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Report of the Working Group on Anchovy and Sardine (WGANSA)

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ICES
International Council for the Exploration of the Sea

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Executive Summary

The Working Group on Anchovy and Sardine (WGANSA) met at IEO, Vigo 24-28 June 2011, chaired by Andrés Uriarte, Spain. There were 13 participants from France, Portugal, Spain and UK. The main task was to assess the state of the stock 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 for horse mackerel in Division IXa. All assessments were updates of previous assessments according to their stock annexes. In addition collation of data was requested for the Horse mackerel (*Trachurus picturatus*) in the waters of the Azores.

The Anchovy in Subarea VIII was estimated to be at 98 450 t in May 2011, well above B_{lim}, with a 100% certainty, according to the Bayesian modelling of the population. This is the fourth highest level of the population since 1987, indicating a recovery with respect to the low levels of SSB in period 2002-2009, which led to the closures of the fishery from 2005 to 2009. This recovery is due to good recruitment in 2011. This allows an ample range of fishing opportunities with little risk of falling below B_{lim} in the next year.

Anchovy in division IXa, demands separate analysis and advice for the western Iberian Atlantic coasts (i.e. Sub-divisions IXa North, Central- North and Central-South) from the southern regions (Algarve and Gulf of Cadiz, i.e. Sub-division IXa South), due to the seemingly independent dynamics of the populations in these regions and to the well separated fisheries. In the western areas catches are generally low, in rare occasion exceeding a thousand tons (as in 1995/96). In 2011, after several years of almost null acoustic Biomass estimates, 27,000 t were found in that area. On the contrary, in the sub-division IXa South, where the bulk of the population is usually concentrated and supports a rather stable fishery, the acoustic Portuguese and Spanish surveys show a declining stock since 2008 up to 2010. The situation in 2011 is still uncertain, as the null acoustic estimate in the area was contradictory with the egg abundances from CUFES during the same survey. Therefore a warning is given for the recent decreasing tendency with an advice for a reduction of catches in the Sub-Division IXa South.

The Iberian Sardine has declined since 2006 due to the lack of any strong recruitment since 2005. In 2011 the SSB is assessed to be 67% below the long-term average, while fishing mortality seems to double the historical average. Although the uncertainties of the estimates in the 2010 and 2011 are high, as shown in a strong retrospective pattern in the assessment, the stock is expected to decline unless a new strong year class appears. MSY reference points are not yet defined, but a reduction of the fishing mortality to the levels before the recent increase of F (i.e. in the period 2002-2007) is advised to slow down the decline of the stock.

Anchovy and Sardine also appears to the North of the assessment areas. There is no request for advice in those areas, but the WG is collating available data on the fisheries in these areas being reported in respective chapters. In addition, for sardine in the Bay of Biscay the collection of catch numbers at age and acoustic survey estimates over some years allows some exploratory assessment of this population which is supposed to be improved within a few years if data continue to be collected. Extending the survey coverage into the Celtic Sea and English Channel was attempted for the last two years, and is strongly encouraged.

The analytical assessment of horse mackerel in Division IXa followed the stock annex produced in its recent benchmarking (WKBENCH2011). The assessment results in a rather stable biomass with an exploitation level that seems sustainable by comparison with an F35%SPR (suggested for F_{msy}). The assessment is itself highly uncertain due to the strong year effects in the tuning combined bottom trawl survey and to some apparent changes in the selectivity at age. The advice was for keeping catches at the same levels of previous years.

For the first time, collation of data for *Trachurus picturatus* in the waters of the Azores was made. The landings of horse mackerel in recent years average 1200 tonnes. The horse mackerel is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990. The horse mackerel is also the main species used as live bait by the local bait boat fleet, that targets on tuna species. The demersal fleet also catches horse mackerel. The available information shows an increasing trend in abundance indices in the last 10 years. As exploitation status is unknown, a PA advice to not increase catches is proposed.

Some discussion about GES indicators, as requested in the General TORs, was dealt within the introduction chapter.

1 Introduction

1.1 Terms of reference

The **Working Group on Anchovy and Sardine** (WGANSA), met in Vigo, Spain, 24–28 June 2011 to:

a) Address generic ToRs (common) for all Fish Stock Assessment Working Groups; related to the production of assessment and advice for the stocks listed below, with information about the quality of the input data, use of INTERCATCH, description of major regulatory changes, and some additional TORs relative to the contribution that ICES may provide for the implantation of the Marine Strategy Framework Directive.

b) Assess the progress on the benchmark preparation of Sardine in Divisions VIIIc and IXa.

The assessments were carried out on the basis of the stock annex during the meeting (not prior to it) for the following stocks:

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

1.2 Report structure

Ad hoc and Generic TOR relative to the stocks for which advice is required are dealt stock by stock in the following sections of the report. In addition information for the Anchovy and sardine to the North of the assessed areas are dealt in separate sections.

The generic TORs c (Overview of the sampling activities on a national basis for 2010) and Generic TORs I, J, m and K, relative to the implementation of the Marine Strategy Framework Directive, are dealt in this introduction section (below section 1.5). However little time was devoted by the WG to these generic TORs.

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

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

The WG this year has been expanded with the inclusion of a new stock for assessment: the southern horse mackerel stock (Division IXa), plus another for collecting data in Jack mackerel in Azores. This has increased the amount work for the group and compressed even further the limited available time which could be devoted for each stock. An additional day of work seems necessary to carry out the work demanded to the working group.

The dates at the end of June were suitable for the completion of the processing of the anchovy biomass estimates arising from the acoustic and DEPM surveys in May. These dates should be maintained in future to assure the quality of these input data for the assessment of anchovy.

The working group proposes to change its name to WGHANSA.

1.4 Overview of the sampling activities on a national basis for 2010 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 Inter-Catch cannot be used? Please specify it shortly. For a more detailed description please write it in the 'The use of Inter-Catch' section.**	**Discrepancy between output from InterCatch and the so far used tool:** - **Non or insignificant** - **Small and acceptable** - **significant and not acceptable** - **Comparison not made**	**Acceptance test. InterCatch has been fully tested with at full data set, and the discrepancy between the output from InterCatch and the so far used system is accept-able. Therefore In-terCatch can be used in the future.**
Example sai-3a46	*Only tool*	*InterCatch was used*	*Non or insignificant*	*Can be used*
ane-bisc	Not used.	Shortage of man-power. Intention of been implemented interseasonally.	Comparison not made	Test not performed yet.
ane-pore	Not used.	Shortage of man-power. Intention of been implemented intersessionally.	Comparison not made.	No acceptance test has been done so far.
Sar-soth	In parallel with another tool	Intercatch was used	Nor or insignificant	Can be used
Sar-north	Not used.	Shortage of man-power. Intention of been implemented interseasonally.	Comparison not made	Test not performed yet.
Hom-sort	Not used	Shortage of man-power. Intention of been implemented intersessionally.	Comparison not made.	Test not performed yet.
Jaa-10	Not used	Shortage of man-power. Intention of been implemented intersessionally.	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	0	n/a	0	0	320	?
France	0.28	7	0	0	1130	2478
Total	0.28	7	0	0	1450	2478

b) Anchovy VIII

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	5 744	100%	180	16 517	2 747
France	4 573	100%	20	1 613	1 146
Total	10 317	100%	200	18 130	3 893

c) Anchovy IXa

Country	Official Catch	% of catch sampled	No. samples	No. measured	No. Aged
Spain	3 080	100%	62	8 224	612
Portugal	130	100%	*	*	*
Total	3 210	100%	62	8 224	612

(*): Anchovy is a group 3 species in the Portuguese sampling plan for DCF.

d) Sardine North

e) Sardine IXa and VIIIc

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	63 727	100%	151	19 188	4 285
Spain	25 843	100%	239	23 194	3 605
Total	89 571	100%	390	42 382	7 890

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

Country	Official Catch	% of catch sampled	No. samples	No.measured	No. Aged
Portugal	11726	100%	173	25336	1998
Spain	15 490	100%	130	7255	1291
Total	27 216	100%	303	32591	3289

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

1.5 Information relevant to implement the Marine Strategy Framework Directive.

1.5.1 Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission Decision and give views on what good environmental status (GES)

Concerning the Generic TORs

i) Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission Decision (available at http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF;

j) Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.

The WG made the following considerations:

The Group felt that of the 11 Descriptors of GES set out in the Commission Decision of 1st of September 2010, the work of WGANSA could contribute to Descriptor 3: *Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock*. This Descriptor has three criteria to assess progress towards the achievement of GES with associated indicators:

1) Level of pressure of the fishing activity

The primary indicator for this level of pressure is Fishing mortality (F) (obtained from analytical assessments). If an analytical assessment is not available, the secondary indicator is the ratio between catch and biomass index (the catch/biomass ratio)

2) Reproductive capacity of the stock

The primary indicator for the reproductive capacity is Spawning Stock Biomass (SSB) (obtained from analytical assessments). If an analytical assessment is not available, the secondary indicator is biomass indices.

3) Population age and size distribution

The primary indicators for population age and size distribution based on the relative abundance of large fish include:

- *Proportion of fish larger than mean size of first sexual maturation*
- *Mean maximum length across all species found in research vessel surveys*
- *95% percentile of the fish length distribution observed in research vessel surveys.*

When such information is not available the secondary indicator is size at first sexual maturation.

Of these three criteria, reference levels have been set out only for the primary indicators of F and SSB and are F_{MSY} and SSB_{MSY} (i.e. the values capable of producing Maximum Sustainable Yield), F below F_{MSY} and SSB above SSB_{MSY} will meet the criteria for GES. In relation to the indicators of Population age and size distribution, no reference levels have been set. Pelt et al. (2010) summarised the current view that "*the health of the stock increases as the age and size distribution consists of more, older fish. This attribute is represented by an indicator best representing the proportion of older and larger fish in the population*". The authors also noted that because "*there is no scientifically agreed reference level for this indicator the absence of a degradation gradient is then considered the best possible criterion*".

Evaluation of Criteria 1 and 2 and alternatives from WGANSA:

WGANSA produces analytical assessments (and F and SSB values) for the Iberian sardine stock, and for the Gulf of Cadiz anchovy population (the latter only exploratory), and also for the anchovy in the Bay of Biscay. WGANSA is also involved in the transition process towards achieving the MSY target (under the reform of the Common Fishery Policy) and as such the development of MSY reference levels would allow assessing the compliance of these F and SSB indicators for GES. At present, there are no estimates of SSB_{MSY} for any of the species covered by WGANSA (this value is not a constant, it has been discussed that it will be dependent on ecosystem productivity and food web dynamics) and therefore it is "easier" to focus on F_{MSY} and probably other reference points for SSB. For anchovy, Blim and Btrigger can already serve to assess the status of the anchovy SSB. And for sardine, reference points have not been defined.

An alternative indicator of the reproductive capacity of the stock could simply be the area being occupied by a population at spawning time estimated from surveys taken place at that time. For instance, the DEPM surveys carried out to estimate the SSB of sardine and anchovy every 3 and 1 year respectively, produce routinely an estimate of the size of the spawning area. This indicator is known to be related to the size of the spawning stock, since for these pelagic species spawning area is related to spawning biomass. The historical series of the parallel estimates of area and biomass could allow the setting of criteria to judge the spatial reproductive capacity of the stock based on its spawning area, by defining the reduced areas typical of depressed periods of the stock. Other indicator could be the density of egg production in space (usually called Daily Egg Production –or P0 – a parameter directly assessed in these DEPM surveys).

A third alternative indicator (intermediate of criteria 1 and 2) could be the %SPR or percentage of spawning per recruit arising from a Yield per recruit analysis, as this encapsulates the fishing pressure exerted to the stock in relation to its unexploited spawning per recruit. Evaluation of such indicator could be based on the %SPR which would correspond to the %SPR at F_{MSY} (so in practice would be quite similar to the evaluation of actual F).

Evaluation of Criterion 3 and alternatives from WGANSA:

The Group noted that the criteria and associated indicators on population age and size distribution were originally developed for demersal stocks sampled by bottom trawls in the North Sea and as such they have not been tested in pelagic stocks and pelagic surveys. It is unclear that indicators developed with (relatively long-lived) demersal fish in mind will always be meaningful for small pelagic species. As part of the MSFD requirements, Member States are required to carry out an initial assessment of the current Environmental status of their waters. MS are therefore producing (independently) a wide range of Indicators and Reference Points at national/regional scales, based on existing data. However, the boundaries of fish stocks (management units) rarely coincide with national boundaries. We illustrate these points in relation to sardine in Spanish Atlantic waters, where as an exercise, data provided by the Spanish PELACUS spring acoustic survey series for the period 2001-2009 was used to calculate the indicators for this criterion (see Figure 1).

The spring acoustic survey series PELACUS assesses the biomass and abundance of sardine and other pelagic species in north and northwest Spanish waters (ICES subdivisions VIIIc and IXaN). The survey adequately covers the distribution of the Spanish part of the sardine stock and as such is used in the assessment together with the results of the Portuguese acoustic survey (PELAGO). Clearly, the PELACUS survey covers only part of the Iberian sardine stock since it does not cover the majority of the Portuguese coast (and indeed does not include the Gulf of Cadiz). The bulk of this stock located in Portuguese waters and the number of fish in Spanish waters is likely to be influenced not only by the movement of fish from Portugal but also by possible migrations of sardine outside the northern border of the stock (French waters). Results of the calculation of the indicators of Criterion 3 for sardine using the PELACUS acoustic survey data are presented in Figure 1.

For the calculation of *Mean maximum length across all species found in research vessel surveys*, only maximum size of sardine is presented in Figure 1. Averages are very influenced by extreme values and abnormally big individuals of several other pelagic species could be present in the survey without being representative of the population´s true size distribution, especially when, as is the case for most of the pelagic species encountered by PELACUS, the area covered by the survey represents only part of the species/stock distributions. Weighting the maximum size value by the number of fish sampled will not deal completely with this problem because it presupposes that the part of the stock sampled is representative of the overall stock and this has not been proven and is likely to be false for at least some of the species routinely encountered (i.e. if bigger blue whiting is found outside the self, etc.). Even if we consider that the data from PELACUS can be representative of the size distribution of sardine, there is still the question as to whether the properties of some of the indicators calculated from these data are at all useful for short-lived pelagic species such as sardine and anchovy. As an example, calculation of percentage of the individuals above the size of first maturity will undoubtedly be more useful in species that do not attain maturity already in the first year(s) of life. This biological fact makes 100% the only possible value for this indicator for anchovy and, in the case of sardine, makes the percentage vary according to the distance in time and space from (and strength of) the last good recruitment. In both cases, this indicator will not reflect undesirable effects of fishing pressure. All indicators show a high variability and lack of common pattern unless in the short series estimated for Figure 1.

Alternative indicator could the mean age per cohort as inferred from surveys (not in the population per year, but per cohorts). So the indicator would encapsulate the most recent years of surveys (not just the last one). It would not be an instantaneous indicator but avoids the disadvantages of the former indices for the pelagics. It could be assessed relative to the mean age per recruit expected without any fishing mortality or versus the one expected at F_{MSY}.

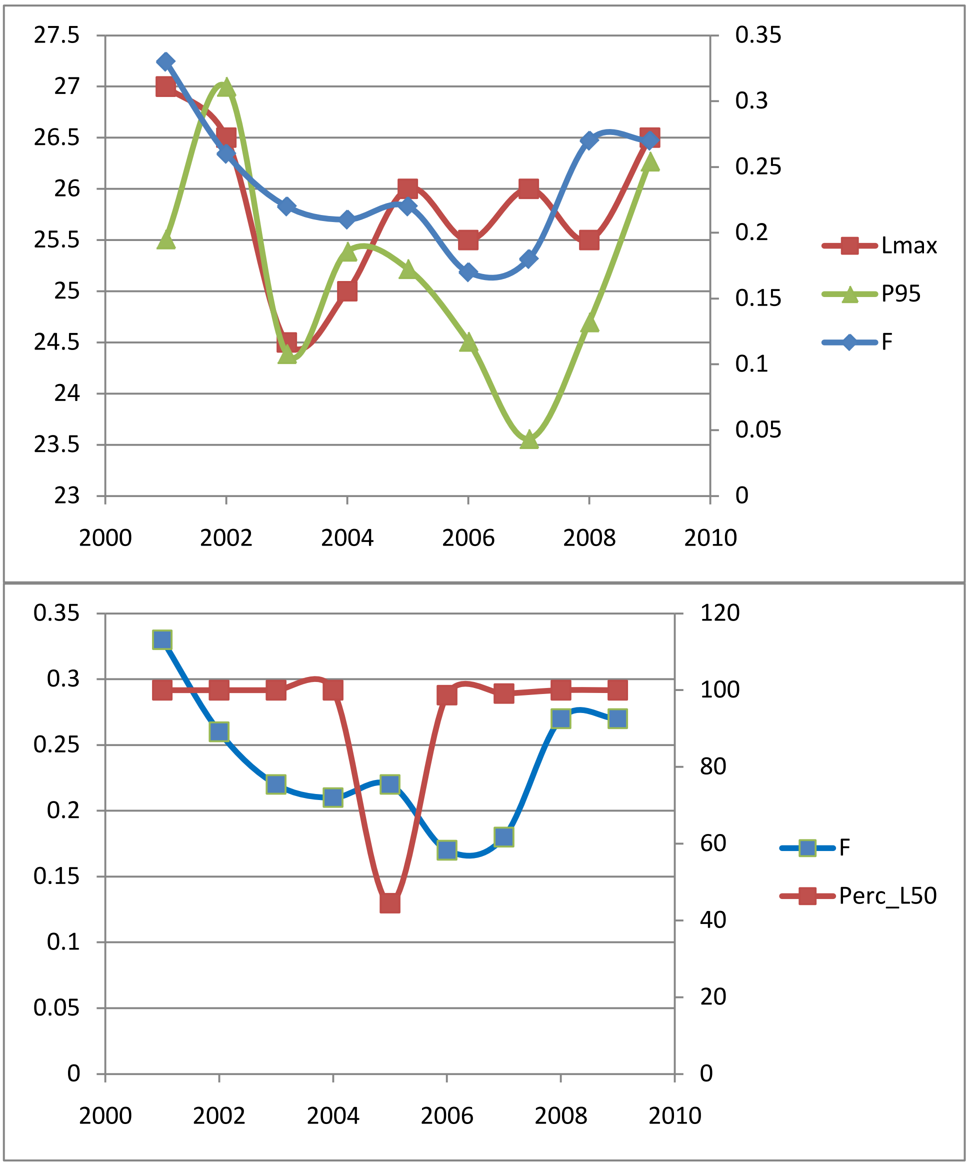


Figure 1. Indicators of Population age and size distribution of sardine based on the data provided by the Spanish spring acustic survey PELACUS and their relationship with the F estimated by the analitycal assessment of the Iberian sardine stock: Proportion of fish larger than mean size of first sexual maturation (Perc_L50), mean maximum length of sardine found in the survey (Lmax) and 95% percentile of the fish length distribution observed (Perc_L50).

1.5.2 Suggest pressure indicators that would complement biodiversity indicators

1.5.3 Identify spatially resolved data

Finally, concerning Generic TORs

k) take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP) http://www.ices.dk/reports/SSGHIE/2011/WKCMSP11.pdf

l) provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.

The WG could not devote time to analyse them.

1.6 Comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP)

The working Group was not able to cover this issue due to the limited time available.

2 Anchovy in northern areas.

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

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

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

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

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

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

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

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

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

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

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

2.2 Data Exploration from fishery statistics.

Landings and effort data were 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 kilos. In division VI, only 83kg were reported by the French fleets in 2000.

2.2.2 Catch in division VII.

In division VII, landings from both French and British fleets have been scarce until 1996 with up to 25t of landed fish (table 2.2.2). The 1997-2010 period has shown a rise of landings up to 244 tons in 2003 followed by a decrease 5 tons over the period 2004-2006 and then strong landings especially in 2009 and 2010 where the strongest landings of the time series were recorded (940 and 1450 tons respectively). The proportion of France and UK landings in the total catch has highly variable between years. Over the last two years, French landings have accounted for 62-78 of the total landings of anchovy in that division. It is unknown if the increase of landings are a consequence of the expansion of stock of anchovy in the Bay of Biscay in the last 2 years.

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

Most of the landings by the UK fleets have been in the last 4 years by ring nets (77% of UK landings in 2010) and purse seiners and midwater trawlers. French catches are mainly made by purse seiners (46%) and midwater pair trawlers (39%) (table 2.2.3).

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

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

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

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

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	1129.6	319.6	1449.2	84.2%	97.0%

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

UK Fleets

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

French Fleets

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

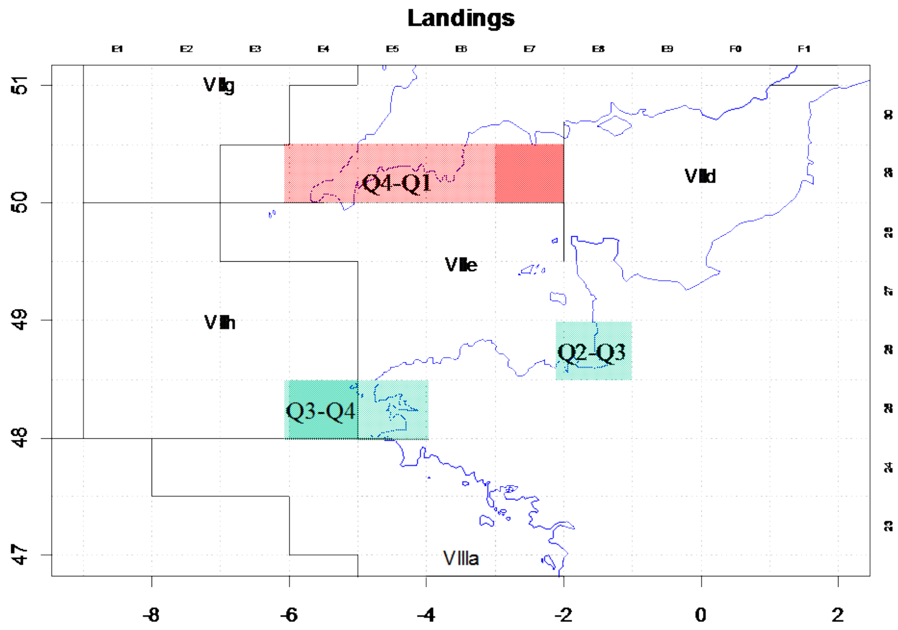


Figure 2.2.1. Map of the statistical rectangles where most of the catches of anchovy occur in ICES division VII for France (Green) and UK (Red).

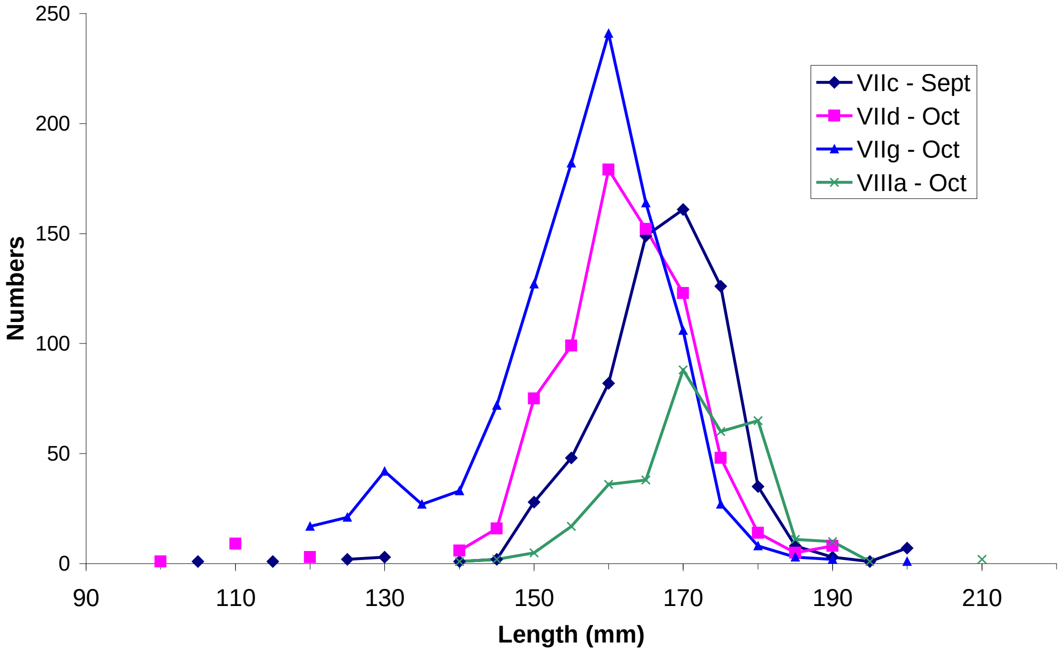


Figure 2.2.2. Length distributions of catch of anchovy in ICES divisionsVIIc, VIId, VIIg and VIIIa.

3 Anchovy in the Bay of Biscay (Subarea VIII)

3.1 ACOM advice for 2010 and 2011

The closure of the fishery in July 2005 and July 2006, due to the low levels of biomass of the anchovy population and the failure of the fishery, was sustained until December 2009.

In December 2009 (doc 5032/10 PECHE 1; http://register.consilium.europa.eu/pdf/en/10/st05/st05032.en10.pdf), "*The Council and the Commission have exceptionally agreed the temporary re-opening of the anchovy fishery in the Bay of Biscay following encouraging indications, based on the results of the research survey 'Juvena09', which preliminary point to a strong incoming recruitment that might increase the stock in 2010 in a substantial manner. They also agree that this agreement is conditional upon a careful validation by STECF of the above-mentioned results using all available scientific information, especially the results of the 2010 spring surveys and the most complete catch data gathered during the fishery. Should the scientific advice indicate that the stock recovery is not confirmed, the Council and the Commission agree that the TAC should be reduced in accordance with the proposed multiannual plan for this stock*."

Neither ICES nor STECF were involved in this process. Both were reluctant to use the juvenile index as an indicator of future recruitment until experience had been gained with the performance of the survey with a better recruitment which should have been confirmed by an ordinary assessment.

The TAC for reopening the fishery was set at 7000 t.

In June 2010, ICES estimated median SSB at 51 350 t with a probability of being above B_{lim} of 100% and considered "this implies a recovery of the population levels, in comparison with the last 5 years when the fishery was closed due to low biomasses". Based on a low recruitment scenario (2002 -2009), ICES adviced that "*with the objective to mantain the spawning biomass above a reference level of MSY* $B_{escapement}$ *by 2011 then a catch of less than 11 100 t can be taken in the period 1st July 2010 – 30th June 2011*". In addition, according to the precautionary approach, ICES especified that "*to reduce the risk to less than 5% that SSB in 2011 will be below* B_{lim}*, catch should be less than 6000 t*".

In July 2010 the Council established the TAC for the fishing season running from 1 July 2010 to 30 June 2011 at 15 600 tonnes (Council Regulation No 685/2010) based on the European Commission long-term management plan proposal. This proposal was presented on 29 July 2009 and at present is subject to revision and agreement between the EC, the Council and the Parliament, according to the procedures established in the Lisbon treaty.

In January 2011 the Council established the prohibition of fishing for anchovy in VIII by vessels flying the flag of France due to quota exhaustion (Council Regulation No 72/2011).

3.2 The fishery in 2010 and 2011

3.2.1 Fishing fleets

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

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

With the reopening of the fishery, in January 2010, the total number of fishing licences for anchovy in Spain was 168. In 2011 the number of fishing licences increased to 175, being distributed by regions as follows:

GALICIA	ASTURIAS	CANTABRIA	PAIS VASCO	TOTAL
58	7	51	59	175

For France the number of purse seiners able to catch anchovy in 2011 is around 27. The exact number of vessels is not fixed, due to important movements in this fleet. Most of them are based in Brittany. The number of Basque purse seiners decreases progressively and some of them will also join the north of the Bay of Biscay in near future. The real target specie of these vessels is sardine and anchovy is opportunistic.

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

3.2.2 Catches

In 2010 the fishery was reopened with a TAC of 7000 t. Catches were allowed since the 1st of March. By the 10th of June the Spanish fishery reached its annual quota of 5,400 t and was subsequently closed. Most of the French fishery started the 1st of June when the pelagic trawlers entered to the fishery. In July 2010 a new TAC of 15 600 t was established for the period July 2010-June 2011. Overall 4207 t were caught in the second half of 2010. The French fishery was closed in January 2011 due to quota exhaustion. The Spanish catches up to the end of May 2011 were around 9600 t.

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

The quarterly catches by country and division in 2010 are given in Table 3.2.2.3. Most of the Spanish catches took place in the second quarter (91%), whereas the major French catches occurred in quarter 3 (64%). Regarding fishing areas, the Spanish catches corresponded to ICES Divisions VIIIc and VIIIb (84 and 16% respectively) and French catches were mostly taken in ICES Division VIIIa (64%) and in the South of the division VII, very close to the border with VIIIa, with a total amount of 27% of annual catches. Anchovy was caught each side of the border between VIIIa and VIIe-h at the same period, and we assumed these VIIe-h catches in VIIIa.

3.2.3 Catch numbers at age and length

Catch numbers at age by quarter and country in 2010 are given in Table 3.2.3.1. Age 1 individuals were predominant in all quarters and areas.

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.

Catch at length data (by 0.5 cm classes) by quarter and country are given in Table 3.2.3.3. During the first and second quarters the modal length was around 15.5 cm. For the third and fourth quarters the individuals landed by the French fleet were larger than the ones landed by the Spanish fleet (modal length at 16 and 11.5 cm respectively).

See the stock annex for methodological issues.

3.2.4 Weights and lengths at age in the catch

The series of mean weight at age in the fishery by half year, from 1987 to 2010, is shown in Table 3.2.4.1. See the stock annex for methodological issues.

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

COUNTRY	FRANCE	SPAIN	SPAIN	INTERNATIONAL
YEAR	VIIIab	VIIIbc, Landings	Live Bait Catches	VIII
1960	1,085	57,000	n/a	58,085
1961	1,494	74,000	n/a	75,494
1962	1,123	58,000	n/a	59,123
1963	652	48,000	n/a	48,652
1964	1,973	75,000	n/a	76,973
1965	2,615	81,000	n/a	83,615
1966	839	47,519	n/a	48,358
1967	1,812	39,363	n/a	41,175
1968	1,190	38,429	n/a	39,619
1969	2,991	33,092	n/a	36,083
1970	3,665	19,820	n/a	23,485
1971	4,825	23,787	n/a	28,612
1972	6,150	26,917	n/a	33,067
1973	4,395	23,614	n/a	28,009
1974	3,835	27,282	n/a	31,117
1975	2,913	23,389	n/a	26,302
1976	1,095	36,166	n/a	37,261
1977	3,807	44,384	n/a	48,191
1978	3,683	41,536	n/a	45,219
1979	1,349	25,000	n/a	26,349
1980	1,564	20,538	n/a	22,102
1981	1,021	9,794	n/a	10,815
1982	381	4,610	n/a	4,991
1983	1,911	12,242	n/a	14,153
1984	1,711	33,468	n/a	35,179
1985	3,005	8,481	n/a	11,486
1986	2,311	5,612	n/a	7,923
1987	4,899	9,863	546	15,308
1988	6,822	8,266	493	15,581
1989	2,255	8,174	185	10,614
1990	10,598	23,258	416	34,272
1991	9,708	9,573	353	19,634
1992	15,217	22,468	200	37,885
1993	20,914	19,173	306	40,393
1994	16,934	17,554	143	34,631
1995	10,892	18,950	273	30,115
1996	15,238	18,937	198	34,373
1997	12,020	9,939	378	22,337
1998	22,987	8,455	176	31,617
1999	13,649	13,145	465	27,259
2000	17,765	19,230	n/a	36,994
2001	17,097	23,052	n/a	40,149
2002	10,988	6,519	n/a	17,507
2003	7,593	3,002	n/a	10,595
2004	8,781	7,580	n/a	16,361
2005	952	176	0	1,128
2006	913	840	0	1,753
2007	140 **	1.2 **	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	4,573	5,744	n/a	10,317
2011 (Up end May)	0	9,621	n/a	9,621
AVERAGE (1960-2004)	6,394	26,337	318	32,824

** : Experimental fishery

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

COUNTRY: FRANCE

Units: t.

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL	Half year basis: 1st half	2nd half	TOTAL
1987	0	0	0	1,113	1,560	268	148	582	679	355	107	87	4,899	2,941.0	1,958.0	4,899.0
1988	0	0	14	872	1,386	776	291	1,156	2,002	326	0	0	6,822	3,047.5	3,774.7	6,822.2
1989	704	71	11	331	648	11	43	56	70	273	9	28	2,255	1,776.0	479.1	2,255.1
1990	0	0	16	1,331	1,511	127	269	1,905	3,275	1,447	636	82	10,598	2,985.0	7,613.2	10,598.2
1991	1,318	2,135	603	808	1,622	195	124	419	1,587	557	54	285	9,708	6,681.8	3,026.5	9,708.2
1992	2,062	1,480	942	783	57	11	335	1,202	2,786	3,165	2,395	0	15,217	5,333.6	9,882.9	15,216.5
1993	1,636	1,805	1,537	91	343	1,439	1,315	2,640	4,057	3,277	2,727	47	20,914	6,851.4	14,062.1	20,913.5
1994	1,972	1,908	1,442	172	770	1,730	663	2,125	3,276	2,652	223	0	16,934	7,994.4	8,939.2	16,933.6
1995	620	958	807	260	844	1,669	389	1,089	2,150	1,231	855	22	10,892	5,157.0	5,735.1	10,892.1
1996	1,084	630	614	206	150	1,568	1,243	2,377	3,352	2,666	1,349	0	15,238	4,250.6	10,987.5	15,238.1
1997	2,235	687	24	36	90	1,108	1,579	1,815	1,680	2,050	718		12,022	4,180.0	7,842.0	12,022.0
1998	1,523	2,128	783	0	237	1,427	2,425	4,995	4,250	2,637	2,477	103	22,987	6,099.4	16,887.8	22,987.2
1999	2,080	1,333	574	55	68	948	1,015	922	3,138	1,923	1,592	0	13,649	5,057.9	8,591.3	13,649.2
2000	2,200	948	825	5	58	1,412	2,190	2,720	3,629	2,649	1,127	0	17,765	5,448.6	12,315.9	17,764.5
2001	717	517	143	46	47	1,311	1,078	3,401	4,309	2,795	2,732	0	17,097	2,781.5	14,315.5	17,097.0
2002	1,435	2,561	1,560	1	30	758	350	979	1,957	771	578	0	10,978	6,344.6	4,633.5	10,978.1
2003	39	2	0	32	123	1,031	284	2,284	1,478	1,319	983	19	7,593	1,226.2	6,367.2	7,593.4
2004	210	106	3	13	145	1,625	853	1,995	2,464	555	813	0	8,781	2,101.6	6,678.9	8,780.5
2005	363	15	33	0	16	525	0	0	0	0	0	0	952	951.8	0.0	951.8
2006	1	0	29	0	0	795	88	0	0	0	0	0	913	825.4	88.0	913.4
2007	0	0	0	39	56	45	0	0	0	0	0	0	140	140.0	0.0	140.0
2008	0	0	0	0	0	0	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	0.0	0.0	0.0
2010	0	0	0	0	0	592	75	630	2,202	862	213	0	4,573	592.6	3,980.5	4,573.1
2011	0	0	0	0	0								0	0.0	0.0	0.0

Table 3.2.2.2 continued.

COUNTRY:
SPAIN

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL	1st half	2nd half	TOTAL
1987	0	0	454	4,133	3,677	514	81	54	28	457	202	265	9,864	8,777.5	1,086.0	9,863.6
1988	6	0	28	786	2,931	3,204	292	98	421	118	136	246	8,266	6,954.6	1,311.3	8,265.9
1989	2	2	25	258	4,295	795	90	510	116	198	1,610	273	8,173	5,377.3	2,796.1	8,173.5
1990	79	6	2,085	1,328	9,947	2,957	1,202	3,227	2,278	123	16	10	23,258	16,401.4	6,856.8	23,258.2
1991	100	40	23	1,228	5,291	1,663	91	60	34	265	184	596	9,573	8,343.2	1,230.1	9,573.3
1992	360	384	340	3,458	13,068	3,437	384	286	505	63	94	89	22,468	21,047.0	1,421.0	22,468.0
1993	102	59	1,825	3,169	7,564	4,488	795	340	198	65	546	23	19,173	17,206.5	1,966.3	19,172.8
1994	0	9	149	5,569	3,991	5,501	1,133	181	106	643	198	74	17,554	15,219.4	2,334.5	17,553.9
1995	0	0	35	5,707	11,485	1,094	50	9	6	152	48	365	18,951	18,321.9	628.9	18,950.8
1996	48	17	138	1,628	9,613	5,329	1,206	298	266	152	225	17	18,937	16,773.5	2,163.9	18,937.4
1997	43	1	81	2,746	2,672	877	316	585	1,898	331	203	185	9,939	6,420.3	3,518.6	9,938.8
1998	35	235	493	371	4,602	1,083	1,518	44	47	3	22	1	8,455	6,818.1	1,636.5	8,454.7
1999	8	26	52	4,626	4,214	1,396	1,037	26	911	207	615	27	13,144	10,322.7	2,821.8	13,144.5
2000	18	0	99	1,952	11,864	3,153	958	342	413	346	83	0	19,230	17,087.2	2,142.6	19,229.8
2001	243	48	337	2,203	14,381	3,102	1,436	1	126	1,055	120	1	23,052	20,313.6	2,738.5	23,052.1
2002	1	0	13	914	2,476	1,340	323	56	1,013	381	1	0	6,519	4,744.8	1,774.3	6,519.1
2003	0	0	0	1,709	767	373	10	12	124	4	3	0	3,002	2,848.1	153.8	3,001.9
2004	0	0	0	2,364	3,102	1,616	50	22	423	1	1	2	7,580	7,081.5	498.3	7,579.7
2005	0	2	2	4	167	0	0	0	0	0	0	0	176	175.5	0.0	175.5
2006	0	0	4	124	630	75	7	0	0	0	0	0	840	833.1	6.9	840.0
2007	0	0	0	0	1	0	0	0	0	0	0	0	1	1.2	0.0	1.2
2008	0	0	0	0	0	0	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	0.0	0.0	0.0
2010	0	0	299	1,324	2,955	940	0	2	223	1	0	0	5,744	5,518.1	226.1	5,744.2
2011	0	0	1,481	3,873	4,267								9,621	9,621.1	0.0	9,621.1

Table 3.2.2.2 continued.

COUNTRY: INTERNATIONAL

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL	1st half	2nd half	TOTAL
1987	0	0	454	5246	5237	782	229	636	707	812	309	352	14763	11,718.5	3,044.0	14,762.6
1988	6	0	42	1657	4317	3979	584	1253	2423	445	136	246	15088	10,002.1	5,086.0	15,088.2
1989	706	73	36	588	4943	806	132	566	186	472	1619	301	10429	7,153.3	3,275.2	10,428.6
1990	80	6	2101	2658	11459	3083	1471	5132	5553	1570	652	92	33856	19,386.4	14,470.0	33,856.5
1991	1418	2175	626	2036	6913	1858	215	479	1621	822	238	882	19282	15,025.0	4,256.6	19,281.6
1992	2422	1864	1282	4241	13125	3448	719	1488	3291	3228	2489	89	37685	26,380.6	11,303.9	37,684.5
1993	1738	1864	3362	3260	7906	5927	2110	2979	4254	3342	3273	70	40086	24,057.9	16,028.4	40,086.3
1994	1972	1917	1591	5741	4761	7231	1796	2306	3382	3295	421	74	34487	23,213.8	11,273.7	34,487.5
1995	620	958	842	5967	12329	2764	439	1098	2155	1382	903	387	29843	23,478.9	6,364.0	29,842.9
1996	1132	647	752	1834	9763	6897	2449	2675	3617	2818	1575	17	34176	21,024.2	13,151.4	34,175.5
1997	2278	688	105	2782	2762	1985	1895	2400	3578	2381	921	185	21961	10,600.3	11,360.6	21,960.8
1998	1558	2363	1276	371	4839	2510	3943	5039	4298	2640	2500	104	31442	12,917.5	18,524.3	31,441.8
1999	2088	1360	626	4681	4282	2345	2052	948	4049	2130	2207	27	26794	15,380.6	11,413.0	26,793.6
2000	2219	948	925	1957	11922	4565	3148	3063	4043	2995	1210	0	36994	22,535.8	14,458.5	36,994.3
2001	960	565	479	2249	14428	4413	2514	3403	4435	3850	2852	1	40149	23,095.1	17,054.0	40,149.1
2002	1436	2561	1573	915	2506	2098	673	1034	2970	1152	578	0	17497	11,089.4	6,407.7	17,497.2
2003	39	2	0	1740	890	1403	294	2297	1602	1322	986	20	10595	4,074.3	6,521.0	10,595.3
2004	210	106	3	2377	3247	3241	902	2017	2886	557	813	2	16360	9,183.1	7,177.2	16,360.2
2005	363	17	35	4	183	525	0	0	0	0	0	0	1127	1,127.3	0.0	1,127.3
2006	1	0	33	124	630	870	95	0	0	0	0	0	1753	1,658.5	94.9	1,753.4
2007	0	0	0	39	57	45	0	0	0	0	0	0	141	141.2	0.0	141.2
2008	0	0	0	0	0	0	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	0.0	0.0	0.0
2010	0	0	299	1324	2955	1532	75	632	2425	863	213	0	10317	6,110.7	4,206.6	10,317.3
2011	0	0	1481	3873	4267								9621	9,621.1	0.0	9,621.1

Table 3.2.2.3: ANCHOVY catches in the Bay of Biscay by country and divisions in 2010 (without live bait catches)

		QUARTERS				CATCH (t)	
COUNTRIES	DIVISIONS	1	2	3	4	ANNUAL	%
SPAIN	VIIIa	0	0	0	0	0	0.0%
	VIIIb	80	816	0	0	896	15.6%
	VIIIc	219	4402	225	1	4848	84.4%
	TOTAL	299	5219	225	1	5744	100
	%	5.2%	90.9%	3.9%	0.0%	100.0%	
FRANCE	VIIe-h *	0	0	788	449	1237	27.1%
	VIIIa	0	180	2112	626	2918	63.8%
	VIIIb	0	413	5	0	418	9.1%
	VIIIc	0	0	0	0	0	0.0%
	TOTAL	0	593	2905	1075	4573	4573
	%	0.0%	13.0%	63.5%	23.5%	100.0%	100%
INTERNATIONAL	VIIIa	0	0	788	449	1237	16.7%
	VIIIb	80	1229	5	0	1314	17.8%
	VIIIc	219	4402	225	1	4848	65.5%
	TOTAL	299	5632	1018	450	7399	100.0%
	%	4.0%	76.1%	13.8%	6.1%	100.0%	

* : anchovy was caught at the border between VIIIa and VII, and we assumed these catches in VIIIa

Table 3.2.3.1: ANCHOVY catch at age in thousands for 2010 by country and quarter (without the catches from the live bait tuna fishing boats).

2010 units: thousands

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIbc	VIIIbc	VIIIabc	VIIIabc	VIIIabc
SPAIN	0	0	0	36	30	66
	1	4173	105709	10527	53	120,461
	2	4532	67330	0	0	71,862
	3	1011	9098	0	0	10,109
	4	506	1071	0	0	1,578
	5	1	0	0	0	1
	TOTAL(n)	10,222	183,208	10,562	84	204,077
	W MED.	29.55	28.74	21.30	10.95	28.39
	CATCH. (t)	299	5219	225	1	5,744.2
	SOP	302	5266	225	1	5,793.5
	VAR. %	100.91%	100.90%	99.89%	102.21%	100.86%

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIab	VIIIab	VIIIab	VIIIab	VIIIab
FRANCE	0	0	0	9101	7120	16,221
	1	0	15316	93955	31035	140,306
	2	0	5480	10241	3623	19,344
	3	0	788	451	364	1,603
	4	0	133	113	76	323
	5	0	1	0	0	1
	TOTAL(n)	0	21,719	113,860	42,218	177,797
	W MED.	0.00	27.28	25.40	25.05	25.55
	CATCH. (t)	0	593	2906	1074	4,573.0
	SOP	0	593	2892	1057	4,542.2
	VAR. %	0.00%	99.99%	99.52%	98.44%	99.33%

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIabc	VIIIabc	VIIIabc	VIIIabc	VIIIabc
TOTAL Sub-area VIII	0	0	0	9,136	7,150	16,287
	1	4,173	121,025	104,482	31,088	260,767
	2	4,532	72,811	10,241	3,623	91,206
	3	1,011	9,886	451	364	11,712
	4	506	1,205	113	76	1,900
	5	1	1	0	0	1
	TOTAL(n)	10,222	204,927	124,423	42,302	381,874
	W MED.	29.55	28.59	25.05	25.02	27.07
	CATCH. (t)	299	5811	3131	1075	10317
	SOP	302	5858	3117	1058	10336
	VAR. %	100.91%	100.81%	99.54%	98.44%	100.18%

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

Units: Thousands

INTERNATIONAL

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

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

YEAR	2005		2006		2007		2008		2009		2010	
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
0	0	0	0	0	0	0	0	0	0	0	0	16,287
1	7,818	0	48,718	3,894	0	0	0	0	0	0	125,198	135,570
2	32,911	0	17,172	991	0	0	0	0	0	0	77,342	13,864
3	6,935	0	6,465	320	0	0	0	0	0	0	10,897	815
4	586	0	49	2	0	0	0	0	0	0	1,711	189
5	0	0	0	0	0	0	0	0	0	0	1	0
Total #	48,250	0	72,405	5,207	0	0	0	0	0	0	215,149	166,725

Table 3.2.3.2 continued

SPAIN

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

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

YEAR	2005		2006		2007		2008		2009		2010	
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
0	0	0	0	0	0	0	0	0	0	0	0	66
1	1,096	0	21,276	355	0	0	0	0	0	0	109,881	10,580
2	4,631	0	7,708	25	0	0	0	0	0	0	71,862	0
3	266	0	3,587	7	0	0	0	0	0	0	10,109	0
4	16	0	0	0	0	0	0	0	0	0	1,578	0
5	0	0	0	0	0	0	0	0	0	0	1	0
Total #	6,009	0	32,571	387	0	0	0	0	0	0	193,431	10,646

Table 3.2.3.2 continued

FRANCE

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

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

YEAR	2005		2006		2007		2008		2009		2010	
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
0	0	0	0	0	0	0	0	0	0	0	0	16,221
1	6722	0	27,442	3,539	0	0	0	0	0	0	15,316	124,989
2	28281	0	9,464	966	0	0	0	0	0	0	5,480	13,864
3	6669	0	2,878	313	0	0	0	0	0	0	788	815
4	570	0	49	2	0	0	0	0	0	0	133	189
5	0	0	0	0	0	0	0	0	0	0	1	0
Total #	42,242	0	39,833	4,820	0	0	0	0	0	0	21,719	156,079

Table 3.2.3.3: Bay of Biscay anchovy: Catch numbers at length by country and quarters in 2010

	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4	
Length (half cm)	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIbc	France VIIIab	Spain VIIIabc	France VIIIab	Spain VIIIabc
3.5								
4								
4.5								
5								
5.5								
6								
6.5								
7								
7.5								
8								
8.5		0		0				
9						1,378		1,641
9.5			10				36	
10								
10.5			39			1,378	145	1,641
11		15,209	68	1		12,403	254	14,765
11.5		29,390	107	274	152	17,915	399	21,327
12		67,601	88	95,228		11,030	938	13,124
12.5		159,455	130	344,866	1,005	15,252	1,169	18,046
13		228,535	101	1,363,860	2,587	8,794	2,210	9,843
13.5		354,971	1,395	3,155,481	4,322	2,163	2,113	1,641
14		337,557	2,535	7,342,676	6,338	2,632	2,788	1,641
14.5		704,351	3,671	15,967,623	7,395	2,247	2,501	
15		962,047	5,757	25,950,682	16,820	3,002	3,690	
15.5		1,383,225	3,211	28,951,828	21,809	1,091	5,372	
16		1,097,751	1,986	25,766,209	21,371	815	6,391	
16.5		1,125,324	821	16,845,577	14,267	270	5,467	
17		993,379	1,036	11,657,864	11,541		3,909	
17.5		869,066	348	8,464,084	4,018	270	2,398	
18		499,754	126	5,602,066	1,784		2,168	
18.5		350,559	270	3,297,167	453	135	305	
19		176,245	19	1,637,114	181		233	
19.5		45,876		488,720			28	
20		2,358	10	252,913	91			
20.5		1		52,048				
21		1					55	
21.5								
22								
22.5								
23								
23.5								
24								
24.5								
25								
25.5								
26								
Total ('000)		9,402,654	21,728	157,236,280	114,132	80,776	42,571	83,668
Catch (t)		299	593	5,219	2,906	225	1,074	1
Mean Length(cm)		16.14	15.14	16.05	14.78	15.05	14.65	12.15

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

nits: grams

INTERNATIONAL

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

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

YEAR	2005		2006		2007		2008		2009		2010	
Sources:	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
Age 0	na	na	na	na	na	na	na	na	na	na	na	14.4
1	19.3	na	20.3	17.8	na	na	na	na	na	na	25.0	25.9
2	24.5	na	27.7	19.7	na	na	na	na	na	na	32.1	27.4
3	27.6	na	31.3	19.7	na	na	na	na	na	na	43.7	43.2
4	24.5	na	37.3	34.3	na	na	na	na	na	na	43.0	44.4
5	na	na	na	na	na	na	na	na	na	na	55.7	na
Total	24.1	na	23.0	18.2	na	na	na	na	na	na	28.6	25.0

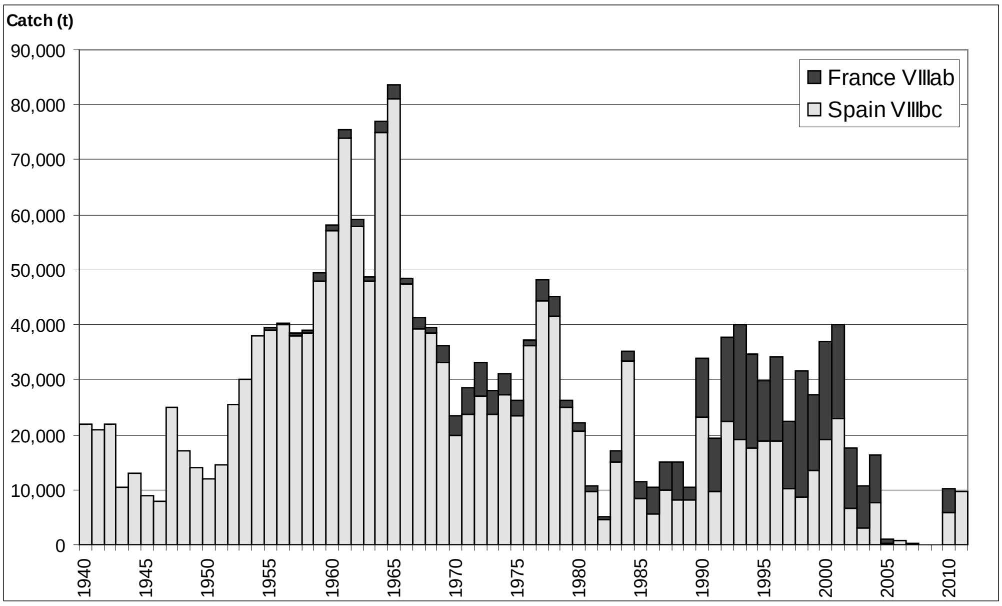


Figure 3.2.2.1. Bay of Biscay: Historical evolution of anchovy catches in division VIII by countries (1940 – first half of 2011).

3.3 Fishery independent data

3.3.1 DEPM survey 2011

All the methodology for the survey and the estimates performance are described in the stock annex - Bay of Biscay Anchovy (Subarea VIII). A detailed report of the survey and results 2011 is attached as **Santos. M *et al.* – WD 2011.**

3.3.1.1 Survey description

The 2011 anchovy DEPM survey was carried out in the Bay of Biscay from 6th to the 27th of May, covering the whole spawning area of the species, following the procedures described in the stock annex- Bay of Biscay Anchovy (Subarea VIII). Two vessels were used at the same time and place: the R/V Investigador to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. In addition, the purse seine fleet collaborated in the adult samples. Sample .specifications could be seen in **table 3.3.1.1.1.**

The anchovy eggs were encountered all along the area but in the Cantabrian coast the eggs were encountered offshore instead of near the coast as usually. Between Adour and Le Gironde approximately between 50 and 150m a gap without eggs was encountered. This year part of the eggs was encountered outside of the platform. (**Figure 3.3.1.1.1**).

In relation with the adult samples, most of the hauls consisted of anchovy, horse mackerel, hake and mackerel. The fishing hauls from the pelagic trawler are summarized in **WD – Santos. M *et al.* 2011**. From 52 pelagic trawl hauls obtained with the research pelagic trawler, 40 had anchovy and were used for the analysis. Apart from those, 6 samples were obtained from the purse seines fleet but were not used for the analysis yet. In general, the small individuals were all along the coast and the big ones were offshore. The spatial distribution of the samples and their species composition is showed in **figure 3.3.1.1.2**; the adults mean weight in **figure 3.3.1.1.3**. **Figure 3.3.1.1.4** shows the age composition by haul.

The salinity data obtained during the survey showed clearly the effect of the river discharges of Adour and Gironde and the dispersion of their plumes. Salinity values between 33.6 and 35.1 PSU, lower than a typical value of 35.6 PSU, were observed over the continental platform, especially around the Gironde mouth. Mean sea surface salinity was 35.25 (min: 33.5 max: 38.19). The temperature field only shows the effect of river discharges in the Gironde (values between 12.8 and 15.8 ºC) and close to the coast. This is possibly due to the high solar radiation observed during the survey; this increase the temperature of the water masses originated from the rivers, having no effect on the salinity field. The mean SST, 16.8ºC, was 3 degrees higher than last year (min: 13ºC, max: 18.8ºC). Following only the values of T-S, the general water mass movement at sea surface seems to be between W and NW, especially when the wind had low intensity (**Figure 3.3.1.1.5)**

3.3.1.2 Total daily egg production estimate

The estimates of daily egg production, daily egg mortality rates and total egg production are given in **Table 3.3.1.2.1** and the mortality curve model used is shown in **Figure 3.3.1.2.1** Total egg production in 2011 (8.75.E+12egg/day) was four times than last year, estimated in the same manner.

3.3.1.3 Daily fecundity

As the adults samples are not fully processed yet, to obtain the preliminary SSB estimate for June, the mean of the historical series, (63.39 egg/ g per day) was used as a proxy for DF (procedure according to WGACEGG 2009) .

3.3.1.4 Preliminary Spawning Stock Biomass estimate and population at age

In 2011 the preliminary SSB estimated was 138,069 t with a CV of 23%, (**Table 3.3.1.4.1**) (**Figure 3.3.1.4.1**) almost four times higher than last year estimate given in June (36,627 t; CV 22%).

To estimate the numbers at age, 4 strata were defined. (**Fig 3.3.1.4.2**). 87% of the anchovy in numbers are individuals of age 1(81%in mass) and 13% of age 2 (**Table 3.3.1.4.2**). The age structure of the population since 2005 indicates that the closure of the fishery had a positive effect in sustaining the recent levels of biomass (**Fig 3.3.1.4.3**)

Table 3.3.1.1.1: Bay of Biscay: Details obtained during anchovy DEPM Survey 2011.

Parameters	**Anchovy DEPM survey**
Surveyed area	(43º17' to 48ºN & 4º55′ to 1º30' W)
R/V	*Investigador* & *Emma Bardán*
Date	6-27/05/11
Eggs	**R/V INVESTIGADOR**
Total egg stations	699
% st with anchovy eggs	69%
Anchovy egg average by st	22 eggs/0.1m^2
Max. anchovy eggs in a St	1,021 eggs/0.1m^2
Total anchovy egg collected	15,204 eggs
North spawning limit	47º23′N
West spawning limit	3º54′W
Total area surveyed	98,445 Km^2
Spawning area	69,131 Km^2
CUFES stations	1,495
Adults	**R/V EMMA BARDAN**
Pelag. trawls + p. seine hauls	52 + 6
With anchovy	40 + 6
Selected for analysis	40 + 6*

*Not included yet in this report analysis

Table 3.3.1.2.1: Bay of Biscay: Daily egg production estimates (P_0), daily egg mortality rates (z) and total egg production (P_{tot}) with their correspondent standard error (s.e.) and coefficient of variation (CV) for 2011.

Parameter	**Value**	**S.e.**	**CV**
P_0	126.68	17.05	0.1346
z	0.30	0.088	0.2921
P_{tot}	8.75.E+12	1.2.E+12	0.1346

Table: 3.3.1.4.1: Bay of Biscay: Preliminary biomass estimate (SSB) for 2011 obtained as the ratio between estimates of P_{tot} derived from the GLM and the mean of Daily Fecundity.

P_{tot} (eggs)			**DF (eggs/gramme)**			**SSB (Ton.)**		
Model	**Estimate**	**Var**	**Predic.Model**	**Estimate**	**Var.Pred.**	**Estimate**	**Var**	**Cv**
GLM	8.75E+12	1.4E+24	df = histor. mean	63.39	139.01	138,069	1.0.E+09	0.2296

Table: 3.3.1.4.2: Bay of Biscay: SSB 2011 estimates, percentage at age, numbers at age, mean weight by age class, SSB at age in mass and percentage at age in mass and the correspondent standard error (s.e.) and coefficient of variation (CV).

Parameter	Estimate	S.e.	CV
Biomass (Tons)	138,069	31,697	0.2296
Total mean W (g)	16.44	1.22	0.0744
Population (millions)	8,398	2026.6	0.2413
Percent age 1	0.8669	0.0197	0.0227
Percent age 2	0.1305	0.0194	0.1484
Percent age 3+	0.0026	0.0011	0.4072
Numbers at age 1	7,280	1764.7	0.2424
Numbers at age 2	1,096	310.4	0.2833
Numbers at age 3+	22	10.3	0.4734
Weight at age 1	15.3		
Weight at age 2	23.7		
Weight at age 3+	31.6		
SSB at age 1 in mass	111,382		
SSB at age 2 in mass	25,999		
SSB at age 3+ in mass	687		
Percent age 1 in mass	0.8067		
Percent age 2 in mass	0.1883		
Percent age 3+ in mass	0.0050		

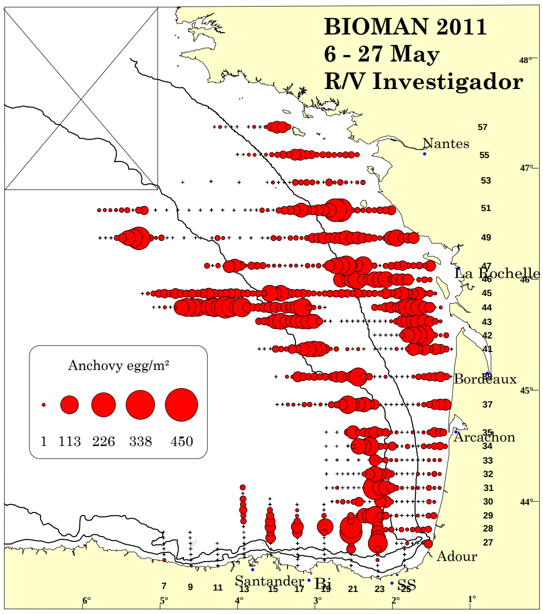


Figure 3.3.1.1.1: Bay of Biscay anchovy: Distribution of egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN2011 obtained with PairoVET. The quadrangle with the cross represents an area close by the French authorities to operate during the period of the survey

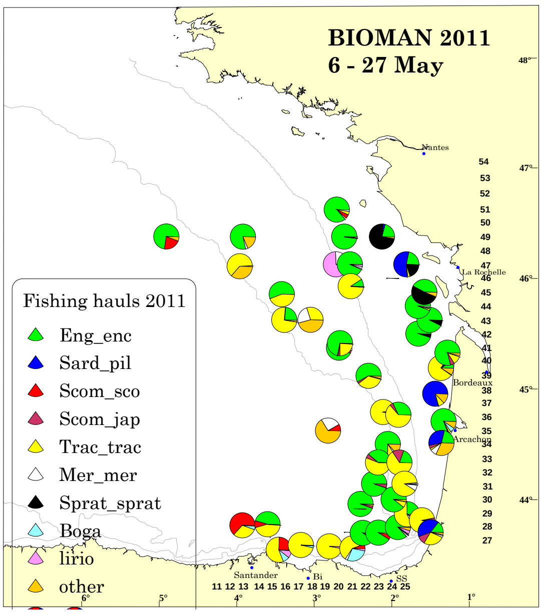


Figure 3.3.1.1.2: Bay of Biscay anchovy: Species composition of the 40 pelagic trawls from the R/V Emma Bardán during BIOMAN2011

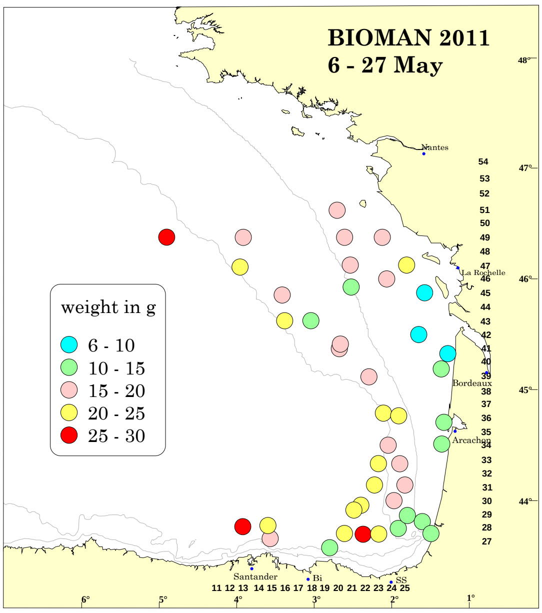


Figure 3.3.1.1.3: Bay of Biscay anchovy: Anchovy (male and female) mean weight per haul in 2011

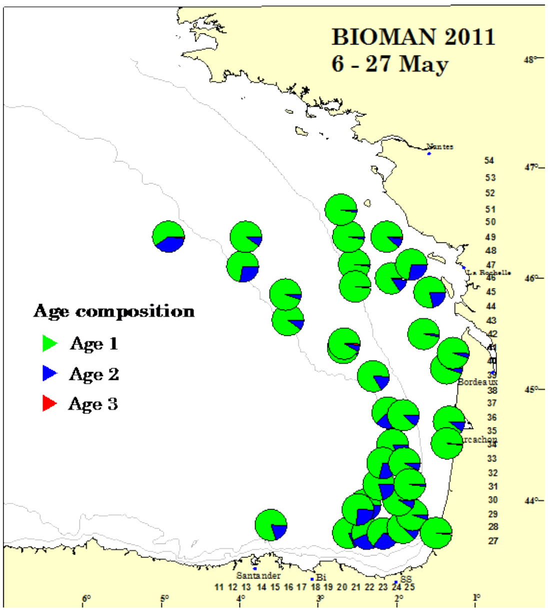


Figure 3.3.1.1.4: Bay of Biscay anchovy: Anchovy age composition per haul in 2011

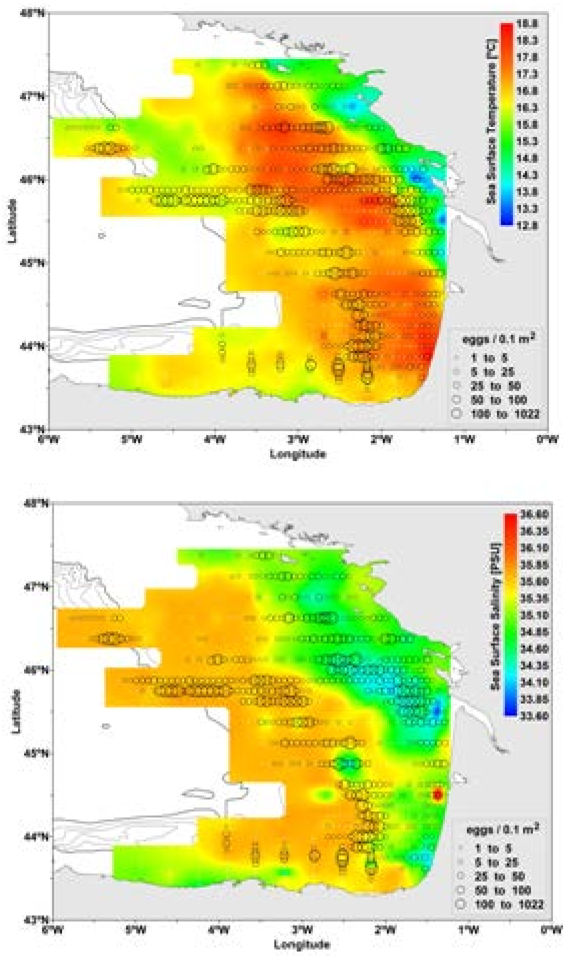


Figure 3.3.1.1.5: Bay of Biscay anchovy: SST and SSS maps (left and right respectively) with anchovy egg distribution.

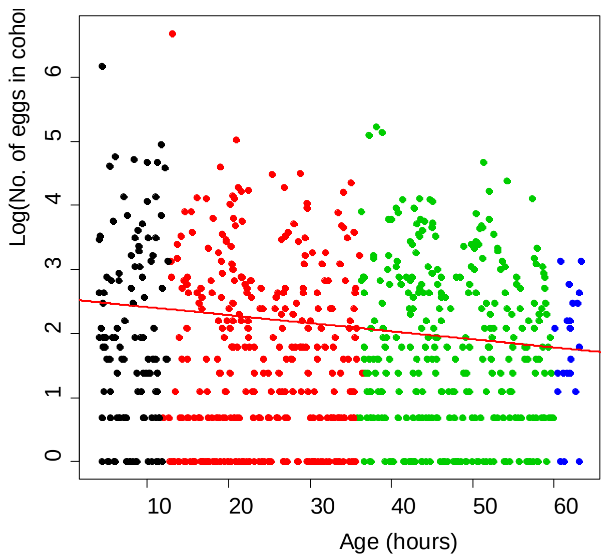


Figure 3.3.1.2.1: Bay of Biscay anchovy: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing, following the Bayesian method. (Spawning peak 23:00h).The red line is the adjust line. The different colours are the different cohorts.

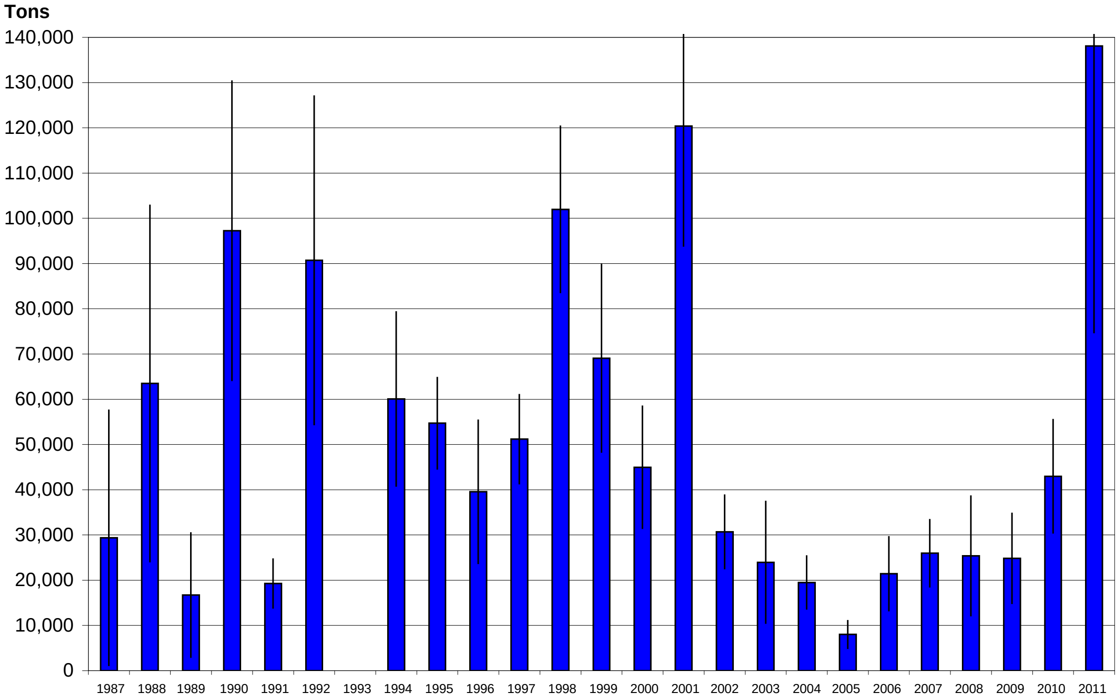


Figure 3.3.1.4.1: Bay of Biscay anchovy: Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. Most of them are full DEPM estimates, except in 1996, 1999 and 2000 which were deduced indirectly.

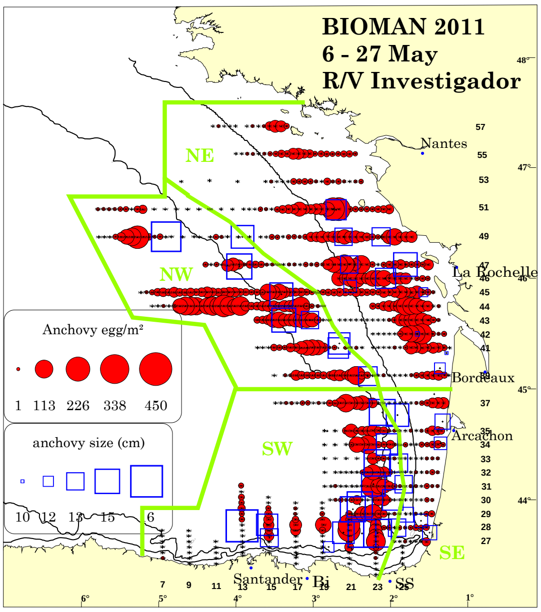


Figure 3.3.1.4.2: Bay of Biscay anchovy: Four strata were defined to estimate the numbers at age in 2011: Northeast, Southeast, Southwest and Northwest. The circles are the anchovy egg abundances (egg/0.1m²) and the squares are anchovy adults mean size (cm) per haul.

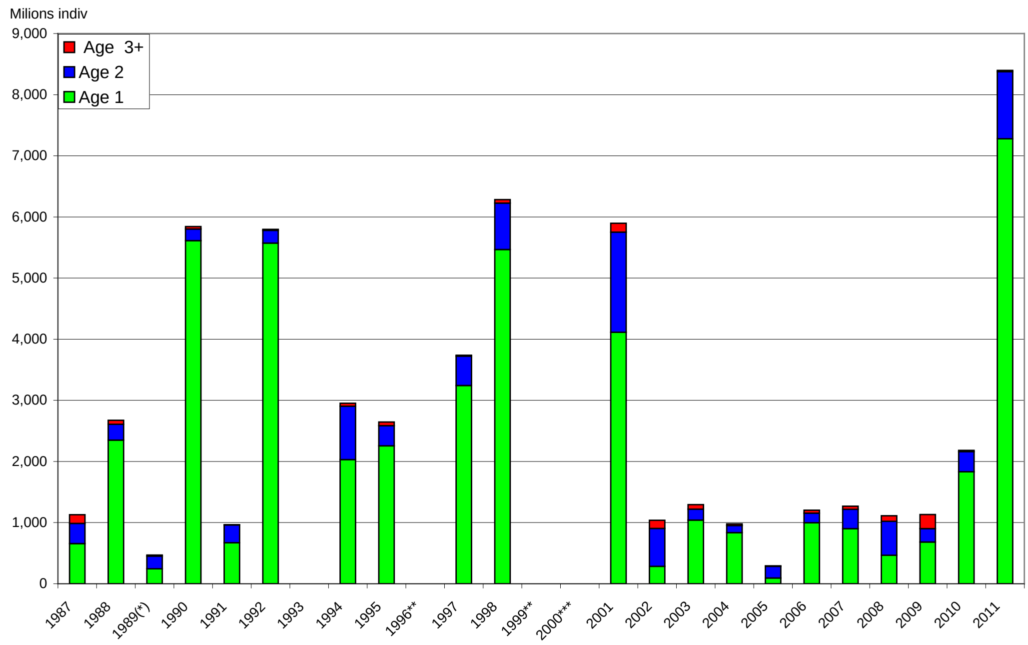


Figure 3.3.1.4.3: Bay of Biscay anchovy: Historical series of numbers at age from 1987 to 2011.

3.3.2 Acoustic survey 2011

3.3.2.1 Description of survey

The acoustic survey PELGAS11 was carried out in the Bay of Biscay from April 26th to June 5th 2011 on board the French research vessel Thalassa. The objectives and methods are described in Stock annex, and a detailed report of the survey is attached as Annex 2: Massé & Duhamel - WD 2011. The protocol for these spring surveys is described in annex 6 of WGACEGG 2009 (PELGAS sea survey protocol, Doray, Massé,& Petitgas in ICES 2009) Details of the 2011 survey are presented in table 3.3.2.1.

As in the 4 previous years, a consort survey was organised with French pair trawlers during the 22 first days and a purse seiner during 2 days. With this approach, in the continuity of last years survey, the commercial vessels hauls were used for echo identification and biological parameters at the same level those by Thalassa. The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and furthermore, to verify that both scientists and fishermen observe the same types of echo-traces and have similar interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check if the catches were well comparable (in proportion of species and, most of the time, in quantity as well).

As last year, the fishing operations by commercial vessels were carried out only during day time (as for Thalassa) each time it was necessary and preferentially at the surface or in mid-water, taking into account that pair trawlers are more efficient at surface than single back trawlers. Acoustic data were collected by Thalassa along 27 transects (2176 nm) perpendicular to bathymetry, upon which 2073 nautical miles (daylight surveyed selected miles during the global coverage) were used for biomass estimate (Figure 3.3.2.1). A total of 117 hauls were carried out during the assessment coverage, 112 were valid including 52 hauls by Thalassa and 60 hauls by commercial vessels (figure 3.3.2.2). Eggs were counted all along the transects by CUFES and sorted onboard. Mammals and birds were continuously identified and counted.

All the area was covered in good weather conditions.

3.3.2.2 Distribution (anchovy and others).

The main observation in 2011 is that anchovy is very spread in the whole bay of Biscay, from the South until the south of Brittany, and from coastal waters (mainly small anchovies) to the shelf break (bigger individuals): It was particularly abundant in three zones: the Gironde plume, the south coast of Brittany, and along the continental slope from 45°N to 46°30 N.

Sardine was still predominant this year with a abundance index of 338 458 tons (which constitute a small decrease from the three previous years). Sardine appeared mostly close to the coast, from the South of the Bay of Biscay until the Brittany coast, but also offshore in shallow waters along the shelf break. Age 3 were predominant (40% in number), confirming the good recruitment of the 2008 year class.

Mackerel, horse mackerel and sprat were dispersed on the platform and not abundant compared to the average on the whole PELGAS series.

3.3.2.3 Stock estimate

As the previous years, after echogram scrutiny, the global area was split into strata where coherent communities were observed (species associations) in order to minimise the variability due to the variable mixing of species (Figure 3.3.2.3.). Allocation to species was therefore done using the standard method (Massé,J, WD2001 and stock annex) and biomass were estimated for main pelagic species in each strata according to aggregation categories and identification hauls (anchovy and sardine in Table 3.3.2.3. and WD Massé & Duhamel 2011).

Anchovy was particularly abundant in coastal areas, and even if age2 were predominant offshore, mainly close to the surface at the shelf-break, age 1 appeared almost pure along the coast, from the Gironde area to the South of Brittany (fig 3.3.2.4 and 3.3.2.5.). It is the first year of the PELGAS series that anchovy is observed so North, and in that abundance. The 1 year old class represents the better recruitment never observed before (115 379 tons, table 3.3.3.3 and figure 3.3.2.6.) on a PELGAS survey (since 2000) and 2 years old are still present, considering the relative high abundance last year of age 1. The PELGAS11 abundance index on anchovy is 142 602 tons.

As usual, the PELGAS survey is carried out within the context of the ecosystemic approach (which includes surveying environmental conditions such as hydrological parameters, plankton abundance, top predators). The biomass are calculated for all pelagic fishes (sardine, horse mackerel, blue whiting, sprat, see table 3.3.3.4).

Parameters	PELGAS11 acoustic survey
Survey area	(43º30' to 48º00'N & 1º10' to 6º00' W)
R/V	THALASSA
commercial vessels	Magayant / Tangaroa : 27/04 to 08/05/2011 Morgane / Virginie : 10/05 to 18/05/2011 Etoile polaire : 18 & 19/05/2011
Date	26/04 – 05/06/2010
Acoustic	**THALASSA**
Miles used for assessment	2 073 NM
Nb of fish measured	18 237
- anchovy	7 329
- sardine	2 541
Nb of otoliths	3 058
- anchovy	1 985
- sardine	1 073
Nb of trawl hauls	52
- nb of surface and pelagic hauls	12
-Nb of hauls closed to the bottom	40
- nb of cancelled hauls	3
Nb CUFES samples	714
CTD stations	86
consort	**Commercial vessels**
dates	27/04 – 19/05/2011
Number of trawl hauls	60
- nb of surface and pelagic hauls	25
-Nb of hauls closed to the bottom	35
- Nb of purse seine hauls	2
- nb of cancelled hauls	2

Table 3.3.2.1: Details of the datasets obtained during the PELGAS acoustic Survey 2011.

Strata	Area	anchovy	sardine
Z1	1 225	2 936	28 524
Z2	3 245	34 488	93 538
Z3	2 925	35 723	134 621
Z4	2 270	6 224	15 869
Z5	6 094	20 426	33 956
Z6	5 905	10 130	7 684
Z7	3 330	6	1
Z8	10 401	16 808	11 494
Z9	7 974	12 822	2 791
Z10	6 691	3 037	9 991
Total		142 601	338 468

Table 3.3.2.3: biomass of anchovy and sardine per strata during PELGAS10

AGE	**Percentage in mass (%)**	**mean Weight (g)**	**Abundance index (tons)**
1	80.9	11.3	115 379
2	16.9	27.1	24 069
3	2.1	26.0	3 063
4	0.1	60.5	90
total	100		142 601

Table 3.3.3.3: anchovy age distribution and mean weight during PELGAS11

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

Table 3.3.3.4: Acoustic abundance indices since 2000

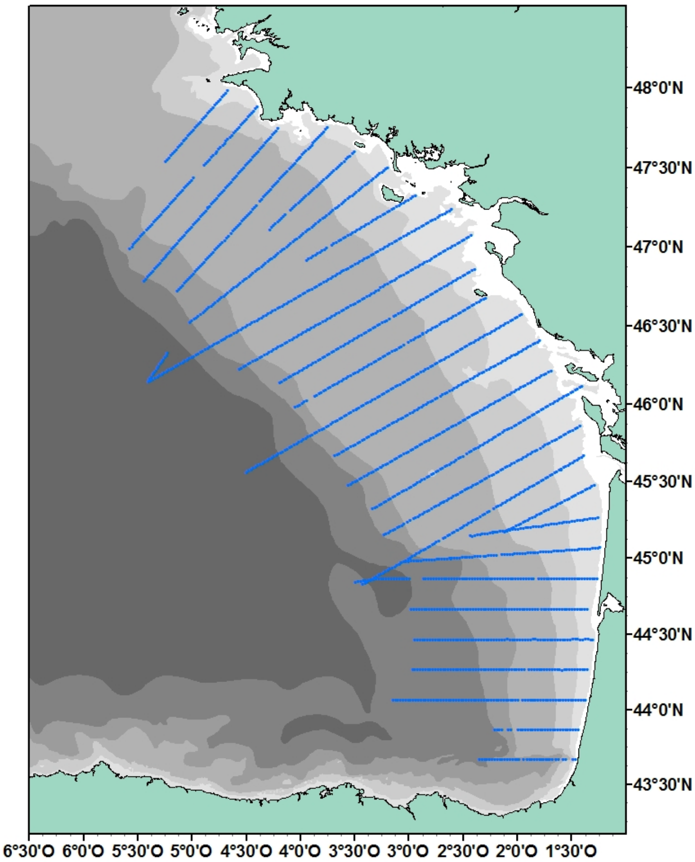


Figure 3.3.2.1. Acoustic transects network during PELGAS11 survey

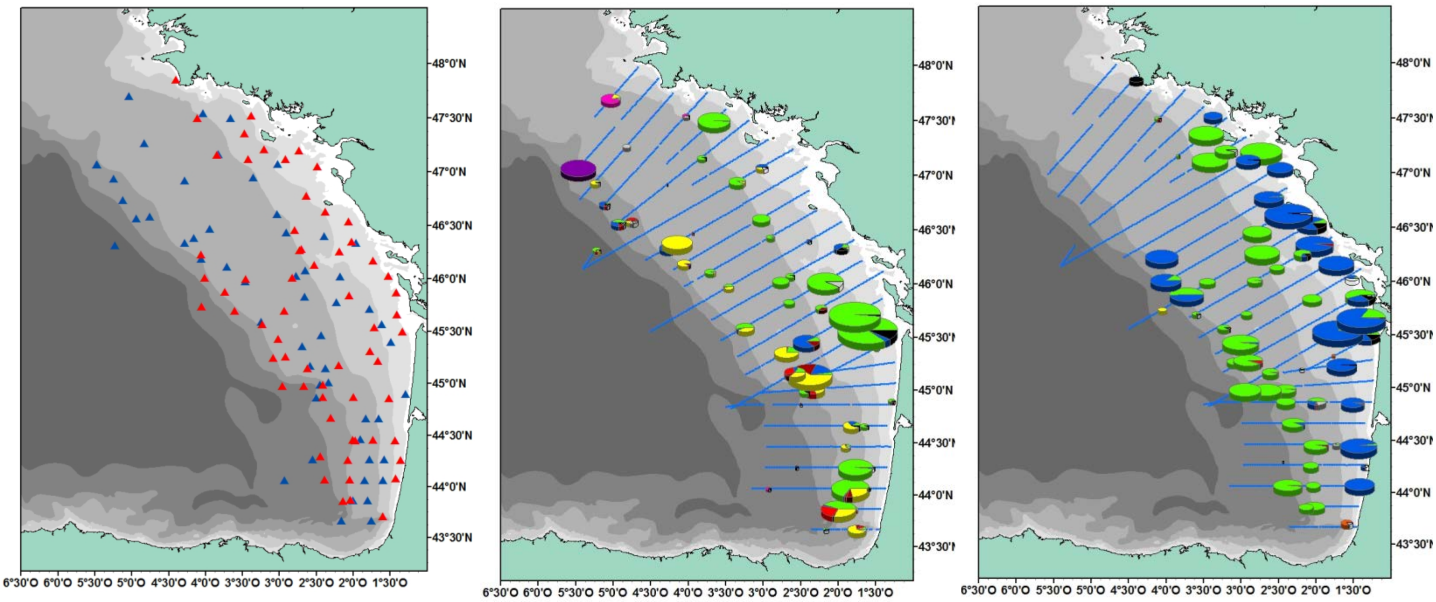
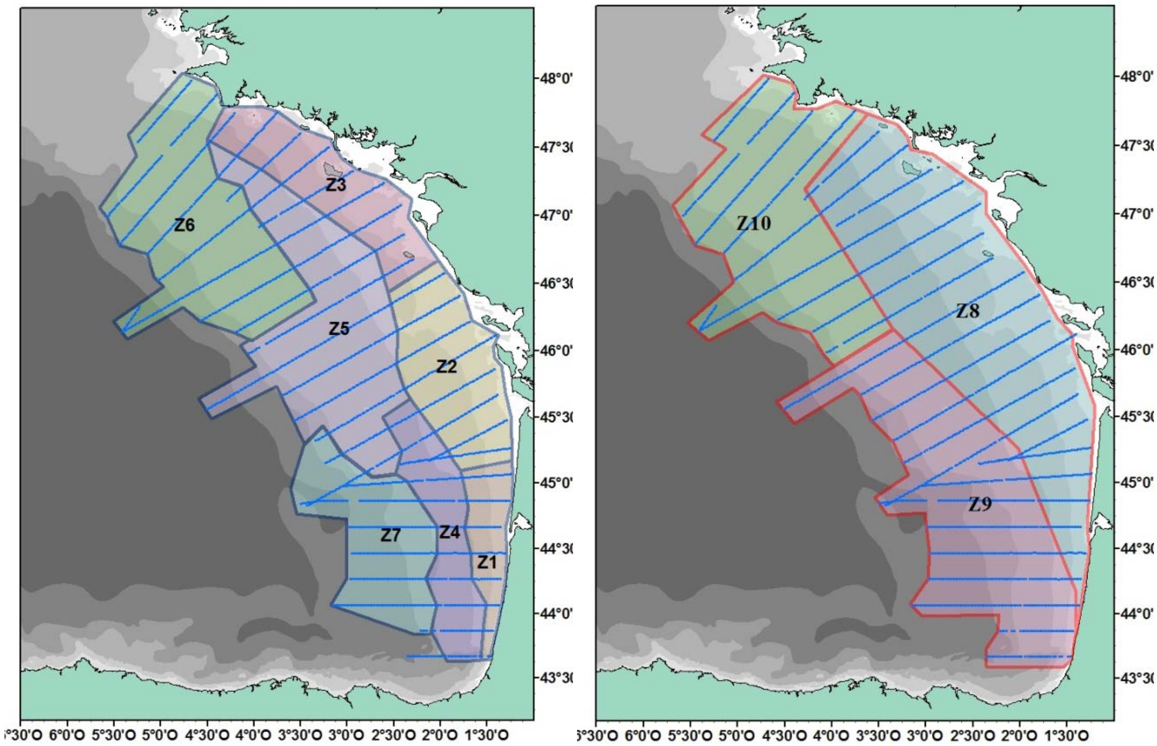


Figure 3.3.2.2 fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS11



Classic strata
Surface strata

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

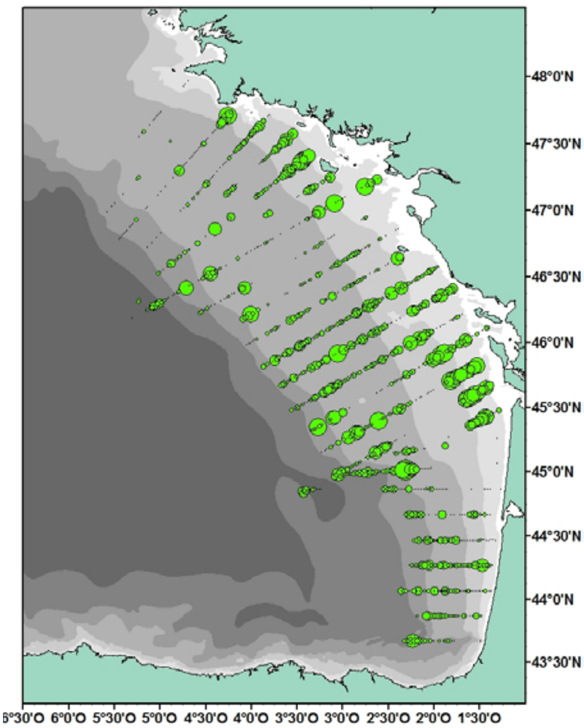


Figure 3.3.2.4. Adult anchovy distribution (density / ESDU)

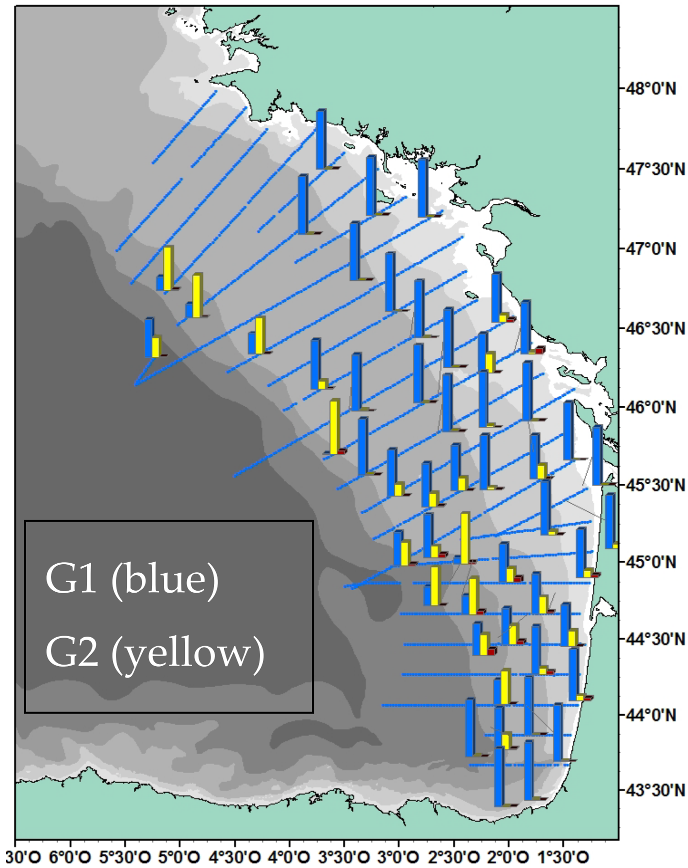


Figure 3.3.2.5 . anchovy age distribution – PELGAS11

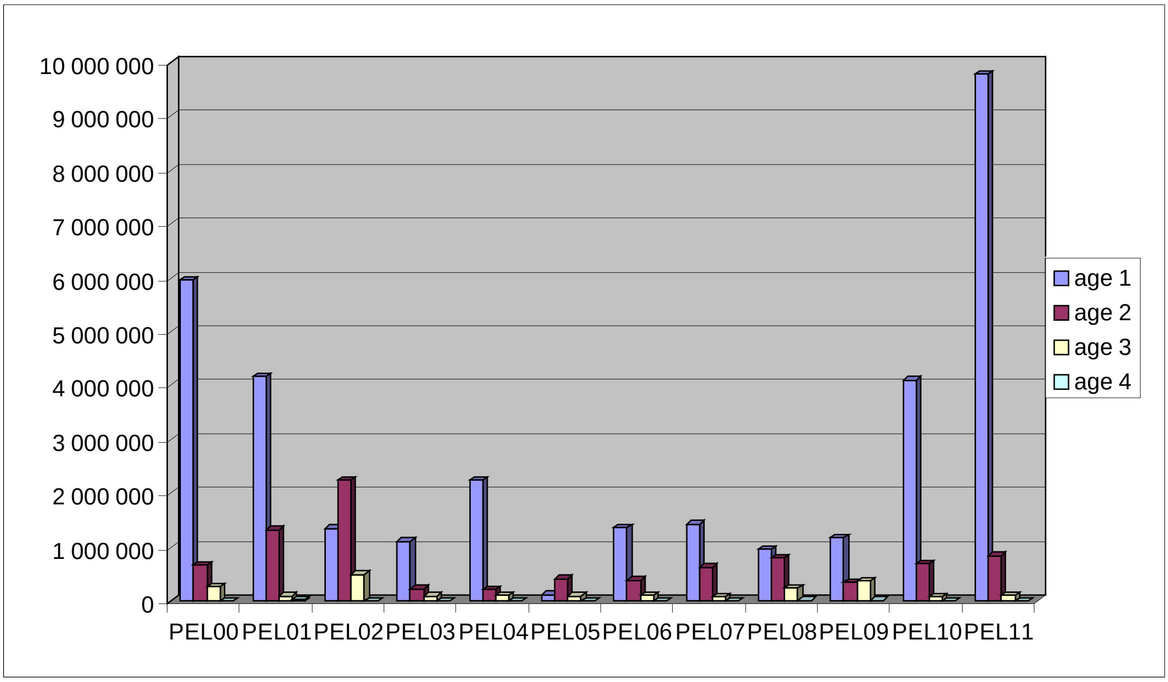


Figure 3.3.2.6. Age distribution of anchovy along PELGAS series.

3.3.3 Autumn juvenile acoustic survey 2010

The JUVENA survey series, including the last survey in autumn 2010, was reported and discussed in WGACEGG (ICES, 2010). JUVENA2010 took place on board two vessels equipped with scientific acoustic equipment and with two different fishing gears: purse seiner Itsas Lagunak and pelagic trawler Emma Bardan. The survey took place during 30 days in September, sampling 4,000 nmi to reach an effective sampling of 2,700 nmi. that provided a coverage of about 40,500 nmi.[2] along the continental shelf and shelf break of the Bay of Biscay, from the 6º W in the Cantabrian area up to 47º 30′ N at the French coast. 79 hauls were done during the survey to identify the species detected by the acoustic equipment, 60 of which were positive for anchovy (**Figure 3.3.3.1**).

Anchovy juveniles were found off the Cantabrian Sea and French shelves near the surface (between 15 and 25 m depth). Anchovy adults (age 1+) were found close to the bottom in the inner shelf in the Cantabrian Sea and French waters (**Figure 3.3.3.2**). In the outer part of the French shelf juveniles and adults were observed near the bottom. In the area located to the North of 47ºN, the distribution of anchovy over the shelf was similar, although juveniles were not detected off the shelf.

The biomass of juveniles estimated for year 2010 was 599,990 tonnes (**Table 3.3.3.1**). Almost the 95% of this biomass was located off-the-shelf or in the outer part of the shelf (**Figure 3.3.3.2**). A 5% of the stock was found on continental shelf waters along the French coast, mainly in waters of less than 100 m depth. A small percentage (less than 1%) of the juvenile anchovy population was located in coastal waters, especially around the plume of the Garonne River.

The biomass estimated for this year 2010 constitutes the highest value in the temporal series of JUVENA (**Table 3.3.3.1**, **Figure 3.3.3.3**), a 237 % higher than the next value corresponding to the year 2009. The mean size of the captured juveniles was 8.3 cm, larger than the average of the temporal series (**Table 3.3.3.1**) and the third highest value of the series (after the years 2004 and 2009). The series (from 2003 to 2010) of JUVENA acoustic estimates of anchovy juvenile abundance in the Bay of Biscay is shown in **Table 3.3.3.1.**

3.3.3.1 Potential use of JUVENA abundance indices

The JUVENA acoustic survey was designed to estimate the abundance of the anchovy juvenile population and their growth condition at the end of the summer in the Bay of Biscay. The assessment of the strength of the recruitment entering the fishery the next year could help to improve the management advice for this stock.

Last year ICES stated that "*Surveys to estimate juvenile abundance in autumn have now been conducted for seven years. So far, ICES has abstained from using it as a recruitment indicator, because the experience was limited up to 2009 to a period with only poor recruitment. The last year class, which was of intermediate strength, was associated with the highest survey index in the series. The correlation between survey index and recruitment now appears to be quite strong and it is statistically significant. Although the predictive power of the survey may still be limited, it is likely that this survey can serve to select, at least in a qualitative way, likely scenarios of next coming recruitment to improve the basis for the management advice for next year. Therefore, ICES is considering the possibility to review the current advice once indications of the next incoming recruitment become available from the autumn survey.* "

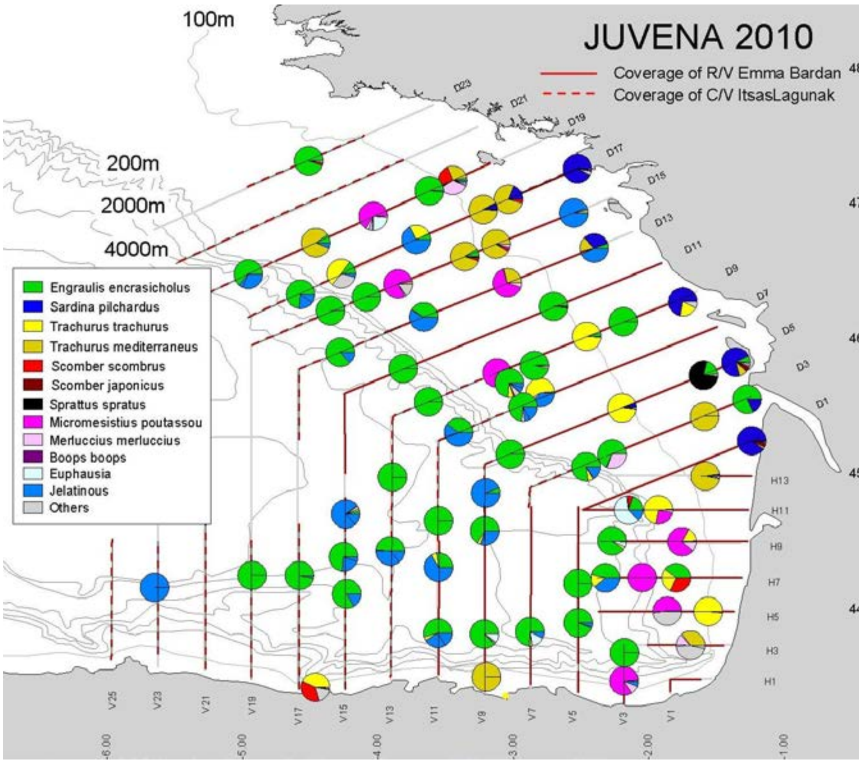
ICES did not revise its management advice once the results of the JUVENA surveys were available. The juvenile biomass estimate in 2010 was by far the largest of the JUVENA historical series since 2003. The recruitment (age 1 biomass at the beginning of the year) estimated by the assessment model (section 3.5) was the third highest since 1987, only after 1991 and 1999 year classes (R in 1992 and 2000). **Figure 3.3.3.4** compares the times series of the JUVENA anchovy juveniles abundance index with the estimates of biomass at age 1 (median values) from this year assessment (section 3.5), when each of the series is standardised according to their mean and variance. The high estimate of anchovy juveniles in JUVENA2010 has been followed by strong anchovy recruitment at age 1 in 2011. In addition, the low juvenile abundance indices of 2004, 2007 and 2008 are associated with the lowest recruitments estimated by the assessment since 2003. The Spearman rank correlation between the JUVENA series and the assessment estimates of recruitment at age 1 is R=0.93, which is statistically significant with p-value=0.0022. Among several candidate models the best fitting was achieved with a log-linear model (**Figure 3.3.3.5**). The model was significant (p-value= 7.1E-05) with R^2=93%.

The addition of the 2011 recruitment has increased the contrast in the range of recruitments entering the series, with a very large size recruitment level. There are still uncertainties on the shape of the relationship between the JUVENA index and the recruitment at age 1 next year, and the predictive power of the survey may still be limited. However, the last observation has corroborated the capacity of JUVENA to outline the strength of the next incoming recruitment. Quantitatively the predictive distribution derived from a fitted parametric model (e.g. log-normal) could be used as the recruitment distribution in the short term forecast (see section 3.6). Alternatively, the JUVENA index could be used in a qualitative way, allowing an informed election of the most likely recruitment scenario (i.e. low, medium and high). Any of the options could help to improve the basis for the short term management advice for next year if provided after the results of JUVENA become available.

The WG recommends that the June management advice is revised in case the abundance index of anchovy juveniles from the survey JUVENA 2011 indicates a low recruitment.

Table 3.3.3.1: Synthesis of the abundance estimation (acoustic index of biomass) for anchovy juveniles over the eight years of JUVENA surveys.

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



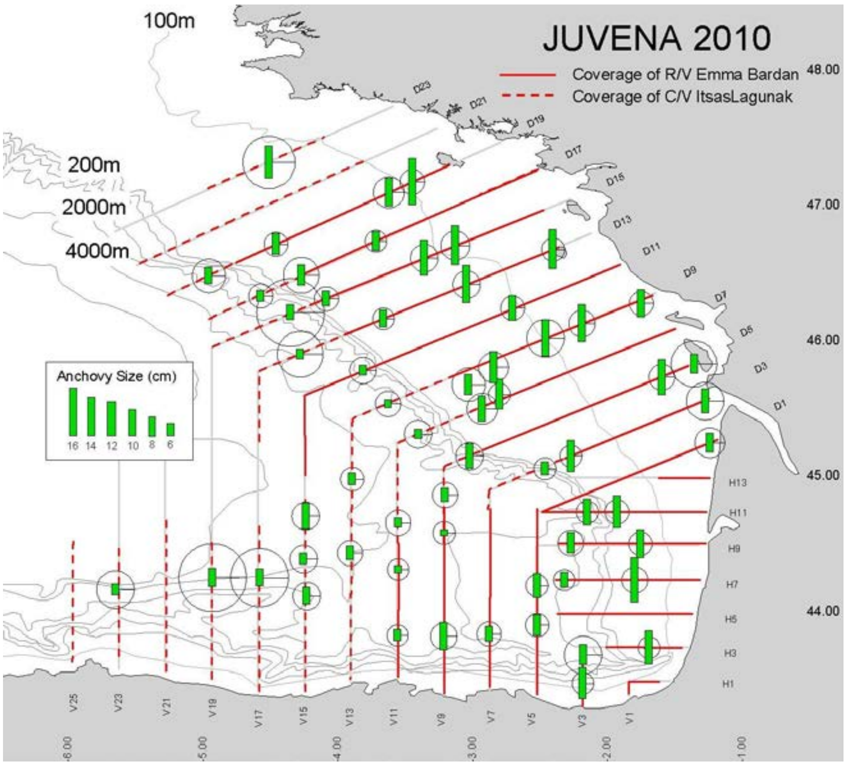


Figure 3.3.3.1. Bay of Biscay anchovy: Distribution of fishing hauls and species composition of each haul (in percentage of abundance) for the identification of echotraces conducted during the JUVENA2010 cruise (top). Positive anchovy hauls. The diameter of the circles is proportional to the captured weight of anchovy. The length of the bars is proportional to the mode of the size (Standard length) of the captured anchovy (bottom).

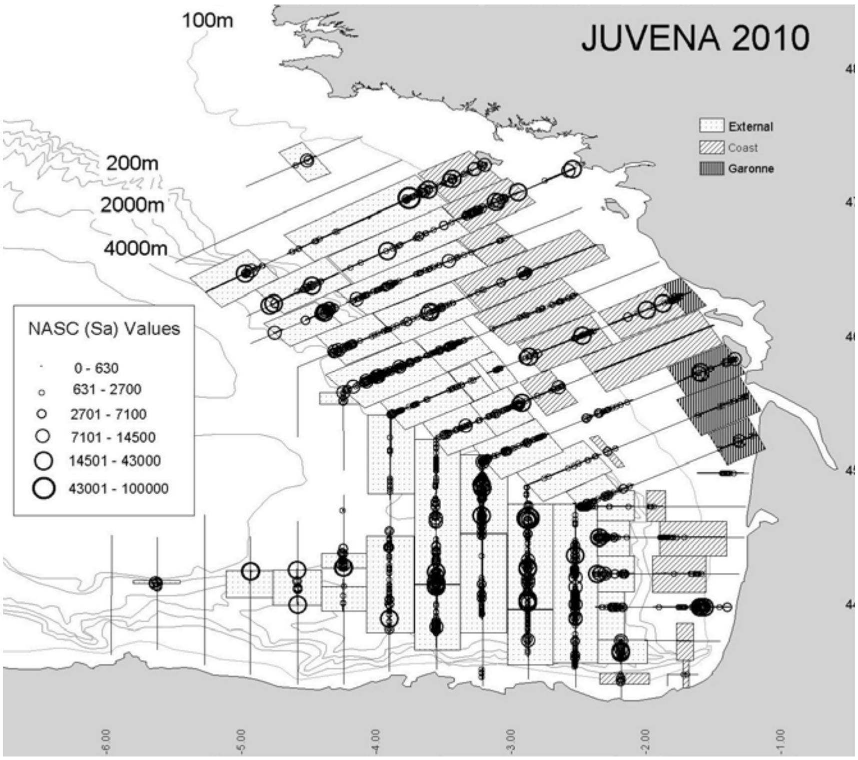


Figure 3.3.3.2. Bay of Biscay anchovy: Effective acoustic coverage of the surveys on Juvenile anchovy in September-October 2009, with indication of the NASC attributed to anchovy.

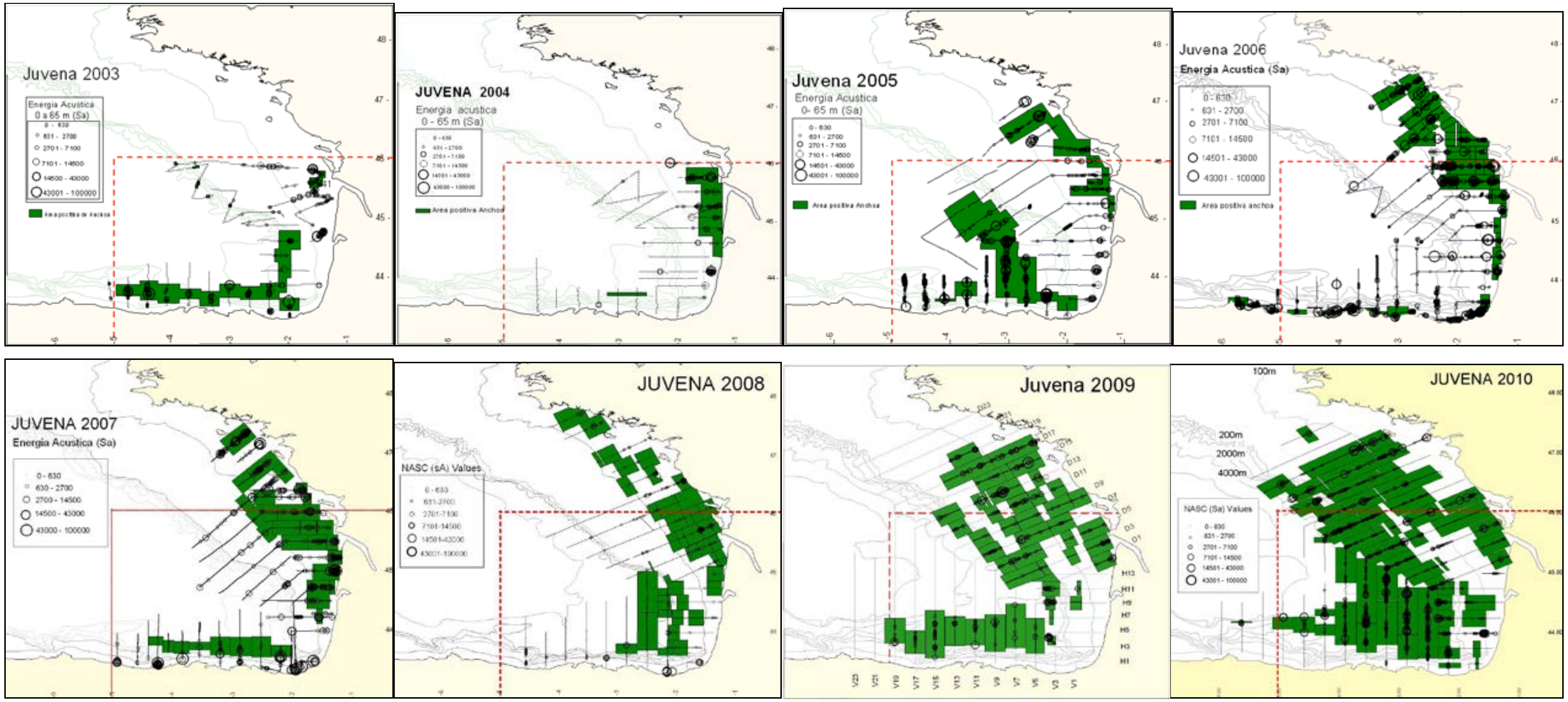


Figure 3.3.3.3. Bay of Biscay anchovy: Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the seven JUVENA surveys.

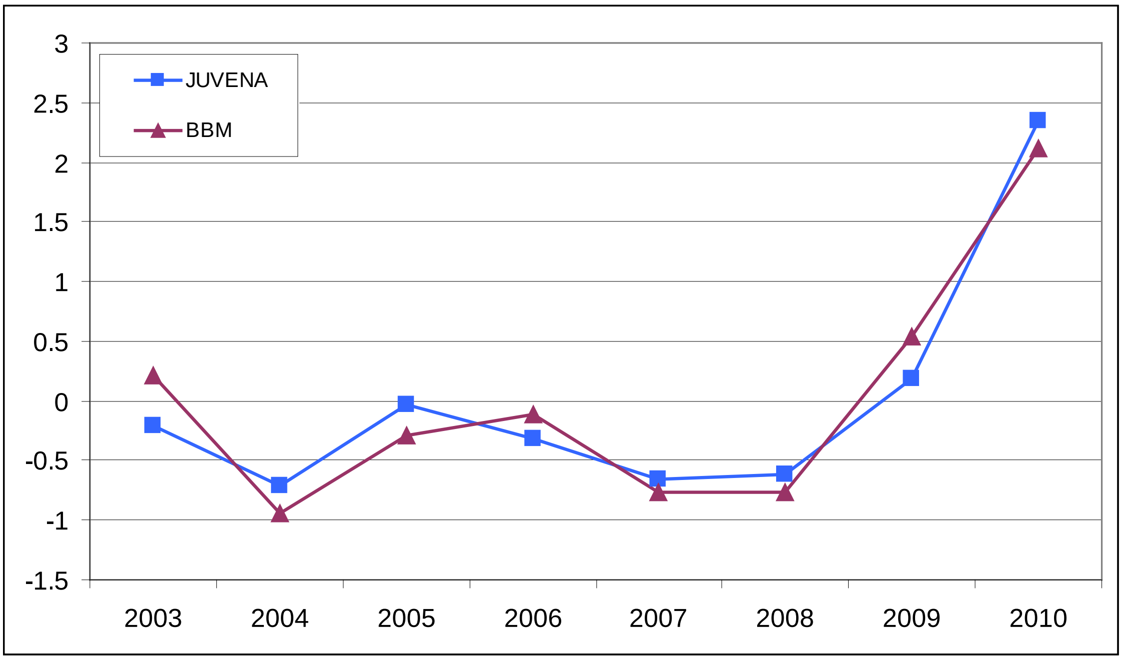


Figure 3.3.3.4. Bay of Biscay anchovy: Times series of the JUVENA anchovy juveniles abundance index (in blue) and of the recruitment (median of the age 1 biomass at the beginning of the next year) as estimated by BBM. Each of the series is standardized according to its mean and its variance.

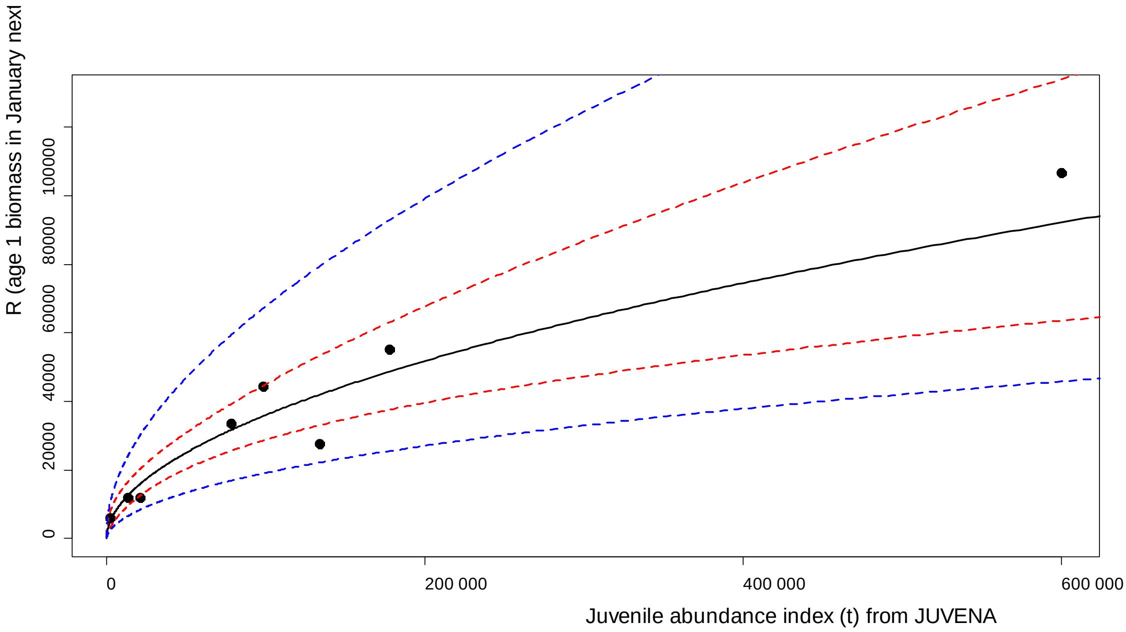


Figure 3.3.3.5. Bay of Biscay anchovy: Log linear model fitted to the recruitment (median of the age 1 biomass at the beginning of the next year, y-axis) as estimated by BBM and the juvenile abundance index from the JUVENA surveys (x-axis, in tones). The bullets represent the observed points from 2003 to 2010. The solid black line is the fitted model, whereas the red and blue dashed lines are the 95% confidence and prediction intervals.

3.3.4 A pilot sentinel surveys experience on sardine and anchovy during 2009–2010

As already reported in WGACEGG10 report, a 2-years pilot study has been carried out between April 2009 and September 2010 based on a partnership with Ifremer (French Institute for the Research and Exploitation of the Sea) , CNPMEM (National Committee of Marine Fisheries and Aquaculture) and DPMA (Direction of Marine Fisheries and Aquaculture). It was funded by national and European funds.

This project aimed at developing an early indicator of the evolution of small pelagic resources (anchovy and sardine) in the Bay of Biscay from observations performed by fishermen assisted by scientists. Surveys have been carried out regularly by pelagic pair trawlers and purse seiners in collaboration with scientists from the EMH (Ecology and Model for Fishery sciences) department of IFREMER, in 2 key zones: Gironde and South Brittany (figure 3.3.4.1.).

Each survey was based on a mutual knowledge enrichment between fishermen and scientists. Fishermen were volunteers and their involvement in the project was balanced by financial compensations for the time at sea. Five surveys have been carried out:

- August 2009
- December 2009
- April 2009
- July 2010
- September 2010

During these short surveys (5 days each) A total of 51 pelagic hauls were carried out and acoustic data were collected from a SIMRAD EK60 used with a towed body. The totality of acoustic data and biological material is not yet totally processed, but some of the results can be already emphasized.

- First of all the partnership between scientists and fishermen is a real success and it increased considerably the dialogue and understanding.
- From acoustic data it is possible to develop a relative abundance index of anchovy and sardine in the two key zones and have a better idea of their relative distributions in these potential areas.
- Biological indicators can be really built from such surveys such as Fulton's condition factor which describes the health condition of fish. This type of indicator is appropriate to characterize habitat suitability in response to environmental change. They are also indicators of the evolution along the year of the health condition of anchovy and sardine.
- Classical parameters such as lengths, weights and ages distributions are available permit to follow the growth and distribution (migration ?) of cohorts all along the year.
- Monitoring of grade (number of fish per kilogram) along the year give an important relative information for the scientists but also for the fishermen, of the availability of commercial grades.

This first experiment during 18 months proves that such surveys were workable and pertinent. They were particularly fruitful as a communication vector between scientists and fishermen, improving the understanding of respective task. Data collected, , combined with the May PELGAS surveys, seem to be satisfying to build a monitoring of anchovy and sardine populations along the year. Data are still processing and all the possible results are not yet available. This first experiment permits at least for the time being to improve the maturity ogive and to observe the arrival of recruitment in 2010. A continuation of these surveys would be necessary to get usable information for management considerations, but it is totally depending on unknown special financing possibilities for the time being. Only a longer series could help to increase our knowledge on the winter survival of juveniles and the real knowledge about the dynamic of migration.

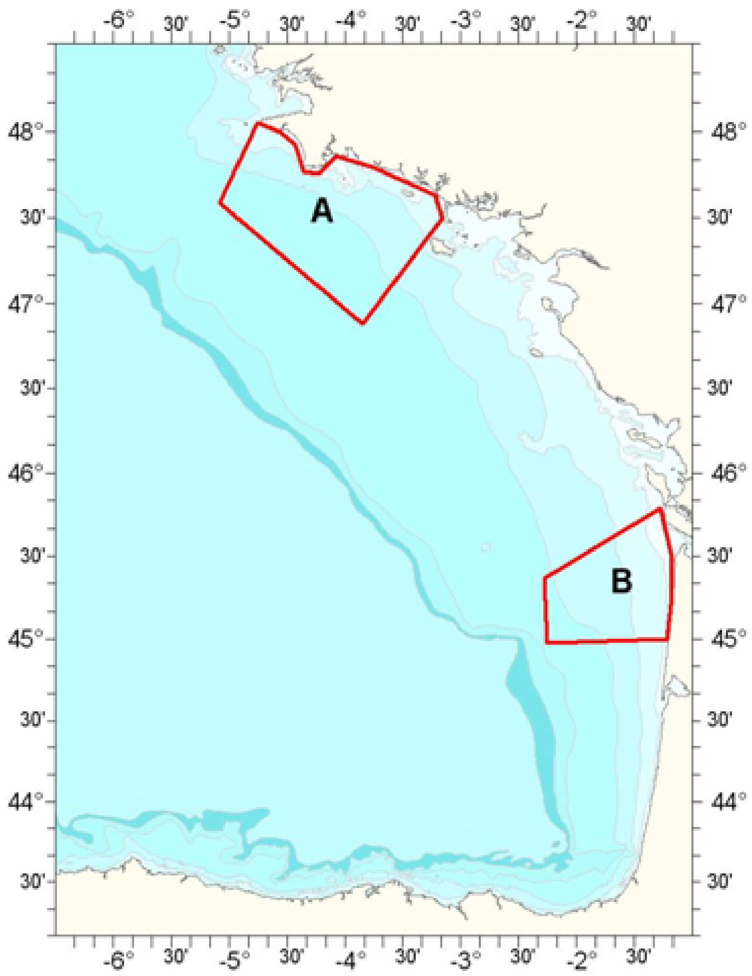


Figure 3.3.4.1. - The two areas investigated during 5 sentinel surveys between April 2009 and September 2010.

3.4 Biological data

3.4.1 Maturity at age

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

3.4.2 Natural mortality and weight at age in the stock

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

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

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

3.5 State of the stock

3.5.1 Stock assessment

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

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

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

The historical series of spawning stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 3.5.1.1. The trends in biomass from both surveys are similar. In particular, from 2003 to 2010 a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. This year both surveys give an almost identical biomass estimate, being the largest of the historical series. The largest discrepancies between DEPM and acoustic surveys occurred in 1991, 1994, 1998, 2000, 2002, 2004 and 2010. The agreement between both surveys is higher when estimating the age structure of the population. Figure 3.5.1.2 compares the historical series of the proportion of age 1 biomass of DEPM and acoustic surveys.

Figure 3.5.1.3 shows the historical series of age 1 and total catches in the first period (1st January-15th May) and of the total catches in the second period (15th May-31st December), which are used in BBM. Catches in the second period are larger than in the first period and most of the catches in the first period correspond to age 1. After various fishery closures due to the low level of the population, in 2010 the fishery was reopened. In 2011 the total catch in the first period was approximately 7500t.

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

Figures 3.5.1.4 and 3.5.1.5 compare prior and posterior distribution of the parameters. Summary statistics (median and 95% probability intervals) of the posterior distributions of recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15th May) and harvest rates (catch/SSB) are shown in Table 3.5.1.2 and Figure 3.5.1.6. The largest probability intervals correspond to the period in which some data are missing. In general recruitment is highly variable from year to year. Recruitment in 2011 is the third highest in the historical series, after 1992 and 2000 recruitments. The median SSB has increased successively in the last two years from a level around B_{lim} (21 000 tones) in 2009 to 98 450 tones in 2011. In order to analyse the biomass trends in relative terms, median and 95% posterior probability intervals of the ratio of spawning stock biomass with respect to 1989 spawning stock biomass, in which B_{lim} is based (ICES 2003), are given in Table 3.5.1.2.

Figure 3.5.1.7 shows the posterior distribution of current level of spawning stock biomass in 2011. Current state of the population is summarized in Table 3.5.1.3. Recruitment in 2011 is 106 800 tones and 95% probability interval between 65 500 and 167 400 tones. The estimated level of biomass in 2011 is 98 500 tones and the 95% probability interval is 60 200 and 151 800 tones. In relative terms the median of the ratio of SSB in 2011 with respect to 1989 biomass (used for defining B_{lim}) is 5.6 (with a 95% interval between 3.4 and 8.9) indicating that current level of the population is well above the biomass in 1989. The biological risk, defined as the probability of SSB in 2011 being below B_{lim} (21 000 tones), is 0.

3.5.2 Reliability of the assessment and uncertainty of the estimation

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

The observation equations of the model refer just to the age 1 biomass proportion and total biomass indices from the research surveys (DEPM and acoustics). Figure 3.5.2.1 shows the posterior distribution of spawning stock biomass from BBM in comparison to the estimates from the DEPM and acoustic surveys (corrected by their catchability, which is assumed to be 1 for the DEPM and estimated as 1.12 for the acoustic survey). In most of the years the SSB estimates of the surveys taking into account their standard errors fall within the 95% probability intervals from the assessment. Figure 3.5.2.2 shows the posterior distribution of age 1 proportion in mass from BBM in comparison to the estimates from the DEPM and acoustic surveys. In all the years the age 1 biomass proportion estimates of the surveys are within the 95% probability intervals from the assessment. Pearson residuals of the four indices do not reveal any clear pattern (Figure 3.5.2.3).

The critical situation of the stock from 2005 to 2009 and the subsequent fishery closure has forced the stock assessment to be conducted just after the spring surveys as soon as the results from the surveys are available in order to provide management advice for the second half of the year. However, it has to be noted that the indices provided in such a short time are preliminary (particularly DEPM) and might be changed later on. As a result the stock assessment has to be considered also as preliminary.

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

The assessment is scaled by the assumption of absolute catchability of DEPM surveys. The current perception of the population in relative terms (SSB/SSB_{1989}) is insensitive to the use of the DEPM survey as absolute or relative. It is the absolute level of the assessment results (i.e. the mass in tonnes corresponding to the spawning population) that is dependent on the catchability assumptions of the assessment. This implies that the absolute level of the harvest rate, defined as the ratio between total annual catches and spawning stock biomass, is also dependent on the catchability assumption. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomasses or harvest rates even under the assumption of DEPM being an absolute abundance estimate.

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

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

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

Figure 3.5.2.4 compares the SSB estimates from the assessment conducted in WGANSA 2010 and the updated assessments. The results are almost identical.

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

			CATCH DATA			DEPM		ACOUSTICS	
Year	h1	h2	C(y,1,1)	C(y,1,1+)	C(y,2,1+)	B(y,1)	B(y,1+)	B(y,1)	B(y,1+)
1987	0.3068	0.1940	2711	8318	6543	14235	29365	NA	NA
1988	0.3253	0.1774	2602	3864	10954	53087	63500	NA	NA
1989	0.2820	0.2328	1723	3876	4442	7282	16720	6476	15500
1990	0.3070	0.2057	9314	10573	23574	90650	97239	NA	NA
1991	0.2347	0.1984	3903	10191	8196	11271	19276	28322	64000
1992	0.2542	0.2184	11933	16366	21026	85571	90720	84439	89000
1993	0.2368	0.2378	6414	14177	25431	NA	NA	NA	NA
1994	0.2331	0.2050	3795	13602	20150	34674	60062	NA	35000
1995	0.2917	0.1751	5718	14550	14815	42906	54700	NA	NA
1996	0.2756	0.1978	4570	9246	23833	NA	39545	NA	NA
1997	0.2078	0.2624	4323	7235	13256	38536	51176	38498	63000
1998	0.1992	0.2567	5898	7988	23588	80357	101976	NA	57000
1999	0.2304	0.2626	2067	10895	15511	NA	69074	NA	NA
2000	0.2569	0.1999	6298	12010	24882	NA	44973	89363	113120
2001	0.2984	0.2195	5481	11468	28671	69110	120403	67110	105801
2002	0.1833	0.2389	1962	7738	9754	6352	30697	27642	110566
2003	0.2997	0.2795	625	2379	8101	16575	23962	18687	30632
2004	0.2989	0.2126	2754	4623	11657	14649	19498	33995	45965
2005	0.1138	0.0741	102	790	372	2063	8002	2467	14643
2006	0.3266	0.0741	484	815	947	15064	21436	18282	30877
2007	0.3181	0.0590	20	67	73	16030	25973	26230	40876
2008	0.2610	0.1991	0	0	0	7579	25377	10400	37574
2009	0.2610	0.1994	0	0	0	9295	24846	11429	34855
2010	0.3134	0.2221	1557	3127	6975	33725	42979	64564	86355
2011	0.2930	NA	3040	7487	NA	111382	138069	115379	142601

h1 and h2 denote the fractions from the beginning of year to the time point within each period when commercial catch is assumed to take place

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

	R (tonnes)			SSB (tonnes)			Harvest rate			SSB/SSB_{1989}		
Year	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%	2.50%	Median	97.50%
1987	14440	17120	22560	18600	21940	28580	0.520	0.677	0.799	0.984	1.279	1.624
1988	36380	41330	49500	31660	35720	43370	0.342	0.415	0.468	1.809	2.074	2.333
1989	9466	11650	15140	13870	17250	23130	0.360	0.482	0.600	1.000	1.000	1.000
1990	80300	89030	103503	58020	65110	77050	0.443	0.524	0.589	2.882	3.768	4.792
1991	20510	26270	34640	23190	30495	41510	0.443	0.603	0.793	1.241	1.752	2.431
1992	82737	139300	224800	56538	103700	173503	0.216	0.361	0.661	3.201	5.940	10.122
1993	41880	91835	130203	85890	97780	116900	0.339	0.405	0.461	4.123	5.681	7.448
1994	40820	49850	66870	50710	60760	81300	0.415	0.555	0.666	2.498	3.512	5.059
1995	35060	59925	107703	27920	52030	97761	0.300	0.564	1.052	1.532	2.950	5.997
1996	35510	65120	89421	51160	59510	74210	0.446	0.556	0.647	2.514	3.441	4.681
1997	40340	52280	74791	38410	50500	73570	0.279	0.406	0.533	1.960	2.894	4.528
1998	53780	82075	140503	46730	74120	130300	0.242	0.426	0.676	2.568	4.217	7.933
1999	35969	79505	121400	53550	76365	102800	0.257	0.346	0.493	2.765	4.370	6.499
2000	108100	130400	152300	102100	120000	134400	0.274	0.307	0.361	4.869	6.959	8.817
2001	74900	83920	99270	92200	100400	113000	0.355	0.400	0.435	4.310	5.837	7.326
2002	10360	12850	17430	32460	37180	45520	0.384	0.470	0.539	1.577	2.161	2.832
2003	24610	30660	37990	29010	34490	42920	0.244	0.304	0.361	1.389	2.009	2.650
2004	36020	44400	56621	34429	42490	55191	0.295	0.383	0.473	1.684	2.478	3.380
2005	4125	6137	9021	13550	18800	27051	0.043	0.062	0.086	0.678	1.096	1.618
2006	20650	27565	37421	22590	29825	41220	0.043	0.059	0.078	1.119	1.741	2.495
2007	25170	33580	46281	31240	40530	54590	0.003	0.003	0.004	1.607	2.345	3.374
2008	8594	12000	16810	22900	29820	39601	0.000	0.000	0.000	1.199	1.720	2.465
2009	8633	12050	16680	18680	24550	32070	0.000	0.000	0.000	0.994	1.406	2.015
2010	40909	55070	76100	38900	52280	70550	0.143	0.193	0.260	2.105	2.990	4.238
2011	65520	106800	167403	60179	98450	151800	0.049	0.076	0.124	3.410	5.608	8.852

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

R_{2011}	Median	106 800
	95 % C.I.	(65 520, 167 403)
SSB_{2011}	Median	98 450
	95 % C.I.	(60 179, 151 800)
SSB_{2011} / SSB_{1989}	Median	5.608
	95 % C.I.	(3.410, 8.852)
P(SSB_{2011} < 21 000)		0

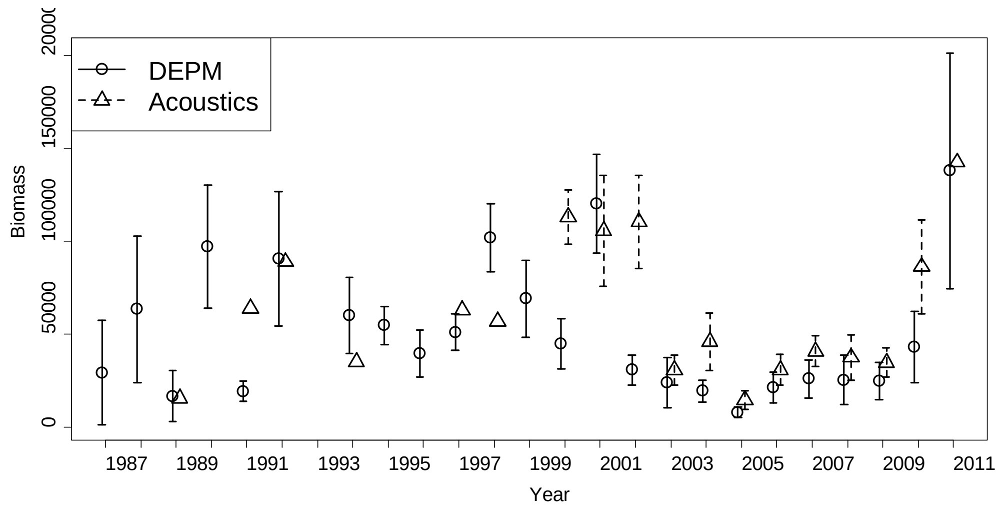


Figure 3.5.1.1: Bay of Biscay anchovy: Historical series of spawning stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

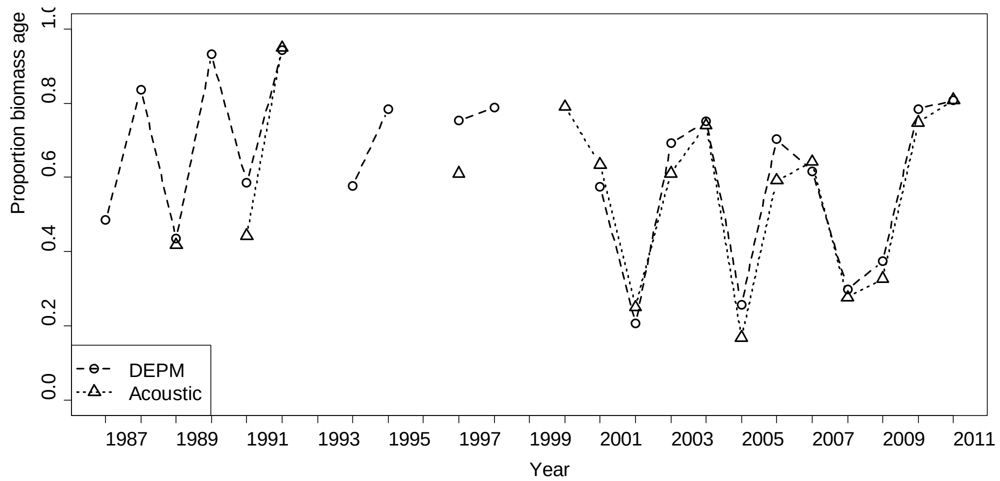


Figure 3.5.1.2: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

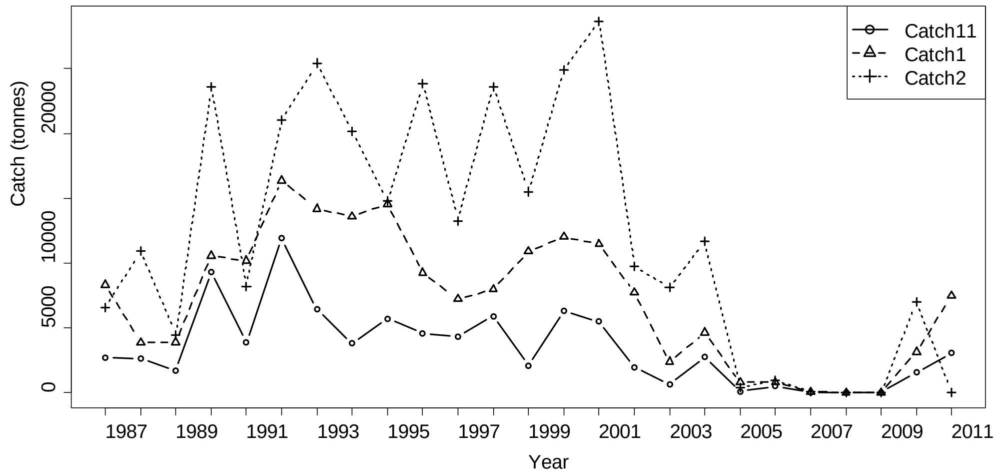


Figure 3.5.1.3: Bay of Biscay anchovy: Historical series of age 1 and total catch in the first period (1st January-15th May) (solid line and open circle and dashed line and triangle respectively) and of total catch in the second period (15th May-31st December) (dotted line and cross).

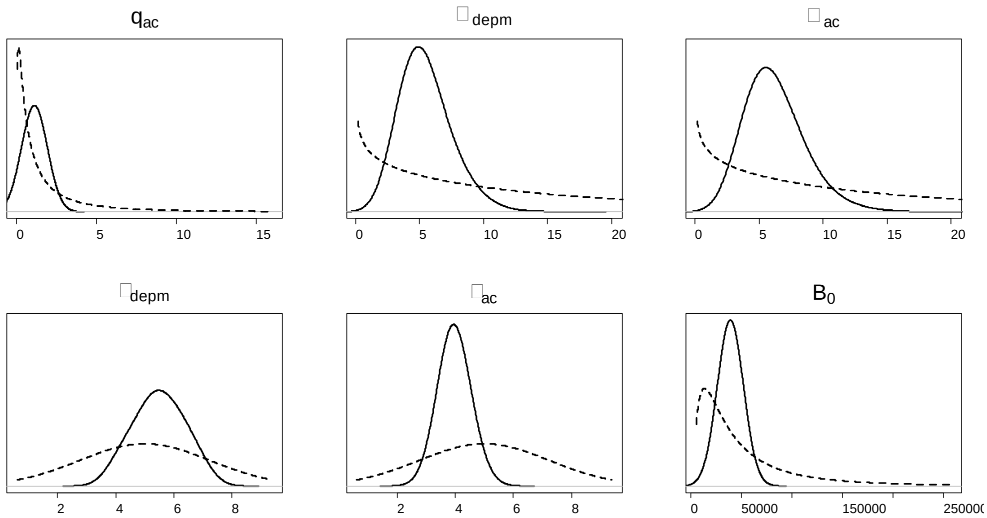


Figure 3.5.1.4: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of BBM.

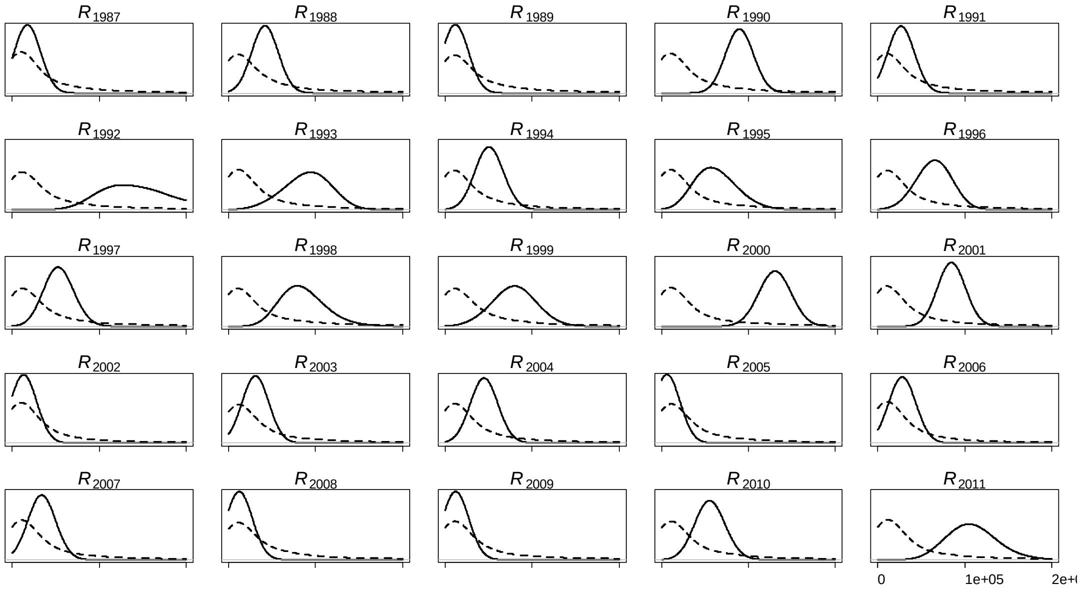


Figure 3.5.1.5: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for recruitment in BBM.

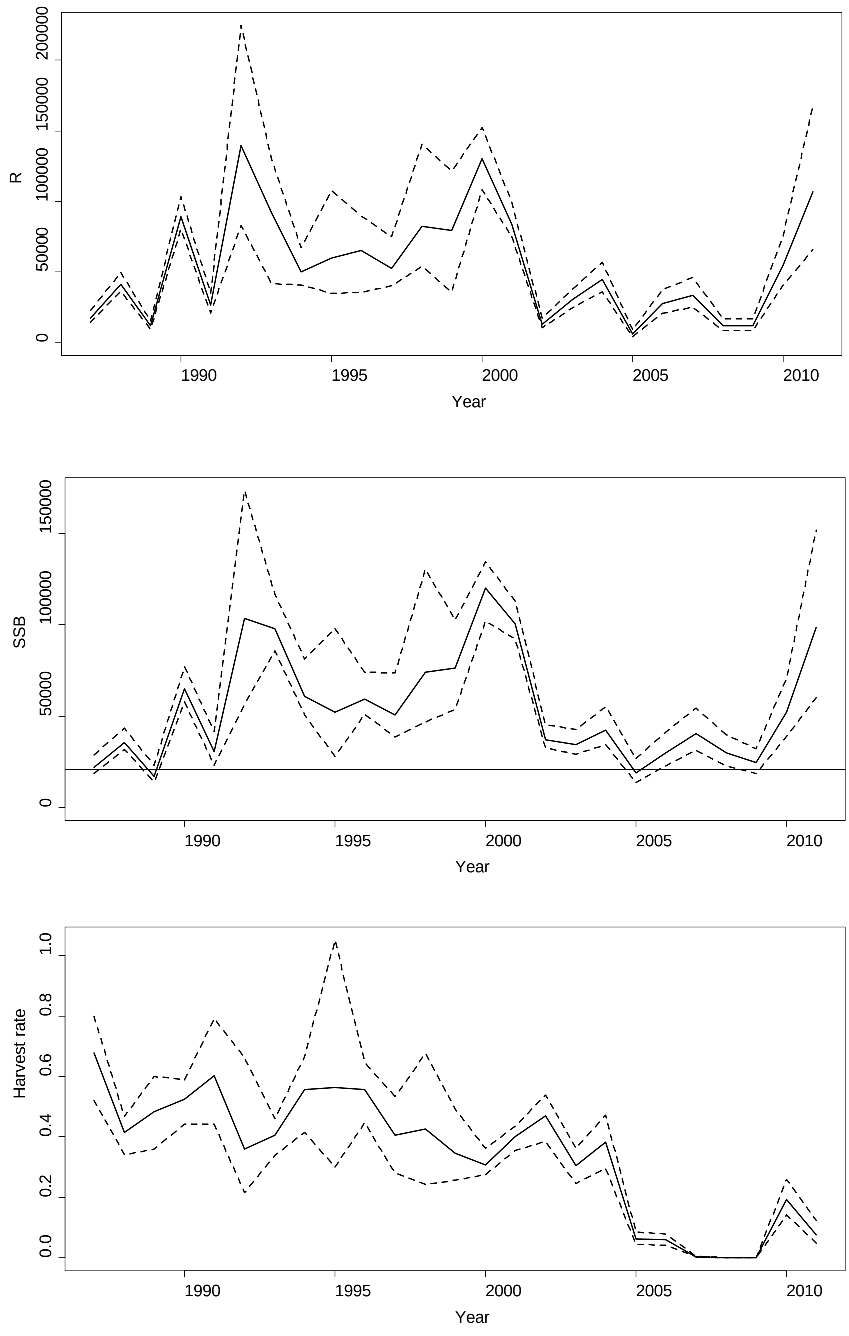


Figure 3.5.1.6: Bay of Biscay anchovy: Posterior median (solid line) and 95% probability intervals (dashed lines) for the recruitment (age 1 in mass in January), the spawning stock biomass and the harvest rates (Catch/SSB) from the BBM. The horizontal line in the mid panel represents Blim (21 000 t).

