ICES WGANSA REPORT 2009

ICES ADVISORY COMMITTEE

ICES CM 2009/ACOM:13

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

15 -20 June 2009

ICES Headquarters, Copenhagen

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

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

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

Recommended format for purposes of citation:

ICES. 2009. Report of the Working Group on Anchovy and Sardine (WGANSA), 15 -20 June 2009, ICES Headquarters, Copenhagen. Diane Lindemann. 354 pp.

Contents

Executive summary

The Working Group on Anchovy and Sardine (WGANSA) met 15-20 June 2009. 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, and for Sardine in Divisions VIIIc and IXa. All assessments were updates of previous assessments.

In addition, the group considered the possibility of making future assessments for the Sardine in Divisions VIIIa,b and possibly parts of Subarea VII.

The Anchovy in Subarea VIII is still recruiting poorly. Despite an increasing contribution to the SSB by ages 2 and 3 which likely is related to the closure of the fishery, no good recruitment occurred in 2009. The stock is close to its historical low and the fishery is closed. Reasons for the failure are not known, despite extensive investigations.

The information on the Anchovy in Division IXa, where the Gulf of Cadiz is the main fishing area, is limited, and no analytic assessment can be done. The available catch and survey data give no indications of major changes in the state of the stock. The catches were reduced last year due to redirection of effort.

The Iberian Sardine has had a series of poor year classes since 2005. The stock is still near the long term average, but is expected to decline unless a new strong year class appears. The stock probably is lightly exploited, but maintaining catches at the current level would imply increasing fishing mortalities.

Sardine also appears to the North of the assessment area, in the Bay of Biscay, Celtic sea, and Western Channel, and the southern North sea. There is no request for advise for sardine in that area at present, but the WG has collected relevant information from the Bay of Biscay (catch numbers at age and acoustic survey estimates) over some years. An assessment tool (TASACS) was used this year to analyze the data and to clarify shortcomings in the available information. The catch data series is still very short, and there are some strong year effects in the survey, probably due to inadequate coverage in time and space in some years. An analytic assessment as basis for advice should be possible within a few years if data continue to be collected.

Extending the survey coverage into the Celtic Sea and English Channel and ageing of catches taken off those waters is recommended.

.

1 Introduction

1.1 Terms of reference

The WGANSA met at ICES headquarters 15 20 June 2009 to address the terms of reference in Council decision 2008/2/ACOM13:

*The **Working Group on Anchovy and Sardine** [WGANSA] (Chair: Dankert Skagen, Norway) will meet at ICES Headquarters, 15-20 June 2009 to:*

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

b) *compile, investigate and report all the information on recent changes in the pelagic community in the Bay of Biscay to assess the possibility of a regime shift.*

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. This will be coordinated as indicated in the table below. ToR b) will need intersectional work prior to the WGANC meeting.

WGANSA will report by 20 June 2009 for the attention of ACOM.

ToR a) includes assessments for Anchovy in the Bay of Biscay, Anchovy in Division IXa and Sardine in Divisions VIIIc and IX a.

In correspondences with ACOM, and in consultation with the European Commission, it was agreed that WGANSA should deliver the assessment and prediction results for Sardine and Bay of Biscay the day before the end of the meeting, to enable a rapid review and advise drafting process.

For some members, this led to the misunderstanding that the meeting would end one day earlier. Hence, the WG in practise only was assembled for 5 days.

1.2 Organizing the report

Each of the stocks is handled in a separate section. One section (Section 4) describes recent developments towards a basis for advice for Sardine North of the Iberian Peninsula.

This year, the report is split in a main part, describing recent developments, assessments, predictions and management considerations, and stock annexes describing material of more premanenet nature, including general biological characteristics, fleet descriptions, standard procedures for producing input data for assessments (catch and survey data) and the methods for analytic assessment and prediction.

Survey reports are presented to the WG as Working Documents. These Working Documents are included in the report as annexes. They are in principle the responsibility of the authors, but have been carefully scrutinized and approved by the WG and constitute a major contribution to the results.

1.3 Comments to the new WG structure and working schedule

The time for the meeting was constrained by the timing of the surveys on one hand and the need for managers to implement the advice immediately on the other. This year, the Sardine was included in the stocks covered by the WG, but the timing issues were dominated by the concerns for the anchovy. It was possible to address the terms of reference at this meeting, but only because no major obstacles appeared. Any difficulties with data or model assumptions, the discovery of significant errors in the input data or even major alterations of the state of the stock that would require a different advice, would have precluded finalizing the task.

It is not possible to start the meeting closer to the finalizing of the anchovy surveys. Rather, the WG considers that the time interval between surveys (both egg surveys and acoustic surveys) and the meeting should be longer. This is both because it is impossible to avoid errors when the work is rushed with very limited opportunities for control, and because of the workload on those responsible for the survey results. Last year and this year it was possible to provide preliminary estimates thanks to an exceptional effort by those involved, which is unacceptable as a routine procedure. This exceptional effort also requires that the right people are available at the right time. Any change in key personnel will necessarily delay the process. The results that are presented now are preliminary, because of the poor opportunities to control essential data.

To conduct the surveys earlier is not an option, because the surveys are on spawning fish. To conduct the egg survey earlier would require that the anchovy spawns earlier. Also the acoustic survey would become incompatible with previous surveys if it were to be moved in time. This would disrupt the survey time series and destroy an assessment procedure that now is satisfactory for this difficult stock. For the sardine, the opportunity to prepare the data and conduct trial assessments prior to the meeting is better. However, also here the time schedule is tight due to the timing of the spring acoustic surveys, and postponing the meeting with two weeks would be very helpful, although not as critical as for the anchovy.

The WGANSA considers that realistically, two extra weeks are needed to prepare survey data in a satisfactory way, both with respect to scientific quality and human workload. This implies having the WGANSA towards the end of June - early July, i.e. in week 26. That will also allow for trial assessments on preliminary data prior to the WG meeting, thus reducing the risk that no advice can be provided due to unexpected assessment problems. There is a clear trade-off between the timing of the advice and the risk that no advice can be provided, which will happen once unforeseen problems appear. The WGANSA recognizes the need for an early advice, but the current time schedule is not acceptable as a routine procedure.

The time allocated to the present meeting was 6 days, but under the condition that the assessment, predictions and draft advice were delivered early on the day before the end of the meeting. These are the core tasks for the WG, which require careful consideration. Delivering the main product at that stage in the meeting was not satisfactory. The WGANSA still considers that 6 meeting days are necessary to do the work properly.

The merging of sardine and anchovy was successful, with good interactions between the experts on the two species, and a quite broad range of expertise. Hence, the WGANSA recommends that it continues to cover both sardine and anchovy .

1.4 Intercatch.

The WG made some progress in implementing Intercatch as its standard tool for reporting and assembling catch data. However, due to the tight time schedule, importing the catch data into Intercatch was not the highest priority. For the Sardine, a successful attempt was made, with some assistance from the ICES staff. For anchovy in the Bay of Biscay the fishery is closed so there are no catches to report. For Anchovy in Division IXa, the intention is to implement Intercatch intersessionally, and use it for next year's WG.

1.5 Sardine and anchovy outside the assessment areas.

Both species exist outside the areas for which assessments are requested and made. Some of these 'other' stocks are handled in some depth in the report. For other areas there may be reasons to collect information about distribution and biology for a number of reasons:

- Sometimes, the stock identity is unclear, and such information can help clarifying such questions.
- Environmental changes, including climate changes may lead to alterations in the distribution of species. For example, it is sometimes suggested that there will be a northwards expansion of sardine and anchovy due to global warming. Whether there is a real change in distribution cannot be concluded without data.

A Working Document by Gröhsler on the occurrence of anchovy in acoustic surveys since 1991 in the Western Baltic was presented to the WG this year. It demonstrates both that anchovy is found in that area, and that the amounts found is increasing. Such contributions are most welcome to build up an understanding of the distribution dynamics of these species. Similar studies from other areas are encouraged. Likewise, historical records of sardine and anchovy fisheries outside the core areas would also be helpful, to decide whether changes seen in recent years are new phenomena, or if similar things have happened before.

Anchovy is found in small amounts in other areas, typically associated with river outlets. In some years, the amount is sufficient to support a fishery.

There are large amounts of sardine in Divisions VIIIa and b, and in Subarea VII. There are also regular fisheries for sardine in these areas. In this year's report the sardine in these areas is considered in Section 4.

There is anecdotal information about both anchovy and sardine to the West of the British Isles, in the North Sea in addition to the Baltic. Systematic studies of available information, as was done for anchovy in the Baltic, are strongly encouraged.

2 Anchovy in the Bay of Biscay (Subarea VIII)

2.1 ACFM advise for 2008 and 2009 and STECF recommendations

In July 2005 the fishery was closed due to the low levels of biomass of the anchovy population and the failure of the fishery. This closure has been prolonged stepwise, and is at present valid until July 2009.

In June 2008 ICES advice stated that "Based on the most recent estimates of SSB, ICES classifies the stock as being at risk of reduced reproductive capacity. SSB in 2008 is estimated to have a 23% probability of being below Blim. Low recruitment since 2002 and almost complete recruitment failure of the 2004 year class are the primary causes of the low stock size". According to that state of the stock, ICES advice to the EC was: "ICES recommends that the fishery should remain closed until the stock condition has improved. The stock condition can be reevaluated when estimates of the 2009 SSB and 2008 year class are available based on the spring 2009 acoustic and DEPM surveys. This implies a closure of the fishery until at least July 2009".

According to that advice the EC did not open the fishery in July 2008.

Subsequently in December 2008, the EU Council decided to continue the fishery closure and established a zero TAC for the Bay of Biscay anchovy in 2009, but allowing for a revision according to scientific advice: "It is necessary, following the advice from the International Council for the Exploration of the Sea (ICES), to maintain the application of a system to manage the catch limits of anchovy in ICES zone VIII. The Commission should fix the catch limits for the stock of anchovy in ICES zone VIII in the light of scientific information collected during the first half of 2009 and of discussions taking place in the context of a multiannual plan for anchovy".

The EC has launched a process for the development of a multiannual management plan for anchovy, which after some delay it is expected to be proposed during 2009. To that purpose, during the first half of 2008 several meetings to deal with a Long Term Management Plan (LTMP) for the anchovy fishery were convened by STECF (see section 2.7). A common meeting between EC and Spanish and French representatives from the administrations and the fishermen (including southern RAC) was held in March 2009 in Santoña (Spain), where the idea of the LTMP was also supported.

2.2 The fishery in 2008 and 2009

2.2.1 Fishing fleets

There was no commercial fishery for anchovy in the Bay of Biscay in 2008 and the first half of 2009, due to the closure of the fishery.

Two fleets used to operate on anchovy in the Bay of Biscay: Spanish purse seines (operating mainly during the spring) and the French fleet constituted of purse seiners (operating mainly in Spring and 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.

2.2.2 Catches

There were no commercial catches for anchovy in the Bay of Biscay in 2008 and the first half of 2009, due to the closure of the fishery. Historical catches by countries since 1960 are presented in Table 2.2.2.1, and Figure 2.2.2.1 show the historical evolution of the fishery since 1940.

2.2.3 Catch numbers at age

No catches at age in recent years due to fishery closures.

Table 2.2.3.1 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. See the stock annex for methodological issues.

2.2.4 Weights and lengths at age in the catch

The series of mean weight at age in the fishery by half year, from 1987 to 2006, is shown in Table 2.2.4.1. See the stock annex for methodological issues.

2.3 Biological data

2.3.1 Maturity at age

As reported in previous years reports, anchovies are fully mature as soon as they reach 1 year old, in the spring the year after they hatched. See stock annex for details.

2.3.2 Natural mortality and weight at age in the stock

Natural mortality is fixed at 1.2, see stock annex 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).

2.4 Fishery independent data

2.4.1 DEPM survey 2009

All the methodology for the survey and the estimates performance are described in the stock annex.

2.4.1.1 Description of survey

The survey took place from 5th to the 25th of May following the procedures described in the stock annex. Specifications are given in table 2.4.1.1.1

2.4.1.2 Egg production estimate

The anchovy eggs were concentrated in three principal areas: the area off the Cantabrian coast where the distribution was wider than last year, the area on the French continental shelf between Cap Breton and Cap Ferret and the area of influence of the Gironde river between 45º22'N and 45º52'N mostly in the area between coast and the isoline of 80m depth. (Fig. 2.4.1.2.1)

The estimates of daily egg production, daily egg mortality rates and total egg production are given in Table 2.4.1.2.1 and the mortality curve model used is shown in Figure 2.4.1.2.2. Total egg production in 2009 was on the same level as last year.

2.4.1.3 Adult sampling and adult parameters

The fishing hauls from the adult sampling are summarized in Santos WD (Annex III).

From the 38 pelagic trawl hauls 34 had anchovy but just 31 were selected for the analysis due to the few anchovy encountered in the other three samples. Figures showing the positive hauls for anchovy and the capture are in Santos WD (Annex III). The spatial distribution of the samples and their species composition is showed in figure 2.4.1.3.1, the adults mean weight and adults mean size are in figures 2.4.1.3.2 and 2.4.1.3.3. Figure 2.4.1.3.4 shows the age composition by haul.

Daily Fecundity (DF) was obtained from a linear regression model between DF and mean sea surface temperature (SST) of the survey BIOMAN09. The 2009 SST obtained was 15.25ºC (Fig.2.4.1.3.5)

DF = -56.71+7.67 *SST; $R^2 = 0.36$; p-value = 0.005

DF = 60.69 egg/g ; CV = 19%

2.4.1.4 Preliminary Spawning Stock Biomass estimate

In 2009 the preliminary SSB estimated was 27,994 t with a CV of 23%, similar to the last year final estimate (25,337 t; CV 26%) (Tab. 2.4.1.4.1) (Fig. 2.4.1.4.1) (Tab.2.4.1.4.2) (Tab.2.4.1.4.3).

To estimate the numbers at age 4 strata were defined. (Fig.2.4.1.4.2)

Approximately 59% of the anchovy in numbers were individuals of age 1 while the contribution in mass of those was only 37% and the contribution in mass of anchovies of age 2+ was 63%. This indicates that the 2008 year class is poor, in line with recent year classes. The population at age estimate indicates that the closure of the fishery had a positive effect in sustaining the recent levels of biomass, because of the high percentage of spawning fish being survivors from past years (age 2+). (Tab. 2.4.1.4.4) (Fig.2.4.1.4.3).

2.4.2 Acoustic survey 2009

2.4.2.1 Description of survey

The 2009 acoustic survey PELGAS09 was carried out in the Bay of Biscay from April 26th to June 5th 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 & al. - WD 2009 .

Details of the survey are presented in table 2.4.2.1.

A consort survey was organized as in 2008 with French pair trawlers during the 21 first days and a purse seiners during 3 days . With this approach, in the continuity of last year 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 that 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.

Acoustic data were collected by Thalassa along 6421 nautical miles, upon which 1873 nautical miles (daylight surveyed selected miles during the global coverage) were used for biomass estimate (Figure 2.4.2.1). A total of 102 hauls were carried out during the assessment coverage including 47 hauls by Thalassa and 55 hauls by commercial vessels (figure 2.4.2.2).

Eggs were counted all along the transects by CUFES and sorted onboard. Mammals and birds were identified and counted when weather conditions permitted (sea surface sometimes rough an fog).

2.4.2.2 Distribution (anchovy and others)

Two principal anchovy concentrations (Figures 2.4.2.2. ans 2.4.2.3.) were observed:

- Offshore on the southern platform, very big anchovy was present between 90m and 110m depth but often mixed with sardine or horse mackerel. Echo-traces were most of the time traditionally vertically distributed, horse mackerel closed to the bottom and anchovy as soft and small schools 15 to 25 meters above. In this area, this year, even if sardine was predominant in the surface and mid-water layers, anchovy was also well present as small schools close to the surface.
- Along the coast from Arcachon (44° 50 N) to the Loire estuary (47°), mostly mixed with sardine and sometimes with horse mackerel or with sprat in the Northern part, with various length distribution and more offshore in front of the Gironde river plume (45°10N), mostly mixed with sardine and sometimes with horse mackerel.

Weather conditions were globally acceptable, except in the north of the surveyed area (outside of the anchovy area) where commercial vessels were obliged to leave.

2.4.2.3 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 minimize the variability due to the variable mixing of species (Figure 2.4.2.1.). 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 (Table 2.4.2.2.).

The anchovy biomass index was estimated to 34 855 t with a coefficient of variation of 11.2% (the method is detailed in Petitgas *et al*., 2003) meaning that the anchovy biomass index according to acoustic data and pelagic hauls should be between 27 047t and 42 662t. Anchovy distribution is shown in Figure 2.4.2.3 and the time series of acoustic biomass estimates is in table 2.4.2.4

The anchovy biomass estimate in tons and in number was processed for each area at age group (table 2.4.2.2.), using length distributions at each closest haul and global age/length key. Length and age distributions of anchovy are shown in Figures 2.4.2.4. and 2.4.2.5.

Two distinctive strata can be distinguished, the south offshore area with very big anchovies both at the bottom and at the surface and the Gironde and coastal area where smaller fish were observed (see Figure 2.4.2.6). Estimates have been calculated in numbers for each area and percentages and mean weights are shown in Table 2.4.2.3.

It is worth noting that 97 % of the recruitment (age 1) observed in the Bay of Biscay in 2009 were concentrated in Gironde and coastal areas whereas big anchovies observed offshore were almost exclusively 2 and 3 years old (only 3 % of the age 1). As the small anchovies were only visible when surveying inshore areas and vessels were not able to work in shallower waters than 15m depth, it is possible that the youngest fishes were closer to the coast and therefore they were underestimated. In normal years, 1 year old individuals were distributed on the whole area even if they were preferentially closer to the coast.

2.4.2.4 Conclusion

The anchovy biomass from the Pelgas09 survey has been estimated at 35 000t with 19 000 t of big anchovies offshore and 16 000 t in the Gironde area and inshore. The number of 1 year old anchovies is still low (1 174 millions fish against 960 millions in 2008) compared to good years. They represent 33% of the biomass (61% in numbers) and are concentrated in the Gironde and coastal area where it is difficult survey them.

Looking at the numbers at ages since 2000 (Figure 2.4.2.8.), the 1 year old class still seems to be low since 2005 and 2 and 3 years old are increasing most likely because of the closure of the fishery.

2.5 State of the stock

2.5.1 Method

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.

2.5.2 Final assessment

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 2.5.2.1. Except in some of the years, like 1994, 1998 or 2004, in which there are some discrepancies, the trends in biomass from both surveys are similar. In particular, in the last years a parallel trend but with larger biomass estimates from the acoustic surveys is apparent. The agreement between both surveys is higher when estimating the age structure of the population. Figure 2.5.2.2 compares the historical series of the proportion of age 1 biomass of DEPM and acoustic surveys.

Figure 2.5.2.3 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. In the last years due to the low level of the population and various fishery closures, the catches have been very low being zero in the last two years.

The data used for the assessment are given in Table 2.5.2.1.

Figures 2.5.2.4 and 2.5.2.5 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 2.5.2.2 and Figure 2.5.2.6. The largest probability intervals correspond to the period in which some data is missing. In general recruitment is highly variable from year to year. However, in the last seven years it has been at very low levels, with the recruitment in 2005 as the lowest in the historical series (posterior median of around 5300 tones and 95 % probability interval between 3300 and 8600 tones). Even though there were no catches in the last two years, and so the harvest rate in 2008 and 2009 is zero, SSB has decreased slightly since last year until a level around to Blim (21 000 tones). In order to analyse the biomass trends in relative terms, median and 95% posterior probability intervals of the ratio of spawning stock biomass with respect to 1989 spawning stock biomass, in which Blim is based (ACFM 2003), are given in Table 2.5.2.2. At the end of the eighties and afterwards, since 2002, the medians of these ratios have been close to 1 and always below 2.

Figure 2.5.2.7 shows the posterior distribution of current level of spawning stock biomass in 2009. Current state of the population is summarized in Table 2.5.2.3. Recruitment in 2009 has been very similar to last year's recruitment only higher than 2005 recruitment with a posterior median of 10 200 tones and 95% probability interval between 6600 and 16 400 tones. The estimated level of biomass in 2009 is 21 300 tones and the 95% probability intervals are 15 400 and 32 200 tones. In relative terms the median of the ratio of SSB in 2009 with respect to 1989 biomass (used for defining Blim) is 1.1 (with a 95% interval between 0.7 and 1.9) indicating that current level of the population is slightly above the biomass in 1989. The biological risk, defined as the probability of SSB in 2009 being below Blim (21 000 tones) is 47%.

2.5.3 Quality of the assessment

2.5.3.1 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 2.5.3.1.1 shows the posterior distribution of spawning stock biomass from BBM in comparison to the estimates from the DEPM and acoustic surveys (corrected by their catchability, which is assumed to be 1 for the DEPM and estimated as 1.16 for the acoustic survey). In most of the years the SSB estimates of the surveys taking into account their standard errors fall within the 95% probability intervals from the assessment. Figure 2.5.3.1.2 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 pattern (Figure 2.5.3.1.3). Therefore, the information from the surveys seems to be well captured by the model.

In general, a model synthesizing information from different sources will try to accommodate all sources of information, i.e. observed data, structural model assumptions and in the Bayesian framework, prior distributions. Included in the structural assumptions of the present model is a requirement for consistency between ages along cohorts. In the present case this is specified through an exponential decay model accounting for natural mortality and growth (g-parameter) which is assumed constant across ages and years.

Accommodating to all information implies that the results may deviate from what is indicated in subsets of the data. In the anchovy assessment this year, the model indicates a decrease in SSB from 2008 – 2009 even though both surveys indicated an almost stable biomass. A detailed analysis of the background for this apparent discrepancy reveals that the low biomass estimate in 2009 is largely caused by a low model estimate of age 2+ in 2009. This low estimate of age 2+ in 2009 comes from a low biomass according to the surveys in 2008, which is further reduced in 2009 by the decay model. In addition, the surveys indicate a low age 1 biomass in 2009. These biomass estimates sum up to a biomass that is lower than the total biomass measured by the surveys in 2009.

This highlights that the assessment is not only influenced by observations in the last year (both SSB and age structure), but also by these observations in previous years in combination with model assumptions. In a Bayesian context the uncertainty caused by divergence in these influences will be encapsulated by the posterior distributions.

This analysis also reveals some important sources of uncertainty.

- The sensitivity to the proportion of age one in the surveys, which can be sensitive to sampling and coverage problems.
- Sensitivity to the assumptions about the g-parameter, and its value.

Both these problems should be considered in the forthcoming benchmark process.

The critical situation of the stock in the last years 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 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, once the fishery opens, 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 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.

The DEPM series of biomass are under revision due to changes in the procedures for spawning frequency estimates. This may imply the revision of the current precautionary reference points for management.

All these model assumptions and potential alternative models will be further explored in the Benchmark Workshop on Short-lived species (WKSHORT) that will take place this year from 31 August to 4 September in Bergen (Norway).

2.5.3.2 Changes in methodology

The methodology is the same as described in Ibaibarriaga *et al*. (2008) and in the stock annex. The only change is that this year the convergence of the MCMC was not as good as in previous years, and 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.

2.5.3.3 Changes in perceived state of the stock

Figure 2.5.3.3.1 shows a retrospective analysis of the performance of the BBM from 2000 to 2008. There seems to be a tendency to underestimate SSB in the assessment year. The proportion of error regarding the median SSB ranges from 0.27 to -0.42 with an average of -0.15 (Table 2.5.3.3.1). However, except in 2000 (when no age structure information from the DEPM survey was available) and 2001 the SSB estimates in the assessment year are within the probability intervals of the SSB in this year assessment (upper panel in Figure 2.5.3.3.1) and for all previous assessment years, the SSB estimates in this year assessment are within the 95% probability intervals of the assessment year (lower panel in Figure 2.5.3.3.1).

2.6 Short term prediction

2.6.1 Recruitment prediction

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

Over the years, several attempts have been made to relate recruitment to hydrographic conditions. A more detailed description of the state of the art in this field is given in the stock annex. At present no environmental factor has been identified that can explain the low recruitment in the last years, and none of the environmental indices have sufficient predictive power to be used as input to the stock prediction.

More recently, surveys in the autumn aiming at measuring age 0 anchovy are being developed. Details are presented in the stock annex, and in Section 2.4. So far, the short time span of this series and the lack of contrast in the range of recruitment observations precludes evaluation of its performance as a predictor of the age 1 entering the population and the fishery the next year. Therefore they cannot yet be incorporated in the basis for management advice. It is strongly recommended that these surveys are continued to allow extending the time span. For the future, these surveys, if successful at predicting recruitment at all levels, will allow firmer predictions at the end of the year for the fishery in the first semester.

At the time of the Working Group meeting, there are no indications how long the low recruitment will last and whether a continued low SSB will reduce future recruitments. ICES advice is made in the frame of the precautionary approach, therefore, in the present situation, the catch forecast is made under the assumption that the recent low recruitment will continue.

Given the absence of any information about the next coming year recruitment and the repeated low levels of recruitment since 2002, the WG decided to make the projections assuming that recruitment at age 1 for 2010 will be similar to the recent years since 2002. The resulting recruitment distribution is shown in figure 2.6.3.1. The median of the distribution is 17 400 tonnes.

2.6.2 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. Starting from the posterior distribution of SSB in 2009 and the recent year's recruitment regime the population was projected one year forward.

2.6.3 Results

Since the fishery has been closed for the first half of 2009, no catches were considered from the 15th May 2009, in which SSB is estimated, to the end of June 2009. Total allowable catch between 1st July 2009 and 30th June 2010 were explored from 0 (fishery closure) to 10 000 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 2009 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 2009 and the first half of 2010 were assumed to occur were computed as the average time points from the historical series from 1987 to 2004 (2005-2009 were not considered as the fishery was closed during all or some part of the year). Similarly, the percentage of catches in the first half of 2010 taken before the 15th May, when SSB is estimated, was assumed to be equal to the average from the historical series between 1987 and 2004 (58%). Probability of SSB in 2010 being below B_{lim} was derived for each of the catch options and for the percentages of catch corresponding to the second half of 2009.

Figure 2.6.3.2 shows the distribution of SSB in 2010 in the absence of fishing from 15th May 2009 to 15th May 2010. Under this condition the probability that SSB in 2010 is below B_{lim} is around 37%.

The probability of SSB in 2010 being below B_{lim} is given in Figure 2.6.3.3 and Table 2.6.3.1. The probability of SSB being below B_{lim} increases rapidly as total catch increases getting to around 60% when total catch is around 15 000 tonnes. The probability of falling below B_{lim} is almost insensitive to the allocation into semesters. The corresponding predicted median SSB values in 2010 are shown in Table 2.6.3.2.

2.7 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. Hence, the WGANC suggests that the B_{pa} is abandoned as a reference point.

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. For anchovy 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).

Since 2002, due to a successive series of low recruitments, the anchovy median SSB estimates have been between B_{pa} and B_{lim},, except for 2005, when the median was estimated below B_{lim}. The continuous recent levels of low recruitments at SSBs near B_{lim} supports that B_{lim} should not be lower than the current level of 21000 tonnes.

Since the B_{lim} is set with reference to a particular year, for which the assessment provides a probability distribution which is updated every year, an alternative would be to consider the current SSB relative to SSB_{1989} in probabilistic terms. This could be done by considering the distribution of the ratio $SSB_{current}/SSB_{1989}$. The median and 95% probability intervals of such ratio for the current assessment is presented in **Table 2.5.2.2,** and the distribution for 2009 indicates that the ratio of 1 corresponds to the 31- percentile. This is smaller than the 47% probability of being below B_{lim} since the present estimate of the biomass in 1989 is lower than the B_{lim} value.

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, when the stock is so small that there may be a risk of being below the limit biomass, the default advice by ICES, in the absence of an established harvest rule, is to rebuild the stock as estimated to above B_{pa} within a short time frame. For anchovy, as there is no established management plan, the default practise applies

2. When *evaluating a harvest control rule* or management strategy, one will consider a plausible range of future natural variations (recruitment, weight, ma-

turity) 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.

For the time being, there are no clear established guidelines for how a precautionary advice should be derived from a probabilistic assessment. WGANSA recommends that ACOM considers this problem on a general basis.

To base the advise 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 sensitive to assumptions. Uncritical use of the 5-percentile as a criterium may lead to an advice to close the fishery far more often than necessary if the distribution is broad enough. For example, the presently estimated distribution of SSB in 2010 without fishing is quite broad, ranging from almost 0 to over 50 000 tonnes (Figure 2.6.3.2). Likewise, the lower bound of the probability interval in the historical SSB estimates (Figure 2.5.6.2) are not very far from the limit value even in the years where the stock was in a good shape.

Ideally, criteria for closing the fishery should be evaluated as part of harvest control rules. The anchovy has large natural variations since the species is short-lived, the stock dominated by recruits and the recruitment highly variable. Therefore, the state of the stock may rapidly come outside the precautionary range, and management measures cannot always be expected to prevent that from happening. Any harvest rule for such a stock must therefore have a provision for stopping the fishery if the stock becomes unacceptably small. The exact criteria for stopping the fishery should be based on the probability of bringing the stock into a less productive phase, taking into account the plausible errors in the decision basis as well as consequences of not stopping in time. Within the outer bounds of the precautionary approach, the acceptable risk level is also a matter for managers. In particular, managers may need to consider the trade-off between large catches and the probability of having to stop the fishery. The current B_{lim} may be an adequate basis for a stopping criterium, but not necessarily in combination with the 5 percentile of the SSB distribution, and alternative criteria may be considered (SGMAS 2008: Report of the study group on management strategies, ICES CM 2008/ACOM:24).

Last year, the advice was to keep the fishery closed since there was a substantial (25%) probability that SSB without fishing would be below B_{lim} in next year (2009). This probability is evaluated even higher in the current assessment (in this year 2009). Hence, to advice a continued closure of the fishery would be consistent with last year’s advice.

Future changes in assessment practise or historical data may change the absolute level of the estimated biomasses. At present, the DEPM survey data are taken as absolute, implying that the results in absolute terms to a large extent are scaled to these data. However, it is likely that the estimate of the present SSB relative to previous SSBs in a year of reference for B_{lim} will be robust to such changes in the historical assessment.

One possible alternative to the current practise could therefore be to advise to stop the fishery if there is a substantial probability that the present SSB is lower than the B_{lim} reference point, taking the distribution of both into account. A substantial probability could probably be more than 5%.

2.7.1 Development of management plans

The past management regime which has been based on fixed annual TAC does not account for variability in recruitment. When a sequence of poor year class occurs, the fishery is unconstrained and likely to lead to overexploitation and subsequent depletion of the stock. With the decline of the fishery since 2002, a poor recruitment sequence since 2002 and the collapse and closure of the fishery in 2005, the need to review the management of this stock has been raised by both scientific working groups (ICES and STECF) and the fishing industry (SWW-RAC) as the current management is not adequate to deal with the occurrence of a stock collapse.

The management cycle of the Bay of Biscay anchovy stock has traditionally run from January to December. The only scientific knowledge on which the management advice is based consists on the spring research surveys (DEPM and acoustics) and there is no information on the next year incoming recruitment before that time. So, in the last years before the closure, ICES advice consisted on a preliminary TAC that should be revised at mid-year, once the population estimates from spring surveys became available. Since 2005 the succession of fishery closures has lead the management advice to be moved to June concerning the catch options for the period July to June next year. This has been already adopted by the STECF, both in ad-hoc assessments and when evaluating long-term management plans. If juvenile survey indices (see Section 2.4.3) become operative as predictors of recruitment, an updated forecast for the first semester would be available in the beginning of the year.

In the recent years a series of possible harvest control rules (HCR) and several technical measures have been proposed and partly evaluated by STECF. All these rules are intended for the situation where the stock has recovered and recruitment is normalized.

The STECF advice in June 2007 mentions: "there is presently no agreed comprehensive long-term management plan for this stock and recommends that alternative or complementary management measures to output control (TAC) need to be further investigated to maintain the longer-term viability of the stock (closed seasons, closed areas, minimum size, etc.). These should only be considered after the stock has recovered to biologically safe levels, and would need to be scientifically evaluated prior to adoption."

The SWW RAC have also proposed several possible elements for a long-term management plan including harvest control rules (HCR), spatial and temporal closures, control on effort and capacity, market measures and cohabitation.

The latest work regarding development of management plan has been performed by STECF in April and June 2008 (STECF-SGRST 2008) as part of the Commission effort to make a proposal for a long-term management plan for the anchovy. The group performed a thorough evaluation of three basic harvest control rules (HCR) both in biological and socio-economical terms. This study has already been evaluated and approved by STECF.

Three types of HCRs have been evaluated by STECF:

A. constant harvest above an escapement, where the TAC is a fraction of the SSB that remains above an escapement value (STECF-SGRST 2008 – Rules A of that report).

B. constant harvest strategies, where the TAC is defined as a proportion of the SSB where the harvest rate decreases linearly depending on the SSB with respect to the biological reference points B_{lim} and B_{pa} (Roel *et al*. 2003 and Ibaibarriaga *et al*. 2005) (STECF-SGRST 2008 – Rules B of that report)..

C. HCRs that aim at keeping a constant biological risk (probability of SSB being below B_{lim}) in the short term have also been suggested by the SWW RAC and tested in STECF-SGRST 2008 (rule C of that report).

The evaluation of the performance of the different Harvest control Rules was made by STECF under two recruitment scenarios:

1. For a recovered anchovy population under a "normal" recruitment behaviour of the population in a Ricker and other stock recruitment relationships.

2. Under a persistent low recruitment scenario, as the recent assessment suggest the population is passing.

The risk under scenario 2 is considerably larger than under scenario 1 for all the harvest control rules.

In 2008, the Pelagic Committee of the South Western Waters Regional Advisory Committee (SSW-RAC) endorsed the adoption of a concrete HCR of type Rule B of the above-mentioned STECF work (at a harvest rate of 0.4) as a compromise between risks of falling below B_{lim} and an economically sustainable levels of catches. The committee also requested the European Commission to evaluate under the low recruitment scenario the biological risk associated to an additional HCR (rule "E") in which for a SSB between 24 000 and 32 500t, a TAC of 5000, 6000 or 7000t would be set. Above 32500 tonnes the rule "B" would be applied. The aim of this proposal would be to assure some minimum viable TAC level (economically speaking) even at low SSB levels. This study has been made by AZTI (Ibaibarriaga and Uriarte, 2009) and is being evaluated by STECF. The EC is working on the concrete proposal to make to managers for the LTMP of anchovy. So far ICES has not been requested to assess the compatibility of any LTMP with the precautionary approach for the management of this stock.

In addition to TAC rules, other elements in long-term management plans have been proposed but not yet adopted nor evaluated by ICES:

- The use of time/area closures to protect spawners and/or juveniles, allowing a larger portion of the newly recruited individuals to spawn. For example, the closure of a nursery area like the area around the Gironde estuary should be considered whenever the assessment reveals in spring a critical level of biomass.

- Provisions on capacity and effort to adapt them to catch possibilities. An annual adjustment of effort would reflect the fluctuating nature of the annual biomass available for fishing. As this fishery is mainly conducted by vessels with opportunistic fishing strategy throughout the year, this would possibly involve redeployment plans. A long-term management plan would also evaluate if the sizes of the current fleets are adequate to catch the levels of anchovy that would result from a long term plan. In addition, control measures such as VMS (Vessel Monitoring System) monitoring could be considered.
- A revision of the market rules for anchovy, including for example a reduction of the number of anchovy per kg for pelagic trawlers, reducing the catch of immature fish to protect ages 0 and 1 before spawning.

2.7.2 Recent recruitment failure

A literature review of the evidence for environmental causes for the recent recruitment failure was presented in last year's report for WGANC. For the time being, the cause of the recruitment failure is not clear, there is nothing to indicate how long it will last, and there are no environmental indicators of recruitment that are sufficiently reliable to be used as management advice.

It is likely that the closure of the fishery for the last two years led to an improved survival and accordingly an increase in the relative abundance of anchovy older than age 1. However, the recruitment has remained low since 2002 and SSB in 2009 remains at similar low levels as in the three previous years. Given the low recruitment in 2008, the contribution of old fish (age 2 and 3+) has been crucial to sustain the biomass in 2009. For the future, preserving older fish to maintain a sufficient spawning stock will always be part of good management, and with low recruitment, it is necessary to ensure sufficient biomass to produce a normal recruitment once conditions improve. Therefore, protecting the incoming year classes and letting them contribute to the spawning stock as long as possible is essential in the present situation.

Table 2.2.2.1: Bay of Biscay Anchovy. Annual catches in tonnes (Sub-area VIII) as reported by 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	n/a	1,128
2006	913	840	n/a	1,753
2007	140 **	1.2 **	n/a	141
2008 (up to June)	0	0		0
AVERAGE (1990-04)	6,394	26,337	318	32,824

** Experimental Fishery

Table 2.2.3.1: Bay of Biscay Anchovy. Catches at age of the fishery in the Bay of Biscay on half year basis as reported up to 1998 to ICES WGs and updated since then (International). No catches in 2009

INTERNACIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994	
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
Age 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
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
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
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
4	14,831	58	1,356	0	54	0	0	0	0	0	0	0	0	0	0	0
5	8,920	0	99	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
Internat Catches	11,718	3,590	10,003	5,579	7,153	3,460	19,386	14,886	15,025	4,610	26,381	11,504	24,058	16,334	23,214	11,417
Var. SOP	100.7%	100.4%	98.3%	101.9%	98.5%	99.3%	100.7%	99.1%	97.6%	98.5%	99.6%	99.9%	101.1%	99.5%	101.0%	100.2%
Annual Catch		15,308		15,581		10,614		34,272		19,635		37,885		40,392		34,631

YEAR	1995		1996		1997		1998		1999		2000		2001		2002	
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
Age 0	0	49,771	0	109,173	0	133,232	0	4,075	0	54,357	0	5,298	0	749	0	267
1	522,361	189,081	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
2	282,301	21,771	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
3	76,525	90	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
4	4,096	7	2,213	42	0	0	155	0	108	0	0	0	4,948	0	76	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	885,283	260,719	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
Internat Catches	23,479	6,637	21,024	13,349	10,704	11,443	12,918	18,700	15,381	11,878	22,536	14,458	23,095	17,054	11,102	6,406
Var. SOP	101.5%	98.2%	99.5%	100.4%	99.7%	102.1%	100.6%	94.8%	102.0%	103.0%	100.8%	97.6%	100.8%	101.1%	97%	102%
Annual Catch		30,116		34,373		22,147		31,617		27,259		36,994		40,149		17,507

YEAR	2003		2004		2005		2006		2007	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0	7,530	0	11,184	0	0	0	0	0	0
1	50,327	133,083	254,504	252,887	7,818	0	48,718	3,894	0	0
2	44,546	87,142	85,679	20,072	32,911	0	17,172	991	0	0
3	34,133	11,459	12,444	1,153	6,935	0	6,465	320	0	0
4	887	1,152	4,598	16	586	0	49	2	0	0
5	0	0	0	0	0	0	0	0	0	0
Total #	129,893	240,366	357,225	285,312	48,250	0	72,405	5,207	0	0
Internat Catches	4,074	6,521	9,183	7,177	1,127	0	1,657	95	141	0
Var. SOP	100%	100%	100%	100%	103%	0%	103%	0%	0%	0%
Annual Catch		10,595		16,360		1,127		1,752		141

Table 2.2.3.1. (Cont. 1): Bay of Biscay Anchovy (Spain).

SPAIN

YEAR		1987		1988		1989		1990		1991		1992		1993		1994
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
Age 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
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
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
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
4	14,831	58	1,356	0	54	0	0	0	0	0	0	0	0	0	0	0
5	8,920	0	99	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
Catch Spain	8,777	1,632	6,955	1,804	5,377	2,981	16,401	7,273	8,343	1,583	21,047	1,621	17,206	2,272	15,219	2,478
Var. SOP	100.7%	99.7%	97.9%	100.6%	97.1%	99.5%	100.9%	99.5%	94.7%	98.2%	99.3%	100.5%	100.8%	100.2%	101.3%	99.6%
Annual Catch		10,409		8,759		8,358		23,674		9,926		22,669		19,479		17,697

YEAR		1995		1996		1997		1998		1999		2000		2001		2002
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 haf
Age 0	0	31,101	0	52,238	0	91,400	0	4,075	0	29,057	0	439	0	748	0	239
1	367,924	17,611	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
2	206,387	1,333	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
3	57,214	90	14,461	499	1,927	195	4,002	9	10,051	525	50,834	2,085	18,854	464	13,702	2,041
4	4,096	7	2,213	42	0	0	155	0	108	0	0	0	4,948	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	635,621	50,142	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
Catch Spain	18,322	902	16,774	2,361	6,420	3,897	6,818	1,812	10,323	3,287	17,087	2,143	20,314	2,738	4,745	1,774
Var. SOP	102.1%	100.1%	99.5%	100.4%	99.5%	98.7%	98.9%	99.8%	102.1%	101.7%	101.1%	100.7%	102.1%	101.7%	101%	101%
Annual Catch		19,224		19,135		10,317		8,630		13,610		19,230		23,052		6,519

YEAR		2003		2004		2005		2006		2007
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0	49	0	115	0	0	0	0	0	0
1	11,761	4,895	183,853	18,994	1,096	0	21,276	355	0	0
2	32,566	1,068	71,589	482	4,631	0	7,708	25	0	0
3	28,809	272	7,461	23	266	0	3,587	7	0	0
4	434	0	4,340	16	16	0	0	0	0	0
5	0	0			0	0	0	0	0	0
Total #	73,569	6,285	267,243	19,630	6,009	0	32,571	387	0	0
Catch Spain	2,848	154	7,081	498	176	0	833	7	1	0
Var. SOP	100%	101%	101%	101%	101%	0%	101%	103%	0%	0%
Annual Catch		3,002		7,580		176		840		1

Table 2.2.3.1. (Cont. 2): Bay of Biscay Anchovy (France).

FRANCE

YEAR	1987		1988		1989		1990		1991		1992		1993		1994	
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
Age 0	0	2,688	0	8,419	0	5,282	0	4,985	0	5,111	0	25,313	0	0	0	912
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
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
3	4,026	0	2,245	0	9,863	0	36	0	26,522	0	6,893	0	4,369	0	17,045	0
4	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
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
Catch France	2,941	1,958	3,048	3,775	1,776	479	2,985	7,613	6,682	3,027	5,334	9,883	6,851	14,062	7,994	8,939
Var. SOP	100.4%	101.0%	99.0%	102.5%	102.6%	97.8%	99.2%	98.7%	101.3%	98.6%	100.5%	99.8%	101.6%	99.4%	100.3%	100.4%
Annual Catch		4,899		6,822		2,255		10,598		9,708		15,217		20,914		16,934

YEAR	1995		1996		1997		1998		1999		2000		2001		2002	
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 haf
Age 0	0	18,670	0	56,936	0	41,832	0	0	0	25,300	0	4,859	0	1	0	29
1	154,437	171,470	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
2	75,914	20,438	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
3	19,311	0	16,631	0	3,653	0	1,594	3,389	7,710	0	33,603	16,528	844	4,631	24,184	1,005
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	76	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	249,662	210,578	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
Catch France	5,157	5,735	4,251	10,987	4,284	7,546	6,099	16,888	5,058	8,591	5,449	12,316	2,782	14,316	6,357	4,631
Var. SOP	99.4%	97.9%	102.8%	99.8%	100.0%	103.9%	102.5%	94.3%	101.7%	103.4%	99.8%	97.0%	100.5%	101.3%	95%	102%
Annual Catch		10,892		15,238		11,830		22,987		13,649		17,765		17,097		10,988

YEAR	2003		2004		2005		2006		2007	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	0	7,481	0	11,069	0	0	0	0	0	0
1	38,567	128,188	70,651	233,893	6722	0	27,442	3,539	0	0
2	11,981	86,074	14,091	19,590	28281	0	9,464	966	0	0
3	5,324	11,187	4,983	1,130	6669	0	2,878	313	0	0
4	453	1,152	258	0	570	0	49	2	0	0
5	0				0	0	0	0	0	0
Total #	56,325	234,082	89,982	265,683	42,242	0	39,833	4,820	0	0
Catch France	1,226	6,367	2,102	6,679	952	0	824	88	140	0
Var. SOP	100%	100%	100%	100%	104%	0%	100%	100%	0%	0%
Annual Catch		7,593		8,781		952		912		140

Table 2.2.4.1: Bay of Biscay Anchovy. Mean weight at age in the international catches in Sub-area VIII on half year basis.

INTERNATIONAL																
YEAR	1987		1988		1989		1990		1991		1992		1993		1994	
Sources	Anon. (1989 & 1991)		Anon. (1989)		Anon. (1991)		Anon. (1991)		Anon. (1992)		Anon. (1993)		Anon. (1995)		Anon. (1996)	
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
Age 0	0.0	11.7	0.0	5.1	0.0	12.7	0.0	7.4	0.0	14.4	0.0	12.6	0.0	12.3	0.0	14.7
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
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
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	0.0	30.7	30.0
4	41.0	40.0	37.6	0.0	27.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	42.0	0.0	48.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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
SOP	11,795	3,605	9,828	5,685	7,043	3,434	19,515	14,752	14,668	4,538	26,264	11,497	24,314	16,257	23,440	11,442
mean weight 3+	39.3	39.2	35.0	44.5	29.7	42.7	44.8	40.8	28.2	39.0	37.7	27.4	30.5	30.5	30.7	30.0

YEAR	1995		1996		1997		1998		1999		2000		2001		2002	
Sources:	Anon. (1997)		Anon. (1998)		Anon. (1999)		Anon (2000)		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
Age 0	0.0	15.1	0.0	12.0	0.0	11.6	0.0	10.2	0.0	15.7	0.0	19.3	0.0	14.3	0.0	9.5
1	22.5	26.9	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
2	32.3	31.3	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
3	36.4	36.4	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
4	37.3	29.1	46.1	39.7	0.0	0.0	31.9	0.0	55.9	0.0	0.0	0.0	40.7	0.0	45.6	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	26.9	25.0	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
SOP	23,830	6,520	21,066	13,139	10,672	11,687	12,996	17,727	15,686	12,229	22,715	14,106	23,272	17,247	11,073	6,415
mean weight 3+	36.5	35.9	35.8	36.0	32.0	29.7	31.9	28.7	35.3	38.9	32.6	36.9	36.3	38.6	43.4	36.5

YEAR	2003		2004		2005		2006		2007	
Sources:	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 *
Age 0	0.0	15.4	0.0	15.5	0.0	0.0	0.0	0.0	na	na
1	21.0	25.4	21.7	24.9	19.3	0.0	20.3	17.8	na	na
2	36.2	29.5	35.7	33.5	24.5	0.0	27.7	19.7	na	na
3	40.3	36.4	39.3	40.7	27.6	0.0	31.3	19.7	na	na
4	36.9	37.9	44.0	42.8	24.5	0.0	37.3	34.3	na	na
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	na	na
Total	31.4	27.1	26.0	25.2	24.1	0.0	23.0	18.2	na	na
SOP	4,078	6,524	9,271	7,181	1,162	0	1,667	95	na	na
mean weight 3+	40.3	36.4	40.6	40.7	27.3	0.0	31.3	19.7	na	na

* Fishery Closed: Very poor data due to the nule or very small catches

Table 2.4.1.1.1: Bay of Biscay: Details obtained in the DEPM egg Survey 2009.

Parameters	Anchovy DEPM survey
Survey area	(43º17' to 46º38′N & 4º50′ to 1º30' W)
R/V	*Investigador* & *Emma Bardán*
Date	5-25/05/09
Eggs	R/V INVESTIGADOR
Total egg stations	409
% st with anchovy eggs	59%
Anch egg average by st	16 eggs/0.1m^2
Max anch egg by St	152 eggs/0.1m^2
Total anch eggs collected	3,778 eggs
French platform limit N	46º38′N
Canabrian limit W	3º33′W
Total area surveyed	60,733 Km^2
Spawning area	28,214Km^2
CUFES stations	987
Adults	R/V EMMA BARDAN
Pelagic trawls	38
With anchovy	34
Selected for analysis	31

Table 2.4.1.2.1: Bay of Biscay: Daily egg production estimates (P_0), the daily egg mortality rates (z) and the total egg production and their coefficient of variation (CV).

Parameter	Value	S.e.	CV
P_0	60.22	8.32	0.14
z	0.28	0.003	0.25
P_{tot}	1.70.E+12	2.E+11	0.14

Table: 2.4.1.4.1: Bay of Biscay: Preliminary biomass estimate for 2009 was obtained from DF predicted model, divided by the estimates of P_{tot} derived from GLM

P_{tot} (eggs)			DF (eggs/gramme)			SSB (Ton.)		
Model	Estimate	Var	Predic.Model	Estimate	Var.Pred.	Estimate	Var	Cv
GLM	1.70E+12	5.5E+22	Df = a + b * sst	60.69	131.26	27,994	4.3.E+07	0.2340

Table: 2.4.1.4.2: Bay of Biscay: SSB 2009 estimates, proportion 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)	27,994	6,439	0.230
Tot.mean W (g)	21.93	2.387	0.109
Population (millions)	1,277	324.8	0.254
Percent age 1	0.59	0.059	0.100
Percent age 2	0.21	0.032	0.151
Percent age 3+	0.20	0.042	0.210
Numbers at age 1	755	206.3	0.273
Numbers at age 2	267	79.1	0.296
Numbers at age 3+	255	84.0	0.330
Weight at age 1	13.8		
Weight at age 2	27.4		
Weight at age 3+	40.5		
SSB at age 1 in mass	10,382		
SSB at age 2 in mass	7,314		
SSB at age 3+ in mass	10,299		
Percent age 1 in mass	37.1%		
Percent age 2 in mass	26.1%		
Percent age 3+ in mass	36.8%		

Table 2.4.2.1. : Details obtained in the PELGAS acoustic Survey 2009 during the assessment coverage

Parameters	PELGAS acoustic survey
Survey area	(43º30' to 48º30'N & 1º10' to 6º00' W)
R/V	THALASSA
commercial vessels	Zéphyr / Carla-Eglantine : 26/04 to 06/05/2009 Magayant / Mary Christo : 07/05 to 16/05/2009 Vag a Lamm : 21/05 to 23/05/2009
Date	25/04 – 05/06/2009
Acoustic	**THALASSA**
Miles used for assessment	1 873 NM
Nb of fish measured	24 144
- anchovy	5 930
- sardine	5 249
Nb of otoliths	2 340
- anchovy	1 183
- sardine	1 157
Nb of trawl hauls	47
- nb of surface and pelagic hauls	4
-Nb of hauls closed to the bottom	40
- nb of cancelled hauls	4
Nb CUFES samples	798
CTD stations	84
consort	**Commercial vessels**
dates	26/04 – 23/05/2009
Number of trawl hauls	47
- nb of surface and pelagic hauls	15
-Nb of hauls closed to the bottom	32
- Nb of purse seine hauls	4
- nb of cancelled hauls	4
Nb of fish measured	13 194
- anchovy	2 230
- sardine	5 240

			anchovy	sardine
Classical	**pel09_1**	South offshore	6 346	19 899
	pel09_2	south coast	511	91 186
	pel09_3	Gironde	10 260	41 624
	pel09_4	North offshore	3	715
	pel09_5	North coast	76	251 381
	pel09_6	Coastal area	5 154	32 478
surface	**pel09_7**	South offshore	12 463	17 227
	pel09_8	south coast	33	11 411
	pel09_10	North offshore	9	6 130
	pel09_11	North coast	0	7 633
		Total	**34 855**	**479 684**
		C.V.	**0.112**	**0.098**

Table 2.4.2.2. : biomass of anchovy and sardine per strata during PELGAS 09

NUMBERS (*1000)				
AGE	coastal	offshore	total	mean W at age (g)
1	59.18%	1.83%	61.00%	15.26
2	9.78%	8.29%	18.07%	31.04
3	4.09%	15.52%	19.62%	40.24
4	0.14%	1.16%	1.31%	41.59
total	73.19%	26.81%	100.00%	28.20

Table 2.4.2.3. : anchovy age distribution and mean weight during PELGAS 09

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

Table 2.4.2.4 : Acoustic abundance indices since 2000

Table 2.4.3.1: Synthesis of the abundance estimation (acoustic index of biomass) for anchovy juveniles and adults over the six years of JUVENA surveys.

Year	Region	Area	<length>_juv	<length>_adul	Biom_juv	Biom_adul
2003	Standard	3,475	8.78	14.11	98,601	1,383
	Extended	0			0	0
	TOTAL	3,475			98,601	1,383
2004	Standard	1,907	9.31	9.18	2,406	3,451
	Extended	0			0	0
	TOTAL	1,907			2,406	3,451
2005	Standard	6,325	8.08	12.4	130,146	9,117
	Extended	1,464	9.77	13.32	3,985	11,253
	TOTAL	7,790			134,131	20,370
2006	Standard	2,680	8.58	12	41,441	10,665
	Extended	3,893	10.3	12	36,858	34,758
	TOTAL	6,573			78,299	45,422
2007	Standard	3,458	10.65	12.97	12,804	7,349
	Extended	2,220	9.63	15.05	317	27,760
	TOTAL	5,678			13,121	35,109
2008	Standard	5,226	9.03	12.14	17,379	22,798
	Extended	1,670	6.91	14.03	3,500	14,922
	TOTAL	6,895			20,879	37,721

Table 2.5.2.1: 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	NA	NA
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	15280	21436	18282	30877
2007	0.3178	0.0594	20	67	73	16025	25973	26230	40876
2008	0.2610	0.1991	0	0	0	7579	25377	10400	37574
2009	0.2610	NA	0	0	0	10382	27994	11429	34855

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 2.5.2.2: 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	14070	17770	25370	18430	22900	32820	0.453	0.649	0.806	0.822	1.235	1.668
1988	35790	42670	57101	31500	37290	50611	0.293	0.397	0.470	1.586	2.001	2.350
1989	9123	12450	19660	13990	18820	29390	0.283	0.442	0.595	1.000	1.000	1.000
1990	79800	90015	107000	58490	66840	81221	0.420	0.511	0.584	2.394	3.557	4.857
1991	19250	25840	35281	23220	31065	43600	0.422	0.592	0.792	1.055	1.639	2.416
1992	81409	139200	223800	56130	103900	172808	0.216	0.360	0.666	2.687	5.509	9.557
1993	45020	89735	130303	81880	97095	117403	0.337	0.408	0.484	3.247	5.206	7.144
1994	38010	49030	65111	49420	59530	78713	0.429	0.567	0.683	1.963	3.201	4.596
1995	34739	57690	98211	27720	49695	88383	0.332	0.591	1.059	1.283	2.608	4.915
1996	41140	67070	90530	51370	60040	74960	0.441	0.551	0.644	2.027	3.201	4.610
1997	36610	50260	70360	36980	49190	70010	0.293	0.417	0.554	1.510	2.613	4.159
1998	53060	79215	135203	46710	71575	120500	0.262	0.441	0.676	1.991	3.788	6.856
1999	41258	82480	120900	54158	76610	103300	0.256	0.345	0.488	2.334	4.007	6.271
2000	101800	126800	151200	96490	117400	133700	0.276	0.314	0.382	3.869	6.204	8.529
2001	73299	84590	103200	89990	99380	113900	0.352	0.404	0.446	3.456	5.315	7.267
2002	10070	13020	19160	31430	36870	46820	0.374	0.474	0.557	1.297	1.970	2.789
2003	22200	29010	37291	26930	33045	42941	0.244	0.317	0.389	1.088	1.764	2.547
2004	33540	41380	56021	31870	39440	54311	0.300	0.413	0.511	1.305	2.094	3.193
2005	3262	5321	8579	11570	16650	25920	0.045	0.070	0.100	0.517	0.879	1.502
2006	16570	24200	35720	18780	26180	38631	0.046	0.067	0.094	0.808	1.385	2.277
2007	21320	29950	46130	26580	35980	53061	0.003	0.004	0.005	1.153	1.888	3.095
2008	6765	10420	18591	19300	26240	40060	0.000	0.000	0.000	0.855	1.385	2.272
2009	6645	10190	16370	15370	21270	32170	0.000	0.000	0.000	0.692	1.118	1.855

Table 2.5.2.3: Bay of Biscay anchovy: Summary table of the current state of the stock from BBM.

R_{2009}	Median	10 190
	95 % C.I.	(6 645, 16 370)
SSB_{2009}	Median	21 270
	95 % C.I.	(15 370, 32 170)
SSB_{2009} / SSB_{1989}	Median	1.118
	95 % C.I.	(0.692, 1.866)
$P(SSB_{2009} < 21\ 000)$		0.471

Table 2.5.3.3.1: Bay of Biscay anchovy: Results of the retrospective analysis of the BBM giving the percentage of error of the SSB estimates in the last assessment year with respect to the SSB estimates in current assessment

YEAR	SSB WGANSA2009	SSB ASSESSMENT YEAR	% ERROR
2000	117400	67465	-0.425
2001	99380	80340	-0.192
2002	36870	46660	0.266
2003	33045	32270	-0.023
2004	39440	30120	-0.236
2005	16650	11390	-0.316
2006	26180	21515	-0.178
2007	35980	28095	-0.219
2008	26240	24940	-0.050
2009	21270		

Table 2.6.3.1: Bay of Biscay anchovy: Probability of SSB in 2010 of being below B_{lim} under the recent year recruitment scenario under different catch options from 1st July 2009 to 30th June 2010 and alternative catch allocation by semesters.

$P(SSB<B_{lim})$	% CATCHES IN THE 2nd SEMESTER 2009										
TOTAL CATCH (1 July 2009 - 30 June 2010)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	0.371	0.371	0.371	0.371	0.371	0.371	0.371	0.371	0.371	0.371	0.371
1000	0.394	0.394	0.395	0.396	0.396	0.397	0.397	0.397	0.398	0.399	0.399
2000	0.416	0.417	0.417	0.418	0.419	0.420	0.421	0.421	0.422	0.422	0.423
3000	0.436	0.437	0.438	0.439	0.440	0.441	0.441	0.442	0.443	0.444	0.445
4000	0.451	0.452	0.452	0.453	0.454	0.455	0.456	0.457	0.458	0.459	0.460
5000	0.464	0.465	0.466	0.467	0.468	0.469	0.470	0.471	0.472	0.473	0.474
6000	0.475	0.476	0.477	0.478	0.479	0.480	0.481	0.482	0.484	0.485	0.486
7000	0.484	0.486	0.487	0.488	0.490	0.491	0.492	0.494	0.496	0.498	0.499
8000	0.495	0.498	0.499	0.500	0.503	0.505	0.507	0.508	0.510	0.511	0.513
9000	0.508	0.509	0.511	0.513	0.515	0.516	0.518	0.521	0.524	0.525	0.526
10000	0.518	0.521	0.524	0.526	0.527	0.529	0.532	0.534	0.536	0.537	0.540
15000	0.582	0.587	0.591	0.595	0.599	0.603	0.608	0.612	0.616	0.620	0.625
20000	0.663	0.669	0.676	0.682	0.687	0.694	0.702	0.709	0.716	0.723	0.729
25000	0.751	0.759	0.766	0.772	0.777	0.783	0.790	0.795	0.801	0.808	0.814
30000	0.817	0.826	0.834	0.838	0.844	0.851	0.856	0.863	0.869	0.873	0.879
33000	0.852	0.859	0.866	0.871	0.877	0.883	0.888	0.894	0.900	0.906	0.911

Table 2.6.3.2: Bay of Biscay anchovy: Median SSB in 2010 under the recent year recruitment scenario under different catch options from 1st July 2009 to 30th June 2010 and alternative catch allocation by semesters.

SSB_{median}	% CATCHES IN THE 2nd SEMESTER 2009										
TOTAL CATCH (1 July 2009 - 30 June 2010)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0	25550	25550	25550	25550	25550	25550	25550	25550	25550	25550	25550
1000	25013	25003	24993	24982	24972	24962	24952	24941	24931	24921	24911
2000	24476	24455	24435	24414	24394	24374	24353	24333	24312	24292	24272
3000	23938	23908	23877	23847	23816	23785	23755	23724	23694	23663	23632
4000	23401	23360	23320	23279	23238	23197	23156	23116	23075	23034	22993
5000	22864	22813	22762	22711	22660	22609	22558	22507	22456	22405	22354
6000	22327	22266	22204	22143	22082	22021	21959	21898	21837	21776	21715
7000	21790	21718	21647	21575	21504	21432	21361	21290	21218	21147	21075
8000	21252	21171	21089	21007	20926	20844	20763	20681	20599	20518	20436
9000	20715	20623	20531	20440	20348	20256	20164	20072	19980	19889	19797
10000	20178	20076	19974	19872	19770	19668	19566	19464	19362	19260	19158
15000	17492	17339	17186	17033	16880	16727	16573	16420	16267	16114	15961
20000	14806	14602	14398	14193	13989	13785	13581	13377	13173	12969	12765
25000	12120	11865	11609	11354	11099	10844	10589	10334	10079	9824	9569
30000	9434	9127	8821	8515	8209	7903	7597	7291	6985	6678	6372
33000	7822	7485	7148	6812	6475	6138	5801	5465	5128	4791	4454

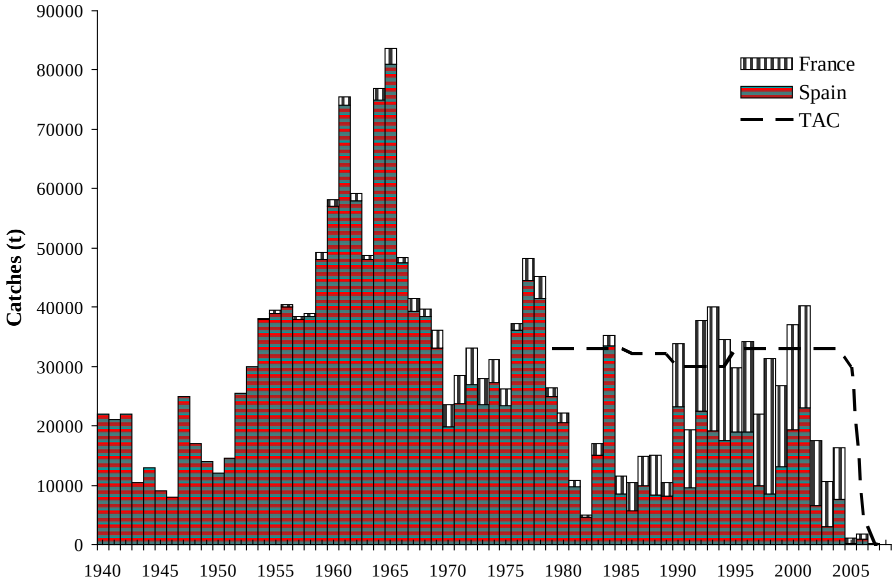


Figure 2.2.2.1 Historical evolution of anchovy catches in subarea VIII by countries (1940-2009).

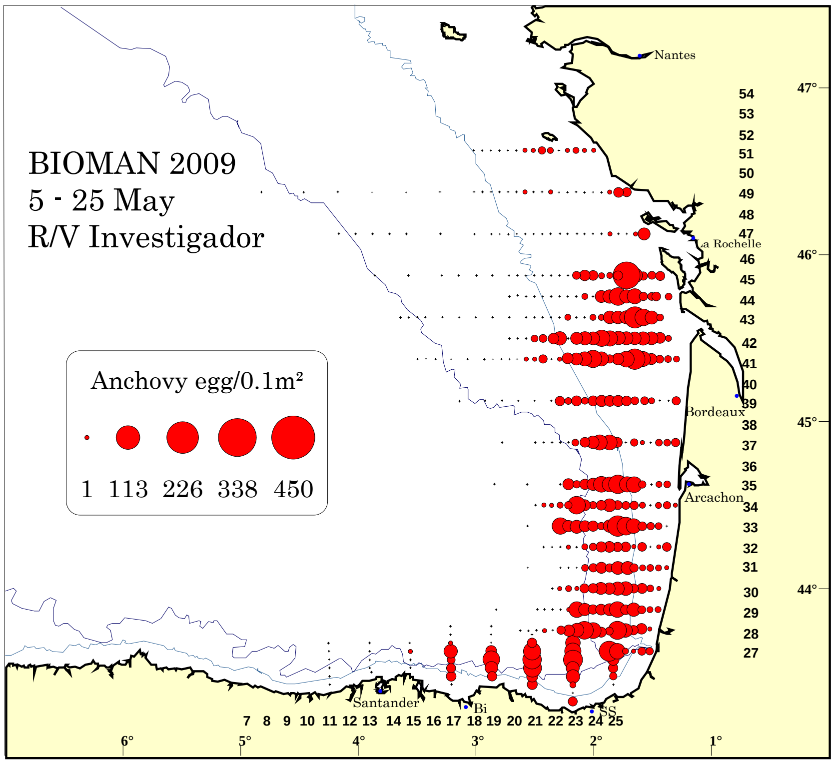


Figure 2.4.1.2.1: Bay of Biscay anchovy: Distribution of egg abundances (eggs per 0.1m²) from the DEPM survey BIOMAN09 obtained with PairoVET.

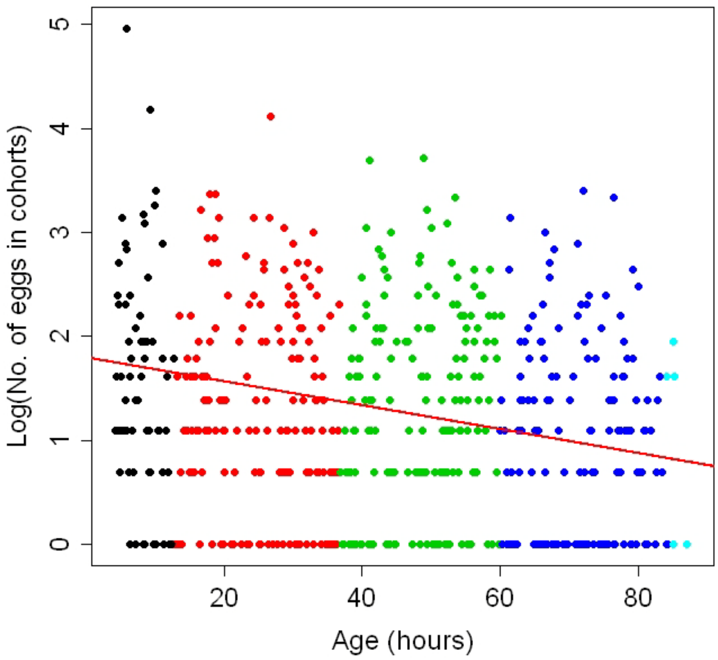


Figure 2.4.1.2.2: Bay of Biscay anchovy: Exponential mortality model adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning peak 23:00h).The red line is the adjust line.

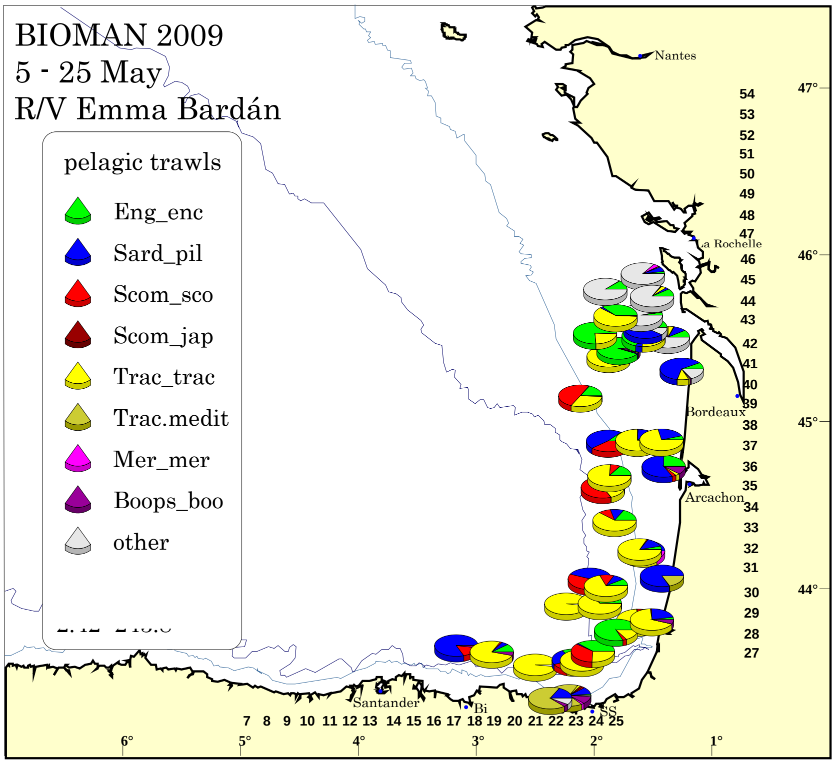


Figure: 2.4.1.3.1: Bay of Biscay anchovy: Species composition of the 38 pelagic trawls from the R/V Emma Bardán during BIOMAN09.

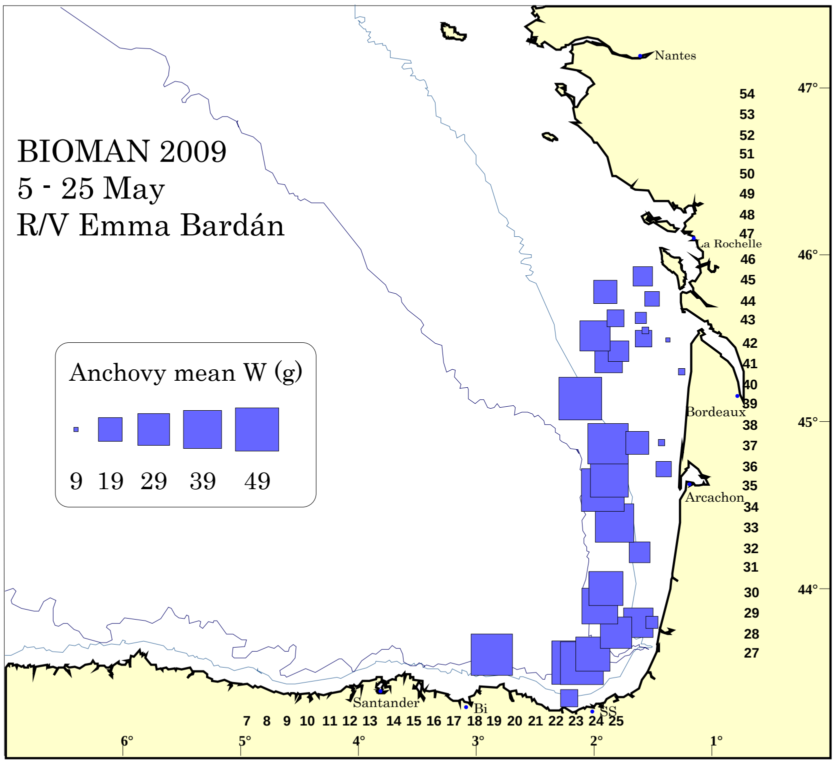


Figure 2.4.1.3.2: Bay of Biscay anchovy: Anchovy (male and female) mean weight per pelagic trawl

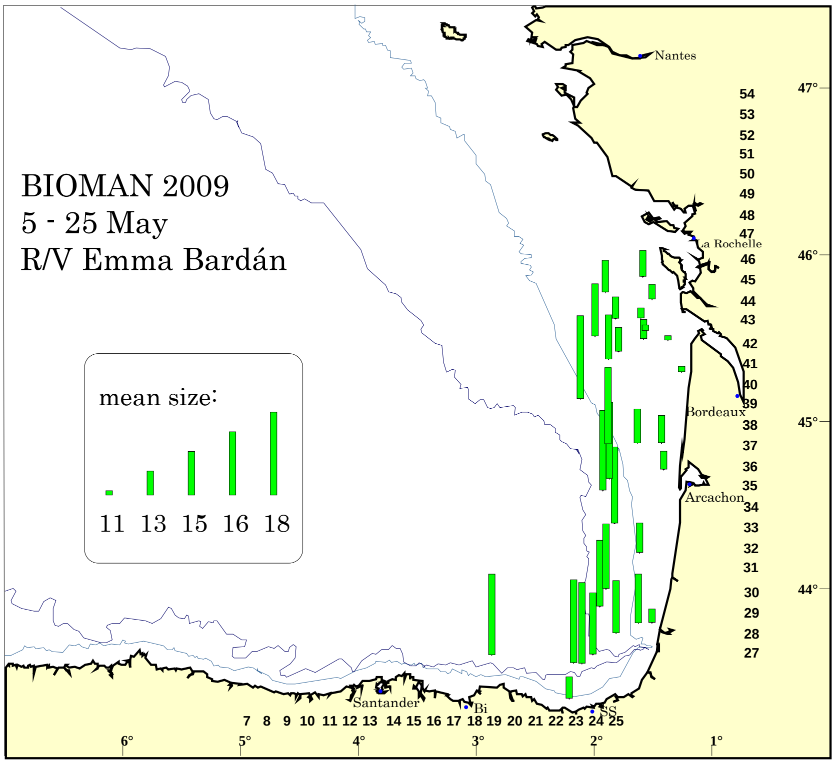


Figure 2.4.1.3.3: Bay of Biscay anchovy: Anchovy (male and female) mean size per pelagic trawl

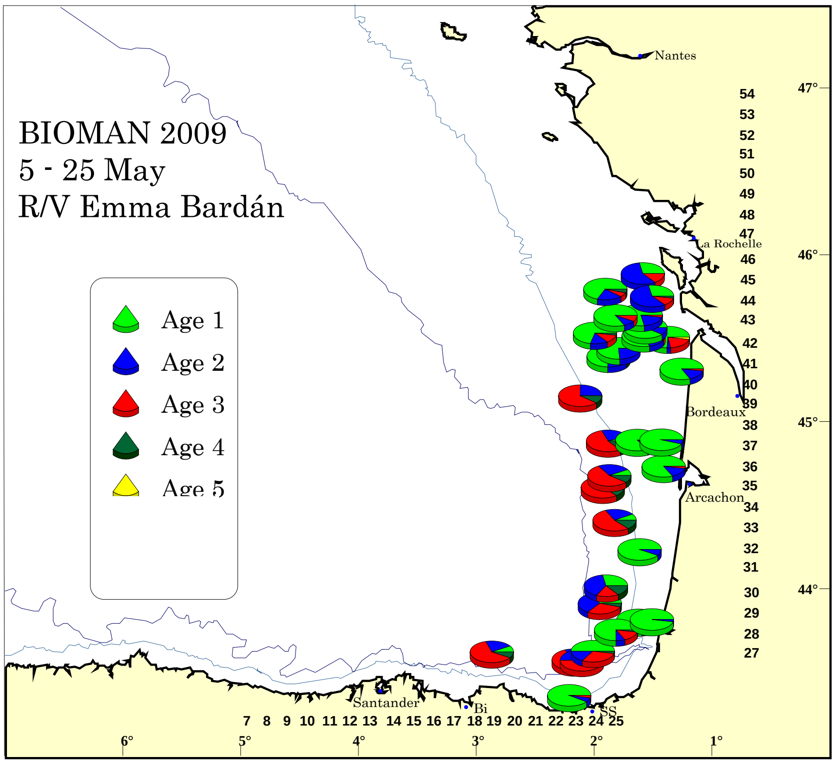


Figure 2.4.1.3.4: Bay of Biscay anchovy: Age composition per haul

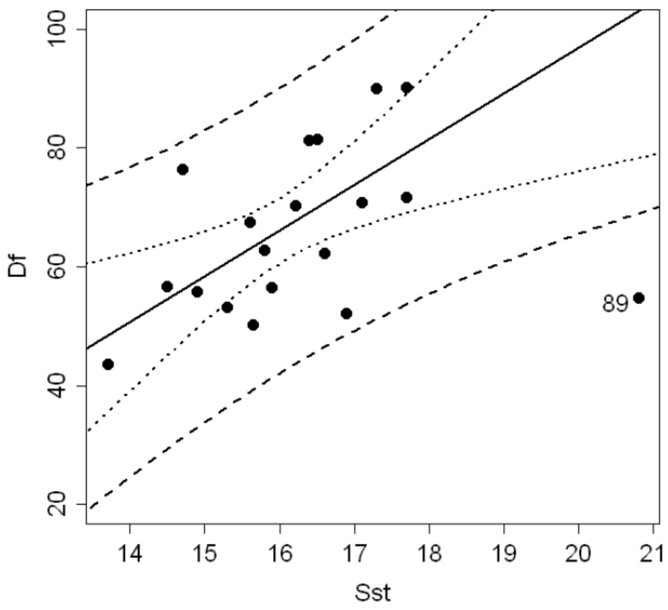


Figure 2.4.1.3.5: Bay of Biscay anchovy: Linear regression model between DF and SST. The solid line represents the fitted line whereas the dotted and the dashed line represent the 95% confidence and prediction intervals, respectively. The points correspond to the observed points each year. The value of June 1989 is omitted form the analysis because of poor reliability.

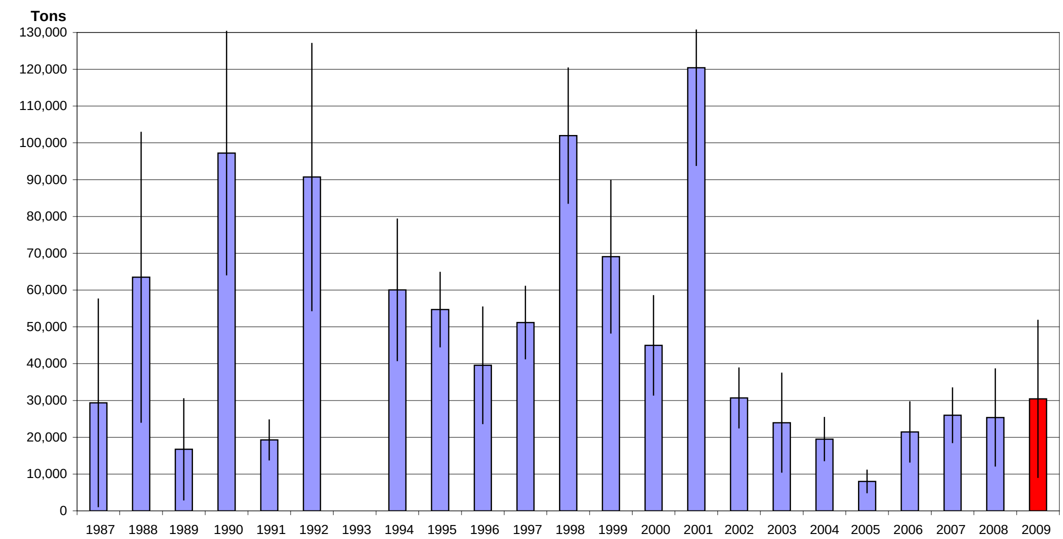


Figure 2.4.1.4.1: Bay of Biscay anchovy: Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. Most of them are full DEPM estimates, except in 1996, 1999, 2000 and 2007, which were deduced indirectly.

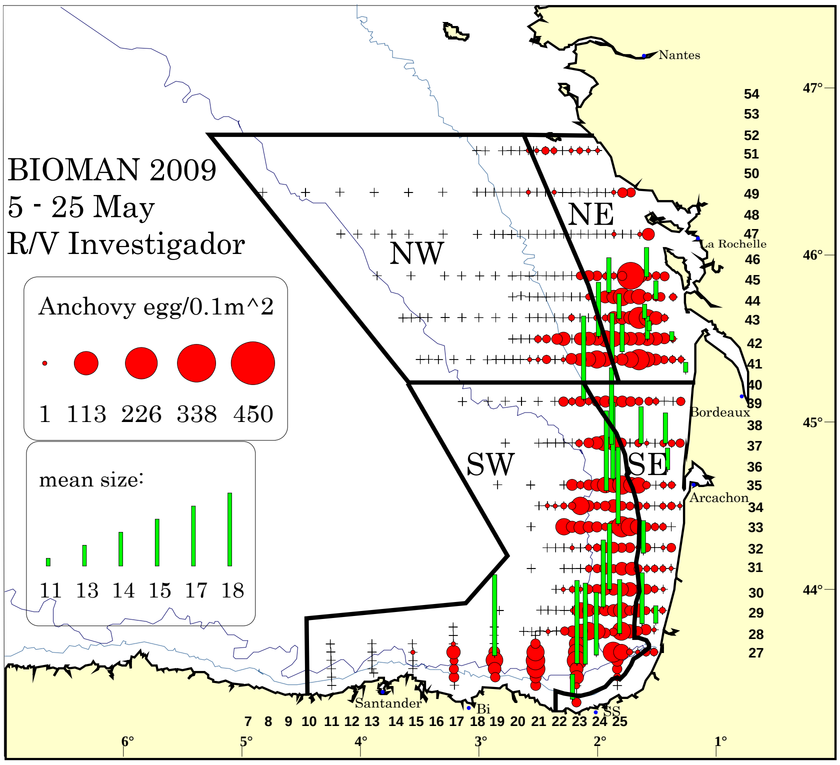


Figure 2.4.1.4.2: Bay of Biscay anchovy: Four strata defined to estimate the numbers at age: North-east (NE), Southeast (SE), Southwest (SW) and Northwest (NW). The circles are the anchovy egg abundances and the bars are the mean size per haul of the anchovy adults.

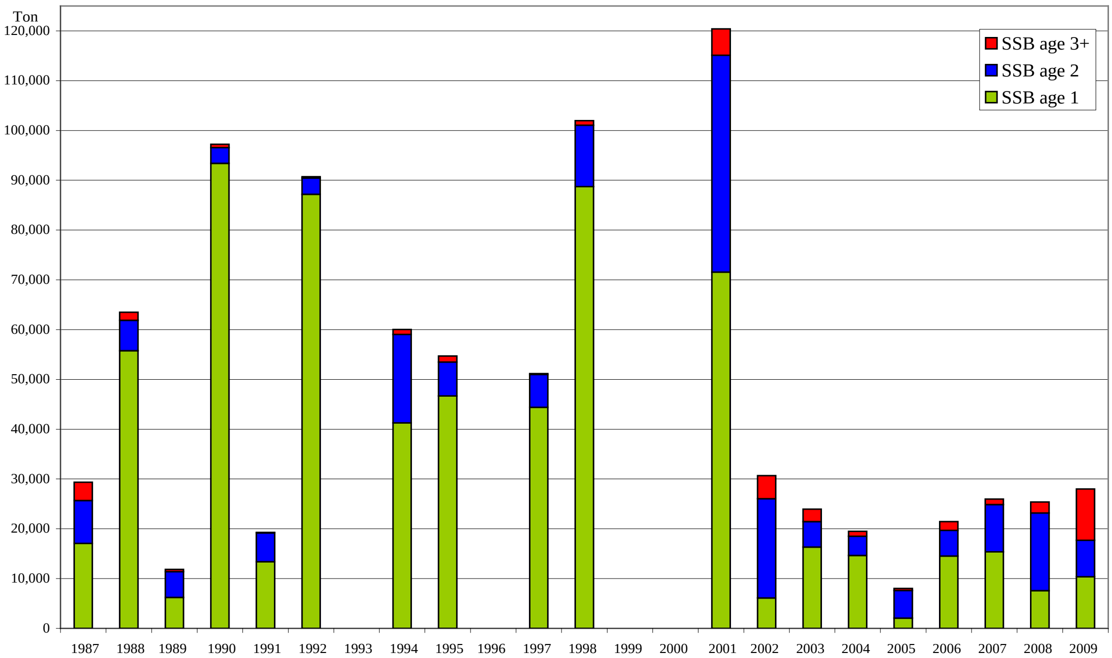


Figure 2.4.1.4.3: Bay of Biscay anchovy: Historical series of biomass at age from 1987 to 2009.

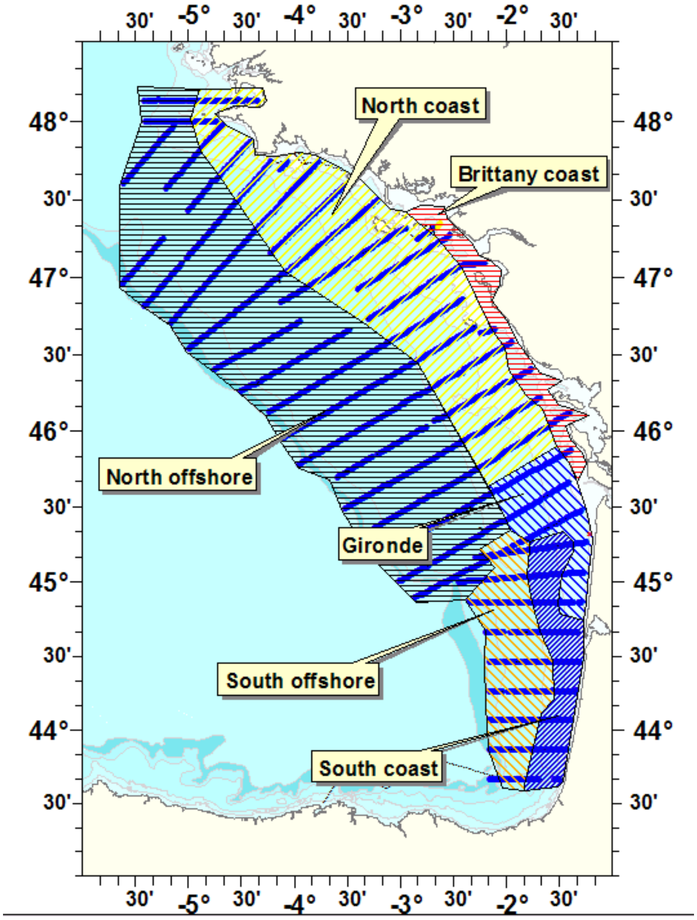


Figure 2.4.2.1. coherent strata, in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS09 survey

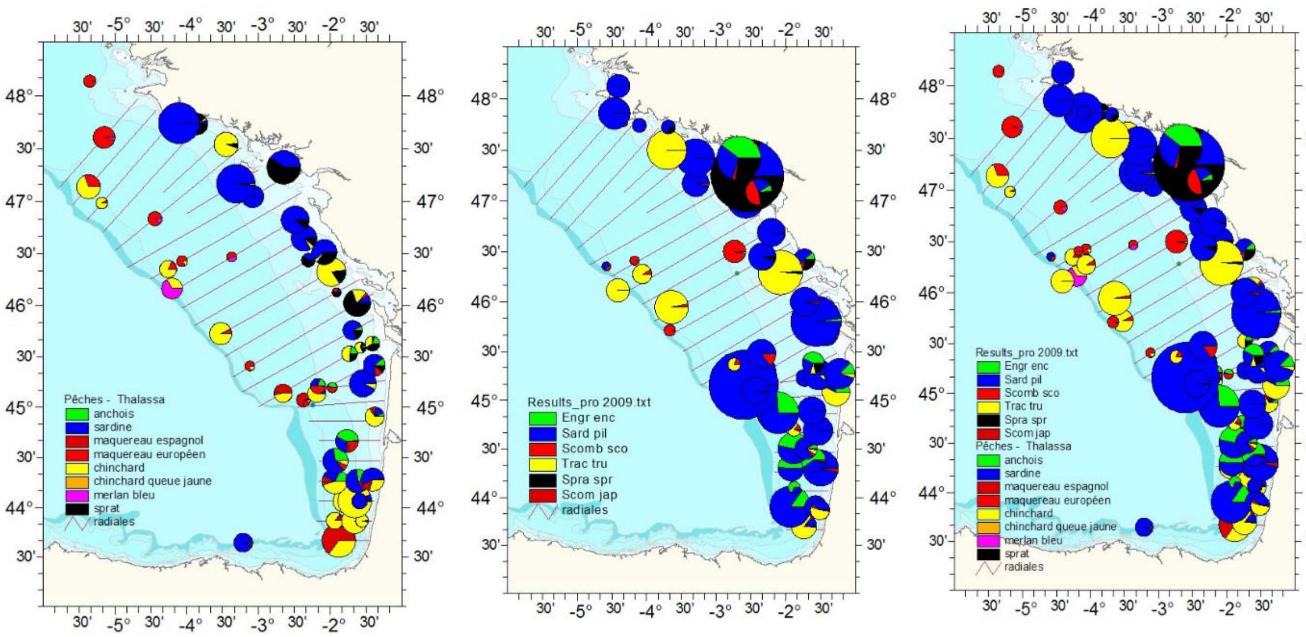


Figure 2.4.2.2 fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS09

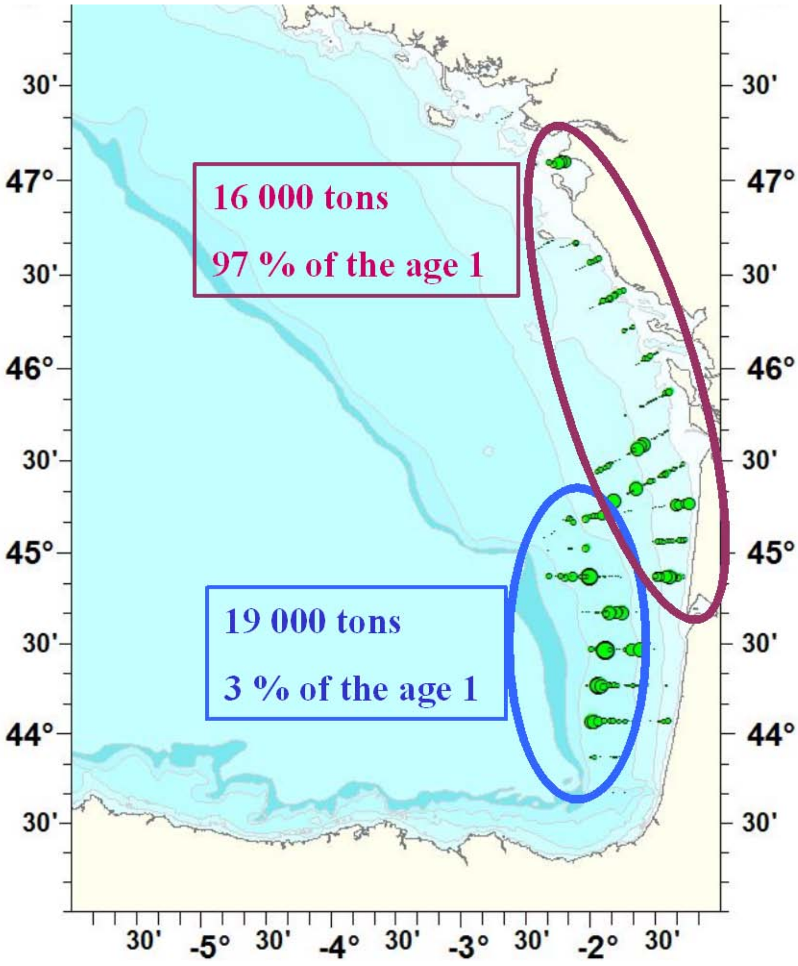


Figure 2.4.2.3. Anchovy distribution observed during PELGAS09 survey.

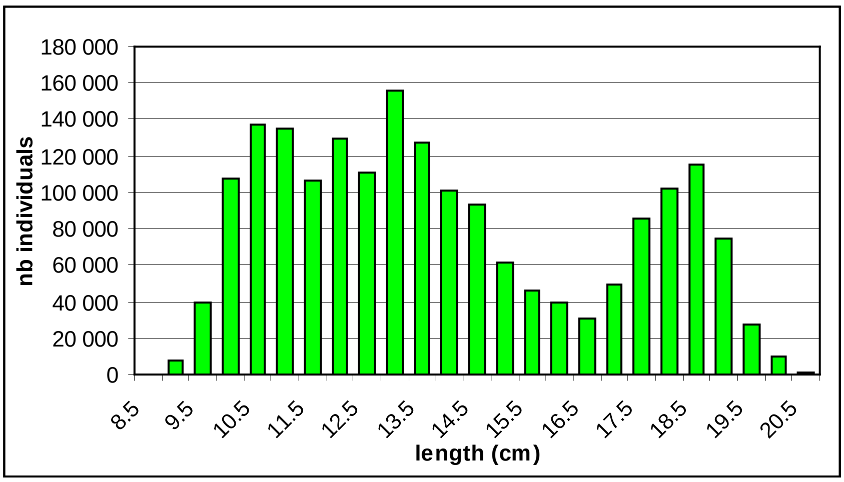


Figure 2.4.2.4. global length structure of anchovy during PELGAS 09 (in numbers)

Figure 2.4.2.5. . global age structure of anchovy during PELGAS 09 (in numbers)

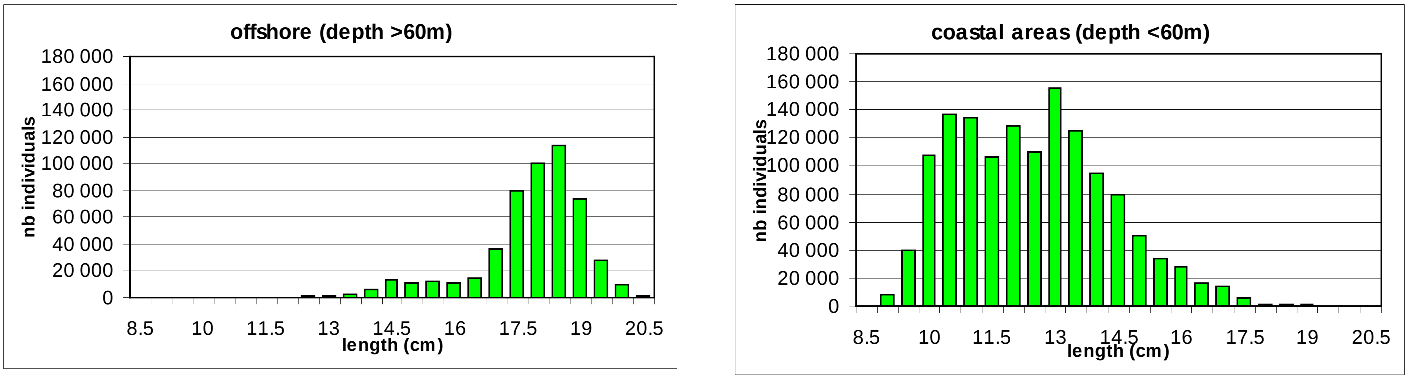


Figure 2.4.2.6. : length structure of anchovy during PELGAS 09 according to the two main areas where anchovy occured

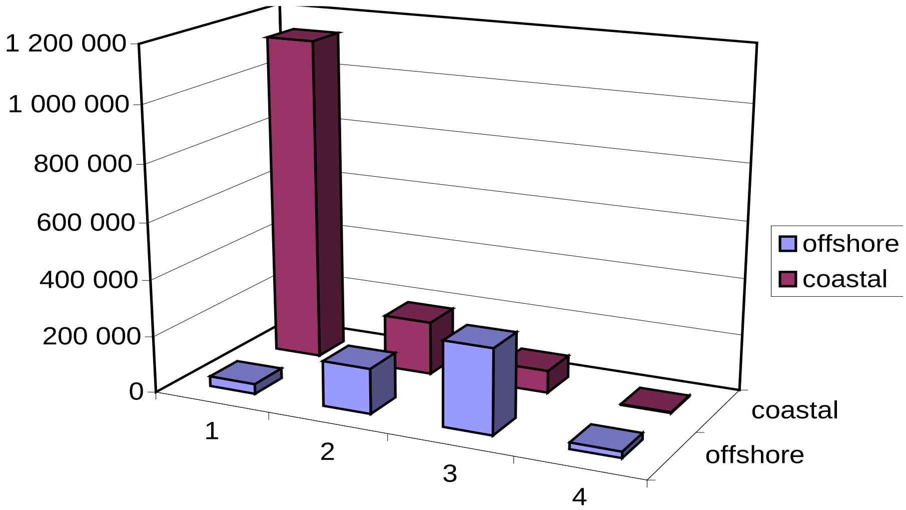


Figure 2.4.2.7. : numbers at age during PELGAS09 according to the two main areas where anchovy occurred.

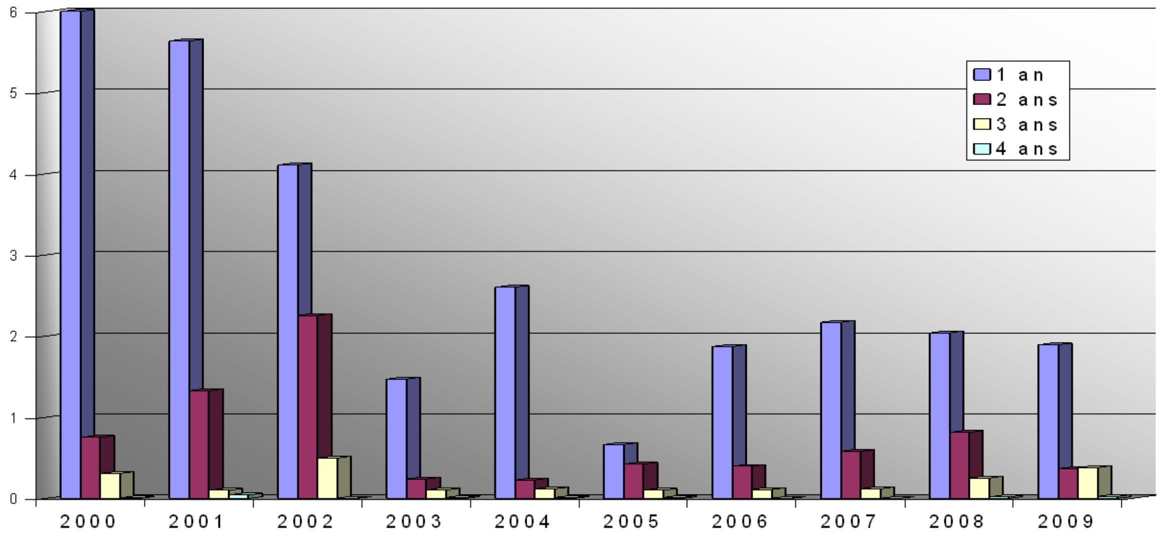


Figure 2.4.2.8. demographic structure of anchovy in the bay of Biscay (numbers at age) since 2000.

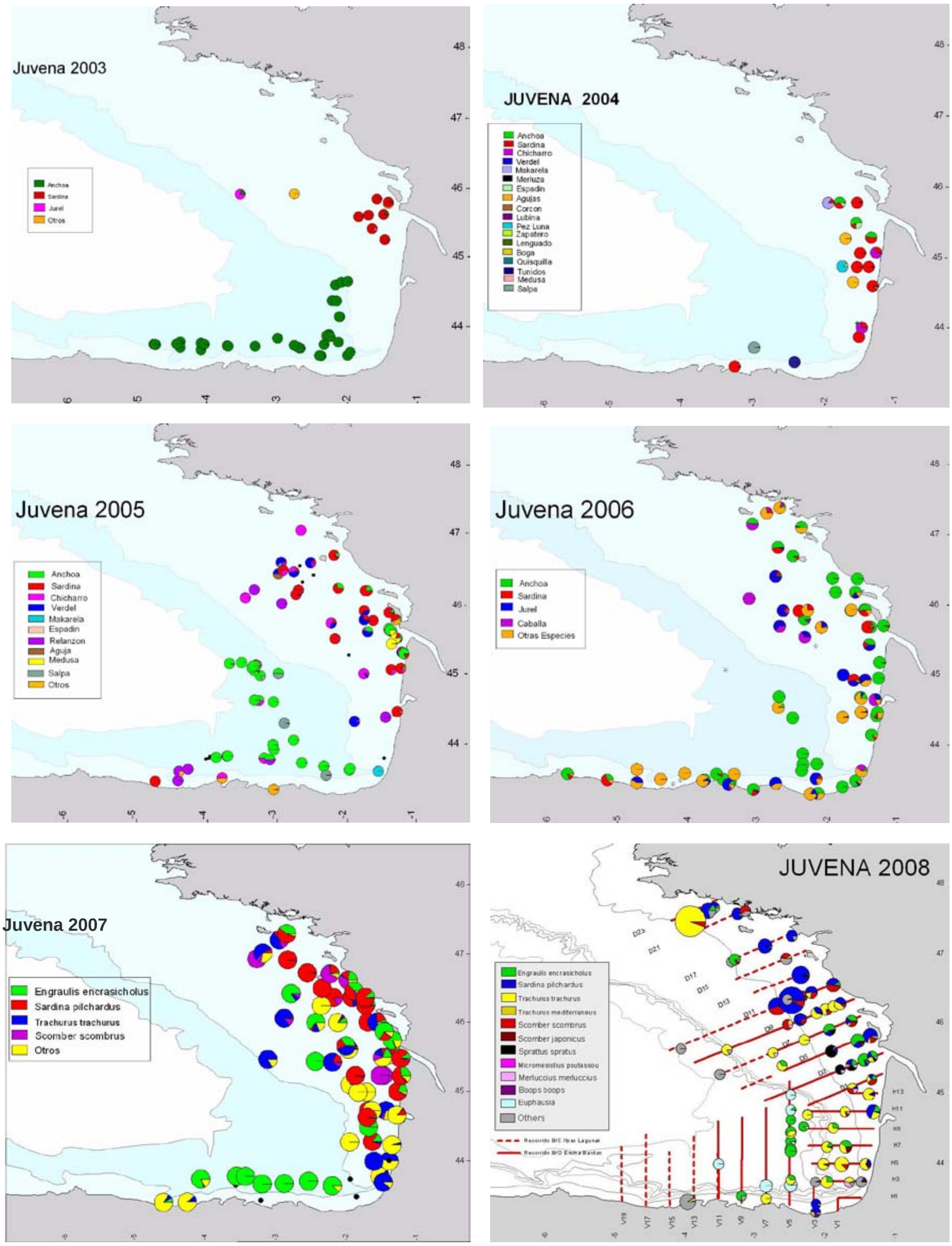


Figure 2.4.3.1: Location of the fishing stations during the past JUVENA surveysand the Species composition per hauls

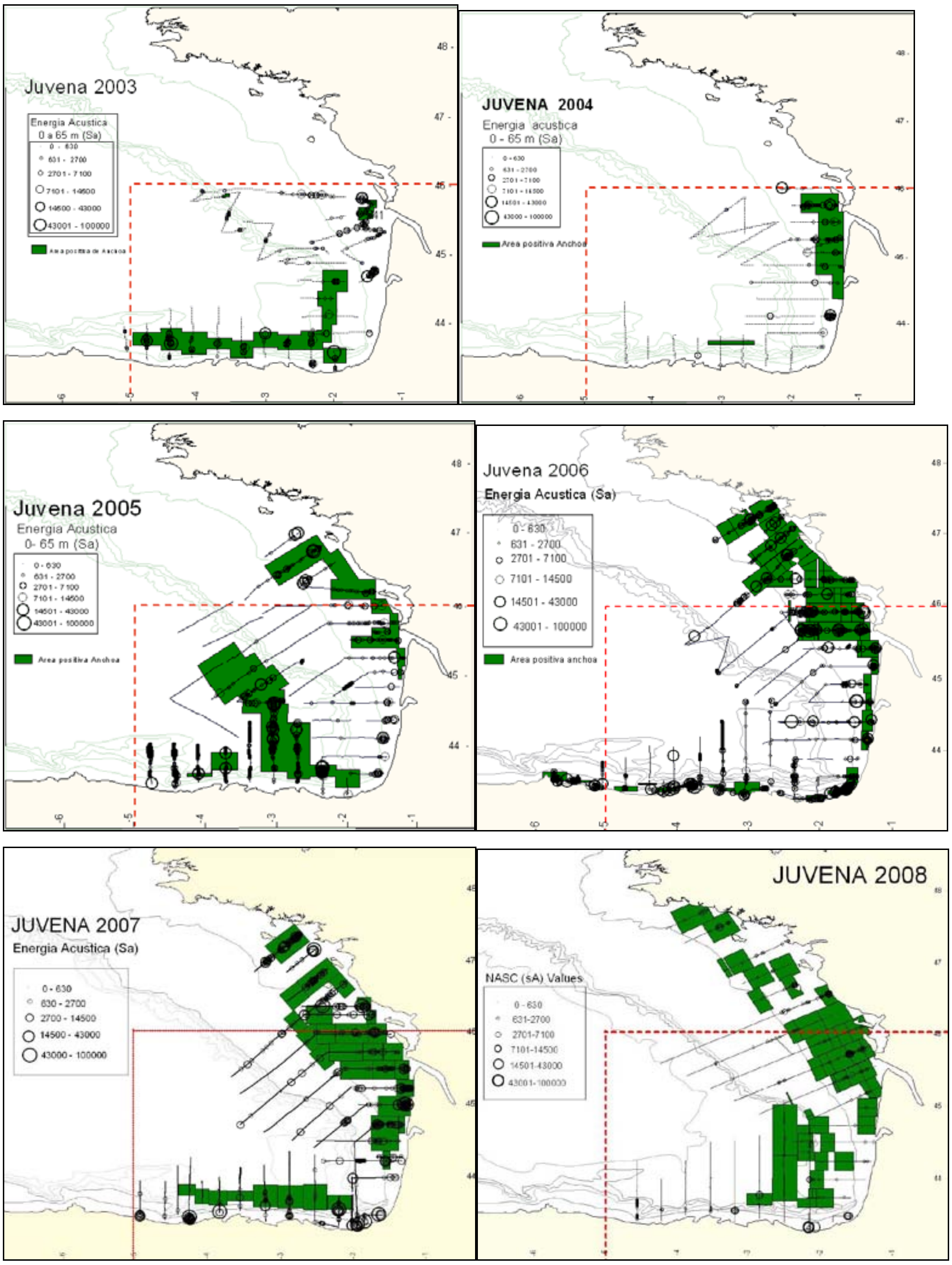


Figure 2.4.3.2: Positive area of presence of anchovy and total acoustic energy echo-integrated (from all the species) for the six JUVENA surveys. The area delimited by the dashed line is the minimum or standard area used for inter annual comparison.

