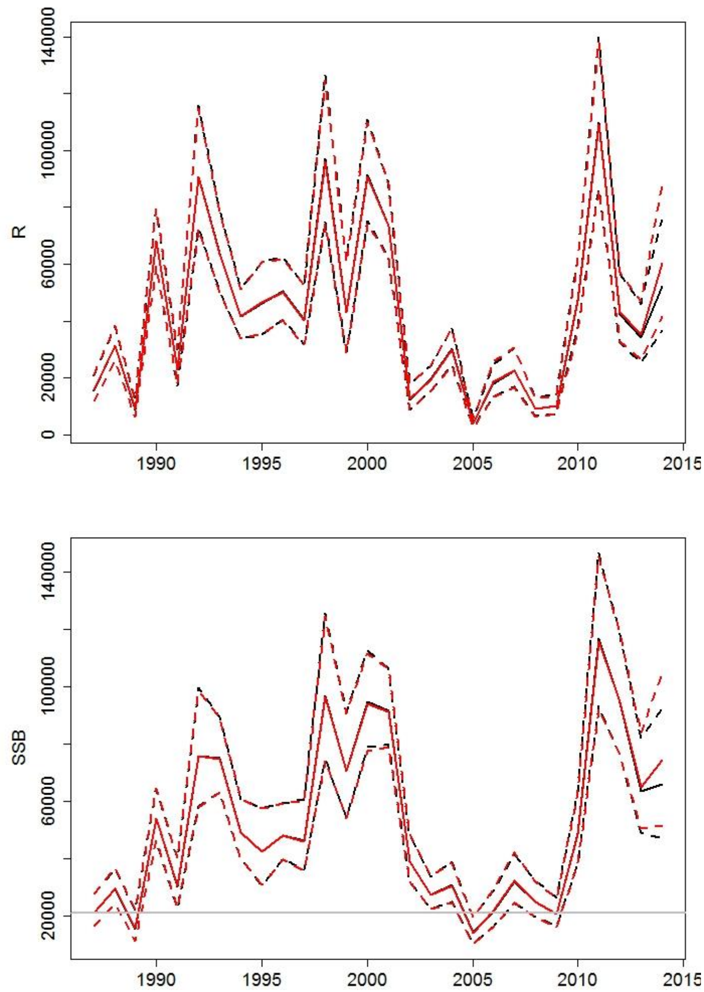


Figure 3.5.2.2 Bay of Biscay anchovy: Comparison between recruitment (top panel) and SSB (bottom panel) for the updated assessment (in black) and the assessment without 2013 juvenile abundance index (in red). Solid and lines represent the medians and the 90% probability intervals respectively.

The residuals of the age 1 proportion (in mass) in the catch of the first semester are negative since 2010 (fishery reopening). This might be due to a change of the selection at age 1 during the first semester, which is assumed to be constant along the time-series in the assessment model. In order to further explore this option the model was adapted to incorporate a change in the selectivity at age 1 parameter during the first semester. Table 3.5.2.1 show the median and 90% probability intervals of the parameters estimated. The selectivity at age 1 during the first semester until 2009 is two times larger than after the fishery reopening (0.53 and 0.24 respectively), whereas the selectivity at age 1 during the first semester is 0.46 when it is assumed constant along the time-series. The recruitment and SSB estimates are almost the same all along the time-series except in the last year in which having a change in selectivity at age 1 during the first semester results in slightly higher recruitment and SSB estimates (Figure 3.5.2.3). The pattern of fishing mortality during the first semester changes, giving lower values before 2010 and higher values after that year with respect to the constant selectivity assumption case (Figure 3.5.1.2). Other parameters, like the surveys catchabilities or the age 1 selectivity during the second semester, also change slightly depending on the selectivity change assumption (Table 3.5.2.1 compared with Table 3.5.1.2). The Pearson residuals for the selectivity change case are given in

Figure 3.5.2.4. Although the residuals for the age 1 proportion in the catch during the first semester improve, pattern of residualsfor other observations are also modified. Given that the number of years since the fishery reopening is low, it is difficult to ascertain whether this change in selectivity is real or not and it should be further investigated in future years.

Table 3.5.2.1 Bay of Biscay anchovy: Median and 90% probability intervals for some of the parameters estimated in the CBBM when the selectivity at age 1 of the first semester is separated in two periods (before and after 2010).

	5.00%	Median	95.00%
qdepm	0.5317	0.6451	0.7799
qac	1.0781	1.3096	1.5910
qrobs	0.0028	0.0588	1.4297
krobs	1.0680	1.3842	1.6805
psidepm	3.4964	6.5938	12.8284
psiac	4.4449	8.5171	16.2920
psirobs	1.2740	3.2932	8.2297
xidepm	3.1329	3.8647	4.7036
xiac	2.7415	3.4271	4.1152
xicatch	2.6802	3.1400	3.6028
B0	15752	20704	26652
mur	10.0803	10.3970	10.6999
psir	0.7609	1.2197	1.8262
sage1sem1per1	0.4482	0.5305	0.6320
sage1sem1per2	0.1704	0.2469	0.3614
sage1sem2	1.0876	1.3334	1.6265
G1	0.4884	0.5548	0.6265
G2	0.1593	0.2247	0.2957
psig	17.8309	27.0350	38.7394

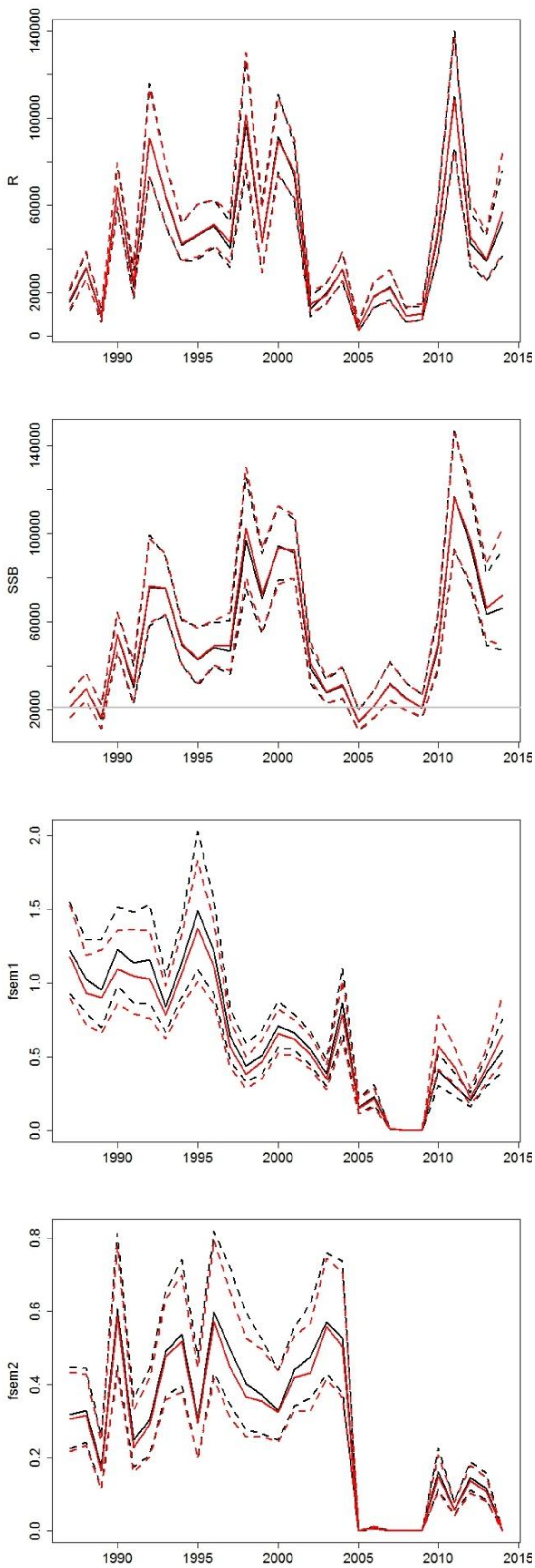


Figure 3.5.2.3 Bay of Biscay anchovy: From top to bottom comparison between recruitment, SSB and fishing mortality by semester for the updated assessment (in black) and the assessment with a change in the selectivity at age 1 in the first semester after the fishery reopening (in red). Solid and lines represent the medians and the 90% probability intervals respectively.

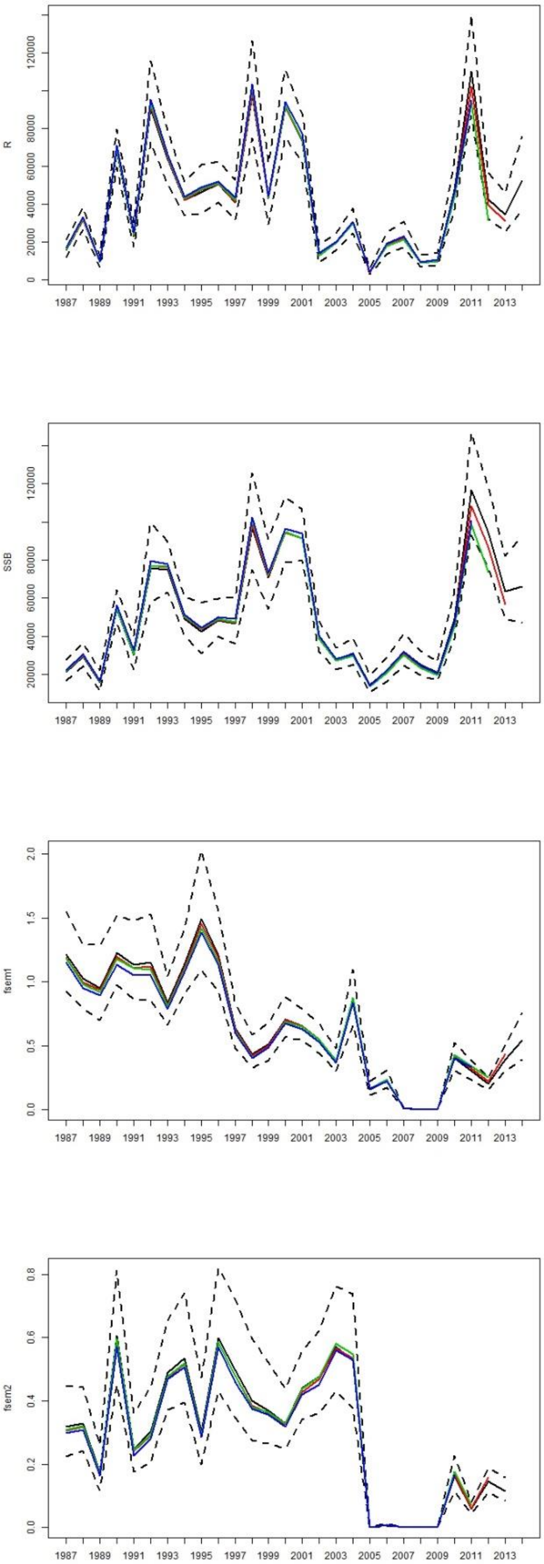


Figure 3.5.2.4 Bay of Biscay anchovy: From top to bottom retrospective analyse for recruitment, SSB and fishing mortality by semester. Solid lines represent the medians, each colour corresponding to the result of removing one year at a time. The black solid and dashed lines are the median and 90% probability intervals of this year's assessment respectively.

The DEPM estimates provided in June are preliminary, given that the spawning frequency is the only adult parameter not estimated yet (see section 3.3.1 and WD Santos *et al*., 2014 in Annex 3.2). The final estimates will be made available to WGACEGG in November. In addition the catch data for 2014 are also preliminary. As a result the stock assessment has to be considered also as preliminary.

The assessment scale is given by the survey catchability estimates. 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.

A retrospective analysis of the current assessment is shown in Figure 3.5.2.4. The results are almost identical, with a small revision upwards of the final recruitment and SSB estimates in the last three years. The retrospective median values are always within the 90% of the probability intervals of the latest assessment.

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. 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 38 850 t, is shown in Figure 3.6.1.1.

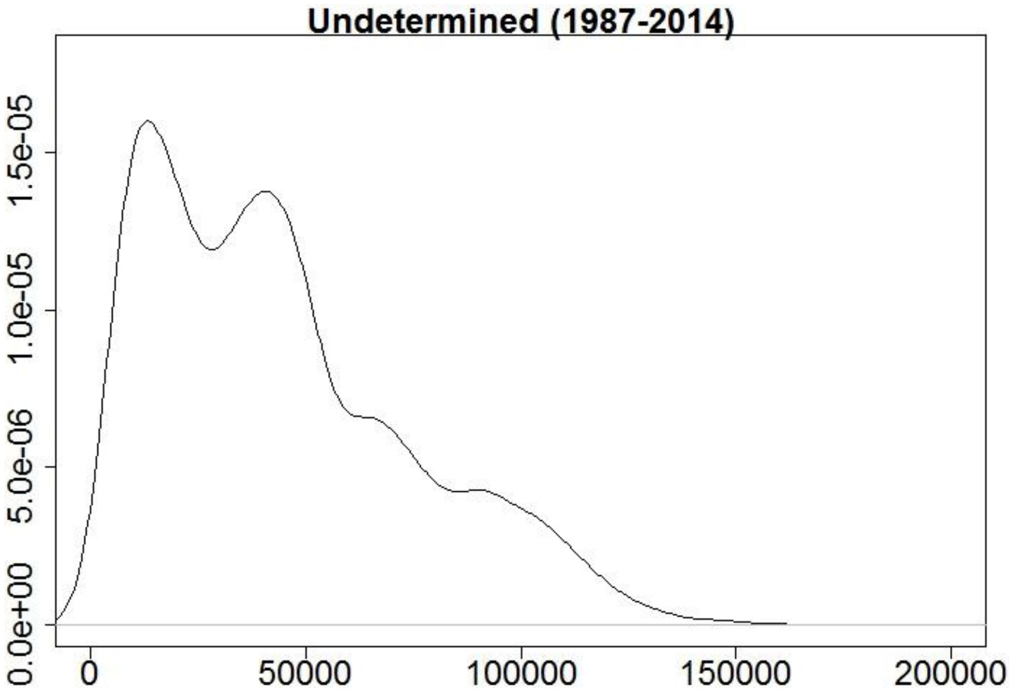


Figure 3.6.1.1 Bay of Biscay anchovy: Undetermined recruitment (age 1 mass in January) scenario for 2015.

3.6.2 Method

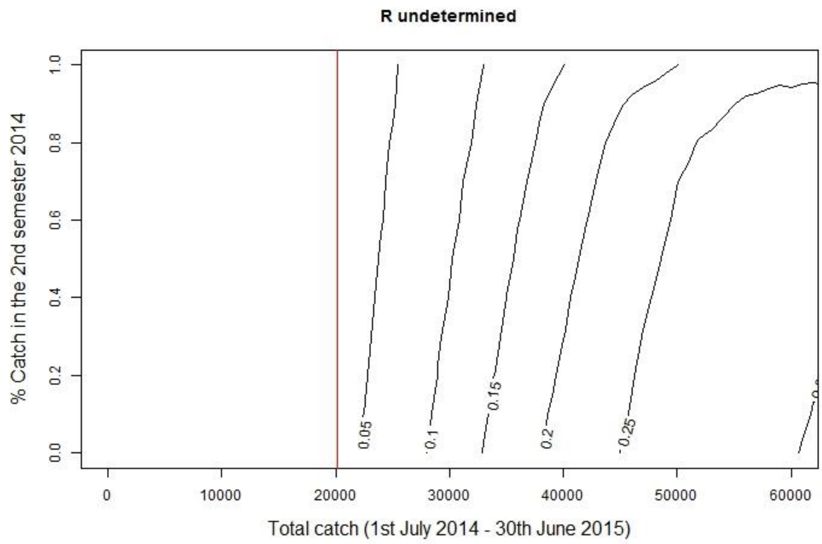
The method for predicting the population is based on the assessment model and it is described in detail in the stock annex that was approved in October 2013 (Annex A.5).

3.6.3 Results

Starting from the posterior distribution of SSB in 2014 the population was projected one year forward under the undetermined recruitment scenario. Uncertainty in the assessment was further propagated in the projection by using the posterior distributions of selectivity at age 1 by semester and the intrinsic growth rates at age.

Total allowable catch between 1^{st}July 2014 and 30^{th}June 2015 were explored from 0 (fishery closure) to 65 000 tonnes with a step of 1000 tonnes. In addition, the effect of the percentage of those total allowable catches corresponding to the second half of 2014 was also studied by considering percentages from 0 to 100% with a step of 5%. Probability distributions of SSB in 2015 were derived for each of the catch options and for the percentages of catch corresponding to the second half of 2014.

The probability of SSB in 2015 being below B_{lim} and the median SSB in 2015 are given in Figure 3.6.3.1 (upper panel) and Table 3.6.3.1. The probability of SSB being below B_{lim} is above 0.05 for catches around 23 000t. The probability of falling below B_{lim} is almost insensitive to the allocation into semesters, but it increases slightly for lower percentages of the TAC taken in the second semester. The corresponding predicted median SSB values in 2014 are shown in Figure 3.6.3.1 (lower panel) and 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 2014 to 30 June 2015 should be established at 20 100 t. The corresponding probability of SSB in 2014 being below B_{lim} under different allocation into semesters is around 0.3.



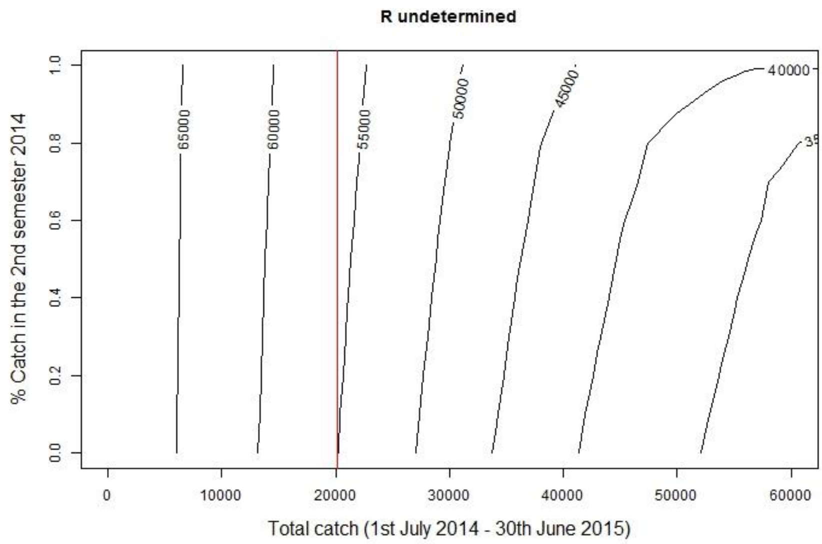


Figure 3.6.3.1 Bay of Biscay anchovy: From top to bottom contour plots of probability of SSB in 2015 of falling below B_{lim} and median SSB in 2015 depending on the total catch from 1st July 2014 to 30th June 2015 (x-axis) and the percentage of catch corresponding to the second half of 2014 (y-axis) under the undetermined recruitment scenario. The vertical red line represents the TAC that would correspond according to the LTMP proposal (20 100 t).

Table 3.6.3.1 Bay of Biscay anchovy: Probability of SSB in 2015 of being below Blim under the undetermined recruitment scenario under different catch options from 1st July 2014 to 30th June 2015 and alternative catch allocation by semesters.

P(SSB<Blim)		% CATCHES IN THE 2nd SEMESTER 2014										
		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 2014 - June 2015)**											
	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	5000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	10 000	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	15 000	0.013	0.012	0.012	0.011	0.011	0.011	0.011	0.010	0.010	0.010	0.009
	20 000	0.035	0.034	0.031	0.029	0.028	0.027	0.026	0.025	0.025	0.024	0.023
	25 000	0.071	0.069	0.064	0.061	0.060	0.058	0.057	0.055	0.052	0.048	0.046
	30 000	0.118	0.115	0.110	0.105	0.101	0.098	0.094	0.090	0.085	0.081	0.077
	35 000	0.171	0.166	0.162	0.156	0.151	0.143	0.138	0.132	0.127	0.121	0.114
	40 000	0.218	0.211	0.206	0.200	0.196	0.190	0.184	0.179	0.172	0.163	0.149
	45 000	0.250	0.247	0.242	0.238	0.234	0.229	0.224	0.218	0.211	0.198	0.172
	50 000	0.270	0.266	0.262	0.260	0.260	0.258	0.253	0.249	0.242	0.224	0.199
	55 000	0.282	0.282	0.282	0.280	0.275	0.275	0.268	0.268	0.263	0.250	0.220
	60 000	0.295	0.295	0.290	0.289	0.286	0.284	0.286	0.281	0.278	0.270	0.225
	65 000	0.313	0.311	0.309	0.305	0.301	0.297	0.289	0.289	0.295	0.285	0.225

Table 3.6.3.2 Bay of Biscay anchovy: Median SSB in 2015 under the undetermined recruitment scenario under different catch options from 1st July 2014 to 30th June 2015 and alternative catch allocation by semesters.

		% CATCHES IN THE 2nd SEMESTER 2014										
P(SSB<Blim)		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 2014 - June 2015)											
	0	69115	69115	69115	69115	69115	69115	69115	69115	69115	69115	69115
	5000	65681	65710	65739	65768	65797	65826	65855	65880	65906	65935	65963
	10 000	62222	62282	62343	62403	62462	62522	62582	62643	62704	62764	62822
	15 000	58721	58824	58920	59024	59124	59222	59319	59419	59514	59612	59710
	20 000	55145	55293	55448	55578	55724	55880	56036	56178	56347	56479	56640
	25 000	51515	51715	51940	52147	52325	52533	52754	52975	53170	53383	53603
	30 000	47772	48106	48371	48632	48900	49204	49465	49742	50033	50297	50633
	35 000	44199	44513	44821	45170	45506	45840	46230	46567	46888	47343	48026
	40 000	40849	41255	41581	41993	42294	42644	43045	43382	43897	44678	45519
	45 000	38222	38512	38686	39094	39449	39822	40183	40698	41264	42150	43795
	50 000	35761	36106	36455	36819	37147	37516	37867	38327	38906	40302	42064
	55 000	33959	34193	34487	34753	35124	35319	35777	36244	37072	38448	40572
	60 000	32663	32844	33179	33502	33656	33856	33957	34326	35218	36957	40557
	65 000	31595	32104	32291	32285	32392	32512	32900	33240	34232	35966	40074

3.7 Reference points and management considerations

3.7.1 Reference points

The reference points and their definitions are found in the Stock annex for this stock, which was approved in October 2013. B_{lim} is set at 21 000t.

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}.

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 (MSY $B_{escapement}$, 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. MSY $B_{escapement}$ has not been defined for this stock.

3.7.2 Short-term advice

Providing a risk adverse advice according to the precautionary approach in the short-term perspective, translates into recommending a TAC which implies a low risk of leading below B_{lim}, for selected scenario(s) of recruitment.

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 JUVENA survey now has been conducted for 11 years (2003-2013). According to the current stock annex, the juvenile abundance index provided by JUVENA is a valid indicator of the strength of the next coming recruitment and therefore it has been included as an observation into the assessment of the Bay of Biscay anchovy since the last benchmark (WKPELA, 2013). This opens the possibility of conducting the assessment of this stock at two points in time: in June when SSB is estimated based on the most recent spring surveys information and in December when the assessment can incorporate the most recent juvenile abundance index from JUVENA, the catches in the second semester and any other updated data.

Similarly, the forecast can be given based either on the June or December assessment. In the former the assessment goes up to June, and given that there is no indication on the strength of the incoming year class, an undetermined scenario is assumed based on a mixture distribution of all the past recruitments. In the later the assessment covers the whole year up to December and the next year recruitment distribution is derived from the assessment which includes the latest juvenile abundance index.

3.7.3 Management plans

A draft management plan was proposed by the EC in 2009 in cooperation between science (STECF) and stakeholders (Southwestern Waters 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 since 2010 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 1stJuly to 30thJune, but with an upper bound on the TAC (of 33 000 t), and with a minimum TAC level (of 7000 t) applicable at SSB estimates between 24 000 tonnes and 33 000 tonnes.

In February 2013 the Bay of Biscay anchovy stock was benchmarked in the Benchmark Workshop on Pelagic Stocks (WKPELA). The new stock annex for this stock was approved in October 2013 after further discussions held during WGHANSA 2013 and afterwards by correspondence.

Given that the current long-term management plan proposal for the stock was based on the methods described in the previous stock annex (approved by WKSHORT 2009), STECF was requested to assess the harvest control rule and possible alternatives scoped with the stakeholders, and provide advice taking into account the long-term biological and economic objectives established in the plan. The STECF expert group met from 14 to 18 October 2013 and concluded that the change in the assessment methodology did not affect the usefulness of the LTMP proposal and that the HCR remained within the precautionary limits of risk.

In addition, the STECF expert group advised on a possible revision of the HCR (including changes regarding the HCR and the management calendar) and set the basis for conducting an impact assessment for the Bay of Biscay anchovy long-term management regulation (STECF, 2013).

The data analysis for support of the impact assessment for the management plan of Bay of Biscay anchovy was carried out by an STECF expert group that met from 10 to 14 March 2014 (STECF, 2014). A range of alternative HCR formulations were tested and they were considered to provide a sound base for developing options for fisheries management. In particular for all the HCRs tested, the STECF noted that changing the management period to January-December reduced the risks of the stock falling below B_{lim}, and leaded to a small increase in quantity and stability of catches compared with the management period July-June.

During the two expert group meetings, the STECF concluded that the HCR in the current LTMP proposal remained appropriate as a basis for advising on TACs. Therefore, it is understood that the TAC this year will again be set according to this draft plan. After the STECF evaluation of alternative HCRs further changes to the current LTMP proposal may be adopted depending upon the dialogue between managers and stakeholders.

3.7.4 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.

3.7.5 Ecosystem effects of fisheries

These effects are not quantified.

3.8 Indicators and thresholds to trigger new advice

ACOM is the process of streamlining the advisory process from assessment EGs to the final advice in order to reduce the workload for the expert community. In future, the idea is that the assessment (and possibly the advice) would not be updated unless one (or more) previously defined indicator (survey or other indices) meets a predefined threshold. This way, working groups would check indicators and only update the assessment and/or the forecast if the indicator shows a significant change from the previous year. Under these circumstances, this year WGHANSA has a generic term of reference (ToR f) asking to *propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis*.

Anchovy in the Bay of Biscay is a short-lived pelagic species. Therefore the population level every year depends strongly on the abundance of the incoming year class which is highly variable and largely dependent on environmental factors. In addition, natural mortality is usually high and very variable from year-to-year. These characteristics make the assessment and management of small pelagic fish difficult (Barange *et al.*, 2009). The most effective management strategies are based on closely monitoring the population by fishery-independent research surveys that can be used either for assessment purposes or as information directly used for management decision-making either in the short or in the long term.

For the Bay of Biscay anchovy the two spring surveys (DEPM and acoustics) provide information on the stock size and its age structure every year, including the strength of new cohort recruited to the population (age 1 individuals). The WG considers that the best indicator on stock size for this stock is the biomass estimate from the assessment and emphasizes the need to conduct spring surveys and update the assessment in June every year.

However, the major difficulty when providing management advice in June is the absence of information on next year recruitment, which will form the major part of the population next year. Currently the JUVENA surveys (available since 2003) provide a reliable index of next year incoming year class that is available by mid-November (see section 3.3.3 and 3.7). This opens the possibility to reopen the advice delivered in July by incorporating to the assessment the most recent juvenile abundance index from JUVENA in November, along with the catches in the second semester and any other updated data (see section 3.7). Currently ICES advice in July is based on the precautionary approach. Under an undetermined recruitment scenario the short-term predictions allow to evaluate the level of risk (probability of SSB being below B_{lim}) associated to different catch options. The advice then indicates the maximum allowable level of catches to keep next year biomass within safe biological levels (i.e. with risk lower than 0.05). These short-term predictions can be updated based on the new assessment in November. Regarding the threshold changes that may trigger an update assessment, the WG considers that ICES advice based on the precautionary approach should be updated at least whenever the advice provided in July is perceived in December to lead to risk above the threshold of 0.05. Alternatively, the thresholds needed to revise the advice when the risk is revised downwards include other socio-economic factors that cannot be evaluated by this WG, as it will be usually associated to higher allowable levels of catches and should be consulted to the stakeholders. In any case, the WG considers the July advice could be revised routinely in December. Table 3.8.1 summarizes the data availability for providing management advice both in June and in December.

Table 3.8.1 Bay of Biscay anchovy: Availability of data for the assessment and short-term projections at the end of June and at the end of November.

Type of input	End of june	End of november
DEPM	Provisional	Definitive
Acoustic	Definitive	Definitive
Juvena	Definitive year Y-1	Quasi definitive year Y
SP Landings semester 1	Quasi-definitive	Definitive
FR Landings semester 1	provisional	definitive
SP landings semester 2	NA	Quasi definitive
FR landings semester 2	NA	Quasi-definitive
Catch @age SP sem1	provisional	Definitive
Catch @age FR sem1	NA	Definitive
Catch @age SP sem2	NA	Provisional
Catch @age FR sem2	NA	Not available

Since July 2010 the European Commission and the Council set the TAC from July to June next year based on the draft long-term management plan for this fishery. This plan was proposed in 2009 by the EC (COM 2009) and it is still waiting for a formal approval. 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 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. As in the case of the ICES July advice based on the short-term predictions, the HCR could include a revision of the TAC set currently from July to June according to the tendency of the forecasted population in relation to last assessment. Alternatively a HCR could provide a TAC going from January to December according to a sustainable harvest rate on the forecasted population over the management year. 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.

4 Anchovy in Division IXa

4.1 ACOM Advice Applicable to 2013 and 2014

ICES advice in 2012 and 2013, either based on its approach for data limited stocks (in 2012) or on precautionary considerations (in 2013), stated that ICES could not give quantitative catch advice neither for 2013 nor 2014 because of the lack of available data on year classes that constitute the bulk of the biomass and catches (no survey indices for such year classes are available at the time of the formulation of the advice). Notwithstanding the above, ICES noted that the historical fisheries and management measures seem to have been sustainable.

For 2013 and 2014 the annual TAC was agreed in 8778 t (with national quotas of 4198 t for Spain and 4580 t for Portugal). The above fishing possibilities by country are those ones corresponding at the beginning of the year. Fishing quotas exchanges have occurred through the year both in 2013 and 2014. In 2013 the Spanish quota was finally established, after successive exchanges, in 6727 t (Spanish landings in 2013 were 5241 t, and the whole fishery landed a total of 5632 t).

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 interannual 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 2013

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 multipurpose fleet (although fishing with artisanal purse-seines);
- Portuguese trawl fleet for demersal fish species;
- Spanish purse-seine fleet;
- Spanish multipurpose fleet (artisanal fleets fishing with purse-seine temporally).

Technical characteristics of the Portuguese fleets fishing anchovy in 2013 in Division IXa are described in the sardine section of this report.

The purse-seine fleet operated by Spain in the Subdivision IXa North was composed in 2013 by a total of 290 vessels (121 single-purpose purse-seiners and 169 artisanal vessels). From this total, 96 vessels (52 purse-seiners and 44 artisanal vessels) captured anchovy in the Subdivision (Table 4.2.1.1).

Number and technical characteristics of the purse-seine vessels operated by Spain in their national waters off Gulf of Cadiz (Subdivision IXa south), differentiated between total operative fleet and fleet targeting anchovy are also summarized in Table 4.2.1.1. In 2013, the Spanish fleet fishing in the Gulf of Cadiz with purse-seine was composed by 99 vessels (82 single-purpose purse-seiners, 16 bottom-trawl trawlers with temporal permission for the chub mackerel purse-seine fishing and 1 artisanal vessel). Gulf of Cadiz anchovy fishing was practiced by the 82 single-purpose purse-seiners only. 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.

Table 4.2.1.1. Anchovy in Division IXa. Composition of the Spanish fleets operating in Southern Galician waters (Subdivision IXa North) and in the Gulf of Cadiz (SubdivisionIXa South) in 2013. Fleets are differentiated into vessels targeting anchovy and total fleet. 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 for the Gulf of Cadiz Spanish fleet in the Stock Annex and previous WG reports.

Subdivision IXa North													
2013	**Vessels targeting anchovy**						**2013**	**Total fleet**					
	Engine (HP)							**Engine (HP)**					
Length (m)	**0-50**	**51-100**	**101-200**	**201-500**	**>500**	**Total**	**Length (m)**	**0-50**	**51-100**	**101-200**	**201-500**	**>500**	**Total**
≤10	42	3				45	≤10	150	10				160
11-15	3	10	10			23	11-15	9	23	26	2		60
16-20			4	9		13	16-20		1	14	24		39
>20			1	13	1	15	>20			1	29	1	31
Total	45	13	15	22	1	96	Total	159	34	41	55	1	290
Subdivision IXa South (Spanish waters)													
2013	**Vessels targeting anchovy**						**2013**	**Total fleet**					
	Engine (HP)							**Engine (HP)**					
Length (m)	0-50	51-100	101-200	201-500	>500	Total	Length (m)	0-50	51-100	101-200	201-500	>500	Total
≤10							≤10						
11-15	2	14	14	2		32	11-15	3	14	15	2		34
16-20		3	23	11		37	16-20		3	29	15		47
>20			2	10	1	13	>20			3	14	1	18
Total	2	17	39	23	1	82	Total	3	17	47	31	1	99

4.2.2 Catches by fleet and area

4.2.2.1 Catches in Division IXa

Anchovy total landings in 2013 were 5632 t, which were of a similar magnitude to the catches landed in the previous year (5589 t) and around the historical average in the recent series (Table 4.2.2.1.1, Figure 4.2.2.1.1).

Table 4.2.2.1.1. Anchovy in Division IXa. Recent historical series of annual landings by Subdivision y total (t) since 1989 on (the period with available data for all the Subdivisions). Landings in Subdivision IXa South are also differentiated between "Algarve" (A; Portuguese waters) and "Cádiz" (C; Spanish waters). (-) not available data; (0) less than 1 tonne (from Pestana, 1989 and 1996, and WGMHSA, WGANC, WGANSA and WGHANSA members). The rest of the historical series of landings is given in the Stock Annex.

Year	IXa N	IXa C-N	IXa C-S	IXa S (A)	IXa S (C)	IXa S (Total)	Total Division
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
2012	39	521	220	56	4754	4810	5589
2013	69	192	131	67	5172	5240	5632

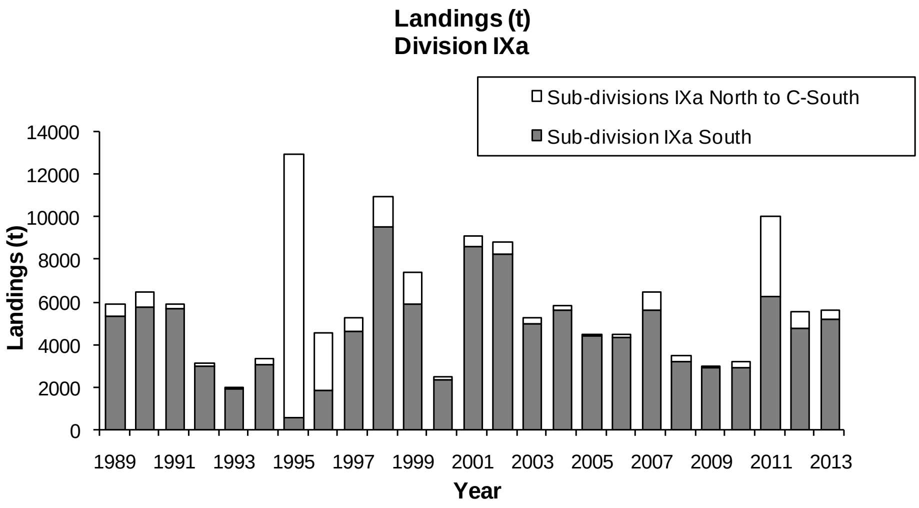


Figure 4.2.2.1.1. Anchovy in Division IXa. Recent series of anchovy landings in Division IXa (1989-2013, the period with data for all the Subdivisions). Sub-areas are pooled in order to differentiate the anchovy fishery harvested throughout the Atlantic façade of the Iberian Peninsula (ICES Subdivisions IXa North, Central-North and Central-South) from the fishery in the Gulf of Cadiz (Subdivision IXa South), where both the stock and the fishery are mainly located.

The contribution by each subdivision to the total catch was characterized in 2013 by a relatively important decrease in landings in the Subdivision IXa Central-North and the location of the bulk of the fishery, as usual, in the Spanish waters of the Gulf of Cadiz (Subdivision IXa South).

As usual, the anchovy fishery in 2013 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.

Table 4.2.2.1.2. Anchovy in Division IXa. Catches (t) by gear and Subdivision in 1989-2013. Landings by gear in Subdivisions IXa C-N to S (Algarve) are not available by Subdivision until 2009.

Sub-area	Gear	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	496	541	210	-	-	-	7056	-	-	-	-	-
IXa S (C)	Demersal Trawl	0	0	0	0	330	152	75	224	190	1148	993	104
	Purse-seine	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	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

4.2.2.2 Landings by Subdivision

The updated historical series of anchovy landings by Subdivision are shown in Table 4.2.2.1.1 (see also Figure 4.2.2.1.1). Table 4.2.2.1.2 shows the contribution of each fleet in the total annual landings by Subdivision. The seasonal distribution of 2013 landings by Subdivision is shown in Table 4.2.2.2.1.

Table 4.2.2.2.1. Anchovy in Division IXa. Quarterly anchovy catches (t) by Subdivision in 2013.

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2012)	
SUBDIVISION	C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
IXa North	7	10.5	7	10.5	27	39.0	28	40.1	69	1.2
IXa Central North	9	4.7	57	29.6	94	48.8	32	16.8	192	3.4
IXa Central South	93	70.6	5	3.6	0.5	0.4	33	25.4	131	2.3
IXa South (Algarve)	62	92.8	4	5.5	1	1.2	0.4	0.6	67	1.2
IXa South (Cádiz)	382	7.4	1832	35.4	2680	51.8	278	5.4	5172	91.8
IXa South	444	8.5	1836	35.0	2681	51.2	279	5.3	5240	93.0
TOTAL	553	9.8	1905	33.8	2802	49.8	372	6.6	5632	100.0

Subdivision IXa North

Anchovy landings in 2013, 69 t, showed a slight increase in relation to the 39 t recorded in 2012. Landings from this Subdivision only accounted for about 1% of total landings in the whole Division IXa and occurred mainly during the second half of the year.

Subdivision IXa Central-North

Anchovy landings in 2013 (192 t) experienced a notable decrease in relation to the previous year (521 t) and they are again placed at the usual low levels observed in the recent series after the noticeable outburst (3239 t) recorded in 2011. Landings from this Subdivision represented 3% of the total anchovy fishery in the Division. The 2013 anchovy fishery in this subdivision was concentrated in the third quarter.

Subdivision IXa Central-South

Anchovy landings in this Subdivision in 2013 were 131 t (2% of total landings in the Division) and accounted a slight decrease with respect to the catches landed in 2012 (220 t), but they still contrast to the almost null landings recorded between 2005 and

2011. The fishery in this subdivision was mainly concentrated in 2013 in the first quarter.

Subdivision IXa South

Landings in 2013 (5240 t; 93% of the whole fishery) slightly increased in relation to 2012 (4810 t). As usual, the Spanish waters of the Subdivision yielded the bulk of the fishery in these southernmost areas (5172 t). In these waters the fishery in 2013 mainly developed through the second and third quarters.

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 Cadiz (Subdivision 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). However, the sampling intensity applied so far to assess the anchovy discarding is very low because it is limited to the agreed minimum sampling scheme (2 trips per quarter, 8 trips per year). In 2013 were sampled a total of 7 fishing trips only (2 trips in the first, second and third quarters, and 1 trip in the fourth one). Such a sampling scheme results in unreliable and not representative quarterly discard estimates which are also affected by high CVs. As also stated for previous years, this low sample size makes their results not conclusive and hence they have not been considered. A more intense sampling scheme is expected to be developed during 2014.

No information on anchovy discarding is available from other subdivisions.

4.2.4 Effort and Landings per Unit Effort

Annual standardized LPUE series for the whole Spanish purse-seine fleet fishing Gulf of Cadiz anchovy (SubdivisionIXa South) are routinely provided to this WG. An update of the available series (1988-2013) has been provided this year to this WG. Details of data availability and the standardization process are commented in the Stock Annex. The recent dynamics of fishing effort and LPUE for this fleet has been described in previous WG reports. Fishing effort has experienced a relative decrease between 2008 and 2010 which was coupled to a relative stable trend in the LPUE (at around 0.7 t/fishing day). A combination of fishing closures, both at 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 reopening of the Gulf of Cadiz fishery (usually in February), may be the causes of the observed decrease in the fishing effort for the period 2008-2010. Since 2011 the EC-Morocco Fishery Agreement was not renewed and the whole fleet was again fishing in the Gulf of Cadiz probably causing the increase in the effort observed that year. The premature closure of the fishery in 2012 because of the consumption of the national quota may be the responsible for the lower total annual effort levels exerted in the fishery.Regarding LPUE, it was suggested in previous WG reports 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 LPUE estimates are shown in Table 4.2.4.1 and Figure 4.2.4.1.

Table 4.2.4.1. Anchovy in Division IXa. Subdivision IXa South. Standardized effort (no. of standardized fishing trips fishing anchovy) and anchovy LPUE (t/fishing trip) data for the Spanish purse-seine fleet operating in the Gulf of Cadiz (1988-2013). Colour intensities denote increasing problems in sampling coverage of fishing effort.

Year	Effort	LPUE
1988	4521	0.938
1989	5645	0.934
1990	6215	0.912
1991	7643	0.737
1992	5558	0.543
1993	2956	0.484
1994	3574	0.721
1995	1786	0.149
1996	5555	0.225
1997	4363	0.924
1998	4974	1.469
1999	5980	0.767
2000	5985	0.347
2001	6700	1.221
2002	7529	1.042
2003	6367	0.747
2004	7121	0.726
2005	5518	0.795
2006	7117	0.614
2007	6871	0.811
2008	4568	0.693
2009	4635	0.631
2010	4342	0.668
2011	6194	1.000
2012	4667	1.019
2013	6235	0.841

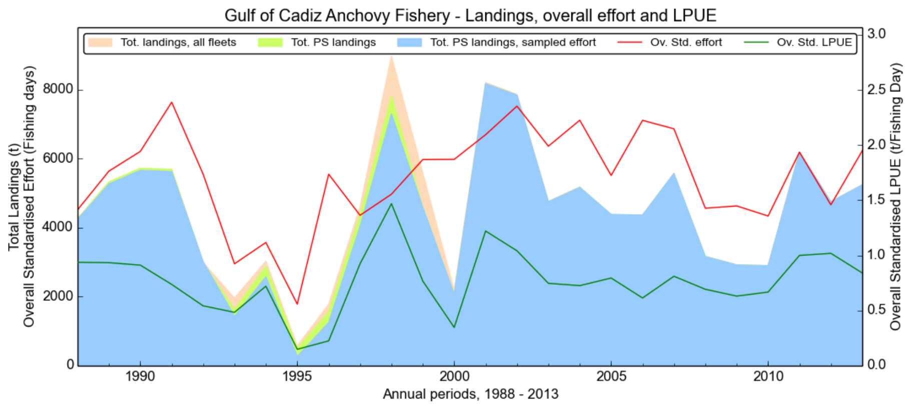


Figure 4.2.4.1. Anchovy in Division IXa. Subdivision IXa South. Spanish purse-seine fishery. Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardized overall effort and LPUE (1988-2013).

4.2.5 Catches by length and catches-at-ageby Subdivision

Length frequency distribution (LFD) of landings and catch-at-age data from the whole Division IXa are routinely provided to this WG from the Spanish fishery operating in the Gulf of Cadiz (Subdivision IXa South), since the anchovy fishery in the Division is traditionally concentrated there. Data from the Spanish fishery in Subdivision IXa North are usually not available since commercial landings used to be almost negligible. The same reason is also valid for the Portuguese subdivisions (included the Portuguese part of the IXa South (Algarve)), 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 that year.

Quarterly LFDs in 2013 has been provided for the Spanish fishery in Subdivisions IXa North and IXa South (Cadiz). LFDs from the Portuguese fishery provided to this WG are those ones from the purse-seine fishery in Subdivisions IXa Central-North and Central-South (only for quarters from the 1st semester and pooled for both subdivisions) and from scanty bottom-trawl catches in quarters 1, 2 and 4 in the Subdivision IXa South (Algarve).

Catch-at-age data in 2013 has been provided for the Spanish fishery in the Subdivision IXa South (Cadiz). There are no catch-at-age estimates for the IXa North. For the Portuguese fishery there are data for the second quarter from the IXa Central-North only.

4.2.5.1 Length distributions

Subdivision IXa North

Quarterly and annual size composition of anchovy landings in the Subdivision IXa North in 2013 are shown in Table 4.2.5.1.1. Annual mean size in landings in 2013 was estimated at 15.4 cm.

Table 4.2.5.1.1. Anchovy in Division IXa. Subdivision IXa North. Spanish purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2013.

2013	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa N	IXa N	IXa N	IXa N	IXa N
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	0	0	0	0
7.5	0	0	0	0	0
8	0	0	0	0	0
8.5	0	0	0	0	0
9	0	0	0	0	0
9.5	0	0	0	0	0
10	0	0	0	0.2	0.2
10.5	0	0.001	0.2	0	0.2
11	1	0.002	2	1	5
11.5	2	0.2	11	4	18
12	3	4	42	19	68

2013	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa N	IXa N	IXa N	IXa N	IXa N
12.5	5	12	63	24	105
13	7	25	108	41	181
13.5	6	27	157	61	251
14	15	33	129	46	223
14.5	40	19	103	35	198
15	58	25	70	85	236
15.5	45	36	46	161	288
16	42	36	47	124	250
16.5	23	32	76	116	248
17	9	18	89	85	201
17.5	6	7	54	83	151
18	5	3	34	6	48
18.5	1	1	23	55	80
19	0.3	0.02	13	1	15
19.5	0	0	6	0	6
20	0	0	3	0	3
Total N	271	279	1077	949	2 575
Catch (T)	7	7	27	28	69
L avg (cm)	15.5	15.2	15.1	15.9	15.4
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Subdivision IXa Central-North and IXa Central-South

The size composition of 2013 anchovy landings by each of these western Subdivisions has not been separately provided to this WG. Instead, pooled LFDs for both Subdivisions and for only the first two quarters in the year are available and shown in Table 4.2.5.1.2. Mean lengths for each of those quarters were estimated at 16.6 cm and 13.9 cm.

Table 4.2.5.1.2. Anchovy in Division IXa. Subdivisions IXa Central-North and IXa Central-South. Portuguese purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2013.

2013	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa CN-CS	IXa CN-CS	IXa CN-CS	IXa CN-CS	IXa CN-CS
6	0	0	n.a.	n.a.	n.a.
6.5	0	0	n.a.	n.a.	n.a.
7	0	0	n.a.	n.a.	n.a.
7.5	0	0	n.a.	n.a.	n.a.
8	0	0	n.a.	n.a.	n.a.
8.5	0	0	n.a.	n.a.	n.a.
9	0	0	n.a.	n.a.	n.a.
9.5	0	0	n.a.	n.a.	n.a.

2013	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa CN-CS	IXa CN-CS	IXa CN-CS	IXa CN-CS	IXa CN-CS
10	0	0	n.a.	n.a.	n.a.
10.5	0	0	n.a.	n.a.	n.a.
11	0	18	n.a.	n.a.	n.a.
11.5	0	0	n.a.	n.a.	n.a.
12	0	201	n.a.	n.a.	n.a.
12.5	0	275	n.a.	n.a.	n.a.
13	0	604	n.a.	n.a.	n.a.
13.5	0	494	n.a.	n.a.	n.a.
14	30	421	n.a.	n.a.	n.a.
14.5	61	403	n.a.	n.a.	n.a.
15	182	256	n.a.	n.a.	n.a.
15.5	334	92	n.a.	n.a.	n.a.
16	850	18	n.a.	n.a.	n.a.
16.5	637	18	n.a.	n.a.	n.a.
17	698	0	n.a.	n.a.	n.a.
17.5	243	0	n.a.	n.a.	n.a.
18	30	0	n.a.	n.a.	n.a.
18.5	0	0	n.a.	n.a.	n.a.
19	0	0	n.a.	n.a.	n.a.
19.5	0	0	n.a.	n.a.	n.a.
20	0	0	n.a.	n.a.	n.a.
Total N	3065	2802	n.a.	n.a.	n.a.
Catch (T)	100	51	87	63	302
L avg (cm)	16.6	13.9	n.a.	n.a.	n.a.
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Subdivision IXa South

As quoted above, the only LFDs available from the Portuguese fishery in this subdivision correspond to those ones from incidental landings by the bottom-trawl fleet for demersal fish in quarters 1, 2, and 4 (**Tables 4.2.5.1.3**). Estimated mean lengths in landings were between 15.9 cm (quarter 4) and 16.6 cm (quarters 1 and 3).

Table 4.2.5.1.3. Anchovy in Division IXa. Subdivision IXa South (Algarve). Portuguese bottom-trawl fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2013.

2013	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa S (A)	IXa S (A)	IXa S (A)	IXa S (A)	IXa S (A)
6	0	n.a.	0	0	n.a.
6.5	0	n.a.	0	0	n.a.
7	0	n.a.	0	0	n.a.
7.5	0	n.a.	0	0	n.a.
8	0	n.a.	0	0	n.a.

2013	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa S (A)	IXa S (A)	IXa S (A)	IXa S (A)	IXa S (A)
8.5	0	n.a.	0	0	n.a.
9	0	n.a.	0	0	n.a.
9.5	0	n.a.	0	0	n.a.
10	0	n.a.	0	0	n.a.
10.5	0	n.a.	0	0	n.a.
11	0	n.a.	0	0	n.a.
11.5	0	n.a.	0	0	n.a.
12	0	n.a.	0	0	n.a.
12.5	0	n.a.	0	0	n.a.
13	0	n.a.	0	0	n.a.
13.5	0	n.a.	0	0	n.a.
14	0	n.a.	0	0.2	n.a.
14.5	0	n.a.	0	0	n.a.
15	0.4	n.a.	1	0.9	n.a.
15.5	1	n.a.	2	0.9	n.a.
16	6	n.a.	5	1.7	n.a.
16.5	3	n.a.	4	1.2	n.a.
17	3	n.a.	5	1.4	n.a.
17.5	0.8	n.a.	1	0.9	n.a.
18	0.4	n.a.	0.3	0.2	n.a.
18.5	0	n.a.	0	0	n.a.
19	0	n.a.	0	0	n.a.
19.5	0	n.a.	0	0	n.a.
20	0	n.a.	0	0	n.a.
Total N	14	n.a.	17	7	n.a.
Catch (T)	0.4	1	0.5	0.2	2
L avg (cm)	16.6	n.a.	16.6	16.5	n.a.
W avg (g)	n.a.	n.a.	n.a.	n.a.	n.a.

Quarterly LFDs from the Spanish fishery in 2013 are shown in Table 4.2.5.1.4. Anchovy mean length and weight in the Spanish 2013 annual catch (11.3 cm and 9.8 g) were still among the highest one ever recorded in the historical series, as it is observed since 2008, although they used to be the smallest anchovies in the Division.

Table 4.2.5.1.4. Anchovy in Division IXa. Subdivision IXa South (Cadiz). Spanish purse-seine fishery. Seasonal and annual length distributions ('000) of anchovy landings in 2013.

2013	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	IXa S (C)	IXa S (C)	IXa S (C)	IXa S (C)	IXa S (C)
6	0	0	0	0	0
6.5	0	0	0	0	0
7	0	577	906	0	1483
7.5	78	1329	1000	0	2407

8	342	2750	3046	506	6646
8.5	695	4900	7723	1013	14 331
9	1797	7970	16 223	1521	27 511
9.5	4058	10 867	26 501	3550	44 976
10	7185	15 934	30 526	8114	61 759
10.5	6900	12 133	30 532	9629	59 194
11	7103	12 130	17 285	8611	45 128
11.5	5530	15 887	16 164	3039	40 621
12	3458	16 613	13 589	1519	35 179
12.5	2953	18 848	20 471	506	42 778
13	630	13 625	21 668	506	36 429
13.5	637	9891	19 005	0	29 533
14	382	5006	9456	0	14 844
14.5	579	3623	6568	0	10 770
15	121	1263	4310	0	5693
15.5	89	1088	1778	0	2954
16	40	463	581	0	1085
16.5	8	106	215	0	329
17	0	77	9	0	87
17.5	0	59	0	0	59
18	0	0	22	0	22
18.5	0	0	0	0	0
19	0	0	0	0	0
19.5	0	0	0	0	0
20	0	0	0	0	0
20.5	0	0	0	0	0
21	0	0	0	0	0
21.5	0	0	0	0	0
22	0	0	0	0	0
Total N	42 584	155 138	247 580	38 516	483 818
Catch (T)	381	1833	2682	276	5172
L avg (cm)	11.1	11.7	11.5	10.7	11.3
W avg (g)	9.0	11.1	9.5	7.2	10.0

4.2.5.2 Catch numbers-at-age

Subdivision IXa North

No estimate from the fishery in this subdivision in 2013 is available. The age composition of landings in previous years with available data is shown in Table 4.2.5.2.1 and Figure 4.2.5.2.1.

Table 4.2.5.2.1. Anchovy in Division IXa. Subdivision IXa North. Spanish annual landings of anchovy ('000) at age (only data for 2011-2012).

Year	Age 0	Age 1	Age 2	Age 3
2011	2725	23 903	380	0
2012	0	668	599	7
2013				

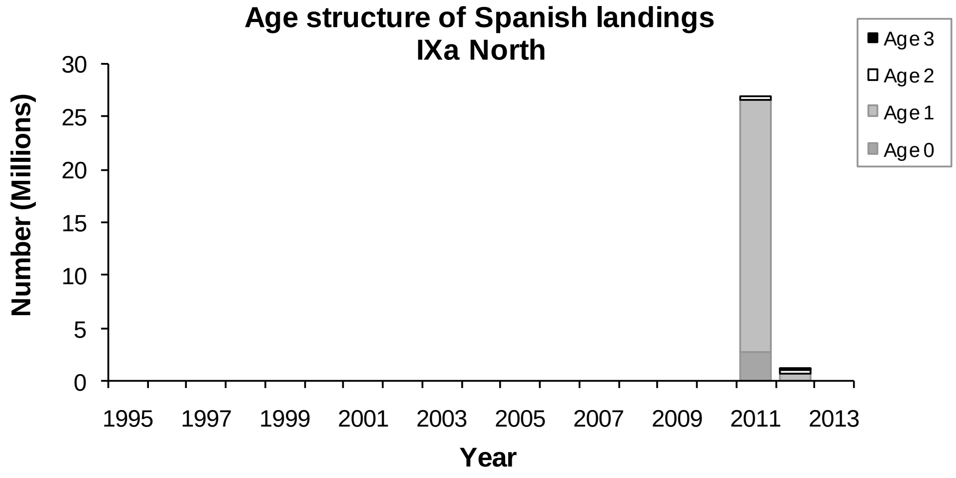


Figure 4.2.5.2.1. Anchovy in Division IXa. Subdivision IXa North. Spanish fishery (all fleets). Age composition in Spanish landings of SW Galician anchovy (only 2011 and 2012 data available).

Subdivision IXa Central-North

Soares *et al*., (2012) described the age reading results from anchovies collected during 2011 from research surveys and commercial samples by IPMA 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 IPMA were clearly improved after this exchange.

Landings at age in 2013 from this subdivision have only been provided to this WG for the purse-seine fishery in the second quarter in the year (Table 4.2.5.2.2). Those landings were composed by anchovies belonging to 1, 2 and 3 age groups, with 1 and 2 years old anchovies accounting for the bulk of that fishery in that quarter.

Table 4.2.5.2.2. Anchovy in Division IXa. Subdivision IXa Central North. Portuguese landings ('000) at age of anchovy in 2013 on a quarterly (Q), half-year (HY) and annual basis (only data available for the purse-seine fishery in the second quarter).

2013	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0		0					
	1		1724					
	2		1312					
	3		75					
	Total (n)		3111					
	Catch (t)	9	57	94	32	66	126	192
	SOP		56					
	VAR.%		102					

Subdivision IXa Central-South

No estimate from this subdivision is available.

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. A new anchovy otolith exchange is planned to be carried out during the fourth quarter this year.

Table 4.2.5.2.3 shows the quarterly and annual anchovy landings at age in the Spanish fishery in 2013.Total landings in the Spanish fishery in 2013 were estimated at 483 million fish, which accounted a slight increase in relation to the 371 million landed the previous year. Such an increase was mainly caused by a greater contribution of age 0 anchovies in landings. Age group 3 anchovies were absent in the fishery.

Table 4.2.5.2.3. Anchovy in Division IXa. Subdivision IXa South. Spanish landings ('000) at age of Gulf of Cadiz anchovy in 2013 on a quarterly (Q), half-year (HY) and annual basis.

2013	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	143	139 310	36 716	143	176 026	176 169
	1	42 119	149 948	106 914	1800	192 067	108 714	300 781
	2	465	5047	437	0	5512	437	5950
	3	0	0	0	0	0	0	0
	Total (n)	42 584	155 138	2682	38 516	197 722	285 177	482 899
	Catch (t)	381	1833	2682	276	2214	2959	5172
	SOP	382	1715	2682	276	2097	2622	4719
	VAR.%	100	107	114	100	106	113	110

The recent historical series of annual landings at age in the Spanish fishery in IXa South are shown in Table 4.2.5.2.4 and Figure 4.2.5.2.2. Description of annual trends of landings-at-age data from the Spanish fishery through the available data series is given in the Stock Annex and in previous WG reports.

No data are available from the Portuguese fishery in this Subdivision.

Table 4.2.5.2.4. Anchovy in Division IXa. Subdivision IXa South. Spanish annual landings s ('000) at age of Gulf of Cadiz anchovy (1995-2013).

Year	Age 0	Age 1	Age 2	Age 3
1995	34497	33961	189	0
1996	484540	162483	2053	0
1997	333758	279641	44823	0
1998	436307	1015535	13260	0
1999	124784	472348	32279	0
2000	118808	197497	3844	0
2001	158126	541331	23342	0
2002	74399	708070	17515	0
2003	71847	381407	13109	0
2004	105958	398862	2590	0
2005	37906	482256	3495	0
2006	11303	491307	5261	0
2007	61692	559217	7342	0
2008	57477	138295	30970	394
2009	9695	184941	20051	2673

2010	34462	210384	11118	257
2011	199191	406217	16117	0
2012	25265	335487	8348	0
2013	176169	300781	5950	0

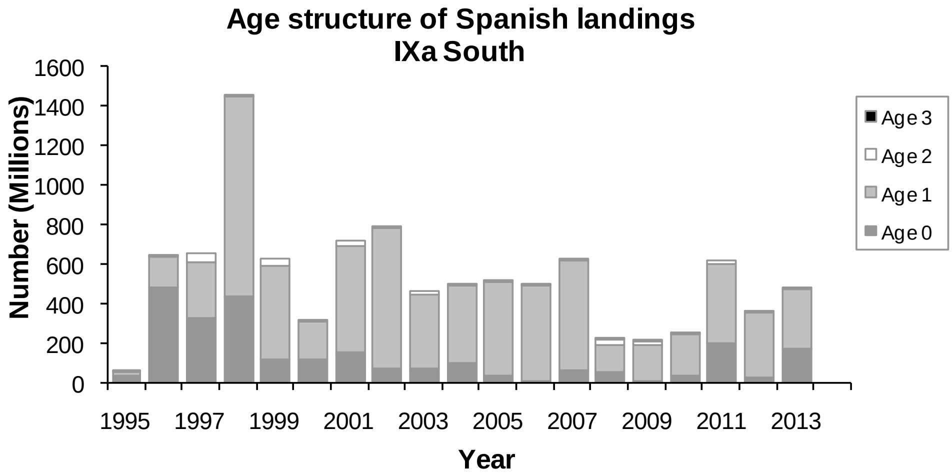
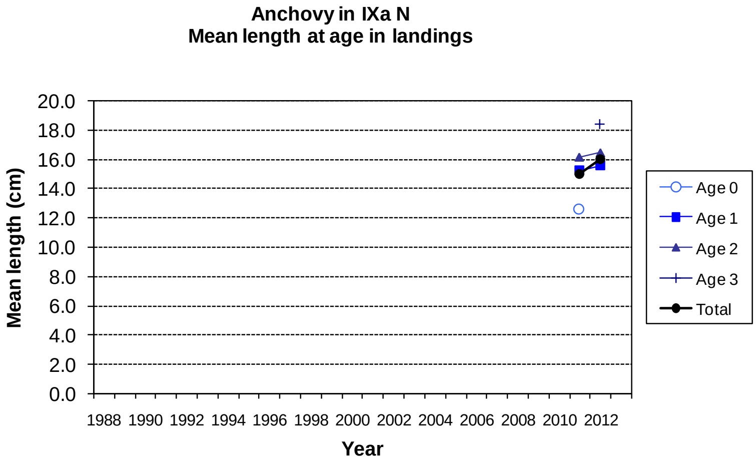


Figure 4.2.5.2.2. Anchovy in Division IXa. SubdivisionIXa South. Spanish fishery (all fleets). Age composition in Spanish landings of Gulf of Cadiz anchovy (1995-2013).

4.2.6 Mean length and mean weight at age in the catch

Subdivision IXa North

There are no available estimates for the fishery in 2013. Previous estimates are shown in Figure 4.2.6.1 and indicate that anchovies from this subdivision are larger and heavier than those harvested in the southernmost areas.



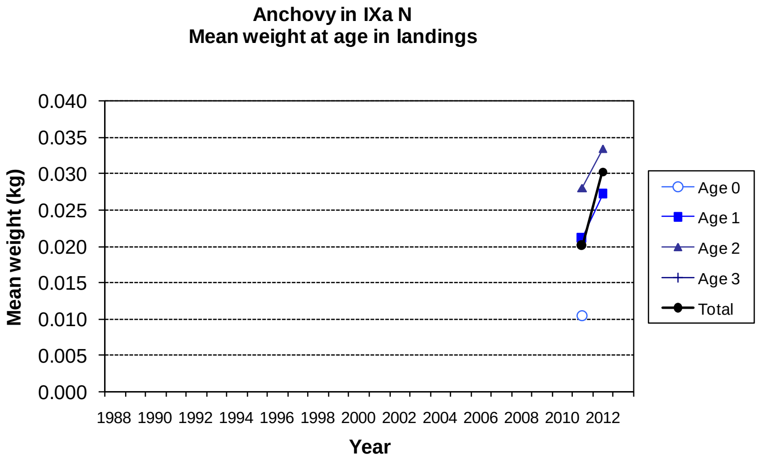


Figure 4.2.6.1. Anchovy in Division IXa. Subdivision IXa North. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Western Galicia anchovy in 2012.

Subdivision IXa Central-North

Estimates from the fishery in this subdivision in 2013 are only available for the second quarter (Tables 4.2.6.1 and 4.2.6.2). These partial data support the same above-mentioned considerations about the differences in size and weight with the southernmost anchovies.

Table 4.2.6.1. Anchovy in Division IXa. Subdivision IXa Central North. Mean length (TL, in cm) at age in the Portuguese catches of anchovy in 2013 on a quarterly (Q), half-year (HY) and annual basis (only data available for the second quarter in 2013).

2013	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0							
	1		13.2					
	2		14.7					
	3		14.6					
	Total		13.9					

Table 4.2.6.2. Anchovy in Division IXa. Subdivision IXa Central North. Mean weight (in kg) at age in the Portuguese catches of anchovy in 2013 on a quarterly (Q), half-year (HY) and annual basis (only data available for the second quarter in 2013).

2013	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0							
	1		0.015					
	2		0.021					
	3		0.021					
	Total		0.018					

Subdivision IXa Central-South

No estimate from this subdivision is available.

Subdivision IXa South

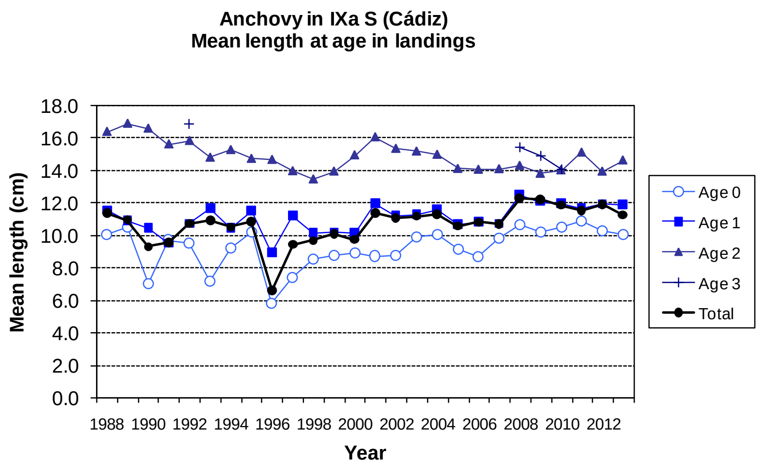
The 2013 estimates of the mean length and weight at age of Gulf of Cadiz anchovy landings are shown in Tables 4.2.6.3 and 4.2.6.4.Figure 4.2.6.2 shows the recent history of the evolution of such estimates. Anchovy mean length and weight in the Spanish 2013 annual landings were estimated at 11.3 cm and 9.8 g respectively.

Table 4.2.6.3. Anchovy in Division IXa. Subdivision IXa South. Mean length (TL, in cm) at age in the Spanish catches of Gulf of Cadiz anchovy in 2013 on a quarterly (Q), half-year (HY) and annual basis.

2013	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0		14.3	9.9	10.6	14.3	10.0	10.0
	1	11.1	11.6	12.6	12.1	11.5	12.6	11.9
	2	15.1	14.5	15.7		14.6	15.7	14.6
	3							
	Total	11.1	11.7	11.1	10.7	11.6	11.0	11.3

Table 4.2.6.4. Anchovy in Division IXa. Subdivision IXa South. Mean weight (in kg) at age in the Spanish catches of Gulf of Cadiz anchovy in 2013 on a quarterly (Q), half-year (HY) and annual basis.

2013	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0		0.020	0.006	0.007	0.020	0.007	0.007
	1	0.009	0.011	0.014	0.010	0.010	0.013	0.011
	2	0.024	0.021	0.026		0.022	0.026	0.022
	3					0.011	0.009	
	Total	0.009	0.011	0.010	0.007	0.020	0.007	0.010



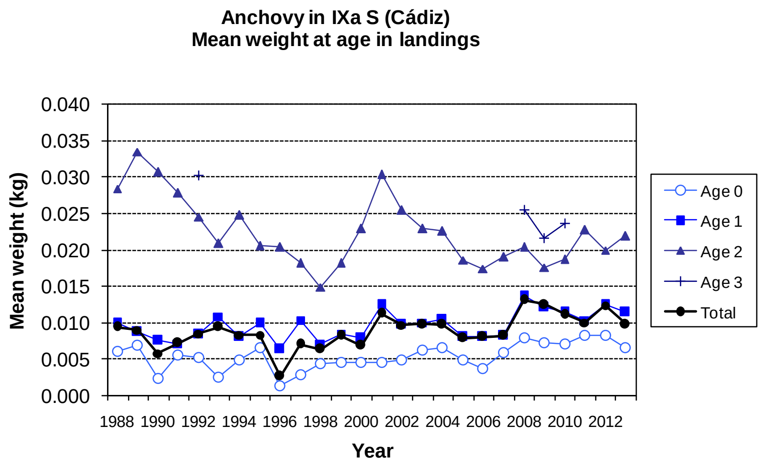


Figure 4.2.6.2. Anchovy in Division IXa. Subdivision IXa South. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Gulf of Cadiz anchovy (1988-2013).

Age 0 and age 1 anchovies have showed a noticeable increasing trend in both estimates in the most recent years, with the 2008-2013 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 since 2011 on a new relative increase. Three year olds were first recorded in the sampled landings in 1992. New occurrences of these anchovies have been observed only 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

BOCADEVA series

Anchovy DEPM surveys in the Division are only conducted by IEO for the SSB estimation of Gulf of Cadiz anchovy (SubdivisionIXa South, *BOCADEVA* survey series, Table 4.3.2.1, Figure 4.3.1.1). 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).

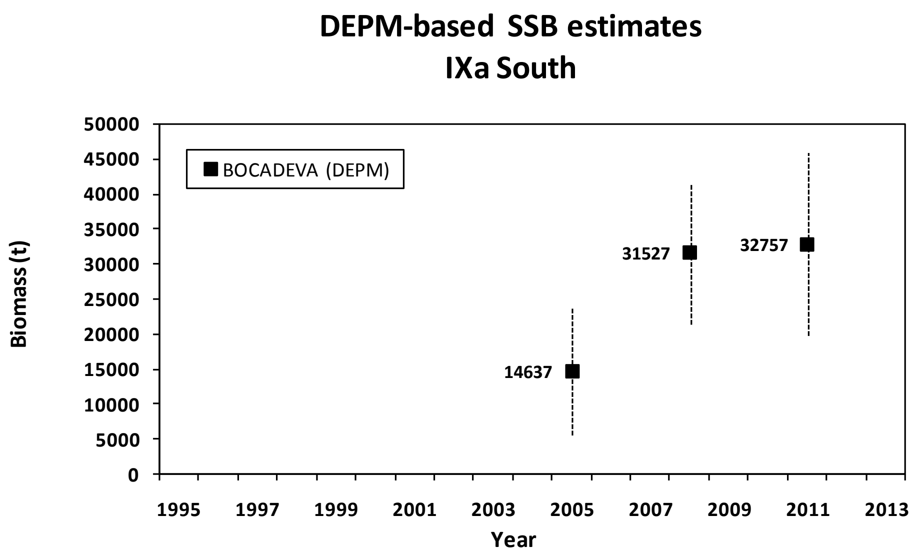


Figure 4.3.1.1. Anchovy in Division IXa. Subdivision IXa South. BOCADEVA survey series (summer Spanish DEPM survey in Subdivision IXa South). Series of SSB estimates (±SD) obtained from the survey series.

The series started in 2005 and their surveys are conducted with a triennial periodicity. The next survey in the series will be conducted in late July this year. This series is not financed by DCF. **The WG recommends that this survey series is maintained to scale properly the assessment of anchovy in Subdivision IXa South**.

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 alsoICES, 2007 b). Survey's methodologies deployed by the respective national Institutes (IPMA and IEO) are also thoroughly described inICES (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 (Subdivisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history.

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 Subdivision IXa South (Algarve and Gulf of Cádiz; see Section 4.5.1); (2): surveys analysed 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 Cadiz 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	ECOCADIZ		ECOCADIZ-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)						Nov		
2013	Mar (2)		Apr (2)			Aug(2)			
2014	Mar (2)		Apr (2)						

Detailed information in the present section will be provided for those surveys carried out during the elapsed time between 2013 and 2014 WGHANSA meetings.

PELACUS series

This Spanish spring acoustic survey series is the only one that samples yearly the waters off the Subdivisions IXa-North and Sub-area VIIIc since 1984. This series is currently funded by DCF.

PELACUS 0314

PELACUS 0314 was conducted between 9th March and 9th April 2014 on board the RV*Miguel Oliver*. Figure 4.3.2.1 shows the distribution and species composition of the 52 valid pelagic hauls carried out during the survey. Eleven (11) fishing hauls were carried out in la Subdivision IXa North. A detailed description of the survey is given by Riveiro and Carrera(WD 2014).

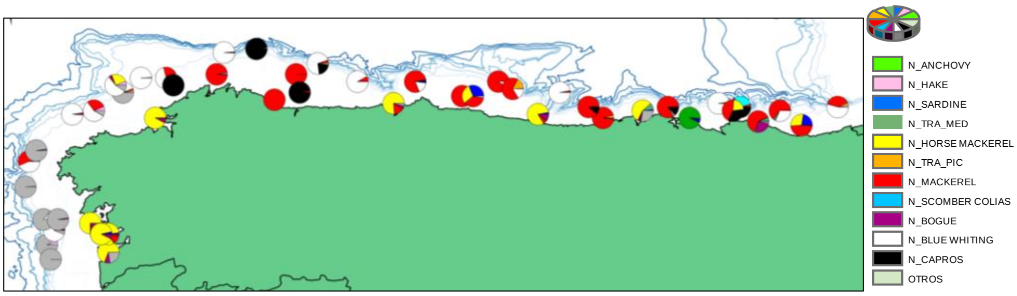


Figure 4.3.2.1. Anchovy in Division IXa. Subdivision IXa North. *PELACUS 0314* survey (spring Spanish acoustic survey in Subdivision IXa North and Sub-area VIII c in 2014). Distribution of pelagic hauls for echotraces identification with indication of the species composition. Subdivision IXa North corresponds to the southwesternmost geographical stratum.

Anchovy was absent in Subdivision IXa North during the present survey. Last year this survey was not able of providing any acoustic estimate for the species in the Subdivision IXa North. Thus, bad weather conditions during that survey caused that the coastal pelagic fish community remained very close to the coast and not accessible to the pelagic gear samplers preventing from a correct allocation of acoustic energy to species.

Table 4.3.2.2 and Figure 4.3.2.2 describe the available anchovy acoustic estimates from this survey series for the Subdivision IXa North.

Table 4.3.2.2. Anchovy in Division IXa. PELACUS survey series (spring Spanish acoustic survey in Subdivision IXa North and Sub-area VIII c). Historical series of acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes) in Subdivision 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
Mar 13	N	-
	B	-
Mar 14	N	0
	B	0

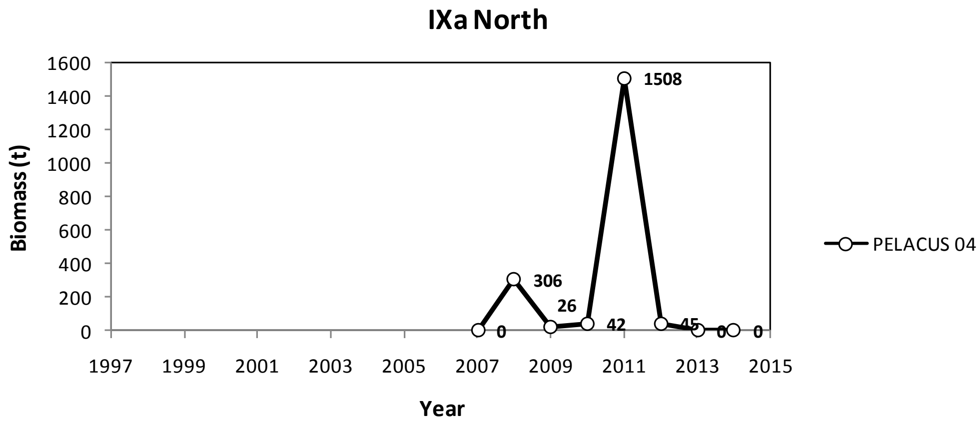


Figure 4.3.2.2. Anchovy in Division IXa. Subdivision IXa North. PELACUS survey series (spring Spanish acoustic survey in Subdivision IXa North and Sub-area VIII c). Historical series of acoustic estimates of anchovy biomass (t) for the Subdivision IXa North.

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 (Subdivisions IXa Central-North, Central-South, and South), between 20 and 200 m depth. This survey series is currently financed by DCF.

The 2012 WGHANSA concluded that the *PELAGO 11* anchovy null estimate in IXa South resulted in a strong underestimation of the actual biomass levels in the region (as inferred by CUFES data during that survey and from the *BOCADEVA 0711* DEPM survey estimates). For this reason the estimates of *PELAGO 11* for anchovy in this area were disregarded for further analyses. There were no *PELAGO* survey in 2012 due to the RV *Noruega* was not operative for the survey season.

PELAGO 14

The *PELAGO 14* survey was conducted this year between the 3rd April and 12nd May on board RV Noruega. Details of the survey are given by Marques *et al*. (WD 2014).

During this survey were performed 44 fishing hauls, with 9 of them being positive for anchovy (Figure 4.3.2.3). The species was mainly found off Cadiz and central Algarve coast. A small anchovy concentration was also found in the west coast, between Matosinhos and Figueira da Foz. Total anchovy biomass in the surveyed area was estimated at 30 864 t (2 371 million fish), with 94% of this biomass being located in Subdivision IXa South (28 917 t) (Table 4.3.2.3; Figures 4.3.2.4 and 4.3.2.6. Age-structured estimates have been provided to this WG only for the Subdivision IXa Central North (Figure 4.3.2.5). In this area anchovy population was composed by fish belonging to the 1, 2, 3 and 4 age groups, with the 1 year anchovies accounting for 74% of the whole estimated population.

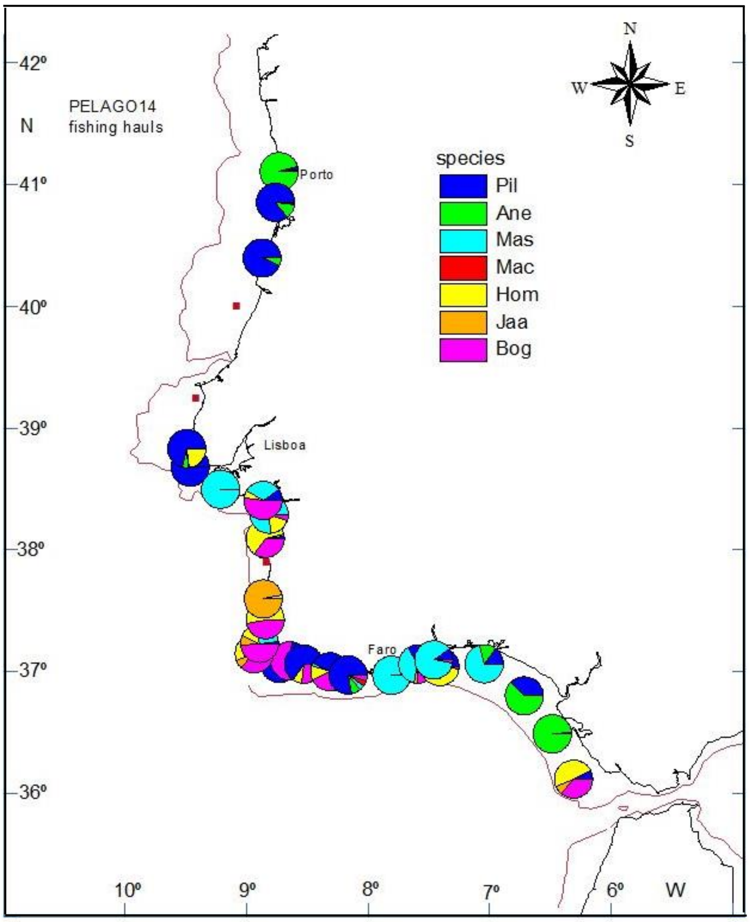


Figure 4.3.2.3. Anchovy in Division IXa. Subdivisions IXa Central-North to IXa South. PELAGO survey series (spring Portuguese acoustic survey in Subdivisions IXa Central-North to IXa South). PELAGO 14 survey. Fishing trawls location and hauls species composition (in number).

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

		Portugal				Spain		
Survey	Estimate	C-N	C-S	S(A)	Total	S(C)	S(Total)	TOTAL
Mar. 99	N	22	15	*	37	2079	2079	2116
	B	190	406	*	596	24 763	24 763	25 359
Mar. 00	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Mar. 01	N	25	13	285	324	2415	2700	2738
	B	281	87	2561	2929	22 352	24 913	25 281
Mar. 02	N	22	156	92	270	3731**	3823**	4001**
	B	472	1070	1706	3248	19 629**	21 335 **	22 877**
Feb. 03	N	0	14	*	14	2314	2314	2328
	B	0	112	*	112	24 565	24 565	24 677
Mar. 04	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 05	N	-	59	-	59	1306	1306	1364
	B	-	1062	-	1062	14 041	14 041	15 103
Apr. 06	N	-	-	319	319	1928	2246	2246
	B	-	-	4490	4490	19 592	24 082	24 082
Apr. 07	N	0	103	284	387	2860	3144	3247
	B	0	1945	4607	6552	33 413	38 020	39 965
Apr.08	N	69	252	213	534	1819	2032	2353
	B	3000	2505	4661	10 166	29 501	34 162	39 667
Apr.09	N	127	0****	159	286	1910	2069	2196
	B	2089	0****	3759	5848	20 986	24 745	26 834
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	27 050	0	0	27 050	0	0	27 050
Apr. 12	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Apr. 13	N	251	0	263	514	634	897	1148
	B	3955	0	5044	8999	7656	12 700	16 655
Apr. 14	N	130	0	26	156	2216	2241	2371
	B	1947	0	509	2456	28 408	28 917	30 864

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

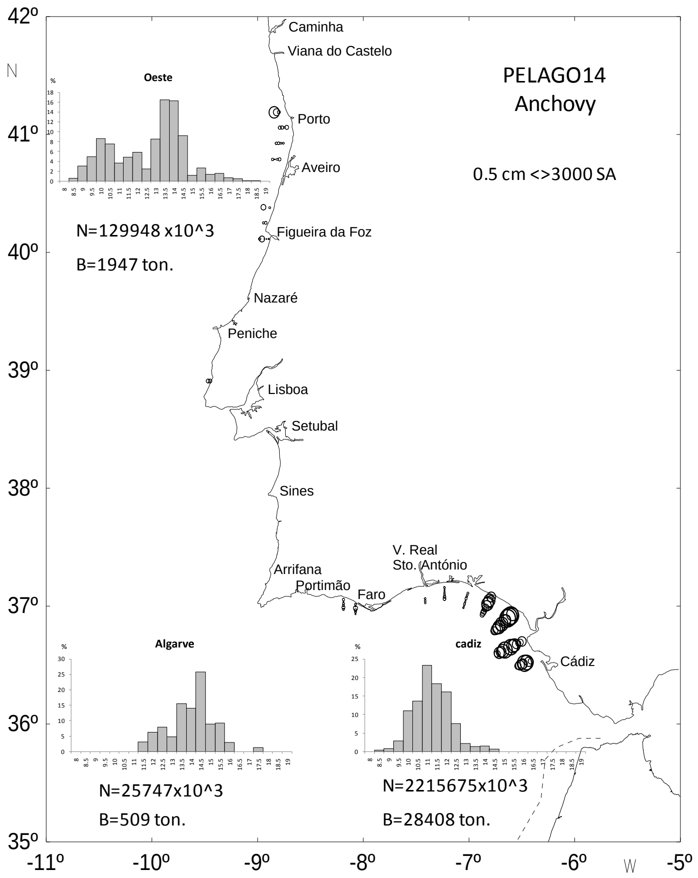


Figure 4.3.2.4. Anchovy in Division IXa. Subdivisions IXa Central-North to IXa South. PELAGO survey series (spring Portuguese acoustic survey in Subdivisions IXa Central-North to IXa South). PELAGO 14 survey. Distribution of the NASC coefficients (m2/mn2) attributed to anchovy, acoustic estimates and size composition of the estimated populations by subareas.

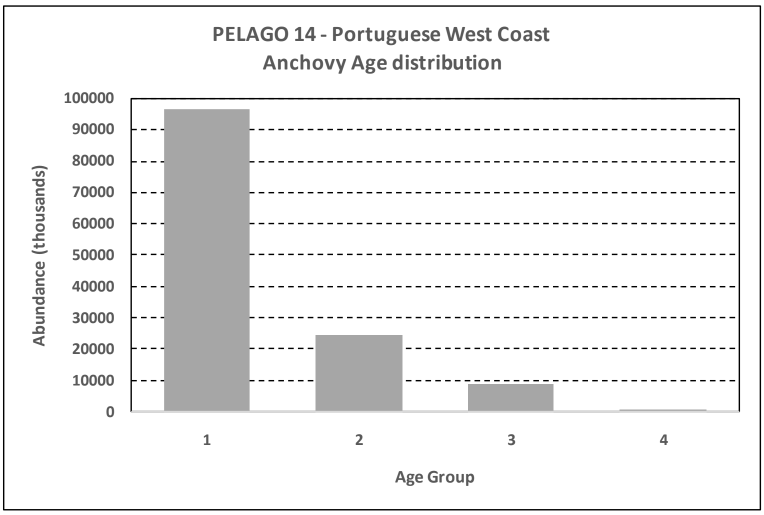
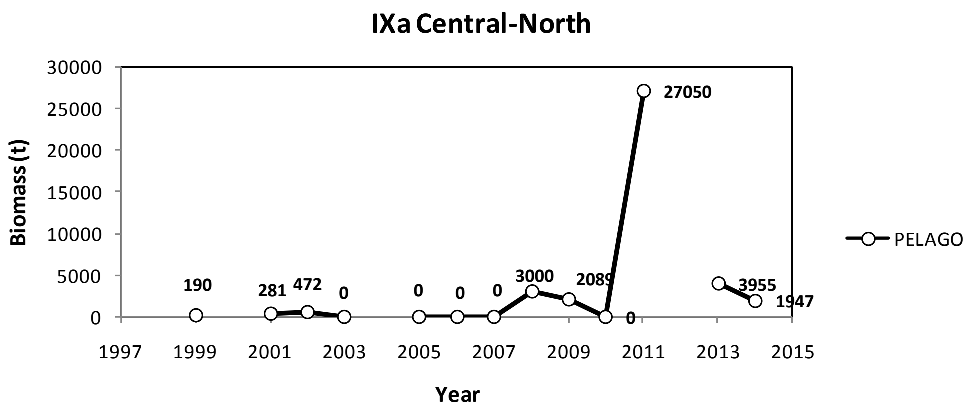
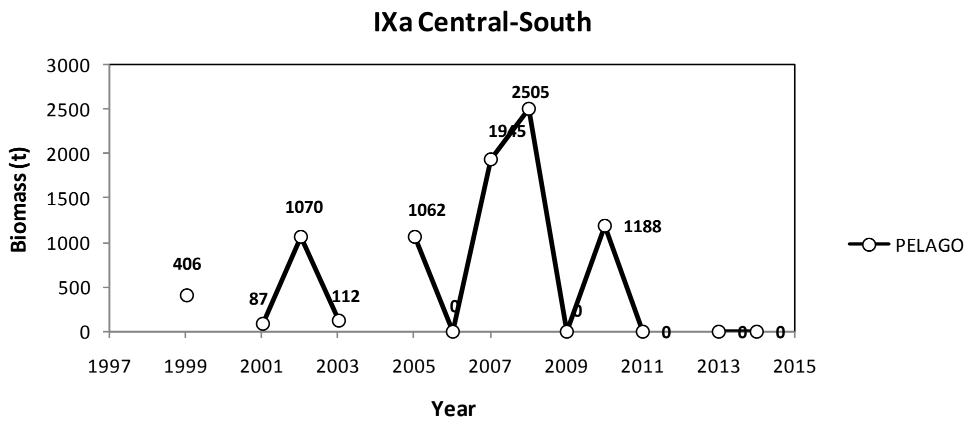


Figure 4.3.2.5. Anchovy in Division IXa. Subdivisions IXa Central-North to IXa South. PELAGO survey series (spring Portuguese acoustic survey in Subdivisions IXa Central-North to IXa South). PELAGO 14 survey. Estimated abundance (number of fish in thousands) by age group from the Subdivision IXa Central North.





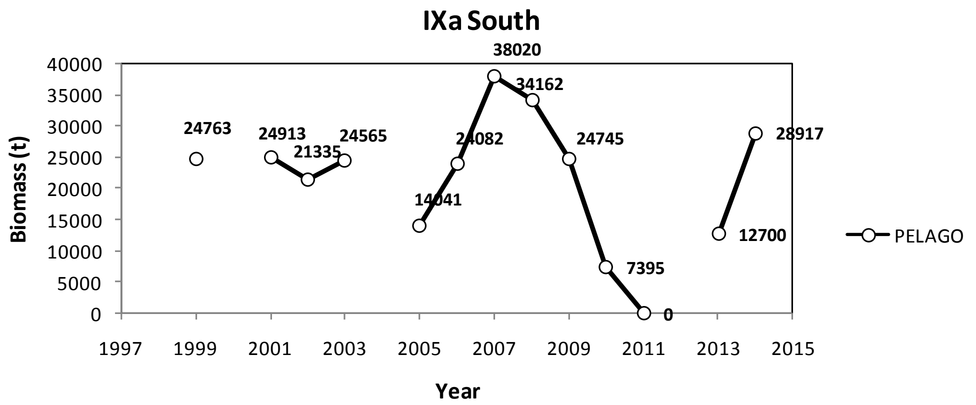
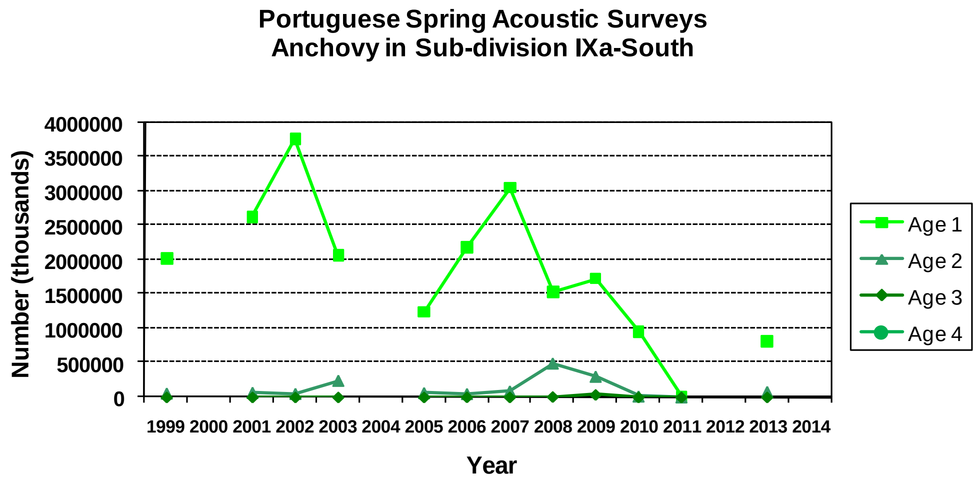


Figure 4.3.2.6. Anchovy in Division IXa. Subdivisions IXa Central-North to IXa South. PELAGO survey series (spring Portuguese acoustic survey in Subdivisions IXa Central-North to IXa South). Historical series of regional acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

Age-structured estimates from the Subdivision IXa South have not been provided to the WG awaiting the validation of age readings from this area which it will be attempted during the next anchovy otolith exchange to be carried out in the fourth quarter this year.

Table 4.3.2.3 and Figure 4.3.2.6 track the historical series of anchovy acoustic estimates from *PELAGO* surveys in the Division IXa. Population levels in the Subdivision IXa South have experienced a remarkable increase which is close to the historical average levels. Conversely, the remaining subdivisions have shown either decreases of different magnitude or they have been maintained around the usually low or even null levels.

Size composition and age structure of the population estimate in IXa South through the series was described in previous reports. In Figure 4.3.2.7 we revisit the trends observed in the age structure of the population as estimated by the *PELAGO* and *ECOCÁDIZ* survey series. For *PELAGO* surveys the 2013 age-structured estimates has been excluded in that figure because they are pending of validation. As described in previous reports, Portuguese acoustic estimates for anchovy until last year were not provided age-structured to the WG. As an alternative, this age structure was estimated by applying the Spanish Gulf of Cadiz commercial age-length keys for the second quarter in the year. It should also be taken into consideration that such keys are based on commercial samples from purse-seine catches and therefore they may result in a biased picture of the population structure because of a different catchability.



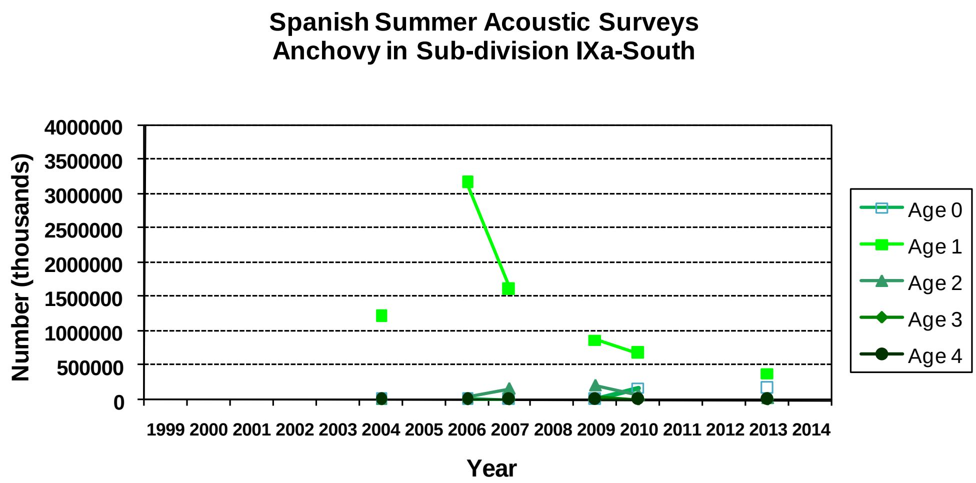


Figure 4.3.2.7. Anchovy in Division IXa. SubdivisionIXa South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cádiz areas by the Portuguese Spring (upper plot) and Spanish summer (lower plot) acoustic surveys. Portuguese estimates has been age-structured using Spanish ALKs from the commercial fishery in the second quarter in the year.

Regarding the last years in the series, the size composition of the estimated population in 2010 it was characterized by a very small number of both small and larger anchovies than in 2009, with larger anchovies than 14 cm being absent, suggesting probably a weak population structure sustaining a very low biomass level in 2010. This perception is corroborated by the age structure as estimated by the Portuguese survey, which evidences a strong decrease in 1 year old anchovies in the population, but especially in 2 year old fish.

The population age structure in previous years suggests strong 2000, (exceptionally) 2001, and 2006 year classes, with the last one still being present in 2009 (as age 3 anchovies). The strength of the 2007, 2008 and 2009 year classes decreased in relation to that observed for the 2006 year class: population numbers of age 1 anchovies in 2008, 2009 and 2010 showed 49.7%, 43.3% and 68.9% decreases in relation those ones estimated in 2007. Notwithstanding the above, the extreme situation that the population reached in spring 2011, when no anchovy was detected in the PELAGO acoustic survey, seems uncertain because the observation of high egg densities during the survey is not consistent with the null detection of biomass with acoustics. Reasons that led to the WG to consider the 2011 acoustic estimate with caution has been commented above. The population age structure in 2013 resembles in a great extent to the one described for 2010. The perception for 2014 is unknown because there is no age structure information on the estimated population.

ECOCADIZ series

The *ECOCADIZ* survey series acoustically samples the shelf waters (20-200 m depth) off the SubdivisionIXa South during midsummer (July).

No *ECOCADIZ* survey was conducted neither in 2011 (ship time invested in the *BOCADEVA 0711* DEPM survey) nor 2012 (no ship-time available). Until 2013 the last estimate from this survey series dates back to 2010 (*ECOCADIZ 0710*).

ECOCADIZ 0813

The *ECOCADIZ 0813* survey was carried out between 2nd and 13th August 2013 on board the Spanish RV*Cornide de Saavedra*. A detailed description of the survey methods and results are given by Ramos *et al*. (WD 2014).

Seventeen (17) fishing operations, 16 of them valid according to a correct gear performance and resulting catches, were carried out (Figure 4.3.2.8).

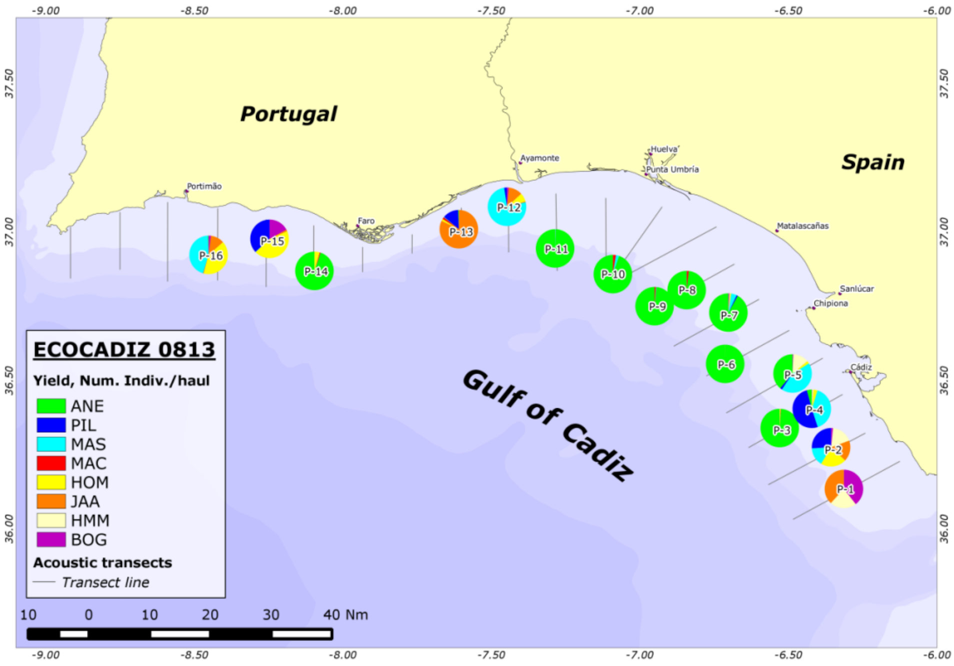


Figure 4.3.2.8. Anchovy in Division IXa. Subdivision IXa South. ***ECOCADIZ 0813*****survey (summer Spanish acoustic survey in Subdivision IXa South).Location of valid fishing stations with indication of their species composition (percentages in number).**

The bulk of the anchovy population was concentrated in the central part of the surveyed area which corresponds to the Spanish shelf. In this area the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus was also recorded to the west of Cape Santa Maria, in waters with a bathymetry between 75 and 108 m depth (Figure 4.3.2.9).

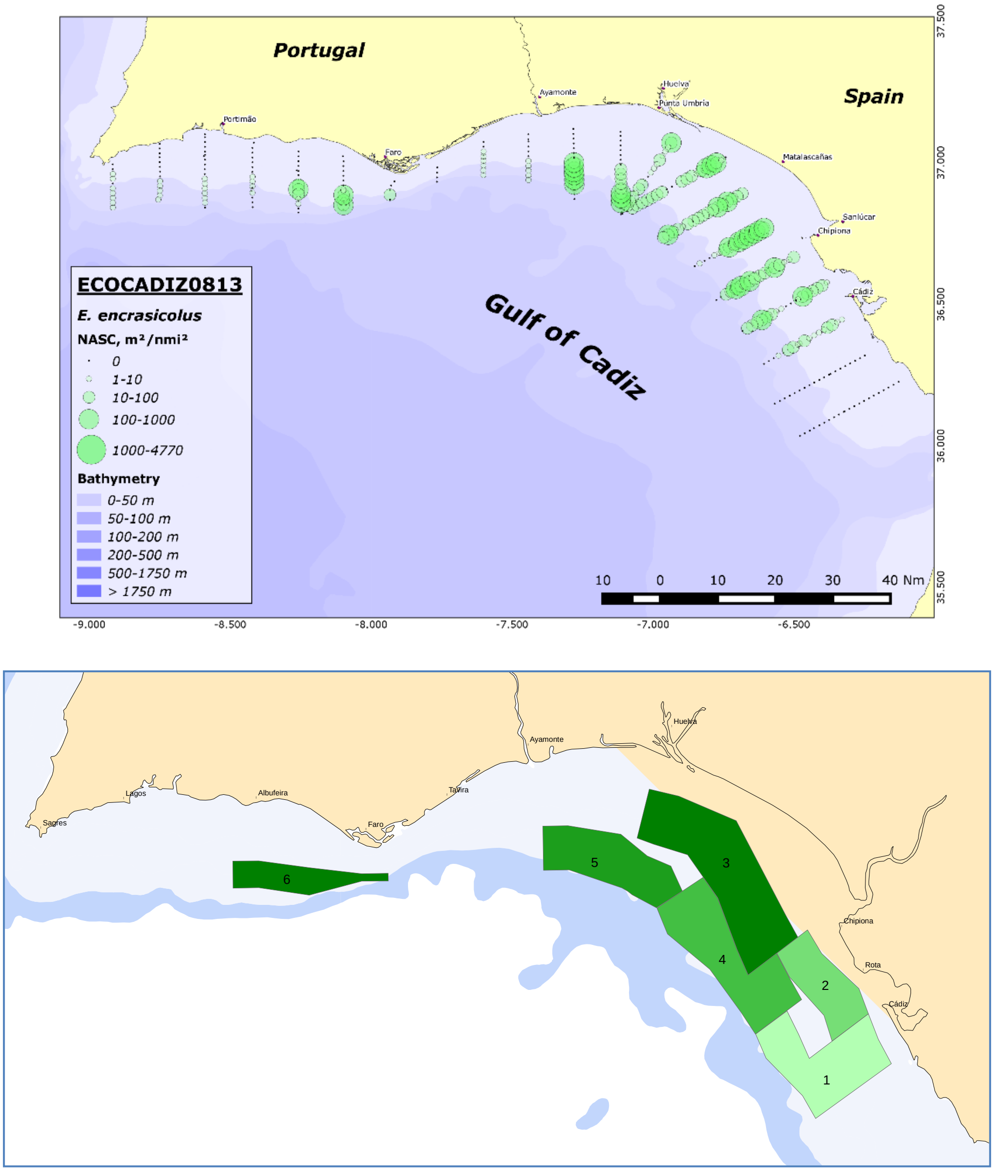
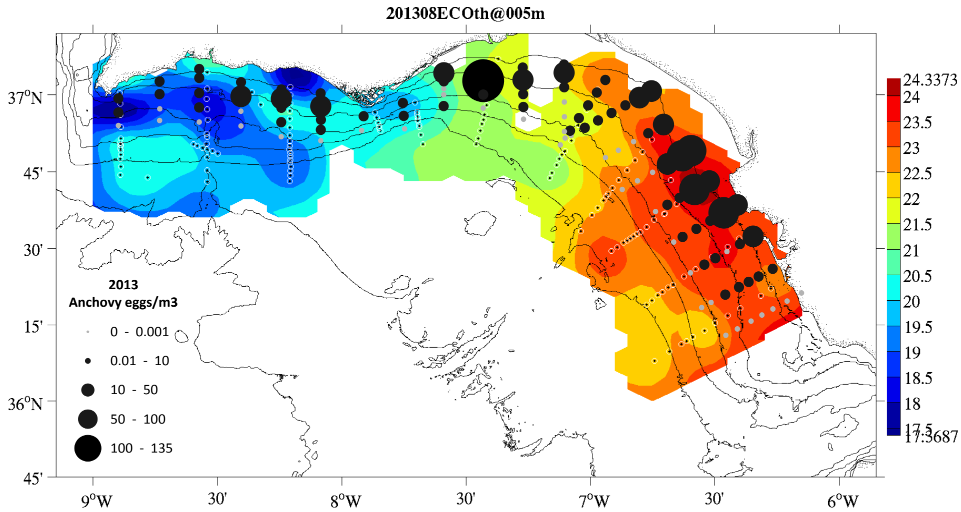


Figure 4.3.2.9. Anchovy in Division IXa. Subdivision IXa South. ***ECOCADIZ 0813*****survey (summer Spanish acoustic survey in Subdivision IXa South).Top: Distribution of the backscattering energy (Nautical area scattering coefficient, NASC, in m² nmi⁻²) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.**

The spatial distribution of anchovy eggs resembled to the above described for the adult population (Figure 4.3.2.10). Greater anchovy egg densities were mainly observed in the inner-middle shelf waters located between Cadiz Bay and Tinto-Odiel rivers mouths. However, the highest egg density (130 eggs m-3) was recorded in a station with a bathymetry of 87.6 m depth located in the closest transect to the Portuguese-Spanish border. In that station were collected a total of 2014 eggs, accounting for 20% of the total of the collected anchovy eggs during the survey, with practically all of them belonging to the *no embryo* stage.



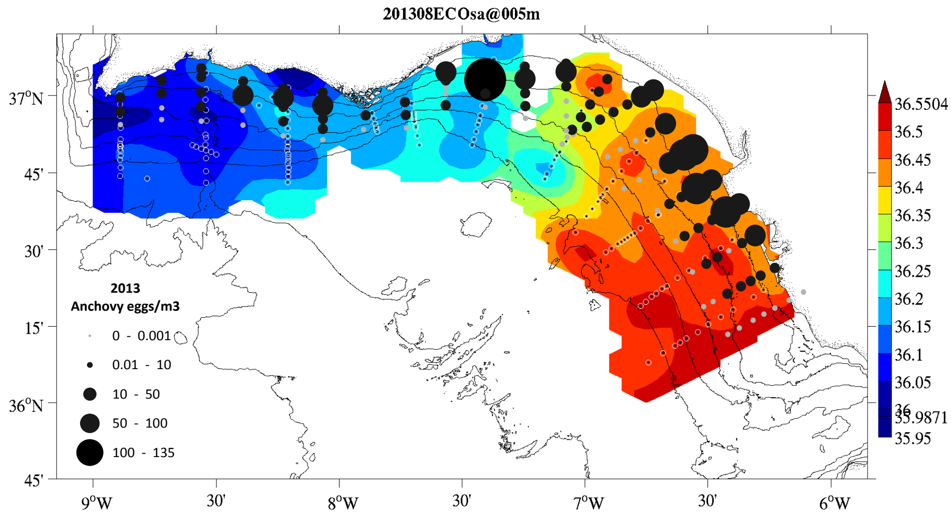


Figure 4.3.2.10. Anchovy in Division IXa. Subdivision IXa South. ***ECOCADIZ 0813*****survey (summer Spanish acoustic survey in Subdivision IXa South).Distribution of anchovy egg densities (eggs m-3) as sampled by CUFES. Both maps show the same egg distribution superimposed to the distribution of sea temperature and salinity at 5 m depth respectively.**

The size class range of the assessed population varied between the 7.5 and 18 cm size classes, with two modal classes at 11 and 14.5 cm. As usual, largest anchovies occurred in the westernmost waters whereas the smallest ones were observed in the central coastal part of the sampled area, coinciding with the location of the main recruitment area close to the Guadalquivir river mouth. The delay of the survey dates in relation to the rest of surveys in the series may be the reason of a higher relative importance of the first modal component in the population, as also happened in the previous survey (in 2010). This fact is a probable consequence of the incorporation of the first waves of recently recruited juveniles to the adult population that usually occur in mid-late summer (Figure 4.3.2.11).

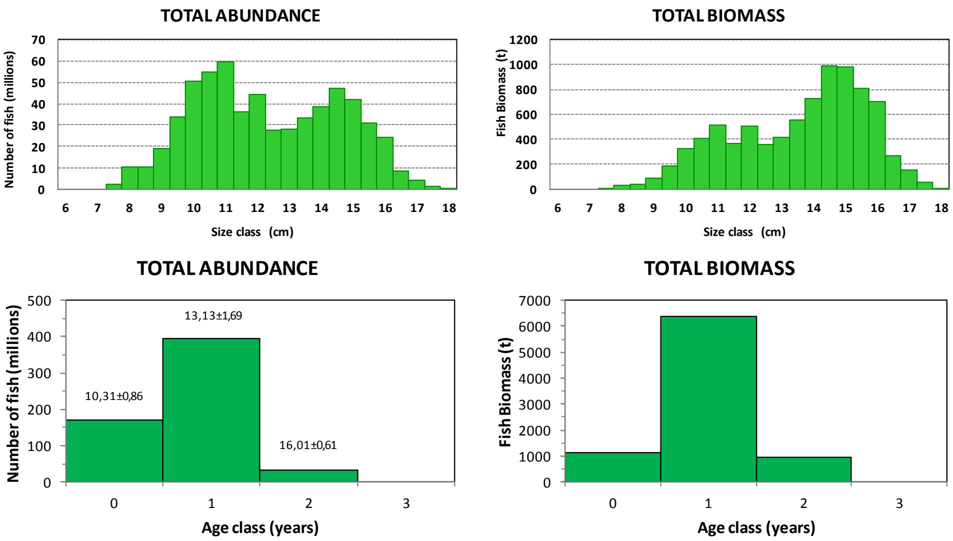


Figure 4.3.2.11. Anchovy in Division IXa. Subdivision IXa South. *ECOCADIZ 0813*survey (summer Spanish acoustic survey in Subdivision IXa South). Estimated abundances and biomasses (number of fish in millions and tonnes, respectively) for the surveyed area. Top row: by length class (cm). Bottom: by age group.

A total of 8487 t and 609 millions of fish have been estimated for this species for the whole surveyed area. Table 4.3.2.4 and Figure 4.3.2.12 track the historical series of anchovy acoustic estimates from *ECOCADIZ* surveys in the Subdivision IXa South.

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

		Portugal	Spain	TOTAL
Survey	Estimate	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	-	-	-

		Portugal	Spain	TOTAL
Survey	Estimate	S(A)	S(C)	S(Total)
	B	-	-	-
Jul. 13	N	50	558	609
	B	1315	7172	8487

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

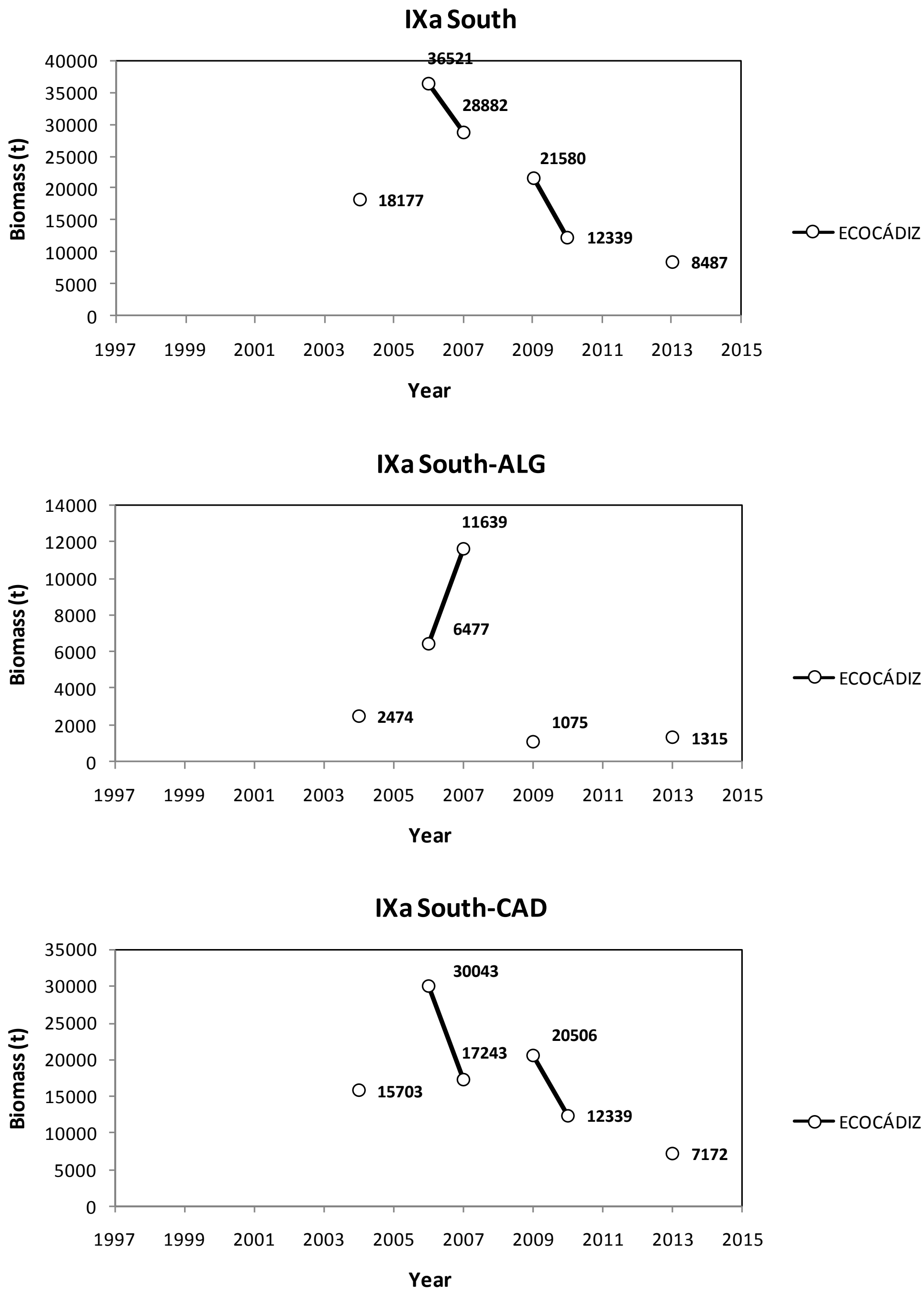


Figure 4.3.2.12. Anchovy in Division IXa. Subdivision IXa South. *ECOCADIZ* survey series (summer Spanish acoustic survey in Subdivision IXa South). Historical series of overall and regional (Algarve, ALG, and Spanish waters of the Gulf of Cádiz, CAD) acoustic estimates of anchovy biomass (t). Note the different scale of the y-axis.

A within-year comparison between *PELAGO 13* and *ECOCADIZ 0813* estimates (see Tables 4.3.2.3 and 4.3.2.4) reveals a marked decrease in the Gulf of Cadiz anchovy population levels in midsummer 2013. During the *ECOCADIZ 0813* survey the greatest decreases in anchovy abundance and biomass were recorded in the Portuguese waters. The above values are also illustrated in the context of their respective historical series in Figure 4.3.2.6 and Figure 4.3.2.11. Anchovy biomass estimates in 2013 were among the lowest ones within their respective survey series. The 2013 *ECOCADIZ* survey estimates even were the lowest ones in the whole series. In their Portuguese counterparts, the anchovy estimate was about the half of the historical average (about 24 kt). In any case, Gulf of Cadiz anchovy has experienced a very fluctuating trend in the recent years.

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). Table4.3.2.5 shows 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 directly used in the qualitative trend-based assessment (but see Figure 4.5.2.2 for estimates in IXa South).

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

		Portugal				Spain		
Survey	Estimate	C-N	C-S	S(A)	Total	S(C)	S(Total)	TOTAL
Nov. 98	N	30	122	50	203	2346	2396	2549
	B	313	1951	603	2867	30 092	30 695	32 959
Nov. 99	N	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-
Nov. 00	N	4	20	*	23	4970	4970	4994
	B	98	241	*	339	33 909	33 909	34 248
Nov. 01	N	35	94	-	129	3322	3322	3451
	B	1028	2276	-	3304	25 578	25 578	28 882
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	16 091	23 723	24 843

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

ECOCÁDIZ-RECLUTAS survey series

This series started in autumn 2009 as the first attempt by the IEO of acoustically assessing the abundance of anchovy and sardine juveniles in their main recruitment areas off the Gulf of Cadiz. However, the succession of a series of unforeseen problems during that survey drastically reduced the foreseen sampling area to the easternmost zone only. The continuation of this survey series was not guaranteed for next years and in fact no survey of these characteristics was carried out in 2010 and 2011. In 2012 the survey was financed by the Spanish Fisheries Secretariat and planned and conducted by the IEO (Table 4.3.2.6). The next survey will be conducted in October this year.

Table 4.3.2.6. Anchovy in Division IXa. ECOCADIZ-RECLUTAS survey series (autumn Spanish acoustic survey in Subdivision IXa South). Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes).