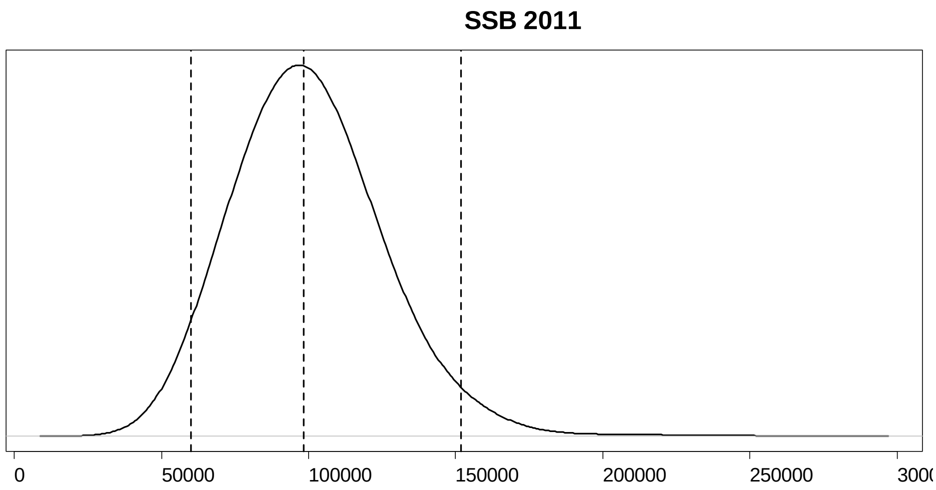


Figure 3.5.1.7: Bay of Biscay anchovy: Posterior distribution of spawning biomass in 2011 from BBM. Vertical dashed lines correspond to posterior median and 95% probability intervals.

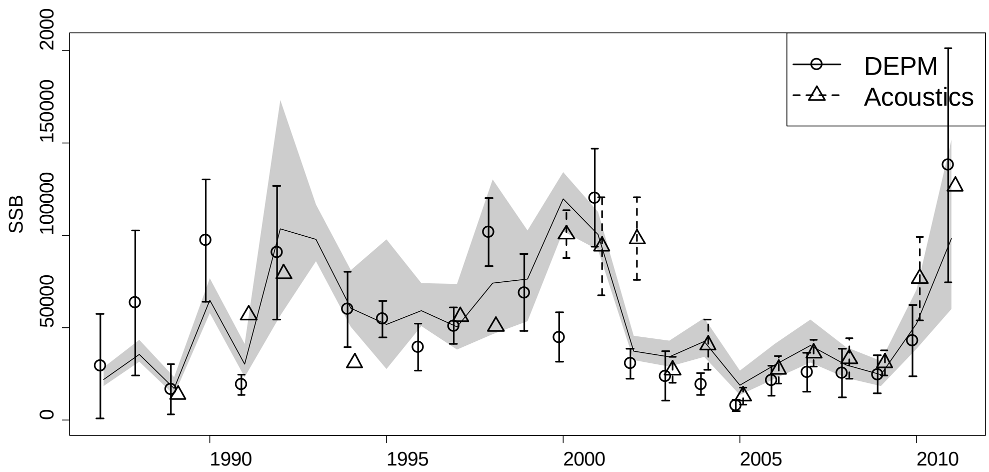


Figure 3.5.2.1: Bay of Biscay anchovy: Comparison of the SSB posterior 95% probability intervals from the BBM (grey area) and the SSB indices corrected by their catchability with the corresponding confidence intervals from DEPM (open circle and solid line) and Acoustics (triangle and dashed line).

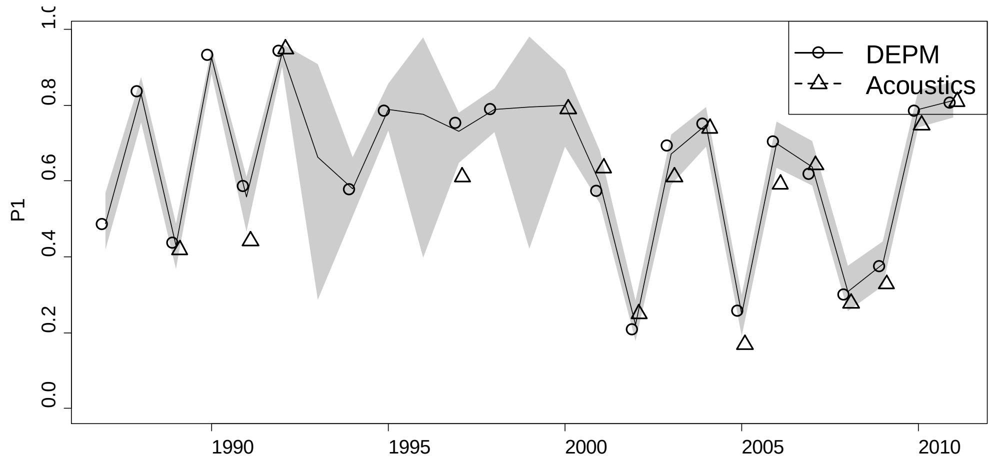


Figure 3.5.2.2: Bay of Biscay anchovy: Comparison of the age 1 biomass proportion posterior 95% probability intervals from the BBM (grey area) and the point estimates from DEPM (open circle) and Acoustics (triangle).

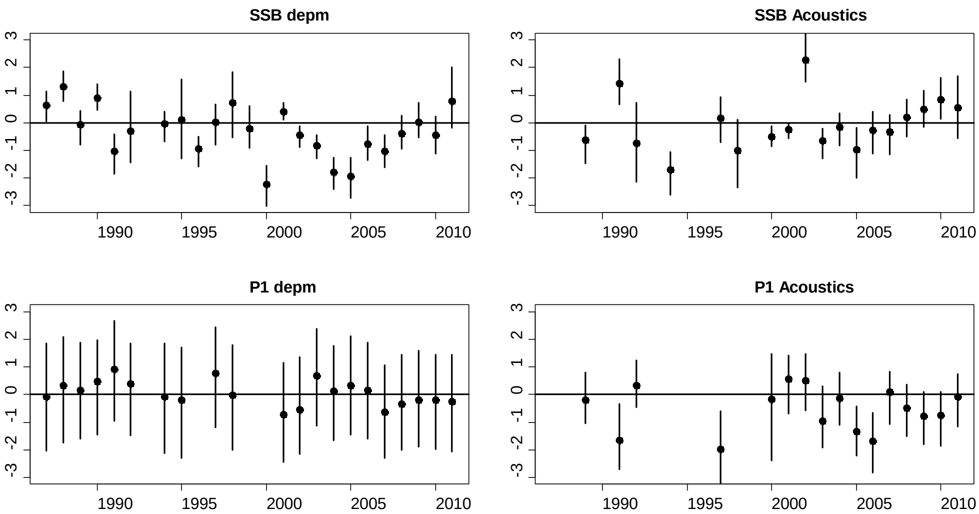


Figure 3.5.2.3: Bay of Biscay anchovy: Pearson residual medians and 95% probability intervals to the four indices used in the BBM.

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

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.

After a series of consecutive low recruitments (2002-2009) last year recruitment increased to intermediate levels and this year recruitment was the third highest of the historical series. At the time of the Working Group meeting, there are no indications about next incoming recruitment. Since the population seems to have recovered from the period of low levels of recruitment, the WG decided to make the projections under an undetermined recruitment scenario, where all the past recruitments are equally likely. The resulting recruitment distribution, with median at 45 700 t, is shown in Figure 3.6.1.1.

The construction of alternative recruitment scenarios based on the recruitment indices from juvenile acoustic surveys and from environmental variables is discussed in sections 3.4.3 and 3.8.

3.6.2 Method

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

3.6.3 Results

Starting from the posterior distribution of SSB in 2011 the population was projected one year forward under the undetermined recruitment scenarios.

Under the assumption that the TAC of 15 600 t is completely taken by the end of June, the catches from the 15th May to the end of June in 2011 were around 3300 t. Total allowable catch between 1st July 2011 and 30th June 2012 were explored from 0 (fishery closure) to 33 000 tonnes with a step of 1 000 tonnes. In addition, the effect of the percentage of those total allowable catches corresponding to the second half of 2010 was also studied by considering percentages from 0 to 100% with a step of 5%. The timing within the year in which the catches in the second half of 2010 and the first half of 2011 were assumed to occur were computed as the average time points from the historical series from 1987 to 2010 excluding the years 2005-2009 in which the fishery was closed during all or some part of the year. Similarly, the percentage of catches in the first half of 2011 taken before the 15th May, when SSB is estimated, was assumed to be equal to the average from the historical series between 1987 and 2010 excluding the years 2005-2009 (58%). Probability of SSB in 2012 being below B_{lim} was derived for each of the catch options and for the percentages of catch corresponding to the second half of 2011.

Figure 3.6.3.1 shows the distribution of SSB in 2012 in the absence of fishing from 15th May 2011 to 15th May 2012. Under this condition the probability that SSB in 2012 is below B_{lim} is 0.

The probability of SSB in 2012 being below B_{lim} is given in Figure 3.6.3.2 (upper panel) and Table 3.6.3.1. The probability of SSB being below B_{lim} is 0 up to catches of 15 000 t and it increases up to 0.02 for catches of 33 000t. The probability of falling below B_{lim} is almost insensitive to the allocation into semesters. The corresponding predicted median SSB values in 2012 are shown in Table 3.6.3.2. According to the harvest control rule included in the long term management plan proposal launched by the European Commission on 29 July 2009, the TAC for the fishing season running from 1 July 2011 to 30 June 2012 should be established at 29 700 t. The corresponding probability of SSB in 2012 being below B_{lim} under different allocation into semesters is shown in Figure 3.6.3.2 (lower panel).

Table 3.6.3.1: Bay of Biscay anchovy: Probability of SSB in 2011 of being below B_{lim} under the undetermined recruitment scenario under different catch options from 1st July 2011 to 30th June 2012 and alternative catch allocation by semesters.

P(SSB<B_{lim})			% CATCHES IN THE 2nd SEMESTER 2011										
			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 2011 - June 2012)	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		5000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		10000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		15000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		20000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002	0.002
		25000	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.007
		30000	0.006	0.007	0.007	0.007	0.008	0.009	0.010	0.011	0.012	0.012	0.014
		33000	0.008	0.009	0.010	0.011	0.012	0.014	0.015	0.017	0.018	0.019	0.020

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

SSBmedian			% CATCHES IN THE 2nd SEMESTER 2011										
			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 2011 - June 2012)	0	85643	85643	85643	85643	85643	85643	85643	85643	85643	85643	85643
		5000	82952	82892	82832	82773	82713	82653	82593	82533	82474	82414	82354
		10000	80261	80141	80022	79902	79783	79663	79543	79424	79304	79185	79065
		15000	77570	77390	77211	77032	76852	76673	76494	76314	76135	75956	75776
		20000	74879	74640	74401	74161	73922	73683	73444	73205	72966	72726	72487
		25000	72188	71889	71590	71291	70992	70693	70394	70095	69796	69497	69198
		30000	69497	69138	68779	68421	68062	67703	67344	66986	66627	66268	65909
		33000	67882	67488	67093	66698	66304	65909	65515	65120	64725	64331	63936

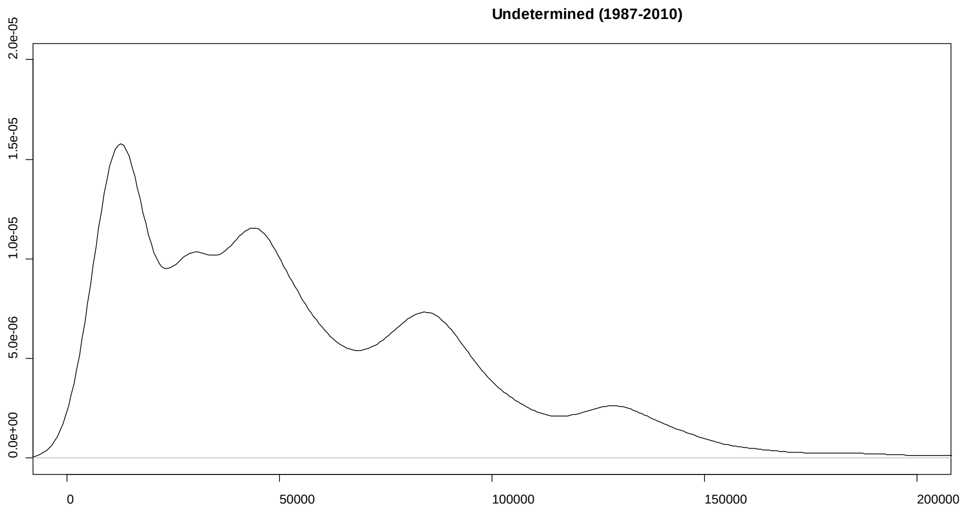


Figure 3.6.1.1: Bay of Biscay anchovy: Undetermined recruitment (age 1 mass in January) scenario for 2012.

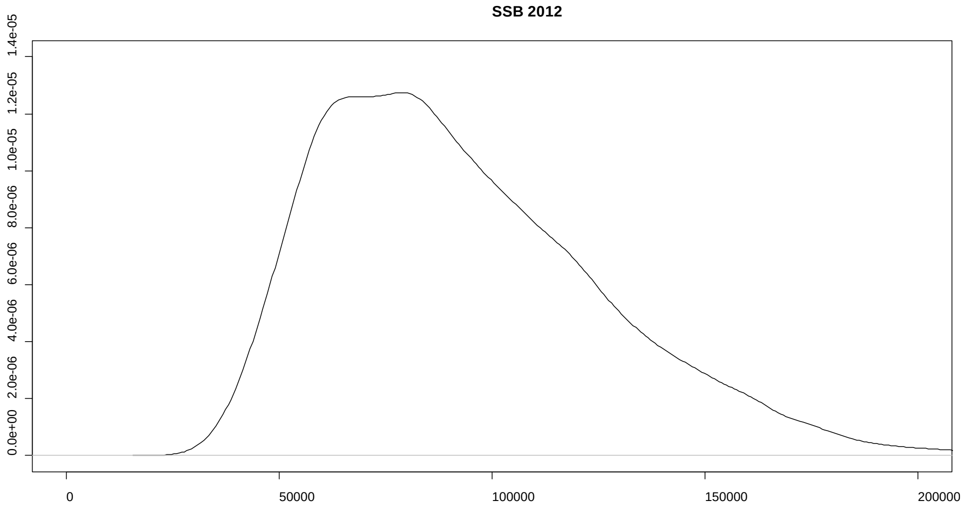
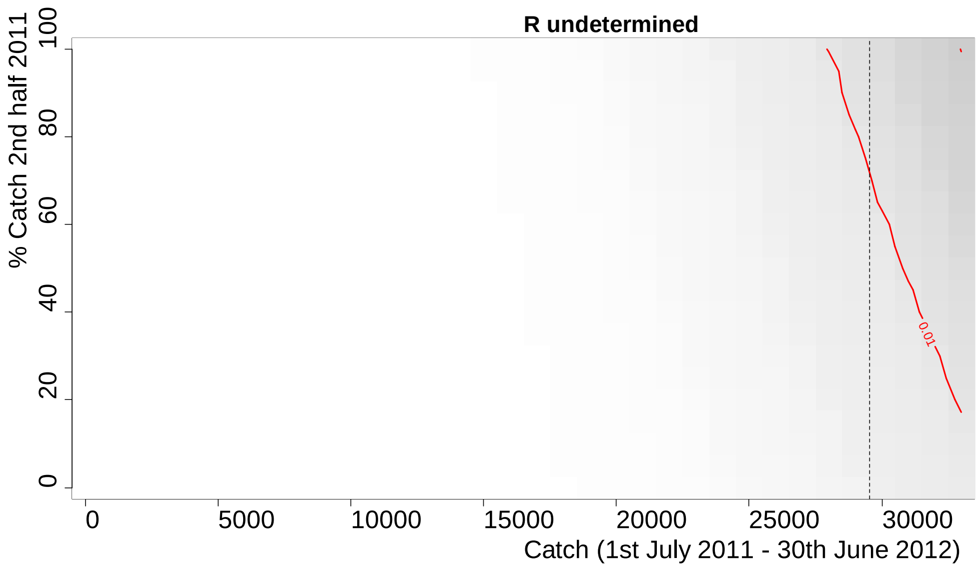


Figure 3.6.3.1: Bay of Biscay anchovy: Distribution of SSB in 2012 constructed from the posterior distribution of SSB in 2011 and the undetermined recruitment scenario in the absence of fishing.



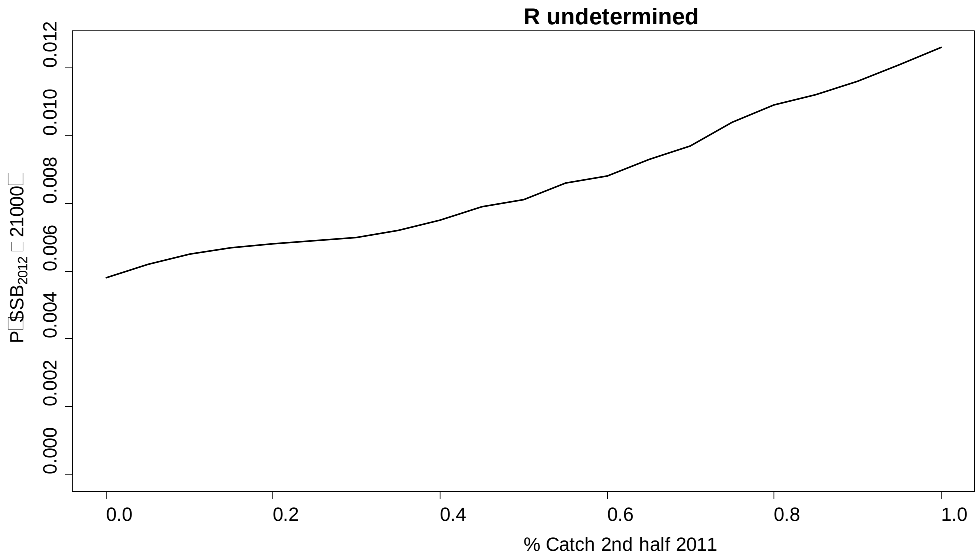


Figure 3.6.3.2: Bay of Biscay anchovy: Contour plots of probability of SSB in 2012 of falling below Blim depending on the total catch from 1st July 2011 to 30th June 2012 (x-axis) and the percentage of catch corresponding to the second half of 2011 (y-axis) under the undetermined recruitment scenario. The vertical dashed line represents the TAC for 2011-2012 under the long term management proposal.

3.7 Reference points and management considerations

Reference points

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

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

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

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

The B_{lim} is set with reference to a particular year where a normal recruitment occurred at the historical low SSB. The assessment provides a probability distribution of SSB_{1989} which is updated every year. An alternative would therefore be to consider the current SSB relative to SSB_{1989} in probabilistic terms. This is now done routinely by considering the distribution of the ratio SSB_y/SSB_{1989}. The median and 95% probability intervals of such ratio for the current assessment is presented in **Table 3.5.1.2** and the distribution for 2011 indicates that there is a 0 probability of being below the 1989 SSB.

MSY and the precautionary approach

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

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

Short term advice

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

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

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

At the time when the short term prediction is made, there is nothing to indicate the strength of the incoming year class. Recently there has been a period (2002-2009) with successive recruitment failures, the reasons for which are poorly known. Last year class was of intermediate level and this year recruitment was the third highest in the historical series. Therefore the immediate option would be to assume a distribution of recruitments representing all previous year classes.

The JUVENA survey now has been conducted for 8 years. Last year ICES considered the possibility to review the June advice once indications of the next incoming recruitment become available from the autumn acoustic survey. However, in July the EC established the TAC from 1st July 2010 to 30th June 2011 according to the long term management plan proposal and ICES did not reviewed its June advice according to the JUVENA results. Although the shape of the relationship between the juvenile abundance index and the actual recruitment is still uncertain and the predictive power of the survey may be limited, the correlation between survey index and recruitment appears to be quite strong and it is statistically significant. This year WGANSA emphasized on the possibility of revising the June advice in case the JUVENA 2011 survey indicates a next low incoming recruitment. In any case, if managers would want to revise the advice for 2012, this could be done once results from the autumn acoustic survey are available.

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

Management plans

A draft management plan was proposed by the EC in 2009 in cooperation between science (STECF) and stakeholders (South Western RAC). This plan has not yet been formally adopted by the EU, and it has not been presented to ICES for evaluation. However, the plan was used last year for establishing the TAC for the period between 1st July 2010 and 30th June 2011. The plan is based on a constant harvest rate (30%), and sets a TAC as a percentage of the point estimate of the SSB as assessed at the start of the TAC period which runs from 1st July to 30th June, but with an upper bound on the TAC (of 33 000 t), and with a minimum TAC level (of 7000 tonnes) applicable at SSB estimates between 24 000 tonnes and 33 000 tonnes. It is understood that the TAC this year will again be set according to this draft plan. The TAC corresponding to the draft management plan for the assessed SSB (see section 3.5) would be 29,700 t.

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

Management considerations for the development of future management plans

There is an ongoing revision of the method to compute the stock abundance from the DEPM data. The procedures for the estimation of the Spawning frequency (S) for the Bay of Biscay anchovy have been revised due to a better understanding of the POF degeneration cycle (Al-day *et al*. 2008) and its application to the estimation of S (Uriarte *et al*. 2011). This will affect the past Spawning Biomass estimates of anchovy by the DEPM leading to a reduction of those estimates. This may lead to a re-scaling of the historical series of SSB and recruitments from the assessment as well. This will have implications for reference points that are set in absolute terms, including the reference points embedded in the draft management plan. Implementing this change in methodology, which from a scientific perspective is a clear improvement, will therefore have implications for future management plans.

Recruitment indicators, such as the JUVENA juvenile abundance index, may open opportunities to consider future management plans with half-yearly decisions and/or revisions of the TAC. A general outline of such adaptive management of short lived species is suggested by ICES in the ACOM report (ICES advice 2010, Book1, Section 1.2 General context of ICES advice).

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

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

This year a working document (Andrés, M. Working Document to WGANSA 2011) describing the socio-economic implications of the anchovy fishery for the Basque purse seiner fleet was presented. Currently ICES does not consider socio-economic aspects when providing management advice. The WG welcomes this type of information, which should be taken into account in the development of future management plans.

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

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.

Ecosystem effects of fisheries

These effects are not quantified.

4 Anchovy in Division IXa

4.1 ACOM Advice Applicable to 2010 and 2011

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

The above advice was revised in 2010 since both the most recent survey biomass index for the Portuguese acoustic survey and the disappearance of 0- group fish in the landings indicated a declining stock in the Sub-division IXa-South, where the bulk of the fishery takes place. Under the MSY approach the facts of a stock showing signs of decrease and the absence of reliable indicators for exploitation status implied that catches should be reduced from recent levels at a rate greater than the rate of stock decrease. In light of the EU policy paper on fisheries management (17 May 2010, COM(2010) 241) this stock can be classified under category 5 because it is a short lived species. However, because no advice based on a biomass escapement strategy is available, the stock was classified under category 9 because the state of the stock is not known precisely, but there were indications of a declining stock. Using the maximum 15% reduction in TAC for this category, the resulting TAC would be 6 800 t. However, ACOM notes that TACs have not been restrictive to the fishery.

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

Anchovy catches in Division IXa in 2010 (3,210 t) accounted for 7% increase in relation to the value recorded in 2009 (3,013 t), but these catches jointly with the 2008 ones are amongst the lowest levels recorded in the recent years. For 2011 this TAC has been agreed in 7,600 t, with national catch quotas being established at 3,635 t for Spain and 3,965 t for Portugal.

4.2 The Fishery in 2010

4.2.1 Fishing fleets

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

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

Technical characteristics of the Portuguese fleets fishing anchovy in 2010 in Division IXa are described in the sardine section of this report.

A total of 26 purse-seine vessels operated by Spain were authorized for fishing anchovy in the Sub-division IXa north in 2010. Their average technical characteristics were 22 m length, 49 GRT and 325 HP.

Number and technical characteristics of the purse-seine vessels operated by Spain in their national waters off Gulf of Cadiz (Sub-division IXa south), differentiated between total operative fleet and fleet targeting anchovy are summarised in **Table 4.2.1.1** and **Figure 3.2.1.1**. In 2010, the entire Spanish purse-seine fleet fishing in the Gulf of Cadiz was composed by 84 vessels, with 76 vessels dedicated in a greater or lesser extent to the anchovy fishing. Details of the dynamics of this fleet in terms of number of operative vessels over time in recent years are given in the Stock Annex and in previous WG reports.

4.2.2 Catches by fleet and area

4.2.2.1 Catches in Division IXa

Anchovy total landings in 2010 were 3,210 t, which represented a 7% increase with regard to the 2009 landings (3,013 t). These landings jointly with those in 2008 were amongst the lowest annual levels ever recorded in the most recent historical series (**Table 4.2.2.1.1**, **Figure 4.2.2.1.1**). The contribution by each sub-division to the total catch was characterized in 2010 by slight increases in landings in the northernmost sub-divisions and the maintenance of low levels in annual landings from Sub-division IXa-S (Cadiz) since 2008. Contributions by each of the Sub-divisions, but Sub-division IXa-S (Cadiz), not surpassed 6% of total landings from the Division.

As usual, the anchovy fishery in 2010 was almost exclusively harvested by purse seine fleets (99% of total catches). Portuguese and Spanish purse-seine landings accounted for 89% and almost the whole of their respective national 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 anchovy as a commercial by-catch) only target anchovy when its abundance is high.

4.2.2.2 Landings by Sub-division

The anchovy fishery was mainly located in 2010 in the Sub-division IXa South (2,929 t, *i.e.*, 91% of total catch in the whole Division; **Table 4.2.2.1.1.1**, **Figure 4.2.2.1.1**). As observed in recent years, the bulk (99%) of these southernmost catches was fished in the Spanish Gulf of Cadiz (2,901 t *vs* 28 t landed in the Algarve). As mentioned above, the relative importance of landings in each of the remaining Sub-divisions was low (not individually surpassing 6%), although sub-divisions IXa North and IXa Central-North showed somewhat higher contributions than in 2009 as result of a slight increase in catches (179 t and 100 t, respectively).

The Spanish fishery in 2010 followed the same distribution pattern described for recent years (see ICES, 2007 a), with almost all anchovy being fished in the Gulf of Cadiz waters (only 179 t in Sub-division IXa North, *i.e.*, southern Galician waters). Despite this, the Gulf of Cadiz fishery still exhibits annual landings at the same low levels recorded since 2008, at about 3 thousand tonnes.

The Portuguese anchovy fishery has historically shown alternate periods of relatively high and low landings in each of their three Sub-divisions, with the anchovy fishery being located either in the IXa South (before 1984), or in the IXa Central-North (from 1984 to 1997, and in 2007, 2008 and 2010), or mainly distributed in both Subareas (from 1998 to 2003, and in 2009), (see **Table 4.2.2.1.1**, Pestana, 1989, 1996; ICES, 2007 a). Traditionally anchovy catches are a commercial by-catch of the sardine fishery.

Seasonal distribution of catches by country and Sub-division in 2010 is shown in **Table 4.2.2.1.1.1**. Anchovy catches were recorded throughout the year in all Sub-divisions, although with a different intensity. Catches from the northernmost Spanish Sub-division (South Galicia) were mainly landed during the second semester. Portuguese catches from the IXa Central-North were mainly landed in autumn, those ones from IXa Central-South during the second semester, whereas catches from IXa South (Algarve) were landed during the second and third quarters. Anchovy fishery season in the Spanish part of the IXa South (Gulf of Cadiz) occurred throughout the second and third quarters, mainly in the spring months.

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).

New data on anchovy discarding 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). Preliminary information on these sampled trips (only 8 in the fourth quarter in 2009 and 7 trips distributed throughout 2010) are available but the resulting discard estimates have not been merged with landings due to uncertainties in the adequacy of the raising methodology used (*i.e.*, estimation of total discards for the whole fleet by raising sampling with anchovy landings as commercial discarded species) and the own low representativeness of the sampled trips. Slipping practices of undersized anchovies are not uncommon and they should also be taken into consideration as an added mortality.

4.2.4 Effort and Catch per Unit Effort

Annual and half-year standardised CPUE series (1988 – 2010) for the whole Spanish purse-seine fleet fishing Gulf of Cadiz anchovy (Sub-division IXa-South) were computed from the quotient between the sum of raw quarterly catches and that of standardised quarterly efforts within the respective time period. Details of data availability and the standardisation process are commented in the Stock Annex. The resulting estimates are shown in **Table 4.2.4.1**.

Series of standardised overall annual effort and CPUE and the historical series of landings from this fishery are shown in **Figure 4.2.4.1**. **Figure 4.2.4.2** shows the annual trends of these variables by purse-seine fleet type. A more detailed description of the fleets' dynamics over time and the impact of the recent closures in effort and CPUE are shown in the Stock Annex.

In 2010 the overall fishing effort of the Spanish purse-seine fleet fishing anchovy in the Gulf of Cadiz fishing ground was estimated in 4,355 standardised fishing days, which accounted for 6.5% decrease with respect to the effort exerted in the previous year (4,659 fishing days in 2009), but is still lower than the levels recorded in 2007 (6,917 fishing days) and before. As also occurred since 2008, a combination of fishing closures, both in the beginning and in the end of the year, bad weather at the start and/or the end of the fishing season, and the displacement of a part of the fleet to the Moroccan fishing grounds (under the EC-Morocco Fishery Agreement) at the same time of the re-opening of the Gulf of Cadiz fishery (in February in 2010), may be the causes responsible for the observed decrease in the fishing effort in the last three years.

The annual CPUE, however, was maintained at a level similar during this same period of years (0.7 t/fishing day). Nevertheless, these relatively stable and high annual yields should be interpreted with caution, at least for these most recent years. Thus, fishermen claimed that more searching time was needed to find out anchovy during the 2010 fishing season, a fact that resulted in an increased number of unsuccessful fishing trips. Therefore, the CPUE in 2010 (and probably before as well) may be overestimated because of the measure of effort available for computing the catch rate so far. This measure is the number of successful fishing trips with anchovy catches, as inferred from the anchovy daily sales per vessel, a measure which has not taken into account those trips with zero anchovy catches.

4.2.5 Catches by length and catches at age

4.2.5.1 Length distributions by fleet

Gulf of Cadiz anchovy quarterly length distributions from the Spanish fishery in 2010, the only available for this WG, are shown in **Table 4.2.5.1.1** and **Figure 4.2.5.1.1**. Smaller anchovy mean sizes and weights in the Gulf of Cadiz fishery are usually recorded in the first and fourth quarters as a consequence of a higher number of juveniles captured.

Gulf of Cadiz anchovy mean length and weight in the 2010 annual catch (11.8 cm and 11.2 g) are, jointly with the 2008 and 2009 estimates, the highest ones ever recorded in the historical series.

4.2.5.2 Catch numbers at age

Catch-at-age data from the whole Division IXa in 2010 are only available from the Spanish Gulf of Cadiz fishery (Sub-division 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. Description of annual trends of catch-at-age data from this fishery through the available data series is given in the Stock Annex. Data from the Spanish fishery in Sub-division IXa North are not available since commercial landings used to be negligible.

Total catch in the Gulf of Cadiz in 2010 was estimated at 256 million fish, which represents a 18% overall increase in numbers with respect to 2009 (217 million), but is still accounting for, as also occurred in 2008 and 2009, more than 60% decrease when compared with the catch at age in 2007 (628 millions). The 2008-2010 levels are close to the recent minima recorded in 1993 (207 million), 1995 (69 million), and 2000 (320 millions). In relation to the previous year, the aforementioned landed numbers in 2010 are the result of the relative increase in landings of the 0 and 1 age-groups, and the decreases in the catches of the oldest anchovies.

Landings of the 0 age-group anchovies in 2010 were restricted to the second half of the year, whereas 1 and 2 year-old catches were present throughout the year. Three year-old anchovies occurred again in the fishery (years when they occurred in the fishery was in 1992, 2008 and 2009). These older anchovies were fished during the third and fourth quarters in the year (**Table 4.2.5.2.1**, **Figure 4.2.5.2.1**).

4.2.6 Mean length and mean weight at age in the catch

Annual mean length and weight at age of Gulf of Cadiz anchovy catches are shown in **Tables 4.2.6.1** and **4.2.6.2**, and **Figure 4.2.6.1**.

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

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 this 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

Spanish Surveys

Anchovy DEPM surveys in the Division are only conducted by IEO for the SSB estimation of Gulf of Cadiz anchovy (Sub-division IXa-South, *BOCADEVA* survey series). So far, only 2 surveys have been carried out within this series with a triennial periodicity: *BOCADEVA 0605*, conducted in 2005, and *BOCADEVA 0608* in 2008. The next survey in this series is planned to be conducted in late July 2011. The methods adopted for both the conduction of the survey and the estimation of parameters are described in the Stock Annex and in ICES (2009 a,b). Revised results from these surveys were reported in the last year's WG report (ICES 2009 a).

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.

As commented in Section New indication about the state of the anchovy biomass will be obtained by the DEPM survey that is planned for late July 2011.

4.3.2 Spring/summer acoustic surveys

General

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

A summary list of the available acoustic surveys providing estimates for anchovy in IXa is given in the text table below.

Surveys	**Year/ Quarter**	**1993**	**....**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
PELAGO	Q1				Mar		Mar	Mar	Feb								
Portuguese	Q2									Jun	Apr	Apr	Apr	Apr	Apr	Apr	Apr
Surveys in	Q3																
IXa C-N to IXa S	Q4			**Nov**		**Nov**	**Nov**		Nov		Nov	Nov	**Nov**	Nov			
PELACUS04	Q1												Mar	Mar	Mar	Mar	Mar
Spanish	Q2																
Surveys in	Q3																
IXa N	Q4																
ECOCADIZ	Q1							Feb									
Spanish	Q2	Jun								Jun		Jun			Jun		
Surveys in	Q3												Jul		Jul	Jul	
IXa S	Q4														Oct		

As for the text table, acoustic estimates from surveys on a black background are those ones used since 2007 as tuning series in the exploratory analytical assessment of anchovy in Sub-division IXa South (Algarve and Gulf of Cadiz; see **Section 4.5.1**). They correspond to the spring Portuguese survey series. Those surveys from the autumn (November) series in bold letter provided anchovy estimates but they were not considered in the abovementioned assessment. Surveys on a white background were carried out but did not provide any anchovy acoustic estimate because of its very low presence and/or for an incomplete geographical coverage (some areas were not covered). Surveys in light grey only covered the Spanish waters of the Gulf of Cadiz and those ones in dark grey the whole Sub-division IXa South.

Results from the Spring Portuguese (*PELAGO 10*) and Spanish (*PELACUS 0410*) acoustic surveys in 2010 were previously described in the last year's WGANSA and WGACEEG reports (ICES, 2010 b, c).Detailed information in the present section will be provided for only those surveys carried out during the interim time between 2010 and 2011 WGANSA meetings.

Portuguese Surveys

The spring Portuguese acoustic survey (*PELAGO* survey series) has been the only acoustic survey carried out during the 2010-2011 WGANSA interim time, namely the April 2011 *PELAGO11* survey, carried out with the R/V *Noruega* and following the standard methodology firstly adopted by the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX (ICES 1986, 1998) and further improved and coordinated by the WGACEGG (see, for instance, ICES 2008 c and 2009 b). The surveyed area usually includes the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Sub-divisions IXa Central-North, Central-South, and South), between 20 and 200 m depth.

PELAGO11 spring survey:

Figure 4.3.2.1 summarises the main results from the April 2011 survey (*PELAGO11*). A more detailed description of the survey is given by Marques *et al*. (WD 2011).

During the survey only 18 trawl hauls were performed due to the lack of fish, mainly in the Sub-division IXa Central-South and in the Spanish waters of the Sub-division IXa South. Anchovy was distributed mainly in the IXa Central-North, between Caminha and Nazaré, sharing the area with sardine schools. In the remaining surveyed area, anchovy was practically absent, mainly in the Spanish waters of the Gulf of Cadiz, where it is usually found. This anomalous situation resulted in an estimate of zero tonnes and zero fish for the whole Sub-division IXa South.

The total biomass estimated was 27 thousand tonnes (1,558 million fish), within the average value for the entire time series, but only distributed in the Central-North area, as pointed out before. In that area anchovy size ranged between the 9 and 17.5 cm size classes, with a main modal class at 14.5 cm and a secondary one at 10.5 cm.

Figure 4.3.2.2 and **Table 4.3.2.1** show the distribution and estimates of anchovy egg densities sampled by CUFES in the Sub-division IXa South for the most recent acoustic surveys. Surprisingly, egg densities, as sampled by CUFES, during the 2011 survey in this area were the highest ones recorded during the most recent surveys in the series, evidence which contrasts with the null acoustic estimates resulting from this survey and raises serious doubts about the perception of the population status provided for the survey for anchovy in IXa South.

Figure 4.3.2.3 and **Tables 4.3.2.2** and **4.3.2.3** tracks the historical series of anchovy acoustic estimates from Spring Portuguese surveys in the Division IXa carried out so far.

Spanish Surveys

The *ECOCÁDIZ 0710* survey, which acoustically samples the shelf waters off the Sub-division IXa-South, was conducted in the early summer in 2010. The only Spanish survey carried out so far in waters of the Division IXa in the first semester in 2011 has been the 2010 early spring survey belonging to the *PELACUS* series, the *PELACUS*

0411 survey, carried out on board R/V *Thalassa*. This survey samples yearly the waters off the Sub-divisions IXa-North and Sub-area VIIIc since 1983.

Protocols and methods adopted by IEO for the Spanish acoustic surveys are described in ICES (2009 b). The main results from these surveys are as follow:

ECOCÁDIZ 0710

Figures 4.3.2.4 and **4.3.2.5** summarises the main results from the summer survey (*ECOCÁDIZ 0710*) surveying the IXa South. A more detailed description of the survey is given by Ramos *et al*. (WD 2011).

The *ECOCÁDIZ 0710* survey was carried out between 25 July and 1 August 2010 onboard the Spanish R/V *Cornide de Saavedra*. Because of a shortage of the ship-time available for this survey, the conventional survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths, was reduced to an area limited by the waters placed between Cape Trafalgar and Cape Santa Maria.

Anchovy occurred all over the shelf of the sampled area, although they showed their highest densities over the middle-outer shelf in the westernmost area. Anchovy eggs were also recorded in all the surveyed transects. The positive stations (75) with anchovy eggs accounted for 74% of the total number of sampled stations (102). The highest anchovy egg densities (> 100 eggs/m^3) were located in a few stations over the middle shelf at both sides of the Portuguese-Spanish border.

A total of 12.3 thousand tonnes and 954 millions of fish have been estimated for this species for the whole surveyed area. The size class range of the assessed population varied between 7.5 and 17.5 cm, with two modal classes at 9.5 and 13 cm. In contrast to the persistent pattern observed throughout the survey series, where largest anchovies usually occur in the western-most waters, this year largest anchovies mainly occurred in the easternmost area. Although westernmost anchovies were of a larger size than in the central part of the sampled area, they did not reach the highest sizes as they are usually recorded. Just in this central part is still recorded the occurrence of the smallest anchovies, coinciding with the location of the main recruitment area close to the Guadalquivir river mouth. Thus, 17% of the whole estimated population was below or equal to 10 cm suggesting a population sustained by smaller anchovies than, at least, in the previous year. This fact may well be a consequence of about one-month delay in the present survey dates, which has allowed sampling the start of the recruiting process to the survey area better than in previous years.

The values from the 2010 survey can hardly be compared with the previous ones because of the differences in the spatial coverage of the survey's area. However, a comparison of the species-specific acoustic estimates derived from the same area surveyed both in this survey as in the last year's *ECOCÁDIZ 0609* is shown in **Table 4.3.2.4**. Regarding total biomass and abundance estimated in each survey we can observe that the computed values are relatively very similar (95 thousand tonnes and 2137 million fish in 2009, 91 thousand tonnes and 3177 millions in 2010), although the allocation by species differs enormously. Regarding anchovy, the species was the second most important one (12.3 thousand t, 954 million fish), showing an abundance similar than the estimated one last year from the same area, although sustained by a lower a biomass, evidencing, therefore, a smaller mean size, as described above.

Figure 4.3.2.6 and **Tables 4.3.2.2** and **4.3.2.3** tracks the historical series of anchovy acoustic estimates from summer Spanish surveys in the Sub-division IXa South carried out so far.

PELACUS 0411

Figure 4.3.2.7 summarises the main results from the April 2011 survey (*PELACUS 0411*) surveying the Sub-division IXa North. A more detailed description of the survey is given by Santos *et al*. (WD 2011).

The spring 2011survey, *PELACUS 0411*, was carried out between 26th March and 22th April. In the Sub-division IXa North, anchovy was found in 4 hauls from the 8 ones carried out in this area, and mainly distributed over the shelf in the southernmost waters. Anchovy biomass and abundance were estimated at only 1.5 thousand tonnes and 66.2 million fish, respectively. Anchovy size composition ranged between 12.5 and 18.5 cm size classes with a mode at 14.5 cm (**Figure 4.3.2.7**). The population in this area (southern rías) was dominated by age 2 and 1 fish.

Some comments on recent trends in acoustic estimates in IXa–South

The historical series of total and regional acoustic estimates of anchovy abundance (millions) and biomass (tonnes) either from the whole Division IXa excepting Sub-division IXa N (Portuguese surveys) or from the Subarea IXa South only (Spanish surveys) are shown in **Tables 4.3.2.2** and **4.3.2.3** and **Figures 4.3.2.3**, **4.3.2.6**.

The estimates from those surveys covering the whole southernmost subarea (the IXa South, whose population has usually been explored by an analytical assessment) show through the series that either the bulk (about or higher than 90% of both the total abundance and biomass) or even the whole of the anchovy population is concentrated in the Spanish waters of the Gulf of Cadiz.

Spring biomass estimates from 1998 to 2003 in the Sub-division IXa-South oscillated around 25 thousand tonnes. However, available estimates, either from Portuguese or Spanish surveys, in 2004 and 2005 decreased down to 18–14 thousand tonnes, evidencing a possible decline in the (spawning) population levels. In the 2005 WGMHSA and WGACEEG meetings was warned that the picture of an alarming decreasing trend just in 2004–2005 should be initially considered with caution for several causes. Firstly, the estimates themselves in such years seemed to be affected by problems related either to the sampling coverage of shallow waters (2004 Spanish survey, ICES, 2006 b) or to the echo-traces discrimination between fish and plankton (2005 Portuguese survey, ICES, 2006 b). Secondly, the survey season for the Spanish surveys (late spring-early summer) entailed a 2–3 months delay relative to the usual March (since 2005 in April) Portuguese survey series, which involves an additional mortality affecting the population estimates and a probable different population structure. Despite these facts the possibility of such a decline in the spawning population in 2005 should not be forgotten.

Notwithstanding the above, the 2005-2009 Portuguese spring survey seasons were coincident and their estimates, therefore, comparable, and they indicate an evident recovered population since 2006 which reaches levels either close (2006, 2009) or even somewhat higher (2007, 2008) to the average estimate in the (Portuguese) historical series (25.6 thousand tonnes). The high 2006 estimate from the Spanish survey reinforces the above statement on a population recovery that year in this Sub-division. However, the inter-annual trend depicted by the 2006 and 2007 Portuguese surveys is much more marked (an increase of about 14 thousand tonnes in 2007 and then a slight decrease of 4 thousand tonnes in 2008) than the trend exhibited by its Spanish counterparts (a 7.6 thousand tonnes decrease). Furthermore, the increased value in the 2007 population numbers, as estimated by the Portuguese survey, was in disagreement with the opposite trend observed from the Spanish surveys. What happened that year for such differences was a matter of concern and some working hypothesis were drawn in the 2007 WGACEEG for explaining the above differences (see ICES, 2007 b, 2008 b for a more detailed description). WGACEEG strengthened the necessity of an extended sampling coverage to shallower waters (<20 m depth) than those usually sampled in surveys surveying the Gulf of Cadiz shelf (both Spanish and Portuguese surveys). Sampling schemes aiming to solve this problem with the conventional vertical acoustics has been previously described (see, for instance, Guillard and Lebourges (1998), Guennégan *et al*. (2004), Brehmer *et al*. (2006), and Ramos *et al*. (WD 2010), amongst others).

Regardless the above discrepancies observed in the 2007 estimates, the provision last year to the WG of the 2010 Spring Portuguese acoustic estimate led to a change in the perception on the relative stability of the stock in recent years. Attempting to analyse the possible causes explaining such a strong decrease (from 24.7 thousand tonnes in 2009 to 7.4 thousand tonnes in 2010, *i.e.* about 70% decrease), both size composition (**Figures 4.3.2.8** and **4.3.2.9**) and age structure (**Figures 4.3.2.10**, **4.3.2.11**, and **4.3.2.12**) of the estimated populations through the historical series were analysed. The age structure of the anchovy population in Subdivision IXa South, as estimated from the Portuguese acoustic survey series, is not available. 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 to the corresponding estimated population numbers by length class. 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.

Our comments herein will be mainly focused in the last years in the series. So, the size composition of the estimated population in 2010 it was characterised by a very low number of both small and larger anchovies than in 2009, with larger anchovies than 14 cm being absent, suggesting a low recruitment in 2009 and 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, suggesting very low recruitments in the period 2007-2009 as well. 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. Such results lead to the WG to consider the 2011 acoustic estimate with caution until some additional evidences (e.g., the DEPM survey in July 2011) confirm or reject such a critical trend.

4.3.3 Recruitment surveys

SAR autumn survey series

At present, the Autumn 2008 survey (*SAR08OUT*; from 2nd to the 27th of October 2008), aimed to cover the sardine early spawning and recruitment season in the Division IXa, has been the last survey within its series. No anchovy acoustic estimates were however provided by IPIMAR from this survey since the species was not a target in that occasion (ICES, 2009 a, b). **Figure 4.3.3.1** shows the historical series of anchovy acoustic estimates from Autumn Portuguese surveys in the Division IXa available so far.

As described in **Section 4.3.2**, anchovy population estimates in the Sub-division IXa South by direct methods are available from the Portuguese acoustic survey series since 1998. Although Portugal provides such estimates as aggregated ones, an estimation of the recruits either from their autumn (as age-0 recruits in the year) or spring surveys (as age-1 fish in the next year) may be derived after the application of Spanish age-length keys, following the same approach described in the previous section. Because of the possible biases derived from the application of commercial age-length keys, the WG encourages to IPIMAR to provide to this WG structured acoustic estimates in the near future. Regardless the above and the considerations about the suitability of the sampling coverage in these surveys for sampling this population fraction (mainly age-0 fish or even adult fish in shallow waters), the series of point estimates is at present scattered and scarce for this autumn series (see **Tables 4.3.2.2** and **4.3.2.3**, and **Figure 4.3.3.1**).

Attempts of new recruitment surveys in the Division

Despite such limitations, during the 2007 WGACEGG meeting, existing experience from the Portuguese and Spanish acoustic surveys in IXa and from the French and Spanish pre-recruit autumn surveys in the Bay of Biscay was used to define a general plan for the design and execution of a potential Atlanto-Iberian sardine (and anchovy) recruitment international survey in the future. Requirements to be fulfilled by this survey were listed in ICES (2007 b). As anchovy is concerned, the surveys should cover the species' potential recruitment grounds in the Gulf of Cadiz, from the 100 m isobath or even less up to below the 20 m isobath to accommodate the potential presence of juvenile anchovy at lower depths. As stated in the 2007 WGACEEG report, this new survey could provide a (local) recruitment index for anchovy (and probably for sardine as well) useful for management decisions.

This survey would obviously require the inshore extension of the surveyed area to the shallow waters of the inner Gulf of Cadiz and the respective ability to fish such targets (problems similar to those faced in the autumn pre-recruitment survey in the Bay of Biscay). In order to the IEO (as proposed responsible for this survey) properly plan this kind of surveys in advance, 2 short pilot experiments were carried out during 2008 aimed to testing the potential, as acoustic sampling platforms of shallow waters, of two smaller research vessels (R/V *Francisco de Paula Navarro* and R/V *Emma Bardán*) than the R/V *Cornide de Saavedra* and R/V *Noruega* usually utilised in conventional surveys (see ICES, 2008 c).

In late October 2009 was conducted the first of these series of Gulf of Cadiz anchovy recruitment surveys (*ECOCÁDIZ-RECLUTAS 1009*). Following the above mentioned WGACEEG recommendations, the survey, aimed to acoustically estimate the abundance and biomass of Gulf of Cadiz anchovy recruits, was planned to be conducted throughout the easternmost Portuguese waters and those waters off the central part of the Spanish Gulf of Cadiz, waters that, from previous ancillary information, were expected to include the main Gulf of Cadiz anchovy recruitment area. 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 one conventionally planned in standard surveys and some other unforeseen circumstances 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. Therefore, although acoustic estimates are available, they have not been provided to this WG awaiting an appropriate revision by this year's WGACEEG. Continuity of this survey in following years is not assured at all and will necessarily depend on external (EC) funding.

4.4 Biological Data

4.4.1 Weight at age in the stock

Weights at age in the stock are shown in **Table 4.5.1.1**. See the Stock Annex for comments on computation and trends.

4.4.2 Maturity at Age

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

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

4.4.3 Natural Mortality

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

4.5 Assessment of the state of the stock

4.5.1 Previous data explorations

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

For the time being, no analytical assessment model has been successfully applied. An *ad hoc* seasonal (half-year) separable model implemented and run on a spreadsheet has been used in the last years for data exploration of anchovy catch-at-age data in Sub-division IXa-South since 1995 onwards. The separable model is fitted to the updated half-year catch-at-age data until the year before the WG and to the available acoustic estimates of anchovy aggregated biomass from the spring Portuguese surveys series only (including the acoustic estimate one year ahead of the assessment's last year). More details on the model settings and assumptions and its performance are described in the Stock Annex. **Table 4.5.1.1** and **Figure 4.5.1.1** show the updating of the input data as if they were to be used this year for the data exploration with the separable model.

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.

In more general terms, estimating the parameters in a separable model with only a biomass index as supporting information is close to over-parameterisation, and the fact that only 2-3 ages are represented in the fishery makes the situation worse. Hence, the assessment became unstable and very sensitive to the assumptions made, especially to the choice of input data for the last semester in the most recent year. Examination of the data indicates that almost all catches are from age 1, plus age 0 in the second semester (**Table 4.5.1.1**, **Figure 4.5.1.1**). The ratio between catches at age 1 and age 2 indicates a total annual mortality in the order of 3-5, which is hardly realistic. To accommodate the trends in the survey data, the model estimated a far lower selection at age 2 than at age 1, which is not compatible with the preferences in the fishery. An alternative explanation to this discrepancy can be migration out of the relatively limited fishing area, for which there is at least some evidence in the length (-age) composition by area in the surveys. So, direct evidences from acoustic surveys (at the peak of the fishing season) show that larger and older anchovies are more common in the westernmost waters of the Sub-division, where there is no fishery targeting anchovy. Therefore, there is some uncertainty about the stock identity.

Hence, the main problems with this assessment seem to be linked to the nature of the stock and the kind of data that can be accessible. As a final consequence, the exploratory model utilised so far does not provide any reliable information about the true levels of the stock, F and Catch/SSB ratios since the assessment is not still properly scaled.

For all the above reasons since 2009 it was preferred not to perform any exploratory assessment with this model.

4.5.2 Qualitative (data trends-based) assessment

Trends of biomass indexes in the Subdivision IXa South.

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

Since 2008 the acoustic estimates of biomass show a continuous declining trend which seems to reach an extreme situation in spring 2011, when no anchovy was detected in the *PELAGO* acoustic survey. However anchovy eggs in CUFES were found at comparable or even higher levels than in the previous year 2010 during that acoustic survey which is not consistent with the null detection of biomass with acoustics (**Figure 4.3.2.2** and **Table 4.3.2.1**). Fishery has maintained its activity throughout 2010 and 2011. Up to 2010 the cpue indexes of the fleet did not show any declining trend (**Figure 4.5.2.1**), although the validity of this CPUE index may be questionable given that the unit effort does not take into account neither the searching time nor the occurrence of fishing trips with zero catches.

For these reasons the working group was reluctant to accept that the fall in biomass in 2011 was so pronounced as the *PELAGO* acoustic survey suggested and questions the validity of this very last point of the series. Nevertheless the low biomass levels in 2010 were partly confirmed by *ECOCADIZ* survey in July which assessed anchovy biomass in Spanish waters around 12,300 t (although Algarve area was not covered). So, the WG considers that the declining trend until 2010 were coherently indicated by the survey indexes, but the actual level in 2011 is highly uncertain. New indication about the state of the anchovy biomass in July 2011 will be obtained by the DEPM survey that is planned for those dates by IEO. This survey will be relevant to verify the actual trend of the stock up to 2011. In the mean while ICES should keep the same advice as given in last year for a stock under a decreasing trend of "a substantial reduction in catch" for this Sub-division IXa South. If required, a revision of the current status of the population in Sub-division IXa South in 2011 could be considered in November 2011 (after or during WGACEGG meeting) incorporating the information from the anchovv DEPM in Cadiz of July.

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

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

Trend of biomass indexes in the whole Division IXa.

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

4.6 Predictions

As stated in the previous section the exploratory assessment is not recommended as a basis for predictions. Nevertheless, the most recent direct acoustic estimates indicate that the stock in Sub-division IXa South was reduced until 2010 from a relatively stable situation (about 30 thousand tonnes as an average for the period 2006-2009) and it might be even at a poorer situation in 2011, although its actual status is uncertain.

4.7 Management considerations

4.7.1 Definition of stock units

A summarised description of the distribution of the main anchovy populations in NE Atlantic European waters is given in the Stock Annex. Traditionally, the distribution of anchovy in the Division IXa has been concentrated in the Sub-division IXa South (**Figure 4.7.1.1.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 4.7.1.1.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. The Working Group has traditionally concentrated its exploratory analysis of the anchovy in Sub-division IXa South, because it was the only persistent population in the area. The perception of the anchovy in other areas of IXa is that they are marginal population of independent dynamics from the anchovy population in IXa South. As such the advice was based solely on the information coming from the anchovy in IXa South (Algarve and Cadiz).

In 2011 the acoustic detection of anchovy biomass by *PELAGO* spring survey in Sub-division IXa Central-North raised up from 0 t in 2010 to 27,000 t in 2011. Contrary to this, the acoustic estimates in subdivision IXa South passed from about 7,400 t in 2010 to 0 t (**Figure 4.7.1.1.c**). Beyond the noise which might be behind these estimates, these data demonstrates the independent dynamics of the anchovy in the northern part of the IXa from the dynamics of the population in IXa south (with examples in the period 1995/96 and in 2011).

This has a direct implication: there is no firm basis to consider the anchovy in Division IXa as a single stock, given that the dynamics of the population (via their recruitment pulses) in the different areas are independent. From 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. At the contrary, it would be better to provide separate advice for the well identified population in Sub-division IXa South, from the rest of the anchovy in the Division (occupying the western waters of the Iberian peninsula: IXa North, Central-North and Central-South). This would demand a separate management of the fisheries on anchovy in these two regions of the Division IXa.

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

4.7.2 Current management situation

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

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

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

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

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

The plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (3000 kg of sardine, 3000 kg of anchovy, 6000 kg of sardine-anchovy mixing but in no case each of these species can exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight could be constituted by fish below the established minimum landing size (10 cm) but fish must always be ≥9 cm.

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

The second management action in force since 15th of July 2004 in Spanish gulf of Cadiz is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure 4.7.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the river-bed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA.

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

Results from the qualitative assessment described in **Section 4.5** suggest that the anchovy population in the Sub-division IXa South may be declining due to a reduced recruitment. The new Gulf of Cadiz DEPM survey data that will become available from July 2011 may change the perception of the population in this region; in any case a precautionary advice would be to reduce the catches allowed to be taken in this Sub-division. On the contrary for the populations in the remaining Sub-divisions no warning is required.

4.7.3 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 WGANSA. In that context, it may be productive to consider before any benchmark process a wide range of assessment approaches in an open-minded way. It is noted that most of the signals in the data are found in the catches at age 1 in both semesters and at age 0 in the second semester, in addition to the trends in the survey biomass measurements. It might be worth exploring the time signal in these data. Production models should also be explored, but large fluctuations of the catches over time give some doubts about the stability of the carrying capacity.

The analyses of the data should also be viewed in the context of the management strategies that might be applied. The surveys have improved greatly in recent years, both through improvements of the acoustic surveys and the initiation of a DEPM survey. In addition, recent scientific efforts have improved the understanding of the biology of the stock. As stated in the last year 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.

4.7.4 Species interaction effects and ecosystem drivers

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

The anchovy population in Sub-division 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. The shallowness of the water column, the influence of the Guadalquivir River, and the local topography favor the existence of warm and chlorophyll-rich waters in the area, thus offering a favorable environment for the development of eggs and larvae. However, spring and early summer easterlies bursts may cause: a) a decrease of the water temperature by several degrees, b) generate oligotrophic conditions in the area, and c) force the offshore transport of waters over this portion of the shelf, advecting early life stages away from favorable conditions. These negative influences on the development conditions of anchovy eggs and larvae can impact on the recruitment of this species in the Gulf of Cadiz and subsequently in the anchovy fishery.

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

4.7.5 Ecosystem effects of fisheries

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

Table 4.2.1.1. Anchovy in División IXa. Sub-division IXa South. Spanish purse-seine fleet composition in the Gulf of Cadiz (Sub-division IXa-South) in 2010. The fleet is differentiated into total fleet and vessels targeting anchovy. The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels). Storage: catches are dry hold with ice (1 fishing trip equals to 1 fishing day). Similar tables for yearly data since 1999 are shown in the Stock Annex.

Total number of operative purse-seiners

2010	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	1	1	0	0	0	2
11-15	2	11	11	2	0	26
16-20	0	3	22	16	0	41
>20	0	0	2	11	2	15
Total	3	15	35	29	2	84

Purse-seiners targeting anchovy

2010	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	0	1	0	0	0	1
11-15	2	11	10	2	0	25
16-20	0	3	20	14	0	37
>20	0	0	2	10	1	13
Total	2	15	32	26	1	76

Table 4.2.2.1.1. Anchovy in Division IXa. Portuguese and Spanish annual landings (t), (from Pestana, 1989 and 1996, and WGMHSA, WGANC and WGANSA members).

	Portugal				Spain			IXa South	TOTAL
Year	IXa C-N	IXa C-S	IXa South	Total	IXa North	IXa South	Total	Total	
1943	7121	355	2499	9975	-	-	-	-	-
1944	1220	55	5376	6651	-	-	-	-	-
1945	781	15	7983	8779	-	-	-	-	-
1946	0	335	5515	5850	-	-	-	-	-
1947	0	79	3313	3392	-	-	-	-	-
1948	0	75	4863	4938	-	-	-	-	-
1949	0	34	2684	2718	-	-	-	-	-
1950	31	30	3316	3377	-	-	-	-	-
1951	21	6	3567	3594	-	-	-	-	-
1952	1537	1	2877	4415	-	-	-	-	-
1953	1627	15	2710	4352	-	-	-	-	-
1954	328	18	3573	3919	-	-	-	-	-
1955	83	53	4387	4523	-	-	-	-	-
1956	12	164	7722	7898	-	-	-	-	-
1957	96	13	12501	12610	-	-	-	-	-
1958	1858	63	1109	3030	-	-	-	-	-
1959	12	1	3775	3788	-	-	-	-	-
1960	990	129	8384	9503	-	-	-	-	-
1961	1351	81	1060	2492	-	-	-	-	-
1962	542	137	3767	4446	-	-	-	-	-
1963	140	9	5565	5714	-	-	-	-	-
1964	0	0	4118	4118	-	-	-	-	-
1965	7	0	4452	4460	-	-	-	-	-
1966	23	35	4402	4460	-	-	-	-	-
1967	153	34	3631	3818	-	-	-	-	-
1968	518	5	447	970	-	-	-	-	-
1969	782	10	582	1375	-	-	-	-	-
1970	323	0	839	1162	-	-	-	-	-
1971	257	2	67	326	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-
1973	6	0	120	126	-	-	-	-	-
1974	113	1	124	238	-	-	-	-	-
1975	8	24	340	372	-	-	-	-	-
1976	32	38	18	88	-	-	-	-	-
1977	3027	1	233	3261	-	-	-	-	-
1978	640	17	354	1011	-	-	-	-	-
1979	194	8	453	655	-	-	-	-	-
1980	21	24	935	980	-	-	-	-	-
1981	426	117	435	978	-	-	-	-	-
1982	48	96	512	656	-	-	-	-	-
1983	283	58	332	673	-	-	-	-	-
1984	214	94	84	392	-	-	-	-	-
1985	1893	146	83	2122	-	-	-	-	-
1986	1892	194	95	2181	-	-	-	-	-
1987	84	17	11	112	-	-	-	-	-
1988	338	77	43	458	-	4263	4263	4306	4721
1989	389	85	22	496	118	5330	5448	5352	5944
1990	424	93	24	541	220	5726	5946	5750	6487
1991	187	3	20	210	15	5697	5712	5717	5922
1992	92	46	0	138	33	2995	3028	2995	3166
1993	20	3	0	23	1	1960	1961	1960	1984
1994	231	5	0	236	117	3035	3152	3035	3388
1995	6724	332	0	7056	5329	571	5900	571	12956
1996	2707	13	51	2771	44	1780	1824	1831	4595
1997	610	8	13	632	63	4600	4664	4613	5295
1998	894	153	566	1613	371	8977	9349	9543	10962
1999	957	96	355	1408	413	5587	6000	5942	7409
2000	71	61	178	310	10	2182	2191	2360	2502
2001	397	19	439	855	27	8216	8244	8655	9098
2002	433	90	393	915	21	7870	7891	8262	8806
2003	211	67	200	478	23	4768	4791	4968	5269
2004	83	139	434	657	4	5183	5187	5617	5844
2005	82	6	38	126	4	4385	4389	4423	4515
2006	79	15	14	108	15	4368	4383	4381	4491
2007	833	7	34	874	4	5576	5580	5610	6454
2008	211	87	37	335	5	3168	3173	3204	3508
2009	35	5	32	72	19	2922	2941	2954	3013
2010	100	2	28	130	179	2901	3080	2929	3210

(-) Not available

(0) Less than 1 tonne

Table 4.2.2.1.2. Anchovy in Division IXa. Catches (t) by gear and country in 1988-2010.

Country/Gear	1988*	1989*	1990*	1991*	1992	1993	1994	1995*	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SPAIN	4263	5454	6131	5711	3028	1961	3153	5900	1823	4664	9349	6000	2191	8244	7891	4791	5187	4389	4383	5580	3173	2941	3080
Artisanal IXa North																4	1				1	0,1	4
Purse seine IXa North		118	220	15	33	1	117	5329	44	63	371	413	10	27	21	19	2	4	15	4	4	18	175
Purse seine IXa South	4263	5336	5911	5696	2995	1630	2884	496	1556	4410	7830	4594	2078	8180	7847	4754	5177	4385	4367	5575	3168	2922	2901
Trawl IXa South						330	152	75	224	190	1148	993	104	36	23	14	6	0,2	0,4	0,3	0,1	0,02	
PORTUGAL	458	496	541	210	275	23	237	7056	2771	632	1613	1408	310	855	915	478	657	126	108	874	335	72	130
Trawl					4	9	1		56	46	37	43	6	16	13	7	5	7	27	14	9	4	14
Purse seine	458	496	541	210	270	14	233	7056	2621	579	1541	1346	297	806	888	287	455	62	57	484	185	30	67
P. seine Polyvalent					1	1	3		94	7	35	20	7	32	13	184	197	57	24	376	141	38	49
Total	4721	5950	6672	5921	3303	1984	3390	12956	4594	5295	10962	7409	2502	9098	8806	5269	5844	4515	4491	6454	3508	3012	3210

* Portuguese catches not differentiated by gear

Table 4.2.2.1.1.1. Anchovy in Division IXa. Quarterly anchovy catches (t) by country and Sub-division in 2010.

COUNTRY	SUBDIVISIONS	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2010)	
		C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
SPAIN	IXa North	0,5	0,3	1	0,7	151	84,6	26	14,4	179	5,8
	IXa South	67	2,3	1698	58,5	907	31,3	229	7,9	2901	94,2
	TOTAL	67	2,2	1699	55,2	1059	34,4	255	8,3	3080	100,0
PORTUGAL	IXa Central North	11	10,6	25	25,2	4	3,9	60	60,2	100	77,1
	IXa Central South	0,005	0,3	0,2	10,9	0,9	49,6	0,7	39,3	2	1,4
	IXa South	0,1	0,2	12	41,4	13	47,4	3	11,0	28	21,4
	TOTAL	11	8,2	37	28,5	18	13,9	64	49,4	130	100,0
TOTAL	IXa North	0,5	0,3	1	0,7	151	84,6	26	14,4	179	5,6
	IXa Central North	11	10,6	25	25,2	4	3,9	60	60,2	100	3,1
	IXa Central South	0,005	0,3	0,2	10,9	1	49,6	0,7	39,3	2	0,1
	IXa South	67	2,3	1709	58,4	921	31,4	232	7,9	2929	91,2
	TOTAL	78	2,4	1736	54,1	1077	33,6	319	9,9	3210	100,0

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

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

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

Table 4.2.5.1.1. Anchovy in Division IXa. Length distribution ('000) of anchovy catches in Division IXa by country and Sub-divisions in 2010. Only available data for the length composition of catches from the Spanish fishery in the Gulf of Cádiz (Sub-division IXa-South).

2010	Q1	Q2	Q3	Q4	TOTAL
Length (cm)	SPAIN IXa South	SPAIN IXa South	SPAIN IXa South	SPAIN IXa South	SPAIN IXa South
3,5					
4					
4,5					
5					
5,5					
6					
6,5					
7	0	0	24	0	24
7,5	0	136	113	0	249
8	17	226	320	51	613
8,5	34	1423	582	4	2043
9	50	1348	2737	330	4465
9,5	374	4563	3633	1346	9916
10	730	8658	3784	3532	16703
10,5	975	20112	4116	6640	31843
11	1135	31060	3399	5754	41348
11,5	1194	35318	3703	3000	43215
12	581	22467	5817	3179	32043
12,5	872	12692	8581	1510	23655
13	98	7050	12975	968	21092
13,5	174	3489	8337	336	12337
14	3	2539	6890	211	9643
14,5	1	1424	2618	28	4072
15	30	740	1125	0	1895
15,5	29	472	180	0	682
16	0	174	61	0	236
16,5	0	50	65	0	115
17	0	34	0	0	34
17,5					
18					
18,5					
19					
19,5					
20					
20,5					
21					
21,5					
22					
Total N	6297	153973	69061	26889	256221
Catch (T)	67	1698	907	229	2901
L avg (cm)	11,5	11,7	12,5	11,3	11,8
W avg (g)	9,5	10,8	13,1	8,5	11,2

Table 4.2.5.2.1. Anchovy in Division IXa. Sub-division IXa South. Spanish catch in numbers ('000) at age of Gulf of Cadiz anchovy (1995-2010) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

1995	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	11256	23241	0	34497	34497
	1	19579	6928	6851	602	26508	7453	33961
	2	189	0	0	0	189	0	189
	3	0	0	0	0	0	0	0
	Total (n)	19769	6928	18107	23843	26697	41950	68647
	Catch (t)	185	80	148	157	265	305	571
	SOP	184	79	148	157	264	305	568
	VAR.%	101	101	100	100	101	100	100
1996	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	413465	71074	0	484540	484540
	1	12772	130880	11550	7281	143652	18832	162483
	2	13	882	826	333	894	1159	2053
	3	0	0	0	0	0	0	0
	Total (n)	12785	131761	425842	78688	144546	504530	649076
	Catch (t)	41	807	585	348	848	933	1780
	SOP	36	743	621	306	779	926	1706
	VAR.%	114	109	94	113	109	101	104
1997	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	237283	96475	0	333758	333758
	1	67055	123878	69278	19430	190933	88708	279641
	2	22601	9828	11649	745	32429	12394	44823
	3	0	0	0	0	0	0	0
	Total (n)	89656	133706	318211	116650	223362	434860	658223
	Catch (t)	906	1110	2006	578	2016	2584	4600
	SOP	844	1273	1923	596	2117	2519	4635
	VAR.%	107	87	104	97	95	103	99
1998	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	75708	360599	0	436307	436307
	1	325407	384529	220869	84729	709936	305599	1015535
	2	11066	879	1316	0	11944	1316	13260
	3	0	0	0	0	0	0	0
	Total (n)	336473	385408	297893	445329	721881	743221	1465102
	Catch (t)	1773	2113	2514	2579	3885	5092	8977
	SOP	1923	2127	2599	2654	4050	5254	9304
	VAR.%	92	99	97	97	96	97	96
1999	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	40549	84234	0	124784	124784
	1	249922	115218	86931	20276	365140	107207	472348
	2	10982	18701	2450	146	29683	2596	32279
	3	0	0	0	0	0	0	0
	Total (n)	260904	133919	129931	104656	394823	234587	629410
	Catch (t)	1335	1983	1582	687	3318	2269	5587
	SOP	1330	1756	1391	673	3087	2064	5150
	VAR.%	100	113	114	102	107	110	108
2000	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	41028	77780	0	118808	118808
	1	75141	65947	46460	9949	141088	56409	197497
	2	638	2670	523	14	3307	537	3844
	3	0	0	0	0	0	0	0
	Total (n)	75779	68617	88011	87743	144395	175755	320150
	Catch (t)	329	660	655	537	989	1193	2182
	SOP	327	659	666	535	986	1201	2187
	VAR.%	101	100	98	100	100	99	100
2001	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	30987	127140	0	158126	158126
	1	98687	227388	177264	37992	326075	215256	541331
	2	4155	14028	4535	624	18183	5159	23342
	3	0	0	0	0	0	0	0
	Total (n)	102842	241416	212785	165756	344258	378541	722800
	Catch (t)	924	3031	3195	1066	3955	4261	8216
	SOP	908	3014	3145	1065	3922	4210	8132
	VAR.%	102	101	102	100	101	101	101
2002	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	45129	29271	0	74399	74399
	1	218090	304295	149120	36565	522385	185685	708070
	2	2004	6083	8808	620	8087	9428	17515
	3	0	0	0	0	0	0	0
	Total (n)	220094	310378	203057	66456	530471	269512	799984
	Catch (t)	1700	2814	2566	789	4515	3355	7870
	SOP	1617	2778	2524	818	3937	3342	7737
	VAR.%	105	101	102	96	115	100	102

2003	AGE	Q1	Q2	Q3	Q4	HY1	HY2	ANNUAL
	0	0	0	26034	45813	0	71847	71847
	1	96135	229184	49058	7028	325320	56087	381407
	2	10041	2587	481	0	12628	481	13109
	3	0	0	0	0	0	0	0
	Total (n)	106176	231772	75574	52841	337948	128415	466363
	Catch (t)	1025	2533	798	413	3557	1211	4768
	SOP	1031	2398	759	378	3430	1137	4567
	VAR.%	99	106	105	109	96	94	104
2004	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	31680	74278	0	105958	105958
	1	157200	165738	69542	6383	322937	75924	398862
	2	388	1419	248	534	1808	782	2590
	3	0	0	0	0	0	0	0
	Total (n)	157588	167157	101470	81195	324745	182665	507410
	Catch (t)	1382	1975	1192	634	3357	1826	5183
	SOP	1284	1844	1194	593	3129	1788	4916
	VAR.%	108	107	100	107	107	102	105
2005	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	24163	13743		37906	37906
	1	195482	249404	36999	371	444886	37370	482256
	2	2716	445	334	0	3161	334	3495
	3	0	0	0	0	0	0	0
	Total (n)	198198	249848	61496	14114	448046	75610	523656
	Catch (t)	1361	2241	705	77	3602	783	4385
	SOP	1302	2098	665	67	3401	732	4132
	VAR.%	105	107	106	115	106	107	106
2006	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	9552	1751	0	11303	11303
	1	152978	296608	41515	206	449586	41721	491307
	2	2944	2317	0	0	5261	0	5261
	3	0	0	0	0	0	0	0
	Total (n)	155922	298925	51068	1957	454847	53024	507871
	Catch (t)	1289	2655	414	9	3944	424	4368
	SOP	1206	2474	387	8	3680	395	4075
	VAR.%	107	107	107	108	107	107	107
2007	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	41020	20672	0	61692	61692
	1	222366	230200	89173	17477	452567	106650	559217
	2	1696	5016	594	35	6712	629	7342
	3	0	0	0	0	0	0	0
	Total (n)	224063	235216	130787	38185	459279	168971	628250
	Catch (t)	1572	2233	1418	351	3806	1770	5576
	SOP	1443	2061	1290	335	3504	1624	5128
	VAR.%	109	108	110	105	109	109	109
2008	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	38173	19304	0	57477	57477
	1	38742	51510	30608	17435	90251	48043	138295
	2	10220	13400	5137	2214	23620	7351	30970
	3	245	149	0	0	394	0	394
	Total (n)	49206	65059	73918	38953	114266	112871	227137
	Catch (t)	590	1117	909	552	1707	1461	3168
	SOP	552	1056	852	518	1608	1369	2978
	VAR.%	107	106	107	107	106	107	106
2009	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	1143	8552	0	9695	9695
	1	24402	93317	64150	3072	117719	67222	184941
	2	11236	6842	1944	28	18079	1972	20051
	3	1463	364	846	1	1827	846	2673
	Total (n)	37101	100523	68084	11652	137624	79736	217360
	Catch (t)	530	1279	1006	107	1809	1113	2922
	SOP	486	1194	937	100	1680	1037	2717
	VAR.%	109	107	107	107	108	107	108
2010	**AGE**	**Q1**	**Q2**	**Q3**	**Q4**	**HY1**	**HY2**	**ANNUAL**
	0	0	0	16924	17538	0	34462	34462
	1	6154	148182	46697	9351	154336	56048	210384
	2	144	5690	5285	0	5833	5285	11118
	3	0	102	155	0	102	155	257
	Total (n)	6297	153973	69061	26889	160271	95950	256221
	Catch (t)	67	1698	907	229	1765	1136	2901
	SOP	60	1664	907	229	1724	1136	2859
	VAR.%	112	102	100	100	102	100	102

Table 4.2.6.1. Anchovy in Division IXa. Sub-division IXa South. Mean length (TL, in cm) at age in the Spanish catches of Gulf of Cadiz anchovy (1995-2010) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm. Data from 1988 to 1994 has been previously reported in WGMHSA reports.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 4.2.6.2. Anchovy in Division IXa. Sub-division IXa South. Mean weight (in kg) at age in the Spanish catches of Gulf of Cadiz anchovy (1995-2010) on a quarterly (Q), half-year (HY) and annual basis. Data for 1994 (not shown) and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm. Data from 1988 to 1994 has been previously reported in WGMHSA reports.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 4.3.2.1. Anchovy in Division IXa. Results from the CUFES sampling of anchovy eggs in the Sub-division IXa South. Data for the most recent spring Portuguese acoustic surveys, with indication of the acoustic estimate of biomass for the sub-division.

Survey	# stations	Positive stations	Total eggs	Filtered vol. (m^3)	Tot. eggs/m^3	Biomass estimate
2007	156	83	9 750	1701	5.73	38 020
2008	186	106	9 185	1967	4.67	34 162
2009	193	82	3 764	2028	1.86	24 745
2010	200	150	9 703	2062	4.71	7 395
2011	194	107	15 012	1926	7.79	0

Table 4.3.2.2. Anchovy in Division IXa. Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) in Division IXa from Portuguese (*SAR-PELAGO* series) and Spanish surveys (*ECOCÁDIZ* series, only for IXa-South, shadowed).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Nov. 98	**N**	30	122	50	203	2346	2396	2549
Mar. 99	**N**	22	15	*	37	2079	2079	2116
Nov. 99	**N**	-	-	-	-	-	-	-
Mar. 00	**N**	-	-	-	-	-	-	-
Nov. 00	**N**	4	20	*	23	4970	4970	4994
Mar. 01	**N**	25	13	285	324	2415	2700	2738
Nov. 01	**N**	35	94	-	129	3322	3322	3451
Mar. 02	**N**	22	156	92	270	3731 **	3823 **	4001 **
Nov. 02	**N**	-	-	-	-	-	-	-
Feb. 03	**N**	0	14	*	14	2314	2314	2328
Nov. 03	**N**	-	-	-	-	-	-	-
Mar. 04	**N**	-	-	-	-	-	-	-
Jun. 04* **	**N**	-	-	125	-	1109	1235	-
Nov. 04	**N**	-	-	-	-	-	-	-
Apr. 05	**N**	-	59	-	59	1306	1306	1364
Nov. 05	**N**	-	-	-	-	-	-	-
Apr. 06	**N**	-	-	319	319	1928	2246	2246
Jun. 06	**N**	-	-	363	-	2801	3163	-
Nov. 06	**N**	-	-	-	-	-	-	
Apr. 07	**N**	0	103	284	387	2860	3144	3247
Jul. 07	**N**	-	-	558	-	1232	1790	-
Nov. 07	**N**	0	59	475	534	1386	1862	1921
Apr.08	**N**	69	252	213	534	1819	2032	2353
Apr.09	**N**	127	0****	159	286	1910	2069	2196
Jul. 09	**N**	-	-	35	-	1102	1137	-
Apr. 10	**N**	0	62	0	62	963	963	1026
Jul. 10	**N**			?	-	954	954 +	-
Apr. 11	**N**	1558	0	0	1558	0	0	1558

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz.** Corrected estimates after detection of errors in the sA values attributed to the Cadiz area (Marques & Morais, 2003). ***Possible underestimation: shallow waters between 20 and 30 m depth were not acoustically sampled. ****Possible underestimation: although no echo-traces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming directly this. + Partial estimate due to an incomplete coverage of the sub-division (only the Spanish part).

Table 4.3.2.3. Anchovy in Division IXa. Historical series of overall and regional acoustic estimates of anchovy biomass (B, tonnes) in Division IXa from Portuguese (*SAR-PELAGO* series) and Spanish surveys (*ECOCÁDIZ* series, only for IXa-South, shadowed).

Survey	Estimate	Portugal				Spain	S(Total)	TOTAL
		C-N	C-S	S(A)	Total	S(C)		
Nov. 98	**B**	313	1951	603	2867	30092	30695	32959
Mar. 99	**B**	190	406	*	596	24763	24763	25359
Nov. 99	**B**	-	-	-	-	-	-	-
Mar. 00	**B**	-	-	-	-	-	-	-
Nov. 00	**B**	98	241	*	339	33909	33909	34248
Mar. 01	**B**	281	87	2561	2929	22352	24913	25281
Nov. 01	**B**	1028	2276	-	3304	25578	25578	28882
Mar. 02	**B**	472	1070	1706	3248	19629 **	21335 **	22877 **
Nov. 02	**B**	-	-	-	-	-	-	-
Feb. 03	**B**	0	112	*	112	24565	24565	24677
Nov. 03	**B**	-	-	-	-	-	-	-
Mar. 04	**B**	-	-	-	-	-	-	-
Jun. 04* **	**B**	-	-	2474	-	15703	18177	-
Nov. 04	**B**	-	-	-	-	-	-	-
Apr. 05	**B**	-	1062	-	1062	14041	14041	15103
Nov. 05	**B**	-	-	-	-	-	-	-
Apr. 06	**B**	-	-	4490	4490	19592	24082	24082
Jun. 06	**B**	-	-	6477	-	30043	36521	-
Nov. 06	**B**	-	-	-	-	-	-	
Apr. 07	**B**	0	1945	4607	6552	33413	38020	39965
Jul. 07	**B**	-	-	11639	-	17243	28882	-
Nov. 07	**B**	0	1120	7632	8752	16091	23723	24843
Apr. 08	**B**	3000	2505	4661	10166	29501	34162	39667
Apr.09	**B**	2089	0****	3759	5848	20986	24745	26834
Jul. 09	**B**	-	-	1075	-	20506	21580	-
Apr. 10	**B**	0	1188	0	1188	7395	7395	8583
Jul. 10	**B**			?	-		12339 +	-
Apr. 11	**B**	27050	0	0	27050	0	0	27050

* Due to the distribution observed during the survey, the last transect (near the border with Spain) that normally belongs to the Algarve sub-area was included in Cadiz.** Corrected estimates after detection of errors in the sA values attributed to the Cadiz area (Marques & Morais, 2003). ***Possible underestimation: shallow waters between 20 and 30 m depth were not acoustically sampled. ****Possible underestimation: although no echo-traces attributable to the species were detected in this area, however, the loss of pelagic gear samplers prevented from confirming directly this. + Partial estimate due to an incomplete coverage of the sub-division (only the Spanish part).

Table 4.3.2.4. Anchovy in Division IXa. Sub-division IXa South. *ECOCÁDIZ 0710* summer Spanish acoustic survey in Sub-division IXa South in 2010. Comparison of species-specific acoustic estimates from this survey with those ones derived from the same area during the *ECOCÁDIZ 0609* survey. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias;* JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops;*

Estimate/Survey	PIL	ANE	MAS	JAA	HOM	HMM	BOG	TOTAL
Biomass (t) ***ECOCÁDIZ 0609***	33 140	20 506	31 263	2 762	2 209	2 705	2 324	**94 909**
Biomass (t) ***ECOCÁDIZ 0710***	66 964	12 339	2 861	4 126	739	3 732	551	**91 354**
Abundance (millions) ***ECOCÁDIZ 0609***	588	1 102	304	48	40	28	27	**2 137**
Abundance (millions) ***ECOCÁDIZ 0710***	2 068	954	43	65	13	28	6	**3 177**

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

Year	Age		
	0	1	2+
1988	0	0,82	1
1989	0	0,53	1
1990	0	0,65	1
1991	0	0,76	1
1992	0	0,53	1
1993	0	0,77	1
1994	0	0,60	1
1995	0	0,76	1
1996	0	0,49	1
1997	0	0,63	1
1998	0	0,55	1
1999	0	0,74	1
2000	0	0,70	1
2001	0	0,76	1
2002	0	0,72	1
2003	0	0,69	1
2004	0	0,95	1
2005	0	0,95	1
2006	0	0,77	1
2007	0	0,91	1
2008	0	0,97	1
2009	0	0,99	1
2010	0	0,97	1

Table 4.5.1.1. Anchovy in Division IXa. Anchovy in Sub-division IXa South (Algarve + Gulf of Cadiz). Updated input values usually needed for running the *ad hoc* seasonal separable assessment model with indication of the runs performed in last years.

Anchovy IXa-South (Algarve+Gulf of Cadiz)
Years: 1995-2010
Fleets: All

Half-year landings (in tonnes, 1995-2010)

1995		1996		1997		1998		1999		2000		2001		2002	
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
265	305	848	983	2018	2596	3957	5586	3633	2309	1083	1276	4285	4370	4740	3523

2003		2004		2005		2006		2007		2008		2009		2010	
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
3567	1401	3361	2257	3635	787	3951	430	3831	1779	1720	1484	1843	1151	1776	1153

Half-year Catch in number (in millions) at age (1995-2010)

	1995		1996		1997		1998		1999		2000		2001		2002	
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
0	0	34,50	0	495,13	0	335,67	0	465,60	0	126,26	0	129,46	0	161,95	0	77,89
1	26,51	7,45	143,75	19,89	191,06	89,10	722,99	341,82	422,57	109,26	161,65	58,89	354,92	220,76	548,23	195,09
2	0,19	0	0,90	1,21	32,46	12,41	12,03	1,51	32,29	2,65	3,51	0,55	19,70	5,29	8,50	9,93
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	2003		2004		2005		2006		2007		2008		2009		2010	
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
0	0	95,72	0	123,63	0	38,75	0	12,45	0	62,11	0	58,31	0	11,53	0	30,63
1	333,99	73,28	323,34	97,73	449,26	37,39	450,39	41,93	455,32	107,16	91,06	48,79	119,50	68,87	155,31	60,09
2	13,15	0,63	1,81	0,92	3,21	0,33	5,27	0,00	6,76	0,63	23,83	7,45	18,64	2,01	5,87	5,90
3	0	0	0	0	0	0	0	0	0	0	0,40	0	1,90	0,86	0,10	0,02

Mean weight at age in the stock (in g) and natural mortality (half-year) estimates

AGE	Mean weight																Natural mortality
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
0	7,03	1,06	2,57	2,65	3,19	3,14	6,21	3,32	5,98	6,64	4,94	3,65	5,36	7,18	4,12	6,73	0,6
1	10,72	6,26	11,06	7,40	12,84	9,96	13,29	10,50	10,57	12,01	9,17	8,21	9,44	14,93	12,19	11,47	0,6
2	22,55	19,98	20,90	20,45	19,99	23,82	31,76	26,29	26,79	21,87	22,62	20,97	20,39	21,77	20,26	19,19	0,6
3	29,00	29,00	29,00	29,00	29,00	29,00	29,00	29,00	29,00	29,00	29,00	29,00	29,00	23,09	24,21	23,01	0,6

Acoustic Biomass estimates (tonnes) in Sub-division IXa South (Algarve+Gulf of Cadiz) (Portuguese surveys). Only Spring surveys series was considered in the last year's assessment.

Nov.-98	Mar.-99	Nov.-99	Mar.-00	Nov.-00	Mar.-01	Nov.-01	Mar.-02	Nov.-02	Feb.-03	Nov.-03	Mar.-04	Nov.-04
30695	24763	-	-	33909	24913	25580	21335	-	24565	-	-	-

Apr.-05	Nov.-05	Apr.-06	Nov.-06	Apr.-07	Nov.-07	Apr.-08	Nov.-08	Apr.-09	Nov.-09	Apr.-10	Apr.-11
14041	-	24082	-	38020	23723	34162	-	24745	-	7395	0

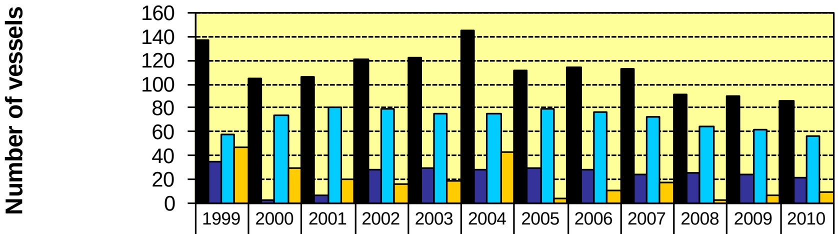
DEPM Biomass estimates (tonnes) in Sub-division IXa-South (Algarve+Gulf of Cádiz) (Spanish surveys). Not included in the exploratory analytical assessment.

Jun.-05	Jun.-06	Jun.-07	Jun.-08
14637	-	-	31527

Exploratory runs with the seasonal separable model

	Portuguese March Ac. Surv.	Biomass Index	Weighting factor for index	F assumptions	Wage stock
RUN1	1999-2011	Relative	1	2009Fratio for FHY2-2010. FHY1-2011:average FHY1 in 3 last years (08-10).	Wage stock in 2011 as the average in 07-10
RUN2		Relative	6		
RUN3		Absolute	1		

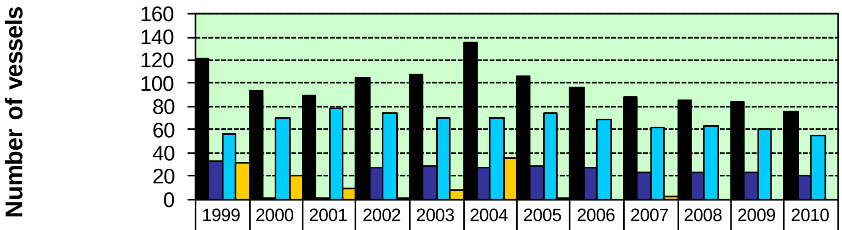
Spanish purse-seine fleets in the Gulf of Cadiz
Total number of operative vessels/fleet type



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

Year

Spanish purse-seine fleets in the Gulf of Cadiz
No. of operative vessels fishing anchovy/fleet type



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

Year

Spanish purse-seine fleets in the Gulf of Cadiz
Percentage of operative vessels fishing anchovy

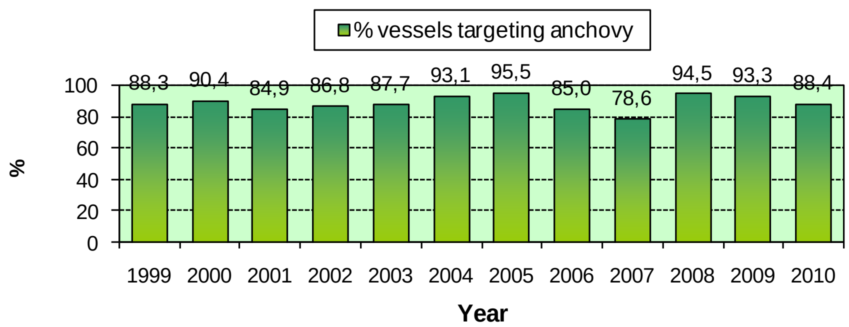


Figure 4.2.1.1. Anchovy in División IXa. Sub-division IXa-South. Spanish purse-seine fishery. Fleet composition operating in the Gulf of Cadiz fishery since 1999. The fleet is differentiated into total fleet and vessels targeting anchovy. The categories include both single purpose purse-seiners and trawl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

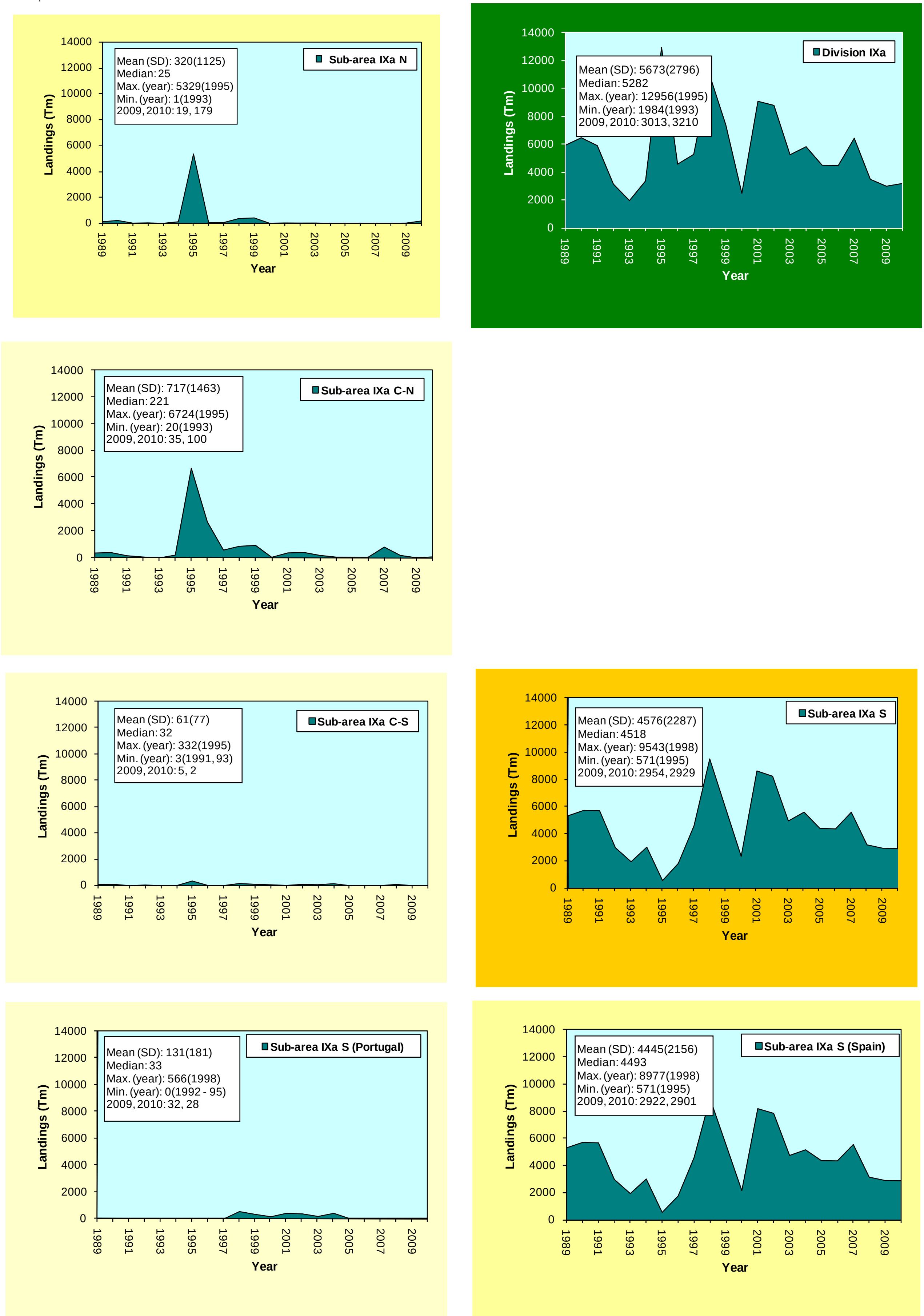


Figure 4.2.2.1.1. Anchovy in Division IXa. Recent series of Portuguese and Spanish (1989-2010) anchovy landings in Division IXa. Sub-areas arranged according to its geographical location along the Atlantic Iberian Peninsula. Series for the whole Division and for the whole Sub-area IXa-South are also shown.

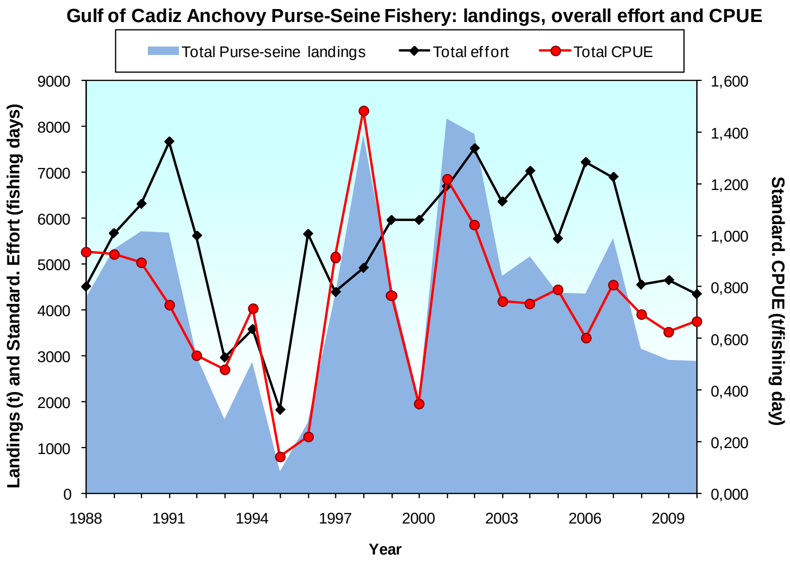


Figure 4.2.4.1. Anchovy in Division IXa. Sub-division IXa-South. Spanish purse-seine fishery. Trends in Gulf of Cadiz anchovy annual landings, and purse-seine fleets' standardised overall effort and CPUE.

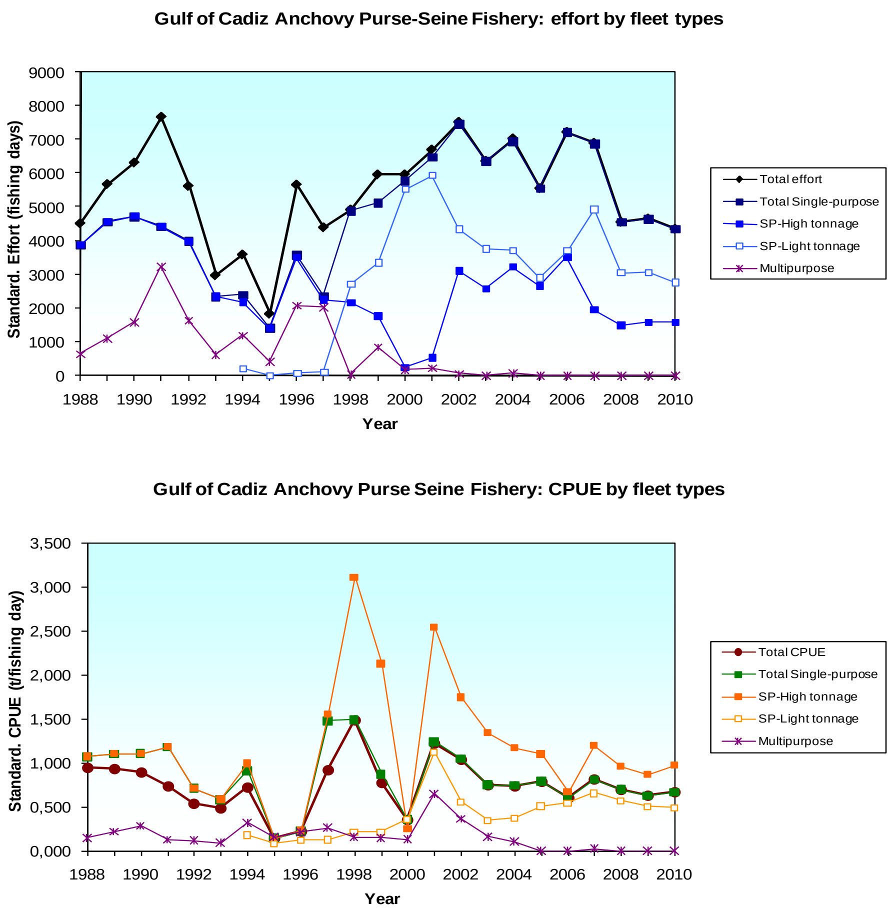


Figure 4.2.4.2. Anchovy in Division IXa. Sub-division IXa-South. Spanish purse-seine fishery. Trends in annual series of anchovy-specific standardized effort (upper panel) and standardized CPUE (bottom panel) by fleet type. Single-purpose fleet is also differentiated in heavy and light GRT vessels.

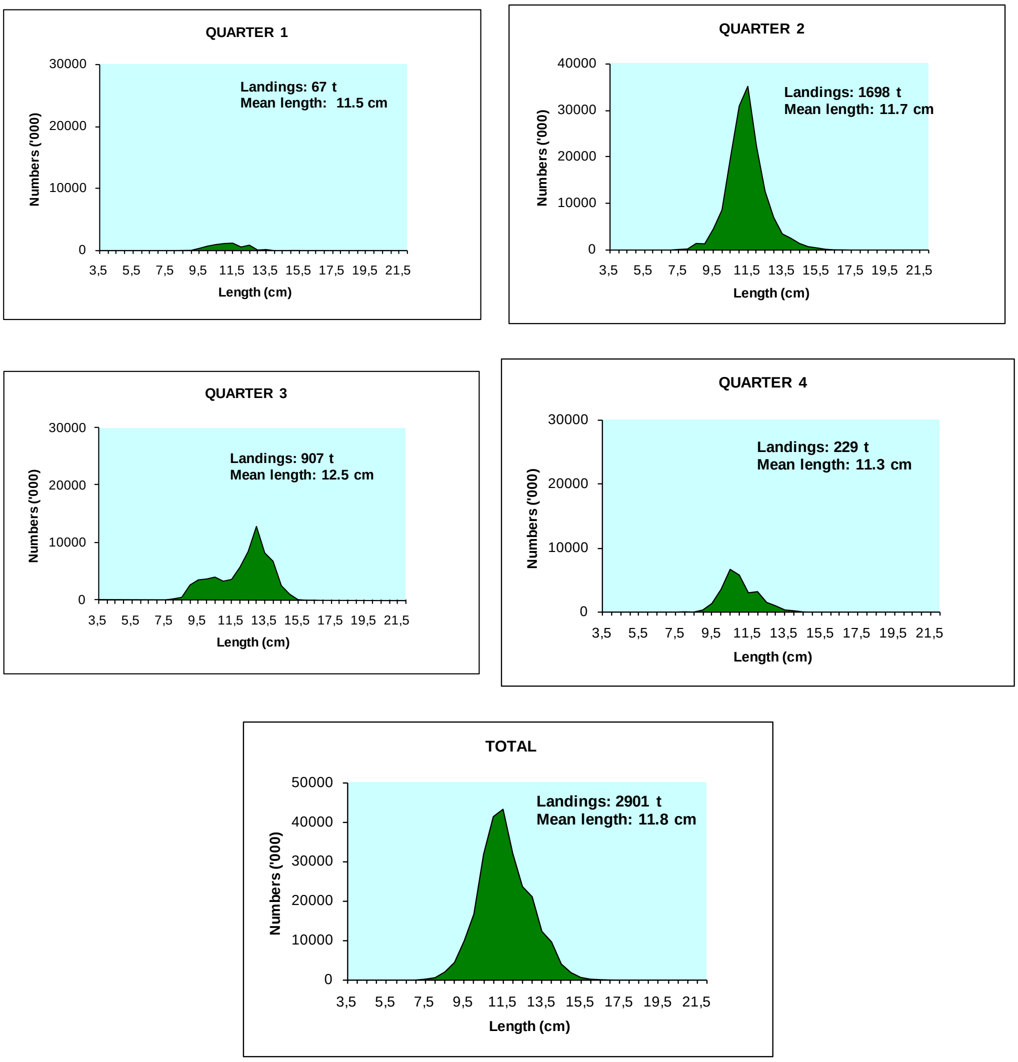


Figure 4.2.5.1.1. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Quarterly and annual length distributions ('000) of Spanish landings of Gulf of Cadiz anchovy in 2010. Without data for the Spanish Sub-division IXa-North (Western Galicia) and for all the Portuguese Sub-divisions.

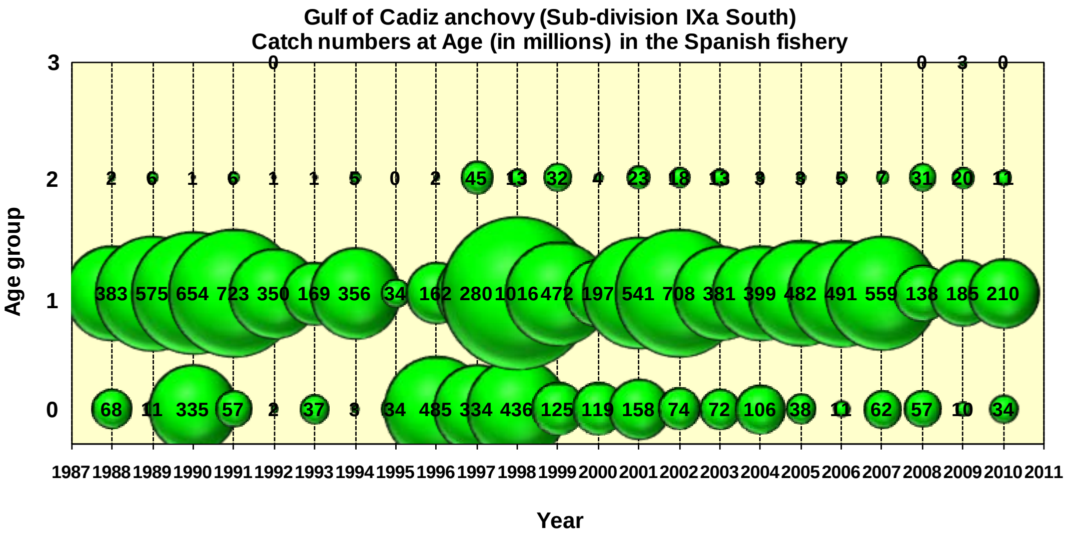
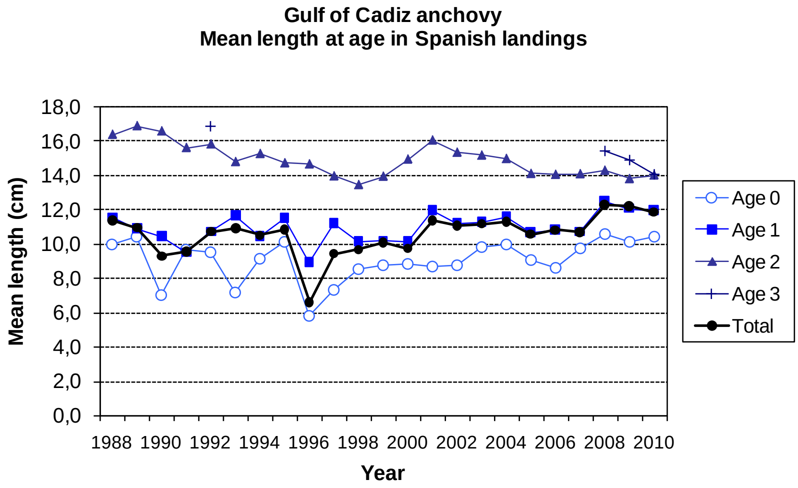


Figure 4.2.5.2.1. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Age composition in Spanish landings of Gulf of Cadiz anchovy (1988-2010). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.



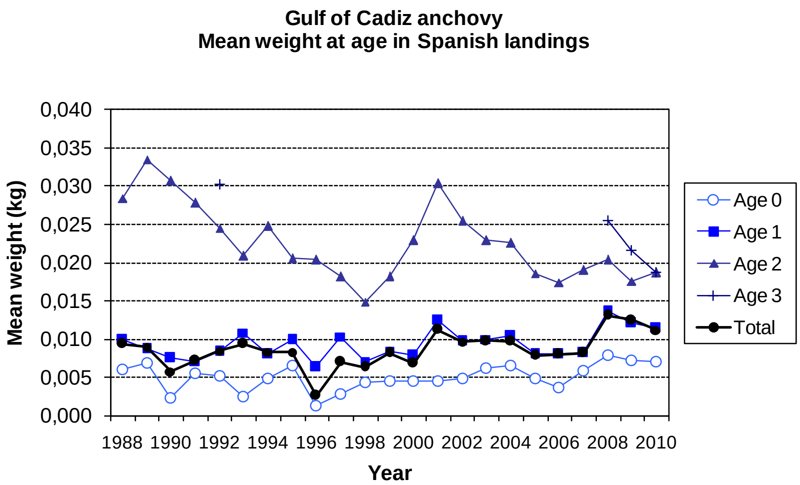


Figure 4.2.6.1. Anchovy in Division IXa. Sub-division IXa-South. Spanish fishery (all fleets). Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Gulf of Cadiz anchovy (1988-2010). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

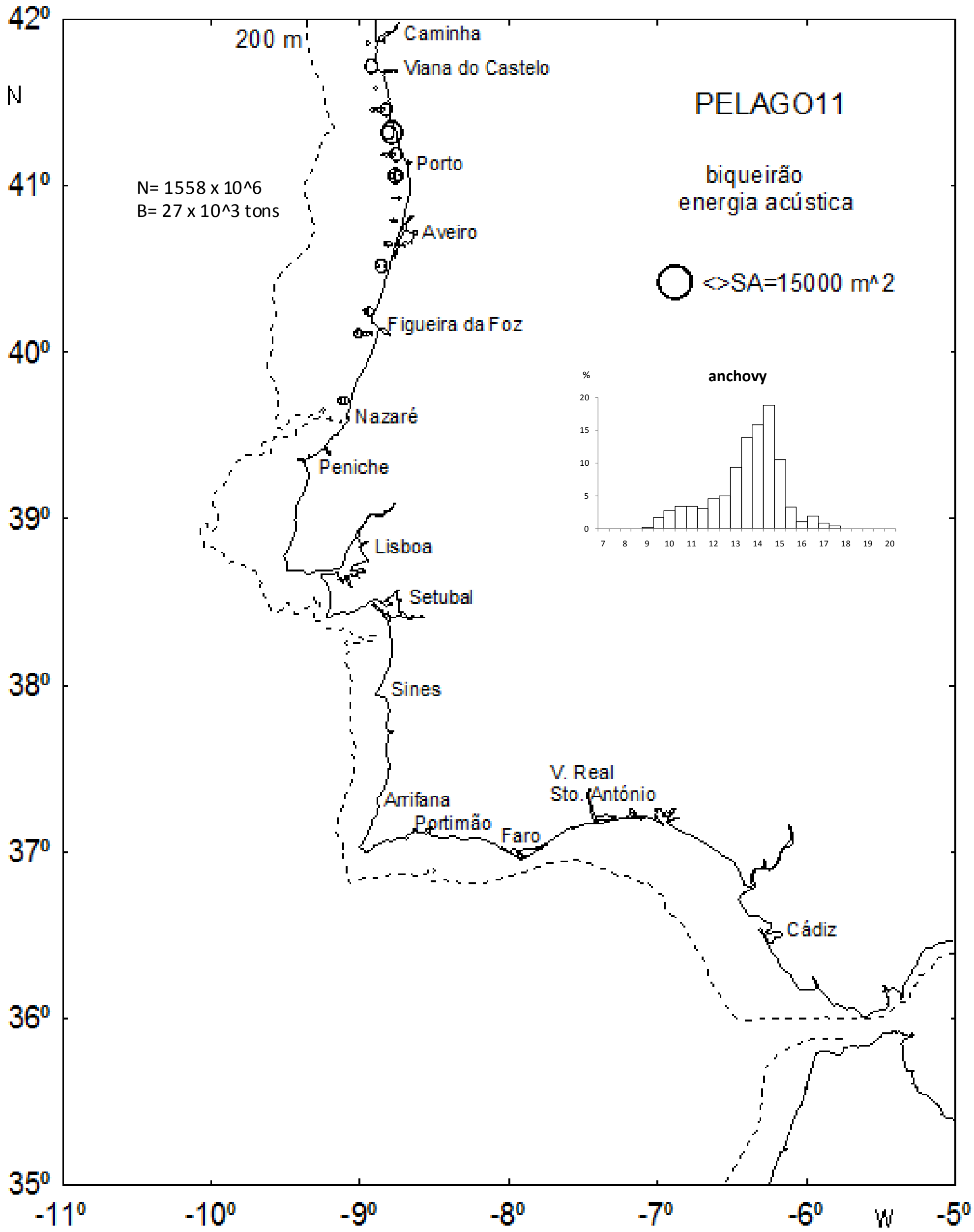


Figure 4.3.2.1. Anchovy in Division IXa. *PELAGO11* spring Portuguese acoustic survey in Division IXa in 2011. Distribution of the *NASC* coefficients (m²/mn²) attributed to anchovy, acoustic estimates and size composition of the estimated populations by subareas.

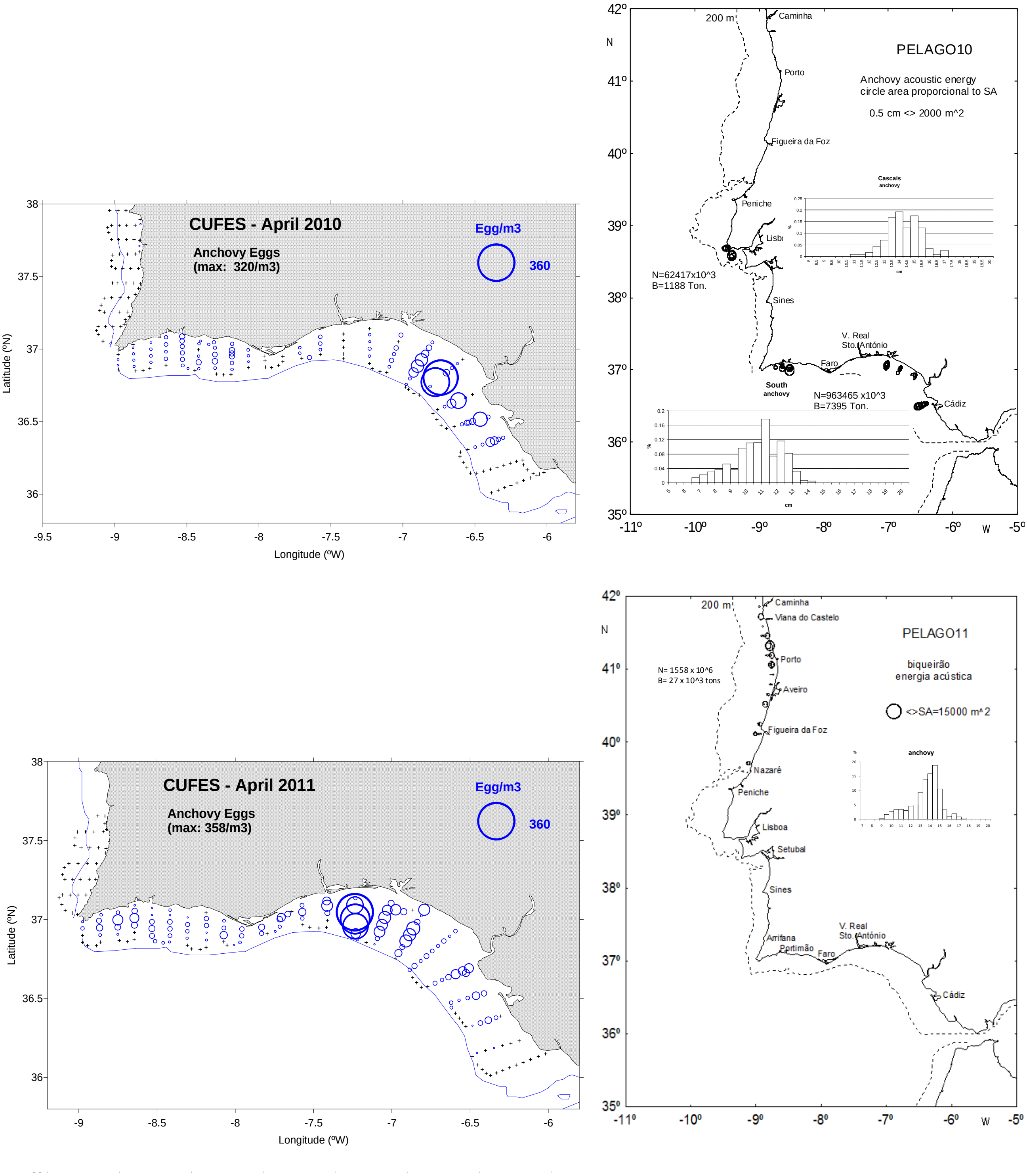


Figure 4.3.2.2. Anchovy in Division IXa. in 2010 and 2011. Anchovy egg densities (eggs/m3) sampled by CUFES in the 2010 (top) and 2011(bottom) *PELAGO* spring Portuguese acoustic surveys in Division IXa. Distribution of the *NASC* coefficients (m²/mn²) attributed to anchovy is also included for comparison.

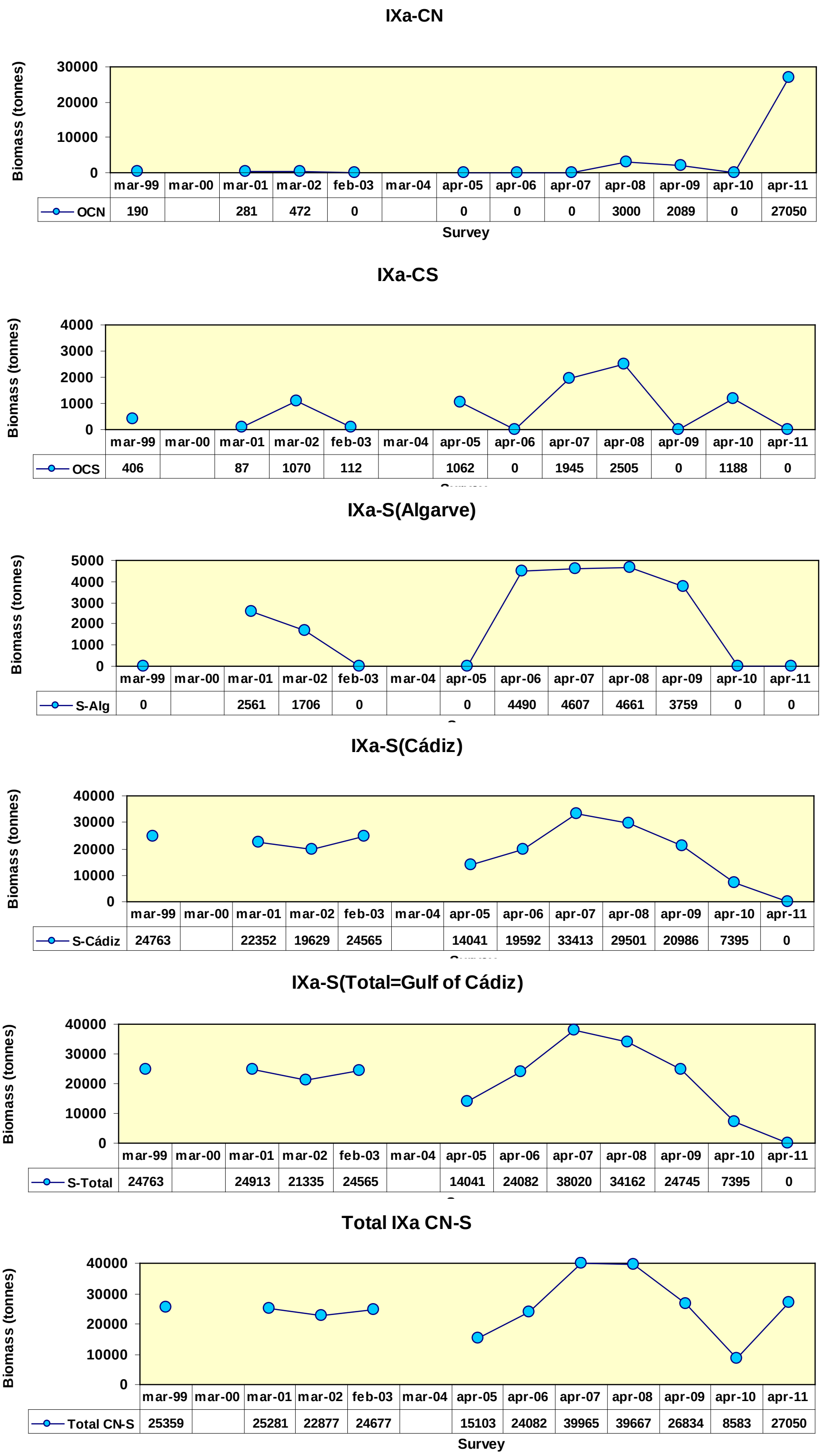


Figure 4.3.2.3. Anchovy in Division IXa. Historical series of acoustic estimates of anchovy biomass (t) from spring Portuguese surveys in the Division IXa (*SAR*-Spring/*PELAGO* survey series). Note the different scale on the y-axis. Although estimates from Subdivision IXa-South in 2010 were not separately provided for Algarve and Cadiz to this WG, the total estimated for the Sub-division was assigned (by assuming some overestimation) to the Cadiz area according to the observed acoustic energy distribution in the area.

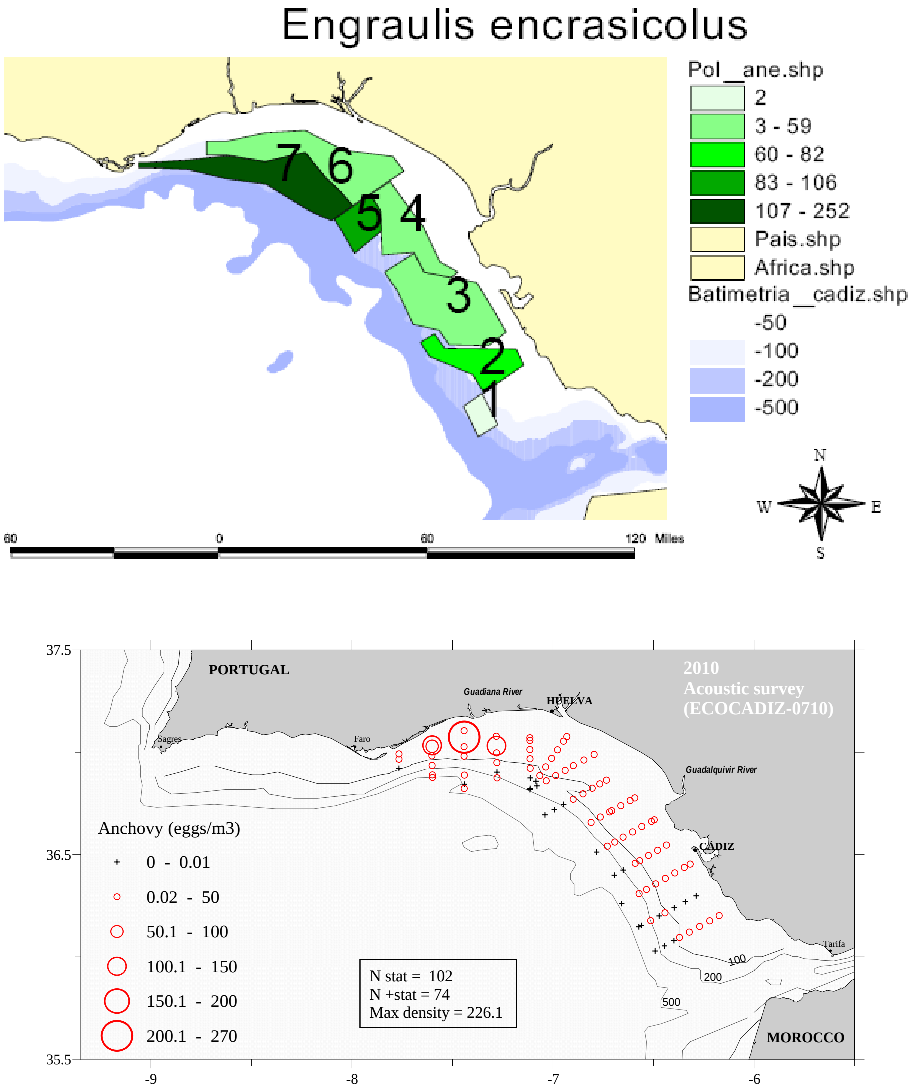


Figure 4.3.2.4. Anchovy in Division IXa. Sub-division IXa South. *ECOCÁDIZ 0710*. Summer Spanish acoustic survey in Sub-division IXa South in 2010. Top: distribution of the *NASC* coefficients (m^2/mn^2) attributed to anchovy. Polygons (*i.e.*, coherent post-strata) encompass the observed echoes and homogenous size composition, and polygon colour indicates the mean value of *NASC* coefficients inside each polygon. Bottom: distribution of anchovy egg densities (eggs/ 100 m^3) as sampled by CUFES.

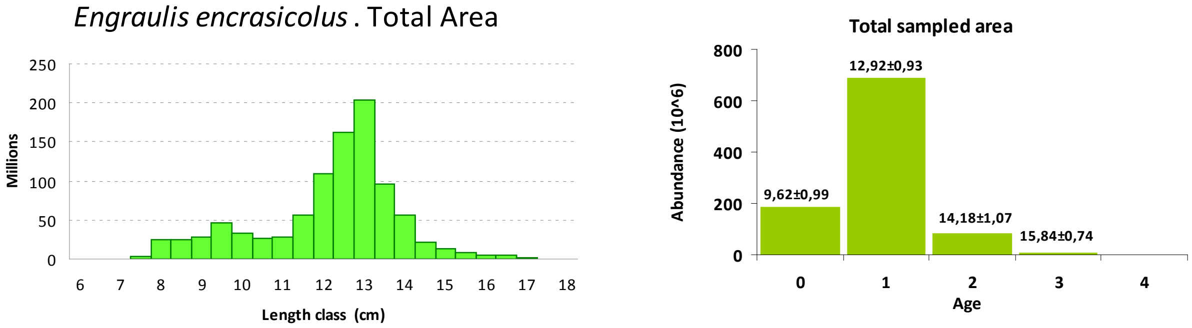


Figure 4.3.2.5. Anchovy in Division IXa. Sub-division IXa South. *ECOCÁDIZ 0710* Summer Spanish acoustic survey in Sub-division IXa South in 2010. Estimated anchovy abundances (millions) by (left) length class (cm) and (right) age class for the total surveyed area.

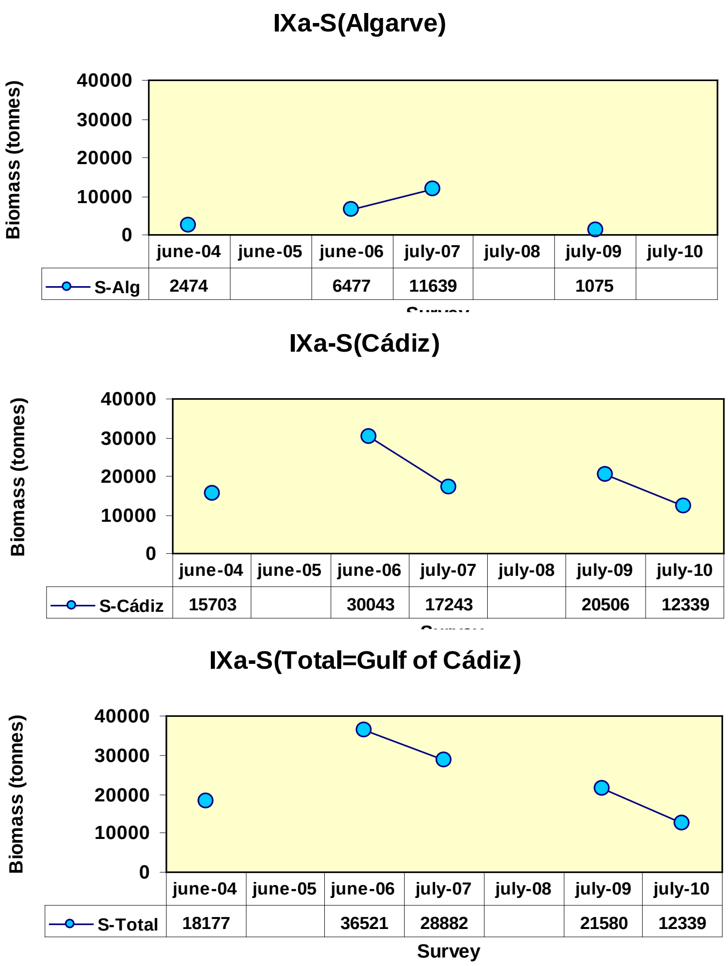


Figure 4.3.2.6. Anchovy in Division IXa. Sub-division IXa South. Historical series of acoustic estimates of anchovy biomass (t) from Summer Spanish surveys in the Subarea IXa-South (*ECOCÁDIZ* survey series).

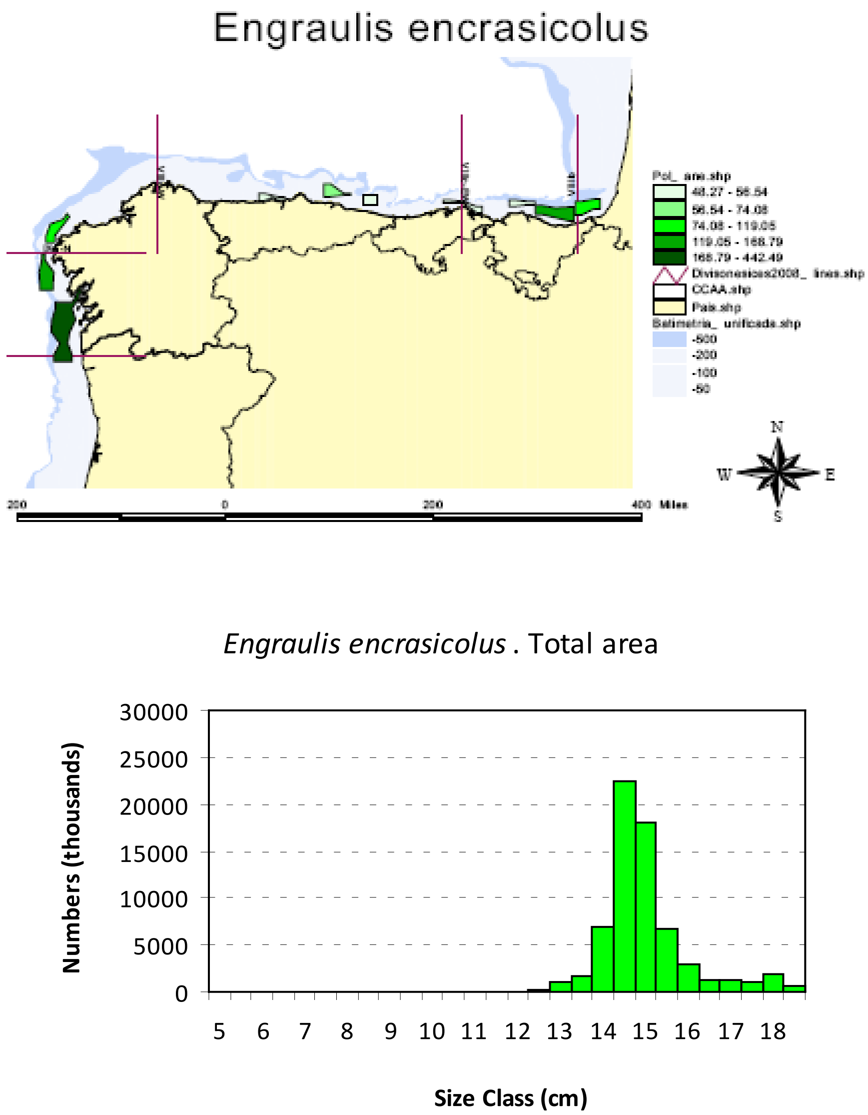


Figure 4.3.2.7. Anchovy in Division IXa. Sub-division IXa North. *PELACUS 0411* Spring Spanish acoustic survey in Sub-division IXa North and Sub-area VIII c in 2011. Top: distribution of the *NASC* coefficients (m^2/mn^2) attributed to anchovy. Sub-division IXa North corresponds to the south westernmost geographical stratum. Polygons (*i.e.*, coherent post-strata) encompass the observed echoes and homogenous size composition, and polygon colour indicates the mean value of *NASC* coefficients inside each polygon. Bottom: size composition of the estimated anchovy population in the Sub-division IXa North during the survey.

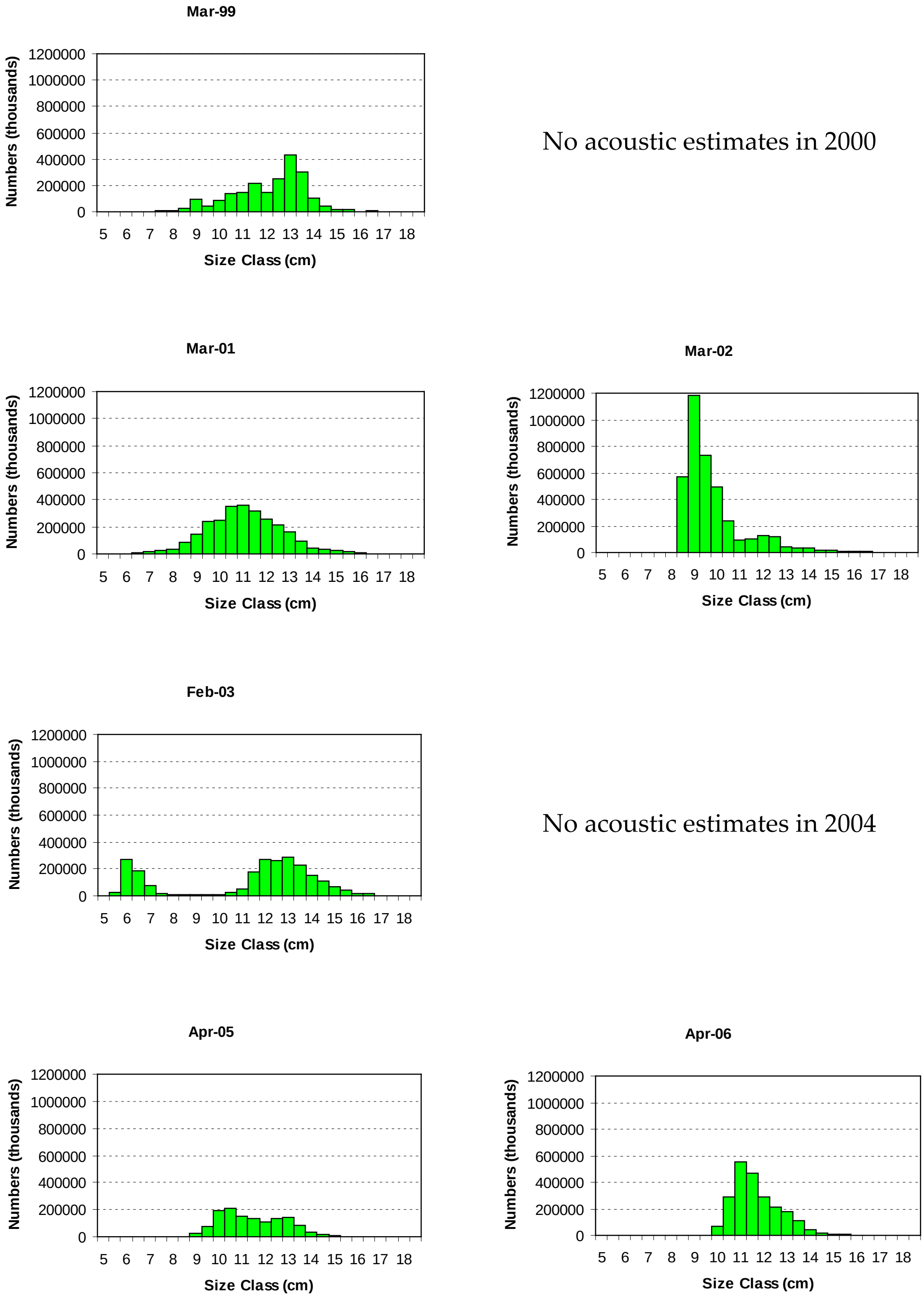


Figure 4.3.2.8. Anchovy in Division IXa. Sub-division IXa-South. Length composition of the estimated population from the Algarve + Gulf of Cádiz areas by the Portuguese spring acoustic surveys (1999-2011).

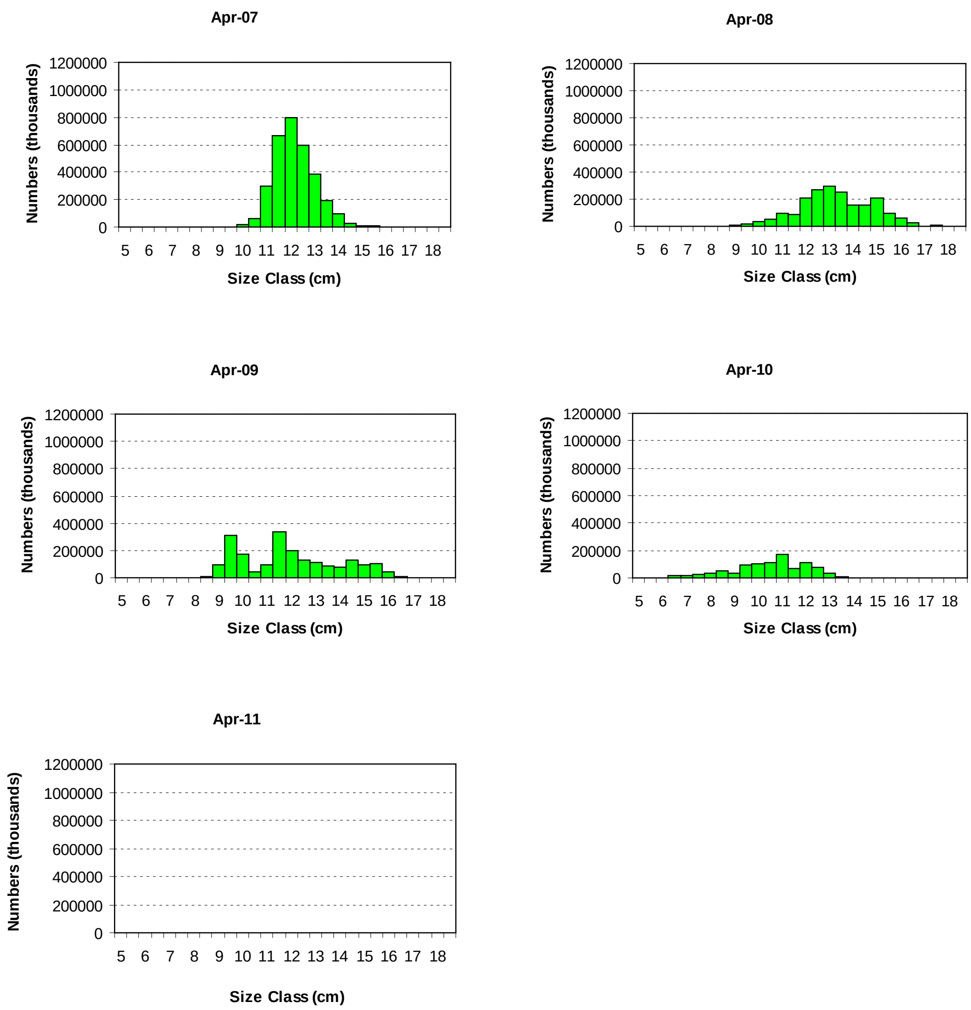


Figure 4.3.2.8 (cont'd).

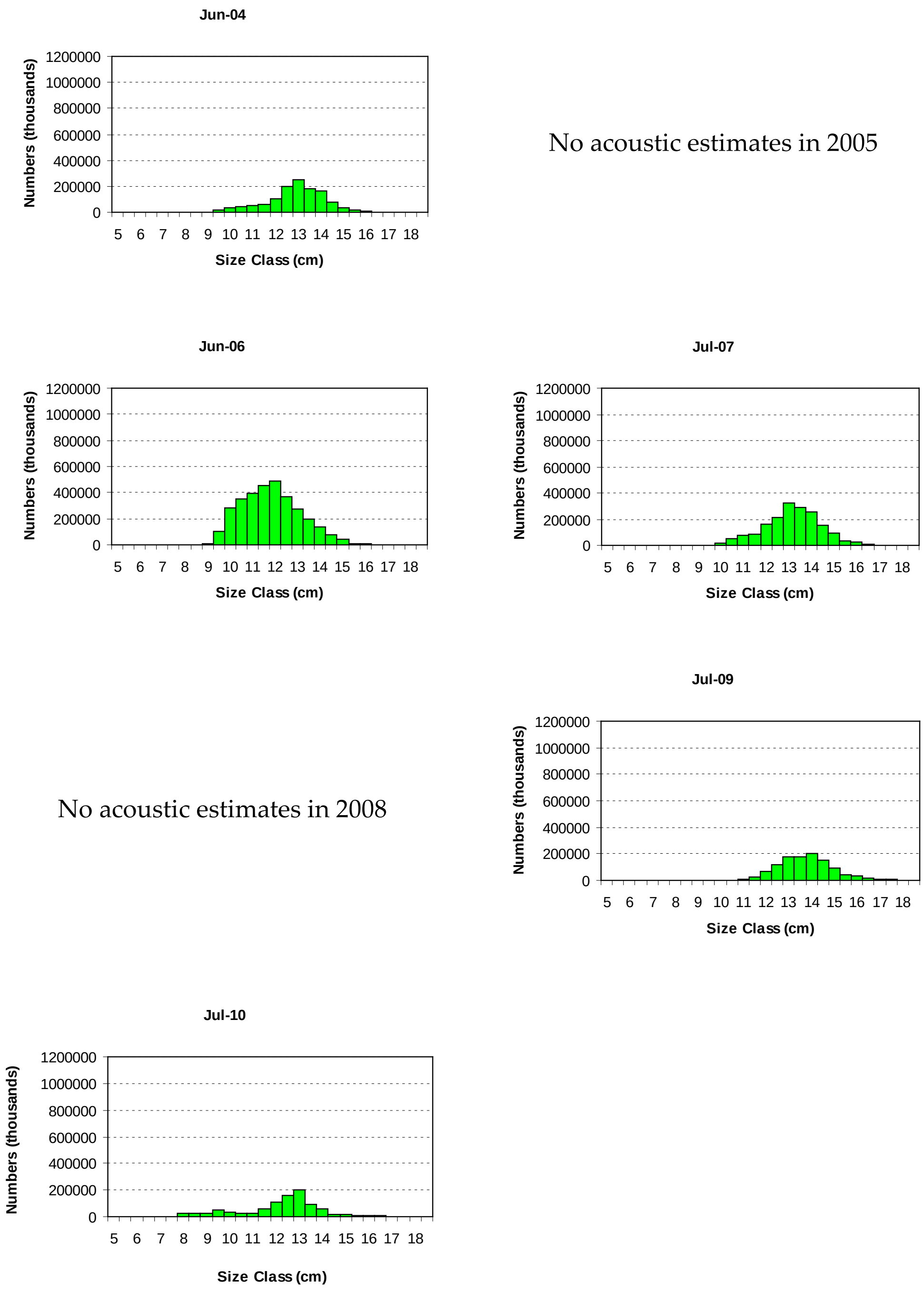


Figure 4.3.2.9. Anchovy in Division IXa. Sub-division IXa-South. Length composition of the estimated population from the Algarve + Gulf of Cádiz areas by the Spanish summer acoustic surveys (2004-2010, but with gaps). The 2010 size distribution only corresponds to the surveyed population that year, which only comprised those anchovies occurring between Cape Trafalgar and Cape Santa Maria. Note the same scale on y-axis than in Figure 4.3.2.8 for comparison.