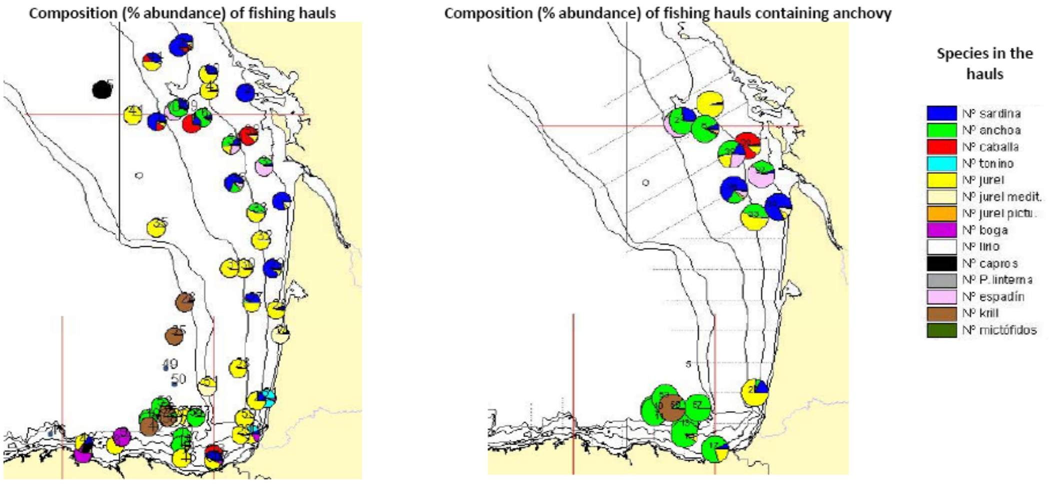


Figure 2.4.3.3. Distribution of fishing hauls and species composition of each haul (in percentage of abundance) for the identification of echotraces conducted during the PELACUS1008 cruise. Total number of hauls (left) and hauls containing anchovy (right).

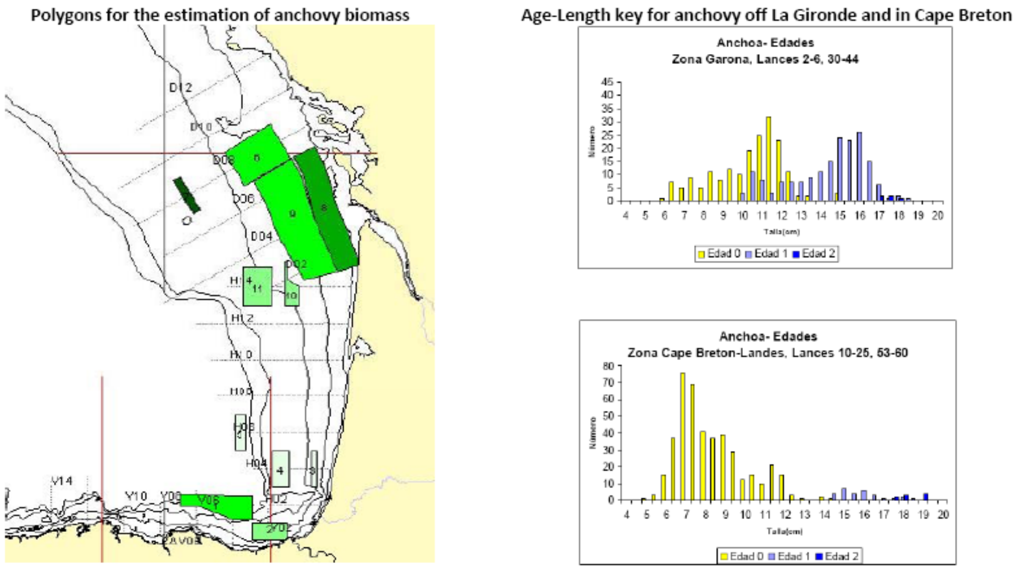
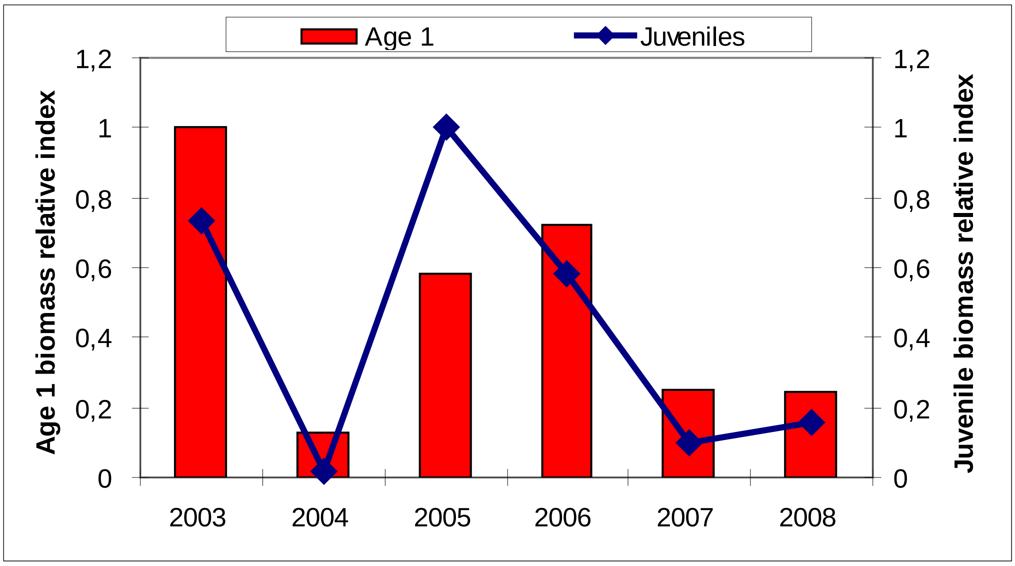


Figure 2.4.3.4. Distribution of polygons for the estimation of biomass of anchovy (left) and length-age distribution applied to split the population in juveniles (age 0) and adults (age 1+) (right-top, for the zone off La Gironde; right-bottom, for the zone of Cape Breton.



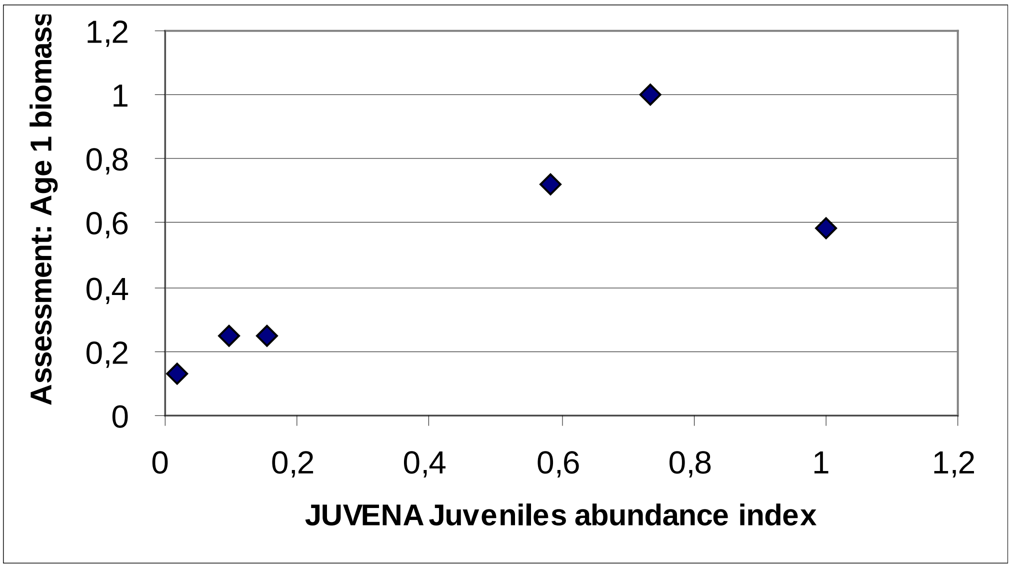


Figure 2.4.3.5 Upper panel: comparison of the times series of the JUVENA anchovy juveniles abundance index with the assessment at age 1 in the following year (median values) produced by Bayesian assessment included in this report. Bottom panel: scatter plot of the series. The comparisons are made in relative terms, scaling the series to their maximum estimate. R=0.801, R2=0.642 P(R=0)=0.06 .

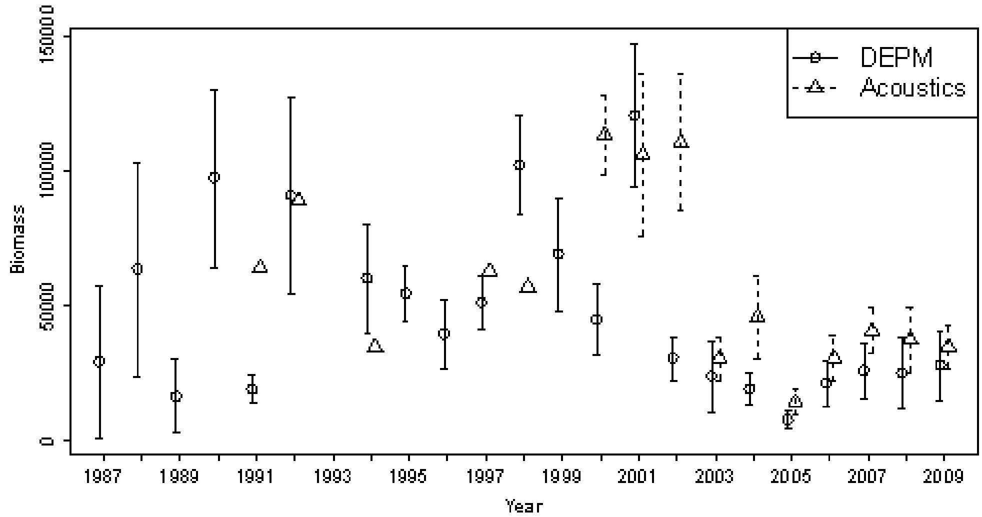


Figure 2.5.2.1: Bay of Biscay anchovy: Historical series of spawning stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

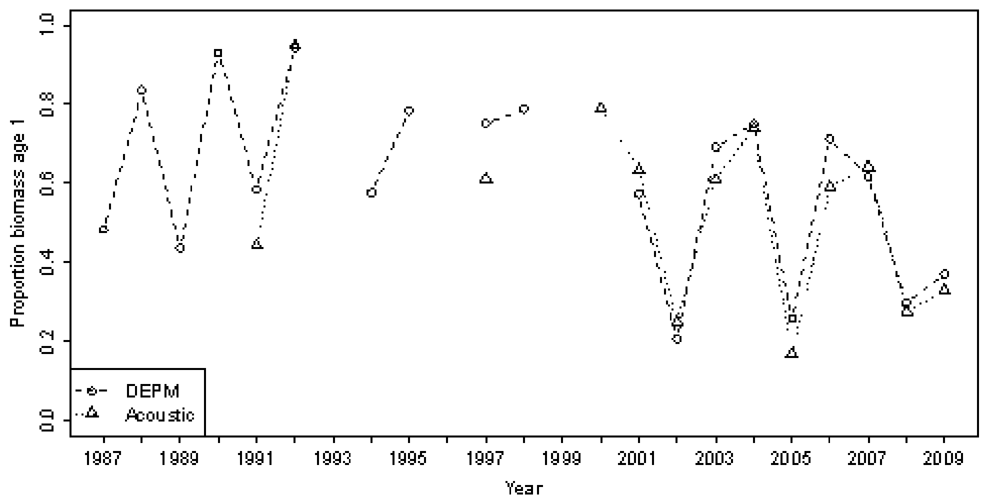


Figure 2.5.2.2: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

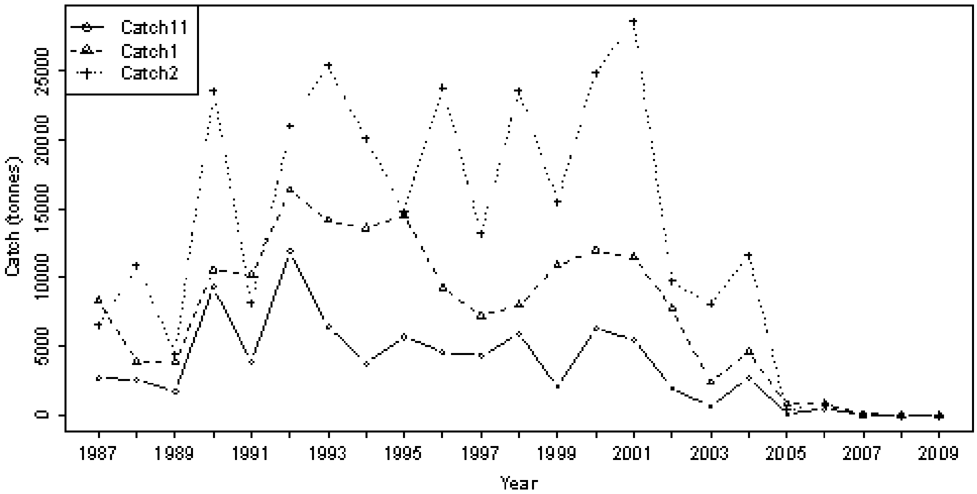


Figure 2.5.2.3: Bay of Biscay anchovy: Historical series of age 1 and total catch in the first period (1st January-15th May) (solid line and open circle and dashed line and triangle respectively) and of total catch in the second period (15th May-31st December) (dotted line and cross).

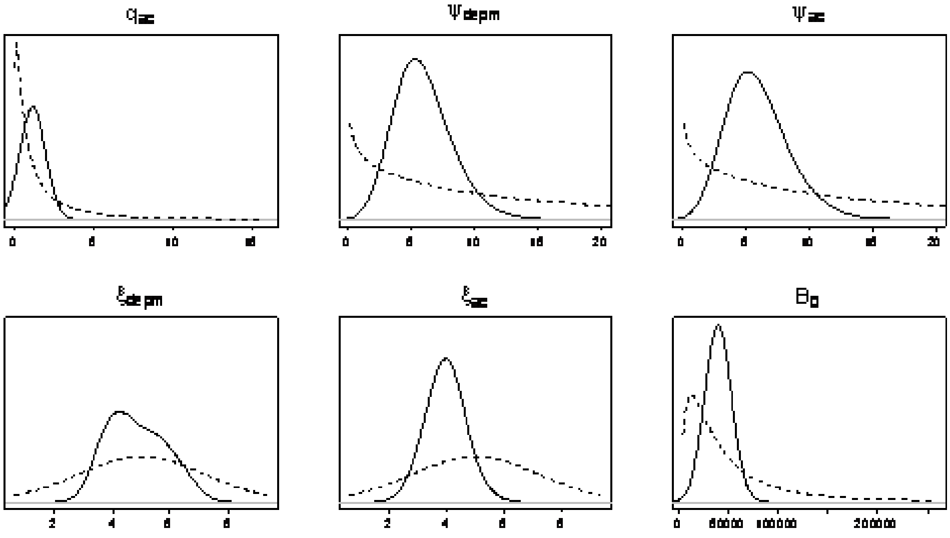


Figure 2.5.2.4: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of BBM.

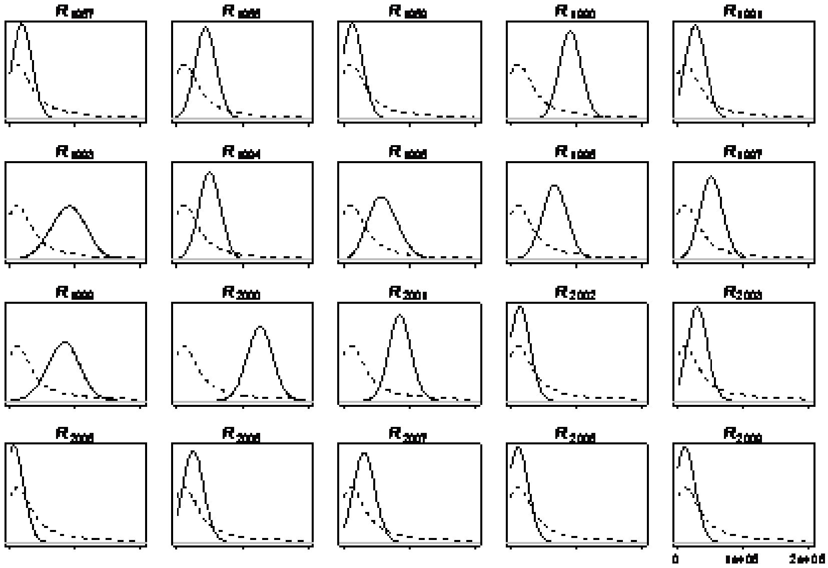


Figure 2.5.2.5: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for recruitment in BBM.

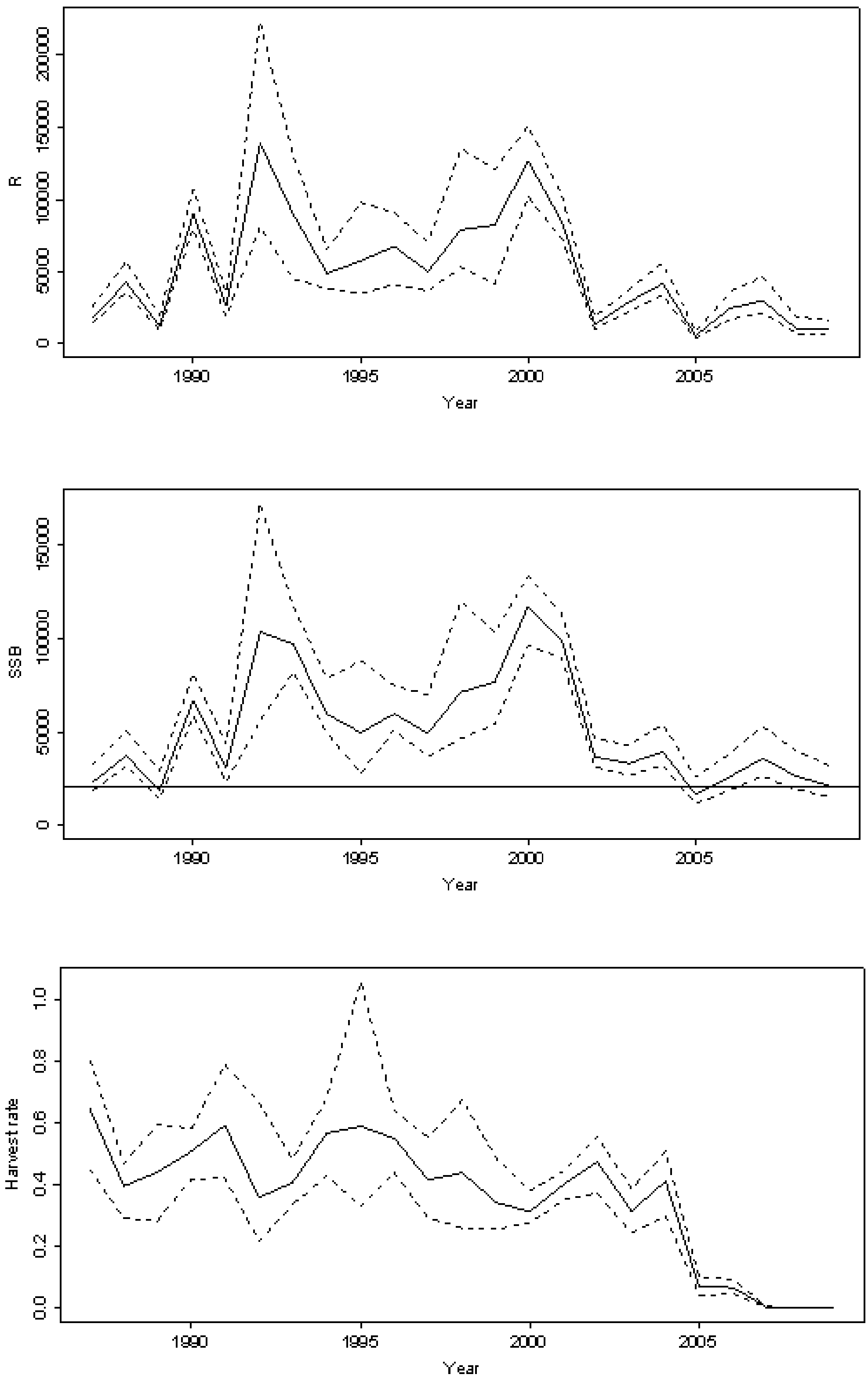


Figure 2.5.2.6: Bay of Biscay anchovy: Posterior median (solid line) and 95% probability intervals (dashed lines) for the recruitment (age 1 in mass), the spawning stock biomass and the harvest rates (Catch/SSB) from the BBM. The horizontal line in the mid panel represents Blim (21 000 t).

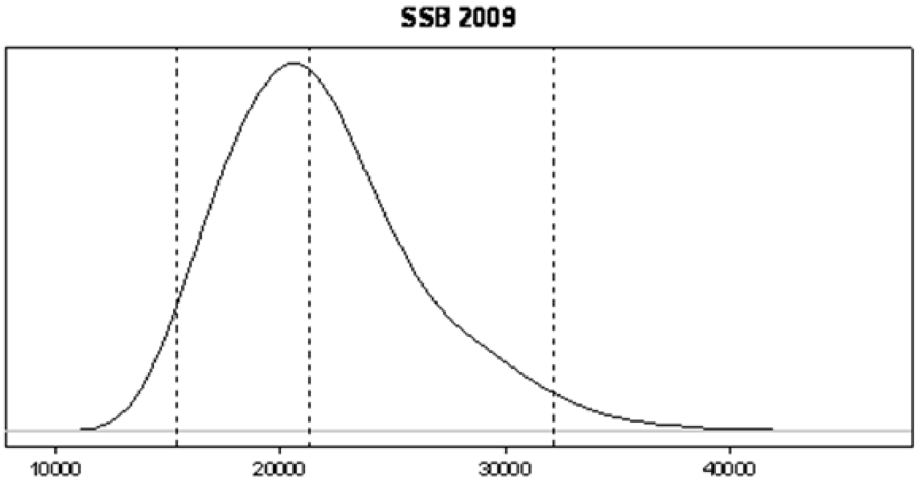


Figure 2.5.2.7: Bay of Biscay anchovy: Posterior distribution of spawning biomass in 2009 from BBM. Vertical dashed lines correspond to posterior median and 95% probability intervals.

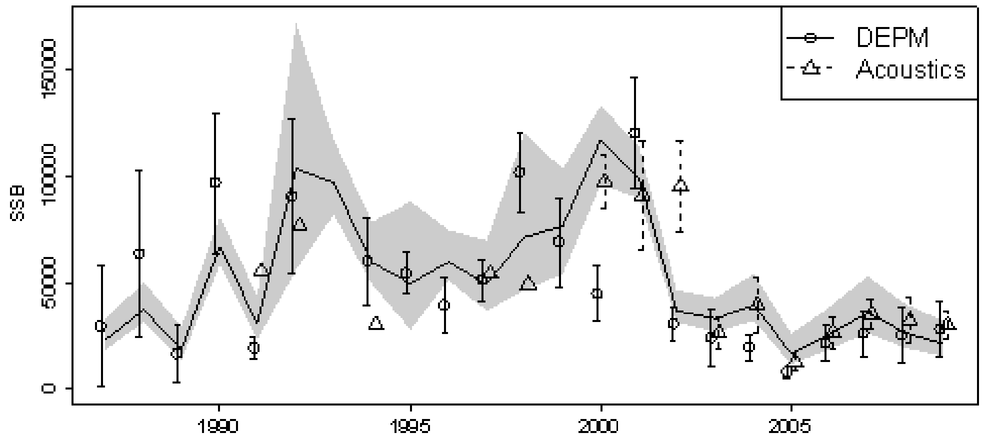


Figure 2.5.3.1.1: Bay of Biscay anchovy: Comparison of the SSB posterior 95% probability intervals from the BBM (grey area) and the SSB indices corrected by their catchability with the corresponding confidence intervals from DEPM (open circle and solid line) and Acoustics (triangle and dashed line).

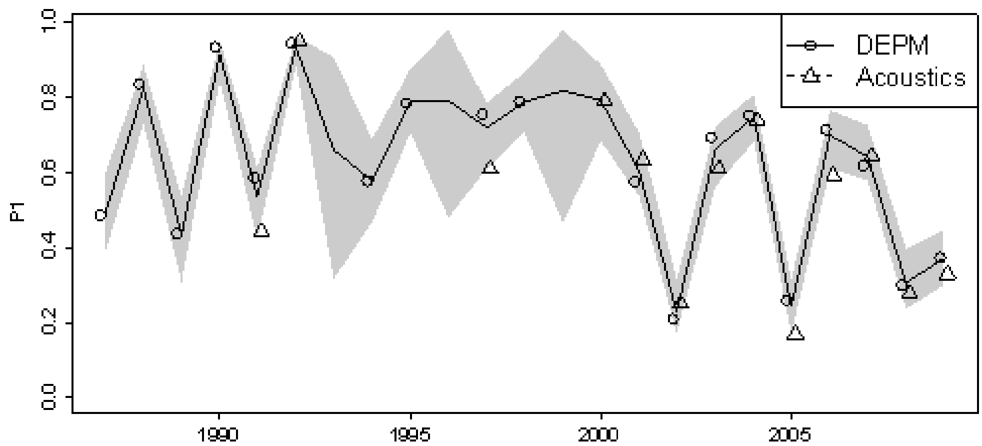


Figure 2.5.3.1.2: Bay of Biscay anchovy: Comparison of the age 1 biomass proportion posterior 95% probability intervals from the BBM (grey area) and the point estimates from DEPM (open circle) and Acoustics (triangle).

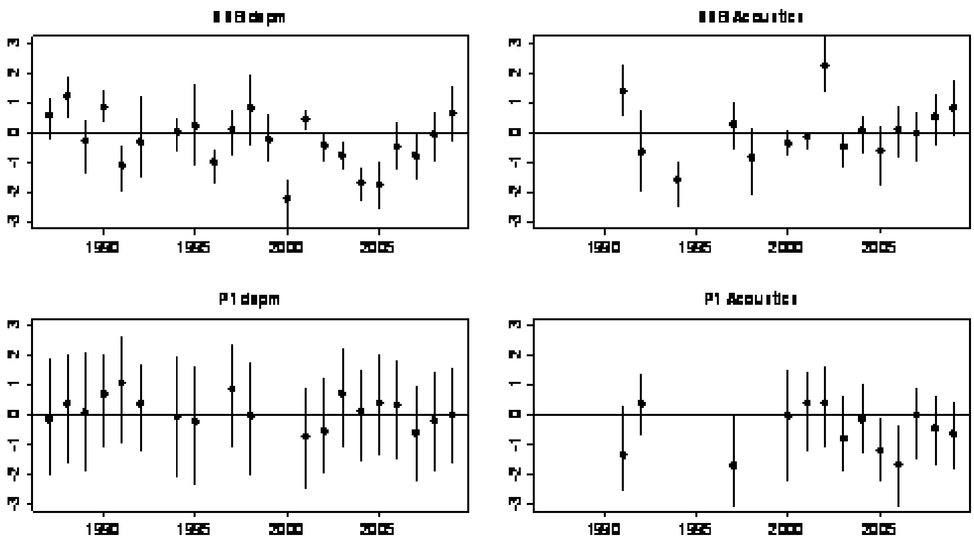


Figure 2.5.3.1.3: Bay of Biscay anchovy: Pearson residual medians and 95% probability intervals of the four indices (SSB and proportion of biomass at age 1 from DEPM and Acoustics) used in the BBM.

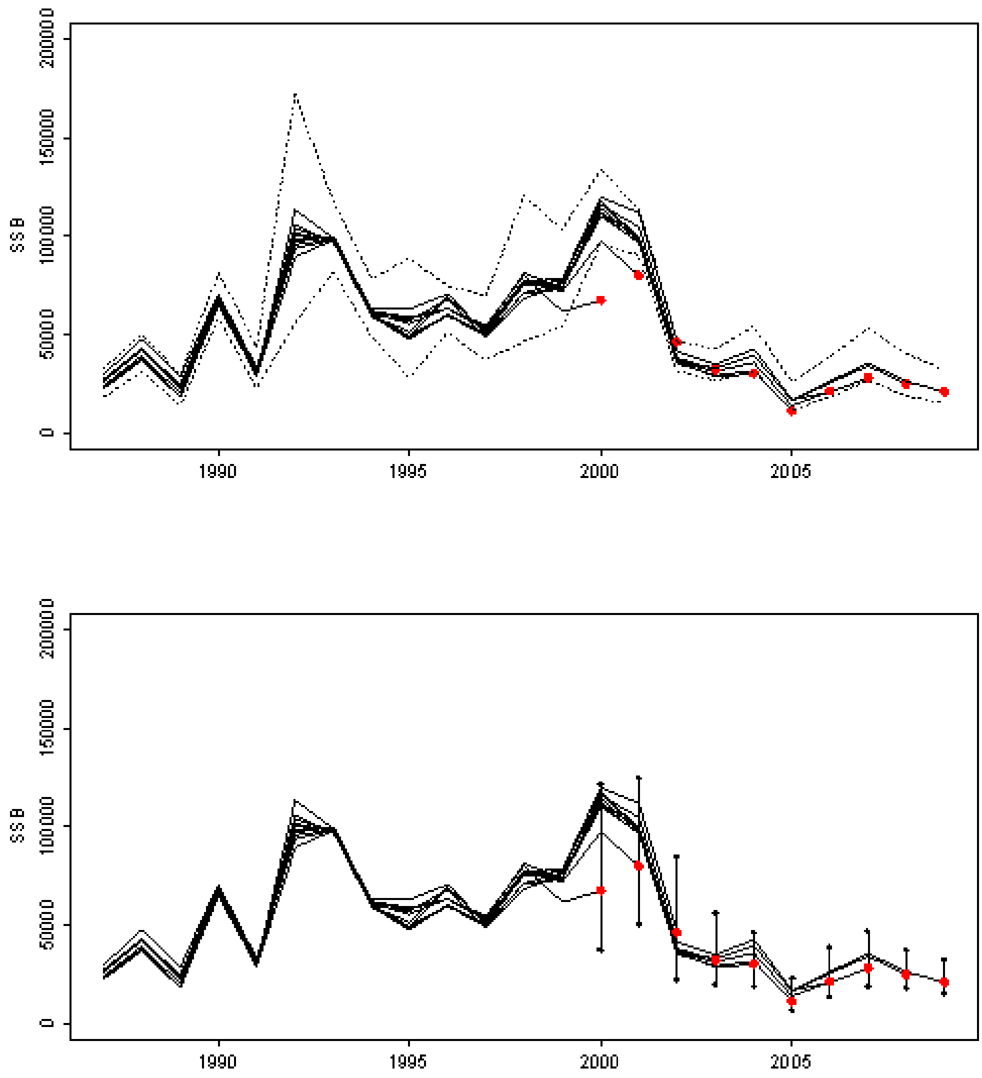


Figure 2.5.3.3.1: Bay of Biscay anchovy: Retrospective analysis for the BBM. Solid lines represent the SSB medians for each annual assessment. The red solid circles are the SSB median from the last year of each annual assessment. The dashed lines in the upper panel represent the 95% probability intervals for the assessment in 2009, whereas the vertical segments in the lower panel represent the 95% probability intervals in the last assessment year.

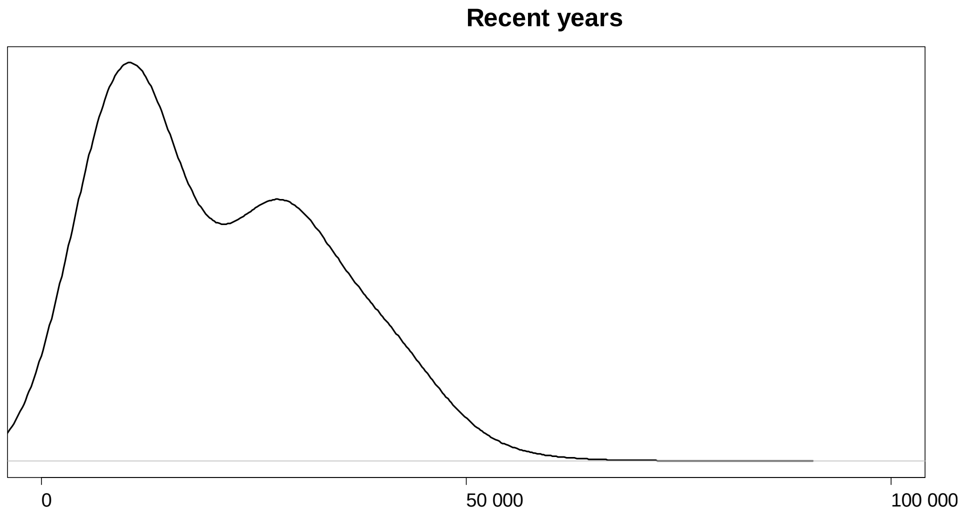
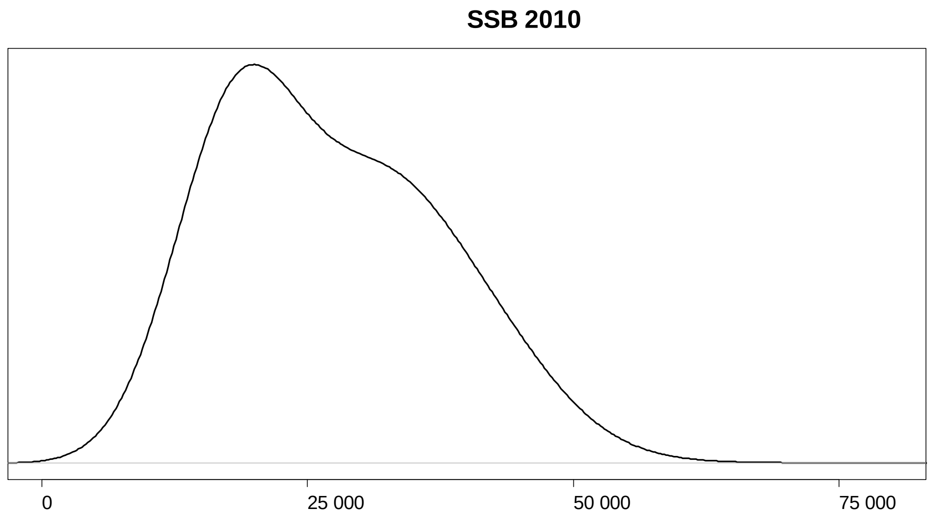


Figure 2.6.3.1: Bay of Biscay anchovy: Recruitment scenario for 2010 constructed as a mixture distribution of the recruitment posterior distribution of recent years (2002-2009).



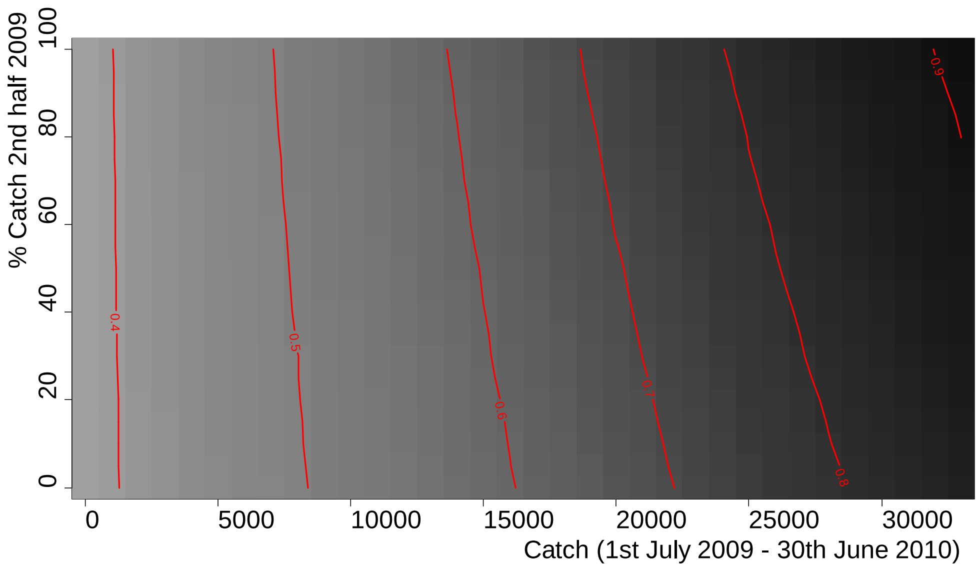


Figure 2.6.3.3: Bay of Biscay anchovy: Contour plots of probability of SSB in 2010 of falling below Blim depending on the total catch from 1st July 2009 to 30th June 2010 (x-axis) and the percentage of catch corresponding to the second half of 2009 (y-axis).

3 Anchovy in Division IXa

3.1 ACFM Advice Applicable to 2008 and 2009

ICES advice from ACFM recommendations in December 2005 (ICES, 2005 a) firstly stated that, at present, the state of the anchovy stock in Division IXa is unknown because of the inadequacy of the available information to evaluate the spawning stock or fishing mortality relative to risk (precautionary limits). So far, these shortcomings are preventing 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 that catches since 2007 should be restricted to 4,800 t (mean catches from the period 1988-2006, 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.

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.

The agreed TAC for anchovy since 2002 (for ICES Subareas IX and X and EC waters of the CECAF Sub-area 34.1.1) is of 8,000 t. Anchovy catches in Division IXa in 2008 (3,508 t) accounted for 46% decrease in relation to the levels recorded in 2007 (6,454 t) and are between the lowest levels recorded in the recent years. For 2009 this TAC has been agreed again in 8,000 t, with national catch quotas being established at 3,826 t for Spain and 4,174 t for Portugal.

3.2 The Fishery in 2008

3.2.1 Fleet composition in 2008

Number and technical characteristics of the purse-seine vessels operated by Spain in the Gulf of Cádiz, differentiated between total operative fleet and fleet targeting anchovy are summarised in Table 3.2.1.1 and in the Stock annex. In 2008, the entire Spanish purse-seine fleet fishing in the Gulf of Cadiz was composed by 91 vessels, with 86 vessels dedicated in a greater or lesser extent to the anchovy fishing.

Details of the fleets' dynamics in terms of number of operative vessels over time in recent years are given in the Stock Annex.

3.2.2 Catches in 2008

3.2.2.1 Landings in Division IXa

Anchovy total landings in 2008 were 3,508 t, which was a 46% decrease compared to the 2007 landings (6,454 t). The landings were amongst the lowest on record in the recent historical series (Table 3.2.2.1.1, Figure 3.2.2.1.1). There was a marked reduction of catches from Subdivision IXa-CN and IXa-S(Cádiz) where most of the catches originate.

As usual, the anchovy fishery in 2008 was almost exclusively by the purse seine fleets (96% of total catches). Portuguese and Spanish purse-seine landings accounted for 55% and almost the total of their respective national total catches (**Table 3.2.2.1.2**). Landings from the Portuguese artisianal fishery as well as from the trawlers (both Spanish and Portuguese) were still small in relation to the whole anchovy fishery in the Division.

The anchovy fishery in 2008 was mainly located in the Subdivision IXa South (3,204 t, *i.e.*, 91% of total catch in the whole Division, Table 3.2.2.1.3, Figure 3.2.2.1.2). As observed in recent years, the bulk (99%) of these southern catches was fished in the Spanish Gulf of Cadiz (3,168 t *vs* 37 t landed in the Algarve). The relative importance of landings in the remaining Subdivisions was negligible excepting in the IXa-CN, where 211 t were landed.

The Spanish fishery in 2008 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 4 t in Subdivision IXa North, *i.e.*, southern Galician waters). Despite this, as advanced in the Section 3.2.1.1 above, the Gulf of Cadiz fishery experienced a marked (43%) decrease in catches in relation to the year before (from 5,576 t in 2007 to 3,168 t in 2008). The possible causes of this decrease are described in Section 3.2.3.

The Portuguese anchovy fishery has historically shown alternate periods of relatively high and low landings in each of their three Subdivisions, anchovy fishery being located either in the IXa South (before 1984), or in the IXa Central-North (from 1984 to 1997, and in 2007 and 2008), or mainly distributed in both Subareas (from 1998 to 2003), (see Table 3.2.2.1.1, Pestana, 1989, 1996; ICES, 2007 a).

The Gulf of Cadiz Spanish purse-seine fishery was closed from mid November 2007 to mid February 2008, and from December 2008 to February 2009 (3 months per period), as part of the management measures included within the "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This management plan was first implemented in 2004 and since then the fishery closures (that lasted 45 days in 2004 and 2005, and the last 2 months in 2006) have been accompanied by a subsidized tie-up scheme for the purse-seine fleet. A more detailed description of this plan and the impact of the previous closures in landings and fishing effort was given in ICES (2007 a). The effects of these closures on the purse-seine quarterly landings in 2004-2008 as compared with preceding years are shown in Figure 3.2.2.1.1. The years included in this figure are those when the whole purse-seine fleet has been exerting its greatest fishing capacity. The impact of the closures, affecting in the beginning and at the end of 2008, in the 2008 annual landings was very evident in the 2008 first quarter and relatively lower in the fourth quarter than in the two preceeding years. Impacts of this management measure in the fishing effort will be discussed in **Sections 3.2.4** and **3.7.2**, and in Stock Annex.

In Portugal, a closure of the purse-seine fishery has been agreed by the producers organisations in the northern Portuguese coast (north of the 39º42'' north, *i.e.* Subdivision IXa Central-North) since 2003. This closure lasts for 2 months, although since 2006 it may be selected between 1st of February and 30th of April (*i.e.* boats stopped fishing in February to March or in March to April). 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.

Seasonal distribution of catches by country and Subdivision in 2008 is shown in Table 3.2.2.1.3. Anchovy catches were recorded throughout the year in all Subdivisions, although with a different intensity. The scanty catches from the northernmost Spanish Subdivision (South Galicia) were mainly landed during the second semester. Portuguese catches from the IXa Central-North were mainly landed during the first quarter, whereas catches from the Central-South and South sub-areas were landed during the fourth quarter. 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.

3.2.2.2 Catch Numbers at Age

Catch-at-age data from the whole Division IXa in 2008 are only available from the Spanish Gulf of Cadiz fishery (Subdivision IXa South). 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 Subdivision IXa North are not available since commercial landings used to be negligible.

Total catch in the Gulf of Cadiz in 2008 was estimated at 227 million fish, which represents a 63.8% overall decrease in numbers with respect to 2007 (628 millions), and a level close to the recent minima recorded in 1993 (207 millions), 1995 (69 millions), and 2000 (320 millions). The aforementioned landed numbers in 2008 are the result of a strong (75,3%) drop in landings of the 1 age-group (from 559 millions in 2007 to 138 millions in 2008). Conversely, the remaining age groups either remained at the same level that in the previous year (*i.e.*, 0 age-group) or even showed increased landings (*i.e.*, 2 and 3 age-groups).

Landings of the 0 age-group anchovies in 2008 were restricted to the second half of the year (although mainly during the third quarter), whereas 1 and 2 year-old catches were present throughout the year. Three year-old anchovies occurred again in the fishery (the last time they occurred in the fishery was in 1992). These older anchovies were fished throughout the first semester (Table 3.2.2.2.1, Figure 3.2.2.2.1).

3.2.2.3 Mean Length- and Mean Weight at Age

Gulf of Cadiz anchovy quarterly length distributions from the Spanish fishery in 2008, the only available for this WG, are shown in Table 3.2.2.3.1 and Figure 3.2.2.3.1. 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. In 2008, however, lower estimates for both variables were recorded in the first and third quarters.

Annual mean length and weight at age of Gulf of Cadiz anchovy are given in Tables 3.2.2.3.2 and 3.2.2.3.3, Figure 3.2.2.3.2

Gulf of Cadiz anchovy mean length and weight in the 2008 annual catch (12.3 cm and 13.1 g) are the highest ever recorded in the historical series, due to high weights at ages 0 and 1.

Age group 0: mean length and weight in 2008 were 10.6 cm and 7.9 g respectively. Through the available data series (1988 onwards) these estimates have ranged between 5.8 cm and 1.3 g (1996), and 10.5 cm and 6.9 g (1989). A noticeable increasing trend has been observed in both estimates in the most recent years. The 2008 estimates are the highest in the historical series.

Age group 1: mean length and weight in 2008 were 12.5 cm and 13.6 g respectively. Mean lengths and weights have oscillated between 8.9 cm-6.4 g (1996) and 12.0 cm-

12.4 g (2001). Both estimates for this age group show a strong increase in relation to the last years. The 2008 estimates are also the highest in the historical series.

Age group 2: mean length and weight in 2008 were 14.3 cm and 20.4 g respectively. Mean lengths have oscillated between 13.5 cm-14.9 g (1998) and 16.9 cm-33.5 g (1989). Since 2002 both estimates have experienced a remarkable decreasing trend which is showing a slight recovery just in 2008.

Age group 3: mean length and weight in 2008 were 15.4 cm and 25.5 g respectively. The first previous occurrence of this age group in the fishery was in 1992 (with mean annual estimates of 16.9 cm and 30.2 g).

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 – 2008 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.

3.2.3 Discards

There is only sparse information about discards, which is further described in the Stock Annex.

3.2.4 Effort and Catch per Unit Effort

Annual and half-year standardised CPUE series (1988 – 2008) for the whole Spanish purse-seine fleet fishing Gulf of Cádiz anchovy (Subdivision 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. Series of standardised overall annual effort and CPUE and the historical series of landings from this fishery are shown in Figures 3.2.4.1. Figures 3.2.4.2 and 3.2.4.3 show annual and quarterly 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 is shown in the Stock Annex.

In 2008 the overall fishing effort of the Spanish purse-seine fleet fishing anchovy in the Gulf of Cádiz fishing ground showed a marked decrease (50.2%), from 6,973 standardised fishing days in 2007 to 3,469 fishing days in 2008. A combination of fishing closures, some periods of bad weather during the fishing season, after the reopening of the fishery in March, the displacement of a part of the fleet to the Moroccan fishing grounds (benefiting from fishing licenses under the EC-Morocco Fishery Agreement), may be the responsible for the decrease in the fishing effort. The annual CPUE, however, was maintained at a level similar (0.913 t/fishing day) to the one recorded the previous year (0.800 t/fishing day).

3.3 Biological Data

3.3.1 Weights at age in the stock

Weights at age in the stock are summarized in Table 3.5.1. See the Stock Annex for comments on computation and trends.

3.3.2 Maturity at Age

Annual maturity ogives for Gulf of Cadiz anchovy are shown in Table 3.3.2.1. See the Stock Annex for comments on computation and trends in the maturity ogives of Gulf of Cádiz anchovy.

3.3.3 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 year for the data exploration, see Table 3.5.1 and Stock Annex).

3.4 Fishery-Independent Information

3.4.1 Acoustic Surveys

A detailed description of the available acoustic surveys providing estimates for anchovy in 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 given in ICES (2008 b).

Results from the spring Portuguese (*PELAGO08*) and Spanish (*PELACUS0408*) acoustic surveys in 2008 were reported in the last year's WGANC and WGACEEG (ICES, 2008 a, b). The present section covers surveys between the (November) 2008 WGACEEG and the present 2009 WGANSA meetings.

3.4.1.1 Portuguese Surveys

Two Portuguese acoustic surveys have been carried out since the last year's WGACEEG meeting: one survey in November 2008 (*SAR08NOV*) and the other one in April 2009 (*PELAGOS09*). Both surveys were carried out with the R/V 'Noruega' and followed the standard methodology adopted by the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX (ICES 1986, 1998) and WGACEGG (see, for instance, ICES 2008 b). The surveyed area usually includes the waters of the Portuguese continental shelf and those of the Spanish Gulf of Cadiz (Subdivisions IXa Central-North, Central-South, and South), between 20 and 200 m depth. Additional results from these surveys concerning to sardine are shown in **Section 5.3.2**.

***SAR08NOV* autumn survey:**

The November 2008 survey (*SAR08NOV*) aimed to cover the sardine early spawning and recruitment season in the Division IXa. The survey took place from the 2nd to the 27th of October covering the Portuguese coast and the Gulf of Cádiz. No anchovy acoustic estimates has been provided by IPIMAR from this survey since the species was not a target in this occasion. **Figure 3.4.1.1** shows the historical series of anchovy acoustic estimates from Autumn Portuguese surveys in the Division IXa so far.

***PELAGOS09* spring survey:**

Figure 3.4.1.2 summarises the main results from the April 2008 survey (*PELAGOS08*) for comparison with the present year's data.

The April 2009 survey (*PELAGOS09*) took place from the 26th of March to the 24th of April and covered the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth.

The anchovy total biomass estimated during this survey for the whole Division IXa was 26.8 thousand tonnes (2,196 million fish), which represent 32.4% and 6.7% decreases in biomass and numbers respectively in relation to the 2008 estimates (39.7 thousand tonnes, 2,353 million fish).

As usual, anchovy was mainly distributed off the Gulf of Cádiz (Subdivision IXa-South(C)), where they were also more abundant (1919 million fish, 21 thousand tonnes). Nevertheless, anchovy biomass in this area experienced a 28.9% decrease with respect to the levels estimated in 2008 (29.5 thousand tonnes). Such a biomass is sustained by a relatively similar level of abundance than in 2008 (1819 millions), evidencing the occurrence in 2009 of smaller anchovies as an average in this area as shown after comparing size histograms from **Figures 3.4.1.2** and **3.4.1.3**. In the Subdivision IXa-South (Algarve) anchovy abundance and biomass were estimated at 159 million fish and 3.8 thousand tonnes and they were mainly distributed close to V. Real de Sto. António in the Portugal-Spain border and in a secondary nucleus in front of Portimão. As usual, anchovies here are larger than in the Spanish part.

In the Subdivision IXa-CN the species occurred in Figueira da Foz and Nazaré (127 million fish, 2 thousand tonnes), whereas in the Subdivision IXa-CS no characteristic echo-traces attributable to the species were detected, mainly in the Lisbon zone, where the species usually occurs. Notwithstanding the above, in this last Subdivision was not possible to perform any pelagic fishing but only bottom-trawl hauls, a cause which conditioned the sampling (**Figure 3.4.1.3**).

Figure 3.4.1.4 shows the historical series of anchovy acoustic estimates from Spring Portuguese surveys in the Division IXa so far.

3.4.1.2 Spanish Surveys

The only Spanish survey carried out in waters of the Division IXa in the first half in 2009 was the *PELACUS0409* survey, performed on board R/V *Thalassa* between 27th March to 23rd April. This survey samples the waters off the Subdivision IXa-North and VIIIc since 1983. The *ECOCÁDIZ 0609* survey, surveying the waters off the Subdivision IXa-South, will be conducted between 26th June to 6th July. No survey from this last series was conducted in 2008 since ship-time was invested in the conduction of the Gulf of Cádiz anchovy DEPM survey (*BOCADEVA 0608*, see **Section 3.5.1**).

***PELACUS* 0409**

Anchovy was almost absent in the Subdivision IXa North, showing an accidental presence in the Galician Rías, rendering an acoustic estimate of only 26 t. In 2008 were also estimated only 306 t (10 million fish) for the same Subdivision. Additional results from the 2009 survey concerning to sardine are shown in **Section 5.3.2**.

3.4.1.3 Some comments on recent trends in acoustic estimates

The historical series of total and regional acoustic estimates of anchovy abundance (millions) and biomass (tonnes) either from the whole Division IXa (Portuguese surveys) or from the Subarea IXa South only (Spanish surveys) are shown in **Table 3.4.1.1** and **Figures 3.4.1.1**, **3.4.1.4**, and **3.4.1.5**.

The estimates from those surveys covering the whole southernmost subarea (the IXa South) show through the series that either the bulk (about or higher than 90% of both the total abundance and biomass) or even all the recorded anchovy is concentrated in the Spanish waters of the Gulf of Cadiz.

The series show several gaps (mainly the Autumn Portuguese one) which make it difficult to follow any clear trend. Biomass estimates from 1998 to 2003 in the Subdivision IXa-South fluctuated between 21 and 34 thousand tonnes. However, available estimates 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 reached 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 Subdivision. 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 a for a more detailed description).

In any case, as recommended by the WGACEEG in the last years, the aforementioned discrepancies strengthen 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 by Guillard and Lebourges (1998), Guennégan *et al*. (2004), and Brehmer *et al*. (2006), amongst others. IEO will try this year to perform two synchronous acoustic surveys in early summer in the Subdivision IXa-South, the standard *ECOCÁDIZ 0609* survey with its flag R/V *Cornide de Saavedra* (20 – 200 m depth) and another coastal one (*ECOCÁDIZ-COSTA 0709*, from the minimum depth possible to 50 m depth) with the smaller draught IEO R/V *Francisco de Paula Navarro* (see also **Section 4.4.3**).

3.4.2 Egg Surveys

3.4.2.1 Spanish Surveys

Anchovy DEPM surveys in the Division are only conducted by IEO for the SSB estimation of Gulf of Cádiz anchovy (Subdivision IXa-South, *BOCADEVA* survey series). So far, only 2 surveys have been carried out within this series with a triennial periodicty: *BOCADEVA 0605*, conducted in 2005, and *BOCADEVA 0608* in 2008. The present report provides information on final (2008) and revised (2005) estimates from these two surveys.

BOCADEVA 0608

The methods adopted for both the conduction of the survey and the estimation of parameters are described in Jiménez and Millán WD (Annex IV) and in the Stock Annex.

The survey was carried out from 21st of June to 3rd of July on board the R/V *Cornide de Saavedra* following the methods described in the Stock Annex and summarised in **Table 3.4.2.1**.

Egg production estimate

The survey covered a total area of 13,029 km^2, of which 6,863 km^2 were considered the spawning area. Anchovy eggs were caught mainly in the coastal area located between Cádiz and the Guadalquivir River mouth. The highest egg abundances were recorded in the stations located below the 100 m isobath. A second area of high egg abundance was also recorded in front of the Guadiana River mouth. Anchovy egg abundance was lower in the stations located in the Portuguese waters (**Figure 3.4.2.1**).

The estimates of daily egg production, daily egg mortality rates and total egg production are shown in **Table 3.4.2.2**. These estimates have associated high, although still relatively acceptable CVs.

Adult sampling and adult parameters estimates

Anchovy showed a high occurrence in fishing stations throughout the surveyed area, with catches in 22 from the 26 fishing stations. These positive stations were carried out between 6:10 and 19:15 GMT and in bathymetric range between 35 and 122 m depth (see Jiménez and Millán WD, Annex IV and **Figure 3.4.2.2**). From these 22 anchovy samples, 18 fulfilled the criterion of minimum sample size (60 anchovies), 13 samples from the Spanish waters and 5 samples from the Portuguese waters. The characteristics of the samples used for the estimation of the adults parameters are described in **Table 3.4.2.2**. The spatial distribution of the mean estimates of the adult parameters per haul is mapped in **Figure 3.4.2.3**.

Figure 3.4.2.4 shows the correction of the increased weight due to hydration in the total weight of hydrated females by a linear regression model between individual data of gonad-free-weight (Wnov) and its corresponding total weight (Wt) from non-hydrated females.

The expected batch fecundity for all mature females (Fexp) was estimated by modelling the observed individual batch fecundity (Fobs) in hydrated females in function of their gonad-free-weights (Wnov) by a GLM model (**Table 3.4.2.3**, **Figures 3.4.2.5** and **3.4.2.6**). The chosen model explained the 47% of the total variance.

Adult parameter estimates are listed in **Table 3.4.2.2**. In this case the resulting estimates showed very low associated CVs.

SSB estimate

The final SSB estimate for the whole spawning area is SSB = 31,527 t. CV 31.9% (see **Table 3.4.2.2**). This estimate is about two fold higher to the one previously estimated in the 2005 survey (see below).

Revision of BOCADEVA 0605 estimates

The 2005 DEPM estimates have been again revised this year after applying the new procedures and software adapted and developed during the WKRESTIM held in April this year. Such methods has been the ones used for the estimation of the 2008 estimates as well. **Table 3.4.2.4** summarises the old and revised egg and adult parameters and SSB estimates for comparison.

The new final 2005 SSB estimate for the whole spawning area is SSB = 14,673 t. CV 61.9%.

3.4.2.2 Considerations on the DEPM estimates and their uncertainty

As stated above, anchovy biomass estimation was based on procedures and software adapted and developed during the WKRESTIM. Although estimation has not yet been validated by the WGACEGG, WKRESTIM members considered that the extensive participation of people involved in sardine and anchovy DEPM and the use of procedures and software adopted in previous applications provide sufficient guarantees that these estimates can be used for assessment purposes in WGANSA. Nevertheless, WGANSA is concerned with the high uncertainty associated to such estimates (mainly to the egg parameters and SSB estimates) and recommend to WGACEGG a thorough review of both the sources for such uncertainty and the methods used for their estimation.

3.4.3 Recruitment surveys

As described in **Section 3.4.1**, anchovy population estimates in the Subdivision 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. However, 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. Since 2005 otolith collections from these surveys are being provided by IPIMAR to IEO in order to derive their corresponding age-length keys. Age reading, despite its difficulty in the case of southern anchovies, is in progress and is expected that disaggregated acoustic estimates will be provided to this WG 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, at least for the November series (see **Table 3.4.1.1** and **Figure 3.4.1.1**).

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 are 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.

The first of these series of Gulf of Cádiz anchovy recruitment surveys (*ECOCÁDIZ-RECLUTAS 1009*) is expected to be carried out in October this year on board of R/V *Emma Bardán*.

3.5 Data exploration

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

For the time being, no analytical assessment model has been successfully applied. An *ad hoc* seasonal (half-year) separable model implemented and run on a spreadsheet has been used in the last years for data exploration of anchovy catch-at-age data in Subdivision IXa-South since 1995 onwards. The separable model was fitted to the updated half-year catch-at-age data until the year before the WG and to the available acoustic estimates of anchovy aggregated biomass from the 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. Updated tables of the input data are in Table 3.5.1.

The main problems with the assessment seem to be linked to the short-lived nature of the stock and the kind of data that can be accessible. The models explored so far cannot be properly scaled and do not provide reliable information about the true levels of both the stock, F and Catch/SSB ratios.

An in-depth evaluation of the possibilities of handling the above problems on the performance and suitability of the analytical model by other kinds of assessment models was out of reach for the WGANSA. In order to make progress, a benchmark process needs to be launched. In that context, it may be productive to consider 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.

For all the above reasons this year has been preferred to do not perform any exploratory assessment with this model. Instead of this, the provision of advice this year will rely in an update of the qualitative assessment carried out the last year and accepted by the Review Group of the 2008 WGANC (2008 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). A summary of these trends is shown in the **Figure 3.5.2**. They indicate a relatively stable stock status with little change from the previous assessment. There is no evidence of serious problems: landings in 2008 experienced a sharp decline, although caused by a parallel fall in the fishing effort, cpue is maintained relatively stable, and survey estimates, although variable, do not show trends. The DEPM estimates are highly uncertain (mainly the 2005 one), and hence ratios of catch in Subdivision IXa-South to DEPM SSB, although are reasonably low, they should be considered with caution. Notwithstanding the above, acoustic estimates still suggest that the stock at present is harvested at acceptable levels.

Future 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. 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, can be examined by simulations, and the basis for conditioning simulation models is to a large extent available.

3.5.1 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 Subdivision IXa South is in a relatively stable situation (about 30 thousand tonnes as an average for the 2006-2009 period), a situation that could be reversed if the fishery, as evidenced by the increased effort levels reached in 2007, is still expanding its fishing capacity.

3.6 Management considerations

3.6.1 Stock definitions

A summarised description of the distribution of the main anchovy populations in NE Atlantic European waters is given in **Section 2** and in the Stock Annex.

3.6.2 Current management situation

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).

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

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

In the Gulf of Cadiz (Subdivision IXa South) the Spanish purse-seine fleet was performing a voluntary closure of three months (December to February) until 1997. Since

2004 two complementary sets of management measures affecting directly to the Gulf of Cadiz fishery have been implemented and are still in force. The first one was the new "*Plan for the conservation and sustainable management of the purse-seine fishery in the Gulf of Cadiz National Fishing Ground*". This plan is in force during 12 months since October the 30th and includes a fishery closure (basically aimed to protect the anchovy recruitment) of either 45 days (between 17th of November to the 31st of December in 2004 and 2005), two months (November and December in 2006) or three months (mid November 2007 to mid February 2008, 1st December 2008 to 28th February 2009), which is accompanied by a subsidized tie-up scheme for the purse-seine fleet. The 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 **Sections 3.2.2.1.1** and **3.2.4** and 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 possibiliy of expanding even more the fishing capacity of the fleets up to the recent maxima reached in the 1998-2002 period (see **Figure 3.2.4.4**).

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 3.7.2.1**). Fishing in the reserve is only allowed (with pertinent regulatory measures) to gill-nets and trammel-nets, although in those waters outside the 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 assess. In any case, the implementation of both of these measures should benefit the stock.

The new landings, fishing effort, cpue, and survey data available this year do not change the perception of the stock and do not give reason to change the advice from 2007. The advice on this stock for the fishery in 2010 is therefore the same as the advice given in 2008 for the 2009 fishery.

Table 3.2.1.1. Anchovy in División IXa. Spanish purse-seine fleet composition in the Gulf of Cadiz (Subdivision IXa-South) in 2008. 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). Length criteria refers to length between perpendiculars. Storage: catches are dry hold with ice (fishing trip equals to fishing day). Similar tables for all years are in the Stock annex.

Total number of operative purse-seiners

2008	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	1	0	1	0	0	2
11-15	2	16	15	3	0	36
16-20	0	3	18	15	0	36
>20	0	0	1	15	1	17
Total	3	19	35	33	1	91

Purse-seiners targeting anchovy

2008	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	1	0	1	0	0	2
11-15	2	16	14	3	0	35
16-20	0	3	18	15	0	36
>20	0	0	1	11	1	13
Total	3	19	34	29	1	86

Table 3.2.2.1.1. Anchovy in Division IXa. Portuguese and Spanish annual landings (tonnes), (from Pestana, 1989 and 1996, and WGMHSA, WGANC and WGANSA members).

	Portugal				Spain			
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	4721
1989	389	85	22	496	118	5330	5448	5944
1990	424	93	24	541	220	5726	5946	6487
1991	187	3	20	210	15	5697	5712	5922
1992	92	46	0	138	33	2995	3028	3166
1993	20	3	0	23	1	1960	1961	1984
1994	231	5	0	236	117	3035	3152	3388
1995	6724	332	0	7056	5329	571	5900	12956
1996	2707	13	51	2771	44	1780	1824	4595
1997	610	8	13	632	63	4600	4664	5295
1998	894	153	566	1613	371	8977	9349	10962
1999	957	96	355	1408	413	5587	6000	7409
2000	71	61	178	310	10	2182	2191	2502
2001	397	19	439	855	27	8216	8244	9098
2002	433	90	393	915	21	7870	7891	8806
2003	211	67	200	478	23	4768	4791	5269
2004	83	139	434	657	4	5183	5187	5844
2005	82	6	38	126	4	4385	4389	4515
2006	79	15	14	108	15	4368	4383	4491
2007	833	7	34	874	4	5576	5580	6454
2008	211	87	37	335	5	3168	3173	3508

(-) Not available
(0) Less than 1 tonne

Table 3.2.2.1.2. Anchovy in Division IXa. Catches (tonnes) by gear and country in 1988-2008.

Country/Gear	1988*	1989*	1990*	1991*	1992	1993	1994	1995*	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
SPAIN	4263	5454	6131	5711	3028	1961	3153	5900	1823	4664	9349	6000	2191	8244	7891	4791	5187	4389	4383	5580	3173
Artisanal IXa North																4	1				1
Purse seine IXa North		118	220	15	33	1	117	5329	44	63	371	413	10	27	21	19	2	4	15	4	4
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
Trawl IXa South						330	152	75	224	190	1148	993	104	36	23	14	6	0.2	0.4	0.3	0.1
PORTUGAL	458	496	541	210	275	23	237	7056	2771	632	1613	1408	310	855	915	478	657	126	108	874	335
Trawl					4	9	1		56	46	37	43	6	16	13	7	5	7	27	14	9
Purse seine	458	496	541	210	270	14	233	7056	2621	579	1541	1346	297	806	888	287	455	62	57	484	185
Artisanal					1	1	3		94	7	35	20	7	32	13	184	197	57	24	376	141
Total	4721	5950	6672	5921	3303	1984	3390	12956	4594	5295	10962	7409	2502	9098	8806	5269	5844	4515	4491	6454	3508

* Portuguese catches not differentiated by gear

Table 3.2.2.1.3. Anchovy in Division IXa. Quarterly anchovy catches (tonnes) by country and Sub-division in 2008.

COUNTRY	SUBDIVISIONS	QUARTER 1		QUARTER 2		QUARTER 3		QUARTER 4		ANNUAL (2008)	
		C(t)	%	C(t)	%	C(t)	%	C(t)	%	C (t)	%
SPAIN	IXa North	0.2	3.1	1	28.0	2	30.3	2	38.6	5	0.2
	IXa South	590	18.6	1117	35.3	909	28.7	552	17.4	3168	99.8
	TOTAL	590	18.6	1119	35.3	910	28.7	554	17.5	3173	100.0
PORTUGAL	IXa Central North	132	62.5	37	17.4	5	2.2	38	17.9	211	62.9
	IXa Central South	18	20.4	4	5.1	1	0.6	65	73.8	87	26.1
	IXa South	10	26.8	3	9.2	2	5.6	21	58.3	37	11.0
	TOTAL	159	47.6	44	13.3	7	2.2	124	36.9	335	100.0
TOTAL	IXa North	0.2	3.1	1	28.0	2	30.3	2	38.6	5	0.2
	IXa Central North	132	62.5	37	17.4	5	2.2	38	17.9	211	6.0
	IXa Central South	18	20.4	4	5.1	1	0.6	65	73.8	87	2.5
	IXa South	600	18.7	1121	35.0	911	28.4	574	17.9	3204	91.4
	TOTAL	749	21.4	1163	33.2	918	26.2	678	19.3	3508	100.0

Table 3.2.2.2.1. Anchovy in Division IXa. Spanish catch in numbers ('000) at age of Gulf of Cadiz anchovy (Subdivision IXa-South, 1995-2008) 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	11256.3	23240.7	0	34497	34497.02
	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			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			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

Table 3.2.2.3.1. Anchovy in Division IXa. Length distribution ('000) of anchovy catches in Division IXa by country and Subdivisions in 2008. Only data available for length composition of catches from the Spanish fishery in the Gulf of Cádiz (Subdivision IXa-South).

2008	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	530			23	553
7.5	2501		2216	140	4856
8	9727	466	5987	406	16586
8.5	15597	1025	8058	919	25600
9	10087	3801	31034	1892	46815
9.5	12714	5255	86940	1425	106333
10	19590	8491	89580	1234	118895
10.5	43810	11698	59392	987	115887
11	59778	31140	34719	1043	126680
11.5	63937	38716	34567	1479	138699
12	77508	43815	50116	2268	173706
12.5	57814	95909	79914	5124	238761
13	40201	106919	93936	5482	246538
13.5	22313	88570	62498	7481	180861
14	20011	88764	40848	3873	153496
14.5	13690	55357	26342	2287	97676
15	9184	37513	18539	1584	66820
15.5	6179	15616	6809	637	29241
16	3447	12674	6133	454	22709
16.5	1723	3615	400	193	5932
17	1723	1247	1114	19	4104
17.5			43		43
18					
18.5					
19					
19.5					
20					
20.5					
21					
21.5					
22					
Total N	492063	650592	739183	38953	1920791
Catch (T)	590	1117	909	552	3168
L avg (cm)	11.8	13.1	11.7	12.6	12.3
W avg (g)	11.2	16.2	11.5	13.3	13.1

Table 3.2.2.3.2. Anchovy in Division IXa. Mean length (TL, in cm) at age in the Spanish catches of Gulf of Cadiz anchovy (Subdivision IXa-South, 1995-2008) 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

Table 3.2.2.3.3. Anchovy in Division IXa. Mean weight (in Kg) at age in the Spanish catches of Gulf of Cadiz anchovy (Subdivision IXa-South, 1995-2008) 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

Table 3.3.2.1. Anchovy in Division IXa. Maturity ogives (ratio of mature fish at age) for Gulf of Cadiz anchovy (Subdivision IXa South).

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

Table 3.4.1.1. Historical series of overall and regional acoustic estimates of anchovy abundance (N, millions) and biomass (B, tonnes) in Division IXa from Portuguese (*SAR-PELAGOS* 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

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

*** 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 echotraces attributable to the species were detected in this area, however, the loss o pelagic gear samplers prevented from confirming directly this.**

Table 3.4.2.1. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Description of the survey.

Parameters	Anchovy DEPM survey *BOCADEVA0608*
Survey area	(36º18'- 36º75'N – 6º22'- 8º92'W)
R/V	*Cornide de Saavedra*
Date	21/06-03/07
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	127
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25 and CTD SBE37
Flowmeter	Yes
CUFES stations	121
CUFES (335µm)	3 nmiles (sample unit)
Environmental data	Fluorescence(surface only),Temperature, Salinity
Adults	
Gears	Pelagic trawl
Trawls	26
Trawls time	During the daylight hours
Biological sampling:	On fresh material, on board of the R/V
Sample size	60 indiv randomly (30 female minimum); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)
Preservation	Formalin

Table 3.4.2.2. Anchovy in División IXa. ***BOCADEVA 0608*** **Spanish DEPM survey in Subdivision IXa-South. Upper table: characteristics of the samples used for the estimation of the adults parameters. Lower table: DEPM parameters and SSB estimates.**

Parameter	Time range GMT	#Samples	#Males	Weight range (gr)	Length range (mm)	#Females	Weight range (gr)	Length range (mm)
Mean Weight & Sex ratio	06:10-19:43	18	651	6,72-39,04	114-176	608	8,78-45,70	112-182
Batch Fecundity	16:20-19:43	4	-	-	-	219	8,78-35,90	112-164
Spawning fraction	06:10-19:43	18	-	-	-	602	8,78-45,70	112-182

Parameter	Algarve	Cádiz	Total Gulf of Cádiz
Eggs 2008			
P0 (eggs/m2/day) (CV%)	184 (44.1)	348 (34.9)	-------
Z ($hour^{-1}$) (CV%)	-0.06 (29.4)		-0.06 (29.4)
P0 tot (eggs/day) ($x10^{12}$) (CV%)	0.31 (44.1)	1.80 (34.9)	2.11
Positive area (Km^2)	1690.44	5172.17	6862.61
Adults 2008			
Female Weight (g) (CV%)	23.67 (5.7)		
Batch Fecundity (CV%)	13.778 (6.6)		
Sex Ratio (CV%)	0.528 (0.5)		
Spawning Fraction (CV%)	0.218 (6.5)		
SSB 2008			
Spawning Biomass – tons (CV%)	4644 (45.4)	26883 (36.6)	31527 (31.9)

Table 3.4.2.3. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Selected Generalized lineal model (GLM) for the modelling of the batch fecundity.

```
Deviance Residuals:
   Min      1Q    Median    3Q      Max
-6625.0  -1805.3  -260.3  1686.0  9187.5

Coefficients:
            Estimate  Std.Error  t value  Pr(>|t|)
(Intercept)  -1703.58    833.50   -2.044   0.0422 *
   Wnov       696.46     44.32    15.716   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 7386978)

    Null deviance:  3427390994  on 218  degrees of freedom
Residual deviance:  1602974271  on 217  degrees of freedom
AIC: 4089. Number of Fisher Scoring iterations: 2
```

Table 3.4.2.4. Anchovy in División IXa. *BOCADEVA 0605* Spanish DEPM survey in Subdivision IXa-South. Summary of revised results for egg, adults and SSB estimates.(1): previous estimates; (2) estimates after WKRESTIM.

Survey	DEPM 2005 (1)		DEPM 2005 (2)	
Sampling area (km^2)	12329		11982	
Spawning area (km^2)	7279		6139	
Parameter/Stratum	Algarve	Cádiz	Algarve	Cádiz
Eggs 2005				
P_0 (eggs/m^2/day)	22.8 (1.0)	214.3 (0.56)	50.8 (0.8)	224.4 (0.69)
z (hour^{-1})	-0.072 (15)	-0.82 (0.67)	-0.039 (0.75)	
P_{tot} (eggs/day^{-1})	$0.03*10^{12}$	$1.08*10^{12}$	$0.07*10^{12}$ (0.76)	$1.06*10^{12}$ (0.65)
Adults 2005				
Sex Ratio	0.53 (0.09)	0.54 (0.09)	0.53 (0.01)	0.54 (0.01)
Female Weight	25.19 (0.16)	16.55 (0.21)	25.22 (0.03)	16.71 (0.04)
Batch Fecundity	13.80 (0.17)	11.47 (0.23)	13.82 (0.05)	11.16 (0.05)
Spawning Frequency	0.23 (0.32)	0.21 (0.27)	0.26 (0.07)	0.21 (0.07)
SSB 2005				
SSB (tons)	396.8 (0.81)	13821.9 (0.61)	963.3 (0.80)	13673.8 (0.66)
	14219 (0.59)		14673 (0.62)	

Table 3.5.1. 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 last year.

Anchovy IXa-South (Algarve+Gulf of Cadiz)
Years: 1995-2008
Fleets: All

Half-year landings (in tonnes, 1995-2008)

1995		1996		1997		1998		1999		2000		2001	
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

2002		2003		2004		2005		2006		2007		2008	
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
4740	3523	3567	1401	3361	2257	3635	787	3951	430	3831	1779	1720	1484

Half-year Catch in number (in millions) at age (1995-2008)

	1995		1996		1997		1998		1999		2000		2001	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	34.50	0	495.13	0	335.67	0	465.60	0	126.26	0	129.46	0	161.96
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
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
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	2002		2003		2004		2005		2006		2007		2008	
AGE	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	77.89	0	95.72	0	123.63	0	38.75	0	12.45	0	62.11	0	58.31
1	548.23	195.09	333.99	73.28	323.34	97.73	449.26	37.39	460.39	41.93	455.32	107.16	91.06	48.79
2	8.50	9.93	13.15	0.63	1.81	0.92	3.21	0.33	5.27	0.00	6.76	0.63	23.83	7.45
3	0	0	0	0	0	0	0	0	0	0	0	0	0.40	0

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	
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	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	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	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	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.

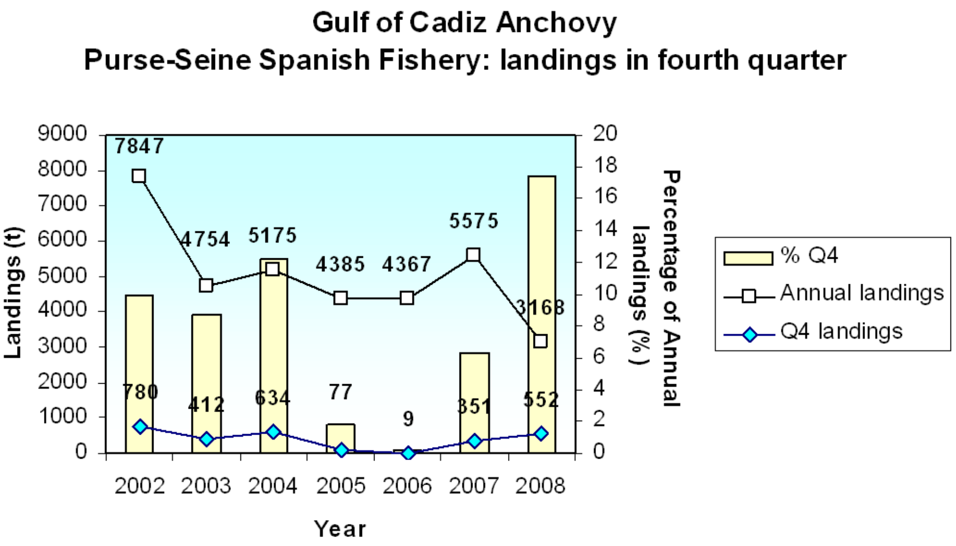
Nov.-98	Mar.-99	Nov.-99	Mar.-00	Nov.-00	Mar.-01	Nov.-01	Mar.-02	Nov.-02	Feb.-03	Nov.-03	Mar.-04	Nov.-04	Apr.-05	Nov.-05	Apr.-06	Nov.-06	Apr.-07	Nov.-07	Apr.-08	Nov.-08	Apr.-09
30695	24763	-	-	33909	24913	25580	21335	-	24565	-	-	-	14041	-	24082	-	38020	23723	34162	-	24745

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	1999-2009	Relative	1	2007Fratio for FHY2-2008. FHY1-2009:average FHY1 in 3 last years (06-0).	Wage stock in 2009 as the average in 06-08
RUN2		Relative	6		
RUN3		Absolute	1		



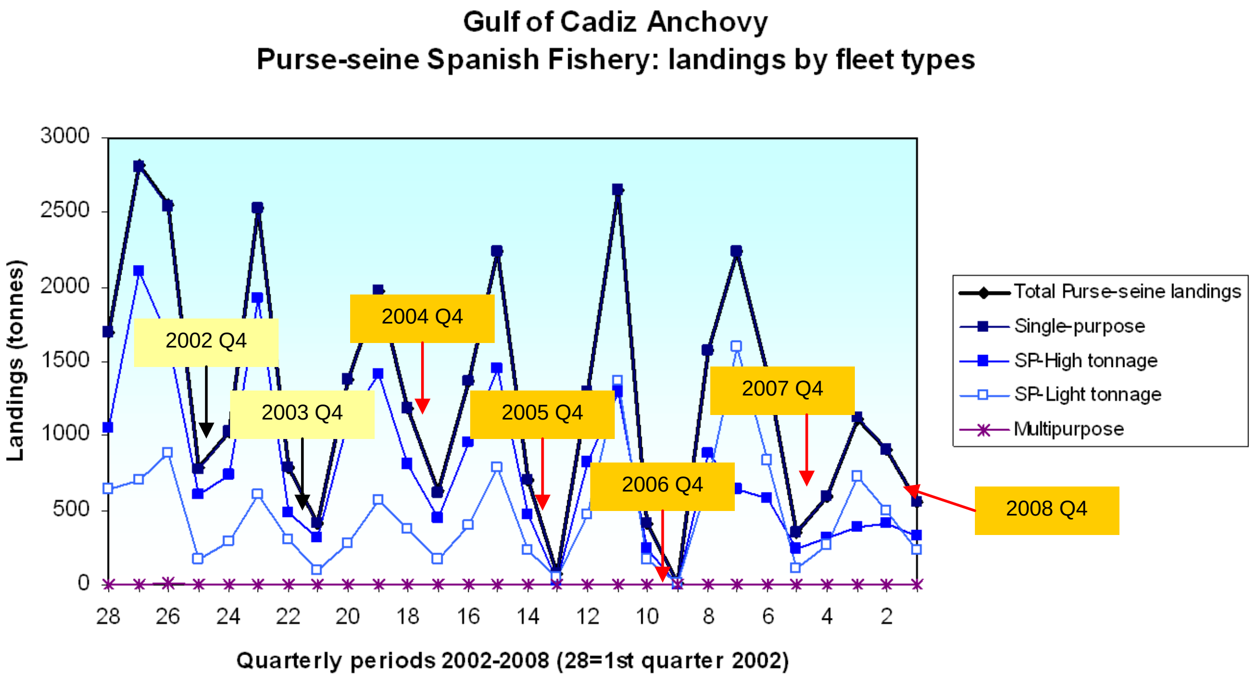


Figure 3.2.2.1.1. Anchovy in Division IXa. Gulf of Cadiz Anchovy (Subdivision IXa-South). Upper panel: comparison of annual purse-seine landings with catches landed in the fourth quarter to assess the effects of the closed season in the fourth quarter in 2004-2008. Bar chart represents the relative importance of landings in the fourth quarter in relation to the annual landings. Lower panel: trends in quarterly series of landings by fleet type. Single-purpose fleet is also differentiated in heavy and light GRT vessels. Fishery closures since 2004 on.

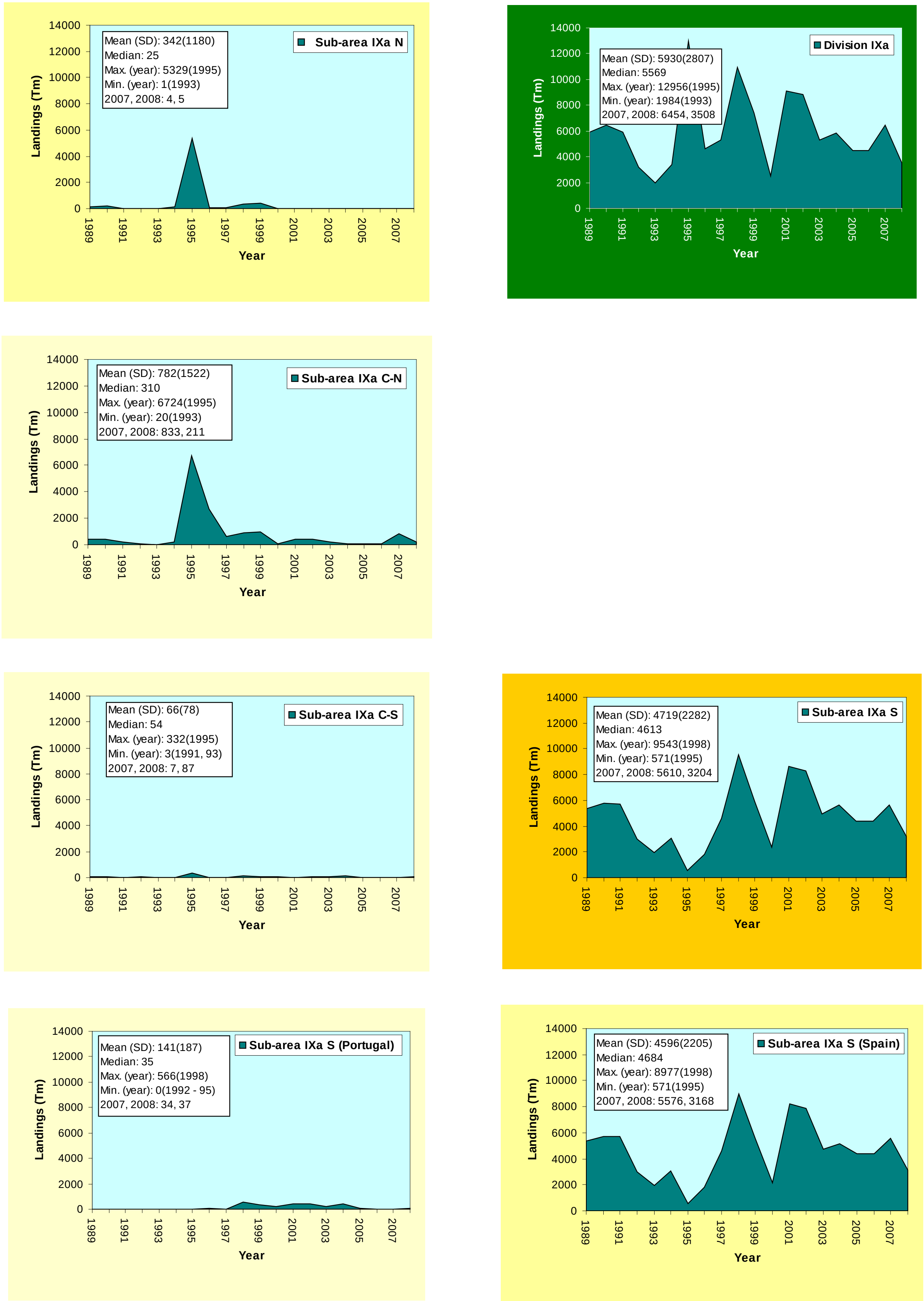


Figure 3.2.2.1.2. Anchovy in Division IXa. Recent series of Portuguese and Spanish (1989-2008) anchovy landings in Division IXa. Sub-areas arranged according to its geographical location along the Atlantic Iberian Peninsula. Series for the whole Division and for the whole Sub-area IXa-South are also shown.

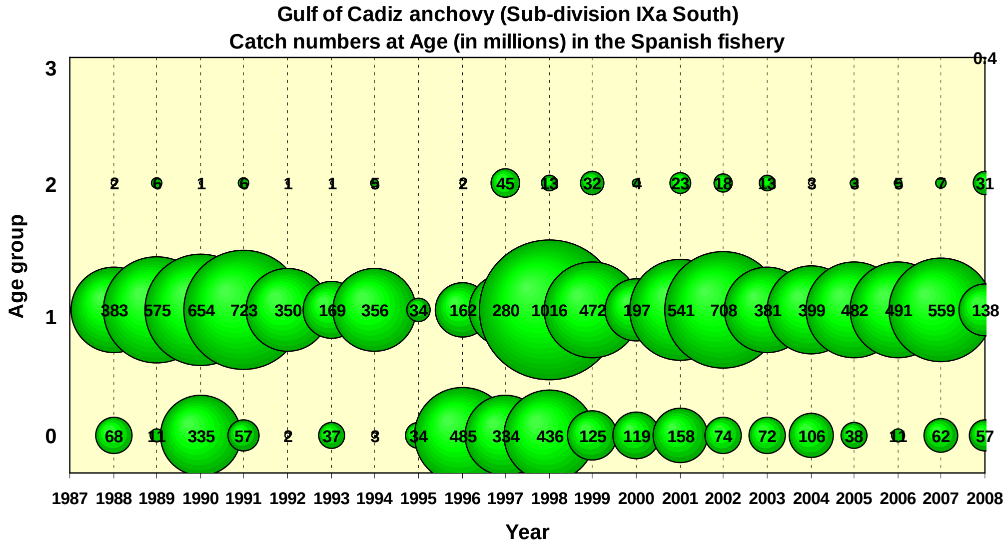


Figure 3.2.2.2.1. Anchovy in Division IXa. Age composition in Spanish landings of Gulf of Cadiz anchovy (Subdivision IXa-South; 1988-2008). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

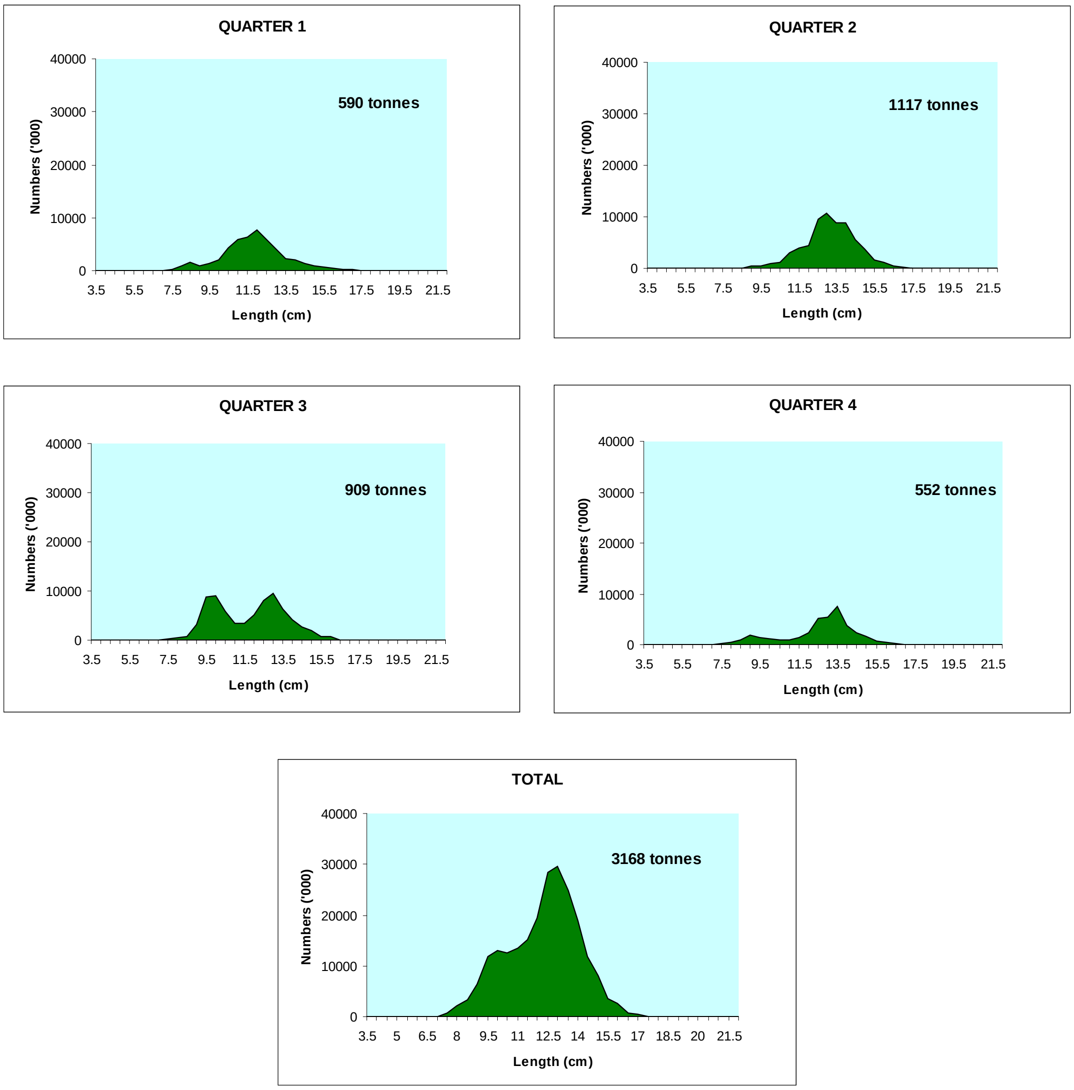
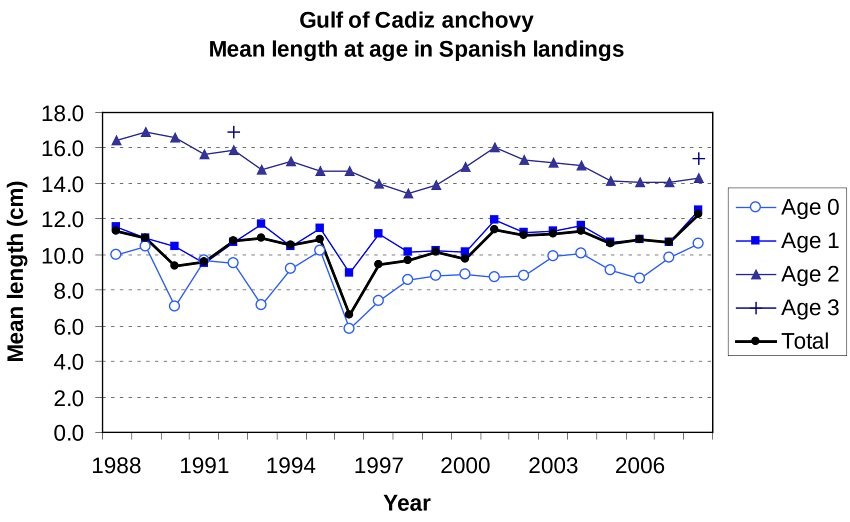


Figure 3.2.2.3.1. Anchovy in Division IXa. Length distribution ('000) of the Spanish quarterly and annual landings of anchovy in Subdivision IXa-South (Gulf of Cadiz) in 2008. Without data for Subdivision IXa-North (Western Galicia).



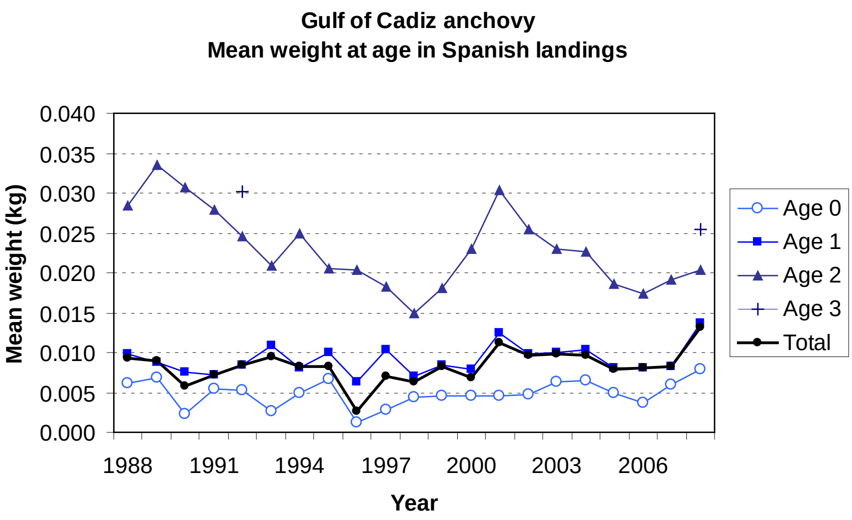


Figure 3.2.2.3.2. Anchovy in Division IXa. Annual mean length (TL, in cm) and weight (kg) at age in the Spanish landings of Gulf of Cadiz anchovy (Subdivision IXa-South, 1988-2008). Data for 1994 and second half in 1995 estimated from an iterated ALK by applying the Kimura and Chikuni's (1987) algorithm.

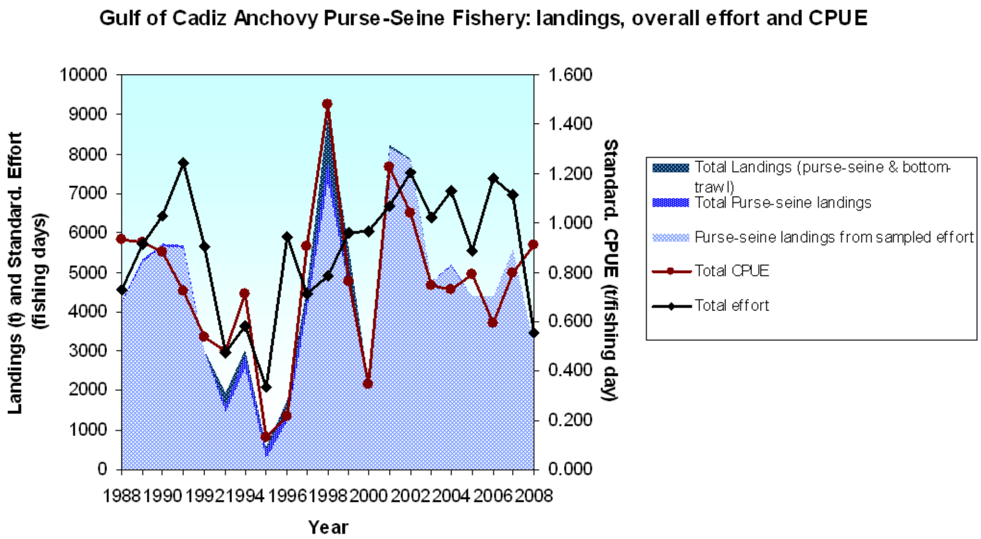
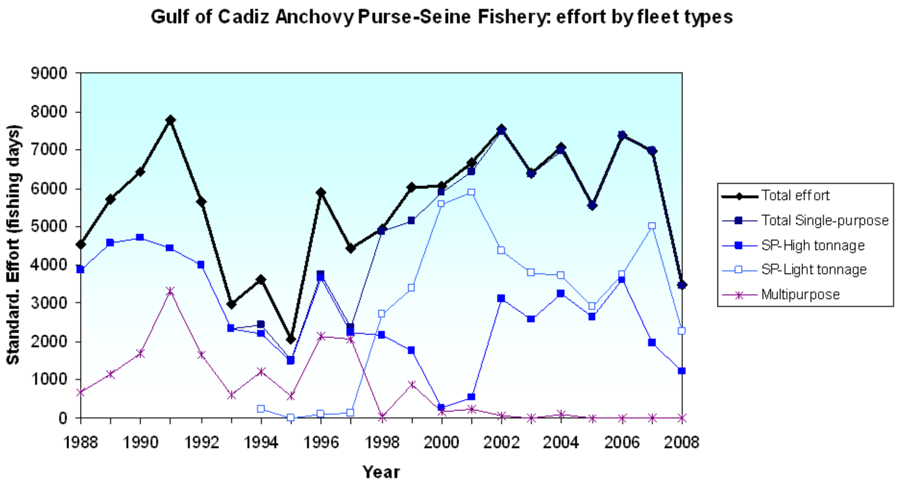


Figure 3.2.4.1. Anchovy in Division IXa. Gulf of Cadiz anchovy Spanish purse-seine fishery. Trends in annual landings, overall effort and CPUE. Landings are differentiated in total landings (purse-seine and bottom trawl fleets), purse-seine landings, and purse-seine landings corresponding to the sampled fishing effort.



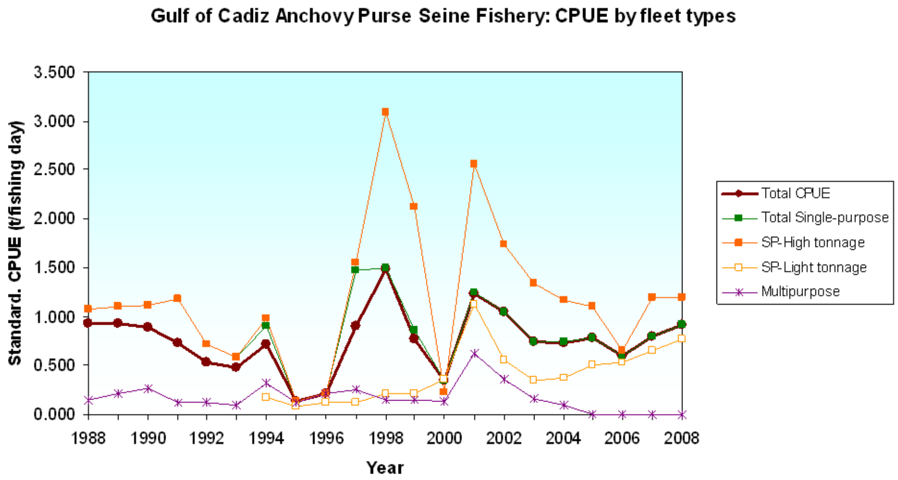


Figure 3.2.4.2. Anchovy in Division IXa. Gulf of Cadiz anchovy Spanish purse-seine fishery. Trends in annual series of effort (upper panel) and CPUE (bottom panel) by fleet type. Single-purpose fleet is also differentiated in heavy and light GRT vessels.

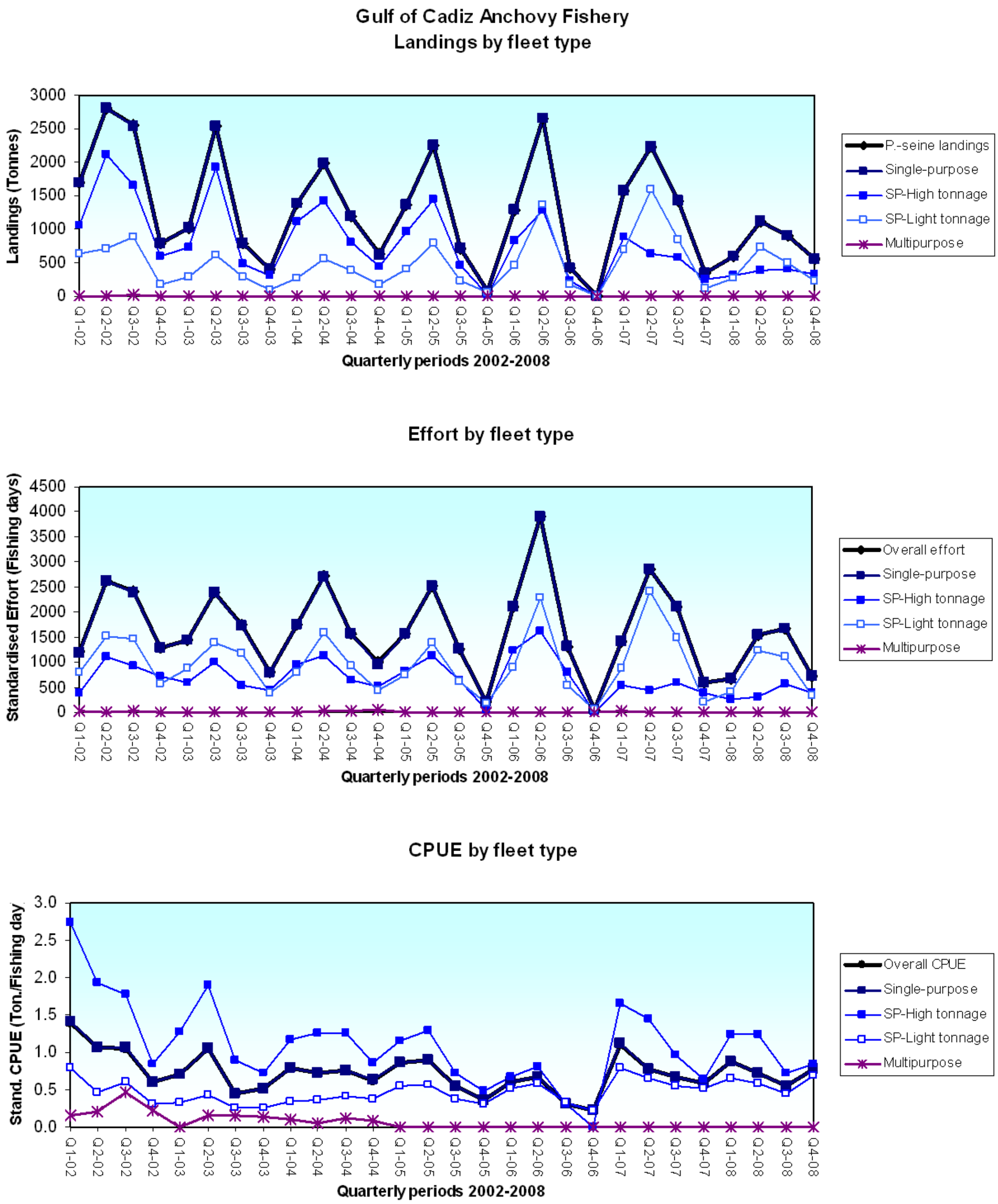


Figure 3.2.4.3. Anchovy in Division IXa. Gulf of Cadiz anchovy purse-seine fishery. Trends in quarterly series of landings (upper panel), effort (middle panel) and CPUE (bottom panel) by fleet type during the 2002-2007 period. A purse-seine fishery closure was implemented during the fourth quarter in 2004, 2005, and 2006 (2004-2005: 15th November-31st December; 2006: 1st November-31st December), and through 2007 fourth quarter and 2008 first quarter (15th November-15th February). Single- purpose fleet is also differentiated in heavy and light GRT vessels.

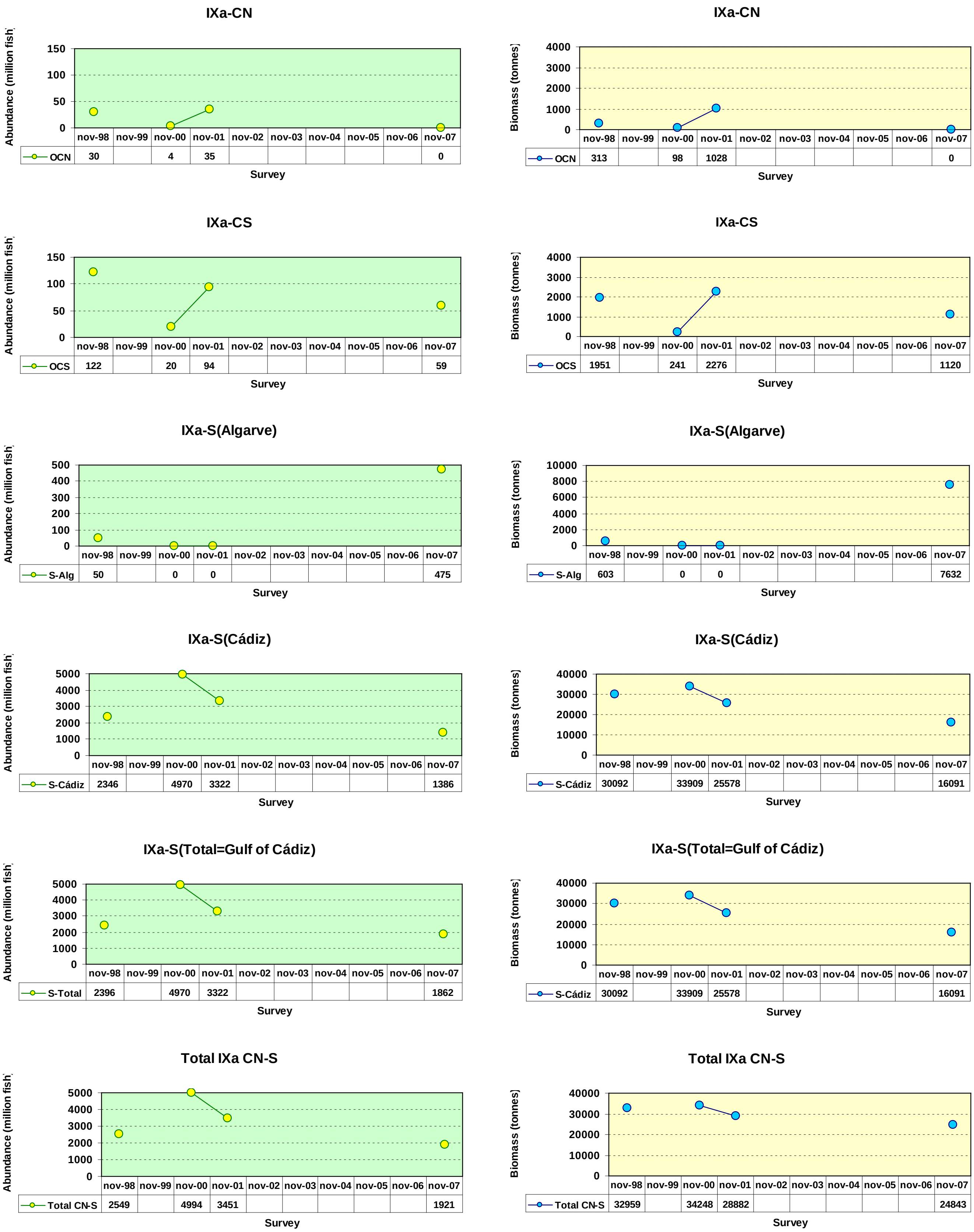


Figure 3.4.1.1. Anchovy in División IXa. Historical series of anchovy acoustic estimates (abundance in million fish, biomass in tonnes) from Autumn Portuguese surveys in the Division IXa. Note the different scale on the y-axis.