		Portugal	Spain	TOTAL
Survey	Estimate	S(A)	S(C)	S(Total)
Nov. 12*	N	-	2649	
	B	-	13 680	

***Partial estimate because only the Spanish waters were acoustically surveyed.**

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.

Table 4.4.1.1. Anchovy in Division IXa. Subdivision 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	
2012	8 300	14 326	22 530	
2013	6 414	11 865	21 767	

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).

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

	Age		
Year	**0**	**1**	**2+**
1988	0	0.82	1
1989	0	0.53	1

Year	Age 0	1	2+
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
2012	0	0.89	1
2013	0	0.94	1

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 were the basis for a previous data exploration of anchovy catch-at-age data in Subdivision IXa South (Algarve and Gulf of Cadiz) until 2009 by applying an*ad hoc* seasonal (half-year) separable model implemented and run on a spreadsheet (Ramos *et al.*, 2001; ICES, 2002). Nevertheless, the exploratory assessments performed with this model were not recommended as a basis for predictions or advice due to they did not provide any reliable information about the true levels of the stock, F and Catch/SSB ratios since the assessment was not 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.

Upon request from the Workshop on the Development of Assessments based on life-history traits and exploitation characteristics (WKLIFE), a first compilation and further exploration of available data on life-history traits (LHTs) of anchovy in Division IXa was presented in the last year's WG.Length-based reference points considered were: length (L_{mat}) at 50% maturity, von Bertalanffy growth parameters (Linf (L_{∞}), K, t_0), mean length at first capture (L_c, determined as the length at half of the maximum frequency in the ascending part of the curve), length where growth rate in weight is maximum (L_{opt}, where L_{opt}= 2/3 of *Linf* (L_{∞})), and the theoretical length resulting from fishing with F = M ($L_{(F=M)}$, where $L_{(F=M)}$= (3 * L_c+ *Linf*)/4). With weighted mean length in the catch (L_{mean}) as indicator (computed as the mean of fish larger than L_c), several of these population characteristics could be used as reference points to infer relative exploitation and relative stock status.

This exploratory analysis was focused in anchovy LHTs from the Subdivision IXa South (Cadiz) because of the greater data availability. Details of this analysis were reported in the last year's WG report. The resulting estimates seemed to suggestthat the stock is supporting in its recent history a reasonable exploitation with L_{mean}above $L_{(F=M)}$ and very close to L_{opt} and L_c=L_{mat}. Nevertheless, WG members questioned the validity or appropriateness of these reference points for short-lived species like anchovy (with stocks and catches supported mainly by only age group and a fishery operating around spawning time). For the above reasons this exploratory analysis has not been updated this year.

4.5.2 Trends of biomass indices

Subdivision IXaSouth

The provision of advice since 2009 has been traditionally restricted to Subdivision 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 and 2009 RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data for the Subdivision IXa South, both fishery-dependent and –independent information (*i.e.* landings, fishing effort, cpue, survey estimates). A summary of these trends for the Subdivision IXa South is shown in Figures 4.5.2.1 and 4.5.2.2. 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 indices (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**)

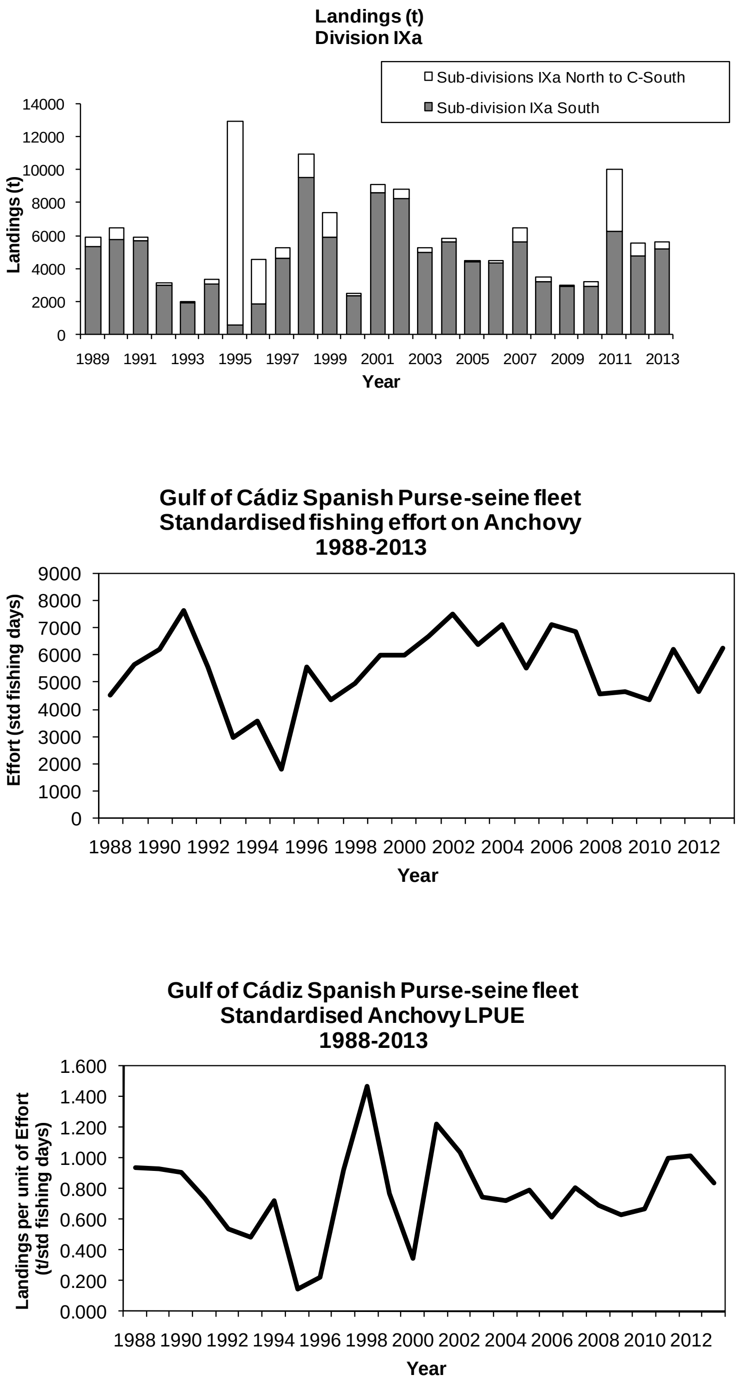
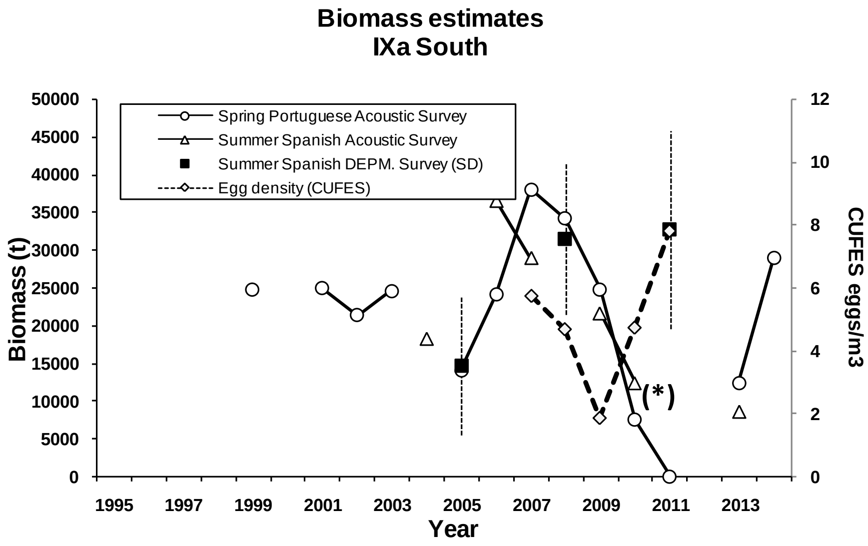


Figure 4.5.2.1. Anchovy in División IXa. Anchovy in SubdivisionIXa South. Information used in the Qualitative (Updated) Assessment. Top: total annual landings in Division IXa differentiated between Subdivision IXa South (Algarve + Gulf of Cádiz) and remaining Subdivisions. Middle: standardized fishing effort (fishing days) exerted by the Spanish purse-seine fleet in the Subdivision. Bottom: standardized anchovy LPUE (tonnes/fishing day) of the same fleet.



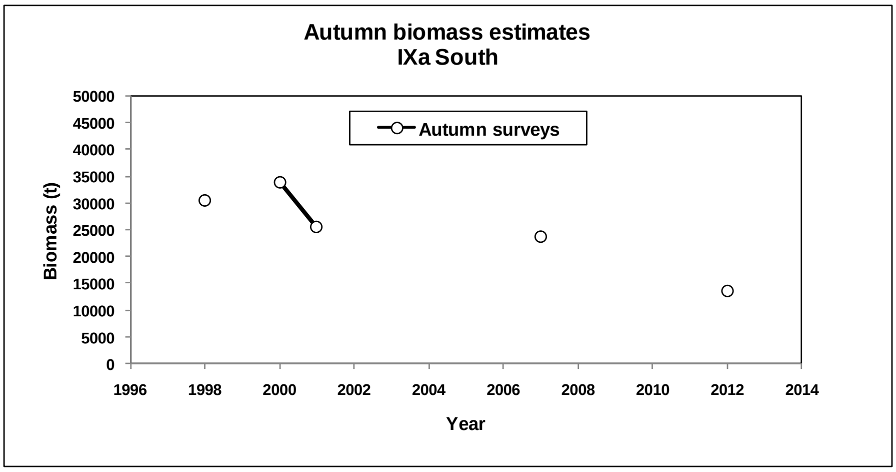


Figure 4.5.2.2. Anchovy in Division IXa. Anchovy in SubdivisionIXa South. Information used in the Qualitative (Updated) Assessment (cont'd). Top: available biomass estimates from research surveys series sampling the Subdivision in spring/summer used for comparative purposes. Anchovy egg densities sampled 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 2011 despite of having independent axis for reference). No CUFES eggs data available for the 2013 and 2014 surveys. Asterisk denotes that the 2010 ECOCÁDIZ survey only partially explored the whole survey area. There are no available estimates in 2012.Bottom: available biomass estimates from research surveys series sampling the Subdivision in autumn. SARNOV (1998, 2000, 2001, 2007) and ECOCÁDIZ-RECLUTAS (2012) surveys have been merged in one only series.

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 eggssampled by CUFES during that survey were found at comparable or even higher levels than in the previous year 2010 during that acoustic survey, which was 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, In addition, the *BOCADEVA* DEPM survey, conducted in July 2011, provided a new indication about the state of the anchovy biomass in 2011, pointing to an SSB estimate of 32 757 t.This confirmed that the reluctance of the WG to adopt the

PELAGO estimate as areliable indicator in that year was correct. *BOCADEVA*indicated a recovery of the biomass in 2011 up to levels above the average. Unfortunately, there was no indication about the state of the anchovy biomass in spring/summer 2012 since no survey index was available. The *ECOCÁDIZ-RECLUTAS 1112* autumn survey provided a partial estimate (since only the Spanish waters were surveyed) of 13 680 t in autumn 2012, which matches well with the estimates provided later by the *PELAGO* survey in spring 2013 (12700 t) and by *ECOCADIZ* survey in summer this same year (8487 t). The *PELAGO 2014* biomass estimate indicates a recovery of the population levels to the average ones in its historical series. Thus, landings suggest a rather stable situation for the fishery in this area, and the most recent population estimates suggest a stock in this area around the average in 2014. Results from the *ECOCÁDIZ* survey in early August this year will contribute to the perception about the state of the anchovy biomass in 2014.

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 4.5.2.3). This was probably due to a strong recruitment in that area (as modal lengths range between 13 and 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-90s, 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. In fact, the anchovy population in this area has experienced a sevenfold decrease in biomass since then (4 thousand tonnes estimated in 2013, and about 2 thousand tonnes in 2014), coming back to its historically usual low population levels.

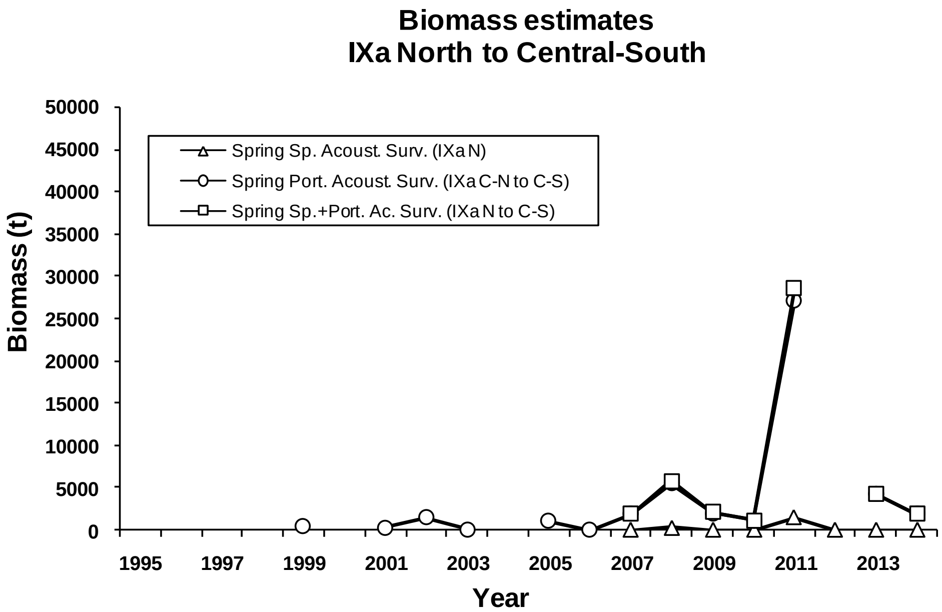


Figure 4.5.2.3. Anchovy in Division IXa. Anchovy in Subdivisions IXa North to Central-South (Western Iberian Atlantic façade). Information used in the Qualitative (Updated) Assessment: available biomass estimates from research surveys series sampling the Subdivisions used for comparative purposes. For 2012 the only available estimates is the one from the PELACUS 04 survey for IXa North.

Whole Division IXa

Figure 4.5.2.4 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 Subdivisions 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 Subdivisions of Division IXa (see management considerations about the definition of stocks in this area below).

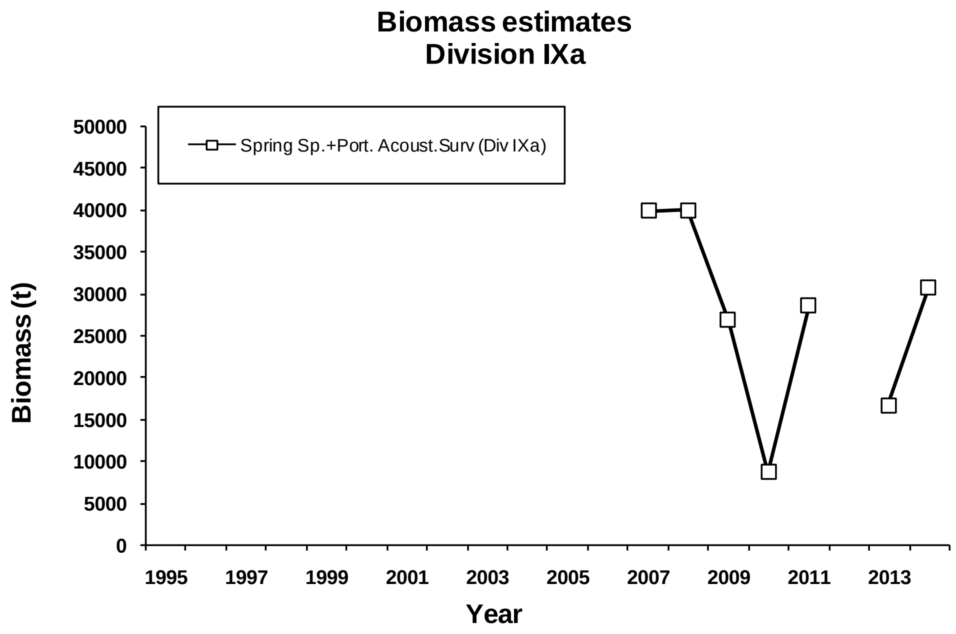


Figure 4.5.2.4. Anchovy in Division IXa. Information used in the Qualitative (Updated) Assessment of the whole Division: available biomass estimates from research surveys series sampling the Division. For consistency, when merging estimates for the whole Division, only spring surveys (both PELACUS 04 and PELAGO) have been considered.

4.5.3 Assessment of 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 IXaSouth was directly tried in last years through the estimation of the quotient between total Catch (tons) and Survey Biomasses for a range of potential catchabilities of the surveys. This has been updated this year for the new surveys in 2013 and 2014. 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. In addition the range of catchabilities explored went from 0.6 to 1.6. The results of harvest rates for the different catchabilitiesare shown by years in **Table 4.5.3.1**. On average, for a catchability = 1, HR = 25.5% (CV of 0.45) and a maximum individual HR happens in 2013 with a HR of 49%. The sensitivity analysis for the range of selected catchabilitiesis at the bottom of Table 4.5.3.1. If catchabilities are higher than 1, the actual biomasses at sea would be lower and hence the HR will be higher than for catchabilities = 1, by a proportion equal to the catchabilityraising factor. As such for a catchability= 1.6the average HR would be around 40.8% (CV of 0.45) and the maximum individual year value would rise up to 79.1%.

Table 4.5.3.1. Anchovy in Division IXa. Subdivision 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).

Biomass (tonnes)	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Mean**	**Desvest**	**CV**	**Max**	**Min**
PELAGO (Acoustic)	24.763		24.913	21.335	24.565		14.041	24.082	38.020	34.162	24.745	7.395	failed		12.700	28.408	22.793	8920.7	39.1%	38.020	7.395
ECOCADIZ (Acoustic)						18.177		36.521	28.882		21.580	12.339			8.487		20.998	10420.3	49.6%	36.521	8.487
BOCADEVA (DEPM)							14.637			31.527			32.757				26.307	10125.2	38.5%	32.757	14.637
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		10.593		23.159	8119.0	35.1%	33.451	9.867
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	4.810	5.240		5.043	1827.7	36.2%	8.655	2.360
Harvest Rate (For Q=1)	24%		35%	39%	20%	31%	31%	14%	17%	10%	13%	30%	19%		49%		25.5%	11.5%	45.1%	49.5%	9.8%
Harvest Rate by Q levels																					
0.6	0.144		0.208	0.232	0.121	0.185	0.185	0.087	0.101	0.059	0.077	0.178	0.115		0.297		15.3%	6.9%	45.1%	29.7%	5.9%
0.8	0.192		0.278	0.310	0.162	0.247	0.247	0.116	0.134	0.078	0.102	0.237	0.154		0.396		20.4%	9.2%	45.1%	39.6%	7.8%
1	0.240		0.347	0.387	0.202	0.309	0.308	0.145	0.168	0.098	0.128	0.297	0.192		0.495		25.5%	11.5%	45.1%	49.5%	9.8%
1.2	0.288		0.417	0.465	0.243	0.371	0.370	0.174	0.201	0.117	0.153	0.356	0.231		0.594		30.6%	13.8%	45.1%	59.4%	11.7%
1.4	0.336		0.486	0.542	0.283	0.433	0.432	0.202	0.235	0.137	0.179	0.416	0.269		0.692		35.7%	16.1%	45.1%	69.2%	13.7%
1.6	0.384		0.556	0.620	0.324	0.494	0.493	0.231	0.268	0.156	0.204	0.475	0.307		0.791		40.8%	18.4%	45.1%	79.1%	15.6%

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 on the different Q values, are at maximum, but generally well below the HR corresponding to the 50% SBR per recruit (= 0.78). As such, the Expected %SBR for the range of HR for this fishery resulting from sensitivity analysis above should generate Spawning Biomass per Recruit above 50% (see summary Table 4.5.3.2), thus the stock seems to be explored sustainable, for any potential catchability value below or equal to 1.6.

Table 4.5.3.2. Anchovy in Division IXa. Subdivision IXa South. Sensitivity assessment of the Status Quo exploitation of Anchovy in IXa South to different levels of average catchability of surveys. For selectivity fixed at F age 1 of 1

Sensitivity Assessment	0.6	0.8	1	1.2	1.4	1.6
Catchability of Surveys	q = 0.6	q = 0.8	q = 1	q = 1.2	q = 1.4	q = 1.6
Mean Harvest Rate (HR)	15.3%	20.4%	25.5%	30.6%	35.7%	40.8%
HR standard Deviation	6.90%	9.20%	11.50%	13.80%	16.10%	45.10%
CV	0.451	0.451	0.451	0.451	0.451	1.105
MIN (HR)	5.9%	7.8%	9.8%	11.7%	13.7%	15.6%
MAX (HR)	29.7%	39.6%	49.5%	59.4%	69.2%	79.1%
%SBR of Mean(HR)	84%	79%	75%	Not made	68%	66%
%SBR of Min(HR)	93%	91%	89%	Not made	86%	82%
%SBR of Max (HR)	72%	67%	61%	Not made	67%	50%

The exercise has not been repeated for the western Subdivisions (IXa North to IXa Central South), but notice that for the year of significant fishery, in 2011, a harvest ratio of about 13% can be derived from the merged acoustic estimates in these subdivisions (28 558 t) in relation to 3782 t of anchovy landings. This rate is even at a lower level than those ones estimated in the Subdivision IXa South.

4.6 Prediction

There is no basis to predict the status of the anchovy population in 2015.

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 be 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:

In 2012 we defined two vectors of relative catches-at-age,generated from the catch statistics:a first vector corresponded to the average age composition in the period 1999-2011. A second vector corresponded to the catches in the earlier period and 2011 (years 1996, 1997, 1998 and 2011) when catches-at-age 0 were more abundant. These two vectors are summarized 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%	

As the addition of the 2012 and 2013 catches would generate mean catches-at-age for the period 1999-2013 almost equal to the period 1999-2011 (see table below), and it is somewhere in the middle between the one typical of the period 1999-2011 and that of the period 1996, 1997, 1998 and 2011.

Mean Catches at age	Age 0	Age 1	Age 2	Age 3	Total
Mean 1999-2013	89.041	402.436	13.977	0.273	505.727
Percentage at age	17.6%	79.6%	2.8%	0.1%	

Then the WG has decided not to remake the calculations associated to the sensitivity analysis which follows (as done in 2012). And as such the two catch-at-age vectors have remained constant and correspond to the two types of catches, one for the period 1999-2011 and the other for the period 1996, 1997, 1998 and 2011 (when ages 0 were more abundant in catches).

Mean weights at age in the catches for the same period 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) ,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 timeswere set to occur at the middle of the year. For the acoustic *ECOCADIZ* and DEPM *BOCADEVA* surveys this is correct, as they are made in June-July, though acoustic *PELAGO* survey is made in April.

Sensitivity to the vector of natural mortality was not made as it has been assumed to be constant across ages at an annual rate of 1.2, which given the extremely few ages 2 or older seems to be plausible value for this population.

The Y/R assessment was made with an Excelspreadsheet, 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 Table 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; As such all reference points calculated, in terms of Spawning Biomass per Recruit (at 50%, 40% and 35%) as well as F_0.1, were rather similar across the potential alternative selectivities at age (Table 4.7.1). 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 to 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 (with a mean and a maximum at 0.25 and 0.79, see **Section 4.5.2**), according to the selected range of potential survey catchabilities, it seems very likely that HR over the last 14 years are at or below HR_50%(SBR), so at sustainablelevels.

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. A plot with the reference points for F and HR corresponding to the selectivity at age fitted with a presumed F at age 1 = 1 (as an example) are shown in Figure 4.7.2. Again F_0.1 is rather similar to assumed M, and F_(35%SPR) and F_50%(SPR) fall to 0.49 and 0.32. The value of F_0.1 was not sustainable, as it resulted in 9% of %SBR. Results in terms of Harvest Rates were rather coincident with the former analysis on the other vector of catches-at-age: 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 (with a mean and a maximum at 0.25 and 0.79, see **Section 4.5.2**), according to the selected range of potential survey catchabilities(from 0.6 to 1.6), it seems very likely that HR over the last 14 years are at or below HR_50%(SBR), so at sustainable levels.

Table 4.7.1. Anchovy in Division IXa. Subdivision 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

ANALYSIS	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

ANALYSIS	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**

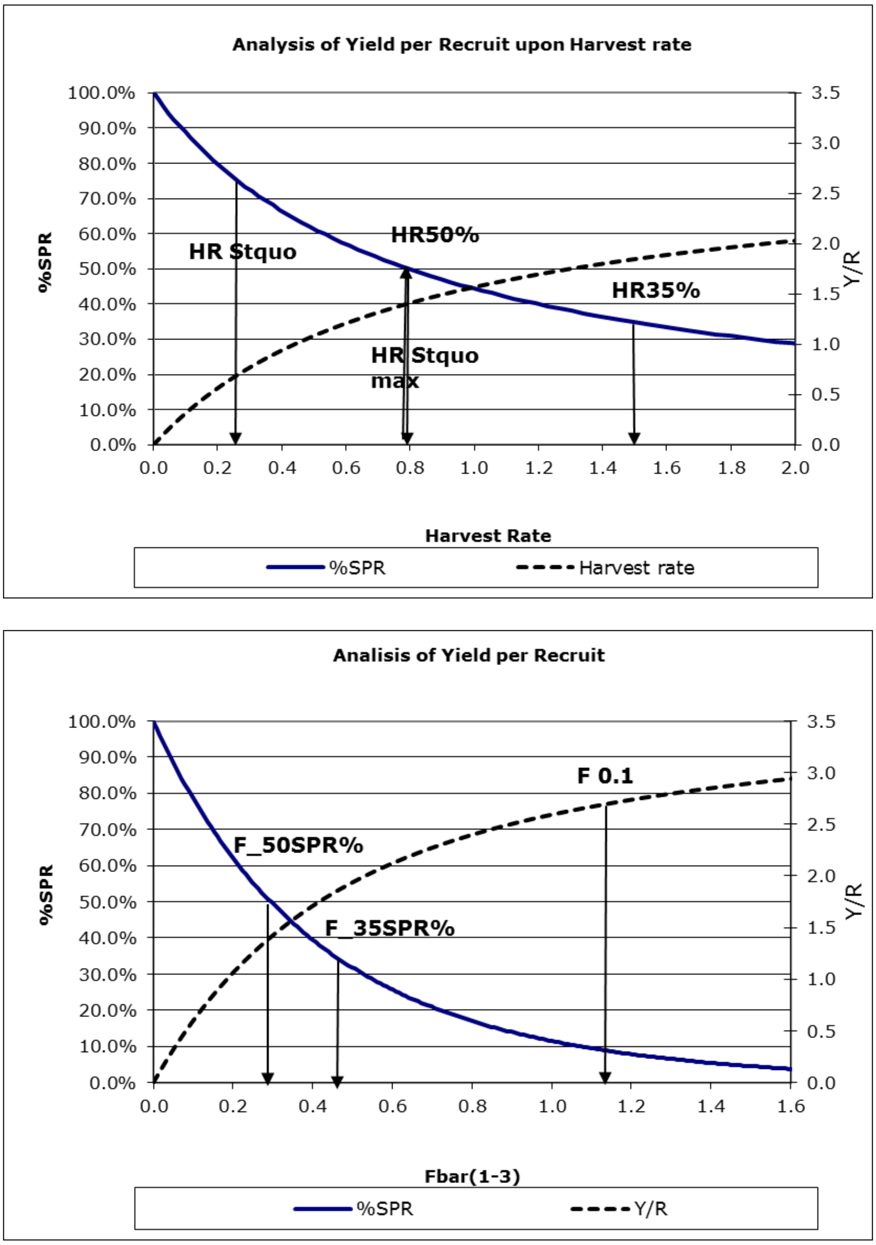
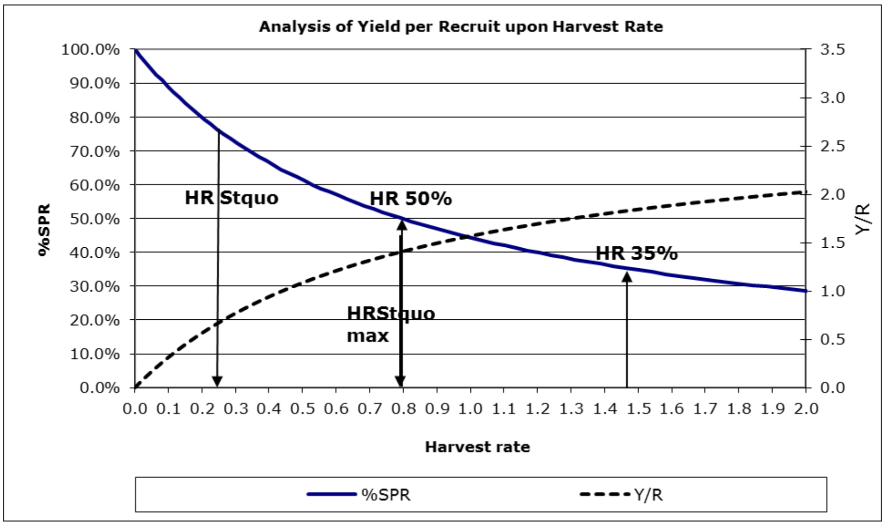


Figure 4.7.1. Anchovy in Division IXa. Subdivision IXa South. Plots with some reference points for Harvest Rate (HR) and Fishing Mortality (F) corresponding to the selectivity at age of the period 1999-2011, fitted with a presumed F at age 1 = 0.6.



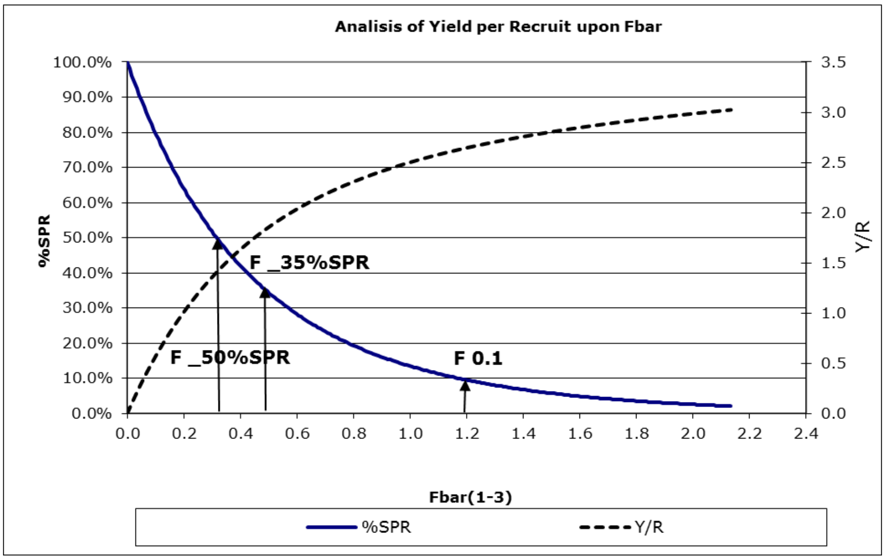


Figure 4.7.2. Anchovy in Division IXa. Subdivision IXa South. Plots with some reference points forHarvest Rate (HR) and Fishing Mortality (F) corresponding to the selectivity at age of the period 1996, 97, 98 and 2011, fitted with a presumed F at age 1 = 1.

4.8 Management considerations

4.8.1 Definition of stock units

A summarized 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 Subdivision 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 Subdivision 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 2014 the acoustic detection of anchovy biomass by *PELACUS* and *PELAGO* spring surveys in Subdivisions IXa North to Central-North drop to 1 947 t from 4 284 t estimated in 2013. Contrary to this, the acoustic estimates in subdivision IXa South raised up to 28 917 t from 12 700 t estimated in the previous year (see Figures 4.5.2.2 and 4.5.2.3). Such 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 of a reversed situation in the period 1995/96 and in 2011, see Figure 4.8.1.1.c).

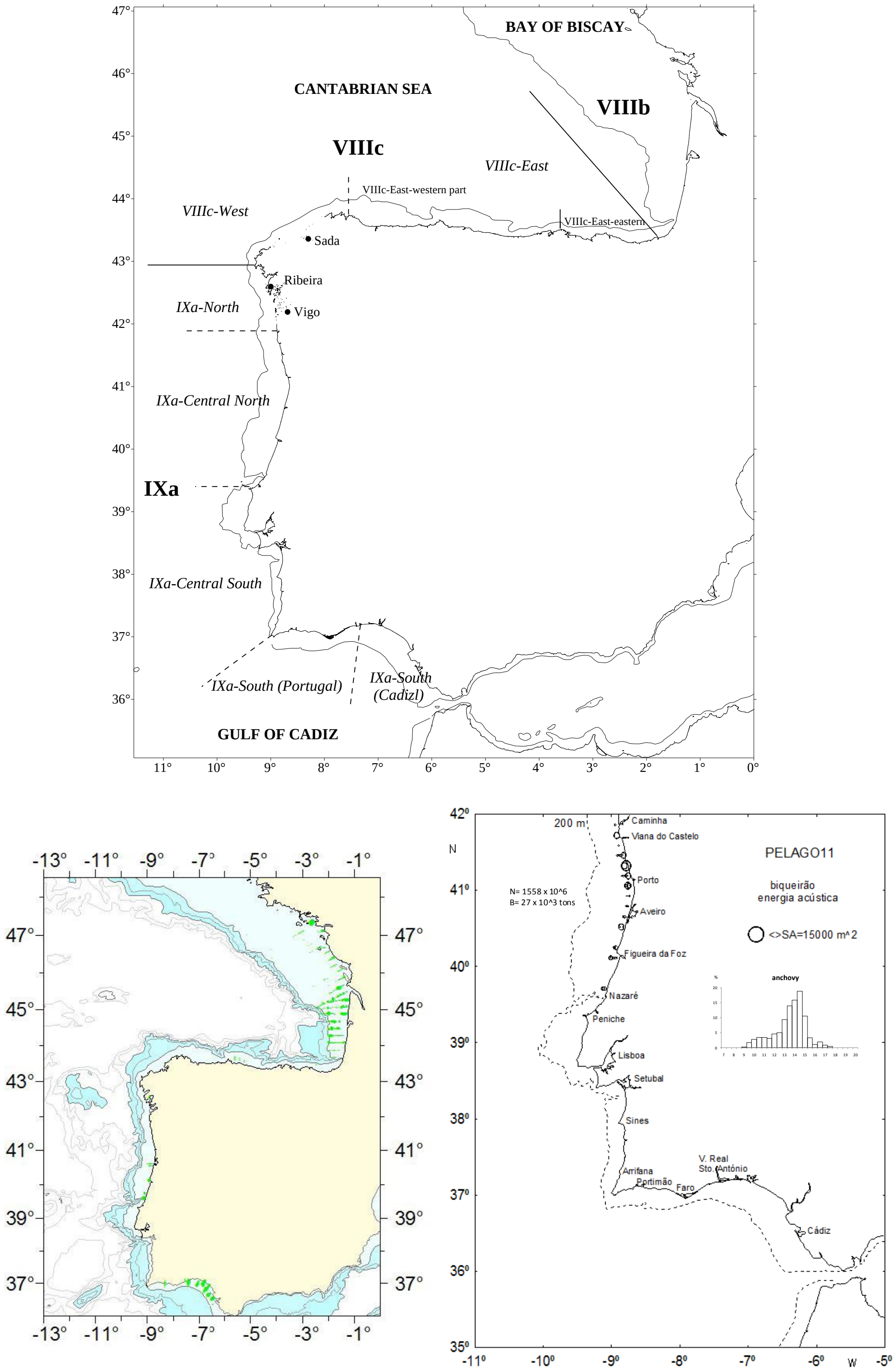


Figure 4.8.1.1. Anchovy in Division IXa. A) Geographical distribution of Subdivisions. B) Usual distribution of the anchovy populations throughout the Division as derived from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b). C) Spatial pattern of the anchovy abundance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

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 from 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 themorphological segregation pattern described by Canecoet *al*., (2004). That study suggests that the differences between areas could reflect slight adaptive reactions to smallenvironmental differences.

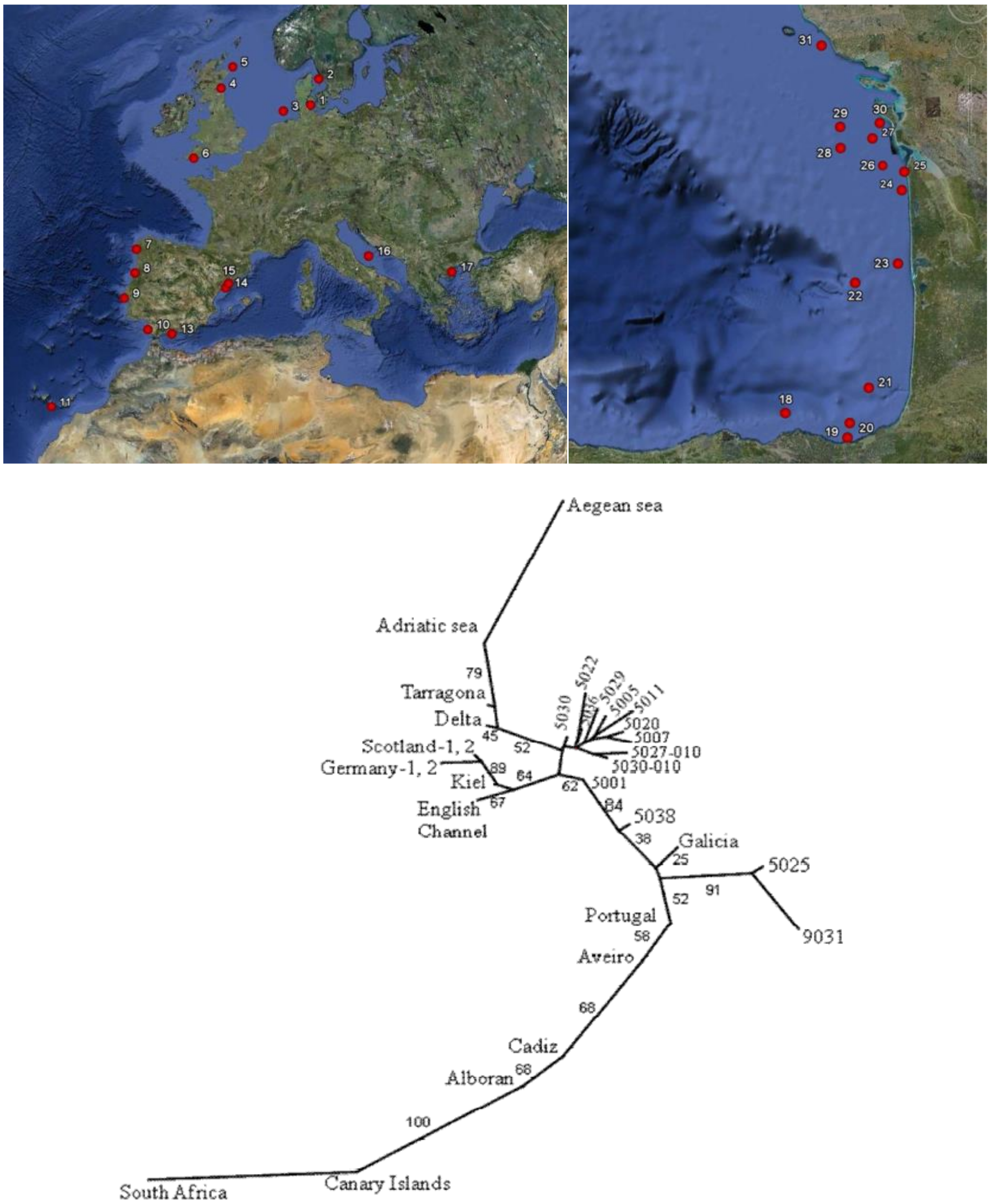


Figure 4.8.1.2. Anchovy in Division IXa. Results from Zarraonandía's (2012) studies on genetic structure of European anchovy populations using single nucleotide polymorphisms (SNP). Upper row: geographical location of the analysed samples. Lower figure: Neighbour-Joining (NJ) dendrogram based on Reynolds distances among all the analysed localities. Topological confidence obtained by 1000 bootstrap replicates.

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 Subdivision 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.

As the last year, this issue will also be translated to the formulation of the advice this year.

4.8.2 Current management situation

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

Portuguese purse-seine fishery has a fishing ban for sardine of 45 days per year since 2011, although catches of other pelagic species is permitted there is marked decline in the fishing effort.

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 summarized 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. Between 2004 and 2012 two complementary sets of management measures affecting directly to the Gulf of Cadiz fishery have been implemented. The first one was the"*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 andincludes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November and 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 autumn 2010-winter 2011 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 autumn 2011-winter 2012 in December 2011 and January 2012.

The plan also included 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. This Plan was in force until 2012.

The second management action in force since 15th of July 2004 inthe 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 gillnets and trammelnets, although in those waters outside the riverbed. Neither purse-seine nor bottom-trawl fishing is allowed all over this MPA.

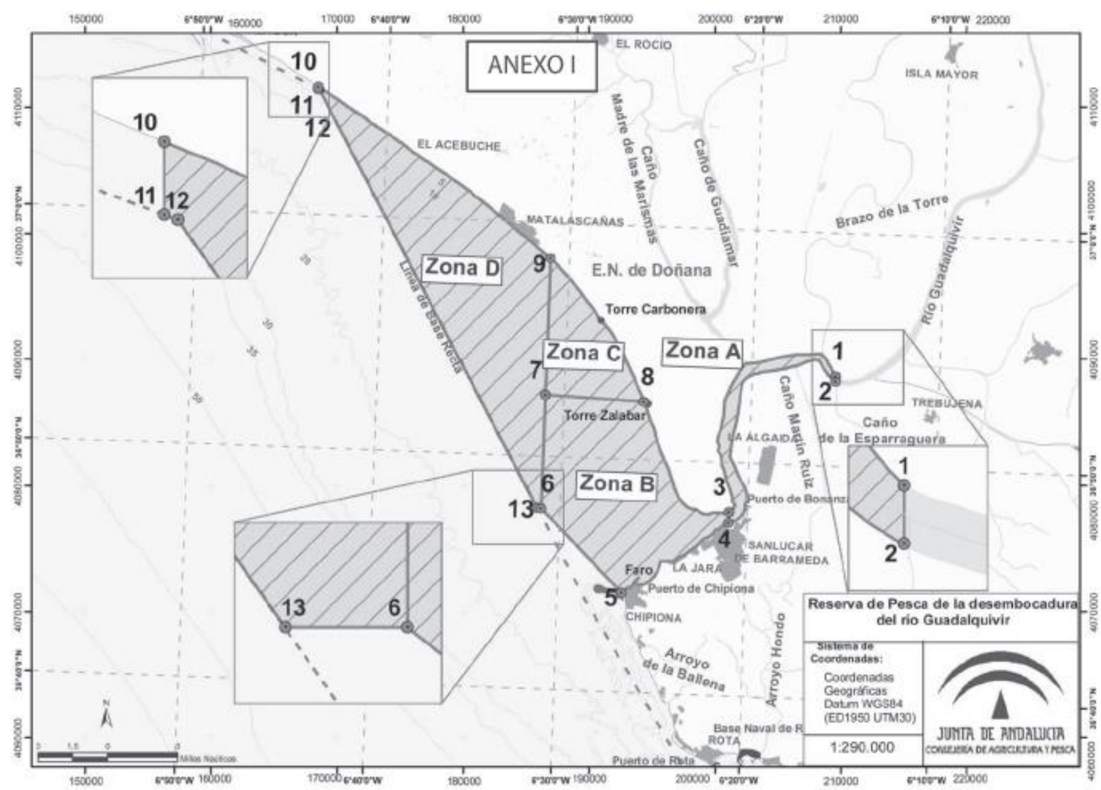


Figure 4.8.2.1. Anchovy in Division IXa. Subdivision IXaSouth. Limits of the Fishing Reserve off the Guadalquivir River mouth (Spanish waters of the Gulf of Cadiz).

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.

In April 2013 Spain has implemented a new management plan for fishing vessels operating in its national fishing grounds, so it affects the purse-seine fishing in Galician (IXa North) and Gulf of Cádiz waters (IXa South (CA)). One of the main measures in this new Plan is the introduction of an individual quota (IQ) system to allocate annual national quotas. In the case of the Gulf of Cádiz purse-seine fishery this measure involves to shift from the abovementioned system of a fixed daily catch quota system for all the fleet to a new one based on the implementation of a IQ system managed quarterly by each fishery association after resolution of the National Fishery Administration on the annual allocation of the national quota by association.

Results from the qualitative assessment described in Section 4.5 suggest that the anchovy population in the Subdivision IXa South is fluctuating population without any neat tendencies, although it is assessed close to the average in 2014. 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 biomass was about normal levels in 2011. The most recent population estimates from acoustic surveys in autumn 2012 and spring 2013, although lower than average levels, don't contradict the abovementioned perception of fluctuating stock within the historical range. According to the Harvest rate analysis exploitation seems to be sustainable. 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 Subdivisions of IXa there is sufficient information as to outline what the situation in 2015 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 Subdivision 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-age1 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 raise 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.

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 seabirds.

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 GuadalquivirRiver, 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 implementedthe Bayesian approach for a state-space model of Gulf of Cadizanchovy life stages. The model is used to infer 17 years (1988-2004) of stock size in the Gulf of Cadiz. Its population dynamics was modelled under the influence of the physical environment and connected to available observations of sea surface temperature, river discharge, wind, catches, catch per unit of 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 Cadizanchovy 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 GuadalquivirRiver 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*Mesopodopsisslabberi*, its main prey.

All of these evidences confirm that the Gulfof Cadizanchovy 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 bycatch 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 bycatch. Other species such as pelagic crabs are released alive and it is likely that the inflicted mortality is low.

4.9 Indicators and thresholds to trigger new advice:

Anchovy, as a short lived species, requires updated assessment every year since the population is basically sustained by the recruited year class (at age 1), so no indicatorto trigger advice is required for this species.

Criteria for reopening the advice in autumn based on summer survey: The adviceprovided in June every year is informed by the spring acoustic surveys*PELACUS–PELAGO*. Currently advice is provided splitted in two regions: one for SubDivision IXa South (Cadiz and Algarve) and the other for the remainder northernareas of Division IXa. For the Sub Division IXa South, a survey every 2 out of 3years is carried out after the June advice; this is the summer acoustic survey*ECOCADIZ*. This survey could trigger revision of the split advice for this SubdivisionIXa South in case of contradicting the tendencies observed by *PELACUS – PELAGO* in this area (as happened in 2011). A threshold level for the changes in therelative tendencies cannot be established easily at this stage as it would depend onthe DLS method being applied (which is not clear) and whether we are in the secondof the two consecutive years or not. *Ad hoc* approaches should be considered according to the series available in case of perceived contradictory information.

4.10 Benchmark preparation (Tor b)

The Benchmark for anchovy in IXainitially foreseen for 2014 is recommended to be delayedto 2016, basically due to limited man power and to allow for the new DEPM2014 survey to be examined by WGACEGGs in Nov2014 and serve as a new inputthe Benchmark.

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 2013 were provided by Portugal, Spain, France, Netherlands, Ireland and UK (England and Wales) (Table 5.1.1.1). Total reported catch was 85 809 tonnes, divided as follows: 32% of the catches by Portugal, 35% by Spain and 24% by France. The remaining 8% of catches are reported by Netherlands, England and Wales, Denmark and Germany. Catches in VIIIc and IXa amount to 53% of the total sardine catches. 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 2013, there was a 2% increase with respect to the total 2012 sardine catches reported in European waters. Portugal showed a 10% decrease while Spain showed the same amount of catches with respect to 2012. Landings in France showed a 27% increase. Overall it seems there was in 2012 and 2013 an increase of catches in Northern areas (VIIIa and VII) while Southern areas had lower catches.

Table 5.1.1.1 Sardine general: 2013 commercial catch data from the ICES area, available to the Working Group.

Divisions	UK (EnglandWal)	Germany	Ireland	Denmark	France	Spain	Portugal	Netherlands	Total
IVa									
IVb									
IVc	2				58			11	71
VIa									
VIIa									
VIIb									
VIIc									
VIId	17	105		19	1731			575	2447
VIIe	2597	58		15	37			923	3630
VIIf	1095								1095
VIIg			236					306	543
VIIh	13	50		6					69
VIIi									
VIIj									
VIIIa					19 016			9	19 025
VIIIb	252					12 423		436	13 111
VIIIc						5272			5272
VIIId									
VIIIe									
IXaN						2128	15 065		17 193
IXaCN							9084		9084
IXaCS									
IXaS-Alg						10 157	4112		14 269
IXaS-Cad									

Total	3976	214	236	40	20 842	29 980	28 261	2260	85 809

6 Sardine in divisions VIIIa, b, d and subarea VII

6.1 Population structure and stock identity

Sardine in Celtic Seas (VIIa, b, c, f, g, j, k), English Channel (VIId, VIIe, VIIh) and in Bay of Biscay (VIIIa, b, d) are considered to belong to the same stock from a genetic point of view. Therefore, the sardine stock in VIIIa, b, d and VII can be considered as a single-stock unit with substantial mixing between areas.

There is evidence from landings that some fish coming from VIIIa are caught in VIIh and VIIe and vice versa. Dutch vessels which operate in the English Channel and North Sea sometimes declare catches in VIIIa. Major landings occur in both VIIIa, b, d and near and in the English Channel (VIId, VIIe, VIIf, VIIh) area. Less landings occur in other VII areas although they reach one or two thousand tons.

Information is almost inexistent regarding biological sampling of sardine in the English Channel and inexistent in the Celtic Sea. From the few information available, it appears that the sardines caught in the Channel tend to be bigger.

From the modelling point of view, the lack of commercial sampling in area VII, 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.

This stock was benchmarked at WKPELA in 2013 by ICES and although it was considered to be a single-stock unit, it was decided to approach this stock by subareas: VIIIa, b, d and VII to account for the regional differences in terms of environment, fisheries and data availability. No analytical assessment is currently usable for these regions therefore the assessment and advice are based on the trends of several indicators defined in the stock annex.

6.2 Input data in VIIIa, b, d and VII

Official landings per country for the whole area are available in Table 6.2.1.1.

Table 6.2.1.1 Official landings reported to ICES (1989-2013).

	VII								VIIIa,b,d								
	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Spain	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	Total
1989	1219	1660	11	0	0	4667	0	0	8811	0	0	0	0	0	0	0	16368
1990	1128	2078	6	0	107	6113	0	0	8543	0	0	0	0	0	0	0	17975
1991	1963	2952	0	0	8	4462	0	0	12482	35	0	0	0	0	0	0	21902
1992	1777	4493	41	0	4	17843	0	0	8847	43	0	0	0	0	0	0	33048
1993	1135	4917	109	0	0	13395	0	0	8805	45	0	0	0	308	0	0	28714
1994	1285	2081	20	0	2	20804	0	0	8604	0	0	0	0	0	0	0	32796
1995	1282	7133	107	0	66	9603	0	0	9877	0	24	0	0	0	0	0	28092
1996	1563	7304	48	0	0	1396	0	0	8604	0	0	0	0	0	0	0	18915
1997	3346	7280	411	0	13	1124	0	0	10706	0	26	0	0	0	0	0	22906
1998	1974	6873	1647	192	100	14316	0	0	9778	873	0	0	0	0	68	0	35821
1999	0	4815	5166	2375	146	3490	0	8	0	2384	0	0	0	124	11	0	18519
2000	1667	4353	6586	354	436	1682	0	0	10444	1989	34	0	0	0	38	0	27583
2001	9625	10375	6609	1060	454	0	0	0	10121	0	333	0	0	0	135	0	38712
2002	8642	7858	1905	2652	224	0	0	10	12316	2881	23	19	276	0	4	0	36810
2003	12546	4358	6897	2580	25	0	0	0	10631	2408	68	1750	68	0	0	0	41331
2004	8882	2681	2187	6195	109	742	0	0	9971	1853	6	1401	0	0	0	0	34027
2005	15363	3631	2231	2083	274	0	0	5	11787	1203	1	974	0	0	54	0	37606
2006	17724	1925	2287	698	481	0	17	2	9810	839	2	49	0	12	78	5	33930
2007	11217	2654	1106	14	0	4	0	0	13966	706	0	0	0	48	0	0	29715
2008	10491	3470	2073	875	42	54	0	0	12111	1989	0	0	1	39	0	0	31145

	VII								VIIIa,b,d								
	France	United Kingdom	Netherlands	Ireland	Germany	Denmark	Lithuania	Spain	France	Spain	Netherlands	Ireland	United Kingdom	Denmark	Germany	Lithuania	Total
2009	14781	2541	3406	33	0	0	0	0	20743	602	0	0	0	0	0	0	42106
2010	8725	2521	6645	25	106	13	0	0	16087	2948	0	0	0	0	0	0	37070
2011	707	3604	513	983	22	3	0	0	5524	0	5	0	0	0	0	0	11361
2012	444	4423	1439	8	0	0	0	0	15952	14948	0	0	0	0	0	0	37214
2013	10155	3722	1804	236	214	40	0	0	16211	12423*	445	0	252	0	0	0	45503

6.2.1 Catch data

Divisions VIIIa, b, d

An update of the French and Spanish catch data series in Divisions VIIIa and VIIIb (from 1983 and 1996 on for France and Spain, respectively) including 2013 catches was presented to this year´s WG (Table 6.2.1.2). The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year. Spanish vessels are purse-seines from the Basque Country which operate mostly in division VIIIb. Spanish landings averaged around 4000t in the late 90s early 2000s with peaks in 1998 and 1999 at almost 8 thousand tonnes. Catches have then decreased until 2010 to below 1 thousand tonnes. Since 2011, catches have raised again reaching 14948 tonnes in 2012 and 12423 tonnes in 2013.

Table 6.2.1.2 Sardine general: Landings by France (1983-2012)and Spain (1996-2012) in ICES divisions VIIIa, VIIIband VIIId as estimated bythe WG.

Year	Catch (tonnes)	
	France	Spain*
1983	4367	n/a
1984	4844	n/a
1985	6059	n/a
1986	7411	n/a
1987	5972	n/a
1988	6994	n/a
1989	6219	n/a
1990	9764	n/a
1991	13 965	n/a
1992	10 231	n/a
1993	9837	n/a
1994	9724	n/a
1995	11 258	n/a
1996	9554	2053
1997	12 088	1608
1998	10 772	7749
1999	14 361	7864
2000	11 939	3158
2001	11 285	3720
2002	13 849	4428
2003	15 494	1113
2004	13 855	342
2005	15 462	898
2006	15 916	825
2007	16 060	1263
2008	21 104	717
2009	20 627	228
2010	19 485	642
2011	17 925	5283
2012	15 952	14 948
2 013	20 066	12 423

*** all landings from division VIIIb**

n/a = not available

French catches consistently increased from 1983 to 2008, with values ranging from 4 367 tonnes in 1983 to 21 104 tonnes in 2008. Since 2009, French landings displayed a decreasing trend which stopped in 2013 with 20066 tonnes landed, which is close to the time-series maximum. .A total of 90% of French catches are taken by purse-seiners while the remaining 10% is reported by pelagic trawlers (mainly pairtrawlers). 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 pairtrawlers and purse-seiners operate close to their base harbour when targeting sardine. The highest catches are taken in summer. Almost all the catches are taken in southwest Brittany.

Catches were sampled and numbers by length-class for divisions VIIIa,b by quarter are shown in Tables 6.2.1.3 and 6.2.1.4 for France and Spain (only VIIIb), respectively. Sardine caught in area VIIIab ranges from 9 to 25cm. In 2013, two peaks are observed in catch distribution over size: the first at 16 to 18 cm length and the second around 21 cm. French vessels catch a majority of small fish, while sardine caught by Spanish vessels shows a more balanced distribution over sizes with similar peaks.

Table 6.2.1.3 Sardine general: French catch length composition (thousands) by ICESdivisions VIIIa,b in 2013.

Length(half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5					
9			3		3
9.5			9		9
10			81		81
10.5			53		53
11		23	56	245	324
11.5		23	47		70
12	11	69	72		151
12.5	33	69	31		133
13	44	183	162	224	613
13.5	94	369	316	224	1003
14	61	597	306	230	1194
14.5	68	1072	526		1666
15	48	966	1982		2996

Length(half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
15.5	37	1420	7166	18	8642
16	80	2625	27822	1011	31538
16.5	126	6333	44 088	4008	54 554
17	285	4906	44 197	5762	55 150
17.5	439	2381	29 606	3159	35 584
18	512	3403	16 718	2239	22 872
18.5	664	3436	12 343	3582	20 025
19	497	4554	9146	2953	17 149
19.5	596	4955	12 137	1834	19 521
20	715	5260	12 072	1817	19 864
20.5	1075	3312	12 880	2633	19900
21	986	5385	12 551	3533	22 454
21.5	900	5074	8533	2798	17 304
22	557	4635	6278	2941	14 412
22.5	343	2382	3406	1716	7847
23	86	1852	852	980	3770
23.5	129	707	1064	245	2145
24		1060	639	123	1821
24.5	43	353			396
25					
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
TOTAL numbers	8427	67 401	265 140	42 275	383 244
Official Catch (t)	444	3913	12 291	2368	**19 016**

Table 6.2.1.4 Sardine general: Spanish catch length composition (thousands) by ICESdivisions VIIIb in 2013.

Length (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
3.5					
4					
4.5					
5					
5.5					
6					
6.5					
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5	14				14
11	74			86	159
11.5	184			257	441
12	439			342	781
12.5	635	4		1112	1752
13	850	57		974	1881
13.5	894	106		1293	2293
14	1150	61		753	1965
14.5	1181	163		1269	2613
15	1229	250		1110	2589
15.5	856	660	1	2236	3753
16	856	1102	2	4926	6886
16.5	875	2182	4	6941	10 002
17	1449	1981	3	10 494	13 927
17.5	1931	2360	4	10 541	14 836
18	2904	1584	3	9421	13 912
18.5	2854	1996	3	8012	12 865
19	2283	2314	4	8313	12914
19.5	2137	1693	3	10 442	14274
20	2562	1950	3	11 885	16400
20.5	1925	1600	3	13 094	16622
21	1156	1437	2	12 690	15285
21.5	777	2311	4	11 141	14233
22	829	1775	3	8664	11272
22.5	453	1368	2	6577	8401
23	218	816	1	3347	4382
23.5	89	304	1	1608	2001
24		120		521	641

Length (half cm)	Quarter 1	Quarter 2	Quarter 3	Quarter 4	All year
24.5		69		259	329
25				19	19
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
29.5					
30					
30.5					
31					
TOTAL numbers	30 804	28 263	48	148 327	207 442
Official Catch (t)	1526	1729	3	9165	**12 423**

Subarea VII

Most of the catches are concentrated close to or in the English Channel (VIId, VIIe, VIIf,). Historically highest landings were made by Franceand the Netherlands, but the participation of the UK increased to become the majority in the last two years. Some landings are occasionally declared by Ireland. No information was available from other countries operating in that subarea. Catches have substantially oscillated with time and between countries (Table 6.2.1.5) from 12 000 to 3800 tons. In 2013, the catches were 8950t.

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

Table 6.2.1.5 Sardine landings (tons) in ICES Subarea VII in 2013.

Year	France	Netherlands	UK	Ireland	Total
1996	1563	48	7304	0	8915
1997	3346	411	7280	0	11037
1998	1974	1647	6873	192	10686
1999	119	5166	4815	3195	13295
2000	1594	6586	4353	2577	15110
2001	2313	6608	10375	2427	21723
2002	2232	1905	7858	5728	17723
2003	5318	6897	4358	2015	18588
2004	3266	2187	2681	1567	9701
2005	4315	2231	3631	461	10638
2006	5156	2287	1925	1211	10580
2007	4418	1106	2654	14	8192
2008	5195	2073	3470	236	10975
2009	6674	3406	2541	33	12654
2010	2787	6645	2521	25	11978

2011	2515	513	3603	983	7615
2012	444	1439	4423	8	6314
2013	1767.95	1439	3722.31	8.272	8950.532

6.2.2 Surveys in Divisions VIIIa, b, d

6.2.2.1 DEPM survey in Divisions VIIIa, b, d

All the methodology for the survey is described in detail in the stock annex - Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey 2014 is attached as Santos. M *et al.*, WD 2014.

Total egg abundance for sardine was estimated as the sum of the numbers of eggs in each station multiplied by the area each station represents. This year sardine egg abundance estimate was 14.3 E+12, the highest in relation with the time-series (Figure6.2.2.1.1, Table6.2.2.1.1). No sardine eggs were encountered in the Cantabrian region (Figure 6.2.2.1.2). In PairoVET a total of 213 (43%) stations had sardine eggs with an average of 8 eggs per 0.1 m-2 per station and a maximum of 301 eggs 0.1m-2.

This year the DEPM for sardine will be applied. The final results will be available at November 2014 at WGACEGG. For that propose, the survey was extended to the North until 48ºN and to the west until the west limit of the sardine spawning area was delimited. To allow comparison with previous years index in the VIIIa, b, d, stations from the Northwest were removed to maintain the same coverage of the area as the rest of the time-series (Figure 6.2.2.1.2; Table 6.2.2.1.1) and the sardine egg abundance resulted in 8.12 E+12.

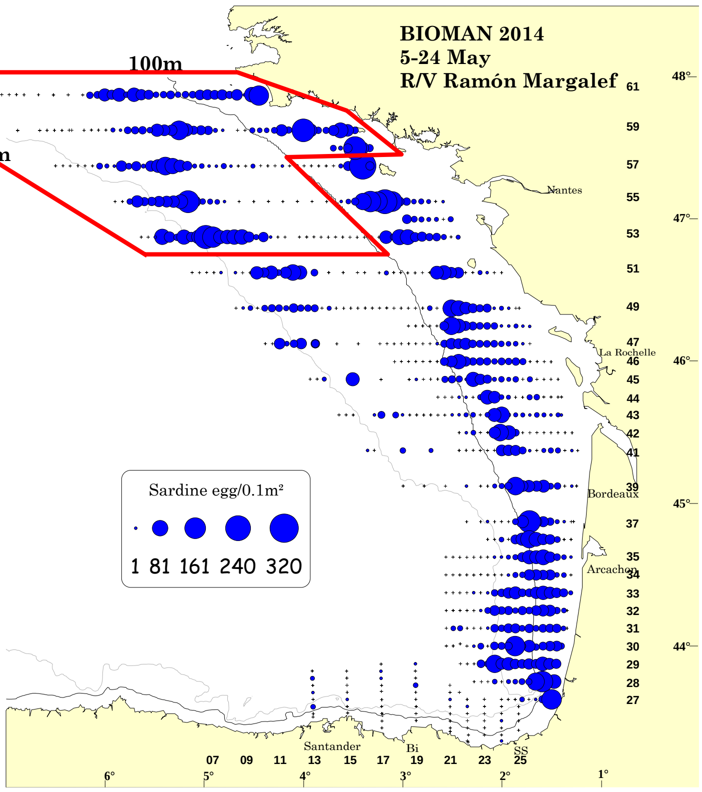


Figure 6.2.2.1.2Distribution of sardine egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN2014 obtained with PairoVET. The red line represents the stations removed for assessment propose in VIIIa, b, d.

Table 6.2.2.1.1Time-series for sardine, Total egg abundances (Σ(egg_St*area_st)) in numbers of eggs, positive area (Km²), total area surveyed (Km²) and % of positive area, with North part and the last line (*) without the North, the one adopted as an input for the assessment of sardine VIIIabd

Year	TotEggAb_Sp	pos area	tot area	% pos area
1999	1.30E+12	26,679	59,193	45
2000	5.00E+12	40,139	52,212	77
2001	9.20E+11	14,547	51,629	28
2002	8.30E+12	39,112	50,951	77
2003	2.80E+12	22,878	47,927	48
2004	9.20E+12	37,289	49,446	75
2005	1.10E+13	38,979	50,202	78
2006	3.80E+12	23,376	45,413	51
2007	2.30E+12	16,710	45,499	37
2008	9.40E+12	20,235	46,501	44
2009	7.53E+12	34,746	60,733	57
2010	1.06.E+13	36,361	61,940	59
2011	4.50.E+12	22,851	98,405	23
2012	5.68E+12	20,054	80,381	25
2013	5.48E+12	25,423	77,838	33
2014	1.43E+13	55,563	104,015	53
2014*	8.12E+12	35,759	70,770	51

6.2.2.2 PELGAS acoustic survey in Divisions VIIIa, b, d

The French acoustic survey PELGAS takes place every spring in the Bay of Biscay on board the RV 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 2014, PELGAS took place from the 24th April to 5th June and detailed objectives, methodology and sampling strategy are described in the WD- *Duhamel et al., (2014)* presented in this group.

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

Sardine was distributed all along the French coast of the Bay of Biscay, from the South to the North. Then, sardine appeared almost pure along the Landes's coast, where an upwelling occurred. Sardine was also present mixed with anchovy from the Gironde to the South coast of Brittany. Sardine appeared also close to the surface in the Northern part of the Bay of Biscay, along the shelf break, sometimes mixed with mackerel, but in lesser abundance than previous years. It must be noticed that, even adults appeared in low quantity in this offshore area, eggs were well present.An hypothesis could be that sardine was so close to the surface that a part of it couldn't be detected by the echosounders because of the blind layer. Another possibility could be that this sardine offshore is bigger than individuals along the coast, and presents a higher fecundity (Figure 6.2.2.2.1).

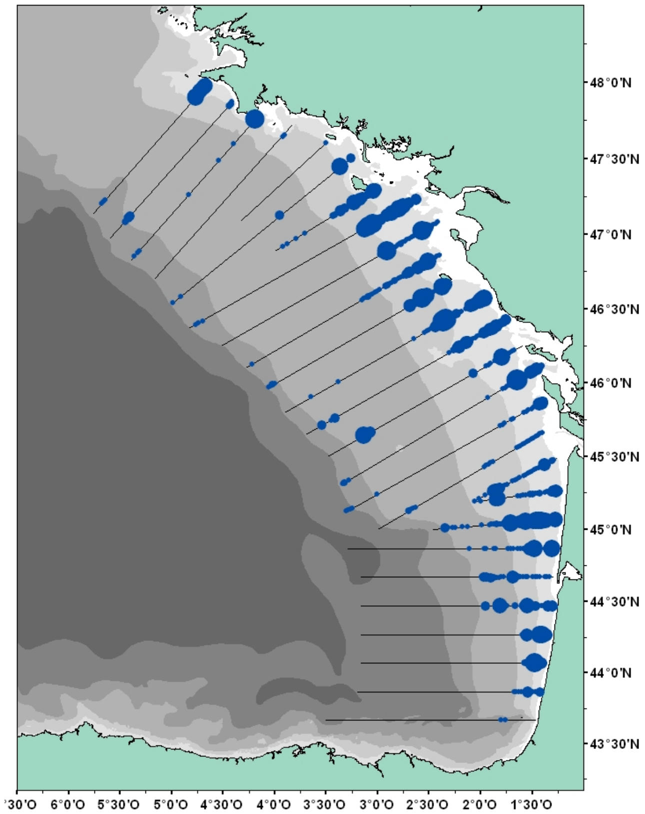


Figure 6.2.2.2.1 Adult sardine distribution (density / ESDU) during PELGAS14

As usual, sardine shows a bimodal length distribution (Figure 6.2.2.2.2), the first one (about 14 cm, corresponding to the age 1, and well present this year along the coast) and the second about 18 cm, which is mainly constituted by the 2 years old.

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 some cohorts (i.e. the very low 2005 age class, or very high 2008 age class). 2003 and 2007 were atypical years in terms of environmental conditions and therefore also in terms of fish (and particularly sardine) distributions.

The relative high abundance of age 2 (37% in number, but 44% in mass) confirms the (very) good recruitment observed last year.

The biomass estimate of sardine observed during PELGAS14 is 339 607 tons, which is at the average level of the PELGAS series, and constituting a small decrease of the biomass compared to last year. 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 species could be present up to the North, in the Celtic sea or Western Channel where another fishery occurs, more or less regularly (Figure 6.2.2.2.4).

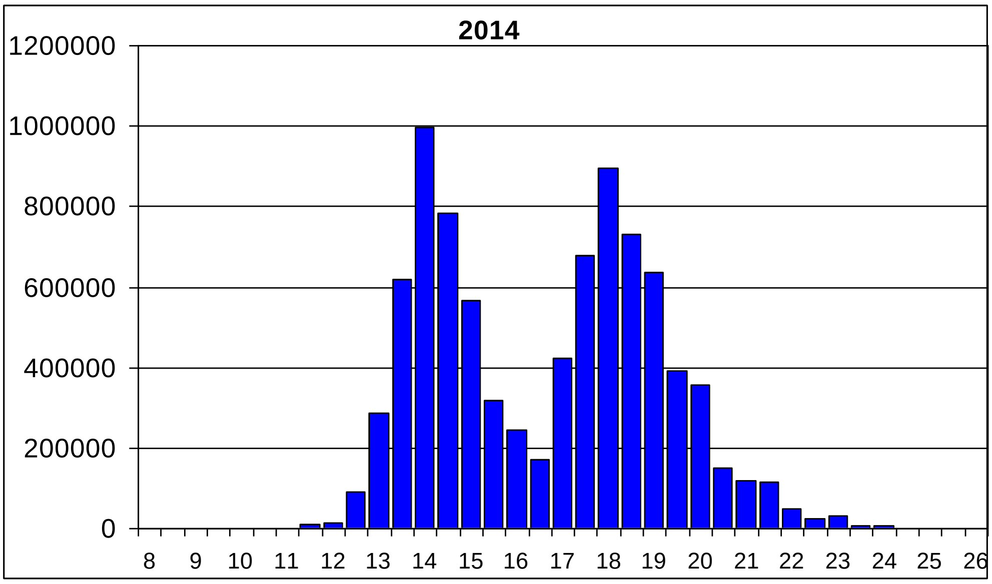


Figure 6.2.2.2.2 Sardine length distribution during PELGAS14

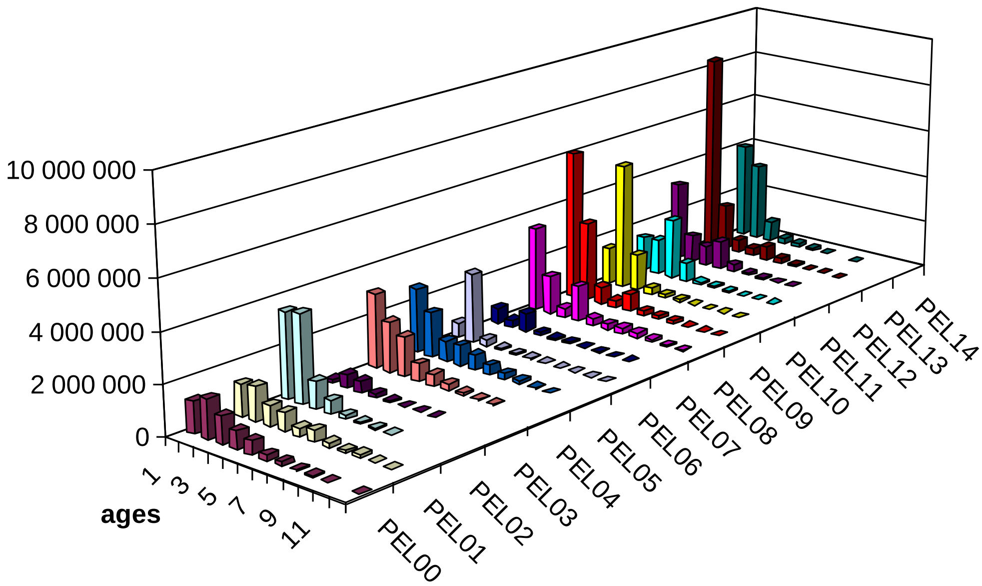


Figure 6.2.2.2.3 sardine age distribution along the PELGAS surveys

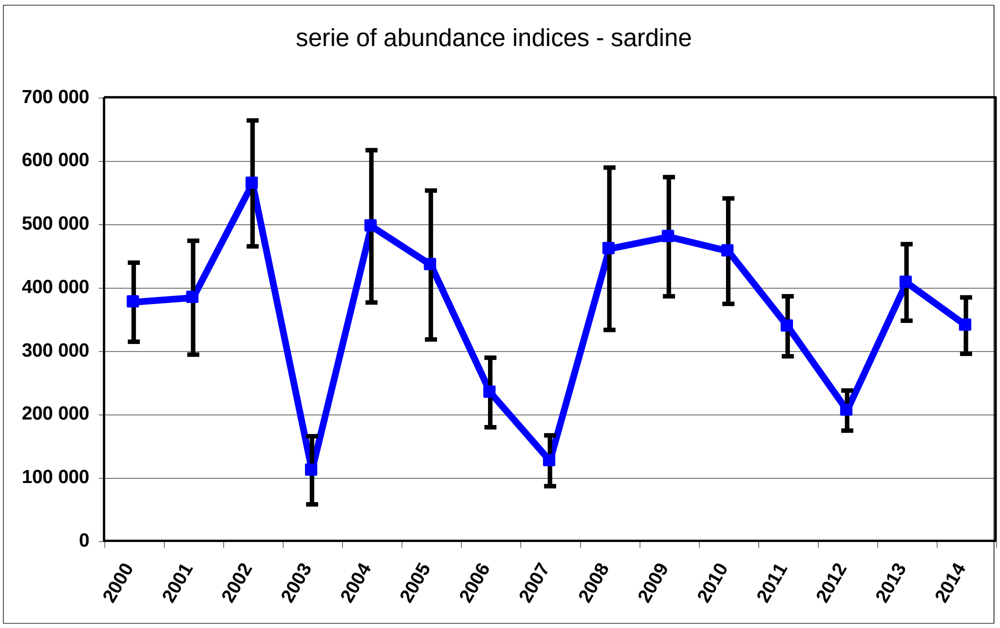


Figure 6.2.2.2.4 sardine abundance indices along the PELGAS surveys

6.2.3 Biological data

6.2.3.1 Catch numbers at length and age

Tables 6.2.3.1.1 and Table 6.2.3.1.2 shows the catch-at-age in numbers for each quarter of 2013 for French and Spanish landings respectively in VIIIa, b. For France, fish of age 1 dominated the fishery while for Spain, age 2 dominated the fishery in 2013. This difference is due to the absence of catch from Spain in quarter 3 as the Spanish vessels are targeting tuna while the French fleets are still fishing sardine.

No data were available for VII.

Table 6.2.3.1.1 French 2013 landings in ICES division VIIIb: Catch in numbers (thousands) at age

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			1218	923	2141
1	799	15095	168370	16844	201108
2	2500	18987	45557	9500	76544
3	1303	8098	9207	2009	20617
4	1100	6365	25274	7184	39922
5	1895	12250	9353	3422	26919
6	616	4455	3488	1394	9952
7	121	1083	1078	528	2810
8	47	742	1184	411	2384
9	33	238	319	61	651
10	13	88	101		
11	0				
12	0				
13	0				
14	0				
15	0				
Total	4282	402216	153088	41234	79845
Official Catch (t)	444.0927	3912.8835	12290.8828	2368.4284	19016.2874

Table 6.2.3.1.2 Spanish 2013 landings in ICES division VIIIb: Catch in numbers (thousands) at age

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0	0	0	1	7679	7680
1	7506	1522	18	46230	55276
2	10401	10956	12	38625	59995
3	3961	3553	7	24510	32031
4	4685	5043	6	20212	29947
5	3841	5935	3	8056	17834
6	393	1098	1	2261	3753
7	18	108	0	376	502
8	0	47	0	376	424
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
Total	15360	110552	####	64062	59893
Official Catch (t)	1526	1728.68	2.93	9165.364	12423.394

6.2.3.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter in 2013 are shown in Tables 6.2.3.2.1-6.2.3.2.4 for both French and Spanish landings in VIIIa, b, d.

No data were available for VII.

Table 6.2.3.2.1 French 2013 landings in divisions VIIIa and VIIIb: Mean length (cm) at age

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			14.03	12.84	13.52
1	15.43	15.95	16.89	17.28	16.84
2	18.63	18.34	18.94	19.07	18.8
3	19.92	19.79	20.52	20.7	20.21
4	20.82	20.84	20.78	21.13	20.86
5	21.34	21.54	21.35	21.8	21.5
6	21.68	22.04	22.16	22.17	22.08
7	22	22.54	22.33	22.53	22.43
8	22.74	23.34	22.1	22	22.48
9	24.16	24.24	24	24	24.1
10	22.5	22.5	22.5		
11					
12					
13					
14					
15					

Table 6.2.3.2.2: French 2013 landings in divisions VIIIa and VIIIb: Mean weight (kg) at age

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			0.021	0.016	0.019
1	0.028	0.031	0.037	0.04	0.037
2	0.051	0.049	0.054	0.055	0.053
3	0.063	0.062	0.07	0.072	0.066
4	0.073	0.073	0.072	0.076	0.073
5	0.079	0.081	0.079	0.084	0.081
6	0.083	0.087	0.089	0.089	0.088
7	0.087	0.094	0.091	0.094	0.092
8	0.097	0.105	0.088	0.087	0.093
9	0.117	0.118	0.115	0.115	0.116
10	0.093	0.093	0.093		
11					
12					
13					
14					
15					

Table 6.2.3.2.3 Spanish 2012 landings in ICES division VIIIb:Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0	0	0	14.87	13.97	13.97
1	14.18	15.44	17.4	17.46	16.96
2	18	17.72	19.83	20.01	19.24
3	19.29	19.59	21.11	21.01	20.64
4	20.48	20.86	21.92	21.74	21.4
5	21	21.61	22.31	22.16	21.73
6	22.6	22.77	22.82	22.8	22.77
7	23.75	24.05	24.12	24.09	24.07
8	0	24.43	24.12	24.09	24.13
9	0	0	0	0	
10	0	0	0	0	

Table 6.2.3.2.4 Sardine general: Spanish 2013 landings in ICES division VIIIb: mean weight (kg) at age

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0	0	0	0.025	0.021	0.021
1	0.022	0.028	0.041	0.042	0.039
2	0.046	0.044	0.063	0.065	0.058
3	0.058	0.061	0.077	0.075	0.072
4	0.069	0.074	0.087	0.084	0.08
5	0.076	0.083	0.091	0.089	0.084
6	0.095	0.097	0.098	0.098	0.097
7	0.111	0.116	0.117	0.116	0.116
8	0	0.122	0.117	0.116	0.117
9	0	0	0	0	
10	0	0	0	0	
11	0	0	0	0	
12	0	0	0	0	
13	0	0	0	0	
14	0	0	0	0	

6.2.4 Exploratory assessments

6.2.4.1 Trends of indicators in VIIIa, b, d

Bay of Biscay has the most available data in the stock unit. However, with most of them starting in 2000-2002, the benchmark WKPELA concluded that for the time being time-series were still too short to be used by an assessment model. It was rather recommended to use indicators in order to assess the state of the stock.

a) comparison between PELGAS (acoustic) and BIOMAN (egg count/DEPM)

Time-series of biomass estimates from the PELGAS acoustic survey are compared against the time-series of number of eggs from the BIOMAN (DEPM) survey. Both indices show very similar long-term trends except for 2001 (correlation between indices is r^2=0.8 if 2001 is removed, 0.68 if included). (Table 6.2.4.1.1, Figure 6.2.4.1.1).

Table 6.2.4.1.1 Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in VIIIa,b,d.Landings in VIIIa,b,d and VII.

	Survey			Landings	
Year	PELGAS	PELGAS	BIOMAN	VIIIabd, VII	% of landed
	age 1 individuals	Biomass	egg count (billions)	(tons)	biomass
1999			1.3	41591.553	
2000	1276312	376442	5	33280.593	11.0
2001	1280080	383515	0.92	37446.176	8.7
2002	3458311	563880	8.3	36520.459	6.6
2003	160136	111234	2.8	37055.0992	32.8
2004	2997203	496371	9.2	26886.5151	7.5
2005	2613794	435287	11	28306.1877	6.2
2006	605847	234128	3.8	27951.403	12.1
2007	631471	126237	2.3	25570.65	22.1
2008	3432039	460727	9.4	32889.708	5.6
2009	6111475	479684	7.53	33508.798	6.9
2010	1511640	457081	10.6	32206.194	7.3
2011	1435411	338468	4.5	30851.424	9.5
2012	3257929	205627	5.68	37214.272	15.0
2013	8334258	407740	5.48	41031.38	9.1
2014	3987596	339607	8.12		12.1

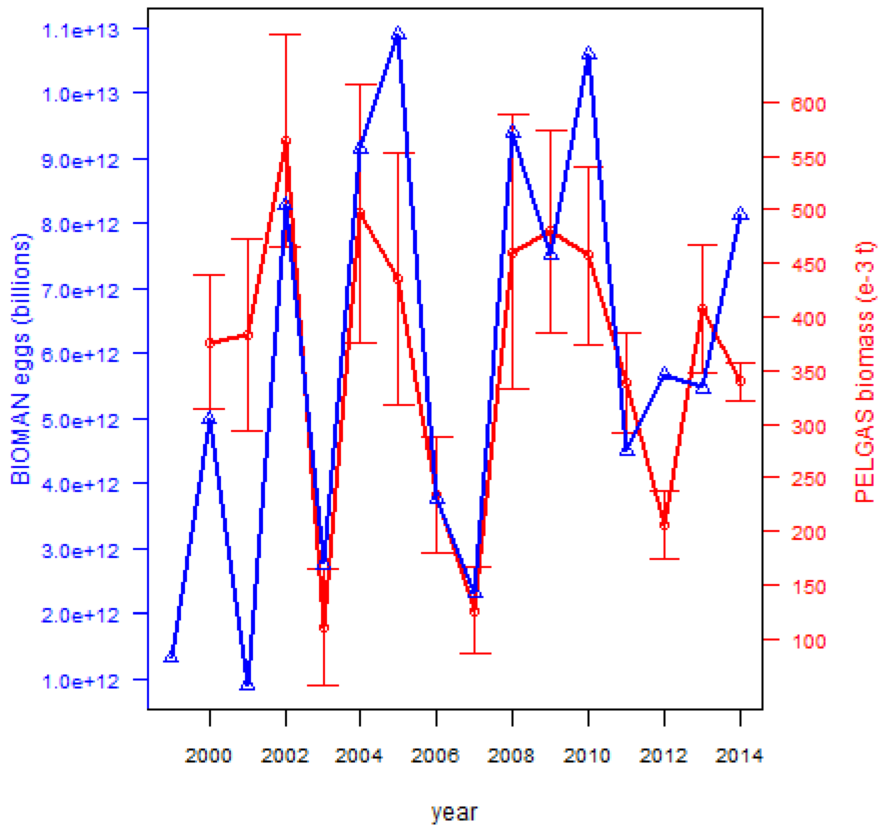


Figure 6.2.4.1.1 Survey indices from Pelgas (acoustic) and Bioman (DEPM) surveys in VIIIa,b,d.

The biomass oscillates over the period covered by the time-series. The last big cycle peaked in 2009-2010. Following years were lower and the trend in the last three years seems to be to a new increase. Compared to last year estimates, both surveys suggest an opposite trend. The value provided by the acoustic survey of 339 thousand tonnes for 2014 is a little lower than the 2013 estimates (407 thousand. tonnes), that is a decrease of 17%. The DEPM estimate, on the other hand, suggests an increase of 50% of the abundance of eggs. PELGAS and BIOMAN estimates thus place 2014 respectively just below and above the long-term average of the series.

The magnitude of landings compared with biomass estimates are very low, around 10%, which suggests low harvest rates.

b) Stock structure

Stock structure at age is available from both catches from Spanish and French fleets and estimates from the PELGAS survey for VIIIa, b, d. Similar information is not available from subarea VII.

Time-series of weight at age and number-at-age for both commercial fleets and surveys are provided in Table 6.2.4.1.2 and Table 6.2.4.1.3.

Table 6.2.4.1.2a Weight at age (in kilograms) from French and Spanish commercial fleets inVIIIa,b,d.

AGE	0	1	2	3	4	5	6	7	8	9
2002	0.018	0.044	0.069	0.08	0.088	0.1	0.112	0.115	0.13	0.133
2003	0.019	0.054	0.08	0.091	0.101	0.111	0.117	0.129	0.132	0.124
2004	0.02	0.04	0.08	0.09	0.095	0.101	0.111	0.12	0.13	0.125
2005	0.018	0.047	0.081	0.089	0.094	0.097	0.105	0.11	0.119	0.133
2006	0.024	0.039	0.074	0.088	0.094	0.101	0.11	0.115	0.118	0.133
2007	0.032	0.053	0.081	0.087	0.099	0.104	0.109	0.12	0.123	0.131
2008	0.018	0.044	0.063	0.076	0.078	0.091	0.1	0.095	0.103	0.11
2009	0.032	0.038	0.062	0.073	0.086	0.087	0.096	0.098	0.1	0.115
2010	0.023	0.038	0.061	0.074	0.081	0.09	0.092	0.102	0.103	0.111
2011	0.028	0.043	0.066	0.074	0.082	0.09	0.096	0.1	0.113	0.115
2012	0.043	0.045	0.056	0.068	0.077	0.082	0.086	0.1	0.102	0.121
2013	0.021	0.037	0.055	0.07	0.076	0.082	0.09	0.096	0.097	0.105

Table 6.2.4.1.2b Weight at age (in grammes) from the Pelgas acoustic survey in VIIIa,b,d

	age											
survey	1	2	3	4	5	6	7	8	9	10	11	13
PEL00	35.05	54.74	69.15	76.46	84.82	89.93	98.83	110.18	105.04	112.87		117.35
PEL01	41.28	58.85	76.83	83.84	93.68	96.92	103.41	105.35	112.71	120.97	119.92	
PEL02	40.48	60.2	74.94	81.7	92.31	99.42	106.68	118.05				
PEL03	53.35	68.04	73.15	78.11	86.04	93.33	88.74	96.09				
PEL04	35.94	64.73	76.54	84.39	95.87	98.83	104.34	109.19	106.15			
PEL05	34.44	63.45	73.29	79.62	84.88	88.96	90.04	105.42	109.45	98.35		
PEL06	39.17	58.37	70.78	81.18	86.37	82.48	91.25	97.22	107.02	112.02	110.9	
PEL07	37.55	65.96	71.77	79.05	84.02	94.45	100.37	96.93	101.27	114.86		
PEL08	33.44	60.33	71.1	75.18	83.82	92.84	90.45	95.67	99.48	101.41	109.39	
PEL09	29.51	57.13	73.62	81.28	83.26	88.35	95.67	91.44	96.50	106.67	82.00	
PEL10	30.33	50.55	64.04	73.05	78.43	87.58	93.16	105.88	106.96	116.01		
PEL11	27.37	50.13	58.69	69.84	78.35	83.00	84.28	108.17	105.38	108.33		
PEL12	22.88	44.66	57.40	65.45	78.42	87.83	95.26	92.27	99.83			
PEL13	21.16	44.33	55.82	68.30	77.42	84.27	89.28	99.10	113.27	89.17		
PEL14	23.02	44.53	55.93	62.07	69.35	76.11	78.46		86.50			

Table 6.2.4.1.3a Catch-at-age (in numbers) from French and Spanish commercial fleets inVIIIa,b,d (Thousands)

Age	0	1	2	3	4	5	6	7	8	9
2002	3703	162938	67783	25016	15760	11127	7444	2157	1170	824
2003	4382	89475	62145	27447	16545	9657	6207	3334	1647	737
2004	22283	88306	50184	36191	15110	9388	2796	1328	632	306
2005	4114	91371	41479	29105	22998	17983	9190	5115	3167	1805
2006	8896	35588	84755	30337	21008	15204	9519	6946	3558	2807
2007	24017	66813	25930	59416	13095	14186	12178	7468	3582	2907
2008	3845	162408	71484	26645	42044	13223	11590	10818	5354	5062
2009	8535	117821	139899	50134	25636	24240	12465	9282	5517	1916
2010	1907	37905	107444	59131	18719	14837	22904	7452	8527	4811
2011	3938	42575	62666	118526	56833	8562	15571	5400	5518	3082
2012	3120	146755	46509	46419	71903	27064	6378	2880	1850	1195
2013	9821	256384	136539	52648	69869	44753	13705	3312	2808	752

Table 6.2.4.1.3b Population at age estimates (in numbers) from the Pelgas acoustic survey inVIIIa,b,d

PELGAS	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
2 000	1 276 312	1 559 347	1 083 847	721 738	551 465	218 657	152 984	132 676
2 001	1 280 080	1 367 856	819 203	751 576	353 970	466 190	175 124	277 453
2 002	3 458 311	3 585 189	1 115 098	566 798	162 725	85 013	38 003	9 120
2 003	160 136	528 081	463 812	165 696	55 940	2 234	5 426	1 090
2 004	2 997 203	2 029 661	1 606 397	706 117	467 766	283 692	95 817	61 324
2 005	2 613 794	1 807 043	824 020	822 188	610 585	383 260	230 492	174 773
2 006	605 847	2 819 592	274 996	90 287	42 056	38 918	13 436	16 260
2 007	631 471	296 092	761 271	131 707	57 856	64 658	27 165	35 554
2 008	3 432 039	1 549 493	383 747	1 478 305	301 616	223 603	241 521	373 181
2 009	6 111 475	3 286 964	707 700	301 305	737 098	215 647	148 810	157 875
2 010	1 511 640	5 227 578	1 558 567	267 859	125 992	122 739	27 877	41 082
2 011	1 435 411	1 504 792	2 516 162	794 842	106 115	64 749	23 433	33 899
2 012	3 257 929	1 129 668	833 824	1 158 709	340 656	77 427	54 120	43 030
2 013	8 334 258	1 934 208	558 270	313 743	563 894	211 086	49 522	47 293
2014	3 987 596	3 240 908	863 755	269 980	183 557	132 252	39 784	4 771

The composition of catches-at-age for the commercial fleets (Figure 6.2.4.1.2) is variable through time. Large proportions of age 1 are observed in 2012 and 2013, as well as a large proportion of age 2 in 2013, consequences of the good recruitments of 2011 and 2012. The composition of catches-at-age from the PELGAS survey (Figure 6.2.4.1.3) shows similarly the dominance of ages 1 and 2 in 2014.

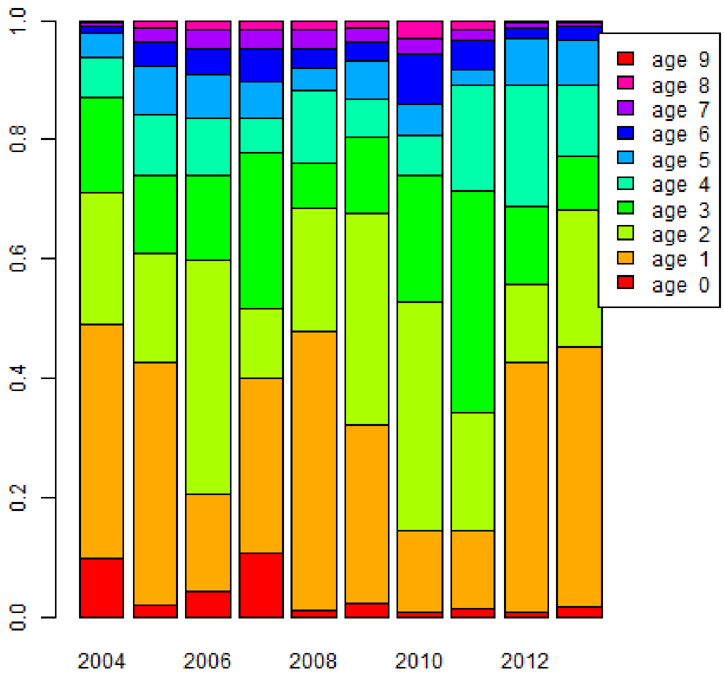


Figure 6.2.4.1.2 Relative composition of catches-at-age for the commercial fleets in VIIIa,b,d

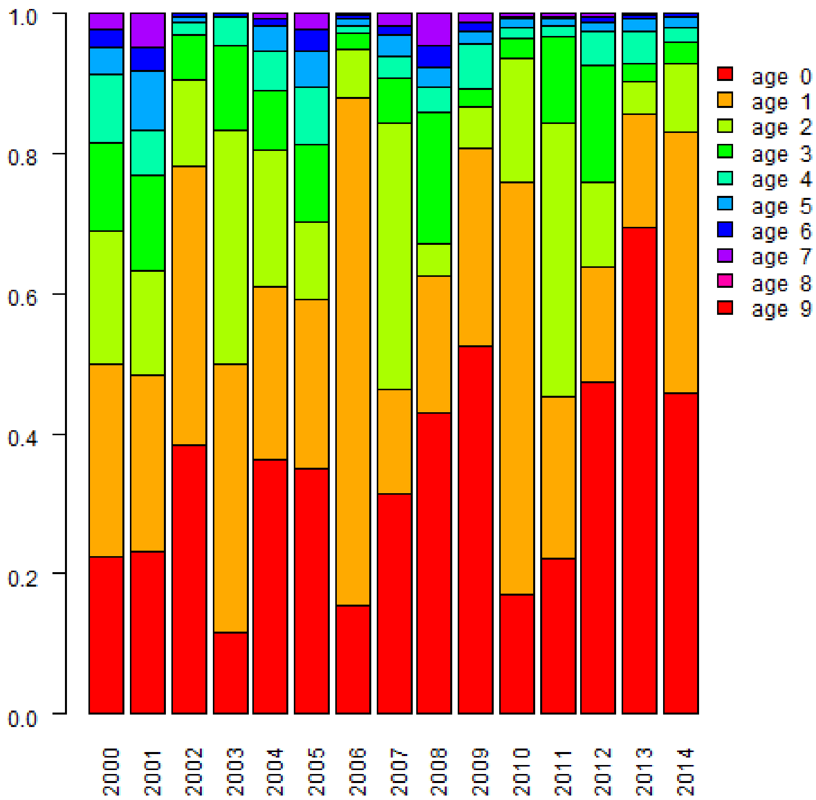


Figure 6.2.4.1.3 Relative composition of the catches-at-age for PELGAS survey in VIIIa,b,d.

Recruitment in 2014 is estimated at 4 million individuals which although much lower than the previous year is among the highest of the time-series.

c) Catch curve analysis on survey and commercial fleets

The catch curve analysis carried out last year, was updated during the working group using 2013 and 2014 numbers for commercial and survey catches respectively.

Neither time-series revealed very efficient at tracking cohorts (Figure 6.2.4.1.4 and 6.2.4.1.5). Estimates of total mortality per year were nonetheless computed mostly to try to detect possible changes in the dynamics of the population since the first evaluation. The average total mortality according to commercial landings is 0.45 (std.dev. 0.29) while Pelgas gives an estimates of 0.68 (std.dev. 1.37) over the same period (2002-2012). The values of Z estimated this year are 0.35 for commercial data (corresponding to 2013) and 1.1 for PELGAS survey (corresponding to 2014). They are thus in the range of previous estimates and in the case of the estimate based on survey, close to the average of the series (Figure 6.2.4.1.6 and Figure 6.2.4.1.7).

Using the same reasoning as last year and assuming a constant mortality-at-age of M=0.33, fishing mortality is assessed close to 0.35, that is, equivalent to natural mortality. Therefore the fishery is likely to be sustainable.

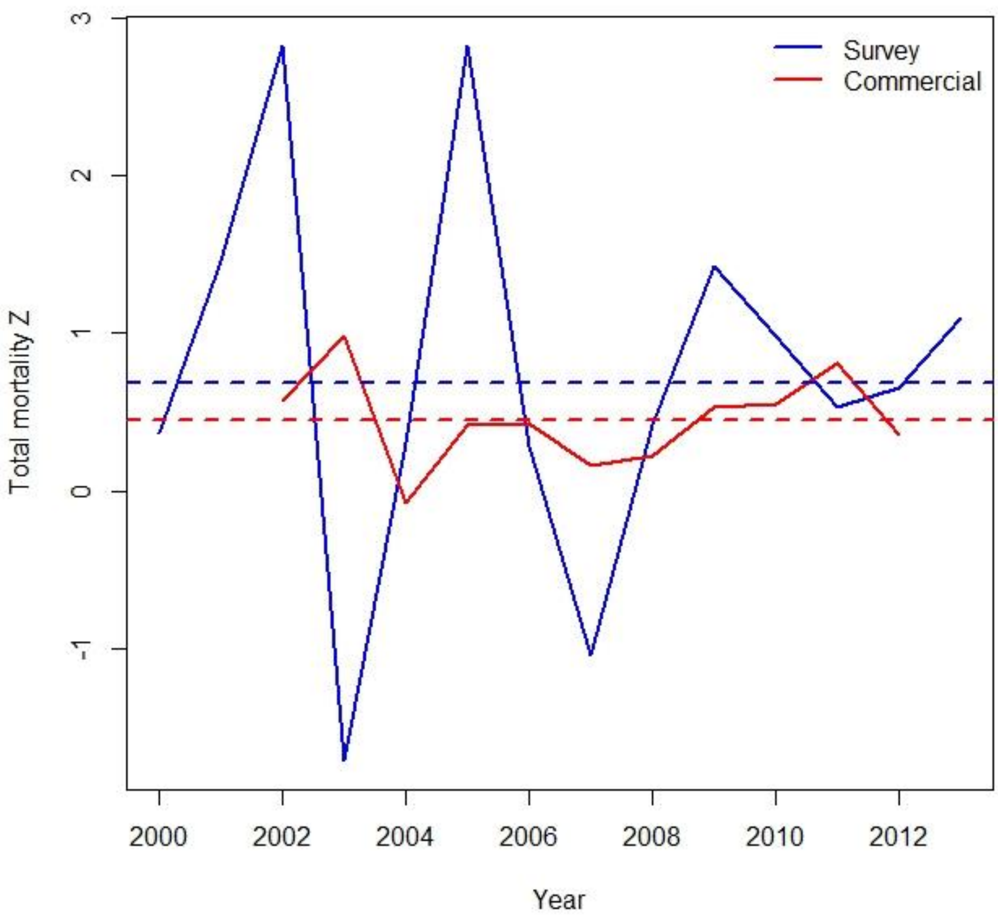


Figure 6.2.4.1.6 Total mortality estimated through survey and commercial catch curve analysis

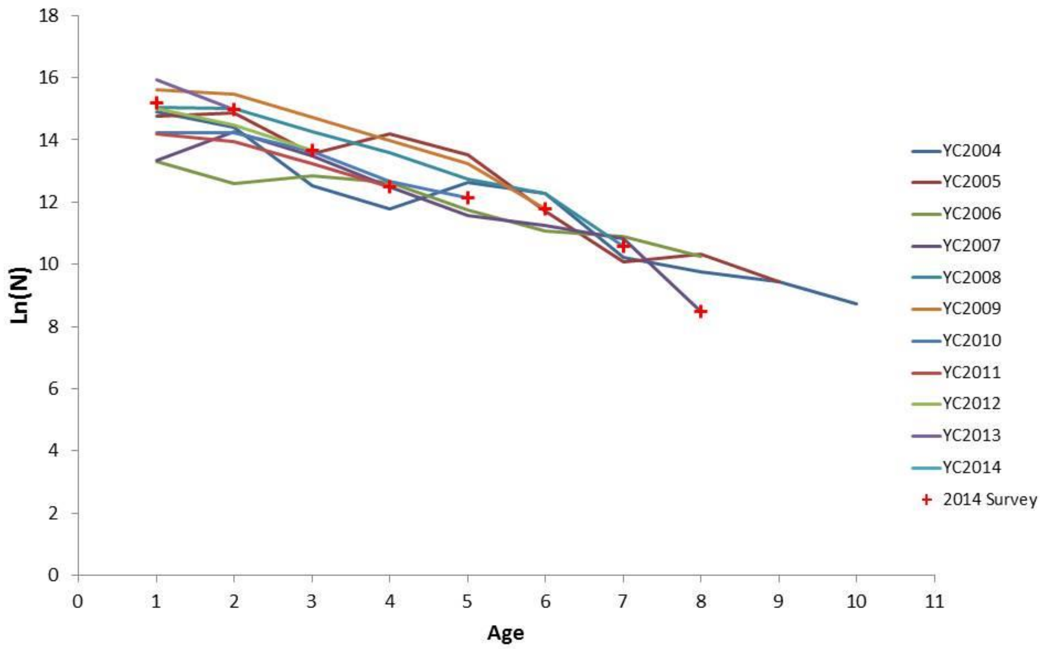


Figure 6.2.4.1.7 Cohort tracking using Pelgas survey catch-at-age data.

6.2.4.2 Trends on landings in subarea VII based on the WKLIFE framework

As only catch and few efforts information are available for subarea VII, it is impossible to use any assessment model for the time being. This substock is considered as a category 4 stock (catch only).

The overall recent trend in landings in subarea VII is a decrease of catch since 2004 amplified sin**ce** 2010 (Figure 6.2.4.2.1). This is mainly due to a decrease in French landings only partly compensated by an increase in landings from the UK. It is worth noting that since 2004 this subarea almost evolve in opposite to the neighbouring landings in the Bay of Biscay. The opportunistic nature of the fisheries and the mixing between VII and VIII makes the interpretation of this decrease difficult. Observations suggest that the stock moves northward therefore the decrease in catch might not be related to a lesser abundance of fish but possibly a lower effort on sardine.

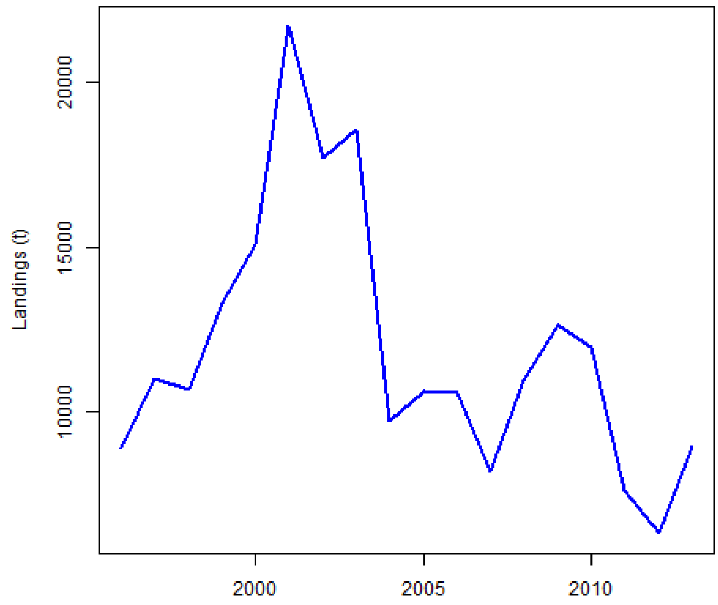


Figure 6.2.4.2.1 Landings in area VII.

6.2.5 Short-term predictions

Due to the exploratory nature of the assessment, no predictions have been carried out.

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.

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 areas VIIIa, b, d and by France, the Netherlands and the United Kingdom in area VII. The trends in indicators in area VIIIa, b, d, suggest no change in the perception of the stock status since 2013 and thus no reason to reopen the advice established in 2013 for 2013 and 2014. The absence of a sampling program in VII makes any attempt to analytically assess this stock useless. If a sampling program were started, several years of data collection would be necessary before the time-series of data are long enough. It is therefore recommended that a proper sampling program should be implemented to monitor the sardine fishery in subarea VII.

7 Sardine in VIIIc and IXa

7.1 ACOM Advice Applicable to 2014, STECF advice and Political decisions

ICES advises on the basis of precautionary considerations that catches in 2014 should be no more than 17 000 tonnes.

7.2 The fishery in 2013

7.2.1 Fishing Fleets in 2013

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 throughout the stock area and the fleet has remained constant in recent years.

Table 7.2.1.1 Sardine in VIIIc and IXa: Spanish fleet that operates in the purse-seine fishery in 2013 and Portuguese composition of the fleet licensed to catch sardine in 2013. 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)	233	Purse-seine	Dry hold with ice	No	250
Spain (Gulf of Cadiz)	yes	17 (meters)	139	Purse-seine	Dry hold with ice	No	82
Portugal	yes	38 (GT)	200	Purse-seine	Dry hold with ice	No	144

In northern Spain, data from 2013 indicates that the number of purse-seiners were 250, with mean vessel length and power of 22 m and 233 HP, respectively. In the Gulf of Cadiz, purse-seiners taking sardine are generally targeting anchovy (n = 82) and range in size from 11 to 25 m with a mean vessel length of 17 m and mean horse power of 139 kW.

In Portuguese waters, fleet data indicate that, in 2013, 144 vessels were licensed for purse seining, with mean vessel length of 38 Gt tonnage and engine power category of 200 kW.

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.

As estimated by the Working Group, total sardine landings in 2013 have suffered a decline compared with those of 2012 (Tables 7.2.2.1 and 7.2.2.2, Figure 7.2.2.1). Total 2013 landings in divisions VIIIc and IXa were 45 818 t, i.e. a decrease of 17% with respect to the 2012 values (54 857). The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine, 17 558 tonnes, have shown a 25% decrease in relation to values from 2012 (23 275 tonnes). Both ICES Subdivisions VIIIc and IXaN showed a substantial decrease in catches (60% in subdivision VIIIc and 49% in IXaN) while subdivision IXaS-Cadiz showed significant increase by 68%. In Portugal, landings in 2013 (28 261 tonnes) were 11% lower than the landings in 2012 (31 583 tonnes). This decrease in landings was originated in the IXaCN subdivision (23% decrease), whilst IXaCS subdivision remains stable and IXaS-Algarve showed a sharp increase (by 42%).

Table 7.2.2.1 Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2013by ICES Subdivision. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	1291	623	93	734	2741
VIIIc-W	561	524	613	833	2531
IXa-N	454	610	615	450	2128
IXa-CN	1450	1954	5988	5673	15065
IXa-CS	765	2828	3613	1878	9084
IXa-S (A)	479	1257	1781	595	4112
IXa-S (C)	735	1536	4603	3283	10157
Total	5734	9332	17307	13446	45819

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	2.82	1.36	0.20	1.60	5.98
VIIIc-W	1.22	1.14	1.34	1.82	5.52
IXa-N	0.99	1.33	1.34	0.98	4.65
IXa-CN	3.17	4.26	13.07	12.38	32.88
IXa-CS	1.67	6.17	7.89	4.10	19.83
IXa-S (A)	1.05	2.74	3.89	1.30	8.98
IXa-S (C)	1.60	3.35	10.05	7.16	22.17
Total	12.51	20.37	37.77	29.35	

Table 7.2.2.2. WG Estimates. Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by subarea and total for the period 1940-2013.

	Sub-area							
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All subareas	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

	Sub-area							
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All subareas	Div. IXa
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

	Sub-area							
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All subareas	Div. IXa
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
2012	13090	4154	19647	9045	2891	6031	54857	41768
2013	5272	2128	15065	9084	4112	10157	45818	40546

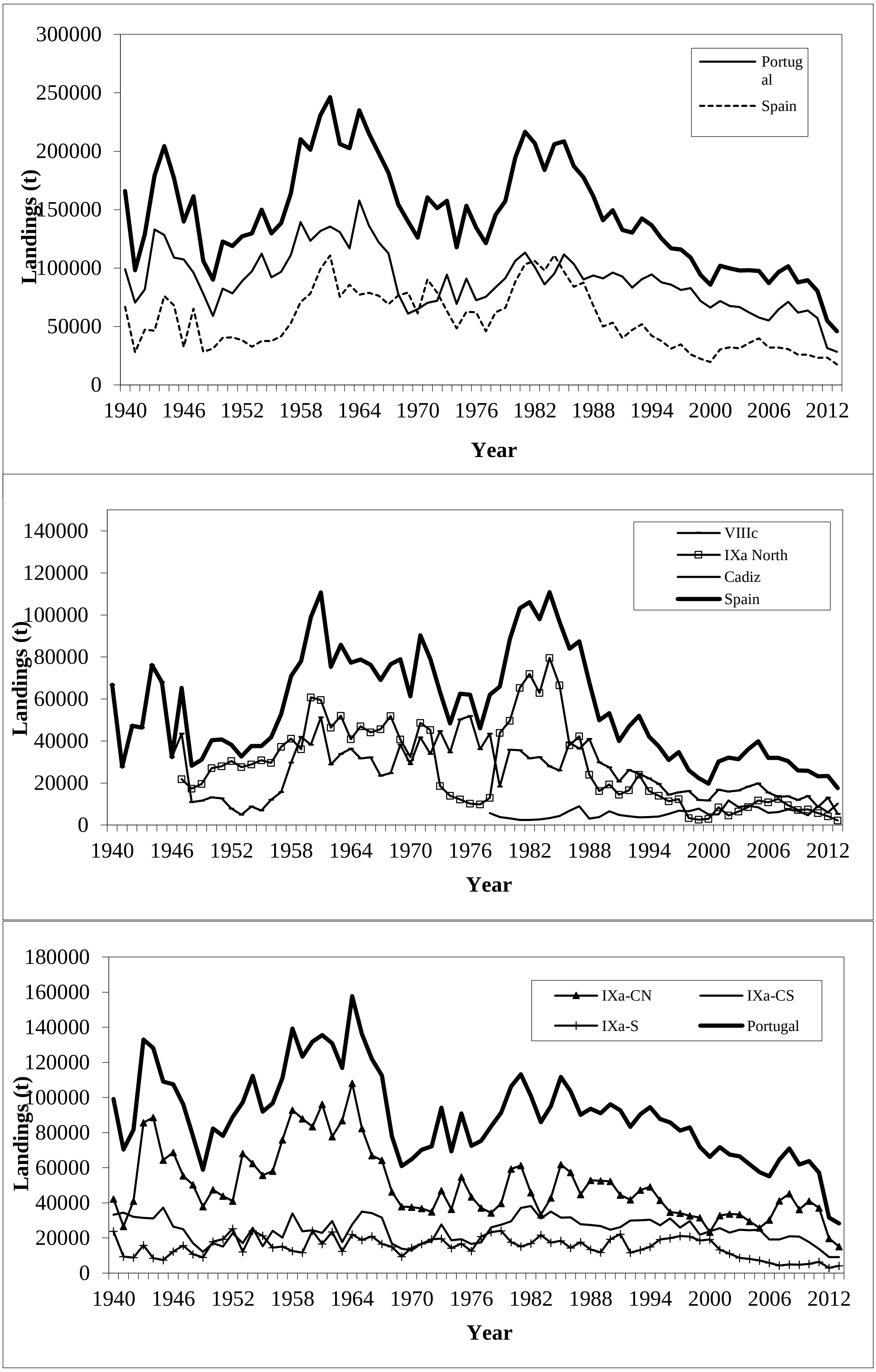


Figure 7.2.2.1Sardine in VIIIc and IXa: WG estimates of annual landings of sardine, by country (upper pannel) and by ICES Subdivision and country.

Table 7.2.2.1 summarizes the quarterly landings and their relative distribution by ICES Subdivision. Sixty-seven percent of the catches were landed in the second semester and 33% of the landings took place off the northern Portuguese coast (IXaCN), showinga slightly lower contributionthan in previous years (i.e. last year the contribution of IXaCN was a 36% of the total catches in the stock vs. 33% of 2013 catches).

The percentage of catches in the northern areas (IXaN and VIIIc) has decreased from last year, due to the reduction in catches of the IXaN and VIIIcWest subdivisions and especially in the VIIIcEast, where catches in 2013 represented on third of the 2012 landings. The Figure 7.2.2.2 shows the historical relative contribution of the different subareas to the total catches.

The southern areas (IXaS Algarve and IXaS Cadiz) doubled their relative contribution in 2013, accounting for 31% of the total values in 2013 (16% in 2012).

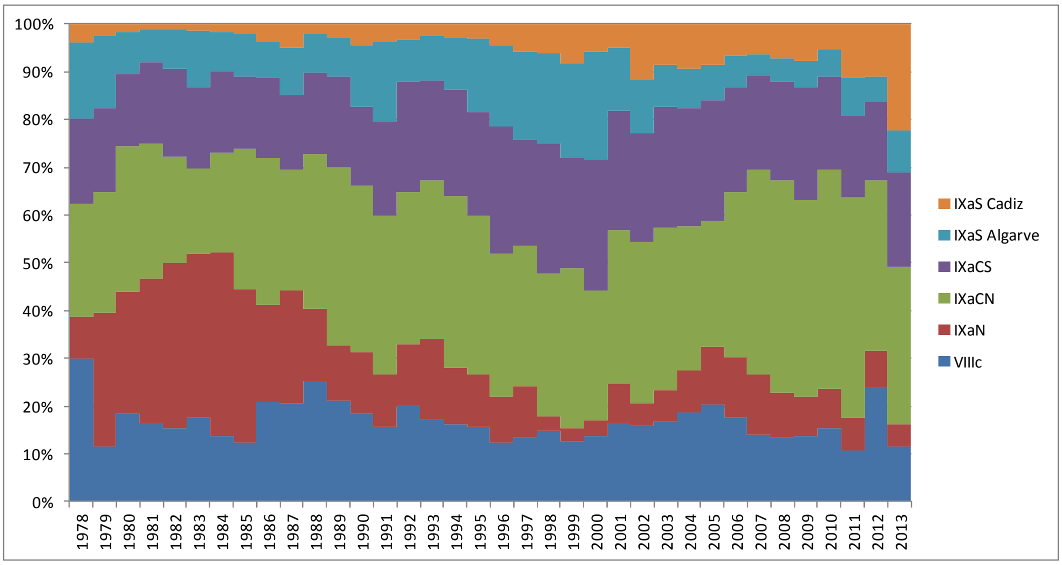


Figure 7.2.2.2 Historical relative contribution of the different subareas to the total catches (1978-2013).

7.2.3 Effort and catch per unit of 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 IXaNorth and VIIIcW and with modes at 15 and 21.5 cm and 14 and 23 cm, respectively. Sardine in IXaS-Cádiz subdivision showed single mode at 16 cm, whilst the VIIIcE length distribution did not showed any clear mode. For Portugal, sardine in IXaCN and IXaS-Algarve subdivisions showed bimodal length distributions (at 16.5 and 20.5 cm and at 16 cm and 19 cm respectively) and length distribution in IXa CS subdivision had a single mode at 21 cm.

Table 7.2.4.1: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2013.