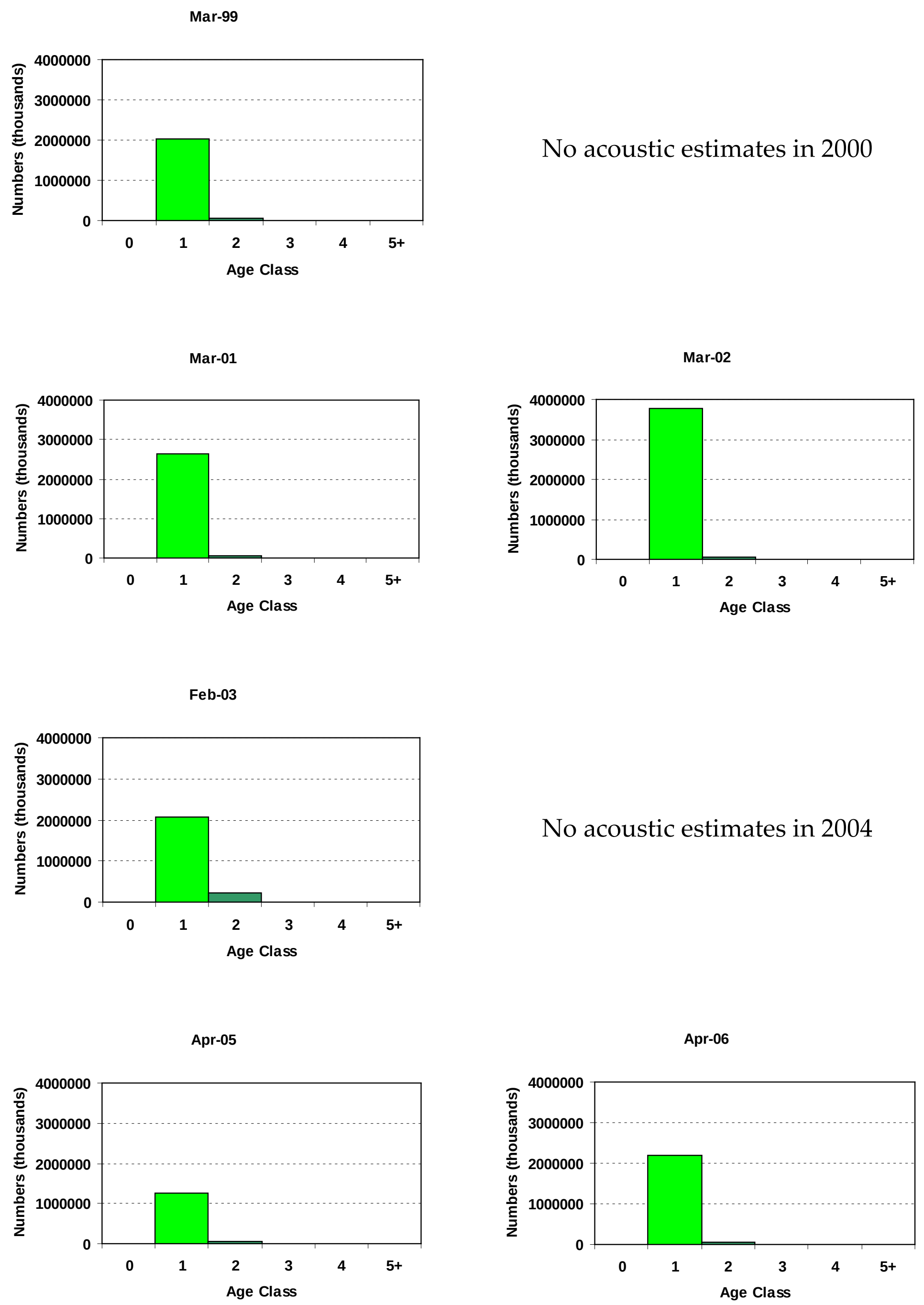


Figure 4.3.2.10. Anchovy in Division IXa. Sub-division IXa-South. Age structure of the estimated population from the Algarve + Gulf of Cádiz areas by the Portuguese spring acoustic surveys (1999-2011). Population age structure was estimated from the application of Spanish commercial age-length keys in the second semester in the survey's year to the estimated population numbers by length class from the corresponding survey.

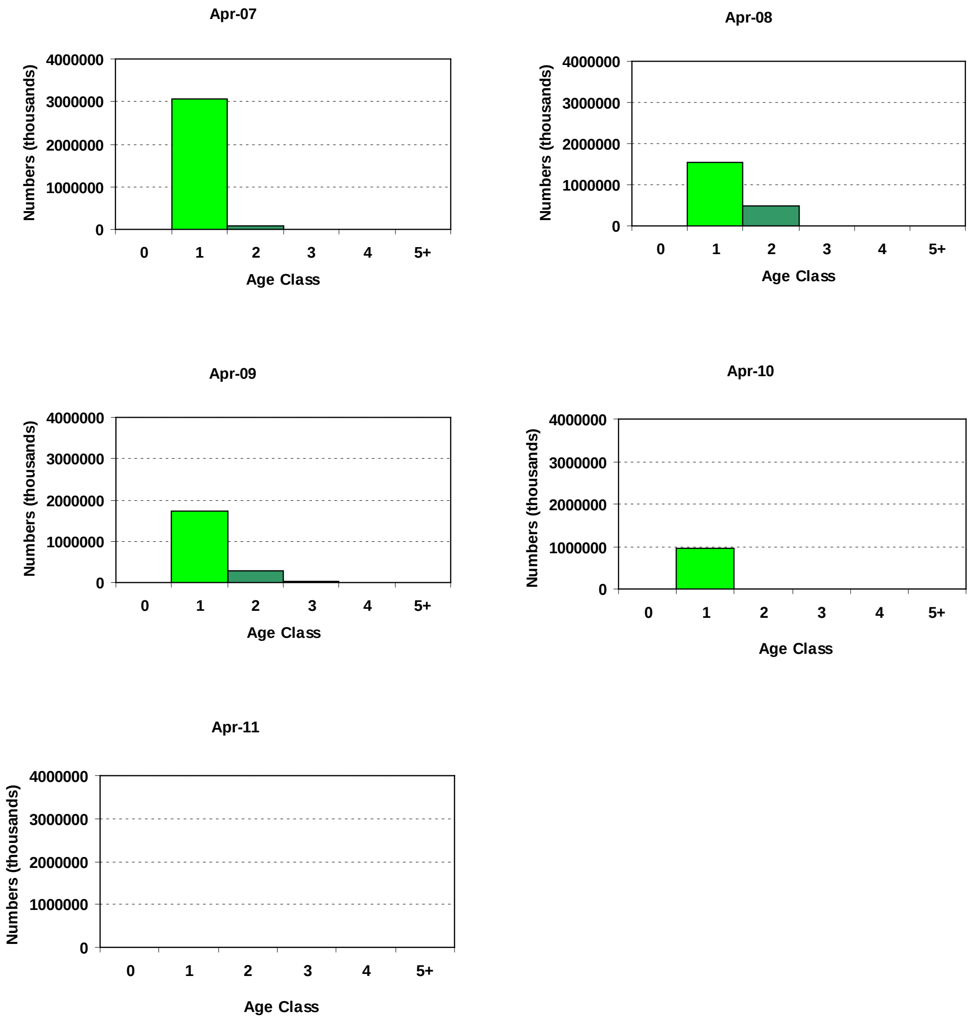
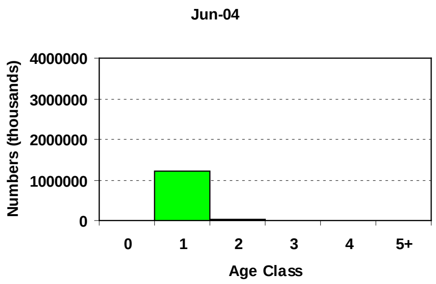
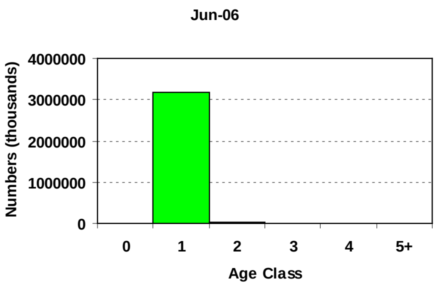
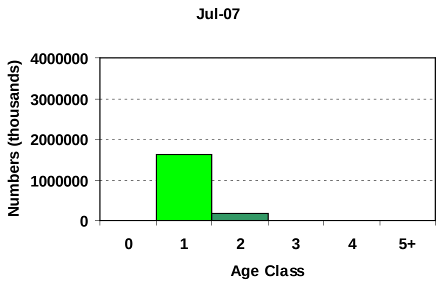


Figure 4.3.2.10 (cont'd).

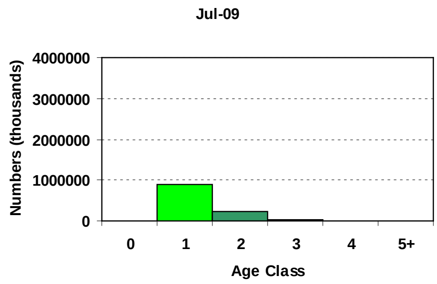


No acoustic estimates in 2005





No acoustic estimates in 2008



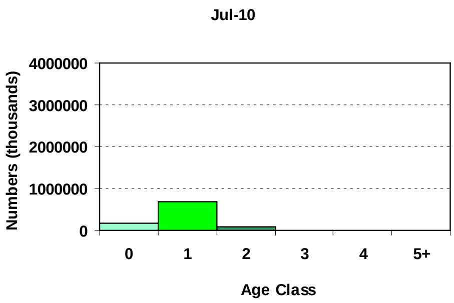
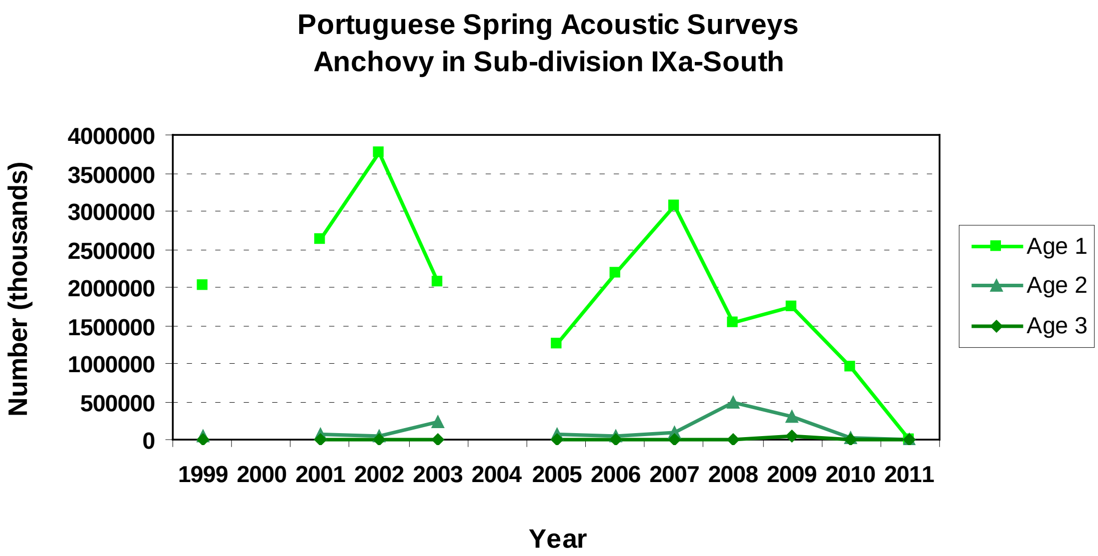


Figure 4.3.2.11. Anchovy in Division IXa. Sub-division IXa-South. Age structure of the estimated population from the Algarve + Gulf of Cádiz areas by the Spanish summer acoustic surveys (2004-2010, but with gaps). The 2010 age structure only corresponds to the surveyed population that year, which only comprised those anchovies occurring between Cape Trafalgar and Cape Santa Maria. Note the same scale on the y-axis than in Figure 4.3.2.10 for comparison.



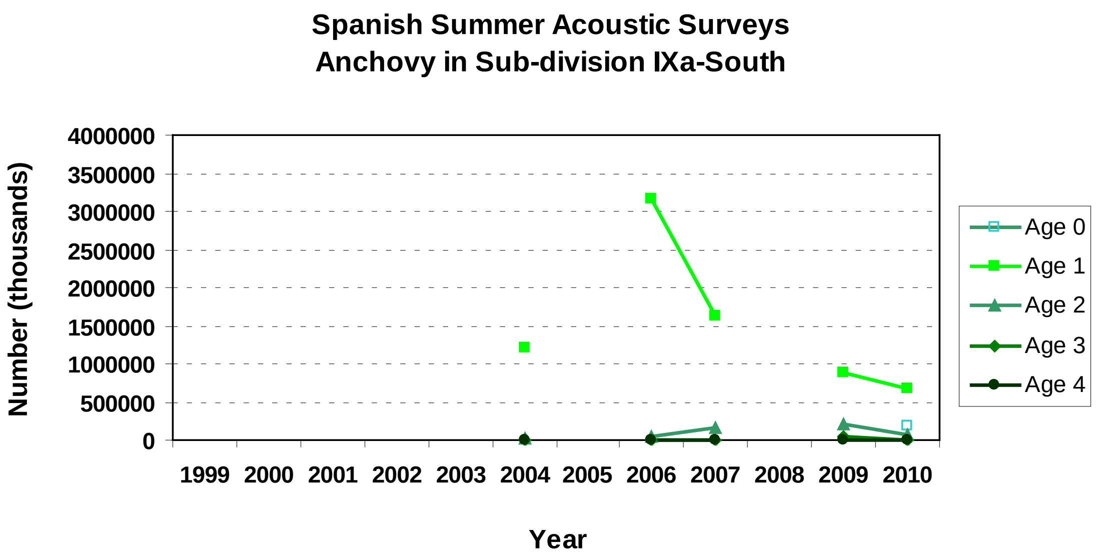


Figure 4.3.2.12. Anchovy in Division IXa. Sub-division IXa-South. Annual trends of the estimated population by age class from the Algarve + Gulf of Cádiz areas by the Portuguese Spring (upper plot) and Spanish summer (lower plot) acoustic surveys.

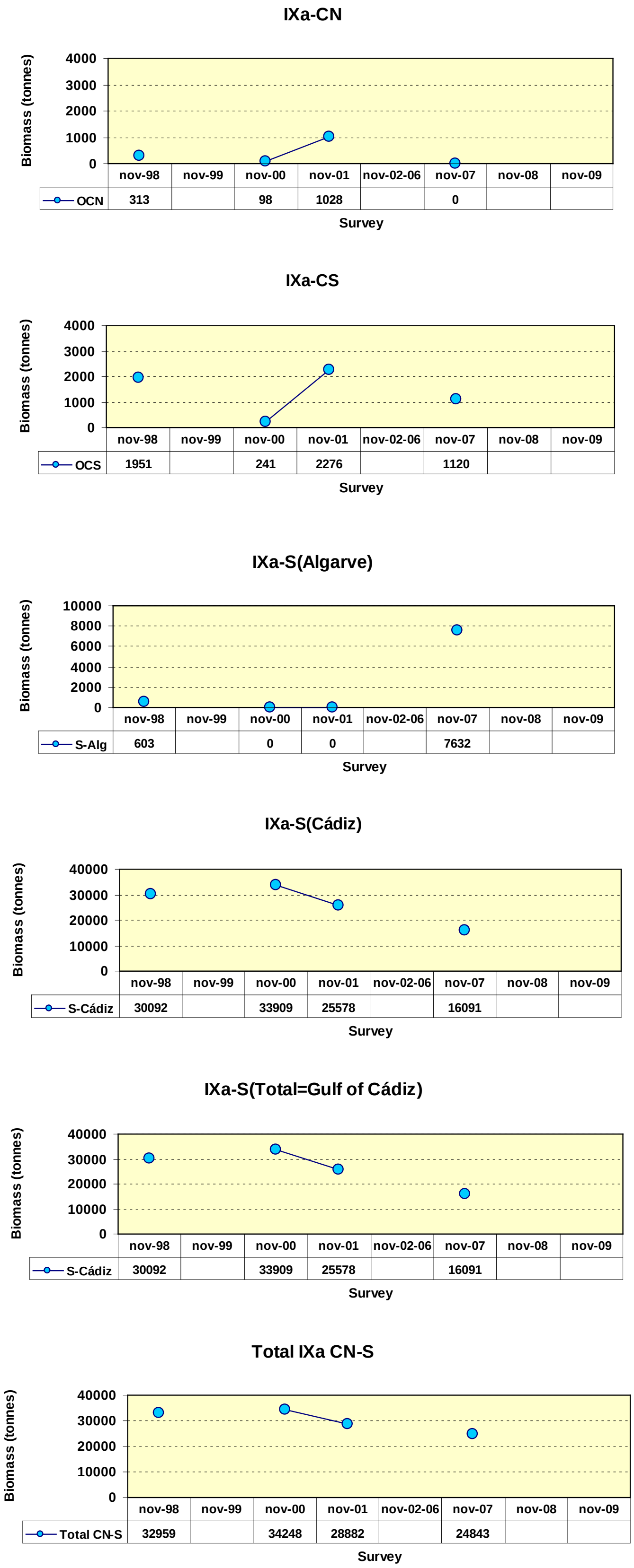


Figure 4.3.3.1. Anchovy in División IXa. Historical series of acoustic estimates of anchovy biomass (t) from autumn Portuguese surveys in the Division IXa. Note the different scale on the y-axis and how the missing data in the x-axis for the period 2002-2006 has been graphically solved.

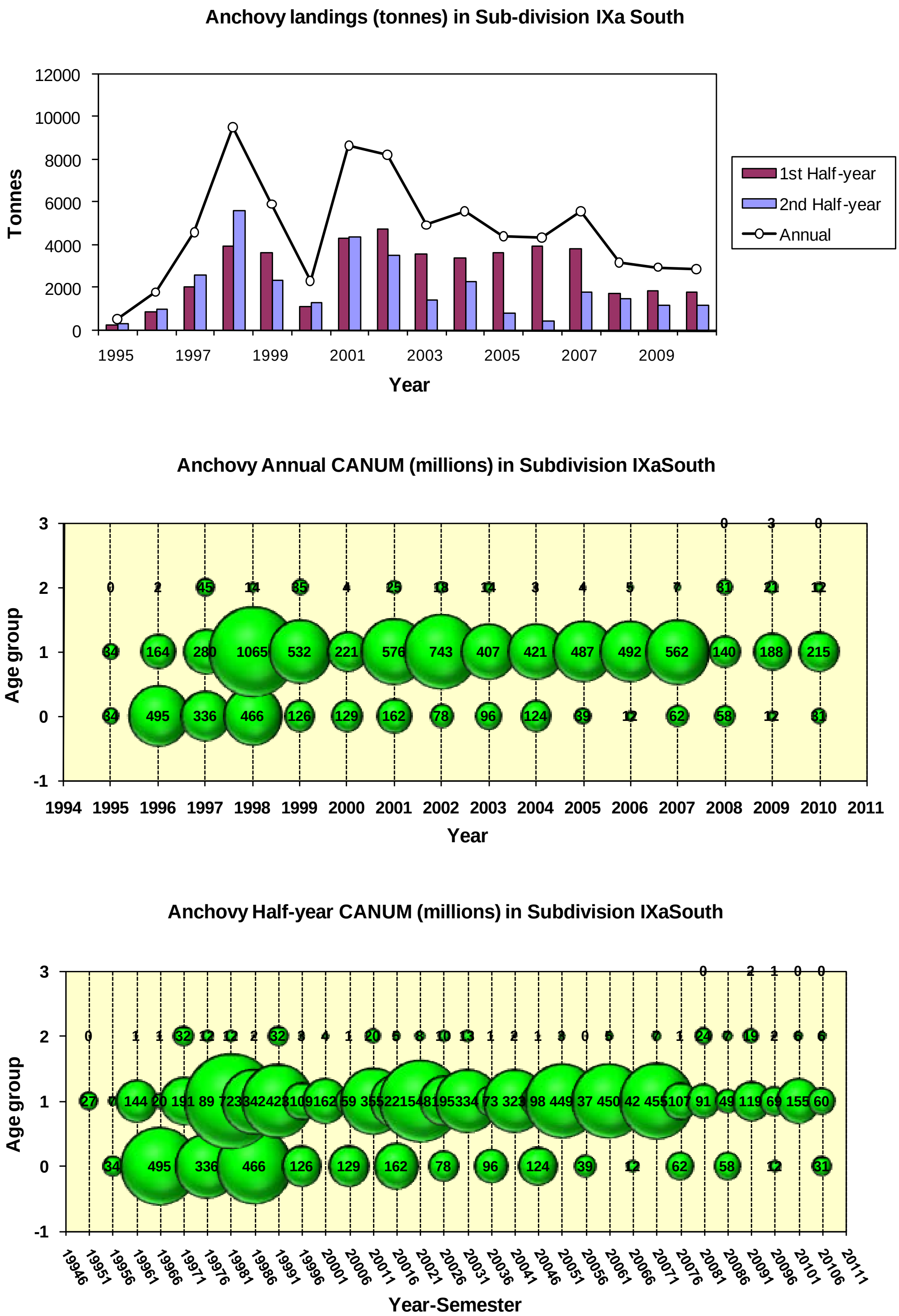
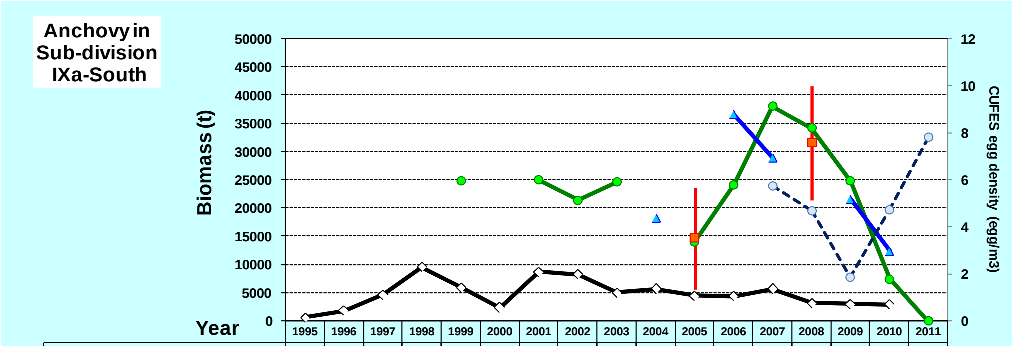


Figure 4.5.1.1. Anchovy in Division IXa. Sub-division IXa-South. Portuguese and Spanish fisheries (all fleets). Trends in Algarve + Gulf of Cadiz anchovy landings (upper panel) and catch-at-age numbers (both on an annual and half-year basis).



Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Spring Portuguese Acoustic Survey					24763		24913	21335	24565		14041	24082	38020	34162	24745	7395	0
Summer Spanish Acoustic Survey										18177		36521	28882		21580	12339*	?
Spring Spanish DEPM. Survey (SD)											14637			31527			
Total Landings IXa South	571	1831	4613	9543	5942	2360	8655	8262	4968	5617	4423	4381	5610	3204	2954	2929	
CUFES eggs dens													5,730	4,670	1,860	4,710	7,790

*: Only sampled the Spanish part of the Sub-division. ?: Next survey in July 2011

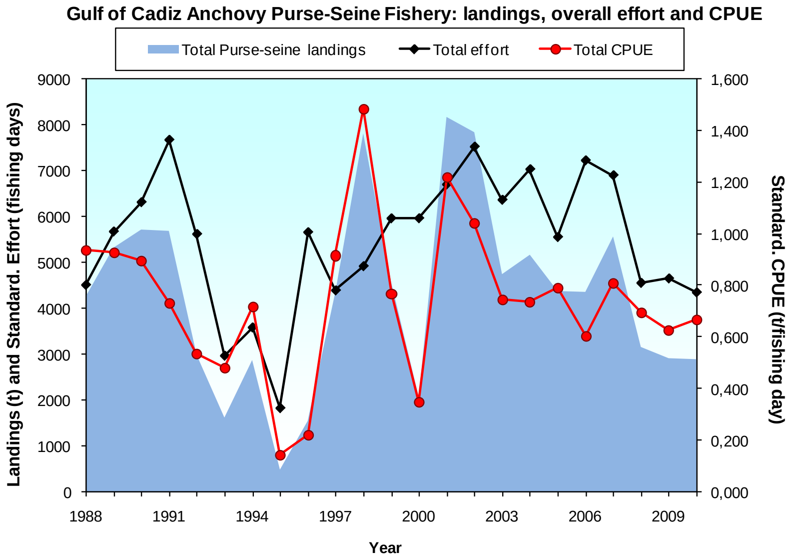
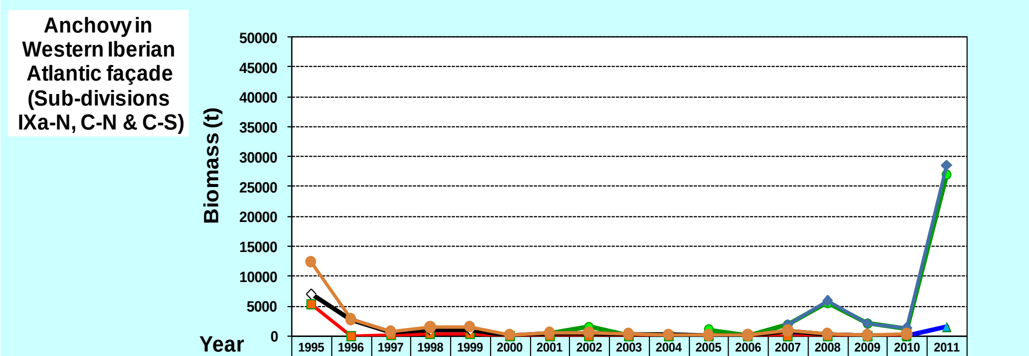
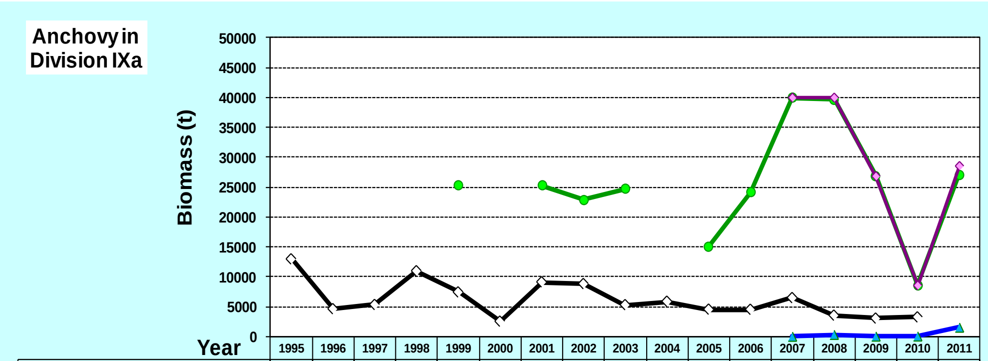


Figure 4.5.2.1. Anchovy in División IXa. Anchovy in Sub-division IXa-South. Information used in the Qualitative (Updated) Assessment. Upper panel: total annual landings (Algarve + Gulf of Cádiz) and available biomass estimates from research surveys series sampling the Sub-division used for comparative purposes. The 2010 Summer Spanish survey only partially explored the whole survey area. The 2011 DEPM survey will be conducted in mid/late July this year. Lower pannel: total annual landings, standardised fishing effort (fishing days) and CPUE (tonnes/fishing day) exerted by the Spanish purse-seine fleet in the Sub-division (same figure as Figure 4.2.4.1).



Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Spring Sp. Acoust. Surv. (IXa N)													0	306	26	42	1508
Spring Port. Acoust. Surv. (IXa C-N & C-S)					596		368	1542	112		1062	0	1945	5505	2089	1188	27050
Spring Sp.+Port. Ac. Surv. (Western IXa)													1945	5811	2115	1230	28558
Total Landings IXa N	5329	44	63	371	413	10	27	21	23	4	4	15	4	5	19	179	
Total Landings IXa C-N&C-S	7056	2720	618	1047	1053	132	416	522	279	223	88	95	840	298	40	102	
Total Landings Western Ixa	12385	2764	682	1418	1466	142	444	543	301	226	92	110	844	303	59	281	

Figure 4.5.2.2. Anchovy in División IXa. Anchovy in Sub-divisions IXa-North to Central-South (Western Iberian Atlantic façade). Information used in the Qualitative (Updated) Assessment: total annual landings from Sub-division and the whole region, and available biomass estimates from research surveys series sampling the Sub-divisions used for comparative purposes.



Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Spring Sp. Acoust. Surv. (IXa N)													0	306	26	42	1508
Spring Port. Acoust. Surv. (IXa C-N & S)					25359		25281	22877	24677		15103	24082	39965	39667	26834	8583	27050
Spring Sp.+Port. Acoust.Surv (Div IXa)													39965	39973	26860	8625	28558
Total Landings Div Ixa	12956	4595	5295	10962	7409	2502	9098	8806	5269	5844	4515	4491	6454	3508	3013	3210	

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

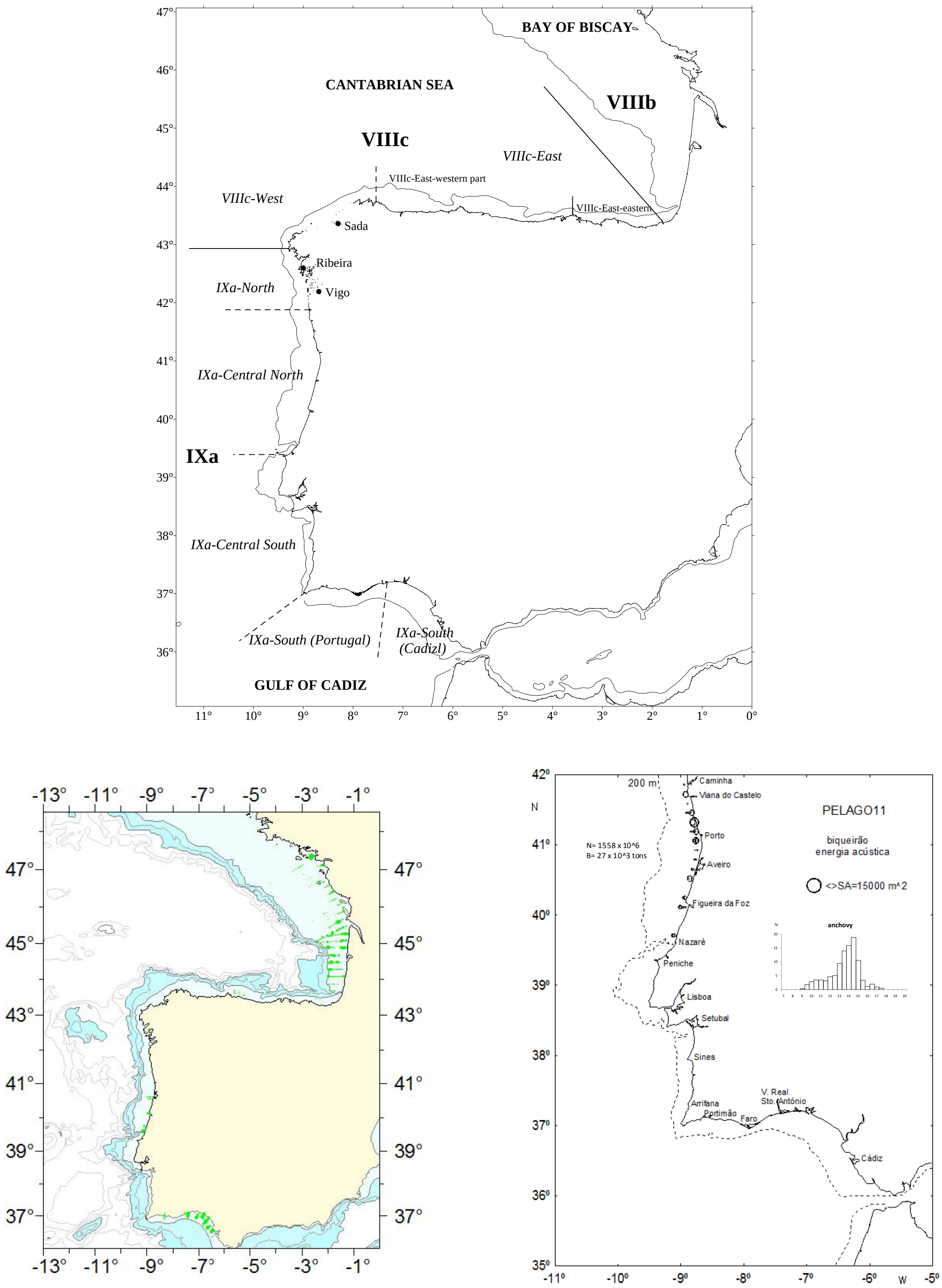


Figure 4.7.1.1. Anchovy in División IXa. A) Geographical distribution of Sub-divisions. B) Usual distribution of the anchovy populations throughout the Division as derived from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b). C) Current spatial pattern of the anchovy abundance in the Division from the 2011 spring Portuguese acoustic survey.

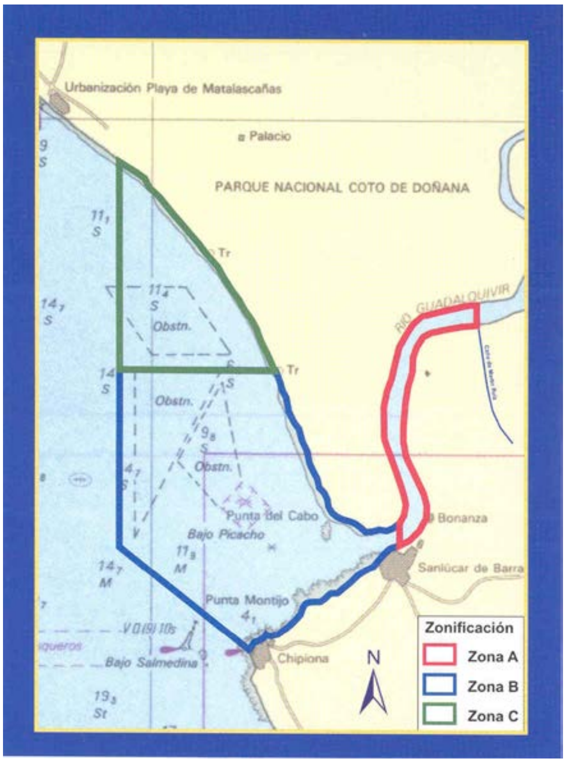


Figure 4.7.2.1. Anchovy in Division IXa. Sub-division IXa-South. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish waters of the Gulf of Cadiz).

5 Sardine outside the Iberian Peninsula

5.1 The fisheries for sardine in the ICES area

5.1.1 Catches for sardine in the ICES area

Commercial catch data for 2010 were provided by Portugal, Spain, France and UK (England and Wales) (**Table 5.1.1.1**). Total reported catch was 112 460 tonnes, divided as follows: 57% of the catches by Portugal, 24% by Spain and 18 % by France. The remaining 2% of catches are reported for divisions VIIe-f and VIIId by England and Wales. Catches in VIIIc and IXa amount to 80% of the total sardine catches(although it should be taken into account that not data were provided to the WG by Netherlands, Ireland and Germany this year). It should be noted that fishing activities are limited in both Spain and Portugal, while there are no catch regulations in place in the other countries. In 2010, there was a 10% increase with respect to the total 2009 sardine catches reported in European waters. Portugal showed a 3% increase while Spain showed a 1% increase in catches with respect to 2009. Landings in France showed a 18% decrease and catches from England and Wales increased by 3% in 2010.

5.2 Catch and survey data for sardine in areas VIIIa and VIIIb

5.2.1 Catch data in areas VIIIa and VIIIb

An update of the French and Spanish catch data series in Divisions VIIIa and VIIIb (from 1983 and 1996 for France and Spain, respectively) including 2010 catches was presented to this year´s WG (**Table 5.2.1.1**). Spanish catches are taken by purse seines from the Basque Country operating only in division VIIIb. Spanish landings peaked in 1998 and 1999 with almost 8 thousand tonnes but have decreased in the last three years to below 1 thousand tonnes. In 2010, 642 tonnes were landed. The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year.

French catches have increased along the series, with values ranging from 4 367 tonnes in 1983 to 21 104 tonnes in 2008 with some small fluctuations; 19 485 tonnes were landed in 2010.

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

Both purse seiners and pelagic trawlers target sardine in French waters. Average vessel length is about 18 m. Purse seiners operate mainly in coastal areas (<10 nautical miles) while trawlers are allowed to fish within 3 nautical miles from the coast. Both pair trawlers and purse seiners operate close to their base harbour when targeting sardine. The highest catches are taken in the summer months. Almost all the catches are taken in south-west Brittany. Figure 5.2.1 shows French annual sardine landings by the different fleet components. Catches by purse seiners show an increasing trend with some decline in 2010, while catches by pelagic trawlers remained stable for recent years.

Numbers by length-class for divisions VIIIa,b by quarter are shown in **Tables 5.2.1.2** and **5.2.1.3** for France and Spain (only VIIIb), respectively. While French catches in divisions VIIIa and VIIIb are constituted by fish of a wide range of sizes with a peak at 20 cm length, sardine taken by Spanish vessels show a narrower range of sizes but with a peak at similar length size.

5.2.2 Acoustic survey in areas VIIIa and VIIIb

The French acoustic survey PELGAS takes place every spring in the Bay of Biscay on board the R/V Thalassa with the main objective of studying the abundance and distribution of pelagic fish in the Bay of Biscay and to study the pelagic ecosystem as a whole. In 2011, PELGAS09 took place from the 26th April to 5th June and detailed objectives, methodology and sampling strategy are described in the WD-Massé and Duhamel (2011) presented in this group.

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

This year, sardine was distributed pure or mixed with anchovy in two principal areas : along to the French coast from the southern part of the Bay of Biscay to the south of Brittany (within the 100m isobath) and offshore, in shallow waters along the end of the continental slope (see **figure 5.2.2.1**) .

Sardine ranged in length from 11 to 25 cm and showed a bimodal distribution (with modes at 12,5 and 19.5cm – see **figure 5.2.2.2**). The smallest fish were found near the Gironde.

The series of age distribution in numbers since 2000 are shown in **figure 5.2.2.**3. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or high 2004 age class). 2003 was an atypical year in terms of environmental conditions and therefore fish distributions.

It must be noticed that the number of age 3 individuals this year is really important (39% in number of total fishes), and confirms a good recruitment of the 2008 year class. The relative high abundance of age 4 (still 13%) corresponds to the good recruitment of the 2007 year class that we observed previous years.

The sardine was still abundant this year with an abundance index of 338 458 tons, even if it constitutes a small decrease from the three previous years (**figure 5.2.2.4**).

5.2.3 Biological data

5.2.3.1 Catch numbers at length and age

Tables 5.2.3.1.1 and 5.2.3.1.2 shows the catch-at-age in numbers for each quarter of 2010 for French and Spanish landings respectively. Both for France and Spain, fish of age 2 and 3 dominated the fishery in 2010.

5.2.3.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter in 2010 are shown in **Tables 5.2.3.2.1 and 5.2.3.2.2** for French landings and in **Tables 5.2.3.2.3** and **5.2.3.2.4** for Spanish landings.

5.3 Data Exploration

A data exploration using a separable model (TASACS implementation) was undertaken this year. The population model was fit to the PELGAS survey numbers at age. Input data consisted of catch at age from the Spanish and French fisheries and weights at age in the catch and the survey. The survey sampling CVs were used to weight the survey data. The 2003 survey was excluded given very low survey estimates linked to unusual high temperatures. Mortality at age was fixed as for the Iberian data (M =0.33 constant across years and ages); maturity at age was based on data collected in the acoustic survey. All input data are shown on **Table 5.3.1**.

The model time framework is from 2000 to 2011. However, catch at age data are only available from 2002 to 2010 so, fishing mortality was fixed in 2000 and 2001 at the same as the estimated for 2002. Survey catchability was fixed = 1. Recruitment in 2011 was fixed equal to the average of the historic series.

Results from the base run: time series of recruitment, total biomass, SSB, average F for ages 2 – 6 and landings, are shown in **Figure 5.3.1.** The model suggests an increasing SSB towards 2009 and a decline after that. Strong recruitments in years 2007 and 2008 followed by a declining recruitment. Fishing mortality is very low suggesting that the fishery is making little impact on the stock. However, caution needs to be exercised because the catch is likely to be an underestimate. Fleets other than the Spanish and French are fishing in VIIIa – b and discarding sardine, but the amounts are not reported. Further, the catchability of the French surveys is not known.

Residuals from the model fit to the catch and the survey data are shown in **Figures 5.3.2 and 5.3.3**. The fit to the catch at age is reasonable suggesting that the separable assumption is sensible however, there are strong negative residuals in the plus group and that may be related to the way the plus groups were set for the survey and for the catch; setting the plus group at age 8 for both the survey and the catch data may be advisable. Year effects are apparent in the survey residuals. Possible cause of those year effects are discussed above. An exploration of the mortality signal provided by the catch and survey data is illustrated in **Figures 5.3.4 and 5.3.5** which also highlights the year effects in the survey data.

Further work on data exploration is encouraged. Questions regarding stock identity and stock area of distribution remain. If the stock extends further north as suggested by the continuous distribution of sardine along the Bay of Biscay, age structure and weight at age of sardine caught in area VII will be required for an assessment.

Table 5.1.1.1: Sardine general: 2010 commercial catch data from the ICES area, available to the Working Group. Unit Tonnes.

Divisions	UK (Engl&Wal)	France	Spain	Portugal	Total
IVa					
IVb					
IVc		69			69
VIa					
VIIa					
VIIb					
VIIc					
VIId	263	132			395
VIIe	1194	18			1212
VIIf	1064				1064
VIIg					
VIIh		18			18
VIIi					
VIIj					
VIIIa		19484			19484
VIIIb			642		642
VIIIc		1	13772		13773
VIIId	5				5
VIIIe					
IXaN			7409		7409
IXaCN				40923	40923
IXaCS				17623	17623
IXaS-Alg				5181	5181
IXaS-Cad			4662		4662
Total	2526	19722	26485	63727	112460

Table 5.2.1.1: Sardine general: Landings by France (1983-2010) and Spain (1996-2010) in ICES divisions VIIIa and VIIIb

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

* all landings from division VIIIb

n/a = not available

Table 5.2.1.2: Sardine general: French catch length composition (thousands) by ICES divisions VIIIa,b in 2010.

Length	1st quarter	2nd quarter	3rd quarter	4th quarter	Total
7					
7.5					
8					
8.5					
9					
9.5				6	6
10					
10.5	4				4
11	56	211	38		305
11.5	99	475	85		659
12	164	631	104		899
12.5	173	844	151		1 167
13	202	1 469	204	3	1 877
13.5	124	1 266	196	8	1 594
14	93	2 142	247	25	2 508
14.5	56	1 457	226	28	1 768
15	53	1 629	598	53	2 332
15.5	51	1 400	798	144	2 393
16	38	1 363	1 155	50	2 608
16.5	28	1 047	1 428	110	2 613
17	32	1 817	2 323	214	4 387
17.5	37	2 697	1 830	308	4 873
18	118	6 211	3 502	972	10 804
18.5	223	9 780	6 765	1 275	18 043
19	299	11 448	9 417	1 847	23 010
19.5	350	8 717	14 037	2 142	25 246
20	437	7 527	14 930	2 463	25 357
20.5	518	5 070	15 226	4 154	24 968
21	656	3 981	14 979	5 282	24 898
21.5	754	4 033	13 432	5 225	23 445
22	779	4 267	11 112	5 588	21 747
22.5	402	2 839	6 654	5 214	15 110
23	252	2 130	4 625	4 383	11 389
23.5	250	1 667	2 804	3 027	7 749
24	76	923	1 995	2 062	5 055
24.5	50	723	371	1 164	2 308
25	25	255	712	632	1 624
25.5		85	85	266	436
26	25	85		37	147
26.5		85			85
27				37	37
Total	6 425	88 188	130 030	46 683	271 326
Mean L	19.09431	18.54108	19.76989	20.78962	19.52859
sd					
Catch	**448**	**5457**	**9631**	**3948**	**19484**

Table 5.2.1.3: Sardine general: Spanish catch length composition (thousands) in ICES division VIIIb in 2010.

Length	1st quarter	2nd quarter	3rd quarter	4th quarter	Total
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5					
11					
11.5					
12					
12.5	1 886	2 953			4 839
13	13 970	0			13 970
13.5	65 784	0			65 784
14	83 633	0			83 633
14.5	102 938	2 432			105 370
15	93 901	2 432			96 332
15.5	76 896	4 864			81 760
16	100 609	660			101 269
16.5	119 593	43 835			163 428
17	292 911	48 245		8 253	349 409
17.5	291 493	147 335		0	438 828
18	446 689	162 438		8 253	617 380
18.5	553 399	324 812		5 362	883 573
19	564 698	231 137		24 760	820 594
19.5	584 873	312 241		25 990	923 104
20	546 585	359 239		73 533	979 357
20.5	343 005	311 402		112 941	767 347
21	384 239	193 675		259 150	837 064
21.5	276 062	148 238		293 498	717 798
22	232 730	126 870		310 400	669 999
22.5	115 633	128 522		207 109	451 263
23	85 972	66 479		180 493	332 944
23.5	55 575	41 434		53 584	150 593
24	36 239	2 222		10 281	48 742
24.5	27 656				27 656
25					
25.5					
26					
26.5					
27					
Total	5 496 968	2 661 461		1 573 606	9 732 036
Mean L	19.3	20.1		21.9	20
sd					
Catch	329.47	176.503		135.644	641.617

Table 5.2.3.1.1: Sardine general: French 2010 landings in divisions VIIIa and VIIIb: Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
			1722.05	162.919	1884.96
1	1173.64	15973.5	16997	2815.43	36959.6
2	1255.2	38317.9	50973.9	12159.7	102707
3	1905.23	18841.9	25066.9	8895.2	54709.2
4	648.319	4608.11	8601.74	3658.09	17516.3
5	399.255	2802.14	6676.85	4123.42	14001.7
6	615.94	4172.04	10836.8	6800.05	22424.8
7	164.616	1206.95	3084.11	2784.11	7239.79
8	114.047	1103.8	3927.8	3256.14	8401.78
9	101.131	841.837	1097.56	817.406	2857.93
10	18.0061	234.785	448.698	606.939	1308.43
11			284.991	294.511	579.503
12					
13					
14					
Total	6395.38	88103	129718	46373.9	270591
Catch (Tons)	448	5457	9631	3948	19484

Table 5.2.3.1.2: Sardine general: Spanish 2010 landings in ICES division VIIIb: Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0					
1		13			502
2	489	940		401	3482
3	2140	1065		819	3731
4	1847	324		186	984
5	474	198		125	662
6	339	69		43	212
7	100	46			125
8	80	7			25
9	18				9
10					
11					
12					
13					
Total	5497	2661	na	1574	11301
Catch (Tons)	329	177	0	136	642

Table 5.2.3.2.1: Sardine general: French 2010 landings in divisions VIIIa and VIIIb: Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			14.1	14.7	14.2
1	13.3	14.7	17.7	18.1	16.3
2	18.8	18.3	19.3	19.6	19.0
3	20.3	19.9	20.3	20.7	20.2
4	20.8	20.7	20.6	20.9	20.7
5	21.2	21.3	21.2	21.7	21.4
6	21.7	21.9	21.3	21.8	21.6
7	21.9	22.1	22.1	22.4	22.2
8	22.5	22.8	22.1	22.3	22.3
9	22.5	22.8	21.9	22.2	22.3
10	23.2	23.2	23.8	23.7	23.7
11			23.0	23.0	23.0
12					
13					
14					

Table 5.3.1. Sardine VIIIab. Separable model input data.

CANUM	0	1	2	3	4	5	6	7	8	9+
2002	3703.326	162937.9	67783.2	25016.34	15769.52	11126.85	7444.364	2156.667	1170.001	823.576
2003	4381.71	89475.43	62145.36	27446.56	16544.5	9645.771	6206.694	3333.872	1646.632	736.523
2004	22283.44	88305.74	50183.74	36191.33	15109.61	9387.926	2795.978	1328.195	632.331	305.6475
2005	4114.096	91371.14	41479.17	29104.73	22997.89	17983.15	9190.096	5114.802	3167.253	1804.778
2006	8895.818	35588.44	84755.39	30337.34	21007.79	15203.65	9519.411	6946.061	3558.309	2806.917
2007	24017.4	66813.24	25930.17	59416.22	13094.72	14185.51	12177.57	7468.423	3582.447	2906.627
2008	3845.384	162408	71483.76	26645.22	42044.05	13223.24	11589.99	10817.63	5354.7	5061.735
2009	8535.446	117820.7	139899.4	50134.15	25635.84	24240.36	12464.92	9281.813	5516.682	1915.835
2010	1907.256	37904.94	107444.1	59131.03	18718.63	14836.94	22904.41	7452.205	8526.829	4811.313

WECA	0	1	2	3	4	5	6	7	8	9+
2002	0.017757	0.044429	0.069176	0.080401	0.087574	0.099835	0.111594	0.115043	0.129899	0.13321
2003	0.018832	0.054002	0.080246	0.091299	0.100752	0.110792	0.116896	0.129285	0.131685	0.124278
2004	0.019664	0.039811	0.079839	0.090177	0.094816	0.101332	0.111007	0.119764	0.129945	0.12539
2005	0.018362	0.046964	0.080617	0.088595	0.093562	0.097238	0.105267	0.109777	0.118986	0.133341
2006	0.023648	0.038989	0.074012	0.088143	0.09405	0.101321	0.109521	0.115305	0.117617	0.13298
2007	0.031837	0.052471	0.080531	0.086959	0.098588	0.103502	0.108951	0.11951	0.122771	0.130517
2008	0.017916	0.043758	0.062572	0.075877	0.07823	0.090829	0.100302	0.095035	0.103438	0.110112
2009	0.031835	0.037861	0.062266	0.07325	0.08608	0.086863	0.095862	0.098196	0.099733	0.114855
2010	0.023132	0.037799	0.060485	0.074175	0.080833	0.089807	0.092446	0.102283	0.102776	0.110504

WEST	1	2	3	4	5	6	7	8+
2000	0.0351	0.0547	0.0692	0.0765	0.0848	0.0899	0.0988	0.1084
2001	0.0413	0.0589	0.0768	0.0838	0.0937	0.0969	0.1034	0.1118
2002	0.0405	0.0602	0.0749	0.0817	0.0923	0.0994	0.1067	0.1181
2003	0.0382	0.068	0.0732	0.0781	0.086	0.0933	0.0887	0.0961
2004	0.0359	0.0647	0.0765	0.0844	0.0959	0.0988	0.1043	0.1084
2005	0.0344	0.0635	0.0733	0.0796	0.0849	0.089	0.09	0.106
2006	0.0392	0.0584	0.0708	0.0812	0.0864	0.0825	0.0913	0.1021
2007	0.0376	0.066	0.0718	0.0791	0.084	0.0945	0.1004	0.0991
2008	0.0334	0.0603	0.0711	0.0752	0.0838	0.0928	0.0905	0.0978
2009	0.0295	0.0571	0.0736	0.0813	0.0833	0.0884	0.0957	0.0934
2010	0.0303	0.0505	0.0640	0.0731	0.0784	0.0876	0.0932	0.1069
2011	0.0274	0.0501	0.0587	0.0698	0.0783	0.0830	0.0843	0.107491

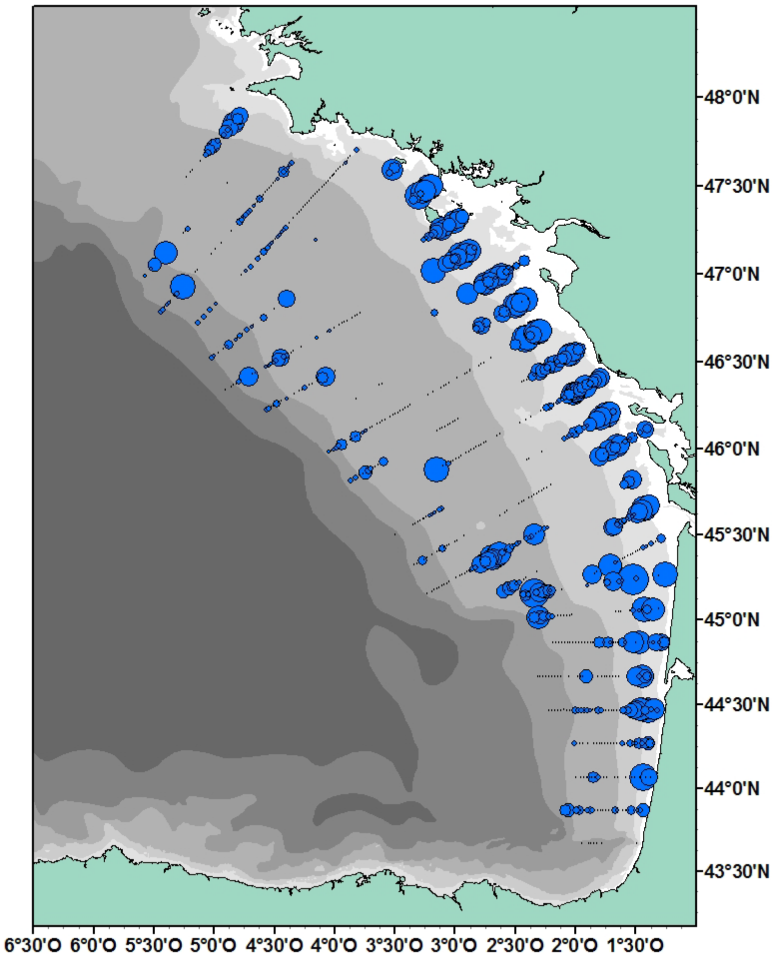


Fig. 5.2.2.1: Adult sardine distribution (density / ESDU) during PELGAS11

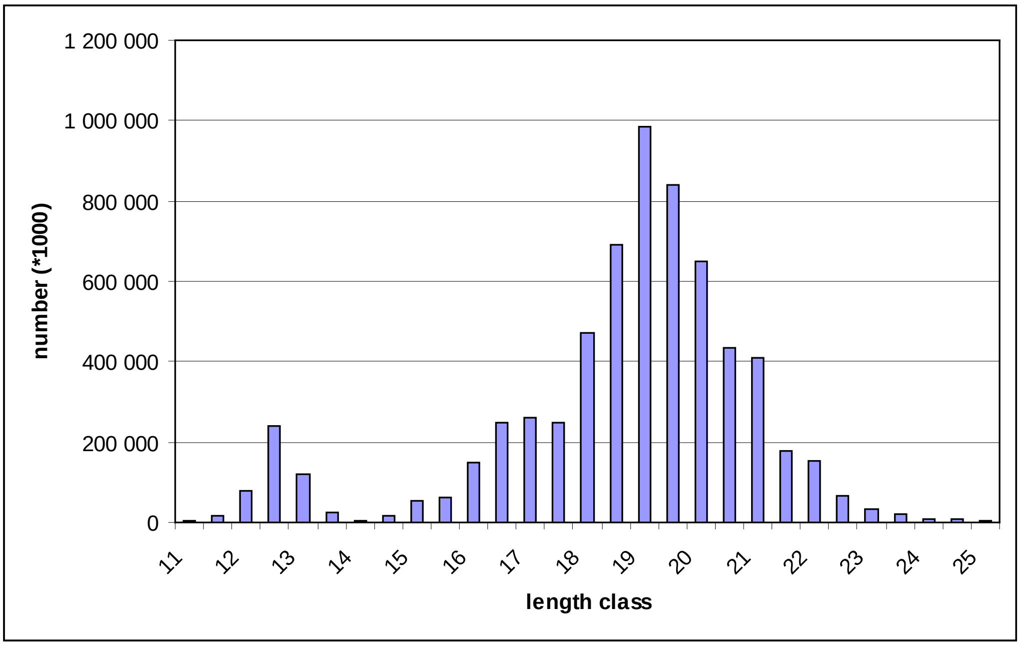


Fig. 5.2.2.2: Sardine length distribution during PELGAS11

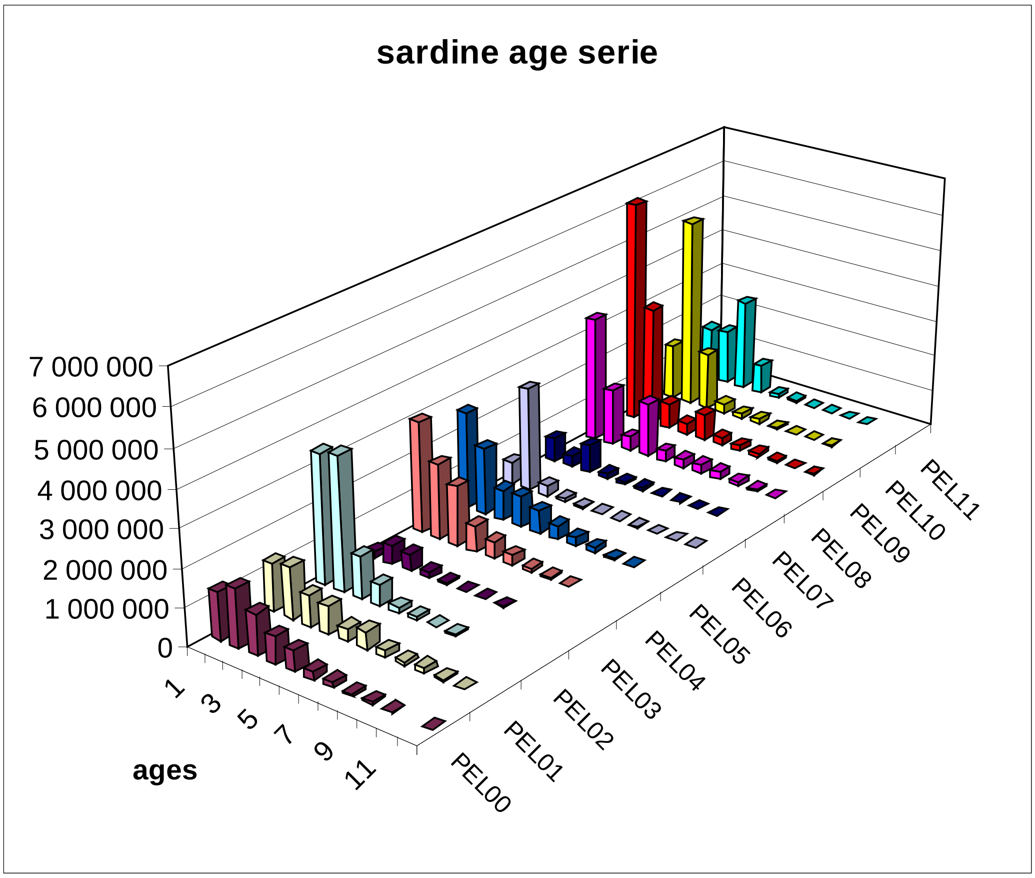


Fig 5.2.2.3: sardine age distribution along the PELGAS surveys

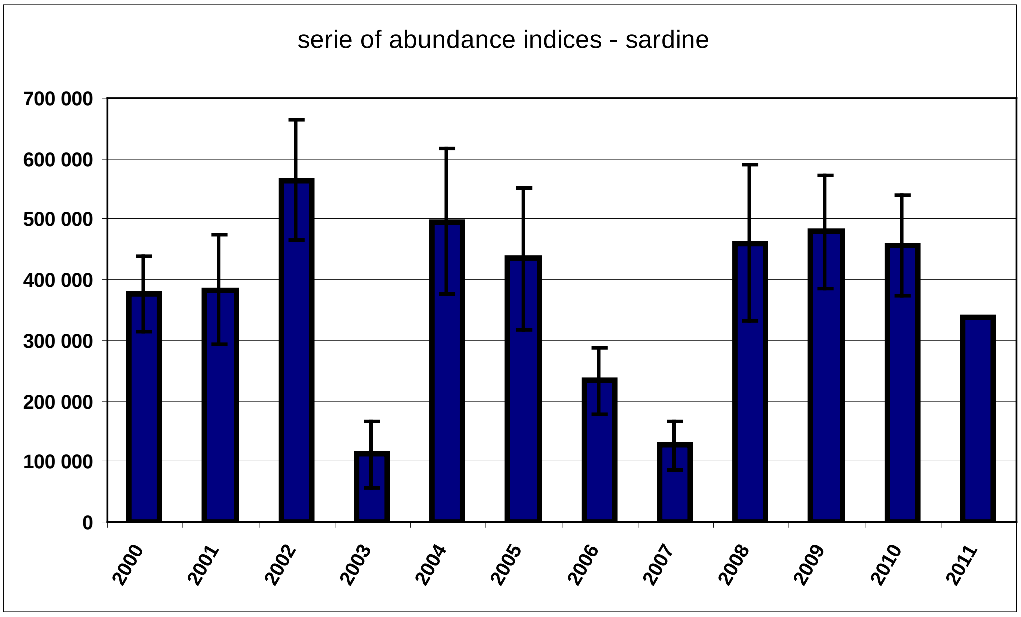


Fig 5.2.2.4: sardine abundance indices along the PELGAS surveys

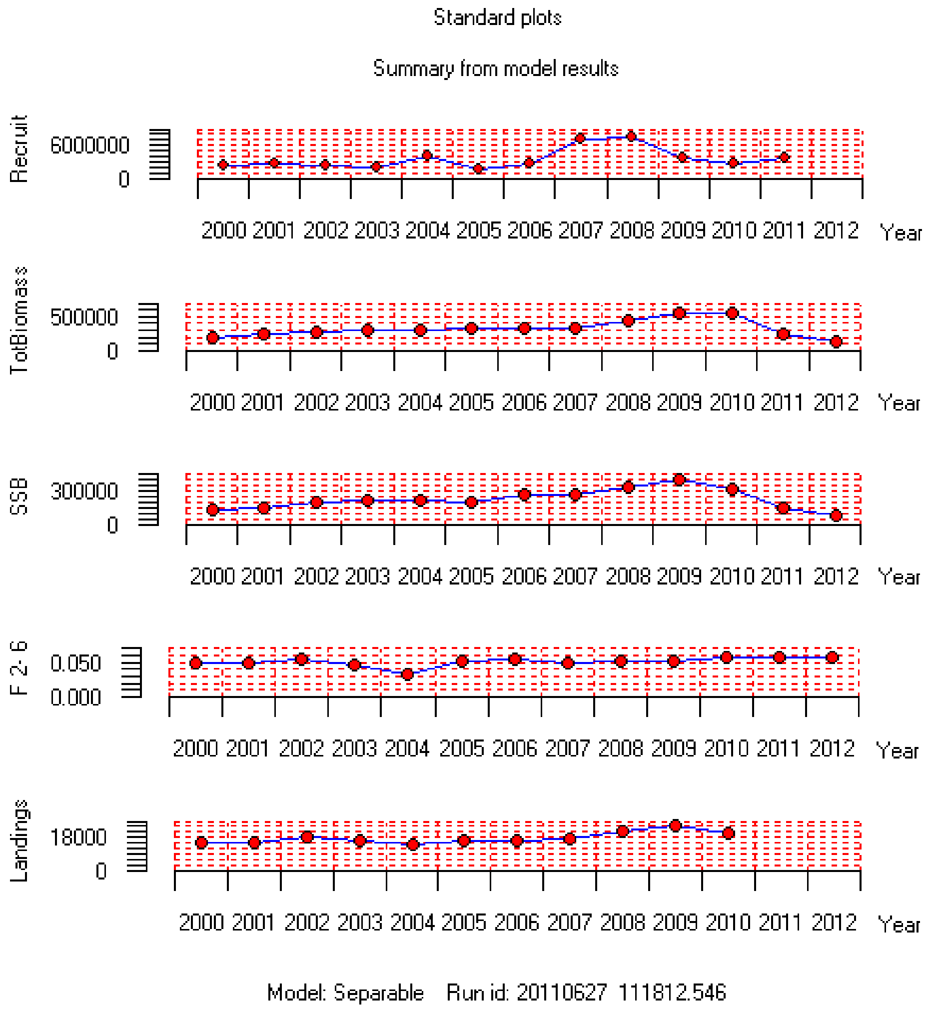


Figure 5.3.1. Sardine in VIIIa – b. Summary plots from data exploration with separable VPA. Base run.

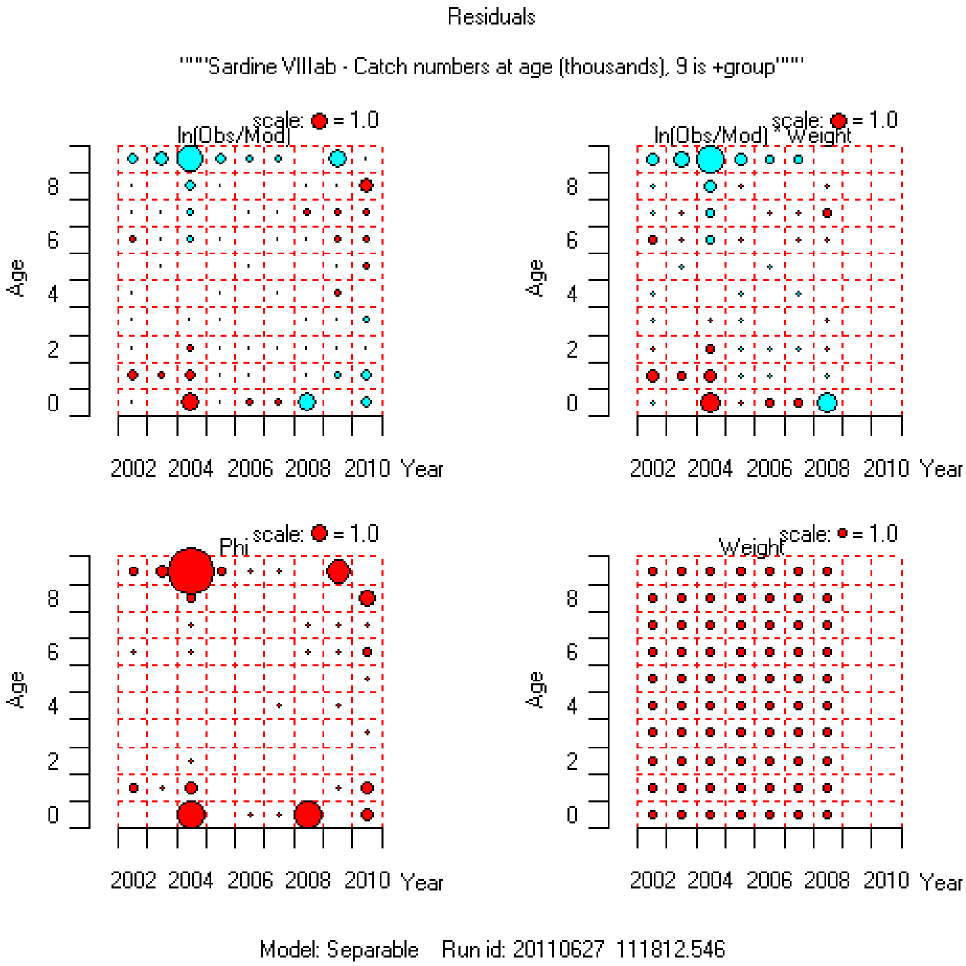


Figure 5.3.2. Sardine in VIIIa – b. Separable VPA, base run. Residuals from catch at age. Upper panels: Log residuals: Left: unweighted, Right: weighted. Lower left: Individual contributions to the objective function. Lower right: Display of the applied weightings.

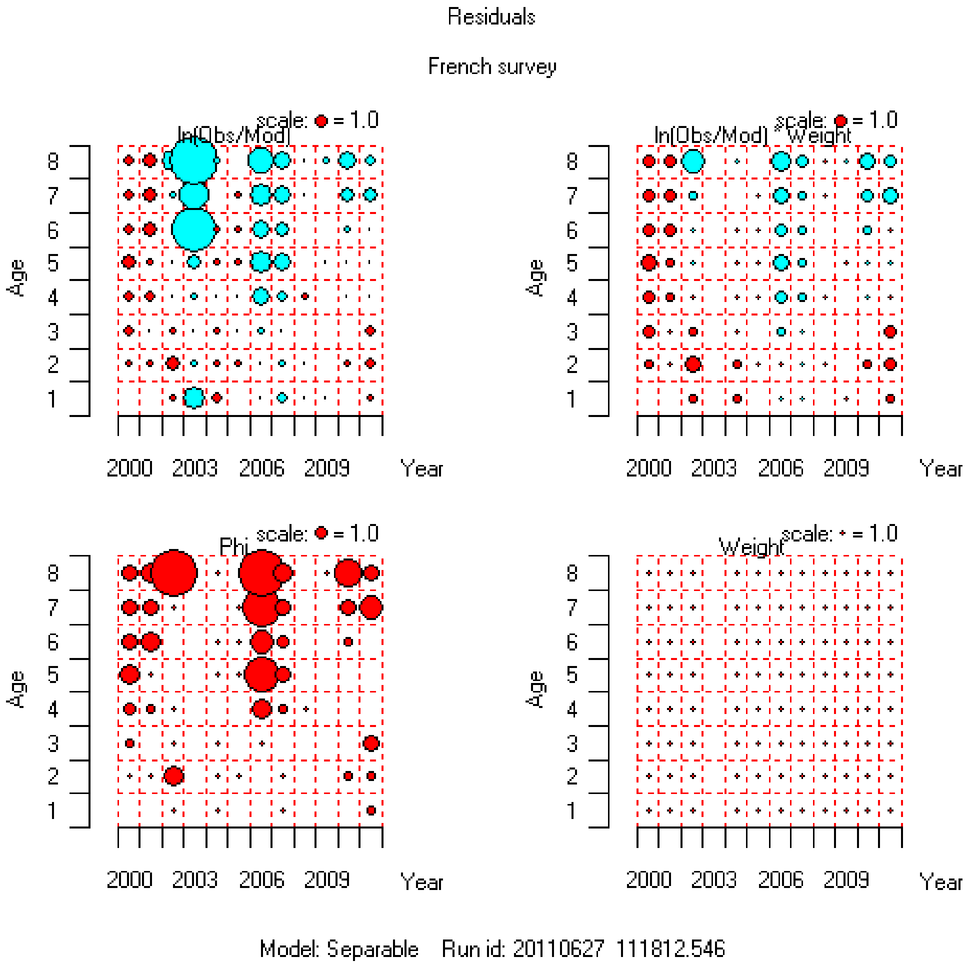


Figure 5.3.3. Sardine in VIIIa – b. Separable VPA, base run. Residuals from survey numbers at age. Upper panels: Log residuals: Left: unweighted, Right: weighted. Lower left: Individual contributions to the objective function. Lower right: Display of the applied weightings.

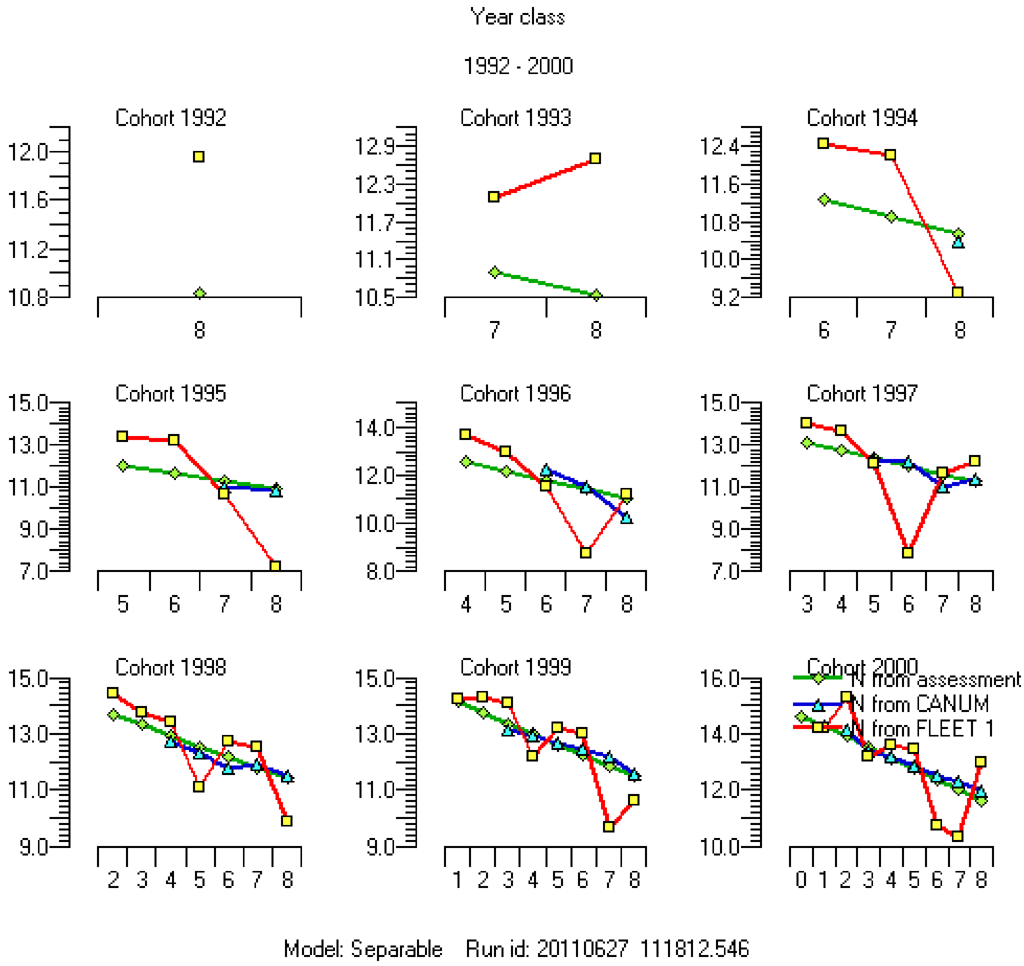


Figure 5.3.4. Sardine in VIIIa – b. Separable VPA, base run. Cohort curves (1992 – 2000) from catch and survey data and estimated by the assessment.

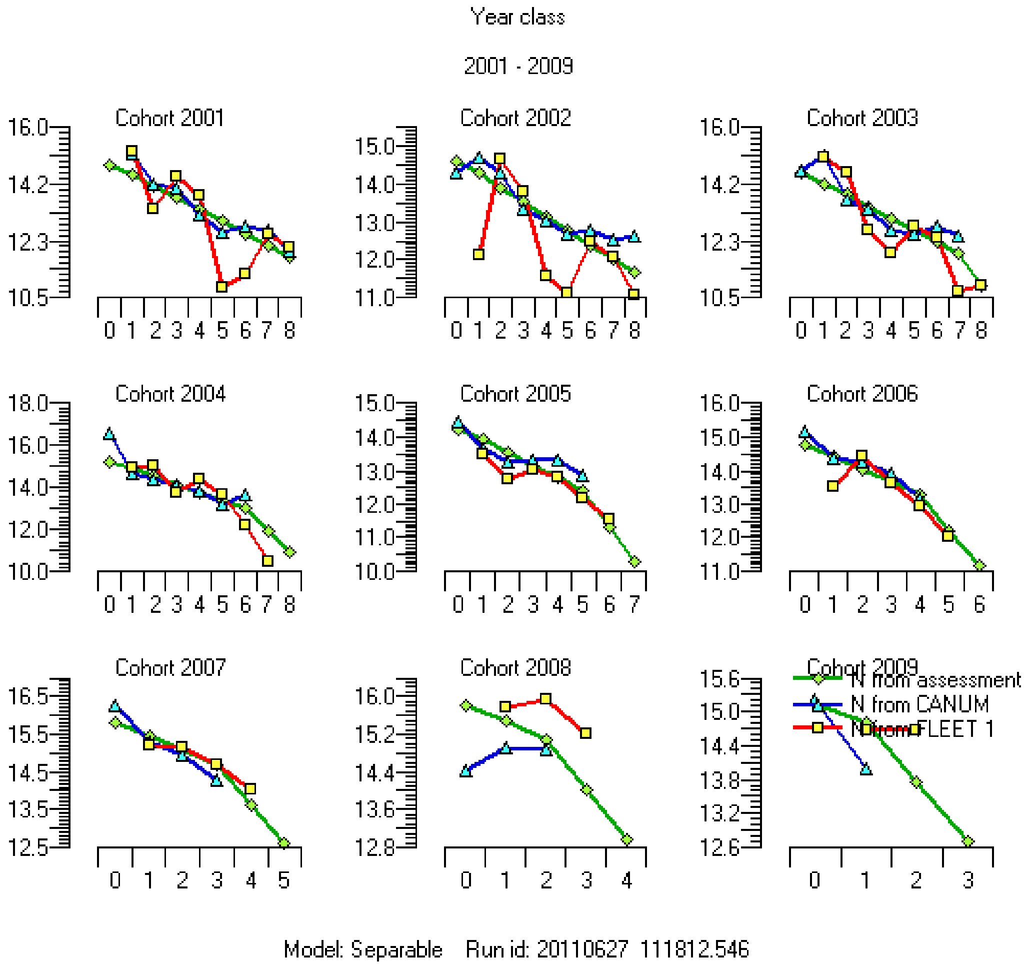


Figure 5.3.5. Sardine in VIIIa – b. Separable VPA, base run. Cohort curves (2001 – 2009) from catch and survey data and estimated by the assessment.

6 Sardine in VIIIc and IXa

6.1 ACOM Advice Applicable to 2010, STECF advice and Political decisions

For 2011, ICES advised that landings should be less than 75 000, corresponding to a 15% reduction relative to landings in 2009. SSB has declined since 2006 due to the lack of strong recruitment and SSB in 2010 was 33% below the long-term average. Fishing mortality in 2009 was at the same level as in 2008, being at the historical level. In light of the EU policy paper on fisheries management this stock is classified under category 9, because the average estimated abundance in the last two years is 39% lower than the average estimated abundance in the three preceding years. Therefore a 15% decrease in TAC applies. ICES notes that no TAC is set for this stock. Landings for 2009 have been used as basis to calculate the results of a 15% reduction. No specific management objectives are known to ICES. The stock is managed by Portugal and Spain through minimum landing size, maximum daily catch, days fishing limitations, and closed areas.

6.2 The fishery in 2010

6.2.1 Fishing Fleets in 2010

Details about the vessels operated by both Spain and Portugal targeting sardine are given in Table 6.2.1.1.

In northern Spanish waters, sardine is taken by purse seine. The total number of vessels with license for this gear in 2010 was 289, showing a decrease with respect to 2009 (with a total number of 339 vessels), and with a mean vessel length and power of 21m and 305 HP, respectively.

In the Gulf of Cadiz, purse seiners taking sardine are generally targeting anchovy (n = 73) and range in size from 8 to 34 m with a mean vessel length of 16 m (horse power between 27 and 800 with a mean of 182). In Portuguese waters, fleet data from 2009 indicate that sardine is taken by coastal purse seiners (number of licenses= 159) ranging in size from 10.5 to 27 m (mean vessel length = 20 m). Vessel engine power ranges between 71 and 447 (mean = 249).

6.2.2 Catches by fleet and area

As estimated by the Working Group, sardine landings in 2010 have slightly increased in comparison with those of 2009 (Tables 6.2.2.1 and 6.2.2.2, Figure 6.2.2.1). Total 2010 landings in divisions VIIIc and IXa were 89 571 t, i.e. an increase of 2% with respect to the 2009 values (87 740). The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine (25 843 tonnes) remained stable respect to the values from 2009 (25 905 tonnes). Both ICES subdivisions VIIIc and IXaN showed an increase in catches (3% in subdivision IXaN and 15% in VIIIc) while subdivision IXaS-Cadiz showed a 31% decrease. In Portugal, landings in 2010 (63 727 tonnes) were 3% higher than the landings in 2009 (61 835 tonnes). This increase in landings originated in all subdivisions (13% increase in catches in IXaCN and a 8% increase in IXaS-Algarve), with the exception of IXaCS that have a 15% decrease.

Table 6.2.2.1 summarises the quarterly landings and their relative distribution by ICES Subdivision. Sixty-one percent of the catches were landed in the second semester (34% in the third quarter) and, 46% of the landings took place off the northern

Portuguese coast (IXaCN). This value is slightly higher than the one reported for last year (41%) The percentage of catches in the northern area of the stock (VIIIc and IXaN) (24%) has slightly increased from last year. The southern areas (IXaS Algarve and IXaS Cadiz) accounts for 11% of the total values in 2010, slightly above the value in 2009.

6.2.3 Effort and catch per unit effort

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

6.2.4 Catches by length and catches at age

Tables 6.2.4.1a,b,c,d show the quarterly length distributions of landings from each subdivision. Annual length distributions were bimodal in Spain in subdivisions IXaN and IXaS-Cádiz with modes at 10.5 and 19.5 cm and 14.5 and 20 cm respectively. Sardine in subdivisions VIIIcW and VIIIcE showed single modes at 22.5 and 21 cm respectively. For Portugal, single modes were observed for IXaCN at 14 cm and for IXaCS at 20 cm while sardine in IXaS-Algarve showed a bimodal length distribution (at 16 and 20 cm).

Table 6.2.4.2 shows the catch-at-age in numbers for each quarter and subdivision. In Table 6.2.4.3, the relative contribution of each age group in each Subdivision is shown as well as their relative contribution to the catches. Age 1 fish (2009 cohort) are only apparent in IXaN and IXaCN. The cohort of 2007 (which was strong in French waters) dominates the catches in VIIIcE. No clear pattern of ages was observed in IXaS-Algarve. The 2009 cohort dominates in IXaS-Cádiz.

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

6.2.5 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 6.2.5.1 and 6.2.5.2.

6.3 Fishery independent information

Figures 6.3.1 and 6.3.2 show the time series of fishery independent information for the sardine stock.

6.3.1 DEPM – based SSB estimates

Two DEPM surveys have been carried out in 2011: the Portuguese one in February-March covering the western and southern distribution area of the stock, and the Spanish survey in March-April covering the northern area. Samples from both surveys are being analysed at present and only preliminary results are summarized here:

- while the 2008 DEPM-based SSB estimate was the largest since 1997 (with an increase particularly evident in the southern and in the western area), estimated total egg production in 2011 is lower in all regions.
- the estimated spawning area in 2011 shows a reduction when compared to the area estimated in 2008 (particularly in the western area). This decrease, apparent in all regions, is the main cause for the differences between the estimates of 2011 and 2008 (together with the decrease in the number of eggs).

- differences between regions were observed with the southern region showing the highest daily egg production per m² (eggs/m²/day)
- mortality values estimated for the southern and western regions are much higher than those estimated in the northern regions (and higher than in 2008)

It should be noted that these values are preliminary estimates and the final figures will be presented in November at the WGACEGG together with a revision of the historical series of DEPM estimates that is underway. SSB results for 2011 will be available after the estimation of fecundity and spawning fraction, only then it will be possible to assess sardine biomass trends from the DEPM series.

6.3.2 Acoustic surveys

There are two annual surveys carried out to estimate small pelagic fish abundance in IXa and VIIIc using acoustic methods. The April-May 2011 Portuguese survey (PELAGOS11) took place onboard the RV "Noruega" while the Spanish survey (PELACUS0411) took place in March-April onboard the RV "Thalassa".

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

6.3.2.1 Portuguese spring acoustic survey

PELAGOS11 survey took place from the 19th April to the 16th May and covered the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth. Detailed objectives, methodology and sampling strategy are described in the WD-Marques *et al.* (2011) presented in this group. A total of 18 fishing stations were carried out, a reduced number when compared with the 2010 survey which was mainly due to the lack of fish detected. Sardine was mainly distributed over the Western coast from Caminha to Cape Espichel. In the Northern West area (OCN) sardine was detected mainly near shore, being more abundant between Porto and Figueira da Foz. In the Southern West area (OCS), sardine was scarce. In Algarve the main sardine concentrations were found in the Western part, between Sagres and Faro. In the Gulf of Cadiz, sardine was very scarce being absent in the eastern part (Figure 6.3.2.1.1). Total estimated sardine biomass in the Portuguese coast was 124 thousand tonnes corresponding to 2 751 million individuals (Table 6.3.2.1.1). These values represent a decrease of 38% in biomass and 70% in numbers compared with the values estimated by last year spring survey (Figures 6.3.1. and 6.3.2) and are the lowest estimates of the series. Age 2 fish (2009 year class) was clearly dominant in the OCN area, followed by age 1 fish (2010 year class). In the remaining areas, age 1 fish was dominant, especially in OCS area.

Data on sardine egg distribution (presence/absence) derived from the CUFES sampling during this survey is shown in Figure 6.3.2.1.2. The area occupied by sardine eggs in April-May 2011 was smaller than that recorded in previous surveys. Despite the fact that the survey took place later into the reproductive season, a high proportion of the population was found to be still active. Sardine eggs were collected in areas (e.g. SW coast and W of Cádiz) where no fishes were detected. The same happened in the case of anchovy, with eggs detected in the Gulf of Cadiz even if fish were practically absent this year in contrast to previous years. Preliminary analysis of the data indicate a decline in the number of sardine eggs. Final results will be available for the WGACEGG meeting in November.

6.3.2.2 Spanish spring acoustic survey

The Spanish survey took place onboard the RV "Thalassa" from the 27th March to 20th April. The area covered extended from the Galician-Portugal border to southern French waters and from 30 to 200 m depth. Detailed objectives, methodology and sampling strategy are described in the WD-Santos *et al*. (2011) presented in this group.

Sardine abundance was estimated as 151 million individuals, while biomass was estimated to be 11.8 thousand tonnes (Table 6.3.2.2.1). Almost all the sardine detected during the survey (81% of the abundance and more than 87% of the biomass) was found in Asturias (ICES sub-area VIIIcE-w). In southern Galician waters (ICES sub-area IXaN) only 11% of the total biomass and 17% of the total abundance was detected (Figure 6.3.2.2.1). These figures represent a decrease of 71% in biomass and 72% in abundance in relation to the estimated values in 2010. The estimates obtained by the 2011 survey are the lowest since 2001.

Sardine ranged in length from 15 to 25.5 cm with a mode at 22.5 cm (Figure 6.3.2.2.2). Applying the ALK obtained from the fish sampled during the survey, most fish (33% by number and 35% of the biomass) in the entire surveyed area were assigned to age class 4 (2007 year class) coming mainly from ICES sub-area VIIIcE-W (Table 6.3.2.2.1). By sub-area, age 2 fish predominated in southern Galician waters (ICES sub-area IXa-N), while age 3 fish predominated in Cantabrian waters (42% and 43% of abundance and biomass respectively in VIIIcE-e).

The distribution of sardine eggs (obtained from the analysis of 291 CUFES stations) indicates that contrary to the situation of adult fish, eggs have been found over most of the prospected area (although also predominantly in the Cantabrian Sea). In all areas, sardine eggs were found concentrated close to the coast (Figure 6.3.2.2.3).

6.4 Biological data

6.4.1 Mean length and mean weight at age in the stock

6.4.2 Maturity at age

The maturity ogive and stock weights for 2010 are show below. Because of the large number of immature fish (Stage I) of large size observed on the 2010 Portuguese (and Spanish) surveys the proportions of mature fish are relatively low at ages 2 and older . Those large fish were most likely post-spawners which had entered the resting period and not virgin fish but macroscopic differentiation of a virgin and a resting gonad is not possible.

Age	0	1	2	3	4	5	6+
% mature fish	0	25.1	76.2	90.7	94.3	95.1	96.7

Age	0	1	2	3	4	5	6+
Weight, kg	0.000	0.018	0.042	0.058	0.064	0.064	0.071

6.4.3 Natural mortality

Natural mortality was estimated at 0.33 by Pestana (1989), and is considered constant for all ages and years.

6.4.4 Report of the Workshop on age reading of sardine (WKARAS11)

Results of a Workshop on Age reading of European Atlantic Sardine (WKARAS) that was held in Lisbon, Portugal, from 14 to 18 February 2011 were presented at the WG. There were 11 participants from five institutes located in France, Spain and Portugal This Workshop was preceded by an otolith exchange in September -December 2010. The otolith exchange included a total of 300 otoliths from samples collected in 2008 spanning the area from ICES Sub-Area VIIIa to Sub-Division IXa-South-Cadiz.The relative accuracy of sardine age determination was generally good: the average percentage of agreement with modal age was 77.0% and 75.2% for the Iberian Stock and the Bay of Biscay respectively. Precision was substantially higher in the Bay of Biscay (CV= 14.1%) than in the Iberian stock area (CV=32.8%), although it should be noted that the latter is strongly influenced by high CVs at age 0 in the Gulf of Cadiz. By excluding age 0, the precision in the Iberian Stock area becomes similar to that in the Bay of Biscay (14.7%). Both figures are still above the 5% threshold recomended by the PGCCDBS Guidelines for Workshops on Age Calibration. Compared to the previous Sardine otolith Workshop, relative accuracy of sardine age determination within the Iberian Stock area has improved substantially and there is less evidence of bias. The identification of the otolith edge and of the first annual ring were the main discrepancies between readers in sardine age determination. These are recurrent issues.The attribution of age in years of young individuals was corroborated by preliminary results from the analysis of daily growth rings of sardine juveniles in northern Portugal. Guidelines related to the age reading problems were modified taking into account recommendations from the participants and their impact on age reading was evaluated by a second reading of a sub-set of the exchange otoliths. Changes in relative accuracy and precision between the first and second readings differ among areas: agreement was similar while precision declined sub-stantially in the Gulf of Biscay, generally worse results were obtained for western Portugal while better results were obtained for the Gulf of Cadiz.

The participants considered that sardine age reading would be improved by taking into account age related differences in edge seasonality and by using a flexible gauge to guide the identification of the first annual ring. These changes were accommodated in the age reading protocol. Conversely, the present birthdate assumption, 1st of January, was considered to be well adapted to the spawning seasonality and growth pattern of sardine across the area.

A reference collection of annotated (catch area and date, fish length and location of modal rings) otolith digital images was assembled.

6.5 Assessment Data of the state of the stock

This year, the assessment of sardine is an update. Catch and acoustic survey data were updated with the estimates from 2010 and 2011, respectively.

6.5.1 Stock assessment

Sardine catch-at-age data and abundance-at-age data from the combined spring acoustic survey are presented in Figures 6.5.1.1 and 6.5.1.2 and listed in Tables 6.5.1.1 f,g, respectively. Both catches and abundance data support earlier indications of very poor year classes in the period 2006 – 2008. The 2009 recruitment was comparatively higher, although it was far from the level of the latest strong recruitments and the 2010 recruitment appears to be poor according to the 2011 acoustic surveys. Figures 6.5.1.3 to 6.5.1.5 show the mean weights-at-age in the catch and in the stock and maturity ogive (data listed in Table 6.5.1.1 a,b,c).

The final stock assessment was an update assessment made with AMCI for one area.

The following data were used:

- Catch numbers at age: 1978-2010
- Combined March acoustic survey: Indices from the Spanish March survey, covering Division VIIIc and Subdivision IXaN, and the Portuguese March survey, covering the remainder of Division IXa, added together without weighting, for the years 1996 to 2011.
- DEPM estimates of spawning stock biomass, covering VIIIc and IXa, for the years 1997, 1999, 2002, 2005 and 2008.

The model was conditioned as follows:

- Selection at age in the fishery at age 4 equal to age 5
- Selection at age in the fishery in 2010 equal to that in 2009
- Survey catchability at age 4 equal to age 5
- DEPM survey as a relative index of SSB
- Selection at age was allowed to change gradually, using the recursive updating algorithm in AMCI, with a gain factor of 0.2 for all ages and years
- Survey catchability assumed constant over time.
- Catchability of the DEPM survey constant over time.
- Natural mortality: Constant at 0.33 (Pestana, 1989).

The following model parameters were estimated:

- Initial numbers in 1978 and recruitments each year except in 2011. Recruitment in 2011 was assumed at 4*109
- Initial selection at age in the fishery, for all ages, but assumed equal for ages 4 and 5. Selection in 2010 assumed equal to 2009.
- Survey catchability at age, for all ages, but assumed equal for ages 4 and 5
- Catchability for the DEPM survey.
- Annual fishing mortalities.

The objective function was a sum of squared log residuals for catch numbers at age, survey indices at age and DEPM indices. Catches at age 0 were down-weighted by a factor of 0.1. The weighting specified was equal for all other observations. The internal weighting in AMCI implies that the set of all acoustic survey observations (6 ages x 13 years), and the set of DEPM observations (5 years), each are given the same weight as each year of catch numbers at age (7 ages) in the objective function. Therefore, catch-at-age data has considerable more weight than either survey on the model fit. The DEPM has the same weight as the acoustic survey.

Results from the assessment are listed in Table 6.5.1.1d-i. Summary plots are presented in Figure 6.5.1.6. Residuals for the catches, acoustic survey and DEPM survey are shown in Figures 6.5.1.7 to 6.5.1.9, respectively. Fishing mortalities at age are shown in Figure 6.5.1.10, and the survey catchability-at-age in Figure 6.5.1.11.

Catch and acoustic survey residuals from this year's assessment are comparable to those obtained last year. These residuals are generally small although the pattern observed particularly in the acoustic and DEPM surveys needs further examination (see section 6.5.2). A large negative residual in the 6+ group in the 1996 survey has also been noticed in previous assessments; the cause of this residual is being investigated for the benchmark.

As in previous assessments, selection shows an increase up to ages 3-4 years (constrained to be equal at ages 4 and 5) and declines sharply in the 6+ group. Survey catchability is the highest at age 1, relatively flat from ages 2 to 5 (constrained to be equal at ages 4 and 5) and also drops in the 6+ group.

Results from this year's assessment show some differences when compared to those produced by the last two assessments, both SSB and R are scaled downwards while F is scaled upwards (see Section 6.5.2). SSB in 2010 is estimated to be 172 thousand tonnes, being 62% below the historical mean (455 thousand tons, mean of 1978 – 2009). SSB shows a declining trend since 2006 due to the lack of strong recruitments since 2004. From 2009 to 2010, SSB dropped 91 thousand tonnes (35%). Fishing mortality ($F_{2\text{-}5}$) in 2010 is estimated to be 0.43 year^{-1}, being double that the historical mean. F_{2010} is higher than F_{2009} reflecting the decline of stock abundance but the stability of catches. The 2010 recruitment (1418 billion individuals, CV=17%) is 76% below the historical geometric mean. A low 2010 recruitment is supported by the 2011 Spring acoustic surveys (at age 1).

Coefficients of variation of the estimated parameters, as derived from the Hessian matrix, are given in Table 6.5.1.2. Correlations between parameter estimates as derived from the Hessian were all below 0.35. It should be noted that since the objective function is not a proper likelihood function due to the externally set weighting of the observations, these CVs and correlations can only be taken as indicative of the uncertainties in the results.

Bootstrap estimates of uncertainty in SSB, recruitment and fishing mortality were made by re-sampling the residuals of all data (catches-at-age, acoustic and DEPM surveys) around the model values. The main results from 100 replicas are shown in Figure 6.5.1.12. 90% confidence limits for the recruitment are narrow, except in the last year of the assessment and both SSB and fishing mortality seem to be estimated with a reasonable and consistent precision across the time series.

6.5.2 Reliability of the assessment

The results from this year's assessment are comparable to those of last year's assessment, in terms of trends (Figure 6.5.1.6). In particular, the decrease in SSB and increase in F since 2007 is consistent in both assessments.

However, as already noticeable in last year's assessment, there is a strong retrospective pattern (2008 – 2010) consisting of a gradual reduction of the SSB estimates and an upward shift in F with some influence backwards in time (reaching up to 2002). This retrospective pattern is caused by the contradictory signals provided by the relatively high level of the 2008 DEPM SSB estimate (when compared to former DEPM estimates, namely the previous one in 2005) versus the decreasing trend provided by the acoustic estimates. As noted in WG2009, the DEPM 2008 estimate had a strong influence the year it was included in the assessment for the first time producing a downward shift in F and an upward shift in SSB. As new years of acoustic surveys and catches were added to the assessment, the influence of this point has declined at the same time that the positive residual for this 2008 DEPM data point has increased. These contrasting trends originating from the DEPM and acoustic surveys contribute also to the pattern of recent negative vs past positive acoustic residuals signalled in previous assessments (see Figure 6.5.1.6 and also Section 6.9). The retrospective pattern reflects the uncertainty of the current assessment in relation to the absolute levels of the biomass and fishing mortality outputs, although does not invalidate the perception of a sharp decreasing trend of biomass and increasing trend in F since 2007. Next year, the results from the DEPM 2011 survey will be available and will enter the assessment. Very preliminary information from this last DEPM survey suggests a reduction of the total egg production in comparison to the previous years' surveys. Although the final results of the new survey are dependent on the adult parameters, a major contradiction in the recent assessment trend is not expected.

The influence of the DEPM 2008 estimate and the strength of the retrospective pattern in the assessment is related to the relative weighting of the surveys in relation to each other and to the catches at age, a matter which should be revised in the benchmark that will take place next year.

A revision of the DEPM survey as well as a comprehensive analysis of the discrepancies between the DEPM and the acoustic survey series is planned for the next meeting of the WGACEGG (November) to provide input for the benchmark. The relative level of the 2008 DEPM survey and the comparison of egg and adult fish distribution (e.g. in the 2011 acoustic survey) deserve particular attention.

The decrease of SSB between 2009 and 2010 is also influenced by the relatively low level of fish mature at age 1 and the low stock weights for age groups 2-6+ encountered in the 2010 surveys. The large interannual variability evident in the maturity ogives calculated from survey samples is a matter of concern and a discussion of the best way to make use of the maturity ogives is planned for the benchmark assessment as well.

Uncertainties in the assessment relating to the extent of sardine movement across the northern stock boundary, the weighting of Portuguese and Spanish acoustic surveys in the combined abundance index, and the estimation of fishery selection and survey catchability patterns for the older age groups still apply.

6.6 Short term predictions (Divisions VIIIc and IXa)

Catch predictions were carried out using results from the final AMCI assessment. Predictions were carried with the following assumptions:

- the input value for the 2010 recruitment was that estimated in the assessment, R_{2010}=1419 million individuals;
- Input values for 2011 and 2012 recruitments were set equal to the geometric mean of the period 2005-2010, $R_{GM(05-10)}$ = 2407 million individuals;
- Weights-at-age in the stock and in the catch were calculated as the arithmetic mean value of the last three years (2008-2010);
- The maturity ogive corresponded to the mean values of the period 2001-2010;
- As in the assessment, input value for natural mortality was 0.33 and input values for the proportion of F and M before spawning were 0.25;

- The exploitation pattern and F_{sq} were the average F(2008-10) unscaled. F_{sq} = 0.36 year^{-1}

The 2010 recruitment estimated by the assessment model was used in the prediction since it is supported by data from the April 2011 acoustic survey (at age 1) (see also section 6.3). The basis for the 2011 – 2012 recruitment is different from that assumed in the WG2010 assessment. The assessment indicates the last strong recruitment was in 2004. Since then, no strong recruitments have been observed and the last five recruitment estimates, 2006 – 2010, are among the lowest of the historical series. The declining trend of the recruitment time series has apparently not stopped (Figure 6.5.1.6). The WG considers that the possibility that low recruitments continue in the near future should be taken into account in the short term predictions. Therefore, a low recruitment, corresponding to the geometric mean of the period 2005 – 2010 is assumed for 2011 – 2012.

The remaining assumptions are equal to those used in catch predictions performed last year.

Input values are shown in Table 6.6.1 and results are shown in Table 6.6.2. The predicted catches with Fsq (0.36) for 2011 are 65 thousand tonnes. Predicted SSB for 2011 is 174 thousand tonnes, which is 61% below the historical mean. If fishing mortality remains at the Fsq level (0.36), the predicted yield in 2012 (57 thousand tonnes) corresponds to a decline of 38% relative to the catch level in recent years (average of 92 thousand tonnes, 2006 – 2010). Predicted SSB for 2012 is 139 thousand tonnes, which means a decrease of 20% with respect to the estimated 2010 SSB.

It should be pointed out that the outcome of short term deterministic predictions is very influenced by the high uncertainty in the population and fishing mortality estimates in the last year of assessment (2010), and to the assumptions of recruitment and fishing mortality in 2011 and 2012 (see section 6.5.2).

6.7 Reference points and harvest control rules for management purposes

The WG examined potential reference points for sardine including the fitting of a stock recruitment relationship with FLR software.

When fitting a Ricker S-R relationship (Figure 6.7.1),

- it was found that the parameters of the S-R relationship were highly dependent on the 2010 estimate of SSB: this was the lowest SSB estimated in the series and it has produced a low recruitment in 2010 (confirmed by the 2011 Acoustic survey at age 1). Comparing the S-R curve obtained this year with the one obtained last year (using the whole series up to 2008) it can be seen that the inclusion of two more years of data, but specifically the 2010 pair of estimates, changes strongly the shape of the curve. This results in a strong decrease of the F_{msy} estimates, from 0.53 to 0.23, respectively.
- This year, as in the past, there was a strong pattern of residuals in time from the fitted S-R relationship, shifting from positive to negative around 1993. This might be indicative of lower productivity of the sardine stock in recent years. The restriction of the fitting to the most recent period (1993-2010) lead also to a remarkable change in the fitted Ricker S-R relationship, resulting in a F_{msy} of about 0.29 i.e. 30% higher than the one obtained from the fitting over the complete historical series. This result is at odds with the precautionary approach rationale behind the selection of this period of the series for the fitting of the S-R relationship.

- As a result of this analysis, it is clear that the Ricker S-R relationship is very unstable and highly dependent on the selection of the set of data used for the fitting and in this particular case, on the inclusion of the last year of the series.
- A segmented regression was explored as well, and although it provided a slightly higher log-likelihood than the Ricker (difference of 0.4 units), it provided a similarly highly uncertain slope.
- This is a natural result if environmental effects on early life stages are the main driver behind recruitment success and therefore a clear relationship between stock and recruitment cannot be established.

Because of the uncertainties surrounding the form and parameters of the S-R relationship, the WG searched for other criteria to outline sustainable fishing mortalities:

- The %SPR: F35%SPR or F40%SPR criteria are robust proxies for setting F_{msy} when no good fitting of a S-R is attainable (Clark 1991, 1993 in ICES WKFRAME Report 2010). Macer and Sissenwine (1993) stated that the higher the natural mortality, the bigger should be kept the percentage of spawning biomass per recruit in relation to the virgin state (the criteria of %SPR). They also indicated that small pelagic species could be poorly resistant to exploitation and for these species the %SPR corresponding with the F_{med} can be as high as 40 % or even in some cases 60%. An exploitation allowing relatively high %SPR is also to be selected while including considerations of the role of this pelagic species as prey of many other valuable predators (as hake, monkfish, cetaceans etc.). As such the WG estimated the F corresponding to 40, 50 and 60%SPR for this stock: resulting in F of 0.31, 0.22 and 0.16 respectively (Table 6.7.1). And it was noted that F50%SPR is coincident with the F_{msy} obtained with FLR after fitting of the Ricker S-R relationship over the whole historical data series.
- A second criterion is the reference of Patterson (1992) for pelagics, after a meta analysis of many pelagic stocks, which suggested that a moderate and sustainable rate of exploitation could be reached at 0.67 times the natural mortality (so a F/Z around 0.4). For the Iberian sardine, that criterion would be =0.67*0.33= 0.22. This value is again coincident with the F50%SPR and with the F_{msy} obtained with FLR after fitting of the Ricker S-R relationship over the whole historical data series.

As a result of these analyses the WG considered that a good candidate for F_{msy} could be in the range 0.22-0.31, and preferable closer to 0.22 at F50%SPR and satisfying the criterion of F/Z=0.4 of Patterson (1992). This range is also in accordance with preliminary simulations carried out last year which indicated that F values between 0.2 and 0.3 $year^{-1}$ may be a reasonable compromise between high yield and low risk in the medium term (20 years) for an assumed B_{lim} (ICES, 2010). If a biomass level is required to trigger management, a natural candidate would be SSB_{2000}= 250 thousand tonnes. This is the second lowest SSB estimate in the historical series and the stock did recover from that low value.

However, as a benchmark for sardine is scheduled for next February, which may result in some revision of the current assessment of this stock, the WG considered that it would be better to wait for the results of the new assessment before making a definitive proposal for the reference points for management within the MSY framework. The WG also considers that candidate reference points need to be evaluated within a management strategy evaluation framework.

6.8 Management considerations

No TAC is set to manage the stock. No specific management objectives are known to ICES.

SSB in 2010 is estimated to be 172 thousand tonnes, being 62% below the historical mean (455 thousand tons, mean of 1978 – 2009). SSB shows a declining trend since 2006 due to the lack of strong recruitments. The assessment indicates the last strong recruitment was in 2004. Since then, no strong recruitments have been observed and the last five recruitment estimates, 2006 – 2010, are among the lowest of the historical series. The declining trend of the recruitment time series has apparently not stopped. From 2009 to 2010, SSB dropped 91 thousand tonnes (35%). Fishing mortality (F_{2-5}) in 2010 is estimated to be 0.43 year^{-1}, being double that the historical mean. F_{2010} is higher than F_{2009} reflecting the decline of stock abundance but the stability of catches. The 2010 recruitment (1418 billion individuals, CV=17%) is 76% below the historical geometric mean. A low 2010 recruitment is estimated in the assessment being supported by the 2011 Spring acoustic surveys (at age 1). With a fishing mortality at 0.36, which is the average for 2008 - 2010, short term predictions indicate that SSB in 2011 will be similar to that in 2010 (174 thousand tonnes). SSB is expected to decrease 20% in 2012 and 12% in 2013 if recruitment continues to be low (average level of 2005 – 2010). Fishing at a level of 0.36 year-1 implies a catch of 57 thousand tonnes which is a reduction of 38% relative to the catch level in recent years (average of 92 thousand tonnes, 2006 – 2010).

The level of SSB and fishing mortality in 2010 are the lowest and the highest of the historical series, respectively. These estimates are considered uncertain due mainly to the contradiction between signals from the DEPM and the acoustic surveys in recent years. The outcome of short term deterministic predictions is very influenced by the high uncertainty in the population and fishing mortality estimates in 2010. Overall, this demands a cautionary use of the outputs of the current assessment, paying far more attention to the relative trends in biomass and fishing mortality levels than to their actual absolute values.

There is a decreasing trend in SSB and increasing trend in F since 2007, which reflect the combination of a series of low recruitments since 2006 and the stability of catches. The magnitude of this decline is however uncertain. The decline in SSB is expected to continue in 2011 since there are indications of a low 2010 recruitment. Preliminary results from the 2011 DEPM survey provide some support to the decline in SSB.

In the late 1990s, an extended period of successive low recruitments combined with high fishing mortality led to a period of low SSB, particularly in the northern areas of the stock (northern Spanish waters) which resulted in a critical phase for the sardine fisheries in that area. During that period, catches in Galicia (NW Spain) dropped to ¼ of previous levels and the spawning area in the northern Iberian waters showed a strong reduction. Unlike what happened at the end of the 90s, sardine catches have remained relatively stable since 2007, although with differences among areas. The spawning area in the north did not show a strong reduction until 2010 but preliminary results of the 2011 DEPM survey provide indication of some reduction mainly off the western waters of the Iberian Peninsula. The acoustic surveys show signs of a generalized decline in abundance although stronger in some areas than others.

As last year, the WG considers that F should be brought back to where it was before the start of the increasing trend, i.e. the 2002 – 2007 level, which is 0.21 year^{-1}. This corresponds to landings of less than 36 thousand tonnes in 2012.

The Iberian sardine (*Sardina pilchardus*) is a good example of the life strategy of small pelagic fish around the world: short life span, fast growth, high fecundity and long spawning season (see Carrera and Porteiro, 2003; Stratoudakis *et al.* 2007 and references therein) and is considered a forage fish, i.e. a fish that provides food for predatory fish as well as marine mammals and birds. Sardine is one of the most abundant small pelagic species in western Iberian waters and has been found to be important in the diet of several species of fish and marine mammals (see Preciado *et al*., 2008, Silva, 1999, Santos *et al*., 2004). Forage fish such as sardine may exert bottom-up control of their predators or top-down control on their zooplanktonic prey, or they may control both prey and predators (wasp-waist control; Cury *et al.* 2003). Because of the their central position in marine food webs it is important to understand their role.

As is the case for most marine fish (Cushing, 1996), recruitment of small pelagic species is highly variable and does not present a clear relationship with spawning stock biomass, due to (among other factors) high and variable mortality rates during the early-life stages, which are thought to be strongly affected by environmental processes. In species with short life-spans, the low number of extant year classes in the population leads to a high dependency of SSB on recruitment. Improving our understanding of the mechanisms underlying sardine recruitment success (or lack thereof) has been the objective of several previous studies. Proposed environmental drivers include various global to local scale environmental variables, integrated over the time periods identified as the most critical to ensure egg and larval survival by reducing the transport of eggs and larvae offshore. Indirect effects, e.g. on growth and condition through variations in food supply or water temperature have been given less attention. Results from such studies show that environmental effects, although present, are often weak and in some cases findings have been contradictory. For example, upwelling intensity has been found to affect recruitment both positively and negatively (Dickson *et al*., 1988; Santos *et al*., 2007). Unfortunately, it is in the nature of short time series that observed correlations tend to vary according to the length of the series available and great care is needed to exclude coincidental relationships (Myers, 1998; Solow 2002). Inconsistent results could also be due in part to the different analytical techniques used, e.g. whether non-linear relationships or time-lagged effects have been considered, or whether autocorrelation has been controlled for. One can hypothesise plausible mechanisms to explain the observed empirical links and there is no doubt that further research on mechanisms by which the environment affects recruitment remains crucial to improve our understanding of the processes. However, such studies, if successful, may not provide a panacea: the environment in which fish live is intrinsically multidimensional and it may simply be wrong to assume that a single process is the most important one (Carrera and Porteiro, 2003).

The majority (99%) of sardine landed in Spain and Portugal are taken by purse seiners. Unlike many other types of fishing gear, purse seines have low by-catch levels of non-target species: when targeting sardine, the catches are virtually monospecific. Observer data and interview surveys of fishers also indicate a low impact on charismatic megafauna (cetaceans, seabirds and turtles) and, because purse seiners operate in open waters, there is little impact on the seabed. Ghost fishing has also been considered to be minimal since loss of gear is rare. Some slippage (release of fish from the net) has been documented but is again considered to have a low impact although its occurrence was found to be very variable in relation to season and region making it very difficult to quantify (Stratoudakis & Marçalo, 2002).

The overall effect of the sardine fishery on the pelagic ecosystem of the Atlantic Iberian waters has not been evaluated. The most likely impacts will take place though alterations of prey-predator relationships via modification of sardine abundance, size structure and behaviour. Sardine is a known prey of several species, and particularly important for some cetaceans and seabirds (see previous section). The low availability of such high energy prey could have adverse consequences for both individual predators and predator populations. Given the complex nature of marine food webs, simulation models offer the most likely means of improving our understanding of effects of fishing on the pelagic ecosystem.

Limitations to fishing effort implemented in Portugal and Spain since 1997 continued to be in effect during 2010. Catch limitations are still in place in Spain. A catch limit of 55 thousand tonnes was set for the Portuguese fishery by the Portuguese authorities for 2010 but was not complied to.

6.9 Benchmark preparation

A benchmark was proposed for sardine in 2012. The last benchmark for Sardine in VIIIc-IXa took place in 2006. There are recurrent problems in the assessment of sardine which have been noted every year in the report but that have not been solved and the following issues were selected to be discussed at the benchmark:

1) Stock identity: following the outcome from project SARDYN, sardine in VIIIc and IXa is considered to be a separate stock from sardine in VIIIb+a and northwest Africa. However, there is indication of some exchange between VIIIc and Biscay North (VIIIb+a).

   Published and unpublished information from sardine in all areas such as morphometrics, genetics, parasites, distribution and, any modelling assessing migration taking place between VIIIc and Biscay is being reviewed and will be examined in the benchmark.

2) Tuning series: (a) the Portuguese and Spanish spring acoustic surveys are combined in a single index of abundance in the assessment. The surveys´ relative catchability and implications for their joint or separate use in tuning the assessment need to be investigated. (b) the DEPM sampling has experienced improvements in sampling, laboratory and data analyses over time. A revision and standardization of the historical series is therefore needed. (c) Survey catchability-at-age has apparently changed from the 1980s to the 1990s. There were improvements in survey methodology over the period and biological changes may also have taken place.

   The planned intercalibration between the Spanish and Portuguese acoustic surveys could not take place due to logistic reasons but the data from the previous intercalibrations (2008 and 2009) is being analysed and results will be presented at the next WGACEGG meeting later on in the year. The revision and standardisation of the DEPM series is also under way and again, results will be presented at the November WGACEGG. An exploration of both surveys´ relative catchability and the sensitivity of the assessment to the tuning surveys has been carried out and was presented to the WG. Results indicate that since 1996, Spanish and Portuguese acoustic surveys are consistent for ages 1-3 years but show differences for older years. In the earlier period, the sparcity of data precludes a comparison. The DEPM and acoustic surveys indicate different stock trends particularly since 2002. Cohort signals are generally consistent in the spring surveys. An analysis of the sensitivity of the assessment to separate acoustic surveys indicates that the two Portuguese surveys provide similar results (used one at a time) which are also comparable to using the joint Spanish-Portuguese survey. Using the Spanish survey only provided similar results to using the DEPM only.

An investigation of the possible trends over the time series of changes in sardine behaviour and /or depth distribution is under way using the haul data from both countries´ surveys.

3) Biological parameters: (a) Maturity ogive shows extensive year-to-year variations. (b) Ogive and weights-at-age were fixed in 1978 – 1985 at values far from long term average at some ages.

A WD presented to the WG (Soares *et al.*, 2011) summarised the progress on the revision work in the maturity ogives and stock weights for the earliers years of the assessment period (1982-1995) which were originally set as fixed values and which are now being recalculated using biologcial data from samples of the fishery for those years. The objective of this work has been to explore the effect on the assessment of these changes. Results indicate that the impact of these changes is limited to the earlier period and no trends in weights-at-age values were found over the time series. Due to the fact that the fixed weight-at-age values were at the lower bound of more recent values (mainly for the younger and more abundant age groups), the new SSB series emphasizes the downward stock trend.

4) Assessment method: (1) Alternatives to the current assessment model (AMCI) are needed since the programme is not going to be maintained in the future; (2) Sensitivity of the assessment to the weighting of the different input data and to assumptions about selectivity, maturity ogive, survey catchability and natural mortality needs to be evaluated

There has been a preliminary exploration of a potential candidate programme to substitute the current assessment tool, AMCI (Skagen, 2005). The candidate programm is Stock Synthesis (v 3) which is as flexible as AMCI, allowing the inclusion of: assumptions such as dome-shaped selectivity-at-age and selectivity varying over time, uncertainty in input data and it can also incorporate some link to environmental data: e.g. in recruitment, selectivity. Preliminary runs of last year assessment in AMCI and SS3 gave similar results.

With respect to (2) preliminary work has been carried out to address these issues and some discussion of the progress achieved was discussed during the WG. For example, with respect to the assumptions on natural mortality (being a constant value of 0.33, following Pestana (1989) for all ages), the WG agrees there is a need to explore the effect of alternative approaches. Variation of M by age is a plausible hypothesis for small pelagics and it has already being adopted for the southern horse mackerel stock following this stock´s benchmark. It is planned to carry out this exploration before the sardine benchmark of next year taking into account also if data on feeding behaviour of sardine predators will provide an indication for the variability of this parameter over time and space.

5) Biological Reference Points: Reference points are not defined for this stock and need to be considered.

During the WG, progress was achieved on the discussion of potential reference points for the Iberian sardine stock (see section 6.7). Candidates were tested using FLR and fitting a stock recruitment relationship with a Ricker curve and a segmented regression.

6) Other issues: (1) Compile information on the role of sardine as a forage fish in the pelagic ecosystem; (2) Study potential environmental drivers.

A WD presented to the WG (Santos *et al.*, 2011) summarised the results of an analysis of environmental effects on recruitment, evaluating a series of large-scale and local-scale variables including time-lagged effects previously identified as being related to recruitment. For those showing significant relationships, the WD explores whether the variable explains trends and/or cycles in recruitment or explains variation around the trend or cycle. The former case includes variables such as sunspot numbers and wind strength, which show trends linearly related to the trend in recruitment, relationships which could be coincidental. More interestingly, variation in SST helps explain recruitment variation around the general trend and variation around the 4-year cyclic trend detected in recruitment was weakly related to the previous year´s SSB, the only evidence found of any stock-recruitment relationship.

7) Work is in progress to quantify predation on sardine by comon dolphins, the most numerous marine mammal in Iberian Atlantic waters, based on stomach contents data collected since 1990. Preliminary analysis shows that the importance of sardine in the diet has declined in the last decade, apparently coincident with the decline in abundance of the Iberian sardine stock.

Table 6.2.1.1: Sardine in VIIIc and IXa: Spanish and Portuguese composition of the fleet licensed to catch sardine in 2010. Length category: range (average) in m, Engine power category: range (average) in HP.

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Country	Details given	Length (metres)	Engine power (Horse Power)	Gear	Storage	Discard estimate	No vessels
Spain (northern)	yes	9-38 (21)	28-950 (305)	Purse seine	Dry hold with ice	No	289
Spain (Gulf of Cadiz)	yes	8-34 (16)	27-800 (182)	Purse seine	Dry hold with ice	No	73
Portugal	yes	10.5 – 27 (20)	71 – 447 (249)	Purse seine	Dry hold with ice	No	159

Table 6.2.2.1 Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2010 by ICES Sub-Division. Above absolute values; below, relative numbers

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	1852	2883	307	818	**5860**
VIIIc-W	706	2055	3944	1208	**7912**
IXa-N	615	2247	2473	2074	**7409**
IXa-CN	3824	8502	14263	14333	**40923**
IXa-CS	4822	4438	5335	3028	**17623**
IXa-S (A)	539	1651	1841	1150	**5181**
IXa-S (C)	410	486	2519	1248	**4662**
Total	**12767**	**22262**	**30682**	**23859**	**89571**

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	2,07	3,22	0,34	0,91	**6,54**
VIIIc-W	0,79	2,29	4,40	1,35	**8,83**
IXa-N	0,69	2,51	2,76	2,32	**8,27**
IXa-CN	4,27	9,49	15,92	16,00	**45,69**
IXa-CS	5,38	4,95	5,96	3,38	**19,67**
IXa-S (A)	0,60	1,84	2,06	1,28	**5,78**
IXa-S (C)	0,46	0,54	2,81	1,39	**5,21**
Total	**14,25**	**24,85**	**34,25**	**26,64**	

Table 6.2.2.2: Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by sub-area and total for the period 1940-2010.

	Sub-area										
Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All sub-areas	Div. IXa	Portugal	Spain (excl.Cadiz)	Spain (incl.Cadiz)
1940	66816		42132	33275	23724		**165947**	**99131**	**99131**	**66816**	**66816**
1941	27801		26599	34423	9391		**98214**	**70413**	**70413**	**27801**	**27801**
1942	47208		40969	31957	8739		**128873**	**81665**	**81665**	**47208**	**47208**
1943	46348		85692	31362	15871		**179273**	**132925**	**132925**	**46348**	**46348**
1944	76147		88643	31135	8450		**204375**	**128228**	**128228**	**76147**	**76147**
1945	67998		64313	37289	7426		**177026**	**109028**	**109028**	**67998**	**67998**
1946	32280		68787	26430	12237		**139734**	**107454**	**107454**	**32280**	**32280**
1947	43459	21855	55407	25003	15667		**161391**	**117932**	**96077**	**65314**	**65314**
1948	10945	17320	50288	17060	10674		**106287**	**95342**	**78022**	**28265**	**28265**
1949	11519	19504	37868	12077	8952		**89920**	**78401**	**58897**	**31023**	**31023**
1950	13201	27121	47388	17025	17963		**122698**	**109497**	**82376**	**40322**	**40322**
1951	12713	27959	43906	15056	19269		**118903**	**106190**	**78231**	**40672**	**40672**
1952	7765	30485	40938	22687	25331		**127206**	**119441**	**88956**	**38250**	**38250**
1953	4969	27569	68145	16969	12051		**129703**	**124734**	**97165**	**32538**	**32538**
1954	8836	28816	62467	25736	24084		**149939**	**141103**	**112287**	**37652**	**37652**
1955	6851	30804	55618	15191	21150		**129614**	**122763**	**91959**	**37655**	**37655**
1956	12074	29614	58128	24069	14475		**138360**	**126286**	**96672**	**41688**	**41688**
1957	15624	37170	75896	20231	15010		**163931**	**148307**	**111137**	**52794**	**52794**
1958	29743	41143	92790	33937	12554		**210167**	**180424**	**139281**	**70886**	**70886**
1959	42005	36055	87845	23754	11680		**201339**	**159334**	**123279**	**78060**	**78060**
1960	38244	60713	83331	24384	24062		**230734**	**192490**	**131777**	**98957**	**98957**
1961	51212	59570	96105	22872	16528		**246287**	**195075**	**135505**	**110782**	**110782**
1962	28891	46381	77701	29643	23528		**206144**	**177253**	**130872**	**75272**	**75272**
1963	33796	51979	86859	17595	12397		**202626**	**168830**	**116851**	**85775**	**85775**
1964	36390	40897	108065	27636	22035		**235023**	**198633**	**157736**	**77287**	**77287**
1965	31732	47036	82354	35003	18797		**214922**	**183190**	**136154**	**78768**	**78768**
1966	32196	44154	66929	34153	20855		**198287**	**166091**	**121937**	**76350**	**76350**
1967	23480	45595	64210	31576	16635		**181496**	**158016**	**112421**	**69075**	**69075**
1968	24690	51828	46215	16671	14993		**154397**	**129707**	**77879**	**76518**	**76518**
1969	38254	40732	37782	13852	9350		**139970**	**101716**	**60984**	**78986**	**78986**
1970	28934	32306	37608	12989	14257		**126094**	**97160**	**64854**	**61240**	**61240**
1971	41691	48637	36728	16917	16534		**160507**	**118816**	**70179**	**90328**	**90328**
1972	33800	45275	34889	18007	19200		**151171**	**117371**	**72096**	**79075**	**79075**
1973	44768	18523	46984	27688	19570		**157533**	**112765**	**94242**	**63291**	**63291**
1974	34536	13894	36339	18717	14244		**117730**	**83194**	**69300**	**48430**	**48430**
1975	50260	12236	54819	19295	16714		**153324**	**103064**	**90828**	**62496**	**62496**
1976	51901	10140	43435	16548	12538		**134562**	**82661**	**72521**	**62041**	**62041**
1977	36149	9782	37064	17496	20745		**121236**	**85087**	**75305**	**45931**	**45931**
1978	43522	12915	34246	25974	23333	5619	**145609**	**102087**	**83553**	**56437**	**62056**
1979	18271	43876	39651	27532	24111	3800	**157241**	**138970**	**91294**	**62147**	**65947**
1980	35787	49593	59290	29433	17579	3120	**194802**	**159015**	**106302**	**85380**	**88500**
1981	35550	65330	61150	37054	15048	2384	**216517**	**180967**	**113253**	**100880**	**103264**
1982	31756	71889	45865	38082	16912	2442	**206946**	**175190**	**100859**	**103645**	**106087**
1983	32374	62843	33163	31163	21607	2688	**183837**	**151463**	**85932**	**95217**	**97905**
1984	27970	79606	42798	35032	17280	3319	**206005**	**178035**	**95110**	**107576**	**110895**
1985	25907	66491	61755	31535	18418	4333	**208439**	**182532**	**111709**	**92398**	**96731**
1986	39195	37960	57360	31737	14354	6757	**187363**	**148168**	**103451**	**77155**	**83912**
1987	36377	42234	44806	27795	17613	8870	**177696**	**141319**	**90214**	**78611**	**87481**
1988	40944	24005	52779	27420	13393	2990	**161531**	**120587**	**93591**	**64949**	**67939**
1989	29856	16179	52585	26783	11723	3835	**140961**	**111105**	**91091**	**46035**	**49870**
1990	27500	19253	52212	24723	19238	6503	**149429**	**121929**	**96173**	**46753**	**53256**
1991	20735	14383	44379	26150	22106	4834	**132587**	**111852**	**92635**	**35118**	**39952**
1992	26160	16579	41681	29968	11666	4196	**130250**	**104090**	**83315**	**42739**	**46935**
1993	24486	23905	47284	29995	13160	3664	**142495**	**118009**	**90440**	**48391**	**52055**
1994	22181	16151	49136	30390	14942	3782	**136582**	**114401**	**94468**	**38332**	**42114**
1995	19538	13928	41444	27270	19104	3996	**125280**	**105742**	**87818**	**33466**	**37462**
1996	14423	11251	34761	31117	19880	5304	**116736**	**102313**	**85758**	**25674**	**30978**
1997	15587	12291	34156	25863	21137	6780	**115814**	**100227**	**81156**	**27878**	**34658**
1998	16177	3263	32584	29564	20743	6594	**108924**	**92747**	**82890**	**19440**	**26034**
1999	11862	2563	31574	21747	18499	7846	**94091**	**82229**	**71820**	**14425**	**22271**
2000	11697	2866	23311	23701	19129	5081	**85786**	**74089**	**66141**	**14563**	**19644**
2001	16798	8398	32726	25619	13350	5066	**101957**	**85159**	**71695**	**25196**	**30262**
2002	15885	4562	33585	22969	10982	11689	**99673**	**83787**	**67536**	**20448**	**32136**
2003	16436	6383	33293	24635	8600	8484	**97831**	**81395**	**66528**	**22819**	**31303**
2004	18306	8573	29488	24370	8107	9176	**98020**	**79714**	**61965**	**26879**	**36055**
2005	19800	11663	25696	24619	7175	8391	**97345**	**77545**	**57490**	**31464**	**39855**
2006	15377	10856	30152	19061	5798	5779	**87023**	**71646**	**55011**	**26233**	**32012**
2007	13380	12402	41090	19142	4266	6188	**96469**	**83088**	**64499**	**25782**	**31970**
2008	13636	9409	45210	20858	4928	7423	**101464**	**87828**	**70997**	**23045**	**30468**
2009	11963	7226	36212	20838	4785	6716	**87740**	**75777**	**61835**	**19189**	**25905**
2010	13772	7409	40923	17623	5181	4662	**89571**	**75798**	**63727**	**21181**	**25843**

Div. IXa = IXa North + IXa Central-North + IXa Central-South + IXa South-Algarve + IXa South-Cadiz

Table 6.2.4.1: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2010.

			Total					
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6,5			22 790					22 790
7								
7,5			257 289					257 289
8			228 361					228 361
8,5			1795 901					1795 901
9			2310 003					2310 003
9,5			4074 947				561 126	4636 073
10			7249 457	46			1904 881	9154 384
10,5			8284 551	23			5002 007	13286 581
11			7646 567	137		153	7445 884	15092 741
11,5	239		7253 359	1 078		76	6801 498	14056 250
12	798		5990 378	8 988		129	5673 784	11674 077
12,5	8 317	82 762	1244 364	14 209	396	585	4384 464	5735 097
13	22 963	319 207	2805 543	24 068		748	6750 826	9923 355
13,5	35 303	425 614	1623 462	21 537		1 430	13250 047	15357 393
14	31 960	283 739	3061 216	31 939	414	2 078	18526 444	21937 789
14,5	53 400	141 869	1904 036	29 232	519	1 559	13647 588	15778 202
15	57 809	70 930	1774 443	37 266	1 246	2 177	9398 838	11342 710
15,5	69 345		3240 967	35 738	207	3 931	4991 027	8341 215
16	80 383		4908 161	43 627	144	7 171	1779 981	6819 467
16,5	74 175		4526 647	36 272	300	4 305	1828 839	6470 538
17	87 966		2905 215	39 333	212	1 853	3817 509	6852 089
17,5	376 440	69 300	5350 165	46 168	2 107	1 034	3437 162	9282 376
18	1481 822	122 757	3426 061	68 003	4 298	1 137	4466 693	9570 770
18,5	2434 046	347 400	7469 421	75 158	9 185	2 422	6769 801	17107 433
19	3456 204	346 493	8249 149	71 096	15 320	5 492	6356 772	18500 526
19,5	4434 057	577 673	8306 709	58 431	25 105	10 532	7342 477	20754 984
20	8264 700	715 501	7014 188	56 672	43 366	13 640	5482 150	21590 216
20,5	8353 058	1574 473	5596 981	43 145	48 018	12 490	2119 062	17747 228
21	13541 516	5304 668	5387 032	33 080	49 866	7 272	1021 164	25344 598
21,5	10033 558	8797 579	5310 471	18 278	32 953	4 366	380 315	24577 519
22	8712 342	14755 894	5904 205	8 645	13 676	1 778	68 036	29464 576
22,5	5886 207	15985 595	4843 996	3 564	5 231	721	42 077	26767 391
23	3210 402	12810 008	3325 815	1 740	662	202	10 823	19359 652
23,5	1371 711	8356 108	1941 252	696	181	5		11669 952
24	1005 419	3696 860	944 421	160				5646 860
24,5	318 230	1154 548	416 744			136		1889 657
25	140 943	445 568	190 821					777 332
25,5	16 750	16 638	36 847					70 235
26								
26,5								
27			11 871					11 871
27,5								
28								
28,5								
29								
Total	73560 063	76401 184	146833 806	808 329	253 405	87 421	143261 275	441 205 482
Mean L	21,2	22,5	0,0	17,8	20,6	19,0	15,2	17,9
sd	1,41	1,54	11871,00	2,48	1,20	2,42	2,90	4,32
Catch	**5860**	**7912**	**7409**	**40923**	**17623**	**5181**	**4662**	**89571**

Table 6.2.4.1a: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the first quarter of 2010.

				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				23				23
11								
11,5				683				683
12				6 093				6 093
12,5				8 870				8 870
13				12 994				12 994
13,5				9 210				9 210
14				8 716				8 716
14,5	2 449			4 946				7 395
15			33 314	4 537		8	219 324	257 183
15,5	9 798			4 398		24	584 863	599 083
16	39 453			4 445		12		43 910
16,5	23 404		33 314	2 143		97	1142 476	1201 434
17	54 522		152 863	1 457		151	1956 635	2165 628
17,5	281 575		33 314	2 494		234	841 408	1159 025
18	710 633		119 552	3 648	131	408	907 205	1741 577
18,5	1233 322	35 520	86 238	5 387	2 727	574	1447 540	2811 308
19	1517 125		305 717	5 292	5 408	969	596 158	2430 668
19,5	2179 052	40 660	391 957	5 444	10 382	1 446	713 794	3342 734
20	3189 002	65 673	1134 825	6 849	17 629	1 548	402 757	4818 284
20,5	3815 475	147 225	1062 264	6 986	17 596	1 164	137 578	5188 288
21	3591 661	506 293	1169 933	4 957	18 062	928	91 716	5383 549
21,5	2625 028	985 989	977 823	3 003	8 145	668		4600 656
22	2073 732	1512 185	1070 006	1 879	3 552	338		4661 691
22,5	1200 693	2020 223	777 969	843	1 258	166		4001 151
23	1301 293	1318 054	425 264	625		37		3045 272
23,5	456 846	777 269	299 767	194		5		1534 081
24	378 145	272 215	52 936	118				703 414
24,5	194 967	95 172	52 936					343 075
25	80 500	68 126						148 626
25,5								
26								
26,5								
27								
27,5								
28								
28,5								
29								
Total	24958 675	7844 602	8179 992	116 233	84 889	8 777	9041 454	50 234 623
Mean L	21,0	22,6	21,3	16,5	20,7	20,1	18,0	20,7
sd	1,47	0,93	1,47	3,25	0,87	1,28	1,31	1,98
Catch	**1 852**	**706**	**615**	**3 824**	**4 822**	**539**	**410**	**12 767**

Table 6.2.4.1b: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the second quarter of 2010.

				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			546 302					546 302
9			944 773					944 773
9,5			1320 129				225	1320 354
10			3709 743				452	3710 195
10,5			4884 263				80 994	4965 257
11			4822 816				921 590	5744 406
11,5	19		4814 698			76	1842 607	6657 400
12	48		3906 224			76	1156 884	5063 232
12,5	57					228	562 652	562 937
13	948		419 563			380	472 573	893 464
13,5	8 076		68 766	801		875	663 898	742 416
14	12 447		1226 589	4 227	208	1 407	574 336	1819 214
14,5	23 173		1383 477	9 440	416	723	1076 600	2493 828
15	35 850		1541 926	13 364	1 040	38	1984 152	3576 370
15,5	34 456		3160 664	16 819	104		1261 937	4473 980
16	27 858		4784 400	21 599	104	64	688 270	5522 295
16,5	44 621		2233 577	21 742	208	51	252 452	2552 652
17	29 838		984 048	21 455		598	772 033	1807 972
17,5	93 197	60 905	691 853	19 877	104	618	805 496	1672 050
18	682 318	107 873	271 484	19 547	104	666	1172 375	2254 367
18,5	1178 215	269 034	487 881	14 303	387	1 004	883 543	2834 368
19	1728 357	287 072	796 902	8 227	875	2 547	1082 190	3906 170
19,5	2046 127	377 647	546 688	5 732	3 746	4 232	258 509	3242 680
20	3824 107	526 543	1246 637	6 975	10 195	4 699	112 551	5731 707
20,5	3552 835	899 013	1118 659	6 040	13 579	4 150	43 333	5637 609
21	6721 301	1726 440	2274 527	5 334	14 307	2 643	2 319	10746 872
21,5	5661 549	2708 536	1876 373	3 328	12 431	1 514	5 058	10268 789
22	4332 500	3568 687	1942 243	1 073	3 855	868		9849 227
22,5	3533 744	3041 145	1394 338	579	2 299	263		7972 368
23	951 586	2980 327	1138 694	408	314	30		5071 359
23,5	551 550	1798 372	762 610	111	142			3112 784
24	468 157	1157 626	433 077	42				2058 902
24,5	105 354	300 049	178 773					584 176
25	36 570	59 599	90 751					186 920
25,5	12 126	13 312	36 847					62 285
26								
26,5								
27			11 871					11 871
27,5								
28								
28,5								
29								
Total	35696 984	19882 180	56052 166	201 024	64 418	27 751	16677 029	128601 552
Mean L	21,2	22,3	15,2	17,5	20,9	19,3	15,2	18,
sd	1,35	1,28	4,45	1,86	1,31	2,40	2,63	4,52
Catch	**2 883**	**2 055**	**2 247**	**8 502**	**4 438**	**1 651**	**486**	**22 262**

Table 6.2.4.1c: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter of 2010.

				Third Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
6,5			22 790					22 790
7								
7,5			257 289					257 289
8			228 361					228 361
8,5			1249 599					1249 599
9			1357 719					1357 719
9,5			2690 035					2690 035
10			3405 384	46				3405 430
10,5			3146 100					3146 100
11			2399 267	137			596 953	2996 357
11,5	220		2100 065	137			1478 507	3578 929
12	750		1218 759	504			2885 931	4105 944
12,5	1 868	68 645	338 214	942			3116 836	3526 505
13	2 838	264 782	611 382	858			5564 358	6444 218
13,5	3 255	353 045	557 133	1 252		310	11748 862	12663 857
14	5 130	235 359	598 566	1 585	206	310	15100 429	15941 584
14,5	10 199	117 679	364 120	2 074	103	310	9139 812	9634 297
15	15 567	58 840	148 657	1 420	206	1 033	4926 460	5152 182
15,5	18 699		63 455	1 463	103	2 272	2696 583	2782 574
16	11 474			2 052	22	3 820	911 131	928 499
16,5	6 150		1247 830	3 286	56	1 859	420 767	1679 948
17	3 606		7 286	6 952	123	413	691 341	709 721
17,5	1 668		3175 556	12 635	257	97	1381 588	4571 801
18	4 388		870 754	19 649	157	21	1756 852	2651 820
18,5	15 045		4129 833	27 186	580	499	2474 321	6647 463
19	22 153	16 439	2441 563	29 342	3 582	1 653	2997 940	5512 671
19,5	44 896	83 544	4757 944	26 921	4 729	3 373	3632 163	8553 570
20	82 833	33 227	3182 896	26 847	10 661	4 814	2200 165	5541 443
20,5	245 897	315 602	2297 817	17 454	13 151	4 643	603 514	3498 079
21	349 576	2282 901	1278 277	13 479	12 652	1 836	541 636	4480 356
21,5	628 305	3791 176	1419 386	6 269	8 378	1 441	288 919	6143 874
22	539 660	7414 820	1660 443	2 442	5 079	531	43 503	9666 478
22,5	472 960	8443 481	1017 791	174	1 674	271		9936 351
23	275 872	6543 074	1021 559	51	348	136	10 823	7851 862
23,5	197 722	4485 159	697 206		39			5380 126
24	115 774	1711 607	357 152					2184 533
24,5	17 273	582 795	185 035			136		785 239
25	16 203	247 717	100 070					363 990
25,5	4 624	1 231						5 855
26								
26,5								
27								
27,5								
28								
28,5								
29								
Total	3114 605	37051 124	50605 293	205 155	62 105	29 775	75209 394	166254 661
Mean L	22,0	22,5	16,3	19,2	20,8	18,9	15,2	17,3
sd	1,54	1,74	4,81	1,69	1,11	2,31	2,39	4,36
Catch	**307**	**3 944**	**2 473**	**14 263**	**5 335**	**1 841**	**2 519**	**30 682**

Table 6.2.4.1d: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter of 2010.