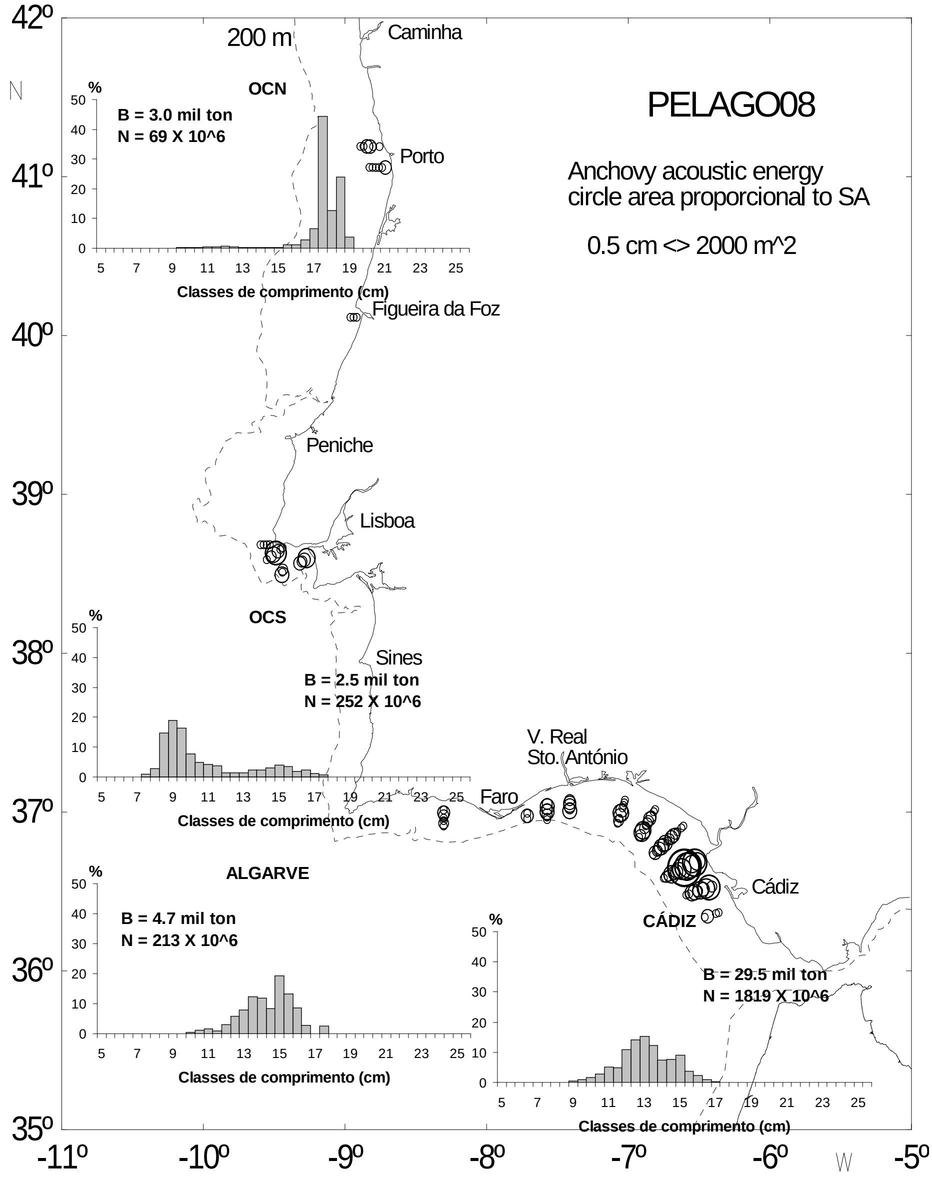


Figure 3.4.1.2. Anchovy in Division IXa. *PELAGOS08* spring Portuguese acoustic survey in Division IXa. Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy, acoustic estimates and size composition of the estimated populations by subareas (source: Vitor Marques, IPIMAR, pers. comm.).

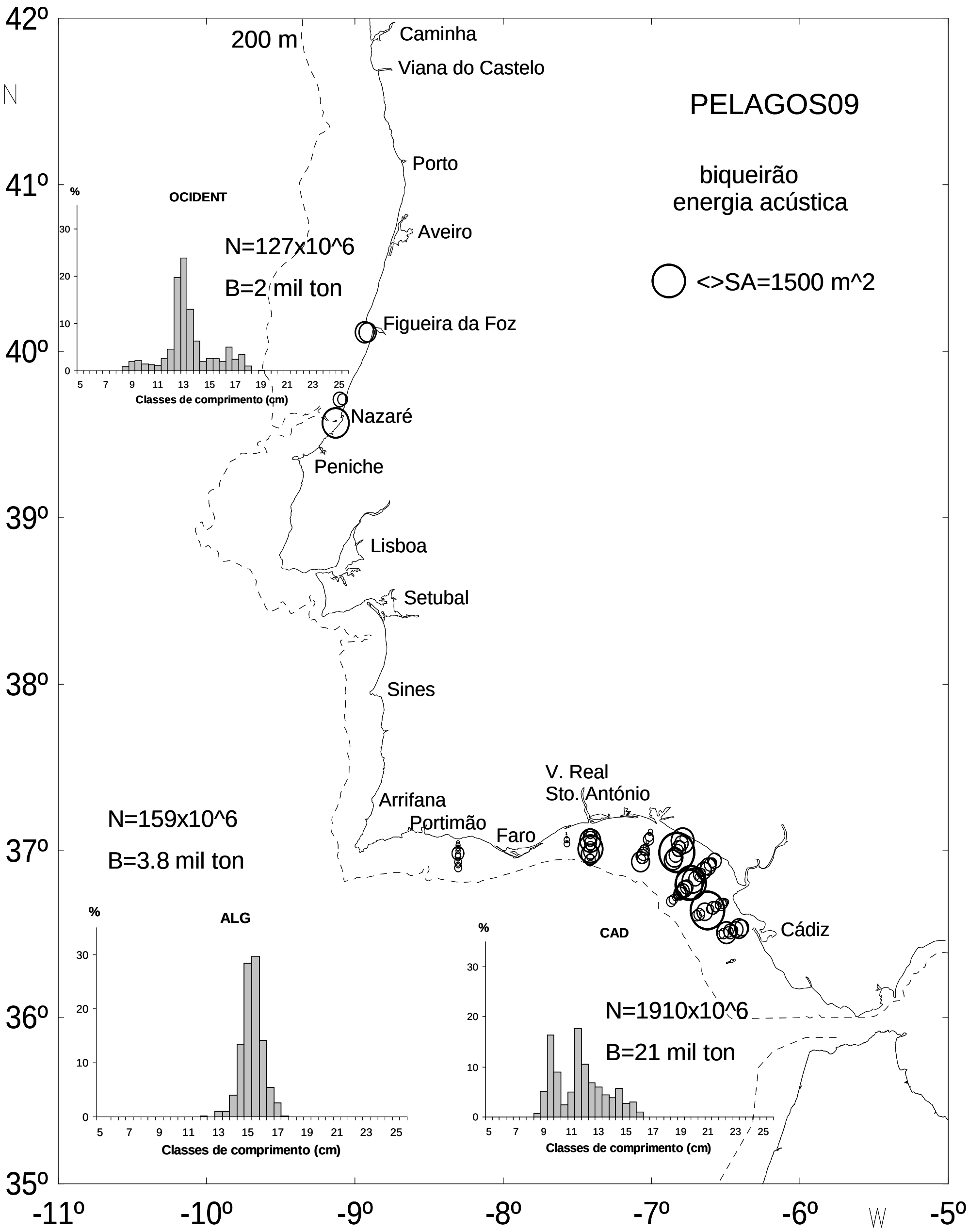


Figure 3.4.1.3. Anchovy in Division IXa. *PELAGOS09* spring Portuguese acoustic survey in Division IXa. Distribution of the NASC coefficients (m^2/mn^2) attributed to anchovy, acoustic estimates and size composition of the estimated populations by subareas (source: Vitor Marques, IPIMAR, pers. comm.).

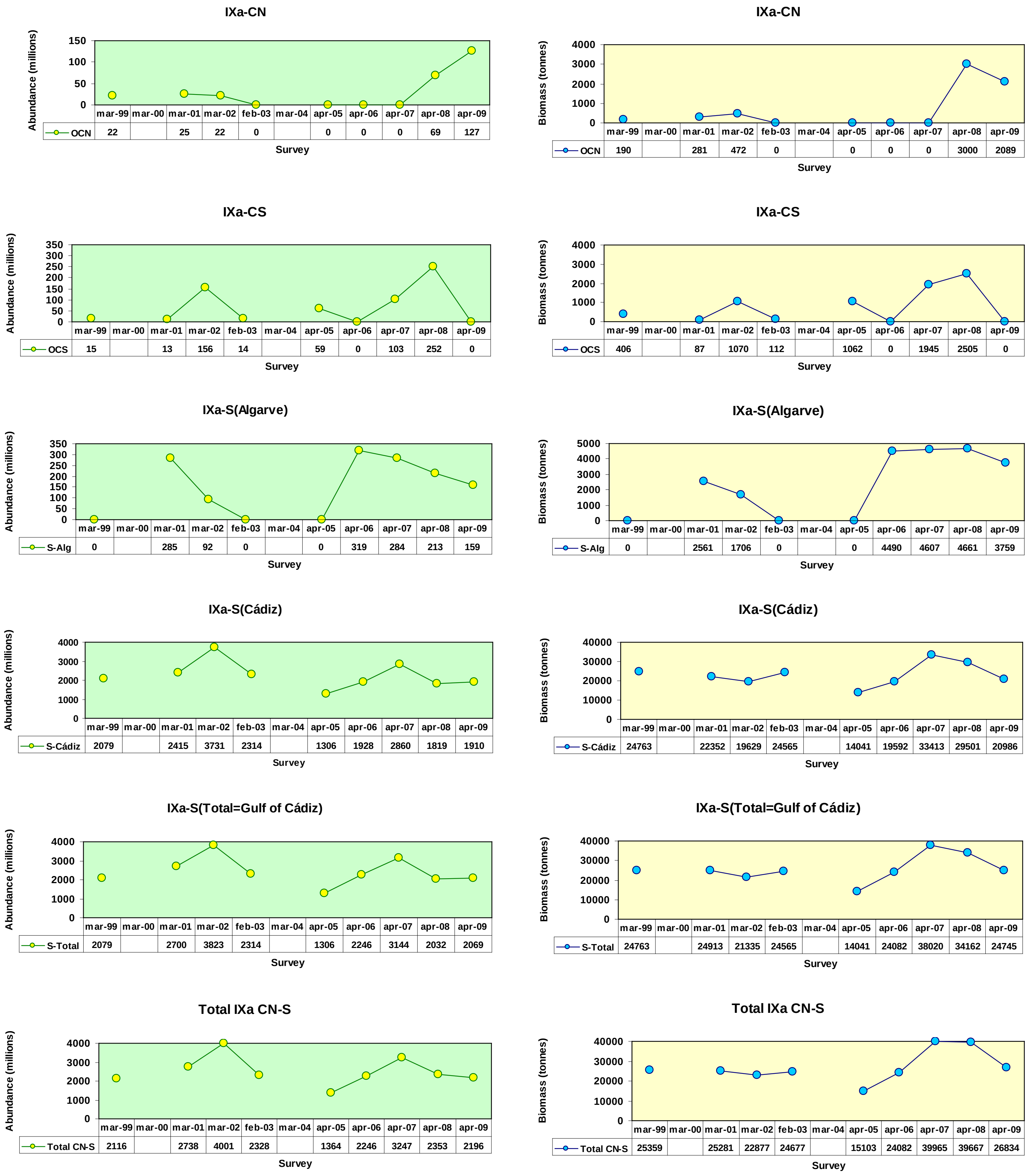


Figure 3.4.1.4. Historical series of anchovy acoustic estimates (abundance in million fish, biomass in tonnes) from Spring Portuguese surveys in the Division IXa. Note the different scale on the y-axis.

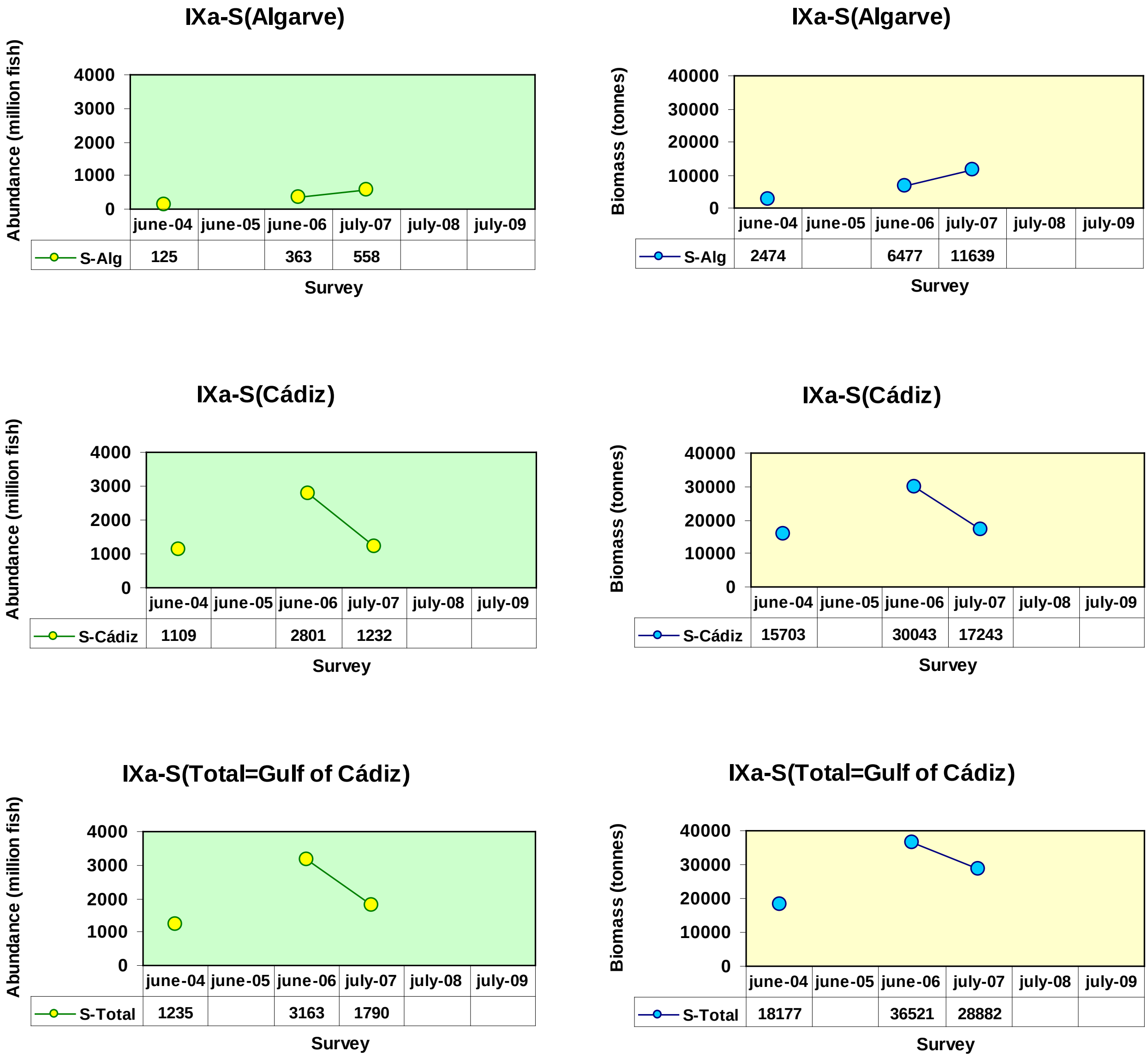


Figure 3.4.1.5. Historical series of anchovy acoustic estimates (abundance in million fish, biomass in tonnes) from Summer Spanish surveys in the Subarea IXa-South. Note the different scale on the y-axis.

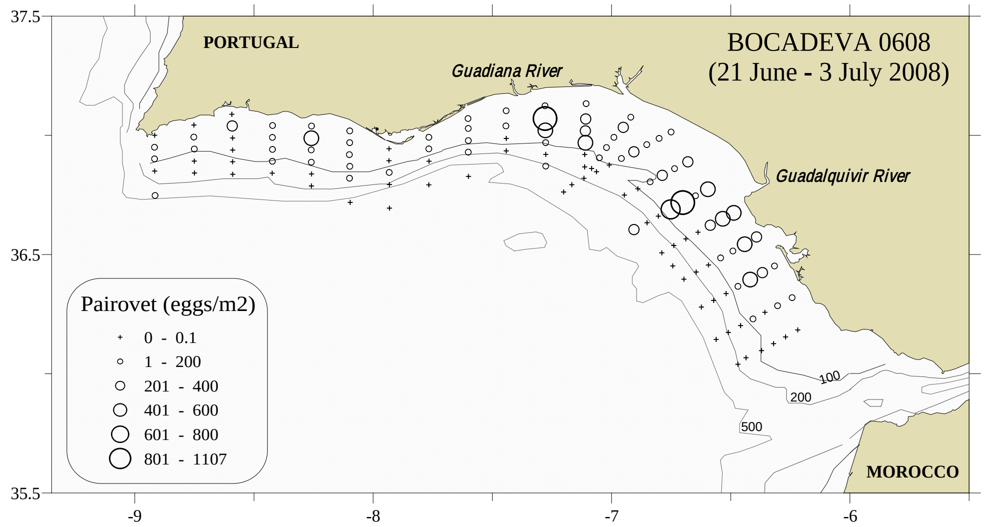


Figure 3.4.2.1. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Abundance distribution of anchovy eggs sampled with PairoVET.

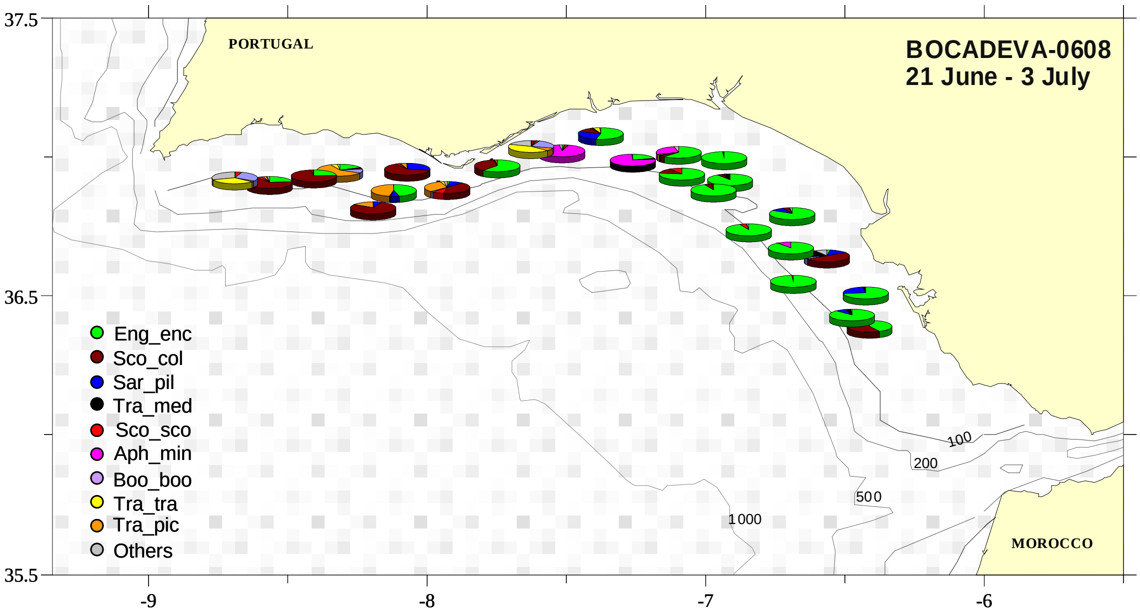


Figure 3.4.2.2. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Spatial distribution of the pelagic trawl hauls with indication of their respective species composition.

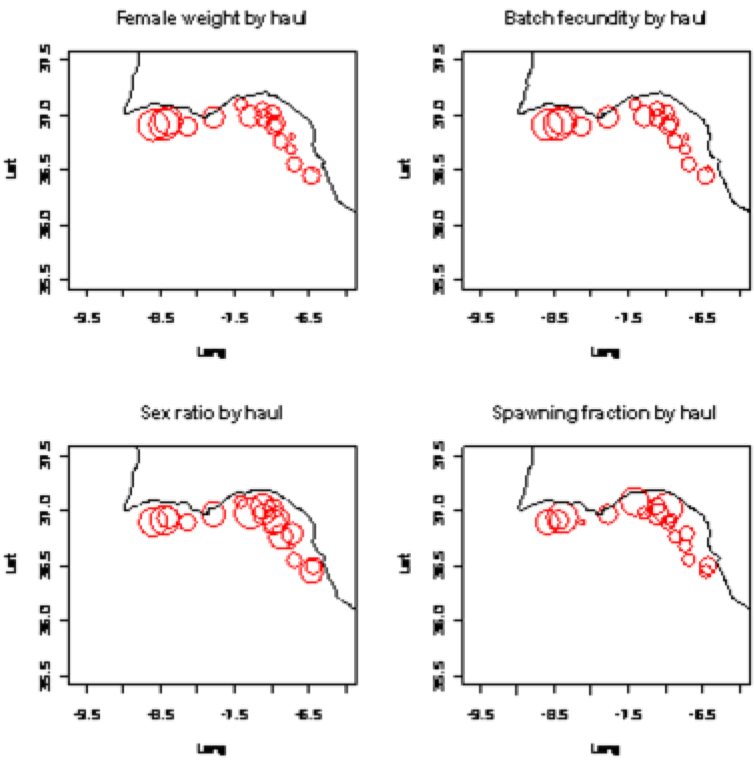


Figure 3.4.2.3. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Spatial distribution of mean estimates of the adult parameters per haul.

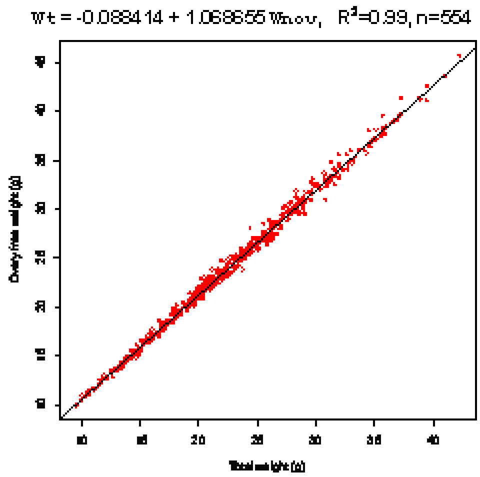


Figure 3.4.2.4. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Linear regression model for the relationship between non-hydrated females total weight (Wt) and ovary-free weight (Wnov).

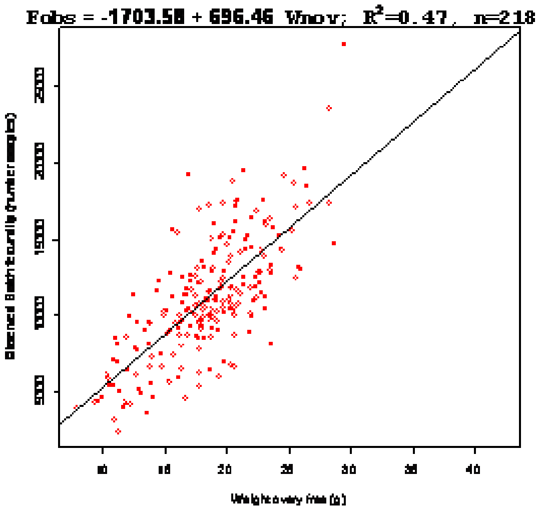


Figure 3.4.2.5. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Generalized linear model for the relationship between observed individual batch fecundity (Fobs) and ovary-free weight (Wnov).

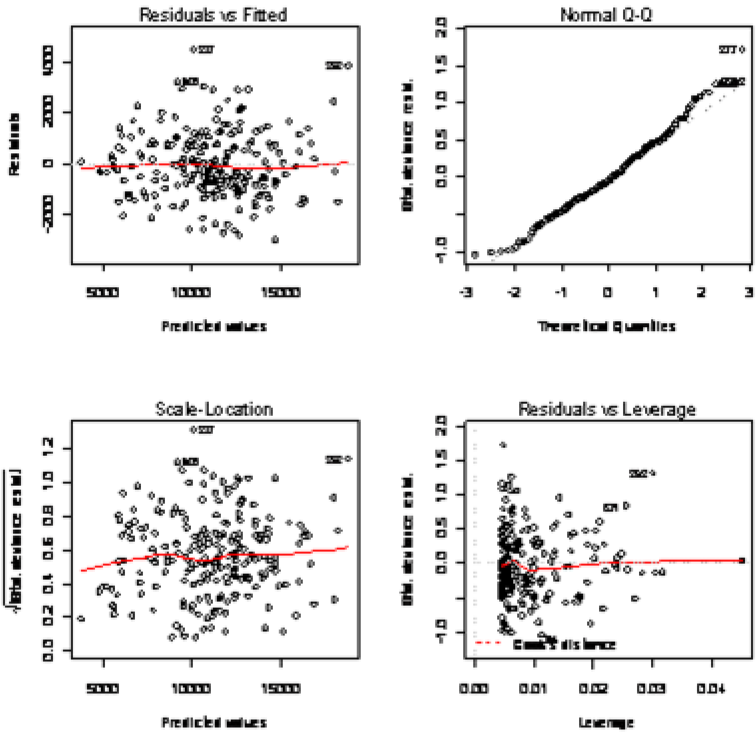


Figure 3.4.2.6. Anchovy in División IXa. *BOCADEVA 0608* Spanish DEPM survey in Subdivision IXa-South. Residual inspection plots for the Generalized Linear Model fitted to anchovy batch fecundity data.

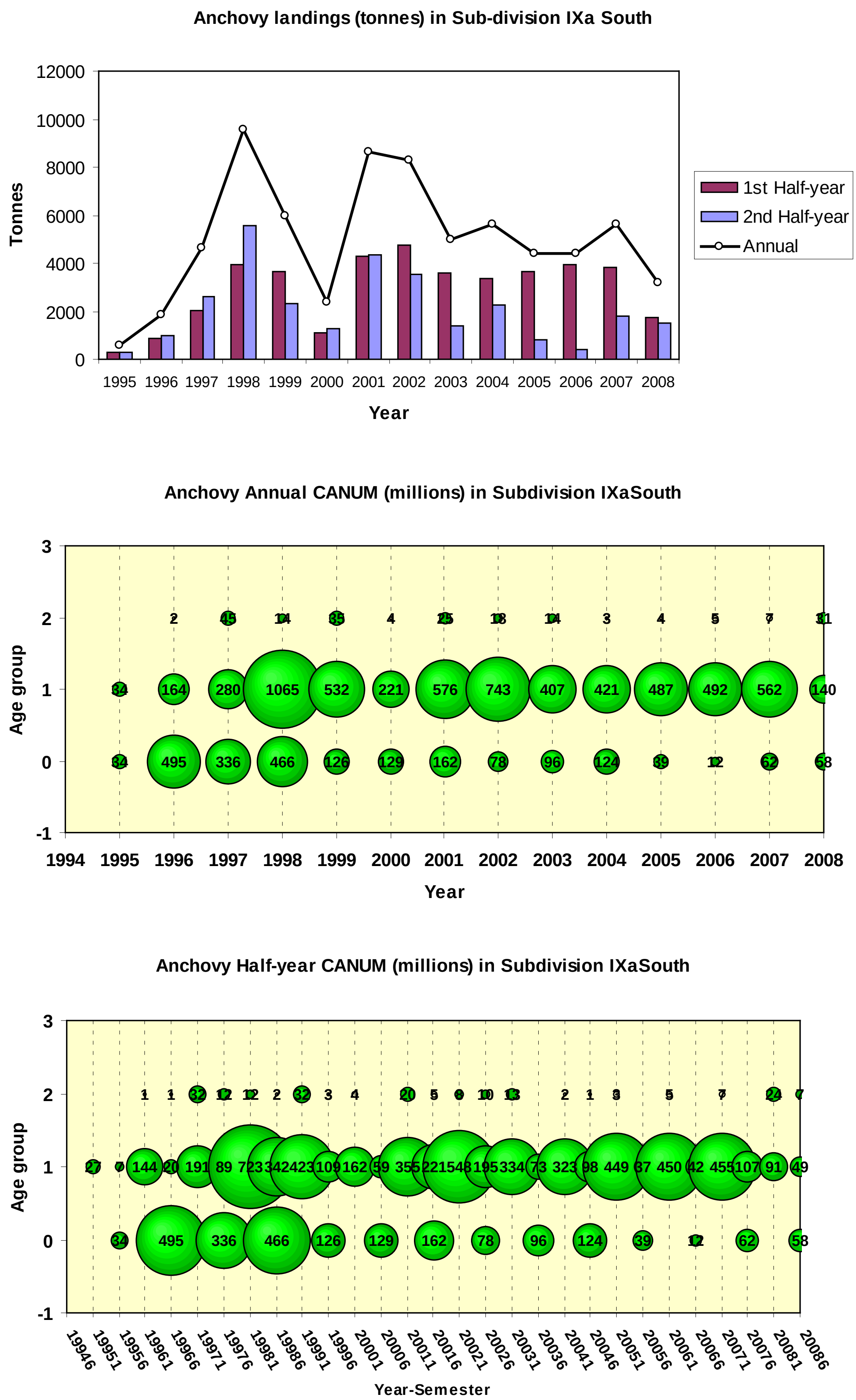
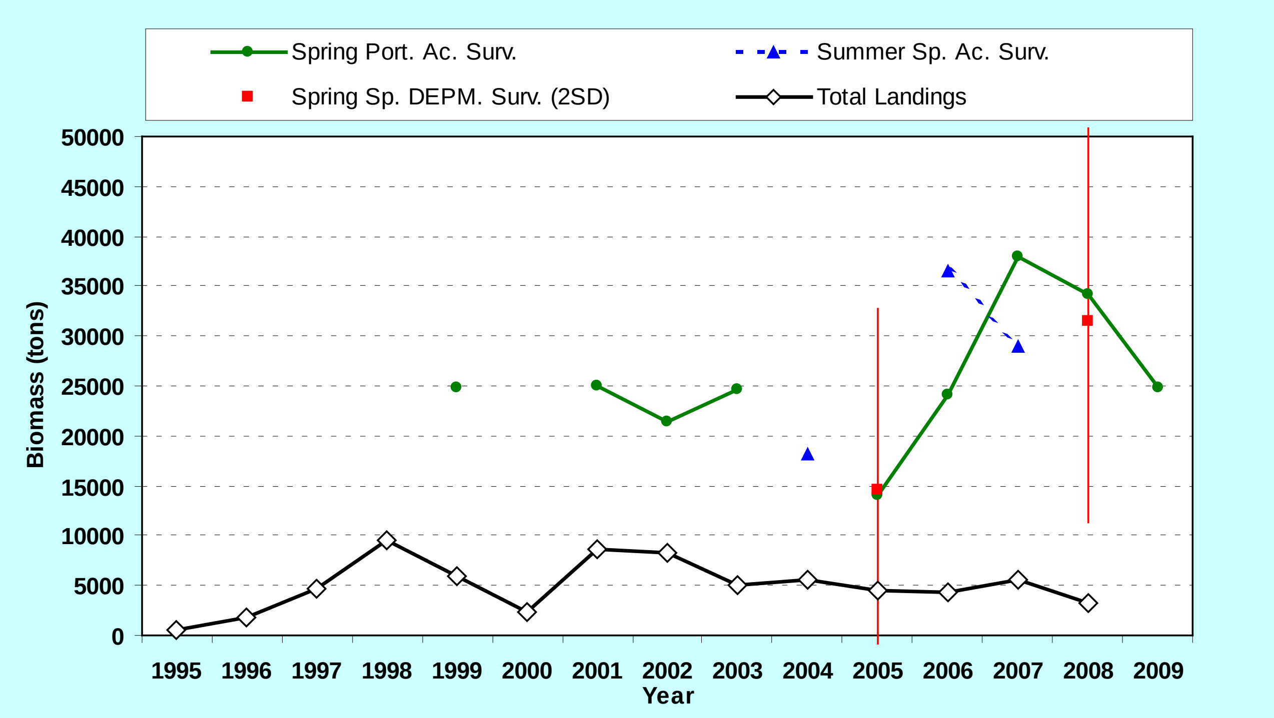


Figure 3.5.1. Anchovy in Division IXa. Anchovy in Subdivision IXa-South (Algarve+Gulf of Cadiz). Trends in landings (upper panel) and catch-at-age numbers (both on an annual and half-year basis).



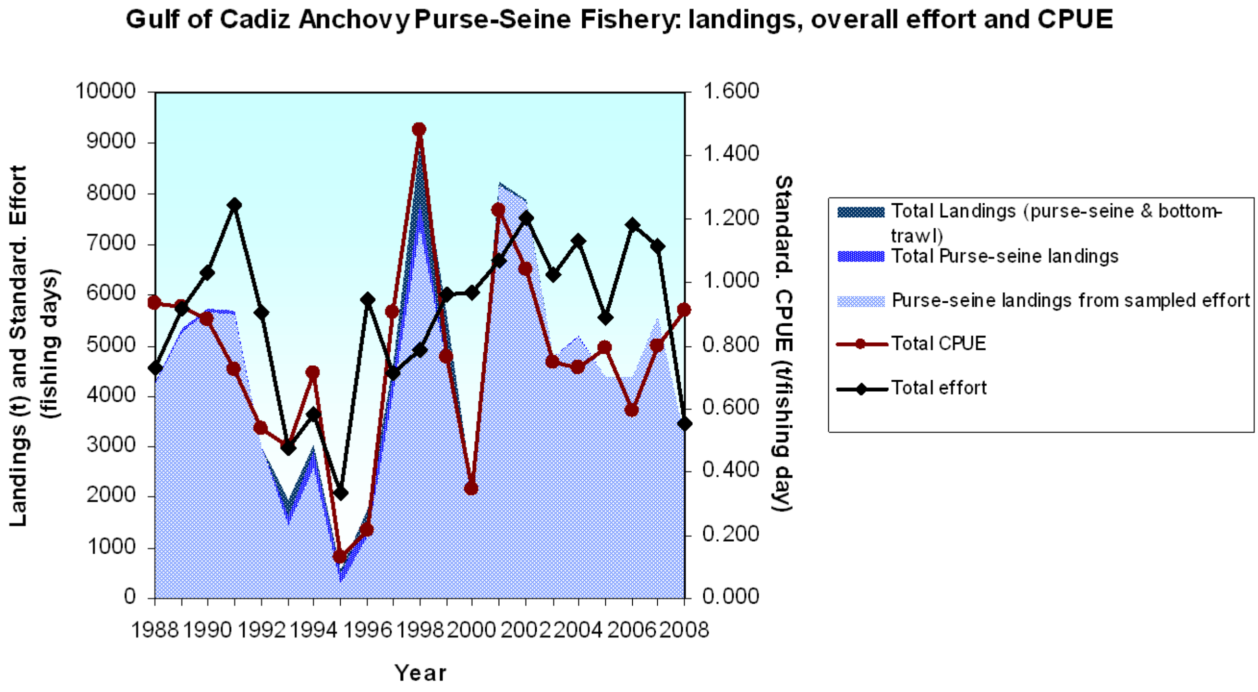


Figure 3.5.2. Anchovy in División IXa. Anchovy in Subdivision IXa-South. Information used in the Qualitative (Update) Assessment. Upper panel: total annual landings (Algarve + Gulf of Cádiz) and available biomass estimates from research surveys series sampling the Subdivision used for comparative purposes. Lower pannel: total annual landings, standardised fishing effort (fishing days) and CPUE (tonnes/fishing day) exerted by the Spanish purse-seine fleet in the Subdivision (same figure as Figure 3.2.4.2).

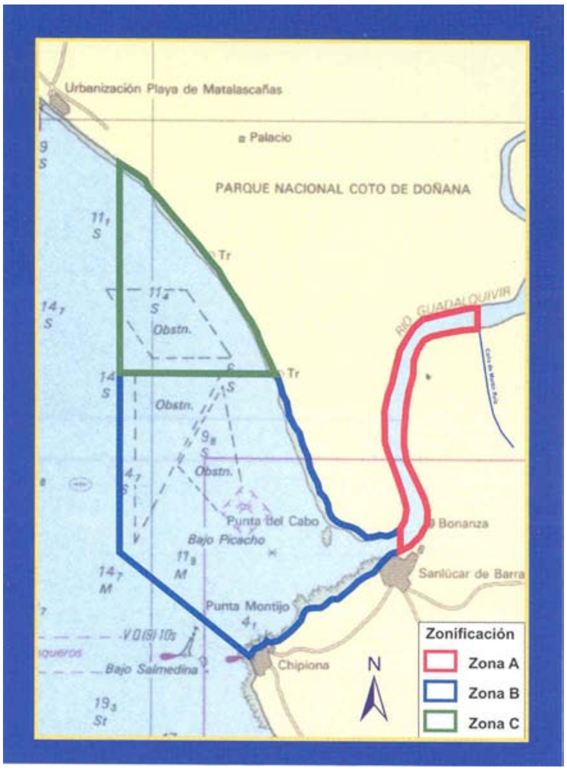


Figure 3.7.2.1. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Subdivision IXa South).

4 Sardine outside the Iberian Peninsula

4.1 The fisheries for sardine in the whole ICES area

4.1.1 Catches for sardine in the ICES area

Commercial catch data for 2008 were provided by Portugal, Spain, France and UK (England and Wales) (Table 4.1.1.1). Total reported catch was 134 696 tonnes, divided as follows: 53% of the catches by Portugal, 23% by Spain and 22% by France. The remaining 2% of catches are reported for divisions VIIe-f by England and Wales. Catches in VIIIc and IXa amount to 75% 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 2008, there was a 8% increase with respect to the total 2007 sardine catches reported in European waters. Portugal showed a 10% increase while Spain showed a 6% decrease in catches with respect to 2007. Landings in France showed a 24% increase and catches from England and Wales increased by 5% in 2008.

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

4.2.1 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 2008 catches was presented to this year´s WG (Table 4.2.1.1). 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 four years to below 1 thousand tonnes. In 2008, landings have decreased to 717 tonnes. The Spanish fishery takes place mainly during March and April and in the fourth quarter of the year.

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

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. Since 2005, due to the closure of the anchovy fishery in autumn, half of the purse seiners operating in the northern part of the Bay of Biscay stopped fishing during a month and a half in exchange for a financial compensation. This decrease in effort is apparent in the autumn landings recorded in those years. Purse seiners fish sardine in the northern part of the Bay of Biscay all year round (in larger quantities in spring and summer), while pelagic trawlers fish sardine in the central Bay of Biscay targeting small fish, mainly during spring. Additionally, a smaller purse seine fleet targeting several species also operates in the Basque Country.

Figure 4.2.1.2. shows French annual sardine landings by the different fleet components. Catches by purse seiners are increasing, while catches by pelagic trawlers remained stable for the last 7 years.

Numbers by length-class for divisions VIIIa,b by quarter are shown in Tables 4.2.1.2 and 4.2.1.3 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, sardine taken by Spanish vessels in 2008 show a clear bimodal distribution (modes at 12.5 and 21 cm).

4.2.2 Acoustic survey in areas VIIIa and VIIIb

Numbers at age for ICES subdivisions VIIIa and VIIIb estimated from the spring French acoustic surveys in 2009 have been made available to the WG. These data together with numbers at age estimated from both Spanish and Portuguese spring acoustic surveys for 2009 for subdivisions VIIIc and IXa are shown in Figure 4.2.2.1. This figure shows the importance of each age class within each subarea in relation to the total sardine population in that subarea (i.e. the proportion of all age classes within subarea sum to 1) and in addition, a pie chart is included to represent the contribution of each subarea to the total estimated biomass. This figure shows that the 2008 recruitment was mainly located in the western area of the Iberian Peninsula. The figure also corroborates earlier evidence of an additional recruitment area in French waters and that the Gulf of Cádiz show the influence of different pulses of recruitment from those of the northwestern Iberian areas.

4.2.2.1 French Spring Acoustic survey 2009

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 2009, PELGAS09 took place from the 26th April to 5th June and detailed objectives, methodology and sampling strategy are described in the WD-Massé *et al.* (2009) presented in this group.

Target species were anchovy and sardine but both species were considered in a multi-species context. To obtain an optimal horizontal and vertical description of the pelagic ecosystem in the area, two types of actions were combined:

i) continuous acquisition by storing acoustic data (from five frequencies: 18, 38, 70, 120 & 200 kHz),

ii) using the CUFES system, pumping sea-water under the surface, in order to evaluate the distribution of fish eggs, and iii) discrete sampling at stations (by trawls, plankton nets, CTD). Concurrently, a visual census of marine mammals and seabirds took place in order to characterise the top predators of the Bay of Biscay pelagic ecosystem.

Sardine was distributed close to the French coast, along the southern Brittany coast pure sardine hauls were obtained (Figure 4.2.2.1.1). In the offshore area, sardine was generally found close to the surface dominating the hauls. As in previous years, young sardine (age 1 fish) were detected close to the coast, along southern Landes and Brittany.

Sardine ranged in length from 8 to 25.5 cm and showed a trimodal length distribution with modes at 12, 16 and at 19 cm (Figure 4.2.2.1.2). Adult fish dominated the population in the offshore strata (depth >60.0 m) while young fish were predominant in the inshore waters of division VIIIb and along the coast of Brittany.

Sardine biomass in the surveyed area (479 684 tons) in 2009 is one of the highest observed in the series. Sardine age distribution for the whole survey series shows poor recruitments in 2005 and 2006 while the 2007 and the 2008 year class (age 1 fish in 2008 and 2009 respectively) appear to be among the strongest of the series (Figure 4.2.2.1.3). During 2003, atypical environmental conditions occurred during the survey and this situation could explain the extremely low biomass estimated that year.

4.2.3 Biological data

4.2.3.1 Catch numbers at length and age

Tables 4.2.3.1.1 and 4.2.3.1.2 shows the catch-at-age in numbers for each quarter of 2008 for French and Spanish landings respectively. In France, fish of age 1 and 2 dominated the fishery in 2008 while in Spain fish of age 1 and age 3 predominated.

4.2.3.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter in 2008 are shown in Tables 4.2.3.2.1 and 4.2.3.2.2 for French landings and in Tables 4.2.3.2.3 and 4.2.3.2.4 for Spanish landings.

4.3 Data Exploration

Further to the exploration by means of a year class curve model (YCC, e.g. Cotter *et al.*, 2007) performed by the WG in 2008, 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 and maturity were not available for this stock so the Iberian data was used(M =0.33 constant across years and ages). All input data are shown on Table 4.3.1.

The model time framework is from 2000 to 2009. However, catch at age data are only available from 2002 to 2008 therefore some assumptions had to be made at the time of running the model to obtain model estimates from 2000. Moreover, the model estimated large catchability factors for the survey which translates into low estimates of biomass. This is likely to be related to high variability in the survey data not supported by the catch or other sources of mortality taken into account. There are two main explanations for the variability in survey data: inconsistent survey area coverage and inter-annual variability in the migrations of the sardine stock into the survey area. This results in a very noisy time-series that the model tries to fit. The sum of squares curve for fixed values of survey catchability between 0.5 and 8, assumed constant across years and ages, is shown in Figure 4.3.1. A minimum was found for catchability around 5. This value was considered unrealistic given the survey catchability estimated in the Iberian Peninsula for sardine (same vessel). Therefore, the survey catchability was fixed in the base run, according to an estimated catchability pattern with maximum catchability at age 2 = 1.

Results from the base run: time series of recruitment, total biomass, SSB, average F for ages 2 – 6 and landings, are shown in Figure 4.3.2. These show a stable biomass and strong recruitments in years 2004 and 2007. 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 4.3.3 and 4.3.4 suggesting some violation of the separability assumption in 2004 catch data and strong year effects in the survey data. 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 4.3.5 and 4.3.6 which also highlights the year effects in the survey data.

The results from this exercise suggest that the catch at age series is still short and the model was sensitive to assumptions to estimate fishing mortality in 2000 and 2001 when only survey data was available. Moreover, 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 4.1.1.1: Sardine general: 2008 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		47			47
VIa					
VIIa					
VIIb					
VIIc					
VIId		8513			8513
VIIe	1114				1114
VIIf	1578				1578
VIIg					
VIIh		160			160
VIIi					
VIIj					
VIIIa		21104			21104
VIIIb			717		717
VIIIc			13636		13636
VIIId					
VIIIe					
IXaN			9409		9409
IXaCN				45 210	45210
IXaCS				20 858	20858
IXaS-Alg				4 928	4928
IXaS-Cad			7423		7423
Total	2692	29824	31184	70996	134696

Table 4.2.1.1: Sardine general: Landings by France (1983-2008) and Spain (1996-2008) 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

* all landings from division VIIIb

n/a = not available

Table 4.2.1.2: Sardine general: French catch length composition (thousands) by ICES divisions VIIIa,b in 2008.

Length	1st quarter	2nd quarter	3rd quarter	4th quarter	Total
7					
7.5					
8					
8.5					
9	36				36
9.5	36				36
10					
10.5					
11	23	25	3		52
11.5					
12	47	49	7	1	103
12.5	94	98	1 218	1	1 411
13	422	441	62	98	1 024
13.5	610	638	1 682	111	3 040
14	879	1 769	1 709	226	4 583
14.5	1 137	2 716	6 550	239	10 641
15	1 087	2 858	13 363	309	17 617
15.5	817	3 244	10 094	222	14 377
16	547	3 140	7 028	178	10 893
16.5	400	3 807	5 047	200	9 453
17	638	3 710	5 547	266	10 161
17.5	796	2 392	10 470	573	14 231
18	1 108	2 140	17 232	806	21 286
18.5	811	2 288	20 952	2 114	26 164
19	1 230	2 165	18 952	3 650	25 997
19.5	2 768	3 512	17 444	2 854	26 578
20	4 260	6 098	16 929	2 540	29 826
20.5	3 818	4 128	15 439	2 935	26 321
21	2 338	3 874	14 599	4 045	24 857
21.5	2 243	3 791	13 091	4 070	23 196
22	2 303	2 467	4 659	4 106	13 534
22.5	2 708	2 340	3 882	3 969	12 899
23	2 768	2 522	1 165	3 447	9 901
23.5	2 219	2 439	776	2 053	7 487
24	1 682	1 551		1 120	4 353
24.5	680	1 396	776	274	3 126
25	501	761			1 262
25.5	107	127			234
26	36	127			163
26.5					
27					
27.5					
28					
28.5					
29					
Total	39 150	66 610	208 676	40 408	354 844
Mean L	20.4	19.3	18.9	21.1	19.4
sd	2.99	3.05	2.29	2.04	2.62
Catch	**2 761**	**4024**	**11 272**	**3047**	**21 104**

Table 4.2.1.3: Sardine general: Spanish catch length composition (thousands) in ICES division VIIIb in 2008.

Length	1st quarter	2nd quarter	3rd quarter	4th quarter	Total
7					
7.5					
8					
8.5					
9					
9.5					
10					
10.5					
11	26	35			61
11.5	121	165			286
12	269	365		12	646
12.5	380	515		59	953
13	198	268		123	589
13.5	89	120		88	297
14	53	72		9	134
14.5	21	29		3	53
15	34	46			80
15.5	20	28			48
16	17	23			40
16.5	13	18			31
17	9	12			20
17.5	5	7		3	16
18	10	13		30	53
18.5	12	16		73	101
19	49	67		111	228
19.5	85	116		220	421
20	110	149		524	783
20.5	135	183		554	872
21	150	203		973	1 326
21.5	113	153		937	1 203
22	118	160		1012	1 290
22.5	119	162		639	921
23	72	98		352	523
23.5	38	52		95	186
24	33	44		10	87
24.5	22	29		3	54
25				1	1
25.5					
26					
26.5					
27					
27.5					
28					
28.5					
29					
Total	2 323	3 148		5 831	11 302
Mean L	16.9	16.9		21.2	19.1
sd	4.43	4.43		2.10	4.03
Catch	**109**	**147**		**461**	**717**

Table 4.2.3.1.1: Sardine general: French 2008 landings in divisions VIIIa and VIIIb:
Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			3265	287	3553
1	8933	27595	111327	11058	158913
2	9820	14406	38061	7412	69699
3	2265	3154	13684	4597	23700
4	7023	9067	17782	6563	40436
5	2361	2541	4341	3522	12764
6	2619	2822	2795	2856	11093
7	2683	2947	3070	1991	10691
8	1699	1927	601	1061	5287
9	931	1176	387	593	3087
10	593	639		160	1392
11	177	266			443
12	46	69			115
13					
14					
Total	39150	66610	195313	40099	341173
Catch (Tons)	2761	4024	11272	3047	21104

Table 4.2.3.1.2: Sardine general: Spanish 2008 landings in ICES division VIIIb:
Catch in numbers (thousands) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0				293	293
1	1258	1705		532	3495
2	213	288		1283	1785
3	292	396		2258	2945
4	300	406		903	1608
5	86	116		257	459
6	100	136		261	497
7	35	47		45	127
8	29	39			68
9	10	14			25
10					
11					
12					
13					
Total	2322	3148	0	5831	11301
Catch (Tons)	109	147	0	461	717

Table 4.2.3.2.1: Sardine general: French 2008 landings in divisions VIIIa and VIIIb: Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			13.1	13.4	13.1
1	15.5	15.8	17.6	18.7	17.2
2	19.2	19.1	19.0	19.5	19.1
3	20.0	19.9	20.2	20.8	20.2
4	20.7	20.6	20.2	20.9	20.5
5	21.8	21.7	21.0	21.6	21.4
6	22.1	22.2	22.1	22.1	22.1
7	22.3	22.3	20.6	21.7	21.7
8	22.4	22.5	21.8	22.1	22.3
9	22.7	22.9	21.8	22.0	22.5
10	22.8	22.8		23.0	22.8
11	23.0	23.7			23.4
12	23.9	23.9			23.9
13					
14					

Table 4.2.3.2.2 Sardine general: French 2008 landings in divisions VIIIa and VIIIb: mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0			0.018	0.019	0.018
1	0.031	0.033	0.047	0.057	0.044
2	0.063	0.062	0.061	0.067	0.062
3	0.071	0.071	0.074	0.082	0.075
4	0.080	0.079	0.074	0.083	0.078
5	0.095	0.094	0.084	0.093	0.091
6	0.101	0.101	0.099	0.100	0.100
7	0.103	0.104	0.079	0.094	0.095
8	0.105	0.106	0.096	0.100	0.103
9	0.110	0.113	0.096	0.098	0.107
10	0.110	0.112		0.114	0.111
11	0.115	0.126			0.122
12	0.130	0.130			0.130
13					
14					

Table 4.2.3.2.3: Sardine general: Spanish 2008 landings in ICES division VIIIb: Mean length (cm) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0				13.3	13.3
1	13.0	13.0		19.9	14.1
2	20.0	20.0		20.8	20.6
3	20.9	20.9		21.8	21.6
4	22.0	22.0		22.4	22.2
5	22.6	22.6		22.7	22.7
6	22.9	22.9		22.5	22.7
7	23.4	23.4		23.6	23.5
8	23.6	23.6			23.6
9	24.5	24.5			24.5
10					
11					
12					
13					
14					

Table 4.2.3.2.4: Sardine general: Spanish 2008 landings in ICES division VIIIb: mean weight (kg) at age.

Age	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Whole Year
0				0.017	0.017
1	0.017	0.017		0.063	0.024
2	0.064	0.064		0.073	0.071
3	0.075	0.075		0.085	0.082
4	0.087	0.087		0.092	0.090
5	0.095	0.095		0.097	0.096
6	0.099	0.099		0.094	0.097
7	0.107	0.107		0.109	0.107
8	0.109	0.109			0.109
9	0.123	0.123			0.123
10					
11					
12					
13					
14					

Sardine VIIIab - Catch numbers at age (thousands), 9 is +group

-1 2
2002 2008
0 9

3703.326	162937.9	67783.2	25016.34	15769.52	11126.85	7444.364	2156.667	1170.001	823.576
4381.71	89475.43	62145.36	27446.56	16544.5	9645.771	6206.694	3333.872	1646.632	736.523
22283.44	88305.74	50183.74	36191.33	15109.61	9387.926	2795.978	1328.195	632.331	305.6475
4114.096	91371.14	41479.17	29104.73	22997.89	17983.15	9190.096	5114.802	3167.253	1804.778
8895.818	35588.44	84755.39	30337.34	21007.79	15203.65	9519.411	6946.061	3558.309	2806.917
24017.4	66813.24	25930.17	59416.22	13094.72	14185.51	12177.57	7468.423	3582.447	2906.627
3845.384	162408	71483.76	26645.22	42044.05	13223.24	11589.99	10817.63	5354.7	5061.735

Age structured tuning indices
101
French survey

	1	2	3	4	5	6	7	8+
2000	1276312	1559347	1083847	721738.2	551464.6	218657.3	152984.1	132676.4
2001	1280080	1367856	819202.6	751576.3	353969.8	466190.4	175123.9	277453.3
2002	3458311	3585189	1115098	566798	162724.7	85013.02	38003.24	9120.009
2003	160135.6	528080.5	463811.6	165696.4	55940.47	2234.164	5426.416	1090.082
2004	2997203	2029661	1606397	706117	467765.6	283691.8	95816.86	61324.34
2005	2613794	1807043	824020.1	822188	610585	383259.9	230491.9	174773.2
2006	605847.3	2819592	274995.7	90287.15	42056.06	38917.75	13436.15	16260.49
2007	631470.6	296091.7	761270.9	131706.5	57855.69	64657.9	27164.71	35553.6
2008	3432039	1549493	383747	1478305	301616.3	223603.2	241520.8	373180.6
2009	6111475	3286964	707700.3	301304.6	737097.7	215646.6	148809.5	157875

Sardine VIIIab: catch weight at age (kg)

	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	0.046965	0.080617	0.088595	0.093562	0.097238	0.105267	0.109777	0.118986	0.133342
2006	0.023648	0.038989	0.074012	0.088143	0.09405	0.101322	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	0.075878	0.07823	0.090829	0.100302	0.095035	0.103438	0.110112

Sardine VIIIab: stock weight at age (kg), 8 is plus group

	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	0.0947

Table 4.3.1: Sardine in VIIIa b. Separable model input data.

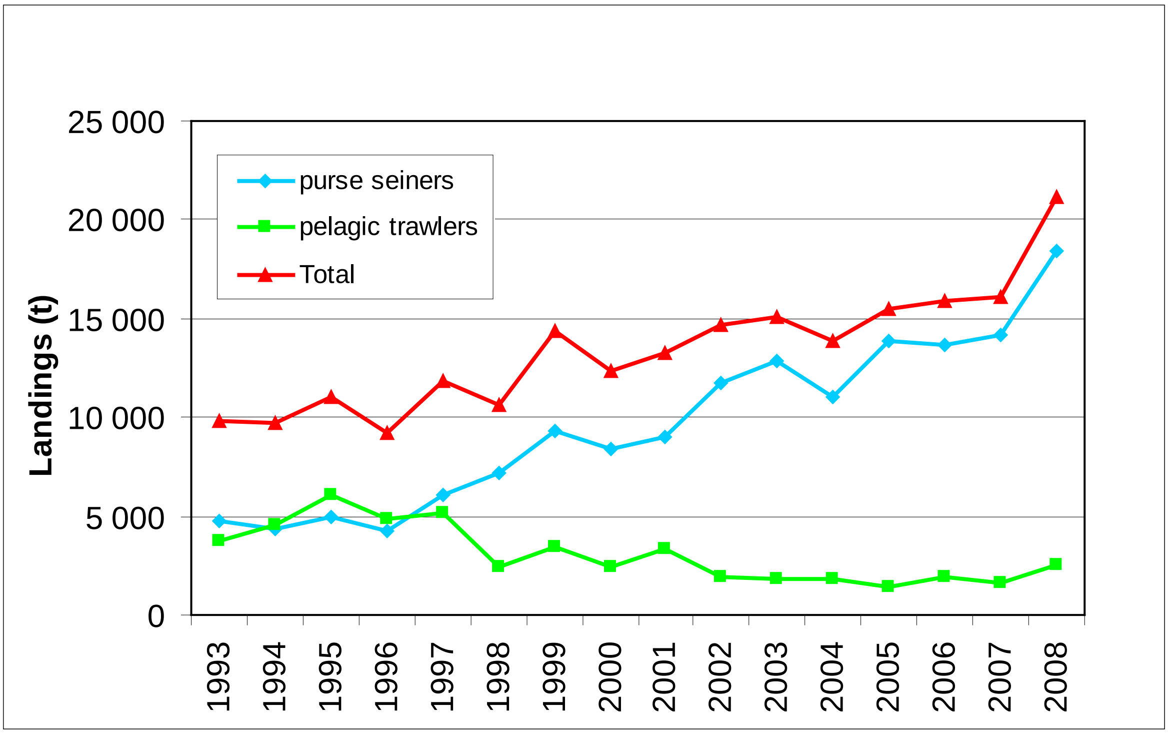


Figure 4.2.1.2: Sardine general: French landings in divisions VIIIa and VIIIb. Annual sardine landings (by different French fleet components since 1993).

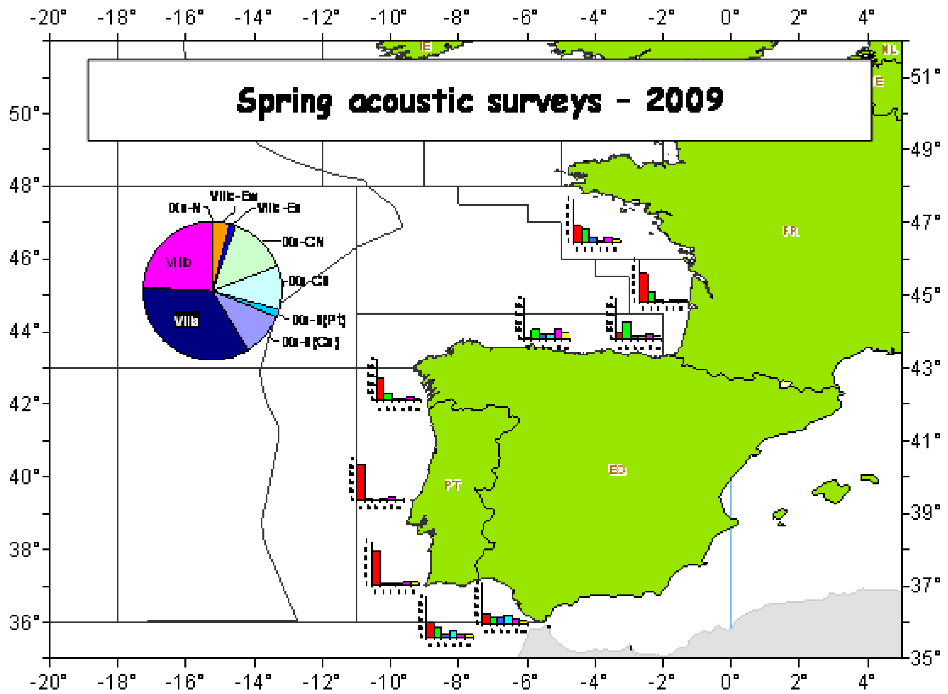


Figure 4.2.2.1: Sardine general: Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2008). Age categories are: 1, 2, 3,…and 6+. The pie chart represents the contribution of each subarea to the total biomass.

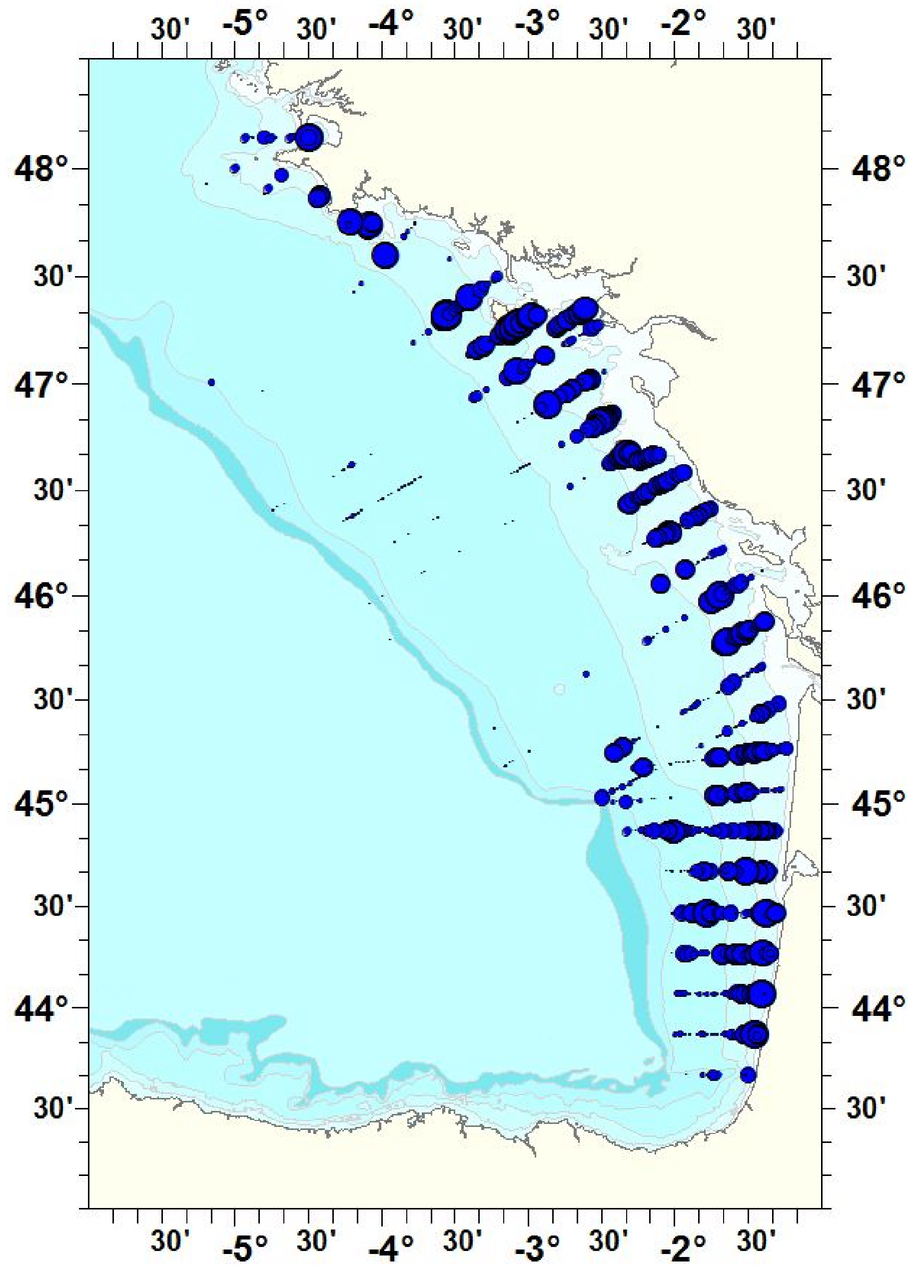


Figure 4.2.2.1.1: Sardine general: Distribution of sardine as observed during the French acoustic survey PELGAS09.

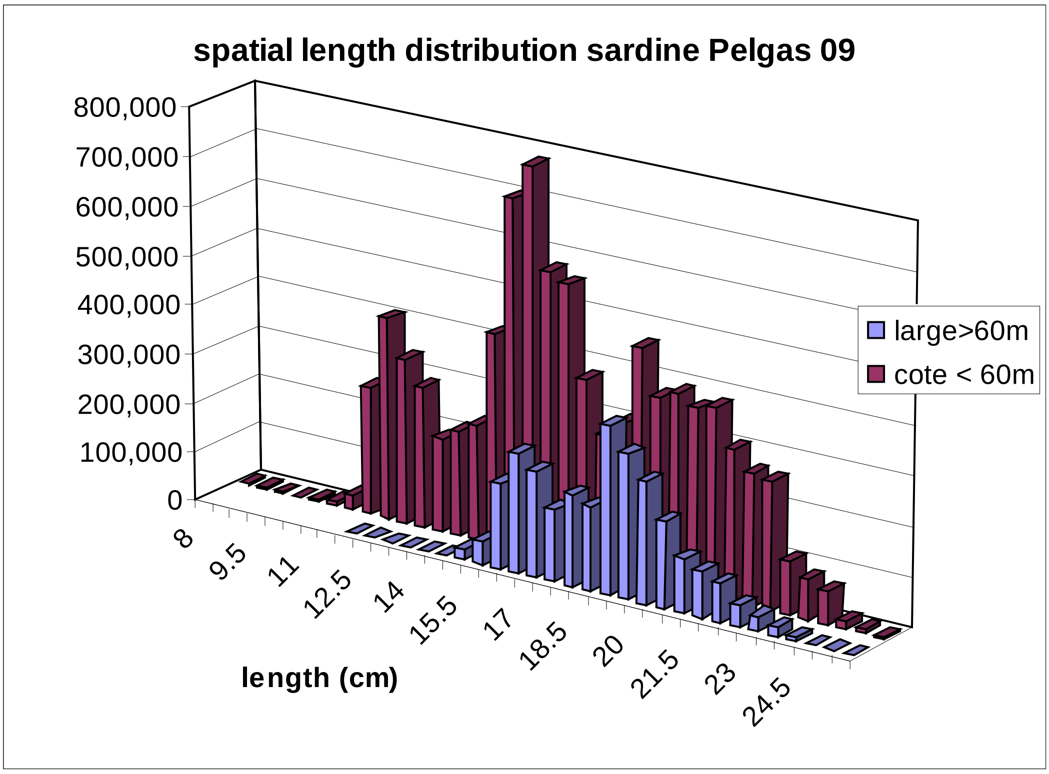


Figure 4.2.2.1.2: Sardine general: Sardine length distribution in numbers of fish for divisions VIIIa+VIIIb in the French acoustic survey PELGAS08.

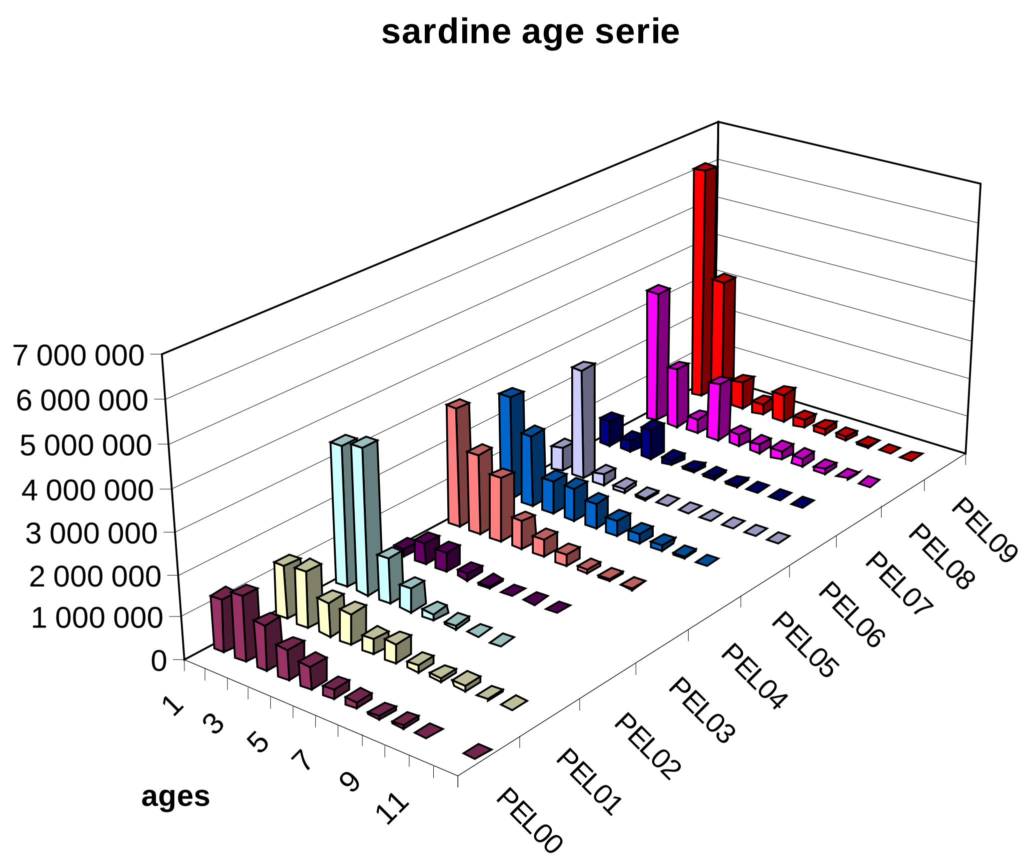


Figure 4.2.2.1.3: Sardine general: Sardine age distribution in numbers of fish for divisions VIIIa and VIIIb in the French acoustic surveys PELGAS 2000 – 2009.

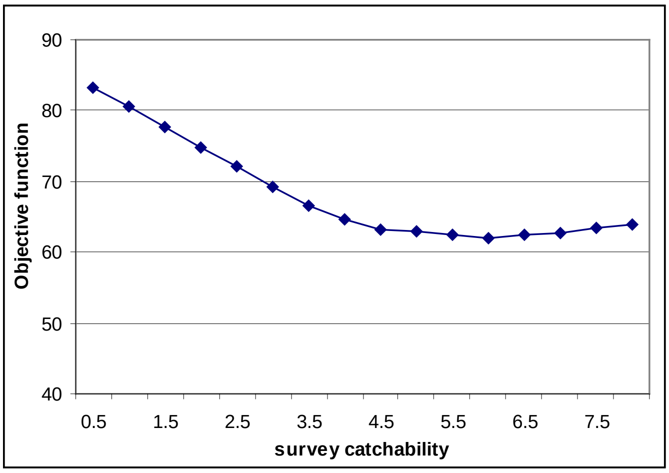


Figure 4.3.1: Sardine in VIIIa – b. SSQ curve for a range of survey catchabilities.

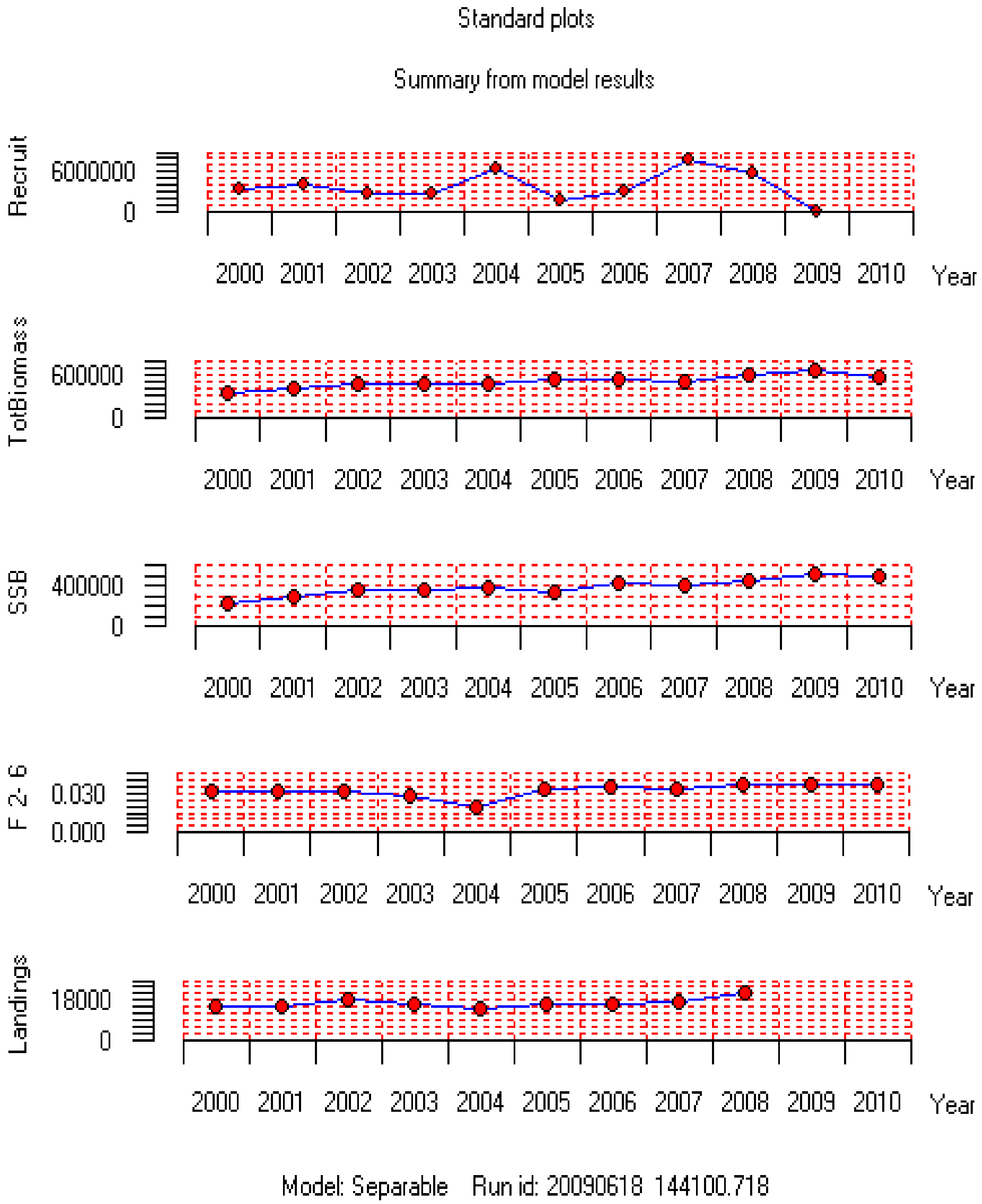


Figure 4.3.2: Sardine in VIIIa – b. Summary plots from data exploration with separable VPA. Base run.

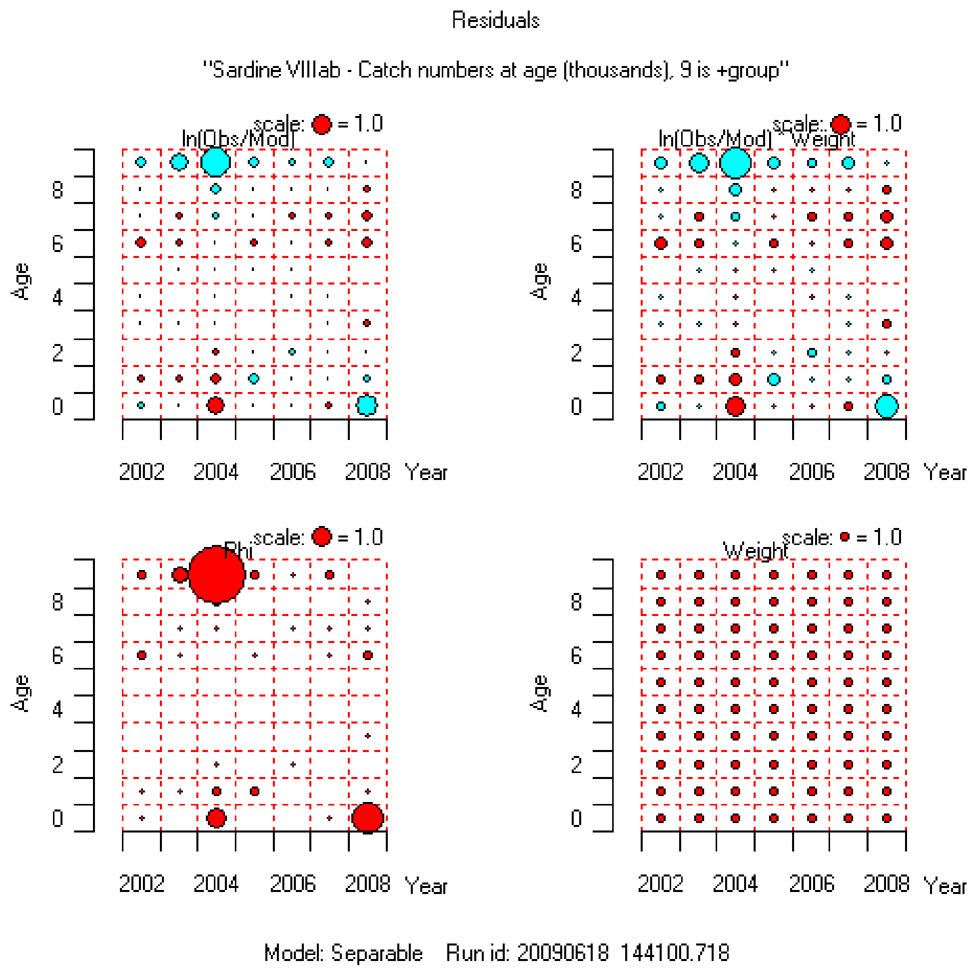


Figure 4.3.3: Sardine in VIIIa – b. Separable VPA, base run. Residuals from catch at age.

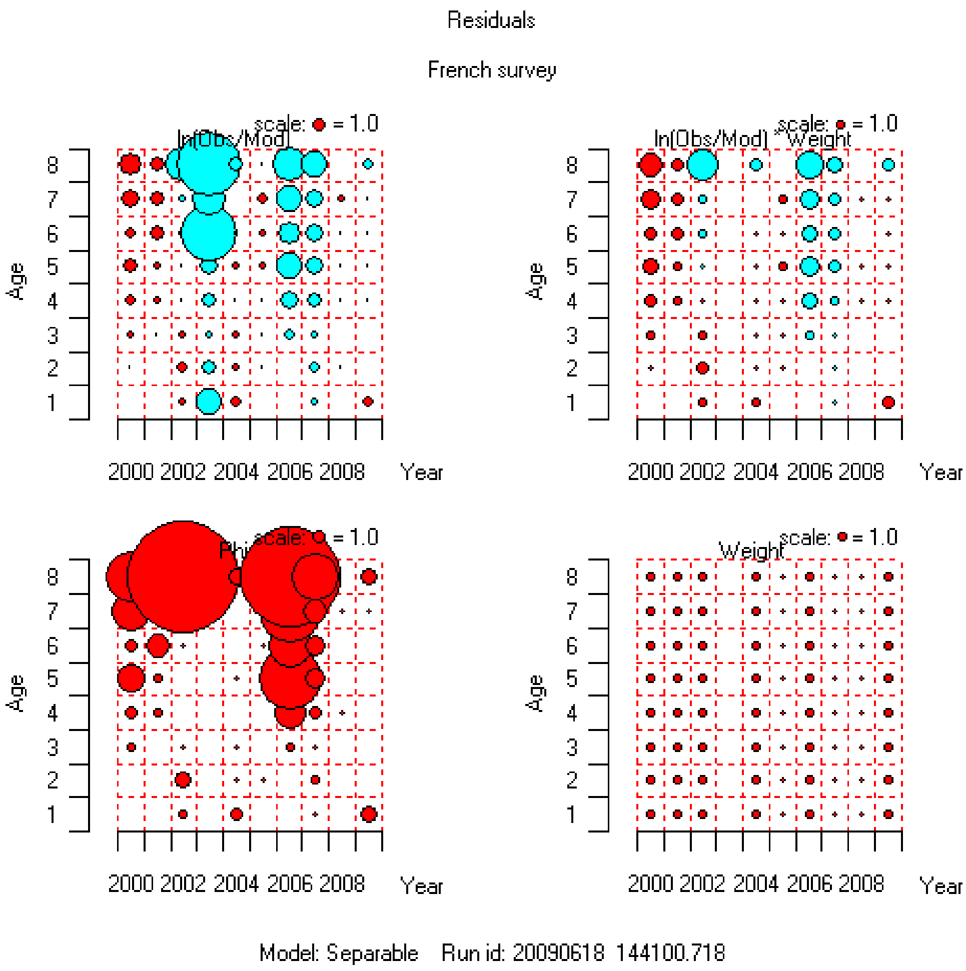


Figure 4.3.4: Sardine in VIIIa – b. Separable VPA, base run. Residuals from survey numbers at age.

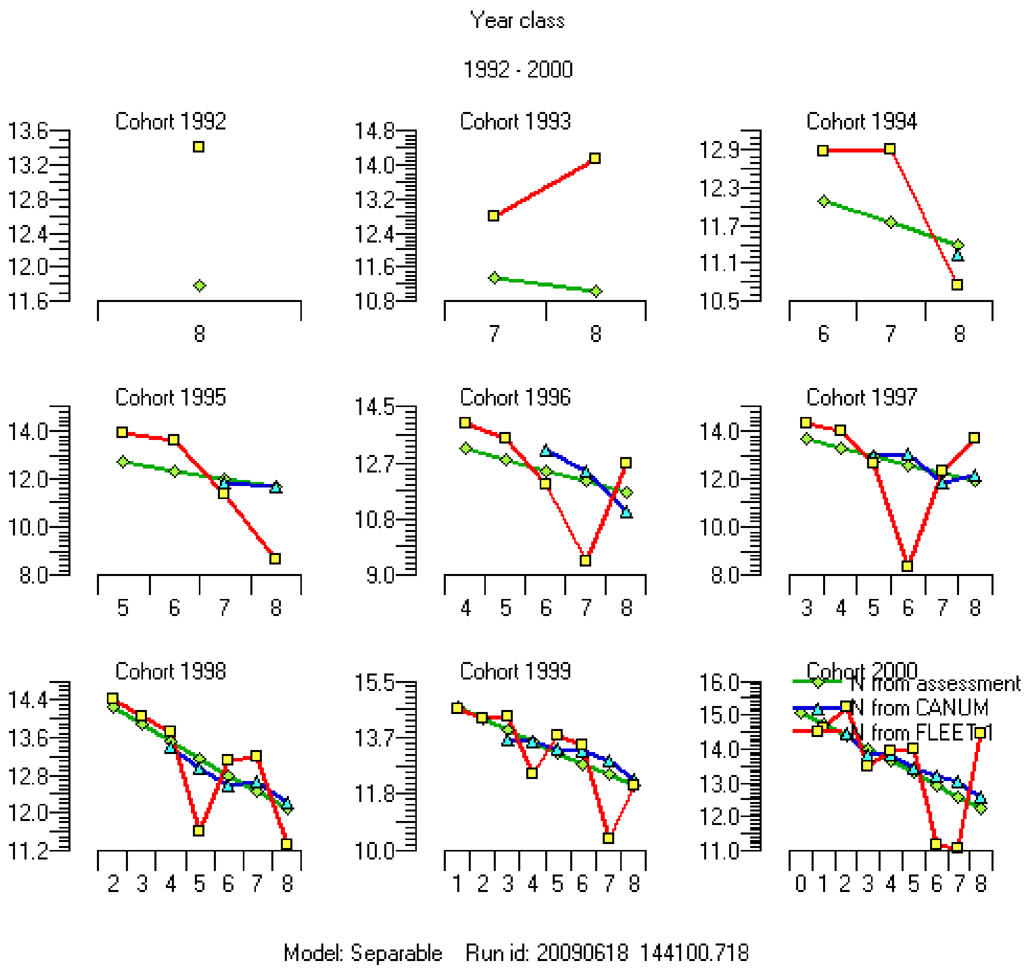


Figure 4.3.5: Sardine in VIIIa – b. Separable VPA, base run. Cohort curves (1992 – 2000) from catch and survey data and estimated by the assessment.

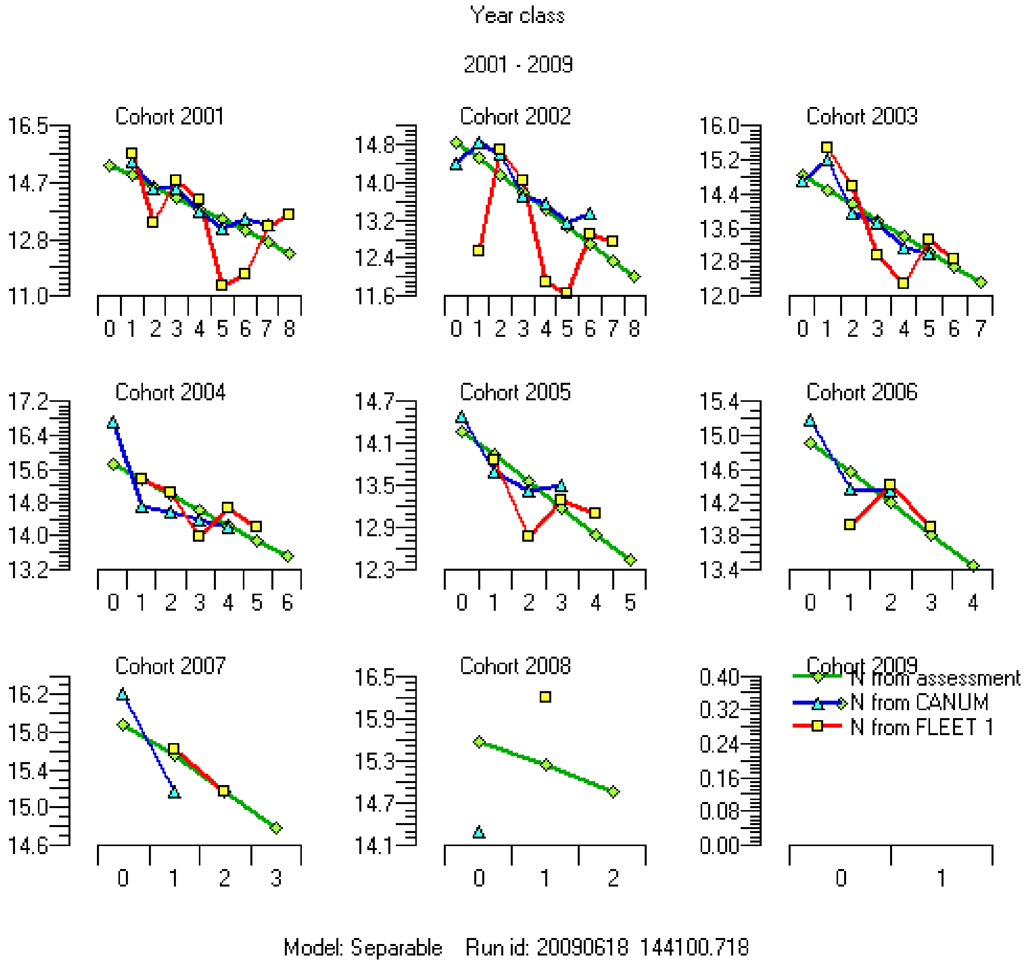


Figure 4.3.6: Sardine in VIIIa – b. Separable VPA, base run. Cohort curves (2001 – 2008) from catch and survey data and estimated by the assessment.

5 Sardine in VIIIc and IXa

5.1 ACFM Advice Applicable to 2008

For 2009, ICES advised that as the current low fishing mortality does not appear to be detrimental for the development of the stock, which is largely driven by the incoming recruitment, ICES recommended that the current fishing mortality (0.20) could be maintained as a guide for management. This corresponds to a catch of 71 thousand tonnes in 2009.

In the absence of defined reference points, the state of this stock cannot be evaluated with regard to these. Based on the most recent assessment, SSB in 2008 was around the long-term average, having decreased in the past two years due to successive low recruitments. Fishing mortality had decreased since 1998 and is now (2008) at a low level.

There are no management objectives for this stock and there is no TAC. The stock is managed by Portugal and Spain through minimum landing size, maximum daily catch, days fishing limitations, and closed areas.

5.2 The fishery in 2008

5.2.1 Catches by fleet and area

As estimated by the Working Group, sardine landings in 2008 show a slight increase in comparison with those of 2007 (Tables 5.2.1 and 5.2.2, Figure 5.2.1). Total 2008 landings in divisions VIIIc and IXa were 101 464 t, i.e. an increase of 5% with respect to the 2007 values (96 469 tonnes). The bulk of the landings (99%) were made by purse-seiners. In Spain, landings of sardine (30 468 tonnes) showed a 5% decrease with respect to the values from 2007 (31 970 tonnes). Both ICES subdivisions VIIIc and IXaS Cadiz showed an increase in catches (2% in subdivision VIIIc and 20% in IXaS-Cadiz) while subdivision IXaN showed a 24% decrease. In Portugal, landings in 2008 (70 997 tonnes) were 10% higher than the landings in 2007 (64 449 tonnes). This increase in landings originated in all subdivisions (10% increase in IXaCN, 9% in IX-aCS and 16% in IXaS).

Table 5.2.1 summarises the quarterly landings and their relative distribution by ICES Subdivision. Sixty-five percent of the catches were landed in the second semester (34% in the third quarter) and almost 45% of the landings took place off the northern Portuguese coast (IXaCN). This value is slightly higher than the one reported for last year. The percentage of catches in the northern area of the stock (VIIIc and IXaN) (23%) has decreased from last year. The southern areas accounts for 12% of the total values in 2008, slightly above the value in 2007.

5.2.2 Fleet Composition in 2008

Details about the vessels operated by both Spain and Portugal targeting sardine are given in table 5.2.1.1. In northern Spanish waters, sardine is taken by purse seine. The total number of vessels with license for this gear in 2008 was 306, ranging in size from 8 to 38 m (mean vessel length = 22 m) and in power between 25 to 1100 (mean = 326 HP).

Half of the purse seiners (53%) are licensed in Galicia, where most of the smaller boats are found since part of the fishing takes place inside the rías. Purse seiners from the Basque Country (26% of the fleet) and Cantabria (18%) are bigger (they generally take longer trips while fishing). The remaining 3% of the fleet is licensed in Asturias.

In the Gulf of Cadiz, purse seiners taking sardine are generally targeting anchovy (n = 99) and range in size from 10 to 25 m with a mean vessel length of 16 m (horse power between 28 to 510 with a mean of 188). In Portuguese waters, fleet data from 2006 indicate that sardine is taken by purse seiners (n = 121) ranging in size from 10.5 to 27 m (mean vessel length = 20 m). Vessel engine power ranges between 71 to 447 (mean = 249).

5.3 Fishery independent information

Figures 5.3.1 and 5.3.2 show the time series of fishery independent information for the sardine stock.

5.3.1 DEPM – based SSB estimates

DEPM surveys were carried out in 2008 by both Spain and Portugal. Objectives, methodologies and results from these surveys are detailed in WD- Bernal *et al.* (2009) and are only briefly summarized here.

The DEPM survey was carried out on board the R/V "Noruega" from the 18th of January to the 17th of February in Portugal. In Spain, the DEPM survey used two vessels: the RV Cornide de Saavedra (for plankton sampling mainly) from the 2nd to the 27th of April and the RV Thalassa (fishing hauls) from the 23rd of March to the 23rd of April. The surveys covered a total area of 90 450 km2, of which 52 478 km2 were considered the spawning area.

Results show that the 2008 DEPM-based SSB estimate is the largest since 1997 (1988 was not included due to incomplete coverage) and this increase is particularly evident in the southern area (with a six fold increase in relation to the 2005 estimate) (Table 5.3.1.1). In the western area the estimated biomass is also among the largest of the time series while in the northern area, the estimate is slightly higher than the one in 2005 (note that the 2005 estimate is believed to be underestimated due to an overestimation of the spawning fraction value in that year). The increase in the SSB estimate in the southern and western area is due to a combination of high egg production (highest of the time series) and high mean weight.

The DEPM survey in 2008 attained a sampling intensity and coverage considered among the best in the time series. In addition, the values obtained proved to be robust to the tests conducted to check the effect on the estimates of several factors, i.e. daily spawning cycle, the cutting points in the data used to estimate the parameters of the mortality curve, the combination of strata used, etc. The high biomass figure obtained in the DEPM survey is corroborated by the observed increase in: the percentage of positive Calvet and Cufes stations (around 50% this year while around 30-35% in previous surveys, e.g. in late 90s), the presence area, the raw number of eggs sampled (around 10 000, as opposed to 3-5 000 in the past) and the estimates of Po (both traditional and GAM-based). In addition, and with respect to the adult parameters, W, R and S were very uniform across the whole Iberian peninsula in consistency with the uniformity of sizes (mostly from the 2004 year class) predominating across the area.

However, there are large differences between the acoustic and DEPM-based SSB estimates, particularly off the southern area, which need to be investigated. This task will be carried out within the WGACEGG and a revision of the time series is expected for the next benchmark assessment for Atlanto-Iberian sardine.

5.3.2 Acoustic surveys

During 2008/2009, two acoustic surveys were carried to estimate sardine and anchovy abundance in IXa. The November 2008 survey (SAR08NOV) aims to cover the early spawning and recruitment season while the April 2009 survey (PELAGOS09) aims to cover the late spawning season. Both surveys took place onboard the RV "Noruega".

Both surveys were conducted following the methodology applied in previous years and agreed and revised at the WGACEGG. No major problems occurred during the surveys with the exception that during PELAGOS09, during the second half of the survey (southwest and south Portuguese coast), both pelagic nets were lost. This loss prevented fishing in the water column during that period of the survey but it is believed to have no major effect on the estimate of sardine.

The November 2008 survey took place from the 2nd to the 27th of October covering the Portuguese coast and the Gulf of Cádiz. A total of 31 trawl hauls were performed with sardine being present in 20 of those. Sardine was mainly found in the western coast, north of Peniche and also in the Gulf of Cádiz (Figure 5.3.2.1.1). Very few sardine was detected south of Cape Espichel and in the Algarve. Total sardine biomass estimated in the surveyed area was 307 thousand tonnes (51% of it being located in Portuguese waters) corresponding to 8 055 million individuals of which 56% were located in Portuguese waters (Table 5.3.2.1.1). These values represent a decrease of 40% in biomass of 17% in numbers compared with the values estimated by last year autumn survey (Figures 5.3.1. and 5.3.2). The age structure was dominated by age 0 fish, and with other year classes detected in low abundance. The strong 2004 year was only apparent detected in the north western area.

Sardine eggs were found in almost all the sampled area, but at lower abundances than in previous cruises. Higher egg densities were detected in Cádiz, Sines, Baia de Lisboa, North of Nazaré and from Douro to Miño rivers (Figure 5.3.2.1.2).

The April 2009 survey (PELAGOS09) took place from the 26th of March to the 24th of April and covered the Portuguese and Gulf of Cádiz waters ranging from 20 to 200 m depth. A total of 35 fishing stations were carried out with sardine being present in 31 of those. Sardine was found throughout the surveyed area but in low numbers (Figure 5.3.2.1.3). The highest concentrations were found from Porto to Figueira da Foz. Total estimated sardine biomass in the surveyed area was 294 thousand tonnes corresponding to 9 529 million individuals (Table 5.3.2.1.2). These values represent an increase of 20% in biomass and 36% in numbers compared with the values estimated by last year spring survey (Figures 5.3.1. and 5.3.2). Age 1 fish (2008 year class) dominated in all areas with the exception of the Gulf of Cádiz where the 2005 cohort was also important. Results from the survey suggest that the level of the 2008 recruitment is close to the average in the series (and higher than the 2007 and 2006 recruitments).

Sardine eggs were found widespread over the surveyed area with an occupied area slightly bigger than in the 2008 survey (Figure 5.3.2.1.4). Higher egg densities were found near Aveiro, Tejo-Sado and western Algarve. Egg densities in Cadiz were lower than in previous surveys

5.3.3 Spanish April 2009 Acoustic Survey

The Spanish survey took place onboard the RV "Thalassa" from the 27th March to 23rd April. The area covered extended from northern Portuguese waters to southern French waters and from 30 to 200 m depth. The survey was conducted following the methodology applied in previous years and agreed and revised at the WGACEGG.

Sardines were present in 28 of the 62 trawl hauls completed during the survey (23 in Spanish waters). Sardine abundance was estimated as 612 million individuals, while biomass was estimated to be 44.6 thousand tonnes (Table 5.3.2.2.1). Less than 10% of the fish (7% by number and less than 5% of the biomass) were found in southern Galician waters (ICES subdivisions IXaN) and mostly very close to the coast. No fish at all were found in northern Galician waters (VIIIcW). In the Cantabrian and Basque Country areas sardine was found more widely distributed, throughout the whole shelf (Figure 5.3.2.2.1). These figures represent a drastic decrease of 68% in biomass and 65% in abundance in relation to the estimated values in 2008.

Sardine ranged in length from 13 to 26.5 cm with a mode at 23 cm (Figure 5.3.2.2.2). Applying the ALK obtained from the fish sampled during the survey, most fish (22% by number and 26% of the biomass) in the entire surveyed area were assigned to age class 5 (2004 year class) (Table 5.3.2.2.1). Considering the age distribution by sub-area, the highest proportion of older fish (up to 9 years old although in very low numbers) was found in Cantabrian and Basque Country waters (ICES subdivision VIIIcE). No fish older than 7 years were found in Galician waters (ICES subdivisions IXaN). Age 5 fish predominated in the Cantabrian (VIIIcW) while age 1 fish predominated in IXaN. In the Basque country, both the 2007 and the 2004 year classes were noticeable (43% and 15% by number, respectively).

In 2009 there was a decrease in the number of eggs and in the number of positive stations. Eggs were found concentrated along the coast with low - zero values near the edge of the shelf (Figure 5.3.2.2.3).

Sardine distribution area seems to have shrunk to coastal areas in recent years, making it less available to the acoustic survey but not the fishery. Further discussion on this topic is planned to take place on the next meeting of WGACEGG that will take place at the end of this year.

5.4 Biological data

5.4.1 Catch numbers at length and age

Tables 5.4.1.1a,b,c,d show the quarterly length distributions of landings from each subdivision. Annual length distributions were bimodal in Spain with the exception of subdivision VIIIcE which showed a unimodal distribution (mode at 22 cm). Modes were 12.5 and 22 cm for VIIIcW, 10.5 and 21 for IXaN and 15 and 20 cm for IXaS Cádiz. For Portugal, single modes were observed for IXaCS and IXaS-Algarve at 20 cm while IXaCN showed a bimodal length distribution (at 15 and 20 cm).

Table 5.4.1.2 shows the catch-at-age in numbers for each quarter and subdivision. In Table 5.4.1.3, the relative contribution of each age group in each Subdivision is shown as well as their relative contribution to the catches. The strong 2004 year class (4-group in 2008) dominates the catches in IXaN, VIIIcE and IXaCS. In VIIIcW age 0 fish (2008 year class) dominated the catches in number while in IXaS Algarve the 2004 year class is as apparent as the 2005 and 2006 year classes. Age 0 fish and age 1 fish (2007 and 2008 year classes) dominates the catches in Cádiz.

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

5.4.2 Mean length and mean weight at age

Mean length and mean weight at age by quarter and Subdivision are shown in Tables 5.4.2.1 and 5.4.2.2.

5.4.3 Maturity and stock weights at age

The maturity ogive and stock weights for 2008 are show below. Maturity at age 1 has decreased from the high value obtained in 2007 (the second highest recorded) to one of the lowest in the series.

AGE	0	1	2	3	4	5	6+
% mature fish	0	29.2	94.3	98.9	99.6	99.8	99.9

AGE	0	1	2	3	4	5	6+
Weight, kg	0	0.017	0.052	0.065	0.070	0.080	0.087

5.4.4 Natural mortality

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

5.5 Effort and catch per unit effort

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

5.6 Data and model exploration

This year, the assessment of sardine is an update and therefore no data and model exploration was carried out. Catch and acoustic survey data were updated with the estimates from 2008 and 2009, respectively. The DEPM spawning biomass series was also updated with the 2008 estimate, which became available this year.

5.6.1 Data exploration

Sardine catch-at-age data and abundance-at-age data from the combined spring acoustic survey are presented in Figures 5.6.1.1 and 5.6.1.2 and listed in Table 5.6.1.1 f,g, respectively. Both catches and abundance data support the strength of the 2004 year class and suggest poor year classes in the period 2006 – 2007. According to the acoustic surveys, the 2008 recruitment has a much lower level than recent strong recruitments although it seems slightly stronger than those of 2006-2007. Catches provide no information on the strength of the 2008 year class since 0-group fish are weakly selected by the fishery. Figures 5.6.1.3 to 5.6.1.5 show the mean weights-at-age in the catch and in the stock and maturity ogive (data listed in Table 5.6.1.1 a,b,c). Sardine mean weights-at-age in the stock and catches show an increasing trend over time particularly in 2 years and older individuals. There is also substantial inter-annual variation in weights-at-age in recent years. Maturity-at-age, particularly for 1-year olds, shows extensive variation between years too; maturity at age 1 declined from 75% in 2007 to 30% in 2008. The causes for such variability are still unclear. There is some evidence of density-dependence in sardine L_{50} (Silva *et al*., 2006) and it is possible that changes in maturity-at-length and age are related to extensive variations of recruitment in recent years. However, other causes related to the biology of the species and also to the sampling strategy, need to be investigated.

5.6.2 Stock assessment

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

The following data were used:

- Catch numbers at age: 1978-2008
- 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 2009.
- DEPM estimates of spawning 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 2008 equal to that in 2007
- 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 2009. Recruitment in 2009 was assumed at $4*10^9$
- Initial selection at age in the fishery, for all ages, but assumed equal for ages 4 and 5. Selection in 2008 assumed equal to 2007.
- 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 5.6.1.1d-i. Summary plots are presented in Figure 5.6.2.1. Residuals for the catches, acoustic survey and DEPM survey are shown in Figures 5.6.2.2 to 5.6.2.4, respectively. Fishing mortalities at age are shown in Figure 5.6.2.5, and the survey catchability-at-age in Figure 5.6.2.6.

Catch and acoustic survey residuals from this year's assessment are comparable to those obtained last year. These residuals do not raise serious concern as they are generally small. As noted in previous assessments, there is some clustering of mostly negative or mostly positive values in both the catches and survey. A large negative residual in the 6+ group in the 1996 survey has also been noticed in previous assessments. The reasons for both this residual and for the weak pattern observed in both catch and survey residuals are unclear and a closer examination of their origin is recommended.

Residuals for the DEPM survey are higher than those of last year's assessment and show an upward trend across the time series. A high residual, 0.35, is observed for the 2008 survey.

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 compared to those of last year's assessment for the most recent years (see Section 5.6.3). SSB shows a decrease of 157 thousand tonnes from 2007 (653 thousand tonnes) to 2008 (496 thousand tonnes) due to successive low recruitments since 2004. Fishing mortality (F_{2-5}) increased 39% from 2007 (0.16 year^{-1}) to 2008 (0.22 year^{-1}), reflecting the increase of catches and decline of stock abundance. However, it is still at a low historical level. The 2008 recruitment (6525 billion individuals, CV=10%) is estimated to be at the level of the geometric mean of historical recruitments. An average 2008 recruitment is supported by the 2009 Spring acoustic survey (at age 1).

Coefficients of variation of the estimated parameters, as derived from the Hessian matrix, are given in Table 5.6.2.1. 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 around the model values. The main results from 100 replicas are shown in Figure 5.6.2.7. 90% confidence limits for the recruitment are narrow and both SSB and fishing mortality seem to be estimated with a reasonable and consistent precision across the time series.

5.6.3 Reliability of the assessment

The results from this year's assessment show some differences compared to those of last year's assessment in recent years (Figure 5.6.2.1). These differences reflect the effect of a new SSB data point from the 2008 DEPM survey. The inclusion of this estimate in the assessment shifted the SSB and recruitment upwards and the fishing mortality downwards with some influence backwards in time (2002). The assessment represents a compromise between the different sources of data.

Data used to update the assessment this year is considered reliable by the WG. There is a discrepancy between the acoustic and the DEPM survey. The WG is not in a position to decide whether one is more reliable than the other. A comprehensive analysis of these surveys will be carried out in the next meeting of the WGACEGG (November). This assessment is an update and therefore, comments reported in ICES (2006, 2007) are still applicable (namely, the abrupt decline of selection and catchability for the 6+ group).

5.6.4 Catch 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 2008 recruitment was that estimated in the assessment, R_{2008}=6525 million individuals;
- Input values for 2009, 2010 and 2011 recruitments were set equal to the geometric mean of the period 1995-2008, $R_{GM(95\text{-}08)}$ = 4923 million individuals;
- Weights-at-age in the stock and in the catch were calculated as the arithmetic mean value of the last three years (2006-2008);
- The maturity ogive corresponded to the mean values of the period 1989-2008 (for which there are annual observations);
- 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(2006-08) unscaled. F_{sq} = 0.18 year^{-1}

The 2008 recruitment estimated by the assessment model was used in the prediction since it is supported by data from the April 2009 acoustic survey (at age 1) and also from the November 2008 survey (see also section 5.3). For 2009 – 2011, the assumed recruitment was based on the period 1995-2008, when the declining trend of the time series has apparently stopped (Figure 5.7.1.1). The assumption of an average recruitment has some support in anecdotal information from the Portuguese fishery in 2009 off the main recruitment area (north Portugal).

In view of the extensive inter-annual variation in maturity-at-age and in order to decrease the influence of this assumption on the results of the catch predictions, it was decided to use a long-term average of the maturity ogive (instead of the maturity for the terminal year, as used in recent years).

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

Input values are shown in Table 5.7.1.1. and results are shown in Table 5.7.1.2. The predicted catches with Fsq (0.18) for 2009 are 80 thousand tonnes. Predicted SSB for 2009 is 421 thousand tonnes, which is below the historical mean. If fishing mortality remains at the Fsq level (0.18), the predicted yield in 2010 (75 thousand tonnes) is 27% lower than the catch level in recent years (average of 96 thousand tonnes, 2004 – 2008). Predicted SSB for 2010 is 425 thousand tonnes, which means a decrease of 14% with respect to the estimated 2008 SSB.

According to catch predictions, the average catch level in the last five years (96 thousand tonnes, 2004-2008) will lead to a fishing mortality of 0.23 and a SSB in 2011 of 393 thousand tons.

As in previous years, it should be pointed out that the outcome of short term deterministic predictions has a high uncertainty due to the use of assumed values of recruitment, possible bias in the assessment and the assumption that current levels of fishing mortality will remain constant in 2009 and 2010.

5.7 Reference points and harvest control rules for management purposes

Precautionary reference points have so far not been defined for this stock. As the assessment now appears to be stable, reference points may be considered.

There are no clear indications of a stock-recruit relationship (Figure 5.8.1). There has been an overall downward trend in the recruitment, from the start of the time series to approximately 1995 (Figure 5.7.1.1). Since then, recruitments have been relatively stable at a low level. There is some time pattern in the recruitment, with one or two strong year classes approximately every 4th year. This pattern was broken in 1996, where one would have expected a new strong year class but the recruitment was at the normal low level. Following that, the SSB was reduced gradually to the lowest on record, (281 thousand tonnes in 2000). In that phase, the sardine almost disappeared from Galician waters, while the abundance in Portuguese waters appeared more normal. This led to a crisis in Galician fisheries that remained until the strong 2000 year class appeared. Therefore, assuming a random recruitment around a long term mean may not be adequate. Furthermore, management plans may need to take into account variations in distribution area.

The yield per recruit curve for this stock is rather uncommon, with a very gradual rise of the yield towards high fishing mortality. The F0.1 value is well above 0.5, which is highest F on record. Hence, F0.1 does not seem to be a good candidate for Fpa.

Work is in progress to develop harvest rules for this stock, although the process still is in an early stage. In that context, a Blim value is the most important. The obvious candidate would be Bloss, which is estimated at 281 thousand tonnes. However, shrinkage of the area of distribution, in particular, disappearance from Galician waters, may be suggested as an additional criterium, both because this may signal a reduced stock and because it may represent an unwanted consequence of stock reduction. Including such criteria would require further exploration of the link between stock abundance and area distribution. Time did not permit that during the present WG meeting.