				Total				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6.5								
7								
7.5								
8			568 605					568 605
8.5			759 563					759 563
9			828 695					828 695
9.5			697 689				50 130	747 819
10	10 886		1230 508				218 393	1459 787
10.5	16 328		1094 619				708 681	1819 628
11	27 214	257 377	1229 100				1726 689	3240 380
11.5	123 578	566 229	1163 146	202			6855 814	8708 969
12	329 853	463 278	1085 784	1 012		38	19435 451	21315 416
12.5	739 180	1565 630	829 387	3 503		76	33563 525	36701 301
13	687 599	963 612	517 107	5 793			31806 079	33980 190
13.5	1027 961	843 278	406 691	9 096	536	114	17210 996	19498 672
14	1372 243	1313 700	1697 097	11 904	793	429	11054 188	15450 355
14.5	1932 765	498 094	2653 557	12 440	1 288	970	12951 928	18051 043
15	1188 754	901 596	2185 872	17 097	1 438	1 478	19898 499	24194 734
15.5	1232 388	734 788	1056 145	12 399	812	1 712	27781 480	30819 724
16	2163 513	835 918	991 599	12 687	368	1 824	24754 236	28760 145
16.5	2447 844	603 413	867 330	7 567	367	1 542	16933 599	20861 662
17	3342 631	835 242	743 885	5 327	545	3 512	16068 355	20999 497
17.5	3406 721	311 013	613 943	3 620	603	5 874	13707 566	18049 339
18	3258 944	335 328	677 096	3 315	778	9 592	13780 686	18065 739
18.5	2899 459	185 766	970 674	6 620	2 867	11 556	13876 272	17953 213
19	3336 343	390 250	1199 214	15 669	4 680	9 214	8562 431	13517 801
19.5	2927 246	620 199	1608 449	23 277	10 230	7 466	9032 805	14229 672
20	2536 002	1174 399	1971 559	24 588	18 447	5 419	4549 015	10279 429
20.5	2350 347	1685 284	2628 771	25 364	19 039	3 278	1928 149	8640 231
21	1922 053	1665 427	3213 221	18 966	21 573	1 800	1287 326	8130 366
21.5	1773 550	2157 431	3389 013	15 876	15 964	813	699 205	8051 851
22	2111 717	3104 927	2212 224	7 608	7 076	145		7443 697
22.5	1721 783	3549 469	1181 823	4 298	2 429	12	125 955	6585 769
23	1530 310	3847 075	410 766	1 972	1 106	10		5791 239
23.5	848 784	2073 571	175 627	266	118			3098 366
24	465 681	954 428	87 999	81	13			1508 202
24.5	279 694	517 684	14 316					811 694
25	16 594	161 332						177 926
25.5	11 085	26 649						37 734
26		9 491						9 491
26.5		9 491						9 491
27								
27.5								
28								
28.5								
29								
Total	48039 050	33161 369	40961 074	250 549	111 070	66 873	308567 453	431 157 438
Mean L	18.6	19.7	17.0	18.4	20.5	18.7	15.4	16.3
sd	2.86	3.96	4.37	2.89	1.61	1.52	2.40	3.19
Catch	**2741**	**2531**	**2128**	**15065**	**9084**	**4112**	**10157**	**45819**

Table 7.2.4.1a: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the first quarter 2013.

				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								
11								
11.5	55 857							55 857
12	167 656						15 261	182 917
12.5	446 936	20 829					32 736	500 501
13	425 393	85 830			13		103 308	614 544
13.5	766 579	95 091					189 535	1051 205
14	740 312	306 601	53 833		10	12	268 785	1369 552
14.5	1265 714	256 516	291 544		10	71	764 651	2578 506
15	506 873	240 775	781 279	323	119	490	2172 159	3702 018
15.5	506 670	68 166	699 803	314	144	703	3102 656	4378 457
16	515 458	67 356	747 038	978	142	1 091	3322 991	4655 054
16.5	893 436	80 278	550 712	1 086	154	875	1944 724	3471 266
17	596 806	140 493	359 447	1 003	228	475	1721 640	2820 092
17.5	1109 221	57 430	216 902	378	88	310	1375 520	2759 849
18	1259 743	9 320	96 957	303	129	571	1085 271	2452 293
18.5	834 936	1 578	216 711	236	133	1 026	1056 787	2111 407
19	1293 888	22 396	271 208	2 110	376	1 114	699 911	2291 004
19.5	1224 048	49 097	272 874	2 687	779	848	698 517	2248 850
20	1134 922	253 800	178 484	2 216	1 407	668	201 011	1772 507
20.5	1250 376	268 323	419 548	2 901	1 845	634	167 407	2111 034
21	1180 944	455 301	900 970	2 074	2 602	487	154 242	2696 619
21.5	1032 808	623 127	1186 583	2 465	1 286	271	58 611	2905 151
22	1378 334	796 186	603 562	1 764	938	96		2780 880
22.5	1256 238	899 356	256 123	967	285	12		2412 980
23	1291 571	1130 516	75 069	687	153			2497 996
23.5	718 277	723 539	48 469					1490 285
24	360 249	443 353	16 730		13			820 345
24.5	264 949	223 170	5 047					493 166
25	14 874	110 321						125 195
25.5	11 085	26 649						37 734
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	22504 153	7455 397	8248 893	22 492	10 852	9 753	19135 723	57 387 264
Mean L	19.1	21.2	18.9	20.1	20.6	18.4	16.8	18.6
sd	3.26	3.21	2.76	1.96	1.58	1.92	1.55	3.09
Catch	**1 291**	**561**	**454**	**1 450**	**765**	**479**	**735**	**5 734**

Table 7.2.4.1b: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the second quarter 2013.

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								
10.5								
11							75 449	75 449
11.5							234 739	234 739
12	318						476 035	476 353
12.5	3 901						743 741	747 642
13	8 203						2241 761	2249 964
13.5	25 480						2250 194	2275 674
14	100 711						2082 939	2183 650
14.5	125 552						1958 655	2084 207
15	146 695			52			1818 170	1964 917
15.5	262 632		7 219	140	2	26	2832 540	3102 559
16	913 896		28 877	282	6	227	3250 317	4193 606
16.5	778 400		99 642	630	86	599	4221 273	5100 630
17	1186 122		187 205	1 153	256	1 818	6691 543	8068 097
17.5	1054 541		342 580	1 750	402	2 413	4046 187	5447 874
18	782 765		557 840	1 379	364	2 467	2851 321	4196 136
18.5	937 395		734 667	1 802	1 325	3 286	2467 602	4146 077
19	904 103	57 196	753 423	3 066	1 827	2 755	891 808	2614 178
19.5	717 830	171 585	598 903	3 682	3 941	2 559	1062 346	2560 846
20	498 208	343 170	614 243	5 349	6 736	2 037	385 607	1855 350
20.5	527 912	457 559	829 528	3 812	6 826	1 156	114 799	1941 592
21	295 178	343 170	904 704	3 193	6 797	643	110 631	1664 316
21.5	377 088	514 755	780 975	1 733	4 545	170	60 124	1739 390
22	289 148	571 949	691 780	916	2 233	41		1556 067
22.5	223 868	1029 508	293 752	396	301			1547 825
23	79 027	915 119	155 684	84	298	10		1150 222
23.5	51 941	400 364	41 726	60	22			494 113
24	55 894	57 196	18 538	17				131 645
24.5		57 196	9 269					66 465
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	10346 808	4918 767	7650 555	29 497	35 964	20 208	40867 781	63869 580
Mean L	18.6	22.2	20.3	19.9	20.7	18.9	16.4	17.7
sd	2.03	1.20	1.63	1.46	1.05	1.20	1.91	2.63
Catch	**623**	**524**	**610**	**1 954**	**2 828**	**1 257**	**1 536**	**9 332**

Table 7.2.4.1c: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter 2013.

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								
10	10 886						118 133	129 019
10.5	16 328							16 328
11	27 214						726 877	754 091
11.5	67 721			202			3015 199	3083 122
12	161 879			708		38	10720 197	10882 822
12.5	287 175			2 861		76	18387 257	18677 369
13	254 003			3 968			14881 046	15139 017
13.5	235 902			6 306		114	7206 404	7448 726
14	490 125			8 813		418	3231 597	3730 953
14.5	407 232			9 549		874	5155 931	5573 586
15	302 147			11 555		987	12357 012	12671 702
15.5	152 939			5 831		836	20603 482	20763 088
16	61 958			2 854		500	17515 446	17580 758
16.5	27 293			960		19	10530 030	10558 302
17	23 098	20 048		299	21	1 102	6766 479	6811 047
17.5	34 929	32 856		321	61	2 673	4432 171	4503 011
18	28 707	124 419	13 371	1 027	147	4 680	4131 830	4304 181
18.5	29 867	78 814	15 710	2 623	583	5 051	3716 394	3849 042
19	43 252	157 739	160 169	7 441	1 107	3 737	2545 671	2919 116
19.5	42 525	193 525	614 690	10 281	2 531	3 319	1719 188	2586 059
20	60 812	254 451	845 730	8 775	6 557	2 206	1200 172	2378 703
20.5	35 920	369 490	960 302	8 034	7 050	1 028	312 527	1694 351
21	21 315	389 994	820 850	5 637	7 812	371	58 424	1304 403
21.5	10 974	566 503	995 150	4 190	7 787	146	78 833	1663 583
22	19 315	731 079	585 354	1 709	2 908	6		1340 372
22.5	7 688	806 148	348 692	843	1 169			1164 540
23	8 018	1028 423	95 011	150	388			1131 989
23.5	1 987	437 748	37 172		62			476 969
24	1 823	231 468	10 794					244 085
24.5		74 023						74 023
25								
25.5								
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	2873 032	5496 728	5502 995	104 939	38 183	28 182	149410 300	163454 360
Mean L	14.8	22.1	21.1	17.4	21.0	18.4	15.1	15.6
sd	2.31	1.51	1.01	3.01	0.91	1.61	2.08	2.61
Catch	**93**	**613**	**615**	**5 988**	**3 613**	**1 781**	**4 603**	**17 307**

Table 7.2.4.1d: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2013.

				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							50 130	50 130
10			5 704				100 260	105 964
10.5			17 113				708 681	725 794
11		257 377	52 057		19		924 363	1233 816
11.5		566 229	254 130				3605 876	4426 235
12		463 278	479 603	304	133		8223 958	9167 276
12.5		1544 801	427 183	642	325		14399 791	16372 742
13		877 782	335 415	1 824	251		14579 964	15795 237
13.5		748 187	370 248	2 789	536		7564 863	8686 624
14	41 095	1007 099	1643 264	3 091	783		5470 867	8166 199
14.5	134 267	241 578	2362 013	2 891	1 278	26	5072 691	7814 744
15	233 039	660 821	1404 593	5 168	1 320		3551 158	5856 098
15.5	310 147	666 622	349 123	6 113	666	147	1242 802	2575 620
16	672 201	768 562	215 684	8 573	220	5	665 482	2330 727
16.5	748 715	523 135	216 976	4 890	128	49	237 572	1731 465
17	1536 605	674 701	197 233	2 872	40	117	888 693	3300 262
17.5	1208 030	220 727	54 461	1 170	51	478	3853 688	5338 605
18	1187 729	201 589	8 928	607	139	1 873	5712 264	7113 129
18.5	1097 261	105 374	3 586	1 960	826	2 192	6635 489	7846 688
19	1095 100	152 919	14 414	3 052	1 370	1 607	4425 041	5693 503
19.5	942 843	205 992	121 982	6 626	2 980	740	5552 754	6833 917
20	842 060	322 978	333 102	8 249	3 747	508	2762 225	4272 869
20.5	536 139	589 912	419 393	10 617	3 318	460	1333 416	2893 254
21	424 616	476 962	586 697	8 062	4 362	299	964 029	2465 028
21.5	352 680	453 046	426 305	7 487	2 346	226	501 637	1743 728
22	424 920	1005 713	331 528	3 218	997	2		1766 378
22.5	233 989	814 457	283 256	2 092	675		125 955	1460 424
23	151 694	773 017	85 002	1 052	267			1011 032
23.5	76 579	511 920	48 260	206	35			637 000
24	47 715	222 411	41 937	64				312 127
24.5	14 745	163 295						178 040
25	1 720	51 011						52 731
25.5								
26		9 491						9 491
26.5		9 491						9 491
27								
27.5								
28								
28.5								
29								
Total	12313 889	15290 477	11089 190	93 619	26 812	8 730	99153 649	137976 367
Mean L	18.8	17.4	16.2	18.6	19.4	19.	15.2	15.9
sd	1.97	4.13	3.23	2.84	2.66	1.1	2.91	3.24
Catch	**734**	**833**	**450**	**5 673**	**1 878**	**595**	**3 283**	**13 446**

Table 7.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision and Table 7.2.4.3. shows the historical catch-at-age data. In Table 7.2.4.4, the relative contribution of each age group in each Subdivision is shown as well as their relative contribution to the catches. In 2013, the dominant age in catches was age-0, whereas in previous years the most abundant year class was age-1. Age 0 fish was dominant in IXaN and IXaCN and IXaS-Cadiz. The cohort of 2007 (which was strong in French waters) had no longer significant contribution in the VIIIcE subdivision and most of catches were age 1(28%) as in the IXaS-Algarve subdivision, where age 1 represented 33% of catches.

Table 7.2.4.2: Sardine in VIIIc and IXa: Catch in numbers (thousands) at age by quarter and by subdivision in 2013.

First Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0								
1	5 418	1 316	4 130	4 195	924	3 669	11 148	30 799
2	4 329	818	998	5 492	1 922	1 466	5 206	20 230
3	4 454	707	666	4 508	3 559	2 318	1 866	18 078
4	2 069	1 554	1 088	5 530	2 564	627	510	13 942
5	2 607	1 298	571	1 547	867	921	240	8 050
6	2 069	1 153	292	458	548	344	166	5 030
7	629	240	220	176	172	261		1 698
8	538	132	199	275	144	110		1 398
9	391	105	86	311	153	39		1 085
10		132						132
11								
12								
Total	22 504	7 455	8 249	22 492	10 852	9 753	19 136	100 442
Catch (Tons)	1 291	561	454	1 450	765	479	735	5 734

Second Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0								
1	1 432	76	2 376	6 325	2 068	3 333	23 817	39 428
2	4 235	883	1 687	10 826	9 485	5 627	11 980	44 724
3	2 790	718	904	6 490	10 965	6 319	3 768	31 954
4	669	1 222	1 386	4 224	5 502	1 595	807	15 405
5	657	979	572	916	3 747	1 857	310	9 038
6	425	809	272	288	2 520	882	184	5 381
7	58	140	190	70	635	384		1 476
8	49	40	163	110	656	211		1 229
9	31	25	100	172	386			715
10		25		78				103
11								
12								
Total	10 347	4 919	7 651	29 497	35 964	20 208	40 868	149 453
Catch (Tons)	623	524	610	1 954	2 828	1 257	1 536	9 332

Third Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	2 339	184	8 482	54 016	19	3 902	85 978	154 920
1	311	1 325	2 181	28 442	5 197	10 999	47 915	96 369
2	124	1 065	1 691	16 026	12 861	7 751	12 674	52 192
3	26	1 300	845	4 955	9 037	2 996	1 697	20 855
4	23	723	407	753	4 679	1 192	824	8 601
5	27	510	128	441	3 670	385	237	5 397
6	15	149	157	30	1 542	364	86	2 342
7	4	156	40	128	798	594		1 721
8	2	85	40	30	250			409
9	1			120				121
10					130			130
11								
12								
Total	2 873	5 497	13 972	104 939	38 183	28 182	149 410	343 057
Catch (Tons)	93	613	615	5 988	3 613	1 781	4 603	17 307

Fourth Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	1 459	8 738	6 745	39 271	5 646	314	63 453	125 624
1	6 247	2 324	2 500	24 214	7 953	3 826	19 273	66 338
2	2 493	1 145	860	16 610	5 737	1 809	10 040	38 695
3	440	1 337	483	6 579	3 423	1 617	3 158	17 037
4	535	780	254	4 909	2 172	340	1 554	10 545
5	577	493	82	786	898	259	1 011	4 105
6	367	177	94	177	558	299	664	2 336
7	82	175	35	845	179	151		1 467
8	69	122	35	60	246	114		647
9	46			169				216
10								
11								
12								
Total	12 315	15 290	11 089	93 619	26 812	8 730	99 154	267 010
Catch (Tons)	734	833	450	5 673	1 878	595	3 283	13 446

Whole Year

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	3 798	8 922	15 227	93 286	5 665	4 216	149 431	280 544
1	13 408	5 042	11 187	63 175	16 142	21 827	102 153	232 934
2	11 182	3 911	5 237	48 953	30 005	16 652	39 901	155 842
3	7 711	4 062	2 897	22 532	26 984	13 250	10 489	87 924
4	3 297	4 279	3 135	15 416	14 916	3 754	3 695	48 492
5	3 868	3 278	1 353	3 690	9 182	3 422	1 798	26 590
6	2 876	2 288	814	953	5 168	1 889	1 100	15 088
7	773	712	486	1 219	1 784	1 389		6 363
8	659	380	439	475	1 296	435		3 683
9	470	131	186	772	539	39		2 136
10		157		78	130			365
11								
12								
Total	48 039	33 161	40 961	250 549	111 811	66 873	308 567	859 962
Catch (Tons)	2 741	2 531	2 128	15 065	9 084	4 112	10 157	45 819

Table 7.2.4.3 Sardine VIIIc and IXa: Historical catch-at-age data.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	869	2297	947	295	137	42	16
1979	674	1536	956	431	189	93	36
1980	857	2037	1562	379	157	47	30
1981	1026	1935	1734	679	195	105	76
1982	62	795	1869	709	353	131	129
1983	1070	577	857	803	324	141	139
1984	118	3312	487	502	301	179	117
1985	268	564	2371	469	294	201	103
1986	304	755	1027	919	333	196	167
1987	1437	543	667	569	535	154	171
1988	521	990	535	439	304	292	189
1989	248	566	909	389	221	200	245
1990	258	602	517	707	295	151	248
1991	1581	477	436	407	266	75	105
1992	498	1002	451	340	186	111	81
1993	88	566	1082	521	257	114	120
1994	121	60	542	1094	272	113	72
1995	31	189	281	830	473	70	64
1996	277	101	348	515	653	197	47
1997	209	549	453	391	337	225	70
1998	449	366	502	352	234	179	106
1999	246	475	362	340	177	106	73
2000	490	355	314	256	194	98	64
2001	220	1172	256	196	126	75	50
2002	107	587	754	181	112	56	40
2003	198	319	446	518	114	61	51
2004	590	181	264	387	378	78	55
2005	169	1006	266	207	191	117	46
2006	18	250	777	129	108	121	81
2007	199	82	313	536	80	83	121
2008	298	219	183	370	412	65	109
2009	378	354	196	125	252	197	84
2010	278	517	263	136	83	129	183
2011	342	452	383	122	88	41	111
2012	220	194	168	123	94	49	53
2013	281	233	156	88	48	27	28

Table 7.2.4.4. 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	IXa-S (Ca)	Total
0	8%	27%	37%	37%	5%	6%	48%	33%
1	28%	15%	27%	25%	14%	33%	33%	27%
2	23%	12%	13%	20%	27%	25%	13%	18%
3	16%	12%	7%	9%	24%	20%	3%	10%
4	7%	13%	8%	6%	13%	6%	1%	6%
5	8%	10%	3%	1%	8%	5%	1%	3%
6+	10%	11%	5%	1%	8%	6%	0%	3%
	100%	100%	100%	100%	100%	100%	100%	100%
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	1%	3%	5%	33%	2%	2%	53%	100%
1	6%	2%	5%	27%	7%	9%	44%	100%
2	7%	3%	3%	31%	19%	11%	26%	100%
3	9%	5%	3%	26%	31%	15%	12%	100%
4	7%	9%	6%	32%	31%	8%	8%	100%
5	15%	12%	5%	14%	35%	13%	7%	100%
6+	17%	13%	7%	13%	32%	14%	4%	100%

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.

Table 7.2.5.1: Sardine VIIIc and IXa: Sardine Mean length (cm) at age by quarter and by subd
in 2013.

						First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	14.5	15.1	16.4	16.7	16.5	16.2	15.9
2	18.1	20.2	20.2	19.7	20.0	18.6	17.4
3	19.6	21.9	21.3	20.6	20.8	19.2	18.6
4	21.7	22.5	21.5	21.7	21.3	19.9	19.7
5	22.0	23.1	21.9	21.9	21.7	20.7	20.0
6	22.4	23.4	22.2	21.8	21.6	21.1	21.1
7	23.4	23.6	22.1	22.3	22.1	21.3	
8	23.6	24.3	22.0	22.1	22.1	21.2	
9	23.9	24.4	22.6	22.2	23.3	21.8	
10		24.7					
11							
12							

						Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	15.9	19.6	18.7	18.0	18.3	17.4	15.4
2	17.8	20.7	20.0	19.8	20.2	18.6	17.6
3	19.1	21.5	20.9	20.5	20.7	18.9	18.5
4	21.1	22.4	21.2	21.3	21.1	20.0	19.3
5	21.4	22.9	22.0	21.2	21.5	20.2	19.9
6	22.0	23.1	22.3	21.8	21.5	20.8	20.9
7	23.1	23.1	22.3	22.3	21.6	20.7	
8	23.2	24.0	22.2	22.4	21.2	20.9	
9	23.4	24.1	22.6	22.2	21.7		
10		24.1		23.9			
11							
12							

						Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	13.9	18.2	10.6	14.6	18.8	15.2	13.8
1	16.9	20.5	20.5	19.8	19.8	18.3	16.7
2	19.9	22.1	21.3	20.7	20.9	19.1	17.4
3	20.9	22.8	21.6	21.5	21.2	19.6	18.8
4	21.6	23.1	21.9	21.7	21.2	20.4	18.9
5	21.8	23.3	21.8	22.0	21.6	20.4	20.3
6	22.4	23.5	21.8	22.8	21.8	20.5	21.3
7	23.0	23.4	22.8	21.3	22.0	20.7	
8	23.2	23.6	22.8	22.8	21.6		
9	23.3			21.8			
10					21.8		
11							
12							

						Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	16.2	14.3	14.2	15.5	14.7	16.3	13.2
1	17.9	19.1	17.3	19.9	19.8	18.6	18.1
2	19.7	22.0	21.4	21.0	20.8	18.9	19.2
3	21.0	22.7	21.8	21.7	21.3	19.3	19.8
4	21.7	23.1	22.0	21.9	21.3	20.7	19.9
5	21.9	23.4	22.2	22.8	21.9	20.6	20.8
6	22.5	23.7	22.1	23.2	22.3	21.0	21.6
7	23.0	23.8	23.0	22.3	22.3	21.4	
8	23.4	24.1	23.0	22.8	22.0	21.6	
9	23.6			22.3			
10							
11							
12							

						Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	14.8	14.4	12.2	15.0	14.7	15.3	13.6
1	16.3	18.4	17.9	19.4	19.4	17.9	16.6
2	18.3	21.4	20.7	20.5	20.6	18.9	17.9
3	19.5	22.4	21.3	21.1	20.9	19.2	19.0
4	21.6	22.7	21.5	21.6	21.2	20.2	19.5
5	21.9	23.1	21.9	21.9	21.6	20.4	20.5
6	22.4	23.3	22.1	22.1	21.7	20.8	21.4
7	23.4	23.5	22.3	22.2	21.9	20.9	
8	23.5	24.0	22.2	22.3	21.5	21.1	
9	23.8	24.4	22.6	22.2	22.1	21.8	
10		24.6			21.8		
11							
12							

Table 7.2.5.2: Sardine VIIIc and IXa: Sardine Mean weight (kg) at age by quarter and by subd in 2013.

						First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	0.026	0.029	0.037	0.037	0.039	0.035	0.033
2	0.047	0.064	0.064	0.059	0.065	0.050	0.042
3	0.058	0.078	0.072	0.068	0.072	0.055	0.050
4	0.076	0.083	0.074	0.079	0.076	0.059	0.057
5	0.079	0.090	0.078	0.082	0.080	0.067	0.060
6	0.083	0.093	0.080	0.080	0.078	0.070	0.068
7	0.093	0.095	0.080	0.085	0.084	0.072	
8	0.095	0.103	0.079	0.083	0.084	0.071	
9	0.098	0.104	0.085	0.085	0.095	0.076	
10		0.107					
11							
12							

						Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	0.035	0.070	0.060	0.049	0.056	0.050	0.031
2	0.051	0.084	0.075	0.065	0.073	0.060	0.044
3	0.065	0.096	0.087	0.072	0.078	0.062	0.050
4	0.090	0.109	0.091	0.080	0.083	0.071	0.056
5	0.094	0.118	0.103	0.080	0.088	0.073	0.061
6	0.103	0.120	0.108	0.087	0.088	0.078	0.069
7	0.121	0.121	0.108	0.093	0.089	0.078	
8	0.123	0.136	0.106	0.094	0.085	0.079	
9	0.127	0.139	0.113	0.092	0.090		
10		0.139		0.113			
11							
12							

						Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0.025	0.058	0.011	0.033	0.068	0.036	0.023
1	0.047	0.087	0.087	0.077	0.080	0.061	0.039
2	0.078	0.110	0.098	0.088	0.093	0.069	0.044
3	0.092	0.122	0.102	0.097	0.097	0.074	0.055
4	0.102	0.128	0.107	0.099	0.097	0.082	0.056
5	0.106	0.132	0.106	0.103	0.102	0.083	0.069
6	0.116	0.135	0.105	0.114	0.105	0.084	0.078
7	0.126	0.134	0.122	0.094	0.108	0.086	
8	0.130	0.137	0.122	0.114	0.103		
9	0.1			0.100			
10					0.104		
11							
12							

						Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0.035	0.024	0.023	0.032	0.028	0.046	0.019
1	0.049	0.064	0.048	0.071	0.071	0.065	0.052
2	0.068	0.098	0.090	0.084	0.083	0.067	0.062
3	0.083	0.109	0.095	0.093	0.089	0.070	0.069
4	0.094	0.117	0.099	0.095	0.089	0.084	0.070
5	0.097	0.121	0.102	0.109	0.097	0.083	0.080
6	0.106	0.126	0.100	0.114	0.103	0.087	0.091
7	0.114	0.129	0.115	0.102	0.103	0.091	
8	0.121	0.134	0.115	0.107	0.1	0.093	
9	0.1			0.100			
10							
11							
12							

						Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0.029	0.025	0.016	0.033	0.028	0.037	0.021
1	0.038	0.061	0.054	0.069	0.070	0.056	0.039
2	0.054	0.091	0.083	0.078	0.083	0.064	0.048
3	0.062	0.106	0.090	0.083	0.085	0.064	0.056
4	0.082	0.104	0.088	0.086	0.087	0.074	0.062
5	0.084	0.109	0.093	0.090	0.094	0.073	0.072
6	0.089	0.108	0.097	0.089	0.094	0.079	0.083
7	0.098	0.117	0.097	0.098	0.098	0.082	
8	0.100	0.124	0.096	0.091	0.091	0.080	
9	0.102	0.111	0.100	0.092	0.091	0.076	
10		0.112			0.104		
11							
12							

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.

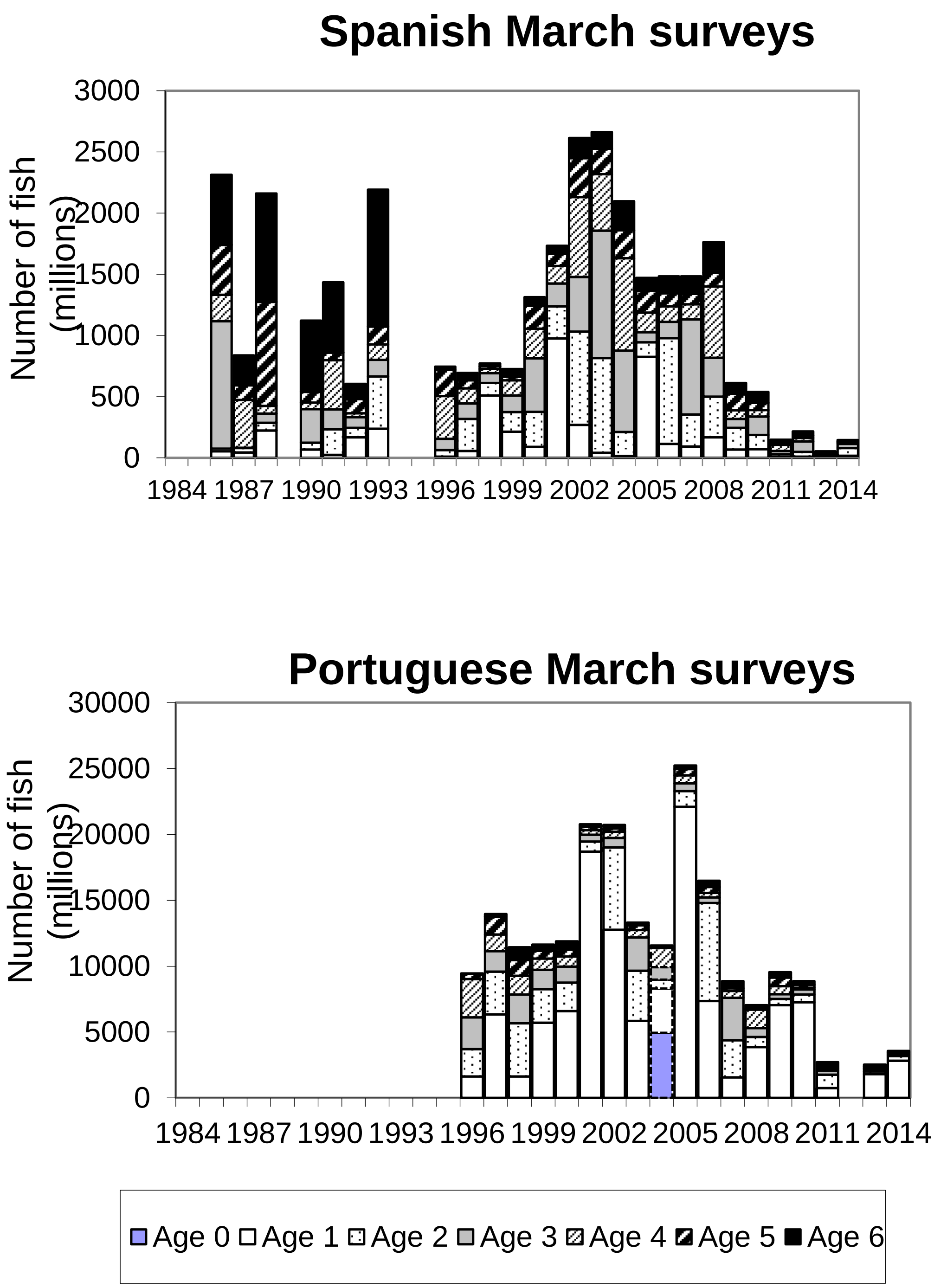


Figure 7.3.1 Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area VIIIc and IXa-N (Galicia) and the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz). Portuguese acoustic survey 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.

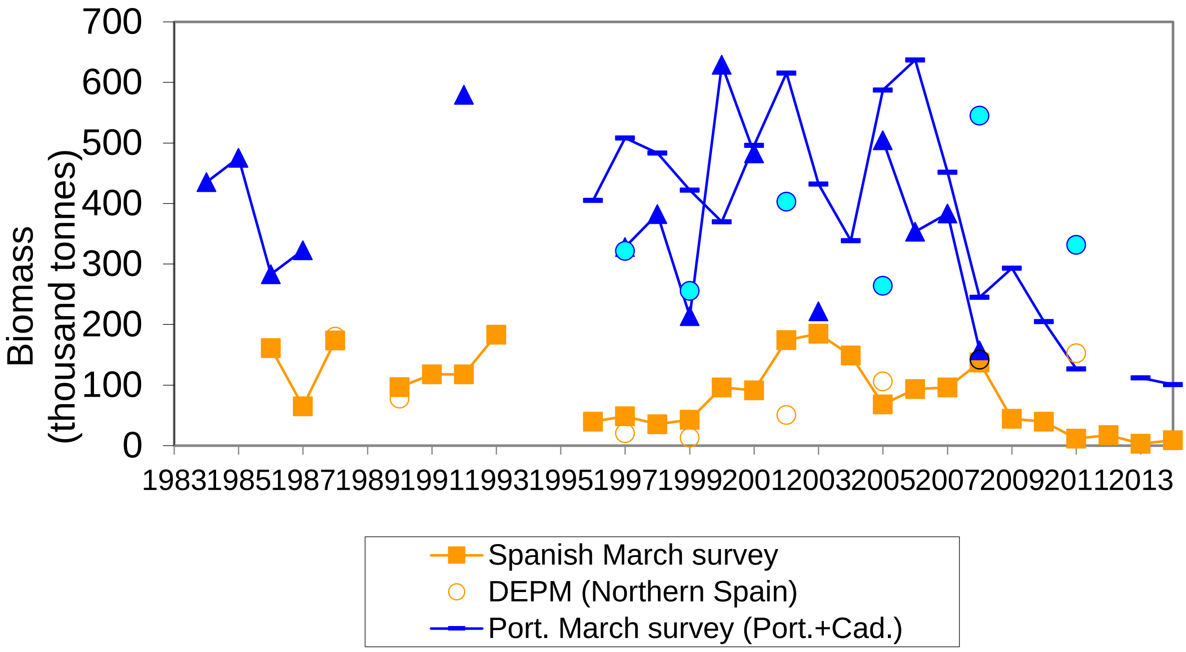


Figure 7.3.2 Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

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

The triennial DEPM for estimation of sardine spawning biomass for the Atlanto-Iberian stock areas IXa-VIIIc and VIIIb up to 45ºN took place in the S and W (IPMA) from 15th March to 26th April and in the N (Galicia, Cantabrian Sea and French coast, IEO) between 29th March and 21st April. Samples from both surveys are being analyzed at present and only preliminary results are summarized here:

- The whole area was surveyed, however Portuguese survey was conducted much later than usual and suffered several interruptions; part of IPMA´s DEPM survey was conducted simultaneously to the acoustics survey on board the same vessel; consequently preventing solid comparisons of the 2014 results with the historic series;
- Spawning area in 2014 for the whole area was slightly reduced compared to 2011 and the smallest of the historic series; patchy egg distribution;
- Spawning area reduction was particularly evident in the north (around 40% of the total spawning area in 2011) while in the west it increased to almost the double;
- The southern and western regions showed similar daily egg production per m² (eggs/m²/day) which was much larger than in the north. For all strata daily egg production per m² was much lower than in recent surveys;
- Sum of total egg production for the 3 strata in 2014 was much lower than in 2011, in particular in the northern and southern regions, similar in the west (Table 7.3.1.1. and Figure 7.3.1.1.);

- Mortality value (single mortality for whole area) was similar to 2005 and one of the lowest of the series but with high CV;
- During the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless 36 samples were obtained, 11 in the south, 10 in the west and 15 in the north; extra samples (14) from purse-seiners were collect in Portugal.

The number of hydrated females collected was higher than in 2011

No estimates are available at present for the adults parameters

It should be noted that these values are preliminary estimates and will not be used in the present assessment. Final figures will be presented in November at the WGACEGG.

Table 7.3.1.1. Preliminary results of the DEPM (SP+PO) surveys in 2014.

Institute	IPMA	IPMA	IEO	IPMA+IEO (total)	IEO
Parameter/Area	IXa South	IXa West	IXa N + VIIIc	IXa+VIIIc	VIIIb (up to 45º N)
Survey area (Km2)	14558.7	27357.3	38914.4	80830.5	13480.4
Positive area (Km2)	6077.2	8895.7	7494.5	22467.4	7913.8
Z (hour-1) (CV%)	-0.012 *(50.3)				-0.021*** (29.2)
P0 (eggs/m2/day) (CV%)	100.3 (27.9)	101.8 (24.4)	37.8 (25.9)		211.5 (27.5)
P0 tot (eggs/day)(x1012) (CV%)	0.61 (27.9)	0.91 (24.4)	0.28 (25.9)	1.80 (16)	1.67 (27.5)

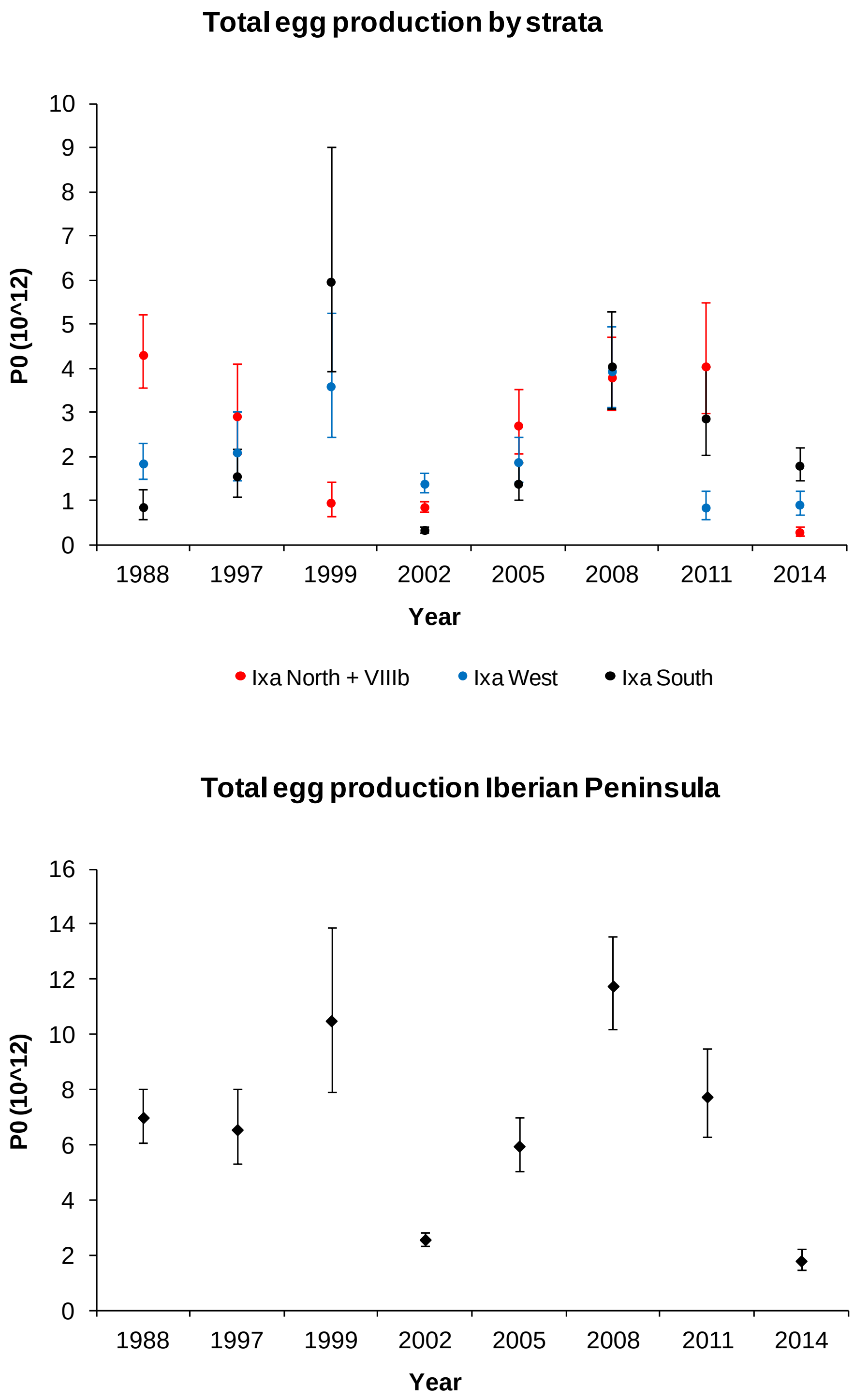


Figure 7.3.1.1. Total egg production (eggs/day*10^{12}) by spatial strata (top panel); black-IXa South, blue-IXa West stratum, red-IXa North + VIIIc and for the total stock area off the Iberian Peninsula (bottom panel). Dots and lines indicate the estimates of egg production and their confidence intervals.

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, 2013). As described in the Stock Annex, the total numbers-at-age from the two surveys are used as input to the assessment.

There are two annual surveys carried out to estimate small pelagic fish abundance in IXa and VIIIc using acoustic methods. The April-May 2014 Portuguese survey (PELAGOS14) took place on board the RV "Noruega" while the Spanish survey (PELACUS0314) took place in March-April on board the RV "Miguel Oliver".

Both surveys were conducted following the methodology applied in previous years and agreed and revised at the WGACEGG.

7.3.2.1 Portuguese spring acoustic survey

PELAGOS14 survey took place from the 3rd April to the 15th May and covered the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth. The 2014 spring acoustic survey took place one month later than planned and lasted longer than usual, and was interrupted several times due to bad weather and ship technical problems.

Detailed objectives, methodology and sampling strategy are described in the WD-Marques *et al.*,(2014) presented in this group.

During the survey 44 trawl hauls were performed (22 of these hauls with sardine). Sardine was distributed mainly in the OCN zone and in the South (Algarve and Cadiz Areas). In the Southwest area sardine was not detected and only a few individuals were fished (Figure 7.3.2.1.1). The estimated biomass for the Portuguese coast was 57 thousand tonnes corresponding to 2297 million individuals, the lowest value in the survey series In the OCS area the sardine estimated abundance was very low (8 thousand tonnes; 244 million individuals), and was found mixed with other pelagic species. On the contrary in the OCN area, sardine recovered from the minimum value found in the last year survey; the sardine biomass increased up to 29 thousand tonnes, corresponding to 1697 million individuals. Algarve showed also a recovery in the sardine abundance, with an estimation of 20 thousand tonnes (356 million individuals). The sardine abundance in Cadiz also recovered, compared with the 2013 survey (44 thousand tonnes; 1260 million individuals).

The sardine length structure in the OCN area was bimodal (9 cm and 15 cm mode), with juveniles (individual total length ≤ 16 cm) contributing with 92%. In the OCS zone the length structure was roughly unimodal; 56% of sardines in the OCS area were juveniles. In Algarve the sardine length distribution was trimodal with modes at 17 cm, 19 cm and 21 cm. In this area only 3% of the individuals were considered juveniles. In the Cadiz area, juveniles represented 61% of the sardine abundance estimated for this area (Figure 7.3.2.1.1, Table 7.3.2.1.1.).

Age 1 is predominant in all areas. However, the total abundance of age 1 fish (2828 thousand fish), corresponding to the survivors of the 2013 cohort, is 13% of the abundance of the 2004 strong cohort at the same age (Table 7.3.2.1.1.).

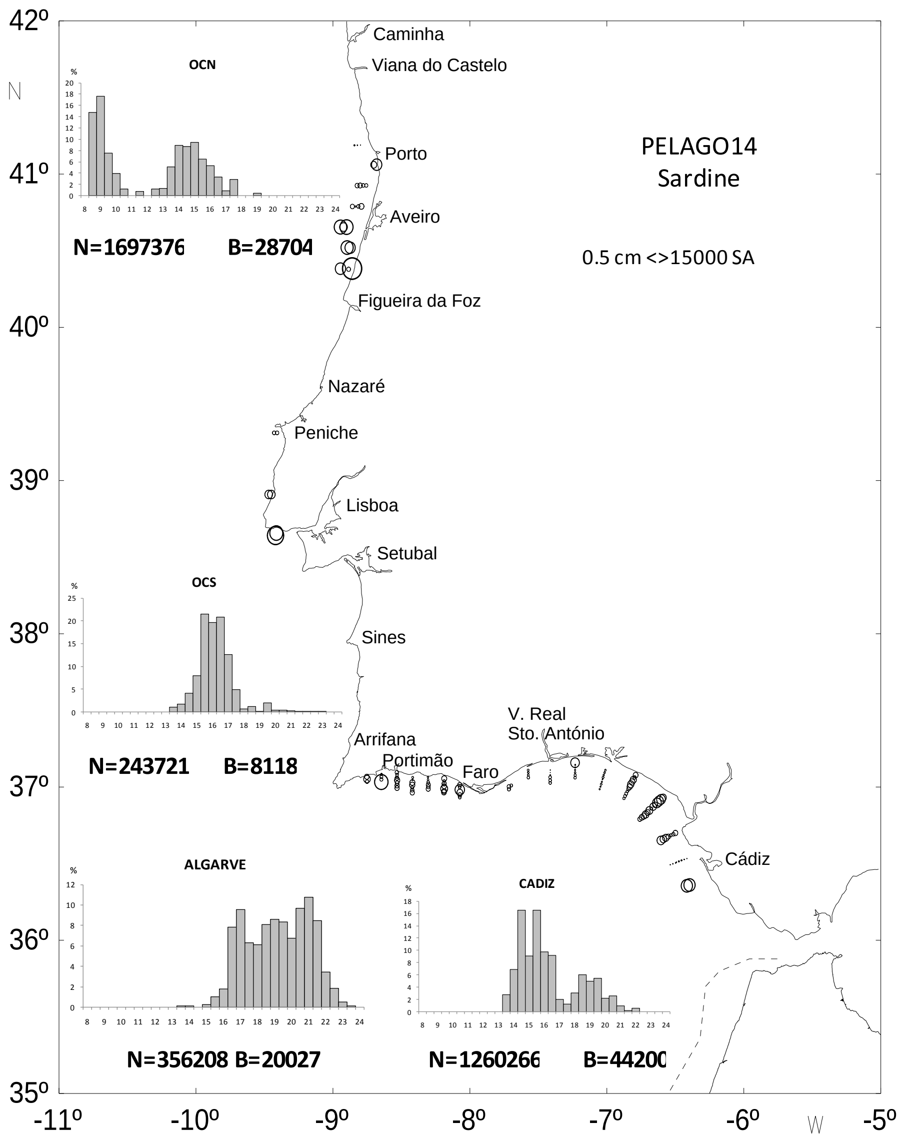


Figure 7.3.2.1.1Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2014. Acoustic energy by nautical mile and abundance (in millions), biomass (in thousand tons) and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

Table 7.3.2.1.1: Sardine in VIIIc and IXa: Sardine Assessment from the 2014 Portuguese spring acoustic survey (PELAGO14). Numbers in thousand fish and biomasss in tonnes.

		AGE						
AREA		1	2	3	4	5	6+	Total
Oc. Norte	Biomass	28217	487	0	0	0	0	28704
	%	98.3	1.7	0	0	0	0	100.0
	No fish	1687553	9823	0	0	0	0	1697376
	%	99.4	0.6	0	0	0	0	100.0
	Mean weight, g	14.5	18.9	0	0	0	0	14.5
	Mean length, cm	12.5	18.8	0	0	0	0	12.5
Oc. Sul	Biomass	6946	963	49	68	14	78	8118
	%	85.6	11.9	0.6	0.8	0.2	1.0	100.0
	No fish	218810	21937	792	1048	211	78	243721
	%	89.8	9.0	0.3	0.4	0.1	0.0	100.0
	Mean weight, g	16.4	18.3	20.3	20.7	21.0	22.4	16.7
	Mean length, cm	16.2	18.0	20.2	20.5	20.9	22.4	16.4
Algarve	Biomass	3102	3187	2730	2985	1878	6145	20027
	%	15.5	15.9	13.6	14.9	9.4	30.7	100.0
	No fish	82910	65671	47720	50799	26591	6145	356208
	%	23.3	18.4	13.4	14.3	7.5	1.7	100.0
	Mean weight, g	17.2	18.8	19.8	20.0	21.2	21.5	19.9
	Mean length, cm	17.1	18.6	19.7	19.8	21.1	21.5	19.4
Cadiz	Biomass	23031	11851	3717	3311	896	1394	44200
	%	52.1	26.8	8.4	7.5	2.0	3.2	100.0
	No fish	838660	266663	66023	57358	13544	1394	1260266
	%	66.5	21.2	5.2	4.6	1.1	0.1	100.0
	Mean weight, g	15.6	18.4	19.7	19.8	20.7	21.8	17.3
	Mean length, cm	15.5	18.0	19.6	19.7	20.7	21.8	16.6
Total Portugal	Biomass	38266	4637	2779	3053	1892	6222	56849
	%	67.3	8.2	4.9	5.4	3.3	10.9	100.0
	No fish	329938	88094	48513	51847	26802	6222	551415
	%	59.8	16.0	8.8	9.4	4.9	1.1	100.0
	Mean weight, g	15.0	18.8	19.8	20.2	21.2	21.6	16.8
	Mean length, cm	13.1	18.5	19.7	20.0	21.1	21.6	14.0
Total	Biomass	61297	16488	6496	6363	2788	7617	101049
	%	60.7	16.3	6.4	6.3	2.8	7.5	100.0
	No fish	1168597	354757	114535	109204	40346	7617	1795056
	%	65.1	19.8	6.4	6.1	2.2	0.4	100.0
	Mean weight, g	15.3	18.8	19.7	19.9	21.0	21.5	17.0
	Mean length, cm	13.8	18.5	19.6	19.8	20.9	21.5	14.9

7.3.2.2 Spanish spring acoustic survey

The Spanish survey took placeon board the RV "Miguel Oliver" from the 9th March to 8th April.

The area covered extended from the Galician-Portugal border to southern French waters and from 30 to 1000 m depth. Detailed objectives, methodology and sampling strategy are described in the WD-Riveiro and Carrera (2014) presented in this group.

Overall, total biomass estimation is 9023 tonnes, corresponding to 147 million fish.

Sardine was mainly detected in south Galicia, inside the Rias Baixas (ICES Subareas IXa-N), showed a gap in the entire VIIIcWest subdivision and reappeared on the Asturias coast, covering all the VIIIcEast subdivision, but with lower densities in the Vasque Country area (Figure 7.3.2.2.1 and Table 7.3.2.2.1).

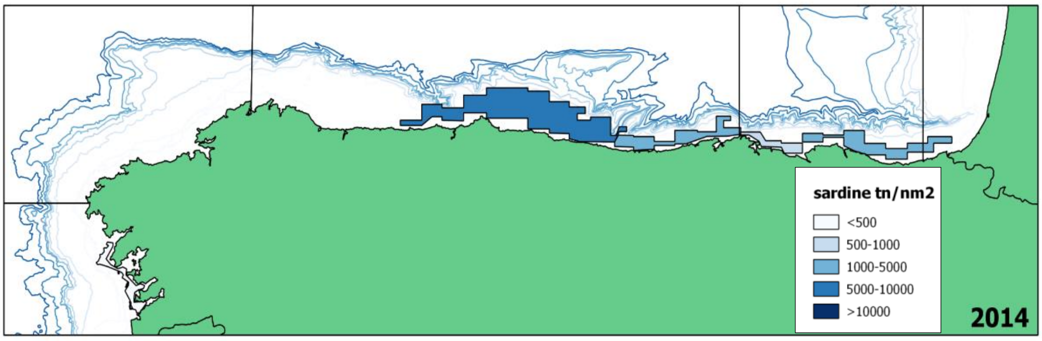


Figure 7.3.2.2.1 Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0314 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m2 within each polygon.

Table 7.3.2.2.1. Sardine in VIIIc and IXa: sardine abundance in number (thousands of fish) and biomass (tons) by age groups and ICES Subdivision in PELACUS0314.

AREA VIIIcE											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	680	3409	2197	855	667	688	357	121			8973
% Biomass	7.6	38.0	24.5	9.5	7.4	7.7	4.0	1.3			100
Abundance (N in '000)	16147	63086	34238	11556	7892	7950	3762	1166			145796
% Abundance	11.1	43.3	23.5	7.9	5.4	5.5	2.6	0.8			100
Medium Weight (gr)	42.14	54.04	64.17	73.96	84.46	86.57	94.80	103.41			75.4
Medium Length (cm)	17.81	19.47	20.73	21.80	22.86	23.06	23.83	24.59			21.8
AREA IXaN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	32	12	3	1	1	1	0	0			50
% Biomass	64.3	24.2	5.8	2.0	1.3	1.8	0.5	0.1			100
Abundance (N in '000)	980	275	45	14	8	10	3	0			1336
% Abundance	73.3	20.6	3.4	1.0	0.6	0.8	0.2	0.0			100
Medium Weight (gr)	32.9	44.1	63.8	72.4	82.3	85.4	88.2	93.5			63.5
Medium Length (cm)	16.4	18.1	20.7	21.6	22.7	23.0	23.2	23.8			20.4
TOTAL SPAIN											
AGE	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (Tonnes)	713	3421	2200	856	667	689	357	121			9023
% Biomass	7.9	37.9	24.4	9.5	7.4	7.6	4.0	1.3			100
Abundance (N in '000)	17229	63917	34731	11738	8029	8079	3824	1180			148728
% Abundance	11.6	43.0	23.4	7.9	5.4	5.4	2.6	0.8			100
Medium Weight (gr)	41.6	54.0	64.2	74.0	84.5	86.6	94.8	103.4			67.0
Medium Length (cm)	17.7	19.5	20.7	21.8	22.9	23.1	23.8	24.6			19.3

Sardine ranged in length from 14 to 25.5 cm, with a mode at 18.5 cm (Figure 7.3.2.2.2.) which corresponds to quite large fish.

Most fish in the entire surveyed area were assigned as belonging to the age 2 (38% of the abundance and 43% of the biomass) and age 3 (24.5% of the abundance and 25.5 % of the biomass) years classes. By subdivisions, the IXaN (South of Galicia) population was dominated by age 1 fish whilst the Cantabrian area was mainly composed by a population of age 2 and age 3 individuals.

The distribution of sardine eggs (obtained from the analysis of 358 CUFES stations) indicates a very coastal distribution, agreeing with that observed in previous years The percentage of positive stations was very similar in both surveys, but total number of sardine eggs detected in Spanish waters was 4214, which represents an important decrease from the 2013 value (Figure 7.3.2.2.3).

The 2013 and 2014 Spanish acoustic surveys were carried out on a new vessel. The technical specifications of the vessel are similar to the previous one (Thalassa). The results of the intercalibration carried out after PELACUS0314 in April 2014 with Thalassa will be presented at the next WGACEGG working group.

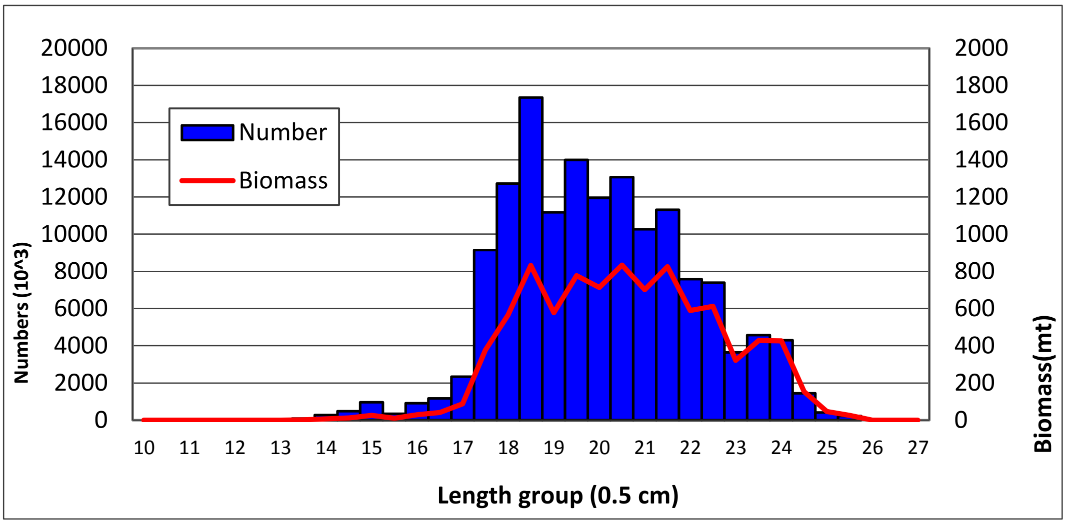


Figure 7.3.2.2.2 Sardine length distribution (cm) in numbers and biomass (tonnes) during the PELACUS0314 survey.

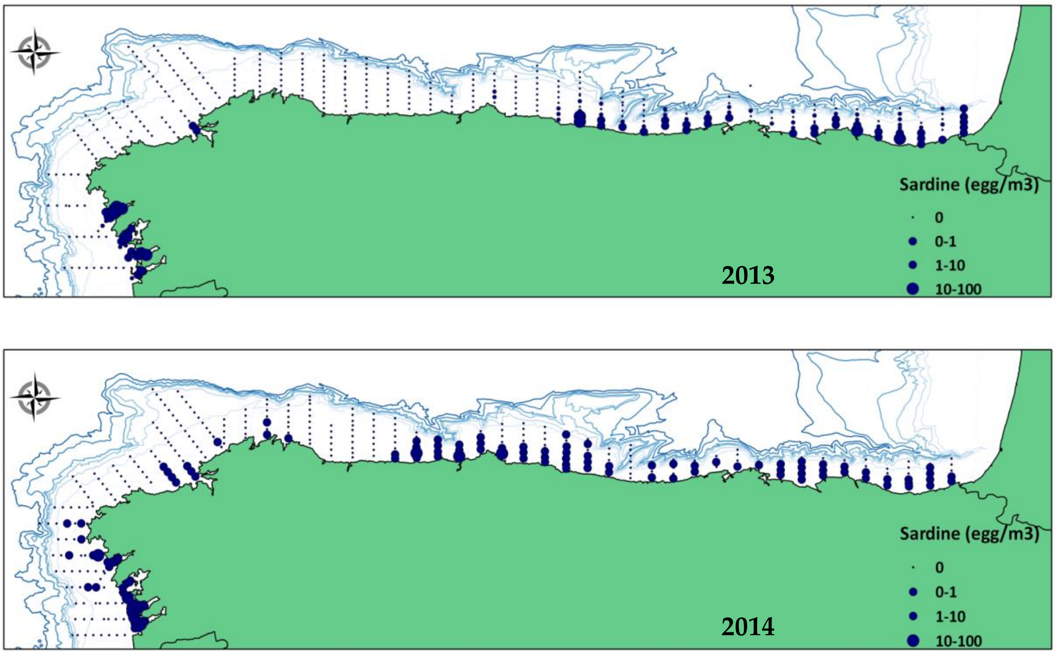


Figure 7.3.2.2.3 Sardine in VIIIc and IXa: Total number of sardine eggs obtained during the PELACUS (2013-2014) surveys. Diameter of circles is proportional to egg density.

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.

According to the stock annex (WKPELA 2012), the mean weight at age in the stock in 2013 was obtained from samples collected in the acoustic surveys (Table 7.4.1b).

Historical weights-at-age show an increase over time. This increase is seen in catch weights since 1991 and in stock weights since 1989 but may have started earlier (in earlier years, fixed weights are used in the assessment; a fixed catch weight of 0.1Kg is used for age 6+). The weight increase is significant for all age groups in the catches and most age groups in the stock (2-4 and 6+) (see Tables 7.4.1a and 7.4.1.b). Stock weights in 2013 are high compared to those in recent years although they are within the range of historical values.

Table 7.4.1a. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the catch. Weights-at-age 1978-1987 are fixed and equal to those in 1988. Age 6+ weight is fixed over time at 0.100 Kg

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
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
2012	0.031	0.056	0.065	0.078	0.083	0.086	0.100
2013	0.025	0.052	0.069	0.077	0.085	0.090	0.100

Table 7.4.1b. Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the stock. Weights-at-age 1978-1989 are fixed and equal to those in 1990.

Year	Age1	Age2	Age3	Age4	Age5	Age6+
1990	0.015	0.038	0.050	0.064	0.067	0.100
1991	0.019	0.042	0.050	0.064	0.071	0.100
1992	0.027	0.036	0.050	0.062	0.069	0.100
1993	0.022	0.045	0.057	0.064	0.073	0.100
1994	0.031	0.040	0.049	0.060	0.067	0.100
1995	0.029	0.050	0.062	0.072	0.079	0.100
1996	0.021	0.042	0.050	0.057	0.065	0.077
1997	0.024	0.032	0.052	0.059	0.064	0.072
1998	0.029	0.037	0.048	0.054	0.059	0.066
1999	0.024	0.040	0.052	0.059	0.067	0.073
2000	0.017	0.043	0.056	0.061	0.067	0.067
2001	0.021	0.041	0.060	0.071	0.072	0.074
2002	0.024	0.040	0.055	0.068	0.074	0.074
2003	0.019	0.043	0.053	0.065	0.070	0.076
2004	0.020	0.045	0.061	0.069	0.076	0.100
2005	0.019	0.045	0.059	0.068	0.073	0.079
2006	0.030	0.042	0.060	0.068	0.068	0.075
2007	0.039	0.054	0.062	0.070	0.076	0.077
2008	0.017	0.052	0.065	0.070	0.080	0.087
2009	0.020	0.053	0.060	0.065	0.069	0.076
2010	0.018	0.042	0.058	0.064	0.064	0.071
2011	0.026	0.048	0.058	0.065	0.066	0.067
2012	0.026	0.048	0.058	0.065	0.066	0.067
2013	0.036	0.052	0.057	0.075	0.075	0.079

7.4.2 Maturity-at-age

Following the Stock Annex (WKPELA 2012), in years with no DEPM survey, maturity-at-age is assumed to be 0 for age 0, 0.8 for age 1 and 1 for ages 2+ (DEPM results for the 2014 survey are not available at the moment).

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

7.4.4 Catch-at-age and abundance-at-age in the spring acoustic survey

The historical series of catches-at-age and abundance-at-age in the spring acoustic survey are presented in Figures 7.4.4.1 and 7.4.4.2.

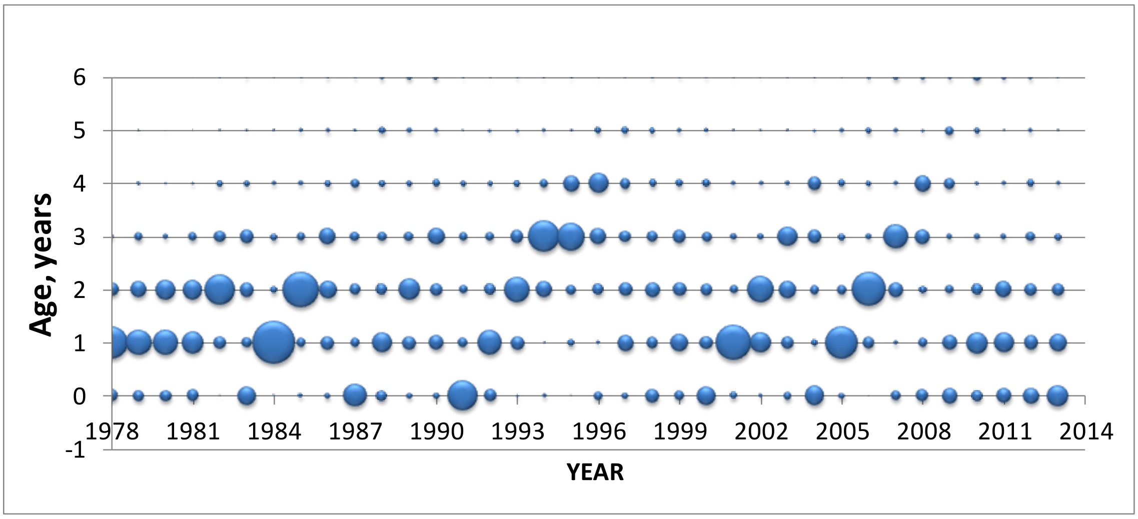


Figure 7.4.4.1. Sardine in VIIIc and IXa: Catches-at-age for 1978-2013.

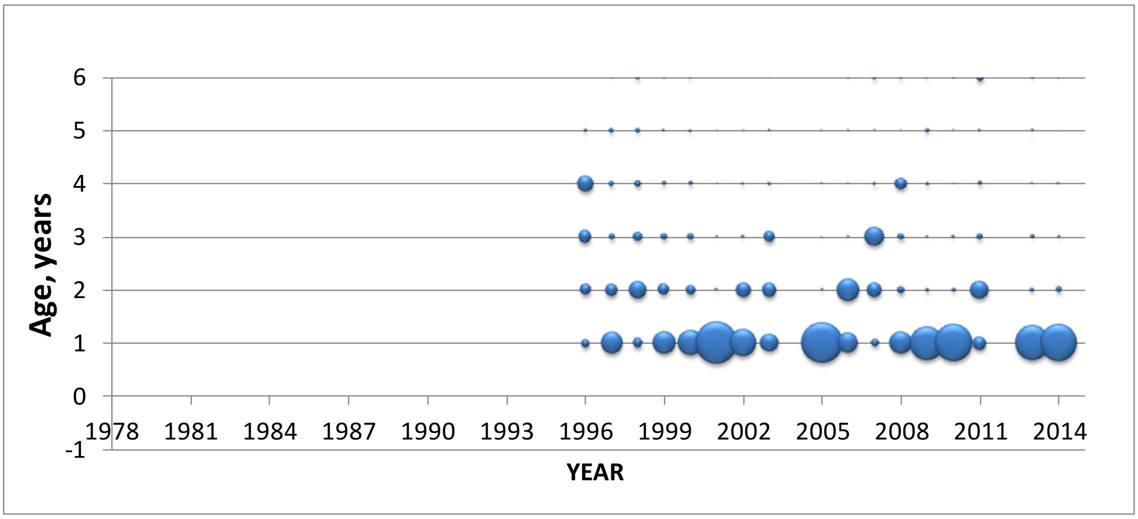


Figure 7.4.4.2. Sardine in VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996-2014.

7.5 Assessment Data of the state of the stock

7.5.1 Stock assessment

The assessment follows the Stock Annex (WKPELA 2012) and is a SPALY.

The table below presents an overview of the model settings. Additional details can be found in the Stock Annex.

Model structure and assumptions:	
M	M-at-age 0=0.8, M-at-age 1=0.5, M-at-age 2=0.4, M-at-age 3+=0.3, all years
Recruitment	No SR model; 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 WGANSA 2011)
Catch biomass	Assumed to be accurate and precise. The F values are tuned to match this catch. Total catch biomas by year is assumed to be a median unbiased index of abundance.
Fishing mortality	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.
Initial population	N-at-age in the first year are parameters, derived from an input initial equilibrium catch, the geometric mean recruitment and the selectivity in the first year.
Fishery selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 0 not estimated, used as the reference; S-at-ages 4 and 5 assumed to be equal to S-at-age 3.
Fishery selectivity over time	Two periods: 1978-1990 with selectivity-at-age varying as a random walk and 1991-last year in assessment for which selectivity-at-age is fixed over time
Survey selectivity-at-age	S-at age are parameters, each estimated as a random walk from the previous age; S-at-age 1 not estimated, used as the reference; S-at-ages 3 to 5 assumed to be equal to S-at-age 2; fixed over time
Fishery catchability	Scaling factor, median unbiased
Acoustic survey catchability	Scaling factor, mean unbiased
DEPM catchability	Scaling factor, mean unbiased
Precision of acoustic data	A standard error of 0.25 assumed for all years for the acoustic index (total number of fish). A sample size=50 is assumed for all years of the acoustic age composition.
Precision of DEPM data	A standard error of 0.25 assumed for all years for the DEPM index (spawning biomass).
Precision of catch-at-age data	Ageing imprecision is 0.1 at Age0, 0.2 at Age1, 0.3 at Ages 2-5, 0.4 at age 6+ .The sample size for annual age compositions is 50 in 1978-1990 and 75 in 1991-2last year in the assessment
Objective function	Log likelihood function, user-weighted composite of components from the different data sources. Variance estimates for all estimated parameters are calculated from the Hessian matrix.

Table 7.5.1.1 shows the parameters estimated by the assessment model. Estimates of fishing mortality-at-age and numbers-at-age are presented in Tables 7.5.1.2 and 7.5.1.3. 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 noted in past assessments, the model fits poorly to some acoustic and DEPM surveys. The three most recent acoustic surveys, 2011, 2013 and 2014 are below the model estimates whereas the two most recent DEPM surveys, 2008 and 2011 are well above the model estimates. Nevertheless, both surveys indicate a decrease of the stock from 2008 to 2011. Preliminary estimates of total egg production from the 2014 DEPM (section 7.3, Figure 7.3.1) indicate the decrease has continued from 2011 to 2014, in agreement with the acoustic index.

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

Parameter	Phase	Initial value	Final Value	Std Dev
SR_LN(R0)	1	8.9	9.302	0.042
Main_RecrDev_1978	_	_	0.754	0.138
Main_RecrDev_1979	_	_	0.884	0.137
Main_RecrDev_1980	_	_	1.016	0.132
Main_RecrDev_1981	_	_	0.548	0.164
Main_RecrDev_1982	_	_	-0.030	0.224
Main_RecrDev_1983	_	_	1.484	0.105
Main_RecrDev_1984	_	_	0.335	0.180
Main_RecrDev_1985	_	_	0.284	0.174
Main_RecrDev_1986	_	_	0.093	0.183
Main_RecrDev_1987	_	_	0.810	0.124
Main_RecrDev_1988	_	_	0.217	0.158
Main_RecrDev_1989	_	_	0.175	0.157
Main_RecrDev_1990	_	_	0.204	0.153
Main_RecrDev_1991	_	_	1.211	0.088
Main_RecrDev_1992	_	_	0.873	0.096
Main_RecrDev_1993	_	_	0.059	0.130
Main_RecrDev_1994	_	_	-0.097	0.123
Main_RecrDev_1995	_	_	-0.421	0.124
Main_RecrDev_1996	_	_	0.023	0.097
Main_RecrDev_1997	_	_	-0.498	0.121
Main_RecrDev_1998	_	_	-0.227	0.106
Main_RecrDev_1999	_	_	-0.432	0.121
Main_RecrDev_2000	_	_	0.697	0.078
Main_RecrDev_2001	_	_	0.179	0.098
Main_RecrDev_2002	_	_	-0.426	0.127
Main_RecrDev_2003	_	_	-0.704	0.154
Main_RecrDev_2004	_	_	0.767	0.066
Main_RecrDev_2005	_	_	-0.259	0.100
Main_RecrDev_2006	_	_	-1.362	0.155
Main_RecrDev_2007	_	_	-0.891	0.115
Main_RecrDev_2008	_	_	-0.683	0.101
Main_RecrDev_2009	_	_	-0.521	0.091
Main_RecrDev_2010	_	_	-1.236	0.130
Main_RecrDev_2011	_	_	-1.244	0.160
Main_RecrDev_2012	_	_	-1.020	0.165
Main_RecrDev_2013	1	0.3	-0.563	0.198
InitF_1purse_seine	1	0	0.448	0.333
Q_base_3_DEPM_survey	2	0.9	0.103	0.140
AgeSel_1P_2_purse_seine	2	0.4	1.048	0.085
AgeSel_1P_3_purse_seine	2	0.1	0.631	0.083
AgeSel_1P_4_purse_seine	2	-0.5	0.361	0.087
AgeSel_1P_7_purse_seine	2	-0.3	-1.123	0.231

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

Parameter	Phase	Initial value	Final Value	Std Dev
AgeSel_2P_3_Acoustic_survey	2	-0.8	-0.269	0.085
AgeSel_2P_7_Acoustic_survey	2	0.9	-0.723	0.256
AgeSel_1P_2_purse_seine_BLK1delta_1978	2	0.4	0.686	0.233
AgeSel_1P_3_purse_seine_BLK1delta_1978	2	0.1	0.098	0.225
AgeSel_1P_4_purse_seine_BLK1delta_1978	2	-0.5	-0.477	0.258
AgeSel_1P_7_purse_seine_BLK1delta_1978	_	_	1.324	0.625
AgeSel_1P_2_purse_seine_DEVrwalk_1978	_	_	0.000	0.100
AgeSel_1P_2_purse_seine_DEVrwalk_1979	_	_	-0.027	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1980	_	_	-0.042	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1981	_	_	-0.048	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1982	_	_	-0.011	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1983	_	_	-0.034	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1984	_	_	-0.038	0.095
AgeSel_1P_2_purse_seine_DEVrwalk_1985	_	_	-0.067	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1986	_	_	-0.075	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1987	_	_	-0.077	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1988	_	_	-0.001	0.096
AgeSel_1P_2_purse_seine_DEVrwalk_1989	_	_	0.021	0.097
AgeSel_1P_2_purse_seine_DEVrwalk_1990	_	_	0.012	0.098
AgeSel_1P_3_purse_seine_DEVrwalk_1978	_	_	0.000	0.100
AgeSel_1P_3_purse_seine_DEVrwalk_1979	_	_	0.046	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1980	_	_	0.013	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1981	_	_	0.018	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1982	_	_	0.030	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1983	_	_	-0.022	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1984	_	_	-0.028	0.093
AgeSel_1P_3_purse_seine_DEVrwalk_1985	_	_	0.005	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1986	_	_	-0.033	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1987	_	_	-0.036	0.094
AgeSel_1P_3_purse_seine_DEVrwalk_1988	_	_	0.017	0.095
AgeSel_1P_3_purse_seine_DEVrwalk_1989	_	_	0.022	0.096
AgeSel_1P_3_purse_seine_DEVrwalk_1990	_	_	0.012	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1978	_	_	0.000	0.100
AgeSel_1P_4_purse_seine_DEVrwalk_1979	_	_	0.027	0.098
AgeSel_1P_4_purse_seine_DEVrwalk_1980	_	_	0.015	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1981	_	_	0.029	0.097
AgeSel_1P_4_purse_seine_DEVrwalk_1982	_	_	0.040	0.096
AgeSel_1P_4_purse_seine_DEVrwalk_1983	_	_	0.018	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1984	_	_	-0.003	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1985	_	_	0.011	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1986	_	_	0.006	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1987	_	_	0.016	0.095
AgeSel_1P_4_purse_seine_DEVrwalk_1988	_	_	0.046	0.095

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

Parameter	Phase	Initial value	Final Value	Std Dev
AgeSel_1P_4_purse_seine_DEVrwalk_1989	_	_	0.043	0.096
AgeSel_1P_4_purse_seine_DEVrwalk_1990	_	_	0.030	0.097
AgeSel_1P_7_purse_seine_DEVrwalk_1978	_	_	0.000	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1979	_	_	0.006	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1980	_	_	0.008	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1981	_	_	0.013	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1982	_	_	0.015	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1983	_	_	0.010	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1984	_	_	0.002	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1985	_	_	0.000	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1986	_	_	0.002	0.100
AgeSel_1P_7_purse_seine_DEVrwalk_1987	_	_	0.003	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1988	_	_	0.006	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1989	_	_	0.000	0.099
AgeSel_1P_7_purse_seine_DEVrwalk_1990			0.002	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	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.050	0.286	0.592	0.528	0.528	0.528	0.645
1979	0.045	0.251	0.544	0.498	0.498	0.498	0.612
1980	0.043	0.226	0.498	0.462	0.462	0.462	0.574
1981	0.041	0.205	0.459	0.439	0.439	0.439	0.551
1982	0.036	0.181	0.419	0.417	0.417	0.417	0.532
1983	0.036	0.174	0.392	0.397	0.397	0.397	0.512
1984	0.037	0.171	0.376	0.380	0.380	0.380	0.490
1985	0.032	0.141	0.310	0.317	0.317	0.317	0.410
1986	0.038	0.152	0.326	0.335	0.335	0.335	0.433
1987	0.045	0.168	0.347	0.363	0.363	0.363	0.471
1988	0.042	0.157	0.330	0.361	0.361	0.361	0.471
1989	0.033	0.124	0.265	0.302	0.302	0.302	0.394
1990	0.038	0.146	0.318	0.373	0.373	0.373	0.488
1991	0.045	0.128	0.240	0.344	0.344	0.344	0.112
1992	0.033	0.094	0.176	0.252	0.252	0.252	0.082
1993	0.034	0.097	0.183	0.262	0.262	0.262	0.085
1994	0.029	0.084	0.158	0.226	0.226	0.226	0.074
1995	0.029	0.082	0.153	0.220	0.220	0.220	0.072
1996	0.038	0.108	0.202	0.290	0.290	0.290	0.094
1997	0.048	0.138	0.259	0.371	0.371	0.371	0.121
1998	0.056	0.159	0.298	0.428	0.428	0.428	0.139
1999	0.053	0.150	0.283	0.405	0.405	0.405	0.132
2000	0.046	0.132	0.248	0.356	0.356	0.356	0.116
2001	0.045	0.128	0.240	0.345	0.345	0.345	0.112
2002	0.038	0.108	0.203	0.291	0.291	0.291	0.095
2003	0.037	0.105	0.197	0.283	0.283	0.283	0.092
2004	0.041	0.116	0.218	0.312	0.312	0.312	0.102
2005	0.040	0.114	0.214	0.307	0.307	0.307	0.100
2006	0.034	0.098	0.185	0.265	0.265	0.265	0.086
2007	0.036	0.104	0.195	0.280	0.280	0.280	0.091
2008	0.055	0.157	0.295	0.423	0.423	0.423	0.137
2009	0.063	0.180	0.338	0.485	0.485	0.485	0.158
2010	0.085	0.242	0.455	0.653	0.653	0.653	0.212
2011	0.096	0.274	0.515	0.739	0.739	0.739	0.240
2012	0.072	0.207	0.388	0.557	0.557	0.557	0.181
2013	0.061	0.175	0.329	0.472	0.472	0.472	0.154

Table 7.5.1.3. Sardine in VIIIc and IXa: Numbers -at-age, in millionsat the beggining of the year, estimated in the assessment. Estimates of survivors in 2014 are also shown. Age 0 in 2014 is the geometric mean recruitment of the historical period.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	23314	4757	2367	1052	540	278	271
1979	26550	9960	2168	877	460	236	227
1980	30286	11399	4701	843	395	207	197
1981	18960	13038	5514	1916	393	184	179
1982	10642	8180	6443	2336	915	188	164
1983	48373	4611	4138	2842	1141	447	163
1984	15331	20966	2351	1875	1415	568	295
1985	14561	6639	10718	1082	950	717	422
1986	12032	6334	3499	5267	584	513	594
1987	24644	5205	3299	1694	2792	310	557
1988	13626	10584	2668	1563	873	1439	417
1989	13067	5869	5485	1286	807	451	936
1990	13451	5684	3146	2822	704	442	715
1991	36816	5818	2978	1535	1439	359	550
1992	26263	15818	3106	1570	806	756	553
1993	11628	11420	8737	1746	904	464	812
1994	9952	5050	6284	4877	995	515	817
1995	7194	4342	2816	3597	2881	588	866
1996	11218	3141	2427	1619	2139	1713	947
1997	6661	4854	1711	1329	898	1186	1588
1998	8735	2852	2565	885	679	459	1649
1999	7116	3712	1476	1276	427	328	1284
2000	22022	3033	1937	746	630	211	996
2001	13112	9448	1612	1013	387	327	767
2002	7164	5633	5042	850	532	203	679
2003	5425	3099	3067	2759	470	294	570
2004	23600	2350	1693	1688	1540	263	550
2005	8462	10182	1269	913	915	835	510
2006	2809	3653	5511	687	497	499	797
2007	4500	1219	2008	3071	390	283	825
2008	5536	1950	667	1107	1719	218	716
2009	6512	2355	1011	333	537	834	568
2010	3186	2747	1193	483	152	245	740
2011	3160	1315	1308	507	186	58	538
2012	3954	1290	606	524	179	66	334
2013	6247	1652	636	276	222	76	234
2014	10965	2640	841	307	127	103	184

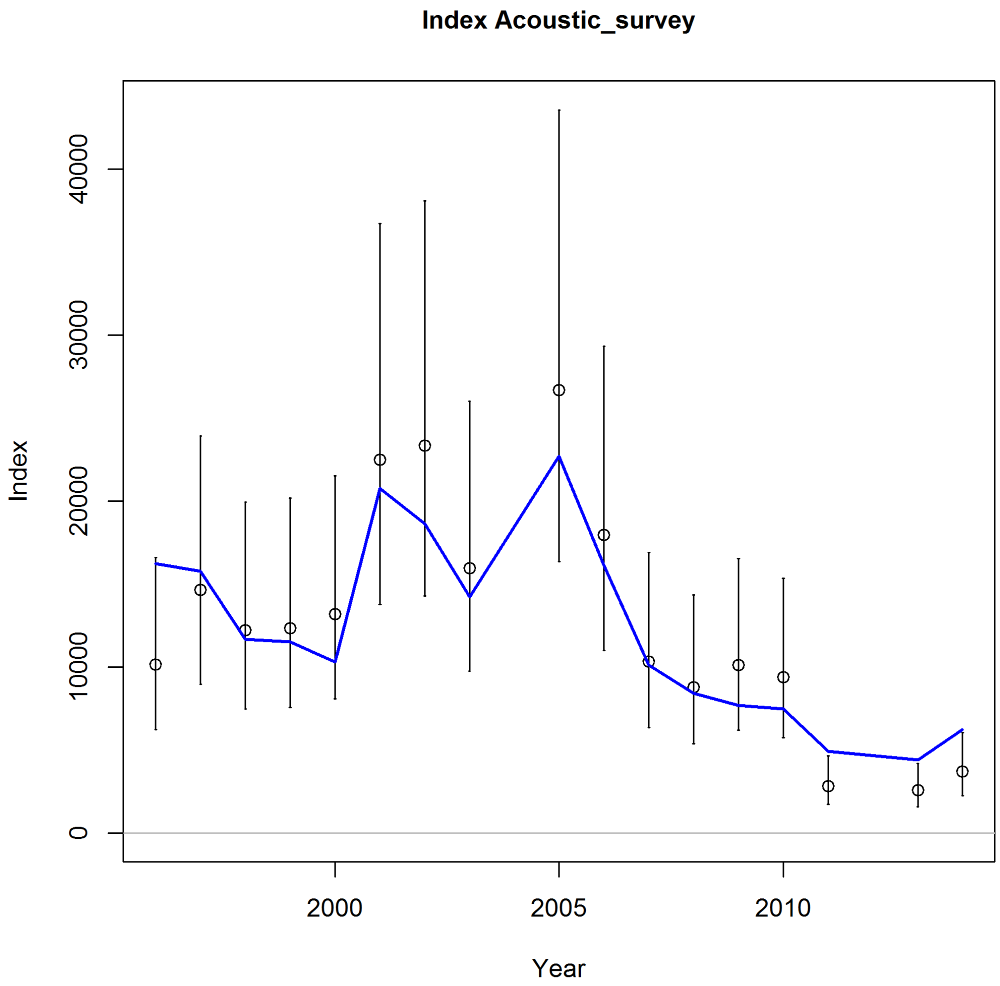


Figure 7.5.1.1. Sardine in VIIIc and IXa: Model fit to the acoustic survey series. The index is total abundance (in thousands of individuals). Bars are standard errors re-transformed from the log scale.

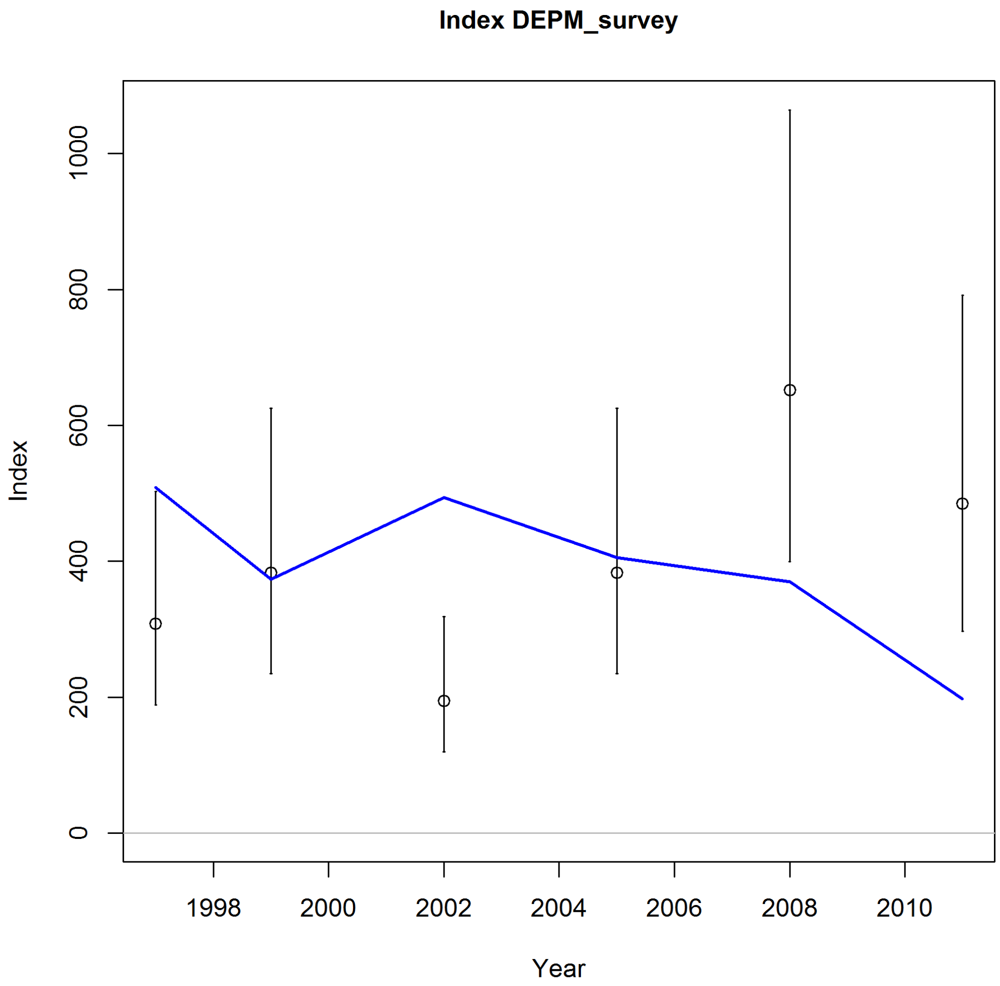


Figure 7.5.1.2: Sardine in VIIIc and IXa: Model fit to the DEPM survey series. The index is SSB (in thousand tons). Bars are standard errors re-transformed from the log scale.

Figure 7.5.1.3 shows the model residuals from the fit to the catch-at-age composition and the acoustic survey age composition. The residuals from the present assessment are comparable to those from last years' 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.

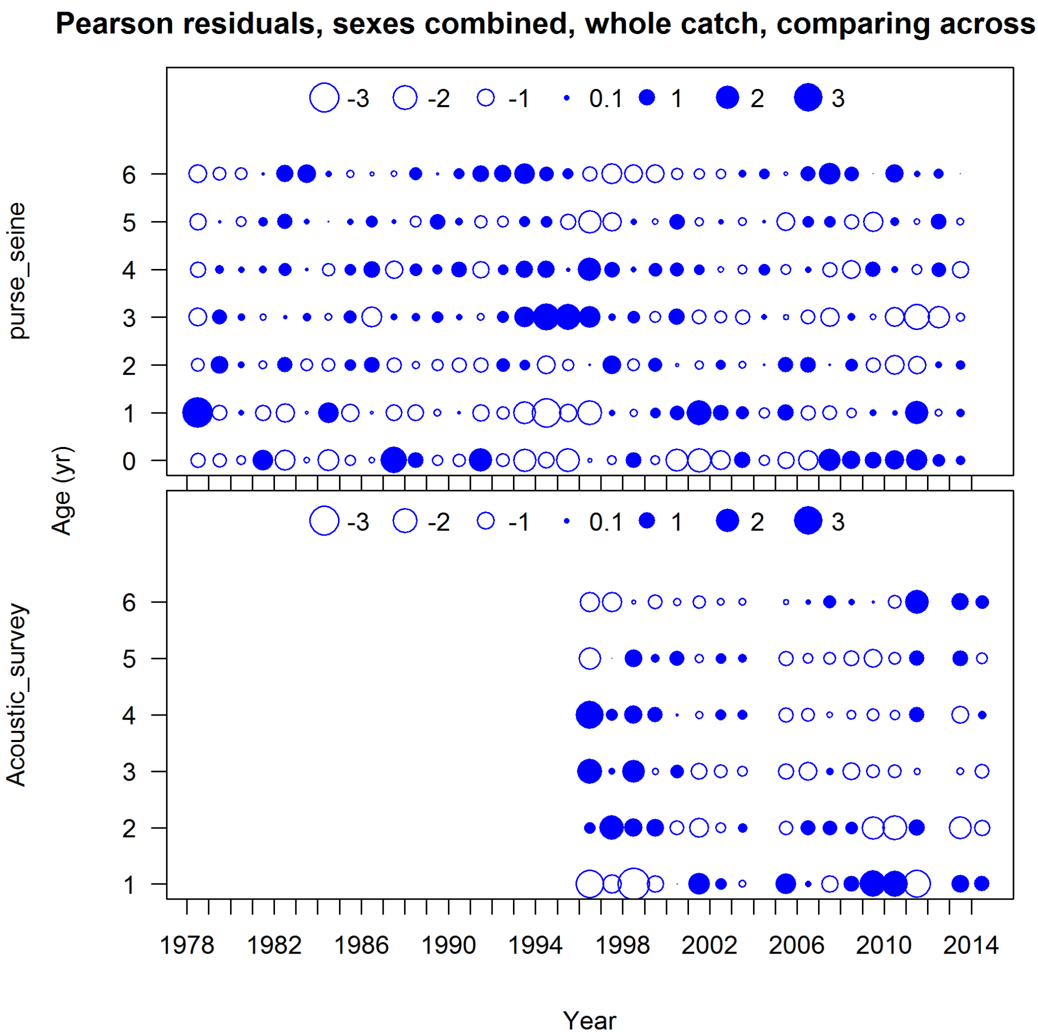


Figure 7.5.1.3. Sardine in VIIIc and IXa: Model residuals from the fit to the catch-at-age composition (top) and the acoustic survey age composition (bottom)

The survey selectivity pattern is comparable to that obtained in last years' assessment (Figure 7.5.1.4). Fishery selectivity for ages 2 and older in the earlier assessment period, 1978-1990, are higher than those estimated in previous assessments. This period corresponds to the period that selectivity is assumed to vary over time in a random walk. The differences increase substantially towards the beggining of the assessment period.

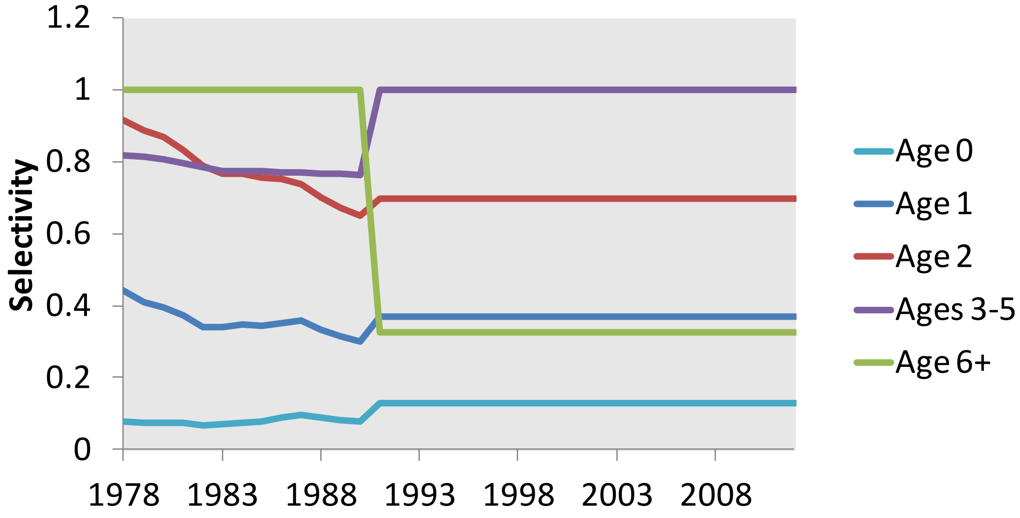


Figure 7.5.1.4. Sardine in VIIIc and IXa: Selectivity-at-age in the fishery (top) and in the acoustic survey (bottom).

Standard deviations of random walk selectivity parameters are exceptionally large, unlike in last years assessment (Table 7.5.1.1). Standard deviations of selectivity parameters for the fixed selectivity period are comparable to those from last years assessment. As a consequence fishing mortality confidence intervals show an abrupt and unrealistic increase from 1991 towards the beggining of the assessment period (1978, Table 7.5.1.4).

The assessment estimates of B1+, recruitment and fishing mortality are presented in Table 7.5.1.4 and Figure 7.5.1.5). The estimate of B1+ in 2014 assumes stock weights are equal to those in 2013. 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).

Table 7.5.1.4. Sardine in VIIIc and IXa: Summary table of the final WGHANSA 2013 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	294	280	0.13	23314	0.13	0.54	0.65	0.73	146
1979	344	314	0.12	26550	0.14	0.51	0.61	0.73	157
1980	451	416	0.11	30286	0.13	0.47	0.57	0.72	195
1981	556	517	0.11	18960	0.17	0.44	0.55	0.71	217
1982	572	547	0.12	10642	0.23	0.42	0.53	0.70	207
1983	488	474	0.14	48373	0.10	0.40	0.51	0.70	184
1984	656	593	0.12	15331	0.18	0.38	0.49	0.68	206
1985	712	692	0.11	14561	0.17	0.32	0.41	0.67	208
1986	622	603	0.12	12032	0.18	0.33	0.43	0.63	187
1987	543	528	0.13	24644	0.13	0.36	0.47	0.62	178
1988	532	501	0.12	13626	0.16	0.35	0.47	0.62	162
1989	536	519	0.12	13067	0.16	0.29	0.39	0.55	141
1990	492	475	0.12	13451	0.16	0.36	0.49	0.56	149
1991	485	462	0.13	36816	0.10	0.32	0.34	0.14	133
1992	775	696	0.11	26263	0.10	0.23	0.25	0.14	130
1993	917	871	0.10	11628	0.14	0.24	0.26	0.13	142
1994	823	792	0.10	9952	0.13	0.21	0.23	0.12	137
1995	830	804	0.10	7194	0.13	0.20	0.22	0.11	125
1996	555	542	0.11	11218	0.10	0.27	0.29	0.12	117
1997	484	459	0.11	6661	0.13	0.34	0.37	0.11	116
1998	393	376	0.11	8735	0.11	0.40	0.43	0.11	109
1999	355	337	0.12	7116	0.13	0.37	0.41	0.12	94
2000	296	287	0.12	22022	0.09	0.33	0.36	0.12	86
2001	433	395	0.10	13112	0.11	0.32	0.35	0.12	102
2002	485	446	0.10	7164	0.13	0.27	0.29	0.12	100
2003	431	419	0.10	5425	0.16	0.26	0.28	0.12	98
2004	407	398	0.11	23600	0.07	0.29	0.31	0.11	98
2005	468	366	0.10	8462	0.10	0.28	0.31	0.11	97
2006	510	488	0.08	2809	0.16	0.25	0.27	0.11	87
2007	459	449	0.08	4500	0.12	0.26	0.28	0.09	96
2008	340	334	0.10	5536	0.11	0.39	0.42	0.10	101
2009	256	247	0.10	6512	0.10	0.45	0.49	0.12	87
2010	205	195	0.11	3186	0.14	0.60	0.65	0.12	90
2011	178	178	0.12	3160	0.18	0.68	0.74	0.15	80
2012	131	125	0.16	3954	0.18	0.51	0.56	0.19	55
2013	149	138	0.20	6247	0.22	0.44	0.47	0.23	46
2014	188	170							

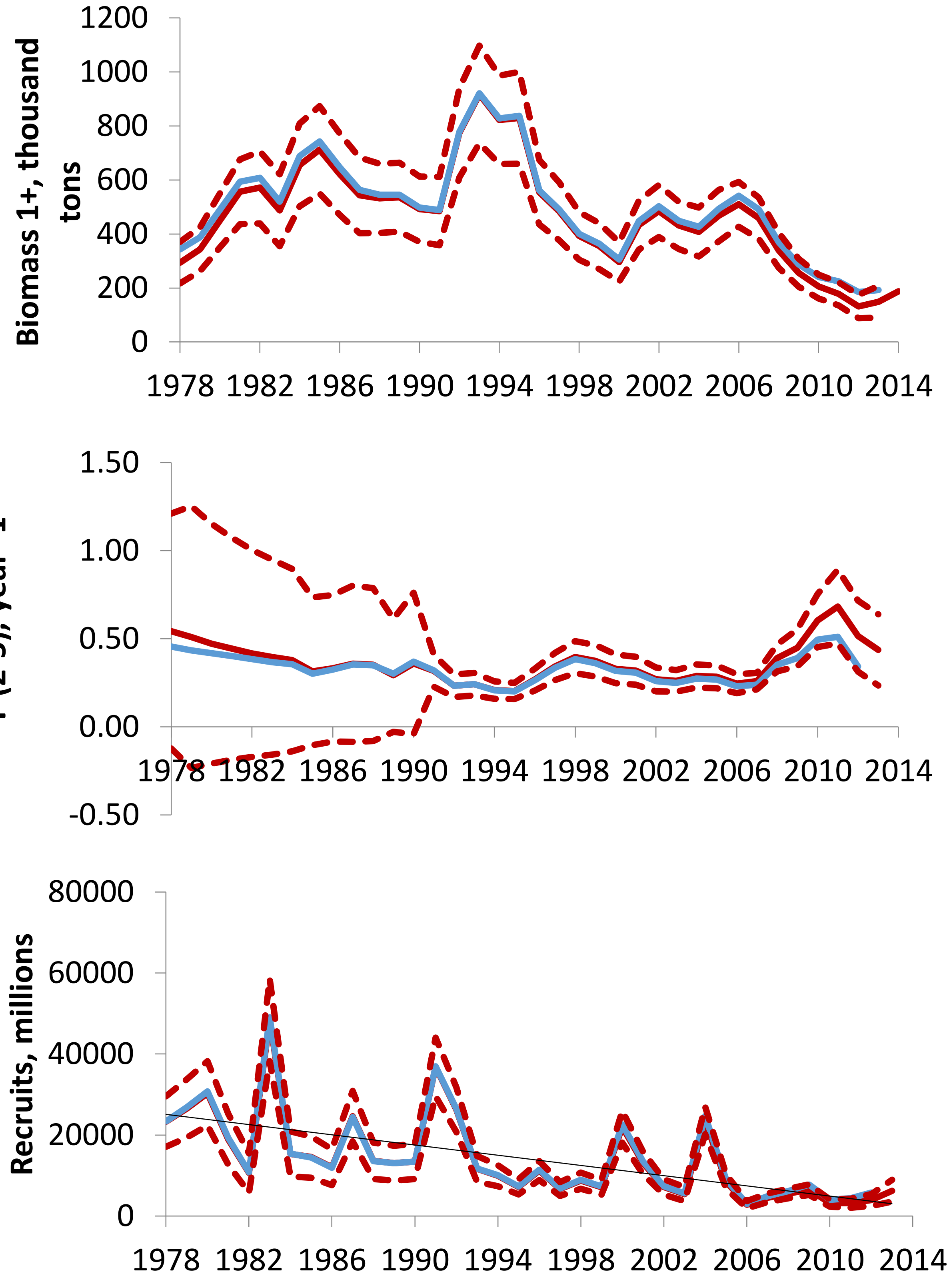


Figure 7.5.1.5. Sardine VIIIc and IXa: Historical B1+ (top), F (middle) and recruitment (bottom) trajectories in the period 1978 – 2013. The WG2013 assessment is shown for comparison.

B1+ in 2013=149 thousand t (CV=20%) is 69% below the historical mean 1978-2012. B1+ shows an increase of 14% from 2012 to 2013. F in 2013 is estimated to be 0.44 year(CV=23%), 21% above the historical mean. F decreased 25% from 2011 to 2012 and 15% from 2012 to 2013. B1+ in 2014 is estimated to be 188 thousand t.

As noted in last years' assessment, the series of historical recruitments 1978-2013 shows a significant linear downward trend (r^2=0.37, p<0.001, n=34).

The R2013 estimate, 6247 millions (CV=22%), is 44% lower than the historical geometric mean. This estimate is slightly above the geometric mean of the recent low recruitments 2009-2013 (RGM(09-13) = 4384. The estimate of the recruitment in the last year of the assessment (2013 in the present assessment) is supported by the 2014 Iberian acoustic survey index.

7.5.2 Sensitivity of the assessment to the assumption of fixed selectivity in 1991–2013

Considering the problems outlined in section 7.5.1 regarding F confidence intervals, we carried out a sensitivity test to evaluate the effect on the assessment of assuming fixed selectivity over time in the recent period (since 1991) in a situation that the real selectivity may be varying over the whole assessment period. There are reasons to suspect that selectivity has increased in recent years: the stock has declined substantially, especially in the traditional fishing areas (northern Portugal and Galicia) and there are indications that the spatial distribution of the fishery may be changing as well (Section 7.2.2). Abrupt changes in the catch composition are observed in the last two years of the assessment period (2012,2013). If selectivity is changing over time and the model forces a fixed pattern which does not reflect the most recent years, the model will possibly accommodatethe discrepancies in the period that selectivity is flexible. Since there are no surveys until 1996, there is wide uncertainty in selectivity estimates.

The test also allowed to investigate the influence of the assumption of constant selectivity in the most recent period on the retrospective pattern seen in recent assessments (including the present one), consisting of a tendency to underestimate F and overestimate biomass. The type ofretrospective pattern seen here was shown to be caused by theassumption that fishery selectivity is fixed over time (e.g. Cadigan and Farrel, 2005; Willberg *et al.*, 2010).

To perform the sensitivity test, the selectivity assumptions used for the early assessment period, 1978-1990, were applied to the remaining assessment period, 1991 – 2013 (see Section 7.5.1; termed Run variable S). The remaining assumptions are those of the SPALY2014 run.

Selectivity patterns for the SPALY2014 assessment and for the variable S run are presented in Figure 7.5.2.1. The variable S run indicates an increase in selectivity-at-age since the early 1990s which seems to have halted or reversed in the past two years. The recent changes are consistent with the major changes in the spatial catch distribution in the last two years . The fixed selectivity model estimates selectivity to be around the mean of the trend thus, much lower than present selectivity.

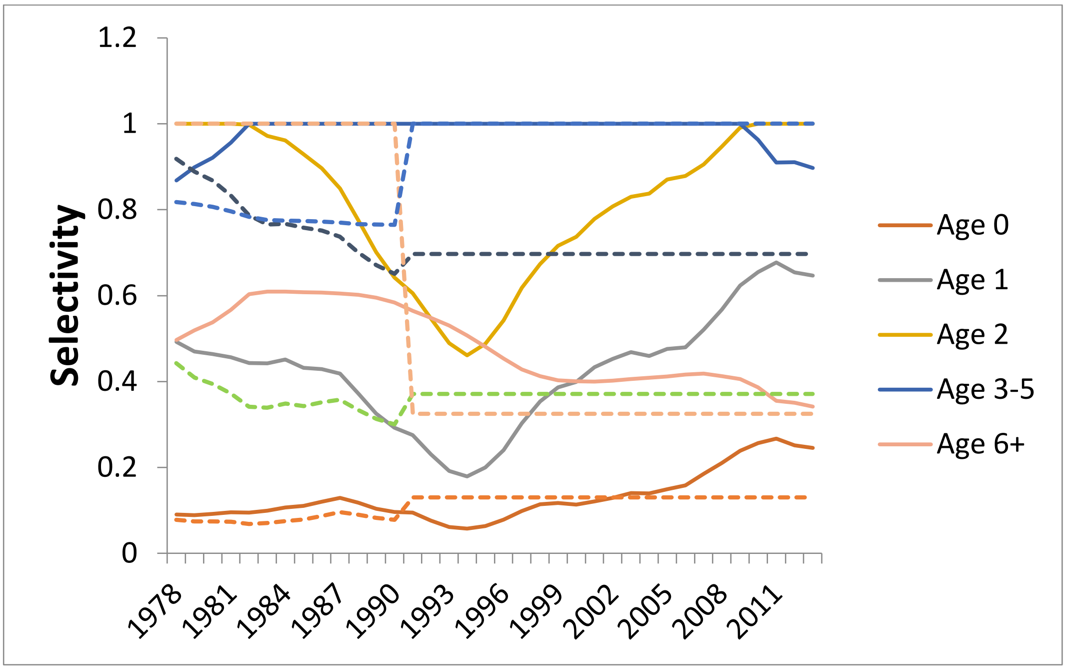


Figure 7.5.2.1 Sardine in VIIIc and IXa: Selectivity-at-age estimated in the Spaly2014 (dashed lines) and in the variable selectivity run (continuous lines).

The assumption of variable selectivity solved the sharp increase in fishing mortality confidence intervals prior to 1991 (Figure 7.5.2.2) indicating that the assumption of fixed selectivity up to the present has become too rigid. Confidence intervals are however wider over the whole period for all stock summaries, as seen in the exploratory work performed in the last benchmark (WKPELA 2012). The results from this run indicate a more optimistic perception of the stock status in recent years compared to the Spaly2014 run (e.g. 44% lower F and 37% higher B1+ in 2013).

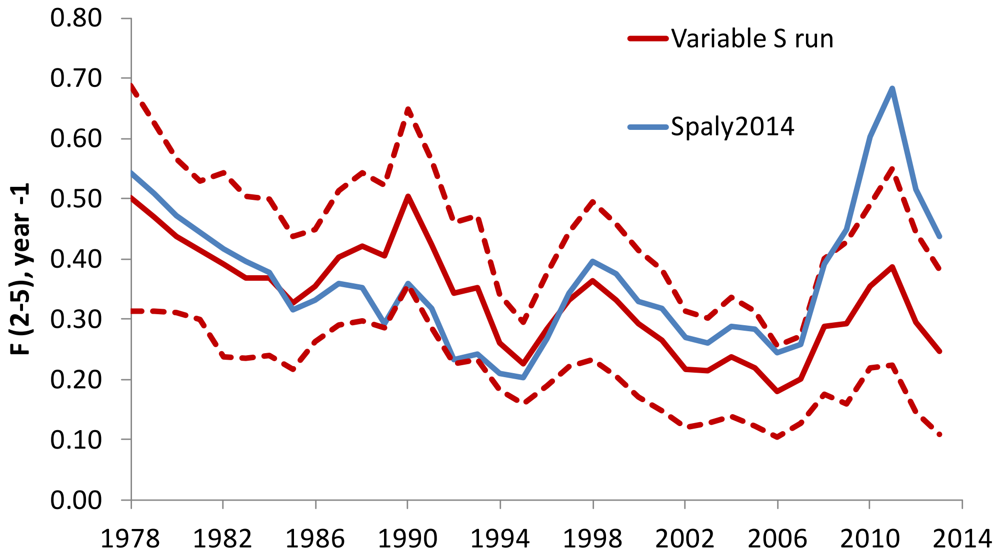


Figure 7.5.2.2 Sardine in VIIIc and IXa: Fishing mortality and corresponding confidence intervals for the variable S run.

The assumption of variable selectivity over the whole assessment period did not reduce the restrospective error of the assessment (Figure 7.5.2.3). It provided slightly less underestimation/overestimation of biomass/F in the last year compared to the Spaly2014 run. However, it resulted in slightly higher underestimation/overestimation of biomass/fishing mortality at longer time-lags.

The Working Group considered these problems should be further explored in a benchmark.

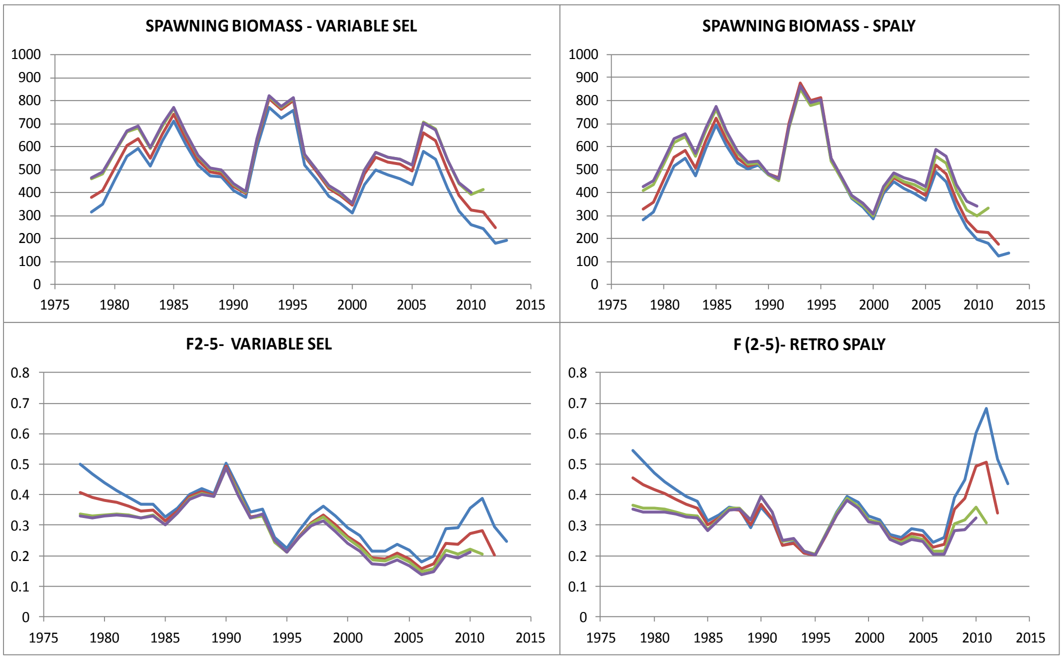


Figure 7.5.2.3 Sardine in VIIIc and IXa: Retrospective error for the biomass (upper panels) and the fishing mortality (bottom panels) in the Spaly2014 run and in the variable selectivity run.

7.5.3 Reliability of the assessment

Compared to last year's assessment, B1+ in 2012 is revised downwards 29%, F2012 is revised upwards 50% and R2012 is revised downards 31%. These differences are part of a retrospective pattern already noticeable in past assessments (Figure 7.5.3.1; e.g. WGANSA 2011, WGHANSA 2013). This pattern consists of a gradual reduction of the SSB estimates and an upward shift in F with some influence backWards in time (reaching up to 2002, Figure 7.5.3.2).

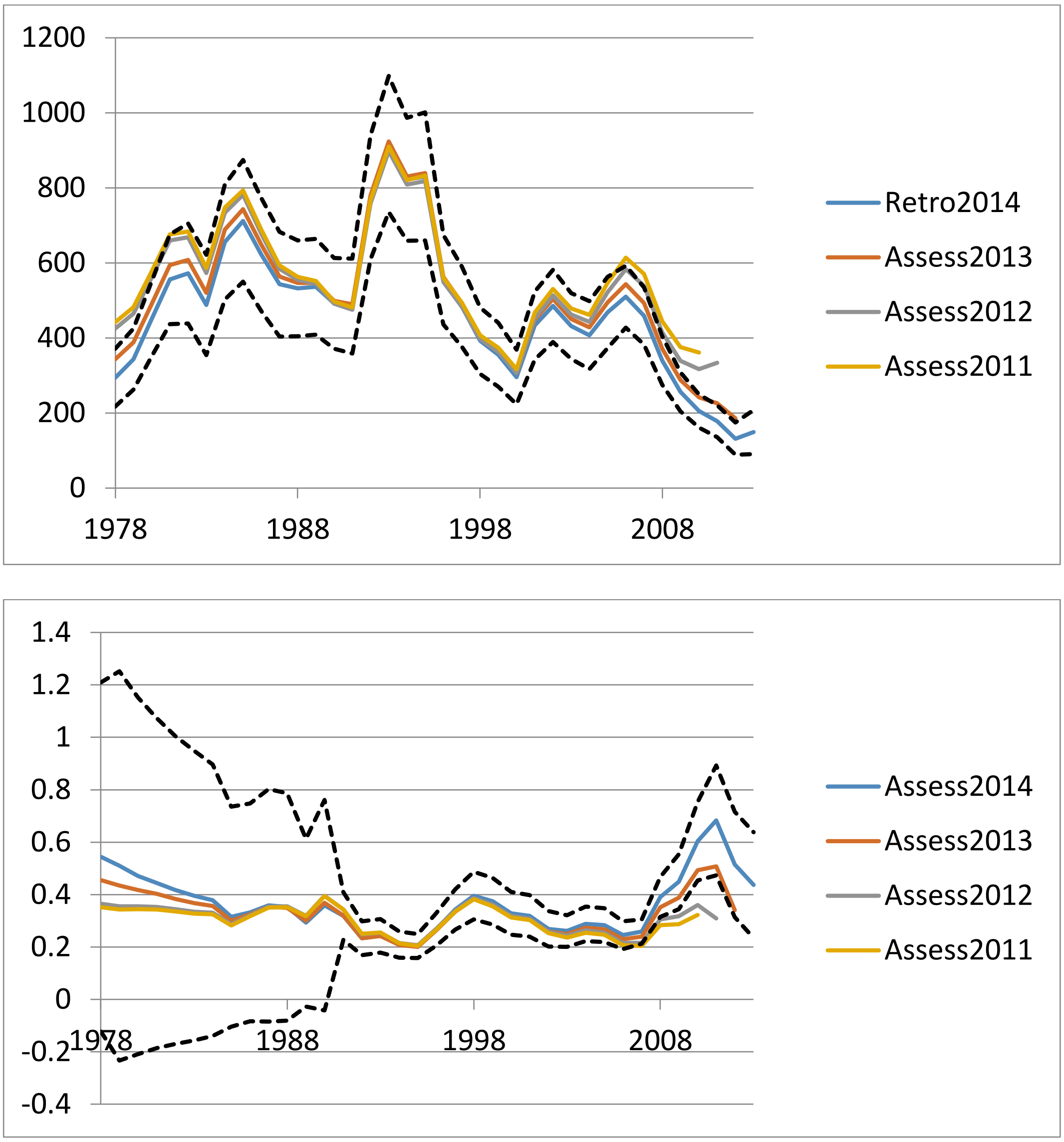


Figure 7.5.3.1 Retrospective error for the Biomass 1+ (above) and F(2-5) (below) in the assessment. Dashed lines represent ± 2 standard deviations of the 2014 estimates. The Assess 2012 results are not comparable because the model structure was different from other years due to the lack of a survey in the interim year.

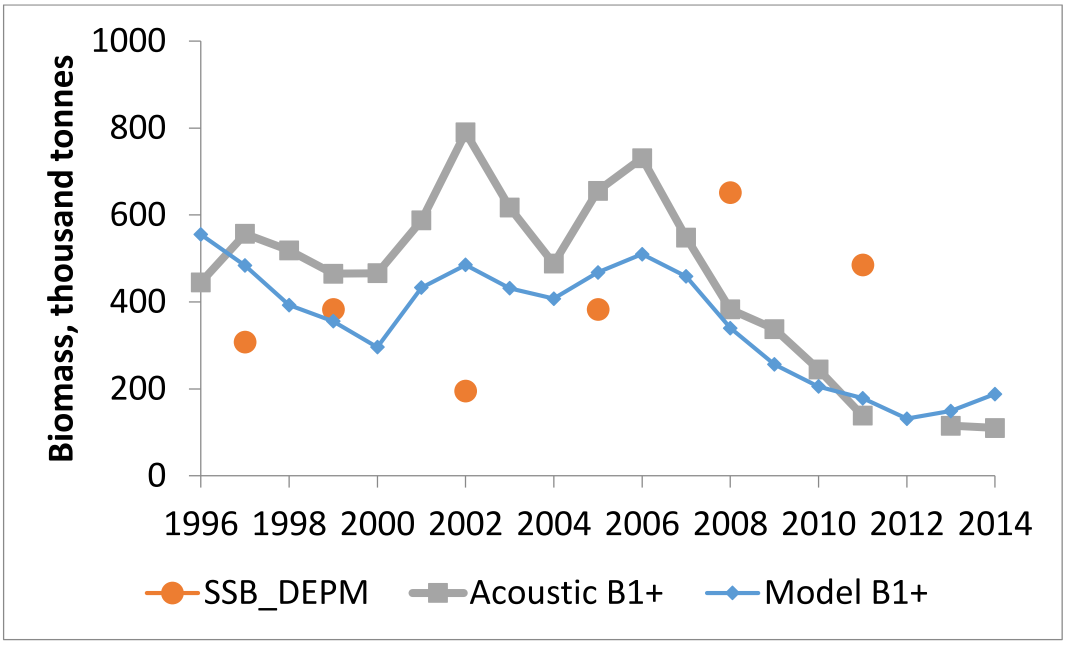


Figure 7.5.3.2. Sardine VIIIc and IXa: Biomass estimates by the acoustic survey, the DEPM survey and the assessment model in 1996-2014.

As seen from the analysis in section 7.5.2, the retrospective error does not appear to be caused by the assumption that fishery selectivity is fixed over time. As discussed in last year's assessment, an alternative explanation is the conflicting signals in the DEPM and acoustic signals in some years. As the influence of the last DEPM data point (2011) on the assessment weakened the assessment became increasingly influenced by the acoustic survey which indicates a sharp abundance decrease. Preliminary estimates of the 2014 DEPM support a decrease of the stock.

The actual causes of the retrospective pattern are however, unclear.