				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			7 511					7 511
9,5			64 783				560 901	625 684
10			134 330				1904 429	2038 759
10,5			254 188				4921 013	5175 201
11			424 484			153	5927 341	6351 978
11,5			338 596	258			3480 384	3819 238
12			865 395	2 391		53	1630 969	2498 808
12,5	6 392	14 117	906 150	4 397	396	357	704 976	1636 785
13	19 177	54 425	1774 598	10 216		368	713 895	2572 679
13,5	23 972	72 569	997 563	10 274		245	837 287	1941 911
14	14 383	48 380	1236 061	17 411		361	2851 679	4168 275
14,5	17 579	24 190	156 439	12 773		526	3431 176	3642 683
15	6 392	12 091	50 546	17 945		1 098	2268 902	2356 974
15,5	6 392		16 848	13 058		1 636	447 644	485 578
16	1 598		123 761	15 531	18	3 275	180 580	324 763
16,5			1011 926	9 100	36	2 299	13 144	1036 505
17			1761 018	9 469	89	691	397 500	2168 768
17,5		8 395	1449 442	11 163	1 746	84	408 670	1879 501
18	84 483	14 883	2164 271	25 159	3 906	42	630 261	2923 006
18,5	7 464	42 845	2765 469	28 282	5 492	344	1964 397	4814 294
19	188 569	42 981	4704 967	28 235	5 456	324	1680 484	6651 016
19,5	163 982	75 822	2610 120	20 334	6 248	1 481	2738 011	5615 999
20	1168 758	90 058	1449 830	16 000	4 881	2 578	2766 677	5498 782
20,5	738 851	212 634	1118 241	12 665	3 692	2 533	1334 637	3423 252
21	2878 978	789 034	664 295	9 311	4 845	1 865	385 493	4733 821
21,5	1118 676	1311 878	1036 889	5 678	3 999	742	86 338	3564 200
22	1766 450	2260 202	1231 513	3 251	1 189	41	24 533	5287 180
22,5	678 810	2480 746	1653 898	1 969		21	42 077	4857 520
23	681 651	1968 554	740 298	657				3391 160
23,5	165 593	1295 309	181 669	390				1642 961
24	43 343	555 412	101 256					700 011
24,5	636	176 532						177 168
25	7 670	70 126						77 796
25,5		2 095						2 095
26								
26,5								
27								
27,5								
28								
28,5								
29								
Total	9789 799	11623 278	31996 355	285 916	41 993	21 117	42333 398	96091 857
Mean L	21,5	22,5	18,1	17,6	19,8	18,	14,5	17,4
sd	1,26	1,57	3,24	2,54	1,4	2,59	3,62	4,28
Catch	**818**	**1 208**	**2 074**	**14 333**	**3 028**	**1 150**	**1 248**	**23 859**

Table 6.2.4.2: Sardine in VIIIc and IXa: Catch in numbers (thousands) at age by quarter and by subdivision in 201

							First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	60	45	722	70 162	15	401	3 585	74 991
2	4 759	477	1 759	19 594	5 402	1 908	4 739	38 639
3	10 085	1 756	1 496	7 758	11 957	1 456	340	34 847
4	3 771	1 031	839	1 661	9 218	1 020	196	17 737
5	3 087	1 487	1 628	5 164	19 378	1 161	143	32 047
6	2 036	2 544	1 405	9 915	29 981	1 162	13	47 058
7	558	232	110	645	3 188	522	13	5 268
8	471	107	110	985	2 262	542	13	4 490
9	131	97	110		2 241	553		3 131
10		69		349	1 247	52		1 716
11								
12								
Total	24 959	7 845	8 180	116 233	84 889	8 777	9 041	259 924
Catch (Tons)	1 852	706	615	3 824	4 822	539	410	12 768

							Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	165	753	41 354	90 830	2 262	4 273	11 537	151 175
2	4 775	2 073	3 937	82 404	4 083	5 855	4 787	107 914
3	13 218	4 244	2 447	9 903	8 311	4 544	256	42 921
4	7 341	2 334	1 549	1 866	6 293	2 916	61	22 362
5	5 513	3 693	2 981	5 298	9 073	4 930	33	31 521
6	3 291	5 670	2 680	8 658	20 862	2 639	1	43 802
7	716	515	321	1 114	5 845	1 249	1	9 761
8	602	244	391	642	4 422	426	1	6 728
9	75	199	391	195	2 292	919		4 071
10		156		103	975			1 235
11				11				11
12								
Total	35 697	19 882	56 052	201 024	64 418	27 751	16 677	421 501
Catch (Tons)	2 883	2 055	2 247	8 502	4 438	1 651	486	22 262

							Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	24	1 098	24 129	14 787	640	4 787	57 758	103 225
1	190	838	15 261	108 855	2 670	6 312	6 209	140 335
2	845	7 134	3 550	33 128	8 217	8 355	7 077	68 306
3	1 188	6 917	1 979	10 632	8 707	3 906	2 001	35 331
4	321	5 089	2 486	9 684	9 441	2 511	1 250	30 781
5	186	9 632	1 974	19 177	16 705	2 106	665	50 446
6	194	4 732	700	8 074	9 242	1 379	70	24 392
7	113	577	250		1 645	120	70	2 775
8	54	639	155	407	2 766	120	110	4 251
9		393	121	232	1 673	179		2 597
10				179	398			578
11								
12								
Total	3 115	37 051	50 605	205 155	62 105	29 775	75 209	463 016
Catch (Tons)	307	3 944	2 473	14 263	5 335	1 841	2 519	30 682

							Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	96	230	11 090	122 980	505	10 342	29 842	175 085
1	652	475	13 651	111 173	20 269	939	2 884	150 043
2	3 850	2 357	2 013	24 793	8 037	1 754	5 670	48 474
3	3 735	2 154	1 470	7 866	3 771	1 859	2 084	22 938
4	720	1 555	1 646	2 943	2 356	1 730	1 001	11 951
5	398	2 928	1 379	5 625	2 516	1 867	707	15 420
6	240	1 441	490	9 581	4 304	1 546	45	17 648
7	69	173	148		235	520	45	1 192
8	30	191	66	551		368	54	1 260
9		119	41	406		118		684
10						74		74
11								
12								
Total	9 790	11 623	31 996	285 916	41 993	21 117	42 333	444 770
Catch (Tons)	818	1 208	2 074	14 333	3 028	1 150	1 248	23 859

							Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	120	1 328	35 220	137 767	1 145	15 130	87 600	278 310
1	1 067	2 111	70 989	381 019	25 216	11 925	24 216	516 544
2	14 230	12 041	11 260	159 919	25 738	17 872	22 272	263 333
3	28 225	15 071	7 392	36 159	32 746	11 764	4 680	136 037
4	12 152	10 010	6 520	16 154	27 309	8 178	2 508	82 831
5	9 184	17 739	7 962	35 264	47 672	10 064	1 549	129 434
6	5 762	14 388	5 275	36 228	64 390	6 727	129	132 899
7	1 456	1 498	829	1 759	10 913	2 411	129	18 997
8	1 158	1 182	723	2 584	9 449	1 456	178	16 729
9	206	807	663	834	6 205	1 768		10 484
10		225		632	2 620	126		3 603
11				11				11
12								
Total	73 560	76 401	146 834	808 329	253 405	87 421	143 261	1 589 211
Catch (Tons)	5 860	7 912	7 409	40 923	17 623	5 181	4 662	89 570

Table 6.2.4.3: Sardine in VIIIc and IXa: Relative distribution of sardine catches. Upper pannel, relative contribution of each group within each subdivision. Lower pannel, relative contribution of each subdivision within each Age Group.

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	0%	2%	24%	17%	0%	17%	61%	18%
1	1%	3%	48%	47%	10%	14%	17%	33%
2	19%	16%	8%	20%	10%	20%	16%	17%
3	38%	20%	5%	4%	13%	13%	3%	9%
4	17%	13%	4%	2%	11%	9%	2%	5%
5	12%	23%	5%	4%	19%	12%	1%	8%
6+	12%	24%	5%	5%	37%	14%	0%	11%
	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	0%	0%	13%	50%	0%	5%	31%	100%
1	0%	0%	14%	74%	5%	2%	5%	100%
2	5%	5%	4%	61%	10%	7%	8%	100%
3	21%	11%	5%	27%	24%	9%	3%	100%
4	15%	12%	8%	20%	33%	10%	3%	100%
5	7%	14%	6%	27%	37%	8%	1%	100%
6+	5%	10%	4%	23%	51%	7%	0%	100%

Table 6.2.5.1: Sardine VIIIc and IXa: Sardine Mean length (cm) at age by quarter and by subdivision in 2010.

First Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	16,2	19,6	18,8	14,2	18,3	17,1	17,1
2	19,2	21,3	20,2	19,1	19,5	18,9	18,3
3	20,6	22,3	21,6	20,3	19,9	19,9	19,9
4	21,6	22,6	21,7	21,1	20,5	20,3	20,2
5	22,1	22,7	21,9	21,0	20,7	20,6	20,7
6	22,7	22,9	22,0	21,2	20,9	20,8	21,3
7	23,2	23,1	23,4	21,7	21,5	20,8	21,3
8	23,8	23,6	23,4	22,1	21,3	21,6	21,3
9	24,6	23,6	23,4		21,8	21,9	
10		23,9		22,3	21,7	20,3	
11							
12							

Second Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0							
1	15,5	19,1	13,0	16,2	15,5	14,3	14,1
2	19,3	20,8	19,2	17,9	20,1	19,1	17,6
3	20,8	22,2	21,8	19,5	20,5	20,0	19,5
4	21,8	22,5	21,9	21,0	21,1	20,6	20,2
5	22,1	22,6	22,1	20,9	21,1	20,7	20,6
6	22,5	23,0	22,4	21,2	21,2	20,8	21,6
7	22,9	23,0	23,7	21,3	21,2	20,9	21,6
8	23,4	23,7	24,0	21,7	21,5	21,3	21,6
9	24,6	23,7	24,0	21,9	22,0	21,9	
10		23,9		22,2	21,7		
11				23,8			
12							

Third Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	14,3	13,9	11,8	14,9	15,0	15,6	14,0
1	19,1	21,4	19,3	18,8	19,4	16,7	18,0
2	21,6	22,3	20,9	20,0	20,0	20,3	19,4
3	22,0	22,5	21,9	20,8	20,7	20,4	20,0
4	22,8	22,9	21,7	20,7	20,8	20,6	20,0
5	22,9	23,1	22,6	20,9	21,1	20,8	20,3
6	23,4	23,0	23,0	21,0	21,3	22,5	21,5
7	23,5	23,5	23,7		21,6	20,3	21,5
8	24,2	23,5	23,8	21,7	21,8	20,3	21,8
9		23,6	24,2	21,3	21,5	20,8	
10				21,8	22,1		
11							
12							

Fourth Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)
0	14,1	13,9	14,5	15,1	13,8	15,7	12,4
1	20,3	20,6	19,1	19,0	19,0	17,0	18,5
2	21,2	22,2	21,0	19,8	20,2	19,8	19,6
3	21,7	22,5	22,1	21,0	20,6	20,4	20,2
4	22,4	22,8	21,9	20,8	21,3	20,6	20,1
5	22,7	23,1	22,5	21,4	21,3	20,9	20,3
6	23,3	22,9	22,7	21,8	21,5	20,9	21,7
7	22,8	23,5	23,0		21,8	20,7	21,7
8	23,8	23,5	23,0	20,8		21,2	21,7
9		23,6	23,2	22,3		20,7	
10						21,8	
11							
12							

Table 6.2.5.2: Sardine VIIIc and IXa: Sardine Mean weight (kg) at age by quarter and by subdivision in 2010.

						First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	0,032	0,058	0,052	0,018	0,039	0,040	0,038
2	0,056	0,075	0,064	0,046	0,048	0,052	0,048
3	0,069	0,086	0,078	0,056	0,051	0,059	0,061
4	0,081	0,089	0,079	0,063	0,055	0,062	0,064
5	0,087	0,090	0,081	0,061	0,057	0,065	0,068
6	0,094	0,094	0,083	0,064	0,059	0,067	0,074
7	0,100	0,096	0,100	0,069	0,064	0,067	0,074
8	0,107	0,103	0,100	0,072	0,062	0,074	0,074
9	0,119	0,102	0,100		0,067	0,077	
10		0,107		0,075	0,066	0,062	
11							
12							

						Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0							
1	0,033	0,063	0,022	0,032	0,030	0,025	0,023
2	0,060	0,083	0,066	0,044	0,061	0,056	0,042
3	0,074	0,100	0,095	0,058	0,065	0,064	0,055
4	0,086	0,105	0,097	0,072	0,071	0,069	0,061
5	0,091	0,107	0,099	0,071	0,071	0,070	0,064
6	0,098	0,112	0,103	0,075	0,071	0,071	0,073
7	0,106	0,113	0,123	0,076	0,071	0,071	0,073
8	0,113	0,125	0,129	0,081	0,074	0,076	0,073
9	0,137	0,124	0,129	0,083	0,079	0,082	
10		0,128		0,086	0,076		
11				0,106			
12							

						Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0,026	0,023	0,016	0,031	0,033	0,035	0,026
1	0,065	0,090	0,065	0,064	0,070	0,042	0,049
2	0,092	0,102	0,083	0,078	0,076	0,072	0,060
3	0,098	0,105	0,097	0,088	0,084	0,073	0,065
4	0,109	0,111	0,094	0,087	0,085	0,075	0,065
5	0,111	0,114	0,107	0,090	0,089	0,078	0,067
6	0,119	0,112	0,114	0,091	0,092	0,096	0,078
7	0,121	0,120	0,124		0,095	0,072	0,078
8	0,133	0,120	0,126	0,101	0,097	0,072	0,080
9		0,122	0,132	0,094	0,094	0,077	
10				0,102	0,101		
11							
12							

						Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0,021	0,033	0,038	0,027	0,024	0,036	0,016
1	0,071	0,084	0,070	0,061	0,062	0,044	0,052
2	0,080	0,099	0,088	0,071	0,075	0,067	0,062
3	0,086	0,102	0,099	0,089	0,080	0,074	0,067
4	0,094	0,106	0,096	0,085	0,090	0,076	0,066
5	0,098	0,109	0,102	0,095	0,089	0,078	0,069
6	0,106	0,107	0,105	0,102	0,091	0,078	0,084
7	0,103	0,113	0,108		0,095	0,076	0,084
8	0,113	0,114	0,108	0,084		0,082	0,084
9		0,115	0,111	0,108		0,077	
10						0,088	
11							
12							

						Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**
0	0,022	0,025	0,023	0,027	0,029	0,036	0,023
1	0,062	0,078	0,041	0,047	0,060	0,036	0,036
2	0,066	0,097	0,075	0,056	0,068	0,064	0,054
3	0,075	0,101	0,093	0,073	0,066	0,068	0,065
4	0,086	0,107	0,093	0,082	0,072	0,071	0,065
5	0,090	0,110	0,098	0,084	0,073	0,073	0,068
6	0,097	0,108	0,100	0,083	0,070	0,077	0,080
7	0,105	0,113	0,118	0,073	0,073	0,071	0,080
8	0,112	0,119	0,122	0,081	0,078	0,076	0,081
9	0,126	0,119	0,123	0,098	0,079	0,079	
10		0,121		0,084	0,075	0,077	
11				0,106			
12							

Table 6.3.2.1.1: Sardine in VIIIc and IXa: Sardine Assessment from the 2011 Portuguese spring acoustic survey (PELAGOS11). Number in thousand fish and biomass in tonnes.

AREA		1	2	3	4	5	6+	Total
Oc. Norte	**Biomass**	12635	44344	10088	5349	2755	14388	**89509**
	%	14	50	11	6	3	16	
	No fish	340032	882911	182654	95090	44609	219952	**1765248**
	%	19	50	10	5	3	12	
Oc. Sul	**Biomass**	5038	1729	951	856	809	5404	**14787**
	%	34	12	6	6	5	37	
	No fish	244230	32804	15673	13479	12004	78878	**397068**
	%	62	8	4	3	3	20	
Algarve	**Biomass**	5092	3509	2849	2407	2725	3491	**20073**
	%	25	17	14	12	14	17	
	No fish	149943	83575	95865	44245	36871	54077	**464576**
	%	32	18	21	10	8	12	
Cadiz	**Biomass**	1215	565	252	123	71	110	**2336**
	%	52	24	11	5	3	5	
	No fish	22804	12710	14580	6729	5608	8225	**70656**
	%	32	18	21	10	8	12	
Total	**Biomass**	22765	49582	13888	8612	6289	23283	**124369**
Portugal	%	18	40	11	7	5	19	
	No fish	734205	999290	294192	152814	93484	352907	**2626892**
	%	28	38	11	6	4	13	
Total	**Biomass**	23980	50147	14140	8735	6360	23393	**126705**
	%	19	40	11	7	6	18	
	No fish	757009	1012000	308772	159543	99092	361132	**2697548**
	%	28	38	11	6	4	13	

Table 6.3.2.2.1:Sardine in VIIIc and IXa: Sardine abundance in number (thousands of fish) and biomass (tons) by age groups and ICES subdivision in PELACUS0411.

AREA VIIIcE east	AGE										
	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tons)	0	12	26	17	2	1	1	0	0	0	60
% Biomass	0.7	20.9	42.8	29.2	2.7	1.4	1.7	0.5	0.3	0.0	100
Abundance (in '000)	11	218	362	223	18	9	10	3	1	0	854
% Abundance	1.3	25.5	42.4	26.1	2.1	1.0	1.2	0.3	0.2	0.0	100
Medium Weight (gr)	38.8	57.2	70.6	78.4	89.8	92.3	101.9	113.9	113.4	0.0	79.7
Medium Length	17.4	19.7	21.1	21.8	22.8	23.0	23.8	24.7	24.7	0.0	20.2
AREA VIIIcE west	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	13	143	2120	4084	1400	836	484	322	401	511	10313
% Biomass	0.1	1.4	20.6	39.6	13.6	8.1	4.7	3.1	3.9	5.0	100
Abundance (in '000)	317	2378	27644	49436	16208	9616	5102	3274	3966	4855	122797
% Abundance	0.3	1.9	22.5	40.3	13.2	7.8	4.2	2.7	3.2	4.0	100
Medium Weight (gr)	40.2	60.2	76.7	82.6	86.4	86.9	94.8	98.4	101.2	105.3	80.8
Medium Length	17.6	20.0	21.7	22.2	22.5	22.6	23.3	23.5	23.8	24.1	21.9
AREA VIIIcW	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	0	0	0	0	0	0	0	0	0	0	0
% Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Abundance (in '000)	0	0	0	0	0	0	0	0	0	0	0
% Abundance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Medium Weight (gr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medium Length	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA IXaN	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	285	1023	0	0	0	0	0	0	0	0	1308
% Biomass	21.8	78.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
Abundance (in '000)	7168	18892	0	0	0	0	0	0	0	0	26060
% Abundance	27.5	72.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
Medium Weight (gr)	39.8	54.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7
Medium Length	17.5	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1
TOTAL SPAIN	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	298	1179	2145	4101	1401	836	485	322	402	511	11681
% Biomass	2.6	10.1	18.4	35.1	12.0	7.2	4.2	2.8	3.4	4.4	100
Abundance (in '000)	7496	21488	28007	49659	16226	9625	5112	3277	3968	4855	149711
% Abundance	5.0	14.4	18.7	33.2	10.8	6.4	3.4	2.2	2.7	3.2	100
Medium Weight (gr)	39.8	54.9	76.6	82.6	86.4	86.9	94.8	98.4	101.2	105.3	82.7
Medium Length	17.5	19.4	21.7	22.2	22.5	22.6	23.3	23.5	23.8	24.1	22.1

Table 6.5.1.1.a Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the catch.

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

Table 6.5.1.1.b Sardine in VIIIc and IXa: Mean weights-at-age (kg) in the stock.

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

Table 6.5.1.1.c. Sardine in VIIIc and IXa: Annual maturity ogives 1978 – 2010.

Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6+
1978	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1979	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1980	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1981	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1982	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1983	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1984	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1985	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1986	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1987	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1988	0.00	0.65	0.95	1.00	1.00	1.00	1.00
1989	0.00	0.23	0.83	0.91	0.92	0.94	0.98
1990	0.00	0.60	0.81	0.88	0.89	0.94	0.99
1991	0.00	0.74	0.91	0.96	0.97	1.00	1.00
1992	0.00	0.79	0.91	0.95	0.98	1.00	1.00
1993	0.00	0.47	0.93	0.94	0.97	0.99	1.00
1994	0.00	0.80	0.89	0.96	0.96	0.97	1.00
1995	0.00	0.73	0.98	0.97	0.99	1.00	1.00
1996	0.00	0.54	0.93	0.99	0.99	1.00	1.00
1997	0.00	0.64	0.94	1.00	1.00	1.00	0.99
1998	0.00	0.69	0.85	0.96	0.98	0.99	0.99
1999	0.00	0.84	0.99	1.00	1.00	1.00	1.00
2000	0.00	0.47	0.92	0.96	0.97	0.98	0.98
2001	0.00	0.43	0.82	0.94	0.97	0.97	0.98
2002	0.00	0.59	0.93	0.98	0.99	1.00	1.00
2003	0.00	0.50	0.94	0.97	0.99	0.99	0.99
2004	0.00	0.49	0.94	0.97	0.98	0.99	1.00
2005	0.00	0.19	0.85	0.97	0.99	0.99	1.00
2006	0.00	0.89	0.99	1.00	1.00	1.00	1.00
2007	0.00	0.75	0.98	0.99	1.00	1.00	1.00
2008	0.00	0.29	0.94	0.99	1.00	1.00	1.00
2009	0.00	0.47	0.99	1.00	1.00	1.00	1.00
2010	0.00	0.25	0.76	0.91	0.94	0.95	0.97

Table 6.5.1.1d

Table 6.5.1.1d:								
Run id 20110624 204313,86								
Stocknumbers at age								
in area 1,								
Data by 1 Jan, except at youngest age which are								
at recruitment time								
Age	1978	1979	1980	1981	1982	1983	1984	1985
0	11659	13689	14888	9455	6897	19941	8496	6493
1	7556	9251	10912	12054	7495	5563	16163	6956
2	3691	4138	5112	6435	6851	4406	3387	9747
3	1233	1781	2021	2711	3187	3465	2354	1886
4	622	613	888	1123	1414	1702	1903	1311
5	190	323	310	499	607	770	958	1097
6	78	141	238	315	444	573	753	984
	1986	1987	1988	1989	1990	1991	1992	1993
0	5414	9066	5824	5777	5442	12550	10368	4630
1	5327	4399	7179	4590	4572	4305	9969	8323
2	4310	3196	2655	4317	2747	2691	2686	6324
3	5458	2277	1701	1413	2270	1413	1532	1568
4	1055	2938	1215	892	720	1093	748	836
5	758	563	1588	646	464	342	582	406
6	1217	1104	943	1382	1115	827	673	726
	1994	1995	1996	1997	1998	1999	2000	2001
0	4540	3841	4868	3797	3855	3741	10382	7121
1	3730	3739	3177	4007	3093	3073	3000	8359
2	5258	2506	2512	2147	2616	1973	1953	1902
3	3608	3293	1565	1561	1261	1480	1141	1137
4	803	2039	1819	838	776	592	739	581
5	430	451	1126	966	394	343	277	353
6	641	650	663	1022	1096	853	700	578
	2002	2003	2004	2005	2006	2007	2008	2009
0	3923	2736	11289	4939	1569	1860	2534	3761
1	5809	3223	2228	9151	4033	1293	1502	1976
2	5350	3762	2077	1430	5915	2648	844	925
3	1154	3304	2320	1268	874	3668	1620	470
4	626	663	1902	1321	743	523	2156	854
5	303	344	367	1037	754	437	302	1125
6	560	537	542	551	953	1071	945	737
	2010	2011						
0	1419	4000						
1	2911	1071						
2	1186	1662						
3	503	597						
4	240	234						
5	428	109						
6	1012	782						

Table6.5.1.1e

Table 6.5.1.1e:								
Total yearly fishing mortalities at age								
Age	1978	1979	1980	1981	1982	1983	1984	1985
0	0.07	0.06	0.05	0.07	0.05	0.05	0.04	0.03
1	0.27	0.26	0.20	0.24	0.20	0.17	0.18	0.15
2	0.40	0.39	0.30	0.37	0.35	0.30	0.26	0.25
3	0.37	0.37	0.26	0.32	0.30	0.27	0.26	0.25
4	0.33	0.35	0.25	0.29	0.28	0.24	0.22	0.22
5	0.33	0.35	0.25	0.29	0.28	0.24	0.22	0.22
6	0.28	0.30	0.20	0.26	0.27	0.25	0.23	0.19
Fref	0.36	0.36	0.26	0.32	0.30	0.26	0.24	0.23
	1986	1987	1988	1989	1990	1991	1992	1993
0	0.04	0.07	0.07	0.07	0.07	0.07	0.05	0.05
1	0.18	0.17	0.18	0.18	0.20	0.14	0.13	0.13
2	0.31	0.30	0.30	0.31	0.33	0.23	0.21	0.23
3	0.29	0.30	0.32	0.34	0.40	0.31	0.28	0.34
4	0.30	0.29	0.30	0.32	0.41	0.30	0.28	0.33
5	0.30	0.29	0.30	0.32	0.41	0.30	0.28	0.33
6	0.22	0.22	0.23	0.24	0.28	0.19	0.17	0.19
Fref	0.30	0.29	0.31	0.33	0.39	0.29	0.26	0.31
	1994	1995	1996	1997	1998	1999	2000	2001
0	0.03	0.02	0.03	0.04	0.06	0.06	0.05	0.04
1	0.07	0.07	0.06	0.10	0.12	0.12	0.13	0.12
2	0.14	0.14	0.15	0.20	0.24	0.22	0.21	0.17
3	0.24	0.26	0.29	0.37	0.43	0.36	0.34	0.27
4	0.25	0.26	0.30	0.43	0.49	0.43	0.41	0.32
5	0.25	0.26	0.30	0.43	0.49	0.43	0.41	0.32
6	0.12	0.12	0.11	0.13	0.15	0.13	0.12	0.10
Fref	0.22	0.23	0.26	0.36	0.41	0.36	0.34	0.27
	2002	2003	2004	2005	2006	2007	2008	2009
0	0.03	0.04	0.04	0.04	0.03	0.05	0.08	0.09
1	0.10	0.11	0.11	0.11	0.09	0.10	0.16	0.18
2	0.15	0.15	0.16	0.16	0.15	0.16	0.26	0.28
3	0.22	0.22	0.23	0.21	0.18	0.20	0.31	0.34
4	0.27	0.26	0.28	0.23	0.20	0.22	0.32	0.36
5	0.27	0.26	0.28	0.23	0.20	0.22	0.32	0.36
6	0.09	0.09	0.10	0.09	0.09	0.11	0.16	0.17
Fref	0.23	0.22	0.24	0.21	0.18	0.20	0.30	0.34
	2010	2011						
0	0.12	0.12						
1	0.23	0.23						
2	0.36	0.36						
3	0.44	0.44						
4	0.46	0.46						
5	0.46	0.46						
6	0.21	0.21						

Table 6.5.1.1f

Table 6.5.1.1f:								
Yearly catch numbers by fleet 1								
In area 1								
Modelled catches by year, Fleet 1 area 1								
Age	1978	1979	1980	1981	1982	1983	1984	1985
0	691	757	620	569	310	811	270	195
1	1545	1839	1680	2167	1173	731	2233	824
2	1045	1142	1150	1721	1745	971	656	1848
3	328	470	394	639	705	702	454	359
4	149	156	166	240	295	316	323	220
5	45	82	58	107	127	143	163	184
6	17	31	37	62	91	110	131	148
	1986	1987	1988	1989	1990	1991	1992	1993
0	209	552	379	355	338	732	509	213
1	758	606	1009	661	714	489	1009	870
2	982	713	593	998	674	481	434	1123
3	1178	504	395	354	645	320	317	387
4	234	626	272	212	209	244	156	204
5	168	120	355	154	135	76	122	99
6	209	185	167	256	234	124	88	109
	1994	1995	1996	1997	1998	1999	2000	2001
0	120	87	132	138	212	188	484	250
1	211	211	165	317	300	307	304	785
2	582	283	293	339	481	332	319	255
3	661	654	343	416	377	389	286	229
4	151	405	408	250	257	178	213	137
5	81	90	253	288	130	103	80	83
6	62	64	62	111	132	88	69	47
	2002	2003	2004	2005	2006	2007	2008	2009
0	112	101	458	169	41	81	188	303
1	493	286	204	790	299	101	185	280
2	647	458	268	183	696	338	164	193
3	198	564	414	202	126	572	371	117
4	126	131	394	233	116	88	509	222
5	61	68	76	183	118	73	71	293
6	40	41	46	42	68	92	119	97
	2010	2011						
0	144	406						
1	514	189						
2	306	429						
3	153	182						
4	76	74						
5	136	35						
6	167	129						
Observed catches by year, Fleet 1 area 1								
Age	1978	1979	1980	1981	1982	1983	1984	1985
0	869	674	857	1026	62	1070	118	268
1	2297	1536	2037	1935	795	577	3312	564
2	947	956	1562	1734	1869	857	487	2371
3	295	431	379	679	709	803	502	469
4	137	189	157	195	353	324	301	294
5	42	93	47	105	131	141	179	201
6	16	36	30	76	129	139	117	103
	1986	1987	1988	1989	1990	1991	1992	1993
0	304	1437	521	248	258	1581	498	88
1	755	543	990	566	602	477	1002	566
2	1027	667	535	909	517	436	451	1082
3	919	569	439	389	707	407	340	521
4	333	535	304	221	295	266	186	257
5	196	154	292	200	151	75	111	114
6	167	171	189	245	248	105	81	120
	1994	1995	1996	1997	1998	1999	2000	2001
0	121	31	277	209	449	246	490	220
1	60	189	101	549	366	475	355	1172
2	542	281	348	453	502	362	314	256
3	1094	830	515	391	352	340	256	196
4	272	473	653	337	234	177	194	126
5	113	70	197	225	179	106	98	75
6	72	64	47	70	106	73	64	50
	2002	2003	2004	2005	2006	2007	2008	2009
0	107	198	590	169	18	199	298	378
1	587	319	181	1006	250	82	219	354
2	754	446	264	266	777	313	183	196
3	181	518	387	207	129	536	370	125
4	112	114	378	191	108	80	412	252
5	56	61	78	117	121	83	65	197
6	40	51	55	46	81	121	109	84
	2010							
0	278							
1	517							
2	263							
3	136							
4	83							
5	129							
6	183							
Residuals: log(Obs/mod), fllet 1 area 1								
Age	1978	1979	1980	1981	1982	1983	1984	1985
0	0.23	-0.12	0.32	0.59	-1.61	0.28	-0.83	0.32
1	0.40	-0.18	0.19	-0.11	-0.39	-0.24	0.39	-0.38
2	-0.10	-0.18	0.31	0.01	0.07	-0.13	-0.30	0.25
3	-0.11	-0.09	-0.04	0.06	0.01	0.13	0.10	0.27
4	-0.08	0.19	-0.06	-0.21	0.18	0.02	-0.07	0.29
5	-0.08	0.13	-0.21	-0.02	0.03	-0.01	0.10	0.09
6	-0.03	0.15	-0.22	0.20	0.35	0.23	-0.11	-0.36
	1986	1987	1988	1989	1990	1991	1992	1993
0	0.38	0.96	0.32	-0.36	-0.27	0.77	-0.02	-0.88
1	0.00	-0.11	-0.02	-0.16	-0.17	-0.03	-0.01	-0.43
2	0.04	-0.07	-0.10	-0.09	-0.27	-0.10	0.04	-0.04
3	-0.25	0.12	0.11	0.10	0.09	0.24	0.07	0.30
4	0.35	-0.16	0.11	0.04	0.34	0.09	0.17	0.23
5	0.15	0.25	-0.20	0.26	0.11	-0.02	-0.09	0.14
6	-0.23	-0.08	0.12	-0.04	0.06	-0.17	-0.09	0.10
	1994	1995	1996	1997	1998	1999	2000	2001
0	0.00	-1.03	0.74	0.41	0.75	0.27	0.01	-0.13
1	-1.26	-0.11	-0.49	0.55	0.20	0.44	0.15	0.40
2	-0.07	-0.01	0.17	0.29	0.04	0.09	-0.02	0.00
3	0.50	0.24	0.41	-0.06	-0.07	-0.14	-0.11	-0.16
4	0.59	0.16	0.47	0.30	-0.09	-0.01	-0.09	-0.08
5	0.34	-0.25	-0.25	-0.25	0.32	0.03	0.20	-0.10
6	0.15	0.00	-0.27	-0.46	-0.22	-0.19	-0.08	0.06
	2002	2003	2004	2005	2006	2007	2008	2009
0	-0.05	0.68	0.25	0.00	-0.81	0.90	0.46	0.22
1	0.17	0.11	-0.12	0.24	-0.18	-0.21	0.17	0.24
2	0.15	-0.03	-0.02	0.38	0.11	-0.08	0.11	0.01
3	-0.09	-0.09	-0.07	0.03	0.03	-0.07	0.00	0.07
4	-0.11	-0.14	-0.04	-0.20	-0.07	-0.10	-0.21	0.12
5	-0.08	-0.11	0.02	-0.45	0.03	0.12	-0.09	-0.40
6	0.01	0.22	0.17	0.09	0.17	0.27	-0.09	-0.15
	2010							
0	0.66							
1	0.01							
2	-0.15							
3	-0.12							
4	0.08							
5	-0.05							
6	0.09							

Table 6.5.1.1g

Table 6.5.1.1g								
Results for survey fleet 1								
Modelled survey indices by year, fleet 1								
Age	1994	1995	1996	1997	1998	1999	2000	2001
0	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	5381	6755	5199	5167	5043	14074
2	-1	-1	2621	2224	2697	2040	2021	1980
3	-1	-1	1481	1463	1173	1387	1072	1078
4	-1	-1	2029	921	847	651	814	647
5	-1	-1	1256	1062	430	377	305	393
6	-1	-1	332	511	546	426	350	290
	2002	2003	2004	2005	2006	2007	2008	2009
0	-1	-1	-1	-1	-1	-1	-1	-1
1	9796	5433	3753	15432	6813	2183	2517	3301
2	5583	3925	2165	1491	6180	2762	871	950
3	1100	3151	2210	1212	838	3508	1529	441
4	701	744	2128	1486	838	589	2398	945
5	339	386	411	1166	851	492	336	1245
6	282	270	272	277	480	538	471	367
	2010	2011						
0	-1	-1						
1	4832	1778						
2	1208	1693						
3	467	555						
4	262	255						
5	468	119						
6	501	387						
Observed survey indices by year, fleet 1								
Age	1994	1995	1996	1997	1998	1999	2000	2001
0	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	1636	6401	2146	5926	6673	19660
2	-1	-1	2136	3501	4118	2713	2456	1037
3	-1	-1	2505	1677	2271	1595	1657	702
4	-1	-1	3257	1384	1468	969	999	480
5	-1	-1	600	1426	1206	624	721	374
6	-1	-1	37	264	1005	533	681	250
	2002	2003	2004	2005	2006	2007	2008	2009
0	-1	-1	-1	-1	-1	-1	-1	-1
1	13041	5885	-1	22922	7455	1645	4020	7096
2	6998	4584	-1	1302	8309	3085	1098	667
3	1164	3568	-1	685	577	4001	998	419
4	1131	1009	-1	763	443	637	1972	691
5	566	570	-1	653	578	283	211	773
6	442	338	-1	369	607	704	494	497
	2010	2011						
0	-1	-1						
1	7340	765						
2	702	1033						
3	537	337						
4	188	209						
5	269	115						
6	366	388						
Survey residuals by year, fleet 1								
Age	1994	1995	1996	1997	1998	1999	2000	2001
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	-1.19	-0.05	-0.88	0.14	0.28	0.33
2	0.00	0.00	-0.20	0.45	0.42	0.29	0.19	-0.65
3	0.00	0.00	0.53	0.14	0.66	0.14	0.44	-0.43
4	0.00	0.00	0.47	0.41	0.55	0.40	0.20	-0.30
5	0.00	0.00	-0.74	0.29	1.03	0.50	0.86	-0.05
6	0.00	0.00	-2.19	-0.66	0.61	0.22	0.66	-0.15
	2002	2003	2004	2005	2006	2007	2008	2009
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.29	0.08	0.00	0.40	0.09	-0.28	0.47	0.77
2	0.23	0.16	0.00	-0.14	0.30	0.11	0.23	-0.35
3	0.06	0.12	0.00	-0.57	-0.37	0.13	-0.43	-0.05
4	0.48	0.31	0.00	-0.67	-0.64	0.08	-0.20	-0.31
5	0.51	0.39	0.00	-0.58	-0.39	-0.55	-0.47	-0.48
6	0.45	0.23	0.00	0.29	0.24	0.27	0.05	0.30
	2010	2011						
0	0.00	0.00						
1	0.42	-0.84						
2	-0.54	-0.49						
3	0.14	-0.50						
4	-0.33	-0.20						
5	-0.55	-0.03						
6	-0.31	0.00						

Table 6.5.1.1h

Spawning stock biomass				
Year	Modelled		Expected	Observed/q
	Total		By fleet	By fleet
1978	302	1	302	-1
1979	371	1	371	-1
1980	459	1	459	-1
1981	575	1	575	-1
1982	606	1	606	-1
1983	562	1	562	-1
1984	615	1	615	-1
1985	718	1	718	-1
1986	668	1	668	-1
1987	565	1	565	-1
1988	491	1	491	-1
1989	411	1	411	-1
1990	374	1	374	-1
1991	378	1	378	-1
1992	493	1	493	-1
1993	548	1	548	-1
1994	552	1	552	-1
1995	605	1	605	-1
1996	410	1	410	-1
1997	363	1	363	301
1998	314	1	314	-1
1999	313	1	313	236
2000	251	1	251	-1
2001	290	1	290	-1
2002	423	1	423	399
2003	430	1	430	-1
2004	428	1	428	-1
2005	345	1	345	368
2006	544	1	544	-1
2007	521	1	521	-1
2008	380	1	380	604
2009	263	1	263	-1
2010	173	1	173	-1
2011	151	1	151	-1

Table 6.5.1.1i

SUMMARY TABLE				
Year	Recruits	SSB	F	Catch
	age 0		02-may	SOP
1978	11659	302	0.3555	173
1979	13689	371	0.3632	162
1980	14888	458	0.2633	204
1981	9455	574	0.3162	242
1982	6897	606	0.3017	214
1983	19940	561	0.2636	176
1984	8495	615	0.238	215
1985	6493	718	0.2343	219
1986	5414	668	0.2988	192
1987	9065	564	0.2923	176
1988	5824	491	0.305	157
1989	5776	411	0.3267	146
1990	5442	373	0.3901	142
1991	12550	378	0.2852	132
1992	10368	493	0.2607	131
1993	4630	547	0.3096	144
1994	4540	552	0.2184	138
1995	3841	604	0.2329	126
1996	4868	409	0.2618	115
1997	3797	362	0.3556	117
1998	3854	313	0.4089	112
1999	3741	313	0.3605	95
2000	10382	250	0.3429	87
2001	7121	290	0.2698	102
2002	3922	422	0.2273	101
2003	2736	430	0.2247	99
2004	11289	427	0.2375	98
2005	4938	345	0.207	97
2006	1568	544	0.1835	88
2007	1859	521	0.2	97
2008	2534	379	0.3022	103
2009	3760	263	0.3358	88
2010	1419	172	0.4284	93
2011	4000	150	0.4284	0

Table 6.5.1.2: Sardine in VIIIc and IXa: Coefficient of variation of estimated parameters from the inverse Hessian

Run id 20110627 155049.380
Coeff. of variation and correlations from inverse Hessian

Parameter	Param. value	CV
1 Initial number 1978 age1	7555.1993	0.0494
2 Initial number 1978 age2	3690.5235	0.0864
3 Initial number 1978 age3	1233.2772	0.1351
4 Initial number 1978 age4	622.1680	0.0922
5 Initial number 1978 age5	189.5737	0.1192
6 Initial number 1978 age6	78.0972	0.2519
7 Recruitment age0 1978	11658.3007	0.0414
8 Recruitment age0 1979	13688.5474	0.0985
9 Recruitment age0 1980	14887.1519	0.0318
10 Recruitment age0 1981	9454.8146	0.0536
11 Recruitment age0 1982	6897.2551	0.0461
12 Recruitment age0 1983	19940.9459	0.0936
13 Recruitment age0 1984	8495.2302	0.1031
14 Recruitment age0 1985	6492.6779	0.0833
15 Recruitment age0 1986	5413.8192	0.0813
16 Recruitment age0 1987	9065.3241	0.0381
17 Recruitment age0 1988	5823.9258	0.0974
18 Recruitment age0 1989	5776.6147	0.0542
19 Recruitment age0 1990	5442.0986	0.1013
20 Recruitment age0 1991	12549.4426	0.0848
21 Recruitment age0 1992	10367.5304	0.0425
22 Recruitment age0 1993	4630.0267	0.0382
23 Recruitment age0 1994	4540.2111	0.0345
24 Recruitment age0 1995	3840.8433	0.0579
25 Recruitment age0 1996	4867.7290	0.0626
26 Recruitment age0 1997	3796.9806	0.0956
27 Recruitment age0 1998	3854.2656	0.0739
28 Recruitment age0 1999	3741.1665	0.0435
29 Recruitment age0 2000	10380.7287	0.0929
30 Recruitment age0 2001	7120.4705	0.0514
31 Recruitment age0 2002	3922.1938	0.0886
32 Recruitment age0 2003	2735.8817	0.0423
33 Recruitment age0 2004	11287.8220	0.0737
34 Recruitment age0 2005	4937.8804	0.0315
35 Recruitment age0 2006	1568.7500	0.1108
36 Recruitment age0 2007	1859.2346	0.0652
37 Recruitment age0 2008	2533.9894	0.0590
38 Recruitment age0 2009	3760.1162	0.0969
39 Recruitment age0 2010	1418.9955	0.1670
40 F-select year 1978 age 0	0.4446	0.4148
41 F-select year 1978 age 1	0.9118	0.1400
42 F-select year 1978 age 2	1.3350	0.1712
43 F-select year 1978 age 3	1.2390	0.1806
44 F-select year 1978 age 4	1.0950	0.0717
45 F-select year 1978 age 6	0.9499	0.0620
46 F year 1978	0.3556	0.0466
47 F year 1979	0.3632	0.0573
48 F year 1980	0.2634	0.0595
49 F year 1981	0.3162	0.0472
50 F year 1982	0.3017	0.0752
51 F year 1983	0.2637	0.0340
52 F year 1984	0.2380	0.0481
53 F year 1985	0.2344	0.0510
54 F year 1986	0.2988	0.0857
55 F year 1987	0.2923	0.0713
56 F year 1988	0.3051	0.0802
57 F year 1989	0.3267	0.0658
58 F year 1990	0.3902	0.0369
59 F year 1991	0.2853	0.0541
60 F year 1992	0.2608	0.0691
61 F year 1993	0.3097	0.0384
62 F year 1994	0.2185	0.0303
63 F year 1995	0.2329	0.0288
64 F year 1996	0.2618	0.0757
65 F year 1997	0.3557	0.0978
66 F year 1998	0.4090	0.0614
67 F year 1999	0.3605	0.0312
68 F year 2000	0.3430	0.0540
69 F year 2001	0.2698	0.0499
70 F year 2002	0.2274	0.0328
71 F year 2003	0.2248	0.0489
72 F year 2004	0.2376	0.1017
73 F year 2005	0.2071	0.0986
74 F year 2006	0.1836	0.0705
75 F year 2007	0.2001	0.0379
76 F year 2008	0.3023	0.0987
77 F year 2009	0.3359	0.0365
78 F year 2010	0.4286	0.0497
79 Joint Spring Acoustic age 1	1.7808	0.0850
80 Joint Spring Acoustic age 2	1.1086	0.1463
81 Joint Spring Acoustic age 3	1.0215	0.1132
82 Joint Spring Acoustic age 4	1.2056	0.0335
83 Joint Spring Acoustic age 6	0.5305	0.1096
84 Q for ssb year 1988	1.1381	0.0534

Table 6.6.1: Sardine in VIIIc and IXa: Input data for short term catch predictions

MFDP version 1a

Run: sar11

Time and date: 09:50 26-06-2011

Fbar age range: 2-5

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2407	0.33	0.00	0.25	0.25	0.000	0.097	0.024
1	1071	0.33	0.48	0.25	0.25	0.018	0.190	0.043
2	1662	0.33	0.91	0.25	0.25	0.049	0.300	0.064
3	597	0.33	0.97	0.25	0.25	0.061	0.363	0.075
4	234	0.33	0.99	0.25	0.25	0.066	0.380	0.079
5	109	0.33	0.99	0.25	0.25	0.071	0.380	0.083
6	782	0.33	0.99	0.25	0.25	0.078	0.180	0.100

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2407	0.33	0.00	0.25	0.25	0.000	0.097	0.024
1	.	0.33	0.48	0.25	0.25	0.018	0.190	0.043
2	.	0.33	0.91	0.25	0.25	0.049	0.300	0.064
3	.	0.33	0.97	0.25	0.25	0.061	0.363	0.075
4	.	0.33	0.99	0.25	0.25	0.066	0.380	0.079
5	.	0.33	0.99	0.25	0.25	0.071	0.380	0.083
6	.	0.33	0.99	0.25	0.25	0.078	0.180	0.100

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2407	0.33	0.00	0.25	0.25	0.000	0.097	0.024
1	.	0.33	0.48	0.25	0.25	0.018	0.190	0.043
2	.	0.33	0.91	0.25	0.25	0.049	0.300	0.064
3	.	0.33	0.97	0.25	0.25	0.061	0.363	0.075
4	.	0.33	0.99	0.25	0.25	0.066	0.380	0.079
5	.	0.33	0.99	0.25	0.25	0.071	0.380	0.083
6	.	0.33	0.99	0.25	0.25	0.078	0.180	0.100

Input units are millions and grams - output in tonnes

Table 6.6.2: Sardine in VIIIc and IXa: Results for short term catch predictions.

MFDP version 1a

Run: sar11

Sardine (VIIIc+IXa), 2006 WG

Time and date: 09:50 26-06-2011

Fbar age range: 2-5

2011				
Biomass	SSB	FMult	FBar	Landings
222	174	1	0.36	65

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
183	150	0	0.00	0	208	171
.	149	0.1	0.04	6	203	165
.	148	0.2	0.07	13	198	160
.	147	0.3	0.11	19	194	154
.	146	0.4	0.14	25	189	149
.	145	0.5	0.18	31	185	145
.	144	0.6	0.21	36	180	140
.	143	0.7	0.25	42	176	135
.	142	0.8	0.28	47	172	131
.	140	0.9	0.32	52	168	127
.	139	1	0.36	57	164	123
.	138	1.1	0.39	62	160	119
.	137	1.2	0.43	67	156	115
.	136	1.3	0.46	72	153	112
.	135	1.4	0.50	76	149	108
.	134	1.5	0.53	81	146	105
.	133	1.6	0.57	85	143	102
.	133	1.7	0.60	89	139	98
.	132	1.8	0.64	94	136	95
.	131	1.9	0.68	98	133	93
.	130	2	0.71	102	130	90

Input units are millions and grams - output in tonnes

Table 6.7.1. Candidate reference points for sardine.

YPR assumptions		Stock-recruitment						Reference Points					
Weights/maturity	F, selectivity	Model	Data	Parameters	SE	Cor.	LogLik	Name	F	Yield	Recruitment	SSB	Biomass
				a [SE]	b [SE]								
Average last 5 years (2006-2010)	Average last 3 years (2008-2010)	Ricker	1978 - 2010	30.5	0.002	0.87	6.5	f0.1	0.46	1	42	1	2
				[6.7]	[0.0007]			fmax	1.27	-1924	-77418	-704	-970
								msy	0.23	89	5287	297	341
								spr.40	0.31	77	4004	183	213
								spr.50	0.22	89	5354	306	350
								spr.60	0.16	80	5926	406	458
Average last 5 years (2006-2010)	Average last 3 years (2008-2010)	Ricker	1993 - 2010	39.3	0.003	0.85	6.4	f0.1	0.46	49	2244	74	89
				[9.0]	[0.0008]			fmax	1.27	-818	-32907	-299	-412
								msy	0.29	72	3820	182	212
								spr.40	0.31	72	3714	170	198
								spr.50	0.22	68	4108	234	268
								spr.60	0.16	57	4198	287	325

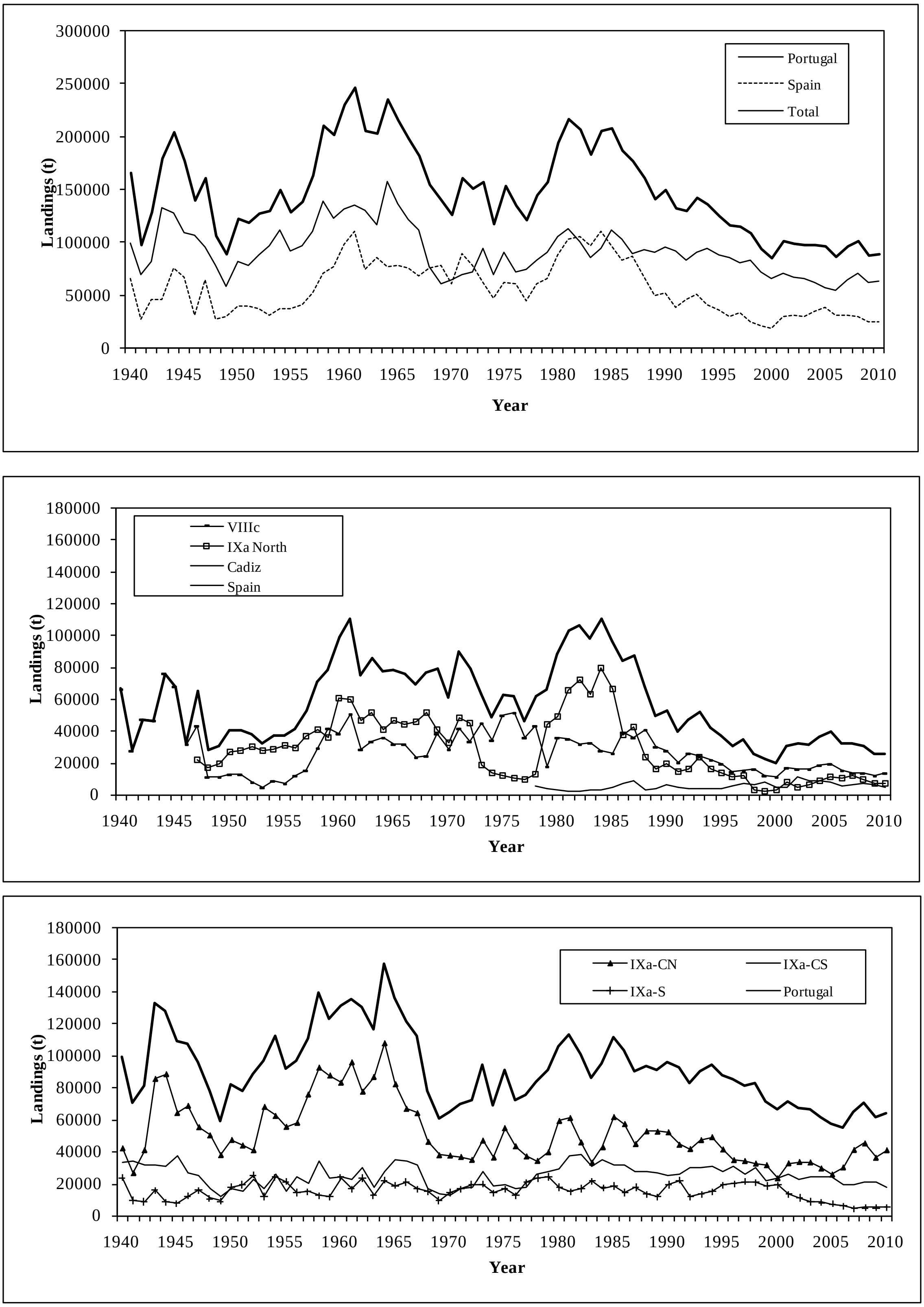


Figure 6.2.2.1: Sardine in VIIIc and IXa: Annual landings of sardine, by country (upper pannel) and by ICES subdivision and country

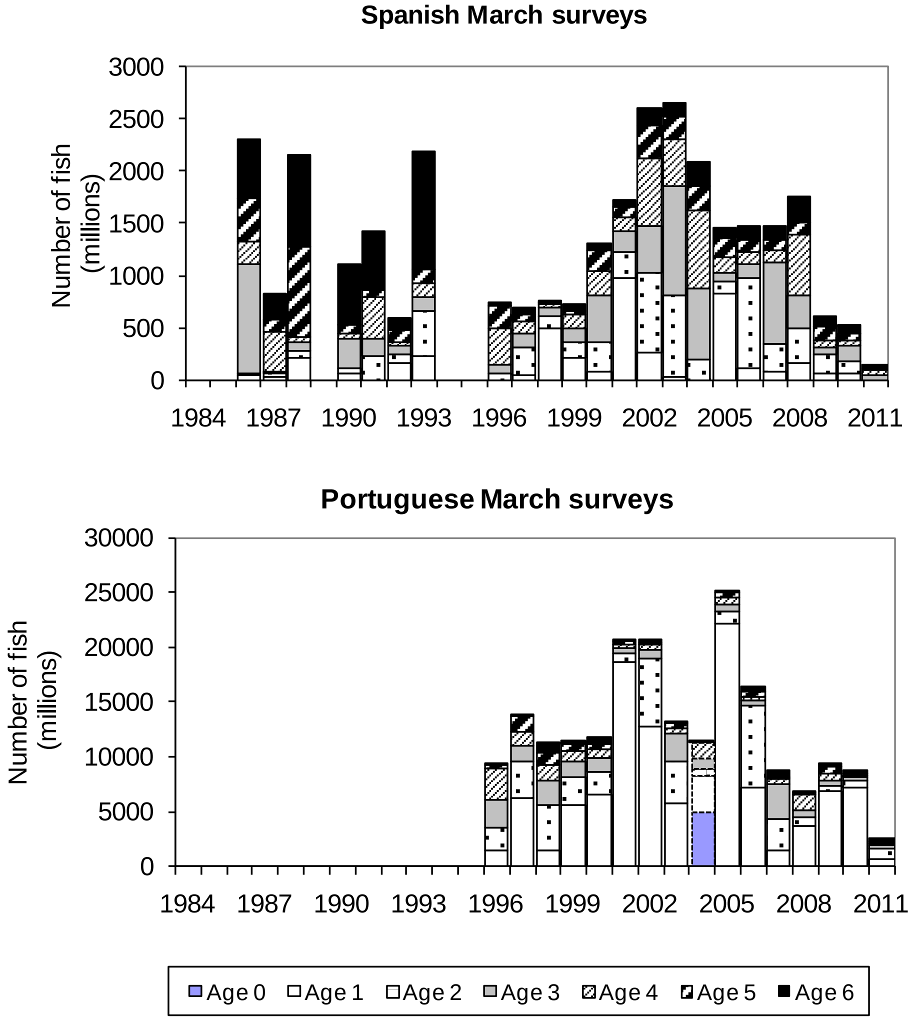


Figure 6.3.1: Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area VIIIc and IXa-N (Galicia) and the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz). Estimates from Portuguese acoustic surveys in June 2004 are considered as indications of the population abundance and are not included in assessment.

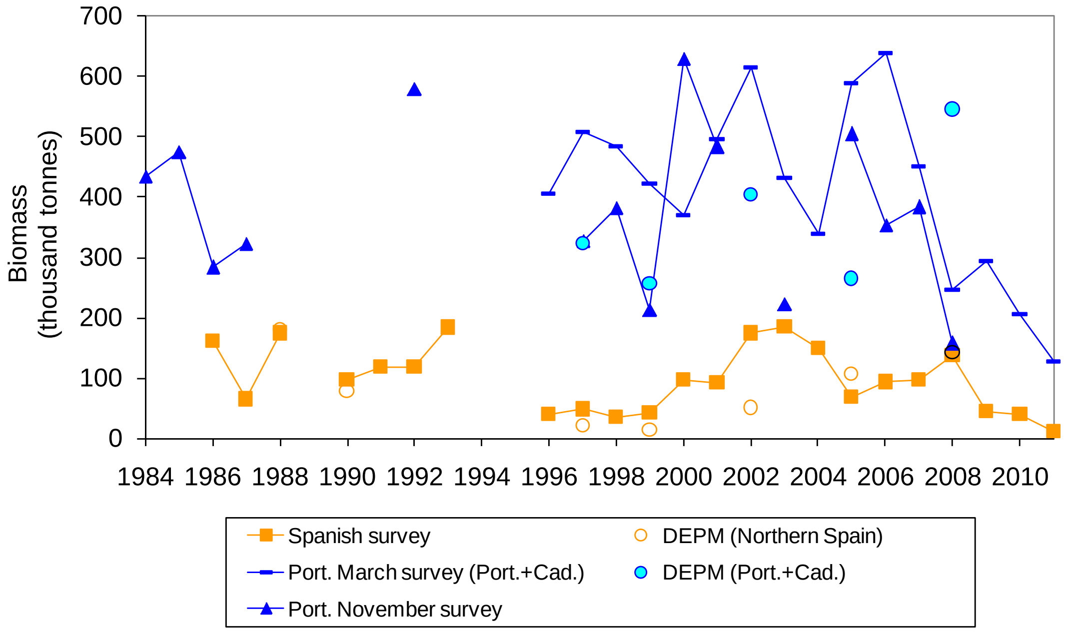


Figure 6.3.2: Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

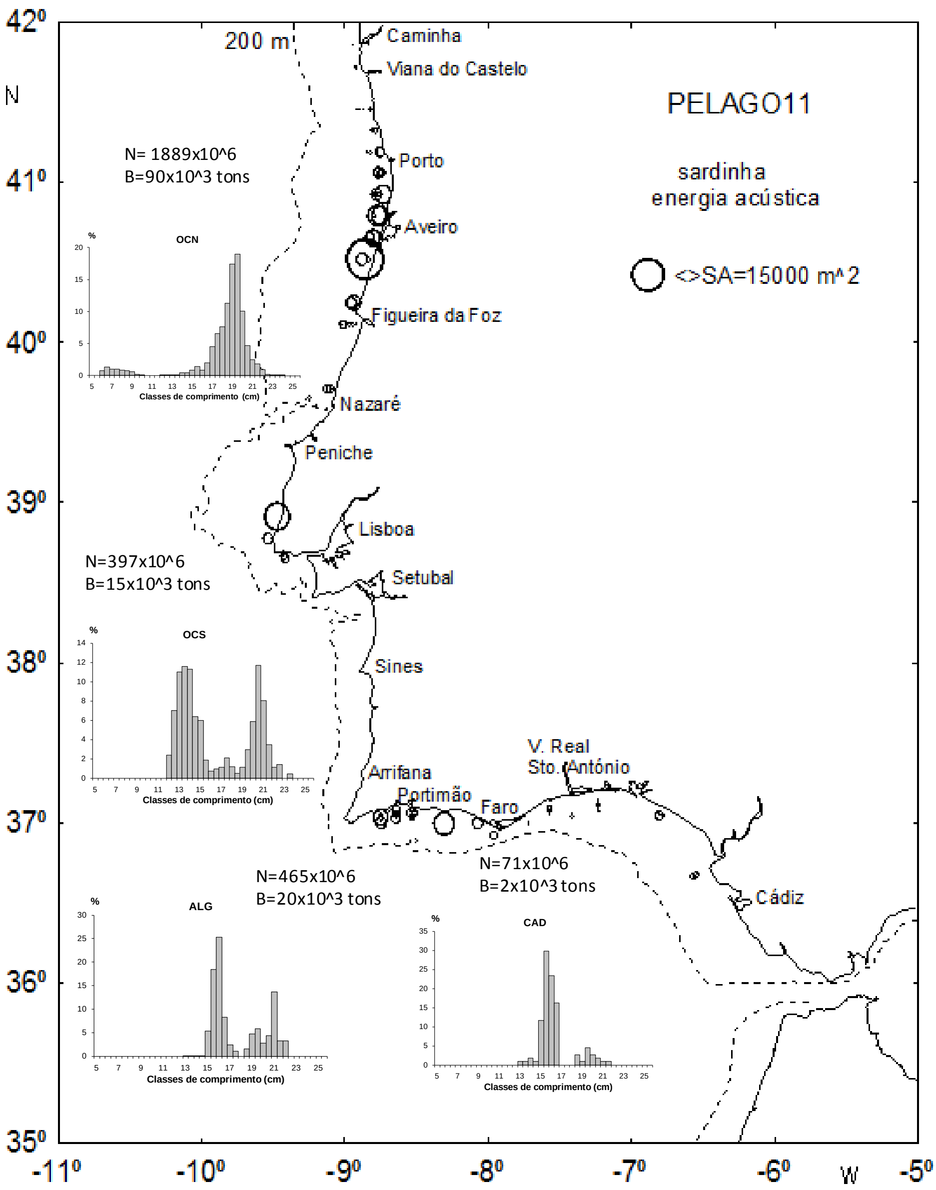


Figure 6.3.2.1.1: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2011. Acoustic energy by nautical mile and abundance (in millions), biomass (in thousand tons) and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

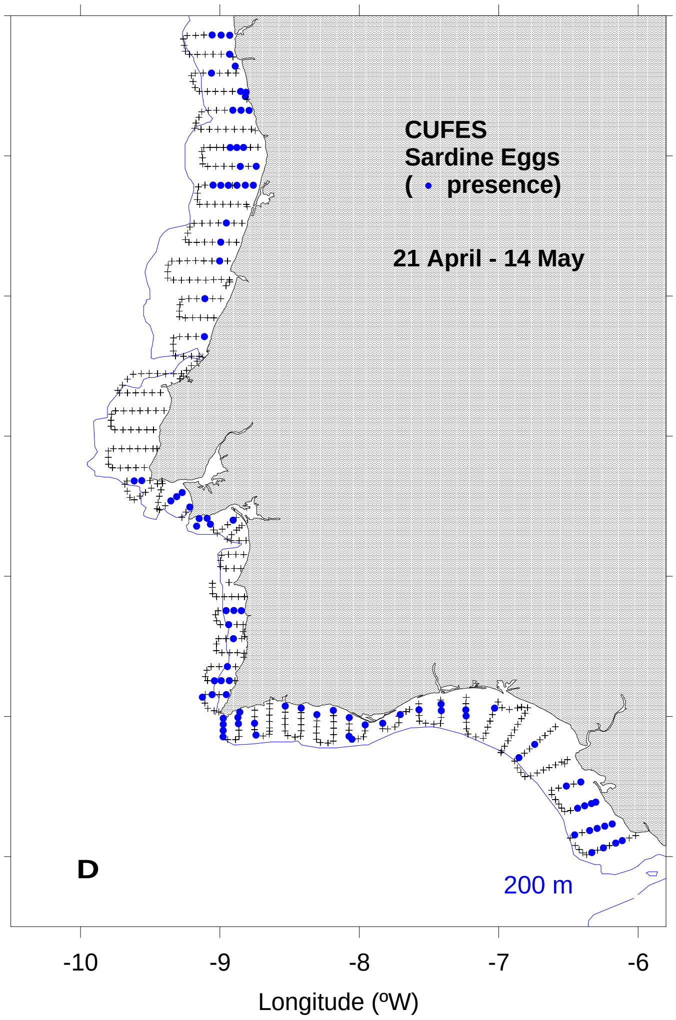


Figure 6.3.2.1.2: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2011. Sardine egg presence (in situ observations) obtained by the CUFES+EDAS system.

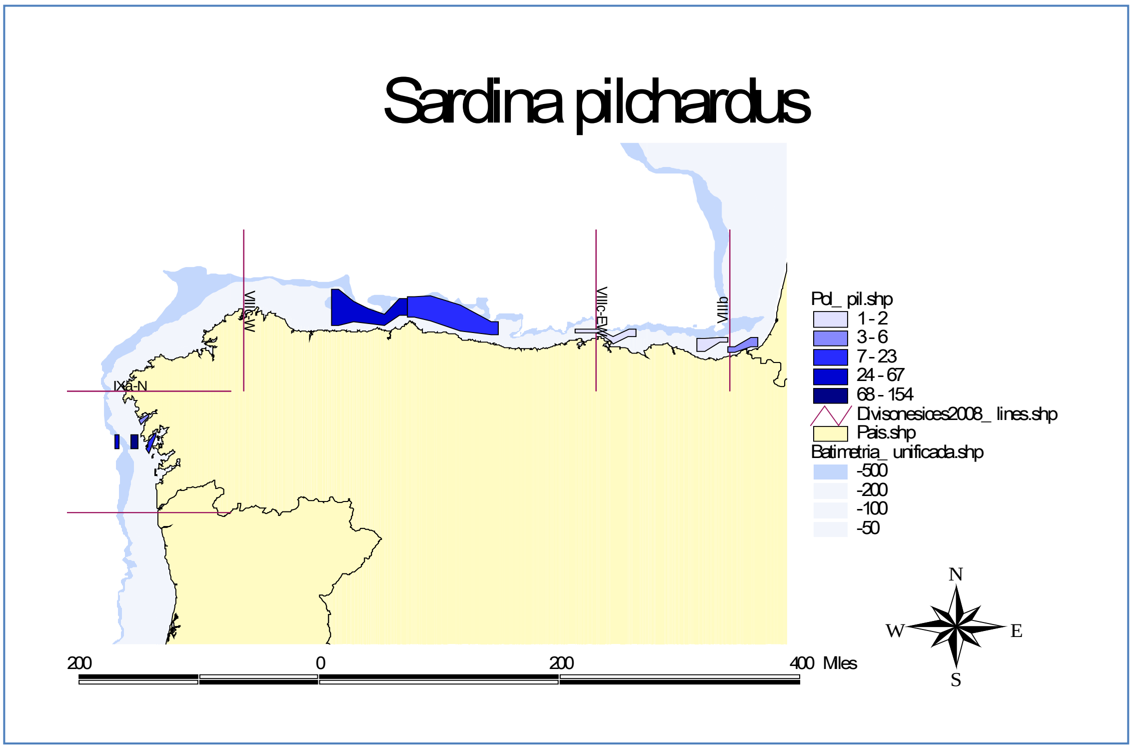
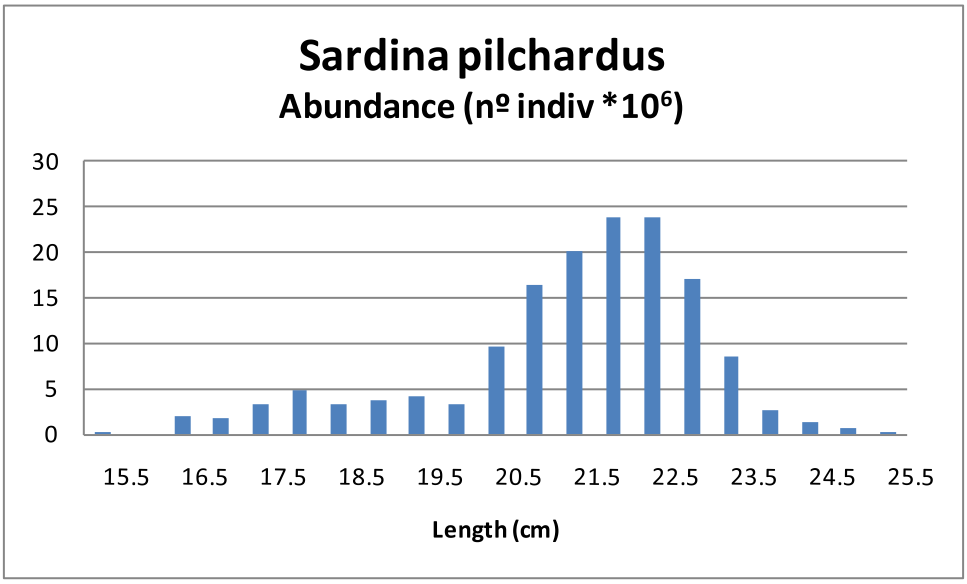


Figure 6.3.2.2.1: Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0411 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon.



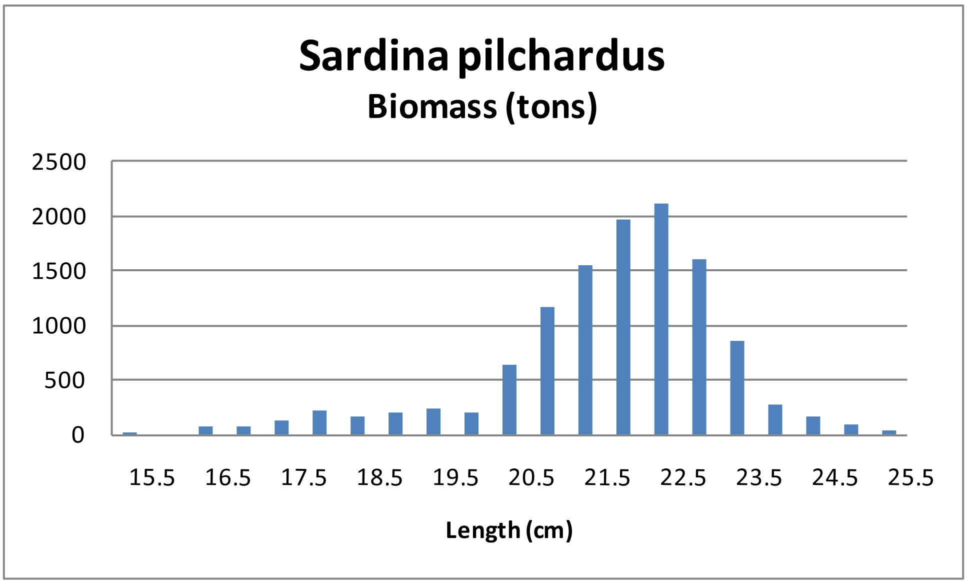


Figure 6.3.2.2.2: Sardine in VIIIc and IXa: Sardine length distribution (cm) in numbers (top) and biomass in tonnes (bottom) during the PELACUS0411 survey.

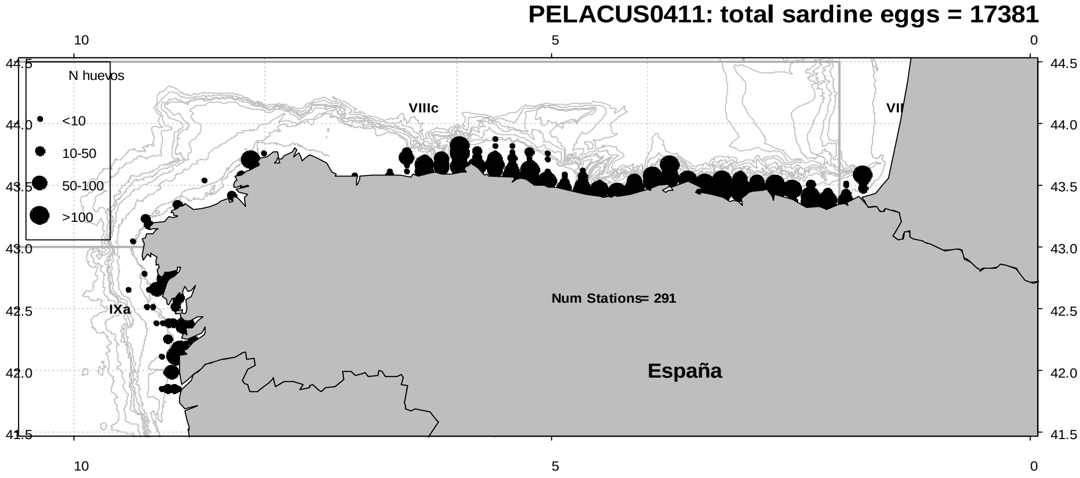


Figure 6.3.2.2.3: Sardine in VIIIc and IXa: Total number of sardine eggs obtained during the PELACUS0411 survey. Circles indicate positive stations with diameter proportional to egg abundance.

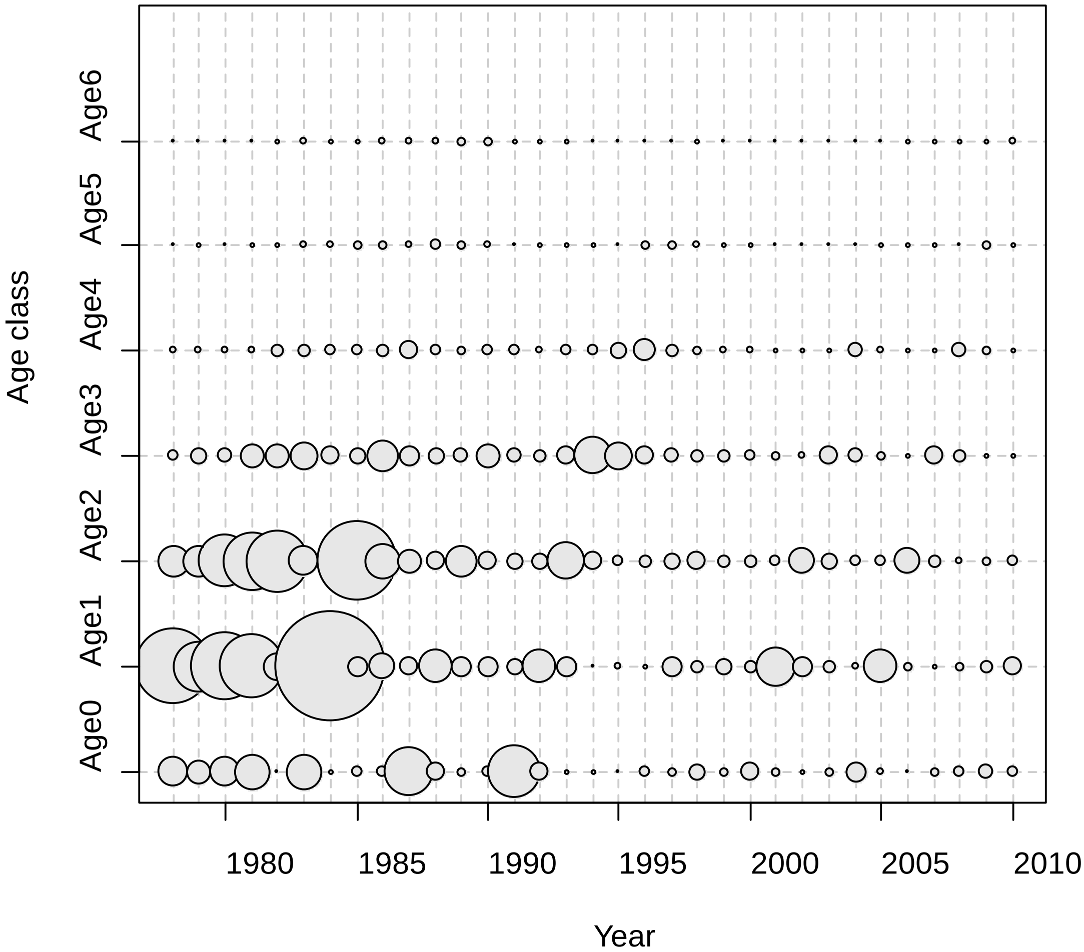


Figure 6.5.1.1: Sardine in VIIIc and IXa: Catches-at-age for 1978-2010.

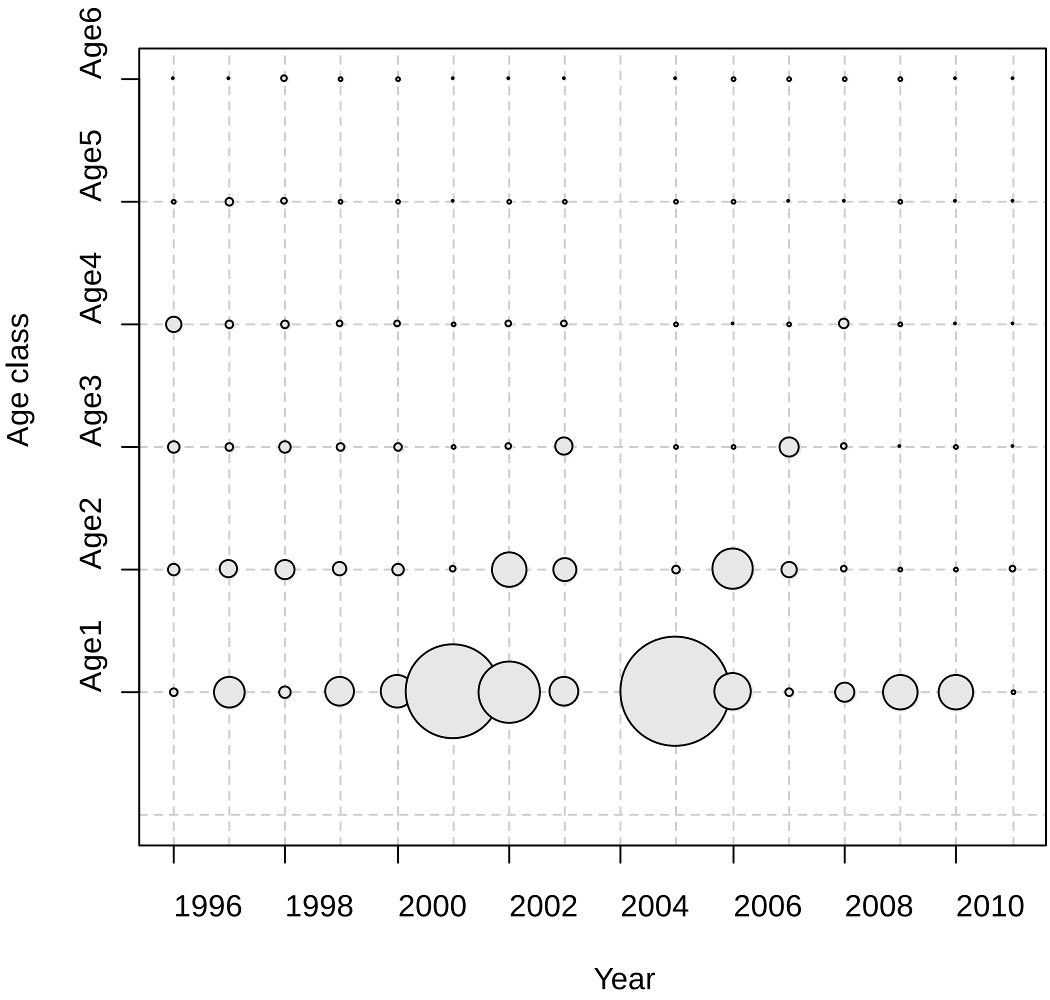


Figure 6.5.1.2: Sardine in VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996-2011.

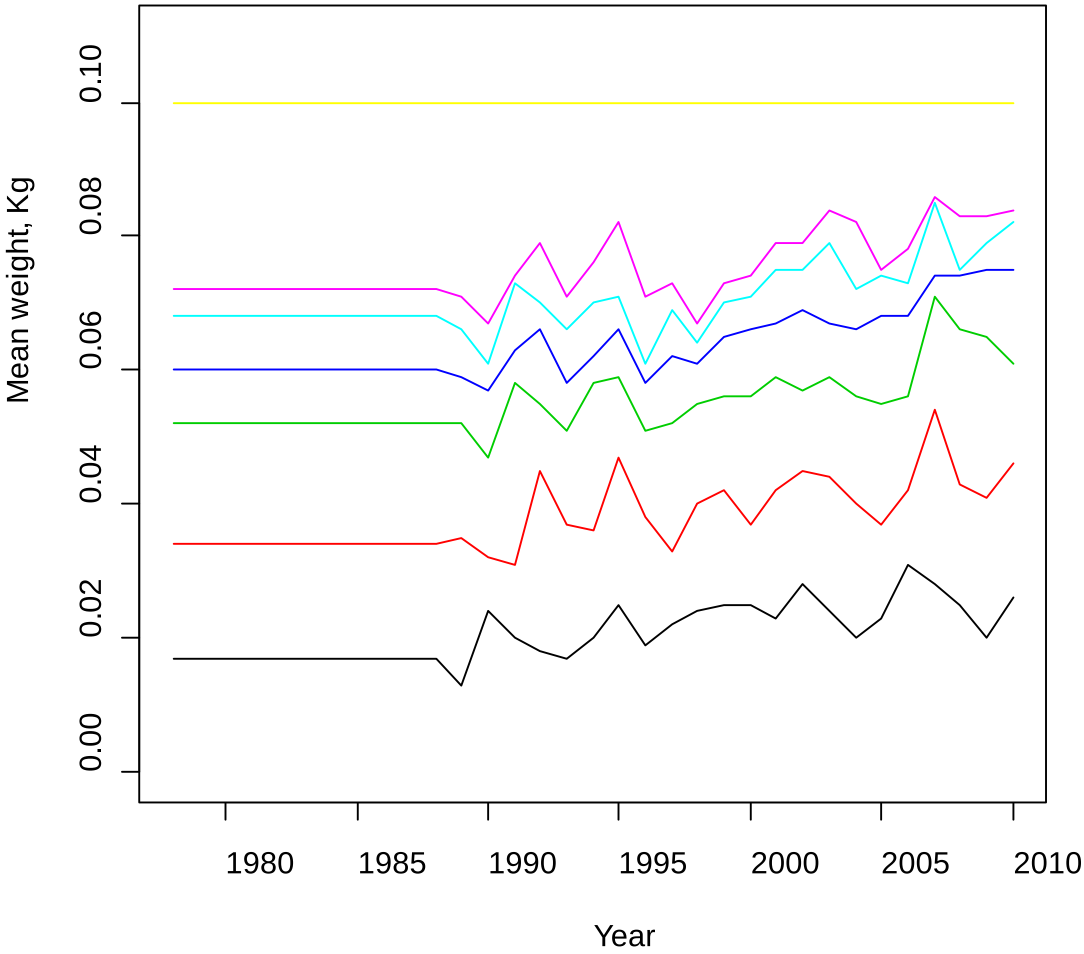


Figure 6.5.1.3: Sardine VIIIc and IXa: Mean weight-at-age in the catches 1978 – 2010.

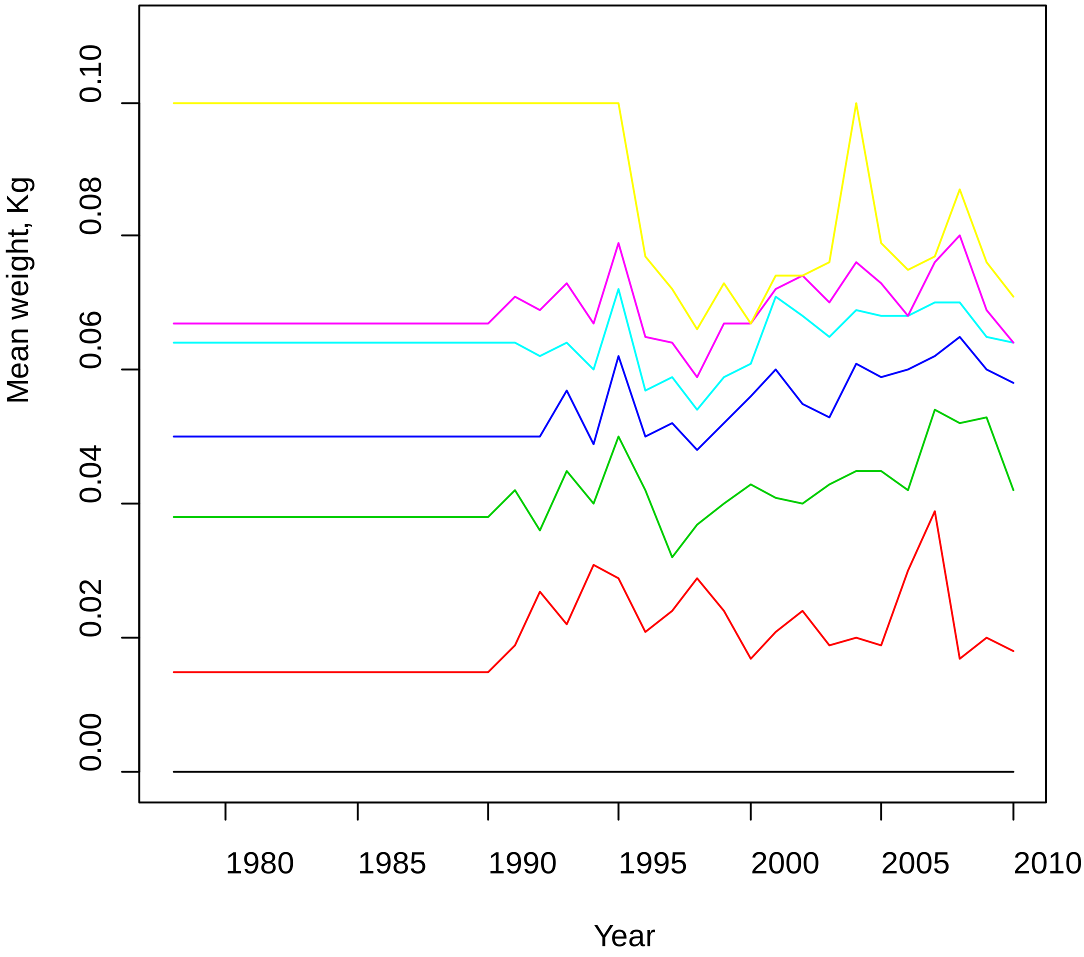


Figure 6.5.1.4: Sardine VIIIc and IXa: Mean weight-at-age in the stock 1978 – 2010.

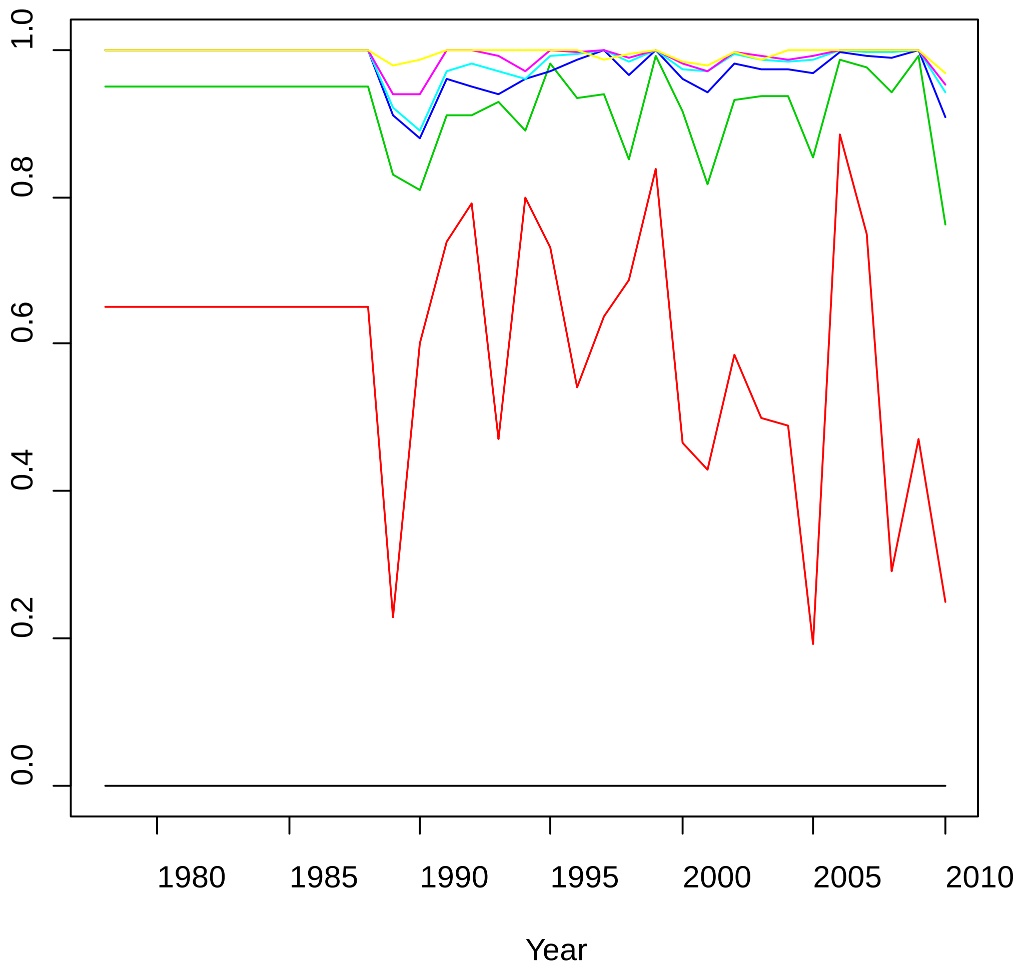


Figure 6.5.1.5: Sardine VIIIc and IXa: Maturity ogives 1978 – 2010.

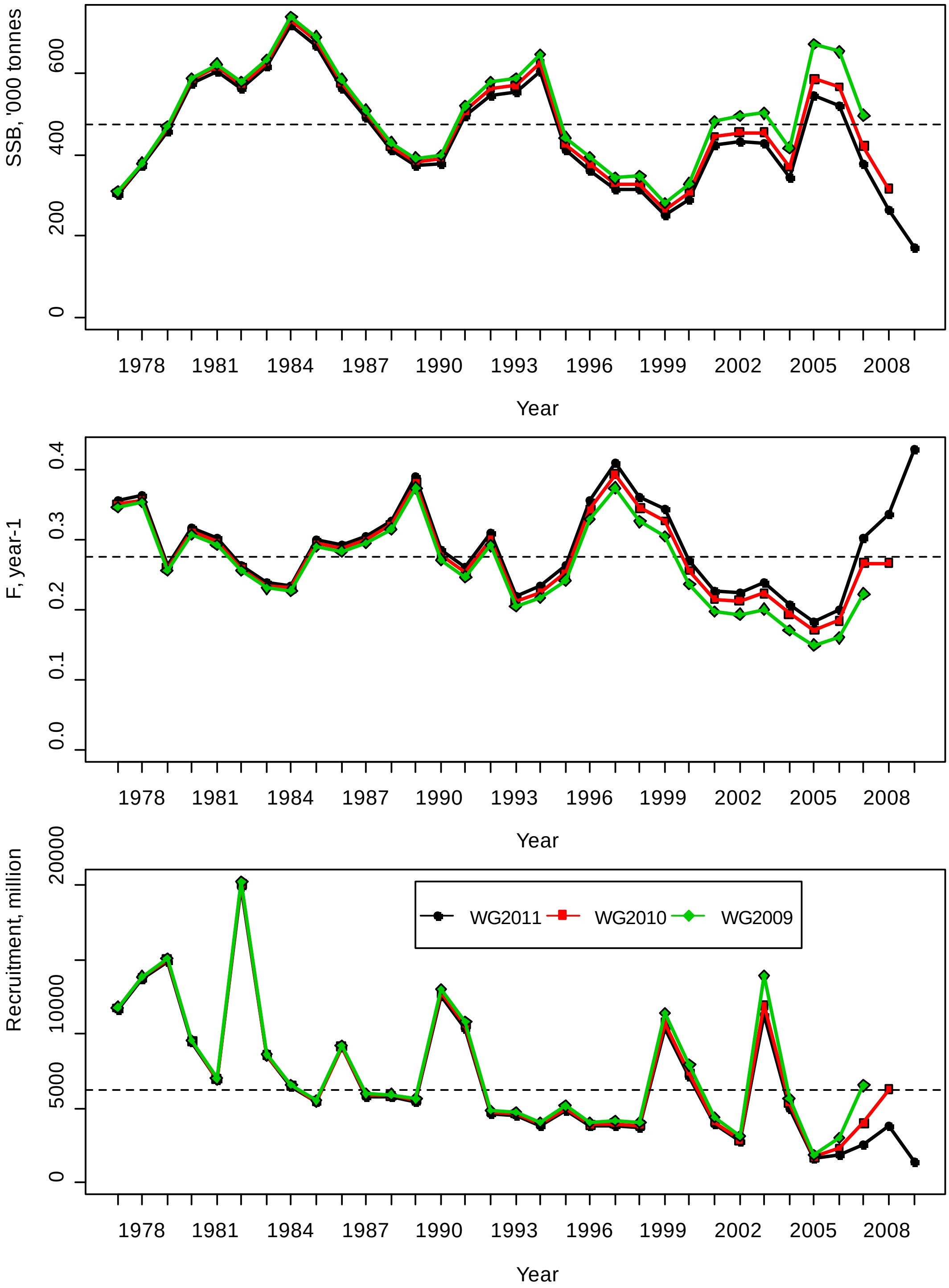


Figure 6.5.1.6: Sardine VIIIc and IXa: SSB (top), F (middle) and recruitment (bottom) trajectories in the period 1978 – 2010 from the sardine AMCI final assessment (WG2011). The WG2010 and WG2009 assessments are shown for comparison.

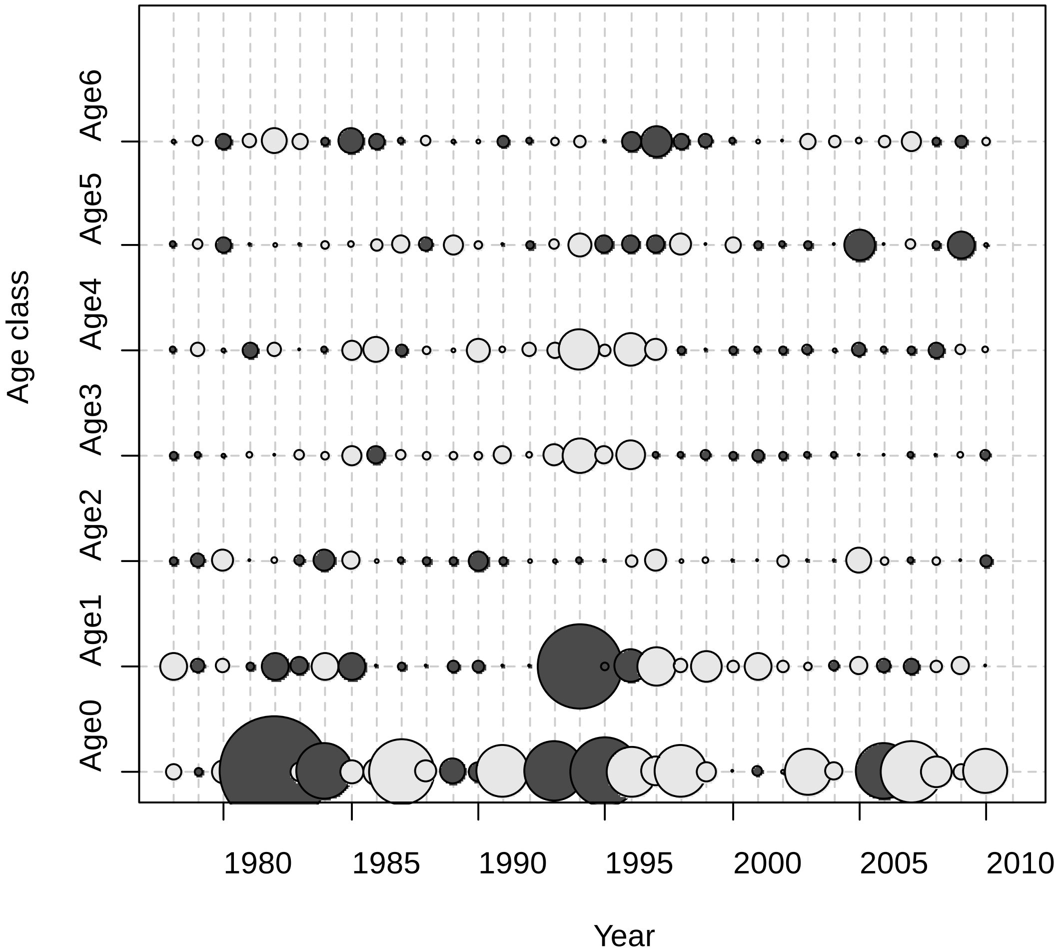


Figure 6.5.1.7: Sardine VIIIc and IXa: Catch residuals 1978 – 2010 (unweighted, negative in black, positive in grey) for the final AMCI assessment. Values are in the range [-1.6, 0.96], the 25% and 75% quantiles are -0.1, 0.2, respectively.

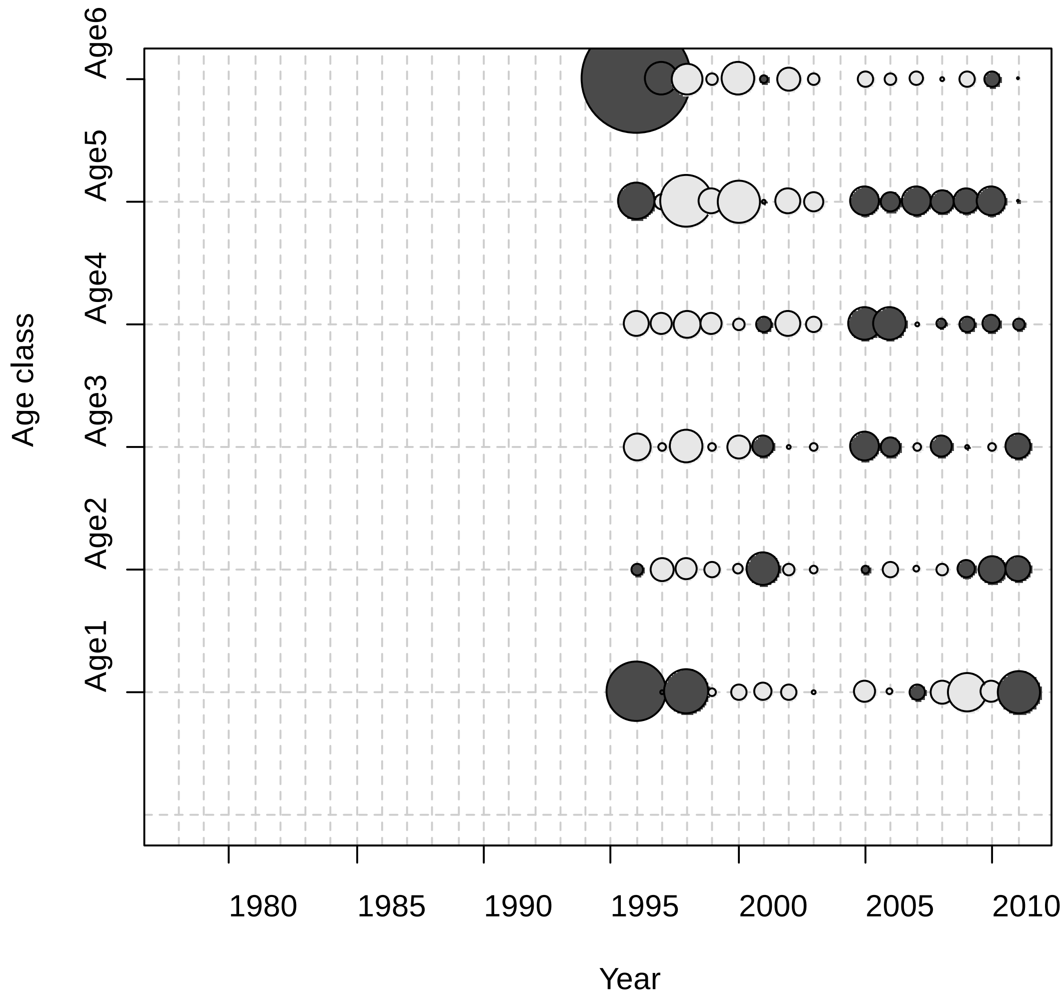


Figure 6.5.1.8: Sardine VIIIc and IXa: Survey residuals (for the combined Iberian spring acoustic survey 1996 - 2011) for the final assessment. Negative residuals in black, positive in grey, values in the range [--2.2, 1.0], the 25% and 75% quantiles are -0.26, 0.31,respectively.

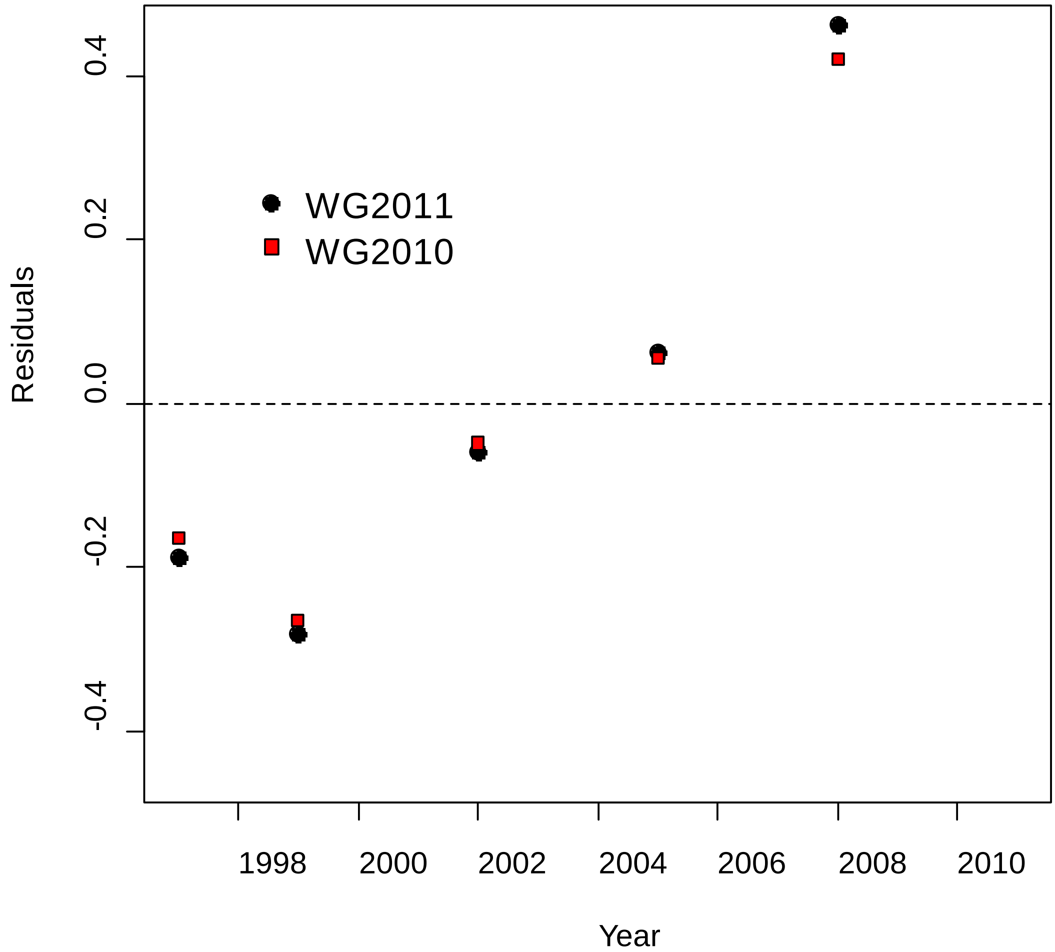


Figure 6.5.1.9: Sardine VIIIc and IXa: DEPM survey residuals (unweighted, log-scale) in the final assessment model. Residuals from the 2010 assessment are shown for comparison.

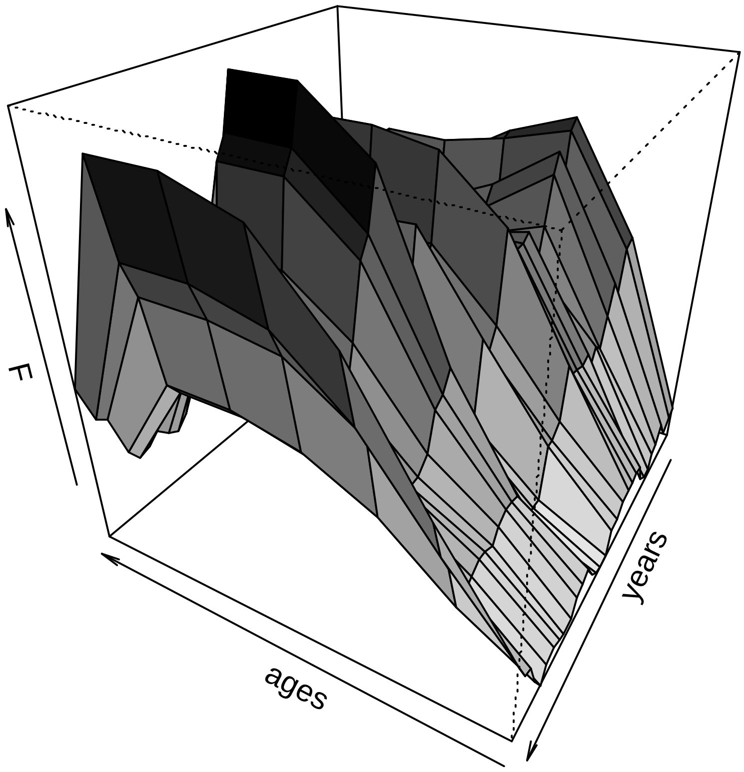


Figure 6.5.1.10: Sardine VIIIc and IXa: Year and age specific fishing mortalities estimated by the final assessment model for the period 1978 – 2010 and age groups 0-6+.

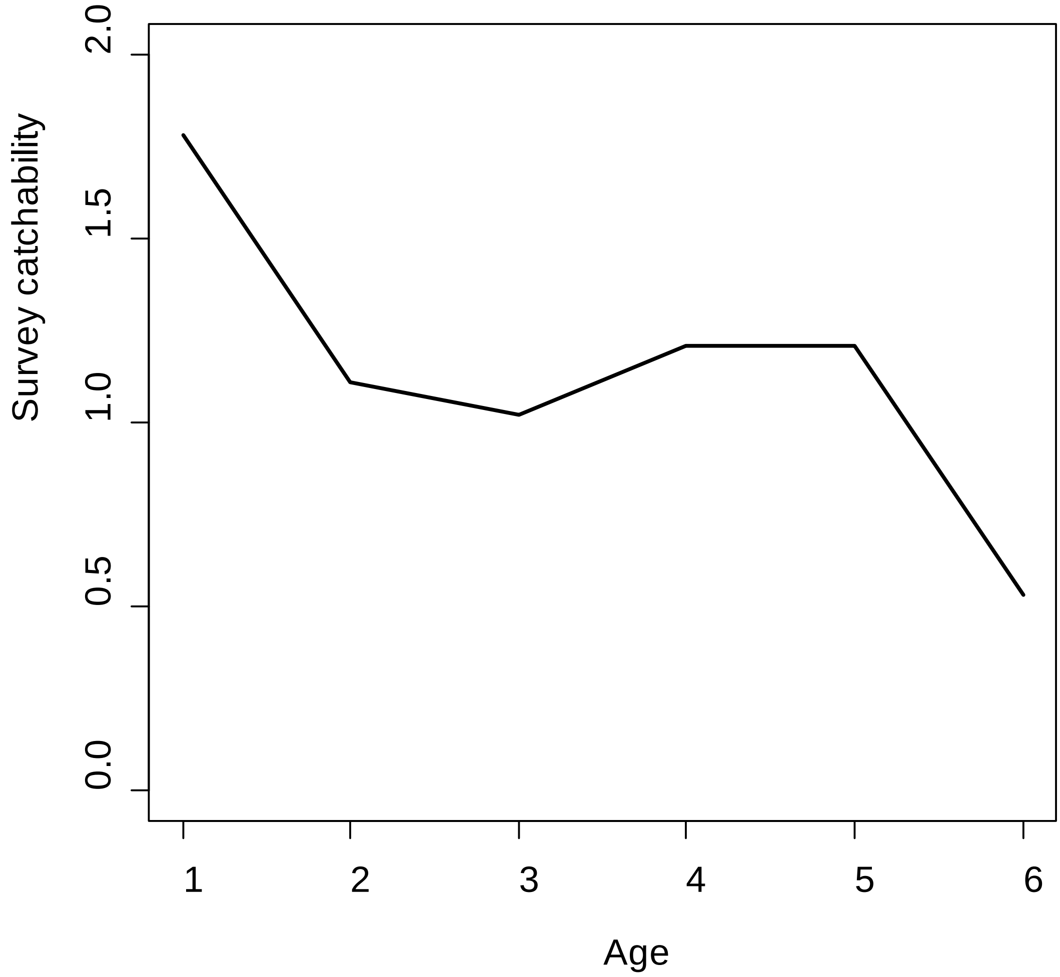


Figure 6.5.1.11: Sardine VIIIc and IXa: Survey catchability for ages 1 to 6+ in the final assessment model.

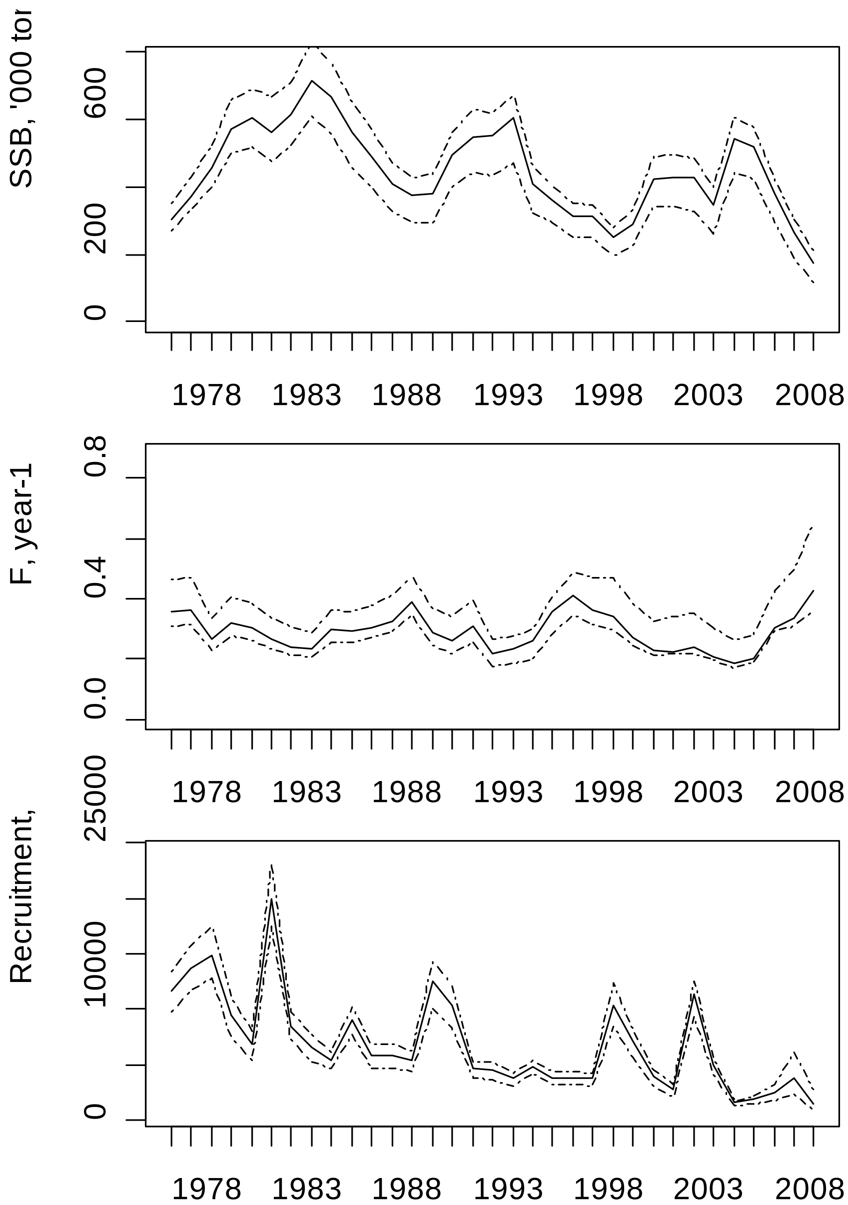


Figure 6.5.1.12: Sardine VIIIc and IXa: Bootstrap trajectories of SSB, recruitment and F for the final assessment model. Dotted lines represent the 5% and 95% quantiles of the distribution.

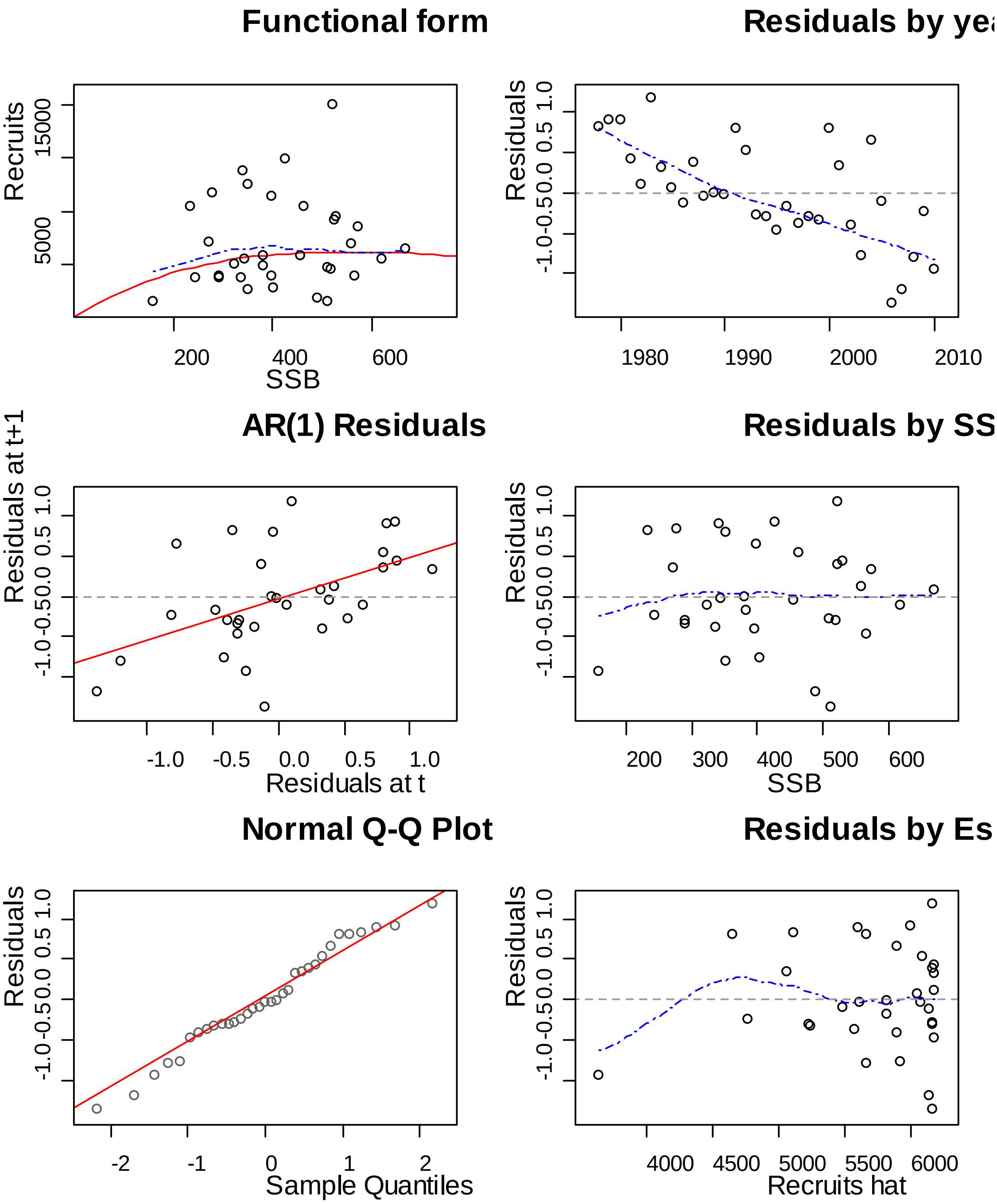


Figure 6.7.1. Fitted model and residual plots for a Ricker curve fitted to sardine stock-recruitment data 1978 – 2010.

7 Southern Horse Mackerel (Division IXa)

7.1 ACOM Advice Applicable to 2010, STECF advice and Political decisions

In 2009 ICES considered that in the absence of defined reference points, the state of this stock cannot be evaluated with regard to these. Catches decreased from the early 1960s but have been relatively stable since the early 1990s. SSB has increased since 2003. ICES further stated that the recent level of catches does not seem to be detrimental to the stock. ICES therefore recommends that catches in 2010 should not exceed the recent average catch of 25 000 t (2000–2004; 2003 is excluded because of the reduced effort following the Prestige oil spill). ICES also recommended that the TAC for this stock should only apply to *Trachurus trachurus.*

The TAC finally accepted by the European Commission was of 31142 ton.

7.2 The fishery in 2012

7.2.1 Fishing Fleets in 2010

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 lower abundance of adults. On the other hand the Portuguese artisanal fleet, and the Spanish bottom trawl and artisanal fleets show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible. Descriptions of the Portuguese and Spanish fleets are given in Stock Annex.

7.2.2 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 1992–2010, and it is expected to go back in time during the next years.

In general Discards of southern horse mackerel are considered scarce. Discard data for southern horse mackerel for 2010 are provided by Spain (Table 7.2.2.1).

The Portuguese catches range from 40% of the total catch of the stock in 2008 to 83% in 1992 (Table 7.2.2.2). The catch time series during the assessment period did not shows a clear trend with a peak reached in 1998 until 2003, when the lowest level of the time series was reached. This low catch level was mainly due to the markedly decrease (-21%) observed in Portuguese catches as compared to the catch reported in 2002. The catches in 2010 showed an increase of 1500 t in relation to 2009.

A historical evolution of catches is detailed in the Stock Annex and in Table 7.2.2.3. The different fleets targeting Southern horse mackerel are described in the Stock Annex.

	IXa-North	IXa-South	Total
Weight (tn)	20.4	148.5	168.9
CV	34.1	63.8	56.2

Discard Number ('000)

Length (cm)	IXa North	XIa South	Total
7		10	10
8		0	0
9		10	10
10		14	14
11		27	27
12		21	21
13		20	20
14		75	75
15		113	113
16		14	14
17		5	5
18		26	26
19		88	88
20		223	223
21		330	330
22		333	333
23		234	234
24		127	127
25		62	62
26	0	31	31
27	4	24	28
28	9	11	20
29	3	4	7
30	10	0	10
31	3		3
32	8		8
33	10		10
34	18		18
35	3		3
36	1		1
37	5		5
38	0		0
39	1		1
40	0		0

Table 7.2.2.1.-Discards length distribution (individual thousand) and discard catch (tn) estimations for southern horse mackerel of Spanish fleet in 2010. Discard sampling was raised to effort.

	Country		
Year	Portugal (Subdivisions: IX a central north; IXa central south and IXa south)	Spain (Subdivisions IXa North and IXa south*)	Total Catch
1991	17,497	4,275	21,772
1992	22,654	4,059[1]	28,411[1]
1993	25,747	6,198	31,945
1994	19,061	9,380[1]	28,441[1]
1995	17,698	7,449	25,147
1996	14,053	6,347[1]	20,400[1]
1997	16,736	10,906	27,642
1998	21,334	20,230	41,564
1999	14,420	13,313	27,733
2000	15,348	11,812	27,160
2001	13,760	11,152	24,910
2002	14,270	8,236 // (9,393)*	22,506 // (23,663)*
2003	11,242	7,645 // (8,324)*	18,887 // (19,566)*
2004	11,875	11,377 // (11,702)*	23,252 // (23,577)*
2005	13,307	9,388 // (9,804)*	22,695 // (23,111)*
2006	14,607	9,295 // (9,951)*	23,902 // (24,558)*
2007	10,381	12,409 // (13,043)*	22,790 // (23,424)*
2008	9290	13,703 // (14,303)*	22,993 // (23,593)*
2009	10841	14,886 // (14,126)*	25,727 // (24,967)*
2010	11726	15,490 // (14,830)*	27,216 // (26,556)*

(*) In parenthesis: the Spanish catches from Subdivision IXa south are also included. These catches are only available since 2002 and they will not be considered in the assessment data until the rest of the time series be completed.

([1]) These figures have been revised in 2008.

Table 7.2.2.2 Time series of southern horse mackerel historical catches by country (in tonnes).

Gear Year	Bottom trawl		Purse seine		Artisanal	
	Portugal	Spain	Portugal	Spain	Portugal	Spain
1992	13,000 (54.7)	1,651 (40.7)	7,354 (30.9)	2,409 (59.3)	3,445 (14.5)	-
1993	16,783 (66.3)	3,877 (62.6)	4,683 (18.5)	2,321 (37.4)	3,841 (15.2)	-
1994	10,466 (55.0)	2,655 (28.3)	5,369 (28.2)	6,724 (71.7)	3,202 (16.8)	-
1995	12601 (71.3)	3,010 (40.4)	2,947 (16.7)	4,440 (59.6)	2,137 (12.1)	-
1996	10,674 (76.3)	2,705 (42.6)	2,085 (14.9)	3,642 (57.4)	1,228 (8.8)	-
1997	12,446 (66.8)	2,130 (19.5)	4,385 (23.5)	8,776 (80.5)	1,800 (9.7)	-
1998	13,170 (61.7)	3,773 (18.6)	5,901 (27.6)	16,458 (81.4)	2,287 (10.7)	-
1999	6,868 (47.6)	3,238 (24.3)	5,707 (39.5)	10,074 (75.7)	1,855 (12.9)	-
2000	7,970 (55.5)	4,727 (40.0)	4,210 (29.3)	7,027 (59.5)	2,169 (15.1)	58 (0.5)
2001	7,690 (55.9)	4,536 (40.7)	4,788 (34.8)	6,260 (56.1)	1,281 (9.3)	356 (3.2)
2002	8,126 (56.9)	4,181 (50.8)	4,271 (29.9)	3,959 (48.1)	1,873 (13.1)	96 (1.2)
2003	6,887 (61.3)	3,229 (42.2)	2,112 (18.8)	4,411 (57.7)	2,243 (20.0)	5 (0.1)
2004	8,625 (65.8)	7,501 (65.9)	2,042 (15.6)	3,658 (32.2)	2,441 (18.6)	217 (1.9)
2005	8,319 (62.5)	5,710 (60.9)	2,444 (18.4)	3,596 (38.3)	2,545 (19.1)	76 (0.8)
2006	9,485 (64.9)	5,534 (59.6)	1,754 (12.0)	3,676 (39.6)	3,368 (23.1)	77 (0.8)
2007	5,706 (55.0)	7,999 (64.5)	2,683 (25.8)	4,092 (33.0)	1,992 (19.2)	316 (2.5)
2008	5,790 (62.0)	6,590 (48.0)	1,090 (12.0)	6,580 (48.0)	2,410 (26.0)	539 (4.0)
2009	4850 (18.9)	2199 (39.7)	3792 (8.5)	10841 (17.4)	10225 (14.7)	4469 (0.7)
2010	5769 (21.4)	10293 (38.2)	1947 (7.2)	4900 (18.2)	4011 (14.9)	297 (1.1)

Table 7.2.2.3. Southern horse mackerel. Landings by gear and by country with and indication (in parenthesis) of the percentage that represent those landings in each country.

7.2.3 Effort and catch per unit effort

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

7.2.4 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 7.2.4.1). In general, catches are dominated by juveniles and young adults, although in recent years there is an increment of catch of older ages.

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 7.2.4.2). Six fishing fleets are considered defined by the gear type (bottom trawl, purse seine and artisanal) and country (Portugal and Spain). The new time series starts in 1992 although it is expected to be extended back in time in the future.

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 lower abundance of adults. On the other hand the Portuguese artisanal fleet, and the Spanish bottom trawl and artisanal fleets show the opposite: a significant presence of adults and low presence of juveniles. The catch of Spanish artisanal fishery is negligible.

	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

Table 7.2.4.1. Southern horse mackerel. Time series of catch at age data in number (thousands).

Pt. Bottom trawl

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	4707	43326	72194	19567	7253	6331	3538	4288	3046	2495	6593	5676
1993	98	8737	40080	77980	28618	10722	9734	6540	3471	1342	1383	3356
1994	3413	16252	37679	55074	16278	3862	1945	900	1263	914	691	1136
1995	3917	12983	18291	22796	11429	5351	2395	2195	2036	2378	1691	17550
1996	30763	10329	10084	19186	23285	6293	4295	2813	2181	1779	1195	3638
1997	2819	180143	67538	14756	7630	4251	1825	779	296	175	172	806
1998	4444	36543	205035	32093	7077	3347	2155	2045	1844	1041	1225	2539
1999	28176	11489	16041	23580	8295	2527	2701	1581	863	932	767	1309
2000	1106	35946	13682	17867	9887	5749	5723	4046	2301	1568	950	769
2001	39825	25156	10755	9140	7377	4284	5419	5757	3687	1331	774	666
2002	3572	58462	49165	11953	4456	3560	3600	4563	2847	1891	775	821
2003	14581	2077	18044	12035	12655	7100	5807	4606	3117	1629	831	347
2004	1335	77202	44073	10862	3388	4640	3772	4340	2829	807	229	125
2005	2943	50534	30346	14960	10564	5227	5228	3751	2836	1720	1180	2200
2006	1223	55455	60260	14803	3643	9412	8894	3068	2630	1797	1218	624
2007	19	2374	14842	31466	10961	2909	1595	632	411	534	772	4181
2008	5512	12786	21009	21454	9703	2290	1172	727	901	623	702	1856
2009	4552	19568	13743	3527	3869	3994	1178	638	693	697	955	4890
2010	10832	46074	15182	11409	6777	3293	1084	945	919	1059	685	2403

Pt. Purse seine

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	6188	36983	47773	12060	3322	2414	1344	1952	1278	1186	2537	2363
1993	2143	44611	72760	9606	2792	477	174	200	73	96	92	175
1994	2378	8351	21613	26189	7060	1706	816	466	580	440	392	452
1995	0	121	2649	15853	8111	1863	354	265	52	299	162	1223
1996	5933	210	1032	3839	3675	244	108	91	256	1522	560	2111
1997	132	80144	25732	5035	2512	920	242	70	44	22	65	0
1998	8511	10500	56107	23166	3661	994	225	69	179	0	0	0
1999	879	1757	5691	27514	19477	4308	1953	361	67	23	11	2
2000	1180	3147	3833	13482	14000	4449	1824	455	150	11	1	2
2001	49834	28340	2185	7538	10979	5726	2627	1048	269	39	17	7
2002	8107	14724	27433	11274	5473	3771	1833	876	291	58	125	0
2003	8945	1558	9762	13652	5428	1574	644	66	10	2	1	0
2004	432	11782	8860	3419	1648	1675	1543	1043	102	15	0	0
2005	9441	35137	12717	4993	1840	1193	863	381	214	76	29	8
2006	589	14848	22692	3355	78	17	0	0	0	0	0	0
2007	65	5327	8411	8935	6005	3106	111	0	0	0	0	2007
2008	9397	8038	2893	1930	2025	178	86	82	102	127	152	100
2009	3481	29109	9444	1814	2823	1440	342	114	92	69	42	15
2010	48907	13654	5640	1319	665	398	149	169	63	39	17	21

Pt. Artisanal

YEAR	AGES 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
1999	2	67	731	1927	2836	2102	2420	1151	433	394	98	564
2000	73	1129	1028	998	1385	1081	2154	2137	1463	717	386	787
2001	420	1011	129	489	841	1194	1482	1557	888	359	228	382
2002	1212	3166	459	588	467	883	1330	1656	1580	1114	533	1095
2003	2537	143	1581	663	1434	1313	2145	2855	2031	1079	601	547
2004	491	7154	1551	431	877	1364	1328	2510	2606	986	357	265
2005	203	738	295	305	323	1306	1607	917	1138	1018	1170	3611
2006	26	5785	1859	590	777	1079	853	1009	1763	1931	1961	3753
2007	0	5	211	1458	1349	1395	415	250	287	307	382	4193
2008	0	312	800	1290	2305	1831	814	480	506	362	405	3751
2009	49	654	694	703	1455	609	553	551	517	486	430	7545
2010	10	14302	6780	3211	2993	2374	1072	1262	551	732	494	5321

Table 7.2.4.2. Southern horse mackerel. Catch in number by gear and country (Pt = Portugal; Sp = Spain)

Sp. Bottom trawl

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	0	0	0	2	12	18	25	51	79	128	416	458
1993	0	2	14	37	42	182	667	1634	1695	2581	1936	6056
1994	0	0	0	5	44	65	193	658	1267	1286	1516	4087
1995	0	0	1	11	18	24	146	85	263	360	447	8060
1996	0	11	39	59	46	33	228	250	590	1466	1015	4973
1997	10	400	792	299	216	286	262	438	516	627	436	3555
1998	0	1	574	901	74	81	332	1518	1256	1377	1498	4686
1999	0	2	18	164	358	388	942	989	787	1000	846	4215
2000	0	0	3	219	876	2141	3457	3611	3245	2578	1594	1747
2001	47	89	106	261	915	2045	3267	4504	3957	1300	782	1940
2002	0	579	237	335	340	901	1500	2718	3220	3306	1896	2336
2003	0	0	35	521	370	426	1603	2334	2928	2337	1424	1179
2004	17	327	98	1787	1370	4474	4014	5276	4046	1559	3594	3834
2005	13	109	43	140	1682	1409	1768	2439	4211	3826	2530	4505
2006	443	4022	915	112	156	411	598	694	1242	2505	3690	9357
2007	0	70	11	4	6	23	388	829	2270	2110	2364	17195
2008	0	1	69	374	705	694	523	439	1017	1055	1671	15025
2009	1	63	815	1506	889	468	404	431	491	1133	1624	23103
2010	0	0	12	25	111	368	640	784	497	472	1212	22815

Sp. Purse seine

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	790	14877	25764	9102	1538	263	18	21	20	18	35	39
1993	4150	6727	10476	6990	1564	317	339	619	472	766	575	1667
1994	5256	37078	24375	13047	4207	1133	563	570	1061	1251	2158	3079
1995	3311	41990	9807	11177	6712	2361	501	180	110	62	55	1024
1996	32956	3237	2769	4350	5279	2672	1514	1016	766	481	331	2190
1997	2079	34040	17176	4762	3895	4855	4138	5230	2663	2809	1473	3672
1998	9782	48725	56279	11227	6232	5034	5613	15313	8741	3621	2760	2041
1999	22602	16480	3749	13518	11994	6377	5824	3473	2025	2442	752	1326
2000	9888	32714	4999	9027	9779	5196	4066	1836	726	327	171	229
2001	15634	22765	18074	6626	3414	3294	2408	1959	901	251	210	637
2002	5553	17461	7083	2330	2421	2270	1971	2634	2145	1083	233	116
2003	13970	3051	7331	1686	2036	2370	4544	3719	2544	1446	674	260
2004	4826	30332	3471	1717	1025	1367	1057	1560	856	474	979	928
2005	8416	21553	5795	3889	3432	2172	1676	418	689	772	571	1018
2006	1048	12448	7154	3779	2024	2192	1506	1225	1638	1804	2037	1514
2007	2798	8476	4006	2296	2014	693	1801	1712	2799	1667	1323	2179
2008	33471	33012	6873	2743	1704	2045	2053	1837	1960	1750	1555	3445
2009	14535	36021	7713	922	727	639	797	1092	949	1099	1094	3185
2010	21299	27779	5931	1448	1393	1133	889	736	383	338	543	1577

Sp. Artisanal

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11+
1992	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	2	26	40	27	30	33	31	25	22	22
2001	0	3	11	50	195	251	189	138	94	31	11	357
2002	0	10	3	3	3	12	29	55	74	73	45	66
2003	0	0	0	3	9	8	7	2	1	0	0	0
2004	0	0	1	25	20	66	121	149	103	35	98	167
2005	0	0	1	3	36	26	36	21	35	33	22	78
2006	0	5	16	27	60	64	41	32	30	33	41	73
2007	3	168	187	198	199	61	149	139	209	130	103	246
2008	0	18	308	268	174	156	134	95	93	58	50	813
2009	0	0	7	10	11	12	16	34	50	95	91	358
2010	0	207	361	85	41	4	14	47	38	31	25	147

Table 7.2.4.2.(cont). Southern horse mackerel. Catch in number by gear and country (Pt = Portugal; Sp = Spain)

7.2.5 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 7.2.5.1 and Table 7.2.5.2 show the mean weight at age in the catch, and the mean length at age in catch respectively. The mean weight at age in the catch increased significantly in 2004 for the ages above 3 years old, being for some of these ages the highest of the historical series (Figure 7.2.5.1). In 2009, there is not a clear pattern, with some ages showing a decrease and others an increase in mean weigh at age. The mean length at age showed a smooth increase trend for those ages since 2002 with a decrease in 2005 and 2006 (Table 7.2.5.2).

	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

Table 7.2.5.1.- Southern horse mackerel. Mean weight (kg) at age in the catch.

Year \ Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	14.931	15.594	17.471	19.843	23.180	25.785	27.384	28.648	29.601	31.152	31.534	32.642	33.284	33.929	34.699	36.815
1993	13.957	15.538	17.405	18.891	21.284	28.235	29.558	31.086	31.701	31.662	32.051	32.451	34.081	34.723	35.814	37.178
1994	13.368	14.584	18.114	21.084	22.665	24.757	27.012	29.532	31.151	31.713	32.383	32.190	33.267	34.173	34.372	36.462
1995	16.038	15.444	19.883	21.769	23.115	24.487	28.645	26.538	30.141	30.901	31.610	32.614	33.945	33.995	35.233	36.943
1996	13.293	18.989	19.683	21.820	24.676	26.323	28.016	28.561	30.336	30.740	31.473	31.951	33.421	32.542	36.151	37.004
1997	13.359	15.813	18.894	20.718	24.274	26.303	27.625	29.455	31.151	32.399	31.881	33.051	34.638	34.824	35.448	38.542
1998	14.493	13.916	15.924	20.449	23.513	25.517	28.313	30.306	26.860	31.690	31.982	32.734	33.439	34.537	36.446	39.077
1999	13.410	16.394	18.968	22.274	24.476	26.201	27.515	28.983	30.291	31.703	32.691	33.264	33.876	34.738	37.315	39.585
2000	13.610	16.373	18.434	21.682	24.757	25.996	27.229	28.573	30.219	30.796	31.524	32.280	32.656	34.228	34.494	34.992
2001	14.111	15.618	20.240	21.851	22.462	25.444	27.364	28.731	29.592	30.854	31.180	32.985	32.843	33.989	34.732	38.228
2002	15.049	15.691	17.509	20.337	23.062	25.383	26.600	28.010	29.581	30.863	31.760	32.601	34.202	34.681	35.433	36.876
2003	12.996	15.723	18.750	20.699	23.143	26.076	26.728	29.192	29.999	31.213	31.956	32.897	33.554	33.927	38.856	35.310
2004	16.172	14.426	17.228	21.174	24.045	26.666	28.076	29.398	30.473	31.616	32.291	32.228	33.047	32.249	36.367	35.881
2005	12.497	13.928	16.624	20.082	23.536	25.924	27.119	28.094	30.021	31.137	31.636	32.785	32.578	33.548	32.586	37.223
2006	14.615	14.659	17.043	19.209	22.207	24.622	25.631	27.208	28.720	30.329	31.476	33.220	34.002	35.863	36.705	36.999
2007	14.601	17.486	18.534	20.015	22.086	23.639	26.897	28.724	30.635	30.325	30.921	31.831	33.424	32.164	34.486	35.742
2008	12.962	17.262	20.483	22.252	23.970	25.422	26.539	27.660	28.778	29.640	30.481	31.276	32.231	33.527	35.584	37.227
2009	12.962	17.262	20.483	22.252	23.970	25.422	26.539	27.660	28.778	29.640	30.481	31.276	32.231	33.527	35.584	37.227
2010	13.133	15.800	18.430	20.809	23.437	25.361	26.892	27.770	28.645	29.246	31.165	31.723	33.484	34.719	36.742	38.036

Table 7.2.5.2. Southern horse mackerel. Mean length (cm) at age in the catch.

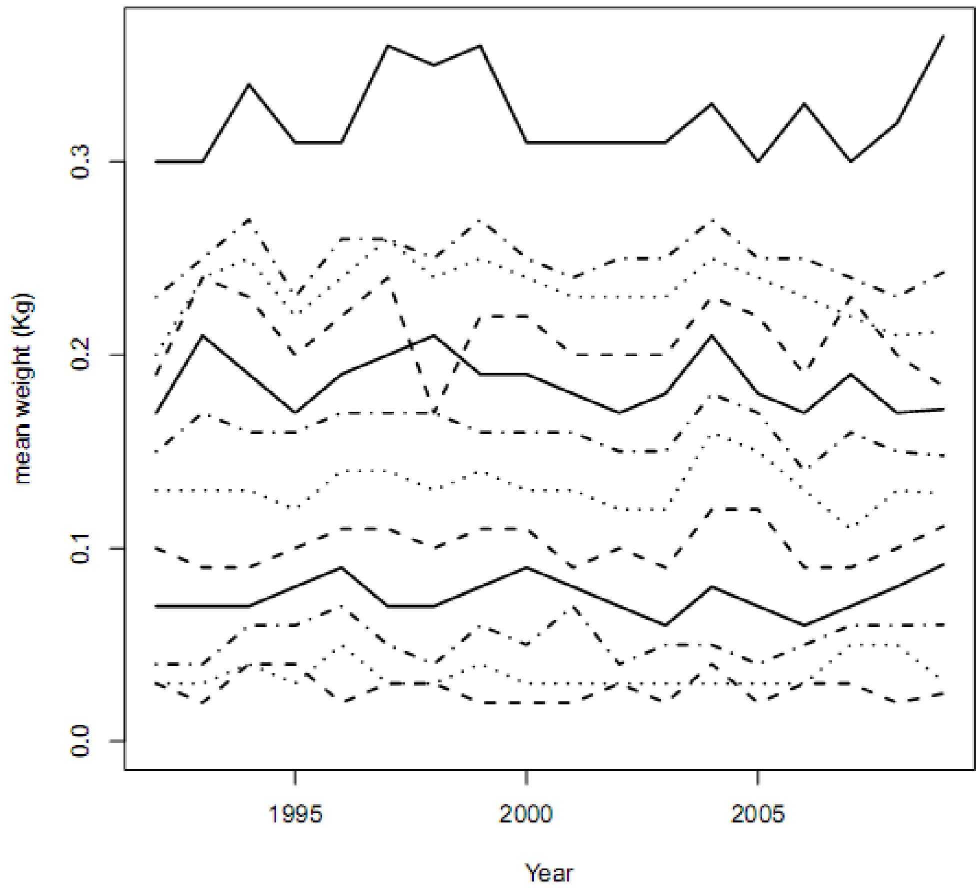


Figure 7.2.5.1. Southern horse mackerel. Time series of mean weight at age in the catch (from age 1 to 11).

7.3 Fishery independent information

7.3.1 DEPM – based SSB estimates

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

7.3.2 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 indexes from these surveys are shown in Table 7.3.2.1. The catchability of these vessels (BO Cornide de Saavedra and NI Noruega) and fishing gears were compared for different fish species during project SESITS (Sanchez *et al.*, no date) and no significant differences were found for horse mackerel. Thus, the raw data (number per hour and age in each haul, including zeros) of the two data sets were merged and treated as a single data set.

The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals.

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

Portuguese October Survey

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1992	442.576	481.596	154.451	54.052	24.596	9.807	6.692	6.926	3.601	2.962	4.017	0.651	0.850	0.251	0.133	0.099
1993	1843.002	247.978	248.997	153.167	36.306	4.770	2.777	1.730	0.988	1.133	0.696	1.672	0.462	0.317	0.073	0.081
1994	3.512	8.819	60.963	55.760	23.209	5.737	2.590	1.769	0.867	0.476	0.298	0.103	0.034	0.009	0.000	0.009
1995	20.555	81.244	116.376	70.528	31.413	5.964	1.226	1.438	0.446	0.215	0.214	0.329	0.274	0.516	0.137	0.185
1996*	1451.930	10.207	16.611	26.841	26.974	5.108	2.064	0.819	0.296	0.162	0.056	0.109	0.080	0.053	0.010	0.010
1997	1148.912	81.033	133.818	39.923	64.940	37.578	7.608	6.045	2.413	2.732	0.995	0.120	0.033	0.144	0.090	0.063
1998	94.047	39.737	111.673	16.168	6.000	3.331	1.788	1.779	0.277	0.053	0.024	0.011	0.022	0.000	0.000	0.010
1999*	132.307	28.140	52.896	62.338	5.233	1.801	0.944	0.228	0.057	0.087	0.024	0.000	0.007	0.007	0.000	0.000
2000	2.970	19.212	25.843	29.044	14.131	7.884	4.074	1.243	0.631	0.086	0.046	0.056	0.033	0.016	0.000	0.000
2001	726.799	1.154	4.708	3.701	5.112	7.263	8.795	13.961	7.605	2.469	1.371	0.396	0.178	0.229	0.045	0.000
2002 [1]	41.584	2.634	8.853	14.569	11.592	5.965	1.880	1.261	0.862	0.518	1.015	0.348	0.242	0.121	0.061	0.030
2003*	75.151	9.546	9.574	18.534	16.488	4.708	2.558	1.570	0.999	0.575	0.243	0.010	0.010	0.005	0.000	0.000
2004	63.076	39.333	140.659	55.221	11.570	4.984	2.355	5.904	7.712	1.217	0.249	0.025	0.000	0.000	0.000	0.000
2005	379.148	1458.428	234.507	80.128	39.376	17.036	20.040	20.362	15.596	8.103	4.942	5.923	5.378	1.012	1.259	0.351
2006	92.049	94.143	250.516	62.414	3.714	11.969	8.645	7.110	2.892	1.586	0.719	0.155	0.044	0.000	0.000	0.000
2007	40.785	0.875	28.201	45.659	34.274	8.576	2.883	1.702	0.170	0.571	1.623	1.465	0.656	0.325	0.333	0.590
2008	51.699	26.651	41.069	23.663	30.395	21.058	2.920	0.976	1.426	2.012	1.373	1.011	0.529	0.944	0.627	2.002
2009	1725.205	81.527	121.152	44.449	35.995	9.965	2.713	1.518	1.154	0.684	0.607	0.519	0.865	1.929	0.501	0.894
2010	77.000	30.733	55.454	45.643	51.817	20.145	9.272	6.549	5.370	4.085	3.721	2.480	2.407	2.941	0.847	1.0327

Spanish October Survey (only Subdivision IXa North)

YEAR	AGES 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1991	0.146	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.878	1.860	0.782	0.829	2.734	1.438	1.699	1.812
1992	6.575	0.000	0.000	0.000	0.092	0.000	0.011	0.200	0.181	0.300	3.386	1.553	1.919	1.086	0.302	2.246
1993	92.068	1.652	5.164	3.945	0.354	0.000	1.152	5.175	5.724	8.721	5.228	10.801	2.235	1.646	0.415	0.958
1994	0.148	0.000	0.477	0.000	0.000	0.000	0.000	0.191	0.574	1.432	2.631	0.191	16.133	12.757	1.255	6.413
1995	0.092	0.000	0.000	0.001	0.000	0.003	0.018	0.018	0.339	0.175	0.761	2.534	3.967	8.751	2.450	2.203
1996	33.649	0.000	0.000	0.000	0.000	0.026	0.260	0.348	0.903	2.708	0.564	0.447	1.838	2.561	1.001	4.410
1997**	2.033	0.007	0.000	0.000	0.016	0.126	0.248	0.980	1.158	1.711	0.779	0.235	0.259	0.800	1.098	2.617
1998	0.976	0.000	0.000	0.000	0.000	0.000	0.134	0.926	0.540	0.253	0.146	0.043	0.078	0.126	0.041	0.163
1999	0.041	0.000	0.000	0.000	0.000	0.000	0.170	0.270	0.630	2.175	3.168	2.597	4.653	1.939	1.633	0.286
2000	0.478	0.000	0.000	0.000	0.000	0.005	0.374	2.792	3.686	3.241	0.721	0.578	0.427	0.537	0.294	0.719
2001	12.742	2.857	0.000	0.000	0.000	0.190	0.411	2.544	4.412	4.127	3.151	1.793	0.998	0.930	0.122	0.312
2002	0.143	0.000	0.000	0.000	0.000	0.000	0.594	1.240	7.291	7.091	8.949	10.386	3.540	4.463	1.336	2.295
2003	8.775	0.000	0.000	0.000	0.000	0.026	0.061	0.194	0.110	0.810	0.880	0.348	0.222	0.119	0.067	0.917
2004	89.967	1.191	2.500	16.218	5.390	4.599	1.710	1.306	0.653	0.290	0.797	0.100	0.350	0.044	0.056	0.070
2005	3520.441	0.045	0.000	0.000	0.348	0.409	0.259	0.252	0.515	0.479	0.140	0.637	0.288	0.194	0.099	0.045
2006	28.401	0.096	0.035	0.114	0.061	0.072	0.044	0.027	0.041	0.075	0.155	0.192	0.256	0.159	0.030	0.218
2007	1.388	0.000	0.000	0.007	0.091	0.210	0.965	1.256	1.634	0.756	0.618	0.641	0.177	0.239	0.190	0.162
2008	17.980	0.000	0.003	0.026	0.026	0.003	0.058	0.081	0.225	0.373	0.372	0.264	0.065	0.041	0.057	0.384
2009	84.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.057	0.163	0.172	0.086	0.833	0.689	0.272
2010	0.578	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.515	0.591	0.503	0.780	1.274	1.140

* The surveys were carried out with a different vessel

** Since 1997 another stratification design was applied in the Spanish surveys

1 In 2002 started a new series in which the duration of the trawling per haul has changed from one hour to thirty minutes

Table 7.3.2.1. Southern horse mackerel. CPUE at age from bottom trawl surveys.