5.8 Management considerations

No TAC is set to manage the stock. Limitations to fishing effort implemented in Portugal and Spain since 1997 continued to be in effect during 2008. Catch limitations are still in place in Spain.

The Spawning Stock Biomass of this stock, 496 thousand tonnes in 2008, is about the average of the historical series (499 thousand tonnes) but is decreasing due to successive low recruitments in the last four years (2005 – 2008). Fishing mortality increased by 40% to 0.22 from 2007 to 2008, reflecting the increase of catches and the decrease in stock abundance, but is still below the historical average. Short term predictions indicate a further decline in SSB in 2009 to 421 thousand tonnes. With a fishing mortality at 0.18, which is the average for 2006 - 2008, the SSB is expected to stabilize or decline only slightly in 2010 and 2011 if the current weak recruitment continues. That mortality implies a reduction in catches for 2010 to 75 thousand tonnes. Catches at the present level will lead to a further decline in biomass and an escalating fishing mortality if the recruitment in the near future continues to be low. In the past, extended periods of successive low recruitments combined with high fishing mortality have led to periods of minimum SSB in the stock history. In the most recent of these periods (late 1990s) the sardine fisheries experienced a critical phase, which was mainly felt in the northern Spanish areas. Hence, fishing mortality should not increase above the 2006 – 2008 level of 0.18, corresponding to a catch of less than 75 thousand tonnes in 2010.

The WG considers that the management of this stock would be facilitated if a management plan were developed. Such development is in progress. So far it is on an early stage, mostly concentrating on developing adequate models for recruitment and other aspects of preparing a sound scientific basis for future dialogue and development process

Table 5.2.1: Sardine in VIIIc and IXa: Quaterly distribution of sardine landings (t) in 2008 by ICES Sub-Division. Above absolute values; below, relative numbers.

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	1490	1132	1558	3699	**7879**
VIIIc-W	474	1820	2120	1343	**5757**
IXa-N	1343	2330	2331	3404	**9409**
IXa-CN	5068	9368	16994	13781	**45210**
IXa-CS	3641	4911	6933	5373	**20858**
IXa-S (A)	850	978	1691	1410	**4928**
IXa-S (C)	800	671	3372	2579	**7423**
Total	**13667**	**21210**	**34998**	**31589**	**101464**

Sub-Div	1st	2nd	3rd	4th	Total
VIIIc-E	1.47	1.12	1.54	3.65	**7.77**
VIIIc-W	0.47	1.79	2.09	1.32	**5.67**
IXa-N	1.32	2.30	2.30	3.36	**9.27**
IXa-CN	5.00	9.23	16.75	13.58	**44.56**
IXa-CS	3.59	4.84	6.83	5.30	**20.56**
IXa-S (A)	0.84	0.96	1.67	1.39	**4.86**
IXa-S (C)	0.79	0.66	3.32	2.54	**7.32**
Total	**13.47**	**20.90**	**34.49**	**31.13**	

Table 5.2.1.1: Sardine in VIIIc and IXa: Spanish and Portuguese composition of the fleet catching sardine in 2008. Length category: range (average) in m, Engine power category: range (average) in HP.[Values from Portugal correspond to 2006 data].

Country	Details given	Length (metres)	Engine power (Horse Power)	Gear	Storage	Discard estimates	No vessels
Spain (northern)	yes	8-38 (22)	25 – 1100 (326)	Purse seine	Dry hold with ice	No	306
Spain (Gulf of Cadiz)	yes	10-25 (16)	28-510 (188)	Purse seine	Dry hold with ice	No	99
Portugal	yes	10.5 – 27 (20)	71 – 447 (249)	Purse seine	Dry hold with ice	No	121

Table 5.2.2: Sardine in VIIIc and IXa: Iberian Sardine Landings (tonnes) by sub-area and total for the period 1940-2008.

			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**

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

Table 5.3.1.1. DEPM estimates of sardine spawning biomass (in thousand tonnes) and CV (between brackets) for the Spanish (North) and Portuguese surveys (Portugal and Gulf of Cadiz) over 1997-2008, using traditional estimation. [The estimate for 2005 in the northern area is believed to be an underestimation due to an overestimation of the spawning fraction value and is pending revision].

Year	NORTH (Spain)	SOUTH (Portugal)	W POR (Portugal)	Total
1997	20.7 (84)	246.9 (47)	75.0 (44)	352.6
1999	13.4 (77)	199.3 (48)	56.3 (37)	269
2002	50.7 (33)	121.5 (48)	281.4 (37)	453.6
2005	154.5 (29)	48.3 (45)	215.8 (39)	418.6
2008	142 (30)	300 (28)	245 (26)	687

Table 5.3.2.1.1: Sardine in VIIIc and IXa: Sardine Assessment from the 2008 Portuguese autumn acoustic survey. Number in thousand fish and biomass in tonnes.

AREA		0	1	2	3	4	5	6+	Total
Oc. Norte	**Biomass**	**70663**	**25578**	**4392**	**4453**	**12985**	**632**	**2774**	**121477**
	%	58	21	4	4	11	1	2	
	No fish	**3119792**	**471576**	**69662**	**64435**	**196668**	**8230**	**31970**	**3962332**
	%	79	12	2	2	5	0	1	
Oc. Sul	**Biomass**	**2567**	**5252**	**4903**	**7203**	**6425**	**3397**	**5804**	**35551**
	%	7	15	14	20	18	10	16	
	No fish	**76228**	**113662**	**73680**	**96764**	**86144**	**40978**	**67210**	**554665**
	%	14	20	13	17	16	7	12	
Algarve	**Biomass**	**47**	**54**	**96**	**185**	**65**	**31**	**122**	**601**
	%	8	9	16	31	11	5	20	
	No fish	**1620**	**996**	**1440**	**2493**	**880**	**361**	**1447**	**9236**
	%	18	11	16	27	10	4	16	
Cadiz	**Biomass**	**38623**	**25159**	**32887**	**34249**	**9211**	**2876**	**6276**	**149281**
	%	26	17	22	23	6	2	4	
	No fish	**1744158**	**462061**	**534959**	**522379**	**137880**	**44464**	**83657**	**3529560**
	%	49	13	15	15	4	1	2	
Total	**Biomass**	**73277**	**30885**	**9391**	**11841**	**19475**	**4060**	**8700**	**157629**
Portugal	**%**	46	20	6	8	12	3	6	
	No fish	**3197640**	**586233**	**144781**	**163692**	**283691**	**49570**	**100626**	**4526233**
	%	71	13	3	4	6	1	2	
Total	**Biomass**	**111900**	**56044**	**42278**	**46091**	**28685**	**6936**	**14977**	**306910**
	%	36	18	14	15	9	2	5	
	No fish	**4941798**	**1048294**	**679741**	**686071**	**421572**	**94034**	**184283**	**8055793**
	%	61	13	8	9	5	1	2	

Table 5.3.2.1.2: Sardine in VIIIc and IXa: Sardine Assessment from the 2009 Portuguese spring acoustic survey (PELAGOS09). Number in thousand fish and biomass in tonnes.

AREA		1	2	3	4	5	6+	Total
Oc. Norte	**Biomass**	74206	4988	1527	8571	19567	3013	**111872**
	%	66	4	1	8	17	3	
	No fish	4448676	111617	27869	142871	321334	43047	**5095414**
	%	87	2	1	3	6	1	
Oc. Sul	**Biomass**	47316	1696	1923	6276	9546	16728	**83486**
	%	57	2	2	8	11	20	
	No fish	2085252	33098	31500	90434	132427	216190	**2588901**
	%	81	1	1	3	5	8	
Algarve	**Biomass**	3455	3215	1515	2466	1496	1540	**13687**
	%	25	23	11	18	11	11	
	No fish	96098	67335	26735	39717	23310	21767	**274962**
	%	35	24	10	14	8	8	
Cadiz	**Biomass**	14254	14533	14895	21168	10374	8734	**83958**
	%	17	17	18	25	12	10	
	No fish	397995	277804	258771	348312	160172	127474	**1570527**
	%	25	18	16	22	10	8	
Total	**Biomass**	124978	9899	4965	17313	30609	21281	**209045**
Portugal	**%**	60	5	2	8	15	10	
	No fish	6630027	212050	86103	273023	477071	281004	**7959277**
	%	83	3	1	3	6	4	
Total	**Biomass**	139232	24433	19860	38481	40982	30015	**293003**
	%	48	8	7	13	14	10	
	No fish	7028022	489853	344875	621334	637242	408478	**9529804**
	%	74	5	4	7	7	4	

Table 5.3.2.2.1: Sardine in VIIIc and IXa: Sardine abundance in number (thousands of fish) and biomass (tons by age groups and ICES subdivision in PELACUS0409.

AREA VIIIcE east	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	918	4257	1262	1085	2094	588	466	302	44	0	11017
% Biomass	8.3	38.6	11.5	9.8	19.0	5.3	4.2	2.7	0.4	0.0	100
Abundance (in '000)	26122	71704	17559	13259	24892	6431	4992	3108	383	0	168450
% Abundance	15.5	42.6	10.4	7.9	14.8	3.8	3.0	1.8	0.2	0.0	100
Medium Weight (gr)	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1
Medium Length (cm)	16.6	20.0	21.3	22.3	22.6	23.2	23.4	23.7	25.1	0.0	20.2

AREA VIIIcE west	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	610	6093	4007	4678	9342	3372	1899	994	287	128	31410
% Biomass	1.9	19.4	12.8	14.9	29.7	10.7	6.0	3.2	0.9	0.4	100
Abundance (in '000)	15906	97335	54604	53934	106612	36798	19688	10348	2718	1130	399073
% Abundance	4.0	24.4	13.7	13.5	26.7	9.2	4.9	2.6	0.7	0.3	100
Medium Weight (gr)	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Medium Length (cm)	17.1	20.3	21.5	22.8	22.9	23.2	23.7	23.6	24.4	25.0	22.2

AREA VIIIcW	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	0	0	0	0	0	0	0	0	0	0	23944
% Biomass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
Abundance (in '000)	0	0	0	0	0	0	0	0	0	0	283267
% Abundance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100
Medium Weight (gr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.1
Medium Length (cm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7

AREA IXaN	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	965	409	109	201	292	98	94	0	0	0	2168
% Biomass	44.5	18.9	5.0	9.3	13.5	4.5	4.3	0.0	0.0	0.0	100
Abundance (in '000)	25810	8246	1711	2951	3964	1301	1171	0	0	0	45153
% Abundance	57.2	18.3	3.8	6.5	8.8	2.9	2.6	0.0	0.0	0.0	100
Medium Weight (gr)	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1
Medium Length (cm)	16.9	18.7	20.5	21.0	21.5	21.7	22.2	0.0	0.0	0.0	20.1

TOTAL SPAIN	1	2	3	4	5	6	7	8	9	10	TOTAL
Biomass (tonnes)	2493	10759	5379	5964	11728	4058	2459	1296	331	128	44595
% Biomass	5.6	24.1	12.1	13.4	26.3	9.1	5.5	2.9	0.7	0.3	100
Abundance (in '000)	67838	177285	73873	70144	135467	44530	25851	13456	3101	1130	612676
% Abundance	11.1	28.9	12.1	11.4	22.1	7.3	4.2	2.2	0.5	0.2	100
Medium Weight (gr)	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1
Medium Length (cm)	16.8	20.1	21.4	22.6	22.8	23.2	23.6	23.6	24.5	0.0	19.9

Table 5.4.1.1: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in 2008.

				Total				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5			142					142
8			570					570
8.5			855					855
9			1 282					1 282
9.5			1 425					1 425
10			3 277	77				3 354
10.5	18		3 277	385	20			3 699
11	192	127	1 917	3 084	40	32	453	5 844
11.5	680	528	791	5 586	70	21		7 676
12	948	3 894	500	11 068	183	64	511	17 167
12.5	720	9 648	456	9 088	318	159	3 590	23 980
13	769	7 643	560	14 638	291	815	7 088	31 805
13.5	444	2 900	188	16 864	353	572	9 059	30 380
14	309	2 143	178	27 285	318	894	12 320	43 449
14.5	227	1 257	170	28 110	487	524	20 011	50 785
15	456	1 139	217	37 707	503	274	26 187	66 484
15.5	741	364	90	27 715	982	167	24 628	54 685
16	851	526	659	17 064	2 194	153	26 980	48 428
16.5	928	283	679	6 332	2 244	133	16 986	27 584
17	813	274	2 126	4 271	2 629	374	12 874	23 361
17.5	820	245	2 260	4 516	2 396	765	5 806	16 807
18	1 355	747	7 145	13 261	5 195	2 351	3 883	33 936
18.5	1 292	542	6 625	26 774	11 011	5 473	4 622	56 339
19	2 997	1 272	12 640	58 416	25 149	9 569	5 803	115 846
19.5	4 085	1 553	10 051	104 662	44 330	14 164	7 299	186 144
20	4 651	2 939	11 524	135 033	61 386	16 267	5 753	237 553
20.5	6 106	4 849	10 343	108 846	60 059	10 576	2 205	202 984
21	8 661	4 742	13 352	66 264	44 941	5 966	1 634	145 560
21.5	10 448	8 307	12 081	26 351	22 262	2 866	176	82 492
22	12 794	11 030	11 732	8 590	11 036	1 039	42	56 264
22.5	12 011	9 749	9 180	3 084	4 118	315		38 458
23	10 138	5 860	5 121	659	1 264	74		23 115
23.5	6 597	2 503	1 842	228	335	17		11 521
24	2 641	777	768	128	59			4 373
24.5	878	268	141		24			1 310
25	232	31	13		10			287
25.5	18				5			23
26	1				2			4
26.5								
27								
27.5								
28								
28.5								
29								
Total	93 818	86 141	134 174	766 087	304 214	73 625	197 909	1 655 969
Mean L	21.2	18.8	19.5	18.7	20.3	19.7	16.2	19.0
sd	2.58	4.27	3.60	2.72	1.29	1.61	1.89	2.88
Catch	**7879**	**5757**	**9409**	**45210**	**20858**	**4928**	**7423**	**101465**

Table 5.4.1.1a: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the first quarter 2008.

				First Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5	18				20			37
11	192			60	40			292
11.5	680	2		241	70			994
12	948	1		724	167			1 840
12.5	719	29		664	164		59	1 634
13	761	27	2	861	104			1 756
13.5	433	60		1 796	148		59	2 496
14	285	55		4 812	65		234	5 452
14.5	177	48	2	6 557	20		666	6 804
15	374	48		11 084	34	7	3 252	11 547
15.5	625	37		7 856	124	7	4 536	8 650
16	748	77	16	3 777	508	34	3 399	5 160
16.5	838	166	13	1 550	233	25	2 087	2 826
17	636	141	258	585	547	60	907	2 227
17.5	542	103	324	326	390	112	515	1 797
18	245	80	986	935	1 065	136	395	3 446
18.5	179	47	484	3 600	2 508	451	963	7 268
19	314	151	1 003	10 577	6 689	1 063	1 372	19 797
19.5	327	380	1 037	15 566	11 096	2 161	1 243	30 567
20	534	784	1 954	14 983	12 247	3 341	1 148	33 843
20.5	894	1 469	2 443	9 274	10 395	2 946	271	27 420
21	1 641	1 028	2 371	5 146	6 455	1 967	142	18 607
21.5	2 102	577	1 914	2 658	2 870	1 111		11 232
22	2 469	511	1 751	906	1 610	475	42	7 721
22.5	2 263	342	1 370	941	371	103		5 391
23	1 946	176	886	217	151	26		3 402
23.5	1 022	169	463	106	23	7		1 791
24	495	26	258	107				886
24.5	110	38	126					275
25	69							69
25.5	9							9
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	22 593	6 571	17 661	105 912	58 113	14 033	21 290	225 236
Mean L	19.4	20.5	21.0	18.2	20.1	20.4	16.9	19.2
sd	3.94	2.07	1.58	2.63	1.37	0.97	1.76	2.61
Catch	**1 490**	**474**	**1 343**	**5 068**	**3 641**	**850**	**800**	**13 667**

Table 5.4.1.1b: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the second quarter 2008.

Second Quarter								
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10								
10.5								
11							56	56
11.5								
12								
12.5								
13								
13.5							120	120
14	2						193	195
14.5	4			4	2		537	546
15	5		90	5	23	19	1 144	1 287
15.5	6			15	61		1 529	1 612
16	10		27	172	324	11	1 759	2 303
16.5	28		264	405	820	42	1 959	3 518
17	77	45	622	1 332	559	179	2 480	5 293
17.5	87	130	978	1 927	370	397	1 288	5 178
18	130	616	3 584	3 674	588	1 024	995	10 611
18.5	115	467	2 419	5 079	1 342	1 362	793	11 576
19	281	1 039	4 730	13 348	4 592	2 343	709	27 043
19.5	380	809	3 503	28 451	10 380	3 146	917	47 586
20	547	939	3 938	38 113	15 989	3 759	576	63 860
20.5	688	939	3 059	26 554	15 638	1 935	438	49 251
21	1 090	1 903	3 403	12 469	11 731	927	59	31 582
21.5	1 506	3 884	2 531	3 668	5 961	314	125	17 988
22	1 884	4 103	1 974	1 176	2 630	90		11 858
22.5	1 930	2 852	1 021	328	1 171	29		7 331
23	1 750	2 051	724	43	249	30		4 848
23.5	1 083	791	66		105	4		2 049
24	541	354	8		47			950
24.5	261	18	4					283
25	81	9	13					104
25.5	5							5
26								
26.5								
27								
27.5								
28								
28.5								
29								
Total	12 492	20 950	32 960	136 763	72 580	15 612	15 676	307 033
Mean L	22.1	21.7	20.1	20.1	20.5	19.8	17.3	20.2
sd	1.51	1.42	1.50	0.90	1.07	0.99	1.68	1.44
Catch	**1 132**	**1 820**	**2 330**	**9 368**	**4 911**	**978**	**671**	**21 210**

Table 5.4.1.1c: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the third quarter 2008.

				Third Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5			142					142
8			570					570
8.5			855					855
9			1 282					1 282
9.5			1 425					1 425
10			3 277					3 277
10.5			3 277	75				3 352
11		127	1 917	1 660		32		3 736
11.5		526	791	3 019				4 336
12		3 893	500	4 227	16	64	511	9 210
12.5	2	9 619	456	1 510	74	159	2 042	13 862
13	8	7 616	558	830	65	795	5 004	14 876
13.5	11	2 840	188	226	34	572	6 546	10 418
14	21	2 088	178	257	8	890	10 180	13 623
14.5	44	1 209	134	84	8	509	16 593	18 581
15	64	1 091	26		44	223	18 124	19 572
15.5	81	326		52	86	135	13 612	14 293
16	38	450	147	27	308	64	13 254	14 286
16.5	22	117	135	105	345	18	6 182	6 923
17	62	88	295	306	464	49	4 488	5 750
17.5	137	12	464	1 156	388	207	1 761	4 125
18	528	51	1 248	6 103	869	921	1 220	10 939
18.5	459	28	1 823	12 387	1 419	2 967	1 484	20 568
19	838	82	3 274	22 366	4 022	4 605	517	35 705
19.5	1 041	303	2 079	40 159	8 797	6 244	819	59 441
20	1 246	1 169	2 398	54 299	16 765	4 699	391	80 966
20.5	880	2 166	2 412	43 608	21 610	1 859	264	72 799
21	584	1 230	4 067	28 608	20 071	417	69	55 046
21.5	1 352	2 035	3 255	10 947	10 784	161	51	28 585
22	2 013	2 805	2 883	3 382	5 368	77		16 527
22.5	2 492	2 702	1 543	513	2 172			9 422
23	2 254	1 765	689	63	753	10		5 533
23.5	1 678	780	210		167			2 835
24	596	180	39					815
24.5	260	111			11			382
25	34	22						57
25.5	5							5
26	1							1
26.5								
27								
27.5								
28								
28.5								
29								
Total	16 748	45 430	42 537	235 971	94 648	25 676	103 111	564 121
Mean L	21.7	16.2	17.0	19.8	20.7	18.9	15.4	18.7
sd	1.90	4.25	5.03	1.97	1.09	2.07	1.39	3.17
Catch	**1 558**	**2 120**	**2 331**	**16 994**	**6 933**	**1 691**	**3 372**	**34 998**

Table 5.4.1.1d: Sardine in VIIIc and IXa: Sardine length composition (thousands) by ICES subdivision in the fourth quarter 2008.

				Fourth Quarter				
Length	**VIIIc E**	**VIIIc W**	**IXa N**	**IXa CN**	**IXa CS**	**IXa S**	**IXa S (Ca)**	**Total**
7								
7.5								
8								
8.5								
9								
9.5								
10				77				77
10.5				310				310
11				1 363			397	1 760
11.5				2 325		21		2 346
12				6 117				6 117
12.5				6 915	80		1 489	8 484
13				12 946	122	21	2 084	15 173
13.5				14 842	170		2 334	17 346
14	1			22 216	245	4	1 713	24 179
14.5	3		34	21 465	457	15	2 214	24 187
15	13		101	26 618	402	25	3 668	30 827
15.5	28		89	19 791	712	24	4 950	25 594
16	55		469	13 088	1 054	44	8 569	23 279
16.5	39		267	4 272	846	47	6 759	12 231
17	38		951	2 049	1 060	86	5 000	9 182
17.5	53		493	1 106	1 247	49	2 242	5 192
18	452		1 326	2 550	2 673	270	1 273	8 544
18.5	540		1 899	5 707	5 742	694	1 383	15 964
19	1 563		3 632	12 124	9 847	1 558	3 204	31 929
19.5	2 337	62	3 431	20 486	14 057	2 613	4 319	47 306
20	2 324	47	3 234	27 639	16 386	4 469	3 637	57 736
20.5	3 644	275	2 430	29 409	12 416	3 835	1 233	53 243
21	5 346	582	3 511	20 041	6 684	2 655	1 364	40 183
21.5	5 488	1 812	4 381	9 078	2 647	1 281		24 687
22	6 429	3 612	5 124	3 127	1 428	397		20 116
22.5	5 326	3 853	5 246	1 302	405	182		16 314
23	4 188	1 868	2 821	336	110	8		9 332
23.5	2 814	763	1 103	121	40	5		4 846
24	1 009	217	462	21	12			1 721
24.5	247	100	10		13			370
25	48				10			58
25.5					5			5
26					2			2
26.5								
27								
27.5								
28								
28.5								
29								
Total	41 984	13 191	41 015	287 441	78 873	18 304	57 832	538 641
Mean L	21.8	22.5	21.	17.3	19.8	20.4	16.9	18.5
sd	1.4	.75	1.8	3.1	1.41	1.06	2.2	3.08
Catch	**3 699**	**1 343**	**3 404**	**13 781**	**5 373**	**1 410**	**2 579**	**31 589**

Table 5.4.1.2: Sardine in VIIIc and IXa: Catch in numbers (thousands) at age by quarter and by subdivision in 2008

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
								First Quarter
0								
1	7 642	853	1 685	41 300	2 746	202	12 196	66 624
2	2 102	720	2 670	5 315	447	971	5 002	17 227
3	2 199	1 943	3 950	15 892	8 054	2 438	2 974	37 450
4	5 768	2 522	6 202	37 770	33 312	3 756	712	90 043
5	2 236	159	771	1 917	3 245	3 252	405	11 986
6	1 538	210	1 272	2 098	4 753	1 459		11 330
7	814	123	681	332	3 744	1 445		7 140
8	169	41	430	1 288	1 510	490		3 928
9	124				217	20		360
10					85			85
11								
12								
Total	22 593	6 571	17 661	105 912	58 113	14 033	21 290	246 173
Catch (Tons)	1 490	474	1 343	5 068	3 641	850	800	13 667

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
								Second Quarter
0								
1	332	670	6 288	6 750	2 668	120	7 813	24 641
2	1 353	1 639	7 588	14 454	2 084	3 686	4 625	35 429
3	1 617	6 297	7 235	47 018	6 572	4 870	2 363	75 972
4	4 654	9 152	9 342	60 741	40 287	2 284	545	127 005
5	1 900	1 009	849	2 070	4 948	2 223	330	13 330
6	1 435	1 317	1 166	2 088	6 501	549		13 057
7	804	598	348	2 467	5 661	1 406		11 283
8	223	268	144	1 175	2 970	297		5 077
9	174				764	177		1 115
10					496			496
11								
12								
Total	12 492	20 950	32 960	136 763	72 951	15 612	15 676	307 404
Catch (Tons)	1 132	1 820	2 330	9 368	4 911	978	671	21 210

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
								Third Quarter
0	267	29 651	15 670	13 535	816	3 509	61 681	125 129
1	4 244	1 678	6 578	15 540	1 873	3 809	30 958	64 680
2	1 512	2 409	2 994	54 825	7 000	9 961	7 765	86 466
3	2 673	4 719	6 697	93 655	39 296	3 458	1 910	152 408
4	3 086	4 656	8 398	45 180	14 927	3 756	797	80 800
5	2 298	1 170	631	4 994	14 975	168		24 237
6	1 491	717	873	2 025	11 262	1 014		17 382
7	767	252	489	4 737	4 020			10 265
8	411	177	207	1 479				2 273
9					480			480
10								
11								
12								
Total	16 748	45 430	42 537	235 971	94 648	25 676	103 111	564 121
Catch (Tons)	1 558	2 120	2 331	16 994	6 933	1 691	3 372	34 998

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
								Fourth Quarter
0	120		446	149 003	4 278	303	19 126	173 276
1	8 341	229	8 342	14 267	13 392	1 223	17 466	63 260
2	5 237	1 208	4 014	13 610	8 444	3 286	7 715	43 515
3	9 119	4 271	9 595	47 581	20 465	5 143	8 249	104 423
4	8 857	4 932	13 416	54 683	22 679	3 920	5 277	113 763
5	5 369	1 268	1 400	2 369	3 612	1 825		15 844
6	3 141	819	1 822	2 730	3 981	2 251		14 743
7	1 230	281	1 141	3 197	2 024	353		8 225
8	570	183	840					1 592
9								
10								
11								
12								
Total	41 985	13 191	41 015	287 441	78 873	18 304	57 832	538 642
Catch (Tons)	3 699	1 343	3 404	13 781	5 373	1 410	2 579	31 589

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
								Whole Year
0	388	4 811	16 116	162 539	5 093	3 812	80 806	273 565
1	20 559	5 642	22 893	77 858	20 679	5 354	68 433	221 418
2	10 204	17 232	17 266	88 204	17 976	17 904	25 106	193 892
3	15 609	39 542	27 477	204 145	74 387	15 909	15 497	392 564
4	22 364	6 266	37 358	198 375	111 206	13 716	7 331	396 615
5	11 803	6 919	3 652	11 351	26 780	7 469	735	68 709
6	7 605	5 414	5 134	8 942	26 496	5 274		58 863
7	3 616	1 537	2 658	10 733	15 448	3 204		37 197
8	1 373	459	1 620	3 942	4 480	787		12 662
9	298				1 460	196		1 954
10					581			581
11								
12								
Total	93 818	87 822	134 174	766 087	304 585	73 625	197 909	1 658 020
Catch (Tons)	7 879	5 757	9 409	45 210	20 858	4 928	7 423	101 464

Table 5.4.1.3: Sardine in VIIIc and IXa: Relative distribution of sardine catches. Upper pannel, relative contribution of each group within each subdivision. Lower pannel, relative contribution of each subdivision within each Age Group.

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	0%	34%	12%	21%	2%	5%	41%	18%
1	22%	4%	17%	10%	7%	7%	35%	13%
2	11%	7%	13%	12%	6%	24%	13%	11%
3	17%	20%	20%	27%	24%	22%	8%	22%
4	24%	25%	28%	26%	37%	19%	4%	25%
5	13%	4%	3%	1%	9%	10%	0%	4%
6+	14%	6%	7%	3%	16%	13%	0%	7%
	100%	100%	100%	100%	100%	100%	100%	100%

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	Xa-S (Ca)	Total
0	0%	10%	5%	54%	2%	1%	27%	100%
1	9%	2%	10%	36%	9%	2%	31%	100%
2	6%	3%	9%	48%	10%	10%	14%	100%
3	4%	5%	7%	55%	20%	4%	4%	100%
4	5%	5%	9%	48%	27%	3%	2%	100%
5	18%	6%	6%	17%	41%	11%	1%	100%
6+	12%	5%	9%	22%	45%	9%	0%	100%

Table 5.4.2.1: Sardine VIIIc and IXa: Sardine Mean length (cm) at age by quarter and by subdivision in 2008.

							First Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	14.5	16.1	18.3	15.2	15.8	17.1	15.9	15.3
2	19.2	20.4	20.0	19.8	19.5	19.5	17.6	19.1
3	21.5	21.0	20.9	20.0	19.7	19.9	18.8	20.1
4	22.2	21.3	21.4	20.2	20.2	20.4	19.9	20.4
5	22.7	22.2	22.2	20.5	20.7	20.6	20.3	21.1
6	23.0	22.7	22.5	21.0	20.9	21.0		21.4
7	23.2	22.7	23.4	21.8	21.0	21.1		21.6
8	23.8	23.8	23.8	22.0	21.6	21.2		22.0
9	24.2				21.9	22.8		22.8
10					23.0			23.0
11								
12								

							Second Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0								
1	17.9	18.2	18.3	18.5	17.3	16.8	16.2	17.6
2	19.9	20.1	19.6	19.5	19.4	19.0	17.7	19.2
3	21.6	21.5	20.4	20.1	19.9	19.7	18.9	20.2
4	22.3	21.9	20.9	20.4	20.4	20.0	19.9	20.6
5	22.8	22.7	21.9	20.5	21.0	20.2	20.5	21.2
6	23.1	22.9	22.1	21.0	21.2	20.9		21.6
7	23.4	22.9	22.9	20.9	21.3	20.5		21.4
8	24.0	23.4	23.6	21.9	21.7	21.4		21.9
9	24.3				21.8	20.7		22.0
10					21.9			21.9
11								
12								

							Third Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	15.3	13.2	10.7	12.8	15.7	14.1	14.7	13.7
1	19.5	19.5	18.8	18.8	18.0	18.9	16.0	17.5
2	21.3	21.2	20.2	20.1	20.0	19.5	16.9	19.8
3	22.3	22.0	21.2	20.4	20.5	20.1	19.2	20.5
4	22.8	22.3	21.4	20.5	20.8	20.2	20.2	20.8
5	22.8	22.8	21.9	20.5	21.5	20.3		21.5
6	23.0	23.2	21.9	21.1	21.4	20.5		21.5
7	23.8	23.5	21.9	21.3	21.4			21.6
8	24.3	23.7	23.0	21.1				22.0
9					21.4			21.4
10								
11								
12								

							Fourth Quarter	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	16.0		15.9	14.6	15.8	16.0	14.9	14.6
1	19.9	21.0	18.6	17.7	18.7	19.1	16.5	18.1
2	21.3	22.1	20.3	19.7	19.8	19.8	17.3	19.6
3	22.0	22.4	21.5	20.5	20.2	20.3	19.8	20.7
4	22.4	22.5	21.8	20.6	20.2	20.8	20.2	20.9
5	22.6	22.9	22.4	21.9	21.3	21.0		22.0
6	22.9	23.2	22.4	20.9	21.0	21.0		21.7
7	23.6	23.4	22.8	21.2	21.8	21.8		22.0
8	24.2	23.5	23.4					23.7
9								
10								
11								
12								

							Whole Year	
Age	**VIIIc-E**	**VIIIc-W**	**IXa-N**	**IXa-CN**	**IXa-CS**	**IXa-S**	**IXa-S (Ca)**	**Total**
0	10.5	13.2	10.8	14.4	15.8	14.2	14.8	14.2
1	17.8	18.5	18.6	16.6	18.1	18.8	16.2	17.0
2	20.7	21.0	19.9	19.9	19.8	19.5	17.3	19.6
3	22.0	21.8	21.1	20.3	20.3	20.0	19.4	20.4
4	22.4	22.1	21.4	20.4	20.4	20.4	20.2	20.7
5	22.7	22.8	22.1	20.8	21.3	20.6	20.4	21.5
6	23.0	23.0	22.3	21.0	21.2	20.9		21.6
7	23.5	23.1	22.8	21.2	21.3	20.9		21.6
8	24.2	23.5	23.5	21.6	21.6	21.3		22.2
9	24.3				21.7	20.9		22.0
10					22.1			22.1
11								
12								

Table 5.4.2.2: Sardine VIIIc and IXa: Sardine Mean weight (kg) at age by quarter and by subdivision in 2008.

First Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0								
1	0.026	0.036	0.050	0.026	0.034	0.038	0.031	0.028
2	0.059	0.070	0.066	0.057	0.058	0.054	0.042	0.055
3	0.081	0.075	0.074	0.059	0.059	0.057	0.051	0.062
4	0.089	0.078	0.079	0.060	0.063	0.060	0.058	0.065
5	0.095	0.089	0.088	0.063	0.068	0.062	0.062	0.072
6	0.098	0.094	0.092	0.068	0.069	0.065		0.075
7	0.101	0.094	0.102	0.075	0.070	0.066		0.077
8	0.110	0.108	0.108	0.079	0.075	0.066		0.081
9	0.114				0.078	0.080		0.091
10					0.089			0.089
11								
12								

Second Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0								
1	0.046	0.054	0.054	0.054	0.041	0.042	0.036	0.047
2	0.065	0.070	0.065	0.062	0.057	0.057	0.045	0.060
3	0.083	0.085	0.073	0.068	0.062	0.062	0.053	0.069
4	0.092	0.089	0.078	0.071	0.067	0.064	0.061	0.072
5	0.098	0.097	0.089	0.072	0.073	0.066	0.065	0.078
6	0.103	0.101	0.091	0.078	0.075	0.072		0.082
7	0.106	0.100	0.099	0.077	0.076	0.068		0.079
8	0.114	0.106	0.108	0.088	0.080	0.076		0.085
9	0.118				0.081	0.070		0.085
10					0.084			0.084
11								
12								

Third Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	0.032	0.021	0.011	0.023	0.033	0.031	0.027	0.024
1	0.063	0.069	0.060	0.061	0.049	0.064	0.037	0.050
2	0.086	0.086	0.075	0.074	0.066	0.070	0.044	0.071
3	0.100	0.097	0.086	0.076	0.071	0.075	0.070	0.076
4	0.107	0.099	0.089	0.077	0.074	0.076	0.082	0.080
5	0.107	0.107	0.095	0.078	0.081	0.077		0.085
6	0.110	0.113	0.095	0.083	0.080	0.080		0.085
7	0.121	0.118	0.096	0.085	0.080			0.087
8	0.130	0.120	0.109	0.083	0.000			0.097
9					0.080			0.080
10								
11								
12								

Fourth Quarter

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	0.034		0.034	0.025	0.033	0.046	0.028	0.025
1	0.066	0.081	0.056	0.048	0.056	0.067	0.039	0.051
2	0.081	0.096	0.074	0.066	0.068	0.072	0.046	0.067
3	0.090	0.100	0.089	0.075	0.072	0.077	0.072	0.078
4	0.095	0.101	0.092	0.078	0.072	0.080	0.077	0.081
5	0.098	0.108	0.101	0.095	0.084	0.082		0.094
6	0.103	0.112	0.101	0.081	0.081	0.082		0.090
7	0.115	0.115	0.107	0.084	0.092	0.090		0.095
8	0.126	0.116	0.115					0.119
9								
10								
11								
12								

Whole Year

Age	VIIIc-E	VIIIc-W	IXa-N	IXa-CN	IXa-CS	IXa-S	IXa-S (Ca)	Total
0	0.022	0.021	0.012	0.024	0.033	0.032	0.028	0.025
1	0.050	0.058	0.056	0.040	0.051	0.064	0.036	0.043
2	0.075	0.082	0.069	0.070	0.066	0.067	0.044	0.066
3	0.090	0.091	0.082	0.073	0.069	0.069	0.065	0.074
4	0.095	0.093	0.086	0.072	0.068	0.071	0.075	0.075
5	0.099	0.104	0.094	0.078	0.078	0.068	0.064	0.083
6	0.103	0.106	0.095	0.078	0.077	0.076		0.084
7	0.111	0.106	0.103	0.083	0.078	0.069		0.085
8	0.123	0.113	0.112	0.083	0.078	0.070		0.090
9	0.117				0.080	0.071		0.085
10					0.085			0.085
11								
12								

Table 5.6.1.1.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	0.06	0.068	0.072	0.1
1979	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1980	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1981	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1982	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1983	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1984	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1985	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1986	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1987	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1988	0.017	0.034	0.052	0.06	0.068	0.072	0.1
1989	0.013	0.035	0.052	0.059	0.066	0.071	0.1
1990	0.024	0.032	0.047	0.057	0.061	0.067	0.1
1991	0.02	0.031	0.058	0.063	0.073	0.074	0.1
1992	0.018	0.045	0.055	0.066	0.07	0.079	0.1
1993	0.017	0.037	0.051	0.058	0.066	0.071	0.1
1994	0.02	0.036	0.058	0.062	0.07	0.076	0.1
1995	0.025	0.047	0.059	0.066	0.071	0.082	0.1
1996	0.019	0.038	0.051	0.058	0.061	0.071	0.1
1997	0.022	0.033	0.052	0.062	0.069	0.073	0.1
1998	0.024	0.04	0.055	0.061	0.064	0.067	0.1
1999	0.025	0.042	0.056	0.065	0.07	0.073	0.1
2000	0.025	0.037	0.056	0.066	0.071	0.074	0.1
2001	0.023	0.042	0.059	0.067	0.075	0.079	0.1
2002	0.028	0.045	0.057	0.069	0.075	0.079	0.1
2003	0.024	0.044	0.059	0.067	0.079	0.084	0.1
2004	0.02	0.04	0.056	0.066	0.072	0.082	0.1
2005	0.023	0.037	0.055	0.068	0.074	0.075	0.1
2006	0.031	0.042	0.056	0.068	0.073	0.078	0.1
2007	0.028	0.054	0.071	0.074	0.085	0.086	0.1
2008	0.025	0.043	0.066	0.074	0.075	0.083	0.1

Table 5.6.1.1.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	0.05	0.064	0.067	0.1
1979	0	0.015	0.038	0.05	0.064	0.067	0.1
1980	0	0.015	0.038	0.05	0.064	0.067	0.1
1981	0	0.015	0.038	0.05	0.064	0.067	0.1
1982	0	0.015	0.038	0.05	0.064	0.067	0.1
1983	0	0.015	0.038	0.05	0.064	0.067	0.1
1984	0	0.015	0.038	0.05	0.064	0.067	0.1
1985	0	0.015	0.038	0.05	0.064	0.067	0.1
1986	0	0.015	0.038	0.05	0.064	0.067	0.1
1987	0	0.015	0.038	0.05	0.064	0.067	0.1
1988	0	0.015	0.038	0.05	0.064	0.067	0.1
1989	0	0.015	0.038	0.05	0.064	0.067	0.1
1990	0	0.015	0.038	0.05	0.064	0.067	0.1
1991	0	0.019	0.042	0.05	0.064	0.071	0.1
1992	0	0.027	0.036	0.05	0.062	0.069	0.1
1993	0	0.022	0.045	0.057	0.064	0.073	0.1
1994	0	0.031	0.04	0.049	0.06	0.067	0.1
1995	0	0.029	0.05	0.062	0.072	0.079	0.1
1996	0	0.021	0.042	0.05	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	0.04	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	0.06	0.071	0.072	0.074
2002	0	0.024	0.04	0.055	0.068	0.074	0.074
2003	0	0.019	0.043	0.053	0.065	0.07	0.076
2004	0	0.02	0.045	0.061	0.069	0.076	0.1
2005	0	0.019	0.045	0.059	0.068	0.073	0.079
2006	0	0.03	0.042	0.06	0.068	0.068	0.075
2007	0	0.039	0.054	0.062	0.07	0.076	0.077
2008	0	0.017	0.052	0.065	0.07	0.08	0.087

Table 5.6.1.1.c. Sardine in VIIIc and IXa: Annual maturity ogives 1978 – 2008.

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

Run id 20090618 175816.680
Stocknumbers at age,
in area 1
Data by 1. Jan., except at youngest age which are
at recruitment time

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

	1978	1979	1980	1981	1982	1983	1984	1985
0	11805.5	13874.8	15081.4	9578	6994	20233.8	8610.9	6584.9
1	7646.1	9375	11069	12218.6	7599.1	5645.1	16411	7053.7
2	3742.9	4200.2	5199.3	6547.8	6969.7	4482.2	3447.1	9927.6
3	1257.3	1817.8	2066.5	2774.1	3267.1	3550.8	2410.1	1930
4	639.9	629.5	914.6	1155.5	1459.2	1758.5	1965	1352.4
5	196.1	335.8	323.1	519.1	630.9	802.3	999.7	1142.7
6	82.7	148.4	253	333.9	471.3	609.6	801.8	1047.7

	1986	1987	1988	1989	1990	1991	1992	1993
0	5500.4	9223	5942.5	5927.7	5622.3	12995.6	10831.8	4841.4
1	5404.3	4471.5	7312.2	4689.6	4698.1	4455.4	10346.3	8714.4
2	4381.7	3251.8	2707.7	4413.4	2818.9	2781.9	2795	6597.3
3	5588.8	2329.6	1742.3	1451.4	2339.8	1465.7	1599.1	1646.8
4	1087.2	3032.1	1254.1	923	747.9	1144.9	786.5	884.6
5	787.9	586.1	1656.8	674.6	486.1	363	619.7	434.8
6	1295.2	1180.8	1013.8	1479.7	1205.2	906.4	744	803

	1994	1995	1996	1997	1998	1999	2000	2001
0	4753.4	4034.4	5147.1	4032.6	4145.6	4057.3	11415	7903.2
1	3909.4	3920	3341.5	4242.5	3291.1	3318.1	3266.4	9230.7
2	5539.2	2635.8	2643.9	2266.5	2785.8	2116.1	2128.2	2094.6
3	3807.7	3496	1660.2	1657.9	1347	1601.8	1244.5	1263.4
4	860	2184	1965.8	906.9	844.7	654.1	825.8	656.3
5	465.3	491.4	1231.2	1069.7	441.9	391.3	320.4	414.9
6	715.2	728	746.6	1155	1258.7	998.8	835.2	702.8

	2002	2003	2004	2005	2006	2007	2008	2009
0	4399.2	3098.1	13888.5	5639.9	1856.3	2992.5	6525.9	4000
1	6470.8	3626.5	2533.9	11331.1	4632.5	1537.1	2450.6	5271.7
2	5979.7	4239.8	2368.1	1651.2	7456.9	3090	1021.7	1579.7
3	1293.5	3757.5	2664.7	1478.7	1035.8	4748.2	1948	611.8
4	717	764.6	2228.1	1569.6	896.1	640.2	2907.4	1120.1
5	357.4	410.2	440.2	1271.6	935.5	548	387.1	1642.5
6	691.2	667.9	681.7	702.4	1227.7	1397.9	1259.6	1029.4

Total yearly fishing mortalities at age

	1978	1979	1980	1981	1982	1983	1984	1985
0	0.0655	0.0609	0.0455	0.0664	0.0493	0.0444	0.0345	0.0326
1	0.2691	0.2595	0.195	0.2314	0.1979	0.1632	0.1726	0.1461
2	0.3922	0.3793	0.2982	0.3652	0.3444	0.2904	0.25	0.2445
3	0.3617	0.3569	0.2513	0.3124	0.2894	0.2617	0.2478	0.2439
4	0.3148	0.3371	0.2364	0.2751	0.2682	0.2347	0.2121	0.2102
5	0.3148	0.3371	0.2364	0.2751	0.2682	0.2347	0.2121	0.2102
6	0.2663	0.2796	0.189	0.2453	0.2545	0.2372	0.2118	0.1796
Fref	0.3459	0.3526	0.2556	0.307	0.2926	0.2554	0.2305	0.2272

	1986	1987	1988	1989	1990	1991	1992	1993
0	0.0421	0.0672	0.0718	0.0675	0.0676	0.063	0.0525	0.0488
1	0.178	0.1716	0.1749	0.179	0.194	0.1363	0.12	0.1231
2	0.3018	0.294	0.2936	0.3046	0.324	0.2237	0.199	0.2196
3	0.2815	0.2893	0.3054	0.3331	0.3847	0.2925	0.2621	0.3196
4	0.2879	0.2744	0.29	0.3111	0.3929	0.2839	0.2626	0.3124
5	0.2879	0.2744	0.29	0.3111	0.3929	0.2839	0.2626	0.3124
6	0.2083	0.2021	0.214	0.2245	0.2564	0.1741	0.1499	0.1712
Fref	0.2898	0.283	0.2947	0.315	0.3736	0.271	0.2466	0.291

	1994	1995	1996	1997	1998	1999	2000	2001
0	0.0278	0.0234	0.0283	0.0382	0.0577	0.0518	0.0474	0.035
1	0.0642	0.0638	0.0582	0.0906	0.1116	0.1141	0.1143	0.1042
2	0.1302	0.1323	0.1367	0.1904	0.2234	0.2008	0.1915	0.152
3	0.2259	0.2457	0.2746	0.3444	0.3924	0.3325	0.3099	0.2364
4	0.2297	0.2431	0.2785	0.389	0.4394	0.3837	0.3582	0.2778
5	0.2297	0.2431	0.2785	0.389	0.4394	0.3837	0.3582	0.2778
6	0.1068	0.1083	0.1013	0.1186	0.1307	0.1096	0.1027	0.0825
Fref	0.2039	0.2161	0.2421	0.3282	0.3736	0.3252	0.3045	0.236

	2002	2003	2004	2005	2006	2007	2008	2009
0	0.0282	0.036	0.0385	0.0318	0.0237	0.0348	0.0484	0.0484
1	0.0928	0.0962	0.0983	0.0884	0.0749	0.0784	0.1091	0.1091
2	0.1346	0.1344	0.1409	0.1364	0.1214	0.1314	0.1829	0.1829
3	0.1958	0.1926	0.1992	0.1708	0.151	0.1605	0.2234	0.2234
4	0.2284	0.222	0.2309	0.1876	0.1618	0.1732	0.2411	0.2411
5	0.2284	0.222	0.2309	0.1876	0.1618	0.1732	0.2411	0.2411
6	0.0699	0.0749	0.0828	0.072	0.0665	0.0794	0.1106	0.1106
Fref	0.1968	0.1928	0.2005	0.1706	0.149	0.1596	0.2221	0.2221

YEARLY CATCH NUMBERS BY FLEET 1
IN AREA 1
****

Modelled catches by year, fleet 1 area 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	690.9	757	619.2	568.2	310.4	811.3	269.5	194.9
1	1547.7	1840.5	1681.1	2166.4	1172.1	730.1	2229.6	822.7
2	1045.5	1141.7	1150.3	1721.4	1744	969.4	654	1846.6
3	328.3	469.5	394.2	639.5	705.3	701.3	453.3	357.9
4	148.5	154.8	165.1	238.7	294.7	315.5	321.9	219.8
5	45.5	82.6	58.3	107.2	127.4	143.9	163.8	185.7
6	16.6	31.1	37.4	62.3	90.8	110.3	131.1	147.6

	1986	1987	1988	1989	1990	1991	1992	1993
0	209.4	552.8	380	357.1	339.7	732.4	511.6	213.1
1	757.1	605.8	1008.3	660.8	713.9	488.3	1005.5	869.5
2	980.6	711.3	592	996.4	672.4	479.4	433.3	1119.1
3	1178	502.4	393.7	353.2	643.1	318.9	316.2	386.7
4	233.3	624.3	271	211.9	208.9	242.7	155.7	203.7
5	169.1	120.7	358	154.9	135.8	76.9	122.7	100.1
6	209.2	185.6	167.7	255.7	234.6	124.5	89	108.7

	1994	1995	1996	1997	1998	1999	2000	2001
0	120.3	86.4	132.6	139.6	214.5	189.2	488	250.8
1	209.8	209.1	163.2	316.8	299.3	307.3	302.8	781.7
2	581.4	280.7	290.6	338.2	480.3	331.1	318.7	253.5
3	659.3	652.5	341.9	415.5	376.5	389.8	285.1	228.2
4	151.1	403.8	409.6	251.2	258.5	179.2	213.6	136.4
5	81.8	90.8	256.6	296.3	135.2	107.2	82.9	86.3
6	62.2	64.2	61.9	111.5	133.2	89.5	70.3	47.9

	2002	2003	2004	2005	2006	2007	2008	2009
0	112.8	101.1	484.1	162.8	40.1	94.4	284.7	174.5
1	490.4	284.5	202.9	819.7	286	99.1	216.9	466.5
2	645.2	456.8	266.6	180	728.5	325.2	146.2	226
3	197.1	564	412.5	198.8	124.2	602.5	334.3	105
4	125.4	130.3	393.4	229.8	114.5	87.1	533.9	205.7
5	62.5	69.9	77.7	186.1	119.5	74.6	71.1	301.6
6	40.1	41.3	46.4	41.8	67.5	91.3	112.8	92.2

Observed catches by year, fleet 1 area 1

	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

Observ ed catches by year, fleet 1 area 1

	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

Observ ed catches by year, fleet 1 area 1

	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

Observe catches by year, fleet 1 area 1

	2002	2003	2004	2005	2006	2007	2008	2009
0	107	198	590	169	18	199	298	0
1	587	319	181	1006	250	82	219	0
2	754	446	264	266	777	313	183	0
3	181	518	387	207	129	536	370	0
4	112	114	378	191	108	80	412	0
5	56	61	78	117	121	83	65	0
6	40	51	55	46	81	121	109	0

Residuals: log (Obs/mod), fleet 1 area 1

	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	0.39	-0.18	0.19	-0.11	-0.39	-0.24	0.4	-0.38
2	-0.1	-0.18	0.31	0.01	0.07	-0.12	-0.29	0.25
3	-0.11	-0.09	-0.04	0.06	0.01	0.14	0.1	0.27
4	-0.08	0.2	-0.05	-0.2	0.18	0.03	-0.07	0.29
5	-0.08	0.12	-0.22	-0.02	0.03	-0.02	0.09	0.08
6	-0.04	0.15	-0.22	0.2	0.35	0.23	-0.11	-0.36

Residuals: log (Obs/mod), fleet 1 area 1

	1986	1987	1988	1989	1990	1991	1992	1993
0	0.37	0.96	0.32	-0.36	-0.27	0.77	-0.03	-0.88
1	0	-0.11	-0.02	-0.15	-0.17	-0.02	0	-0.43
2	0.05	-0.06	-0.1	-0.09	-0.26	-0.09	0.04	-0.03
3	-0.25	0.12	0.11	0.1	0.09	0.24	0.07	0.3
4	0.36	-0.15	0.12	0.04	0.34	0.09	0.18	0.23
5	0.15	0.24	-0.2	0.26	0.11	-0.03	-0.1	0.13
6	-0.23	-0.08	0.12	-0.04	0.06	-0.17	-0.09	0.1

Residuals: log (Obs/mod), fleet 1 area 1

	1994	1995	1996	1997	1998	1999	2000	2001
0	0.01	-1.03	0.74	0.4	0.74	0.26	0	-0.13
1	-1.25	-0.1	-0.48	0.55	0.2	0.44	0.16	0.4
2	-0.07	0	0.18	0.29	0.04	0.09	-0.01	0.01
3	0.51	0.24	0.41	-0.06	-0.07	-0.14	-0.11	-0.15
4	0.59	0.16	0.47	0.29	-0.1	-0.01	-0.1	-0.08
5	0.32	-0.26	-0.26	-0.28	0.28	-0.01	0.17	-0.14
6	0.15	0	-0.28	-0.47	-0.23	-0.2	-0.09	0.04

Residuals: log (Obs/mod), fleet 1 area 1

	2002	2003	2004	2005	2006	2007	2008	2009
0	-0.05	0.67	0.2	0.04	-0.8	0.75	0.05	0
1	0.18	0.11	-0.11	0.2	-0.13	-0.19	0.01	0
2	0.16	-0.02	-0.01	0.39	0.06	-0.04	0.22	0
3	-0.09	-0.09	-0.06	0.04	0.04	-0.12	0.1	0
4	-0.11	-0.13	-0.04	-0.18	-0.06	-0.09	-0.26	0
5	-0.11	-0.14	0	-0.46	0.01	0.11	-0.09	0
6	0	0.21	0.17	0.1	0.18	0.28	-0.03	0

RESULTS FOR SURVEY FLEET 1
****

Modelled surveys indices by year, fleet 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	-1	-1	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1	-1	-1	-1
4	-1	-1	-1	-1	-1	-1	-1	-1
5	-1	-1	-1	-1	-1	-1	-1	-1
6	-1	-1	-1	-1	-1	-1	-1	-1

	1986	1987	1988	1989	1990	1991	1992	1993
0	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	-1	-1	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1	-1	-1	-1
4	-1	-1	-1	-1	-1	-1	-1	-1
5	-1	-1	-1	-1	-1	-1	-1	-1
6	-1	-1	-1	-1	-1	-1	-1	-1

	1994	1995	1996	1997	1998	1999	2000	2001
0	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	4758.7	6016.8	4655.3	4694.4	4622	13083.6
2	-1	-1	2573.1	2190.7	2681.6	2043.5	2057.9	2036
3	-1	-1	1409.5	1394.7	1126.6	1349.3	1051.3	1076.8
4	-1	-1	1931.2	879.5	814.2	634.6	803.6	644.9
5	-1	-1	1209.5	1037.4	425.9	379.7	311.8	407.7
6	-1	-1	310.4	478.8	520.9	414.5	347	292.9

	2002	2003	2004	2005	2006	2007	2008	2009
0	-1	-1	-1	-1	-1	-1	-1	-1
1	9185.9	5146.3	3594.6	16095.6	6591.1	2185.9	3471.5	7467.9
2	5826.8	4131.8	2305.9	1609.4	7281.6	3013.6	990.2	1530.9
3	1108.1	3220.4	2281.9	1270.8	892.3	4086	1663.4	522.4
4	708.6	756.1	2201.2	1558.5	892.6	636.8	2868	1104.9
5	353.2	405.7	434.9	1262.6	931.7	545.1	381.8	1620.2
6	288.6	278.7	284.3	293.3	513.1	583.4	523.6	427.9

Observed surveys indices by year, fleet 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	-1	-1	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1	-1	-1	-1
4	-1	-1	-1	-1	-1	-1	-1	-1
5	-1	-1	-1	-1	-1	-1	-1	-1
6	-1	-1	-1	-1	-1	-1	-1	-1

	1986	1987	1988	1989	1990	1991	1992	1993
0	-1	-1	-1	-1	-1	-1	-1	-1
1	-1	-1	-1	-1	-1	-1	-1	-1
2	-1	-1	-1	-1	-1	-1	-1	-1
3	-1	-1	-1	-1	-1	-1	-1	-1
4	-1	-1	-1	-1	-1	-1	-1	-1
5	-1	-1	-1	-1	-1	-1	-1	-1
6	-1	-1	-1	-1	-1	-1	-1	-1

	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

Survey residuals by year, fleet 1

	1978	1979	1980	1981	1982	1983	1984	1985
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0

	1986	1987	1988	1989	1990	1991	1992	1993
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0

	1994	1995	1996	1997	1998	1999	2000	2001
0	0	0	0	0	0	0	0	0
1	0	0	-1.07	0.06	-0.77	0.23	0.37	0.41
2	0	0	-0.19	0.47	0.43	0.28	0.18	-0.67
3	0	0	0.58	0.18	0.7	0.17	0.45	-0.43
4	0	0	0.52	0.45	0.59	0.42	0.22	-0.3
5	0	0	-0.7	0.32	1.04	0.5	0.84	-0.09
6	0	0	-2.13	-0.6	0.66	0.25	0.67	-0.16

	2002	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0	0
1	0.35	0.13	0	0.35	0.12	-0.28	0.15	-0.05
2	0.18	0.1	0	-0.21	0.13	0.02	0.1	-0.83
3	0.05	0.1	0	-0.62	-0.44	-0.02	-0.51	-0.22
4	0.47	0.29	0	-0.71	-0.7	0	-0.37	-0.47
5	0.47	0.34	0	-0.66	-0.48	-0.66	-0.59	-0.74
6	0.43	0.19	0	0.23	0.17	0.19	-0.06	0.15

SPAWNING STOCK BIOMASS

Year	Modelled Total		Expected By fleet	Observed/q By fleet
1978	308.23	1	308.23	-1
1979	378.94	1	378.94	-1
1980	469.49	1	469.49	-1
1981	588.32	1	588.32	-1
1982	622.16	1	622.16	-1
1983	578.62	1	578.62	-1
1984	633.61	1	633.61	-1
1985	739.43	1	739.43	-1
1986	689.22	1	689.22	-1
1987	584.53	1	584.53	-1
1988	509.83	1	509.83	-1
1989	429.02	1	429.02	-1
1990	391.25	1	391.25	-1
1991	398.26	1	398.26	-1
1992	518.96	1	518.96	-1
1993	579.27	1	579.27	-1
1994	587.68	1	587.68	-1
1995	646.8	1	646.8	-1
1996	441.6	1	441.6	-1
1997	393.85	1	393.85	351
1998	342.79	1	342.79	-1
1999	346.5	1	346.5	275.6
2000	281.09	1	281.09	-1
2001	328.68	1	328.68	-1
2002	480.38	1	480.38	464.73
2003	495.24	1	495.24	-1
2004	502.36	1	502.36	-1
2005	416.58	1	416.58	428.87
2006	671.66	1	671.66	-1
2007	654	1	654	-1
2008	496.82	1	496.82	703.85
2009	413.88	1	413.88	-1

SUMMARY TABLE

Year	Recruits age 0	SSB	F 02-May	Catch SOP
1978	11805	308	0.3459	173
1979	13874	378	0.3526	162
1980	15081	469	0.2556	204
1981	9578	588	0.307	242
1982	6994	622	0.2926	214
1983	20233	578	0.2554	176
1984	8610	633	0.2305	215
1985	6584	739	0.2272	219
1986	5500	689	0.2898	192
1987	9223	584	0.283	176
1988	5942	509	0.2947	157
1989	5927	429	0.315	146
1990	5622	391	0.3736	142
1991	12995	398	0.271	132
1992	10831	518	0.2466	131
1993	4841	579	0.291	144
1994	4753	587	0.2039	138
1995	4034	646	0.2161	126
1996	5147	441	0.2421	115
1997	4032	393	0.3282	117
1998	4145	342	0.3736	112
1999	4057	346	0.3252	95
2000	11414	281	0.3045	87
2001	7903	328	0.236	102
2002	4399	480	0.1968	101
2003	3098	495	0.1928	99
2004	13888	502	0.2005	98
2005	5639	416	0.1706	97
2006	1856	671	0.149	88
2007	2992	653	0.1596	97
2008	6525	496	0.2221	103
2009	4000	413	0.2221	0

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

Run id 20090614 115442.209

Coeff. of variation and correlations from inverse Hessian

Parameter	Name	Value	CV
1	Initial number 1978 age1	7646.126	0.0517
2	Initial number 1978 age2	3742.927	0.0945
3	Initial number 1978 age3	1257.315	0.0363
4	Initial number 1978 age4	639.9227	0.1011
5	Initial number 1978 age5	196.0815	0.1043
6	Initial number 1978 age6	82.661	0.2368
7	Recruitment age0 1978	11805.54	0.0261
8	Recruitment age0 1979	13874.8	0.0882
9	Recruitment age0 1980	15081.42	0.0333
10	Recruitment age0 1981	9578.013	0.0386
11	Recruitment age0 1982	6994.011	0.034
12	Recruitment age0 1983	20233.79	0.1001
13	Recruitment age0 1984	8610.932	0.1006
14	Recruitment age0 1985	6584.882	0.097
15	Recruitment age0 1986	5500.381	0.0698
16	Recruitment age0 1987	9223.039	0.0335
17	Recruitment age0 1988	5942.511	0.0387
18	Recruitment age0 1989	5927.736	0.0369
19	Recruitment age0 1990	5622.278	0.0802
20	Recruitment age0 1991	12995.62	0.0699
21	Recruitment age0 1992	10831.82	0.0476
22	Recruitment age0 1993	4841.362	0.068
23	Recruitment age0 1994	4753.441	0.0419
24	Recruitment age0 1995	4034.442	0.0701
25	Recruitment age0 1996	5147.144	0.0452
26	Recruitment age0 1997	4032.596	0.0286
27	Recruitment age0 1998	4145.645	0.0349
28	Recruitment age0 1999	4057.348	0.033
29	Recruitment age0 2000	11415	0.0974
30	Recruitment age0 2001	7903.21	0.0274
31	Recruitment age0 2002	4399.214	0.1017
32	Recruitment age0 2003	3098.055	0.0875
33	Recruitment age0 2004	13888.5	0.0613
34	Recruitment age0 2005	5639.943	0.1408
35	Recruitment age0 2006	1856.286	0.1643
36	Recruitment age0 2007	2992.534	0.0365
37	Recruitment age0 2008	6525.949	0.0955
38	F-select year 1978 age 0	0.4098	0.439
39	F-select year 1978 age 1	0.8415	0.0428
40	F-select year 1978 age 2	1.2266	0.0446
41	F-select year 1978 age 3	1.1313	0.1638
42	F-select year 1978 age 4	0.9843	0.0386
43	F-select year 1978 age 6	0.8327	0.1034
44	F year 1978	0.3459	0.0978
45	F year 1979	0.3526	0.0512
46	F year 1980	0.2556	0.0386
47	F year 1981	0.307	0.0245
48	F year 1982	0.2926	0.0704
49	F year 1983	0.2554	0.0724
50	F year 1984	0.2305	0.0373
51	F year 1985	0.2272	0.0416
52	F year 1986	0.2898	0.0501
53	F year 1987	0.283	0.0351
54	F year 1988	0.2947	0.1008
55	F year 1989	0.315	0.1014
56	F year 1990	0.3736	0.0339
57	F year 1991	0.271	0.0309
58	F year 1992	0.2466	0.0495
59	F year 1993	0.291	0.024
60	F year 1994	0.2039	0.0376
61	F year 1995	0.2161	0.0476
62	F year 1996	0.2421	0.0411
63	F year 1997	0.3282	0.1016
64	F year 1998	0.3736	0.0883
65	F year 1999	0.3252	0.0587
66	F year 2000	0.3045	0.0508
67	F year 2001	0.236	0.0535
68	F year 2002	0.1968	0.0231
69	F year 2003	0.1928	0.0475
70	F year 2004	0.2005	0.0794
71	F year 2005	0.1706	0.0799
72	F year 2006	0.149	0.098
73	F year 2007	0.1596	0.0515
74	F year 2008	0.2221	0.117
75	Joint Spring Acoustic age :	1.4964	0.2197
76	Joint Spring Acoustic age :	1.0327	0.2197
77	Joint Spring Acoustic age :	0.9144	0.0773
78	Joint Spring Acoustic age ‹	1.0584	0.0244
79	Joint Spring Acoustic age (	0.4391	0.0627
80	Q for ssb year 1988	0.9761	0.0347

Table 5.7.1.1: Sardine in VIIIc and IXa: Input data for short term catch predictions.

MFDP version 1a
Run: sardine09_meanR
Time and date: 19:12 17/06/2009
Fbar age range: 2-5

2009

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4923	0.33	0.00	0.25	0.25	0.000	0.036	0.028
1	5272	0.33	0.58	0.25	0.25	0.029	0.087	0.046
2	1580	0.33	0.91	0.25	0.25	0.049	0.145	0.064
3	612	0.33	0.96	0.25	0.25	0.062	0.178	0.072
4	1120	0.33	0.98	0.25	0.25	0.069	0.192	0.078
5	1642	0.33	0.99	0.25	0.25	0.075	0.192	0.082
6	1029	0.33	0.99	0.25	0.25	0.080	0.086	0.100

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4923	0.33	0.00	0.25	0.25	0.000	0.036	0.028
1	.	0.33	0.58	0.25	0.25	0.029	0.087	0.046
2	.	0.33	0.91	0.25	0.25	0.049	0.145	0.064
3	.	0.33	0.96	0.25	0.25	0.062	0.178	0.072
4	.	0.33	0.98	0.25	0.25	0.069	0.192	0.078
5	.	0.33	0.99	0.25	0.25	0.075	0.192	0.082
6	.	0.33	0.99	0.25	0.25	0.080	0.086	0.100

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	4923	0.33	0.00	0.25	0.25	0.000	0.036	0.028
1	.	0.33	0.58	0.25	0.25	0.029	0.087	0.046
2	.	0.33	0.91	0.25	0.25	0.049	0.145	0.064
3	.	0.33	0.96	0.25	0.25	0.062	0.178	0.072
4	.	0.33	0.98	0.25	0.25	0.069	0.192	0.078
5	.	0.33	0.99	0.25	0.25	0.075	0.192	0.082
6	.	0.33	0.99	0.25	0.25	0.080	0.086	0.100

Input units are millions and kg - output in thousand tonnes

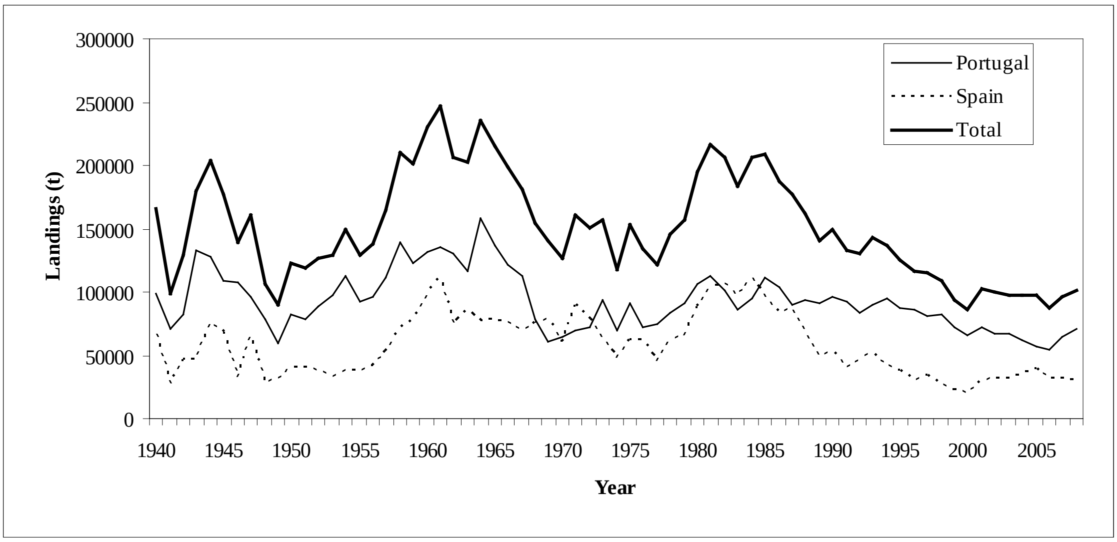
Table 5.7.1.2: Sardine in VIIIc and IXa: Results for short term catch predictions.

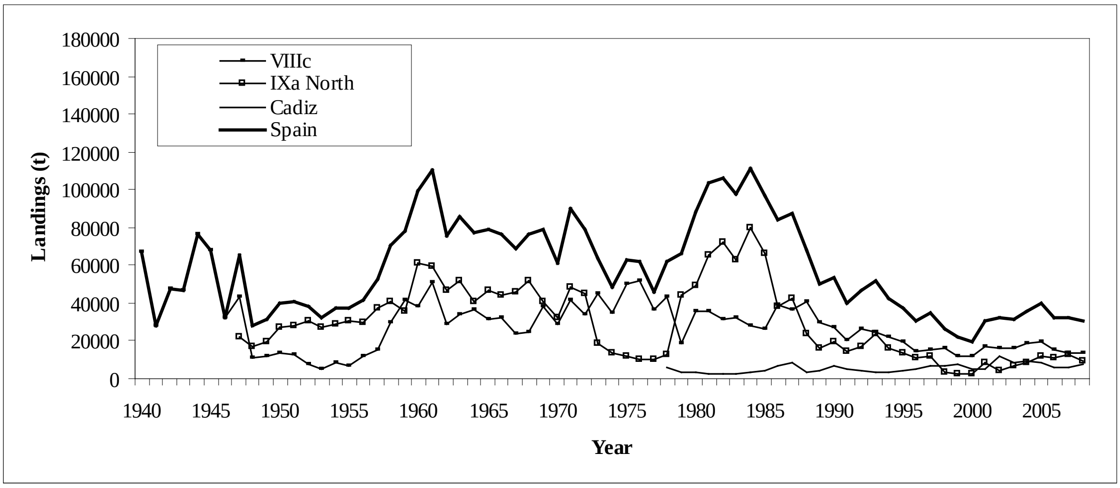
MFDP version 1a
Run: sardine09_meanR
Sardine (VIIIc+IXa), 2006 WG
Time and date: 19:12 17/06/2009
Fbar age range: 2-5

2009				
Biomass	SSB	FMult	FBar	Landings
549	421	1	0.1769	80

2010					2011	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
537	440	0	0.00	0	580	478
.	438	0.1	0.02	8	573	471
.	437	0.2	0.04	16	567	464
.	435	0.3	0.05	24	561	457
.	434	0.4	0.07	31	554	450
.	432	0.5	0.09	39	548	443
.	431	0.6	0.11	46	542	437
.	430	0.7	0.12	54	536	430
.	428	0.8	0.14	61	531	424
.	427	0.9	0.16	68	525	417
.	425	1	0.18	75	519	411
.	424	1.1	0.19	82	513	405
.	422	1.2	0.21	89	508	399
.	421	1.3	0.23	96	502	393
.	420	1.4	0.25	103	497	387
.	418	1.5	0.27	109	492	382
.	417	1.6	0.28	116	486	376
.	416	1.7	0.30	122	481	370
.	414	1.8	0.32	129	476	365
.	413	1.9	0.34	135	471	360
.	411	2	0.35	142	466	355

Input units are millions and kg - output in thousand tonnes





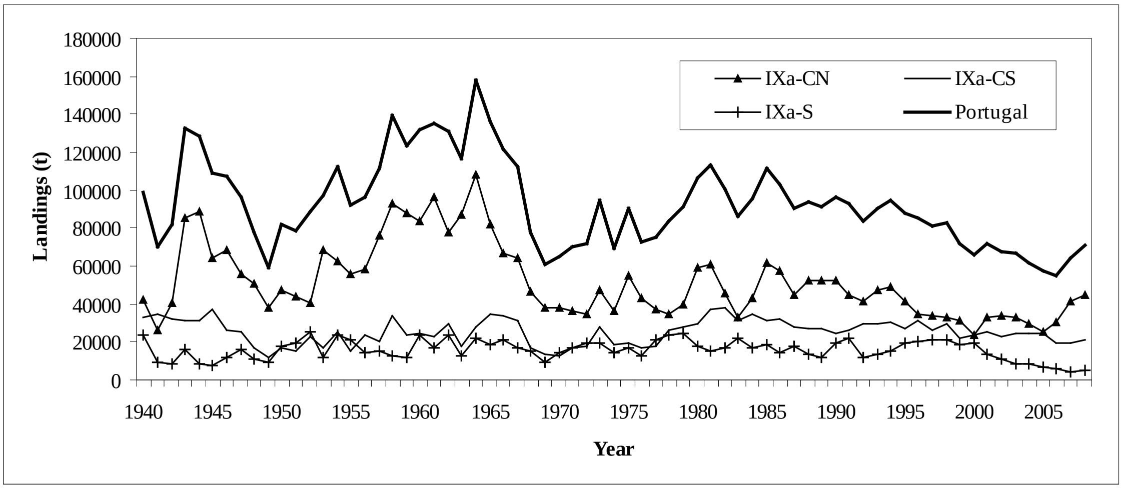


Figure 5.2.1: Sardine in VIIIc and IXa: Annual landings of sardine, by country (upper pannel) and by ICES subdivision and country.

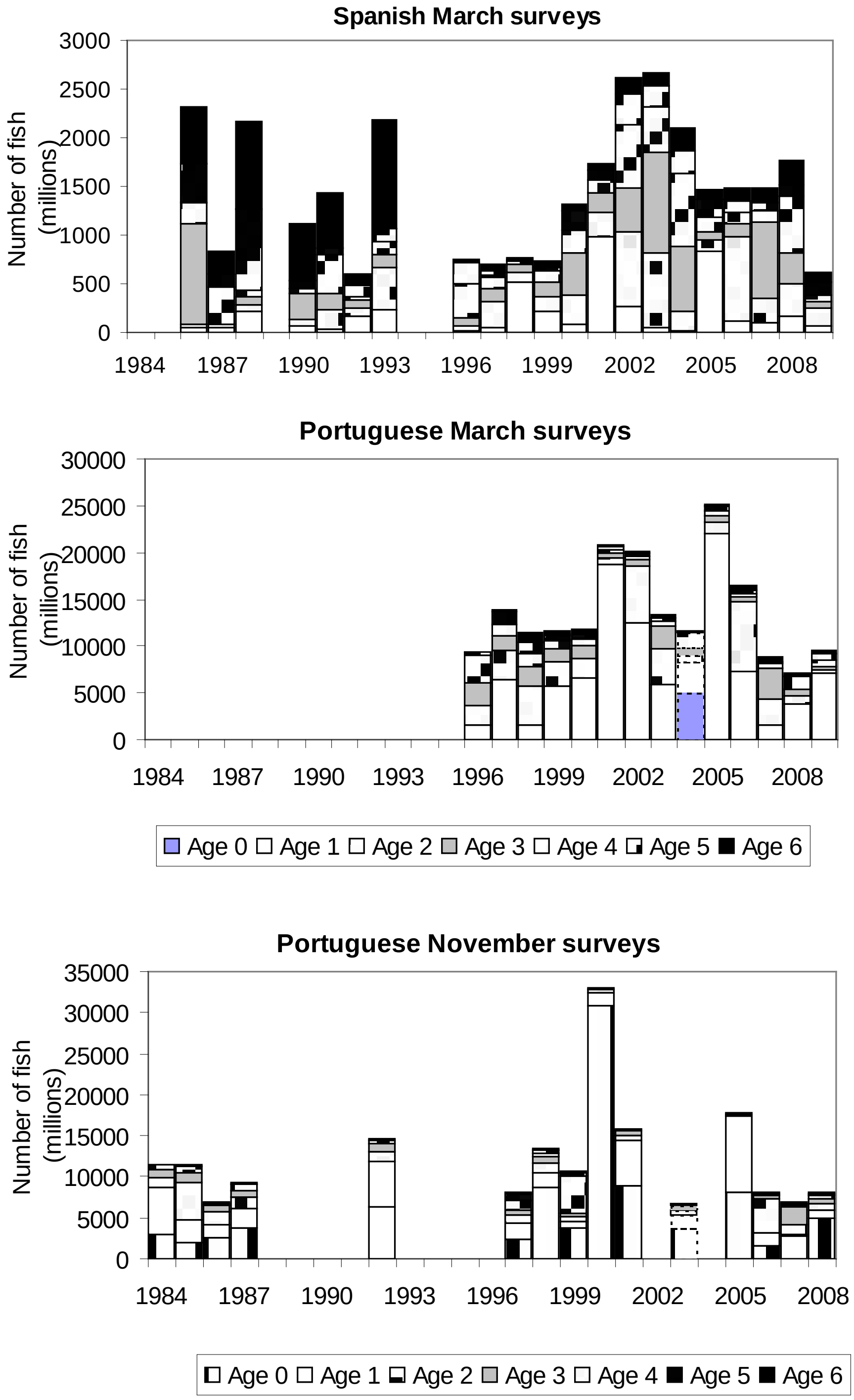


Figure 5.3.1: Sardine in VIIIc and IXa: Total abundance and age structure (numbers) of sardine estimated in the acoustic surveys. The Spanish March survey series covers area VIIIc and IXa-N (Galicia), the Portuguese March surveys covers the Portuguese area and the Gulf of Cadiz (Subdivisions IXa-CN, IXa-CS, IXa-S-Algarve and IXa-S-Cadiz) and the Portuguese November survey covers only the Portuguese waters. Estimates from Portuguese acoustic surveys in November 2003 and June 2004 are considered as indications of the population abundance and are not included in assessment.

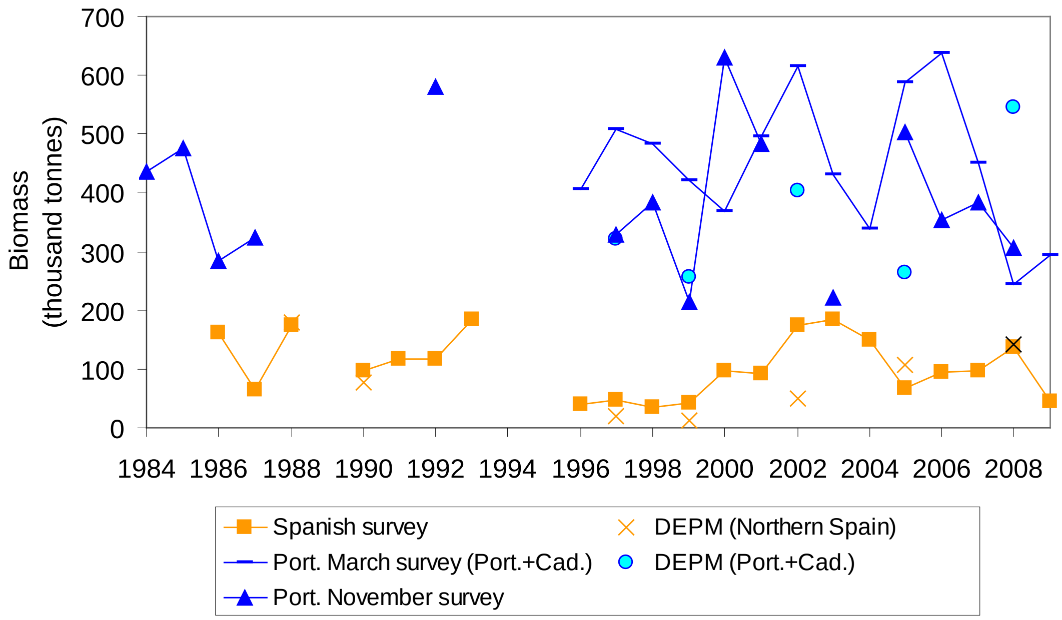


Figure 5.3.2: Sardine in VIIIc and IXa: Total sardine biomass (thousand tonnes) estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern area and the west and southern area of the stock.

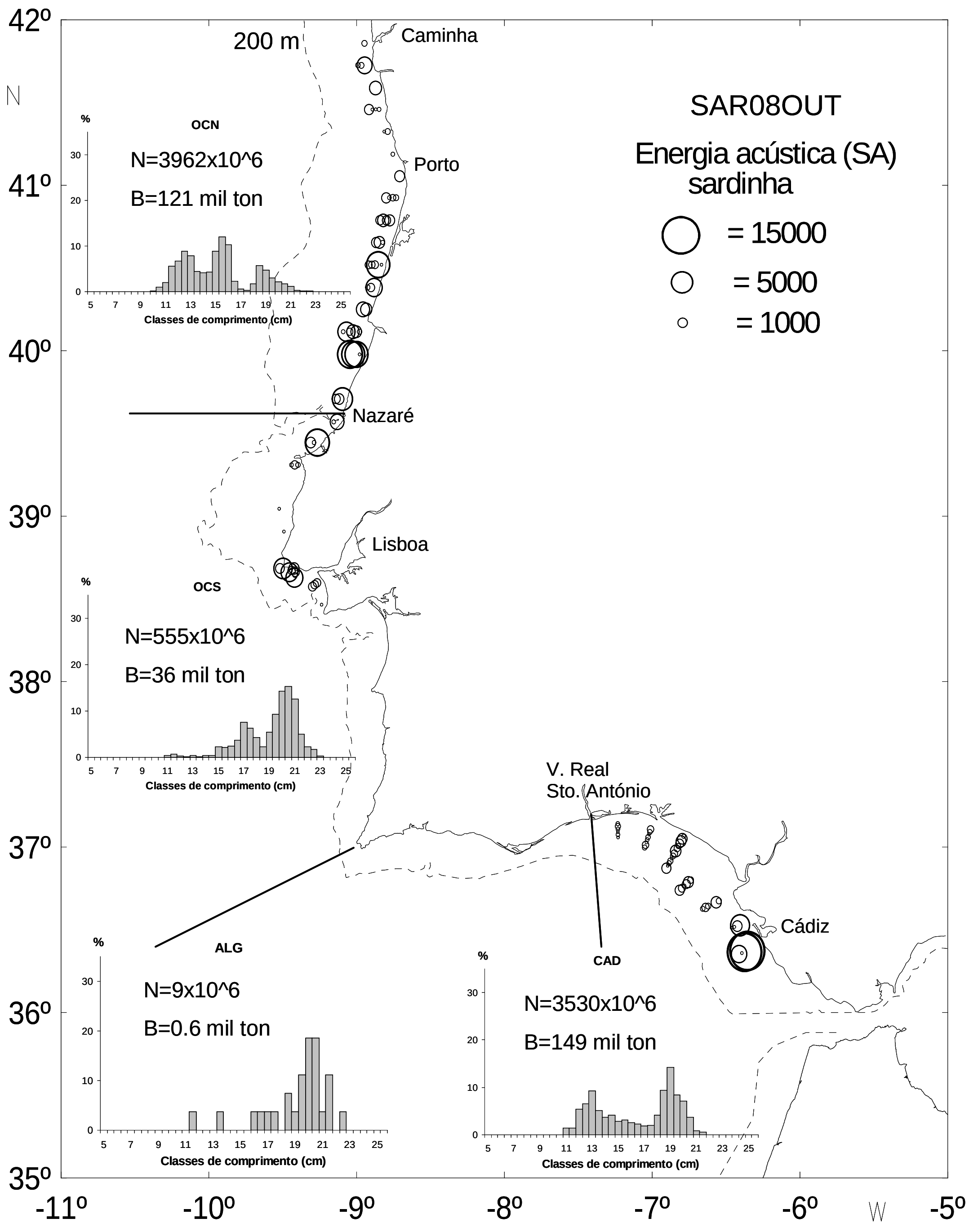


Figure 5.3.2.1.1: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2008. Acoustic energy by nautical mile and abundance and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

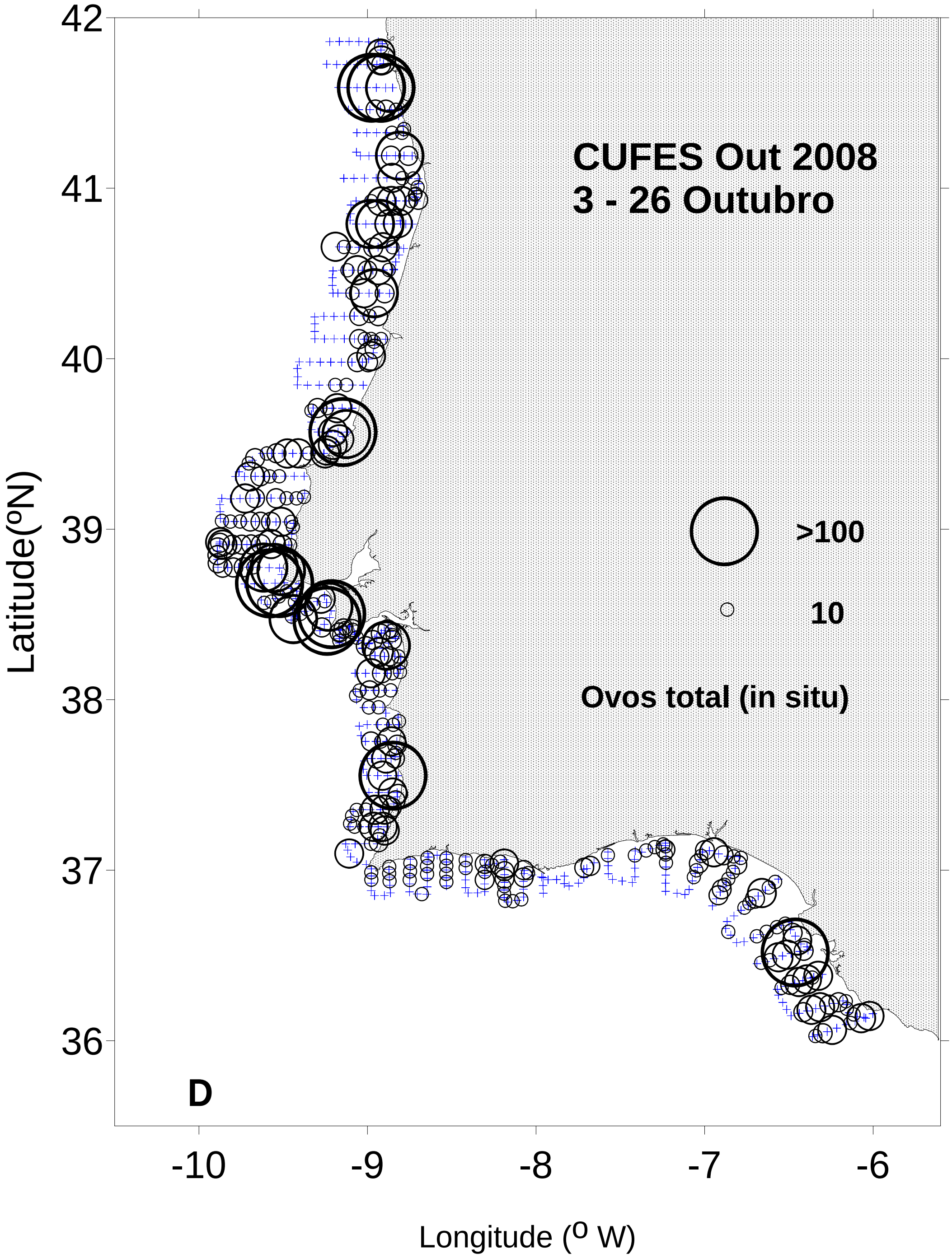


Figure 5.3.2.1.2: Sardine in VIIIc and IXa: Portuguese autumn acoustic survey in 2008. Total number of sardine eggs obtained during the survey.

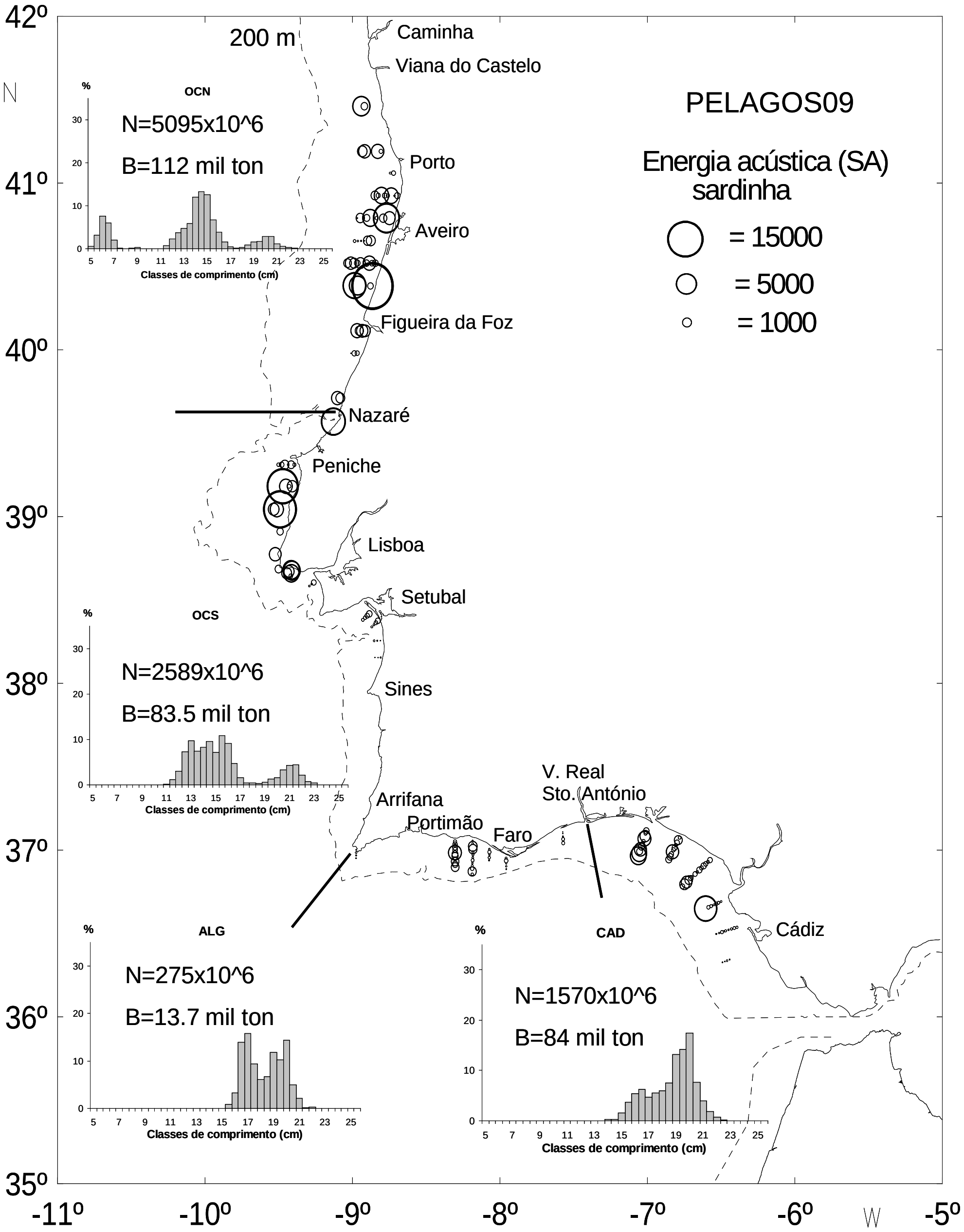


Figure 5.3.2.1.3: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2009. Acoustic energy by nautical mile and abundance and length structure by area. Circle area is proportional to the acoustic energy (S_A m²/nm²).

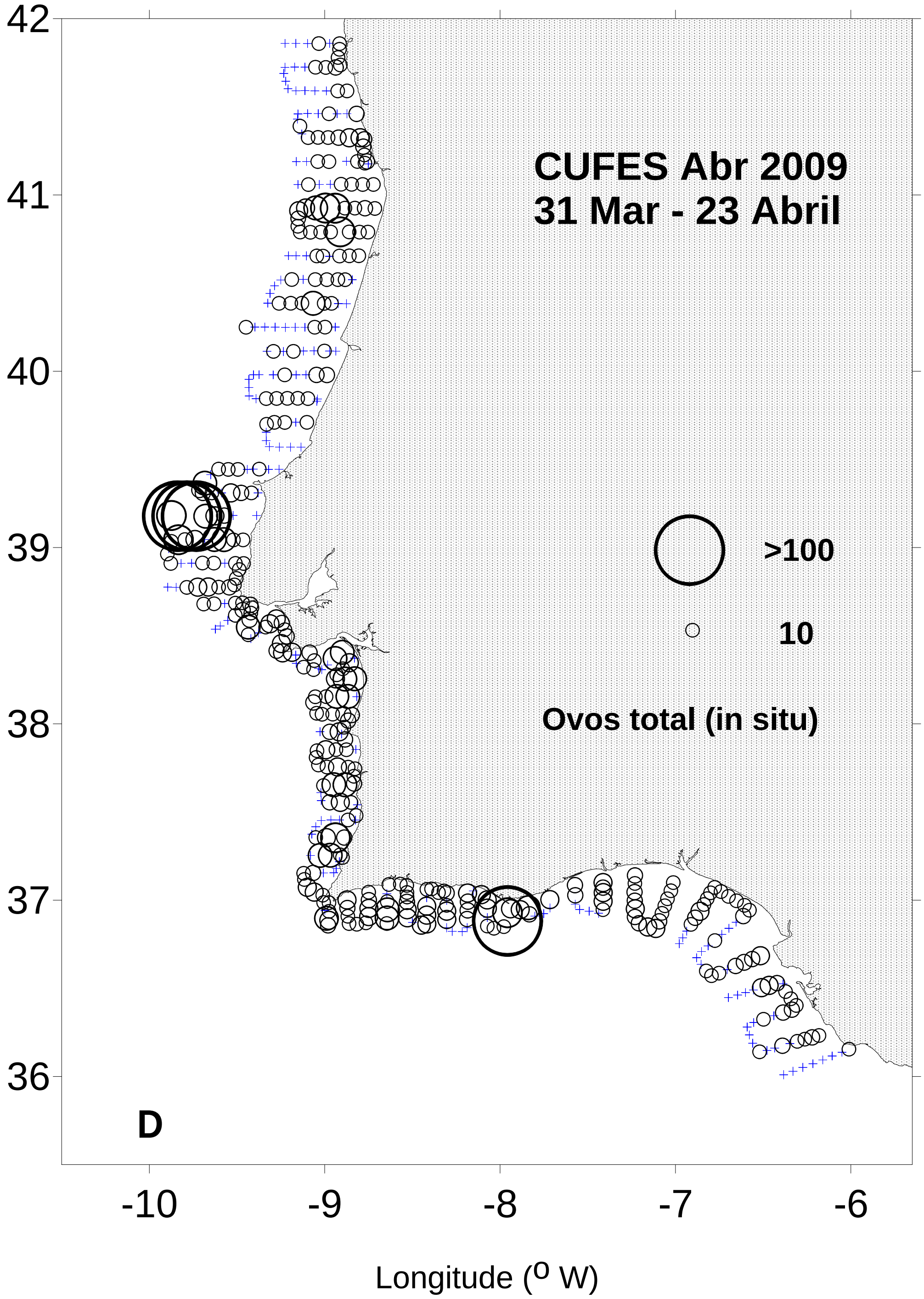


Figure 5.3.2.1.4: Sardine in VIIIc and IXa: Sardine in VIIIc and IXa: Portuguese spring acoustic survey in 2009. Total number of sardine eggs obtained during the survey.

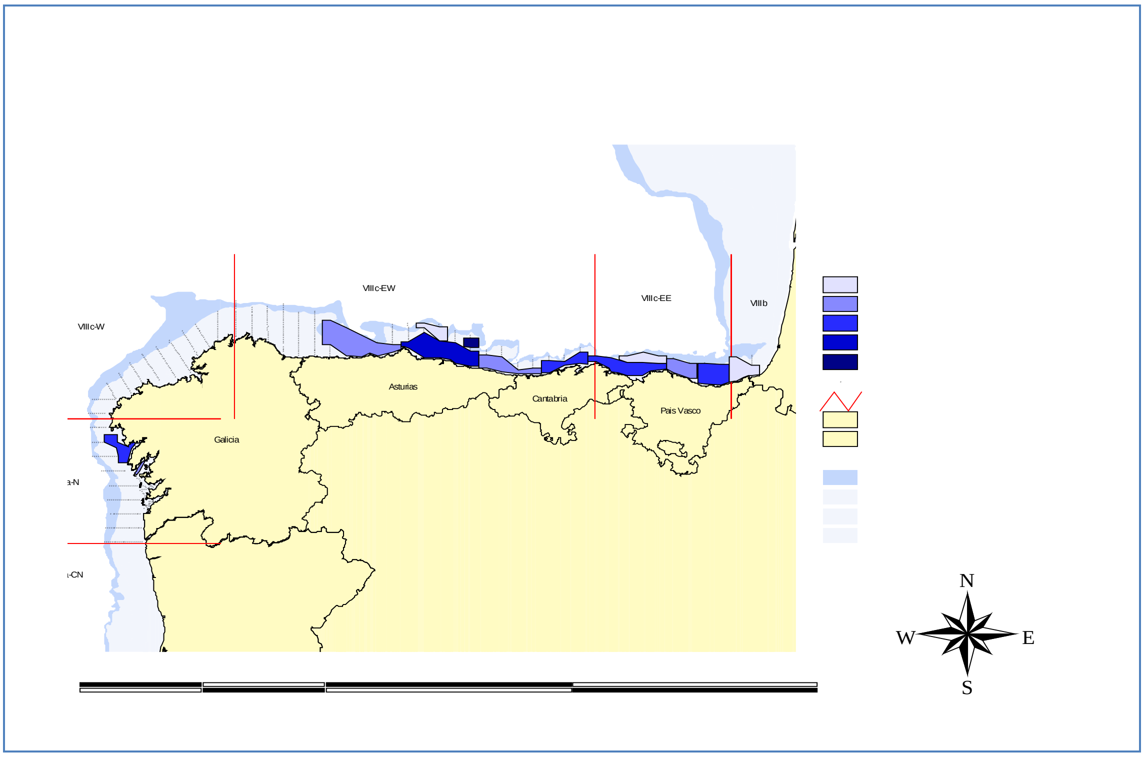
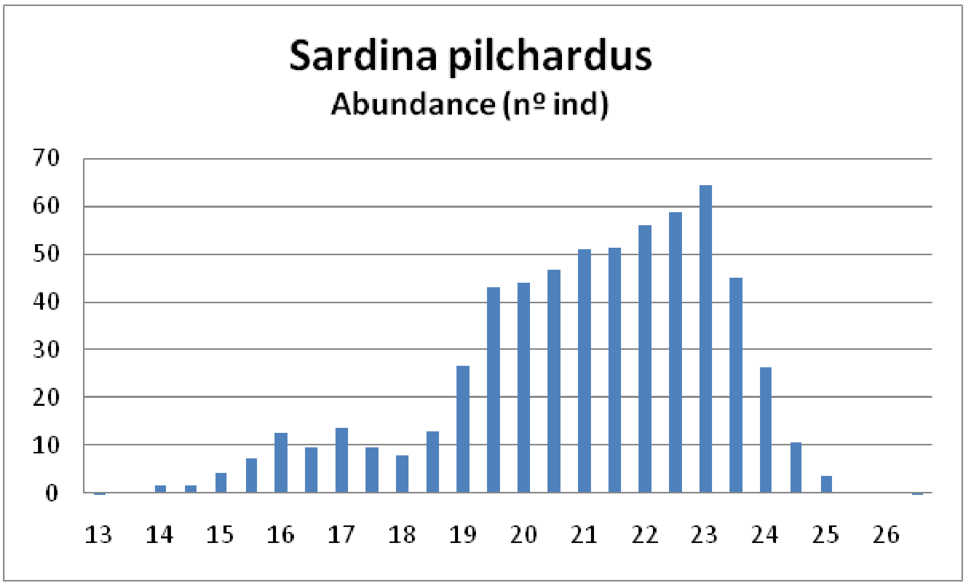


Figure 5.3.2.2.1: Sardine in VIIIc and IXa: Spatial distribution of energy allocated to sardine during the PELACUS0409 cruise. Polygons are drawn to encompass the observed echoes, and polygon colour indicates integrated energy in m² within each polygon.



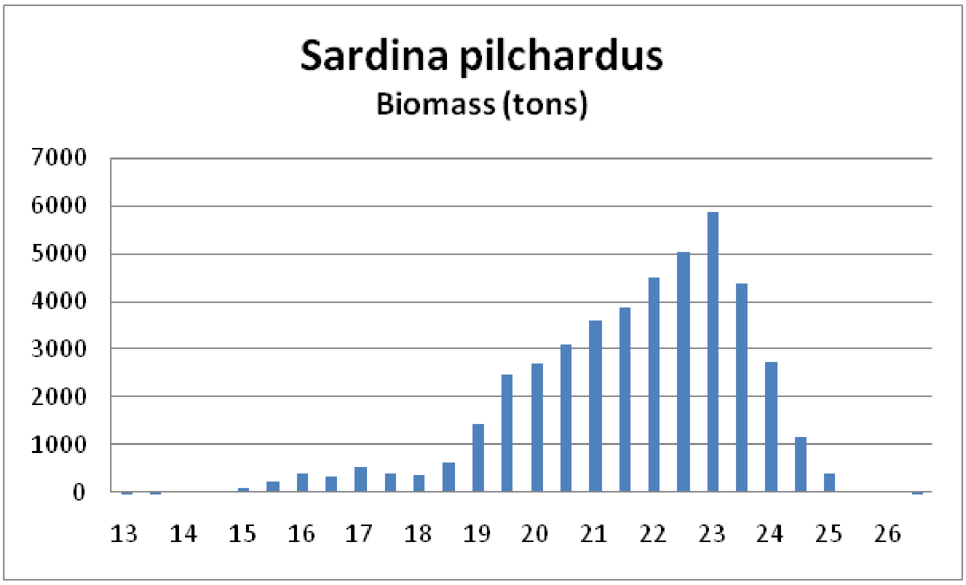


Figure 5.3.2.2.2: Sardine in VIIIc and IXa: Sardine length distribution (cm) in numbers (top) and biomass in tonnes (bottom) during the PELACUS0409 survey.

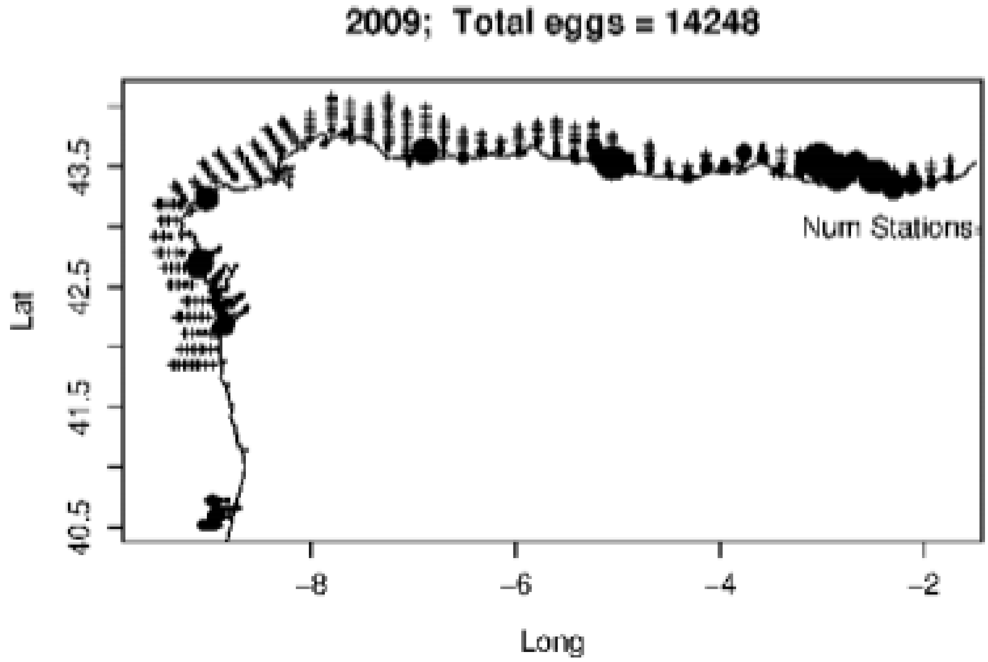


Figure 5.3.2.2.3: Sardine in VIIIc and IXa: Total number of sardine eggs obtained during the PELACUS0409 survey.

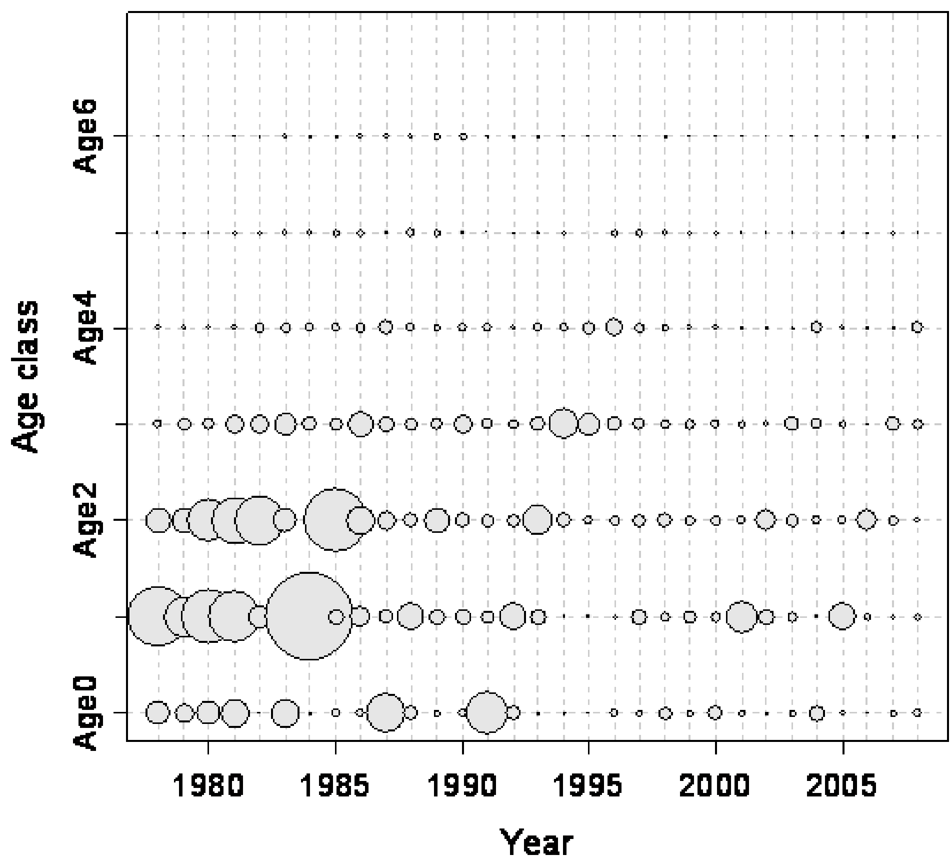


Figure 5.6.1.1: Sardine in VIIIc and IXa: Catches-at-age for 1978-2008.