This year's assessment indicates that estimates of fishing mortality in the earlier period of the assessment, 1978-1990, have high uncertainty. There may be also some slight scaling effects on F (upwards) and biomass (downwards) in recent years due to the assumption of fixed catchability. Nevertheless, the estimates from last year's assessment are within the confidence interval of those from this year's assessment.

Uncertainties in the assessment related to the extent of sardine movement across the northern stock boundary still apply.

7.6 Short-term predictions (Divisions VIIIc and IXa)

Catch predictions are carried out following the Stock Annex, apart from the assumptions about recruitment and about fishing mortality in the interim year.

Recruitment (Age 0) estimated in the final year of the assessment, 2013, was accepted for the projection since it is supported by the acoustic survey in the interim year.

Input values for 2014 and 2015 recruitments (Age0) were set equal to the geometric mean of the period 2009-2013, RGM(09-13) = 4384 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 recruitment estimates, 2009-2013, 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 last five years, 2009-2013, is assumed for 2013-2014. The 2012 recruitment was included in the geometric mean since it is supported by the acoustic survey in 2013.

Input values for weights-at-age in the stock and in the catch are mean values of the last three years (2011-2013) as indicated in the Stock Annex. Historical weights at age show an increase over time reflecting an improvement of sardine condition. In this situation, an average of the most recent weights at age (2011-2013) was considered to be representative of weights at age in the short term. The 2013 stock weights at age are relatively higher than expected from the long-term increasing trend. This led to a difference between B1+ 2014 estimated in the assessment (that used the 2013 weights) and B1+ 2014 estimated by MFDP (that used the average of the last 3 years).

The assessment assumes the exploitation pattern is fixed over time since 1991 and that it is equal for ages 3-5 years. The exploitation pattern estimated by the assessment since 1991 was considered to apply in the short term. Natural mortality-at-age is assumed to be equal to that used in the assessment.

Predictions were carried out with an $F_{multiplier}$ assuming an F_{sq} equal to the average estimate of the last three years in the assessment, scaled to the 2013 F (F_{sq}=0.45). This is a deviation from the stock annex. The WG adopted it because F shows a marked downward trend in the past two years. A management plan has been developed for the fishery. Portugal and Spain agreed to implement the management plan in 2014. Fsq is applied to the interim year as well.

Input values are shown in Table 7.6.1 and results are shown in Table 7.6.2.

Table 7.6.1 - Sardine in VIIIc and IXa: Input data for short-term catch predictions. N-at-age for 2013. Input values of natural mortality (M), Maturity (Mat), proportion of F (PF), proportion of M (PM).

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4384	0.8	0	0	0	0.000	0.061	0.027
1	2640	0.5	1	0	0	0.029	0.175	0.051
2	841	0.4	1	0	0	0.049	0.329	0.066
3	307	0.3	1	0	0	0.058	0.472	0.076
4	127	0.3	1	0	0	0.068	0.472	0.082
5	103	0.3	1	0	0	0.069	0.472	0.084
6	184	0.3	1	0	0	0.071	0.154	0.100

2015

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4384	0.8	0	0	0	0.000	0.061	0.027
1	.	0.5	1	0	0	0.029	0.175	0.051
2	.	0.4	1	0	0	0.049	0.329	0.066
3	.	0.3	1	0	0	0.058	0.472	0.076
4	.	0.3	1	0	0	0.068	0.472	0.082
5	.	0.3	1	0	0	0.069	0.472	0.084
6	.	0.3	1	0	0	0.071	0.154	0.100

Table 7.6.2 - Sardine in VIIIc and IXa: Output data for short-term catch predictions. Note: the biomass estimate at the beginning of the year for the forecast is different from that estimated in the assessment because the forecast considers mean stock weights 2009-2013 and in the assessment the 2013 stock weights are used in the projection to 2014.

2014				
Biomass	SSB	FMult	FBar	Landings
165	165	1	0.44	51

2015					2016	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
169	169	0	0.00	0	205	205
.	169	0.1	0.04	6	200	200
.	169	0.2	0.09	12	196	196
.	169	0.3	0.13	18	191	191
.	169	0.4	0.17	24	187	187
.	169	0.5	0.22	30	183	183
.	169	0.6	0.26	35	179	179
.	169	0.7	0.31	40	176	176
.	169	0.8	0.35	45	172	172
.	169	0.9	0.39	50	168	168
.	169	1	0.44	55	165	165
.	169	1.1	0.48	60	162	162
.	169	1.2	0.52	64	158	158
.	169	1.3	0.57	69	155	155
.	169	1.4	0.61	73	152	152
.	169	1.5	0.65	77	149	149
.	169	1.6	0.70	82	146	146
.	169	1.7	0.74	86	143	143
.	169	1.8	0.79	89	141	141
.	169	1.9	0.83	93	138	138
.	169	2	0.87	97	135	135

Input units are millions and kg - output in kilotonnes

7.7 Reference points and harvest control rules for management purposes

ICES has not defined a B_{lim} for this stock (*ICES Advice 2013, Book 7, Section 7.3.5.1).*

ICES evaluated potential values for F_{MSY}. The highest yield was obtained with F = 0.34 (estimated with stochastic yield-per-recruit analysis, *ICES Advice 2013, Book 7, Section 7.3.5.1*), but this implied a 0.44 probability of $B_{1+}<B_{loss}$ which was considered not precautionary. Therefore, ICES has not defined an F_{MSY} for this stock.

7.8 Management considerations

There is no international TAC.

In order to ensure recovery of the sardine stock, Portugal and Spain developed a multiannual management plan.

This management plan consists in a rule where the TAC is set at a fixed level, but reduced if the biomass (B1+) is below a trigger B1 (368.4 kt), and the fishery is stopped at B1+ below another reference point B0 (135 kt).

This plan was evaluated by ICES (at the request of the European Commission) in a workshop in June 2013 (WKSardineMP, 2013; ICES, 2013) with scientists and stakeholders.

The workshop discussed the definition of reference points in order to evaluate the management plan (this stock has no agreed biomass reference points), and considered alternative approaches to assess if the plan was precautionary, as well as alternative settings of the harvest control rule itself.

Given the data available, ICES therefore concludes that the plan is provisionally precautionary, based on three criteria:

1) A very low probability of F in the plan exceeding F loss;
2) A low probability of B1+<Bloss (Bloss= 306 kt);
3) A high probability of recovery if B1+ declines below Bloss.

B1+ at the beginning of 2013, 149 thousand t is 69% below the historical mean biomass B1+(1978-2013)= 480 thousand t. Fsq=0.44 is 42% above the historical mean. The assessment indicates a 14% increase in B1+ and a 15% decrease of F from 2012 to 2013 which reflect a slight increase in recruitment and a drop in catches (16%). B1+ in 2014= 188 thousand t.

F has increased since 2008, shows values above the historical range in 2010 and 2011 and has decreased 36% from 2011 to 2013. If F2014 does not exceed F2013=0.44, corresponding to catches in 2014of 51 thousand t and the 2014 recruitment continues to be at a low level (RGM(09-13) = 4384 million individuals) B1+ in 2015 is estimated to be 169 thousand t, i.e. at a level similar to 2014. The 2013 recruitment, estimated to be 6247 million individuals (CV=22%), is 43% above the RGM(09-13) and is expected to contribute to reverse the decrease of the stock.

Alternatives:

Following the proposed EC management plan implies that the TAC is set by the formula 0.36 × (B1+ (2014) – lower trigger level) = (0.36 × (188 − 135))) because the biomass is currently between the two trigger points in the harvest rule, resulting in catches of no more than 19 095 t in 2015.

Following precautionary considerations:

The stock biomass is at an historically low level and fishing mortality has increased to historically high levels in recent years. F should be brought back to where it was before the start of this increase, i.e. the 2002–2007 average. However, taking into account the low biomass, below previous B_{loss} and the below-average recruitment, fishing mortality F should be reduced further. For F to be reduced to zero at zero biomass the reduction should be the ratio between the current biomass ($B_{1+(2014)}$ = 188 kt) and the average biomass in this period (460 kt, ratio of 41%) to F = 0.11.This results in catches of no more than 16 000 t.

The stock biomass shows a declining trend since 2006 due to the lack of strong recruitments. 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).

7.9 Reply to reviewers comments

Most general and technical comments from the reviewers were taken into account.

Consistent historical data on the size of the fleet is not currently available.

7.10 Indicators and thresholds to trigger new advice.

There is at present no coordinated survey to assess sardine recruitment (a Portuguese autumn survey was discontinued in 2008) although in recent years, both Portugal and Spain have carried out surveys to assess recruitment. Given the low level of the stock, the dynamics of the stock and therefore the short-term catch options for the fishery are almost exclusively determined by the strength of the incoming recruitment. In case there is data from an autumn recruitment survey, these data could be evaluated within an ICES subgroup (e.g. working by correspondence) to decide if the advice should be reopened.

8 Southern Horse Mackerel (Division IXa)

8.1 ACOM Advice Applicable to 2013 STECF advice and Political decisions

In 2013 ICES considered that the fishing mortality has decreased in the last two years. The SSB has decreased gradually since 2007 and was around 30% below the long-term average. Recruitment was estimated to be above average in 2011. The ICES advice was based on the MSY approach. ICES therefore recommended that catches in 2014 should not exceed 35 000 t. ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus*.

8.2 The fishery in 2013

8.2.1 Fishing Fleets in 2013

Six fleets used to target on southern horse mackerel in 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 lesser abundance of adults. Moreover 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 (<5%). Description of the Portuguese and Spanish fleets is available in Stock Annex.

8.2.2 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 1992–2013, 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 8.2.2.1). The relative contribution of each gear to the total catch is given in Table 8.2.2.2. In 2013 the relative contribution of each gear has changed due to there has been a significant decrease in landings for Spanish bottom-trawl fleet and a significant increase for Portuguese and Spanish purse-seine fleet landings (Figure 8.2.2.1). The different fleets targeting Southern horse mackerel are described in the Stock Annex. Spanish landings from the Gulf of Cádiz represent less than 5% of total landings and are not included in the assessment.

Table 8.2.2.1 Time-series of southern horse mackerel historical catches (in tonnes).

Year	Total Catch
1991	34 992
1992	27 858
1993	31 521
1994	28 4411
1995	25 147
1996	20 4001
1997	29 491
1998	41 564
1999	27 733
2000	26 160
2001	24 910
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	21 875// (22575)*
2012	24 868//(25316)*
2013	28 993//(29 382)*

(*) In parentheses: 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 8.2.2.2. Southern horse mackerel. Landings by gear with an indication (in parentheses) of the percentage that represent those landings.

	Gear		
Year	Bottom trawl	Purse-seine	Artisanal
1992	14651	9763	3445
	52.6%	35.0%	12.4%
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

	Gear		
Year	Bottom trawl	Purse-seine	Artisanal
	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	11038	7301	3530
	50.40%	33.30%	16.40%
2012	7839	12897	4579
	30.97%	50.95%	18.09%
2013	99221	16774	2687
	33.77%	57.09%	9.14%

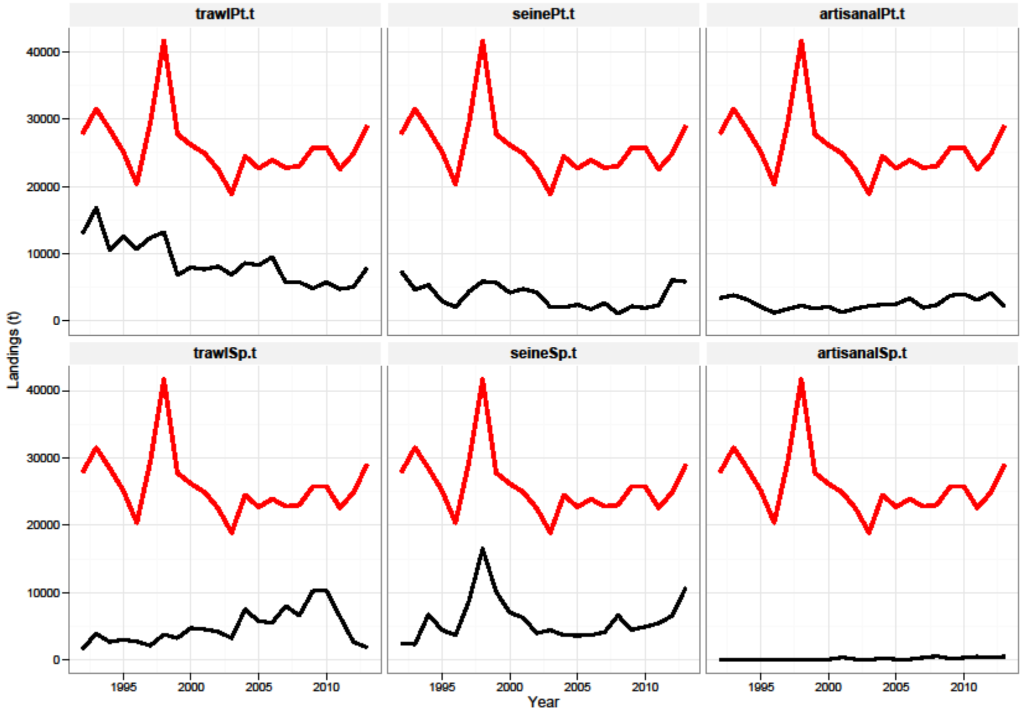


Figure 8.2.2.1. Southern horse mackerel. Landings by country and gear

In general, discards of southern horse mackerel are considered scarce. Spain and Portugal provided discards for 2013. The Horse mackerel Spanish Discards are low, in particular in Subdivision IXa North. Spanish discards come from the bottom-trawl fleet. Spanish discard was estimated in 70 t at IXa North and 794 t at IXa South for 2013 (Table 8.2.2.3a).

Table 8.2.2.3.a Discards age distribution (individual thousand) and discard catch (t) estimations for southern horse mackerel of Spanish fleet in 2013. Discard sampling was raised to effort.

	Trip Sampling level		Weight in tn		
	IXaN-Trawl	IXaS	IXaN-trawl	IXaS-Trawl	IXaS-P. Seine
2003	18	-	4.5	-	-
2004	10	-	3.4	-	-
2005	24	26	24.0	18.2	-
2006	25	29	118.5	152.3	-
2007	20	28	16.4	63.4	-
2008	25	18	45.9	71.2	-
2009	52	29	62.6	134.7	-
2010	15	30	12.8	112.3	16.8
2011	15	33	6.5	41.8	38.6
2012	23	40	2.7	123.1	134.8
2013	14	33	70.3	635.6	158.4

2013		Discard N. ('000)
Age	IXaN	IXaS (trawl)
0	5	387
1	14	7928
2	87	5077
3	210	1907
4	165	78
5	70	37
6	19	18
7	8	15
8	4	9
9	4	8
10	5	5
11	14	4
12	16	4
13	7	2
14	3	1
15+	5	1

The Portuguese discards of horse mackerel are usually very low and not frequent. The discard raising algorithm combines haul level discard data with total effort data derived from logbooks and sales slips to obtain annual fleet level discard estimates for different vessel-length strata. Discards cannot be reliably estimated for species with low frequency of occurrence (<30%) in discard samples.Therefore, horse mackerel discards from the bottom-trawl fleet targeting finfish have been estimated only for 2005 (61 tons). For other years, estimates were not obtained once the frequency of occurrence of discards was too low, and therefore estimates could be highly biased (see Prista *et al*., 2014WD in Annex) (Table 8.2.2.3b).

Landings are considered to be representative of horse mackerel catches, given that discards are believed to be negligible.

Table 8.2.2.3.b Portuguese frequency of occurrence (%) of horse mackerel discards of bottom-trawl fisheries (2004-2013), estimated discards (ton) and age distribution for 2005. (a) – low frequency of occurrence (<30%); OTB_CRU = crustacean fishery, OTB_DEF = demersal fish fishery.

	OTB_CRU			OTB_DEF		
	Hauls			Hauls		
Year	sampled trips	% occurence	discard (ton)	sampled trips	% occurence	discard (ton)
2004	17	2	(a)	24	8	(a)
2005	15	8	(a)	39	32	61 (30%)
2006	7	7	(a)	42	13	(a)
2007	12	8	(a)	38	4	(a)
2008	12	11	(a)	34	10	(a)
2009	16	17	(a)	38	11	(a)
2010	16	24	(a)	31	16	(a)

2011	13	25	(a)	30	5	(a)
2012	13	9	(a)	31	13	(a)
2013	6	7	(a)	27	14	(a)

	OTB_DEF
age	**HOM, 2005**
0	1653
1	5852
2	63
3	10
4	11
5	9
6	3
7	3
8	0
9	0
10	0
11+	0

8.2.3 Effort and catch per unit of effort

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

8.2.4 Catches by length and catches-at-age

The procedure to estimate numbers-at-age in the catch is described in the Stock Annex.

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 8.2.4.1, Figure 8.2.4.1). In general, catches are dominated by juveniles and young adults.

Table 8.2.4.1. Southern horse mackerel. Time-series of catch-at-age data in number (thousands).

	AGES											
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	11684	95186	145732	40736	12171	9102	5018	6864	5155	4761	13973	14354
1993	6480	66211	137089	100515	35418	13367	12938	10495	6597	5552	4497	14442
1994	12713	63230	86718	96253	28761	7628	4398	3433	5209	4834	6047	12264
1995	7230	55380	31265	52030	28199	11010	4003	3139	2720	3352	2530	31343
1996	69651	13798	14021	28125	33937	9861	6611	4501	4164	5504	3306	14243
1997	5056	295329	112210	26236	17168	12886	7780	7169	3938	3867	2425	8847
1998	22917	95950	320721	68438	18770	11317	9712	20627	12760	6686	6212	11323
1999	51659	29795	26231	66704	42960	15700	13840	7555	4175	4790	2475	7417
2000	12246	72936	23547	41618	35968	18643	17254	12118	7915	5227	3124	3557
2001	105759	77364	31261	24104	23721	16794	15391	14964	9795	3310	2023	3989
2002	18444	94402	84379	26482	13161	11396	10263	12501	10156	7525	3607	4433

2003	40033	6830	36754	28559	21931	12790	14751	13582	10631	6492	3531	2333
2004	7101	126797	58054	18243	8328	13586	11836	14878	10542	3876	5258	5318
2005	21015	108070	49197	24289	17877	11334	11179	7927	9124	7445	5502	11420
2006	3329	92563	92896	22665	6738	13176	11892	6029	7303	8070	8947	15322
2007	2885	16419	27667	44357	20534	8187	4459	3563	5975	4748	4943	30001
2008	48380	54167	31951	28058	16616	7194	4782	3660	4579	3975	4537	24990
2009	22618	85415	32416	8482	9774	7162	3289	2860	2791	3579	4236	39096
2010	81048	102016	33906	17496	11979	7569	3847	3942	2452	2671	2977	32284
2011	85973	23285	20987	19082	15047	7199	4272	3511	2885	5250	4639	22097
2012	201691	119136	30060	13964	14547	7693	5322	4373	2731	3218	4373	14562
2013	35849	123495	109557	30511	17468	9670	4085	3600	3123	2763	2488	17864

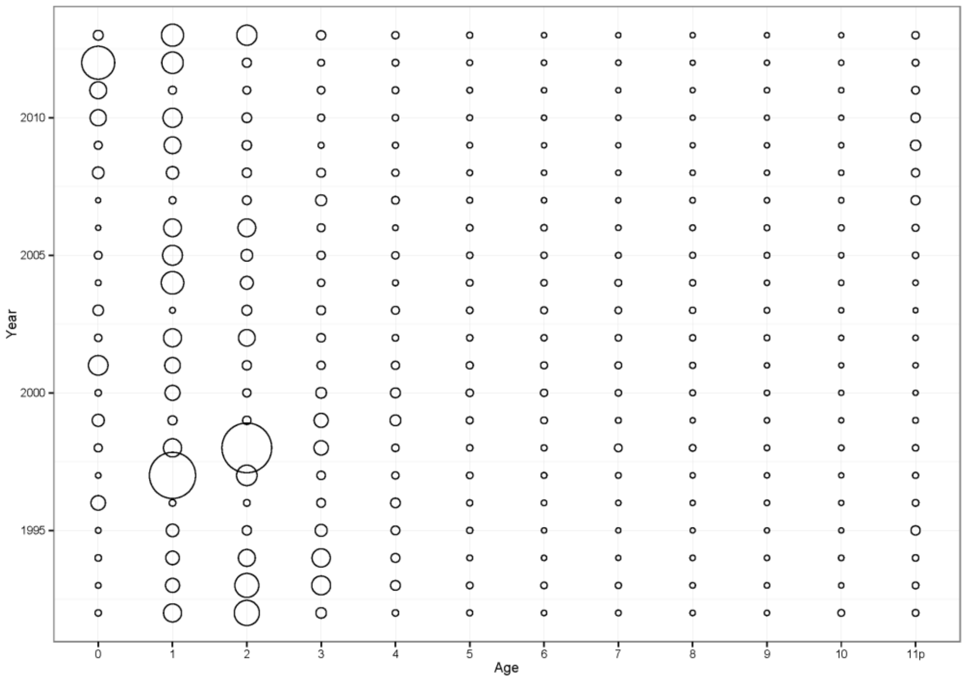


Figure 8.2.4.1. Southern horse mackerel. Bubble plot of proportions of the catch in numbers-at-age by year

To know more in depth the exploitation history of the southern horse mackerel a series of catch in numbers-at-age by fishing fleet is provided (Table 8.2.4.2, Figure 8.2.4.2). Three fishing fleets are considered defined by the gear type (bottom trawl, purse-seine and artisanal) and country (Portugal and Spain). The time-series starts in 1992 although it is expected to be extended back in time in future.

Table 8.2.4.2. Southern horse mackerel. Catch in number by gear.

Bottom trawl												
						AGES						
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	4707	43326	72194	19569	7265	6349	3562	4339	3125	2623	7008	6134
1993	98	8739	40094	78016	28660	10904	10401	8174	5166	3923	3319	9412
1994	3413	16252	37679	55079	16322	3926	2138	1559	2530	2200	2207	5223
1995	3917	12983	18292	22807	11447	5375	2541	2280	2299	2739	2138	25610
1996	30763	10340	10123	19245	23331	6326	4524	3063	2772	3245	2211	8611
1997	2828	180543	68330	15055	7846	4536	2087	1216	811	801	608	4360
1998	4444	36544	205609	32994	7151	3427	2487	3562	3100	2418	2724	7225
1999	28176	11492	16059	23745	8653	2914	3643	2570	1650	1932	1614	5525
2000	1106	35946	13685	18085	10763	7890	9180	7657	5546	4146	2544	2516
2001	39871	25245	10861	9401	8291	6329	8686	10261	7644	2630	1556	2606
2002	3572	59041	49402	12288	4796	4461	5100	7280	6068	5197	2671	3156
2003	14581	2077	18079	12556	13025	7525	7410	6940	6045	3966	2255	1526
2004	1352	77529	44171	12649	4758	9114	7787	9616	6875	2366	3823	3958
2005	2956	50643	30389	15100	12246	6636	6997	6190	7047	5546	3710	6705
2006	1666	59477	61175	14915	3798	9822	9492	3762	3871	4302	4908	9981
2007	19	2444	14853	31470	10967	2932	1983	1461	2681	2644	3135	21375
2008	5512	12787	21078	21828	10408	2984	1695	1166	1918	1678	2373	16881
2009	4552	19630	14558	5033	4758	4463	1581	1070	1183	1830	2579	27993
2010	10832	46074	15193	11434	6888	3661	1723	1728	1417	1531	1897	25218

Bottom trawl												
							AGES					
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
2011	5984	3440	9440	9357	6696	2999	1871	1655	1426	3414	2876	16256
2012	7674	20041	14102	4899	4089	1915	2101	1356	987	1094	1799	7586
2013	6928	23225	29279	11222	3625	1573	903	1283	1357	1233	1170	11420

Table 8.2.4.2. (cont.) Southern horse mackerel. Catch in number by gear.

Purse-seine												
							AGES					
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	6977	51859	73537	21162	4860	2677	1362	1973	1299	1204	2572	2402
1993	6293	51337	83236	16597	4355	795	512	819	544	862	667	1842
1994	7634	45429	45987	39236	11267	2838	1379	1036	1640	1691	2550	3530
1995	3311	42111	12457	27030	14822	4224	854	445	163	362	217	2247
1996	38888	3446	3801	8189	8955	2917	1621	1107	1022	2003	891	4301
1997	2211	114184	42908	9797	6407	5775	4380	5300	2707	2831	1539	3672
1998	18294	59225	112386	34393	9893	6028	5838	15381	8920	3621	2760	2041
1999	23481	18237	9440	41032	31471	10684	7777	3835	2092	2465	764	1328
2000	11068	35861	8832	22508	23779	9645	5890	2291	876	338	172	231
2001	65468	51105	20260	14164	14394	9020	5035	3008	1170	290	227	644
2002	13660	32185	34516	13604	7895	6041	3804	3510	2435	1141	359	116
2003	22915	4609	17093	15338	7464	3944	5188	3784	2554	1447	675	260
2004	5258	42114	12332	5137	2673	3042	2600	2603	958	489	980	929

Purse-seine												
						AGES						
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
2005	17856	56690	18512	8881	5272	3365	2539	799	904	848	600	1026
2006	1637	27295	29845	7133	2103	2210	1506	1225	1638	1804	2037	1514
2007	2863	13802	12416	11231	8019	3800	1912	1712	2799	1667	1323	4186
2008	42868	41050	9766	4672	3729	2223	2138	1918	2063	1877	1707	3544
2009	18016	65130	17157	2736	3551	2078	1139	1206	1041	1168	1136	3200
2010	70206	41433	11571	2766	2058	1531	1038	904	446	377	561	1598
2011	76225	18619	10553	7915	5197	1941	1480	719	315	707	723	1881
2012	193478	96833	12558	5530	7261	3945	1375	1991	1106	1282	1279	1268
2013	28908	98794	77552	17612	12427	7287	2665	1692	1196	1033	730	2644

Table 8.2.4.2. (cont.) Southern horse mackerel. Catch in number by gear.

Artisanal												
						AGES						
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	0	0	1	5	45	76	93	553	731	935	4393	5818
1993	89	6135	13760	5902	2402	1668	2025	1501	886	766	511	3187
1994	1666	1549	3052	1939	1171	863	882	839	1039	943	1290	3511
1995	2	286	516	2193	1929	1410	608	415	258	252	175	3485
1996	0	11	97	692	1651	618	465	331	370	255	205	1330
1997	17	602	972	1384	2915	2575	1313	653	420	235	278	814
1998	180	181	2726	1051	1726	1861	1387	1684	740	647	728	2056

Artisanal												
	AGES											
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1999	2	67	731	1927	2836	2102	2420	1151	433	394	98	564
2000	73	1129	1030	1024	1425	1108	2184	2171	1494	743	408	810
2001	420	1014	140	539	1036	1445	1671	1695	981	390	240	739
2002	1212	3176	461	591	471	895	1358	1711	1653	1187	578	1161
2003	2537	144	1581	665	1442	1320	2152	2858	2032	1079	601	547
2004	491	7154	1552	457	897	1429	1449	2659	2709	1021	455	431
2005	203	738	295	308	359	1332	1643	938	1174	1051	1193	3689
2006	26	5790	1875	617	837	1144	894	1041	1793	1964	2002	3826
2007	3	173	398	1656	1548	1456	563	390	496	438	486	4440
2008	0	330	1108	1557	2479	1987	948	576	599	420	456	4564
2009	49	654	701	713	1465	621	569	585	567	581	521	7903
2010	10	14509	7141	3295	3033	2378	1087	1309	589	763	519	5469
2011	3764	1226	992	1810	3153	2258	920	1137	1143	1126	1039	3951
2012	539	2263	3401	3535	3197	1833	1846	1026	637	843	1295	5708
2013	14	1477	2726	1677	1416	810	516	625	570	497	588	3800

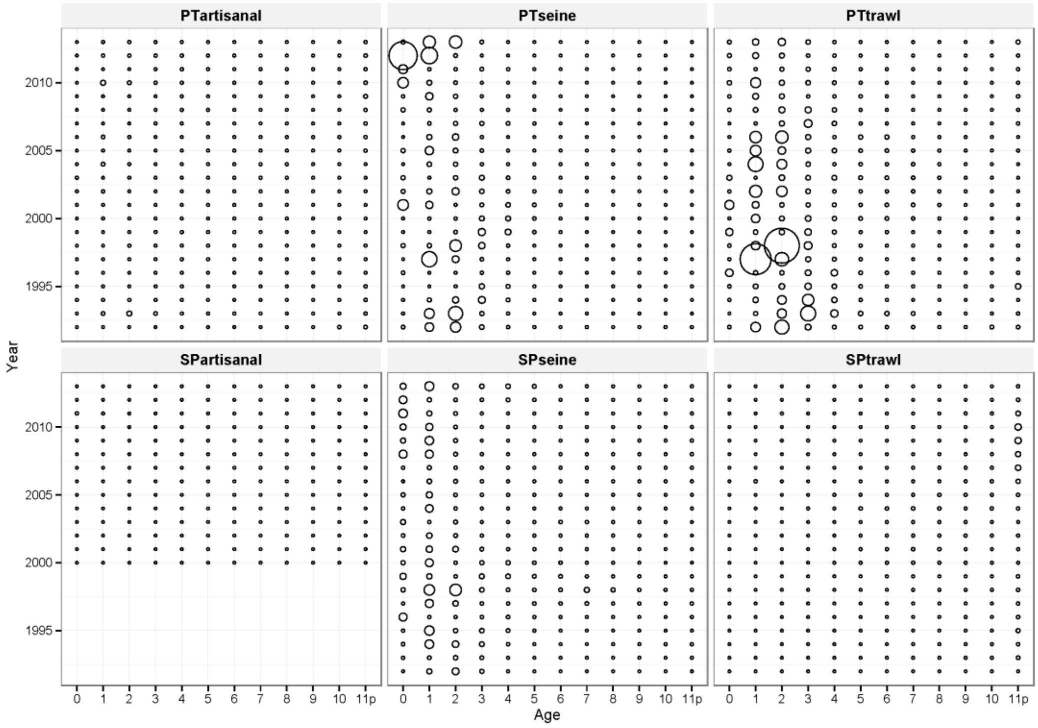


Figure 8.2.4.2. Southern horse mackerel. Bubble plot of proportions of the catch in numbers-at-age by year, gear and country.

The following fleets: 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 lesser 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.

8.2.5 Mean weight at age in the catch

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

Table 8.2.5.1 and Table 8.2.5.2 show the mean weight at age in the catch, and the mean length-at-age in catch respectively from 1992 to 2013. Deviations from the mean weight at age in the catch recorded in 2013 are of a similar magnitude to previous years although there appears to be a smooth decrease in the weights-at-age for the older ages in the last years (Figure 8.2.5.1). The variations of mean length-at-age are of a similar scale along temporal series (Table 8.2.5.2).

Table 8.2.5.1. Southern horse mackerel. Mean weight (kg) at age in the catch.

	AGES											
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	0.034	0.056	0.066	0.084	0.108	0.135	0.167	0.183	0.191	0.223	0.264	0.354
2012	0.02	0.03	0.07	0.10	0.13	0.16	0.18	0.19	0.21	0.24	0.28	0.37
2013	0.05	0.04	0.05	0.09	0.13	0.16	0.18	0.20	0.21	0.23	0.26	0.56

Table 8.2.5.2. Southern horse mackerel. Mean length (cm) at age in the catch.

	Age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	14.9	15.6	17.5	19.8	23.2	25.8	27.4	28.6	29.6	31.2	31.5	32.6	33.3	33.9	34.7	36.8
1993	14.0	15.5	17.4	18.9	21.3	28.2	29.6	31.1	31.7	31.7	32.1	32.5	34.1	34.7	35.8	37.2
1994	13.4	14.6	18.1	21.1	22.7	24.8	27.0	29.5	31.2	31.7	32.4	32.2	33.3	34.2	34.4	36.5
1995	16.0	15.4	19.9	21.8	23.1	24.5	28.6	26.5	30.1	30.9	31.6	32.6	33.9	34.0	35.2	36.9
1996	13.3	19.0	19.7	21.8	24.7	26.3	28.0	28.6	30.3	30.7	31.5	32.0	33.4	32.5	36.2	37.0
1997	13.4	15.8	18.9	20.7	24.3	26.3	27.6	29.5	31.2	32.4	31.9	33.1	34.6	34.8	35.4	38.5
1998	14.5	13.9	15.9	20.4	23.5	25.5	28.3	30.3	26.9	31.7	32.0	32.7	33.4	34.5	36.4	39.1
1999	13.4	16.4	19.0	22.3	24.5	26.2	27.5	29.0	30.3	31.7	32.7	33.3	33.9	34.7	37.3	39.6
2000	13.6	16.4	18.4	21.7	24.8	26.0	27.2	28.6	30.2	30.8	31.5	32.3	32.7	34.2	34.5	35.0
2001	14.1	15.6	20.2	21.9	22.5	25.4	27.4	28.7	29.6	30.9	31.2	33.0	32.8	34.0	34.7	38.2
2002	15.0	15.7	17.5	20.3	23.1	25.4	26.6	28.0	29.6	30.9	31.8	32.6	34.2	34.7	35.4	36.9
2003	13.0	15.7	18.8	20.7	23.1	26.1	26.7	29.2	30.0	31.2	32.0	32.9	33.6	33.9	38.9	35.3
2004	16.2	14.4	17.2	21.2	24.0	26.7	28.1	29.4	30.5	31.6	32.3	32.2	33.0	32.2	36.4	35.9
2005	12.5	13.9	16.6	20.1	23.5	25.9	27.1	28.1	30.0	31.1	31.6	32.8	32.6	33.5	32.6	37.2

2006	14.6	14.7	17.0	19.2	22.2	24.6	25.6	27.2	28.7	30.3	31.5	33.2	34.0	35.9	36.7	37.0
2007	14.6	17.5	18.5	20.0	22.1	23.6	26.9	28.7	30.6	30.3	30.9	31.8	33.4	32.2	34.5	35.7
2008	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2009	13.0	17.3	20.5	22.3	24.0	25.4	26.5	27.7	28.8	29.6	30.5	31.3	32.2	33.5	35.6	37.2
2010	13.1	15.8	18.4	20.8	23.4	25.4	26.9	27.8	28.6	29.2	31.2	31.7	33.5	34.7	36.7	38.0
2011	15.1	18.4	19.5	21.3	23.3	25.2	27.4	28.1	28.6	30.2	32.0	33.3	34.2	35.0	36.5	39.0
2012	15.7	15.8	18.4	22.8	24.9	26.5	27.8	28.8	29.9	31.1	33.2	34.4	35.5	36.7	39.4	39.8
2013	16.8	16.8	17.9	21.4	24.6	26.2	27.5	28.3	29.1	29.7	31.0	32.5	34.7	35.7	37.9	36.3

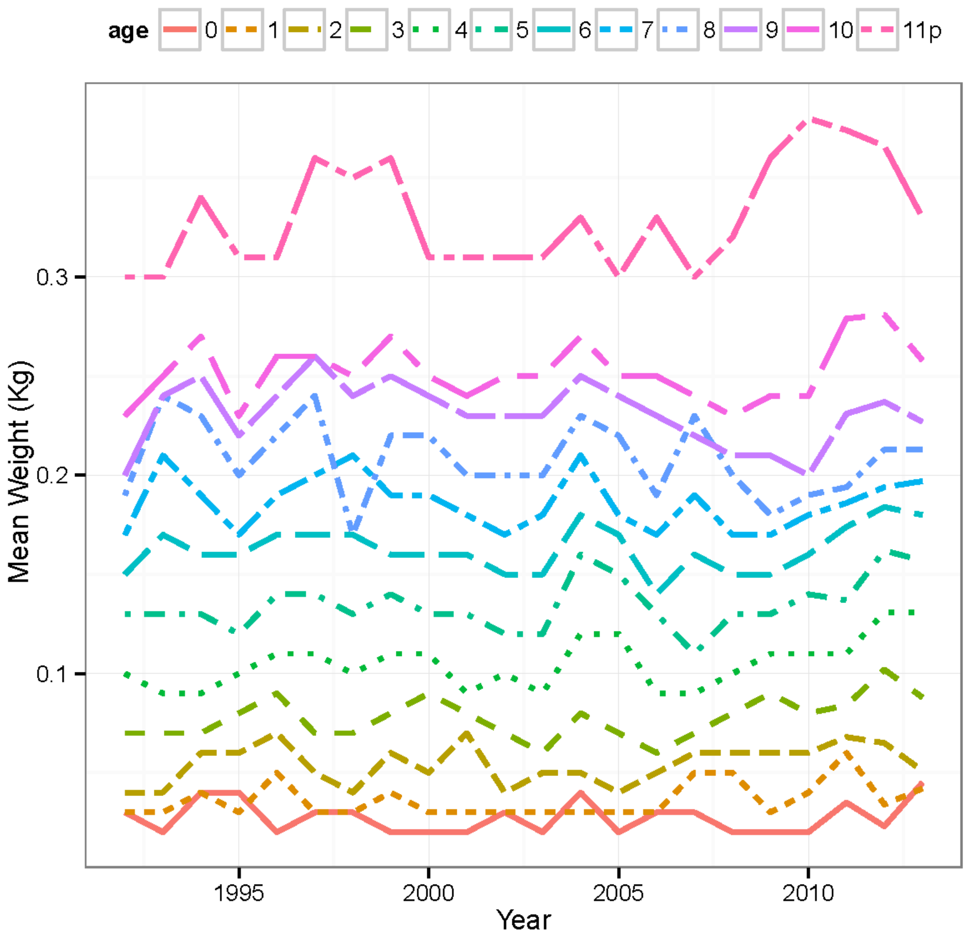


Figure 8.2.5.1. Southern horse mackerel. Time-series of mean weight at age in the catch (from age 1 to 11).

8.3 Fishery-independent information

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.

8.3.1 Bottom-trawl surveys

The Spanish survey from Subdivision IXa North and the Portuguese survey are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawl gears.

The survey indices from these surveys are shown in Table 8.3.1.1. 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 in order to estimate a combined survey index. Since there was not the Portuguese survey in 2012, it could not be estimated the combined survey index for 2012.

Table 8.3.1.1. Southern horse mackerel. cpue at age from bottom-trawl surveys.

Portuguese October Survey

	AGES															
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1992	442.6	481.6	154.5	54.1	24.6	9.8	6.7	6.9	3.6	3.0	4.0	0.7	0.8	0.3	0.1	0.1
1993	1843.0	248.0	249.0	153.2	36.3	4.8	2.8	1.7	1.0	1.1	0.7	1.7	0.5	0.3	0.1	0.1
1994	3.5	8.8	61.0	55.8	23.2	5.7	2.6	1.8	0.9	0.5	0.3	0.1	0.0	0.0	0.0	0.0
1995	20.6	81.2	116.4	70.5	31.4	6.0	1.2	1.4	0.4	0.2	0.2	0.3	0.3	0.5	0.1	0.2
1996*	1451.9	10.2	16.6	26.8	27.0	5.1	2.1	0.8	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0
1997	1148.9	81.0	133.8	39.9	64.9	37.6	7.6	6.0	2.4	2.7	1.0	0.1	0.0	0.1	0.1	0.1
1998	94.0	39.7	111.7	16.2	6.0	3.3	1.8	1.8	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
1999*	132.3	28.1	52.9	62.3	5.2	1.8	0.9	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	3.0	19.2	25.8	29.0	14.1	7.9	4.1	1.2	0.6	0.1	0.0	0.1	0.0	0.0	0.0	0.0
2001	726.8	1.2	4.7	3.7	5.1	7.3	8.8	14.0	7.6	2.5	1.4	0.4	0.2	0.2	0.0	0.0
2002 1	41.6	2.6	8.9	14.6	11.6	6.0	1.9	1.3	0.9	0.5	1.0	0.3	0.2	0.1	0.1	0.0
2003*	75.2	9.5	9.6	18.5	16.5	4.7	2.6	1.6	1.0	0.6	0.2	0.0	0.0	0.0	0.0	0.0
2004	63.1	39.3	140.7	55.2	11.6	5.0	2.4	5.9	7.7	1.2	0.2	0.0	0.0	0.0	0.0	0.0
2005	379.1	1458.4	234.5	80.1	39.4	17.0	20.0	20.4	15.6	8.1	4.9	5.9	5.4	1.0	1.3	0.4
2006	92.0	94.1	250.5	62.4	3.7	12.0	8.6	7.1	2.9	1.6	0.7	0.2	0.0	0.0	0.0	0.0
2007	40.8	0.9	28.2	45.7	34.3	8.6	2.9	1.7	0.2	0.6	1.6	1.5	0.7	0.3	0.3	0.6
2008	51.7	26.7	41.1	23.7	30.4	21.1	2.9	1.0	1.4	2.0	1.4	1.0	0.5	0.9	0.6	2.0
2009	1725.2	81.5	121.2	44.4	36.0	10.0	2.7	1.5	1.2	0.7	0.6	0.5	0.9	1.9	0.5	0.9
2010	77.0	30.7	55.5	45.6	51.8	20.1	9.3	6.5	5.4	4.1	3.7	2.5	2.4	2.9	0.8	1.0

	AGES														
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
2011	89.1	35.7	34.5	56.8	53.7	13.2	5.8	8.2	4.0	5.1	5.7	2.1	1.8	1.8	1.0	0.9
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	20.8	371.8	797.5	142.9	34.9	3.9	2.5	2.6	2.0	2.2	1.6	1.2	2.9	1.0	0.9	0.5

Spanish October Survey (only Subdivision IXa North)

	AGES															
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1991	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.9	0.8	0.8	2.7	1.4	1.7	1.8
1992	6.6	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.3	3.4	1.6	1.9	1.1	0.3	2.2
1993	92.1	1.7	5.2	3.9	0.4	0.0	1.2	5.2	5.7	8.7	5.2	10.8	2.2	1.6	0.4	1.0
1994	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.2	0.6	1.4	2.6	0.2	16.1	12.8	1.3	6.4
1995	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.8	2.5	4.0	8.8	2.4	2.2
1996	33.6	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.9	2.7	0.6	0.4	1.8	2.6	1.0	4.4
1997**	2.0	0.0	0.0	0.0	0.0	0.1	0.2	1.0	1.2	1.7	0.8	0.2	0.3	0.8	1.1	2.6
1998	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	0.5	0.3	0.1	0.0	0.1	0.1	0.0	0.2
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.6	2.2	3.2	2.6	4.7	1.9	1.6	0.3
2000	0.5	0.0	0.0	0.0	0.0	0.0	0.4	2.8	3.7	3.2	0.7	0.6	0.4	0.5	0.3	0.7
2001	12.7	2.9	0.0	0.0	0.0	0.2	0.4	2.5	4.4	4.1	3.2	1.8	1.0	0.9	0.1	0.3
2002	0.1	0.0	0.0	0.0	0.0	0.0	0.6	1.2	7.3	7.1	8.9	10.4	3.5	4.5	1.3	2.3
2003	8.8	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.8	0.9	0.3	0.2	0.1	0.1	0.9
2004	90.0	1.2	2.5	16.2	5.4	4.6	1.7	1.3	0.7	0.3	0.8	0.1	0.3	0.0	0.1	0.1
2005	3520.4	0.0	0.0	0.0	0.3	0.4	0.3	0.3	0.5	0.5	0.1	0.6	0.3	0.2	0.1	0.0

	AGES														
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
2006	28.4	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.2	0.0	0.2
2007	1.4	0.0	0.0	0.0	0.1	0.2	1.0	1.3	1.6	0.8	0.6	0.6	0.2	0.2	0.2	0.2
2008	18.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.4	0.3	0.1	0.0	0.1	0.4
2009	84.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.8	0.7	0.3
2010	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.5	0.8	1.3	1.1
2011	1.5	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.5	1.1	1.2	0.1	0.1	0.0	0.2	0.6
2012	12.9	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2
2013	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

*** The surveys were carried out with a different vessel**

**** Since 1997 another stratification design was applied in the Spanish surveys1 In 2002 started a new series in which the duration of the trawling per haul has changed from one hour to thirty minutes**

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.

Table 8.3.1.2 shows the combined survey index (mean number per hour, by age and year) used in the assessment. There are two very clear features in this 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. 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 of age 0 and the apparent year-effects must be accounted for in the assessment model to be fitted to these data.

Table 8.3.1.2. Time-series of cpue at age from Portuguese and Spanish combined bottom trawl. It is showed with the period and the age plus was considered in the assessment.

	AGES											
YEAR	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11+**
1992	329.79	355.18	113.94	39.86	18.21	7.25	4.93	5.20	2.74	2.34	4.70	5.06
1993	1451.66	190.40	192.85	119.01	27.93	3.66	2.63	3.64	3.35	4.84	2.92	9.37
1994	2.92	7.18	49.83	45.48	18.92	4.68	2.11	1.47	0.88	0.91	1.18	13.04
1995	16.63	65.59	93.98	56.92	25.36	4.81	0.99	1.15	0.47	0.21	0.44	8.78
1996	1144.22	7.93	12.93	20.89	20.99	3.97	1.73	0.81	0.59	1.29	0.29	4.72
1997	844.43	59.50	98.27	29.34	47.67	27.65	5.73	4.98	2.40	2.92	1.17	3.49
1998	77.56	32.60	91.65	13.25	4.92	2.74	1.53	1.77	0.40	0.13	0.07	0.20
1999	104.55	22.21	41.75	49.25	4.13	1.42	0.82	0.32	0.34	0.99	1.15	3.66
2000	2.53	15.43	20.76	23.35	11.36	6.34	3.40	2.01	1.86	1.28	0.30	1.04
2001	545.08	1.90	3.51	2.73	3.79	5.49	6.71	11.50	7.63	3.66	2.41	2.61
2002	32.48	2.04	6.89	11.33	9.00	4.62	1.76	1.59	3.96	3.51	4.56	9.90
2003	62.51	7.54	7.57	14.64	13.03	3.73	2.06	1.30	0.85	0.74	0.48	0.66
2004	82.36	31.80	113.13	49.81	11.13	5.62	2.48	5.19	6.39	1.08	0.47	0.23
2005	1438.11	1189.30	189.50	64.68	31.95	13.92	16.24	16.54	12.74	6.70	4.02	11.63
2006	84.24	76.65	206.84	52.26	3.88	12.03	8.51	7.29	2.58	1.42	0.66	0.49
2007	34.22	0.72	23.33	37.78	28.41	7.16	2.69	1.78	0.64	0.71	1.55	3.26
2008	48.48	21.65	33.42	19.24	24.72	17.09	2.40	0.80	1.24	1.74	1.24	4.36
2009	1436.41	66.51	98.82	36.24	29.39	8.12	2.20	1.26	0.93	0.58	0.55	4.57
2010	64.94	31.91	33.91	34.16	47.54	14.94	4.81	6.39	4.12	3.95	1.57	11.06
2011	120.96	33.85	22.38	16.19	6.85	1.65	0.52	0.69	0.45	0.85	1.01	1.53
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	16.99	300.7	644.92	115.58	28.2	3.16	2.04	2.07	1.64	1.78	1.27	5.31

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 special reason to consider that the mean-weight at age in the catch is significantly different from the mean weight at age 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, 2011) showing the possible variation in SSB caused by poor coverage of the ages range when sampling for the maturity ogive. The Group 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
Maturity	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
Nat Mort	0.9	0.6	0.4	0.3	0.2	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 stock assessment has been performed as agreed during the latest benchmark (ICES, 2011), with the settings and method as described in the Stock Annex. For further details see the Stock Annex and 2011 report (WGANSA 2011).

The assessment was tuned with the combined series from the Portuguese and Spanish bottom-trawl surveys. The stock assessment was performed with the survey series updated to 2013, though without tuning index for 2012 (in 2012 Portuguese survey was not carried out then the combined survey index for 2012 could not be estimated).

The survey data are especially noisy in the younger ages. This variability is partially due to natural causes and partly due to the low availability of very young fish to the fishing gear of the survey, because of a more pelagic behaviour (being the gear a bottom-trawl) and a distribution closer to the shore, where it is frequently difficult to trawl. For this reason, the age 0 is excluded from the tuning data used in the assessment.

Strong year-effects in the survey data are present as large fluctuations in overall abundance from year-to-year (e.g. Figure 8.5.1.1) but also strong variability at age 0 (Figure 8.5.2.3). To account for these characteristics of the dataset, four selectivity vectors of parameters changing over periods of time were estimated (Figure 8.5.1.2). For the catch proportions at age, two selectivity parameter vectors also changing over periods of time were estimated (Figure 8.5.1.3). In all selectivity vectors of parameters, ages above 8 were kept constant and with the same value estimated to age 8 (which was the reference age).

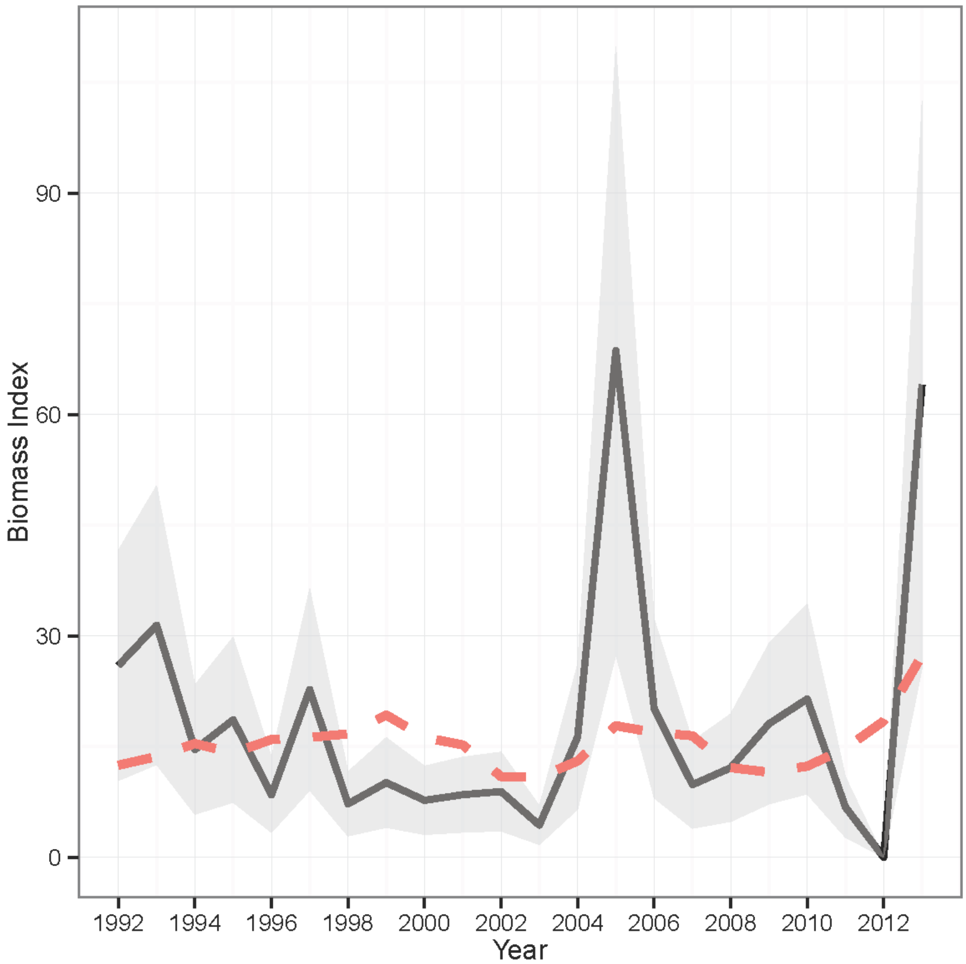


Figure 8.5.1.1. Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (solid black line) and by the assessment model (dashed red line).

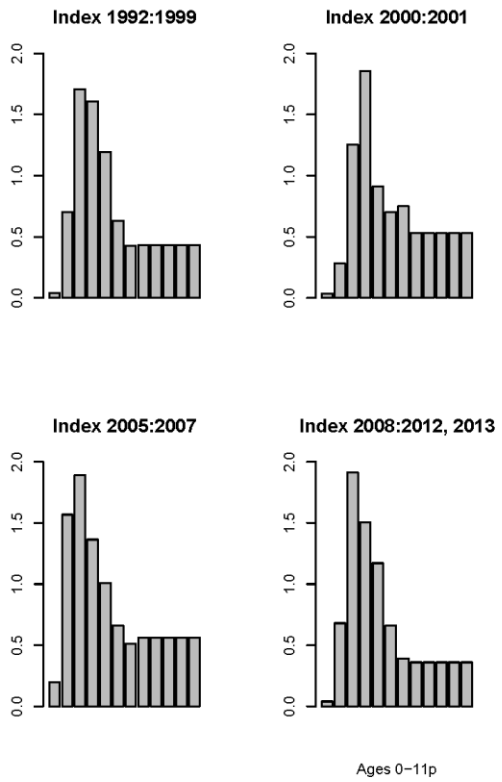


Figure 8.5.1.2. Southern horse mackerel. Selectivity patterns of survey index. Proportions of catches-at-age by selectivity period (1992-1999; 2000-2001; 2002-2004; 2005-2007; 2008-2013).

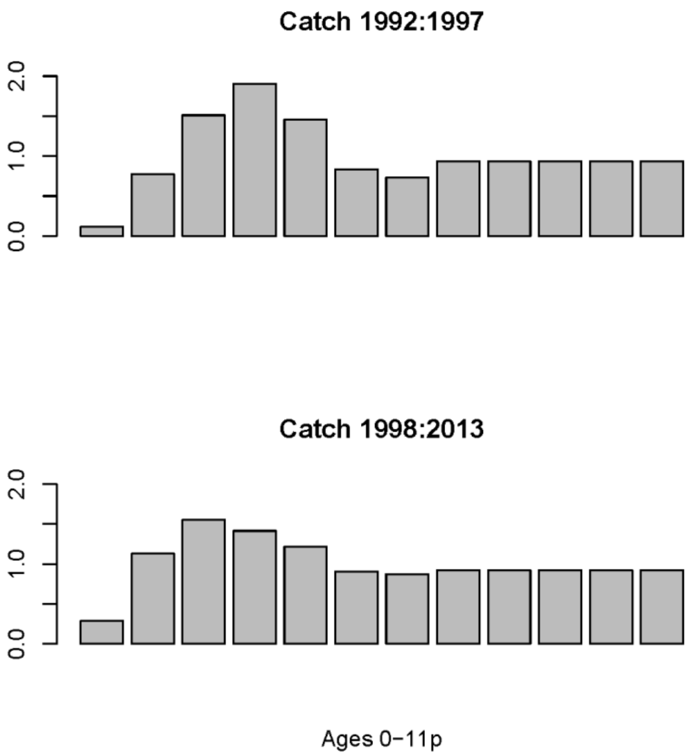
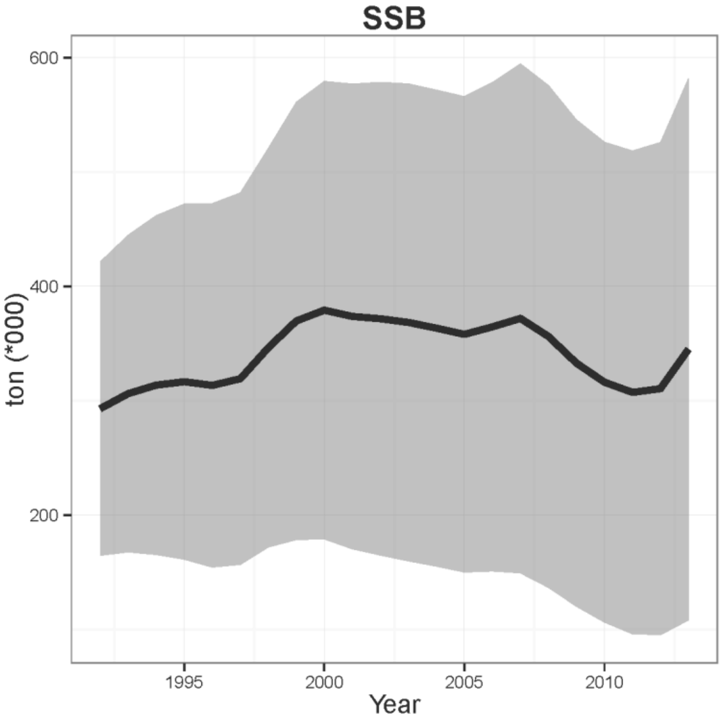
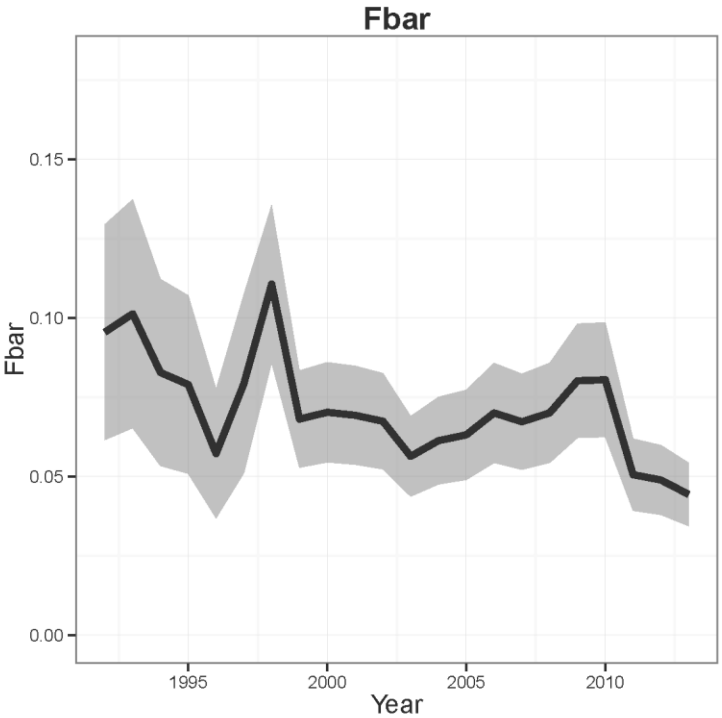


Figure 8.5.1.3. Southern horse mackerel. Selectivity patterns of catch data (1992-1997; 1998-2013). Proportions of catches-at-age by selectivity period.

The summarized results of the stock assessment are shown in Figure 8.5.1.4 and Table 8.5.1.1. The estimated SSB shows some gradual decrease from 2007 to 2011 and an increase in 2012-2013 to slightly above the long-term average, though with wide confidence intervals. The fishing mortality shows a significant decrease since 2010 being at present around 60% below the long-term average. Recruitment shows an important increase in 2011 and 2012, though the latter with wide confidence intervals. The strong year-class in 2011 is supported both by the survey index and the catch data. Figure 8.5.1.5 shows the scatterplot of the estimated spawning-stock biomass (SSB) and recruitment series.


SSB
ton (*000)
600
400
200
1995
2000
2005
2010
Year


Fbar
Fbar
0.15
0.10
0.05
0.00
1995
2000
2005
2010
Year

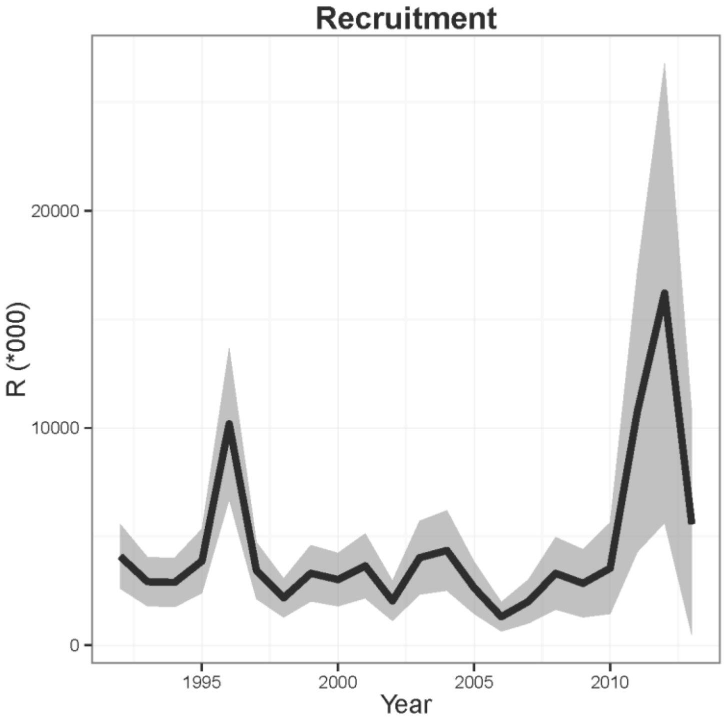


Figure 8.5.1.4. Southern horse mackerel. Final assessment. Stock summary. Plots of SSB, recruitment and fishing mortality. SSB and catch are in tons, and recruitment in thousands. (CVs of SSB in the range 22-35%).

Table 8.5.1.1. Southern horse mackerel. Final assessment. Stock summary table.

Year	Recruits (10*6)	SD Rec	SSB(ton)	SD SSB	mean F(2-10)	SD mean F (2-10)	Landings
1992	4083	752	293104	65507	0.10	0.03	27858
1993	2918	571	306248	70717	0.10	0.04	31521
1994	2891	575	313640	75656	0.08	0.03	28451
1995	3875	751	316608	79277	0.08	0.03	25132
1996	10185	1772	313428	81139	0.06	0.02	20360
1997	3436	664	319228	82894	0.08	0.03	29491
1998	2173	452	346332	88955	0.11	0.02	41661
1999	3309	657	369734	97589	0.07	0.02	27768
2000	3019	622	379130	102087	0.07	0.02	26161
2001	3649	756	373656	103718	0.07	0.02	24911
2002	2038	466	371652	105492	0.07	0.02	22506
2003	4027	861	368434	106446	0.06	0.01	18887
2004	4358	939	363440	106228	0.06	0.01	24485
2005	2645	609	357986	106091	0.06	0.01	22689
2006	1308	341	364560	108982	0.07	0.02	23895
2007	2014	512	371932	113566	0.07	0.02	22787
2008	3305	847	356158	111982	0.07	0.02	22993
2009	2846	796	332868	108507	0.08	0.02	25727
2010	3541	1069	316202	107076	0.08	0.02	27217

Year	Recruits (10*6)	SD Rec	SSB(ton)	SD SSB	mean F(2–10)	SD mean F (2–10)	Landings
2011	10762	3298	307288	107729	0.05	0.01	22575
2012(*)	16206	5390	310576	109826	0.05	0.01	24868
2013(*)	5577	2605	344974	120792	0.04	0.01	28988

(*) Assessment estimate (not accepted for the short-term forecast)

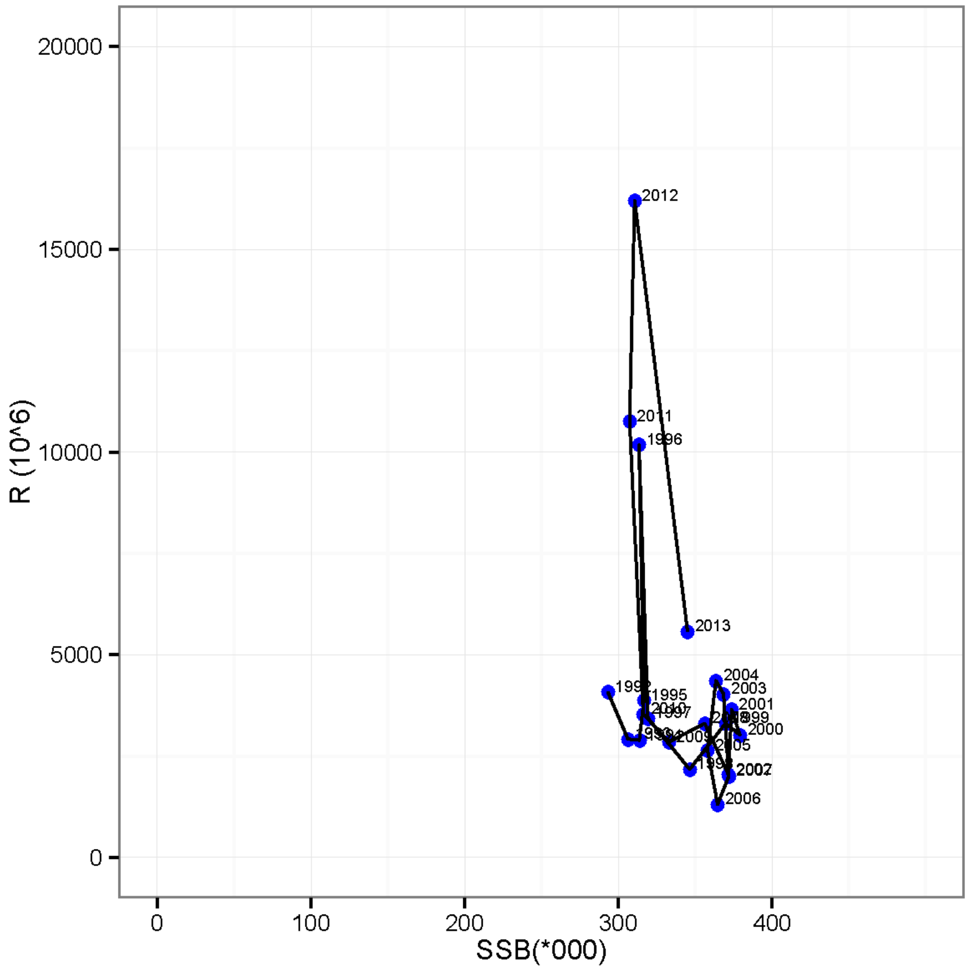


Figure 8.5.1.5. Stock–recruitment relationship for southern horse mackerel

8.5.2 Reliability of the assessment

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

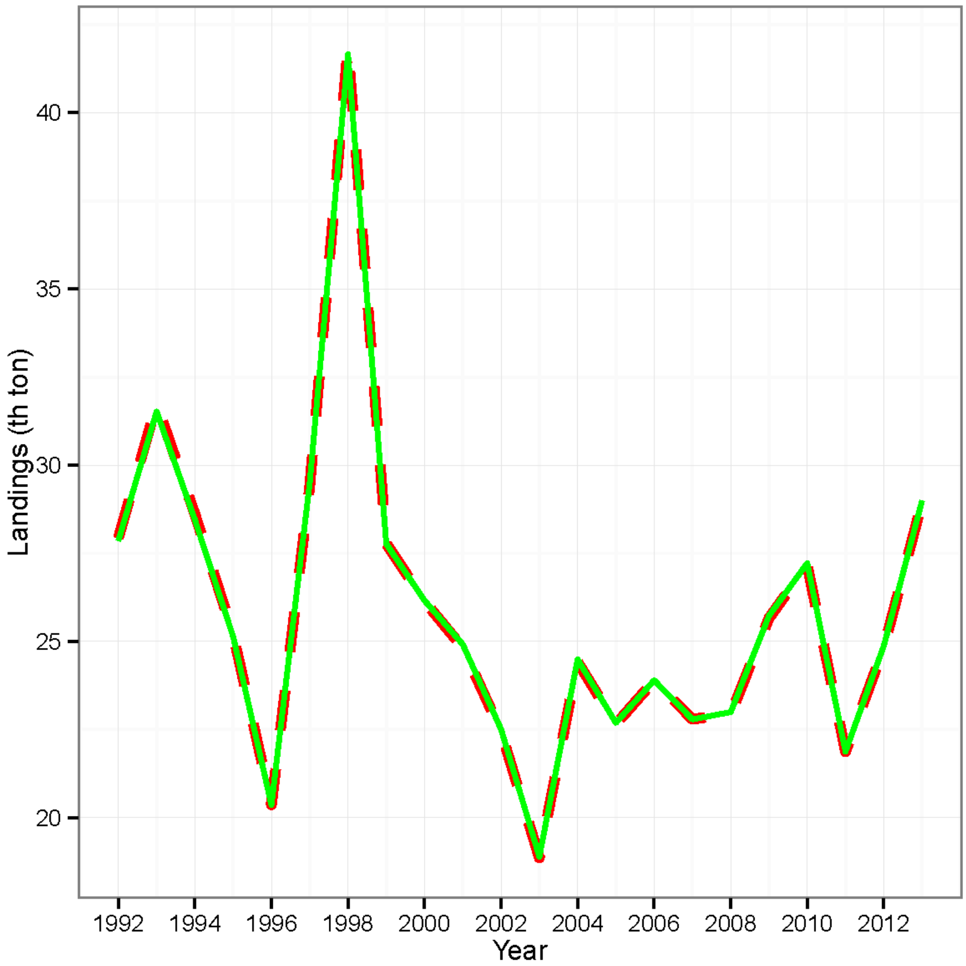


Figure 8.5.2.1. Southern horse mackerel. Fitting of historical series of stock landings (solid green line) and estimated landings by the assessment model (dashed red line).

A good fit was also obtained for the proportions at age of the catch in numbers (Figure 8.5.2.2) as well as for the abundance indices in number/hour from the bottom-trawl surveys (Figure 8.5.2.3). The bubble plots of the residuals corresponding to the fitting of those data are shown in Figures 8.5.2.4 and 8.5.2.5, respectively.

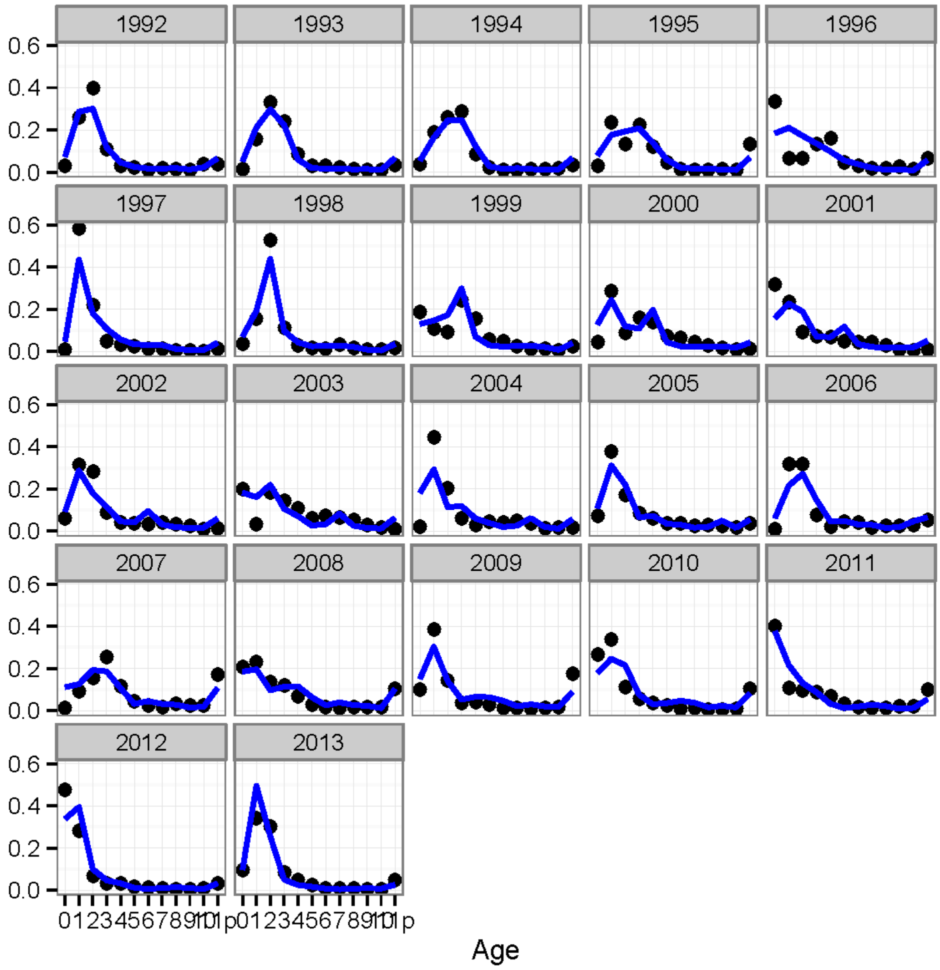


Figure 8.5.2.2. Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values = dots; fitted values = solid lines.

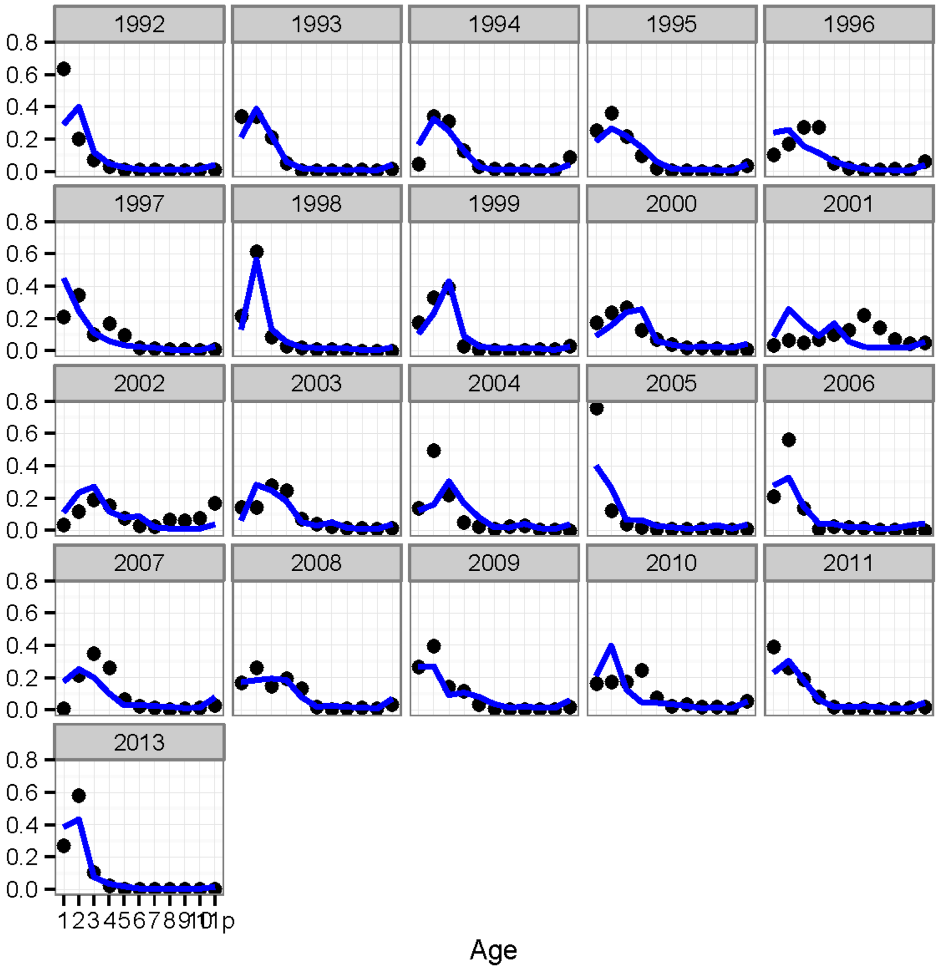


Figure 8.5.2.3. Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in survey data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

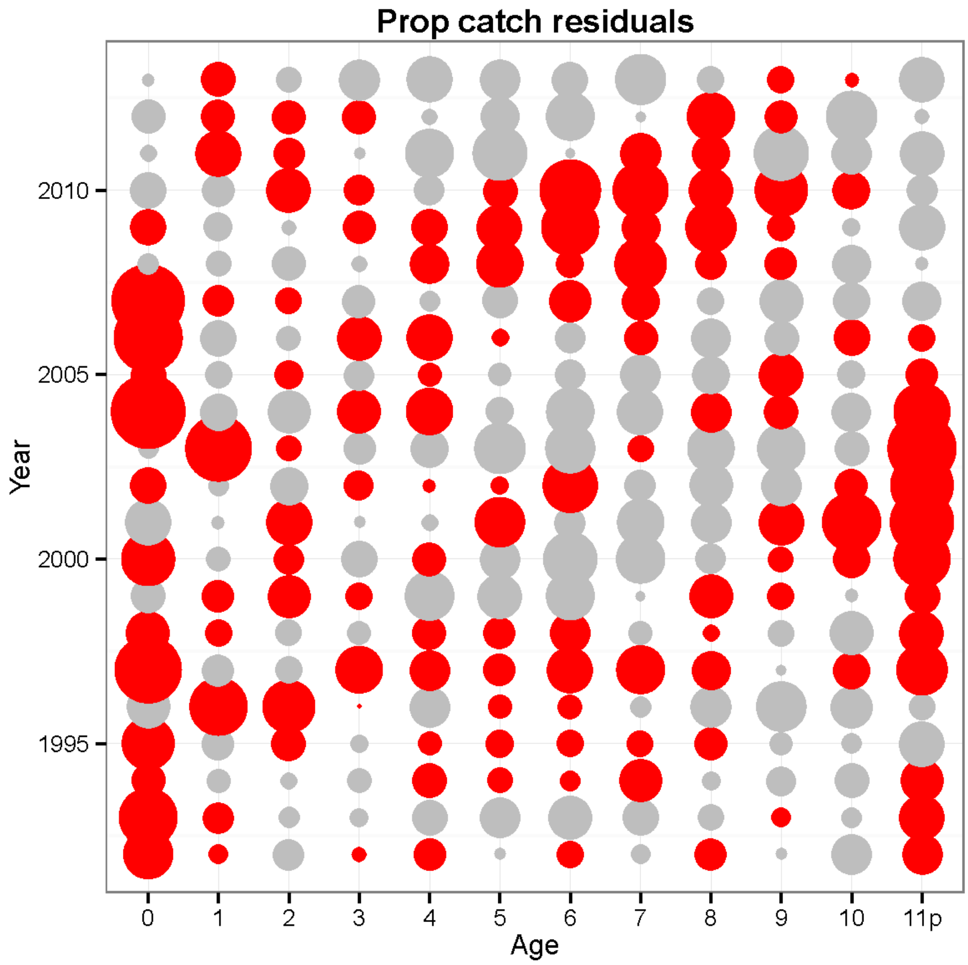


Figure 8.5.2.4. Southern horse mackerel. Bubble plot of catch data residuals from the AMISH assessment. (Negative residuals-red bubbles)

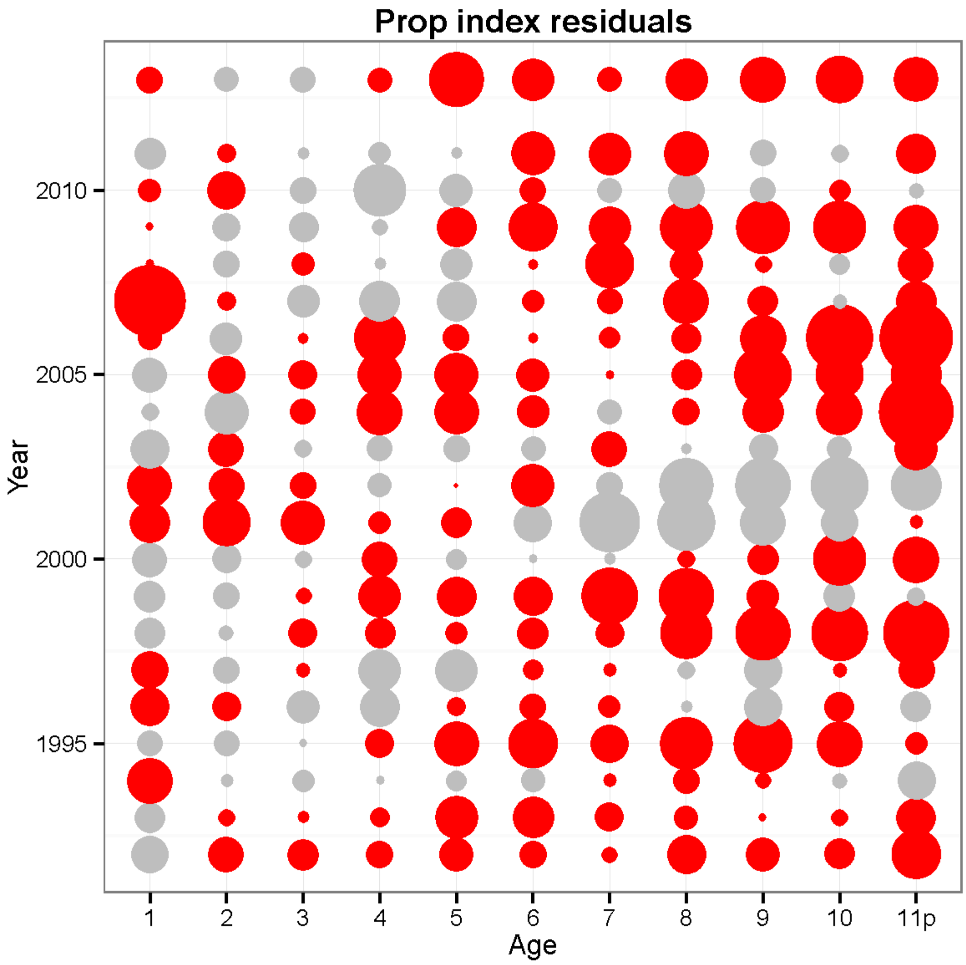
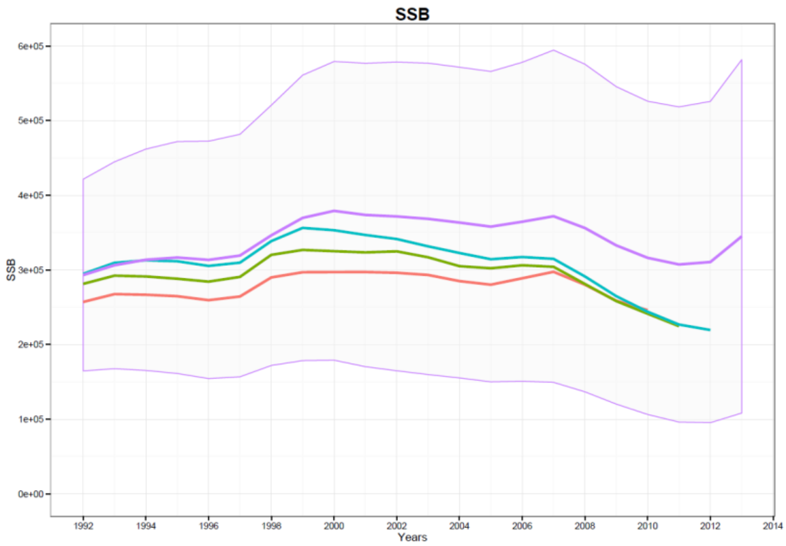


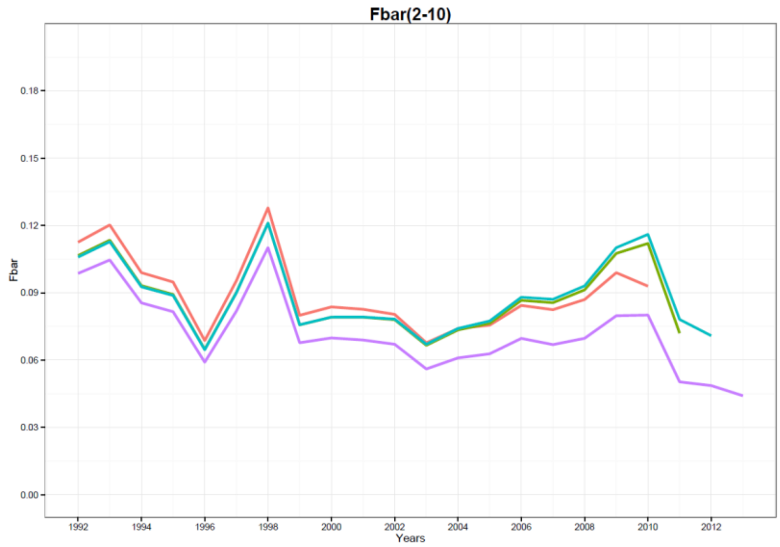
Figure 8.5.2.5. Southern horse mackerel. Bubble plot of bottom-trawl survey residuals from the AMISH assessment. (Survey index not available for 2012; negative residuals-red bubbles)

The model down weighted the large total biomasses observed in the survey in 2005 and 2013 (Figure 8.5.1.1) given that it was fitted assuming for the survey index data a coefficient of variation of 30%. The high survey biomass in 2005 is mainly due to a few sampling stations with very high catch rates, most likely due to fluctuations in availability rather than to natural causes. The increase in survey biomass in 2013 is mainly due to the increase in the abundance of ages 1 and 2, the survivors of the estimated strong recruitments in 2011 and 2012. However, given that for 2012 no combined index is available there is high uncertainty about this biomass increase, also downweighted by the model fit.

Recruitment estimates show a sharp increase in 2011 (to the level of the 1996 year-class) and in 2012 (the strongest recruitment in the time-series) but the latter is very uncertain (Figure 8.5.1.4). There is a significant decrease of F since 2010 but uncertainty (95% confidence intervals) of recent F levels is not higher in recent years. SSB confidence intervals (95%) are, however, very wide.

The retrospective analysis suggests an underestimation of SSB, an overestimation of F and changes in SSB and in F in the previous assessments, mostly deviating since 2007 (Figure 8.5.2.6). A substantial shift is also present since the earlier period of the series (1992 and onwards). This shift was present in last year's assessment but with a lower magnitude. This suggest that the good recruitments estimates in 2011 and 2012 from the survey in 2013 might not be handled well by the model. Another possible reason for the retrospective pattern may be due to a change in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages (Figure 8.5.2.7) in recent years. This change is caused by the increase in the Portuguese bottom trawl, Portuguese purse-seine and Spanish purse-seine catches that target young ages (of around 60% in 2013) and a decrease in the Spanish bottom trawl and in the Portuguese artisanal catches that target older ages (of around 50% in 2013). Since this year's assessment was an update, the selectivity vectors (stock Annex) were not changed. However if the strength of the 2011 and 2012 recruitments are further confirmed (in survey and catches) a change in the selectivity vectors could be considered.





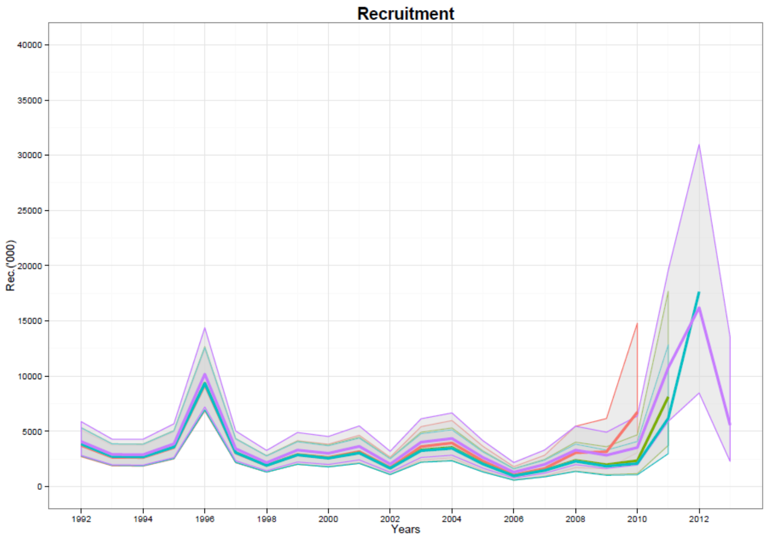


Figure 8.5.2.6. Southern horse mackerel. Retrospective analysis results.

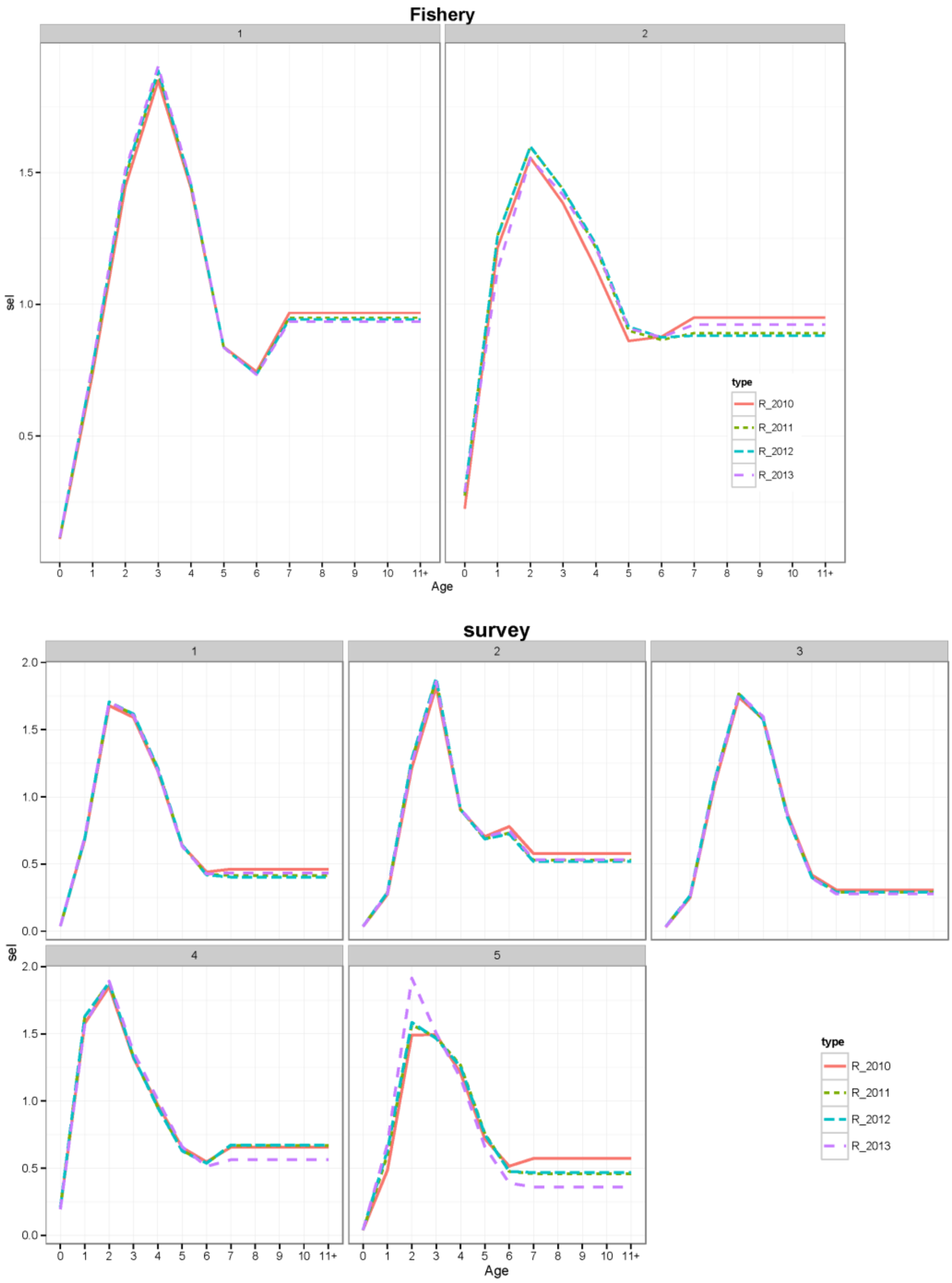


Figure 8.5.2.7. Southern horse mackerel. Retrospective analysis results. Selectivity patterns of catch and survey index (proportions at age by selectivity periods, catch: (1) 1992-1997; (2) 1998-2013 and survey: (1) 1992-1999; (2) 2000-2001; (3) 2002-2004; (4) 2005-2007; (5) 2008-2013).

8.6 Short-term predictions

Deterministic short-term forecasts were made with the MFDP software, assuming a constant recruitment in 2014-2016 corresponding to the geometric mean recruitment of the period 1992-2011 (3357 million fish). For the forecasts, the recruitment estimates for 2012 and 2013 were also replaced by geometric mean recruitment. The weights at age in the stock and in the population, and the fishing mortality used for the forecasts were those of the last assessment year (stock Annex). The abundances at age 1 and at age 2 in 2014 are the survivors of the geometric mean recruitments assumed in 2012 and 2013, respectively. The input data used for the forecasts is presented in Table 8.6.1.

Table 8.6.1. Southern horse mackerel. Short-term forecast (2014-2016).

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3357	0.9	0	0.08	0.08	0.045	0.0119	0.045
1	1349	0.6	0	0.08	0.08	0.042	0.0464	0.042
2	707	0.4	0.36	0.08	0.08	0.051	0.0638	0.051
3	1415	0.3	0.82	0.08	0.08	0.088	0.0581	0.088
4	320	0.2	0.95	0.08	0.08	0.131	0.0500	0.131
5	193	0.15	0.97	0.08	0.08	0.157	0.0373	0.157
6	177	0.15	0.99	0.08	0.08	0.180	0.0360	0.180
7	87	0.15	1	0.08	0.08	0.197	0.0379	0.197
8	46	0.15	1	0.08	0.08	0.213	0.0379	0.213
9	75	0.15	1	0.08	0.08	0.227	0.0379	0.227
10	102	0.15	1	0.08	0.08	0.258	0.0379	0.258
11	353	0.15	1	0.08	0.08	0.330	0.0379	0.330

2015

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3357	0.9	0	0.08	0.08	0.045	0.0119	0.045
1		0.6	0	0.08	0.08	0.042	0.0464	0.042
2		0.4	0.36	0.08	0.08	0.051	0.0638	0.051
3		0.3	0.82	0.08	0.08	0.088	0.0581	0.088
4		0.2	0.95	0.08	0.08	0.131	0.0500	0.131
5		0.15	0.97	0.08	0.08	0.157	0.0373	0.157
6		0.15	0.99	0.08	0.08	0.180	0.0360	0.180
7		0.15	1	0.08	0.08	0.197	0.0379	0.197
8		0.15	1	0.08	0.08	0.213	0.0379	0.213
9		0.15	1	0.08	0.08	0.227	0.0379	0.227
10		0.15	1	0.08	0.08	0.258	0.0379	0.258
11		0.15	1	0.08	0.08	0.330	0.0379	0.330

2016

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	3357	0.9	0	0.08	0.08	0.045	0.0119	0.045
1		0.6	0	0.08	0.08	0.042	0.0464	0.042
2		0.4	0.36	0.08	0.08	0.051	0.0638	0.051
3		0.3	0.82	0.08	0.08	0.088	0.0581	0.088
4		0.2	0.95	0.08	0.08	0.131	0.0500	0.131
5		0.15	0.97	0.08	0.08	0.157	0.0373	0.157
6		0.15	0.99	0.08	0.08	0.180	0.0360	0.180
7		0.15	1	0.08	0.08	0.197	0.0379	0.197
8		0.15	1	0.08	0.08	0.213	0.0379	0.213
9		0.15	1	0.08	0.08	0.227	0.0379	0.227
10		0.15	1	0.08	0.08	0.258	0.0379	0.258
11		0.15	1	0.08	0.08	0.330	0.0379	0.330

Table 8.6.2 shows the management options table from the deterministic short-term forecasts. At current fishing mortality (mean F of 0.044), SSB in 2014 is estimated to be 39 500 tonnes and yield is estimated to be 21 000 tonnes. If F remains at current level in 2014, the predicted yield in 2015 is 22 000 tonnes (below the average of the catch level in recent years). Predicted SSB for 2016 is 42 500 tonnes, corresponding to an increase of 24% in relation to the estimated 2013 SSB.

The forecasts presented in Section 8.6 are deterministic; hence no estimate of uncertainty is calculated. Sources of uncertainty in the outcomes are the uncertainty in the 2012-2013 recruitments, the assumptions on mean fishing mortality with a significant decreasing trend since 2010 and the likely changes in the fishery selection pattern in most recent years.

Table 8.6.2. Short-term forecast (2014-2016) for southern horse mackerel. SSB corresponds to both sexes combined at spawning time.

MFDP version 1a

2014				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
659	395	1	0.0441	21

2015					2016	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
674	422	0	0	0	698	446
.	422	0.2	0.0088	4	694	441
.	421	0.4	0.0176	9	689	437
.	421	0.6	0.0265	13	685	433
.	421	0.8	0.0353	17	680	429
.	420	1	0.0441	22	676	425
.	420	1.2	0.0529	26	671	420
.	420	1.4	0.0617	30	667	416
.	420	1.6	0.0706	34	663	412
.	419	1.8	0.0794	38	658	408
.	419	2	0.0882	42	654	405
.	419	2.2	0.097	46	650	401
.	418	2.4	0.1058	50	646	397
.	418	2.6	0.1147	54	642	393
.	418	2.8	0.1235	58	638	389
.	418	3	0.1323	62	634	386
.	417	3.2	0.1411	66	630	382
.	417	3.4	0.1499	70	626	378
.	417	3.6	0.1588	74	622	375
.	416	3.8	0.1676	77	618	371
.	416	4	0.1764	81	614	367

Units: thousand tonnes

8.7 Reference points and harvest control rules for management purposes

Given the apparent stability in the exploitation and dynamics of this stock during the assessment period, and the lack of a well-defined stock–recruitment relationship (Figure 8.5.1.5), last year $F_{35\%SPR}$ (0.11) was adopted as a proxy for $F_{MSY}$for this stock (ICES, 2013=WGHANSA 2013). The $F_{35\%SPR}$ as estimated in this year´s assessment is 0.12 (Table 8.7.1), thus very close to the value adopted in 2013. This year no further analysis on reference points were carried out given the (still) short time-series and the lack of a well-defines S-R relationship.

Table 8.7.1. Results of yield-per-recruit analysis for southern horse mackerel.

Yield per results

FMult	Fbar	Catch Nos	Yield	StockNos	Biomass	Spwn NosJan	SSBJan	Spwn NosSpwn	SSBSpwn
0	0	0	0	2.5414	0.2647	0.956	0.1917	0.956	0.1917
0.1	0.0044	0.0068	0.0008	2.5065	0.2561	0.923	0.1831	0.923	0.1831
0.2	0.0088	0.0132	0.0016	2.4735	0.2479	0.8917	0.1751	0.8917	0.1751
0.3	0.0132	0.0195	0.0023	2.442	0.2402	0.8621	0.1675	0.8621	0.1675
0.4	0.0176	0.0255	0.003	2.412	0.233	0.8339	0.1604	0.8339	0.1604
0.5	0.022	0.0312	0.0036	2.3835	0.2261	0.8071	0.1537	0.8071	0.1537
0.6	0.0265	0.0368	0.0041	2.3562	0.2196	0.7816	0.1473	0.7816	0.1473
0.7	0.0309	0.0422	0.0047	2.3302	0.2135	0.7573	0.1413	0.7573	0.1413
0.8	0.0353	0.0474	0.0052	2.3053	0.2077	0.7341	0.1356	0.7341	0.1356
0.9	0.0397	0.0524	0.0056	2.2814	0.2023	0.712	0.1303	0.712	0.1303
1	0.0441	0.0572	0.006	2.2586	0.1971	0.6909	0.1252	0.6909	0.1252
1.1	0.0485	0.062	0.0064	2.2367	0.1921	0.6707	0.1203	0.6707	0.1203
1.2	0.0529	0.0665	0.0068	2.2157	0.1875	0.6514	0.1158	0.6514	0.1158
1.3	0.0573	0.0709	0.0072	2.1956	0.183	0.6329	0.1114	0.6329	0.1114
1.4	0.0617	0.0752	0.0075	2.1762	0.1788	0.6152	0.1073	0.6152	0.1073
1.5	0.0661	0.0794	0.0078	2.1576	0.1747	0.5982	0.1034	0.5982	0.1034
1.6	0.0706	0.0835	0.0081	2.1396	0.1709	0.5819	0.0996	0.5819	0.0996
1.7	0.075	0.0874	0.0083	2.1224	0.1672	0.5663	0.0961	0.5663	0.0961
1.8	0.0794	0.0913	0.0086	2.1057	0.1637	0.5513	0.0927	0.5513	0.0927
1.9	0.0838	0.095	0.0088	2.0897	0.1604	0.5369	0.0894	0.5369	0.0894
2	0.0882	0.0987	0.009	2.0742	0.1572	0.523	0.0863	0.523	0.0863

Reference point	F multiplier	Absolute F
Fbar(2-10)	1	0.0441
FMax	>=1000000	
F0.1	3.6877	0.1626
F35%SPR	2.7535	0.1214

Weights in kilograms

8.8 Management considerations

The outputs of the assessment of this stock show no signs of depletion and indicate a sustainable exploitation level. Fishing mortality seems to be low. The conservative F_{MSY} proxy ($F_{35\%SPR}$) is well above fishing mortality in most of time-series. Nevertheless, and although a negative retrospective bias (underestimation of SSB; overestimation of F) is observed, there is a high level of uncertainty in the estimates, notably SSB. The current assessment points a F value well below the F_{MSY} proxy since 2011.

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 unprofitable to fishermen. Although the catch in 2013 (29000 tonnes) was close to the TAC (30 000 tonnes), usually the catches were below the TACs. According to the short-term forecast, fishing at F_{MSY} implies increasing current F by 2.5, corresponding to catches in 2015 of 52 000 tonnes (50% above the TAC set for 2014).

This stock has supported a stable exploitation level for a long period. It is clear that the apparent stability in the overall exploitation level is due to a decrease in fishing mortality in some fleets and an increase in others. The traditional exploitation pattern across fleets has been, for a long time, the targeting of juvenile age classes. This targeting of juveniles at a moderate level of exploitation does not seem to have been detrimental to the dynamics of this stock, which has been stable along the years. However, there seems to have been a new change in exploitation pattern since 2010 and there is also a migratory pattern of southern horse mackerel that makes age classes not evenly distributed along the stock area, with old fish mostly present in the waters of Galicia and northern Portugal. Therefore, a TAC for 2015 similar to the one of 2014 (35 000 tonnes) would already allow some increase of catches and to keep F at a likely sustainable level, given the high uncertainty of the estimates related to the state of the stock.

9 Blue Jack Mackerel (*Trachurus picturatus*) in the waters of Azores

The *T. picturatus* is the only species of genus Trachurus that occurs in the Azores region (northeastern Atlantic). It is a pelagic species found around the islands shelves, banks and seamounts up to 300 m depth. However, a different size structure was observed between islands shelf and offshore areas. The island shelf areas seems to function as nursery or growth zones, while the seamount/bank offshore areas as feeding zones where adults predominate (Menezes *et al.*, 2006).

In the Azores, the *T. picturatus* is 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, and bottom longline.Purse-seines are also used by the tuna bait boat fleet, which targets the *T. picturatus* to be used as live bait for tuna. The blue mackerel is also a very popular species among the recreational fisherman that fish along the coast of all islands.

The *T. picturatus* landings were considerably high during the 1980's, however changes in the local markets lead to a strong reduction in the catches afterwards. This reduction was also accompanied by a sharp decrease in the fleet targeting small pelagic fish. Since this period, the catches maintained at a low level due to a voluntary auto regulation adopted by the fishermen associations. Despite this reduction in the landings, this fishery still has a strong impact on some fishermen communities, which directly depends on the income of this fishery.

9.1 General Blue Jack Mackerel in ICES areas

The blue mackerel, *Trachurus picturatus Bowdich*, 1825 (Carangidae) has a broad geographical distribution within the Eastern Atlantic waters and can be found from the southern Bay of Biscay to southern Morocco, including the Macaronesian archipelagos, Tristan de Cunha and Gough Islands and also in the western part of the Mediterranean Sea and the Black Sea (Smith-Vaniz, 1986). It is a pelagic fish species which 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, Azores and Canary islands (Isidro, 1990; Jesus, 1992; Gouveia, 1993; Vasconcelos *et al.*, 2006; Jurado-Ruzafa and Santamaría, 2012) indicated similar growth rates and reproductive season. However, biological differences on age at first maturity seem to exist between individuals from the Azores compared with those from the Madeira and Canary islands (Jesus, 1992; Jurado-Ruzafa and Santamaría, 2012). The morphometric studies carried out on *T. picturatus* from Azores archipelago (Isidro, 1990), western coast of Portugal (Mendes *et al.*, 2004) and western Mediterranean (Merella *et al.*, 1997) revealed similar population parameters for the estimated relationships. On the contrary, some variation was found between different geographic areas in the number of soft spines from the second dorsal fin (Shaboneyev and 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 and 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 blue 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 2014

The advice for this stock is biennial and so the 2012 advice is valid for 2013 and 2014 (see ICES, 2012): ICES advises on the basis of the approach for data limited stocks that catches should be no more than 1800 tonnes.

9.3 The fishery in 2013

Commercial catches for 2013 include landings, discards (estimated for 2013), tuna bait catches and recreational catches. For 2013, the discards observer programme didnot occur due to financial constraints, and so the longline discards (including bait consumption by this fleet) were estimated taking into account the results from the previous years.

In 2013, length frequencies and ages from landings sampling were collected and commercial abundance indices from the main fleets catching juveniles were also taking into account (LPUE_Purse-seiners and cpue_BaitBoat).

9.3.1 Fishing Fleets in 2013

The blue mackerel is mostly landed by the artisanal fleet, using purse-seines. This fleet landings represents around 90% of the total landings and the catches about 60% of the total catches of blue mackerel, in Azores.

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 has remained quite stable in the recent years, with 120 vessels registered last year. The contribution of this fleet to the landings and the number of vessels of each size category, for the last 12 years is showed in **Error! Reference source not found.**.1.

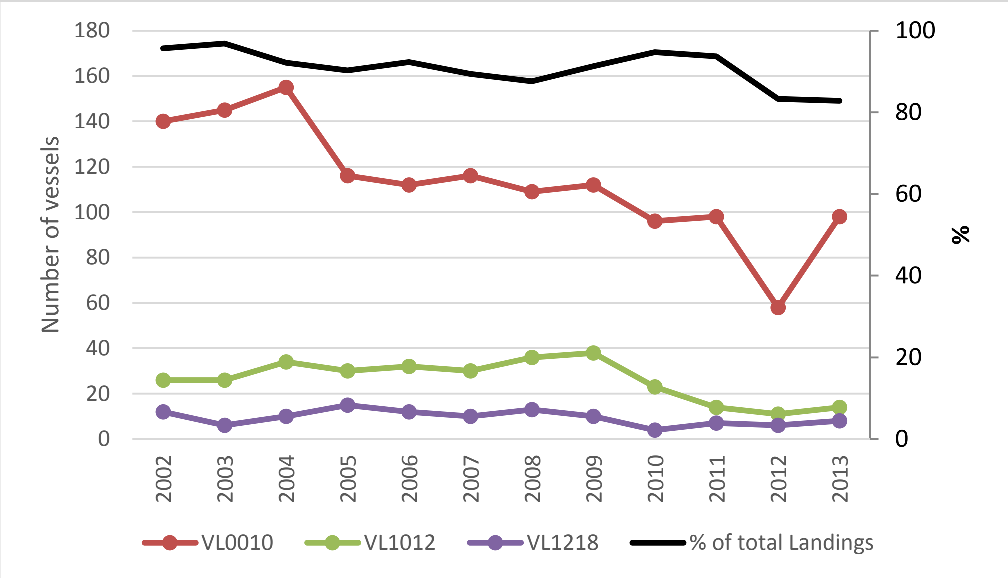


Figure 9.3.1.1 Contribution of purse-seine fleet to the landings of blue mackerel in Azores, between 2002 and 2013, and the number of vessels of each size category.

9.3.2 Catches

Commercial catches including landings, discards (estimated for 2013), tuna bait catches and recreational catches, for the period 1978 to 2013, are presented in **Error! Reference source not found.**.

Total estimated catches of blue mackerel in the Azores, for the considered period in **Error! Reference source not found.**.1 (2002-2013), are around 1650 tonnes; while landings, in same period,are in average 1100 tonnes. In the last three years, the average catches and landings decreased to about 1330 and 750 tonnes, respectively.

Table 9.3.2.1 – Estimated catches of blue jack mackerel (*T. picturatus*) by fishery, in the Azores from 1978 to 2013.

Year	Tuna bait	Recreational	Discards/Bait (LL)	Discards (PS)	PS	LL+Hand	Total
1978	115	129	15	0	2657	78	2995
1979	118	130	15	0	4114	61	4439
1980	210	132	22	0	2920	70	3354
1981	229	135	9	0	2104	39	2516

Year	Tuna bait	Recreational	Discards/Bait (LL)	Discards (PS)	PS	LL+Hand	Total
1982	239	142	10	0	2429	43	2862
1983	231	142	21	0	3711	67	4172
1984	295	135	17	0	3180	62	3689
1985	303	136	11	0	3442	60	3952
1986	433	135	9	0	3282	58	3918
1987	491	139	8	0	2974	53	3666
1988	586	143	8	0	3032	55	3824
1989	352	138	9	0	2824	50	3373
1990	345	117	11	27	2472	48	3021
1991	242	115	6	127	1247	33	1770
1992	249	121	6	126	1226	35	1762
1993	375	130	22	173	1684	70	2454
1994	264	125	18	179	1745	59	2390
1995	474	119	24	182	1769	79	2648
1996	351	110	38	173	1642	123	2437
1997	259	110	31	192	1849	72	2513
1998	308	111	52	151	1387	120	2129
1999	141	119	37	35	609	84	1024
2000	83	117	23	32	602	53	910
2001	59	121	24	110	1046	55	1415
2002	82	132	28	145	1387	63	1837
2003	140	128	21	150	1455	47	1941
2004	208	111	19	125	1148	98	1709
2005	124	120	236	123	1111	120	1834
2006	264	111	40	124	1145	96	1781
2007	370	115	58	115	1032	122	1812
2008	205	110	75	111	980	139	1620
2009	230	119	115	112	1023	98	1697
2010	313	114	75	116	1021	57	1696
2011	510	118	79	105	920	62	1794
2012	399	42	41	Not available	467	94	1043
2013	237	147	54	Not available	592	123	1153

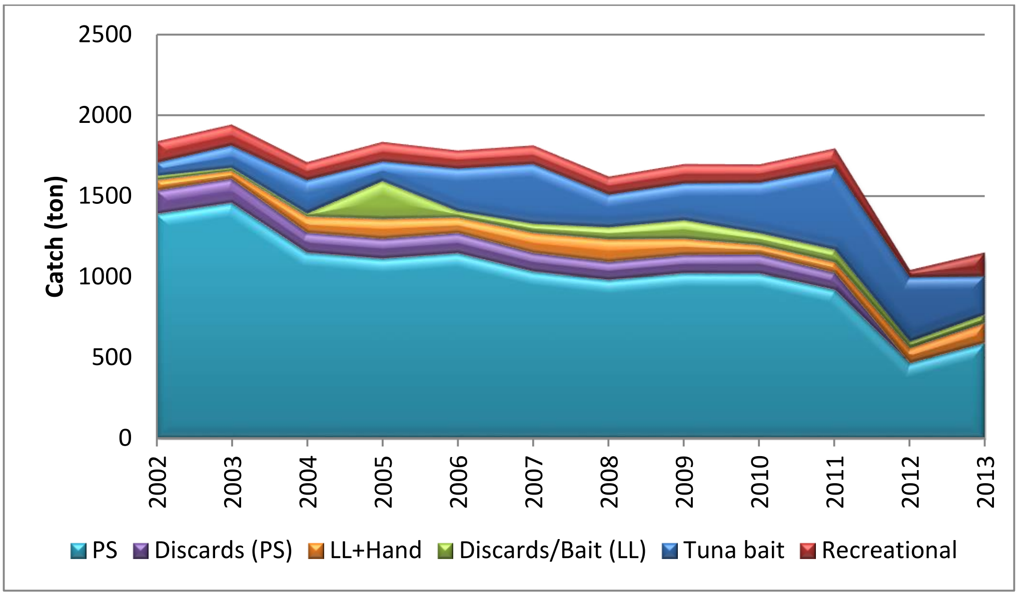


Figure 9.3.2.1 Estimated catches of blue mackerel (*T. picturatus*) in the Azores (ICES Subdivision Xa2) from 2002 to 2013.

An important reduction was observed in the catches of all fishing gears in 2012, but particularly for those targeting the juveniles, such as the artisanal purse-seine fleet and the tuna baitboats fleet. In the case of the artisanal seiners the reduction observed was close to 50%. The cause of this reduction is unknown. Concerning the longliners, the reduction observed in 2012 is mostly related to the practice of using the blue mackerel for bait, since their market price is too low.These values increased in 2013, although still are below the average of the preceding 10 years to 2012.

9.3.3 Effort and catch per unit of effort

The fishing effort in number of days at sea is presented by year and by vessel size category in **Error! Reference source not found.**.1.The majority of the effort is conducted by the small segment of the fleet (VL0010 – vessel with less than 10m), followed by the fleet segment VL1012 (vessels between 10 and 12 metres).

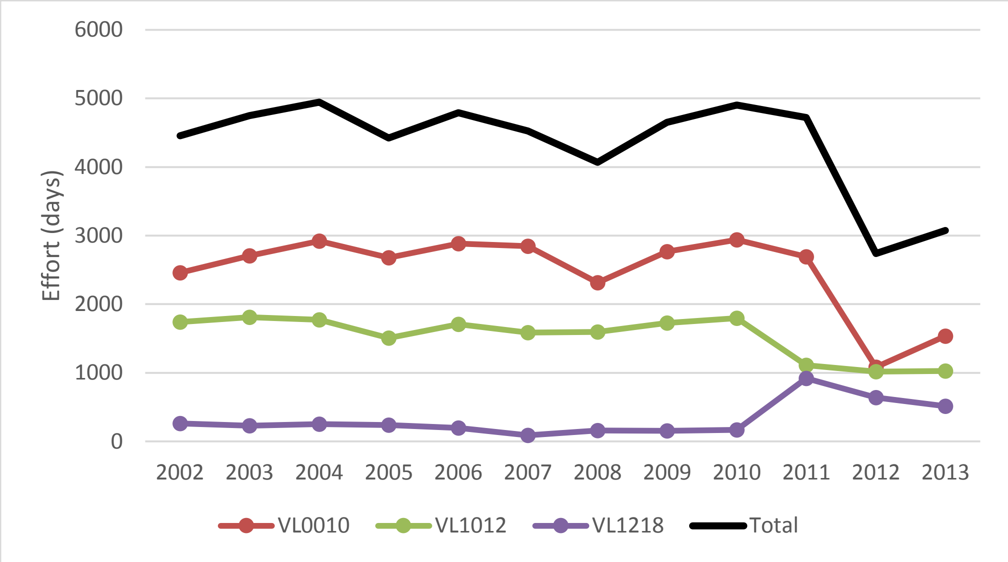


Figure 9.3.1.1 Nominal effort (number of days) of the purse-seine fleet, total and by vessel size category for the period 2002-2013.

For the last twelve years, and with the reduction of this fleet in the 90's, the threshold of 5000 fishing days has never been exceeded.

The standardized cpue/LPUE series were updated for the small purse-seine fleet (**Error! Reference source not found.Error! Reference source not found.**) and the tuna baitboat fleet (**Error! Reference source not found.**) of blue jack mackerel, up to 2013. Landings of blue jack mackerel from the longliners are less representative once a considerable part of the catch is not landed being either discarded or used as bait. The source of data for updating CPUE series from this fleet is through the discards observer sampling programme but, since it wasnot possible to conduct it in 2013, the CPUE series for the longliners was not updated.