	AGES											
YEAR	0	1	2	3	4	5	6	7	8	9	10	11+
1992	329.80	355.18	113.91	39.86	18.19	7.23	4.94	5.21	2.75	2.34	4.71	5.14
1993	1451.63	190.41	192.85	119.00	27.93	3.65	2.64	3.64	3.34	4.83	2.91	9.42
1994	2.92	7.19	49.85	45.43	18.91	4.67	2.11	1.51	0.90	0.90	1.20	13.08
1995	16.63	65.59	93.95	56.94	25.36	4.82	1.00	1.17	0.49	0.24	0.47	8.86
1996	1144.25	7.94	12.92	20.88	20.98	3.98	1.72	0.79	0.63	1.32	0.29	4.74
1997	844.41	59.49	98.25	29.31	47.69	27.66	5.71	4.97	2.42	2.95	1.18	3.49
1998	77.56	32.60	91.63	13.27	4.92	2.73	1.52	1.76	0.40	0.13	0.07	0.21
1999	104.54	22.23	41.79	49.25	4.13	1.42	0.83	0.31	0.34	0.99	1.16	3.65
2000	2.53	15.45	20.78	23.35	11.36	6.34	3.40	2.01	1.88	1.29	0.31	1.05
2001	545.08	1.88	3.50	2.75	3.80	5.48	6.72	11.52	7.62	3.66	2.43	2.64
2002	32.48	2.05	6.87	11.31	9.00	4.63	1.75	1.58	3.96	3.51	4.56	9.90
2003	63.14	7.62	7.64	14.79	13.16	3.77	2.06	1.33	0.84	0.75	0.52	0.67
2004	82.37	31.80	113.13	49.83	11.15	5.61	2.49	5.18	6.38	1.08	0.48	0.23
2005	1451.28	1188.35	191.08	65.29	32.23	14.03	16.40	16.68	12.89	6.78	4.08	11.82
2006	84.21	76.75	204.14	50.90	3.05	9.78	7.06	5.80	2.37	1.32	0.65	0.50
2007	34.22	0.72	23.34	37.79	28.39	7.16	2.68	1.80	0.65	0.71	1.54	3.25
2008	48.47	21.67	33.39	19.25	24.72	17.12	2.39	0.82	1.23	1.76	1.24	4.43
2009	1436.39	66.51	98.83	36.26	29.36	8.13	2.21	1.26	0.94	0.58	0.55	4.60
2010	62.23	24.76	44.67	36.77	41.74	16.23	7.47	5.28	4.33	3.29	3.17	9.48

Table 7.3.2.2. 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.

7.4 Biological data

7.4.1 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 in the catch is significantly different from the mean weight in the stock.

7.4.2 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 Grop has discussed this problem, and i 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

7.4.3 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

7.5 Assessment of the state of the stock

7.5.1 Stock assessment

The stock assessment was carried out as agreed during the latest benchmark (ICES, 2011), with the settings and method as described in the Stock Annex (Table 8 of the Stock Annex). The only tuning data included in the assessment was the combined series from the Portuguese and Spanish surveys ((Pt-GFS-WIBTS-Q4 and Pt-GFS-WIBTS-Q4) carried out in ICES division IXa every year in the 4th quarter. These data were used in the tuning as a series of total biomass indices by year, and as a series of proportions of abundance-at-age for each year.

The survey data is very noisy, especially 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 because of the presence of static fishing gears. For this reason, the age 0 was 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, and also in differences in the proportions at age from year to year. To account for these characteristics of the data set, four selectivity vectors of parameters were estimated (Figure 7.5.1.1). These correspond to one more change in selectivity than in the settings used in the latest benchmark assessment, which can be explained by the inclusion of one more year in the time series and the correction of some errors in the data. For the catch proportions at age, two selectivity parameter vectors were estimated (Figure 7.5.1.1). 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).

The summarised results of the stock assessment are shown in Figure 7.5.1.2 and Table 7.5.1.1. With the estimated spawning stock biomass (SSB) and recruitment series, a segmented stock-recruitment relationship was fitted (Figure 7.5.1.3).

Year	Recruits('000)	Females SSB(ton)	Total SSB(ton)	Fmult	mean F(2-10)	Landings
1992	3749400	137260	274520	0.097267	0.11	27858
1993	2667100	136840	273680	0.10389	0.12	31521
1994	2633700	135770	271540	0.085548	0.1	28450
1995	3492900	132920	265840	0.082079	0.09	25132
1996	9075200	135090	270180	0.059677	0.07	20360
1997	3027600	147200	294400	0.083142	0.09	29491
1998	1941100	150090	300180	0.11874	0.13	41661
1999	2907900	149930	299860	0.074345	0.08	27768
2000	2641600	149790	299580	0.077849	0.08	26160
2001	3163500	149130	298260	0.076936	0.08	24911
2002	1750800	147480	294960	0.074906	0.08	22506
2003	3591500	143240	286480	0.063262	0.07	18887
2004	3921200	140670	281340	0.069268	0.07	24485
2005	2326400	144620	289240	0.070805	0.08	22689
2006	1097500	148690	297380	0.079057	0.08	23895
2007	1678400	140110	280220	0.077152	0.08	22787
2008	3043400	129550	259100	0.081287	0.09	22993
2009	3037400	123210	246420	0.092689	0.1	25726
2010	6057700	120700	241400	0.088125	0.09	27217

Table 7.5.1.1.- Southern horse mackerel. Final assessment. Stock summary table.

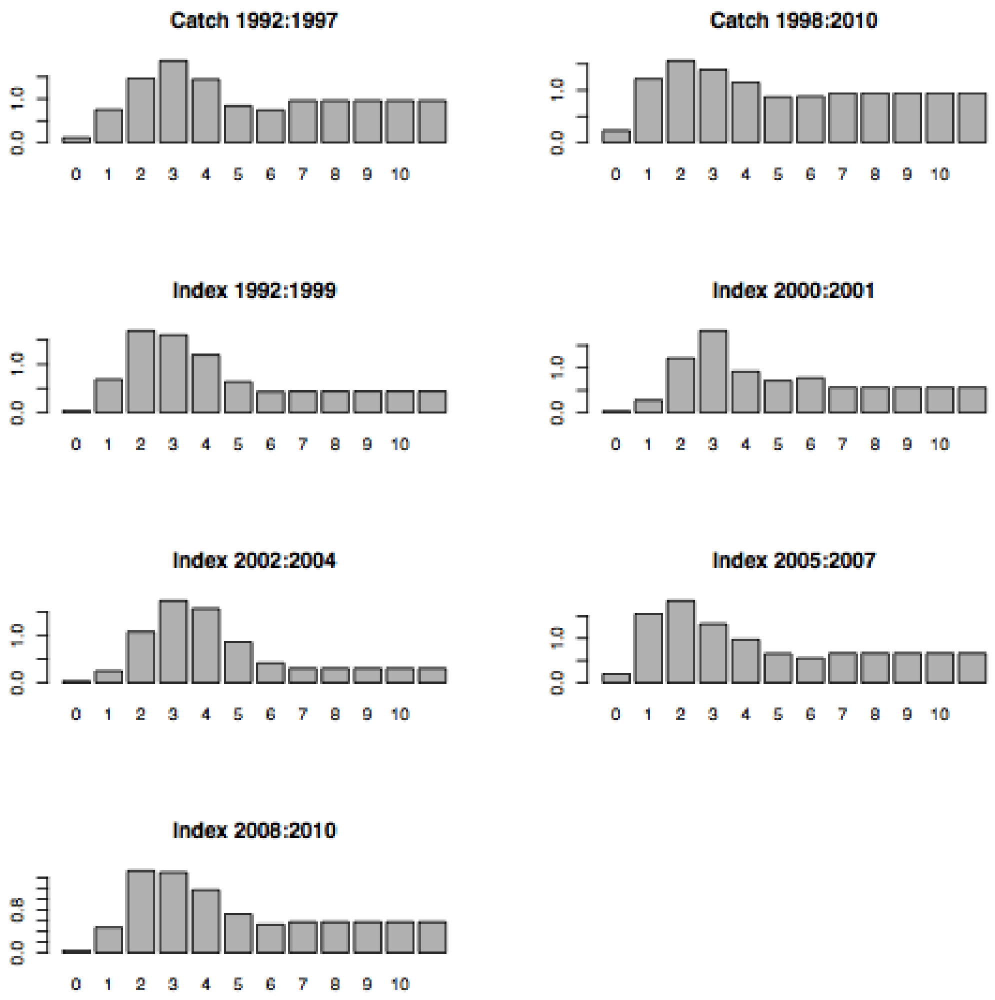


Figure 7.5.1.1 – Southern horse mackerel. Selectivity patterns of survey index and catch data. Proportions of catches at age by selectivity period.

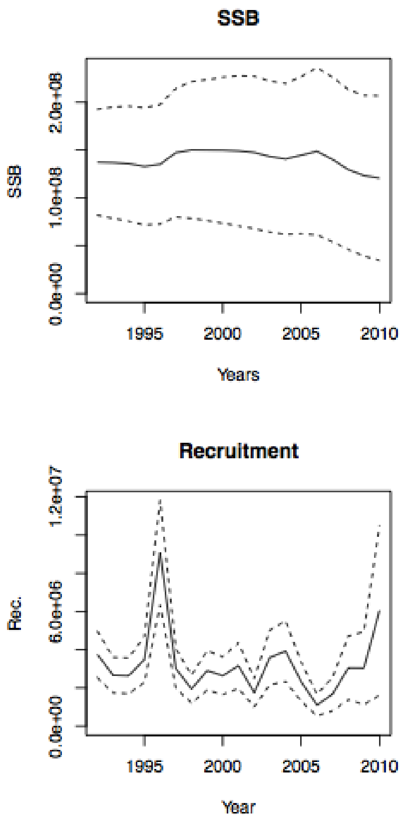


Figure 7.5.1.2 - Southern horse mackerel. Final assessment. Stock summary. Plots of SSB (females), recruitment and fishing mortality. SSB and catch are in tons, and recruitment in thousands.

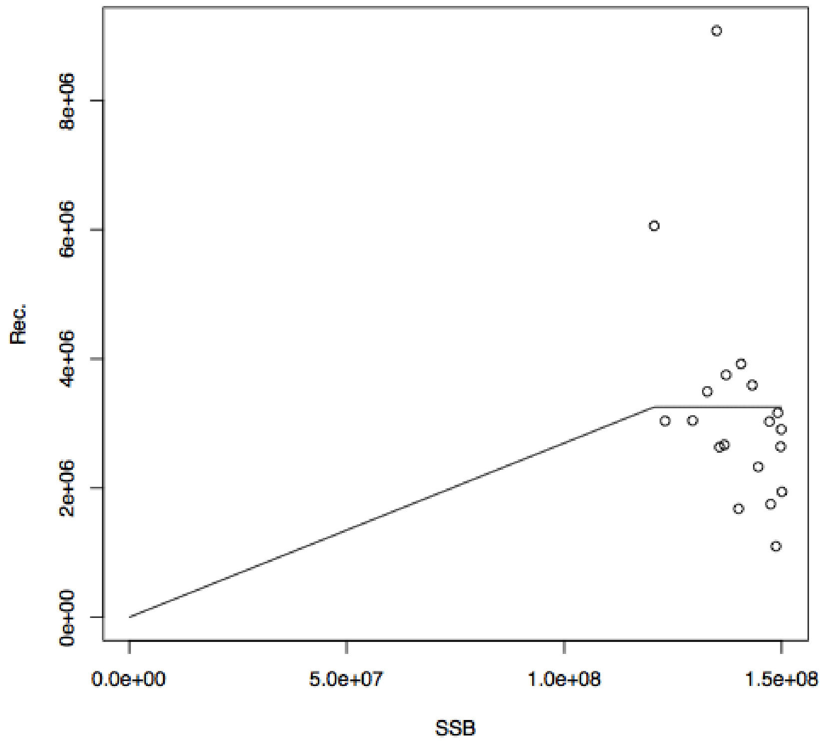


Figure 7.5.1.3 - Stock-recruitment relationship for southern horse mackerel

7.5.2 Reliability of the assessment

Given the high fluctuations in total biomass from year to year as measured by the survey, and the fact that horse mackerel can be considered a long-lived species (living more than 30 years), it is unlikely that the large fluctuations observed (Figure 7.3.2.1) correspond to actual fluctuations of biomass. A more probable hypothesis is that they are due to fluctuations in availability due to natural causes.

Therefore, to force the model to fit well to the biomass index would result in a poor fit to other data sources and could make the model to provide spurious results. Thus, the biomass index is mainly helping the model to estimate an overall level of biomass, and the fitted values can be seen as a rough smoother for the variable values of the index (Figure 7.5.2.1).

The landings of this stock are believed to be fairly accurate, given the good sampling coverage, few discards (according to onboard observers) and the existence of well-defined ageing criteria. Therefore, a higher weight was given to the data series of landings in weight, which was very well fitted by the model (Figure 7.5.2.2).

A good fit was also obtained for the proportions at age of catch in numbers (Figure 7.5.2.3) and for the proportions at age of the abundance indices in number/hour from the bottom-trawl surveys, although the fit of this latter data series was slightly poorer (Figure 7.5.2.5). The bubble plots of the residuals corresponding to the fitting of those data are respectively in Figures 7.5.2.4 and 7.5.2.6. The results of a retrospective analysis show an underestimation of SSB and recruitment, and an overestimation of F (Figure 7.5.2.7).

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

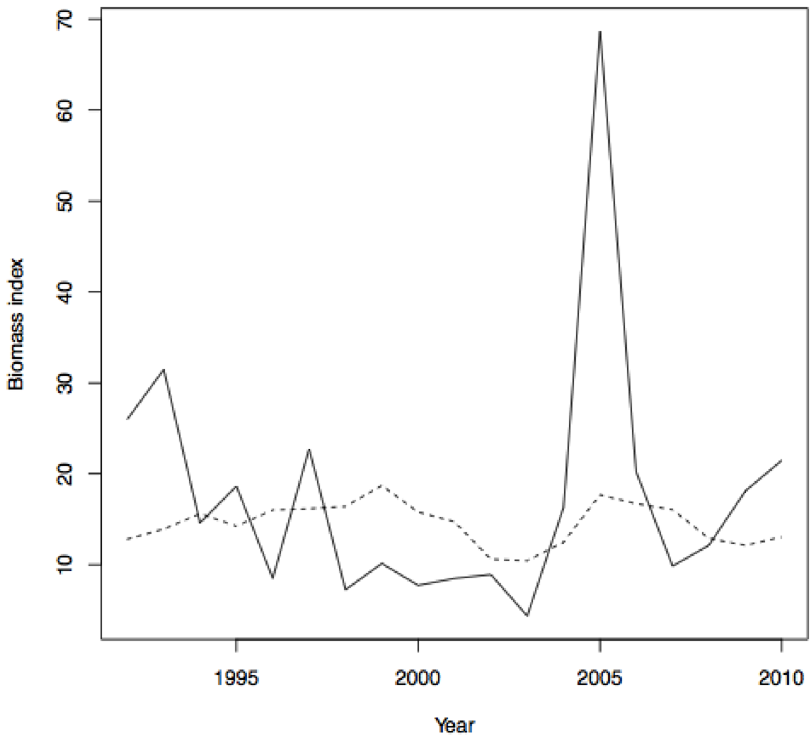


Figure 7.5.2.1.- Southern horse mackerel. Historical series of biomass index estimates from the combined bottom-trawl survey (solid line) and by the assessment model (dashed line).

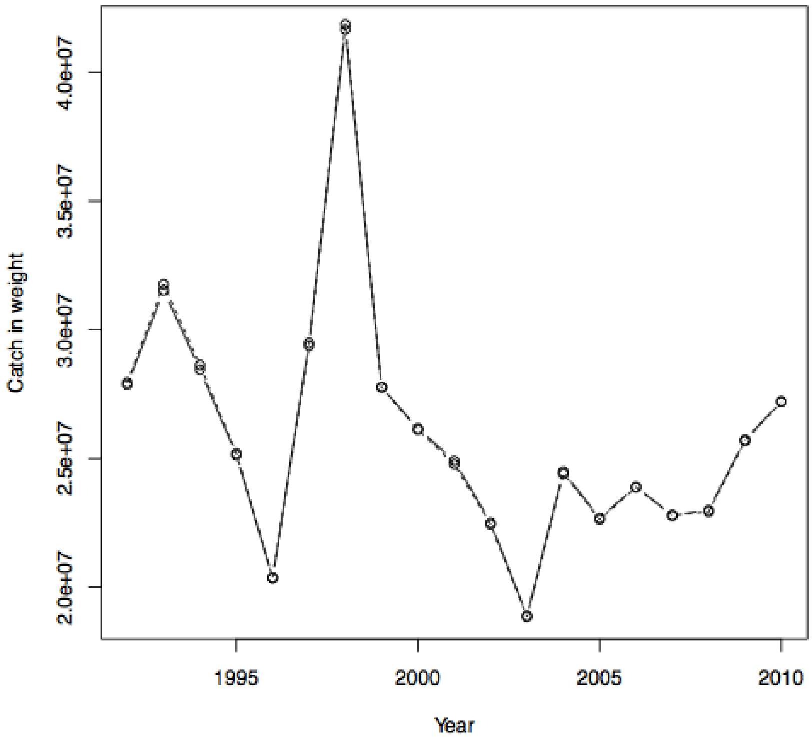


Figure 7.5.2.2 - Southern horse mackerel. Fitting of historical series of stock landings (solid line) and estimated landings by the assessment model (dashed line).

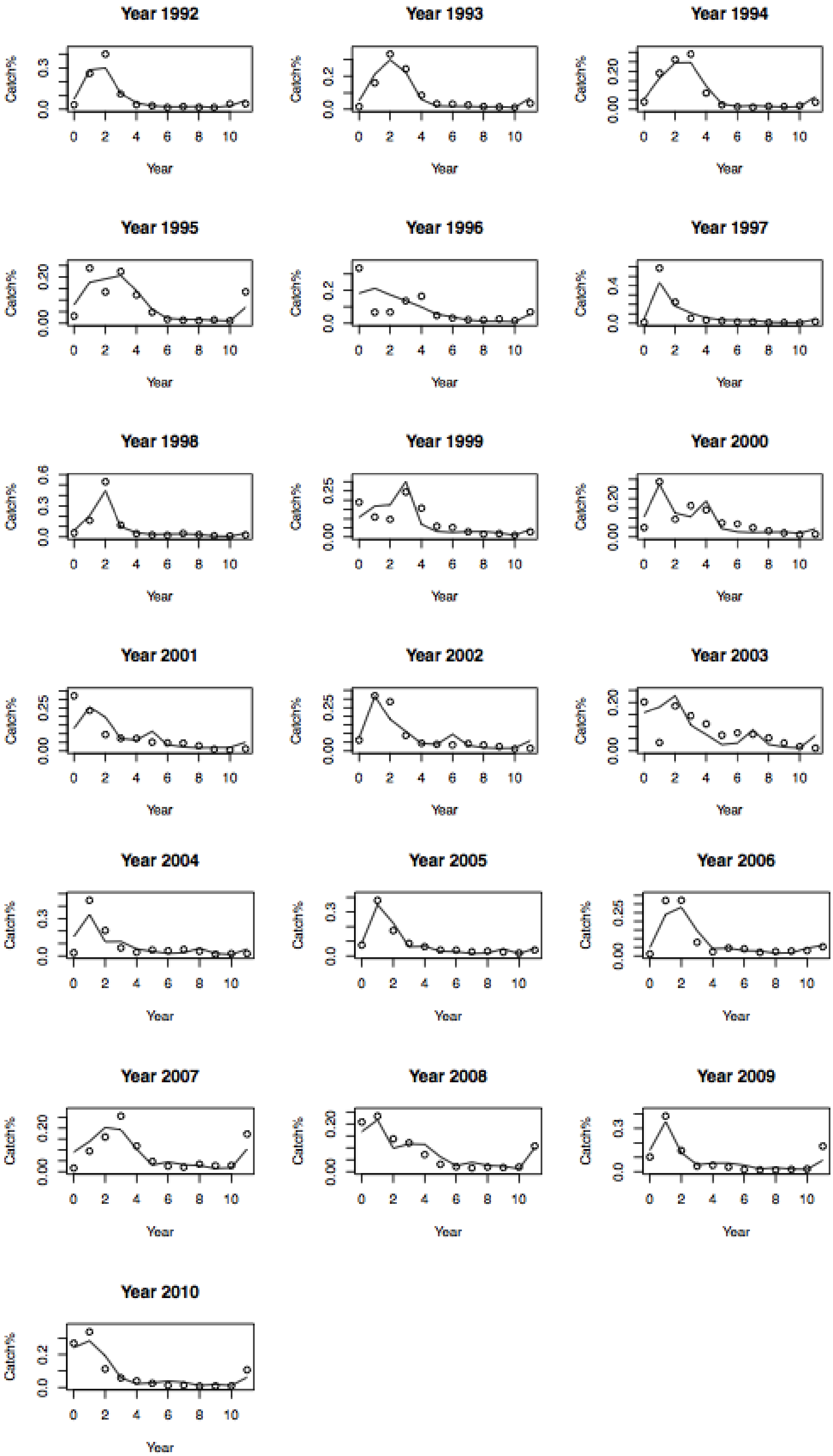


Figure 7.5.2.3 - Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in catch data and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

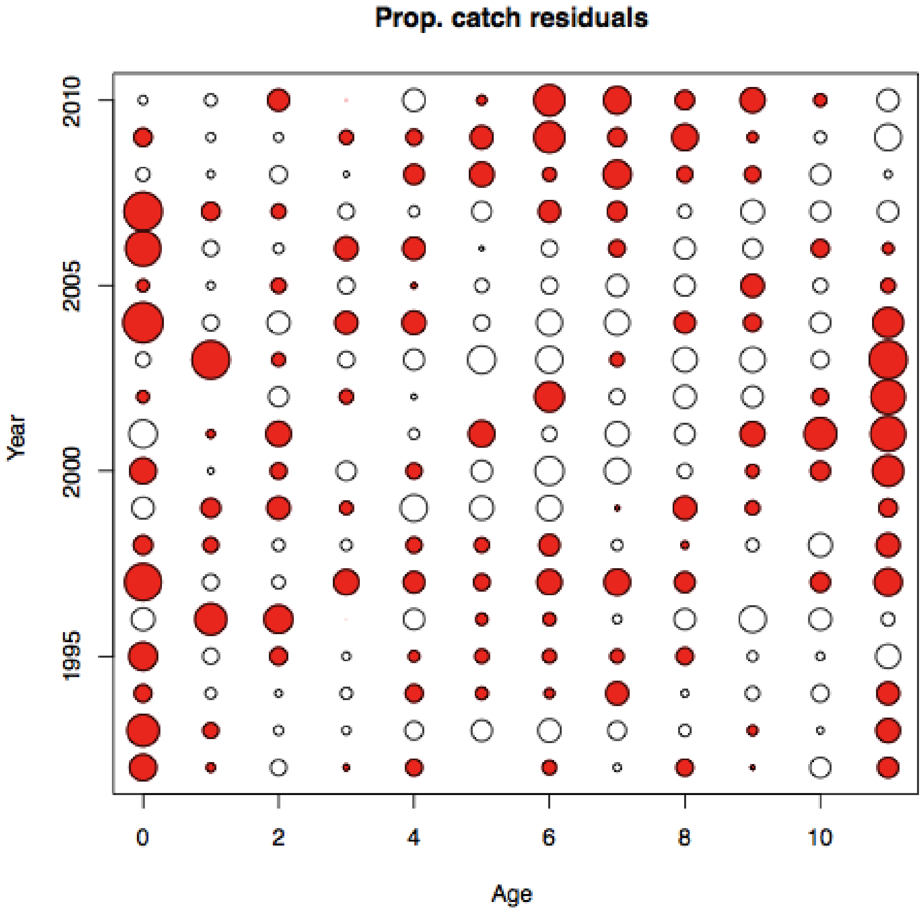


Figure 7.5.2.4 - Southern horse mackerel. Bubble plot of catch data residuals from the AMISH assessment.

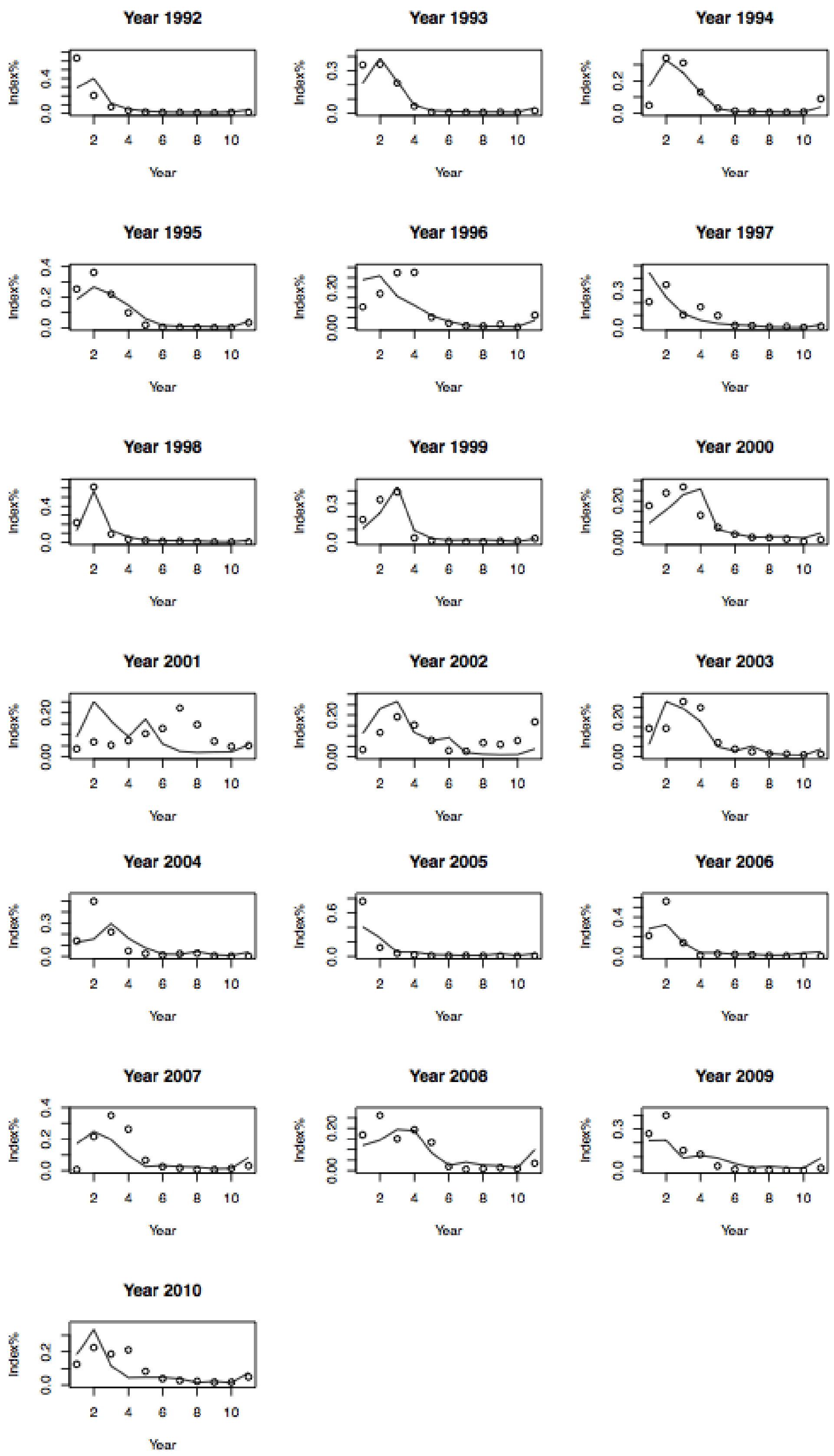


Figure 7.5.2.5 - Southern horse mackerel. Comparison of proportions at age of the abundance indices observed in bottom trawl survey and those fitted by the AMISH model. Observed values =dots; fitted values = solid lines.

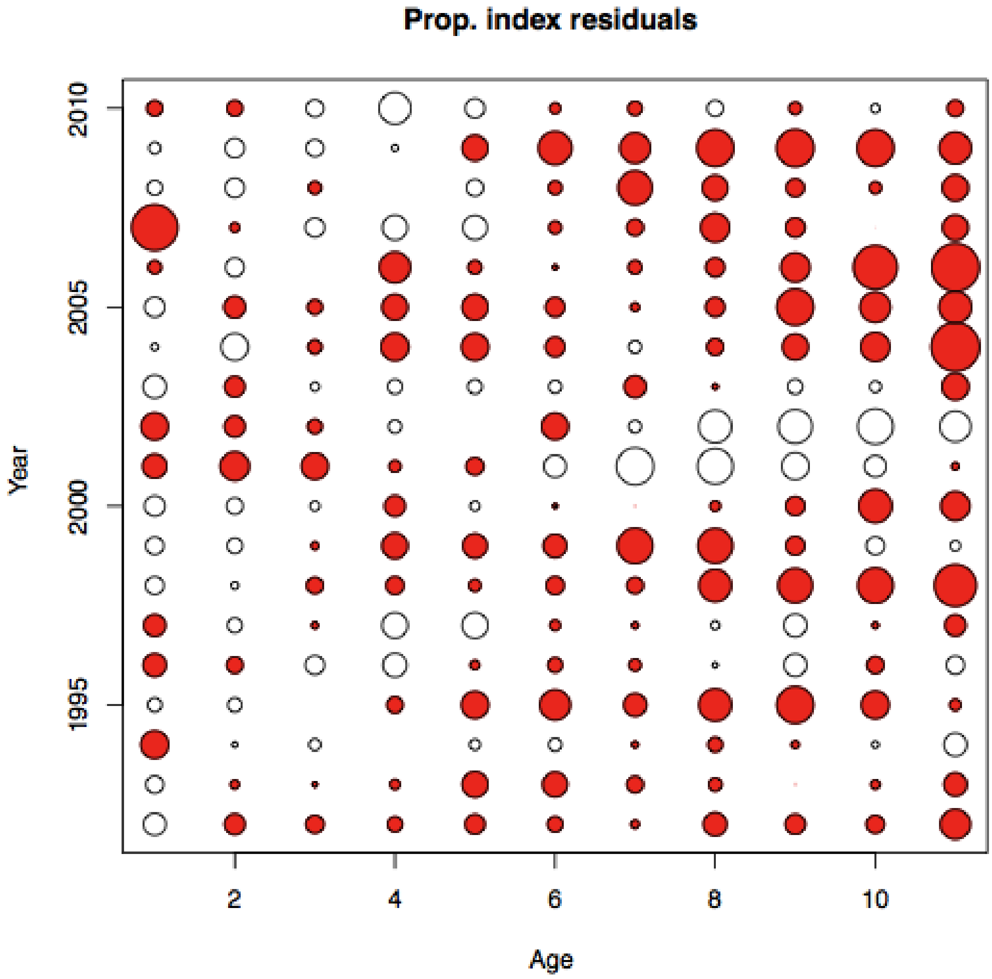


Figure 7.5.2.6 - Southern horse mackerel. Bubble plot of bottom trawl survey residuals from the AMISH assessment.

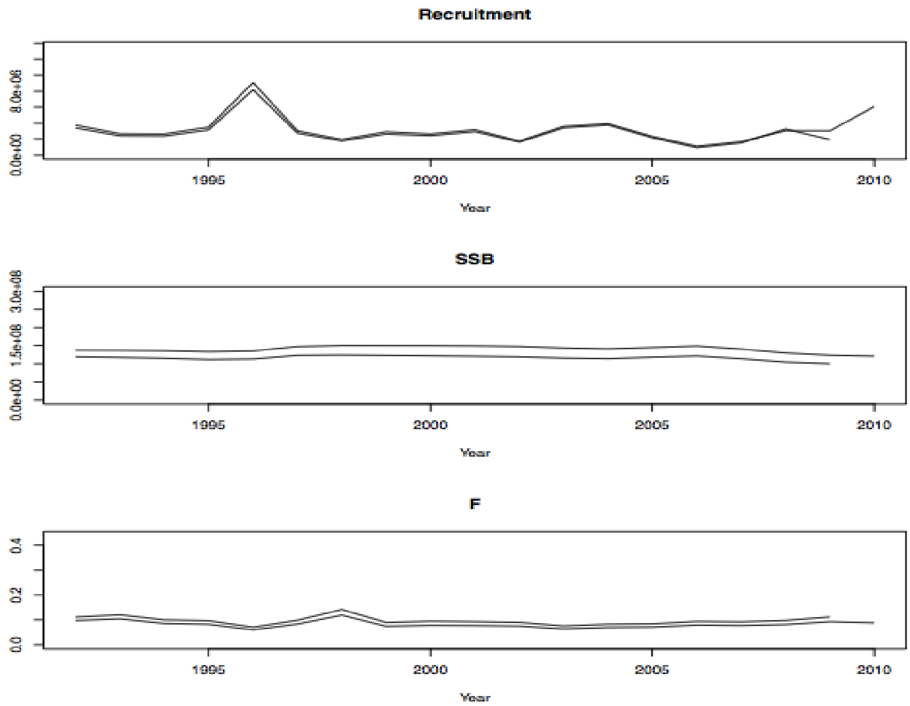


Figure 7.5.2.7 - Southern horse mackerel. Retrospective analysis results. Trajectories of SSB, recruitment and F are shown.

7.6 Short Term predictions

Deterministic short-term forecasts were made with the software MFDP, assuming a constant recruitment corresponding to the geometric mean of all estimated recruitments, except the one for the last year in the assessment. For the forecasts, the recruitment estimated for 2010 was also replaced by that average 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. Status-quo fishing mortality was calculated as the mean of fishing mortalities of ages 2 to 10. The input data used for the forecasts is in Table 7.6.1.

Table 7.6.2 shows the management options table obtained from the deterministic short-term forecasts. According to those results, and with the assumptions described above, only with a F-multiplier close to 2 would the SSB decrease in 2013, corresponding to a catch of around 70000 tons in 2012. At F-status-quo, catches would increase slightly above the 2011 TAC of 31000 tons and SSB would increase 9% from the beginning of 2012 to the beginning of 2013.

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2806204	0.9	0	0.08	0.08	0.02	0.0201	0.02
1	4812897	0.6	0	0.08	0.08	0.04	0.1073	0.04
2	596039	0.4	0.36	0.08	0.08	0.06	0.1373	0.06
3	347933	0.3	0.82	0.08	0.08	0.08	0.1225	0.08
4	126731	0.2	0.95	0.08	0.08	0.11	0.1007	0.11
5	62334	0.15	0.97	0.08	0.08	0.14	0.0763	0.14
6	107143	0.15	0.99	0.08	0.08	0.16	0.0775	0.16
7	147086	0.15	1	0.08	0.08	0.18	0.0831	0.18
8	109296	0.15	1	0.08	0.08	0.19	0.0831	0.19
9	43296	0.15	1	0.08	0.08	0.2	0.0831	0.2
10	62883	0.15	1	0.08	0.08	0.24	0.0831	0.24
11	257507	0.15	1	0.08	0.08	0.38	0.0831	0.38

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2806204	0.9	0	0.08	0.08	0.02	0.0201	0.02
1	.	0.6	0	0.08	0.08	0.04	0.1073	0.04
2	.	0.4	0.36	0.08	0.08	0.06	0.1373	0.06
3	.	0.3	0.82	0.08	0.08	0.08	0.1225	0.08
4	.	0.2	0.95	0.08	0.08	0.11	0.1007	0.11
5	.	0.15	0.97	0.08	0.08	0.14	0.0763	0.14
6	.	0.15	0.99	0.08	0.08	0.16	0.0775	0.16
7	.	0.15	1	0.08	0.08	0.18	0.0831	0.18
8	.	0.15	1	0.08	0.08	0.19	0.0831	0.19
9	.	0.15	1	0.08	0.08	0.2	0.0831	0.2
10	.	0.15	1	0.08	0.08	0.24	0.0831	0.24
11	.	0.15	1	0.08	0.08	0.38	0.0831	0.38

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	2806204	0.9	0	0.08	0.08	0.02	0.0201	0.02
1	.	0.6	0	0.08	0.08	0.04	0.1073	0.04
2	.	0.4	0.36	0.08	0.08	0.06	0.1373	0.06
3	.	0.3	0.82	0.08	0.08	0.08	0.1225	0.08
4	.	0.2	0.95	0.08	0.08	0.11	0.1007	0.11
5	.	0.15	0.97	0.08	0.08	0.14	0.0763	0.14
6	.	0.15	0.99	0.08	0.08	0.16	0.0775	0.16
7	.	0.15	1	0.08	0.08	0.18	0.0831	0.18
8	.	0.15	1	0.08	0.08	0.19	0.0831	0.19
9	.	0.15	1	0.08	0.08	0.2	0.0831	0.2
10	.	0.15	1	0.08	0.08	0.24	0.0831	0.24
11	.	0.15	1	0.08	0.08	0.38	0.0831	0.38

Input units are thousands and kg - output in tonnes

Table 7.6.1. Sourthern horse mackerel. Short-term forecast (2011-2013).

2011				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
520892	238339	0.8205	0.0772	31142

2012					2013	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
483629	278062	0	0	0	493484	336632
.	277845	0.1	0.0094	3997	489219	332859
.	277629	0.2	0.0188	7953	485001	329130
.	277413	0.3	0.0282	11868	480829	325445
.	277197	0.4	0.0376	15743	476703	321804
.	276982	0.5	0.0471	19578	472622	318206
.	276766	0.6	0.0565	23373	468586	314650
.	276551	0.7	0.0659	27129	464594	311136
.	276336	0.8	0.0753	30847	460646	307663
.	276121	0.9	0.0847	34526	456741	304231
.	275906	1	0.0941	38168	452879	300839
.	275692	1.1	0.1035	41773	449059	297488
.	275478	1.2	0.1129	45340	445281	294175
.	275263	1.3	0.1223	48871	441544	290901
.	275049	1.4	0.1317	52367	437847	287666
.	274835	1.5	0.1412	55826	434191	284468
.	274622	1.6	0.1506	59250	430575	281308
.	274408	1.7	0.16	62639	426998	278185
.	274195	1.8	0.1694	65994	423461	275099
.	273982	1.9	0.1788	69315	419961	272048
.	273769	2	0.1882	72601	416500	269033

Input units are thousands and kg - output in tonnes

Table 7.6.2. Short-term forecast (2011-2013) for southern horse mackerel. SSB corresponds to both sexes combined at spawning time. It is assumed that 8% of mortality takes place before spawning.

7.7 Reference points and harvest control rules for management purposes

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

A yield-per-recruit analysis was therefore carried out using the software MFYPR using identical options and input data files to the ones used for the short-term forecasts. The results of this analysis are shown in Table 7.7.1. An estimate for F_{max}, which is commonly used as a proxy for F_{msy}, could not be obtained. However, it was possible to calculate F0.1 (0.14) and F35%SPR (0.11). The Group has discussed the use of these two candidates for F_{msy} proxies, and was of the opinion that F35%SPR was a more sensible option, because of the way it is defined, which has stronger biological basis than F0.1, and because is close to the levels of F estimated for the assessment time period. The option of the group in this matter is coincident with the opinions of many authors who advocated F35%SPR as a generally desirable proxy for F_{msy} (Gabriel and Mace, 1999 and references therein).

Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0	0	0	0	2.5414	0.2429	0.956	0.1948	0.9412	0.1923
0.1	0.0094	0.014	0.0017	2.469	0.2237	0.8873	0.1759	0.8727	0.1734
0.2	0.0188	0.0269	0.0031	2.404	0.2069	0.826	0.1593	0.8117	0.1569
0.3	0.0282	0.0387	0.0043	2.3454	0.1922	0.771	0.1448	0.7568	0.1425
0.4	0.0376	0.0497	0.0053	2.2922	0.1791	0.7214	0.132	0.7074	0.1298
0.5	0.0471	0.0599	0.0061	2.2438	0.1676	0.6765	0.1207	0.6627	0.1186
0.6	0.0565	0.0694	0.0068	2.1996	0.1573	0.6356	0.1106	0.6221	0.1086
0.7	0.0659	0.0783	0.0074	2.159	0.1482	0.5984	0.1017	0.5851	0.0998
0.8	0.0753	0.0867	0.008	2.1216	0.1399	0.5644	0.0937	0.5513	0.0918
0.9	0.0847	0.0947	0.0084	2.0871	0.1325	0.5331	0.0865	0.5202	0.0847
1	0.0941	0.1022	0.0088	2.0551	0.1259	0.5044	0.08	0.4917	0.0783
1.1	0.1035	0.1093	0.0091	2.0254	0.1198	0.4779	0.0742	0.4654	0.0725
1.2	0.1129	0.1161	0.0094	1.9978	0.1144	0.4534	0.0689	0.441	0.0673
1.3	0.1223	0.1225	0.0097	1.972	0.1094	0.4307	0.0641	0.4185	0.0626
1.4	0.1317	0.1287	0.0099	1.9479	0.1048	0.4096	0.0598	0.3976	0.0583
1.5	0.1412	0.1346	0.0101	1.9253	0.1007	0.39	0.0558	0.3782	0.0544
1.6	0.1506	0.1402	0.0102	1.9041	0.0969	0.3717	0.0522	0.3601	0.0508
1.7	0.16	0.1457	0.0104	1.8841	0.0934	0.3547	0.0489	0.3432	0.0475
1.8	0.1694	0.1509	0.0105	1.8653	0.0902	0.3387	0.0458	0.3274	0.0445
1.9	0.1788	0.1559	0.0106	1.8475	0.0872	0.3238	0.0431	0.3127	0.0418
2	0.1882	0.1607	0.0107	1.8307	0.0845	0.3098	0.0405	0.2988	0.0393

Reference p	F multiplier	Absolute F
Fbar(2-10)	1	0.0941
FMax	>=1000000	
F0.1	1.4782	0.1391
F35%SPR	1.2	0.1129

Weights in kilograms

Table 7.7.1. Results of yield per recruit analysis for southern horse mackerel by MFYPR (Multi-Fleet Yield per Recruit Program).

7.8 Management considerations

Several estimates obtained during the assessment of this stock show no signs of depletion and indicate an exploitation level that seems sustainable. The level of the fishing mortality rates is low, although that is also a cause of the high values for natural mortality that were adopted during the latest benchmark assessment. Also, the lowest observed stock biomass originated the second highest recruitment estimate in the series. A conservative F_{msy} proxy calculated in equilibrium conditions (F35%SPR) is higher than most of the estimates obtained for the fishing mortality rates. Nevertheless, all these indicators of the condition and state of exploitation of the stock are based on estimates that have a very high level of uncertainty associated, which is clear from the observation of the large asymptotic confidence intervals for F and SSB.

Therefore, and from a precautionary point of view, a too optimistic advice for stock exploitation should be avoided. The catches of horse mackerel are currently mainly limited by effort limitations of the bottom-trawl fleets, due to management plans for other species caught in the same mixed-fisheries (e.g. hake), and to a low demand of this species in the market, which makes its price to drop sometimes to levels unsustainable to fishermen. The TACs of the latest years were not achieved, and according to the short-term forecasts performed a status-quo F will result in higher catches. Thus, a TAC for 2012 identical to the one of 2011 would keep the stock at a sustainable level, and would maintain the same fishing opportunities for the industry, while taking into account the high uncertainty of the estimates related to the state of the stock.

This stock has supported a stable exploitation level for a long time 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 one with the highest increase is the Spanish bottom-trawl fleet operating in subdivision IXa North, which accounted less than 20% of the total catches until 2003 and has reached to a level of 37% of the total catches in 2010. This overall stability can change drastically if there is a change in the fishing mortality trend of any of the Portuguese fleets or a faster rise in the Spanish fleets. Such change in fishing mortality has been observed in the late 1990s due to a decrease in sardine abundance, which made many purse-seiners to start targeting horse mackerel. Such a drastic change, in the current conditions, could lead to a decline of the reproductive potential of the stock.

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, both artisanal fleets and the Spanish bottom-trawl fleet target adult fish, especially above 6 years old. There is 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 high fishing mortality focused on those areas may deplete the spawning stock in a faster way than if the fish were homogeneously distributed, which would reduce the reproductive capacity of the stock.

8 Horse Mackerel *T. picturatus* in the waters of the Azores

8.1 ACOM Advice Applicable to 2010

No advice has ever been given to this stock.

8.2 The fishery in 2010.

8.2.1 Fishing Fleets in 2010

The horse mackerel is mostly landed by the artisanal fleet, using purse seines. The fleet segments that use hand lines and bottom longlines also catches horse mackerel, but the catches are only partially landed, since an important part of their catches is used for bait in the demersal species fishery. The catches made by the tuna bait boat fleet, for use as live bait for tuna, are not landed. Those catches are estimated by the tuna observer program and from the information in the logbooks.

8.2.2 Catches

The evolution of the landing of horse mackerel, from 1980 to 2010, is presented in Table 8.2.2.1 and Figure 8.2.2.1.

Year	Landings (t)	Year	Landings (t)	Year	Landings (t)	Year	Landings (t)
1980	2968.3	1990	2509.5	2000	644.1	2010	1049.4
1981	2133.9	1991	1274.2	2001	1101.0		
1982	2461.3	1992	1255.2	2002	1449.9		
1983	3757.0	1993	1731.9	2003	1501.5		
1984	3226.0	1994	1785.7	2004	1245.9		
1985	3490.9	1995	1823.5	2005	1230.7		
1986	3330.7	1996	1727.1	2006	1241.4		
1987	3019.5	1997	1921.2	2007	1154.6		
1988	3078.9	1998	1507.4	2008	1118.8		
1989	2865.7	1999	693.4	2009	1121.3		

Table 8.2.2.1 - Landings of horse mackerel (*T. picturatus*) from the Azores (ICES area X) from 1980 to 2010.

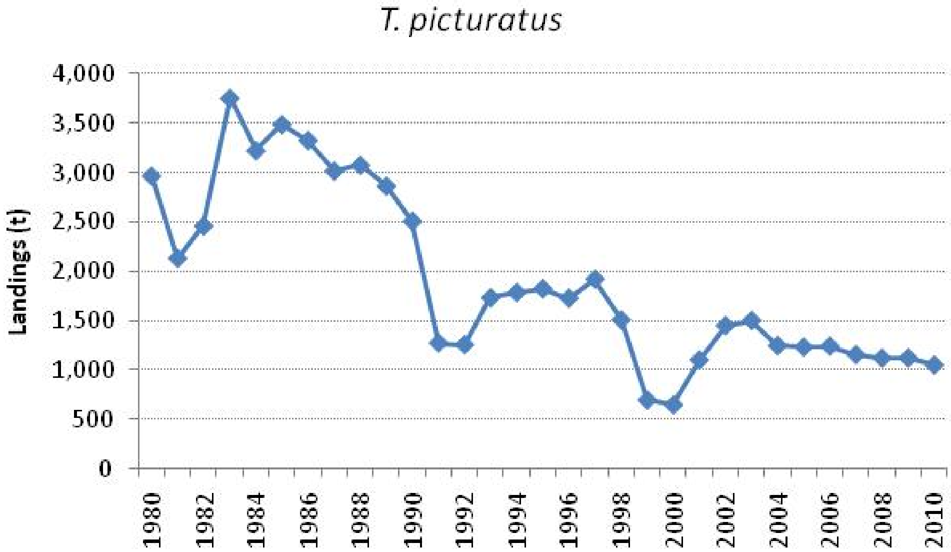


Figure 8.2.2.1 - Annual landings of horse mackerel (*T. picturatus*) in the Azores (ICES area X) from 1980 to 2010.

8.2.3 Effort and catch per unit effort

In Figure 8.2.3.1, the standardized cpue (kg/1000 hooks) is presented for the adult stock, caught by the longliners.

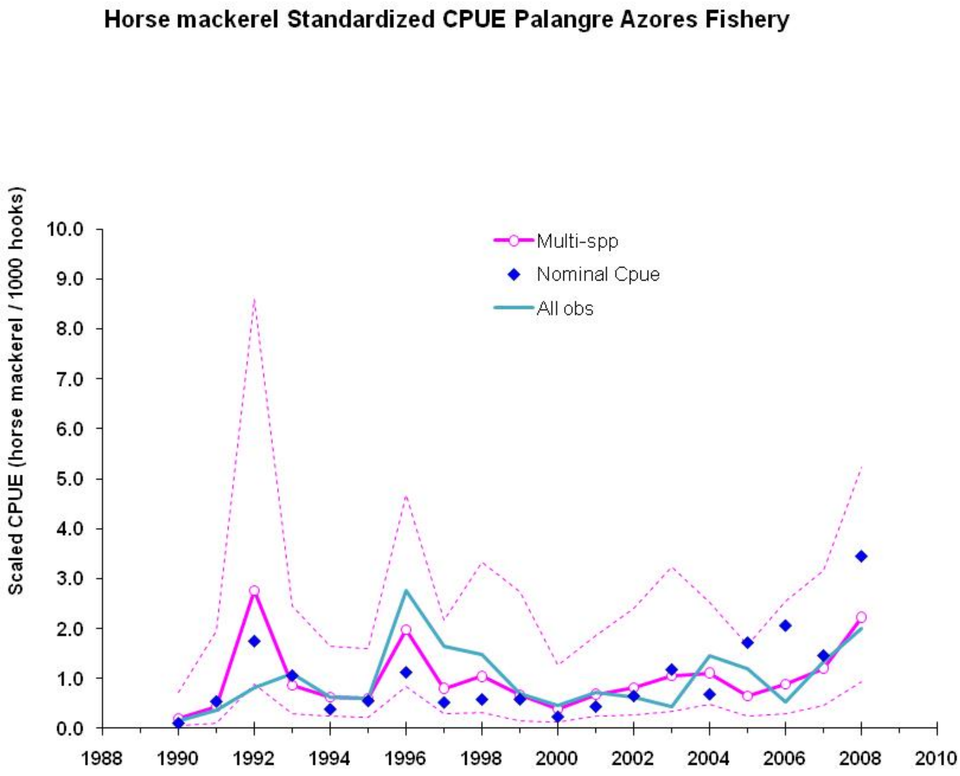


Figure 8.2.3.1 - Standardized cpue (kg/1000 hooks) for the horse mackerel (T. picturatus), caught in the Azores with longlines (adult stock).

8.2.4 Catches by length

Size frequencies for the horse mackerel caught in the Azores are available since 1980. In Figure 8.2.4.1, is presented the size distribution of the landings (catch at size) for the years 2001 to 2010. The size distribution (catch at size) of the landings of horse mackerel caught by two of the main métiers involved in the fishery, artisanal purse seiners and longliners, is presented in Figure 8.2.4.2.

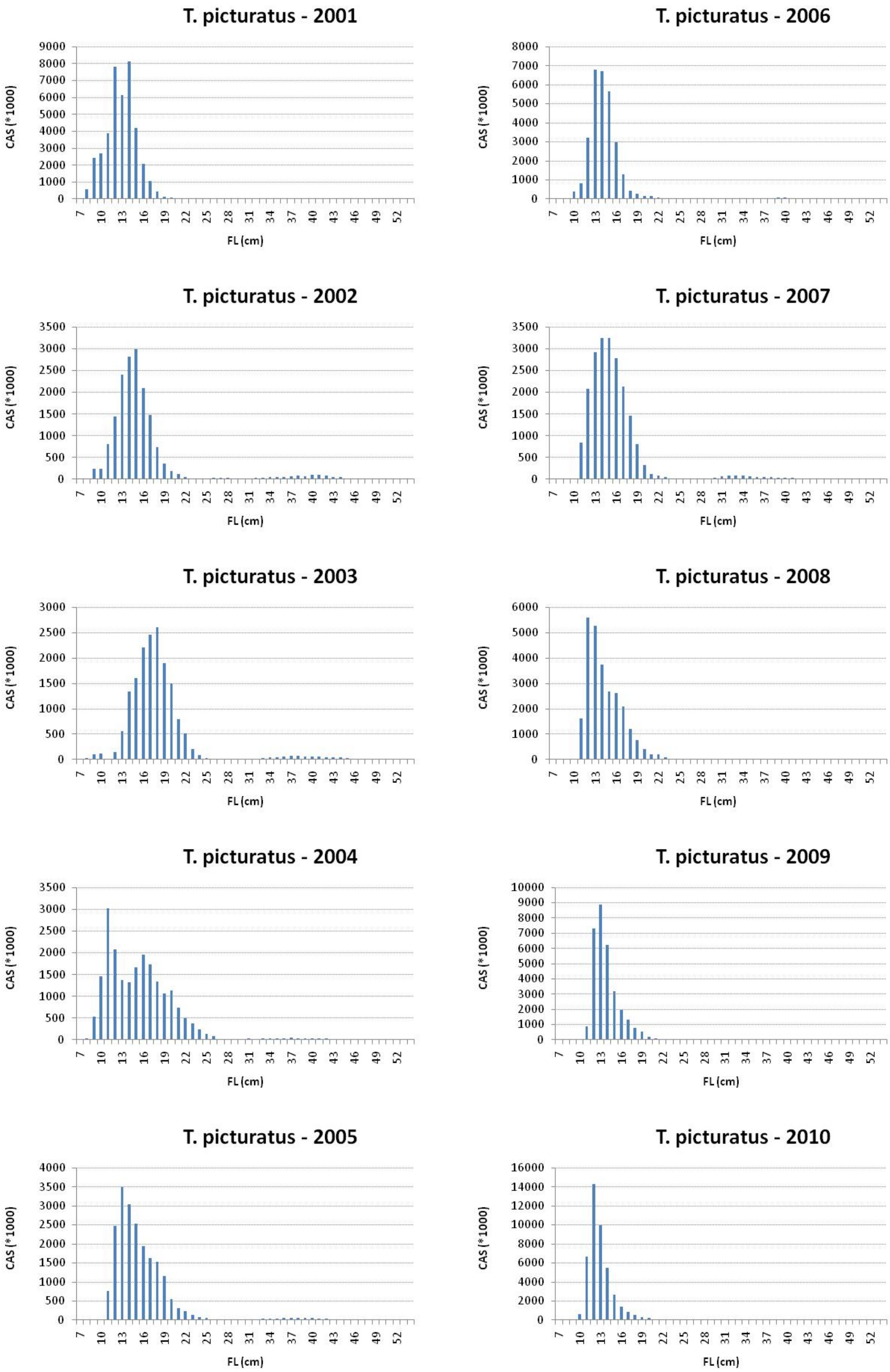


Figure 8.2.4.1 - Size frequencies of the catches of horse mackerel (*T. picturatus*) in the Azores fishery, from 2001 to 2010.

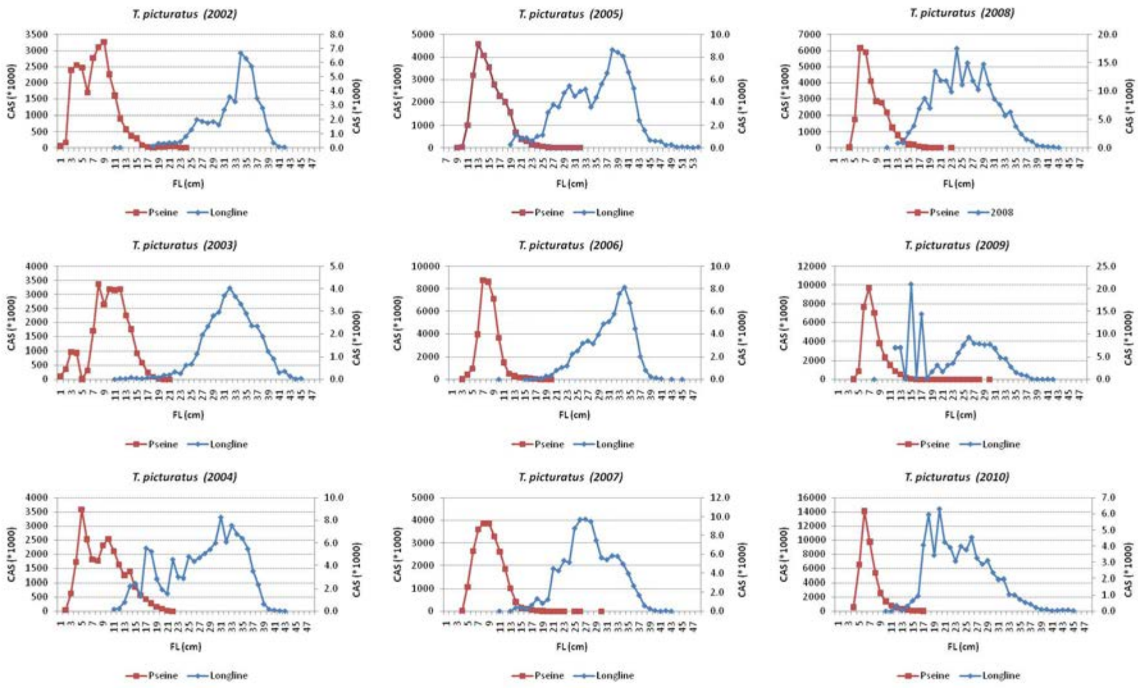


Figure 8.2.4.2 - Size frequencies of horse mackerel (*T. picturatus*) caught in the Azores by purse seine and longlines, from 2002 to 2010.

8.2.5 Mean weights in the catch

The analysis of the sizes caught shows stability along the analyzed period, which is also confirmed by the stability in the average weights (figure 8.2.4.3) of the fish caught by the different métiers involved in the fishery.

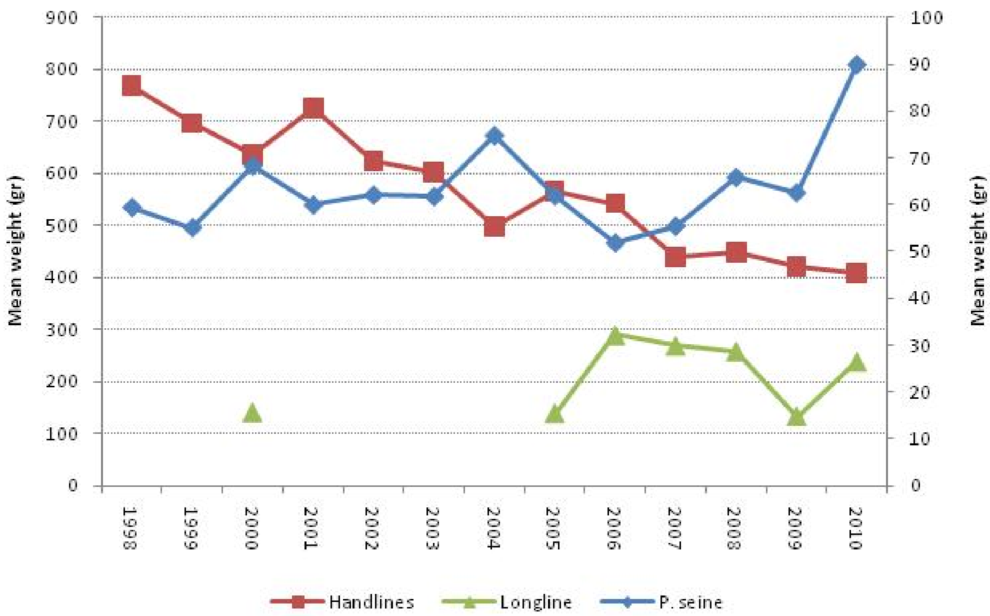


Figure 8.2.4.3 - Annual mean weights of the Horse mackerel caught in the Azores by different métiers.

8.3 Biological data

8.3.1 Length-weight relationship

A total of 3372 specimens of horse mackerel were sampled for weight and length, and the length-weight relationships were calculate separately for males and females and for both sexes together. The parameters of the fork length to total weight relationships are given in Figure 8.3.1.1.

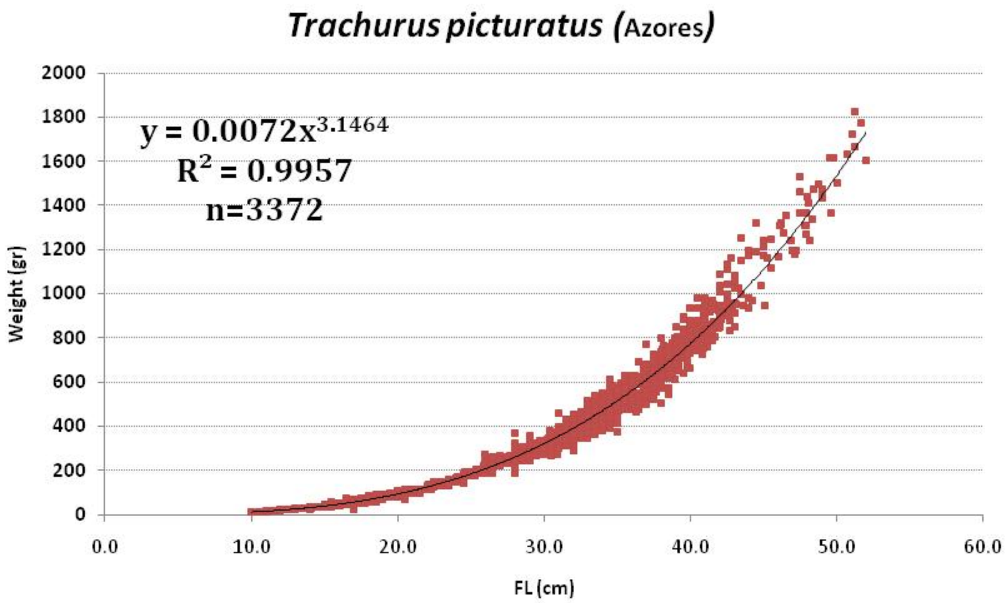


Figure 8.3.1.1 - Length-weight relationship for the horse mackerel (*T. picturatus*) from the Azores.

8.3.2 Maturity at length

The logistic curve fitted to the proportion of sexually mature horse mackerel estimated the mean length at sexual maturity at 28.5 cm of fork length, as showed in figure 8.3.2.1.

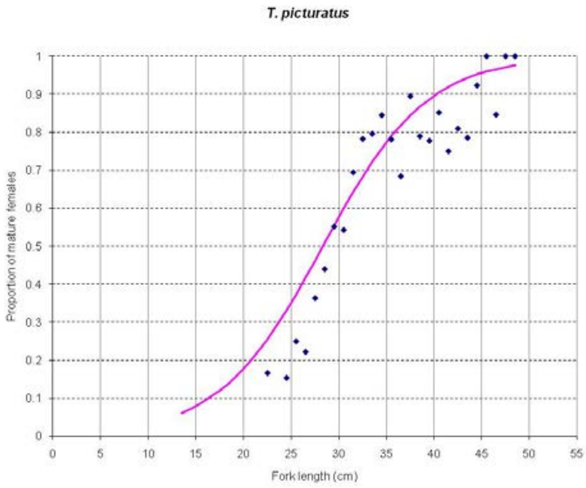


Figure 8.3.2.1 - Size at sexual maturity (FL_{50}) for the horse mackerel from the Azores.

8.4 Management considerations

The landings of horse mackerel in recent years average 1200 tonnes. The horse mackerel is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman association, due to market restrictions. This stability of the catches is mostly observed in S. Miguel Island, where around 70% of the annual catches occur. Continuous reductions in the demands from the consumers lead to the catch limits auto adopted by the fleet, which explains the reduction observed in the catches along the recent years.

9 Recommendations

9.1 General Recommendations

WGANSA 2011 Recommendations	**to**
The WGANSA recommends that the Portuguese spring acoustic survey provides the age composition of anchovy in Division IXa by carrying out the reading of the otoliths collected during the survey, and that the support by ICES for such an effort is communicated to the Portuguese Institute (IPIMAR).	PGCCDBS
Given the strong influence on the retrospective pattern of the series of sardine DEPM SSB estimates in the Division IXa, WGANSA asks WGACEGG to analyse if there is evidence that the adult parameters defining the Daily Fecundity of sardine (and particularly for the spawning frequency) are statistically different between years, so that their respective independent use among DEPM estimates is justified.	WGACEGG
WGANSA recommends that an otolith exchange and an age reading workshop for horse mackerel be carried out in 2012, in order to ensure an agreement of ageing criteria among readers and a good quality of the catch-at-age and abundance-at-age data. The otolith collection from the 1982 year-class, being kept by IMARES (the Netherlands) should be used during the workshop, given that it is the only otolith collection with validated ages.	PGCCDBS & RCM's
The WG recommends that a TOR to explore the status of sardine in subareas VIIIabd and VII is included for the next WGANSA meeting in 2012	ACOM
The WG recommends that a proper sampling for length and age in subarea VII is set up in order to allow to assess the status of sardine and anchovy in that subarea VII	PGCCDBS & RCM's
The WG recommends that studies to determine the stock identity and migrations of sardine along the European coasts (and in subareas VIII and VII in particular) are carried out.	PGCCDBS & RCM's
The WG recommends that a new benchmarking for anchovy in VIII takes place in 2013 or at the latest in 2014. The new benchmark is required to deal with a revision of the DEPM series (according to new spawning fraction estimates) which may have an effect on the scale of the biomasses assessed with the current methods, and in order to discuss the best use of the JUVENA indexes of biomass, natural mortality and new methods of assessment. New indexes such as egg abundance estimates from CUFES might also be available.	ACOM
WGANSA recommends that next year's meeting is held in Azores at similar dates of June and for one more day than for this 2011 meeting (so for 6 days).	ACOM, Delegates
The WG suggest changing its name WGHANSA due to the incorporation of Horse mackerel south in its TORs.	

9.2 Data Problems Relevant to Data Collection

Stock	Data Problem	How to be addressed in DCR	By who
Stock name	***Data problem identification***	***Description of data problem and recommend solution***	***Who should take care of the recommended solution and who should be notified on this data issue.***
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.* *Such a survey would also support studies of ecological process in the area and their relation to recruitment* *In the present situation of successive low recruitments of sardine and anchovy, such survey is increasingly relevant.*	***The WG recommends DCR to economically support an autumn acoustic survey for provision of recruitment indices for sardine and anchovy*** ***Since the recruitment area for sardine is located in Western Portugal and Gulf of Cadiz, and the Gulf of Cadiz is the main location of anchovy in Division IXa, this problem could be addressed by a coordinated survey between IPIMAR and IEO.***	*ICES ACOM, SSGESST and PGCCDBS should support the idea of such a Survey and communicate to RCM and to relevant bodies accordingly* *The same idea was recommended by WGANSA and WGACEGG in 2009 and 2010*
Anchovy in Subarea VIII	The French pilot 'sentinel' surveys carried out in collaboration between fishermen and scientists since 2009 provide additional acoustical, biological data on migration, growth and survival for both anchovy and sardine which are crucial for a better use of scientific spring and autumn surveys.	The WG recommends the continuation this consort survey through DCR or national fundings.	*PGCCDBS*
Anchovy in Subarea VIII	Since 2007, the collaboration between the R/V Thalassa and commercial vessels has increased considerably the reliability of the abundance index estimate, particularly in terms of echoe determination (on average	The WG recommends the continuation through DCR or national fundings.	*PGCCDBS*
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*	***DCR to economically support the continuation and coordination of the acoustic assessment of juveniles in the Bay of Biscay (termed JUVENA survey)***	*ICES ACOM, SSGESST and PGCCDBS should support the idea of such a Survey and communicate to RCM and to relevant bodies accordingly* *The same idea was recommended by WGANSA and WGACEGG in 2009 and 2010*

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24 – 28 June 2011

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Annex 2 List of Working Documents and Presentations

List of Working Documents submitted to this Working Group on Anchovy and Sardine [WGANSA, 24 – 28 June 2011, Vigo (Spain)]. ***(Including a small abstract per WD)***

Andrés M.WD 2011. Closure of the Bay of Biscay anchovy fishery and its consequences

Abstract: This report tries to clarify the real impact of anchovy fishery closure on the Basque purse seiner fleet. This species is one of the main sources of revenues for the purse seiner fleet of this area and it is highly valued by the customer and the canning industry. Several years of low level of recruitments since 2001 and a recruitments failure in 2004 led to the closure of this fishery from 2005 to 2009. The fishery was reopened in 2010 but with a very low TAC. During the anchovy closure period, the Basque Purse seiner fleet, which is a sequential fishery, tried unsuccessfully to maintain its profit in the same level as before the closure fishing other target species. Furthermore, when the fishery was reopened, fishermen found that the niche of the market left by the anchovy closure of the Bay of Biscay was occupied by foreign anchovy. This fact has caused a price reduction for the local anchovy. As a result, the fishermen have looked for tools to revalorise the anchovy of the Bay of Biscay up to the extent that currently a Protected Geographical Indications (PGI) is under development with the aim to recover the original price of this species. Therefore, it may be said that a fishery closure affects not only to the fishermen, but also to the market and other non-target species which are related to that closed fishery.

Massé, M., Duhamel, E., Doray, M., Haouchine, M., Sanchez, F. WD 2011. Direct assessment of small pelagic fish by the PELGAS11 acoustic survey. PELGAS11 Survey Report. 27p.

Abstract: An acoustic survey was carried out in the Bay of Biscay from April 25st to June 5th on board the French research vessel Thalassa. The objective of PELGAS11 survey was to study the abundance and distribution of pelagic fish in the Bay of Biscay. The target species were mainly anchovy and sardine and were considered in a multi-specific context. To assess an optimum horizontal and vertical description of the area, two types of actions were combined: i) Continuous acquisition by storing acoustic data from five different frequencies and counting the number of fish eggs using CUFES system, and discrete sampling at stations. Commercial vessels were accompanying Thalassa for most of the time, such as to double the number of identifications hauls and increase the reliability of identification of echoes. This WD report acoustic assessments and length distributions of main species, age distribution for anchovy and sardine and some environmental data. Anchovy recruitment appears as one of the best one in the time series, with an index of abundance of 142 600 tons. Concerning sardine, the strong 2008 cohort is predominant, and the biomass has been calculated at a level of 338 450 tons, which constitute a small decrease from the three previous years.

Gil Pereira, J., WD2011. Statistics and biological data on horse mackerel (*T. picturatus*) from the Azores.

Abstract: Statistic information and biological data are presented for the Horse mackerel (*Trachurus picturatus*) caught in the Azores. Statistics includes catch data and respective size frequencies. Length weight relationships are given for the all population and for separate sexes. Biological data includes information on sex ratio, sexual maturity and reproduction.

Marques, V., A. Silva, M.M. Angélico and E. Soares, WD2011: Sardine acoustic survey carried out in April-May 2011 off the Portuguese Continental Waters and Gulf of Cadiz, onboard RV "Noruega".

Abstract: The main results of the Portuguese acoustic survey directed to sardine and anchovy estimates in ICES sub area IX shows a reduction in sardine and anchovy biomass. The sardine abundance was the lowest of the time series, following the tendency of the last years. In the Occidental north zone (OCN), the distribution area was very narrow. Age 2 sardines (2009 year class) were predominant in OCN area; in the Occidental south zone (OCS) the age 1 year class was predominant. The anchovy abundance suffered a strong reduction in the Cadiz Bay area, where it practically disappears. On the contrary in the OCN zone anchovy was more abundant than ever and was mixed with sardine schools.

The 2011 spring acoustics survey took place three to four weeks later than usual. Plankton production was established and maximum sea surface temperature was slightly higher than during previous campaigns.

A.G. Murta, A.M. Costa, P. GonçalveS, WD2011: Variability in the maturity ogives of horse mackerel estimated with microscopic criteria.

Santos, M., L. Ibaibarriaga and A. Uriarte, WD2011: Preliminary Spawning Stock Biomass estimates for the Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2011 applying the DEPM.

Abstract: The research survey BIOMAN 2011 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy was conducted in May 2011 from the 6th to the 27th covering the whole spawning area of the species. The total area covered was 98,405Km^2 and the spawning area was 69,094Km^2. During the survey 699 plankton samples were obtained and 52 pelagic trawls were performed, from which 40 contained anchovy and were selected for the analysis. 6 additional samples were obtained from the purse seine fleet.

In the Cantabrian coast the spawning limit was observed at 3º54'W and to the North the sampling was stopped due to bad weather at 47º23'N once passed Nantes. The anchovy eggs were encountered all along the area but in the Cantabrian coast the eggs were encountered offshore instead of near the coast as usually. Between Arcachon and Le Gironde approximately between 50 and 150m a gap without eggs was encountered.

A preliminary SSB estimate is obtained as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (DF) estimates. P_{tot} is calculated as the product

of the spawning area and the daily egg production rate (P_0), which is obtained from the exponential mortality model fitted as a Generalized Linear Model (GLM) to the egg daily cohorts. As the adults samples are not fully processed yet, the DF is taken as a mean of the historical DF series. The resulting preliminary biomass estimate is 138,069 t with a coefficient of variation of 23%. This estimate is more than three times last year estimate. Approximately 87% of the anchovy are individuals of age 1 in numbers and the contribution in mass of those is 81%. The contribution in mass of anchovies of age 2+ is 19%. This indicates a good recruitment level in comparison with previous years.

Santos, M.B., R. González-Quirós, I. Riveiro, J.M. Cabanas, C. Porteiro and G.J. Pierce, WD2011: Cycles, trends and residual variation in the Iberian sardine (*Sardina pilchardus*) recruitment series and their relationship with the environment.

Abstract: Recruitment variability is an important component of the dynamics of Iberian sardine (*Sardine pilchardus*). Since 2006, poor recruitment has led to a fall in stock biomass, the latest in a series of such crises for sardine fisheries. Understanding the mechanism behind recruitment fluctuations has been the objective of many previous studies, which proposed various relationships between recruitment and environmental variables. However, such studies face several analytical challenges including short time series and autocorrelated data. We carry out new analysis of empirical relationships with environmental series using statistical methods designed to cope with these issues, including dynamic factor analysis, generalised additive models and mixed models. Our results identify relationships between recruitment and global (number of sunspots), regional (NAO_{Autumn}) and local (winter wind strength, 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, possible mechanisms for which are discussed. After removal of trend and cyclic components, recruitment also shows a weak relationship with the previous year's spawning stock biomass.

Santos, M.B., M. Iglesias, J. Miquel, D. Oñate, B. Villamor and I. Riveiro, WD2011: Sardine and anchovy in Galicia and Cantabrian waters: results from the Spanish spring acoustic survey PELACUS0411.

Abstract: A total of just 11,768 tons of sardine (151 million fish) was estimated to be present in northwest and northern Spanish waters by the Spanish spring acoustic survey PELACUS0411 carried out from 26th March to 20th April 2011. Sardine was found in some numbers only in Asturias (ICES sub-area VIIIcE-w) and was almost absent from Galicia (ICES sub-areas IXa-N and VIIIcW). Most fish were 4-year old (fish born in 2007), which predominated in Asturias and Cantabria (ICES sub-areas VIIIcE-w). Younger fish, age 1 and 2 predominated in Galicia (ICES sub-area IXaN) while age 3 fish were abundant in the Basque country (ICES sub-area VIIIcE-e). The estimates obtained by the 2011 survey are the lowest since 2001 and give cause for concern on the status of the stock. Unless another strong recruitment comes along (the last one was in 2004), biomass and abundance values will probably continue to decrease in Spanish waters. For anchovy, 2701 tons, corresponding to 142 million fish, were detected during the survey, and occupied two separate areas: south Galicia (ICES sub-area IXa-N)

and the Basque country/ French border (ICES sub-area VIIIcE-e and ICES Division VIIIb). In the latter area, age 1 fish dominated the sample. Anchovy has shown an increase from previous years both in number of fish and in the area occupied.

In contrast with the situation for adult fish, CUFES data indicated that sardine eggs are distributed throughout the surveyed area (although closer to the coast than in previous surveys) and in similar numbers to those obtained in last year´s survey. For anchovy, there has been a big increase in the number of eggs detected in 2011 and in the area occupied (extending well beyond the traditional area of the inner Bay of Biscay).

Soares, E., I. Riveiro and A. Silva, WD2011: Revision of maturity-at-length and weight-at-length for the Iberian sardine stock in 1982 – 1995.

Abstract: This document presents progress on the revision of maturity ogives and stock weights for the earlier years of the sardine assessment period (1982 – 1995). Maturity-at-length and weight-at-length were calculated using commercial catch samples collected in the first quarter of the year at the main fishing ports of the Iberian Peninsula. The results were compared to those in the subsequent period, 1996 -2010. The main objective was to use a standardized methodology with data and methods as consistent as possible for the whole assessment period.

List of Presentations made to this Working Group on Anchovy and Sardine [WGANSA, 24 – 28 June 2011, Vigo (Spain)].

Andrés M.WD 2011. Closure of the Bay of Biscay anchovy fishery and its consequences

Boyra. G, U. Martínez and A. Uriarte. WD2010. Acoustic surveying of anchovy Juveniles in the Bay of Biscay: JUVENA 2010 Survey Report. (this was a WD to WGACEGG 2010 meeting).

Abstract: 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 2010 the survey has taken place onboard two vessels equipped with scientific acoustic equipments and with two different fishing gears: purse seiner Itsas Lagunak and pelagic trawler Emma Bardan. The survey took place during 30 days in September, sampling 4,000 n.mi. to reach an effective sampling of 2,700 n.mi. that provided a coverage of about 40,500 n.mi.^{2} along the continental shelf and shelf break of the Bay of Biscay, from the 6º W in the Cantabrian area up to 47º 30′ N at the French coast. 79 hauls were done during the survey to identify the species detected by the acoustic equipment, 60 of which resulted positive of anchovy.

The biomass of juveniles estimated for this 2010 is 599,990 tonnes, which is the highest value in the temporal series, a 237% higher (more than the triple) than the next value in this ranking, corresponding to the year 2009. The area of occupation of the juvenile anchovy has also been the largest in the series (60% higher than the next one, in 2009); the size of the captured juveniles has also been large, 8.3 cm of mean size, above the average of the series. All these facts point towards a probable raise of the recruitment level of anchovy for the year 2011, above the levels observed in the last seven years.

The objectives of this year survey have been reached. The extension of the area of occupation of juvenile anchovy has been located with high degree of certainty, both in the southern and in the northern areas. The correct assignation of acoustic echoes is assured by the high number of fishing hauls. Being also the results of the survey coherent with the estimates of the other anchovy juvenile survey and with the information collected from the live bait fleet between summer and autumn, that is also presented in the report.

Massé, J., E. Duhamel, M. Doray and M. Haouchine. PELGAS11 acoustic survey - Abundance indices by acoustics in the Bay of Biscay.

Ramos, F. Qualitative assessment of Anchovy in Division IXa: Data & Trends.

Ramos, F., M. Iglesias, J. Miquel, D. Oñate, J. Tornero and A. Ventero, WD2011: Acoustic assessment and distribution of the main pelagic fish species in the ICES Subdivision IXa South during the ECOCÁDIZ 0710 Spanish survey (July 2010). (this was a WD to WGACEGG 2010 meeting).

Abstract: The present working document summarises the main results from the Spanish acoustic (pelagic ecosystem-) survey conducted by IEO between 25th July and 1st August 2010 in the Portuguese (but with an incomplete coverage) and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V "Cornide de Saavedra". The survey season was coincident with the anchovy (*Engraulis encrasicolus*) peak spawning to achieve an acoustic estimate of its SSB in the study area as well. This year the surveyed area was reduced to an area limited by the waters placed between Cape Trafalgar and Cape Santa Maria. 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. In the sampled area, anchovy was distributed all over the shelf of the study area with the densest concentrations being recorded over the middle-outer shelf in the westernmost area. The total biomass estimated for anchovy was 12.3 thousand tons (954 million fish) and sustained, as an average, by smaller anchovies than those observed the last year. Sardine (*Sardina pilchardus*) occurred all over the inner-middle shelf, in shallower waters than anchovy, and also showing the highest densities in the westernmost coastal waters of the sampled area. The species was the most important one in terms of both biomass (67 thousand tonnes) and abundance (2 thousand million fish) and showed evidences of a relatively good recruitment. Chub mackerel (*Scomber colias*) was almost absent in the shallower waters and in the whole central part of the sampled area. This species was amongst the species which less contributed to the total biomass and abundance of the pelagic species assemblage, with almost 3 thousand tonnes and 43 million fish only. 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 or even absence in the study area during the survey. Because of the problems with the acoustic sampling coverage, results from this survey are not directly comparable with those provided by IPIMAR from its PELAGO10 spring survey, although some inferences on the most recent trends in the population levels of the main species may still be raised.

Roel, B. Peltic: a survey on sardine and other pelagic species in the western Channel and Celtic Sea.

Santos M., L. Ibaibarriaga and A. Uriarte. Preliminary Spawning Stock Biomass estimates for the Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) in 2011 applying the DEPM.

Santos, M.B., R. González-Quirós, I. Riveiro, J.M. Cabanas, C. Porteiro and G.J. Pierce, WD2011: Cycles, trends and residual variation in the Iberian sardine (*Sardina pilchardus*) recruitment series and their relationship with the environment.

Santos, M.B., I. Riveiro and A. Silva. Results from the 2011 surveys and overview of 2010 landings for sardine.

Silva, A. Preliminary results on sardine selectivity and changes in distribution over time.

Silva, A. Sensitivity of the sardine assessment to tuning surveys.

Silva, A. Exploring Stock Synthesis for the assessment of sardine.

Annex 3 – Appending Relevant Working Documents

Working Document for WGANSA (Vigo, June. 2011)

A.3.1 Direct assessment of small pelagic fish by the PELGAS11 acoustic survey

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1. Material and method

1.1 PELGAS survey on board Thalassa

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

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area covered from Gibraltar to Brest with the same protocol regarding sampling strategy. This year, an additional acoustic survey (PELTIC) was carried out in the western channel and the Celtic Sea by the English institute CEFAS. Data are available for the ICES working groups WGANSA, WGWIDE and WGACEGG.

In the spirit of the ecosystemic approach, the pelagic ecosystem is characterized at each trophic level. To achieve this and to assess an optimum horizontal and vertical description of the area, two types of actions are combined :

1) Continuous acquisition of acoustic data from five different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler)), and
2) discrete sampling at stations (by trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modeling will be also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling

strategy. Concurrently, a visual counting and identification of cetaceans (from board) and of birds (by plane) will be carried out in order to characterise the higher level predators of the pelagic ecosystem.

The strategy this year was the identical to previous surveys (2000 to 2010). The protocol for acoustics has been described during WGACEGG in 2009 (*Doray et. Al, 2009*):

- acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles and cover the continental shelf from 20 m depth to the shelf break (or sometimes more offshore – see figure below).

-acoustic data were only collected during the day because of pelagic fishes behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer of the echo sounder between the surface and 8 m depth.

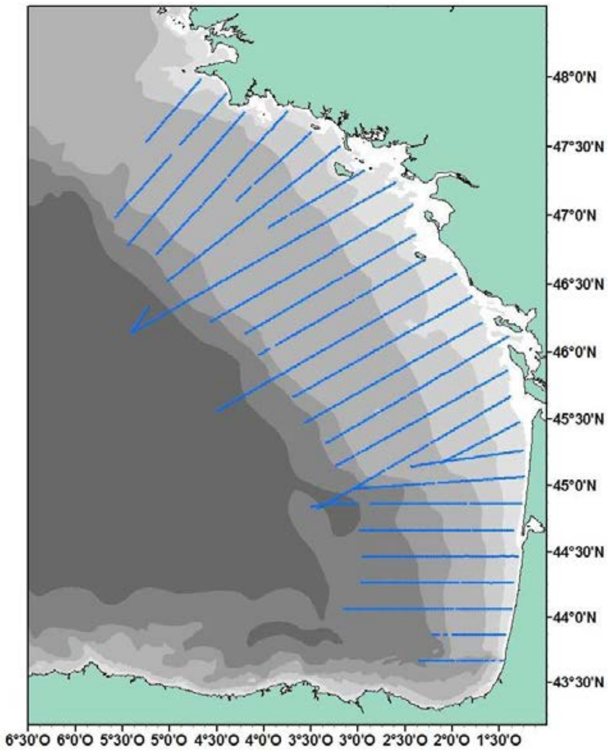


Fig. 1.1.1 - Transects prospected during PELGAS11 by Thalassa.

Three different echosouders were used during the survey :

In 2011, as in previous surveys (since 2009), three modes of acoustic observations were used :

- 5 split beam vertical echosounders (EK60), 5 frequencies, 18, 38, 70, 120 and 200 kHz
- 1 horizontal echosounder on the starboard side for surface echo-traces
- 1 SIMRAD ME70 multi-beam echosounder (32 x 2°beams, from 70 to 120 kHz) used essentially for visualisation to observe the behaviour and shapes of fish schools during the whole survey. It was particularly helpful this year to visualize the small anchovy

schools at the surface. Nevertheless, only echoes stored on the vertical echosounder were used for abundance index calculation.

Energies and samples provided by all sounderswere simultaneously visualised and stored using the MOVIES+ and MOVIES3D softwares and stored at the same standard HAC format.

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

Acoustic data were collected by R/V Thalassa along a total amount of 6450 nautical miles from which 1626 nautical miles on one way transect were used for assessment. A total of 18 237 fishes were measured onboard Thalassa (including 7329 anchovies and 2541 sardines) and 3058 otoliths were collected for age determinations (1985 anchovy and 1073 sardine).

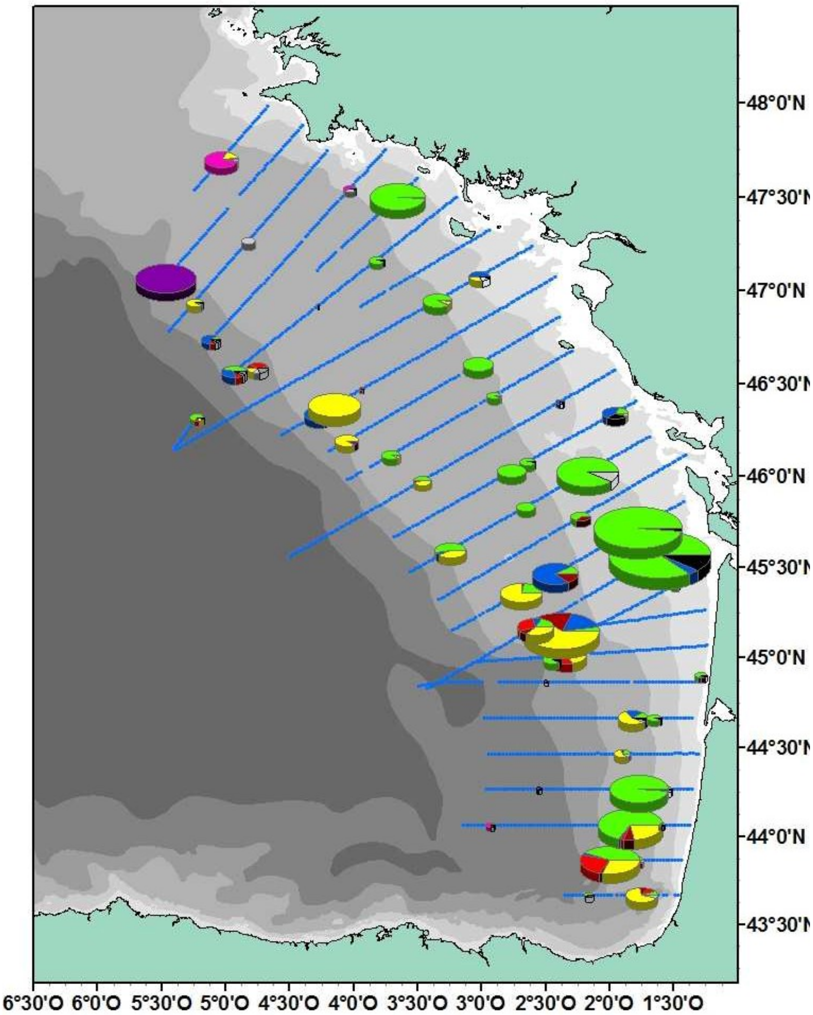


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2 The consort survey

A consort survey is routinely organized since 2007 with French pair trawlers during the 22 first days and purse seiners during 2 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.

Five commercial vessels (two pair of pair trawlers and two purse seiners) participated to PELGAS11 survey:

Vessel	gear	Period	Days at sea
Arlequin2 / La Colombine	Pelagic pair trawl	27/04 to 08/05/2011	12
Jérémi-Simon / Prométhée	Pelagic pair trawl	10/05 to 18/05/2011	9
Etoile Polaire 3	Purse seine	18-19/05/2011	2

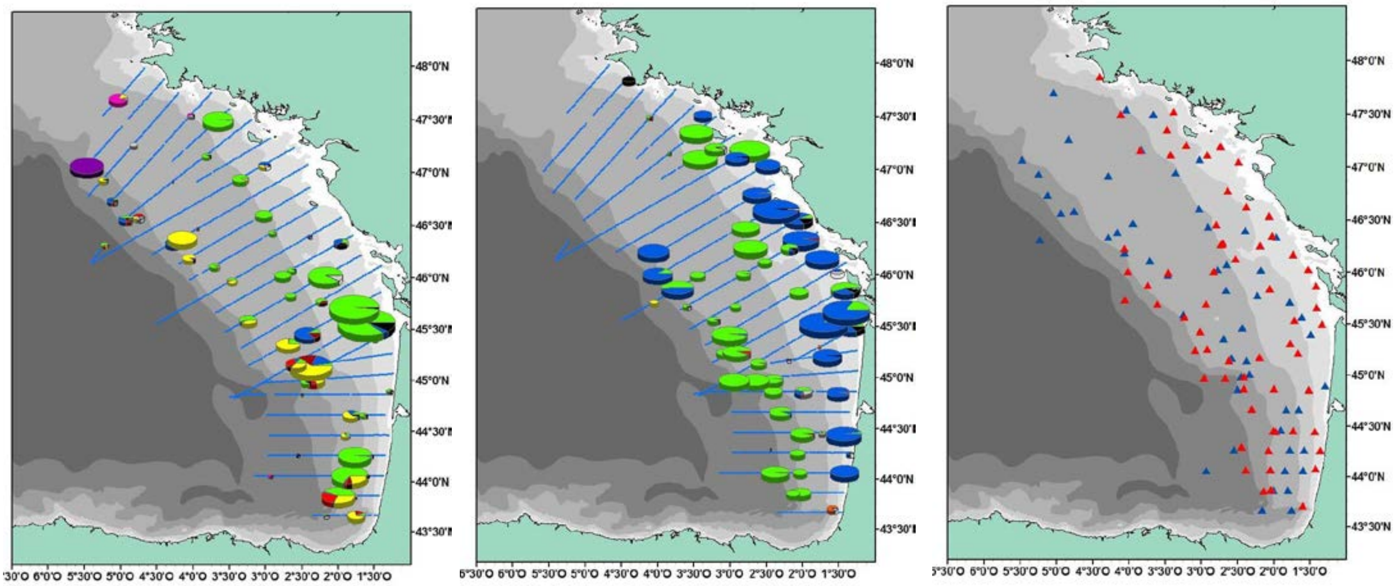
The transects network agreed for several years for Thalassa is 12 miles separated parallel transects. Commercial vessels worked between standard transects and 4 NM northern. Sometimes, they carried out fishing operations on request (complementary to Thalassa, particularly for surface hauls or in very coastal areas) or, sometimes, according to their survey coverage 4 NM northern than our transects. Their pelagic trawl was until 35 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).

A scientific observer was onboard to control every operation, and to collect biological data. The fishing operations were systematically agreed after a radio contact with Thalassa in order to confirm their usefulness. In some occasions, the use was to check the spatial extension of species already observed and identified by Thalassa (and therefore the spatial distribution), in others the objective was to enlarge the vertical distribution description by stratified catches. Globally, a great attention was given on a good distribution of samples to avoid over-sampling on some situations. Sometimes a biological sample was provided by commercial vessels to Thalassa to improve otoliths collection and sexual maturity (10 samples of sardine, 16 of anchovy). A total of 9671 fishes were measured onboard commercial vessels, including 4923 anchovies and 3002 sardines.

The catches and biological data have been directly used with the same consideration than Thalassa ones for identification and biological characterisation.

A total of 117 hauls were carried out during the assessment coverage including 55 hauls by Thalassa and 62 hauls by commercial vessels.

The fishing operations by commercial vessels were carried out as Thalassa only during day time each time it was necessary and preferentially at the surface or in mid-water, taking into account the fact that pair trawlers are more efficient at surface than single back trawlers.



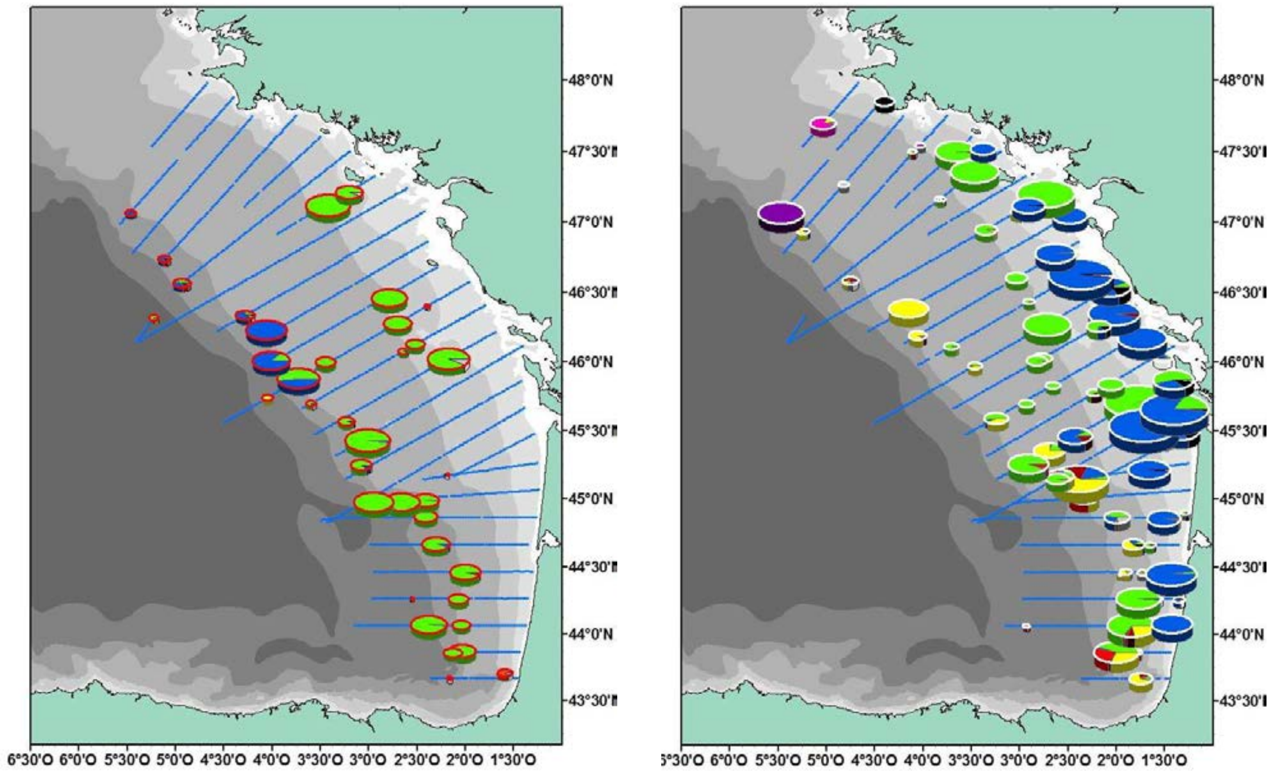
a) Thalassa (nb :55) *b) Commercial vessels (nb : 62)* *c) all fishing hauls (nb :117)*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS11

The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and furthermore, to verify that both scientists and fishermen observe the same types of echo-traces and have similar interpretations. Some fishing operations were done in parallel by Thalassa and commercial vessel in order to check if the catches were well comparable (in proportion of species and, most of the time, in quantity as well). As last year, the fishing operations by commercial vessels were carried out only during day time (as for Thalassa) each time it was necessary and preferentially at the surface or in mid-water, since the pair trawlers are more efficient at surface than single back trawlers.

	R/V Thalassa	Commercial vessels	Total
Surface Hauls	12	25	37
Classic Hauls	40	35	64
Valid	52	60	112
Null	3	2	5
Total	55	62	117

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS11



a) Hauls carried out at surface or in mid-water levels (Thalassa & commercial vessels)

b) classic Hauls carried out closed to the bottom and 50m upper (Thalassa + commercial vessels)

Figure 1.2.4 : Localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS11

2. Acoustics data processing

2.1. Echo-traces classification

All the acoustic data along the transects were processed and scrutinised by the date of the meeting (figure 2.2.1). Acoustic energies (Sa) have been cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into 7 categories of echo-traces :

D1 – energies attributed to mackerel, horse mackerel, blue whiting, various demersal fish, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sprat, sardine and herring corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well defined, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometimes more offshore.

D3 – energies attributed to blue whiting, myctophids and capros aper offshore, just closed to the shelf-break.

D4 – energies attributed to sardine, mackerel, horse mackerel and anchovy corresponding to small and dense echoes, very close to the surface.

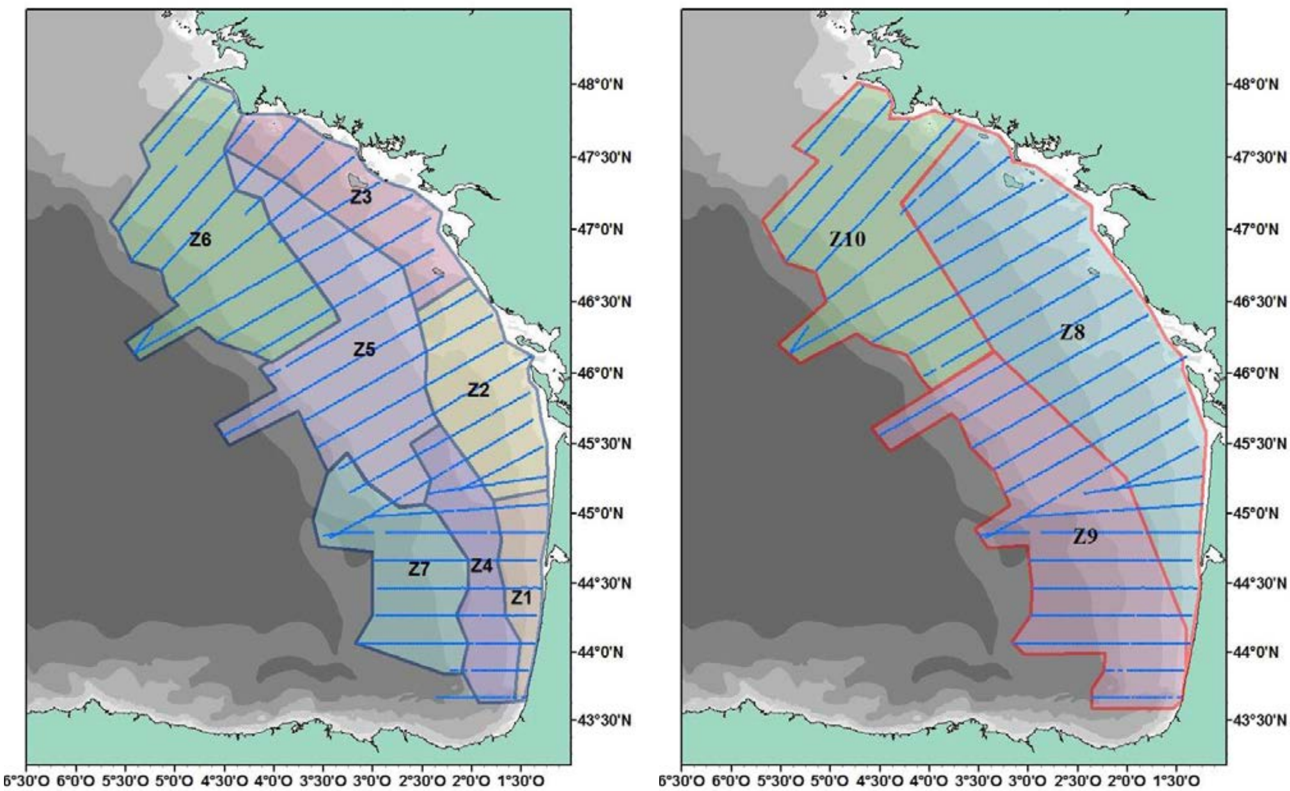
D6 – energies attributed to a mix, usually between 50 and 100 m depth when D1 and D2 were not separable

D7 – energies attributed exclusively to anchovy (big schools).

D8 – energies attributed exclusively to sardine (big and very dense schools).

2.2. Splitting of energies into species

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



Coherent classic strata Coherent surface strata

Fig. 2.2. – Coherent strata (classic and surface), in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS11 survey.

2.3. Biomass estimates

The fishing strategy has been followed all along the survey in order to profit of the best efficiency of each vessel and maximise the number of samples (in term of identification and biological parameters as well). Therefore, the commercial vessels carried out mostly surface hauls when Thalassa fish preferably in the bottom layer. According to previous strata, using both Thalassa and consort fishing operations, biomass estimates have been calculated for each main pelagic species in the surveyed area.

Biomass estimates and respective coefficient of variation are gathered below. No estimate has been provided for Mackerel according to the low level of TS and particular behaviour in the Bay of Biscay where it is totally scattered and mixed with soft plankton echoes.

Anchovy was well present this year, as the strong maximum abundance observed on the whole time series, from the Spanish coast to the south of Brittany. This is very unusual to observe anchovy so North, and with that abundance. Sardine was present from South to North, in very coastal waters. It was also spotted offshore, in lower quantities, close to the surface. About other species, the main characteristic of this year is that mackerel, horse mackerel, and blue whiting were very rare, totally scattered along the shelf.

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

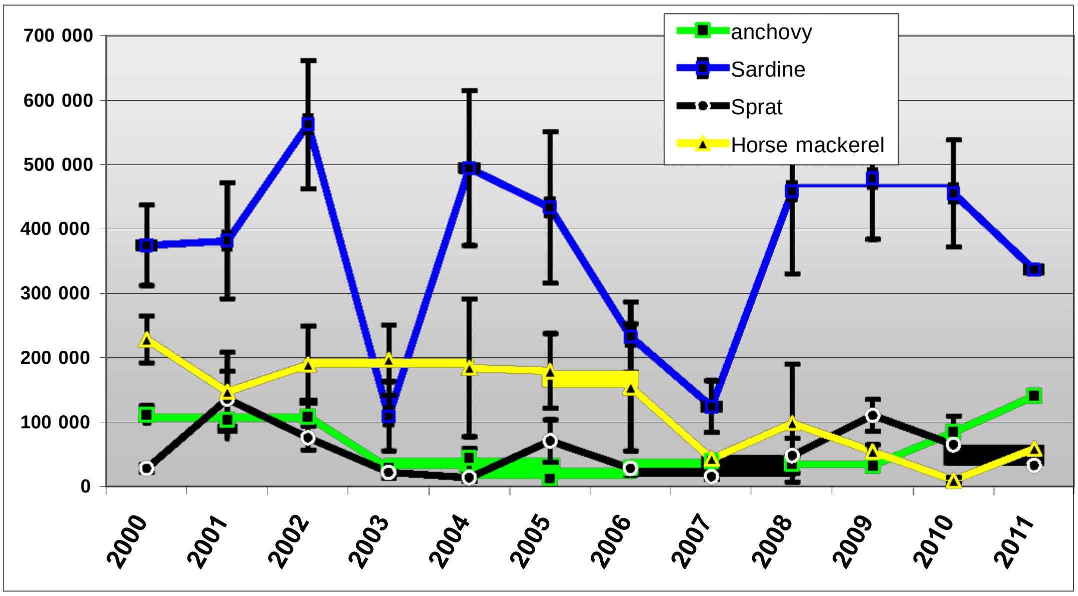


Table and figure 2.3. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + pair trawlers) and coefficients of variation associated.

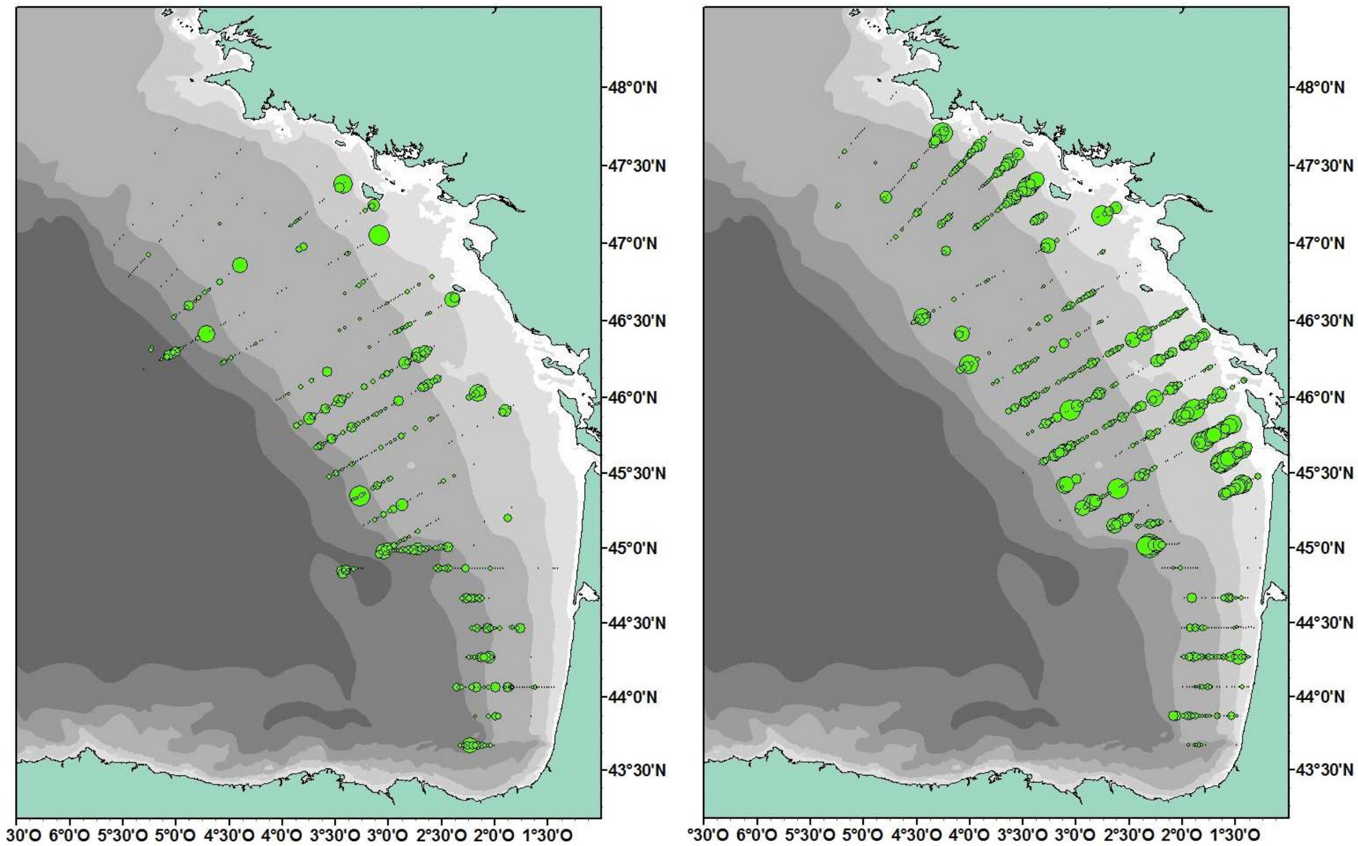
3. Anchovy data

3.1. anchovy biomass

The main observation in 2011 is that anchovy is very spread in the whole bay of Biscay, from the South until the south of Brittany, and from coastal waters (mainly small anchovies) to the shelf break (bigger individuals) : It was particularly abundant in three zones : the Gironde plume, the south coast of Brittany, and along the continental slope from 45°N to 46°30 N.

On the platform, anchovy echo-traces were most of the time traditionally vertically distributed, as soft and small schools (but sometimes very numerous) 15 to 25 meters above the bottom. Nevertheless, anchovy echo-traces this year appeared also in a non traditional way, as small and very dense schools at the surface. Their geographic distribution shows a high abundance northern, as never observed in the whole PELGAS series.

Anchovies were observed in front of the Gironde mixed with sardine, and more or less pure in other areas.



Surface distribution

Classic distribution, between the bottom and 40m above

Figure 3.1. – Anchovy distribution according to PELGAS11 survey.

3.2. Anchovy length structure

Length distribution in the trawl haul were estimated from random samples. The population length distributions (figures 4.2.1 and 4.2.2) has been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul.

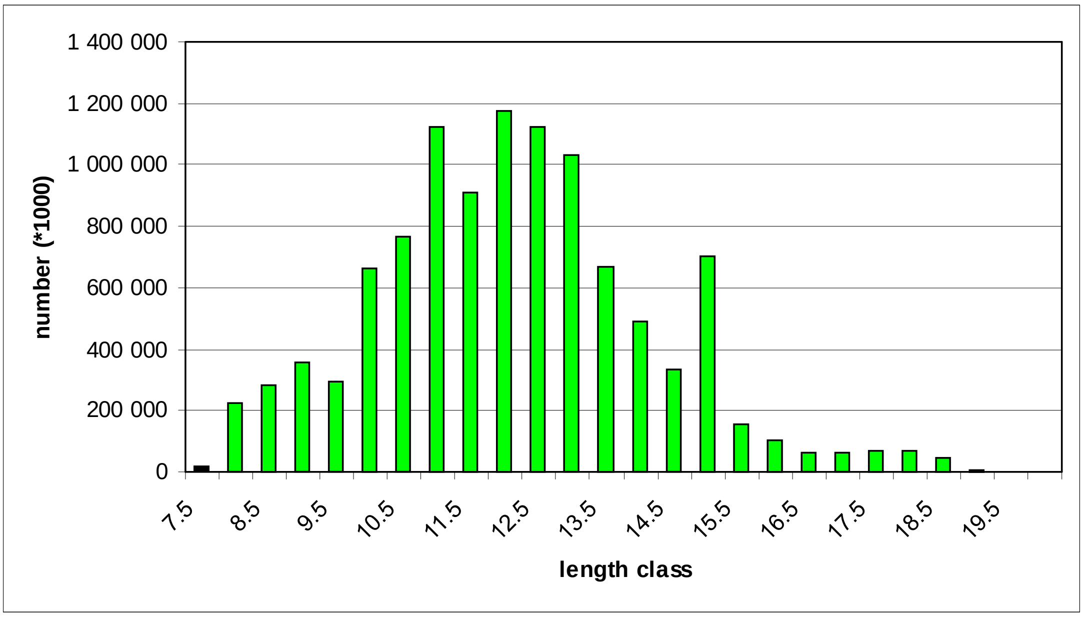


Figure 3.2.1: length distribution of global anchovy as observed during PELGAS11 survey

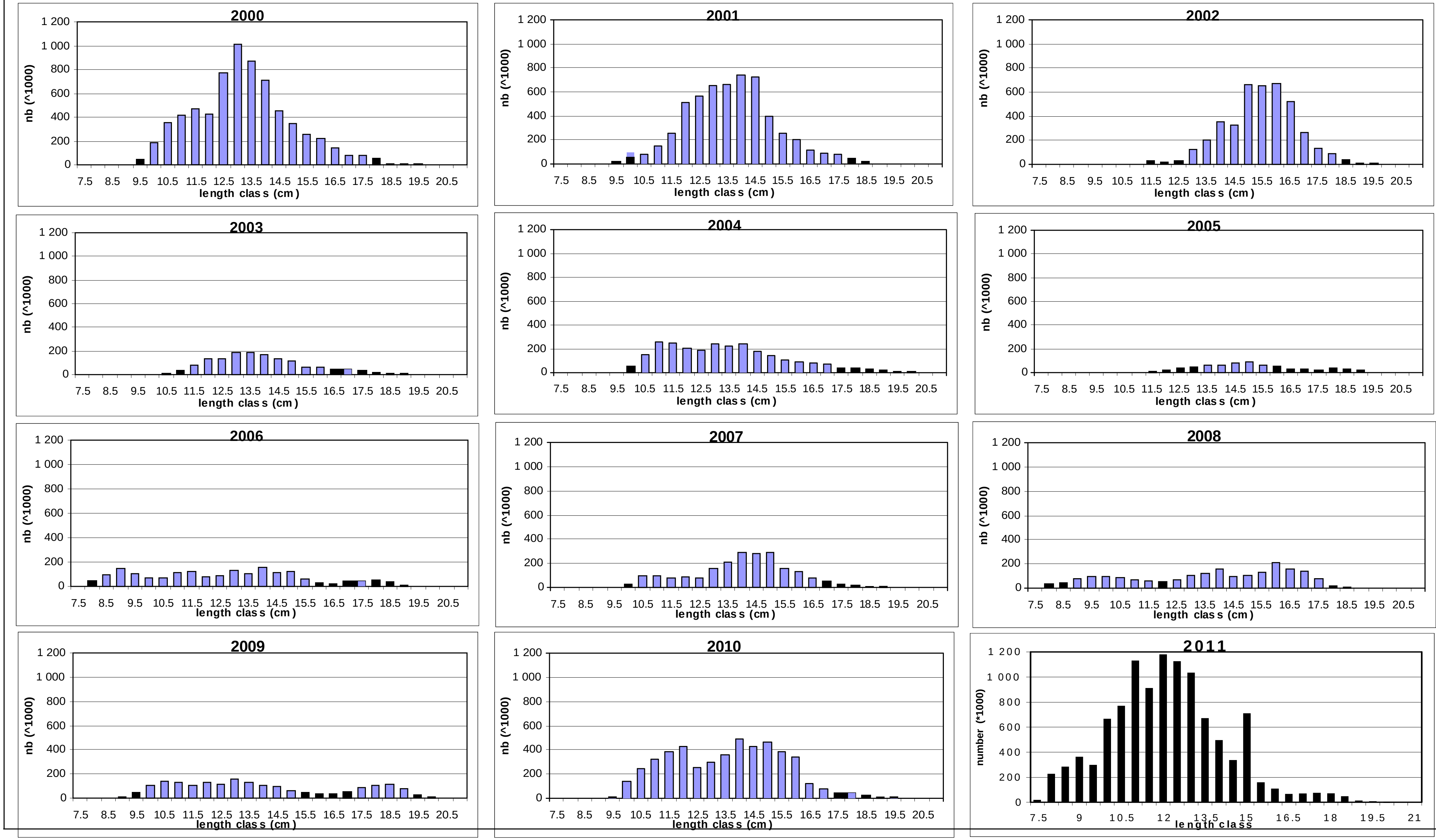


Figure 3.2.2. – length composition of anchovy as estimated by acoustics since 2000

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3.3. Demographic structure

An age length key was built for anchovy from the trawl catches (Thalassa hauls) and samples from commercial vessels. We took the otoliths from a set number of fishes per length class (4 to 6 in/half-cm), for a total amount of around 50 fishes per haul. As there was a lot of fishing operations where anchovy was present, the number of otoliths we took during the survey was more or less the double of the number read each previous years (1985 anchovies aged in 2011).

The population length distributions were estimated by a weighted use of length distributions in the hauls. Weights used are acoustic coefficients (Dev*Xe*Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance sampled by each trawl haul.

NB Age	Age				
taille	1	2	3	4	Total
7.5	100.00%	0.00%	0.00%	0.00%	100.00%
8	100.00%	0.00%	0.00%	0.00%	100.00%
8.5	100.00%	0.00%	0.00%	0.00%	100.00%
9	100.00%	0.00%	0.00%	0.00%	100.00%
9.5	100.00%	0.00%	0.00%	0.00%	100.00%
10	100.00%	0.00%	0.00%	0.00%	100.00%
10.5	100.00%	0.00%	0.00%	0.00%	100.00%
11	100.00%	0.00%	0.00%	0.00%	100.00%
11.5	100.00%	0.00%	0.00%	0.00%	100.00%
12	99.29%	0.71%	0.00%	0.00%	100.00%
12.5	98.26%	1.74%	0.00%	0.00%	100.00%
13	94.27%	4.17%	1.56%	0.00%	100.00%
13.5	91.67%	6.86%	1.47%	0.00%	100.00%
14	83.92%	12.56%	3.52%	0.00%	100.00%
14.5	76.74%	22.09%	1.16%	0.00%	100.00%
15	67.36%	29.17%	3.47%	0.00%	100.00%
15.5	61.47%	36.70%	1.83%	0.00%	100.00%
16	36.46%	57.29%	6.25%	0.00%	100.00%
16.5	13.16%	78.95%	7.89%	0.00%	100.00%
17	1.59%	88.89%	9.52%	0.00%	100.00%
17.5	0.00%	92.31%	7.69%	0.00%	100.00%
18	0.00%	97.67%	2.33%	0.00%	100.00%
18.5	0.00%	78.95%	21.05%	0.00%	100.00%
19	0.00%	42.86%	57.14%	0.00%	100.00%
20	0.00%	0.00%	0.00%	100.00%	100.00%
Total	73.64%	23.44%	2.87%	0.05%	100.00%

Table 3.3.1. PELGAS11 anchovy age/Length key.

Applying the age distributions to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated. The total biomass used here has been updated with the value obtained from the previous method based on strata.

Age distribution is shown in figures 3.3.2. The age distributions compared from 2000 to 2011 are shown in figure 3.3.3.

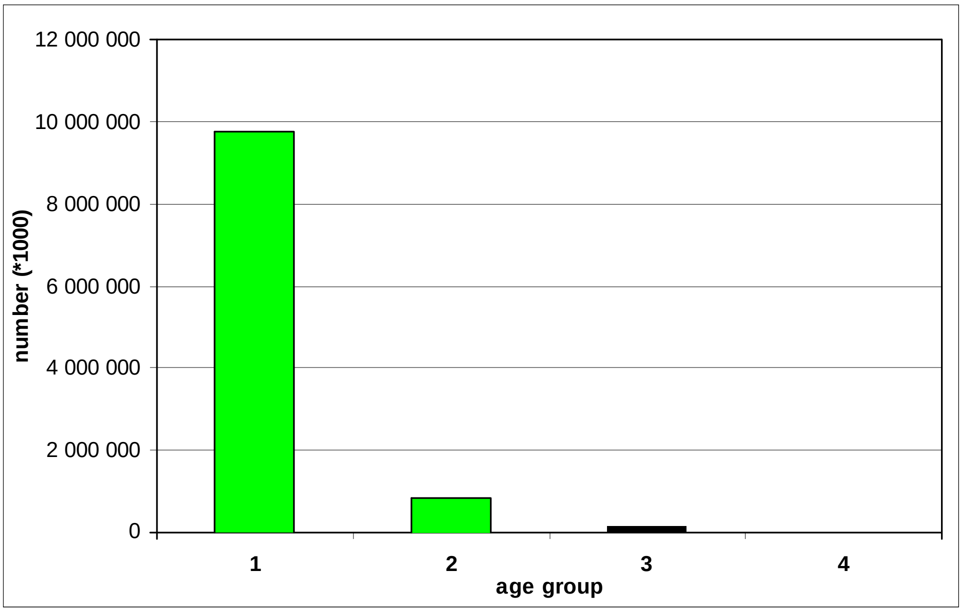

Figure 3.3.2– global age composition of anchovy as observed during PELGAS11 survey

Looking at the numbers at age since 2000 (fig 3.3.3.), the number of 1 year old anchovies this year seems to be strong maximum of the whole time series (9 770 millions fish against 1174 in 2009 and 4 100 millions in 2010). They represent 80 % of the biomass (91% in numbers). The 1 year old class represents the better recruitment never observed before on a PELGAS survey (since 2000) and 2 years old are still present, considering the relative high abundance last year of age 1.

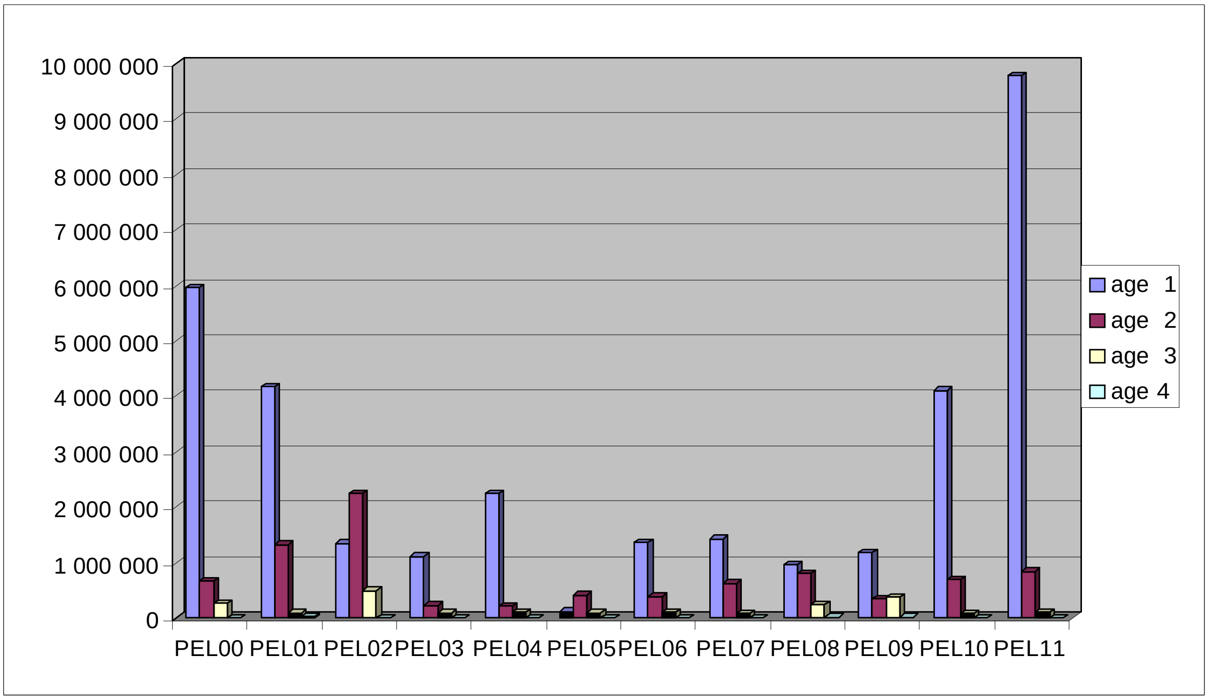

Figure 3.3.3 Anchovy numbers at age as observed during PELGAS surveys since 2000

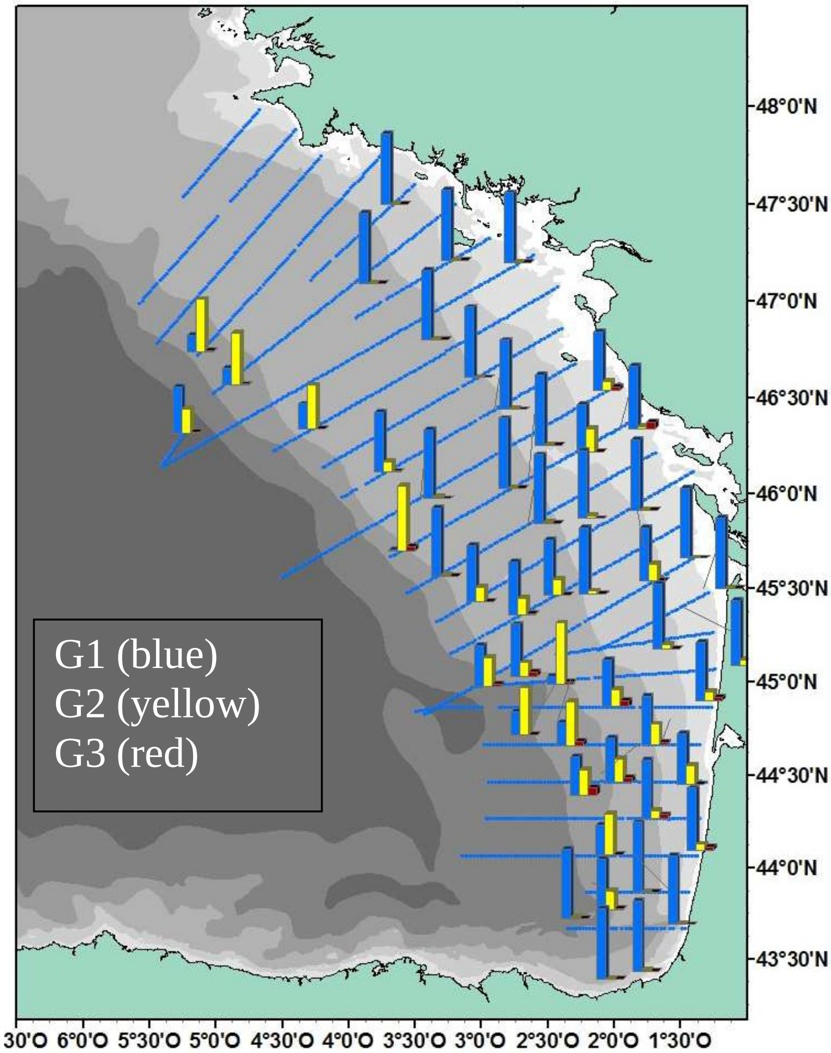

Figure 3.3.4 Anchovy proportion at age in each haul as observed during PELGAS11 survey.

During previous surveys, anchovy was well geographically stratified depending on the age (*see WD 2010, Direct assessment of small pelagic fish by the PELGAS10 acoustic survey, Masse J and Duhamel E.*). It is less true this year, even if age2 were predominant offshore, mainly close to the surface at the shelf-break. Along the coast, from 45°N to the South of Brittany, age 1 appeared in a almost exclusive way.

3.4. Weight/Length key

Based on 1985 weight of individual fishes, the following weight/length key was established (figure 4.5.) :

$W = 0.00268L^{3.3319}$ (with $R^2 = 0.9576$)

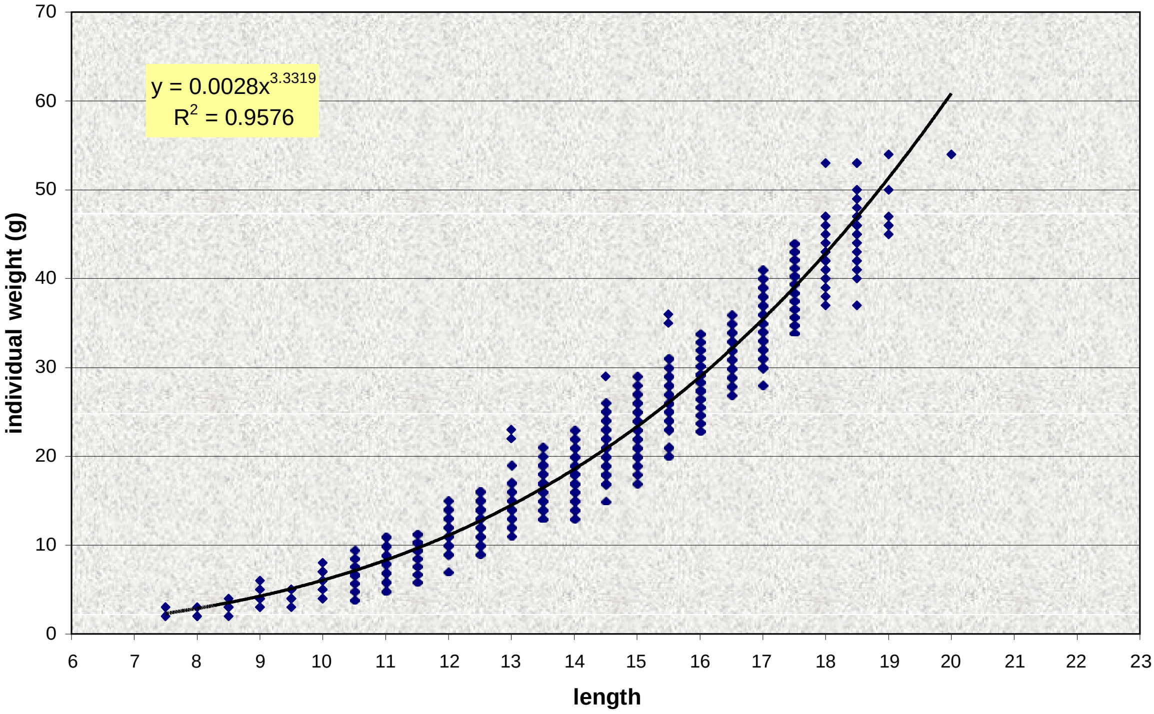

Fig. 3.4. – Weight/length key of anchovy established during PELGAS11

3.5. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 743 CUFES samples were collected and counted, 89 vertical plankton hauls and 113 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

We observed an egg distribution very unusual to what is usually seen in May, with a presence over the shelf-break (between 45°30N and 46°30N) until 30NM, and an extension to the North to the south-west coast of Brittany, which is the northern observation of anchovy eggs for the PELGAS series. (figure 3.5.1.).

Looking at the time series from 2000 to 2010 (Figure 3.5.2. and 3.5.3.), anchovy eggs abundance constitute the strong maximum of the time series since 2000. Eggs were abundant almost all along the shelf of Bay of Biscay, with a peak close to the coast and offshore, along the end of the continental slope.

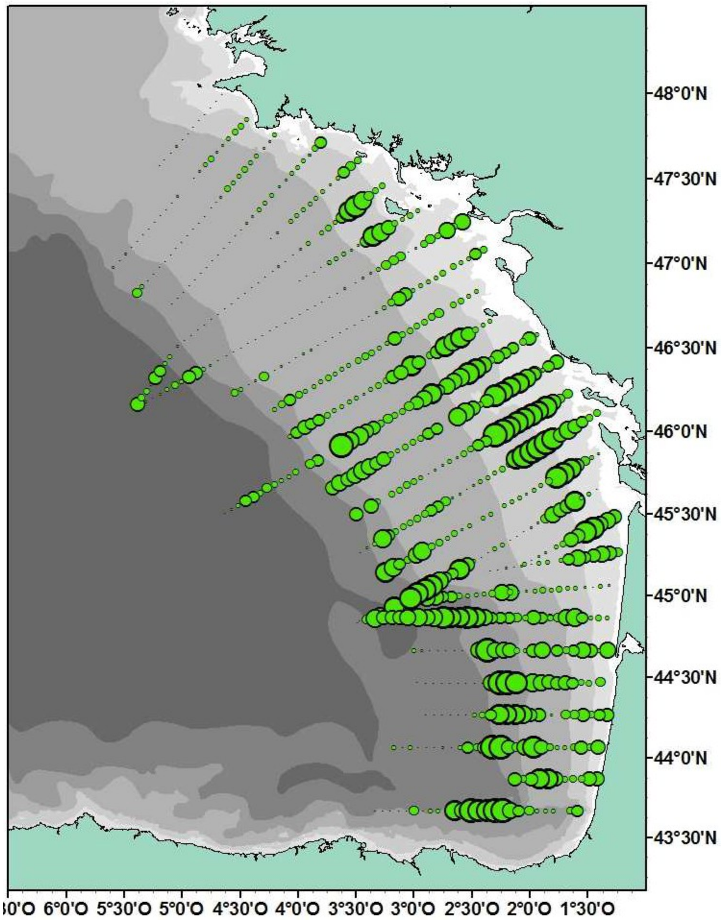

Figure 3.5.1 – Distribution of anchovy eggs observed with CUFES during PELGAS11.

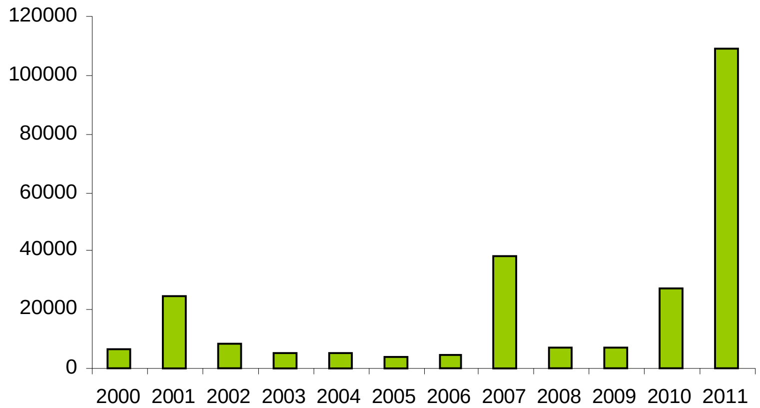

Figure 3.5.2 – Number of eggs observed during PELGAS surveys from 2000 to 2011

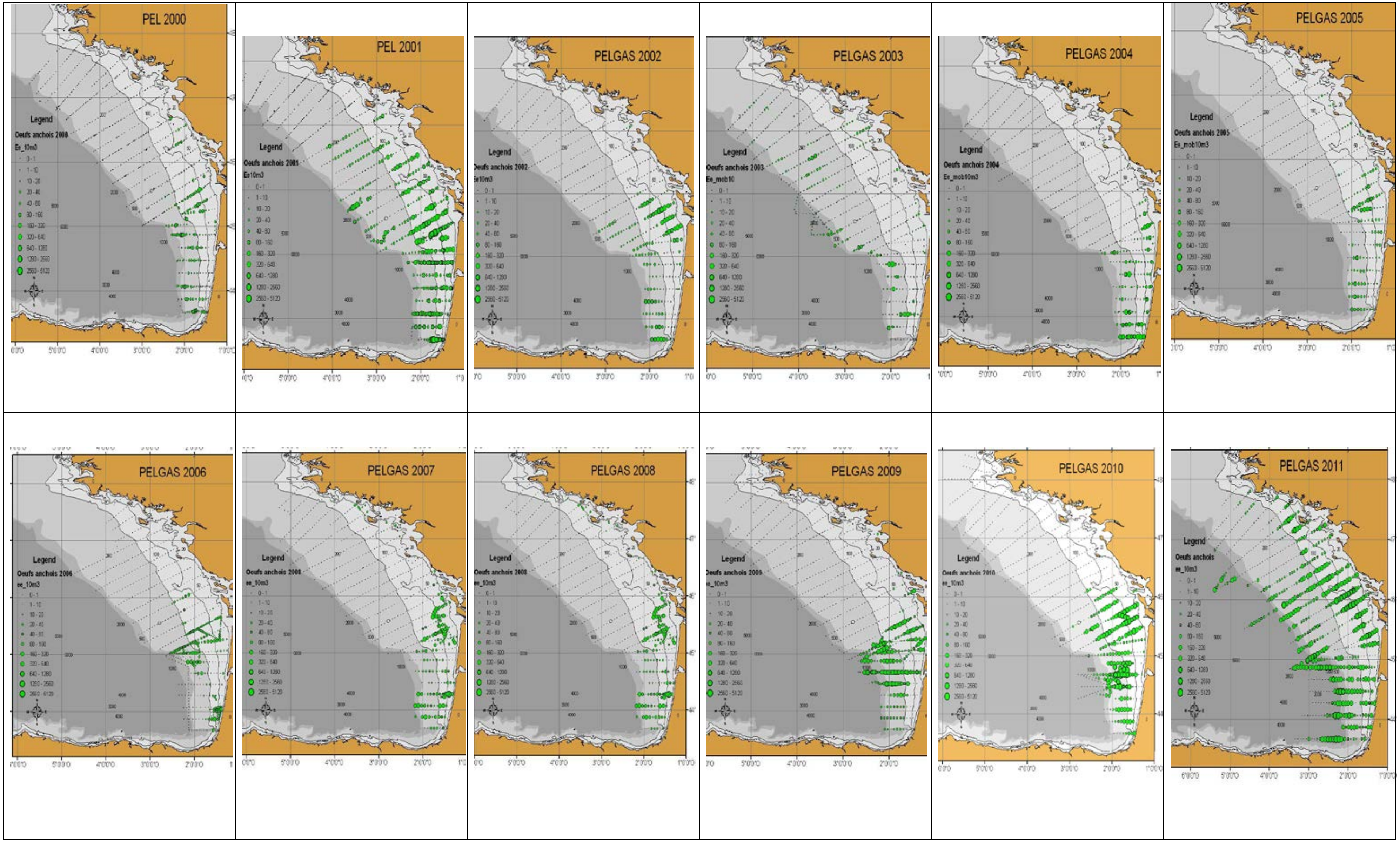

Figure 3.5.3 – distribution of anchovy eggs observed with CUFES during PELGAS from 2000 to 2011 (number for 10m^3).

4. Sardine

4.1. Adults

The biomass estimate of sardine observed during PELGAS11 is 338 468 tons (table 2.3.), which is on the average level of the PELGAS series, but a little bit decreasing compare to the last 3 years. It must be enhance that these surveys don't cover the total area of potential presence of sardine. It is possible that some years, this specie could be present up to the north, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, apparently more and more. It is also possible that sometimes, a small fraction of the population could be present in very coastal waters, when the R/V Thalassa is unable to operate in those waters. The estimate is representative of the sardine present in the survey area at the time of the survey and can be therefore considered as an estimate of the Bay of Biscay (VIIIab) sardine population.

Sardine was distributed pure or mixed with anchovy in two principal areas : along to the French coast from the southern part of the Bay of Biscay to the south of Brittany, and offshore, in shallow waters along the end of the continental slope.

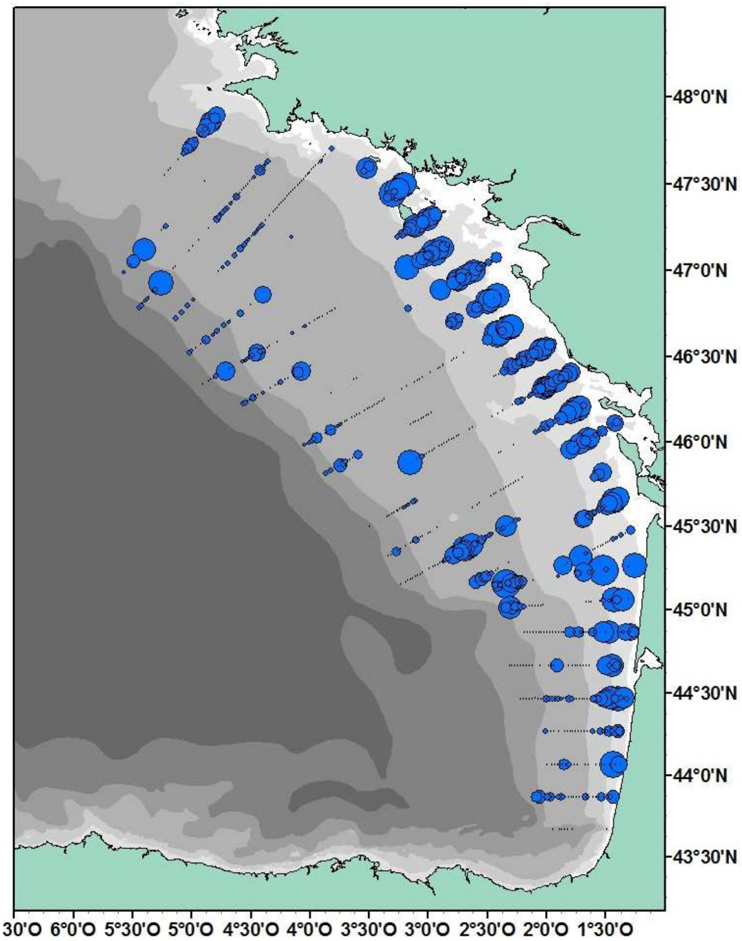

Figure 4.1.1 – distribution of sardine observed by acoustics during PELGAS11

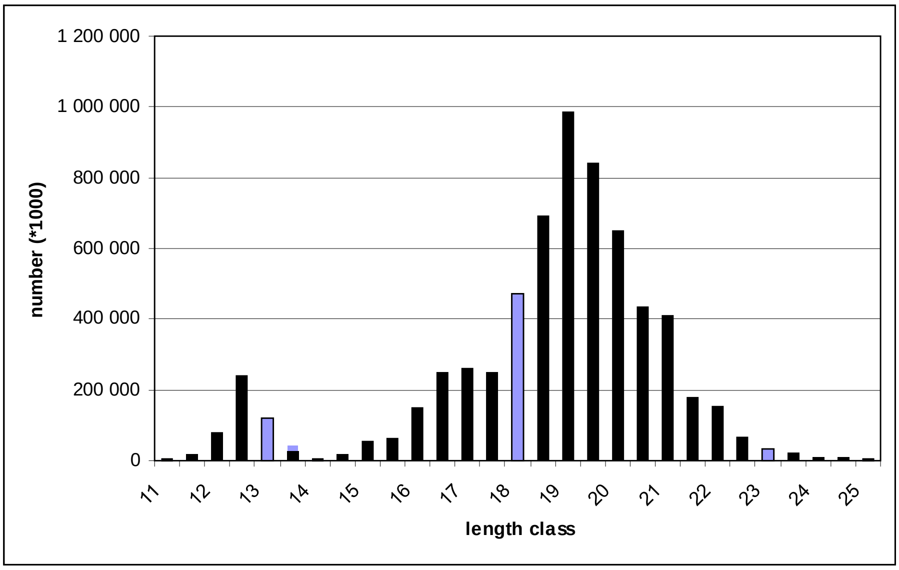

Figure 4.1.2. – length distribution of sardine as observed during PELGAS11.