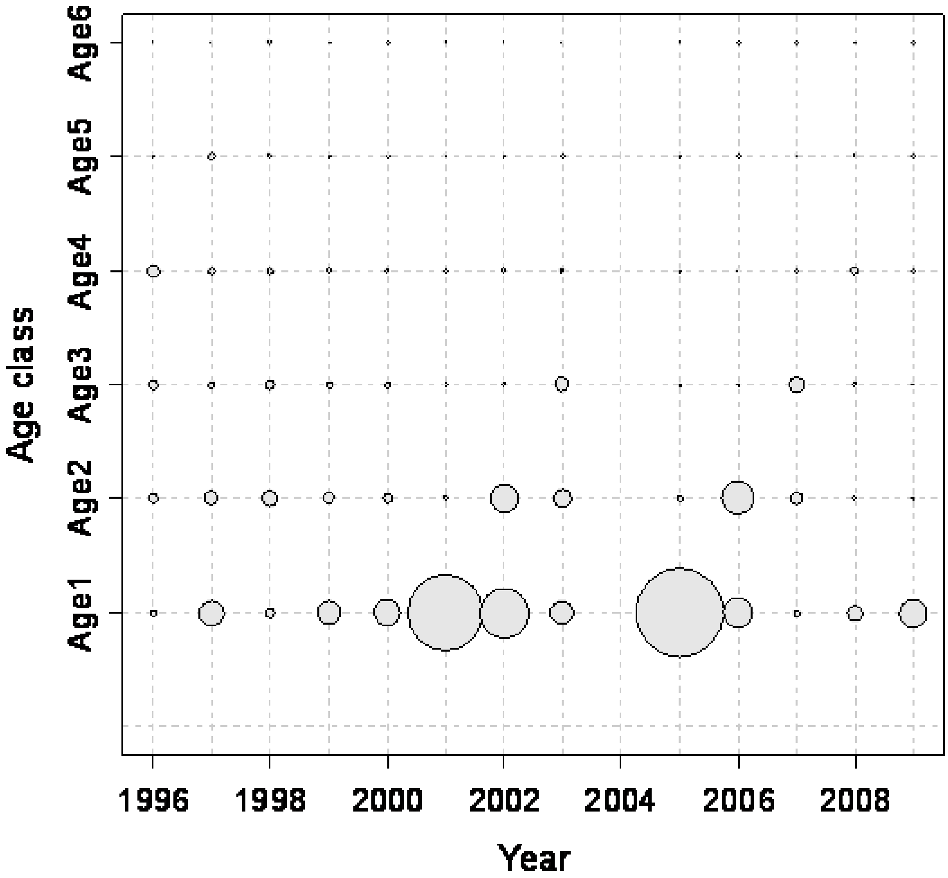


Figure 5.6.1.2: Sardine in VIIIc and IXa: Abundance-at-age in the joint Spanish-Portuguese spring acoustic survey 1996-2009.

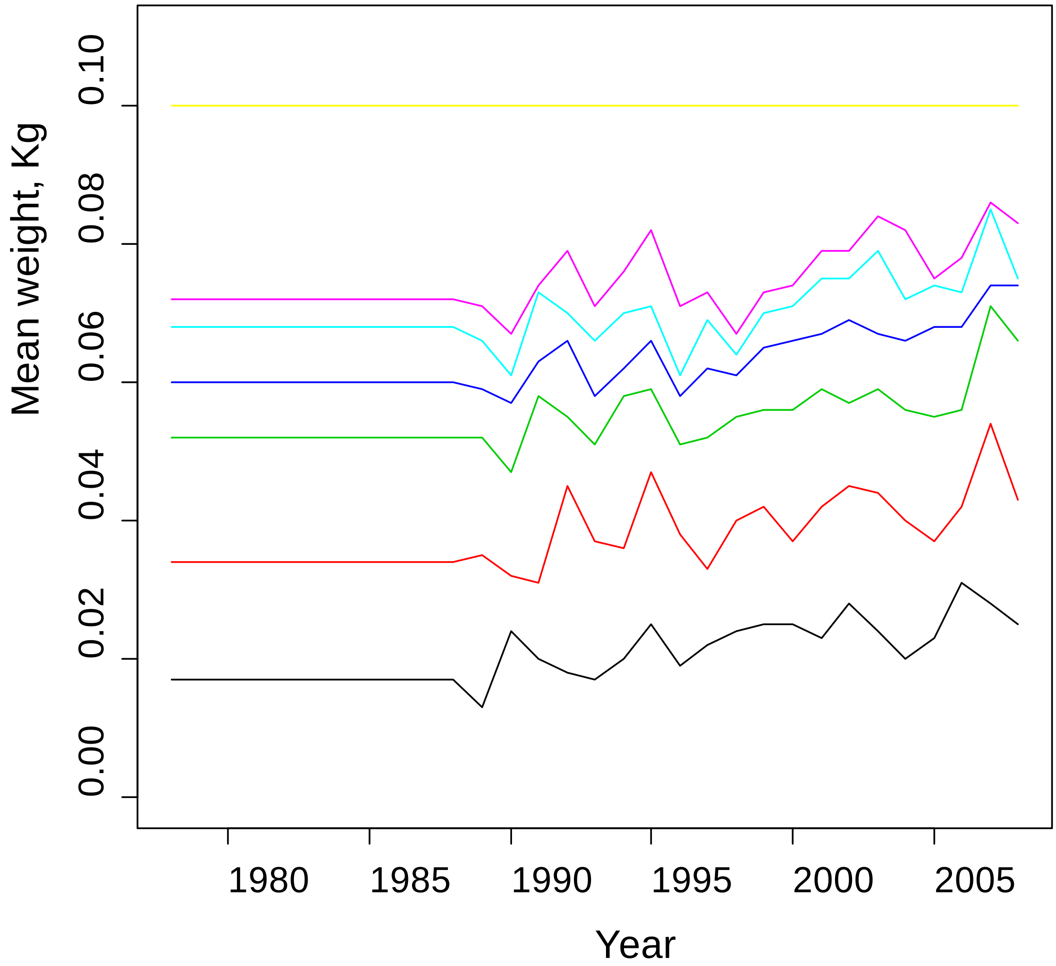


Figure 5.6.1.3: Sardine VIIIc and IXa: Mean weight-at-age in the catches 1978 – 2008.

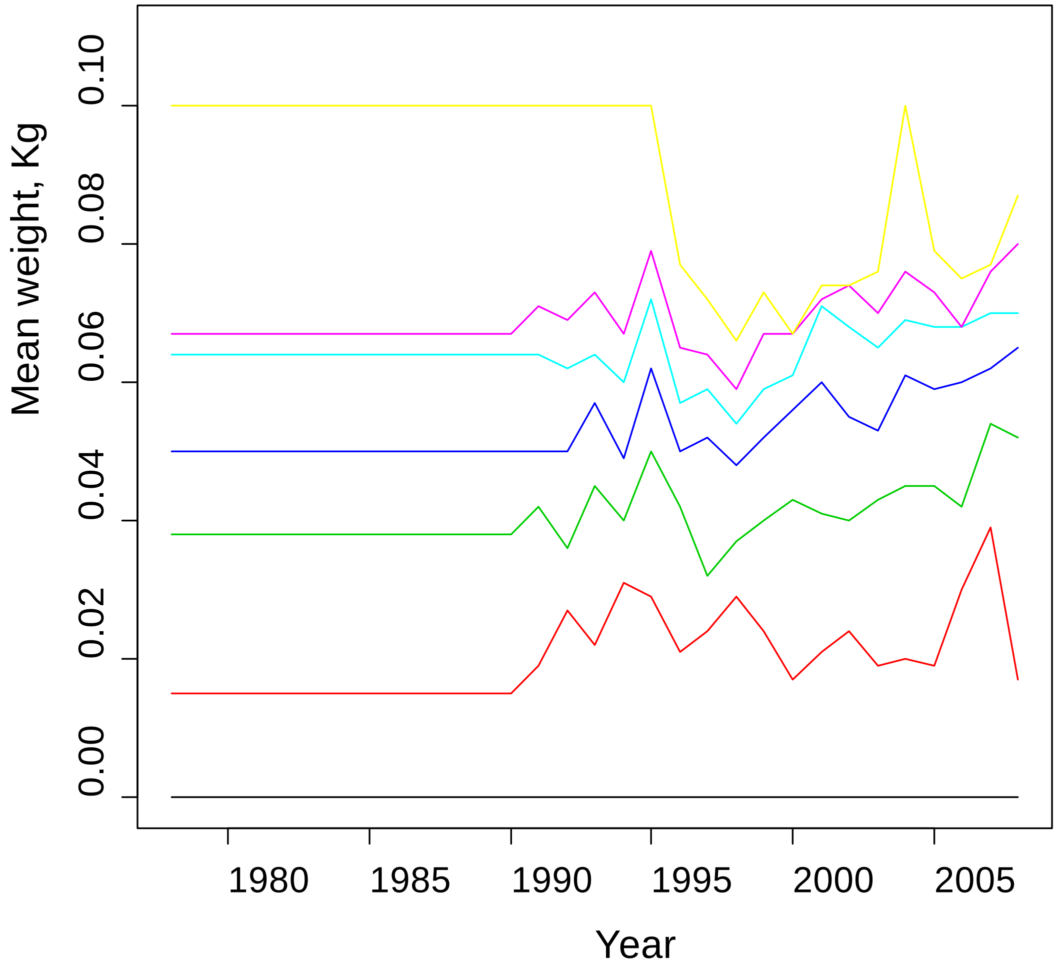


Figure 5.6.1.4: Sardine VIIIc and IXa: Mean weight-at-age in the stock 1978 – 2008.

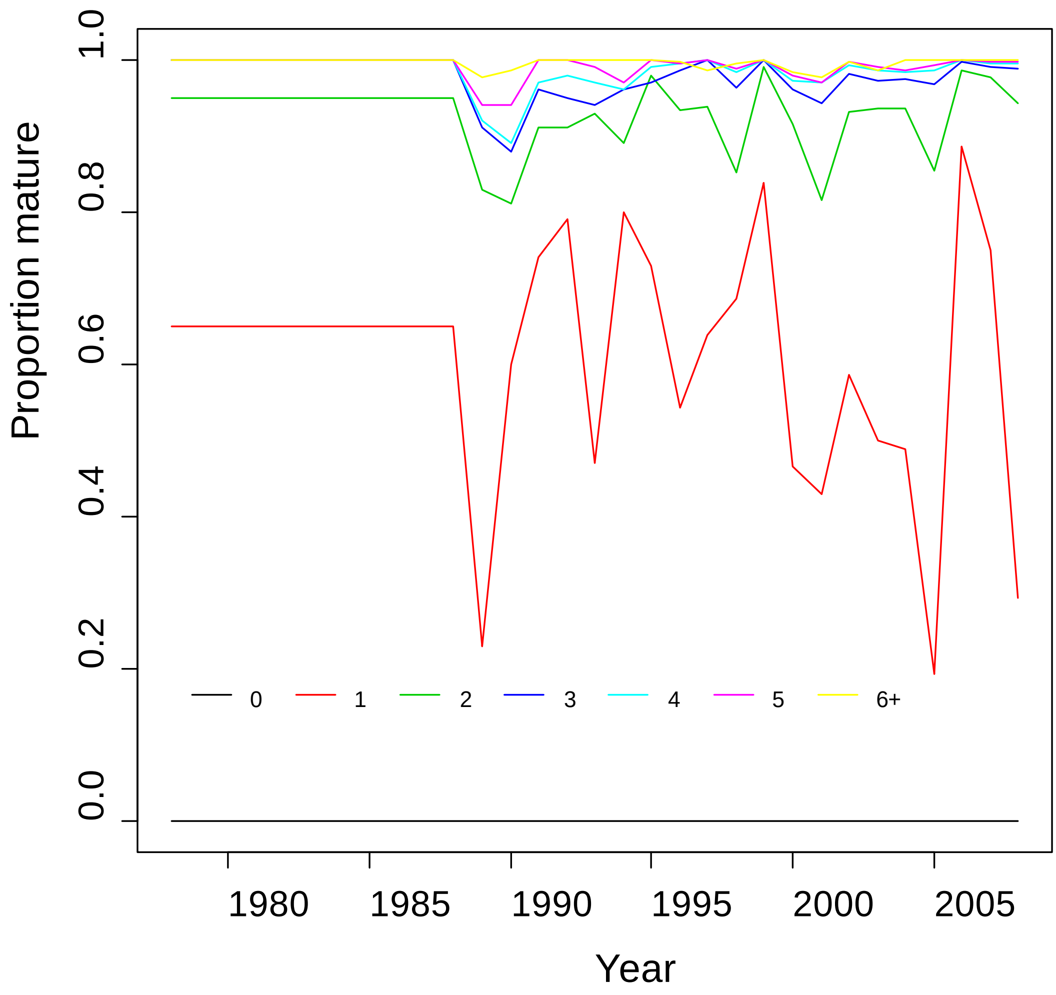


Figure 5.6.1.5: Sardine VIIIc and IXa: Maturity ogives 1978 – 2008.

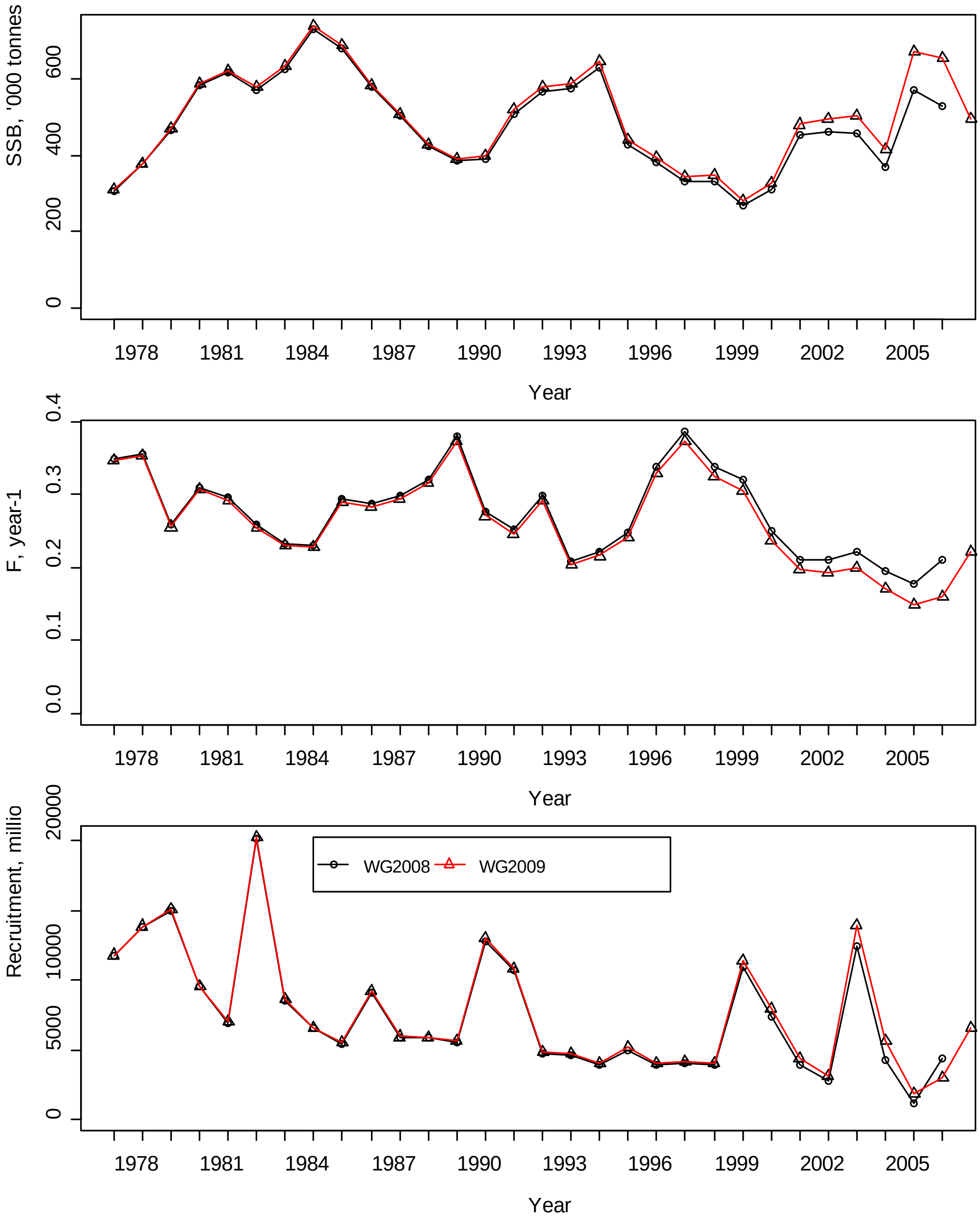


Figure 5.6.2.1: Sardine VIIIc and IXa: SSB (top), F (middle) and recruitment (bottom) trajectories in the period 1978 – 2008 from the sardine AMCI final assessment (WG2009). The WG2008 assessment is shown for comparison.

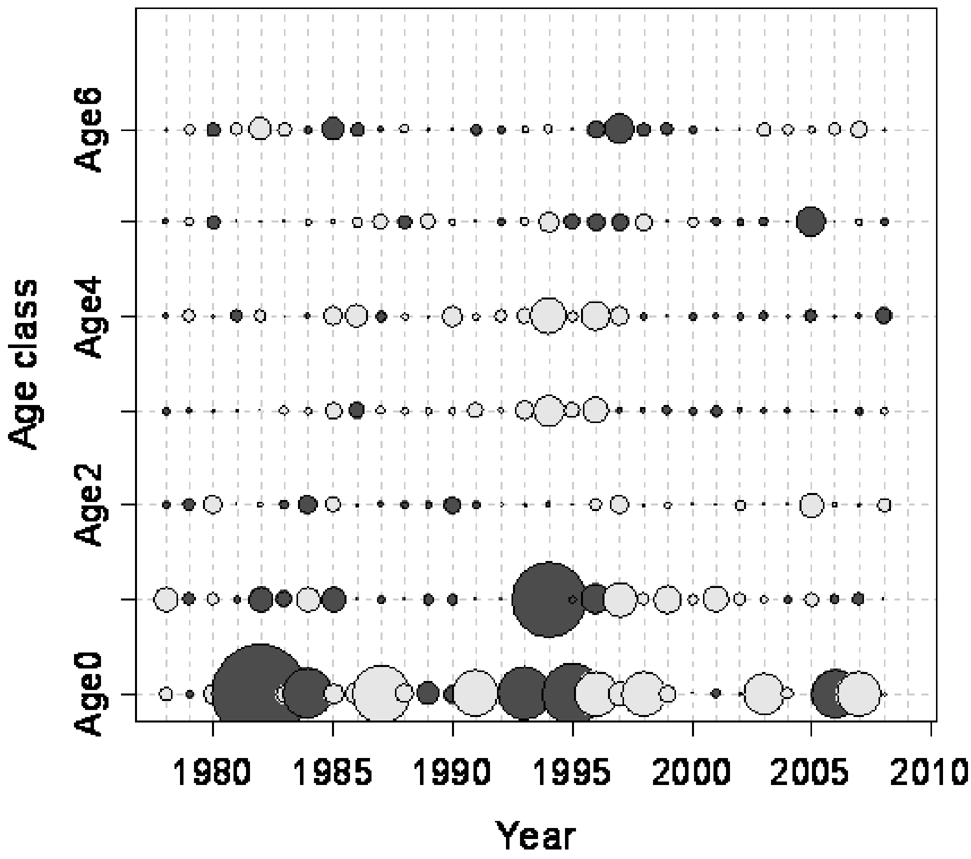


Figure 5.6.2.2: Sardine VIIIc and IXa: Catch residuals 1978 – 2008 (unweighted, negative in black, positive in grey) for the final AMCI assessment. Values are in the range [-1.6, 0.96].

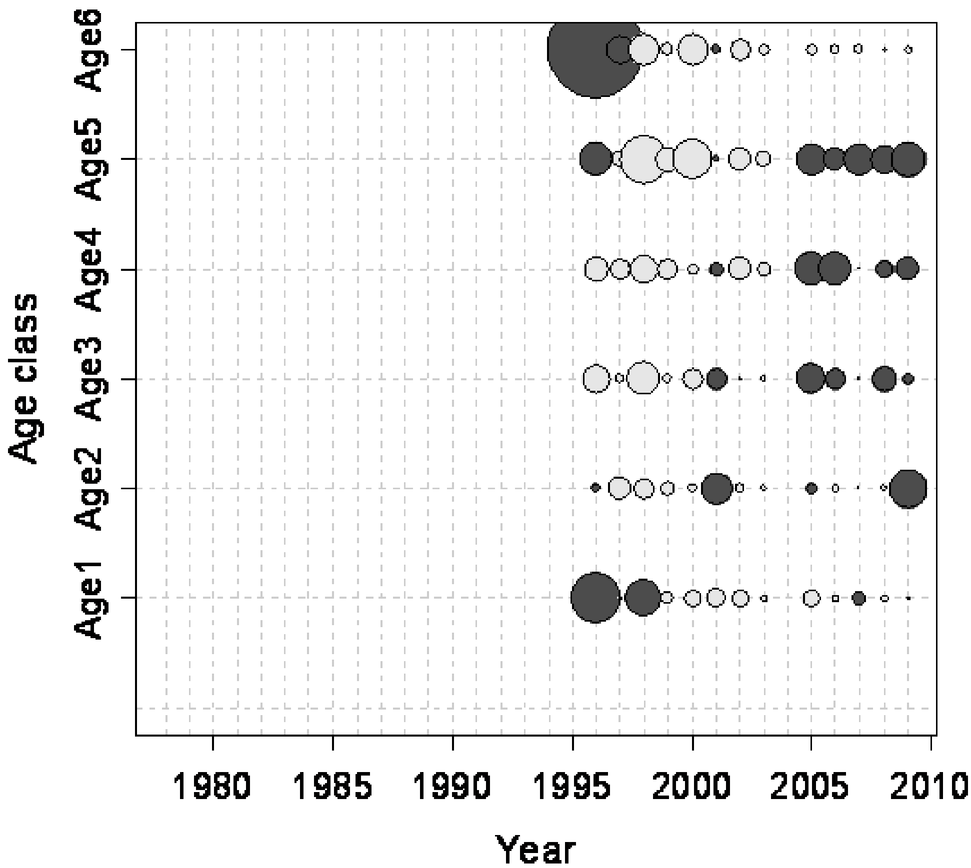


Figure 5.6.2.3: Sardine VIIIc and IXa: Survey residuals (for the combined Iberian spring acoustic survey 1996 - 200) for the final assessment. Negative residuals in black, positive in grey, values in the range [-2.1, 1.04].

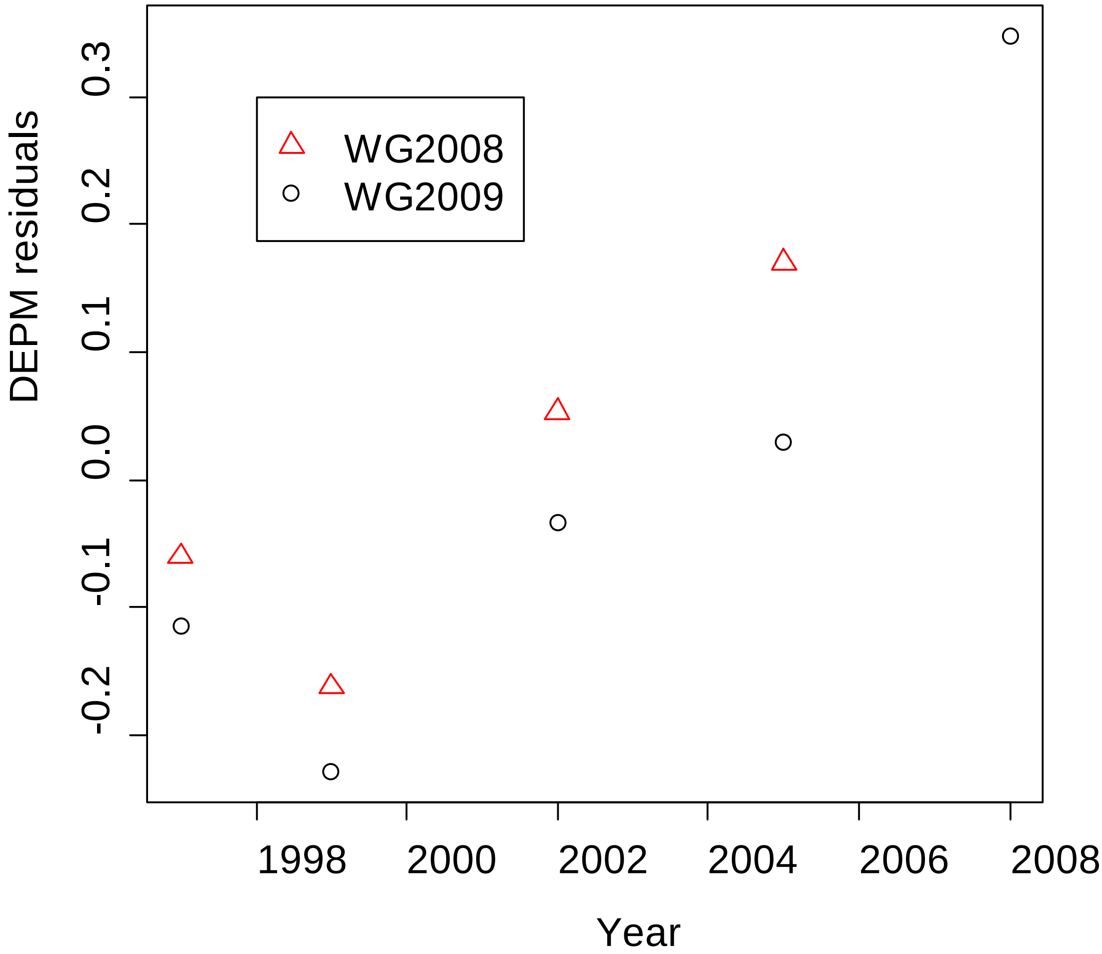


Figure 5.6.2.4: Sardine VIIIc and IXa: DEPM survey residuals (unweighted) in the final assessment model. Residuals from the 2008 assessment are shown for comparison.

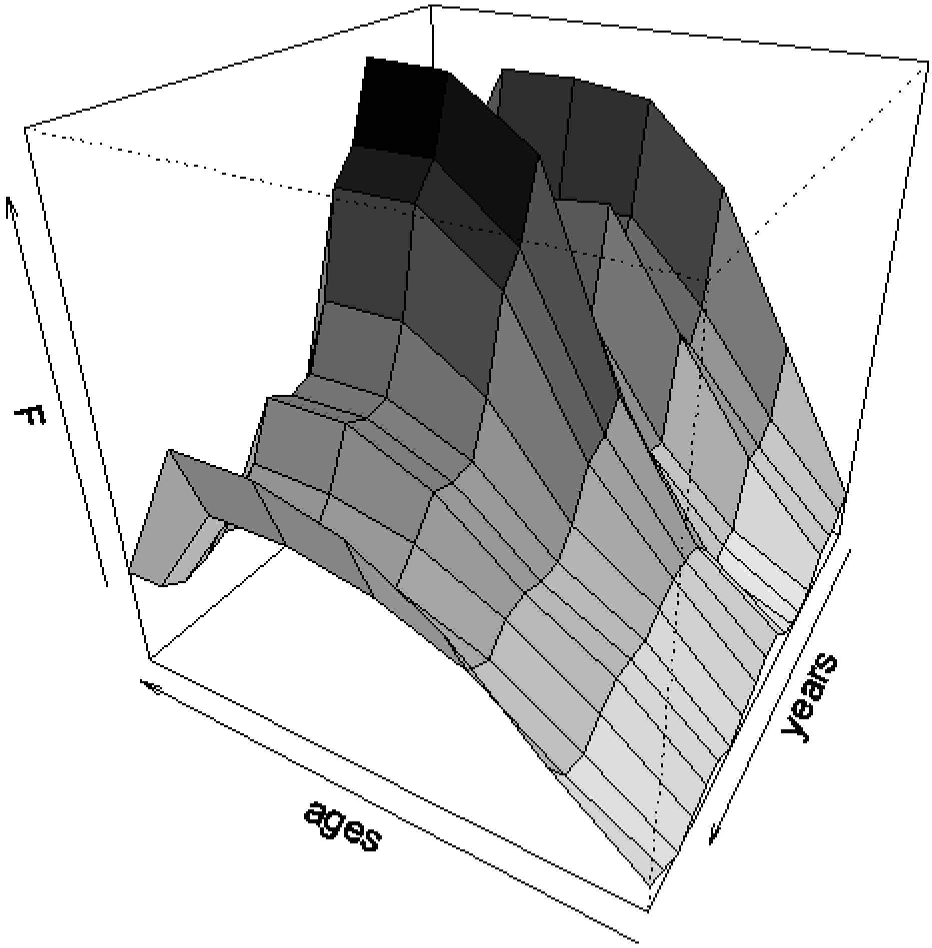


Figure 5.6.2.5: Sardine VIIIc and IXa: Year and age specific fishing mortalities estimated by the final assessment model for the period 1978 – 2008 and age groups 0-6+.

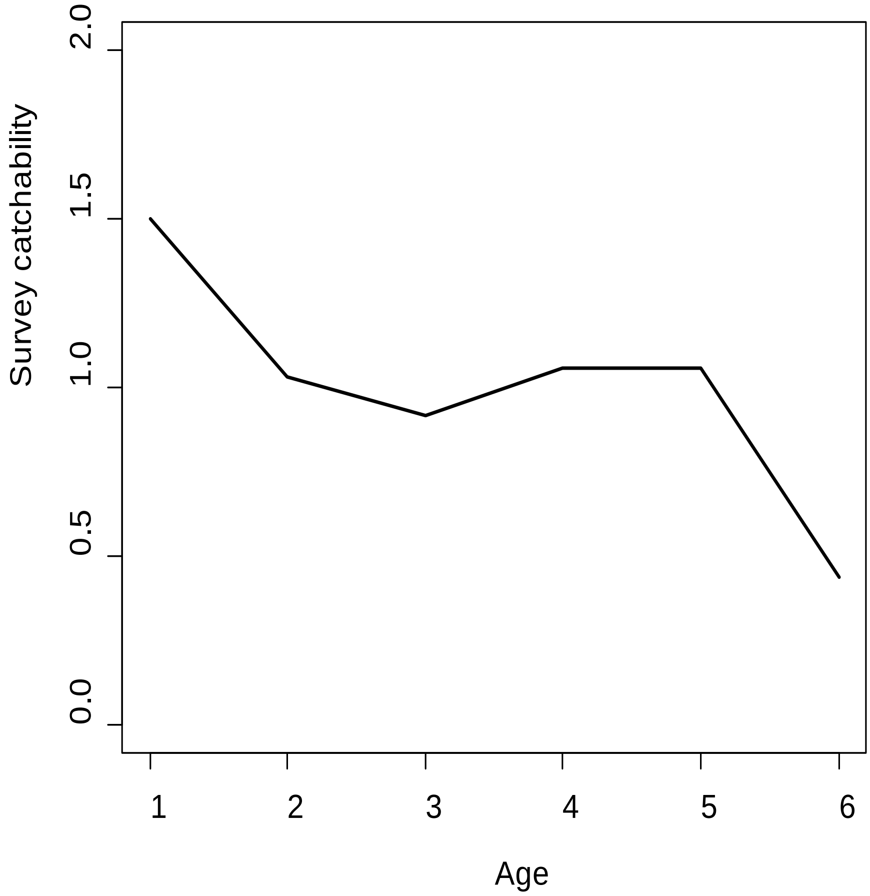


Figure 5.6.2.6: Sardine VIIIc and IXa: Survey catchability for ages 1 to 6+ in the final assessment model.

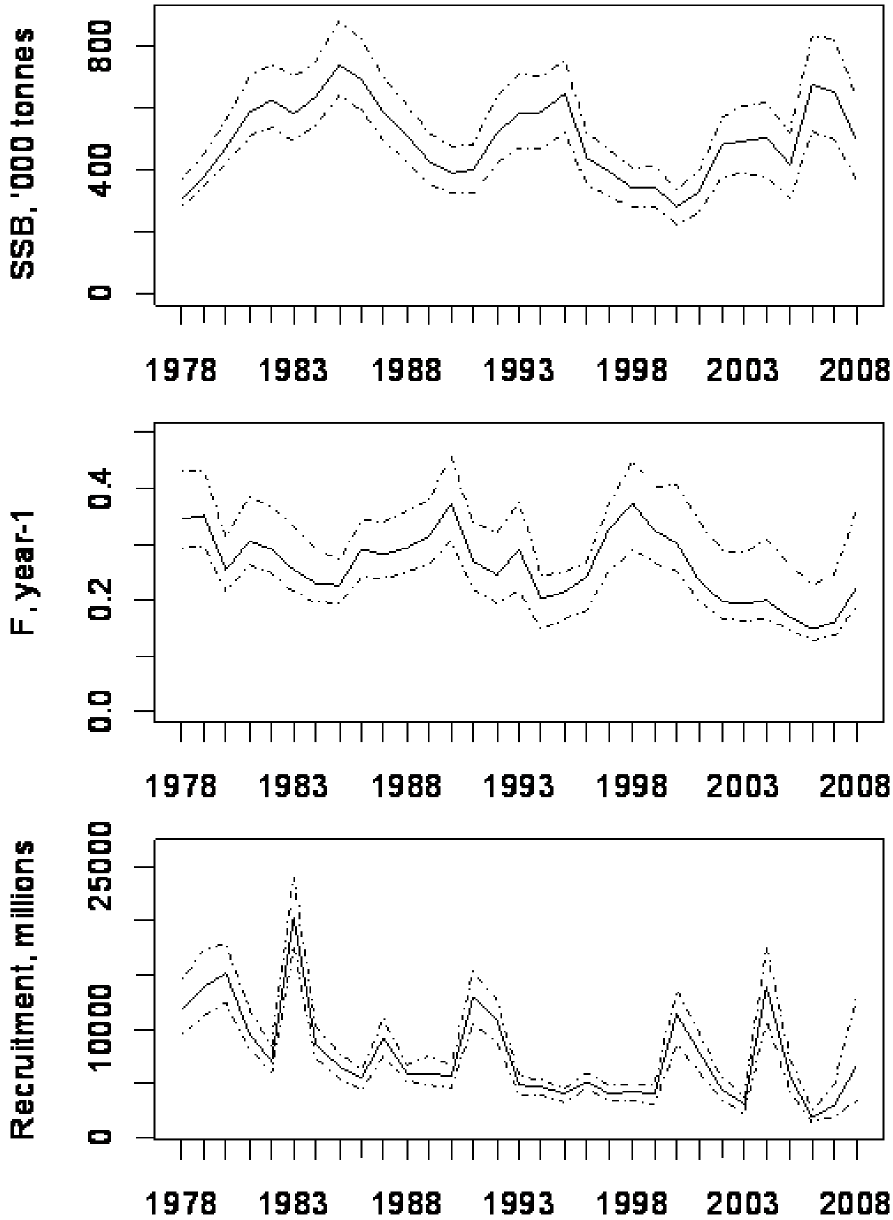


Figure 5.6.2.7: Sardine VIIIc and IXa: Bootstrap trajectories of SSB, recruitment and F for the final assessment model. Dotted lines represent the 90% limits

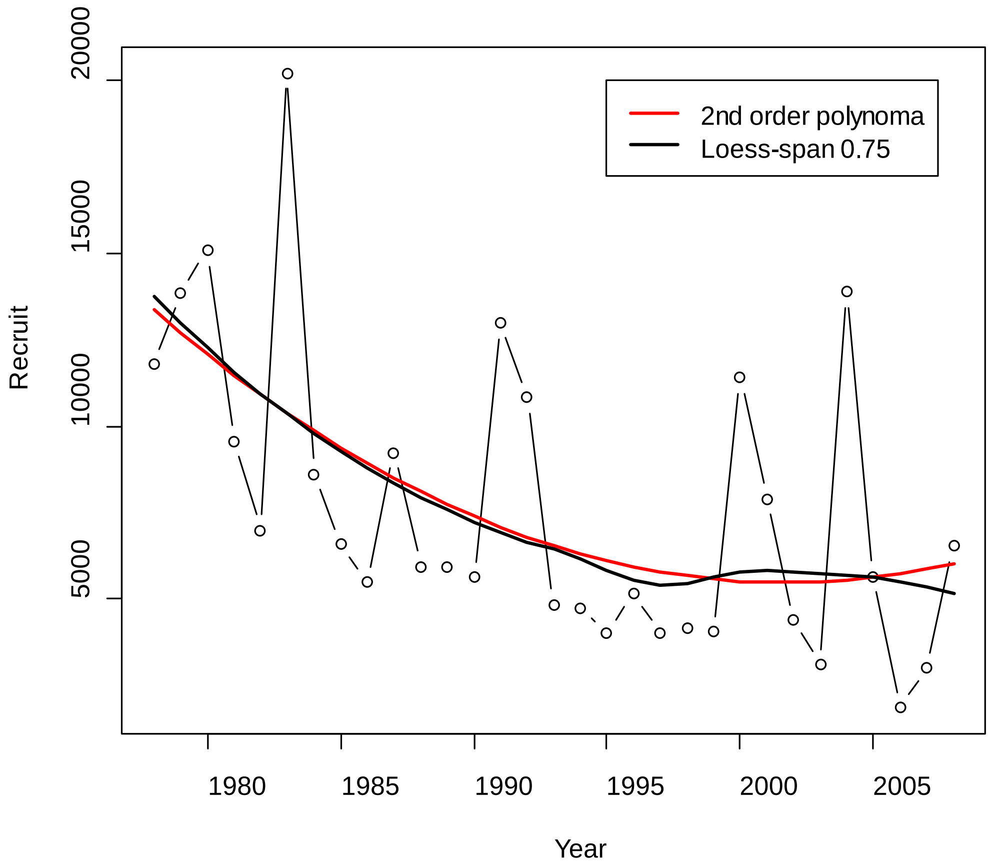


Figure 5.7.1.1: Sardine in VIIIc and IXa: Recruitment of sardine estimated by the assessment. The red line shows a 2nd order polynoma and the black line shows a loess smoother (span=0.75) fitted to the data.

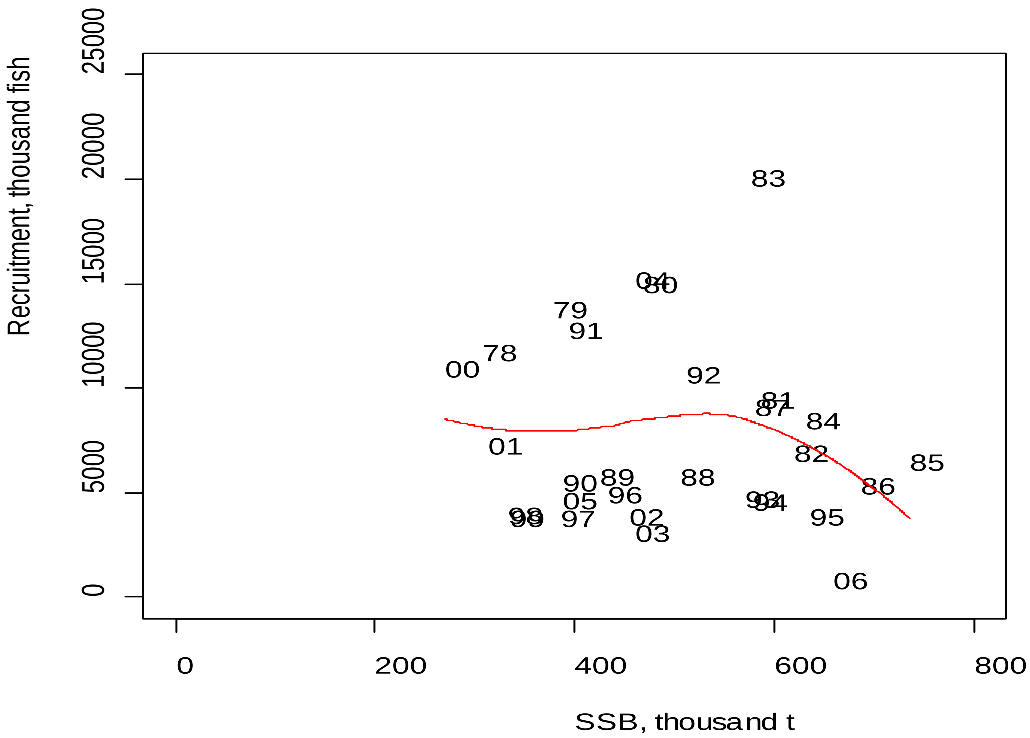
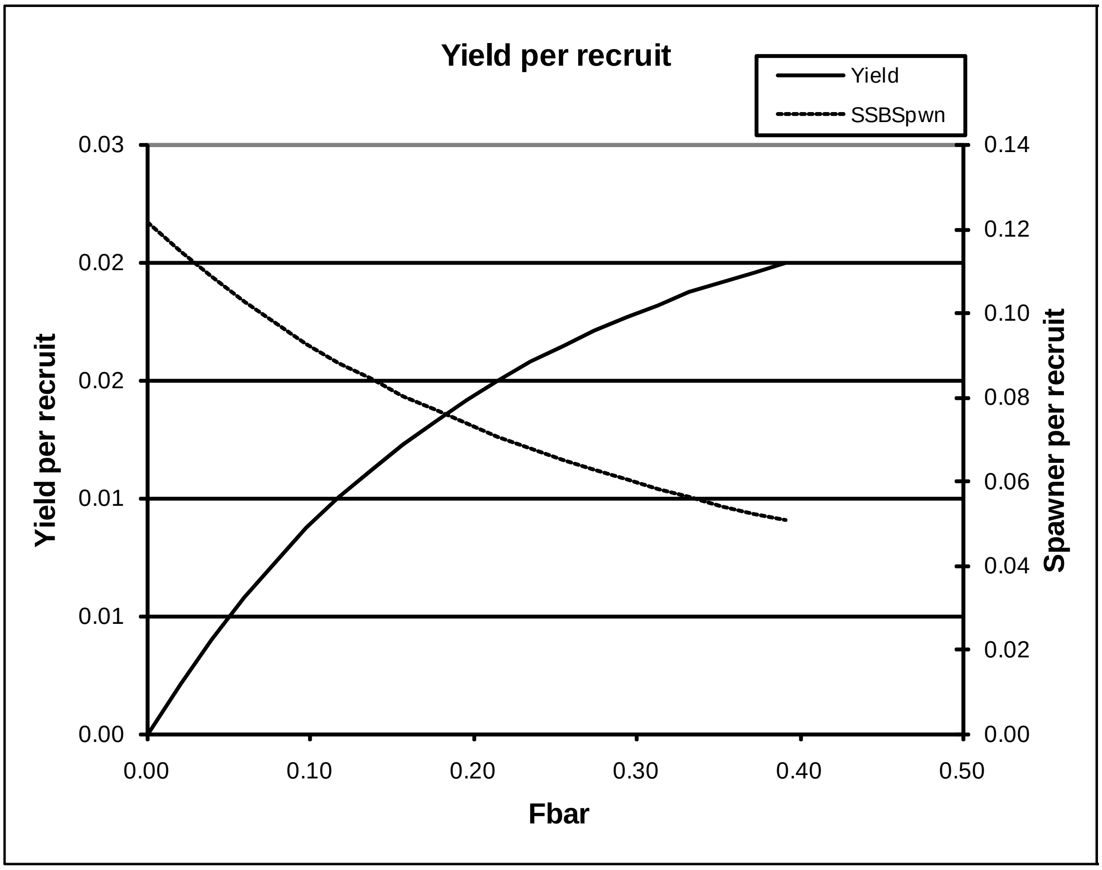


Figure 5.8.1: Sardine in VIIIc and IXa: Scatterplot of stock and recruitment. The red line shows a loess smoother (span=1) fitted to the data.



MFYPR version 2a
Run: sar-soth
Time and date: 07:23 09-09-2008

Reference	point	F multiplier
Fbar(2-5)	1.0000	0.1957
FMax	12.1813	2.3835
F0.1	2.7865	0.5452
F35%SPR	2.6040	0.5095

Weights in kilograms

Figure 5.8.2: Sardine in VIIIc and IXa: Yield and spawner per recruit curve.

6 Recommendations

STOCK DATA PROBLEMS RELEVANT TO DATA COLLECTION – EG NAME: WGANSA (WG ON THE ASSESSMENT OF ANCHOVY AND SARDINE)

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 subareas VIII and VII	*Sardine populations are expanding and fisheries increasing to the North of Iberian Region. Advice may be required in the future for this species in those areas. But No complete coverage of the sardine north of the Iberian Peninsula is achieved.*	*DEPM and acoustic surveys in Subarea VIII usually leave northwest of division VIIIa uncoverd, due to have anchovy as primary target species. And no survey is made in subarea VII for sardine. DEPM surveys for sardine around the Iberian Peninsula are made every three years. Next one will be in 2011.* ***The proposal is to coordinate research institutes in 2011 to expand current acoustic and DEPM surveys in VIII to completely cover that region and for relevant parts of subarea VII to be covered in cooperation with interested northern countries.***	*ACOM, RCM and PGCCDBS should support the idea of such a Survey and and communicate with relevant bodies accordingly.* *The same idea was recommended by WGWIDE and WGACEGGs. in 2008*
Sardine in VIIIc and IXa ***Anchovy in IXa.***	*Both for sardine and anchovy in the area, an indication of the strength of incoming year classes would improve the advice on management.*	***The WG recommends DCR to economically support an autumn acoustic survey for provision of recruitment indices for sardine and anchovy*** ***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.***	*ACOM, RCM and PGCCDBS should support the idea of such a Survey and and communicate with relevant bodies accordingly* *The same idea was recommended by WGWIDE and WGACEGG in 2008*
Anchovy in Subarea VIII	*For the future management of this stock, a continuation of surveys to monitor recruitment in the autumn is mandatory.*	***DCR to economically support the continuation of the acoustic assessment of juveniles in the Bay of Biscay***	*ICES secretariat to pass the support to this survey to the EC and DCR meeting on surveys*
Sardine	*Age reading has not been standardized between the VIIIc- IXa stock and outside areas (VII and VIIIa,b)*	*A workshop in 2010 on sardine age reading is recommended, to standardize age reading methodology and criteria between the different areas.*	*PGCCDBS*

WGANSA 2009 Recommendations	to
1. The WGANSA recommends that age composition of anchovy in Division IXa by age readings of otoliths in the Spring Portuguese acoustic surveys is done, and that the support by ICES for such an effort is communicated to the Portuguese insititute (IPIMAR).	ICES secretariat
2. Given the high uncertainties of the estimates of DEPM SSB of anchovy in the Division IXa in 2005 and 2008, WGANSA asks WGACEGGs to analyse the sources of uncertainties and come up with suggestions for improving such estimates in future surveys (including improvement of sampling design, if necessary).	WGACEGGs
WGANSA suggest that ICES should claim for a broad participation in WKSHORT concerning specialists from implied institutes in environmental and ecosystem interaction with anchovy dynamics.	ACOM and ICES secretariat
For Ancovy in Subarea VIII and several other stocks, the standard assessment procedure produces results in probabilistic terms. WGANSA recommends ACOM to provide guidelines, on a generic level, on how to adapt PA advice to probabilistic assessments and predictions.	ACOM
WGANSA strongly recommends that next years working group is held 2 weeks later than this year, i.e. in week 26. There is a substantial amount of work needed to assemble and analyze both acoustic and egg survey data after the survey to provide survey estimates of stock abundance. The present time schedule makes the time available in that phase unacceptably short, and severe errors are bound to occur. The surveys cannot be conducted earlier due to the biology of the stock.	ACOM and ICES secretariat
WGANSA recommends that next year's meeting is held in Lisboa (or some alternative place in Iberia), to reduce travel expenses for the majority of the participants.	ACOM, Delegates

7 References

7.1 Section 2

Allain, G., Petitgas, P. and Lazure, P. 2001. The influence of mesoscale ocean processes on anchovy (Engraulis encrasicolus) recruitment in the Bay of Biscay estimated with a three-dimensional hydrodynamic mode. Fisheries Oceanography 10(2): 151-163.

Barange, M., Bernal, M., Cercole, M.C., Cubillos, L., Cunningham, C.L., Daskalov, G.M., de Oliveira, J.A.A., Dickey-Collas, M., Hill, K., Jacobson, L., Köster, F.W., Masse, J., Nishida, H., Ñiquen, M., Ooseki, Y., Palomera, I., Saccardo, S.A., Santojanni, A., Serra, R., Somarakis, S., Stratoudakis, Y., van der Lingen, C.D., Uriarte, A. and Yatsu, A., in press. Current trends in the assessment and management of small pelagic fish stocks. In: D. Checkley, C. Roy, J. Alheit and Y. Oozeki (Editor), Climate Change and Small Pelagic Fish. Cambridge University Press.

Borja, A., Uriarte, A. Egaña, J., Motos, L. and Valencia, V. 1998. Relationships between anchovy (Engraulis encrasicolus) recruitment and environment in the Bay of Biscay (1967-1996). Fisheries Oceanography 4(3/4): 375-380.

Borja, A. Fontán, A., Saez, J. and Valencia, V. 2008. Climate, oceanography, and recruitment: the case of the Bay of Biscay anchovy (Engraulis encrasicolus). Fisheries Oceanography 17 (6): 477–493.

Freon, P., Cury, P., Shannon, L. and Roy, C. 2005. Sustainable exploitation of small pelagic fish stocks challenged by environmental and ecosystem changes: A review. Bulletin of Marine Science, 76: 385-462.

Huret, M., and Petitgas, P. 2007. Anchovy recruitment forecasting and environment. Working document to ICES WGMHMSA 2007.

Ibaibarriaga, L., Fernandez, C., Uriarte, A and Roel, B.A. 2008. A two-stage biomass dynamic model for the Bay of Biscay anchovy: A Bayesian Approach. ICES Journal of Marine Science, 65: 191 – 205.

Ibaibarriaga, L. and Uriarte, A. 2009. Continuation of the Management Strategy Evaluation for the Bay of Biscay anchovy: Testing the step TAC Rule at Spawning biomasses below Bpa suggested by SWW.RAC. Working document to SWW RAC, European Commission, Basque Government and Spanish Ministry.

ICES. 2003. Report of the Study Group on precautionary reference points for advice on fishery management. ICES CM 2003/ACFM:15.

ICES 2007 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES CM 2007/ACFM:31.

ICES 2007 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG). ICES CM 2007/LRC:16.

ICES. 2008. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17. 183 pp.

ICES. 2008. Report of the Study Group on Management Strategies (SGMAS), 17 - 21 November 2008, Lisbon, Portugal. ICES CM 2008/ACOM: 24. 74 pp.

Lazure, P. and Dumas, F. 2007. An external-internal mode coupling for a 3D hydrodynamical model for applications at regional scale (MARS). Advances in Water Resources 31: 233-250.

Petitgas, P., Massé, J., Beillois, P., Lebarbier, E. and Le Cann, A. 2003. Sampling variance of species identification in fisheries acoustic surveys based on automated procedures associating acoustic images and trawl hauls. ICES Journal of Marine Science 60: 437-445.

STECF-SGRST 2008. Report of the Meeting to inform the Commission on a long-term management plan for the stock of anchovy in the Bay of Biscay (ICES Subarea VIII).

Werner, F.E., Quinlan, J.A., Lough, R. G. and Lynch, D.R. 2001. Spatially-Explicit Individual Based Modeling of Marine Populations: A Review of the Advances in the 1990's. Sarsia 86: 411-421.

7.2 Section 3

Brehmer, P., J. Guillard, Y. Guennégan, J.L. Bigot, B. Liorzou, 2006. Evidence of a variable ''unsampled'' pelagic fish biomass in shallow water (<20 m): the case of the Gulf of Lion. *ICES Journal of Marine Science*, 63 (3): 444-451.

Guillard, J., A. Lebourges, 1998. Preliminary results of fish populations' distribution in a Senegalese coastal area with depths less than 15 m, using acoustic methods. *Aquat. Living Resour.*, 11: 13-20.

Guennégan, Y., J. Guillard, J-L. Bigot, P. Brehmer, M. Colon, Y. Cheret, B. Liorzou, 2004. Importance de la zone côtière dans les évaluations des stocks de petits poissons pélagiques: Analyse d'une série de campagnes acoustiques et d'une expérimentation en zone côtière. Working Document to the Working Group on Small Pelagics. Scientific Advisory Committee-GFCM. Sub-Committee of Stock Assessment. Málaga, Spain, 6-7 May, 2004. 17 pp.

ICES, 1986. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. Lisbon, 1-4 April 1986. ICES CM 1986/H:27. 7 pp.

ICES, 1998. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. A Coruña, 30-31 January 1998. ICES CM 1998/G:2. 17 pp.

ICES, 2005 a. Report of the ICES Advisory Committee on Fishery Management and Advisory Committee on Ecosystems. *ICES Advice*. Volumes 1-11. 1418 pp.

ICES, 2007 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), 4 - 13 September 2007, ICES Headquarters. ICES CM 2007/ACFM:31. 712 pp.

ICES, 2007 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 26 - 30 November 2007, Palma de Mallorca, Spain. ICES C.M. 2007/LRC:16. 167 pp.

ICES. 2008 a. Report of the Working Group on Anchovy (WGANC), 13 - 16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

ICES. 2008 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17. 183 pp.

Pestana, M.G., 1989. Manacial ibérico-atlântico de sardinha (*Sardina pilchardus*, Walb.) Sua avaliação e medidas de gestão. Dissertaçao, Instituto Nacional de Investigação Científica, Lisbon, 192 pp.

Pestana, G. 1996. Anchovy in Portuguese waters (IXa): landings and length distribution in surveys. Working documente presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 1996/Assess:7.

Ramos F., Uriarte A., Millán M. and Villamor B., 2001. Trial analytical assessment for anchovy (*Engraulis encrasicolus*, L.) in ICES Subdivision IXa-South. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2002/ACFM:06

7.3 Section 4-5

Cotter, A. J. R., Mesnil, B., and Piet, G. J. 2007. Estimating stock parameters from trawl cpue-at-age series using year class curves. ICES Journal of Marine Science, 64: 234–247.

Pestana, G., 1989. Manacial Ibero-Atlântico de sardinha (Sardina pilchardus, Walb). Sua avaliação e medidas de gestão. Dissertação para provas de acesso à categoria de Investigador Auxiliar, Instituto nacional de Investigação das Pescas.

Annex 1 – LIST OF PARTICIPANTS

NAME	ADDRESS	PHONE/FAX	EMAIL
Dankert Skagen (Chair)	Institute of Marine Research P.O. Box 1870 N-5817 Bergen Norway	Phone +47 55 238419 Fax +47 55 238687	dankert.skagen@imr.no
Erwan Duhamel	IFREMER Lorient Station 8 rue François Toullec F-56100 Lorient France		Erwan.Duhamel@ifremer.fr
Leire Ibaibarriaga	AZTI-Tecnalia Txatxarramendi Ugartea z/g 48395 Sukarrieta Spain	Phone +34 94 602 94 00 Fax +34 94 657 25 55	libaibarriaga@azti.es
Jacques Massé	IFREMER Nantes Centre P.O. Box 21105 F-44311 Nantes Cédex 03 France	Phone +33 (0)240374075	jacques.masse@ifremer.fr
Lionel Pawlowski	IFREMER Lorient Station 8 rue François Toullec F-56100 Lorient France	Phone +33 2 97 87 38 46 Fax: +33 2 97 87 38 36	lionel.pawlowski@ifremer.fr
Fernando Ramos	Instituto Español de Oceanografía Unidad de Cádiz Puerto Pesquero, Muelle de Levante s/n E-11071 Cádiz Spain	Phone +34 956016290	fernando.ramos@cd.ieo.es
Isabel Riveiro	Instituto Español de Oceanografía Centro Oceanográfico de Vigo P.O. Box 1552 E-36200 Vigo (Pontevedra) Spain	Phone + Fax +	Isabel.riveiro@vi.ieo.es
Beatriz Roel	Centre for Environment, Fisheries & Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1 502 52 4358 Fax +44 1502 524 511	beatriz.roel@cefas.co.uk

Maria Begoña Santos	Instituto Español de Oceanografía Centro Oceanográfico de Vigo P.O. Box 1552 E-36200 Vigo (Pontevedra) Spain	Phone +34 986492111 Fax +34	m.b.santos@vi.ieo.es
Maria Santos	AZTI-Tecnalia Herrera Kaia, Portualde z/g E-20110 Pasaia (Gipuzkoa) Spain	Phone +34 943004800 Fax +34 94 657 25 55	msantos@azti.es
Andrés Uriarte	Andrés Uriarte AZTI-Tecnalia Herrera Kaia, Portualde z/g E-20110 Pasaia (Gipuzkoa) Spain	Phone +34 943004816 / 800 Fax +34 94 657 25 55	auriarte@azti.es

Working Document for WGANSA (Copenhagen, June. 2009)

Direct assessment of small pelagic fish by the PELGAS09 acoustic survey

Jacques Massé[1], Erwan Duhamel[2]

(1) IFREMER, lab. Fisheries Ecology, BP 21105, F- 44311, Nantes, France.
[tel: +33 240 374000, fax: +33 240 374075, e-mail: Jacques.Masse@ifremer.fr]
(2) IFREMER, lab. Fisheries Research, 8 rue François Toullec 56100 Lorient, France.
[tel: +33 297 87 38 37, fax: +33 297 87 38 36, e-mail: Erwan.Duhamel@ifremer.fr

Special thanks to: Pierre Beillois, Damien Delaunay[1], Patrick Grellier[1], Martin Huret[1], Mathieu Doray[1], Pierre Petitgas[1]

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 on board the French research vessel Thalassa. The objective of PELGAS surveys is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine but they are considered in a multi-specific context and in 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 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.

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 :

1) 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
2) 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 this year was the identical to previous surveys (2000 to 2008) :
- 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 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 for the echo sounder between the surface and 8 m depth.

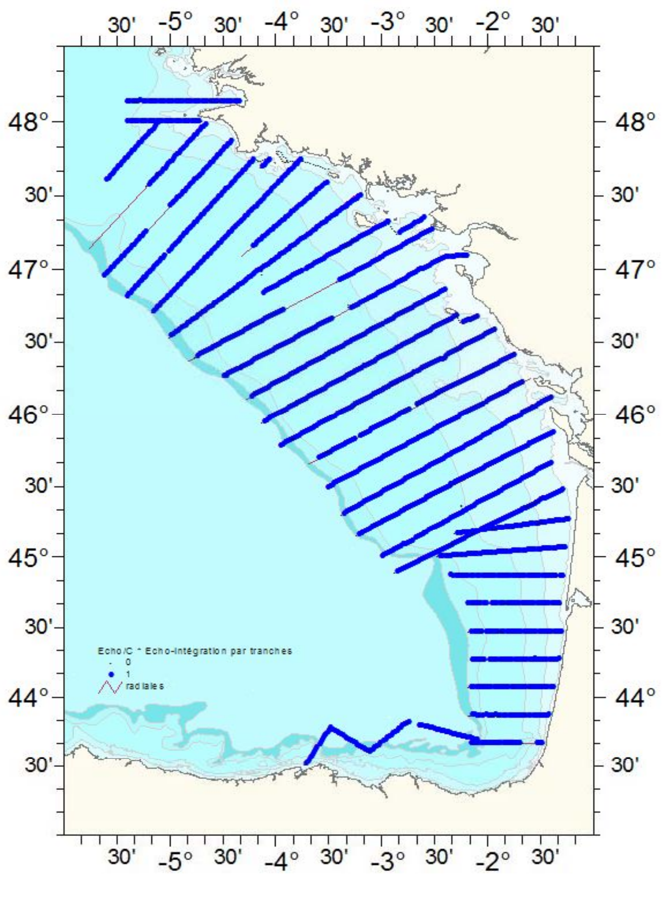


Fig. 1.1.1 - Transects prospected during PELGAS09 by Thalassa.

Two vertical echo-sounders were used during survey (SIMRAD EK60 for vertical echo-sounding and OSSIAN 500 as netsonde). In 2009 the SIMRAD ME70 has been used for multi-beam visualisation and was helpful to determine behaviour and forms of fish schools.. 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 was the same that the one described for the previous years (see W.D. 2001) and was performed at anchorage in the Douarnenez bay, in the west side of Brittany, in optimum meteorological conditions.

Acoustic data were therefore collected by Thalassa along a total amount of 6421 nautical miles from which 1873 nautical miles on one way transect were used for assessment. A total of 24 144 fish were measured on board Thalassa (including 5930 anchovy and 5249 sardine) and 2340 otoliths were collected for age determinations (1 183 anchovy and 1 157 sardine).

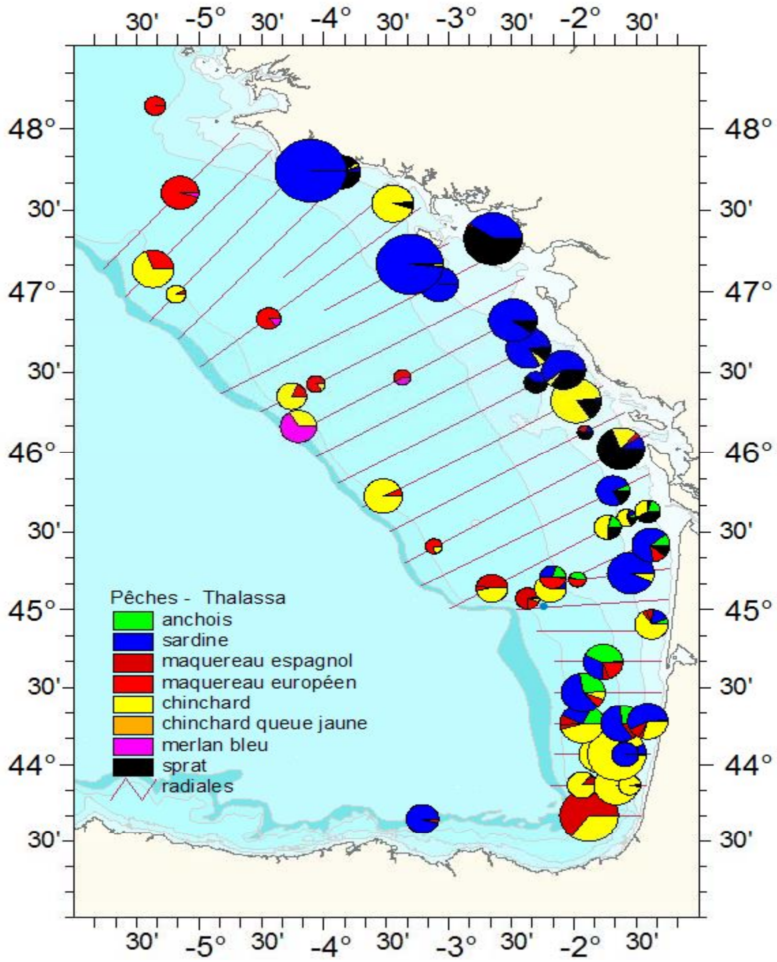


Fig. 1.1.2: Species distribution according to Thalassa identification hauls.

1.2 The consort survey

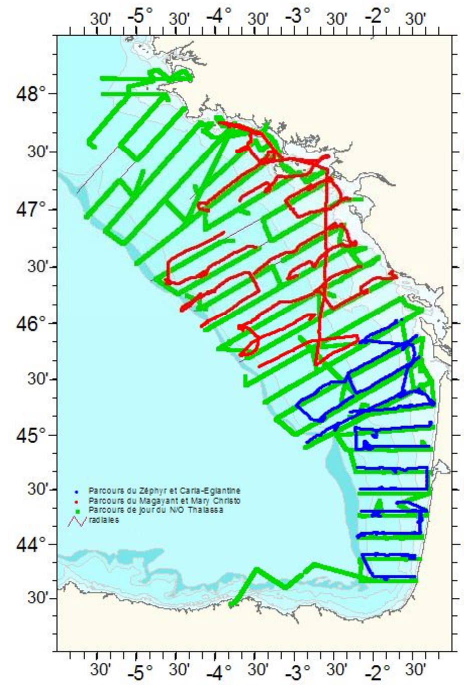
A consort survey was organized as in 2008 with French pair trawlers during the 21 first days and a purse seiners during 3 days . This approach, in the continuity of last year survey, and the commercial vessels hauls were used for echo identification and biological parameters at the same level than Thalassa one.

Five commercial vessels (two pair trawlers and a purse seiner) participated to PELGAS09 survey:

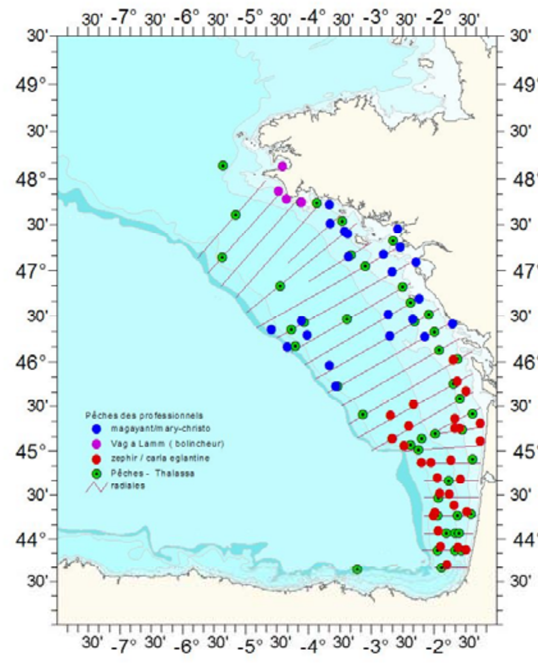
Vessel	gear	Period	Days at sea	Prospected area
Zéphyr / Carla-Eglantine	Pelagic pair trawl	26/04 to 06/05/2009	11	43°40'N to 46°05'N
Magayant / Mary Christo	Pelagic pair trawl	07/05 to 16/05/2009	10	46°10'N to 47°45'N
Vag a Lamm	Purse seine	21/05 to 23/05/2009	3	47°40'N to 48°12'N

Due to bad weather, pair trawlers had to go back to their harbour one day earlier than scheduled.

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 demand (complementary to Thalassa, particularly for surface hauls or in very coastal areas) or, sometime, according to their surveying 4 NM northern than our transects. Their pelagic trawl was until 30 m vertical opening and the mesh of their codend was similar to Thalassa (12 mm).



Acoustic transects network (Thalassa and commercial vessels)



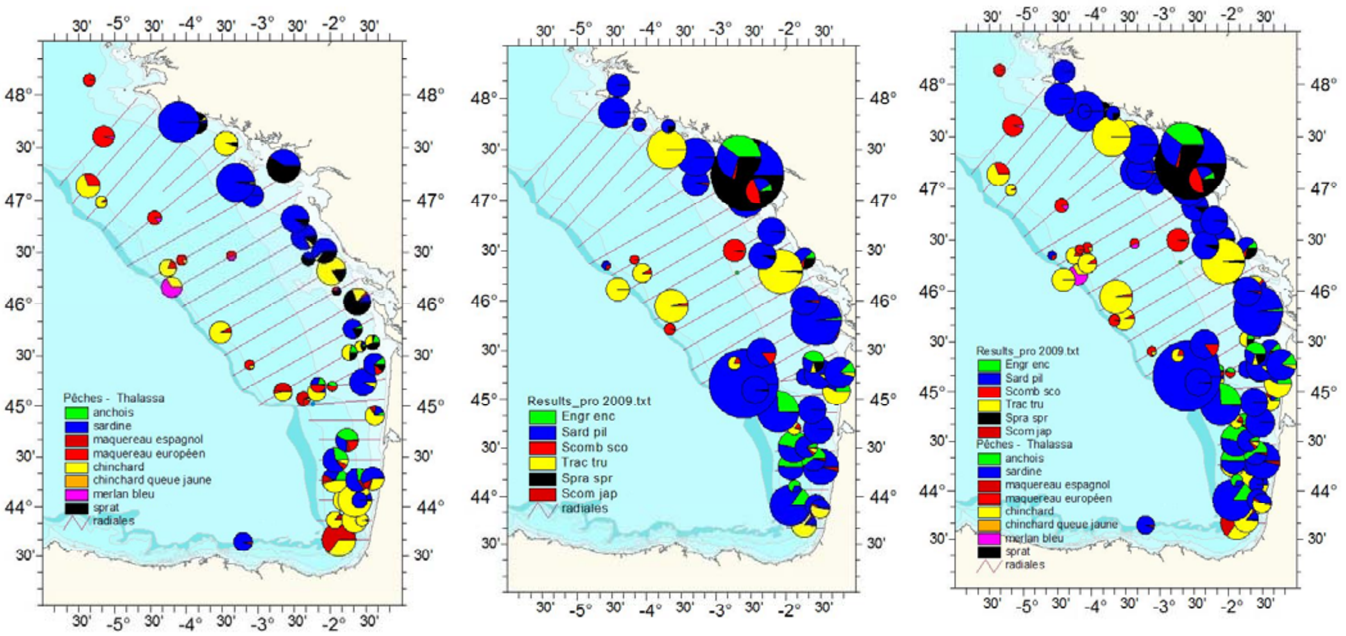
Fishing operations (Thalassa in red, commercial vessels the others)

Fig. 1.2.1 – Transects network and fishing operations resulting of the combination of Thalassa and commercial vessels during PELGAS09 survey.

A scientific observer was onboard to control every operation, to collect acoustic data and biological data. Their fishing operations were systematically previously agreed after a radio contact with Thalassa in order to confirm its utility. In some occasions, the use was to check the spread of a 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 taken 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 collecting and sexual maturity (one sample of sardine, eleven of anchovy). A total of 13 194 fishes were measured onboard commercial vessels, including 5 240 sardines and 2 230 anchovies.

It must be noticed that the commercial vessels were this year equipped with a precision weighting machine and a calibrated echo-sounders (Simrad ER60 – 70 kHz) able to store data at a standard format. But because of a technical problem at the beginning of the consort survey, a second sounder (Simrad ER60 – 120 kHz) was finally adapted. This sounder was not calibrated, but an inter-calibration was performed by surveying simultaneously 2 parallel transects 50 m away from each other. to compare energies. Their consort surveying and fishing operations can be so considered this year as qualitative and could be used as quantitative as well. The catches and biological data have been directly used at the same level than Thalassa one for identification and biological characterisation. The echo sounder was implemented on board the commercial vessel on a small towed body and because of a non sufficient stability during the first 2 weeks (17m vessel length) the data was stored only during small sequences when notable echo-traces were observed and mainly after fishing. Commercial vessel acoustic data will be processed later in order to compare the echo types and energies to Thalassa one in identical place or similar conditions. They were not available for the present WG and will not be used for assessment.

A total of 102 hauls were carried out during the assessment coverage including 47 hauls by Thalassa and 55 hauls by commercial vessels (figures 1.2.2.a and 1.2.2.b). 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.



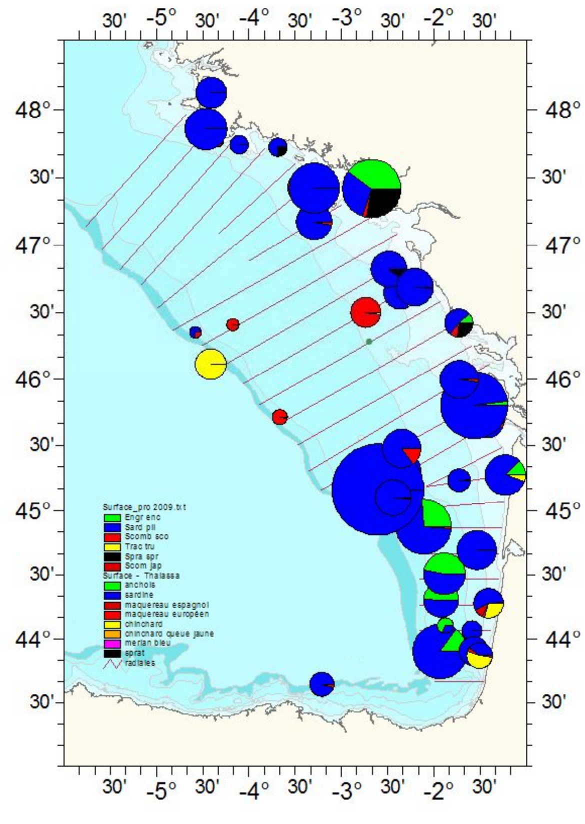
a) Thalassa (nb :47) *b) Commercial vessels (nb : 55)* *c) all fishing hauls (nb :102)*

Figure 1.2.2 : fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS09

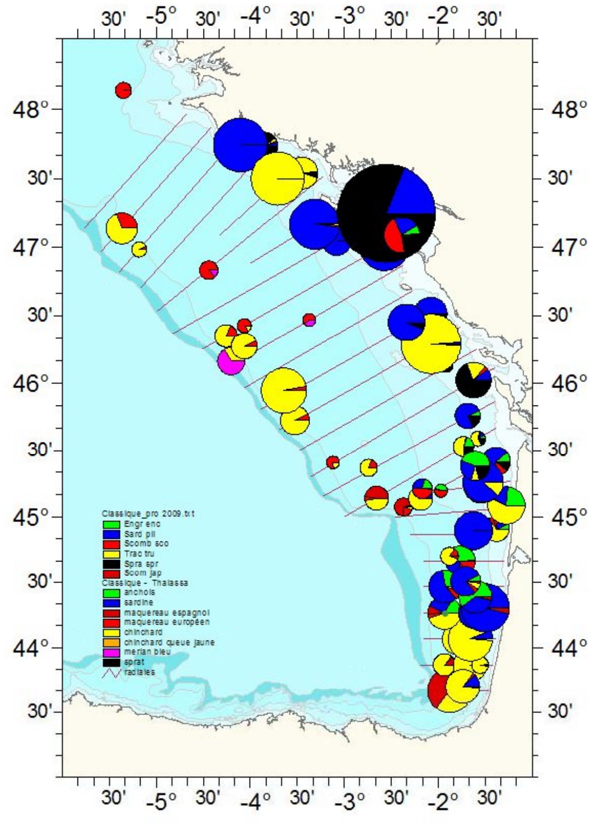
The collaboration between Thalassa and commercial vessels was excellent. It was once more a very good opportunity to explain to fishermen our methodology and more, to verify that both scientists and fishermen observe the same types of echo-traces and that the catches were well comparable (in proportion of species and, most of the time, in quantity as well). As last year, the fishing operations by commercial vessels were carried out 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.

	R/V Thalassa	**Commercial vessels**	**Total**
Surface hauls	**4**	**15**	**19**
Classic hauls	**40**	**32**	**72**
Purse seines	**0**	**4**	**4**
null	**3**	**4**	**7**
Total	**47**	**55**	**102**

Table 1.2.3. : number of fishing operations carried out by Thalassa and commercial vessels during consort survey PELGAS09



a) Hauls carried out at surface or in mid-water levels (Thalassa & commercial vessels)



b) Hauls carried out at surface or in mid-water levels (Thalassa + commercial vessels)

Figure 1.2.4 : Localisation of fishing operations carried out by Thalassa and commercial vessels during survey PELGAS09

2. Acoustics data processing

2.1. Echo-traces classification

All the acoustic data along the transects were processed and scrutinised at 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, 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.

D5 – energies attributed to small horse mackerel only when they are gathered in very dense schools

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 sardine (big and very dense schools).

2.2. Splitting of energies into species

As 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 2.2.1 shows the strata considered to evaluate biomass of each species. For each strata, energies where converted into biomass by applying catch ratio, length distributions and weighted by abundance of fish in the haul surrounded area.

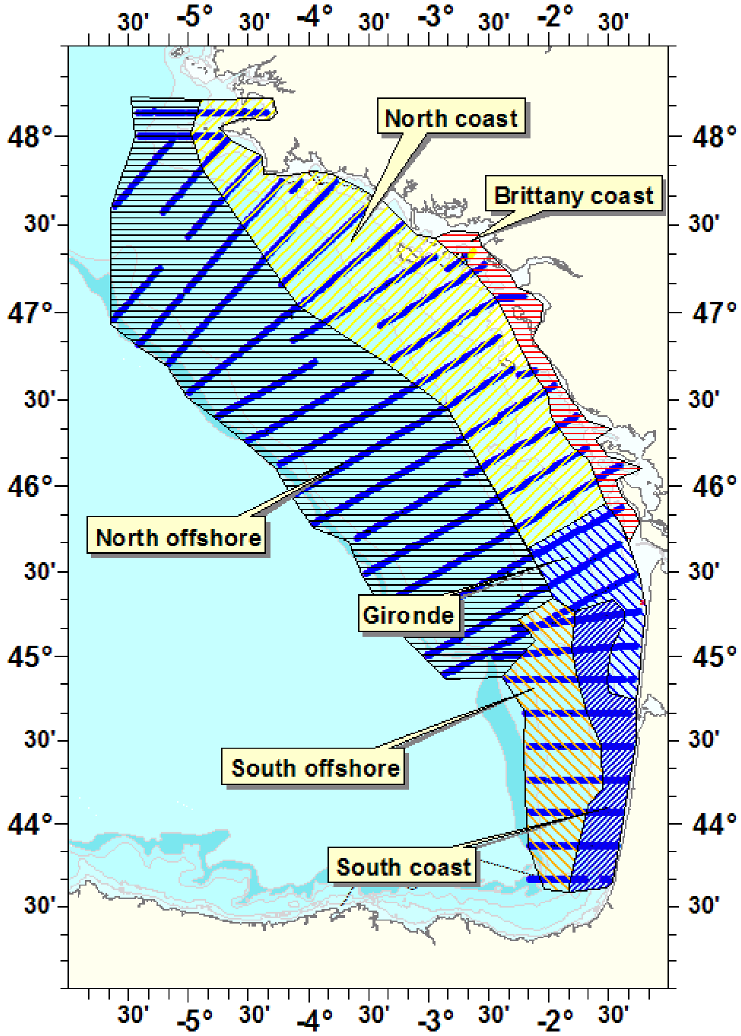


Fig. 2.2. – coherent strata, in terms of echoes and species distribution, taken into consideration for multi-species biomass estimate from acoustic and catches data during PELGAS09 survey

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.

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

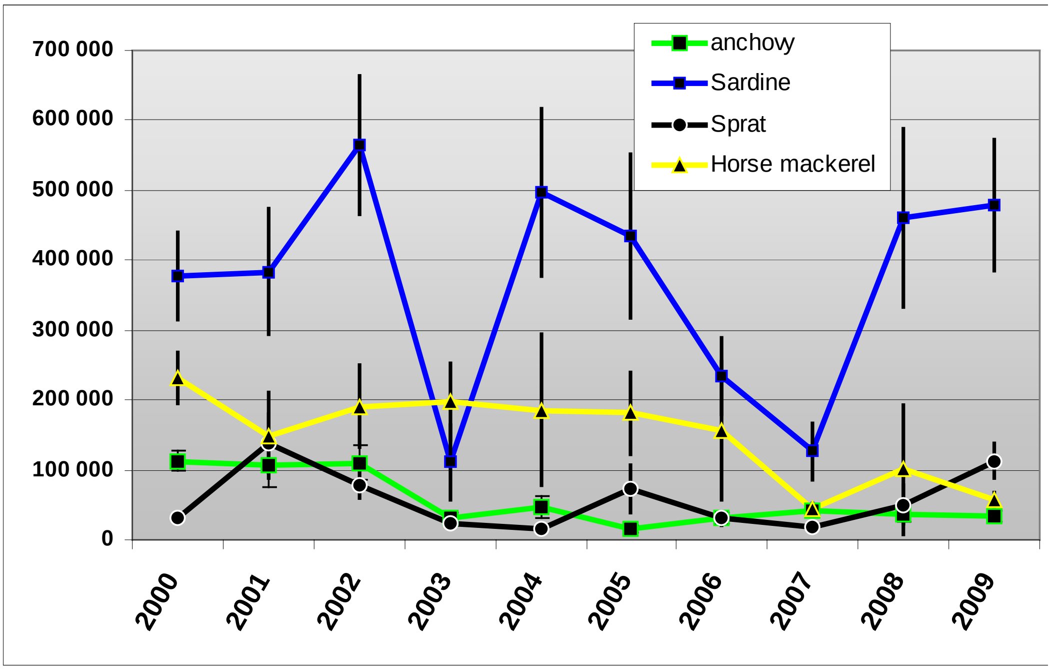


Table and figure 2.3. – biomass estimate using Thalassa acoustic data along transects and all the consort identification fishing operations (Thalassa + pair trawlers) and coefficients of variation associated.

4. Anchovy data

4.1. anchovy biomass

Two principal anchovy concentration (figure 2.4.2.2. & 2.4.2.3.) were observed :

Offshore on the southern platform, very big anchovy was present between 90m and 110m depth but often mixed with sardine or horse mackerel. Echo-traces were most of the time traditionally vertically distributed, horse mackerel closed to the bottom and anchovy as soft and small schools 15 to 25 meters above. In this area, this year, even if sardine was predominant in the surface and mid-water layers, anchovy was also well present as small schools close to the surface.

Along the coast from Arcachon (44° 50 N) to the Loire estuary (47°), mostly mixed with sardine and sometimes with horse mackerel or with sprat in the Northern part, with various length distribution and more offshore in front of the Gironde plume (45°10N), mostly mixed with sardine and sometimes with horse mackerel.

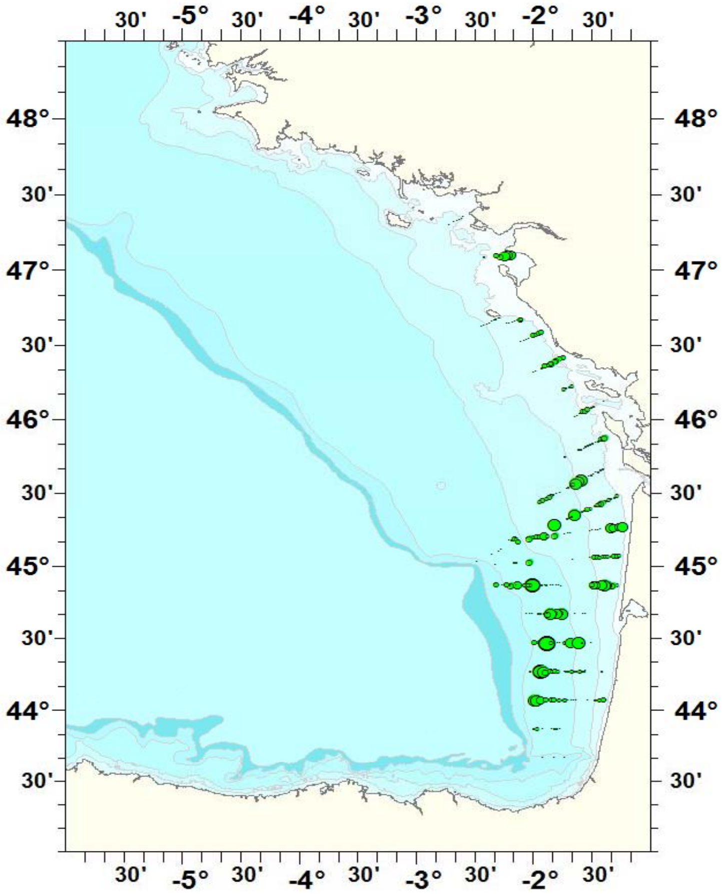


Figure 4.1. – Anchovy distribution according to PELGAS09 survey.

4.2. 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.

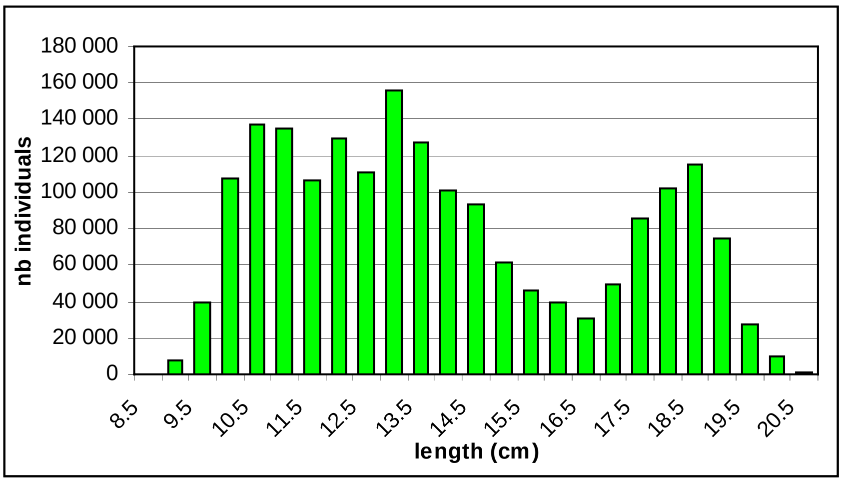


Figure 4.2.1: length distribution of global anchovy as observed during PELGAS09 survey

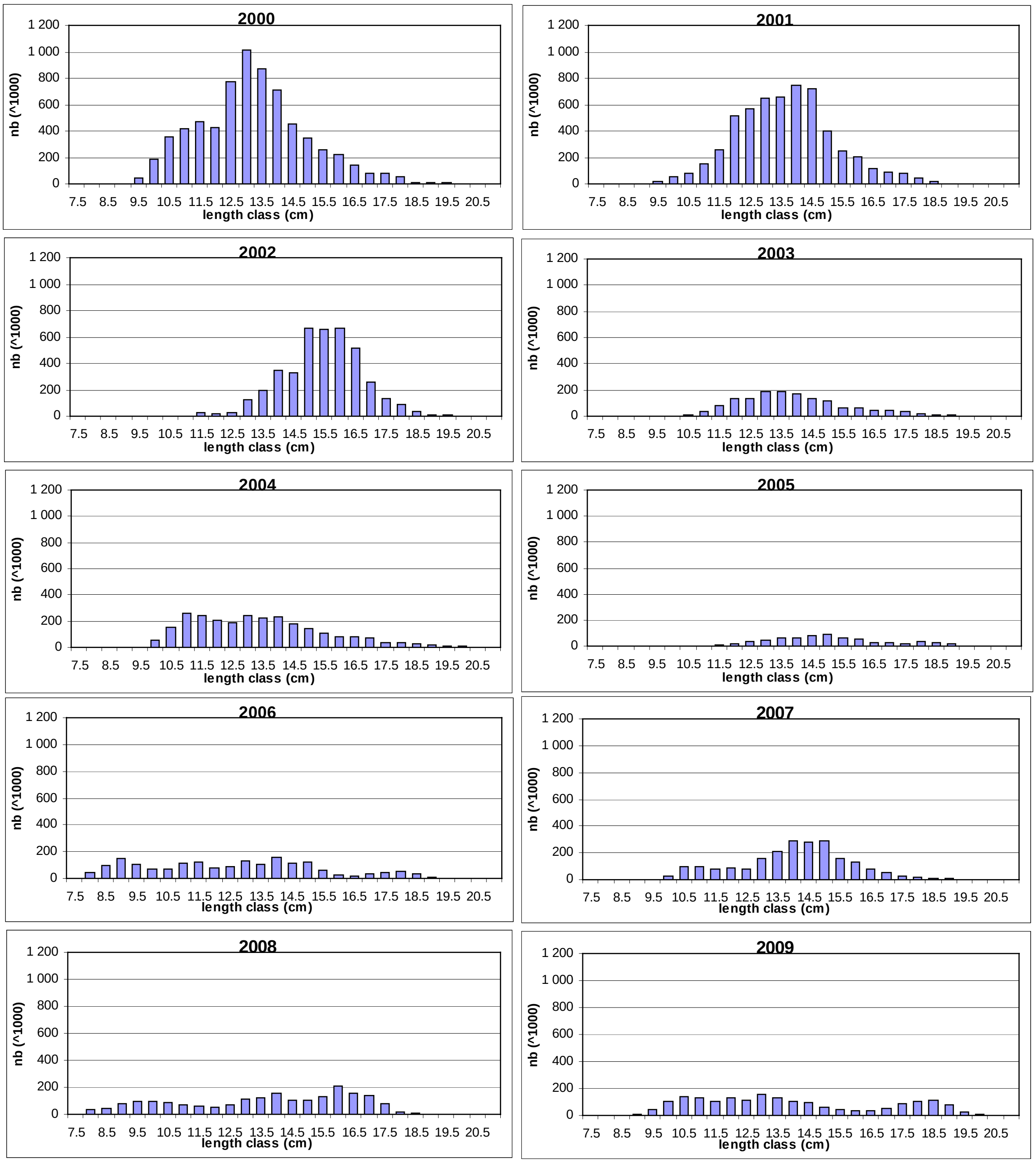


Figure 4.2.2. – length composition of anchovy as estimated by acoustics since 2000.

4.3. Demographic structure

An age length key was built for anchovy from the trawl catches (Thalassa hauls) and some samples from commercial vessels. Sub-samples (1164 otoliths for the whole survey) were taken from the previous samples, according to a stratified scheme based on length classes. The population length distribution was 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 in the area sampled by each trawl haul.

NB Age	Age					
Long.(1/2cı	1	2	3	4	5	Total
8.5	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
9	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
9.5	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
10	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
10.5	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
11	96.43%	3.57%	0.00%	0.00%	0.00%	100.00%
11.5	87.50%	12.50%	0.00%	0.00%	0.00%	100.00%
12	74.00%	22.00%	4.00%	0.00%	0.00%	100.00%
12.5	68.33%	25.00%	6.67%	0.00%	0.00%	100.00%
13	61.54%	29.23%	9.23%	0.00%	0.00%	100.00%
13.5	66.67%	21.21%	10.61%	1.52%	0.00%	100.00%
14	61.54%	26.15%	12.31%	0.00%	0.00%	100.00%
14.5	67.27%	23.64%	9.09%	0.00%	0.00%	100.00%
15	55.74%	29.51%	14.75%	0.00%	0.00%	100.00%
15.5	43.86%	38.60%	17.54%	0.00%	0.00%	100.00%
16	25.86%	41.38%	31.03%	1.72%	0.00%	100.00%
16.5	6.67%	36.67%	48.33%	6.67%	1.67%	100.00%
17	0.00%	40.45%	55.06%	4.49%	0.00%	100.00%
17.5	0.00%	39.29%	55.95%	4.76%	0.00%	100.00%
18	0.00%	34.48%	63.22%	2.30%	0.00%	100.00%
18.5	0.00%	32.86%	62.86%	4.29%	0.00%	100.00%
19	0.00%	20.34%	72.88%	6.78%	0.00%	100.00%
19.5	0.00%	16.67%	73.33%	10.00%	0.00%	100.00%
20	0.00%	0.00%	92.31%	7.69%	0.00%	100.00%
20.5	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Total	38.23%	27.41%	31.96%	2.32%	0.09%	100.00%

Table 4.3.1. – anchovy age/Length key from PELGAS09 samples

Applying the age distributions to the abundance in biomass and numbers, the distribution in age of the biomass has been calculated and gathered in the table 8. The total biomass used here has been up-dated with the value obtained from the previous method based on strata.

Figure 4.3.2– global age composition of anchovy as observed during PELGAS09 survey

Age distributions per area and global are shown in figures 4.3.2. & 4.3.3. The age distributions compared from 2000 to 2009 are shown in figure 4.3.4.

	Biomass	numbers	G1	G2	G3	G4

Total		**1 925 435**	1 174 546	347 990	377 739	25 160
% (numbers)			*61.0 %*	*18.1 %*	*19.6 %*	*1.3 %*
Mean weight (g)			15.28	32.49	41.39	42.76
Mean length (g)			12.84	16.20	17.61	18.00
Coefficient of variation	*0.112*	*0.106*				

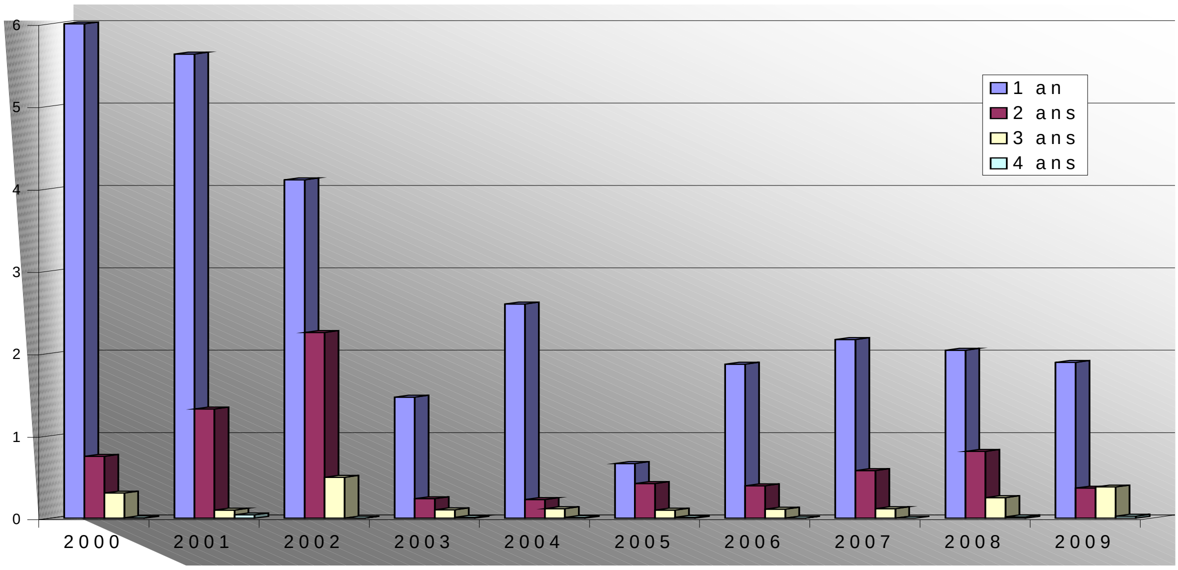


Figure 4.3.4 Anchovy numbers at age as observed during PELGAS surveys since 2000

Looking at the numbers at age since 2000 (fig 4.3.4.), the 1 year old class still seems to be low since 2005, and 2 and 3 years old are increasing most likely because of the closure of the fishery.

4.4. Strata comparison

Because of the separate distribution of species as observed previously for assessment purposes, two distinctive strata could be considered as significant anchovy biomass : the coastal area (gironde, landes's coast) and the offshore one. Length and age distributions have been splitted and show that the most part of age 1 in 2009 was concentrated along the coast (table 4.4.1 and figures 4.4.2).

AGE	1	2	3	4	total
coastal	1 139 397	188 303	78 840	2 734	1 409 274
south offshore	35 149	159 687	298 899	22 426	516 161
total	1 174 546	347 990	377 739	25 160	**1 925 435**

%	**1**	**2**	**3**	**4**
coastal	59.18%	9.78%	4.09%	0.14%
south offshore	1.83%	8.29%	15.52%	1.16%

total	61.00%	18.07%	19.62%	1.31%

Table 4.4.1. - age distribution of anchovy in numbers as estimated from PELGAS09 survey according to separate distribution coastal – offshore areas

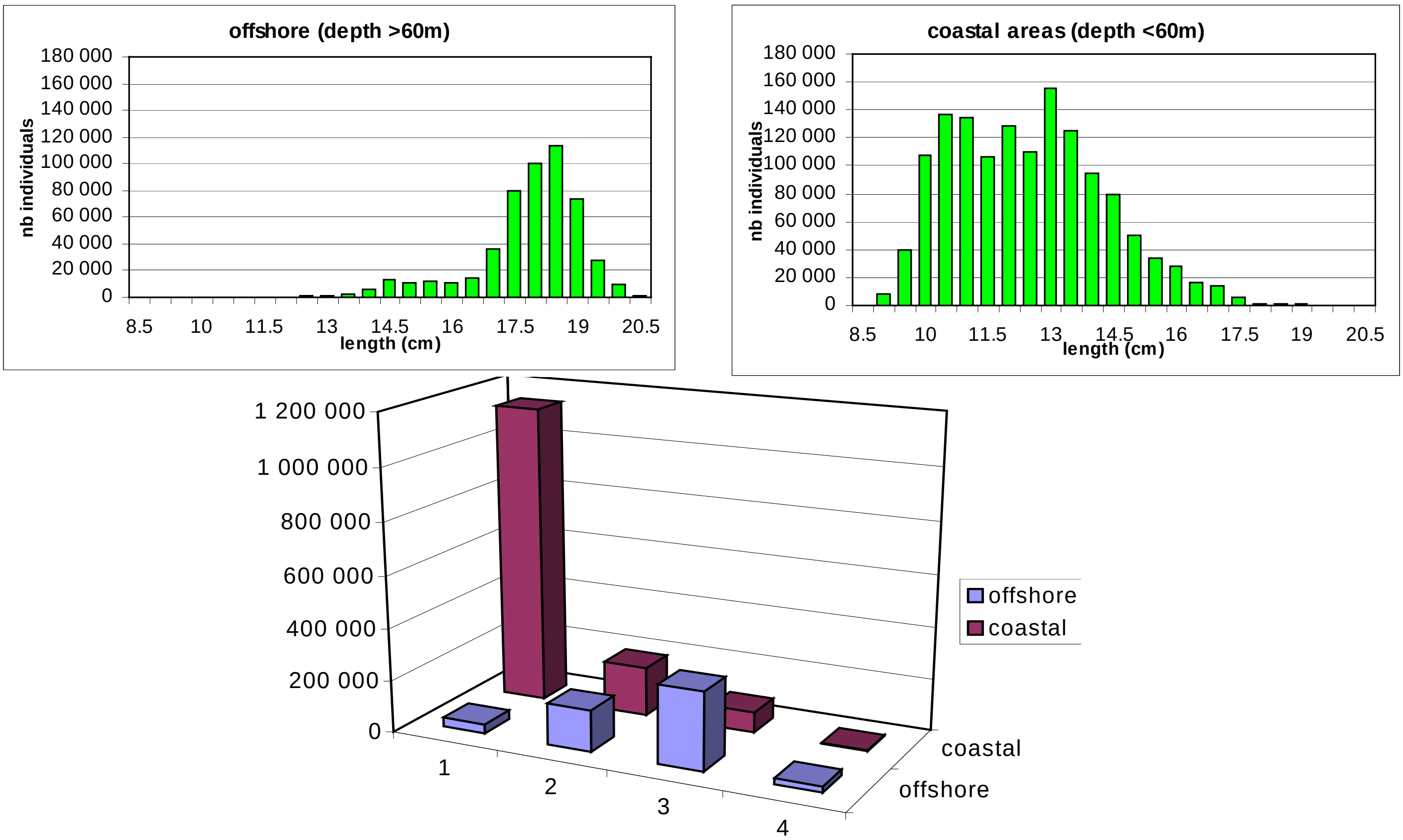
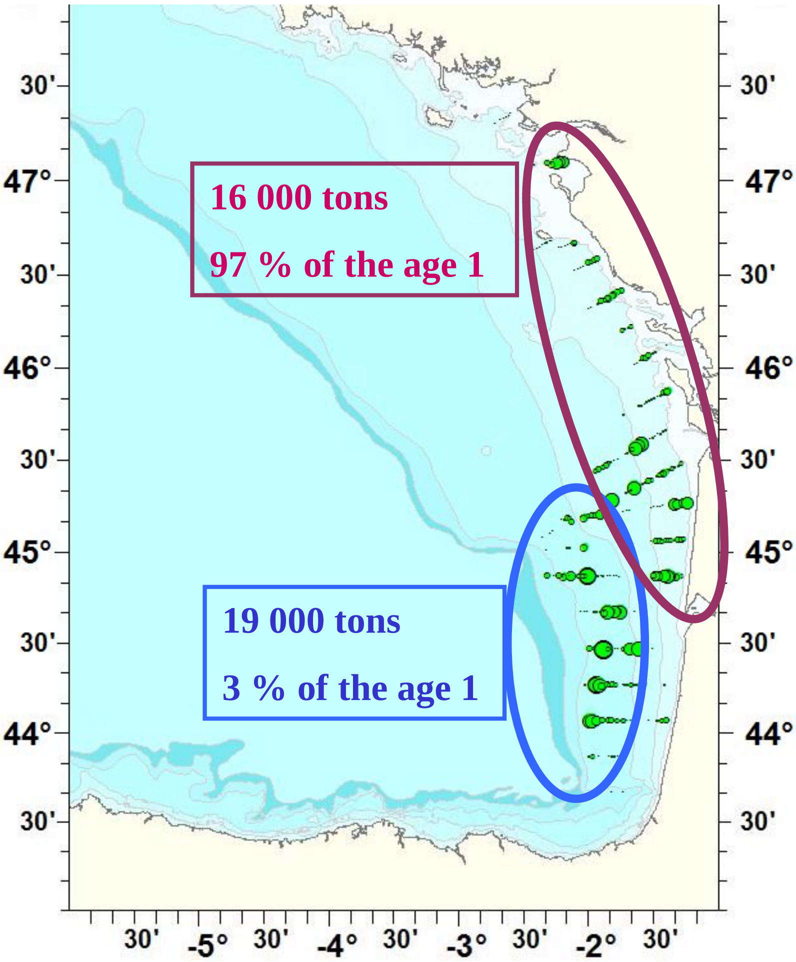


Fig 4.4.2. : length and age distribution during PELGAS09 according to the two main areas where anchovy occurred.

It is worth noting that 97 % of the recruitment (age 1) observed in the Bay of Biscay in 2009 were concentrated in Gironde and coastal areas whereas big anchovies observed offshore were almost represented by 2 and 3 years old (only 3 % of the age 1). As the small anchovies were only visible when surveying inshore areas and vessels were not able to work in shallower waters than 15m depth, it is possible that the youngest fishes were closer to the coast and therefore they were underestimated. Nevertheless, we must keep in mind that during normal years, 1 year old individuals were distributed on the whole area even if they were preferentially closer to the coast.



4.5. Weight/Length key

Based on 3674 weight of individual fishes, the following weight/length key was established (figure 4.5.) :

$W = 0.0052\ L^{3.1186}$ (with $R^2 = 0.9723$)

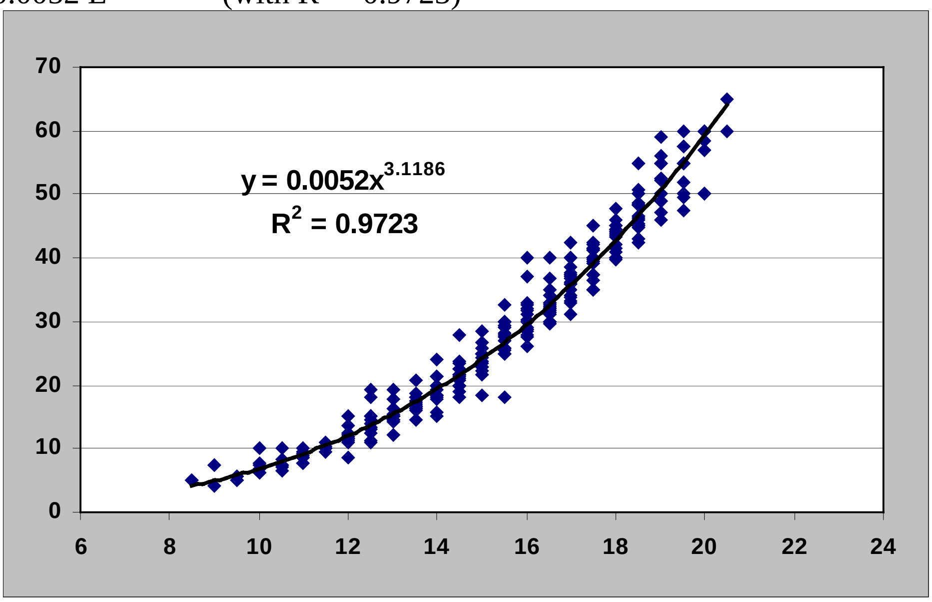


Fig. 4.5. – Weight/length key of anchovy established during PELGAS09

4.6. Eggs

During this survey, in addition of acoustic transects and pelagic trawl hauls, 928 CUFES samples were collected and counted, 76 vertical plankton hauls and 106 vertical profiles with CTD were carried out. Eggs were sorted and counted during the survey.

The last week was spent prospecting the southern area (where eggs where more abundant) between the Gironde plume (figure 4.6.1), the area called "Fer à cheval", and a little bit offshore of Arcachon. The main objective was to study the nyctemeral behaviour of anchovy, the coherence between the eggs and the adults distribution, and to collect data on eggs density and vertical distribution with the multinet (MINOF, 27 hauls). The last experiments were carried out in order to validate a vertical model of egg distribution, which could be used in the future to extrapolate the CUFES data over the whole water column for a quantitative use.

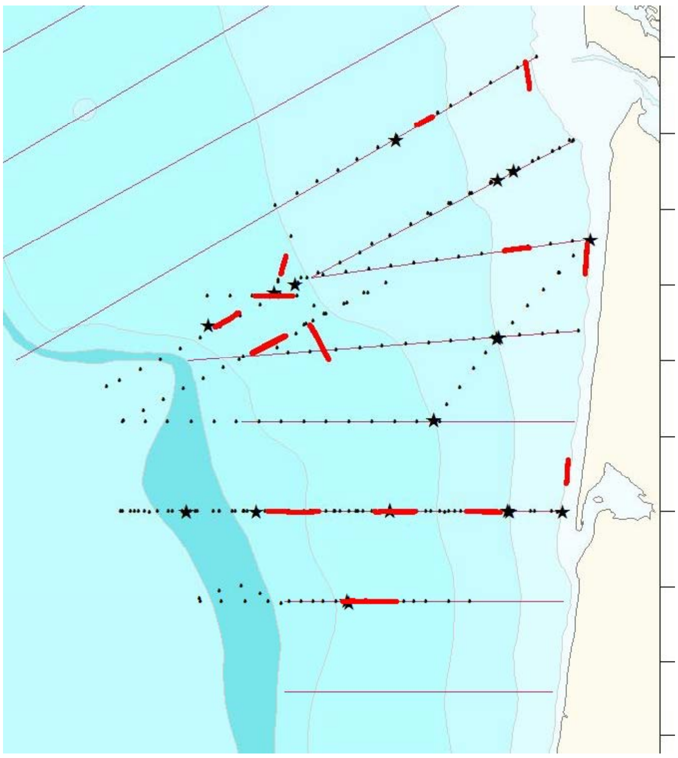


Figure 4.6.1 – Studied area prospected during the last week of the PELGAS09 with the CUFES network, hydrology stations, and pelagic hauls.

The number of eggs collected by CUFES during the survey (figures 4.6.2, 4.6.3 and 4.6.4) was almost the same as 2008, and of course very low compared to 2007, which was a strong maximum for the time series.

Anchovy eggs abundance was close to the average of the time series since 2000. Eggs were abundant on Plateau des Landes around 44°N and around the Gironde plume. North of Gironde, eggs were coastal only and in low quantity. Both abundance and spatial distribution display an average pattern. This year, some eggs (and adults) were found on the south coast of Brittany but in a low quantity and very closed to the coast (less than 15meters depth), in the Vilaine bay.