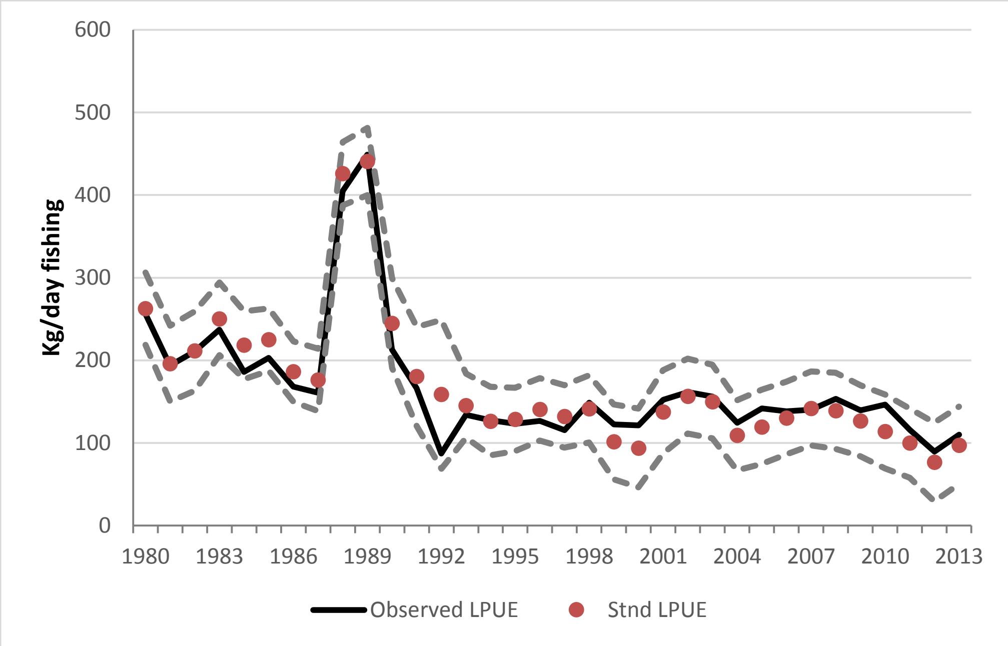


Figure 9.3.3.2 Standardized and observed LPUE for blue jack mackerel from the Azores small purse-seine fishery, for the years 1980-2013. Broken lines indicate 95% confidence intervals.

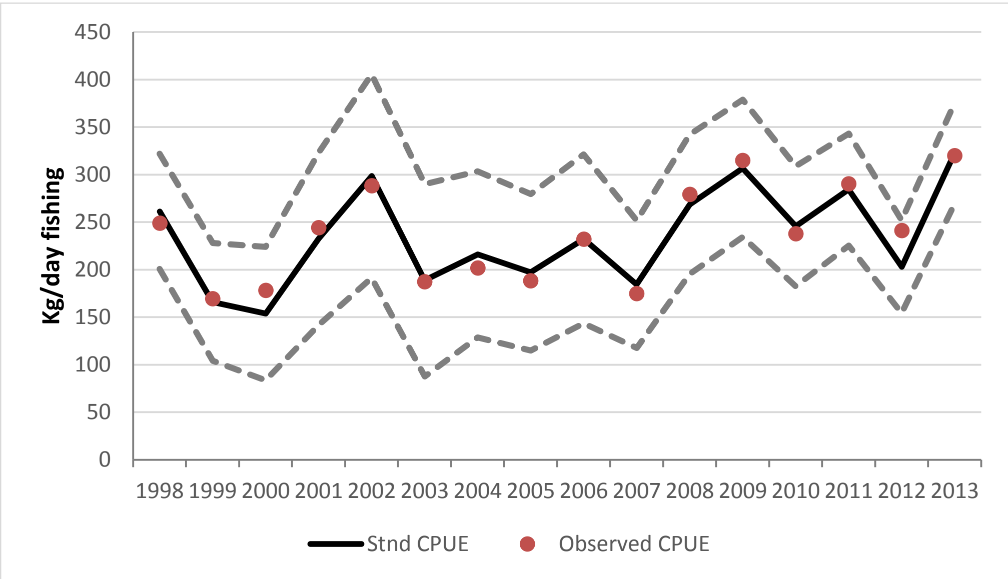


Figure 9.3.3.3 Standardized and. observed CPUE for blue jack mackerel from the Azorean baitboat tuna fishery, for the years 1998-2013. Broken lines indicate 95% confidence intervals.

9.3.4 Catches by length

Size frequencies for the jack mackerel caught in the Azores are available since 1980. In **Error! Reference source not found.**, is presented the size distribution of the landings (catch at size) for the years 2002 to 2013. 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.

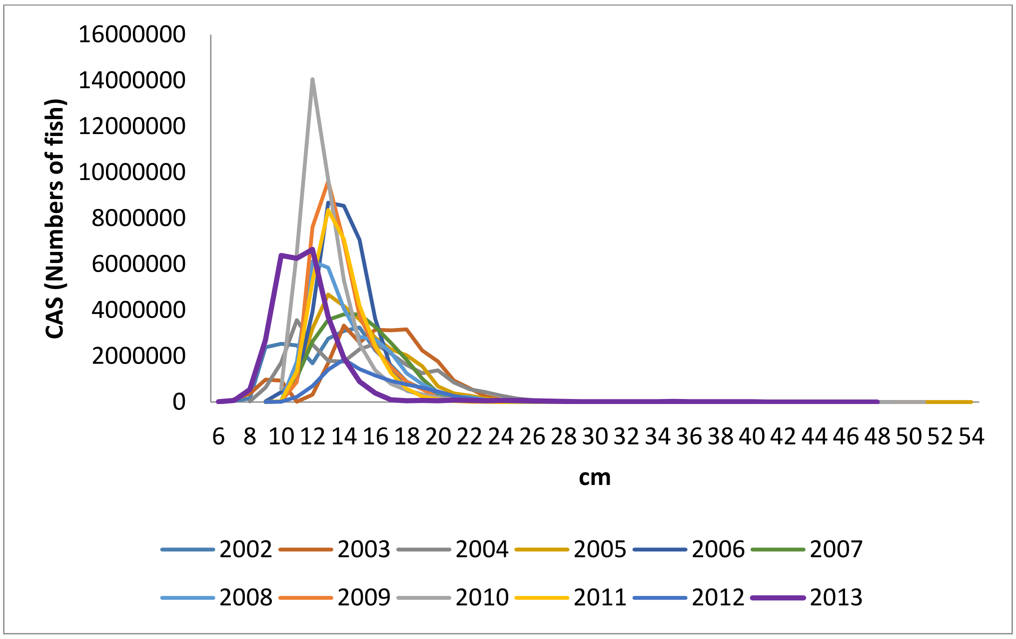


Figure 9.3.4.1 Annual size frequencies of the catches of blue mackerel (*T. picturatus*) in the Azores, from 2002 to 2013.

Assessment of the state of the stock

The assessment method is described in the stock annex.

9.4 Management considerations

The Regional Administration intends, during the current year, put in place a specific management measure for the purse-seine fleet with the aim of regulate markets. This measure allows only 200kg per vessel, per day: Also states that fishing and consequent landings shall also be forbidden on weekends.

10 General Recommendations

WGHANSA 2014 General Recommendations	To
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. The WGHANSA recommends that the BOCADEVA DEPM survey series is maintained to scale properly the assessment of anchovy in Subdivision IXa South. The WGHANSA considers each of the survey series directly assessing anchovy in Division IXa as an essential tool for the direct assessment of the population in their respective survey areas (Subdivisions) and recommends their continuity in time, mainly in those series that are suffering of interruptions through its recent history.	PGCCDBS, RCM's
The Benchmark for anchovy in IXa is recommended to be delayed to 2016, basically due to limited man power over the data compilation. Benchmark for both sardine stocks in IXa, VIIIc and in VII, VIIIabd are recommended in 2017 and should be carried out simultaneously within the same benchmark workshops. Benchmark for Horse Mackerel in IXa is recommended in 2017	ICES secretariat
WGHANSA recommends investigation on possible separate stock identity for Anchovy in IXa to be carried out by the Working group on Stock Identity (SIMWG).	

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Annex 2: List of WD and presentations

Angélico, M.M., Diaz, P., Franco., C., Lago de Lanzós, A., Nunes, C., Pérez, J.R. WD 2014. DEPM 2014: Preliminary Egg Results for the Atlanto-Iberian Sardine ICES VIII and IXa.

Abstract: The triennial DEPM for estimation of sardine spawning biomass for the Atlanto-Iberian stock areas IXa, VIIIc and VIIIb up to 45ºN took place in the S and W (IPMA) from 15th March to 26th April and in the N (Galicia, Cantabrian Sea and French coast, IEO) between 29th March and 21st April. The whole area was surveyed however the Portuguese survey occurred much later than usual and suffered several interruptions; part of IPMA´s DEPM survey was conducted simultaneously to the acoustics survey on board the same vessel. The number of fishing samples was maintained at levels similar to other years but it was evident that sardine schools were less available than during previous surveys in particular in the western and northern shores. Preliminary estimates highlighted a sharp decrease in egg production from 2011 to 2014; this pattern was particularly clear in the northern stratum.

Duhamel, E., Doray, M., Huret, M., Authier, M., Gestin, T. WD 2014. Direct assessment of small pelagic fish by the PELGAS14 acoustic survey. PELGAS14 Survey Report. 31p.

Abstract: An acoustic survey was carried out in the Bay of Biscay from April 24st to June 5th on board the French research vessel Thalassa. The objective of PELGAS14 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 during 18 days, such as to improve the number of identifications hauls and increase the reliability of identification of echoes. This WD reports acoustic assessments and length distributions of main species, age distribution for anchovy and sardine and some environmental data. Anchovy was present this year as an abundance index a bit above the average on the serie, 125 427 tonnes. The biomass estimate of sardine observed during PELGAS14 is 339 607 tons, which constitutes a small decrease of the last year level of biomass, but this specie is still at a high level of abundance in the bay of Biscay.

Marques, V., Angélico, M.M., Silva, A., Soares, E., Nunes, C. WD 2014. Acoustic survey carried out from 3 April to 12 May 2014 off the Portuguese Continental Waters and Gulf of Cadiz, on board RV "Noruega"

Abstract: The main results of the Portuguese acoustic survey directed to sardine and anchovy estimates in ICES sub area IX show a reduction in sardine biomass. The sardine biomass was the lowest of the time series, following the tendency of the last years. In the Occidental south zone (OCS), the estimated biomass was very low (8 thousand tonnes). Age 1 was predominant in the survey area although the absolute number was low, indicating a low 2013 recruitment. Results on egg density distribution from CUFES sampling are not yet available. Sardine egg distribution from Cal-

VET surveying (for DEPM) taken concomitantly to the acoustic observations (during the night) show a spawning area and densities slightly higher than during the 2011 DEPM survey. The egg distribution in the southern and northwestern shores matched fairly the sardine acoustic energy mapping.

The anchovy abundance suffered a reduction in the West coast area. On the contrary in the South coast, anchovy biomass was higher, in relation to the last survey, in 2013. Age 1 anchovy was predominant in the West coast. Concerning Southern areas (Algarve and Cadis Bay) anchovy otoliths ageing still rise some difficulties due to their less clear structures than in the remaining areas, rising the need for an intercalibration between the Portuguese IPMA and the Spanish IEO-Cadiz readers. This action is being prepared to be undertaken this year and therefore, it was not considered as appropriate the inclusion of these ageing results in this document.

The 2014 spring acoustics survey took place one month later than planned and lasted longer than usual, and was interrupted several times due to bad weather and ship technical problems.

Ramos, F., Iglesias, M., Jiménez, P., Miquel, J., Oñate, D. Tornero, J., Ventero, N., Diaz, N. WD 2014. Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the ECOCADIZ 0813 Spanish survey (August 2013).

Abstract: The present working document summarises the main results from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 2nd and 13th August 2013 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz on board the RV "Cornide de Saavedra". The survey dates were somewhat delayed in relation to the usual ones and to the anchovy (*Engraulis encrasicolus*) peak spawning as well. Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their back-scattering energies. The bulk of the anchovy population was concentrated in the Spanish shelf, with a residual nucleus to the west of Cape Santa Maria. A delay of the usual survey dates may be the reason of a higher relative importance of smaller anchovies in the population as a probable consequence of the incorporation of the first waves of recently recruited juveniles to the adult population. The total biomass estimated for anchovy was 8.5 thousand tonnes (609 million fish), the lowest estimate in its series. Sardine showed a distribution pattern almost complementary to that described for anchovy, with higher densities occurring over the inner-middle shelf of both extremes of the surveyed area, mainly west to Cape Santa Maria, and in shallower waters than anchovy. Sardine yielded a total of 9.7 thousand tonnes (232 million fish). The 2013 sardine estimate was also the lowest one in its series and corroborates a clear recent decline in the population which has also been evidenced by the PELAGO surveys. Chub mackerel was present all over the surveyed area although showed a more "oceanic" distribution in the westernmost waters. The species was the most important in terms of assessed biomass, rendering estimates of 31.3 thousand tonnes (333 million fish). Acoustic estimates for jack and horse-mackerel species (*Trachurus* spp.), and bogue (Boops boops) are also given in the WD. No acoustic estimates either for mackerel *S. scombrus* or round sardinella (Sardinella aurita) were computed because their incidental occurrence in the study area during the survey.

Riveiro, I., Carrera, P. WD 2014. Preliminary results of the pelacus0314 survey: estimates of sardine abundance and biomass in Galicia and Cantabrian waters

Abstract: A total of 9023 tons of sardine (147 million fish) was estimated to be present in northwest and northern Spanish waters by the Spanish spring acoustic survey PELACUS0314, carried out from 9th March to 8th April 2014. That represents an important increase in relation to 2013 abundance and biomass, but still at the lower levels of the time series.

Fish were mainly found in Cantabrian area (mainly in VIIIc East-West subdivision) and inside Rias Baixas (South Galicia, ICES sub-areas IXa-N) and was almost absent from the rest of the surveyed area. Most fish in the entire surveyed area were assigned as belonging to the age 2 (38% of the abundance and 43% of the biomass) and age 3 (24.5% of the abundance and 25.5% of the biomass) years classes. By subdivisions, the IXaN (South of Galicia) population was dominated by age 1 fish whilst the Cantabrian area was mainly composed by a population of age 2 and age 3 individuals.

The distribution of sardine eggs (obtained from the analysis of 358 CUFES stations) indicates a very coastal distribution, agreeing with that observed in previous years. The percentage of positive stations was very similar in both surveys, but total number of sardine eggs detected in Spanish waters was 4214, which represents an important decrease from the 2013 value.

Santos, M., Ibaibarriaga, L. and Uriarte A. WD 2014. Preliminary index of biomass of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2014 applying the DEPM and sardine total egg abundance. 31p.

Abstract: The research survey BIOMAN 2014 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy and sardine was conducted in May 2014 from the 5th to the 24th covering the whole spawning area of the species. Two vessels were used: the RV Ramón Margalef to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 104 115Km2 and the spawning area was 35 317Km2. During the survey 767 vertical plankton samples were obtained, 1708 CUFES samples and 51 pelagic trawls were performed, from which 42 contained anchovy and 41 of them were selected for the analysis. Moreover, 6 extra samples were obtained from the commercial fleet. In total there were 47 samples for the adult parameters estimates. No anchovy eggs were found in the Cantabrian Coast. The spawning area started at 43º37'N in the French platform and the northern limit was found at 47ºN. The eggs, in the French platform where encountered in the historical common places: Between Adour and Arcachon passed the 200 m depth from the coast and in the area of influence of Le Gironde, from the coast to the 100 m depth line. The weather conditions during the survey were good in general with a mean Sea Surface Temperature (SST) of 14.8ºC.

Total egg production (P_{tot}) was calculated as the product of the spawning area and the daily egg production rate (P0), which was obtained from the exponential decay mortality model fitted as a Generalized Linear Model (GLM) to the egg daily cohorts. The adult parameters, Sex Ratio, preliminary Batch Fecundity and Weight of mature females, were estimated based on the adult samples obtained during the survey and the Spawning frequency estimate was obtained as the mean of the historical series. The index of biomass estimate resulted in 87 225 t with a coefficient of variation of 16%, the second higher of the series since 1987, the highest was the one estimate in

2011. Total abundance of sardine was 14.3 E^{12} eggs, the highest of the series since 1990.

G. Boyra and U. Martinez (AZTI) WD 2014: JUVENA 2013 – autumn acoustic survey of juvenile anchovy in the BoB Update estimates for WGHANSA (June 2014).

Abstract: The survey JUVENA 2013 took place between the 1st and 30th of September. The survey took place during 30 days, sampling 2,250 nautical miles that provided a coverage of about 32 500 $n.mi.^2$ along the continental shelf and shelf break of the Bay of Biscay, from the 7º10'W in the Cantabrian area up to 47º30'N at the French coast. 69 hauls were done during the survey to identify the species detected by the acoustic equipment, 47 of which were positive of anchovy. This year, as usual, we have found anchovy distributed along two different strata: a pure juvenile anchovy stratum, located at the outer part of the continental shelf and slope waters, and a mixed juvenile-adult stratum located at the inner part of the continental shelf and coastal waters. The biomass of juveniles estimated for this year 2013 is 105 300 tonnes, supposing a minor correction regarding the estimate reported to WGACEGG of 109 000 t. This value is about 25% less than the average of the biomasses of the temporal series. The area of distribution of juvenile anchovy this year was considerably large (among the highest ones in the temporal series), but the densities were low. Almost the 85% of this biomass was located off-the-shelf or in the outer part of the shelf in surface waters (5-25 m). Due to an extremely close-to-surface distribution of juvenile anchovy in the oceanic area, part of the stock was outside the 38 kHz detection range (inside the near field). In order to correct this, the energy collected by the 120 kHz in the range 5-10 m was correct by a conversion factor for the Energies 38/120, so that this problem was minimized. Adult biomass estimates were also corrected but they are not used for the integrated assessment of the stock.

Annex 3: Appending Relevant WDs

Annex 3.1 JUVENA 2013 – Autumn acoustic survey of juvenile anchovy in the BoB – Update estimates for WGHANSA (June 2014).

Working Document to ICES WGHANSA 20-26 June 2014.

JUVENA 2013 – Autumn acoustic survey of juvenile anchovy in the BoB

Update estimates for WGHANSA (June 2014).

By G. Boyra and U. Martinez (AZTI)

The project JUVENA aims at estimating the abundance of the anchovy juvenile population and their growth condition at the end of the summer in the Bay of Biscay. The long term objective of the project is to be able to assess the strength of the recruitment entering the fishery the next year.

This year 2013 the survey was coordinated between AZTI and IEO. AZTI leaded the traditional assessment studies of the JUVENA series and IEO leaded the ecological studies, substantially increasing the planktonic sampling effort and adding ecological-environmental objectives to the project, as top predators observation or intensive hydrological transects. The ecological results are not reported in this WD. The survey JUVENA 2013 took place between the 1stand 30th September with two Vessels the RV Ramon Margalef (RM) of the IEO and the RV Enma Bardán (EM).

The survey JUVENA 2013 took place between the 1stand 30thof September with two Vessels the RV Ramon Margalef (RM) of the IEO and the RV Enma Bardán (EM) (see Table 2). In the RV Ramon Margalef the transducers were installed in a drop keel, at 6.5 m depth. But additionally, this year, the 120 kHz transducer was replaced with one that was installed in a pole attached to the side of the vessel at 2.5 m depth. In the RV/Emma Bardan, the transducers were installed in the hull at 2.5 m depth. For the 30 days of surveying, acoustic sampling of 2250 n.mi. were carried out that provided a coverage of about 32 500 n.mi.^{2} along the continental shelf and shelf break of the Bay of Biscay, from the 7º10’W in the Cantabrian area up to 47º30’N at the French coast. A total of 69 hauls were done during the survey to identify the species detected by the acoustic equipment, 47 of which were positive of anchovy.

The coverage of the campaign can be observed in Figure 1. The survey was covered by both vessels in coordination, concentrating the sampling effort of each vessel in the most appropriate areas according to their efficiency: this is, oceanic and slope waters for the RM and continental shelf for the smaller pelagic trawler EB.

This year, as usual, we have found anchovy distributed along two different strata: a pure juvenile anchovy stratum, located at the outer part of the continental shelf and slope waters, and a mixed juvenile-adult stratum located at the inner part of the continental shelf and coastal waters (Figures 2 and 3):

- **Pure juvenile stratum**: In this stratum, anchovy was located in the uppermost part of the water column forming the typical superficial aggregations of pure juvenile anchovy (Figure 4), mixed in occasions with smaller proportions of juvenile horse mackerel, gelatinous species and krill. In order to simplify description, we can divide this stratum in two areas, Cantabric and French.

- **Cantabric sub-stratum**: in this area, anchovy juveniles were extended along a strip around the shelf break edge, from 6º40'W to 1º30'W (Figure 4). The extension of the strip was shorter on the West. There was a slight gradient of juvenile anchovy sizes from West to East, being the larger (8 cm) found at the Western part and the smaller at the Eastern part of the stratum (7 cm; Figure 3).
- **French sub-stratum**: this area was extended in front of the Southern French Coast (to the South of 45ºN), from coastal areas to the slope waters. Sizes in this area varied between 5 and 6 cm (Figure 3). The superficial aggregations of anchovy were composed by a majority of juvenile anchovy, mixed with small quantities of horse mackerel and jellyfish.

- **Mixed stratum**: Anchovy size in this stratum was bigger, between 11 and 15 cm (Figure 3), a mix of adult and juvenile (Figure 4), 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 and blue whiting on the mid continental shelf (Figure 2). This year, the mixed stratum was located closer to the shore than usual.
- **Garonne:** Around the plume of the Gironde River, a positive area was found extending from the coast to about 50 m isobath. Here, anchovy included both adults and juveniles, and was found mixed with sardine, sprat, horse mackerel and other species (Figure 2), distributing along the whole water column. The hauls provided typical examples of the so called "beach anchovy" by the Spanish fishermen, that shows some morphologic differences with the rest. The sizes ranged from 8 to 13 cm (Figure 3).

The biomass of juveniles estimated for this year 2013 is 105 300 tonnes (Table 7). This value is about 25% less than the average of the biomasses of the temporal series (Figure 5). The area of distribution of juvenile anchovy this year was considerably large (among the highest ones in the temporal series, see Figure 4), but the densities were low. Almost the 85% of this biomass was located off-the-shelf or in the outer part of the shelf (Figure 4) in surface waters (5-25 m).

Biomass estimation of the close-to-surface layers

This year we found an especially close-to-surface distribution of juvenile anchovy in the oceanic area. Part of the stock was in the 5-10 m depth layers, thus outside the 38 kHz detection range (inside the near field of this transducer, see Figure 5). In the methodology of JUVENA survey, in order to take into account potential close-to-surface layers of juvenile anchovy survey, we deployed the 120 kHz transducer at 2.5 m depth on board both vessels. The combination of shallow deployment and short near field range of this transducer allowed the authors to echo-integrate from depths of 5 meters depth when necessary (Figure 5) for the oceanic areas. Therefore, additionally to the standard echointegration of the layers deeper than 10 m depth using the 38 kHz transducer, in some oceanic transects, the abundance in the layer 5-10 m depth was calculated based on the 120 kHz frequency data. In these surface layers, the 120 kHz was echointegrated instead of the 38 kHz one.

In absence of a consistent TS value for anchovy at 120 kHz, in order to convert 120 kHz echointegrals to biomass, the 38/120 NASC ratio was calculated and multiplied to the 120 kHz data, thus re-scaling them to be comparable with the 38 kHz data. We chose around 400 ESDUs of pure monospecific juvenile anchovy aggregations and echo-integrated them at 38 and 120 kHz transducers in transects where the juveniles were deep enough to be detected by both transducers. Thus, the 10-45 m depth layers were echointegrated at both frequencies. From these data we calculated the ratio of 38/120, obtaining a median value of 4.47 (n=368) with a cv of about 5% (Figure 6) (estimated a SQR(exp(σ^2)-1), where sigma is the standard error of the ratio estimates in log scale). After this surface correction procedure, around 65% of the NASC of the "Pure juvenile" area was located in the 5-10 m depth layer (Figure 7).

Thanks to the aid of this 120 kHz transducer, we considered that the fraction of juveniles which might have been missed in the first depth layers was minimized (Figure 5). However, given the extra processing step introduced with the 120 to 38 kHz scale conversion, it must be taken into account that it will introduce some additional potential uncertainty in this year's estimate.

Revision of the preliminary estimation

In the preliminary estimation of abundance of the survey, reported in November 2013 to ICES WGACEGG, a high biomass of adult anchovy in the North was estimated. A large part of this biomass was located in a few coastal strata of small size and high density. These strata were very shallow and with a combination of rough bottom and presence of commercial nets in the area. In these conditions, it was not possible to fish and the identification of the high acoustic energy found in these strata was uncertain. This acoustic energy was originally attributed to adult anchovy, based on the catches of the available nearby fishing operations. Other possible candidate species to attribute this biomass, based on the acoustic typology and the usual species composition in this area, were sardine and sprat.

In a revision of the preliminary abundance estimate, the acoustic energy from these poorly identifiable strata was removed, resulting in a reduction of the estimated biomass, especially of adult anchovy (from 180 000 to 78 000 t). The biomass of juvenile anchovy was also changed from 109 700 to 105 300 t.

Recruitment prediction capability

The recruitment prediction capability of the JUVENA index, evaluated by fitting the biomass estimates of age-0 anchovy in autumn with the estimates of age-1 at the beginning of the next year can be observed in Figure 8. The simple regression between the variables showed that there exists a positive and significant correlation between the variables. Using a log-log regression between the variables, the relationship is significant too, both for the slope and the intercept (Figure 9). This predicts a medium recruitment (about 37 000 tonnes) for next year. The confidence intervals at 95% were around 21 000 and 61 000 tonnes. However, given the extra processing step introduced with the 120 to 38 kHz scale conversion, it must be taken into account that it will introduce some additional potential uncertainty in this year's estimate.

The recruitment prediction capability of the JUVENA index, evaluated by fitting the biomass estimates of age-0 anchovy in autumn with the estimates of age-1 at the beginning of the next year can be observed in Figure 8. The simple regression between the variables showed that there exists a positive and significant correlation between the variables. Using a log-log regression between the variables, the relationship is

significant too, both for the slope and the intercept. This predicts a medium recruitment for year 2014.

Tables and Figures

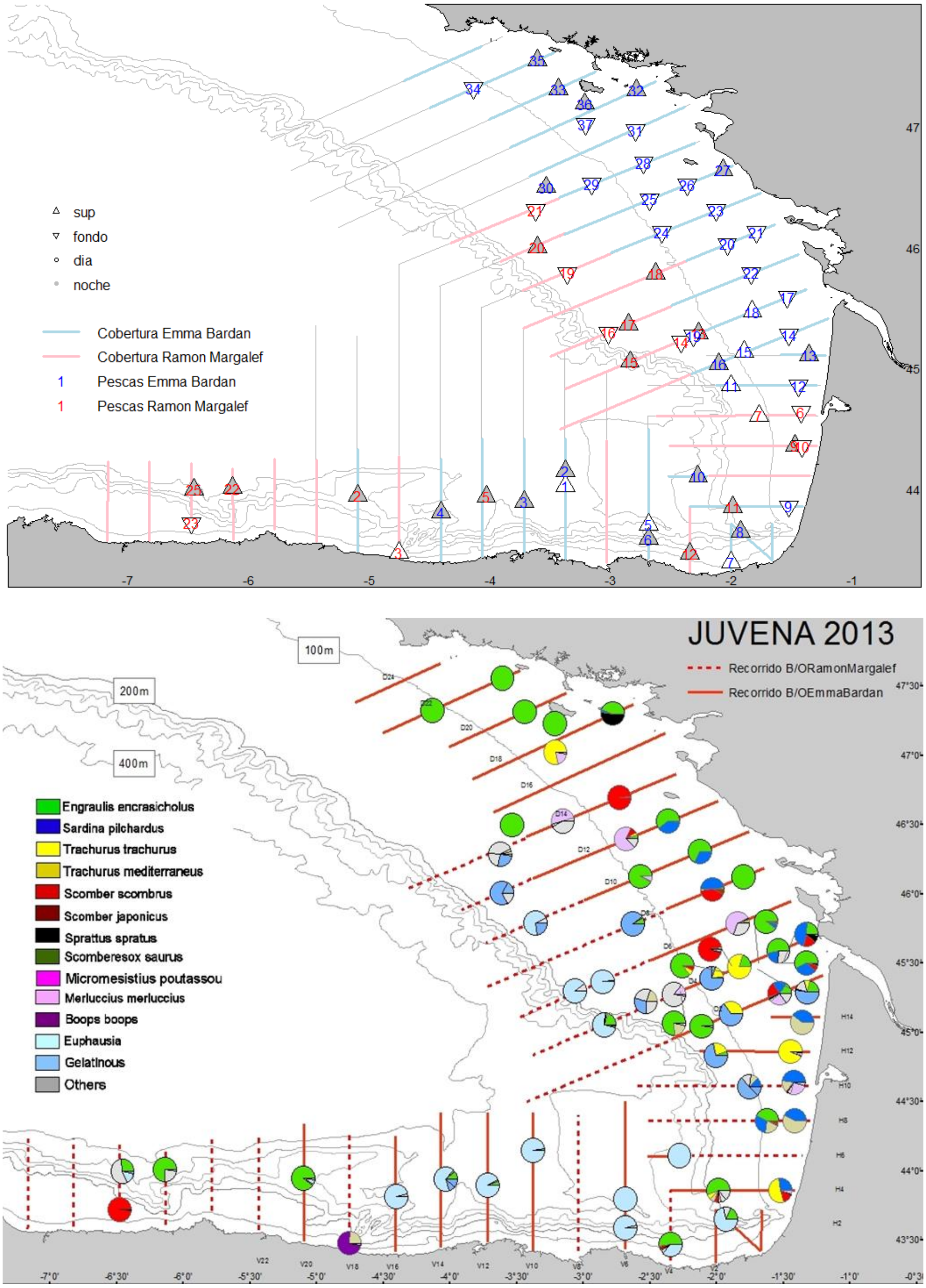


Figure 1. Top panel: position of the fishing stations. Hauls performed by B.O. Emma Bardán (EB) are numbered from 9001 to 9030; the transects are marked with solid lines; hauls performed in the B.O. Ramón Margalef (RM) are numbered from 9201 to 9235 and the transects are marked with dashed lines. Bottom panel: Species composition of the hauls.

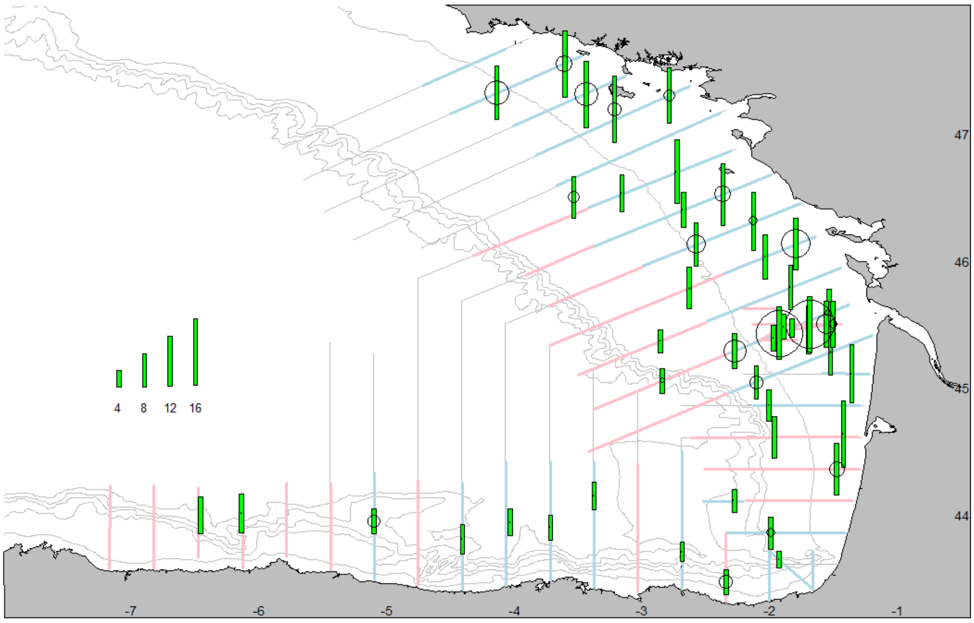


Figure 2: Positive anchovy hauls. The diameter of the circles is proportional to the weight of captured anchovy. The length of the bars is proportional to the mode of the size (standard length) of the captured anchovy.

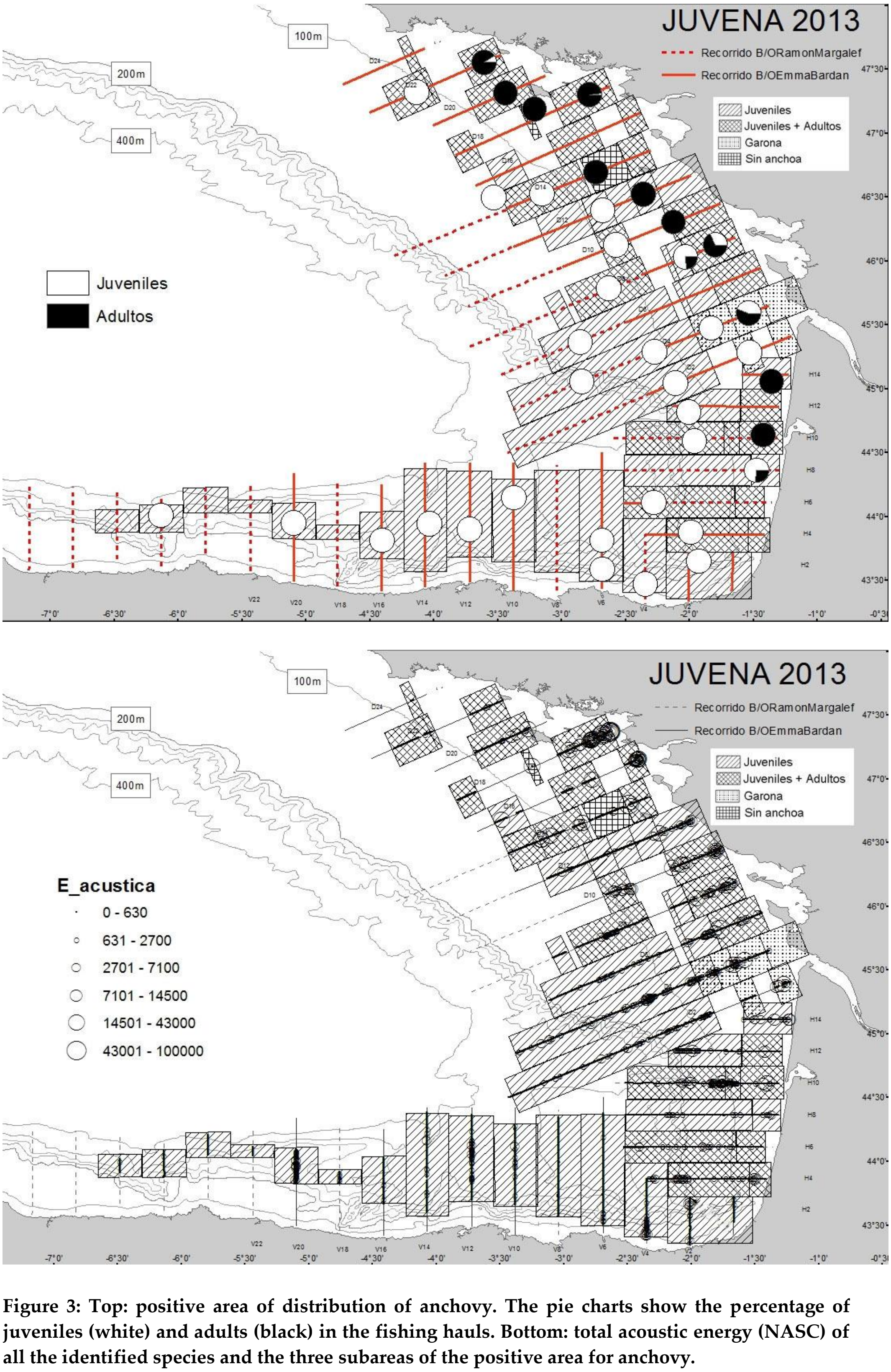
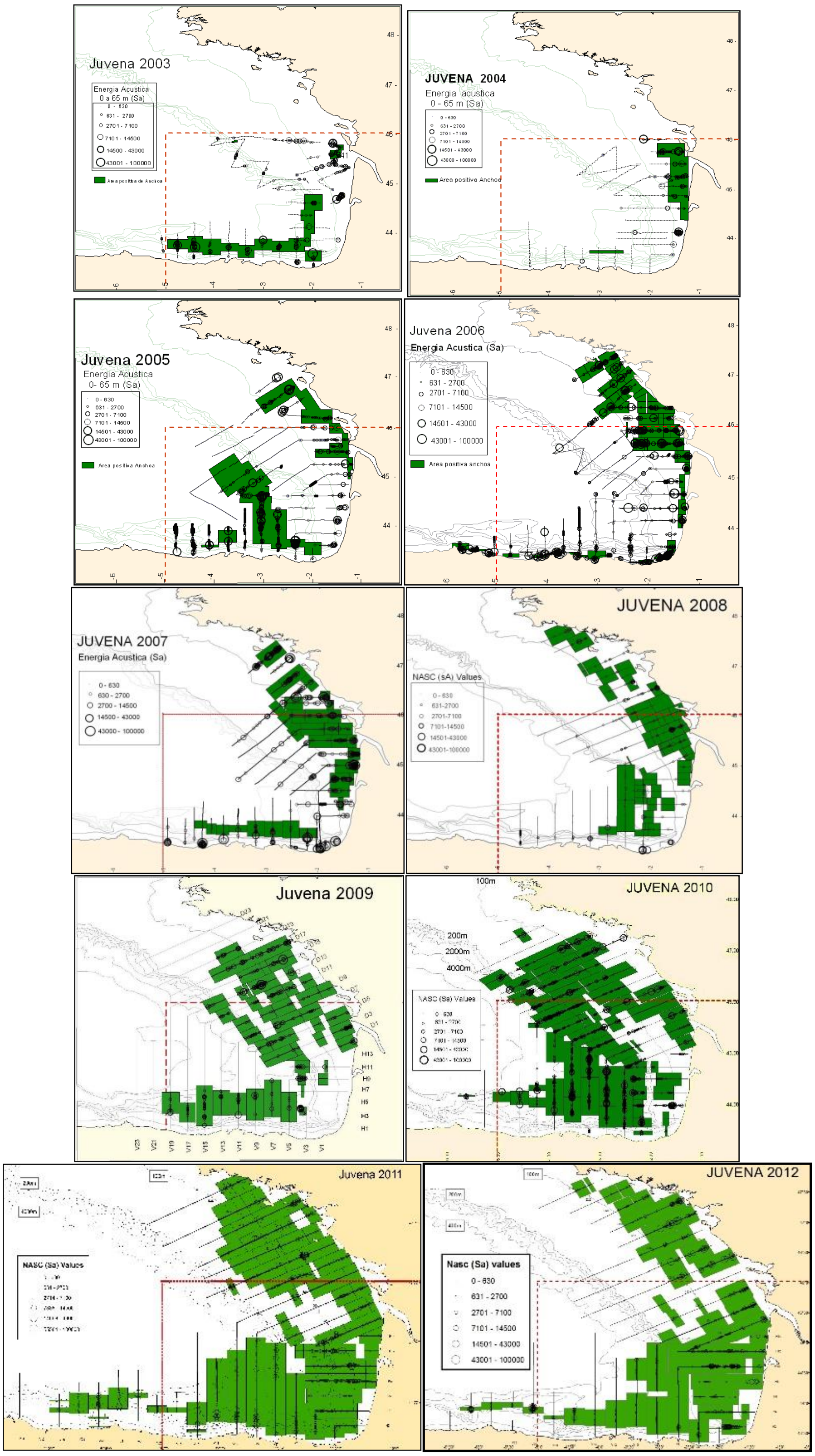


Figure 3: Top: positive area of distribution of anchovy. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls. Bottom: total acoustic energy (NASC) of all the identified species and the three subareas of the positive area for anchovy.



Juvena 2003
Energia Acustica
0 a 65 m (Sa)
JUVENA 2004
Energia acustica
0 - 65 m (Sa)
Juvena 2005
Energia Acustica
0- 65 m (Sa)
Juvena 2006
Energia Acustica (Sa)
0 - 630
631 - 2700
2701 - 7100
7101 - 14500
14501 - 43000
43001 - 100000
Area positiva anchoa
JUVENA 2007
Energia Acustica (Sa)
0 - 630
630 - 2700
2700 - 14500
14500 - 43000
43000 - 100000
JUVENA 2008
NASC (sA) Values
Juvena 2009
JUVENA 2010
100m
200m
2000m
4000m
Juvena 2011
NASC (Sa) Values
JUVENA 2012
Nasc (Sa) values
0 - 630
631 - 2700
2701 - 7100
7101 - 14500
14501 - 43000
43001 - 100000

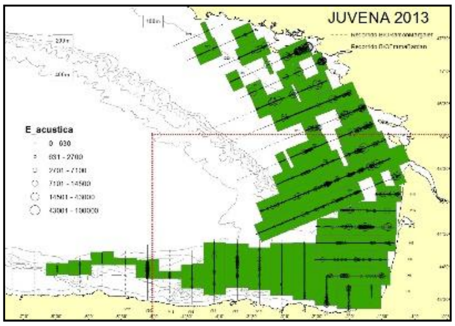


Figure 4: Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the ten years of surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

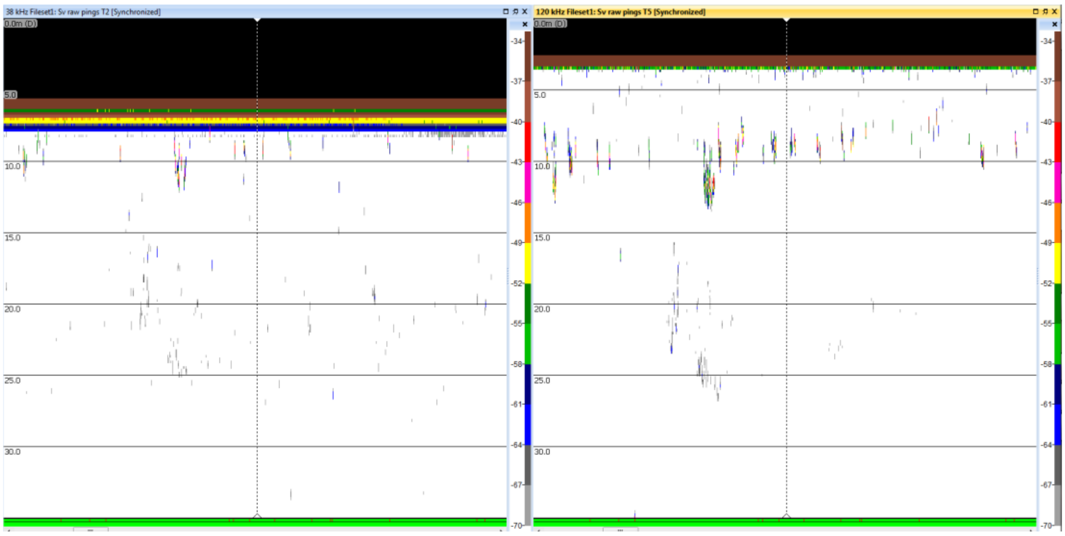


Figure 5. Echogram showing an example of the close-to-surface distribution of juvenile anchovy found in JUVENA 2013. The echogram shows the convenience of having a side-mounted high frequency transducer at 2.5 m depth to increase the sampling capacity close to the surface (right panel) compared to the typical hull mounted low frequency transducer (left panel) for these type of surveys.

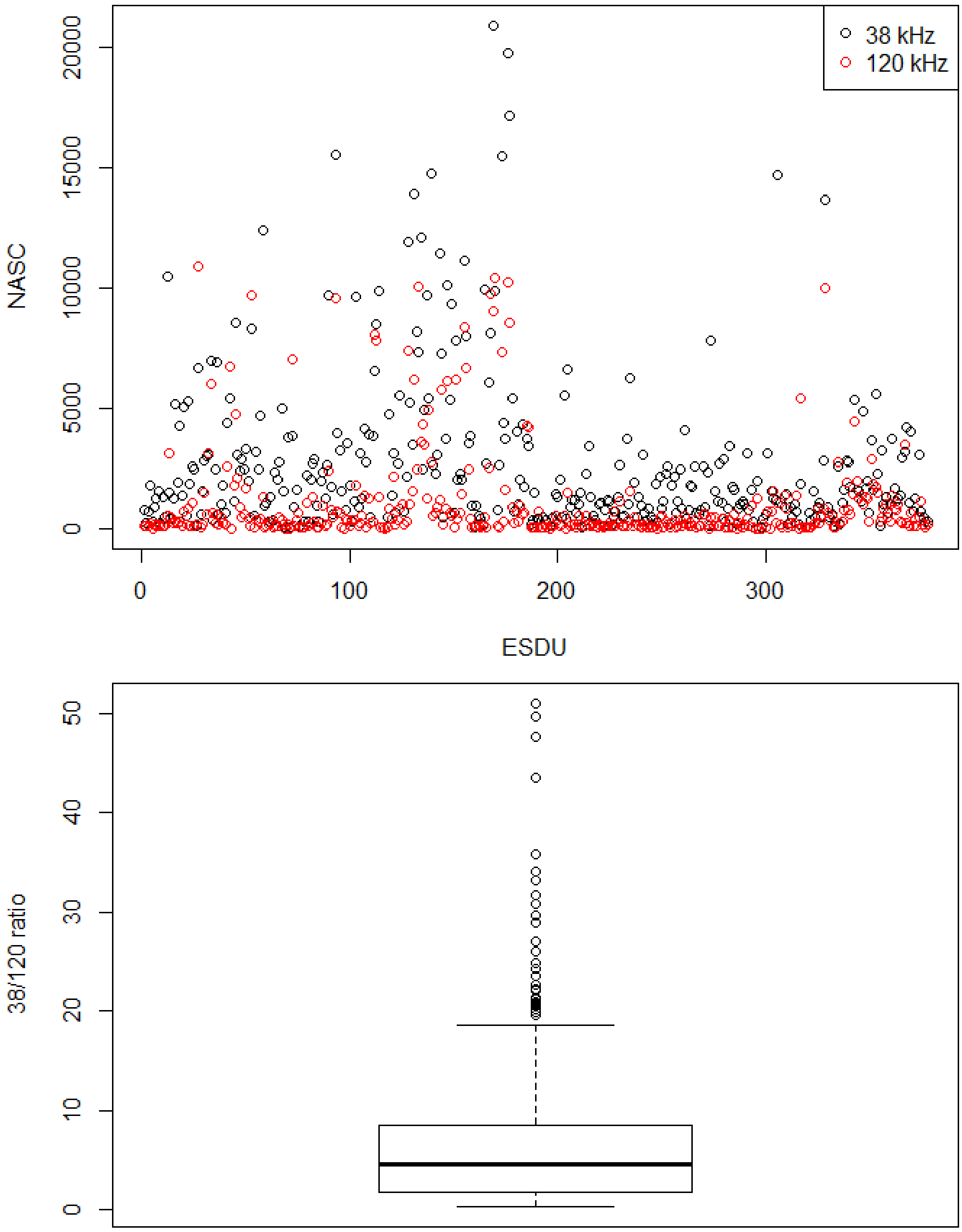


Figure 6. Top panel: Boxplot of the ratio of 38 and 120 kHz echo-integrated acoustic backscattering on the selected NASCs of pure juvenile anchovy aggregations.

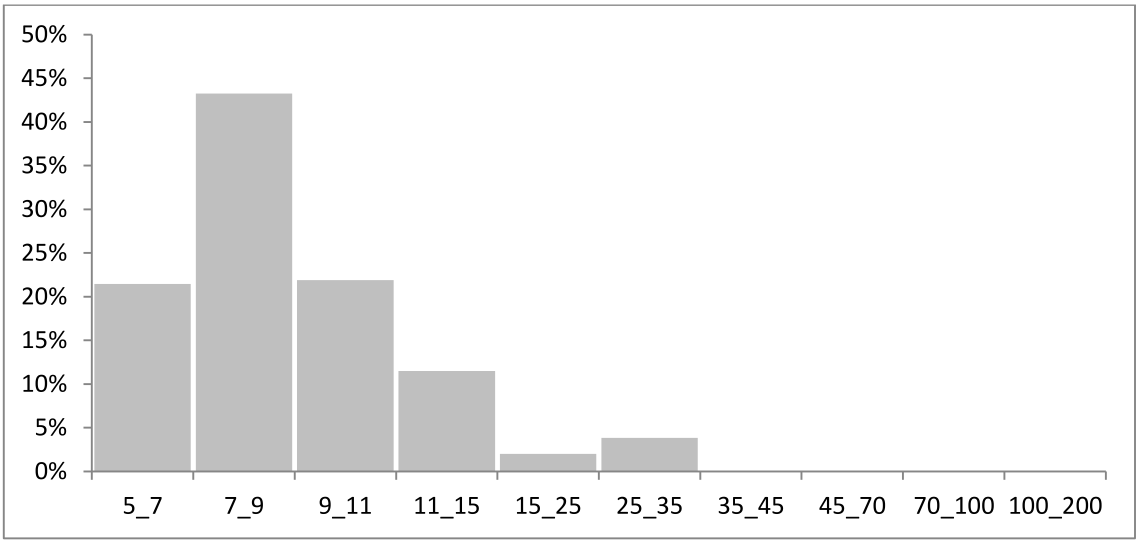


Figure 7. Vertical distribution of NASC in the "Pure juvenile" area, including the acoustic backscattering added by the 120 kHz transducer. In total about 65% of the juvenile anchovy was located in the 5-10 m depth layer in this area.

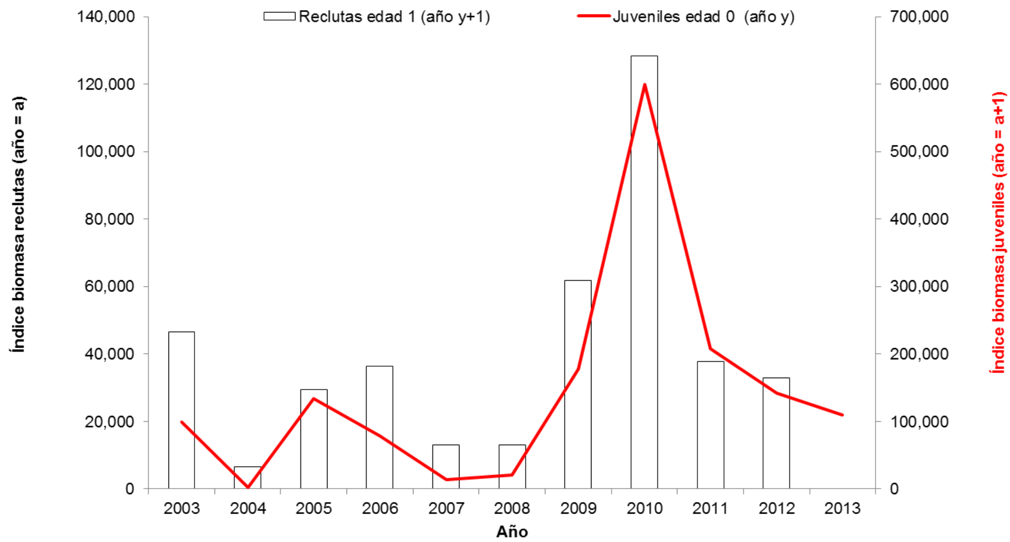


Figure 8: Temporal series of the estimated abundances of anchovy juveniles (blue) against the Bayesian Based Model synthetic estimated abundances of age 1 anchovy next spring (red), based on PELGAS and BIOMAN surveys plus the catches.

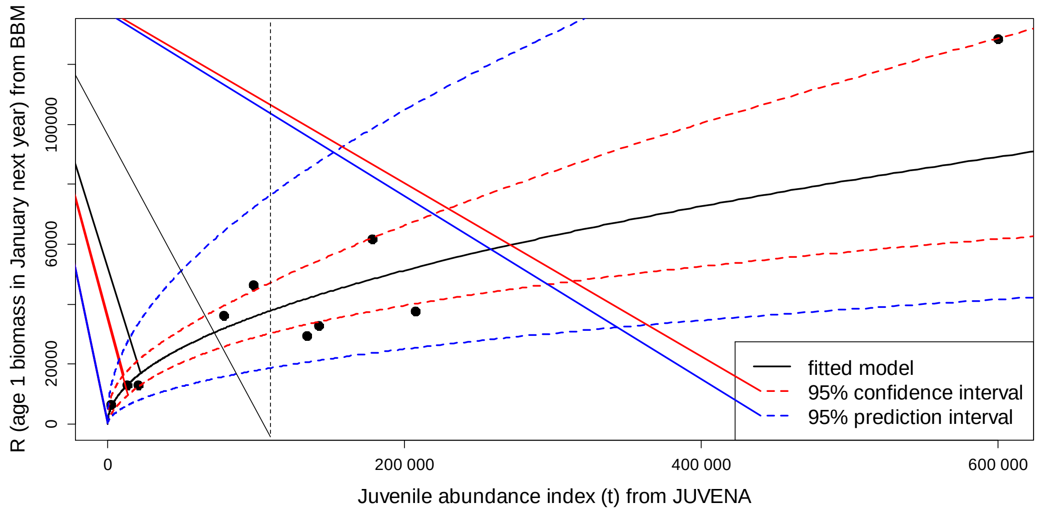


Figure 9: Linear regression between log of the juvenile index and the log of the synthetic recruitment estimate provided by the BBM. The discontinuous line shows the 95 % confidence interval of the linear regression and the discontinuous blue line shows the 95 % confidence interval of each single prediction.

Table 1: Synthesis of the abundance estimation (acoustic index of biomass) for Juvena 2013 for each of the main strata

	NASC (m2/ n.m.2)	Area (n.m.2)	Mean length (cm)	Biomass (t)
Pure Juvenile	151	12824	7.2	90,862.00
Shelf	678	4778	9.3	9,284.63
Garonne	455	588	11.0	5,124.79

Table 2: Synthesis of the abundance estimation (acoustic index of biomass) for the ten years of surveys.

Year	Sampled area (mn2)	Posit area (mn2)	Size juv (cm)	Biom Juvenile (year y)	Recruits age 1 (year y+1)
2003	16 829	3 476	7.9	98 601	46 500
2004	12 736	1 907	10.6	2 406	6 648
2005	25 176	7 790	6.7	134 131	29 530
2006	27 125	7 063	8.1	78 298	36 350
2007	23 116	5 677	5.4	13 121	12 960
2008	23 325	6 895	7.5	20 879	13 010
2009	34 585	12 984	9.1	178 028	61 755
2010	40 500	21 110	8.3	599 990	128 400
2011	37 500	21 063	6.0	207 625	37 650
2012	31 724	14 271	6.4	142 083	32 860
2013	32 500	18 189	7.4	105 271	

Annex 3.2 Acoustic survey carried out from 3 April to 12 May 2014 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega"

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ABSTRACT

The main results of the Portuguese acoustic survey directed to sardine and anchovy estimates in ICES sub area IX show a reduction in sardine biomass. The sardine biomass was the lowest of the time series, following the tendency of the last years. In the Occidental south zone (OCS), the estimated biomass was very low (8 thousand tonnes). Age 1 was predominant in the survey area although the absolute number was low, indicating a low 2013 recruitment. Results on egg density distribution from CUFES sampling are not yet available. Sardine egg distribution from CalVET surveying (for DEPM) taken concomitantly to the acoustic observations (during the night) show a spawning area and densities slightly higher than during the 2011 DEPM survey. The egg distribution in the southern and northwestern shores matched fairly the sardine acoustic energy mapping.

The anchovy abundance suffered a reduction in the West coast area. On the contrary in the South coast, anchovy biomass was higher, in relation to the last survey, in 2013. Age 1 anchovy was predominant in the West coast. Concerning Southern areas (Algarve and Cadis Bay) anchovy otoliths ageing still rise some difficulties due to their less clear structures than in the remaining areas, rising the need for an intercalibration between the Portuguese IPMA and the Spanish IEO-Cadiz readers. This action is being prepared to be undertaken this year and therefore, it was not considered as appropriate the inclusion of these ageing results in this document.

The 2014 spring acoustics survey took place one month later than planned and lasted longer than usual, and was interrupted several times due to bad weather and ship technical problems.

INTRODUCTION

This paper presents the main results of the Portuguese acoustic survey carried out from 3 April to 12 May, on board RV "Noruega". The objectives of the survey were to estimate the spatial distribution and the abundance of sardine (*Sardina pilchardus*) andanchovy (*Engraulis encrasicolus*) by length classes and by age groups, in the surveyed area.All the 69 planned acoustic tracks were performed. Fish egg and larvae distributions, and surface, temperature, salinity and fluorescence were also monitored along the acoustics track. Exceptionally in 2014, part of the DEPM survey was conducted together with the acoustic survey. PNAB/EU Data Collection/DCF Programme supports the acoustics and the DEPM surveys.

MATERIAL AND METHODS

Survey execution and abundance estimation followed the methodologies adopted by the ICES WGACEGG. The survey area, over the shelf until the 200 m isobath, was covered following a parallel grid with a mean distance between transects of 8 nautical miles. Average survey speed was 8 knots and the acoustic signals were integrated over one nautical mile intervals. Echo integration was carried out with a Simrad 38 kHz EK500 scientific echo sounder. The acoustic data was recorded in MOVIES+ (Weill *et al.*, 1993), which was also used to integrate the fish acoustic energy. The echogram bottom was manually corrected prior to the acoustic energy extraction. In the beginning of the survey, an acoustic calibration with a copper sphere was carried out, following the standard procedures (Foote *et al.*, 1981). For presentation purposes and results comparison, the surveyed area was divided, as usual, into 4 sub-areas or regions: OCN (from Caminha to Nazaré), OCS (from Nazaré to Cape S. Vicente), Algarve (from Cape S. Vicente to V. R. Santo António) and Cadiz (from V. R. Santo António to Cape Trafalgar).

To collect the biological data, a pelagic and a bottom trawl were used. The trawl samples were also used to identify the species and to split the acoustic energy by species and by length, within each species. Fishing was carried out according to the echogram information. Nevertheless, due to the presence of fixed commercial fishing gears it was not always possible to make hauls in some areas. Biological sampling of sardine and anchovy was performed in each haul. Sardine and anchovy otoliths were collected and used for age reading and for the production of the Age Length Keys (ALK's). For each species, the abundance (x 1000) by age group and area was estimated from the combination of the ALK and the estimates of abundance at length from the echointegration in each area.

Fish egg and larvae were collected using the CUFES system (335 μm mesh net). The water was pumped, from 3 m depth, underway along the acoustics transects; plankton samples were taken every 3 miles. Concurrently, data on surface temperature, salinity and fluorescence were acquired by the sensors associated to the CUFES sampler and GPS information gathered from the vessel system; compilation was carried out using the EDAS software.

In 2014, exceptionally, due to logistical and technical issues with the research vessel that delayed the DEPM survey, part of the DEPM survey was undertaken simultaneously to the acoustic surveying. The CalVET plankton samples were collected after the daily acoustic observations, and the trawling results used for both surveys.

RESULTS

Trawl hauls

During the survey 44 trawl hauls were performed (Figure 1); 22 of these hauls had sardine sampled and 9 of them had anchovy sampled. Sardine was usually captured together with other pelagic species, being the most abundant chub mackerel (*Scombrus colias*), horse mackerel (*Trachurus trachurus*) and bogue (Boops boops). Off the south coast, some mediterranean horse mackerel (*Trachurus mediterraneus)* and blue jack mackerel (*Trachurus picturatus*) were also found. Anchovy was mainly found off Cadiz Bay, but it was also found, in less quantity, in the west coast, from Matosinhos to Figueira da Foz.

Spatial Distribution

Sardine

As seen in Figure 2, sardine was distributed mainly in the OCN zone and in the South (Algarve and Cadiz Areas). In the Southwest area sardine was not detected and only a few individuals were fished.

Anchovy

Anchovy was distributed mainly in the Algarve and Cadiz zones, sharing the space with other pelagic species (Figure 1). In the remaining area, anchovy was practically absent, with the exception of an area, off the North coast, from Matosinhos to Figueira da Foz.

Abundance estimates

Sardine

The estimated biomass for the Portuguese coast was 57 thousand tonnes corresponding to 2297 million individuals, the lowest value in the survey series (Table 1 and 2). In the OCS area the sardine estimated abundance was very low (8 thousand tonnes; 244 million individuals), and was found mixed with other pelagic species. On the contrary in the OCN area, sardine recovered from the minimum value found in the last year survey; the sardine biomass increased up to 29 thousand tonnes, corresponding to 1697 million individuals. Algarve showed also a recovery in the sardine abundance, with an estimation of 20 thousand tonnes (356 million individuals). The sardine abundance in Cadiz also recovered, in comparison with the 2013 survey (44 thousand tonnes; 1260 million individuals).

Anchovy

The total anchovy biomass estimated was 31 thousand tonnes (2372 x 10^6 individuals), and was mainly found in Cadiz, were the abundance doubled in relation to the last survey. On the contrary, in the OCN zone, the anchovy biomass declined to 2.5 thousand tonnes (156 x 10^6 individuals).

Anchovy with age 1 to 4 years was found in the West coast and the modal age was 1 year.

Sardine LENGTH AND age structure

The sardine length structure in the OCN area was bimodal (9 cm and 15 cm mode), with juveniles (individual total length ≤ 16 cm) contributing with 92%. In the OCS zone the length structure was roughly unimodal; 56 % of sardines in the OCS area were juveniles. In Algarve the sardine length distribution was trimodal with modes at 17cm, 19cm and 21 cm. In this area only 3% of the individuals were considered juveniles. In the Cadiz area, juveniles represented 61% of the sardine abundance estimated for this area (Figure 2).

Age 1 is predominant in all areas. However, the total abundance of age 1 fish (2828 thousand fish), corresponding to the survivors of the 2013 cohort, is 13% of the abundance of the 2004 strong cohort at the same age.

Environmental setting

Surface temperature, salinity and fluorescence and location of the CUFES samples are shown in Figure 7. In 2014, due to weather conditions and logistical constraints the survey was not carried out continuously in one same direction from start to finish, hence some, non synoptic, particular patterns may have been captured. The region of western Algarve was surveyed following days of fairly strong northwesterly and westerly winds (generating colder waters), as surveying progressed to the east, the weather improved (and the shore is less exposed to NW winds) and surface waters were warmer; the shallower shelf waters of the inner Cadiz Bay were warmer and with higher phytoplankton density. The southwestern region, up to Lisbon, was also surveyed during very mild atmospheric conditions. In contrast, the northwestern shelf was occupied during a period of intermittent northerly wind events that induced upwelling, lowering the temperature in the coastal strip; associated to these events higher phytoplankton production was detected and large volumes of zooplankton were observed. Globally the water temperatures were within the range observed for this period of the year, nonetheless the southern coast water temperatures were lower than during other recent spring surveys.

Egg distribution

The ichthyoplankton results from CUFES sampling are not yet available since priority had to be directed at processing the sardine DEPM samples (CalVET) that were in 2014 collected much later than usual. Sardine egg distribution results from one of the double CalVET nets are shown in figure 6. The CalVET observations available at present include the southern and southwestern regions covered during the same period as the acoustic surveying (4-20, 25-26 Apr) while the results for the northwestern region were obtained earlier, during the second half of March (15-21), when the first leg of the DEPM took place, and therefore not contemporaneous to acoustics. Despite the time lag between surveying in the northern region, sardine eggs and adults were mainly observed in the area between Cabo Mondego and river Douro, where the distributions overlapped fairly well. Also, south of Cabo Carvoeiro and in the southern coast, Algarve and Cadiz Bay, eggs and fish schools occurred in parallel; the exception occurred in the southwestern region where sardine eggs are regularly observed but sardine schools rarely spotted. Sardine egg densities and spawning area (CalVET samples) were slightly higher than during the previous DEPM survey, in 2011, but still there was a large area of the northern platform where no eggs were collected.

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Tables and Figures

Table 1 – Sardine: Abundance (million) in each zone, Portugal and total area, for the acoustic surveys carried out between April 2005 and April 2014.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR05ABR	16900	5900	1200	1229	24000	25229
SAR05NOV	16622	863	333	-	17818	-
SAR06ABR	9514	2856	716	3399	13086	16485
SAR06NOV	4577	1602	635	1317	6814	8131
PELAGO07	4181	1924	690	2077	6795	8873
SAR07NOV	4634	2141**	180***	2733	6955	9688
PELAGO08	3303	1493	472	1763	5268	7031
SAR08OUT	3962	555	9	3529	4526	8055
PELAGO09	5095	2589	275	1570	7959	9529
PELAGO10	4481	922	530	2928	5933	8861
PELAGO11	1889	397	465	71	2751	2821
PELAGO13	255	1575	197	493	3978	4471
PELAGO14	1697	244	356	1260	2297	3557

**** the area between Capes Espichel and S. Vicente was not covered.**

***** part of Algarve was not covered**

Table 2 – Sardine: Biomass (thousand tonnes) in each zone, Portugal and total area, for the acoustic surveys carried out between April 2005 and April 2014.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR05ABR	286	199	62	40	547	587
SAR05NOV	458	34	12	-	504	-
SAR06ABR	370	138	40	89	548	637
SAR06NOV	257	69	27	58	353	411
PELAGO07	215	89	40	107	344	452
SAR07NOV	258	114**	11***	133	384	517
PELAGO08	170	13	26	35	209	244
SAR08OUT	121	36	0.6	149	158	307
PELAGO09	112	84	14	84	210	294
PELAGO10	125	43	11	26	179	205
PELAGO11	90	15	20	2	125	127
PELAGO13	9	72	9	21	90	112
PELAGO14	29	8	20	44	57	101

**** the area between Capes Espichel and S. Vicente was not covered.**

***** part of Algarve was not covered**

Table 3 – Anchovy: estimated abundance (billion) for the West coast, South coast and total area, for the acoustic surveys carried out between April 2005 and April 2014.

Survey	West	South	TOTAL
April 2014	156	2216	2372
April 2013	251	896	1147
April 2011	1558	0	1558
April 2010	62	963	1025
April 2009	127	2069	2196
April 2008	321	2032	2353
April 2007	103	3144	3247
April 2006	0	2247	2247
April 2005	59	1306	1365

Table 4 – Anchovy: estimated biomass (tonnes) for the West coast, South coast and total area, for the acoustic surveys carried out between April 2005 and April 2014.

campanha	Oeste	Sul	TOTAL
April 2014	2459	28408	30867
April 2013	3955	12700	16655
April 2011	27050	0	27050
April 2010	1188	7395	8583
April 2009	2000	24800	26800
April 2008	5500	34200	39700
April 2007	1945	38020	39965
April 2006	0	24082	24082
April 2005	1062	14041	15103

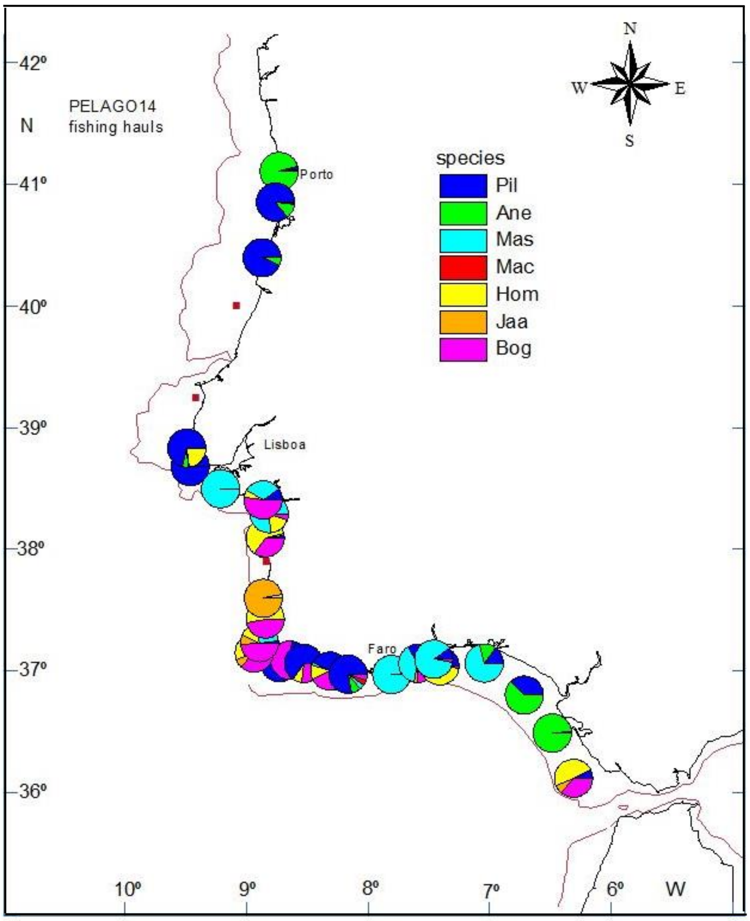

Figure 1 - Fishing trawl location and haul species composition (in number).

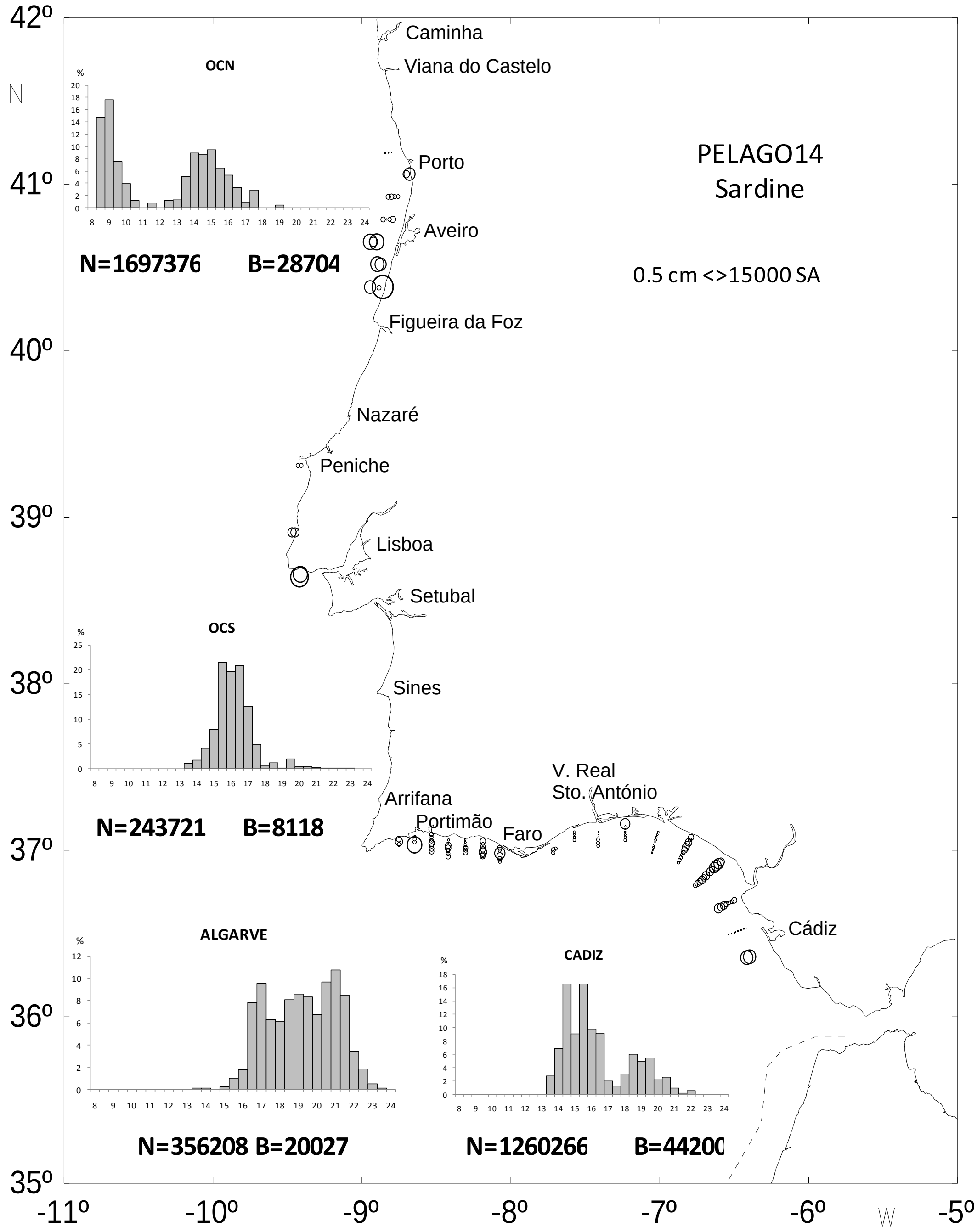

Figure 3 – Sardine biomass evolution for each zone, along the acoustic spring survey series, since 2005.

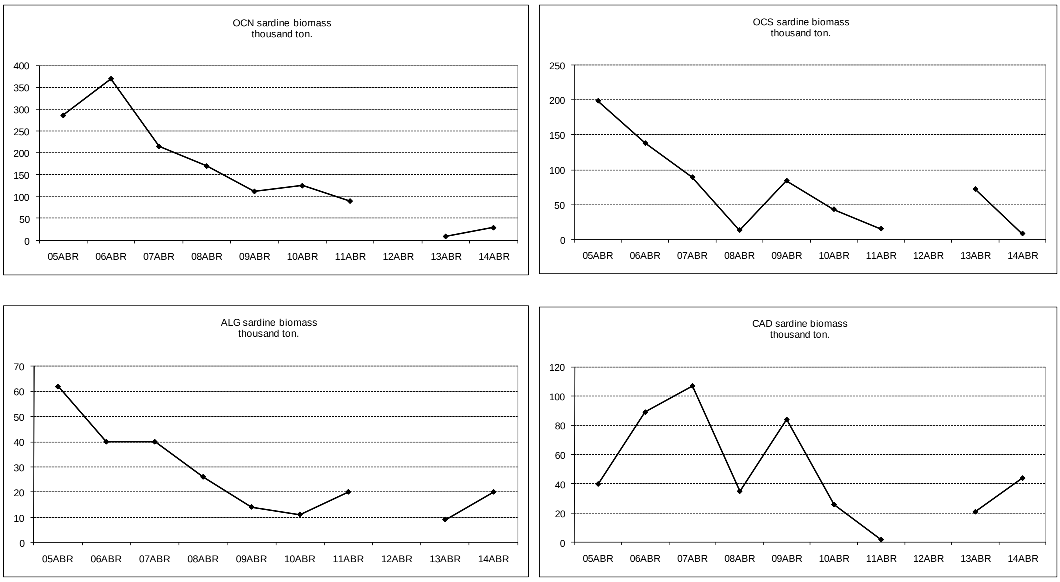

Figure 2 – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m²/nm²). Sardine abundance and length structure for each zone.

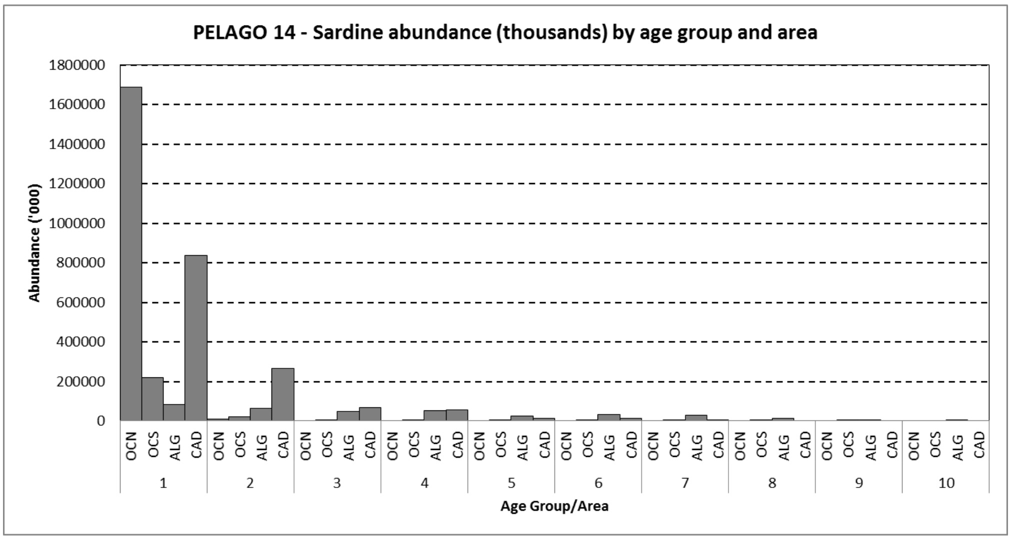

Figure 4 – Sardine abundance (x1000) per age group, for each zone.

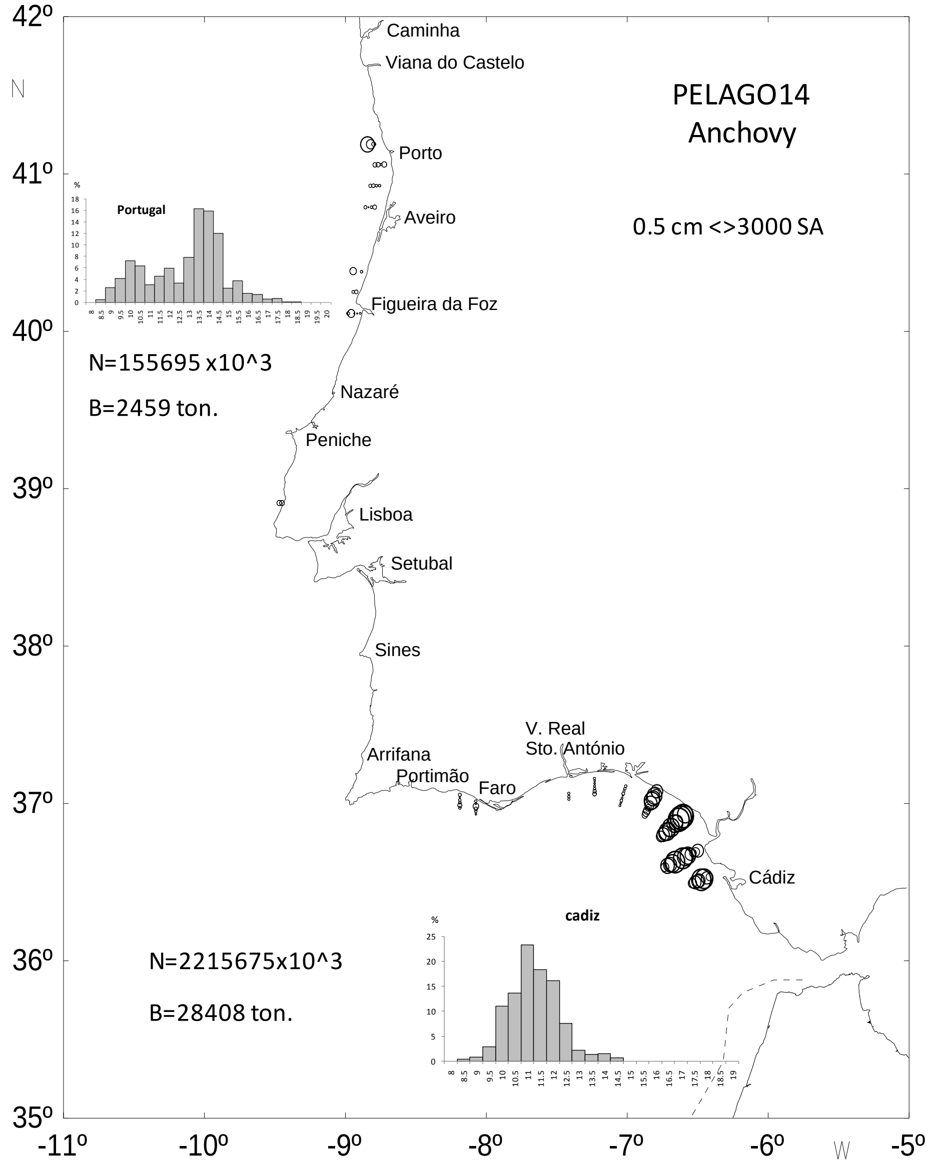

Figure 5 – Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m²/nm²). Anchovy abundance and length structure for West and South areas.

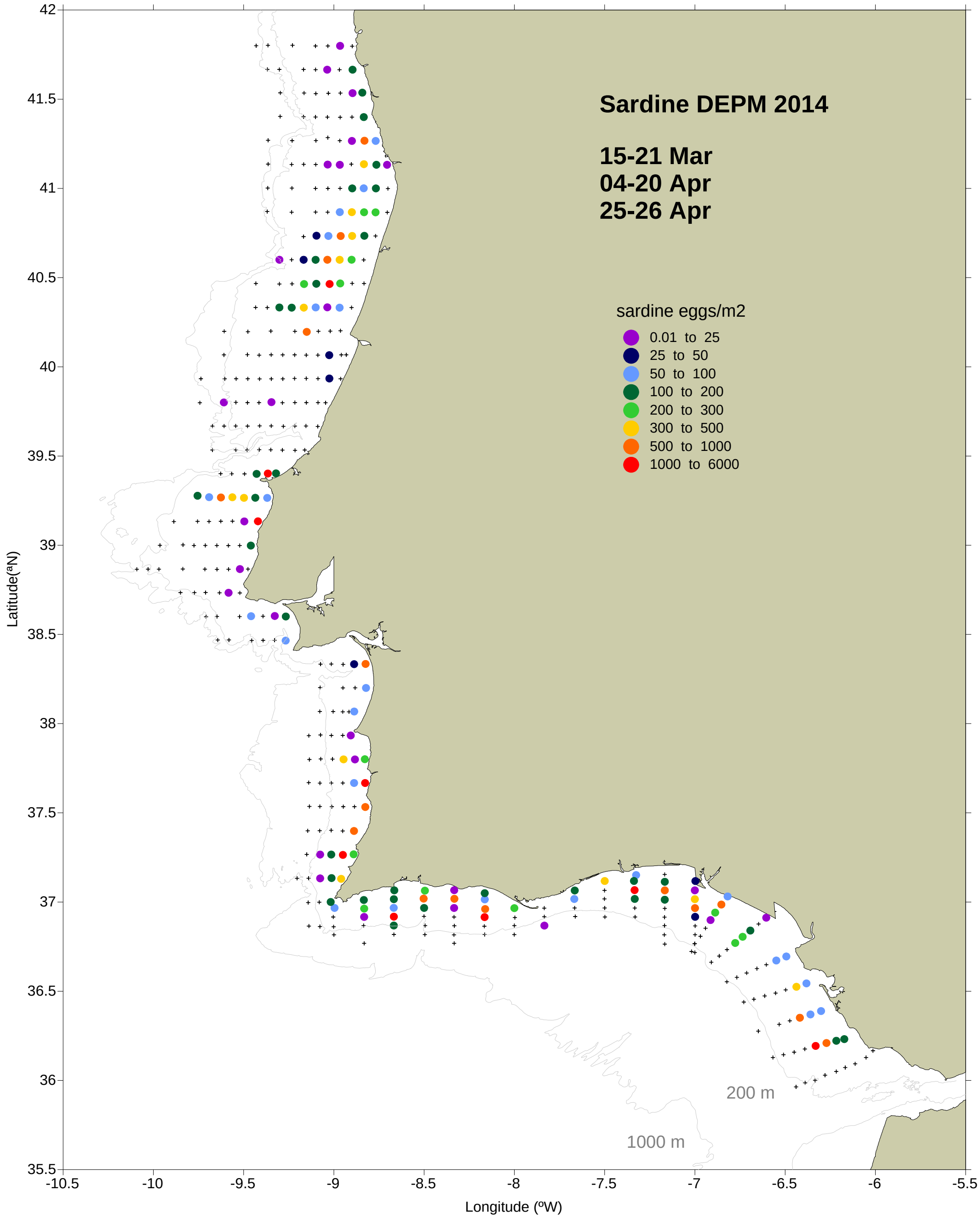

Figura 6. CalVET samples locations and sardine egg density (m^{-2}) distribution (from 1 of the 2 nets) during the period 15-21 March + 4-20, 25-26 April.

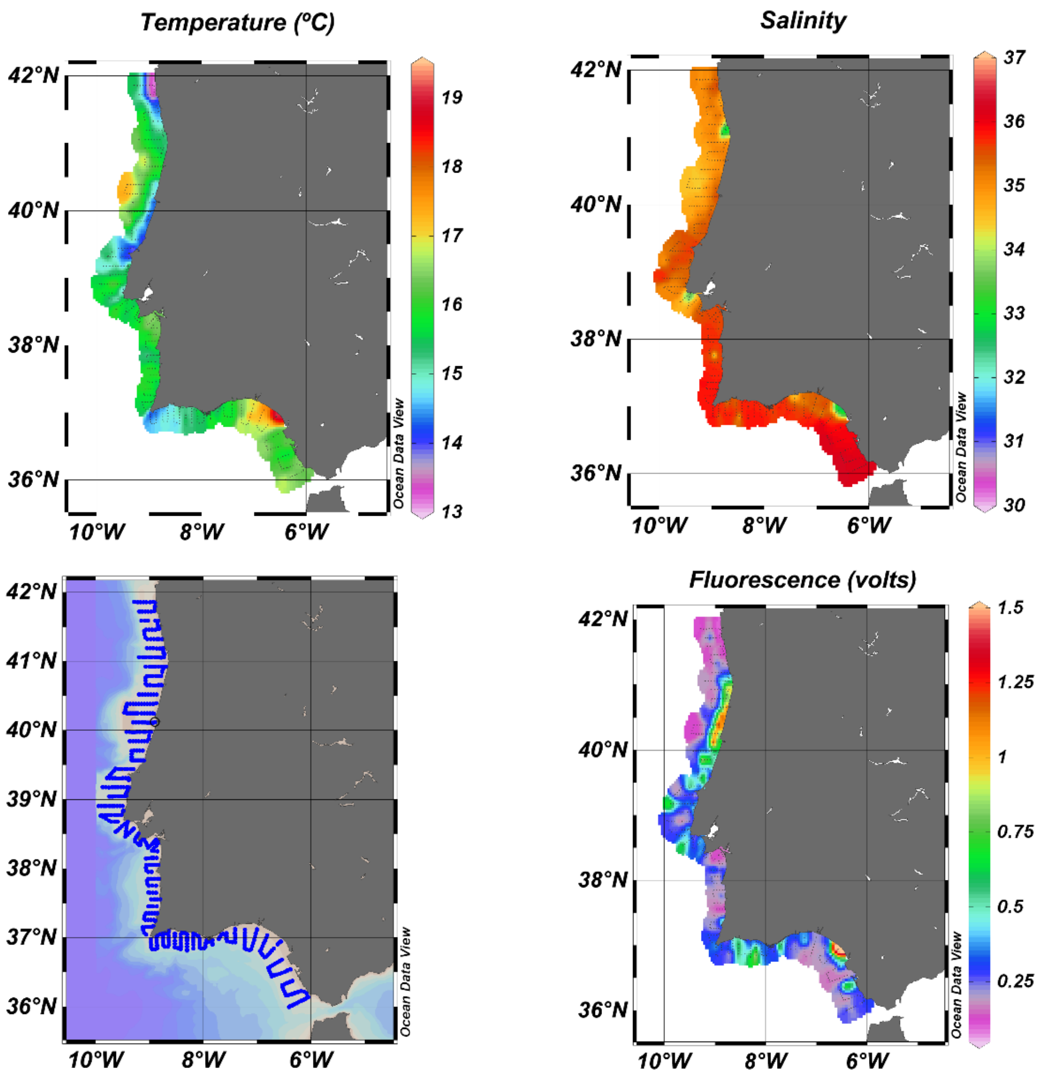

Figure. 7. Surface temperature (top left), salinity (top right), fluorescence (bottom right) distributions and zooplankton samples location (bottom left); information collected by the CUFES system and associated CTF sensors, (4-20, 25-26 April, 3-12 May)

Annex 3.3 Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECO-CADIZ 0813* Spanish survey (August 2013)

Working document presented in the:ICES Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). Copenhagen, Denmark, 20-25 June 2014.

ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). Vigo, Spain, 17-21 November 2014.

Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the *ECOCADIZ 0813* Spanish survey (August 2013).

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ABSTRACT

The present working document summarises the main results from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 2nd and 13th August 2013 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the RV "Cornide de Saavedra". The survey dates were somewhat delayed in relation to the usual ones and to the anchovy (*Engraulis encrasicolus*) peak spawning as well. Abundance and biomass estimates are given for all the mid-sized and small pelagic fish species susceptible of being acoustically assessed according to their occurrence and abundance levels in the study area. The distribution of these species is also shown from the mapping of their back-scattering energies. The bulk of the anchovy population was concentrated in the Spanish shelf, with a residual nucleus to the west of Cape Santa Maria. A delay of the usual survey dates may be the reason of a higher relative importance of smaller anchovies in the population as a probable consequence of the incorporation of the first waves of recently recruited juveniles to the adult population. The total biomass estimated for anchovy was 8.5 thousand tonnes (609 million fish), the lowest estimate in its series. Sardine showed a distribution pattern almost complementary to that described for anchovy, with higher densities occurring over the inner-middle shelf of both extremes of the surveyed area, mainly west to Cape Santa Maria, and in shallower waters than anchovy. Sardine yielded a total of 9.7 thousand tonnes (232 million fish). The 2013 sardine estimate was also the lowest one in its series and corroborates a clear recent decline in the population which has also been evidenced by the PELAGO surveys. Chub mackerel was present all over the surveyed area although showed a more "oceanic" distribution in the westernmost waters. The species was the most important in terms of assessed biomass, rendering estimates of 31.3 thousand tonnes (333 million fish). Acoustic estimates for jack and horse-mackerel species (*Trachurus spp*.), and bogue (Boops boops) are also given in the WD. No acoustic estimates either for mackerel S.

scombrus or round sardinella (*Sardinella aurita*) were computed because their incidental occurrence in the study area during the survey.

INTRODUCTION

ECOCADIZ surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision IXa South (Algarve and Gulf of Cadiz, between 20-200 m depth) under the "pelagic ecosystem survey" approach onboard RV *Cornide de Saavedra*. This series started in 2004 with the *BOCADEVA 0604* pilot acoustic - anchovy DEPM survey. The following surveys within this new series (named *ECOCADIZ* since 2006 onwards) are planned to be routinely performed on a yearly basis, although the series, because of the available ship time, has shown some gaps in those years coinciding with the conduction of the (initially triennial) anchovy DEPM survey (the true *BOCADEVA* series, which first survey started in 2005).

Results from the *ECOCADIZ* series are routinely reported to ICES Expert Groups on both stock assessment (formerly in WGMHSA, WGANC, WGANSA, at present in WGHANSA) and acoustic and egg surveys (WGACEGG).

The present Working Document summarises the main results from the *ECOCADIZ 0813* survey. After conducting this survey the RV *Cornide de Saavedra* was definitively out of service.

MATERIAL AND METHODS

The *ECOCADIZ 0813* survey was carried out between 2nd and 13th August 2014 on board the Spanish RV *Cornide de Saavedra* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (Figure 1).

Echo-integration was carried out with a *Simrad™EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was between 7.5 - 8 knots (see below) and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.*, ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *MEDIAS07 2013* acoustic survey, a survey conducted in the Spanish Mediterranean waters just before the *ECOCADIZ* one, following the standard procedures (Foote *et al*., 1987).

Vessel self-noise tests and the revision/calibration of the *Scanmar* depth sensor were carried out on 2nd August after the finalization of the acoustic sampling and fishing hauls. Vessel self-noise tests were carried out with only one of the two R/V engines, since it was agreed to conduct the survey with only one engine in order to save fuel. With only one engine the maximum speed achievable by this RV is of 8.6 knots (with good weather and sea conditions), or even decrease up to 7 knots with bad sea conditions.

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations were opportunistic, according to the echogram information, and they were carried out using a ca. 16 m-mean vertical opening pelagic trawl (*Tuneado* gear) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Length frequency distributions (LFD) by 0.5 cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	b20
Sardine (Sardina pilchardus)	-72.6
Round sardinella (Sardinella aurita)	-72.6
Anchovy (Engraulis encrasicolus)	-72.6
Chub mackerel (Scomber japonicus)	-68.7
Mackerel (S. scombrus)	-84.9
Horse mackerel (Trachurus trachurus)	-68.7
Mediterranean horse-mackerel (T. mediterraneus)	-68.7
Blue jack mackerel (T. picturatus)	-68.7
Bogue (Boops boops)	-67.0

Trawl samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

A *Continuous Underway Fish Egg Sampler* (CUFES), a *Sea-bird Electronics™ SBE 21 SEACAT* thermo-salinometer and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously monitor the anchovy egg abundance and to collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence). Vertical profiles of hydrographical variables were also recorded by night from 146CTD stations by using a *Sea-bird Electronics™ SBE 911+SEACAT* profiler (Figure 2). Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

ECOCADIZ 0813 was also utilized this year as observational platform for the IFAPA (Instituto de Investigación y Formación Agraria y Pesquera)/IEO research project entitled *Ecology of the early stages of the anchovy life-cycle: the role of the coupled Guadalquivir estuary-coastal zone of influence in the species' recruitment process (ECOBOGUE)*. Thus, an *ad hoc* sampling grid of 4 stations including Carousel-CTD-LDCP, Bongo 40 and suprabenthic sledge samplings and 4 opportunistic Bongo 90 hauls were carried out in order to characterize the ichthyoplankton, mesozooplankton and suprabenthos species assemblages in the eastern sector of the study area (coastal area surrounding the Guadalquivir river mouth) and their relationships with environmental conditions (Figure 3).

RESULTS

Vessel self-noise tests

Results of the vessel self-noise tests (expressed in dB) are shown in the following enclosed table and revealed that the use of a single engine generated greater amount of self-noise than if the two vessel's engines were used. In any case, the tests' results advised to perform the acoustic sampling with a 40° blade pitch, equivalent to a speed of 8.6 knots.

Tests/Working freq.	18 kHz	38 kHz	70 kHz	120 kHz	200 kHz	Speed
Propeller: disengaged	-152	-158	-161	-163	-167	-
Propeller: engaged	-122	-144	-159	-165	-165	0.8
Blade pitch: 10°	-124	-144	-157	-163	-166	1.2
Blade pitch: 20°	-106	-119	-135	-146	-156	5.0
Blade pitch 30°	-110	-124	-140	-155	-163	7.0
Blade pitch: 40°	-115	-130	-143	-158	-164	8.6
Tacking to port	-115	-128	-145	-157	-165	-
Tacking to starboard	-116	-128	-145	-153	-164	-

Acoustic sampling

The acoustic sampling was carried out during the periods of 02 – 05 and 07 – 11 August (Table 1). The acoustic sampling started in the coastal end of the transect RA01 on 02 August towards the RA21. The acoustic sampling stopped on 06 August in order to dedicate that day to the sampling tasks of the *ECOBOGUE* project. Until 09 August the acoustic sampling started every day at 05:30 UTC. From then on (in the westernmost Algarve waters) the acoustic sampling started half an hour later. The whole 21-transect sampling grid was sampled. The foreseen start of transect RA09 by the coastal end had to be slightly displaced in order to avoid some tugs manoeuvring in such shallow waters. As commented above, in order to save fuel, the acoustic sampling was carried out with only one of the two RV engines. Such a limitation entailed navigation and acoustic sampling speeds of about 7,5 – 8 knots as an average, speeds quite lower than those ones considered as standard (10 knots). Lower speeds than the standard one negatively impacted in the progress of both the acoustic sampling and mainly in the number of fishing hauls per day (see below).

Groundtruthing hauls

Seventeen (17) fishing operations, 16 of them valid according to a correct gear performance and resulting catches, were carried out (Table 1, Figure 4). Such a number of fishing hauls was nearly the half of hauls that are usually carried out during a standard survey.

As usual in previous surveys, some fishing hauls were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way the mixing of different size compositions (*i.e.*, bi-, multi-modality of length frequency distributions) was avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf. Given that all of these situations were not very uncommon in the sampled area, 31% of valid hauls (5 hauls) were conducted over isobath.

Because of the echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 36-146 m.

During the survey were captured 1 species of Chondrichthyans, 38 species of Osteichthyes and 5 species of Cephalopods. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 5**). Chub mackerel and blue jack mackerel (13 hauls), and anchovy and horse-mackerel (12 hauls) stood especially out from the set of small and mid-sized pelagic fish species. They were followed by mackerel (11 hauls), bogue (10), sardine (9), and Mediterranean horse mackerel (6 hauls).

Species	# of positive fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	14	88	150	1364
Scomber colias	13	81	2862	28981
Trachurus picturatus	13	81	279	5258
Engraulis encrasicolus	12	75	1324	65335
Trachurus trachurus	12	75	496	10360
Scomber scombrus	11	69	82	471
Boops boops	10	63	93	941
Spondyliosoma cantharus	10	63	10	87
Loligo media	10	63	6	1325
Sardina pilchardus	9	56	362	10122
Loligo vulgaris	7	44	1	28
Trachurus mediterraneus	6	38	340	1921

For the purposes of the acoustic assessment, anchovy, sardine, round sardinella, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g.*, flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*". According to the above premises, during the survey were captured a total of 6 092 kg and 158 thousand fish (Table 2). 47% of the total fished biomass corresponded to chub mackerel, 22% to anchovy, 8% to horse mackerel, 6% to sardine and Mediterranean horse mackerel, and 5% to blue jack-mackerel. The most abundant species in groundtruthing trawl hauls was anchovy (42%) followed by a long distance by chub mackerel (19%), horse-mackerel and sardine (7% each). Total catches and yields of Mediterranean horse-mackerel and blue jack mackerel were very low, with those of bogue, mackerel and round sardinella being almost incidental. The species composition, in terms of percentages in number, in each valid fish station is shown in Figure 5.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 320 n.mi. (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 206 n.mi. (11 transects) were sampled in Spanish waters, and 114 n.mi. (10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

SA (m2 nmi-2)	Total spp.	Sardine	Round sardinella	Anchovy	Mackerel	Chub mack.	Horse-mack.	Medit. h-mack.	Blue jack-mack.	Bogue
Total Area	89375	6062	6	10168	16	38545	16084	4832	5689	7973
(%)	(100.0)	(6.8)	(0.0)	(11.4)	(0.0)	(43.1)	(18.0)	(5.4)	(6.4)	(8.9)
Portugal	38858	3752	0	1194	5	3502	13950	0	3546	7149
(%)	(43.5)	(61.9)	(0.0)	(11.7)	(34.1)	(24.0)	(86.7)	(0.0)	(62.3)	(89.7)
Spain	50517	2310	6	8974	10	29284	2133	4832	2143	824
(%)	(56.5)	(38.1)	(100.0)	(88.3)	(65.9)	(76.0)	(13.3)	(100.0)	(37.7)	(10.3)

For this "pelagic fish assemblage" has been estimated a total of 89 375 m^2 nmi^{-2}. Portuguese waters accounted for 43.5% of this total back-scattering energy and the Spanish waters the remaining 56.5%. However, given that the Portuguese sampled ESDUs were almost the half of the Spanish ones, the (weighted-) relative importance of the Portuguese area (*i.e.*, its density of "pelagic fish") is actually much higher. The mapping of the total back-scattering energy is shown in Figure 6. By species, chub mackerel accounted for 43.1% of this total back-scattering energy, a relative importance corroborated by its high frequency of occurrence in hauls. Horse mackerel is the following species in importance with 18.0%. Anchovy only contributed with 11.4%, followed by bogue with 8.9%, sardine with 6.8%, blue jack mackerel with 6.4%, Mediterranean horse mackerel with 5.4%, and negligible energetic contributions by mackerel and round sardinella.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: round sardinella, Mediterranean horse mackerel, anchovy, mackerel and chub mackerel seem to show greater densities in the Spanish waters, whereas bogue, horse mackerel, blue jack mackerel and sardine may be considered as typically "Portuguese species" in this survey.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel and bogue.

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 11**. The back-scattering energy attributed to this species, positive valid fishing stations with anchovy and the coherent strata considered for the acoustic estimation are shown in Figure 6. The estimated abundance and biomass by size and age class are given in Tables 3 and 4 and Figures 8 and 9.

The bulk of the anchovy population was concentrated in the central part of the surveyed area which corresponds to the Spanish shelf. In this area the species distributed all over the shelf showing spots of high density at different depths. A residual nucleus was also recorded to the west of Cape Santa Maria, in waters with a bathymetry between 75 and 108 m depth (Figure 6).

The size class range of the assessed population varied between the 7.5 and 18 cm size classes, with two modal classes at 11 and 14.5 cm. As usual, largest anchovies occurred in the westernmost waters whereas the smallest ones were observed in the central coastal part of the sampled area, coinciding with the location of the main recruitment area close to the Guadalquivir river mouth. The delay of the survey dates in relation to the rest of surveys in the series may be the reason of a higher relative importance of the first modal component in the population, as also happened in the previous survey (in 2010). This fact is a probable consequence of the incorporation of the first waves of recently recruited juveniles to the adult population that usually occur in mid-late summer (Tables 3 and 4, Figures 7 and 8).

Six sectors have been differentiated according to the S_A value distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous stratum and total area are shown in Tables 3 and 4, and Figures 7 and 8. A total of 8487 t and 609 millions of fish have been estimated for this species for the whole surveyed area.

A total of 107 stations were sampled by CUFES from which 68 stations (64%) were positive with anchovy eggs. These positive stations were distributed all over the acoustic transects but the easternmost one and rendered a total of 10 005 anchovy eggs. The spatial distribution of anchovy eggs resembled to the above described for the adult population. Total, maximum and mean anchovy egg densities were estimated at 769, 130 and 7 eggs m^{-3} respectively. Greater anchovy egg densities were mainly observed in the inner-middle shelf waters located between Cadiz Bay and Tinto-Odiel rivers mouths. However, the highest egg density (130 eggs m^{-3}) was recorded in a station with a bathymetry of 87.6 m depth located in the closest transect to the Portuguese-Spanish border (Figure 9). In that station were collected a total of 2014 eggs, accounting for 20% of the total of the collected anchovy eggs during the survey, with practically all of them belonging to the *no embryo* stage.

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 11**. The back-scattering energy attributed to this species, positive valid fishing stations with sardine and the coherent strata considered for the acoustic estimation are shown in Figure 10. Estimated abundance and biomass by size class are given in Table 5 and Figure 11.

Sardine preferably occurred over the inner-middle shelf of both extremes of the surveyed area, in shallower waters than anchovy, and curiously in those waters where anchovy was absent, resulting in a distribution pattern almost complementary to the one deployed by this last species (Figure 10). In any case, higher sardine densities were more constantly recorded in the waters west to Cape Santa Maria.

The size range of the assessed population ranged between 11 and 21.5 cm size classes, with two modal classes, a secondary one at 13 and the most important at 17 cm. As also evidenced in previous surveys, the size composition of the surveyed population evidences that the central coastal area might correspond with a recruitment area for the species (Table 5, Figure 11).

Five size-based homogeneous sectors were delimited for the acoustic assessment. The acoustic estimates by homogeneous stratum and total area are shown in Table 5 and Figure 11. Sardine was the third most important species in terms of both biomass and abundance: 9670 t and 232 millions of fish have been estimated for this species for the whole surveyed area.

Round sardinella and Mackerel

The occurrence of round sardinella during the survey was incidental and restricted to a very small coastal area between Rota and Chipiona, in the eastern waters of the Gulf (Figure 12). Acoustic integration for the species was considered negligible and therefore the species was not acoustically assessed. The same also applies to mackerel, although in this case the species showed a wider distribution, occurring in all transects but the two easternmost ones, with the species distributing over the middle and outer shelf waters of the Gulf (Figure 12).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in Table 11. The back-scattering energy attributed to this species, positive valid fishing stations with chub mackerel and the coherent strata considered for the acoustic estimation are shown in Figure 13. Estimated abundance and biomass by size class are given in Table 6 and Figure 14.

Chub mackerel was present all over the surveyed area although in the westernmost waters showed a more "oceanic" distribution than in the rest of the surveyed area, where the highest densities were mainly recorded in different locations over the inner shelf (Figure 13). The size class range for the assessed population oscillated between 19 and 32 cm size classes. Two mixed size cohorts may be differentiated in the sampled population, both corresponding to juvenile/sub-adult fish (with modes at 20 and 22 cm; Table 6 and Figure 14). Larger fish were more frequent in the central area.

Seven sectors were differentiated for the purposes of acoustic assessment. The acoustic estimates by homogeneous stratum and total area are shown in Table 6 and Figure 14. Chub mackerel in the sampled area was the most important species in terms of assessed biomass, rendering estimates of 31 267 t and 333 million fish.

Blue jack-mackerel

The survey's length-weight relationship for this species is given in Table 11. The back-scattering energy attributed to this species, the species' positive fishing stations and the coherent strata considered for the acoustic estimation are illustrated in Figure 15. Estimated abundance and biomass by size class are given in Table 7 and Figure 16.

Blue jack mackerel occurred in 3 main locations: the area between Cape San Vicente and Cape Santa Maria, the area close to the Guadiana river mouth (where the highest densities were recorded), and the easternmost extreme of the surveyed area. Spots of high density were indistinctly recorded both in the inner and middle shelf (Figure 15). The sampled population showed a well bell-shaped length frequency distribution, with size classes ranging between 14.5 and 21.5 cm, and a modal class at 17.5 cm, all of them probably corresponding to juvenile/sub-adult fish. Larger fish were mainly recorded in the easternmost waters of the sampled area (Table 7, Figure 16).

The estimates for the four post-strata considered in the assessment are shown in Table 7 and Figure 16. A total of 3 889 t and 76 millions of fish were estimated for the whole surveyed area.

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in Table 11. The back-scattering energy attributed to this species, the distribution of fishing stations and their coherent strata are shown in Figure 17. Estimated abundance and biomass by size class are given in Table 8 and Figure 18.

The spatial distribution of acoustic energy attributable to horse mackerel resembled in a great extent to that previously described for sardine and blue jack mackerel, with highest densities occurring in both extremes of the surveyed area and a relatively scarce presence in the central part. Again, westernmost Portuguese shelf waters were those where the species recorded the highest values (Figure 17). The sampled population, which ranged between 10.5 and 22.5 cm size classes, was basically distributed amongst two cohorts with one main mode at 17 cm (sub-adults), and a secondary one at 12.5 cm (juveniles, which were located in the central part of the middle-inner shelf of the surveyed area) (Table 8, Figure 18).

The estimates for the four coherent strata considered in the assessment and for the whole surveyed area are given in Table 8 and illustrated in Figure 18. During this survey were estimated 10 398 t and 228 million fish of horse mackerel in the surveyed area, the species ranking as the second most important one in terms of biomass.

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in Table 11. Positive fishing stations, back-scattering energy attributed to the species and coherent strata are represented in Figure 19. Estimated abundance and biomass by size class are given in Table 9 and Figure 20.

Mediterranean horse-mackerel was only present over the Spanish inner shelf waters, with the densest concentrations being recorded in the easternmost waters (Figure 19). Size range of the sampled population oscillated between 17 and 38 cm size classes, showing 3 modal classes at 19, 28.5 and 35 cm, although the bulk of the sampled specimens occurred around the second mode, between 22.5 and 32 cm. Again, the smallest fish occurred in the central part of the surveyed area, in front of the Coto de Doñana National Park (Table 9, Figures 19, 20).

The acoustic estimates, given in Table 9 and Figure 20, were: 4853 t and 26 millions of fish.

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 11**. Positive fishing hauls, back-scattering energy attributed to bogue and coherent strata delimited for acoustic estimations are shown in Figure 21. Estimated abundance and biomass by size class are given in Table 10 and Figure 22.

Bogue was mainly located in the westernmost Portuguese waters, where the species also recorded the highest densities. In the rest of the area the species showed a very scattered distribution with very low densities (Figure 21). The sampled population was composed by fish belonging to size classes comprised between 10.5 and 24 cm, although mainly distributed between the 19 and 24.5 cm size classes. Three modes were identified at 13.5, 17 and, the most important, at 21 cm. Large fish were mainly located in the western coherent strata, whereas juveniles were only observed in front of the Coto de Doñana and in the easternmost waters (Table 10, Figure 22).

The bogue acoustic estimates for the whole surveyed area, shown in Table 10 and Figure 22, were: 4783 t and 52 million fish.

(SHORT) DISCUSSION

No standard acoustic survey (neither *PELAGO* nor *ECOCADIZ*) was carried out in 2012 in the Gulf of Cadiz for different reasons. Spain could finally conduct between 10 and 27 November of that year the *ECOCADIZ-RECLUTAS 1112* survey, a survey aimed at obtaining acoustic estimates of Gulf of Cadiz anchovy and sardine juveniles in their main recruitment areas off the Gulf (Ramos *et al*., 2013). Although a probable underestimation should be assumed, since the surveyed area was restricted to the Spanish waters only, 2012 autumn acoustic estimates for anchovy (2649 million fish, 13 680 t) and sardine (603 million fish, 22 119 t) were close to those ones estimated by IPMA five months after (5 April – 15 May 2013) during the *PELAGO 13* survey (Marques *et al*., 2013; Table 12). A further within-year comparison between *PELAGO 13* and *ECOCADIZ 0813* estimates reveals however marked decreases in the population levels of both species in mid-summer 2013, with the decrease exhibited by sardine being much more evident. During the *ECOCADIZ 0813* survey the greatest decreases in abundance and biomass were recorded in the Portuguese waters for anchovy and, more dramatically, in the Spanish ones for sardine. The above values are also illustrated in the context of their respective historical series in Figure 23. Anchovy and sardine biomass estimates in 2013 are amongst the lowest ones within their respective survey series. For both species, the 2013 *ECOCADIZ* survey estimates even were the lowest ones in the whole series. In their Portuguese counterparts, the anchovy estimate was about the half of the historical average (about 24 kt). In any case, Gulf of Cadiz anchovy has experienced a very fluctuating trend in the recent years. Since 2007 on the sardine biomass, as estimated by the *PELAGO* surveys, is experiencing a clear decreasing trend, which culminated in 2011 and it is still maintaining in the latest years. This decline is also corroborated, although based on less data points, by the Spanish summer surveys.