Length distributions in the trawl hauls were estimated from random samples. The population length distributions have been estimated by a weighted average of the length distribution in the hauls. Weights used are acoustic coefficients (Dev*Xe Moule in thousands of individuals per n.m.^{2}) which correspond to the abundance in the area sampled by each trawl haul. The global length distribution of sardine is shown on figure 4.1.2.

As usual, sardine shows a bimodal length distribution, the first one (about 13 cm, corresponding to the age1 ,and not well present this year) and the second about 19.5 cm, where mainly is constituted by the 3 years old.

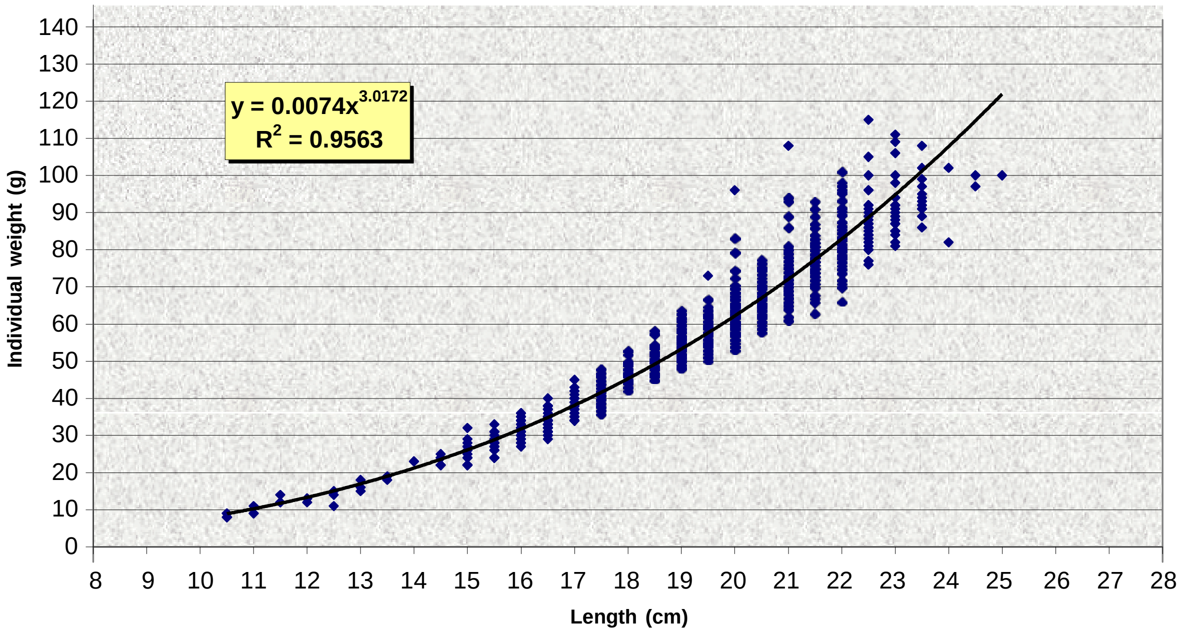

Figure 4.1.3 – Weight/length key of sardine established during PELGAS11

NB age	age										
longueur (cm)	1	2	3	4	5	6	7	8	9	10	Total
10.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
12.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
13.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
14.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
15.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
16.5	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17	84.38%	15.63%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17.5	64.29%	35.71%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18	9.09%	70.45%	20.45%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18.5	0.00%	56.94%	40.28%	2.78%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19	0.00%	43.82%	53.93%	2.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19.5	0.00%	18.81%	74.26%	6.93%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20	0.00%	6.80%	69.90%	23.30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20.5	0.00%	2.88%	61.54%	30.77%	2.88%	1.92%	0.00%	0.00%	0.00%	0.00%	100.00%
21	0.00%	1.01%	44.44%	41.41%	9.09%	3.03%	1.01%	0.00%	0.00%	0.00%	100.00%
21.5	0.00%	0.00%	26.97%	60.67%	7.87%	2.25%	2.25%	0.00%	0.00%	0.00%	100.00%
22	0.00%	0.00%	17.86%	58.33%	14.29%	7.14%	2.38%	0.00%	0.00%	0.00%	100.00%
22.5	0.00%	0.00%	9.76%	46.34%	9.76%	21.95%	12.20%	0.00%	0.00%	0.00%	100.00%
23	0.00%	0.00%	0.00%	30.00%	35.00%	15.00%	5.00%	0.00%	15.00%	0.00%	100.00%
23.5	0.00%	0.00%	0.00%	8.33%	8.33%	41.67%	8.33%	16.67%	0.00%	16.67%	100.00%
24	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
24.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.00%	0.00%	50.00%	100.00%
25	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Total	17.64%	15.10%	36.02%	22.23%	4.03%	2.81%	1.13%	0.38%	0.38%	0.28%	100.00%

Table 4.1.4 : sardine age/length key from PELGAS11 samples (based on 1073 otoliths)

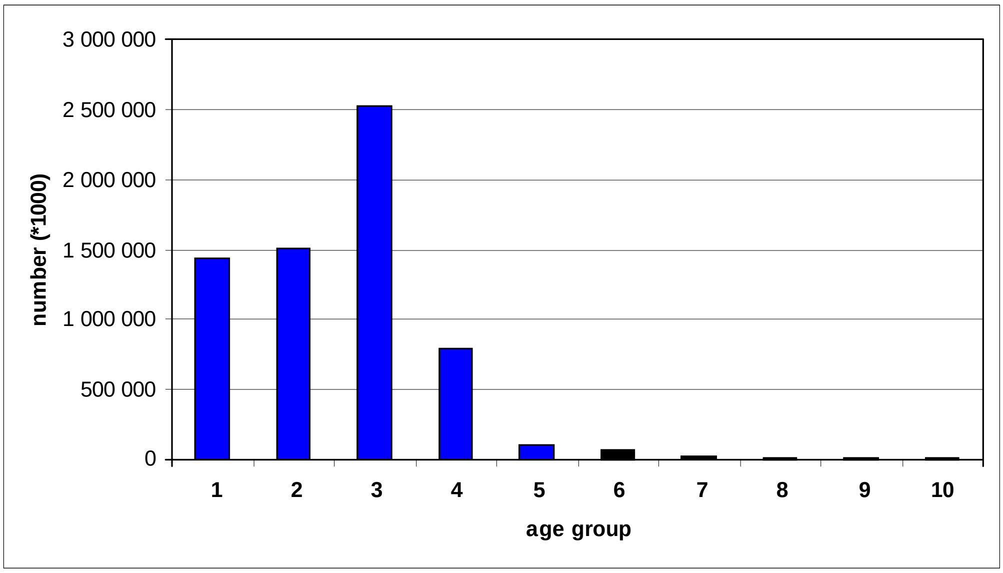

Figure 4.1.5.- Global age composition of sardine as observed during PELGAS 11

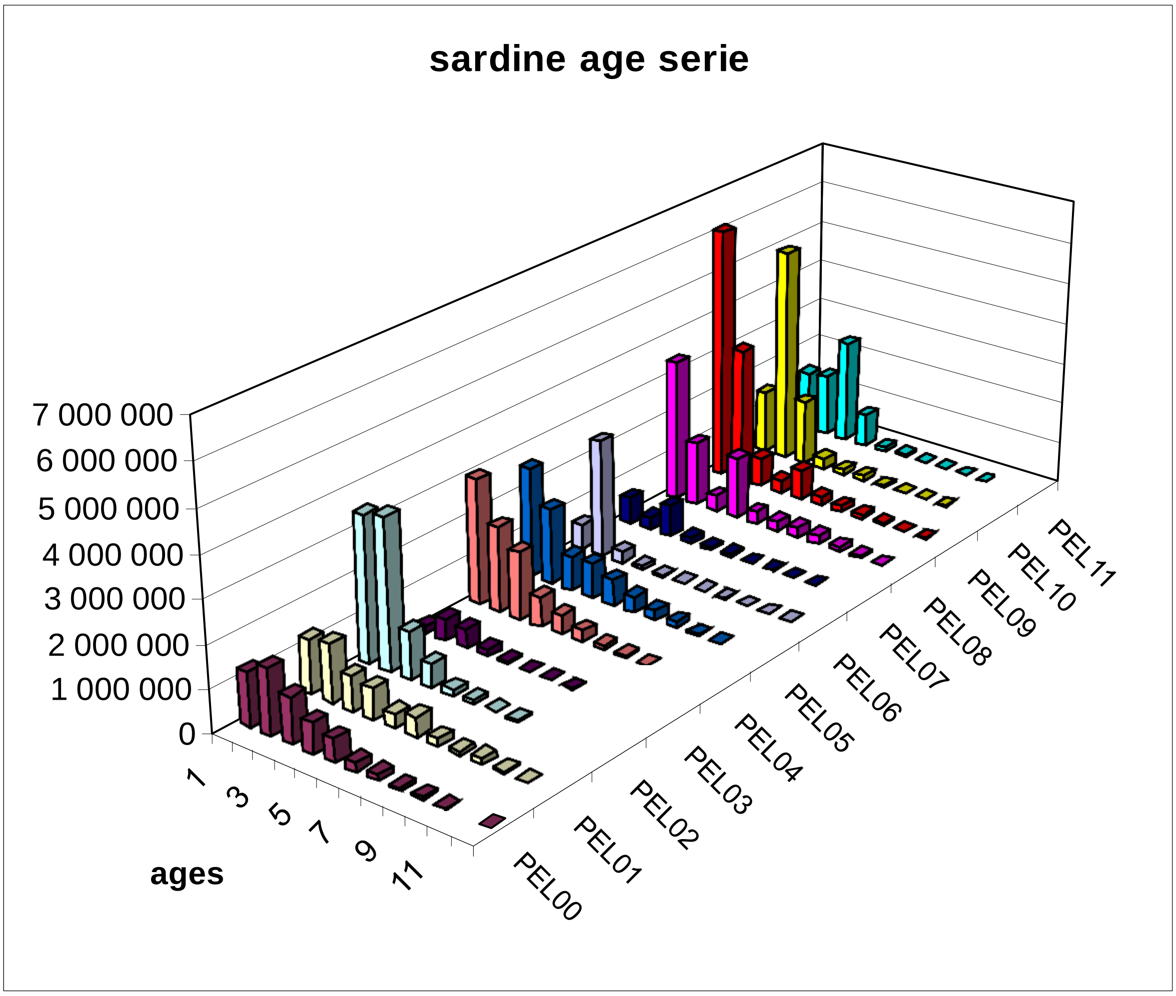

Figure 4.1.6- Age composition of sardine as estimated by acoustics since 2000

The series of age distribution in numbers since 2000 are shown in figure 5.1.6. We can observe that we can follow cohorts (i.e. the very low 2005 age class, or high 2004 age class). 2003 was an atypical year in terms of environmental conditions and therefore fish distributions.

It must be noticed that the number of age 3 individuals this year is really important (39% in number of total fishes), and confirms a good recruitment of the 2008 year class. The relative high abundance of age 4 (still 13%) corresponds to the good recruitment of the 2007 year class that we observed previous years.

4.2. Eggs

Sardine eggs were observed mainly along the coast within the 100m isobath, from the south of the bay of Biscay to the south of Brittany. Then, another lower concentration was visible along the end of the continental slope northern than 45°30N, according to the presence of adults in shallow waters

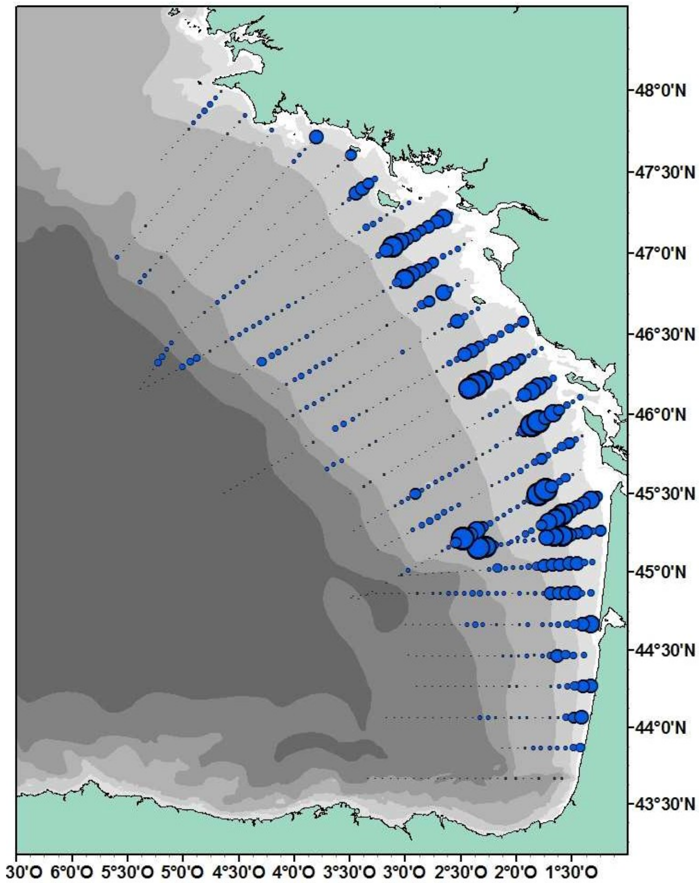

Figure 4.2.1. Distribution of sardine eggs observed with CUFES during PELGAS11.

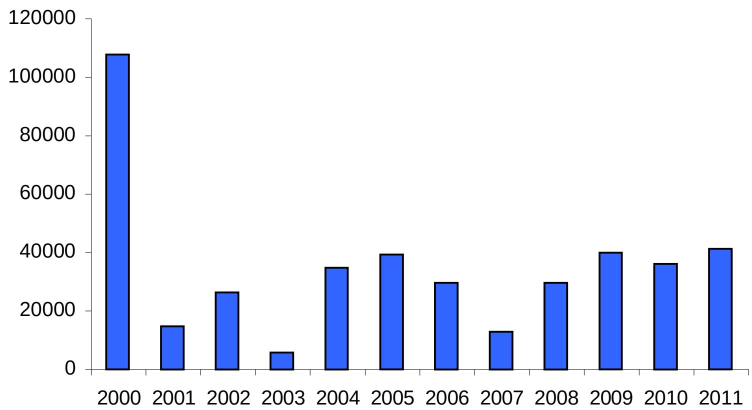

Figure 4.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2011

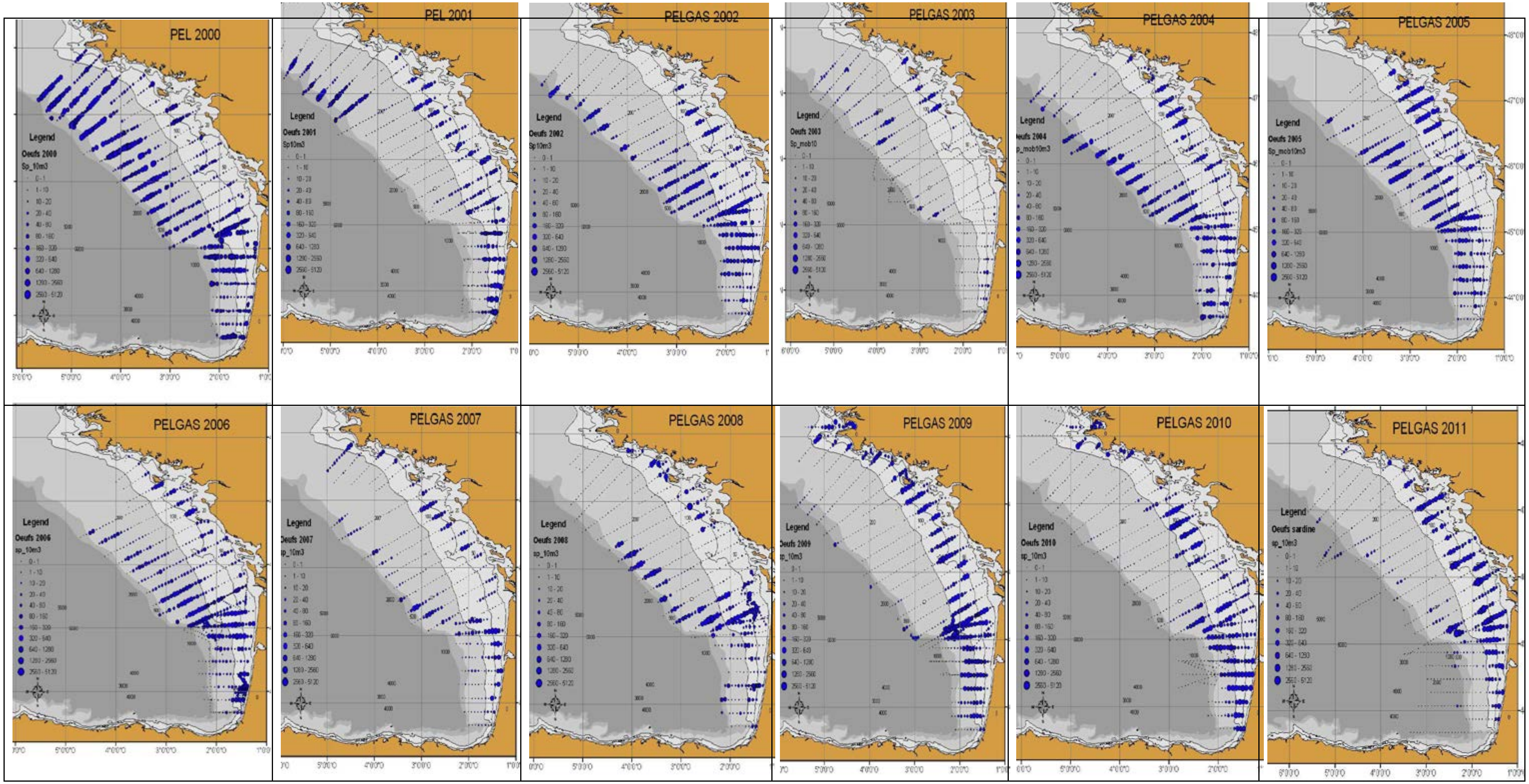

Figure 4.2.3 – distribution of sardine eggs observed with CUFES during PELGAS from 2000 to 2011 (number for 10m^3).

The number of eggs collected by CUFES during the PELGAS11 survey was comparable to previous years but still far below the maximum observed in 2000.

5. Top predators

5.1 – Birds

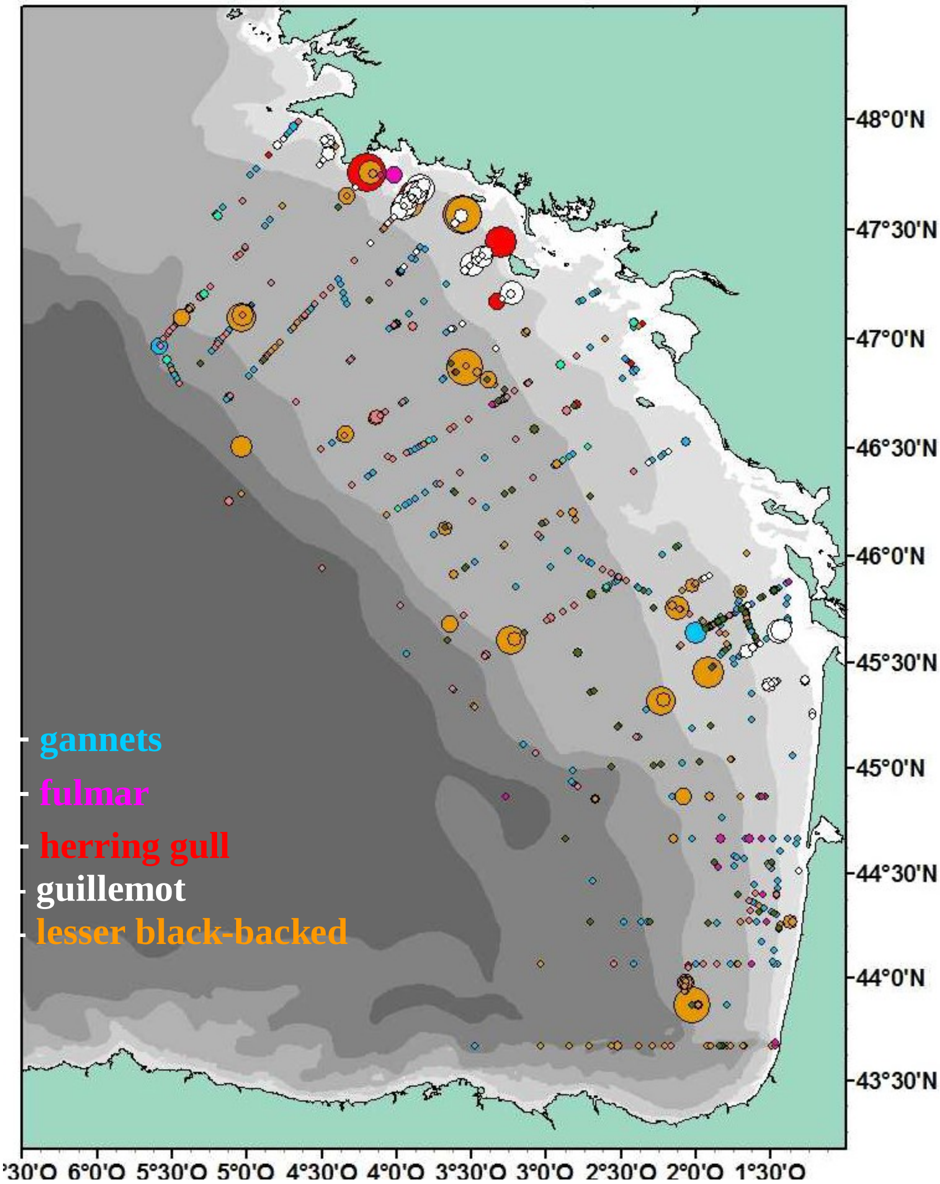

Figure 5.1.1 Distribution of marine birds observed during the PELGAS11 survey

Globally, the gannets (*Sula bassana*) and the lesser black-backed gulls (*Larus fuscus*) were present in medium quantity all over the area prospected, without a real concentration area .

The guillemot habitat and the herring gull one are, as usual, coastal and these species are rarely observed over the 50 meters bathymetric line.

Fulmar were mainly observed, as previous years, in the northern and offshore part of the bay of Biscay.

5.2 – Mammals

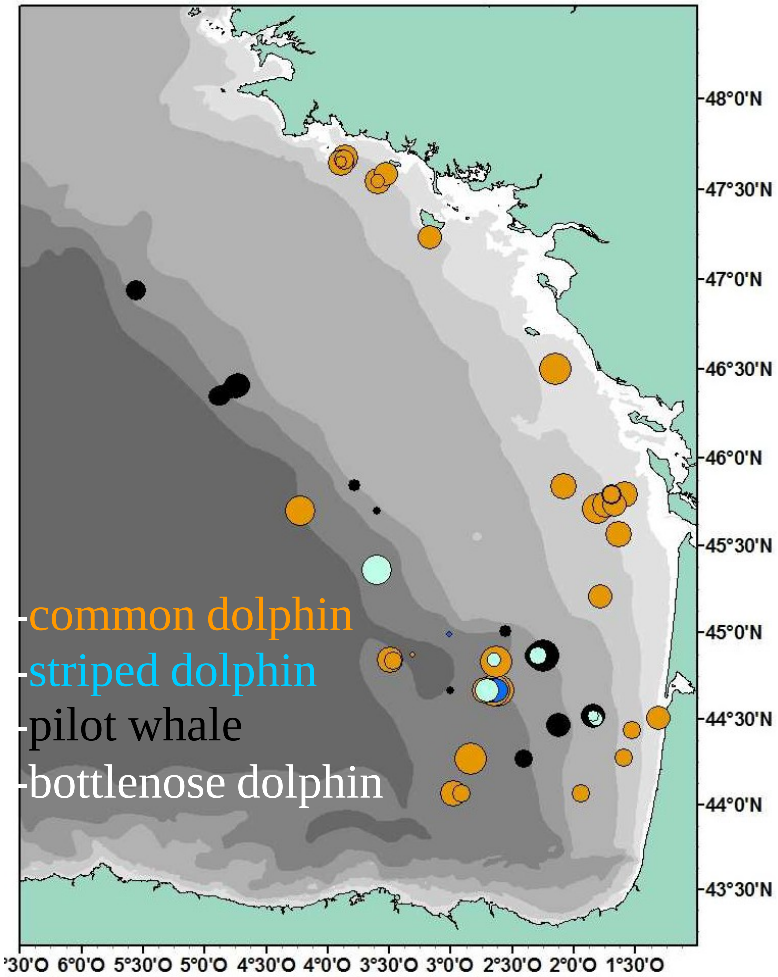

Figure 5.2.1 Distribution of mammals during the PELGAS11 survey.

The first observation we can have this year is a low number of mammals observations : no large mammals detected (whales, sperm whales), the mammals met were in small groups. That is not due to the conditions of observation, because the whole survey experienced good weather.

The more frequent cetacean species is the common dolphin, *Delphinus delphis*, present this year in coastal waters and at the end of the continental slope. Then the pilot whales (*Globicephala melas*) and the bottlenose dolphins (*Tursiops truncatus*), who were as usual distributed along the shelf edge in the Bay of Biscay and this distribution is similar to the previous years (but in lower number)

6. Hydrological conditions

Stable anticyclonic conditions dominated the Pelgas11 survey. However, a period of moderate winds (20 knots) from the NW occurred without really mixing the water column that were strongly stratified at the end of April, after a stable and anticyclonic situation during april.

These situation in April (it seems to be one of the warmest month of April since one century) succeed to warm sea surface temperature and establish a strong stratification for the period of the survey. SST are above the average on the time series, and relatively homogeneous (15.5 to 17 °C). Temperature profiles show a strong stratification, without real mix layer at the beginning of the period, and a thermocline between 20 and 30 meters depth.

The amount of freshwater from the rivers were small, which resulted in a weak plume pattern, according to a very dry month of April (amplified with low rainfalls during winter).Thus, surface temperature on the platform shows relative high salinity, without value less than 33. During the transects, river plumes were oriented to the North, due to the lack of significant wind.

The phytoplanktonic production started earlier than previous years, with a spring bloom having occurred before the survey. Furthermore, low river discharges resulted in small production in plumes zones. The most important phytoplanktonic production are located between the Gironde and the Loire estuaries, and above the shelf break in the North. Some concentrations met in the middle of May, a little bit more important, are maybe due to a mix cause of a continuous wind during some days.

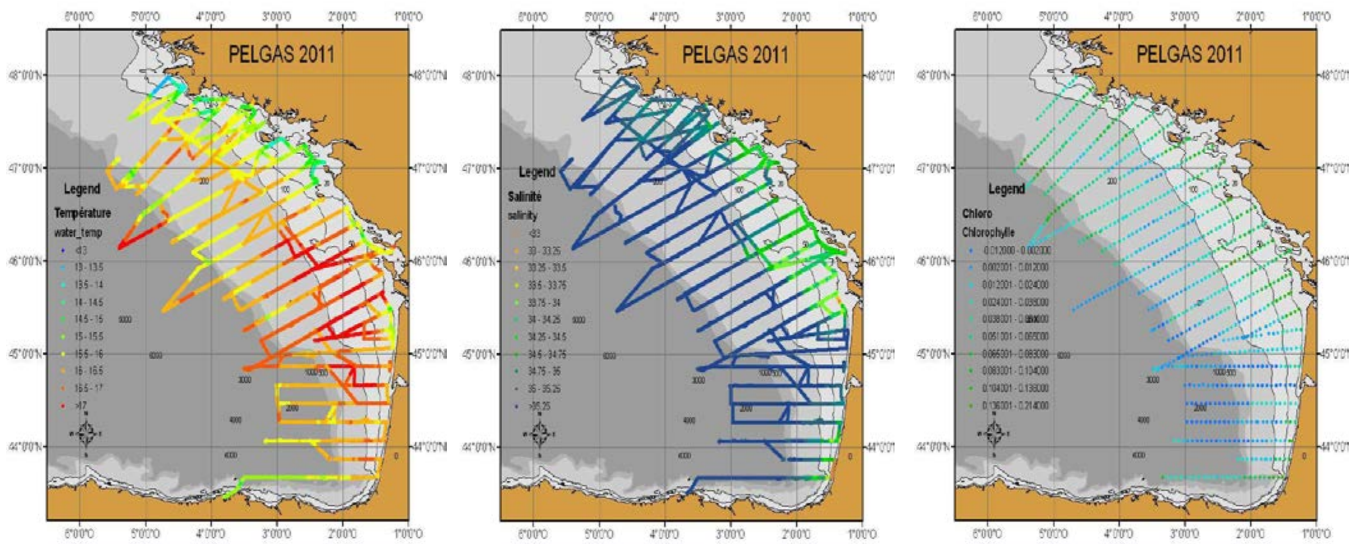

Figure 6.1. – Surface temperature, salinity and fluorescence observed during PELGAS11.

7. Conclusion

The Pelgas11 acoustic survey has been carried out with good weather conditions for the whole area, from the south of the bay of Biscay to the west of Brittany. The help of commercial vessels (two pair of trawlers and a purse seiner) during most of the survey provided about 110 identification hauls as a whole instead of about 50 the years before, when Thalassa was alone to identify echo traces. Their participation increased the precision of identification of echoes and some double hauls permitted to confirm that results provided by the two types of vessels (R/V and Fishing boats) were comparable and usable all together for biomass estimate purposes. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration.

Temperature and salinity recorded during PELGAS11 were affected by weather conditions before and during the survey. During the whole survey, water column showed a strong stratification, with a high surface temperature due to the hot and dry month of April (one of the warmest and hottest April of the last century).

Even if the sardine was still predominant this year with an abundance index of 338 458 tons (which constitute a small decrease from the three previous years), the PELGAS11 survey observed a high abundance of anchovy, widely spread on the French continental slope, and sometimes more offshore, with a total abundance index of 142 602 tons. The good recruitment of age 1 this year is particularly clear, representing 91% of the total number of anchovies (80 % in mass).

Anchovy was particularly abundant in coastal areas, and even if age2 were predominant offshore, mainly close to the surface at the shelf-break, age 1 appeared almost pure along the coast, from the Gironde area to the South of Brittany. It is the first year of the PELGAS series that anchovy is observed so North, and in that abundance.

Sardine appeared mostly close to the coast, from the South of the bay of Biscay until the Brittany coast, but also offshore in shallow waters along the shelf break. Age 3 were predominant (40% in number), confirming the good recruitment of the 2008 year class.

Mackerel, horse mackerel and sprat were dispersed on the platform and not abundant compared to the average on the whole PELGAS series.

A.3.2 - SARDINE AND ANCHOVY IN GALICIA AND CANTABRIAN WATERS: RESULTS FROM THE SPANISH SPRING ACOUSTIC SURVEY PELACUS0411

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Abstract

A total of just 11,768 tons of sardine (151 million fish) was estimated to be present in northwest and northern Spanish waters by the Spanish spring acoustic survey PELACUS0411 carried out from 26th March to 20th April 2011. Sardine was found in some numbers only in Asturias (ICES sub-area VIIIcE-w) and was almost absent from Galicia (ICES sub-areas IXa-N and VIIIcW). Most fish were 4-year old (fish born in 2007), which predominated in Asturias and Cantabria (ICES sub-areas VIIIcE-w). Younger fish, age 1 and 2 predominated in Galicia (ICES sub-area IXaN) while age 3 fish were abundant in the Basque country (ICES sub-area VIIIcE-e). The estimates obtained by the 2011 survey are the lowest since 2001 and give cause for concern on the status of the stock. Unless another strong recruitment comes along (the last one was in 2004), biomass and abundance values will probably continue to decrease in Spanish waters. For anchovy, 2701 tons, corresponding to 142 million fish, were detected during the survey, and occupied two separate areas: south Galicia (ICES sub-area IXa-N) and the Basque country/ French border (ICES sub-area VIIIcE-e and ICES Division VIIIb). In the latter area, age 1 fish dominated the sample. Anchovy has shown an increase from previous years both in number of fish and in the area occupied.

In contrast with the situation for adult fish, CUFES data indicated that sardine eggs are distributed throughout the surveyed area (although closer to the coast than in previous surveys) and in similar numbers to those obtained in last year´s survey. For anchovy, there has been a big increase in the number of eggs detected in 2011 and in the area occupied (extending well beyond the traditional area of the inner Bay of Biscay).

Introduction

The Spanish Institute of Oceanography began its spring acoustic surveys in 1984 with the aim of assessing the fishery resources in the north and northeast shelf of the Iberian Peninsula (ICES divisions IXa – South Galicia and VIIc – Cantabrian Sea). The annual (with some interruptions) survey series has suffered some methodological changes over the years and a shift in its main aim. During the first years of the series (until 1996) the main objective of the surveys (SARACUS, PELACUS) was the estimation of the abundance and distribution of the sardine stock by acoustic methods combined with the information provided by pelagic trawls. During the surveys, information was also collected to characterize the hydrographic conditions and to determine the composition and distribution of plankton. In 2000 the survey produced, in addition to sardine, abundance estimates also for mackerel and horse mackerel and, since 2007, other pelagic fish species have also been evaluated. Parallel to the increase in the number of species assessed, the objectives of the survey have expanded to include the study of other components of the pelagic ecosystem (since 2007 information has also been collected on the distribution and abundance of seabirds and marine mammals) and their interrelationships (for many years the stomach contents of several fish species have been analysed). The main reason behind these changes has been to allow the evolution of the survey into a platform for the monitoring of the pelagic ecosystem of the northern and northwestern peninsular platform.

PELACUS 0411 is the twenty-eighth year of the time series and we present the results on the distribution of sardine and anchovy egg and adult fish together with the estimated values of adult fish abundance and biomass obtained in the survey. We also compare the new values with those obtained in previous years (the same methodology has been applied to the acoustic data collected on board since 2001 and sardine egg data are available since 2000).

Material and methods

Methods are as described in Iglesias et al. (2010) and are reproduced here. Acoustic sampling takes place during the day over a grid of parallel transects separated by 8 nm and perpendicular to the coastline (Figure 1). The area of the continental shelf covered in 2011 (27th March to 20th April) extended from 30 to 200 m depth and from northern Portuguese waters to southern French waters. During the survey, in addition to measuring the acoustic energy reflected by marine organisms, data are also routinely collected on the hydrography and hydrodynamic of the water masses (with rosettes and CTD), on the composition of the ichthyoplankton (using a Continuous Underwater Fish Egg Sampler, CUFES) and fishing communities (carrying out trawl stations). Figures 1 and 2 show an outline of the sampling effort.

Distribution of sardine eggs during PELACUS is sampled using an internal CUFES, with the water intake located at 5 m depth. The acoustic energy is measured using a EK-60 scientific echosounder (Simrad) working at five frequencies (18, 38, 70, 120 and 200 KHz). Frequencies were calibrated at the start of the survey using recommended methods (Foote *et al*., 1987). The elementary distance sampling unit (EDSU) was fixed at 1 nm. Acoustic data were obtained only during daytime at a survey speed of 10 knots. Data were stored in raw format and post-processed using SonarData Echoview software. The integration values are expressed as nautical area scattering coefficient (NASC) units or s_A values (m^2 x nm $-^2$) (MacLennan *et al*., 2002).

Fish abundance was calculated with the 38 kHz frequency as recommended at the PGAAM (ICES 2002). Nevertheless, echograms from 120 kHz were used to visually discriminate between fish and other scatter-producing objects such as plankton or bubbles, and to distinguish different fish according to the strength of their echo. The threshold used to scrutinize the echograms was –60 dB. Backscattered energy (s_A) was allocated to fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975). For this purpose, the following TS values were used: sardine and anchovy, -72.6 dB (b_{20}); horse mackerels (*Trachurus trachurus, T. picturatus* and *T. mediterraneus*), –68.7 dB, bogue (*Boops boops*), –67 dB, chub mackerel (*Scomber colias*), -68.7, mackerel (*Scomber scombrus*), –84.9 dB and blue whiting (*Micromesistius poutassou*), -67.5 dB.

Fishing trawls were conducted during the day using a pelagic trawl, and aimed to identify the species producing echo traces detected during the track survey, and to provide information on the pelagic community from the coast to the shelf break depth and along the coast strata. Hauls had a minimum duration of 20 minutes. Length frequency distributions (LFD) were obtained for all the fish species in the trawl (either from the total catch or from a representative random sample of 100-200 fish). For the purpose of acoustic assessment, only those size distributions which were based on a minimum of 30 individuals and which presented a normal distribution were considered. In the case of sardine, it was not possible to get enough individual fish in any one haul in Galician waters to obtain a representative length distribution and therefore the length distribution from market sample fished in the area at the time of the survey was used instead. In the survey, random samples of the main pelagic species, consisting of up to 100 fish from each haul, were measured and weighed to obtain a length-weight relationship. Otoliths were also extracted from anchovy, sardine, horse mackerel, blue whiting and mackerel in order to estimate age and obtain the age-length key (ALK) for each species for each area.

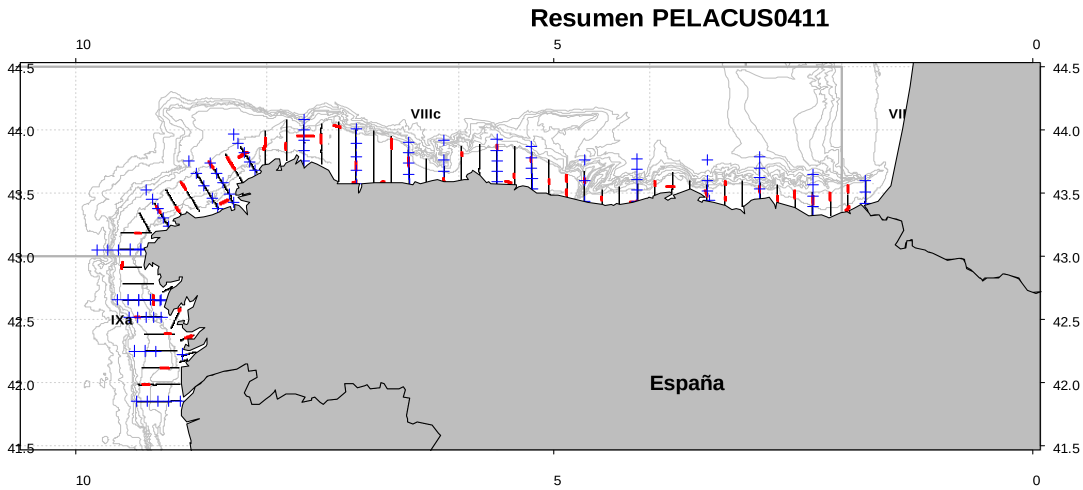


Figure 1. PELACUS00411 sampling effort. Black lines indicate acoustic transects, red lines indicate fishing stations, and blue crosses indicate hydrography stations.

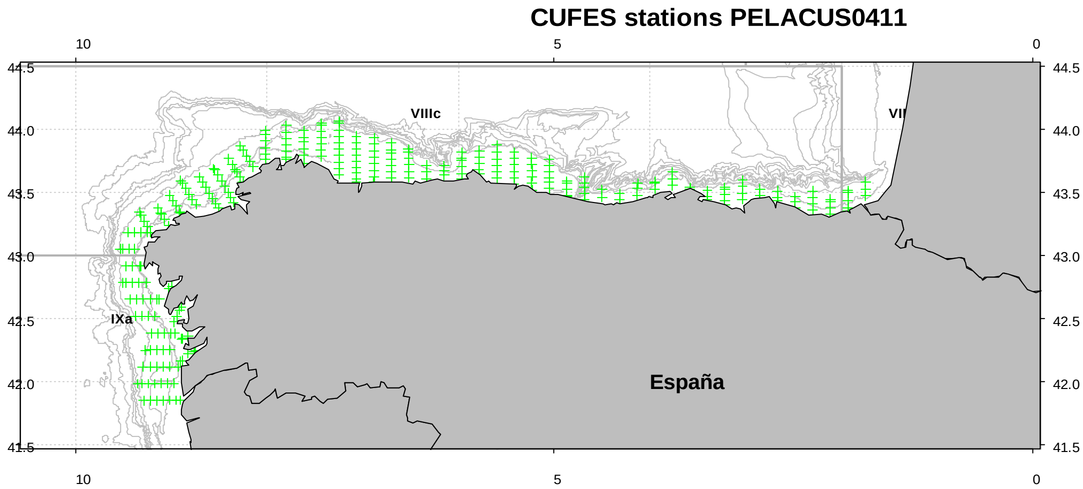


Figure 2. PELACUS00411 sampling effort. Green crosses indicate CUFES stations.

Results

Sardine

Sardine acoustic detection during the survey has been the lowest of the series, with values always below 1000 m^2/mn^2 and mainly concentrated in Asturias (ICES sub-area VIIIcE-w). Low detections were also found in the Basque country (ICES sub-area VIIIcE-e) and in the south of Galicia (ICES sub-area IXa-N) (Figure 4). Adult sardine were found in sufficient numbers to present a representative length distribution in only 10 of the 51 trawl hauls completed during the survey (see Figure 3). The total sardine abundance for the whole area surveyed was estimated as 151×10^6 individuals (of which 1.17×10^6 individuals were estimated in ICES division VIIIb, Table 1), while biomass was estimated at 11,768 tons (87 tons were estimated in ICES division VIIIb, Table 2). Of the 10 species for which abundance and biomass were determined during the survey, mackerel represented half of the total estimated biomass, followed by boarfish with 33.7% (Table 3). Sardine represented less than 2% of the total estimated biomass. Almost all the sardine detected during the survey (81% of the abundance and more than 87% of the biomass) was found in Asturias (ICES sub-area VIIIcE-w). In southern Galician waters (ICES sub-area IXaN) only 11% of the total biomass and 17% of the total abundance was detected.

Sardine ranged in length from 15.5 to 25.5. cm, with a mode at 22.5 cm (Figure 5) which corresponds to quite large fish. Most fish (33% of the abundance and 35% of the biomass) in the entire surveyed area were assigned as belonging to the age class 4

(Table 4, Figure 6). By sub-area, age 2 fish predominated in southern Galician waters (ICES sub-area IXa-N), while age 3 fish predominated in eastern Cantabrian waters (42% and 43% of abundance and biomass respectively in VIIIcE-e).

The distribution of sardine eggs (obtained from the analysis of 291 CUFES stations, Figure 2) indicates that contrary to the situation of adult fish, eggs have been found over most of the prospected area (although also predominantly in the Cantabrian Sea). In all areas, sardine eggs were found concentrated close to the coast (Figure 7).

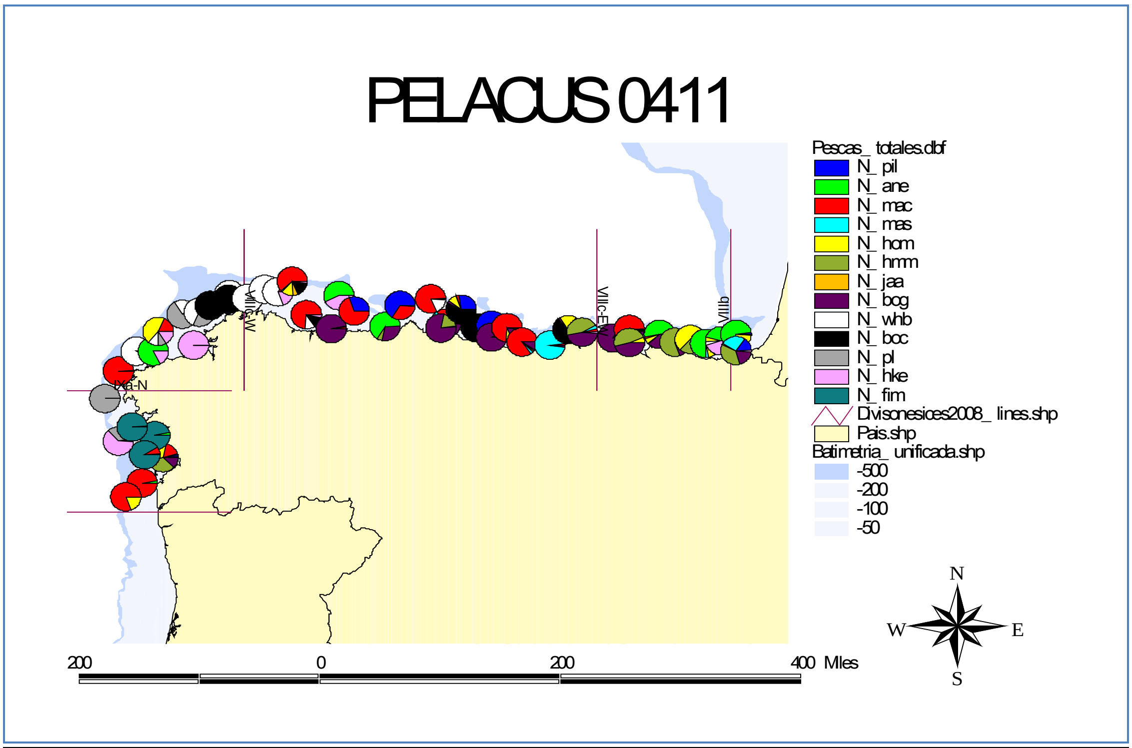


Figure 3. *Pelagic trawl location and species composition during PELACUS0411 (n = 51).*

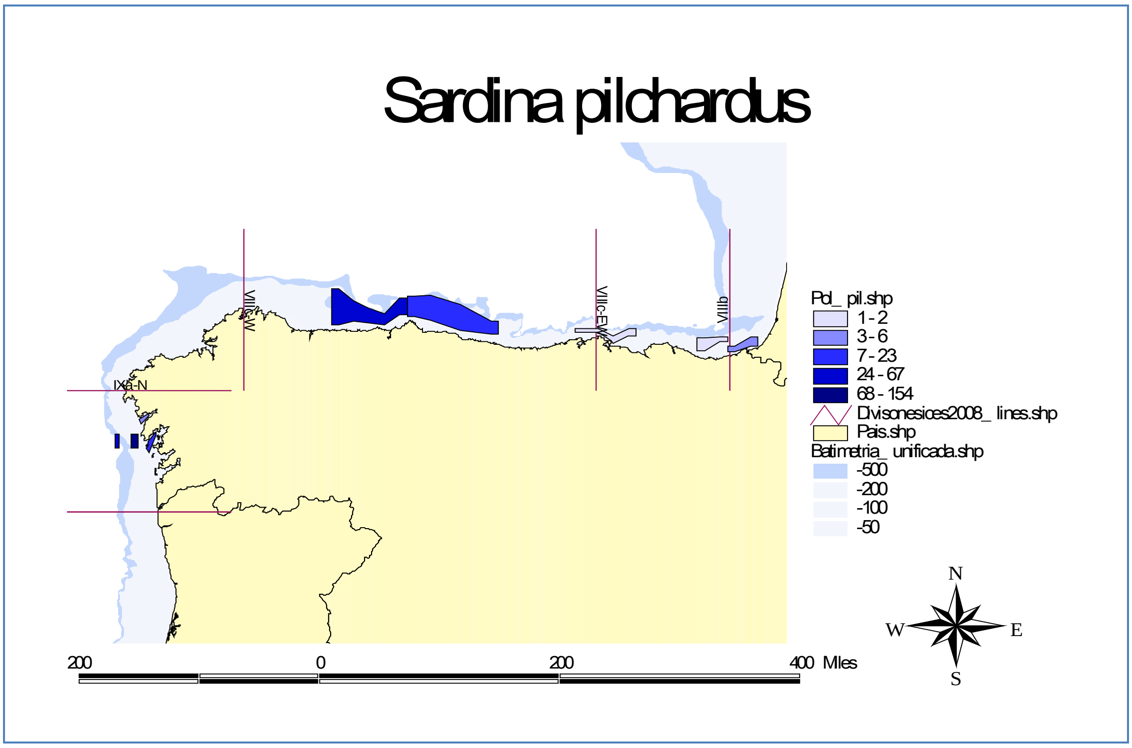
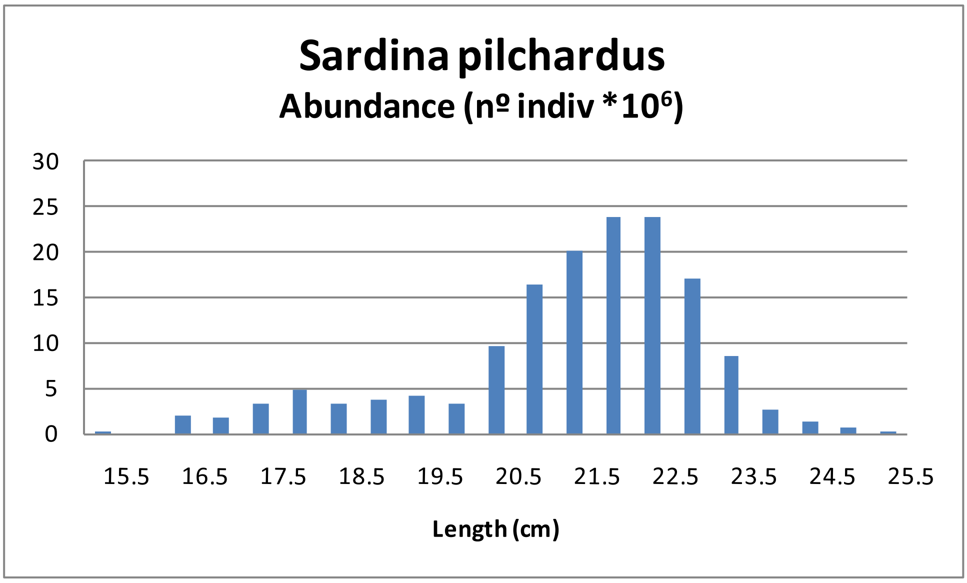


Figure 4. Sardine: spatial distribution of energy allocated to sardine during the PELACUS0411 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon.



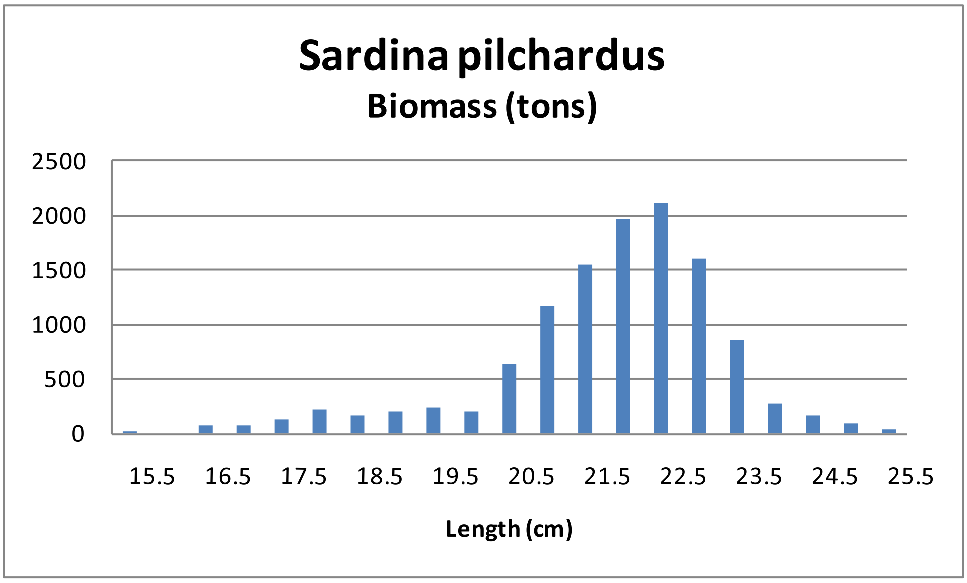
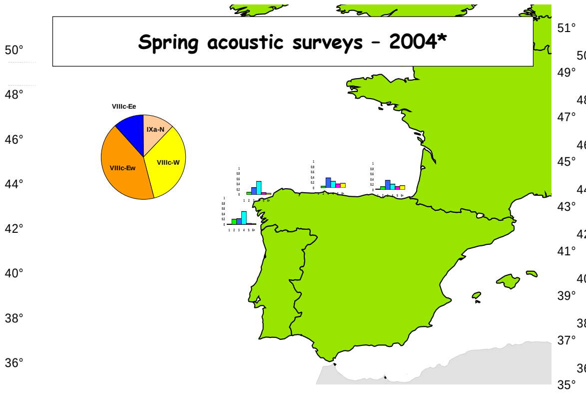
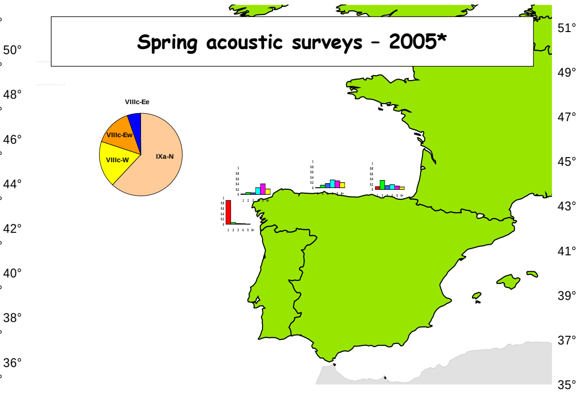
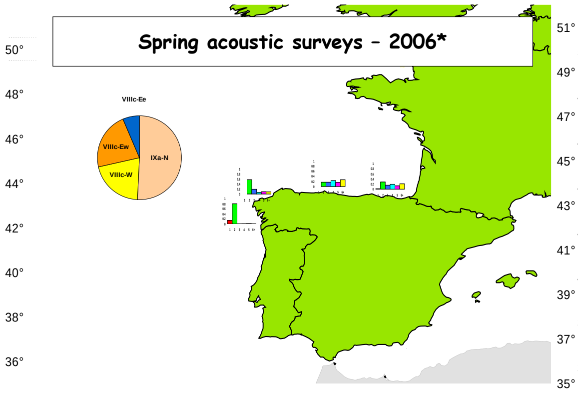
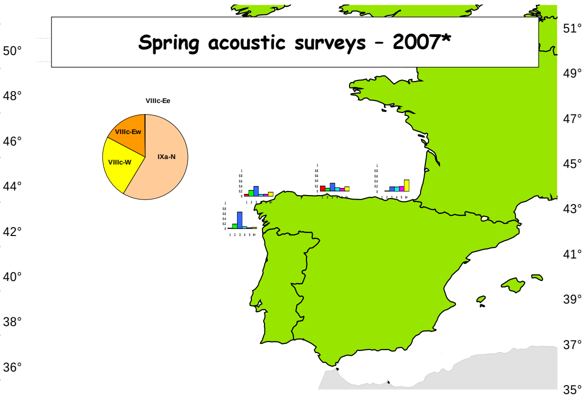


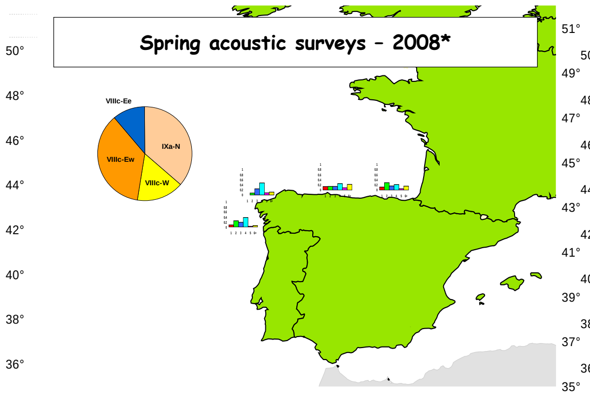
Figure 5. Sardine: fish length distribution in numbers (top) and biomass (bottom) during the PELACUS0411 survey.

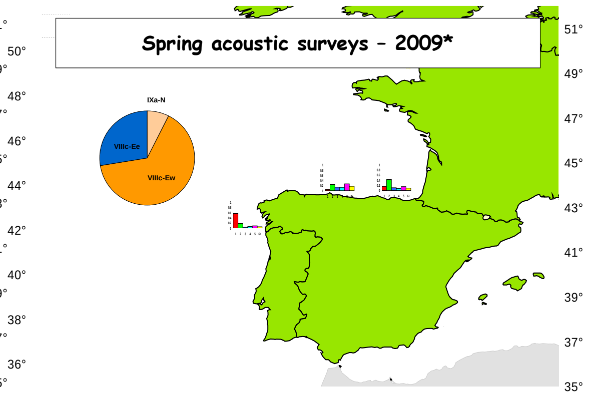

Spring acoustic surveys - 2004*
VIIIc-Ee
IXa-N
VIIIc-W
VIIIc-Ew

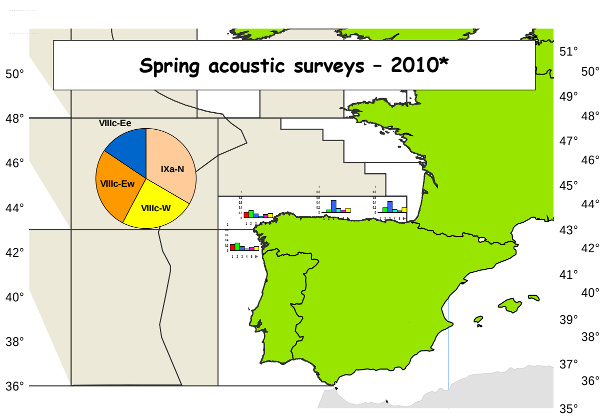

Spring acoustic surveys - 2005*
VIIIc-Ee
VIIIc-Ew
VIIIc-W
IXa-N


Spring acoustic surveys - 2006*
VIIIc-Ee
VIIIc-Ew
IXa-N
VIIIc-W


Spring acoustic surveys - 2007*
VIIIc-Ee
VIIIc-Ew
VIIIc-W
IXa-N


Spring acoustic surveys - 2008*
VIIIc-Ee
IXa-N
VIIIc-Ew
VIIIc-W


Spring acoustic surveys - 2009*
IXa-N
VIIIc-Ee
VIIIc-Ew


Spring acoustic surveys - 2010*
VIIIc-Ee
IXa-N
VIIIc-Ew
VIIIc-W

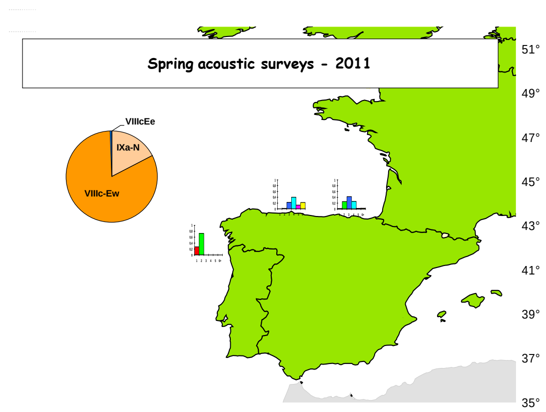

Spring acoustic surveys - 2011
VIIIcEe
IXa-N
VIIIc-Ew

Figure 6. Sardine: relative abundance at age in each sub-area (i.e. the proportion of all age classes within sub-area sum to 1) estimated in the PELACUS spring surveys (2004-2011). The pie chart shows the contribution of each sub-area to the total stock numbers.

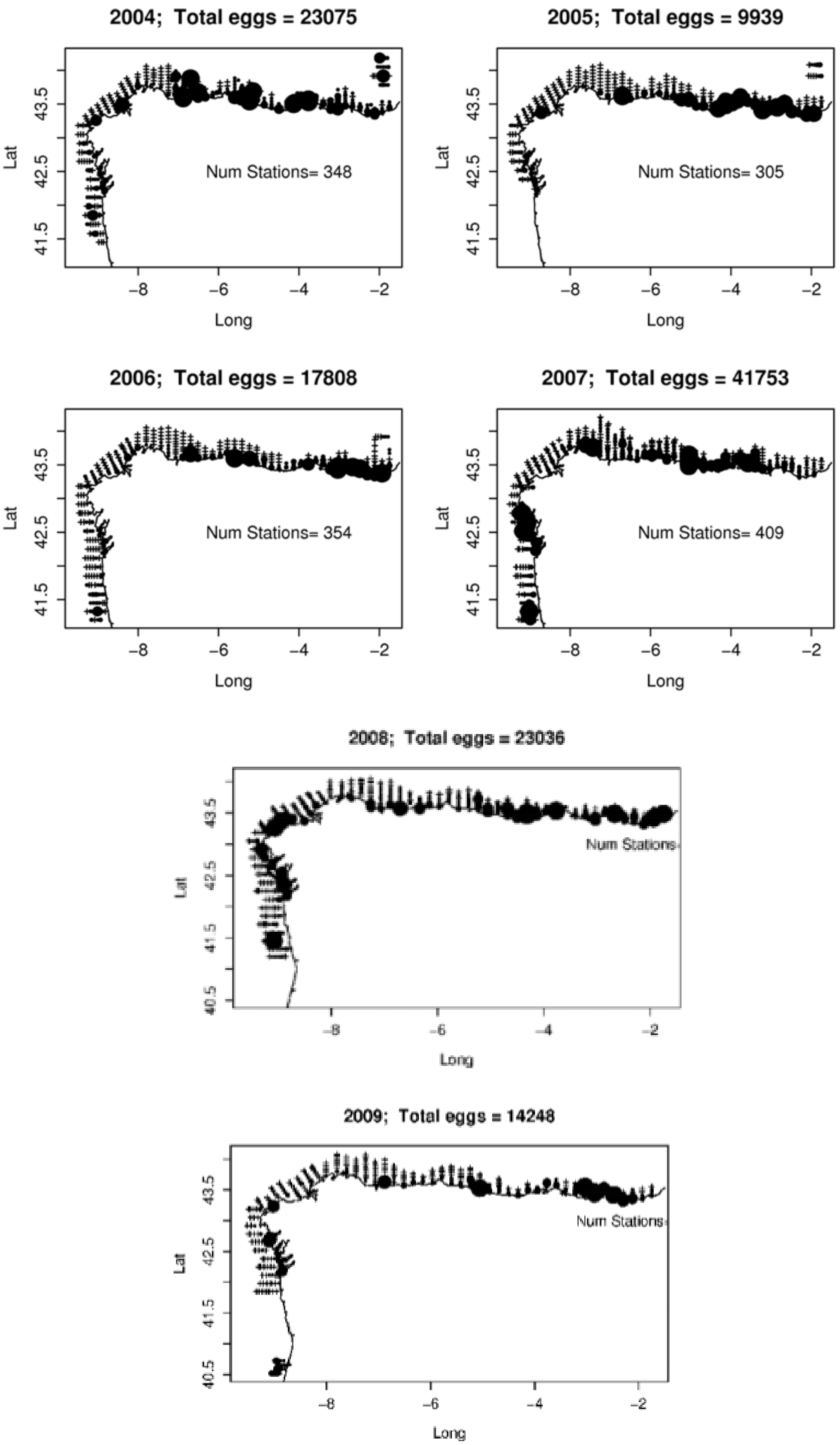
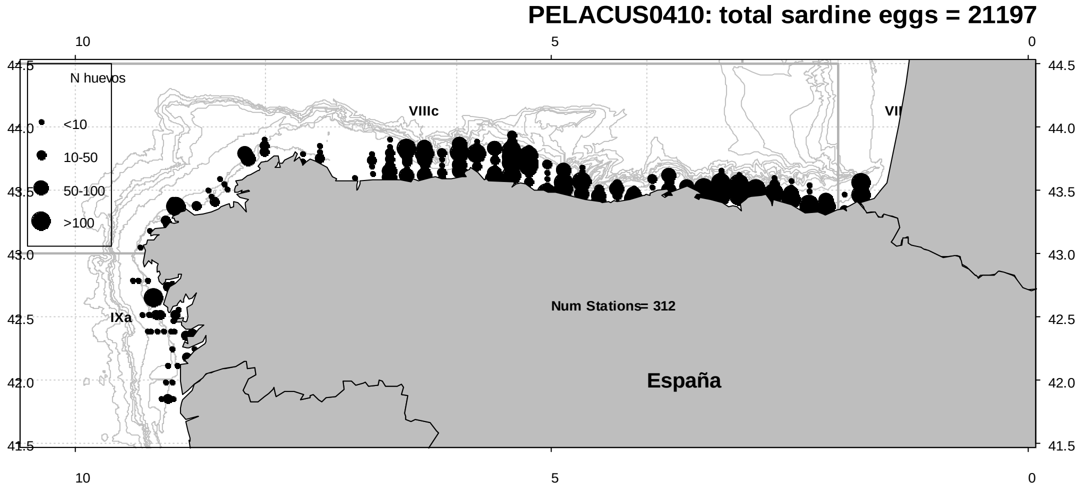

2004; Total eggs = 23075
Num Stations= 348
2005; Total eggs = 9939
Num Stations= 305
2006; Total eggs = 17808
Num Stations= 354
2007; Total eggs = 41753
Num Stations= 409
2008; Total eggs = 23036
Num Stations
2009; Total eggs = 14248
Num Stations
Lat
Long

Figure 7. Sardine: distribution of eggs through the PELACUS time series (2004-2011). Crosses indicate negative stations in 2004-2009, negative stations are not shown in 2010-11. Circles indicate positive stations with diameter proportional to egg abundance.



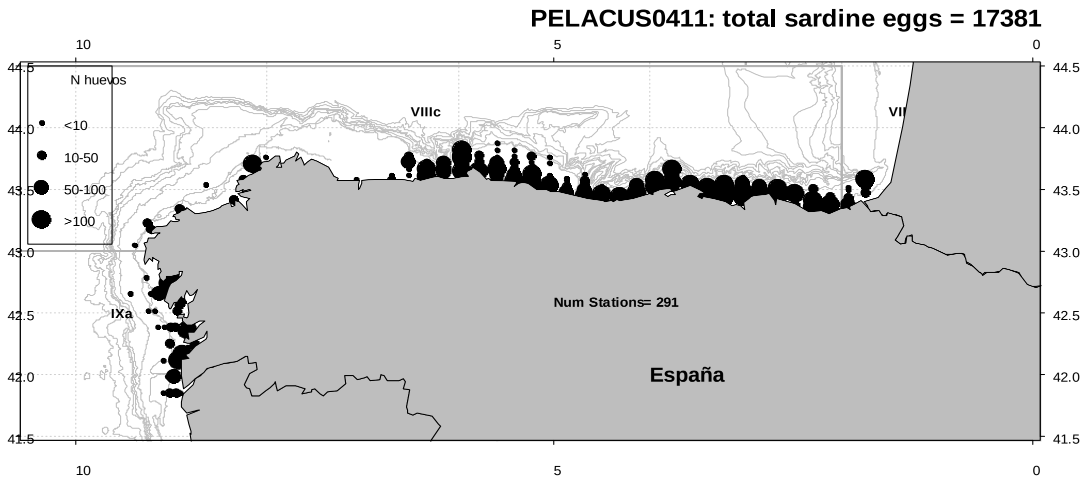


Figure 7. (Cont.)

Anchovy

Anchovy was caught in sufficient numbers to present a representative length distribution in 13 out of the 51 hauls carried out during the survey, with catches ranging from 1 to 60 kg. Anchovy abundance was estimated as 142×10^6 individuals (Table 3), while biomass was estimated at 2702 tons (Table 3). Fifty-five percent of the estimated biomass was detected in southern Galician waters (ICES sub-area IXa-N) while 33.5% of the total biomass was concentrated in the Basque Country – French border (ICES sub-areas VIIIcE-e and VIIIb respectively (see Figure 8). Positive anchovy hauls also took place in the area north of Finisterre (ICES subdivision VIIIcW) and in Asturias (ICES sub-area VIIIcE-w). Anchovy biomass represented 0.4% of the total estimated biomass by the ten pelagic species assessed in the survey (Table 3).

Anchovy ranged in length from 11 to 18.5 cm with a mode at 14.5 cm for biomass and for fish abundance (Figure 9). Applying the ALK obtained from the fish sampled in the survey, age 1 fish (2010 recruitment) dominated the sample in the Basque Country – French border and in Asturias. Very few anchovies of age 2 (2009 recruitment) were found and none of ages 3 and 4. In Galicia, age 2 fish followed closely by age 1 fish dominated the sample in the southern rías while the situation was the opposite north of Finisterre. Anchovy eggs were found throughout the whole of the ICES sub-area VIIIcE, although highest concentrations were recorded in the inner Bay of Biscay (Figure 10). In addition, low numbers of eggs were also found in the Galician rías (ICES sub-areas IXa-N and VIIIcW). The total number of recorded eggs in the survey was 2797.

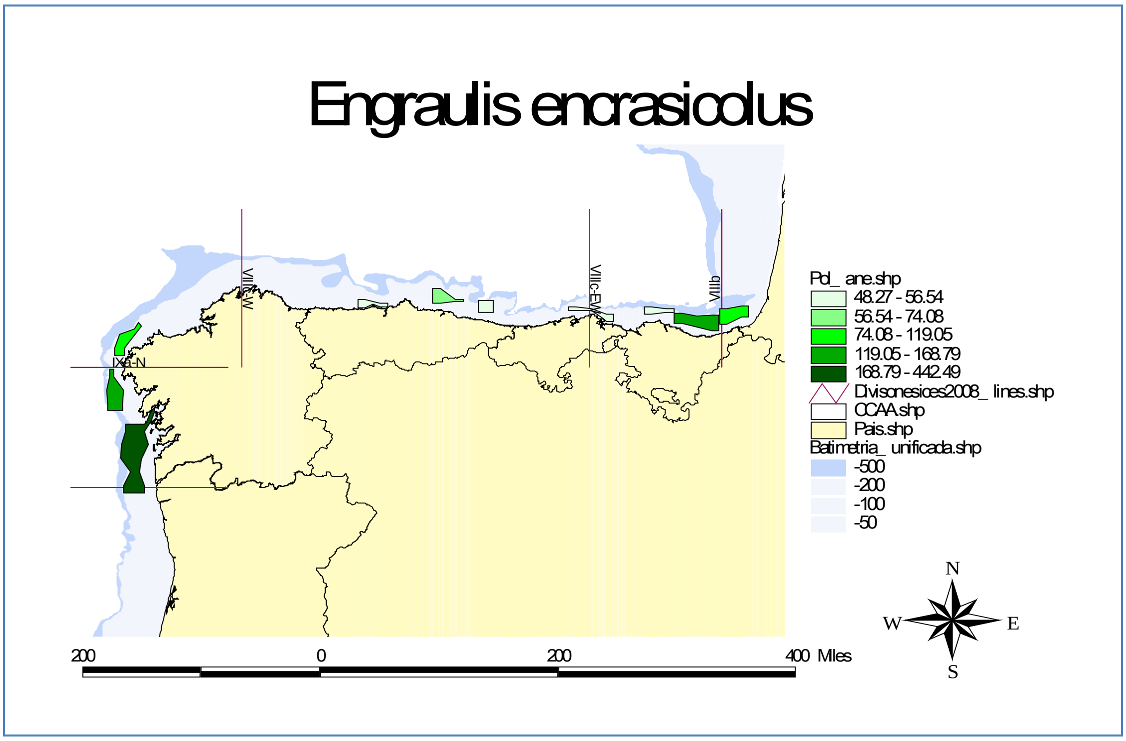
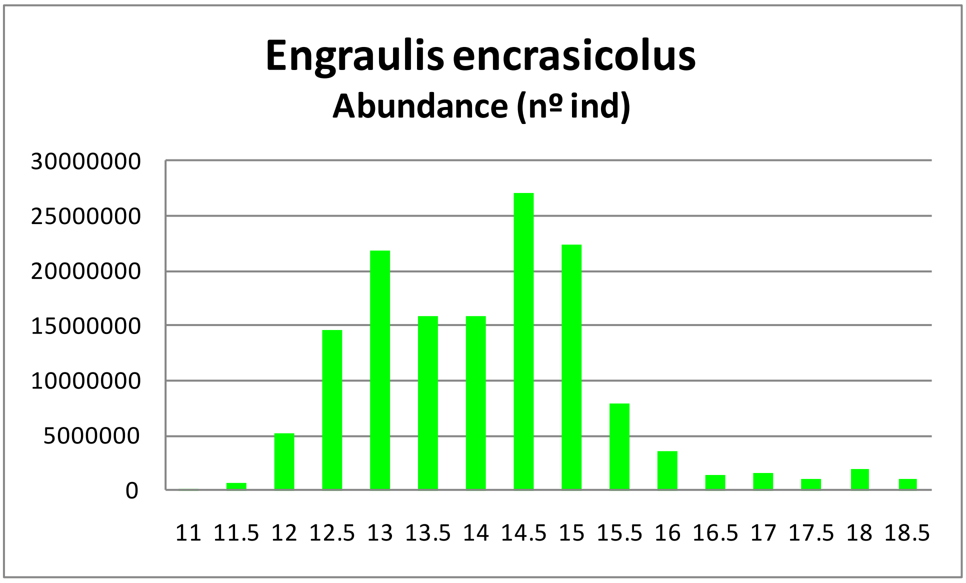


Figure 8. Anchovy: spatial distribution of energy allocated to anchovy during the PELACUS0411 survey. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon.



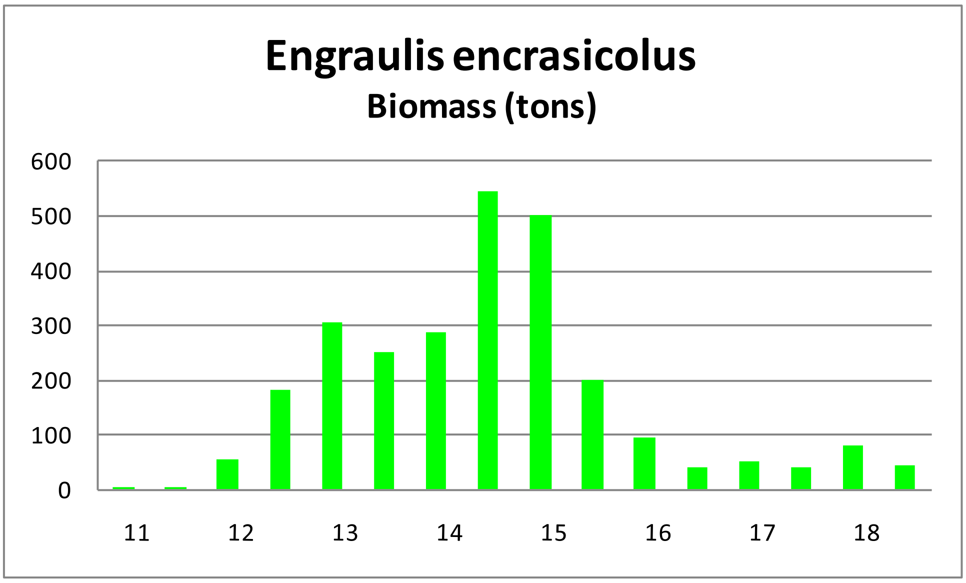
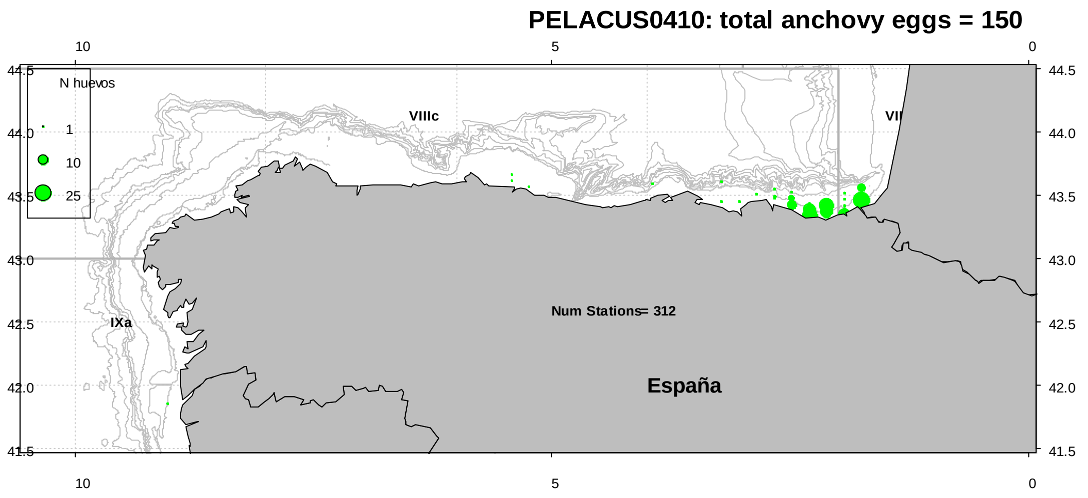


Figure 9. Anchovy: fish length distribution in numbers (top) and biomass (bottom) during the PELACUS0411 survey.



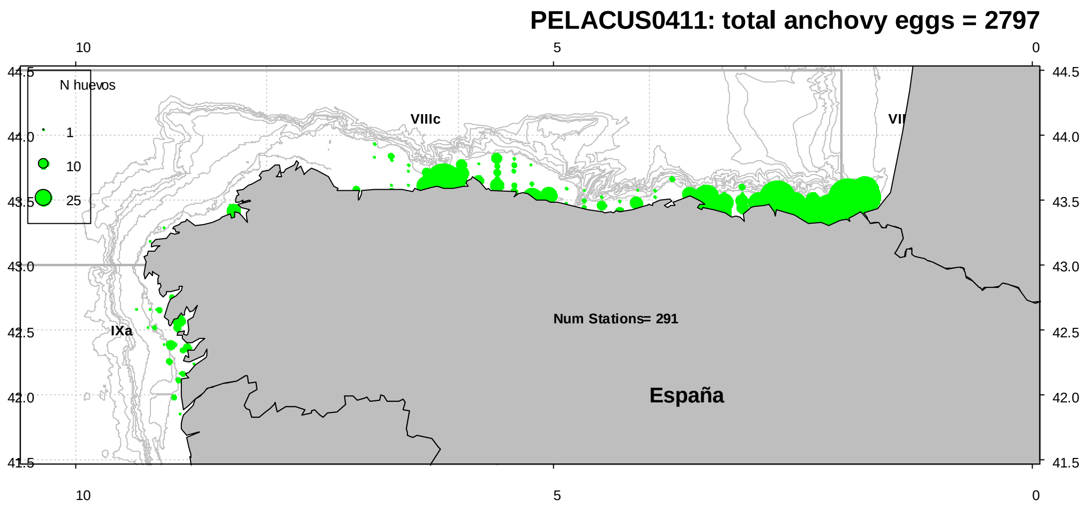


Figure 10. Anchovy: distribution of anchovy eggs detected during the PELACUS0410 (top) and PELACUS0411 (bottom) surveys. Green circles indicate positive stations with diameter proportional to egg abundance (see legend).

Table 1. Estimated sardine abundance (nº fish in thousands) by length class and ICES sub-area in PELACUS0411.

	ICES Sub-area					
Length class	**IXa-N**	**VIIIc-W**	**VIIIc-EW**	**VIIIc-EE**	**VIIIb**	**Total**
15.5	314	0	0	0	0	**314**
16	0	0	0	0	0	**0**
16.5	1884	0	0	0	0	**1884**
17	1570	0	220	8	0	**1798**
17.5	2826	0	414	5	0	**3245**
18	4710	0	167	8	38	**4923**
18.5	3140	0	167	36	19	**3363**
19	3454	0	167	52	19	**3692**
19.5	3768	0	247	64	96	**4175**
20	1256	0	1887	110	115	**3369**
20.5	2198	0	7157	138	115	**9608**
21	942	0	15020	164	250	**16376**
21.5	0	0	19715	96	211	**20022**
22	0	0	23604	68	96	**23768**
22.5	0	0	23760	54	135	**23949**
23	0	0	16927	27	19	**16973**
23.5	0	0	8489	11	0	**8500**
24	0	0	2581	3	19	**2603**
24.5	0	0	1385	11	19	**1415**
25	0	0	669	0	19	**688**
25.5	0	0	220	0	0	**220**
Total	**26060**	**0**	**122797**	**854**	**1173**	**150884**

Table 2. Estimated sardine biomass (tons) by length class and ICES sub-area in PELACUS0411.

	ICES Sub-area					
Length class	**IXa-N**	**VIIIc-W**	**VIIIc-EW**	**VIIIc-EE**	**VIIIb**	**Total**
15.5	9		0	0	0	**9**
16	0		0	0	0	**0**
16.5	65		0	0	0	**65**
17	60		8	0	0	**68**
17.5	117		17	0	0	**134**
18	212		8	0	2	**222**
18.5	154		8	2	1	**165**
19	183		9	3	1	**196**
19.5	216		14	4	6	**240**
20	78		117	7	7	**209**
20.5	147		478	9	8	**641**
21	68		1078	12	18	**1176**
21.5	0		1520	7	16	**1544**
22	0		1951	6	8	**1964**
22.5	0		2102	5	12	**2119**
23	0		1601	3	2	**1605**
23.5	0		857	1	0	**858**
24	0		278	0	2	**280**
24.5	0		159	1	2	**162**
25	0		81	0	2	**84**
25.5	0		28	0	0	**28**
Total	**1308**	**0**	**10313**	**60**	**87**	**11768**

Table 3. Abundance (in million individuals) and biomass (in tons) acoustic estimates for the different pelagic species assessed in all the PELACUS0411 surveyed area: Sp = Sardina pilchardus, Ee= Engraulis encrasicolus, Ss= Scomber scombrus, Sc= Scomber colias, Tt = Trachurus trachurus, Tp = Trachurus picturatus, Tm = Trachurus mediterraneus, Bb = Boops boops, Mp = Micromesistius poutassou, Ca = Capros aper.

	Sp	Ee	Ss	Sc	Tt	Tm	Tp	Bb	Mp	Ca	Total
Abundance	151	142	2583	42	54	35	2	132	146	3519	**6806**
Biomass	11768	2702	363669	12794	10582	8547	486	27005	4833	224879	**667265**

Table 4. Sardine abundance in number (thousand fish) and biomass (tons) by age group and ICES sub-area in PELACUS0411.

AREA VIIIcE east					**AGE**						
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	0	12	26	17	2	1	1	0	0	0	60
% Biomass	0.7	20.9	42.8	29.2	2.7	1.4	1.7	0.5	0.3	0.0	100
Abundance (in '000)	11	218	362	223	18	9	10	3	1	0	854
% Abundance	1.3	25.5	42.4	26.1	2.1	1.0	1.2	0.3	0.2	0.0	100
Medium Weight (gr)	38.8	57.2	70.6	78.4	89.8	92.3	101.9	113.9	113.4	0.0	79.7
Medium Length (cm)	17.4	19.7	21.1	21.8	22.8	23.0	23.8	24.7	24.7	0.0	20.2
AREA VIIIcE west	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	13	143	2120	4084	1400	836	484	322	401	511	10313
% Biomass	0.1	1.4	20.6	39.6	13.6	8.1	4.7	3.1	3.9	5.0	100
Abundance (in '000)	317	2378	27644	49436	16208	9616	5102	3274	3966	4855	122797
% Abundance	0.3	1.9	22.5	40.3	13.2	7.8	4.2	2.7	3.2	4.0	100
Medium Weight (gr)	40.2	60.2	76.7	82.6	86.4	86.9	94.8	98.4	101.2	105.3	80.8
Medium Length (cm)	17.6	20.0	21.7	22.2	22.5	22.6	23.3	23.5	23.8	24.1	21.9
AREA VIIIcW	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	0	0	0	0	0	0	0	0	0	0	0
% Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Abundance (in '000)	0	0	0	0	0	0	0	0	0	0	0
% Abundance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Medium Weight (gr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medium Length (cm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AREA IXaN	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	285	1023	0	0	0	0	0	0	0	0	1308
% Biomass	21.8	78.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
Abundance (in '000)	7168	18892	0	0	0	0	0	0	0	0	26060
% Abundance	27.5	72.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
Medium Weight (gr)	39.8	54.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7
Medium Length (cm)	17.5	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1
TOTAL SPAIN	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAL**
Biomass (tons)	298	1179	2145	4101	1401	836	485	322	402	511	11681
% Biomass	2.6	10.1	18.4	35.1	12.0	7.2	4.2	2.8	3.4	4.4	100
Abundance (in '000)	7496	21488	28007	49659	16226	9625	5112	3277	3968	4855	149711
% Abundance	5.0	14.4	18.7	33.2	10.8	6.4	3.4	2.2	2.7	3.2	100
Medium Weight (gr)	39.8	54.9	76.6	82.6	86.4	86.9	94.8	98.4	101.2	105.3	82.7
Medium Length (cm)	17.5	19.4	21.7	22.2	22.5	22.6	23.3	23.5	23.8	24.1	22.1

Discussion

Sardine abundance in northwestern Spanish waters (Galicia) has always depended on the occurrence of strong recruitments in northern Portugal (the main recruitment area for the stock over the last 2 decades). Young fish of the year will appear in southern Galician waters where they would be the target of the purse seine fishery in summer - together with adult fish that would be performing a feeding migration (Carrera & Porteiro, 2003). The consequences of the series of consecutive low or average recruitments since 2004 have been picked up by the PELACUS surveys, with a continuing decrease of both abundance and sardine biomass in Spanish waters since 2002 (Figure 11). The good 2004 recruitment stopped this downward trend for a few years (although values obtained for number of fish per age class seem to indicate that it was not at the level of the 2000 recruitment at least in Spanish waters) but evidence from both commercial catches and survey indicates that this cohort has disappeared. At present both abundance and biomass are at the lowest levels ever recorded. In the Cantabrian Sea, influence of the movement of fish from French waters - where strong recruitments have been detected by the French acoustic survey PELGAS - is likely. However, the PELACUS estimates also show a downward trend in biomass in recent years (Figure 11).

Because the main bulk of the Iberian sardine stock (considered as a single unit for management purposes, see ICES, 2006) is located in Portuguese waters, results from the Portuguese survey (PELAGOS) are important to obtain a more complete image of the stock status. The PELAGOS spring survey has also shown a decrease in both sardine abundance and biomass since 2006, both time series reaching their lowest values to date in 2011 (Marques et al., 2011).

Sardine eggs were still found throughout most of the PELACUS surveyed area in 2011 with the total number of eggs being similar that encountered in the 2010 survey (taking into account the small reduction in stations sampled in 2011 compared with 2010). However, there has been a decrease in the relative number of positive stations between both surveys and sardine eggs have been found concentrated close to the coast throughout the area (a situation that has not been apparent to such a extent before: for comparison Figure 7 shows the egg distribution found throughout the PELACUS time series, 2004-11). Eggs have also been found in high numbers inside the rias in southern Galicia, a situation that has persisted since 2007 in contrast with previous years when almost no eggs were found in this area. CUFES results should be used with caution since egg distribution and abundance are likely to be heavily influenced by the predominant winds and current prevalent in the area immediate before and during the sampling. For comparison, results from the Spanish DEPM survey (SAREVA), which covered the same area of PELACUS at the same time, show a somewhat different situation, with very few sardine eggs recorded in the whole of Galicia (Figure 12).

Pooling together the evidence provided by the acoustic and DEPM surveys taking place in 2011, and the overview of the stock trend provided by previous surveys, the sardine stock seem to have been gradually contracting its distribution towards the core of the stock situated in northern Portuguese waters in parallel to a decrease in stock size. In Spanish waters there also seems to have been a concentration of the remaining individuals in coastal waters, which has probably made the fish even more vulnerable to fishing and could explain why catches have not decreased in 2010 in spite of decreasing abundance. In 2011, fishermen have complained of lack of sardine in Galician waters during the first quarter of the year, and the sales of fish in the harbours have reflected this low availability, with sales not picking up until April-May.

The situation for anchovy is somewhat less grim. Although PELACUS surveys are not good indicators of the state of the Bay of Biscay anchovy stock (since they cover only a small area of the stock distribution), they can provide useful information on the extent of the fish distribution as stock size fluctuates. Since 2009 there has been an increase in the number of adult fish and eggs but also in the spatial distribution where adult fish and eggs have been encountered (for comparison Figure 10 shows the egg distribution found in the 2010 and 2011 surveys). The effect of the closure of the fishery was apparent in the results from the surveys, with more fish and also with the appearance of older age classes in the hauls (Figure 13). Results from the 2011 survey indicate that there seems to have been a very good recruitment in 2010 with the majority of the fish being now 1 year old. Older fish (2, 3 years old) are now only apparent in the hauls taken in area IXaN. Anchovy in this area had always shown a different age distribution from the Bay of Biscay stock, with different age classes (from 1 to 5+) present every year without a clear pattern. These fish correspond to small residual populations isolated inside the rías.

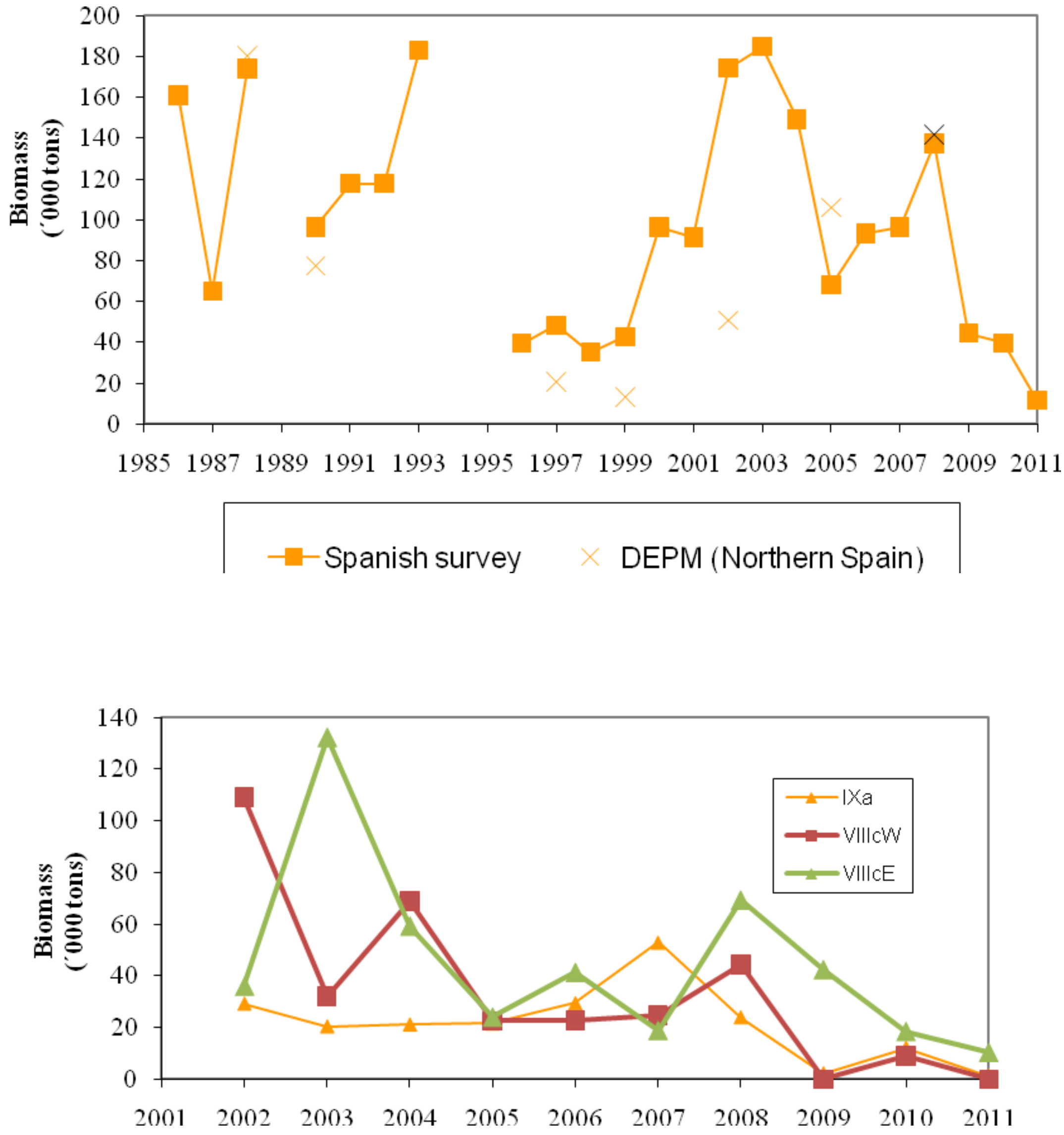


Figure 11. Sardine: values of biomass (thousand tons, top) estimated during the PELACUS spring acoustic surveys (2001-2011). The bottom graph illustrates the sardine biomass estimated by ICES sub-area during the PELACUS surveys (2002-2011).

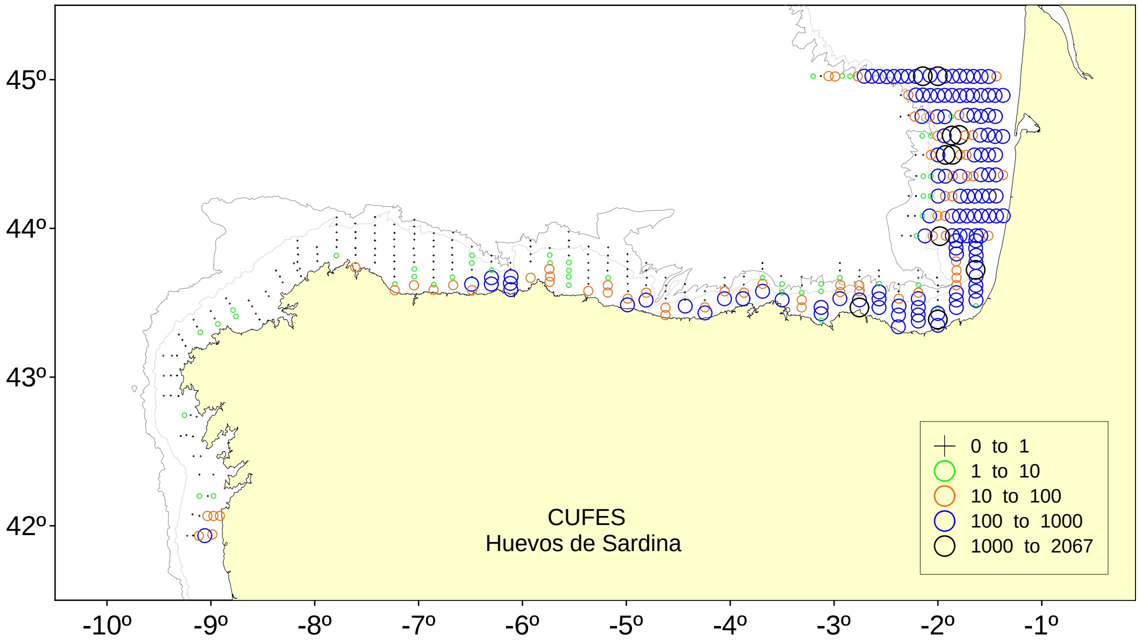
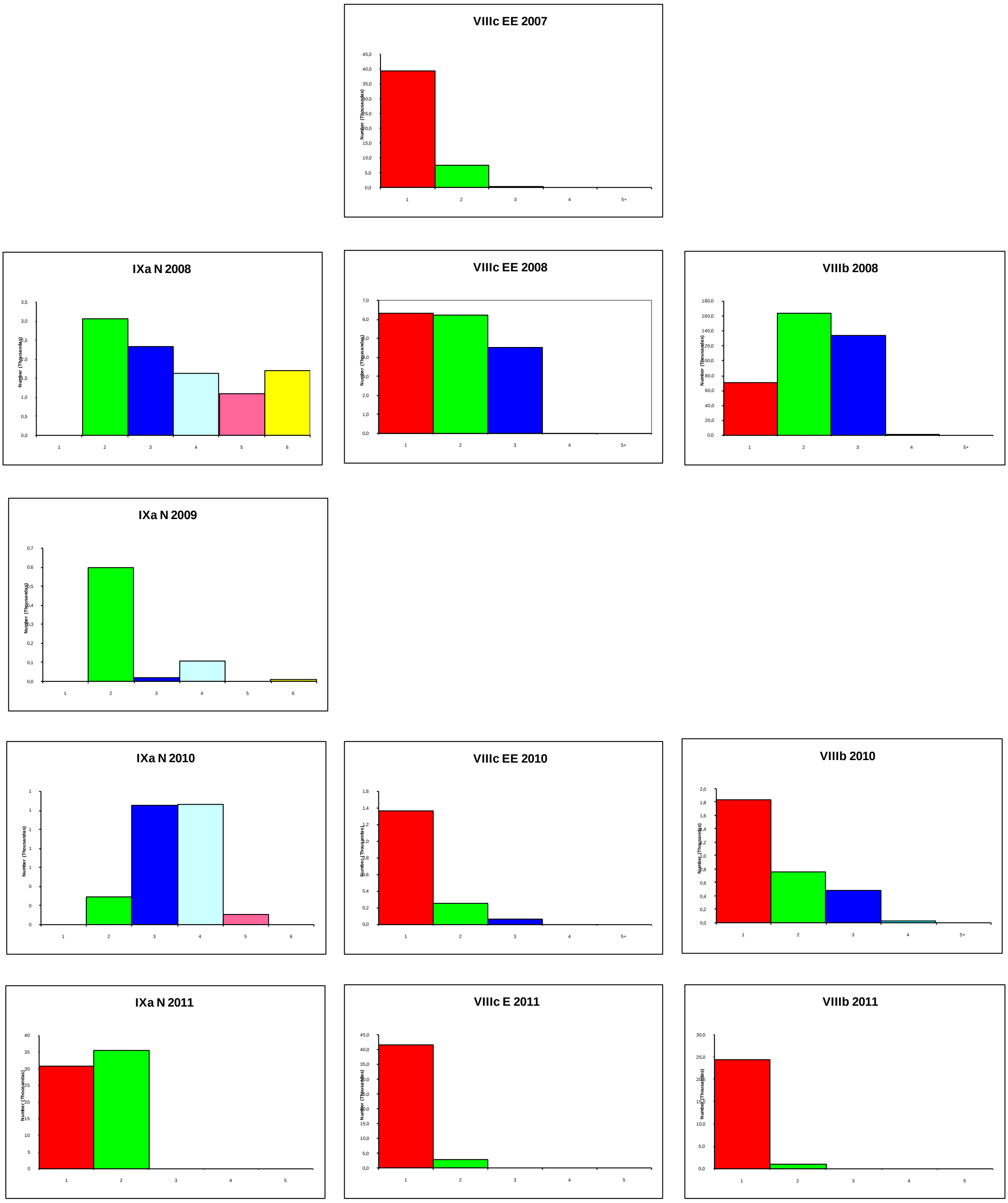


Figure 12. Sardine: distribution of sardine eggs detected during the SAREVA11 survey. Crosses indicate negative stations while open circles indicate positive stations with colour proportional to egg abundance (see legend).

Figure 13. Anchovy: abundance at age in each sub-area estimated in the PELACUS spring surveys (2007-2011).



Acknowledgements

We would like to thank all the participants and crew of the PELACUS surveys.

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Working Document to be presented to the Working Group on Anchovy and Sardine, Vigo, 24-28 June 2011

A.3.3 Sardine acoustic survey carried out in April-May 2011 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 shows a reduction in sardine and anchovy biomass. The sardine abundance was the lowest of the time series, following the tendency of the last years. In the Occidental north zone (OCN), the distribution area was very narrow. Age 2 sardines (2009 year class) were predominant in OCN area; in the Occidental south zone (OCS) the age 1 year class was predominant.

The anchovy abundance suffered a strong reduction in the Cadiz Bay area, where it practically disappears. On the contrary in the OCN zone anchovy was more abundant than ever and was mixed with sardine schools.

The 2011 spring acoustics survey took place three to four weeks later than usual. Plankton production was established and maximum sea surface temperature was slightly higher than during previous campaigns.

INTRODUCTION

This paper presents the main results of the Portuguese acoustic survey carried out during April/May 2011 onboard R. V. "Noruega". The objectives of the survey were to estimate the spatial distribution and the abundance of sardine (*Sardina pilchardus*) and anchovy (*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. The European DCF partially supports this survey.

MATERIAL AND METHODS

Survey execution and abundance estimation followed the methodologies adopted by the WGACEGG ICES working group. The surveyed area, limited by 20 m and 200 m isobaths, was covered following a parallel grid with a mean distance between transects of 8 nautical miles. Average survey speed was 9-10 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. 672 sardine otolith pairs were collected and used for age reading and for the production of the Age Length Keys (ALK's). Due to the absence of sardine samples in the OCS and CAD areas, ALK's from the respective adjacent areas were used for the estimation of abundance of sardine by age group (Table 3) and for the production of respective abundance distribution graphics (Figure 4): ALK of OCN area were used for OCS area and ALK of ALG for CAD area (Annex I - Tables 1 and 2). The sardine abundance (x 1 000) by age group and area were estimated based on the frequency by age group and length class from ALK's extrapolated to the sardine abundance by length class estimated by sardine echointegration in each area.

Fish egg and larvae were collected using the CUFES system (335 µm mesh net). The water is 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 are acquired by the sensors associated with the CUFES sampler and GPS information gathered from the vessel system; compilation is carried out using the EDAS software.

RESULTS

TRAWL HAULS

During the survey only 18 trawl hauls were performed (Figure 1) due to the lack of fish, mainly in the OCS and Cadiz zones. Sardine was the dominant species in the West Coast, between Caminha and Cape Espichel, and was frequently mixed with anchovy in the OCN zone. In the remaining Portuguese coast sardine was usually captured together with other pelagic species: horse mackerel (*Trachurus trachurus*), mediterranean horse mackerel (*Trachurus mediterraneus*), chub mackerel (*Scombrus colias*) and bogue (*Boops boops*).

SPATIAL DISTRIBUTION

Sardine

As seen in Figure 2 sardine was mainly distributed over the Western coast from Caminha to Cape Espichel. In the Northern West area (OCN) sardine was detected mainly near shore, being more abundant between Porto and Figueira da Foz. In the Southern West area (OCS), sardine was scarce. In Algarve (ALG) the main sardine concentrations were found in the Western part, between Sagres and Faro. In the Cadiz Bay (CAD) sardine was very scarce being absent in the eastern part.

Anchovy

Anchovy was distributed mainly in the North, between Caminha and Nazaré, sharing the area with sardine schools (Figure 5). In the remaining area, anchovy was practically absent, mainly in the Cadiz bay, where it is usually found.

ABUNDANCE ESTIMATES

Sardine

The estimated biomass for the Portuguese coast was 124 thousand tonnes corresponding to 2751 million individuals (Tables 1 and 2), the lowest abundance in the survey series (Figure 3). In the OCN area the estimated abundance was slightly lower than for recent surveys, and the sardine was concentrated near shore, mixed with anchovy schools. On the contrary in the OCS area sardine abundance was one of the lowest of the series (15 thousand tonnes; 397 million individuals). Algarve registered an increase of sardine abundance with an estimation of 20 thousand tonnes (465 million individuals). The sardine abundance in Cadiz area was the lowest of the series (2 thousand tonnes; 71 million individuals).

Anchovy

The total biomass estimated was 27 thousand tonnes (1558 x 10^6 individuals), within the average value for the entire time series (Table 5), but only distributed in OCN zone, as pointed out before.

SARDINE LENGTH AND AGE STRUCTURE

The sardine length structure in the OCN area was bimodal, with the adult's mode dominating the length distribution. In the remaining three areas it was clearly bimodal, with a less expressive second mode of larger individuals in the Cadiz area (Figure 2). Only 11% of sardines in the OCN area were juveniles (with individual total length ≤ 16 cm). In the OCS area, 58% of the individuals were juveniles, mainly distributed off Cascais and Cape da Roca. In Algarve juveniles represented 49% of the sardine abundance estimated for this area, while in the Cadiz area, the juvenile's percentage was 69%.

The sardine age structure (Table 3, Figure 4) shows that age group II (2009 annual class) was clearly dominant in OCN area, followed by age group I (2010 annual class). In the remaining areas age group I was dominant, being more evident in the OCS area.

SURFACE TEMPERATURE, SALINITY AND FLUORESCENCE DISTRIBUTIONS

During the month of April the weather conditions were very unstable over the Iberian shores with episodes of heavy rain and gale force winds from variable directions. The temperature, salinity and fluorescence distributions shown in figure 6 A, B, C reflect the prevailing conditions in the region during the 2011 spring period. River outflow are evident for the major systems, this can be observed not only in the temperature/salinity signatures but also in the phytoplankton concentration that can be inferred from the fluorescence distribution. High fluorescence values appeared in other coastal areas where the associated lower temperature may indicate upwelled waters and nutrient availability. Zooplankton production was also well underway and that was observed in CUFES samples and corroborated by the acoustic energy attributed to DBT. Surface temperature ranged from 15 to 20.5ºC. These values were slightly higher than in other spring surveys, in particular in the west coast, but the 2011 campaign was carried out later than in previous years. Nevertheless, surface temperature in the southern coast was lower during the 2011 survey than in the preceding spring, higher temperatures were limited to the shallower, inner, Gulf of Cádiz.

Sardine spawning area represented in figure 6 D was derived from egg presence/absence registered onboard (more precise and detailed data will be available after laboratorial processing). The area occupied by sardine eggs in April-May 2011 was smaller than in other spring periods. This was particularly clear for some regions, promontório da Estremadura, where high abundance of egg and larvae are usually observed, further north between Cabo Carvoeiro and Aveiro and also in western Algarve. Despite the fact that the campaign was conducted later into the reproductive season a high proportion of the population was still active. The decline in the number of sardine eggs collected (work in progress) is in agreement with the drop in fish biomass observed by echosounding. Similarly to past acoustic surveying, sardine eggs were collected in regions where no fishes were detected (SW coast and W of Cádiz).

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Table 1 – Sardine: Abundance (billion) in each zone, Portugal and total area, for the acoustic surveys carried out between May 1995 and April 2011.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR95MAI	1627	2117	2661	4113	6405	10518
SAR96FEV	1037	2718	2148	3523	5903	9426
SAR96JUL	3105	2914	1986	2673	8005	10678
SAR97MAR	4760	3735	1904	3558	10399	13957
SAR97NOV	2801	3447	1908	-	8156	-
SAR98MAR	4750	3129	1282	2279	9161	11440
SAR98NOV	7072	4421	2018	7657	13511	21168
SAR99MAR	4447	831	862	5495	6140	11635
SAR99NOV	3402	1599	1537	1328	6538	7866
SAR00MAR	3685	2715	1011	4463 (65%)	7411	11875 *
SAR00NOV	29399	2984	723	2909	33106	36015
SAR01MAR	13531	3093	1107	3547	17223	20770
SAR01NOV	7918	6542	1751	9765	16210	25976
SAR02MAR	7963	3631	2871	6263	14466	20728
SAR03FEV	4861	5370	1201	1858	11433	13290
SAR03NOV	3333	2820**	626	-	6779	-
SAR04JUN	8954	1884	734	-	11572	-
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

* only 65% of Cadiz area was covered

** 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 May 1995 and April 2011.

Survey	OCN	OCS	Algarve	Cadiz	Portugal	Total Area
SAR95MAI	105	133	133	168	371	539
SAR96FEV	27	118	106	154	251	405
SAR96JUL	154	165	108	82	427	509
SAR97MAR	153	152	96	107	401	508
SAR97NOV	87	135	106	-	328	-
SAR98MAR	191	131	65	97	387	484
SAR98NOV	151	137	95	238	383	621
SAR99MAR	158	35	39	191	232	423
SAR99NOV	89	32	92	58	213	271
SAR00MAR	98	90	59	122 (65%)	247	370 *
SAR00NOV	555	43	31	81	629	710
SAR01MAR	333	40	24	88	408	496
SAR01NOV	281	147	55	292	483	775
SAR02MAR	233	96	105	181	434	615
SAR03FEV	153	145	60	73	359	432
SAR03NOV	95	90**	37	-	222	-
SAR04JUN	240	60	39	-	339	-
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

* only 65% of Cadiz area was covered

** the area between Capes Espichel and S. Vicente was not covered.

*** part of Algarve was not covered

Table 3 – Sardine abundance (x1 000) by age group and area

Age Group	OCN	OCS	ALG	CAD
1	340032	244230	149943	22804
2	882911	32804	83575	12710
3	182654	15673	95865	14580
4	95090	13479	44245	6729
5	44609	12004	36871	5608
6	115254	36711	36871	5608
7	97136	38450	14748	2243
8	4776	2539	2458	374
9	1527	705	0	0
10	1259	473	0	0
TOTAL	**1765249**	**397070**	**464577**	**70655**

Tabela 4 – anchovy: estimated biomass (tonnes) for the West coast, South coast and total area.

Survey	west	South	TOTAL
April2011	**27050**	**0**	**27050**
April 2010	1188	7395	8583
April2009	2000	24800	26800
April 2008	5500	34200	39700
April 2007	1945	38020	39965
April 2006	0	24082	24082
April 2005	1062	14041	15103
March 2002	1542	21335	22877
March 2001	368	24913	25281
March 1999	596	24763	25359

Tabela 5 – anchovy: estimated abundance (billion) for the West coast, South coast and total area.

Survey	west	South	TOTAL
April 2011	**1558**	**0**	**1558**
April 2010	62	963	1025
April2009	127	2069	2196
April 2008	321	2032	2353
April 2007	103	3144	3247
April 2006	0	2247	2247
April 2005	59	1306	1365
March 2002	178	3823	4001
March 2001	38	2700	2738
March 1999	37	2079	2116

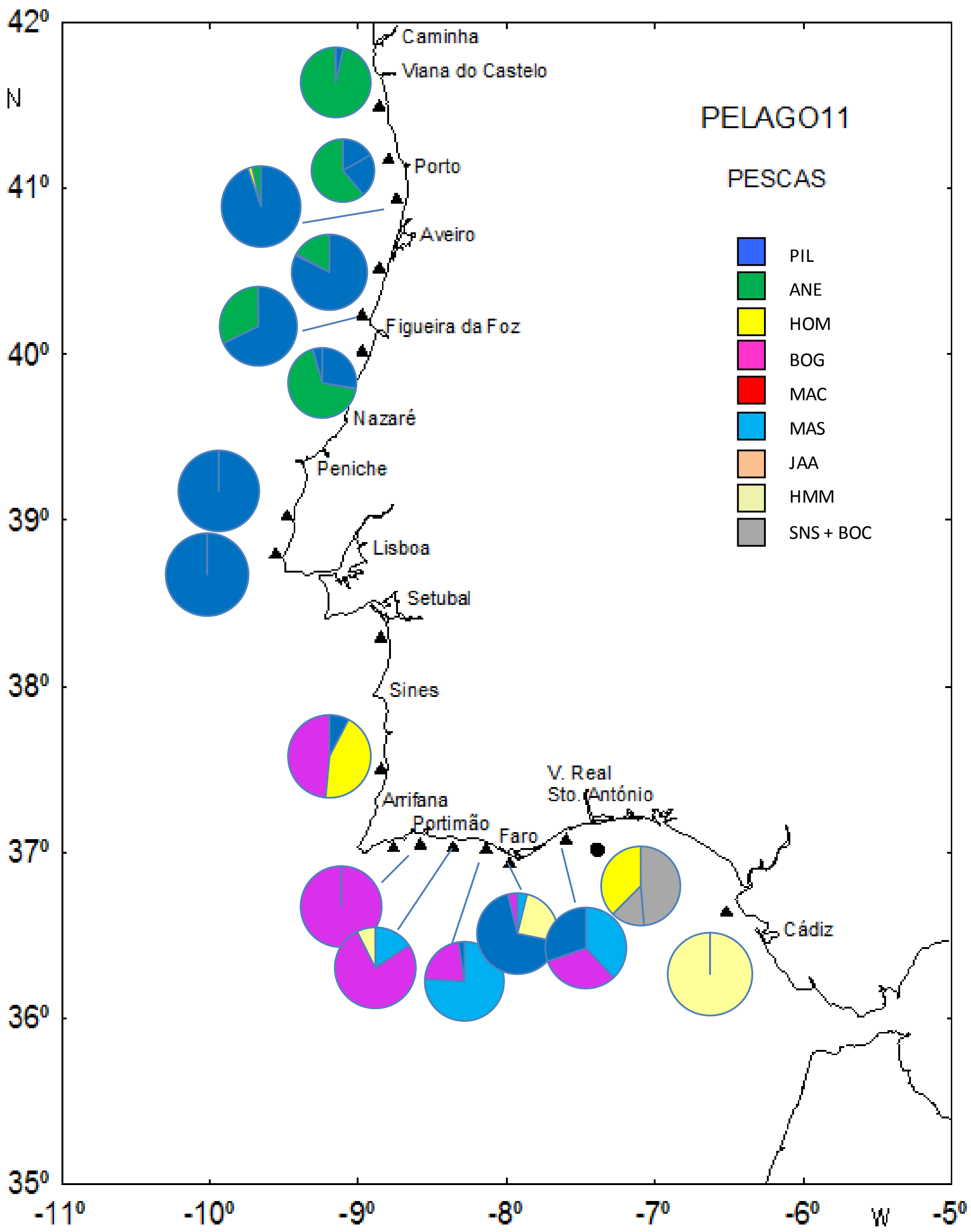


Figure 1 - Fishing trawl location and haul species composition (percentage in number).

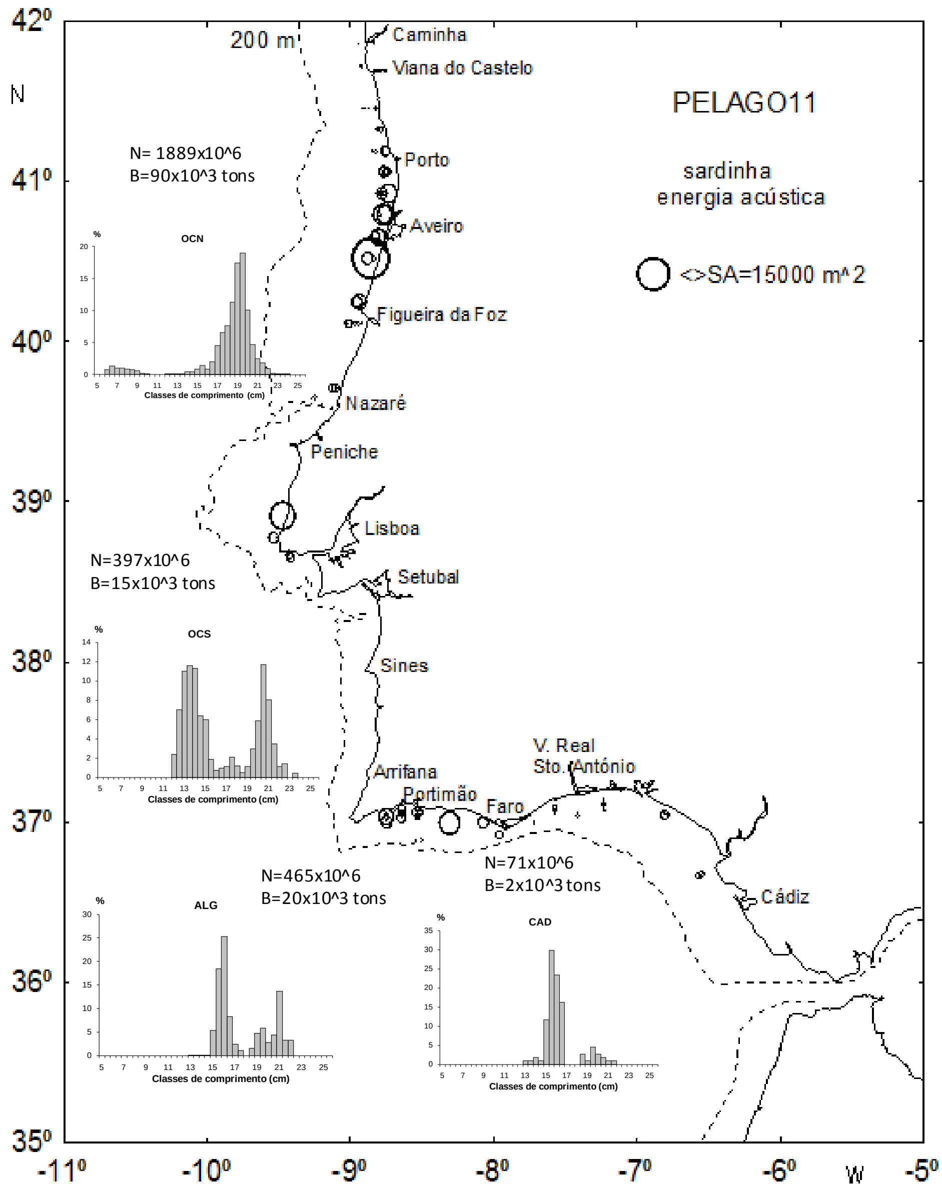


Figure 2 – Sardine acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Sardine abundance and length structure for each zone.

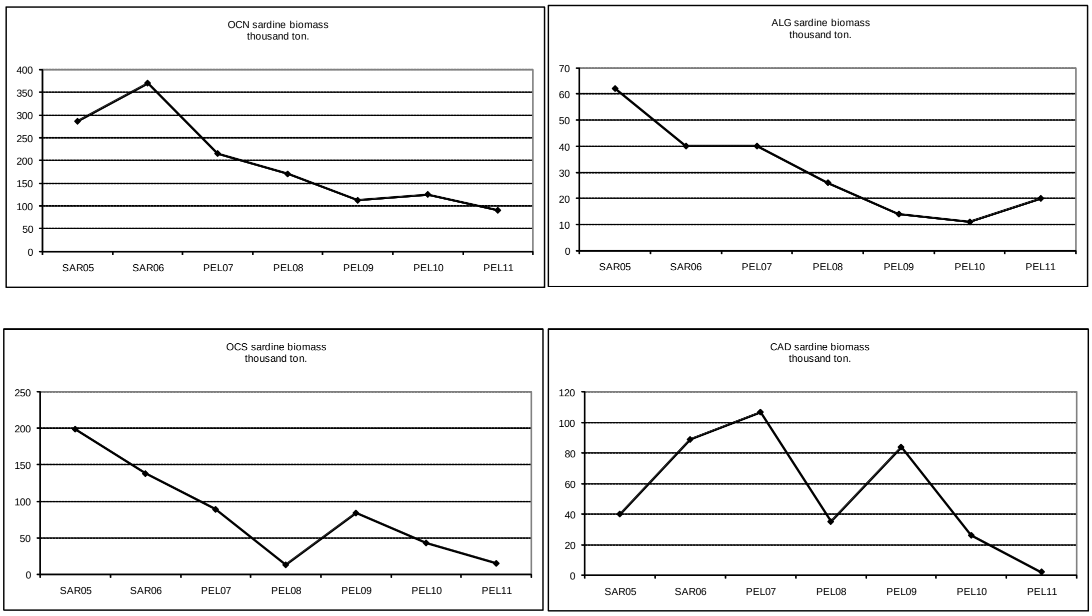


Figure 3 – sardine biomass evolution for each zone, along the acoustic spring survey series, since 2005.

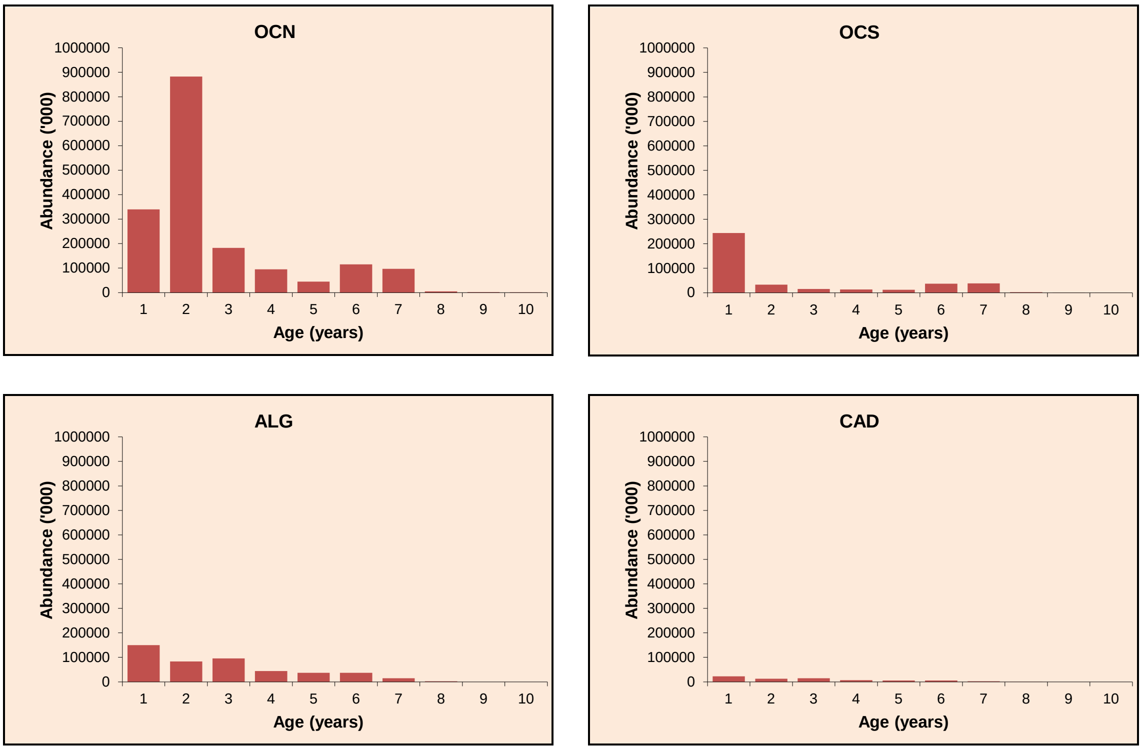
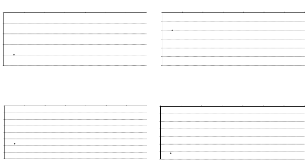


Figure 4 – Sardine abundance (x1000) per age group, for each zone.



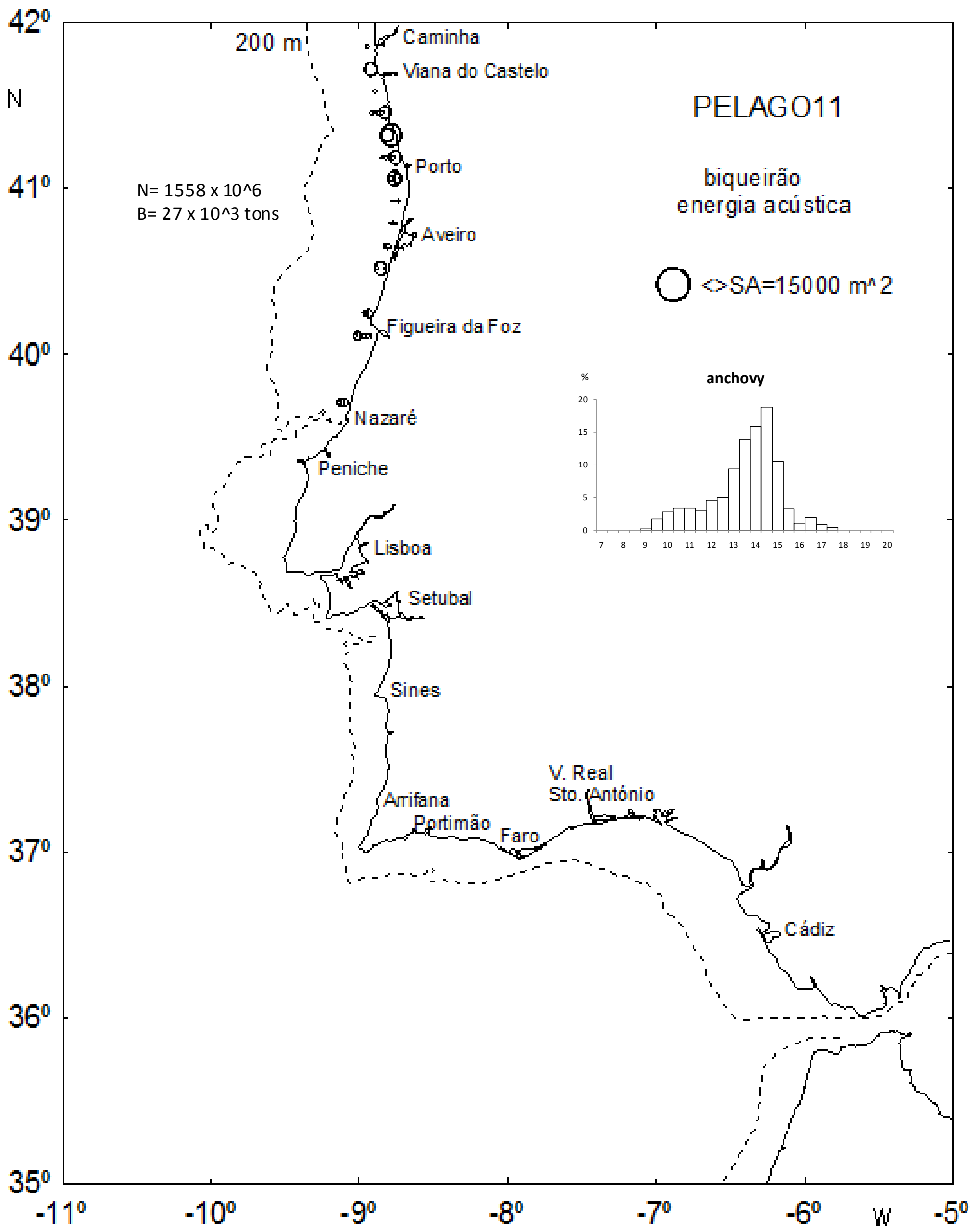


Figure 5 – Anchovy acoustic energy spatial distribution. Circle area is proportional to the acoustic energy (S_A m^2/nm^2). Anchovy abundance and length structure for West and South areas.

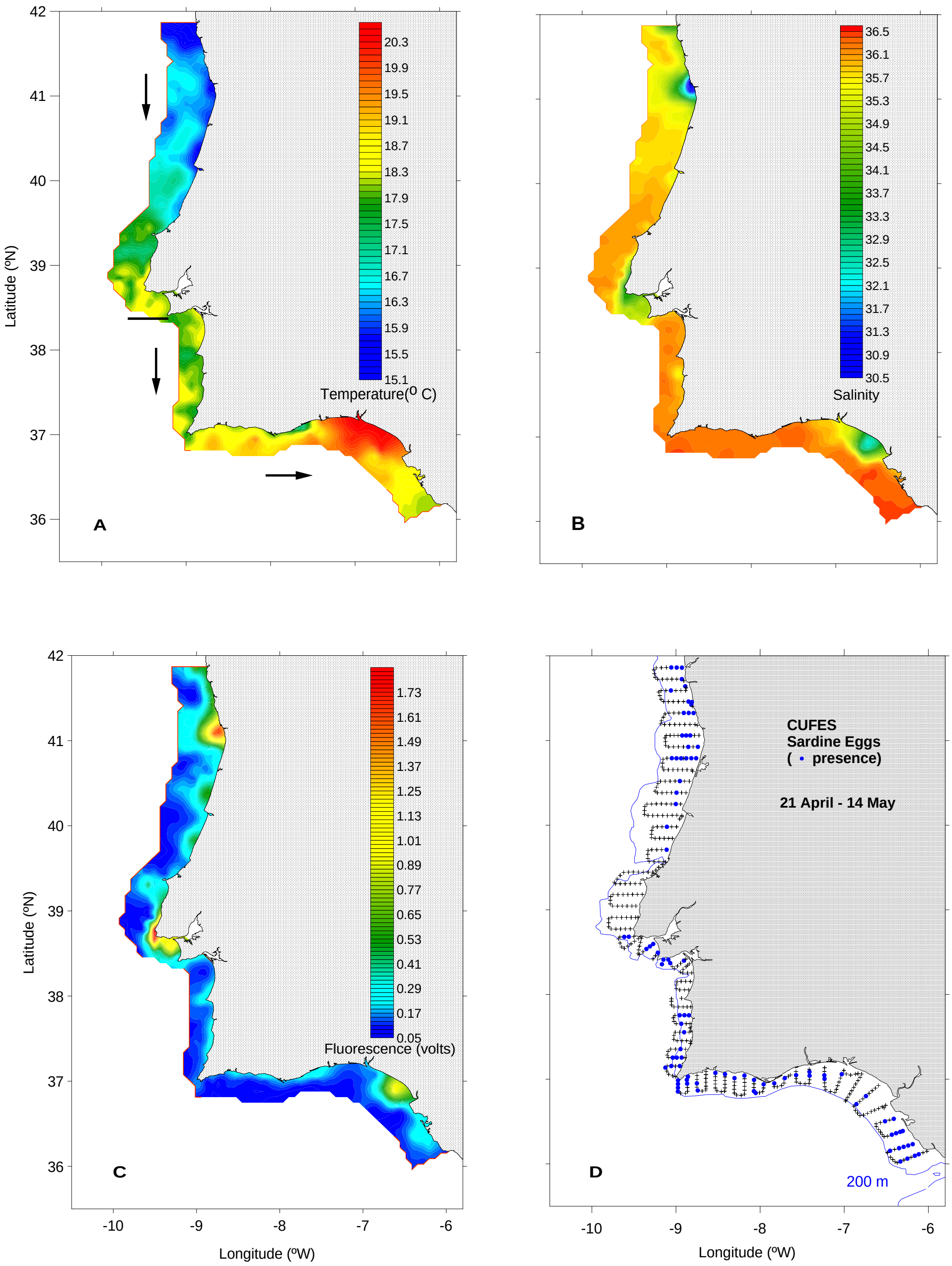


Figure 6 – Surface temperature (A), salinity (B) and fluorescence (C) and sardine egg presence (*in situ* observations) obtained by the CUFES+EDAS system. The arrows indicate surveying course, undertaken in two legs: 21-30 April and 3-18 May.

Annex I – Age-Length Keys

Table 1 – Age-Length key of OCN area

OCN											
Length Class (cm)	Age Group										General Total
	1	2	3	4	5	6	7	8	9	10	
12	6										6
12,5	9										9
13	10										10
13,5	12										12
14	16										16
14,5	16										16
15	21	1									22
15,5	21										21
16	24										24
16,5	19	1									20
17	20	2									22
17,5	13	8									21
18	9	19									28
18,5	2	19									21
19		17	7	2							26
19,5		18	1	3	1	2					25
20		8	11	1	2	5	4				31
20,5		3	3	6	2	8	7	1			30
21		1		1	4	15	9				30
21,5			2		3	2	16	1	1		25
22				1	1	5	16			1	24
22,5				1	3	3	10	1		1	19
23					1	4	6			2	13
23,5				1		5	3	1	1		11
24								1			1
General Total	198	97	24	16	17	49	71	5	2	4	483

Table 2 – Age-Length key of ALG area

ALG											
Length Class (cm)	Age Group										Total Geral
	1	2	3	4	5	6	7	8	9	10	
12											
12,5											
13	2										2
13,5	2										2
14	8										8
14,5	9										9
15	13										13
15,5	14										14
16	6	8									14
16,5	5	9									14
17	2	8	2								12
17,5		4	1								5
18		1	5								6
18,5		2	8		1						11
19		1	10	2							13
19,5			9	2		1					12
20		1	3	5	1	3					13
20,5				4	4	2	3				13
21			1	3	4	4					12
21,5				2	3	3	1	1			10
22					2	1	2				5
22,5						1					1
23											
23,5											
24											
General Total	61	34	39	18	15	15	6	1			189

A.3.4 Preliminary Spawning Stock Biomass estimates for the Bay of Biscay anchovy

(Engraulis encrasicolus, L.) applying the DEPM

by

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ABSTRACT

The research survey BIOMAN 2011 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy was conducted in May 2011 from the 6th to the 27th covering the whole spawning area of the species. Two vessels were used: the R/V Investigador to collect the plankton samples and the pelagic trawler Emma Bardán to collect the adult samples. The total area covered was 98,405Km^2 and the spawning area was 69,094Km^2. During the survey 699 plankton samples were obtained and 52 pelagic trawls were performed, from which 40 contained anchovy and were selected for the analysis. 6 additional samples were obtained from the purse seine fleet.

In the Cantabrian coast the spawning limit was observed at 3º54'W and to the North the sampling was stopped due to bad weather at 47º23'N once passed Nantes. The anchovy eggs were encountered all along the area but in the Cantabrian coast the eggs were encountered offshore instead of near the coast as usually. Between Arcachon and Le Gironde approximately between 50 and 150m a gap without eggs was encountered.

A preliminary SSB estimate is obtained as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (DF) estimates. P_{tot} is calculated as the product of the spawning area and the daily egg production rate (P_0), which is obtained from the exponential mortality model fitted as a Generalized Linear Model (GLM) to the egg daily cohorts. As the adults samples are not fully processed yet, the DF is taken as a mean of the historical DF series. The resulting preliminary biomass estimate is 138,069 t with a coefficient of variation of 23%. This estimate is more than three times last year estimate.

Approximately 87% of the anchovy are individuals of age 1 in numbers and the contribution in mass of those is 81%. The contribution in mass of anchovies of age 2+ is 19%. This indicates a good recruitment level in comparison with previous years.

The complete estimate of the anchovy biomass will be obtained from the BIOMAN 2011 survey (DEPM) carried out by AZTI, the PELGAS 2011 survey (Acoustic) carried out by IFREMER and the commercial catch. This analysis will take place during this ICES WGANSA from 24 to 28 of June at Vigo (Spain).

1. INTRODUCTION

Anchovy (Engraulis encrasicolus) is one of the commercial species of high economic importance in the Bay of Biscay. The economy of the Spanish purse seine fleets (primarily from the Basque Country, Cantabria and Galicia) and the French fleet rely greatly on this resource (Uriarte et al., 1996 and Arregi et al., 2004). In order to provide proper advice on the fishery management, it is necessary to conduct annually a monitoring of the population. Thanks to that monitoring, ICES (International Council for the Exploration of the Sea) detected the crisis of the fishery during the last decade due to the poor level of biomass after several failures of recruitments since 2001 (ICES, 2010). In consequence the fishery was closed by the European Council in 2005. In 2010, following the indices of good recruitment detected in September 2009, the fishery was provisionally open by the European Council, with a limited TAC of 7,000 t. For 2011 again due to the indices of good recruitment detected in September 2010 the fishery was open with a TAC of 15,600t conditioned to the confirmation of the recovery of the population above Bpa (precautionary approach biomass) levels (33,000 t) from the surveys in May 2011. The situation will be reviewed once scientific advice from this DEPM survey and the Acoustic one performed by IFREMER (France) becomes available at this WGANSA 2011 in Vigo (Spain).

Anchovy is a short-lived species, for which the evaluation of its biomass has to be conducted by direct assessment methods as the daily egg production method (DEPM) (Barange et al, 2009). This method consists of estimating the spawning stock biomass (SSB) as the ratio between the total daily egg production (P_{tot}) and the daily fecundity (DF) estimates. It requires a survey to collect anchovy eggs (plankton sampling) for estimating the total daily egg production and to collect anchovy adults (adult sampling) for estimating the adult parameters. Since 1987, AZTI-Tecnalia (Marine and Food Technological Centre, Basque country, Spain), either alone or in collaboration with other institutes, has conducted annually specific surveys to obtain anchovy biomass indices (Somarakis et al., 2004; Motos et al., 2005). In addition, the Basque fishery on anchovy has been continuously monitored. This information has been submitted annually to ICES, to advice on the exploitation of the fishery (ICES, 2010).

The survey for the application of the DEPM to estimate the Bay of Biscay anchovy biomass is one of the two surveys which give information about the anchovy population. The other one carried out at the same time in May is the acoustic French survey. The biomass indices provided by the acoustic and DEPM surveys together with the information supplied by the fleet are used as input variables for a two stage biomass model used to assess the Bay of Biscay anchovy population (Ibaibarriaga et al., 2008). Apart from the anchovy SSB estimates the DEPM survey in the Bay of Biscay gives information on the distribution and abundance of sardine eggs and environmental conditions. Moreover, this year sardine adults were collect to contribute to the sardine biomass estimate from 45ºN to 48ºN collaborating with the triennial spawning stock biomass estimate of sardine.

This working document describes the BIOMAN2011 survey for the application of the DEPM for the Bay of Biscay anchovy in 2011. First, the data collection and the estimation of the egg production are described in detail. Then, a preliminary SSB indices based on the ratio between the total daily egg production (P_{tot}) estimate and a preliminary daily fecundity (DF) estimate derived from the mean historical series and the age structure indices are given as they were used for the assessment and posterior management of this stock. Finally the historical trajectory of the population is showed.

2. MATERIAL AND METHODS

2.1 Survey description

The BIOMAN2011 survey was carried out at the spawning peak of the species covering the whole spawning area of the anchovy in the Bay of Biscay. During the survey, icthyoplankton and adult samples were obtained for the estimation of the total daily egg production and the total daily fecundity respectively. The age structure of the population was also estimated.

The collection of plankton samples was carried out on board R/V Investigador from the 6th to the 27th May. The area covered was the southeast of the Bay of Biscay (Fig. 1), which corresponds to the main spawning area and spawning season of anchovy. The strategy of egg sampling was identical to that used in previous years (Uriarte et al., 1999), i.e. a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found. Stations were located every 3 miles, along 15-mile-apart transects perpendicular to the coast. The sampling strategy was adaptive. The survey started from the West (transect 7, at 4º55'W), and covered the Cantabrian Coast eastwards up to Pasajes (transect 25, approx. 1º50'W) (Fig. 1). Then, the survey continued to the north, in order to find the Northern limit of the spawning area. The spawning was stopped due to the bad weather at 47º23'N once passed Nant. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were completed. This occurred in the area of Cap Breton until Arcachon and the area of influence of Gironde inshore and this year offshore as well.

At each station a vertical plankton haul was performed using a PairoVET net (2-Calvet nets, Smith *et al*., 1985 in Lasker, 1985) with a net mesh size of 0.150mm for a total retention of the anchovy eggs under all likely conditions. The net was lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net was retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to detect sequential clogging of the net during a series of tows.
Immediately after the haul, the net was washed and the samples obtained were fixed in formaldehyde 4% buffered with sodium tetraborate in sea water. After six hours of fixing, anchovy, sardine and other eggs species were identified, sorted out and counted onboard. Afterwards, in the laboratory, a percentage of the samples were checked to assess the quality of the sorting made at sea. According to that, a portion of the samples were sorted again to ensure no eggs were left in the sample. In the laboratory, anchovy and sardine eggs were classified into morphological stages (Moser and Alshtrom, 1985).

Sample depth, temperature, salinity and fluorescence profiles were obtained at each sampling station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity were recorded in each station with a manual termosalinometer WTW LF197. At some points determinate before the survey, water was filtered from the surface to obtain chlorophyll samples to calibrate the chlorophyll data.

The Continuous Underway Fish Egg Sampler (CUFES, Checkley *et al*., 1997) was used to record the eggs found at 3m depth with a net mesh size of 350µm. The samples obtained were immediately checked under the microscope so that the presence/absence of anchovy eggs was detected in real time. When anchovy eggs were not found in six consecutive CUFES samples in the oceanic area transect was abandoned. The CUFES system had a CTD to record simultaneously temperature and salinity at 3 m depth, a flowmeter to measure the volume of the filtered water, a fluorimeter and a GPS (Geographical Position System) to provide sampling position and time. All these data were registered at real time using the integrated EDAS (Environmental Data Acquisition System) with custom software.