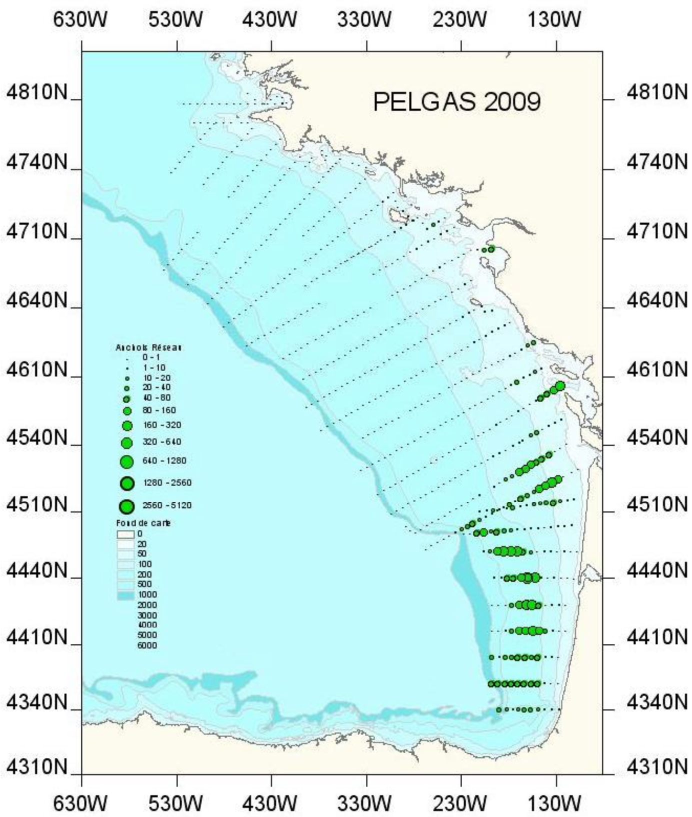


Figure 4.6.2 – Distribution of anchovy eggs observed with CUFES during PELGAS09.

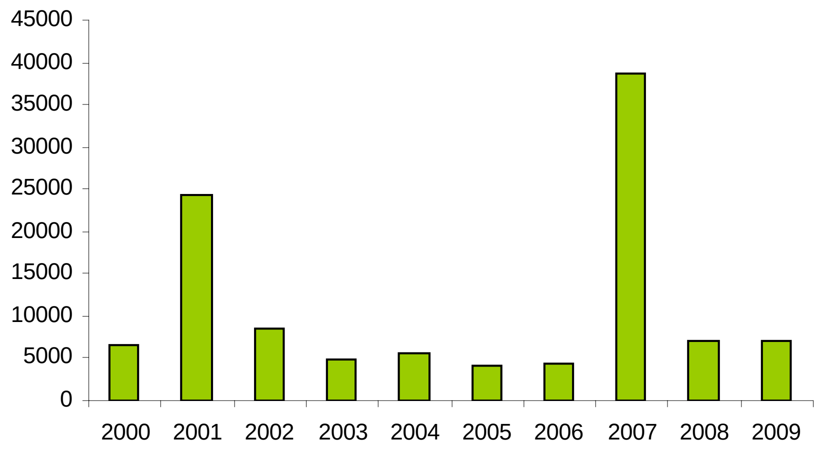


Figure 4.6.3 – Number of eggs observed during PELGAS surveys from 2000 to 2009

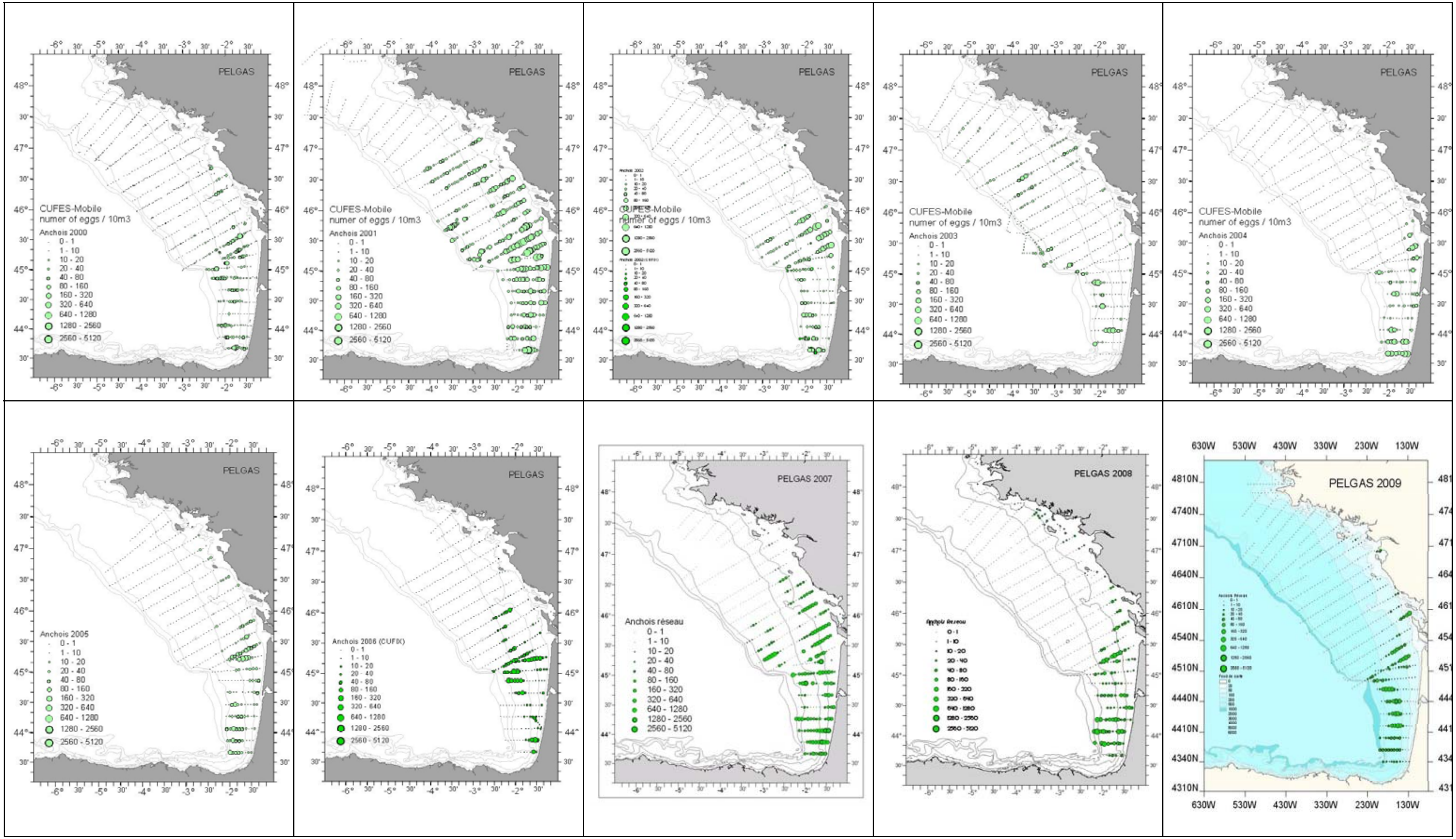


Figure 4.6.4 – distribution of anchovy eggs observed with CUFES during PELGAS from 2000 to 2009 (number for 10m^3).

5. Sardine

5.1. Adults

The biomass estimate of sardine observed during PELGAS09 is 479 684 tons (table 2.3.), which is one of the highest level of the PELGAS series. It must be enhance that these surveys don't cover the total area of potential presence of sardine. It is possible that some years, this species could be present up to the north, in the Celtic sea, SW of Cornouailles or Western Channel where some fishery occurs, apparently more and more. 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 all along to the French coast. In the southern part of the Bay of Biscay (Landes), they were mixed with anchovy in surface, and with horse mackerel closed to the bottom. Along the southern Brittany coast pure sardine fishing hauls were obtained (Figure 1.2.2.), and she was mixed with sprat in the Loire’s plume. This year, in the offshore area, sardine was rather absent northern than the area called “fer à cheval”, except at the surface whereas other species where closed to the bottom. As usual, small sardine (with 60 % of 1 year old) were mainly closed to the coast.

It must be noticed that the number of age 1 this year is still important, and implicates a good recruitment of the 2008 year class. The high abundance of age 2 confirms the good recruitment of the 2007 year class that we observed last year.

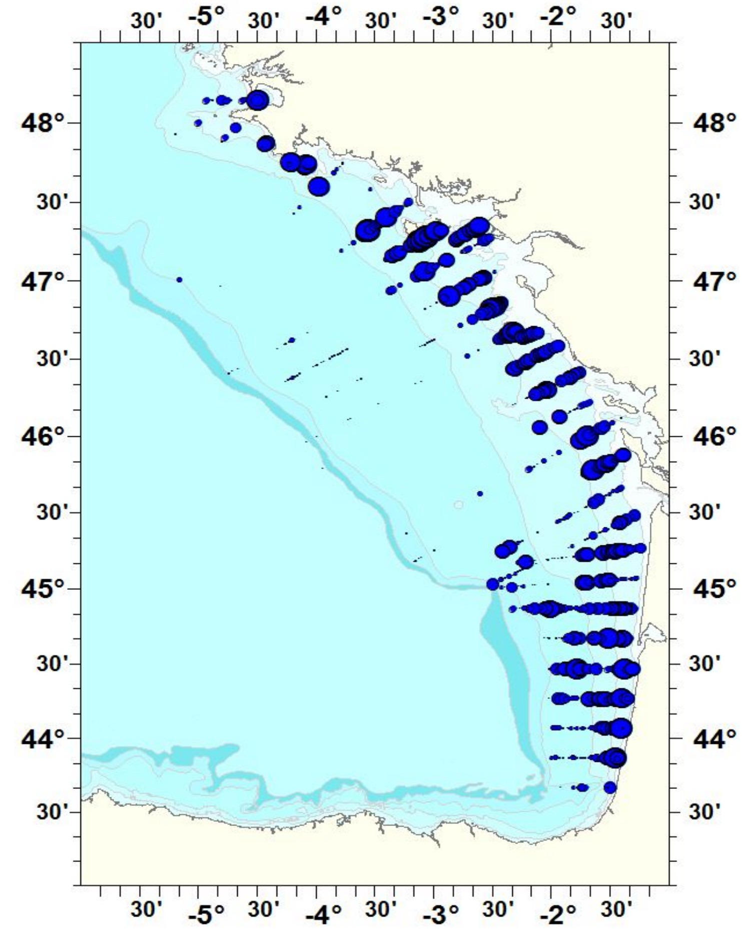


Figure 5.1.1 – distribution of sardine observed by acoustics during PELGAS09

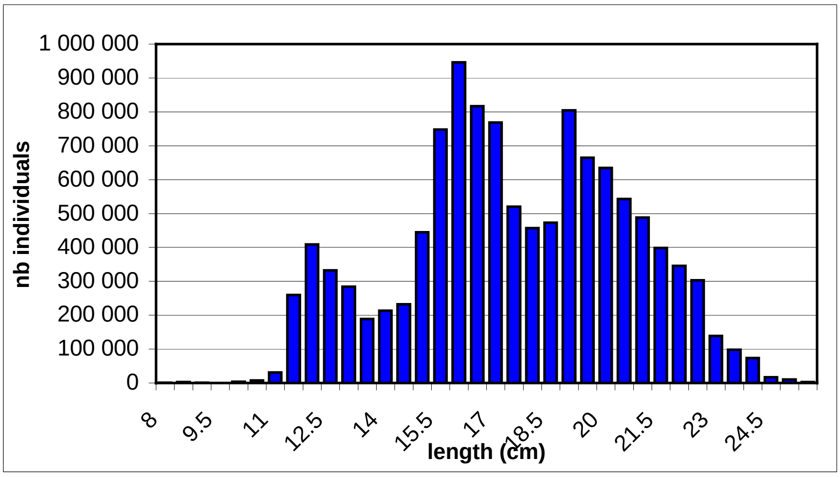


Figure 5.1.2. – length distribution of sardine as observed during PELGAS09.

Length distribution in the trawl haul 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 5.1.2.

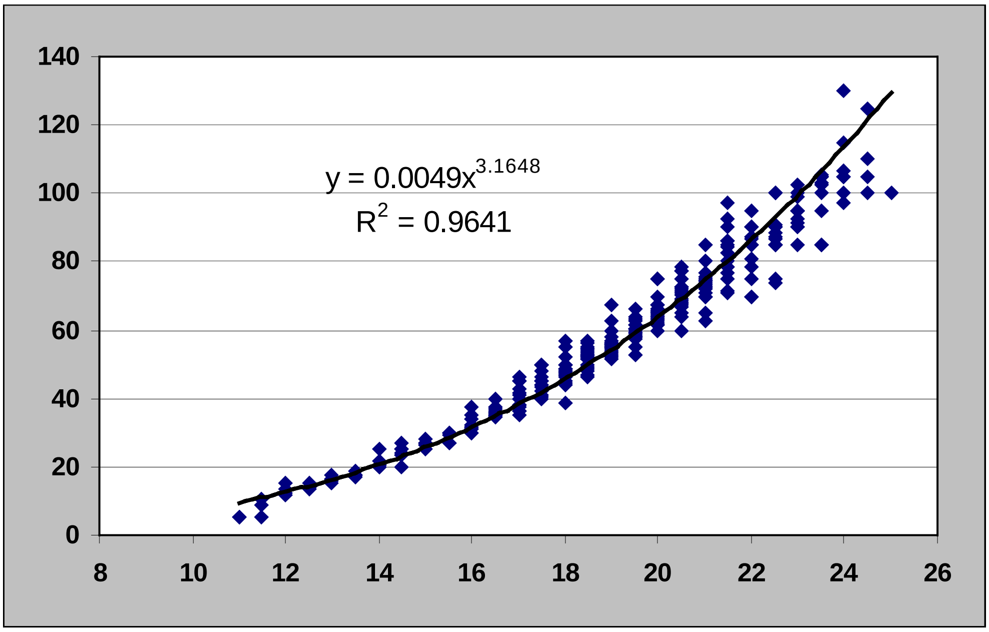


Figure 5.1.3 – Weight/length key of sardine established during PELGAS09

Sardine biomass estimates, length distributions and age compositions along the 8 years series of PELGAS surveys (until 2007) have been revised during the last WGACEGG (Palma de Majorca, November 2007) and are presented in table 2.3. above with coefficients of variation.

The series of length distributions in numbers as observed since 2000 are shown in figure 5.1.6. As usual, sardine shows a bimodal length distribution, the first one (about 16 cm) represent mainly age 1, (table 5.1.7). Small sardine was well present this year which suggest one of the best recruitment in the 10 years series.

The series of age distribution in numbers since 2000 are shown in figure 5.1.10. 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.

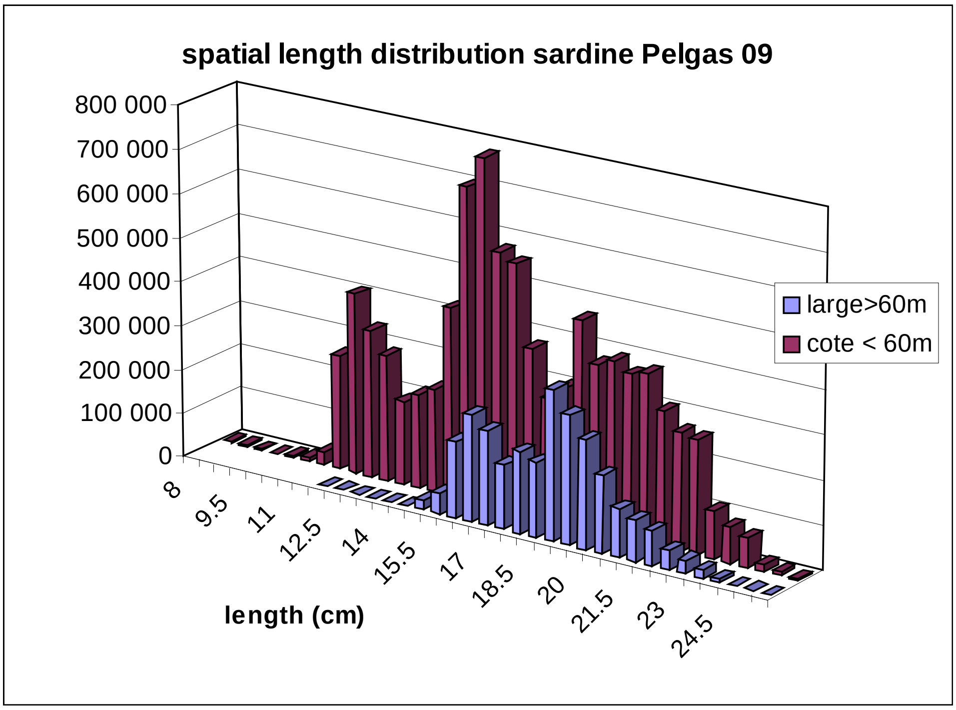


Figure 5.1.4: length distribution of sardine by geographical area (offshore/coastal waters) as observed during PELGAS09 survey

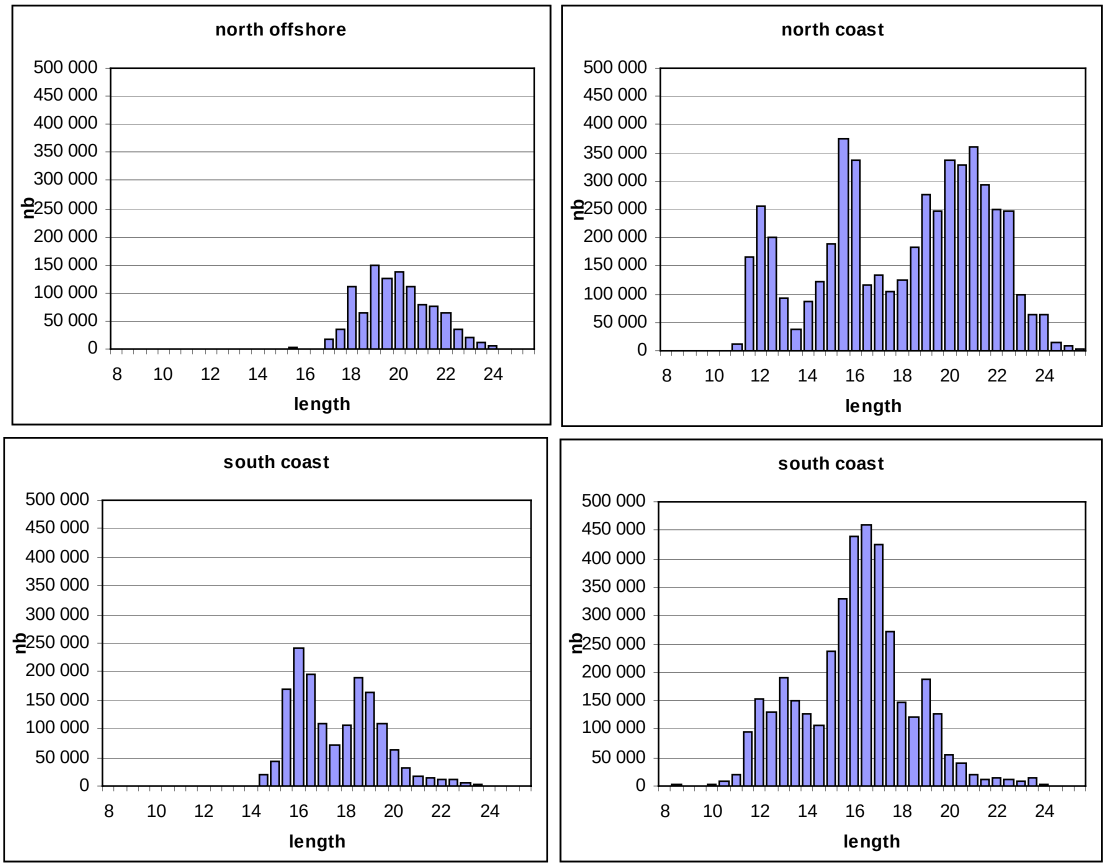


Figure. 5.1.5: length distribution of sardine by geographical area (VIIIa/VIIIb and offshore/coastal waters) as observed during PELGAS09 survey

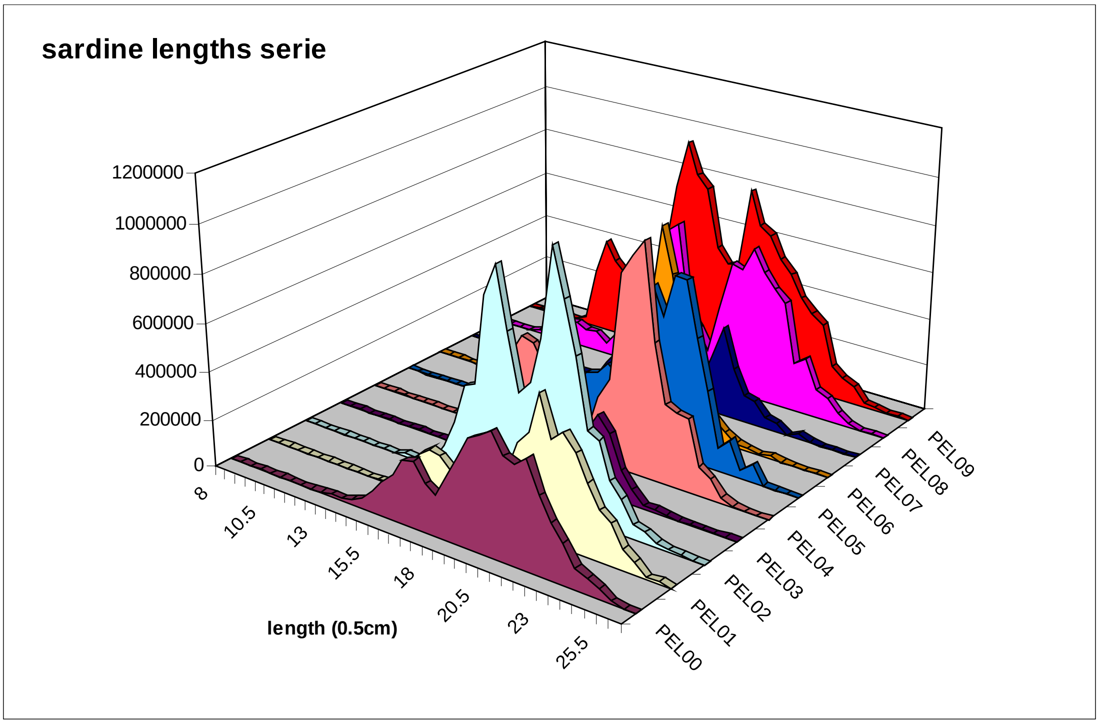


Figure 5.1.6. – length composition of sardine as estimated by acoustics from 2000 to 2009.

NB age	age											
longueur (cm)	1	2	3	4	5	6	7	8	9	10	11	Total
11	100.00%	0.00%	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%	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%	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%	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%	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%	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%	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%	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%	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%	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%	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%	0.00%	100.00%
17	89.83%	10.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
17.5	67.24%	32.76%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18	22.37%	77.63%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
18.5	3.70%	95.06%	1.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19	2.25%	93.26%	4.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
19.5	0.00%	95.18%	2.41%	1.20%	1.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20	0.00%	83.72%	13.95%	1.16%	1.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
20.5	1.54%	41.54%	33.85%	7.69%	13.85%	1.54%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
21	0.00%	16.13%	45.16%	11.29%	25.81%	1.61%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
21.5	0.00%	3.77%	20.75%	20.75%	43.40%	5.66%	3.77%	1.89%	0.00%	0.00%	0.00%	100.00%
22	0.00%	0.00%	21.43%	7.14%	38.10%	14.29%	4.76%	9.52%	4.76%	0.00%	0.00%	100.00%
22.5	0.00%	0.00%	0.00%	17.24%	41.38%	20.69%	13.79%	6.90%	0.00%	0.00%	0.00%	100.00%
23	0.00%	0.00%	0.00%	14.81%	33.33%	18.52%	14.81%	11.11%	3.70%	3.70%	0.00%	100.00%
23.5	0.00%	0.00%	0.00%	4.35%	21.74%	30.43%	21.74%	4.35%	13.04%	0.00%	4.35%	100.00%
24	0.00%	0.00%	0.00%	6.25%	31.25%	12.50%	25.00%	25.00%	0.00%	0.00%	0.00%	100.00%
24.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	28.57%	14.29%	28.57%	28.57%	0.00%	100.00%
25	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Total	34.86%	38.10%	7.81%	3.42%	8.52%	2.72%	2.11%	1.40%	0.70%	0.26%	0.09%	100.00%

Table 5.1.7 : sardine age/length key from PELGAS09 samples (based on 1157 otoliths)

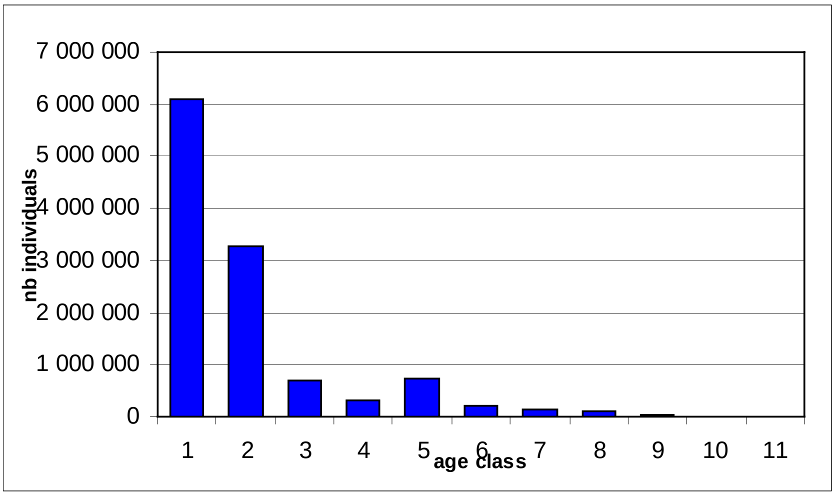


Figure 5.1.8.- Global age composition of sardine as observed during PELGAS 09

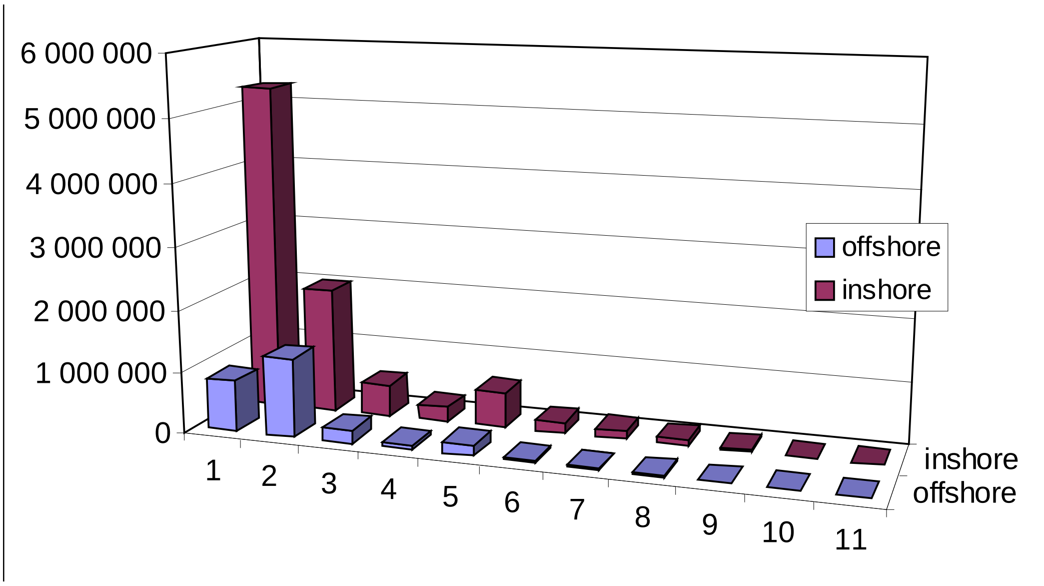


Figure 5.1.9: age distribution of sardine by geographical area (offshore/coastal waters) as observed during PELGAS09 survey

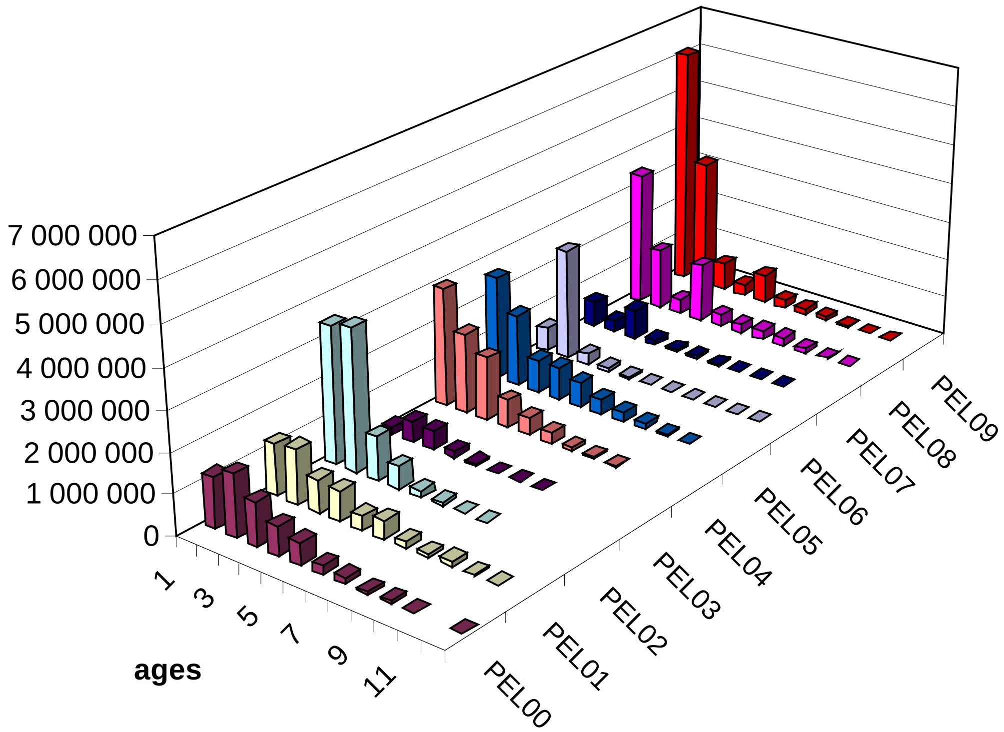


Figure 5.1.10- Age composition of sardine as estimated by acoustics since 2000

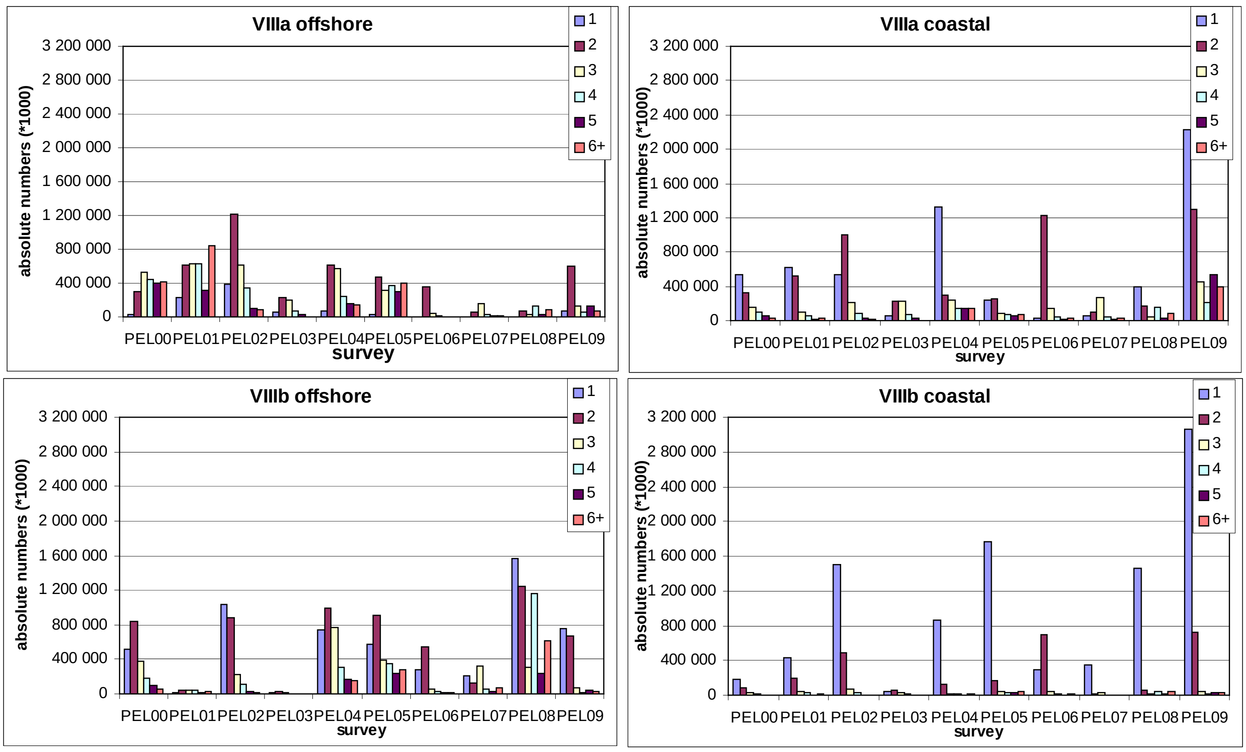


Figure 5.1.11- Age composition of sardine splitted by geographical areas (VIIIa/VIIIb and offshore/coastal waters) as observed during PELGAS09 survey

5.2. Eggs

Eggs were present on the whole platform between 43°50N and 45°30N, then very abundant between the area called “fer a cheval” and the Gironde. Then a new concentration was well visible along the coast, from the Gironde to the Douarnenez bay, in the west side of Brittany. Eggs appear also at the shelf break, in small quantity, linked with small detection of adults close to the surface.

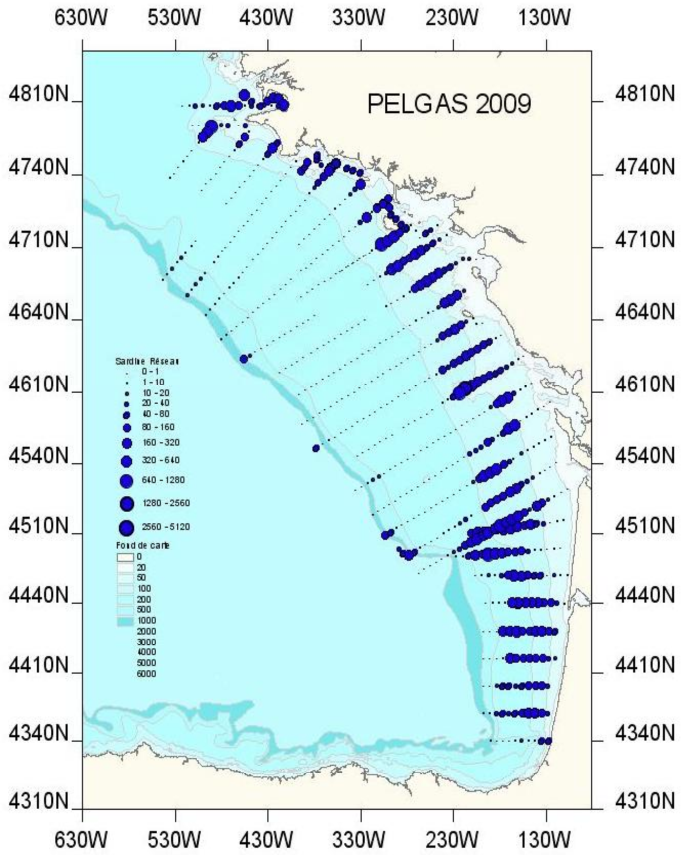


Figure 5.2.1. Distribution of sardine eggs observed with CUFES during PELGAS09.

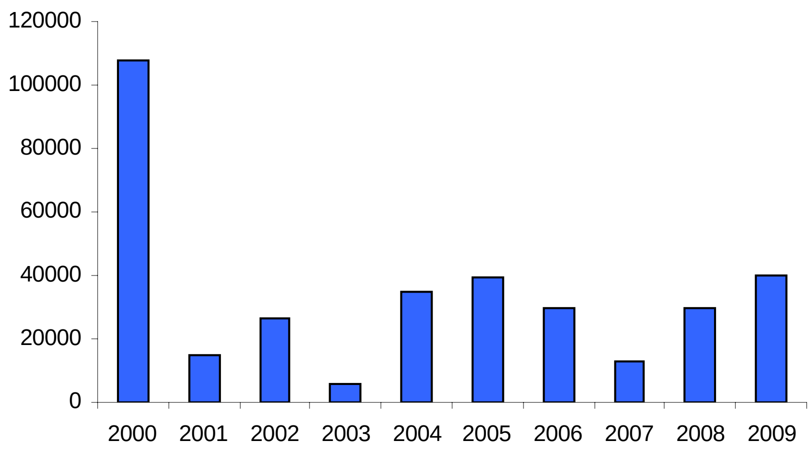


Figure 5.2.2. Number of eggs observed during PELGAS surveys from 2000 to 2009

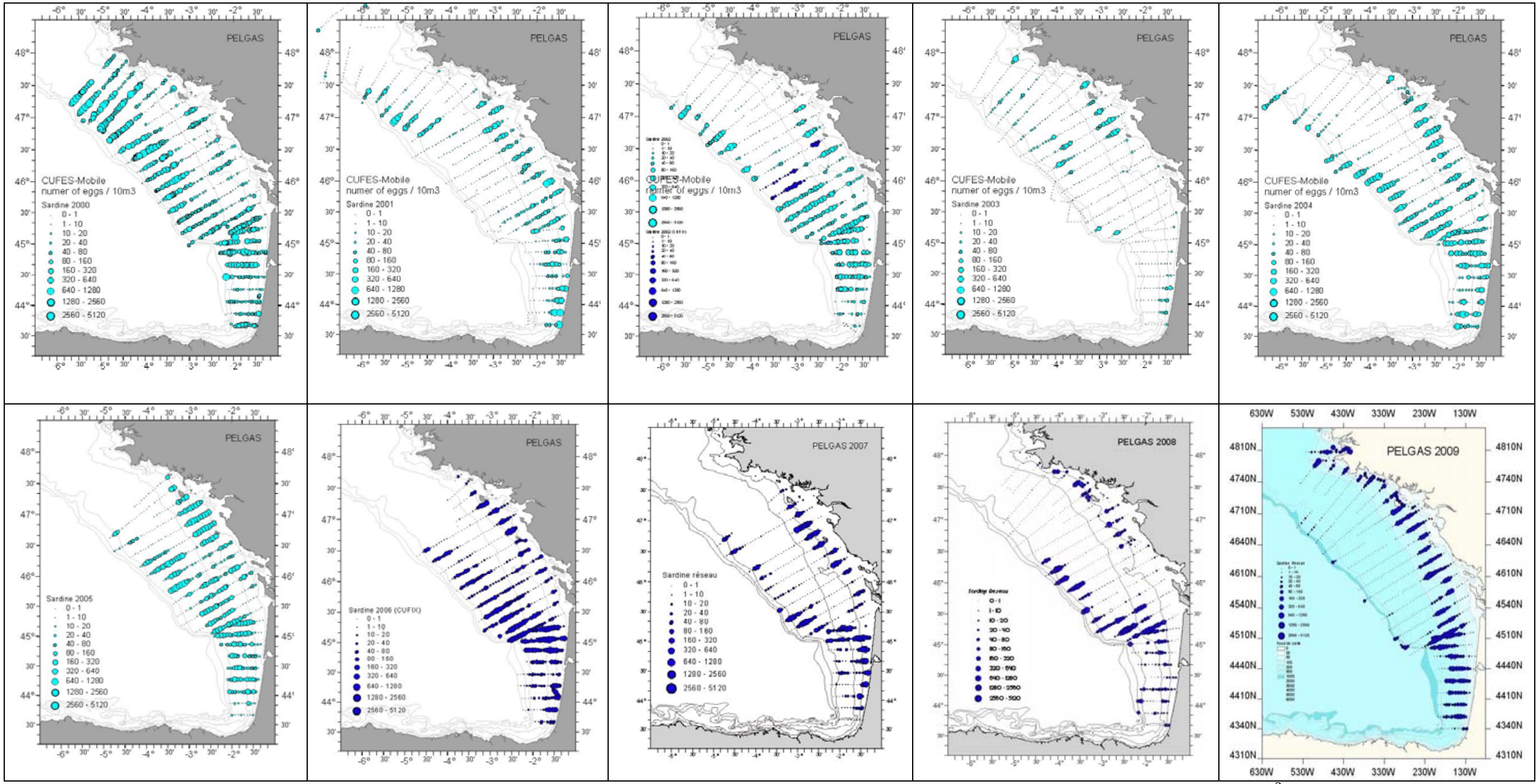


Figure 5.2.3 – distribution of sardine eggs observed with CUFES during PELGAS from 2000 to 2009 (number for $10m^3$).

The number of eggs collected by CUFES during the PELGAS09 survey was comparable to previous years but of course still far below the maximum observed in 2000.

6. Top predators

6.1 – Birds

The most abundant bird species were the lesser black-backed gull (Larus fuscus) with 1773 individuals, and the gannets (Morus bassana) with 886 individuals. The more frequent other species were the Herring gull (Larus argentatus, 582), the northern fulmar (Fulmarus glacialis, 330), the guillemot (Uria aalge, 146), the sandwich tern (Sterna sandevicensis, 102), the great skua (Catharacta skua, 48), the kittiwake (Rissa tridactyla, 46), the European Shag (Phalacrocorax aristotelis, 36), the manx shearwater (Puffinus puffinus, 35), the European Storm Petrel (Hydrobates pelagicus, 31). Some other species, less common, were also observed, like the Arctic Tern (Sterna paradisea, 2 ind.), or the Pomarine Skua (Stercorarius pomarinus, 1ind).

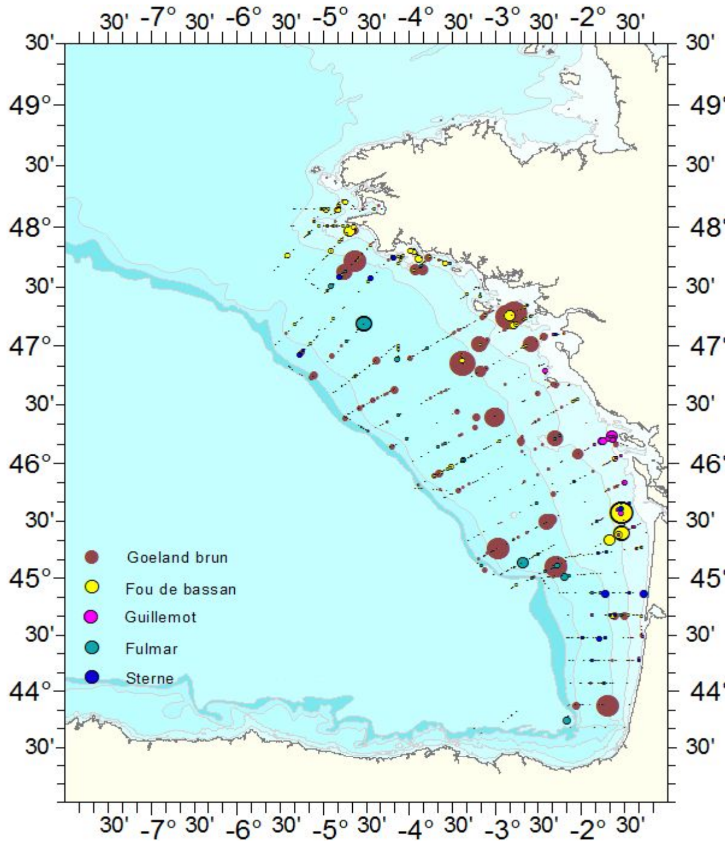


Figure 6.1. Distribution of marine birds observed during the PELGAS09 survey

Globally, the number of birds observed have decreased for all most important species compared to 2008 (i.e. about 2000 gannets in 2008, less than the half in 2009). The decreasing of birds observed is probably linked with bad conditions for observation during almost one third of the coverture (see figure 6.3)

Seagulls and gannet have a similar and homogeneous distribution in the area of the Bay of Biscay. For the comparison, each specie have the same plot size. Seagulls were met, as usual, in big concentrations in some areas (particularly in the south of Brittany)

The guillemot habitat is more coastal and this species is rarely observed over the 50 meters bathymetric line.

6.2 – Mammals

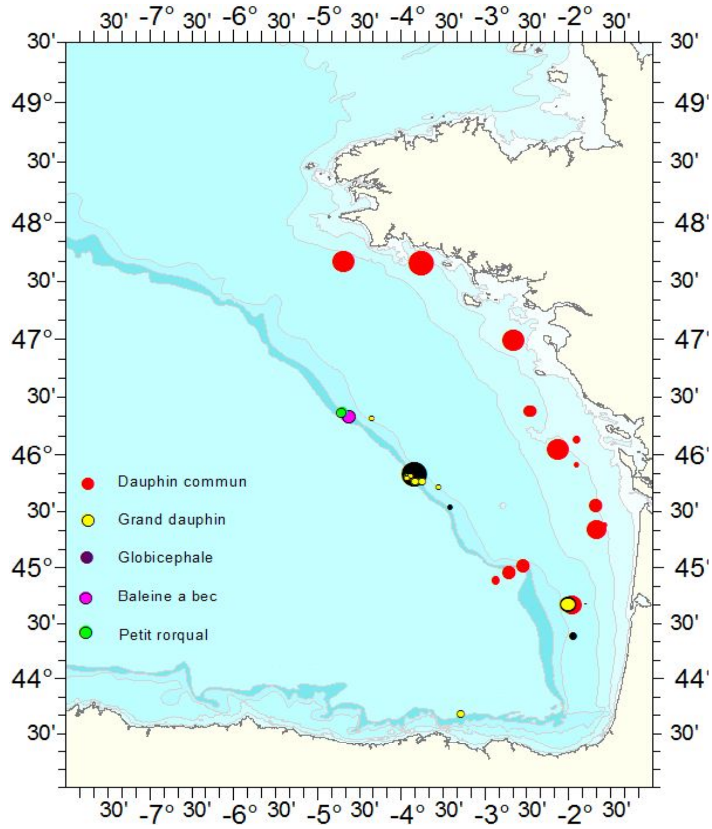
The more frequent cetacean species is the common dolphin, Delphinus delphis with 380 individuals. Then the bottlenose dolphin (Tursiops truncatus, 92), the pilot whale (Globicephala melas, 72), and 4 beaked whale (Ziphidae spp).

Bottlenose dolphin, pilot whale and beaked whale are as usual distributed along the shelf edge in the Bay of Biscay and this distribution is similar to the year before (but the number decreased).

The number of common dolphins have decreased compared to year 2008 (which was the strong maximum of mammals observed in the series). However, the distribution is similar to the last years and common dolphins occupy essentially the continental shelf both in the southern and northern parts of the Bay, and this year they were especially observed in the coastal area, were fish was present (high abundance of sardine, see fig 5.1.1.).

Furthermore, the bad weather conditions (see fig 6.3.) have been responsible for a reduced number of mammals sightings.

Figure 6.2. distribution of mammals observed during the PELGAS09 survey



6.3 – Conditions of observation

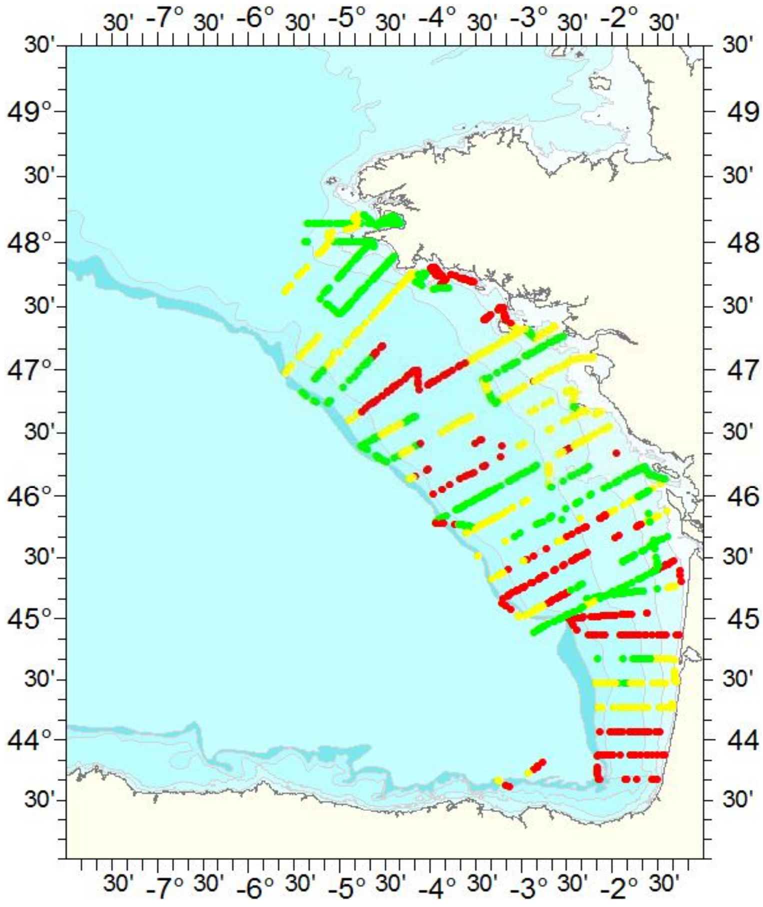


Figure 6.3. conditions of observation of top predators

For each observation of a top predator (bird, mammal), the condition of observation was noted. In red we can see the bad weather conditions (lot of wind, fog, etc). average conditions are in orange, and optimum ones are in green.

We can see that this year, we met a lot of bad weather conditions of observation, which explain the low number of mammals and birds observed. Maybe this fact is also an effect of the fish global distribution (closed to the coast, very low abundance of all pelagic species at more than 20 nautical miles from the coast).

It must be noticed that in the last part of the survey, during the study of the nyctemeral behaviour of anchovy, an important number of observations was realised, particularly for mammals : 6 sperm whales, fin whales, lots of dolphins…

7. Hydrological conditions

Surface water temperature (13-14°C) was close to the normal situation during PELGAS 2009. We observed a slight negative anomaly at the beginning of the survey which turns to positive at the end of the network of the survey. Comparatively last two years showed consequent positive anomalies. Bottom water temperature are quite cold with a marked cold tongue in the north of the Bay. Low discharges in March and April give plumes with relatively low extension.

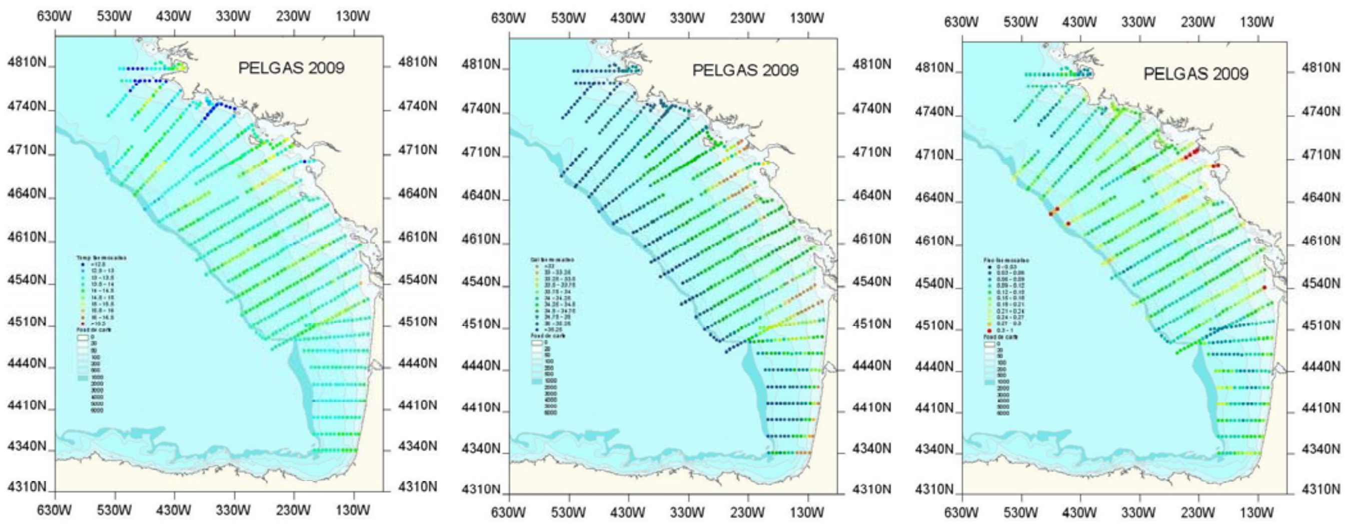


Figure 7.1. – Surface temperature, salinity and fluorescence observed during PELGAS09.

8. Conclusion

The Pelgas09 acoustic survey has been carried out in variable 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 the whole coverage provided about 100 identification hauls as a whole instead of about 50 the years before, when only thalassa did trawls hauls to identify echo traces. These commercial vessels participated to the PELGAS survey in a very good spirit of collaboration. This year, as the last one, they were equipped of scientific echo-sounder and acoustic data will be considered in the near future. It increased the precision of identification of echoes and some double hauls permitted to confirm that results of both hauls were comparable and usable for biomass estimate purposes at the same time. Only catches were included in the assessment process.

Temperature and salinity recorded during PelGas were affected by weather conditions before and during the survey. At the start of the survey in the South, temperature were medium (13-14°C) due to heating and medium mixing before and during the first week of the survey. Then good weather resulted in sea surface warming and therefore the North of the Bay shows higher sea surface temperatures (14-15.5°C) than the Southern part. River discharge gave plumes oriented to the South for Gironde and Loire. The spatial extent of the low salinity is from the coast to the isobath 50 m approx, where as the plume (salinity <34) may extent to the isobath 100 m.

Sardine was predominant during this survey with a biomass of 479 684 tons mainly small showing a high level of recruitment in the Bay of Biscay this year (year class 2008). As usual, small and young fish were closed to the coast, while bigger and older were observed a little bit more offshore. Anchovy were present along the coast from Bayonne to the Arcachon (between 90 and 110 m depth), and in the Gironde plume, with a total biomass of 34 855 tons. As usual, anchovy appears as small schools, mainly mixed with sardine and horse mackerel. The recruitment was still low.

Concerning anchovy, it is worth noting that 97 % of the recruitment (age 1) observed in the Bay of Biscay in 2009 were concentrated in Gironde and coastal areas whereas big anchovies observed offshore were almost represented by 2 and 3 years old (only 3 % of the age 1). As the small anchovies were only visible when surveying inshore areas and vessels were not able to work in shallower waters than 15m depth, it is possible that the youngest fishes were closer to the coast and therefore they were underestimated. Nevertheless, we must keep in mind that during normal years, 1 year old individuals were distributed on the whole area even if they were preferentially closer to the coast.

Working Document to WGANSA, 15-20 June 2009, Copenhagen

Preliminary estimates of the Spawning Stock Biomass of the Bay of Biscay anchovy (*Engraulis encrasicolus*, L.) applying the DEPM

by

M. Santos[1], A. Uriarte[1] and L.Ibaibarriaga[1]

[1] AZTI-Tecnalia, Instituto Tecnológico Pesquero y Alimentario, Pasaia, SPAIN.
msantos@azti.es; auriarte@azti.es; libaibarriaga@azti.es

Abstract

The research survey BIOMAN 2009 for the application of the Daily Egg Production Method (DEPM) in the Bay of Biscay anchovy has been conducted in May 2009 from the 5th to the 25th covering the whole spawning area of the species. 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 estimate is based on its relationship with the average Sea Surface Temperature (SST) inferred from the historical series as last years. The preliminary biomass estimate in that manner is 27,994 t with a coefficient of variation of 23% what is similar to the last year estimate (25,377 t, cv: 26%).
Approximately 59% of the anchovy are individuals of age 1 but the contribution in mass of those is only 37% and the contribution in mass of anchovies of age 2+ is 63%. This is due to the difference in the mean weight by age. This indicates a new failure in the recruitment, as in last years. The population at age estimate indicates that the closure of the fishery had a positive effect in the actual biomass levels.

1. INTRODUCTION

A research survey for the application of the Daily Egg Production Method (DEPM) for the Bay of Biscay anchovy, consisting of both ichthyoplankton and adult sampling, has been conducted by AZTI-Tecnalia. The survey took place from the 5^{th} to the 25^{th} of May covering the whole spawning distribution area of the species, these allows obtaining direct estimates of population biomass and age composition.

This survey, called BIOMAN09, 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 Data Collection Regulation. The General Secretariat of Marine Fisheries has also collaborated providing the R/V Emma Bardán.

In December 2008 the European Commission established a zero TAC for the Bay of Biscay anchovy until June 2009. Ministers agreed with the Commission's proposal. The situation will be reviewed once scientific advice from this DEPM survey and the Acoustic one performed by IFREMER (France) becomes available at this working group WGANSA 2009 in Copenhagen.

This working document describes the BIOMAN09 survey and provides a preliminary SSB estimate based on the ratio between the total daily egg production (P_{tot}) estimate and a preliminary daily fecundity (DF) estimate derived from the historical series. Besides the population at age estimates are obtained.

2. METHODOLOGY

The different sources of the samples obtained for the implementation of the DEPM in 2009 are summarised in **table 1**. There were collected ichthyoplankton samples to estimate the total egg production and the spawning area and adult samples to estimate the daily fecundity of the adults and the population at age estimates.

Table 1: Description of egg and adult samples obtained for the implementation of the DEPM in 2009

Parameters to estimate	Survey	Vessel	Date	Samples	Selected samples
Total egg production & Spawning area	BIOMAN09	R/V Investigador	5-25 May	409	408
Daily fecundity & Numbers at age	BIOMAN09	R/V E. Bardán	5-25 May	38	31

2.1 Collection of plankton samples

The collection of plankton samples has been carried out on board R/V Investigador from 5th to the 25th of May. The area covered was the southeast of the Bay of Biscay (**Fig. 1**), which corresponds to the main spawning area and season of anchovy. The limit of the spawning area has been found at: 3º33'W to the West in the Cantabrian Coast and 46º38'N to the North in the French platform. The sampling was conducted in two phases:

- The first phase, from 5th to the 14th of May, covered the Cantabrian Coast from 4º14'W to the east, up to 45º38'N. The survey was stopped due to bad weather from 14 to 18 in the port of La Pallice (La Rochelle). There was a change of the scientific crew.

- The second phase, from 18th to 25th May, left from the port of La Pallice to cover the remainder French platform up to 46º38'N and 4º50'W, getting back to the port of Pasajes where the survey finished.

Distributions of the vertical hauls performed with the PairoVET net are shown in **Figure 1**. 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 of Santander (transect R11, approx. 4º14'W), and covered the Cantabrian Coast eastwards up to Pasajes (transect R25, approx. 1º50'W) (**Fig. 1**). Then, the survey continued to the north, in order to find the Northern limit of the spawning area. When the egg abundances found were relatively high, additional transects separated by 7.5 nm were completed.

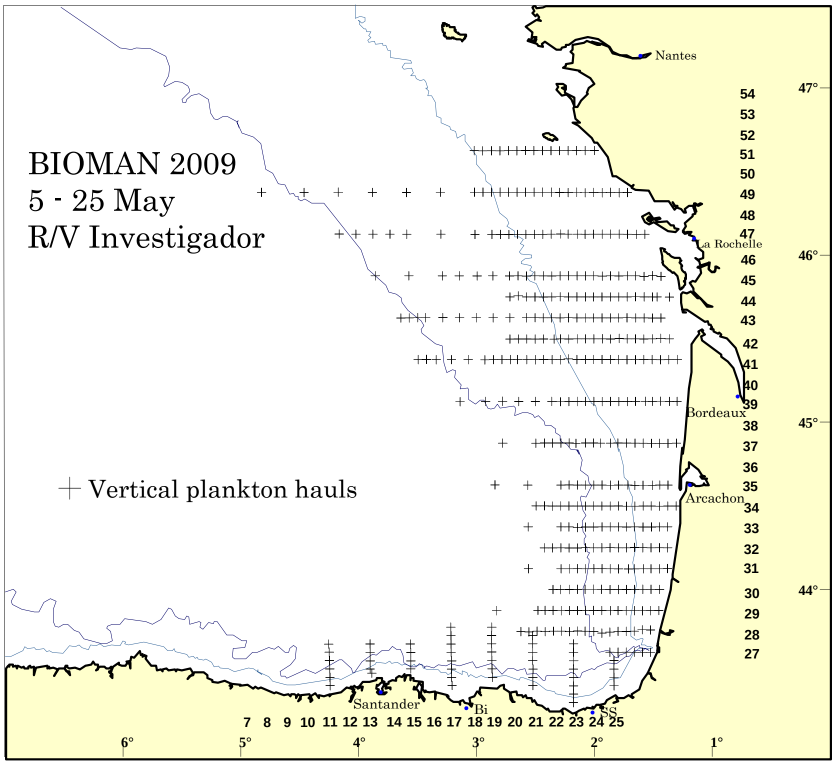


Figure 1: Plankton stations obtained during BIOMAN 09.

The samples obtained were fixed in formaldehyde 4% buffered with sodium tetra borate. After 6h of fixing, anchovy, sardine and other species eggs were identified and sorted out. All the samples were sorted on-board. Afterwards, in the laboratory a percentage of the samples were checked to assess the quality of the sorting work made at sea. According to that, when necessary, a portion of the samples were sorted again to assure no eggs were left. In the laboratory the anchovy eggs were staged. The total number of PairoVET obtained was 409.

The Continuous Underway Fish Egg Sampler (CUFES) was also used to record the eggs found at 3m depth. The samples obtained were immediately checked under the microscope so that presence/absence of anchovy eggs was detected in real time. This allowed knowing whether there were anchovy eggs in the area. When anchovy eggs were not found in 6 consecutive CUFES samples in the oceanic area, transect was left. The CUFES samples obtained were 987.

2.2 Collection of adult samples

The adult samples were obtained on-board the pelagic trawler R/V Emma Bardán. This vessel was covering the same area as the plankton vessel. When the plankton vessel encountered areas with anchovy eggs, the R/V Emma Bardán was directed to those areas

to fish. Most hauls consisted of horse mackerel, sardine, anchovy and mackerel (**Annex I**). In each haul 100 individuals of each species were measure.
Immediately after fishing, anchovy were sorted from the bulk of the catch and a sample of near 2 Kg was selected at random. Sampling finished as soon as a minimum of 1 kg or 60 anchovies were sexed, and from those, 25 non-hydrated females (NHF) were preserved. Sampling was also stopped when more than 120 anchovies had to be sexed to achieve the target of 25 NHF. Moreover, otholits were extracted to obtain the age composition per sample. 38 pelagic trawls were performed, from those 34 had anchovy but only 31 were selected for the analysis due to the few anchovies encountered in some of the samples. The spatial distribution of the fishing hauls are shown in **Figure 2**.

Currently, the adult samples are being processed for the estimation of the daily fecundity and are not available to apply the complete DEPM to obtain the final SSB estimate.

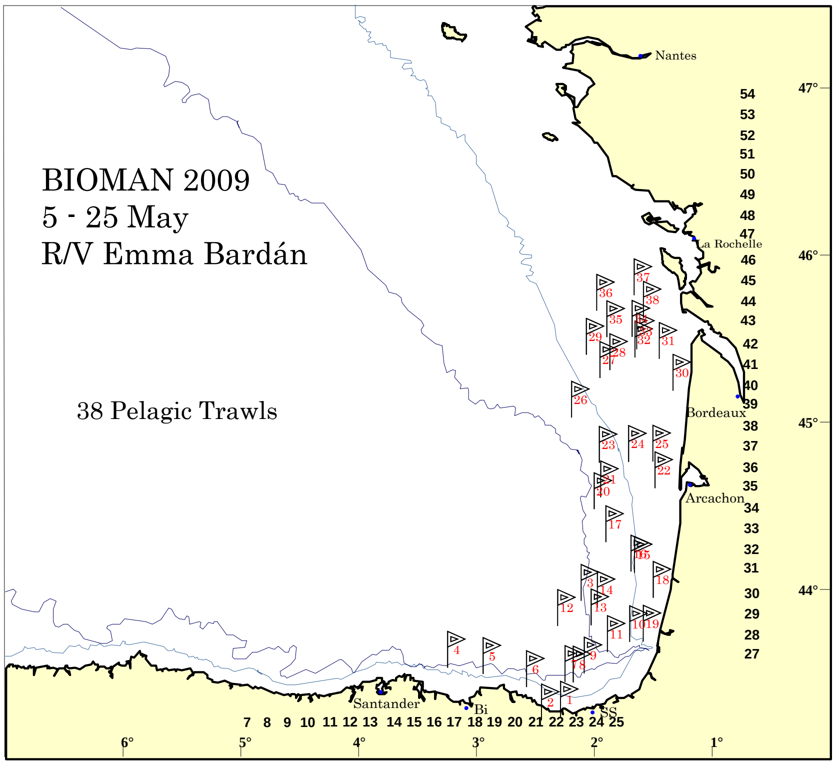


Figure 2: Spatial distribution of fishing hauls from R/V Emma Bardán in 2009.

2.3 Hydrographical parameters

At each PairoVET sampling station, sea surface temperature and salinity were measured with a manual thermosalinometer (**Fig.3**). In addition, temperature and salinity were recorded in the water column at each plankton haul using a CTD RBR XR420.
CUFES had a CT to record temperature and salinity, 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 software EDAS.

An ADCP (Acoustic Doppler Current Profiler) allowed to record data on currents.

At some of the sampling stations additional samples of water were obtained in order to obtain chlorophyll samples for calibration.

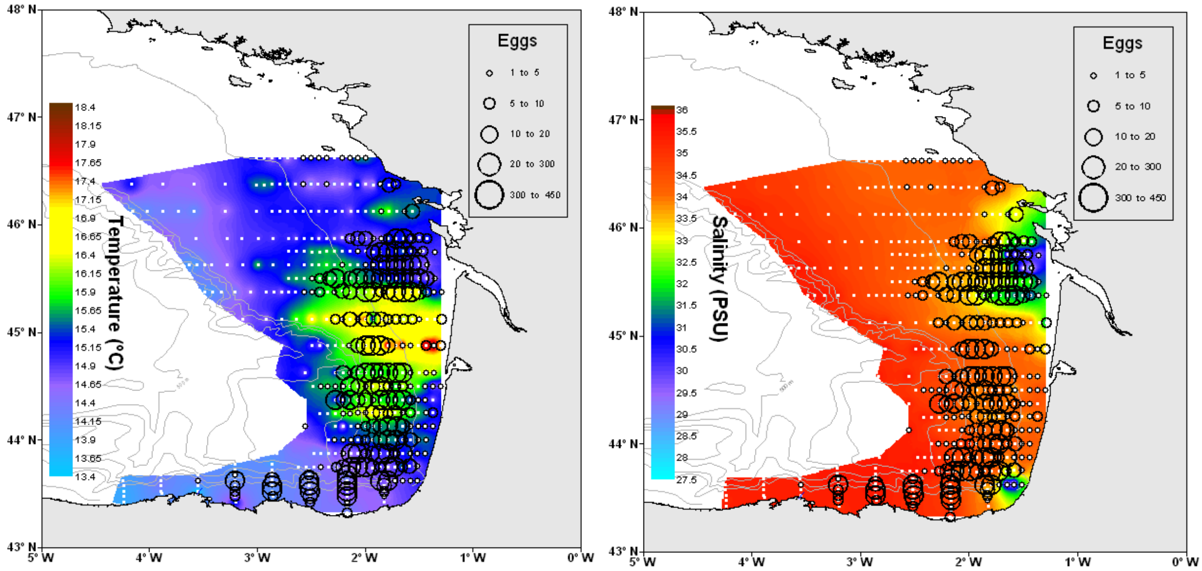


Fig.3: SST and SSS maps with the egg distribution.

2.4 Estimation of the spawning stock biomass

The Daily Egg Production Method (DEPM), first introduced by Parker (1980), consists on estimating the spawning stock biomass as the ratio between the total daily egg production and the daily fecundity estimates:

$$SSB = \frac{P_{tot}}{DF} = \frac{P_0 SA}{RSF \big/ W_f}$$

The full application of the DEPM requires the estimation of all the parameters.

2.4.1 Preliminary SSB estimate based on the ratio between P_{tot} and a preliminary estimate of DF from the historical series

When all the anchovy eggs are sorted and staged, it is possible to estimate P_{tot} using the standard procedures. However, as the adult samples are not processed yet, DF has to be derived from the past historical series. The estimation of each of these parameters is as follows:

Total daily egg production is calculated as the product between the daily egg production and the positive area

$$P_{tot} = P_0 \ SA$$

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 (Z) rates 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.
Daily Fecundity estimate were obtained from the historical series, the procedure is the same followed last year: DF is linearly dependent on Sea Surface Temperature (SST).
Then, SSB is just the ratio between the P_{tot} and DF estimates and its variance can be computed using the Delta method (Seber, 1982):

$$V\hat{a}r[SSB] = \frac{V\hat{a}r[Ptot]}{DF^2} + \frac{P_{tot}{}^2 V\hat{a}r[DF]}{DF^4}$$

2.5 Numbers at age

For the purposes of producing population at age estimates, the age readings based on 1,873 otholits from 31 samples collected on board R/V Emma Bardán 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 4 strata as defined in **figure 4**: NW, NE, SW and SE. The separation between N and S was made at 45ºN. The separation between NW and NE was made along the 80 m isoline. And the separation between SW and SE was made along the 100 m isoline.

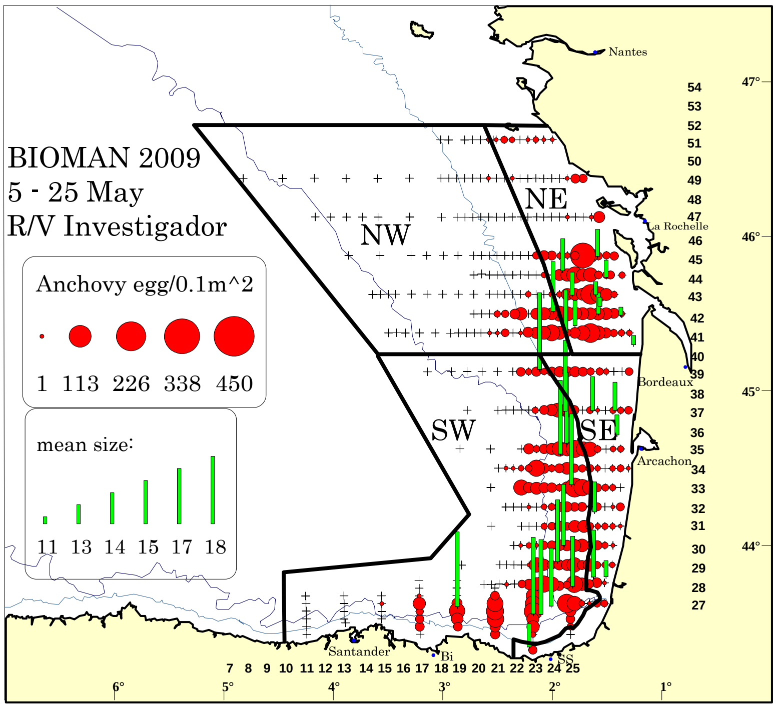


Figure 4: Four strata defined to estimate the numbers at age.

3. RESULTS

3.1 Egg sampling

The total area surveyed was 60,733 Km^2 and the spawning area was 28,214Km^2.
A total of 409 vertical plankton tows were completed using a PairoVET net 150µm (2-CalVET nets, Smith *et al.*, 1985). A total of 987 CUFES samples were obtained.
From 409 PairoVET, 240 were positive for anchovy eggs (59%) with an average of 16 eggs/0.1m^2 per station and a maximum of 152 eggs/0.1m^2. A total of 3,778 anchovy eggs were encountered.
The anchovy eggs were concentrated in three principal areas: the area of the Cantabrian coast where the distribution was wider than last year, the area of the French continental shelf between Cap Breton y Cap Ferret and the area of influence of the Gironde river between 45º22'N and 45º52'N mostly in the area between coast and the isoline of 80m depth. (**Fig. 5**)

As a result, immediately after the survey the total egg abundance (Ab_{tot}) calculated as the egg encountered in each station by the area represented by each station was 4.03 10^{12} eggs/0.1m^2. Last year was 3.58 10^{12} eggs/0.1m^2.

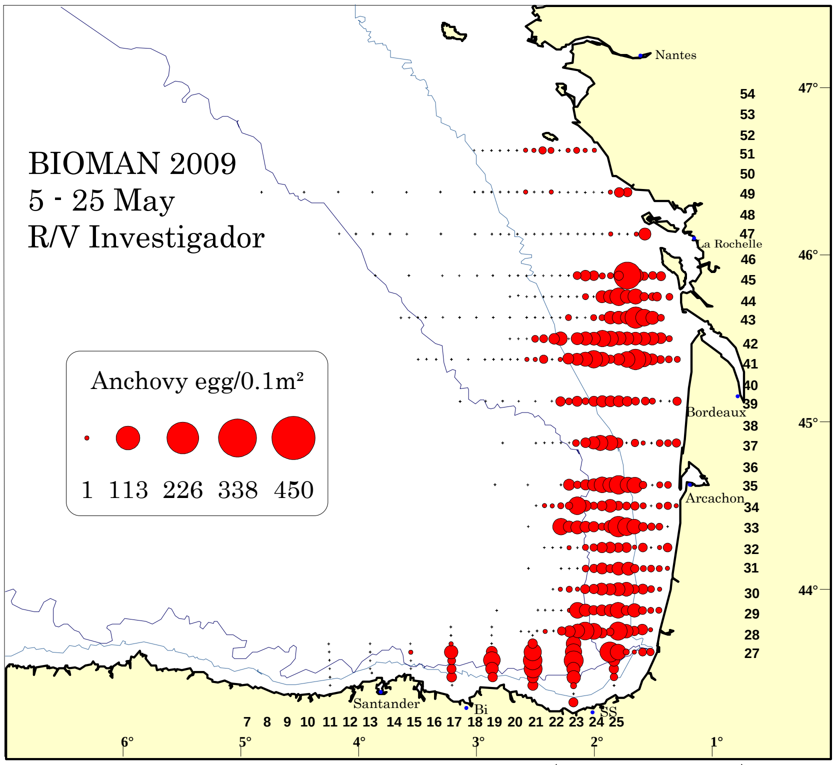


Figure 5: Distribution of egg abundances (eggs per 0.1m^2) from the DEPM survey BIOMAN09 obtained with PairoVET.

3.2 Adult sampling

The fishing hauls for adult sampling are summarised in **Annex I**. From the 38 pelagic trawl hauls performed on-board R/V Emma Bardán 34 had anchovy but in three of them the individuals encountered were not sufficient to consider them for the analysis. The spatial distribution of the samples and their composition is showed in **figure 6. Figure 7** shows the positive hauls for anchovy and the capture, **figure 8** shows the mean weight, figure 9 the mean size and figure 10 the age composition. Most of the spawning in the southern region was outside the 100 m depth were the 3 years old anchovies had a relevance presence.

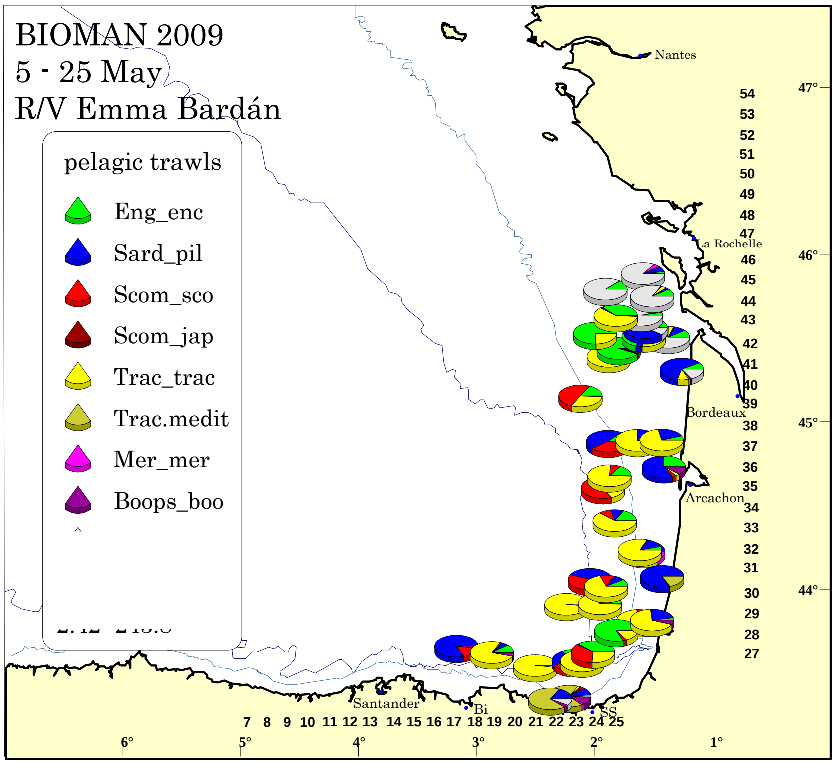


Figure 6: Species composition of the 38 pelagic trawls from the R/V Emma Bardán during BIOMAN09.

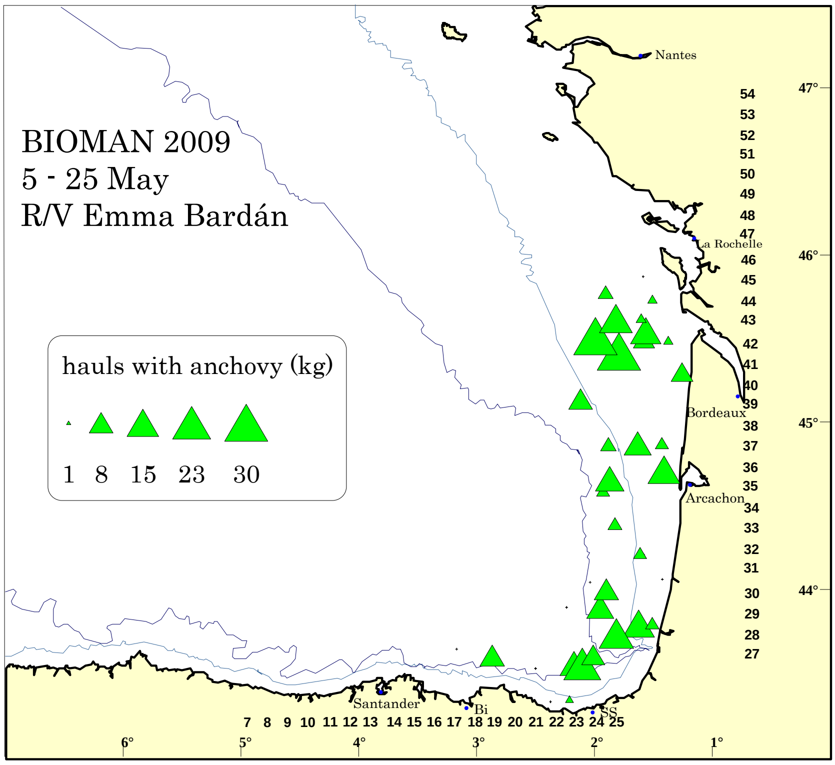


Figure 7: Anchovy catches in the pelagic trawls.

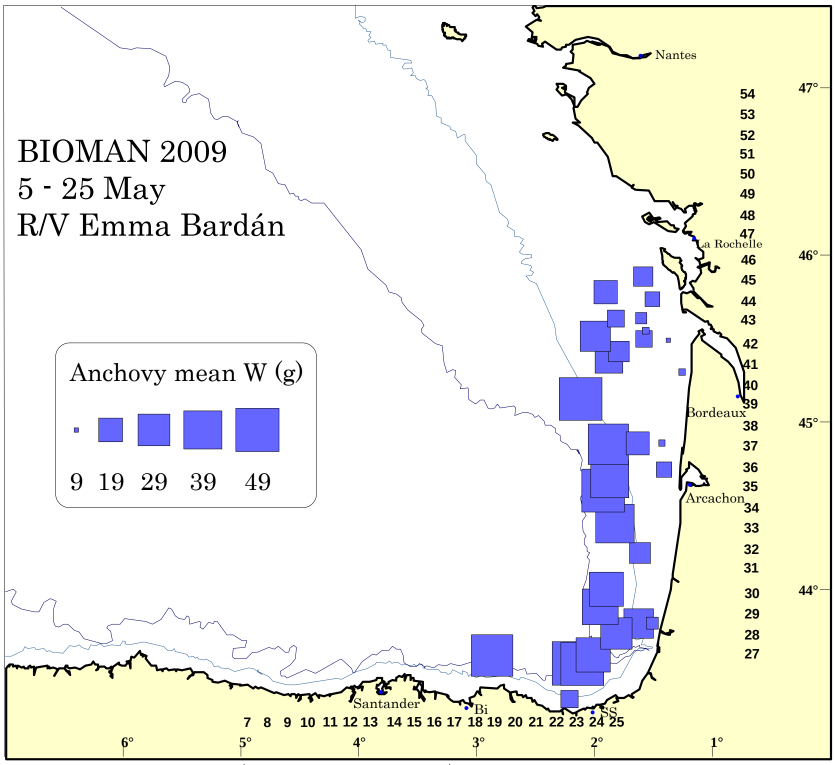


Figure 8: Anchovy (male and female) mean weight per pelagic trawl

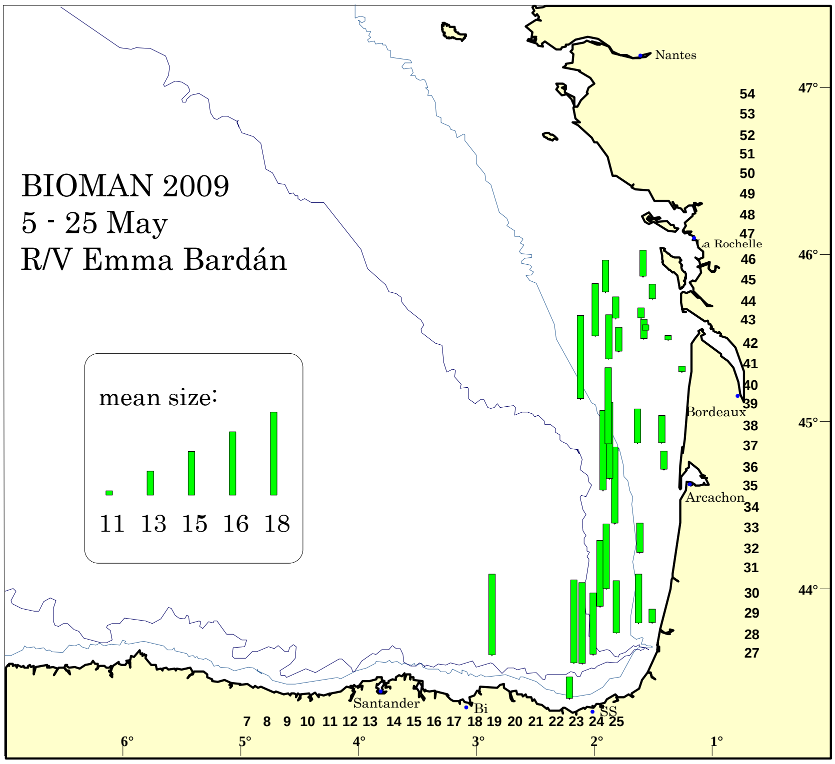


Figure 9: Anchovy (male and female) mean size per pelagic trawl

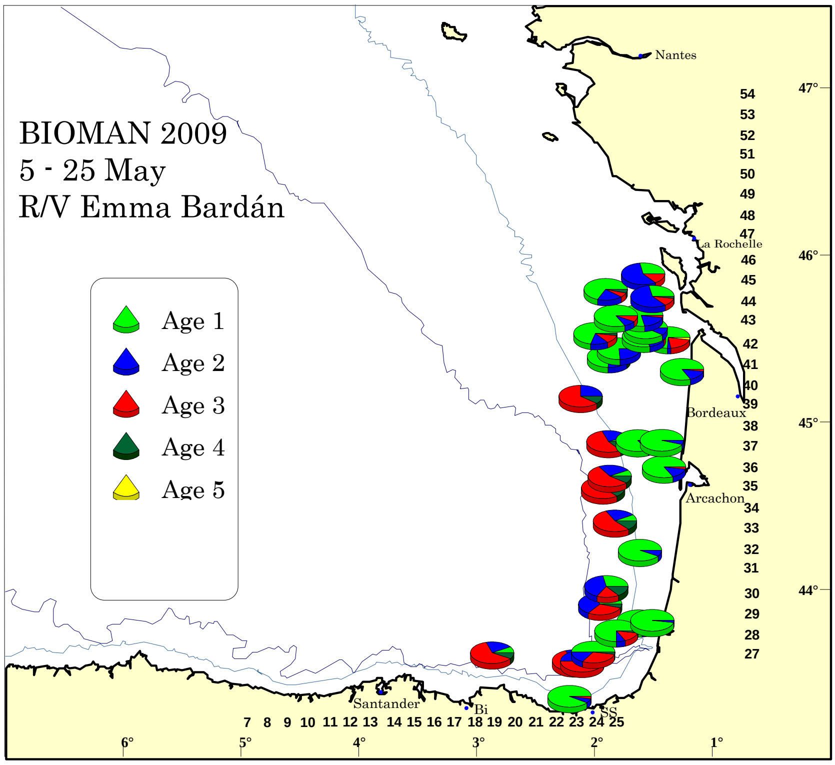


Figure 10: age composition per haul

3.3 Preliminary SSB estimate based on the ratio between P_{tot} and a preliminary estimate of DF from the historical series

3.3.1 Total egg production (P_{tot}) estimates

For the P_{tot} estimation, the staged eggs are transformed into daily cohort abundances, using the Bayesian ageing method. **Figure 11** shows the numbers of eggs by age (hours) and the different cohorts. An exponential mortality model was fitted to estimate P_0 and z, with a glm (generalised linear model) with a negative binomial and log link. **(Fig.12)**

Table 2 shows the daily egg production estimates (P_0), the daily egg mortality rates (z) and the total egg production and their coefficient of variation (CV).

Table 2: P_0, z and P_{tot} estimates with corresponding CV

	Value	S.e.	CV
P_0	60.22	8.32	0.14
z	0.28	0.003	0.25
Ptot	1.70.E+12	2.85.E-03	0.14

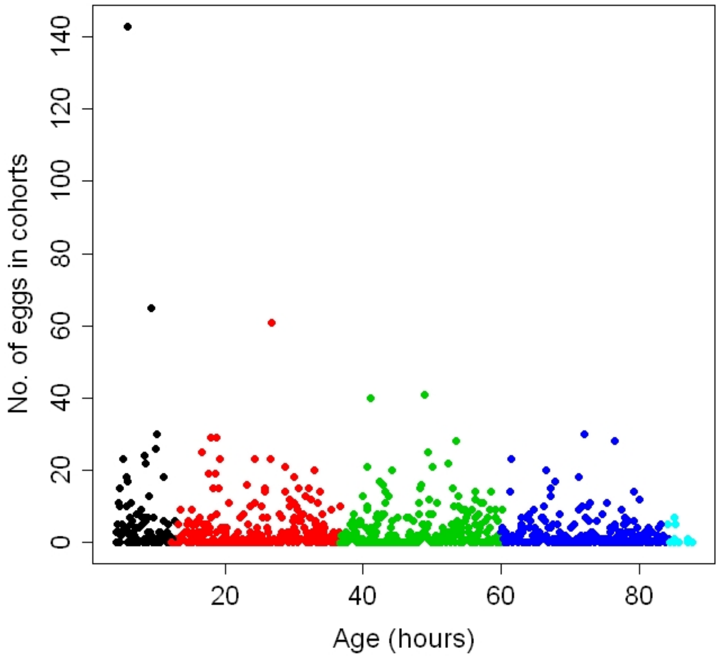


Figure 11: Daily cohort abundance.

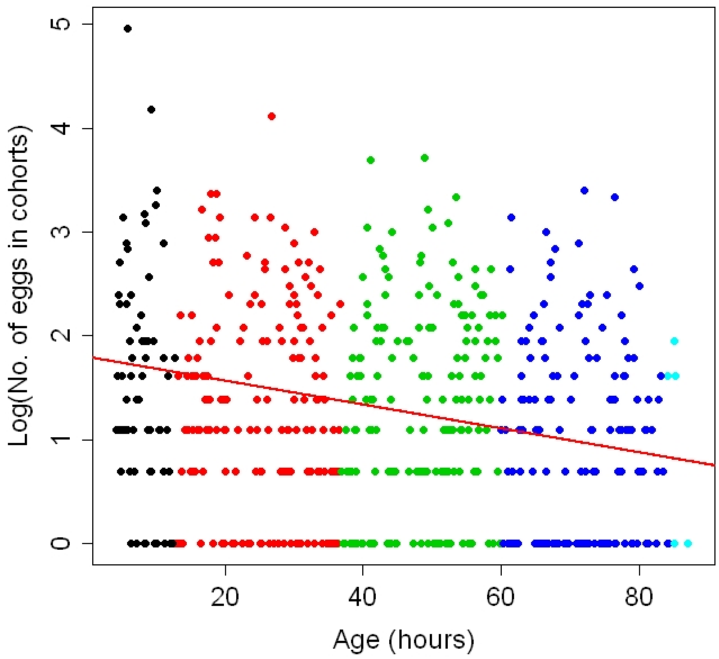


Figure12: exponential mortality models adjusted applying a GLM to the data obtained in the ageing following the Bayesian method (spawning pick 23:00h).The red line is the adjust line.

3.3.2 Daily fecundity and SSB preliminary estimates

The DF estimate was obtained from a linear regression model between DF and sea surface temperature (SST). The mean sea surface temperature this year was 15.25ºC.

The coefficient of determination was 19%. The standard error corresponded to the prediction standard error (the value of June 1989 is omitted form the analysis because of poor reliability). (Fig.13; Table 3)

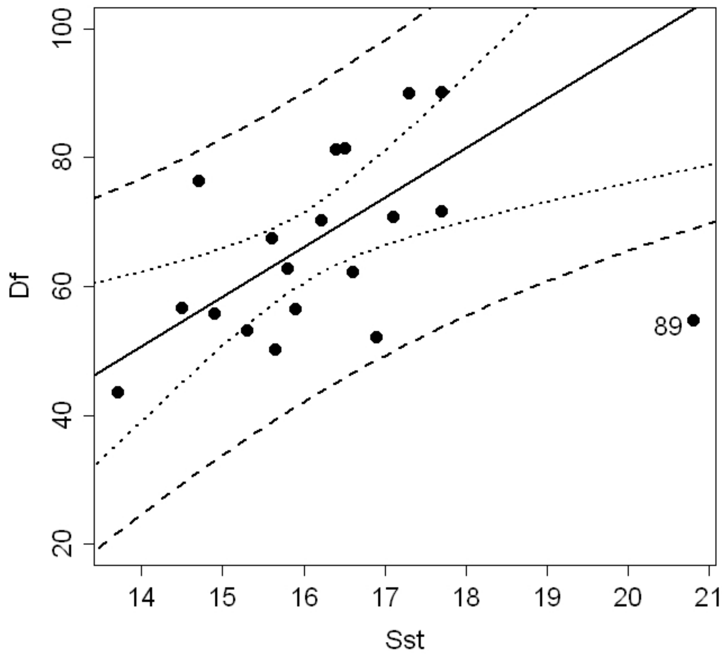


Figure 13: Linear regression model between DF and SST. The solid line represents the fitted line whereas the dotted and the dashed line represent the 95% confidence and prediction intervals, respectively. The points correspond to the observed points each year. The value of June 1989 is omitted form the analysis because of poor reliability

Table 3: Resultant parameters from the lineal regression model for DF

	Estimate	P-value
Intercept	-56.706	0.156
SST	7.673	0.005

The predicted Daily Fecundity value together with the coefficient of variation (CV) and the 95 % intervals for the confidence and the prediction from the model is showed below.

Model for DF	ESTIMATE	CONFIDENCE				PREDICTION			
	DF	SE	CV	Interval 95%		SE	CV	Interval 95 %	
df = a + b * sst	**60.69**	3.12	0.05	54.09	67.30	11.46	0.19	36.41	84.98

Preliminary biomass estimate for 2009 was obtained from DF predicted model, divided by the estimates of P_{tot} derived from GLM. Those results are showed in the table below.

Ptot (eggs)			DF (eggs/gramme)			SSB (Ton.)		
Model	Estimate	Var	Predic.Model	Estimate	Var.Pred.	Estimate	Var	Cv
GLM	1.70E+12	5.5E+22	Df = a + b * sst	60.69	131.26	27,994	4.3.E+07	0.2340

The preliminary spawning stock biomass estimated resulted in 27,994 with a CV 23%.

3.4 Numbers at age

The percentages at age in the population were the average of proportions at age of samples, weighted by the population each sample represents. Given the fact that mean weight of anchovies changes between different strata (**Figure 4**) proportionality between the amount of samples and approximate biomass indices by strata was checked. The approximate index of biomass by strata was set equal to egg abundance by areas (assuming equal daily fecundity at each area) (**table 4**). According to that table samples selected can not be considered to be balanced between strata and different weighting factors were applied to each sample for the purposes of the number at age estimates. Mean weight, age composition and weighting factors by sample are presented in **table 4**. The proportion by aage, population at age, weight and biomass by age estimate are given in **table 5.**

Table 4: 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 arise from the 31 adult samples selected for the analysis.

Estrata	NE	SE	SW	NW	Addition
Total egg abundance	1.14E+12	2.59E+11	2.44E+12	1.88E+11	4.03E+12
% egg abundance	28%	6%	61%	5%	100%
Nº of adult samples	11	6	13	1	31
%Egg/sample	0.03	0.01	0.05	0.05	
Proportion of SSB relative to estrata SW	**2.41**	**1.00**	**4.35**	**4.36**	
W. factor proportional to the population	**2.41/wi**	**1/wi**	**4.35/wi**	**4.36/wi**	
Mean weight of anchovies by region	13.6	13.4	39.0	26.5	

Table 5: SSB 2009 estimates and the correspondent standard error (S.e.) and coefficient of variation (CV) of the proportion by age and population at age estimates, with the mean weight by age class.

Parameter	Estimate	S.e.	CV
Biomass (Tons)	27,994	6,439	0.2300
Tot.mean W (g)	21.93	2.39	0.1089
Population (millions)	1,277	324.8	0.2545
Percent age 1	0.59	0.0590	0.0998
Percent age 2	0.21	0.0316	0.1512
Percent age 3+	0.20	0.0418	0.2098
Numbers at age 1	755	206.3	0.2733
Numbers at age 2	267	79.1	0.2960
Numbers at age 3+	255	84.0	0.3298
Weight at age 1	13.8		
Weight at age 2	27.4		
Weight at age 3+	40.5		
SSB at age 1 in mass	10,382		
SSB at age 2 in mass	7,314		
SSB at age 3+ in mass	10,299		
Percent age 1 in mass	37.1%		
Percent age 2 in mass	26.1%		
Percent age 3+ in mass	36.8%		

3.5 Overview of past time series

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 12 DEPM surveys were compiled and compared (**Fig 16**). The whole series of biomass estimates from the DEPM, including the current preliminary estimate for 2009, are presented in **figure 14**. The historical series of numbers at age in mass is shown in **figure 15.**
The series of biomass estimates from the DEPM was completed with this year preliminary estimates. Values are shown in **table 7** and acronyms in **table 8.**

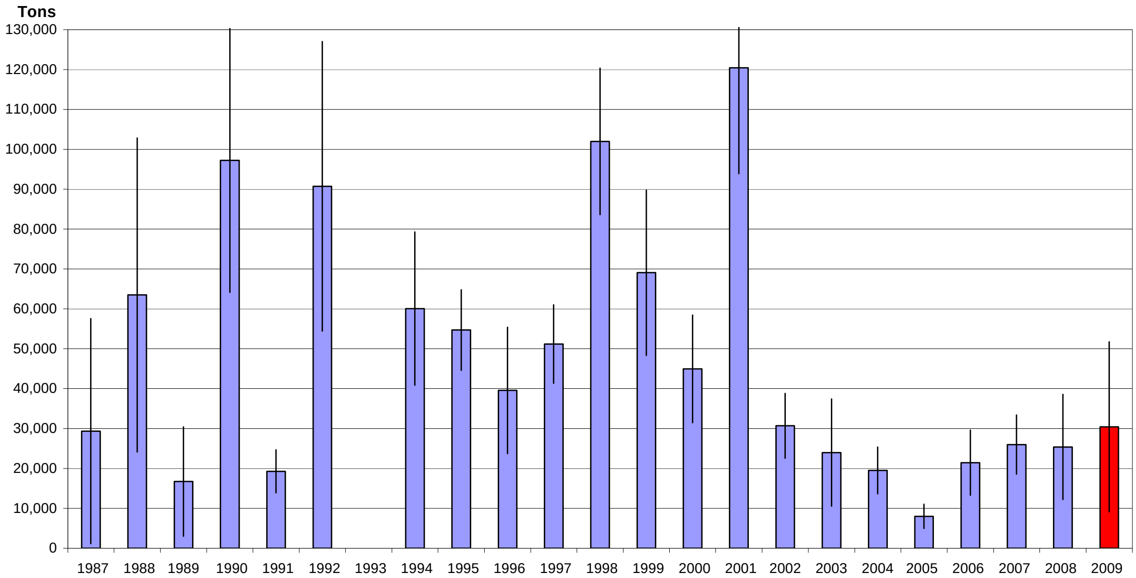


Figure 14: Series of Biomass estimates (tonnes) obtained from the DEPM since 1987. Most of them are full DEPM estimates, except in 1996, 1999, 2000 and 2007, which were deduced indirectly.

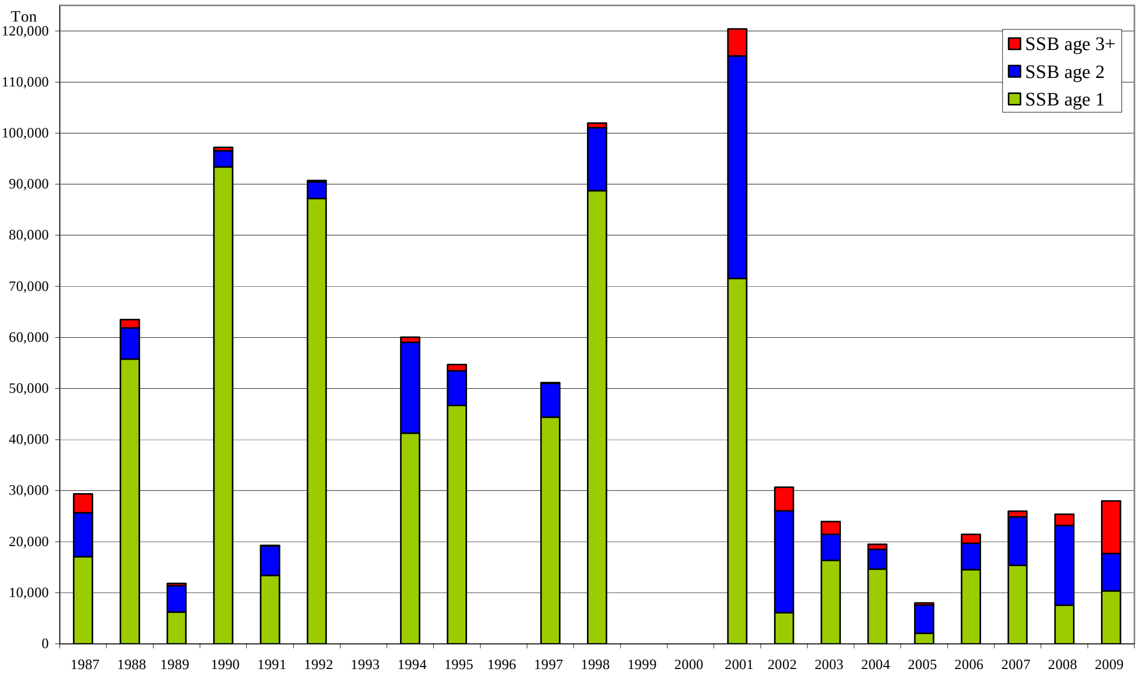


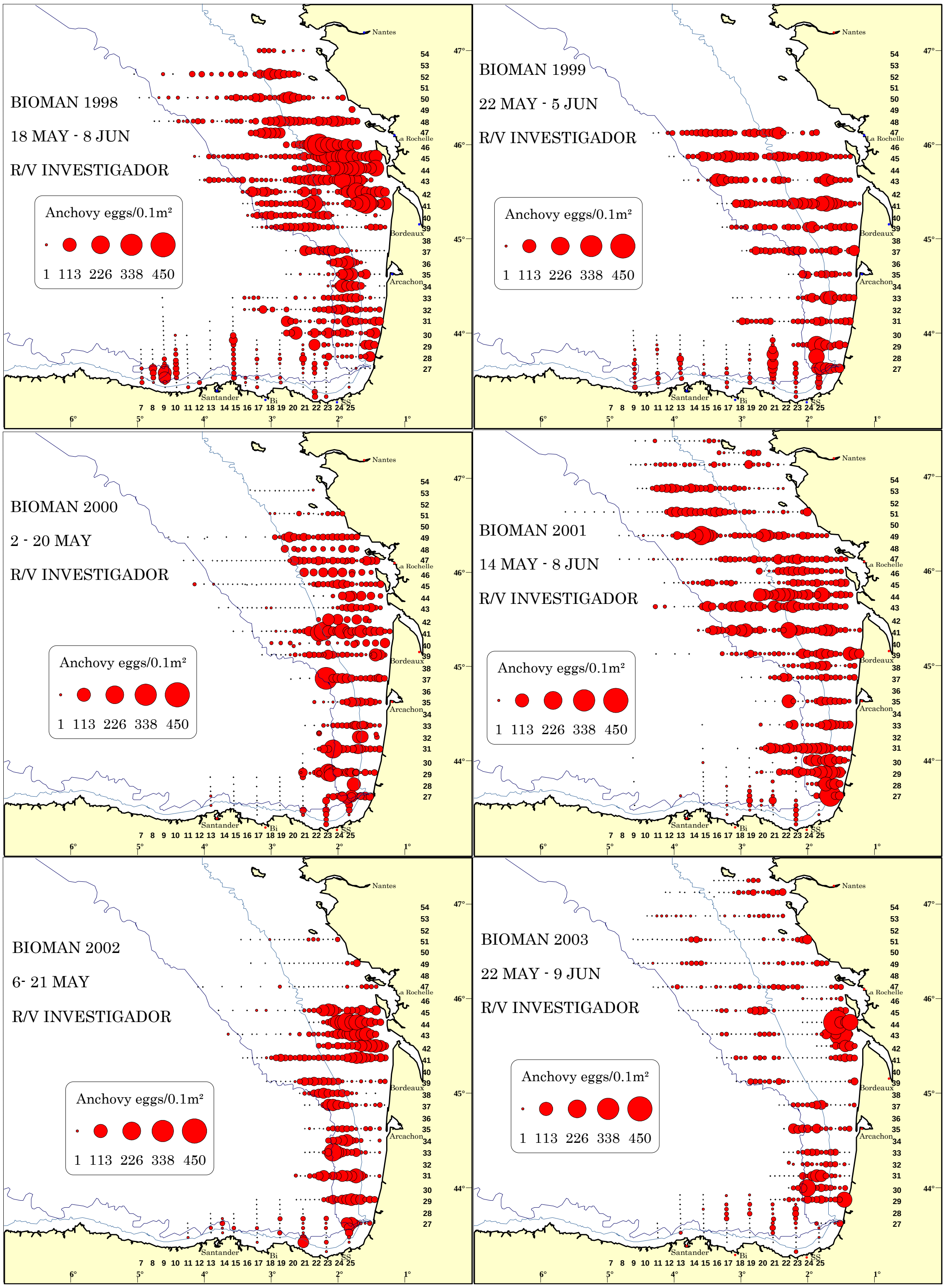
Figure 15: Historical series of biomass at age from 1987 to 2009.

Table 7: Historical series of DEPM surveys with their estimates and 2009 preliminary estimates. In years 1996, 1999, 2000 and 2007 DF was deduced indirectly.