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Tables and Figures

Table 1. ***ECOCADIZ 0813*** **survey. Descriptive characteristics of the acoustic tracks.**

			Start				End			
Acoustic track	**Location**	**Date**	Latitude	Longitude	UCT time	Mean depth (m)	Latitude	Longitude	UCT time	Mean depth (m)
R01	Trafalgar	02/08/2013	36º 13,670 N	6º 7,620 W	10:17	25	36º 2,070 N	6º 28,560 W	14:44	190
R02	Sancti-Petri	03/08/2013	36º 19,320 N	6º 14,630 W	5:38	31	36º 8,980 N	6º 34,070 W	9:38	208
R03	Cádiz	03/08/2013	36º 17,250 N	6º 36,600 W	11:00	172	36º 27,180 N	6º 19,110 W	17:18	24
R04	Rota	04/08/2013	36º 34,460 N	6º 23,260 W	5:35	23	36º 24,510 N	6º 40,740 W	9:50	214
R05	Chipiona	04/08/2013	36º 30,990 N	6º 46,430 W	10:49	189	36º 40,160 N	6º 29,810 W	14:35	25
R06	Doñana	05/08/2013	36º 37,920 N	6º 51,430 W	6:01	149	36º 46,410	6º 41,050 W	10:28	23
R07	Matalascañas	05/08/2013	36º 53,510 N	6º 41,050 W	10:28	23	36º 43,980 N	6º 58,190 W	14:11	211
R08	Mazagón	07/08/2013	36º 49,120 N	7º 6,730 W	5:37	191	37º 1,070 N	6º 44,520 W	8:25	21
R09	Punta Umbría	07/08/2013	37 º4,530 N	6º 55,870 W	9:47	28	36º 49,040 N	7º 6,860 W	11:54	200
R10	El Rompido	07/08/2013	36º 49.170 N	7º 6.810 W	14:44	195	37º 6.860 N	7º 6.910 W	16:41	24
R11	Isla Cristina	08/08/2013	36º 52,370 N	7º 16,710 W	5:36	200	37º 7,150 N	7º 16,950 W	9:13	20
R12	V. R. de Sto. Antonio	08/08/2013	37º 6,190 N	7º 26,510 W	10:11	30	36º 56,190 N	7º 26,500 W	12:56	241
R13	Tavira	08/08/2013	36º 57,070 N	7º 36,100 W	14:29	125	37º 4,940 N	7º 36,050 W	16:55	21
R14	Fuzeta	08/08/2013	36º 59,280	7º 45,930 W	18:19	78	36º 55,7 N	7º 45,850 W	18:34	160
R15	Cabo de Sta. María	09/08/2013	36º 56,000 N	7º 55,080 W	5:33	67	36º 51,870 N	7º 55,990 W	6:02	217
R16	Cuarteira	09/08/2013	36º 50,170 N	8º 5,900 W	7:52	122	37º 1,340N	8º 5,960 W	11:12	21
R17	Albufeira	09/08/2013	37º 2,450 N	8º 15,430 W	12:12	31	36º 49,380 N	8º 15,490 W	15:26	175
R18	Alfanzina	10/08/2013	37º 4,170 N	8º 25,300 W	6:04	32	36º 50,360 N	8º 25,240 W	10:18	213
R19	Portimao	10/08/2013	36º 51,480 N	8º 35,360 W	11:42	115	37º 6,020 N	8º 35,390 W	14:43	25

Acoustic track	Location	Date	Start Latitude	Longitude	UCT time	Mean depth (m)	End Latitude	Longitude	UCT time	Mean depth (m)
R20	Burgau	11/08/2013	37º 1,400 N	8º 45,040 W	10:04	60	36º 52,380 N	8º 45,030 W	11:10	229
R21	Ponta de Sagres	11/08/2013	36º 50,820 N	8º 54,970 W	12:10	161	37º 0,490 N	8º 55,010 W	13:23	25

Table 2. ***ECOCADIZ 0813*** **survey. Descriptive characteristics of the fishing stations. Null hauls shadowed.**

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	02/08/2013	36° 07.5001 N	6° 19.9345 W	36° 08.5708 N	6° 16.9120 W	12:13	12:41	42,81	35,86	00:28	00:58	2,672	R01	Trafalgar
02	03/08/2013	36° 15.4470 N	6° 21.8920 W	36° 16.4845 N	6° 19.9524 W	07:01	07:28	50,52	45,12	00:27	00:55	1,88	R02	Sancti-Petri
03	03/08/2013	36° 21.1015 N	6° 31.9429 W	36° 18.7477 N	6° 30.6034 W	13:09	13:47	97,68	95,96	00:38	01:08	2,588	R03	Cádiz
04	03/08/2013	36° 24.6126 N	6° 23.6392 W	36° 23.4348 N	6° 25.7391 W	15:36	16:08	50,52	56,67	00:32	10:22	2,063	R03	Cádiz
05	04/08/2013	36° 31.6408 N	6° 28.1515 W	36° 30.6189 N	6° 29.9770 W	07:24	02:50	46,66	54,38	00:26	00:59	1,791	R04	Rota
06	04/08/2013	36° 33.9931 N	6° 41.0815 W	36° 32.4217 N	6° 43.9122 W	11:54	12:35	95,03	119,96	00:41	01:13	2,768	R05	Chipiona
07	05/08/2013	36° 43.7650 N	6° 40.7755 W	36° 42.5242 N	6° 43.0849 W	07:35	08:07	39,53	59,51	00:32	00:56	2,232	R06	Coto Doñana
08	05/08/2013	36° 47.6104 N	6° 51.5898 W	36° 48.9349 N	6° 49.2508 W	12:11	12:43	87,58	64,8	00:32	01:06	2,297	R07	Matalascañas
09	05/08/2013	36° 44.4166 N	6° 57.3940 W	36° 45.5032 N	6° 55.4485 W	14:45	15:15	140,95	115,33	00:30	01:10	1,903	R07	Matalascañas
10	07/08/2013	36° 50.6850 N	7° 06.0118 W	36° 52.2754 N	7° 04.7218 W	12:19	12:48	145,93	115,87	00:29	01:09	1,896	R09	Punta Umbría

Fishing station	Date	Start Latitude	Start Longitude	End Latitude	End Longitude	UTC Time Start	UTC Time End	Depth (m) Start	Depth (m) End	Duration (min.) Effective trawling	Duration (min.) Total manoeuvre	Trawled Distance (nm)	Acoustic transect	Zone (landmark)
11	08/08/2013	36° 57.6747 N	7° 16.7926 W	36° 55.4401 N	7° 16.7557 W	06:45	07:17	99,08	119,77	00:32	01:07	2,232	R11	Isla Cristina
12	08/08/2013	37° 04.9612 N	7° 27.5697 W	37° 04.9858 N	7° 25.2487 W	10:47	11:13	39,66	37,73	00:26	00:51	1,857	R12	V. R. Sto. Antonio
13	08/08/2013	37° 01.0086 N	7° 36.0274 W	36° 59.0446 N	7° 36.0439 W	15:12	15:41	93,71	108,98	00:29	01:12	1,962	R13	Tavira
14	09/08/2013	36° 51.5641 N	8° 06.3967 W	36° 52.5043 N	8° 04.3080 W	08:56	09:26	104,07	103,62	00:30	00:01	1,921	R16	Quarteira
15	09/08/2013	36° 57.8074 N	8° 12.8953 W	36° 58.5202 N	8° 15.4957 W	13:30	14:01	52,57	50,04	00:31	01:00	2,202	R17	Albufeira
16	10/08/2013	36° 55.3374 N	8° 27.8494 W	36° 55.1391 N	8° 25.3438 W	08:09	08:39	106,72	103,76	00:30	01:03	2,019	R18	Alfanzina
17	11/08/2013	37° 01.9326 N	8° 44.5479 W	37° 02.0304 N	8° 45.1161 W	06:41	06:50	51,07	50,97	00:09	01:05	0,465	R20	Burgau

Table 2. ***ECOCADIZ 0813*** **survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.**

	ABUNDANCE (n°)										
Fishing station	Anchovy	Sardine	Chub mack.	Mackerel	Horse-mack.	Blue Jack-mack.	Medit. Horse-mack.	Bogue	Silvery lightfish	Other spp.	TOTAL
01						29	17	30		10	86
02		441	264		367	300	302	27		65	1766
03	2628		1	8	18		2			290	2947
04	694	8469	6706		543	28	182	32		232	16886
05	4070	185	4519		231	12	1378	66		116	10577
06	6339			2	2	1			9	251	6604
07	8596	107	438	1	95	2	40	76		640	9995
08	350			5				1		100	456
09	7750		37	90						155	8032
10	5224		142	139		2			31835	174	37516
11	20663	2	81	19	2	4				69	20840
12		271	8717	44	852	1342		164		176	11566
13	12	234	7	31	30	1449		2		30	1795
14	8898		10	72	405	7				59	9451
15		404	3		484	16		186		66	1159
16	111	9	8056	60	7331	2066		357		95	18085
TOTAL	65335	10122	28981	471	10360	5258	1921	941	31844	2528	157761

	BIOMASS (kg)										
Fishing station	Anchovy	Sardine	Chub mack	Mackerel	Horse-mack.	Blue Jack-mack.	Medit. Horse-mack.	Bogue	Silvery lightfish	Other spp.	TOTAL
01						1,556	2,734	2,103		0,79	7,183
02		25,74	23,1		13,767	16,22	50,875	2,039		7,468	139,209
03	54,44		0,122	1,285	0,854		0,219			28,515	85,435
04	12,701	269,107	640,059		21,842	1,979	31,793	3,78		26,998	1008,259
05	56,034	6,862	476,077		8,804	0,794	247,517	8,361		12,221	816,67
06	108,547			0,268	0,015	0,023			0,004	19,955	128,812
07	93,6	4,496	72,7	0,256	3,546	0,161	7,15	12,4		26,188	220,497
08	6			1,078				0,119		8,251	15,448
09	172,16		5,222	10,7						20,88	208,962
10	117,24		18,2	22,08		0,136			22,34	15,672	195,668
11	461,477	0,127	10,352	3,236	0,033	0,196				6,297	481,718
12		16,884	719,557	16,613	34,13	65,851		16,003		18,219	887,257
13	0,331	13,61	0,546	5,446	1,553	74,94		0,171		5,51	102,107
14	237,798		1,358	10,683	19,167	0,446				6,219	275,671
15		24,78	0,358		21,226	0,976		12,425		14,724	74,489
16	3,248	0,434	894,281	10,075	371,554	115,802		35,812		13,085	1444,291
TOTAL	1323,576	362,04	2861,932	81,72	496,491	279,08	340,288	93,213	22,344	230,992	6091,676

Table 3. ***ECOCADIZ 0813*** **survey. Anchovy (*E. encrasicolus*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in Figure 6.**

ECOCADIZ 0813 . *Engraulis encrasicolus* . ABUNDANCE (in number of fish).								
Size class	POL01	POL02	POL03	POL04	POL05	POL06	TOTAL *n*	Millions
6	0	0	0	0	0	0	0	0
6,5	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
7,5	0	0	2108395	0	0	0	2108395	2
8	0	0	10541977	0	0	0	10541977	11
8,5	0	0	10541977	0	0	0	10541977	11
9	0	0	19015339	0	0	0	19015339	19
9,5	0	0	33774106	0	0	0	33774106	34
10	0	0	50641280	0	0	0	50641280	51
10,5	0	0	54897852	0	0	0	54897852	55
11	0	249819	59114625	0	0	0	59364444	59
11,5	0	499639	35882489	0	0	0	36382128	36
12	0	5959978	37990893	424102	0	0	44374973	44
12,5	1061277	9186217	14758767	2653834	0	0	27660095	28
13	3079196	8443898	8433580	6893501	1386595	0	28236770	28
13,5	6940750	2234100	4216790	12548190	7545128	0	33484958	33
14	8787371	1734461	0	13219247	12905746	2165248	38812073	39
14,5	7554796	499639	0	11312930	22877712	4759035	47004112	47
15	5626037	249819	0	6183753	18348680	11677680	42085969	42
15,5	3163653	0	0	3282773	11189921	13408748	31045095	31
16	452536	0	0	2388186	10320276	11243501	24404499	24
16,5	266812	0	0	791844	2967353	4324858	8350867	8
17	0	0	0	447198	1781239	2165248	4393685	4
17,5	0	0	0	148199	791469	434177	1373845	1
18	0	0	0	148199	0	0	148199	0
TOTAL *n*	36932428	29057570	341918070	60441956	90114119	50178495	608642638	609
Millions	37	29	342	60	90	50	609	

ECOCADIZ 0813 . *Engraulis encrasicolus* . BIOMASS (t).							
Size class	POL01	POL02	POL03	POL04	POL05	POL06	TOTAL
6	0	0	0	0	0	0	**0**
6,5	0	0	0	0	0	0	**0**
7	0	0	0	0	0	0	**0**
7,5	0	0	5,404	0	0	0	**5,404**
8	0	0	33,139	0	0	0	**33,139**
8,5	0	0	40,162	0	0	0	**40,162**
9	0	0	86,862	0	0	0	**86,862**
9,5	0	0	183,227	0	0	0	**183,227**
10	0	0	323,487	0	0	0	**323,487**
10,5	0	0	409,706	0	0	0	**409,706**
11	0	2,163	511,807	0	0	0	**513,97**
11,5	0	4,986	358,082	0	0	0	**363,068**
12	0	68,149	434,407	4,849	0	0	**507,405**
12,5	13,829	119,703	192,318	34,581	0	0	**360,431**
13	45,496	124,762	124,609	101,854	20,487	0	**417,208**
13,5	115,742	37,255	70,318	209,251	125,821	0	**558,387**
14	164,67	32,503	0	247,721	241,846	40,575	**727,315**
14,5	158,453	10,479	0	237,276	479,834	99,815	**985,857**
15	131,575	5,842	0	144,618	429,116	273,103	**984,254**
15,5	82,21	0	0	85,305	290,779	348,437	**806,731**
16	13,023	0	0	68,729	297,004	323,573	**702,329**
16,5	8,478	0	0	25,16	94,283	137,415	**265,336**
17	0	0	0	15,642	62,303	75,735	**153,68**
17,5	0	0	0	5,691	30,392	16,672	**52,755**
18	0	0	0	6,231	0	0	**6,231**
TOTAL	**733,476**	**405,842**	**2773,528**	**1186,908**	**2071,865**	**1315,325**	**8486,944**

Table 4. *ECOCADIZ 0813* survey. Anchovy (*E. encrasicolus*). Estimated abundance (thousands of individuals) and biomass (tonnes) by age group. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in Figure 6 and ordered from west to east.

Age class	POL06	POL05	POL03	POL04	POL02	POL01	TOTAL
	Number	Number	Number	Number	Number	Number	Number
0	0	140	167444	403	958	186	169131
I	35607	76721	161824	56519	28081	35140	393891
II	14572	13253	0	3520	19	1606	32970
III	0	0	0	0	0	0	0
TOTAL	50178	90114	329268	60442	29058	36932	595992

Age class	POL06	POL05	POL03	POL04	POL02	POL01	TOTAL
	Weight	Weight	Weight	Weight	Weight	Weight	Weight
0	0	2	1105	6	12	3	1128
I	889	1684	1630	1079	394	688	6364
II	426	386	0	102	0	42	957
III	0	0	0	0	0	0	0
TOTAL	1315	2072	2735	1187	406	733	8448

Table 5. ***ECOCADIZ 0813*** **survey. Sardine (*S. pilchardus*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in Figure 10.**

***ECOCADIZ 0813* . *Sardina pilchardus* . ABUNDANCE (in number of fish).**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL *n***	**Millions**
8	0	0	0	0	0	0	**0**
8,5	0	0	0	0	0	0	**0**
9	0	0	0	0	0	0	**0**
9,5	0	0	0	0	0	0	**0**
10	0	0	0	0	0	0	**0**
10,5	0	0	0	0	0	0	**0**
11	0	0	36825	0	0	36825	**0**
11,5	0	0	184124	0	0	184124	**0**
12	0	3195967	405072	0	0	3601039	**4**
12,5	0	14275531	441897	0	0	14717428	**15**
13	294457	15866996	36825	0	0	16198278	**16**
13,5	147228	7274144	36825	0	0	7458197	**7**
14	147228	2811152	36825	0	0	2995205	**3**
14,5	147228	4960128	36825	0	0	5144181	**5**
15	1361863	4960128	36825	0	0	6358816	**6**
15,5	1509091	1651838	110474	0	1505941	4777344	**5**
16	2134811	4847806	110474	0	5722577	12815668	**13**
16,5	1509091	4078177	184124	0	15661787	21433179	**21**
17	1509091	4847806	405072	76766	37046166	43884901	**44**
17,5	1656320	3031445	184124	643122	21384367	26899378	**27**
18	1509091	4847806	368248	2203682	14155847	23084674	**23**
18,5	1361863	2918864	257773	2114660	18673667	25326827	**25**
19	1509091	1651838	331423	1552191	4216636	9261179	**9**
19,5	1214635	1267024	478722	809833	2710695	6480909	**6**
20	147228	0	184124	522010	0	853362	**1**
20,5	0	0	36825	76766	0	113591	**0**
21	0	0	36825	230298	0	267123	**0**
21,5	0	0	0	153532	0	153532	**0**
22	0	0	0	0	0	0	**0**
22,5	0	0	0	0	0	0	**0**
23	0	0	0	0	0	0	**0**
TOTAL *n*	16158316	82486650	3940251	8382860	121077683	232045760	**232**
Millions	**16**	**82**	**4**	**8**	**121**	**232**	

Table 5 (cont'd).

***ECOCADIZ 0813 . Sardina pilchardus* . BIOMASS (t).**						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL**
8	0	0	0	0	0	**0**
8,5	0	0	0	0	0	**0**
9	0	0	0	0	0	**0**
9,5	0	0	0	0	0	**0**
10	0	0	0	0	0	**0**
10,5	0	0	0	0	0	**0**
11	0	0	0,414	0	0	**0,414**
11,5	0	0	2,376	0	0	**2,376**
12	0	47,122	5,972	0	0	**53,094**
12,5	0	239,166	7,403	0	0	**246,569**
13	5,578	300,575	0,698	0	0	**306,851**
13,5	3,139	155,101	0,785	0	0	**159,025**
14	3,519	67,183	0,88	0	0	**71,582**
14,5	3,928	132,342	0,983	0	0	**137,253**
15	40,418	147,209	1,093	0	0	**188,72**
15,5	49,648	54,344	3,635	0	49,544	**157,171**
16	77,606	176,229	4,016	0	208,03	**465,881**
16,5	60,434	163,317	7,374	0	627,202	**858,327**
17	66,386	213,259	17,819	3,377	1629,692	**1930,533**
17,5	79,825	146,097	8,874	30,995	1030,598	**1296,389**
18	79,476	255,31	19,394	116,057	745,518	**1215,755**
18,5	78,189	167,581	14,8	121,409	1072,112	**1454,091**
19	94,238	103,152	20,696	96,93	263,317	**578,333**
19,5	82,323	85,874	32,446	54,887	183,721	**439,251**
20	10,808	0	13,516	38,321	0	**62,645**
20,5	0	0	2,922	6,092	0	**9,014**
21	0	0	3,153	19,72	0	**22,873**
21,5	0	0	0	14,16	0	**14,16**
22	0	0	0	0	0	**0**
22,5	0	0	0	0	0	**0**
23	0	0	0	0	0	**0**
TOTAL	**735,515**	**2453,861**	**169,249**	**501,948**	**5809,734**	**9670,307**

Table 6. *ECOCADIZ 0813* survey. Chub mackerel (*S. colias*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in Figure 13.

***ECOCADIZ 0813* . *Scomber colias* . ABUNDANCE (in number of fish).**									
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**TOTAL *n***	**Millions**
13	0	0	0	0	0	0	0	0	**0**
13,5	0	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	0	**0**
14,5	0	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	0	**0**
15,5	0	0	0	0	0	0	0	0	**0**
16	0	0	0	0	0	0	0	0	**0**
16,5	0	0	0	0	0	0	0	0	**0**
17	0	0	0	0	0	0	0	0	**0**
17,5	0	0	0	0	0	0	0	0	**0**
18	0	0	0	0	0	0	0	0	**0**
18,5	0	0	0	0	0	0	0	0	**0**
19	0	0	0	0	0	7808826	0	7808826	**8**
19,5	0	0	0	0	0	19522061	874020	20396081	**20**
20	0	0	0	0	0	27312978	3053165	30366143	**30**
20,5	0	291024	0	0	0	14310211	5238217	19839452	**20**
21	3688690	589707	646142	0	0	9098356	13529596	27552491	**28**
21,5	15961106	2052485	161535	0	0	3904412	6549247	28628785	**29**
22	18412628	3224240	161535	0	0	13002768	7417359	42218530	**42**
22,5	17175463	2933216	323071	0	51422	13002768	3927185	37413125	**37**
23	10541533	6456139	484606	0	77133	14310211	4364195	36233817	**36**
23,5	4086622	3813948	928829	0	192858	6501385	874020	16397662	**16**
24	1968065	6157455	1251900	3274	204664	5211855	1311030	16108243	**16**
24,5	1354612	3224240	1574971	13096	216520	5211855	437010	12032304	**12**
25	1933855	2343510	1574971	11459	120603	5211855	0	11196253	**11**
25,5	1047885	880731	928829	13096	88989	3904412	0	6863942	**7**
26	0	880731	807677	14733	75133	2596971	0	4375245	**4**
26,5	0	1171755	928829	1637	45519	2596971	0	4744711	**5**
27	0	291024	2059578	1637	17807	1307441	0	3677487	**4**
27,5	0	291024	928829	1637	17807	1307441	0	2546738	**3**
28	0	0	928829	0	13856	0	0	942685	**1**
28,5	0	0	646142	0	0	0	0	646142	**1**
29	0	0	1090364	0	0	0	0	1090364	**1**
29,5	0	0	646142	0	0	0	0	646142	**1**
30	0	0	484606	0	0	0	0	484606	**0**
30,5	0	0	161535	0	0	0	0	161535	**0**
31	0	0	484606	0	0	0	0	484606	**0**
31,5	0	0	161535	0	0	0	0	161535	**0**
32	0	0	323071	0	0	0	0	323071	**0**
32,5	0	0	0	0	0	0	0	0	**0**
33	0	0	0	0	0	0	0	0	**0**
TOTAL *n*	76170459	34601229	17688132	60569	1122311	156122777	47575044	333340521	**333**
Millions	**76**	**35**	**18**	**0**	**1**	**156**	**48**	**333**	

Table 6 (cont'd).

ECOCADIZ 0813 . Scomber colias . BIOMASS (t).								
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**TOTAL**
13	0	0	0	0	0	0	0	**0**
13,5	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
14,5	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	**0**
15,5	0	0	0	0	0	0	0	**0**
16	0	0	0	0	0	0	0	**0**
16,5	0	0	0	0	0	0	0	**0**
17	0	0	0	0	0	0	0	**0**
17,5	0	0	0	0	0	0	0	**0**
18	0	0	0	0	0	0	0	**0**
18,5	0	0	0	0	0	0	0	**0**
19	0	0	0	0	0	430,085	0	**430,085**
19,5	0	0	0	0	0	1166,571	52,228	**1218,799**
20	0	0	0	0	0	1767,2	197,545	**1964,745**
20,5	0	20,349	0	0	0	1000,579	366,26	**1387,188**
21	278,205	44,476	48,733	0	0	686,207	1020,416	**2078,037**
21,5	1296,215	166,684	13,118	0	0	317,081	531,87	**2324,968**
22	1607,392	281,471	14,102	0	0	1135,12	647,523	**3685,608**
22,5	1609,194	274,817	30,269	0	4,818	1218,248	367,944	**3505,29**
23	1058,353	648,186	48,654	0	7,744	1436,722	438,158	**3637,817**
23,5	439,015	409,722	99,782	0	20,718	698,426	93,894	**1761,557**
24	225,907	706,792	143,701	0,376	23,493	598,25	150,488	**1849,007**
24,5	165,918	394,917	192,908	1,604	26,52	638,368	53,527	**1473,762**
25	252,422	305,893	205,577	1,496	15,742	680,292	0	**1461,422**
25,5	145,579	122,357	129,039	1,819	12,363	542,427	0	**953,584**
26	0	130,074	119,285	2,176	11,096	383,544	0	**646,175**
26,5	0	183,758	145,661	0,257	7,138	407,264	0	**744,078**
27	0	48,408	342,582	0,272	2,962	217,475	0	**611,699**
27,5	0	51,29	163,695	0,289	3,138	230,421	0	**448,833**
28	0	0	173,261	0	2,585	0	0	**175,846**
28,5	0	0	127,445	0	0	0	0	**127,445**
29	0	0	227,186	0	0	0	0	**227,186**
29,5	0	0	142,085	0	0	0	0	**142,085**
30	0	0	112,365	0	0	0	0	**112,365**
30,5	0	0	39,459	0	0	0	0	**39,459**
31	0	0	124,609	0	0	0	0	**124,609**
31,5	0	0	43,687	0	0	0	0	**43,687**
32	0	0	91,826	0	0	0	0	**91,826**
32,5	0	0	0	0	0	0	0	**0**
33	0	0	0	0	0	0	0	**0**
TOTAL	**7078,2**	**3789,194**	**2779,029**	**8,289**	**138,317**	**13554,28**	**3919,853**	**31267,162**

Table 7. ***ECOCADIZ 0813*** **survey. Blue jack-mackerel (*T. picturatus*). Estimated abundance and biomass by size class. Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in Figure 15.**

ECOCADIZ 0813 . Trachurus picturatus . **ABUNDANCE (in number of fish).**						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL *n***	**Millions**
10	0	0	0	0	0	**0**
10,5	0	0	0	0	0	**0**
11	0	0	0	0	0	**0**
11,5	0	0	0	0	0	**0**
12	0	0	0	0	0	**0**
12,5	0	0	0	0	0	**0**
13	0	0	0	0	0	**0**
13,5	0	0	0	0	0	**0**
14	0	0	0	0	0	**0**
14,5	236152	0	0	0	236152	**0**
15	314869	0	0	0	314869	**0**
15,5	118076	574977	0	0	693053	**1**
16	551021	275989	0	0	827010	**1**
16,5	787172	5427785	0	167142	6382099	**6**
17	1456269	10280592	0	1177957	12914818	**13**
17,5	2322158	9153634	1022971	2515096	15013859	**15**
18	1456269	4852808	3568773	3693053	13570903	**14**
18,5	1653062	275989	6637684	3016524	11583259	**12**
19	1456269	0	4254628	3183667	8894564	**9**
19,5	669096	0	848601	2515096	4032793	**4**
20	551021	0	511485	167142	1229648	**1**
20,5	118076	0	0	0	118076	**0**
21	118076	0	0	0	118076	**0**
21,5	118076	0	0	0	118076	**0**
22	0	0	0	0	0	**0**
22,5	0	0	0	0	0	**0**
23	0	0	0	0	0	**0**
23,5	0	0	0	0	0	**0**
24	0	0	0	0	0	**0**
24,5	0	0	0	0	0	**0**
25	0	0	0	0	0	**0**
25,5	0	0	0	0	0	**0**
26	0	0	0	0	0	**0**
26,5	0	0	0	0	0	**0**
27	0	0	0	0	0	**0**
27,5	0	0	0	0	0	**0**
28	0	0	0	0	0	**0**
TOTAL *n*	11925662	30841774	16844142	16435677	76047255	**76**
Millions	**12**	**31**	**17**	**16**	**76**	

Table 7 (cont'd).

ECOCADIZ 0813 . *Trachurus picturatus* . BIOMASS (t).					
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL**
10	0	0	0	0	**0**
10,5	0	0	0	0	**0**
11	0	0	0	0	**0**
11,5	0	0	0	0	**0**
12	0	0	0	0	**0**
12,5	0	0	0	0	**0**
13	0	0	0	0	**0**
13,5	0	0	0	0	**0**
14	0	0	0	0	**0**
14,5	6,546	0	0	0	**6,546**
15	9,629	0	0	0	**9,629**
15,5	3,971	19,337	0	0	**23,308**
16	20,318	10,177	0	0	**30,495**
16,5	31,737	218,837	0	6,739	**257,313**
17	64,029	452,014	0	51,792	**567,835**
17,5	111,067	437,813	48,928	120,296	**718,104**
18	75,593	251,903	185,25	191,702	**704,448**
18,5	92,921	15,514	373,114	169,563	**651,112**
19	88,459	0	258,44	193,387	**540,286**
19,5	43,833	0	55,592	164,765	**264,19**
20	38,857	0	36,069	11,787	**86,713**
20,5	8,947	0	0	0	**8,947**
21	9,597	0	0	0	**9,597**
21,5	10,278	0	0	0	**10,278**
22	0	0	0	0	**0**
22,5	0	0	0	0	**0**
23	0	0	0	0	**0**
23,5	0	0	0	0	**0**
24	0	0	0	0	**0**
24,5	0	0	0	0	**0**
25	0	0	0	0	**0**
25,5	0	0	0	0	**0**
26	0	0	0	0	**0**
26,5	0	0	0	0	**0**
27	0	0	0	0	**0**
27,5	0	0	0	0	**0**
28	0	0	0	0	**0**
TOTAL	**615,782**	**1405,595**	**957,393**	**910,031**	**3888,801**

Table 8. *ECOCADIZ 0813* survey. Horse mackerel (*T. trachurus*). Estimated abundance and biomass by size class. Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in Figure 17.

***ECOCADIZ 0813* . *Trachurus trachurus* . ABUNDANCE (in number of fish).**						
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL *n***	**Millions**
10	0	0	0	0	0	**0**
10,5	0	36363	0	0	36363	**0**
11	0	36363	0	0	36363	**0**
11,5	0	327267	0	0	327267	**0**
12	0	363630	0	0	363630	**0**
12,5	0	1418157	0	0	1418157	**1**
13	0	690897	0	0	690897	**1**
13,5	0	290904	0	0	290904	**0**
14	0	145452	0	0	145452	**0**
14,5	50650	109089	0	0	159739	**0**
15	1002859	36363	207396	0	1246618	**1**
15,5	3245639	0	1055836	0	4301475	**4**
16	5978250	0	3808552	5588103	15374905	**15**
16,5	5255795	0	6335017	32632875	44223687	**44**
17	2518284	0	2545319	55828023	60891626	**61**
17,5	1142183	0	1055836	43941502	46139521	**46**
18	530503	0	641043	22613200	23784746	**24**
18,5	320713	0	414793	12189257	12924763	**13**
19	151951	0	0	4457895	4609846	**5**
19,5	50650	0	0	5619913	5670563	**6**
20	50650	0	0	3160522	3211172	**3**
20,5	50650	0	0	1828186	1878836	**2**
21	50650	0	0	0	50650	**0**
21,5	50650	0	0	0	50650	**0**
22	50650	0	0	0	50650	**0**
22,5	50650	0	0	0	50650	**0**
23	0	0	0	0	0	**0**
23,5	0	0	0	0	0	**0**
24	0	0	0	0	0	**0**
24,5	0	0	0	0	0	**0**
25	0	0	0	0	0	**0**
25,5	0	0	0	0	0	**0**
26	0	0	0	0	0	**0**
26,5	0	0	0	0	0	**0**
27	0	0	0	0	0	**0**
27,5	0	0	0	0	0	**0**
28	0	0	0	0	0	**0**
TOTAL *n*	20551377	3454485	16063792	187859476	227929130	**228**
Millions	**21**	**3**	**16**	**188**	**228**	

Table 8 (cont'd).

***ECOCADIZ 0813 . Trachurus trachurus* . BIOMASS (t).**					
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**TOTAL**
10	0	0	0	0	**0**
10,5	0	0,374	0	0	**0,374**
11	0	0,43	0	0	**0,43**
11,5	0	4,416	0	0	**4,416**
12	0	5,572	0	0	**5,572**
12,5	0	24,551	0	0	**24,551**
13	0	13,449	0	0	**13,449**
13,5	0	6,34	0	0	**6,34**
14	0	3,535	0	0	**3,535**
14,5	1,367	2,945	0	0	**4,312**
15	29,973	1,087	6,198	0	**37,258**
15,5	107,032	0	34,818	0	**141,85**
16	216,86	0	138,155	202,708	**557,723**
16,5	209,114	0	252,053	1298,374	**1759,541**
17	109,599	0	110,776	2429,711	**2650,086**
17,5	54,235	0	50,135	2086,518	**2190,888**
18	27,418	0	33,131	1168,699	**1229,248**
18,5	17,999	0	23,279	684,095	**725,373**
19	9,241	0	0	271,098	**280,339**
19,5	3,331	0	0	369,563	**372,894**
20	3,595	0	0	224,301	**227,896**
20,5	3,872	0	0	139,765	**143,637**
21	4,164	0	0	0	**4,164**
21,5	4,47	0	0	0	**4,47**
22	4,791	0	0	0	**4,791**
22,5	5,127	0	0	0	**5,127**
23	0	0	0	0	**0**
23,5	0	0	0	0	**0**
24	0	0	0	0	**0**
24,5	0	0	0	0	**0**
25	0	0	0	0	**0**
25,5	0	0	0	0	**0**
26	0	0	0	0	**0**
26,5	0	0	0	0	**0**
27	0	0	0	0	**0**
27,5	0	0	0	0	**0**
28	0	0	0	0	**0**
TOTAL	**812,188**	**62,699**	**648,545**	**8874,832**	**10398,264**

Table 9. *ECOCADIZ 0813* survey. Mediterranean horse-mackerel (*T. mediterraneus*). Estimated abundance and biomass by size class. Polygons (*i.e.,* coherent or homogeneous post-strata) numbered as in Figure 19.

ECOCADIZ 0813 . Trachurus mediterraneus . ABUNDANCE (in number of fish).					
Size class	**POL01**	**POL02**	**POL03**	**TOTAL *n***	**Millions**
10	0	0	0	0	**0**
10,5	0	0	0	0	**0**
11	0	0	0	0	**0**
11,5	0	0	0	0	**0**
12	0	0	0	0	**0**
12,5	0	0	0	0	**0**
13	0	0	0	0	**0**
13,5	0	0	0	0	**0**
14	0	0	0	0	**0**
14,5	0	0	0	0	**0**
15	0	0	0	0	**0**
15,5	0	0	0	0	**0**
16	0	0	0	0	**0**
16,5	0	0	0	0	**0**
17	0	0	35982	35982	**0**
17,5	0	0	71963	71963	**0**
18	0	0	107945	107945	**0**
18,5	0	0	215890	215890	**0**
19	0	0	179908	179908	**0**
19,5	0	0	215890	215890	**0**
20	0	0	143926	143926	**0**
20,5	0	0	179908	179908	**0**
21	0	0	71963	71963	**0**
21,5	0	0	71963	71963	**0**
22	0	0	35982	35982	**0**
22,5	0	148192	35982	184174	**0**
23	0	148192	35982	184174	**0**
23,5	0	148192	35982	184174	**0**
24	0	296384	0	296384	**0**
24,5	0	444575	0	444575	**0**
25	0	740959	0	740959	**1**
25,5	77257	862791	0	940048	**1**
26	154515	503055	0	657570	**1**
26,5	347658	1699278	0	2046936	**2**
27	849830	1307367	0	2157197	**2**
27,5	849830	1229179	0	2079009	**2**
28	1506517	1298293	0	2804810	**3**
28,5	1738290	1420126	0	3158416	**3**
29	927088	1239814	0	2166902	**2**
29,5	270400	906436	0	1176836	**1**
30	270400	302145	0	572545	**1**
30,5	231772	180313	0	412085	**0**
31	154515	180313	0	334828	**0**
31,5	231772	121833	0	353605	**0**
32	154515	58480	0	212995	**0**
32,5	0	58480	0	58480	**0**
33	77257	58480	0	135737	**0**
33,5	77257	58480	0	135737	**0**
34	115886	0	0	115886	**0**
34,5	695316	0	0	695316	**1**
35	1004345	0	0	1004345	**1**
35,5	965716	0	0	965716	**1**
36	424915	0	0	424915	**0**
36,5	309029	0	0	309029	**0**
37	77257	0	0	77257	**0**
37,5	77257	0	0	77257	**0**
38	38629	0	0	38629	**0**
38,5	0	0	0	0	**0**
39	0	0	0	0	**0**
TOTAL *n*	11627223	13411357	1439266	26477846	**26**
Millions	**12**	**13**	**1**	**26**	

Table 9 (cont'd).

ECOCADIZ 0813 . Trachurus mediterraneus . BIOMASS (t).				
Size class	**POL01**	**POL02**	**POL03**	**TOTAL**
10	0	0	0	**0**
10,5	0	0	0	**0**
11	0	0	0	**0**
11,5	0	0	0	**0**
12	0	0	0	**0**
12,5	0	0	0	**0**
13	0	0	0	**0**
13,5	0	0	0	**0**
14	0	0	0	**0**
14,5	0	0	0	**0**
15	0	0	0	**0**
15,5	0	0	0	**0**
16	0	0	0	**0**
16,5	0	0	0	**0**
17	0	0	1,522	**1,522**
17,5	0	0	3,298	**3,298**
18	0	0	5,348	**5,348**
18,5	0	0	11,539	**11,539**
19	0	0	10,353	**10,353**
19,5	0	0	13,349	**13,349**
20	0	0	9,546	**9,546**
20,5	0	0	12,777	**12,777**
21	0	0	5,464	**5,464**
21,5	0	0	5,832	**5,832**
22	0	0	3,108	**3,108**
22,5	0	13,623	3,308	**16,931**
23	0	14,48	3,516	**17,996**
23,5	0	15,37	3,732	**19,102**
24	0	32,589	0	**32,589**
24,5	0	51,764	0	**51,764**
25	0	91,25	0	**91,25**
25,5	10,052	112,26	0	**122,312**
26	21,218	69,081	0	**90,299**
26,5	50,336	246,03	0	**296,366**
27	129,602	199,378	0	**328,98**
27,5	136,382	197,26	0	**333,642**
28	254,183	219,051	0	**473,234**
28,5	308,08	251,691	0	**559,771**
29	172,449	230,62	0	**403,069**
29,5	52,746	176,816	0	**229,562**
30	55,27	61,759	0	**117,029**
30,5	49,603	38,59	0	**88,193**
31	34,599	40,376	0	**74,975**
31,5	54,261	28,523	0	**82,784**
32	37,794	14,304	0	**52,098**
32,5	0	14,935	0	**14,935**
33	20,587	15,583	0	**36,17**
33,5	21,467	16,249	0	**37,716**
34	33,556	0	0	**33,556**
34,5	209,687	0	0	**209,687**
35	315,262	0	0	**315,262**
35,5	315,35	0	0	**315,35**
36	144,265	0	0	**144,265**
36,5	109,029	0	0	**109,029**
37	28,31	0	0	**28,31**
37,5	29,389	0	0	**29,389**
38	15,247	0	0	**15,247**
38,5	0	0	0	**0**
39	0	0	0	**0**
TOTAL	**2608,724**	**2151,582**	**92,692**	**4852,998**

Table 10. *ECOCADIZ 0813* survey. Bogue (*B. boops*). Estimated abundance and biomass by size class. Estimated abundance and biomass by size class. Polygons (*i.e.,* coherent or homogeneous post-strata) numbered as in Figure 21

***ECOCADIZ 0813* . *Boops boops* . ABUNDANCE (in number of fish).**							
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**TOTAL *n***	**Millions**
10	0	0	0	0	0	0	**0**
10,5	0	0	38941	0	0	38941	**0**
11	0	0	38941	0	0	38941	**0**
11,5	0	0	38941	0	0	38941	**0**
12	0	0	155764	0	0	155764	**0**
12,5	46357	0	155764	0	0	202121	**0**
13	92714	0	389411	0	0	482125	**0**
13,5	139071	0	389411	0	0	528482	**1**
14	92714	0	311528	0	0	404242	**0**
14,5	46357	0	233646	0	0	280003	**0**
15	185428	0	194705	0	0	380133	**0**
15,5	231785	0	194705	0	0	426490	**0**
16	231785	0	116823	0	0	348608	**0**
16,5	139071	0	194705	0	0	333776	**0**
17	185428	0	350469	0	0	535897	**1**
17,5	0	0	116823	91682	0	208505	**0**
18	0	0	38941	183363	0	222304	**0**
18,5	0	0	0	91682	0	91682	**0**
19	0	0	0	275045	0	275045	**0**
19,5	0	0	0	275045	3139387	3414432	**3**
20	0	50136	0	531753	2052676	2634565	**3**
20,5	0	74082	0	183363	2052676	2310121	**2**
21	0	98027	0	348390	12316057	12762474	**13**
21,5	0	148163	0	183363	7244742	7576268	**8**
22	0	139932	0	275045	9297417	9712394	**10**
22,5	0	121973	0	183363	2052676	2358012	**2**
23	0	98027	0	275045	1086711	1459783	**1**
23,5	0	71837	0	91682	2052676	2216195	**2**
24	0	0	0	91682	1086711	1178393	**1**
24,5	0	0	0	0	1086711	1086711	**1**
25	0	0	0	0	0	0	**0**
25,5	0	0	0	0	0	0	**0**
26	0	0	0	0	0	0	**0**
26,5	0	0	0	0	0	0	**0**
27	0	0	0	0	0	0	**0**
27,5	0	0	0	0	0	0	**0**
28	0	0	0	0	0	0	**0**
TOTAL *n*	1390710	802177	2959518	3080503	43468440	51701348	**52**
Millions	**1**	**1**	**3**	**3**	**43**	**52**	

Table 10 (cont'd).

ECOCADIZ 0813 . *Boops boops* . BIOMASS (t).						
Size class	POL01	POL02	POL03	POL04	POL05	TOTAL
10	0	0	0	0	0	**0**
10,5	0	0	0,467	0	0	**0,467**
11	0	0	0,535	0	0	**0,535**
11,5	0	0	0,609	0	0	**0,609**
12	0	0	2,757	0	0	**2,757**
12,5	0,924	0	3,105	0	0	**4,029**
13	2,072	0	8,703	0	0	**10,775**
13,5	3,47	0	9,716	0	0	**13,186**
14	2,572	0	8,644	0	0	**11,216**
14,5	1,425	0	7,183	0	0	**8,608**
15	6,294	0	6,609	0	0	**12,903**
15,5	8,659	0	7,274	0	0	**15,933**
16	9,502	0	4,789	0	0	**14,291**
16,5	6,239	0	8,735	0	0	**14,974**
17	9,078	0	17,159	0	0	**26,237**
17,5	0	0	6,227	4,887	0	**11,114**
18	0	0	2,254	10,614	0	**12,868**
18,5	0	0	0	5,751	0	**5,751**
19	0	0	0	18,657	0	**18,657**
19,5	0	0	0	20,135	229,821	**249,956**
20	0	3,953	0	41,93	161,86	**207,743**
20,5	0	6,281	0	15,546	174,031	**195,858**
21	0	8,92	0	31,704	1120,763	**1161,387**
21,5	0	14,448	0	17,88	706,459	**738,787**
22	0	14,599	0	28,695	969,986	**1013,28**
22,5	0	13,594	0	20,436	228,776	**262,806**
23	0	11,655	0	32,701	129,202	**173,558**
23,5	0	9,098	0	11,612	259,981	**280,691**
24	0	0	0	12,354	146,43	**158,784**
24,5	0	0	0	0	155,588	**155,588**
25	0	0	0	0	0	**0**
25,5	0	0	0	0	0	**0**
26	0	0	0	0	0	**0**
26,5	0	0	0	0	0	**0**
27	0	0	0	0	0	**0**
27,5	0	0	0	0	0	**0**
28	0	0	0	0	0	**0**
TOTAL	**50,235**	**82,548**	**94,766**	**272,902**	**4282,897**	**4783,348**

Table 11. ***ECOCADIZ 0813*** **survey. Parameters of the size-weight relationships for survey's target species. Mackerel was not acoustically assessed because of the negligible backscattering energy attributed to the species. FAO codes for the species: PIL:** ***Sardina pilchardus;*** **ANE:** ***Engraulis encrasicolus;*** **MAS:** ***Scomber colias;*** **MAC:** ***Scomber scombrus;*** **JAA:** ***Trachurus picturatus;*** **HOM:** ***Trachurus trachurus;*** **BOG:** ***Boops boops;*** **HMM:** ***Trachurus mediterraneus*****.**

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG
n	347	555	443	213	266	439	228	260
a	0.0049376	0.0031904	0.0045302	0.0019810	0.0099823	0.0073594	0.0143861	0.0103193
b	3.1936283	3.2664826	3.1802800	3.3993235	2.9462604	3.0497220	2.8043959	2.9723640
r2	0.98	0.95	0.97	0.95	0.95	0.91	0.99	0.97

Table 12. ***ECOCADIZ 0813*** **survey. Comparison of anchovy (ANE) and sardine (PIL) acoustic estimates from the present survey with those ones derived from the same area during the** ***ECOCADIZ-RECLUTAS 1112*** **(10-27 November 2012)** ***PELAGO13*** **(5 April-15 May 2013) surveys. ALG: Portuguese (Algarve) waters; CAD: Spanish waters. Sardine estimates from the post-stratum 4 in the** ***ECOCADIZ 0813*** **survey (shared between Portuguese and Spanish waters) have been equally allocated between both countries for the purposes of this table.**

ESTIMATE	SURVEY	ANE			PIL		
		ALG	CAD	TOTAL	ALG	CAD	TOTAL
ABUNDANCE (Millions)	ECOCADIZ-R 1112	?	2649	?	?	603	?
	PELAGO 13	262	634	897	197	493	690
	ECOCADIZ 0813	50	558	609	125	107	232
BIOMASS (t)	ECOCADIZ-R 1112	?	13680	?	?	22119	?
	PELAGO 13	5044	7656	12 700	9492	21 049	30 541
	ECOCADIZ 0813	1315	7172	8487	6061	3609	9670

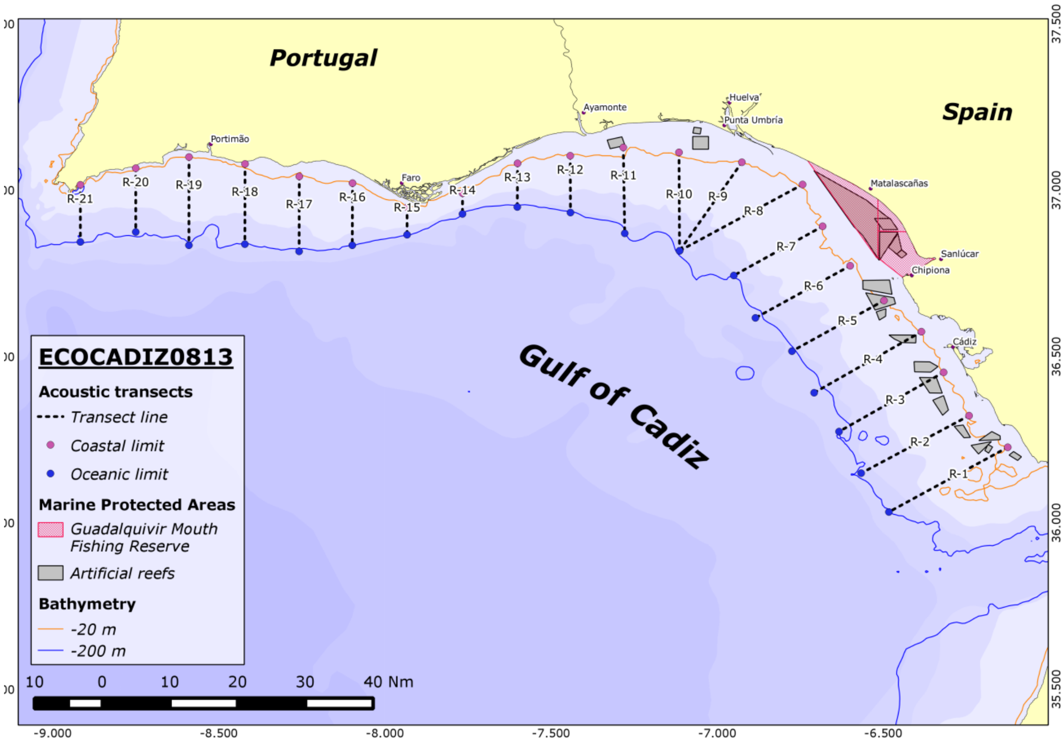


Figure 1. ***ECOCADIZ 0813*** **survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.**

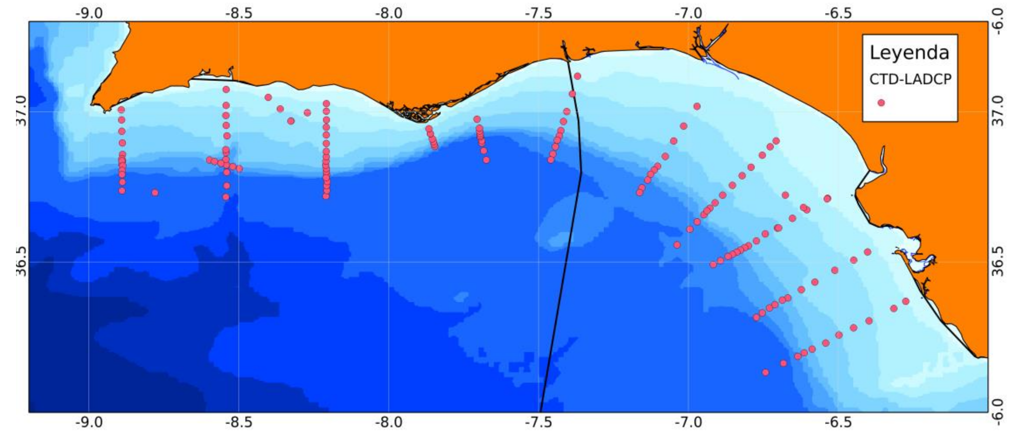


Figure 2. ***ECOCADIZ 0813*** **survey.Sampling grid of CTD stations.**

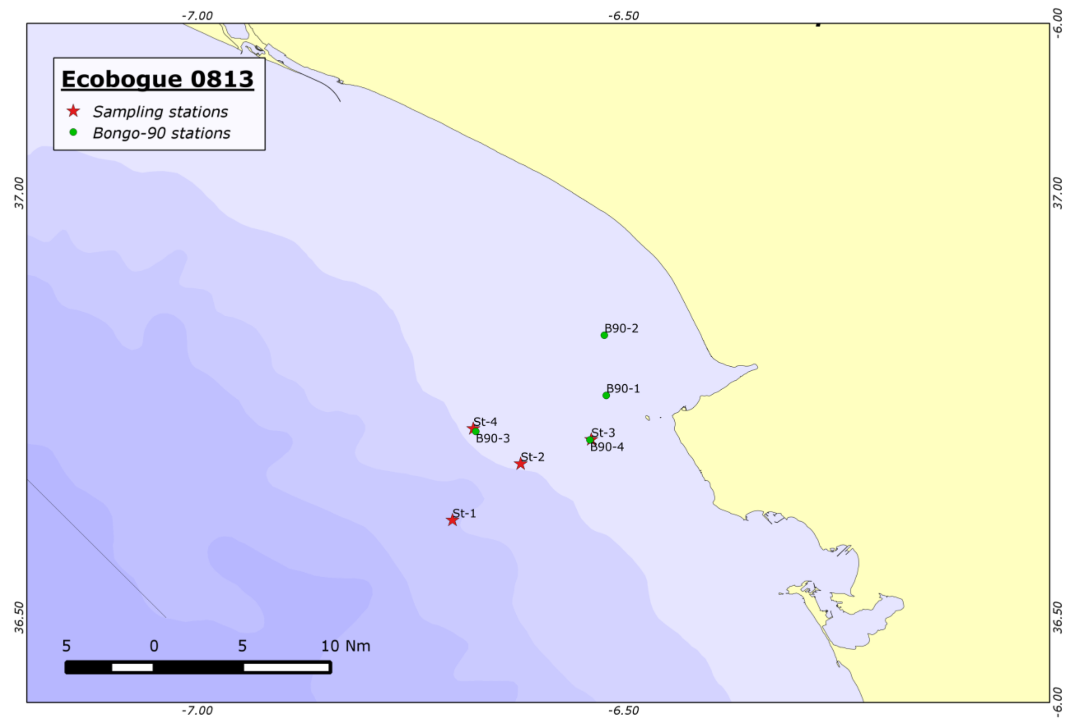


Figure 3. ***ECOCADIZ 0813.*** **Location of the** ***ECOBOGUE*** **research project sampling stations.**

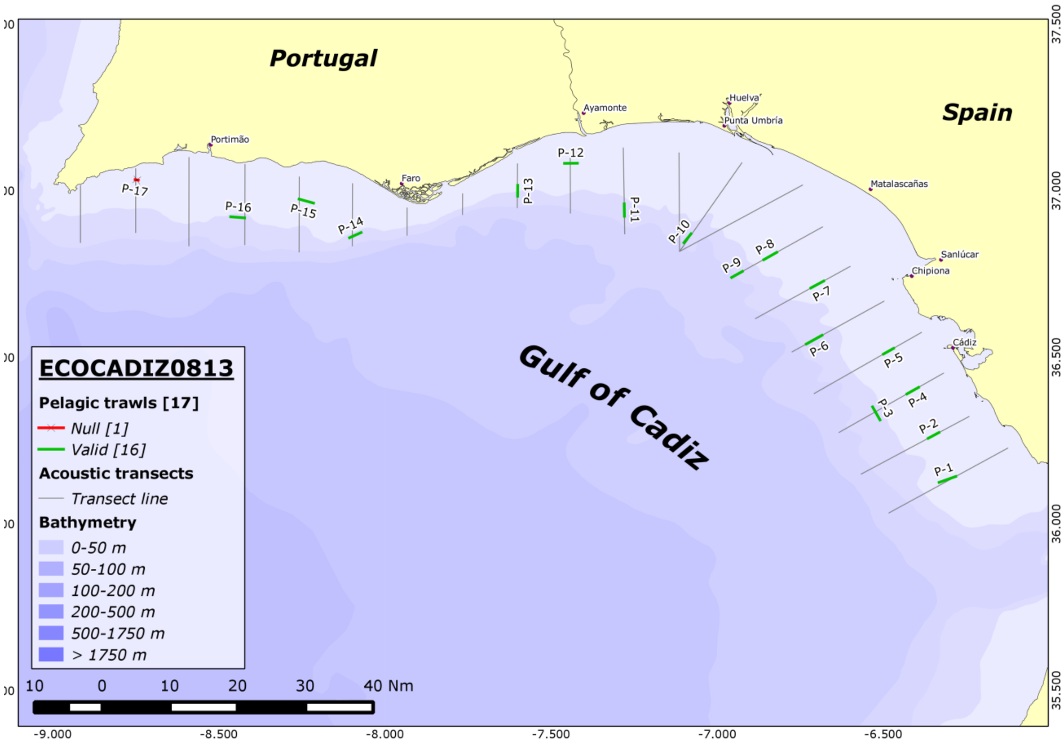


Figure 4. ***ECOCADIZ 0813*****. Location of groundtruthing fishing hauls. Null hauls in red.**

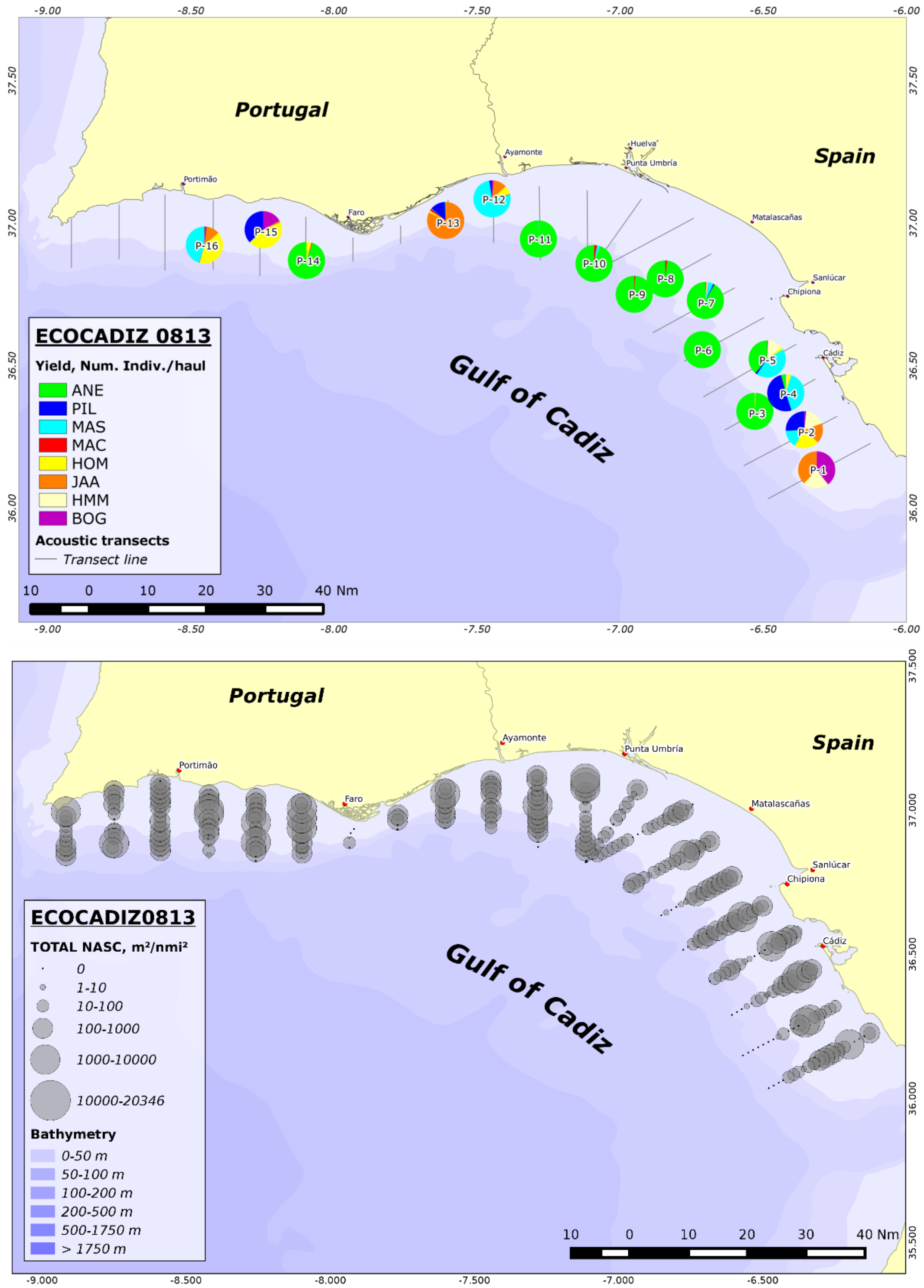


Figure 5. ***ECOCADIZ 0813*** **survey. Top: species composition (percentages in number) in fishing hauls. Bottom: Distribution of the total backscattering energy (Nautical area scattering coefficient,** ***NASC*****, in m² nmi⁻²) attributed to the pelagic fish species assemblage.**

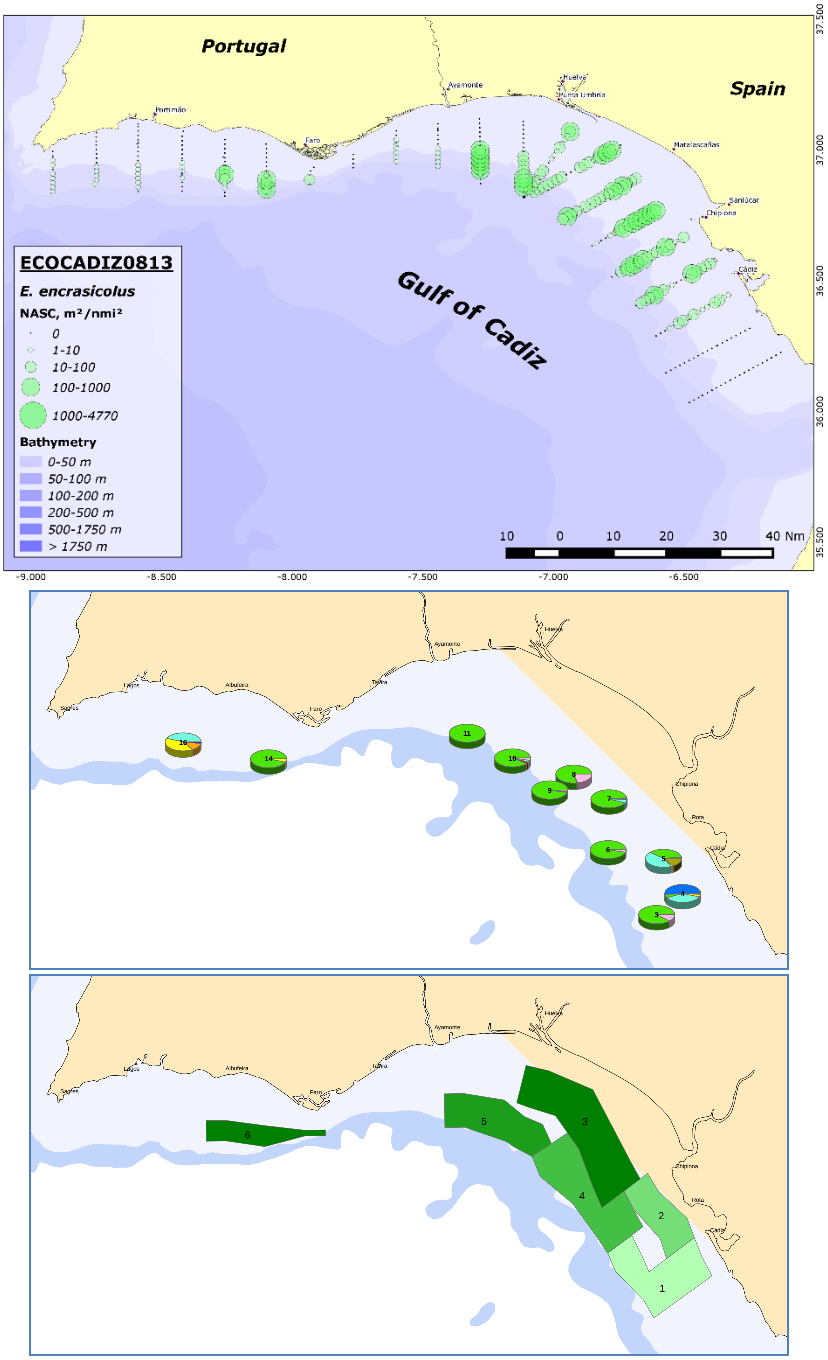


Figure 6. ***ECOCADIZ 0813*** **survey. Anchovy (*****Engraulis encrasicolus*****). Top: distribution of the total backscattering energy (Nautical area scattering coefficient,** ***NASC*****, in m² nmi⁻²) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum. Bottom right: distribution of anchovy egg densities (eggs 100 m⁻³) as sampled by CUFES.**

ECOCADIZ 0813: **Anchovy (E. encrasicolus)**

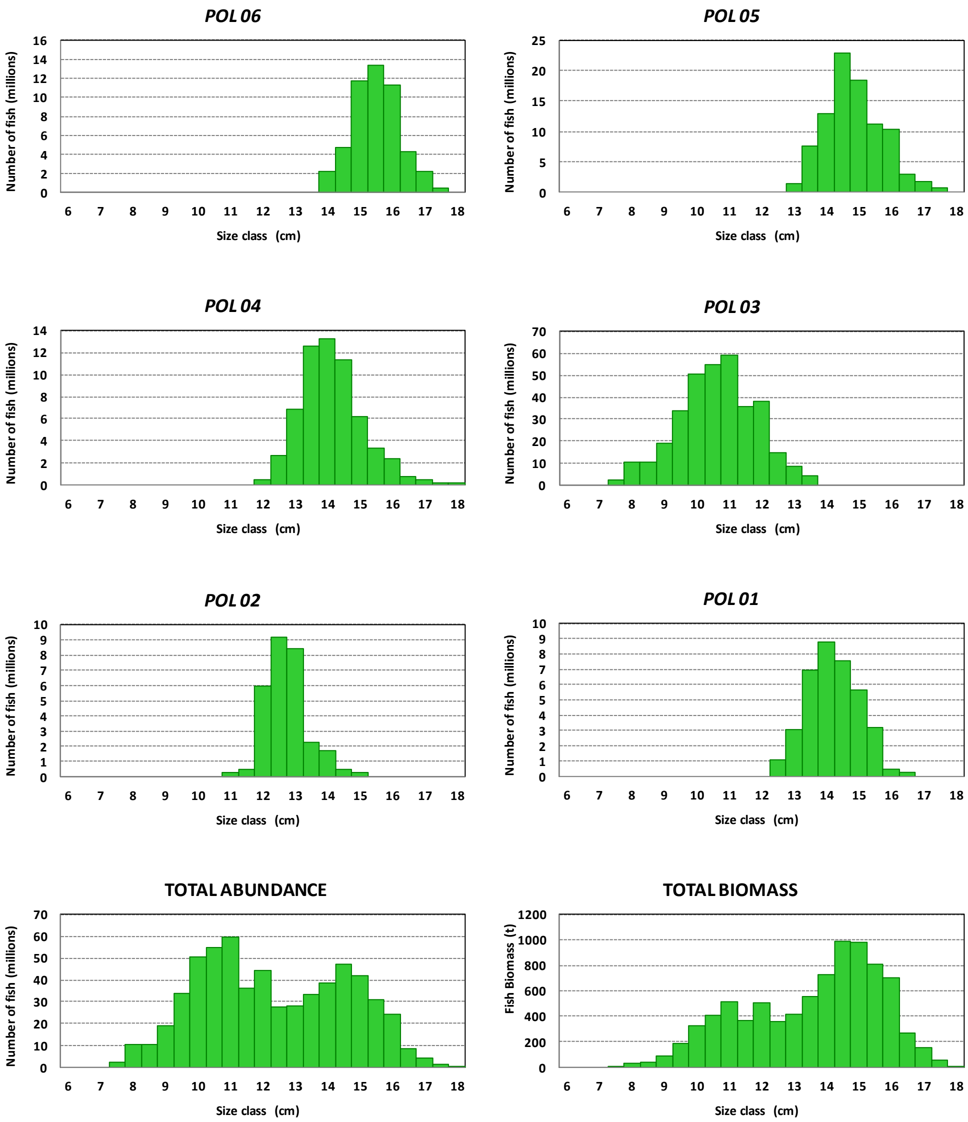


Figure 7. ***ECOCADIZ 0813*** **survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 6) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.**

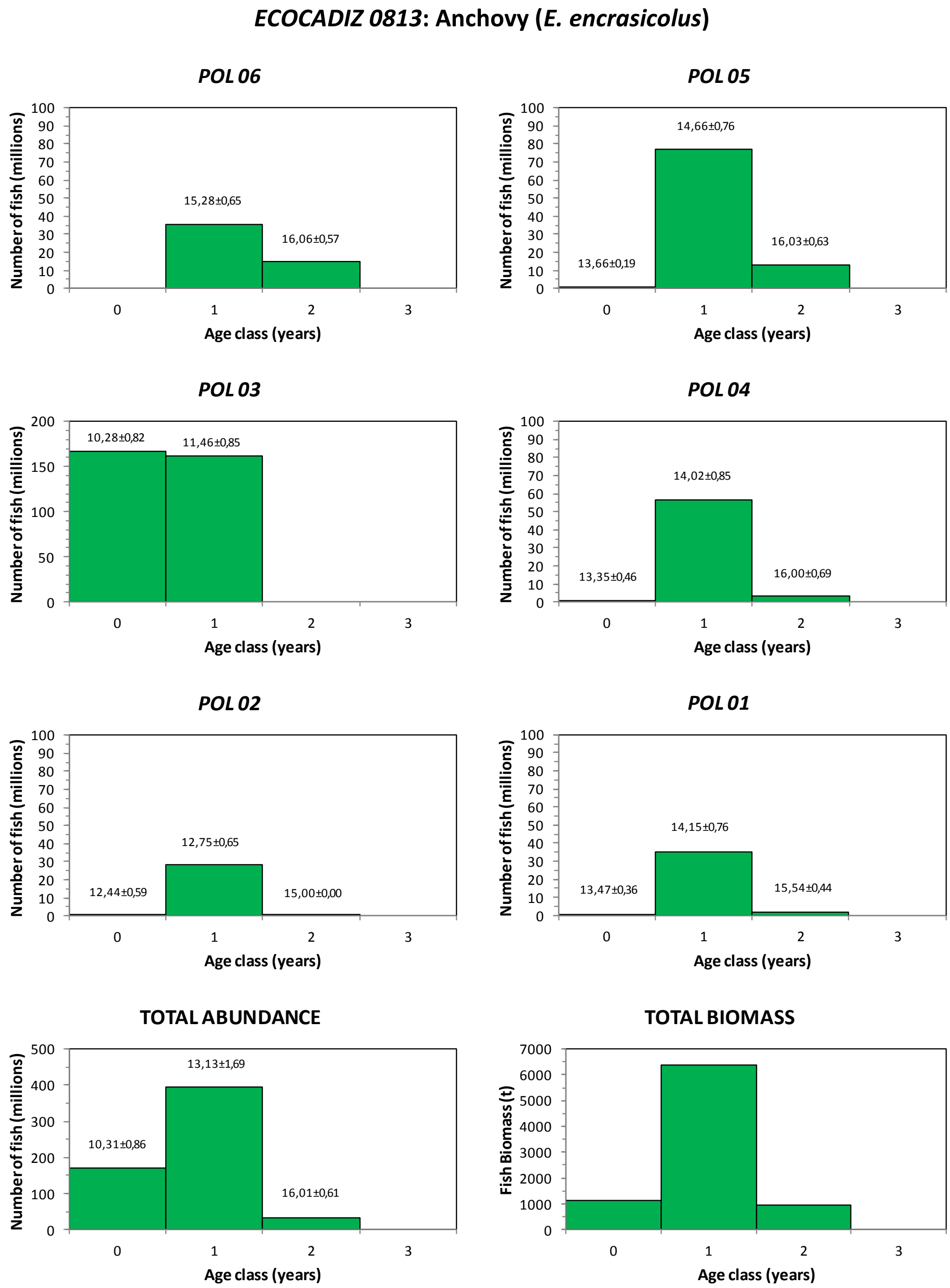


Figure 8. ECOCADIZ 0813 survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by age class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 6) and total sampled area. Post-strata ordered in the W-E direction. Mean length (±SD) by age group is also shown.The estimated biomass (t) by age class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

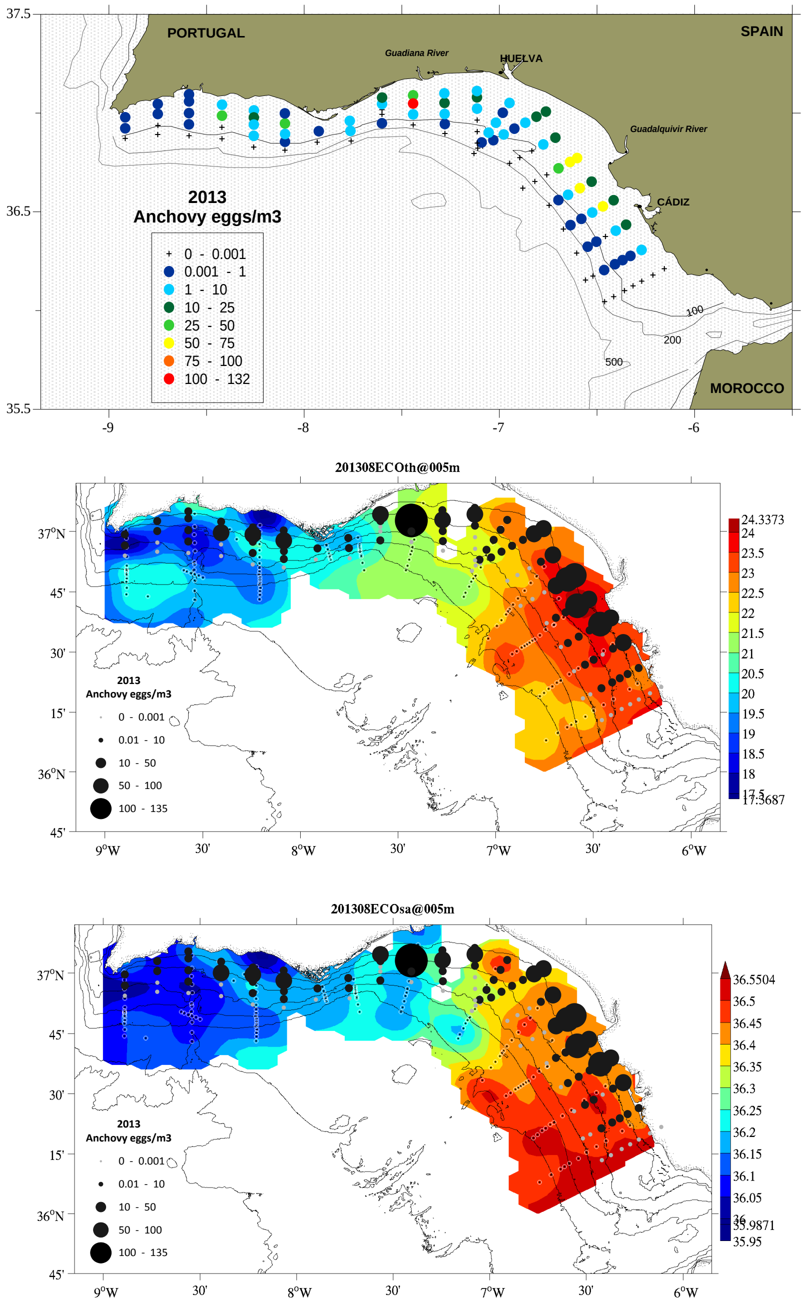


Figure 9. *ECOCADIZ 0813* **survey. Anchovy (*Engraulis encrasicolus*). Distribution of anchovy egg densities (eggs m^{-3}) as sampled by CUFES. Middle and bottom panels show the same egg distribution superimposed to the distribution of sea temperature and salinity at 5 m depth respectively.**

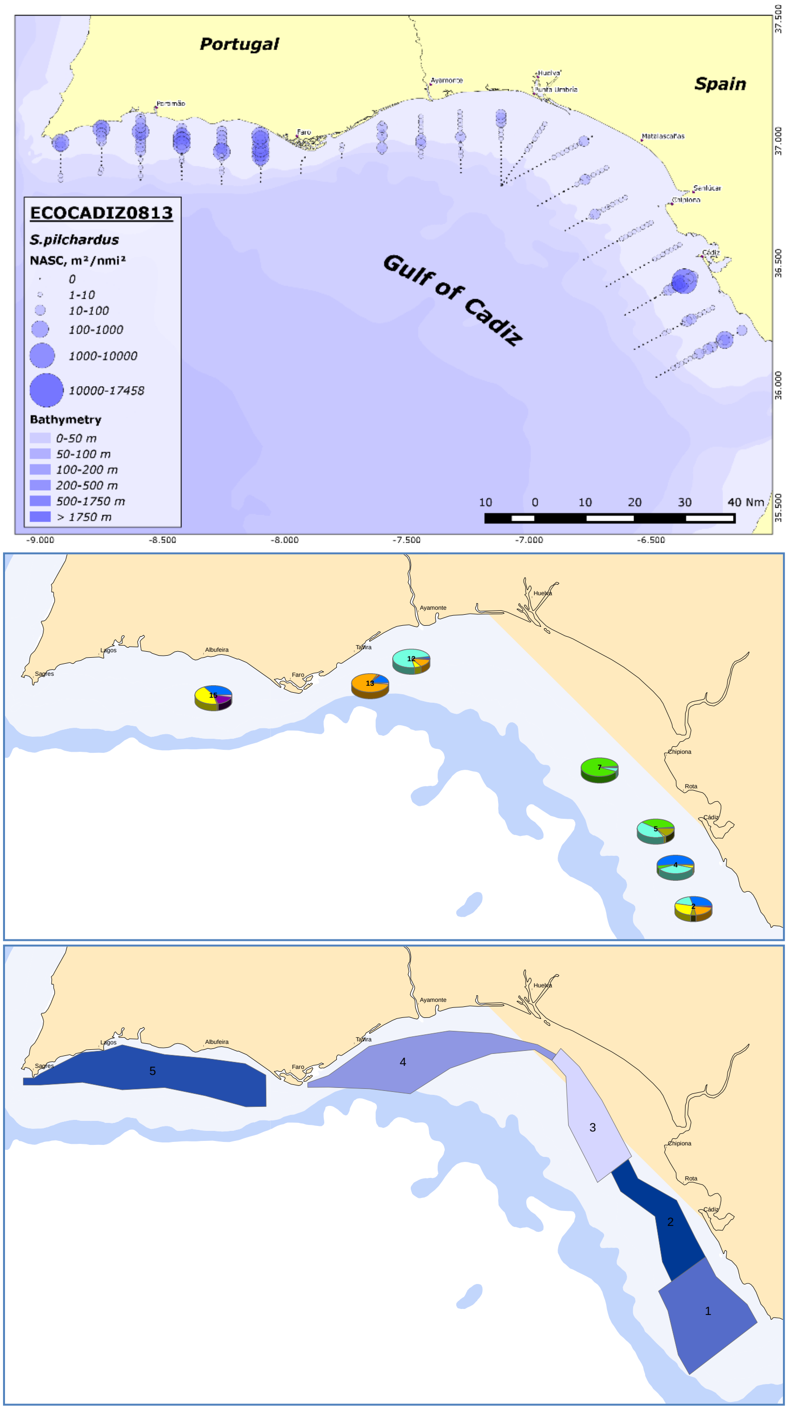


Figure 10. ***ECOCADIZ 0813*** **survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m² nmi⁻²) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the bio-mass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.**

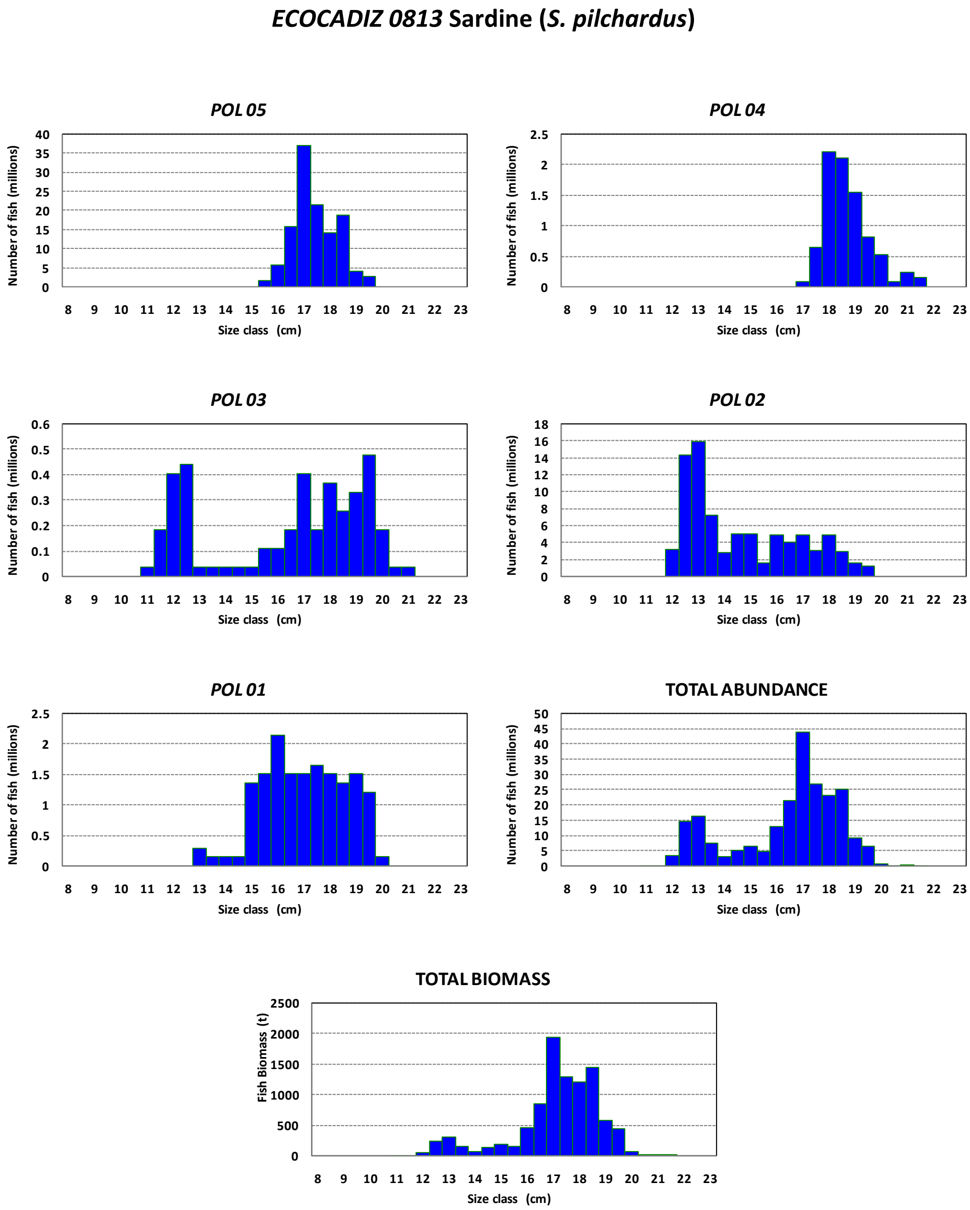
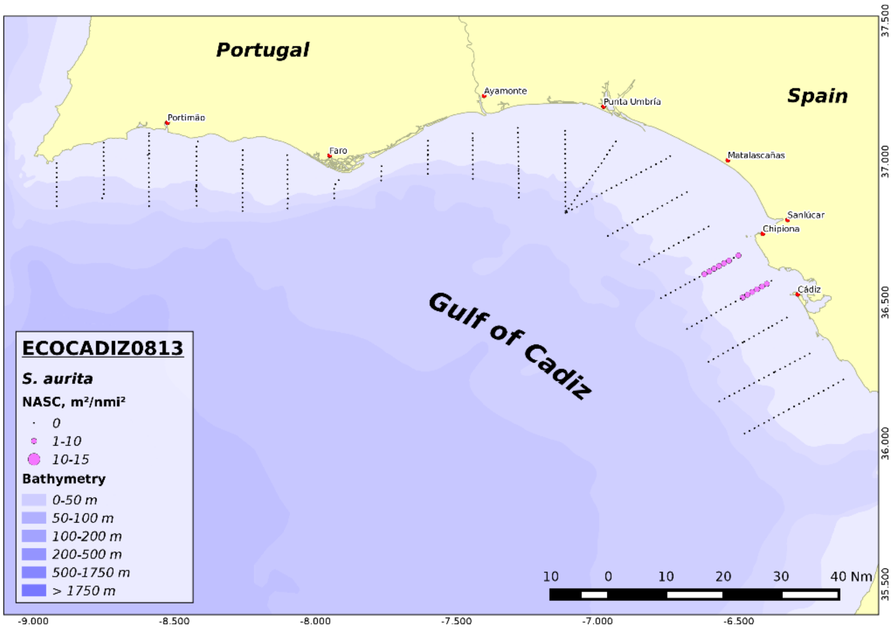


Figure 11. ***ECOCADIZ 0813*** **survey. Sardine (*****S. pilchardus*****). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 10) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.**



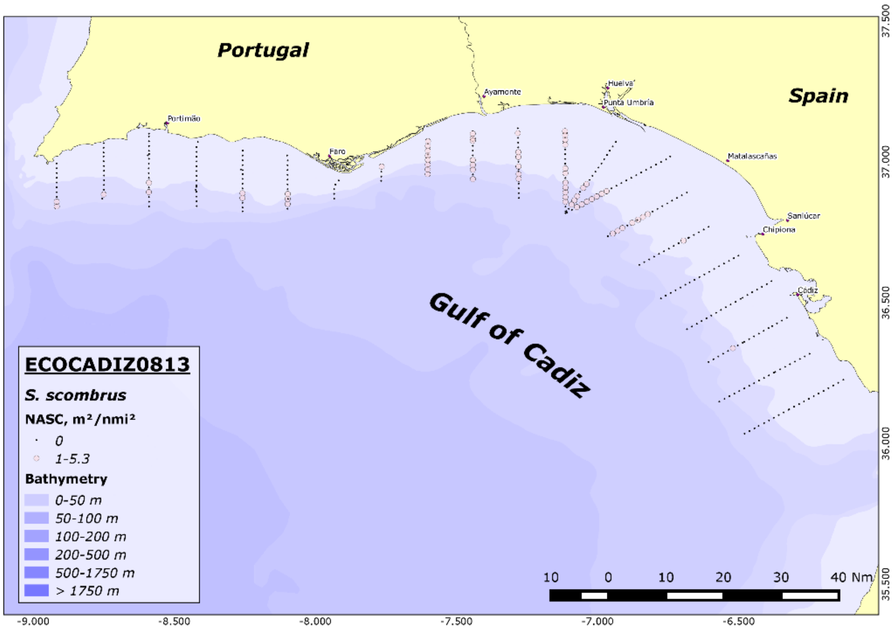


Figure 12. ***ECOCADIZ 0813*** **survey. Round sardinella (*Sardinella aurita*) and Mackerel (*Scomber scombrus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m² nmi⁻²) attributed to the species.**

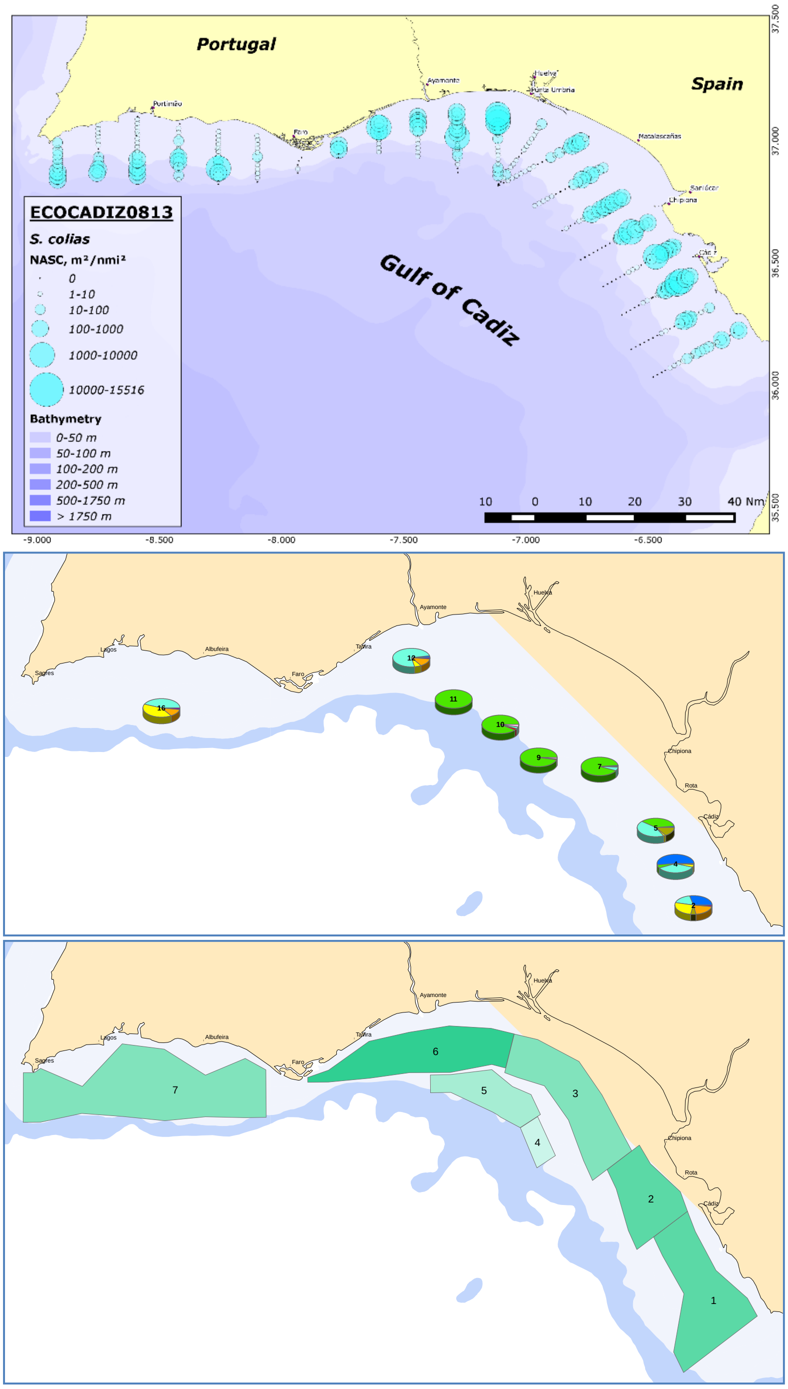


Figure 13. ***ECOCADIZ 0813*** **survey. Chub mackerel (*****Scomber colias*****). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m² nmi⁻²) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.**

ECOCADIZ 0813:* Chub mackerel *(S. colias)

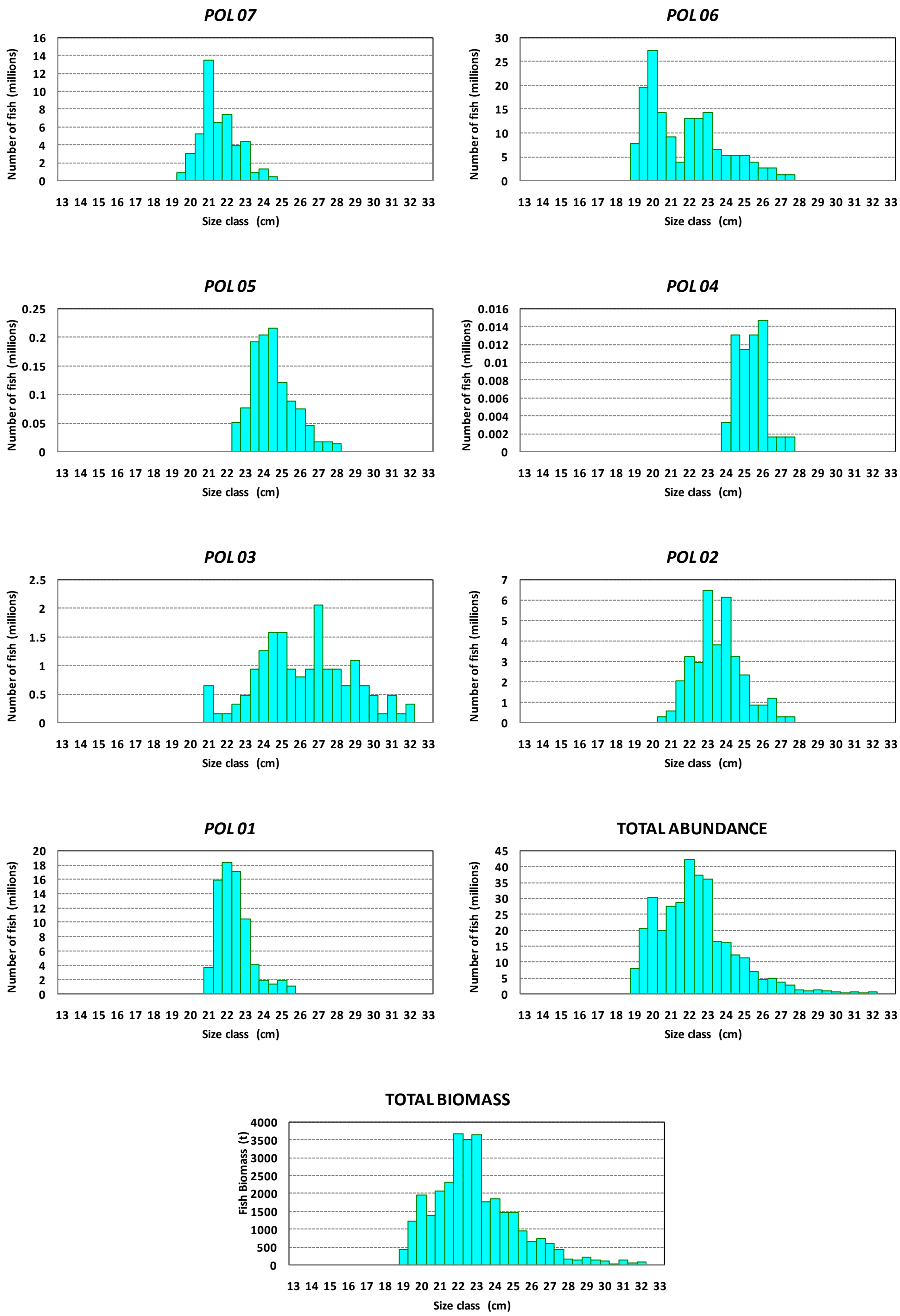


Figure 14. *ECOCADIZ 0813* survey. Chub mackerel (*S. colias*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 13) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

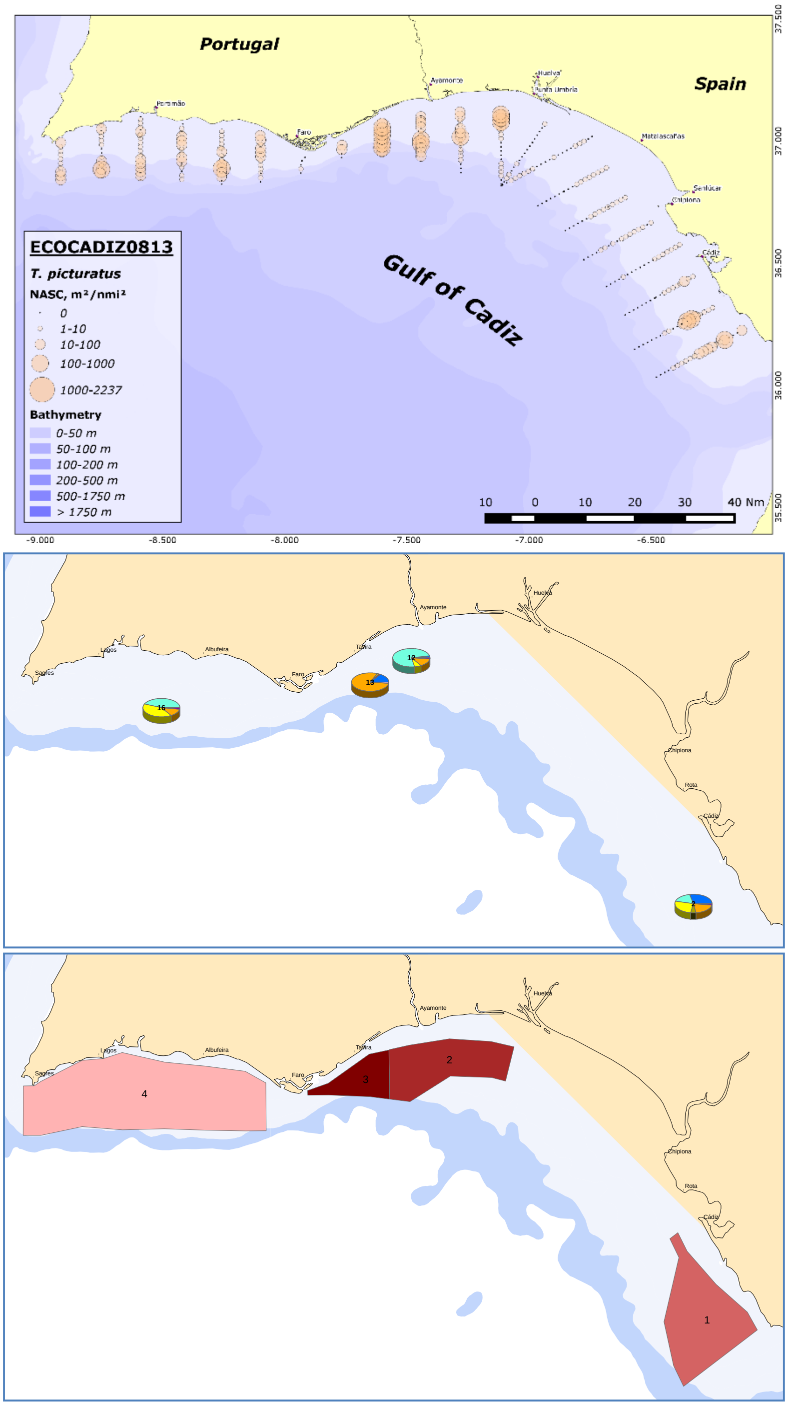


Figure 15. ***ECOCADIZ 0813*** **survey. Blue jack mackerel (*Trachurus picturatus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m² nmi⁻²) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.**

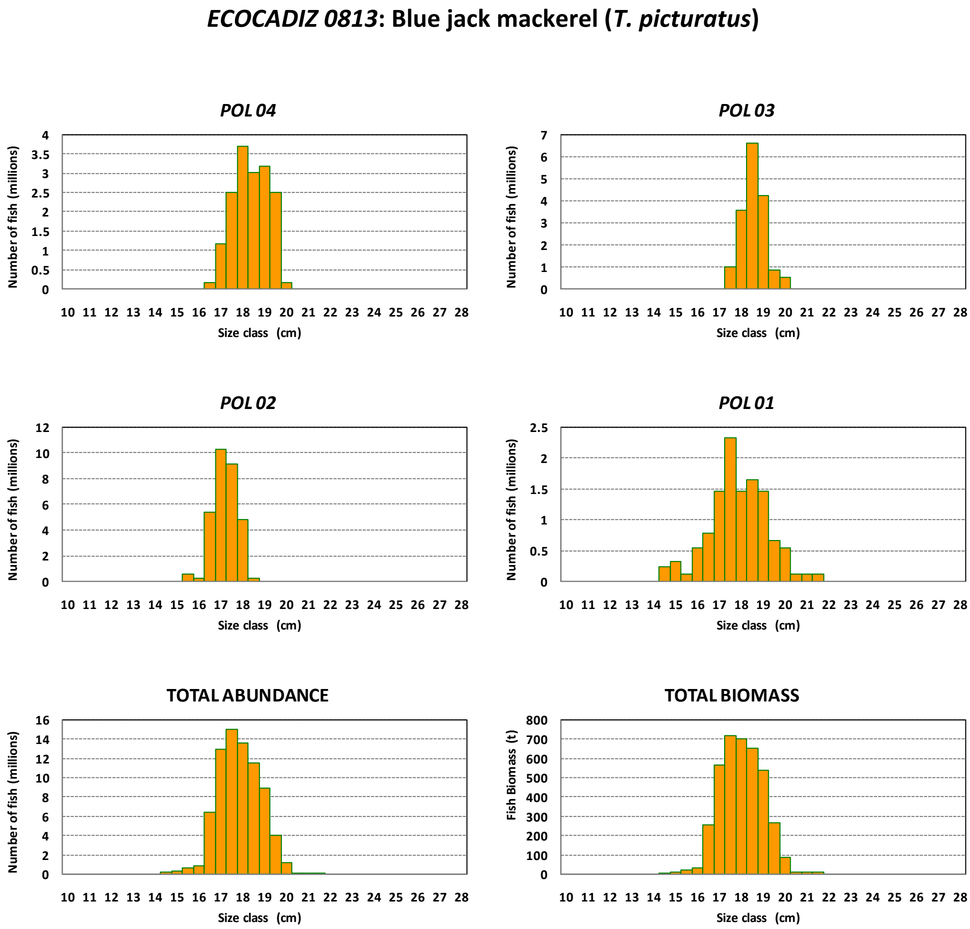


Figure 16. ***ECOCADIZ 0813*** **survey. Blue jack mackerel (*T. picturatus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 15) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.**

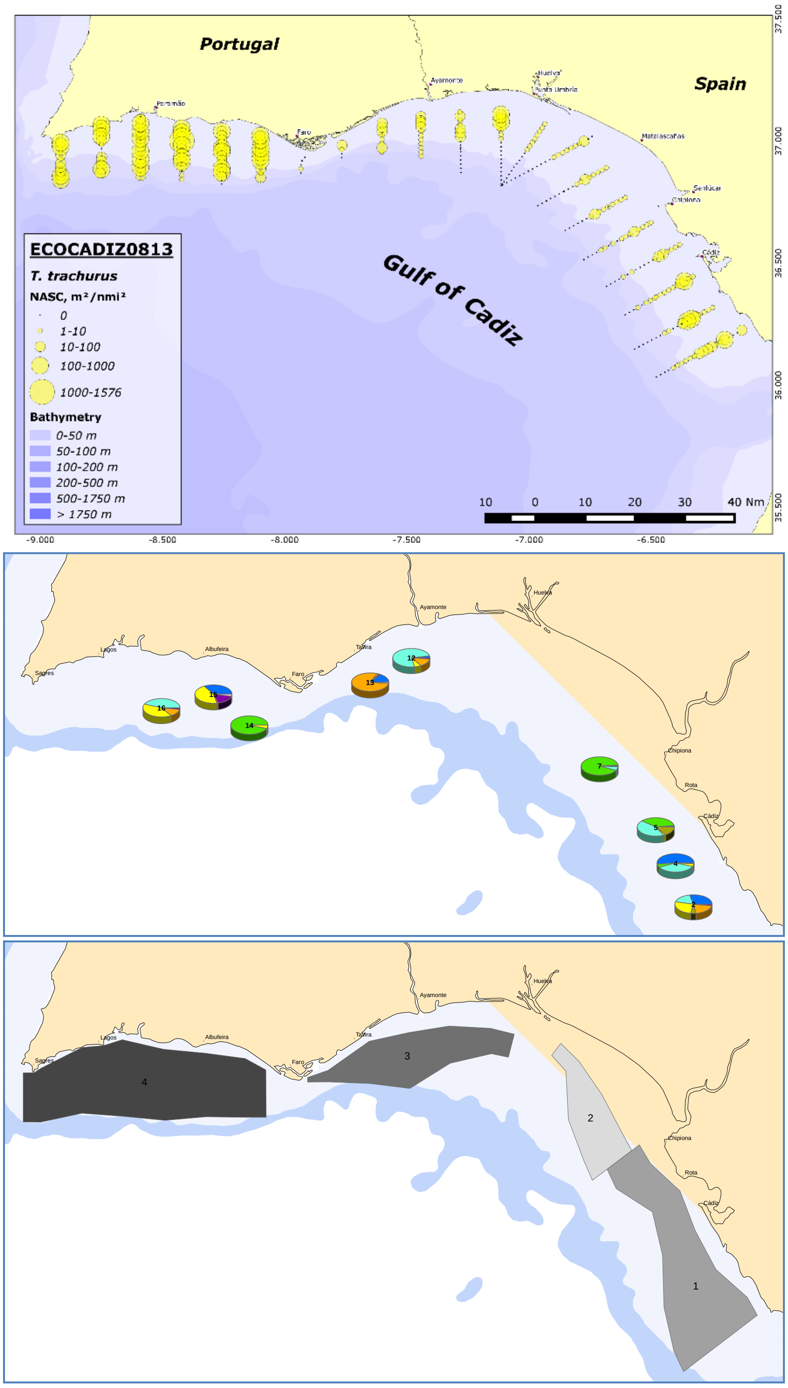


Figure 17. ***ECOCADIZ 0813*** **survey. Horse mackerel (*Trachurus trachurus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m² nmi⁻²) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.**

***ECOCADIZ 0813*: Horse mackerel (*T. trachurus*)**

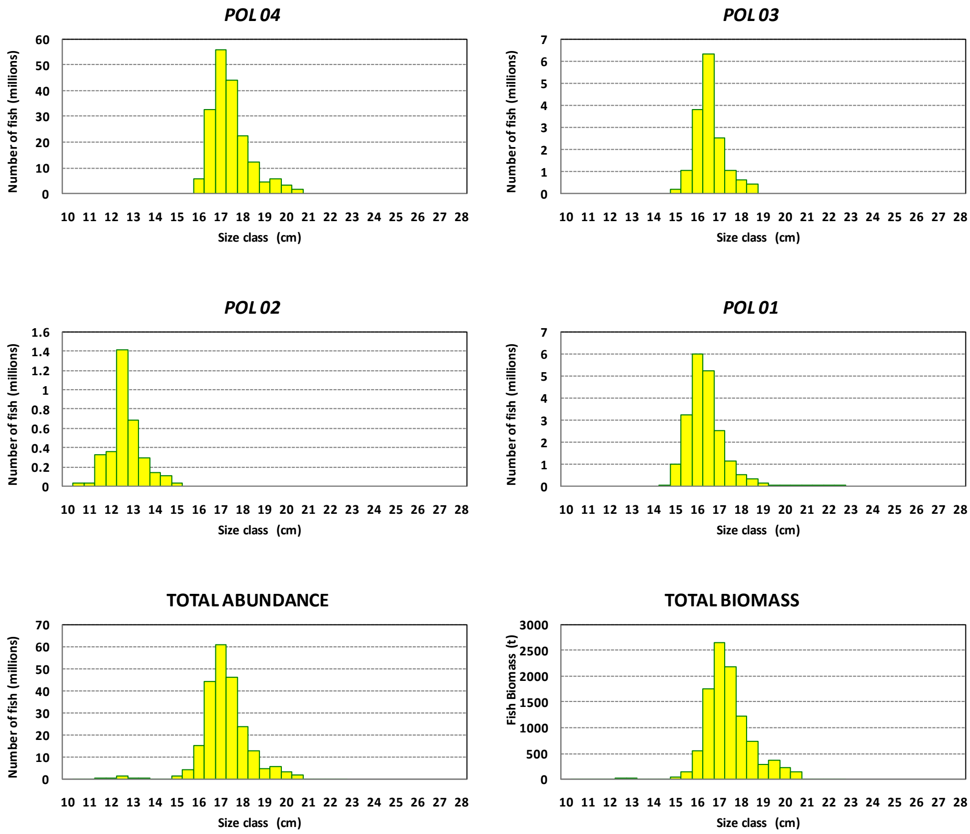


Figure 18. ***ECOCADIZ 0813*** **survey. Horse mackerel (*T. trachurus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 17) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.**

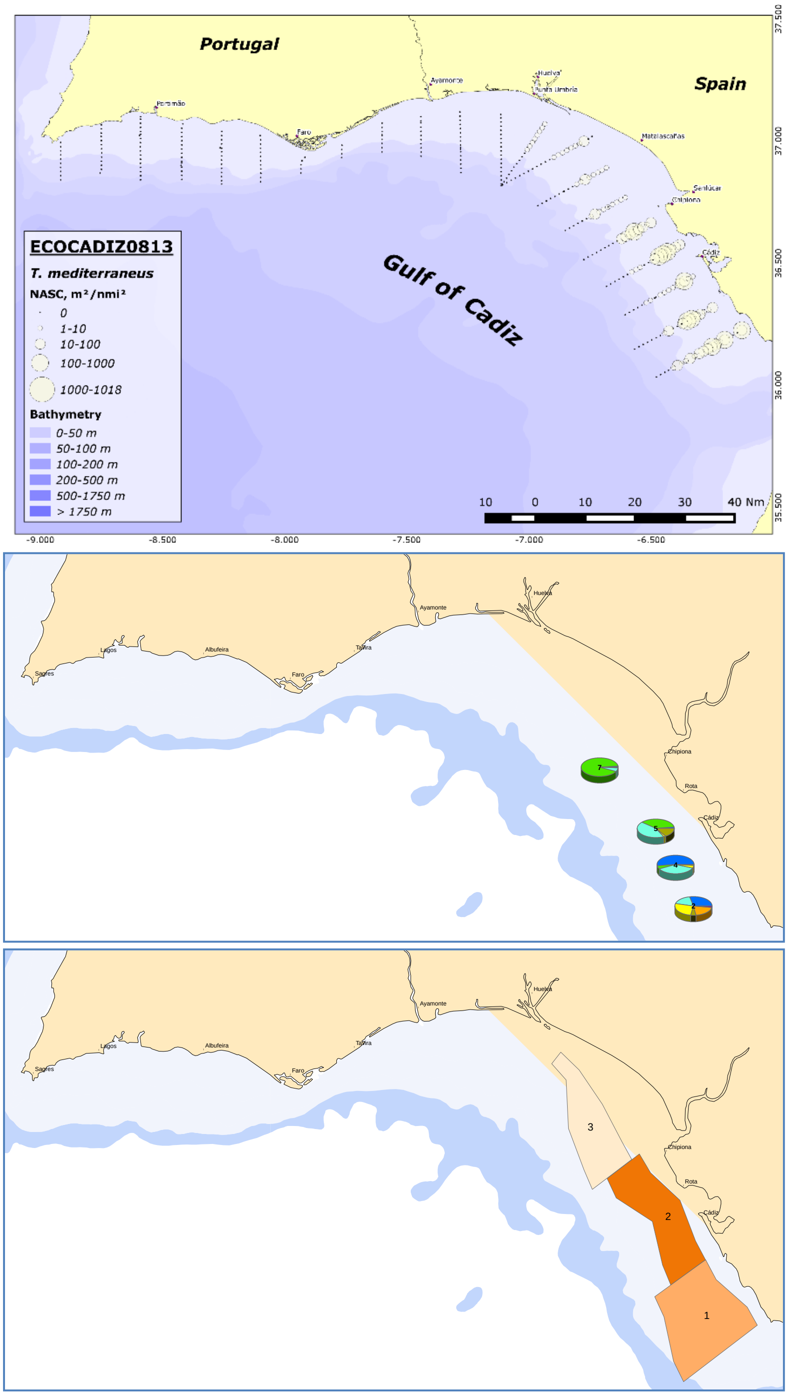


Figure 19. *ECOCADIZ 0813* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

***ECOCADIZ 0813*: Mediterranean horse mackerel (*T. mediterraneus*)**

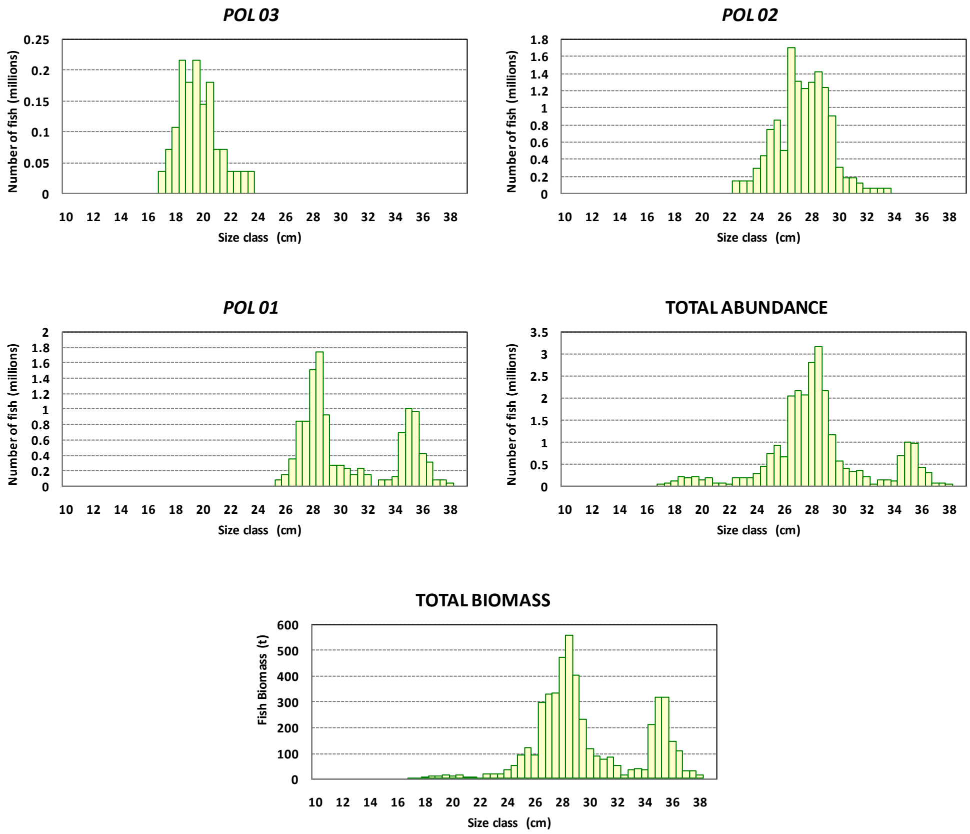


Figure 20. *ECOCADIZ 0813* survey. Mediterranean horse mackerel (*T. mediterraneus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 19) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

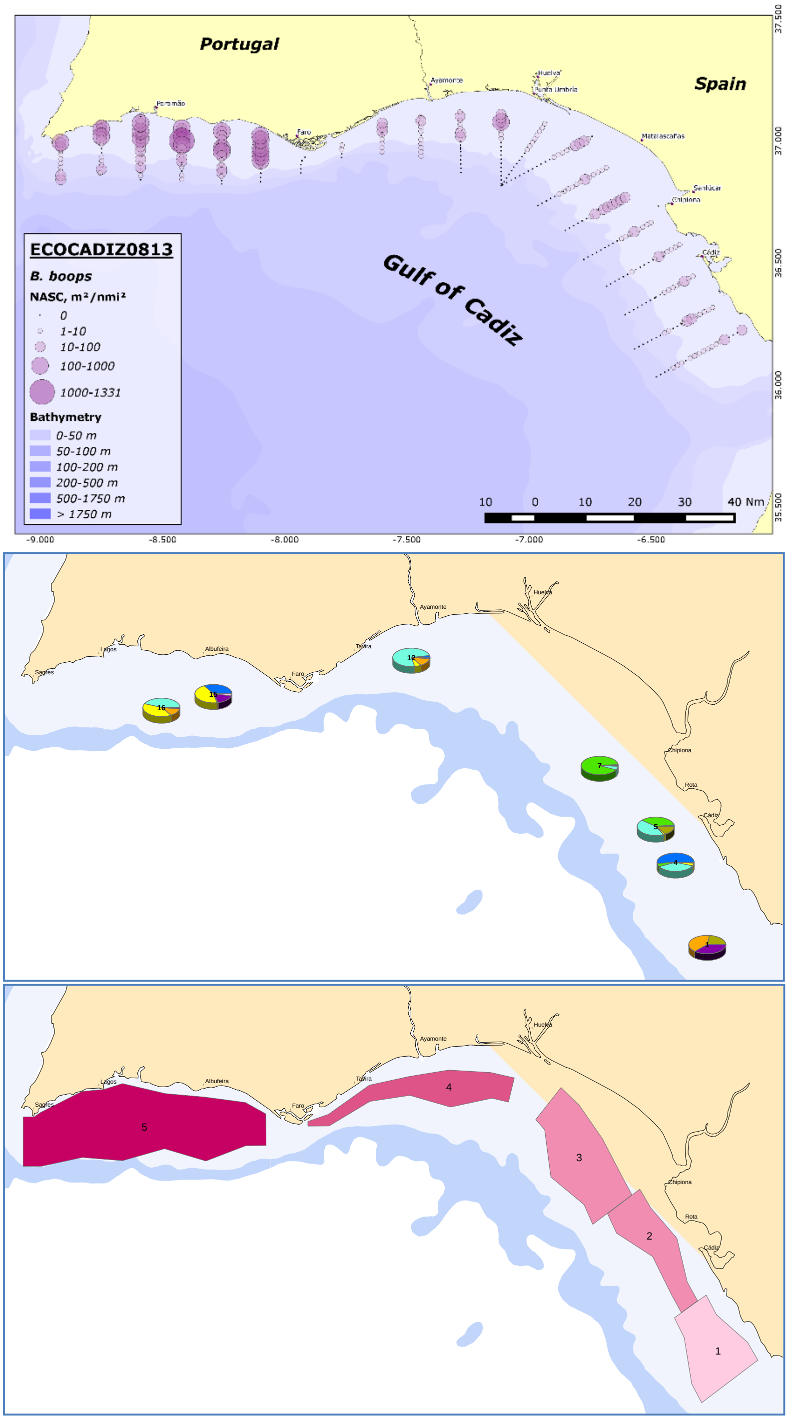


Figure 21. ***ECOCADIZ 0813*** **survey. Bogue (*Boops boops*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m² nmi⁻²) attributed to the species. Middle: valid fishing hauls for the species (more than 30 individuals showing a normal distribution). Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.**

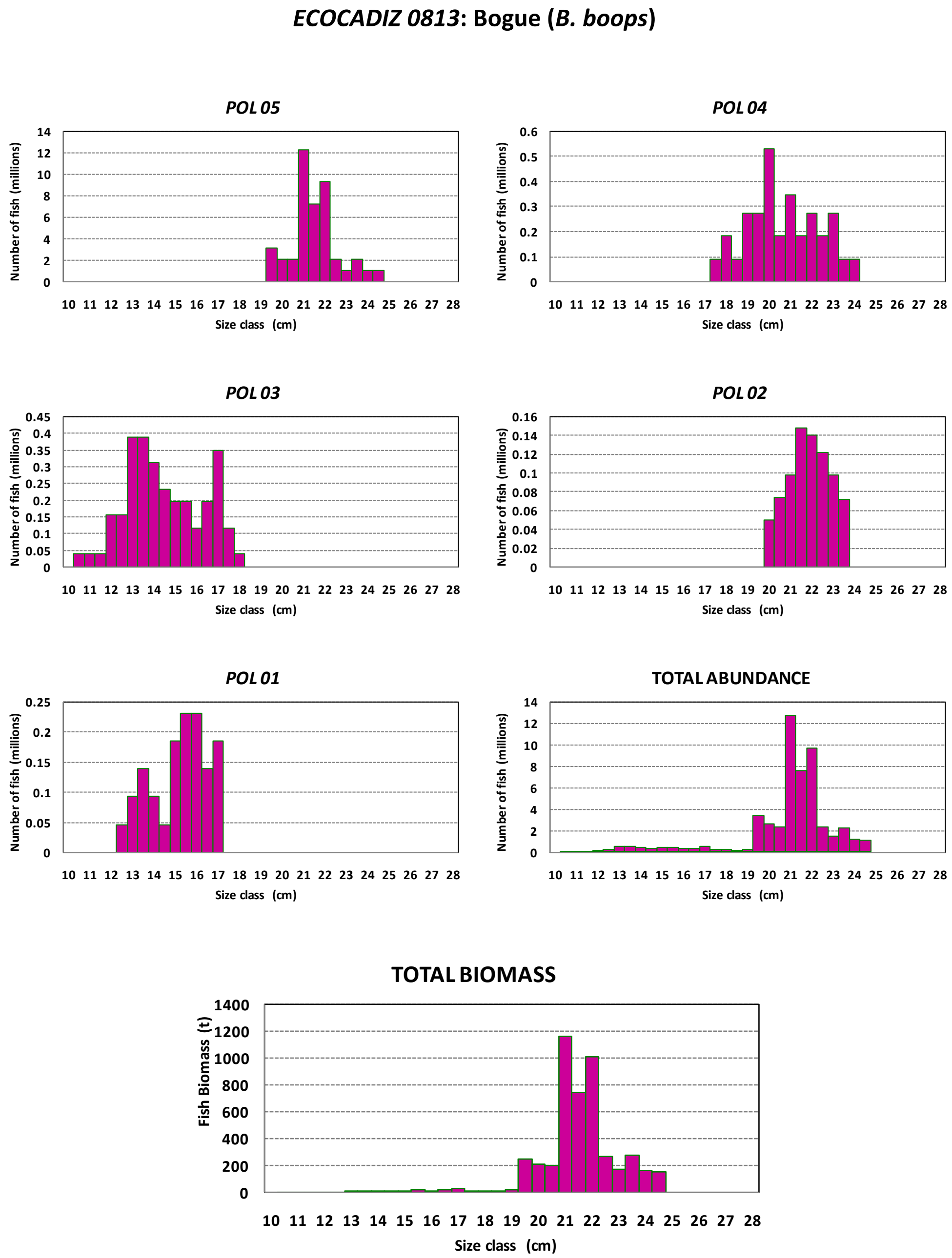
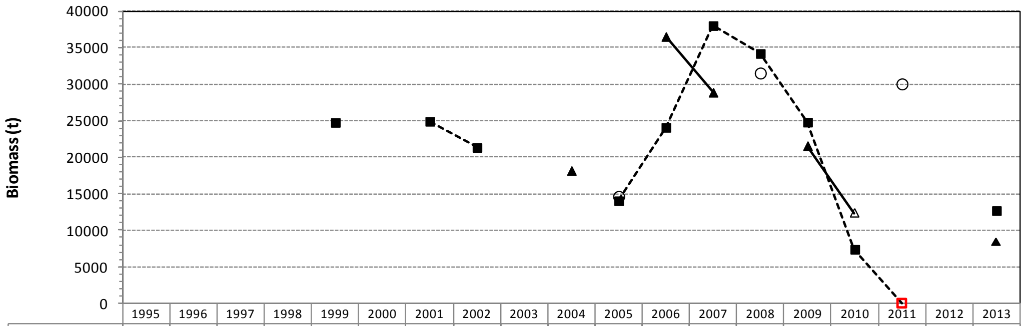


Figure 22. ***ECOCADIZ 0813*** **survey. Bogue (*B. boops*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in Figure 21) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.**

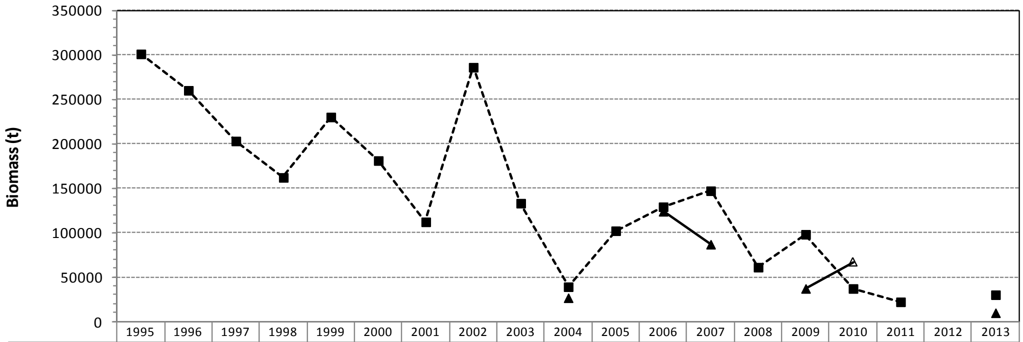
Biomass trends (in tonnes)

Anchovy biomass estimates



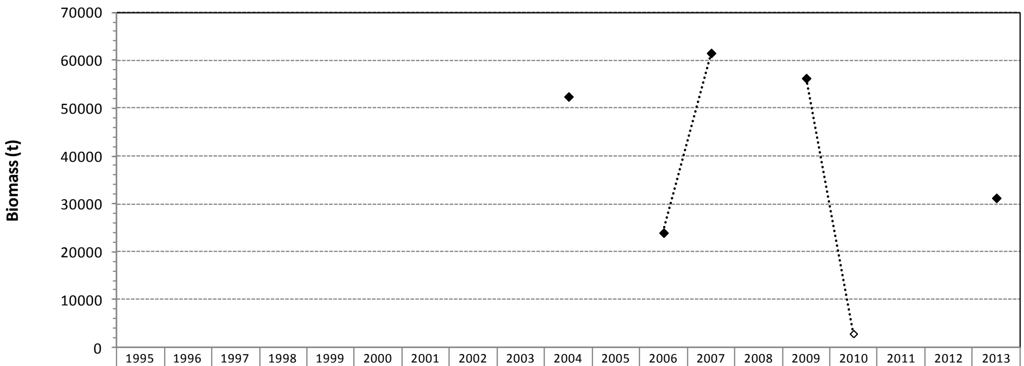
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PELAGO					24763		24913	21335			14041	24082	38020	34200	24800	7395	0		12700
ECOCADIZ										18177		36521	28882		21580	12339			8487
BOCADEVA											14637			31527			30037		

Sardine biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PELAGO	301000	260000	203000	162000	230000	181000	112000	286000	133000	39000	102000	129000	147000	61000	98000	37000	22000		30000
ECOCADIZ										26568		123849	86777		37020	66964			9670

Chub mackerel biomass estimates



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ECOCADIZ										52440		23994	61530		56276	2861			31267

Figure 23. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ*) survey series. Gaps for the 2005, 2008 and 2011 anchovy acoustic estimates in the *ECOCADIZ* series are filled with the *BOCADEVA* Spanish egg survey estimates. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.