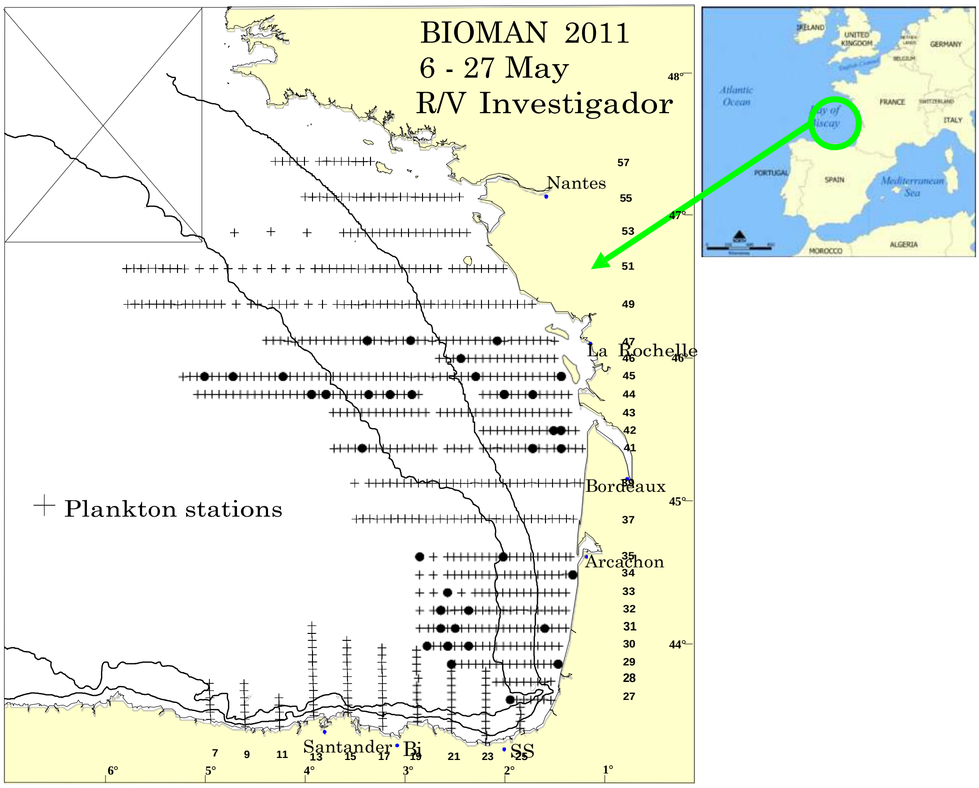

Figure 1: Plankton stations obtained during BIOMAN 11. The area with the cross was close by the French authorities to operate. The quadrangle with the cross represents an area close by the French authorities to operate during the period of the survey

The adult samples were obtained mainly on board R/V Emma Bardán (pelagic trawler) from the 6th to the 28th May coinciding in space and time with the plankton sampling. When the plankton vessel encountered areas with anchovy eggs, the R/V Emma Bardán was directed to those areas to fish. In each haul, immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of two kg was selected at random. A minimum of one kg or 60 anchovies were weighted, measured and sexed and from the mature females the gonads of 25 non-hydrated females (NHF) were preserved. If the target of 25 NHF was not completed 10 more anchovies were taken at random and processed in the same manner. Sampling was stopped when more than 120 anchovies had to be sexed to achieve the target of 25 NHF. Otoliths were extracted onboard and read in the laboratory to obtain the age composition per sample. In addition, a piece of each anchovy was frozen to do genetic analysis afterwards on land. In each haul 100 individuals of each species were measured. Extra anchovy samples were frozen to obtain morphometric measurements.

Six additional anchovy adult samples were obtained from the commercial Basque purse seine fleet. Onboard the purse seines a sample of two kg was selected from the bulk of the catch and was directly kept in 4% formaldehyde in a container. Afterwards, in the laboratory the samples were processed in the same way as explained above. As the otoliths were not valid

after keeping them in formaldehide the age structure of these samples will be deduced from an Age Length Key derived from the anchovies fished with the pelagic trawler.
At the same time, samples of adult sardine were kept in formaldehyde and after in the laboratory the same procedure as for anchovy will be followed. The spatial distribution of the pelagic hauls is shown in Figure 2.

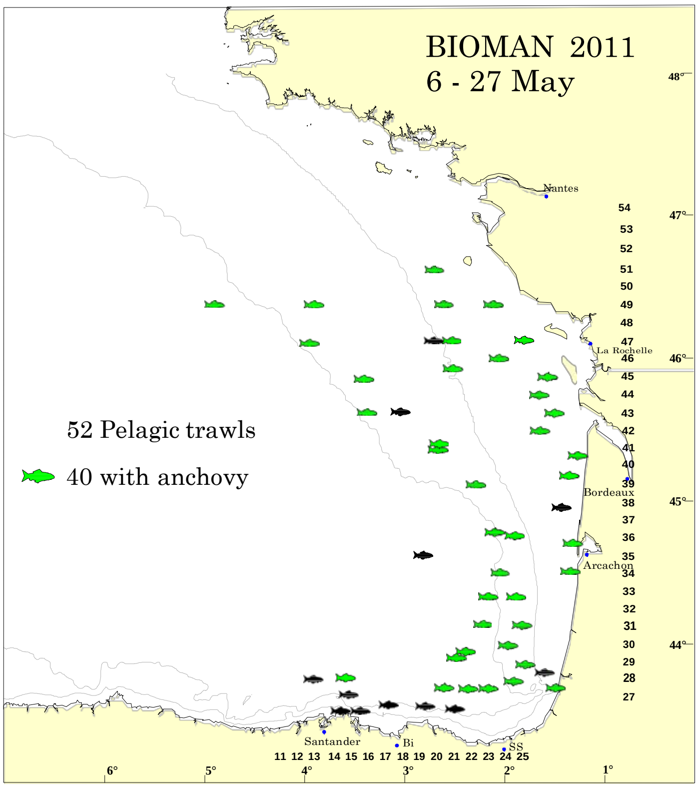

Figure 2: Spatial distribution of fishing hauls from R/V Emma Bardán in 2011.

2.2 Total daily egg production

Total daily egg production (P_{tot}) was calculated as the product between the spawning area (SA) and the daily egg production (P_0) estimates:

(1) $$P_{tot} \quad P_0\, SA.$$

A standard PairoVET sampling station represented a surface of 45 Nm^2 (i.e. 154 km^2). Since the sampling was adaptive, the area represented by each station was corrected according to the sampling intensity and the cut of the coast. The total area was calculated as the sum of the area represented by each station. The spawning area (SA) was delimited with the outer zero anchovy egg stations although it could contain some inner zero anchovy egg stations embedded. The spawning area was computed as the sum of the area represented by the stations within the spawning area.
The daily egg production per area unit (P_0) was estimated together with the daily mortality rate (Z) from a general exponential decay mortality model of the form:

(2) $$P_{i,j} \quad P_0 \exp \quad Z\, a_{i,j} \ ,$$

where $P_{i,j}$ and $a_{i,j}$ denote respectively the number of eggs per unit area in cohort *j* in station *i* and their corresponding mean age. Let the density of eggs in cohort *j* in station *i*, $P_{i,j,}$ be the ratio between the number of eggs $N_{i,j}$ and the effective sea area sampled R_i (*i.e.* $P_{i,j} = N_{i,j} / R_i$). The model was written as a generalised linear model (GLM, McCullagh and Nelder, 1989; ICES, 2004) with logarithmic link function:

(3) $$\log E[N_{i,j}] \quad \log(R_i) \quad \log P_0 \quad Z\, a_{i,j} \ ,$$

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) $$f(age \mid stage, temp) \quad f(stage \mid age, temp)\, f(age)\, .$$

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 of having an age *age* is the product of the probability of an egg being spawned at time - *age* and the probability of that egg surviving since then (*exp(-Z age)*):

(5) $$f(age) \quad f(spawn \qquad age) \exp(\;\; Z\, age) \ .$$

The pdf of spawning time *f(spawn= - age)* allows refining the ageing process for species with spawning synchronicity that spawn at approximately certain times of the day (Lo, 1985a; Bernal *et al*., 2001). Anchovy spawning time was assumed to be normally distributed with mean at 23:00h GMT and standard deviation of 1.25 (ICES, 2004). The peak of the spawning time was also used to define the age limits for each daily cohort (spawning time peak plus and minus 12 hours). Details on how the number of eggs in each cohort and the corresponding mean age are computed from the pdf of age are given in Bernal *et al* (2011).

Given that this ageing process depends on the daily mortality rate which is unknown, an iterative algorithm in which the ageing and the model fitting are repeated until convergence of the *Z* estimates was used (Bernal *et al.*, 2001; ICES, 2004; Stratoudakis *et al.*, 2006). The procedure is as follows:

Step 1. Assume an initial mortality rate value

Step 2. Using the current estimates of mortality calculate the daily cohort frequencies and their mean age.

Step 3. Fit the GLM and estimate the daily egg production and mortality rates. Update the mortality rate estimate.

Step 4. Repeat steps (1)-(3) until the estimate of mortality converged (i.e. the difference between the old and updated mortality estimates was smaller than 0.0001).

Incomplete cohorts, either because the bulk of spawning for the day was not over at the time of sampling, or because the cohort was so old that its constituent eggs had started to hatch in substantial numbers, were removed in order to avoid any possible bias. At each station, younger cohorts were dropped if they were sampled before twice the spawning peak width after the spawning peak and older cohorts were dropped if their mean age plus twice the spawning peak width was over the critical age at which less than 99% eggs were expected to be still unhatched. In addition, eggs younger than 4 hours and older than 90% of the survey incubation time (Motos, 1994) were removed.
The incubation temperature was taken as the temperature obtained with the CTD at 10m depth. Once the final model estimates were obtained the coefficient of variation of P_0 was given by the standard error of the model intercept (log(P_0)) (Seber, 1982) and the coefficient of variation of Z was obtained directly from the model estimates.
The analysis was conducted in R (www.r-project.org). The ”MASS” library was used for fitting the GLM with negative binomial distribution and the ”egg” library (http://sourceforge.net/projects/ichthyoanalysis/) for the ageing and the iterative algorithm .

2.3 Daily fecundity

The daily fecundity (DF) is usually estimated as follows:

(6) $$DF \quad \frac{R \;\; F \;\; S}{W_f} ,$$

where R is the sex ratio in weight, F is the batch fecundity (eggs per batch per female weight), S is the spawning frequency (percentage of females spawning per day) and W_f is the female mean weight. However, as the adult samples are not processed yet, DF had to be derived from the past historical series using the procedure accorded in WGACEGG 2009: the mean of the historical DF series. The resulted DF from the surveys carried out in June were not taken into account. The last four years were also removed because the Spawning Frequency was not fully estimated; it was deduced from a relation between the historical relationship between S and SST or as an historical mean.

2.3 **Spawning stock biomass and numbers at age**

The Spawning Stock Biomass (*SSB*) was estimated as the ratio between the total egg production (P_{tot}) and daily fecundity (*DF*) estimates and its variance was computed using the Delta method (Seber, *1982*).
To deduce the numbers at age four stratum, Northeast (NE), Northwest (NW), Southeast(SE) and Southwest (SW) , were defined depending on the distribution of the adult samples (size, weight and age) and the distribution of anchovy eggs (**Figure 3**). Mean and variance of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples (equations 9 and 10) where the weights were proportional to the population (in numbers) in each stratum. In particular, the weighting factors were proportional to the egg abundance divided by the numbers of adult samples in the stratum and the mean weight of anchovy per sample.

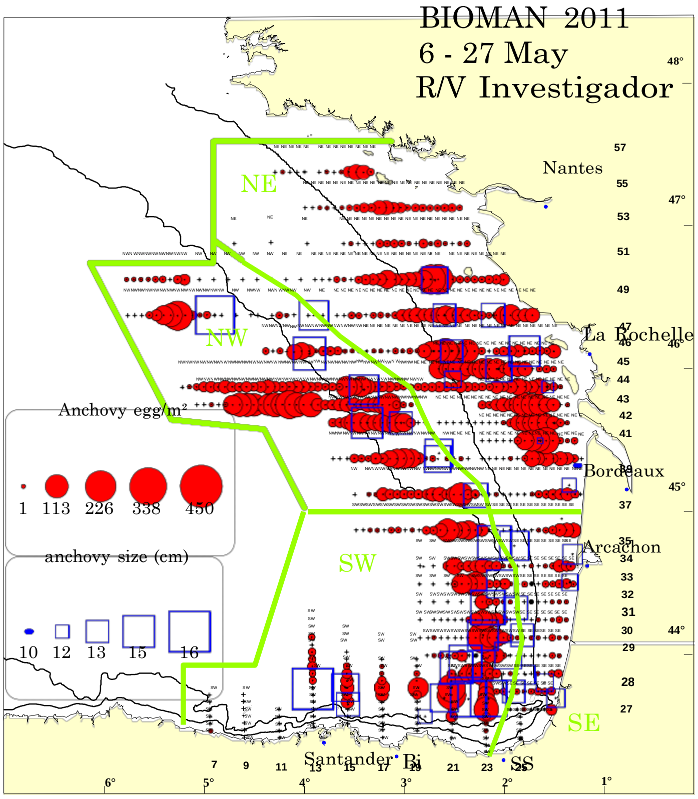

Figure 4: Four strata defined to estimate the numbers at age.

3. RESULTS

3.1 Survey description

The limit of the spawning area was found at 3º54'W to the west in the Cantabrian Coast and to the North in the French platform the spawning was stopped due to bad weather at 47º23' once passed Nantes The total number of PairoVET samples obtained was 699. The number of CUFES samples obtained was 1,495. The total area surveyed was 98,445 km^2 and the spawning area was 69,131 km^2. From 699 PairoVET samples, 481 had anchovy eggs (69%) with an average of 22 eggs 0.1m^{-2} per station and a maximum of 1,021 eggs 0.1m^{-2} in a station. A total of 15,204 anchovy eggs were encountered and classified.

The anchovy eggs were encountered all along the area but in the Cantabrian coast the eggs were encountered offshore instead of near the coast as usually. Between Adour and Le Gironde approximately between 50 and 150m a gap without eggs was encountered. This year part of the eggs was encountered outside of the platform. (**Figure 5**).

Physical variables such as Temperature, Salinity and Wind at the sea surface are indicators of the currents that control the water mass movements. The salinity field obtained during the survey shows clearly the effect of the river discharges of Adour and Gironde and the dispersion of their plumes. Salinity values between 33.6 and 35.1 PSU, lower than a typical value of 35.6 PSU, were observed over the continental platform, especially around the Gironde mouth. The temperature field only shows the effect of river discharges in the Gironde (values between 12.8 and 15.8 ºC,) and close to the coast.

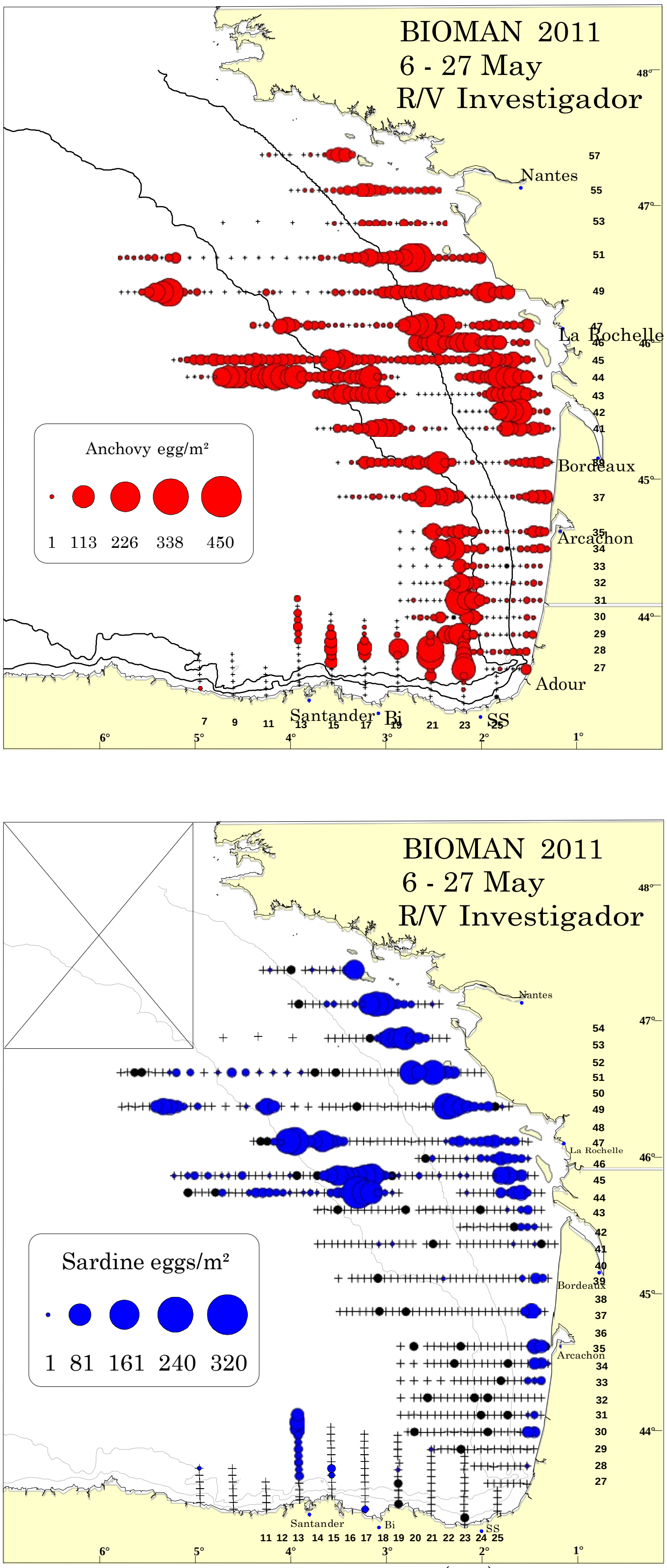

Figure 5: Distribution of anchovy (red) and sardine (blue) egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN2011 obtained with PairoVET.

This is possibly due to the high solar radiation observed during the survey; this increase the temperature of the water masses originated from the rivers, having no effect on the salinity field. Following only the values of T-S, the general water mass movement (with its associated particles) at sea surface seems to be between W and NW, especially when the wind had low intensity.

Figure 6 shows the sea surface temperature and sea surface salinity maps overlapped with the abundance of anchovy eggs as observed during the BIOMAN2011 survey.
This year the mean SST of the survey (16.8ºC) was three degrees higher than last year. The mean SSS (35.25 UPS) was at the same levels of last year (35 UPS).

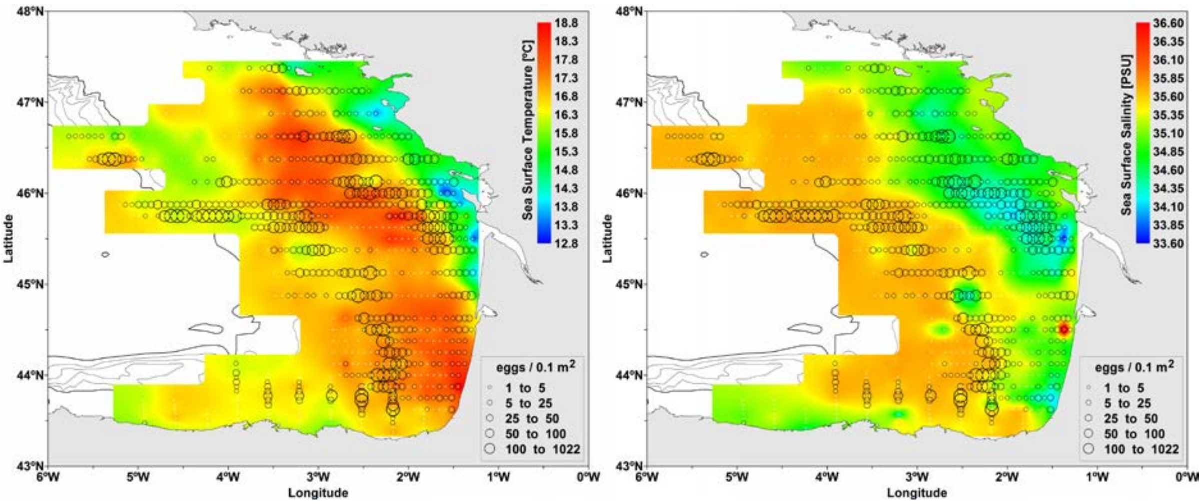

Fig.6: SST and SSS maps (left and right respectively) with anchovy egg distribution.

In relation with the adult samples, most of the hauls consisted of anchovy, horse mackerel, hake and mackerel (Annex I). 52 pelagic trawls were performed, of these, 40 provide anchovy and were selected for the analysis. The spatial distribution of the samples and their composition is showed in figure 7. Figure 8 shows the mean weight.
The 6 samples from the fleet are not analysed yet, neither two samples from the pelagic trawler, they will be available at WGACEGG that will take place in Barcelona from 21st to 25th of November 2011.

3.2 Total daily egg production

As a result of the adjusted GLM (**Figure 9**) the daily egg production (P_0) was 126.68 egg m^{-2} day $^{-1}$ with a standard error of 17.05 and a CV of 0.14. The daily mortality z was 0.30 with a standard error of 0.088 and a CV of 0.29. Then, the total daily egg production as the product of spawning area and daily egg production was 8.75 E+12 with a standard error of 1.2 E+12 and a CV of 0.1249.

3.3 Daily fecundity

The Daily Fecundity obtained as a mean of the historical series was 63.39egg/g. with a variance of 139.

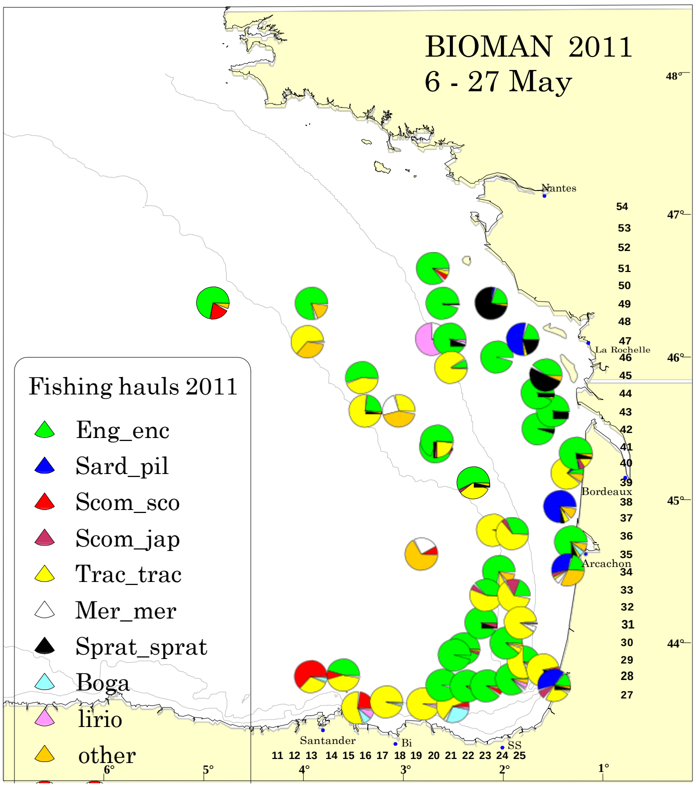

Figure 7: Species composition of the 40 pelagic trawls from the R/V Emma Bardán during BIOMAN11

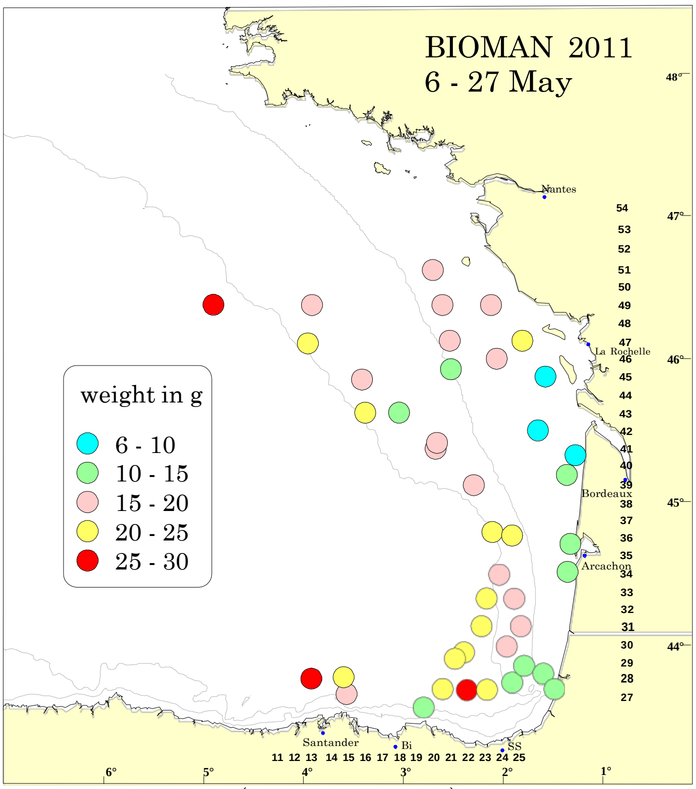

Figure 8: Anchovy (male and female) mean weight per haul

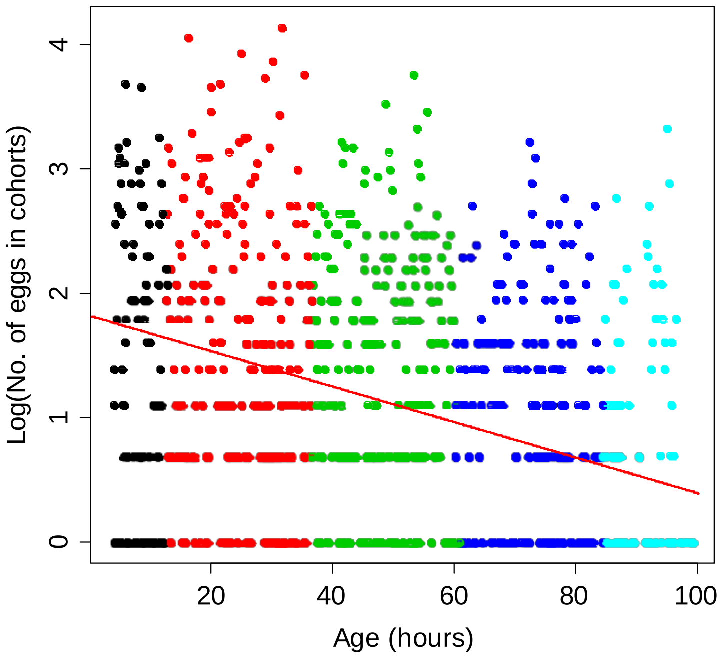

Figure 9: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 23:00h).The red line is the adjusted line. Data in Log scale.

3.4. Preliminary SSB and numbers at age

Preliminary spawning stock biomass indices resulted in 138,069t with a CV of 23%, obtained as the ratio between the estimates of P_{tot} derived from the GLM and the mean DF. These results are showed in table 1 below.

Ptot (eggs)			DF (eggs/gramme)			SSB (Ton.)		
Model	Estimate	Var	Predic.Model	Estimate	Var.Pred.	Estimate	Var	Cv
GLM	8.75E+12	1.4E+24	df = histor. mean	63.39	139.01	138,069	1.0.E+09	0.2296

For the purposes of producing population at age estimates, the age readings based on 2,611 otoliths from 38 samples were available. There are two left from the pelagic trawler and 6 from the purse seines that will be processed for WGACEGG in November. Estimates of anchovy mean weights and proportions at age in the population were the average of proportions at age in the samples, weighted by the population each sample represents. Given that mean weights of anchovies change between different regions (**Figure 4**) proportionality between the amount of samples and approximate biomass indices by regions was checked. The approximate index of biomass by regions was set equal to egg abundance by areas (assuming equal daily fecundity at each area) (**Table 2**). According to that table, the 38 samples selected can not be considered to be balanced between these regions and differential weighting factors were applied to each sample coming from one or the other stratum for the purposes of the number at age estimates. The proportion by age, numbers by age,weight at age and biomass by age estimates are given in **Table 3, Figure 12**.

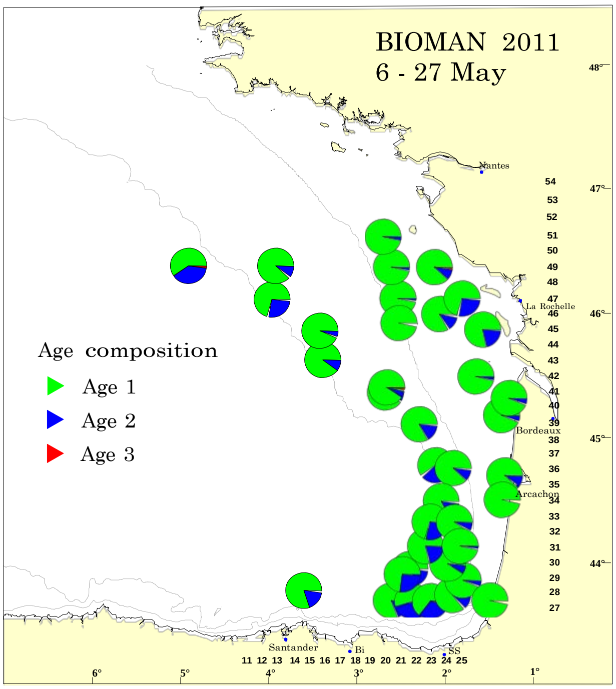

Figure 10: Anchovy age composition per haul

Table 2: Balance of the adult sampling to egg abundance by 4 strata in the Bay of Biscay (see figure 4). The row of the table above the mean weights corresponds to the weighting factor of each of the samples by strata to obtain the preliminary population structure. Mean weight by strata arises from the 38 adult samples selected at the moment for the analysis.

Estrata	NE	SE	SW	NW	Addition
Total egg abundance	5.7E+12	3.2E+11	5.6E+12	6.5E+12	1.82E+13
% egg abundance	0.314	0.018	0.310	0.358	100%
Nº of adult samples	**11**	**7**	**12**	**8**	38
%Egg/sample	0.03	0.003	0.03	0.04	
Proportion of SSB relative to estrata NW	0.64	0.06	0.58	1.00	
W. factor proportional to the population	0.64/wi	0.06/wi	0.58/wi	1/wi	
Mean weight of anchovies by region	13.5	14.6	21.6	20.2	

Table 3: SSB 2011 estimates and the correspondent standard error (S.e.) and coefficient of variation (CV) of the percentage by age and numbers at age estimates, with the mean weight by age class.

Parameter	**Estimate**	**S.e.**	**CV**
Biomass (Tons)	138,069	31,697	0.2296
Tot.mean W (g)	16.44	1.22	0.0744
Population (millions)	8,398	2026.6	0.2413
Percent age 1	0.8669	0.0197	0.0227
Percent age 2	0.1305	0.0194	0.1484
Percent age 3+	0.0026	0.0011	0.4072
Numbers at age 1	7,280	1764.7	0.2424
Numbers at age 2	1,096	310.4	0.2833
Numbers at age 3+	22	10.3	0.4734
Weight at age 1	15.3		
Weight at age 2	23.7		
Weight at age 3+	31.6		
SSB at age 1 in mass	111,382		
SSB at age 2 in mass	25,999		
SSB at age 3+ in mass	687		
Percent age 1 in mass	0.8067		
Percent age 2 in mass	0.1883		
Percent age 3+ in mass	0.0050		

3.5. Historical perspective

The whole series of biomass estimates from the DEPM, including the current preliminary estimate for 2011, are presented in figure 11. The historical series of numbers at age in numbers is shown in figure 12. In order to provide a broader point of view for the interpretation of current survey results, distribution maps of the anchovy egg abundances in the last 18 DEPM surveys were compiled (Fig 13).

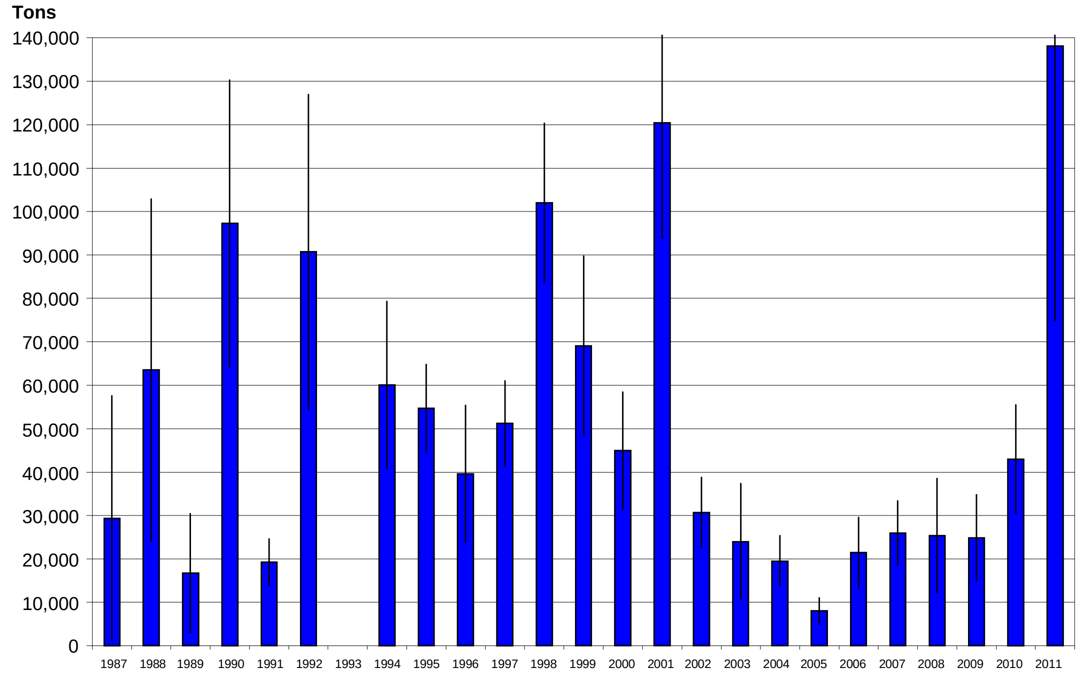

Figure 11: Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. Most are full DEPM estimates, except for 1996, 1999, 2000, 2007, 2008, 2009 and 2010 where S was deduced indirectly.

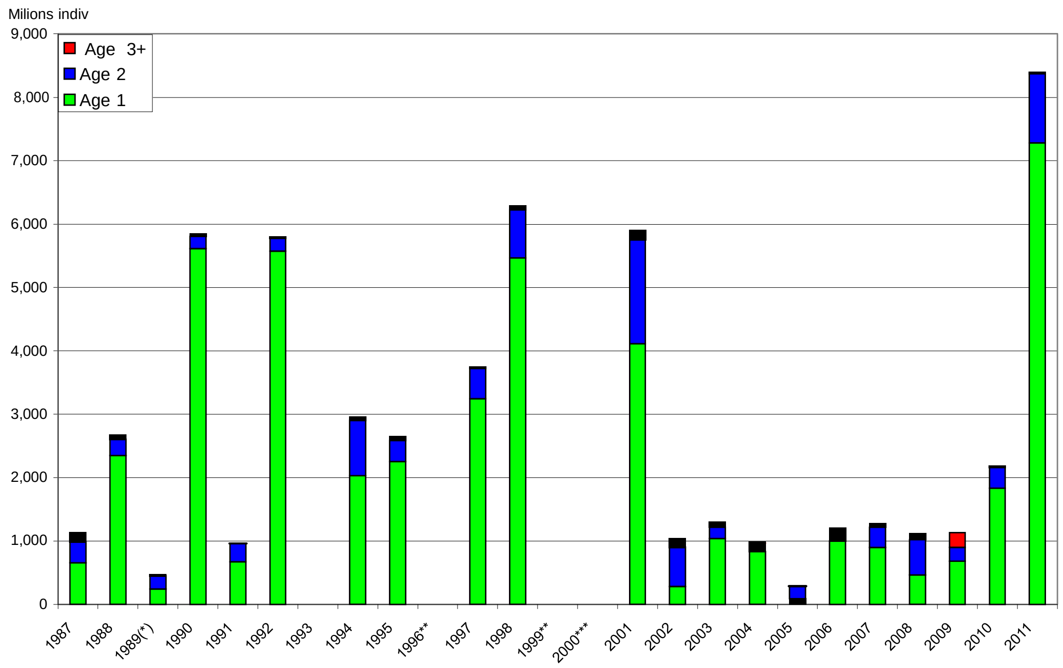

Figure 12: Historical series of numbers at age from 1987 to 2011.

4. CONCLUSIONS

The survey BIOMAN2011 has covered the spawning area satisfactory and the total egg production has been estimated in the distribution area of the population. Moreover there were obtained 52 pelagic trawls, from those 40 were positive for anchovy and were selected for the analysis. Those were obtained simultaneously to the egg sampling.

To estimate the total egg production an exponential mortality model was applied. The adjustment of the model was satisfactory. To estimate the DF a mean of the DF historical series was done. This procedure was accorded during ICES WGACEGG 2009.

The spawning area in 2011 is twice the one from 2010 and the total egg production and preliminary SSB of anchovy are more than three times the values given in 2010 from BIOMAN 2011.
Approximately 87% of the anchovy are individuals of age 1 and the contribution in mass of those is 81% while the contribution in mass of anchovies of age 2+ is 19%. This is due to the difference in the mean weights by age.

The complete estimate of the anchovy biomass will be obtained taking into account both the BIOMAN survey (DEPM) index (carried out by AZTI) and the PELGAS Acoustic index (carried out by IFREMER), and including commercial catch by the fleet. This analysis will take place during the ICES WGANSA meeting which will be held from 24 to 28 of June.

5. ACKNOWLEDGEMENTS

We thank all the crew of the R/V Investigador and Emma Bardán and all the personal that has participated in BIOMAN 2011 for their excellent job and collaborative support. This work has been founded by the Agriculture, Fisheries and Food Technology Department of the Basque Government and by the European Commission within the frame of the National Sampling Programme. The General Secretariat of Marine Fisheries has also collaborated providing the R/V Emma Bardán.

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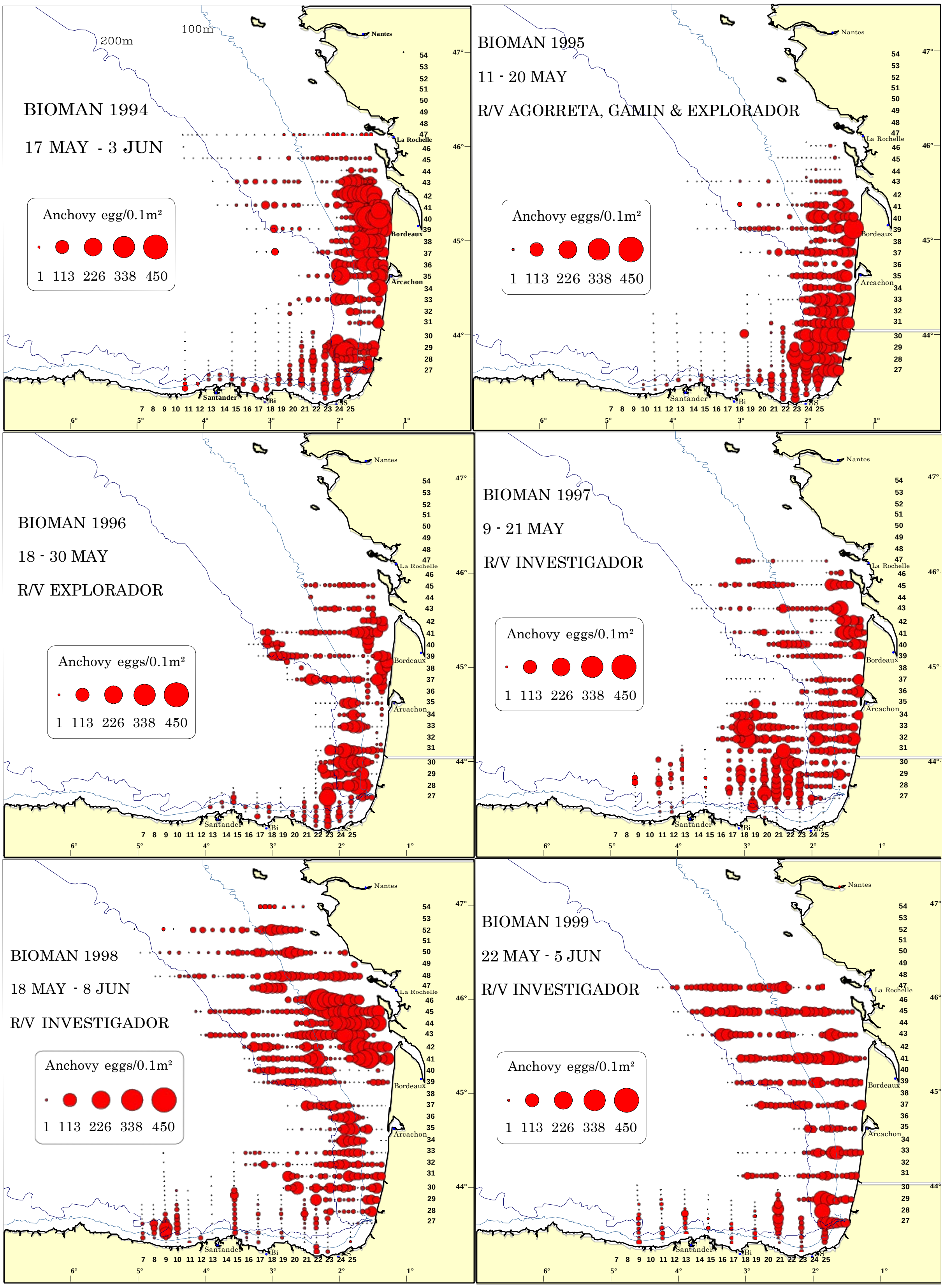
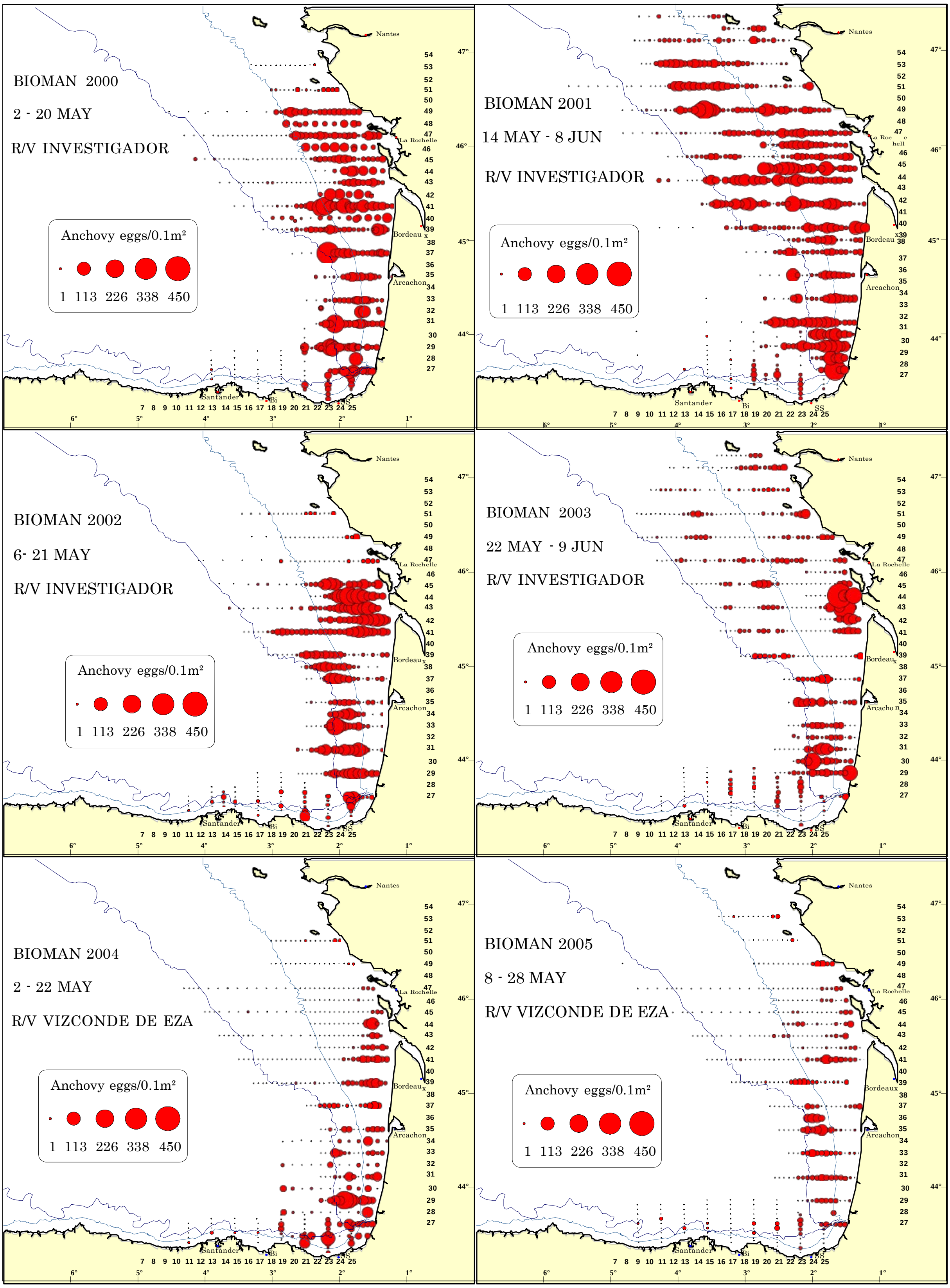

BIOMAN 1994
17 MAY - 3 JUN
Anchovy egg/0.1m²
1 113 226 338 450
200m
100m
BIOMAN 1995
11 - 20 MAY
R/V AGORRETA, GAMIN & EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1996
18 - 30 MAY
R/V EXPLORADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 1997
9 - 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
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
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°


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°
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1°

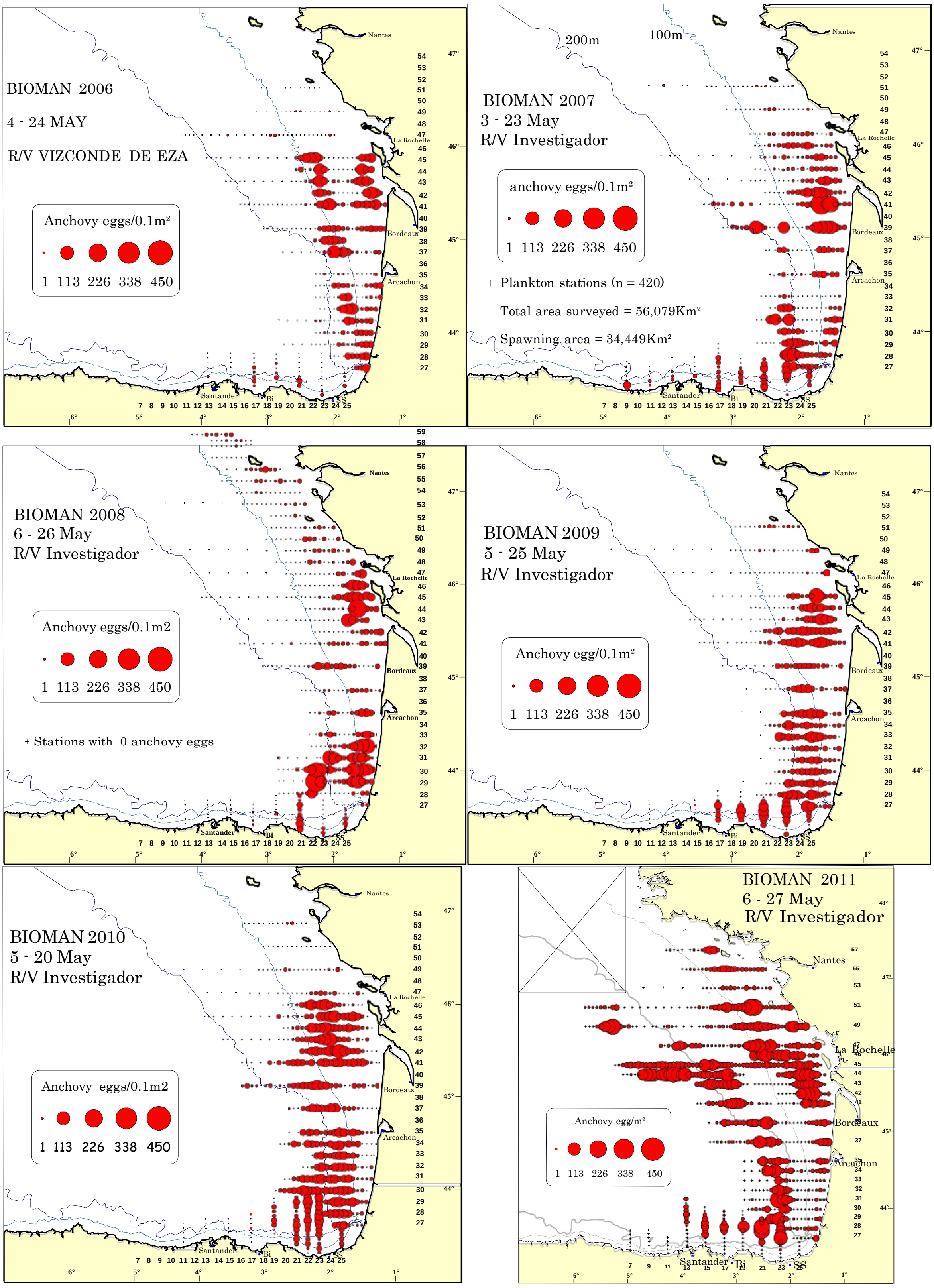

Figure 13: Anchovy egg distribution and abundance from 1994 to 2011.

ANNEX I: Summary of pelagic trawls in 2011

Haul	Date	End hour	Lat end	Lon end	SST	Depth	Fishing depth	Eng_enc	Sard_pil	Scom_sco	Scom_jap	Trac_
1	07/05/2011	22:19	433276	33784	19.8	300	20	0	0	0	0	0
2	07/05/2011	0:05	433273	32607	19.3	100-70	10	0	0	3.1	0	6.9
3	08/05/2011	13:48	433954	33302	19.2	2000	10	0.3	0	0	0	0
4	08/05/2011	22:42	434598	35421	19.6	1000	11	0.08	0	31	0	16
5	09/05/2011	1:35	434658	33475		2500	8	1	0	0.19	0	1
6	09/05/2011	22:30	433530	30900	20.3	600-190	15	0	0	0	0	22.3
7	10/05/2011	0:50	433457	24694	16.2	470	5	0.02	0	0	0	1.6
8	10/05/2011	3:10	433343	22910	16.8	700-190	17	0	0	3.2	0	29.0
9	10/05/2011	22:40	434228	23552	17.3	2000	4	1.1	0	0	0	0
10	10/05/2011	1:40	434187	22105	16.4	2000	10	15.5	0	0.65	0	0.9
11	11/05/2011	3:30	434200	20900	15.7	1000	10 a 17	36.3	0	2.6	0	0.8
12	11/05/2011	13:20	434501	15385	18.1	130	120	190.1	0	4.95	0	0.8
13	11/05/2011	22:47	435757	22280	16.4	800	10	106.05	0	0	3.45	2.4
14	11/05/2011	0:20	435497	22820	16.0	900	13	78.1	0	0	0	0
15	12/05/2011	11:41	435202	14677	12.3	108	119	21.25	0	0	0	46
16	12/05/2011	15:08	440006	15716	12.3	136	120	250	0	0	0	21.
17	12/05/2011	23:10	440853	21227	16.2	900	14	176	0	0.4	9.1	0
18	14/05/2011	23:26	434870	13524	18.0	72	14	0.59	0	0	8.75	22
19	15/05/2011	21:47	444244	11851	14.6	21.7	7	57.5	0	0.3	0.75	1.8
20	15/05/2011	0:18	443070	12016	14.7	33.5	8	3.35	4.74	0	0.6	0.3
21	16/05/2011	10:49	450707	21656	12.3	119	108	20.35	0	0	0.9	12.7
22	16/05/2011	0:30	444741	20537	6.2 - 13	500	11 a 25	1.2	0	6.7	1.35	30
23	17/05/2011	1:01	444597	15352	16.6	130	16	7.1	0	0	0.9	13.9
24	17/05/2011	12:38	443006	20167	12.8	140	130	28	0	0	0	3.6
25	17/05/2011	23:22	442009	20923	16.7	1000	10	10	0	0	1.35	14.
26	18/05/2011	1:37	442002	15268	16.9	130	16	2	0	0	1.4	6.5
27	18/05/2011	10:35	440852	14872	12.2	122	110	0.78	0	0	0.8	64.
28	18/05/2011	19:35	434226	12854	15.8	29	14	24.4	64.4	0	17	44.
29	20/05/2011	23:10	445734	12500	16.2	41	8	0	19.1	0	0.06	1.9
30	21/05/2011	2:10	451134	12059	16.8	36	9	8.25	6.1	0	0.55	69.2
31	21/05/2011	12:55	451960	11548	13.4	26	16	225	0	0	15.3	31.
32	21/05/2011	23:44	452231	23946	17.4	130	10	418.5	0	0	18.3	8.1
33	22/05/2011	2:22	452478	23868	16.4	124	8 a 23	85	0	1.45	2.95	29.
34	22/05/2011	12:53	443734	24794	12.3	125	110	0	0	0.5	0	0
35	22/05/2011	16:11	453744	30148	12.2	136	125	0.4	0	0	0	2.4
36	22/05/2011	21:52	453741	32178	11.8	147	135	29	0	0.5	0	89.
37	23/05/2011	1:20	455134	32371	16.7	140	12	28.5	0	0	0	23
38	23/05/2011	11:12	460647	35633	11.8	150	140	2.5	0	0.66	0	14
39	23/05/2011	21:15	460752	24181	11.6	105	90	0	0	0	0	4.1
40	23/05/2011	0:08	460755	23102	17.2	100	10	30	0	0	0	0.4
41	24/05/2011	1:33	455565	23033	17.6	100	7.5	8.05	0	0	0	72.6
42	24/05/2011	12:40	452994	13799	12.0	55	35	714	0	0	0	0
43	24/05/2011	20:28	453737	12934	12.7	36	20	511	0	0	0	0.5
44	24/05/2011	23:27	454499	13845	16.0	46	7	210	0	0	0	5
45	25/05/2011	9:33	455254	13343	11.8	32	19	83	0	1	0	0
46	25/05/2011	15:06	460004	20279	16.8	63	8	50	0	0	0	0
47	25/05/2011	16:32	460754	14737	11.6	37	25	23	55	0.85	0	3
48	27/05/2011	21:10	462255	20622	11.8	37.5	24	12.70	1.50	0	0	0.0
49	27/05/2011	0:05	462257	23540	17.3	80	12	72.10	0.07	0	0	0.3
50	28/05/2011	2:40	463721	24118	14.7	75	11	31.50	0.65	2.00	0	1.6
51	28/05/2011	12:45	462253	35383	11.6	143	125	7.90	0	0.00	0	0
52	28/05/2011	21:50	462262	45310	15.4	2000	12	18.00	0	5.60	0	0

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The ICES Working Working Group on Anchovy and Sardine (WGANSA 2011)

A.3.5 Statistics and biological data on horse mackerel (*T. picturatus*) from the Azores

by

João Gil Pereira [1]

ABSTRACT

Statistic information and biological data are presented for the Horse mackerel (*Trachurus picturatus)* caught in the Azores. Statistics includes catch data and respective size frequencies. Length weight relationships are given for the all population and for separate sexes. Biological data includes information on sex ratio, sexual maturity and reproduction.

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KEYWORDS

Horse mackerel, statistics, length weight, sexuality, reproduction, Azores

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1. Introduction

The horse mackerel (*Trachurus picturatus*) has traditionally been one of the favourite species of the Azorean population and is targeted by an artisanal fleet using seine nets close to the coast of the Azorean islands. The horse mackerel is also the main species used as live bait by the local bait boat fleet, that targets on tuna species. The demersal fleet also catches horse mackerel, usually large specimens, in the multispecific fishery for deep water species, where several types of hooks and lines gears are used. Those gears vary from hand lines, using one to several hundred hooks, to the bottom longlines**.**

In this document the available information on statistics and biology, collected from 1998 to 2010, of the horse mackerel caught in the Azores are presented.

2. Statistics

The landings of horse mackerel in recent years average 1200 tonnes. The horse mackerel is mostly landed by the artisanal fleet, using purse seines and their catches have been maintained at a relatively stable level since 1990, by an auto regulation adopted by the fisherman association, due to market restrictions. This stability of the catches is mostly observed in S. Miguel Island, where around 70% of the annual catches occur. Continuous reductions in the demands from the consumers lead to the catch limits auto adopted by the fleet, which explains the reduction observed in the catches along the recent years.

The fleet segments that use hand lines and bottom longlines also catches horse mackerel, but the catches are only partially landed, since an important part of their catches is used for bait in the demersal species fishery.

The catches made by the tuna bait boat fleet, for use as live bait for tuna, are not landed. Those catches are estimated by the tuna observer program and from the information in the logbooks.

The evolution of the landing of horse mackerel, from 1980 to 2010, is presented in table 1 and figure 1.

Nominal catch per unit of effort (cpue) were calculated for the two fleets using purse seine nets, targeting the juvenile population, the coastal artisanal fleet and the tuna bait boats that use the horse mackerel as live bait for tuna. Those cpue's are presented in figure 2. Due to the catch limits auto imposed by the artisanal fleet, the cpue for this fleets should not be considered as a true index of abundance. In figure 3, the standardized cpue (kg/1000 hooks) is presented for the adult stock, caught by the longliners.

Size frequencies for the horse mackerel caught in the Azores are available since 1980. In figure 4, is presented the size distribution of the landings (catch at size) for the years 2001 to 2010. The size distribution (catch at size) of the landings of horse mackerel caught by two of the main métiers involved in the fishery, artisanal purse seiners and longliners, is presented in figure 5.

The analysis of the sizes caught shows stability along the analyzed period, which is also confirmed by the stability in the average weights (figure 6) of the fish caught by the different métiers involved in the fishery

3. Length weight relationship

A total of 3372 specimens of horse mackerel were sampled for weight and length, and the length-weight relationships were calculate separately for males and females and for both sexes together. The parameters of the fork length to total weight relationships are given in table 2 and figure 7.

4. Sex ratio

During the biological sampling, sex was determined for a total of 2136 specimens of horse mackerel, from which 1080 were males (50.6%) and 1056 where females (49.4%). The overall ratio of males to females, was not significantly different from the 1:1 ratio. The sex ratio by size classes shows an increasing proportion of males for sizes over 47 cm and for lengths greater than 49 cm no females were observed. The sex ratio of the observed horse mackerel, by size classes, is presented in figure 8.

5. Maturity

The sex and stage of maturity of the sampled specimens were recorded by macroscopic examination of the gonads and the gonads weighted at the nearest 0.01 g. A macroscopic scale of 8 stages was used to classify the different stages of maturity.
The monthly frequencies of occurrence of the various maturity stages of the gonads of male and female horse mackerel are shown in figure 9.
The evolution of the gonadosomatic index ($GSI=Gonad_{weight}/Total_{\ weight} *100$), in a monthly basis, also confirms the previous observations, since the average GSI for both sexes has its higher values in January-February, confirming the spawning period (figure 10).

The proportion of mature and immature females of the horse mackerel by size category is presented in figure 11. The logistic curve fitted to the proportion of sexually mature horse mackerel estimated the mean length at sexual maturity at 28.5 cm of fork length, as showed in figure 12.

Year	Landings (t)	Year	Landings (t)	Year	Landings (t)	Year	Landings (t)
1980	2968.3	1990	2509.5	2000	644.1	2010	1049.4
1981	2133.9	1991	1274.2	2001	1101.0		
1982	2461.3	1992	1255.2	2002	1449.9		
1983	3757.0	1993	1731.9	2003	1501.5		
1984	3226.0	1994	1785.7	2004	1245.9		
1985	3490.9	1995	1823.5	2005	1230.7		
1986	3330.7	1996	1727.1	2006	1241.4		
1987	3019.5	1997	1921.2	2007	1154.6		
1988	3078.9	1998	1507.4	2008	1118.8		
1989	2865.7	1999	693.4	2009	1121.3		

Table 1 Landings of horse mackerel (*T. picturatus*) from the Azores (ICES area X) from 1980 to 2010.

	Sexes combined	Males	Females
n	3372	1260	1144
a	0.0072	0.0095	0.0083
b	3.1464	3.0658	3.1035
r^2	0.9957	0.9922	0.9907
FL range	8.1 – 52.0 cm	10.0 – 52.0 cm	12.5 – 49.8 cm

Table 2. Parameters of the length weight relationship for the horse mackerel (*T. picturatus*) from the Azores.

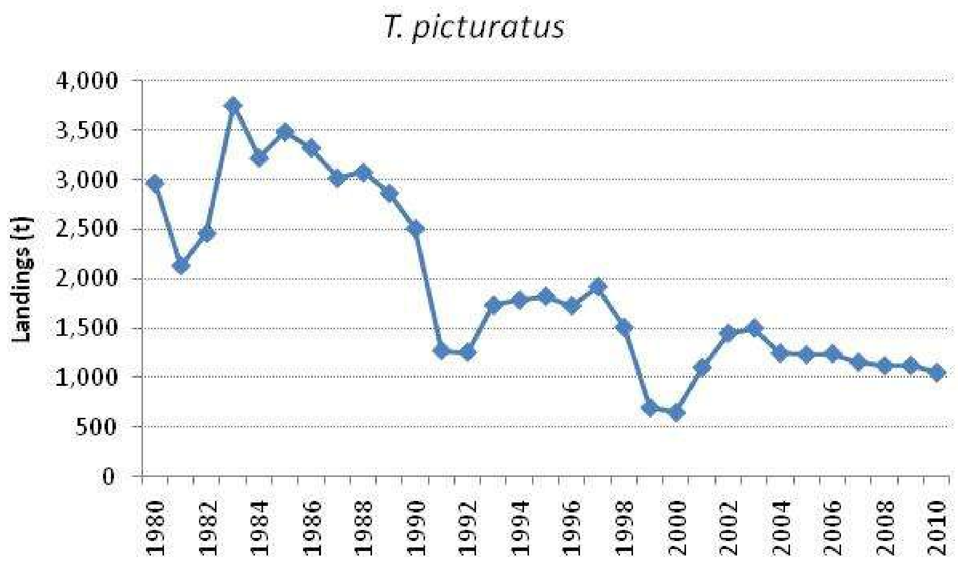


Figure 1. Annual landings of horse mackerel (*T. picturatus*) in the Azores (ICES area X) from 1980 to 2010.

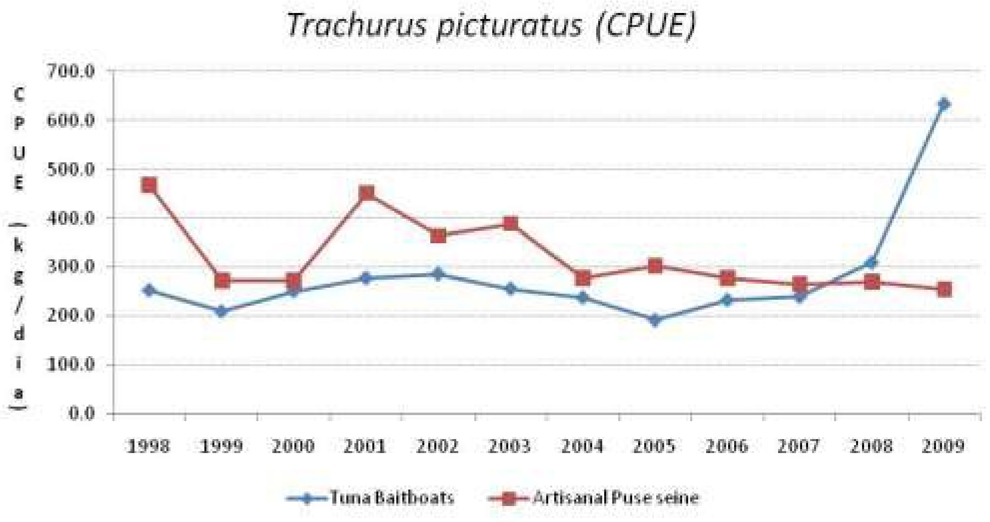


Figure 2. Cpue (kg/day) for the horse mackerel (*T. picturatus*), caught in the Azores with purse seines by the artisanal fleet and the tuna bait boats.

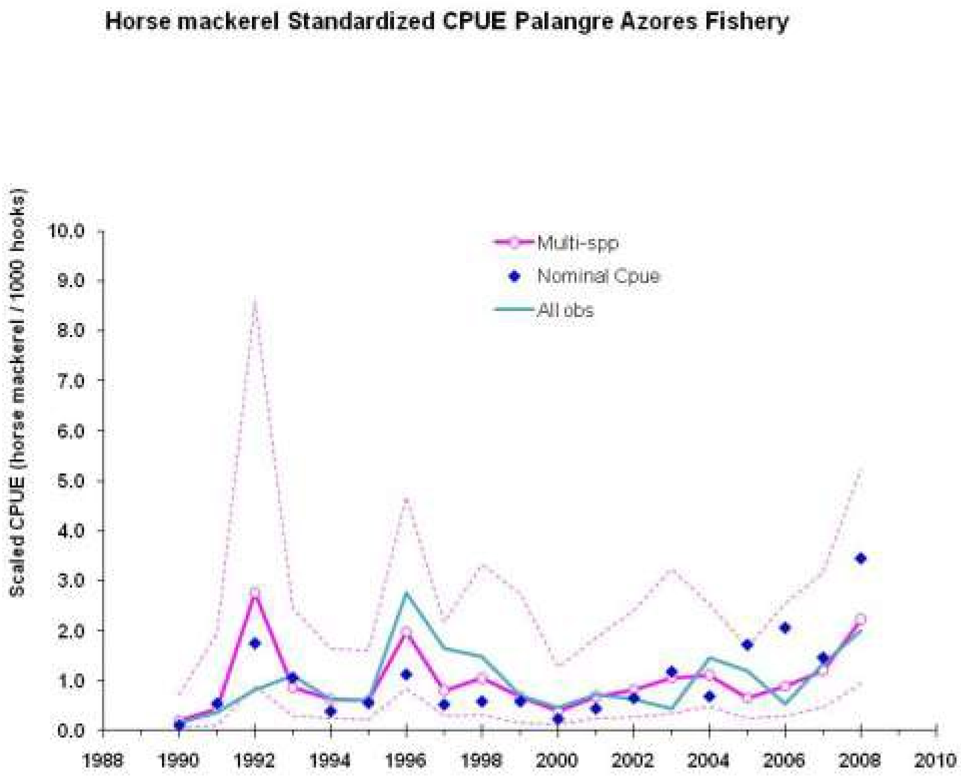


Figure 3. Standardized cpue (kg/1000 hooks) for the horse mackerel (*T. picturatus*), caught in the Azores with longlines (adult stock).

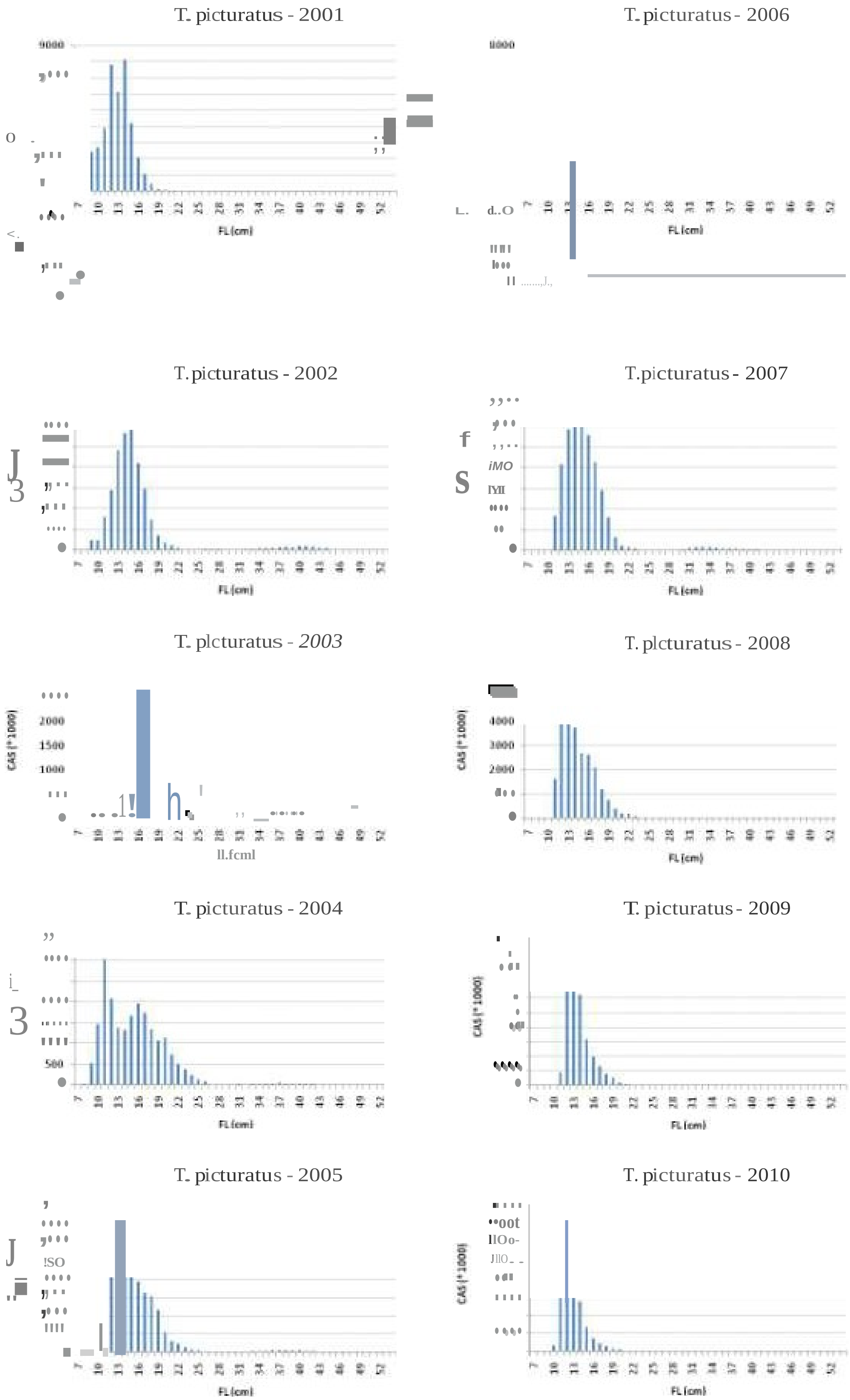


Figure 4. Size frequencies of the catches of horse mackerel *(T. picturotus)* in the Azores fishery, from 2001 to 2010.

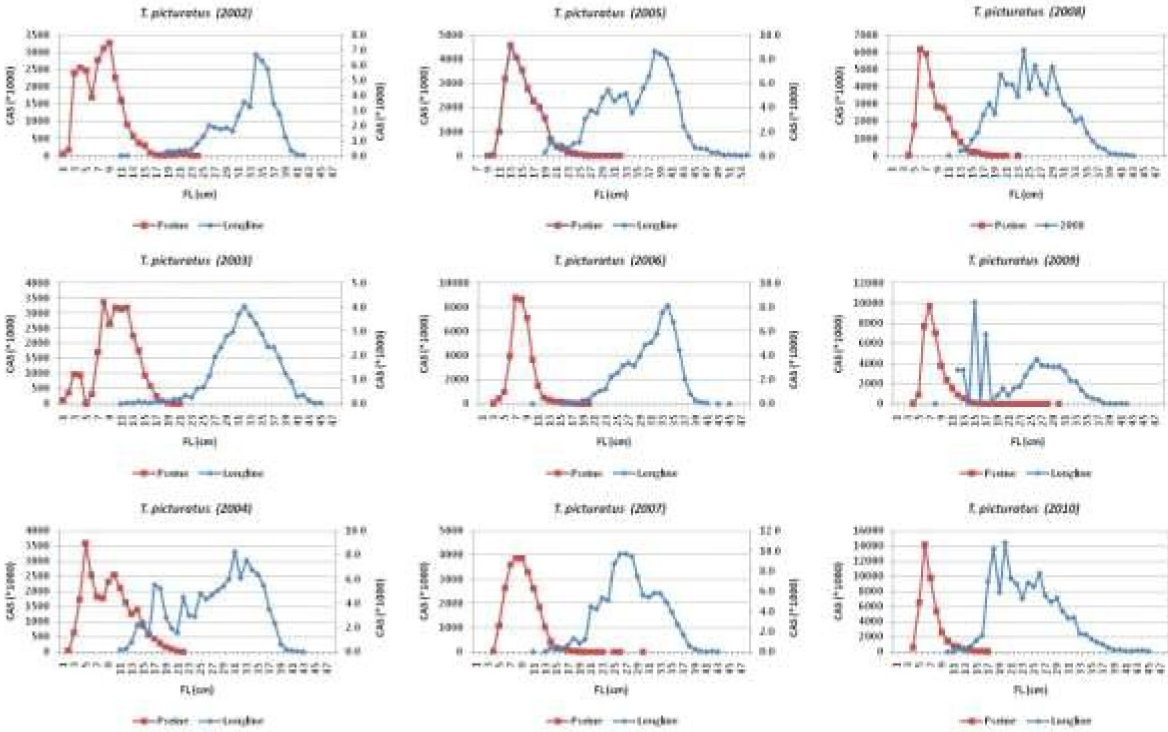


Figure 5. Size frequencies of horse mackerel (*T. picturatus*) caught in the Azores by purse seine and longlines, from 2002 to 2010.

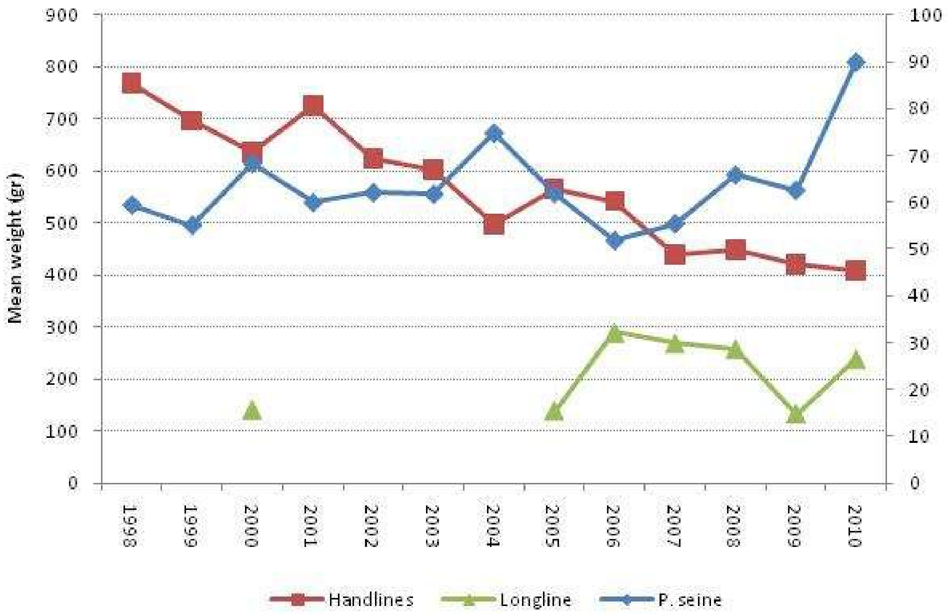


Figure 6. Annual mean weights of the Horse mackerel caught in the Azores by different métiers.

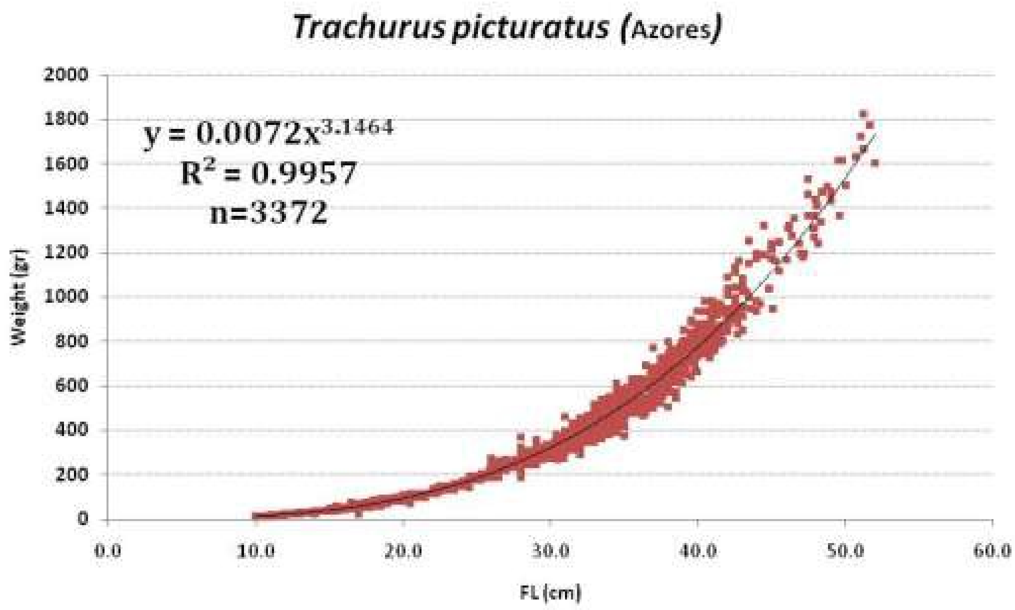


Figure 7. Length weight relationship for the horse mackerel (*T. picturatus*) from the Azores.

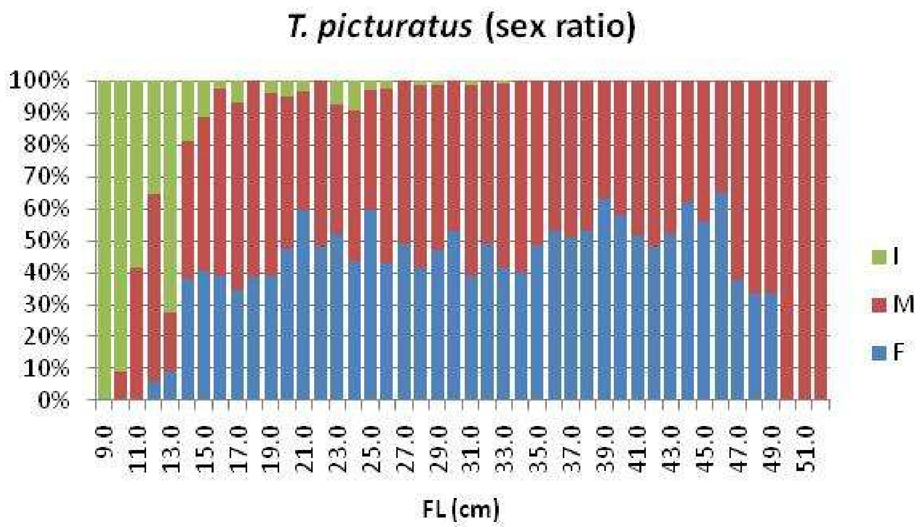
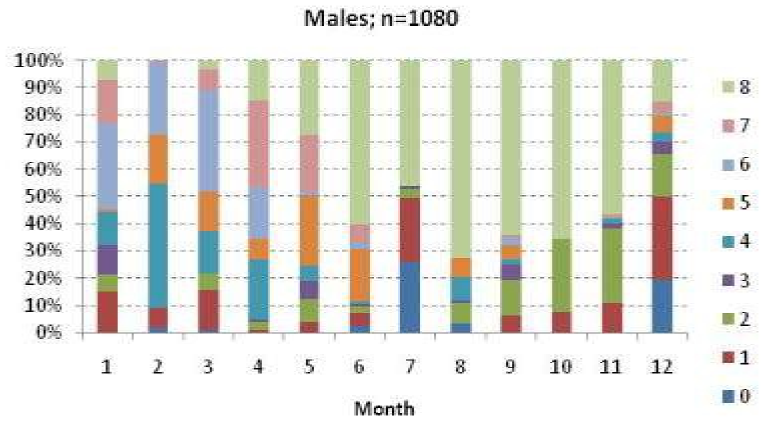


Figure 8. Sex ratio of the horse mackerel (*T. picturatus*) caught in the Azores



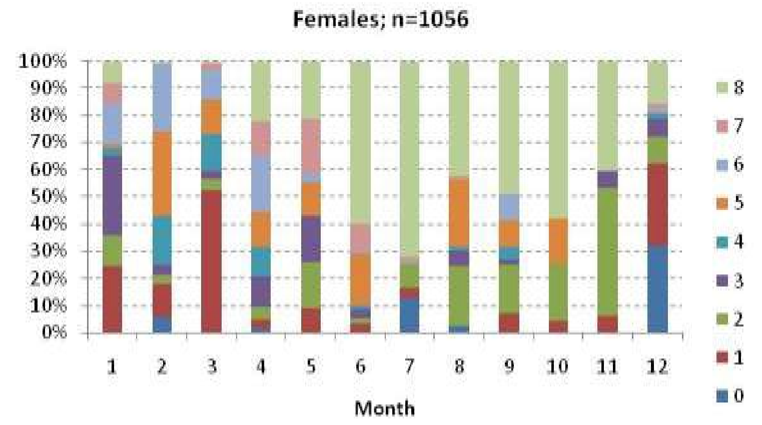


Figure 9. Monthly changes in the frequency of occurrence of the various maturity stages of the gonads of male and female of horse mackerel in Azores.

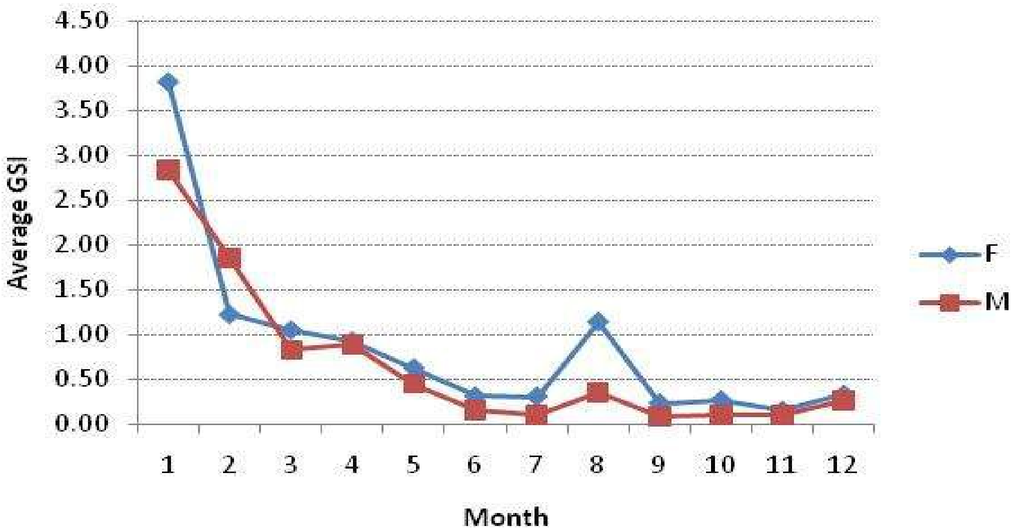


Figure 10. Monthly evolution of the average gonadosomatic index (GSI) for the horse mackerel from the Azores.

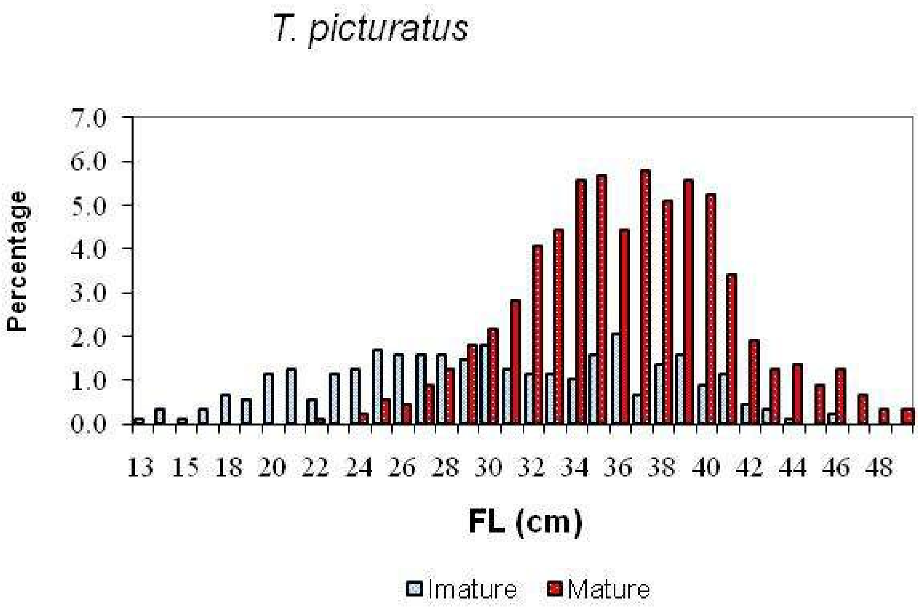


Figure 11. Proportion of mature and immature females of the horse mackerel by size category.

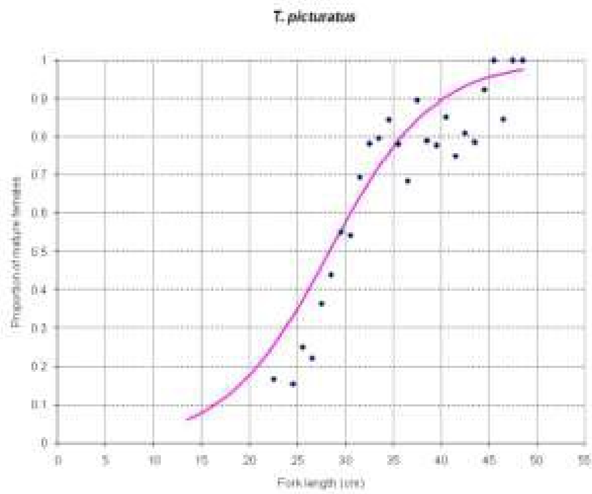


Figure 12. Size at sexual maturity (FL_{50}) for the horse mackerel from the Azores.

Annex 4 – Data Tables

WG:	WGANSA 2011
Stock name:	Anchovy in Subarea VIII (Bay of Biscay)

Country:	Landings					Discards					Tuning fleet data		
	Landings: Age	Landings: Length	Landings: Weight	Landings: Maturity	Landings: Sex ratio	Discards: Age	Discards: Length	Discards: Weight	Discards: Maturity	Sex ratio	Commercial fleets	Surveys at Sea	Additional comments
Belgium													
Denmark													
Estonia													
Finland													
France	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	A. Not relevant	C2. Data available but not relevant in the model we use for assessment for the time being	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	C2. Data available but not relevant in the model we use for assessment for the time being	D. Data available and used in assessment	Maturity not relevant, because all anchovy are mature at age 1. Discard data not available but its relevance is
Germany													
Greenland													
Iceland													
Ireland													
Latvia													
Lithuania													
Netherlands													
Norway													
Poland													
Portugal													
Russia													
Spain	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	A. Not relevant	C2. Data available but not relevant in the model we use for assessment for the time being	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	C2. Data available but not relevant in the model we use for assessment for the time being	D. Data available and used in assessment	relevant, because all anchovy are mature at age 1. Discard data not available but its relevance is considered to be
Sweden													
UK													
UK-England&Wales													
UK - Scotland													
UK-North Ireland													
Faroe Islands													

A. **Not relevant**

B. **Data relevant** but **not available** to ICES

C. **Data available** to ICES but **not used** in assessment

C.1. **Data available but** time series too short

C2. **Data available but** not relevant in the model we use for assessment for the time being

C.3. **Data are available** from this country **but** since other countries do not submit it we cannot use it

C.4. **Data are available but** they have insufficient representativity or quality for us to use them

D. **Data available** and **used** in assessment

WG:	WGANSA
Stock name:	Anchovy in Division IXa

	Landings					Discards					Tuning fleet data		
Country:	Landings: Age	Landings: Length	Landings: Weight	Landings: Maturity	Landings: Sex ratio	Discards: Age	Discards: Length	Discards: Weight	Discards: Maturity	Sex ratio	Commercial fleets	Surveys at Sea	Additional comments
Belgium													
Denmark													
Estonia													
Finland													
France													
Germany													
Greenland													
Iceland													
Ireland													
Latvia													
Lithuania													
Netherlands													
Norway													
Poland													
Portugal	B. Data relevant but not available to ICES	B. Data relevant but not available to ICES	D. Data available and used in assessment	C2. Data available but not relevant in the model we use for assessment for the time being	C2. Data available but not relevant in the model we use for assessment for the time being	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	D. Data available and used in assessment	D. Data available and used in assessment	Anchovy is a group 3 species in the Portguese sampling plan for DCF. Surveys used: PELAGO (co-financed by DCF), SAR (not financed by DCF
Russia													
Spain	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	C2. Data available but not relevant in the model we use for assessment for the time being	C2. Data available but not relevant in the model we use for assessment for the time being	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	D. Data available and used in assessment	D. Data available and used in assessment	Surveys used: PELACUS04 (co-financed by DCF), ECOCÁDIZ (not funded by DCF), BOCADEVA (not funded by DCF).
Sweden													
UK													
UK-England&Wales													
UK - Scotland													
UK-North Ireland													
Faroe Islands													

A. **Not relevant**
B. **Data relevant** but **not available** to ICES
C. **Data available** to ICES but **not used** in assessment
C.1. **Data available but** time series too short
C2. **Data available but** not relevant in the model we use for assessment for the time being
C.3. **Data are available** from this country **but** since other countries do not submit it we cannot use it
C.4. **Data are available but** they have insufficient representativity or quality for us to use them
D. **Data available** and **used** in assessment

WG:	WGANSA
Stock name:	Horse mackerel (Trachurus trachurus) in Division IXa (Southern stock)

Country:	Landings					Discards					Tuning fleet data		
	Landings: Age	Landings: Length	Landings: Weight	Landings: Maturity	Landings: Sex ratio	Discards: Age	Discards: Length	Discards: Weight	Discards: Maturity	Sex ratio	Commercial fleets	Surveys at Sea	Additional comments
Belgium													
Denmark													
Estonia													
Finland													
France													
Germany													
Greenland													
Iceland													
Ireland													
Latvia													
Lithuania													
Netherlands													
Norway													
Poland													
Portugal	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	C.1. Data available but time series too short	C.1. Data available but time series too short	C.1. Data available but time series too short	C.1. Data available but time series too short	C.1. Data available but time series too short	C.4. Data are available but they have insufficient representativity or quality for us to use them	D. Data available and used in assessment	
Russia													
Spain	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	C.1. Data available but time series too short	C.1. Data available but time series too short	C.1. Data available but time series too short	C.1. Data available but time series too short	C.1. Data available but time series too short	C.4. Data are available but they have insufficient representativity or quality for us to use them	D. Data available and used in assessment	
Sweden													
UK													
UK-England&Wales													
UK - Scotland													
UK-North Ireland													
Faroe Islands													

A. **Not relevant**
B. **Data relevant** but **not available** to ICES
C. **Data available** to ICES but **not used** in assessment
C.1. **Data available but** time series too short
C2. **Data available but** not relevant in the model we use for assessment for the time being
C.3. **Data are available** from this country **but** since other countries do not submit it we cannot use it
C.4. **Data are available but** they have insufficient representativity or quality for us to use them
D. **Data available** and **used** in assessment

WG:	WGANSA 2011												
Stock name:	Horse mackerel (Trachurus picturatus) in the waters of the Azores												
	Landings					Discards					Tuning fleet data		
Country:	Landings: Age	Landings: Length	Landings: Weight	Landings: Maturity	Landings: Sex ratio	Discards: Age	Discards: Length	Discards: Weight	Discards: Maturity	Sex ratio	Commercial fleets	Surveys at Sea	Additional comments
Belgium													
Denmark													
Estonia													
Finland													
France													
Germany													
Greenland													
Iceland													
Ireland													
Latvia													
Lithuania													
Netherlands													
Norway													
Poland													
Portugal	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	C. Data available to ICES but not used in assessment	A. Not relevant	No assessment has ever been carried out because advice has never been asked to ICES
Russia													
Spain													
Sweden													
UK													
UK-England&Wales													
UK - Scotland													
UK-North Ireland													
Faroe Islands													

A. **Not relevant**
B. **Data relevant** but **not available** to ICES
C. **Data available** to ICES but **not used** in assessment
C.1. **Data available but** time series too short
C2. **Data available but** not relevant in the model we use for assessment for the time being
C.3. **Data are available** from this country **but** since other countries do not submit it we cannot use it
C.4. **Data are available but** they have insufficient representativity or quality for us to use them
D. **Data available** and **used** in assessment

WG:	WGANSA
Stock name:	Sardine in Divisions VIIIc and IXa

Country:	Landings					Discards					Tuning fleet data		Additional comments
	Landings: Age	Landings: Length	Landings: Weight	Landings: Maturity	Landings: Sex ratio	Discards: Age	Discards: Length	Discards: Weight	Discards: Maturity	Sex ratio	Commercial fleets	Surveys at Sea	
Belgium													
Denmark													
Estonia													
Finland													
France													
Germany													
Greenland													
Iceland													
Ireland													
Latvia													
Lithuania													
Netherlands													
Norway													
Poland													
Portugal	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	C2. Data available but not relevant in the model we use for assessment for the time	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	C2. Data available but not relevant in the model we use for assessment for the time being	D. Data available and used in assessment	
Russia													
Spain	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	D. Data available and used in assessment	C2. Data available but not relevant in the model we use for assessment for the time being	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	A. Not relevant	C2. Data available but not relevant in the model we use for assessment for the time being	D. Data available and used in assessment	
Sweden													
UK													
UK-England&Wales													
UK - Scotland													
UK-North Ireland													
Faroe Islands													

A. **Not relevant**
B. **Data relevant** but **not available** to ICES
C. **Data available** to ICES but **not used** in assessment
C.1. **Data available but** time series too short
C2. **Data available but** not relevant in the model we use for assessment for the time being
C.3. **Data are available** from this country **but** since other countries do not submit it we cannot use it
C.4. **Data are available but** they have insufficient representativity or quality for us to use them
D. **Data available** and **used** in assessment

Annex 5 – Stock Annexes

5.1 Stock Annex – Bay of Biscay Anchovy (Subarea VIII)

Quality Handbook **Annex:A.5.1**

Stock specific documentation of standard assessment procedures used by ICES

Stock: Bay of Biscay Anchovy (Subarea VIII)

Working Group: WGANSA (working group on the assessment of anchovy and sardine)

Date: 15th to 20th of June, 2009

Revised at: WGANSA2009, WKSHORT2009 and WGANSA2010

Authors by alphabetic order: E. Duhamel, L. Ibaibarriaga, J. Massé, L. Pawlowski, M. Santos and A. Uriarte.

A. General

A.1. Stock definition

Anchovy (*Engrulis encrasicolus, L*) stock in Subarea VIII (Bay of Biscay) is considered to be isolated from a small population in the English Channel and from the population in the area IXa. No subpopulations have been defined, although morfometrics and meristic studies suggest some heterogeneity at least in morphotipes (*Prouzet and Metuzals, 1994*; *Junquera and Perez-Gandaras, 1993*). Some genetic heterogeneity based on proteins allocime loci have been found between the Garonne spawning regions and southern regions in the Bay of Biscay (Adour and Cantabrian shores) (*Sanz et al., 2008*). Nevertheless, the evident inter connection of fisheries and rather homogenous recruitment pulses occurring in the Bay of Biscay lead ICES to consider that the anchovy in this area should be dealt as a single stock for assessment and management (ICES 2007).

A.2. Fishery

The fisheries were closed since June 2006 to December 2009 due to poor condition of the stock. It was reopened in January 2010 with a TAC of 7,000t. The fisheries for anchovy are targeted by purse-seiners and pelagic trawlers. The Spanish and French fleets fishing for anchovy in Subarea VIII are spatially and temporally quite well separated. The Spanish fleet (purse seine fleet) operates mainly in Divisions VIIIc and VIIIb in spring, while the French fleet (mainly pelagic trawlers) operates in Division VIIIa in summer and autumn and in Division VIIIb in winter and summer. A small fleet of French purse seiners operates in the South of the Bay of Biscay (VIIIb) in spring and in the North (VIIIa) during the autumn. An overview of the history of the fishery until the mid nineties and its spatial behaviour is found in Junquera (1986) and Uriarte *et al.* (1996) and for more recent perspective see ICES 2007 & 2008 or STECF 2008 for the international fishery and Uriarte *et al.* (2008) Villamor *et al.* (2008) for the Spanish fishery and Duhamel (2004) and Vermard *et al.* (2008) for the French pelagic trawlers. A recent updated information (2009) provided by the SWW RAC shows a 18% decrease in the fleet size operating on anchovy since the closure of the fishery (2005). This decrease is much more important for the pelagic trawlers' fleet (-39%) than for the purse seiners (-11%). Since the fishery closure, the fleets have redeployed their effort mainly towards other small pelagic species (57%) and tunas (29%) (Table A.2.2).

Table A.2.1: Evolution of the French and Spanish fleets on anchovy in Sub-area VIII. Fishery closed in 2006, 2007 and 2008. Units: numbers of boats.

	France				Spain *	
Year	**P. seiner**	**P. trawl**		**Total**	**P. seiner**	**Total**
1960	-	-			571	571
1972	-	-			492	492
1976	-	-			354	354
1980	-	-			293	293
1984	-	-			306	306
1987	-	-			282	282
1988	-	-			278	278
1989	18	6	(1,2)	24	215	239
1990	25	48	(1,2)	73	266	339
1991	19	53	(1,2)	72	250	322
1992	21	85	(1,2)	106	244	350
1993	34	108	(1,2)	142	253	395
1994	34	77	(1,2)	111	257	368
1995	33	44	(1,2)	77	257	334
1996	30	60	(1,2)	90	251	341
1997	27	52	(1,2)	79	267	346
1998	29	44	(1,2,3)	73	266	339
1999	30	49	(1,2)	79	250	329
2000	32	57	(1,2)	89	238	327
2001	34	60	(1,2)	94	220	314
2002	32	47	(1,2)	79	215	294
2003	19	47	(1,2)	66	208	274
2004	31	54	(1,2)	85	201	286
2005	8	41	(1,2,4)	49	197	246
2006	1 **	6 **	(1,2,4)	7 **	0	7
2007	0	0		0	0	0
2008	0	0		0	0	0
2009						
2010	2	30	(2)	32		

*** Spanish purse seiners are those with licences that landed anchovy**

(1) Only purse seiners having catch anchovy at least once a year but fishing sardine most of the time

(2) only trawlers that targeted anchovy (annual catch > 50 t)

(3) doubtful in terms of separation between gears because of misreporting

(4) Provisional estimate

**** French number of boats involved in the experimental fishery; not the actual size of the fleet**

Table A.2.2. Approximate figures for the anchovy fleet and fishing effort displacement for the the period 2005-2009 (based on reports from stakeholders 28th August 2009, provided by the SWW RAC). Report vers = report to add; bolincheurs sud bretagne = purse seiners in southern Brittany; chinchard = horse mackerel; maquerau = mackerel; thon rouge = bluefin tuna; thon blanc = albacore; Autres = others

Fishing ports	Seiners		Pelagic trawlers		report vers												number of targeted species
					sardine		chinchard		maquereau		thon rouge		thon blanc		autres		
	2005	2009	2005	2009													
Galice	67	61			1	15,3	1	15,3	1	15,3					1	15,3	4
Asturies	10	6			1	3,0	1	3,0									2
Cantabrie	54	47			1	9,4	1	9,4	1	9,4	1	9,4	1	9,4			5
Vizcaya	25	25			1	5,0	1	5,0	1	5,0	1	5	1	5			5
Guipuzkoa	52	44			1	8,8	1	8,8			1	8,8	1	8,8	1	8,8	5
StJean de Luz	8	8	4	4			1	12,0									1
la Turballe			39	23									1	11,5	1	11,5	2
St Gilles			24	14	1	0,0					1	0					2
Bolincheurs sud bretagne	8	8			1	2,7	1	2,7							1	2,7	3

2010 St jena de luz 2 Lorient 2 La Turbballe 20 St Gilles 6 (15 pairs of pair pelagic trawlers)

A.3. Ecosystem aspects

Anchovy is a prey species for other pelagic and demersal species in the Bay of Biscay, and also for cetaceans and birds.

The recruitment depends strongly on environmental factors. Two environmental recruitment indices have been considered during the last 10 years: i) Borja's *et al.* (1998) index, which is an upwelling index, and ii) Allain's *et al.* (2001) index, which is a combination of upwelling and stratification breakdown. Allain's model was reviewed by Huret & Petitgas (WD 2007 in ICES2008) including a) the previous "upwelling" index, plus a new "stratification" index according to a new hydrodynamic model and b) an adult spatial indicator. The role of the Eastern Atlantic pattern in relation to the Upwelling index and the recruitment of anchovy have also been recently pointed out (Borja *et al.*, 2008). Other approaches based on coupling spawning habitat with hydrodynamic and production models are being tried for this anchovy population with promising results (Allain *et al.*, 2007).

The significance and reliability of all these indices is considered still insufficient for their consideration in the provision of management advice and no update was provided on their performance for the meeting in 2010 of WGANSA. Recent reviews have suggested that comparison with global indexes and correlation analysis may not be the best approach to understand and consequently predict recruitment in small pelagic fish (Barange *et al.*, 2009).

Fernandes et al (2010) presents an alternative to attempt to relate environmental indices with recruitment by means of linear models. It uses machine-learning techniques to obtain the probability of having a recruitment discretized into low, medium and high classes depending on environmental variables. The proposed methodology consists of performing supervised predictors discretization, carrying out supervised predictors selection and learning a 'naive Bayes' classifier. The approach can be applied to a dataset where the values of the recruitment have been discretized by the end-user, or the recruitment discretization can be part of the proposed model-building process in a bootstrap scheme. The results up to now are promising.

B. Data

B.1. Commercial catches:

Fishery closed from July 2006 to December 2009. reopened with 7,000t the 1st of March 2010

Annual Landings are available since 1940. The fishing statistics are considered accurate. Discards are not measured and hence not included in the assessment, but nowadays they are considered not relevant for the two fleets. In the past (late eighties and early nineties for the French Pelagic trawlers and sixties and seventies for the Spanish Purse seine fleet) they seemed to be more relevant (according to disputes among fishermen), but were never quantified.

B.2. Biological

- Catches at length and catches at age are known since 1984 for Spain and since 1987 for France. They are obtained by applying to the monthly Length distributions half year or quarterly ALKs (and when possible monthly ALKs, as for the Spanish fishery in spring). Biological sampling of the catches has been generally sufficient, except for 2000 and 2001, when an increase of the sampling effort seemed useful to have a better knowledge of the age structure of the catches during the second semester in the North of the Bay of Biscay. Complete age composition and mean weight at age on half year basis, were reported in ICES (2008- WGANC report).
- Age reading is considered accurate. The most recent cross reading exchanges and workshop between Spain and France took place in 2005 and 2006 respectively (Uriarte *et al.*, 2006 and 2007). The overall level of agreement and precision in anchovy age reading determinations seems to be satisfactory: Most of the anchovy otoliths were well classified by most of the readers during the 2006 workshop (with an average agreement of 92.7 % and a CV of 9.2%). CVs were on average smaller than 15% for any age, although individual CVs for ages or readers might be 30-35%. A new otolith exchange and age reading workshop took place in November 2009.
- Anchovies are mature at their 1st year of life.
- Growth in weight and length are well known from Surveys and from the monitoring of the fishery (Uriarte *et al.*, 1996).
- Natural mortality is fixed at 1.2 as an average of varying values obtained under the assumption of past DEPM providing absolute estimates of the population in numbers at age (*Uriarte et al.*, 1996). This parameter is considered to vary between years, but it is assumed to be constant for the assessment of the stock.
- In the Bayesian Biomass Model, the parameter g describes the annual change in mass of the population by encapsulating the growth in weight (G) and the natural Mortality (M) of the population as G-M (0.52-1.2=-0.68)

B.3. Surveys

Spring surveys: series of DEPM(Daily egg production method) and acoustic surveys in Spring every year.

The population is monitored by the two annual surveys carried out in spring on the spawning stock, namely, the Daily Egg Production Method (since 1987 with a gap in 1993) (Santiago and Sanz, 1992; Motos *et al.*, 2005) and the Acoustics surveys (regularly since 1989, although surveys were also conducted in 1983, 1984 and some in the seventies) (Massé 1988, 1994, 1996). Both surveys provide spawning biomass and population at age estimates. The surveys have shown pronounced inter-annual variability of biomass according to the pulse of recruitments, since one year old anchovies can conform up to more than 75% of the spawning population. Spawning area and biomass are positive and closely related, revealing expansion of the area occupied by the population when SSB increases (Uriarte *et al.*, 1996, Somarakis *et al.*, 2004).

This survey based monitoring system provides population estimates by the middle of the year, when about half of the annual catches have been already taken; and provide very little information about the anchovy population in the next year, since the bulk of it will consist of 1 year old anchovies being born at the time the surveys take place. Spawning Biomass in spring equals total stock biomass since all anchovies are mature (the youngest being 1 year old by then).

B.3.1 Anchovy Daily Egg Production Method

B.3.1.1 The DEPM model

The anchovy spawning stock biomass estimates is derived according to Parker (1980) and Stauffer & Picquelle (1980) from the ratio between daily production of eggs in the sea and the daily specific fecundity of the adult population:

Equation 1 $$SSB = P_{tot}/DF = \frac{P_0 \cdot A+}{k \cdot R \cdot F \cdot S/W}$$

Where,

SSB = Spawning stock biomass in metric tons

P_{tot} = Total daily egg production in the sampled area

P_0 = daily egg production per surface unit in the sampled area

A+ = Spawning area, in sampling units

DF = Daily specific fecundity. $DF = \frac{k \cdot R \cdot F \cdot S}{W}$

W = Average weight of mature females in grams,

R = Sex ratio, fraction of population that are mature females, by weight.

F = Batch fecundity, numbers of eggs spawned per mature females per batch

S = Fraction of mature females spawning per day

k = Conversion factor from gram to metric tons (10^6)

An estimate of an approximate variance and bias for the biomass estimator derived using the *delta* method (Seber, 1982, *in* Stauffer & Picquelle, *op. cit.*) was also developed by the latter authors.

Population estimates of numbers at age are derived as follows:

Equation 2
$$N_a = N \cdot E_a = \frac{SSB}{W_t} \cdot E_a$$

Where,

Na = Population estimate of numbers at age *a*.

N = Total spawning stock estimate in numbers. $N = \frac{SSB}{W_t}$

B = spawning stock biomass estimate.

Wt = average weight of anchovies in the population.

Ea = Relative frequency (in numbers) of age *a* in the population.

Variance estimate of the anchovy stock in numbers at age and total is derived applying the delta method.

B.3.1.2 Collection of plankton samples

Every year the area covered to collect the plankton samples is the southeast of the Bay of Biscay which corresponds to the main spawning area and season of anchovy.

Predetermined distributions of the vertical hauls that will be performed with the PairoVET net are shown in **Figure B.3.1.2.1**. The strategy of egg sampling is as follow: a systematic central sampling scheme with random origin and sampling intensity depending on the egg abundance found. Stations are located every 3 miles, along 15-mile-apart transects perpendicular to the coast. The sampling strategy is adaptive. When the egg abundances found are relatively high, additional transects separated by 7.5 nm are completed.

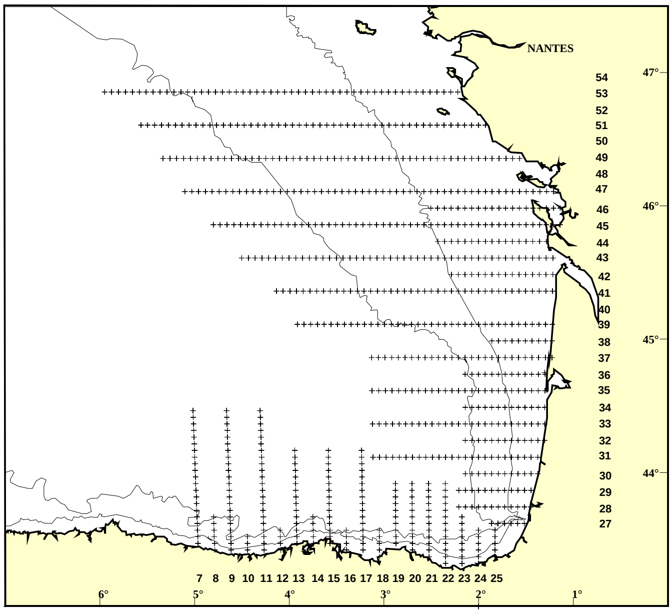


Figure B.3.1.2.1: Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey

The Continuous Underway Fish Egg Sampler (CUFES) is also used to record the eggs found at 3m depth. The samples obtained are immediately checked under the microscope so that presence/absence of anchovy eggs is detected in real time. This allowed knowing whether there were anchovy eggs in the area. When anchovy eggs are not found in 6 consecutive CUFES samples in the oceanic area, transect is left.

A vertical plankton haul is performed in each sampling station, using a PairoVET net (2-Calvet nets, Smith *et al.*, 1985 in Lasker, 1985) with a mouth aperture of 0.05 m^2 each CalVET. The frame was equipped with nets of 150 µm. The net is lowered to a maximum depth of 100 m or 5 m above the bottom in shallower waters. After allowing 10 seconds at the maximum depth for stabilisation, the net is retrieved to the surface at a speed of 1 m s^{-1}. A 45 kg depressor was used to allow for correctly deploying the net. "G.O. 2030" flowmeters were used to know the amount of water filtered during the tow.

Immediately after the haul, the net is washed and the samples obtained are fixed in formaldehyde 4% buffered with sodium tetra borate in sea water. After 6h of fixing, anchovy, sardine and other species eggs are identified and sorted out on board. Afterwards, in the laboratory a percentage of the samples are checked to assess the quality of the sorting made at sea. According to that a portion of the samples are sorted again to assure no eggs are left. In the laboratory the anchovy eggs are staged (Moser and Alshtrom, 1985).

During the survey, the presence/absence of eggs was recorded per PairoVET station and the area where anchovy eggs occurred was quantified. The spawning area was delimited with the outer zero anchovy egg stations. It contains some inner zero egg stations embedded on it (Picquelle and Stauffer, 1985). Following the systematic central sampling scheme (Cochran, 1977) each station was located in the centre of a rectangle. Egg Abundance found at a particular station was assumed to represent the abundance in the whole rectangle. The area represented by each station was measured. A standard station has a surface of 45 squared nautical miles (154 km^2) = 3 (distance between two consecutive stations) x 15 (distance between tow consecutive transects) nautical miles. Since sampling was adaptive, station area changed according to sampling intensity.

Real depth, temperature, salinity and chlorophyll profiles are obtained in every station using a CTD RBR-XR420 coupled to the PairoVET. In addition, surface temperature and salinity is recorded in each station with a manual termosalinometer WTW LF197.Moreover current data are obtained all along the survey with an ADCP(Acoustic Doppler Current Profiles).In some point determinate previously to the survey, water is filtered from the surface to obtain chlorophyll samples.

B.3.1.3 Collection of adult samples

In 1987 and 1988 the samples were obtained from commercial purse seines, the adult sampling was opportunistic. From years 1989 to 2005 the adult samples were obtained both from commercial purse seines and a research vessel with pelagic trawl so the adult sampling was both opportunistic and directed. Since 2006 the samples are obtained from a research vessel with pelagic trawl but not from the purse seines due to the closure of the fishery so the adult sampling is only directed not opportunistic. Since the reopening of the fisheries in March 2010 the commercial purse seines are providing again samples for the analysis apart from the ones from the research vessels.

The research vessel pelagic trawler covers the same area as the plankton vessel. When the plankton vessel encountered areas with anchovy eggs, the pelagic trawler is directed to those areas to fish. In each haul 100 individuals of each species are measure. Immediately after fishing, anchovy is sorted from the bulk of the catch and a sample of near 2 Kg is selected at random. Sampling finished as soon as a minimum of 1 kg or 60 anchovies are sexed, and from those, 25 non-hydrated females (NHF) are preserved. Sampling is also stopped when more than 120 anchovies have to be sexed to achieve the target of 25 NHF. Moreover, otoliths are extracted to obtain the age composition per sample.

In the case the sample are obtained from the purse seines a sample of near 2kg is selected from the fishing and are directly kept in 4% formaldehyde. Afterwards, in the laboratory the samples are process in the same way as explained above.

B.3.1.4 Total daily egg production estimates

When all the anchovy eggs are sorted and staged, it is possible to estimate total daily egg production (P_{tot}). This is calculated as the product between the daily egg production (P_0) and the spawning area (SA)

$$P_{tot} = P_0\ SA$$

A standard sampling station represents a surface of 45 nm^2 (i.e. 154 km^2). Since the sampling was adaptive, area per station changes according to the sampling intensity and the cut of the coast. The total area is calculated as the sum of the area represented by each station. The spawning area (SA) is delimited with the outer zero anchovy egg stations but it can contain some inner zero stations embedded. The spawning area is computed as the sum of the area represented by the stations within the spawning area.

The staged eggs are transformed into daily cohort abundances using the Bayesian ageing method (ICES 2004) Daily egg production (P_0) and daily mortality rates (Z) are estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age.

The model is fitted as a Generalised Linear Model (GLM) with Negative Binomial distribution and log link.

The ageing process and the model fitting are repeated until convergence. Eggs younger than 4 hours and older than 90% of the incubation time are removed from the model fitting to avoid any possible bias.

B3.1.5 Adult parameters and Daily Fecundity estimates

The DF estimate for this WGANSA in June is obtained from a linear regression model between DF and sea surface temperature (SST). Two weeks after arriving from the survey the adult parameters are not processed yet, uniquely the anchovies were weighted, measured, sexed and the otoliths were extracted, consequently Daly Fecundity has to be derived from the past historical series. Afterwards in the ICES WGACEGG in November the complete DEPM with all the adult parameters estimates is presented and approval. This occurred since 2005 when the advice started demanding SSB estimates in June, however the historical series of DF is being revised within WGACEGG (ICES 2009). Until DF is fully revised and its relationship with temperature corroborated by WGACEGG, the WGANSA decided to use the historical mean of DF (63.39 egg/ g per day) to obtain the preliminary SSB estimate for June.

From the whole set of adult samples gathered during the survey, a subset is chosen for final processing with the criterion of collection within ±5 days of the egg sampling in the same particular area. In the last years the samples are collected within the same day as the egg sampling. These samples are used to obtain adult parameters estimates leading to the estimate of Daily Fecundity, i.e. batch fecundity, spawning fraction, average female weight and sex ratio. These adult parameters are estimates for November as follows:

Sex Ratio (R): Given the large variability among samples of the sex ratio and taking into account that for most of the years when the DEPM has been applied to this population the final estimate has come out to be not significantly different from 50 % for each sex (in numbers), since 1994 the proportion of mature females per sample is being assumed to be equal to 1:1 in numbers. This leads to adopt as R the value of the average sample ratio between the average female weight and the sum of the average female and male weights of the anchovies in each of the samples.

Total weight of hydrated females is corrected for the increase of weight due to hydration. Data on gonad-free-weight (Wgf) and correspondent total weight (W) of non hydrated females is fitted by a linear regression model. Gonad-free-weight of hydrated anchovies is then transformed to total weight by applying the following equation:

$$W = -a + b * W_{gf}$$

For the **Batch fecundity (F)** estimates i.e. number of eggs laid per batch and female, the hydrated egg method was followed (Hunter et al, 1985). The number of hydrated oocytes in gonads of a set of hydrated females is counted. This number is deduced from a sub-sampling of the hydrated ovary: Three pieces of approximately 50 mg are removed from different parts of each ovary, weighted with precision of 0.1 mg and the number of hydrated oocytes counted. Sanz & Uriarte (1989) showed that 3 tissue samples per ovary are adequate to get good precision in the final batch fecundity estimate and the location of sub-samples within the ovary do not affect it. Finally the number of hydrated oocytes in the sub-sample is raised to the total gonad of the female according to the ratio between the weights of the gonad and the weight sub-sampled.

A linear regression between female weight and batch fecundity is established for the subset of hydrated females and used to calculate the batch fecundity of all mature females. The average of the batch fecundity estimates for the females of each sample as derived from the gonad free weight – eggs per batch relationship is then used as the sample estimate of batch fecundity.

Moreover, an analysis is conducted to verify if there are differences in the batch fecundity if strata are defined to estimate SSB.

To estimate **Spawning Frequency (S)**, i.e. the proportion of females spawning per day, until the new series of spawning frequency (S) is accepted a model based on the historical series was considered. This model relates S linearly with Sea Surface Temperature (SST).

Mean and variance of the adult parameters are estimated following equations for cluster sampling (as suggested by Picquelle & Stauffer, 1985):

Equation 3

$$Y = \frac{\sum_{i=1}^{n} M_i \, y_i}{\sum_{i=1}^{n} M_i}$$

Equation 4
$$Var(Y)=\frac{\sum_{i=1}^{n} M_i^{2}(y_i - Y)^2}{\overline{M}^2\, n(n-1)}$$

Where,

Y_i is an estimate of whatever adult parameter from sample *i* and M_i is the size of the cluster corresponding to sample *i*. occasionally a station produced a very small catch, resulting in a small sub-sample size. To reflect the actual size of the station and its lower reliability, small samples were given less weight in the estimate. For the estimation of W, F and S, a weighting factor was used, which equalled to 1 when the number of mature females in station *i* (M_i) was 20 or greater and it equalled to $M_i/20$ otherwise. In the case of R when the total weight of the sample was less than 800 g then the weighting factor was equal to total weight of the sample divided by 800g, otherwise it was set equal to 1. In summary for the estimation of the parameters of the Daily Fecundity we are using a threshold-weighting factor (TWF) under the assumption of homogeneous fecundity parameters within each stratum.

B.3.1.6 SSB estimates

In the WGANSA during June the Spawning Stock Biomass is preliminary estimates as the ratio between the total egg production (P_{tot}) and Daily Fecundity (DF) estimates and its variance is computed using the Delta method (Seber, *1982*):

$$V\hat{a}r[SSB]=\frac{V\hat{a}r[Ptot]}{DF^2}+\frac{P_{tot}^{\;2}V\hat{a}r[DF]}{DF^4}$$

The definitive SSB estimate with all the adult parameters is presented and approval at the WGACEGG during November.

B.3.1.7 Numbers at age

For the purposes of producing population at age estimates, the age readings based on otoliths from the adult samples collected were available. Estimates of anchovy mean weights and proportions at age in the adult population were computed as a weighted average of the mean weight and age composition per samples where the weights were proportional to the population (in numbers) in each stratum. These weighting factors are proportional to the egg abundance per stratum divided by the numbers of samples in the stratum and the mean weight of anchovy per sample. Weighting factors were allocated according to the relative egg abundance and to the amount of samples in the strata defined for the proposed of the estimation of the numbers at age. These strata are defined each year depending on the distribution of the adult samples i.e. size, weight, age and the distribution of the anchovy eggs.

Mean and variance of the adult parameters of the Population in numbers at age and the Population length distribution (total weight, proportion by ages and length distribution) are estimated following equations 4 and 5 for cluster sampling.

B.3.2. Anchovy acoustic indices

Acoustic surveys are carried out every year in the Bay of Biscay in spring on board the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species is anchovy but it will be considered in a multi-specific context as species located in the centre of ecosystem.

These surveys are connected with IFREMER programs on data collection for monitoring and management of fisheries and ecosystemic approach for fisheries. This task is formally included in the first priorities defined by the Commission regulation EU N° 199/2008 of 06 November 2008 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000. These surveys must be considered in the frame of the Ifremer fisheries ecology action "resources variability" which is the French contribution to the international Globec programme. It is planned with Spain and Portugal in order to have most of the potential area to be covered from Gibraltar to Brest with the same protocol for sampling strategy. Data are available for the ICES working groups WGANSA, WGWIDE and WGACEGG.

B.3.2.1. Method and sampling strategy

In the frame of an ecosystemic approach, the pelagic ecosystem is characterized at each trophic level. In this objective, to assess an optimum horizontal and vertical description of the area, two types of actions are combined:

- Continuous acquisition by storing acoustic data from five different frequencies and pumping sea-water under the surface in order to evaluate the number of fish eggs using a CUFES system (Continuous Under-water Fish Eggs Sampler), and
- Discrete sampling at stations (by trawls, plankton nets, CTD). Satellite imagery (temperature and sea colour) and modelisation will be also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy. Concurrently, a visual counting and identification of cetaceans (from board) and of birds (by plane) will be carried out in order to characterise the higher level predators of the pelagic ecosystem.

Satellite imagery (temperature and sea colour) and modelisation are also used before and during the cruise to recognise the main physical and biological structures and to improve the sampling strategy.

Concurrently, a visual counting and identification of cetaceans and of birds (from board) is carried out in order to characterise the top predators of the pelagic ecosystem.

The strategy was the identical to previous surveys (2000 to 2009):

- Acoustic data were collected along systematic parallel transects perpendicular to the French coast (figure 1.1.1). The length of the ESDU (Elementary Sampling Distance Unit) was 1 mile and the transects were uniformly spaced by 12 nautical miles covering the continental shelf from 20 m depth to the shelf break.

- Acoustic data were collected only during the day because of pelagic fish behaviour in this area. These species are usually dispersed very close to the surface during the night and so "disappear" in the blind layer for the echo sounder between the surface and 8 m depth.

Two echo-sounders are usually used during surveys (SIMRAD EK60 for vertical echo-sounding and OSSIAN 500 on the pelagic trawl). In 2009 the SIMRAD ME70 has been used for multi-beam visualisation. Energies and samples provided by split beam transducers (5 frequencies EK60, 18, 38, 70, 120 and 200 kHz), simple beam (OSSIAN 49 kHz) and multibeam echo-sounder were simultaneously visualised, stored using the MOVIES+ software and at the same standard HAC format.

The calibration method is the same that the one described for the previous years (see W.D. 2001) with a tungsten sphere hanged up 20 m below the transducer and is generally performed at anchorage in front of Machichaco cap or in the Douarnenez bay, in the west side of Brittany, in optimum meteorological conditions.

Acoustic data are collected by Thalassa along the totality of the daylight route from which about 2000 nautical miles on one way transect are usable for assessment. Fish are measured on board (for all species) and otoliths (for anchovy and sardine) are collected for age determinations.

B.3.2.2. Echoes scrutinizing

Most of the acoustic data along the transects are processed and scrutinised during the survey and are generally available one week after the end of the survey (figure 2.2.1). Acoustic energies (Sa) are cleaned by sorting only fish energies (excluding bottom echoes, parasites, plankton, etc.) and classified into several categories of echo-traces according to the year fish (species) structures.

Some categories are standard such as:

D1 – energies attributed to mackerel, horse mackerel, blue whiting, divers demersal fish, corresponding to cloudy schools or layers (sometimes small dispersed points) close to the bottom or of small drops in a 10m height layer close to the bottom.

D2 –energies attributed to anchovy, sprat, sardine corresponding to the usual echo-traces observed in this area since more than 15 years, constituted by schools well designed, mainly situated between the bottom and 50 meters above. These echoes are typical of clupeids in coastal areas and sometime more offshore.

D3 – energies attributed to blue whiting and myctophids offshore, just closed to the shelf-break.

D4 – energies attributed to sardine, mackerel or anchovy corresponding to small and dense echoes, very close to the surface.

D6 – energies attributed to a mix, usually between 50 and 100 m depth when D1 and D2 were not separable

Some particular categories are usually specifically designed according to several identifications during the survey (when Thalassa and/or commercial vessels hauls are available), such as:

D7 – energies attributed exclusively to sardine (big and very dense schools).

D5 – energies attributed to small horse mackerel only when they are gathered in very dense schools this category is usually used for typical echoes which occur along particular surveys. In the case of 2010, it was used to gather energies which occurred all along the transects in the. northern platform where a continuous cover of mainly blue whiting was observed.

B.3.2.3. Data processing

The global area is split into several strata where coherent communities are observed (species associations) in order to minimise the variability due to the variable mixing of species. For each stratum, a mean energy is calculated for each type of echoes and the area measured. A mean haul for the strata is calculated to get the proportion of species into the strata. This is obtained by estimating the average of species proportions weighted by the energy surrounding haul positions. Energies are therefore converted into biomass by applying catch ratio, length distributions and TS relationships. The calculation procedure for biomass estimate and variance is described in Petitgas et.al 2003.

The TS relationships used since 2000 are still the same and as following:

Sardine, anchovy & sprat : TS = 20 Log L – 71.2

Horse-mackerel : TS = 20 Log L – 68.7

Blue whiting : TS = 20 Log L – 67.0

Mackerel : TS = 20 Log L – 86.0

The mean abundance per species in a stratum (tons m.n.$^{-2}$) is calculated as:

$$M_e(k)=\sum_D \bar{s}_A(D,k)\bar{X}_e(D,k)$$

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:

$$Var.M_e(k)=\sum_D \bar{s}_A^{\,2}(D,k)Var[X_e(D,k)]/n.cha(k)+\bar{X}_e^{\,2}\,\mathrm{var}[s_A(D,k)]/n.esu(D,k)$$

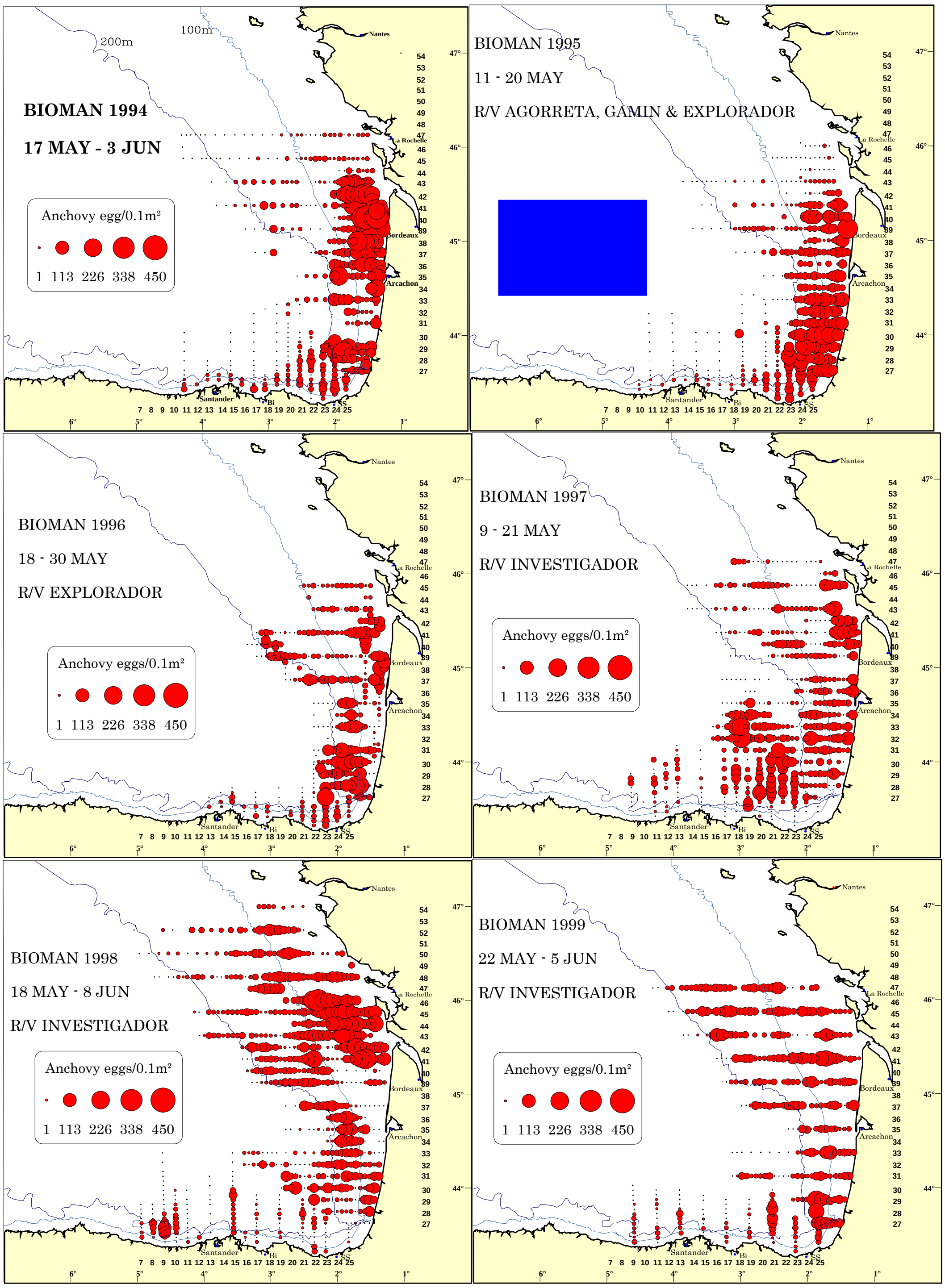
$$Var.B_e=\sum_k A^2(k)Var.Me(k)$$

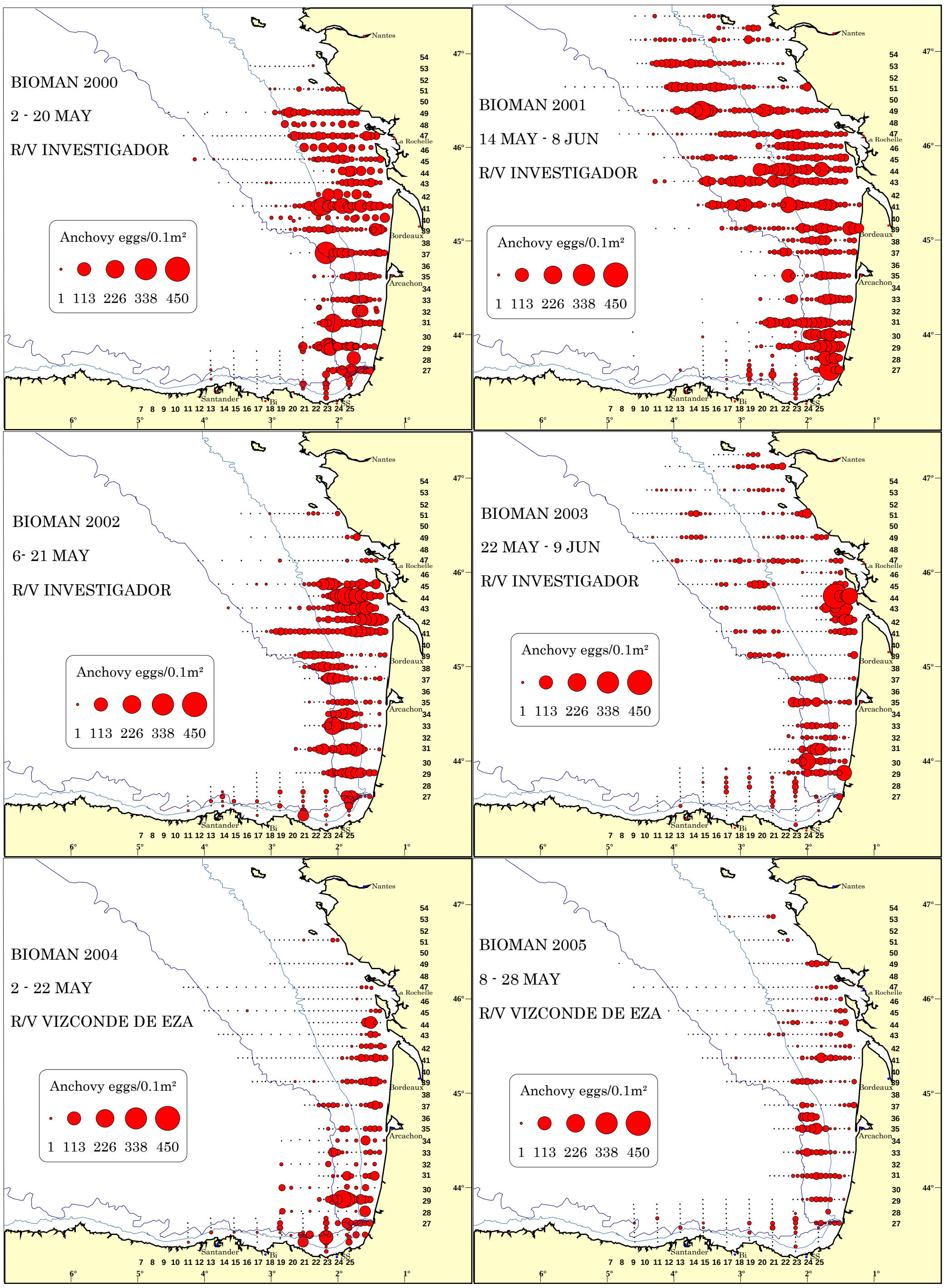
$$cv=\sqrt{Var.Be}\big/Be$$

At the end, density in numbers and biomass by length and age are calculated for each species in each ESDU according to the nearest haul length composition. These numbers and biomass are weighted by the biomass in each stratum and data are used for spatial distributions by length and age.

The detailed protocol for these surveys (strategy and processing) is described in annex 6 of WGACEGG report in 2009

B.3.3 Historical series DEPM and acoustic surveys




BIOMAN 2000
2 - 20 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2001
14 MAY - 8 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2002
6- 21 MAY
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2003
22 MAY - 9 JUN
R/V INVESTIGADOR
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2004
2 - 22 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
BIOMAN 2005
8 - 28 MAY
R/V VIZCONDE DE EZA
Anchovy eggs/0.1m²
1 113 226 338 450
Nantes
Bordeaux
Arcachon
Santander

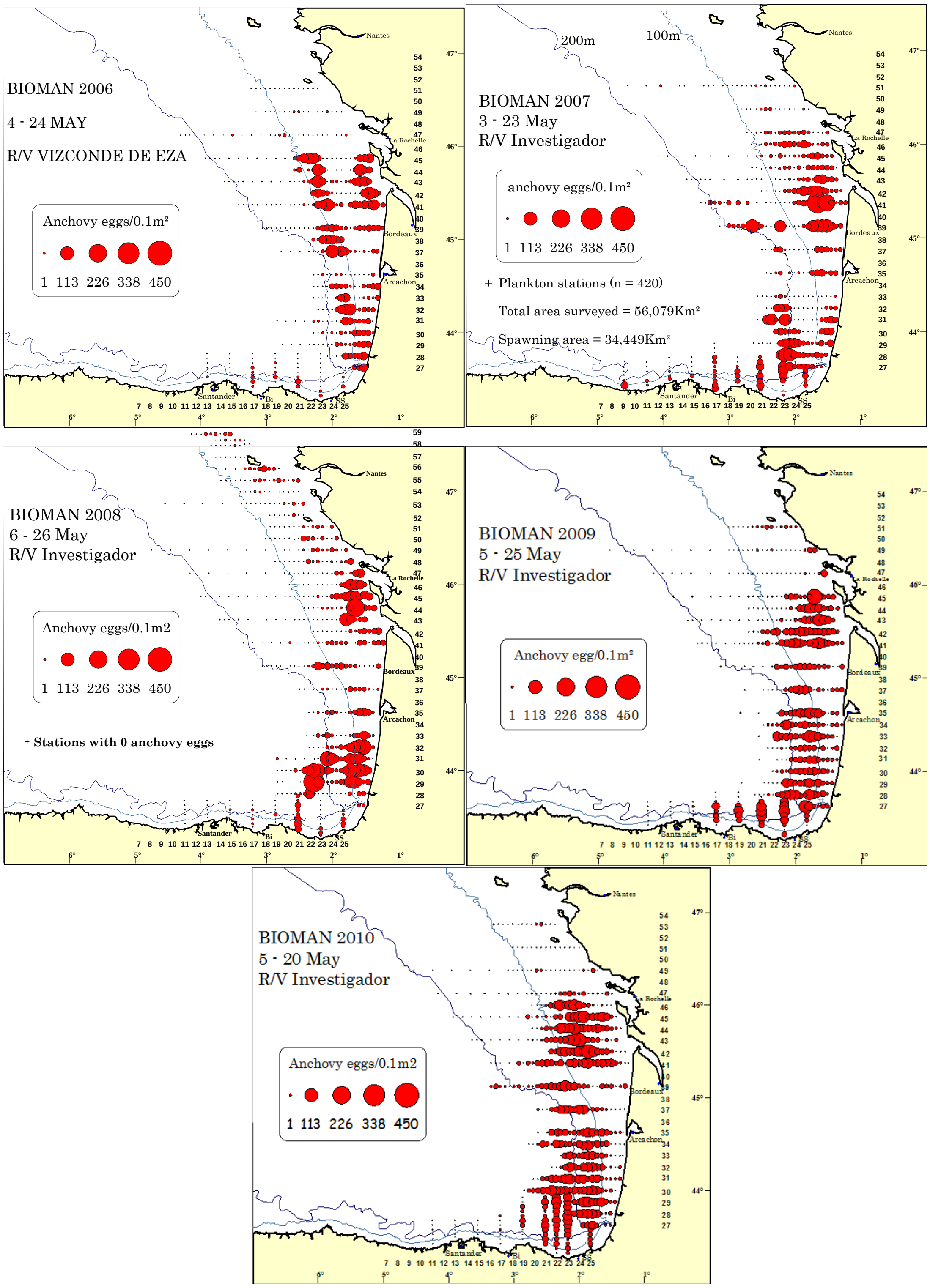
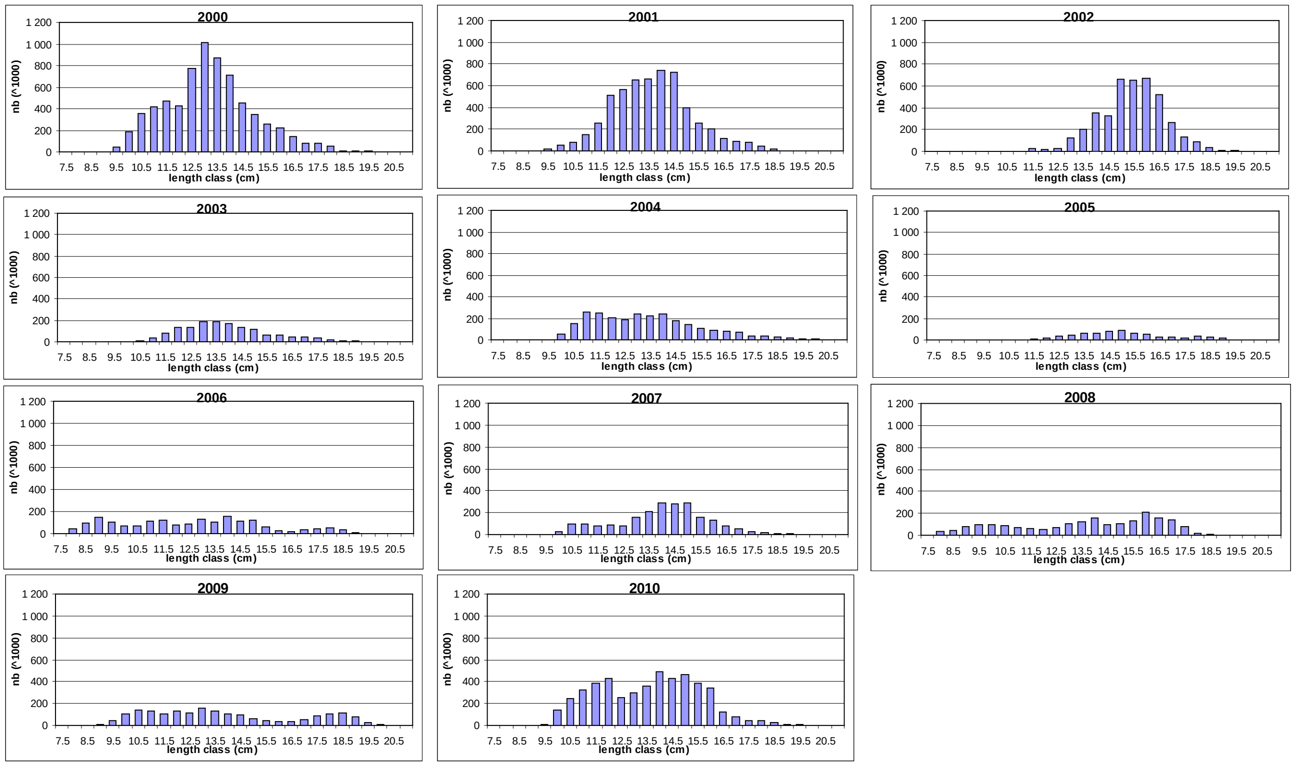
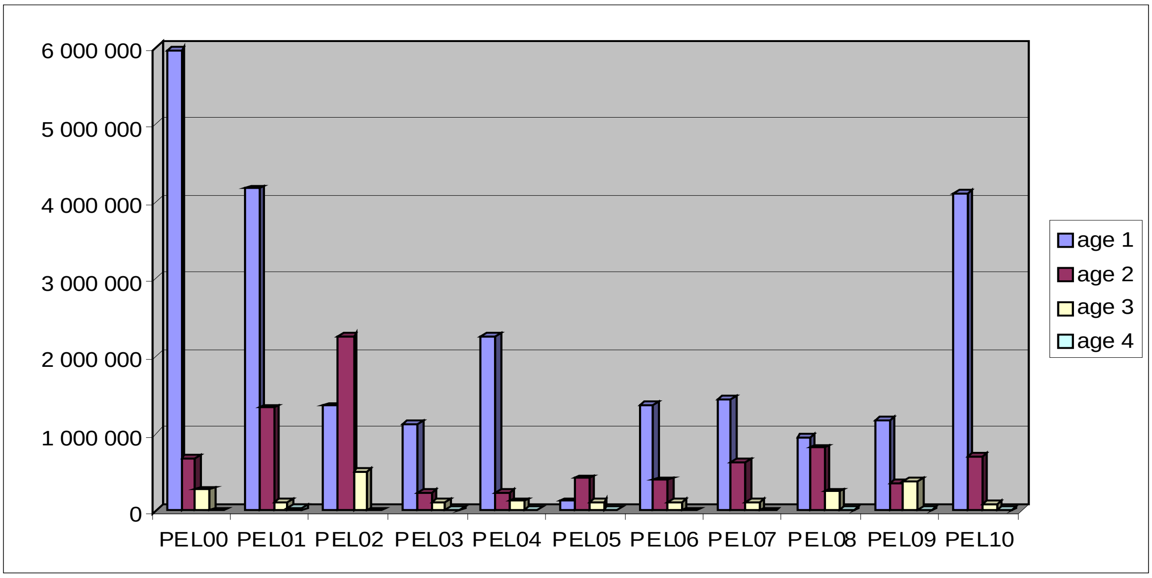


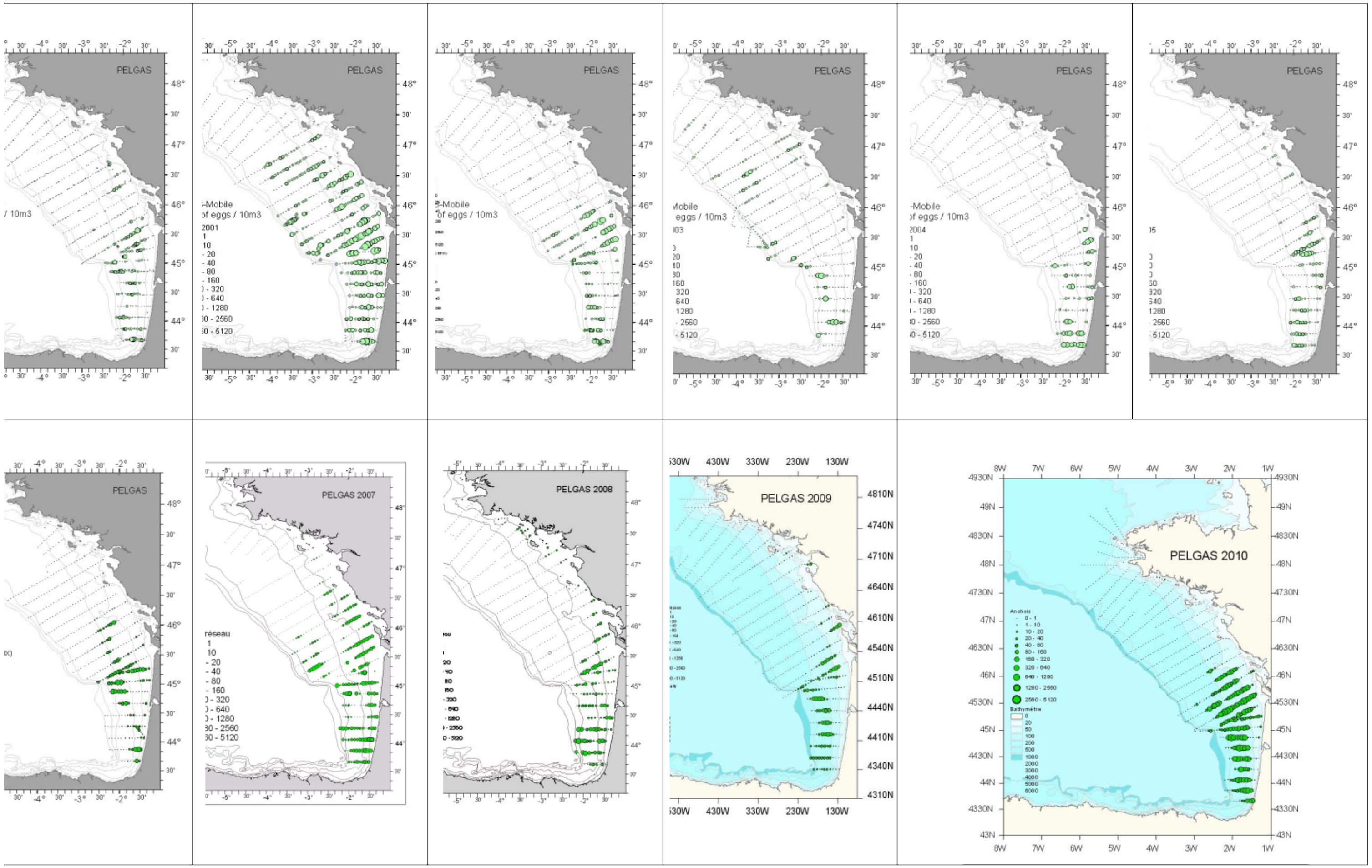
Figure B.3.3.1: Anchovy egg distribution from 1998 to 2009.The circles represent the anchovy egg abundance /0.1m² encountered in each plankton station.