Year	Actual dates	SSB	cv	Ptot	cv	P0	cv	Z	cv	Abtot	SA	DF	cv	SST[a]
1987	2 - 7 Jun	29,365	0.48	2.199	0.39	4.61	0.32	0.26	0.78	3.41	23,850	81.3	0.36	16.4
1988	21 - 28 May	63,500	0.31	5.010	0.24	5.52	0.21	0.18	0.68	10.41	45,384	81.4	0.23	16.5
1989	10 - 21 May	11,861	0.41	0.730	0.40	2.08	0.27	0.18	0.99	0.90	17,546	62.3	0.13	16.6
1989	14-24 Jun	10,058	0.55	0.83	-	1.50	0.30	0.94	0.41	0.79	27,917	54.8	0.28	20.8
1990	4 - 15 May	97,237	0.17	4.52	0.15	3.78	0.20	0.34	0.39	7.84	59,757	52.2	0.36	16.9
1990	29 May- 15 Jun	77,254	0.19	7.24	-	5.21	0.13	0.62	0.31	8.05	69,471	90.1	0.12	17.7
1991	16May-07Jun	19,276	0.14	1.24	0.06	2.55	0.22	0.22	0.65	3.18	24,264	67.5	0.15	15.6
1992	16May-13Jun	90,720	0.20	5.79	0.14	4.27	0.14	0.22	0.65	13.09	67,796	71.6	0.24	17.7
1994	17 May-3Jun	60,062	0.17	3.83	0.14	3.93	0.19	0.11	-	11.33	48,735	62.9	0.07	15.8
1995	11 - 25 May	54,701	0.09	3.09	0.07	4.96	0.12	0.19	0.34	8.75	31,189	56.7	0.06	14.2
1996	18 - 30 May	-	-	2.77	0.16	4.87	0.19	0.31	0.41	5.95	28,448	-	-	15.3
1997	9 - 21 May	51,176	0.10	2.70	0.07	2.69	0.14	0.19	0.47	7.12	50,133	53.2	0.06	15.1
1998	18 May - 8 Jun	101,976	0.09	5.59	0.05	3.83	0.12	0.28	0.25	11.96	73,131	56.5	0.06	16.5
1999	22 May - 5 Jun	-	-	3.59	0.09	3.52	0.08	0.12	0.40	9.06	51,019	-	-	17.1
2000	2- 20 May	-	-	2.61	0.19	3.45	0.28	0.18	1.02	7.95	37,883	-	-	16.5
2001	14-May - 8 Jun	120,403	0.11	8.48	0.09	5.89	0.11	0.45	0.20	12.36	72,022	70.8	0.06	16.8
2002	6 - 21 May	30,697	0.13	2.34	0.13	3.28	0.13	0.13	0.51	6.17	35,980	76.4	0.04	14.7
2003	22 may-9Jun	23,962	0.28	2.15	0.28	2.53	0.28	0.33	0.66	7.30	42,535	89.9	0.04	17.3
2004	2 - 17 May	19,498	0.15	0.84	0.11	1.82	0.11	0.10	-	2.80	23,124	43.6	0.09	13.7
2005	8 - 28 may	8,002	0.19	0.44	0.16	0.79	0.16	0.20	0.45	1.33	27,863	55.7	0.08	14.9
2006	4 - 24 may	21,436	0.19	1.07	0.17	2.16	0.17	0.27	0.40	2.66	24,614	50.1	0.09	15.6
2007	3-23 may	25,973	0.14	1.55	0.04	2.25	0.04	0.20	0.00	4.22	34,449	61.3	0.05	15.4
2008	6-26 may	25,337	0.26	1.78	0.09	2.66	0.09	0.32	0.15	3.58	33,502	67.4	0.04	16.2
2009	5 - 25 may	**27,994**	0.23	1.70	0.14	3.01	0.14	0.28	0.25	4.03	28,214	60.7	0.05	15.25

Table 8: Parameters with the acronyms and meaning of the estimates and units

Acronyms	Estimates of...	Units
P_0	Daily Egg Production per surface unit	Eggs/0.05 m^2/day
Z	Daly mortality of eggs	
SA	Positive Spawning Area	Km^2
P_{tot}	Total Daily Egg Production of the Population	Eggs/day *10E+12
SST	Sea Surface Temperature	ºC
SSB	SPAWNING STOCK BIOMASS	tonnes
DF	Daily Fecundity of the Population	eggs/gramme
AB_{tot}	Total Egg Abundace in the area surveyed	eggs *10E+12


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
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
Nantes
La Rochelle
Bordeaux
Arcachon
Santander
Bi
SS
47°
46°
45°
44°
6°
5°
4°
3°
2°
1°
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

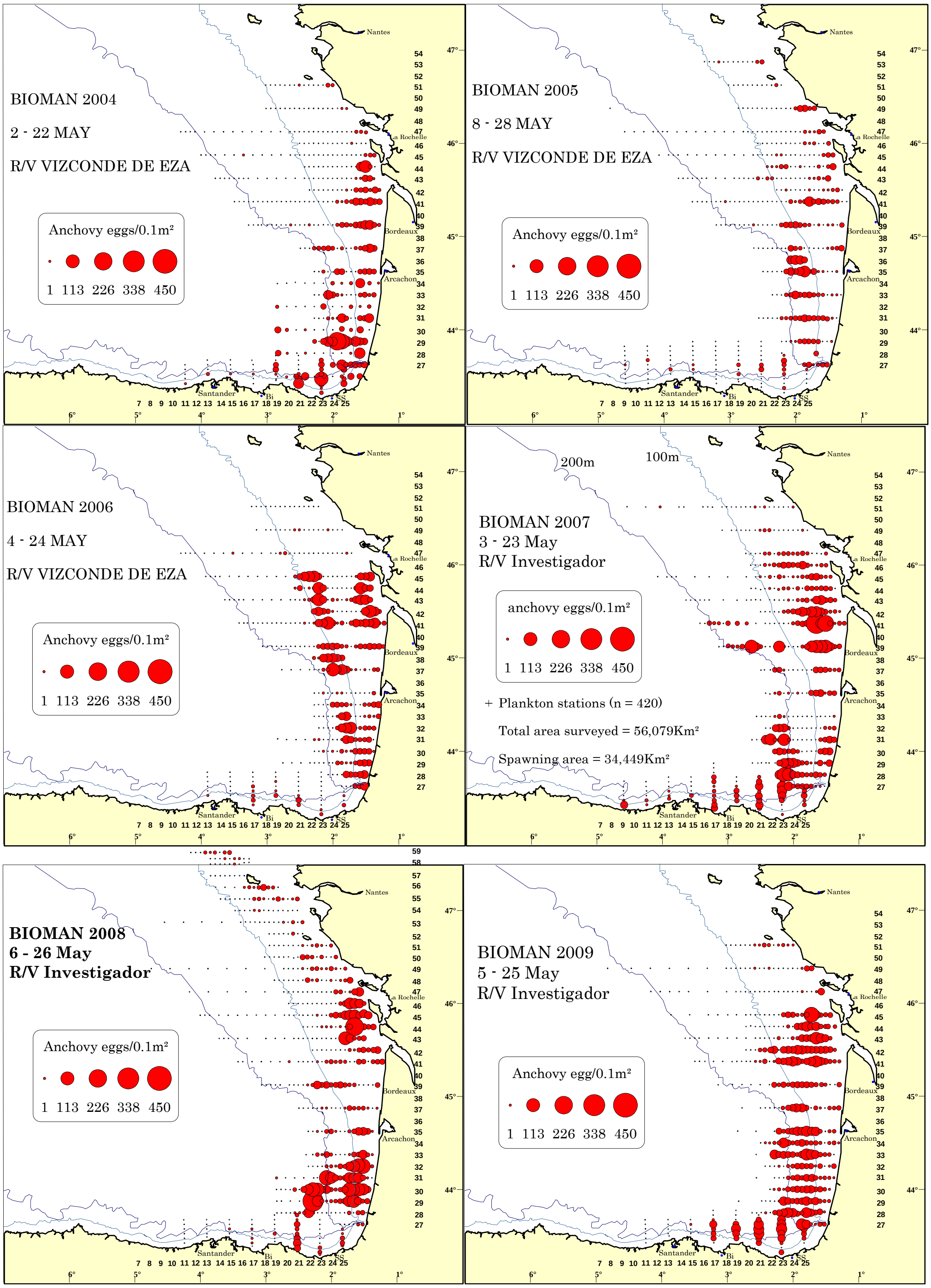


Figure 16: Anchovy egg distribution from 1998 to 2009.

4. DISCUSSION

The survey BIOMAN 09 has covered the spawning area satisfactory and the total egg production has been estimated in the distribution area of the population. Moreover it has obtained 38 pelagic trawls, 34 positive for anchovy and 31 were selected for the analysis. Those were obtained simultaneously to the egg sampling. The anchovy egg distribution in 2009 and the total egg production are slightly higher than last year.

To estimate the total egg production an exponential mortality model was applied.
The adjustment of the model was satisfactory.
To estimate the DF a linear regression model between DF and sea surface temperature from the historical series was adjusted. This procedure was applied in the same manner in previous years.

The SSB obtained this year as the ratio between the total daily egg production and the daily fecundity estimates is 27,994 t with a CV of 23%.

Approximately 59% of the anchovy are individuals of age 1 but the contribution in mass of those is only 37% while the contribution in mass of anchovies of age 2+ is 63%. This is due to the difference in the mean weights by age. This indicates a new failure in the recruitment, as in last years. The population at age estimate indicates that the closure of the fishery had a positive effect in sustaining the recent levels of biomass, because of the high percentage of spawning being sustained by survivors from past years.

The SSB estimate presented in this report is provisional. This provisional result from BIOMAN 09 based on the DEPM, doesn't show a significant recovery of the stock, as the 2009 level of biomass can not be statistically distinguished from the last year estimate of 25,377 t (CV: 26%).

The definitive perception of the status of the stock will be obtained from both the BIOMAN survey (MPDH) carried out by AZTI and the PELGAS survey (Acoustic) carried out by IFREMER. This analysis will take place during the ICES WGANC from 15 to 20 of June. The ACOM (Advisory Committee) of ICES will deliver its advice to the European Commission on the 23rd 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 09 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.

6. REFERENCES

BORJA, A., A. URIARTE, L. MOTOS AND V. VALENCIA. 1996. Relationship between anchovy (*Engraulis encrasicolus L.*) recruitment and the environment in the Bay of Biscay. Sci., Mar., 60 (Supl. 2): 179-192.

HIRST A. G. & T. KIORBOE 2002: Mortality of marine planktonic copepods global rates and patterns. Mar. Ecol. Prog. Ser. Vol. 230: 195- 209.

ICES, 2004. The DEPM estimation of spawning-stock biomass for sardine and anchovy. ICES Cooperative Research Report, 268. 91pp.

ICES 2005: Report of the Working Group on the assessment of mackerel, horse mackerel, sardine and anchovy. 7–16 September 2004 ICES, Copenhagen. ICES CM 2005/ACFM:08.

ICES. 2006. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX, 24–28 October 2005, Vigo, Spain. ICES CM 2006/LRC:01. 126 pp.

MOTOS L., A. URIARTE, V. VALENCIA 1996: The spawning environment of the Bay of Biscay anchovy (Engraulis encrasicolus L.). Sci. Mar.,60 (Supl.2): 117-140

URIARTE, A., L.MOTOS, P. ALVAREZ, M. SANTOS, P. PROUZET and J. MASSÉ, 1999: Population estimates of the Bay of Biscay anchovy by the Daily Egg Production Method. Final Report to European Commission of Project 96/034, issued in December 1999.

PEPIN P. 1991: Effect of Temperature and Size on Development, Mortality, and Survival Rates of the Pelagic Early Life History Stages of Marine Fish. Canadian Journal of Fisheries and Aquatic Sciences CJFSDX, Vol. 48, No. 3, p 503-518.

ANNEX I: Summary of pelagic trawls

Haul	Vessel	Date	Start H	End H	End Lat	End Long	SST	Depth	Fishing Depth	Eng_enc	Sard_pil	Scom_sco	Scom_jap	Trac_trac	Trac_medit	Mer_mer	Boops_bo	other	Total
1	Emma Bardan	06/05/2009	2:50	3:30	432066	21236	14	>200	10	0.77	5.15	1.1	1.65	2.1	60	1.55	5.5	0.65	78.47
2	Emma Bardan	06/05/2009	11:35	12:34	431968	22205	14	39	10	0.007	1.17	0	0	0.003	7	0	0.266	0.487	8.933
3	Emma Bardan	07/05/2009	11:00	11:53	440256	20186	13.8	155	15	0	1.12	0.95	0.35	0	0	0	0	0	2.42
4	Emma Bardan	07/05/2009	19:54	21:12	433858	30986	14.2	700	10	0.05	14.85	2.3	0	0	0	0	0.3	0	17.5
5	Emma Bardan	08/05/2009	0:08	1:30	433630	25177	13.4	500	12	8.4	6	2.35	0	100	0	0	3.4	0	120.15
6	Emma Bardan	08/05/2009	14:52	15:25	433164	22966	11.8	175	100	0	0	0	0	3	0	0	0	0	3
7	Emma Bardan	08/05/2009	20:30	22:05	433345	21007	14.3	200	12	11.5	4.2	3.5	0	10	0	0	0	0	29.2
8	Emma Bardan	08/05/2009	23:57	0:57	433326	20588	14.2	700	12	21.1	6	4.5	0.35	107.85	0	0	0	0.3	140.1
9	Emma Bardan	09/05/2009	3:21	3:55	433652	20030	13.2	500	8	7.4	0.2	5.35	0	4.6	0	0	0	0	17.55
10	Emma Bardan	09/05/2009	21:55	23:05	434778	13714	13.8	100	9	14.7	14.3	37	1.3	175	0	1.4	0.1	0	243.8
11	Emma Bardan	10/05/2009	1:25	2:25	434420	14849	13.6	130	10	18.1	0	0.85	0	2.5	0	0	0	0	21.45
12	Emma Bardan	10/05/1900	21:05	21:30	435358	21383	12.5	500	48	0	0	0	0	4.5	0	0	0	0	4.5
13	Emma Bardan	10/05/2009	23:45	0:50	435377	15676	14.1	140	10	10.5	0	2.3	0	21	0	0.08	0	0	33.88
14	Emma Bardan	11/05/2009	3:10	3:55	440008	15362	15.1	125	7	8.35	12.3	27.5	0	95	0	0.05	0	0	143.2
15	Emma Bardan	11/05/2009	21:33	22:25	441260	13471	15	85	5	0	1.44	0.46	0	1.35	0	0.31	0	0	3.56
16	Emma Bardan	11/05/2009	23:56	1:13	441309	13648	15.1	110	2	2	8.65	1	0	65	0	0.05	0	0	76.7
17	Emma Bardan	12/05/2009	4:31	5:35	442362	14925	15.6	125	4	2.3	3.1	2	0	10	0	0	0	0	17.4
18	Emma Bardan	13/05/2009	20:19	21:14	440364	12511	13.4	40	20	0	46.8	0	0.3	0	8	0	0	0	55.1
19	Emma Bardan	13/05/2009	0:22	1:45	434792	13021	13.4	47	5	2.1	27.65	0	2	80	0	0.1	4	0	115.85
20	Emma Bardan	18/05/2009	22:05	23:37	443548	15523	15	130	5	2	0.3	27.55	0.1	4.65	0	0.15	0	0	34.75
21	Emma Bardan	19/05/2009	2:24	3:24	443972	15189	15.8	120	10	12	0.15	12.5	0.15	80	0	0.25	0	0	105.05
22	Emma Bardan	19/05/2009	14:10	15:00	444299	12423	15.2	35	15	15.4	38	2.25	0	1.8	0	0	4.15	0.25	61.85
23	Emma Bardan	19/05/2009	20:03	21:20	445212	15257	15	120	15	3	15	13.65	0	0	0	0	0	0	31.65
24	Emma Bardan	19/05/2009	23:45	0:25	445242	13766	15.4	80	10	10.5	18	1.1	0	89.5	0	0.1	0	0	119.2
25	Emma Bardan	20/05/2009	2:45	3:18	445252	12532	15.1	40	8	2	17	0	0	44	0	0.05	0	0	63.05
26	Emma Bardan	20/05/2009	22:35	0:18	450835	20672	15.8	120	10	7.85	0.35	30	0	22	0	0.3	0	0	60.5
27	Emma Bardan	21/05/2009	3:53	5:00	452257	15228	15.6	75	3	0	0.25	0.75	0.05	19.1	0	0	0	0.4	20.55
28	Emma Bardan	21/05/2009	20:26	22:30	452538	14722	14.8	60	20	30	0.25	0	0	0.2	0	0.5	0	0.51	31.46
29	Emma Bardan	22/05/2009	2:11	3:05	453088	15920	15.5	85	8	30	0.15	0	0	9.1	0	0.2	0	0	39.45
30	Emma Bardan	22/05/2009	20:00	20:45	451800	11506	14.6	25	7	6.4	76.1	0.35	0	19	2	0.15	1.5	15	120.5
31	Emma Bardan	22/05/2009	22:45	23:35	452942	12208	13.5	30	5	1	1.65	0.15	0	1.25	0.75	2.45	0.1	9.1	16.45
32	Emma Bardan	23/05/2009	2:10	2:45	452991	13446	15.8	50	6	6.1	0.8	0	0	2.45	0	0	0	0.12	9.47
33	Emma Bardan	23/05/2009	19:45	20:40	453285	13355	14.4	43	9	13.8	58.75	0	0	0	0	0	0	5	77.55
34	Emma Bardan	23/05/2009	23:05	0:32	453734	13587	15.5	55	5	1.2	0.05	0	0	0.35	0	0	0.05	54.7	56.35
35	Emma Bardan	24/05/2009	3:10	4:05	453721	14875	15.5	70	5	16.3	0.7	0	0	22.65	0	0.15	0	0.1	39.9
36	Emma Bardan	24/05/2009	21:45	22:58	454668	15395	15.6	70	10	2.7	0	0	0	0.1	0	0	0	30	32.8
37	Emma Bardan	24/05/2009	23:02	23:45	455227	13486	15.8	40	5	0.15	0.4	0	0	0.07	0.03	0.4	0	8.4	9.45
38	Emma Bardan	25/05/2009	2:40	3:56	454417	13015	15.6	38	6	1	0.35	0	0	0.65	0.1	0.05	0	13.55	15.7

Annex 4 - South-Atlantic Iberian (Gulf of Cádiz) anchovy Spawning Stock Biomass through the application of DEPM in 2008

M.P. Jiménez, M. Millán and Miguel Bernal

Instituto Español de Oceanografía. Centro Oceanográfico de Cádiz. Puerto Pesquero, Muelle de Levante s/n. 11006 (Cádiz, Spain)

1 Introduction

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). The first survey of this series was in 2005 (Jiménez *et al*., 2005). The DEPM survey *BOCADEVA-0608 (*the second anchovy DEPM survey in the series) is one of the 2008 research activities developed under the *ICTIOEVA06* IEO's project (*Métodos de Producción de Huevos, Estimación de la biomasa de especies pelágicas de interés comercial: sardina, anchoa, caballa y jurel*). The survey has been carried out on board R/V *Cornide of Saavedra* (IEO) from 21st June to 3rd July 2008. The date of the survey was determinated by the reproductive cycle of the species in the study area, and it should coincide with the peak spawning. The surveyed area extended from Strait of Gibraltar to Cape San Vicente, that include the Spanish and Portuguese waters in the Gulf of Cadiz. Plankton samples, along a grid of parallel transects perpendicular to the coast, are obtained for spawning area delimitation and daily egg production density estimation; concurrently, fishing hauls are undertaken for estimation of adult parameters (sex ratio, female weight, batch fecundity and spawning fraction) within the mature component of the population. The survey objectives also included to obtain the length distributions and the biological parameters for other important commercial fish species in the area, and to characterize oceanographic and meteorological conditions in the study area during the survey

This working document provides a brief description of the survey, laboratory analysis and estimation procedures used to obtain the spawning stock biomass estimate for the 2008 DEPM application to the South-Atlantic Iberian anchovy stock.

Methodology

Table 1 summarises the methodology used in order to obtain the eggs and adults samples, during the survey.

Egg sampling and processing

The strategy of egg sampling was identical to that used in previous *BOCADEVA-0605.* An adaptative sampling was carried out, in E-W, using the net PairoVET in fixed stations as main sampler, and a registration in continuous with CUFES (Continuous Underwater Fish Egg Sampler) as secondary sampler.

The sampling grid was established on the continental shelf following a systematic transects perpendicular to the coast and spaced 8 nm. Egg samples were always taken every 3 nm in the inner shelf, up to 100 m depth (ICES, 2003). The inshore limit of transects was determined by bottom depth (as close to shore as possible), while the offshore extension was decided adaptively depending on the results of the most recent CUFES sample.

Vertical haulages of plankton with a PairoVET, equipped with nets of 150 μm of mesh size, were carried out. Haulages were carried out until a maximum depth of 100 m or of 5 m on the bottom in smaller depths, and to a speed of 1 m/s., approximately. Sampling depth and temperature of the water column were registered using a CTD SBE 19 fitted to the net. Flowmeters were used to calculate the volume of filtered water during each haul. Egg samples were analysed onboard. A preliminary identification and counting of anchovy eggs and larvae, as well as other commercial species were carried out. Samples were sorted, counted and preserved in a 4 % buffered formaldehyde solution. Later, the anchovy eggs were classified in 11 stages of development, according to the key proposed by Moser and Ahlstrom (1985).

During the CUFES (Checkley *et al.*,2000) sampling the volume of filtered water (600 l/min, approximately) was also integrated each 3 nm (at fix depth 5 m). The collector of CUFES was provided with a 335 μm net. The anchovy eggs were classified in three stages: No-Embryo (I-III), Early Embryo (IV-VI) and Late Embryo (VII-XI).

Adult sampling and processing

In order to obtain the necessary adult anchovy samples for DEPM purposes the pelagic trawl hauls (20-m vertical opening) were carried out during the survey. The location of fishing stations was opportunistic, according to the echogram information on expected anchovy presence (visual scrutiny based on expertise) recorded with a *Simrad® EK60* echo-sounder.

Fishing stations were mostly conducted during daylight hours and carried out over isobath, once echotraces supposedly belonging to anchovy were detected by echosounder. In such situations, and depending on the survey's logistic, either the ichthyoplancton sampling was interrupted for doing the fishing stations or these ones were carried out once the eggs sampling over transect was finished.

From the total of fished species, chub mackerel (*Scomber colias*) was the species yielding the highest total catch in weight (1688 kg), followed by anchovy (840 kg), blue jack mackerel (*T. picturatus*; 447 kg), and sardine (237 kg).

In each haul, a random sample of 60 anchovies during the biological sampling (*i.e.*, individual length, weight, sex, maturity stage, and otoliths) was utilised for the estimation of the sex ratio (*R*) and female mean weight (*W*) parameters. A goal of 30 non-hydrated females (NHF) per sample was pursued in order to obtain a estimate of the spawning fraction (*S*). If such goal was not achieved from the initial random sample, the sampling continued up to achieve a maximum of 120 sexed anchovies.

When hydrated females (HF) appeared, an additional sampling was done in order to obtain a minimum of 150 HF for the whole area prospected. These females were sampled as described above. Gonads from both hydrated and non-hydrated females were preserved in 4% buffered formaldehyde.

Mean female weight (*W*) was estimated after correction for the increase in weight due to the hydration in hydrates females. Sex ratio (*R*) was estimated as the weight ratio of females in the mature population.

The individual batch fecundity (*Fobs*) was estimated by the hydrated oocyte method (Hunter *et al.*, 1985). The spawning fraction (*S*) was determined by a histological analysis of the post-ovulatory follicles, POFs (Hunter and Macewicz, 1985). Post-ovulatory follicles (POF's) were assigned to stages-ages according to the Motos' (1996) classification (Day-0 POFs (0-6 h); Day-1 POFs (7-30 h); Day-2 POFs (31-54 h); Day-2+ POFs (older than 54 h), although considering as the peak spawning time the species-specific one in the study area.

Data analysis and estimation

Anchovy biomass estimation 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). Although estimation has not yet been validated by the WGACEGG, the extensive participation of people involved in sardine and anchovy DEPM and the use of procedures and software adopted in previous applications provide sufficient guarantees that the estimate provided can be used for assessment purposes in WGANSA.

Egg Production (P_{tot}) estimation and area calculation (A)

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).

$$N_{i,t} \sim \mathrm{Mult}\,(N, p_{i,t})$$

$$p_{i,t} = f\,(\mathrm{Age, Temp})$$

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).

p(age | stage, temp, time) a p (stage | age, temp) p (age | time)

ageing development model synchronicity

Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential mortality model to the egg abundance by cohorts and corresponding mean age. The model was fitted using a generalized linear model (GLM) with negative binomial distribution. The ageing process and the GLM fitting were iterative until the value of z converged. [depm.control (spawn.mu=22; how.complete=0.95; spawn.sig=2), initial z =0.01].

$$P_{age} = P_0\, e^{-z\,age}$$

$$\log\left(\frac{N_{age}}{area}\right) = \log(P_0) - z\,age \;\rightarrow\; \log(N_{age}) = \log(area) + \log(P_0) - z\,age$$

Finally, the total egg production was calculated as: $P_{tot} = P_0\,A+$

Adults parameters

The adult parameters estimated for each fishing haul considered only the mature fraction of the population (determined by the fish macroscopic maturity data). Before the estimation of the mean female weight per haul (W), the individual total weight of the hydrated females was corrected by a linear regression between the total weight of non-hydrated females and their corresponding gonad-free weight (Wnov). The sex ratio (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.

Spawning Stock Biomass

The spawning biomass was computed according to: $SSB = \dfrac{P_0 * Area +}{F * S * R}$

Results

The surveyed area (13028.87 km²) extends from Cabo de Trafalgar (Spain) to Cabo de San Vicente (Portugal), from 36º18′ N to 36º75′ N and –6º22′ W to –8º92′ W. This area includes the continental shelf of the Gulf of Cadiz (ICES, Subdivision IXa South). The survey was carried out from East to West, starting in the radial 1, located close the strait of Gibraltar. Fig. 1 shows the trip of the R/V Cornide de Saavedra during the survey, with indication of the date in passing.

Eggs

A total of 127 PairoVET stations were carried out. In 70 stations (55%) there were presence of anchovy eggs (positive station) (Fig. 2). A total of 656 anchovy eggs were captured. Similar to the previous survey (2005), most of them (83.4%) were obtained in the eastern transects of the study area, in Spanish waters. Anchovy eggs were caught mainly in the coastal area located between Cadiz and the radial 6, in front of the mouth of the Guadalquivir River. Higher abundances were found in the stations inside isobaths of the 100 m. A second area of high egg abundance was also registered in the radial 11, in front of the mouth of the Guadiana River. In a coastal station of this radial (situated at 35 m depth), the number of eggs was higher (52 in total). Anchovy eggs abundance was lower in the stations located in Portuguese waters. Only in one of the stations, also very coastal, something was registered by more than

20 eggs. Anchovy larvae (265 in number) were more abundant in the area between Cadiz and Huelva. The station showing the highest larvae abundance was located in the shallower waters of the radial in front to Chipiona. Anchovy larvae presented a less coastal distribution than eggs.

93.4% of the anchovy eggs have been classified into 11 stages according to the degree of embryonic development. It has been found anchovy eggs in all the described stages. The most abundant development stages were II and III stages (14.8 and 29.7%, respectively). Although just 1 egg was found in stage I and eggs in the XI stage, right before the hatching, represented 1.4%. (Fig. 3).

The icthyoplankton sampling almost covered the whole 24 hours' day-time period except for small intervals of time when fishing hauls were carried out in order to collect anchovy adults. As mentioned above, only 1 stage I egg was found, that is, right after having been laid. This egg was caught in a station close to the coast, in an important spawning area for anchovy (Anonymous, 2005; Anonymous, 2007). Besides, the sampling was carried out at 20:23 hours GMT, in agreement with the peak spawning established for this species in Gulf of Cadiz.

The eggs classified in the stage II were mainly caught around 20:00 h, increasing their capture gradually, and they decreased from the 07:00 hrs (Fig. 4). Eggs in state III were more abundant between 07:00 to 13:00 h, with a maximum at 9:00 h. Eggs in stage VI were more abundant between 17:00 to 19:00 h.

A total of 121 samples by CUFES were collected, 50 of them with presence of anchovy eggs (45.9%), which rendered a total of 9592 of anchovy eggs during the continuous sampling. The spatial distribution of the anchovy eggs abundance (number/m^3) by CUFES shows a clear concentration area in a small coastal area between Huelva and Isla Cristina (Radials 10 and 11). Only in these two radials almost 2700 eggs were caught, accounting for 34% of the total (Fig. 5). The stations with higher abundances (450 to 800 anchovy eggs) were close to the coast (<100 m). In the rest of the sampled stations the eggs caught were lower. In general, a preference for the most coastal areas is observed. In the same way that in the vertical sampling, sardine eggs in CUFES were hardly found. Only 13 anchovy larvae were found. The station with a higher number of anchovy larvae was in radial 11, in front of Isla Cristina.

Adults

Anchovy showed a high occurrence in fishing stations throughout the surveyed area, with catches in 22 from the 26 fishing stations. These positive stations were carried out between 6:10 and 19:15 GMT and in bathymetric range between 35 and 122 m depth (Table 2, Figure 6). From these 22 anchovy samples, 18 fulfilled the criterion of minimum sample size (60 anchovies), 13 samples from the Spanish waters and 5 samples from the Portuguese waters.

The characteristics of the samples used for the estimation of the adults parameters are described in the following text table:

Parameter	Time range GMT	#Samples	#Males	Weight range (gr)	Length range (mm)	#Females	Weight range (gr)	Length range (mm)
Mean Weight & Sex ratio	06:10-19:43	18	651	6,72-39,04	114-176	608	8,78-45,70	112-182
Batch Fecundity	16:20-19:43	4	-	-	-	219	8,78-35,90	112-164
Spawning fraction	06:10-19:43	18	-	-	-	602	8,78-45,70	112-182

Estimation of adult parameters by haul

Mean female weight, *W*.

The total weight of hydrated females was corrected for the increase of weight due to the hydration by a linear regression model between individual data of gonad-free-weight (Wnov) and its corresponding total weight (Wt) from non-hydrated females (Figure 7):

The expected female weight (Wexp) for all mature females was also estimated using this linear regression model.

Sex ratio, *R*

The sex ratio in weight per sample was estimated as the ratio between the female total weight (weight.by.haul*female.by.haul) and the total (females+males) weight (totweight.by.haul):

Batch Fecundity, *F*.

The expected batch fecundity for all mature females (Fexp) was estimated by modelling the observed individual batch fecundity (Fobs) in hydrated females in function of their gonad-free-weights (Wnov) by a GLM model (Figure 8).

This model was chosen for the information provided by the residual inspection plots (Figure 9) and explained the 47% of the total variance (Table 3).

Spawning fraction, *S*.

The spawning fraction estimates by haul according to the different estimators considered are shown in Table 4. Only the Day 0 estimator showed a pattern related to the spawning dynamics, with the highest values of this estimator occurring in those samples obtained during the spawning time.

The *S* weighted average values for the Day 0, Day 1, Day 2, and Day 3 estimators were quite similar.

Results from this exploratory analysis showed the consistence of the estimators utilized and the possibility of combining both the Day1 and Day2 estimators in order to achieve a more precise estimate of the daily spawning fraction. Therefore, the spawning fraction (*S*) was determined based on the average number of mature females whose post-ovulatory follicles were classified as Day 1 and Day 2.

This estimate, however, should still be considered with caution because of the probable bias which might be caused by the adoption of the POF degeneration rate from the Bay of Biscay anchovy stock.

Spatial mapping of the estimates of the adult parameters by haul.

The spatial mapping of the mean estimates per haul evidenced a certain structure for the mature female mean weight and batch fecundity (Figure 10), in agreement with the distribution pattern previously described in the area: an east-west size (-age) gradient, with the largest (and oldest) anchovies being more abundant in the westernmost limit of their distribution.

This spatial pattern was considered in the 2005 batch fecundity estimation by considering a post-stratification of individual samples (ICES; 2006). However, unlike the 2005 DEPM survey, the pattern observed in this survey was much less pronounced and based on a much lower number of samples. So, because of this, the suitability of a post-stratification of the adults data couldn't be considered for the estimation of the batch fecundity in the 2008 DEPM survey.

SSB estimates

The total surveyed area (*A*) was 13028 Km^2. The analysis of the spawning area showed (as in 2005) two clear positive areas. Therefore, two strata were considered to estimate the daily egg production (P_0 = eggs/m^2/day) and the corresponding total egg production (P_{tot} = eggs/day). The limit was fixed in –7.85 W: Algarve and Cádiz. A common egg mortality rate (z = day^{-1}) was considered.

The values of the mean estimates and their associated variances for the egg and adult parameters, and the final SSB, are summarized in the Table 5. A total of 31527 tons have been estimated for the total area (Algarve + Cádiz).

Table 6 summarises the previous and new DEPM estimates for the 2005 survey (*BOCADEVA 0605*) resulting from the application of procedures and software adapted and developed during the WKRESTIM. The new estimation process yielded a smaller sampling area because of a better correction of the coastal line in relation with the previous computations. Furthermore, in the estimation of egg parameters the model showing best fitting was the one which considered the estimation of a common egg mortality rate (z = day^{-1}). The final SSB estimate was of 14673 tons, a value very close to the previously estimated (14219 tons).

REFERENCES

Anonymous, 2005. Los Recursos Pesqueros del Golfo de Cádiz. Junta de Andalucía, Consejería de Agricultura y Pesca. 247 pp.

Anonymous, 2007. Fluctuaciones y potencialidad de especies pesqueras de plataforma en la Región atlántica Andaluza. Informe anualidad 2007. Junta de Andalucía.

Bernal, M., Ibaibarriaga, L., Lago de Lanzos, A., Lonergan, M.E., Hernandez, C., Franco, C., Rasines, I., Valdes, L. and Borchers, D.L., 2008. Using multinomial models to analyse data from Iberian sardine egg incubation experiments: a comparison with traditional techniques. *ICES J. Mar. Sci*., 65:51–59.

Duarte, J, M. Bernal, M.P. Jiménez, J. Canoura, E. García, A. Juárez, I. Muñoz, 2007. Egg development model for anchovy (*Engraulis encrasicolus*) in the Gulf of Cádiz. ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG).

Hunter, J.R., B.J. Macewicz, 1985. Measurement of spawning frequency in multiple spawning fishes. *In* : Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. *NOAA Tech. Rep. NMFS* 36: 7-16 pp.

Hunter, J.R., N.C.H. Lo, R.J.H. Leong, 1985. Batch fecundity in multiple spawning fishes. *In*: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. *NOAA Tech. Rep. NMFS* 36: 66-77 pp.

Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D.L., Lonergan, M.E., and Wood, S.N. 2007. Characterization of stage-classified biological processes using multinomial models: a case study of anchovy (*Engraulis encrasicolus*) eggs in the Bay of Biscay. Canadian Journal of Fisheries and Aquatic Sciences, 64:539–553.

ICES, 2003. Report of the Study Group on the Estimation of Spawning Stock Biomass of Sardine and Anchovy (SGSBSA),

ICES 2006. Report of the Working Group on Acoustic and Eggs Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). ICES Living Resources Committee. ICES CM 2006/LCR:18. Ref.ACFM.

ICES 2007. Report of the Working Group on Acoustic and Eggs Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG). ICES Living Resources Committee. ICES CM 2007/LCR:36. Ref.ACFM.

Jiménez, M.P., M. Millán, M. Bernal, G. Costas, 2005. Estimación de la biomasa de reproductores del stock de *Engraulis encrasicolus* del Golfo de Cádiz por el Método de Producción Diaria de Huevos (MPDH). Informe de incidencias y resultados preliminares. Documento interno IEO. 62 pp.

Jiménez, M.P., G. Costas, M. Bernal, E. García-Isarch, 2006. Estimation of the Anchovy Daily egg Production (P0) in the Gulf of Cadiz using R. *ICES Working Group on Acoustics and Egg surveys for Sardine and Anchovy in ICES areas VIII and IX(WGACEGGS)*. Lisbon (Portugal) 27/11–01/12 2006. Working Document

Moser H.G, E.H Ahlstrom, 1985 Staging Anchovy EggsIn: R. Lasker (editor), An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: Application t o theNorthern Anchovy, Engraulis mordax. NOAA Tech. Rep. NMFS 36. US. Dep. Commer., Wash., D.C., 99 p.

Motos, L.,1996. Reproductive biology and fecundity of the Bay of Biscay anchovy (*Engraulis encrasicolus* L.). *Scientia Marina*, 60 (supplement 2): 195-207.

Picquelle, S., Stauffer, G., 1985. Parameter estimation for an egg production method of northern anchovy biomass assessment. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. NNAA Tech. Rep. NMFS 36: 43-50 pp.

Table 1. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. General sampling.**

Parameters	Anchovy DEPM survey *BOCADEVA0608*
Survey area	(36º18′-36º75′N –6º22′-–8º92′W)
R/V	Cornide de Saavedra
Date	21/06-03/07
Eggs	
Transects (Sampling grid)	21 (8x3)
Pairovet stations (150 µm)	127
Sampling maximum depth (m)	100
Hydrographic sensor	CTD SBE25 and CTD SBE37
Flowmeter	Y
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 day 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

Table 2. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Descriptive characteristics of hauls and catches by species in weight (kg) from the fishing stations.**

Haul	Latitude	Longitude	Depth (m)	Anchovy	Sardine	Mackerel	Chub Mackerel	Horse Mackerel	Med.Horse Mackerel	Blue Jack Mackerel
01	36º 23.671 N	6º 25.626 W	55	0.41	-	0.13	1.54	-	-	-
02	36º 28.227 N	6º 27.442 W	52	52.00	9.04	1.07	2.82	-	7.39	-
03	36º 37.602 N	6º 33.736 W	43	0.21	4.15	0.15	33.85	-	16.80	0.08
04	36º 42.029 N	6º 44.672 W	72	37.80	-	0.39	0.10	-	-	-
05	36º 46.794 N	6º 42.551 W	37	41.20	2.83	0.28	15.95	-	2.03	-
06	36º 54.728 N	6º 55.248 W	62	13.15	-	1.66	2.40	-	1.90	-
07	36º 54.405 N	6º 58.947 W	83	127.45	-	6.56	32.70	-	0.29	0.02
08	37º 01.396 N	6º 59.344 W	41	64.54	0.16	0.46	1.67	-	0.11	-
09	37º 03.621 N	7º 06.479 W	41	17.85	-	0.26	7.98	1.91	0.82	0.05
10	36º 57.668 N	7º 16.699 W	99	17.80	-	5.24	4.24	-	-	-
11	37º 05.236 N	7º 25.848 W	35	16.45	25.25	3.64	19.35	4.10	0.39	0.05
12	36º 29.497 N	6º 25.044 W	41	147.25	88.85	2.52	9.39	2.27	13.70	-
13	36º 58.377 N	7º 07.588 W	77	76.70	-	42.60	79.20	-	-	-
14	36º 46.796 N	6º 53.095 W	90	39.00	-	9.58	0.15	-	-	-
15	36º 34.004 N	6º 41.949 W	100	10.25	-	0.51	0.02	-	-	-
16	37º 01.804 N	7º 34.808 W	83	0.43	-	4.40	1.16	0.17	-	0.14
17	37º 03.177 N	7º 36.399 W	39	-	0.07	0.84	1.64	9.61	-	2.03
18	36º 54.744 N	7º 56.069 W	73	0.72	7.85	13.15	50.15	1.93	-	28.75
19	36º 54.230 N	8º 06.830 W	80	92.00	32.05	2.38	5.23	1.62	-	258.20
20	36º 55.904 N	8º 05.867 W	50	-	24.55	4.49	63.05	-	-	3.93
21	36º 57.151 N	8º 24.710 W	84	2.78	0.05	1.25	0.94	1.23	-	18.04
22	36º 53.174 N	8º 35.389 W	113	6.34	0.06	2.95	53.65	0.45	-	0.94
23	36º 56.681 N	8º 45.043 W	109	-	-	1.47	0.04	7.87	-	0.30
24	36º 50.619 N	8º 14.277 W	115	-	41.99	1.14	945.52	0.16	-	130.78
25	36º 57.193 N	7º 46.278 W	90	48.08	-	2.02	138.16	0.08	0.55	3.79
26	36º 53.316 N	8º 25.765 W	122	23.34	-	4.51	217.00	0.24	0.09	0.13

Table 3. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Batch fecundity. Selected Generalized lineal model (GLM).**

```
Deviance Residuals:
   Min      1Q   Median     3Q     Max
-6625.0  -1805.3  -260.3  1686.0  9187.5

Coefficients:
            Estimate  Std.Error  t value  Pr(>|t|)
(Intercept)  -1703.58    833.50   -2.044   0.0422 *
  Wnov         696.46     44.32   15.716   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for gaussian family taken to be 7386978)

    Null deviance:  3427390994  on 218  degrees of freedom
Residual deviance:  1602974271  on 217  degrees of freedom
AIC: 4089. Number of Fisher Scoring iterations: 2
```

Table 4. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Daily spawning frequency estimates per haul according to different estimators. Last row shows the weighted mean values of the respective estimates with their associated coefficients of variation.**

Day 0	Day 1	Day 2	Day 3	No POFs
NA	NA	NA	NA	NA
0.3	0	0.35	0.38	0.12
0	0.24	0.18	0.5	0.06
1.41	0	0.15	0.12	0.03
0	0.19	0.25	0.5	0.06
0	0.22	0.25	0.42	0.06
1.76	0	0.12	0	0
0.22	0.22	0.22	0.34	0
0	0.24	0.22	0.43	0.11
1.07	0.3	0.13	0.03	0
0	0.06	0.48	0.39	0.06
NA	NA	NA	NA	NA
NA	NA	NA	NA	NA
0	0	0.17	0.47	0.37
0	0.83	0.13	0.03	0
0	0.56	0.22	0.12	0.09
0	0.15	0.45	0.3	0.03
0.34	0.34	0.14	0.29	0.03
0	0.21	0.41	0.26	0.12
0	0.29	0.16	0.47	0.08
0	0.19	0.26	0.48	0.06
0.28 [0.52]	0.22 [0.21]	0.24 [0.11]	0.31 [0.13]	0.07 [0.35]

Table 5. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Summary of results for egg, adults and SSB estimates.**

Parameter	Algarve	Cádiz	Total Gulf of Cádiz
Eggs 2008			
P0 (eggs/m2/day) (CV%)	184 (44.1)	348 (34.9)	-------
Z ($hour^{-1}$) (CV%)	-0.06 (29.4)		-0.06 (29.4)
P0 tot (eggs/day) ($x10^{12}$) (CV%)	0.31 (44.1)	1.80 (34.9)	2.11
Positive area (Km^2)	1690.44	5172.17	6862.61
Adults 2008			
Female Weight (g) (CV%)	23.67 (5.7)		
Batch Fecundity (CV%)	13.778 (6.6)		
Sex Ratio (CV%)	0.528 (0.5)		
Spawning Fraction (CV%)	0.218 (6.5)		
SSB 2008			
Spawning Biomass – tons (CV%)	4644 (45.4)	26883 (36.6)	31527

Table 6. ***BOCADEVA 0605*** **Gulf of Cádiz anchovy DEPM survey. Summary of revised results for egg, adults and SSB estimates.(1): previous estimates; (2) estimates after WKRESTIM.**

Survey	DEPM 2005 (1)		DEPM 2005 (2)	
Sampling area (km^2)	12329		11982	
Spawning area (km^2)	7279		6139	
Parameter/Stratum	Algarve	Cádiz	Algarve	Cádiz
Eggs 2005				
P_0 (eggs/m^2/day)	22.8 (1.0)	214.3 (0.56)	50.8 (0.8)	224.4 (0.69)
z (hour^{-1})	-0.072 (15)	-0.82 (0.67)	-0.039 (0.75)	
P_{tot} (eggs/day^{-1})	$0.03*10^{12}$	$1.08*10^{12}$	$0.07*10^{12}$ (0.76)	$1.06*10^{12}$ (0.65)
Adults 2005				
Sex Ratio	0.53 (0.09)	0.54 (0.09)	0.53 (0.01)	0.54 (0.01)
Female Weight	25.19 (0.16)	16.55 (0.21)	25.22 (0.03)	16.71 (0.04)
Batch Fecundity	13.80 (0.17)	11.47 (0.23)	13.82 (0.05)	11.16 (0.05)
Spawning Frequency	0.23 (0.32)	0.21 (0.27)	0.26 (0.07)	0.21 (0.07)
SSB 2005				
SSB (tons)	396.8 (0.81)	13821.9 (0.61)	963.3 (0.80)	13673.8 (0.66)
	14219		14673	

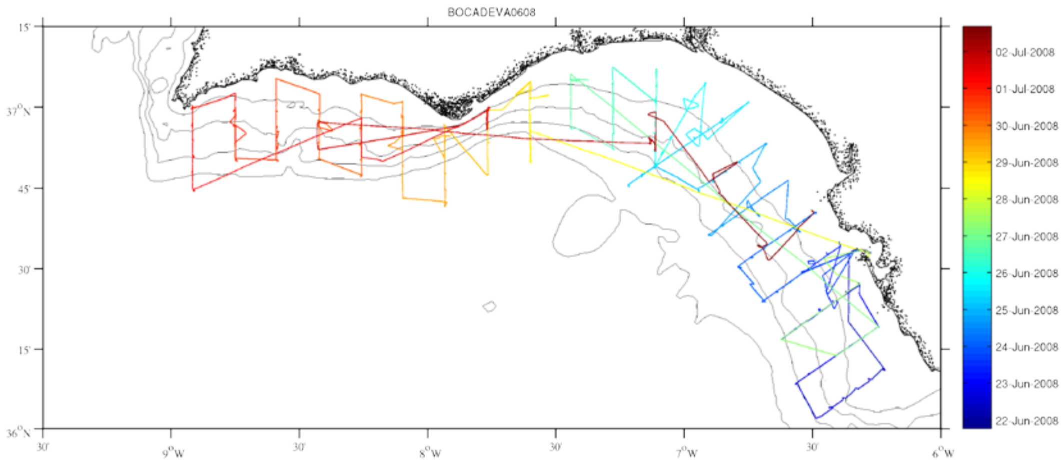


Figure 1. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Journey of the R/V Cornide of Saavedra during the survey. The palette of colours indicates the date (GMT).**

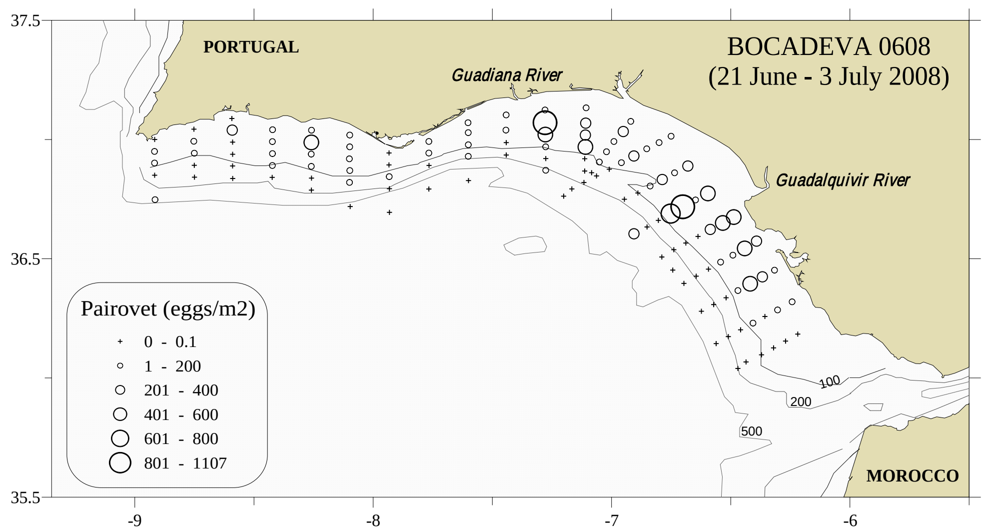


Figure 2. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Abundance distribution of anchovy eggs sampled with PairoVET.**

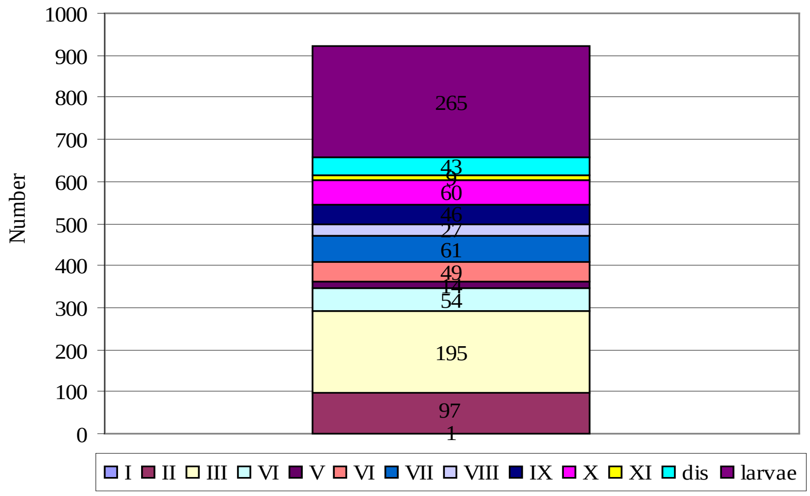


Figure 3. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Number of anchovy eggs classified into the different stages according to the development degree (PairoVET).**

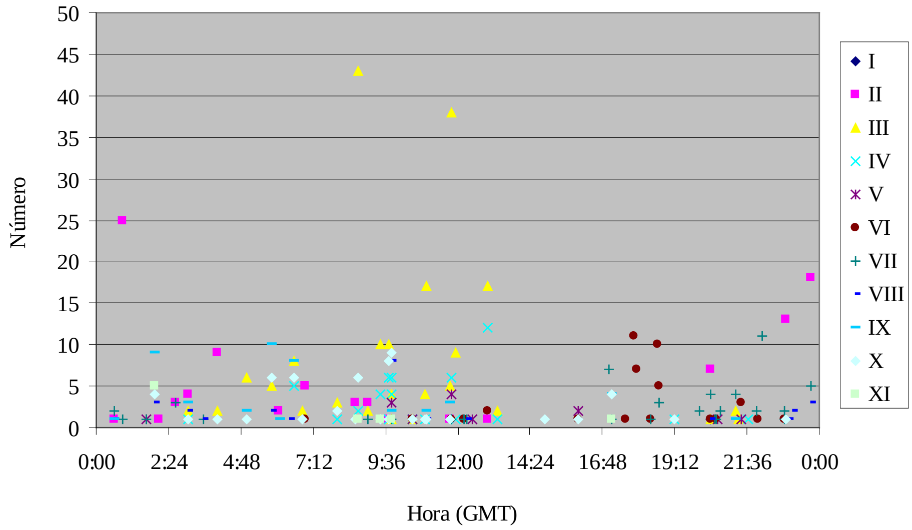


Figure 4. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Number of eggs caught by development stage by the sampling time (PairoVET).**

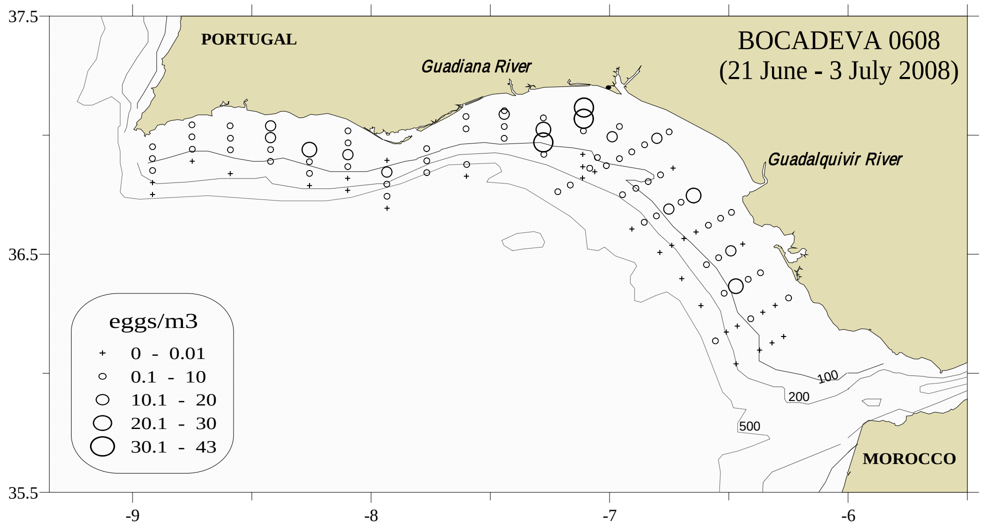


Figure 5. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Abundance distribution of anchovy eggs sampled with CUFES.**

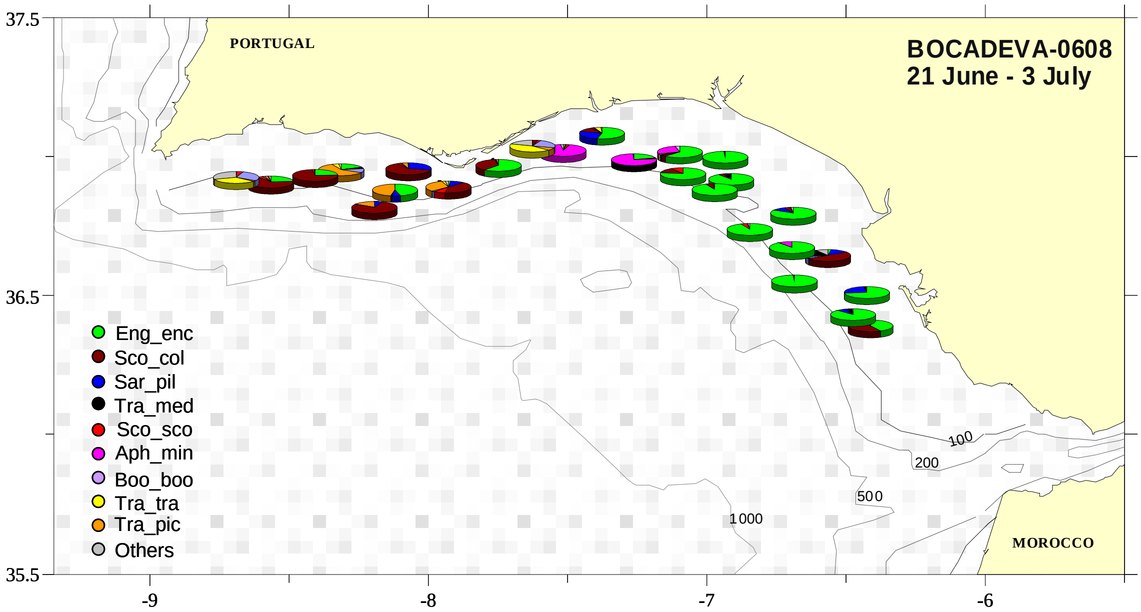


Figure 6. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Species composition from the pelagic trawl hauls.**

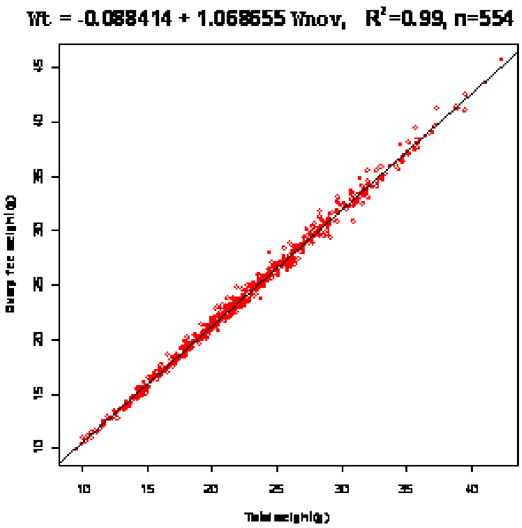


Figure 7. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Linear regression model for the relationship between non-hydrated females total weight (Wt) and ovary-free weight (Wnov).**

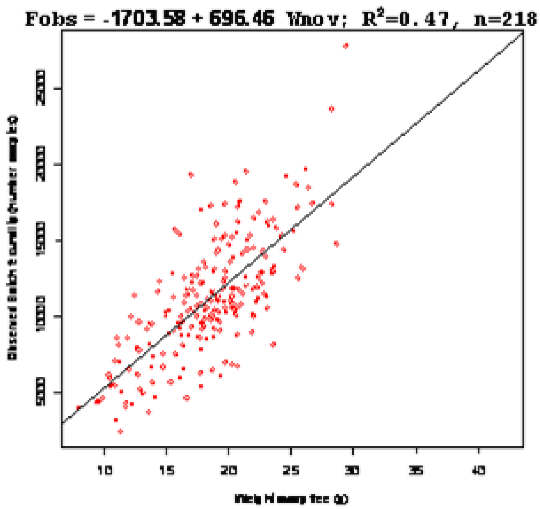


Figure 8. ***BOCADEVA 0608*** **Gulf of Cádiz anchovy DEPM survey. Generalized linear model for the relationship between observed individual batch fecundity (Fobs) and ovary-free weight (Wnov).**

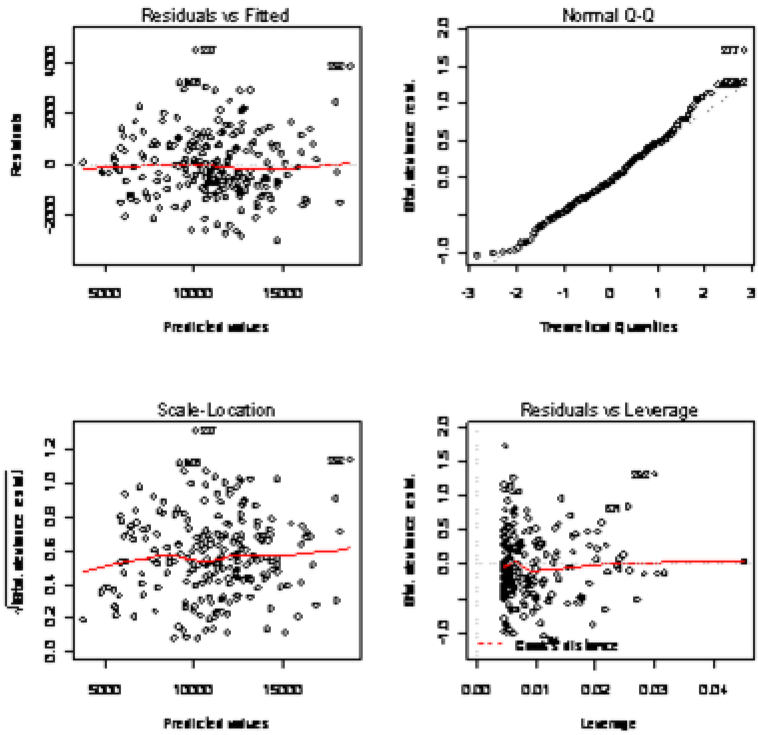


Figure 9. *BOCADEVA 0608* Gulf of Cádiz anchovy DEPM survey. Residual inspection plots for the Generalized Linear Model fitted to anchovy batch fecundity data.

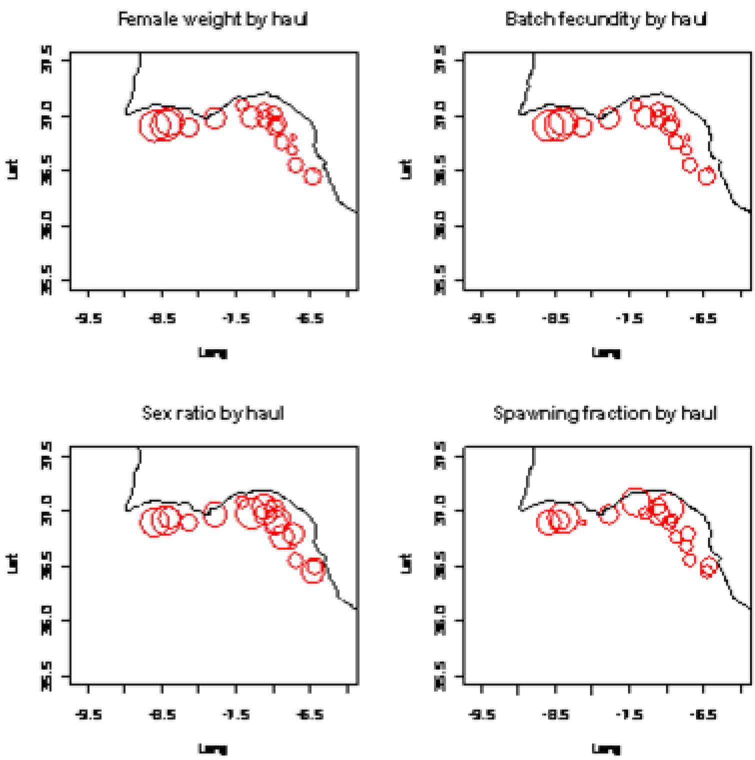


Figure 10. *BOCADEVA 0608* Gulf of Cádiz anchovy DEPM survey. Spatial distribution of mean estimates of the adult parameters per haul.

Annex 5 - Atlanto-Iberian sardine spawning biomass estimation through the application of DEPM in 2008

Miguel Bernal[1], Maria Manuel Angélico[2], Gersom Costas[1], Cristina Nunes[2], Ana Lago de Lanzós[1], José Ramon Perez[1], Concha Franco[1], Antonio Solla[1], Alexandra Silva[2], Yorgos Stratoudakis[2].

[1] Instituto Español de Oceanografía, Centros Oceanográficos de Cádiz, Santander, Vigo y Madrid.

[2] Instituto Nacional de Recursos Biologicos – INRB/IPIMAR. Av. de Brasília 1449-006, Lisboa, Portugal

Introduction

The DEPM for estimation of sardine spawning biomass within the Atlanto-Iberian stock area is conducted every three years by IPIMAR (Portugal) and IEO (Spain) in an internationally coordinated survey, planned under the framework of ICES WGACEGGS and executed with the co-financing of DCF. For this application, the entire stock area is surveyed from Cape Trafalgar in the Gulf of Cadiz to the north of the French/Spanish border in the Bay of Biscay; plankton samples, along a grid of parallel transects perpendicular to the coast, are obtained for spawning area delimitation and daily egg production density estimation; concurrently, fishing hauls are undertaken for estimation of adult parameters (sex ratio, female weight, batch fecundity and spawning fraction) within the mature component of the population. In 2008, the Portuguese survey took place in January/February covering the Atlantic waters from the entrance of the Strait of Gibraltar to the northern border of Portugal, while the Spanish survey took place in March/April covering the northern stock area from the river Minho to the south of the Armorican shelf (in French waters).

This working document provides a brief description of the survey, laboratory analysis and estimation procedures used to obtain the spawning stock biomass estimate for the 2008 DEPM application to the Atlanto-Iberian sardine stock. Estimation was based on procedures and software adapted and developed during the WKRESTIM that took place between 27-30/4/2009 in Madrid (with e-participation of IPIMAR members from Lisbon). Although estimation has not yet been validated by the WGACEGG, the extensive participation of people involved in sardine DEPM and the use of procedures and software adopted in previous applications provide sufficient guarantees that the estimate provided can be used for assessment purposes in WGANSA. However, the discrepancies between estimates derived from acoustics and DEPM surveying must be investigated to identify potential biases of both methods in recent times.

Material and Methods

Surveying

The Portuguese DEPM was carried out from 18 January to 17 February onboard RV Noruega, while the Spanish survey was undertaken using two vessels, from 2 to 27 of April onboard RV Cornide de Saavedra (for plankton sampling mainly) and from 23 March to 23 April using RV Thalassa to carry out the fishing hauls (Table 1). During both surveys, vertical plankton hauls were carried out following a pre-defined grid of sampling stations along transects perpendicular to the coast and spaced 8 nmiles

(Figure 1). The inshore limit of the transects was dependent on bottom depth (as close to the shore as possible), while the offshore extension was decided adaptively. The PairoVET sampler (=double CalVET) included 2 nets (Ø 25cm) with 150 μm mesh size and a CTDF probe; sampling covered the water column from bottom, or 150m (100 m for IEO) (beyond the 150 isobath) depth, to the surface. CUFES was used as the auxiliary egg sampler, helping in defining vertical hauls density and offshore extension of the transects. All plankton samples were preserved in formalin at 4% in distilled water and the 2 samples from each net stored in separate containers. For IPIMAR both nets were used for egg density estimates while IEO used 1 net (the other being used for plankton dried mass calculations).

Fishing hauls were conducted by pelagic or bottom trawling following sardine schools detection by the echo-sounder. The number of samples and its spatial distribution was organized to ensure good and homogeneous coverage of the survey area (Figure 2). In the Portuguese survey, the samples collected by the RV were complemented with samples obtained from commercial purse-seiners at Olhão, Portimão, Sines Setúbal, Sesimbra, Peniche, Figueira da Foz and Matosinhos. Samples from the fishing fleet were acquired within a week of the surveying by RV Noruega in each area (exception for F. da Foz, where a 2 week lag due to fishing seasonal closure).

Onboard the RV, and for each haul, a minimum of 60 sardines were randomly selected and biologically sampled. These could also be complemented by additional fish in order to achieve a minimum of 30 females per haul for histology, and/or to obtain extra hydrated females for the fecundity estimations. The biological sampling and ovaries fixation (with a 4% formaldehyde solution diluted in distilled water) were always carried out in fresh material, with the exception of 8 commercial samples for which the ovaries were removed from the fish body and preserved immediately after the fish were landed, while the remaining body of the fish was frozen for posterior biological sampling in laboratory.

Details of the methodologies are summarized in Tables 1 and 2.

Laboratorial work

In the laboratory, all sardine eggs were sorted from PairoVET and CUFES samples. The eggs from the vertical hauls (2 nets – IPIMAR, 1 net –IEO) were all counted and staged according to the 11 stages of development classification (adapted from Gamulin and Hure, 1955). For IPIMAR, the eggs from the CUFES survey were all counted and a sub-sample of a minimum of 100 was staged per sample; IEO counted total number of eggs onboard.

The preserved ovaries were weighted in laboratory and the obtained weights corrected by a conversion factor (between fresh and formaldehyde fixed material) established previously. These ovaries were then processed for histology: they were embedded in either resin (IEO) or paraffin (IPIMAR), the histological sections were stained with haematoxylin and eosin, and the slides examined and scored for their maturity state, POF presence and age assignment (Hunter and Macewicz 1985, Pérez et al. 1992a, Ganias et al. 2007). Prior to fecundity estimation, hydrated ovaries were also processed histologically in order to check for POF presence and thus avoid underestimating fecundity (Pérez et al. 1992b). The individual batch fecundity was then measured, by means of the gravimetric method applied to the hydrated oocytes, on 1-3 whole mount sub-samples per ovary, weighting on average 50-150 mg (Hunter et al. 1985).

Data analyses

All calculations for area delimitation, egg ageing and model fitting for egg production (P_0) estimation were carried out using the R packages (*geofun, eggsplore and shachar*) available within the open source project *ichthyoanalysis* (http://sourceforge.net/projects/ichthyoanalysis). The model of egg development with temperature was derived from the incubation experiment data available within the *sardata* R library. Egg ageing was achieved by a multinomial Bayesian approach described by Bernal *et al*. (2008) and using *in situ* SST. Prior distribution of the daily spawning cycle was assumed as a normal distribution, with a "peak" at 21:00h GMT and a standard deviation of 3 h. With these assumptions, daily spawning encompass half the daily cycle, from 15:00 GMT to 03:00 GMT (21 GMT ± 2 * 3 h) . The exponential model: $E[P] = P0\ e^{-Z\ age}$ was fitted by a Generalized Linear Model (GLM), assuming a negative binomial distribution. Eggs released within the spawning daily cycle (i.e. found before 03:00 GMT and with age less than 6 hours), as well as those with ages larger than the ones at which hatching start were excluded from the analysis to avoid bias (Lasker, 1985). The upper age cutting limit was estimated as the age at which eggs reared at the cumulative temperature that encompasses 95% of the eggs of a given stratum started to hatch (with a 5 % probability, based on incubation experiments; see Stratoudakis et al., 2006). Two different sets of strata were used in the analysis, based on previous analysis and the results found in this work (see Bernal et al., 2007):

- Three strata; **South**, encompassing from the strait of Gibraltar to Cape St. Vicente, **West**, from Cape St. Vicente to the northern limit between the Spain and Portugal, and **North**, between the Spanish-Portuguese northern limit and the Spanish-French Atlantic limit.
- Two strata; **South-West**, encompassing the Gulf of Cádiz and the Western Iberian coast up to the northern Portuguese Spanish limit (stratum south and west above), which includes the area covered by the Portuguese survey, and **North**, which coincides with the northern stratum defined above.

The first set of strata represent the current view of the different nuclei of the stock (Bernal et al., 2007, Silva 2007), while the second set of strata represent the area covered by the Portuguese and Spanish survey respectively, which were carried out with 2 months difference. Estimates of egg production and mortality were initially estimated independently for each stratum of the first set. Then, a series of tests were carried out in which estimates of mortality and/or egg production were aggregated first into the two strata of the second set and then into a unique estimate for all Atlanto-Iberia. The final model was selected using a combination of AIC criterion and a requisite of significance of the mortality estimates.

A spatial distribution of egg production using GAMs was also obtained. Those estimates were obtained with two sets of fixed mortality, i) the one used in the review of the historical series using GAMs carried out in Bernal et al. (in press) and ii) the estimates of mortality obtained in the traditional models described above. As none of these estimates were obtained in the same way as described in Bernal et al (in press) for the spatially-explicit estimates of egg production, egg production estimates from this analysis are considered preliminary and therefore not of use to the assessment working group.

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) (Pérez et al. 1992a, Ganias et al. 2007). The mean and variance of the adult parameters for all the samples collected was then obtained using the methodology from Picquelle and Stauffer 1985 (weighted means and variances). All estimations and statistical analysis were performed using the R software.

Results

Eggs

Sardine egg distribution, obtained from the PairoVET and CUFES systems, for the whole area is presented in Figure 1. The main sampler for the DEPM is the PairoVET net that collects eggs through the water column at point stations, the CUFES system operates at the surface collecting eggs while the vessel is underway; the latter sampling strategy is auxiliary intended to help defining the limits of the spawning area. Egg counts for the samples from the CUFES system are not yet available for both institutes and therefore are represented here as presence/absence information. The egg distribution pattern derived from the observations from both samplers is very similar. Almost the entire shelf (from coast to slope) was occupied by sardine eggs. Some zones of weaker density or gaps in the distribution were nevertheless observed, mainly in the NW coast, and that was particularly evident off southern Galicia (this is a recurrent feature). Spots of higher density occurred off Cadiz, W Algarve, in the W coast, south of Lisbon and over the NW wider platform, and in the W Cantabrian Sea. The surveys covered a total area of 90450 km2 of which 52478 km2 were considered the spawning area. In total 888 PairoVET hauls and 912 CUFES samples were obtained. The percentage of stations with sardine eggs was 52% for the vertical tows and 52% for the surface samples. In total approximately 21200 sardine eggs were captured (with the PaioVET nets) in the area studied. The oceanographic setting during the period of the surveys was the typical for the region. Measured SST ranged from 11.8 to 17.5ºC (maps in ICES - WGACEGG report 2008). The higher temperature values were observed in the southern area and the lower values registered for the Cantabrian Sea.

Final egg production model selected include an independent egg production estimate for the South, West and North stratum, while only two independent estimates of mortality; one for the South and West combined stratum, and one for the Northern stratum (Figure 3). The reason to choose this model include a low AIC, only larger than a model which includes a separate mortality estimate for the three strata, but in which mortality estimate of the southern stratum is not significantly different from zero. Total egg production estimate for the whole Atlanto Iberian stock vary around 15 % among all models tested. Preliminary GAM-based egg production estimates (results not shown) obtained from the two sets of mortality assumed are very stable in the north, and quite similar to the ones obtained in this analysis, and more variable in the west and southern area, with the traditional estimate located within the maximum and minimum value of the GAM estimates for both regions.

Egg production estimates were the highest of the series for the S and W strata and among the highest for the N, excluding 1988. Egg production in the S was higher than in the W as a result of high egg production density (eggs per day per square metre); this pattern was observed previously in 1997 and 1999 (Tables 4 and 5 and Figure 4). Also the distribution of eggs is in general more widespread than previous years of the series (Figure 5).

Adults

For the 2008 survey an effort was made to guarantee at least the same level of sampling already achieved in the 2002 and 2005 surveys, and effectively the objectives were more than accomplished. On the whole, around 85 fishing hauls which caught sardines were performed during the surveys covering the whole area and complemented by ca. 30 samples obtained from the Portuguese purse-seine fleet (Figure 2). On the whole, almost 7600 sardines were sampled and more than 2600 ovaries were collected, preserved and analysed histologically.

The N and NW coast of Spain presented values of mean female weight and batch fecundity similar to those obtained in other sardine DEPM years, with the Cantabrian Sea showing, as in previous years, the larger mean female weight values of the whole Iberian Peninsula. On the contrary, the Portuguese coast and Gulf of Cadiz showed the highest values of these parameters from the whole historical series, so that in 2008 spatial differences in whole Iberia appeared somewhat less contrasted than before (but still, sufficiently pronounced to justify post-stratification between the two surveys). In fact, the mode of females age distribution in the S and W areas was 4 years old (representing ca. a third of the total and likely corresponding to the 2004 strong recruitment). The minimum mean weights were observed in the Gulf of Cadiz, in the Bay of Biscay (mainly its inner part) and in the North of Portugal (indicating possible recruitment areas). The female weights observed in the Galician NW coast showed to be intermediate between the North coast of Portugal and the West Cantabrian Sea. The geographical distribution of the parameters in the S and W areas did not suggest the need for a spatial stratification in view of the adult parameters estimation. Concerning the spawning fraction and sex ratio estimates, this year's values are for the first time quite homogeneous across the whole Iberian Peninsula.

SSB estimate

The 2008 DEPM-based SSB estimate is the largest since 1997 (1988 is not included as southern area was not covered). The largest increase in relation to previous years is found in the southern area, with an increase larger than six fold the biomass estimated in 2005.

Biomass in the southern area is the highest estimate of the time series, while in the western area is also among the largest of the time series, with an intermediate value between the estimates of 2002 and 2005. In the northern area, the 2008 and 2005 estimates are comparable and in any case much lower than that of 1988 (not used in the assessment because it does not cover the southern area). It is important to note that SSB estimates for the northern area in 2005 are still under revision and current estimate is not considered reliable.

Brief discussion

The highest estimates in southern and western area found in 2008 are related to a combination of high egg productions and high mean weight. Egg production estimates in the western and southern area are the highest of the time series in those areas, although within the limits observed in the time series (taking into consideration the uncertainties reflected in the confidence intervals). The large egg production estimate in the southern area is sustained by a high egg production density (in eggs per day per square meter). This high egg production rate is similar to the production rate found for anchovy in the area (see WD DEPM based SSB estimates of Gulf of Cádiz anchovy), although the spawning area of sardine in the southern stratum is much higher than that of anchovy in the same area. In the western area, the high egg production rate is related both to a large spawning area and a relatively high egg production rate. It is important to note that DEPM-based SSB estimates for the northern area in 2005 are still pending revision and current estimates are not considered reliable. However, revised estimates are not expected to change the perception of the stock provided by the DEPM.

The estimates presented for 2008 are a priori considered reliable, as the sampling intensity was considered among the best in the time series, and the estimates are robust to a battery of tests on the underlying assumptions of the DEPM (daily spawning cycle, cutting points of the data used to estimate the parameters of the mortality curve, combination of strata used). The estimates of egg production are also in line to the preliminary estimates obtained with the spatial based egg production estimators. However, the large differences between the acoustic and DEPM-based SSB estimates should be investigated to identify potential biases of both methods in recent times (Figure 6). A revision of the time series of DEPM-based SSB estimates is expected for the next benchmark assessment for Atlanto-Iberian sardine.

References

Bernal, M., Stratoudakis, Y., Coombs, S., Angelico, M., Lago de Lanzós, A., Porteiro, C., Sagarminaga, Y., Santos, M., Uriarte, A., Cunha, E., Valdes, L. and Borchers, D. 2007. Sardine spawning off the European Atlantic coast: Characterization of and spatio-temporal variability in spawning habitat. Progress in Oceanography, 74: 210-227.

Bernal, M., Ibaibarriaga, L., Lago de Lanzós, A., Lonergan, M. E., Hernández, C., Franco, C., Rasines, I., Valdés, L., and Borchers, D. L. 2008. Using multinomial models to analyse data from Iberian sardine egg incubation experiments: a comparison with traditional techniques. –

ICES Journal of Marine Science, 65: 51–59.

Bernal, M., Stratoudakis, Y., Wood, S., Ibaibarriaga, L., Valdés, L. and Borchers, D.L. Submitted. A revision of the daily egg production estimation methods, with application to Atlanto-Iberian sardine (II): Spatially and environmentally explicit egg production estimates. ICES Journal of Marine Science.

Gamulin, T., and Hure, T. 1955. Contribution a la connaissance de l'ecologie de la ponte de la

sardine, Sardina pilchardus (Walb.) dans l'Adriatique. Acta Adriat. 7(8): 1-22.

Ganias K., C. Nunes, Y. Stratoudakis 2007. Degeneration of postovulatory follicles in the Iberian sardine *Sardina pilchardus*: structural changes and factors affecting resorption. Fish. Bull. 105:131–139.

Hunter, J.R., B.J. Macewicz 1985. Measurement of spawning frequency in multiple spawning fishes. In: Lasker (ed.) An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*. NOAA Tech. Rep. NMFS 36: 79–93.

Hunter J.R., N.C.H. Lo, R.J.H. Leong 1985. Batch fecundity in multiple spawning fishes. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. NOAA Tech. Rep. NMFS 36: 66-77.

ICES 2008. Report of the Working Group on Acoustic and Egg Surveys for Sardine and

Anchovy in ICES Areas VIII and IX (WGACEGG), 26_30 November 2008, Nantes, France. ICES CM 2008/LRC:17. 181 pp.

Pérez N., I. Figueiredo, B.J. Macewicz 1992a. The spawning frequency of sardine, *Sardina pilchardus* (Walb.), off the Atlantic Iberian coast. Bol. Inst. Esp. Oceanogr. 8:175−189.

Pérez N, Figueiredo I, Lo NCH 1992b Batch fecundity of sardine, *Sardina pilchardus* (Walb.), off the Atlantic Iberian coast. Boletin del Instituto Español de Oceanografia **8**: 155-162.

Picquelle S., Stauffer G. 1985. Parameter estimation for an egg production method of northern anchovy biomass assessment. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. NOAA Tech. Rep. NMFS 36: 43-50.

Silva, A. 2007. Geographic variation in sardine population traits: implications for stock assessment. PhD thesis, Universidad do Algarve. 235pp.

Stratoudakis, Y. Bernal, M., Ganias, K. and Uriarte A. 2006. The daily egg production methods: recent advances, current applications and future challenges. Fish and Fisheries, 7: 35-57.

Table 1. General Sampling DEPM 2008

DEPM Surveys	Portugal (IPIMAR)	Spain (IEO)
Survey area	Portugal & Gulf of Cadiz	NW and N Spain
SURVEY EGGS	DEPM08	SAREVA0408
R/V	Noruega	Cornide de Saavedra
Date	18/01-17/02	2-27/04
Transects (Sampling grid)	57 (8x3)	62 (8x3)
PairoVET stations (nets)	462 2	426 1
PairoVET stations with sardine eggs (%) + tot eggs from 2 nets	53 13622	54 ~ 3788*2 (only 1 counted)
Sampling maximum depth (m)	150	100
Hydrographic sensor	CTDF (FSI)	CTD (Seabird37) CTD SBE25
Flowmeter	Y	Y
Clinometer	Y	Y
CUFES, mesh 335µm	3nmilles (sample unit)	3nmilles (sample unit)
CUFES stations	497	415
CUFES stations with sardine egg (%) + tot number of eggs	55 30339	51 17117
Environmental data	temperature, salinity fluorescence	temperature, salinity, fluorescence (surface only)
SURVEY ADULTS	DEPM08	PELACUS0408
R/V	Noruega	Thalassa Cornide de Saavedra (3T)
Gears	Pelagic and Bottom trawl, purse-seiner	Pelagic trawl
Date	18 January-17 February	24 March-23 April
Trawls	51 (44+) +34 (commercial purse seiners)	42 (36+)
Trawls time	07:00-19:00 (01:00-22:00, commercial)	07:00-21:00
Biological sampling:	On fresh material, on board of the R/V and on frozen for commercial; gonads fresh	On fresh material, on board of the R/V
Sample size	60 indiv randomly (30 female minimum); extra if needed and if hydrated found	60 indiv randomly (30 mature female); extra if needed and if hydrated found
Fixation	Buffered formaldehyde 4% (distilled water)	Buffered formaldehyde 4% (distilled water)
Preservation	ethanol 70º	formalin

Table 2. Processing and analyses for eggs and adults

DEPM Processing 2008	Portugal (IPIMAR)	Spain (IEO)
EGGS		
PairofVET Eggs staged (n egg) (stages from Gamulin and Hure, 1955)	All (2 nets)	All (1 net)
CUFES Eggs staged (stages from Gamulin and Hure, 1955)	In the lab, all or sub-sample if more than 100 per sample	No
Temperature for egg ageing	Surface (continuous underway CTF)	10 m
Peak spawning hour	21 (PDF 21 ± 2 * 3)	(PDF 21 ± 2 * 3)
Egg ageing	Bayesian (Bernal et al, 2008)	Bayesian (Bernal et al, 2008)
Egg Production	GLM	GLM
ADULTS		
Histology: - Embedding material - Stain	 Paraffin Haematoxilin-Eosin	 Resin Haematoxilin-Eosin
S estimation	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)	Day 1 and Day 2 POFs (according to Pérez et al. 1992a and Ganias et al. 2007)
R estimation	The observed weight fraction of the females	The observed weight fraction of the females
F estimation	On hydrated females (without POFs), according to Pérez et al. 1992b	On hydrated females (without POFs), according to Pérez et al. 1992b

Table 3. Results DEPM 2008

Parameter	South	W Portugal	NW and N Spain	Total
Eggs 2008				
P0 (eggs/m2/day) (CV%)	527 (25.3)	220 (23.34)	109 (20)	-------
Z ($hour^{-1}$) (CV%)	0.03 (25.7)		0.01 (38.7)	--------
Daily mortality rate (%)	63.7 (25.7)		30.9 (38.7)	--------
P0 tot (eggs/day) ($x10^{12}$) (CV%)	4.91 (25.3)	4.17 (23.2)	2.64 (20)	--------
Survey area (Km^2)	17646.96	30481.31	42321.25	90449.52
Positive area (Km^2)	9315.15	18960.29	24202.55	52477.99
Adults 2008	South	W Portugal	NW and N Spain	
Survey trawls (with sardine)	32 (27)	19 (17)	41(36)	--------
Commercial trawls	8	26	NA	--------
Total sardine sampled	1579	3317	2361	--------
Female for histology	754	1643	594	--------
Hydrated females	130	101	180	--------
Variable				
Female Weight (g) (CV%)	57 (5)	59.2 (3.5)	81.9 (5)	--------
Batch Fecundity (CV%)	20966 (5.5)	25831 (4.4)	34023 (7.2)	--------
Sex Ratio (CV%)	0.52 (1.2)	0.52 (0.6)	0.51 (0.8)	--------
Spawning Fraction (CV%)	0.086 (7.8)	0.075 (10)	0.088 (18.1)	--------
Spawning Biomass – thousand tons (CV%)	300 (27.6)	245 (26)	142 (29.5)	687 (16)

Table 4: DEPM parameter estimates and sardine spawning biomass for the Spanish surveys (northern Spain) over 1997-2008, using traditional estimation. Post-stratification was only considered necessary in 2002. The spawning fraction for 2005 is considered to be bias (overestimated) and pending revision

	1997	1999	2002	2005	2008
Egg Production (Po, 10^12)	0.72 (82)	0.34 (44)	GAL: 0 WCAN: 0.66 (32) ECAN: 0.20 (31)	3.50 (21)	2.64 (20)
Mean female weight (W)	70.1 (6)	66.3 (41)	GAL: 67.6 (11) WCAN: 78.6 (8) ECAN: 77.7 (6)	78.5 (22)	81.9 (5)
Batch fecundity (F) (1000 eggs)	26.5 (5)	21.8 (12)	GAL: 23.6 (13) WCAN: 27.7 (8) ECAN: 26.9 (6)	32.3 (20)	34.0 (7)
Spawning fraction (S)	0.18 (15)	0.14 (26)	GAL: 0.24 (38) WCAN: 0.07 (14) ECAN: 0.12 (20)	0.06 (40)	0.09 (18)
Sex ratio (R)	0.52 (11)	0.55 (45)	GAL: 0.52(7) WCAN: 0.60(14) ECAN: 0.49 (22)	0.52 (7)	0.51 (1)
SSB	20.7 (84)	13.4 (77)	50.7 (33)	154.5 (29)	142 (30)

Table 5: DEPM parameter estimates and sardine spawning biomass for the Portuguese surveys (Portugal and Gulf of Cádiz) over 1997-2008, using traditional estimation, with and without post-stratification into western and southern area (egg production x10 ^{12}; weight in g; batch fecundity x10^{3}; SSB tonnes x10^{3}; CVs %)

Year	Variable	SOUTH	W PORT	Total (Strata sum)	Total (no Strata)
1997	Egg production	3.24 (39)	1.10 (34)		4.72 (32)
	Female weight	43.1 (7)	48.5 (7)		46.6 (5)
	Batch fecundity	16.1 (6)	18.0 (6)		17.4 (5)
	Spawning fraction	0.061 (24)	0.060 (25)		0.060 (17)
	Sex ratio	0.576 (6)	0.659 (4)		0.609 (4)
	Spawning biomass	246.9 (47)	75.0 (44)	321.9 (37)	345.2 (37)
1999	Egg production	3.15 (34)	2.07 (30)		5.00 (35)
	Female weight	42.1 (6)	45.8 (6)		44.8 (5)
	Batch fecundity	17.6 (6)	18.6 (6)		18.4 (5)
	Spawning fraction	0.070 (32)	0.133 (19)		0.113 (17)
	Sex ratio	0.540 (7)	0.681 (5)		0.602 (5)
	Spawning biomass	199.3 (48)	56.3 (37)	255.6 (38)	179.0 (40)
2002	Egg production	0.89 (36)	1.32 (24)		1.69 (24)
	Female weight	40.0 (5)	45.1 (5)		42.5 (4)
	Batch fecundity	12.6 (6)	14.5 (7)		13.5 (5)
	Spawning fraction	0.038 (31)	0.024 (27)		0.030 (21)
	Sex ratio	0.612 (5)	0.608 (3)		0.610 (3)
	Spawning biomass	121.5 (48)	281.4 (37)	402.9 (31)	302.8 (33)
2005	Egg production	1.21 (39)	3.04 (34)		3.76 (27)
	Female weight	46.4 (7)	45.4 (6)		45.7 (5)
	Batch fecundity	18.6 (8)	18.9 (7)		18.8 (5)
	Spawning fraction	0.122 (15)	0.060 (15)		0.079 (11)
	Sex ratio	0.512 (13)	0.564 (6)		0.545 (6)
	Spawning biomass	48.3 (45)	215.8 (39)	264.1 (33)	212.3 (31)
2008	Egg production	4.91 (25)	4.17 (23)		9.22(22)
	Female weight	57.0 (5)	59.2 (4)		58.4 (3)
	Batch fecundity	21.0 (5)	25.8 (4)		23.5 (3)
	Spawning fraction	0.086 (8)	0.078 (10)		0.079 (7)
	Sex ratio	0.518 (1)	0.520 (1)		0.519 (1)
	Spawning biomass	300 (28)	245 (26)	545 (27)	558.8(24)

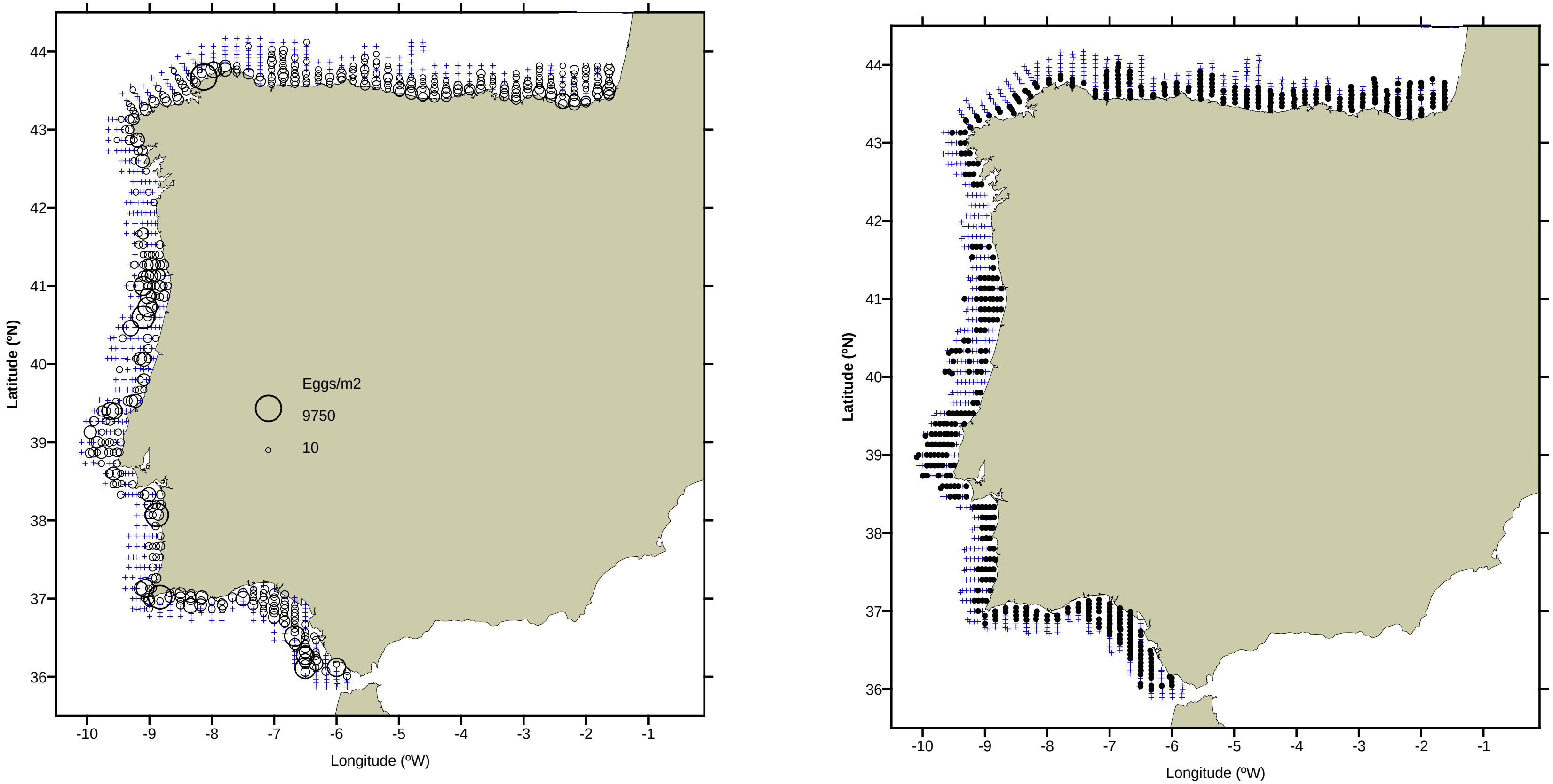


Figure 1. Sardine egg distribution. Left panel: Egg/m2 from PairoVET sampling; Right panel: Egg presence/absence from CUFES sampling; (+, egg absence).

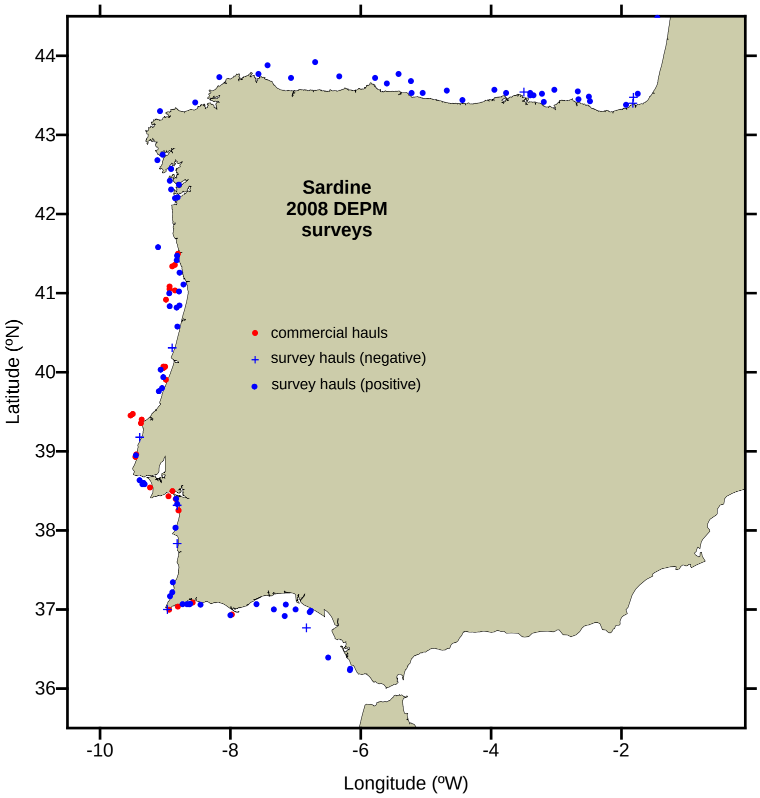


Figure 2. Spatial distribution of the fishing hauls

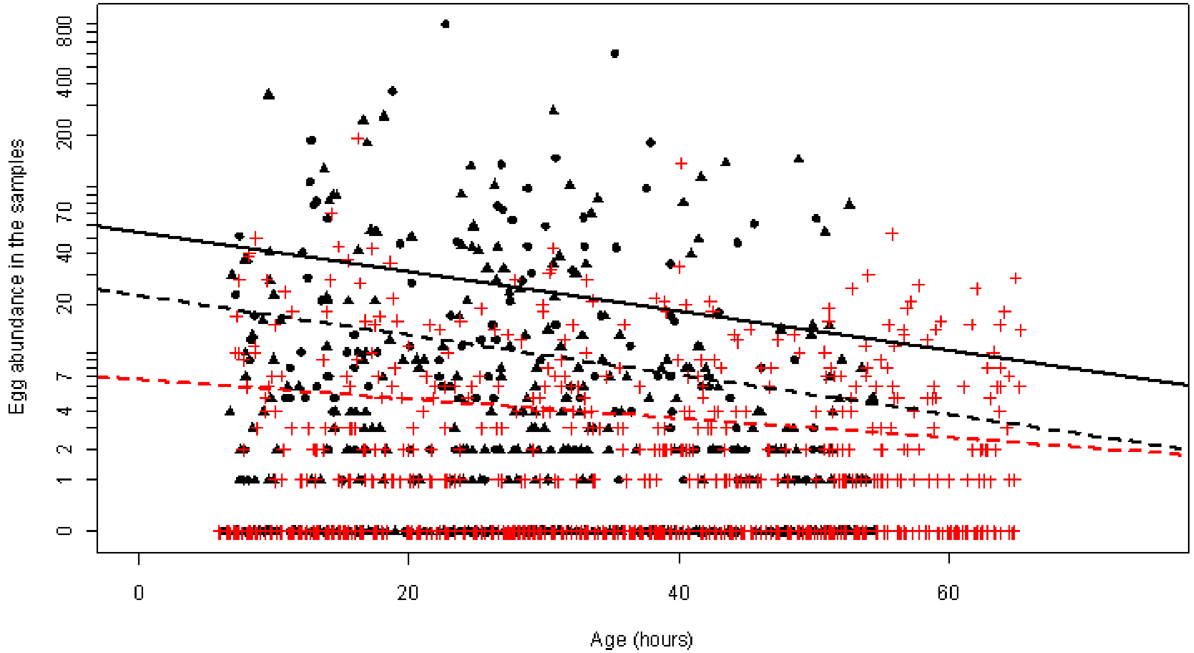


Figure 3: Abundance by age of eggs in the different spatial stratum (black circles = south stratum, black triangles = west Stratum, red crosses = north stratum) and its corresponding fitted mortality curve (black solid = south Stratum, black dashed = west Stratum and red dashed = north Stratum). Note that southern and western mortality curves were forced to have a common slope (mortality) and that duration of the egg phase is larger in the northern stratum, due to lower temperatures.

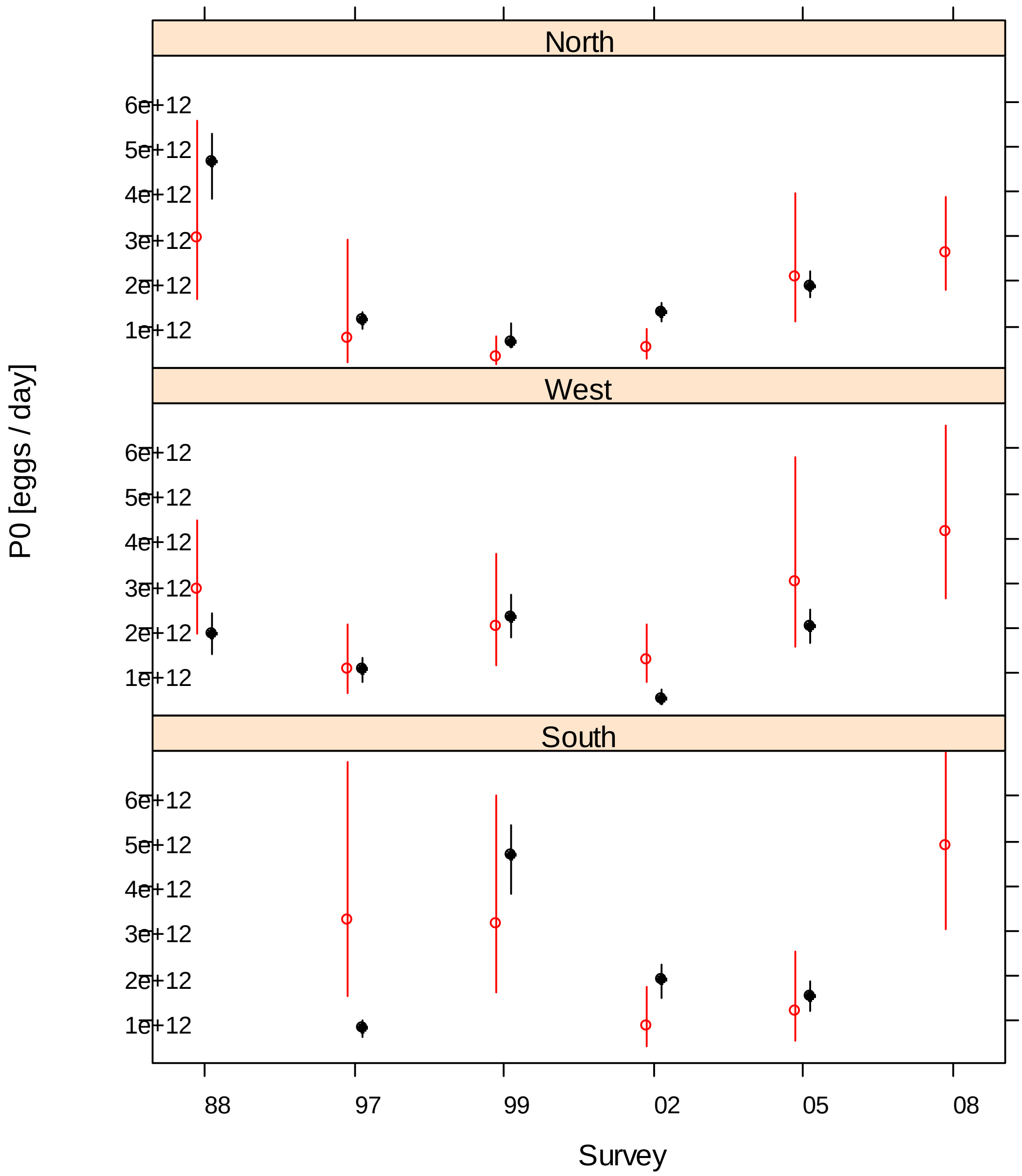


Figure 4: Time series of traditional (red) and GAM-based (black) egg production estimates in the three strata (north, west and southern Atlantic Iberia). Vertical lines indicate confidence intervals (updated from Bernal et al. submitted).

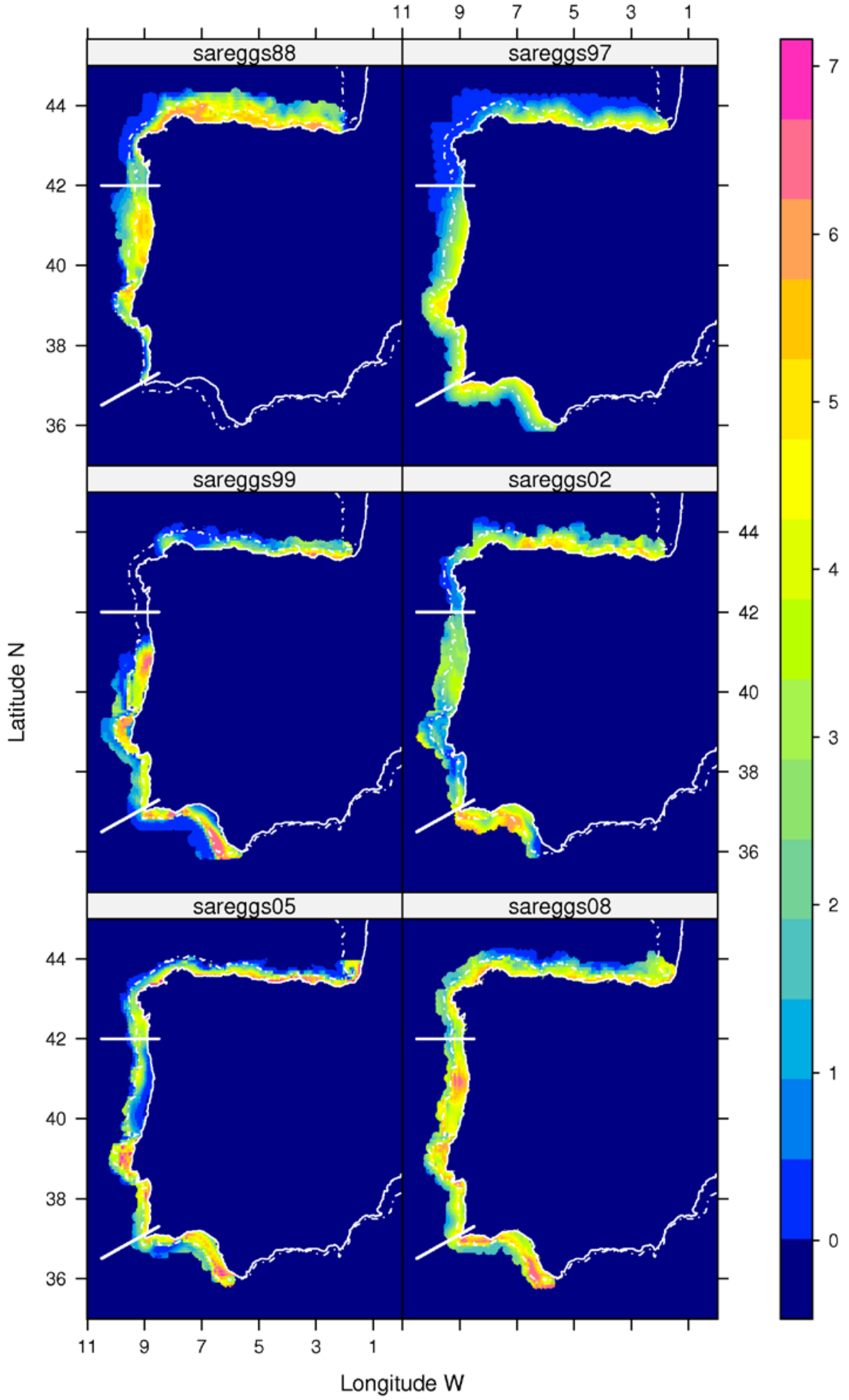


Figure 5: distribution of egg production in space using GAMs

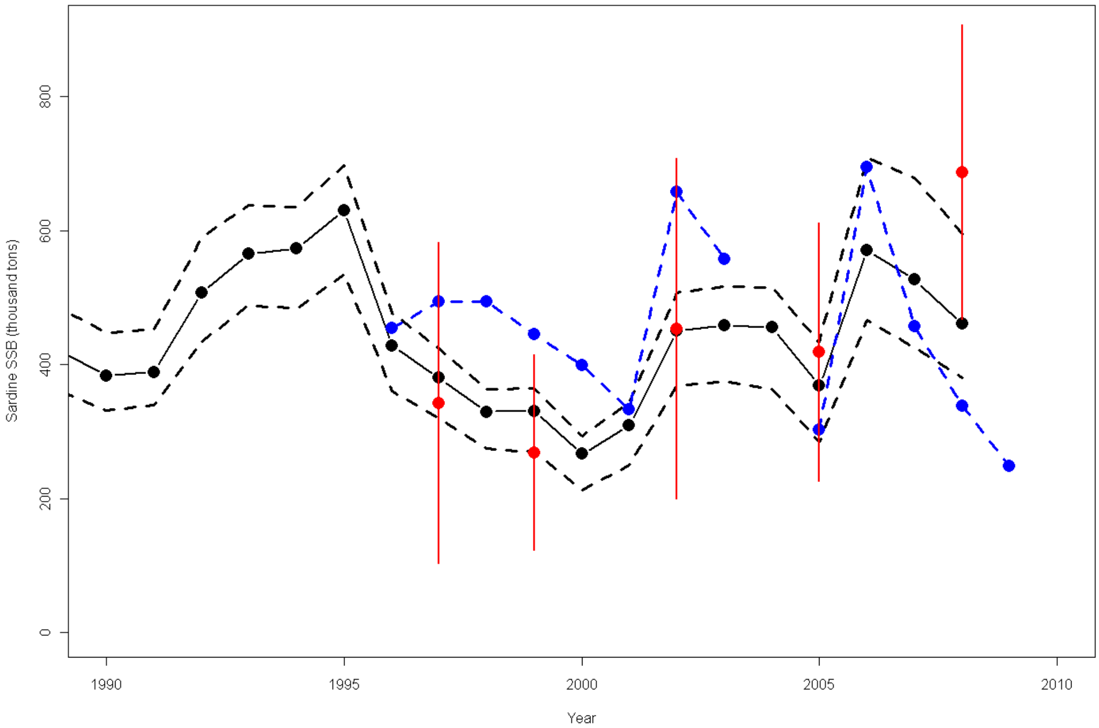


Figure 6: Time series of the acoustic (blue) and DEPM (red) based SSB estimates. Vertical red bars indicate the DEPM-based SSB approximate 95% confidence intervals. Black lines indicate the sardine assessment estimates, with 80% confidence intervals (10-90 percentiles from bootstrap estimates in AMCI).

Stock Annex – Anchovy in Division IXa

Quality Handbook ANNEX: 3

Stock specific documentation of standard assessment procedures used by ICES.

This is a preliminary version, that will be further elaborated inter-sessionally

Stock	Anchovy in Division IXa
Working Group:	WGANSA (Working Group on the Assessment of Anchovy and Sardine)
Date:	19th June 2009
Revised by	………..

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 (Subdivision IXa-South(C), **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, 2007b) 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).

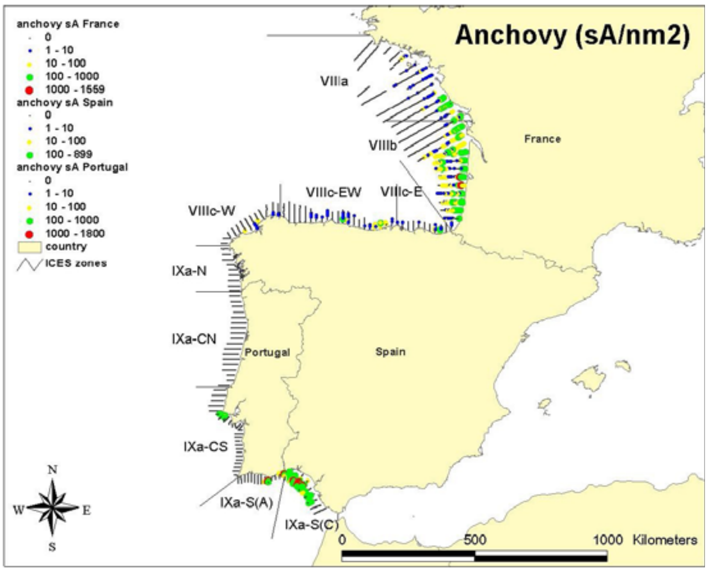


Figure A.1.1. Distribution of acoustic energy allocated to anchovy from the combined 2007 acoustic surveys off Iberia and the Armorican shelf (from ICES, 2007b).