Annex 3.4 DEPM 2014 Preliminary Egg Results for the Atlanto-Iberian Sardine ICES VIII and IXa

Working Document to be presented to the WGHANSA, Copenhagen, 20-25 June 2014

DEPM 2014 Preliminary Egg Results for the Atlanto-Iberian SardineICES VIII and IXa

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Jose Ramón Pérez[1].

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[2]Instituto Portugués do Mar e da Atmosfera – IPMA, Lisboa

This document provides the preliminary egg parameter results from the 2014 sardine DEPM (IPMA + IEO). This survey will be reported to WGACEGG in November 2014.

Summary

The triennial DEPM for estimation of sardine spawning biomass for the Atlanto-Iberian stock areas IXa-VIIIc and VIIIb up to 45ºN took place in the S and W (IPMA) from 15th March to 26th April and in the N (Galicia, Cantabrian Sea and French coast, IEO) between 29th March and 21st April. The whole area was surveyed however the Portuguese survey occurred much later than usual and suffered several interruptions; part of IPMA´s DEPM survey was conducted simultaneously to the acoustics survey onboard the same vessel. The number of fishing samples was maintained at levels similar to other years but it was evident that sardine schools were less available than during previous surveys in particular in the western and northern shores. Preliminary estimates highlighted a sharp decrease in egg production from 2011 to 2014; this pattern was particularly clear in the northern stratum.

Background

The DEPM for estimation of sardine spawning biomass within the Atlanto-Iberian stock area is conducted every three years by IPMA (Instituto Português do Mar e da Atmosfera, Portugal) and IEO (Instituto Español de Oceanografía, Spain) in an internationally coordinated survey. The Portuguese survey covers the Atlantic waters from the entrance of the Strait of Gibraltar to the northern border of Portugal in January/February, while the Spanish survey takes place in March/April in the northern area, from the Portuguese/Galician border to the south of the Armorican shelf, in French waters.

In 2014, the Portuguese survey (PT-DEPM14-PIL) took place exceptionally late in the reproductive season (off peak) due to technical constraints with the research vessel (RV Noruega); moreover it was interrupted in several occasions owing to adverse weather conditions and additional logistical issues. The region north of Lisbon was surveyed during the second half of March (15-21), the survey was then interrupted only to be resumed on the 4th of April; by this time together with the acoustics survey (PELAGO14) and restarting from south. During the period from 4th April to 13th May both surveys were carried out concurrently; the night period was used for plankton sampling while during light hours the acoustics surveying took place; adult sampling was directed at both surveys. Plankton surveying was repeated in the area north of Lisbon during the acoustics coverage in the region (1-13 May); the egg results available at present do not include the second coverage of the northern area.

The Spanish DEPM survey (SAREVA0414) was undertaken using two vessels; RV Vizconde de Eza , for plankton sampling mainly, from the 28th March to the 21thof April, and RV Miguel Oliver to obtain adult samples which were collected during the acoustics survey (PELACUS0414) from 26thMarch to 22ndApril. In 2014 IEO´s survey took place on board RV Vizconde de Eza (mostly for plankton surveying) instead of RV Cornide de Saavedra which was used from 1988 to 2011.

Analyses methodology

All calculations for area delimitation, egg ageing and model fitting for egg production (P0) estimation were carried out using the R packages (geofun, eggsplore and shachar) available at ichthyoanalysis (http://sourceforge.net/projects/ichthyoanalysis). The model of egg development with temperature was derived from the incubation experiment data available within the *sardata*, R library. Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*., (2008); a normal probability distribution was used with peak spawning assumed to be at 21:00h with 3h standard deviation. The exponential model: $E[P] = P_0\ e^{-Z\ age}$ was fitted by Generalized Linear Model (GLM), with a negative binomial function.

Strata definition (Figure 1): Stratum 1- South (IXa South): Strait of Gibraltar to Cape S. Vicente, Stratum 2 - West (IXa West) Cape S. Vicente to northern limit between Portugal and Spain; Stratum 3 -North (IXa North + VIIIc) from the Portuguese-Spanish border to the Spanish-French Atlantic limit.

The stratum furthest north, in French waters (sub-area of VIIIb up to 45ºN) was analysed separately.

Results

The surveys, in areas VIIIc and IXa, covered a total area of 80 830 km^2 of which 22 467 km^2 were considered the spawning area (Figures 1 to 3). In total 793 PairoVET samples were obtained (Table 1). Sardine egg distribution, derived from the PairoVET system, for the whole area is presented in Figure 3. The percentage of stations in the whole area with sardine eggs was 26.0% (S: 41.8%, W: 31.7%, N: 16.7%). In total, 2406 sardine eggs were collected by one of the paired PairoVET nets per survey. The egg numbers obtained in the south and west were comparable to 2011 but were much lower in the north. Measured SST ranged from 12.3 to 19.9ºC. Temperature distribution followed the common patterns; the highest temperature values were observed in the southern area and the lowest values registered for the Cantabrian Sea. The higher temperatures recorded in the south were likely due to the period of surveying later than usual, already after the onset of spring. The winter/spring atmospheric conditions in the Atlanto-Iberian region during the first quarter of 2014 were very unstable with episodes of heavy rain and strong wind events, this background led to a highly variable hydrodynamic setting with agitated shelf waters for quite long periods.

The egg production model selected includes independent egg production for the three strata and a common mortality (same model selected for the 2012 series revision, ICES 2012). It was not possible to estimate mortality per strata as the value for the western stratum was non-coherent (Table 2, Figure 4).

Summary:

- Portuguese survey conducted much later than usual (and with interruptions); consequently preventing solid comparisons of the 2014 results with the historic series;
- spawning area in 2014 for the whole area slightly reduced compared to 2011 and the smallest of the historic series; patchy egg distribution;
- spawning area reduction particularly evident in the north (around 40% of the total spawning area in 2011) while in the west it increased to almost the double;
- the southern and western regions showed similar daily egg production per m^2 (eggs/m^2/day) which was much larger than in the north; for all strata daily egg production per m^2 was much lower than in recent surveys;
- sum of total egg production for the 3 strata in 2014 much lower than in 2011, in particular in the northern and southern regions, similar in the west (Table 2 and Figure 5);
- mortality value (single mortality for whole area) similar to 2005 and one of the lowest of the series but with high CV;
- to note that these are preliminary estimates; the complete set of data will be available before the WGACEGG meeting and the analyses repeated and further discussed;
- during the 2014 survey the availability of adult sardine for trawling was limited in the whole area; nevertheless 36 samples were obtained, 11 in the south, 10 in the west and 15 in the north; extra samples (14) from purse-seiners were collect in Portugal;
    - the number of hydrated females collected was higher than in 2011
    - no estimates are available at present for the adults parameters

sub-region VIIIb (French waters)

- 128 PairoVET samples taken in French waters in area VIIIb; 60% with eggs
- high egg densities were observed in the area furthest north; the large majority of the sardine eggs observed during the IEO survey (1449 in a total of 1765; 82%) were collected in the sub-region VIIIb;
- spawning area in 2014 reduced to 7914 km^2 compared to 2011 survey (12 400 km^2);
- daily egg production per m^2in 2014 (212) similar to 2011 survey and much larger than in previous surveys;
- total egg production (eggs/day) in 2014 lower than in 2011, 1.67 compared to 2.72 respectively;
- daily egg production per m^2 and total egg production (eggs/day) much higher than in the adjacent stratum, in Cantabrian waters (IXa North + VIIIc).

<u>GLM model adjustment:</u>

```
Call:
glm.nb(formula = cohort ~ offset(log(Efarea)) - 1 + Stratum +
    age, data = aged.data, weights = Rel.area, init.theta = 0.292046895523314,
    link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.68744  -1.04106  -0.73700   0.02468   3.27516

Coefficients:
```

```
        Estimate Std. Error z value Pr(>|z|)
Stratum1  4.60780    0.27945  16.489   <2e-16 ***
Stratum2  4.62316    0.24360  18.978   <2e-16 ***
Stratum3  3.63291    0.25887  14.034   <2e-16 ***
age      -0.01250    0.00629  -1.988   0.0468 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(0.292) family taken to be 1)

    Null deviance: 4367.54  on 521  degrees of freedom
Residual deviance:  413.08  on 517  degrees of freedom
AIC: 1758.9

Number of Fisher Scoring iterations: 1


              Theta:  0.2920
          Std. Err.:  0.0272

 2 x log-likelihood:  -1748.9290
```

References

Bernal, M., Ibaibarriaga, L., Lago de Lanzós, A., Lonergan, M., Hernández, C., Franco, C., Rasines, I., et al. 2008. Using multinomial models to analyze data from sardine egg incubation experiments; a review of advances in fish egg incubation analysis techniques. ICES Journal of Marine Science, 65: 51–59.

ICES. 2012. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 26-30 November 2012, Fuenguirola, Spain. ICES CM 2012/SSGESST:16. 221 pp.

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Tables and Figures

Table 1. General egg and adult sampling sardine DEPM 2014.

*** acoustics surveying included, not all hauls directed at sardine echotraces**
purse-seiners samples not included

Institute	IPMA	IPMA	IEO	IPMA/IEO	IEO
Survey area	IXa South	IXa West	IXa N + VIIIc	IXa+VIIIc	VIIIb (up to 45º N)
SURVEY EGGS					
R/V	Noruega	Noruega	Vizconde de Eza		Vizconde de Eza
Date	04/04-15/04	15-21/03; 15-26/04	29/03-21/04		09/04-16/04
PairoVET stations	134	265	394	793	128
Positive stations	56	84	66	206	77
Tot. Eggs	1042	1051	316	2406	1449
Max eggs/m2	5900	1620	704	5900	2619
Temp (ºC) min-max	14.4-19.9	12.8-14.9	12.3-14.9	12.3-19.9	12.3-14.5

Institute	IPMA	IPMA	IEO	IPMA/IEO	IEO
Survey area	IXa South	IXa West	IXa N + VIIIc	IXa+VIIIc	VIIIb (up to 45º N)
SURVEY EGGS					
Max age (hour)	57.7	59.2	74.2	56.1	74.3
SURVEY ADULTS					
Numbers of hauls*	13	31	57	101	13
Positive hauls	11	10	15	36	3

Table 2. Egg parameters from 2014 sardine DEPM survey.

Institute	IPMA	IPMA	IEO	IPMA+IEO (total)	IEO
Parameter/Area	IXa South	IXa West	IXa N + VIIIc	IXa+VIIIc	VIIIb (up to 45º N)
Survey area (Km2)	14558.7	27357.3	38914.4	80830.5	13480.4
Positive area (Km2)	6077.2	8895.7	7494.5	22467.4	7913.8
Z (hour-1) (CV%)	-0.012 *(50.3)				-0.021*** (29.2)
P0 (eggs/m2/day) (CV%)	100.3 (27.9)	101.8 (24.4)	37.8 (25.9)		211.5 (27.5)
P0 tot (eggs/day)(x1012) (CV%)	0.61 (27.9)	0.91 (24.4)	0.28 (25.9)	1.80 (16)	1.67 (27.5)

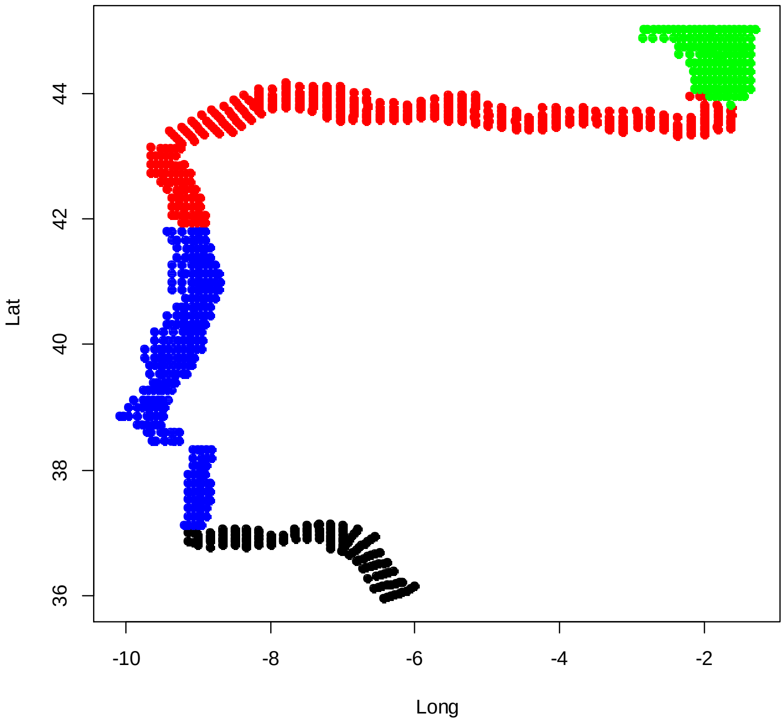


Figure 1. PaioVET hauls undertaken and spatial strata definition (black- IXa South; blue – IXa West; red – Ixa North+ VIIIc; green – sub-area of VIIIb).

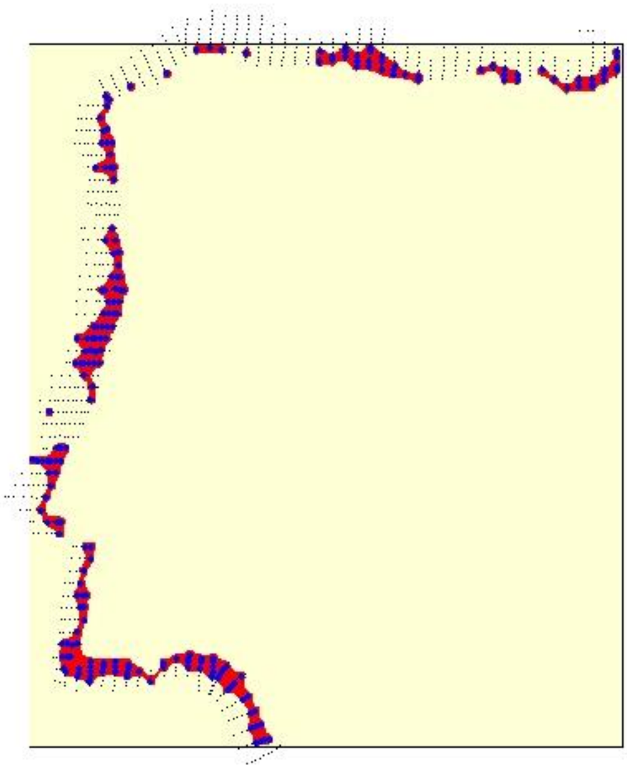


Figure 2. Positive area estimated for area VIIIc and IXa (22 467.4 km2 from a total Iberian Peninsula surveyed area of 80830.5 km2).

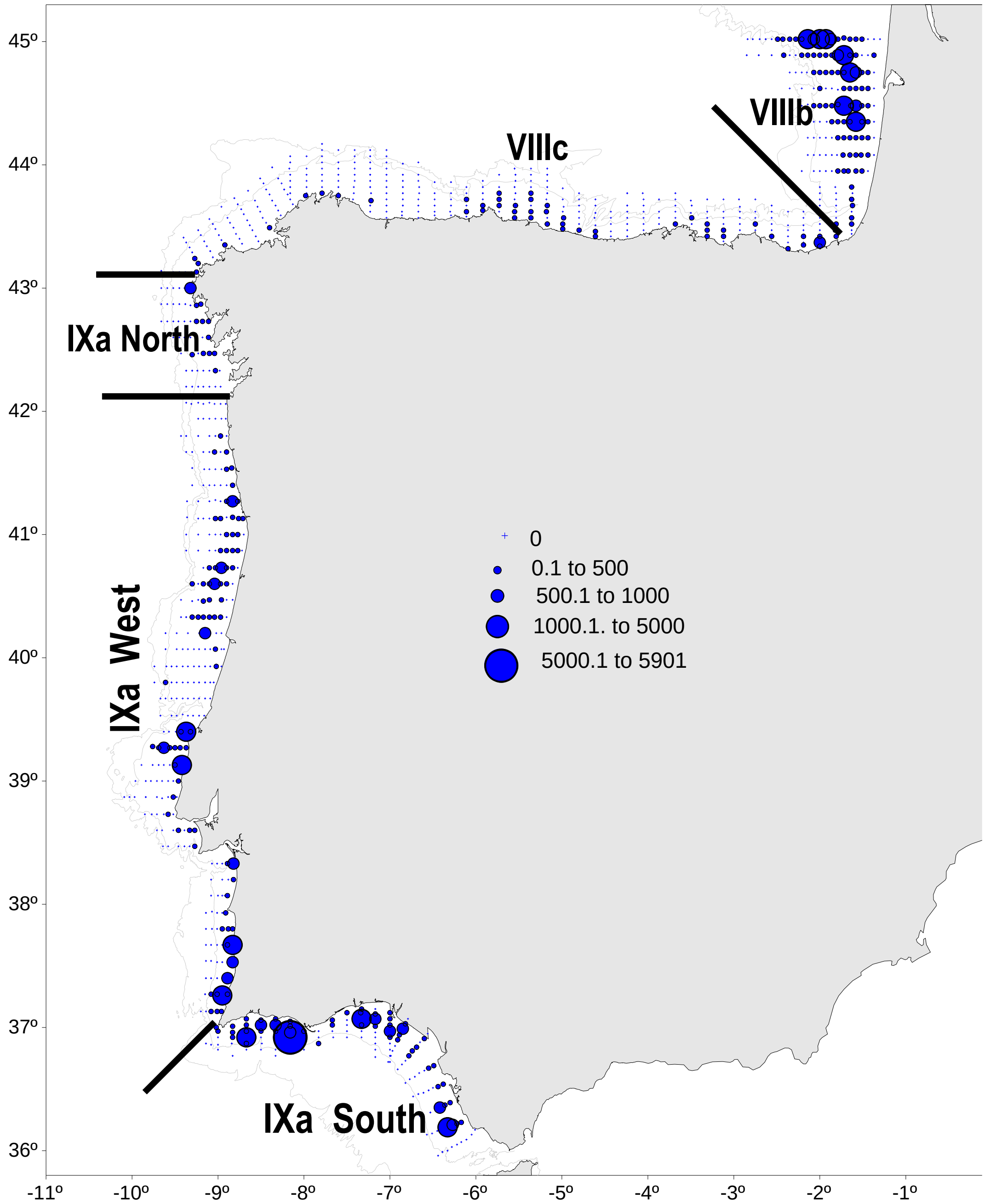


Figure 3. Sardine egg distribution. Egg/m2 from PairoVET sampling (+, egg absence). The areas indicated refer to the nomenclature used in the text

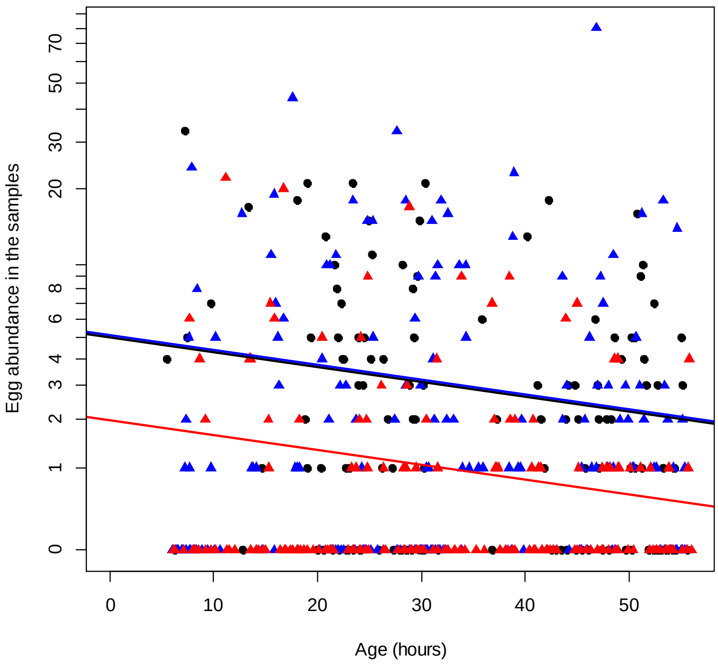
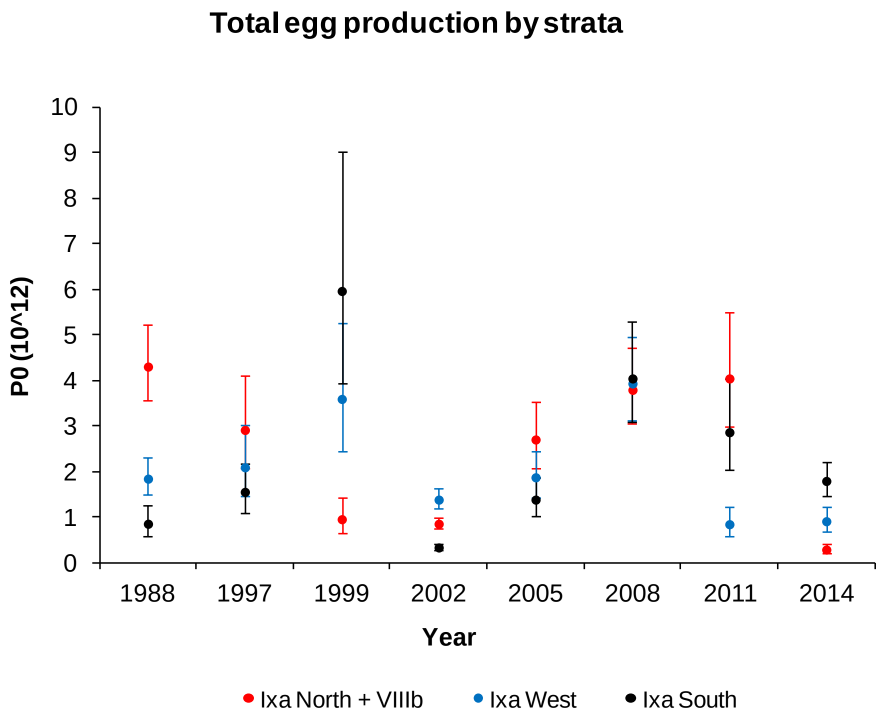


Figure 4. Abundance by age of eggs in the different spatial strata (black-south, blue-west stratum, red-north) and fitted mortality curve (single mortality for all strata).



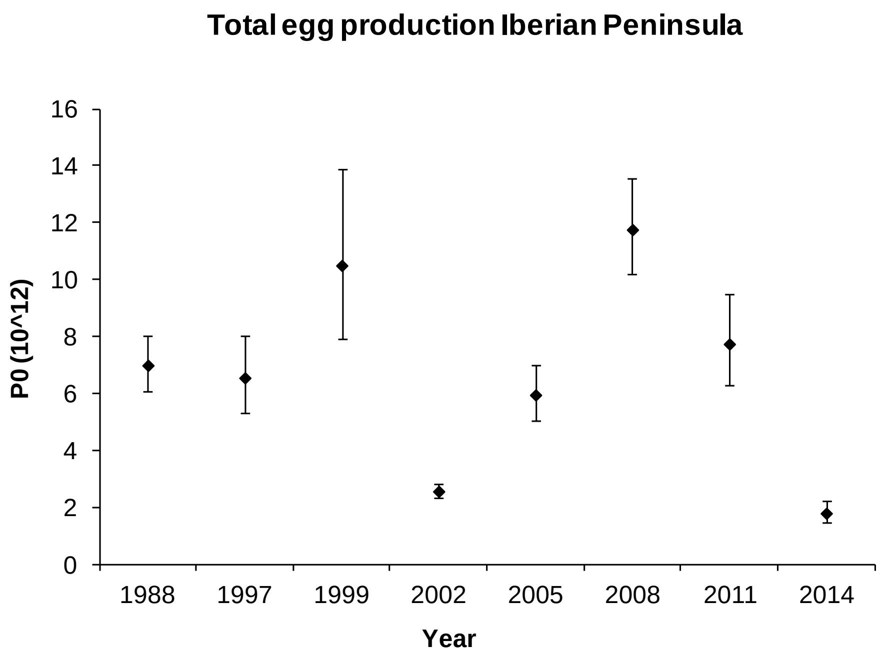


Figure 5. Total egg production (eggs/day*10^{12}) by spatial strata (top panel); black – IXa South, blue - IXa West stratum, red – IXa North + VIIIc and for the total stock area off the Iberian Peninsula (bottom panel). Dots and lines indicate the estimates of egg production and their confidence intervals.

Annex 3.5 Preliminary index of biomass of Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2014 applying the DEPM and sardine total egg abundance

Pdf document on the following pages

Annex 3.6 Direct assessment of small pelagic fish by the PELGAS14 acoustic survey

Pdf document on the following pages

Annex 3.7 Update on the discards of WGHANSA species by the Portuguese bottom otter trawl fisheries in ICES Division IXa (2004–2013)

Pdf document on the following pages

Annex 3.8 Preliminary results of the pelacus0314 survey: estimates of sardine abundance and biomass in Galicia and Cantabrian waters

Pdf document on the following pages

Annex 4: Stock Data Problems Relevant to Data Collection – WGHANSA

Stock	Data Problem	How to be addressed in	By who[1]
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.
Blue Jack Mackerel in the waters of the Azores	Missing longline CPUEs time series since 2011	Longline CPUEs provide indices on adult abundance. These indices are derived from observer at sea program. Those datasets should be collected and be made available on an annual basis	PGCCDBS, national administration
Anchovy in IXa South.	Spanish survey on anchovy in Cadiz (DEPM BOCADEVA) which is one of the pillars for the trend assessment are not guarantee by Spanish administration and Not funded within the DCF.	These survey need to be funded by the EC through the DCF	PGCCDBS, and RCM SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)
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 recommendsDCFto economically support an autumn acoustic survey for provision of recruitment indices for sardine and anchovy. This could be addressed by a coordinated survey between IPMA and IEO, covering the NW of Portugal and Cadiz where major recruitment of sardine and anchovy occur.	SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST) PGCCDBS should support the idea of such a Survey and communicate to RCM and to relevant bodies accordingly The same idea was recommended by WGHANSA and WGACEGG since 2009

[1] Recommendations on surveys for be addressed by the SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)

Stock	Data Problem	How to be addressed in	By who1
Sardine in VIIIc and IXa Anchovy in IXa.	No intercalibration has been made between R/V Noruega and R/V Miguel Oliver	The WG recommends an intercalibration between the Spanish, Portuguese to ensure the correct use of the joint biomass indexfor sardine in the assessment along the time series and compatibility between surveys results for anchovy.	To SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST) and WGACEGGs And to IEO and IPMA
Anchovy in IXa	There is a need to improve the age reading methodology, specially on the southern areas of the stock.	The WG recommends an otolith exchange between Spain and Portugal	PGCCDBS
Sardine in subarea VII	The WG noticed that there is no monitoring program of sardine catches, age lenth keys, lenth distribution, discards and effort data in subarea VII. This hampers assessment and provision of advice for this region	The WG demands that a Monitoring of sardine (catches, lenth, ALK, effort and discards) 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. This is recommended since 2011. No information has been made available so far.
Sardine in VIIIc& IXa	Due to low sardine abundance in the Galician and Cantabrian areas, collaboration between the R/V Miguel Oliver and commercial vessels will increase considerably the reliability of the abundance index estimate, particularly in terms of echoe determination	The WG recommends the continuation through DCFor national fundings.	SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST) PGCCDBS This is a recommendation already made in 2013.
Sardine in VIIIc& IXa	Differences in trends between DEPM and acoustics.	Cross validation between DEPM and acoustics indices (namely 2014 surveys)	WGACEGG
Sardine in subarea VIIIabd and VII	The WG noticed that there is a need for surveys in VII on small pelagics.	Design and support economically such a survey	SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)

Stock	Data Problem	How to be addressed in	By who1
Anchovy in Subarea VIII	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.	DCFto economically support the continuation of the acoustic assessment of juveniles in the Bay of Biscay (JUVENA survey)	SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST) 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	The WG recommends the continuation through DCFor national fundings.	SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST) 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.
Southern Horse Mackerel in IXa	Combination of indices from trawl surveys carried out in contiguous areas	Development and testing and methodologies to provide a combined abundances at age indices	SCICOM Steering Group on Ecosystem Surveys, Science and Technology (SSGESST)

Annex 5: Stock annexes

Annex 5.1Stock Annex: Bay of Biscay Anchovy (Subarea VIII)

Stock	Bay of Biscay Anchovy (Subarea VIII)
Working Group	WGHANSA (Working Group on the Assessment of Southern Horse Mackerel, Anchovy and Sardine)
Date	October 2013
Revised at	WKPELA 2013 and during & after WGHANSA2013 and approved by ICES ACOM
Authors	G. Boyra, E. Duhamel, L. Ibaibarriaga, J. Massé, L. Pawlowski, M. Santos and A. Uriarte.

A. General

A.1. Stock definition

The Anchovy (*Engraulis encrasicolus* L) inhabiting Subarea VIII (Bay of Biscay) is considered to be isolated from a small population in the English Channel and from the populations in western Iberia (Division IXa) (Magoulas *et al*., 2006; Zarraonaindia *et al*., 2012). Morfometrics and meristic studies suggest some heterogeneity at least in morphotipes (Prouzet and Metuzals, 1994; Junquera and Pérez-Gandaras, 1993). Along the North of Spain (in Division VIIIc) Junquera and Pérez-Gandaras (1993) had already reported significant morphological differences in anchovies between Galicia, Asturias, and the Basque Country, and recently Borrell *et al*. (2012) have pointed out that there is some genetic isolation of anchovies in the middle west side of this division from the eastern one. In addition, 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). Despite the evidences for some heterogeneity and perhaps subpopulation in parts of the Bay of Biscay (western Cantabria), there are ample evidences that the major part of the population inhabits the Eastern and northern parts of the Bay of Biscay and show rather homogenous recruitment pulses and have a rather well understood common spatial dynamics throughout the year (Uriarte *et al*., 1996). This leads ICES to consider that the anchovy in this area should be dealt as a single stock for assessment and management.

A.2. Fishery

The fisheries were closed from July 2005 to December 2009 due to poor condition of the stock. It was reopened in January 2010 with a TAC of 7000t. 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, Uriarte *et al.* (2008);Villamor *et al.* (2008), for the Spanish fishery and Duhamel(2004) and Vermard *et al.* (2008) for the French pelagic trawler. According to information provided by the SWWRAC in 2009 during the closure of the fishery the fleet size operating on anchovy decreased and the fleets redeployed their effort towards other small pelagic species (57%) and tuna (29%).

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 (Goñi *et al*., 2011a,b; López-López *et al*., 2012). In addition to predator interactions on adults, in recent years major attention is being paid to the role that intraguild predation may have in affecting the survival of early life stages (Irigoien and Ross, 2011), and for this anchovy the potential influence of sardine predating on anchovy eggs has been evidenced (Bachiller *et al*., submitted).

The recruitment depends strongly on environmental factors. Recently ICES WGSPEC (ICES, 2012) has reviewed the role that environmental factors may have on determining the success of recruitment. Two environmental recruitment indices have been considered during the last ten 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 and Petitgas (WD 2007, 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). From the latter studies the issue of much drifting (induced by the Upwelling) of the anchovy eggs and larval out of the shelf is controversial among scientists (Borja *et al*., 1996; 1998; Uriarte, 2001; Allain *et al*., 2001; 2007; Irigoien, 2007; 2008).

Recent research for identifying and monitoring limiting factors of anchovy recruitment in the Bay of Biscay was made by Petitgas (2011). Indices of physical features were estimated (river plumes, gyres, stratification, fronts) as well as indices of larval dispersal, primary production and temperature. Indices of spawning aggregations derived from fisheries survey data were also estimated. Results showed that the larval period was where many indices responded, confirming that it is a critical period. The limiting factors changed across the series, confirming the multiple nature of the determinism of recruitment.

Fernandes *et al*. (2010) presents an alternative to attempt to relate environmental indices with recruitment by means of linear models. They use 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. Environmental variables seem to explain a significant part of the observed variability of the small pelagics but not more than 50% of it (at least from the available indicators), so that there is space for looking for other supplementary variables driving recruitment for these species. The significance and reliability of all these indices is considered still insufficient for their consideration alone in the provision of management advice. But they are considered valuable informationaccompanying the forecasts given from recruitment surveys such as JUVENA. It is certainly useful their consideration for further improvements.

B. Data

B.1. Commercial catches

Annual landings are available since 1940. 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.
- Age reading is considered accurate.

  The most recent cross reading exchanges and workshop took place in 2009 WKARA (ICES CM 2009/ACOM:43). The overall level of agreement and precision in anchovy age reading determinations seemed to be satisfactory: Most of the anchovy otoliths were well classified by most of the readers during the exchange (with an average agreement of 88.8% and a CV of 12.9%). CV was minimum at age 0 and increased slightly with age while the percentage of agreement decreased with age (with Percentage of agreement with the modal ages of 100%, 83%, 91% and 63% respective to ages 0, 1, 2 and 3). The most expert readers who are in charge of the largest fraction of the international catches showed higher agreements than the rest of readers.
- In former workshops between Spain and France which 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 was also 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%. 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 0.8 for age 1 and at 1.2 for older individuals. This parameter is considered to vary between years, but it is assumed to be constant for the assessment of the stock.

- In the CBBM assessment model the parameters G_1 and G_{2+} representing the annual intrinsic growth of the population by age class are assumed constant along years and are estimated based on the weight-at-age data.

B.3. Surveys

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; Santos *et al.*,2011) 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 (this equals total stock biomass since all anchovies are mature in spring) and population-at-age estimates. The surveys have shown pronounced interannual 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).

The spring surveys provide 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 one year old anchovies being born at the time the surveys take place. Since 2003 an autumn acoustic survey (JUVENA) is conducted yearly. The main objective of this survey is estimating the anchovy juvenile abundance in order to forecast the strength of the recruitment that will enter the fishery the next year.

B.3.1 Anchovy Daily Egg Production Method

B.3.1.1 The DEPM model

The anchovy spawning–stock biomass estimate is derived according to Parker (1980) and Stauffer and Picquelle (1980) from the ratio between daily production of eggs in the sea and the daily specific fecundity of the adult population:

$$SSB = P_{tot} / DF = \frac{P_0 \cdot A+}{k \cdot R \cdot F \cdot S / W} \qquad \text{Equation B.3.1.1}$$

Where,

SSB = Spawning–stock biomass in metric tons

$\mathbf{P_{tot}}$= Total daily egg production in the sampled area

$\mathbf{P_0}$= daily egg production per surface unit in the sampled area

A+ = Spawning area, in sampling units

DF = Daily specific fecundity. $DF = \frac{k \cdot R \cdot F \cdot S}{W_f}$ Equation B.3.1.2

$\mathbf{W_f}$ = 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* Parker 1985.) was also developed by the latter authors.

Population estimates of numbers-at-age are derived as follows:

$$N_a = N \cdot E_a = \frac{SSB}{W_t} \cdot E_a \qquad \text{Equation B.3.1.3}$$

Where,

N_a = Population estimate of numbers-at-age *a*.

N = Total spawning–stock estimate in numbers. $N = \frac{SSB}{W_t}$

SSB = spawning–stock biomass estimate.

W_t= average weight of anchovies in the population.

E_a = Relative frequency (in numbers) of age *a* in the population.

W_t and E_a are obtained from the average of the mean weight and the percentages by ages across the anchovy samples from the survey (see the adult parameter section below).

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 spawning season of anchovy.

Predetermined distribution of stations is 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 (Motos, 1994). Stations are located every three 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.

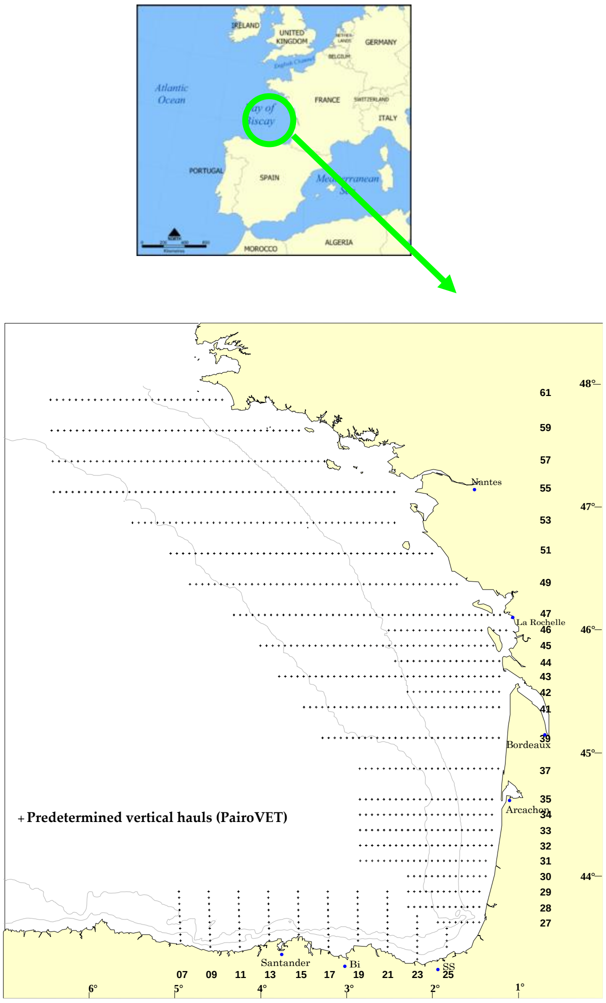


Figure B.3.1.2.1. Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey.

At each station a vertical plankton haul is performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al.*, 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the anchovy eggs under all likely conditions. The net is lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing ten 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 is used to allow for correctly deploying the net. "G.O. 2030" flowmeters are used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the net is washed and the samples obtained are fixed in formaldehyde 4% buffered with sodium tetra borate in seawater. After six hours of fixing, anchovy, sardine and other eggs species are identified, sorted out and counted 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 ensure no eggs were left in the sample. In the laboratory, anchovy eggs are classified into morphological stages (Moser and Alshtrom, 1985).

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al.*, 1997) is used to record the eggs found at 3m depth with a net mesh size of 350µm. The samples obtained are immediately checked under the microscope so that the presence/absence of anchovy eggs is detected in real time. When anchovy eggs are not found in six consecutive CUFES samples in the oceanic area transect is abandoned. The CUFES system has 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 are registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

During the survey, the anchovy, sardine and other eggs are recorded per PairoVET station and the area where anchovy eggs occurred is quantified. The spawning area is 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 is located in the centre of a rectangle. Egg abundance found at a particular station is assumed to represent the abundance in the whole rectangle. The area represented by each station is 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 two consecutive transects) nautical miles. Since sampling is adaptive, station area changed according to sampling intensity and the cut of the coast.

Sample depth, temperature, salinity and fluorescence profiles are obtained in every station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity are 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 to calibrate the chlorophyll data.

The historical maps of anchovy egg distribution obtained with PairoVET are shown in Figure B.3.1.2.2.

B.3.1.3 Collection of adult samples

In 1987 and 1988 the samples were obtained from commercial purse-seines and 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. Samples from the purse-seines were not available due to the closure of the fishery. Since the reopening of the fisheries in March 2010 the commercial purse-seines are providing again samples for the analysis apart from the ones obtained from the research vessel.

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 measured. Immediately after fishing, anchovy is sorted from the bulk of the catch and a sample of two Kg is selected at random. A minimum of one kg or 60 anchovies are weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) are preserved. If the target of 25 NHF is not completed ten more anchovies are taken at random and process in the same manner. Sampling is stopped when 120 anchovies have to be sexed to achieve the target of 25 NHF. Otoliths are extracted on board and read in the laboratory to obtain the age composition per sample. In case samples are obtained from the purse-seines, a sample of two kg is selected from the fishing and is directly kept in 4% formaldehyde. Afterwards, in the laboratory the samples are process in the same manner 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 the total daily egg production (P_{tot}). This is calculated as the product between the daily egg production (P_0) and the spawning area (SA):

$$P_{tot} = P_0 \, SA \qquad (1)$$

A standard sampling station represents a surface of 45 nm² (i.e. 154 km²). 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 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:

$$P_{i,j} = P_0 \exp\left(-Z \, a_{i,j}\right), \qquad (2)$$

where Pi,j and ai,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, Pi,j, be the ratio between the number of eggs Ni,j and the effective sea area sampled Ri (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:

$$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z \, a_{i,j} \, , \qquad (3)$$

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:

$$f(age \mid stage, temp) \propto f(stage \mid age, temp) \, f(age) \qquad (4)$$

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 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)):

$$f(age) \propto f(spawn = \tau - age)\exp(-Z\ age) \quad (5)$$

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). The incubation temperature considered was the one obtained from the CTD at 10m in the way up.

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, cohorts in which hatching has started are excluded: Upper limit is set at the age in which 99% of the eggs are unhatched, having developed at the 50 quantile of the incubation temperature.

Once the final model estimates were obtained the coefficient of variation of P_0 was calculated from the standard error of the model intercept (log(P0)) (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.

B3.1.5 Adult parameters and daily fecundity estimates

The daily fecundity (DF) estimate for the WGHANSA in June is obtained following the equation B.3.1.2. The adult parameters sex ratio (R), Batch fecundity (F) and average weight of mature female (W_f) are estimate in June from the adults obtained during the survey as explained below. The Spawning frequency (S) is taken in June as the mean of the historical series because histologic processing is required for this parameter and this takes longer than 15 days (time lapsed from the end of the survey until the evaluation meeting inJune).Afterwards in the ICES WGACEGG in November the complete DEPM with all the adult parameters,including S estimates, is presented and approved. This occurred since 2005 when the advice started demanding SSB estimates in June.

In case of not having time enough after the survey in a particular year as to process the adult parameters for the June assessment then the mean of past Daly Fecundity estimates would be preliminarily borrowed from the historical series.

Ordinary processing of the adult parameters: 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 were collected within the same day as the egg sampling. Batch fecundity (F), spawning fraction (S), average female weight (W) and sex ratio (R) are estimated 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 subsampling 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 and Uriarte (1989) showed that three tissue samples per ovary are adequate to get good precision in the final batch fecundity estimate and the location of subsamples within the ovary do not affect it. Finally the number of hydrated oocytes in the subsample is raised to the total gonad of the female according to the ratio between the weights of the gonad and the weight subsampled.

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 between different strata if strata are defined to estimate SSB.

To estimate **Spawning Frequency (S)**, i.e. the proportion of females spawning per day:Spawning frequency estimates are obtained applying the new classification for oocyte and POFs stage of Alday *et al*. (2008) and the procedures described in Uriarte *et al*. (2012). The degeneration of postovulatory follicles (POFs) in time at different temperatures was studied for the Bay of Biscay anchovy by Alday *et al*. (2008). For this purpose a key of seven POF stages, solely defined on the basis of their histological degeneration characteristics, was applied (Alday *et al*., 2008; 2010). The novelty of this procedure is that it separates staging of POFs from their ageing process. The ovaries, taken from several captivity experiments and field samples, were classified in this way. There was close agreement in the succession of POF stages after spawning between the experiment and the field samples. The first four stages of POF occurred in less than 24 h, and by the end of the first day the POFs were mainly in Stage V. Stages VI and VII showed their highest occurrence during the first and second half of the second day after spawning, respectively. Full reabsorption of POFs was achieved in 55–60 h. For the range of temperatures examined (13–19˚C), little effect of temperature on the degeneration of POF was noticed.

The procedure to assign mature females to spawning classes was improved by incorporating all the knowledge on oocyte maturation and degeneration of POFs in a matrix system which defines the probabilities of females with those histological indicators belonging to pre- or post-spawning cohort according to the time of capture (Uriarte *et al*., 2012).

Finally, the selected estimator is the mean of S (day 0) and S (day 1). Corrections of sample estimates +/-five hours around peak spawning time (23:00 hours) were applied according to the formulas in Uriarte *et al*. (op. cit.) for an average S of 0.39.

For the years with S estimates which could not be reviewed by the time of WKPELA 2013 (2006, 1989, 1988 and 1987), but have their own estimates of the other reproductive parameters, the average of the historical series (1990–2012) of new S was considered. For the years which did not have any adult reproductive parameters, 1996, 1999 and 2000, the average Daily Fecundity (DF) estimate across the historical series (1990–20012) was adopted (of about 98.5 eggs gram-1 day-1).

Mean and variance of the adult parameters are estimated following equations for cluster sampling (as suggested by Picquelle and Stauffer, 1985):

$$Y = \frac{\sum_{i=1}^{n} M_i y_i}{\sum_{i=1}^{n} M_i} \qquad \text{Equation 6}$$

$$Var(Y) = \frac{\sum_{i=1}^{n} M_i^2 (y_i - Y)^2}{\overline{M}^2 n(n-1)} \qquad \text{Equation 7}$$

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 subsample 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 one 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 800 g, otherwise it was set equal to one. 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 WGHANSA during June the spawning–stock biomass (SSB) is preliminary estimated,following equation B.3.1.1, as the ratio between the total egg production (P_{tot}) and Daily Fecundity (DF) (the latter estimated as the equation 2 with the exception of the S parameter that is obtained as the mean of the historical series).TheSSB variance is computed using the Delta method (Seber, 1982):

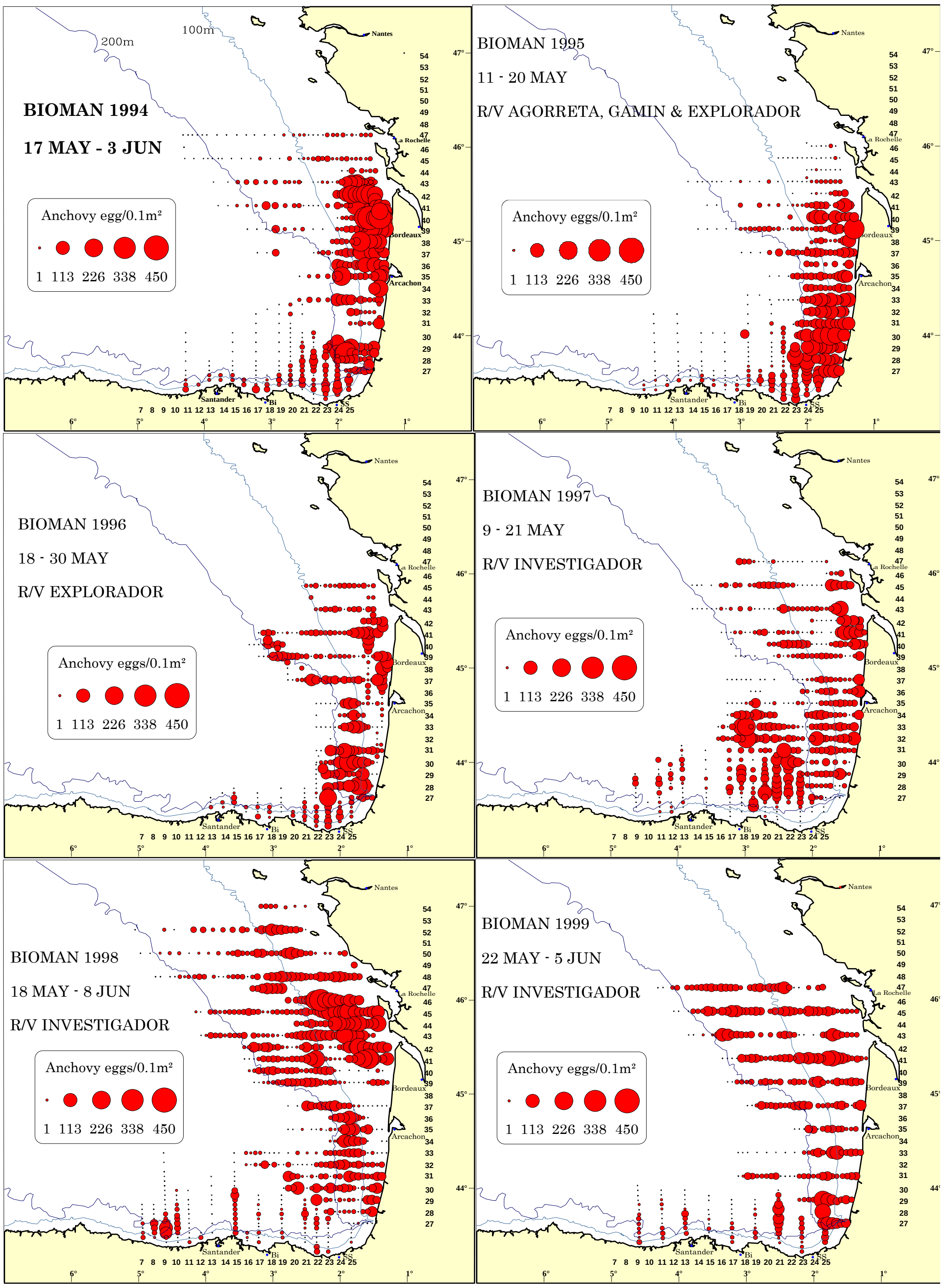
$$\hat{Var}[SSB] = \frac{\hat{Var}[Ptot]}{DF^2} + \frac{P_{tot}^{\ 2}\hat{Var}[DF]}{DF^4}$$

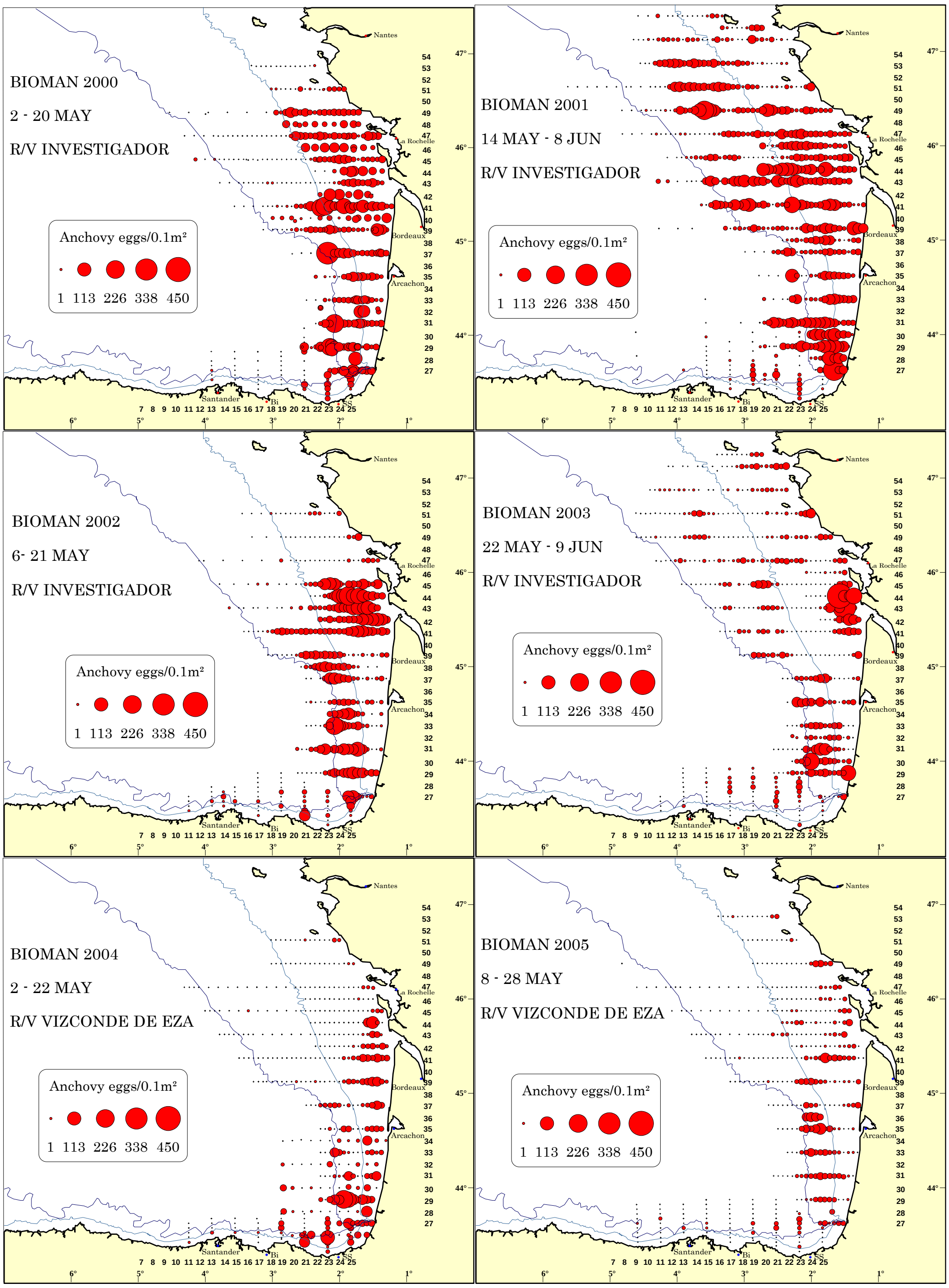
The definitive SSB estimate, following B.3.1.1, with all the adult parameters including the S estimate is presented and approved at WGACEGG during November.

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 are available. Estimates of anchovy mean weights and proportions-at-age in the adult population are computed as a weighted average of the mean weight and age composition per samples where the weights are proportional to the population (in numbers) in each stratum considered. 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 6 and 7 for cluster sampling.


BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
200m
100m
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
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
6° 5° 4° 3° 2° 1°
44° 45° 46° 47°


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
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°

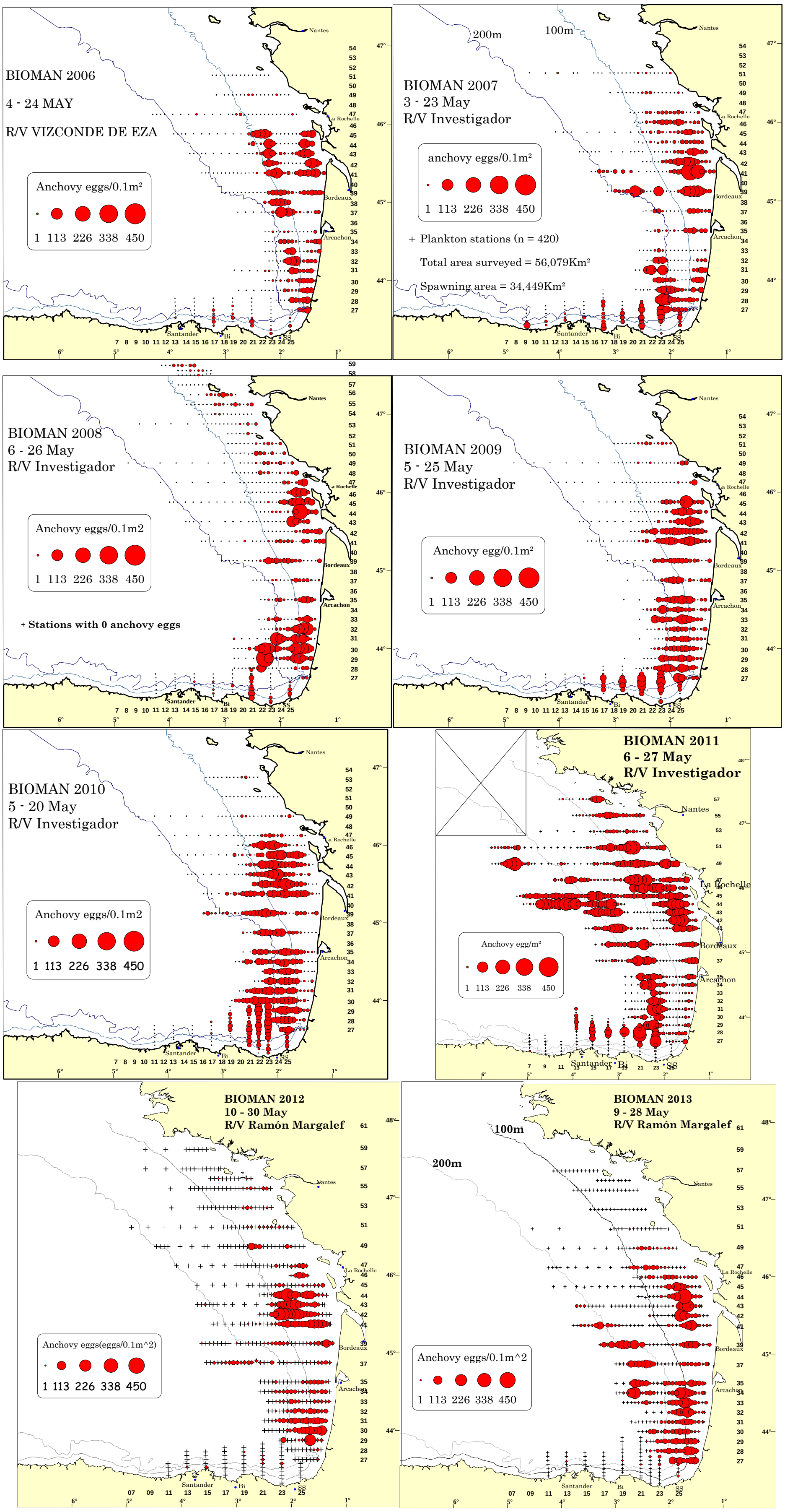

BIOMAN 2006
4 - 24 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2007
3 - 23 May
R/V Investigador
200m
100m
anchovy eggs/0.1m²
1 113 226 338 450
+ Plankton stations (n = 420)
Total area surveyed = 56,079Km²
Spawning area = 34,449Km²
BIOMAN 2008
6 - 26 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
+ Stations with 0 anchovy eggs
BIOMAN 2009
5 - 25 May
R/V Investigador
Anchovy egg/0.1m²
1 113 226 338 450
BIOMAN 2010
5 - 20 May
R/V Investigador
Anchovy eggs/0.1m2
1 113 226 338 450
BIOMAN 2011
6 - 27 May
R/V Investigador
Anchovy egg/m²
1 113 226 338 450
BIOMAN 2012
10 - 30 May
R/V Ramón Margalef
Anchovy eggs(eggs/0.1m^2)
1 113 226 338 450
BIOMAN 2013
9 - 28 May
R/V Ramón Margalef
100m
200m
Anchovy eggs/0.1m^2
1 113 226 338 450
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS

Figure B.3.1.2.2. Anchovy egg distribution from 1998 to 2013.The circles represent the anchovy egg abundance /0.1m² encountered in each plankton station.

B.3.2. Anchovy acoustic indices

Acoustic surveys are carried out every year in the Bay of Biscay in springon 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 multispecific context as species located in the centre of ecosystem.

These surveys are connected with Ifremer programmes 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 (PELACUS) and Portugal (PELAGO) 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 WGHANSA, 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 seawater 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 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 B3.2.1.1). 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 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 echosounder between the surface and 8 m depth.

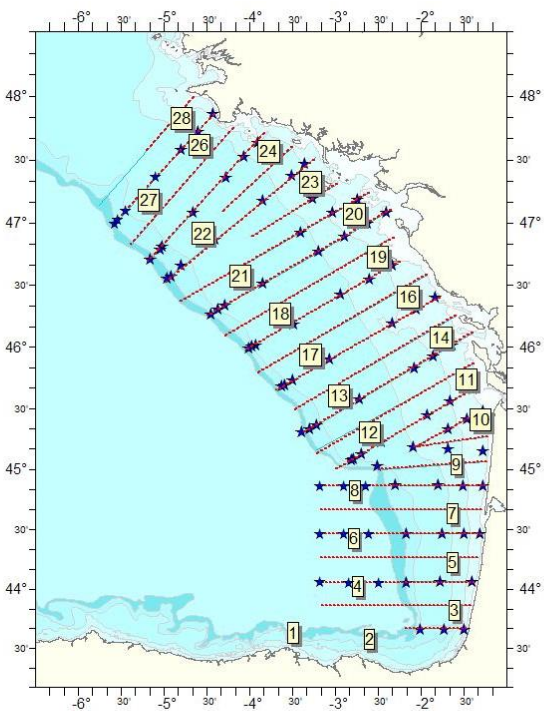


Figure B 3.2.1.1. Acoustic transects and stations during PELGAS surveys since 2000.

Two echosounders are usually used during surveys (SIMRAD EK60 for vertical echosounding and SIMRAD ME70 multibeam echosounder for a 3D approach since 2009). Energies and samples provided by split beam transducers (six frequencies EK60, 18, 38, 70, 120, 200 and 333 kHz), and multibeam echosounder 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 WD 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, at 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 echotraces 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 echotraces 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 shelfbreak.

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 and 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:

$$M_e(k)=\sum_D \bar{s}_A(D,k)\bar{X}_e(D,k)$$

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:

$$Var.M_e(k) = \sum_D \bar{s}_A^{\,2}(D,k) Var[X_e(D,k)] / n.cha(k) + \bar{X}_e^{\,2} \mathrm{var}[s_A(D,k)] / n.esu(D,k)$$

$$Var.B_e = \sum_k A^2(k) Var.Me(k)$$

$$cv = \sqrt{Var.Be} / Be$$

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 the WGACEGG Report in 2009.

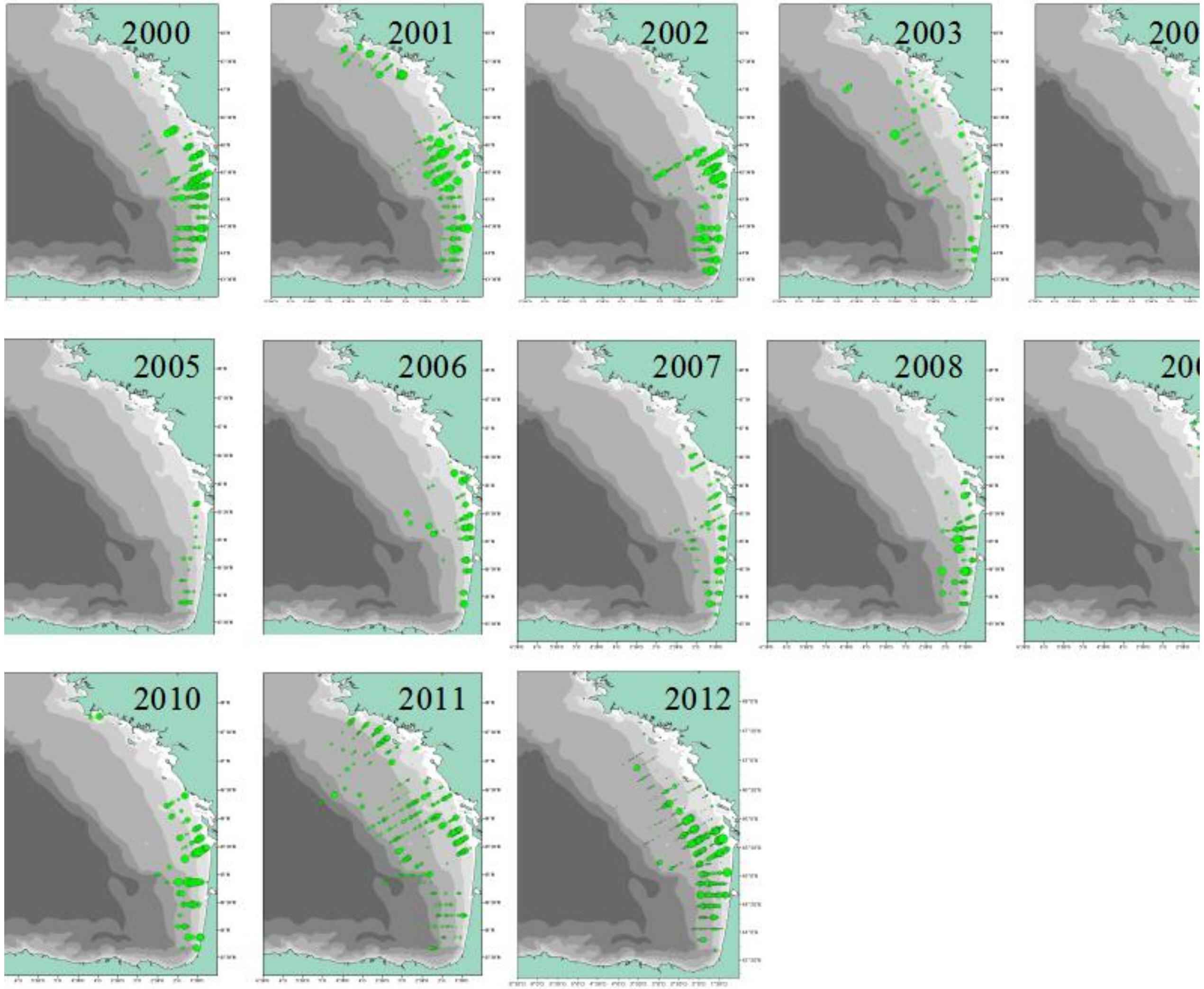


Figure B 3.2.1. Back-scattered energies (SA) registered for anchovy during PELGAS surveys since 2000.

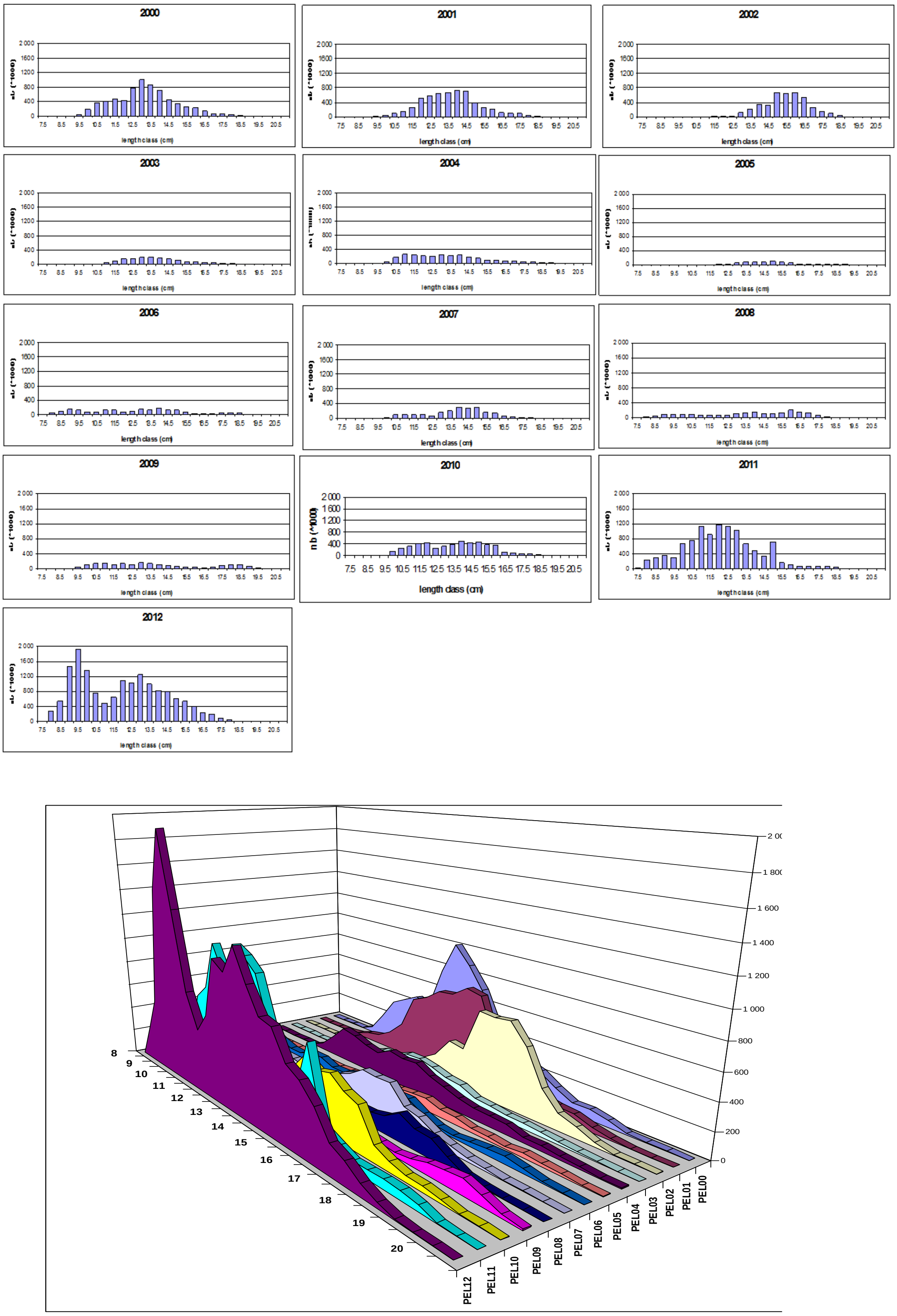


Figure B 3.2.2. Length composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.

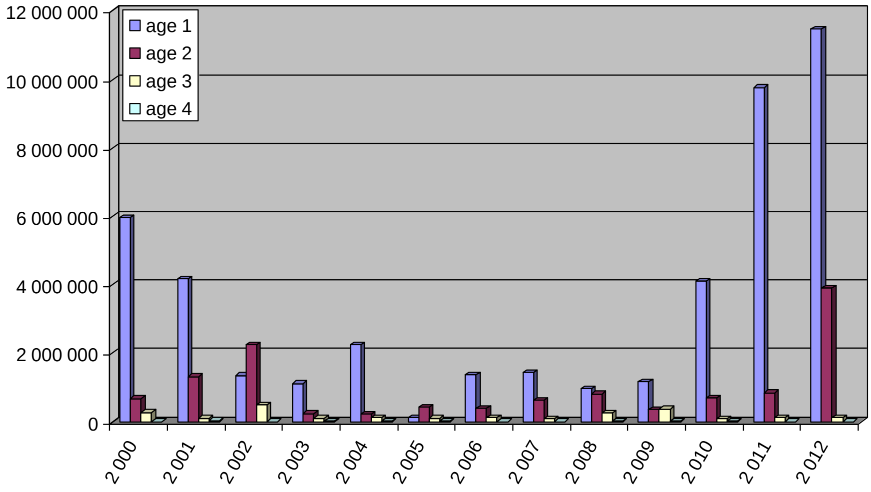


Figure B 3.2.3. Age composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.

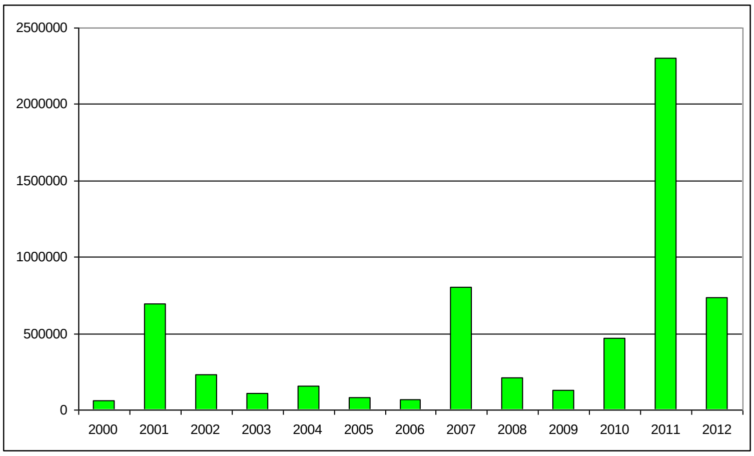


Figure B 3.2.4. Number of eggs observed during PELGAS surveys with CUFES from 2000 to 2010.

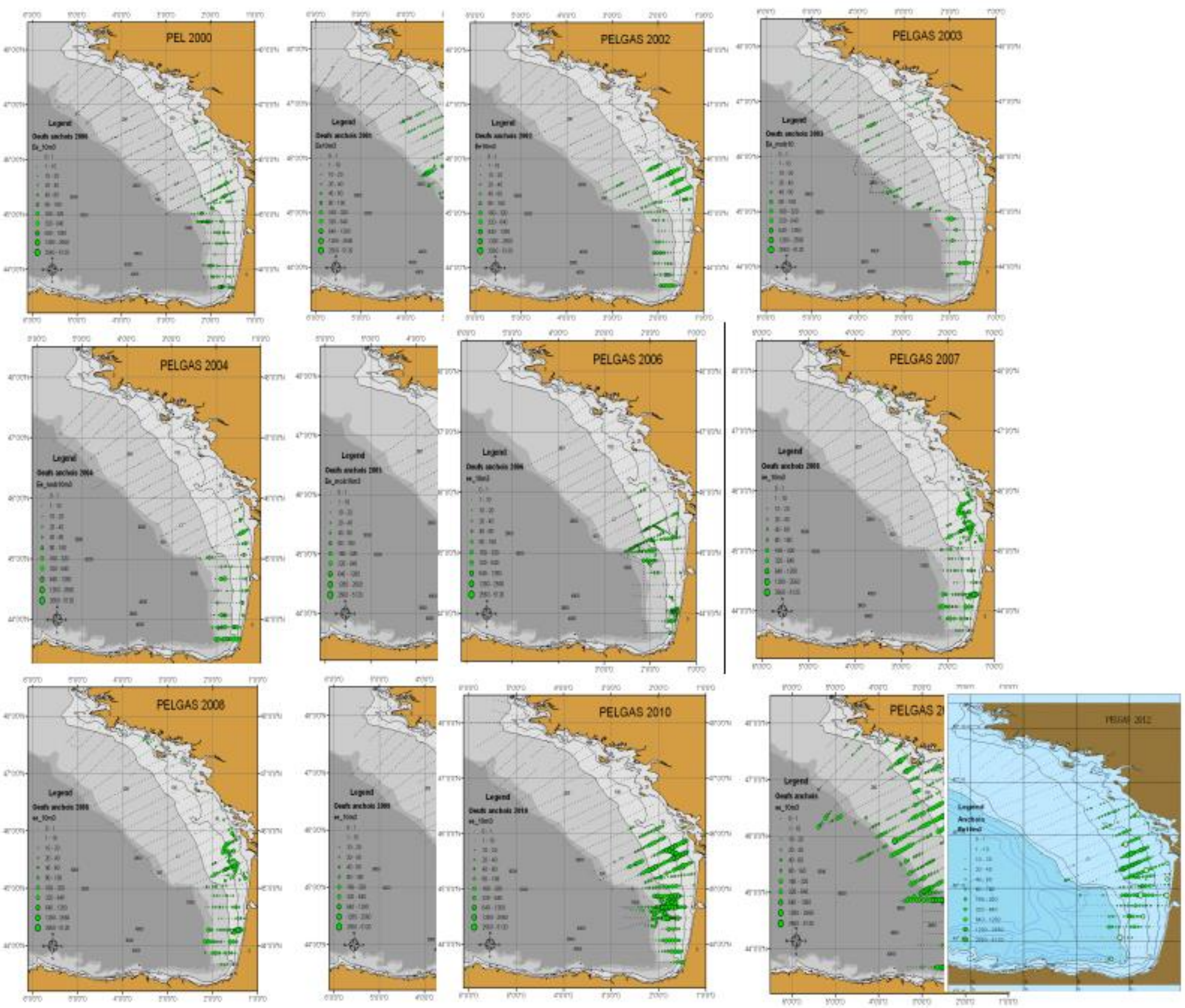


Figure B 3.2.5. Distribution of anchovy eggs observed with CUFES during PELGAS surveys from 2000 to 2012 (number for 10m³).

B.3.4 Autumn survey JUVENA on juvenile anchovy

Since year 2003, there is an acoustic survey to estimate abundance of juvenile anchovy (JUVENA) every September–October, with the long-term objective of forecasting the strength of the anchovy recruitment which will enter the fishery the next year (ICES 2008–2011 WGACEGG reports, Boyra*et al.*2013). The survey was conducted by AZTI from 2003 to 2009, and is coordinated between AZTI and IEO since year 2010. The IEO conducted a parallel acoustic survey on anchovy, PELACUS10, from 2006 to 2009. Both surveys were merged in year 2010 in a joint JUVENA AZTI-IEO survey coordinated in ICES WGACEGG. This survey is expected to provide further insights on the recruitment process and additional knowledge on the biology and ecology of the juveniles.

The recruitment prediction capability of the survey has been tested by comparing the biomass estimates of juveniles and the next year's age-1 recruits for a wide range of recruitment values, and has been confirmed by the significant ($p<0.001$) positive correlations between them.

B.3.4.1 Sampling strategy

The JUVENA surveys were carried out annually between September and October in the Bay of Biscay. In these months the juveniles have grown enough to be visible to the echosounders (allowing the tuna fishing fleet to target them as live bait) and normally occupy large outer and off shelf areas in front of the Cantabric and west French coasts (Uriarte *et al.*, 2001; Cort *et al.*, 1976; Martin, 1976). Acoustic sampling was performed during the day because at this time of year juveniles usually aggregate in schools in the upper layers of the water column during the day, and can be distinguished from plankton structures (Uriarte *et al.*, 2001; Cort *et al.*, 1976). The sampling was carried out following a regular grid formed by transects arranged perpendicular to the coast (Figure B.3.4.1), spaced at 17.5 n.mi. (from 2003 to 2005) or 15 n.mi. (2006 onwards) to ensure their independence (Carrera *et al.*, 2006). Sampling started in the Cantabrian Sea, going from west to east, and then moved to the north to cover the waters in front of the French coast. It is important to conduct the survey in the precise temporal window that extends from mid-August to mid-October, which is not too early, so juveniles have sufficiently grown and hence can be detected and caught, and not too late, so they have not yet abandoned the offshore grounds towards the coasts.

The survey covered the entire expected spatial distribution of juvenile anchovy in these months of the year, from offshore areas well beyond the continental shelf to very coastal waters, because the spatial process of anchovy juvenile recruitment occurs from offshore areas towards the coast during autumn (Uriarte *et al.*, 2001). This exploration area can vary from year to year and is potentially large. Consequently, considerable effort was made to achieve the broadest possible coverage of the area by using an adaptive sampling strategy. In this strategy, the boundaries of the sampling area were defined according to the findings of each survey and the parallel information obtained from the commercial fishing fleet, which uses juvenile anchovy as live bait for tuna fishing. Along the Spanish and French coastlines, the minimum limits of the sampling area were set at 5°W and 46°N respectively. According to previous information on juvenile distribution, this area was expected to contain the vast majority of the juvenile anchovy abundance (Uriarte *et al.*, 2001; Carrera *et al.*, 2006; Cort *et al.*, 1976). For practical reasons, a maximum surveying area was set within the limits 6°W and 48°N. Between these limits, the actual along-coastline boundaries were set each year at the points where there was a clear decrease in abundance or, if possible, a transect in which juvenile anchovy were not detected. The length of the transects extended from about the 20 m to at least the 1000 m isobaths, and, according to the adaptive scheme of the survey, if the detections continued they were enlarged offshore to 4 n.mi. beyond the last detection of an anchovy school. In addition, the information from the commercial live bait tuna fishery collected before and during each survey was taken into account when decisions about the sampling strategy were made during the surveys. As a result of this sampling scheme, the years with a larger abundance of anchovy required a larger sampling coverage.

In the period from 2003 to 2004, the area was sampled with a single commercial purse-seiner subcontracted for the survey and equipped with scientific echosounders. In 2005 a second purse-seiner was added to the survey to provide extra fishing operations, and in 2006 a pelagic trawler with complete acoustic equipment, the R/V Emma Bardán, replaced the second purse-seiner.

B.3.4.2 Data acquisition

The acoustic equipment included Simrad EK60 split-beam echosounders (Kongsberg Simrad AS, Kongsberg, Norway) of 38 and 120 kHz from 2003 to 2006, plus a 200 kHz transducer from 2007 (Table 2). The transducers were installed looking vertically downwards, at about 2.5 m depth, at the end of a tube attached to the side of the vessel in the case of the commercial fishing vessels and on the vessel hull in the case of the research vessel. The transducers were calibrated using standard procedures (Foote, 1987).

The water column was sampled acoustically to a depth of 200 m. Catches from the fishing hauls and echotrace characteristics were used to identify fish species and determine the population size structure. Purse-seining was used to collect samples up to 2005 and then this was combined with pelagic trawls from 2006 onwards. To improve species identification in the first three surveys when only purse-seiners were available, additional night fishing operations were performed by focusing bright light on the water to attract the fish from surrounding waters. In 2006 pelagic trawling was included in the surveys, which made it possible to fish at greater depths than the purse-seine range (50 m maximum). The purse-seiners generally covered the coastal areas and the waters off the shelf where juveniles occupy the surface waters and are accessible to the purse-seine fishing range. The pelagic trawler covered the intermediate shelf regions where it may be necessary to sample at all depth layers. In addition, when deep, anchovy like aggregations were detected by the purse-seiners, the pelagic trawler temporally left its coverage area to carry out additional fishing operations in these areas.

For the years when pelagic trawling was carried out in the surveys (2006 onwards) we have assessed the fraction of juvenile biomass observed deeper than 45 m below the surface. This assessment was restricted to the areas over the shelf because pure aggregations of juveniles off the shelf were all above 45 m depth. This was done in order to determine by how much the limited vertical fishing range of purse-seines could have affected the detection and estimates of juvenile biomass in the years 2003–2005, when only this fishing gear was available, and to eventually correct the potential underestimation of the juvenile biomass detected over the shelf in those years.

B.3.4.3 Intercalibration of acoustic data between vessels

Since the 2006 survey, when the acoustic sampling was split between two vessels, intercalibration exercises between the two vessels were routinely carried out each year based on the intercalibration methodology described by Simmonds and MacLennan (2005). The intercalibration process consisted in comparing the echointegration of the bottom echo in areas with a smoothly variable bottom (visible as overlapping transects in Figure B.3.4.1). A minimum distance of 30 n.mi. was covered simultaneously by the two vessels for these exercises (Figure B.3.4.1). The NASC values (Maclennan *et al*., 2002) obtained by the layer echointegration of both the water column and bottom echos obtained by the two vessels were compared to detect recording biases or other potential problems.

B.3.4.4 Abundance estimates

Echograms were examined visually with the aid of the catch species composition to identify positive anchovy layers. Noise from bubbles, double echoes, and, when necessary, plankton were removed from the echograms. Acoustic data were processed in the positive strata by layer echo integration using an ESDU (Echo integration Sampling Distance Unit) of 0.1 n.mi. with the Movies+ software (Ifremer, France). Echoes were thresholded to -60 dB and integrated into six depth channels: 7.5–15 m, 15–25 m, 25–35 m, 35–45 m, 45–70 m and 70–120 m (no anchovies were found below 120 m depth).

Generally, only the 38 kHz data were echo integrated using the TS-length relationships agreed in ICES WGACEGG for the main species (ICES, 2006; Table B.3.4.1). Each fishing haul was classified into species. A random sample of each species was measured to determine the length–frequency distribution of the different species in 0.5 cm classes for the smaller species (anchovy and sardine) and one cm classes for the rest. Complete biological sampling of anchovy was performed to analyse age, size and the size–weight ratio. The hauls were grouped by strata of homogeneous species and size composition. The species and size composition of each homogeneous stratum were obtained by averaging the composition (in numbers) of the individual hauls contained in the stratum weighted to the acoustic density in the vicinity (2 n.mi. diameter). This species and size composition of each stratum was used to obtain the mixed species echointegrator conversion factor (Simmonds and Maclennan, 2005) for converting the NASC values of each ESDU into numbers of each species. However, although the methodology involved estimating multiple species, the survey strategy was focused strongly on juvenile anchovy and only the positive areas for anchovy were processed. Therefore, only estimates of this species were considered reliable and thus produced.

The procedure is as follows:

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:

$$w_i = \sum_j w_{ij} = \sum_j \left(\frac{\sum_{k=1}^{M} \left(q_{ijk} \cdot E_k / Q_k \right)}{\sum_{k=1}^{M} E_k} \right).$$

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 $< W_i >$.

Anchovy juveniles (age=0) and adults (age ≥ 1) were separated and treated as different species. To separate juveniles from adults, the length frequency distribution of anchovy by haul was multiplied by a corresponding age-length key. The key was determined every year for three broad areas: the pure juvenile area, the mixed juvenile area (with a mix of juveniles and adults), and the Garonne area (also a mixed area but here adult anchovy were usually smaller than in the other areas).

B.3.4.5 Recruitment predictive capability

The annual biomass estimates for anchovy juveniles were compared with the estimates of anchovy recruitment the following year. The recruitment is the biomass of age-1 anchovy in January of the following year, estimated according to the ICES assessment using a Bayesian model with inputs from catches and biomass estimates of two spring surveys: an acoustic one (PELGAS), conducted by Ifremer, and a survey based on DEPM (BIOMAN), conducted by AZTI (ICES, 2011). Up to 2012, 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. In addition, JUVENA’s juvenile abundance index shows also statistically significant (Pearson’s) correlations with the series of recruit estimates provided independently by each of the spring surveys (R=0.94 P(R=0)=0.000 for DEPM and R=0.89 P(R=0)=0.001 for Acoustics). WGHANSA (2012), like Boyra *et al.* (2013), concluded that the JUVENA acoustic index of juveniles is a valid indicator of the strength of the incoming recruitment and hence useful for improving the forecast of the population and potentially its assessment.

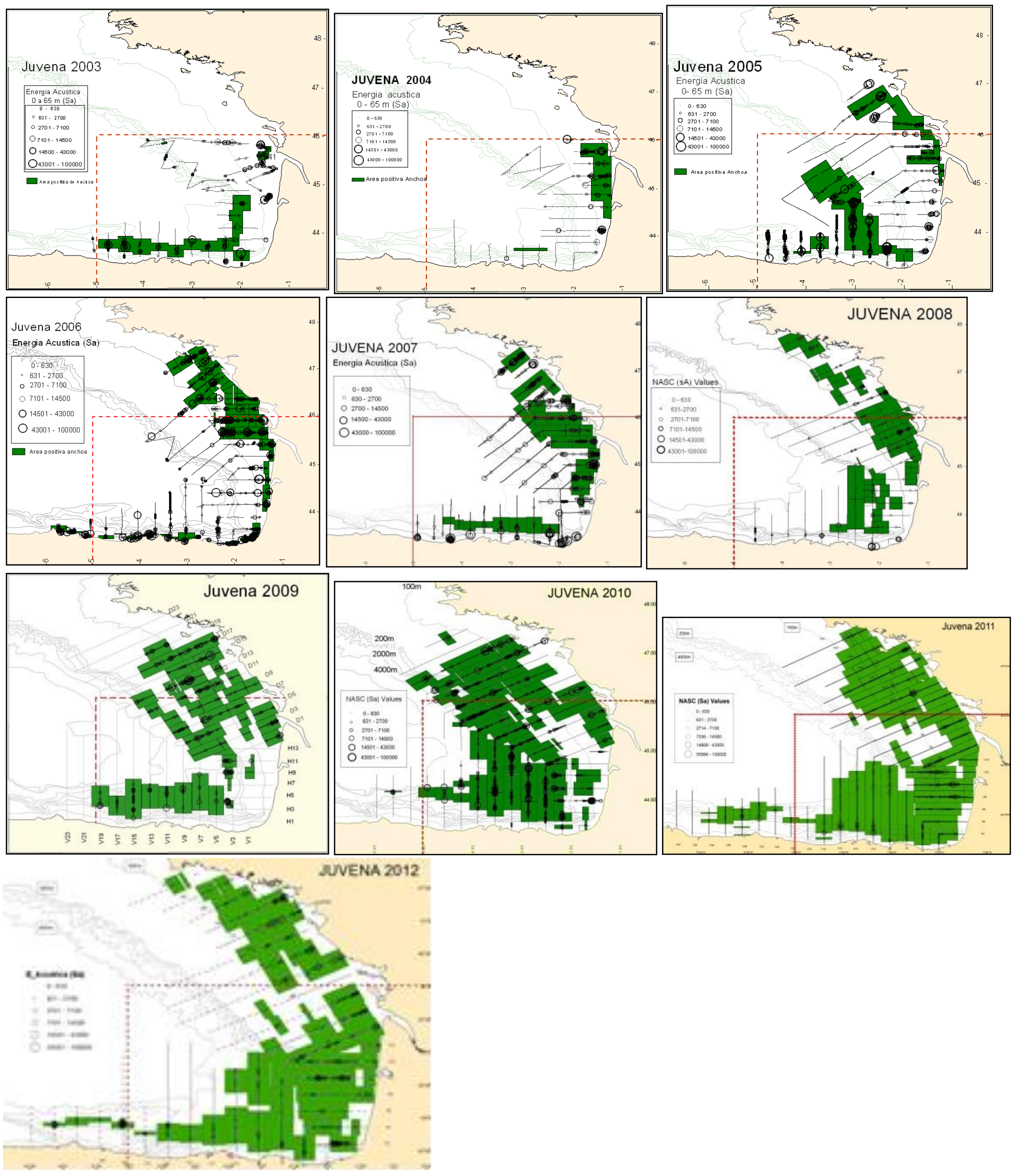


Figure B.3.4.1. Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the ten years of surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

Table B.3.4.1. Vessels and equipment.

			VESSEL 1	VESSEL 2
Vessel	name		Variable*	Emma Bardán
	Length (m)		30–35	27
	Side (m)		8	7
	Draft (m)		3.5–4	3.5
	Acoustic installation		side perch	hull
Acoustic Equipment	Transducer frequencies (kHz)		38,120, (200)**	38,120,200
	Power (for 38, 120, 200 kHz) (W)		1200, 250, (210)**	1200, 250, 210
	Pulse duration (10^{-6}s)		1024	1024 (except in 2006: 256)
	Ping interval (s)		0.25–0.5	
Target Strength (b_{20})***	*Engraulis encrasicolus* *Sardina pilchardurs* *Sprattus sprattus*	-72.6 dB	Degnbol *et al.* (1985)	
	Trachurus trachurus *Trachurus mediterraneus* *Scomber japonicas*	-68.7 dB	ICES (2006)	
	Scomber scombrus	-88 dB	Clay and Castonway (1996)	
	Jellyfish (mean TS)	-81.7 dB	Average TS for jellyfish species in Simmonds and Maclennan (2005)	
Fishing gear****	Pelagic trawl	nº of doors		2
		vert opening		15
		Mesh size (mm)		4
	Purse-seine	Depth	75	
		Perimeter	400	
		Mesh size	4	

(*Vessel names: Divino Jesus de Praga (2003), Nuevo Erreñezubi (2004), Mater Bi (2005), Gure Aita Joxe (2005, 2008), Itsas Lagunak (2006, 2007, 2009, 2010, 2011, Ramón Margalef (2012)). **The 200 kHz transducer has been available onboard purse-seiners since 2007. ***TS of the mean pelagic species. The TS is obtained according to the relationship TS = b20 - 20log(L), where L is the standard length of the fish in cm. ****The fishing gear of RV Ramon Margalef in 2012 was a pelagic trawl identical to the Emma Bardan one.

B.4 Commercial cpue

According to literature, cpue indices have been considered as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1980, 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).

B.5 Other relevant data

Members of the South Western Waters Regional Advisory Council (SWWRAC) participated in the benchmark workshop process for the Bay of Biscay anchovy stock. They provided their opinion relative to the anchovy assessment (SWW RAC Opinion 69, 22 November 2012) and participated to WKPELA, their input being reflected in the report.

C. Stock assessment method

There are two points in time where an assessment can be given for this stock: in June when SSB is estimated based on the most recent spring surveys information andin December when the assessment can incorporate the most recent juvenile abundance index from JUVENA, the catches in the second semester and any other updated data. In the former the assessment goes up to June, whereas in the latter the assessment covers the whole year up to December.

C.1 June assessment

Model used:

The assessment for the Bay of Biscay anchovy population is a Bayesian two-stage biomass-based model (CBBM) (Ibaibarriaga *et al.*, 2011), 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 changes exponentially with time according to intrinsic growth, natural mortality and fishing mortality rates. Growth and natural mortality are separated processes that are assumed constant along time but distinct across age groups (recruits and older individuals). Fishing is treated as a continuous process in time separated by semester. The first semester fishery consists mainly of the Spanish purse-seine fishery operating in spring, and the second semester fishery primarily relates to the French fleet. Furthermore, fishing mortality by semester is separable into age and year effects.

The observation equations consist of:

- log-normally distributed spawning–stock biomass from the acoustics and DEPM surveys, where the biomass observed is scaled to the true population biomass by the catchability coefficient of each of the surveys. The variance of the SSB observation equations from the surveys are split as the sum of the variances obtained from the surveys (sampling error changing from year to year and fixed according to the survey results) and the residual variance (constant parameter across years estimated from the model).
- 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.
- log-normally distributed juvenile abundance index from the JUVENA surveys, where the abundance index observed in year (y-1) is related to the true recruitment (age 1 biomass in January of year y) by a power model:

$$\log\left(R_{\mathrm{juv}}(y)\right) \sim \mathrm{Normal}\left(\log\left(q_{\mathrm{juv}}\right) + k_{\mathrm{juv}} \log\left(R_y\right), \frac{1}{\psi_{\mathrm{juv}}}\right),$$

  where q_{juv}, k_{juv} and ψ_{juv} are respectively the catchability, the power and the precision of the JUVENA surveys that need to be estimated.

- log-normally distributed total catch by semester.
- beta distributed age 1 biomass proportion in the catch by semester.
- normally distributed growth rates by ages.

The unknown parameters are the initial biomass, the mean and the precision of the recruitment process in log scale, the acoustic and DEPM surveys catchabilities, the catchability and the power parameters of the JUVENA index, the parameters affecting the precision of the survey and catch observation equations, the year and age components of the fishing mortality by semester, the annual intrinsic growth rates by age, the precision of the observation equations for growthand the annual natural mortality rates by age, though in the standard assessment the natural mortality will be fixed at the values agreed by the WG (see below).

Inference on the unknowns is made using Markov Chain Monte Carlo (MCMC).

Software used:

The model is implemented in BUGS (www.mrc-bsu.cam.ac.uk/bugs/). The WinBUGS development interface was used to reduce run times. The assessment is run from R (www.r-project.org) using the package R2WinBUGS.

Model Options chosen:

- Catchability of the DEPM and acoustic SSB estimates and of the juvenile abundance indices are estimated. DEPM and acoustic surveys are assumed to provide unbiased proportion of age 1 biomass estimates in the stock.
- Natural mortality rates are fixed at M_1=0.8 and M_{2+}=1.2.

The set of priors as defined in Ibaibarriaga *et al*., 2011 are used. The logarithm of the power parameter of the JUVENA index was assumed to have a normal prior distribution with median at 0 and precision 0.5. The prior distribution of the catchability parameter of the JUVENA index was considered wider than that assumed for the acoustic and DEPM surveys. A normal distribution with median at 0 and precision 0.1 was selected for the logarithm of the JUVENA index catchability. The prior distribution of the precision of the JUVENA index observation equation was the same as for the acoustic and DEPM surveys.

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 semesters	1987–latest year	1 to 2+	Yes
Canum	Catch-at-age in numbers by semesters	1987–latest year	1 & 2+	Yes
Weca	Weight-at-age in the commercial catch by semesters	1987–latest year	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=0.8 and M_{2+}=1.2	1987–latest year	1 to 2+	No
G	Intrinsic growth rate	1987–latest year	1 to 2+	Yes

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	DEPM SSB spring series	1987–latest year (with gap in 1993)	
Tuning fleet 2	Acoustic SSB spring series	1989–latest year (with gaps)	
Tuning fleet 3	DEPM P1 (B1/SSB) spring series	1987–latest year (with gaps)	
Tuning fleet 4	Acoustic P1 (B1/SSB) spring series	1989–latest year (with gaps)	
Tuning fleet 5	Juvenile abundance index from JUVENA autumn survey	2003–latest year	Recruitment

Prior distributions of the parameters:

The current prior distributions (see table below) are described and justified in Ibaibarriaga *et al.* (2011) and in Ibaibarriaga and Uriarte (2013, WD to WGHANSA-ICES CM 2013/ACOM:16).

Parameter	Hyperparameter	Median (90% probability interval)
q_{surv}	$\mu_{q_{\text{surv}}} = 0 \;\; \psi_{q_{\text{surv}}} = 2$	1(0.3, 3.2)
q_{juv}	$\mu_{q_{\text{juv}}} = 0 \;\; \psi_{q_{\text{juv}}} = 0.1$	1(0.005, 181.5)
k_{juv}	$\mu_{k_{\text{juv}}} = 0 \;\; \psi_{k_{\text{juv}}} = 0.5$	1(0.098, 10.2)
ψ_{surv}	$a_{\psi_{\text{surv}}} = 0.9 \;\; b_{\psi_{\text{surv}}} = 0.02$	29.8(1.7, 139.9)
ψ_{juv}	$a_{\psi_{\text{juv}}} = 0.9 \;\; b_{\psi_{\text{juv}}} = 0.02$	29.8(1.7, 139.9)
ξ_{surv}	$\mu_{\xi_{\text{surv}}} = 5 \;\; \psi_{\xi_{\text{surv}}} = 0.2$	5(1.3, 8.7)
ξ_{catch}	$\mu_{\xi_{\text{catch}}} = 5 \;\; \psi_{\xi_{\text{catch}}} = 0.2$	5(1.3, 8.7)
B_0	$\mu_{B_0} = 10.3 \;\; \psi_{B_0} = 1.0$	29 733(5 740, 154 022)
μ_R	$\mu_{\mu_R} = 9.8 \;\; \psi_{\mu_R} = 1.0$	9.8(8.2, 11.4)
ψ_R	$a_{\psi_R} = 2 \;\; b_{\psi_R} = 3$	0.6(0.1, 1.6)
$s(\text{sem}_j, 1)$	$a_s = 0 \;\; b_s = 2$	1.0(0.1, 1.9)
$f(\text{sem}_j, y)$	$\mu_f = -0.9 \;\; \psi_f = 1$	0.4(0.1, 2.1)
G_a	$\mu_{\log(G)} = -0.7 \;\; \psi_{\log(G)} = 2$	0.5(0.2, 1.6)
ψ_G	$a_{\psi_G} = 1.5 \;\; b_{\psi_G} = 0.1$	11.8(1.8, 39.1)

Note: Sufix surv refers to either acoustic or DEPM spring surveys

C.2 December assessment:

The assessment conducted in June can be updated using the same settings in December once the results from the JUVENA survey and the catch levels during the second semester are available. The definitive DEPM estimates which are obtained after the full processing of the adult samples are completed by November and should be incorporated in this update. It must be taken into account that only preliminary estimates of the total catch in the first and the second semesters and of the age structure of the catch during the first semester of the interim year Y would be available in December.

D. Short-term projection

The forecast can be given either based on the June or on the December assessment. In June, there is no indication on next year recruitment, so the forecast is based on an assumed scenario constructed from past recruitments. In December the forecast can be based on the next year recruitment distribution derived from the December assessment (which will be informed ultimately by the JUVENA anchovy juvenile index).

D.1 June forecast:

Model used:

The CBBM model (Ibaibarriaga *et al.* 2011) 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 B_{lim} under a recruitment scenario based on the past recruitment-series and under alternative exploitation levels for the second half of the current year and the first half of next year. Exploitation can be given either in terms of fishing mortality or in terms of catches.

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 $\sum w_y = 1$. When no information about incoming recruitment is available all the years are equally weighted, resulting in an undetermined recruitment scenario. This is the typical situation in June.

Software used:

The projections are implemented in R (www.r-project.org), using ad hoc script for the anchovy model.

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):

Intrinsic growth rates are assumed distinct by age groups and their posterior distribution from the assessment is used.

Natural mortality rate (M):

Assumed constant same as in the assessment (M_1=0.8 and M_{2+}=1.2)

Exploitation pattern:

Alternative options for the year effect of fishing mortality by semester are tested. The age effects of the fishing mortality by semester are taken from the posterior distribution from the assessment.

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. The default recruitment scenario in June is the undetermined case, where all past years are equally likely. However, if there are other reliable indications available, different recruitment scenarios could be constructed by giving different weights to the past series recruitments.

Procedures used for splitting projected catches: NA

D.2 December forecast

The method for the short-term projections based on the December assessment is the same as the ones based on the June assessment, the main difference being that the next year recuitment distribution is obtained directly from the assessment. This recruitment distribution is mainly obtained by the latest JUVENA juvenile abundance index and the parameters of the JUVENA observation equations estimated from the model. Therefore, if the latest juvenile abundance index is high/low, the recruitment distribution are centered around high/low values. The December assessment provides estimates of the fishing mortality in the second semester in the interim year and the December short-term projections allow for exploring catch options for the first semester of the following year. For the current management calendar, where the TAC is set from July to June next year, the December short-term projections could be used to adjust the TAC accordingly for the first semester until a new assessment in June. At request, the December forecast can be extended for the whole year subject to a range of annual catches and the apportioning between the two halves of the year.

E. Medium-term projections

No medium-term projections are applied to this fishery for the provision of advice by ICES.

F. Long-term projections

No long-term projections are applied to this fishery for the provision of advice by ICES. Long-term projections (ten years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC. This work was based in other assessment models and assumptions. Thus, the biomass estimates obtained with the new methods are not valid to inform the harvest control rules in the draft management plan proposal of this stock. The long-term management plan proposal should be revised accordingly.

G. Biological reference points

The results of applying the CBBM according to this stock annex in June 2013 are shown in Annex 1 and they are used here as the basis for the definition of Biological reference points.

A stock–recruitment relationship is not explicitly used, given that no clear pattern arises from the scatter plot of SSB and Recruits (Figure G.1):

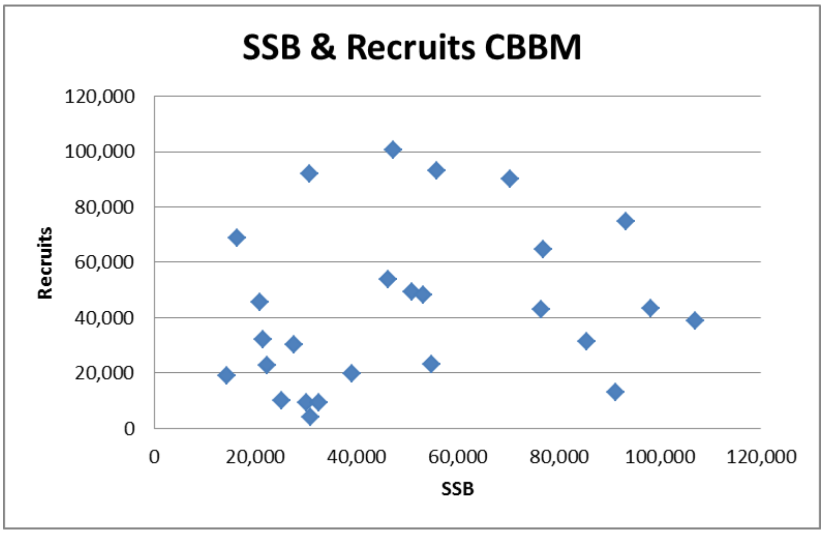


Figure G.1: Plots of Recruits vs parental Spawning Biomass (SSB) from the CBBM assessment in June 2013 see data in Annex1).

Fitting a segmented regression resulted in an inflection point at 48 362 t. (just around the historical median SSB of 46 715 t.) and was not statistically significant (P= 0.24). Such fitting would lead to admit that B_{lim} could be at the median biomass since 1987, and therefore the fishery would have been operating on a population below Blim half of the years. This is hard to believe for a fishery leading to harvest rate around 0.54 (between 1987-2004) and with more than 50% of the catches being taken after mid spawning time. So it was considered better searching for a Blim somewhere in the lower range of historical SSB values.

B_{lim} is defined as B_{loss} (minimum estimated biomass which still produced a substantial recruitment) based on the posterior median of the 1987 and 2009 SSB estimates (of 21425t and 20776 t respectively in the 2013 CBBM assessment), which are the third and fourth lowest values in the series. This results in B_{lim} at 21000 t. Notice that 2009 is the year afterwhich a series of weak SSB abundances (since 2005 accompanying a repeated failure of the fishery and its closure) produced a significant recruitment restoring the population to medium levels. The Biomass in 1987, which was very similar to the 2005 one, did also produce a significant recruitment (close to geometric mean R). The two lowest SSB values arose in years 1989 and 2005 (assessed at 16 404 t and 14 291 t respectively) with a mean of 15 348 t. These two values were omitted when calculating Bloss for the following two reasons: The 2005 SSB value was the lowest in the series and correspond with the failure and closure of the fishery. The stock did not recover the next year (in 2006) and took 5 years (until 2010) to get a substantial recovery of biomasses as to reopen the fishery. The 1989 level is likely to be an underestimate in the current assessment. The 1989 SSB (at 16404 t) which was used in the former stock annex as the year of reference for definition of B_{lim}, is not considered any longer a proper reference point. The 1989 DEPM SSB input value used to be corrected upward by 1 SD in the past assessments because of presumed underestimat.ion, However nowadaysthat input value is not corrected as the underestimation is considered likely but of uncertain magnitude and the former correction would be too strong. . As such, the SSB estimate may suffer some uncertain underestimate and it is preferable avoiding taking the 1989 SSB biomass as the reference value for the Blim.

This B_{lim}value (21000t) is also approximately the median of the seven lowest SSB levels in the series, (years: 1987/1989/2003/2005/2006/2008/2009), a range of SSB where low recruitments occurred more often (in 71.5%) than medium or high recruitments. This median SSB is 21435 t.Therefore, the probability of suffering impaired recruitment under these levels is presumed in accordance with the B_{lim} definition.

	TYPE	VALUE	TECHNICAL BASIS
MSY	MSY $B_{trigger}$	Not defined	
Approach	F_{MSY}	Not defined	
	B_{lim}	21 000 t	B_{loss} (median of SSB estimates in years 1987 and 2009, minimum estimated biomasses which still produced a substantial recruitment)
Precautionary	B_{pa}	Not defined	
Approach	F_{lim}	Not defined	
	F_{pa}	Not defined	

H. Other issues

None.

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Annex 1

Results of applying the June assessment in June 2013

These results were obtained after WKPELA2013 and after WGHANSA 2013 as required to close properly the stock annex and the definition of the biological reference points. It includes the latest inputs from surveys in the spring 2013.

Table A.1: Summary output of the CBBM assessment of the Bay of Biscay anchovy, following the stock annex of WKPELA but with Power catchability for the JUVENA series and Variance setting of the Spring Survey biomasses as Case 2 (Var.Estimated as in Annex 3 of WKPELA).

	Recruitment			SSB			F.sem1			F.sem1		
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
1987	12,076	16,147	22,026	16,502	21,435	28,658	0.91	1.19	1.52	0.21	0.31	0.43
1988	26,357	32,209	40,135	24,311	30,034	38,405	0.76	0.98	1.23	0.23	0.31	0.41
1989	6,667	9,377	13,333	11,376	16,406	23,173	0.65	0.91	1.26	0.11	0.16	0.24
1990	59,874	68,872	80,017	47,056	54,869	64,470	0.95	1.18	1.43	0.44	0.58	0.77
1991	17,694	23,156	30,946	22,918	30,675	40,371	0.85	1.11	1.44	0.17	0.24	0.34
1992	72,403	92,042	117,008	57,908	77,009	100,542	0.83	1.11	1.48	0.19	0.29	0.43
1993	51,534	64,861	80,822	64,002	76,479	91,251	0.64	0.81	1.01	0.35	0.47	0.62
1994	35,242	43,045	53,130	41,706	50,932	62,686	0.87	1.09	1.35	0.37	0.50	0.69
1995	38,561	49,513	66,171	34,185	46,253	62,666	1.01	1.36	1.81	0.18	0.27	0.41
1996	42,617	53,637	66,836	43,263	53,167	66,407	0.83	1.08	1.39	0.37	0.52	0.72
1997	37,049	48,050	61,698	42,708	55,793	71,423	0.41	0.53	0.70	0.28	0.39	0.56
1998	71,682	92,967	120,572	76,029	98,194	125,454	0.31	0.41	0.54	0.27	0.39	0.57
1999	30,638	43,478	60,476	54,213	70,369	90,608	0.38	0.51	0.68	0.26	0.36	0.52
2000	73,865	90,219	110,194	76,534	93,280	112,433	0.56	0.70	0.89	0.24	0.33	0.44
2001	62,318	74,608	89,322	78,671	91,202	107,170	0.54	0.65	0.79	0.33	0.43	0.54
2002	9,127	13,030	18,564	31,747	39,140	49,225	0.43	0.55	0.67	0.35	0.46	0.61
2003	15,553	19,634	24,835	22,514	27,703	34,913	0.29	0.38	0.47	0.41	0.56	0.74
2004	24,588	30,333	38,561	24,414	30,871	40,026	0.64	0.84	1.09	0.36	0.52	0.72
2005	2,636	3,942	5,866	10,265	14,291	20,122	0.11	0.16	0.22	NA	NA	NA
2006	13,440	18,864	26,370	16,221	22,222	30,027	0.16	0.22	0.30	0.01	0.01	0.01
2007	16,465	22,697	30,638	24,197	32,421	42,245	0.01	0.01	0.02	NA	NA	NA
2008	6,464	9,173	13,083	19,333	25,169	32,478	NA	NA	NA	NA	NA	NA
2009	7,347	10,199	14,273	16,190	20,776	26,782	NA	NA	NA	NA	NA	NA
2010	35,596	45,707	61,084	37,423	47,177	62,060	0.31	0.41	0.52	0.11	0.16	0.23
2011	79,221	100,710	130,679	84,720	107,123	138,804	0.24	0.32	0.41	0.05	0.06	0.09
2012	28,854	38,949	52,575	66,548	85,539	111,661	0.17	0.22	0.29	0.12	0.16	0.21
2013	21,829	31,257	44,356	42,813	58,475	80,380	0.24	0.33	0.45	NA	NA	NA

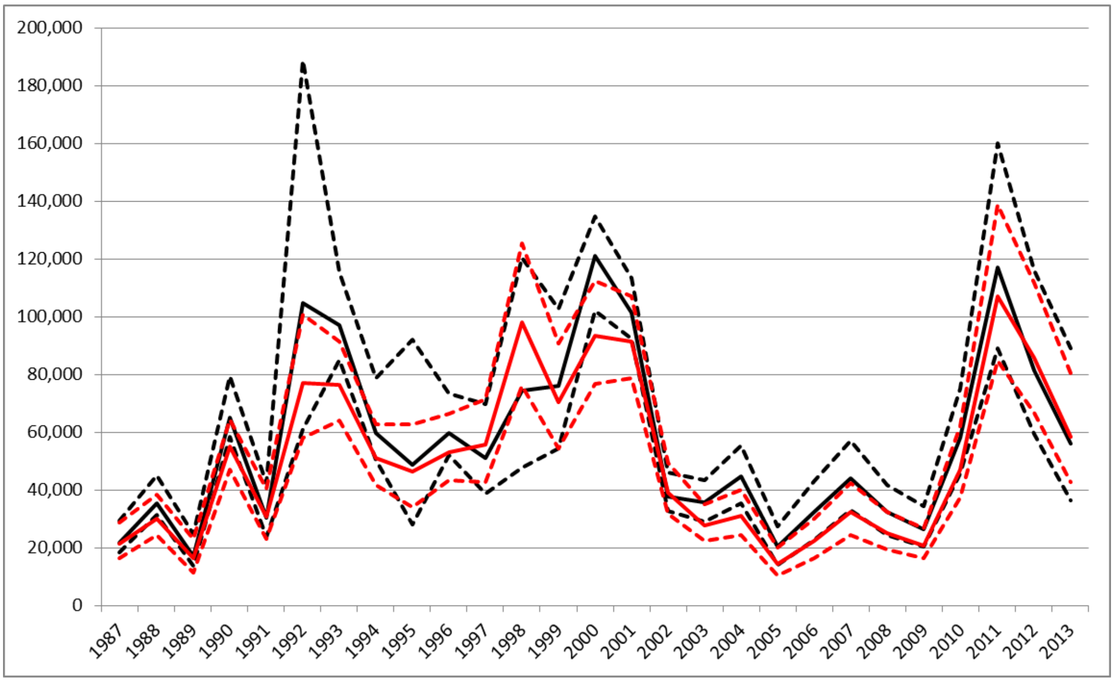

Figure A.1: Comparison of the Anchovy Spawning Biomass series from the old BBM model (from the June 2013 WGHANSA assessment- ICES 2013) (in black) and the CBBM with the new settings in the current Stock Annex (in red).

Annex 5.2 Stock Annex Anchovy in Division IXa

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 12 000 tn (Millán, 1992; García-Isarch *et al*., 2008).