Length composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.



Number of eggs observed during PELGAS surveys with CUFES from 2000 to 2010



Distribution of anchovy eggs observed with CUFES during PELGAS surveys from 2000 to 2010 (number for 10m³).

B.3.4 Autumn surveys on Juveniles, still under testing period

In recent years two series of acoustic surveys on juvenile anchovy (JUVENA and PELACUS10) have been launched in September-October, expecting that in the future the estimates can allow forecasting the strength of the anchovy recruitment which will enter the fishery the next year (ICES 2008 – WGACEGG report). Both surveys were coordinated with WGACEGG and are being merged nowadays. These surveys are expected to provide further insights on the recruitment process and additional knowledge on the biology and ecology of the juveniles Despite the encouraging results obtained with the series of 6 years of data available, the lack of sufficient contrast in the recent levels of recruitments prevents a proper evaluation of its performance as a predictor and the series are therefore not yet used for improving the management advice for the population (ICES 2008 - WGANC report).

B.3.4.1 Juvena survey

B.3.4.1.1 Data acquisition

JUVENA surveys take place annually since 2003, around September. In the period 2003 to 2005, the area was covered onboard commercial purse seiners. Since 2006 in addition to purse seiners, an oceanographic vessel, the R/V Emma Bardán, was incorporated to the survey. The abundance estimation is obtained by means of acoustic methodology (MacLennan and Simmonds, 1992). The acoustic equipment includes split beam echo sounders Simrad EK60 (Kongsberg Simrad AS, Kongsberg, Norway). The transducers of 38 kHz and 120 kHz (and 200kHz since 2006) were installed looking vertically downwards, about 2.5 m deep, at the end of a tube attached to the side of the purse seiners and at the hull in the case of the R/V Emma Bardan. The transducers were calibrated using standard procedures (Foote *et al.* 1987). Fishing was based on purse seining up to 2005 but since then onwards both pelagic trawling and purse seines are being used for species identification and biological sampling, along with hydrological recordings. In addition, the spatial distribution of the juvenile population is studied along with their growth condition. Two boats have been used since 2005 and therefore some extension of the northern limits of the surveys thus facilitated.

The water column was sampled to depths of 200 m. A threshold of -100 dB was applied for data collection. Acoustic back-scattered energy by surface unit (S_A, MacLennan *et al.* 2002) was recorded for each geo-referenced ESDU (Echointegration Sampling Distance Unit) of 0.1 nautical mile (185.2 m). Fish identity and population size structure was obtained from fishing hauls and echotrace characteristics. The commercial vessels used a purse seine of about 400 m of perimeter and 75 m height to fish the samples to depths of 50 m and the R/V Emma Bardan used a pelagic trawl. Acoustic data, thresholded to -60 dB, was processed using Movies+ software (Ifremer) for biomass estimation and the processed data was represented in maps using Surfer (Golden Software Inc., CO, USA) and ArcView GIS. Hydrographic recording was made with CTD casts.

B.3.4.1.2 Sampling strategy

The sampling area covered the waters of the Bay of Biscay (being 5º W and 47º45′ N the limits). Sampling was started from the Southern part of the sampling area, the Cantabrian Sea, moving gradually to the North to cover the waters in front of the French Coast. The acoustic sampling was performed during the daytime, when the juveniles are supposed to aggregate in schools (Uriarte 2002 FAIR CT 97-3374) and can be distinguished from plankton structures.

The vessels followed parallel transects, spaced 15 nm., perpendicular to the coast along the sampling area, taking into account the expected spatial distribution of anchovy juveniles for these dates, that is, crossing the continental shelf in their way to the coast from offshore waters (Uriarte et al. 2001).

B.3.4.1.3 Other sources of information

During the summer, information from the commercial live bait tuna fishery was collected, in order to have knowledge about the spatial distribution and relative abundance of anchovy previous to the beginning of the survey. We continued collecting this information about the captures of the fleet during the survey itself. In addition we maintained a constant communication with the responsible of the survey Pelacus-10, conducted by the IEO and Ifremer, survey performed onboard R/V Thalassa with a double objective: juvenile abundance estimation and ecologic studies.

B.3.4.1.4 Biological processing

Each fishing haul was classified to species and a random sample of each species was measured to produce size frequencies of the communities under study. A complete biological sampling of the anchovy juveniles collected is performed in order to analyze biological parameters of the anchovy juvenile population, as the age, size or size-weight ratio. Using these and other environmental parameters we will try to obtain, in a long term, indexes of the state of condition of the juvenile population, in order to be able to improve the prediction of the strength of the recruitment.

B.3.4.1.5 Acoustic data processing

Acoustic data processing was performed by layer echo-integration by 0.1 nautical mile (s_A) of the first 65 m of the water column with Movies+ software, after noise filtering and bottom correction, increasing or decreasing this range when the vertical distribution of juveniles made it necessary.

The hauls were grouped by strata of homogeneous species and size composition. Inside each of these homogeneous strata, the echo-integrated acoustic energy s_A was assigned to species according to the composition of the hauls. Afterwards, the energy corresponding to each specie-size was converted to biomass using their corresponding conversion factor.

Each fish species has a different acoustic response, defined by its scattering cross section that measures the amount of the acoustic energy incident to the target that is scattered backwards. This scattering cross section depends upon specie *i* and the size of the target *j*, according to:

$$\sigma_{ij} = 10^{TS_j/10} = 10^{\{(a_i + b_i \log L_j)/10\}}$$

Here, L_j represents the size class, and the constants a_i and b_i are determined empirically for each species. For anchovy, we have used the following TS to length relationship:

$$TS_j = -72.6 + 20 \log L_j$$

The composition by size and species of each homogeneous stratum is obtained by averaging the composition of the individual hauls contained in the stratum, being the contribution of each haul weighted to the acoustic energy found in its vicinity (2 nm of diameter). Thus, given a homogeneous stratum with M hauls, if E_k is the mean acoustic energy in the vicinity of the haul k, w_i, the proportion of species i in the total capture of the stratum, is calculated as follows:

$$w_i = \sum_j w_{ij} = \sum_j \left(\frac{\sum_{k=1}^{M} \left(q_{ijk} \cdot E_k \big/ Q_k \right)}{\sum_{k=1}^{M} E_k} \right).$$

Being q_{ijk} the quantity (in mass) of species i and length j in the haul k; and Q_k, the total quantity of any species and size in the haul k.

In order to distinguish their own contribution, anchovy juveniles and adults were separated and treated as different species. Thus, the proportion of anchovy in the hauls of each stratum (w_{ij}) was multiplied by a age-length key to separate the proportion of adults and juveniles. Then, separated w_i were obtained for each.

Inside each homogeneous stratum, we calculated a mean scattering cross section for each species, by means of the size distribution of such specie obtained in the hauls of the stratum:

$$\langle \sigma_i \rangle = \frac{\sum_j w_{ij} \sigma_{ij}}{w_i}.$$

Let s_A be the calibration-corrected, echo-integrated energy by ESDU (0.1 nautical mile). The mean energy in each homogeneous stratum, $E_m = < s_A >$, is divided in terms of the size-species composition of the haul of the stratum. Thus, the energy for each species, E_i, is calculated as:

$$E_i = \frac{w_i \langle \sigma_i \rangle E_m}{\left(\sum_i w_i \langle \sigma_i \rangle \right)}$$

Here, the term inside the parenthesis sums over all the species in the stratum. Finally, the number of individuals F_i of each species is calculated as:

$$F_i = H \cdot l \frac{E_i}{\langle \sigma_i \rangle}$$

Where l is the length of the transect or semi-transect under the influence of the stratum and H is the distance between transect (about 15 nm.). To convert the number of juveniles to biomass, the size-length ratio obtained in each stratum is applied to obtain the average weight of the juveniles in the stratum:

$$< W_i >= a \cdot < L_i >^b$$

Thus, the biomass is obtained by multiplying F_i times $< W_i >$.

B.3.4.1.6 Commercial CPUE

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). Current series of CPUE available for the Spanish Purse seine are not considered of utility for the monitoring of the fishery (Uriarte *et al.*, 2008).

C. Stock assessment method

Model used:

The assessment for the Bay of Biscay anchovy population is a Bayesian two-stage biomass-based model (BBM) (Ibaibarriaga *et al*., 2008), where the population dynamics are described in terms of biomass with two distinct age groups, recruits or fish aged 1 year, and fish that are 2 or more years old. The biomass decreases exponentially on time by a factor g accounting for intrinsic rates of growth (G) and natural mortality (M) which are assumed year- and age-invariant.

Two periods are distinguished within each year. The first begins on 1 January, when it is assumed that age incrementing occurs and age 1 recruit enter the exploitable population, and runs to the date when the monitoring research surveys (acoustics and DEPM) take place. The second period covers the rest of the year (from 15th May to 31st December). Catch is assumed to be taken instantaneously within each of these periods.

The observation equations consist on log-normally distributed spawning stock biomass from the acoustics and DEPM surveys, where the biomass observed is proportional to the true population biomass by the catchability coefficient of each of the surveys, and the beta distributed age 1 biomass proportion from the acoustics and DEPM surveys, with mean given by the true age 1 biomass proportion in the population.

The model unknowns are the initial population biomass (in 1987), the recruitment each year, the catchability of the surveys and the variance related parameters of the observation equations. The model can be cast into a Bayesian state-space model framework where inference on the unknowns is done using Markov Chain Monte Carlo (MCMC).

Software used:

The model is implemented in BUGS (www.mrc-bsu.cam.ac.uk/bugs/) and it is run from R (www.r-project.org) using the package R2WinBUGS.

Model Options chosen:

Catchability for the DEPM SSB is set to 1 because it is assumed to be an absolute indicator of Biomass and for consistency with the past practice in the assessment of this stock. Catchability of the acoustic SSB is estimated. DEPM and acoustic surveys are assumed to provide unbiased proportion of age 1 biomass estimates in the stock. The first set of priors as defined in Ibaibarriaga et al. 2008 is used. The length of the MCMC run, the burn-in period (removal of the first draws to avoid dependency on the initial values) and the thinning to diminish autocorrelation should be enough to ensure convergence and obtain a representative joint posterior distribution of the parameters.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year. Yes/No
Caton	Catch in tonnes by periods	1987-2010	1 to 2+	Yes
Canum	Catch at age in numbers by periods	1987-2010	1 & 2+	Yes
Weca	Weight at age in the commercial catch by periods	1987-2010	1 to 2+	Yes
Mprop	Proportion of natural mortality before spawning	Not applicable		
Fprop	Proportion of fishing mortality before spawning	Not applicable		
Matprop	Proportion mature at age	Not applicable		
Natmor	Natural mortality M=1.2	1987-2010	1 to 2+	No
G	Intrinsic growth rate G= 0.52	1987-2010	1 to 2+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	DEPM SSB spring series	1987-2010 (with gap in 1993)	
Tuning fleet 2	Acoustic SSB spring series	1989-2010 (with gaps)	
Tuning fleet 3	DEPM P1 (B1/SSB) spring series	1987-2010 (with gaps)	
Tuning fleet 4	Acoustic P1 (B1/SSB) spring series	1989-2010 (with gaps)	

Prior distributions of the parameters:

The current prior distributions (see table below) are described and justified in Ibaibarriaga *et al.* (2008) and ICES WGANC (2008)

Parameter	Prior 1	
	Hyper-parameters	Median (95% CI)
q_{surv}	$\mu_{q_{surv}} = 0$	1 (0.1, 16.0)
	$\psi_{q_{surv}} = 0.5$	
ψ_{surv}	$a_{\psi_{surv}} = 0.8$	10 (0.2, 65.1)
	$b_{\psi_{surv}} = 0.05$	
ξ_{surv}	$\mu_{\xi_{surv}} = 5$	5 (0.6, 9.4)
	$\psi_{\xi_{surv}} = 0.2$	
B_0	$\mu_{B_0} = 10.5$	36 316 (5 116, 257 806)
	$\psi_{B_0} = 1.0$	
μ_R	$\mu_{\mu_R} = 9.8$	9.8 (7.0, 12.6)
	$\psi_{\mu_R} = 0.5$	
ψ_R	$a_{\psi_R} = 4$	1.8 (0.5, 4. 4)
	$b_{\psi_R} = 2$	
g	$\mu_g = \log(0.7)$	0.7 (0.1, 5.0)
	$\psi_g = 1$	

The benchmark workshop recommended to conduct some sensitivity analysis on the prior distributions. In particular, to test the effect of having more informative priors on the surveys' catchability and precision and on the g parameter. If this is done, any changes in the prior distributions of the parameters should be documented and justified in the ICES anchovy assessment working group report (WGANSA).

D. Short-Term Projection

Model used:

The Bayesian two-stage biomass-based model (Ibaibarriaga *et al.* 2008) used for the assessment of the stock is used to project the population one year forward from the current state and to analyse the probability of the population in the next year of being below the biological reference point Blim (21 000 tonnes) under a recruitment scenario based on the past recruitment series and under alternative catch options for the second half of the current year and the first half of next year.

The predictive distribution of recruitment at age 1 (in mass) in January next year is defined as a mixture of the past series of posterior distributions of recruitments as follows:

$$R_{2008} = \sum_{y=1987}^{2007} w_y \; p(R_y|\cdot\,) ,$$

where $p(R_y|\cdot)$ denotes the posterior distribution of recruitment in year y and w_y are the weights of the mixture distribution, such that $\sum w_y = 1$. These weights can be based on information about incoming recruitment or on assumptions regarding different scenarios.

Software used:

The projections are implemented in R (www.r-project.org)

Projection period:

One year ahead from the spawning period (15th May) in the last assessment year

Initial stock size:

Posterior distribution of SSB in the last assessment year

Maturity: NA

F and M before spawning: NA

Weight at age in the stock: NA

Weight at age in the catch: NA

Intrinsic growth rate (G):

Assumed constant same as in the assessment (G=0.52)

Natural mortality rate (M):

Assumed constant same as in the assessment (M=1.2)

Exploitation pattern:

Alternative options for splitting catches by periods are tested

Intermediate year assumptions: NA

Stock recruitment model used:

No implicit S/R model is used. Recruitment is sampled from the posterior distributions of past series recruitments. Different recruitment scenarios are constructed by giving different weights to the past series recruitments.

Procedures used for splitting projected catches: NA

E. Medium-Term Projections

No Medium term projections are applied to this fishery for the provision of advice by ICES. Long term projections (10 years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC, based on a Ricker stock recruitment relationship.

F. Long-Term Projections

No Long term projections are applied to this fishery for the provision of advice by ICES. Long term projections (10 years ahead) were run by STECF in 2008 to set the basis of a management plan on anchovy to the EC, based on a Ricker stock recruitment relationship.

G. Biological Reference Points

A stock/recruitment relationship is not explicitly used.

Current biological reference points for the Bay of Biscay anchovy were defined by ICES ACFM in October 2003 as follows:

	ICES considers that:	ICES proposes that:
Limits reference points	B_{lim} is 21,000 t, the lowest observed biomass in 2003 assessment.	B_{pa}= 33,000 t.
	There is no biological basis for defining F_{lim}.	F_{pa} be established between 1.0-1.2.
Target reference points		

Technical basis:

$B_{lim} = B_{loss}$ = 21,000 t.	$B_{pa} = B_{loss}$ * 1.645.
	F_{pa}= F for 50% spawning potential ratio, i.e., the F at which the SSB/R is half of what it would have been in the absence of fishing

H. Other Issues

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Annex 5.2 Stock Annex Anchovy in Division IXa

Quality Handbook	ANNEX: A.5.2

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Anchovy in Division IXa
Working Group:	WGANSA (Working Group on the Assessment of Anchovy and Sardine)
Date:	24th June 2011
Revised by	Fernando Ramos

A. General

A.1. Stock definition

The distribution of anchovy in the Division IXa is nowadays mainly concentrated in the Spanish waters of the Gulf of Cádiz (Sub-division IXa-South, **Figure A.1.1**). Outside the main nucleus of the Gulf of Cádiz, resilient anchovy populations have been detected in all fishery independent surveys (ICES, 2007 b) and previous records on large catches in ICES areas IXa North, Central North and South (Algarve) suggest that abundance in those areas have been high in early years of the time series. In the south, outside the Gulf of Cádiz anchovy is abundant to the East of the Strait of Gibraltar, in the Mediterranean Sea (GFCM, 2002) as well as in northern Africa, where a combined Spanish-Morocco fishery produces landings of up to 12000 tn (Millán, 1992; García-Isarch *et al*., 2008).

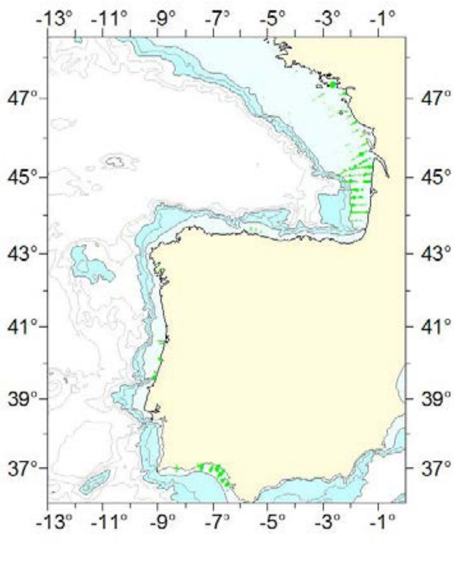

Figure A.1.1. Distribution of acoustic energy allocated to anchovy from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2009b).

A.2. Fishery

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

- Portuguese purse-seine fleet
- Portuguese trawl fleet
- Portuguese artisanal fleet (although fishing with artisanal purse-seines)
- Spanish purse-seine fleet
- Spanish trawl fleet (in Subarea IXa-South (Cádiz))

Purse-seine fleets are the main responsibles for the anchovy fishery in the Division (usually more than 90% of total annual landings in the Division). Spanish fleets operate in Sub-divisions IXa-North (Southern Galicia) and IXa-South (Gulf of Cadiz), and the Portuguese ones along its national peninsular fishing grounds (Sub-divisions IXa-Central North, -Central South and South (Algarve)). Most of the fishery for this anchovy stock in the Division takes place in Sub-division IXa-South (C), where anchovy is the target species. The fleets in the northern part of Division IXa (targeting sardine) occasionally target anchovy when abundant, as occurred in 1995.

Data on number and technical characteristics for the Portuguese fleets are available for 2006 (ICES, 2007 a). The Portuguese purse- seine fleet (n =121 in 2006) presently ranges in size from 10.5 to 27 m (mean vessel length = 20 m) and between 71 to 447 HP (mean = 249) in vessel engine power. Portuguese producers organisations traditionally agree a voluntary closure of the purse-seine fishery in the northern part (north of the 39º 42" North) of the Portuguese coast. This closure usually lasted from the 1st of February to 31 of March. Since 2006, the closure, also lasting 2 months, may however be selected between 1st of February and 30th of April (*i.e.* boats stopped fishing in February to March or in March to April).

Since 1999 the number of Gulf of Cadiz purse-seiners operated by Spain has oscillated between 145 (in 2004) and 84 (in 2010) vessels, and the vessels within this fleet targeting anchovy between 76 (2010) and 135 (2004) vessels. As it has been previously reported (ICES, 2007 a), the observed fluctuations during this period were mainly motivated by the ending of the fifth EU-Morocco Fishery Agreement (in 1999, which affected the heavy-tonnage fleet in the following two years: acceptation of tie-up scheme in 2000 and 2001), the rising of the light-tonnage purse seiners on those dates, and the fluctuations showed by the multipurpose vessels. These vessels fishing for anchovy account for more than 85% of the whole fleet during the available series, evidencing the importance of anchovy as a target species in the Gulf of Cadiz purse-seine fishery. Since 2008 the EU–Morocco Fishery Agreement was renewed, and part of the fleet (the heavier/larger vessels) devoted to the anchovy fishing in the Moroccan grounds, which entailed an important reduction of the fishing effort in the Gulf of Cadiz.

A first attempt of identifying *métiers* in this last fleet/fishery was presented in the 2007 WGMHSA meeting (ICES, 2007 a). This study (see also Silva *et al*., 2007, for details) focused on the application of a non-hierarchical clustering data-mining technique (*CLARA*, *C*lustering *LAR*ge *A*pplications) for classifying the fishing trips from 2003 to 2005. The classification of individual trips was only based on the species composition of landings from logbooks, hence the preliminary character of this study. Up to four clusters (catch profiles) were identified from each of the annual datasets according to the targeted species: 1) trips targeting anchovy, 2) trips targeting sardine; 3) trips targeting a mackerel (*Scomber* spp.) species mixture; and 4) trips targeting an anchovy and sardine mixture. The first three groupings were considered as clearly identifiable *métiers* according to the knowledge on the fishery. At present no comparable information on Portuguese *métiers* is available.

The regulatory measures in place for the Spanish anchovy purse-seine fishing in this Division were the same as for the previous years and are summarized as follows:

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

Until 1997, the Spanish purse-seine fleet voluntary closed the fishery each year from December to February in the Gulf of Cadiz (Sub-division IXa-South(C)). Since 2004, two complementary sets of management measures have been in force in this part of the Sub-division. The first one is the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months from 30th October and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid February 2008; 1st December 2008 to 28th February 2009), accompanied by a subsidized tie-up scheme for the purse-seine fleet. The expected subsidized 3-month closure from 2009 mid-autumn to the 2010 mid-winter was restricted to one month only, in December 2009, although the fishery was practically closed since November 2009 until February 2010 for persistent bad sea conditions during all these months. This same scheme was accomplished for the 2010-2011 autumn/winter closure. This plan also includes additional regulatory measures on the fishing effort (200 fishing days/vessel/year as a maximum) and daily catch quotas per vessel (6000 kg of sardine-anchovy mixing, but the catch of each of these species cannot exceed 3000 kg). A new regulation approved in October 2006 establishes that up to 10% of the total catch weight may contain fish below the established minimum landing size (10 cm), but fish must always be ≥9 cm.

The effort exerted by the entire purse-seine fleet since 1997 has been high (even with the fishing closures since 2004 on). While the effects of the fishery closures have not been formally evaluated, it appears that they have limited a further expansion of effort.

The second management action in force since 15th of July 2004 is the delimitation of a marine protected area (fishing reserve) in the mouth and surrounding waters of the Guadalquivir river, a zone that plays a fundamental role as nursery area of fish (including anchovy) and crustacean decapods in the Gulf (**Figure A.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the riverbed. Neither purse-seine nor bottom trawl fishing is allowed all over this MPA. The effects of such closures and MPA in the Gulf of Cádiz anchovy recruitment are not still possible to be directly assessed. In any case, the implementation of both of these measures should benefit the stock.

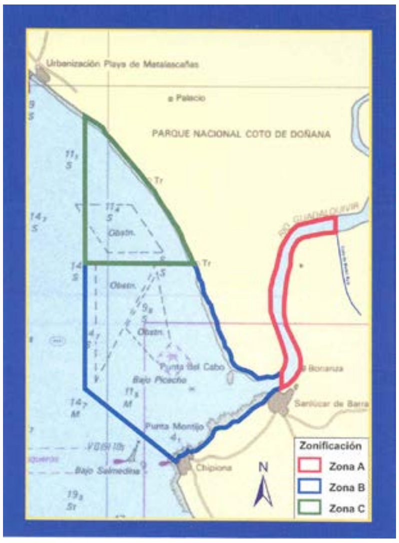

Figure A.2.1. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Sub-division IXa South).

A.3. Ecosystem aspects

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

The anchovy population in Subdivision IXa-South appears to be well established and relatively independent of populations in other parts of the Division. These other populations seem to be abundant only when suitable environmental conditions occur.

B. Data

B.1. Commercial catch

Portuguese annual landings from their respective Sub-divisions are available since 1943. Spanish landings started to be available since 1989.

No information on anchovy discarding in the Division IXa has been available until 2005. That year several pilot surveys for estimating discards in the Gulf of Cadiz Spanish fisheries (trawl, purse-seine and artisanal) were conducted by an IEO observer's programme onboard commercial vessels lasting five months and covering the whole study area. Preliminary results (average estimates from 6 purse-seine trips – 13 hauls –, not raised to total annual landings) from these pilot surveys were described in ICES (2006 a) although there were concerns about the reliability of such estimates and the ratios derived from them due to their extremely high associated CVs. On the other hand, discarded anchovies were of commercial and legal size, between 10 and 15 cm (mode at 12.5 cm), but reasons for discarding anchovy were not reported to that WG. Anchovy catches in sampled trips from the bottom otter-trawl fleet were negligible. Slipping practices are probable but not directly evidenced by sampling onboard. New data on anchovy discarding have started to be gathered since 2009 on within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR).

B.2. Biological

Annual and quarterly length compositions of anchovy landings in Division IXa are routinely provided by Spain for its Sub-division IXa-South(C). This series dates back to 1988. Length distributions for the Spanish fishery in Sub-division IXa-North are only available for the 1995-1999 period and they were characterized, with the exception of 1998, by fish larger than 12.5 cm (ICES, 2007 a). At present, Portugal does not provide either length distributions or catches at age of their anchovy landings in Division IXa due to their scarce catches.

Catches at age from the whole Division IXa are only available from the Spanish Gulf of Cadiz fishery (Sub-division IXa South (C)). Problems with ageing/reading Gulf of Cádiz anchovy otoliths still persist.

The age composition of the Gulf of Cadiz anchovy in Spanish landings is available since 1988 (see ICES, 2007 a, for tabulated data from years not shown in this report). The catch-at-age series shows that 0, 1 and 2 age groups support the Gulf of Cadiz anchovy fishery and that the success of this fishery largely depends on the abundance of 1 year-old anchovies. The contribution of age-2 anchovies usually accounts for less than 1% of the total annual catch (except in 1997, 1999, the 2001-2003 period and since 2008 on, with contributions oscillating between 2% and 14%). Likewise, age-3 anchovies only occurred in the first quarter in 1992 and since 2008 on, but the importance of this age class in the total annual catch those years was insignificant. Inter-annual variations in the contribution of each age group in landings throughout the historical series are described in ICES (2007 a, 2008 a). Weights at age in the stock for the Gulf of Cádiz anchovy correspond to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (throughout the spawning season).

Catches at age from the Spanish fishery in Sub-division IXa North are presently not available since commercial landings used to be negligible. Mean length- and mean weight-at-age data are only available for Gulf of Cadiz anchovy catches. The analysis of small samples of otoliths from Subdivision IXa North in 1998 and 1999 rendered estimates of mean sizes at ages 1, 2 and 3 of 15.5 cm, 17.6 cm and 17.9 cm respectively (ICES, 2000, 2001). A sample of 78 otoliths from the same area was collected during the *PELACUS 0402* acoustic survey. Mean lengths at age 1 and 2+ were 13.7 cm and 17.0 cm (Begoña Villamor, pers. comm.). Comparisons of these estimates with the ones from the Gulf of Cadiz anchovy indicate that southern anchovies attain smaller sizes at age.

Previous biological studies based on commercial samples of Gulf of Cadiz anchovy (Millán, 1999) indicate that its spawning season extends from late winter to early autumn with a peak spawning time for the whole population occurring from June to August. Length at maturity was estimated in that study at 11.09 cm in males and 11.20 cm in females. However, it was evidenced that size at maturity may vary between years, suggesting a high plasticity in the reproductive process in response to environmental changes. Annual maturity ogives for Gulf of Cadiz anchovy are routinely provided to ICES. They represent the estimated proportion of mature fish at age in the total catch during the spawning period (second and third quarters) after raising the ratio of mature-at-age by size class in monthly samples to the monthly catch numbers-at-age by size class.

Natural mortality is unknown for this stock. By analogy with anchovy in Sub-area VIII, natural mortality is probably high (M=1.2 is used for the data exploration).

B.3. Surveys

B.3.1. Acoustic surveys

The IPIMAR's Portuguese surveys series (*SAR* and *SARNOV* series, carried mainly out with the R/V *Noruega*) correspond to those ones routinely performed for the acoustic estimation of the sardine abundance in Division IXa off the Portuguese continental shelf and Gulf of Cadiz, during March-April (sardine late spawning season) and November (early spawning and recruitment season). Since 2007 on, the Spring surveys are being planned as 'pelagic community' surveys. This shift in planning mainly entailed, as compared with previous years, a substantial increase in the number of fishing stations in the Sub-division IXa-South, where the species diversity is higher, changing the series its former name by the one of *PELAGO* surveys. Anchovy estimates from these survey series started to be available since November 1998.

Spanish 'pelagic community' acoustic surveys have been conducted by IEO in Sub-division IXa North and Division VIIIc since 1983 (the spring *PELACUS* series with the R/V *Thalassa*). Results from these surveys for the Sub-division IXa North have shown the scarce presence or even the absence of anchovy in this area (Carrera, 1999, 2001; Carrera *et al*., 1999). This situation still continues in the most recent years (surveys in the 2003-2010 period, see Porteiro *et al*., 2005; Iglesias *et al*., 2007).

Spanish acoustic surveys in the Gulf of Cadiz waters (Sub-division IXa-South) have been sporadically conducted by IEO from 1993 to 2003. A consistent yearly series of early summer acoustic surveys (*ECOCÁDIZ* series) estimating the anchovy abundance in the Subdivision IXa South (Algarve and Gulf of Cadiz) started in 2004. Surveys in this new series are also planned under the 'pelagic community' approach. Unfortunately, this series may show some gaps in those years coinciding (same dates and surveyed area) with the conduction of the (initially triennial) anchovy DEPM survey because of the available ship time (R/V *Cornide de Saavedra*). In 2009 two additional surveys to the conventional one were also conducted, but mainly restricted to the Spanish waters. So, in July 2009 a complementary and almost synchronous survey to the *ECOCÁDIZ 0609* conventional survey was carried out with a small-draught vessel, R/V *Francisco de Paula Navarro*, aiming to survey shallower waters than 20 m depth not sampled by no vessel, either Spanish or Portuguese, routinely surveying the study area (*ECOCÁDIZ-COSTA 0709* survey). The acoustic estimates from this survey were separately given in the 2010 WG report from its conventional survey awaiting an intercalibration of data for a further merging of estimates if possible.

In October 2009 a new autumn survey (*ECOCÁDIZ-RECLUTAS 1009*, R/V *Emma Bardán*), aimed to acoustically estimate the abundance and biomass of Gulf of Cádiz anchovy recruits, was planned to be conducted throughout the easternmost Portuguese waters and those waters off the central part of the Spanish Gulf of Cádiz, waters that supposedly include the main Gulf of Cádiz anchovy recruitment area. Unfortunately, the shortness of the available ship-time to cover a more intensive acoustic sampling grid (*i.e.* 4 nm spaced transects from 100 to 7-10 m depth) than the conventionally planned in standard surveys and some other unforeseen circumstances (e.g., a one-day technical stop for crew replacement, 2-day military manoeuvres just in the middle of both the survey area and calendar) prevented finally from covering the whole survey area. For the above reasons, the surveyed area was restricted to a relatively small central area in front the Guadalquivir river mouth rendering a very probable underestimation of the recruits abundance. Continuity of this survey in following years will necessarily depend on external (EC) funding.

All these surveys followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Subareas VIII and IX (ICES, 1986; 1998) and recommendations given by the WGACEGG (ICES, 2006 b,c). The methodological differences between these recent surveys are not considered by the WGACEGG as important as to prevent from any comparison between their results, such differences being basically due to:

• The echo-sounder and working frequencies used (IPIMAR surveys: Simrad EK 500 working at 38 and 120 KHz; IEO surveys since 2007 onwards: Simrad EK 60 working at 18, 38, 70, 120, and 200 KHz).

• The fishing gear used as sampler for echo-trace identification/confirmation and gathering biological data (IPIMAR surveys: bottom and pelagic trawl gears; IEO surveys: pelagic trawl).

• The software used for data storage and post-processing (IPIMAR surveys: Movies+ software; IEO surveys: SonarData EchoView software).

• The set of species-specific TS-length relationships: at present, the new IPIMAR spring survey series, *PELAGOS*, takes into account the same agreed species-specific TS values than the IEO surveys, but for mackerel (b_{20} IPIMAR= – 82.0 vs b_{20} IEO= – 84.9).

Regarding their respective objectives, the *SAR* Portuguese November surveys, as presently planned, are mainly aimed at the mapping of the spatial distribution of sardine *Sardina pilchardus*, and anchovy *Engraulis encrasicolus*, and the provision of acoustic estimates of their abundance and biomass by length class and age groups, speciallly the computation of a sardine recruitment index (for the time being age-structured estimates are only available for sardine).

Although the main objective of the *ECOCÁDIZ* Spanish surveys was formerly the mapping and the size-based and age-structured acoustic assessment of the anchovy

SSB, and hence the survey's dates, mapping and acoustic estimates of all of those species susceptible of being assessed (according to their occurrence frequency and abundance levels in fishing stations) are also obtained. This same 'multi-species' or 'pelagic community' approach has also been adopted in the new *PELAGO* Spring Portuguese survey series, at least, for the time being, for the southern area (Subarea IXa South), which has involved a substantial increase in the number of fishing stations as compared with previous surveys. In any case, the progressive inclusion of alternative (continuous and discrete) samplers for collecting ancillary information on the physical and biological environment (including top predators) are shaping these surveys as true 'pelagic ecosystem surveys'.

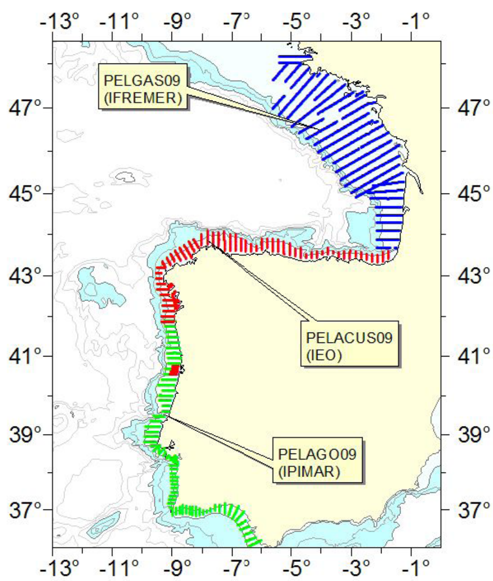

Figure B.3.1.1. Transects surveyed by the Spring *PELAGO*, *PELACUS* and *PELGAS* surveys. The early Summer *ECOCÁDIZ* surveys samples the same area that the *PELAGO* one in the Gulf of Cádiz waters (from Cape San Vicente to Cape Trafalgar).

B.3.2. DEPM Surveys

The Daily Egg Production Method (DEPM) for estimation of anchovy spawning biomass of the Gulf of Cádiz (South-Atlantic Iberian waters) is conducted every three years by IEO (Spain) since 2005. The first survey of this series was in 2005 (*BOCADEVA 0605*) and the second one in 2008 (*BOCADEVA 0608*). As described for the acoustic surveys, methods adopted for Gulf of Cádiz anchovy DEPM surveys follow the standards and recommendations given. **Figure B.3.2.1** shows the grid of egg sampling with the PairoVET sampler. **Table B.3.2.1** summarises the methodology used in these surveys (*BOCADEVA 0608* used as example) in order to obtain the eggs and adults samples.

Table B.3.2.1 ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. General sampling.**

Parameters	**Anchovy DEPM survey** ***BOCADEVA0608***
Survey area	(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

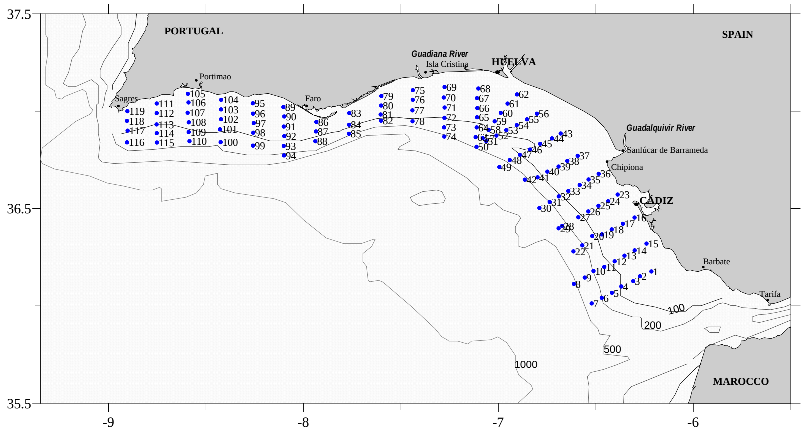

Figure B.3.2.1. Sampling grid adopted in the ***BOCADEVA*** **anchovy DEPM surveys series.**

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 incubation experiment carried out in Cádiz in July 2007

(Duarte *et al*., 2007). A multinomial model was applied (Ibaibarriaga *et al.*, 2007, Bernal *et al.* 2008) considering only the interaction Age*Temp (other interactions were not significant). Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST; a normal probability distribution was used with peak spawning assumed to be at 22:00h with 2h standard deviation. This method uses the multinomial development model and the assumption of probabilistic synchronicity (assuming a normal distribution). Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. Finally, the total egg production was calculated as: $P_{tot} = P_0\ A+$

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (*W*), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (*Wnov*). The sex ratio (*R*) in weight per haul was obtained as the quotient between the total weight of females on the total weight of males and females. The expected individual batch fecundity for all mature females (hydrated and non-hydrated) was estimated by modelling the individual batch fecundity observed (*Fobs*) in the sampled hydrated females and their gonad-free weight (*Wnov*) by a GLM. The fraction of females spawning per day (*S*) was determined, for each haul, as the average number of females with Day-1 or Day-2 POF, divided by the total number of mature females (the number of females with Day-0 POF was corrected by the average number of females with Day-1 or Day-2 POF, and the hydrated females were not included). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer (1985; i.e., weighted means and variances). All estimations and statistical analysis were performed using the R software. The spawning biomass was computed according to:

$$SSB = \frac{P_0 * Area+}{(F * S * R)/W}$$

The high uncertainty associated to the estimates (especially to those ones related to the egg sampling in the 2005 survey) was matter of concern for the 2009 WGANSA and it was recommended that the appropriateness of the egg sampling scheme were revised in the 2009 WGACEGG. It was concluded by this last working group that reducing the variance in future surveys can probably be attained by increasing the number of stations in the actual positive spawning areas (adaptive sampling) and perhaps by applying GAM based estimators.

B.4. Commercial CPUE

The annual series of both nominal fishing effort (number of fishing trips) and CPUE indices of anchovy in Division IXa are available for the Gulf of Cadiz Spanish purse-seine fishery since 1988. The data series from the Spanish purse-seine fishery off southern Galician waters (Sub-division IXa North) only comprise the 1995-1999 period whereas no data from the Portuguese purse-seine fisheries along the Division are available. Causes for this scarcity or even absence of data from the later fisheries must be found in their low anchovy annual catches during the last 3-4 decades and mainly by the fact that these fisheries target sardine.

Regarding the Gulf of Cadiz anchovy Spanish fishery, data on annual values of nominal effort (fishing trips targeting on anchovy) and CPUE by fleet type have routinely been provided to ICES. The series of effective effort and CPUE from all of the Spanish fleets exploiting the Gulf of Cadiz anchovy were provided for the first time to the WGMHSA in 2004. For such a purpose, vessels from single-purpose fleets were additionally differentiated according to their tonnage in heavy- (≥30 GRT) and light- (<30 GRT) tonnage vessels, rendering a total of 11 fleet types.

The standardisation procedure was performed in the last years by fitting quarterly log-transformed CPUE's from fleet types composing the fishery to a GLM (Robson, 1966; Gavaris, 1980) which only included the effects of quarter and fleet type (without any interaction), (ICES, 2007 a). Since 2008 the GLM fitting is performed with the following modifications to the original version: (a) the effect of missing values in the nominal CPUE data was smoothed by adding a constant value to data before their log-transformation (ICES, 2008 b). In this case, this constant was computed as the 10% of the average value for the whole nominal CPUE series resulting in log(CPUE adjusted) data. (b) the model includes year, quarter, fleet type and first order interaction effects. Reference fleet (*métier* or fleet type), year and season used in the standardisation were the Barbate's single-purpose high-tonnage fleet, the first year in the series, 1988, and the first quarter in the year, respectively. The updated series of standardised effort and CPUE from all of the fleets exploiting the fishery is provided to the WG each year. Annual and half-year standardised CPUE series for the whole fleet are computed from the quotient between the sum of raw quarterly catches and that of standardised quarterly efforts within each of the respective time periods.

According to literature, CPUE indices have been considered, as not reliable indicators of abundance for small pelagic fishes (Ulltang, 1982, Csirke 1988, Pitcher 1995, Mackinson *et al.* 1997). At present, the series of CPUE indices is only used for interpreting the fleet's dynamics.

B.5. Other relevant data

C. Historical Stock Development

Model used:

For the time being, no analytical assessment model has been successfully applied. An exploratory assessment was under development until 2008. This exploratory assessment carried out so far was only performed for the anchovy population nucleus in the Gulf of Cádiz (Sub-division IXa-South: Algarve + Cádiz zones), the remaining resilient anchovy populations along the Atlantic Iberian façade of the Division being out of the scope of this assessment. The model used was an *ad hoc* seasonal separable model implemented and run on a spreadsheet for data exploration of anchovy catch-at-age data in IXa South since 1995 onwards. Given the nature of stock, short-lived, data in this model were analysed by half-year-periods, those from the Algarvian anchovy being previously compiled by applying Gulf of Cadiz ALKs. Weights at age in the catches were estimated as usual, whereas weights at age in the stock corresponded to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters (reproductive season). The model was fitted to the updated half-year catch-at-age data until the assessment's last year and to the available acoustic estimates of anchovy aggregated biomass from the spring Portuguese surveys series only (including the acoustic estimate one year ahead of the assessment's last year).

Reasons for the choice of the above tuning index were: (a) the Spanish acoustic survey series (2004, 2006, 2007), was not used as a tuning index because of its shortness; (b) neither the DEPM-based anchovy SSB was considered since it has only 1 data point until the last year, but it was provided for comparison with the acoustic and model-predicted biomass estimates; (c) both Portuguese acoustic surveys series (spring and autumn surveys) were used as tuning indices in the past, assuming the same catchability coefficient. However, each survey series cover different fractions of the population so, the assumption of same catchability is probably inappropriate. Given that the model is unlikely to be able to estimate the extra parameter and that the spring survey series has a better coverage both in space and time, only this survey series was recently used.

The exploratory runs were recently performed under the following assumptions:

–Assessment only tuned by Spring Portuguese acoustic surveys (for the reasons above).

–Catches at age are assumed by the model to be linked by the Baranov catch equations.

–The relationship between the index series and the stock sizes is assumed linear.

–A constant selection pattern is assumed for the whole period.

–F values for 1995 (assessment's first year) are computed as an average of the Fs in subsequent years.

–F in the 2nd half-year in the assessment's last year estimated as a ratio of the F estimated in the 1st half by applying the ratio of seasonal Fs in the previous year (affected by a closure as well in the last years).

–No available Cages for the first half in the year ahead of the assessment's last year: assumed as the same ones that in first half in the assessment's last year.

–Wagesstock in the year ahead of the assessment's last year: average of the estimates in the 3 last years in the assessment.

–F in the 1st half year of the assessment's last year: average of estimated 1st half-year Fs counterparts for the same period of years.

– Log-residuals of Cages in the year ahead of the assessment's last year excluded from the minimisation routine whereas the residuals from the biomass acoustic estimate in the year ahead of the assessment's last year are included in the model fitting.

Runs explored last years consisted in:

- **RUN 1**: Acoustic surveys as a relative tuning index and a weighting factor= 1.
- **RUN 2**: Acoustic surveys as a relative tuning index and a weighting factor= 6.
- **RUN 3**: Acoustic surveys as an absolute tuning index and a weighting factor= 1.

An upweighting factor of 6 for the acoustic estimates in RUN 2 was selected in order to balance the influence of their annual residuals in relation to those from catches at age (3 age groups x 2 semesters in a year). The rational for RUN 3 is the similarity between the estimates by the Portuguese survey and the Spanish DEPM in 2005 (around 14,000 tonnes).

Parameters estimated are selectivity at age for both half-year-periods in relation to the reference age (age 1), recruitment, an average SSB, survey catchability (Q) and annual F values per half-year-period. Parameters are estimated by minimising the sum of squares of the log-residuals from the catch-at-age and the acoustics biomass data.

The exploratory assessments performed so far with this *ad hoc* model have not been recommended as a basis for predictions or advice. The immediate reason is that it usually estimated a large drop in fishing mortality and rapid increase in stock abundance in recent years, which is not supported by the data or the development of the fishery. The residuals showed large clusters over time, indicating that the selection may not be constant, one of the model's assumptions. Migration between the main nucleus in the Gulf of Cádiz and adjacent areas might be one of the causes explaining the discrepancies found in the assessment and it should be properly studied. The exploratory model utilised so far does not provide any reliable information about the true levels of both the stock, F and Catch/SSB ratios since the assessment is not still properly scaled.

For all the above reasons in 2009 was preferred to do not perform any exploratory assessment with this model. Instead of this, the provision of advice relies in an update of the qualitative assessment carried out in 2008 and accepted by the Review Groups of the 2008 and 2009 WGANC (RGANC). This qualitative assessment is based on the joint analysis of trends showed by the available data, both fishery-dependent and –independent information (*i.e.*, landings, fishing effort, cpue, survey estimates).

Advice is framed in a precautionary manner to limit exploitation and, accordingly, the basis for advice is average catches over a reference period.

Software used: the exploratory model was implemented and run in a MicroSoft Excel spreadshet.

Model Options chosen:

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes			
Canum	Catch at age in numbers			
Weca	Weight at age in the commercial catch			
West	Weight at age of the spawning stock at spawning time.			
Mprop	Proportion of natural mortality before spawning			
Fprop	Proportion of fishing mortality before spawning			
Matprop	Proportion mature at age			
Natmor	Natural mortality			

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1			
Tuning fleet 2			
Tuning fleet 3			
….			

D. Short-Term Projection

Model used:

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Procedures used for splitting projected catches:

E. Medium-Term Projections

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock recruitment model used:

Uncertainty models used:

1. Initial stock size:

2. Natural mortality:

3. Maturity:

4. F and M before spawning:

5. Weight at age in the stock:

6. Weight at age in the catch:

7. Exploitation pattern:

8. Intermediate year assumptions:
9. Stock recruitment model used:

F. Long-Term Projections

Model used:

Software used:

Maturity:

F and M before spawning:

Weight at age in the stock:

Weight at age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological Reference Points

H. Other Issues

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A.5.3 Stock Annex – Sardine in Division VIIIc and IXa (Sar-Soth)

Quality Handbook ANNEX:A 5.3

Stock specific documentation of standard assessment procedures used by ICES.

This is a preliminary version of the stock annex for the sardine stock in Divisions VIIIc and IXa. The present text needs to be completed and reviewed by other people involved in sardine research.

Stock:	Sardine in Divisions VIIIc and IXa (sar-soth).
Working Group:	WGANSA
Date:	24 June 2010
Revised by:	**Authors:** Begoña Santos, Isabel Riveiro, Alexandra Silva.

A. General

A.1. Stock definition

Sardine (*Sardina pilchardus*, Walb) distribution in the North-East Atlantic covers a wide area, ranging from southern Mauritania to the northern part of the North Sea. The sardine stock assessed by ICES covers the Atlantic waters of the Iberian Peninsula (ICES areas VIIIc and IXa).

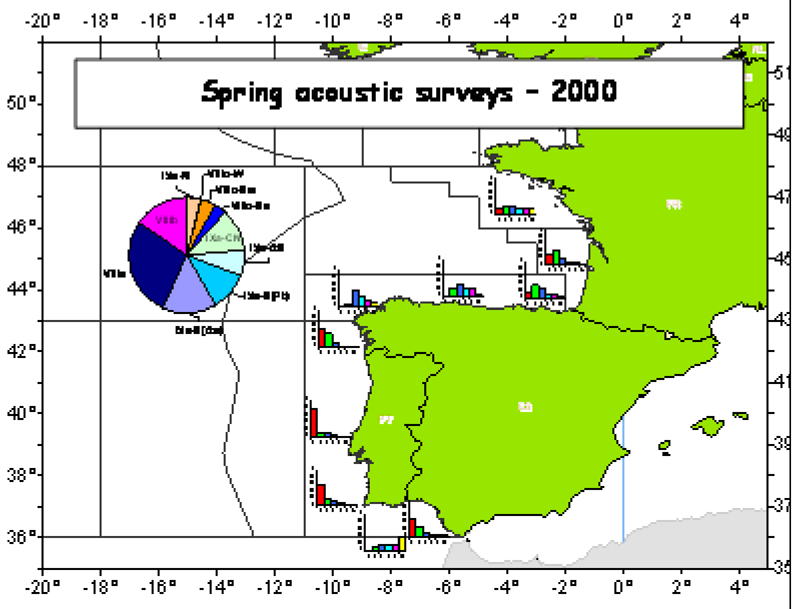
Sardine from ICES Divisions VIIIc and IXa is part of the north-Atlantic genetic stock, which spans the continental waters from the Agadir area in north Morocco to the North Sea. In addition to genetic similarity, there is other evidence of mixing between ICES Division VIIIa and b and the actual assessed stock area (ICES areas VIIIc and IXa): existence of a continuous distribution of both eggs and adult fish from south of the Iberian Peninsula to the British Isles and the similarity of body morphology, growth and other life history properties across the area (results of the EU Q5RS-CT-2002-00818 project SARDYN "*Sardine dynamics and stock structure in the North-East Atlantic*", Anon. 2006). Catch and survey_at_age data from French waters provides some support to this hypothesis by showing a connection between strong year classes observed in east Cantabrian Sea and southern French waters (Figure A.1). Some emigration of juvenile fish into the Cantabrian area is a likely hypothesis but mixing was shown to have limited influence on the dynamics of the overall stock.

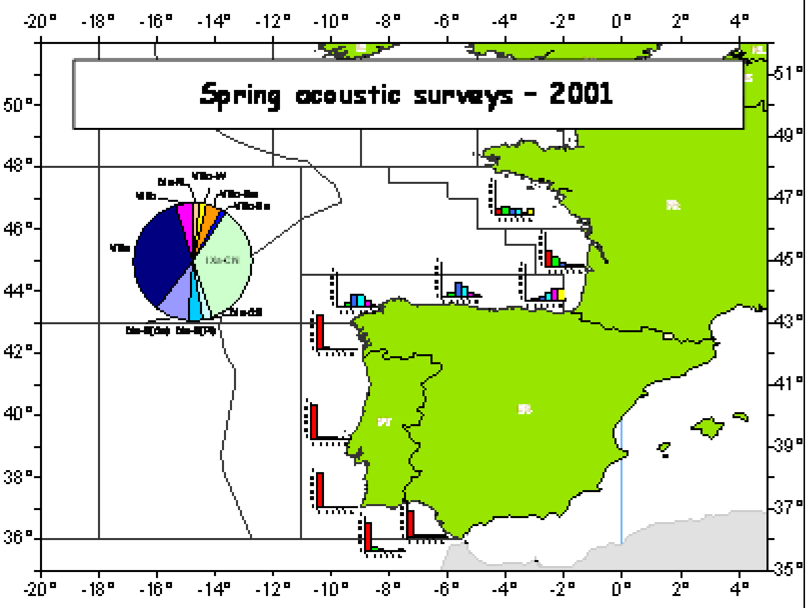
Genetic and life history characters provide also indication of some mixing that across the southern stock limit (Gulf of Cadiz) with sardine populations from southwest Mediterranean and northern Morocco (SARDYN project results). However, the absence of large sardine populations in these areas points to a limited potential to influence the dynamics of the Iberian stock.

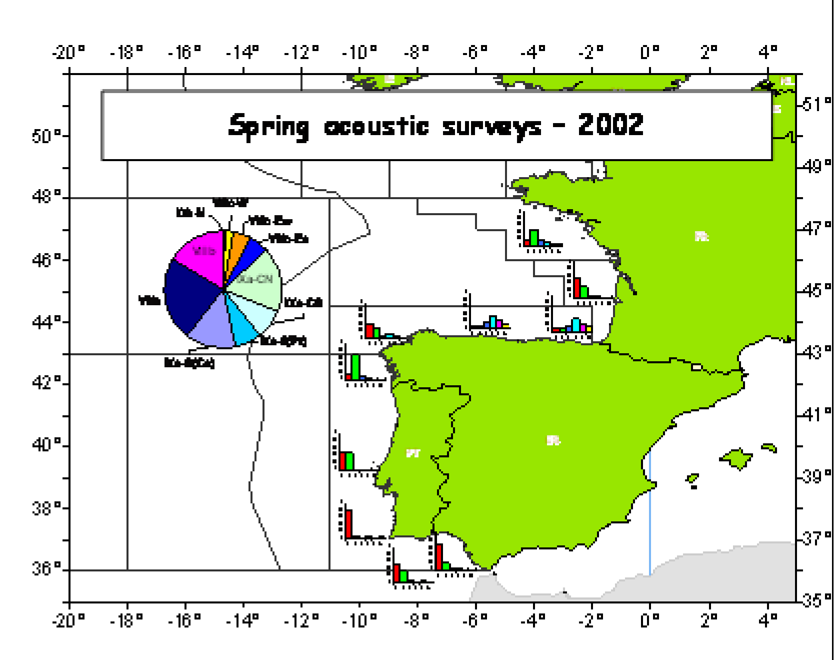
There are also indications of spatial population sub-structuring across Iberian waters: evidence of distinct recruitment pulses off the two main recruitment areas in some years (northern Portugal and the Gulf of Cadiz) and observation that these mainly influence the demography of adjacent populations but not that of distant ones. Persistent spatial differences in growth and spawning temperature tolerance have also been found and these together with the existence of a persistent gap in the spawning area corroborate the hypothesis of spatial heterogeneity of sardine populations. The northwest (Cape Finisterra) and southwest (Cape St. Vincent) corners of the Iberian Peninsula would be the most likely candidates for population discontinuities across the area. However, indirect evidence of movements from otolith chemistry and cohort analyses suggest that sardines recruiting on the western area move gradually north or south as they grow, crossing the above potential discontinuities.

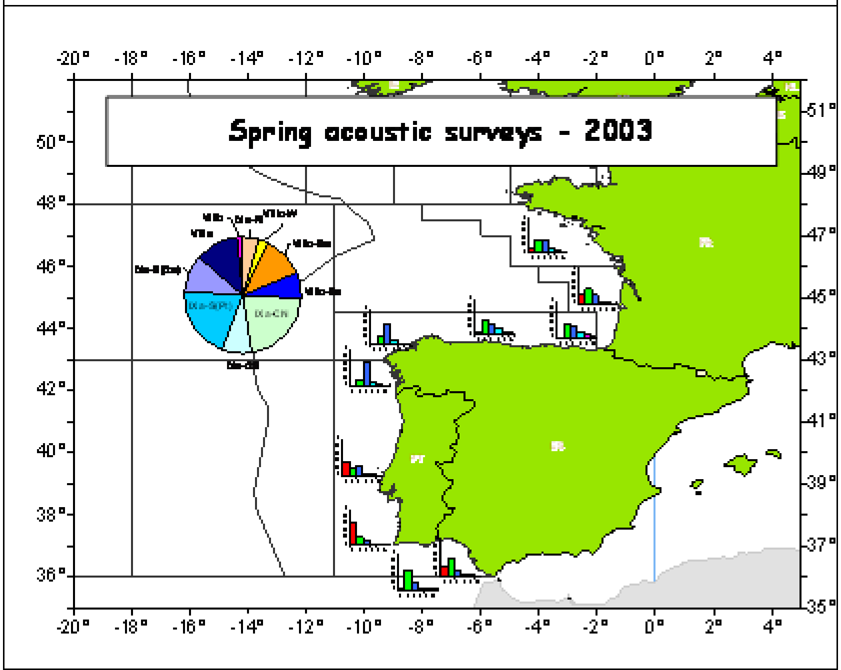
Despite the likelihood of some mixing across the stock borders and of some spatial heterogeneity in life history and dynamics, there is currently no evidence that the dynamics of the stock is strongly influenced by sardine populations outside the stock area. Therefore, the perception of the stock obtained from the assessment is considered unbiased by mixing.

Figure A.1. Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2008). Age categories are: 1, 2, 3,…and 6+. The pie chart represents the contribution of each subarea to the total biomass.






Spring acoustic surveys - 2002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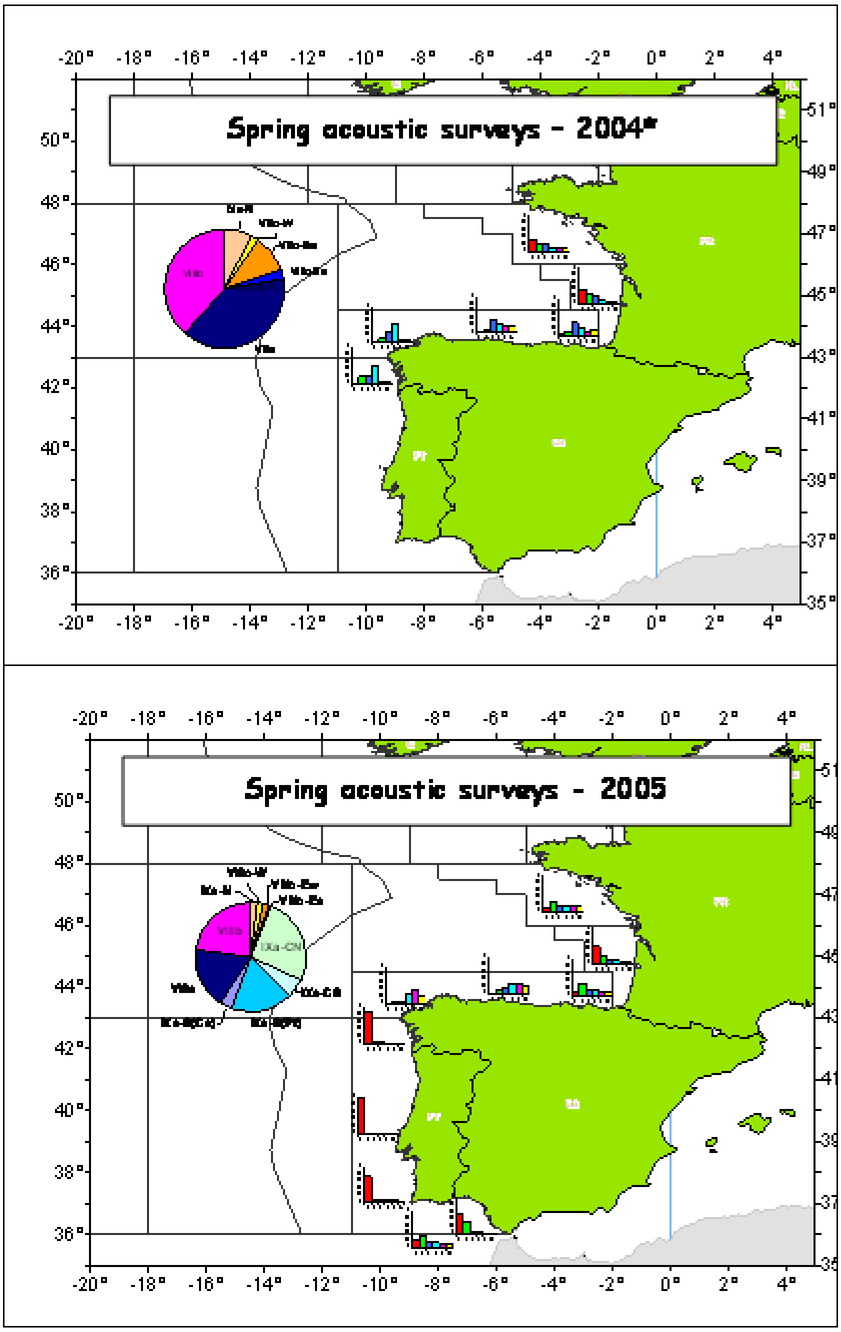
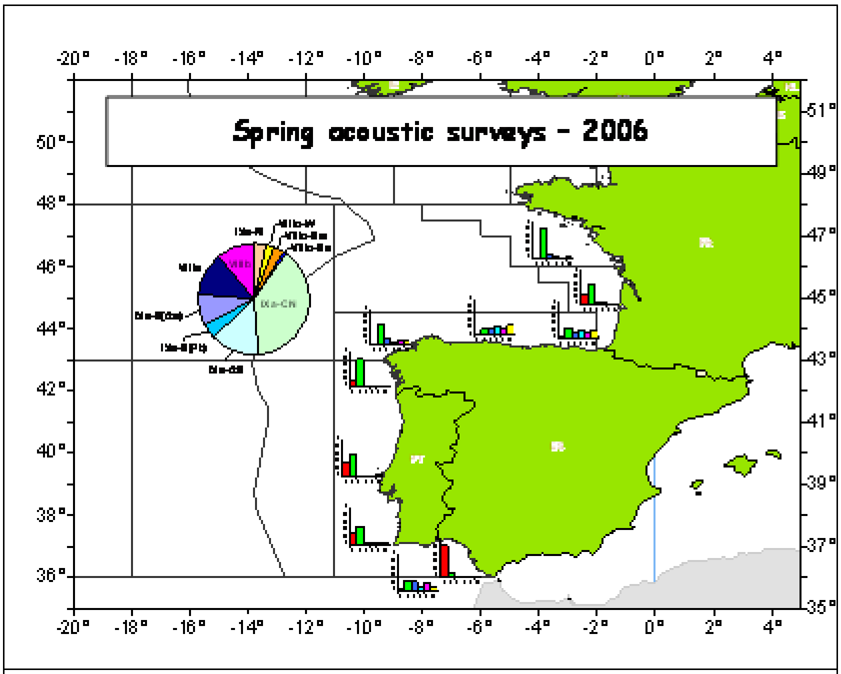

Spring acoustic surveys - 2004*
Spring acoustic surveys - 2005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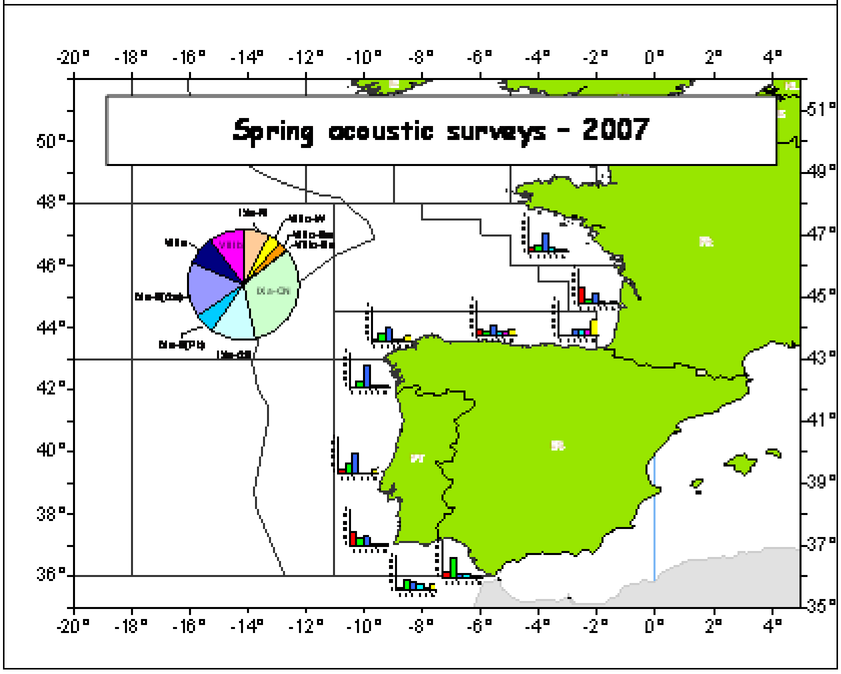
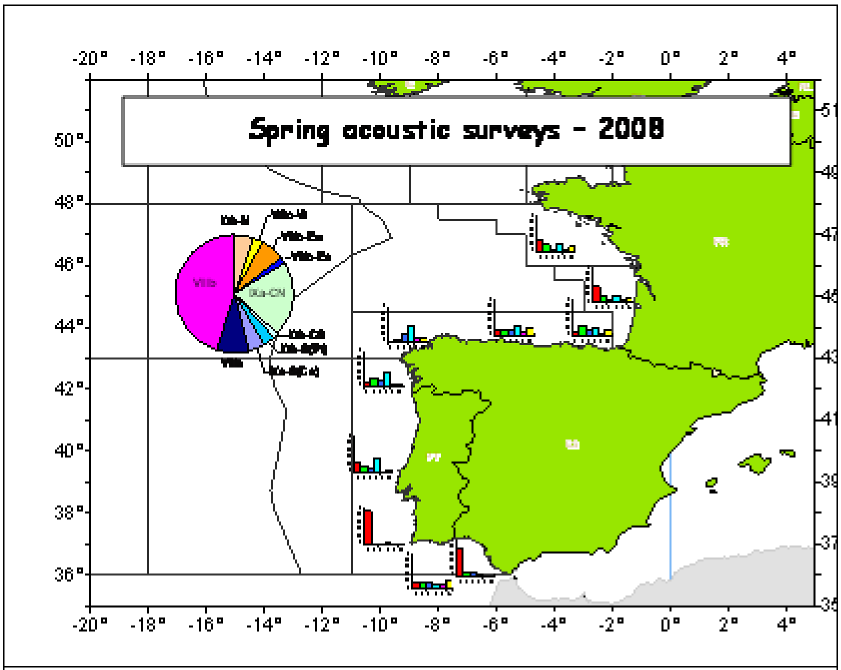
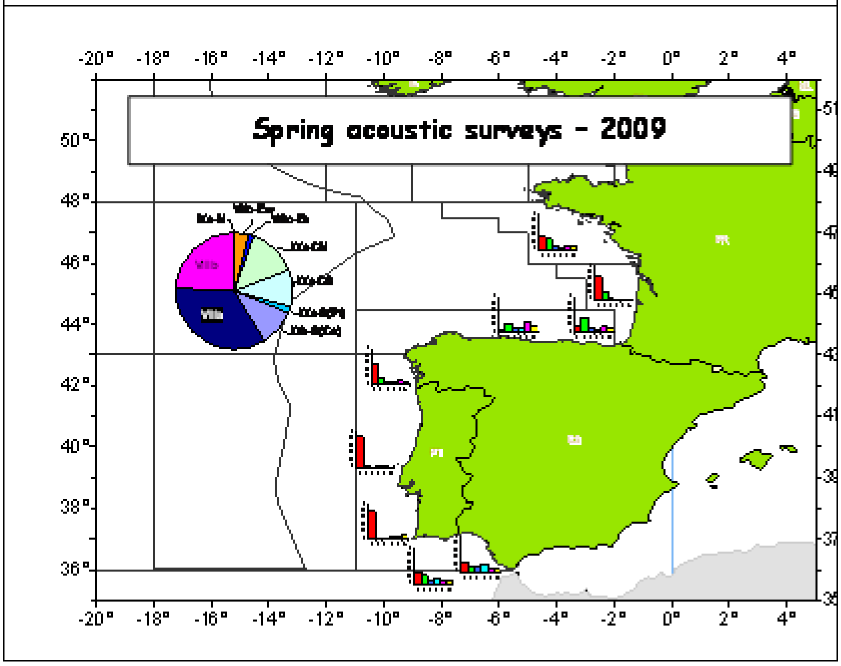
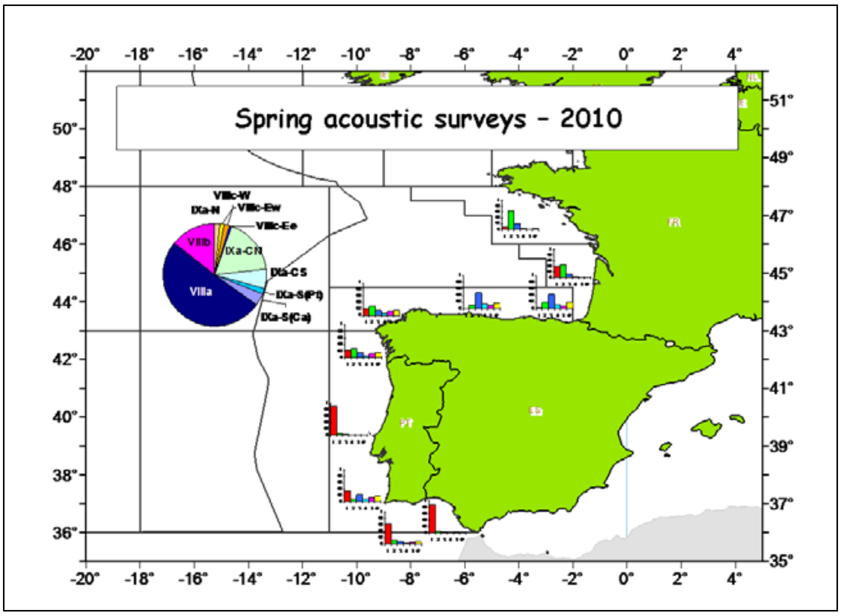

Spring acoustic surveys - 2007


Spring acoustic surveys - 2008


Spring acoustic surveys - 2009


Spring acoustic surveys - 2010
VIIIc-W
IXa-N
VIIIc-Ew
VIIIc-Ee
VIIIb
IXa-CN
IXa-CS
VIIIa
IXa-S(Pt)
IXa-S(Ca)
-20° -18° -16° -14° -12° -10° -8° -6° -4° -2° 0° 2° 4°
50° 48° 46° 44° 42° 40° 38° 36°
51° 49° 47° 45° 43° 41° 39° 37° 35°

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. 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 echo-sounders 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 engine power 450hp, 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		1997
Sardine	Catch limitation	National (ES)	max 7 000 kg/day/boat fish > 15 cm, max 500 kg/day/boat fish between 11 and 15 cm. IXaS Cadiz: in addition max 3 000 kg/day/boat		1997
Sardine/anchovy	Area closure	National (ES)	IXaS Cádiz: fishing closures implemented annually between November-February		2004 and 2005: 45 days closure; 2006: 60 dys; 2007-08: 90 dys; 2008-09: 90 dys; 2009-10: 30 dys.
Sardine/Anchovy	Effort limitations	National (PT)	IXa: max number of fishing days/week: 5, max number of fishing days/year: 180		1997
Sardine/Anchovy	Area closure	National (PT)	no purse-seine fishery north of 39°42'N between 1.February and 31.March	on voluntary basis	1997
Sardine	Catch limitation	National (PT)	55000 tons	only applicable to vessels associated under OP (Producer Organisation)	2010
All species	Mesh sizes	European	different specifications acc. to catch compositions		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, 2001) and the Atlantic French coast (Meynier, 2004). Also feeding on sardine but to a lesser extent are: 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 4 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 90s, 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.

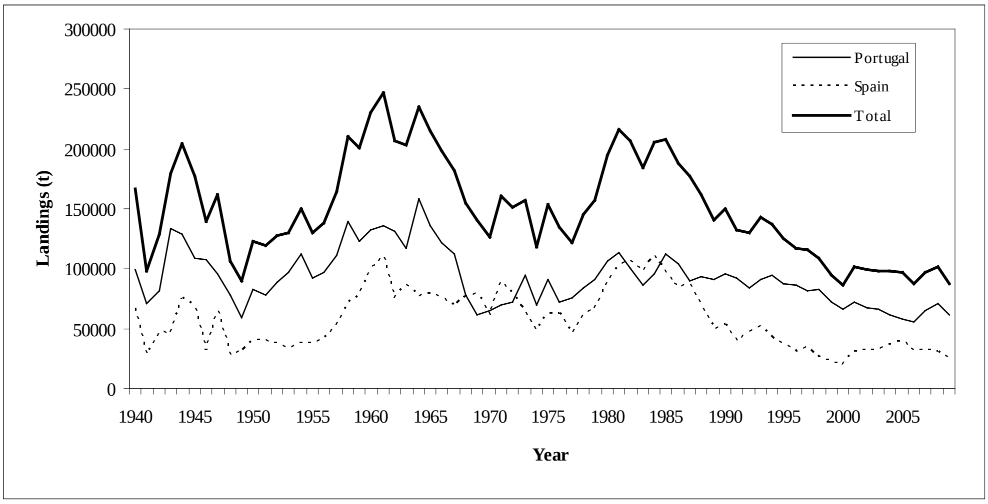
Upwelling intensity was shown to affect both positively and negatively sardine recruitment (Dickson et al., 1988; Roy *et al.*, 1995) but the main direct effect was due to the transport of eggs and larvae offshore by northern winds (Guisande *et al.*, 2001). In this way, strong upwelling during the recruitment 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).

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 under reported.

Figure B.1. Annual landings of sardine, by country.



Discards data on the fishery are not available and it is very difficult to measure. As with other pelagic fisheries that exploit schooling fish discarding occurs in a sporadic way and with often extreme fluctuation in discard rates (100% or null discards). Extreme discards occur especially when the entire catch is released ("slippage") which tend to be related to quota limitations, illegal size and mixture with unmarketable bycatch. Quantifying such discards at a population level is extremely difficult because they vary considerably between years, seasons, species targeted and geographical region. A discard programme, sampling purse seine vessels, has started in Portugal. Nevertheless, discard estimates are still not available to the working group. There is some slipping in northern Portugal (division IXa) but mostly in years with high recruitment. During a 12 week lasting study, the sampled fleet (nine vessels) landed 2196 t and released an estimated 4979 t (CV 33.6%) (Stratoudakis & Marcalo 2002). More than 95% of the total catch was sardine.

Since 1999 (catch data 1998), both Spanish and Portuguese labs 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 onboard observers. In Spain, samples for age length keys are pooled on a half year basis for each subdivision while length/weight relationships are calculated for each quarter. Age length key and length/weight relationship from Cádiz area (IXaS Cádiz) have also been used. 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 and proportions mature (maturity ogive) are derived from the March/April acoustics survey (see next paragraph).

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	% Catch covered	Nº samples	Nº fish measured	Nº fish aged
1992	164,000	79	788	66,346	4,086
1993	149,600	96	813	68,225	4,821
1994	162,900	83	748	63,788	4,253
1995	138,200	88	716	59,444	4,991
1996	126,900	90	833	73,220	4,830
1997	134,800	97	796	79,969	5,133
1998	209,422	92	1,372	123,754	12,163
1999	101,302	93	849	91,060	8,399
2000	91,718	94	777	92,517	7,753
2001	110,276	92	874	115,738	8,058
2002	99,673	100	814	96,968	10,231
2003	97,831	100	756	93,102	10,629
2004	91,886	100	932	112,218	9,268
2005	97,345	100	925	116,400	9,753
2006	87,848	100	927	122,185	9,165

B.3. Surveys

B.3.1. DEPM surveys

The Daily Egg Production Method started being applied to sardine in the Iberian Peninsula during the 80s but surveys were interrupted for almost 10 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 standardised in 2002 in order to guarantee good coordination of the surveys and analyses of the data collected.

I 2008, four DEPM independent surveys were conducted in the Iberian Peninsula (ICES Areas VIII and IX) by the Spanish (IEO, AZTI) and the Portuguese (IPIMAR) fisheries institutions to estimate the population spawning biomass of both sardine and/or anchovy (ICES 2008). The 2008 DEPM survey targeting the Atlantic ‐ Iberian sardine covered the area from the Gulf of Cadiz to the Southern part of Brittany. The region on the Gulf of Cadiz to the northern Portugal/Spain border (River Minho) was surveyed by IPIMAR in January-February, while IEO covered the northwestern and north Iberian Peninsula and part of the Bay of Biscay (from 42°N to 45°N) in April. The remainder area of the Bay of Biscay and the French coast from 45ºN to 48º latitude N, was covered by AZTI, that took the opportunity to carry out the DEPM for sardine together with anchovy (main target species). The extension of the surveyed area almost up to Southern Brittany (following a recommendation from the previous meeting) resulted in a very good 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. (Taken from ICES 2008).

Table B.3.1. Processing and analysis for eggs and adults.

DEPM	Portugal (IPIMAR)	Spain (IEO)	Spain (AZTI)
EGGS			
PairoVET eggs staged sardine (Gamulin & Hure , 1955)	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	
Temperature for egg ageing	Surface (continuous underway CTF at 3 m)	10 m	
Peak spawning hour	21		
Egg ageing	Bayesian (Bernal et al. 2008)		
Egg production	GLM (and GAMs available)		
ADULTS			
Histology			
-Embedding material	Paraffin	Resin	
-Stain	Haematoxilin-Eosin	Haematoxilin-Eosin	
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)		
R estimation	The observed weight fraction of the females		
F estimation	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, 2007). 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. It has been argued for many years that many of the problems with the assessment of Iberian sardine emerge from the use of local surveys to represent the stock as a whole. This is problematic both because a variable fraction of the stock may be covered by each survey. Since 1996, the spring surveys have been coordinated and performed in both areas in most years. There are some differences in survey methodology, and it is unclear to what extent that influences the efficiency of the survey. There is some indication from the results of the SARDYN project that the Spanish survey may have a higher local catchability than the Portuguese survey. During the benchmark assessment carried out in 2006 a joint survey data series 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 are analysed within WGACEGG.

In addition to the spring surveys, there is a Portuguese acoustic survey carried out in November and covering the Portuguese waters and, in most years, the Gulf of Cadiz. 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 an additional information on recruitment strength. 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).

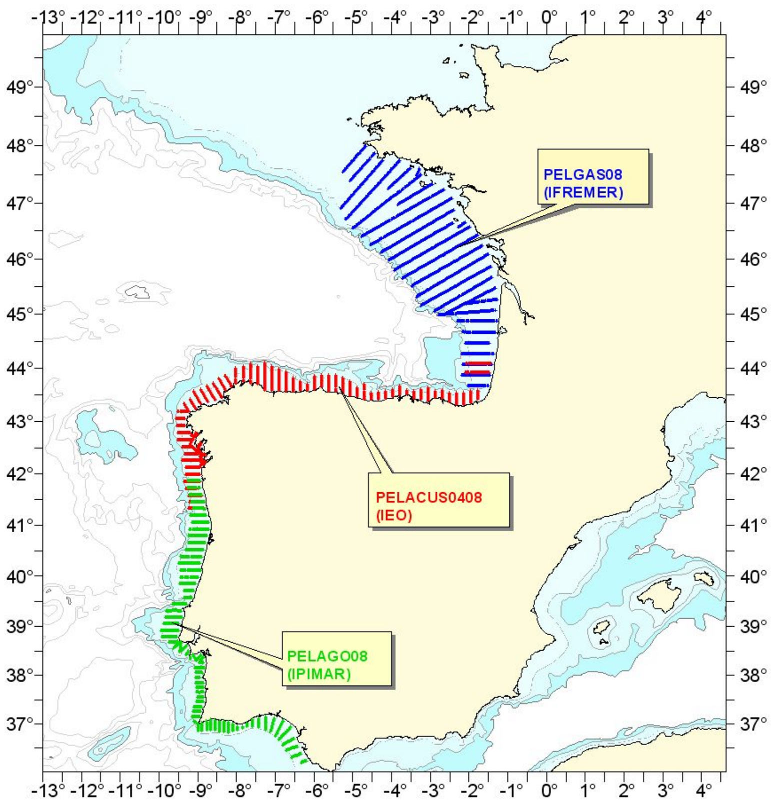


Figure B.3.2.1. Transects surveyed by PELAGO (Portugal), PELACUS (Spain) and PELGAS (France) surveys during spring 2008.

B.3.2.1.1 Portuguese Spring acoustic survey: PELAGOS

This survey is carried out with the RV "Noruega" and covers the Atlantic - Iberian Portuguese continental shelf waters and the Spanish Gulf of Cadiz. The survey follows the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Subareas VIII and IX (ICES, 1986; 1998) and recommendations given by this WG (ICES, 2006, 2007). The acoustic equipment consists of a Simrad EK500 echosounder controlling a 38 kHz split - beam and 120kHz single beam transducers. Acoustic data are stored in *.HAC format using Movies+ software. In addition to sardine, abundance indices are also provided for the most abundant neritic species following a 'pelagic community' approach that started in the 2007 survey.

Environmental and surface plankton sampling are performed by CUFES (Continuous Underway Fish Egg Sampler) performed along the acoustic tracks. The sampling unit for CUFES is 18 minutes of integration along the acoustic track, which for a vessel speed of 10 knots corresponds to a distance of 3 nautical miles.

Similar methodology, aims and sampling design is employed in the autumn survey although the continuation of this survey is in danger since it is not covered by the EU DG XIV project "Data Directive".

B.3.2.1.2 Spanish Spring acoustic survey: PELACUS

The spring acoustic survey PELACUS (on board the RV "Thalassa") follows the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES

Subareas VIII and IX (ICES, 1986; 1998) and recommendations given by this WG (ICES, 2006, 2007). The scientific echosounder is a Simrad EK60 working at five frequencies (18, 38, 70, 120 and 200 kHz). Acoustic data are stored as *.raw format using SonarData Echoview software. The area of the continental shelf covered extends from 30 to 200 m depth, from northern Portuguese waters to southern French waters. The survey design comprises 53 tracks, plus 23 tracks inside the Rías in (Galician waters).

The objective of the survey is the estimation of the abundance and biomass of the main fish pelagic species that form the pelagic community in northern Spanish waters: sardine, anchovy, horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus)*, chub mackerel (*Scomber colias*), blue horse mackerel (*Trachurus picturatus*), bogue (*Boops boops*), blue whiting (*Micromesistius poutassou*) and boarfish (*Capros aper*).

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 and information on pelagic fish species distribution and abundance is available since 2000. The survey takes place onboard the R/V Thalassa. The main species targeted is anchovy but the survey is part of the IFREMER programs 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 WGANSA, 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 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 are collected only during the day because of pelagic fishes 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 echo sounder between the surface and 8 m depth.

Since 2008, PELGAS survey has been accompanied by pelagic pairtrawlers that follow the R/V Thalassa transects. Identification hauls were carried out both by the R/V 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 R/V Thalassa.

B.4. Commercial CPUE

CPUE indices are not considered reliable indicators of abundance for small pelagic fish (Ulltang, 1982; Csirke, 1988; Pitcher, 1995; Mackinson *et al.*, 1997) and are not used.

B.5. Other relevant data

C. Historical Stock Development

Model used: The stock is assessed using AMCI, an age structured model (AMCI, Assessment Model Combining Information from various sources, Skagen 2005). The model has large flexibility with the possibility for area and fleet disaggregation, different time steps, several stock-recruitment and fishing mortality models and objective functions.

For the assessment of this stock, no spatial disaggregation or fleet disaggregation is assumed and time steps are years. The population model is an exponential mortality model. The initial abundances in numbers of each year class are specified as parameters. The plus group is modeled as a dynamic pool. Selection-at-age is allowed to change gradually across the period using a recursive updating algorithm. This provides a fishery mortality model close to separable. Observation models describe the relation between the modelled population and the observed data through the estimation of catchability parameters. No process errors are assumed. Observation errors are not assumed to follow specific distributions. The objective function is a sum of squared log residuals. Asymptotic estimates of variance and correlations by the inverse of the Hessian matrix. Median and 90% limits of SSB, R and F trajectories estimated by non-parametric bootstrap of catch and survey residuals.

More detailed information on AMCI can be found in Skagen (2005).
Software used: **AMCI Version 2.4. Assessment model combining information from various sources. August 2005. D. Skagen, 2005.** Available in the ICES webpage (www.ices.dk) or from the author dankert@imr.no.

Model Options chosen:

The model is conditioned as follows:

- Selection at age in the fishery at age 4 equal to age 5
- Selection at age in the fishery in the last year of the assessment equal to that of the previous year
- Survey catchability at age 4 equal to age 5
- DEPM survey as a relative index of SSB
- Selection at age allowed to change gradually, using the recursive updating algorithm in AMCI, with a gain factor of 0.2 for all ages and years
- Survey catchability assumed constant over time.
- Catchability of the DEPM survey constant over time.
- Natural mortality: Constant at 0.33 (Pestana, 1989).

The following model parameters are estimated:

- Initial numbers in the first year of the assessment and recruitments each year
- Initial selection at age in the fishery, for all ages (but see above)
- Survey catchability at age, for all ages, but assumed equal for ages 4 and 5
- Catchability for the DEPM survey.
- Annual fishing mortalities.

The objective function is a sum of squared log residuals for catch numbers at age, survey indices at age and DEPM indices. 0-group fish are not fully selected by the fishery and catches at-age for this age group are very noisy and biased. Therefore, catches at age 0 are downweighed by a factor of 0.1. The internal weighting in AMCI implies that the set of all acoustic survey observations (number ages x number years), and the set of DEPM observations (number years), each are given the same weight as each year of catch numbers at age (number ages) in the objective function. Therefore, catch-at-age data has considerable more weight than either survey on the model fit. The DEPM has the same weight as the acoustic survey.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978-2009	0-6+	No
Canum	Catch at age in numbers	1978-2009	0-6+	Yes
Weca	Weight at age in the commercial catch	1978-2009	0-6+	Yes
West	Weight at age of the spawning stock at spawning time.	1978-2009	0-6+	Yes (fixed until 1988)
Mprop	Proportion of natural mortality before spawning	1978-2009	0-6+	No
Fprop	Proportion of fishing mortality before spawning	1978-2009	0-6+	No
Matprop	Proportion mature at age	1978-2009	0-6+	Yes (fixed until 1988)
Natmor	Natural mortality	1978-2009	0-6+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Acoustic SSB spring survey (data summed from one Spanish and one Portuguese survey, the former covering also the Gulf of Cadiz)	1996 – 2010 (gap in 2004)	1-6+
Tuning fleet 2	DEPM SSB spring series (data summed from one Spanish and one Portuguese survey)	Triennial since 1997	
Tuning fleet 3			
….			

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A.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)

A. General

A.1. Stock definition

Stock units

For many years the Working Group has considered the horse mackerel in the northeast Atlantic as separated into three stocks: the North Sea, the Southern and the Western stocks (ICES, 1990; ICES 1991). Until the results from the EU project (HOMSIR, QLK5-Ct1999-01438), were available, the separation into stocks was based on the observed egg distributions and the temporal and spatial distribution of the fishery. The extremely strong 1982 year class appeared for the first time in the eastern part of the North Sea in 1987, during the third and mainly the fourth quarter. This year class was the basis for the start of the Norwegian horse mackerel fishery in the eastern part of North Sea during the third and mainly the fourth quarter. Since Western horse mackerel are assumed to have broadly similar migration patterns as NEA mackerel the Norwegian catches have been considered to be fish of western origin migrating to this area to feed. In addition, there is a fishery further south in the North Sea which is considered to be fish of North Sea origin. These views were supported by results from the mentioned EU project which was reviewed in ICES (2004) which also concluded to include Division VIIIc as part of the distribution area of the western horse mackerel stock (see also Abaunza *et al.*, 2008 for a comprehensive discussion of the results from the HOMSIR project). Horse mackerel off the west coast of the Iberian Peninsula have characteristics (morphometry, parasites, distribution and migratory circuit) that distinguish them from the rest of the samples collected in the northeast Atlantic. The border between southern and western horse mackerel stocks may therefore lie at the level of Cape Finisterre on the coasts of Galicia at 43°N, which is also the limit between Division VIIIc and IXa. The southern limit of the southern horse mackerel stock is not as evident due to the lack of samples from the north of Africa. Based on morphometric studies, Murta (2000) showed that the horse mackerel of the Portuguese coast was closer to the northwest coast of Morocco than to the Gulf of Cadiz in the south of Spain. However, the respective parasite composition suggests that the populations off the north of Africa and the west of the Iberian Peninsula are not part of a continuous stock.

Data from bottom-trawl surveys carried out throughout the Atlantic waters of the Iberian Peninsula during the autumn supported the existence of ontogenic migrations (Murta *et al.*, 2008). Analysis of the proportion of each year class in each area off the Portuguese coast indicated that most year classes recruit to the northwest area (close to Area 8) and then move progressively southwards. After six years of age, they return to the north.

Allocation of catches to stocks

Based on spatial and temporal distribution of the horse mackerel fishery, the catches were allocated to the three stocks as follows:

Western stock: Divisions IIa, IIIa (western part), Vb, IVa (third and fourth quarter), VIa, VIIa–c,e–k and VIIIa–e. Although it seems strange that only catches from western part of Division IIIa are allocated to this stock, the catches in the western part of this Division taken in the fourth quarter often are taken in neighbouring area of catches of western fish in Division IVa. The Working Group is not sure if catches in Divisions IIIa and IVa during the first two quarters are of western or North Sea origin. Usually this is a minor problem because the catches here during this period are small. However, in 2006 relatively larger catches were taken in this area during the first half of the year (3600 tons) and these catches were allocated to the North Sea stock. In 2007, 2100 tons were caught during the two first quarters in Divisions IVa and IIIa and were allocated to the North Sea stock.

North Sea stock: Divisions IIIa (eastern part), IVa (first and second quarter), IVb,c and VIId. The catches in 3–4 quarters of Divisions IVa and IIIa and 1–4 quarters from Divisions IVb,c and VIId were allocated to the North Sea stock. In 2007, some small catches were reported from Divisions IIIb (4 tons) and IIIc (21.5 tons) and were allocated to the North Sea stock.

Southern stock: Division IXa. All catches from these areas are allocated to the southern stock.

A.2. Fishery

The catches of horse mackerel in Division IXa (Subdivision IXa North, Subdivision IXa Central-North, Subdivision IXa Central-South and Subdivision IXa South) are allocated to the Southern horse mackerel stock. In the years before 2004 the catches from Subdivisions VIIIc West and VIIIc East, were also considered to belong to the southern horse mackerel stock.

The Spanish catches in Subdivision IXa South (Gulf of Cádiz) are available since 2002. They will not be included in the assessment data until they are available for all assessment years, to avoid a possible bias in the assessment results. On the other hand, the total catches from the Gulf of Cádiz are scarce and represent less than the 5% of the total catch. Therefore, their exclusion should not affect the reliability of the assessment.

The "Prestige" oil spill had also an effect on the fishery activities in the Spanish area (Division IXa North) in 2003. The Spanish catches increased markedly from 1991 until 1998, whereas the Portuguese catches were more stable, showing a smooth decreasing trend since the peak observed in 1992 (with a secondary peak in 1998).

Catches in Subdivisions IXa Central-North showed a decreasing trend whereas in Subdivision IXa North they increased markedly until 1998, and since then, the catches always have been higher than 7000 t. The catches from bottom trawlers are the majority in both countries. The rest of the catches are taken by purse seiners, especially in the Spanish area and by the artisanal fleet which is much more important in the Portuguese area.

Description of the Portuguese fishing fleets operating in Division IXa (data provided by the Portuguese Fisheries Directorate) and catch horse mackerel (only trawlers and purse seiners):

Gear	Length	Storage	Number of boats
Trawl	10-20	Freezer	2
Trawl	20-30	Freezer	7
Trawl	30-40	Freezer	5
Trawl	0-10	Other	259
Trawl	10-20	Other	68
Trawl	20-30	Other	60
Trawl	30-40	Other	29
Purse seine	0-10	Other	79
Purse seine	10-20	Other	103
Purse seine	20-30	Other	79

Note that horse mackerel is also caught in all polyvalent and most small scale fisheries.

Description of the Spanish fishing fleets operating in Division IXa including the Gulf of Cádiz (Southern stock) and Division VIIIc (Western stock) (Hernández, 2008):

Gear	Bottom trawl	Purse seine	Lgline Bottom	Lgline surface	Gillnet (big mesh size)	Gillnet	Other artisanal
Number	282	410	100	67	35	57	5379
Construction year (mean)	1996	1992	1990	1995	1990	1993	1982
Length	9–35 (22.9)	8–38 (21)	6–28 (15.1)	18–38 (27.6)	4–28.6 (14)	12–27 (17.2)	3–27 (7)
Power	66–800 (322.3)	24–1100 (302.5)	12–476 (150.3)	175–780 (418.9)	10–500 (141.8)	50–408 (164.9)	2–450 (32.6)
Tonnage	6–228 (81.2)	4–221 (56.6)	2–118 (26)	37–206 (116)	1–110 (23.7)	10–99 (27.6)	0.3–83 (3.5)

It is indicated the range and the arithmetic mean (in parenthesis). Data from official census (Hernández, 2008). Note that horse mackerel in the Spanish area is mainly fished by bottom trawlers and purse seiners.

The Spanish bottom-trawl fleet operating in ICES Divisions VIIIc (Western stock) and Subdivision IXa north (Southern stock), historically relatively homogeneous, has evolved in the last decade (approximately since 1995) to incorporate several new fishing strategies. A classification analysis for this fleet between the years 2002 and 2004 was made based on the species composition of the individual trips (Castro and Punzón, 2005). The analysis resulted in the identification of five catch profiles in the bottom otter trawl fleet: 1) targeting horse mackerel (>70% in landings), 2) targeting mackerel (>73% in landings); 3) targeting blue whiting (>40% in landings); 4) targeting demersal species; and 5) a mixed "métier". In the bottom pair trawl fleet the classification analysis showed two métiers: 1) targeting blue whiting; and 2) targeting hake. These results should help in obtaining standardized and more coherent cpue series from fishing fleets.

In the Portuguese area (Division IXa) Silva and Murta (2007) classified trawl fleet in two main types: those targeting fish and cephalopods species and those fishing crustaceans. Looking at the fishing trips of those that catch fish and cephalopods, they identified three main clusters: 1) targeting horse mackerel, 2) targeting cephalopods, and 3) a poorly defined mixed cluster.

In 2005, the landings of blue whiting increased, probably due to increased market demand and consequent reduction of discards, resulting in a fourth specific cluster. The Crustacean trawl clusters do not follow the same pattern every year, depending on the abundance of the two main target crustacean species, which are Norway lobster and deep-water rose shrimp. There can be one target species by cluster or mixed clusters with different percentages of these two species.

A.3. Ecosystem aspects

Influence of environmental drivers on the stock dynamic

The southern horse mackerel stock is distributed along the western and southern Atlantic coasts of the Iberian Peninsula, which is an area subject to upwelling events. There is already evidence in the literature that horse mackerel recruitment is influenced by environmental drivers. The analysis carried out under the IN EX Fish project (Frid *et al*., 2009) showed that non-linear combinations of NAO and upwelling indices were able to explain the strength of past recruitments. The rise and fall of this horse mackerel stock was probably caused by a complex interaction of different factors, both human and natural. However, it is very likely that changes in recruitment due to upwelling and NAO events may have played an important role.

Role of multispecies interactions

Horse mackerel is a schooling species and often close to the sea floor. Shelf attachment is a predominant distributional pattern for this stock. Therefore, horse mackerel is in relation with other fish and invertebrate species that are usually caught during the bottom-trawl surveys and share the same habitat. These species are mainly: snipefish, boarfish, blue whiting, European hake, sardine, blue jack mackerel, squid and pelagic crabs (Sousa *et al*., 2006).

Trophic interactions

Young horse mackerel is a feeding resource consumed by several demersal, benthic and pelagic predators present in the distribution area like: hake, monkfish, John Dory, bluefin tuna and dolphins.

Horse mackerel is mainly a zooplanktivorous species. Diet variations with fish length and water depth are correlated: small fish are closely associated with coastal areas where they feed on copepods and decapod larvae (Cabral and Murta, 2002). However, they can prey on fish as they grow. They become *Ichthyophagous* when they reach large sizes.

B. Data

B.1. Commercial catch

Mean length-at-age and mean weight-at-age

Both mean length-at-age and mean weight-at-age values are calculated by applying the mean, weighted by the catch, over the mean weights or mean lengths-at-age obtained by Subdivision.

Taking in consideration that the spawning season is very long, from September to June, and that the whole length range of the species has commercial interest in the

Iberian Peninsula, with probably very scarce discards, there is no special reason to consider that the mean weight in the catch is significantly different from the mean weight in the stock.

Catch in numbers-at-age

The sampling scheme is believed to achieve a good coverage of the fishery (above 95% of the total catch). The number of fish aged seems also to be sufficient through the historical series. Catch in numbers-at-age have been obtained by applying a quarterly ALK to each of the catch length distribution estimated from the samples of each subdivision. In the case of Subdivision IXa north, the catch in number estimates before 2003 have changed. In previous years the age–length key applied to the length distributions from Subdivision IXa north had included otoliths from Division VIIIc, which has been defined recently as part of the western stock. Since 2003, the catch in numbers-at-age from Subdivision IXa north were estimated using age–length keys which included only otoliths from Division IXa.

B.2. Biological

Maturity-at-age

For multiple spawners, such as horse mackerel, macroscopical analysis of the gonads cannot provide a correct and precise means to follow the development of both ovaries and testes. Histological analysis has to be included because it provides precise information on oocyte developmental stages and it can distinguish between immature gonads and regressing ones, or those partly spawned (Abaunza *et al.*, 2008). The HOMSIR project provided microscopical maturity ogives from the different IXa subdivisions. The maturity ogive from Subdivision IXa South is adopted here as the maturity-at-age for all years until 2006 of the southern stock, since it was based on a better sampling than in the others subdivisions. The percentage of mature female individuals per age group was adjusted to a logistic model.

In 2007 a new estimate of maturity proportion by age was available for Division IXa for the application of the Daily Egg Production Method (DEPM). This maturity ogive was then adopted since 2007 and will be revised with new data collected in the DEPM to be carried out in 2010.

Natural mortality

Natural mortality has been considered to be 0.15. This level of natural mortality was adopted for all horse mackerel stocks since 1992. However, the presence of very old horse mackerel specimens in the southern stock is much scarcer than in the western or North Sea stocks. On the other hand, the available references on natural mortality estimates for other *Trachurus* species (e.g. *Trachurus capensis, Trachurus japonicus* and *Trachurus murphyi*) show higher natural mortality values, being higher than 0.3 in the majority of cases (range from 0.1 to 0.5) (Cubillos *et al.*, 2008; MFMR, 2006; Zhang, 2001). Also, the assumption that natural mortality is the same for all ages is highly unrealistic, given that the chances of a 10 cm fish of being predated are much higher than those of a 30 cm fish.

As a conclusion, it is considered that the value of natural mortality (0.15) is an underestimation for southern horse mackerel stock. It is generally accepted that natural mortality is very high during larval stages and decreases as the age of the fish increases, approaching a steady rate (Jennings *et al.*, 2001). The natural mortality adopted in the assessment (mean = 0.3) is dependent on age, being higher for younger ages. The adopted values are the following and are based in the estimates for other similar pelagic species, observed diet composition of fish predators in the area and taking into account the observed mean life span in southern horse mackerel.

Age	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Nat Mor	0.9	0.6	0.4	0.3	0.2	0.15	0.15	0.15	0.15	0.15	0.15

B.3. Surveys

The only survey datasets currently available for the assessment of southern horse mackerel are those from the bottom-trawl surveys carried out in the 4th quarter (October) by Portugal (Pt-GFS-WIBTS-Q4) and Spain (Sp-GFS-WIBTS-Q4) in ICES Division IXa. These surveys cover contiguous areas at the same time but do not cover the southern part of the stock distribution area, corresponding to the Spanish part of the Gulf of Cadiz. In that area another bottom-trawl survey is carried out Sp-GFS-caut-WIBTS-Q4), usually in November, but the raw data were unavailable in time for this workshop to investigate the effect of merging it with the datasets from the other areas. This work is expected to be completed in time for the next assessment working group, in June 2011.

As suggested in previous reviews of the assessment of this stock, the Spanish survey from Subdivision IXa North (Sp-GFS-WIBTS-Q4) and the Portuguese survey (Pt-GFS-WIBTS-Q4) are treated as a single survey, although they are carried out with different vessels and slightly different bottom-trawls. The catchability of these vessels (BO Cornide de Saavedra and NI Noruega) and fishing gears were compared for different fish species during project SESITS (EU Study Contract 96-029) and no significant differences were found for horse mackerel. Thus, the raw data (number per hour and age in each haul, including zeros) of the two datasets were merged and treated as a single dataset.

The abundance data by age and year do not follow a Normal distribution, having a big proportion of zeros and a few extreme values. This is explained by the patchiness in the distribution of horse mackerel and by its characteristic of forming large shoals. Therefore, it is questionable whether a simple average of the number-per-hour, by age and year, is an adequate abundance index for tuning the stock assessment. Different ways of obtaining an abundance index by age and year were explored, all of them based on the smoothing of the data assuming probability distributions other than the Normal one. For this, we fitted Generalized Additive Models (GAM) to the raw data using the package "mgcv" (Wood, 2006) in the R statistical computing language (R Core Development Team, 2010). Data smoothing was tried with four different strategies: by year class (one GAM for each year-class, with age as covariate), by age (one GAM by age with year as covariate), by year (one GAM by year with age as covariate), and by age and year (one GAM using a bi-dimensional smoother by age and year). A log link function was used in all cases, and the error was modelled with a binomial negative distribution. Other distributions and transformations of the data were tried, but with worse fittings than with these settings.

An example of the GAM fitting diagnostics with each of these four strategies showed in all cases a poor fitting, with the residuals showing undesirable patterns. Looking at the differences between the indices matrix obtained with each of these strategies and the one obtained by a simple average of the raw data, it is clear that most of the attempted strategies to smooth the data would result in strong differences, especially for the youngest ages. Given that an acceptable fit could not be achieved with these

GAMs, it was decided to use the simple averaged data as abundance indices for tuning the assessment. Further work must be carried out in the future to better address this problem.

Two very clear features can be observed in the abundance indices dataset: a strong variability of age 0 and strong year effects (some years with higher abundance of all ages than others). The first feature may be explained by the greater aggregation tendency of these small fish in dense shoals and by their typically pelagic behaviour, which makes them less available to the bottom trawl. When, by chance, one or a few of those shoals are captured by the bottom trawl (e.g. at the end of a haul when the trawl is being towed at mid-water), it contributes to a high abundance estimate of that age class. The apparent year effects in the data are more difficult to explain, and are likely due to natural variations in the availability of the fish in that time of the year and small variations in sampling effort (e.g. due to bad weather). Both the variability in age 0 and the apparent year effects must be accounted for in the assessment model to be fitted to these data.

Recent work suggests that horse mackerel has indeterminate fecundity (Gordo *et al.*, 2008), which makes the Annual Egg Production Method (AEPM) unsuitable to estimate SSB for this species. For species with indeterminate fecundity, the Daily Egg Production Method (DEPM) must be used instead. The existence of different series of data from egg surveys covering the whole area of the southern horse mackerel stock makes it possible to obtain egg production estimates using DEPM.

For this stock, a total of three SSB estimates, for the years 2002, 2005 and 2007, were made available. The SSB estimate and variance for 2007 was obtained from a DEPM egg survey directed at horse mackerel. Details of the sampling procedure, data obtained and methods followed are available from the 2008 report of the Working Group on Mackerel and Horse Mackerel Egg Surveys (ICES, 2008. ICES CM 2008/LRC:09). However, some details were corrected after the WGMEGS report, namely the total egg distribution area (which was corrected from 1.7e11 sq.meter to 7.1e11 sq.meter) and the fitting of the mortality curve to the egg abundance data, which was done using a GLM with a log link and assuming a Poisson distribution for the variance, instead of the non-linear regression described in the WGMEGS report. This resulted in a change of egg production from 13 eggs/sq.meter to 17 eggs/sq.meter.

The 2002 and 2005 estimates were obtained with egg abundance data collected during the surveys directed at sardine in 2002 and 2005 and from horse mackerel adult samples collected at the same time of those surveys. The methodology followed to estimate SSB was the same as the one for 2007, although the area covered in the egg sampling, which corresponded to the sampling grid for sardine, was smaller than in 2007.

There are different criteria that can be used to estimate the spawning fraction, such as the presence of migratory nucleus, hydrated oocytes or post-ovulatory follicles (POF). Estimates of SSB were obtained for the three years with all these criteria, and the obtained trends in SSB were parallel but with different levels. The POF criteria, assuming POF last for two days as in other species at similar temperatures (Ganias *et al.*, 2003; Hunter and Macewicz, 1985) was the one providing the lowest CV, being therefore adopted to use in the assessment. However, given the uncertainty in the absolute value of SSB, partly due to the choice of the criteria for the spawning fraction, the SSB index for the assessment must be treated as relative and a corresponding catchability parameter has to be estimated.

Still another source of uncertainty is the egg distribution area, which was roughly defined and kept fixed for the three years. In all these egg surveys, there are several transects with the presence of eggs in the most offshore station, which indicates that the area with egg presence must, in some cases, be extended further away from the coast. However, a good approximation of that area is impossible to obtain with the available data.

B.4. Commercial cpue

No commercial cpue data is used in the stock assessment.

B.5. Other relevant data

There were no other data considered at this time.

C. Assessment: data and method

Model used: AMISH (Assessment Method for the Ibero-Atlantic Stock of Horse-Mackerel).

A model similar to the one adopted by the South Pacific Regional Fishery Management Organization (SPRFMO) for the assessment of Chilean jack mackerel (*Trachurus murphyi*) was modified for application with horse mackerel. This method (Lowe *et al*., 2009) models the population numbers-at-age as projections forward based on recruitment estimates leading up the initial population numbers-at-age (in 1992 for this case) and subsequent annual recruitment and fishing mortalities parameters. These underlying population numbers-at-age are fit through an observation model for parameter estimation via a penalized likelihood applied to a quasi-Newton minimisation routine with partial derivatives calculated by automatic differentiation (Griewank and Corliss, 1991). The automatic differentiation and minimisation routines are those from the package AD Model Builder (ADMB). A similar model is currently used in many stock assessments in North American waters (e.g., Atka mackerel, eastern Bering Sea pollock, Pacific Ocean perch). It is a simple, well tested, and widely used methodology. The population equations, model fitting components, and model settings are listed in Tables 1–4.

The approach differs from the XSA methods in that:

calculations proceed from the initial conditions to the present and into the future,

the catch-at-age is not assumed to be known exactly,

the inclusion of annual estimates of sampling variability (for both age composition and survey index precision) is allowed,

fishing mortality is separable but selection-at-age is allowed to change gradually over time,

separate components of the fishery are treated independently,

some parameters, which are assumed constant in XSA, such as the catchability coefficients associated with tuning indices, may be allowed to change over time,

statistical basis allows for careful consideration of data quality and the impact on the uncertainty of estimates.

The model begins in the first year of available data with an estimate of the population abundance-at-age. Recruitments are estimated for each year. In subsequent ages and years the abundance-at-age is reduced by the total mortality rate. This projection continues until the terminal year specified. If data are unavailable to estimate recruitment, the model will use the geometric mean value and hence can be projected to any arbitrary year (assuming specified catches).

The fishing mortality rates for each sector in the fishery are assumed to be separable into an age component (called selectivity) and a year component (called the F multiplier). The selectivity patterns are allowed to change over time. Expected catches are computed according to the usual catch equation using the determined fishing mortality rate, the assumed natural mortality rate, and the estimated population abundance described above. The statistical fitting procedure used with the model will try to match the indices and the catch-at-age. The emphasis of each of these sources of information depends on the values of the relative weights assigned to each component by the user.

The minimization processes proceeds in phases, in which groups of parameters are estimated simultaneously, while the remaining parameters are maintained at their initially assigned values. Once the objective function is minimized for a particular phase, more parameters are treated as unknown and added to those being estimated. This process of estimation in phases continues until all parameters to be estimated contribute to the objective function and the best set of all parameters that minimize the objective function value is determined.

The software code and input files is available on request.

Model Options chosen:

The objective function is the sum of a number of negative log-likelihoods generally following two types of error distributions: the lognormal and multinomial and details are listed in Table 3. The specifications of input sampling levels (in terms of sample size or variance term) are provided in Table 4.

The separability in the fishing mortality was allowed to vary according to a shift in fleet composition. An F multiplier was estimated for the first year, and was allowed to change in time by estimating deviations to this parameter for each year. The fishing mortality at each age, year and fleet resulted from the product of the F multipliers by the selectivity parameter at each age and fleet. Three selectivity vectors were estimated, corresponding to blocks of fleets sharing a similar selectivity-at-age. This is a useful feature of the model that helps to avoid overparameterisation. By looking at the plots of catch-at-age by fleet, it was decided to have a common selectivity for the purse-seine fleets, together with the Portuguese bottom-trawl fleet, another one for the artisanal fleets and a third one just for the Spanish bottom-trawl fleet. One catchability parameter for the abundance index was kept fixed over time.

The model fitting is affected by statistical weights (lambdas or inverse variance functions) as part of the objective function. Specified input variance assumptions can influence the fitting of the model, by attributing a lower or higher importance to different data sources that contribute to the objective function. The variance assumption assumed the highest precision for landings data by year and fleet. The fishery proportions-at-age for the moment were assumed to have an "effective sample size" of 100 compared to the value of ten specified for the survey estimates of age composition. The survey index data was fit assuming that the coefficient of variation was 30%. These values are typical for this type of information and diagnostic plots of model fits confirmed that they are reasonable. As more data become available, these assumptions can be modified to more appropriate and potentially time-varying values.

D. Short-term projection

Model used: Apropos designed function, named *mff*, to perform deterministic forecast, only with catch constraints (allowing the introduction of variability in the assumed recruitment values). Having the initial numbers-at-age at the beginning of the year, the total F at age in the assessment year y-1 and the assumptions we want to make on the weight-at-age, the selectivity-at-age by fleet, the maturity ogive, the natural mortality rate and the recruitment. We can project forward the population given a level of catches for the intermediate year y and for the protection year y+1. It is also possible to add some variability to the recruitments, by including a standard deviation value.

The method starts projecting the population numbers-at-age from the last assessment year with the estimated the fishing mortality rates by fleet,

$$N_0 = rec \cdot e^{\varepsilon}, \quad \varepsilon \sim N(0,\sigma)$$
$$N_1 = N_0 \cdot e^{-(M_0+F_0)p}$$
$$N_a = N_{a-1} e^{-(M_{a-1}+F_{a-1})}, \quad a \text{ in } 2,\ldots,\text{A-1}$$
$$N_A = N_{A-1} e^{-(M_{A-1}+F_{A-1})} + N_A e^{-(M_A+F_A)}$$

where rec corresponds to the assumed recruitment level, N_a are the numbers-at-age a, M_a is the natural mortality-at-age a, F_a is the fishing mortality-at-age a, σ is the standard deviation of the recruitment and p is the proportion of the year from the recruitment time to the end of the year.

For the intermediate year in the short-term projections, the population numbers-at-age are calculated assuming catch constraints by fleet, using Pope's approximation forward,

$$\lambda = \frac{catch}{\sum_a S_a \cdot N_a \cdot W_a}, \quad proportiontothe \max imumthatcouldbecaptured$$
$$C_a = \sum_a S_a \cdot N_a \cdot \lambda$$
$$N_0 = rec \cdot e^{\varepsilon}, \quad \varepsilon \sim N(0,\sigma)$$
$$N_1 = \left(N_0 - C_0 \cdot e^{M_0 \cdot p/2}\right) e^{-M_0 \cdot p}$$
$$N_a = \left(N_{a-1} - C_{a-1} e^{M_{a-1}/2}\right) e^{-M_{a-1}}, \quad a \text{ in } 2,\ldots,\text{A-1}$$
$$N_A = \left(N_{A-1} - C_{A-1} e^{M_{A-1}/2}\right) e^{-M_{A-1}} + \left(N_A - C_A e^{M_A/2}\right) e^{-M_A}$$

where λ is the proportion to the maximum catch that could be captured, rec corresponds to the assumed recruitment, N_a are the numbers-at-age a, M_a is the natural mortality-at-age a, F_a is the fishing mortality-at-age, S_a is the selectivity-at-age, a and p is the proportion of the year from the recruitment time to the end of the year.

The source code is available on request.

Software used*:* R (www.r-project.org)

Initial stock size: the one estimated by the assessment model

Maturity: the same as in the previous year of the assessment

F and M before spawning: both of them are 0

Weight-at-age in the stock: the same as in the previous year of the assessment

Weight-at-age in the catch: assumed equal to the weight-at-age in the stock

Exploitation pattern: the one estimated in the assessment model

Intermediate year assumptions: the catches by fleet are assumed to be exactly the same as the ones in the previous year

Stock–recruitment model used: no stock–recruitment model is used, the recruitment is assumed to be stochastic in all the years (the assessment year, the intermediate and the projection year), around the geometric mean of the historical values with the same variability as the one observed in the series.

Procedures used for splitting projected catches:

E. Medium–term projections

No medium-term projection has been performed for this stock

Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

F. Long-term projections

No long-term projection has been performed for this stock.

Model used:

Software used*:*

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

G. Biological reference points

Reference points have not been defined for this stock.

H. Other issues

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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 = {1992, …., 2010}	i	
Age index: j = { 0,1,2, …, 11+}	j	
Mean weight in year t by age j	Wt,j	
Maximum age beyond which selectivity is constant	Maxage	Selectivity parameterization
Instantaneous Natural Mortality	Mj	Fixed M=0.8,0.5,0.3,0.2,0.1…0.1, for j=0,1,2…11
Proportion females mature at age j	pj	Definition of spawning biomass
Sample size for proportion in year i	T_i	Scales multinomial assumption about estimates of proportion at age
Survey catchability coefficient	q^s	Prior distribution = lognormal(μ_q^s , σ_q^2)
Stock-recruitment parameters	R_0 h σ_R^2	Unfished equilibrium recruitment, steepness, variance
Virginal biomass	ϕ	Spawning biomass per recruit when there is not fishing
Estimated parameters		
φ_i $R_0, h, \varepsilon_i, \mu^f, \mu^s, M, \eta_j^s, \eta_j^f, q^s$		

Note that the number of selectivity parameters estimated depends on the model configuration.

Table 6. Variables and equations describing implementation of the horse mackerel assessment model.

Eq	Description	Symbol/Constraints	Key Equation(s)
1)	Survey abundance index (s) by year (Δ^s represents the fraction of the year when the survey occurs)	I_i^s	$I_i^s = q^s \sum_{j=0}^{11} N_{ij} W_{ij} S_j^s e^{-\Delta^s Z_{ij}}$
2)	Catch biomass by year	C_i	$\hat{C}_{ij}^f = \sum_{j=0}^{11} N_{ij} W_{ij} \frac{F_{ij}^f}{Z_{ij}} (1 - e^{-Z_{ij}})$
3)	Proportion at age j, in year i	$P_{ij}, \sum_{j=0}^{11} P_{ij} = 1.0$	$p_{ij}^f = \frac{\hat{C}_{ij}^f}{\sum_j \hat{C}_{ij}^f}$
4)	Initial numbers at age	j = 0	$N_{1992,j} = e^{\mu_R + \varepsilon_{1992}}$
5)		0 < j < 10	$N_{1992,j} = e^{\mu_R + \varepsilon_{1993-j}} \prod_{j=1}^{j} e^{-M}$
6)		j = 11+	$N_{1992,11} = N_{1992,10} \left(1 - e^{-M}\right)^{-1}$
7)	Subsequent years (i >1992)	j = 0	$N_{i,2} = e^{\mu_R + \varepsilon_i}$
8)		0 < j < 10	
9)		j = 11+	$N_{i,11} = N_{i-1,10} e^{-Z_{t-1,10}} + N_{i-1,11} e^{-Z_{i-1,11}}$
10)	Year effect and individuals at age 2 and i = 1981, …, 2010	$\varepsilon_i, \sum_{i=1981}^{2010} \varepsilon_i = 0$	$N_{i,0} = e^{\mu_R + \varepsilon_i}$
11)	Index catchability Mean effect Age effect	μ^s, μ^f $\eta_{ij}, \sum_{j=0}^{11} \eta_{ij} = 0$	$q_i^s = e^{\mu^s}$ $s_j^s = e^{\eta_j^s}$ $j \le$ maxage $s_j^s = e^{\eta_{\text{maxage}}^s}$ $j >$ maxage
12)	Instantaneous fishing mortality		$F_{ij}^f = e^{\mu^f + \eta_j^f + \varphi_i}$
13)	Mean fishing effect	μ^f	
14)	Annual effect of fishing mortality in year i	$\varphi_i, \sum_{i=1992}^{2010} \varphi_i = 0$	
15)	age effect of fishing (regularized) In year time variation allowed In years where selectivity is constant over time	$\eta_{ij}^f, \sum_{j=2}^{12^+} \eta_{ij} = 0$ $\eta_{i,j}^f = \eta_{i-1,j}^f$	$s_{ij}^f = e^{\eta_j^f}$, $j \le$ maxage $s_{ij}^f = e^{\eta_{\text{maxage}}^f}$ $j >$ maxage $i \ne$ change year
16)	Natural Mortality vector	Mj	0.8 0.5 0.3 0.2,0.1…0.1 for ages 0 - 11
17)	Total mortality		$Z_{ij} = \sum_f F_{ij}^f + M$

Eq	Description	Symbol/Constraints	Key Equation(s)
17)	Spawning biomass (note spawning taken to occur at mid of January)	Bi	$B_i = \sum_{j=0}^{11} N_{ij} e^{-\frac{0.5}{12} Z_{ij}} W_{ij} p_j$
18)	Recruitments (Beverton-Holt form) at age 0.	$\tilde{R}_i$	$\tilde{R}_i = \frac{\alpha B_i}{\beta + B_i}$, $\alpha = \frac{4hR_0}{5h-1}$ and $\beta = \frac{B_0(1-h)}{5h-1}$ where $B_0 = R_0\varphi$ $\varphi = \sum_{j=2}^{12} e^{-M(j-1)} W_j p_j + \frac{e^{-12M} W_{12} p_{12}}{1-e^{-M}}$ h=0.8

Table 7. Specification of objective function that is minimized (i.e., the penalized negative of the log-likelihood).

	Likelihood /penalty component		Description / notes
44)	Catch biomass likelihood	$L_1 = \sum_f \lambda_4^f \sum_{i=1992}^{2010} \ln\left(\frac{C_i^f}{\hat{C}_i^f}\right)^2$	Fit to catch biomass in each year
19)	Abundance indices	$L_2 = \sum_s \lambda_1^s \sum_i \ln\left(\frac{I_i^s}{\hat{I}_i^s}\right)^2$	Survey abundances
20)	Proportion at age likelihood	$L_k = \sum_{k,i,j} \tau_i^k P_{ij}^k \ln\left(\hat{P}_{ij}^k\right) \quad k = 3,4$	k=3 for the fishery, k=4 for the survey
21)	Penalty on smoothness for selectivities	$L_k = \sum_k \lambda_k \sum_{j=0}^{11} \left(\eta_{j+2}^l + \eta_j^l - 2\eta_{j+1}^l\right)^2 \; k = 6,9$	Smoothness (second differencing), Note: k=6 for the fishery, k=9 for the survey
22)	Penalty on recruitment regularity	$L_{11} = \lambda_{11} \sum_{i=1981}^{2010} \varepsilon_i^2$	Influences estimates where data are lacking (e.g., if no signal of recruitment strength is available, then the recruitment estimate will converge to median value).
23)	Recruitment curve penalty	$L_6 = \lambda_6 \sum_{i=1992}^{2010} \ln\left(\frac{N_{i,0}}{\tilde{R}_i}\right)^2$	Conditioning on stock-recruitment curve over period 1992–2007 (but reduced to have negligible effect on estimation).
24)	Overall objective function to be minimized	$\dot{L} = \sum_k L_k$	

Table 8. Input variance □ or sample size (τ □) assumptions and corresponding penalties (□) used on log-likelihood functions in the base model.

L	Abundance index	□	τ	□L
1	Landings	0.05	-	200
2	Combined index	0.3	-	5.556
3	Fishery age composition	-	100	-
4	Survey age composition	-	10	-
5	Time-change in fishery selectivities	0.8		0.78
6	Fishery age-specific penalties	1.0	-	0.5
7	Fishery descending selectivity-with-age penalty	10	-	0.1
8	Time-change in survey selectivities	0.8		0.78
9	Survey age-specific penalties	1.0	-	0.5
10	Survey descending selectivity-with-age penalty	10	-	0.1
11	Recruitment regularity	10	-	0.1
12	S-Recruitment curve fit (for period 1992–2007, scale only)	1.9	-	0.14

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1992–2008	0–11+	Si
Canum	Catch-at-age in numbers	1992–2008	0–11+	Si
Weca	Weight-at-age in the commercial catch	1992–2008	0–11+	Si
West	Weight-at-age of the spawning stock at spawning time.	1992–2008	0–11+	Si
Mprop	Proportion of natural mortality before spawning	1992–2008	0–11+	Si
Fprop	Proportion of fishing mortality before spawning	1992–2008	0–11+	No
Matprop	Proportion mature-at-age	1992–2008	0–11+	No
Natmor	Natural mortality	1992–2008	0–11+	No
	Spanish-Portuguese bottom-trawl survey	1992–2009	0–11+	

Annex 6 Benchmark preparation

X.1 Latest benchmark results

X.2 Planning future benchmarks

Stock	Ass status	Latest benchmark	Benchmark agreed	Planning in future	Further planning	Comments
example	*Update OK,* *Update deviating from bench-mark*	*Year*	*If Agreed by ACOM* *Update X.3!!*	*Proposal to ACOM* *Fill in X.3!!*	*Future proposals for internal use*	*Data deteriorating, new method available, etc*
ane-pore						
ane-bisc	Update OK New datasets and methods available for evaluation	2009		2013	A preparatory meeting might be needed. This would take place once the revision of the DEPM estimates is finalised by WGACEGG.	New development available on the assessment model. Incorporation of data from the Juvena survey into the advice needs to be evaluated. DEPM data are being revised by WGACEGG which might change substantially the biomass estimates. There are evidences that the current mortality rates might not be appropriate. All the above changes will require the revision of the biological reference points.

sar-soth			2012 agreed			
hom-soth						
jaa-10						

X.3 Issue lists for stocks with upcoming benchmarks [Mind: describe in short *both the problem and the proposed solution*. It helps if it is clear the solution can be brought about at the proposed time]

Issue list template:

Stock	Ane-bisc	
Benchmark	Year:	Planned by EG /Agreed by ACOM
Stock coordinator	Name:	Email:
Stock assessor	Name:	Email:
Data contact	Name:	Email:

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark
Tuning series				Who, what type of expertise
Discards				
Biological Parameters				
Ecosystem/mixed fisheries considerations				
Assessment method				
Forecast method				
Biological Reference Points				

Annex 7 – Technical Minutes

Working Group on Anchovy and Sardine, 24-28 June 2011, Vigo, Spain

Reviewers:	Morten Vinther	Denmark (chair)
	Margit Eero	Denmark
	Sascha Fässler	Netherlands
Chair WG:	Andres Uriarte	Spain
Secretariat:	Barbara Schoute	ICES

Anchovy in Division IXa

The assessment is qualitative, based on trends from surveys.

Assessment type: update

1) **Assessment**: trends
2) **Forecast**: not presented
3) **Assessment model**: qualitative analyses of surveys and commercial CPUE
4) **Consistency**: Consistent with previous assessment
5) **Stock status**: Stock status in Subdivision IXa South is uncertain due to conflicting signals from surveys. Zero biomass in the area in 2011 was estimated from an acoustic survey, whereas egg abundances in the same area were among the highest in record. In the area IXa North, Central North and Central-South, an anchovy outburst was registered in 2011, with the highest biomass recorded in this area since 1995.
6) **Man. Plan.**: no EU management plan exists for Division IXa.

General comments

The report is generally well structured and presents the available information in an adequate manner. However, the sections describing surveys which have not been updated since previous report could be shortened, for not repeating in detail the information that was provided in previous years (and could be found in stock annex). This could help to keep the report concise and focused on new information which has become available for this year’s assessment.

Technical comments

i) The report is describing several surveys which are not always consistently referred to, which makes it difficult to follow. The text is mainly using acronyms (such as PELACUS, PELAGO etc), while the figures and tables often refer to these surveys by a description (e.g. spring Portuguese Acoustic survey). For the sake of clarity, survey names should always be kept consistent throughout the text, figures and tables.

ii) Figure 4.5.2.2., it is unclear where the estimate 28558 for 2011 is coming from? Which survey is this, and where is it described in the text? The table 4.3.2.3 provides only one available estimate (27050 t) for 2011, from PELAGO series (which is also included in Figure 4.5.2.2). Is the other survey shown in Figure 4.5.2.2 PELACUS 0411, which is described in the text as an additional one available for spring 2011? In this case the biomass does not match as the estimate given in the text for PELACUS 0411 is 1.5 thousand tons, whereas Figure 4.5.2.2 gives 28.5 thousand tons?

iii) Table 4.2.1.1 and Figure 4.2.1.1 , the total number of vessels in 2010 is different (84 and 86, respectively

Conclusions

Current sock status is uncertain due to contradicting survey information for spring 2011. Advice has traditionally been restricted to IXa South as an area with persistent population and fishery for anchovy. The acoustic survey in spring 2011 estimated zero biomass in IXa South, whereas the biomass in northern areas (IXa-N, C-N, C-S) was estimated to be the highest in record. The zero biomass acoustic estimate for spring 2011 in IXa South is contradictory to egg abundances in the same area, which were among the highest in the available time-series. The WG, justifiably, questions the quality of the 2011 acoustic survey. New information can be obtained from survey to be conducted in late July 2011, and TAC could be revised accordingly.

In present situation with clearly distinct stock developments in IXa South and in areas IX a-N,C-N, C-S, the WG questions the appropriateness of current definition of stock units and unified management in the Division IXa. These doubts are supported by data.

Anchovy in Subarea VIII (Bay of Biscay)

The update assessment for the Bay of Biscay anchovy is based on a two-stage biomass-based model (BBM), described in Stock Annex.

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Bayesian two-stage biomass-based model, tuning by two series of surveys, i.e. Daily Egg Production method (DEPM) and spring acoustic survey
5) **Consistency**: Consistent with previous assessment.
6) **Stock status**: The median SSB has increased successively in the last two years. Median SSB in 2011 estimated at 98 450 t, which is, with 100% probability, above B_{lim}. Recruitment in 2011 is the third highest in the historical series.
7) **Man. Plan.**: A draft plan proposed by the EC in 2009. The plan is based on a constant harvest rate (30%) , and sets a TAC as a percentage of the point estimate of the SSB at the start of TAC period (1st July) with an upper bound on the TAC (33000 t), and a minimum TAC (7000 t) applicable at SSB estimates between 24000-33000 t. The plan is not formally adopted or evaluated. However, the plan was used for establishing TAC for 1 July 2010-30th June 2011.

General comments

The report is well structured and easy to follow. The material and analyses are generally well described, and satisfactory for concluding on the status of the stock.

Concerning the TAC for the period 1 July 2011-30 June 2012 according to draft management plan (29 700 t), it is unclear from the report which SSB estimate is used to calculate this. It is apparently not exactly the SSB estimate provided for 2011 (98450 t), as 30 % of this would give a TAC of 29535 t. If the stock is projected forward to 1 July for TAC calculation, the corresponding SSB value should also be given in the report.

Technical comments

iv) Tables 3.2.2.1 and 3.2.2.2, the Spanish catch for 2011 is different in the two tables.

v) Total international catch in 2010 in Table 3.2.2.3 (7399 t) does not match with the 2010 catch number in tables 3.2.2.1 and 3.2.2.2 (10 317 t)

vi) Figure 3.3.2.2 is lacking sufficient information in figure caption. What are the pie charts representing?

vii) Figure 3.3.2.6 y-axis is lacking the label/units; is it numbers, biomass or something else?

viii) Throughout the text the terms “abundance” and “biomass” seem to be used as equivalents. It would be clearer if the stock measure in weight units (tons) would always be called biomass, as abundance can also be understood as numbers of fish.

ix) Figure 3.5.1.3. It would be clearer to keep the catch value for 2011 second period blank (as data not available yet) instead of showing it as zero catch.

In Advice sheet:

i) Landings shown for 2011 in Figure 7.4.8.1, in 7.4.8.4., and in Table 7.4.8.2 are all different.

ii) In Figure 7.4.8.1 the Recruitment unit should be thousand tons

Conclusions

The information from DEPM, spring acoustic survey and autumn acoustic survey for 2011 is consistent, both in terms of biomass and recruitment. All survey information indicates substantially higher stock size in 2011 compared to previous years. In light of recent strong recruitment, after a series of weak year-classes, the assumption of undetermined recruitment in short-term forecast (where all past recruitments are equally likely) seems reasonable.

Natural mortality is currently kept constant for all ages and years. With changing stock size, natural mortality could also be expected to change. This should be investigated for next Benchmark, as also pointed out by the WG.

Horse mackerel (*Trachurus picturatus*) in the waters of the Azores (report section 8))

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type: No Advice**
2) **Assessment**: not presented
3) **Forecast**: not presented
4) **Assessment model**: n.a.
5) **Consistency**: data was collated for the first time ever
6) **Stock status**: the stock is exploited mostly by the artisanal fishing fleet. Landings in the past 5-10 years average 1200 tonnes and are based on market demand. Some catches are used by the longline fleet as bait. The same is true for the tuna bait boat fleet that is monitored by the observer program. Catch data is available since 1980. Mean lengths and weights of fish caught by metier have been stable throughout the time series.
7) **Man. Plan.**: no management plan exists for this stock.

General comments

The report is well written and structured containing all the relevant parts.

Technical comments

i. Place table captions above the tables throughout the section.

Conclusions

Currently, cpue is the only available index. It shows an increasing trend over the past 10 years. At the same time, due to reduced consumer demand, catches have decreased since the 1980s from about 3000 tons and stabilized at a level of 1200 tons per year.

Annex 2

Checklist for review process

General aspects

- Has the WG answered those TORs relevant to providing advice?
- Is the assessment according to the stock annex description?
- Is general ecosystem information provided and is it used in the individual stock sections.
- Has the group carried out evaluations of management plans?
- Has the group collected and analyzed mixed fisheries data?

For stocks where management plans or recovery plans have been agreed

- Has the management plan been evaluated in earlier reports?
- If the management plans has been evaluated during this WG:
  - Is the evaluation credible and understandable
  - Are the basic assumptions, the data and the methods (software) appropriate and available?

For update assessments

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

For overview sections

- Are the main conclusions in accordance with the WG report?
- Verify that tables and figures been updated and are correct (except for the advice table)

Horse mackerel (*Trachurus trachurus*) in Division IXa (report section 7)

1) **Assessment type: update**
2) **Assessment**: trends
3) **Forecast**: presented
4) **Assessment model**: AMISH
5) **Consistency**: consistent with previous assessment.
6) **Stock status**: SSB and F were similar as last year with a slightly higher recruitment. The assessment suggests no signs of depletion and sustainable harvest levels. Although, reference levels have never been proposed. Catches and stock dynamics have been stable throughout the assessment time series, however, a well-defined SSB-R relationship is lacking.
7) **Man. Plan.**: no management plan exists for this stock.

General comments

The report reads well and has a good structure. The assessment was done according to the stock annex and ToR's have been met. The bottom trawl survey data is notoriously noisy, especially at young ages, making the assessment uncertain. Consequently, it made sense to exclude age 0 from the index. This has been pointed out and it is mentioned that DEPM methods are under revision and may be also used in the future. There is no acoustic survey index. A long term average was used for the maturity ogive to account for inter-annual variability. If there is strong evidence for a trend, a shorter averaging period will be chosen (c.f. Sardine last year). However, there is no figure about temporal maturity at age changes given.

Higher weighing is put on the landings time series which is the main source of information for the assessment. The retrospective analysis suggests an underestimation of SSB and recruitment, and an overestimation of F in the previous assessment. For the forecast, the geometric mean of all estimated recruitments up to the last year was used.

Technical comments

i. Put table captions above tables.
ii. Obsolete "and" in table caption 7.2.2.3.
iii. In Figure 7.2.5.1 it is not clear what line corresponds to what age. A legend within the Figure would help.
iv. Text for section 7.3.2. (bottom trawl survey) is absent.
v. From Figure 7.5.1.1. it is not clear what the "four selectivity vectors of parameters" described in the text (section 7.5.1) are.
vi. Year 2013 is missing in Table 7.6.2.

Conclusions

The assessment has been performed correctly according to the stock annex produced at the latest benchmark. There are issues with the noisy trawl survey index, increasing the uncertainty in the assessment. Given the stable exploitation levels and assessment results it makes sense to recommend the same catch levels of previous years.

It will be useful to look at the DEPM as an additional tuning index once the methods have been revised by WGMEGS.

Sardine in Division VIIIc and IXa (Sar-Soth) (report section 6))

1) **Assessment type: update**
2) **Assessment**: presented
3) **Forecast**: presented
4) **Assessment model**: AMCI
5) **Consistency**: Trends from this year are comparable to the previous year. Decrease in SSB and increase in F since 2007 is consistent. In contrast to last year, the recruitment used for the short term prediction is based on the geometric mean of period 2005-2010. Unlike assumed in last year's report, the declining trend of the recruitment time series has apparently not stopped. Therefore, the WG assumes a low recruitment, corresponding to the geometric mean of the period 2005 – 2010, for 2011 – 2012. The 2010 year class was used in the prediction as it was supported by data from the 2011 acoustic survey. Notable is the relatively large number of immature fish at age 1 observed in the acoustic surveys.
6) **Stock status**: SSB continues to decline since 2006 and is now 62% below the mean over the period 1978-2009. Recruitment in 2010 appears to be poor according to the latest survey (76% below historical mean). Fishing mortality in 2010 was 0.43, being higher than last year (0.25) and double the historical mean, reflecting stable catches but declining stock abundance. No reference points defined for this stock.
7) **Man. Plan.**: no management plan exists for this stock.

General comments

The report is well structured and generally clear to understand. ToRs have been met as assessment was updated with new abundance and catch indices. Survey updates are described. Catch and survey residuals are comparable to last year. It made sense to update the approach taken with the recruitment used for the short term predictions, since the recruitment trend is still declining.

Technical comments

i. Table 6.2.4.1.d should be for the fourth quarter, but the caption sais "third".

ii. There should be a consistent use of either survey acronyms (e.g. "PELAGO") or survey description (e.g. "spring Portuguese Acoustic survey") and not a mix of both, throughout the report. At the moment there are acronyms used in the text and survey description in the Figure and Table captions. This leads to confusion.

iii. There is no content in "6.4.1 Mean length and mean weight at age in the stock"

iv. Table 6.5.1.1.f is very hard to read. Maybe consider presentation over more than just one page.

v. There is a contradiction between the sentence in section 6.5.1. ("Results from this year's assessment show some differences when compared to those produced by the last two assessments, both SSB and R are scaled downwards while F is scaled upwards (see Section 6.5.2).”), and the one in section 6.5.2. (“The results from this year’s assessment are comparable to those of last year’s assessment, in terms of trends (Figure 6.5.1.6). In particular, the decrease in SSB and increase in F since 2007 is consistent in both assessments.”).

Conclusions

The assessment results are consistent with the increasing trend in F and decreasing trend in SSB observed over the past few years since 2007. Inclusion of the DEPM survey results in 2008 had a big influence, suggesting a decrease in F and increase in SSB, which was contradictory to the acoustic survey.

New DEPM data will be available next year. Possible discrepancies between the DEPM and acoustic survey should be looked into during the next benchmark, since it has been a concern since 2002. This is stated in the report, however, preliminary results suggest that inclusion of the 2011 DEPM survey will not lead to changes in the trend.

It is correctly mentioned that the large variability in maturity ogives calculated from survey samples between years is a matter of concern, and should be looked into during the next benchmark. The group was looking into various reference points but rightly concluded that this will be more meaningful after the next benchmark in February 2012. Various relevant issues to be discussed at the benchmark next year were suggested by the WG.