Despite the known fluctuations in anchovy distribution and abundance along the Atlantic European waters, and even in the current low abundance situation in the Bay of Biscay, both the Bay of Biscay and the Gulf of Cádiz continue to be regarded as the main nucleus for Atlanto-European anchovy. Migration intensity between those main nucleus and surrounding areas are however unknown and data for Atlanto-European anchovy outside the main nucleus is scarce and is not routinely reported to ICES WG on the assessment of these stocks (WGMHSA, WGANC, WGANSA).

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
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 Subdivisions IXa-North (Southern Galicia) and IXa-South (Gulf of Cádiz), and the Portuguese ones along its national fishing grounds (Subdivisions IXa-Central North, -Central South and South (Algarve)). Most of the fishery for this anchovy stock in the Division takes place in Subdivision IXa-South (C), where anchovy is the target species. The fleets in the northern part of Division IXa 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).

Details on the purse-seine vessels operated by Spain in the Gulf of Cadiz (the main responsible for the anchovy harvesting in the whole Division), differentiated between total operative fleet and fleet targeting anchovy, are given in **Table A.2.1** and **Figure A.2.1**.

Table A.2.1. Anchovy in Division IXa. Spanish purse-seine fleet composition in the Gulf of Cadiz (differentiated into total fleet and vessels targeting anchovy) in 2008. Length criteria refers to length between perpendiculars.

Total number of operative purse-seiners

1999	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	16	23	20	1	0	60
11-15	0	7	28	16	0	51
16-20	0	0	2	20	1	23
>20	0	0	0	3	0	3
Total	16	30	50	40	1	137

2000	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	14	13	27	1	0	55
11-15	1	7	33	6	0	47
16-20	0	0	0	2	0	2
>20	0	0	0	0	0	0
Total	15	20	60	9	0	104

2001	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	11	18	20	1	0	50
11-15	1	8	33	8	0	50
16-20	0	0	1	5	0	6
>20	0	0	0	0	0	0
Total	12	26	54	14	0	106

2002	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	8	16	20	0	0	44
11-15	1	10	27	16	0	54
16-20	0	0	4	17	0	21
>20	0	0	0	2	0	2
Total	9	26	51	35	0	121

2003	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	9	15	15	1	0	40
11-15	2	11	29	15	0	57
16-20	0	0	4	21	0	25
>20	0	0	0	0	0	0
Total	11	26	48	37	0	122

2004	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	11	12	19	0	0	42
11-15	2	16	46	16	0	80
16-20	0	0	3	20	0	23
>20	0	0	0	0	0	0
Total	13	28	68	36	0	145

2005	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	5	9	16	0	0	30
11-15	1	13	30	16	0	60
16-20	0	0	2	19	0	21
>20	0	0	0	0	0	0
Total	6	22	48	35	0	111

Purse-seiners targeting anchovy

1999	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	9	21	19	1	0	50
11-15	0	6	25	16	0	47
16-20	0	0	2	19	0	21
>20	0	0	0	3	0	3
Total	9	27	46	39	0	121

2000	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	10	11	26	1	0	48
11-15	1	7	30	6	0	44
16-20	0	0	0	2	0	2
>20	0	0	0	0	0	0
Total	11	18	56	9	0	94

2001	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	8	14	20	1	0	43
11-15	1	8	29	6	0	44
16-20	0	0	1	2	0	3
>20	0	0	0	0	0	0
Total	9	22	50	9	0	90

2002	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	4	13	19	0	0	36
11-15	1	9	25	13	0	48
16-20	0	0	2	17	0	19
>20	0	0	0	2	0	2
Total	5	22	46	32	0	105

2003	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	5	11	15	0	0	31
11-15	2	10	27	14	0	53
16-20	0	0	3	20	0	23
>20	0	0	0	0	0	0
Total	7	21	45	34	0	107

2004	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	11	12	19	0	0	42
11-15	2	15	40	14	0	71
16-20	0	0	3	19	0	22
>20	0	0	0	0	0	0
Total	13	27	62	33	0	135

2005	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	5	8	14	0	0	27
11-15	1	13	28	16	0	58
16-20	0	0	2	19	0	21
>20	0	0	0	0	0	0
Total	6	21	44	35	0	106

Table A.2.1 cont.

Total number of operative purse-seiners

2006	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	6	8	12	0	0	26
11-15	1	13	31	18	0	63
16-20	0	0	3	20	0	23
>20	0	0	0	1	0	1
Total	7	21	46	39	0	113

2007	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	7	5	15	0	0	27
11-15	3	15	26	17	0	61
16-20	0	0	5	14	1	20
>20	0	0	0	4	0	4
Total	10	20	46	35	1	112

2008	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	1	0	1	0	0	2
11-15	2	16	15	3	0	36
16-20	0	3	18	15	0	36
>20	0	0	1	15	1	17
Total	3	19	35	33	1	91

Purse-seiners targeting anchovy

2006	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	4	6	11	0	0	21
11-15	1	10	28	16	0	55
16-20	0	0	2	18	0	20
>20	0	0	0	0	0	0
Total	5	16	41	34	0	96

2007	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	2	3	12	0	0	17
11-15	3	13	20	14	0	50
16-20	0	0	3	13	1	17
>20	0	0	0	4	0	4
Total	5	16	35	31	1	88

2008	Engine (HP)					
Length (m)	0-50	51-100	101-200	201-500	>500	Total
<10	1	0	1	0	0	2
11-15	2	16	14	3	0	35
16-20	0	3	18	15	0	36
>20	0	0	1	11	1	13
Total	3	19	34	29	1	86

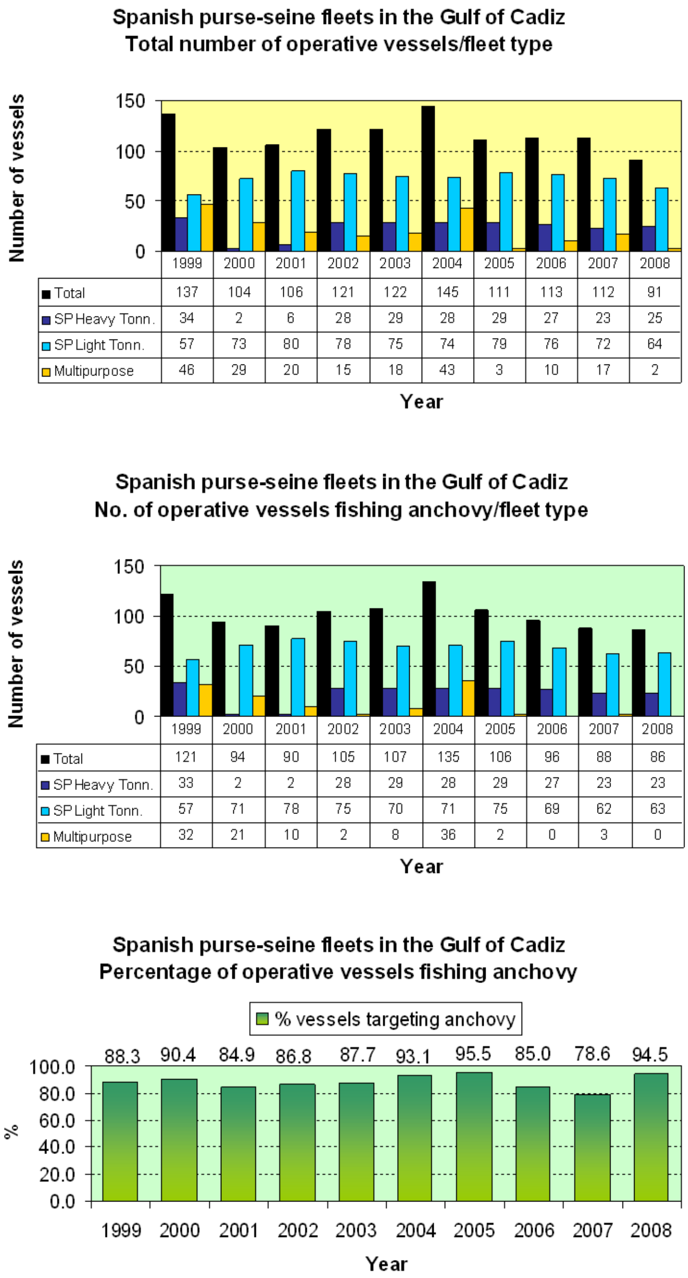


Figure A.2.1. Anchovy in División IXa. Spanish purse-seine fleet composition in the Gulf of Cadiz (Subdivision IXa-South) since 1999. The fleet is differentiated into total fleet and vessels targeting anchovy. The categories include both single purpose purse-seiners and trawl and artisanal vessels fishing with purse-seine in some periods through the year (multi-purpose vessels).

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*, Clustering *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.

Since 1999 the number of Gulf of Cádiz purse-seiners has oscillated between 145 (in 2004) and 104 (in 2000) vessels, and the vessels within this fleet targeting anchovy between 90 (2001) 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. In 2008, the entire Spanish purse-seine fleet fishing in the Gulf of Cadiz was composed by 91 vessels, with 86 vessels dedicated in a greater or lesser extent to the anchovy fishing. 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, wich entailed an important reduction of the fishing effort in the Gulf of Cádiz.

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 (Subdivision IXa-South(C)). Since 2004, two complementary sets of management measures have been in force in this part of the Subdivision. 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. 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 sourrounding 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.2.2**). 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.2.2. Anchovy in Division IXa. Limits of the Fishing Reserve off the Guadalquivir river mouth (Spanish Gulf of Cadiz. Subdivision 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.

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 Subdivisions are available since 1943. Spanish landings started to be available since 1989. **Figure B.1.1** describes the most recent (1989 – 2008) landings trajectory for the period with available data for the whole Division. Landings for the whole Division oscillate between 13 thousand tonnes (1995) and 2 thousand tonnes (1993). Average landings are estimated at 5.6 thousand tonnes. Landings in 2008 were below this average (3,5 thousand tonnes). By comparing the figures from **Figure B.1.1** is evidenced that the bulk the fishery recently occurs in the Southernmost Subdivision.

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 are expected to be gathered since 2009 on within the Spanish National Sampling Scheme framed into the EC Data Collection Regulation (DCR).

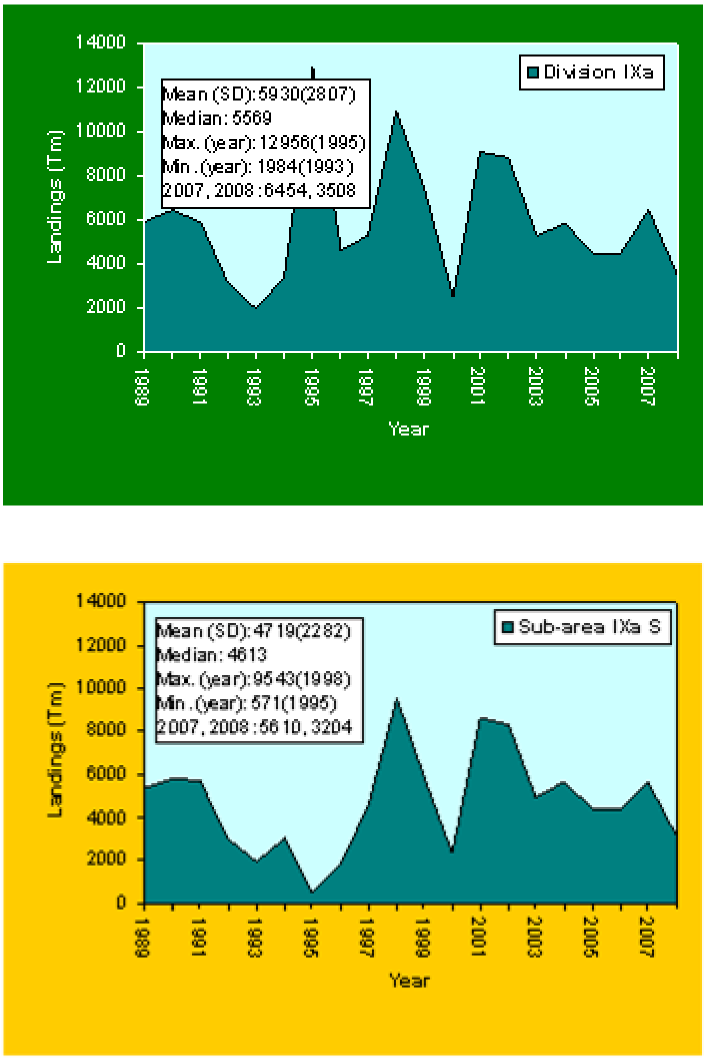


Figure B.1.1. Anchovy in Division IXa. Recent (1989-2008) series of anchovy landings in Division IXa (upper panel). Series for the whole Sub-area IXa-South is also shown (lower panel).

B.2. Biological

Annual and quarterly length compositions of anchovy landings in Division IXa are routinely provided by Spain for its Subdivision IXa-South(C). This series dates back to 1988. Length distributions for the Spanish fishery in Subdivision IXa-North are only available for the 1995-1999 period and they were characterised, with the expception of 1998, by fish larger than 12.5 cm (ICES, 2007 a). Portugal does not currently provide neither length distributions nor 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 (Subdivision 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 2008, with contributions oscillating between 2% and 14%). Likewise, age-3 anchovies only occurred in the first quarter in 1992 and 2008 but their importance in the total annual catch that year 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 Subdivision 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 Subarea VIII, natural mortality is probably high (M=1.2 is used for the data exploration).

B.3. Surveys

B.3.1. Acoustic surveys

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
Portuguese Surveys	Q1				Mar		Mar	Mar	Feb						
	Q2									Jun	Apr	Apr	Apr	Apr	Apr
	Q3														
	Q4			**Nov**		**Nov**	**Nov**		Nov		Nov	Nov	**Nov**	Nov	
Spanish Surveys	Q1							Feb							
	Q2	Jun								Jun		Jun			
	Q3												Jul		
	Q4														

The IPIMAR's Portuguese surveys series (*SAR* and *SARNOV* series) 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 Subdivision IXa-South, where the species diversity is higher, changing the series its former name by the one of *PELAGOS* surveys. Anchovy estimates from these survey series started to be available since November 1998.

Spanish 'pelagic community' acoustic surveys have been conducted by IEO in Subdivision IXa North and Division VIIIc since 1983 (the spring *PELACUS* series). Results from these surveys for the Subdivision 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 2003-2009 period, see Porteiro *et al*., 2005; Iglesias *et al*., 2007; this present WG). For these reasons, this series has not included in the table above.

Spanish acoustic surveys in the Gulf of Cadiz waters (Subdivision 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, as it happened in 2005 and in 2008 as well, 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.

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 assessment of anchovy in Subdivision IXa South (Algarve and Gulf of Cadiz). They correspond to the spring Portuguese survey series. Those surveys from the November series in bold letter provided anchovy estimates but they are not presently considered in the 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 the one in dark grey the whole Subdivision IXa South.

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 *PELAGOS* 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'.

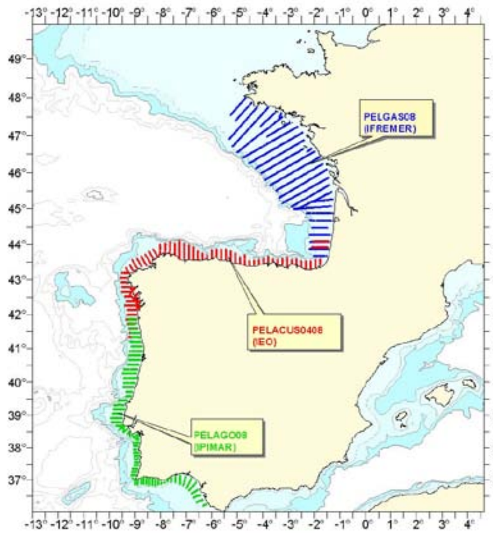


Figure B.3.1.1. Transects surveyed by the Spring *PELAGOS*, *PELACUS* and *PELGAS* surveys. The early Summer *ECOCÁDIZ* surveys samples the same area that the *PELAGOS* one in the Gulf of Cádiz waters (from Cape San Vicente to Cape Trafalgar).

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

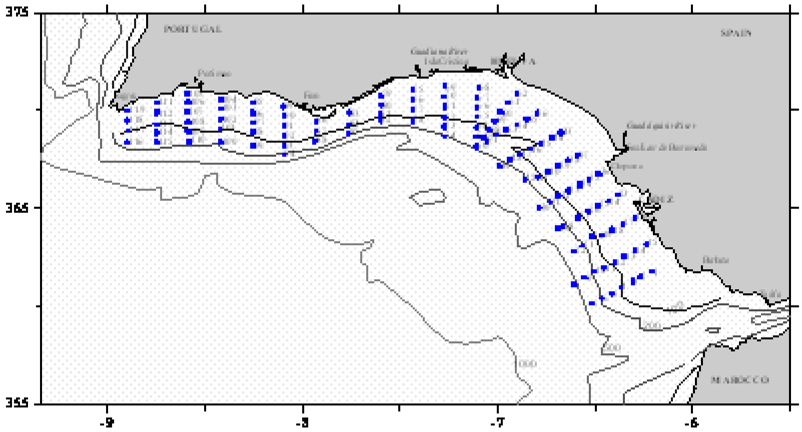


Figure B.3.2.1. Sampling grid adopted in the ***BOCADEVA*** **anchovy DEPM surveys series.**

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). 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:

$$SSB = \frac{P_0 * Area+}{(F*S*R)/W}$$

Although estimation has not yet been validated by the WGACEGG, the extensive participation of people involved in sardine and anchovy DEPM and the use of procedures and software adopted in previous applications provide sufficient guarantees on the robustness of the estimation methods and of the estimate provided. 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 this WGANSA and it is recommended that the appropiatness of the egg sampling scheme be revised in the next WGACEGG.

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 (Subdivision 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 (1988-2008) 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.

Results on goodness of fit of the generalised modelling used for CPUE and effort standardisation as assessed by ANOVA and model graphical diagnosis are shown in Table B4.1 and Figure B4.1. The resulting estimates are shown in Table B4.2.

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.

Table B4.1. Anchovy in Division IXa. ANOVA results of the GLM used for standardisation of CPUE data for Spanish fleets in Subdivision IXa-South (Gulf of Cadiz).

ANOVA:Tests of between-subjects effects
Dependent variable: Ln CPUE adjusted

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta-Squared	Noncentrality parameter	Observed power (a)
Corrected Model	1330.415	323	4.119	16.710	4.247E-180	0.900	5397.429	1.000
Intercept	3494.703	1	3494.703	14177.836	0.000E+00	0.959	14177.836	1.000
YEAR	272.206	20	13.610	55.216	1.229E-121	0.648	1104.325	1.000
QUARTER	6.224	3	2.075	8.416	1.739E-05	0.040	25.249	0.993
FLEET	453.068	10	45.307	183.807	2.427E-175	0.754	1838.075	1.000
YEAR * QUARTER	31.265	60	0.521	2.114	6.031E-06	0.175	126.841	1.000
YEAR * FLEET	546.241	200	2.731	11.080	1.095E-116	0.787	2216.072	1.000
QUARTER * FLEET	21.412	30	0.714	2.896	7.276E-07	0.126	86.868	1.000
Error	147.894	600	0.246					
Total	4973.013	924						
Corrected Total	1478.310	923						

a Computed using alfa = ,05
b R Squared = ,900 (Adjusted R squared = ,846)

Table B4.2. Anchovy in Division IXa. Standardised effort (no. of standardised fishing trips fishing anchovy) and CPUE (Tonnes/fishing trip) data for Spanish fleets in Subdivision IXa-South (Gulf of Cadiz). Color 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	CPUE
Year	Tonnes/fishing trip															
1988	1.071	-	0.131	-	0.144	n.a.	n.a.	n.a.	n.a.	n.a.	-	1.071	?	1.071	0.143	0.934
1989	1.102	-	0.112	-	0.229	n.a.	n.a.	n.a.	n.a.	n.a.	-	1.102	?	1.102	0.210	0.922
1990	1.107	-	0.158	-	0.275	n.a.	n.a.	n.a.	n.a.	n.a.	-	1.107	?	1.107	0.264	0.883
1991	1.177	-	0.134	-	0.122	n.a.	n.a.	n.a.	n.a.	n.a.	-	1.177	?	1.177	0.123	0.725
1992	0.710	-	0.091	-	0.121	n.a.	n.a.	n.a.	n.a.	n.a.	-	0.710	?	0.710	0.117	0.535
1993	0.587	-	0.096	-	0.095	n.a.	n.a.	n.a.	n.a.	n.a.	-	0.587	?	0.587	0.095	0.483
1994	0.983	-	0.151	-	0.347	n.a.	n.a.	0	0.173	0.093	-	0.983	0.173	0.906	0.317	0.710
1995	0.133	-	0.163	-	0.162	n.a.	n.a.	0	0.080	0.003	-	0.133	0.080	0.132	0.115	0.128
1996	0.217	-	0.282	-	0.208	n.a.	n.a.	0	0.121	0.115	-	0.217	0.121	0.214	0.208	0.212
1997	1.549	0.177	0.298	-	0.257	n.a.	n.a.	0	0.099	0.083	-	1.549	0.125	1.477	0.258	0.907
1998	3.093	0.433	0	0.203	0	n.a.	n.a.	0	0.223	0.145	-	3.093	0.211	1.495	0.145	1.484
1999	2.124	0.259	0.238	0.229	0	0.142	0.145	0	0.153	0.142	-	2.124	0.206	0.868	0.145	0.763
2000	0.228	1.192	0.086	0.201	0	0.162	0.133	0	0.364	0	-	0.228	0.356	0.350	0.132	0.343
2001	3.383	2.280	0.969	0.232	0	0.964	0.132	2.332	1.567	0.085	2.073	2.554	1.131	1.250	0.622	1.228
2002	1.777	1.043	0.425	0.201	0	0.577	0.150	0.405	0.654	0	0.940	1.736	0.552	1.047	0.361	1.041
2003	1.368	0.626	0.162	0.311	0	0.291	0	0.533	0.309	0	0	1.344	0.340	0.746	0.162	0.744
2004	1.221	0.687	0.051	0.253	0	0.328	0.125	0.371	0.355	0.052	0	1.169	0.370	0.740	0.091	0.731
2005	1.138	0.624	0	0.501	0	0.454	0	0.569	0.489	0	0	1.099	0.507	0.789	0	0.789
2006	0.649	0.573	0	0.813	0	0.485	0	0.662	0.477	0	0	0.650	0.536	0.592	0	0.592
2007	1.215	0.930	0	0.763	0	0.586	0	1.096	0.526	0	0	1.197	0.647	0.801	0	0.800
2008	1.137	1.002	0	1.161	0	0.606	0	1.805	0.676	0	0	1.195	0.764	0.913	0	0.913

	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	3870	-	60	-	611	n.a.	n.a.	n.a.	n.a.	n.a.	-	3870	?	3870	671	4541
1989	4562	-	186	-	965	n.a.	n.a.	n.a.	n.a.	n.a.	-	4562	?	4562	1151	5714
1990	4709	-	168	-	1541	n.a.	n.a.	n.a.	n.a.	n.a.	-	4709	?	4709	1709	6418
1991	4439	-	101	-	3227	n.a.	n.a.	n.a.	n.a.	n.a.	-	4439	?	4439	3329	7768
1992	3982	-	221	-	1447	n.a.	n.a.	n.a.	n.a.	n.a.	-	3982	?	3982	1667	5649
1993	2340	-	14	-	610	n.a.	n.a.	n.a.	n.a.	n.a.	-	2340	?	2340	624	2964
1994	2192	-	119	-	1031	n.a.	n.a.	0	231	53	-	2192	231	2424	1203	3627
1995	1499	-	14	-	387	n.a.	n.a.	0	14	167	-	1499	14	1514	567	2081
1996	3664	-	99	-	1964	n.a.	n.a.	0	86	75	-	3664	86	3750	2139	5888
1997	2246	40	118	-	1942	n.a.	n.a.	0	80	20	-	2246	120	2366	2080	4445
1998	2175	81	0	2435	0	n.a.	n.a.	0	192	41	-	2175	2709	4884	41	4925
1999	1773	140	8	2278	0	663	588	0	288	271	-	1773	3369	5142	868	6010
2000	277	846	1.8	2277	0	1857	181	0	614	0	-	277	5594	5871	183	6054
2001	179	1042	138	1430	0	2328	56	93	1092	38	265	537	5893	6430	233	6662
2002	2982	597	46	1127	0	2160	14	17	467	0	124	3124	4352	7475	60	7535
2003	2501	441	16	1227	0	1382	0	76	744	0	0	2576	3794	6371	16	6386
2004	3035	519	18	734	0	1620	51	199	865	27	0	3233	3738	6972	95	7067
2005	2463	666	0	502	0	1221	0	181	528	0	0	2643	2917	5560	0	5560
2006	3348	440	0	495	0	1490	0	273	1335	0	0	3621	3760	7381	0	7381
2007	1650	688	17	955	0	1703	0	304	1657	0	0	1954	5002	6956	17	6973
2008	1099	337	2	310	0	888	0	104	729	0	0	1203	2264	3467	2	3469

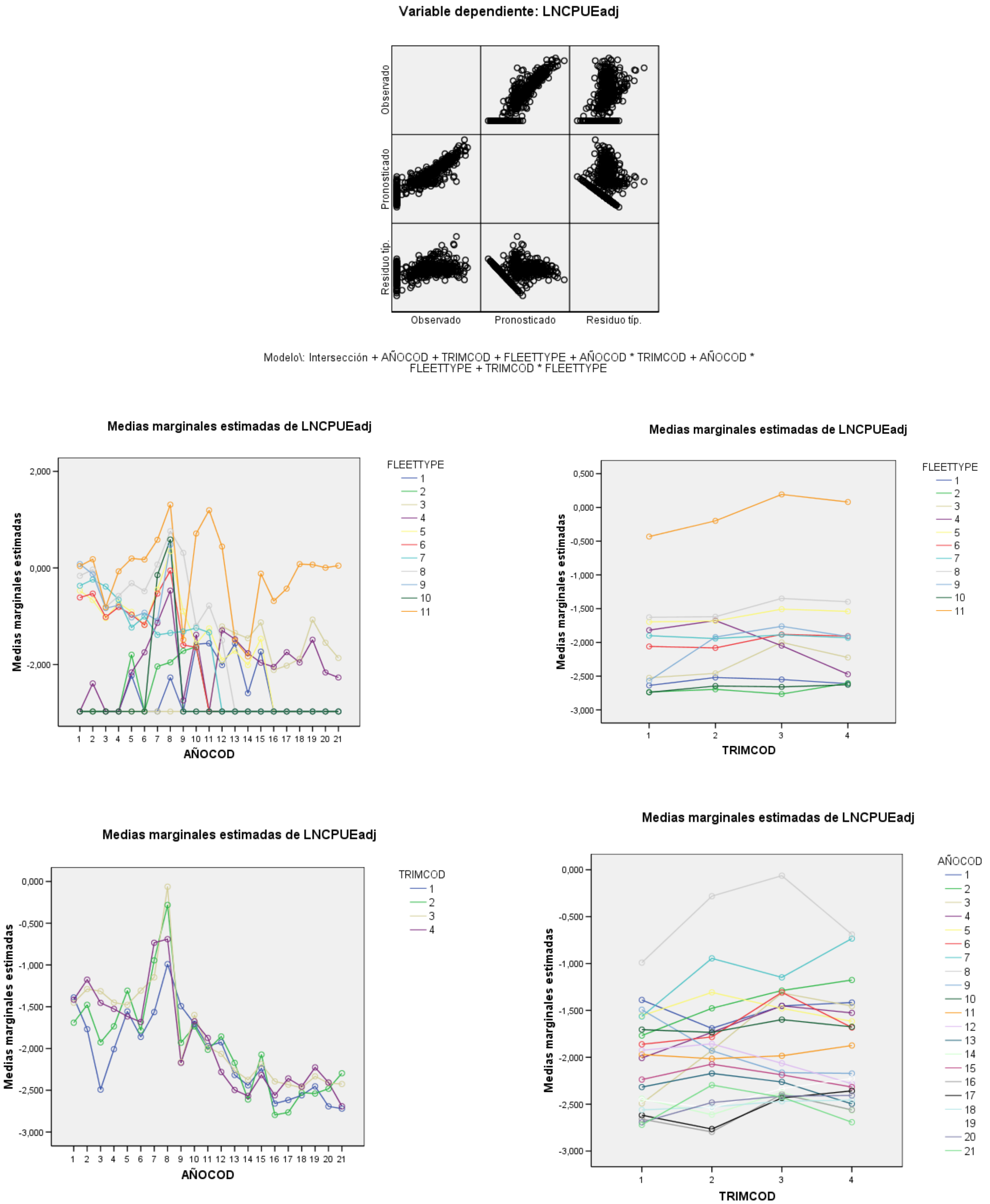


Figure B.4.1. Anchovy in Division IXa. Residuals and Profile plots for the GLM used for the standardisation of the Spanish fleets' CPUE data in Subdivision IXa-South (Gulf of Cadiz).

B.5. Other relevant data

C. Historical Stock Development

Model used:

For the time being, no analytical assessment model have been successfully applied. An exploratory assessment is under development. This exploratory assessment carried out so far is only performed for the anchovy population nucleus in the Gulf of Cádiz (Subdivision 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 is 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 are 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 are estimated as usual, whereas weights at age in the stock correspond to yearly estimates calculated as the weighted mean weights-at-age in the catches for the second and third quarters. The model is at present 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 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 sprig survey series has a better coverage both in space and time, only this survey series has been recently used.

The exploratory runs has 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 2008 biomass acoustic estimate 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 has 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 this year has been 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 the last year and accepted by the Review Group of the 2008 WGANC (2008 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, as was done last year.

Software used: the exploratory model is implemented and run in a MicroSoft Excel spreadshet.

D.Short-Term Projection

Not applicable

E. Medium-Term Projections

Not appliccable

F. Long-Term Projections

Not applicable

G. Biological Reference Points

Not defined

H. Other Issues

I. References

Bernal, M., Ibaibarriaga, L., Lago de Lanzos, A., Lonergan, M.E., Hernandez, C., Franco, C., Rasines, I., Valdes, L. and Borchers, D.L., 2008. Using multinomial models to analyse data from Iberian sardine egg incubation experiments: a comparison with traditional techniques. *ICES J. Mar. S*ci., 65:51–59.

Carrera, P. 1999. Acoustic survey JUVESU 0899: preliminary results. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2000/ACFM:05.

Carrera, P. 2001. Acoustic abundance estimates from the multidisciplinary survey PELACUS 0401. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2002/ACFM:06.

Carrera, P., Villamor, B., Abaunza, P. 1999. Report of the acoustic survey PELACUS 0399: results on sardine, mackerel, horse mackerel and anchovy. Working Document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2000/ACFM:05.

Duarte, J, M. Bernal, M.P. Jiménez, J. Canoura, E. García, A. Juárez, I. Muñoz, 2007. Egg development model for anchovy (Engraulis encrasicolus) in the Gulf of Cádiz. ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG).

García-Isarch, E., Millán, M., Ramos, F., García-Santamaría, T and Burgos, C. 2008. Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa. Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa, available at http://www.smallpelagics2008.org/index.html

Gavaris, S., 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. *Can. J. Fish. Aquat. Sci*., 37: 2272-2275.

Ibaibarriaga, L., Bernal, M., Motos, L., Uriarte, A., Borchers, D.L., Lonergan, M.E., and Wood, S.N. 2007. Characterization of stage-classified biological processes using multinomial models: a case study of anchovy (*Engraulis encrasicolus*) eggs in the Bay of Biscay. *Canadian Journal of Fisheries and Aquatic Sciences*, 64:539–553.

ICES, 1986. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. Lisbon, 1-4 April 1986. ICES CM 1986/H:27. 7 pp.

ICES, 1998. Report of the Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX. A Coruña, 30-31 January 1998. ICES CM 1998/G:2. 17 pp.

ICES. 2000. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES, C.M. 2000/ACFM:05.

ICES. 2001. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES, C.M. 2001/ACFM:06.

ICES, 2006 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy. ICES CM 2006/ ACFM: 36.

ICES, 2006 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX (WGACEGG), 24-28 October 2005, Vigo, Spain. ICES, C.M. 2006/LRC: 01. 126 pp.

ICES, 2006 c. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 27 November-1 December 2006, Lisbon, Portugal. ICES C.M. 2006/LRC:18. 169 pp.

ICES 2007 a. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). ICES CM 2007/ACFM:31

ICES 2007 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovyin ICES areas VIII and IX (WGACEGG). ICES CM 2007/LRC:16

ICES. 2008 a. Report of the Working Group on Anchovy (WGANC), 13 - 16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

ICES. 2008 b. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 24–28 November 2008, Nantes, France. ICES CM 2008/LRC:17. 183 pp.

Millán, M., 1992. Descripción de la pesquería de cerco en la Región Sur-atlántica Española y Atlántico-Norte Marroquí. *Informes Técnicos Instituto Español Oceanografía* 136, 70pp.

Millán, M. 1999. Reproductive characteristics and condition status of anchovy *(Engraulis encrasicolus*, L.) from the Bay of Cadiz (S.W. Spain). *Fish. Res*., 41: 73-86.

Picquelle, S., Stauffer, G., 1985. Parameter estimation for an egg production method of northern anchovy biomass assessment. In: Lasker (ed.) An Egg Production Method for Estimating Spawning Biomass of Pelagic Fish: application to the northern anchovy, *Engraulis mordax*. *NOAA Tech. Rep.* NMFS 36: 43-50 pp.

Robson, D.S., 1966. Estimation of the relative fishing power of individual ships. *ICNAF Research Bulletin*, 3:5-14.

Silva, L., Castro J., Ramos, F. and Punzón A., 2007. Identification of métiers in the Gulf of Cadiz Spanish purse-seine fishery (ICES Subdivision IXa-South). Working document presented to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES, C.M. 2007/ACFM:31.

Stock Annex – Sardine in Division VIIIc and IXa (Sar-Soth)

Quality Handbook ANNEX:_V___

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: 19 June 2009

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).

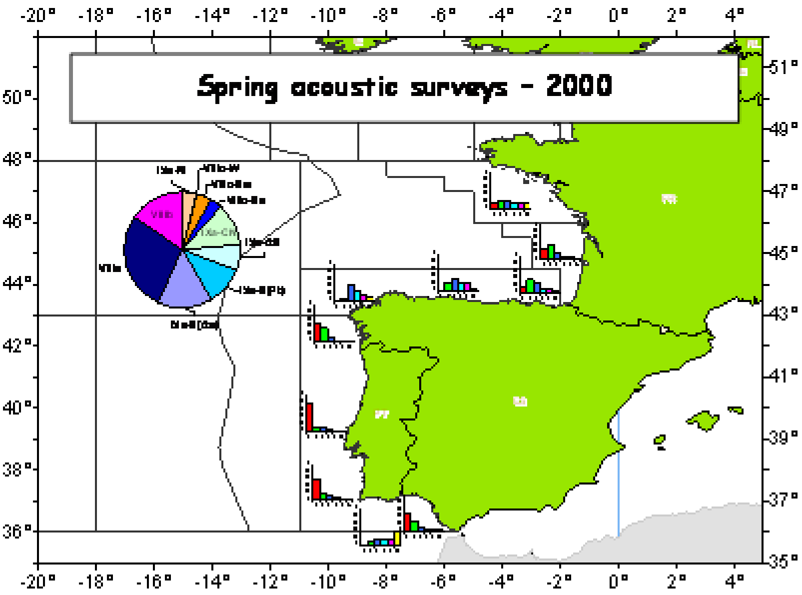
Sardine from ICES Divisions VIIIc and IXa is part of the north-Atlantic genetic stock, which spans the continental waters from the Agadir area in north Morocco to the North Sea. In addition to genetic similarity, there is other evidence of mixing between ICES Division VIIIa and b and the actual assessed 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.

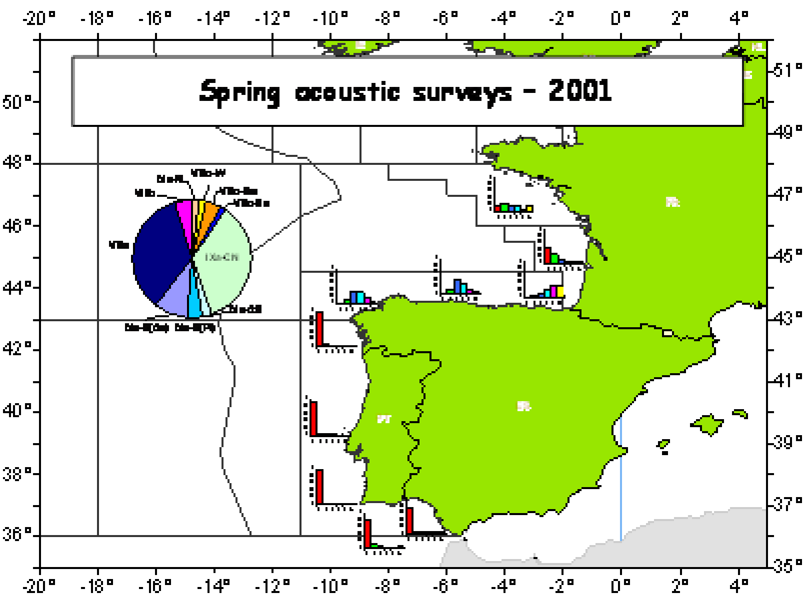
Genetic and life history characters provide also indication of some mixing that across the southern stock limit (Gulf of Cadiz) with sardine populations from southwest Mediterranean and northern Morocco (SARDYN project results). However, the absence of large sardine populations in these areas points to a limited potential to influence the dynamics of the Iberian stock.

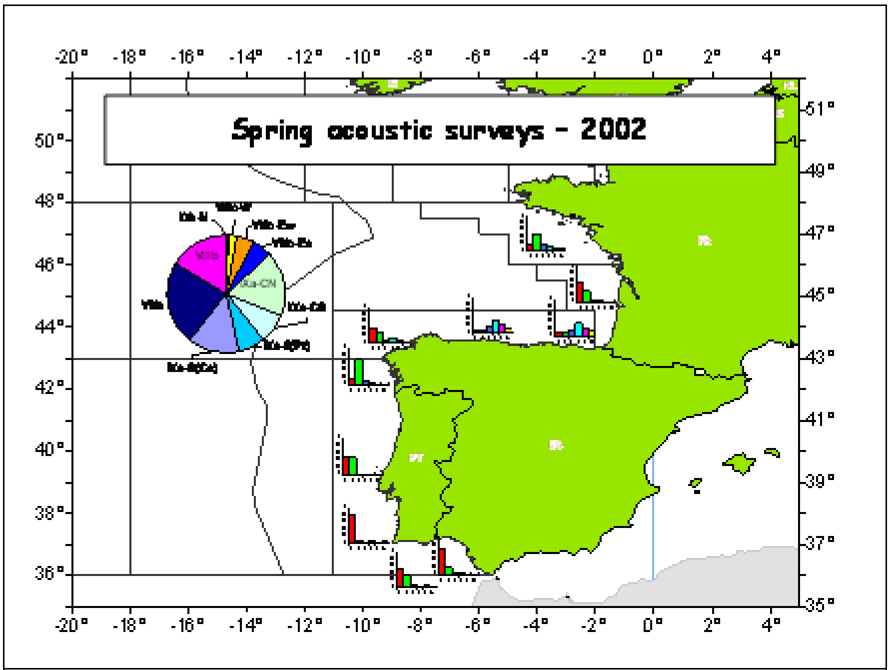
There are also indications of spatial population sub-structuring across Iberian waters: evidence of distinct recruitment pulses off the two main recruitment areas in some years (northern Portugal and the Gulf of Cadiz) and observation that these mainly influence the demography of adjacent populations 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.

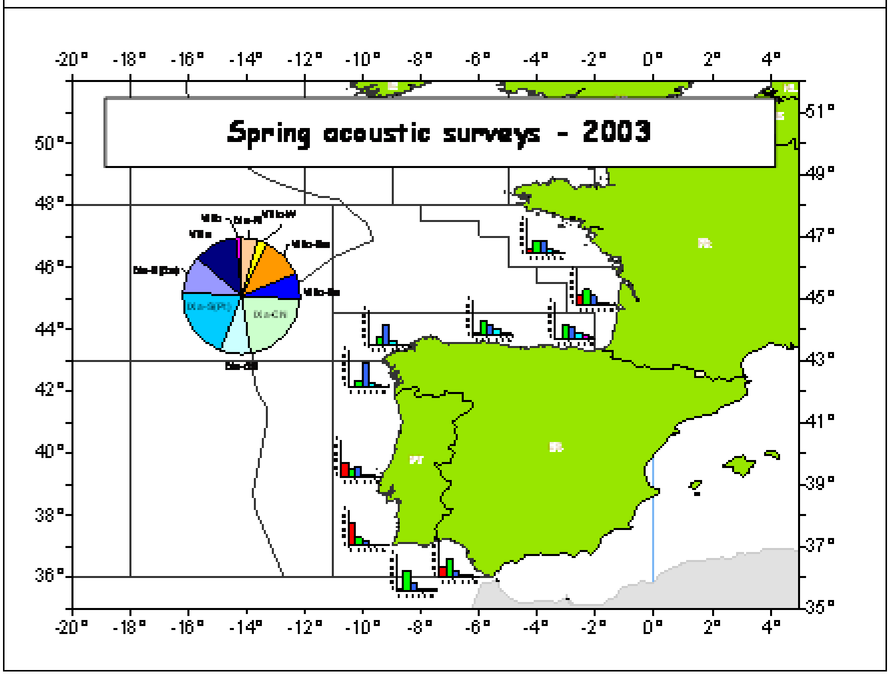
Despite the likelihood of some mixing across the stock borders and of some spatial heterogeneity in life history and dynamics, there is currently no evidence that the dynamics of the stock is strongly influenced by sardine populations outside the stock area. Therefore, the perception of the stock obtained from the assessment is considered unbiased by mixing.

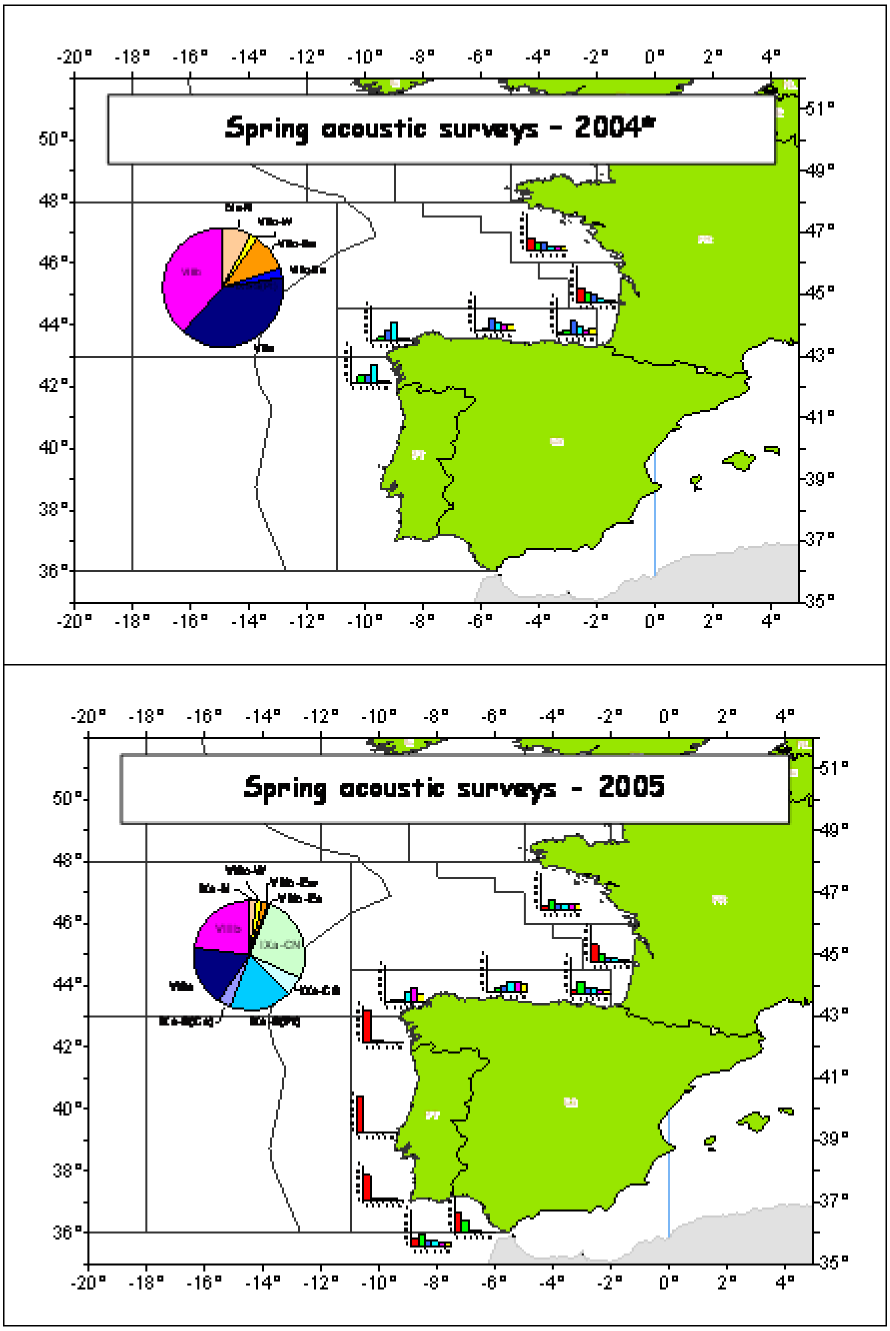
Figure A.1. Sardine age frequency distribution by subarea showing the importance of each age class in each subarea in relation to the total sardine population in that subarea as estimated by the spring surveys carried out by France, Spain and Portugal (2008). Age categories are: 1, 2, 3,…and 6+. The pie chart represents the contribution of each subarea to the total biomass.

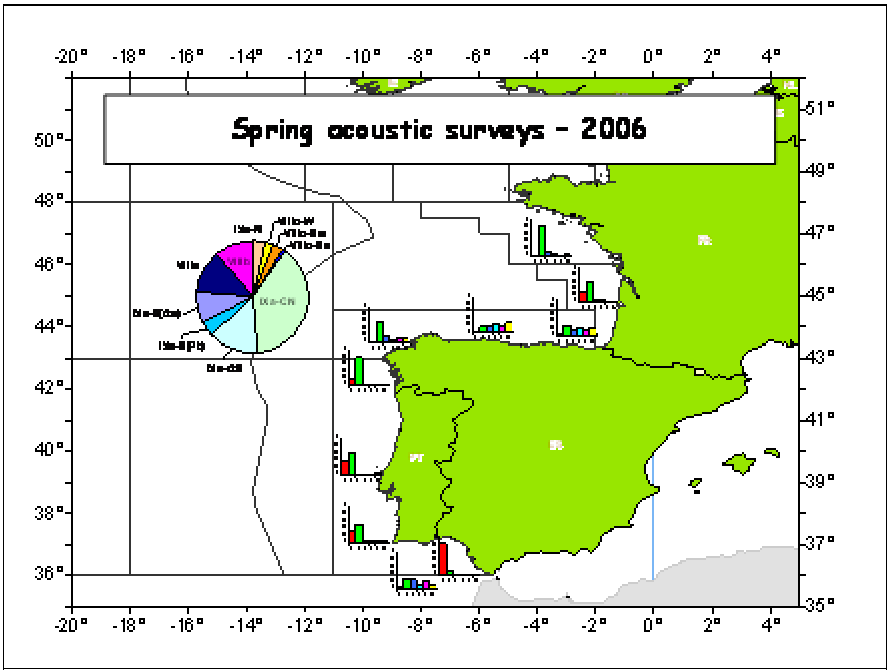


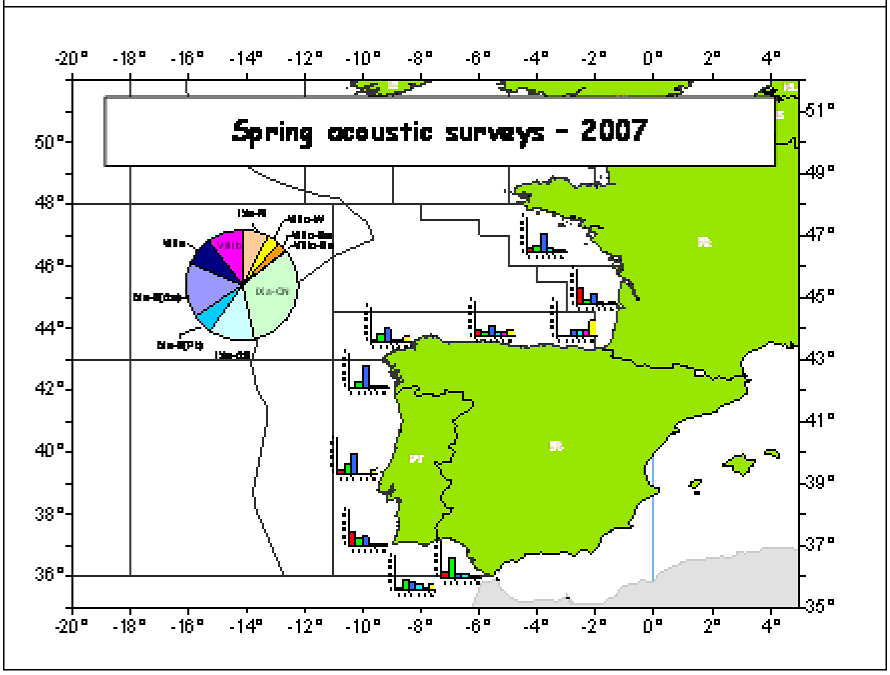


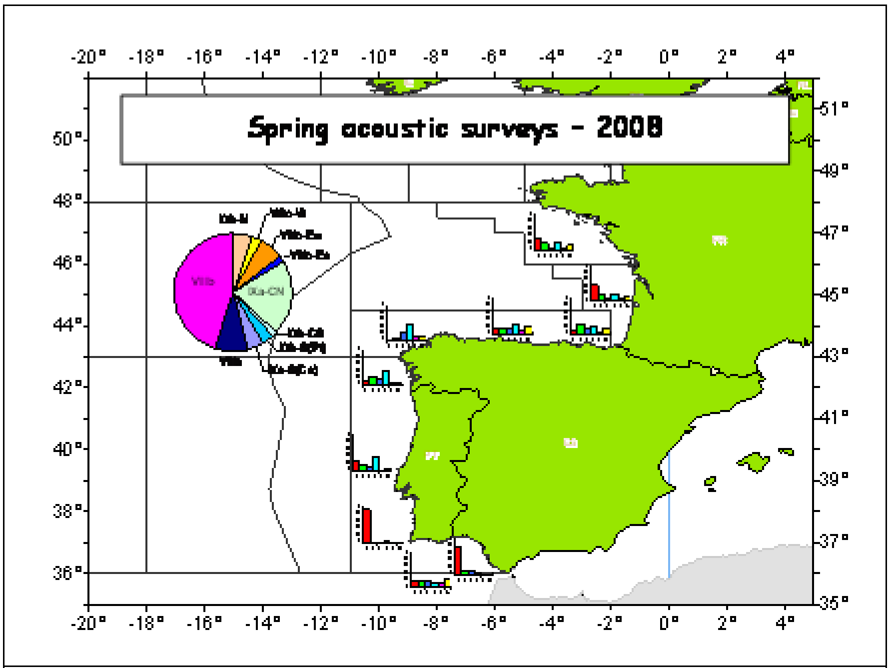

Spring acoustic surveys - 2002

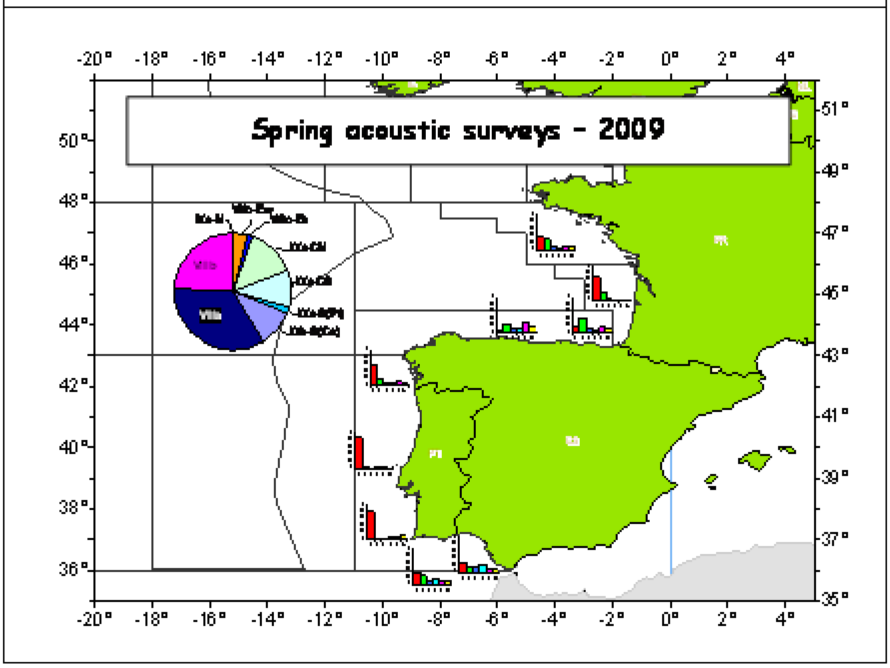

Spring acoustic surveys - 2003


Spring acoustic surveys - 2004*
Spring acoustic surveys - 2005


Spring acoustic surveys - 2006


Spring acoustic surveys - 2007


Spring acoustic surveys - 2008
-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°


Spring acoustic surveys - 2009
-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. 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. According to Stratoudakis and Marçalo (2002), fishing is usually close to the home port, on short (daily) trips where the net is set once or twice, usually around dawn. A large part of a typical fishing trip is spent searching for schools with echosounders and sonars. Once schools of pelagic fish have been detected, large nets (up to 800 m long and 150 m deep) are set rapidly with the help of an auxiliary small vessel, and hauled in a largely manual operation involving all members of the crew (usually between 15-20 people) (Mesquita, 2008).

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.

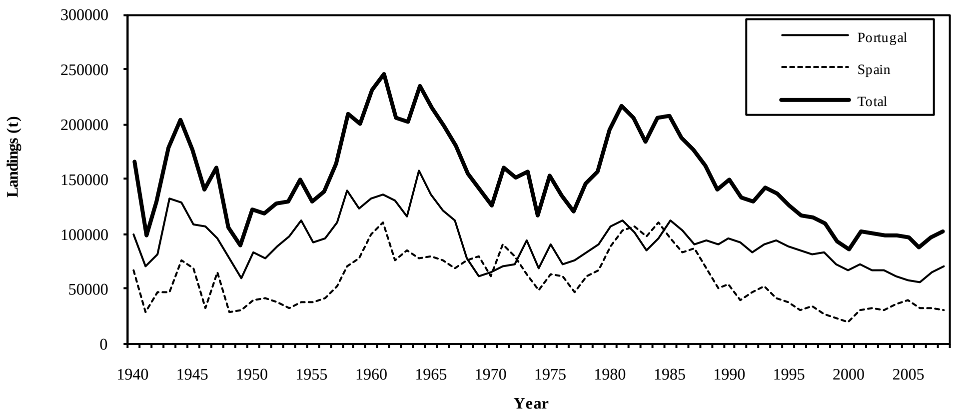
Upwelling intensity was shown to affect both positively and negatively sardine recruitment (Dickson et al., 1988; Roy et al., 1995) but the main direct effect was due to the transport of eggs and larvae offshore by northern winds (Guisande et al., 2001). In this way, strong upwelling during the recruitment 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 on-board observers. In Spain, samples for age length keys are pooled on a half year basis for each subdivision while length/weight relationships are calculated 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 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.

In 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).

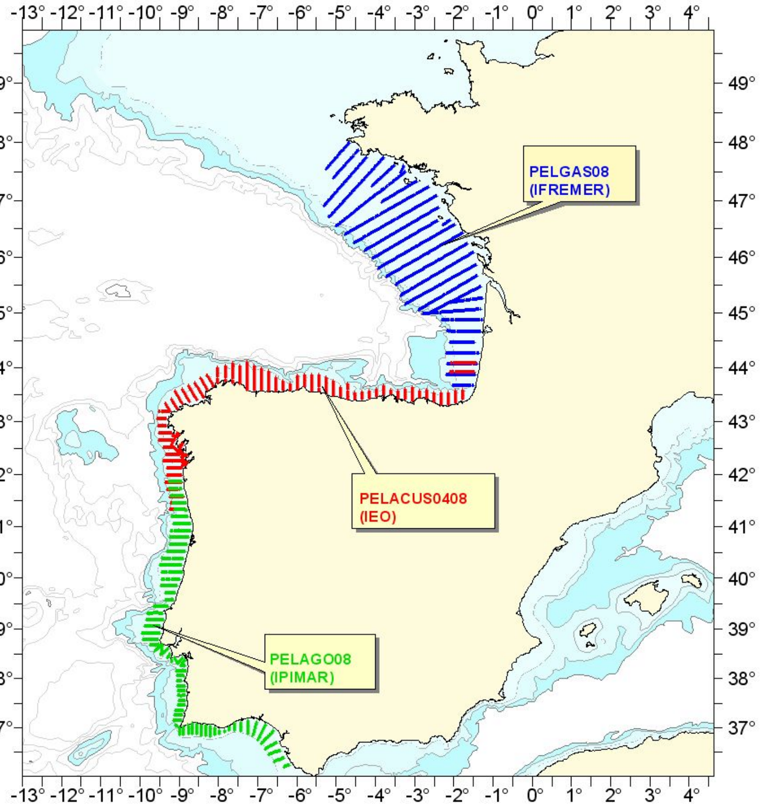


Figure B.3.2.1. Transects surveyed by PELAGO (Portugal), PELACUS (Spain) and PELGAS (France) surveys during spring 2008.

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, that 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.

For the past two years (2008 and 2009), 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 preferiantilly 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 disagregation, 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	1978-2008	0-6+	No
Canum	Catch at age in numbers	1978-2008	0-6+	Yes
Weca	Weight at age in the commercial catch	1978-2008	0-6+	Yes
West	Weight at age of the spawning stock at spawning time.	1978-2008	0-6+	Yes (fixed until 1988)
Mprop	Proportion of natural mortality before spawning	1978-2008	0-6+	No
Fprop	Proportion of fishing mortality before spawning	1978-2008	0-6+	No
Matprop	Proportion mature at age	1978-2008	0-6+	Yes (fixed until 1988)
Natmor	Natural mortality	1978-2008	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 – 2009 (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			
….			

D. Short-Term Projection

Model used: Age structured deterministic short term prediction.

Software used: MFDP. Multi Fleet Deterministic Projection. ICES, 2000.

Initial stock size: Stock estimated by the assessment model at the beginning of the intermediate year.

Maturity: Maturity-at-age shows extensive inter-annual variation, mainly for age 1 fish. In order to decrease the influence of this assumption on the results of the catch predictions, an arithmetic mean of the whole historical data (since 1989, when annual observations become available) is used in short term predictions.

F and M before spawning: 0.25, spawning time assumed to be 1st March.

Weight at age in the stock: Arithmetic mean of the last three years of the assessment.

Weight at age in the catch: Arithmetic mean of the last three years of the assessment.

Exploitation pattern: Arithmetic mean of the last three years of the assessment.

Intermediate year assumptions: Fsq is the average F of the last three years of the assessment, unscaled. Recruitment is a geometric mean of the period starting in 1995.

Stock recruitment model used: No stock-recruitment model is used. Sardine recruitment shows a declining trend over time. This trend seems to have stopped around 1995. Since then recruitment has fluctuated more or less randomly around a low level. Therefore, recruitment assumed in the projection is a geometric mean of the period starting in 1995.

Procedures used for splitting projected catches: Not applicable.

E. Medium-Term Projections

No medium term projections are applied to this fishery for the provision of advice by ICES.

F. Long-Term Projections

No long term projections are applied to this fishery for the provision of advice by ICES.

G. Biological Reference Points

There are no Reference Points for this stock.

H. Other Issues

I. References

Abad, E., Castro, J., Punzón, A. and Abaunza, P. 2008. Métiers of the Northern Spanish coastal fleet using purse seine gears. WD presented to the ICES WGWIDE 2008 meeting.

Anon.2006. SARDYN "*Sardine dynamics and stock structure in the North-East Atlantic*" (EU Q5RS-CT-2002-00818). Final Report. Available from Yorgos@ipimar.pt

Bernal, M. 2008. Modelling the abundance, distribution and production of sardine (*Sardina pilchardus*, Walb.) eggs in the Iberian Peninsula. PhD Thesis, Universidad de Cádiz, Cádiz, Spain, 262pp

Bode, A., Alvarez-Ossorio, M.Y., Carreara, P. and Lorenzo, J. 2004. Reconstruction of trophic pathways between plankton and the North Iberian sardine (*Sardina pilchardus*) using stable isotopes. *Scientia Marina* 68:175-178.

Bode, A., Carrera, P. and Lens, S. 2003. The pelagic foodweb in the upwelling ecosystem of Galicia (NW Spain) during spring: natural abundance of stable carbon and nitrogen isotopes. ICES Journal of Marine Science 60:11-22.

Bode, A., Alvarez-Ossorio M.T., Cunha, M.E., Garrido, S., Peleteiro, J.B., Porteiro, C., Valdés, L. and Varela, M. 2007. Stable nitrogen isotope studies of the pelagic food web on the Atlantic shelf of the Iberian Peninsula. Progress in Oceanography 74:115-131.

Carrera, P. and Porteiro, C. 2003. Stock dynamic of the Iberian sardine (*Sardine pilchardus,* W.) and its implication on the fishery off Galicia (NW Spain). Scientia Marina 67 (Suppl.1): 245-258.

Csirke, J. 1988. Small shoaling pelagic fish stocks. In: Fish population dynamics, J.A. Gulland (Ed.), John Wiley y Sons., New York, 271-302.

Dickson, R.R., Kelly, P.M., Colebrook, J.M., Wooster, W.S. and Cushing, D.H. 1988. North winds and production in the eastern North Atlantic. J. Plankton Res. 10: 151-169.

Garrido S., Marçalo A., Zwolinski J. and van der Lingen C.D. 2007. Laboratory investigations on the effect of prey size and concentration on the feeding behaviour of *Sardina pilchardus*. Marine Ecology Progress Series. 330:189–199.

Guisande, C., Cabanas, J.M., Vergara, A.R., Riveiro, I. 2001. Effect of climate on recruitment success of Atlantic Iberian sardine *Sardina pilchardus.* Marine Ecology Progress Series. 223: 243-250.

ICES. 2007. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. ICES CM 2007/ACFM: 31.

Kaufman, L., Rousseeuw, P. J. 1990. Finding Groups in Data: An Introduction to Cluster Analysis. A Wiley-Interscience Publication. John Wiley & Sons, Inc. New York.

Lucio, P. 1997. Biological aspects of Spanish (chub) mackerel (Scomber japonicus, Houttuyn, 1782) in the Bay of Biscay from the Basque Country catches. ICES CM 1997/BB:10.

Mackinson, S., Vasconcellos, M. C., Pitcher, T. and Walters, C. J. 1997. Ecosystem impacts of harvesting small pelagic fish in upwelling systems using a dynamic mass-balance model. Proceedings Forage Fishes in Marine Ecosystems. Fairbanks: Anchorage, Alaska. Alaska Sea Grant College Program. AK9701: 15-30.

Meynier, L. 2004. Food and feeding ecology of the common dolphin, *Delphinus delphis*, in the Bay of Biscay: interspecific dietary variation and food transfer modelling. MSc Thesis, University of Aberdeen, UK.

Mesquita, C. 2008. Application of Linear Mixed Models in the study of LPUE patterns in the Portuguese purse seine fishery for sardine (*Sardina pilchardus* Walbaum, 1792). PhD Thesis. School of Biological Sciences, University of Aberdeen.

Morais, P., Faria, A., Chícharo, M.A., Chícharo, L. (2009) The unexpected occurrence of late Sardina pilchardus (Walbaum, 1792) (Osteichthyes: Clupeidae) larvae in a temperate estuary. Cahiers de Biologie Marine 50 (1), pp. 79-89

Patterson, K.R. 1998. A programmeme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Porteiro C., Carrera P., Miquel J., 1996. Analysis of Spanish acoustic surveys for sardine, 1991–1993: abundance estimates and inter-annual variability. ICES Journal of Marine Science 53:429–433.

Santos, M.B, Pierce, G.J., López, A., Martínez, J.A., Fernández, M.T., Ieno, E., Mente, E., Porteiro, C., Carrera, P. and Meixide M. 2004. Variability in the diet of common dolphins (*Delphinus delphis*) in Galician waters 1991-2003 and relationship with prey abundance. ICES CM 2004/Q:09.

Santos, M.B., Fernández, R., López, A., Martínez, J.A. and G.J. Pierce. 2007. Variability in the diet of bottlenose dolphin, *Tursiops truncatus*, in Galician waters, north-western Spain, 1990-2005. Journal of the Marine Biological Association of the U.K. 87: 231-241.

SGDFF 2003. Report of the Study Group on the Development of Fishery-based Forecasts. ICES CM 2003/ACFM:08 Ref. D.

Silva, A. 2007. Geographic variation in sardine population traits: implications for stock assessment. PhD thesis, Universidad do Algarve. 235pp.

Silva, M.A. 2001. Diet of common dolphins, *Delphinus delphis*, off the Portuguese continental coast. Journal of the Marine Biological Association of the U.K. 87: 231-241.

Skagen, D.W. 2005. AMCI, Version 2.4 Assessment model combining information from various sources. Available from the author (dankert@imr.no).

Stratoudakis, Y. and Marcalo, A. 2002. Sardine slipping during purse-seining off northern Portugal. ICES Journal of Marine Science. 59: 1256-1262.

Uriarte, A., Prouzet, P. and Villamor, B. 1996. Bay of Biscay and Ibero Atlantic anchovy populations and their fisheries. Scientia Marina, 60 (Supl. 2): 237-255.

Villamor, B., Abaunza, P., Lucio, P. and Porteiro, C. 1997. Distribution and age structure of mackerel (*Scomber scombrus* L.) and horse mackerel (*Trachurus trachurus* L.) in the northern coast of Spain. Scientia Marina. 61: 345-366.

Villamor, B., Abaunza, P., Punzón, A., Gancedo, R.M., González, F., Mene, L., Millán, M., Morlán, R., Otero, R., Patiño, B. and Artetxe, I. 1998. Description of the Spanish fishing fleets which catch pelagic species in the ICES area: main changes occurring between 1993 and 1997. Working Document to 1998 Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy.

Villamor, B., Aranda, M., Punzón, A., Uriarte, A. and Baez, J.C. 2008. The anchovy fishery in the Bay of Biscay: Description and analysis of the Spanish fleet (2000-2005). ICES CM 2008/ I: 31. Theme session I.

ICES 2008. Report of the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX (WGACEGG), 26_30 November 2008, Nantes, France. ICES CM 2008/LRC:17. 181 pp.

Zwolinski, J., P. Oliveira, A. Morais, V. Marques and Stratoudakis. Y. 2008. Distribution of sardine and anchovy potential habitat of Southern Iberia. International Symposium on Ecosystem Approach with Fisheries Acoustics and Complementary Technologies (SEAFACTS), Bergen, Bergen, Norway, 16-20 June 2008.

Stock Annex – Bay of Biscay Anchovey (Subarea VIII)

Quality Handbook ANNEX: 2

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: WGANSA

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

Presently the fishery is closed since June 2006 due to poor condition of the stock. 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.

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

* 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

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 2008 of WGANC (ICES 2008).

B. Data

B.1. Commercial catches:

Fishery closed since July 2006.

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 will take 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,

N_a = Population estimate of numbers at age *a*.

N = Total spawning stock estimate in numbers. $N = \frac{SSB}{W_t}$

B = spawning stock biomass estimate.

W_t = average weight of anchovies in the population.

E_a = Relative frequency (in numbers) of age *a* in the population.

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.

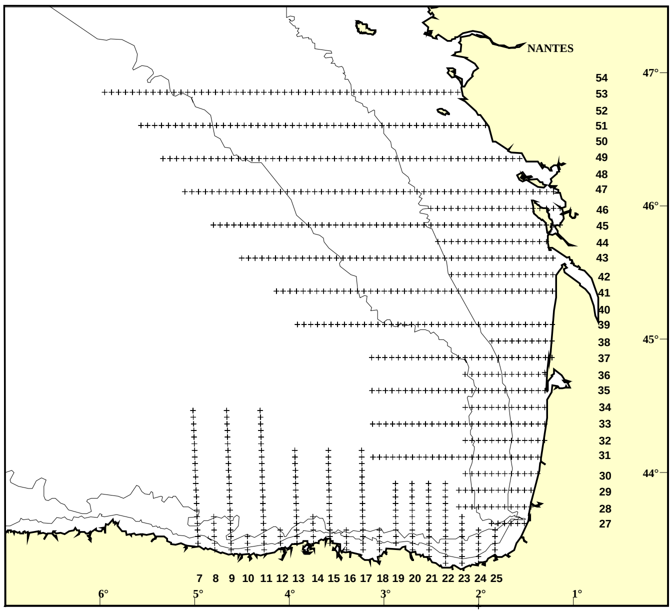


Figure B.3.1.2.1: Predetermined stations of the vertical hauls (PairoVET) that could be performed during the survey

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, when necessary, 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 and salinity 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.

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.

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 2008):

- 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

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:

$$M_e(k)=\sum_D \bar{s}_A(D,k)\overline{X}_e(D,k)$$

and total biomass (tons) by : $B_e=\sum_k A(k)Me(k)$

where,

k : strata index

D : echo type

e : species

$\mathbf{S_A}$: Average S_A (NASC) in the strata (m2/n.mi.2)

$\mathbf{X_e}$: species proportion coefficient (weighted by energy around each haul) (tons m^{-2})

A : area of the strata (m.n.^{2})

Then variance estimate is:

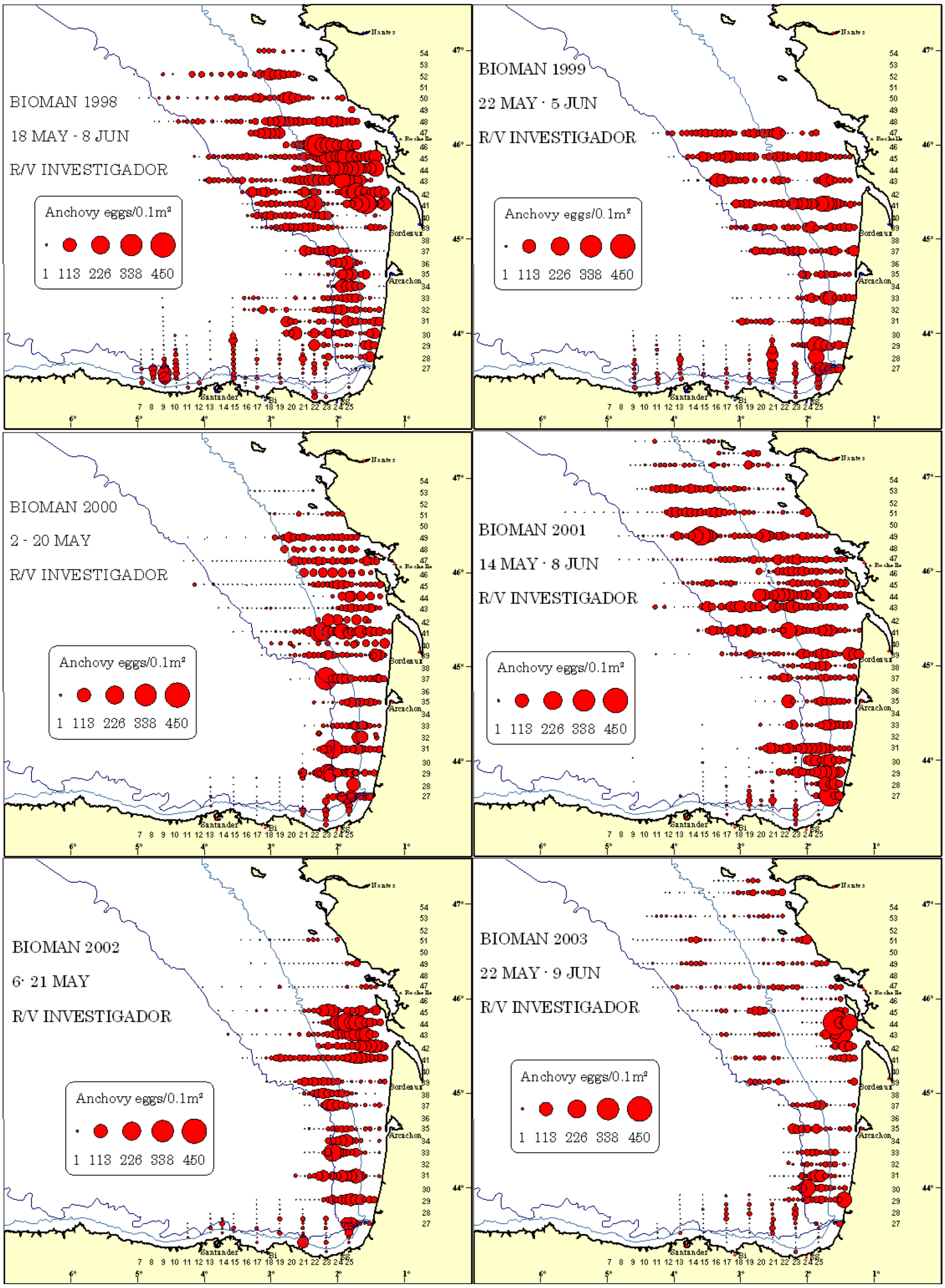
$$Var.M_e(k) = \sum_D \bar{s}_A^{\,2}(D,k)Var[X_e(D,k)]/n.cha(k) + \bar{X}_e^{\,2}\,\mathrm{var}[s_A(D,k)]/n.esu(D,k)$$

$$Var.B_e = \sum_k A^2(k)Var.Me(k)$$

$$cv = \sqrt{Var.Be}\Big/Be$$

At the end, density in numbers and biomass by length and age are calculated for each specie 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.

B.3.3 Historical series DEPM and acoustic surveys



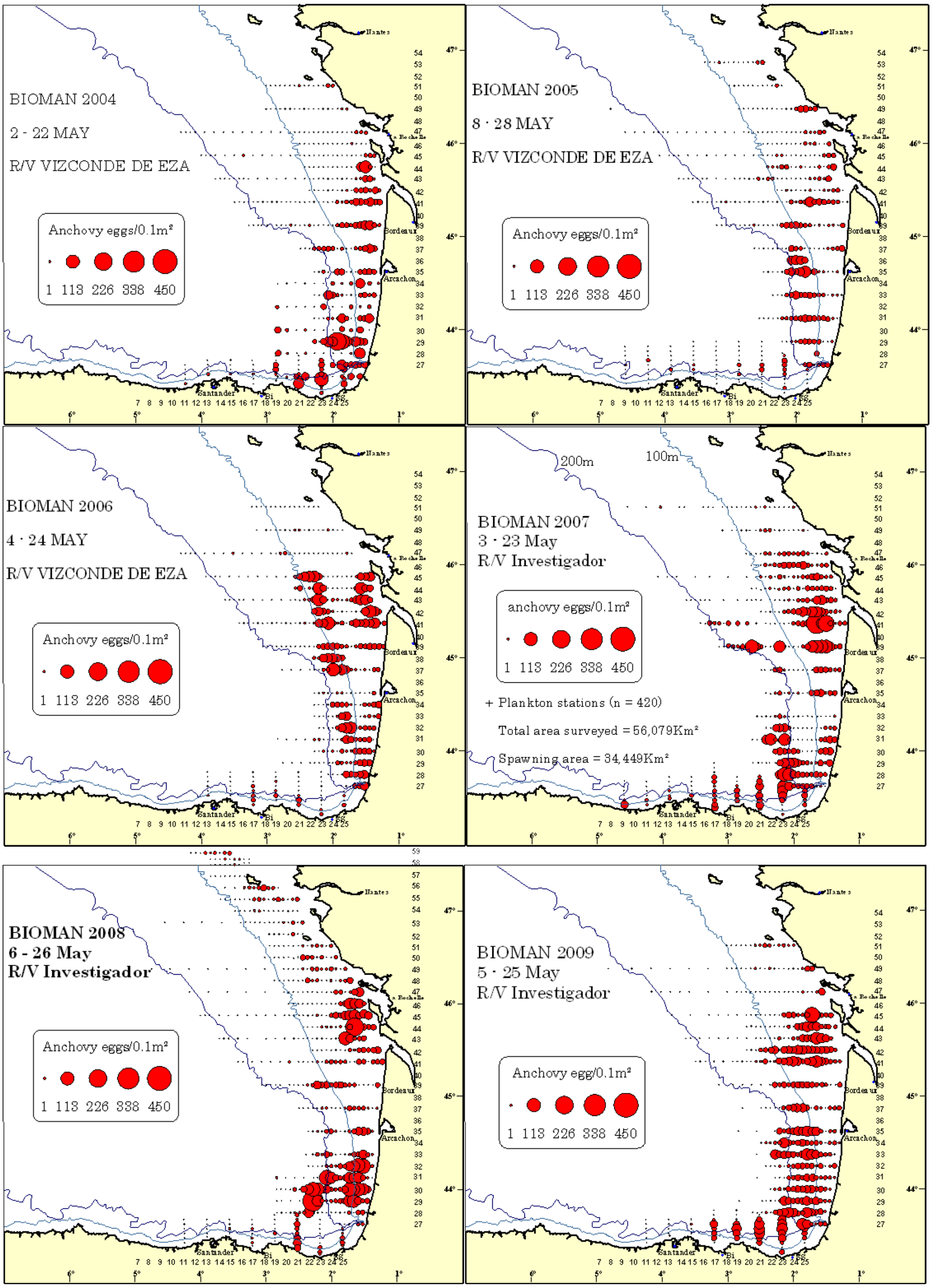
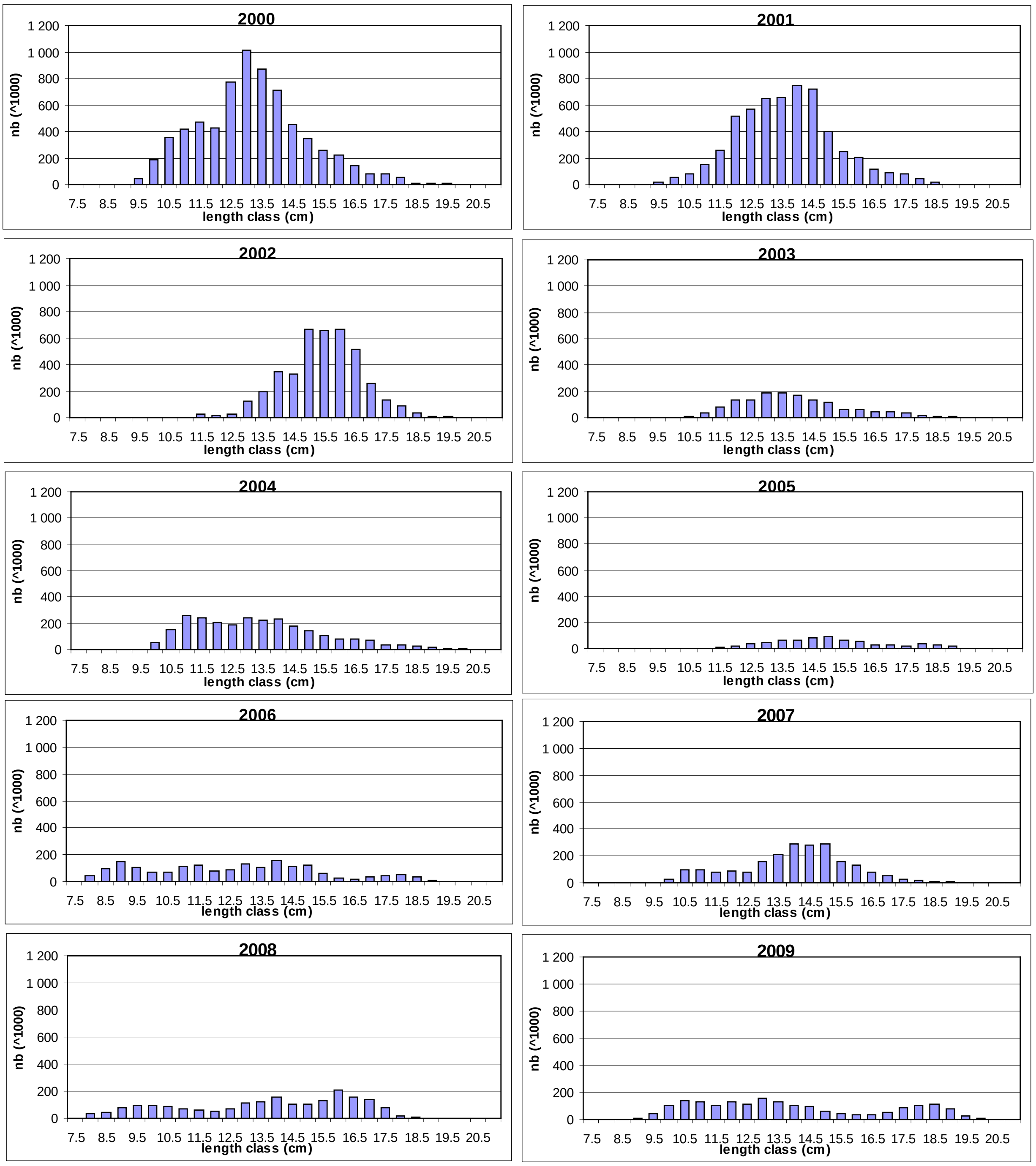
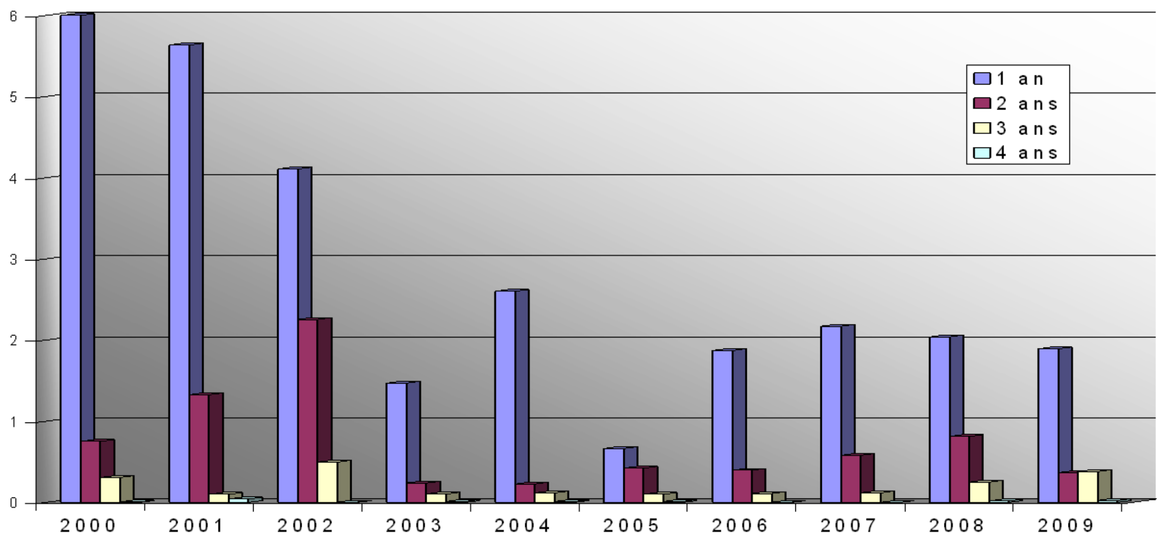


Figure B.3.3.1: Anchovy egg distribution from 1998 to 2009.The circles represent the anchovy egg abundance /0.1m² encountered in each plankton station.

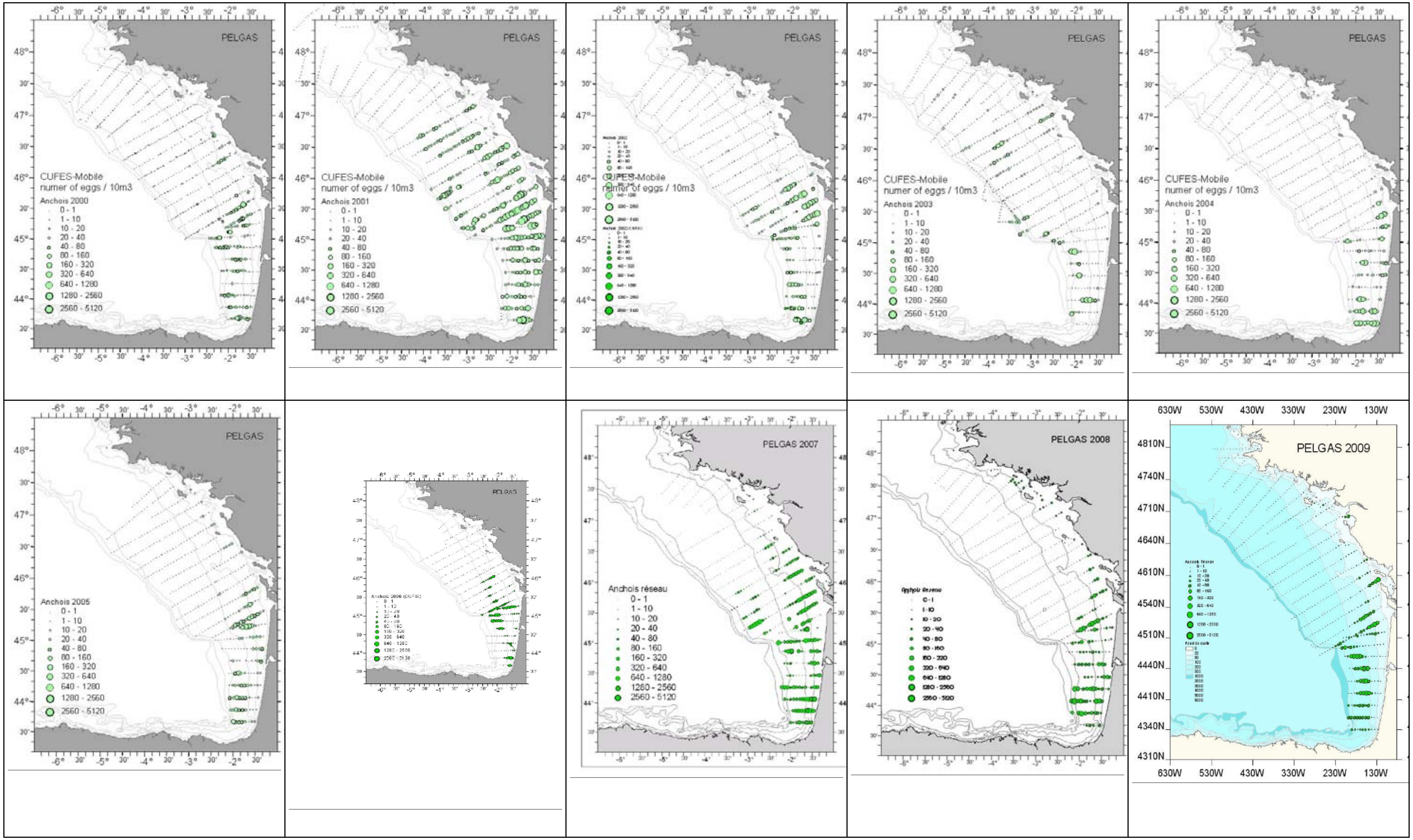


Length composition of adults of anchovy as estimated by acoustics since 2000 during PELGAS surveys.



Anchovy numbers at age as observed during PELGAS surveys since 2000. The 1 year old class still seems to be low since 2005, and 2 and 3 years old are increasing most likely because of the closure of the fishery.

Number of eggs observed during PELGAS surveys with CUFES from 2000 to 2009



Distribution of anchovy eggs observed with CUFES during PELGAS surveys from 2000 to 2009 (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, aobut 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 onwarwds 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 it self. 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. Historical Stock Development

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 recruits 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. Each MCMC run has 150,000 draws, with a burn-in period of 50,000 (i.e. remove the first 50,000 draws to avoid dependency on the initial values) and keeping only 1 out of 10 draws (thinning) to diminish autocorrelation. Thus, the final chains have 10,000 values representing the 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	1987-2009	1 to 2+	Yes
Canum	Catch at age in numbers by periods	1987-2009	1 & 2+	Yes
Weca	Weight at age in the commercial catch by periods	1987-2009	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	1987-2009	1 to 2+	No
G	Intrinsic growth rate G= 0.52	1987-2009	1 to 2+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	DEPM SSB spring series	1987-2009 (with gap in 1993)	
Tuning fleet 2	Acoustic SSB spring series	1989-2009 (with gaps)	
Tuning fleet 3	DEPM P1 (B1/SSB) spring series	1987-2009 (with gaps)	
Tuning fleet 4	Acoustic P1 (B1/SSB) spring series	1989-2009 (with gaps)	

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	$\mathbf{B_{lim}}$ is 21,000 t, the lowest observed biomass in 2003 assessment.	B_{pa}= 33,000 t.
	There is no biological basis for defining F_{lim}.	F_{pa} be established between 1.0-1.2.
Target reference points		

Technical basis:

$B_{lim} = B_{loss}$ = 21,000 t.	$B_{pa} = B_{loss}$ * 1.645.
	F_{pa}= F for 50% spawning potential ratio, i.e., the F at which the SSB/R is half of what it would have been in the absence of fishing

H. Other Issues

I. References

Allain, G., Petitgas, P. and Lazure, P. 2001. The influence of mesoscale ocean processes on anchovy (*Engraulis encrasicolus*) recruitment in the Bay of Biscay estimated with a three-dimensional hydrodynamic model. Fisheries Oceanography, 10: 151-163.

Allain, G., Petitgas, P., Lazure, P. and Grellier, P., 2007. Biophysical modelling of larval drift, growth and survival for the prediction of anchovy recruitment in the Bay of Biscay (NE Atlantic). Fisheries Oceanography, 16(6), 489-505.

Borja, A. Uriarte, A., Egana, J., Motos, L. and Valencia, V. 1998. Relationships between anchovy (*Engraulis encrasicolus*) recruitment and environment in the Bay of Biscay (1967-1996). Fisheries Oceanography, 7(3-4), 375-380.

Borja, A. Fontán, A., Saez, J. and Valencia, V. 2008: Climate, oceanography, and recruitment: the case of the Bay of Biscay anchovy (*Engraulis encrasicolus*). Fish. Oceanogr. 17:6, 477–493, 2008

Cochran, W.G., 1977. Sampling techniques. John Wiley and sons (ed,.) 428 pp, N.Y.

Csirke J. 1988. Small shoaling pelagic fish stocks. In Fish Population Dynamics (Second Edition). Edited by J.A. Gulland. John Wiley & Sons Ltd.

Duhamel, E., Biseau, A., Massé, J. and Villalobos, H. 2004. The French fishery. Working document to the ICES Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), 7-16 September 2004, ICES Headquarters, ICES CM 2005/ACFM:08.

Hunter, J. R., et al. Batch fecundity in multiple spawning fishes, R. Lasker (ed.), p. 67-77. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 36.

Huret, M., and Petitgas, P. 2007. Anchovy recruitment forecasting and environment. Working document to ICES WGMHMSA 2007.

Ibaibarriaga, L., Fernández, C., Uriarte, A., and Roel, B. A. 2008. A two-stage biomass dynamic model for Bay of Biscay anchovy: a Bayesian approach. – ICES Journal of Marine Science, 65: 191–205

ICES. 2007. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA), 4 - 13 September 2007, ICES Headquarters. ICES CM 2007/ACFM:31. 712 pp.

ICES. 2008a. Report of the Working Group on Anchovy (WGANC), 13 - 16 June 2008, ICES Headquarters, Copenhagen. ICES CM 2008 ACOM:04. 226 pp.

ICES. 2008b. Report of the ICES Advisory Committee, 2008. ICES Advice, 2008. Book 7, 122 pp.

Junquera, S., 1986. Pêche de l'anchois (*Engraulis encrasicholus*) dans le golfe de Gascogne et sur le littoral atlantique de Galice depuis 1920. Variations quantitatives. Rev. Trav. Inst. Pêches Marit., 483-4: 133-142.

Junquera, S. and Perez-Gandaras, G. 1993. Population diversity in Bay of Biscay anchovy (*Engraulis engrasicholus*, L. 1758) as revealed by multivariate analisis of morphometric and meristic characters. ICES J. mar. Sci., 50:383:396.

Lasker, R., 1985. An Egg Production Method for Estimating Spawning Biomass of pelagic fish: Application to the Northen Anchovy, *Engraulis Mordax*. NOAA Technical report NMFS 36:100p.

Mackinson, S., Sumaila, U. R. and T. J. Pitcher. 1997. Bioeconomics and catchability: fish and fishers behaviour during stock collapse. Fisheries Research 31: 11-17.

Massé, J. 1988. Utilisation de l'echo-integration en recherche halieutique (analyse des campagnes effectuées dans le Golfe de Gascogne de 1983 à 1987). Direction des Ressources Vivantes, IFREMER.

Massé J. 1994. Acoustic Surveys DAAG 90, DAAG 91, DAAG 92. Annex to: Orestes (editor): Improvement of stock assessment by direct methods, its application to the anchovy (*Engraulis encrasicholus*) in the Bay of Biscay. Report of the EC FAR Project (1991-1993) (Contract No. MA 2495 EF), 90 pp. + annexes.

Massé, J. (1996). "Acoustics observation in the Bay of Biscay: schooling, vertical distribution, species assemblages and behaviour." Scientia Marina 60(Suppl. 2): 227-234.

Moser, H.G. and E. H. Ahlstrom, 1985. Staging anchovy eggs. In: "An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, *Engraulis mordax*, R. Lasker (ed.), p. 7-16. U. S. Dep. Commer., NOAA Tech. Rep. NMFS 36.

Motos L., A. Uriarte, P. Prouzet, M. Santos, P. Alvarez and Y. Sagarminaga. 2005: Assessing the Bay of Biscay anchovy population by DEPM: a review 1989-2001. In Castro, LR, P. Fréon , C.D.

Petitgas, P., Massé, J., Beillois, P., Lebarbier, E. and Le Cann, A. (2003) Sampling variance of species identification in fisheries acoustic surveys based on automated procedures associating acoustic images and trawl hauls ICES Journal of Marine Science 60: 437-445 (1)

Pitcher, T. J., 1995 : The impact of pelagic fish behaviour on fisheries. Sci. Mar., 59 (3-4): 295-306.

Prouzet, P. and Metuzals, K. 1994. Phenotypic and genetic studies on the Bay of Biscay anchovy. InCendrero (Eds) 1994. Final report of the EC FAR project (1991–1993).

Santiago, J. and A. Sanz, 1992. Egg production estimates of the Bay of Biscay anchovy, Engraulis encrasicolus (L.), spawning stock in 1987 and 1988 (Estimaciones de la producción de huevos de l stock reproductor de anchoa, *Engraulis encrasicolus* (L.), del Golfo de Vizcaya en 1987 y 1988). Bol. Inst. Esp. Oceanogr. 8 (1):225-230

Sanz, N., García-Marín, J-L., Viñas, J., Roldán, M., and Pla, C. 2008. Spawning groups of European anchovy: population structure and management implications. – ICES Journal of Marine Science, 65.

Sanz, A. & A. Uriarte, 1989. Reproductive cycle and batch fecundity of the Bay of Biscay anchovy (*Engraulis encrasicholus* L.) in 1987. CalCOFI Rep., vol. 30: 127-135.

Stauffer, G. and S. J. Picquelle, 1980. Estimates of the 1980spawning biomass of the of the central subpopulation of northern anchovy. Natl. Mar. Fish. Serv. , NOAA. Southw. Fish . Cent. Admin. Rep. LJ-80-09, 41 p.

Picquelle, S. J. and G. Stauffer, 1985. Parameter estimation for an egg production method of anchovy biomass assessment. In R. Lasker (editor), An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, *Engraulis mordax*, p. 7-16. U.S. Dep. Commer., NOAA Tech. Rep. NMFS36.

STECF-SGRST 2008: Report of the Meeting to inform the Commission on a long-term management plan for the stock of anchovy in the Bay of Biscay (ICES Sub-area VIII). Held in Hamburg, 14-18 April 2008

STECF/SGBRE-08-01: Working Group Report on the long term management of Bay of Biscay anchovy. San Sebastian, 2-6 June

Seber, G.A.F., 1982. Estimation of animal abundance and related parameters. Macmillan, New York.

Somarakis, S., Palomera, I., Garcia, A., Quintanilla, L., Koutsikopoulos, C. Uriarte, A. and L. Motos, 2004: Daily egg production of anchovy in European waters. ICES Journal of Marine Science, 61: 944-958

Ulltang, O. 1980. Factors affecting the reaction of pelagic fish stocks to exploitation and requiring a new approach to assessment and management, Rapp. Procès-Verb. Réun. Cons. Int. Explor. Mer 177. 489-504.

Uriarte, A. 2005: Assessment of the Bay of Biscay anchovy by means of a seasonal separable VPA. Working Document to the ICES Working Group on the assessment of mackerel, horse mackerel, sardine and anchovy, held in Vigo from 06 to 15 September 2005.

Uriarte, A., Prellezo, R., Punzón, A., Aranda, M. and Villamor, B. 2008. The Spanish fishery on anchovy in the Bay of Biscay: Analysis of the relationship between fishing Capacity, Effort and mortality. ICES CM 2008/I:18.

Uriarte A. Prouzet, P. and B. Villamor 1996: Bay of Biscay and Ibero atlantic anchovy populations and their fisheries. Sci. Mar. 60 (Supl.2): 237-255

Uriarte A (Coordinator), M. Blanco, E. Duhamel, P. Grellier, I. Rico, B. Villamor 2006: 2005 Anchovy otolith exchange programme from subarea VIII: Working Document to the 2006

ICES Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) 24 February 2006

Uriarte, A. C. Dueñas, E. Duhamel, P. Grellier, I. Rico, B. Villamor, 2007: 2006 Anchovy Otolith Workshop. Working Document to the 2007 ICES Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) (5-9 March)

Vermard, Y., Marchal, P., Mahevas, S. and Thebaud, O. 2008. A dynamic model of the Bay of Biscay pelagic fleet simulating fishing trip choice: the response to the closure of the European anchovy (Engraulis encrasicolus) fishery in 2005. Can. J. Fish. Aquat. Sci. 65: 2444–2453.

Villamor B., Aranda M., Punzón A., Uriarte A., Báez J. C., (2008): The Anchovy fishery in the Bay of Biscay I: Description and Analysis of the Spanish Fleet (2000-2005). ICES CM 2008/ I:30 (Theme session I).

Technical Minutes - Anchovy in the Gulf of Cadiz

Assessment Type:	Update
Assessment:	Accepted
Forecast:	Not carried out
Assessment model:	Qualitative analysis
Consistency:	Highly consistent with previous assessment
Stock status:	No evidence of serious problems
Management plan:	none
Reviewer:	Henrik Sparholt

General

The report was well structured, well written and almost packed with information. The focus of the assessment was anchovies in area IXa south. Anchovy stocks in other parts of area IXa are less unimportant. The fishery in IXa south is minor compared to fisheries for other species, such as sardine.

The remarkable disappearance of fish after age 1 due, apparently, to ontogenetic movement patterns raises serious issues about the whether we are dealing with a stock or only a spawning/juvenile area. It seems of an overriding concern to resolve this issue before a proper assessment can be done. The wg deals with the issue rather extensively but seems to be limited to the ICES area and not in sufficient degree consider connections with areas south of Gilbraltar.

Some survey information available from surveys used for other species. Data from a spring acoustic appear potentially most useful. A DEMP (egg) survey in 2005 and 2008 as well. Ageing is difficult due to southern habitat area. Catch at age data have, however, been produced.

A variety of exploratory assessment models were examined but no analytical assessment models have been successfully applied. In particular, a separable model tuned to catch at age and acoustic data did not give reasonable results.

A big reduction in landings from 2007 to 2008 naturally raises concern about the stock. However, both cpue data, acoustic survey data and egg survey data indicated that the reduction in catches was due to reduction in effort and not in the stock. Effort was low in 2008 as the fleet were fishing more in Marokko waters.

Figure 3.5.2 is a nice presentation in one page of the important data for the qualitative assessment.

Technical comments

In the absence of a stock assessment model, reviewers agreed that a qualitative assessment, based on the working group’s evaluation of the available data, was appropriate and sufficient.

Figure 3.4.1.2 and 3 contains unexplained values like B which is several mill tons in some areas. It is unlikely to be biomass of anchovy.

Conclusion

Available fishery independent data indicate stable stock status with little change from the previous assessment. Effort was low in 2008.

The ratio of catch in Area IXa south to fishery independent biomass estimates during 2008 and 2009 is reasonably low (about 0.2).

It is important to continue the current spring acoustic survey, and to carry out more

DEPM surveys on a regular basis, if possible.

The qualitative assessment presented seems appropriate as an up-date assessment.

Technical Minutes – Sardine in Divisions VIIIc and IXa

Assessment type:	Update assessment
Assessment:	presented and agreed
Forecast:	presented and agreed
Assessment model:	AMCI (Assessment model incorporating data from various sources)
Consistency:	same as last year with addition of 1 extra year, except that maturity in the forecast this year is the mean over 1989-2008 and not just the 2008 values, and in the AMCI R in terminal year (this year 2009) was set to 4 billion instead of 9 billion used last year (for 2008).
Stock status:	stock currently slightly above average of last 30 years but declining and expected to decline further as recruitment has been poor in recent years. There are no reference points for this stock
Man. Plan.:	no management plan exists for this stock.
Reviewer:	Henrik Sparholt.

General comments

1) The TOR for this stock was met as it was an update assessment. The catch and abundance indices were updated appropriately.

2) The surveys are well described relative to the last survey conducted, however the WG report would benefit from having a more complete description of the survey in terms of time series available about the spatial distribution of the stock especially in relation to the issue of sardine reducing especially in the northern areas when the stock in total declines.

3) The assessment needs among other things recruitment input for 2009 because it uses survey data from 2009. Last year this was set to 9 billions (for R in 2008) but this year 4 billions (for R in 2009). The value of 4 billions seems more in line with current recruitment. Whether 4 or 9 billion is used influences only marginally the assessment. In the future it might be best to use the value used in the forecast (this year it is 4.923 billion for R 2009 in the forecast).

4) The forecast is as last year except that the maturity ogive was calculated as the mean over 1989-2008 and not just 2008. As this means that the maturity of age 1 used increases to 0.58 compared to 0.29 means that the SSB forecasted increases by about 5-10%. Maybe a more recent average, say the past 3 or 5 years, would be better because in order to take account of any possible trend over time. It seems justified not to used just the last year of observation as this is too variable from year to year.

5) The main issue in this year's assessment is probably the high egg survey estimate from 2008 while the acoustic survey indicates a somewhat lower

stock size. However, the assessment seems to handle that in an appropriate way.

6) The text about future exploration on precautionary reference points is useful and appropriate, putting focus on Blim, management plans and interestingly on spatial distribution of the stock. The relative abundance is the northern areas are considered to be included in one way or another as a precautionary reference point. This seems as a relevant consideration.

7) Egg sampling at the acoustic surveys are mentioned in text and figures but are not considered in the assessment. It is not clear from the report what the intention with this is.

Technical comments:

Some figures in the report regarding the survey contain unexplained information. For instance in Figure 5.3.2.1.1 a parameter called B, probably biomass, but values like 149 mill tons is given so it cannot be biomass of sardine.

Conclusions

In spite of the minor points mentioned above the assessment of the present stock status and the forecast are accepted as an up-date assessment and forecast of the stock.

Technical Minutes - Anchovy in Subarea VIII (Bay of Biscay) (report section 2.5-2.7))

The update assessment for the Bay of Biscay anchovy population is based on a two-stage biomass-based model (BBM) published in Ibaibarriaga *et al.* (2008) and is described in the stock annex.

1) **Assessment type:** **update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: Bayesian two-stage biomass-based model – tuning by DEPM and acoustic surveys
5) **Consistency**: Consistent with previous assessment
6) **Stock status**: B at about Blim, fishery closed
7) **Man. Plan.**: No management plan exists for this stock but the present closure of the fishery aims at protecting the remaining stock until a strong year class recruits to the stock

Reviewer: Carl O'Brien

General comments

These are well documented, well ordered and considered sections. They are easy to follow and interpret. The assumptions and conclusions are clearly presented and described.

The situation for Bay of Biscay anchovy seems to be similar to the situation last year – the biomass estimated from the surveys is at a similar low level to last year (possibly, even lower) and the age-1 abundance remains low.

The harvest rate in 2008 was zero. The fishery has been closed for the first half of 2009 – no catches from the 15th May 2009 to 30th June 2009.

Technical comments

The assessment has been performed correctly; together with the forecast which is made under the assumption that the recent low recruitment will continue into the future.

The only change to the assessment methodology this year resulted from the convergence properties of the MCMC which was not as fast as in previous years - longer runs with longer burn-in periods and higher thinning were required. These convergence properties are neither considered an issue nor concern.

Conclusions

The assessment of the present stock status and the forecast are accepted as an update assessment and forecast of the stock.

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 accepted and the reference points should be reviewed within that conceptual framework. The Bayesian assessment, for example, provides the probability distribution for SSB so the rationale to maintain a B_{pa} is debatable.

Harvest control rules (HCRs) for anchovy have been under consideration and the results of the ICES' benchmark workshop on short-lived species (WKSHORT) to be held in Bergen, Norway later in the year should further assist this development.