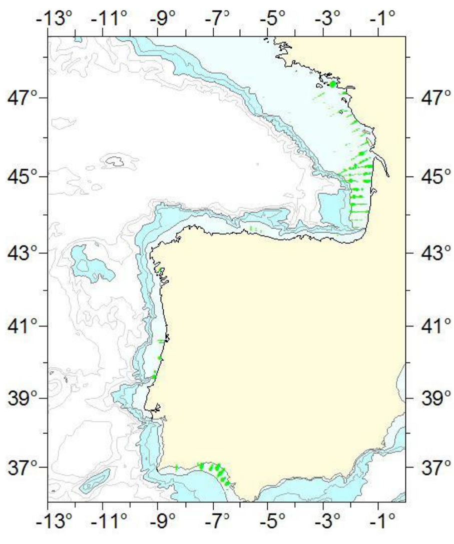

Figure A.1.1. Distribution of acoustic energy allocated to anchovy from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b).

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 responsible 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 hr to Sunday 12:00 hr;
- 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.

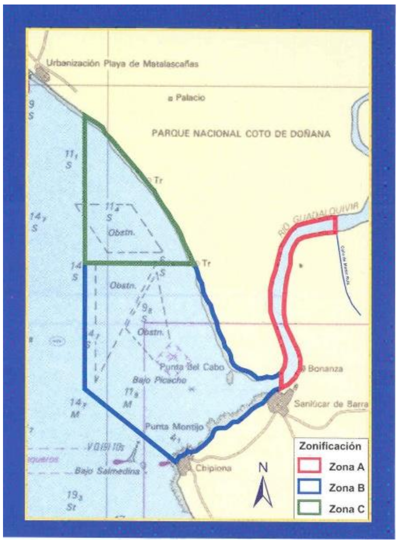

Figure A.2.1. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (SpanishGulf of Cadiz. Sub-division IXa South).

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 northeastern sector of the Gulf of Cadiz. The shallowness of the water column, the influence of the GuadalquivirRiver, 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 RV *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 (RV *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*, RV *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'.

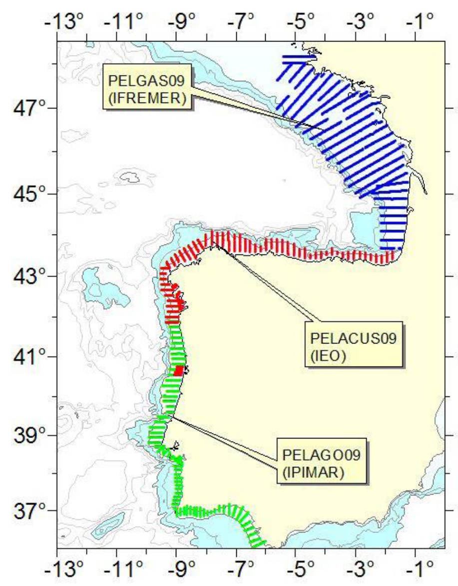

Figure B.3.1.1. Transects surveyed by the Spring *PELAGO*, *PELACUS* and *PELGAS* surveys. The early Summer *ECOCÁDIZ* surveys samples the same area that the *PELAGO* one in the Gulf of Cádiz waters (from Cape San Vicente to Cape Trafalgar).

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. TableB.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	(36°18'- 36°75'N – 6°22'- 8°92'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

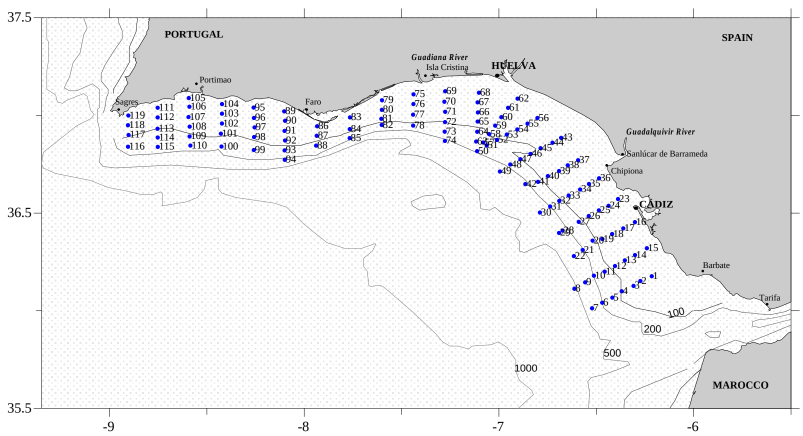

Figure B.3.2.1. Sampling grid adopted in the *BOCADEVA* anchovy DEPM surveys series.

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 incubationexperiment 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 amultinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST; a normal probabilitydistribution was used with peak spawning assumed to be at 22:00h with 2h standarddeviation. 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 spreadsheet.

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			

Type	Name	Year range	Age range	Variable from year to year Yes/No
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

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Annex 5.3 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).

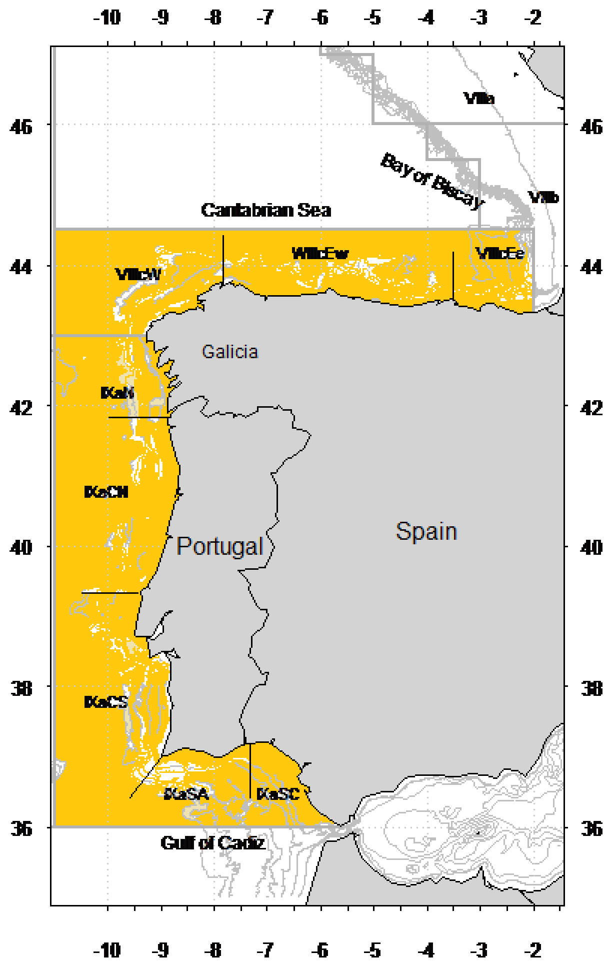

Figure A.1. Map of the current Iberian sardine stock area showing (in orange) the ICES Divisions and subdivisions currently considered in the assessment of the stock.

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 yearclasses 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	11cm	10% undersized allowed	EU Reg 850/98 amended 1999, 2000, 2001, 2004
Sardine/Anchovy	Effort limitations	National (ES)	VIIIc,IXa: minimum vessel tonnage 20GRT, maximum enginepower 450 hp, max length purse-seine 450m, max height purse-seine 80m, minimum mesh size 14mm, 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: 3000kg/vessel day(<10% of small sardine (<9cm))		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.

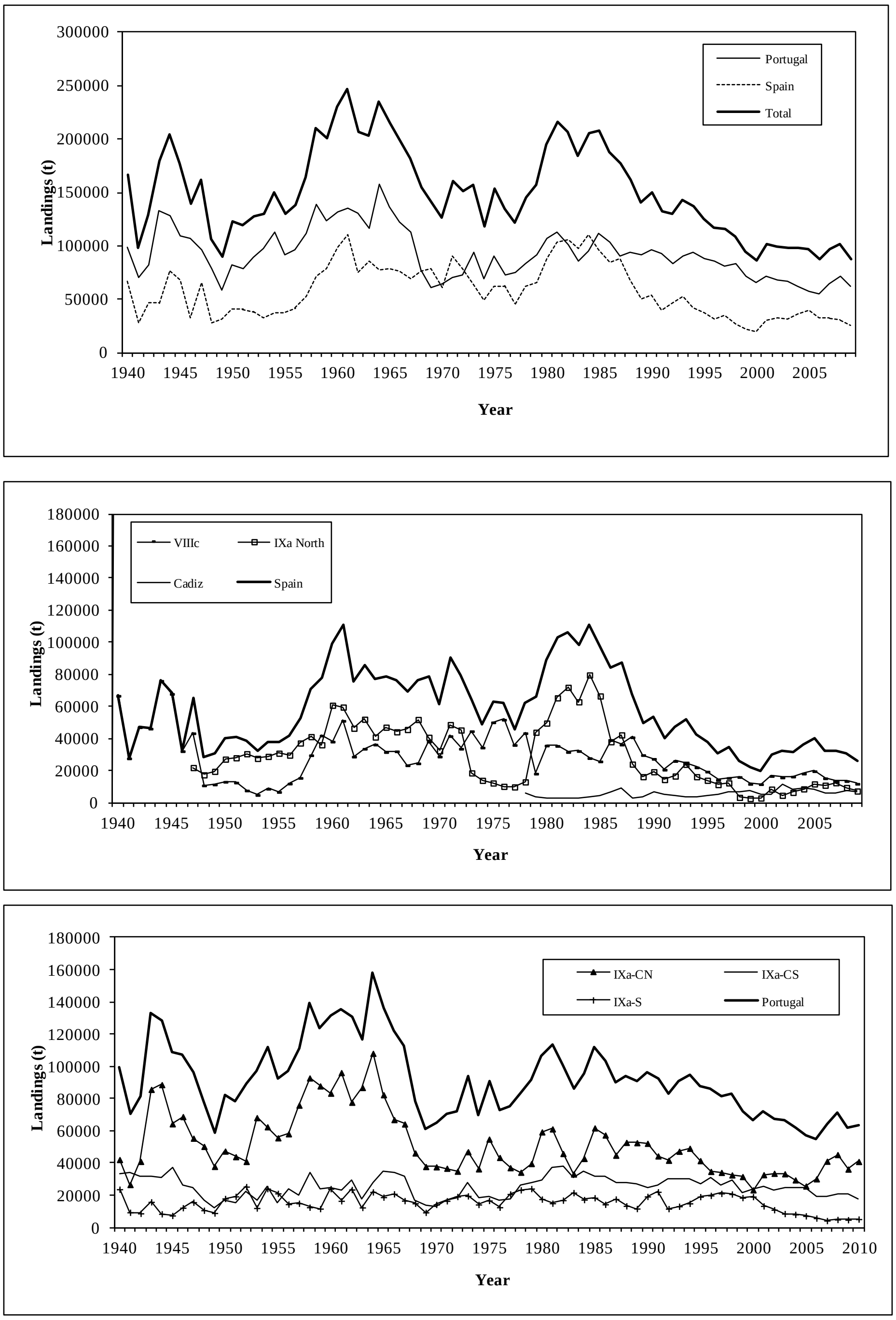

Figure B.1. Annual landings of sardine, by country and area.

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 be-cause 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 3m)	10m	10m
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 (onboard 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.

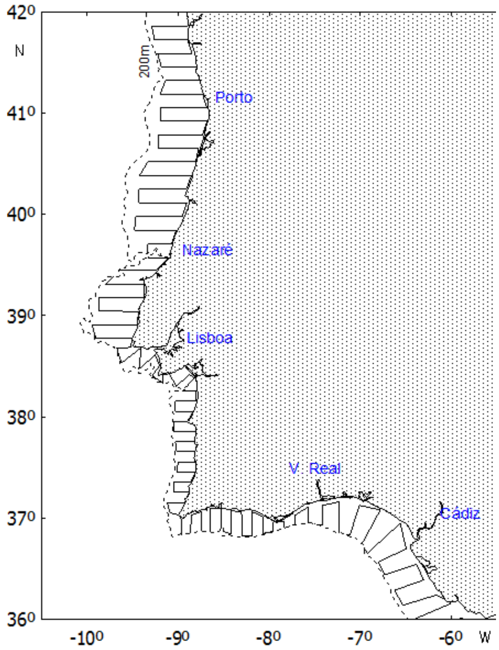

Figure B.3.2.1.1. Acoustic transects sampled during the PELAGOS acoustic survey in 2011.

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 (onboard 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.

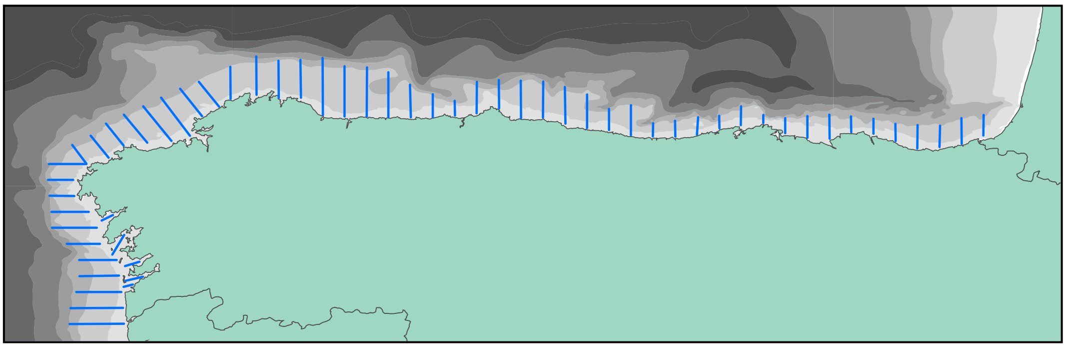

Figure B.3.2.1.2. Acoustic transects sampled during the PELACUS acoustic survey in 2011.

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.

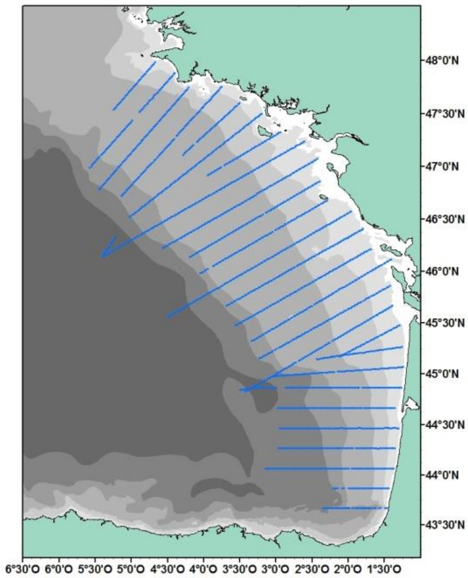

Figure B.3.2.1.3. Acoustic transects sampled during the PELGAS acoustic survey in 2011.

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		Acoustic survey	
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-depenv-varextra_seQ_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#	AgeSel_2P_2_Acoustic_survey
-5	9	-0.3	0	-1	0.01	2	0	0	0	0	0	0	0#	AgeSel_2P_3_Acoustic_survey
-5	9	0	0	-1	0.01	-2	0	0	0	0	0	0	0#	AgeSel_2P_4_Acoustic_survey
-5	9	0	0	-1	0.01	-2	0	0	0	0	0	0	0#	AgeSel_2P_5_Acoustic_survey

-5 9 0 0 -1 0.01 -2 0 0 0 0 0 0 0# AgeSel_2P_6_Acoustic_survey

-5 9 -0.8 -1 -1 0.01 2 0 0 0 0 0 0 0# AgeSel_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/surveyphasevaluesizefreq_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

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Annex 5.4 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)
Revised by	Manuela Azevedo, Gersom Costas (WGHANSA 2014)

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.

It is noted that SSB is estimated by the model assuming that the input for maturity ogive is representative only for females. Hence, total SSB should be computed from the model estimates by raising the estimates by a factor of 2.0. Consequently, the corresponding standard deviation (SD) should also be computed by raising by a factor of 2.0 the model estimates of the SD for the females SSB.

For horse mackerel the annual mean F is the average fishing mortality for ages 2 to 10 which can be computed from the matrix output "TotF".

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: Deterministic short-term projections

Software: Multi Fleet Deterministic Projection (MFDP)

The initial stock size corresponds to the assessment estimates for ages 1–11+ at the final year. Assuming a constant recruitment, the recruitment estimated in the final year of the assessment is replaced by the geometric mean recruitment of the time series

Maturity: Fixed Mat= 0, 0, 0.36, 0.82, 0.95, 0.97, 0.99, 1, 1, 1, 1, 1, for j=0,...,11

Natural mortality: Fixed M=0.15+(0.75, 0.45, 0.25, 0.15, 0.05, 0, 0, 0, 0, 0, 0, 0) for j=0,..., 11

Input values for the proportion of F and M before spawning are 0.08, which correspond to the mid of January when the spawning takes places.

Weights-at-age in the stock and in the catch are the values of the last year of the assessment.

The exploitation pattern is the estimates of the last year in the assesment.

Predictions are carried out with for $F_{multiplier}$, usually ranging from 0 to 2.. In the interim year, population size at age 1 is the survivors of the geometric mean recruitment assumed in the previous year.

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. YPR analysis

YPR analysis were performed in 2013.

Model: Deterministic short-term projections

Software:Multi fleet Yield Per Recruit (MYPR)

Maturity: Fixed Mat= 0, 0, 0.36, 0.82, 0.95, 0.97, 0.99, 1, 1, 1, 1, 1, for j=0,...,11

Natural mortality: Fixed M=0.15+(0.75, 0.45, 0.25, 0.15, 0.05, 0, 0, 0, 0, 0, 0, 0) for j=0,..., 11

F and M before spawning: PF=PM=0.08

Weight-at-age in the stock: last year of the assessment

Weight-at-age in the catch:last year of the assessment

Exploitation pattern:last year of the assessment

Input values for the proportion of F and M before spawning are 0.08, which correspond to the mid of January when the spawning takes places.

G. Biological reference points

$F_{35\%SPR}$, computed from YPR analysis was proposed as proxy for F_{MSY} (ICES, 2011) and adopted by ICES in 2013 as the basis for the advice for this stock according to the MSY approach.

H. Other issues

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Table 5. Symbols definitions used for model equations.

General Definitions	Symbol/Value	Use in Catch-at-age Model
Year index	i	
Age index	j	
Mean weight in year *i* and age *j*	W_{ij}	
Maximum age beyond which selectivity is constant	*Maxage*	Selectivity parameterization
Instantaneous Natural Mortality-at-age	M_j	Fixed in time: M = 0.9, 0.6, 0.4, 0.3, 0.2, 0.15,…, 0.15
Proportion of females mature at age	p_j	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_{s}^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 no fishing

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)
Survey abundance index by year (δ represents the fraction of the year when the survey occurs)	I_i	$I_i = q \sum_j N_{ij} W_{ij} S_j e^{-\delta Z_{ij}}$
Catch biomass by year	C_i	$\hat{C}_{ij} = \sum_j N_{ij} W_{ij} (1 - e^{-Z_{ij}}) F_{ij} / Z_{ij}$
Proportion at age j in year i	P_{ij}, $\sum_j P_{ij} = 1$	$P_{ij} = C_{ij} / \sum_j C_{ij}$
Numbers at age in first year and age	$j = 0$, i = first year (1992)	$N_{ij} = e^{\mu_R + \varepsilon_i}$
Numbers at age in first year	$0 < j < 11$, i = first year (1992)	$N_{ij} = e^{\mu_R + \varepsilon_{1993-j}} \prod_j e^{-M_j}$
Numbers at age in first year in age plus-group	$j = 11+$, i = first year (1992)	$N_{ij} = N_{i,j-1} / (1 - e^{-M_{j-1}})$
Numbers at age 0 in remaning years	$j = 0, \sum_i \varepsilon_i = 0$	$N_{ij} = e^{\mu_R + \varepsilon_i}$
Numbers at age in remaining years	$0 < j < 11$	$N_{ij} = N_{i-1,j-1} e^{-Z_{i-1,j-1}}$
Numbers at age group plus in remaining years	$j = 11+$	$N_{ij} = N_{i-1,j-1} e^{-Z_{i-1,j-1}} + N_{i-1,j} e^{-Z_{i-1,j}}$
Catchability of abundance index	μ^s	$q_i^s = e^{\mu s}$
Instantaneous fishing mortality		$F_{ij} = e^{\mu + \eta_j + \phi_i}$
Mean fishing effect	μ	
Annual effect of fishing mortality in year i	$\phi_i, \sum_i \phi_i = 0$	
Age effect of fishing (regularized) in years with time variation allowed	$\eta_{ij}, \sum_j \eta_{ij} = 0$	$s_{ij} = e^{\eta_j}$
Age effect of fishing (regularized) in years where selectivity is constant over time	$\eta_{ij} = \eta_{i-1,j}$	
Natural mortality vector	M_j	
Total mortality	Z_{ij}	$Z_{ij} = F_{ij} + M_j$
Spawning biomass (spawning takes place at mid January)	B_i	$B_i = \sum_j N_{ij} e^{-(0.5/12) Z_{ij}} W_{ij} p_j$
Recruitment at age 0 (Beverton-Holt function)	$\ddot{R}_i$	$\ddot{R}_i = \alpha B_i / (\beta + B_i)$, $\alpha = 4hR_o/(5h-1)$, $\beta = B_o(1-h)/(5h-1)$, B_0 is virgin biomass, R_0 is recruitment at virgin biomass, and $h = 0.8$

Table 7. Specification of objective function that is minimized (i.e., the penalized negative of the log-likelihood).

Likelihood/penalty component		Description / notes
Catch biomass likelihood	$L_1 = \lambda_1 \sum_i ln(C_i/\hat{C}_i)^2$	Fit to catch biomass in each year
Abundance indices	$L_2 = \sum_s \lambda_{2^s} \sum_i ln(I_i^s/\hat{I}_i^s)^2$	Survey abundances
Proportion at age	$L_k = \sum_{k,i,j} \tau_i^k P_{ij}^k \, ln(\ddot{P}_{ij}^k)$	k = 3 for the fishery and k = 4 for the survey
Penalty on smoothness for selectivities	$L_k = \sum_k \lambda_k \sum_j (\eta_{j+2}^l + \eta_j^l - 2\eta_{j+1}^l)^2$	k = 5 for the fishery and k = 6 for the survey
Penalty on recruitment regularity	$L_7 = \lambda_7 \sum_i \epsilon_i^2$	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).
Penalty on recruitment curve	$L_8 = \lambda_8 \sum_i ln(N_{i,0}/\tilde{R}_i)^2$	Conditioning on stock-recruitment curve (but reduced to have negligible effect on estimation).
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 5.5 Stock Annex:Sardine Subarea VII and VIIIabd

Stock	Sardine Subarea VII + VIIIabd
Working Group	WGHANSA
Date	4th to 8th of February, 2013
Revised at	WKPELA
Authors	E. Duhamel, L. Ibaibarriaga, J. Massé, L. Pawlowski, M. Santos and A. Uriarte.

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).

Sardine in Celtic Seas (VIIabcfgjk), English Channel (VIId, VIIe, VIIh) and in Bay of Biscay (VIIIabd) are considered to belong to the same stock from a genetic point of view. Therefore, the sardine stock in VIIIabd and VII can be considered as a single stock unit but it is important to note that there should be some distinction within the stock structure to take account of some regional differences between fisheries as there are some locally important fisheries operating in some area.

The availability of data strongly differs between the northern (Celtic Seas, English Channel) and the southern component (Bay of Biscay). Additionally, each area presents different historical exploitation patterns. Therefore analysis and management advice between the areas may differ, even if the advice covers the whole stock.

A.2. Fishery

There are currently no management measures implemented for this stock. The fisheries appear to be regulated by market price. Some fisheries (e.g. French fleets in the Bay of Biscay) have set their own local management in order to sustain correct market prices which imply targeting fish of certain sizes and limit to the total amount of catch. The absence of TAC is currently not seen as a problem for the management of those fisheries as the demand of sardine is considered to be low.

Divisions VIIIabd (Bay of Biscay)

An update of the French and Spanish catch dataseries in Divisions VIIIa and VIIIb (from 1983 and 1996 for France and Spain, respectively) including 2011 catches was presented to this benchmark. 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. 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 4400 tonnes in 1983 to 23 000 tonnes in 2011 (Figure A.2.1). 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.

Spanish catches were unusually high prior 1989 where a strong drop occurs. The reason of this drop is unknown and likely to be related to some data aggregation issues which make any uses of landings prior this year uncertain.

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 southwest Brittany.

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.

The Bay of Biscay sardine fisheries overlaps with VIIe and VIIh (statistical rectangle 25E4, 25E5). Catches in those rectangles are assumed to be of sardine from Bay of Biscay. Therefore landings in Bay of Biscay and English Channel are corrected to take account of this phenomenon by adding the catches in those rectangles to the Bay of Biscay landings time-series.

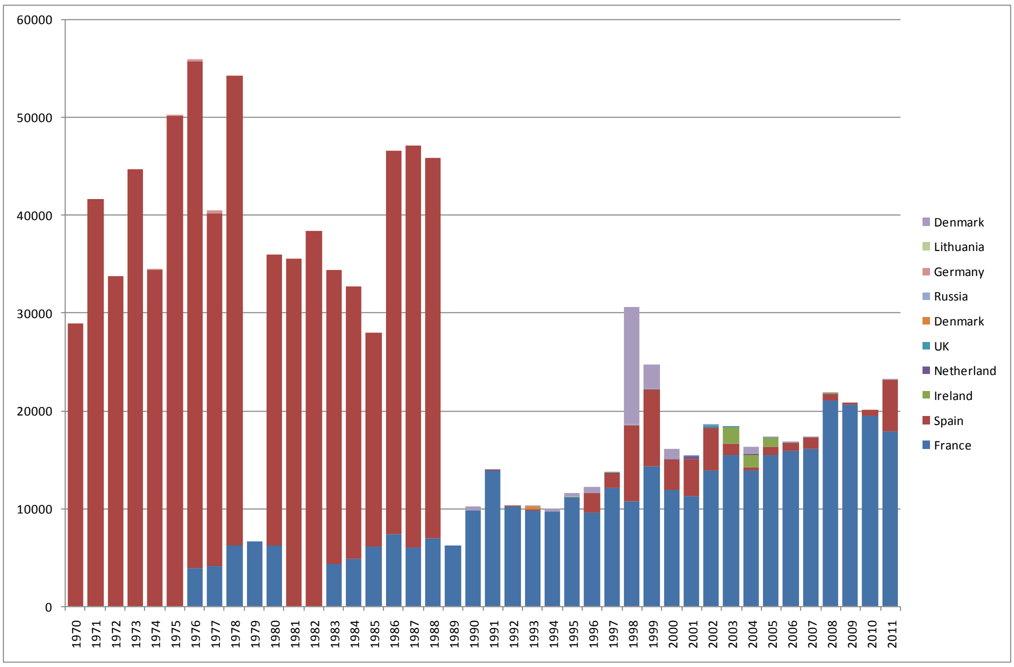


Figure A.2.1. Historical time-series of landings of sardine per country in the Bay of Biscay.

Subareas VIIdeh (English Channel and VIIh)

Most of the catches are concentrated close to or in the English Channel (VIId, VIIe, VIIh) with major landings from France and Netherlands, other catches being taken by England and Wales. Little information was available from other countries operating in that subarea. Catches have substantially oscillated with time and between countries from 25 000 to less than 2000 tons. This region has been harvested substantially in the past by various fleets (Figure A.2.2) from various countries that are no longer operating in those waters. The peak of fishing activity was in the early 1990s at around 25 000 tons. Over the last decades, the landings have been between nearly 5000 to 11 000 tons with no particular trends. The English Channel is after Bay of Biscay the second fishing area for sardine.

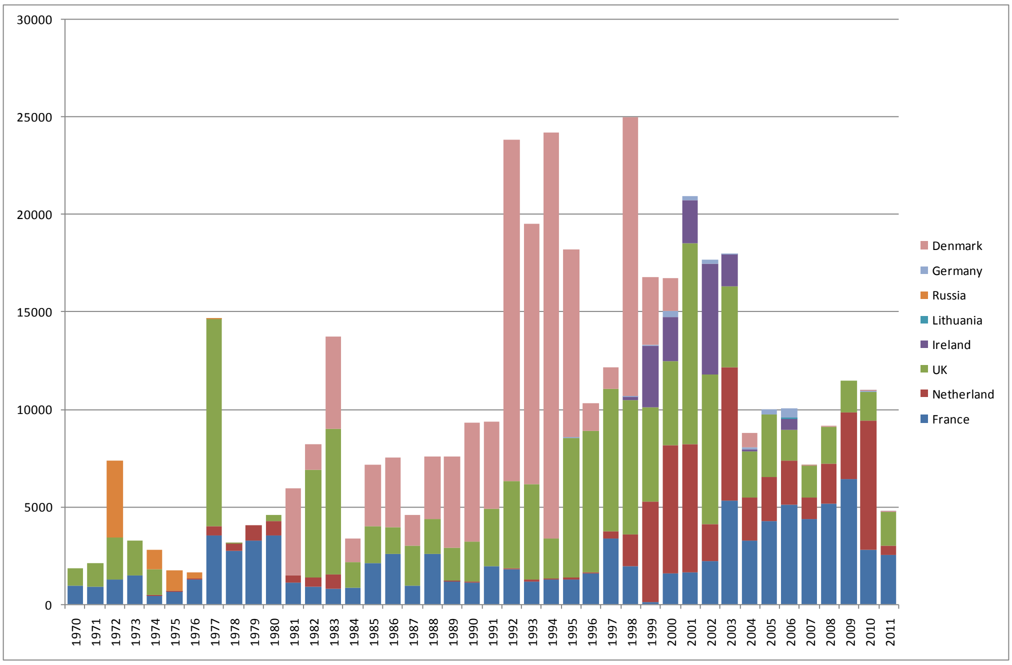


Figure A.2.2. Historical time-series of landings of sardine per country in the English Channel and VIIh.

As mentioned for the Bay of Biscay, catches in rectangles 25E4, 25E5 are removed from the official landings and added to the catches in the Bay of Biscay to take account of the mixing at the borders of Division VIIIa and VIIh and VIIe.

Subareas VIIabcfgjk (Celtic Seas)

Catches in this area are very low.

A.3. Ecosystem aspects

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.*, 2011) 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).

B. Data

B.1. Commercial catches

Landings data have been available for since 1950 on various aggregation levels. Data are considered to be accurate for all countries starting 1989 within the whole area. Discards were measured only in 2012 and were low based on the French Observers at sea program in the Bay of Biscay and hence not included in the assessment. 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. Length distribution of discards are also available from Netherlands in the English Channel for 2011.

B.2. Biological

- Catches-at-length and catches-at-age are known since 1984 for Spain and since 2002 for France in the Bay of Biscay. Because of the availability of the datasets only the period starting in 2000 is used. They are obtained by applying to the monthly Length distributions half year or quarterly ALKs. Biological sampling of the catches has been generally sufficient, and 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 each year reported in ICES (WGHANSA report, ICES 2012).
- Age reading is considered accurate. The most recent cross reading exchanges and workshop between Spain and France (but other countries, too) took place in 2011 (WKARAS report, ICES 2011). The overall level of agreement and precision in sardine of the Bay of Biscay age reading determinations seems to be satisfactory: Most of the sardine otoliths were well classified by most of the readers during the 2011 workshop (with an average agreement 75% and a CV of 14%).
- Sardines are mature in their 1st year of life.
- Growth in weight and length are routinely obtained from surveys and from the monitoring of the fishery.
- Natural mortality is fixed at 0.33 based on the assessment for sardine in VIIIc and IXa. This parameter is considered to vary between years and ages, but it is assumed to be constant for the assessment of the stock.

B.3. Surveys

Relevant surveys are available for the Bay of Biscay only. Some sardines are caught during the various demersal surveys (e.g FR-IBTS) occuring each year in the Celtic Seas, Bay of Biscay and English Channel but those catches are not substantial enough to be considered as indicators of the stock status.

Some abundance indices are available every year for the Bay of Biscay through two spring surveys based on acoustic surveys (PELGAS) and DEPM (Daily egg production method - BIOMAN).

The population present in the Bay of Biscay is monitored by the two annual surveys carried out in spring on the spawning stock, namely, the Daily Egg Production Method 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.

This survey based monitoring system provides population estimates by the middle of the year, when a small part of the annual catches have been already taken.

B.3.1. Sardine acoustic indices (PELGAS survey)

Acoustic surveys are carried out every year in the Bay of Biscay in springon board the French research vessel Thalassa since 1997. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay.

These surveys are connected with Ifremer programmes 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 WGHANSA, WGWIDE and WGACEGG.

In 2003, survey data are considered less reliable because of unusual environmental conditions linked to the heat wave over Europe. Results this year were considered not representative of the true status of the stock.

B.3.1.1. PELGAS Method and sampling strategy

In the frame of an ecosystemic approach, the pelagic ecosystem is characterised 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 seawater 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 and birds (from board) is 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.

The strategy of the survey is the same for the whole series (since 2000).

- Acoustic data were collected along systematic parallel transects perpendicular to the French coast (Figure B.3.1.1). 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 MARPORT on the pelagic trawl). Since 2009 the SIMRAD ME70 is used for multibeam visualisation. Energies and samples provided by split beam transducers (six frequencies EK60, 18, 38, 70, 120, 200 and 333 kHz), simple beam (MARPORT) and multibeam echosounder 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, on the west side of Brittany, in optimal 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.

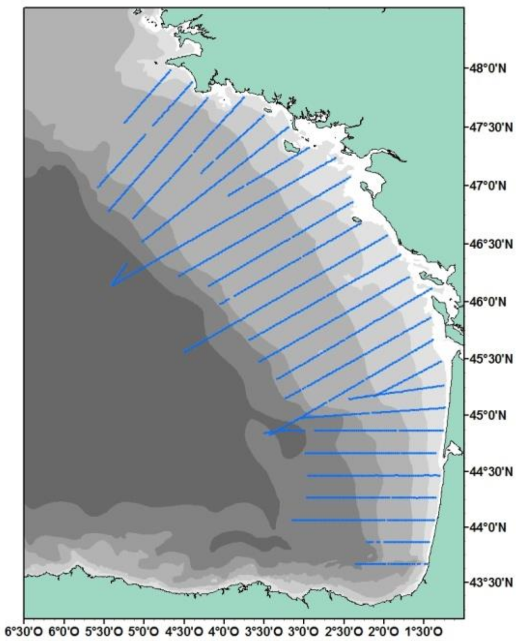


Figure B.3.1.1. The acoustic transects network of the PELGAS survey.

B.3.1.2. 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. Acoustic energies (Sa) are cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into several categories of echotraces according to the year fish (species) structures.

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 10 m 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 boarfish 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).

B.3.1.3. 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:

$$M_e(k) = \sum_D \bar{s}_A(D,k)\bar{X}_e(D,k)$$

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 (m_2/n.mi.$_2$)

$\mathbf{X_e}$: species proportion coefficient (weighted by energy around each haul) (tons m^{-2})

A : area of the strata (m.n.^{2})

Then variance estimate is:

$$Var.M_e(k)=\sum_D \bar{s}_A^{\,2}(D,k)Var[X_e(D,k)]/n.cha(k)+\overline{X}_e^{\,2}\,\mathrm{var}[s_A(D,k)]/n.esu(D,k)$$

$$Var.B_e=\sum_k A^2(k)Var.Me(k)$$

$$cv=\sqrt{Var.Be}/Be$$

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 (ICES 2009).

B.3.2 Anchovy Daily Egg Production Method (BIOMAN Survey)

B.3.2.1 the DEPM model

The sardine spawning–stock biomass estimates is derived according to Parker (1980) and Stauffer and Picquelle (1980) from the ratio between daily production of eggs in the sea and the daily specific fecundity of the adult population:

$$SSB = P_{tot}/DF = \frac{P_0 \cdot A+}{k \cdot R \cdot F \cdot S/W}$$

Equation 1

Where,

SSB = Spawning–stock biomass in metric tons

$\mathbf{P_{tot}}$= Total daily egg production in the sampled area

$\mathbf{P_0}$= daily egg production per surface unit in the sampled area

A+ = Spawning area, in sampling units

DF = Daily specific fecundity. $DF = \dfrac{k \cdot R \cdot F \cdot S}{W}$

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 and Picquelle, *op. cit.*) was also developed by the latter authors.

Population estimates of numbers-at-age are derived as follows:

$$N_a = N \cdot E_a = \frac{SSB}{W_t} \cdot E_a$$

Equation 2

Where,

Na = Population estimate of numbers-at-age *a*.

N = Total spawning–stock estimate in numbers. $N = \frac{SSB}{W_t}$

SSB = 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 sardine stock in numbers-at-age and total is derived applying the delta method.

B.3.2.2 Collection of plankton samples

Every year the area covered to collect the plankton samples is the southeast of the Bay of Biscay taking in advance the anchovy survey in the Bay of Biscay.

Predetermined distribution of stations is 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 (Motos, 1994). Stations are located every 3 miles along 15-mile-apart transects perpendicular to the

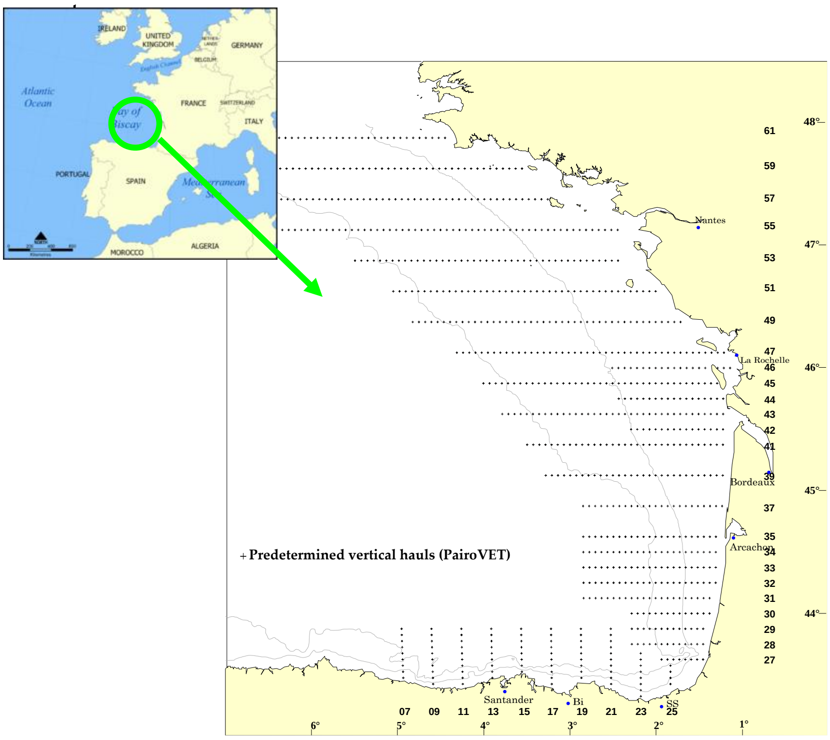


Figure B.3.1.2.1. Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey.

At each station a vertical plankton haul is performed using a PairoVET net (Pair of Vertical Egg Tow, Smith *et al.*, 1985 in Lasker, 1985) with a net mesh size of 150 µm for a total retention of the sardine eggs under all likely conditions. 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 is used to allow for correctly deploying the net. "G.O. 2030" flowmeters are used to detect sequential clogging of the net during a series of tows.

Immediately after the haul, the net is washed and the samples obtained are fixed in formaldehyde 4% buffered with sodium tetra borate in seawater. After six hours of fixing, anchovy, sardine and other eggs species are identified, sorted out and count 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 ensure no eggs were left in the sample. In the laboratory, sardine eggs are classified into morphological stages (adapted from Gamulin and Hure, 1955).

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) is used to record the eggs found at 3 m depth with a net mesh size of 350 µm. The CUFES system has 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 are registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

During the survey, the anchovy, sardine and other eggs are recorded per PairoVET station and the area where sardine eggs occurred is quantified. Following the systematic central sampling scheme (Cochran, 1977) each station is located in the centre of a rectangle. Egg Abundance found at a particular station is assumed to represent the abundance in the whole rectangle. The area represented by each station is 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 two consecutive transects) nautical miles. Since sampling is adaptive, station area changed according to sampling intensity and the cut of the coast.

Sample depth, temperature, salinity and fluorescence 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 to calibrate the chlorophyll data.

B.3.2.3 Collection of adult samples

Since 2008 each three years adults are being obtained from a research vessel with pelagic trawl taking in advance the anchovy survey.

The research vessel pelagic trawler covers the same area as the plankton vessel. When the plankton vessel encountered areas with sardine eggs, the pelagic trawler is directed to those areas to fish. In each haul 100 individuals of each species are measure. Immediately after fishing, sardine is sorted from the bulk of the catch and a sample is selected at random. A minimum of 60 anchovies are weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) are preserved. If the target of 25 NHF is not completed 10 more anchovies are taken at random and process in the same manner. Sampling is stopped when 120 anchovies have to be sexed to achieve the target of 25 NHF. Otoliths are extracted on board and read in the laboratory to obtain the age composition per sample.

B.3.2.4 Total daily egg production estimates

Since 1999 the sardine eggs were counted but only were staged in years 1999, 2002, 2008 and 2011.

In years without egg stages it was considered the total abundances of eggs defined as the sum along all the stations of the sardine eggs in each station multiplied by the area each station represents.

In years when sardine eggs are sorted and staged (1999, 2002, 2008 and 2011), 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 sardine 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 daily egg production per area unit (P0) 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 Pi,j and ai,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, Pi,j, be the ratio between the number of eggs Ni,j and the effective sea area sampled Ri (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) $$\log\left(E[N_{i,j}]\right) = \log(R_i) + \log\left(P_0\right) - Z \, a_{i,j},$$

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 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). Sardine spawning time was assumed to be normally distributed with mean at 21:00h GMT and standard deviation of 3 (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 15 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). The incubation temperature considered was the one obtained from the CTD at 10 m in the way up.

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. Once the final model estimates were obtained the coefficient of variation of P0 was given by the standard error of the model intercept (log(P0)) (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.

B3.2.5 Adult parameters, daily fecundity and SSB estimates

In 2008 and 2011 adult samples were collected within the same day as the egg sampling. These samples are used to obtain adult parameters to estimate the daily fecundity, i.e. batch fecundity, spawning fraction, average female weight and sex ratio.

These adult parameters are estimates as follows:

Sex Ratio (R): It is calculate as 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 nonhydrated 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 and Uriarte (1989) showed that three 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 subsample is raised to the total gonad of the female according to the ratio between the weights of the gonad and the weight subsampled.

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, was estimated from the incidence of postovulatory follicles 1 and 2 day old in the gonads of mature females (Hunter and Macewicz, 1985) (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF).

Mean and variance of the adult parameters are estimated following equations for cluster sampling (as suggested by Picquelle and 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 800 g, 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.

The Spawning–Stock Biomass is estimates as the ratio between the total egg production (P_{tot}) and Daily Fecundity (DF).

B3.2.6 Egg abundance estimates 1999–2012

Table B3.2.6.1. Sardine egg abundances in the Bay of Biscay from 1999 to 2012.

Ab.tot.Sp is the sum along all the stations of the sardine eggs in each station multiplied by the area each station represents. Pos.area is the positive area for sardine; tot area is the total area surveyed; %pos area is the percentage the positive area represents in relation to the total area and Ptot is the total egg production.

Ab.tot_Sp	pos area	tot area	% pos area	Ab.tot/pos.area	Ptot(egg/day)
1.3E+12	26,679	59,193	45	5.0E+07	7.8E+11
5.0E+12	40,139	52,212	77	1.2E+08	
9.2E+11	14,547	51,629	28	6.3E+07	
8.3E+12	39,112	50,951	77	2.1E+08	4.4.E+12
2.8E+12	22,878	47,927	48	1.2E+08	
9.2E+12	37,289	49,446	75	2.5E+08	
1.1E+13	38,979	50,202	78	2.8E+08	
3.8E+12	23,376	45,413	51	1.6E+08	
2.3E+12	16,710	45,499	37	1.4E+08	
9.4E+12	20,235	46,501	44	4.6E+08	6.0.E+12
7.53E+12	34,746	60,733	57	2.2E+08	
1.06.E+13	36,361	61,940	59	2.9E+08	
4.50.E+12	22,851	98,405	23	2.0E+08	available
5.68E+12	20,054	80,381	25	2.8E+08	

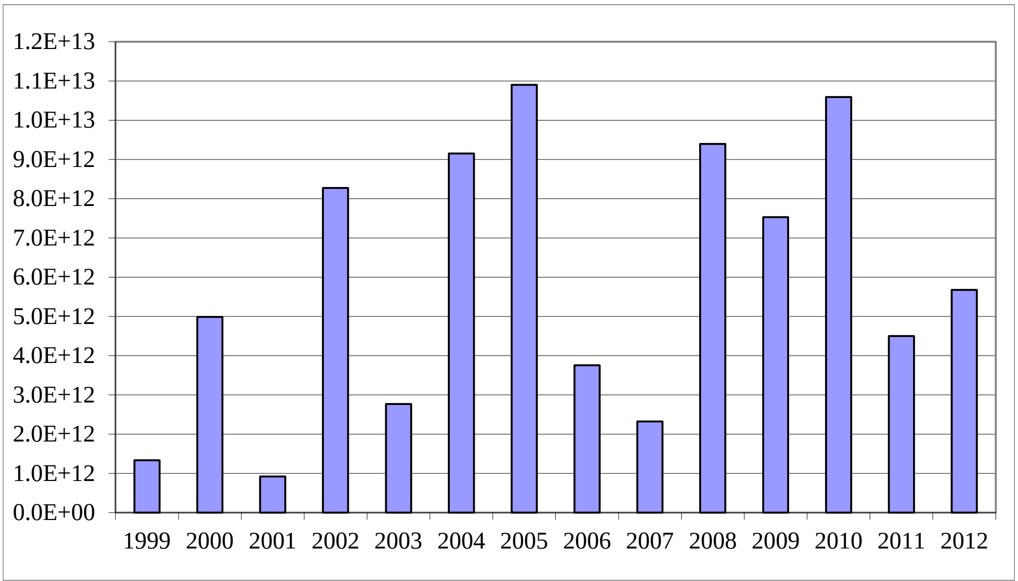
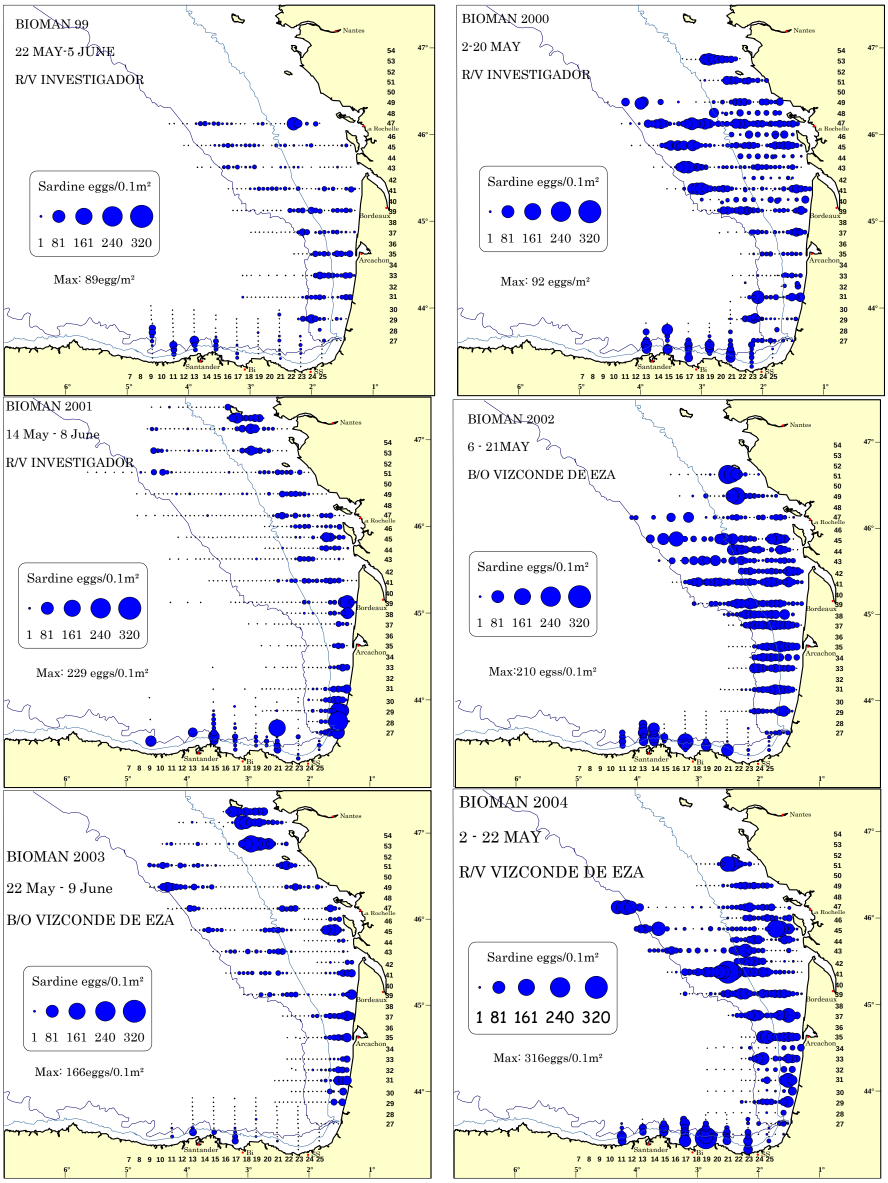
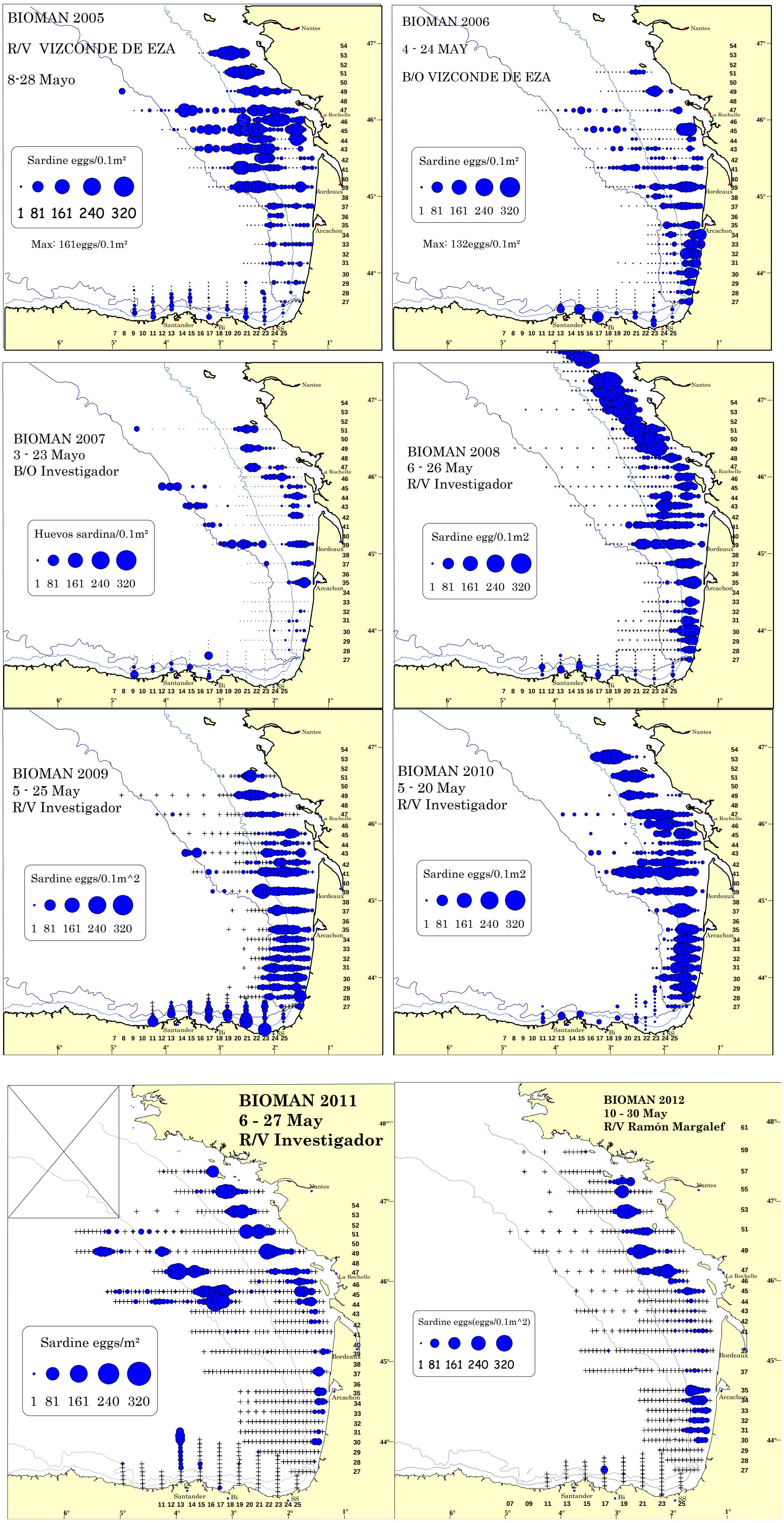


Figure B3.2.6.1. Total sardine egg abundance estimates from 1999 to 2012 in the Bay of Biscay.

B.3.2.7 Historical series DEPM and acoustic surveys




BIOMAN 2005
R/V VIZCONDE DE EZA
8-28 Mayo
Sardine eggs/0.1m²
1 81 161 240 320
Max: 161eggs/0.1m²
BIOMAN 2006
4 - 24 MAY
B/O VIZCONDE DE EZA
Sardine eggs/0.1m²
1 81 161 240 320
Max: 132eggs/0.1m²
BIOMAN 2007
3 - 23 Mayo
B/O Investigador
Huevos sardina/0.1m²
1 81 161 240 320
BIOMAN 2008
6 - 26 May
R/V Investigador
Sardine egg/0.1m2
1 81 161 240 320
BIOMAN 2009
5 - 25 May
R/V Investigador
Sardine eggs/0.1m^2
1 81 161 240 320
BIOMAN 2010
5 - 20 May
R/V Investigador
Sardine eggs/0.1m2
1 81 161 240 320
BIOMAN 2011
6 - 27 May
R/V Investigador
Sardine eggs/m²
1 81 161 240 320
BIOMAN 2012
10 - 30 May
R/V Ramón Margalef
Sardine eggs(eggs/0.1m^2)
1 81 161 240 320
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS

B. 3.3 Sardine Daily Egg Production Method (SAREVA Survey) in the inner of the Bay of Biscay

B.3.3.1 Introduction

The Daily Egg Production Method (DEPM) is a well-established methodology to assess the spawning biomass (SSB) of fish species with indeterminate fecundity. The Sardine DEPM is based on the equation (Picquelle and Stauffer, 1985; Lasker, 1985):

$$SSB = \frac{Area^{+} * P0 * W}{F * S * R}$$

Where

P_0: Daily egg production (eggs/m^2/day)

Area $^+$: Spawning area

W: Average weight of mature females in grams

F: Batch fecundity, number of eggs spawned per mature female per batch

S: Spawning fraction, fraction of mature females spawning per day

R: Sex Ratio is the fraction of the mature population that are females by weight.

The Daily Egg Production Method (DEPM) for sardine has been applied by Instituto Español de Oceanografía (IEO) to estimate the spawning–stock biomass of the North Atlanto-Iberian sardine stock since 1988 (García *et al.*, 1992) and then repeated in 1990, 1997, 1999, 2002, 2005, 2008 and 2011. From 2000 onwards the surveys have been planned and conducted within the framework of ICES, on a triennial basis. Spring surveys for the application of the DEPM, consisting of ichthyoplankton, adults and hydrographic sampling, and since 1997 the sampling area was extended in order to reach the 45 degrees latitude North, covering the region from the northwestern (border Minho River), north Iberian Peninsula (north Spanish Atlantic and Cantabrian waters, ICES Division IXa North and VIIIc) and the inner part of the Bay of Biscay (from 42 ºN to 45°N, ICES Division VIIIb).

This section provides a description of the sampling, laboratory analysis and estimation procedures used to obtain the sardine spawning–stock biomass estimate for the application of DEPM conducted by IEO from 1997 to present in the inner of the Bay of Biscay (ICES Division VIIIb). Since 2002 extra effort was put in place in order to standardize methodologies for surveying, laboratorial and data analyses. These objectives were possible due to methodological developments and effective coordination undertaken first by the SGSBSA (ICES 2002–2004) and later by the WGACEGG (Stratoudakis *et al*., 2004; Stratoudakis *et al*., 2006; ICES, 2009; ICES, 2010; ICES, 2011).

Estimations for area delimitation (surveyed & spawning), egg ageing, mortality and model fitting for egg production (P_0) are presented. Results from adults fishing sampling are showed and parameters from the mature fraction of the population (mean females weight, sex ratio, batch fecundity and spawning fraction) are calculated. Estimates were based on procedures and software adapted and developed during the WKRESTIM 2009 and modifications carried out subsequently for the revision of the sardine DEPM historical series (1988–2011) in Divisions IXa and VIIIc.

Sardine DEPM estimates in the inner of the Bay of Biscay (the inner part of Divisions VIIIb until 45˚N) from 1997 until 2011, were presented in ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX

(WGACEGG) last November of 2012, in order to be considered as a contribution for the ICES WKPELA 2013 meeting for sardine in Subarea VII and Divisions VIIIa, b, d.

B.3.3.2 Methodology

B.3.3.2.1 Surveying

From 1997, six DEPM surveys were carried out by IEO (1997, 1999, 2002, 2005, 2008 and 2011). The Spanish surveys were undertaken using two vessels, RV Cornide de Saavedra for plankton sampling mainly and RV Thalassa to carry out the fishing hauls (in 2008 and 2011 some fishing hauls were carried out on RV Cornide de Saavedra). The surveys were designed to obtain en adequate spatial and temporal coverage during the spawning peak of sardine in the area.Due to the bad weather, in 2005 was not possible to complete the plankton sampling coverage, so no data for this year is presented in this work.

Plankton sampling

The main egg sampler for the DEPM is the PairoVET net that collects eggs through the water column at point stations. The PairoVET sampler (=double CalVET) includes two nets (Ø 25cm) with 150 µm mesh size; sampling covered the water column from bottom, or 100 m (beyond the 100 isobath) depth, to the surface. Vertical plankton hauls were carried out following a pre-defined grid (Figure 3.3.2.1.1) of sampling stations along transects perpendicular to the coast and spaced 8 miles from 2005 onwards. The inshore limit of the transects is determined by bottom depth (as close to shore as possible) while the offshore extension was decided adaptively, based on the presence of eggs and covering the extension of the platform to the 200 m isobath.

From 2002, the Continuous Underway Fish Egg Sampler (CUFES) was used as an auxiliary egg sampler, helping in defining the offshore extension of the transects and to modify adaptively the intensity of CalVET sampling. The outer limit of a transect was reached when two consecutive CUFES samples were negative beyond the 200 m depth.

From 1997 to 2005, a CTD (Sea Bird-25) profile (Temperature and Salinity) was carried out in each CalVET station. From 2008 to 2011 the Sea Bird-25 was used in each transect head and in alternate stations along the transects, meanwhile a CTD (Sea Bird-37) was coupled to the CalVET sampler. General Oceanics Flowmeters were used to record the towing length and estimate the sampled water volume (assuming a filtration efficiency of 100%).

After hauling, nets are washed from the outside with seawater under pressure and plankton samples from the two nets are preserved in formalin at 4% in distilled water and the two samples from each net stored in separate containers. Samples for one net are then sorted, and sardine, anchovy and other eggs are identified and counted. The total numbers of eggs from both plankton samplers, CalVET and CUFES, were counted onboard in order to obtain a preliminary data of sardine egg abundance and distribution.

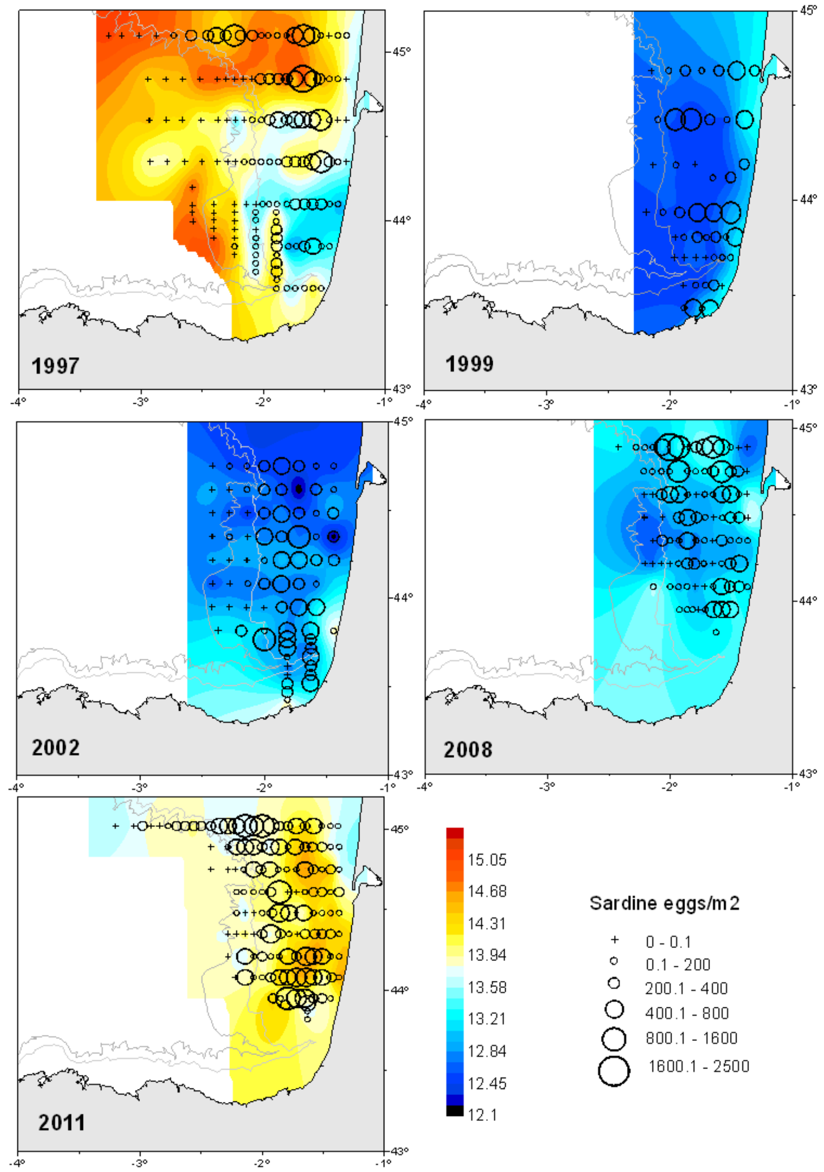


Figure 3.3.2.1.1. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Sardine egg distribution (eggs/m² from PairoVET sampler) and SST (ºC) by year.

Adult fish surveying

Fishing hauls were conducted by pelagic trawling following sardine schools detection by the echosounder (for RV Thalassa). The number of samples and its spatial distribution was organized to ensure good and homogeneous coverage of the survey area (Figure 3.3.2.1.2) in order to obtain a representation of the sardine population.

Onboard the RV, and for each haul, a minimum of 60 sardines were randomly selected and biologically sampled. These could also be 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. The biological sampling was always carried out in fresh material, and ovaries were immediately collected and preserved in a formaldehyde buffered solution (4% diluted in distilled water) for posterior histological processing and analysis at the laboratory. Moreover, otoliths were extracted on board to obtain the age composition per sample in the laboratory.

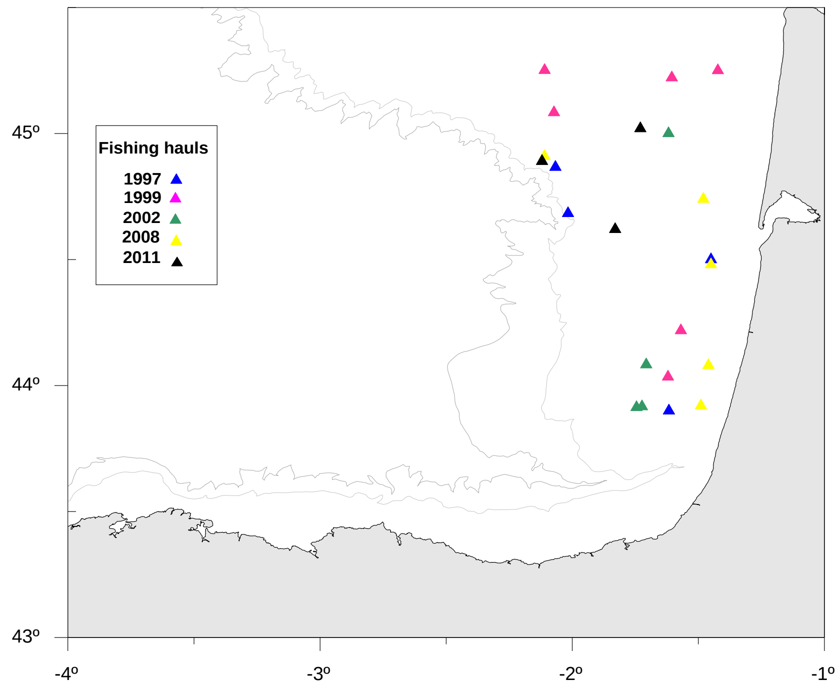


Figure 3.3.2.1.2. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Spatial distribution of the positive fishing hauls by year.

B.3.3.2.2. Laboratorial analysis

Plankton samples

In the laboratory, all sardine eggs were sorted from PairoVET samples. The eggs from the vertical hauls (one net) were all counted and staged according to the eleven stages of development classification (adapted from Gamulin and Hure, 1955). Samples for the second net are used for plankton biomass quantification.

Adult fish samples

The preserved ovaries were weighted in laboratory and the obtained weights corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries were processed for histology, first, they were embedded in resin (paraffin before 2005), the histological sections were stained with haematoxylin and eosin, and then the slides examined and scored for their maturity state, POF presence and age assignment (Hunter and Macewicz, 1985; Pérez *et al.*, 1992a; 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 subsamples per ovary, weighting on average 50–150 mg (Hunter *et al.*, 1985).

B.3.3.2.3 Data analysis

Databases with date, time, position, bottom depth and other variables registered during the sampling on board and in the laboratory, were merged in a common standardised dataset (eggs and adults data separately) and include all surveys undertaken in the period from 1997 to 2011. The dataset for eggs and adults include minor corrections (e.g. wrong geographical coordinates, duplicated points, ovary and total weights data, etc.), that were observed as mistakes in a first exploration data. All estimations and statistical analysis were performed using the R software (www.r-projet.org).

Egg data

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.

The coastline and depth contour were imported from the GEBCO coastline, transformed into spatial objects to be used with the statistical software R. The limits of the survey area (sampled) and positive area (area with eggs), both offshore and coastal, were estimated using the library geofun, which mainly use the spatial analysis functionality provided by spatstat. To define the precision of the poligons to be selected, a 600x600 resolution was used in the spatstat function (spatstat.options(npixel=c(600,600)).

To find the geographical limits of sampled and positive areas the findlimits.fun function was used. The procedure includes an automated routine using neighbourhood distance, in km, between stations (minimum distance in ratio represented by each station). The routine thus generates circles around each sampling point and uses the intercepts between circles to define the sampling area. To estimate the limits of the sampled area, the argument dist was set to 15 km (findlimits.fun (data, dist = 15, plot = "limits")) and all the sampled stations were used in the analysis.

The limits of the spawning area (positive area) were obtained using only those stations with eggs, the diameter of the circles was the same referred above (15 km) allowing embedment of negative stations fully surrounded by positive stations. After this initial delimitation of positive area, the function erode.owin (with diameter = 10 km) was used to reduce the external limits of the positive area, in order to limit the amount of negative (offshore) stations included in the positive area. With this trimming only the negative stations on the borders are excluded from the positive areas. The stations within that domain are flagged as positive and thereafter used in the analyses. Both the survey and total areas were afterwards corrected to avoid extrapolation to the coast, by computing the intercept between the areas estimated as above and the area delimited by the coastline.

To avoid high and low extremes values detected in the area represented by each sampled station, the parameter "area.range" was 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 area.range parameter was included in the estimate.sea.area function during the present analyses to avoid over estimation of the areas on the borders of the survey limits. The range 25–175 was selected to be a mean interval suitable for all the surveys, according to the distance between transect and stations (that varied in the initial years; from 2002 onwards it was fixed to be 8 nm between transects and 3 or 6 nm between stations, along transects).

The area represented by each station within the survey limits is estimated by a dirichlet tessellation of the survey stations, using the survey limits as estimated above. The positive area is the sum of the areas of the individual stations included in the positive area (including also the negative stations embed in the positive area).

The model of egg development with temperature was derived from the incubation-experiment data available within the *sardata* R library. Egg ageing was achieved by amultinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST.

depm.control function from *egg* package, controls some constants for DEPM as the assumption of spawning peak, the proportion of eggs that must still be unhatched (i.e. not transformed to larvae) at "2*sig" past the last cohort mean age (how.complete) and the distribution of the daily spawning cycle. For the present analyses the 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 entire area considered and it is not dependent on the individual stations (upper.age=F). Older cohorts are dropped if their mean age plus 2* st-dev 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).

The exponential model: E [P] = P0 e $^{-Z\ age}$ was fitted as a Generalized LinearModel (GLM) with negative binomial distribution and log link. For 1999 survey a model without mortality was applied since an estimate for mortality led to non-coherent mortality. Weights proportional to the relative area represented by each station (estimated using the dirichlet tessellation and divided by the mean area represented by a station) were used to account for increased sampling in areas of expected high egg densities.

Finally, the total egg production is calculated multiplying the daily egg production ratio (eggs per m^2 and day) by the positive area (in m^2).

*Ptot =P0 *A+*

Fish data

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 surveys. For the present estimations, a minimum sample criterion (n = 30) was introduced: a few hauls containing less than 30 fish sampled were excluded from the mean and variance calculations.

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 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).

In 1999 no histology samples were available to estimate spawning fraction (S) and a non-parametric bootstrap approach was performed using mean spawning fraction by each haul obtained along the all series and considering a single haul as the basic sampling unit. Hauls were resampling with replacement from the original dataset, leading to a new, artificial sample that was then used to estimate S parameter. By repeating this procedure an adequate number of times (1000 in this application), we obtained an empirical probability distribution for the S parameter.

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 hydrated females and their gonad-free weight (Wnov) by a GLM (with a negative binomial error distribution and an identity link). In 1999, 2002 and 2008, no hydrated o very few hydrated females were collected off the Inner of the Bay of Biscay (no one in 1999 and 2002, and n = 3 in 2008). For these years, F was modelled polling data from the inner Bay of Biscay and North Spanish coast, but F estimates were nevertheless calculated for the two areas separately.

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).

Spawning–stock biomass (SSB)

Spawning–stock biomass (SSB) is obtained based on the equation proposed by Picquelle and Stauffer (1985):

$$SSB = \frac{Area^{+} * P0 * W}{F * S * R}$$

For the calculation of the coefficient of variation, variance is estimated using the Delta method (Seber, 1982), in which the squared CV of the product of several parameters is equal to the sum of their squared CVs:

$$CV(B)^2 = CV(P)^2 + CV(W)^2 + CV(R)^2 + CV(F)^2 + CV(S)^2.$$

B.3.3.3 Results

Eggs

Total transects and PairoVET stations that were sampled along the years are summarised on Table 3.3.3.1. In 1997 and 2011 the number of samples performed was higher than others years and 1999 was the year with less stations sampled. The percentage of stations with sardine eggs was higher than 63% for all years and has been increasing from the first survey (1997) until the last one (2011), reaching 85% in 2011. In total 6667 were sorted, staged and counted for the vertical tows in the area studied, of which 2764 were caught in 2011, around 1100 in 1997, 2002 and 2008, and 586 in 1999. The highest egg abundances per haul were 2332.1 (eggs/m^2) and 2321.7 (eggs/m^2) reached in 2008 and 2011 respectively. The lowest egg abundance per haul was 1185.4 (eggs/m^2) in 1999 and with values ranged from 1185.5 to 1669.6 (eggs/m^2) for 2002 and 1997 respectively.

Table 3.3.3.1.Sardine DEPM IEO surveys in the inner of the Bay of Biscay. General sampling for eggs.

SURVEY EGGS	1997	1999	2002	2008	2011
R/V	Cornide de Saavedra				
Date	27/03–02/04	03/04–05/04	06/04–12/04	20/04–24/04	09/04–15/04
Transects	12	11	10	8	10
PairoVET stations	140	48	75	97	134
Positive stations	89 (63.6)	37 (77.1)	55 (73.3)	74 (76.3)	114 (85.1)
Tot. Eggs	1123	586	1090	1104	2764
Max eggs/m^2	1669.6	1185.4	1220.1	2332.1	2321.7
Temp (˚C) min/mean/max	12.8/14.1/15.3	12.5/12.7/13.3	12.1/12.9/13.9	12.6/13.1/13.9	13/14/14.7
CUFES stations	-	-	130	95	137
Positive CUFES stat.	-	-	88(67.7)	84 (88.4)	124 (90.5)
Tot. Eggs CUFES	-	-	7108	13837	39798
Max eggs/m^3	-	-	83.6	215.5	97.3

For all the surveys, 99.2% of the sardine eggs have been classified into eleven stages according to the degree of embryonic development. It has been found sardine eggs in all the described stages (except stage I in 1999 and 2002). The most abundant development stages were II, V and VI. Very few eggs of stage I and XI (right after and before the spawning and hatching respectively) were found along the series.

Sardine egg distribution, obtained from the PairoVET sampler, for the whole area is presented in Figure 3.3.2.1.1. Almost the entire shelf (from coast to slope) was occupied by sardine eggs. For some years (1997, 2008 and 2011), two areas of spots with higher density occurred along the coast and offshore, namely in waters along the end of the continental slope (200 m depth), meanwhile some zones of weaker density in the distribution were observed between both, coast and offshore waters.

The oceanographic setting during the period of the surveys for the region was showed in Figure 3.3.2.1.1 and Table 3.3.3.1. Minimum, mean and maximum measured SST ranged from 12.1 to 15.3˚C. The highest temperature values were observed in 1997 and 2011; meanwhile the lowest one was registered in 2002.

The estimates of both surveyed and spawning area, mortality, daily egg production and total egg production are given in Table 3.3.3.2.

The largest area sampled was reached in 1997, covering a total of 20 149 km^2 (Table 3.3.3.2), while the smallest one was 6793 km^2 in 1999. The spawning area was quite similar in 1997 and 2011 (12 755 km^2 and 12 400 km^2 respectively), smaller in 2002 and 2008 (9154 km^2 and 8167 km^2) and the lowest value was obtained in 1999 (5724 km2). The percentage of spawning area over the sampling area was all the years greater than 60%, reaching the 80% in 1999, 2008 and 2011.

Table 3.3.3.2. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Summary of the results for eggs.

PARAMETER	YEAR				
Eggs	**1997**	**1999**	**2002**	**2008**	**2011**
Survey area (Km²)	20 149	6793	11 888	10 187	14 091
Positive area (Km²) (%)	12 755(63)	5724(84)	9154(77)	8167(80)	12 400(88)
Z (hour⁻¹)(CV%)	-0.012(41)	-0.006(89)	-0.022(18)	-0.019(26)	-0.018(22)
Max age (hours)	66.8	81.6	81.6	78.6	68.8
Daily mortality rate (%)	25.3	13.7	41.7	37.3	35.6
P0 (eggs/m²/day)(CV%)	136.6(20)	78.7(13)	182.3(19)	171.4(23)	219.1(16)
P0 tot (eggs/day) (x10¹²) (CV%)	1.74(20)	0.45(13)	1.67(18)	1.4(23)	2.72(16)

Mortality values for the period between 2002 and 2011 are much higher than for the 1997 values. Mortality calculated for each one of the years surveyed (except 1999) shows negative and significantly different from zero values and was considered acceptable for egg production estimation. For 1999 survey a model without mortality was applied since an estimate for mortality led to non-coherent (positive) mortality.

Daily egg production per m^2 (eggs/m^2/day) in 2011 (219) is the highest in the series, meanwhile the lowest (78.7) corresponds to 1999. Total egg production (eggs/day) estimated by year is shown in Figure 3.3.3.1 and ranged between 0.45×10^{12} (1999) to 2.72×10^{12} (2011). Total egg production in 2011 was almost two times higher than 1997, 2002 and 2008 estimated.

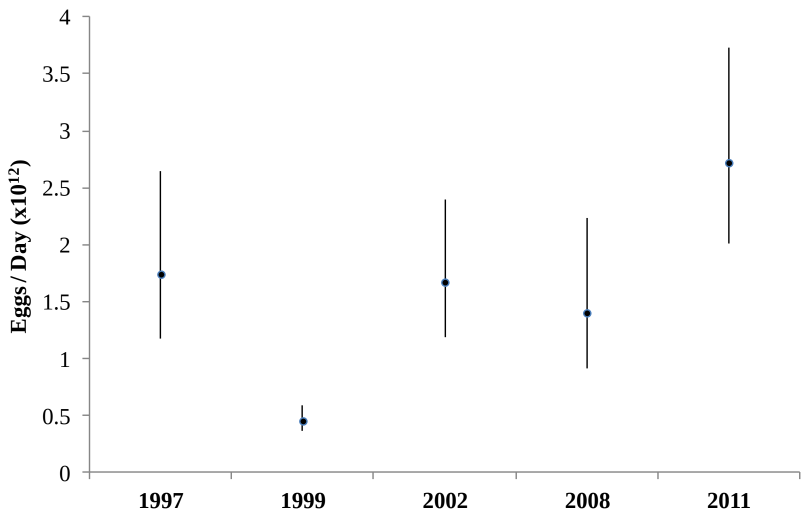


Figure 3.3.3.1. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Time-series of total egg production (eggs/day x 10^{12}) estimates. Vertical lines indicate confidence intervals.

Adults

On the whole DEPM series, 22 fishing hauls which caught sardines were performed during the surveys using pelagic trawling (Figure 3.3.2.1.2). The fishing effort and its spatial distribution were made to guarantee good and homogeneous level of sampling for the survey area.

In total, almost 1759 sardines were sampled (Table 3.3.3.3) and more than 500 ovaries were collected, preserved and analysed histologically. On the whole, a total of 749 otoliths were removed for age determination in 1999, 2002, 2008 and 2011. A total of 71 hydrated females were caught for batch fecundity estimation, although ovaries from hydrated females caught in 1999 (12) and 2002 (2) were not preserved for histological analysis on the laboratory and not number of oocytes was obtained to estimate batch fecundity.

Table 3.3.3.3. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. General sampling for adults.

SURVEY ADULTS	1997	1999	2002	2008	2011
R/V	Thalassa	Thalassa	Thalassa	Thalassa/ Cornide de Saavedra	Cornide de Saavedra
Number positive hauls	4	6	4	5	3
Date	29/03–31/03	06/03–10/03	29/03–31/03	21/04–24/04	13/04–15/04
Time range			07:00–20:00		
Total sardine sampled	239	516	199	503	302
Total males	104	241	106	280	150
Total females (% Mature)	135 (100)	271 (98)	93 (100)	223 (100)	152 (100)
Length range (mm)	180–255	123–260	152–244	154–250	175–243
Weight range (g)	45–144	13–152	23–104	25–114	41–102
Oocyte stage ovaries	68	50	20	164	127
Hydrated females (Batch fecundity)	42	12		3	14
Females for spawning	68		20	161	124
Otoliths	NA	328	195	97	129
Ages Range		1–10	1–8	1–9	1–9

Length and age distribution of sardine is showed in Figure 3.3.3.2. Sardine shows a bimodal length distribution in 1999 and 2008, with the first mode about 15 and 17 cm respectively and the second about 21 and 20 cm. In 1999 the size range is the wider for the whole historical series, with a minimum of size measured of 12.3 cm and a maximum of 26 cm. The age structure of the sampled population is different by year, and it must be noticed that the number of individuals, especially between 1 and 3 ages were really important in all years which otholits were collected.

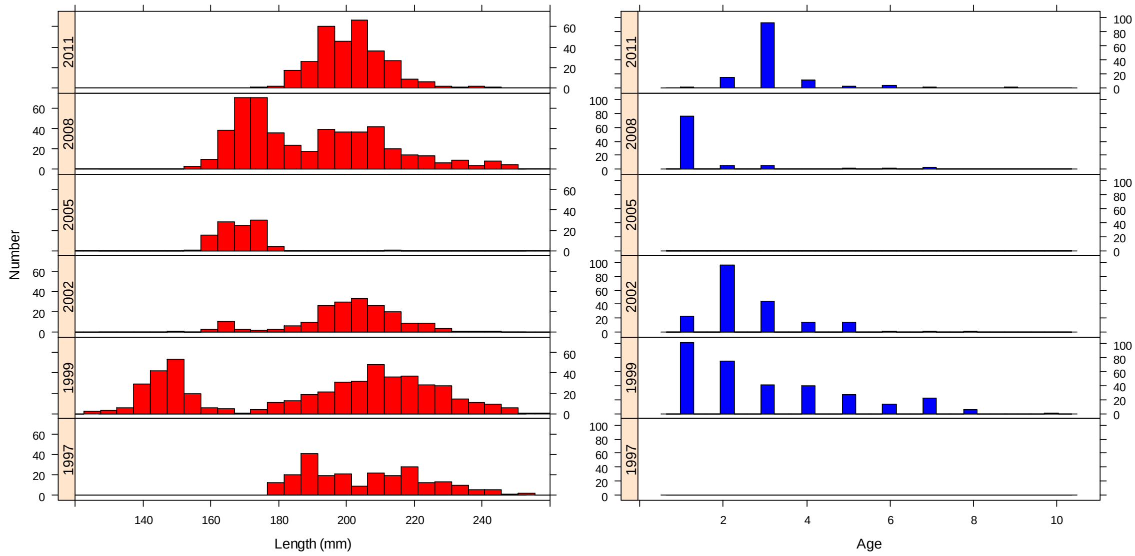


Figure 3.3.3.2. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Length (mm) and age distribution of sardine by year. No otoliths for age reading were available in 1997.

Final estimates of the mean female weight (W), batch fecundity (F), sex ratio (R), spawning frequency (S) and spawning–stock biomass (SSB) with their CVs are given in Table 3.3.3.4.

Table 3.3.3.4. Sardine DEPM IEO surveys in the inner of the Bay of Biscay. Summary of the results for eggs, adults and SSB estimates.

PARAMETER	YEAR				
Eggs	**1997**	**1999**	**2002**	**2008**	**2011**
Positive area (Km²) (%)	12 755(63)	5724(84)	9154(77)	8167(80)	12 400(88)
Z (hour⁻¹)(CV%)	-0.012(41)	-0.006(89)	-0.022(18)	-0.019(26)	-0.018(22)
P0 (eggs/m2/day)(CV%)	136.6(20)	78.7(13)	182.3(19)	171.4(23)	219.1(16)
P0 tot (eggs/day) (x10¹²) (CV%)	1.74(20)	0.45(13)	1.67(18)	1.4(23)	2.72(16)
Adults					
Female Weight (g) (CV%)	74.5(11.8)	63.6(12.7)	62.9(5.6)	55.4(11.1)	61.3(9)
Batch Fecundity (CV%)	32 269(17)	32704(45)	24577	15849(29)	30 383(4)
Sex Ratio (CV%)	0.508(8.1)	0.535(10.7)	0.492(22.9)	0.483(8.9)	0.51(19.6)
Spawning Fraction (CV%)	0.131(9.7)	0.124(15.4)	0.143	0.137(24.4)	0.066(49.2)
Spawning Biomass (tons) (CV%)	**60 332(31)**	**13 200(52)**	**60 720**	**73 942(47)**	**162 930(55)**

The minimum mean weights by haul were observed in 1999 and the maximum 1997. Mean female weight (W) was similar for 1999, 2002 and 2011(63.6, 62.9 and 61.3, respectively) and considerably higher in 1997 (74.5). Mean females weights in 2008 survey present the lowest value of the historical series (38.1). Concerning sex ratio estimates, mean values are quite homogeneous across the whole surveys.

Considering that few hydrated females (n=3) were collected in 2008 and no hydrated females were available in 1999 and 2002, the data from these three years were pooled with data from North Atlantic Spanish coast, for the modelling of batch fecundity. Mean batch fecundity estimate (F) was considerably lower (15849 number of oocytes, 286 oocytes/gr) in 2008 according to the mean female weight estimated. On the contrary the first two surveys (1997 and 1999) presented the highest estimates (32 269, 433 oocytes/gr and 32 704, 514 oocytes/gr) of the historical series, though similar to the one obtained for the 2011(30 383, 495 oocytes/gr) survey. In particular, for 2002, although mean female weight was similar to the ones obtained during the 1999 and 2011 surveys, batch fecundity estimate was reduced to 24 577 (390 oocytes/gr) when compared to the values obtained these years.

Bootstrapped estimate of spawning fraction for 1999 was 0.124. Mean Spawning fraction estimate for 2011 survey was among the lowest (0.066) of the time-series. For the remaining surveyed years the values are generally quite high and homogeneous (between 0.124 and 0.137).

SSB estimate

The whole survey-series DEPM-based SSB estimate is showed in Table 3.3.3.4. SSB in 2011 is the highest estimate of the time-series (162 930 tons), while 1999 is among the lowest of the time-series (13 200 tons). In 1997 and 2002 estimates are comparable (60 332 and 60 720 tons respectively) and in 2008 an increase in relation to the previous surveyed years was found (73 942 tons).

The lowest and highest SSB estimates found in 1999 and 2011 respectively are related to the egg production. Egg production estimate in the 1999 survey is the lowest of the time-series, probably due to the egg survey period has not covered the amount of spawning peak activity. By the contrary the large egg production estimate in 2011 is sustained by a combination of high egg production density (in eggs per day per square meter) and large spawning area. Moreover, the contribution of the lowest spawning fraction value (0.066) estimated in 2011 on the equation applied to estimate SSB, has largely increased the SSB value.

The estimates presented from DEPM application in the inner of the Bay of Biscay, are *a priori* considered provisionally. The way to obtain batch fecundity estimates for 1999, 2002 and 2008, modelling together with data from the North Atlantic Spanish coast, prevents to consider these preliminary results as definitely ones. Moreover, to solve the unreliable egg mortality estimated in 1999 an aggregated model similar to that used by Bernal *et al.*, 2011, could be tried. All these issues require further analysis in terms of implications for the best estimation procedures and reliability of the results.

B.4. Commercial cpue

According to literature, cpue indices have been considered as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1980; Csirke, 1988; Pitcher, 1995; Mackinson *et al.*, 1997). Commercial catch per unit of effort data are available at various levels of aggregation (subarea/gear/years) from official data, but these are not considered indicative of stock trends (see also information from the industry, below).

B.5. Other relevant data

Interviews with the French fishing industry operating in the Bay of Biscay highlighted a potential displacement of the stock further north. This could partly explain the increase of activity in the Celtic Sea over the last decade. According to fishermen, the main driver of the Bay of Biscay fishery is the market. Many fishers could catch more sardine as regards sardine availability, but this would not be suitable due to poor levels of prices. Thus, the industry data should not directly be put in relation to variation of sardine abundance.

C. Assessment-data and method

From the modelling point of view, the lack of sampling, survey, biological information in the English Channel and Celtic Seas 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, for practical reasons related to the availability of data between the English Channel, Celtic Seas and Bay of Biscay, it was decided to divide this stock into two "data" regions: VIIIabd and VII.

The following indicators are considered relevant for the description of the stock in the different regions:

Subdivision VIIIabd

4) Trends in the Pelgas survey index;

5) Trends in the DEPM survey index.

Subdivision VII

6) Trends in size (age?) distribution in catches (to be built up).

D. Short-term projection

No short-term projection method is currently set for this stock.

E. Medium-term projections

No medium-term projection method is currently set for this stock.

F. Long-term projections

No long-term projection method is currently set for this stock.

G. Biological reference points

No reference points are currently set for this stock. Given the differences of availability of data between the Celtic Seas, Bay of Biscay and English Channel, any set reference should take account of this or some regional reference points should be set accordingly.

Given the current lack of assessment, advices could be based on other indicators such as successive recruitment failure. These indicators are available from the current commercial and survey datasets.

H. Other issues

While the stock is considered to spread over Celtic Seas (VIIabcfjk), Bay of Biscay (VIIIabd) and English Channel (VIIdeh), the critical lack of information in Celtic Seas and English Channel impairs the possibility of assessing this stock for the whole area.

H.1. Historical overview of previous assessment methods

2013 is the first year ICES is requested to give advice for sardine in VIIIabd and VII. In previous years, exploratory assessments using TASACS were carried out during the working group on horse mackerel, anchovy and sardine (WGHANSA). Cohort tracking analyses have also been conducted this year.

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Annex 5.5 Stock Annex:Blue Jack Mackerel (Azores)

Stock	Blue Jack mackerel (*Trachurus picturatus*) in Subdivision Xa2 (Azores)
Working Group:	WGHANSA
Date:	June 2014
Revised by	

A. General

A.1. Stock definition

The blue Jack mackerel *Trachurus picturatus* (Bowdich 1825) has a broad geographical distribution within the Eastern Atlantic waters and can be found from the southern Bay of Biscay to southern Morocco, including the Macaronesian archipelagos, Tristan de Cunha and Gough Islands and also in the western part of the Mediterranean Sea (Smith-Vaniz, 1986).

The *T. picturatus* is the only species of genus Trachurus that occurs in the Azores region (north-eastern Atlantic). It is a pelagic species found around the islands shelves, banks and sea mounts up to 300 m depth. However, a different size structure was observed between islands shelf and offshore areas. The island shelf areas seems to function as nursery or growth zones, while the seamount/bank offshore areas as feeding zones where adults predominate (Menezes et al., 2006).

A.2. Fishery

In the Azores, the *T. picturatus* is 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, and bottom longline. Purse seiners usually target juveniles in island shelf areas (Figure 2), while bottom longliners target adult specimens in seamounts areas (Figure 2, left panel). Purse seines are also used by the tuna bait boat fleet, which targets the *T. picturatus* to be used as live bait for tuna (Figure 2, right panel). The Blue Jack mackerel is also a very popular species among the recreational fisherman that fish along the coast of all islands.

The *T. picturatus* landings were considerably high during the 1980's, however changes in the local markets lead to a strong reduction in the catches afterwards. This reduction was also accompanied by a sharp decrease in the fleet targeting small pelagic fishes. Since this period, the catches maintained at a low level due to a voluntary auto regulation adopted by the fishermen associations. Despite this reduction in the landings, this fishery still has a strong impact on some fishermen communities, which directly depends on the income of this fishery.

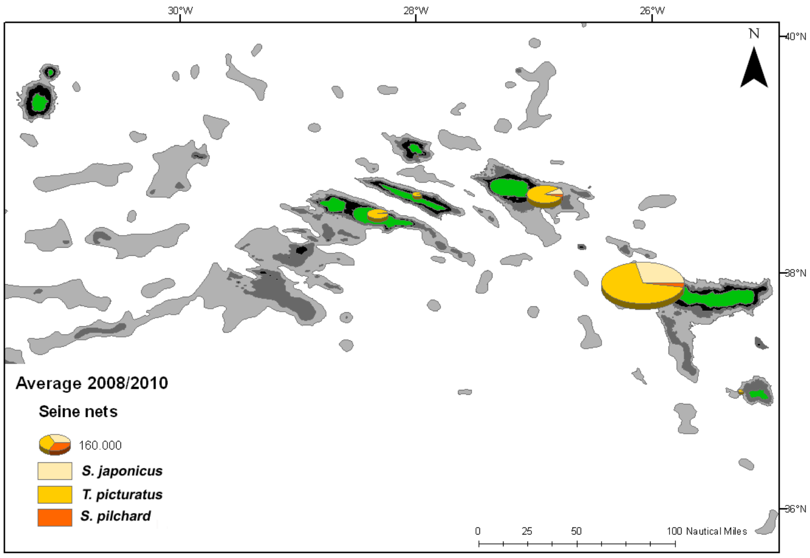

Figure 2 – Geographical distribution of the catches of small pelagics by the artisanal purse seine fleet in the Azores.

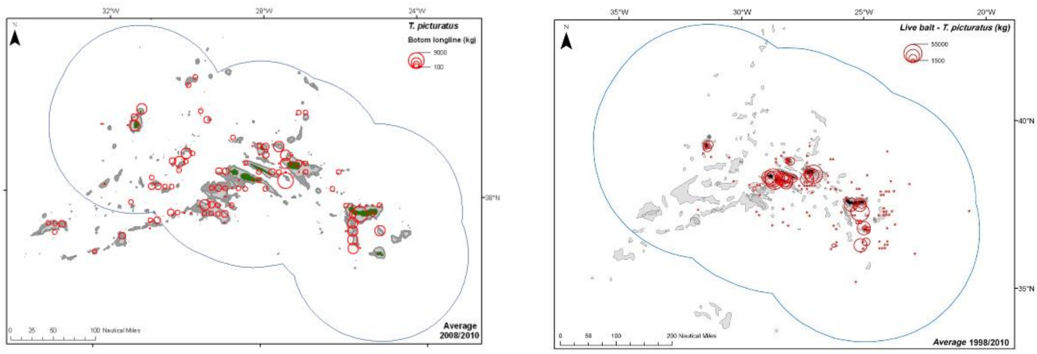

Figure 3 - Geographical distribution of the catches of horse mackerel by the longline fleet (left panel) and the tuna baitboat fleet (right panel) in the Azores (average 2008-2010).

The artisanal purse seine fleet is composed by small open deck vessels, mostly with less than 12 meters of length. The composition of this fleet, classified in three length categories (LOA) as showed inFigure 4, presented a sharp decrease in the number of vessels during the exploitation period considered, and has remained stable in the recent years. The demersal fleet, composed of vessels using longlines and a variety of handlines, catch blue Jack mackerel, mostly as bycatch, in the multi-specific demersal fishery. One other important component of the surface fishery is the tuna baitboat fleet that also uses purse seines to catches Blue Jack mackerel to be used as live bait for tuna. The variability of the catches from these fleets reflects also the availability of tuna in the Azorean area in each year.

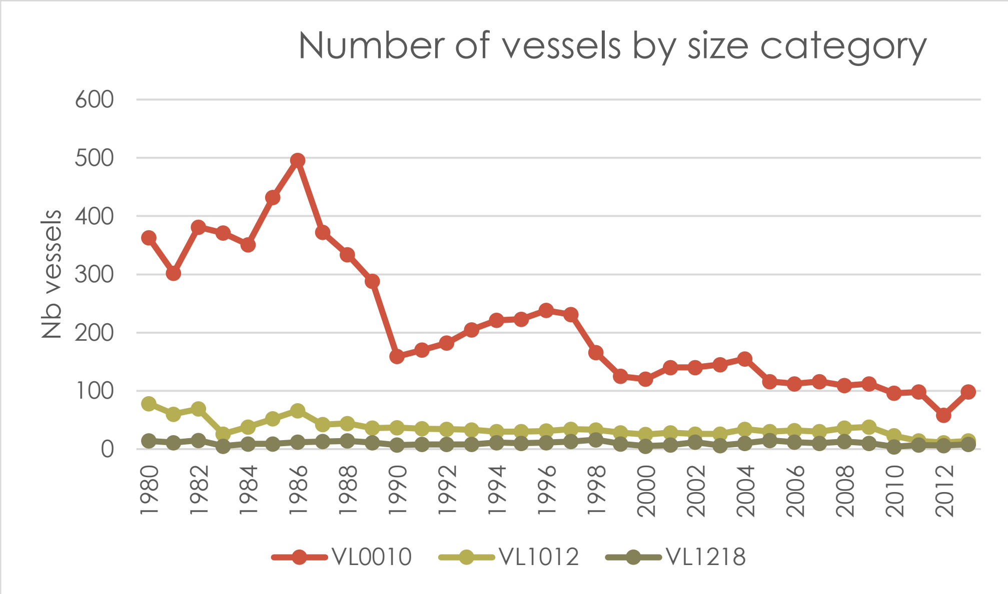

Figure 4 – Number of vessels, by size category, using purse seines for Blue Jack mackerel (VL0010 – vessel length between 0 and 10 meters; VL1012 – vessel length between 10 and 12 meters; VL1218 – vessel length between 12 and 18 meters).

A.3. Ecosystem aspects

Blue Jack mackerel is a pelagic small predator which diet is mainly composed by phytoplankton and zooplankton. It is a prey species for other pelagic and demersal species and also for sharks, rays, cetaceans and seabirds. They schooling behaviour and availability in Azorean waters turned this species susceptible to be preyed by several species and it has been found to be the main food item of several oceanic seabirds species (Paiva et al., 2010; Xavier et al., 2011), yellowmouth barracuda (Barreiros et al, 2002) and silver scabbardfish (Gomes et al., 1998). There are also other species feeding on blue Jack mackerel despite the reduced importance on their diets, such as the case of the tope shark (Gomes et al., 1998), the conger eel (Gomes et al., 1998), the thornback ray (Gomes et al., 1998) and the squids (Guénette and Morato, 2001). The dependence of several species on blue Jack mackerel has several implications, as it is an important commercial species both for human consumption and for live bait in tuna fishing. Several studies illustrated the importance of the blue Jack mackerel, as other small pelagic species, in structuring marine ecosystems in particular across seamount systems in which they play key roles.

B. Data

B.1. Commercial catch

The Blue Jack mackerel is mostly landed by the artisanal fleet, using purse seines. The fleet segments that use hand lines and bottom longlines also catches Blue 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. Historic landings (1978-2013) of Blue Jack mackerel in the Azores (Figure 5) only includes catches from the artisanal purse seines fleet and fleet that uses hand lines and bottom longlines.

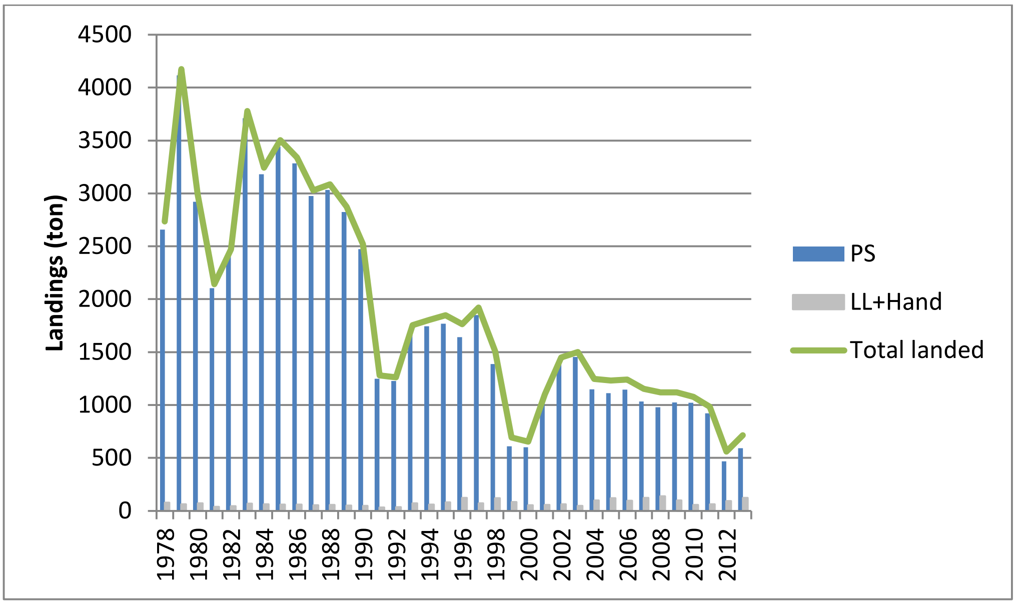

Figure 5 – Historic landings of blue Jack mackerel in the Azores. (PS – Purse seiners; LL+Hand – Longliners and handlines)

The catches made with purse seines by the tuna baitboat fleet that use Blue Jack mackerel as live bait, are not landed. Two sources of data are used to estimate the Blue 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 catches.

The discards observer programme for the longline fleet contributed for the estimation of Blue Jack mackerel discarded or used as bait in those fisheries for the years 2004 to 2012. In the previous years and in 2013, although the program did not existat that time or simply did not occur, the discards/bait data for longline fleetwere also estimated by the results of the programme in 2004-2012.

The auto regulation adopted by the fishermen associations for the artisanal purse seine fleet results in some fish removed from the market, i.e. prevented from being unloaded at the auction market – the so called purse seine discards. These amounts should be communicated by the fishermen associations to the administration and was not since 2011, probably due to the end of this practice since then.

The last component of catches considered was the recreational fishery; once this is very appreciate by the general population. This value is estimated with information collected by the nautical sports clubs in the Region.

The estimated catches of Blue Jack mackerel by fishery, from 1978 to 2013, are presented in Table 1.

Size frequencies for the Blue Jack mackerel caught in the Azores are available since 1980 for the two main métiers involved in the fishery – artisanal purse seiners and longliners. The size distribution (catch at size) of the landings of blue Jack mackerel derived from the samples collected at the market and by on-board observers. The two main fisheries target on different size categories, the surface fleets catches the juvenile fraction of the population, while the longliners target the adults.

The catch at age was estimated using the parameters of the growth equation in a slicing procedure applied to the catch at size data.

Table 1 – Estimated catches of blue Jack mackerel (*T. picturatus*) by fishery, in the Azores from 1978 to 2013.

Year	Tuna bait	Recreational	Discards/Bait (LL)	Discards (PS)	PS	LL+Hand	Total
1978	115	129	15	0	2657	78	2995
1979	118	130	15	0	4114	61	4439
1980	210	132	22	0	2920	70	3354
1981	229	135	9	0	2104	39	2516
1982	239	142	10	0	2429	43	2862
1983	231	142	21	0	3711	67	4172
1984	295	135	17	0	3180	62	3689
1985	303	136	11	0	3442	60	3952
1986	433	135	9	0	3282	58	3918
1987	491	139	8	0	2974	53	3666
1988	586	143	8	0	3032	55	3824
1989	352	138	9	0	2824	50	3373
1990	345	117	11	27	2472	48	3021
1991	242	115	6	127	1247	33	1770
1992	249	121	6	126	1226	35	1762
1993	375	130	22	173	1684	70	2454
1994	264	125	18	179	1745	59	2390
1995	474	119	24	182	1769	79	2648
1996	351	110	38	173	1642	123	2437
1997	259	110	31	192	1849	72	2513
1998	308	111	52	151	1387	120	2129
1999	141	119	37	35	609	84	1024
2000	83	117	23	32	602	53	910
2001	59	121	24	110	1046	55	1415
2002	82	132	28	145	1387	63	1837
2003	140	128	21	150	1455	47	1941
2004	208	111	19	125	1148	98	1709
2005	124	120	236	123	1111	120	1834
2006	264	111	40	124	1145	96	1781
2007	370	115	58	115	1032	122	1812
2008	205	110	75	111	980	139	1620
2009	230	119	115	112	1023	98	1697
2010	313	114	75	116	1021	57	1696
2011	510	118	79	105	920	62	1794
2012	399	42	41		467	94	1043
2013	237	147	54		592	123	1153

B.2. Biological

The blue Jack mackerel (*Trachurus picturatus*) is one of the species included in the Data Collection Programme in Azores and consequently its landings are subject to regular sampling. The biological data available includes length, weight, age and maturity.

The length-weight relationships were calculated from 3372 specimens, separately for males and females and for both sexes. The estimated parameters of the fork length vs total weight relationship are given in **Error! Reference source not found.**.

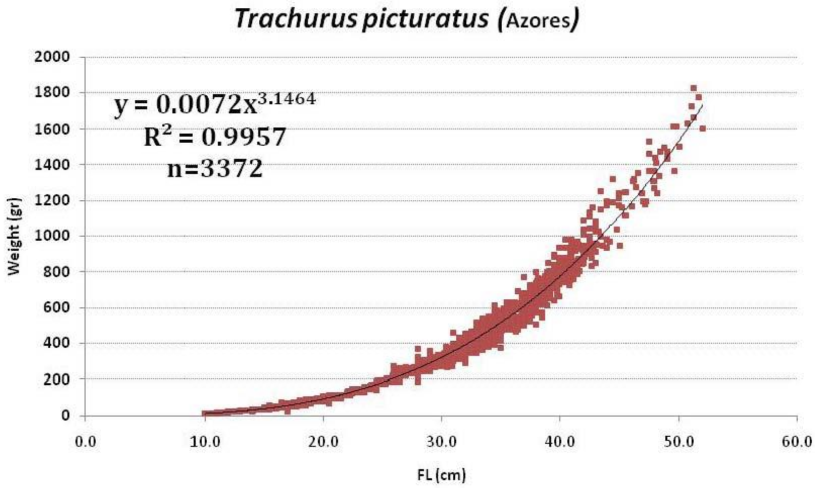

Figure 6 - Length-weight relationship for the blue Jack mackerel (*T. picturatus*) from the Azores.

The logistic curve fitted to the proportion of sexually mature blue Jack mackerel estimated the mean length at sexual maturity at 28.5 cm of fork length, as showed in Figure 7.

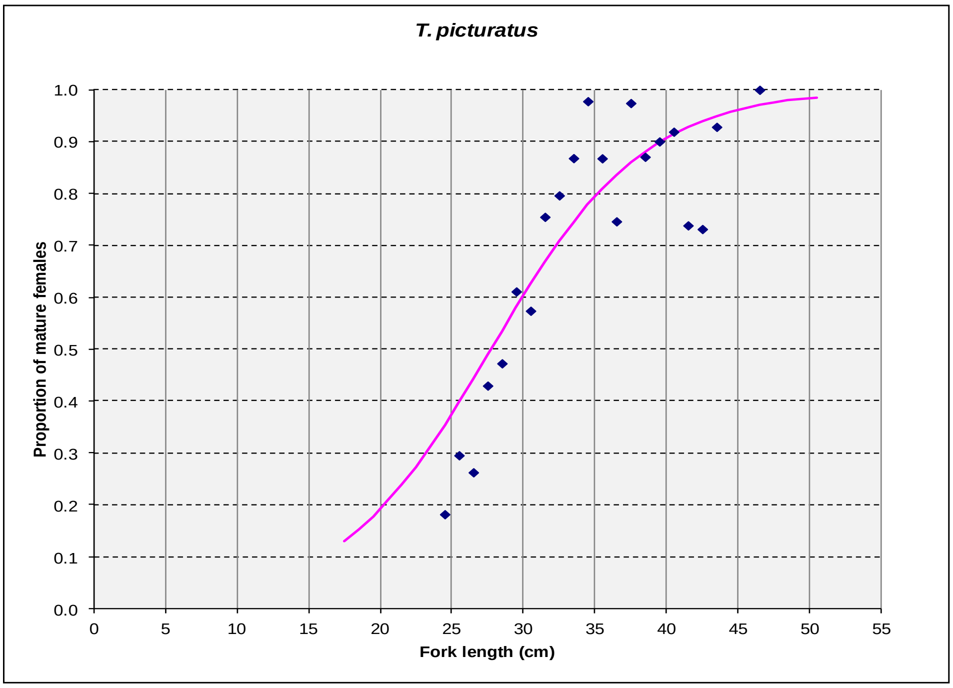

Figure 7 - Size at sexual maturity (FL50) for the blue Jack mackerel from the Azores.

For the determination of age and growth, otoliths were collected from 405 specimens. 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 8and the estimated parameters are: L∞=62.65 cm; k=0.08 year^{-1}and t_0=-2.82 year.

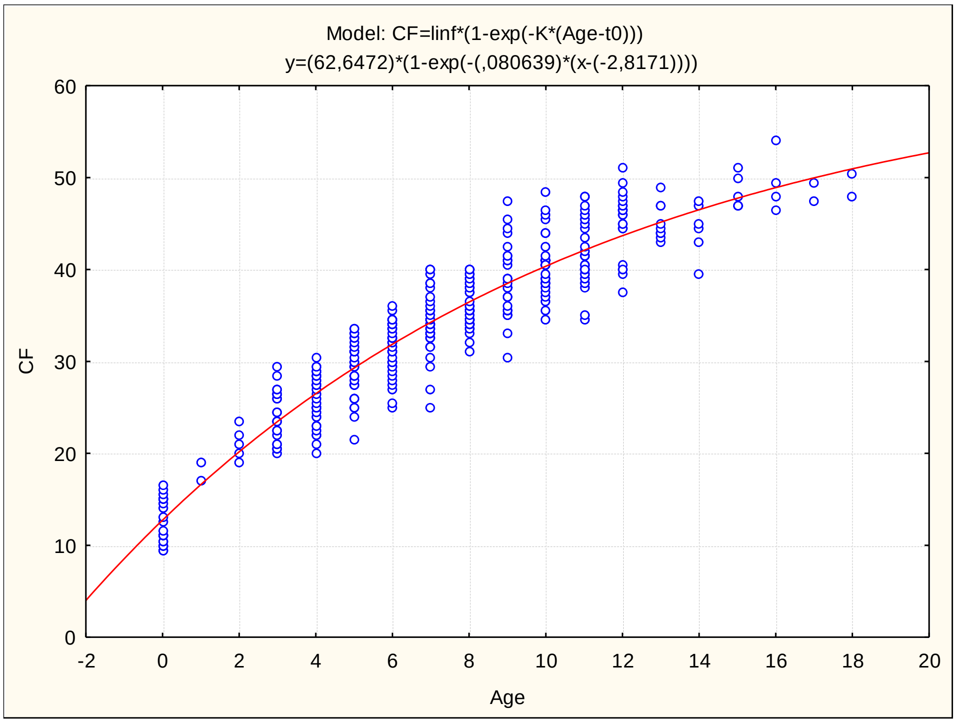

Figure 8 – von Bertalanffy growth curve for *T. picturatus* from the Azores.

B.3. Surveys

No survey information is available for this stock.

B.4. Commercial cpue

The catch and effort data collected includes fleet characteristics, total catch and landed, fishing effort, gears used and fishing grounds. These data was obtained through interviews to the fishermen at the landing sites, logbooks and by on board observers. Two observer programs are actually in course, one on the demersal logline fleet (not for 2013), collecting detailed information on fishing operations, such as the total catch 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 catch of bait species, among which the blue Jack mackerel is the main target species.

Standardized CPUE are available for 3 of the fisheries catching blue Jack mackerel, the small purse seine fleet, the tuna baitboat catches of blue Jack mackerel to be used as live bait for tuna and the catches of the bottom longline fleet. The standardized CPUE series were updated for the small purse seine fleet and the baitboat catches of blue Jack mackerel, up to 2013. The CPUE series for the longliners was not updated.

B.5. Other relevant data

There were no other data considered at this time.

C. Assessment: data and method

The assessment follows ICES approach to data limited stocks.

The blue Jack mackerel (*Trachurus picturatus*) inSubdivision Xa2 (Azores) is a data limited stock category 3.x.x.

Trends on juvenile abundance are estimated upon tuna baitboat and purse seine standardized CPUEs.

Trends on adult abundance are estimated upon longline vessels standardized CPUEs.

D. Short-term projection

No short-term projection has been performed for this stock

E. Medium-term projections

No medium-term projection has been performed for this stock

F. Long-term projections

No long-term projection has been performed for this stock.

G. Biological reference points

Reference points have not been defined for this stock.

H. Other issues

I. References

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Annex 6 Benchmark preparation

6.1 Latest benchmark results

Last benchmark relevant to WGHANSA were carried out during WKPELA in 2013 (Sardine in Divisions VIIIa, b, d-VII, Bay of Biscay Anchovy) and WKPELA in 2012 (Sardine in Division VIIIc-IXa). Horse mackerel in Division IXa was last benchmarked at WKBENCH in 2011. The other stocks relevant to WGHANSA have not been benchmarked yet.

6.2 Planning future benchmarks

Stock	Assess. status	Latest benchmark	Benchmark next year	Planning in future	Further planning	Comments
ane-pore	Update OK			2016	2017	
sar-bisc	Update OK	2013		2017		To be carried out at the same time than sar-soth
Hom-soth	Update OK	2011		2017		
sar-soth	Update OK	2012		2017		To be carried out at the same time than sar-bisc

6.3 Issue lists for stocks with upcoming benchmarks

Issue list template:

Stock	Sar-bisc	
Benchmark	Year: 2017	Planned by EG /Agreed by ACOM
Stock coordinator	Name: Lionel Pawlowski	Email: lionel.pawlowski@ifremer.fr
Stock assessor	Name: Lionel Pawlowski	Email:
Data contact	Name: Lionel Pawlowski	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	- Short times series during last benchmark (2013). Relatively bad cohort tracking - no coverage of area VII. Few information available from sampling	Alternate indices (combined information from the different surveys ?)	Data are already collected	Experts on tuning indices
Discards	Not a problem			
Biological Parameters	Not a problem			
Ecosystem/mixed fisheries considerations		Alternate solution to provide an assessment might be to look at more closely to the hydrographic conditions in the relevant areas	Survey/Hydrographic data	Ecosystem/environmental modelling experts
Assessment method	Trends based assessment for the time being.	Development on a surplus production model in progress. Preliminary runs in line with previous approaches.		Experts in DLS for short-lived species or integrated assessment

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
Forecast method	No STF other than the DLS approaches	Dependant on the assessment method.		Experts in DLS for short-lived species or integrated assessment
Biological Reference Points	Not defined	Review of existing information and appropriate tools to estimates ref. points		Experts in DLS for short-lived species or integrated assessment

Stock	Ane-pore	
Benchmark	Year: 2016	Planned by EG /Agreed by ACOM
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
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.	Experts from ICES Stock Identity Methods Working Group (SIMWG)

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
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.	Experts from ICES Stock Identity Methods Working Group (SIMWG)
Tuning series	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. The survey relative catchability and implications for their joint or separate use in tuning the assessment should be investigated.	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. To investigate the influence of changes in methodology (e.g. echo-sounder, vessel, fishing gear) and anchovy behaviour and/or depth distribution changes along the survey historical series.	Results from 2008, 2009, and 2011 intercalibrations are available from IPMA and IEO and have been reported to WGACEGG. Information on survey methodology and data on anchovy distribution are available from IPMA and IEO databases.	Experts on tuning indices. ICES WGACEEG experts.

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
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.	Experts from ICES Stock Identity Methods Working Group (SIMWG)
Discards	The actual magnitude of discarding practices in the Division is unknown			

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
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.	Experts from ICES Stock Identity Methods Working Group (SIMWG)
Biological Parameters	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). Biological parameters (Maturity ogives, weight at age in the stock, etc, are only available for the Spanish part of the IXa South). Natural Mortality is assumed to be equal to the one estimated for Bay of Biscay Anchovy.	Investigate availability of these data to obtain a consistent data series allowing a further (analytical) assessment. Ditto. Explore different approaches (empirical, etc.) to derive the estimate of Natural Mortality.	Data available (IPMA, IEO data bases), but their availability has to be explored. Ditto. Ditto.	

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
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.	Experts from ICES Stock Identity Methods Working Group (SIMWG)
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	Experts in DLS for short-lived species or integrated assessment
Forecast method	No forecast	Dependant on the assessment method.		Experts in DLS for short-lived species or integrated assessment
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.	Experts in DLS for short-lived species or integrated assessment

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
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.	Experts from ICES Stock Identity Methods Working Group (SIMWG)
Other issues	Compile information on the role of anchovy as a forage fish in the pelagic ecosystem. Understand what environmental issues may drive the fluctuations and intensity of the recruitment pulses in IXa South and western sub-divisions.	Review results from studies on the diet of anchovy predators, including inter-annual, seasonal and geographic variation in anchovy importance in their diets. Review results from studies on the impact of the environmental forcing in anchovy recruitment	Published and unpublished information. Published and unpublished information.	